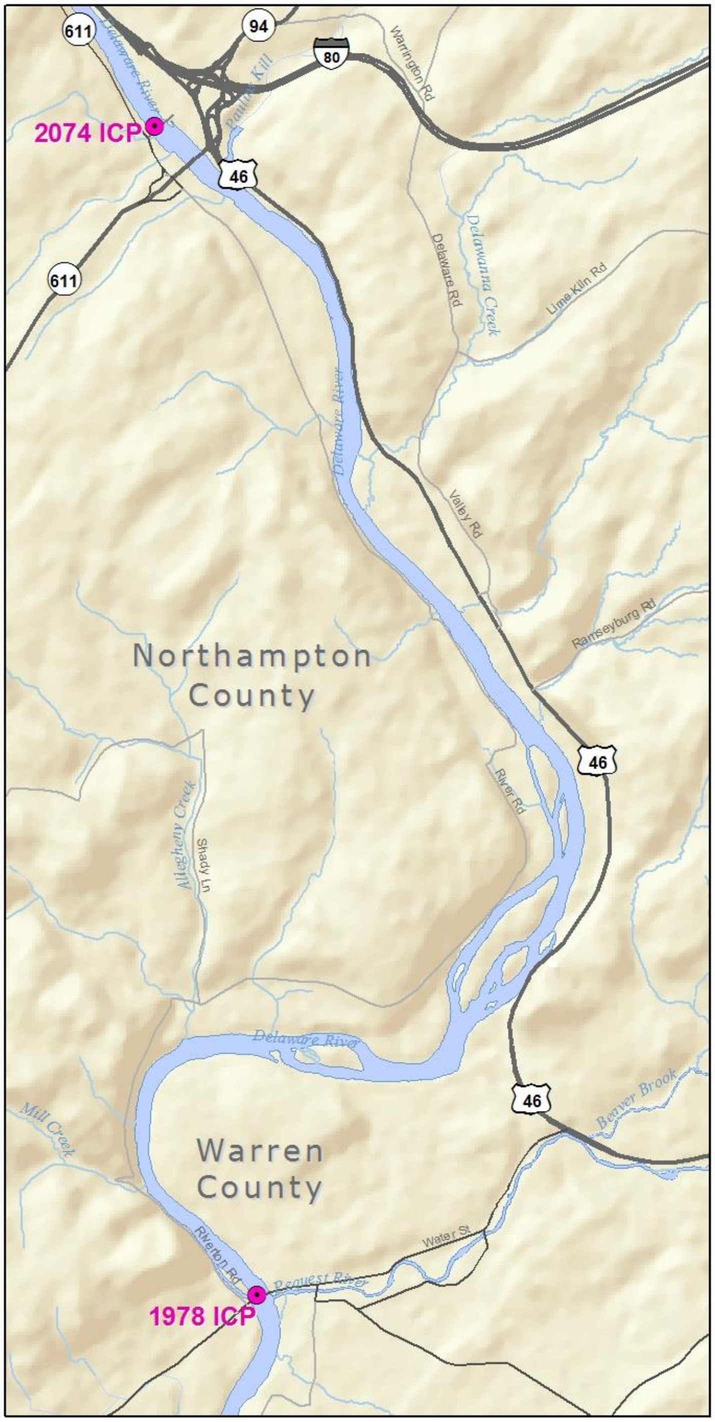
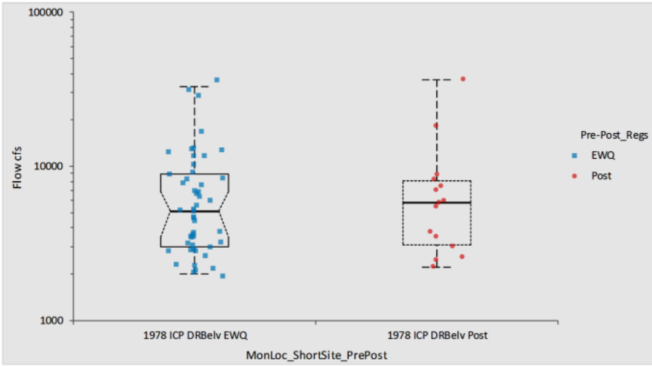
Chapter 22: 1978 ICP Delaware River at Belvidere



1978 ICP
Delaware River at Belvidere Bridge

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



N	65

Flow cfs by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1978 ICP DRBelv EWQ	1906	3026	5127	8860	35780	5834
1978 ICP DRBelv Post	2220	3092	5810	8098	36300	5007

Flow was roughly the same between the EWQ and post-EWQ periods. Post-EWQ median flow at Belvidere was about 700 cfs higher than EWQ median flow. Too few samples were collected in the post-EWQ period (n=15). The range of flow conditions sampled was about the same, but more samples would have produced better representation of all flow conditions throughout the range. Considering the under-representation of the flow regime in the post-EWQ data, there is a possibility that water quality differences can falsely interpreted as significant when they really are not. This point is closely considered in each analysis to follow.

Kruskal-Wallis test

Flow cfs by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1978 ICP DRBelv EWQ	50	1.6	0.03
1978 ICP DRBelv Post	15	5.4	0.36

H statistic	0.02
X^2 approximation	0.02
DF	1
p-value	0.8886[1]

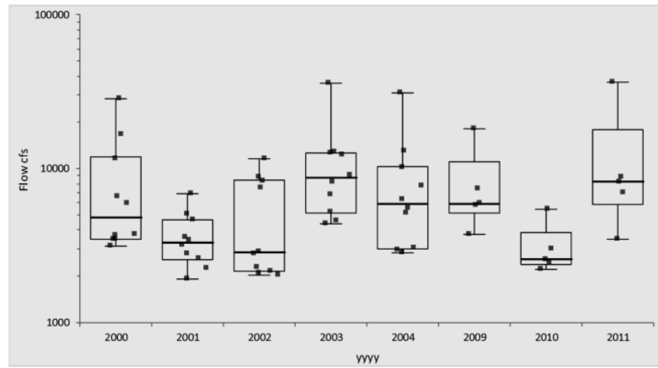
H0: $\theta_1 = \theta_2 = \theta$...
The median of the populations are all equal.
H1: $\theta_i \neq \theta_j$ for at least one i,j
The median of the populations are not all equal.
[1] Do not reject the null hypothesis at the 5% significance level.

Upstream ICP: Delaware River at Portland 2070 ICP
Downstream ICP: Delaware River at Easton 1838 ICP

BCP Watersheds in upstream reach:

Paulins Kill River – 2070 BCP

All other tributaries are less than 20 square miles drainage area.



N	65

Flow cfs by yyyy	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
2000	3128	3474	4832	11948	28624	8474
2001	1906	2566	3300	4669	6895	2103
2002	2044	2147	2854	8382	11505	6234
2003	4373	5167	8670	12664	35780	7497
2004	2838	3026	5937	10336	31111	7311
2009	3720	5113	5930	11027	18200	5913
2010	2220	2373	2570	3833	5460	1460
2011	3450	5817	8230	17980	36300	12163

Annual May to September flow statistics associated with water quality measurements are plotted above. These are flow measurements or sometimes estimates associated with the time of each water quality sample. Mean annual flow at this location is about 8,070 cfs; harmonic mean flow is 7460 cfs; and average May to September flow is about 5,770 cfs, which is most typical of summer flow conditions. Though a wide range of flows were sampled by DRBC, these data are most representative of summer flow conditions. Flows corresponding to each water quality sample were taken directly from instantaneous water discharge data from the USGS gage No. 01446500 on the Delaware River at Belvidere.

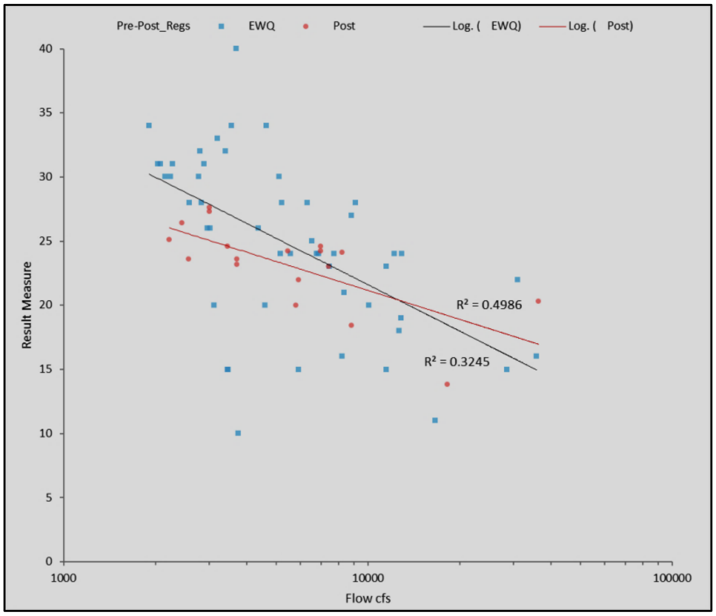
USGS and PADEP maintain a long-term water quality monitoring station at this site. They sample once per quarter every year, whereas DRBC samples twice per month from May through September for three to four year periods. DRBC uses the PADEP/USGS data to check its own results and to supplement the long-term monitoring of PADEP/USGS with more intensive sampling during selected study periods.

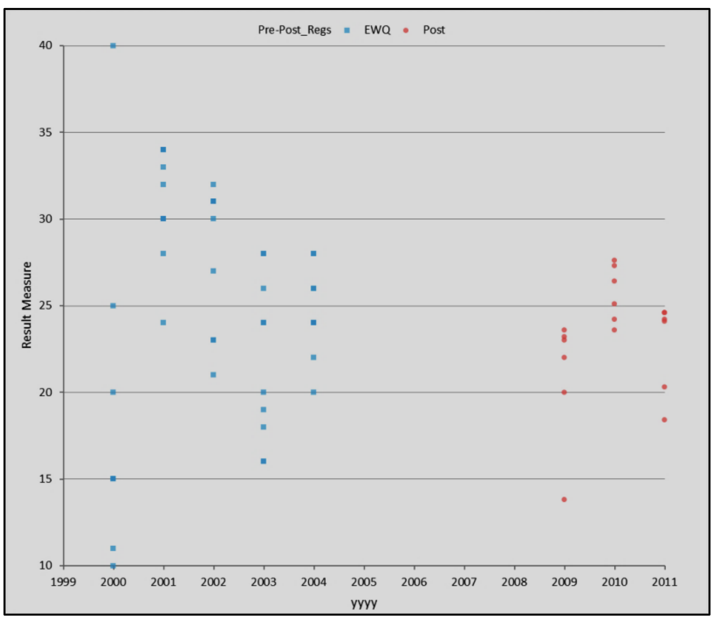
Chapter 22: 1978 ICP Delaware River at Belvidere

Alkalinity as CaCO3, Total mg/l

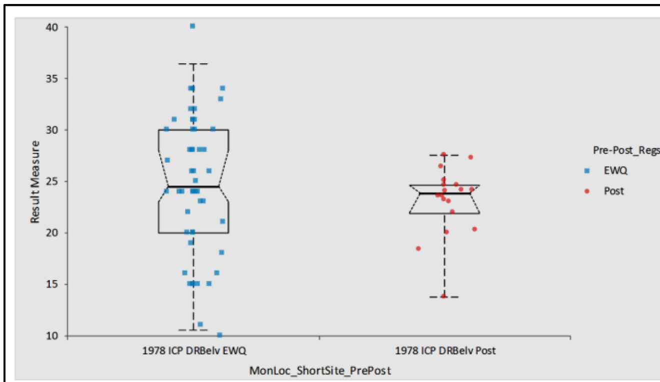
Existing Water Quality (Table 2E):

Median 26 mg/l (recalculated to 25 mg/l, fixed error)
Lower 95% Confidence Interval 24 mg/l
Upper 95% Confidence Interval 28 mg/l
Defined in regulations as a flow-related parameter

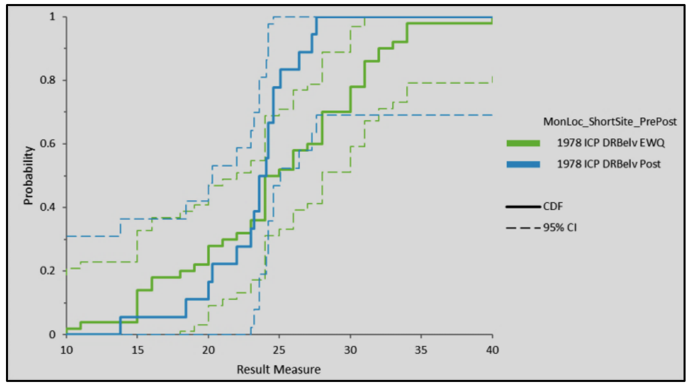




No water quality degradation is evident here. Alkalinity apparently did not measurably change between the EWQ and post-EWQ periods.



N	68					
Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1978 ICP DRBelv EWQ	10	20	25	30	40	10
1978 ICP DRBelv Post	14	22	24	25	28	3



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1978 ICP DRBelv EWQ	50	144.5	2.89
1978 ICP DRBelv Post	18	401.4	22.30

H statistic	1.40
X^2 approximation	1.40
DF	1
p-value	0.2367 [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.

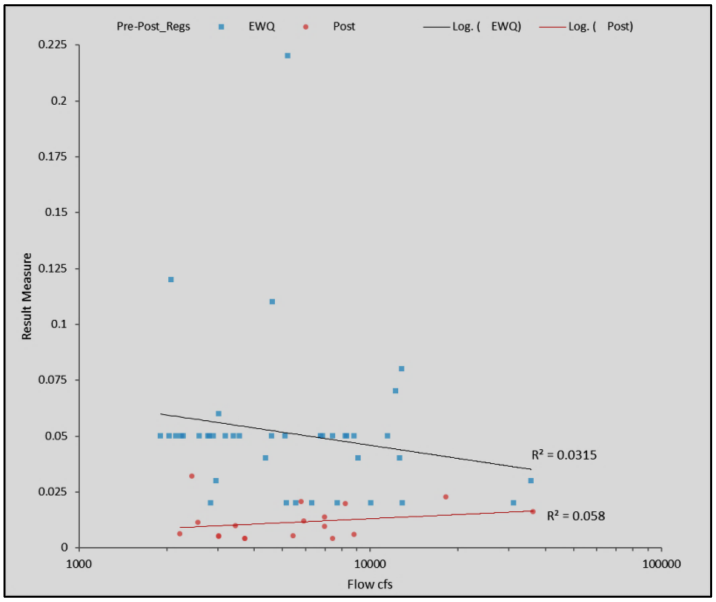
However, sources of analytical uncertainty included potential laboratory artifacts, insufficient post-EWQ sampling (n=18), and insufficient representation of flow conditions. Alkalinity is inversely related to flow in both data sets. Post-EWQ median alkalinity fell within EWQ 95% confidence intervals. Flow is plotted on a logarithmic scale. There were too few samples in the post-EWQ data set, as noted by the pattern of the post-EWQ cumulative distribution function line which not as smooth or gradual as the EWQ line. PADEP and USGS samples were comparable with DRBC results.

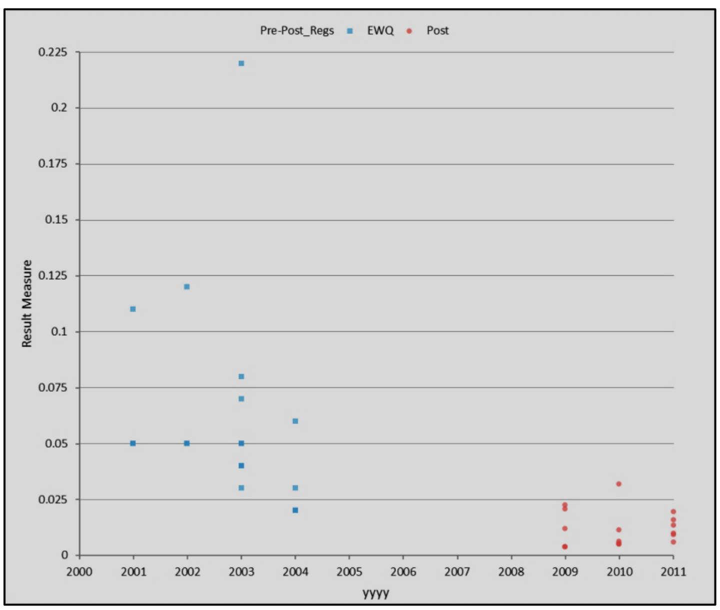
Chapter 22: 1978 ICP Delaware River at Belvidere

Ammonia Nitrogen as N, Total mg/l

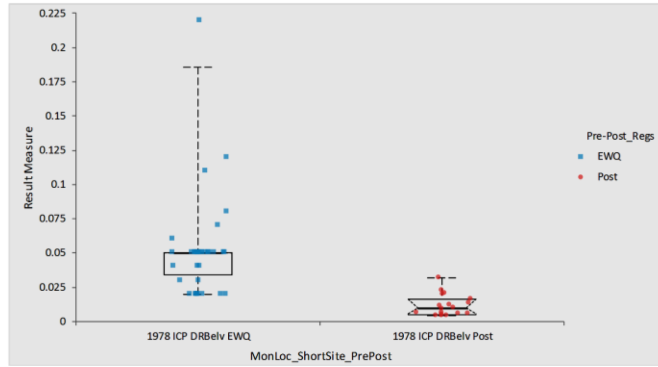
Existing Water Quality (Table 2E):

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



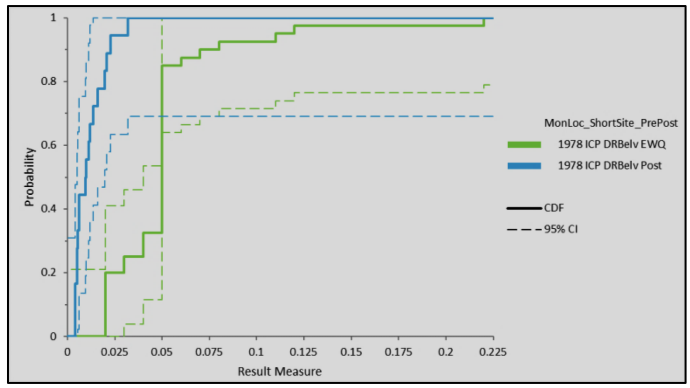


No water quality degradation is evident here. Ammonia concentrations apparently declined. However, sources of analytical uncertainty included potential laboratory artifacts, insufficient post-EWQ sampling (n=18), and insufficient representation of flow conditions.



N 58

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1978 ICP DRBelv EWQ	0.020	0.034	0.050	0.050	0.220	0.016
1978 ICP DRBelv Post	0.004	0.005	0.010	0.016	0.032	0.011



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1978 ICP DRBelv EWQ	40	2788.9	69.72
1978 ICP DRBelv Post	18	6197.6	344.31

H statistic	33.18
X^2 approximation	33.18
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.

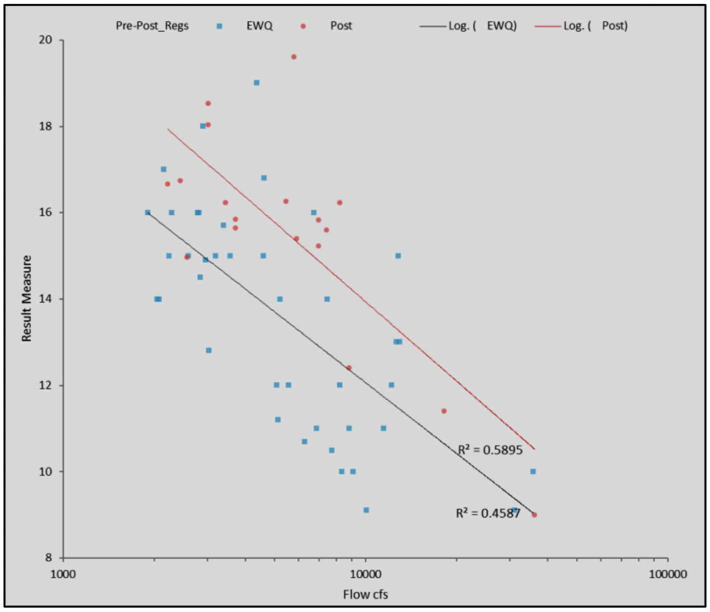
Post-EWQ median ammonia concentration was below the EWQ lower 95% confidence interval. PADEP/USGS data were comparable to DRBC results, with high non-detect frequency and similar concentrations. Flow is plotted on a logarithmic scale. EWQ data included high frequency of undetected results (33 of 40 samples), which interfered with calculation of the median. Under 2009-2011 lower detection levels there were 5/18 undetected results, and the median is a real measurement. Some water quality improvement possibly took place, as the post-EWQ data contained no concentrations greater than 0.032 mg/l, unless the difference is due to laboratory artifacts.

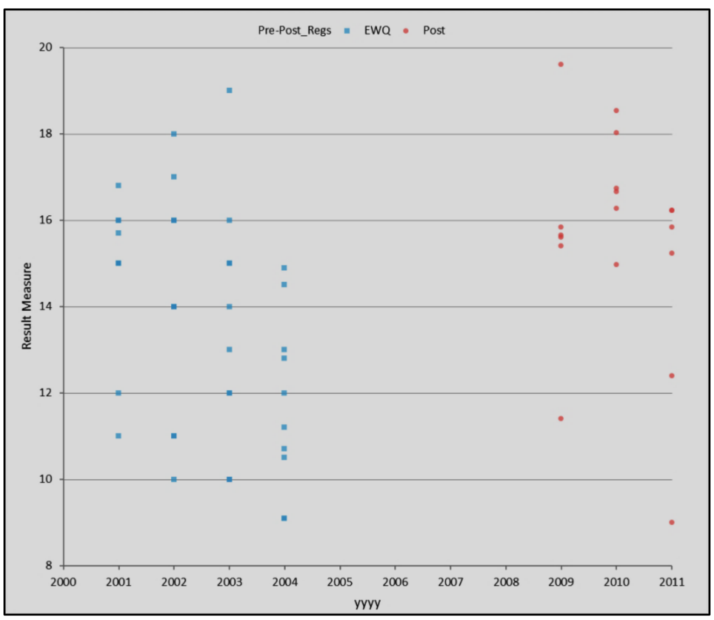
Chapter 22: 1978 ICP Delaware River at Belvidere

Chloride, Total mg/l

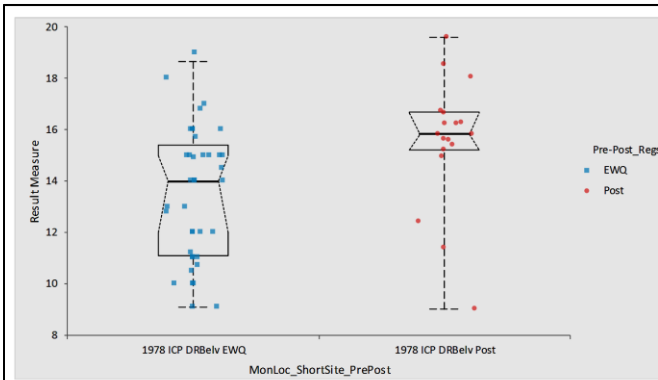
Existing Water Quality (Table 2E):

Median 14 mg/l
Lower 95% Confidence Interval 12 mg/l
Upper 95% Confidence Interval 15 mg/l
Defined in regulations as a flow-related parameter



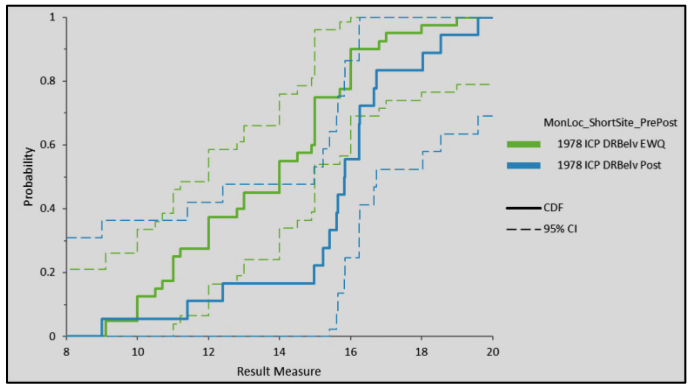


Water quality degradation is evident here. Median chloride concentrations apparently rose by 1.8 mg/l between the two periods.



N 58

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1978 ICP DRBelv EWQ	9.1	11.1	14.0	15.4	19.0	4.3
1978 ICP DRBelv Post	9.0	15.2	15.8	16.7	19.6	1.5



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1978 ICP DRBelv EWQ	40	722.5	18.06
1978 ICP DRBelv Post	18	1605.6	89.20

H statistic	8.19
X^2 approximation	8.19
DF	1
p-value	0.0042 [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.

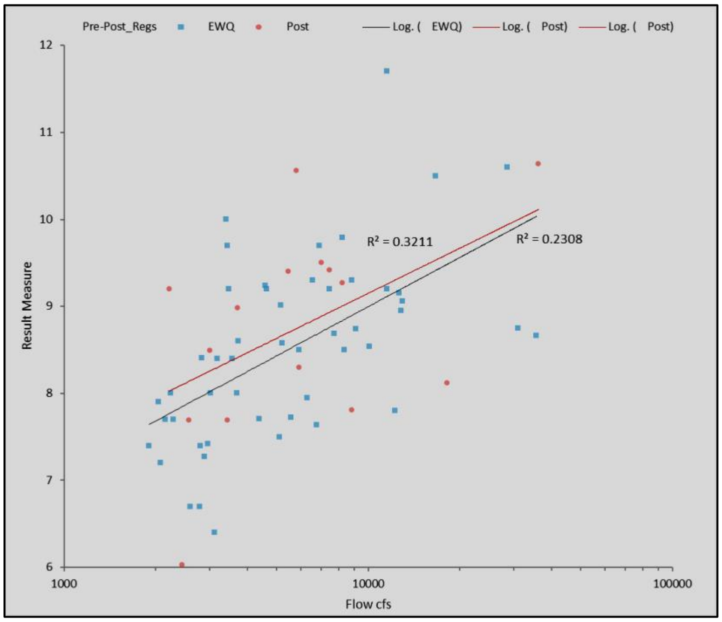
However, sources of analytical uncertainty included potential laboratory artifacts, insufficient post-EWQ sampling (n=18), and insufficient representation of flow conditions. Post-EWQ median concentration rose to just above the EWQ upper 95% confidence interval. There is an obvious separation of about 2 mg/l between the cumulative distributions and concentration vs. flow trends. Chloride concentration is inversely related to flow in both data sets. Flow is plotted on a logarithmic scale. PADEP/USGS data were not numerous enough to validate this conclusion.

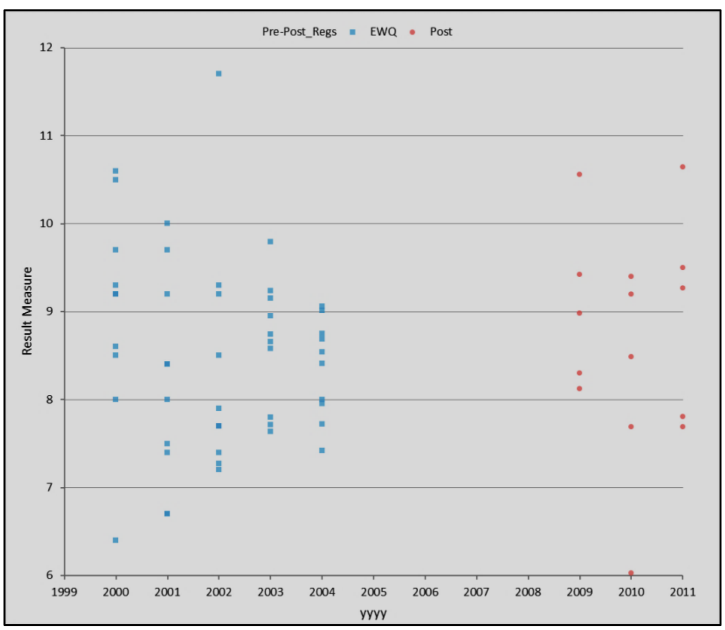
Chapter 22: 1978 ICP Delaware River at Belvidere

Dissolved Oxygen (DO) mg/l

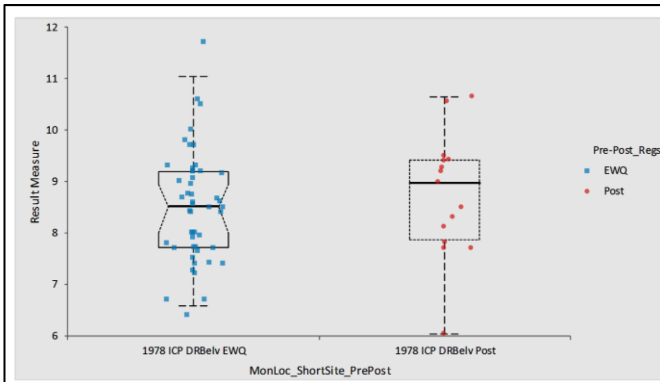
Existing Water Quality (Table 2E):

Median 8.52 mg/l
Lower 95% Confidence Interval 8.00 mg/l
Upper 95% Confidence Interval 8.95 mg/l



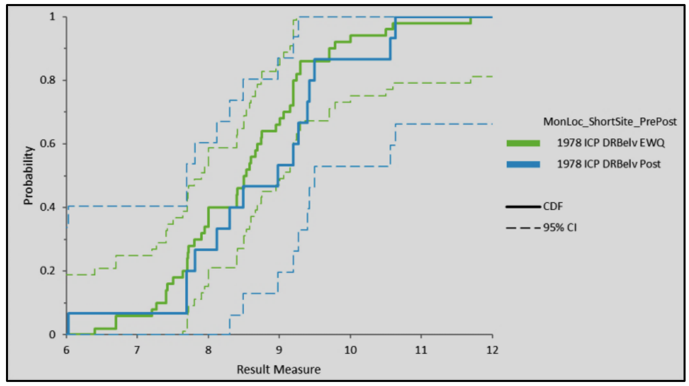


No water quality degradation is evident here. No measurable change took place between the EWQ and Post-EWQ periods.



N 65

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1978 ICP DRBelv EWQ	6.40	7.71	8.52	9.20	11.70	1.49
1978 ICP DRBelv Post	6.03	7.86	8.98	9.42	10.64	1.56



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1978 ICP DRBelv EWQ	50	74.4	1.49
1978 ICP DRBelv Post	15	248.1	16.54

H statistic	0.90
X^2 approximation	0.90
DF	1
p-value	0.3421 [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.

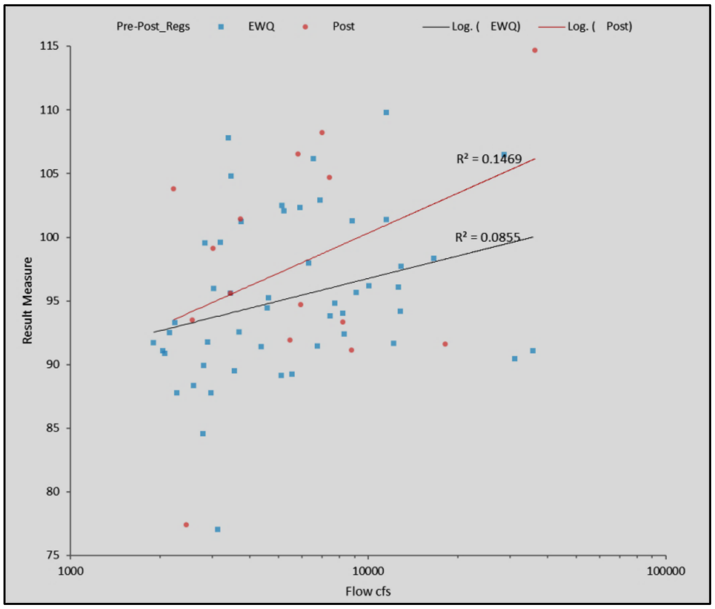
However, analytical uncertainty included insufficient post-EWQ sampling (n=18). Post-EWQ median DO was above the upper EWQ 95% confidence interval, but the increase was not significant and implies water quality improvement. DO is weakly related to flow in both data sets. The site is located on a large pool in the Delaware River, so perhaps oxygen concentrations rise when higher flow conditions produce turbulence that adds oxygen, or it could also be that there are less oxygen-demanding pollutants in the pool than there used to be. Flow is plotted on logarithmic scale. The low reading of 6 mg/l in 2010 was probably a probe malfunction. PADEP/USGS data were comparable to DRBC results.

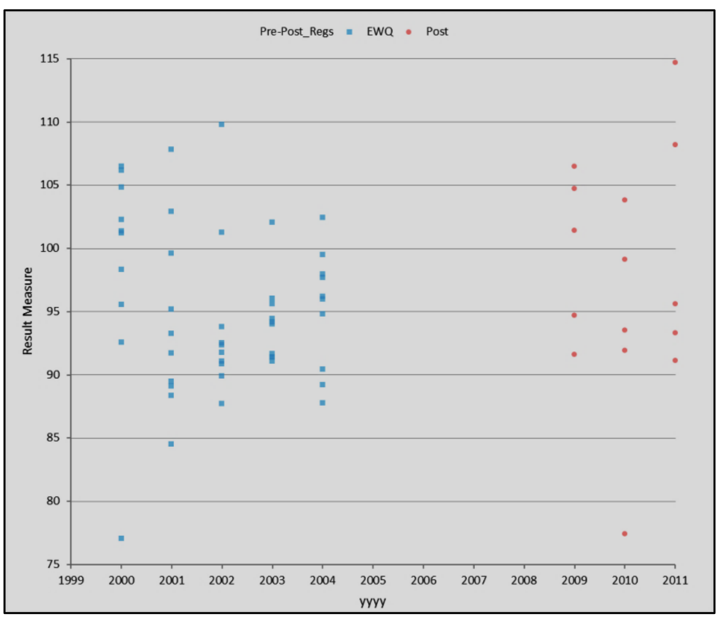
Chapter 22: 1978 ICP Delaware River at Belvidere

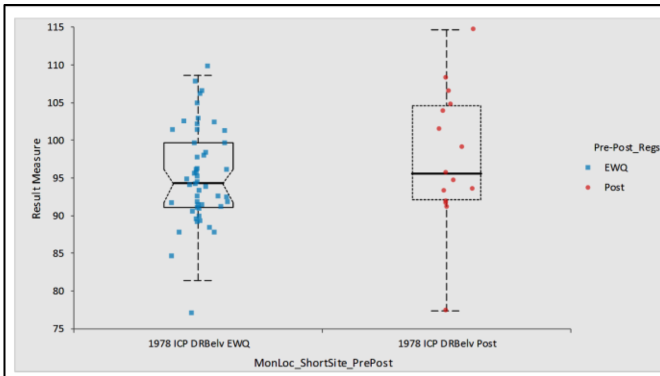
Dissolved Oxygen Saturation %

Existing Water Quality (Table 2E):

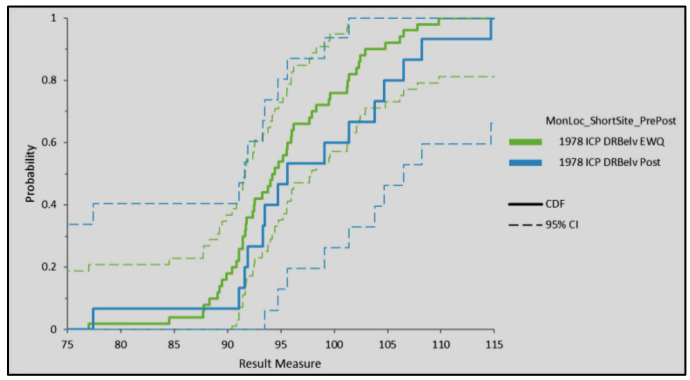
Median 94%
Lower 95% Confidence Interval 92%
Upper 95% Confidence Interval 96%







N	65					
Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1978 ICP DRBelv EWQ	77	91	94	100	110	9
1978 ICP DRBelv Post	77	92	96	105	115	12



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1978 ICP DRBelv EWQ	50	144.5	2.89
1978 ICP DRBelv Post	15	481.7	32.11

H statistic	1.75
X^2 approximation	1.75
DF	1
p-value	0.1857[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.

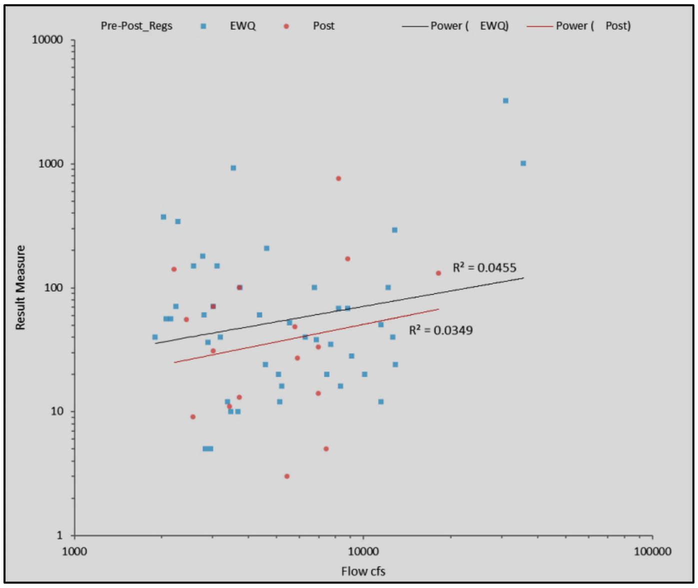
No water quality degradation is evident here. Dissolved Oxygen Saturation is unrelated to flow, and did not measurably change between the EWQ and post-EWQ periods. However, analytical uncertainty included insufficient post-EWQ sampling (n=18). Post-EWQ median DO saturation fell within the EWQ 95% confidence intervals. Flow is plotted on logarithmic scale. There were two low saturation values of 77% and 77.4% found in July 2000 and July 2010, 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.

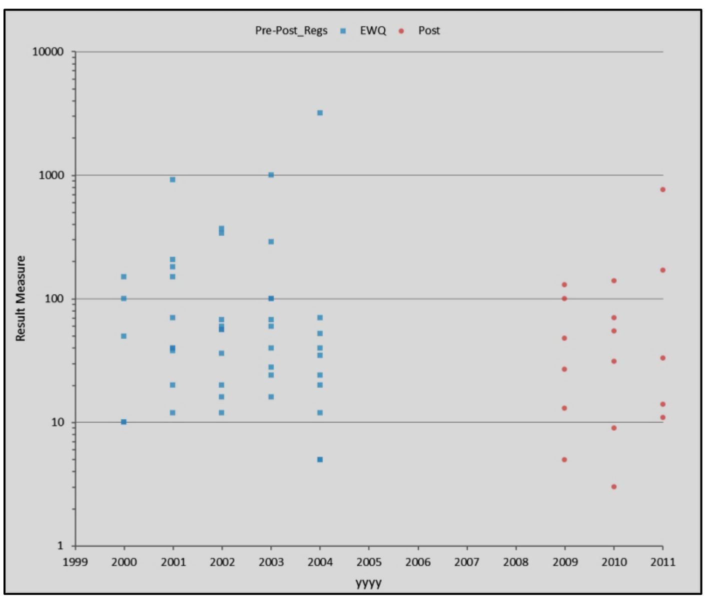
Chapter 22: 1978 ICP Delaware River at Belvidere

Enterococcus colonies/100 ml

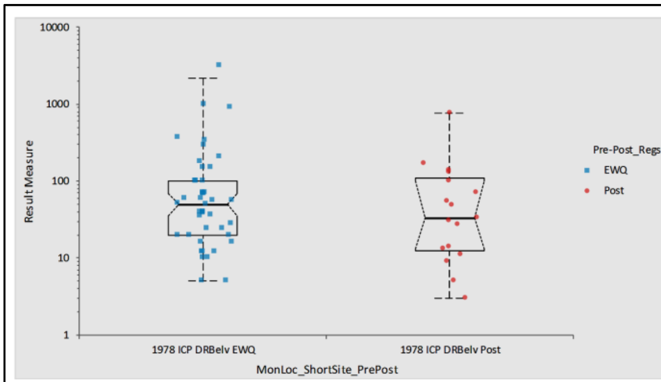
Existing Water Quality (Table 2E):

Median 50/100 ml
Lower 95% Confidence Interval 35/100 ml
Upper 95% Confidence Interval 68/100 ml



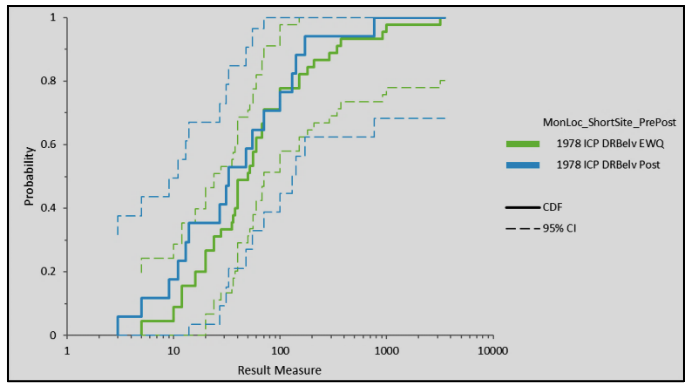


No water quality degradation is evident here. Enterococci apparently declined between the EWQ and Post-EWQ periods, but not significantly.



N 62

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1978 ICP DRBelv EWQ	5	20	50	100	3200	80
1978 ICP DRBelv Post	3	12	33	110	760	98



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1978 ICP DRBelv EWQ	45	74.8	1.66
1978 ICP DRBelv Post	17	197.9	11.64

H statistic	0.84
X^2 approximation	0.84
DF	1
p-value	0.3598[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.

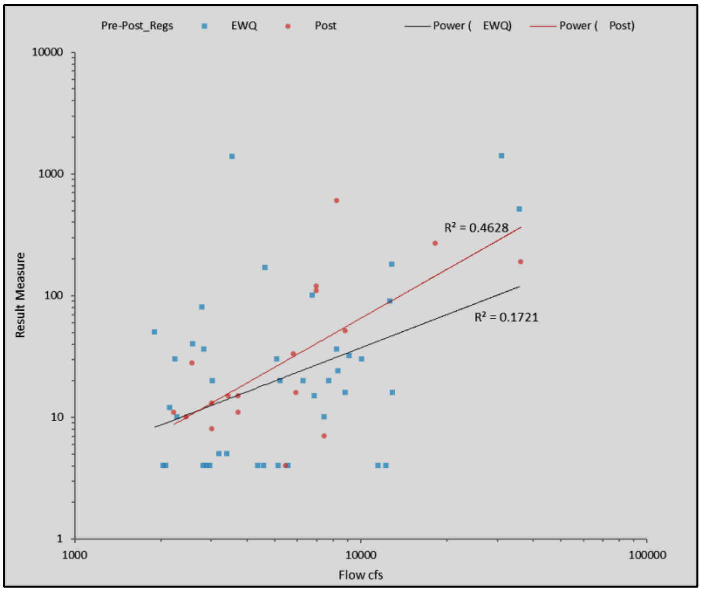
However, sources of analytical uncertainty included potential laboratory artifacts, insufficient post-EWQ sampling (n=18), and insufficient representation of flow conditions. Biweekly instead of monthly sampling is recommended. Enterococcus concentrations are unrelated to flow in both data sets. Concentrations 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.

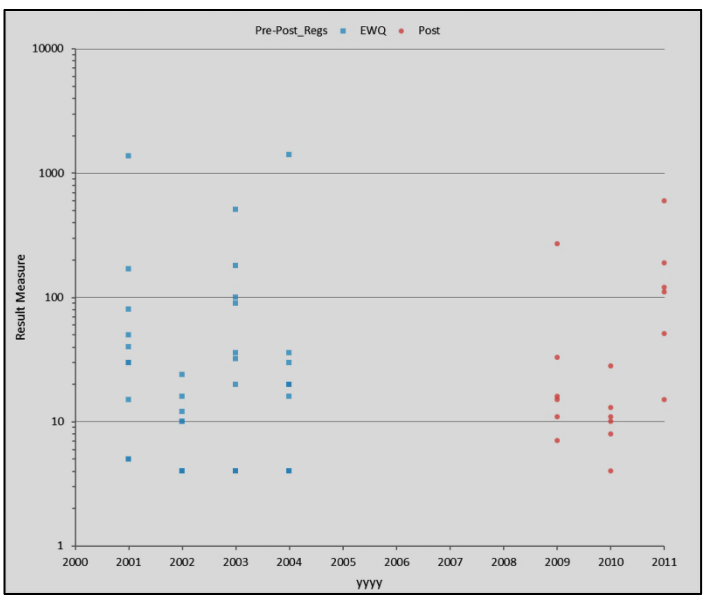
Chapter 22: 1978 ICP Delaware River at Belvidere

Escherichia coli colonies/100 ml

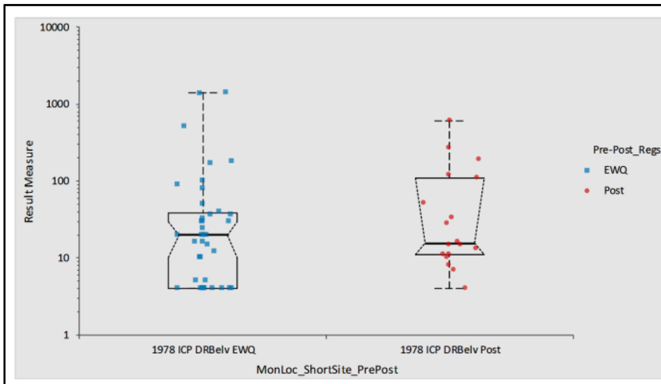
Existing Water Quality (Table 2E):

Median 20/100 ml
Lower 95% Confidence Interval 5/100 ml
Upper 95% Confidence Interval 30/100 ml
Defined in rules as a flow-related parameter



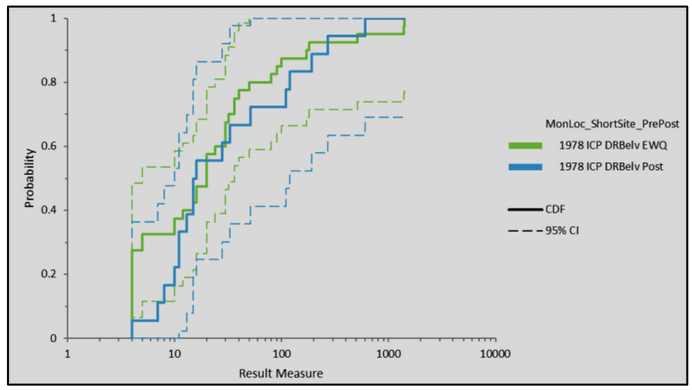


No water quality degradation is evident here. E. coli concentrations apparently did not measurably change between the EWQ and Post-EWQ periods.



N 58

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1978 ICP DRBelv EWQ	4	4	20	38	1400	34
1978 ICP DRBelv Post	4	11	16	111	600	100



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1978 ICP DRBelv EWQ	40	58.8	1.47
1978 ICP DRBelv Post	18	130.7	7.26

H statistic	0.67
X^2 approximation	0.67
DF	1
p-value	0.4127 [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.

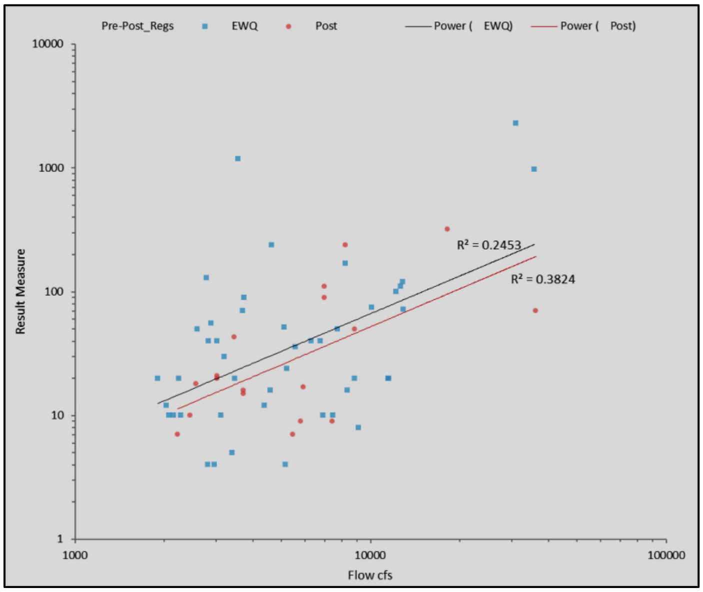
However, sources of analytical uncertainty included potential laboratory artifacts, insufficient post-EWQ sampling (n=18), and insufficient representation of flow conditions. Post-EWQ median E. coli fell within the EWQ 95% confidence intervals. Concentrations and flows are plotted on logarithmic scale, and regressions are power relationships. Biweekly instead of monthly sampling is recommended when assessing this site. E. coli concentrations are 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.

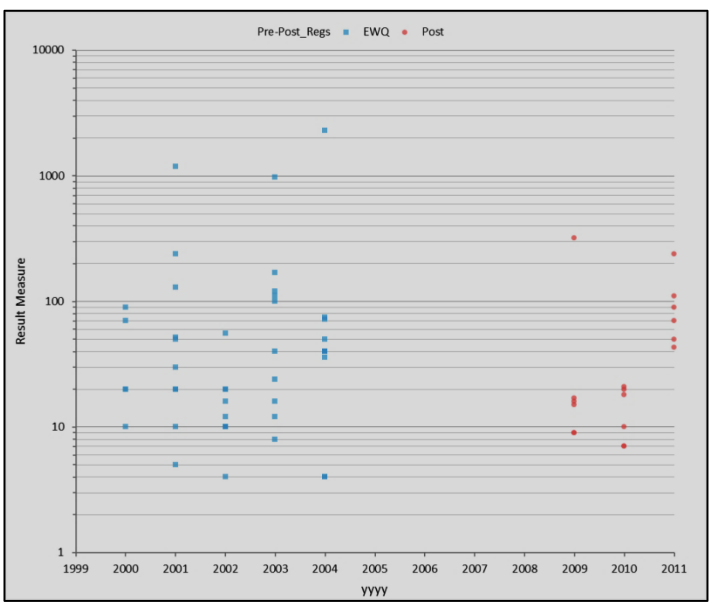
Chapter 22: 1978 ICP Delaware River at Belvidere

Fecal coliform colonies/100 ml

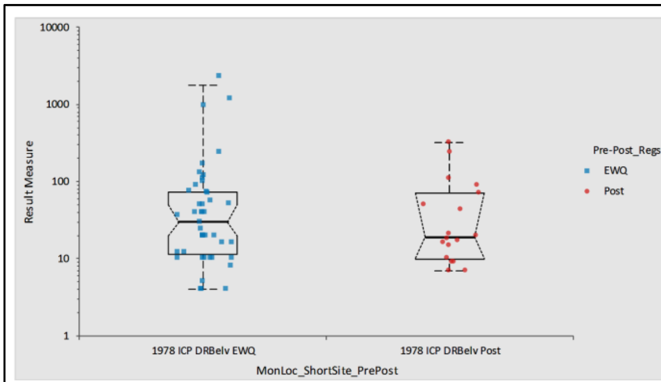
Existing Water Quality (Table 2E):

Median 30/100 ml
Lower 95% Confidence Interval 20/100 ml
Upper 95% Confidence Interval 50/100 ml



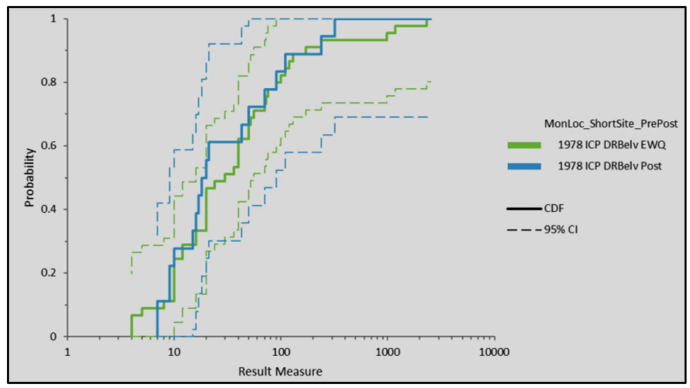


No water quality degradation is evident here. Fecal coliform concentrations fell below the lower EWQ 95% confidence interval, but apparently did not measurably change between the EWQ and post-EWQ periods.



N 63

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1978 ICP DRBelv EWQ	4	11	30	73	2300	62
1978 ICP DRBelv Post	7	10	19	72	320	62



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1978 ICP DRBelv EWQ	45	30.4	0.68
1978 ICP DRBelv Post	18	76.1	4.23

H statistic	0.32
X² approximation	0.32
DF	1
p-value	0.5728 [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.

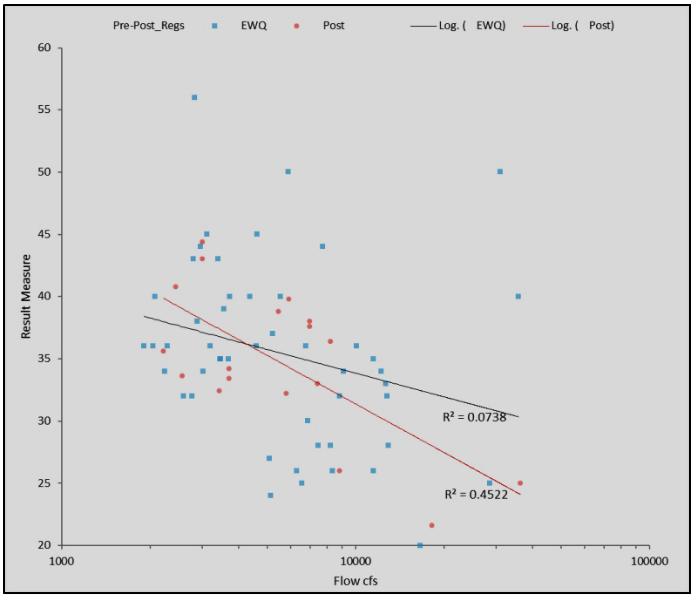
However, sources of analytical uncertainty included potential laboratory artifacts, insufficient post-EWQ sampling (n=18), and insufficient representation of flow conditions. Fecal coliform concentrations are weakly related to flow in both data sets. Biweekly instead of monthly sampling is recommended. Concentrations and flows are plotted on logarithmic scale, and regressions are power relationships. No independent data were available for comparison with DRBC data.

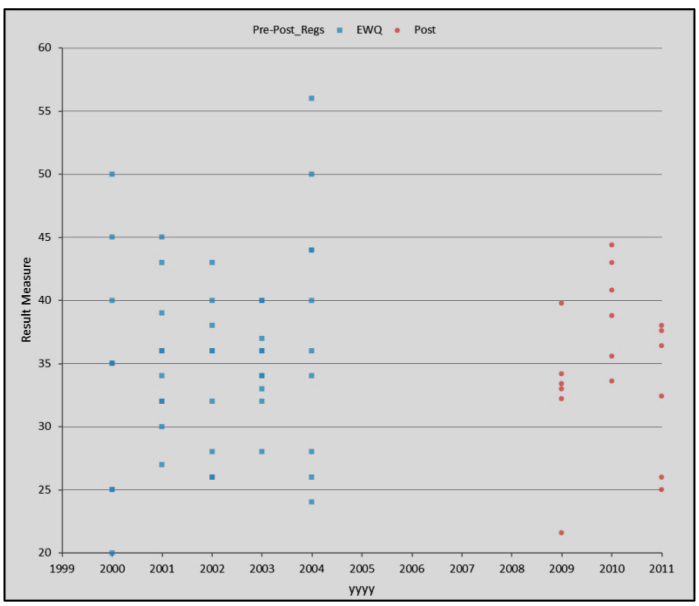
Chapter 22: 1978 ICP Delaware River at Belvidere

Hardness as CaCO3, Total mg/l

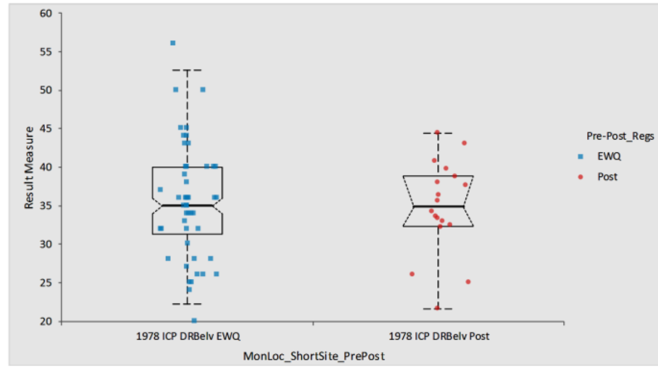
Existing Water Quality (Table 2E):

Median 35 mg/l
Lower 95% Confidence Interval 33 mg/l
Upper 95% Confidence Interval 36 mg/l



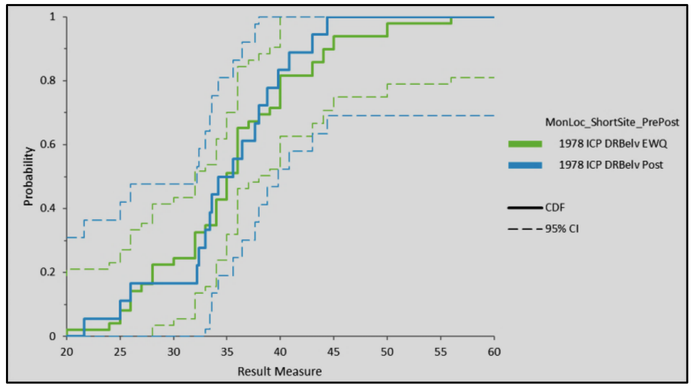


No water quality degradation is evident here. Hardness apparently did not measurably change between the EWQ and post-EWQ periods.



N 67

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1978 ICP DRBelv EWQ	20	31	35	40	56	9
1978 ICP DRBelv Post	22	32	35	39	44	6



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1978 ICP DRBelv EWQ	49	2.3	0.05
1978 ICP DRBelv Post	18	6.1	0.34

H statistic	0.02
X² approximation	0.02
DF	1
p-value	0.8818 [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.

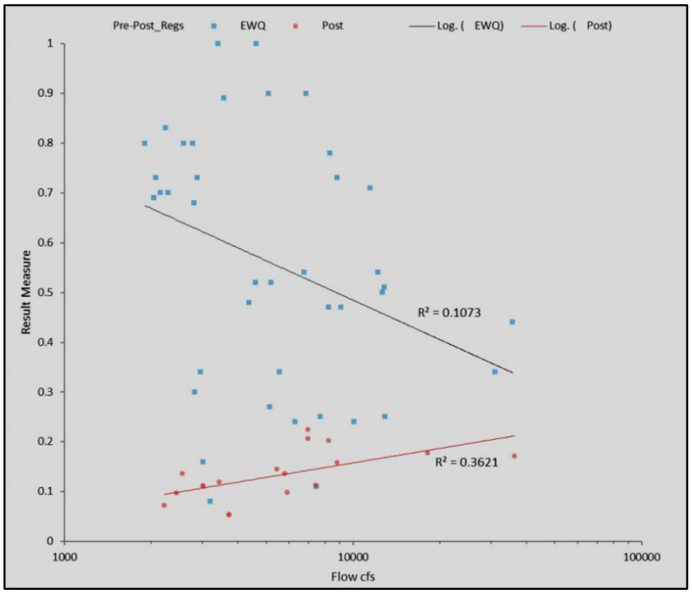
However, sources of analytical uncertainty included potential laboratory artifacts, insufficient post-EWQ sampling (n=18), and insufficient representation of flow conditions. Hardness is unrelated to flow in the EWQ data set, but inversely related to flow in the post-EWQ data set. The strength of the relationship in the post-EWQ data is influenced by only two values, so the relationship is not certain. Post-EWQ median hardness fell within the EWQ 95% confidence intervals, and the cumulative distributions were nearly identical. Flow is plotted on logarithmic scale. USGS/PADEP data were comparable with DRBC results.

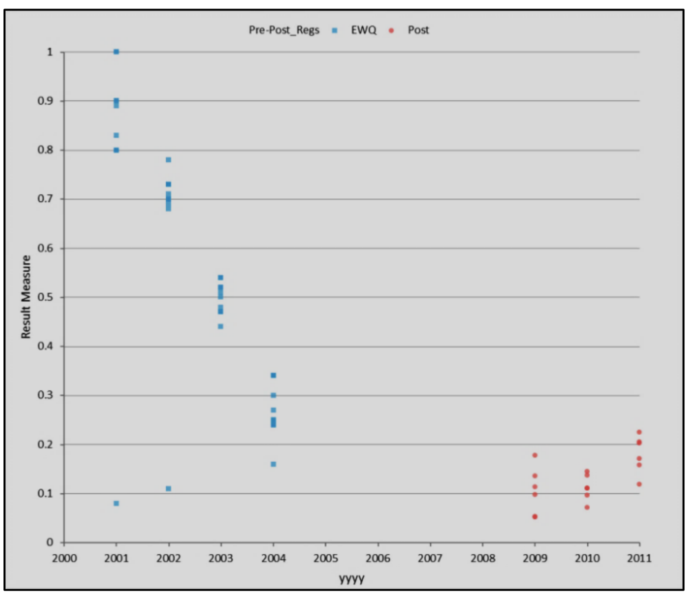
Chapter 22: 1978 ICP Delaware River at Belvidere

Nitrate + Nitrite as N, Total mg/l

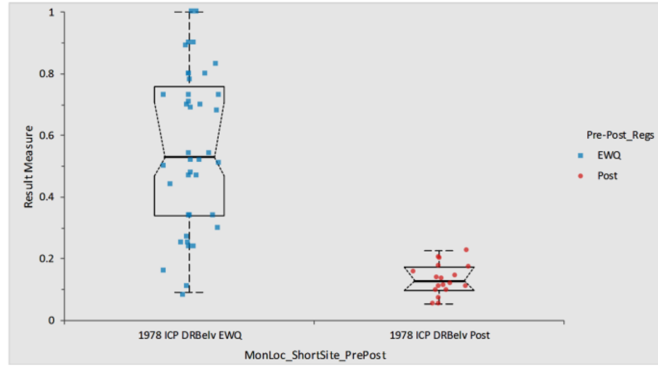
Existing Water Quality (Table 2E, as Nitrate only):

Median 0.53 mg/l
Lower 95% Confidence Interval 0.47 mg/l
Upper 95% Confidence Interval 0.71 mg/l



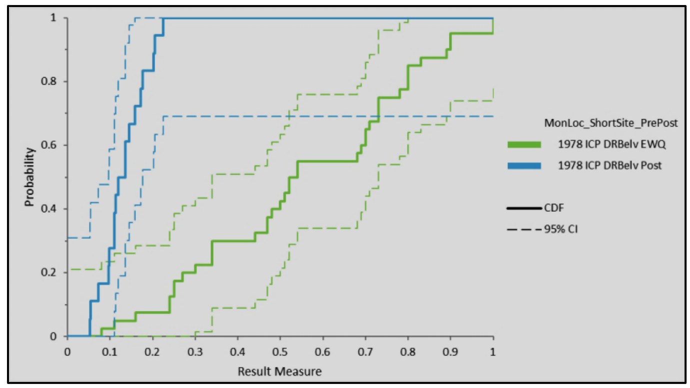


No water quality degradation is evident here. Nitrate concentrations apparently declined between the two periods. Sources of analytical uncertainty included potential laboratory artifacts, insufficient post-EWQ sampling (n=18), and under-representation of flow conditions.



N 58

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1978 ICP DRBelv EWQ	0.08	0.34	0.53	0.76	1.00	0.42
1978 ICP DRBelv Post	0.05	0.10	0.13	0.17	0.23	0.07



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1978 ICP DRBelv EWQ	40	2673.2	66.83
1978 ICP DRBelv Post	18	5940.5	330.03

H statistic	30.23
X^2 approximation	30.23
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.

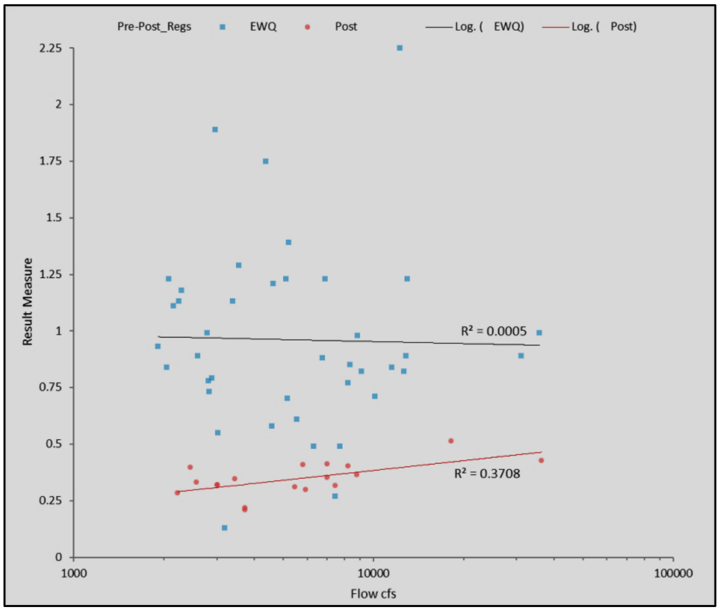
Nitrate is unrelated to flow in EWQ data, but weakly related to flow in post-EWQ data. Post-EWQ nitrate concentrations fell below the lower EWQ 95% confidence interval, and were less variable than EWQ nitrate. Post-EWQ nitrate + nitrite concentrations were assumed equivalent with EWQ nitrate concentrations since EWQ nitrite concentrations were never detected. USGS and PADEP data were most similar to DRBC post-EWQ data, and did not so precipitously decline. However, USGS/PADEP data were also similar to DRBC 2003-2004 data, so perhaps some decline is real and represents an improvement of water quality. Of course the difference could also be mere laboratory artifacts.

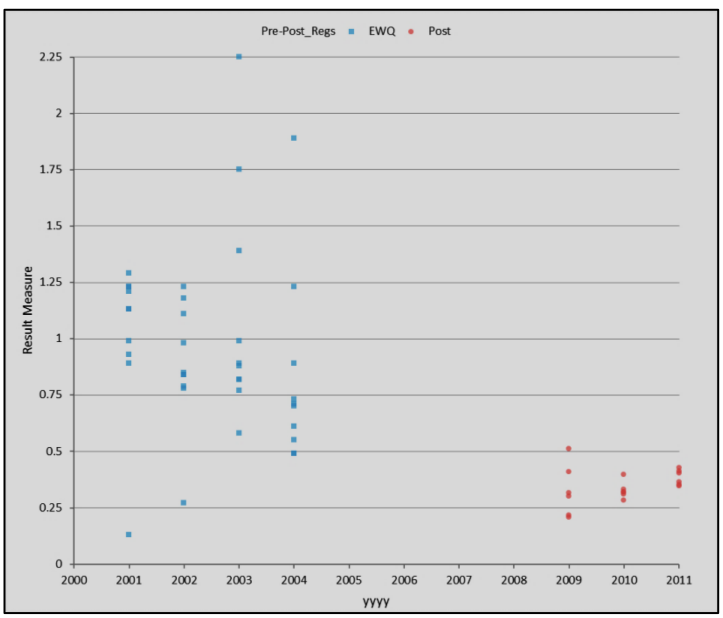
Chapter 22: 1978 ICP Delaware River at Belvidere

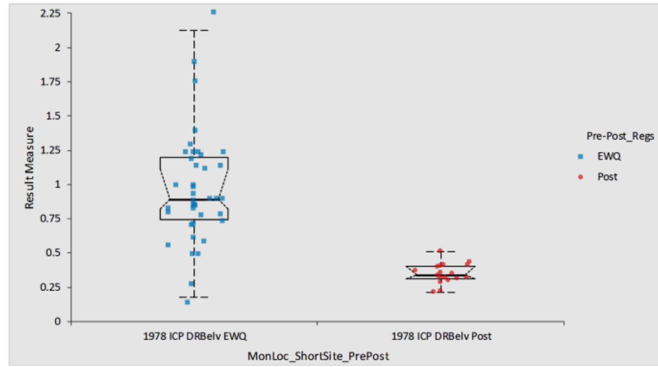
Nitrogen as N, Total (TN) mg/l

Existing Water Quality (Table 2E):

Median 0.89 mg/l
Lower 95% Confidence Interval 0.82 mg/l
Upper 95% Confidence Interval 1.11 mg/l

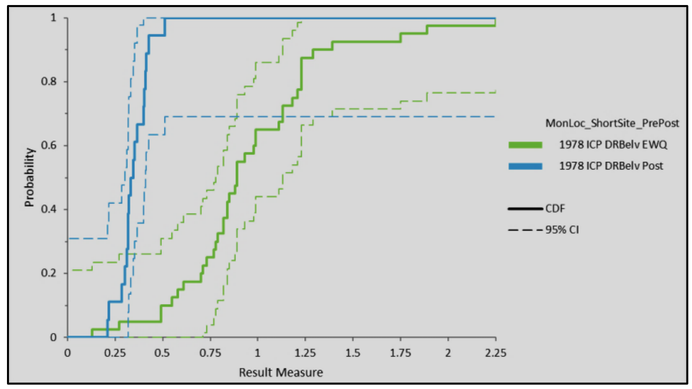






N 58

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1978 ICP DRBelv EWQ	0.13	0.75	0.89	1.20	2.25	0.45
1978 ICP DRBelv Post	0.21	0.31	0.34	0.40	0.51	0.09



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1978 ICP DRBelv EWQ	40	2624.4	65.61
1978 ICP DRBelv Post	18	5832.0	324.00

H statistic	29.67
X^2 approximation	29.67
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.

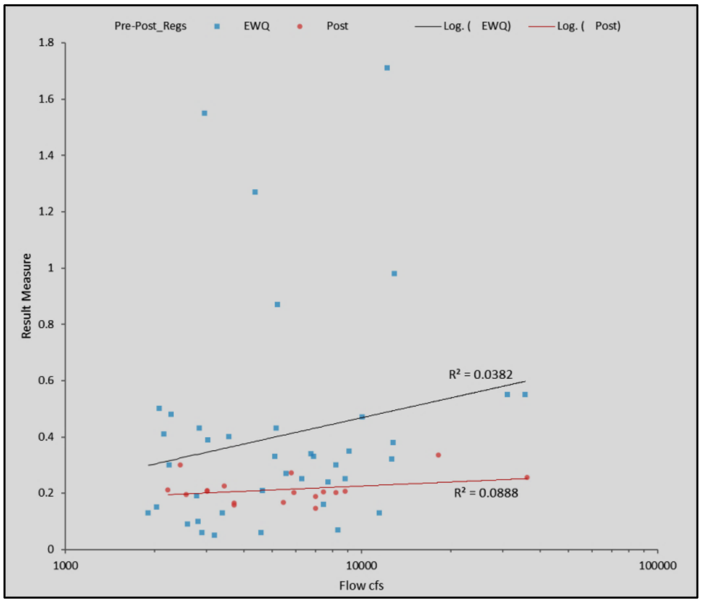
No water quality degradation is evident here. TN apparently declined between the two periods. Sources of analytical uncertainty included potential laboratory artifacts, insufficient post-EWQ sampling (n=18), and under-representation of flow conditions. TN is unrelated to flow in EWQ data but weakly related in post-EWQ data. Post-EWQ median TN concentrations fell below the EWQ lower 95% confidence intervals, perhaps indicating a water quality improvement. USGS/PADEP data were similar to DRBC 2003-2011 results, showing a slight decline in concentrations but not as drastic as DRBC results indicate.

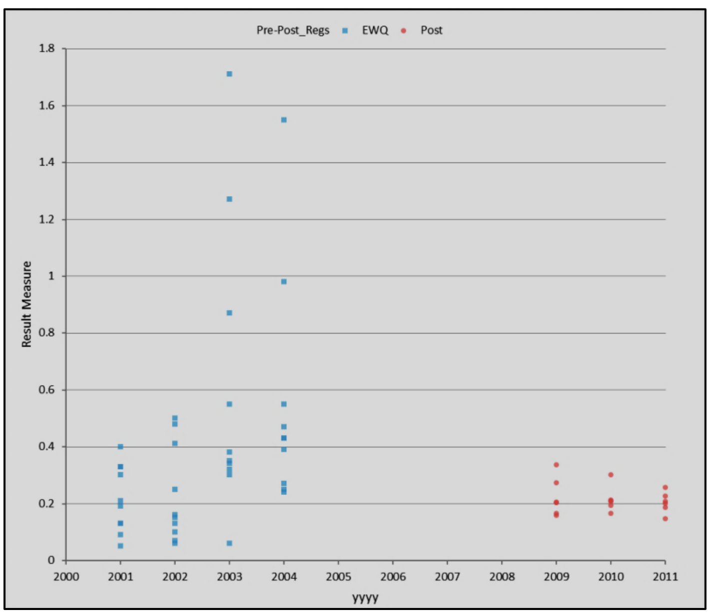
Chapter 22: 1978 ICP Delaware River at Belvidere

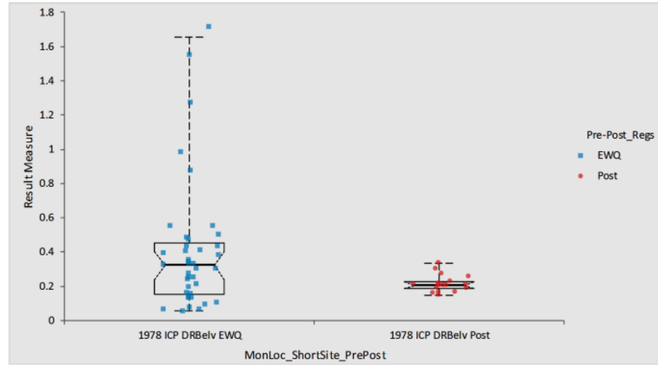
Nitrogen, Kjeldahl as N, Total (TKN) mg/l

Existing Water Quality (Table 2E):

Median 0.33 mg/l
Lower 95% Confidence Interval 0.24 mg/l
Upper 95% Confidence Interval 0.40 mg/l

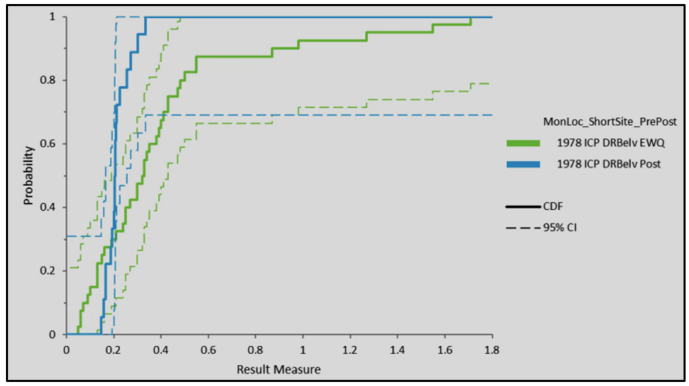






N	58

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1978 ICP DRBelv EWQ	0.05	0.15	0.33	0.45	1.71	0.30
1978 ICP DRBelv Post	0.15	0.19	0.21	0.23	0.33	0.04



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1978 ICP DRBelv EWQ	40	384.4	9.61
1978 ICP DRBelv Post	18	854.2	47.46

H statistic	4.34
X^2 approximation	4.34
DF	1
p-value	0.0371 [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.

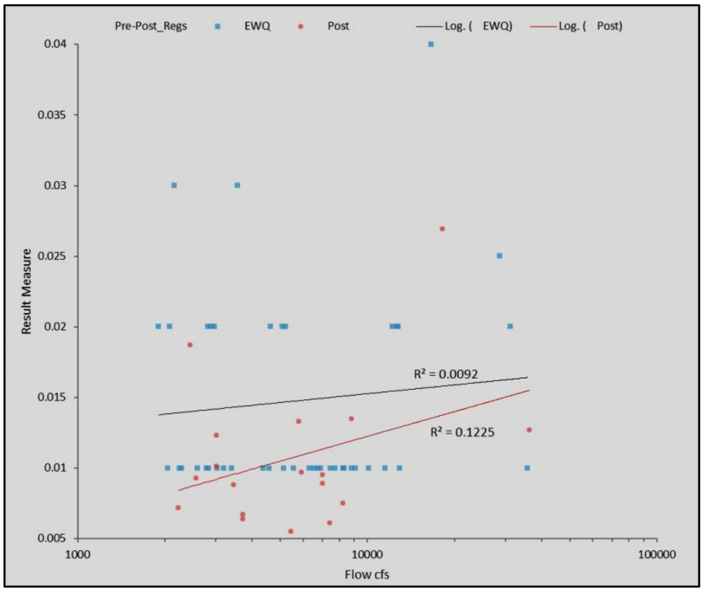
No water quality degradation is evident here. TKN apparently declined between the two periods. Sources of analytical uncertainty included potential laboratory artifacts, insufficient post-EWQ sampling (n=18), and under-representation of flow conditions. The post-EWQ range was far narrower and all concentrations 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 post-EWQ independent data to confirm DRBC results (n=4, all EWQ time frame), but USGS/PADEP values were similar to DRBC results during the EWQ period.

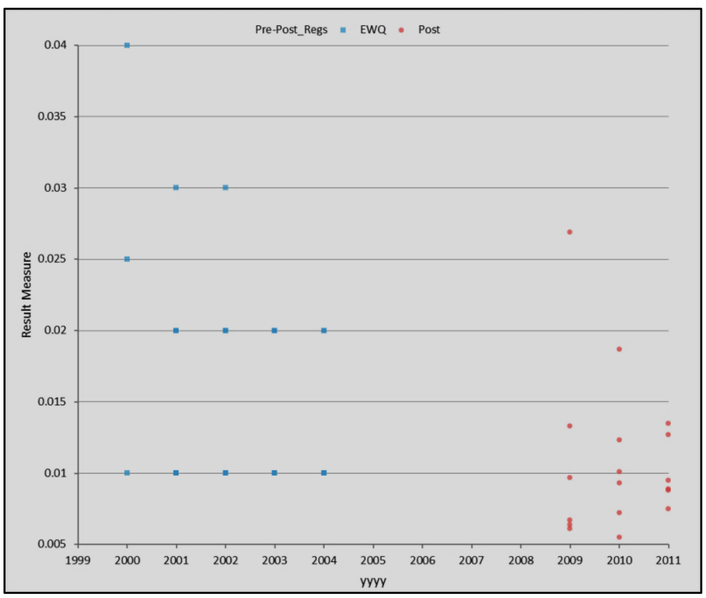
Chapter 22: 1978 ICP Delaware River at Belvidere

Orthophosphate as P, Total mg/l (OP)

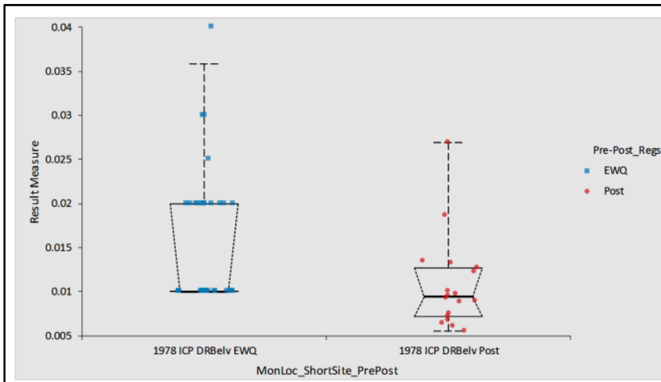
Existing Water Quality (Table 2E):

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

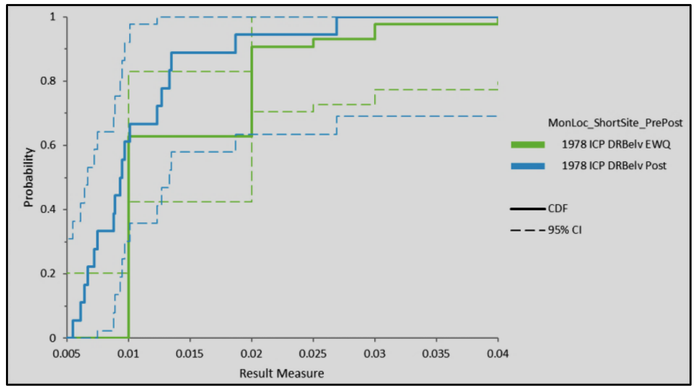




No water quality degradation is evident here. OP apparently declined between the two periods. Sources of analytical uncertainty included potential laboratory artifacts, detection limit differences, insufficient post-EWQ sampling (n=18), and under-representation of flow conditions.



N	61					
Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1978 ICP DRBelv EWQ	0.010	0.010	0.010	0.020	0.040	0.010
1978 ICP DRBelv Post	0.006	0.007	0.009	0.013	0.027	0.006



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1978 ICP DRBelv EWQ	43	795.9	18.51
1978 ICP DRBelv Post	18	1901.4	105.63

H statistic	9.45
X² approximation	9.45
DF	1
p-value	0.0021 [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.

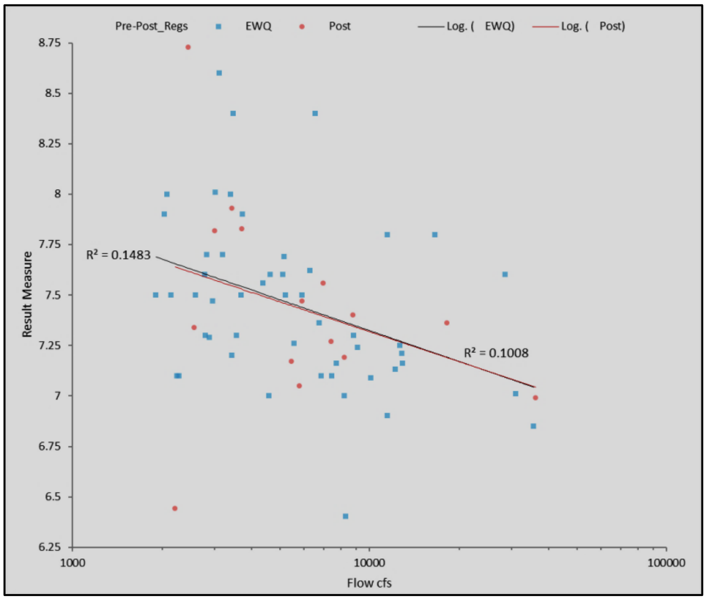
OP is unrelated to flow in both data sets. Post-EWQ median orthophosphate fell below the EWQ lower 95% confidence interval, and the upper quartile of data decreased significantly. This may be due to laboratory artifacts, but perhaps indicates a water quality improvement in that there were no post-EWQ concentrations higher than 0.027 mg/l. The EWQ orthophosphate non-detection rate was 27/43 samples, so the undetected results interfered with estimation of the median and lower confidence interval. Under lower post-EWQ detection limits there were no undetected results. Post-EWQ orthophosphate ranged less widely than EWQ data. USGS/PADEP data were similar to DRBC results.

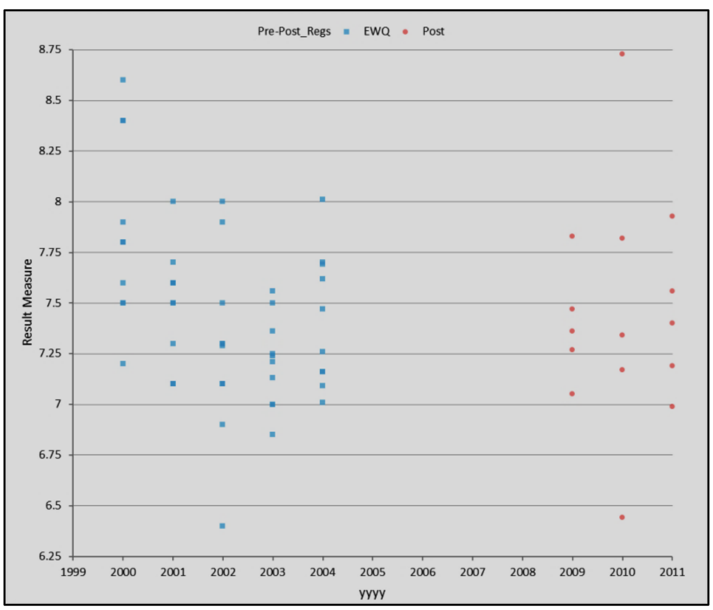
Chapter 22: 1978 ICP Delaware River at Belvidere

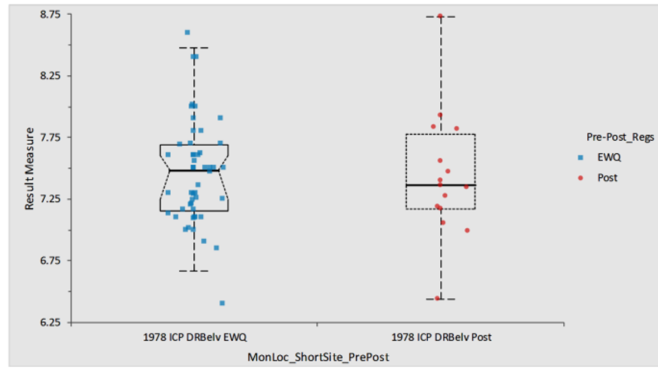
pH

Existing Water Quality (Table 2E):

Median 7.49 standard units
Lower 95% Confidence Interval 7.25 standard units
Upper 95% Confidence Interval 7.60 standard units

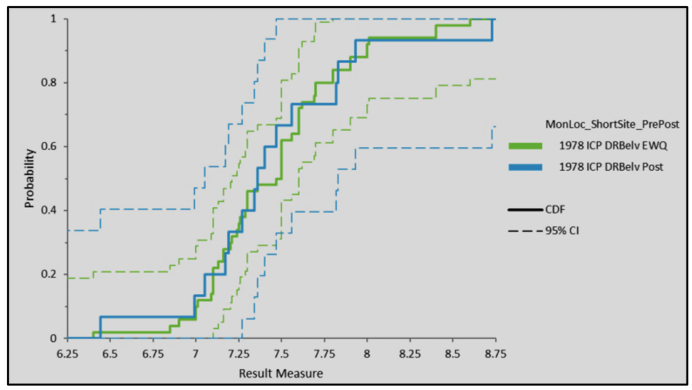






N 65

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1978 ICP DRBelv EWQ	6.40	7.16	7.49	7.69	8.60	0.53
1978 ICP DRBelv Post	6.44	7.17	7.36	7.78	8.73	0.60



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1978 ICP DRBelv EWQ	50	3.6	0.07
1978 ICP DRBelv Post	15	12.2	0.81

H statistic	0.04
X² approximation	0.04
DF	1
p-value	0.8334 [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.

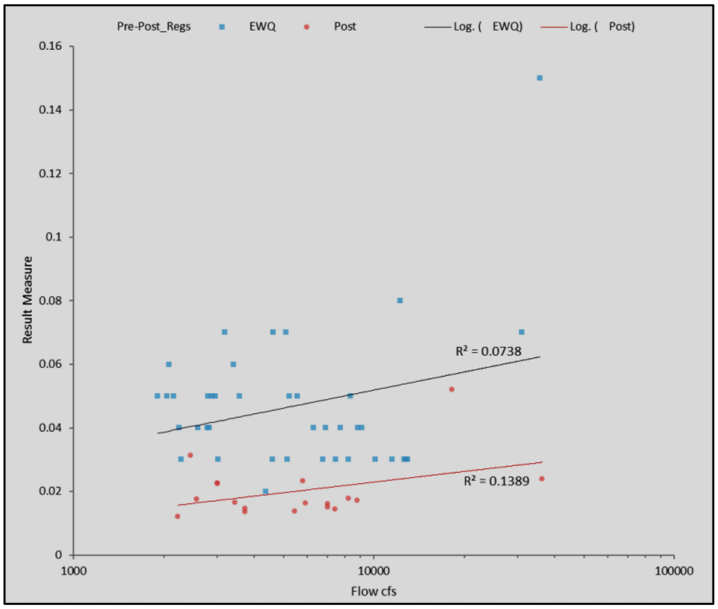
No water quality degradation is evident here. pH apparently did not measurably change between the EWQ and post-EWQ periods. Analytical uncertainty included insufficient post-EWQ sampling (n=18). pH is unrelated to flow in both data sets, but tends toward neutral as flow increases. Post-EWQ median pH was within the EWQ 95% confidence intervals. USGS/PADEP data were similar to DRBC results.

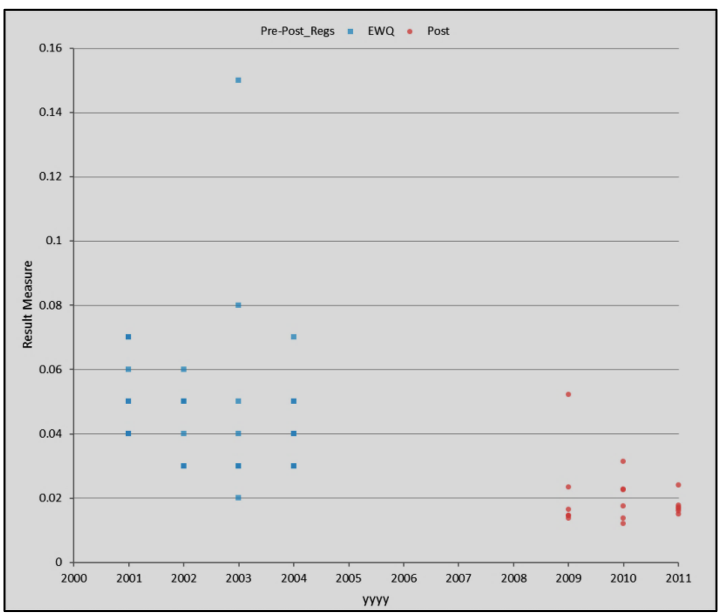
Chapter 22: 1978 ICP Delaware River at Belvidere

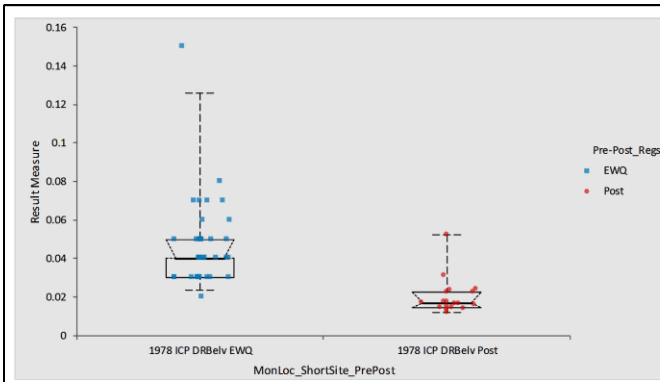
Phosphorus as P, Total (TP) mg/l

Existing Water Quality (Table 2E):

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

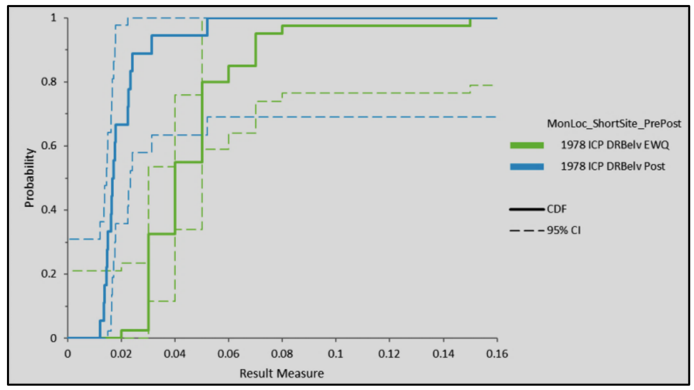






N | 58

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1978 ICP DRBelv EWQ	0.020	0.030	0.040	0.050	0.150	0.020
1978 ICP DRBelv Post	0.012	0.015	0.017	0.023	0.052	0.008



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1978 ICP DRBelv EWQ	40	2418.0	60.45
1978 ICP DRBelv Post	18	5373.4	298.52

H statistic	27.82
X² approximation	27.82
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.

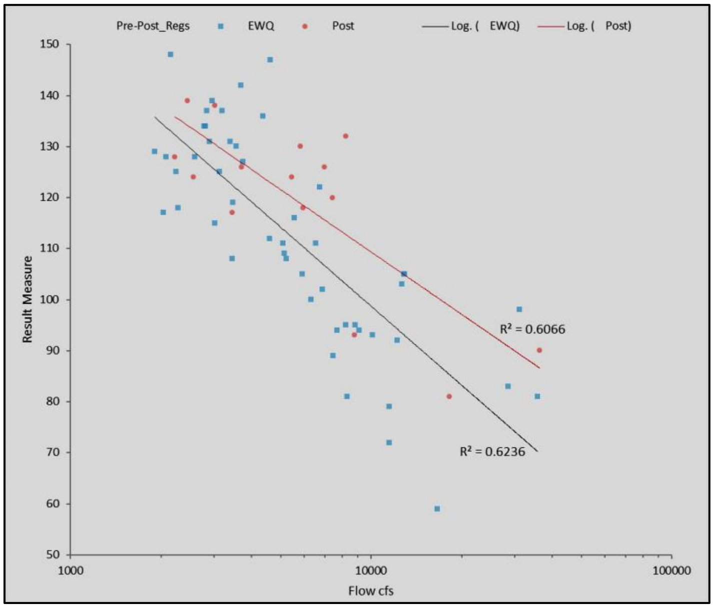
No water quality degradation is evident here. TP apparently declined between the two periods. Sources of analytical uncertainty included potential laboratory artifacts, detection limit differences, insufficient post-EWQ sampling (n=18), and under-representation of flow conditions. Post-EWQ median total phosphorus fell below the EWQ lower 95% confidence interval. TP is unrelated to flow in both data sets. USGS/PADEP data confirmed DRBC results.

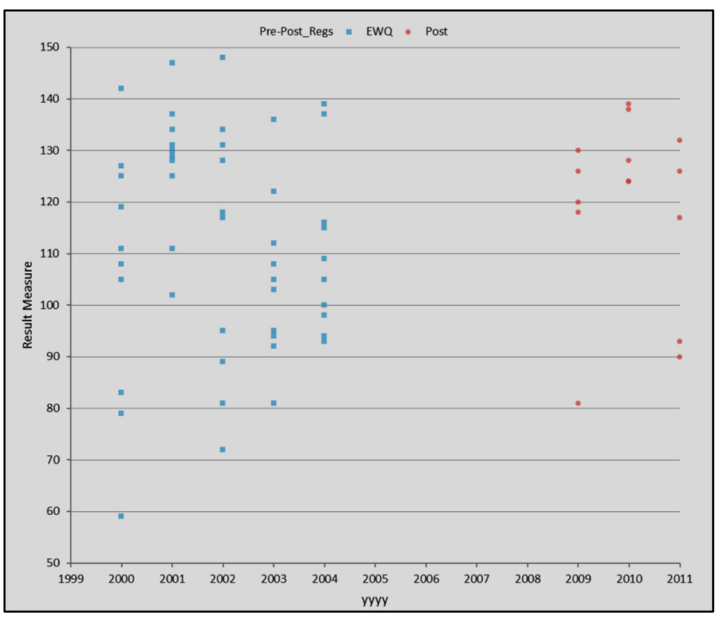
Chapter 22: 1978 ICP Delaware River at Belvidere

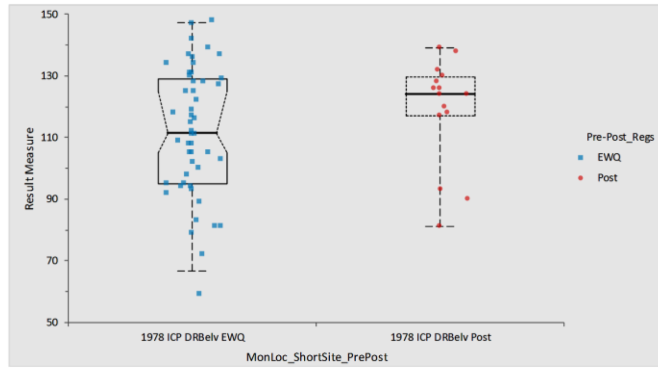
Specific Conductance µmho/cm

Existing Water Quality (Table 2E):

Median 112 µmho/cm
Lower 95% Confidence Interval 105 µmho/cm
Upper 95% Confidence Interval 125 µmho/cm
Defined in regulations as a flow-related parameter

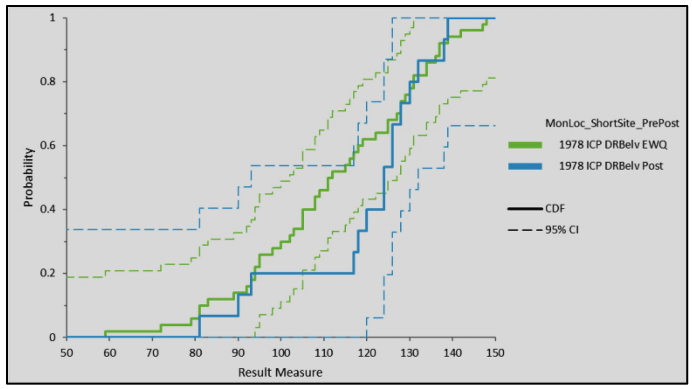






N	65

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1978 ICP DRBelv EWQ	59	95	112	129	148	34
1978 ICP DRBelv Post	81	117	124	130	139	13



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1978 ICP DRBelv EWQ	50	108.0	2.16
1978 ICP DRBelv Post	15	360.2	24.01

H statistic	1.31
X^2 approximation	1.31
DF	1
p-value	0.2523 [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.

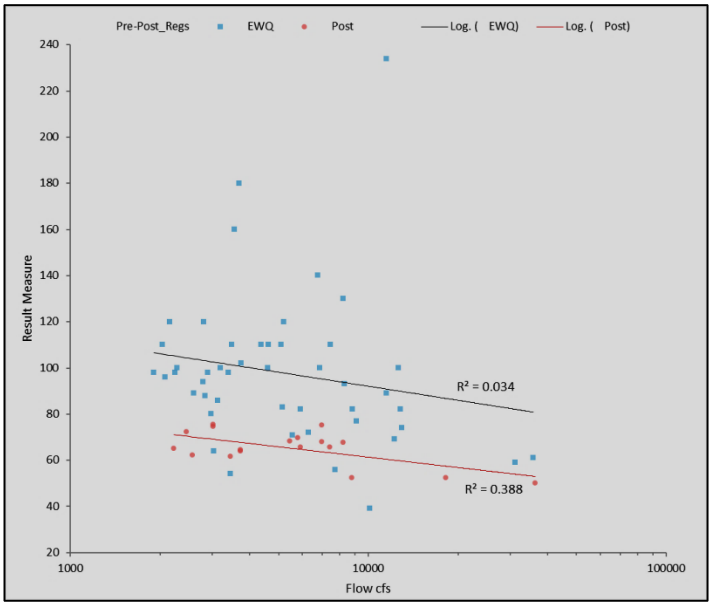
There is slight evidence here of water quality degradation. Specific conductance increased (by about 12 µmho/cm) between the two periods. Analytical uncertainty included insufficient post-EWQ sampling (n=18), and under-representation of flow conditions. Post-EWQ median specific conductance increased near the upper EWQ 95% confidence interval. There were an insufficient number of post-EWQ samples (n=15). Biweekly instead of monthly sampling is recommended here. Specific conductance is inversely related to flow in both data sets. Flow is plotted on logarithmic scale. PADEP data were similar to DRBC results, also showing a slight increase in concentration.

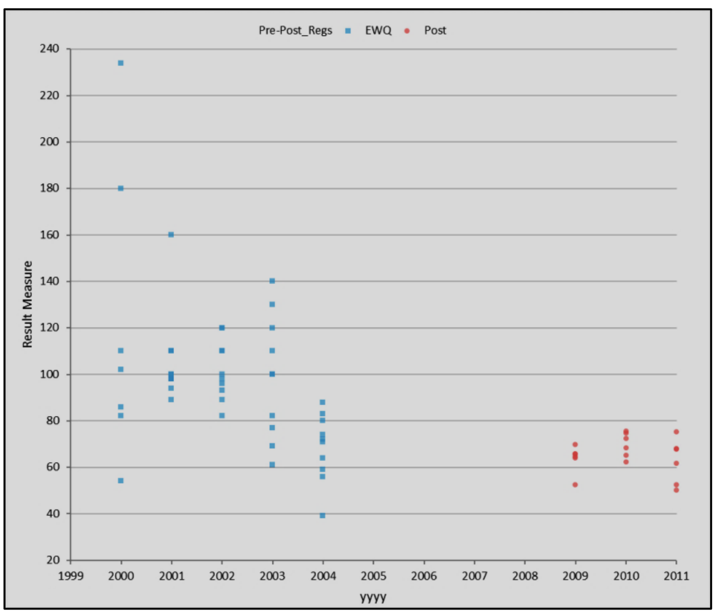
Chapter 22: 1978 ICP Delaware River at Belvidere

Total Dissolved Solids (TDS) mg/l

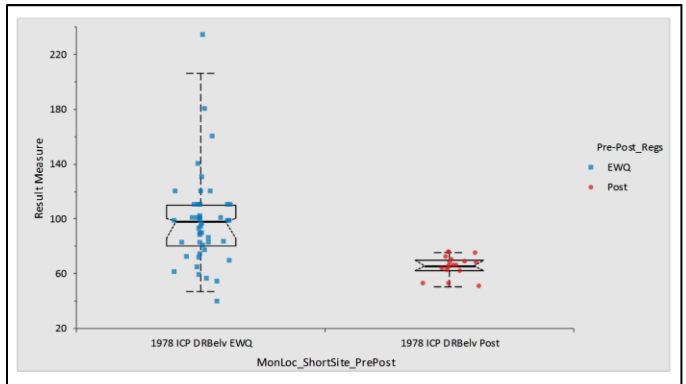
Existing Water Quality (Table 2E):

Median 98 mg/l
Lower 95% Confidence Interval 86 mg/l
Upper 95% Confidence Interval 100 mg/l

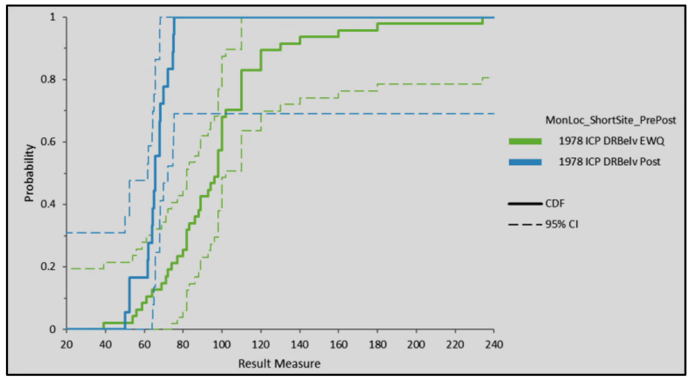




No water quality degradation is evident here. TDS apparently declined between the two periods. Sources of analytical uncertainty included potential laboratory artifacts, insufficient post-EWQ sampling (n=18), and under-representation of flow conditions.



N	65					
Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1978 ICP DRBelv EWQ	39	80	98	110	234	30
1978 ICP DRBelv Post	50	62	66	70	75	8



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1978 ICP DRBelv EWQ	47	2138.1	45.49
1978 ICP DRBelv Post	18	5582.7	310.15

H statistic	21.63
X^2 approximation	21.63
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.

TDS is unrelated to flow in EWQ data but weakly and inversely related in post-EWQ data. Post-EWQ median TDS fell below the EWQ lower 95% lower confidence interval, and was less variable than the baseline samples. Detection limits were different though there were no undetected results at any time. Perhaps this decline is not real but an artifact of different laboratories, though the 2004 data are similar to 2009-2011 data, so some trend may be real. Few PADEP data were available for comparison with results. They were comparable to DRBC results but did not decline.

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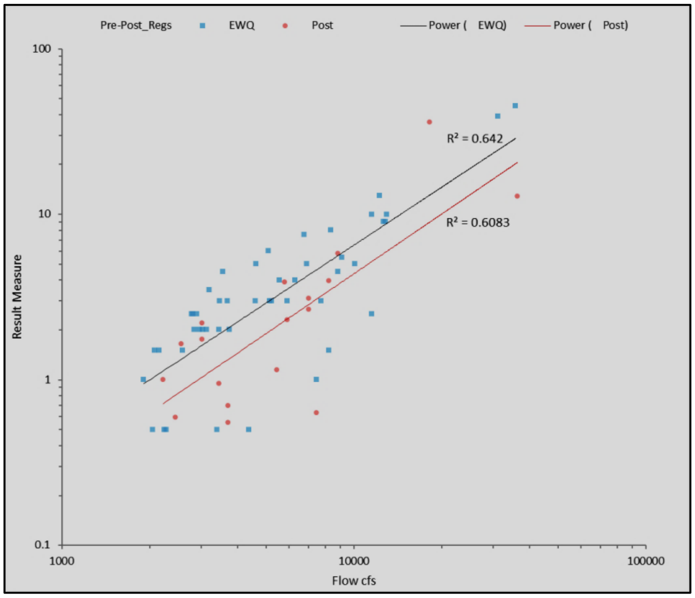
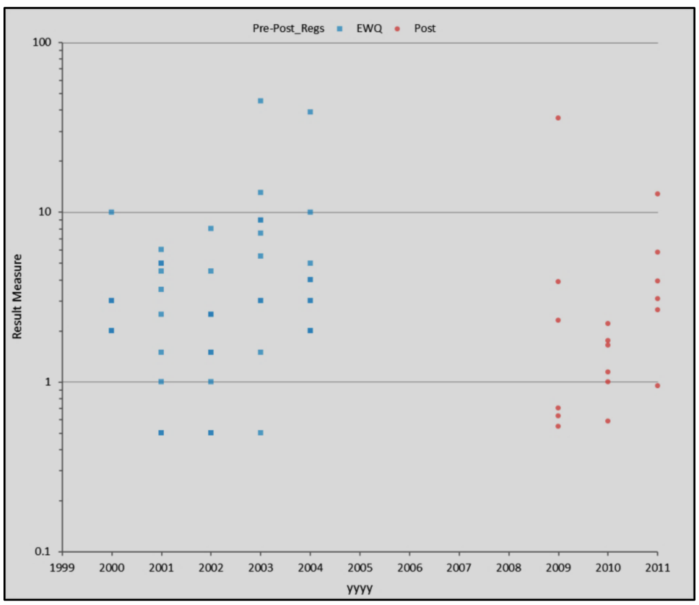
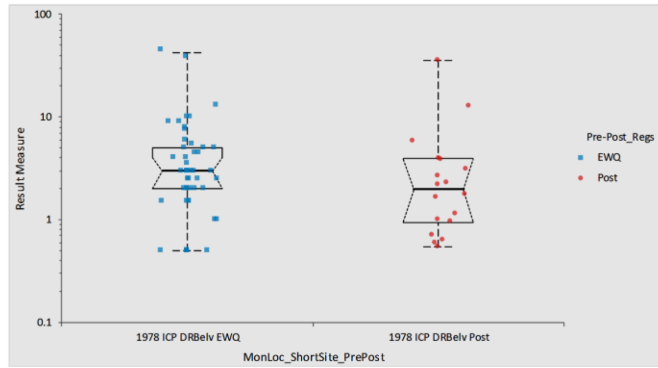
Total Suspended Solids (TSS) mg/l

Existing Water Quality (Table 2E):

Median 3.0 mg/l
Lower 95% Confidence Interval 2.0 mg/l
Upper 95% Confidence Interval 4.0 mg/l
Defined in regulations as a flow-related parameter

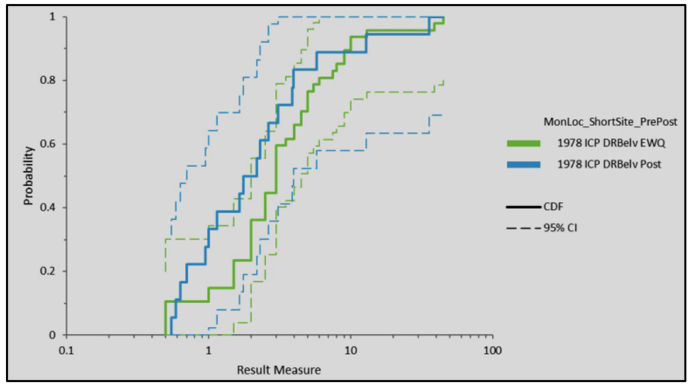






N 65

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1978 ICP DRBelv EWQ	0.5	2.0	3.0	5.0	45.0	3.0
1978 ICP DRBelv Post	0.6	0.9	2.0	3.9	35.9	3.0



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1978 ICP DRBelv EWQ	47	200.2	4.26
1978 ICP DRBelv Post	18	522.7	29.04

H statistic	2.03
X^2 approximation	2.03
DF	1
p-value	0.1544 [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. Sources of analytical uncertainty included potential laboratory artifacts and insufficient post-EWQ sampling (n=18). TSS is positively related to flow in both data sets. Post-EWQ median TSS fell to the lower EWQ 95% confidence interval. Flows and concentrations are plotted on logarithmic scale, and regressions are power relationships. USGS/PADEP data were comparable with DRBC results.

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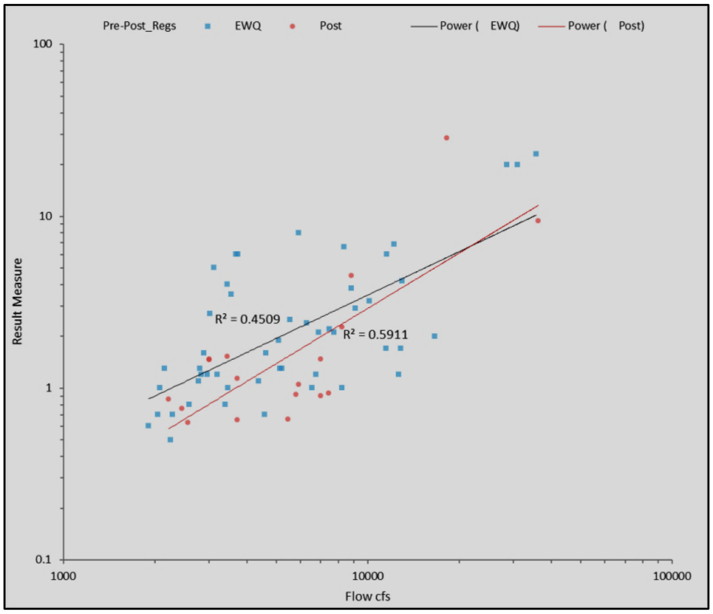
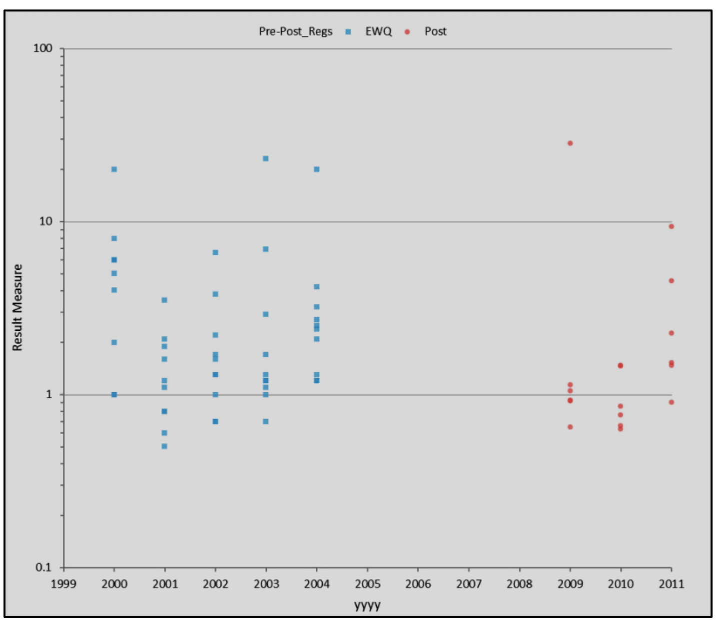
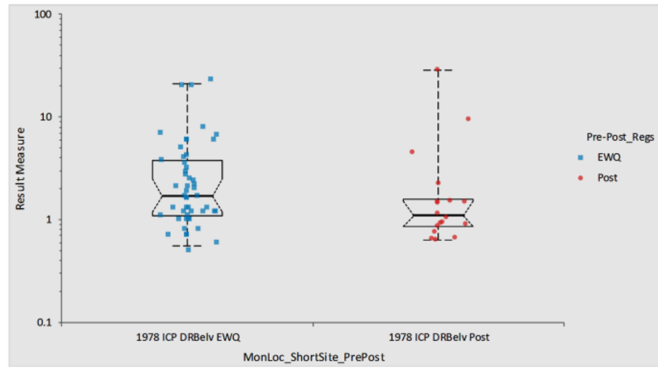
Turbidity NTU

Existing Water Quality (Table 2E):

Median 1.7 NTU
Lower 95% Confidence Interval 1.2 NTU
Upper 95% Confidence Interval 2.5 NTU
Defined in regulations as a flow-related parameter

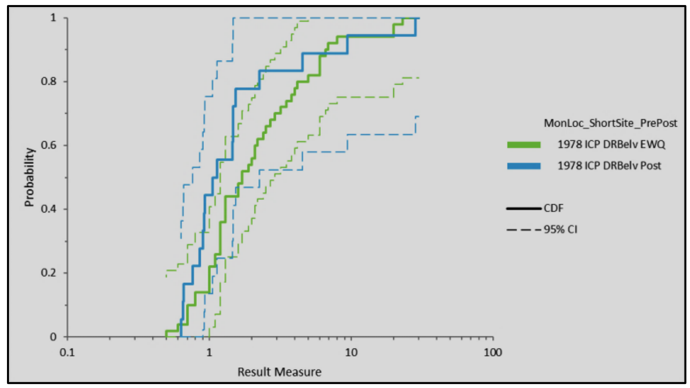






N	68					

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1978 ICP DRBelv EWQ	0.5	1.1	1.7	3.8	23.0	2.7
1978 ICP DRBelv Post	0.6	0.9	1.1	1.6	28.4	0.7



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1978 ICP DRBelv EWQ	50	343.2	6.86
1978 ICP DRBelv Post	18	953.4	52.97

H statistic	3.32
X² approximation	3.32
DF	1
p-value	0.0685 [1]

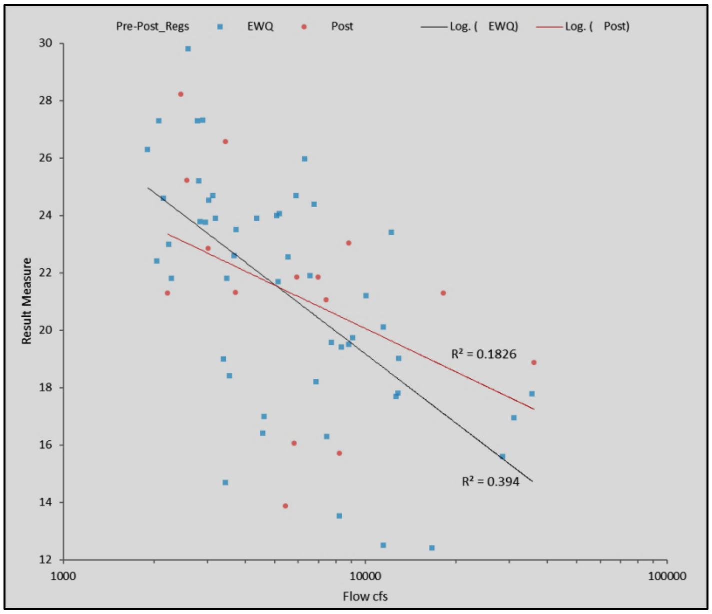
H0: $\theta_1 = \theta_2 = \theta ...$
The median of the populations are all equal.
H1: $\theta_i \neq \theta_j$ for at least one i,j
The median of the populations are not all equal.
[1] Do not reject the null hypothesis at the 5% significance level.

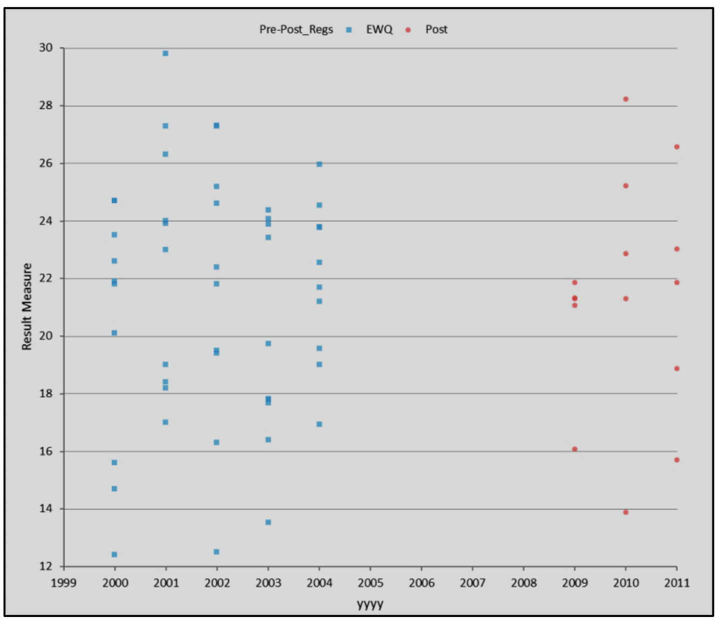
No water quality degradation is evident here. Turbidity apparently declined between the EWQ and post-EWQ periods, but not significantly due to an insufficient number of post-EWQ samples (n=18). The post-EWQ median turbidity fell below the lower EWQ 95% confidence interval. Turbidity is positively related to flow in both data sets; power regression lines are shown. Concentrations and flows are represented on logarithmic scale. There were no independent data available for comparison with DRBC results. Biweekly instead of monthly sampling is recommended at this location.

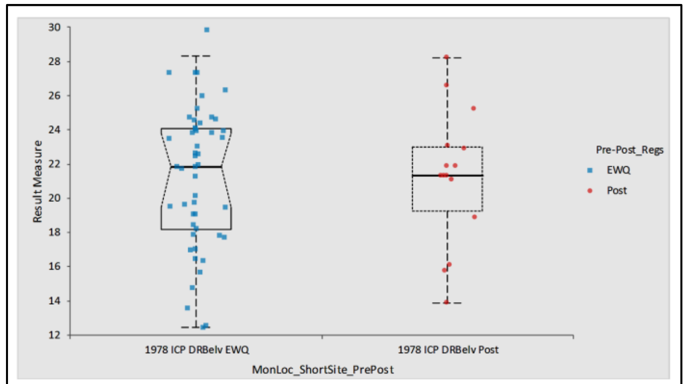
Chapter 22: 1978 ICP Delaware River at Belvidere

Water Temperature, degrees C

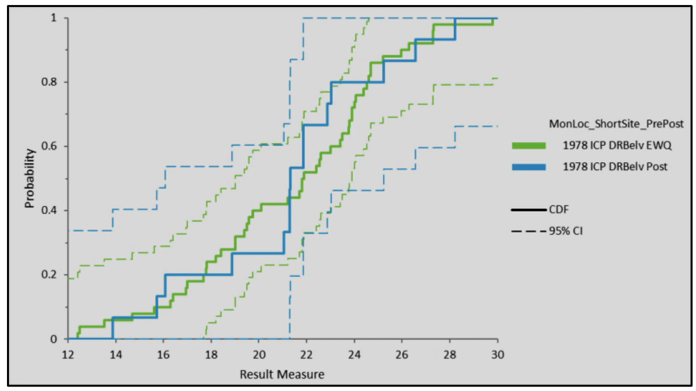
Not included in DRBC Existing Water Quality rules







N	65					
Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1978 ICP DRBelv EWQ	12.4	18.2	21.9	24.1	29.8	5.9
1978 ICP DRBelv Post	13.9	19.2	21.3	23.0	28.2	3.8



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1978 ICP DRBelv EWQ	50	3.4	0.07
1978 ICP DRBelv Post	15	11.3	0.75

H statistic	0.04
X² approximation	0.04
DF	1
p-value	0.8396 [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 included insufficient post-EWQ sampling (n=15). Water temperature is inversely related to flow in the post-EWQ data set, but very weakly related to flow in the EWQ data. Flow is plotted on logarithmic scale. PADEP data were comparable with DRBC results.