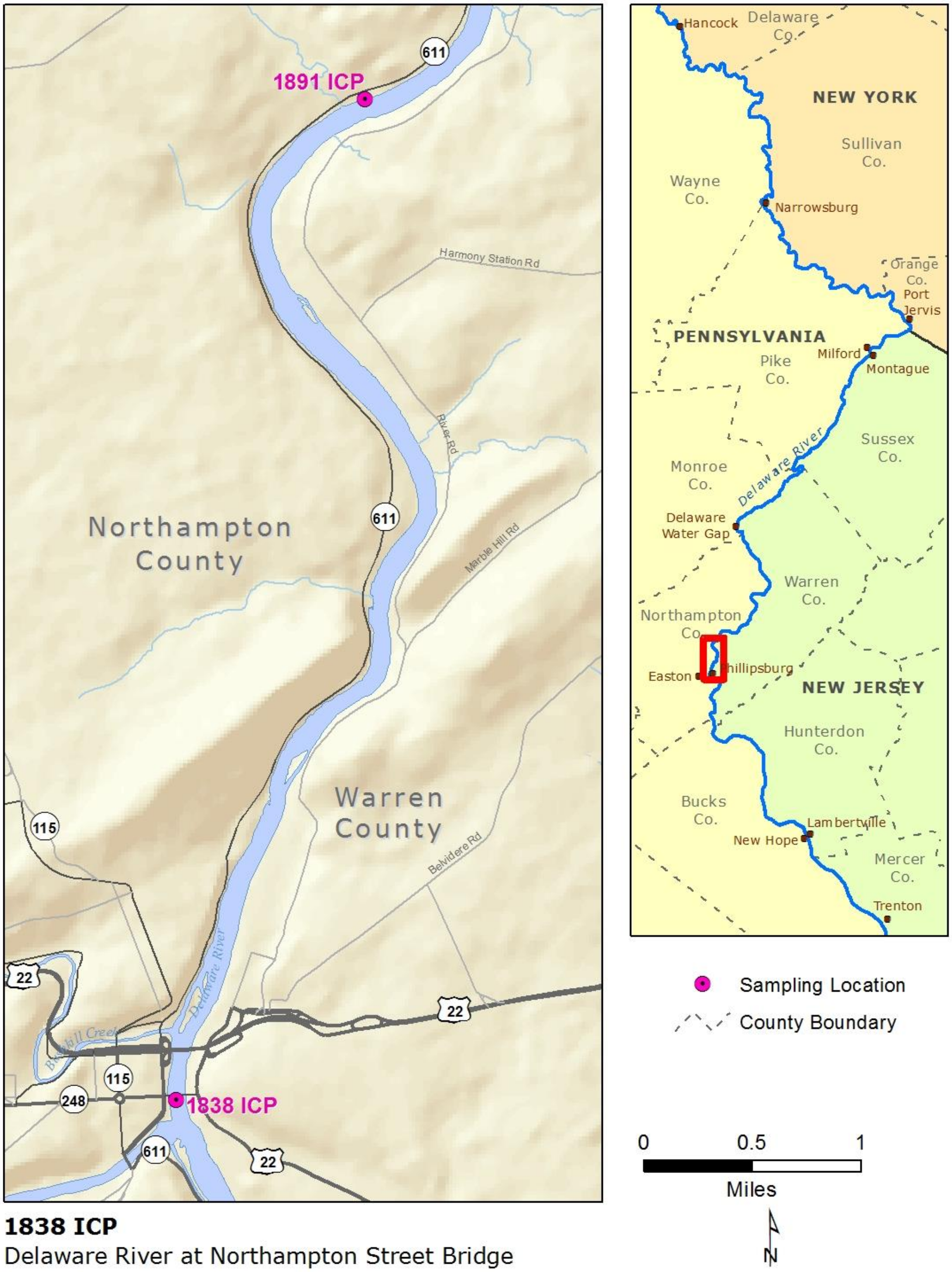
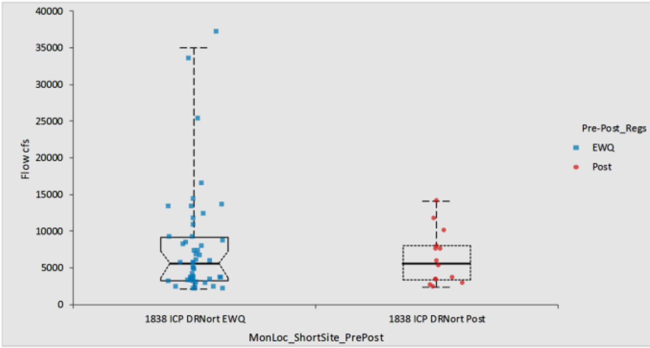
Chapter 18: 1838 ICP Delaware River at Easton



1838 ICP
Delaware River at Northampton Street Bridge

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



N | 64

Flow cfs by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1838 ICP DRNort EWQ	2,091	3,287	5,613	9,210	37,211	5,923
1838 ICP DRNort Post	2,351	3,358	5,570	8,075	14,042	4,718

Flow was roughly the same between EWQ and post-EWQ periods. Too few post-EWQ samples were collected (n=14). The range of flow conditions sampled was wider in the EWQ period, and the EWQ data represented the full range of flow conditions better than the post-EWQ data. Not many EWQ samples were collected at high flow, but without that high flow regime represented in post-EWQ data, there is a possibility that water quality differences can falsely interpreted as significant when they really are not. This point is considered in each analysis to follow.

Kruskal-Wallis test

Flow cfs by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1838 ICP DRNort EWQ	50	3.9	0.08
1838 ICP DRNort Post	14	14.0	1.00

H statistic	0.05
X^2 approximation	0.05
DF	1
p-value	0.8201[1]

H0: $\theta_1 = \theta_2 = \theta \ldots$

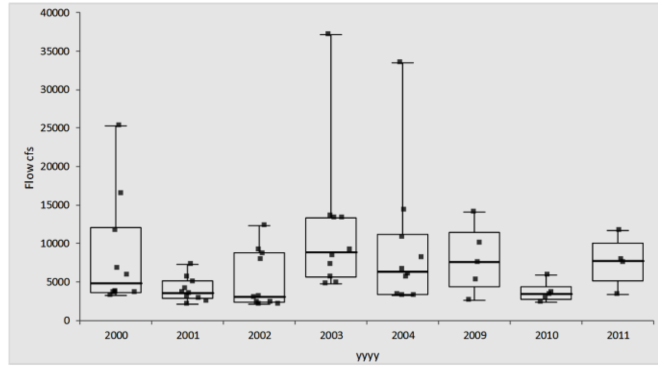
The median of the populations are all equal.

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.

At this location, the Bushkill has not fully mixed with the Delaware – composite sampling is necessary to capture the unequal water quality between the PA and NJ sides of the river.



N | 64

Flow cfs by yyyy	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
2000	3,288	3,616	4,847	12,061	25,298	8,445
2001	2,091	2,819	3,530	5,083	7,351	2,264
2002	2,101	2,312	3,064	8,748	12,312	6,437
2003	4,734	5,600	8,836	13,348	37,211	7,748
2004	3,259	3,366	6,344	11,163	33,542	7,797
2009	2,569	4,330	7,562	11,386	14,042	7,056
2010	2,351	2,704	3,401	4,368	5,929	1,664
2011	3,443	5,133	7,697	10,085	11,649	4,952

Annual May to September flow statistics are plotted above. These are flow measurements or estimates associated with the time of each water quality sample. Mean annual flow is about 8,070 cfs; and average May to September flow is about 5,770 cfs. Though DRBC sampled a wide range of flows, these data are most representative of summer flow conditions. Flows were calculated using instantaneous water discharge data from the USGS gage No. 01446500 on the Delaware River at Belvidere times a drainage area ratio.

Upstream ICP: Delaware River at Belvidere 1978 ICP
Downstream ICP: Del. River at Riegelsville 1748 ICP

<u>Tributary BCP Watersheds in Upstream Reach:</u>
Bushkill Creek, PA – 1841 BCP
Delaware River at Sandts Eddy – 1891 MCP*
Martins Creek, PA – 1907 BCP
Del. River at Martins Creek RR Bridge – 1908 PADEP*
Pequest River, NJ – 1978 BCP

*Non-ICP/BCP monitoring locations used to model river water quality. MCP designates "modeling control point"; PADEP designates a site monitored as part of the Pennsylvania Water Quality Network.

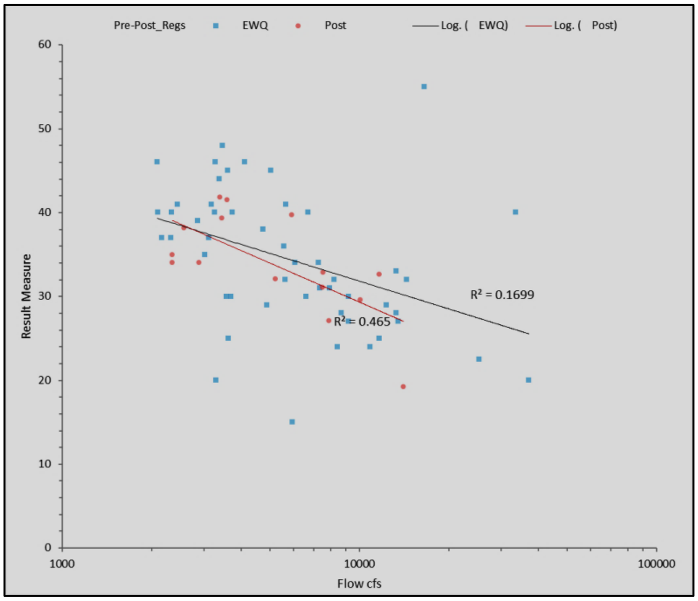
Remaining upstream tributaries are less than 20 square miles watershed size, and are not expected to have major water quality effects upon the Delaware River.

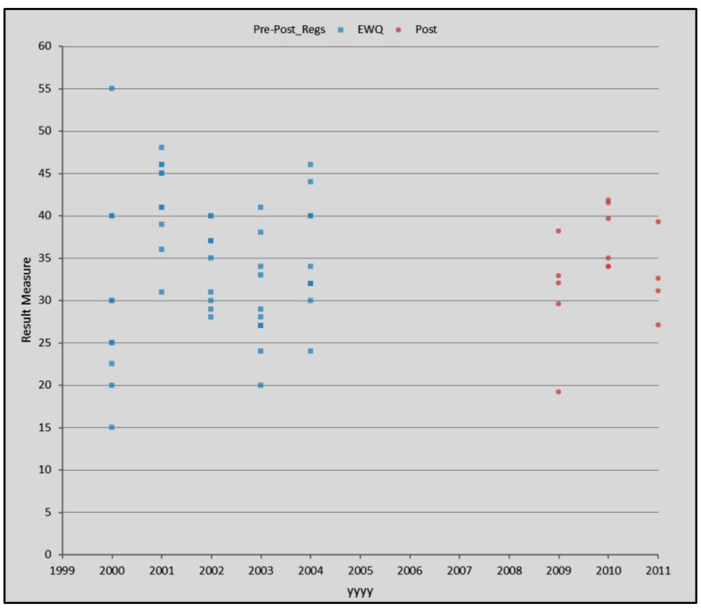
Chapter 18: 1838 ICP Delaware River at Easton

Alkalinity as CaCO3, Total mg/l

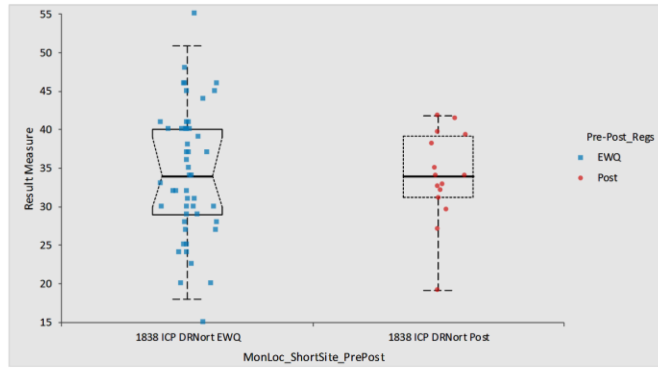
Existing Water Quality (Table 2I):

Median 34 mg/l
Lower 95% Confidence Interval 30 mg/l
Upper 95% Confidence Interval 39 mg/l
Defined in regulations as a flow-related parameter



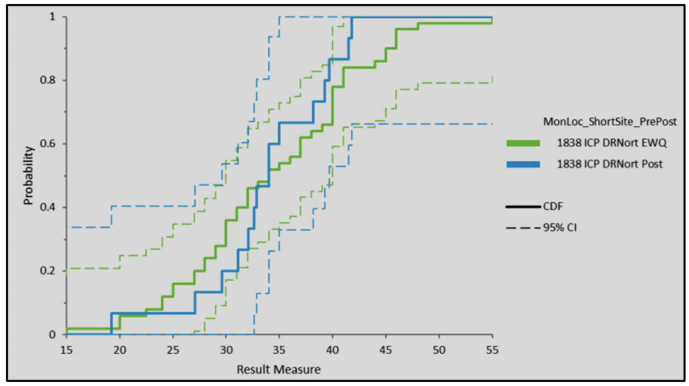


No water quality degradation is evident here. Alkalinity apparently did not measurably change between the EWQ and post-EWQ periods.



N	65

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1838 ICP DRNort EWQ	15	29	34	40	55	11
1838 ICP DRNort Post	19	31	34	39	42	8



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1838 ICP DRNort EWQ	50	0.1	0.00
1838 ICP DRNort Post	15	0.4	0.03

H statistic	0.00
X^2 approximation	0.00
DF	1
p-value	0.9689[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.

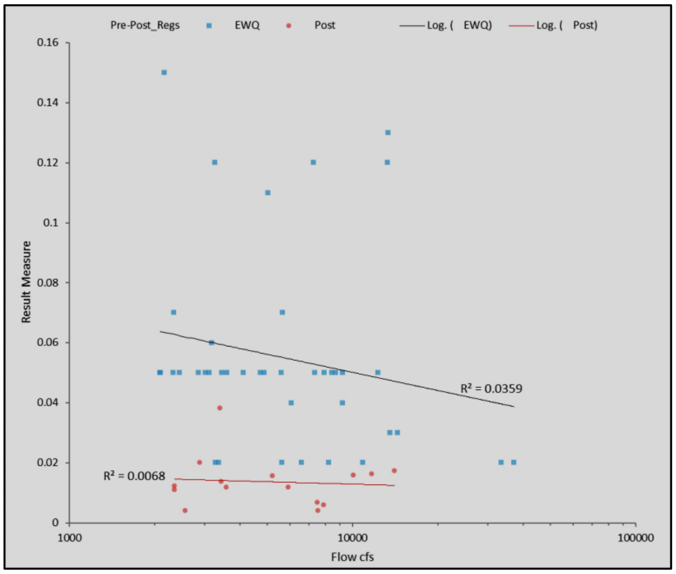
Sources of analytical uncertainty included potential laboratory artifacts, insufficient post-EWQ sampling frequency, and post-EWQ under-representation of flow conditions. Alkalinity is inversely related to flow in both data sets, though weakly in the EWQ period. Post-EWQ median alkalinity fell within EWQ 95% confidence intervals. Flow is plotted on logarithmic scale. The full flow regime was not fully represented in the post-EWQ data, as noted by the short regression line in the flow vs. concentration plot. There were no independent samples available for comparison with DRBC data.

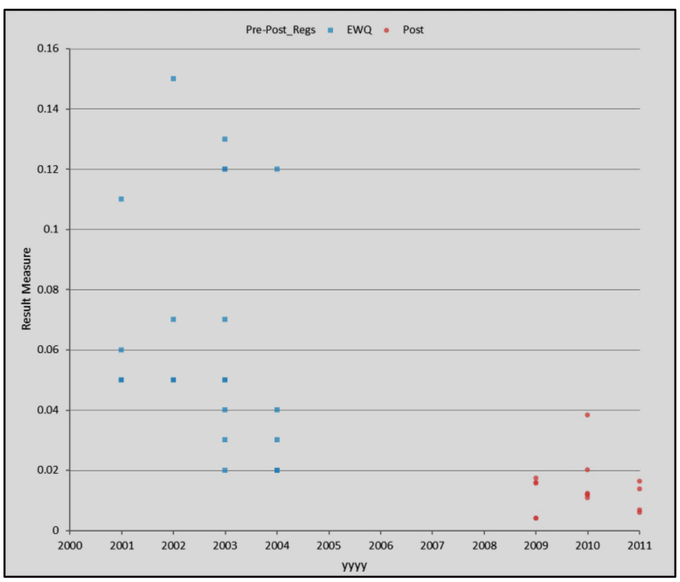
Chapter 18: 1838 ICP Delaware River at Easton

Ammonia Nitrogen as N, Total mg/l

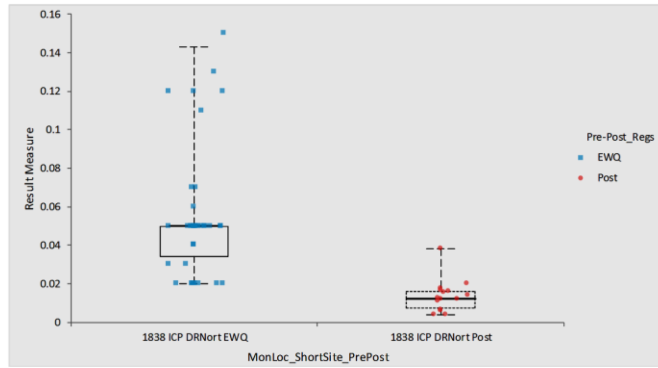
Existing Water Quality (Table 2I):

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

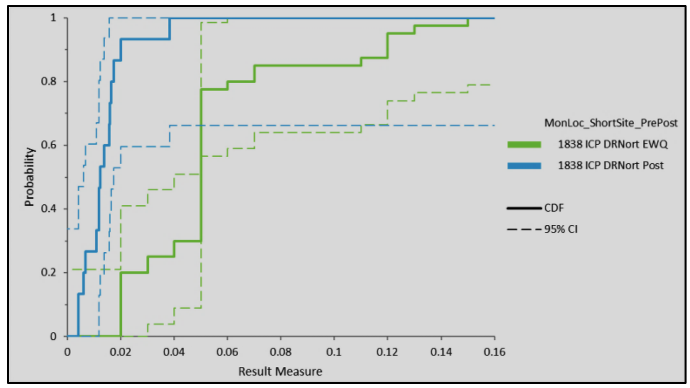




No water quality degradation is evident here. Ammonia concentrations apparently declined. Sources of analytical uncertainty included potential laboratory artifacts, detection limit differences, insufficient post-EWQ sampling frequency, and post-EWQ under-representation of flow conditions.



N	55					
Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1838 ICP DRNort EWQ	0.02	0.03	0.05	0.05	0.15	0.02
1838 ICP DRNort Post	0.00	0.01	0.01	0.02	0.04	0.01



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1838 ICP DRNort EWQ	40	1988.1	49.70
1838 ICP DRNort Post	15	5301.6	353.44

H statistic	29.72
X² approximation	29.72
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.

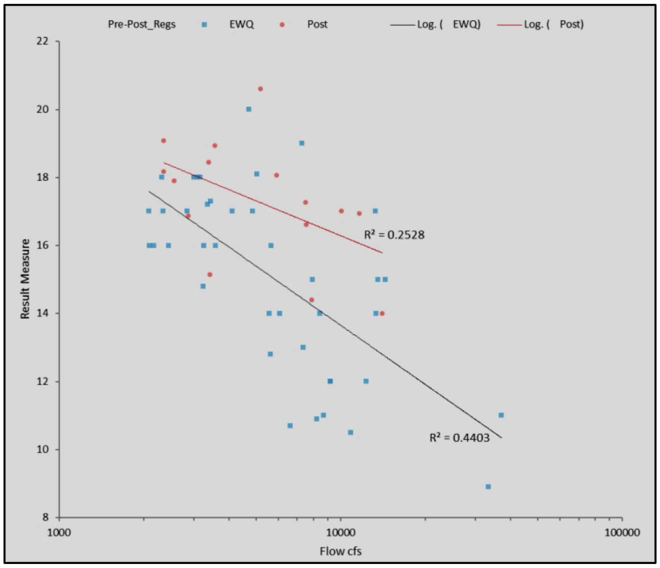
Post-EWQ median ammonia concentration was below the EWQ lower 95% confidence interval. We were better able to measure ammonia in the post-EWQ period due to improved detection limits. No independent data were available to validate DRBC results. Flow is plotted on a logarithmic scale. EWQ data possessed 27/40 undetected results that interfered with estimation of the EWQ median. With post-EWQ lower detection levels there were 3/15 undetected results, avoiding such interference and revealing lower concentrations. Some water quality improvement possibly took place, as post-EWQ concentrations were less than 0.04 mg/l. Of course this could also be a laboratory artifact.

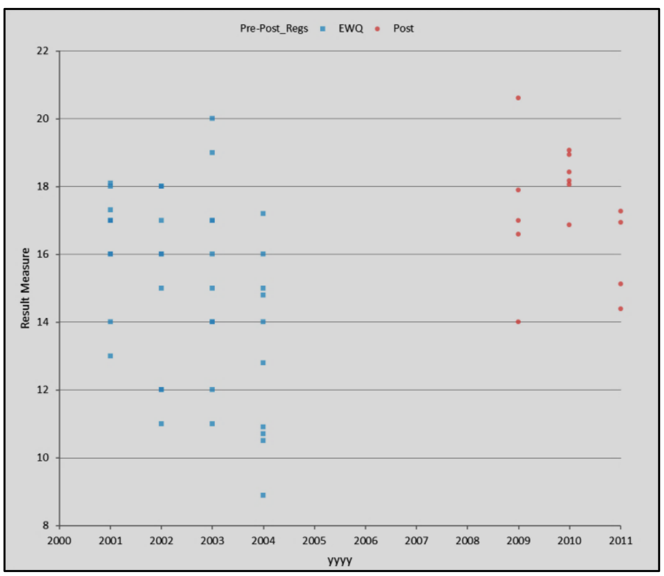
Chapter 18: 1838 ICP Delaware River at Easton

Chloride, Total mg/l

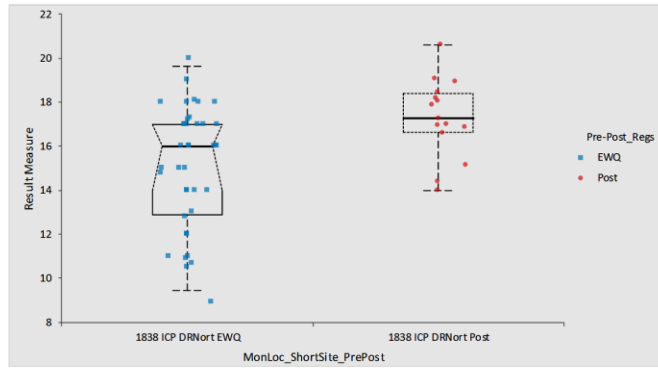
Existing Water Quality (Table 2I):

Median 16 mg/l
Lower 95% Confidence Interval 14 mg/l
Upper 95% Confidence Interval 17 mg/l
Defined in regulations as a flow-related parameter



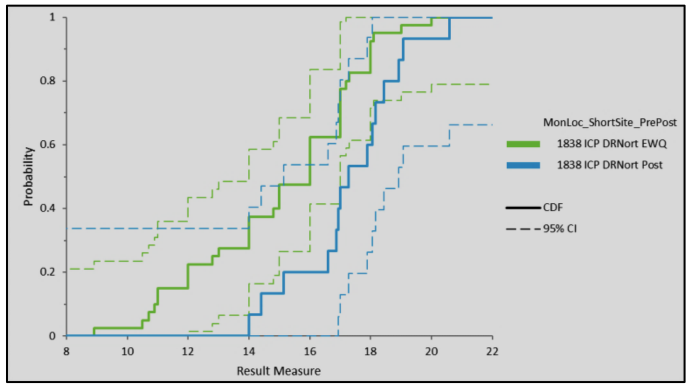


Some evidence of water quality degradation is presented. Median chloride concentrations apparently rose between the two periods. Analytical uncertainty sources included potential laboratory artifacts, insufficient post-EWQ sampling frequency, and flow differences.



N	55

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1838 ICP DRNort EWQ	9	13	16	17	20	4
1838 ICP DRNort Post	14	17	17	18	21	2



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1838 ICP DRNort EWQ	40	525.6	13.14
1838 ICP DRNort Post	15	1401.7	93.44

H statistic	7.54
X^2 approximation	7.54
DF	1
p-value	0.0060[1]

H0: $\theta_1 = \theta_2 = \theta\ldots$
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.

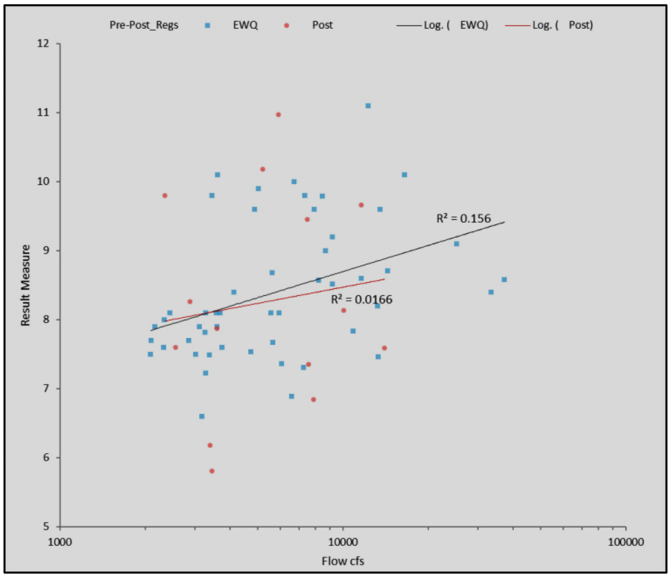
Post-EWQ median chlorides rose to the EWQ upper 95% confidence interval. Chloride concentration is related to flow in the EWQ data, but weakly related to flow in the post-EWQ data due to too few post-EWQ samples (n=15). Higher flow conditions were not well-represented in post-EWQ data, so there were fewer low concentrations measured. Flow is plotted on a logarithmic scale. No other data were available to validate DRBC results.

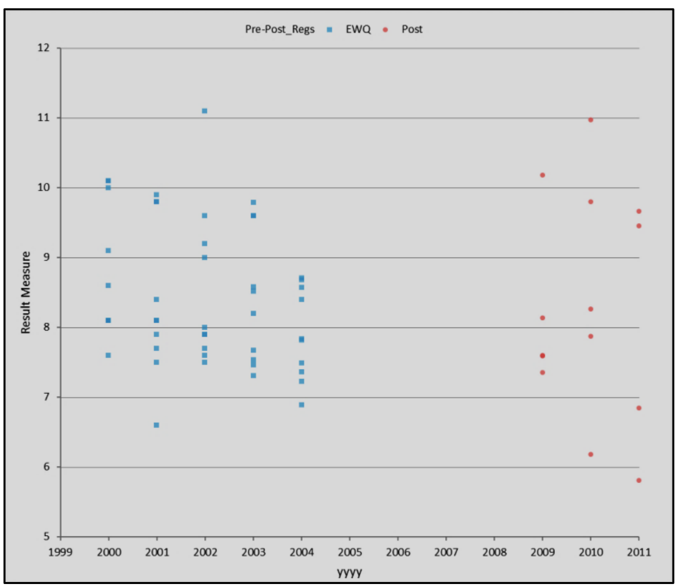
Chapter 18: 1838 ICP Delaware River at Easton

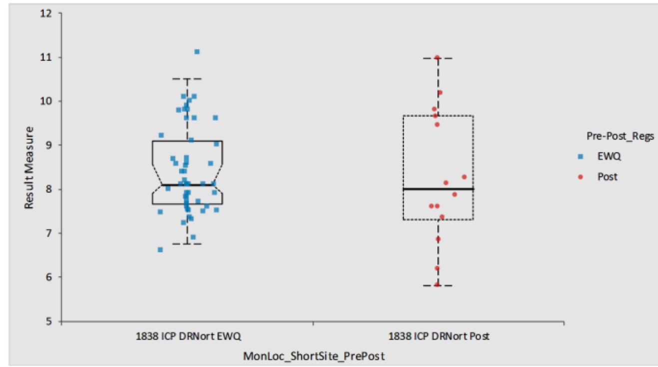
Dissolved Oxygen (DO) mg/l

Existing Water Quality (Table 2I):

Median 8.10 mg/l
Lower 95% Confidence Interval 7.90 mg/l
Upper 95% Confidence Interval 8.58 mg/l

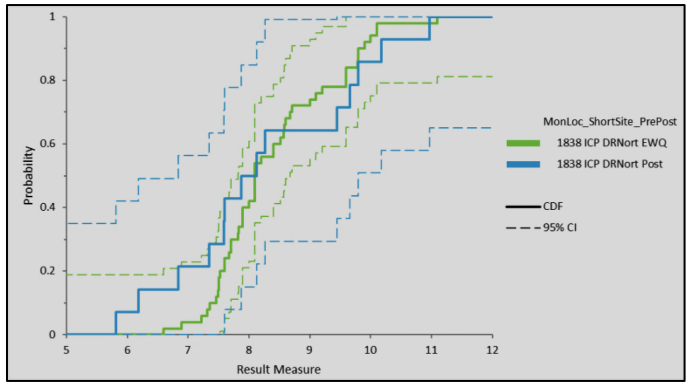






N	64

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1838 ICP DRNort EWQ	6.60	7.66	8.10	9.11	11.10	1.44
1838 ICP DRNort Post	5.81	7.31	8.00	9.67	10.97	2.36



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1838 ICP DRNort EWQ	50	16.8	0.34
1838 ICP DRNort Post	14	60.1	4.29

H statistic	0.22
X^2 approximation	0.22
DF	1
p-value	0.6375 [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.

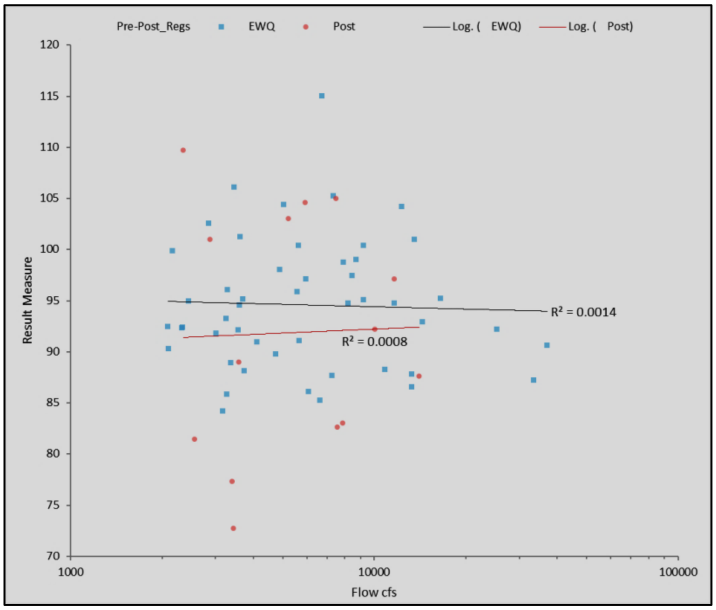
No water quality degradation is evident here. No measurable change took place between the EWQ and Post-EWQ periods. Post-EWQ median DO concentration fell within the EWQ 95% confidence intervals. There were too few post-EWQ samples collected (n=14). DO concentration is unrelated to flow in both data sets. Flow is plotted on a logarithmic scale.

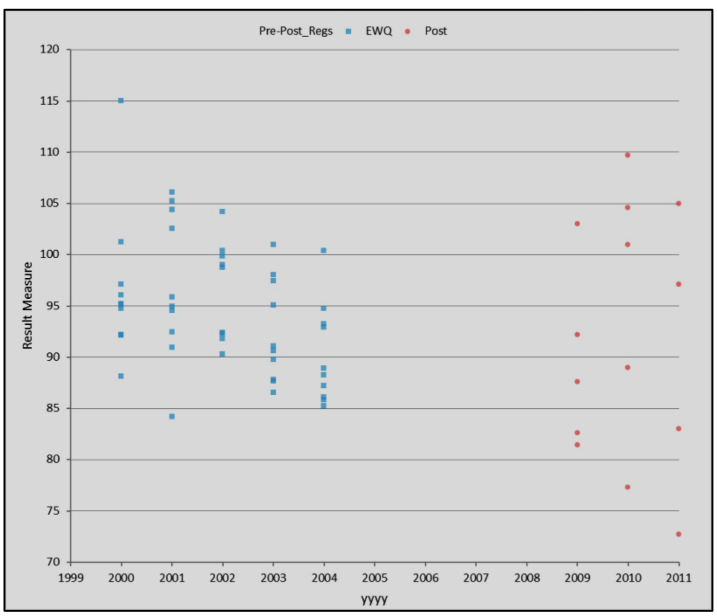
Chapter 18: 1838 ICP Delaware River at Easton

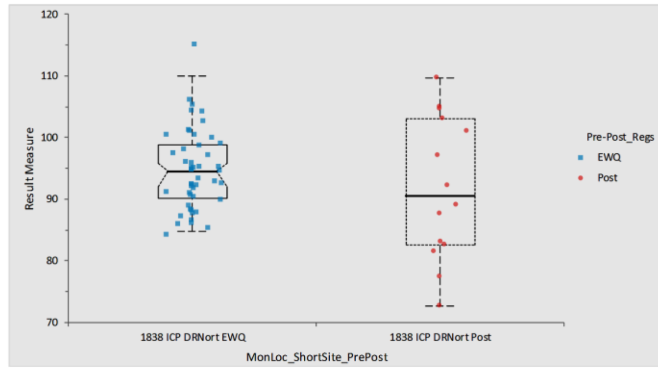
Dissolved Oxygen Saturation %

Existing Water Quality (Table 2I):

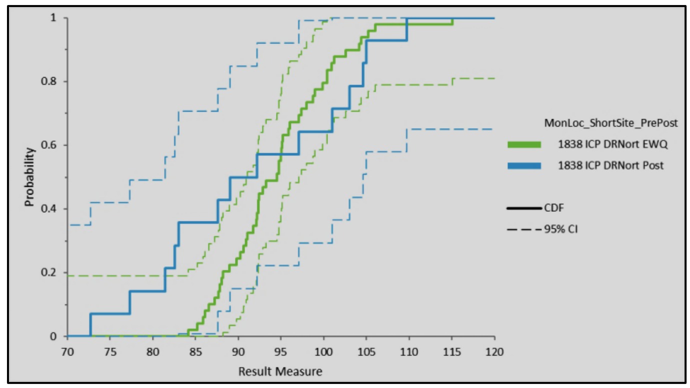
Median 95%
Lower 95% Confidence Interval 92%
Upper 95% Confidence Interval 96%







N	63					
Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1838 ICP DRNort EWQ	84	90	95	99	115	9
1838 ICP DRNort Post	73	83	91	103	110	21



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1838 ICP DRNort EWQ	49	47.0	0.96
1838 ICP DRNort Post	14	164.6	11.76

H statistic	0.63
X^2 approximation	0.63
DF	1
p-value	0.4275 [1]

H0: $\theta_1 = \theta_2 = \theta\ldots$
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.

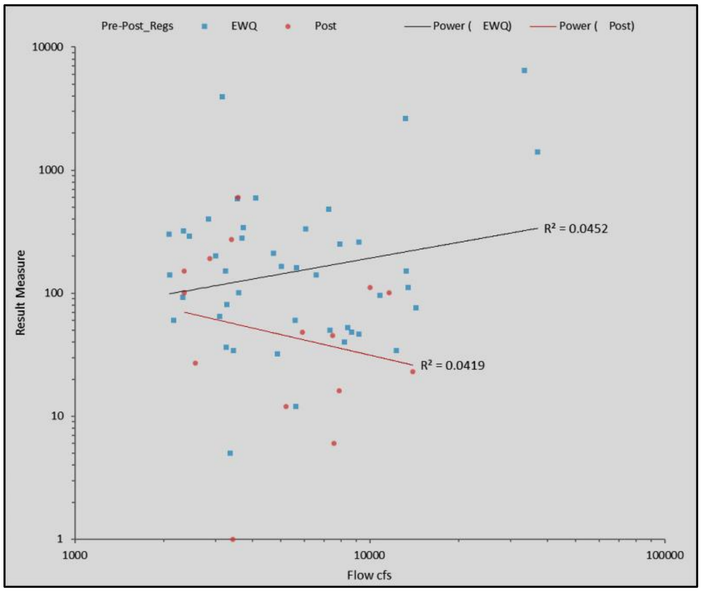
No water quality degradation is evident here. Dissolved Oxygen Saturation is unrelated to flow, and did not measurably change between the EWQ and post-EWQ periods. Analytical uncertainty sources included insufficient post-EWQ sampling frequency. Post-EWQ median DO saturation fell below the lower EWQ 95% confidence interval, but there were insufficient data to indicate a measurable change. Flow is plotted on a logarithmic scale. There were two low saturation values of 73% and 77% found in July 2010 and August 2011, respectively under low flow conditions. Biweekly instead of monthly sampling is recommended for this location. No independent data were available for comparison with DRBC results.

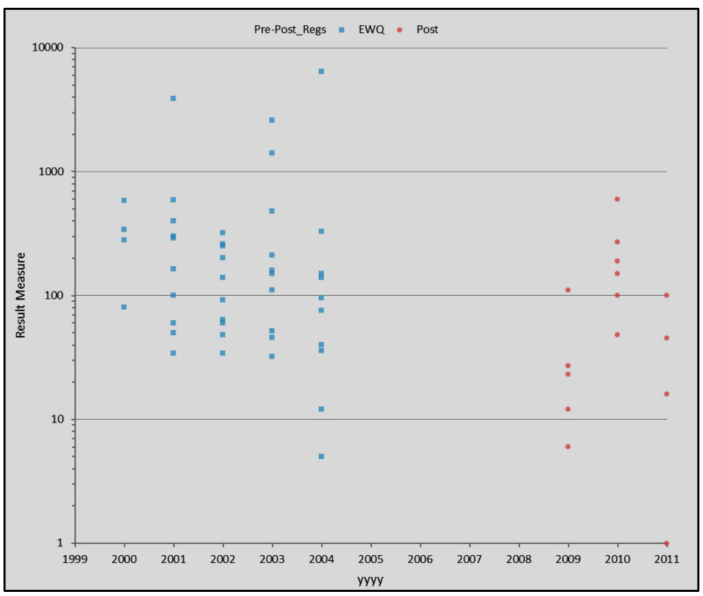
Chapter 18: 1838 ICP Delaware River at Easton

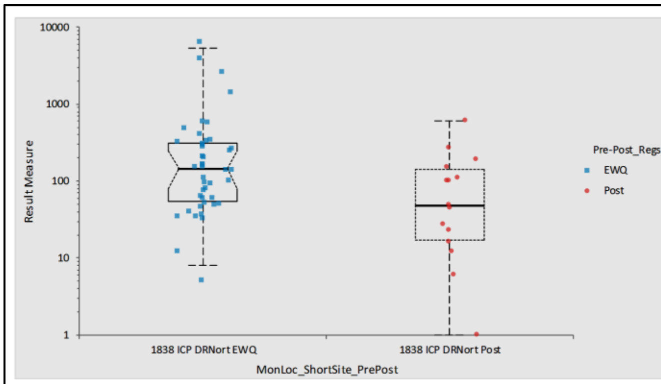
Enterococcus colonies/100 ml

Existing Water Quality (Table 2I):

Median 145/100 ml
Lower 95% Confidence Interval 80/100 ml
Upper 95% Confidence Interval 250/100 ml

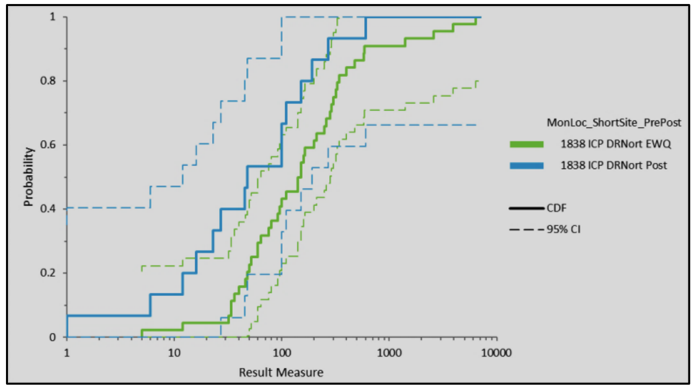






N	59

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1838 ICP DRNort EWQ	5	55	145	312	6400	256
1838 ICP DRNort Post	1	17	48	143	600	126



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1838 ICP DRNort EWQ	44	387.1	8.80
1838 ICP DRNort Post	15	1135.4	75.69

H statistic	5.16
X^2 approximation	5.16
DF	1
p-value	0.0231[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.

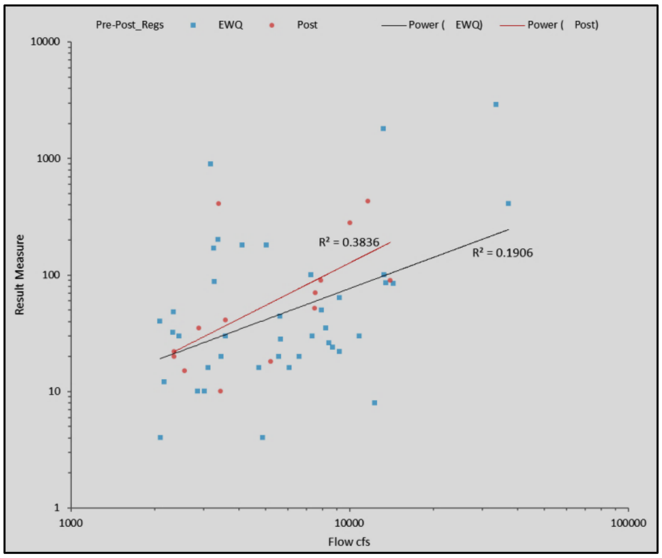
No water quality degradation is evident here. Enterococci apparently declined between the EWQ and Post-EWQ periods. Analytical uncertainty sources included potential laboratory artifacts, insufficient post-EWQ sampling frequency, and flow differences. Enterococcus concentrations are unrelated to flow in both data sets. Concentrations and flows are plotted on logarithmic scale, and regressions are power relationships. Post-EWQ median enterococcus concentrations fell below the lower EWQ 95% confidence interval. No independent data were available for comparison with DRBC results at this location.

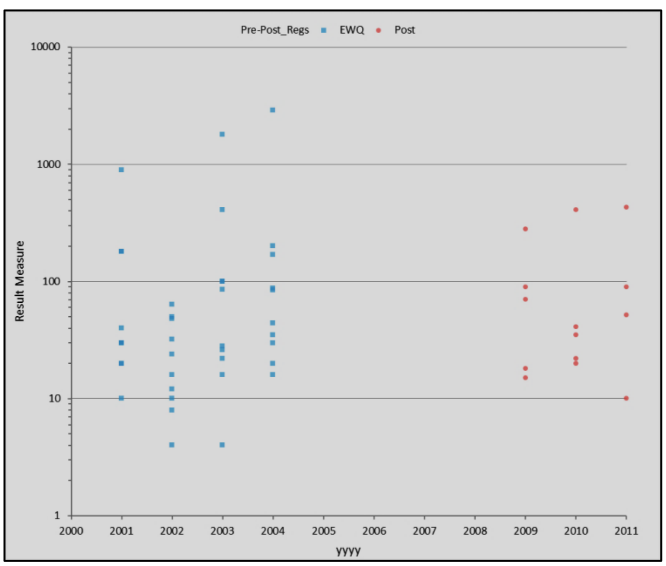
Chapter 18: 1838 ICP Delaware River at Easton

Escherichia coli colonies/100 ml

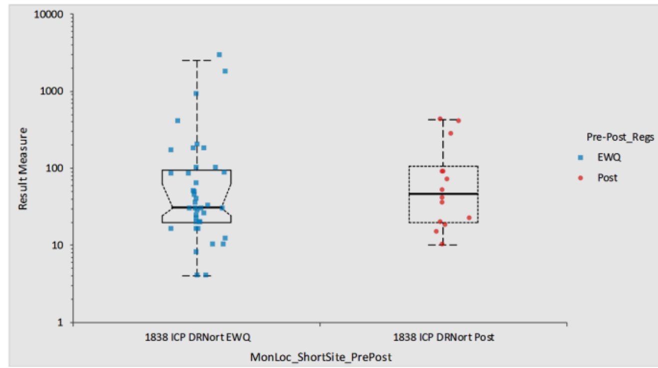
Existing Water Quality (Table 2I):

Median 31/100 ml
Lower 95% Confidence Interval 24/100 ml
Upper 95% Confidence Interval 64/100 ml
Defined in regulations as a flow-related parameter



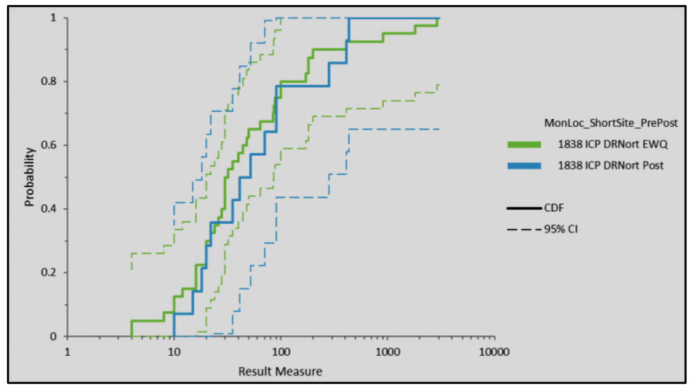


No water quality degradation is evident here. E. coli concentrations apparently did not measurably change between the EWQ and Post-EWQ periods. Analytical uncertainty sources included potential laboratory artifacts, insufficient post-EWQ sampling frequency, and flow differences.



N 54

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1838 ICP DRNort EWQ	4	20	31	95	2900	75
1838 ICP DRNort Post	10	20	47	106	430	86



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1838 ICP DRNort EWQ	40	21.0	0.53
1838 ICP DRNort Post	14	60.1	4.29

H statistic	0.33
X² approximation	0.33
DF	1
p-value	0.5668 [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.

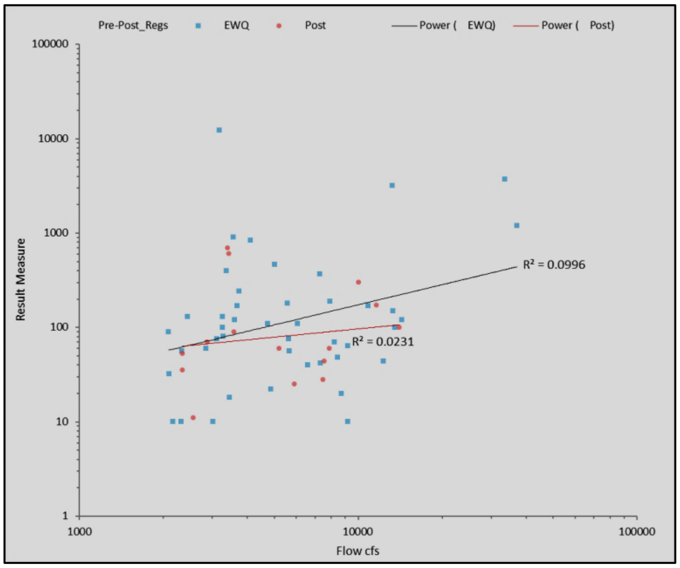
Post-EWQ median E. coli fell within the EWQ 95% confidence intervals. Concentrations and flows are plotted on logarithmic scale, and regressions are power relationships. E. coli concentrations are very weakly related to flow in the EWQ data set, but positively related to flow in the post-EWQ data set. No independent data were available to validate DRBC results at this location.

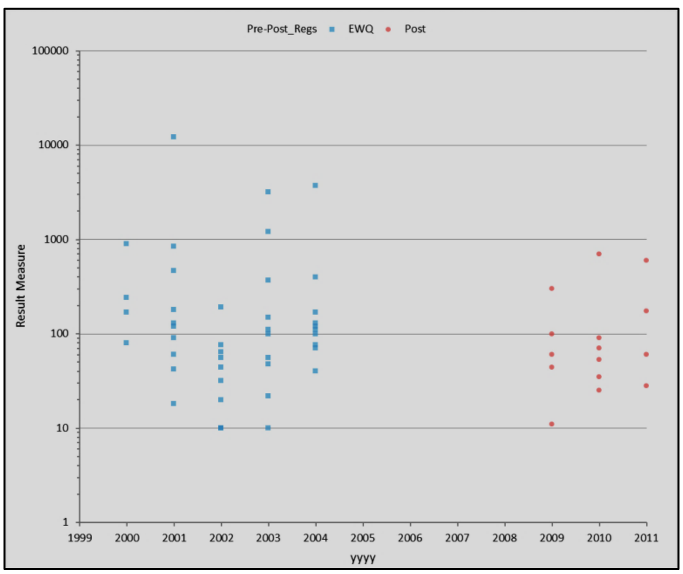
Chapter 18: 1838 ICP Delaware River at Easton

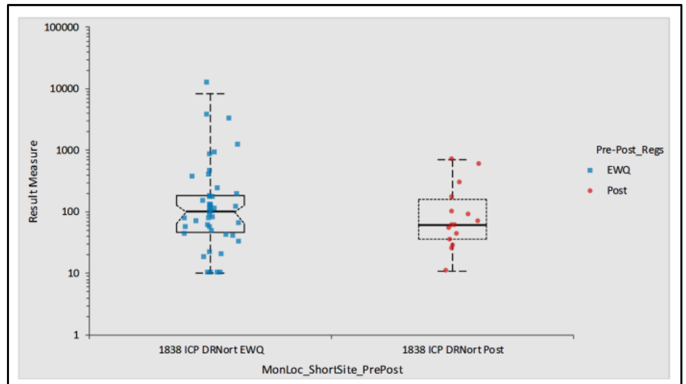
Fecal coliform colonies/100 ml

Existing Water Quality (Table 2I):

Median 100/100 ml
Lower 95% Confidence Interval 64/100 ml
Upper 95% Confidence Interval 130/100 ml

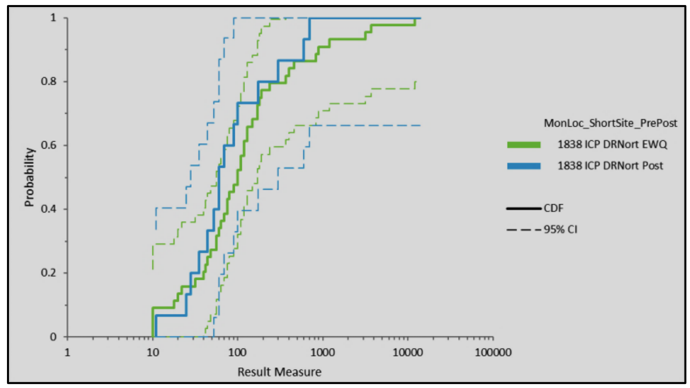






N	59

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1838 ICP DRNort EWQ	10	46	100	186	12200	140
1838 ICP DRNort Post	11	37	60	161	700	124



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1838 ICP DRNort EWQ	44	58.0	1.32
1838 ICP DRNort Post	15	170.0	11.33

H statistic	0.77
X^2 approximation	0.77
DF	1
p-value	0.3792 [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.

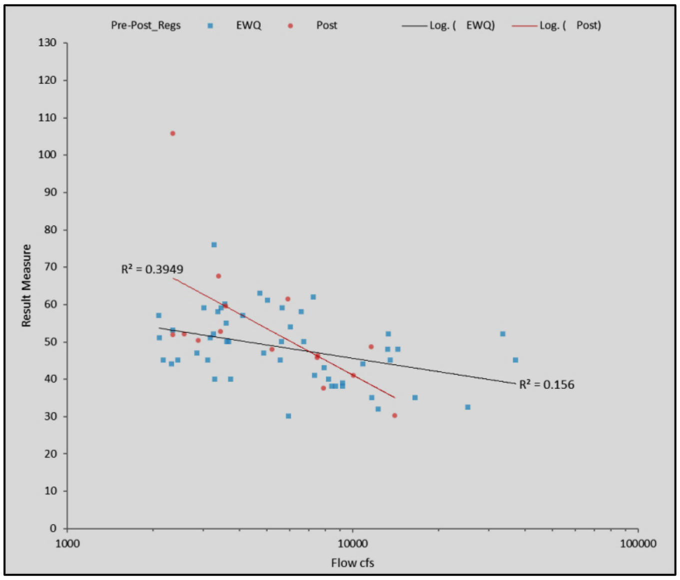
No water quality degradation is evident here. Fecal coliform concentrations apparently fell below the lower EWQ 95% confidence interval, but did not measurably change between the EWQ and post-EWQ periods. Analytical uncertainty sources included laboratory artifacts, insufficient post-EWQ sampling frequency (n=15), and flow differences. Fecal coliform is unrelated to flow in both data sets. Post-EWQ data were not fully representative of the flow regime. Concentrations and flows are plotted on logarithmic scale. No independent data were available for comparison with DRBC data.

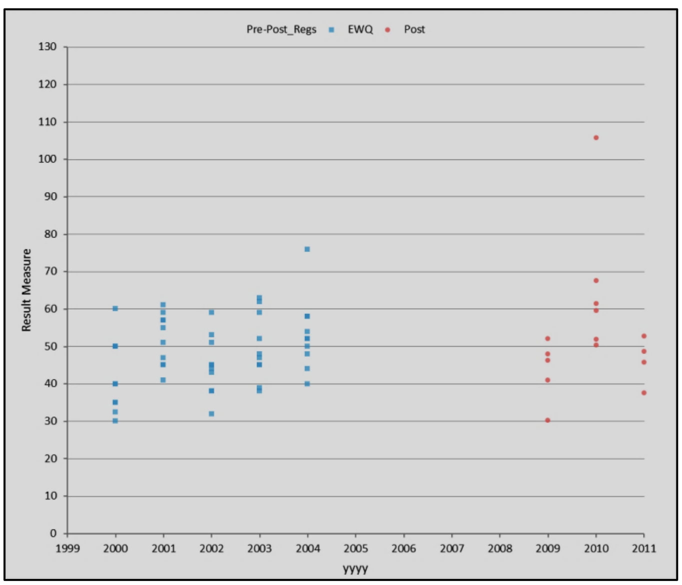
Chapter 18: 1838 ICP Delaware River at Easton

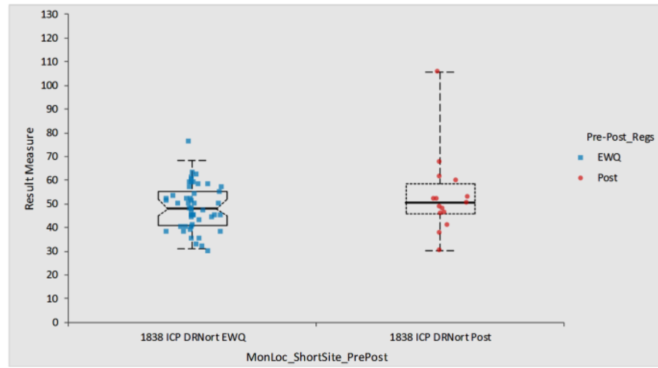
Hardness as CaCO3, Total mg/l

Existing Water Quality (Table 2I):

Median 48 mg/l
Lower 95% Confidence Interval 45 mg/l
Upper 95% Confidence Interval 52 mg/l

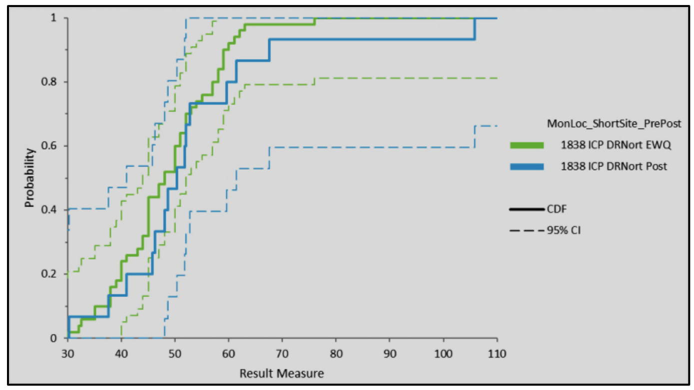






N 65

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1838 ICP DRNort EWQ	30	41	48	55	76	14
1838 ICP DRNort Post	30	46	50	58	106	13



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1838 ICP DRNort EWQ	50	72.0	1.44
1838 ICP DRNort Post	15	240.0	16.00

H statistic	0.87
X² approximation	0.87
DF	1
p-value	0.3498 [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.

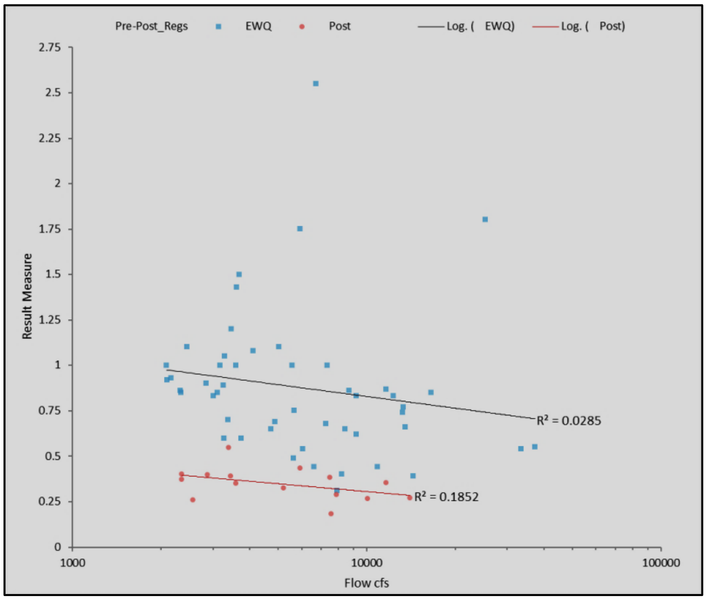
No water quality degradation is evident here. Hardness apparently did not measurably change between the EWQ and post-EWQ periods. Analytical uncertainty sources included potential laboratory artifacts, insufficient post-EWQ sampling frequency, and flow differences. Hardness is weakly related to flow in both data sets, though the strength of the relationship in the post-EWQ data is influenced by a single outlier value. Post-EWQ median hardness fell within the EWQ 95% confidence intervals. Flow is plotted on a logarithmic scale. No independent data were available for comparison with DRBC results.

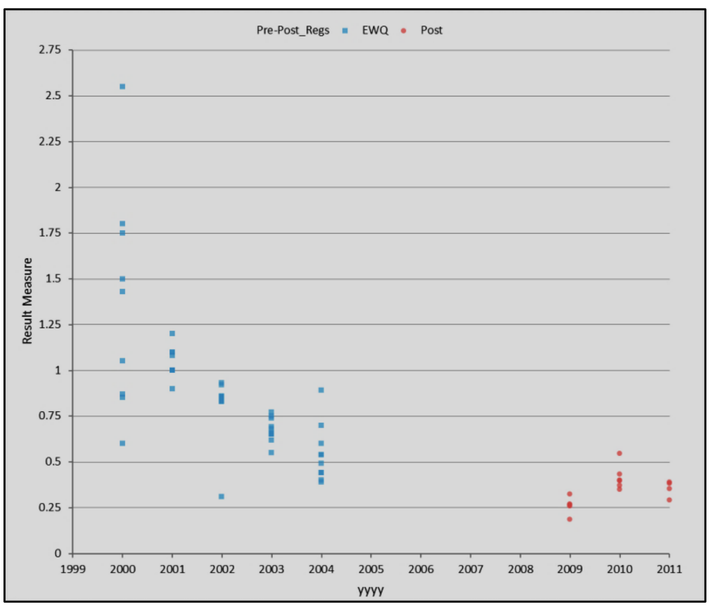
Chapter 18: 1838 ICP Delaware River at Easton

Nitrate + Nitrite as N, Total mg/l

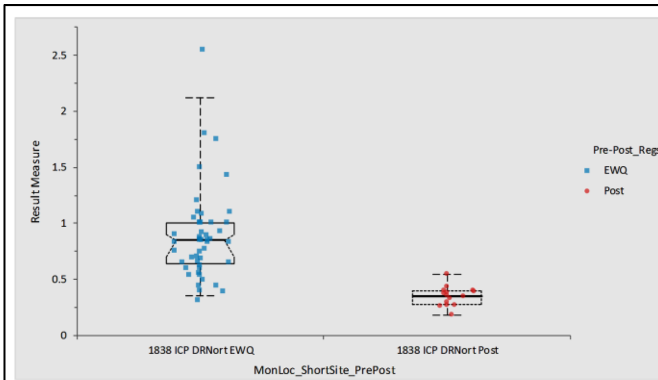
Existing Water Quality (Table 2I, as Nitrate only):

Median 0.85 mg/l
Lower 95% Confidence Interval 0.70 mg/l
Upper 95% Confidence Interval 0.90 mg/l



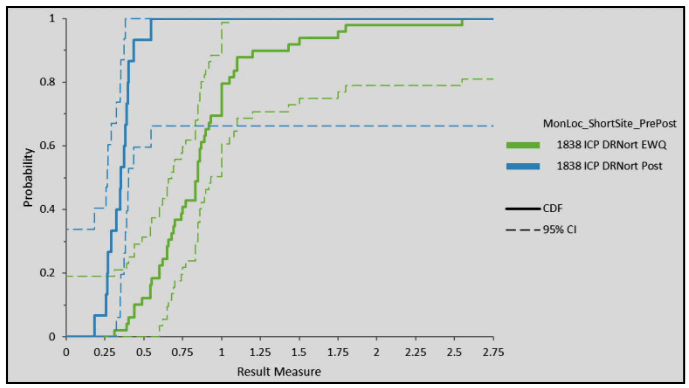


No water quality degradation is evident here. Nitrate concentrations apparently declined between the EWQ and post-EWQ periods. Analytical uncertainty sources included potential laboratory artifacts, detection limit differences, insufficient post-EWQ sampling frequency, and flow differences.



N | 64

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1838 ICP DRNort EWQ	0.31	0.64	0.85	1.00	2.55	0.36
1838 ICP DRNort Post	0.18	0.27	0.35	0.40	0.55	0.12



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1838 ICP DRNort EWQ	49	2422.0	49.43
1838 ICP DRNort Post	15	7912.0	527.47

H statistic	29.83
X² approximation	29.83
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.

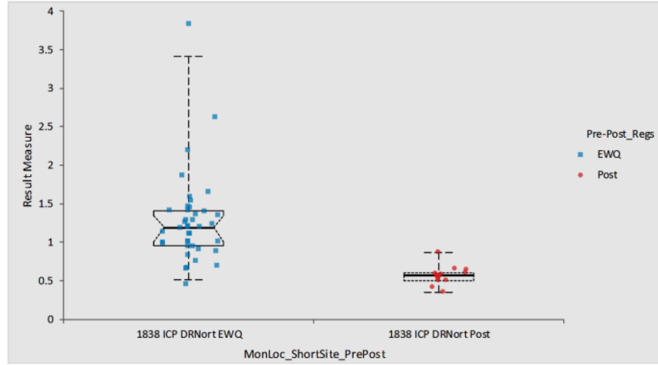
Nitrate is unrelated to flow in both data sets. Post-EWQ nitrate concentrations fell below the lower EWQ 95% confidence interval. Post-EWQ nitrate + nitrite concentrations were assumed equivalent for comparison with EWQ nitrate concentrations since EWQ nitrite concentrations were never detected. Independent data were not available for validation of DRBC data.

Chapter 18: 1838 ICP Delaware River at Easton

Nitrogen as N, Total (TN) mg/l

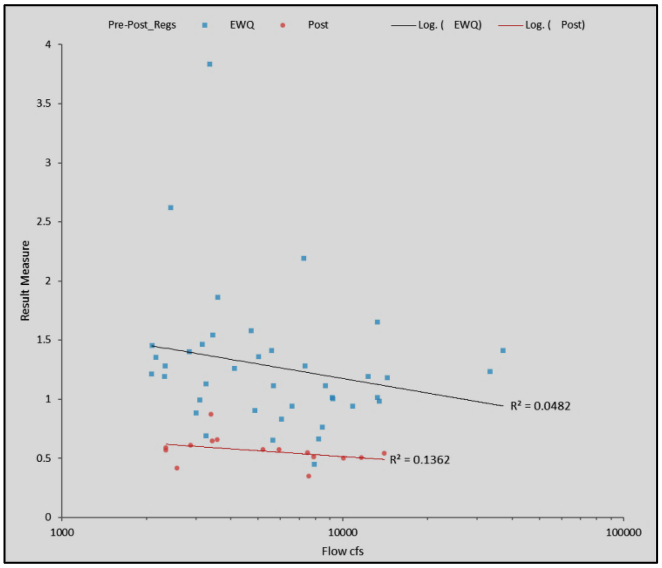
Existing Water Quality (Table 2I):

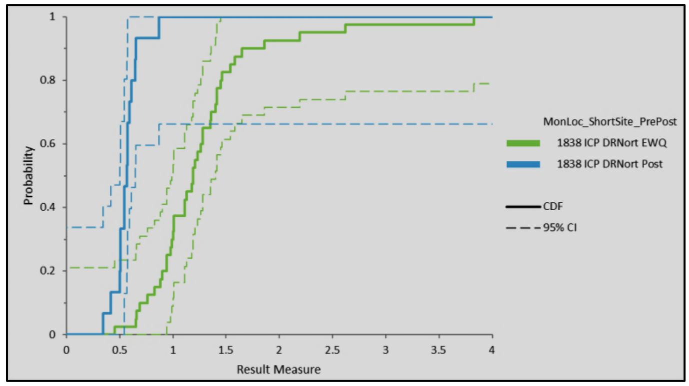
Median 1.19 mg/l
Lower 95% Confidence Interval 1.01 mg/l
Upper 95% Confidence Interval 1.35 mg/l

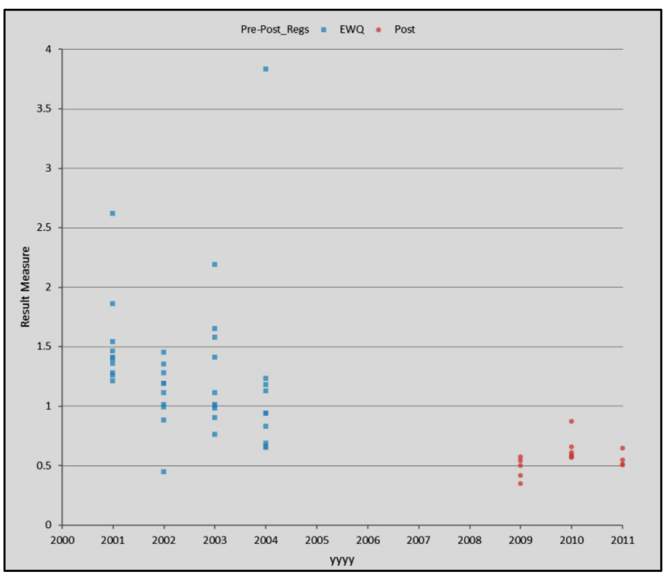


N 55

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1838 ICP DRNort EWQ	0.45	0.96	1.19	1.41	3.83	0.45
1838 ICP DRNort Post	0.35	0.51	0.57	0.61	0.87	0.10







Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1838 ICP DRNort EWQ	40	1974.0	49.35
1838 ICP DRNort Post	15	5264.1	350.94

H statistic	28.21
X² approximation	28.21
DF	1
p-value	<0.0001 [1]

H0: $\theta_1 = \theta_2 = \theta\ldots$
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.

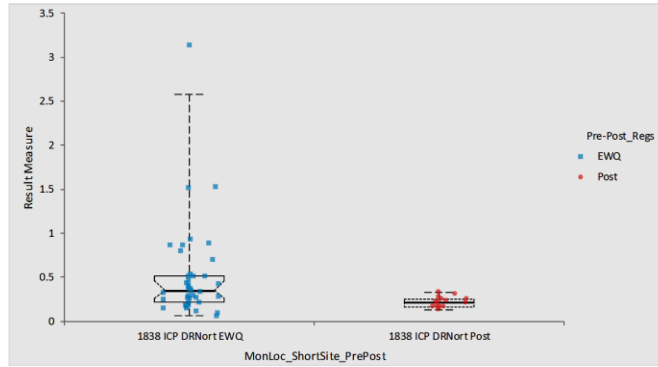
No water quality degradation is evident here. Total Nitrogen concentrations apparently declined between the EWQ and post-EWQ periods. Analytical uncertainty sources included potential laboratory artifacts, detection limit differences, insufficient post-EWQ sampling frequency, and flow differences. TN is unrelated to flow in both data sets. Post-EWQ median TN concentrations fell below the EWQ lower 95% confidence interval. No independent data were available to validate DRBC results.

Chapter 18: 1838 ICP Delaware River at Easton

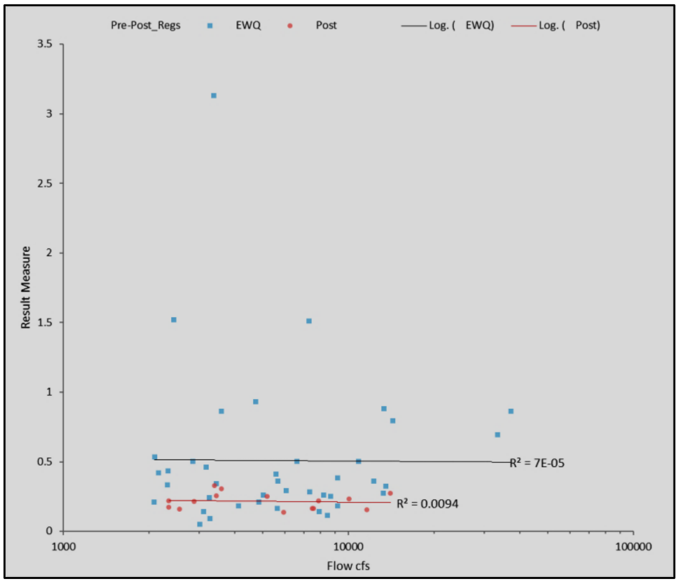
Nitrogen, Kjeldahl as N, Total (TKN) mg/l

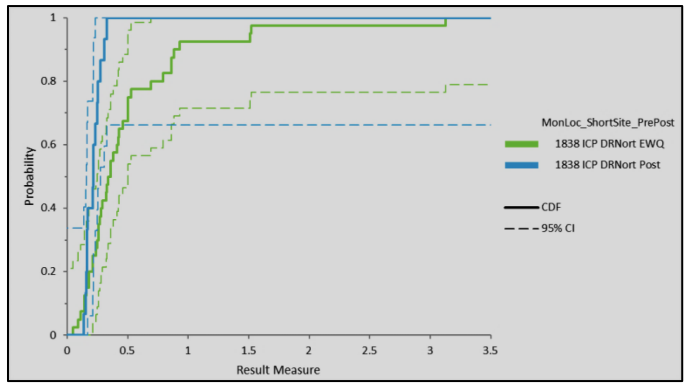
Existing Water Quality (Table 2I):

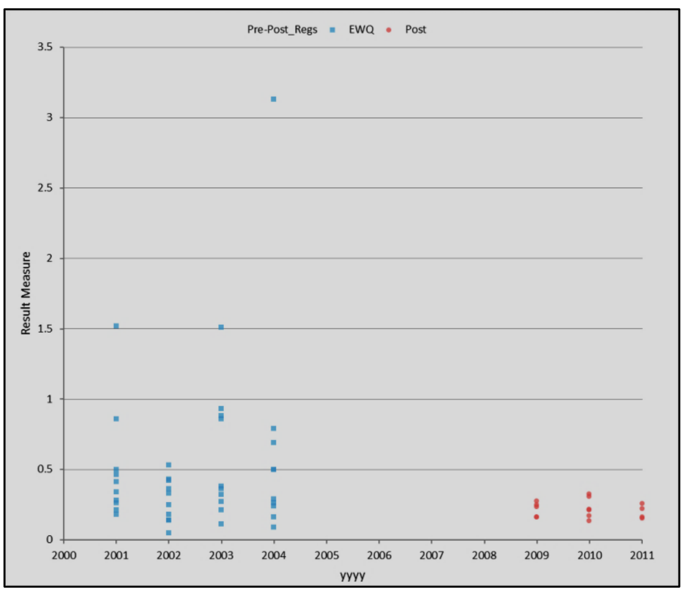
Median 0.35 mg/l
Lower 95% Confidence Interval 0.26 mg/l
Upper 95% Confidence Interval 0.46 mg/l



N	55					
Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1838 ICP DRNort EWQ	0.05	0.22	0.35	0.52	3.13	0.30
1838 ICP DRNort Post	0.14	0.16	0.22	0.25	0.33	0.09







Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1838 ICP DRNort EWQ	40	608.4	15.21
1838 ICP DRNort Post	15	1622.4	108.16

H statistic	8.69
X^2 approximation	8.69
DF	1
p-value	0.0032 [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.

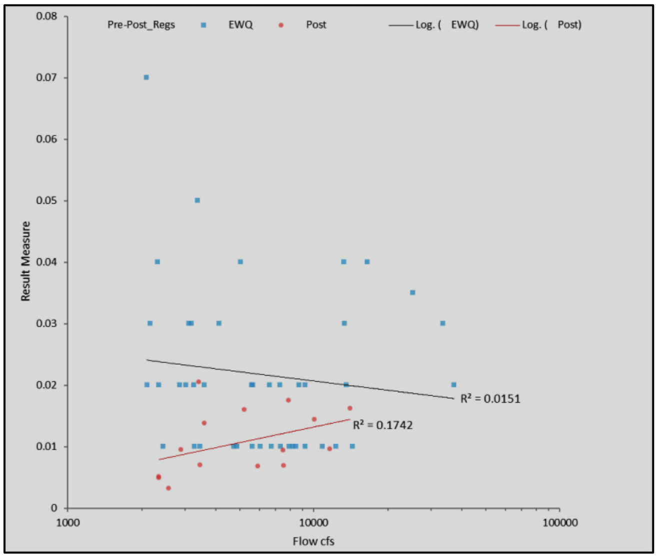
No water quality degradation is evident here. TKN concentrations apparently declined between the EWQ and post-EWQ periods. However, analytical uncertainty sources included potential laboratory artifacts, insufficient post-EWQ sampling frequency, and flow differences. The post-EWQ range was far narrower and all concentrations were less than 0.33 mg/l. TKN concentration is unrelated to flow in both data sets. Post-EWQ median TKN fell below the lower EWQ 95% confidence interval. There were no independent data to confirm DRBC results.

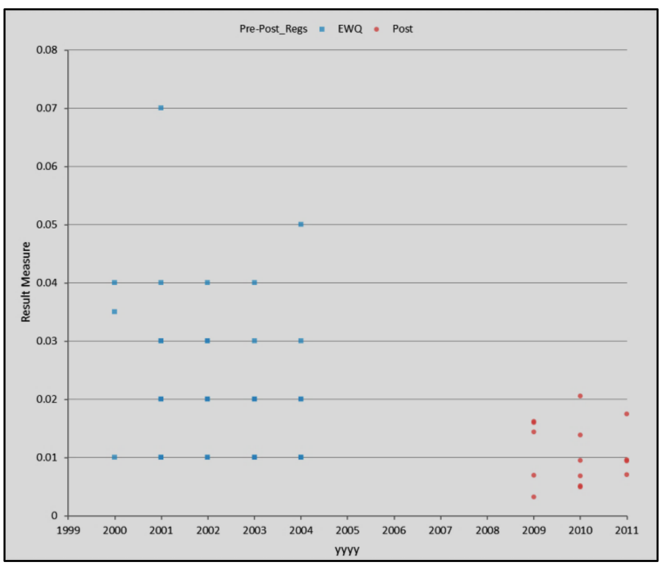
Chapter 18: 1838 ICP Delaware River at Easton

Orthophosphate as P, Total mg/l (OP)

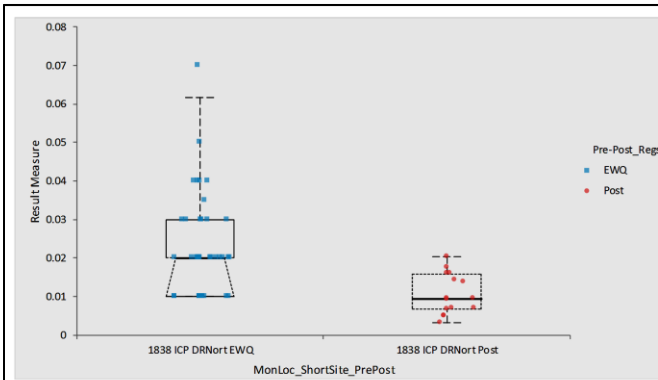
Existing Water Quality (Table 2I):

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



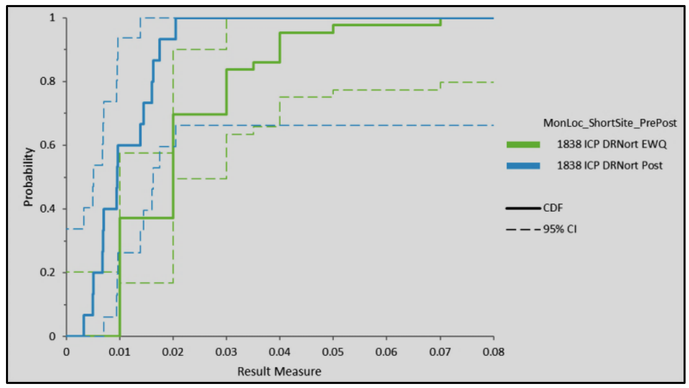


No water quality degradation is evident here. OP concentrations apparently declined between the EWQ and post-EWQ periods. However, analytical uncertainty sources included potential laboratory artifacts, detection limit differences, insufficient post-EWQ sampling frequency, and flow differences.



N	58

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1838 ICP DRNort EWQ	0.010	0.010	0.020	0.030	0.070	0.020
1838 ICP DRNort Post	0.003	0.007	0.010	0.016	0.021	0.009



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1838 ICP DRNort EWQ	43	1050.1	24.42
1838 ICP DRNort Post	15	3010.4	200.69

H statistic	14.78
X^2 approximation	14.78
DF	1
p-value	0.0001 [1]

H0: $\theta_1 = \theta_2 = \theta\ldots$
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.

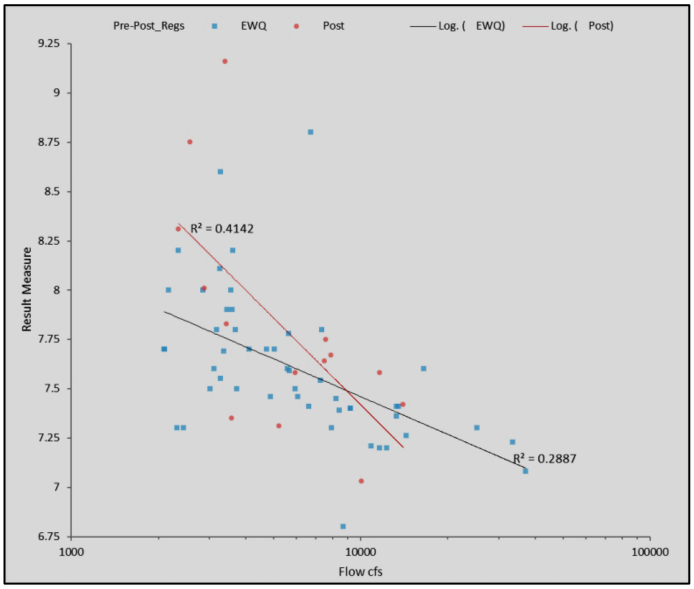
OP is unrelated to flow in both data sets. Post-EWQ median orthophosphate fell to the EWQ lower 95% confidence interval. This may indicate a water quality improvement in that there were no post-EWQ concentrations higher than 0.02 mg/l, but could also be a laboratory artifact. The EWQ orthophosphate undetected results rate was 16 out of 43 samples. The detection limit was lower in the post-EWQ results, and there were no undetected results. Post-EWQ orthophosphate ranged narrower than EWQ data. There were no independent data to confirm DRBC results.

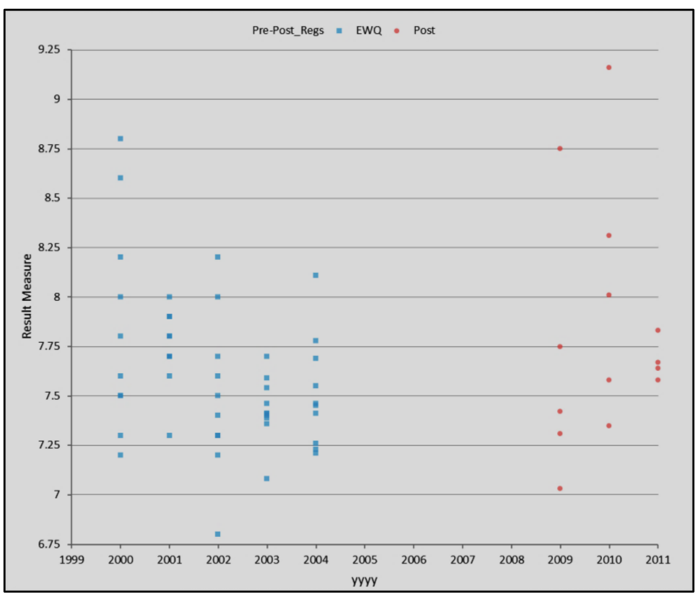
Chapter 18: 1838 ICP Delaware River at Easton

pH

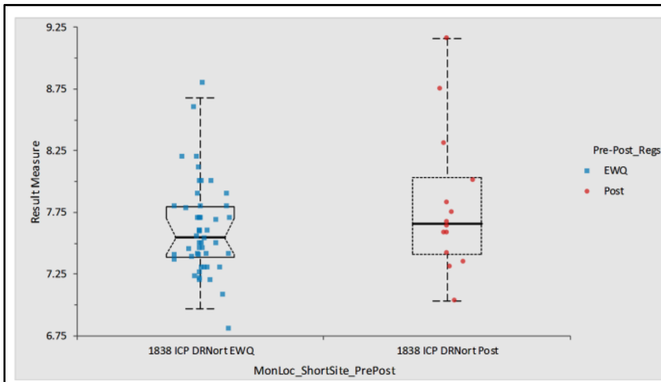
Existing Water Quality (Table 2I):

Median 7.55 standard units
Lower 95% Confidence Interval 7.41 standard units
Upper 95% Confidence Interval 7.70 standard units



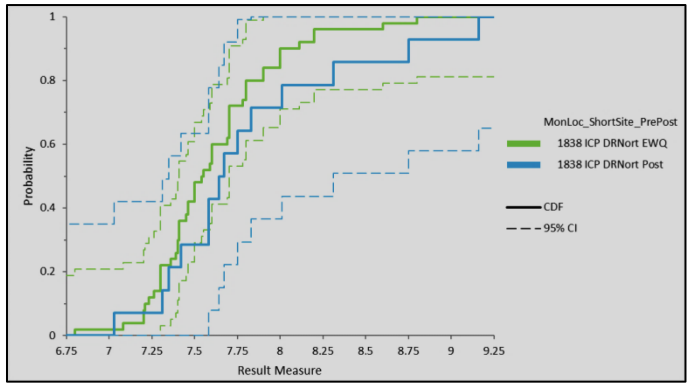


No water quality degradation is evident here. pH apparently did not measurably change between the EWQ and post-EWQ periods. However, analytical uncertainty sources included insufficient post-EWQ sampling frequency and flow differences.



N 64

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1838 ICP DRNort EWQ	6.80	7.39	7.55	7.80	8.80	0.41
1838 ICP DRNort Post	7.03	7.41	7.66	8.04	9.16	0.62



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1838 ICP DRNort EWQ	50	100.8	2.02
1838 ICP DRNort Post	14	360.1	25.72

H statistic	1.33
X^2 approximation	1.33
DF	1
p-value	0.2486 [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.

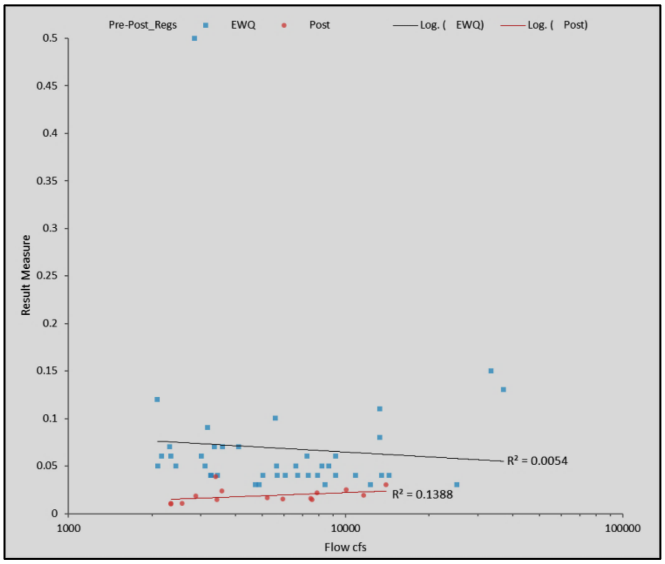
pH is weakly related to flow in the EWQ data set and inversely related to flow in the post-EWQ data. pH tends toward neutral at higher flow conditions. Post-EWQ median pH was near the upper EWQ 95% confidence interval, but there were too few data (n=14) to measure a true difference. In July 2010 there was one spike above pH 9, indicating high algal productivity during that dry sampling period. There is a very large aquatic plant bed just upstream of this location. No independent data were available to confirm DRBC results.

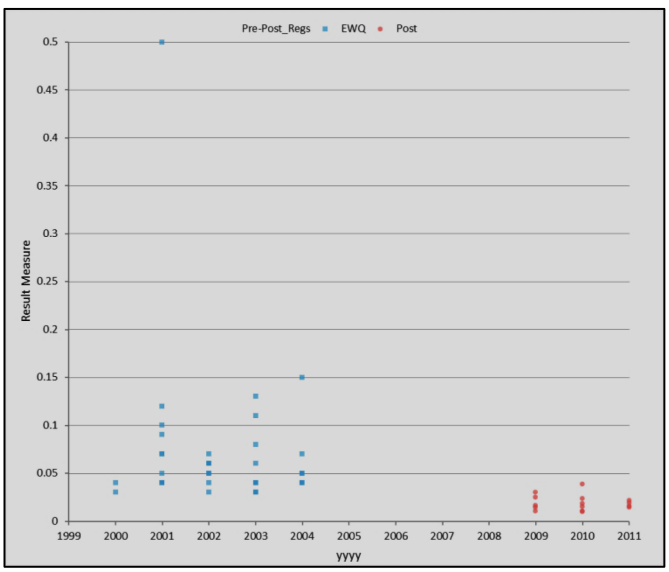
Chapter 18: 1838 ICP Delaware River at Easton

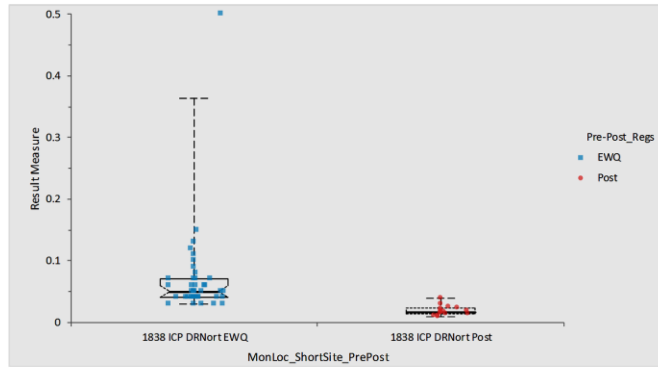
Phosphorus as P, Total (TP) mg/l

Existing Water Quality (Table 2I):

Median 0.05 mg/l
Lower 95% Confidence Interval 0.04 mg/l
Upper 95% Confidence Interval 0.06 mg/l

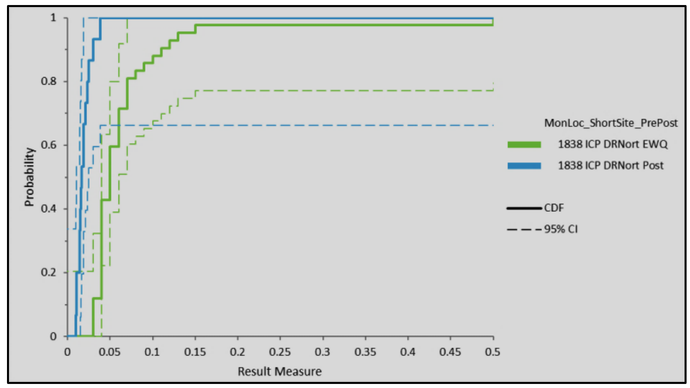






N 57

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1838 ICP DRNort EWQ	0.030	0.040	0.050	0.070	0.500	0.030
1838 ICP DRNort Post	0.010	0.014	0.016	0.023	0.039	0.009



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1838 ICP DRNort EWQ	42	2251.3	53.60
1838 ICP DRNort Post	15	6303.8	420.25

H statistic	31.55
X^2 approximation	31.55
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.

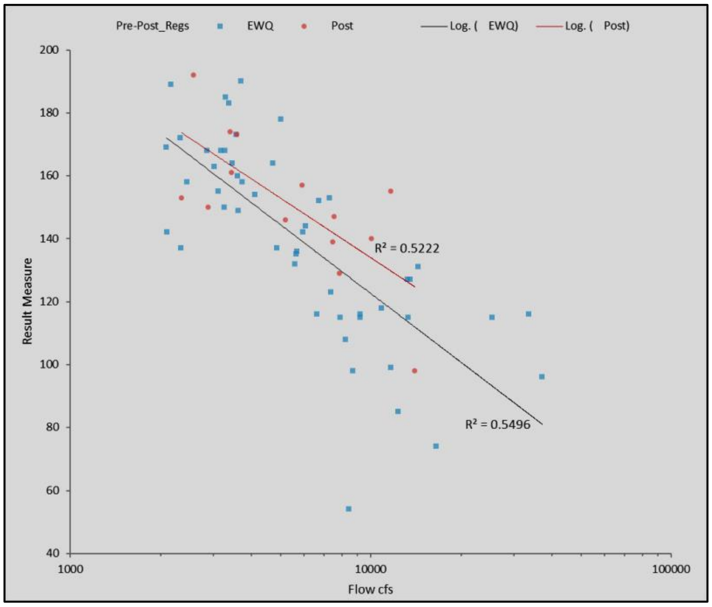
No water quality degradation is evident here. Total Phosphorus (TP) concentrations apparently declined between the EWQ and post-EWQ periods. However, analytical uncertainty sources included potential laboratory artifacts, detection limit differences, insufficient post-EWQ sampling frequency, and flow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

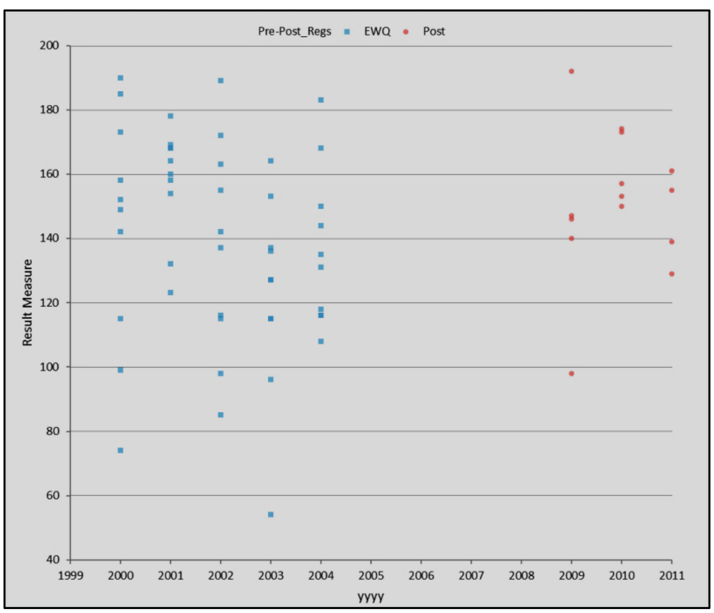
Chapter 18: 1838 ICP Delaware River at Easton

Specific Conductance µmho/cm

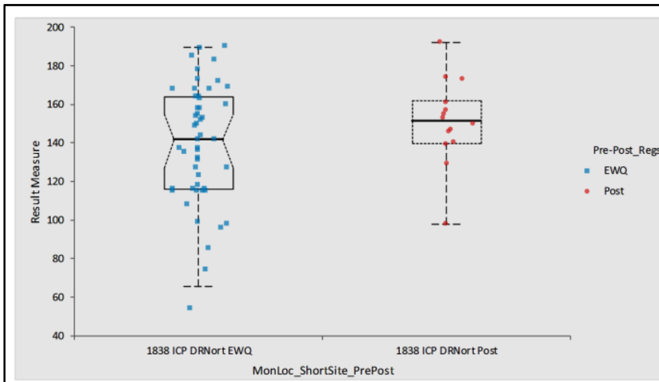
Existing Water Quality (Table 2I):

Median 142 µmho/cm
Lower 95% Confidence Interval 127 µmho/cm
Upper 95% Confidence Interval 155 µmho/cm
Defined in regulations as a flow-related parameter



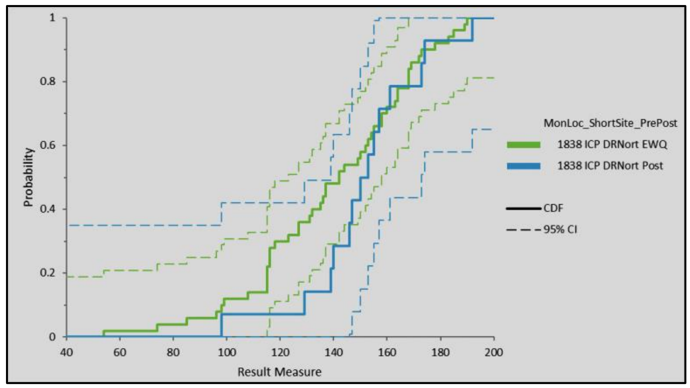


No water quality degradation is evident here. Specific conductance apparently did not measurably change between the EWQ and post-EWQ periods. However, analytical uncertainty sources included insufficient post-EWQ sampling frequency and flow differences.



N | 64

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1838 ICP DRNort EWQ	54	116	142	164	190	48
1838 ICP DRNort Post	98	140	152	162	192	22



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1838 ICP DRNort EWQ	50	111.0	2.22
1838 ICP DRNort Post	14	396.4	28.32

H statistic	1.46
X² approximation	1.46
DF	1
p-value	0.2262 [1]

H0: $\theta_1 = \theta_2 = \theta\ldots$
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.

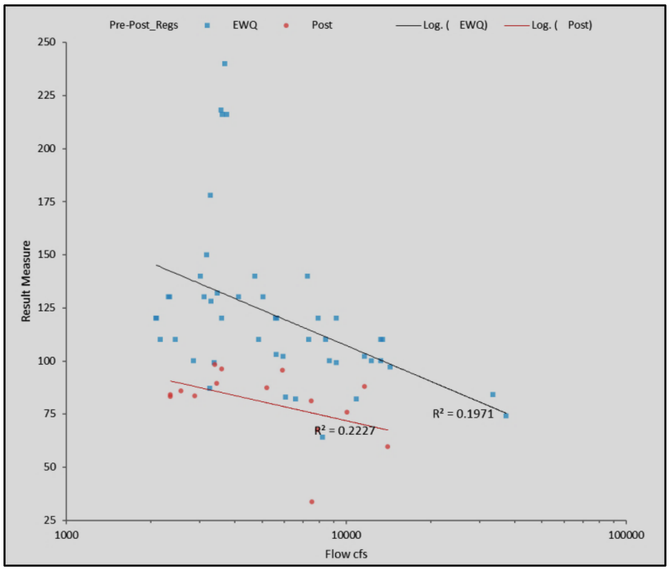
Post-EWQ median specific conductance fell within the EWQ 95% confidence intervals. Specific conductance is inversely related to flow in both data sets. The rise in specific conductance seen elsewhere is not apparent here; probably because the full flow regime is not well-represented in the post-EWQ data. Median specific conductance rose by 10 µmho/cm but there were insufficient post-EWQ samples (n=14) for a valid comparison. No independent data were available for comparison with DRBC results.

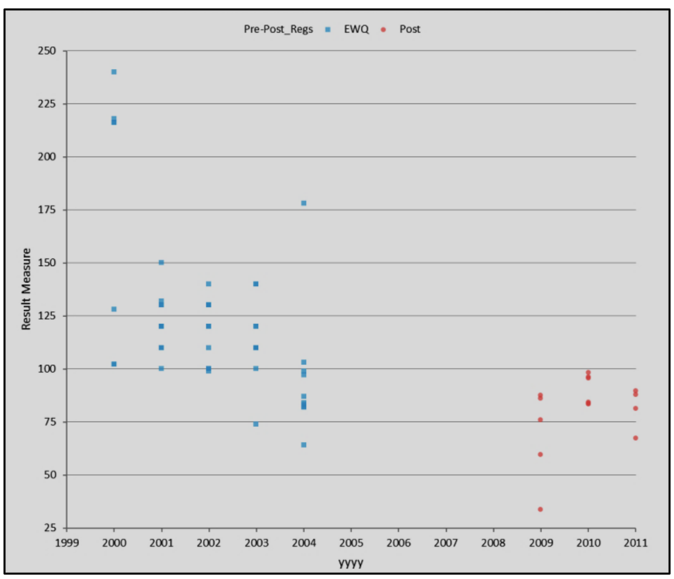
Chapter 18: 1838 ICP Delaware River at Easton

Total Dissolved Solids (TDS) mg/l

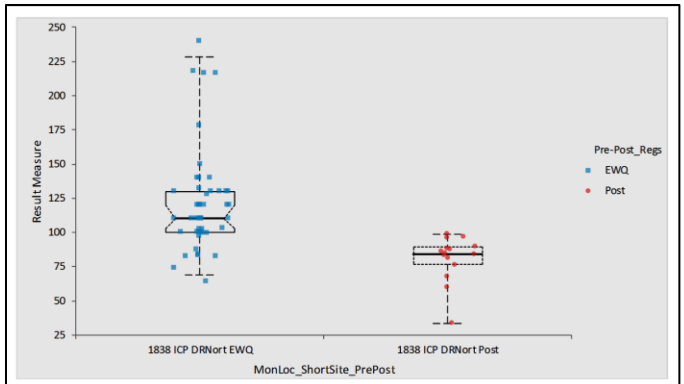
Existing Water Quality (Table 2I):

Median 110 mg/l
Lower 95% Confidence Interval 103 mg/l
Upper 95% Confidence Interval 120 mg/l

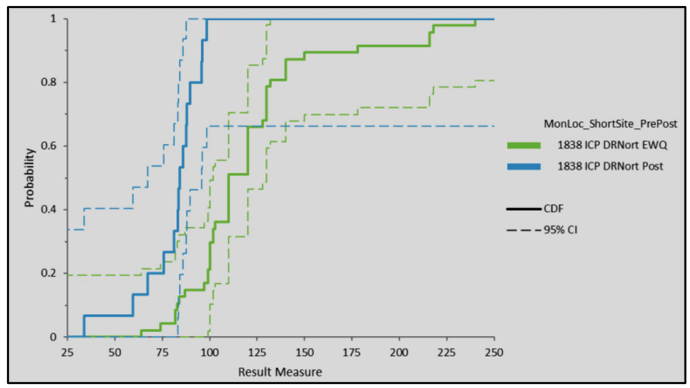




No water quality degradation is evident here. TDS apparently declined between the EWQ and post-EWQ periods. However, analytical uncertainty sources included potential laboratory artifacts, detection limit differences, insufficient post-EWQ sampling frequency, and flow differences. TDS is unrelated to flow in both data sets.



N	62					
Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1838 ICP DRNort EWQ	64	100	110	130	240	30
1838 ICP DRNort Post	34	77	84	89	98	12



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1838 ICP DRNort EWQ	47	1698.0	36.13
1838 ICP DRNort Post	15	5320.4	354.69

H statistic	21.64
X² approximation	21.64
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.

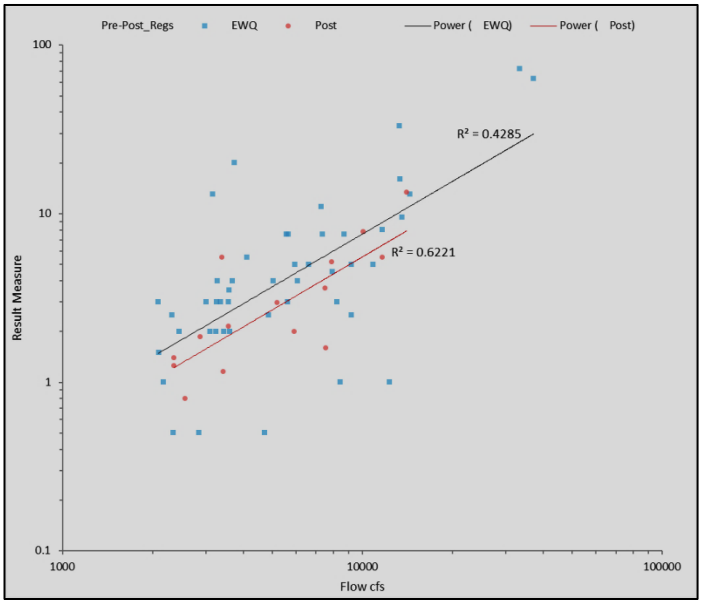
Post-EWQ median TDS fell below the EWQ lower 95% lower confidence interval, and were less variable than the baseline samples as well. Post-EWQ detection limits were lower than EWQ detection limits, though there were no non-detect results at any time. Perhaps this decline is not real but an artifact of different laboratory practices. The annual plot shows clear differences in data from three different contract labs used in 2000, 2001-2004 and 2009-2011. To solve or at least account for this problem, blind standards and split samples should be sent to different laboratories used by the monitoring program.

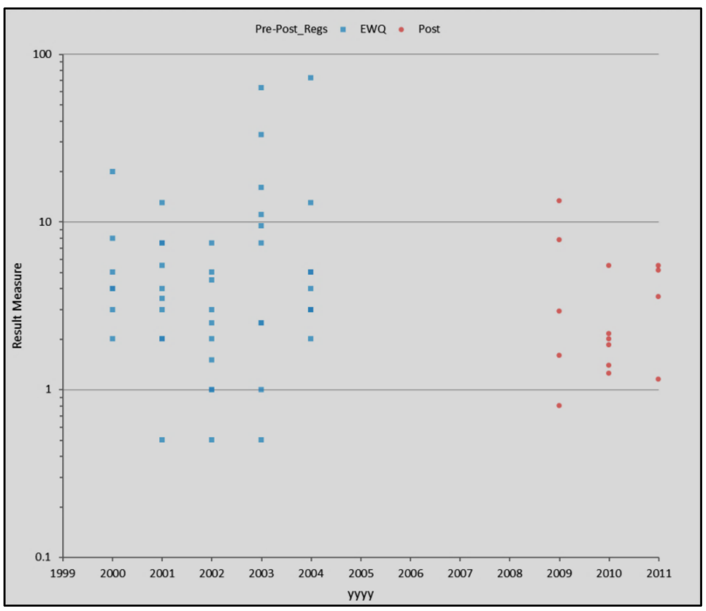
Chapter 18: 1838 ICP Delaware River at Easton

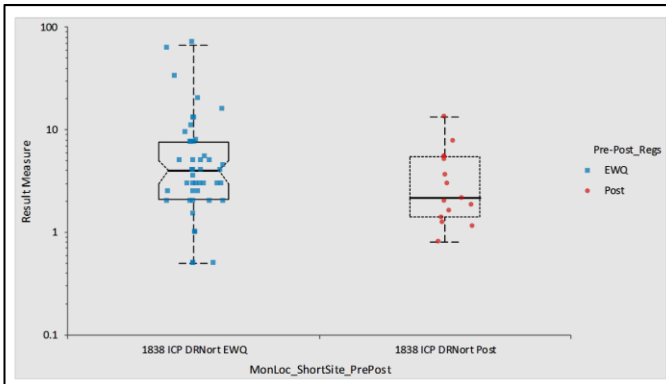
Total Suspended Solids (TSS) mg/l

Existing Water Quality (Table 2I):

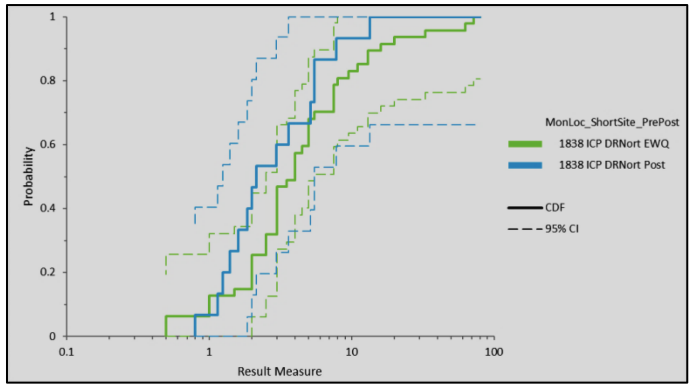
Median 4.0 mg/l
Lower 95% Confidence Interval 3.0 mg/l
Upper 95% Confidence Interval 5.0 mg/l
Defined in regulations as a flow-related parameter







N	62					
Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1838 ICP DRNort EWQ	0.5	2.1	4.0	7.5	72.0	5.4
1838 ICP DRNort Post	0.8	1.4	2.2	5.4	13.4	4.0



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1838 ICP DRNort EWQ	47	148.3	3.16
1838 ICP DRNort Post	15	464.8	30.99

H statistic	1.89
X² approximation	1.89
DF	1
p-value	0.1693 [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.

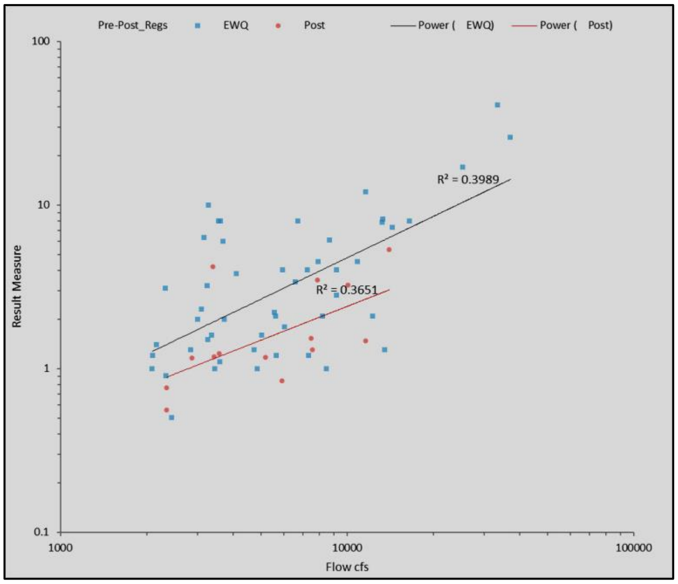
No water quality degradation is evident here. TSS apparently did not measurably change between the EWQ and post-EWQ periods. However, analytical uncertainty sources included potential laboratory artifacts, insufficient post-EWQ sampling frequency, and flow differences. TSS is positively related to flow in both data sets. Post-EWQ median TSS fell below the lower EWQ 95% confidence interval, but there were insufficient post-EWQ data (n=14) for valid comparison. Flows and concentrations are plotted on logarithmic scale, and regressions are power relationships. No independent data were available for comparison with DRBC results.

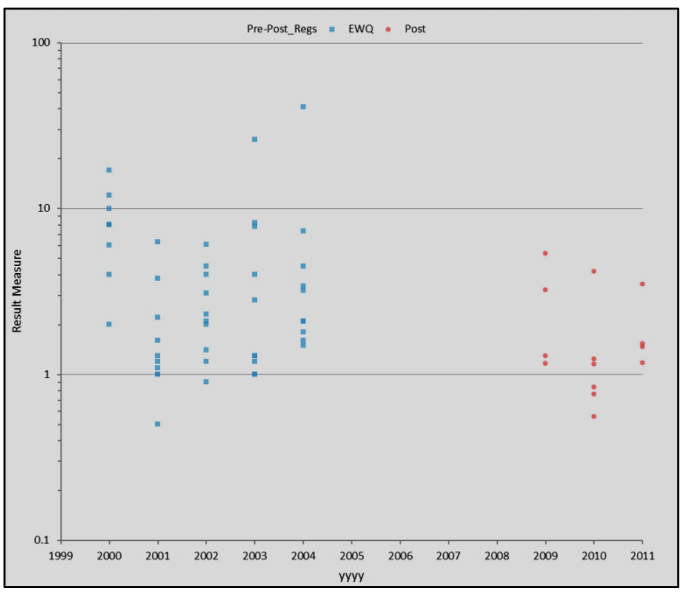
Chapter 18: 1838 ICP Delaware River at Easton

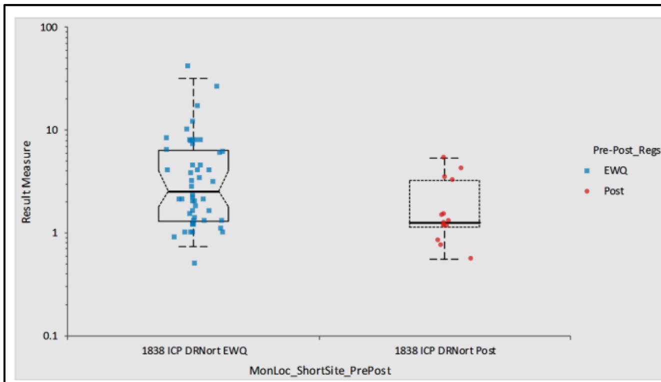
Turbidity NTU

Existing Water Quality (Table 2I):

Median 2.6 NTU
Lower 95% Confidence Interval 1.8 NTU
Upper 95% Confidence Interval 4.0 NTU
Defined in regulations as a flow-related parameter

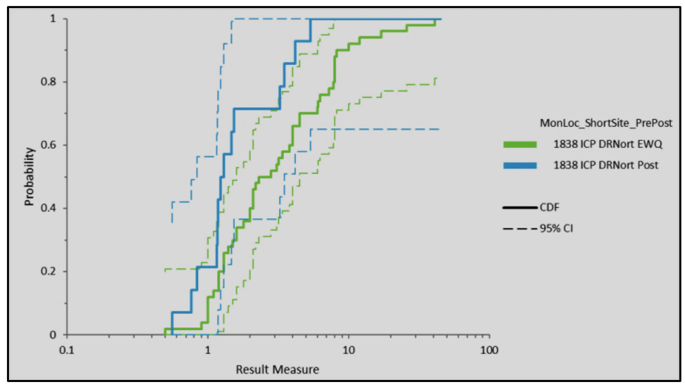






N	64

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1838 ICP DRNort EWQ	0.5	1.3	2.6	6.4	41.0	5.1
1838 ICP DRNort Post	0.6	1.1	1.3	3.3	5.4	2.1



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1838 ICP DRNort EWQ	50	453.0	9.06
1838 ICP DRNort Post	14	1617.9	115.56

H statistic	5.98
X^2 approximation	5.98
DF	1
p-value	0.0145 [1]

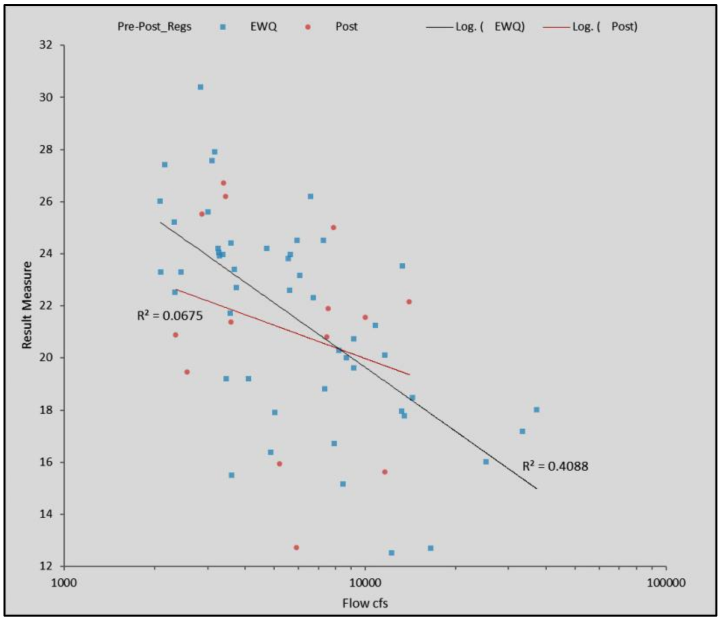
H0: $\theta_1 = \theta_2 = \theta...$
The median of the populations are all equal.
H1: $\theta_i \neq \theta_j$ for at least one i,j
The median of the populations are not all equal.
[1] Reject the null hypothesis in favour of the alternative hypothesis at the 5% significance level.

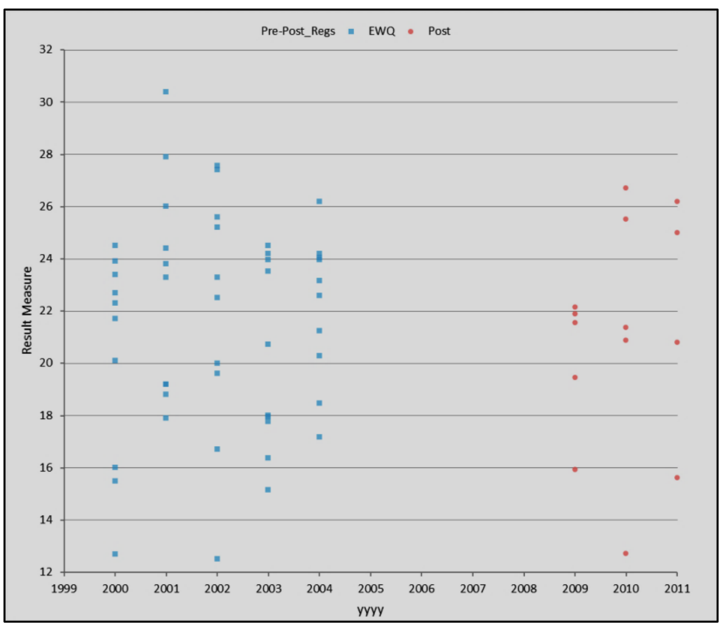
No water quality degradation is evident here. Turbidity apparently declined between the EWQ and post-EWQ periods. However, analytical uncertainty sources included insufficient post-EWQ sampling frequency, and flow differences. Post-EWQ median turbidity fell below the lower EWQ 95% confidence interval of the median, but the comparison is not valid due to too few post-EWQ samples (n=14) and no post-EWQ high-flow samples. Turbidity is positively related to flow in both data sets, power regression lines are shown. There were no independent data available for comparison with DRBC results.

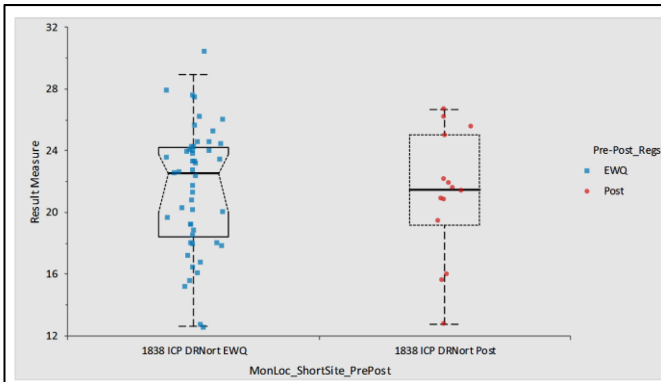
Chapter 18: 1838 ICP Delaware River at Easton

Water Temperature, degrees C

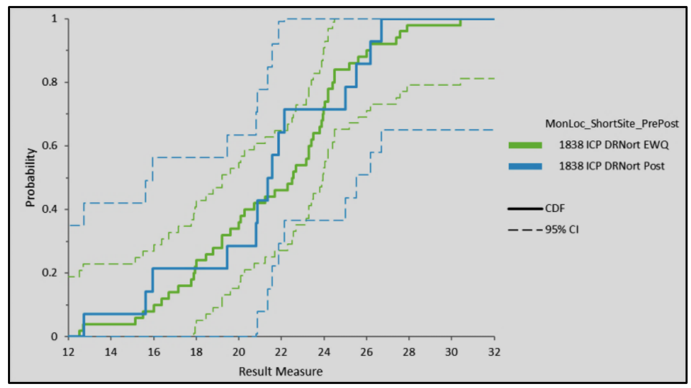
Not included in DRBC Existing Water Quality rules







N	64					
Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1838 ICP DRNort EWQ	12.5	18.4	22.5	24.2	30.4	5.8
1838 ICP DRNort Post	12.7	19.2	21.5	25.0	26.7	5.9



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1838 ICP DRNort EWQ	50	5.1	0.10
1838 ICP DRNort Post	14	18.3	1.31

H statistic	0.07
X^2 approximation	0.07
DF	1
p-value	0.7950 [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 apparently did not measurably change between the EWQ and post-EWQ periods. However, analytical uncertainty sources included insufficient post-EWQ sampling frequency, and flow differences. Water temperature is inversely related to flow in the EWQ data set, but unrelated to flow in the post-EWQ data. There were insufficient samples taken in the post-EWQ period to account for a sufficient range of flow conditions, thus the lack of relationship of temperature to flow. Note that flows are plotted on a logarithmic scale. No independent data were available for comparison with DRBC results.