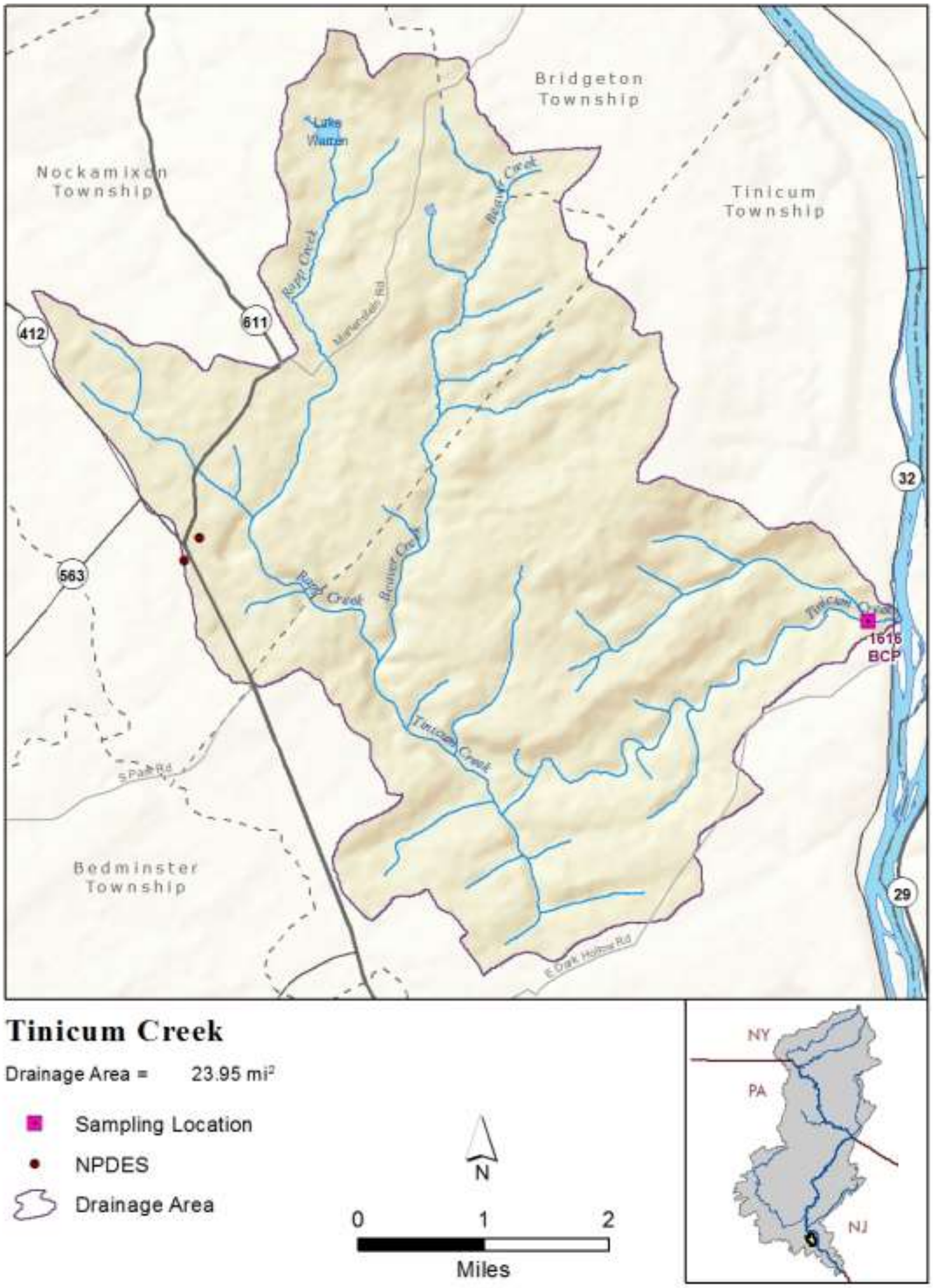
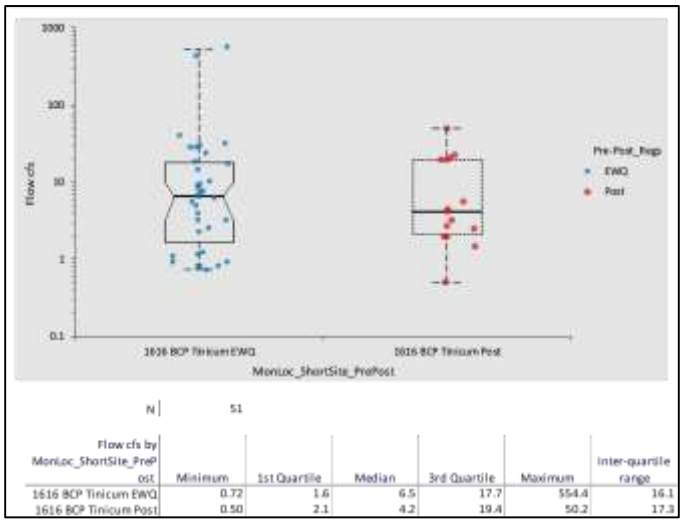
Chapter 10: 1616 BCP Tinicum Creek, Bucks County, PA



Analysis of flow differences between the EWQ and post-EWQ periods:



N	51					
Flow cfs by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1616 BCP Tinicum EWQ	0.72	1.6	6.5	17.7	554.4	16.1
1616 BCP Tinicum Post	0.50	2.1	4.2	19.4	50.2	17.3

Flow was roughly the same between the EWQ and post-EWQ periods. Fewer samples were collected in the post-EWQ period, and the range of flow conditions sampled was narrower. Flow is plotted on a logarithmic scale.

Kruskal-Wallis test

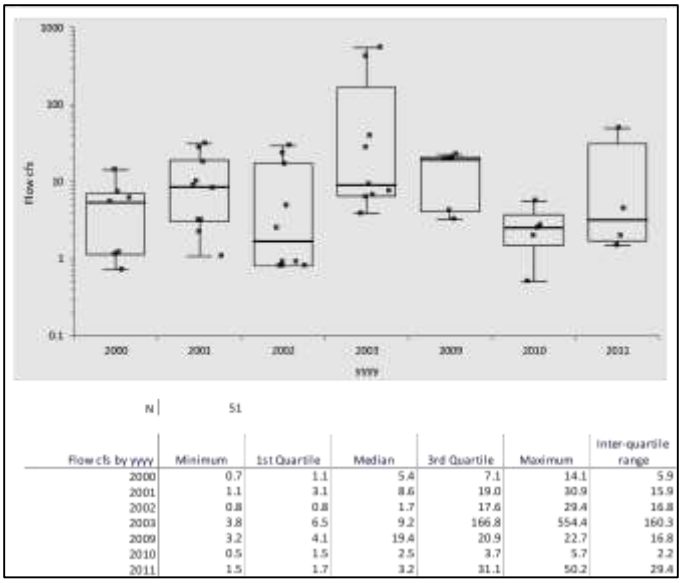
Flow cfs by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1616 BCP Tinicum EWQ	36	9.5	0.26
1616 BCP Tinicum Post	15	22.8	1.52

H statistic	0.15
X^2 approximation	0.15
DF	1
p-value	0.7021[1]

H0: $\theta_1 = \theta_2 = \theta...$
The median of the populations are all equal.
H1: $\theta_i \neq \theta_j$ for at least one i,j
The median of the populations are not all equal.
[1] Do not reject the null hypothesis at the 5% significance level.

The 24 square mile Tinicum Creek watershed was included in the Lower Delaware Wild and Scenic designation for its scenic and natural value. The watershed is about 77% forested and less than 1% urban land cover. There is no underlying carbonate bedrock in the watershed, so water quality is typical of a Piedmont stream. Much of the stream flows over and along exposed bedrock, and the headwaters include some PA Exceptional Value streams.

Upstream ICP: Delaware River at Milford 1677 ICP
Downstream ICP: Del. River at Bulls Island 1554 ICP



N	51					
Flow cfs by yyyy	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
2000	0.7	1.1	5.4	7.1	14.1	5.9
2001	1.1	3.1	8.6	19.0	30.9	15.9
2002	0.8	0.8	1.7	17.6	29.4	16.8
2003	3.8	6.5	9.2	166.8	554.4	160.3
2009	3.2	4.1	19.4	20.9	22.7	16.8
2010	0.5	1.5	2.5	3.7	5.7	2.2
2011	1.5	1.7	3.2	31.1	50.2	29.4

Annual May to September flow statistics are plotted above. Flow is plotted on a logarithmic scale. These are flow measurements or associated with the time of each water quality sample. Mean annual flow is about 37 cfs; and harmonic mean flow is about 11 cfs (USGS StreamStats retrieval) which is more typical of summer flow conditions. Though a wide range of flows were sampled by DRBC, these data sets appear to be most representative of low to low-normal flow conditions except for high-flow years 2003 and 2009. Flows corresponding to each water quality sample were estimated using either a gage-discharge rating constructed by DRBC or the USGS BaSE* program. There was an excellent correspondence between sample flows determined by the DRBC gage and BaSE-derived estimates, so DRBC intends to use the BaSE program for future flow estimates. DRBC's gages here have been destroyed many times by floods. Maintaining a gage at DRBC's monitoring site is no longer economically viable.

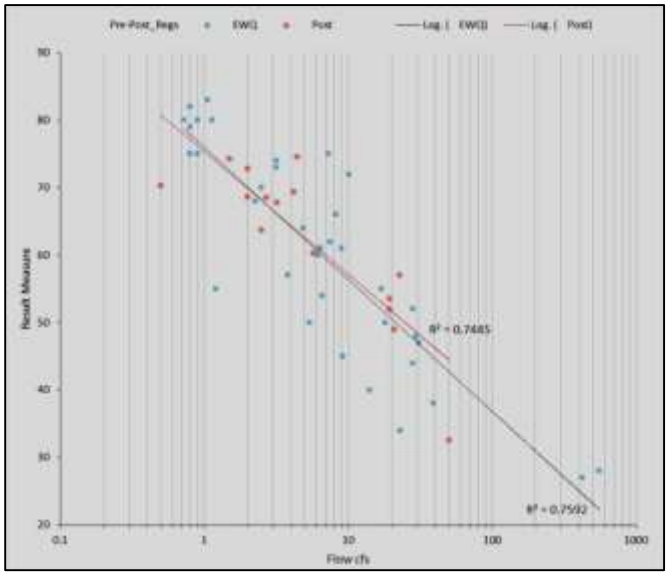
*Stuckey, M.H., Koerkle, E.H., and Ulrich, J.E., 2012, Estimation of baseline daily mean streamflows for ungaged locations on Pennsylvania streams, water years 1960–2008: U.S. Geological Survey Scientific Investigations Report 2012–5142, 61 p.)

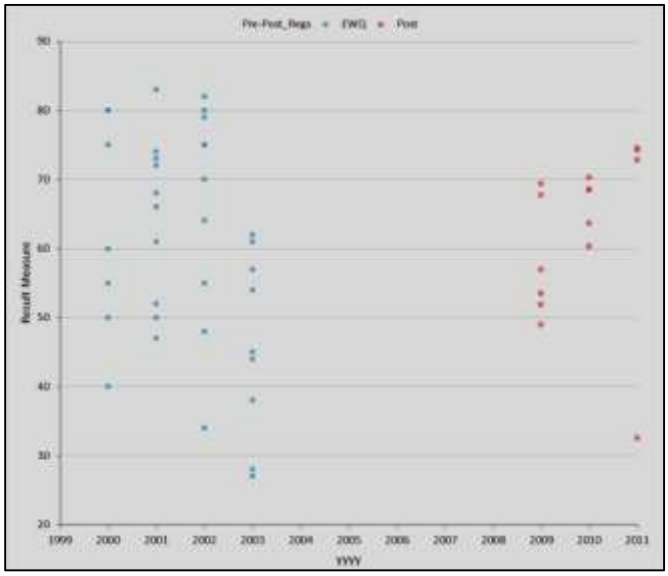
Chapter 10: 1616 BCP Tinicum Creek, PA

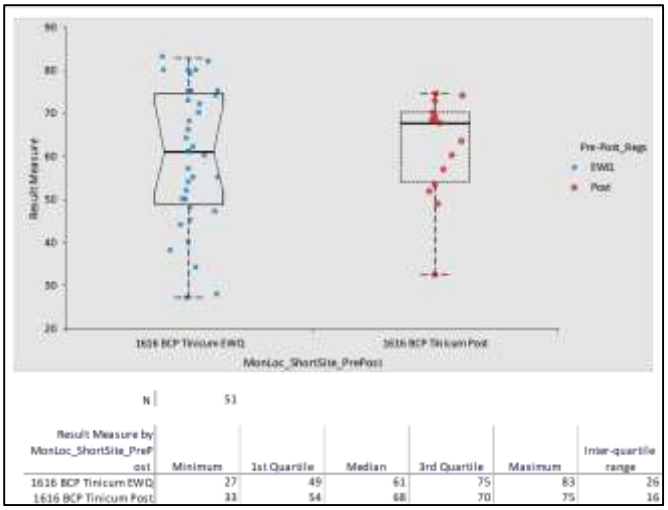
Alkalinity as CaCO3, Total mg/l

Existing Water Quality (Table 2Q):

Median 61 mg/l
Lower 95% Confidence Interval 52 mg/l
Upper 95% Confidence Interval 72 mg/l
Defined in regulations as a flow-related parameter

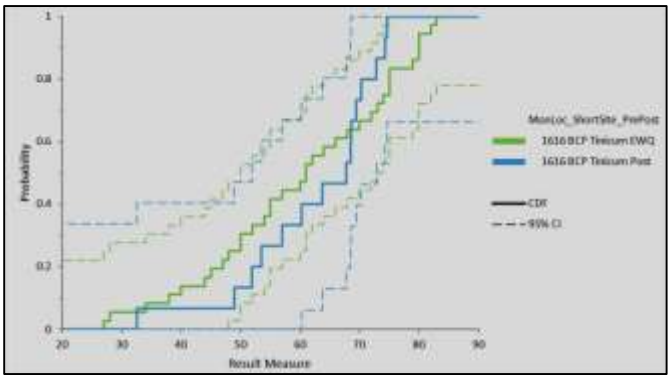






N	51

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1616 BCP Tinicum EWQ	27	49	61	75	83	26
1616 BCP Tinicum Post	33	54	68	70	75	16



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1616 BCP Tinicum EWQ	36	3.1	0.09
1616 BCP Tinicum Post	15	7.3	0.49

H statistic	0.05
X^2 approximation	0.05
DF	1
p-value	0.8281 [1]

H0: $\theta_1 = \theta_2 = \theta...$
The median of the populations are all equal.
H1: $\theta_i \neq \theta_j$ for at least one i,j
The median of the populations are not all equal.
[1] Do not reject the null hypothesis at the 5% significance level.

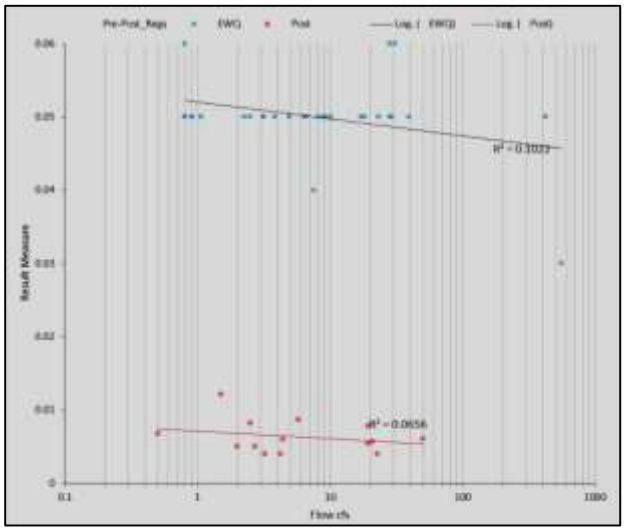
No water quality degradation is evident here. Alkalinity did not measurably change between the EWQ and post-EWQ periods. Alkalinity is inversely related to flow in both data sets. Post-EWQ median alkalinity fell within EWQ 95% confidence intervals. Flow is plotted on a logarithmic scale.

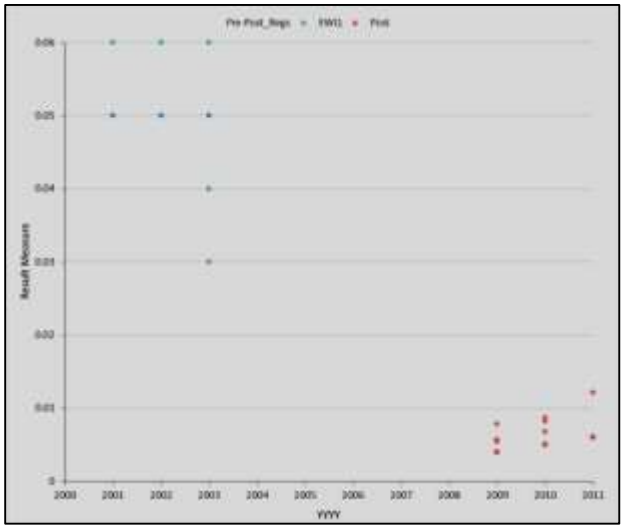
Chapter 10: 1616 BCP Tinicum Creek, PA

Ammonia Nitrogen as N, Total mg/l

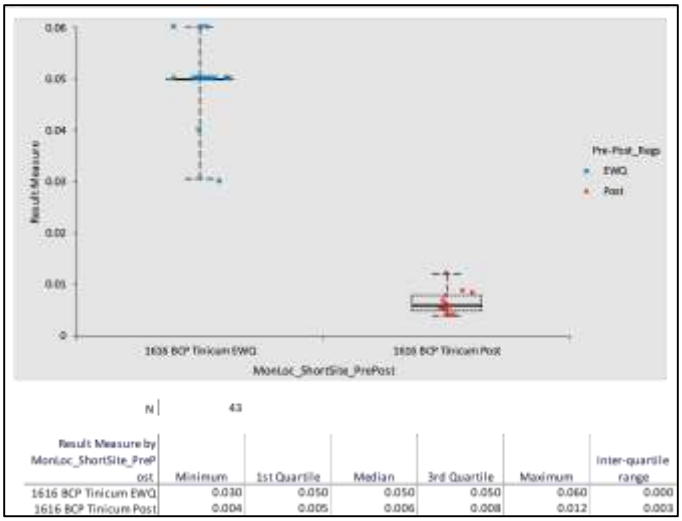
Existing Water Quality (Table 2Q):

Median <0.05 mg/l
Lower 95% Confidence Interval <0.05 mg/l
Upper 95% Confidence Interval <0.05 mg/l

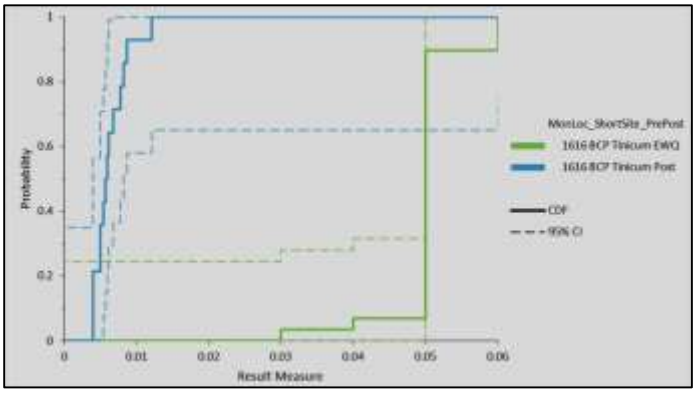




No water quality degradation is evident here. Ammonia concentrations apparently declined. Post-EWQ median ammonia concentration was below the EWQ lower 95% confidence interval. However, potential laboratory artifacts, detection limit differences, and insufficient post-EWQ sampling frequency introduced uncertainty into conclusions.



Result Measure by MonLoc_ShortSite_PreP ost	N	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1616 BCP Tinicum EWQ	43	0.030	0.050	0.050	0.050	0.060	0.000
1616 BCP Tinicum Post		0.004	0.005	0.006	0.008	0.012	0.003



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PreP ost	n	Rank sum	Mean rank
1616 BCP Tinicum EWQ	29	1421.0	49.00
1616 BCP Tinicum Post	14	2943.5	210.25

H statistic	33.53
X^2 approximation	33.53
DF	1
p-value	<0.0001 [1]

H0: $\theta_i = \theta_2 = \theta...$
The median of the populations are all equal.
H1: $\theta_i \neq \theta_j$ for at least one i,j
The median of the populations are not all equal.
[1] Reject the null hypothesis in favour of the alternative hypothesis at the 5% significance level.

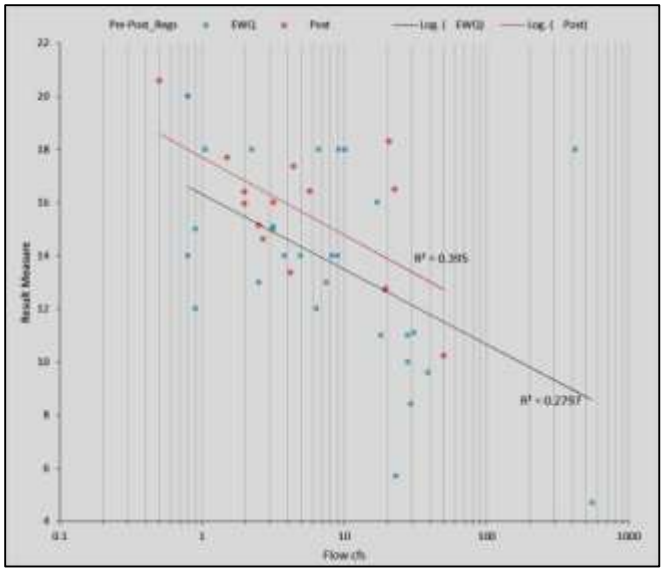
No independent data were available to validate results. EWQ data possessed 26/29 undetected results, which interfered with calculation of the median. Thus EWQ was established as <0.05 mg/l, the detection limit at the time. Post-EWQ 2009-2011 lower detection levels of 0.004-0.006 mg/l still resulted in 6 of 14 non-detects. So rather than a real change in ambient concentrations we are now able to measure actual lower concentrations. Improvement possibly took place, as the post-EWQ data contained no concentrations over 0.012 mg/l. Flow is plotted on a logarithmic scale.

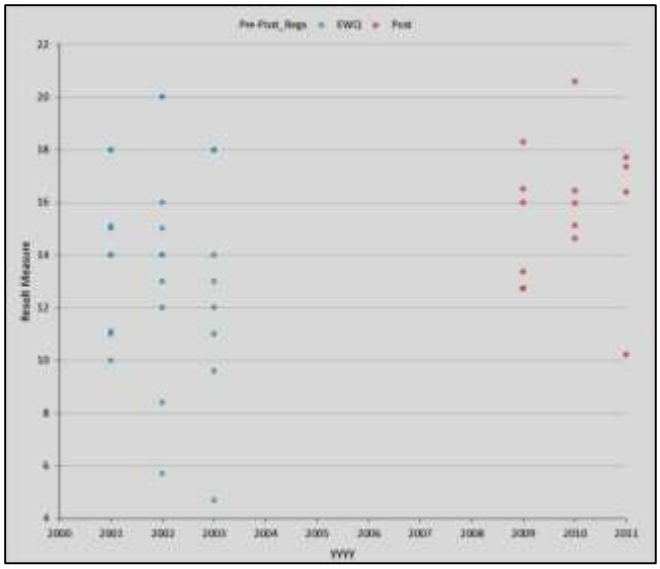
Chapter 10: 1616 BCP Tinicum Creek, PA

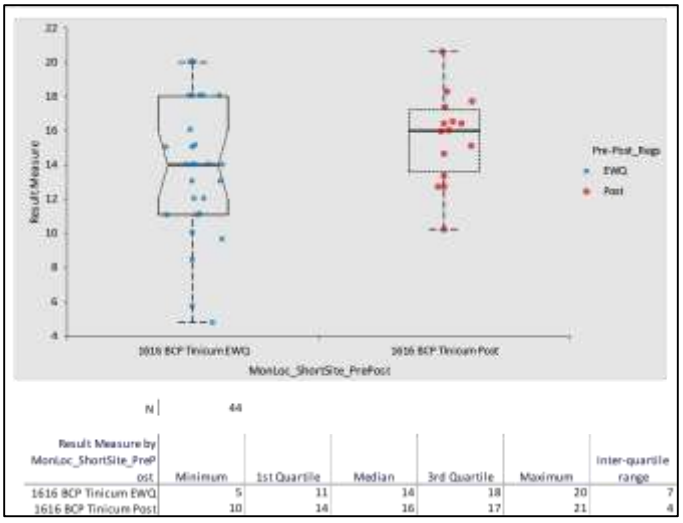
Chloride, Total mg/l

Existing Water Quality (Table 2Q):

Median 14 mg/l
Lower 95% Confidence Interval 12 mg/l
Upper 95% Confidence Interval 16 mg/l

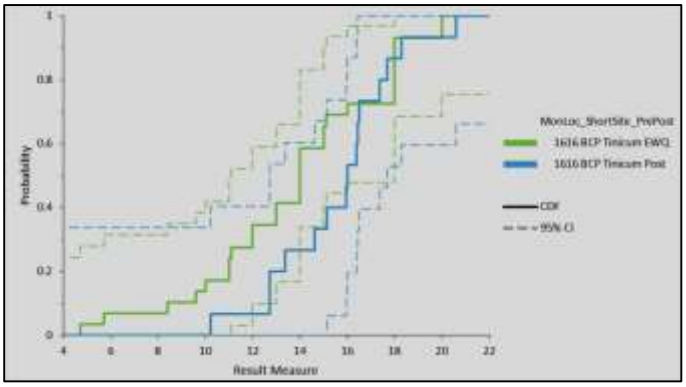






N	44

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1616 BCP Tinicum EWQ	5	11	14	18	20	7
1616 BCP Tinicum Post	10	14	16	17	21	4



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1616 BCP Tinicum EWQ	29	116.0	4.00
1616 BCP Tinicum Post	15	224.3	14.95

H statistic	2.07
X^2 approximation	2.07
DF	1
p-value	0.1501 [1]

H0: $\theta_i = \theta_2 = \theta...$
The median of the populations are all equal.
H1: $\theta_i \neq \theta_j$ for at least one i,j
The median of the populations are not all equal.
[1] Do not reject the null hypothesis at the 5% significance level.

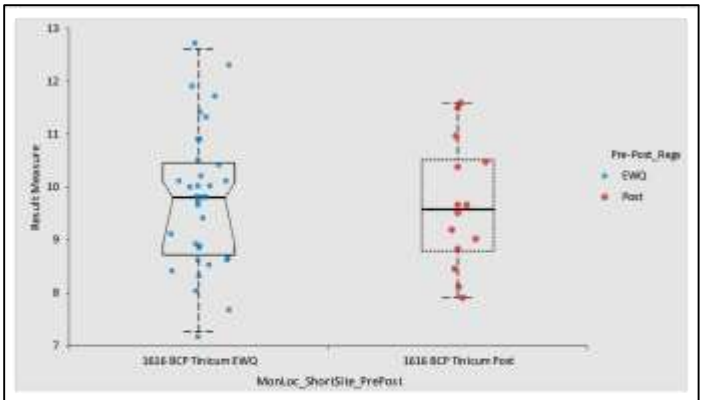
No water quality degradation is evident here. Chloride concentrations did not measurably change between the two periods. Post-EWQ median concentration rose to the EWQ upper 95% confidence interval. Flow is plotted on a logarithmic scale.

Chapter 10: 1616 BCP Tinicum Creek, PA

Dissolved Oxygen (DO) mg/l

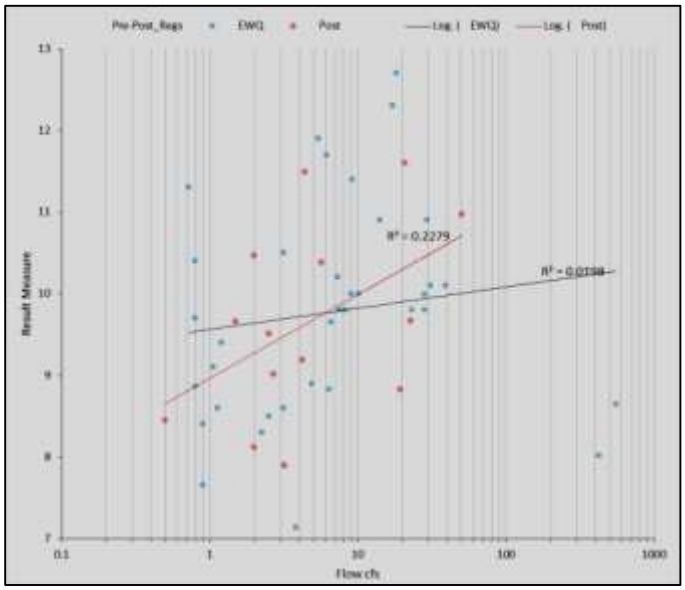
Existing Water Quality (Table 2Q):

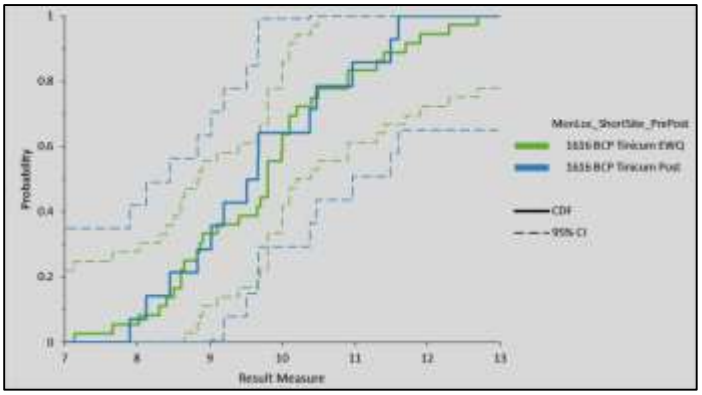
Median 9.80 mg/l
Lower 95% Confidence Interval 8.90 mg/l
Upper 95% Confidence Interval 10.10 mg/l

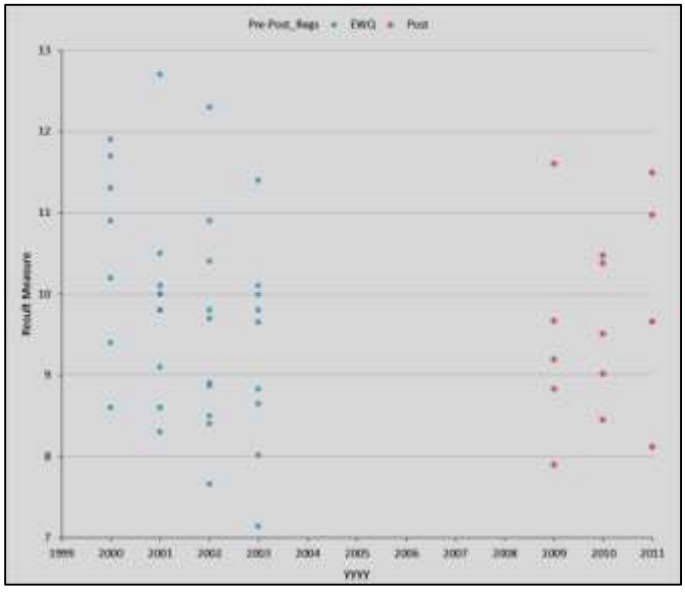


N	50

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1616 BCP Tinicum EWQ	7.14	8.73	9.80	10.46	12.70	1.73
1616 BCP Tinicum Post	7.90	8.80	9.59	10.51	11.60	1.71







Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1616 BCP Tinicum EWQ	36	7.6	0.21
1616 BCP Tinicum Post	14	19.4	1.39

H statistic	0.13
X^2 approximation	0.13
DF	1
p-value	0.7214 [1]

H0: $\theta_1 = \theta_2 = \theta...$
The median of the populations are all equal.
H1: $\theta_i \neq \theta_j$ for at least one i,j
The median of the populations are not all equal.
[1] Do not reject the null hypothesis at the 5% significance level.

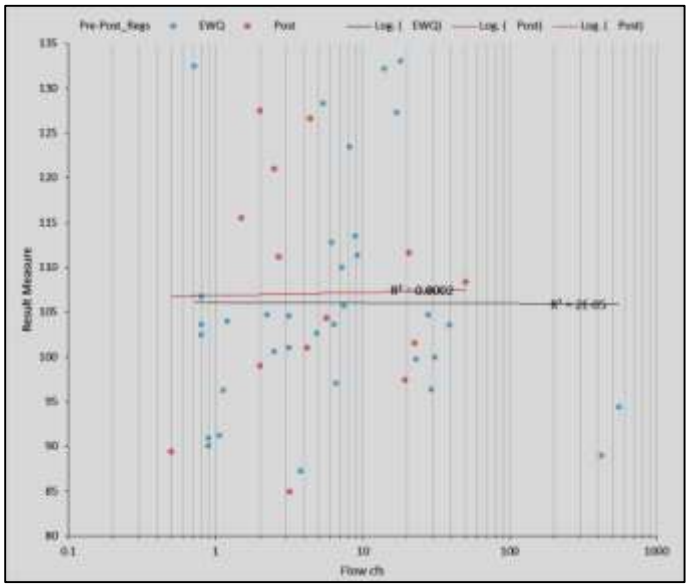
No water quality degradation is evident here. No measurable change took place between the EWQ and Post-EWQ periods. Post-EWQ median DO concentration fell within the EWQ 95% confidence intervals. Flow is plotted on a logarithmic scale. DO concentration is unrelated to flow in both data sets.

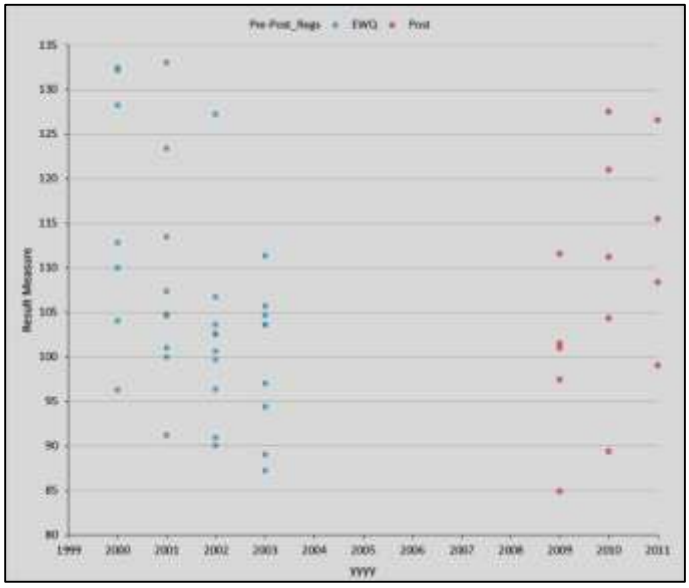
Chapter 10: 1616 BCP Tinicum Creek, PA

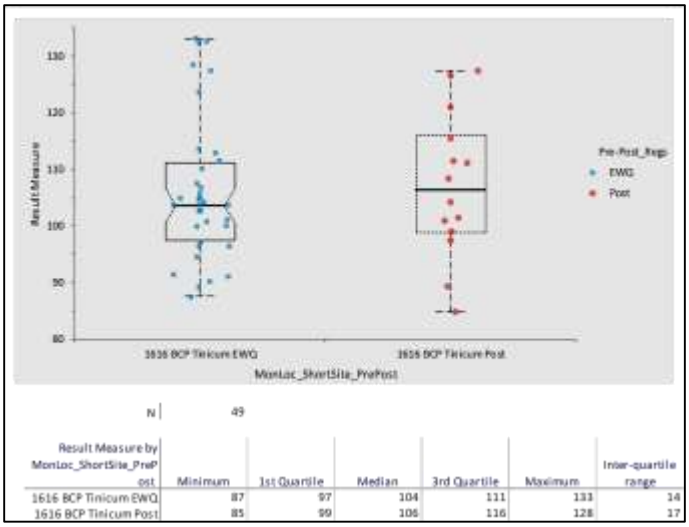
Dissolved Oxygen Saturation %

Existing Water Quality (Table 2Q):

Median 104%
Lower 95% Confidence Interval 101%
Upper 95% Confidence Interval 107%

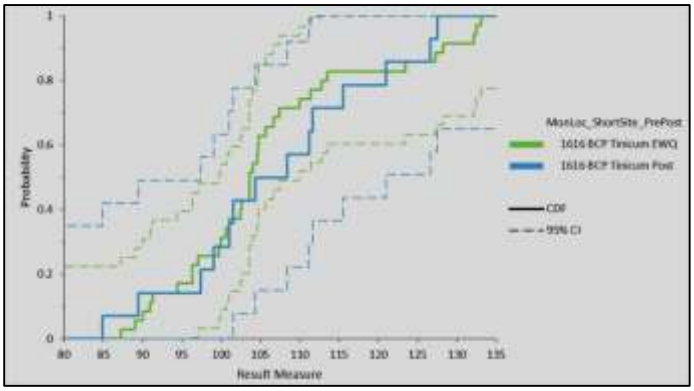






N	49

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1616 BCP Tinicum EWQ	87	97	104	111	133	14
1616 BCP Tinicum Post	85	99	106	116	128	17



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1616 BCP Tinicum EWQ	35	7.3	0.21
1616 BCP Tinicum Post	14	18.3	1.31

H statistic	0.13
X^2 approximation	0.13
DF	1
p-value	0.7233 [1]

H0: $\theta_i = \theta_2 = \theta...$
The median of the populations are all equal.
H1: $\theta_i \neq \theta_j$ for at least one i,j
The median of the populations are not all equal.
[1] Do not reject the null hypothesis at the 5% significance level.

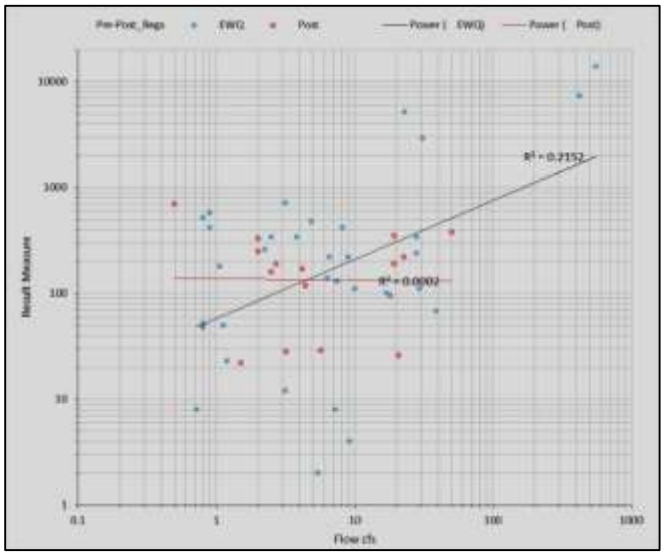
No water quality degradation is evident here. Dissolved Oxygen Saturation is unrelated to flow, and did not measurably change between the EWQ and post-EWQ periods. Post-EWQ median DO saturation was within the EWQ 95% confidence intervals. Flow is plotted on a logarithmic scale. Tinicum Creek is wide and shallow, without full shading by riparian vegetation in many locations. This promotes increased algal production because sunlight can reach all parts of the stream bottom. During mid-day hours the algae and aquatic plants produce oxygen super-saturation conditions, thus there are frequently observed saturation values over 120%.

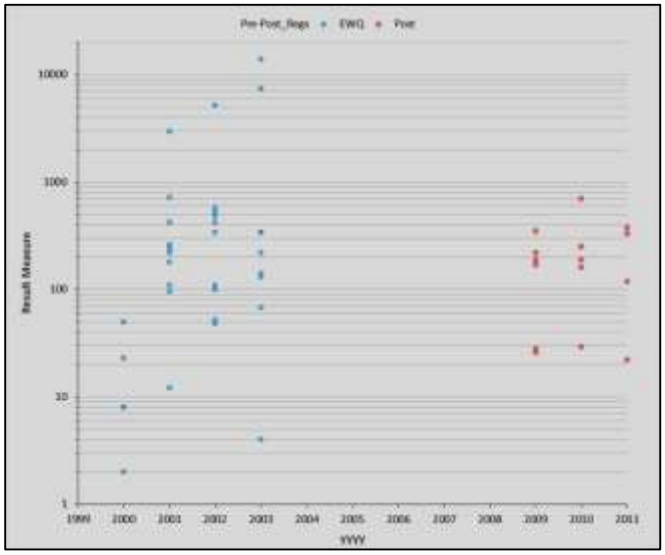
Chapter 10: 1616 BCP Tinicum Creek, PA

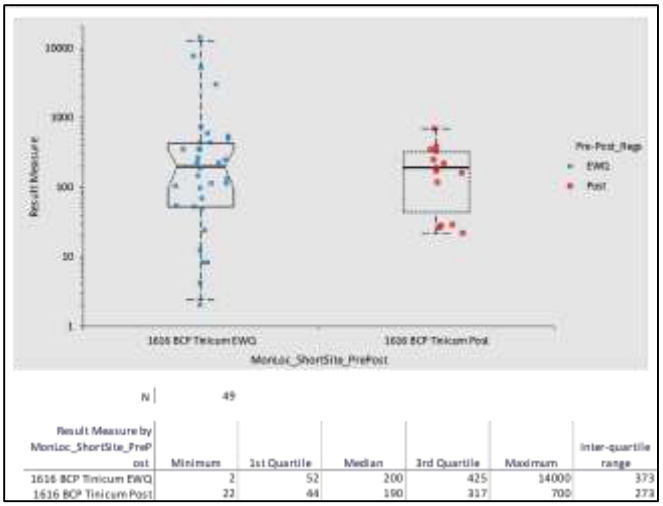
Enterococcus colonies/100 ml

Existing Water Quality (Table 2Q):

Median 200/100 ml
Lower 95% Confidence Interval 96/100 ml
Upper 95% Confidence Interval 340/100 ml

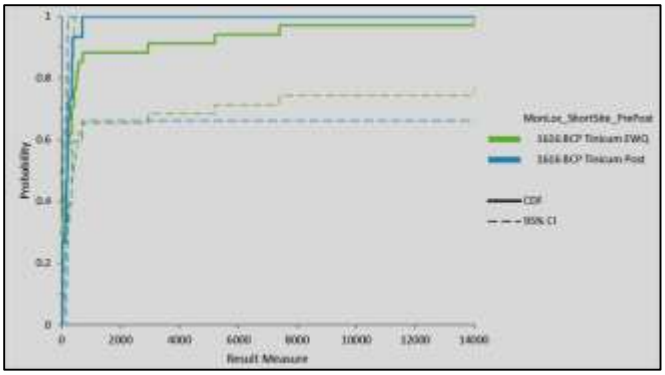






N	49

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1616 BCP Tinicum EWQ	2	52	200	425	14000	373
1616 BCP Tinicum Post	22	44	190	317	700	273



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1616 BCP Tinicum EWQ	34	7.5	0.22
1616 BCP Tinicum Post	15	17.1	1.14

H statistic	0.12
X^2 approximation	0.12
DF	1
p-value	0.7284 [1]

H0: $\theta_1 = \theta_2 = \theta...$
The median of the populations are all equal.
H1: $\theta_i \neq \theta_j$ for at least one i,j
The median of the populations are not all equal.
[1] Do not reject the null hypothesis at the 5% significance level.

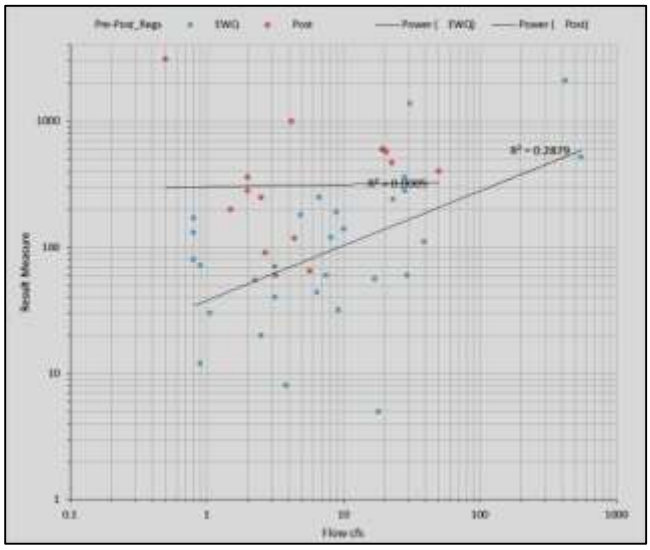
No water quality degradation is evident here. Enterococci did not measurably change between the EWQ and Post-EWQ periods. Enterococcus concentrations are unrelated to flow in both data sets. Concentrations and flows are plotted on a logarithmic scale, and regressions are power relationships. Post-EWQ median enterococcus concentrations were within the EWQ 95% confidence intervals.

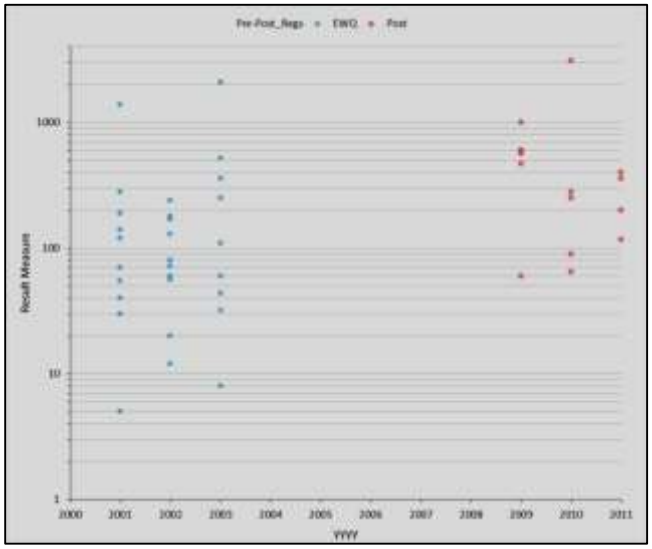
Chapter 10: 1616 BCP Tinicum Creek, PA

Escherichia coli colonies/100 ml

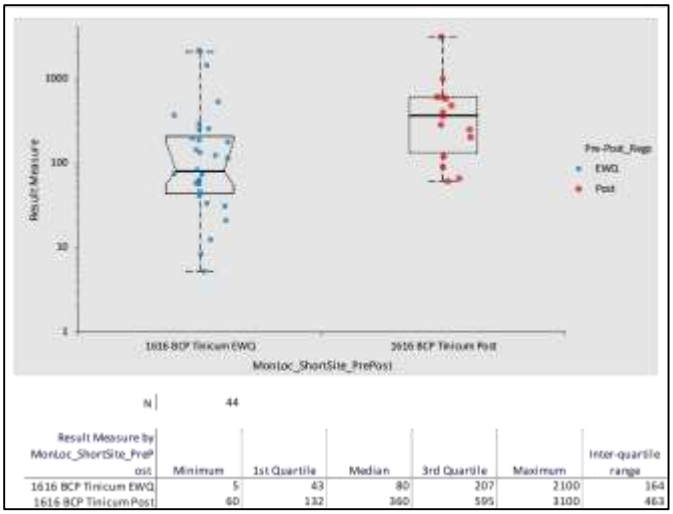
Existing Water Quality (Table 2Q):

Median 80/100 ml
Lower 95% Confidence Interval 55/100 ml
Upper 95% Confidence Interval 180/100 ml



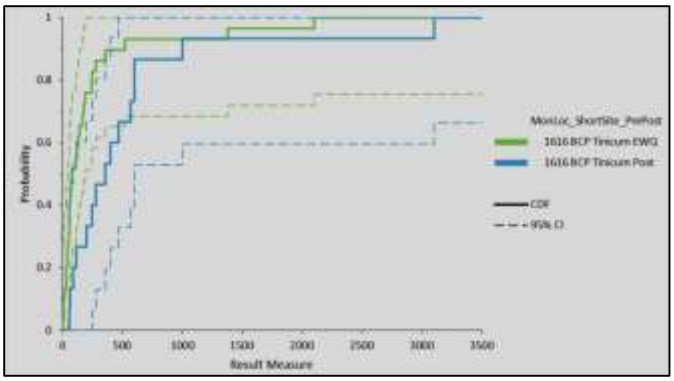


Evidence of water quality degradation is shown here. E. coli concentrations apparently increased between the EWQ and Post-EWQ periods. However, conclusions are obscured by uncertainty introduced by potential laboratory artifacts and insufficient post-EWQ sampling frequency. Post-EWQ median E. coli rose above the EWQ upper 95% confidence interval.



N	44

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1616 BCP Tinicum EWQ	5	43	80	207	2100	164
1616 BCP Tinicum Post	60	132	360	595	3100	463



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1616 BCP Tinicum EWQ	29	504.9	17.41
1616 BCP Tinicum Post	15	976.1	65.07

H statistic	8.98
X^2 approximation	8.98
DF	1
p-value	0.0027 [1]

H0: $\theta_1 = \theta_2 = \theta...$
The median of the populations are all equal.
H1: $\theta_i \neq \theta_j$ for at least one i,j
The median of the populations are not all equal.
[1] Reject the null hypothesis in favour of the alternative hypothesis at the 5% significance level.

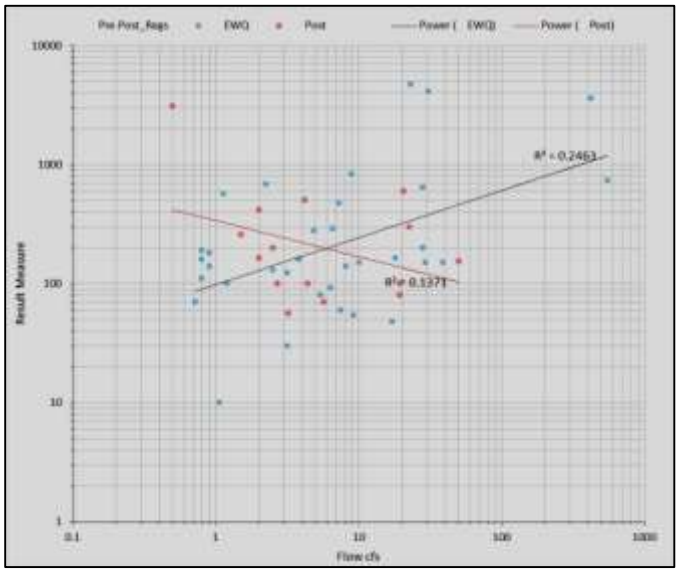
Concentrations and flows are plotted on logarithmic scale and regressions are power relationships. E. coli concentrations were positively but weakly related to flow in the EWQ data set, but unrelated to flow in the post-EWQ data set – possibly due to too few post-EWQ samples (n=15). No independent data from other agencies were available at this site to validate DRBC's conclusion.

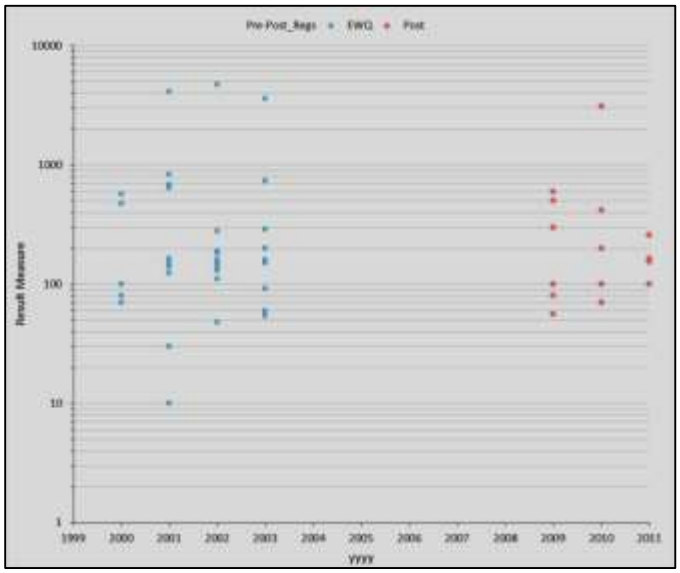
Chapter 10: 1616 BCP Tinicum Creek, PA

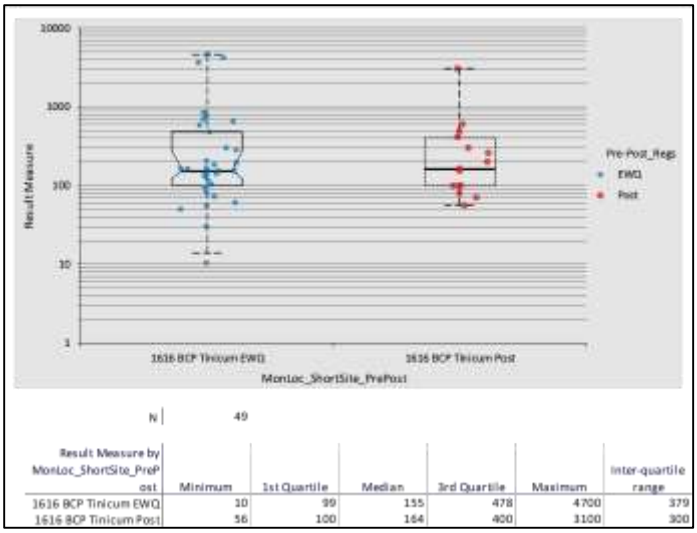
Fecal coliform colonies/100 ml

Existing Water Quality (Table 2Q):

Median 155/100 ml
Lower 95% Confidence Interval 124/100 ml
Upper 95% Confidence Interval 280/100 ml

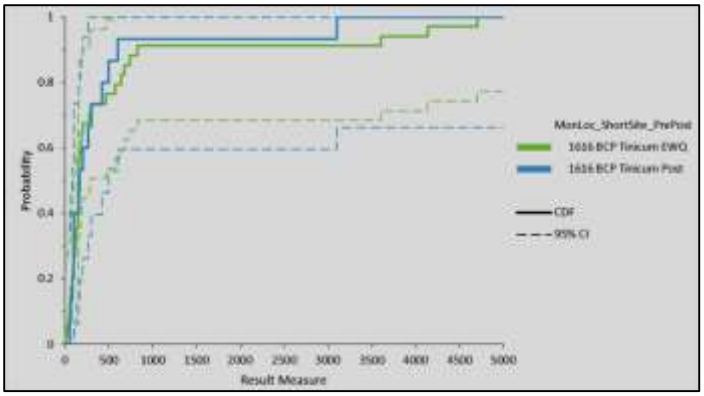






N	49

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1616 BCP Tinicum EWQ	10	99	155	478	4700	379
1616 BCP Tinicum Post	56	100	164	400	3100	300



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1616 BCP Tinicum EWQ	34	0.2	0.01
1616 BCP Tinicum Post	15	0.4	0.03

H statistic	0.00
X^2 approximation	0.00
DF	1
p-value	0.9567 [1]

H0: $\theta_1 = \theta_2 = \theta...$
The median of the populations are all equal.
H1: $\theta_i \neq \theta_j$ for at least one i,j
The median of the populations are not all equal.
[1] Do not reject the null hypothesis at the 5% significance level.

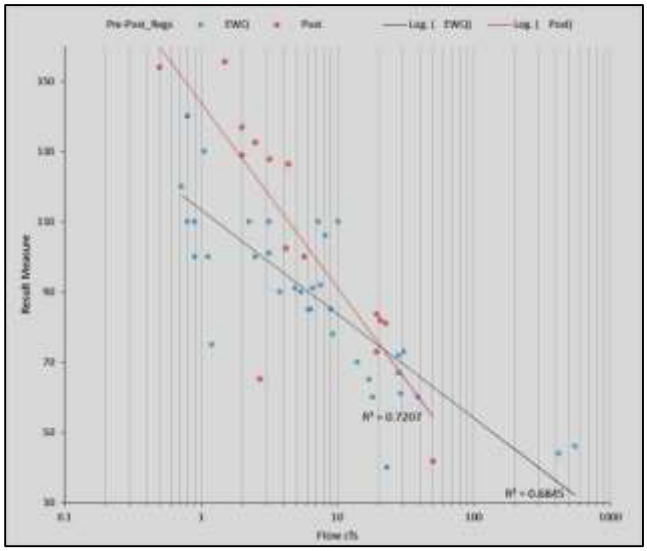
No water quality degradation is evident here. Fecal coliform concentrations did not measurably change between the EWQ and post-EWQ periods. Fecal coliform concentrations are unrelated to flow in both data sets. Post-EWQ median concentrations were within the EWQ 95% confidence intervals. Concentrations and flows are plotted on logarithmic scale and regressions are power relationships.

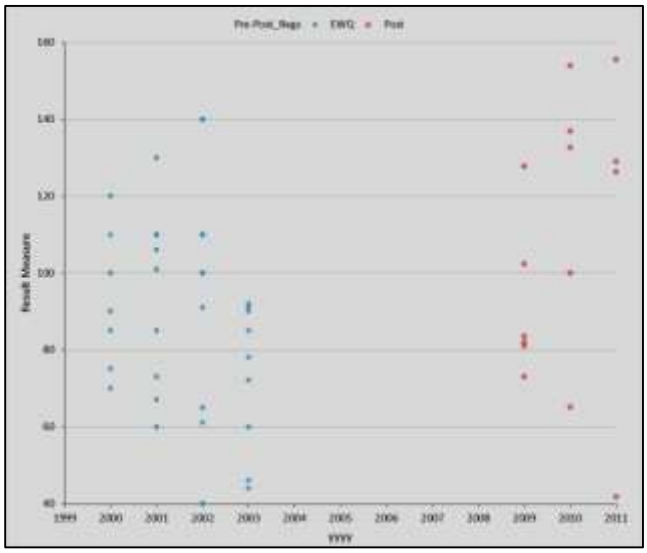
Chapter 10: 1616 BCP Tinicum Creek, PA

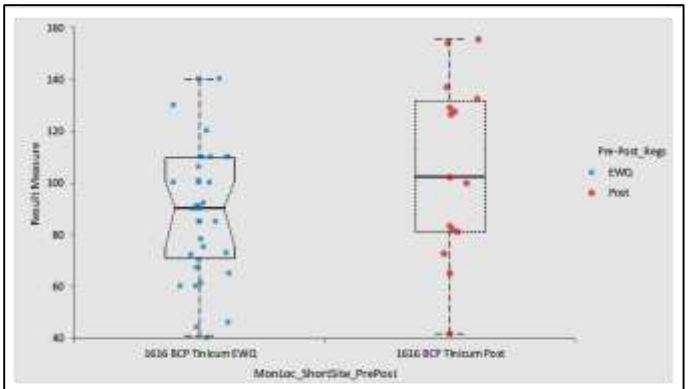
Hardness as CaCO3, Total mg/l

Existing Water Quality (Table 2Q):

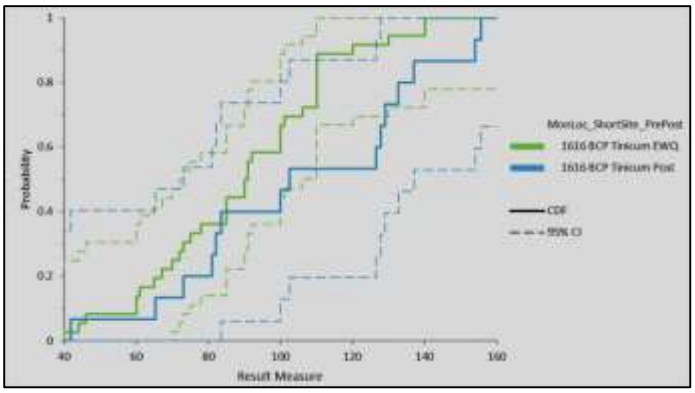
Median 91 mg/l
Lower 95% Confidence Interval 75 mg/l
Upper 95% Confidence Interval 101 mg/l
Defined in regulations as a flow-related parameter







N	51					
Result Measure by MonLoc_ShortSite_PreP ost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1616 BCP Tinicum EWQ	40	71	91	110	140	39
1616 BCP Tinicum Post	42	81	102	132	156	51



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PreP ost	n	Rank sum	Mean rank
1616 BCP Tinicum EWQ	36	152.1	4.23
1616 BCP Tinicum Post	15	365.1	24.34

H statistic	2.35
X^2 approximation	2.35
DF	1
p-value	0.1256 [1]

H0: $\theta_i = \theta_2 = \theta...$
The median of the populations are all equal.
H1: $\theta_i \neq \theta_j$ for at least one i,j
The median of the populations are not all equal.
[1] Do not reject the null hypothesis at the 5% significance level.

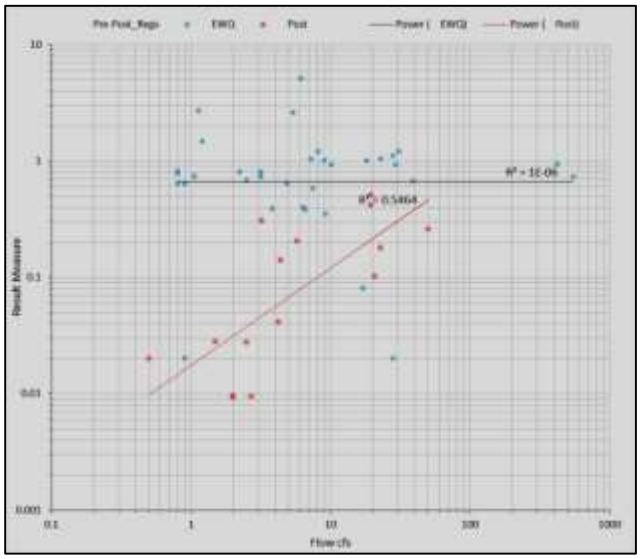
No water quality degradation is evident here. Hardness did not measurably change between the EWQ and post-EWQ periods. Hardness is inversely related to flow in both data sets. Post-EWQ median hardness was above the EWQ upper 95% confidence interval, but the increase was not significant because too few post-EWQ samples were taken (n=15) to be able to distinguish a real difference between the two periods. Flow is plotted on logarithmic scale.

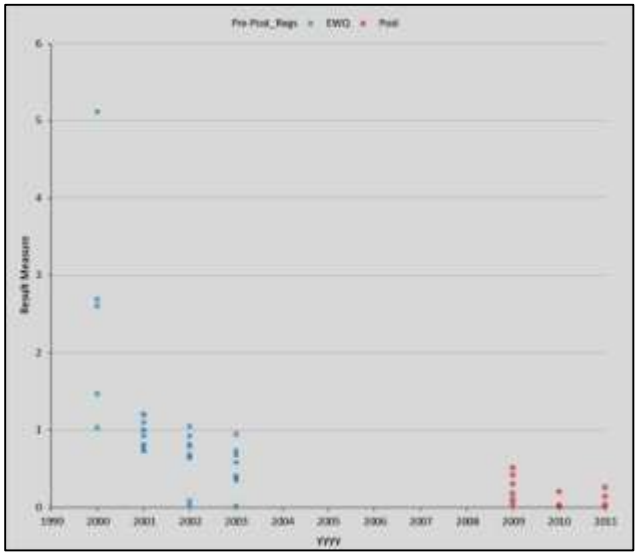
Chapter 10: 1616 BCP Tinicum Creek, PA

Nitrate + Nitrite as N, Total mg/l

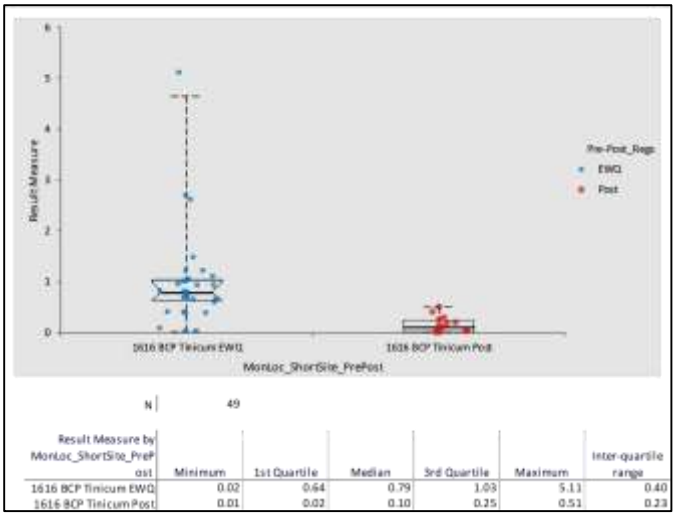
Existing Water Quality (Table 2Q, as Nitrate only):

Median 0.79 mg/l
Lower 95% Confidence Interval 0.64 mg/l
Upper 95% Confidence Interval 1.00 mg/l

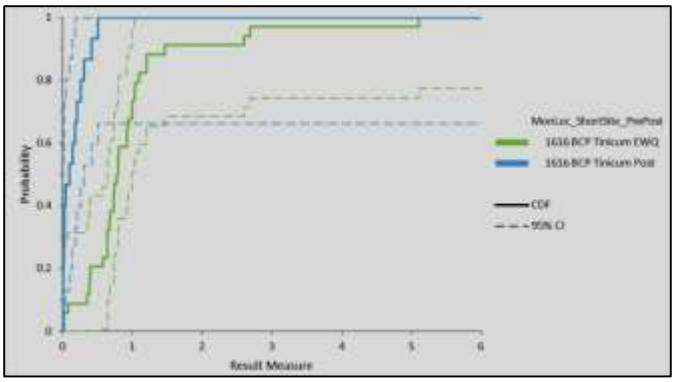




No water quality degradation is evident here. Nitrate concentrations apparently declined between the EWQ and post-EWQ periods. However, this conclusion is uncertain because of potential laboratory artifacts and insufficient post-EWQ sampling frequency. Nitrate is unrelated related to flow in the EWQ data set, but positively related to flow in the post-EWQ data set.



N	49					
Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1616 BCP Tinicum EWQ	0.02	0.64	0.79	1.03	5.11	0.40
1616 BCP Tinicum Post	0.01	0.02	0.10	0.25	0.51	0.23



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1616 BCP Tinicum EWQ	34	1359.6	39.99
1616 BCP Tinicum Post	15	3081.7	205.44

H statistic	21.76
X^2 approximation	21.76
DF	1
p-value	<0.0001 [1]

H0: $\theta_1 = \theta_2 = \theta...$
The median of the populations are all equal.
H1: $\theta_i \neq \theta_j$ for at least one i,j
The median of the populations are not all equal.
[1] Reject the null hypothesis in favour of the alternative hypothesis at the 5% significance level.

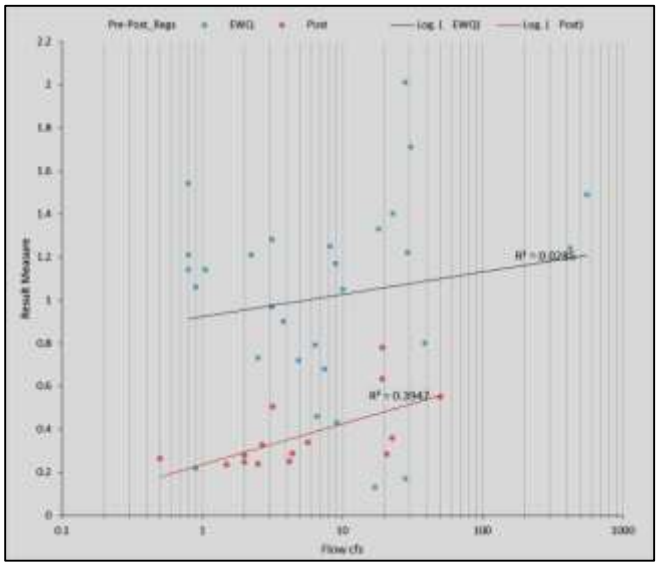
Due to the small number of post-EWQ data, flow conditions are not fully represented. Post-EWQ nitrate + nitrite concentrations were assumed equivalent for comparison with EWQ nitrate concentrations since EWQ nitrite concentrations were never detected. Independent data were not available for validation of the apparent decline. Even though the clear trend in the annual graph may show nothing more than differences between laboratories, there is some evidence for water quality improvement in that there are no concentrations higher than 0.51 mg/l in the post-EWQ data.

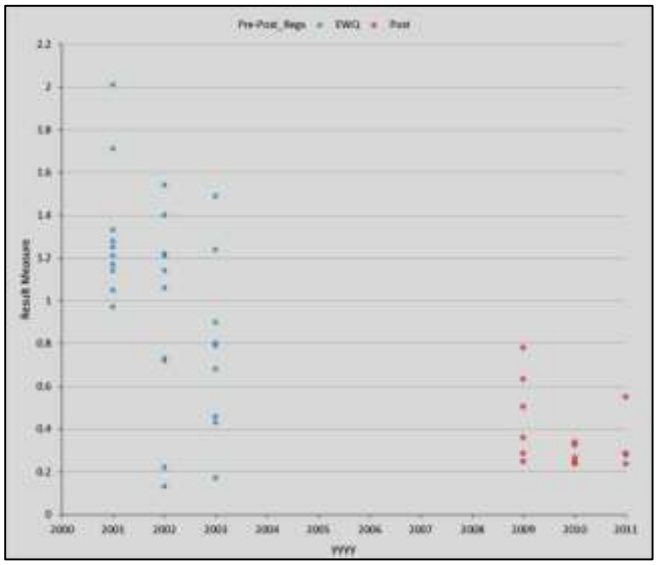
Chapter 10: 1616 BCP Tinicum Creek, PA

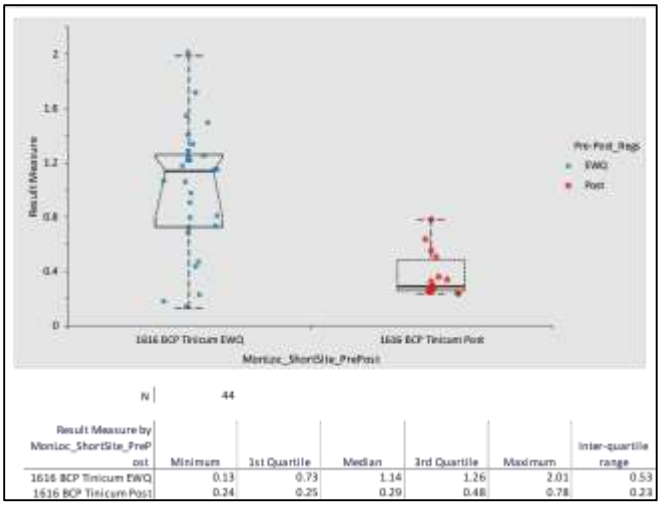
Nitrogen as N, Total (TN) mg/l

Existing Water Quality (Table 2Q):

Median 1.14 mg/l
Lower 95% Confidence Interval 0.79 mg/l
Upper 95% Confidence Interval 1.23 mg/l

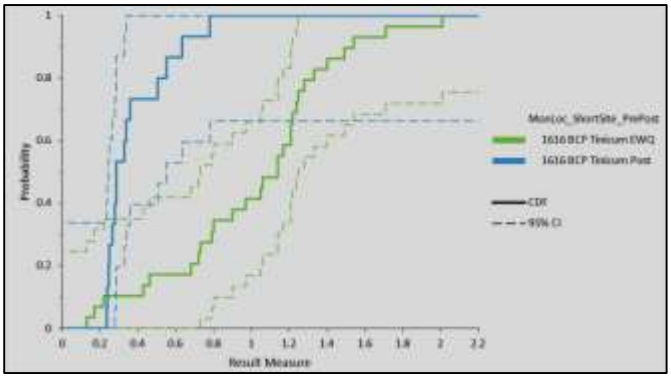






N	44

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1616 BCP Tinicum EWQ	0.13	0.73	1.14	1.26	2.01	0.53
1616 BCP Tinicum Post	0.24	0.25	0.29	0.48	0.78	0.23



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1616 BCP Tinicum EWQ	29	899.4	31.01
1616 BCP Tinicum Post	15	1738.8	115.92

H statistic	15.99
X^2 approximation	15.99
DF	1
p-value	<0.0001 [1]

H0: $\theta_1 = \theta_2 = \theta...$
The median of the populations are all equal.
H1: $\theta_i \neq \theta_j$ for at least one i,j
The median of the populations are not all equal.
[1] Reject the null hypothesis in favour of the alternative hypothesis at the 5% significance level.

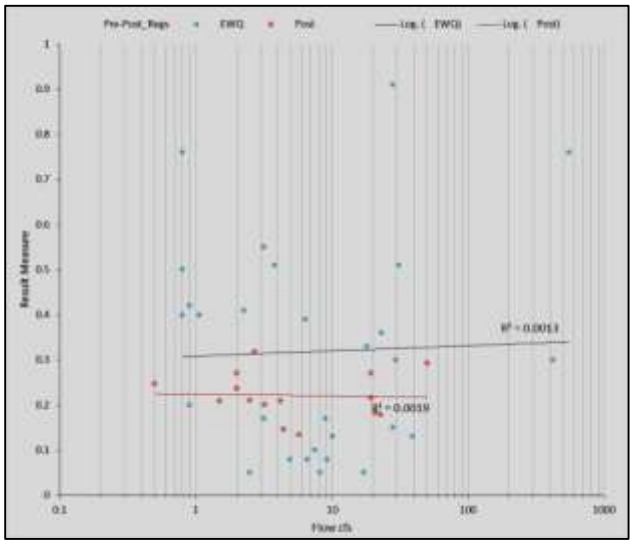
No water quality degradation is evident here. Total Nitrogen concentrations apparently declined between the EWQ and post-EWQ periods. Such a conclusion is uncertain because of potential laboratory artifacts and insufficient post-EWQ sampling frequency. TN is positively related to flow in the post-EWQ data set, but unrelated to flow in the EWQ data set. Flow is plotted on logarithmic scale. DRBC results could not be independently validated. Post-EWQ median TN concentrations fell below the EWQ lower 95% confidence interval.

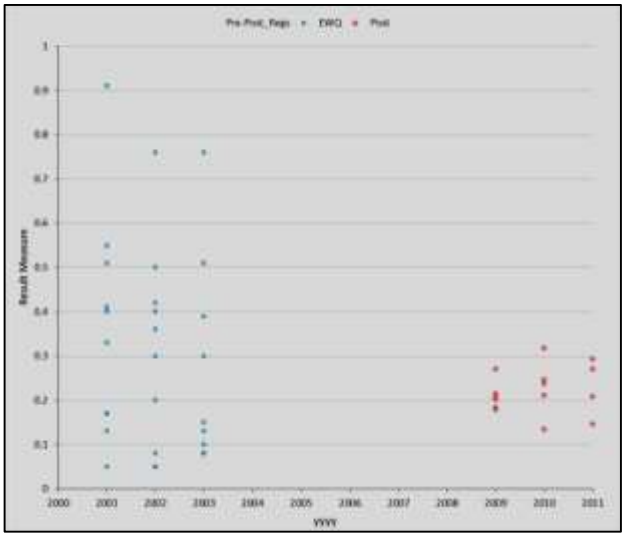
Chapter 10: 1616 BCP Tinicum Creek, PA

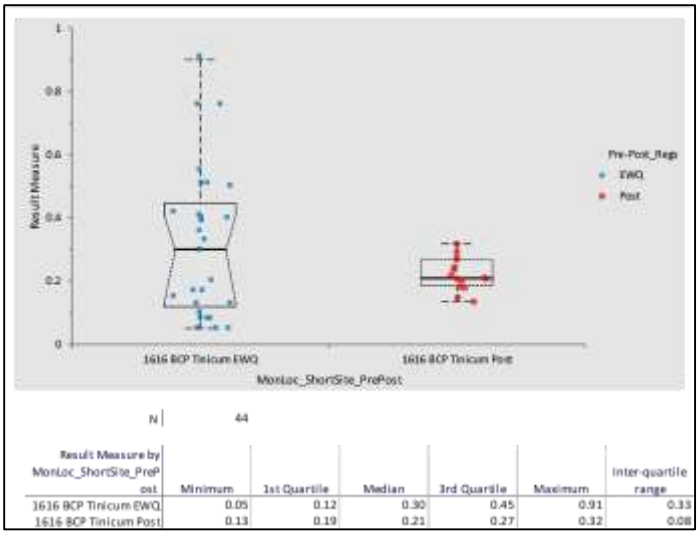
Nitrogen, Kjeldahl as N, Total (TKN) mg/l

Existing Water Quality (Table 2Q):

Median 0.30 mg/l
Lower 95% Confidence Interval 0.13 mg/l
Upper 95% Confidence Interval 0.41 mg/l

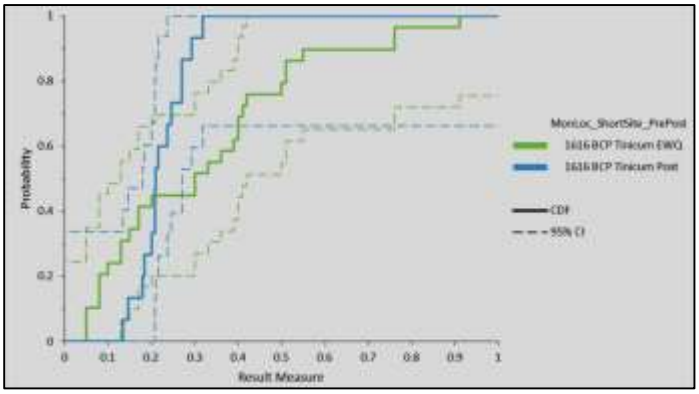






N	44

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1616 BCP Tinicum EWQ	0.05	0.12	0.30	0.45	0.91	0.33
1616 BCP Tinicum Post	0.13	0.19	0.21	0.27	0.32	0.08



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1616 BCP Tinicum EWQ	29	32.1	1.11
1616 BCP Tinicum Post	15	62.0	4.13

H statistic	0.57
X^2 approximation	0.57
DF	1
p-value	0.4499 [1]

H0: $\theta_1 = \theta_2 = \theta...$
The median of the populations are all equal.
H1: $\theta_i \neq \theta_j$ for at least one i,j
The median of the populations are not all equal.
[1] Do not reject the null hypothesis at the 5% significance level.

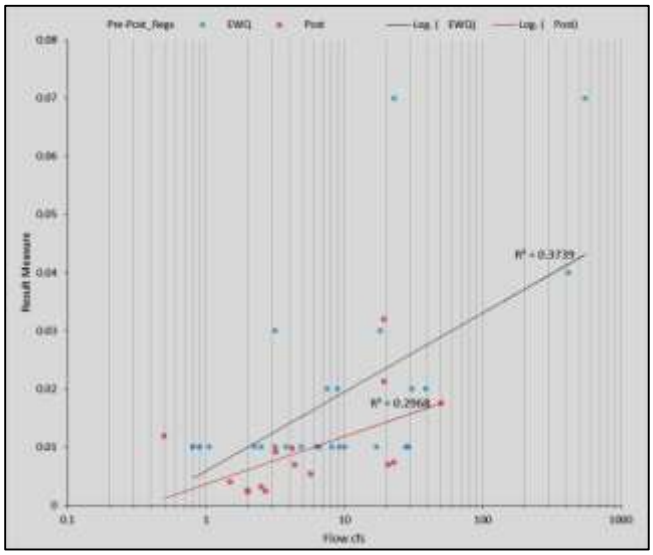
No water quality degradation is evident here. TKN concentrations did not measurably change between the EWQ and post-EWQ periods. Potential laboratory artifacts introduced uncertainty into apparently obvious trends. TKN concentration is unrelated to flow in both data sets. TKN ranges less widely and is less variable in the post-EWQ data set. Flow is plotted on logarithmic scale. Post-EWQ median TKN was within the EWQ 95% confidence intervals.

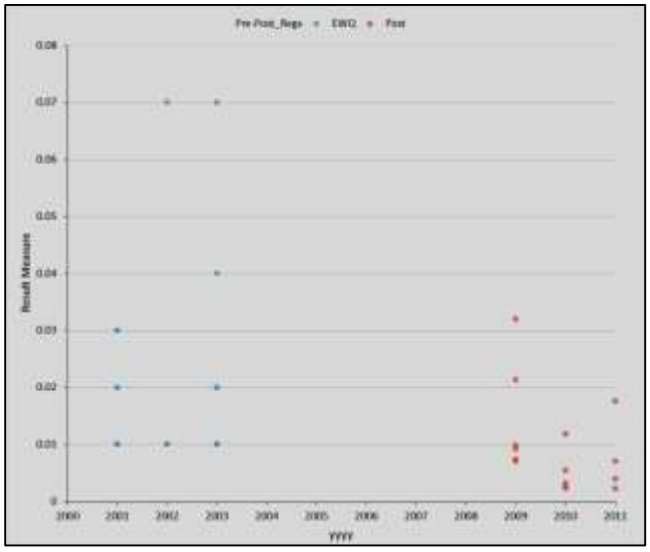
Chapter 10: 1616 BCP Tinicum Creek, PA

Orthophosphate as P, Total mg/l

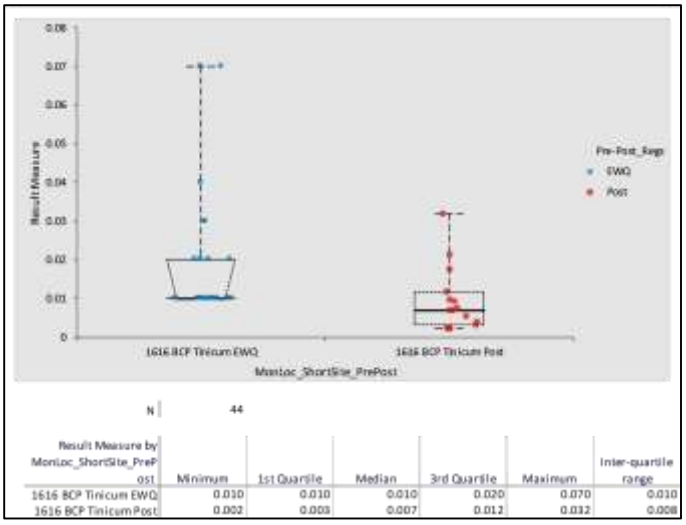
Existing Water Quality (Table 2Q):

Median 0.01 mg/l
Lower 95% Confidence Interval 0.01 mg/l
Upper 95% Confidence Interval 0.02 mg/l



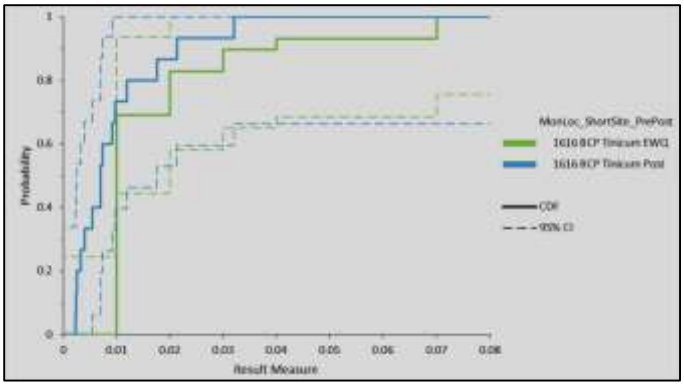


No water quality degradation is evident here. Orthophosphate concentrations apparently declined between the EWQ and post-EWQ periods. Detection limit differences, potential laboratory artifacts and insufficient post-EWQ sampling frequency introduced uncertainty into conclusions.



N	44

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1616 BCP Tinicum EWQ	0.010	0.010	0.010	0.020	0.070	0.010
1616 BCP Tinicum Post	0.002	0.003	0.007	0.012	0.032	0.008



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1616 BCP Tinicum EWQ	29	560.6	19.33
1616 BCP Tinicum Post	15	1083.8	72.25

H statistic	11.01
X^2 approximation	11.01
DF	1
p-value	0.0009 [1]

H0: $\theta_i = \theta_2 = \theta...$
The median of the populations are all equal.
H1: $\theta_i \neq \theta_j$ for at least one i,j
The median of the populations are not all equal.
[1] Reject the null hypothesis in favour of the alternative hypothesis at the 5% significance level.

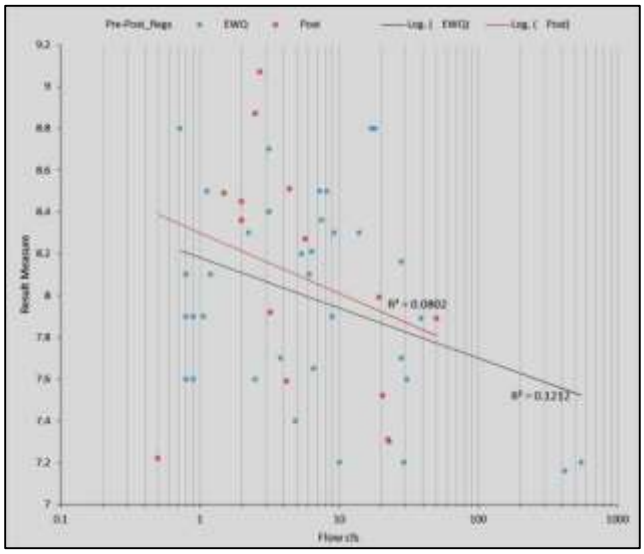
Orthophosphate is weakly related to flow in both data sets. Flow is plotted on logarithmic scale. Post-EWQ median orthophosphate fell below the EWQ lower 95% confidence interval. Post-EWQ data describe actual orthophosphate concentrations better than the EWQ data, where 19/29 undetected results interfered with calculation of the median. There were no undetected results in the post-EWQ data, when detection limits were lower. There were no independent data to confirm DRBC results.

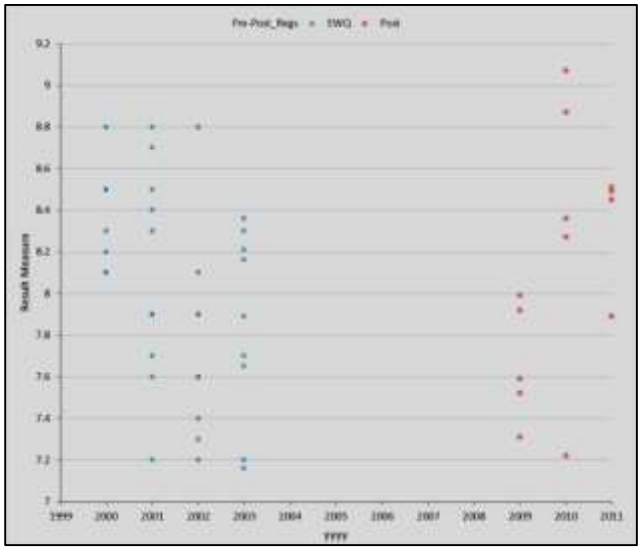
Chapter 10: 1616 BCP Tinicum Creek, PA

pH, units

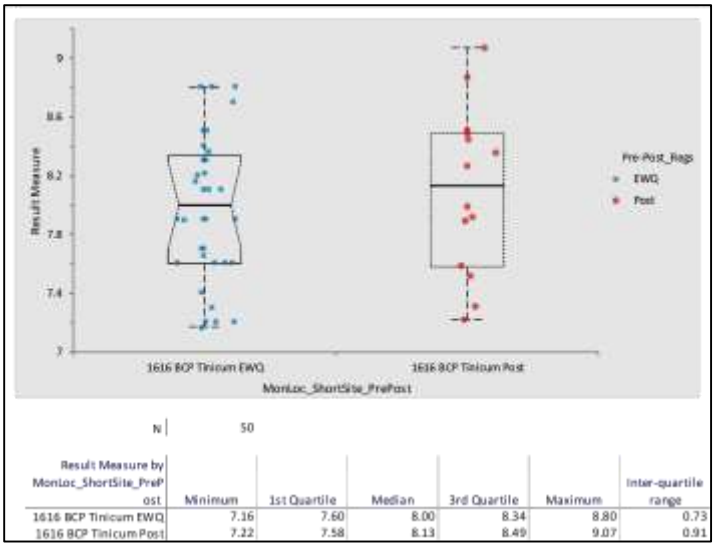
Existing Water Quality (Table 2Q):

Median 8.00 standard units
Lower 95% Confidence Interval 7.70 standard units
Upper 95% Confidence Interval 8.30 standard units



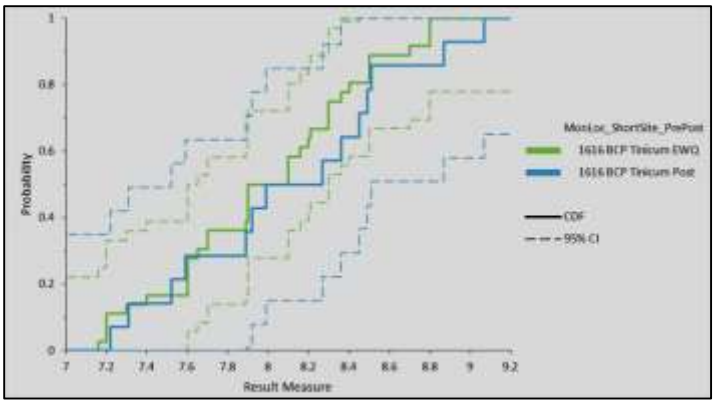


No water quality degradation is evident here. pH did not measurably change between the EWQ and post-EWQ periods. pH is unrelated to flow in both data sets. pH tends toward neutral during higher flow conditions. Flow is plotted on logarithmic scale. Post-EWQ median pH was within the EWQ 95% confidence intervals.



N	50

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1616 BCP Tinicum EWQ	7.16	7.60	8.00	8.34	8.80	0.73
1616 BCP Tinicum Post	7.22	7.58	8.13	8.49	9.07	0.91



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1616 BCP Tinicum EWQ	36	28.4	0.79
1616 BCP Tinicum Post	14	73.1	5.22

H statistic	0.48
X^2 approximation	0.48
DF	1
p-value	0.4889 [1]

H0: $\theta_1 = \theta_2 = \theta...$
The median of the populations are all equal.
H1: $\theta_i \neq \theta_j$ for at least one i,j
The median of the populations are not all equal.
[1] Do not reject the null hypothesis at the 5% significance level.

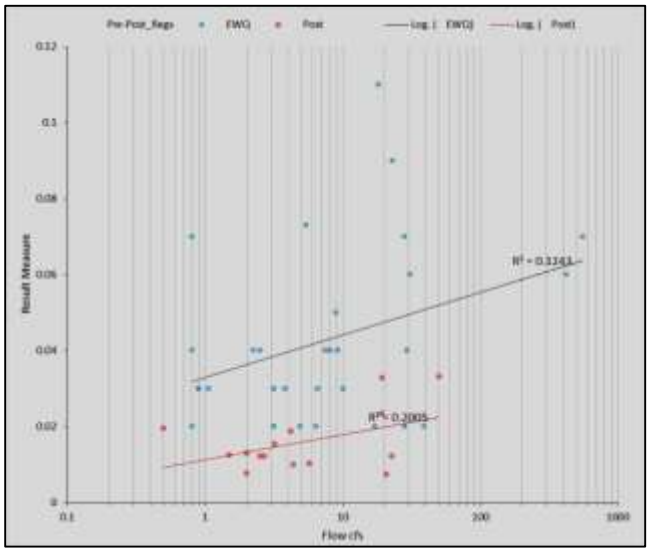
In Tinicum Creek, mid-day pH tends to run higher than some other watersheds due to its wide, shallow channel. There is high algae production at the DRBC monitoring site driving up the mid-day pH. Pennsylvania pH criteria occasionally are exceeded here.

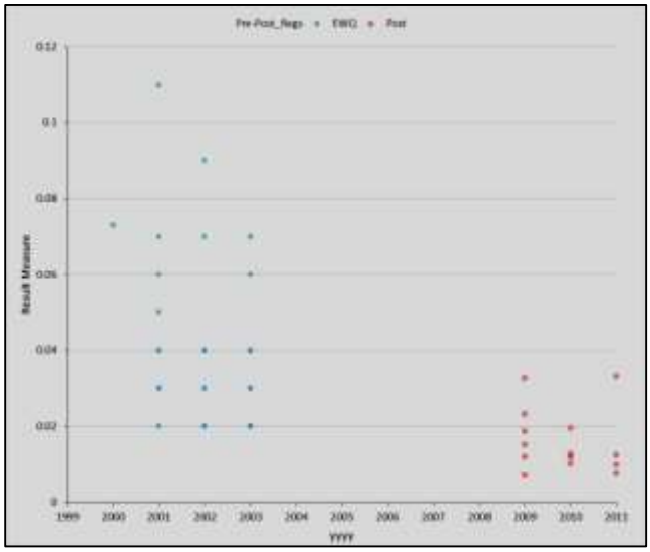
Chapter 10: 1616 BCP Tinicum Creek, PA

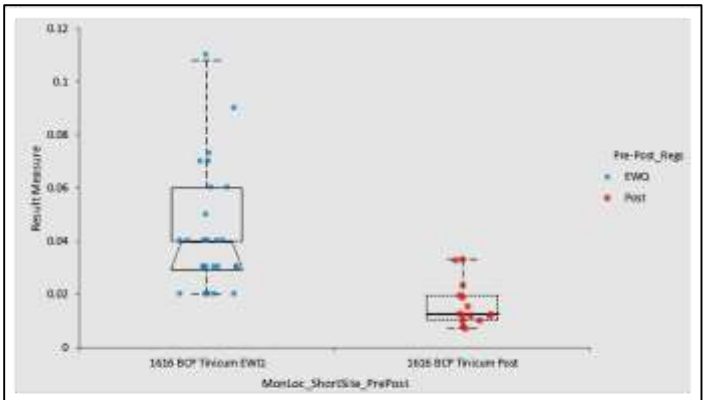
Phosphorus as P, Total (TP) mg/l

Existing Water Quality (Table 2Q):

Median 0.04 mg/l
Lower 95% Confidence Interval 0.03 mg/l
Upper 95% Confidence Interval 0.04 mg/l

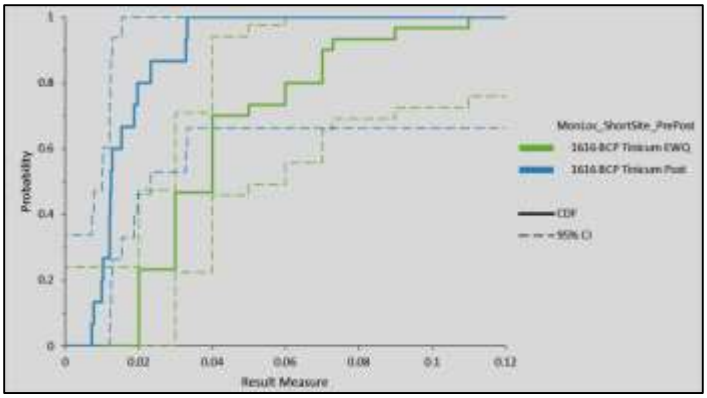






N	45

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1616 BCP Tinicum EWQ	0.020	0.029	0.040	0.060	0.110	0.031
1616 BCP Tinicum Post	0.007	0.011	0.013	0.019	0.033	0.009



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1616 BCP Tinicum EWQ	30	1203.3	40.11
1616 BCP Tinicum Post	15	2406.7	160.44

H statistic	21.17
X^2 approximation	21.17
DF	1
p-value	<0.0001 [1]

H0: $\theta_1 = \theta_2 = \theta...$
The median of the populations are all equal.
H1: $\theta_i \neq \theta_j$ for at least one i,j
The median of the populations are not all equal.
[1] Reject the null hypothesis in favour of the alternative hypothesis at the 5% significance level.

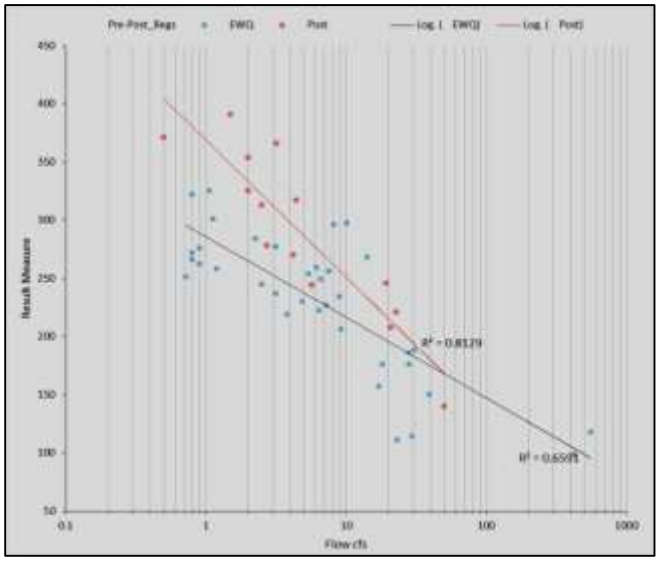
No water quality degradation is evident here. Total Phosphorus (TP) concentrations apparently declined between the EWQ and post-EWQ periods. However, detection limit differences, potential laboratory artifacts and insufficient post-EWQ sampling frequency introduced uncertainty into conclusions. Post-EWQ median total phosphorus fell below the EWQ lower 95% confidence interval. TP is very weakly related to flow in both data sets. No independent data were available to confirm these results.

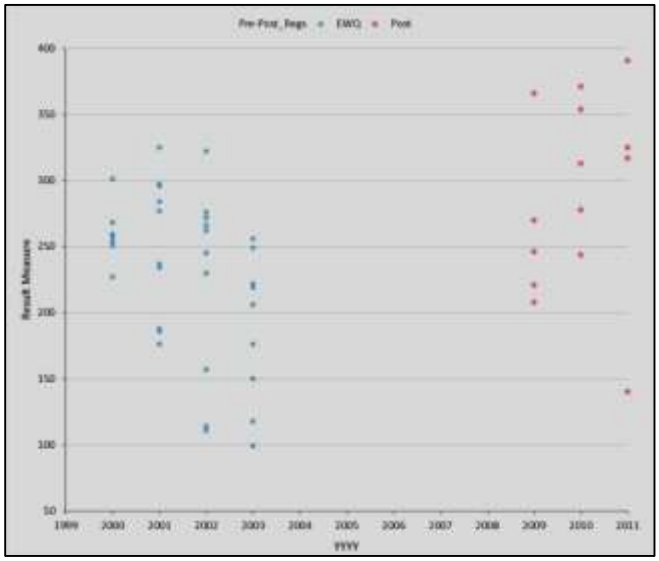
Chapter 10: 1616 BCP Tinicum Creek, PA

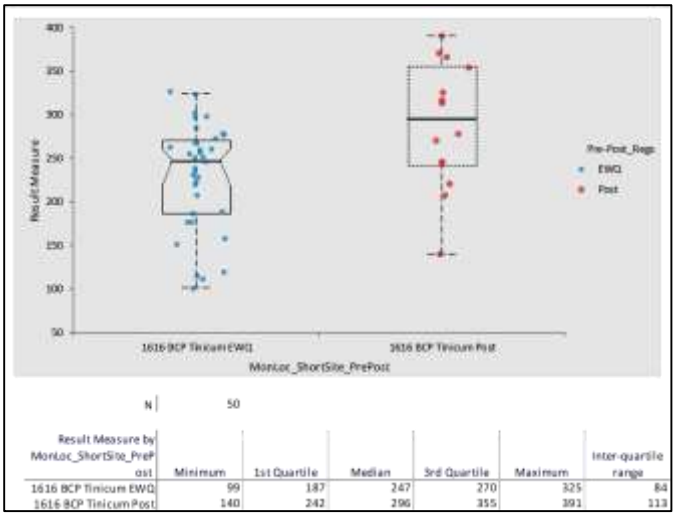
Specific Conductance µmho/cm

Existing Water Quality (Table 2Q):

Median 247 µmho/cm
Lower 95% Confidence Interval 219 µmho/cm
Upper 95% Confidence Interval 262 µmho/cm
Defined in regulations as a flow-related parameter

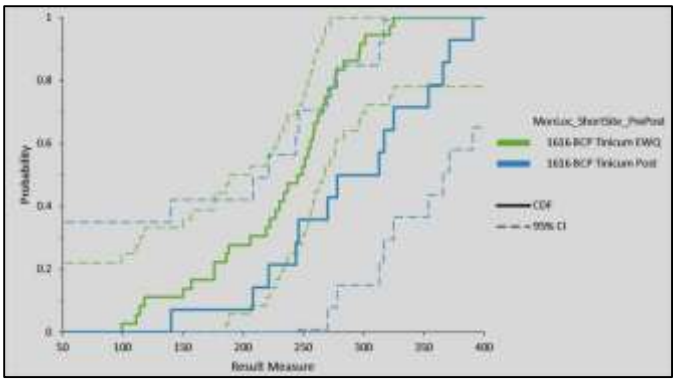






N	50

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1616 BCP Tinicum EWQ	99	187	247	270	325	84
1616 BCP Tinicum Post	140	242	296	355	391	113



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1616 BCP Tinicum EWQ	36	364.2	10.12
1616 BCP Tinicum Post	14	936.4	66.89

H statistic	6.12
X^2 approximation	6.12
DF	1
p-value	0.0134 [1]

H0: $\theta_1 = \theta_2 = \theta...$
The median of the populations are all equal.
H1: $\theta_i \neq \theta_j$ for at least one i,j
The median of the populations are not all equal.
[1] Reject the null hypothesis in favour of the alternative hypothesis at the 5% significance level.

There is some evidence of water quality degradation here. Specific conductance rose above the EWQ upper 95% confidence interval between the EWQ and post-EWQ periods. Specific conductance is inversely related to flow in both data sets. Flow is plotted on logarithmic scale.

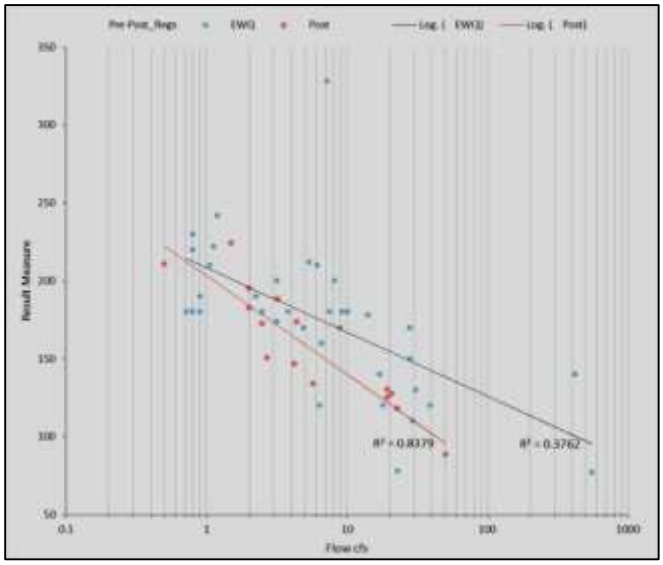
The rise in specific conductance may be partially attributable to the concurrent rise in chloride concentrations. Median specific conductance has risen from 247 to 296 µmhos/cm, a 20% increase.

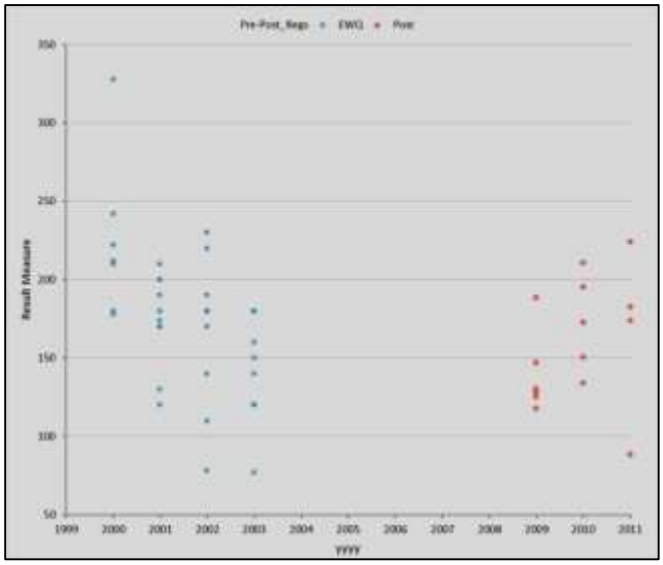
Chapter 10: 1616 BCP Tinicum Creek, PA

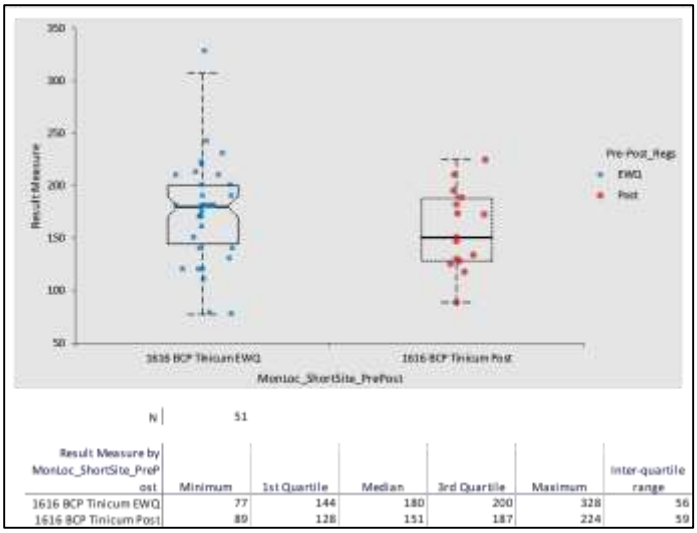
Total Dissolved Solids (TDS) mg/l

Existing Water Quality (Table 2Q):

Median 180 mg/l
Lower 95% Confidence Interval 170 mg/l
Upper 95% Confidence Interval 190 mg/l
Defined in regulations as a flow-related parameter

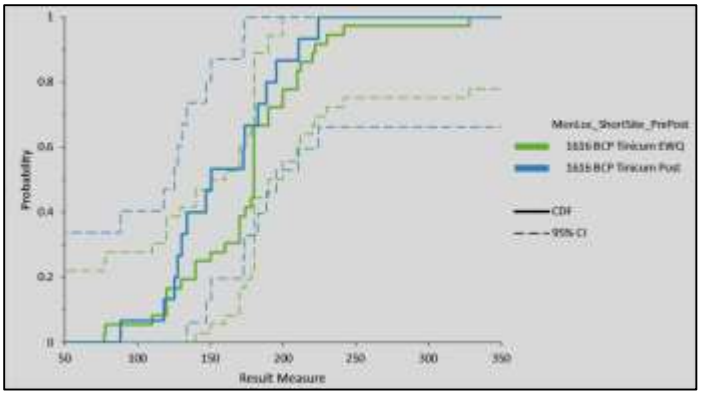






N	51

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1616 BCP Tinicum EWQ	77	144	180	200	328	56
1616 BCP Tinicum Post	89	128	151	187	224	59



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1616 BCP Tinicum EWQ	36	84.0	2.33
1616 BCP Tinicum Post	15	201.7	13.44

H statistic	1.30
X^2 approximation	1.30
DF	1
p-value	0.2545[1]

H0: $\theta_1 = \theta_2 = \theta...$
The median of the populations are all equal.
H1: $\theta_i \neq \theta_j$ for at least one i,j
The median of the populations are not all equal.
[1] Do not reject the null hypothesis at the 5% significance level.

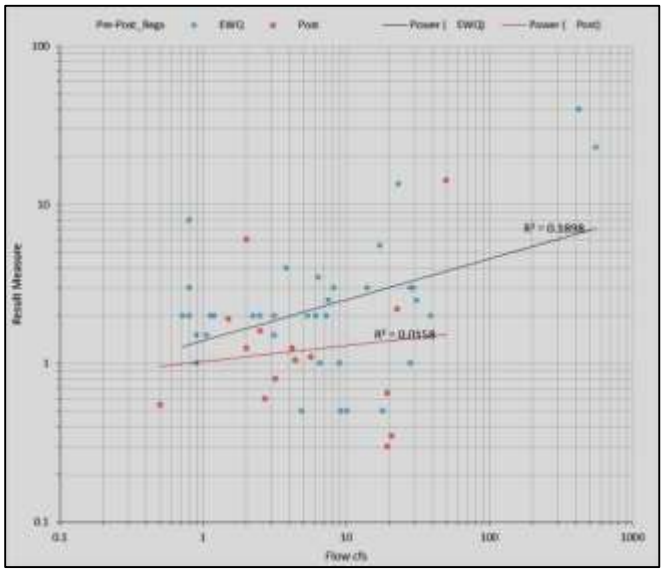
No water quality degradation is evident here. TDS apparently declined between the EWQ and post-EWQ periods, but not significantly. Conclusions are uncertain because of potential laboratory artifacts. TDS is inversely related to flow in both data sets. Post-EWQ median TDS fell below the EWQ lower 95% lower confidence interval. Post-EWQ detection limits were lower than EWQ detection limits, though there were no non-detect results at any time. Flow is plotted on logarithmic scale.

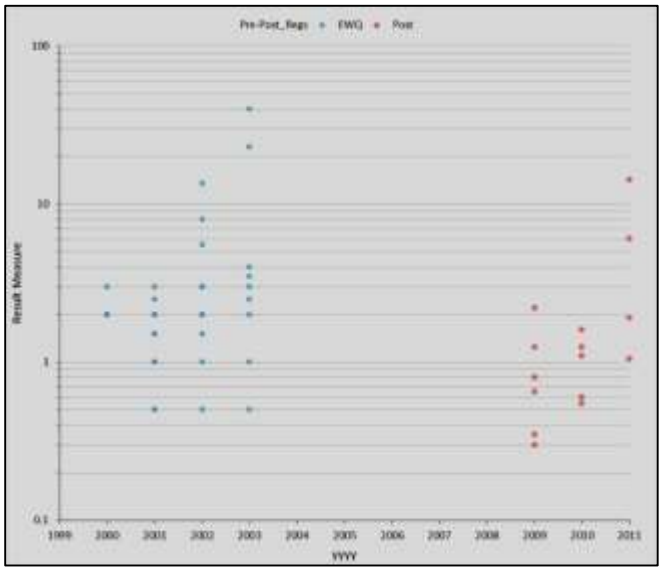
Chapter 10: 1616 BCP Tinicum Creek, PA

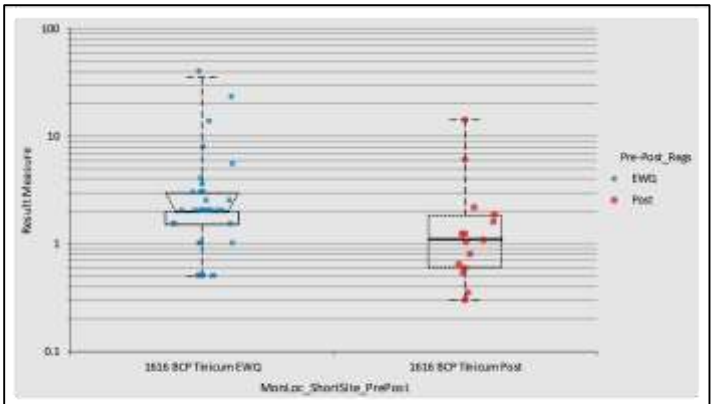
Total Suspended Solids (TSS) mg/l

Existing Water Quality (Table 2Q):

Median 2.0 mg/l
Lower 95% Confidence Interval 1.0 mg/l
Upper 95% Confidence Interval 3.0 mg/l

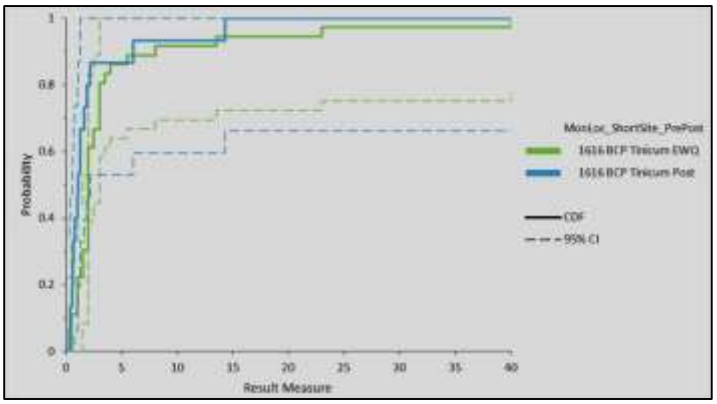






N	51

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1616 BCP Tinicum EWQ	0.5	1.5	2.0	3.0	40.0	1.5
1616 BCP Tinicum Post	0.3	0.6	1.1	1.8	14.3	1.2



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1616 BCP Tinicum EWQ	36	348.4	9.68
1616 BCP Tinicum Post	15	836.3	55.75

H statistic	5.43
X^2 approximation	5.43
DF	1
p-value	0.0198 [1]

H0: $\theta_i = \theta_2 = \theta...$
The median of the populations are all equal.
H1: $\theta_i \neq \theta_j$ for at least one i,j
The median of the populations are not all equal.
[1] Reject the null hypothesis in favour of the alternative hypothesis at the 5% significance level.

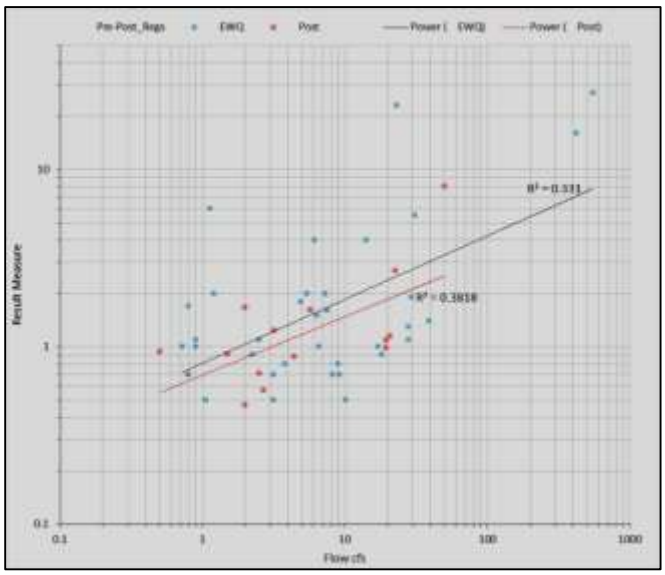
No water quality degradation is evident here. TSS apparently declined between the EWQ and post-EWQ periods. Sources of uncertainty included potential laboratory artifacts and insufficient post-EWQ sampling (n=15). TSS is unrelated to flow in both data sets, mainly because it is unsafe to sample Tinicum Creek at this site during high-flow so a flow relationship could not be defined. Post-EWQ median TSS was within the EWQ 95% confidence intervals, but the difference in median concentrations was significant. Flows and concentrations are plotted on logarithmic scale and regressions are power relationships.

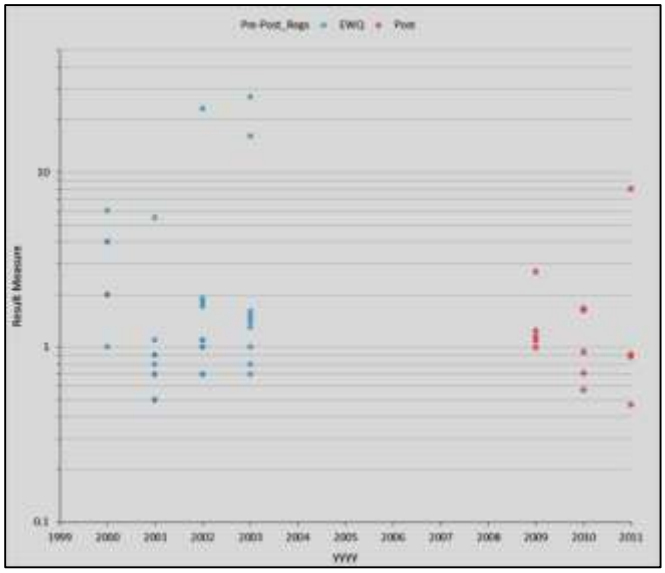
Chapter 10: 1616 BCP Tinicum Creek, PA

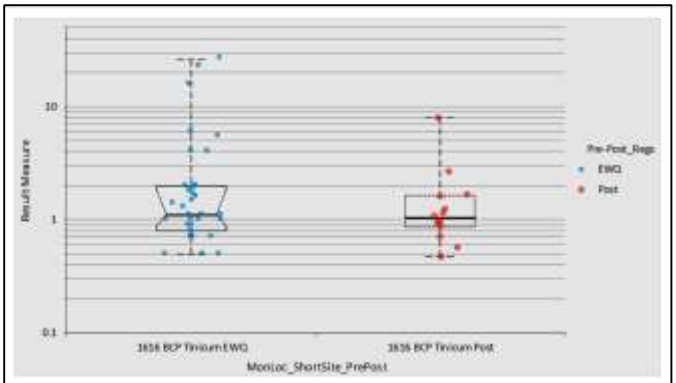
Turbidity NTU

Existing Water Quality (Table 2Q):

Median 1.1 NTU
Lower 95% Confidence Interval 0.9 NTU
Upper 95% Confidence Interval 1.8 NTU
Defined in regulations as a flow-related parameter

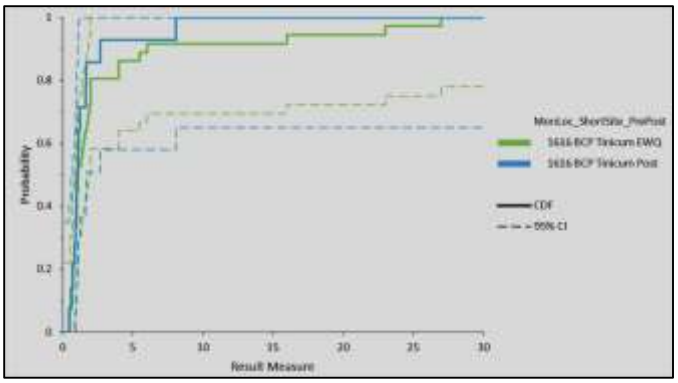






N	50

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1616 BCP Tinicum EWQ	0.5	0.8	1.1	2.0	27.0	1.2
1616 BCP Tinicum Post	0.5	0.9	1.0	1.6	8.0	0.8



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1616 BCP Tinicum EWQ	36	30.3	0.84
1616 BCP Tinicum Post	14	77.8	5.56

H statistic	0.51
X^2 approximation	0.51
DF	1
p-value	0.4754 [1]

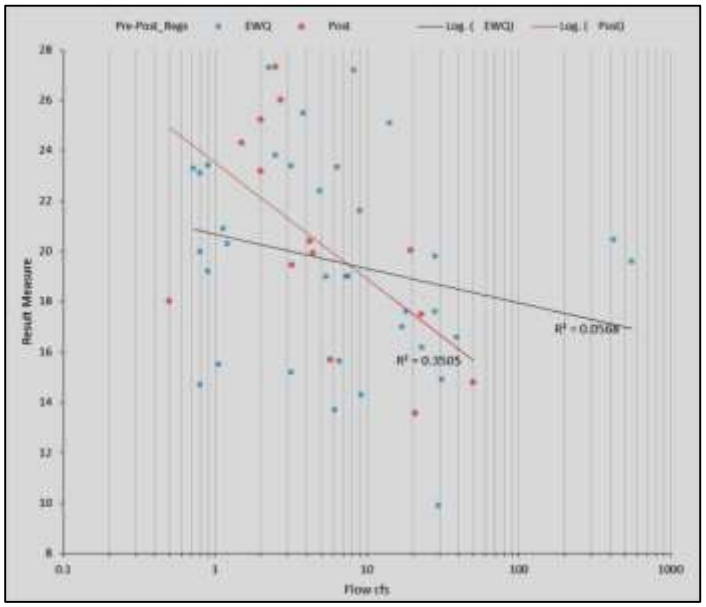
H0: $\theta_1 = \theta_2 = \theta...$
The median of the populations are all equal.
H1: $\theta_i \neq \theta_j$ for at least one i,j
The median of the populations are not all equal.
[1] Do not reject the null hypothesis at the 5% significance level.

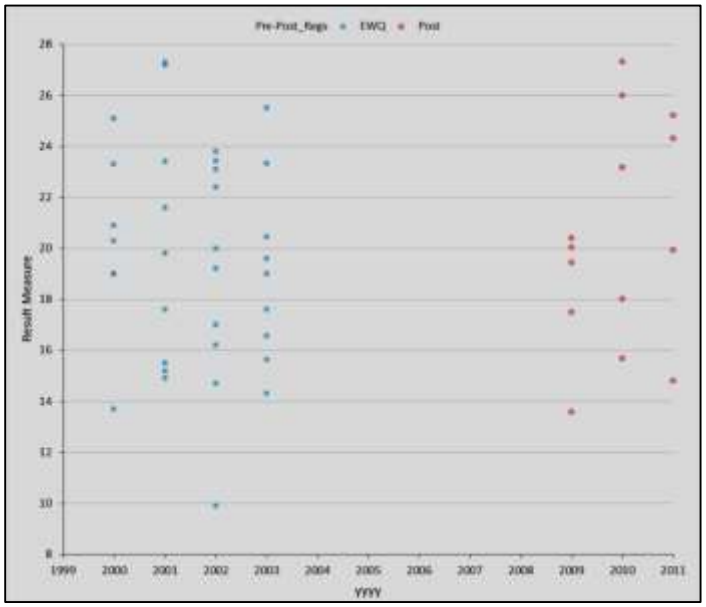
No water quality degradation is evident here. Turbidity did not measurably change between the EWQ and post-EWQ periods. Analytical uncertainty was introduced by insufficient post-EWQ sampling (n=14). Post-EWQ median turbidity fell within the EWQ 95% confidence intervals. Turbidity is related to flow in both data sets. Concentrations and flows are represented on logarithmic scale, and regressions are power relationships.

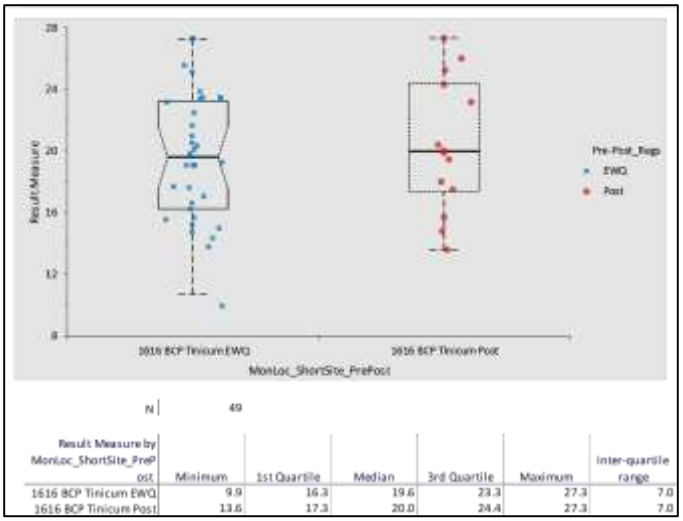
Chapter 10: 1616 BCP Tinicum Creek, PA

Water Temperature, degrees C

Not included in DRBC Existing Water Quality rules

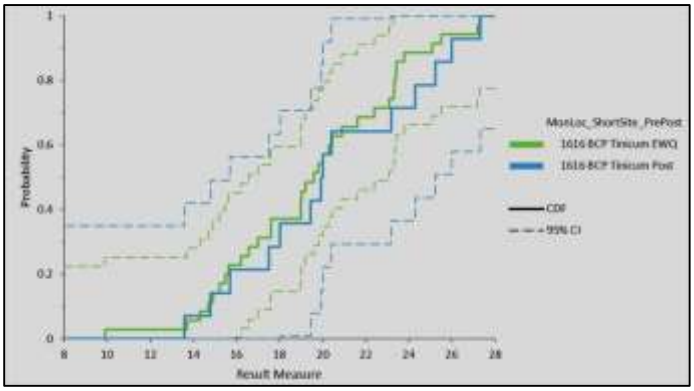






N	49

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1616 BCP Tinicum EWQ	9.9	16.3	19.6	23.3	27.3	7.0
1616 BCP Tinicum Post	13.6	17.3	20.0	24.4	27.3	7.0



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1616 BCP Tinicum EWQ	35	19.3	0.55
1616 BCP Tinicum Post	14	48.3	3.45

H statistic	0.33
X^2 approximation	0.33
DF	1
p-value	0.5650 [1]

H0: $\theta_1 = \theta_2 = \theta...$
The median of the populations are all equal.
H1: $\theta_i \neq \theta_j$ for at least one i,j
The median of the populations are not all equal.
[1] Do not reject the null hypothesis at the 5% significance level.

No water quality degradation is evident here. Water temperature did not measurably change between the EWQ and post-EWQ periods. Analytical uncertainty was introduced by insufficient post-EWQ sampling (n=14). Water temperature is unrelated to flow in the EWQ data set but inversely related to flow in the post-EWQ data set. Flow is plotted on logarithmic scale.