2016

ASSESSMENT OF MEASURABLE CHANGES TO EXISTING WATER QUALITY, ROUND 1: BASELINE EWQ (2000-2004) VS. POST-EWQ (2009-2011)

DELAWARE RIVER BASIN COMMISSION, SCENIC RIVERS MONITORING PROGRAM

Delaware River Basin Commission
DELAWARE • NEW JERSEY
PENNSYLVANIA • NEW YORK
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DRBC | West Trenton, NJ

Delaware River Basin Commission

Lower Delaware River
Special Protection Waters

Assessment of Measurable Changes to Existing Water Quality, Round 1: Baseline EWQ (2000-2004) vs. Post-EWQ (2009-2011)

Citation

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Executive Summary

Introduction: The Lower Delaware is a 76-mile reach of the Delaware River extending from just below the Delaware Water Gap at Portland, PA (River Mile 209.5) to Calhoun Street Bridge at Trenton, NJ (River Mile 134.3). In 2000, federal legislation was enacted adding key segments of the Lower Delaware and selected tributaries to the National Wild and Scenic Rivers System. This designation was followed in April 2001 with a petition to DRBC from the Delaware Riverkeeper Network to classify the Lower Delaware as Special Protection Waters (SPW). In 2008, the DRBC by unanimous vote (DRBC 2008) added the Lower Delaware to Special Protection Waters as Significant Resource Waters, and adopted Existing Water Quality definitions for specific control points.

In partnership with the National Park Service (NPS), the Delaware River Basin Commission established the **Scenic Rivers Monitoring Program (SRMP)** to define the water quality for this reach of the river and assess any measurable changes to these high quality waters. The NPS administers a Lower Delaware Management Plan created for the Wild and Scenic designated reaches of the river. DRBC monitors the Lower Delaware, and is the lead agency for the first objective of the NPS management plan: to maintain existing water quality and to improve it where practical. The NPS management plan objective slightly differs from that of DRBC water quality regulations, which is to prevent degradation of water quality unless toward natural conditions.

Implementing the No Measurable Change management policy requires a periodic assessment of the water quality conditions of the Lower Delaware at specific control points in the main stem river and at the confluence of tributaries to the main stem. The existing water quality at the time of the SPW designation at these points was established as medians and upper and lower 95th confidence intervals for 20 parameters using a data set from 2000 through 2004. The current assessment utilizes data collected over three years from 2009 through 2011.

Monitoring Design: DRBC collected water quality samples for parameters in the DRBC water quality regulations from May through September at fixed sites called **Control Points** in the Lower Delaware River corridor from 2009 to 2011, with sampling targeted bi-weekly or monthly for a total of 5-10 samples per season at each location. This design resulted in a total of 15-30 samples during the study period. The control points were designated as **Interstate Control Points (ICP's)** if the point was located on the main stem of the interstate Delaware River, or as **Boundary Control Points (BCP's)** if they were located on tributaries in New Jersey or Pennsylvania near the confluence of each tributary watershed with the river. ICP's are monitored to document longitudinal water quality changes along segments of the Delaware River. BCP's are monitored to document watershed influences upon the Delaware River, and to measure water quality changes that occur in watersheds between the time periods.

Assessment Methodology – generalized approach: One of the important objectives of this study was to establish a replicable and dependable assessment methodology for identifying water quality changes that constitute "measurable change" as defined in DRBC water quality rules. The assessment methodology included in this report is graphical plots and statistical tests along with watershed characteristics to provide qualitative and quantitative assessments of measurable change. This report includes chapters for each of the ICPs and BCPs that describe in detail the information used in the assessment.

Summary of Assessment Results: A tabular summary of the assessment at each control point is presented in a matrix. No measurable change took place for 17 out of 20 parameters tested at almost all control points in the 2009-2011 assessment period. These include general water quality parameters such as alkalinity, hardness, pH, dissolved oxygen, temperature, turbidity, dissolved and suspended solids, all nutrient forms (ammonia, nitrate + nitrite, total nitrogen, total phosphorus, and orthophosphate), and 2 of 3 tested bacteria parameters (Enterococcus and Fecal coliforms). It should be noted that all seven of the parameters including all nutrient parameters that are evaluated for wastewater treatment facilities are included in this group.

Measurable change toward degraded water quality conditions was detected for three parameters: chlorides and specific conductance at almost all sites, and for *E. coli* at sites from Nishisakawick Creek in Frenchtown, NJ (River Mile 164.1) and downstream.

Recommendations are included in the report for future monitoring and policy considerations.

Contents

Download Individual Chapters:

Abbreviations

#/100 ml	Colonies per 100 milliliters, a unit of bacteria concentration
BaSE	Baseline Streamflow Estimator (USGS computer application)
BCP:	Boundary Control Point: A fixed monitoring location on a tributary to the Delaware River.
CDF:	Cumulative Distribution Function
CFS:	Cubic Feet per Second
DAW	Drainage Area Weighting
DO:	Dissolved Oxygen
DO%:	Dissolved Oxygen Percent Saturation
DEWA	Delaware Water Gap
DRBC:	Delaware River Basin Commission
DWGNRA	Delaware Water Gap National Recreation Area
EWQ:	Existing Water Quality (defined during 2000-2004), the baseline water quality data
ICP:	Interstate Control Point: A fixed monitoring location on the Delaware River
LDEL:	Lower Delaware (Delaware River mile 134.3 at Trenton to mile 209.5 at Portland)
MCP:	Monitoring Control Point – a site not meant for rules, but for modeling and diagnostic monitoring
mg/l	Milligrams per Liter, a unit of concentration
N+N	Nitrate plus Nitrite
NMC:	No Measurable Change, specifically defined in DRBC rules
NJDEP:	New Jersey Department of Environmental Protection
NJDOH-ECLS	New Jersey Department of Health, Environmental Chemistry and Laboratory Services
NPS	National Park Service
NWIS	National Water Information System (USGS water quality data repository)
OP:	Orthophosphate
PADEP:	Pennsylvania Department of Environmental Protection
Post-EWQ:	The 2009-2011 test water quality data used to assess water quality changes from baseline
QAPP	Quality Assurance Project Plan
QA/QC	Quality Assurance / Quality Control
SpC:	Specific Conductance
SPW:	Special Protection Waters
SRMP:	Scenic Rivers Monitoring Program
TDS:	Total Dissolved Solids
TKN:	Total Kjeldahl Nitrogen
TN:	Total Nitrogen
TP:	Total Phosphorus
TSS:	Total Suspended Solids
UDSRR	Upper Delaware Scenic and Recreational River
µmho/cm	Micro-mhos per centimeter, a unit of specific conductance (also µS/cm – micro-Siemens/cm)
UPDE	Upper Delaware
USEPA	United States Environmental Protection Agency
USGS:	United States Geological Survey
WQN:	Water Quality Network: PADEP's fixed water quality stations

Introduction

This document contains a discussion of water quality changes at each Special Protection Waters control point along the Lower Delaware River. At 24 sites located between the Delaware Water Gap and Trenton, NJ (see Chapters 1-24), water quality was compared between two time periods: the 2000-2004 Existing Water Quality (EWQ) baseline period and the 2009-2011 post-EWQ period, also referred to as the Lower Delaware Measurable Change Assessment Round 1. A matrix summarizing the assessment is also included.

Appendix A contains site-specific definition of Existing Water Quality at one new Monitoring Control Point location on the Delaware River (Sandts Eddy Fishing and Boating Access in Northampton County, PA), and at two new Boundary Control Point tributary watershed locations (Slateford Creek, PA and Lopatcong Creek, NJ). These EWQ definitions are provided as guidance for evaluation of new or expanding wastewater treatment plants and for consideration for future DRBC water quality rules.

Appendix B contains brief descriptions of the plots and statistical tests, with notes about interpretation of the plots. Additional information about the DRBC Special Protection Waters Program may be found here: http://www.state.nj.us/drbc/programs/quality/spw.html

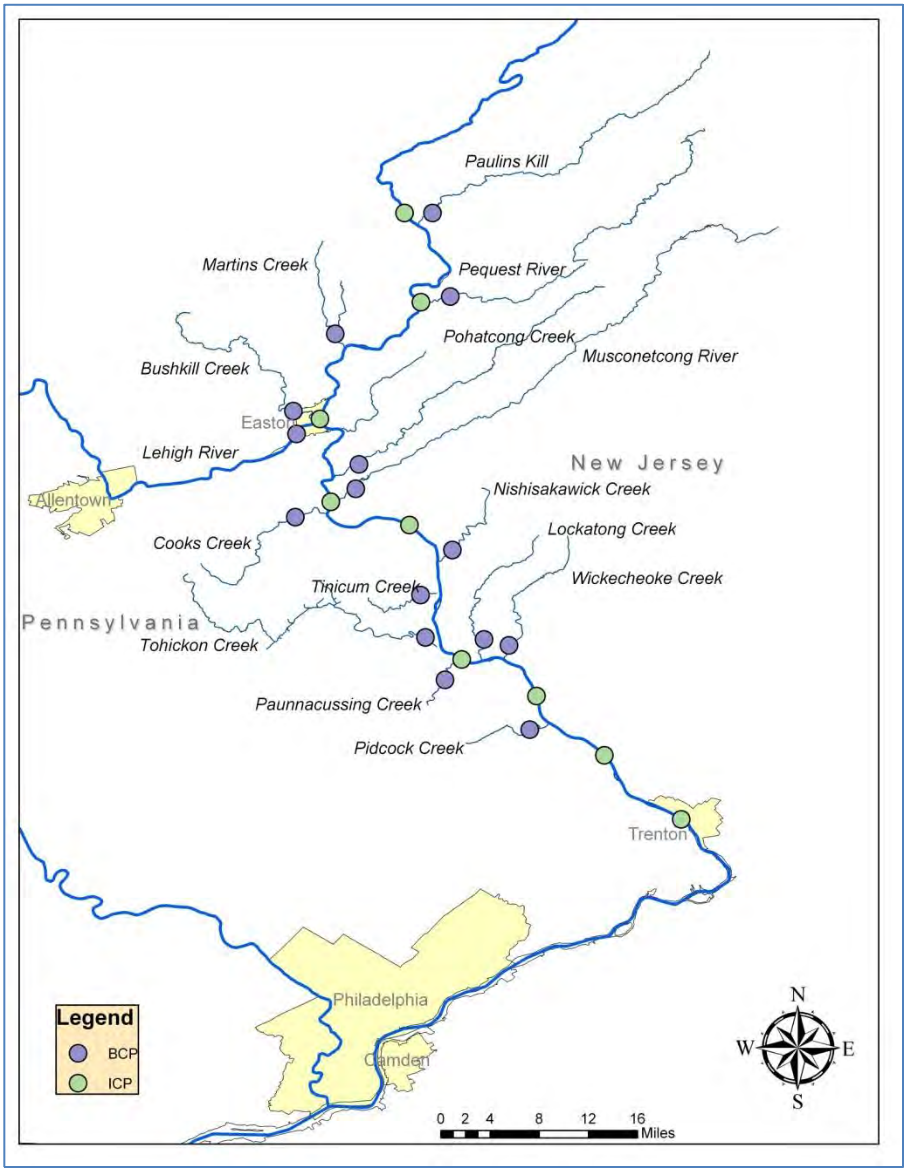
Appendix C contains a detailed description of our methods for estimating discharge at ungaged locations, and how those data are associated with the site-specific water quality data.

Program Description

The Lower Delaware is a 76-mile reach of the Delaware River extending from just below the Delaware Water Gap at Portland, PA (River Mile 209.5) to Calhoun Street Bridge at Trenton, NJ (River Mile 134.3). In 2000, federal legislation was enacted adding key segments of the Lower Delaware and selected tributaries to the National Wild and Scenic Rivers System. This designation was followed in April 2001 with a petition to DRBC from the Delaware Riverkeeper Network to classify the Lower Delaware as Special Protection Waters (SPW). In 2008, the DRBC by unanimous vote (DRBC 2008) added the Lower Delaware to Special Protection Waters as Significant Resource Waters, and adopted Existing Water Quality definitions for specific control points. As part of this action, extensive revisions to Article 3 of the Commission's Water Quality Regulations were approved to incorporate 24 tables, one for each of the Control Point, defining the Existing Water Quality (EWQ) at each of the points.

In partnership with the National Park Service (NPS), the federal agency that administers Lower Delaware Wild and scenic River, the Delaware River Basin Commission established the **Scenic Rivers Monitoring Program (SRMP)** to define the water quality for this reach of the river and assess any measurable changes to these high quality waters. This program also includes components for the Middle Delaware River and Upper Delaware River. The NPS administers a Lower Delaware Management Plan created for the Wild and Scenic designated reaches of the river. DRBC monitors the Lower Delaware, and is the lead agency for the first objective of the NPS management plan: to maintain existing water quality and to improve it where practical. This objective slightly differs from that of DRBC water quality regulations, which is to prevent degradation of water quality unless toward natural conditions.

Figure 1: Lower Delaware Monitoring Locations for Special Protection Waters



Monitoring Description

In the SRMP, monitoring sites are classified as **Control Points,** which are fixed sites along the Delaware River corridor: **Interstate Control Points (ICP's)** are locations on the interstate Delaware River, and **Boundary Control Points (BCP's)** are New Jersey or Pennsylvania sites located near the confluence of each tributary watershed entering the Delaware River. BCP's are monitored to document their influence upon the Delaware River, and to measure water quality changes that occur in the watershed between selected time periods. This report contains the first assessment of measurable changes to EWQ in the Lower Delaware (LDEL).

DRBC designed the SRMP to define and assess changes to site-specific water quality for as many tributaries as possible with the following objectives:

1. Covering as much watershed area as possible: the SRMP currently encompasses all watersheds of more than 20 square miles in size. This enables DRBC to evaluate approximately 85% of the watershed area of the Delaware River Basin above Trenton with as few sites as possible.
2. Monitor smaller watersheds that presently or in the future contain dischargers subject to Special Protection Waters regulations (e.g., Slateford Creek, PA);
3. Monitor smaller watersheds that have been designated as Wild and Scenic by the National Park Service (e.g., Paunnacussing Creek, PA);
4. Representatively monitor some small watersheds that possess general water quality characteristics of physiographic regions or ecoregions along the Delaware River (e.g., Pidcock Creek, PA represents the Piedmont physiographic region);
5. Within some large watersheds, conduct additional monitoring for construction and calibration of water quality models (e.g., Lehigh River, PA, Neversink River, NY, and Brodhead Creek, PA).

A complete description of the monitoring program is provided in the Scenic Rivers Monitoring Program Quality Assurance Project Plan (DRBC 2006, 2009, 2013). DRBC collects water quality samples from May through September in selected years, preferably sampling bi-weekly for a total of 10 samples per season at each location. This is conducted for 3 to 5-year periods, providing 30 to 50 samples per study period.

Monitoring Station numbering examples

- For ICPs, 'Delaware River at Trenton – 1344 ICP': River Mile 134.4, ICP = Interstate Control Point,
- For BCPs, 'Paulins Kill River, NJ – 2070 BCP: Delaware River Mile 207.0 at confluence, BCP = Boundary Control Point

Assessment Approach

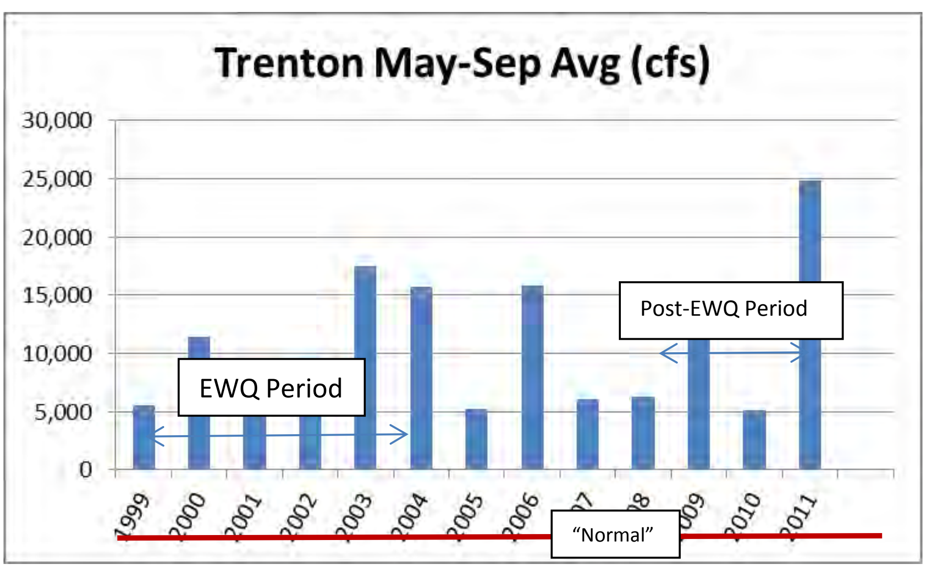
Each chapter of this report is organized by site and contains within-site water quality comparisons where Existing Water Quality (EWQ) was site-specifically defined in DRBC Special Protection Waters regulations. Each chapter starts with a short analysis of the flow conditions sampled during each study period and possible effects upon the water quality analyses. For each parameter listed in DRBC water quality regulations (Tables 2C to 2Z) the following plots are shown:

1. Scatter Plot of Concentration vs. Stream Flow (cfs), EWQ vs. Post-EWQ Monitoring Periods
2. Scatter Plot of Annual Concentration, 2000-2011
3. Box Plot Comparison of EWQ vs. Post-EWQ Concentrations
4. Cumulative Distribution Function (CDF) Comparison of EWQ vs. Post-EWQ Concentrations
5. Kruskal-Wallis Statistical Test of Difference between EWQ and Post-EWQ Concentrations
6. Short Discussion of Results

In this study, the plots are systematically used to qualitatively and quantitatively determine measurable change to existing water quality, an important concept in DRBC Special Protection Waters rules. The specific definition from DRBC water quality regulations follows:

> "Measurable Change to Existing Water Quality" is defined as an actual or estimated change in a seasonal or non-seasonal mean (for SPW waters upstream and including River Mile 209.5) or median (for SPW waters downstream of River Mile 209.5) in-stream pollutant concentration that is outside the range of the two-tailed upper and lower 95 percent confidence intervals that define Existing Water Quality.

The definition of measurable change is fairly simple, but some influential variables must be considered in order to make a fair and accurate assessment with an unbiased conclusion. An original objective of this program was to define EWQ to represent the full range of hydrologic conditions experienced at that location along the Delaware River or one of its tributaries. A five-year period (2000-2004) was used to define baseline EWQ. In the Lower Delaware, EWQ was defined "seasonally" by sampling 10 times within the annual May to September periods, and in fact represents very well almost the entire hydrograph.



The chart to the left indicates that comparison of the EWQ data set with the post-EWQ data set is not as simple as direct statistical comparison of medians and confidence intervals employed by the Kruskal-Wallis test. Many parameters are **flow related**, so comparing two time intervals means that flow must be accounted into the analysis.

That is why the scatter plots are included in this analysis, and why the decision that "measurable change" has occurred is more of a qualitative judgment rather than a direct quantitative test. Further information is supplied by the box plots and the cumulative distribution functions, which allow for comparison of the entire data distribution between the two periods rather than just the median and confidence intervals. All of the plots together, along with the statistical test, allow for a fairly accurate judgment of measurable change within a replicable decision process.

Significant Findings

No Measurable Change:

Almost universally throughout the Lower Delaware there was no degradation, and possibly may have been improvement in concentrations of: ammonia, nitrate + nitrite, total nitrogen, Kjeldahl nitrogen, orthophosphate, and total phosphorus. All told there have been about 140 wastewater projects in Special Protection Waters reviewed and approved by DRBC since 1992. About 1/3 of the projects are located in the Lower Delaware and were implemented since the 2005 interim Lower Delaware SPW designation.

There are a few watersheds where bacteria levels apparently declined: Cooks Creek, PA; Musconetcong River, NJ; Pohatcong Creek, NJ; Lehigh River, PA; Martins Creek, PA; Pequest River, NJ; the Paulins Kill River, NJ; and the Delaware River near Riegelsville, Easton, and Belvidere. See individual chapters for discussion of each stream.

In Martins Creek, PA, improvements were apparent not only for the above-mentioned parameters but also dissolved oxygen, dissolved oxygen saturation, total suspended solids, and turbidity. A number of stream restoration and watershed protection projects were undertaken recently and may have shown tangible water quality benefits. Mr. John Mauser of the Martins-Jacoby Watershed Association presented a number of case studies, found here: http://www.dcnr.state.pa.us/cs/groups/public/documents/document/dcnr_002582.pdf

The **removal of dams on the Musconetcong River** may have provided water quality benefits. Although water quality of the Musconetcong is still poor relative to the Delaware River, slight improvements were observed in dissolved oxygen concentration and saturation values, and total suspended solids.

Measurable Change:

Chlorides and **specific conductance** rose in almost every watershed and at many Delaware River locations. Similar to other northern locations throughout the U.S. and Canada (Evans and Frick 2001; Kaushal et. al. 2005; Cunningham et. al. 2008; Kelly et. al. 2008; Daley et. al. 2009; Gardner and Royer 2010; Findlay and Kelly 2011; New Hampshire DES 2011; Hunt et. al. 2012; Cañedo-Argüelles 2013), the rise may be attributable to winter road salt applications. In a suburban watershed near the Lower Delaware, Skippack Creek concentrations are reaching levels that allow for growth of brackish-water algae instead of the expected freshwater species (USEPA and PADEP 2005). Concentrations in the Lower Delaware are presently well below such effect levels, and meet PA and NJ water quality criteria levels developed to protect human health. However, it appears that chloride concentrations and specific conductance are increasing.

Specific conductance is largely unregulated and understudied – there are no established ambient water quality criteria that are relevant to aquatic life, because there are many ions that can make up specific conductance. U.S. EPA published chloride criteria for aquatic life in 1986 that are applicable in the basin states: the acute criterion maximum concentration (CMC) is 860 mg/l, and the chronic criterion continuous concentration (CCC) is 230 mg/l (U.S. EPA 1986). The human health criterion throughout the basin states is 250 mg/l, but may only be applied at water supply intake locations, not for all ambient waters. Pennsylvania DEP has studied the issue of chloride impacts upon aquatic life, and recently made recommendations in their triennial review of water quality standards to improve chloride criteria for protection of aquatic life (PADEP 2015). Chlorides are naturally present in streams, mostly contributed by geological formations underlying the streams. So chloride concentrations up to approximately 30 mg/l are expected here. Winter road salting is proportionally the largest anthropogenic source, is also unregulated, and merits further investigation. Other man-made sources are smaller in their contributions, and include various industrial effluents, sewage, landfill leachate, agricultural runoff, and hydraulic fracturing products. Within the DRBC anti-degradation policy structure, these parameters have shown measurable changes to existing water quality, and not toward natural conditions.

We unexpectedly found that although chlorides and specific conductance increased, total dissolved solids appeared to decline or stay the same. Upon seeing this, our first response was to question our TDS laboratory methods, because specific conductance and TDS are expected to respond similarly – as one increases so does the other. We ultimately could not rule out inter-laboratory differences as the cause for these unexpected results. Although there were never any undetected TDS results, post-EWQ detection limits were lower than EWQ detection limits. All laboratories used the same EPA-approved method, but perhaps the overall testing range shifted lower along with the detection limits. This appeared to happen with several parameters – as detection limits declined, overall the data became less variable, slightly lower in concentration, and with fewer extreme high values.

Escherichia coli concentrations increased beyond EWQ targets in all watersheds downstream of Frenchtown, NJ except for the Paunnacussing Creek watershed in Bucks County. High levels of E. coli concentrations have sporadically been detected based on monitoring data at: Nishisakawick Creek (NJ), Tinicum Creek (PA), Lockatong Creek (NJ), Wickecheoke Creek (NJ), Pidcock Creek (PA), and at Bulls Island, Lambertville, Washington Crossing and Trenton on the Delaware River. E. coli concentrations increase with increasing flow conditions.

Analytical Limitations and Sources of Uncertainty in this Assessment

There are several factors that contribute to uncertainty in the data. While these factors are not unique to this study, they are important to consider as part of the overall comparison between the EWQ and post-EWQ periods. Limitations and sources of uncertainty are described in more detail below.

Dissimilar hydrological periods: the EWQ period was composed of one "normal" flow year, two low-to-normal flow years, and two wet flow years. The post-EWQ period contained one normal flow year, one dry flow year, and one very wet flow year. This presented a problem at Trenton (see Chapter 1), where the Calhoun Street Bridge was closed for the entire dry 2010 monitoring season. So the Trenton post-EWQ data contain more high flow measurements and less low-flow measurements than the EWQ data, making direct comparison difficult at that location. There were a few other locations where wet or dry-weather samples were under-represented in the post-EWQ data, and those circumstances are noted in each chapter. This limitation is not deemed severe as long as flow is accounted into the analysis so that flow effects are recognized, if not fully controlled.

Future solution: for future assessment rounds, best attempts should be made to: 1) monitor for a minimum of three years at a rate of 10 samples per May to September season; and 2) classify samples on the flow duration curve for each site; then decide if additional monitoring (up to two additional years) might provide the most representative balance of low, normal and high-flow samples. This would ensure that variability attributable to flow is controlled to provide a clear and reliable judgment of water quality changes between the EWQ baseline (control) and subsequent assessment (test) periods.

Another challenge to direct comparison is the **number of data points** per period (N). Through this monitoring program we sought to balance collection of a statistically appropriate number of data points with the reality of competing resource demands. The first assessment round completed during 2009-2011 was designed to test measurable changes from the baseline but used a smaller data set. Some sites were sampled 10 times per season for three years (N=30), others only monthly within the May to September period for three years (N=15). Fewer observations result in higher variability, reduced ability to detect changes, and potential introduction of bias. In water quality analyses, a higher number of observations is preferable but not always obtainable. In future assessments, it may be preferable to drop sites in order to retain a higher number of observations at sites that are sampled.

Some water quality parameters are more **naturally variable** than others and thus less predictable without closely defining the conditions under which the samples were taken or vastly increasing the sampling rate. Examples of this include bacteria (Enterococcus, E. coli and Fecal Coliform) and Total Suspended Solids (TSS). Given that fewer data were collected from 2009-2011 than from 2000-2004, direct statistical comparison between the two data sets is confounded by influential factors that may not easily be quantified, such as land use changes or ecological processes. Other water quality parameters "behave" much more conservatively, and it takes fewer data to draw fairly accurate conclusions about changes. Examples of conservative parameters include specific conductance, total phosphorus, chloride and total dissolved solids (TDS).

Time of day is an influential factor for parameters that cycle up and down each day, such as dissolved oxygen, pH, water and air temperature, and nitrate. In this program, sampling is scheduled so that these parameters are at or near their daily maxima when sampled (roughly mid-day), and sites are visited in different order so that the sample time is varied within the daily time range when these parameters are near their daily maximum concentration. Note that in DRBC or state water quality regulations, many criteria are expressed as 24-hour averages, minima or maxima. These data do not represent daily lows or averages, which are better obtained from continuous monitoring stations such as those at Trenton, Frenchtown, Riegelsville and Belvidere. Comparison against criteria must take into account the difference in averaging period. DRBC recognizes the value of continuous monitoring stations for proper assessment of water quality standards, and has been supporting the addition of water quality meter installation at USGS gages located in all Zones of the Delaware River.

Another factor that may cause imbalance in data analyses is the water quality **test method** itself, as well as the **laboratory** performing the test. Since inception of this program, DRBC has changed contract laboratories several times. DRBC employed standard QA/QC safeguards to minimize the impact of using different labs including requiring that labs be state-certified for regulatory testing of the parameter list and use of EPA-approved methods for testing of ambient surface water. In addition, DRBC routinely performed blinded replicate samples and blinded rinsate blank samples to ensure the accuracy and precision of reported results. The fact remains however that method detection limit levels must be low enough to provide reliable information about high-quality streams and rivers. Many commercial laboratories typically test wastewater, not high-quality ambient surface water. Thus low-level analytical capability was uncommon in our earliest results through about 2002. As this low-level capability increases in the analytical community, we were better able to quantify low-concentration ambient surface waters. The early portion of the EWQ data set thus contains a fair amount of non-detect results and wide variability, whereas the latter portion of the baseline data and all of the post-EWQ data set contain virtually no non-detect results even in the best streams. This analytical difference hampers comparison. See Table 1 for detection limits from 2000-2011 for Scenic Rivers Monitoring Program parameters.

Table 1: Detection Limits for Selected Scenic Rivers Monitoring Program Parameters, 2000-2013

Year	Ammonia mg/l	Nitrate + Nitrite mg/l**	Ortho-Phosphate mg/l	Total Phosphorus mg/l	TKN mg/l	TDS mg/l	TSS mg/l	Lab	Comment
2000	0.10*	0.50	0.01	0.01	0.10	20.0	2.0	QC	
2001	0.05	0.02	0.01	0.02	0.05	8.0	0.5	NJAL	
2002	0.05	0.02	0.01	0.02	0.05	8.0	0.5	NJAL	
2003	0.05	0.02	0.01	0.02	0.05	6.0	0.5	NJAL	
2004	0.02	0.02	0.01	0.01	0.05	6.0	2.0	NJAL	
2006	0.01	No Tests	No Tests	No Tests	No Tests	5.0	5.0	ANSP	No Lower Del. sampling
2007	0.005	0.007	0.002	0.002	0.038	3.1	0.43	ANSP	No Lower Del. sampling
2008	0.005	0.003	0.003	0.002	0.032	3.45	0.38	ANSP	No Lower Del. sampling
2009	0.004	0.007	0.002	0.002	0.044	3.71	0.75	ANSP	
2010	0.004	0.006	0.002	0.002	0.061	3.74	0.59	ANSP	
2011	0.004	0.006	0.002	0.002	0.050	1.57	0.75	ANSP	
2012	0.006	0.003	0.002	0.002	0.039	2.19	0.3	ANSP	No Lower Del. sampling
2013	0.006	0.004	0.002	0.008	0.028	1.0	1.0	NJDOH	No Lower Del. sampling

* In Table 1 above there are no data for ammonia samples taken in 2000. That year the detection limit was so high that almost all results were non-detects. Those data were discarded from this study.

**For the Lower Delaware EWQ definition period of 2000-2004, DRBC requested that the laboratories perform tests for Nitrate and for Nitrite individually, so the detection limits from 2000-2004 above are for Nitrate only. Nitrite sample results were almost exclusively non-detects, because Nitrite is converted relatively quickly to Nitrate in streams that Nitrite is rarely detected. Since 2004 Nitrate + Nitrite testing was requested to save on costs, and it is confident that Nitrate is proportionally so much greater than Nitrite that Nitrite is negligible.

Recommendations:

Monitoring Recommendations

1. **Sampling frequency** during selected years should always be twice monthly rather than once monthly. Once-monthly sampling does not represent the full range of flow conditions. Also, once-monthly sampling reduces the overall number of data which leads to a reduction in our ability to detect changes.
2. DRBC monitoring programs should continue to **use BaSE (USGS Baseline Streamflow Estimator model) to estimate stream flow** at ungaged water quality monitoring sites. Results from BaSE compared very favorably to our flow measurements made using benchmark gages and rating curves at considerably reduced effort.
3. When DRBC changes contract laboratories or makes use of multiple labs, we should **conduct more split sampling** analyses so that we can compare results among multiple laboratories conducting a selected USEPA-approved analytical method.
4. **Automate and add to this assessment procedure using R**. Creation of R scripts to automatically retrieve, process, and plot the latest water quality data would greatly enhance our assessment capability.
5. **Conduct bacterial track-down studies** for the Delaware River and its tributaries between Frenchtown-Uhlerstown and Trenton-Morrisville, NJ-PA. *E. coli* concentrations have risen within this reach and in most tributary watersheds. In addition there are several tributaries where recreational criteria are still exceeded, even though bacterial concentrations may have remained stable or dropped including Cooks Creek, PA; Musconetcong River, NJ; Pohatcong Creek, NJ; Bushkill Creek, PA (Northampton County).
6. **Continue to define site-specific water quality** for key tributaries within multiple objectives:
    a. Define EWQ for watersheds of more than 20 square miles in size. This enables DRBC to evaluate approximately 85% of the watershed area of the Delaware River Basin above Trenton with as few sites as possible.
    b. As necessary, monitor smaller watersheds that presently or in the future contain dischargers subject to Special Protection Waters regulations (e.g., Slateford Creek, PA);

c. As necessary, monitor smaller watersheds that have been designated as Wild and Scenic by the National Park Service (e.g., Paunnacussing Creek, PA);
d. Representatively monitor some smaller watersheds that possess general water quality characteristics of physiographic regions or ecoregions along the Delaware River (e.g., Pidcock Creek, PA represents small Delaware River tributaries within the Piedmont region);
e. Within some large watersheds, conduct additional monitoring for construction and calibration of water quality models to evaluate cumulative impacts of multiple dischargers and apportion capacity so that EWQ is not degraded.

Policy and Water Quality Standards Recommendations

1. DRBC should adopt updated **recreational criteria** as recommended by U.S. EPA and implemented by our basin states.
2. **Provide support for stream gages** and **continuous water quality.** Monitoring installations operated by the U.S. Geological Survey are critically necessary for understanding and managing our water resources. DRBC currently provides support for numerous stream gages and continuous water quality monitors . DRBC specifically recommends new gaging as described below:
    - The **Paulins Kill River** is gaged at Blairstown, NJ, but there should be a stream gage placed below Columbia Lake's hydropower generating station near the Paulins Kill mouth. The hydropower facility alters the flow regime of the Paulins Kill, and the reservoir acts as a pollutant sink for the watershed area upstream. The Paulins Kill is a major tributary to the Delaware River. At this location, water from a 177 square mile watershed area enters the Delaware River and its impact must be considered. A similar situation existed with the Mongaup River, NY, where DRBC recently required re-installation of the stream gage below a hydropower facility so the Mongaup's influence upon the Delaware River could be measured.
3. Staff recommends that discussions with our basin states and advisory committees be initiated to identify and **implement ways to reduce chloride concentrations and stream conductivity**. Both water quality targets of DRBC anti-degradation rules and policies have been exceeded within a very short time period.
4. **Determine impact of non-seasonal water quality**: DRBC's dockets or permits allow higher effluent limitations especially for ammonia (2 to 3 times of summer limit) for October through April. The impact has not been evaluated sufficiently enough to determine non-seasonal effluent limitations that are protective of EWQ. Higher winter pollutant loads may harm aquatic life and may affect summer EWQ, and warrant further investigation.

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Lower Delaware River Special Protection Waters
Measurable Change Matrix - Key to Symbols

Site Key

Delaware River at Trenton	Delaware River Interstate Control Point (ICP) - dark blue
Pidcock Creek, PA	Pennsylvania Boundary Control Point (BCP) - dark red
Wickecheoke Creek, NJ	New Jersey Boundary Control Point (BCP) - dark green

Assessment Key (2000-2004 baseline vs. 2009-2011 assessment round 1)

	No indication of measurable change to EWQ
**	Indication of measurable water quality change toward more degraded status
~	Weak indication of measurable water quality change toward more degraded status

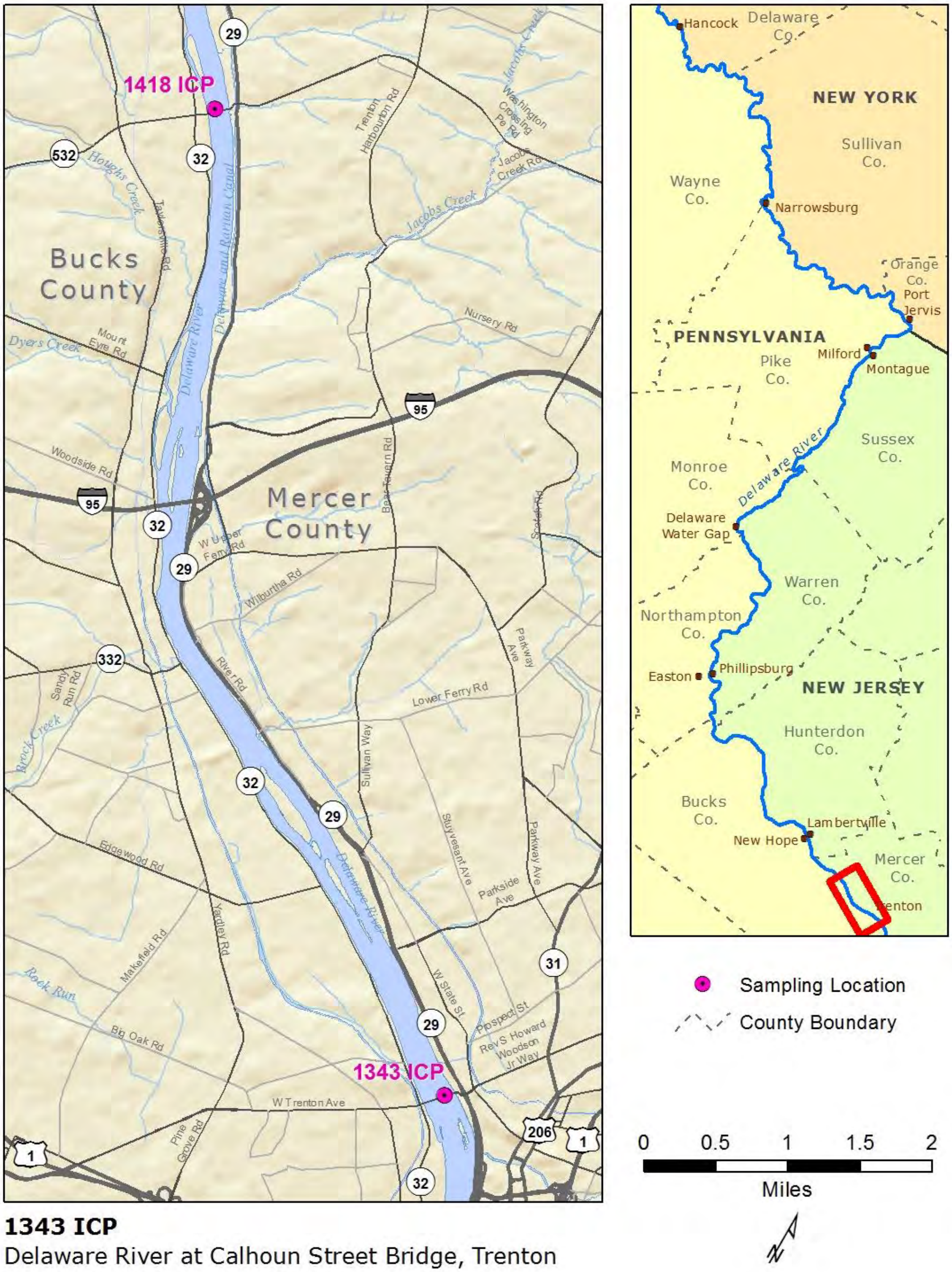
Summary Matrix of Water Quality Changes at Lower Delaware Control Points: 2000-2004 Baseline vs. 2009-2011 Assessment Round 1

Site Color Key: Dark Blue =Interstate Control Point (ICP); Dark Red =Pennsylvania Tributary Boundary Control Point (BCP); Dark Green =New Jersey Tributary Boundary Control Point (BCP)

	Parameter / Site--->	Del. River at Trenton	Del. River at Washngtn Crossing	Pidcock Creek, PA	Delaware River at Lambrtvlle	Wicke-cheoke Creek, NJ	Lockatong Creek, NJ	Delaware River at Bulls Island	Pauna-cussing Creek, PA	Tohickon Creek, PA	Tinicum Creek, PA	Nishi-sakawick Creek, NJ	Del. River at Milford	Cooks Creek, PA	Musco-netcong River, NJ	Del. River at Rieglsvll	Pohat-cong Creek, NJ	Lehigh River, PA	Del. River at Easton	Bushkill Creek, PA	Martins Creek, PA	Pequest River, NJ	Del. River at Belvidere	Paulins Kill River, NJ	Del. River at Portland
	Site Number--->	1343 ICP	1418 ICP	1463 BCP	1487 ICP	1525 BCP	1540 BCP	1554 ICP	1556 BCP	1570 BCP	1616 BCP	1641 BCP	1677 ICP	1737 BCP	1746 BCP	1748 ICP	1774 BCP	1837 BCP	1838 ICP	1841 BCP	1907 BCP	1978 BCP	1978 ICP	2070 BCP	2074 ICP
Field	Dissolved Oxygen (DO) mg/l											~													
	Dissolved Oxygen Saturation %											~													
	pH, units																								
	Water Temperature, degrees C																								
Nutrients	Ammonia Nitrogen as N, Total mg/l																								
	Nitrate + Nitrite as N, Total mg/l																**								
	Nitrogen as N, Total (TN) mg/l																**								
	Nitrogen, Kjeldahl, Total (TKN) mg/l																								
	Orthophosphate as P, Total mg/l																								
	Phosphorus as P, Total (TP) mg/l																								
Bacteria	Enterococcus colonies/100 ml	~			~																				
	Escherichia coli colonies/100 ml	**	**	**	**	**	**			**	**	**													
	Fecal coliform colonies/100 ml																								
Conventionals	Alkalinity as CaCO3, Total mg/l																								
	Hardness as CaCO3, Total mg/l											~													
	Chloride, Total mg/l			**		**	**	**	**	**		**	**	**	**	**	**	**	~	**	**	**	**		**
	Specific Conductance µmho/cm			**		**	**	~	**	**	**	**	**	**	**	~	**	**	~	~	~	**	~		
	Total Dissolved Solids (TDS) mg/l																								
	Total Suspended Solids (TSS) mg/l																								
	Turbidity NTU																								

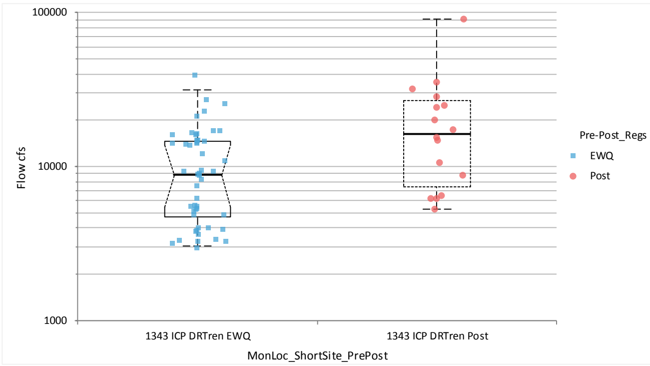
KEY: (blue) = No indication of measurable change to EWQ; ** = Indication of measurable water quality change toward more degraded status; ~ = Weak indication of measurable water quality change toward more degraded status

Chapter 1: 1343 ICP Delaware River at Trenton/Morrisville, NJ/PA



1343 ICP
Delaware River at Calhoun Street Bridge, Trenton

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



N | 66

Flow cfs by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1343 ICP DRTren EWQ	2,918	4,688	8,847	14,521	38,824	9,833
1343 ICP DRTren Post	5,270	7,440	16,350	26,925	90,900	19,485

Kruskal-Wallis test

Flow cfs by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1343 ICP DRTren EWQ	50	729.6	14.59
1343 ICP DRTren Post	16	2280.1	142.50

H statistic	8.17
X^2 approximation	8.17
DF	1
p-value	0.0043 [1]

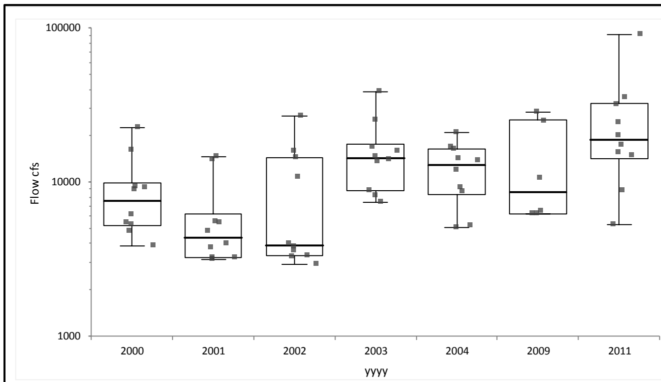
H0: $\theta_1 = \theta_2 = \theta$...
The median of the populations are all equal.
H1: $\theta_i \neq \theta_j$ for at least one i,j
The median of the populations are not all equal.
[1] Reject the null hypothesis in favour of the alternative hypothesis at the 5% significance level.

Flow was higher in the post-EWQ period at this location. EWQ flow was slightly below normal for the May to September period and post-EWQ flow was generally above-normal. For flow-related parameters, this difference can lead to misinterpretation of results, so comparisons are carefully reviewed, especially in cases where statistical differences are significant. Flow is plotted on a logarithmic scale.

Upstream ICP: Del. River at Washington Crossing
Downstream ICP: None. This is the southern terminus of the DRBC Special Protection Waters region. At the geological fall line just below Calhoun Street Bridge, is the freshwater tidal portion of the Delaware River (DRBC Water Quality Zone 2).

Tributary BCP Watersheds in Upstream Reach:

None. All tributaries are less than 20 square miles drainage area and are expected to exert minimal water quality influence upon the Delaware River. These small tributaries are infrequently monitored.



N | 66

Flow cfs by yyyy	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
2000	3,833	5,231	7,501	9,905	22,722	4,675
2001	3,161	3,253	4,364	6,221	14,515	2,968
2002	2,918	3,312	3,868	14,443	26,718	11,131
2003	7,386	8,763	14,243	17,545	38,824	8,782
2004	5,070	8,322	12,857	16,525	21,104	8,203
2009	6,170	6,170	8,545	25,275	28,300	19,105
2011	5,270	14,298	18,750	32,475	90,900	18,178

Annual flow statistics are plotted above. Note that no samples were taken in the dry 2010 season due to closure of the Calhoun Street Bridge. This is why post-EWQ data were not representative of flow conditions. Post-EWQ data were also insufficient in the number of samples taken (n=16), which also reduces overall confidence in statistical comparisons between the two periods. Flow statistics are derived from May to September flow measurements associated with the time of each water quality sample. Flow is based on the USGS gage 01463500 at Trenton, NJ. "Normal" May to September flow is about 10,000 cfs at this location on the Delaware River.

Within the data, annual summer flow is below normal to normal for 4 years and above normal for 3 years. When examining annual summer Trenton water quality statistics between the EWQ and post-EWQ periods, post-EWQ water quality is likely most comparable to EWQ 2003-2004 data when flow was above normal.

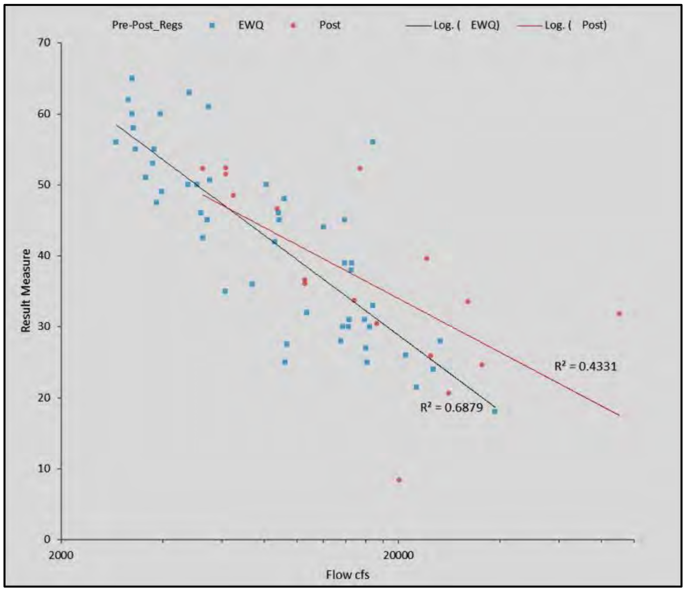
This location is also monitored by NJDEP (USGS) and PADEP. Those data are not included in DRBC's analyses, but were held back as confirmatory data for significant results found by DRBC. The state/USGS programs generally monitor quarterly for long-term water quality changes. DRBC's monitoring design is more intensive and less long-term, taking 5 to 10 samples each May-September season depending on the sampling location.

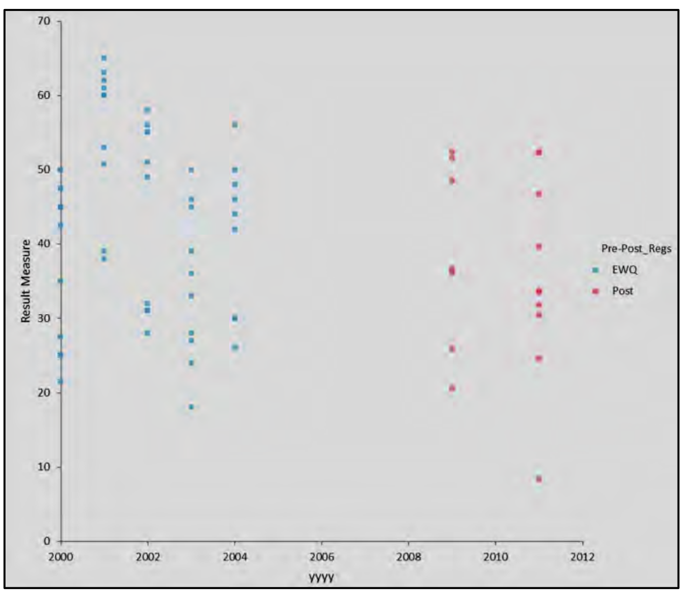
Chapter 1: 1343 ICP Delaware River at Trenton, NJ

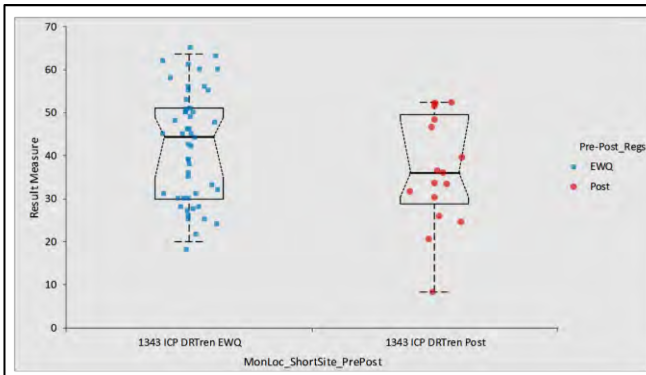
Alkalinity as CaCO3, Total mg/l

Existing Water Quality:

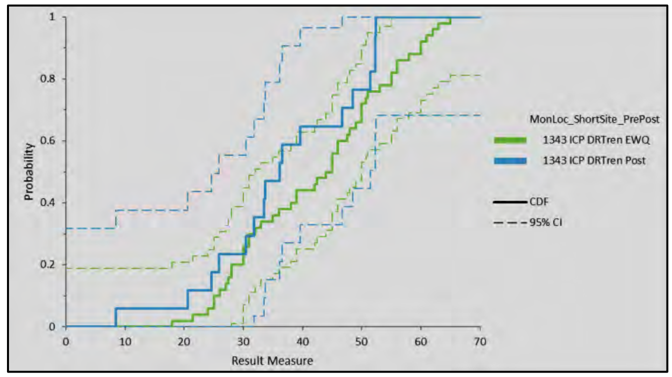
Median 45 mg/l
Lower 95% Confidence Interval 36 mg/l
Upper 95% Confidence Interval 50 mg/l
Defined in regulations as a flow-related parameter







Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
N	67					
1343 ICP DRTren EWQ	18.0	30.0	44.5	51.2	65.0	21.2
1343 ICP DRTren Post	8.4	28.9	36.1	49.5	52.4	20.6



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1343 ICP DRTren EWQ	50	128.0	2.56
1343 ICP DRTren Post	17	376.5	22.15

H statistic	1.33
X^2 approximation	1.33
DF	1
p-value	0.2489 [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.

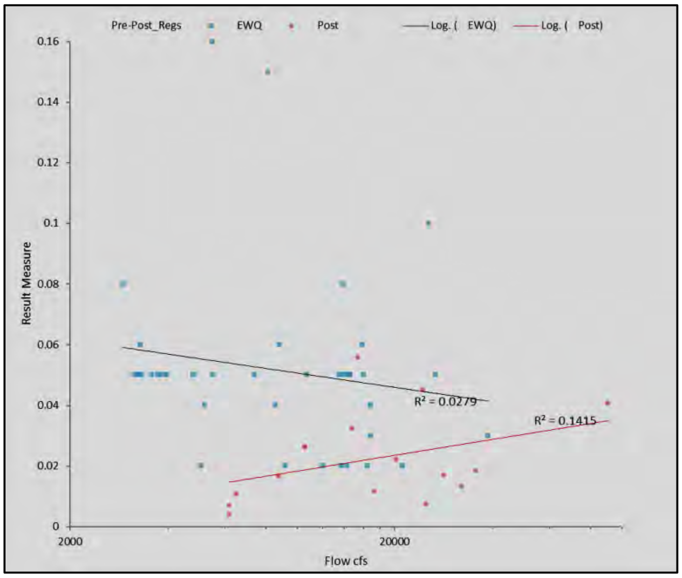
No water quality degradation is indicated. Alkalinity concentrations appear to decline between the EWQ and post-EWQ periods, but the post-EWQ samples were taken under generally higher flow conditions and do not differ statistically. However, potential laboratory artifacts and insufficient post-EWQ sampling (n=17) introduced analytical uncertainty. Alkalinity is inversely related to flow. No 2010 samples were taken at this site due to bridge closure. As 2010 was a dry year, such dry-weather samples are under-represented in the post-EWQ data set. Note that flow is plotted on a logarithmic scale.

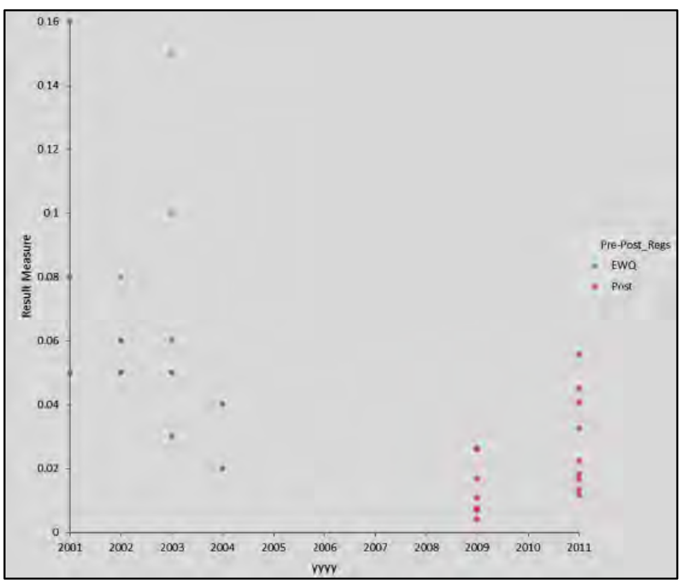
Chapter 1: 1343 ICP Delaware River at Trenton, NJ

Ammonia Nitrogen as N, Total mg/l

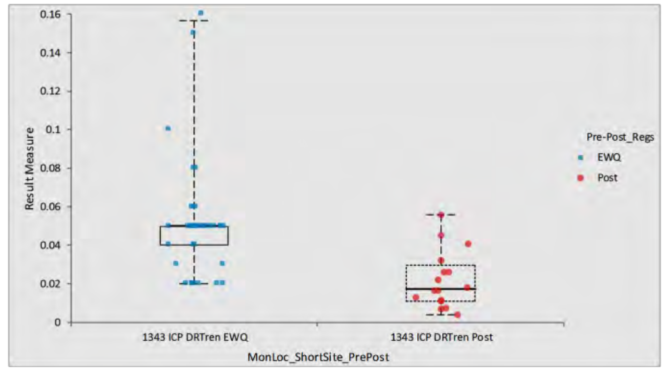
Existing Water Quality:

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





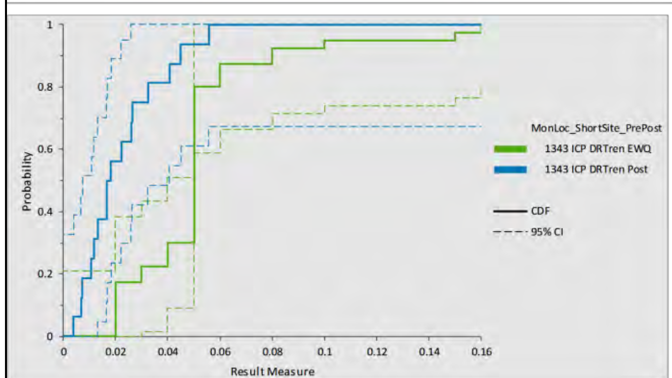
No water quality degradation is indicated. Ammonia concentrations appeared to decline, though detection limit differences, flow differences, insufficient post-EWQ sampling (n=16) and potential laboratory artifacts produced analytical uncertainty. No 2010 samples were taken at this site due to bridge closure.



N 56

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1343 ICP DRTren EWQ	0.0200	0.0400	0.0500	0.0500	0.1600	0.0100
1343 ICP DRTren Post	0.0040	0.0112	0.0176	0.0299	0.0557	0.0187

Cumulative Distribution Function



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1343 ICP DRTren EWQ	40	1368.9	34.22
1343 ICP DRTren Post	16	3422.3	213.89

H statistic	18.91
X^2 approximation	18.91
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.

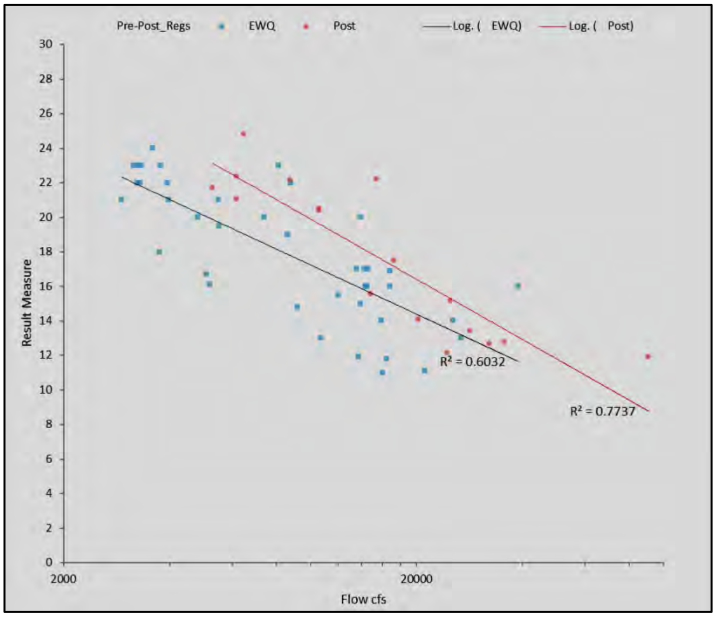
Ammonia is unrelated to flow in both data sets. No declining trend was found in independent USGS, PADEP or NJDEP data. EWQ data contained 29/40 undetected results that interfered with estimates of the median and its confidence intervals. Thus all we could determine about ammonia was that concentrations were known to be <0.05 mg/l. There were no undetected results in the post-EWQ samples. However, some water quality improvement might have occurred, in that there were no post-EWQ values over 0.056 mg/l.

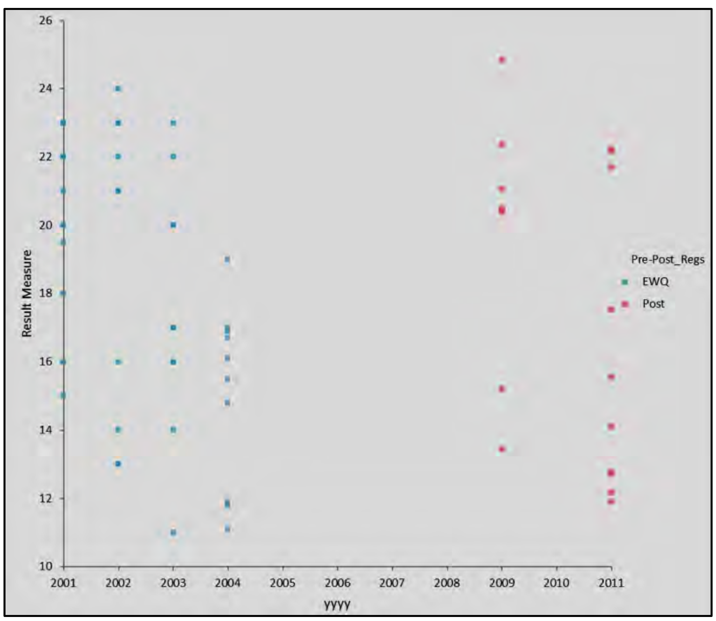
Chapter 1: 1343 ICP Delaware River at Trenton, NJ

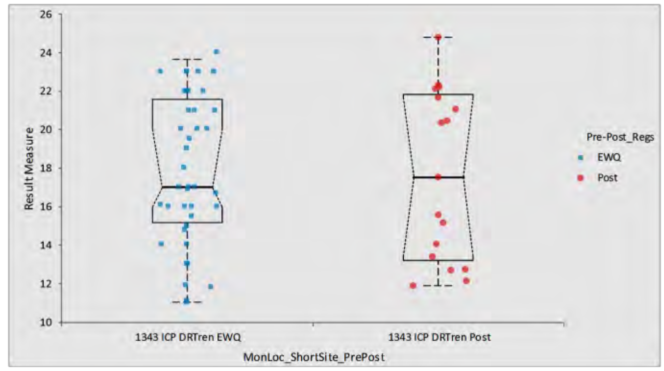
Chloride, Total mg/l

Existing Water Quality:

Median 17 mg/l
Lower 95% Confidence Interval 16 mg/l
Upper 95% Confidence Interval 21 mg/l
Defined in regulations as a flow-related parameter



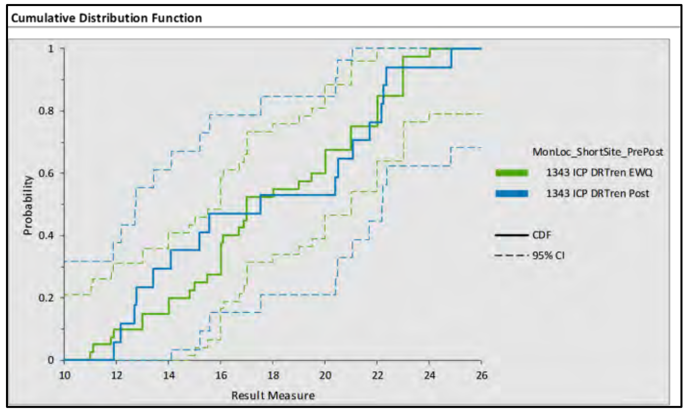




N	57

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1343 ICP DRTren EWQ	11.0	15.2	17.0	21.6	24.0	6.4
1343 ICP DRTren Post	11.9	13.2	17.5	21.9	24.8	8.6

Cumulative Distribution Function



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1343 ICP DRTren EWQ	40	3.6	0.09
1343 ICP DRTren Post	17	8.5	0.50

H statistic	0.04
X^2 approximation	0.04
DF	1
p-value	0.8341[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.

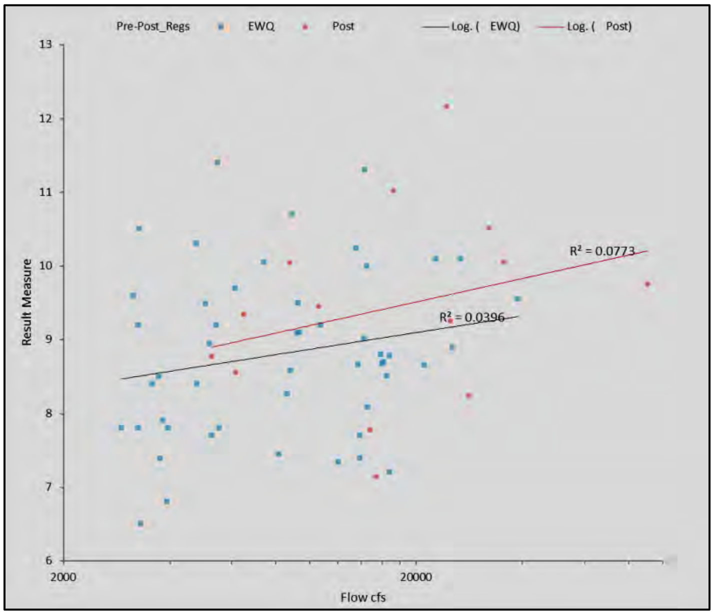
Some evidence of water quality degradation is indicated, though chloride concentrations apparently did not change between the two periods. Flow differences, insufficient post-EWQ sampling (n=16) and potential laboratory artifacts produced analytical uncertainty. Chloride is inversely related to flow. No 2010 samples were taken due to bridge closure. If more post-EWQ samples were taken, and if post-EWQ data were more representative of low-flow conditions, there might have been a significant rise in chlorides. On the first graph of concentrations vs. flow, the rise in concentrations appears to be approximately 1 to 3 mg/l.

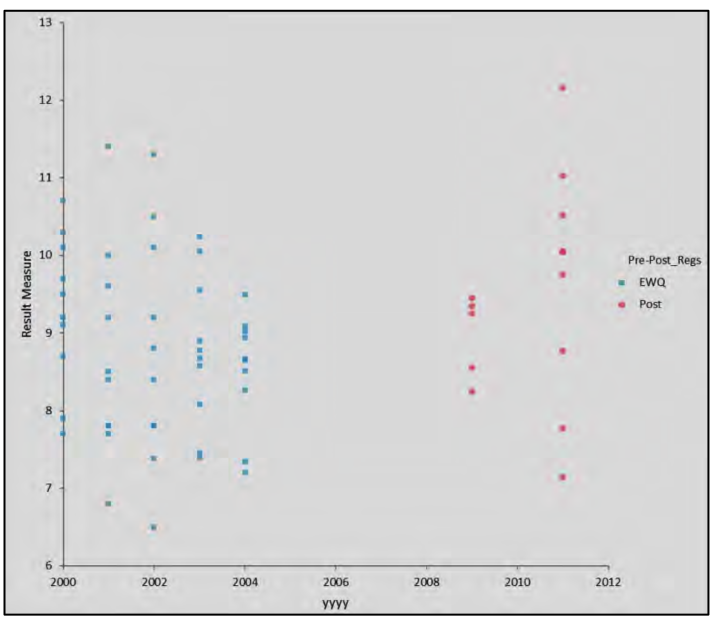
Chapter 1: 1343 ICP Delaware River at Trenton, NJ

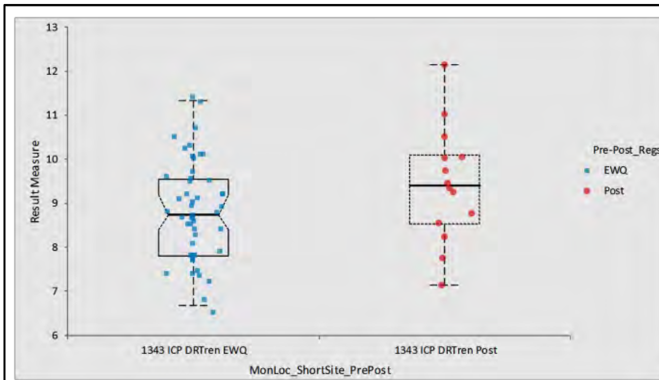
Dissolved Oxygen (DO) mg/l

Existing Water Quality:

Median 8.74 mg/l
Lower 95% Confidence Interval 8.40 mg/l
Upper 95% Confidence Interval 9.20 mg/l

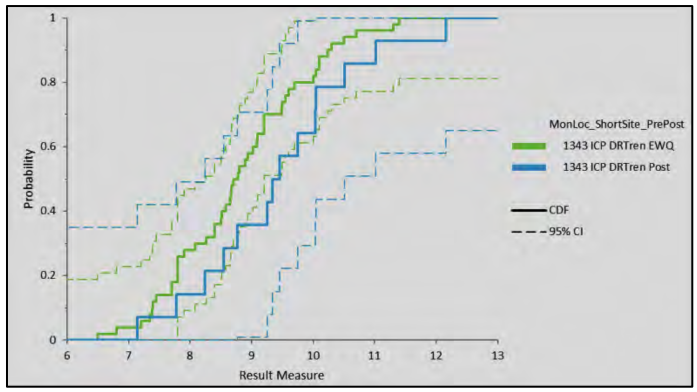






N 64

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1343 ICP DRTren EWQ	6.50	7.800	8.740	9.554	11.40	1.754
1343 ICP DRTren Post	7.14	8.524	9.395	10.088	12.16	1.564



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1343 ICP DRTren EWQ	50	174.8	3.50
1343 ICP DRTren Post	14	624.4	44.60

H statistic	2.31
X^2 approximation	2.31
DF	1
p-value	0.1288[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.

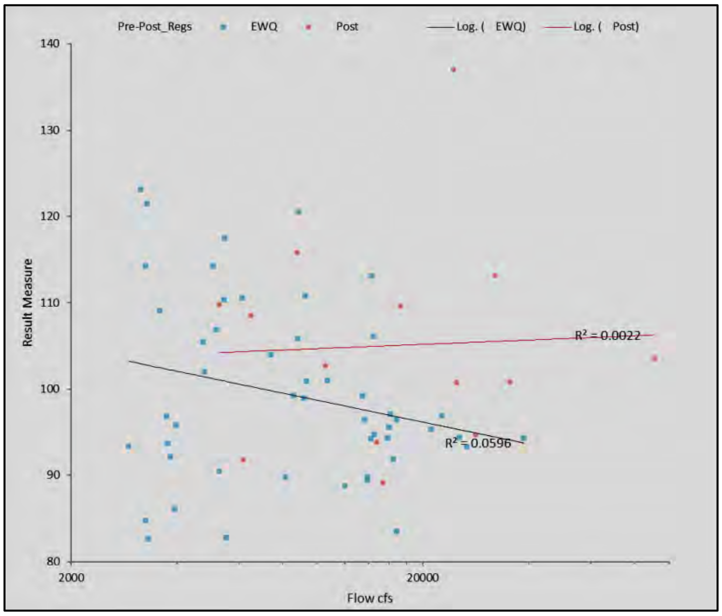
Dissolved Oxygen (DO) concentration is unrelated to flow. No measurable change took place between the EWQ and Post-EWQ periods. Median post-EWQ DO concentration was above the EWQ upper 95% confidence interval, but there were an insufficient number of post-EWQ samples taken to detect a significant change. Such a change would constitute a water quality improvement in any case. No 2010 samples were taken due to bridge closure. Daily DO ranges widely at this location due to growth of aquatic plants and algae (primary production). Values shown best represent mid-day concentrations, when DO is typically at or near its maximum daily value.

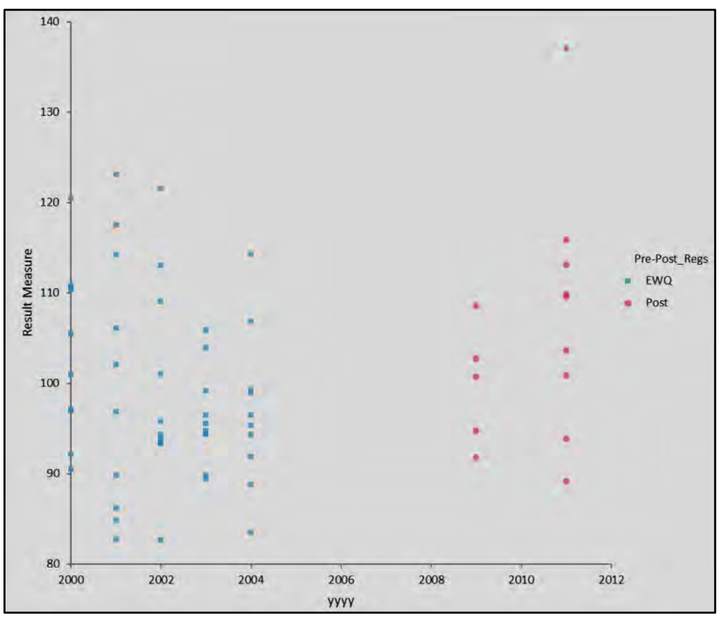
Chapter 1: 1343 ICP Delaware River at Trenton, NJ

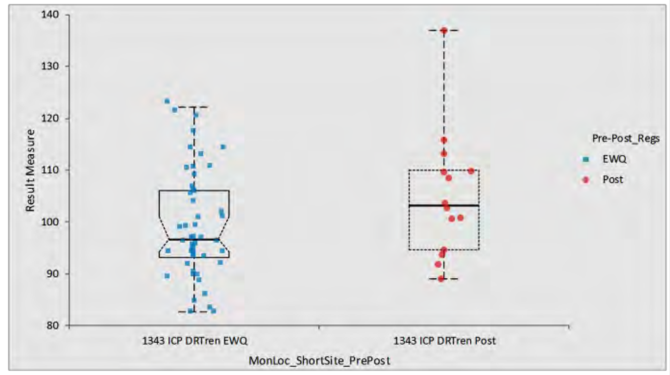
Dissolved Oxygen Saturation %

Existing Water Quality:

Median 97%
Lower 95% Confidence Interval 94%
Upper 95% Confidence Interval 101%

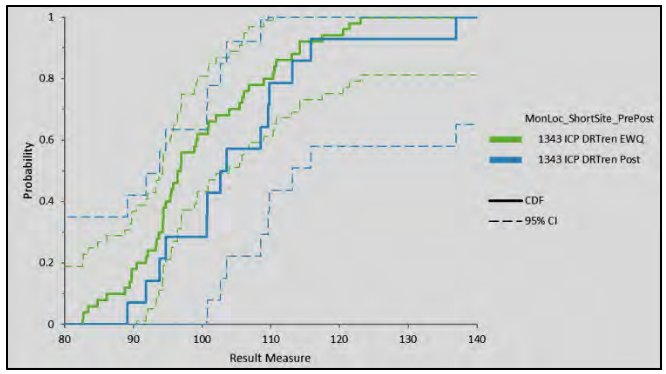






N 64

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1343 ICP DRTren EWQ	82.60	93.192	96.634	106.128	123.07	12.936
1343 ICP DRTren Post	89.10	94.625	103.150	110.075	137.00	15.450



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1343 ICP DRTren EWQ	50	158.4	3.17
1343 ICP DRTren Post	14	565.8	40.41

H statistic	2.09
X^2 approximation	2.09
DF	1
p-value	0.1484 [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.

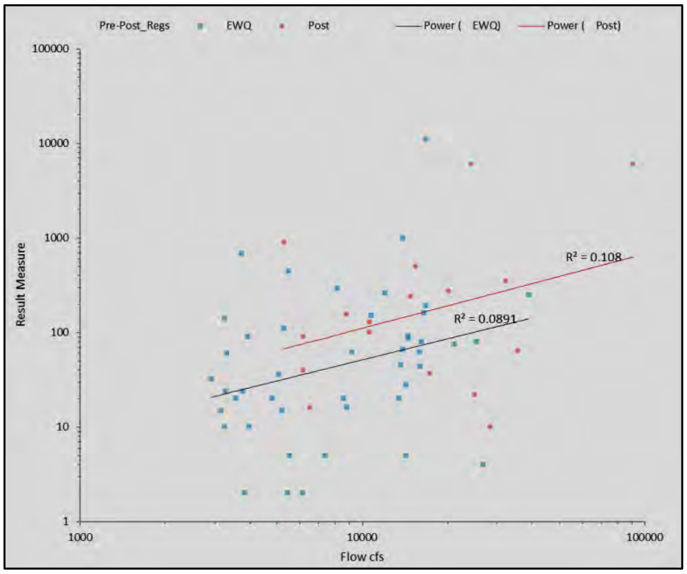
Dissolved Oxygen Saturation is unrelated to flow, and did not measurably change between the EWQ and post-EWQ periods. No 2010 samples were taken at this site due to bridge closure. As a rule-of-thumb, saturation values greater than 120% indicated super-saturation conditions, usually produced by very high algae and aquatic plant activity.

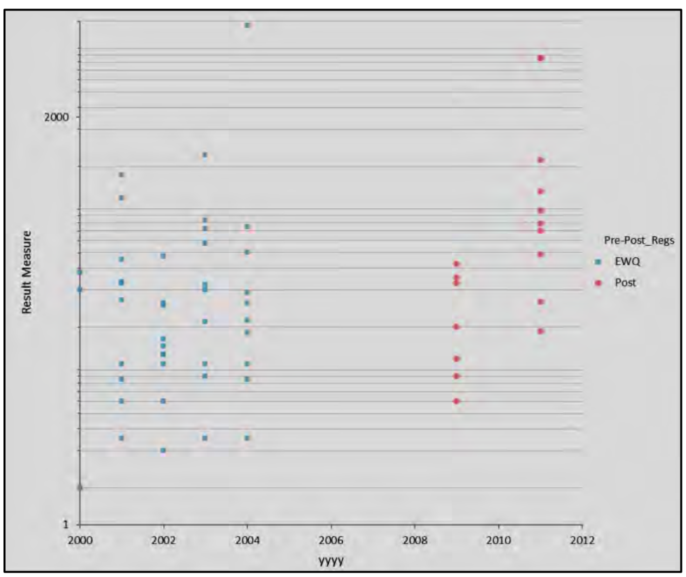
Chapter 1: 1343 ICP Delaware River at Trenton, NJ

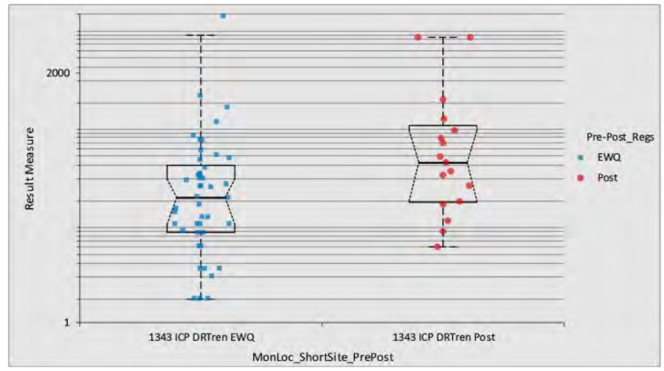
Enterococcus colonies/100 ml

Existing Water Quality:

Median 45/100 ml
Lower 95% Confidence Interval 20/100 ml
Upper 95% Confidence Interval 80/100 ml

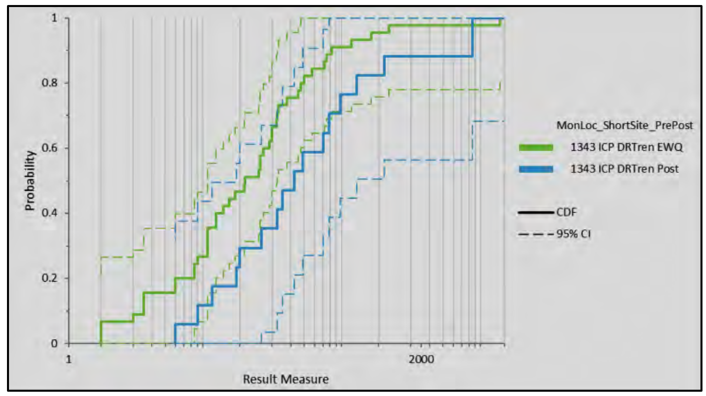






N | 62

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1343 ICP DRTren EWQ	2.00	15.667	45.000	120.000	11000.00	104.333
1343 ICP DRTren Post	10.00	39.000	130.000	400.000	6000.00	361.000



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1343 ICP DRTren EWQ	45	483.5	10.74
1343 ICP DRTren Post	17	1279.8	75.28

H statistic	5.42
X^2 approximation	5.42
DF	1
p-value	0.0199 [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.

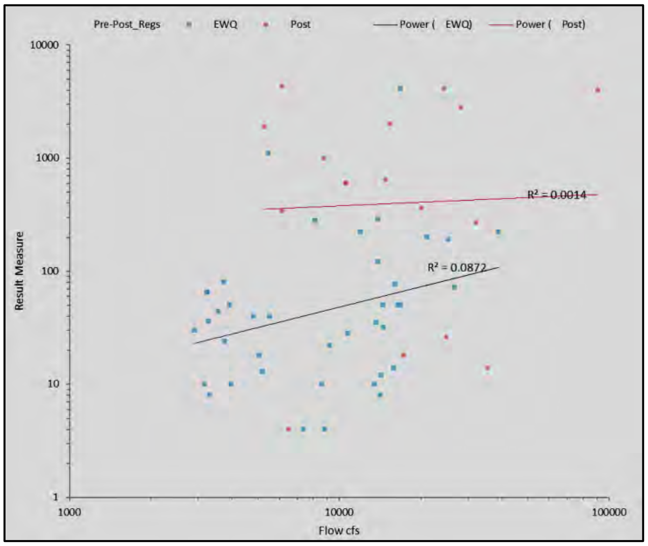
Enterococci apparently rose between the EWQ and Post-EWQ periods. Flow differences, insufficient post-EWQ sampling (n=17) and potential laboratory artifacts produced analytical uncertainty. No 2010 samples were available, as the bridge was closed that summer. Enterococcus concentration is unrelated to flow in both data sets. Note that concentrations are plotted on a logarithmic scale.

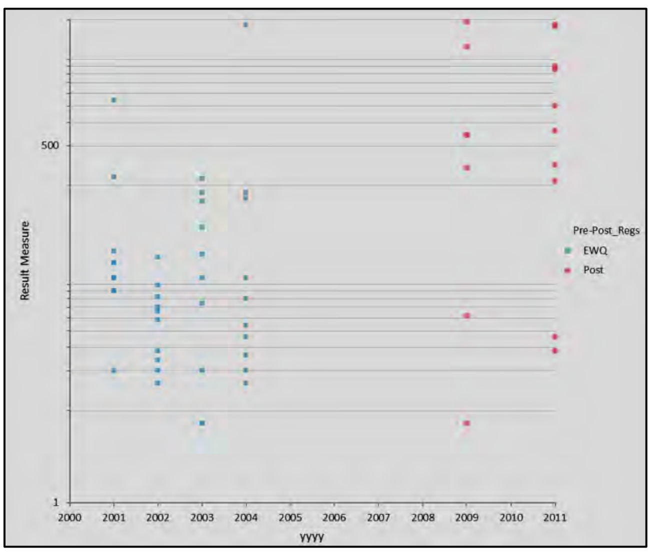
Chapter 1: 1343 ICP Delaware River at Trenton, NJ

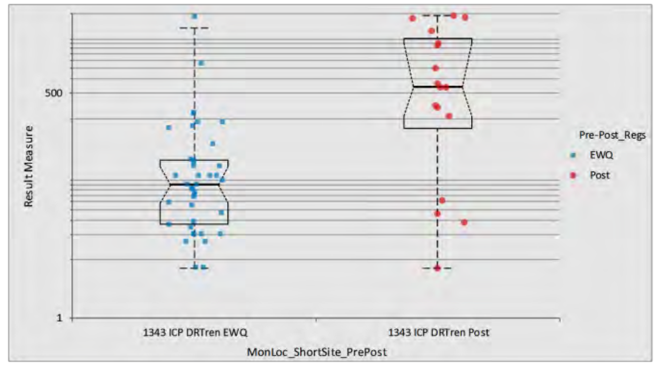
Escherichia coli colonies/100 ml

Existing Water Quality:

Median 40/100 ml
Lower 95% Confidence Interval 24/100 ml
Upper 95% Confidence Interval 65/100 ml

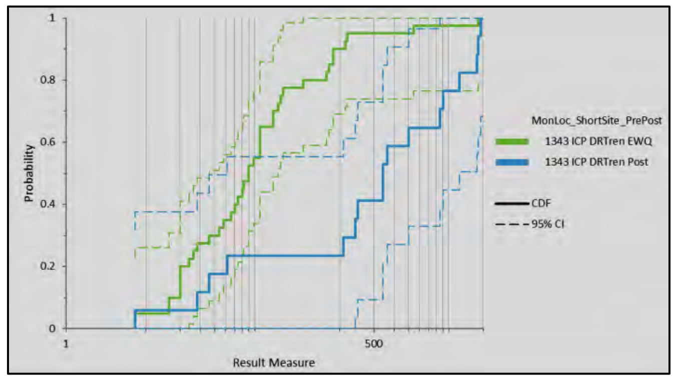






N 57

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1343 ICP DRTren EWQ	4	13	40	78	4100	65
1343 ICP DRTren Post	4	189	600	2267	4300	2078



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1343 ICP DRTren EWQ	40	965.3	24.13
1343 ICP DRTren Post	17	2271.3	133.61

H statistic	11.76
X^2 approximation	11.76
DF	1
p-value	0.0006 [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.

Some evidence of water quality degradation is indicated. E. coli concentrations apparently rose between the two periods. Flow differences, insufficient post-EWQ sampling (n=17) and potential laboratory artifacts produced analytical uncertainty. No 2010 dry-weather samples were available due to bridge closure.

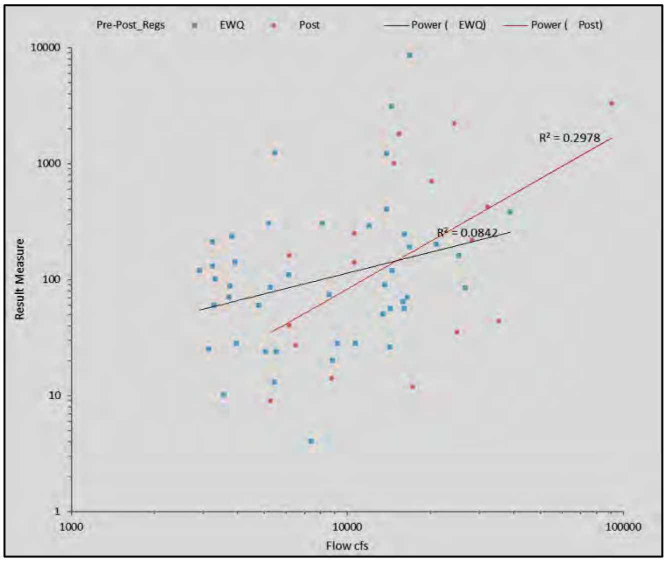
Flow and concentrations are plotted on a logarithmic scale; regressions are power relationships. USGS, PADEP and NJDEP data were tested to confirm DRBC's result of significant rise in E. coli. Baseline EWQ concentrations were confirmed by independent data, establishing that DRBC's baseline is reasonable. However, the significant 2009-2011 increase found by DRBC was not confirmed by independent data. Confidence of an increase is low because of low N, high variability, and flow differences.

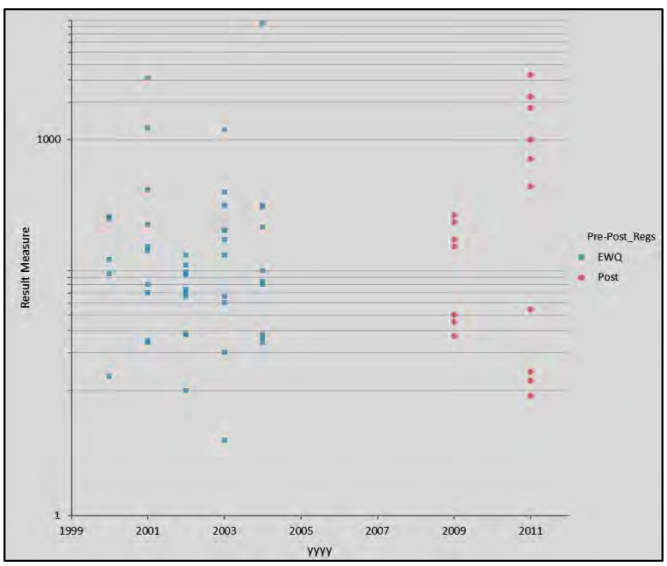
Chapter 1: 1343 ICP Delaware River at Trenton, NJ

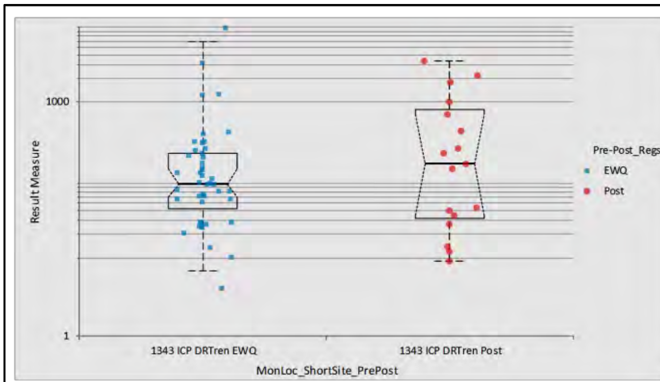
Fecal coliform colonies/100 ml

Existing Water Quality:

Median 88/100 ml
Lower 95% Confidence Interval 60/100 ml
Upper 95% Confidence Interval 140/100 ml

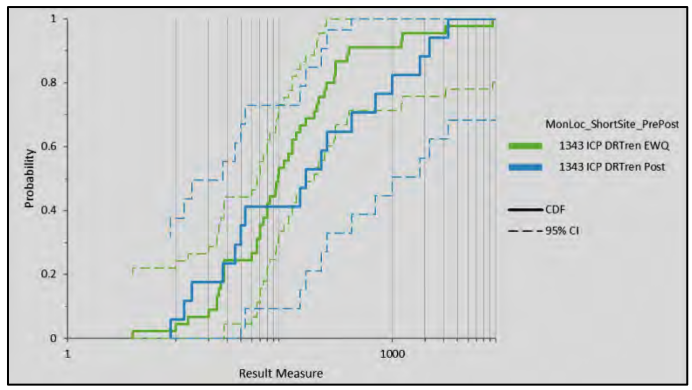






N 62

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1343 ICP DRTren EWQ	4	43	88	218	8500	176
1343 ICP DRTren Post	9	32	160	800	3300	768



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1343 ICP DRTren EWQ	45	50.1	1.11
1343 ICP DRTren Post	17	132.7	7.81

H statistic	0.56
X^2 approximation	0.56
DF	1
p-value	0.4535 [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.

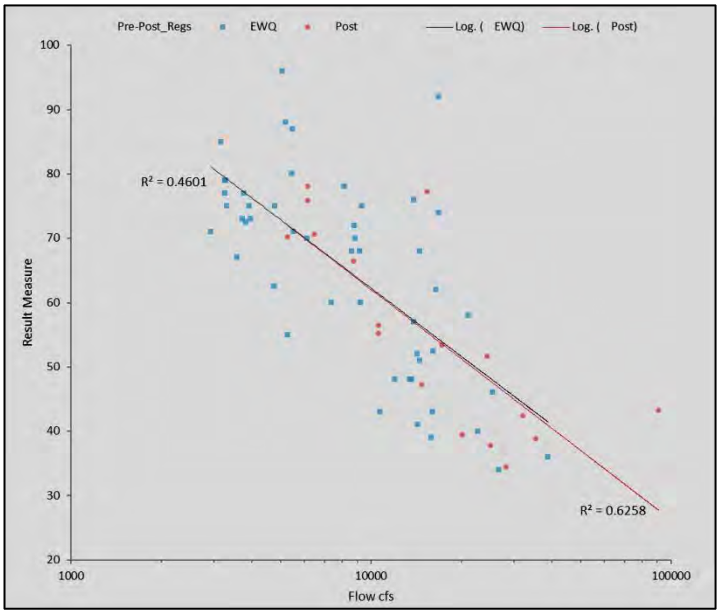
No water quality degradation is indicated. Fecal coliform concentrations did not measurably change between the EWQ and post-EWQ periods. Flow differences, insufficient post-EWQ sampling (n=17) and potential laboratory artifacts produced analytical uncertainty. Post-EWQ fecal coliform concentrations are positively but weakly related to flow. No 2010 samples were collected due to bridge closure.

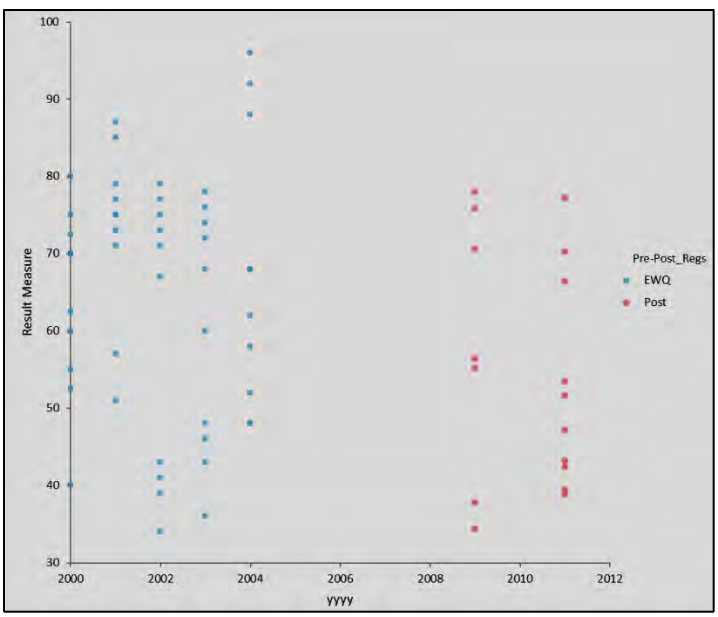
Chapter 1: 1343 ICP Delaware River at Trenton, NJ

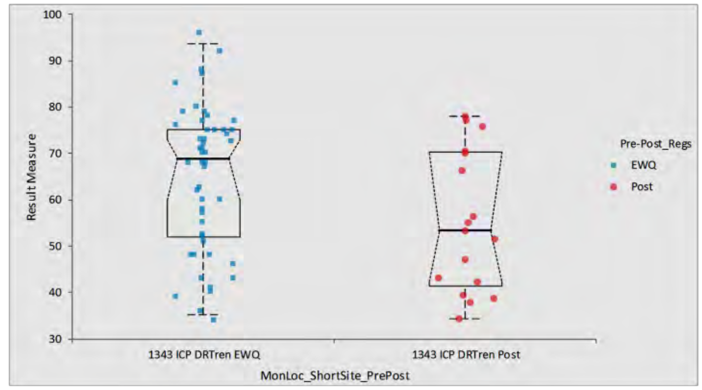
Hardness as CaCO3, Total mg/l

Existing Water Quality:

Median 69 mg/l
Lower 95% Confidence Interval 60 mg/l
Upper 95% Confidence Interval 73 mg/l
Defined in regulations as a flow-related parameter



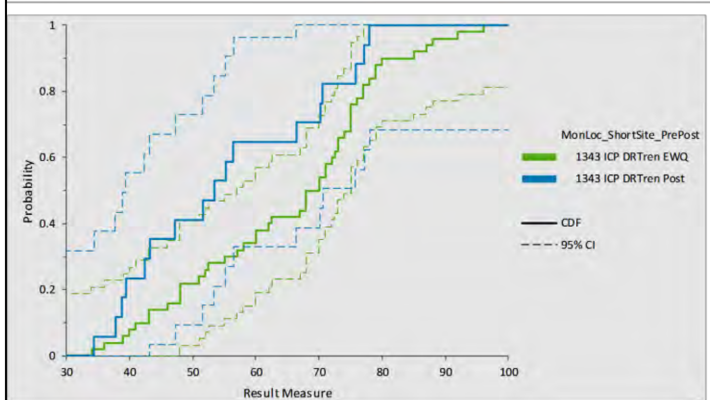




N | 67

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1343 ICP DRTren EWQ	34.0	51.9	69.0	75.1	96.0	23.2
1343 ICP DRTren Post	34.4	41.4	53.4	70.3	78.0	28.9

Cumulative Distribution Function



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1343 ICP DRTren EWQ	50	423.4	8.47
1343 ICP DRTren Post	17	1245.3	73.25

H statistic	4.40
X^2 approximation	4.40
DF	1
p-value	0.0360[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.

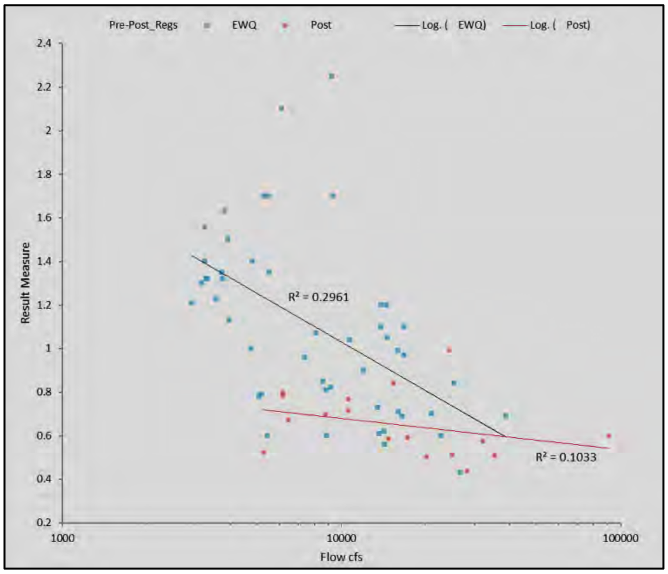
No water quality degradation is indicated. Hardness appeared to decline between the EWQ and post-EWQ periods. Flow differences, insufficient post-EWQ sampling (n=17) and potential laboratory artifacts produced analytical uncertainty. Hardness is inversely related to flow. No 2010 samples were taken at this location due to bridge closure. If more post-EWQ samples were taken under low flow conditions, there probably would have been no change in hardness.

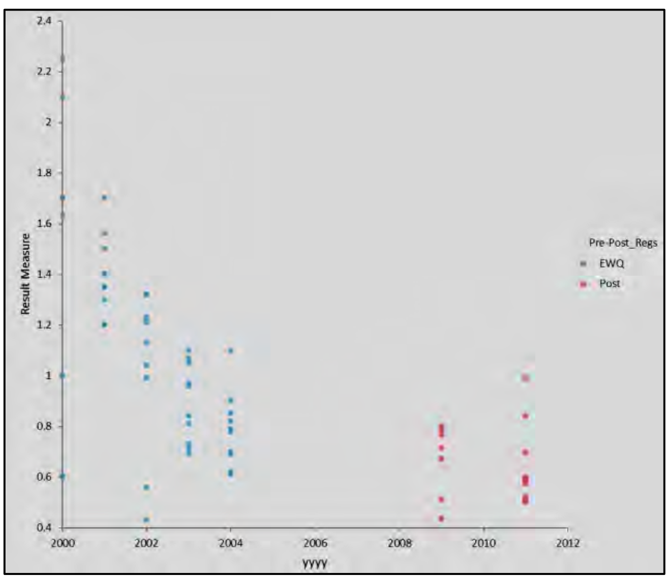
Chapter 1: 1343 ICP Delaware River at Trenton, NJ

Nitrate + Nitrite as N, Total mg/l

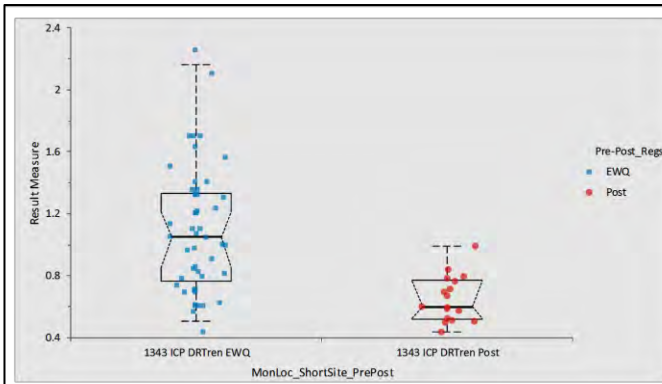
Existing Water Quality (as Nitrate only):

Median 1.05 mg/l
Lower 95% Confidence Interval 0.85 mg/l
Upper 95% Confidence Interval 1.21 mg/l



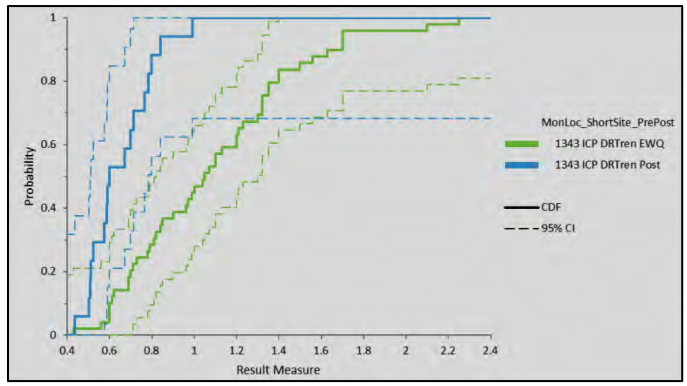


No water quality degradation is indicated. Nitrate concentrations apparently declined between the EWQ and post-EWQ periods, but differences in flow, detection limits, laboratory artifacts, and low post-EWQ N produced analytical uncertainty. EWQ nitrate was inversely but weakly related to flow.



N 66

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1343 ICP DRTren EWQ	0.430	0.763	1.050	1.330	2.250	0.567
1343 ICP DRTren Post	0.436	0.520	0.598	0.772	0.991	0.252



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1343 ICP DRTren EWQ	49	1818.4	37.11
1343 ICP DRTren Post	17	5241.3	308.31

H statistic	19.16
X^2 approximation	19.16
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.

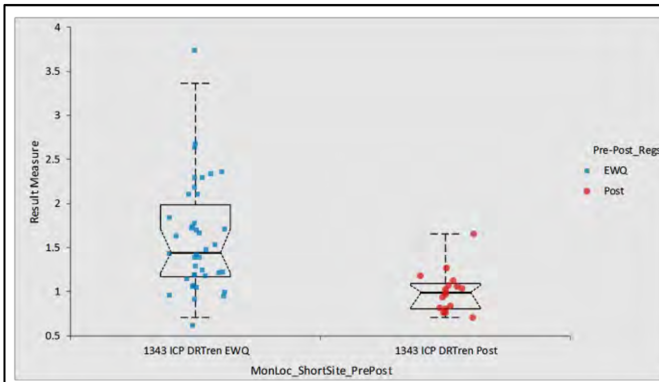
Post-EWQ nitrate + nitrite are not related to flow, though there is a single influential data point taken during flood conditions that drives the regression; as well as too few low-flow samples. 2010 samples were not taken due to bridge closure. Independent USGS and PADEP data were analyzed to validate DRBC results, but the decline could not be confirmed. Both data sets exhibited more variability in the EWQ period than the post-EWQ period. The early portion of DRBC EWQ data showed higher concentrations than both DRBC post-EWQ data and the independent data. DRBC 2003-2011 and USGS/PADEP independent data were very similar.

Chapter 1: 1343 ICP Delaware River at Trenton, NJ

Nitrogen as N, Total (TN) mg/l

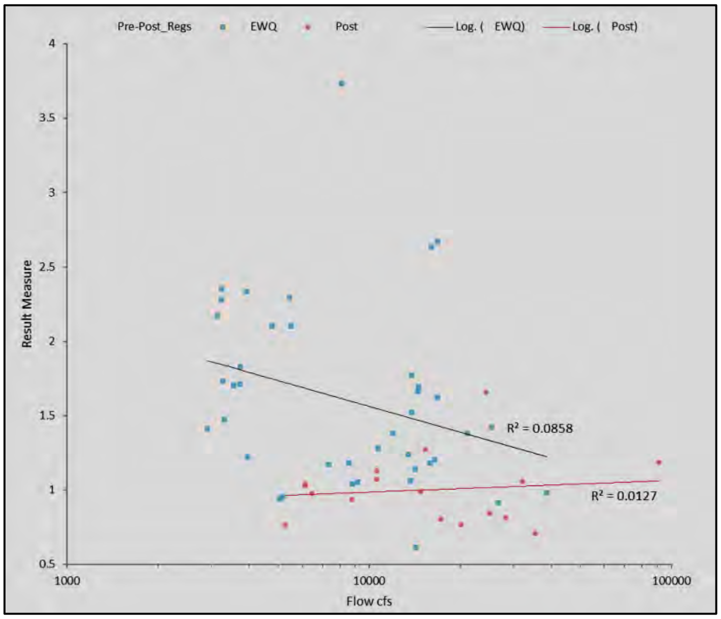
Existing Water Quality:

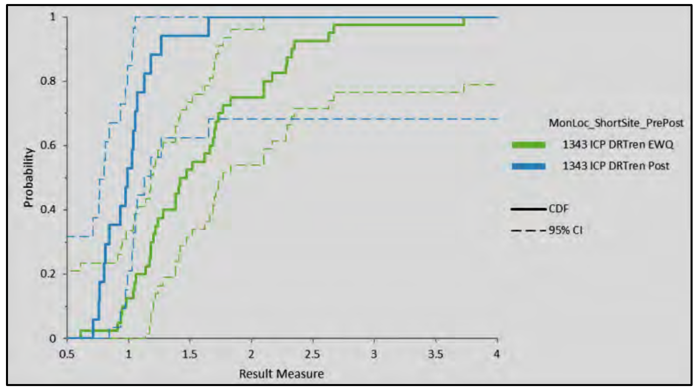
Median 1.45 mg/l
Lower 95% Confidence Interval 1.22 mg/l
Upper 95% Confidence Interval 1.71 mg/l

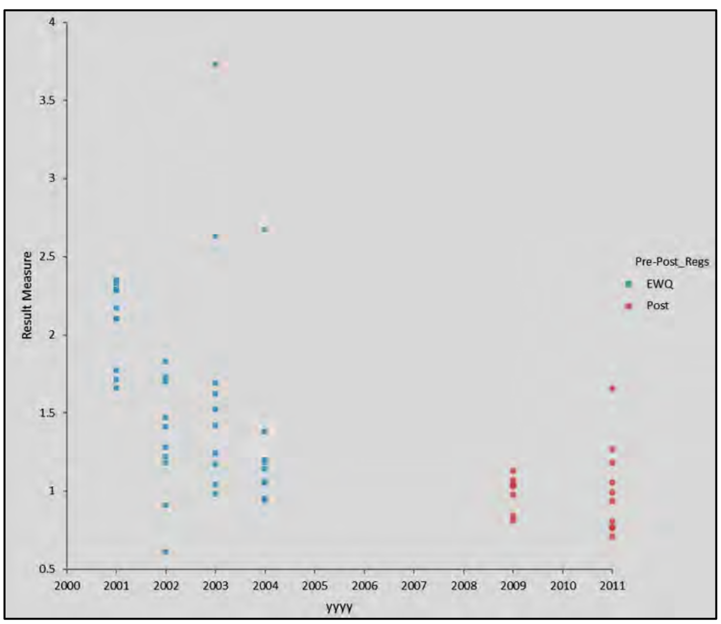


N | 57

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1343 ICP DRTren EWQ	0.610	1.174	1.445	1.988	3.730	0.813
1343 ICP DRTren Post	0.709	0.810	0.989	1.089	1.654	0.279







Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1343 ICP DRTren EWQ	40	1434.0	35.85
1343 ICP DRTren Post	17	3374.1	198.48

H statistic	17.45
X^2 approximation	17.45
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.

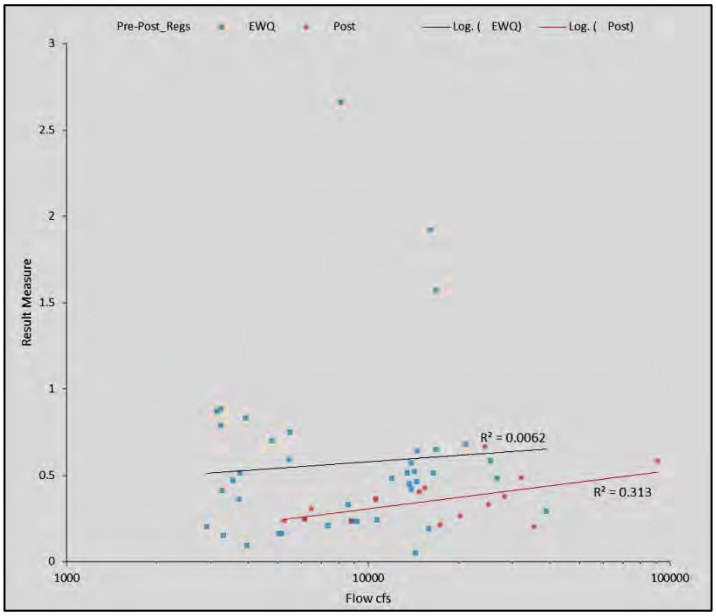
No water quality degradation is indicated. Total Nitrogen concentrations apparently declined between the EWQ and post-EWQ periods, but differences in flow, detection limits, potential laboratory artifacts, and low post-EWQ N produced analytical uncertainty. TN is unrelated to flow in both periods. The EWQ data overall are far more variable than the post-EWQ data. No 2010 samples were taken due to bridge closure. Independent PADEP and USGS data did not display the same decline, thus the DRBC results could not be independently validated.

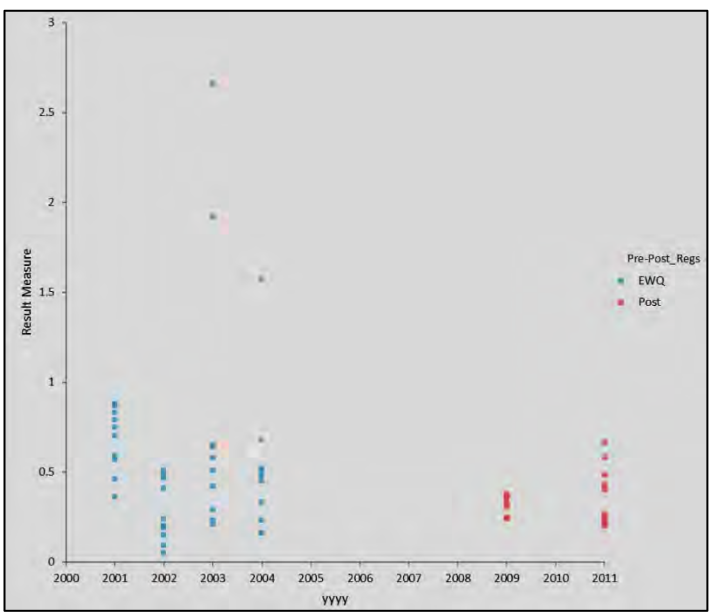
Chapter 1: 1343 ICP Delaware River at Trenton, NJ

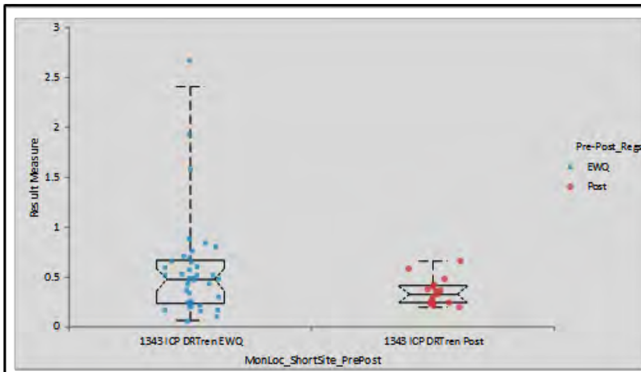
Nitrogen, Kjeldahl as N, Total (TKN) mg/l

Existing Water Quality:

Median 0.48 mg/l
Lower 95% Confidence Interval 0.36 mg/l
Upper 95% Confidence Interval 0.58 mg/l

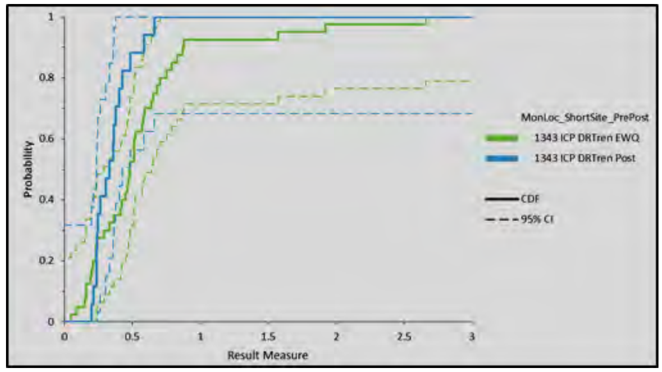






N 57

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1343 ICP DRTren EWQ	0.0500	0.23417	0.48000	0.66750	2.6600	0.43333
1343 ICP DRTren Post	0.2010	0.24033	0.32880	0.41057	0.6631	0.17023



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1343 ICP DRTren EWQ	40	245.0	6.13
1343 ICP DRTren Post	17	576.5	33.91

H statistic	2.98
X^2 approximation	2.98
DF	1
p-value	0.0842 [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.

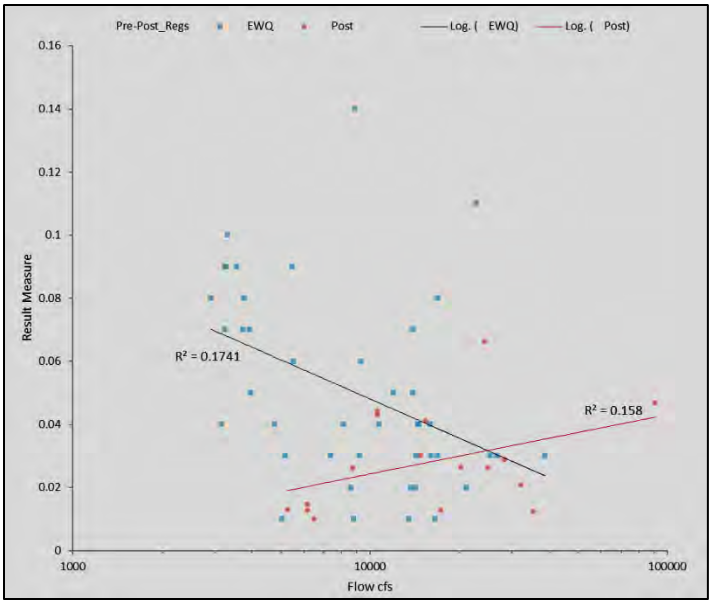
No measurable change occurred in TKN concentrations between the EWQ and post-EWQ periods. Flow differences, insufficient post-EWQ sampling (n=17) and potential laboratory artifacts produced analytical uncertainty. TKN concentration is unrelated to flow in both data sets. No 2010 samples were taken due to bridge closure.

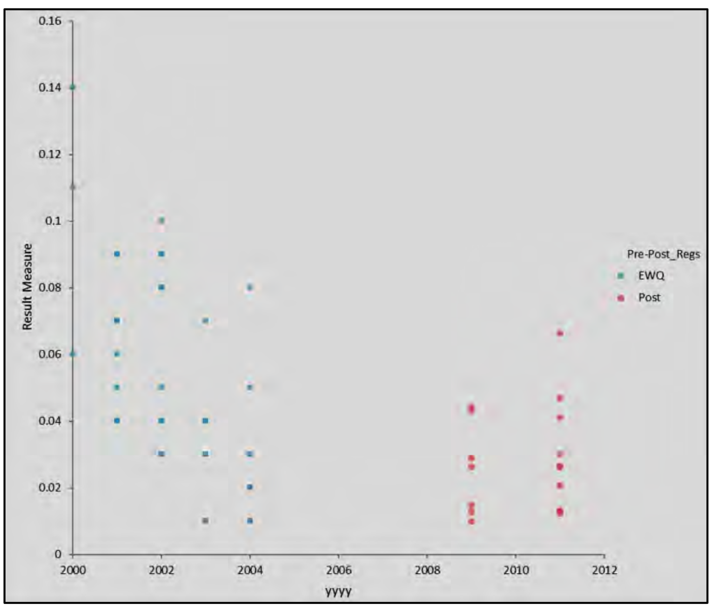
Chapter 1: 1343 ICP Delaware River at Trenton, NJ

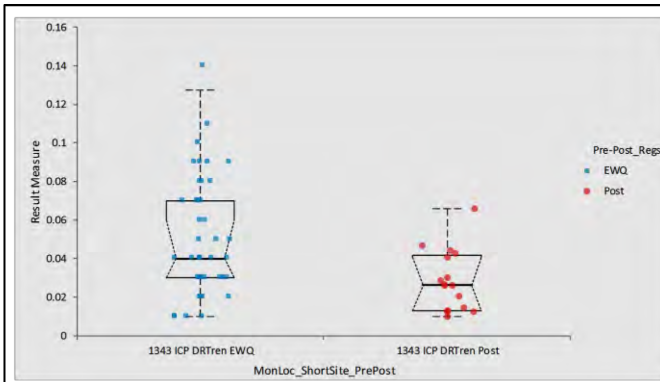
Orthophosphate as P, Total mg/l (OP)

Existing Water Quality:

Median 0.04 mg/l
Lower 95% Confidence Interval 0.03 mg/l
Upper 95% Confidence Interval 0.06 mg/l

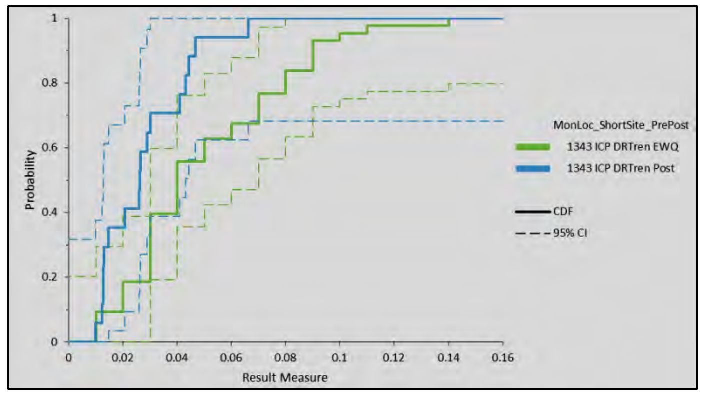






N | 60

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1343 ICP DRTren EWQ	0.010	0.030	0.040	0.070	0.140	0.040
1343 ICP DRTren Post	0.010	0.013	0.026	0.042	0.066	0.029



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1343 ICP DRTren EWQ	43	621.7	14.46
1343 ICP DRTren Post	17	1572.5	92.50

H statistic	7.24
X^2 approximation	7.24
DF	1
p-value	0.0071 [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.

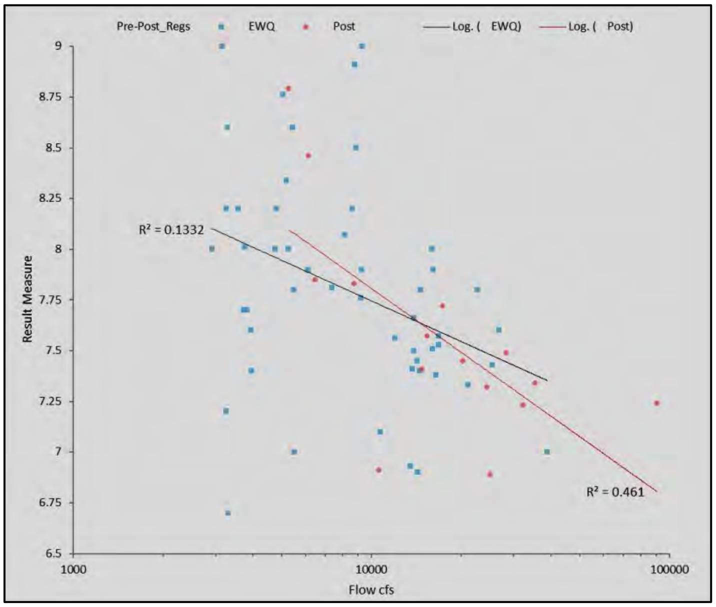
No water quality degradation is indicated. OP apparently declined between the two periods, though differences in flow, detection limits, and low post-EWQ N produced uncertainty. Orthophosphate is unrelated to flow in both data sets. No 2010 samples were collected at this location due to bridge closure. There were too few available independent data to confirm DRBC results, though PADEP concentrations were similar in magnitude and variability throughout both study periods. DRBC detection limits improved between the two periods, so the decline may be influenced by improved laboratory method sensitivity.

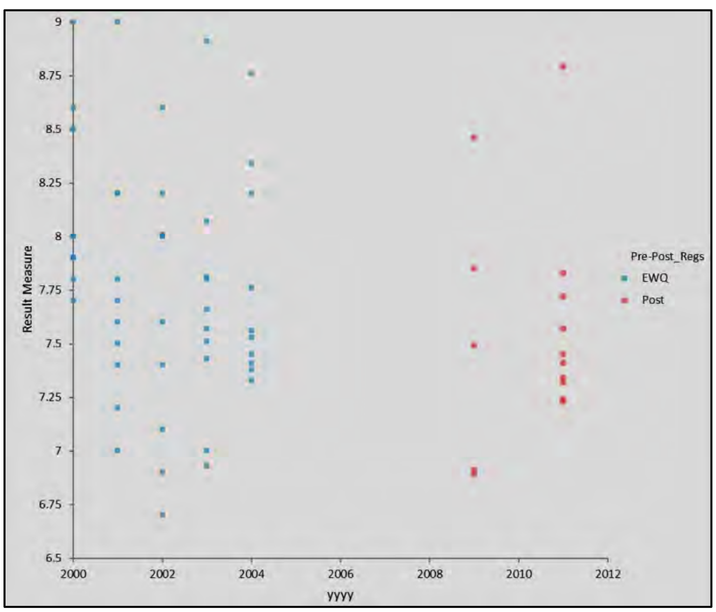
Chapter 1: 1343 ICP Delaware River at Trenton, NJ

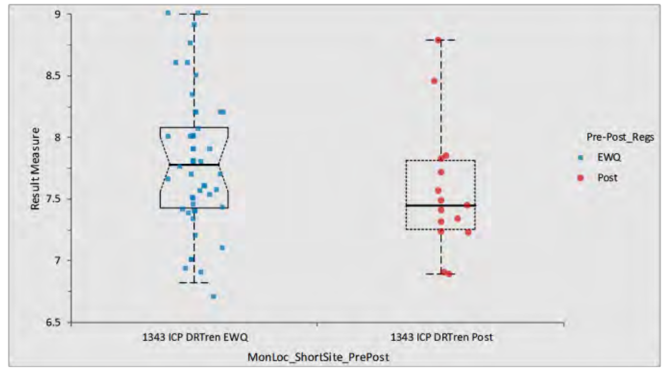
pH, units

Existing Water Quality:

Median 7.78 standard units
Lower 95% Confidence Interval 7.56 standard units
Upper 95% Confidence Interval 8.00 standard units

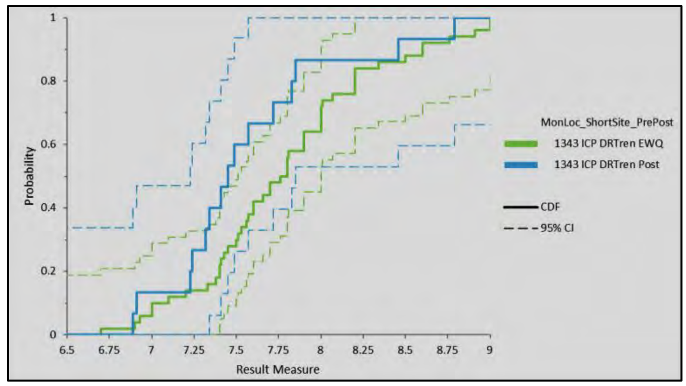






N 65

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1343 ICP DRTren EWQ	6.70	7.43	7.78	8.08	9.00	0.65
1343 ICP DRTren Post	6.89	7.25	7.45	7.81	8.79	0.56



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1343 ICP DRTren EWQ	50	257.6	5.15
1343 ICP DRTren Post	15	858.8	57.25

H statistic	3.13
X^2 approximation	3.13
DF	1
p-value	0.0771 [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 indicated. PH did not measurably change between the EWQ and post-EWQ periods. Under higher flow conditions, pH tends toward neutral. During low flow and high primary productivity periods, pH criteria are frequently exceeded (>9.0 units). No 2010 samples were collected at this location due to bridge closure.

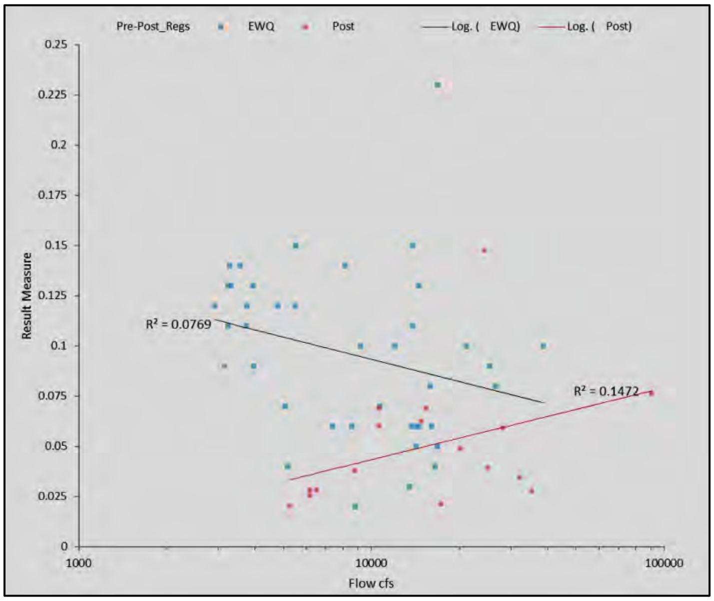
PH is unrelated to flow in the EWQ data, but inversely related to flow in the post-EWQ data. Flow is plotted on a logarithmic scale.

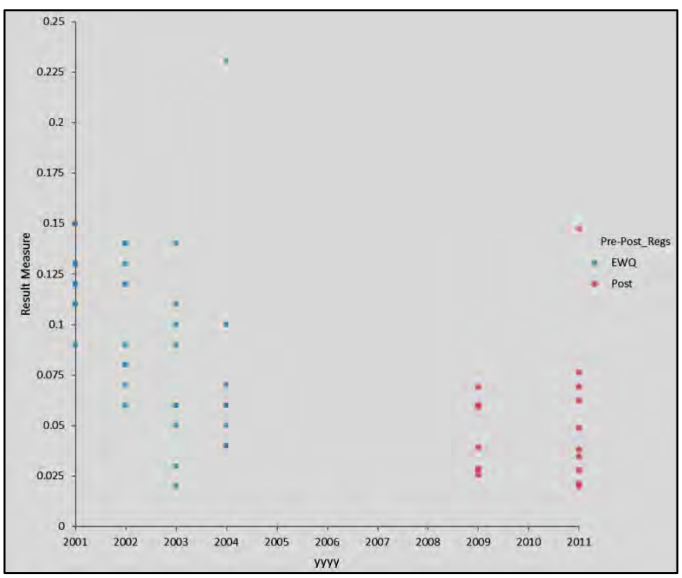
Chapter 1: 1343 ICP Delaware River at Trenton, NJ

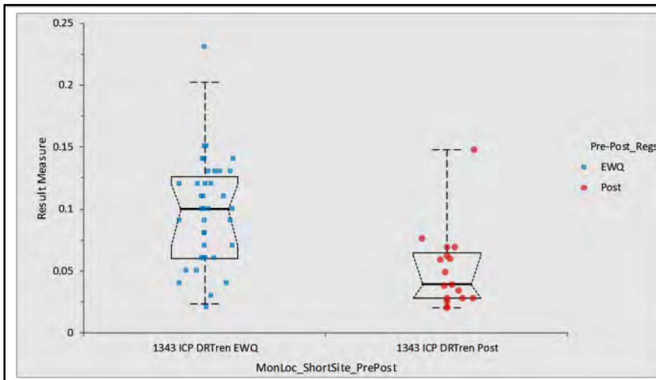
Phosphorus as P, Total (TP) mg/l

Existing Water Quality:

Median 0.10 mg/l
Lower 95% Confidence Interval 0.07 mg/l
Upper 95% Confidence Interval 0.12 mg/l

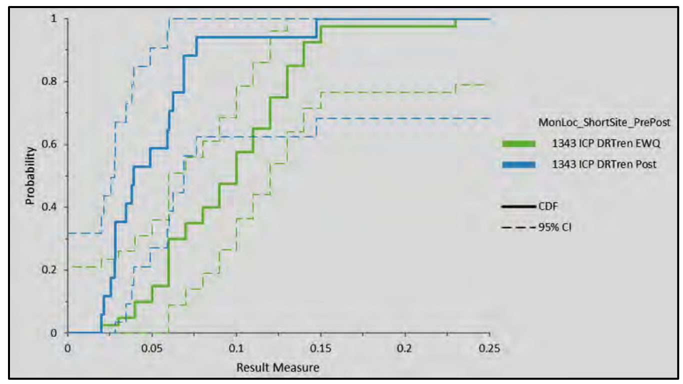






N 57

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1343 ICP DRTren EWQ	0.020	0.060	0.100	0.126	0.230	0.066
1343 ICP DRTren Post	0.020	0.028	0.039	0.065	0.148	0.037



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1343 ICP DRTren EWQ	40	1199.0	29.98
1343 ICP DRTren Post	17	2821.2	165.96

H statistic	14.63
X^2 approximation	14.63
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.

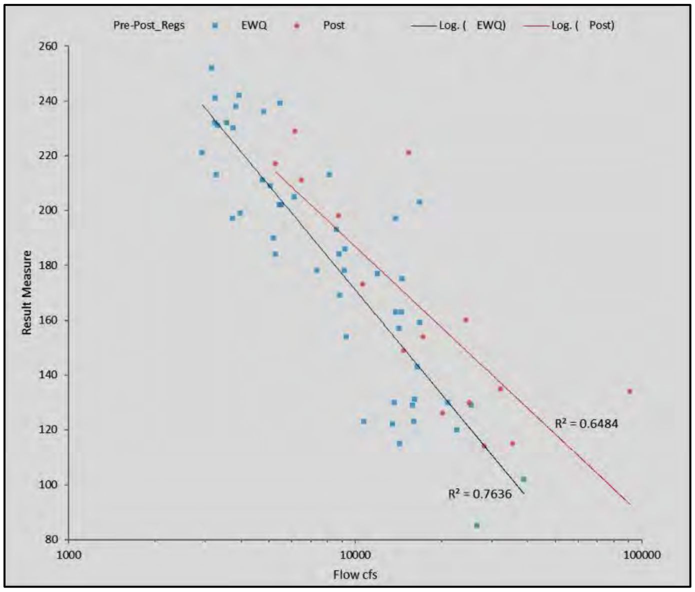
No water quality degradation is indicated. Total Phosphorus (TP) concentrations appeared to decline significantly between the EWQ and post-EWQ periods, though differences in flow conditions, potential laboratory artifacts and low post-EWQ N produced uncertainty. TP is unrelated to flow in both data sets. No 2010 samples were taken due to bridge closure. At other sites where nutrient concentrations are lower, the decline in concentration may be partially due to improved laboratory detection limits. At Trenton, however, there were no undetected results at any time. These results could not be independently confirmed by PADEP and USGS data.

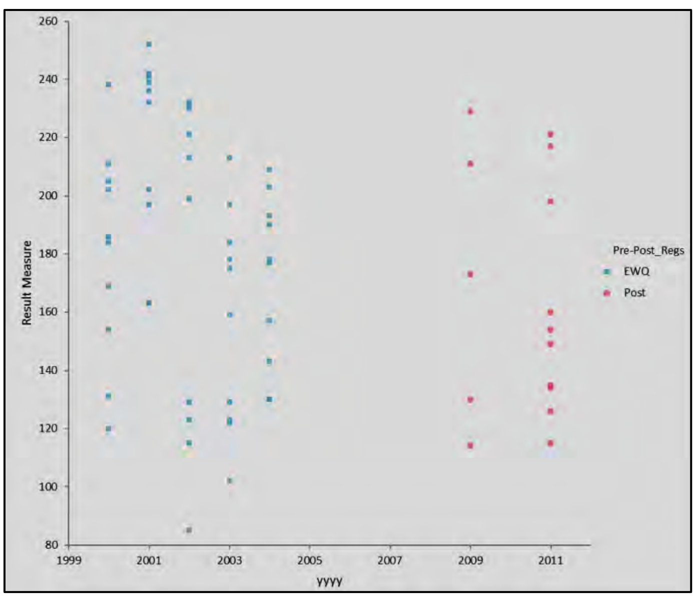
Chapter 1: 1343 ICP Delaware River at Trenton, NJ

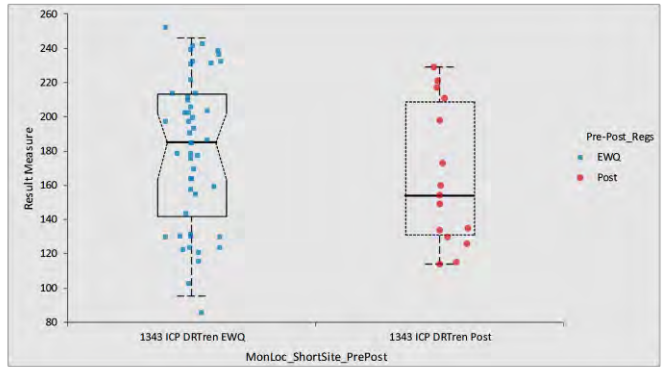
Specific Conductance µmho/cm

Existing Water Quality:

Median 185 µmho/cm
Lower 95% Confidence Interval 163 µmho/cm
Upper 95% Confidence Interval 202 µmho/cm
Defined in regulations as a flow-related parameter

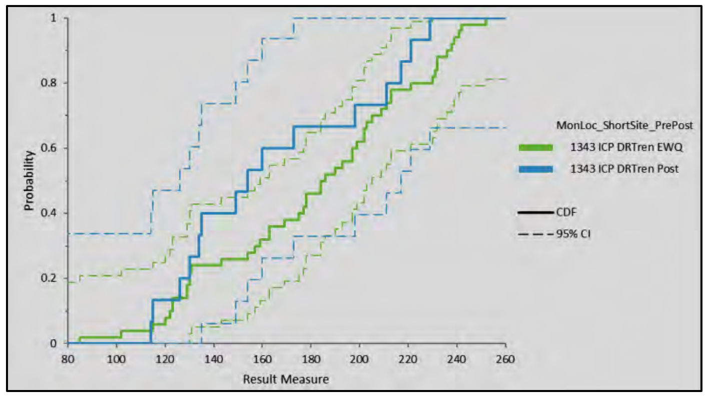






N 65

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1343 ICP DRTren EWQ	85	142.0	185.0	213.0	252	71.0
1343 ICP DRTren Post	114	130.7	154.0	208.8	229	78.2



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1343 ICP DRTren EWQ	50	137.8	2.76
1343 ICP DRTren Post	15	459.3	30.62

H statistic	1.67
X² approximation	1.67
DF	1
p-value	0.1962 [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.

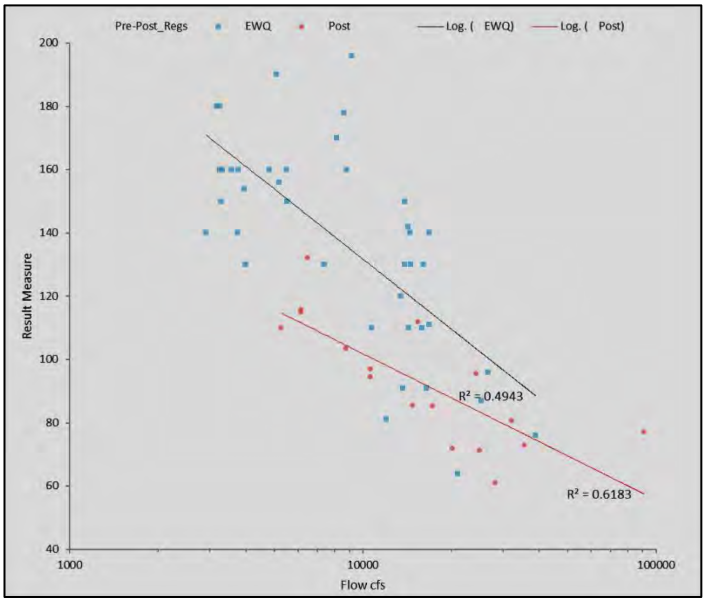
No water quality degradation is indicated. Specific conductance did not measurably change between the EWQ and post-EWQ periods. In both data sets, specific conductance is inversely related to flow. In the post-EWQ data, a single outlier pulls off the slope of the regression – a consequence of too few samples taken in the post-EWQ period (n=15). The outlier was a sample taken during flood conditions. No 2010 (low-flow, dry weather) samples were taken at this location due to bridge closure.

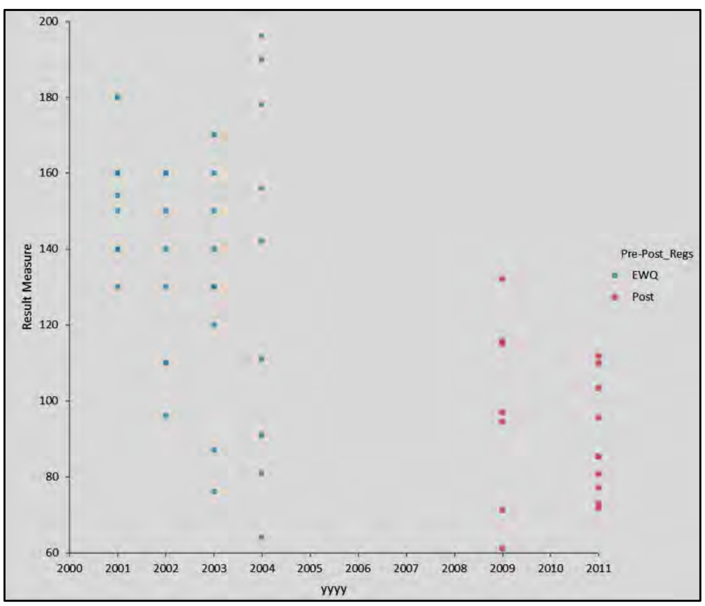
Chapter 1: 1343 ICP Delaware River at Trenton, NJ

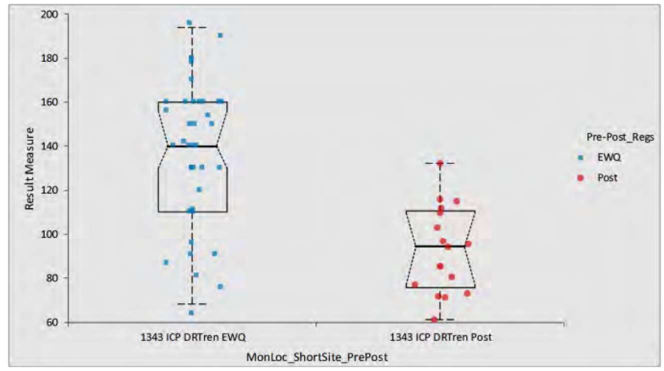
Total Dissolved Solids (TDS) mg/l

Existing Water Quality:

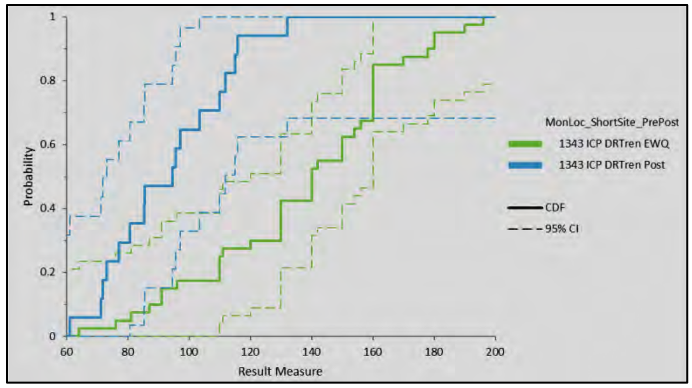
Median 140 mg/l
Lower 95% Confidence Interval 130 mg/l
Upper 95% Confidence Interval 156 mg/l
Defined in regulations as a flow-related parameter







N	57					
Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1343 ICP DRTren EWQ	64	110.4	140.0	160.0	196	49.6
1343 ICP DRTren Post	61	75.7	94.5	110.6	132	34.9



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1343 ICP DRTren EWQ	40	1488.4	37.21
1343 ICP DRTren Post	17	3502.1	206.01

H statistic	18.17
X^2 approximation	18.17
DF	1
p-value	<0.0001 [1]

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

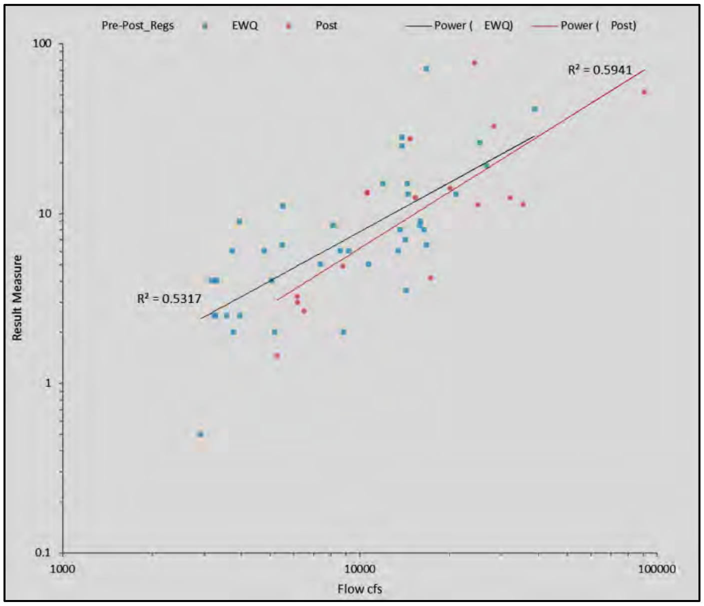
No water quality degradation is indicated. TDS appeared to measurably decline between the EWQ and post-EWQ periods. However, such a decline is uncertain because of differences in flow, potential laboratory artifacts, and too few post-EWQ samples. TDS is inversely related to flow. Since far fewer of the post-EWQ samples were low-flow samples, much of the apparent decline in TDS is probably attributed to flow effects at the time of sampling. Most samples were taken at higher flow conditions, and there were an insufficient number of samples taken under low flow conditions.

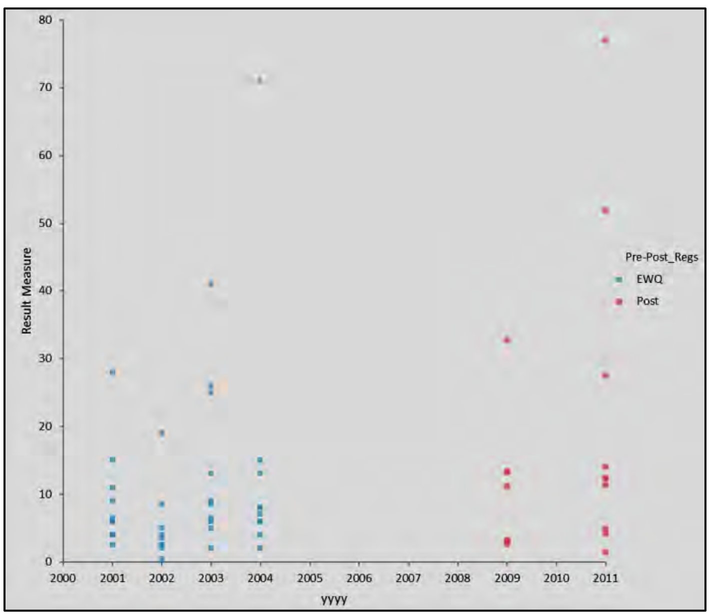
Chapter 1: 1343 ICP Delaware River at Trenton, NJ

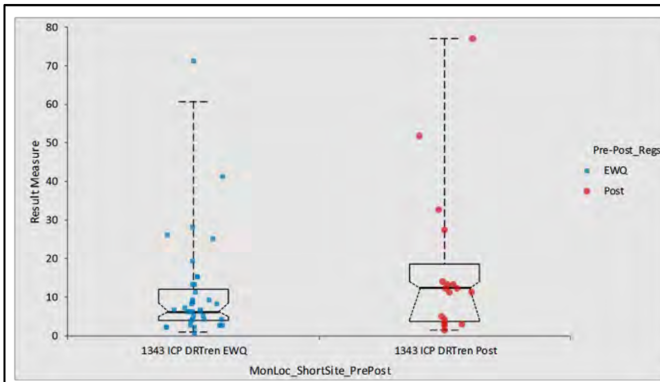
Total Suspended Solids (TSS) mg/l

Existing Water Quality:

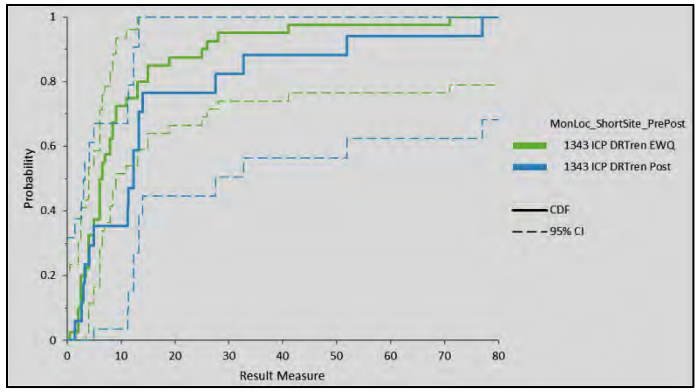
Median 6.3 mg/l
Lower 95% Confidence Interval 5.0 mg/l
Upper 95% Confidence Interval 8.5 mg/l
Defined in regulations as a flow-related parameter







N	57					
Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1343 ICP DRTren EWQ	1	4.0	6.3	12.2	71	8.2
1343 ICP DRTren Post	1	3.9	12.4	18.5	77	14.7



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1343 ICP DRTren EWQ	40	164.0	4.10
1343 ICP DRTren Post	17	385.9	22.70

H statistic	2.00
X^2 approximation	2.00
DF	1
p-value	0.1573 [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.

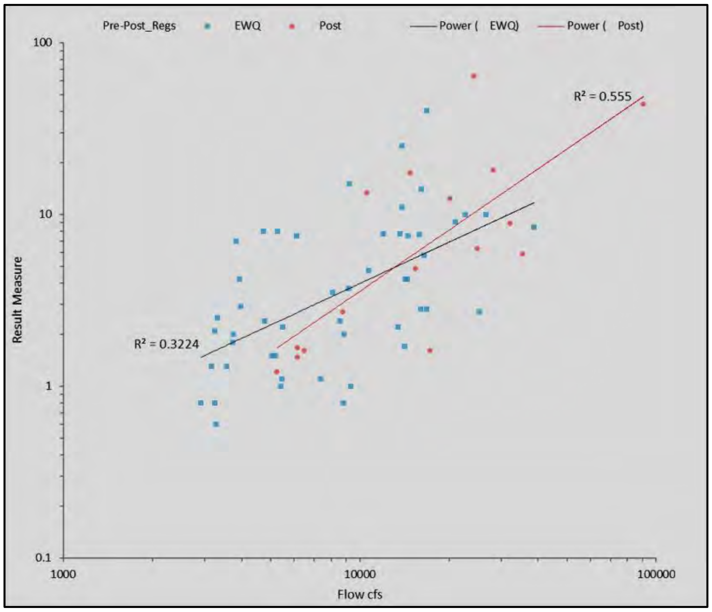
No water quality degradation is indicated. TSS did not measurably change between the EWQ and post-EWQ periods. Flow differences, insufficient post-EWQ sampling (n=17) and potential laboratory artifacts produced analytical uncertainty. TSS is positively related to flow in both data sets. No samples were taken at this location in 2010 due to bridge closure.

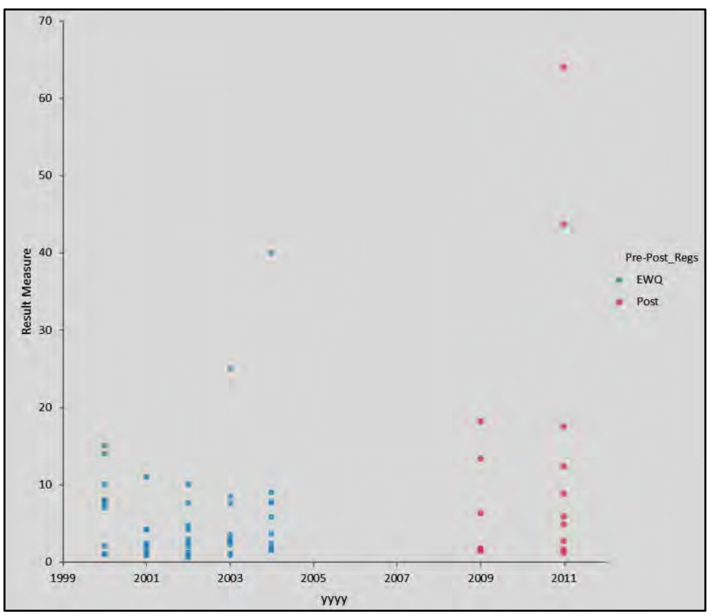
Chapter 1: 1343 ICP Delaware River at Trenton, NJ

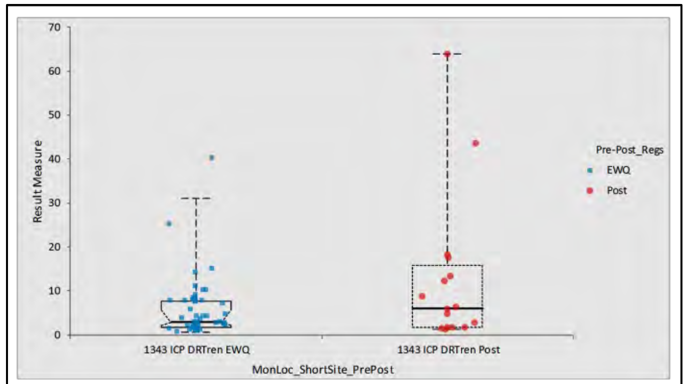
Turbidity NTU

Existing Water Quality:

Median 2.9 NTU*
Lower 95% Confidence Interval 2.2 NTU
Upper 95% Confidence Interval 5.8 NTU
*Should have been defined as flow-related in rules

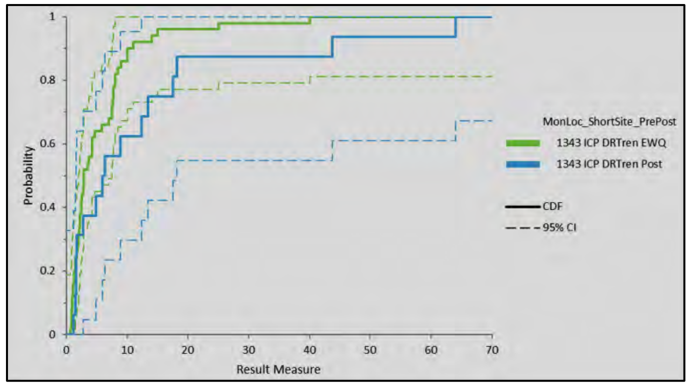






N 66

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1343 ICP DRTren EWQ	1	1.7	2.9	7.7	40	6.0
1343 ICP DRTren Post	1	1.6	6.1	15.8	64	14.2



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1343 ICP DRTren EWQ	50	220.5	4.41
1343 ICP DRTren Post	16	689.1	43.07

H statistic	2.47
X^2 approximation	2.47
DF	1
p-value	0.1161 [1]

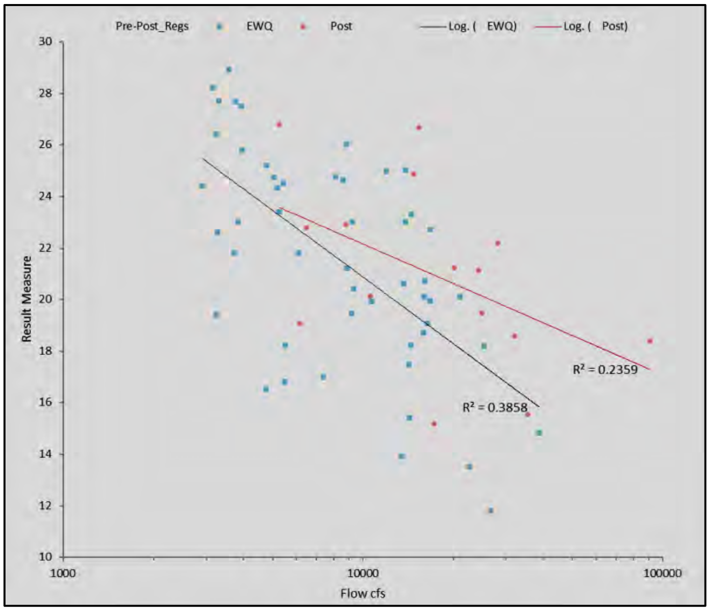
H0: $\theta_1 = \theta_2 = \theta\ldots$
The median of the populations are all equal.
H1: $\theta_i \neq \theta_j$ for at least one i,j
The median of the populations are not all equal.
[1] Do not reject the null hypothesis at the 5% significance level.

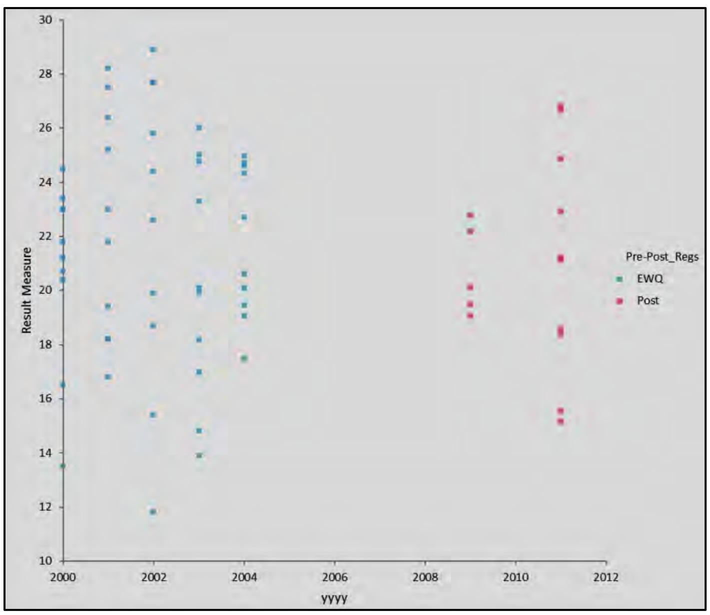
No water quality degradation is indicated. All but two post-EWQ turbidity results were within the expected EWQ range of 0-40. Both were taken during high flow conditions: one within the previously-sampled range of flows, and one far outside that range during a major flood event. Flow differences and insufficient post-EWQ sampling (n=16) produced analytical uncertainty. The post-EWQ median turbidity was above the EWQ upper 95% confidence interval, but the increase was not significant. In both data sets, the turbidity vs. flow relationship is positive. No 2010 samples were taken at this location due to bridge closure.

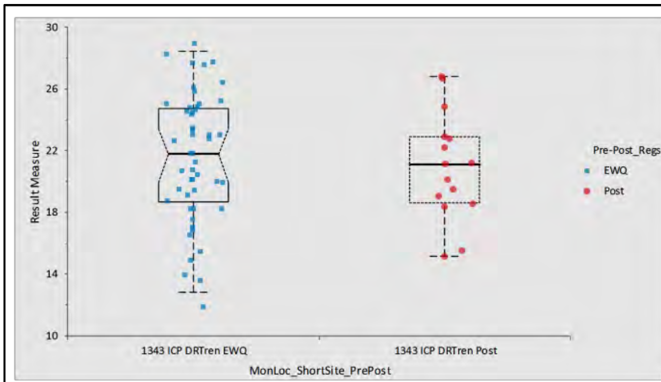
Chapter 1: 1343 ICP Delaware River at Trenton, NJ

Water Temperature, degrees C

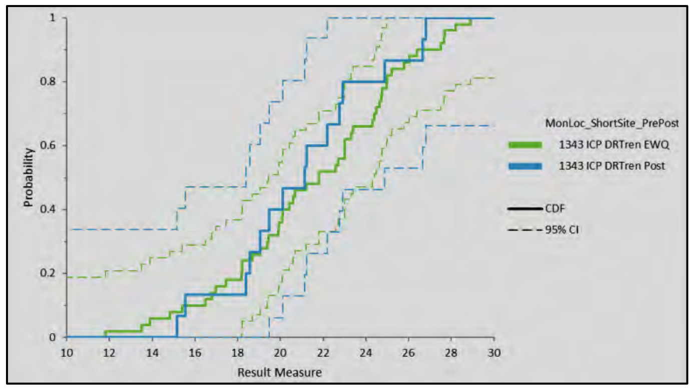
Not included in DRBC Existing Water Quality rules







N	65					
Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1343 ICP DRTren EWQ	12	18.7	21.8	24.7	29	6.1
1343 ICP DRTren Post	15	18.7	21.1	22.9	27	4.2



Kruskal-Wallis test

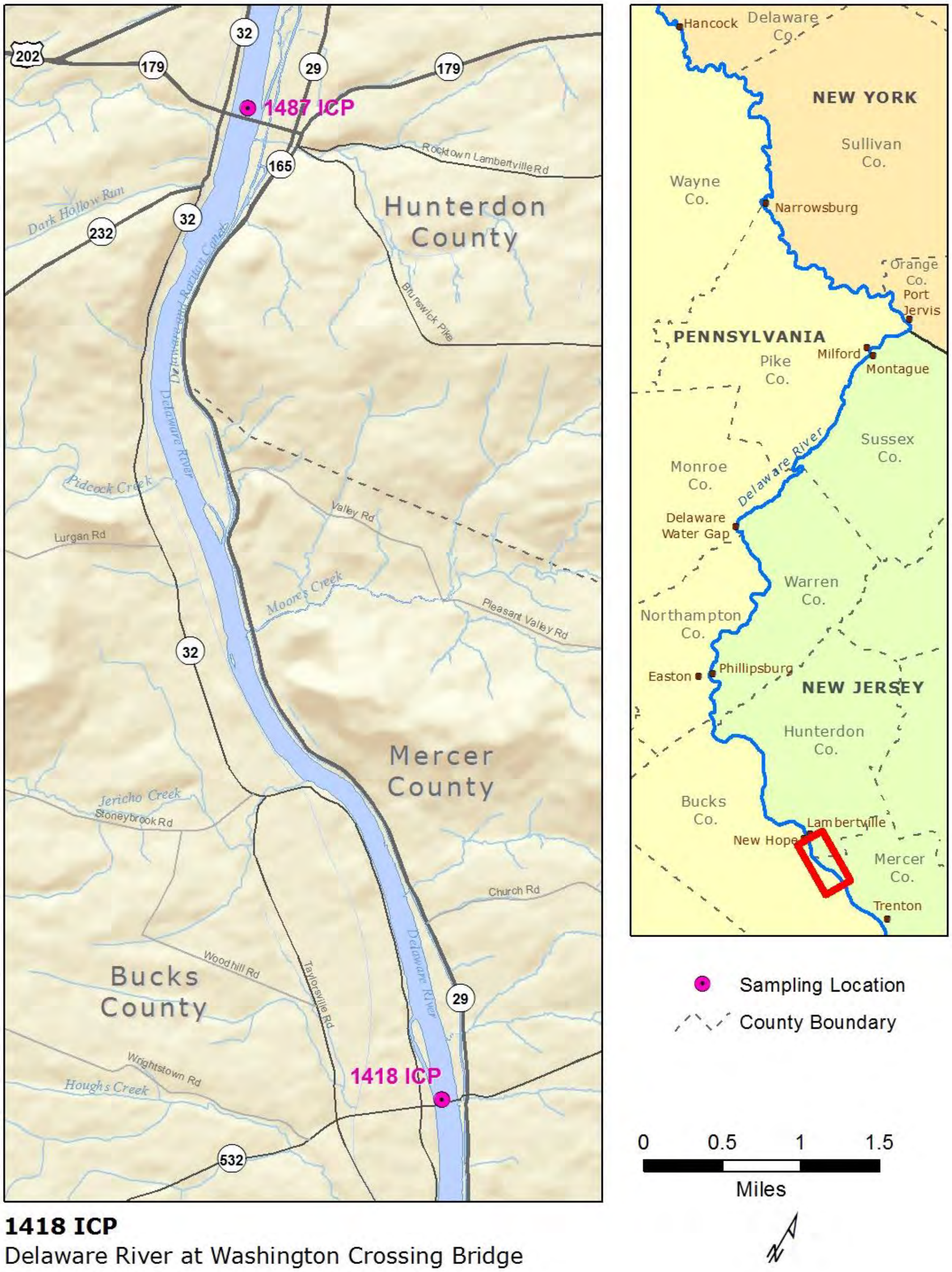
Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1343 ICP DRTren EWQ	50	23.8	0.48
1343 ICP DRTren Post	15	79.4	5.29

H statistic	0.29
X² approximation	0.29
DF	1
p-value	0.5911[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.

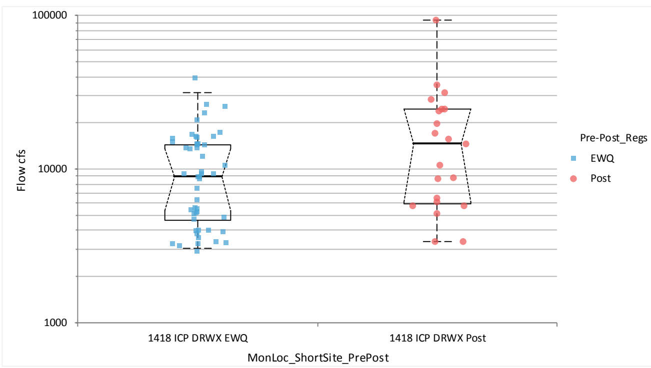
No water quality degradation is indicated. Water temperature did not measurably change between the EWQ and post-EWQ periods. Flow differences and insufficient post-EWQ sampling (n=15) produced analytical uncertainty. Water temperature is inversely related to flow, though the relationship is weak. No samples were taken in 2010 at this location due to bridge closure.

Chapter 2: 1418 ICP Delaware River at Washington Crossing, NJ/PA



1418 ICP
Delaware River at Washington Crossing Bridge

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



N 71

Flow cfs by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1418 ICP DRWX EWQ	2,878	4,618	8,976	14,472	38,899	9,854
1418 ICP DRWX Post	3,387	5,967	14,702	24,800	93,873	18,833

Kruskal-Wallis test

Flow cfs by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1418 ICP DRWX EWQ	50	544.5	10.89
1418 ICP DRWX Post	21	1296.4	61.73

H statistic	4.32
X^2 approximation	4.32
DF	1
p-value	0.0376 [1]

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

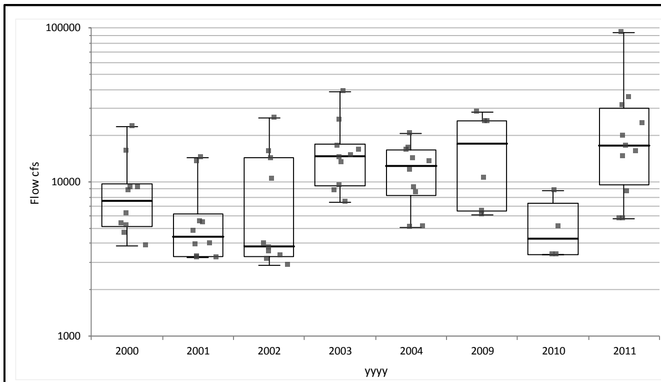
The median of the populations are all equal.

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.

Flow was different between the two periods at this location. Overall EWQ flow was low to near-normal for the May to September period and post-EWQ flow was generally above-normal. For flow-related parameters, this difference can lead to misinterpretation of results, so confidence in statistical comparisons is low even in cases where statistical differences are significant. Flow is plotted on a logarithmic scale.



N 71

Flow cfs by yyyy	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
2000	3,833	5,149	7,519	9,795	22,885	4,646
2001	3,229	3,272	4,386	6,214	14,441	2,942
2002	2,878	3,294	3,845	14,305	26,192	11,011
2003	7,395	9,460	14,622	17,774	38,899	8,313
2004	5,077	8,228	12,763	16,207	20,761	7,979
2009	6,080	6,456	17,700	25,100	28,400	18,644
2010	3,387	3,387	4,272	7,259	8,761	3,872
2011	5,742	9,660	17,185	30,397	93,873	20,736

Annual flow statistics are plotted above. Flow is plotted on a logarithmic scale. These are May to September flow measurements associated with the time of each water quality sample. Flow is estimated at this location using drainage area weighting based on the USGS continuous stream gage at Trenton, NJ. “Normal” flow is about 10,000 cfs at this location on the Delaware River.

Within the data, annual summer flow is below normal for 4 years and above normal for 4 years. When examining annual summer Washington Crossing water quality statistics between the EWQ and post-EWQ periods, post-EWQ water quality is likely most comparable to EWQ 2003-2004 data when flow was above normal.

Upstream ICP: Delaware River at Lambertville 1487 ICP

Downstream ICP: Delaware River at Trenton 1343 ICP

Tributary BCP Watersheds in Upstream Reach:

Pidcock Creek, PA – 1463 BCP

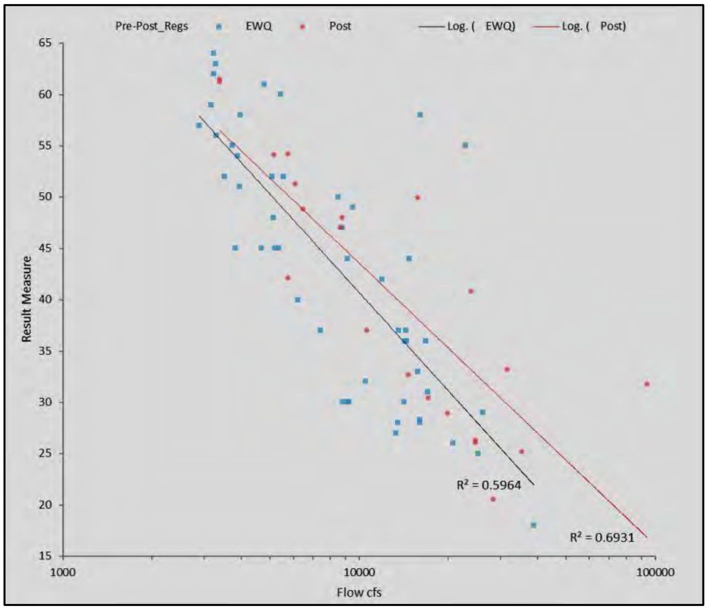
All other tributary watersheds to the upstream reach are less than 20 square miles drainage area, possess no wastewater discharges, and are expected to exert minimal water quality influence upon the Delaware River.

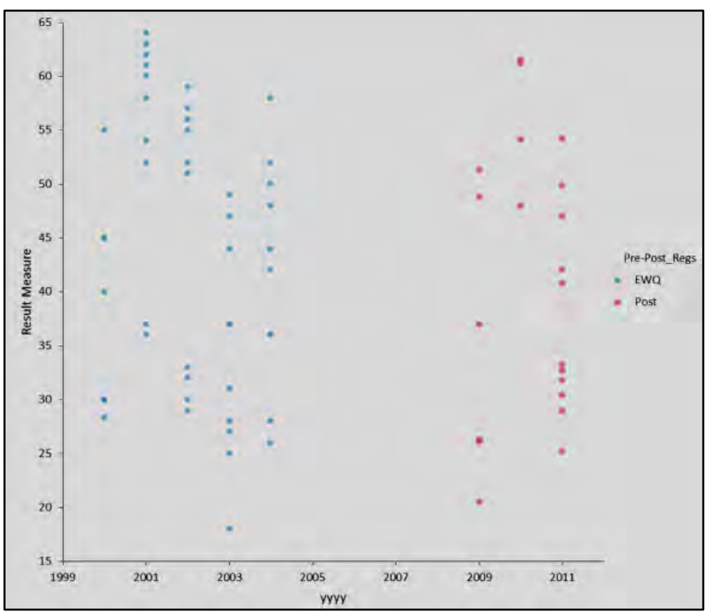
Chapter 2: 1418 ICP
Delaware River at Washington Crossing Bridge

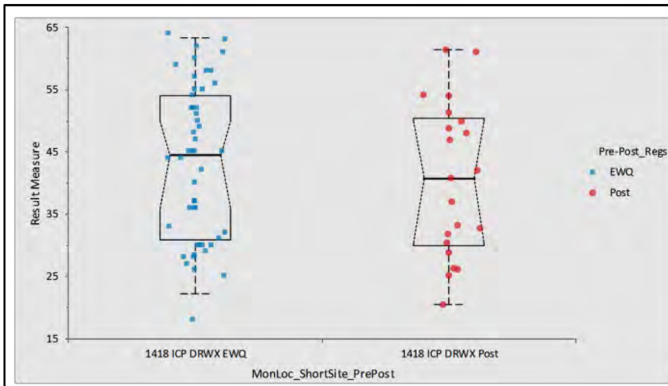
Alkalinity as CaCO3, Total mg/l

Existing Water Quality (Table 2Y):

Median 45 mg/l
Lower 95% Confidence Interval 36 mg/l
Upper 95% Confidence Interval 50 mg/l
Defined in regulations as a flow-related parameter

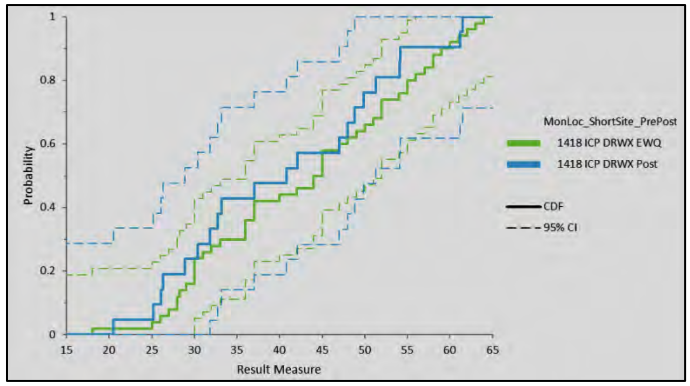






N	71

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1418 ICP DRWX EWQ	18.0	30.92	44.50	54.08	64.0	23.17
1418 ICP DRWX Post	20.5	29.90	40.80	50.37	61.5	20.47



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1418 ICP DRWX EWQ	50	80.6	1.61
1418 ICP DRWX Post	21	192.0	9.14

H statistic	0.64
X^2 approximation	0.64
DF	1
p-value	0.4235 [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 indicated. Alkalinity did not measurably change between the EWQ and post-EWQ periods. However, potential laboratory artifacts and insufficient post-EWQ sampling (n=21) introduced analytical uncertainty. Alkalinity is inversely related to flow.

Chapter 2: 1418 ICP

Delaware River at Washington Crossing Bridge

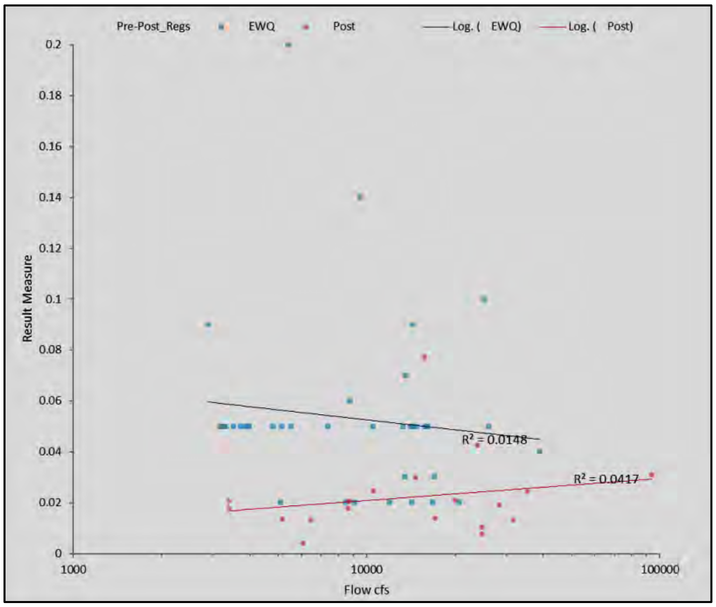
Ammonia Nitrogen as N, Total mg/l

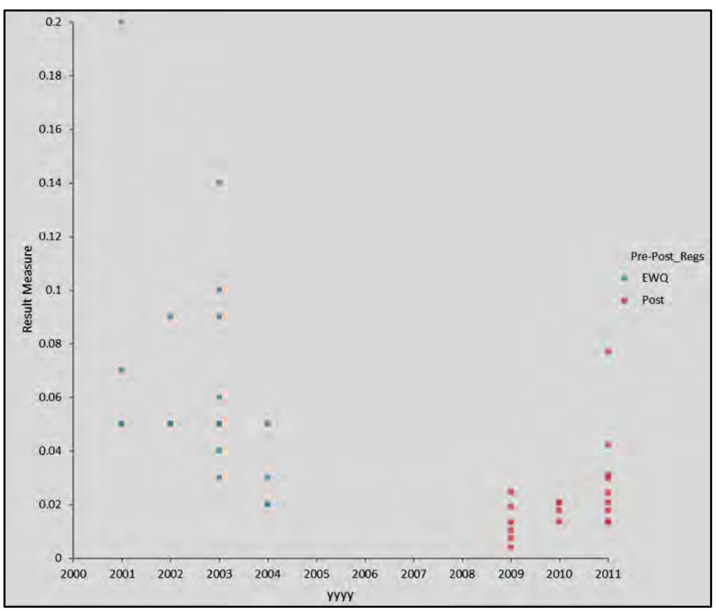
Existing Water Quality (Table 2Y):

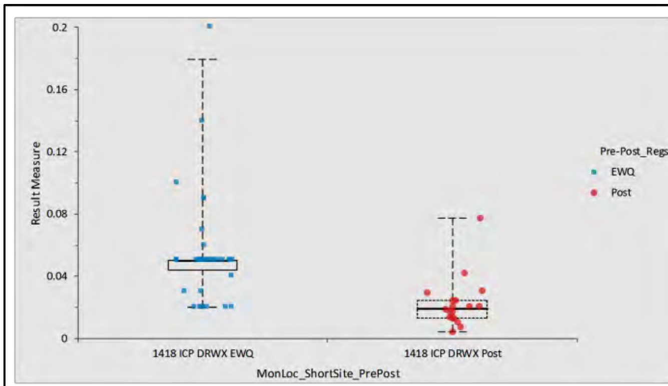
Median <0.05 mg/l

Lower 95% Confidence Interval <0.05 mg/l

Upper 95% Confidence Interval 0.09 mg/l

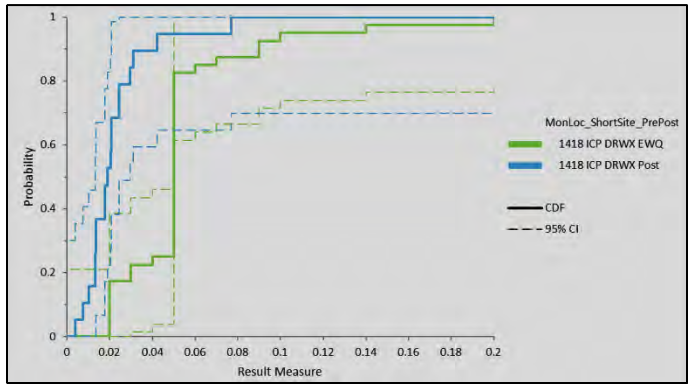






N 59

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1418 ICP DRWX EWQ	0.0	0.04	0.05	0.05	0.2	0.01
1418 ICP DRWX Post	0.0	0.01	0.02	0.02	0.1	0.01



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1418 ICP DRWX EWQ	40	2016.4	50.41
1418 ICP DRWX Post	19	4245.1	223.42

H statistic	22.60
X^2 approximation	22.60
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.

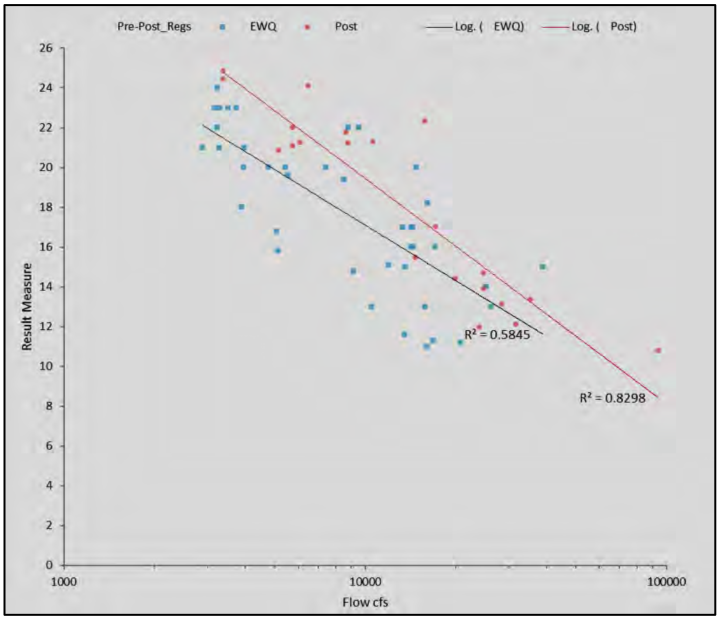
No water quality degradation is indicated. Ammonia concentrations appeared to decline, though differences in flow conditions, detection limits and potential laboratory artifacts produced uncertainty. No independent data were available to validate the decline. EWQ data possessed 29/40 undetected results that interfered with estimation of the median and its confidence intervals. There was 1 non-detect result in the post-EWQ samples. We are now able to measure ammonia at lower concentrations. However, some water quality improvement is indicated by the lack of high values in the post-EWQ data.

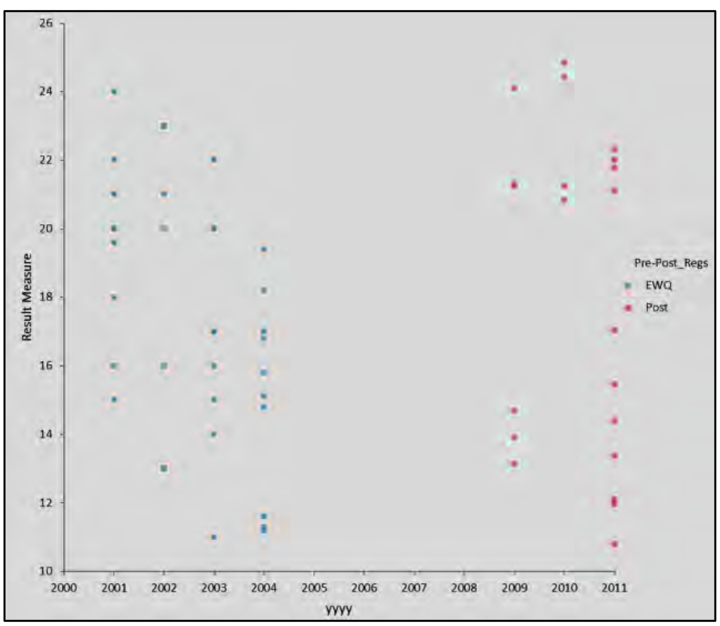
Chapter 2: 1418 ICP
Delaware River at Washington Crossing Bridge

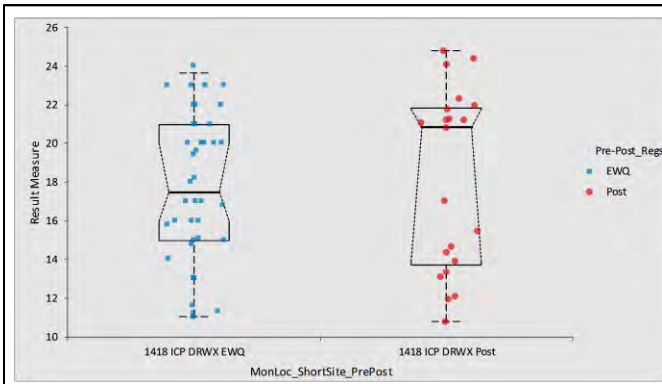
Chloride, Total mg/l

Existing Water Quality (Table 2Y):

Median 18 mg/l
Lower 95% Confidence Interval 16 mg/l
Upper 95% Confidence Interval 20 mg/l
Defined in regulations as a flow-related parameter

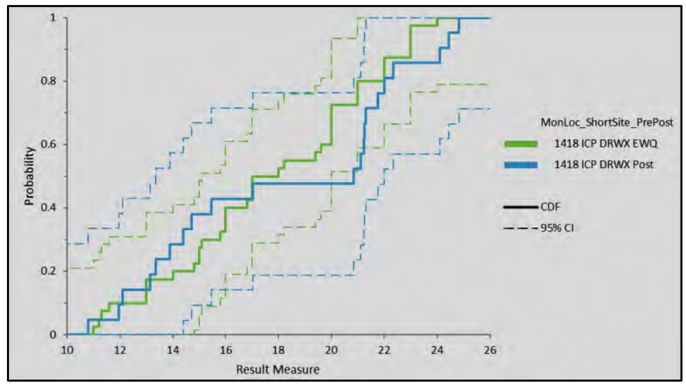






N | 61

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1418 ICP DRWX EWQ	11.0	15.0	17.5	21.0	24.0	6.0
1418 ICP DRWX Post	10.8	13.7	20.8	21.8	24.8	8.1



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1418 ICP DRWX EWQ	40	27.2	0.68
1418 ICP DRWX Post	21	51.9	2.47

H statistic	0.25
X^2 approximation	0.25
DF	1
p-value	0.6162 [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.

Some evidence of water quality degradation is indicated, although chloride concentrations did not measurably change between the two periods. However, potential laboratory artifacts and insufficient post-EWQ sampling (n=21) introduced analytical uncertainty. Though post-EWQ median concentration rose by 3 mg/l, which is above the EWQ upper 95% confidence interval, the difference was not statistically significant due to fewer samples taken during the post-EWQ period.

Chapter 2: 1418 ICP

Delaware River at Washington Crossing Bridge

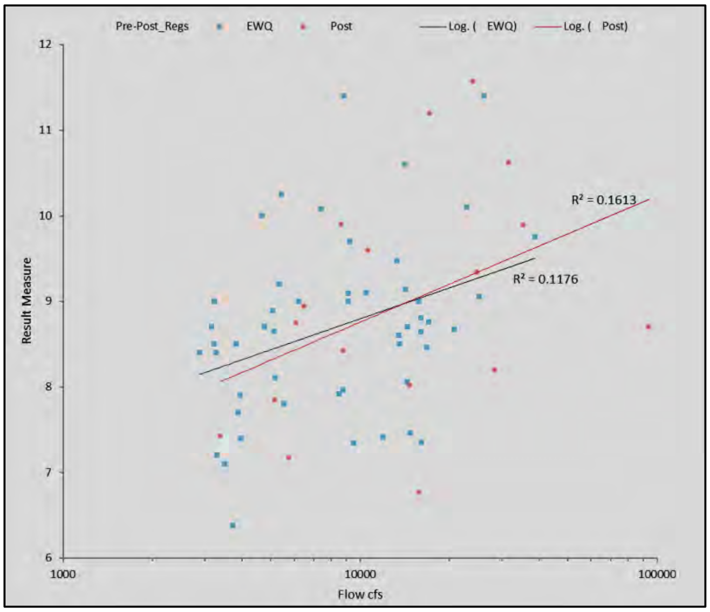
Dissolved Oxygen (DO) mg/l

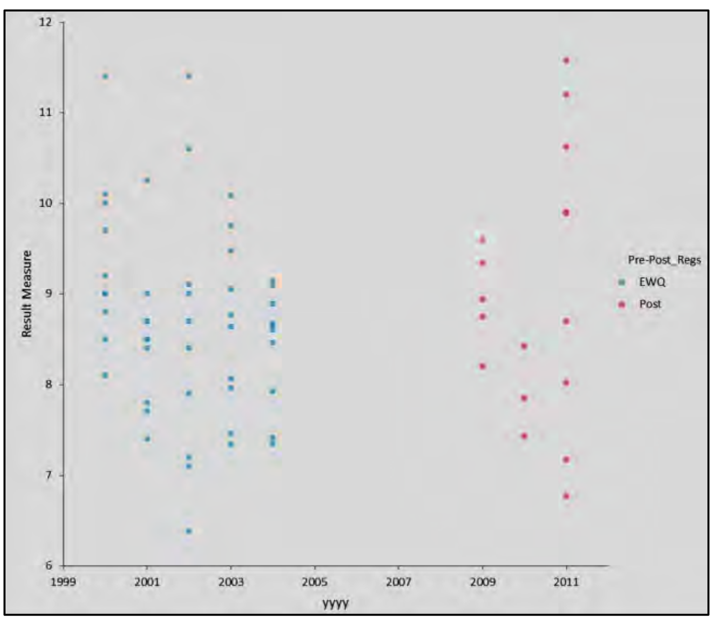
Existing Water Quality (Table 2Y):

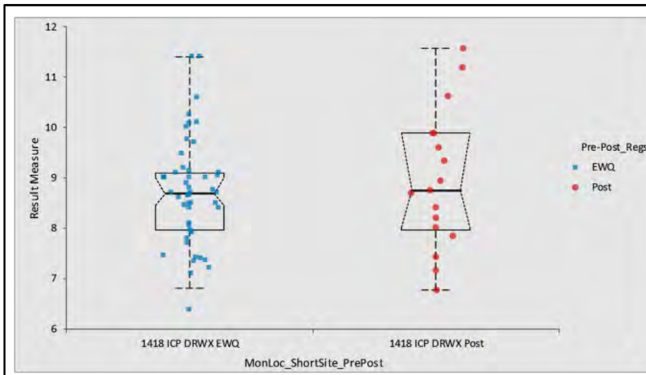
Median 8.69 mg/l

Lower 95% Confidence Interval 8.46 mg/l

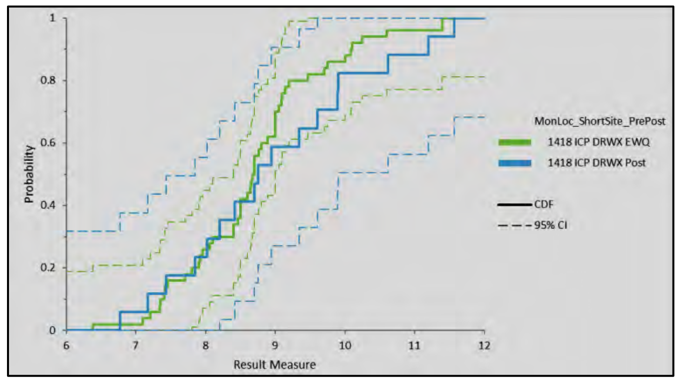
Upper 95% Confidence Interval 9.00 mg/l







Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
N	67					
1418 ICP DRWX EWQ	6.38	7.957	8.685	9.103	11.40	1.147
1418 ICP DRWX Post	6.77	7.963	8.750	9.893	11.57	1.930



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1418 ICP DRWX EWQ	50	29.6	0.59
1418 ICP DRWX Post	17	87.2	5.13

H statistic	0.31
X² approximation	0.31
DF	1
p-value	0.5790[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.

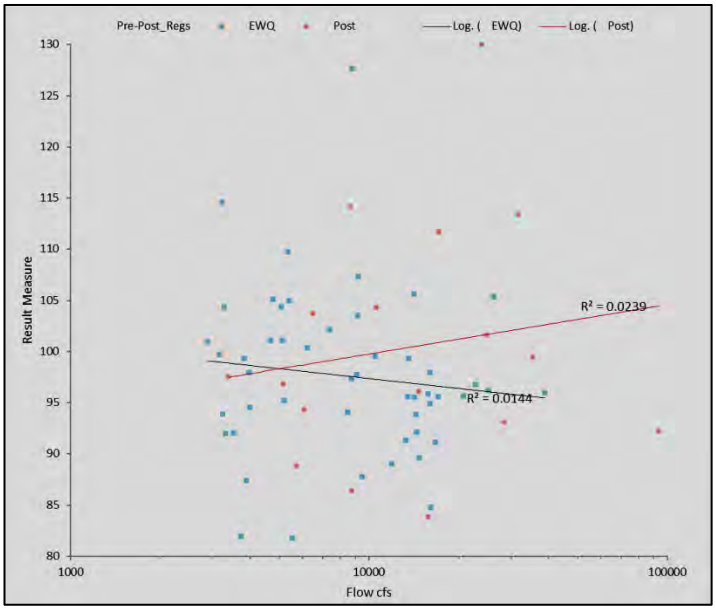
No water quality degradation is indicated. No measurable change took place between the EWQ and Post-EWQ periods. Post-EWQ median DO concentration fell within the EWQ 95% confidence intervals, and the data distributions of the two periods were similar. DO was unrelated to flow in both data sets.

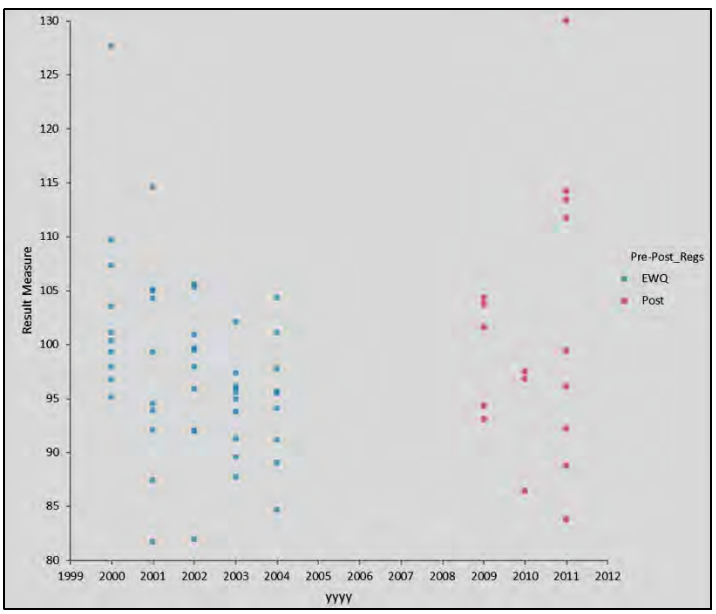
Chapter 2: 1418 ICP
Delaware River at Washington Crossing Bridge

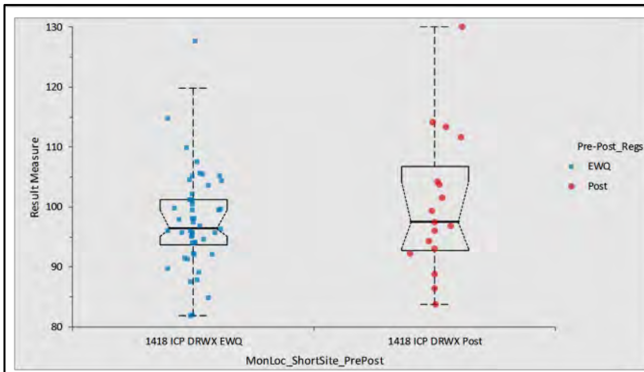
Dissolved Oxygen Saturation %

Existing Water Quality (Table 2Y):

Median 96%
Lower 95% Confidence Interval 95%
Upper 95% Confidence Interval 99%

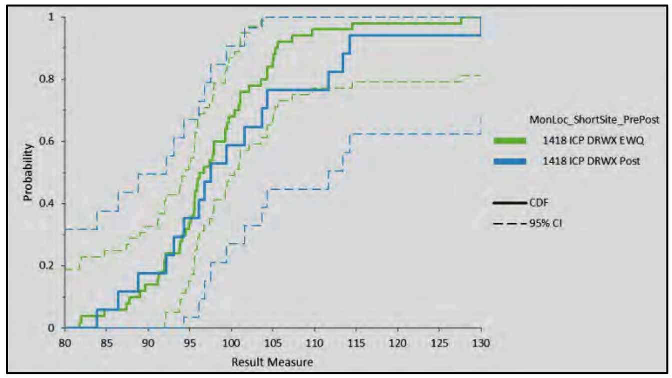






N | 67

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1418 ICP DRWX EWQ	81.7	93.6	96.4	101.2	127.6	7.5
1418 ICP DRWX Post	83.8	92.8	97.5	106.8	130.0	14.0



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1418 ICP DRWX EWQ	50	42.3	0.85
1418 ICP DRWX Post	17	124.5	7.32

H statistic	0.44
X^2 approximation	0.44
DF	1
p-value	0.5075 [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.

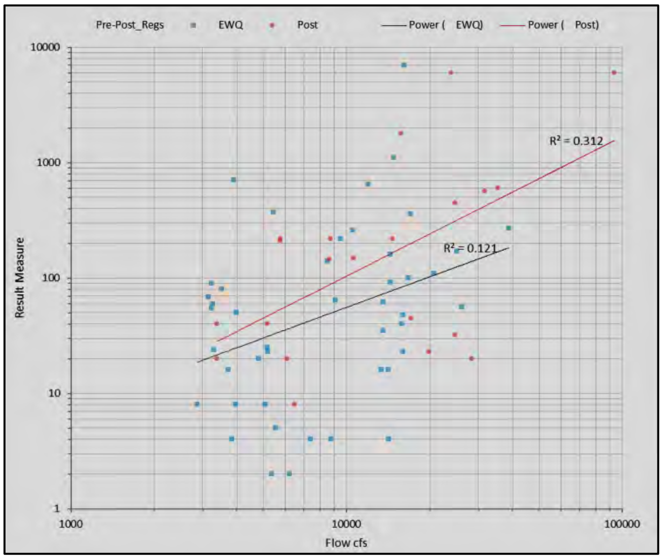
No water quality degradation is indicated. Dissolved Oxygen Saturation is unrelated to flow, and did not measurably change between the EWQ and post-EWQ periods. DO saturation ranged widely in 2011, possibly indicating higher than usual primary productivity by algae and plant activity that summer.

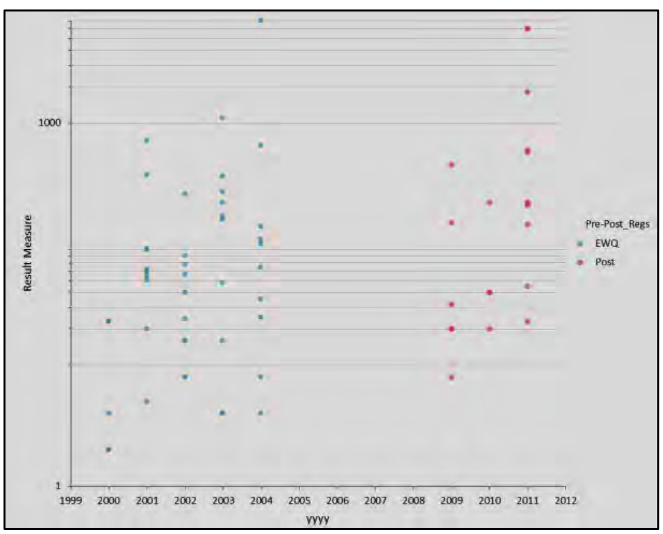
Chapter 2: 1418 ICP
Delaware River at Washington Crossing Bridge

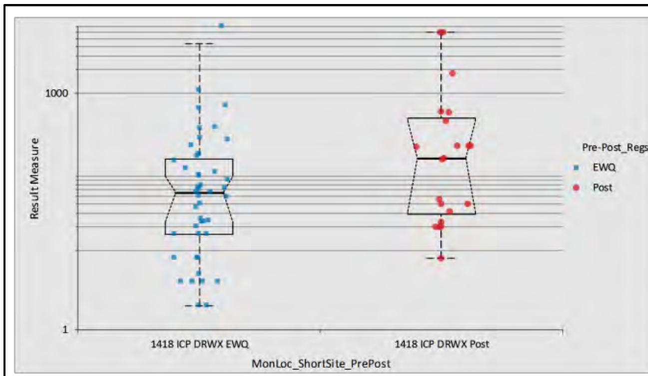
Enterococcus colonies/100 ml

Existing Water Quality (Table 2Y):

Median 55/100 ml
Lower 95% Confidence Interval 23/100 ml
Upper 95% Confidence Interval 90/100 ml

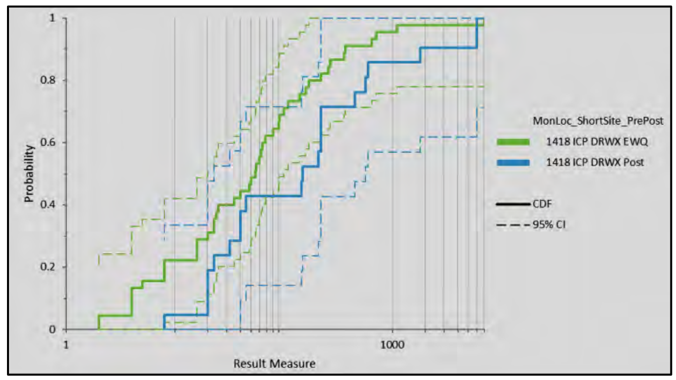






N | 66

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1418 ICP DRWX EWQ	2	16	55	147	7000	131
1418 ICP DRWX Post	8	29	150	490	6000	461



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1418 ICP DRWX EWQ	45	417.1	9.27
1418 ICP DRWX Post	21	893.8	42.56

H statistic	3.56
X^2 approximation	3.56
DF	1
p-value	0.0591 [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.

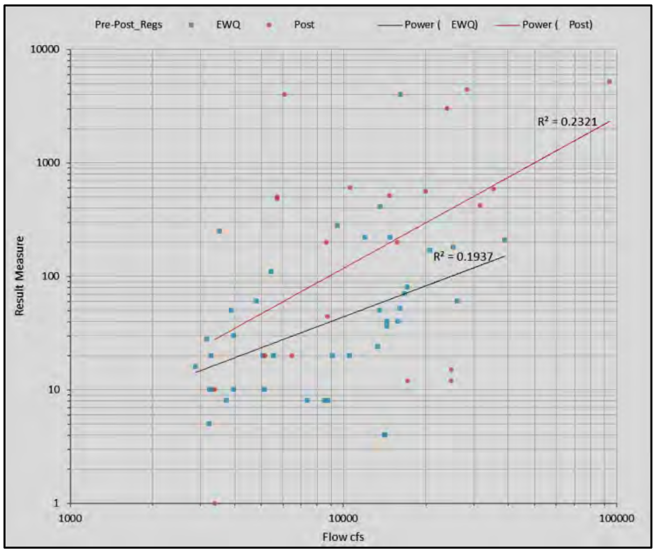
No water quality degradation is indicated. Enterococci did not measurably change between the EWQ and Post-EWQ periods, but the median for the post-EWQ period was higher than the upper 95% confidence interval established in the rules. There may have been an increase, but high variability and smaller post-EWQ N produced statistical uncertainty. Dry-weather samples are under-represented in post-EWQ data. Enterococcus concentrations are positively related to flow in the post-EWQ data set, but the regression is driven by an outlier sample taken during flood conditions. Concentrations are plotted on a logarithmic scale.

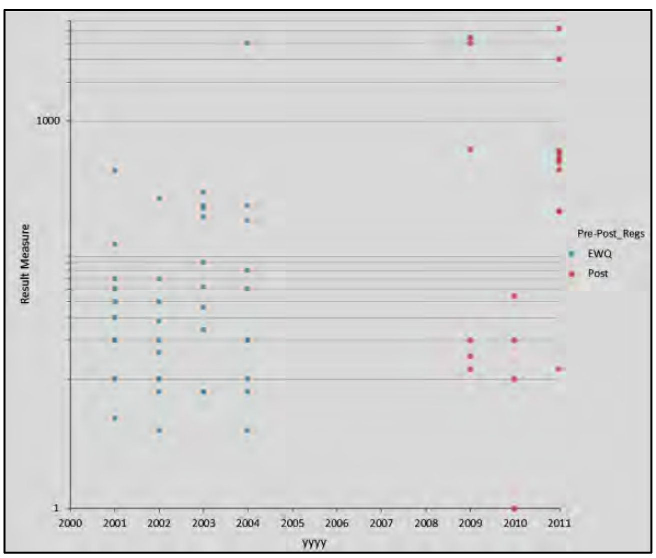
Chapter 2: 1418 ICP
Delaware River at Washington Crossing Bridge

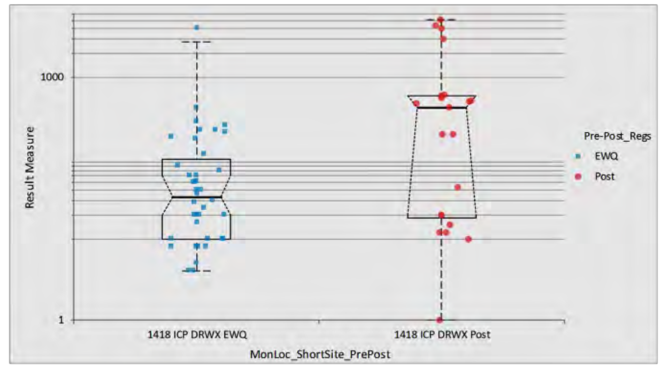
Escherichia coli colonies/100 ml

Existing Water Quality (Table 2Y):

Median 33/100 ml
Lower 95% Confidence Interval 20/100 ml
Upper 95% Confidence Interval 60/100 ml

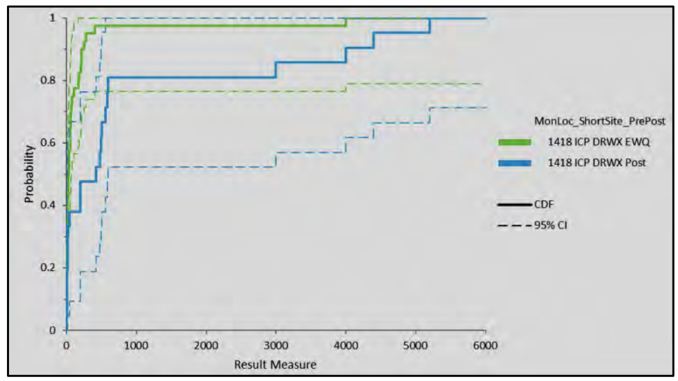






N 61

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1418 ICP DRWX EWQ	4	10	33	98	4000	88
1418 ICP DRWX Post	1	18	420	593	5200	575



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1418 ICP DRWX EWQ	40	735.3	18.38
1418 ICP DRWX Post	21	1400.6	66.69

H statistic	6.79
X^2 approximation	6.79
DF	1
p-value	0.0091 [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.

E. coli concentrations apparently rose between the EWQ and Post-EWQ periods. However, potential laboratory artifacts and insufficient post-EWQ sampling (n=21) introduced analytical uncertainty. There is a weak relationship of E. coli to flow, and dry weather samples were under-represented in the post-EWQ data.

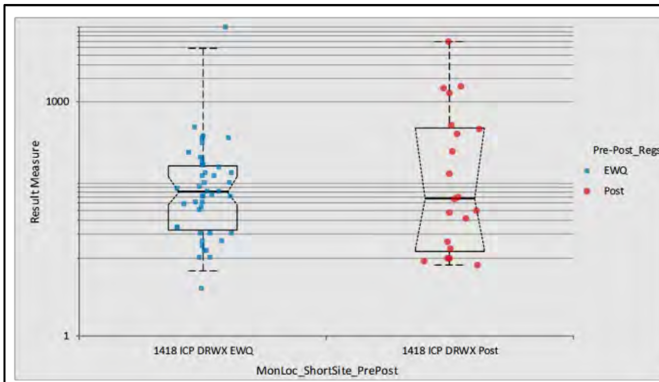
No independent data were available at this site to validate DRBC results. The increase is reported as such in the summary matrix, but confidence is low because of low N and high variability. The reason for the increase remains unexplained other than the prevalence of higher flow conditions in the post-EWQ period.

Chapter 2: 1418 ICP
Delaware River at Washington Crossing Bridge

Fecal coliform colonies/100 ml

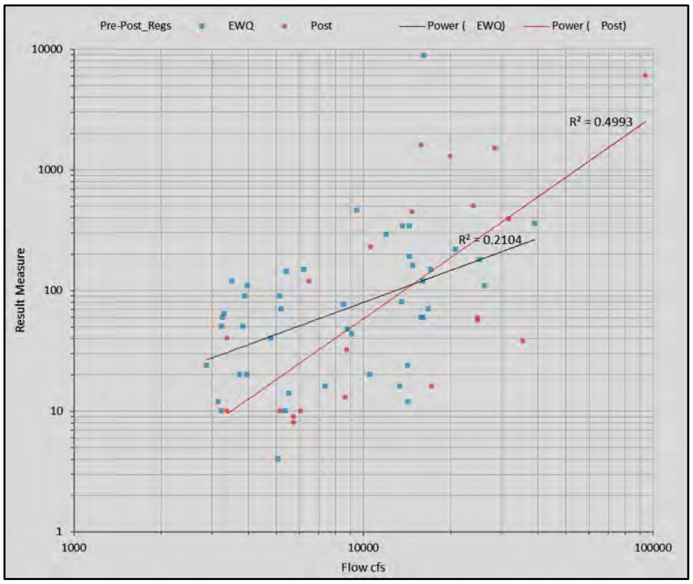
Existing Water Quality (Table 2Y):

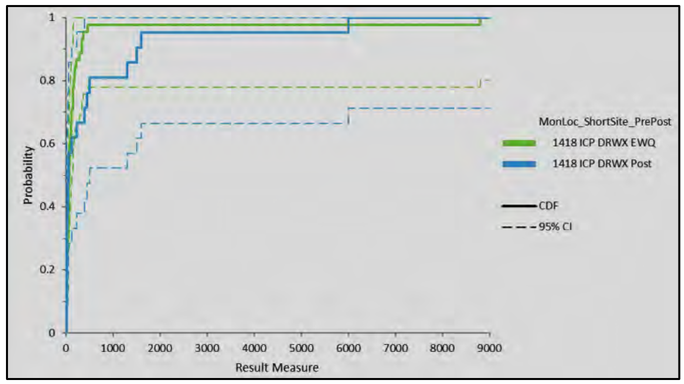
Median 70/100 ml
Lower 95% Confidence Interval 48/100 ml
Upper 95% Confidence Interval 110/100 ml



N 66

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1418 ICP DRWX EWQ	4	22.7	70.0	150.0	8800	127.3
1418 ICP DRWX Post	8	12.0	57.0	466.7	6000	454.7



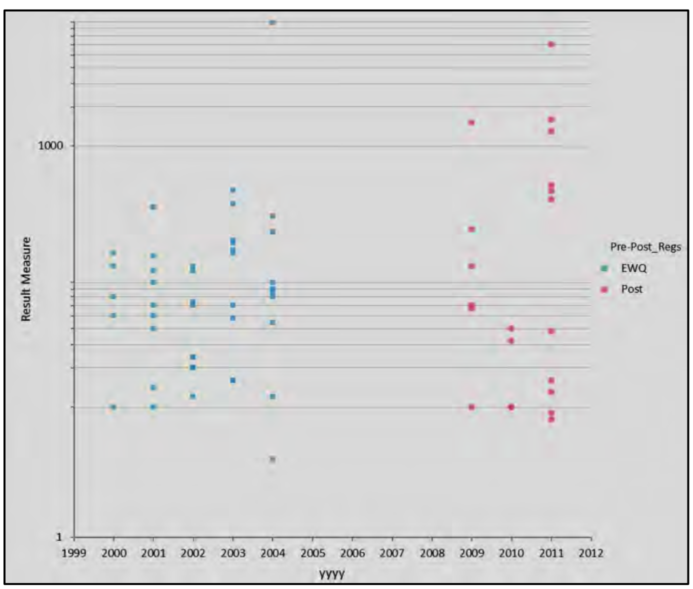


Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1418 ICP DRWX EWQ	45	0.0	0.00
1418 ICP DRWX Post	21	0.0	0.00

H statistic	0.00
X^2 approximation	0.00
DF	1
p-value	0.9945 [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.



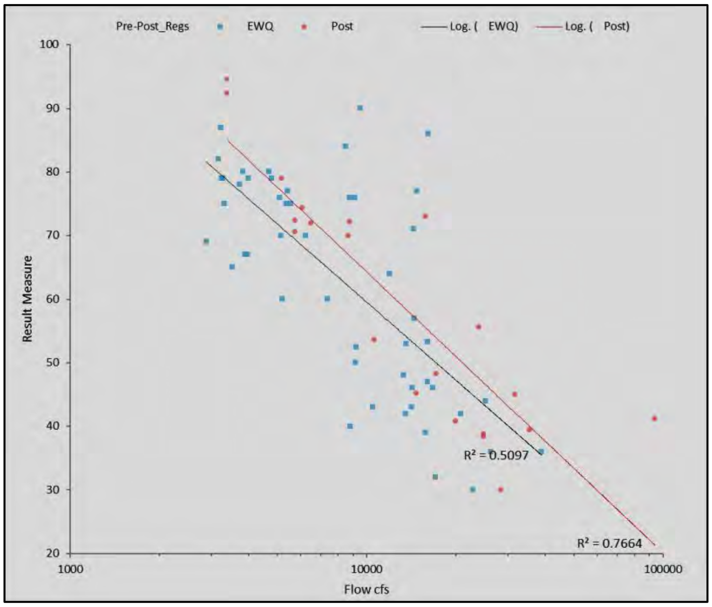
Fecal coliform concentrations did not measurably change between the EWQ and post-EWQ periods. However, potential laboratory artifacts and insufficient post-EWQ sampling (n=21) introduced analytical uncertainty. Post-EWQ fecal coliform concentrations are positively related to flow, but the regression is driven by a single outlier sample taken during flood conditions. Post-EWQ median concentrations fell within the EWQ 95% confidence intervals.

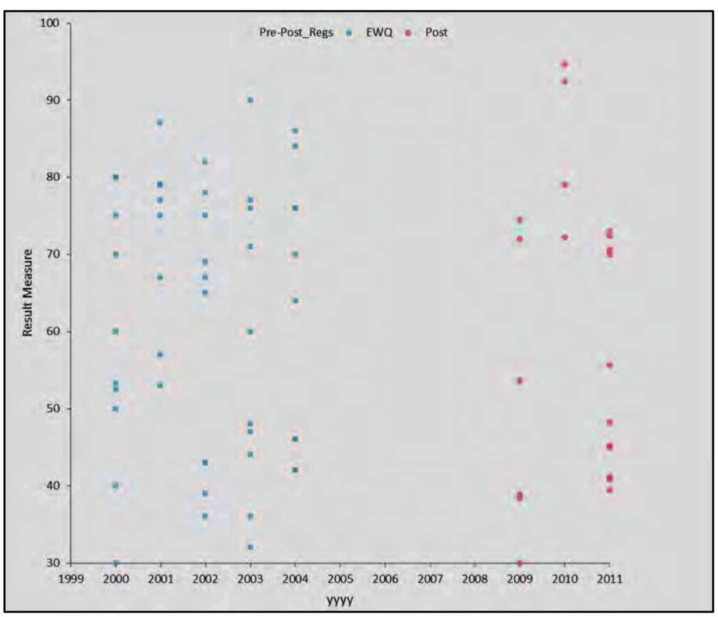
Chapter 2: 1418 ICP
Delaware River at Washington Crossing Bridge

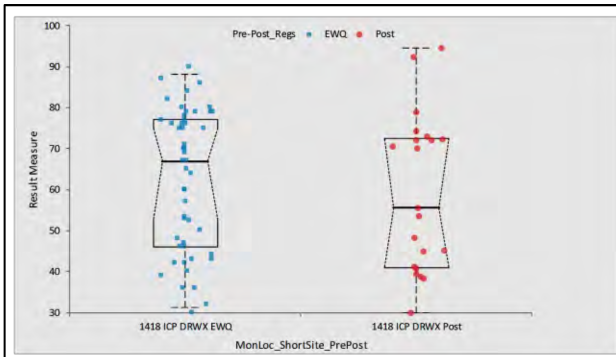
Hardness as CaCO3, Total mg/l

Existing Water Quality (Table 2Y):

Median 67 mg/l
Lower 95% Confidence Interval 53 mg/l
Upper 95% Confidence Interval 75 mg/l
Defined in regulations as a flow-related parameter

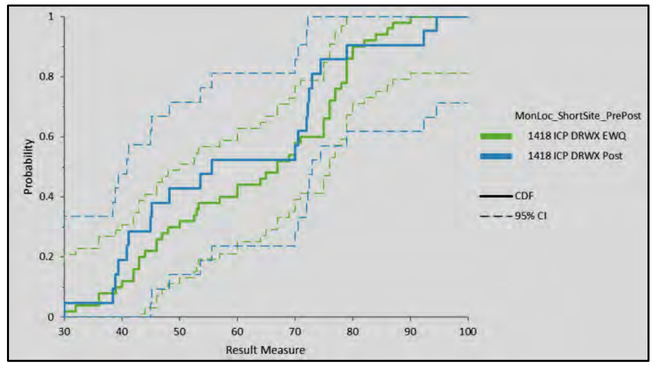






N 71

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1418 ICP DRWX EWQ	30.0	46.00	67.00	77.08	90.0	31.08
1418 ICP DRWX Post	30.0	41.07	55.60	72.60	94.6	31.53



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1418 ICP DRWX EWQ	50	117.0	2.34
1418 ICP DRWX Post	21	278.7	13.27

H statistic	0.93
X^2 approximation	0.93
DF	1
p-value	0.3350 [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.

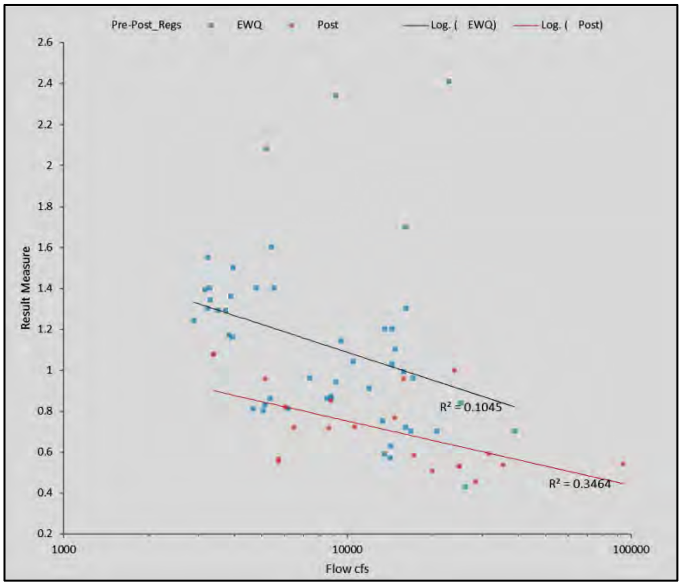
Hardness did not measurably change between the EWQ and post-EWQ periods. However, potential laboratory artifacts and insufficient post-EWQ sampling (n=21) introduced analytical uncertainty. Hardness is inversely related to flow. Post-EWQ median hardness fell within the EWQ 95% confidence intervals.

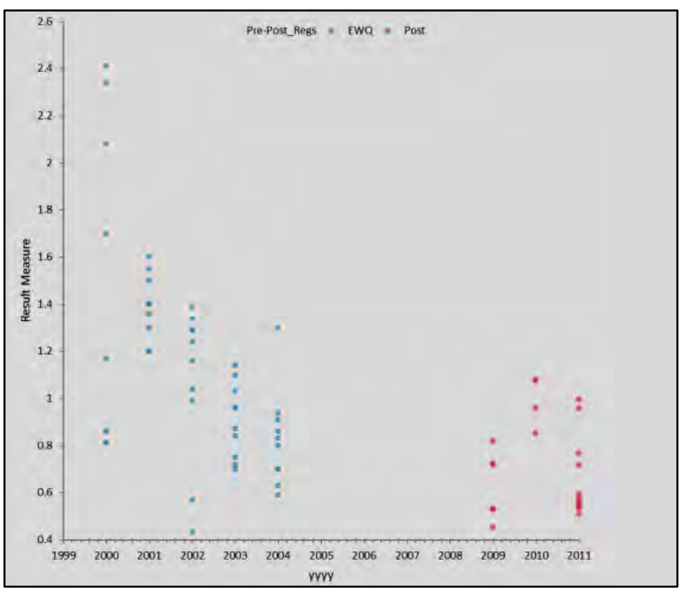
Chapter 2: 1418 ICP
Delaware River at Washington Crossing Bridge

Nitrate + Nitrite as N, Total mg/l

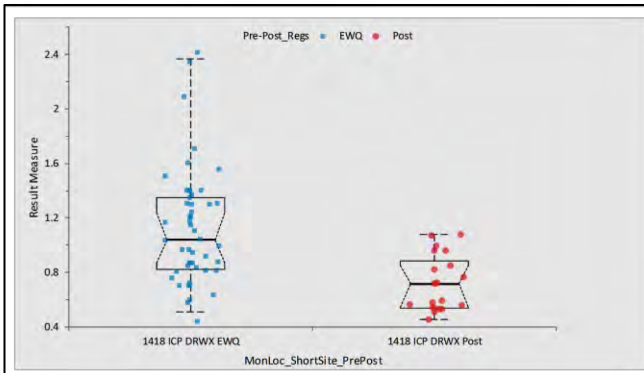
Existing Water Quality (Table 2Y, as Nitrate only):

Median 0.99 mg/l
Lower 95% Confidence Interval 0.86 mg/l
Upper 95% Confidence Interval 1.20 mg/l

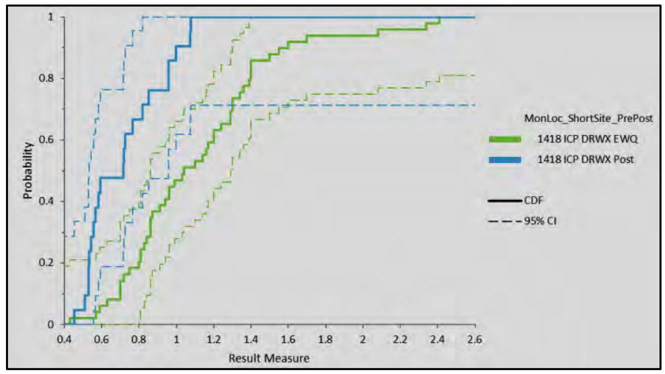




No water quality degradation is indicated. Nitrate concentrations apparently declined between the EWQ and post-EWQ periods, though flow differences and potential laboratory artifacts as well as low post-EWQ N produced uncertainty.



Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
N 70						
1418 ICP DRWX EWQ	0.430	0.823	1.040	1.347	2.410	0.523
1418 ICP DRWX Post	0.454	0.540	0.717	0.887	1.079	0.347



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1418 ICP DRWX EWQ	49	2229.2	45.49
1418 ICP DRWX Post	21	5201.4	247.69

H statistic	17.95
X^2 approximation	17.95
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.

On the annual plot there is a declining trend in concentration within the EWQ period that appears to stabilize in the post-EWQ period. 2002-2004 EWQ nitrates appear to match well with post-EWQ nitrate + nitrite. Nitrate + Nitrite concentrations are judged to be equivalent for comparison with EWQ nitrate concentrations, since EWQ nitrite was never detected at this location. Independent data were not available for validation of the apparent decline in nitrate + nitrite concentrations shown by DRBC. Post-EWQ median nitrate + nitrite concentrations fell below the EWQ lower 95% confidence interval.

Chapter 2: 1418 ICP

Delaware River at Washington Crossing Bridge

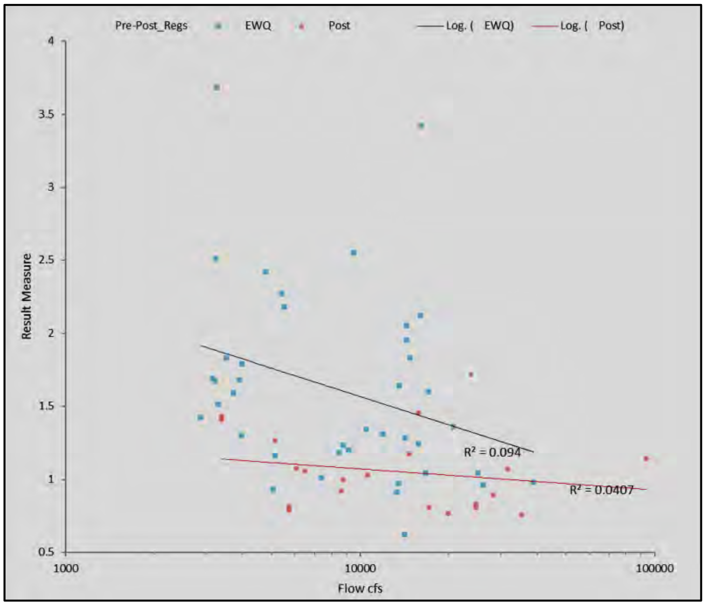
Nitrogen as N, Total (TN) mg/l

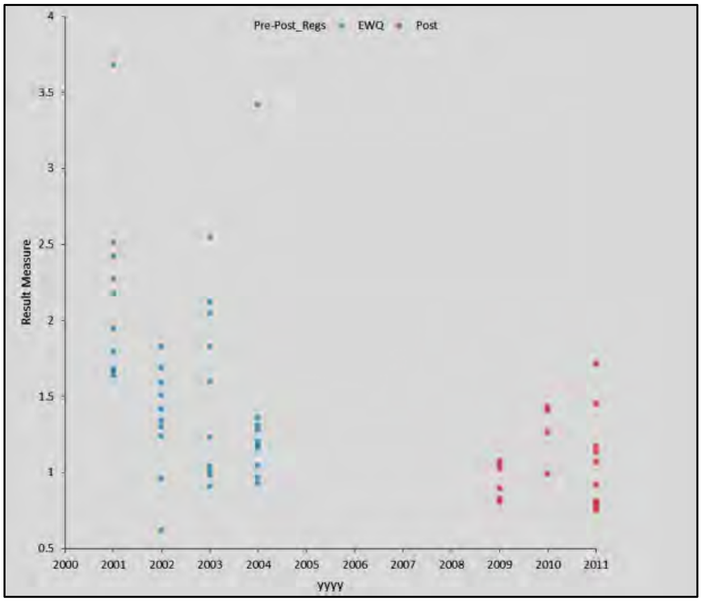
Existing Water Quality (Table 2Y):

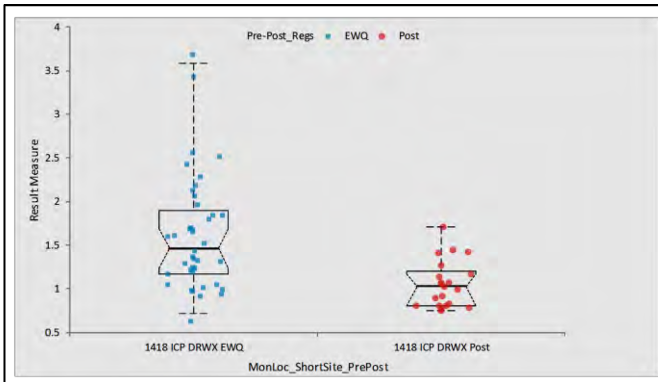
Median 1.47 mg/l

Lower 95% Confidence Interval 1.24 mg/l

Upper 95% Confidence Interval 1.69 mg/l

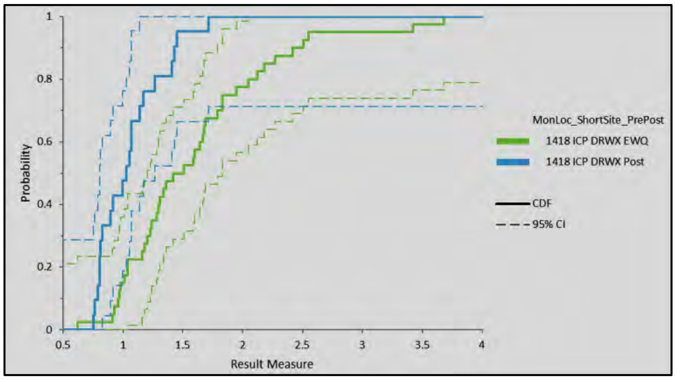






N	61

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1418 ICP DRWX EWQ	0.620	1.168	1.465	1.900	3.680	0.732
1418 ICP DRWX Post	0.754	0.808	1.028	1.203	1.716	0.395



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1418 ICP DRWX EWQ	40	1575.0	39.38
1418 ICP DRWX Post	21	3000.0	142.86

H statistic	14.52
X^2 approximation	14.52
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.

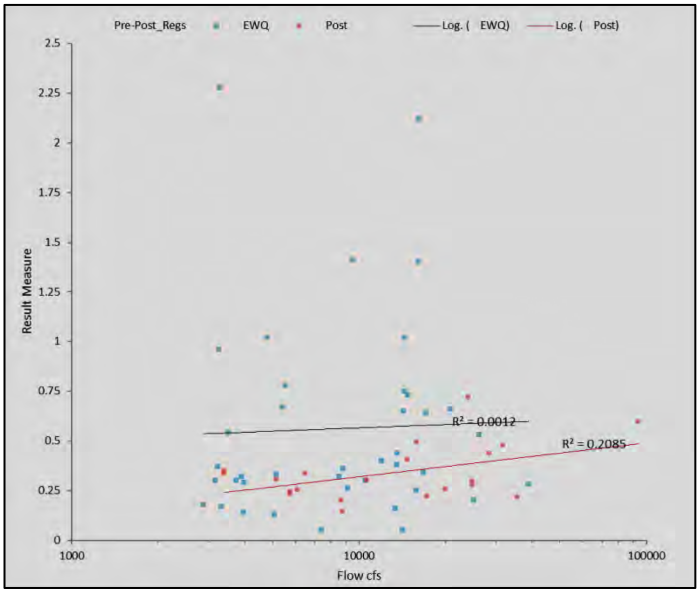
No water quality degradation is indicated. Total Nitrogen concentrations apparently declined between the EWQ and post-EWQ periods, though flow differences, potential laboratory artifacts, and too few post-EWQ samples produced uncertainty. TN is unrelated to flow in both periods. The EWQ data overall are far more variable than the post-EWQ data. DRBC results could not be independently validated. Post-EWQ median TN concentrations fell below the EWQ lower 95% confidence interval.

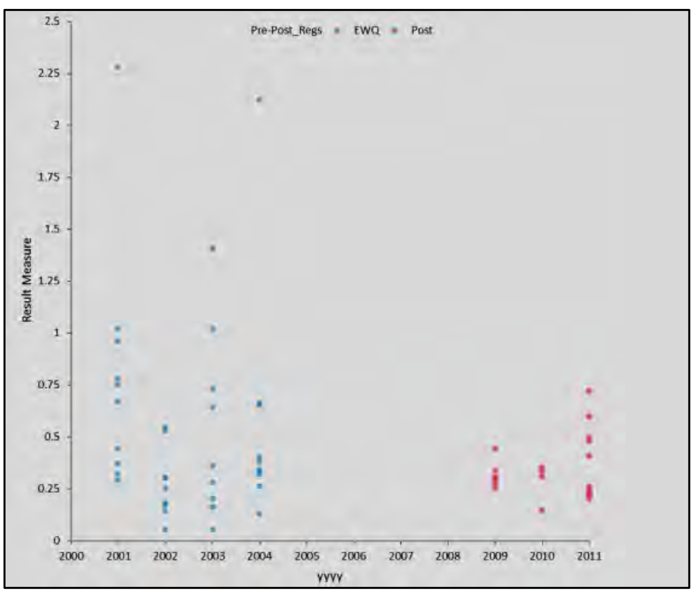
Chapter 2: 1418 ICP
Delaware River at Washington Crossing Bridge

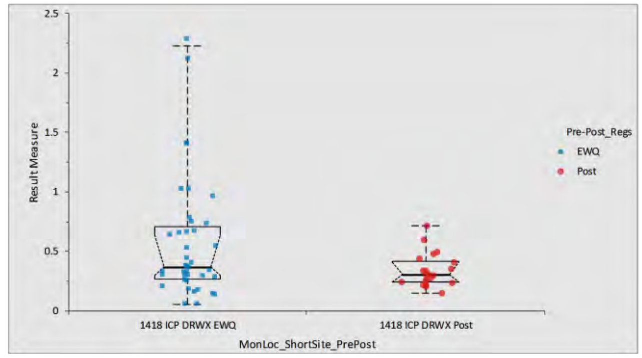
Nitrogen, Kjeldahl as N, Total (TKN) mg/l

Existing Water Quality (Table 2Y):

Median 0.37 mg/l
Lower 95% Confidence Interval 0.30 mg/l
Upper 95% Confidence Interval 0.64 mg/l

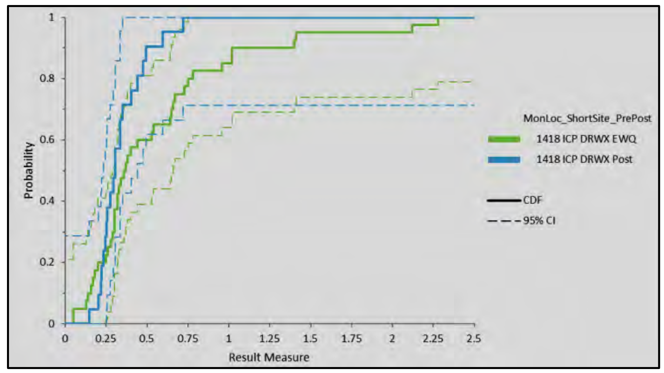






N 61

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1418 ICP DRWX EWQ	0.050	0.268	0.365	0.705	2.280	0.437
1418 ICP DRWX Post	0.145	0.240	0.304	0.417	0.719	0.177



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1418 ICP DRWX EWQ	40	255.0	6.38
1418 ICP DRWX Post	21	485.8	23.13

H statistic	2.35
X^2 approximation	2.35
DF	1
p-value	0.1252 [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.

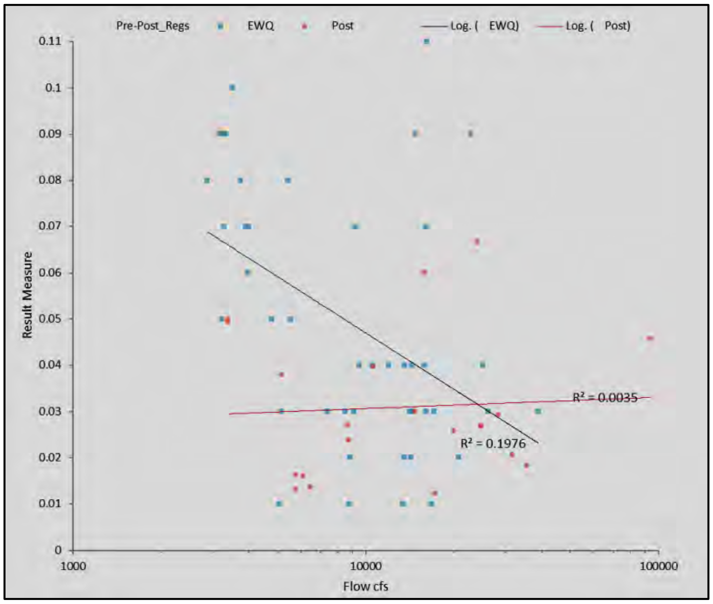
No water quality degradation is indicated. No measurable change occurred in TKN concentrations between the EWQ and post-EWQ periods. TKN concentration is unrelated to flow in both data sets. Post-EWQ TKN was far less variable than EWQ TKN. Post-EWQ median TKN fell within EWQ 95% confidence intervals, but just barely. Though there was no statistical difference between EWQ and post-EWQ TKN due to fewer post-EWQ data (n=21), concentrations fell somewhat and were far more stable, which may be real or may be a laboratory artifact.

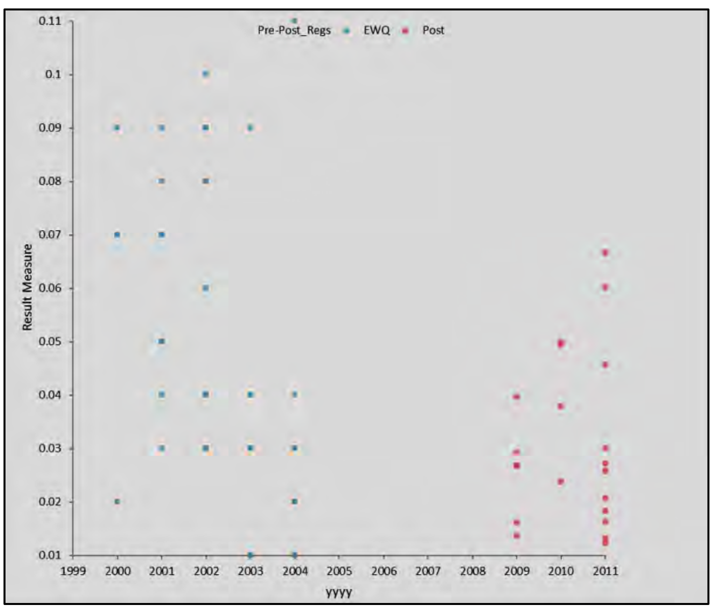
Chapter 2: 1418 ICP
Delaware River at Washington Crossing Bridge

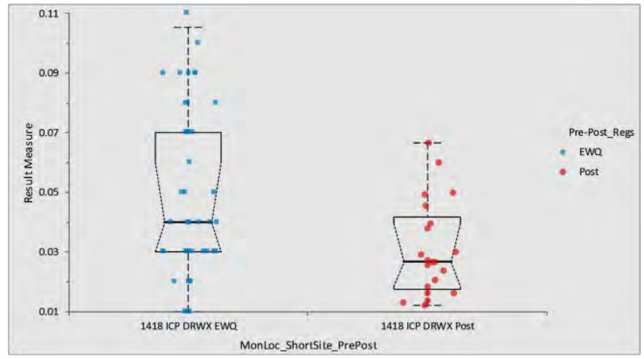
Orthophosphate as P, Total mg/l (OP)

Existing Water Quality (Table 2Y):

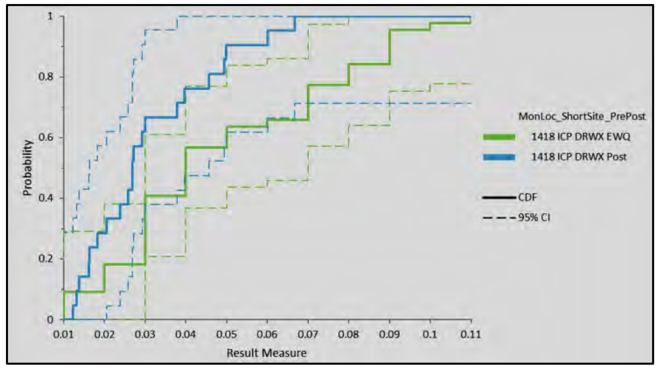
Median 0.04 mg/l
Lower 95% Confidence Interval 0.03 mg/l
Upper 95% Confidence Interval 0.06 mg/l







N	65					
Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1418 ICP DRWX EWQ	0.010	0.030	0.040	0.070	0.110	0.040
1418 ICP DRWX Post	0.012	0.018	0.027	0.042	0.067	0.024



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1418 ICP DRWX EWQ	44	909.1	20.66
1418 ICP DRWX Post	21	1904.8	90.70

H statistic	7.93
X² approximation	7.93
DF	1
p-value	0.0049 [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 indicated. OP appeared to decline between the EWQ and post-EWQ periods. However, differences in flow conditions, detection limits, potential laboratory artifacts, and too few post-EWQ samples produce uncertainty in the conclusion. Orthophosphate is unrelated to flow in both data sets. There were no independent data to confirm DRBC results. DRBC detection limits improved between the two periods, but concentrations are sufficiently high at this location that there were few undetected results in either data set.

Chapter 2: 1418 ICP

Delaware River at Washington Crossing Bridge

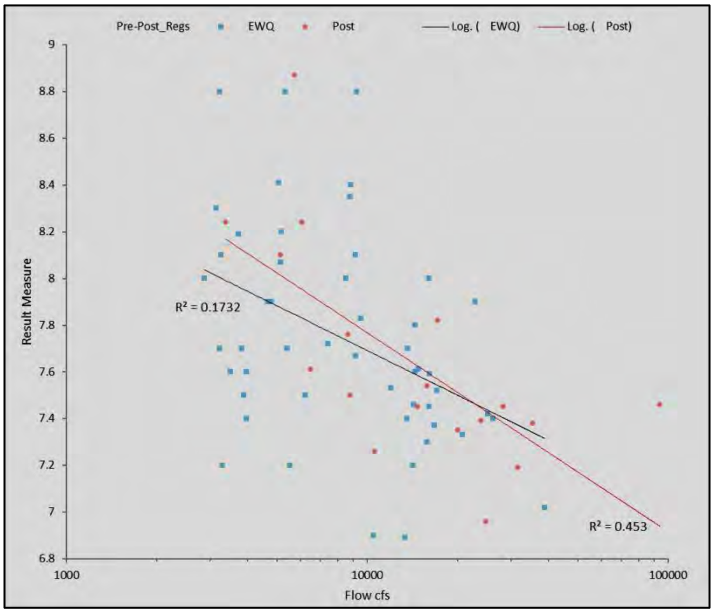
pH, units

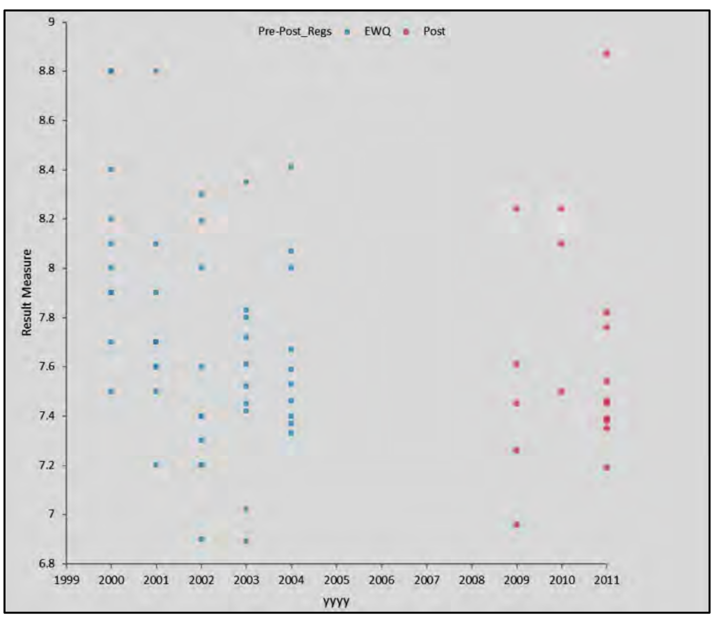
Existing Water Quality (Table 2Y):

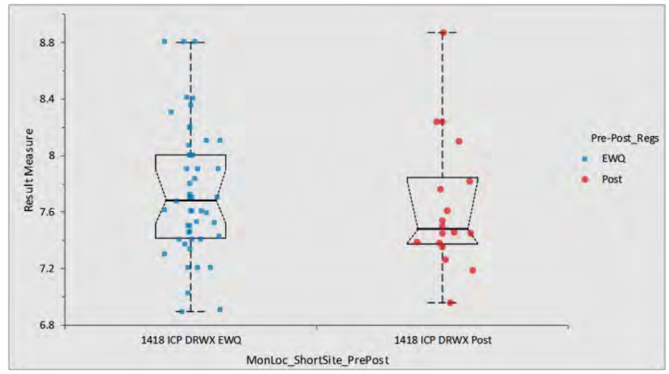
Median 7.69 standard units

Lower 95% Confidence Interval 7.52 standard units

Upper 95% Confidence Interval 7.90 standard units

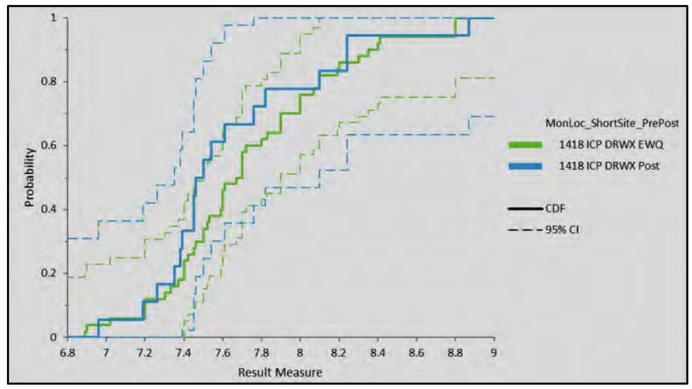






N 68

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1418 ICP DRWX EWQ	6.89	7.42	7.69	8.01	8.80	0.59
1418 ICP DRWX Post	6.96	7.38	7.48	7.84	8.87	0.47



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1418 ICP DRWX EWQ	50	115.5	2.31
1418 ICP DRWX Post	18	320.9	17.83

H statistic	1.12
X^2 approximation	1.12
DF	1
p-value	0.2905 [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 indicated. pH did not measurably change between the EWQ and post-EWQ periods. Under higher flow conditions, pH tends toward neutral. pH is inversely related to flow in the post-EWQ data.

Chapter 2: 1418 ICP

Delaware River at Washington Crossing Bridge

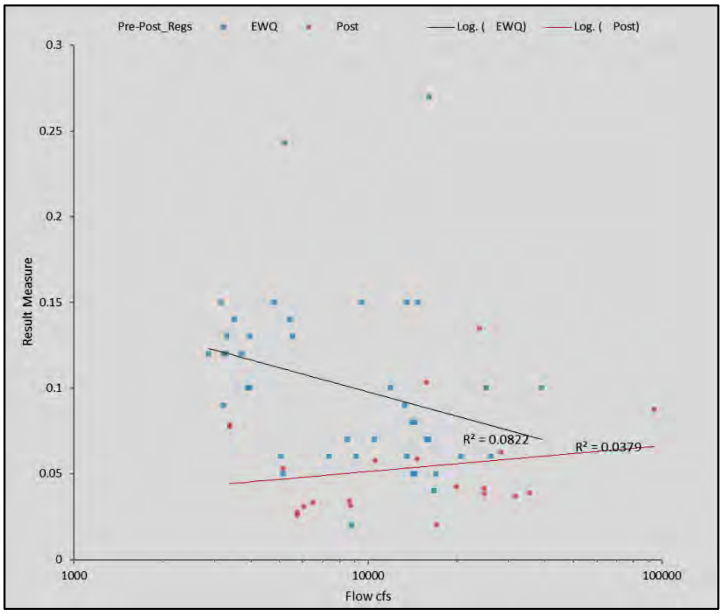
Phosphorus as P, Total (TP) mg/l

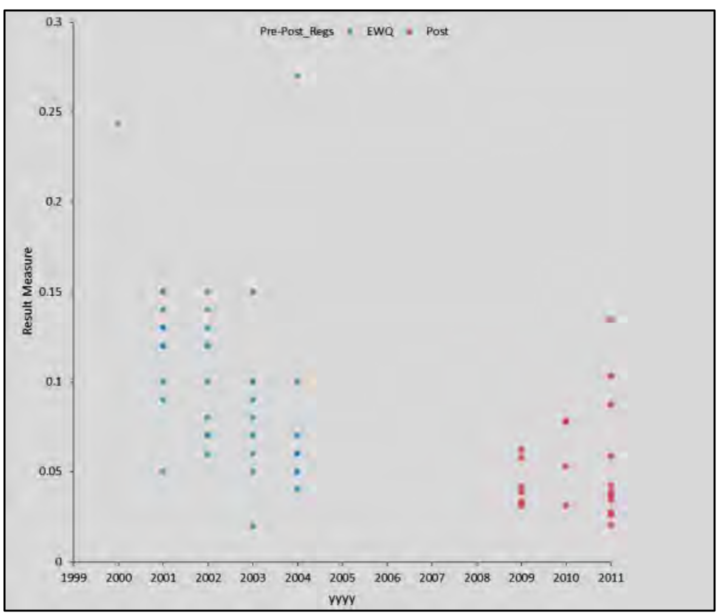
Existing Water Quality (Table 2Y):

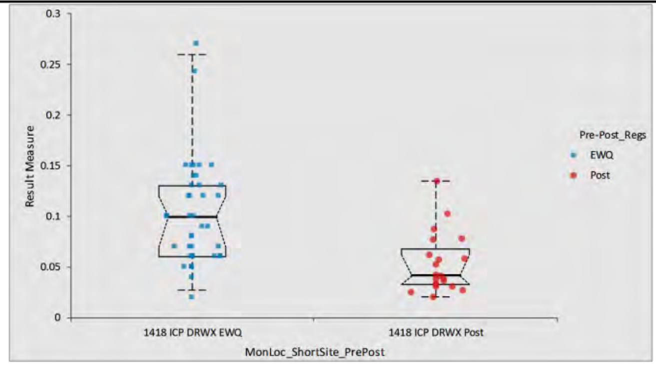
Median 0.10 mg/l

Lower 95% Confidence Interval 0.07 mg/l

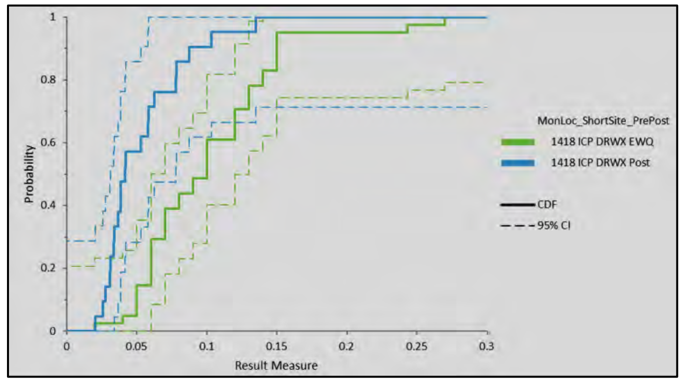
Upper 95% Confidence Interval 0.12 mg/l







N	62					
Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1418 ICP DRWX EWQ	0.020	0.060	0.100	0.130	0.270	0.070
1418 ICP DRWX Post	0.020	0.033	0.042	0.068	0.135	0.035



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1418 ICP DRWX EWQ	41	1905.4	46.47
1418 ICP DRWX Post	21	3720.0	177.14

H statistic	17.33
X^2 approximation	17.33
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.

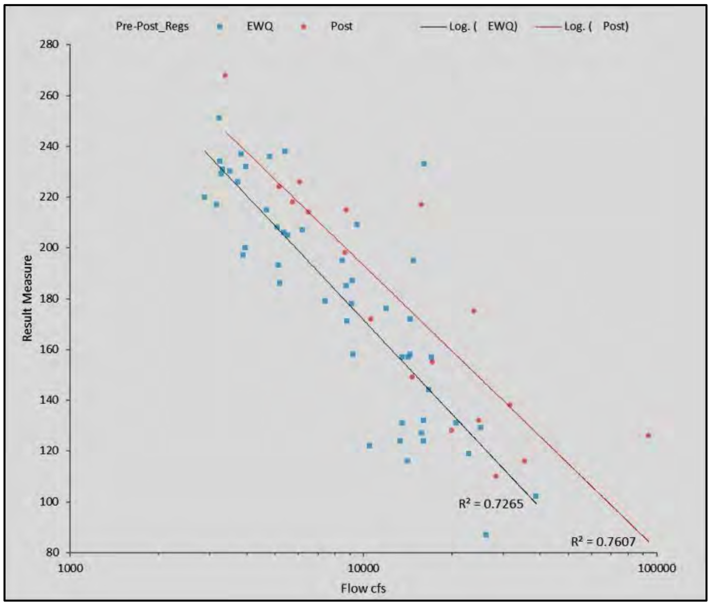
No water quality degradation is indicated. Total Phosphorus (TP) concentrations appeared to decline significantly between the EWQ and post-EWQ periods. However, differences in flow conditions, detection limits, potential laboratory artifacts, and too few post-EWQ samples produced uncertainty. TP is unrelated to flow in both data sets. There were no undetected results in either data set. No independent data were available to confirm these results.

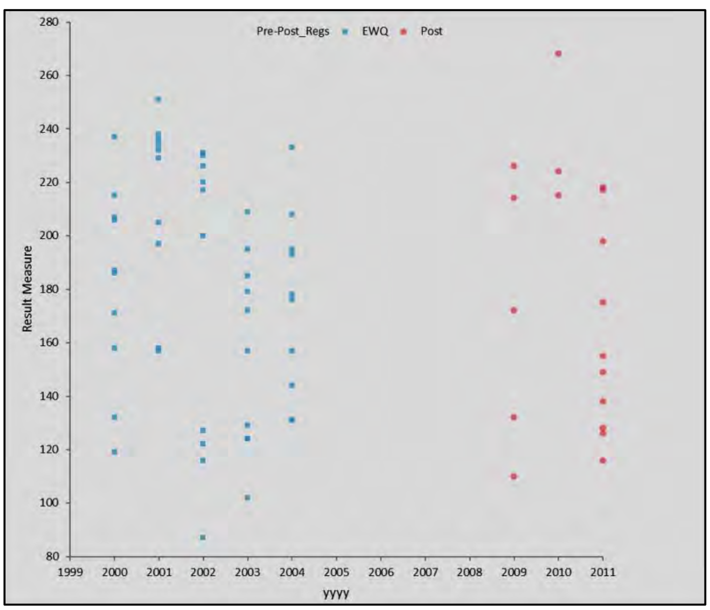
Chapter 2: 1418 ICP
Delaware River at Washington Crossing Bridge

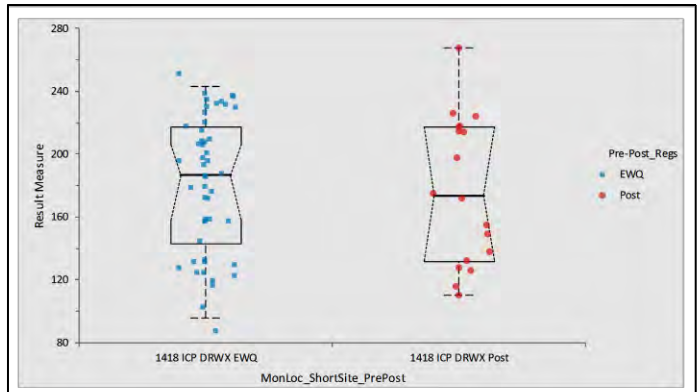
Specific Conductance µmho/cm

Existing Water Quality (Table 2Y):

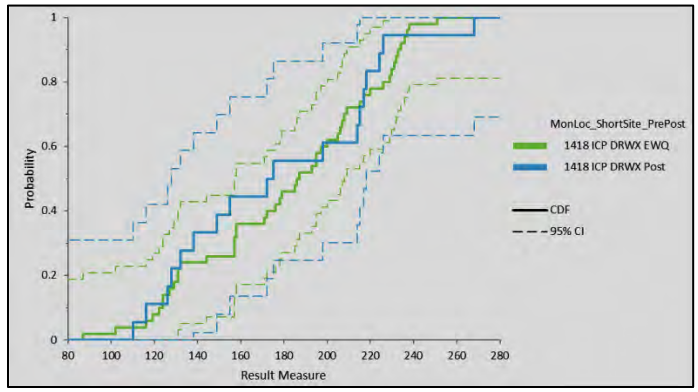
Median 187 µmho/cm
Lower 95% Confidence Interval 158 µmho/cm
Upper 95% Confidence Interval 206 µmho/cm
Defined in regulations as a flow-related parameter







N	68					
Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1418 ICP DRWX EWQ	87	143.0	186.5	217.3	251	74.3
1418 ICP DRWX Post	110	131.7	173.5	217.1	268	85.4



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1418 ICP DRWX EWQ	50	24.5	0.49
1418 ICP DRWX Post	18	68.1	3.78

H statistic	0.24
X² approximation	0.24
DF	1
p-value	0.6265 [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.

Some evidence of water quality degradation is indicated. Specific conductance did not measurably change between the EWQ and post-EWQ periods. In both data sets, specific conductance is inversely related to flow. In the post-EWQ data, low-flow conditions are under-represented – with the higher flow driving the median concentration down, even though post-EWQ concentration appears to be about 10 µmho/cm higher on the flow relationship graph. Post-EWQ median specific conductance fell within the EWQ 95% confidence intervals.

Chapter 2: 1418 ICP

Delaware River at Washington Crossing Bridge

Total Dissolved Solids (TDS) mg/l

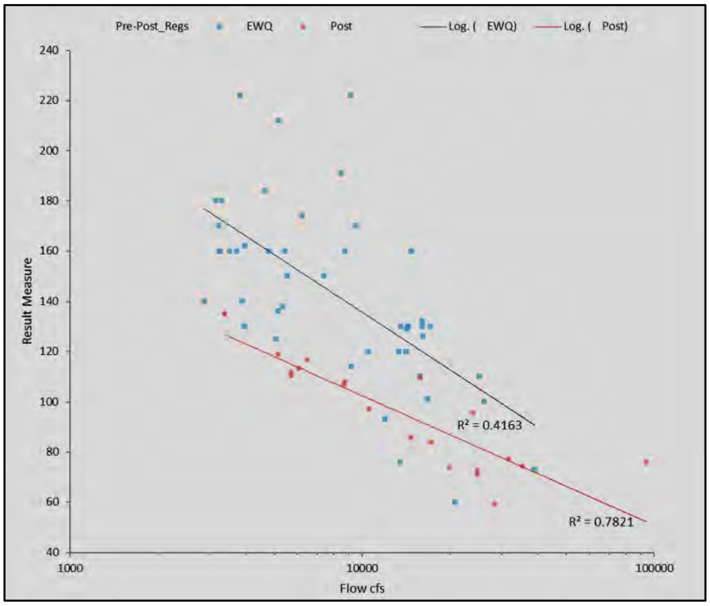
Existing Water Quality (Table 2Y):

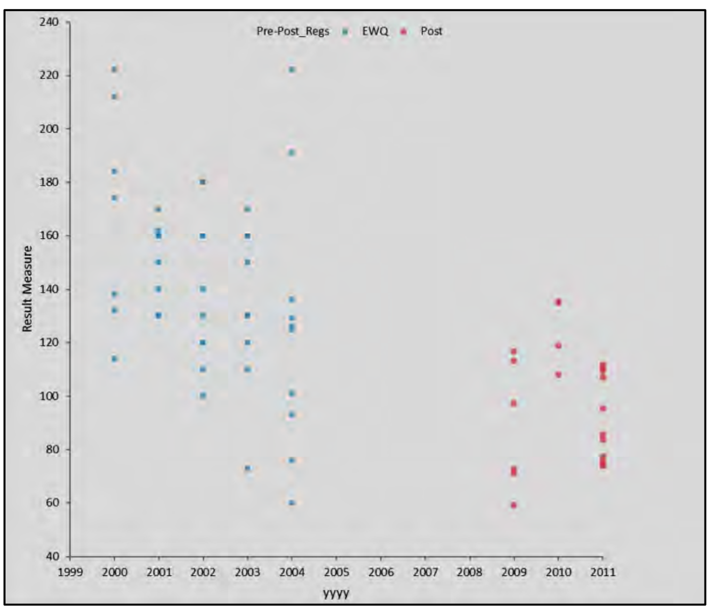
Median 138 mg/l

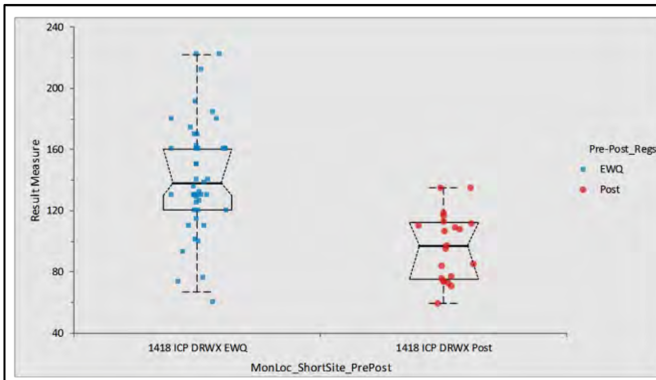
Lower 95% Confidence Interval 130 mg/l

Upper 95% Confidence Interval 160 mg/l

Defined in regulations as a flow-related parameter

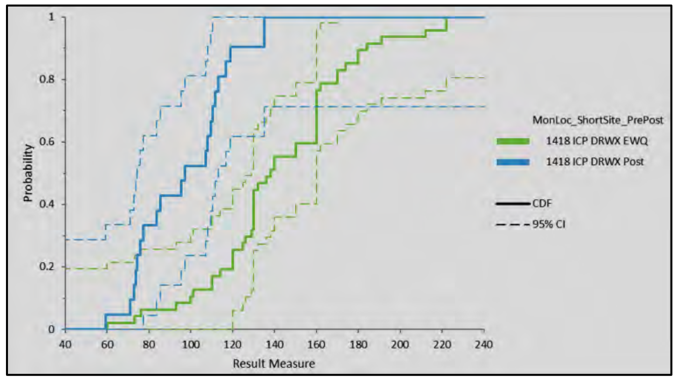






N 68

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1418 ICP DRWX EWQ	60.0	120.8	138.0	160.0	222.0	39.2
1418 ICP DRWX Post	59.2	75.2	97.2	112.2	135.1	37.0



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1418 ICP DRWX EWQ	47	2826.8	60.14
1418 ICP DRWX Post	21	6326.7	301.27

H statistic	23.47
X² approximation	23.47
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.

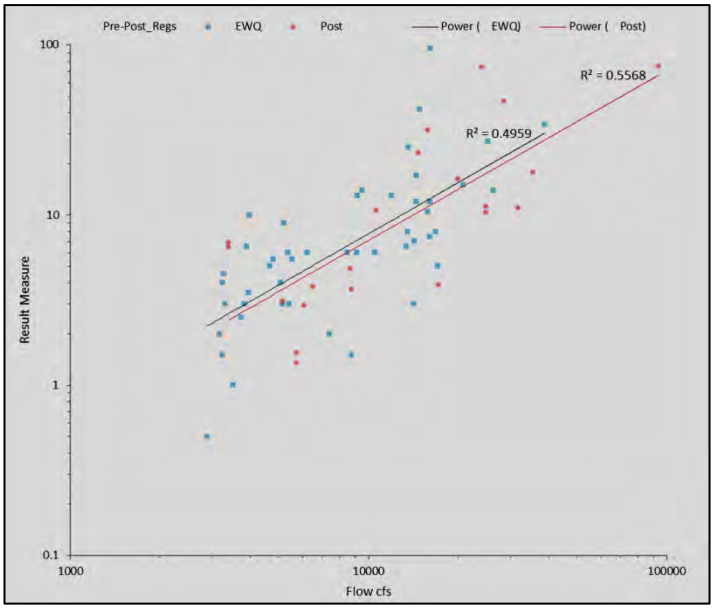
No water quality degradation is indicated. TDS apparently declined between the EWQ and post-EWQ periods. However, differences in flow conditions, potential laboratory artifacts, and too few post-EWQ samples produced uncertainty in the conclusion. TDS is inversely related to flow. Post-EWQ median TDS was below the EWQ 95% lower confidence interval, and post-EWQ TDS range was narrower than EWQ TDS. Post-EWQ detection limits were lower than EWQ detection limits, though there were no non-detect results even in 2000 when the detection limit was 20 mg/l.

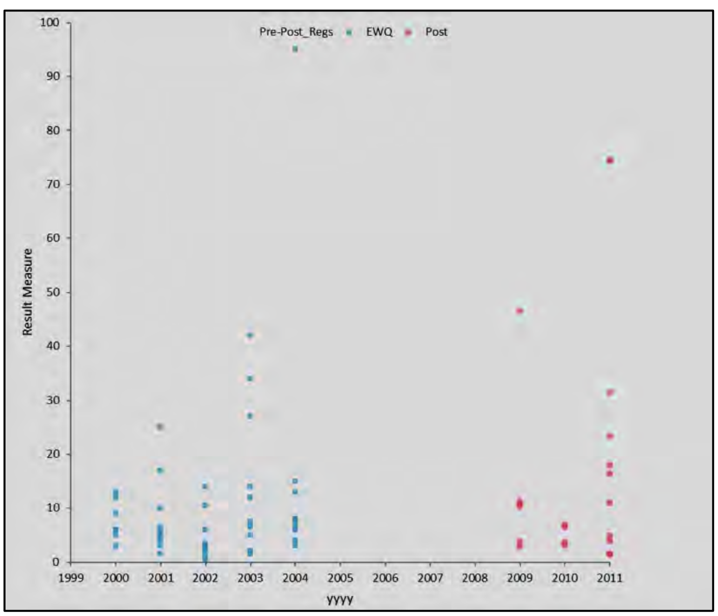
Chapter 2: 1418 ICP
Delaware River at Washington Crossing Bridge

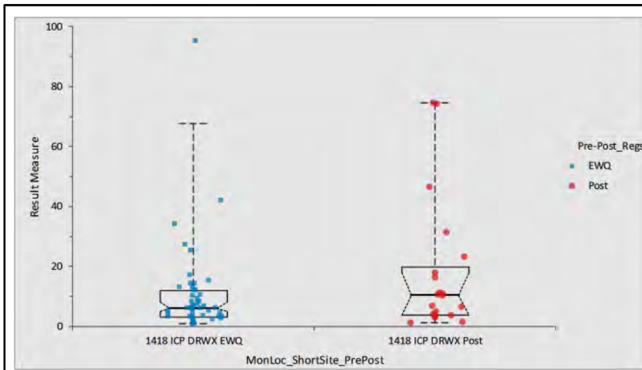
Total Suspended Solids (TSS) mg/l

Existing Water Quality (Table 2Y):

Median 6.0 mg/l
Lower 95% Confidence Interval 5.0 mg/l
Upper 95% Confidence Interval 8.0 mg/l
Defined in regulations as a flow-related parameter

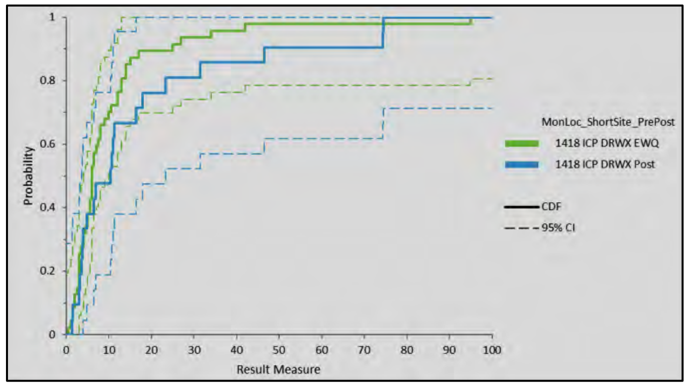






N 68

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1418 ICP DRWX EWQ	0.5	3.1	6.0	12.0	95.0	8.9
1418 ICP DRWX Post	1.3	3.7	10.4	19.7	74.5	16.0



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1418 ICP DRWX EWQ	47	137.9	2.93
1418 ICP DRWX Post	21	308.6	14.69

H statistic	1.14
X^2 approximation	1.14
DF	1
p-value	0.2850[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.

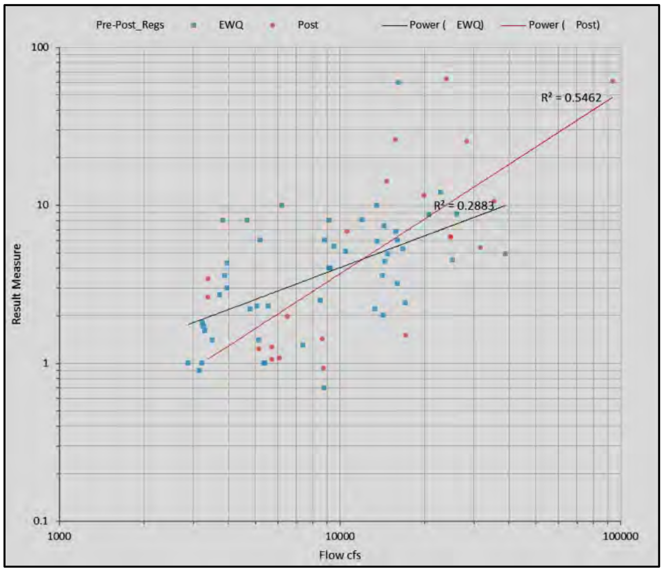
No water quality degradation is indicated. TSS did not measurably change between the EWQ and post-EWQ periods. However, potential laboratory artifacts and insufficient post-EWQ sampling (n=21) introduced analytical uncertainty. TSS is positively related to flow in both data sets. Post-EWQ median TSS was well above the EWQ upper 95% confidence interval, but this was only because low-flow conditions were under-represented in the post-EWQ data. Both distributions were similarly shaped. On the flow vs. concentration graph, both flow and concentration are plotted on a logarithmic scale, and the regression is a power relationship.

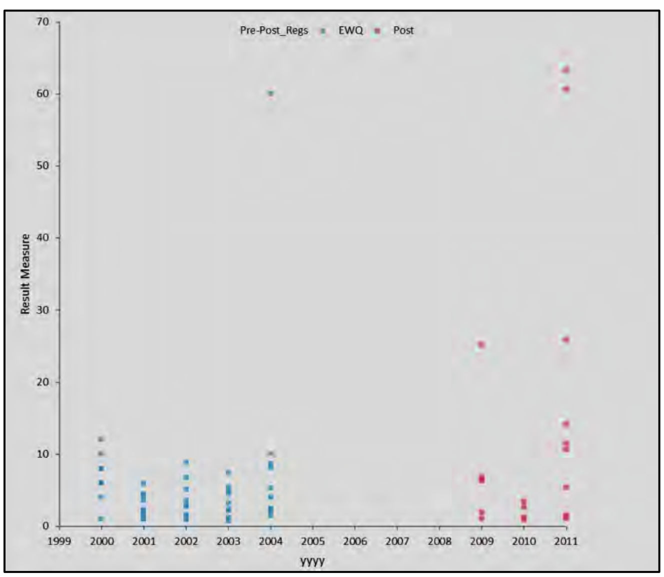
Chapter 2: 1418 ICP
Delaware River at Washington Crossing Bridge

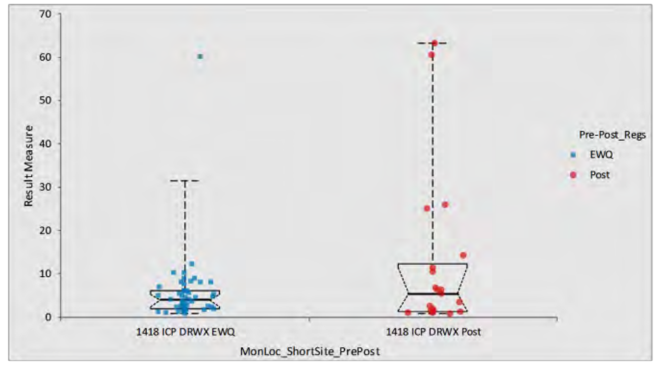
Turbidity NTU

Existing Water Quality (Table 2Y):

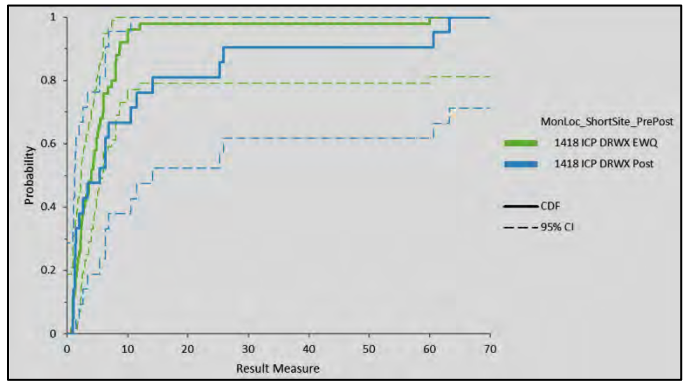
Median 4.0 NTU*
Lower 95% Confidence Interval 2.4 NTU
Upper 95% Confidence Interval 5.3 NTU
*Should have been designated in rules as flow-related







Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
N	71					
1418 ICP DRWX EWQ	0.70	1.98	4.00	6.07	60.00	4.08
1418 ICP DRWX Post	0.93	1.37	5.39	12.40	63.30	11.03



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1418 ICP DRWX EWQ	50	79.4	1.59
1418 ICP DRWX Post	21	189.0	9.00

H statistic	0.63
X² approximation	0.63
DF	1
p-value	0.4273 [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.

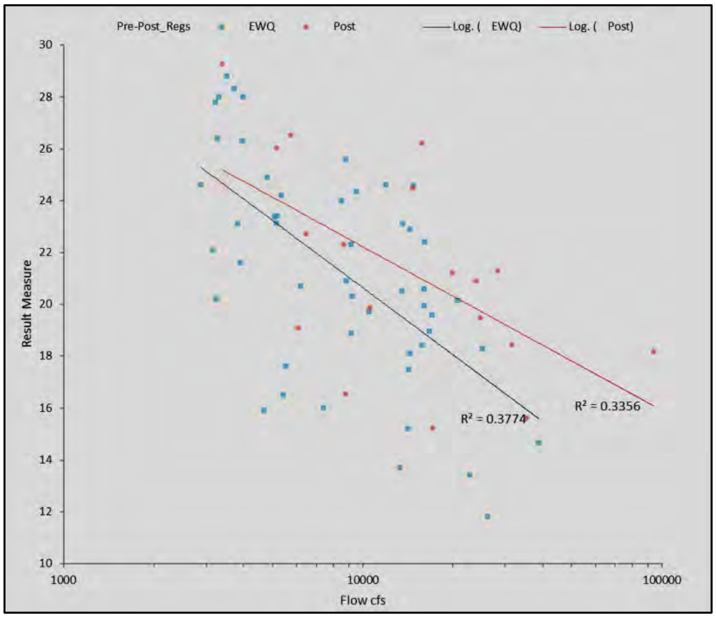
No water quality degradation is indicated. All but five post-EWQ turbidity results were within the expected EWQ range of 0-15. All five were taken during high flow conditions. However, insufficient post-EWQ sampling (n=21) introduced analytical uncertainty. The post-EWQ median turbidity was well above the EWQ upper 95% confidence interval of the median, but overall turbidity did not measurably change between the EWQ and post-EWQ periods. In both data sets, the turbidity vs. flow relationship is weakly positive. Post-EWQ N was far less than EWQ N, and dry-weather samples were under-represented in the post-EWQ data set.

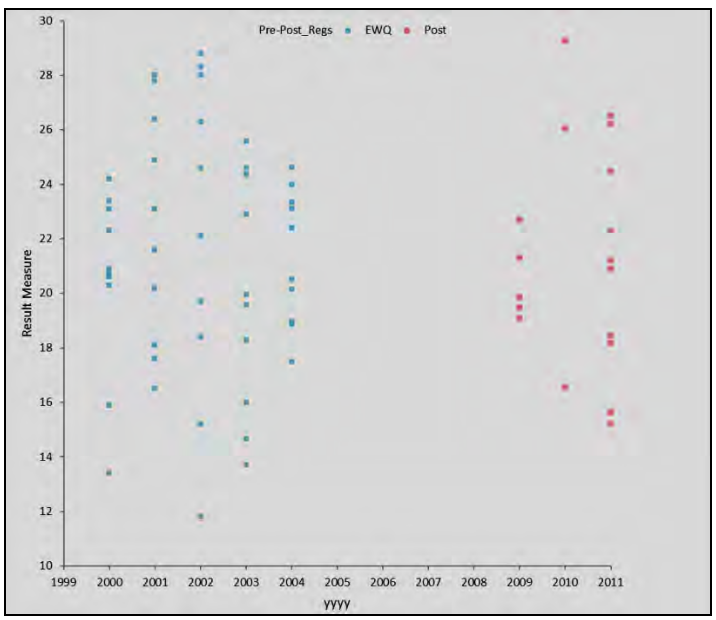
Chapter 2: 1418 ICP

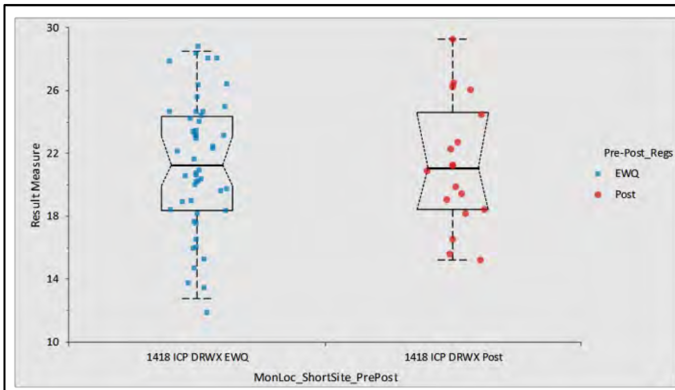
Delaware River at Washington Crossing Bridge

Water Temperature, degrees C

Not included in DRBC Existing Water Quality rules

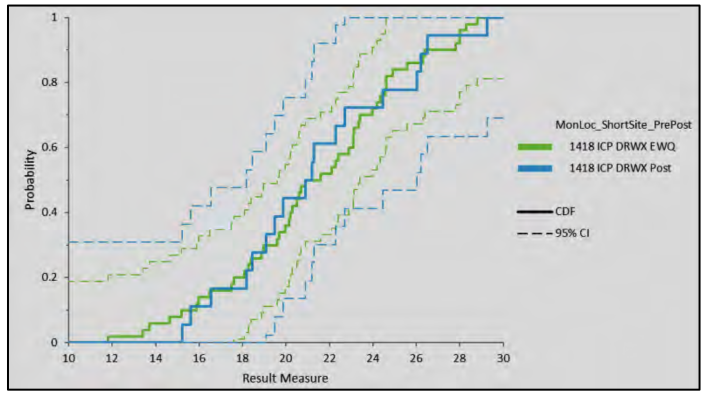






N	68

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1418 ICP DRWX EWQ	11.8	18.4	21.3	24.4	28.8	6.0
1418 ICP DRWX Post	15.2	18.4	21.1	24.6	29.3	6.2



Kruskal-Wallis test

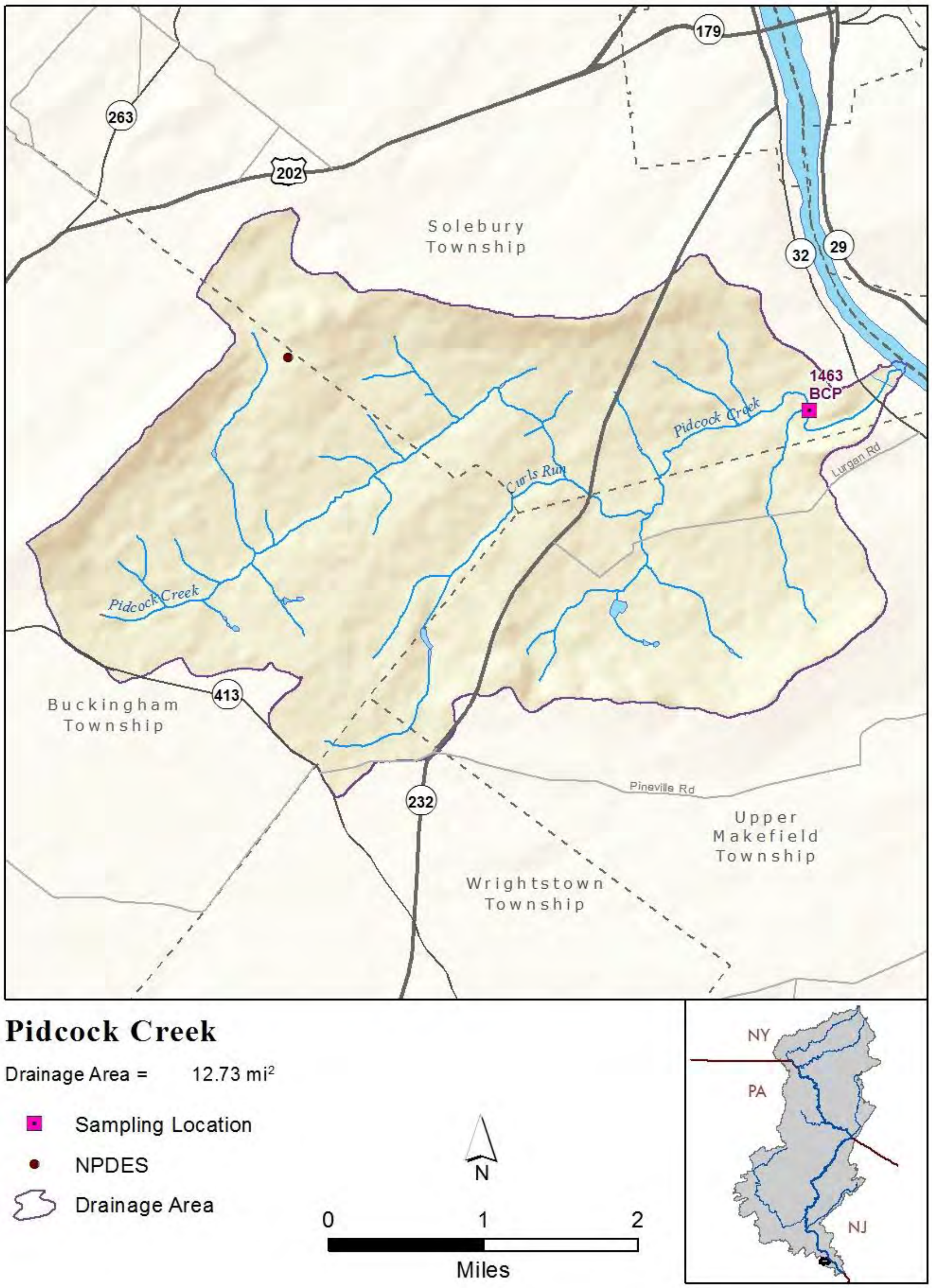
Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1418 ICP DRWX EWQ	50	2.2	0.04
1418 ICP DRWX Post	18	6.1	0.34

H statistic	0.02
X² approximation	0.02
DF	1
p-value	0.8839[1]

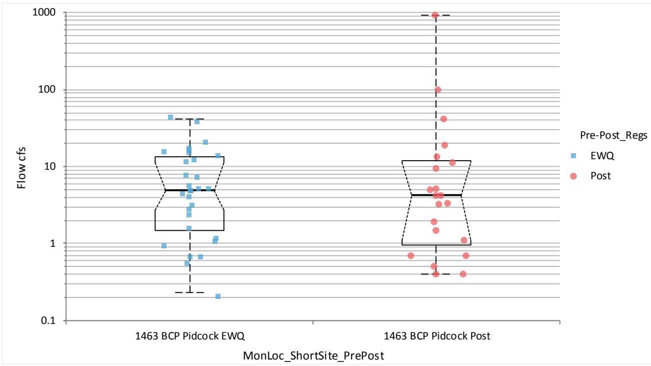
H0: $\theta_1 = \theta_2 = \theta_{...}$
The median of the populations are all equal.
H1: $\theta_i \neq \theta_j$ for at least one i,j
The median of the populations are not all equal.
[1] Do not reject the null hypothesis at the 5% significance level.

No water quality degradation is indicated. Water temperature did not measurably change between the EWQ and post-EWQ periods. However, insufficient post-EWQ sampling (n=21) introduced analytical uncertainty. Water temperature is inversely related to flow, though the relationship is weak. The distributions were similar, except post-EWQ minimum and maximum temperatures were higher than EWQ temperatures.

Chapter 3: 1463 BCP Pidcock Creek, Bucks County, PA



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



N 51

Flow cfs by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1463 BCP Pidcock EWQ	0.20	1.49	4.87	13.40	42.74	11.91
1463 BCP Pidcock Post	0.40	0.97	4.26	11.97	939.00	11.00

Kruskal-Wallis test

Flow cfs by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1463 BCP Pidcock EWQ	30	20.0	0.67
1463 BCP Pidcock Post	21	28.6	1.36

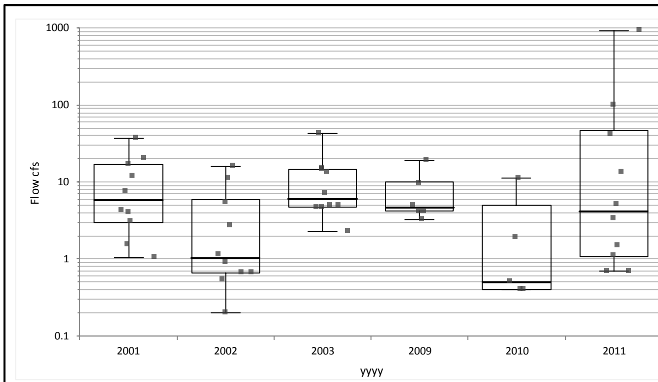
H statistic	0.22
X^2 approximation	0.22
DF	1
p-value	0.6391 [1]

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.

Flow was not significantly different between the two periods. On an annual flow-duration curve, “normal” flow of Pidcock Creek is about 11.3 cfs. The flow conditions shown here represent actual measurements taken during the May to September periods of multiple years. Summer flow conditions are usually much dryer as plant growth takes up much of the rainfall and reduces baseflow.

Upstream ICP: Delaware River at Lambertville 1487 ICP
Downstream ICP: Delaware River at Washington Crossing 1418 ICP

At the Bowman’s Hill Wildflower Preserve sampling site the upstream drainage area is about 11.7 square miles. Overall watershed size is 12.7 square miles. The watershed is about 60% forested, only 0.3% urban lands, and the underlying geology contains only 2.8% carbonate bedrock. We chose Pidcock Creek as a representative small Piedmont Watershed.



N 51

Flow cfs by yyyy	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
2001	1.0	3.0	5.8	17.1	36.9	14.2
2002	0.2	0.7	1.0	5.9	16.1	5.3
2003	2.3	4.7	6.0	14.5	42.7	9.9
2009	3.3	4.2	4.7	10.2	18.9	6.0
2010	0.4	0.4	0.5	5.1	11.3	4.7
2011	0.7	1.1	4.2	46.5	939.0	45.4

Annual flow statistics are plotted above. Flow is plotted on a logarithmic scale. These are May to September flow measurements associated with the time of each water quality sample. “Normal” flow is about 11.3 cfs at this location, but less (about 4 cfs) during the summer. Note the maximum flow sampled in 2011, which was sampled during a major flood (flow estimated). The lowest flow we ever measured was 0.2 cfs in 2002. In this watershed, a high-flow event is difficult to sample unless specifically targeted. This is because the geology of this Piedmont stream does not retain water very well. Most rainfall runs off within a very short period. This “flashy” condition persists in many other Piedmont streams of the Lower Delaware.

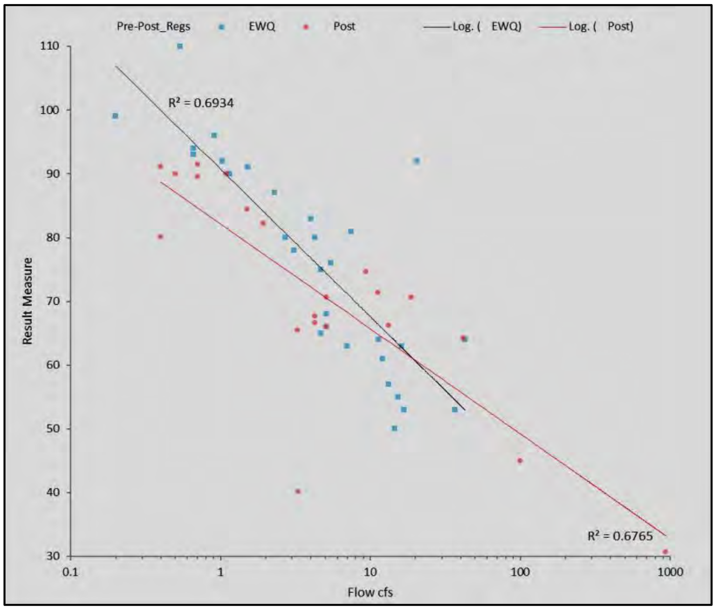
Under low to normal flow conditions, Pidcock Creek is captured by the Delaware Canal. Its water quality influence upon the Delaware River is minimal except during high flow conditions. Many of the small Pennsylvania streams located between Morrisville and Easton are captured by the canal unless aqueducts were historically built to pass canal flow over the stream.

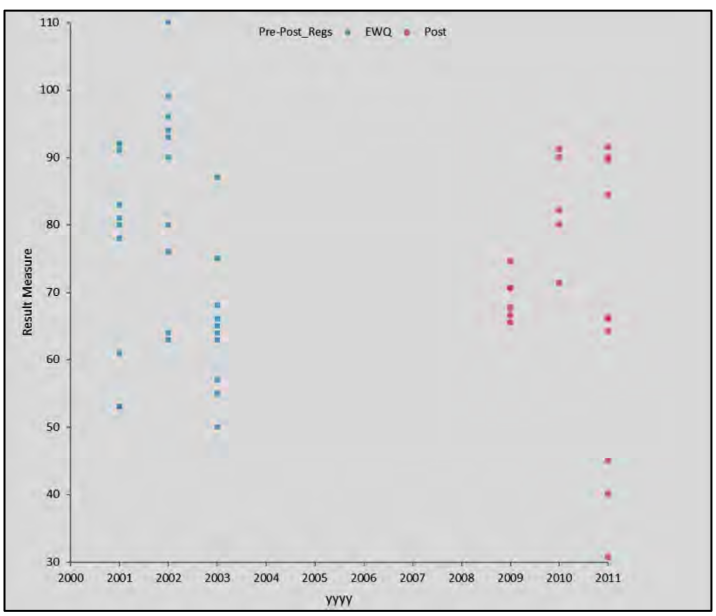
Chapter 3: 1463 BCP
Pidcock Creek, PA

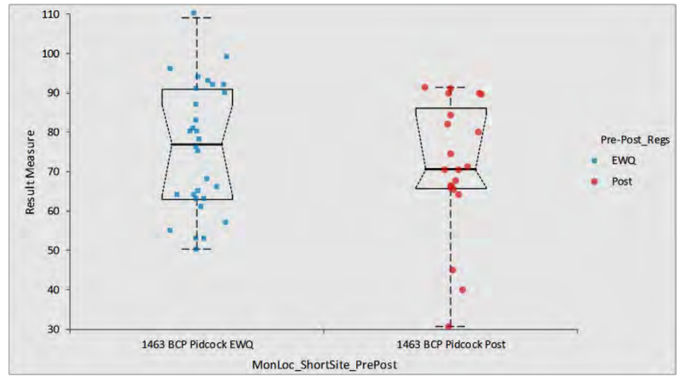
Alkalinity as CaCO3, Total mg/l

Existing Water Quality (Table 2X):

Median 77 mg/l
Lower 95% Confidence Interval 64 mg/l
Upper 95% Confidence Interval 87 mg/l
Defined in regulations as a flow-related parameter

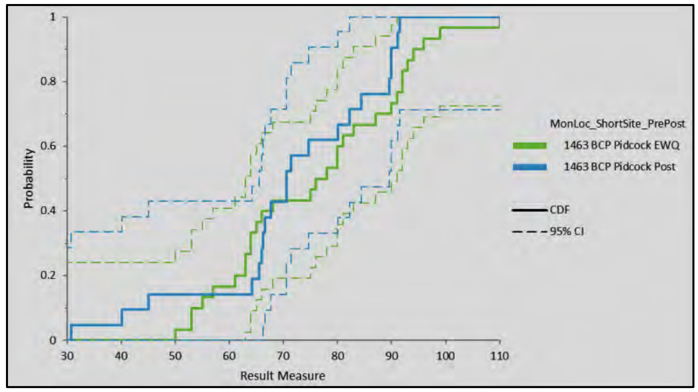






N 51

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1463 BCP Pidcock EWQ	50.0	63.0	77.0	91.1	110.0	28.1
1463 BCP Pidcock Post	30.7	65.8	70.6	86.1	91.5	20.3



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1463 BCP Pidcock EWQ	30	25.2	0.84
1463 BCP Pidcock Post	21	36.0	1.71

H statistic	0.28
X^2 approximation	0.28
DF	1
p-value	0.5986 [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.

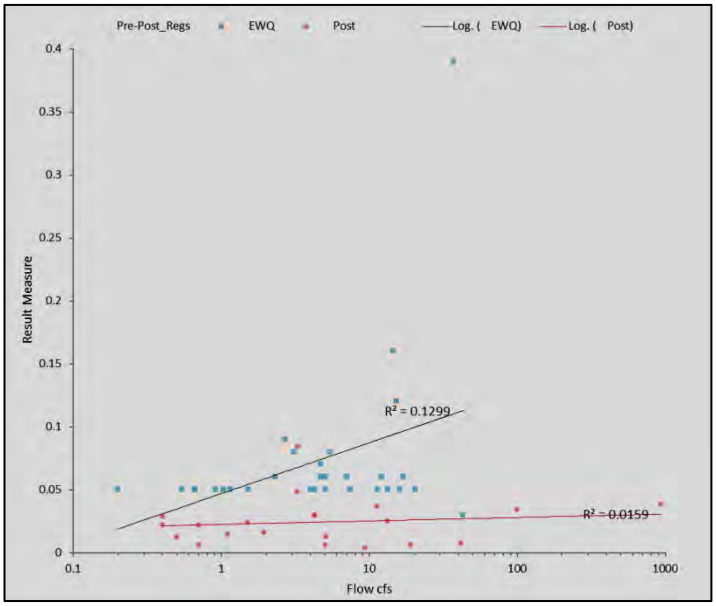
No water quality degradation is indicated. Alkalinity did not measurably change between the EWQ and post-EWQ periods. Alkalinity is inversely related to flow in both data sets. Post-EWQ median alkalinity fell within EWQ 95% confidence intervals, and the post-EWQ data were under-represented by dry weather samples. The unusually low values seen on the post-EWQ box plot are all high-flow samples. Flow is plotted on a logarithmic axis because the flood samples stand out so much that they obscure the view of the remaining data.

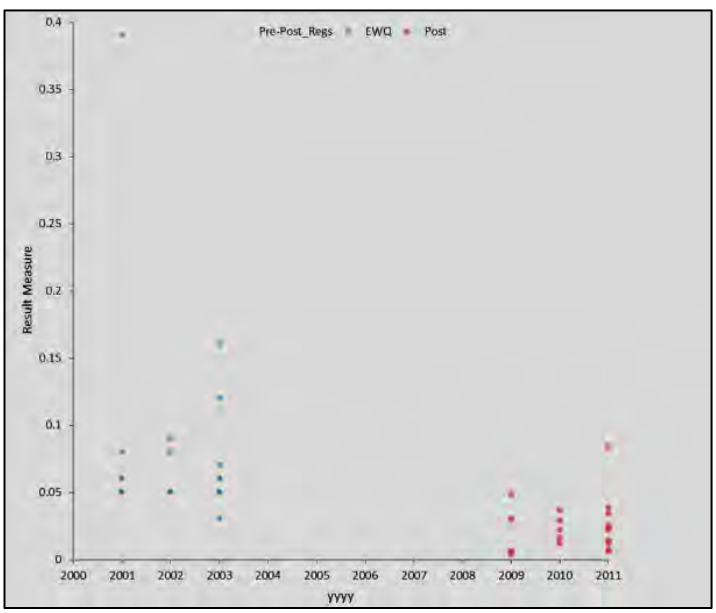
Chapter 3: 1463 BCP
Pidcock Creek, PA

Ammonia Nitrogen as N, Total mg/l

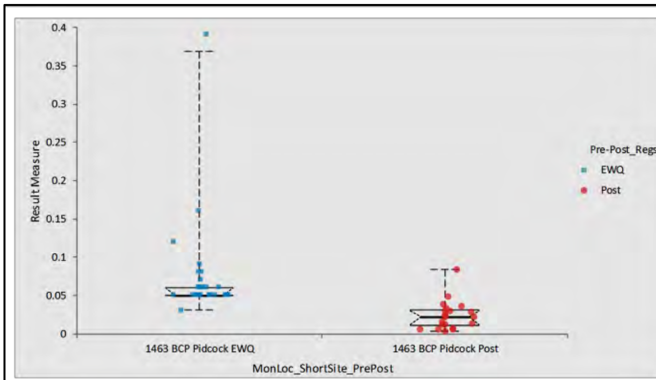
Existing Water Quality (Table 2X):

Median <0.05 mg/l (corrected from 0.05)
Lower 95% Confidence Interval <0.05 mg/l
Upper 95% Confidence Interval 0.06 mg/l



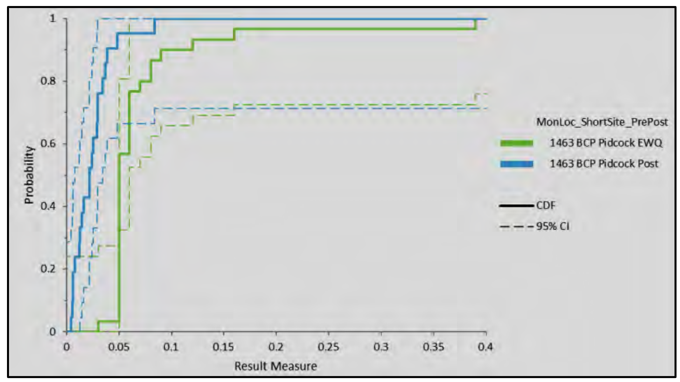


No water quality degradation is indicated. Ammonia concentrations appeared to decline. No independent data were available to validate the decline.



N | 51

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1463 BCP Pidcock EWQ	0.030	0.050	0.050	0.061	0.390	0.011
1463 BCP Pidcock Post	0.004	0.011	0.022	0.031	0.084	0.020



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1463 BCP Pidcock EWQ	30	2707.5	90.25
1463 BCP Pidcock Post	21	3867.9	184.18

H statistic	30.75
X^2 approximation	30.75
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.

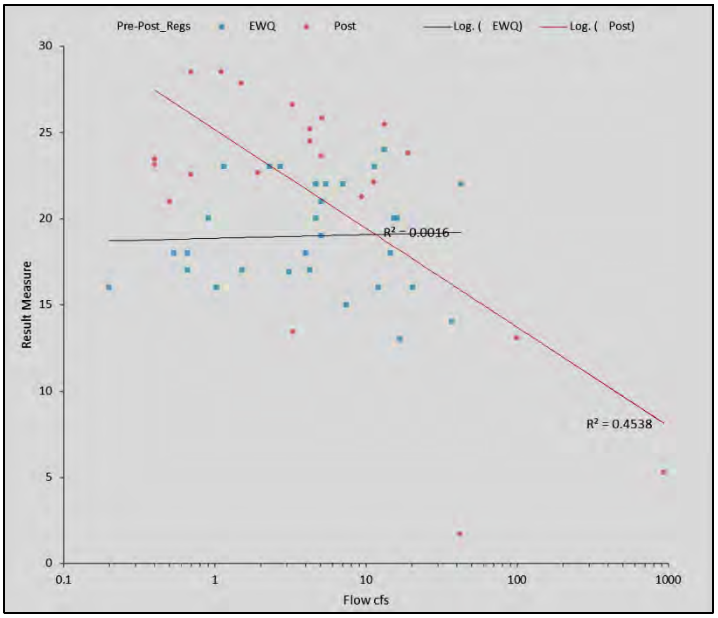
DRBC's post-EWQ detection limit was much lower than during the EWQ period. The EWQ data set possessed fairly high frequencies of non-detect results (17 of 30 samples), interfering with estimation of the median. There were 2 non-detect results in the 2009-2011 data. Thus the result found by DRBC is most likely due to adoption of more sensitive laboratory methods rather than a real change in ambient concentrations. Some improvement possibly took place, as the post-EWQ data contained fewer high concentrations. Flow is plotted on a logarithmic axis.

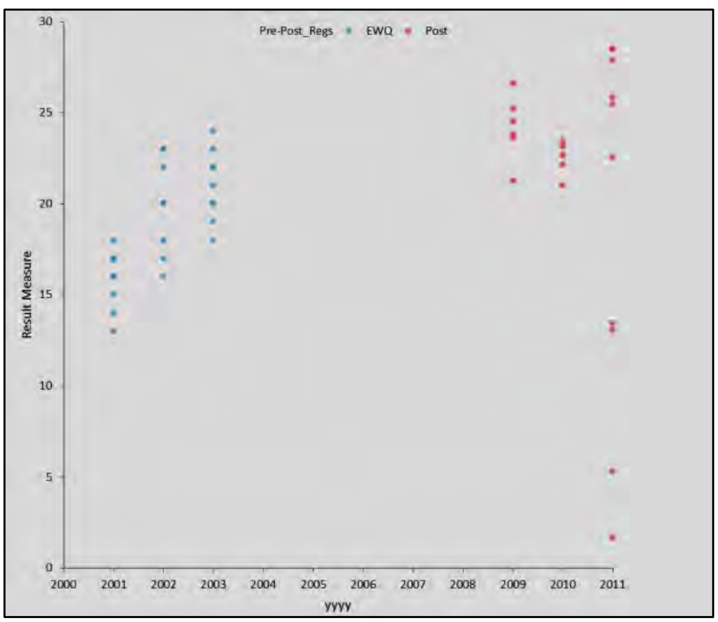
Chapter 3: 1463 BCP
Pidcock Creek, PA

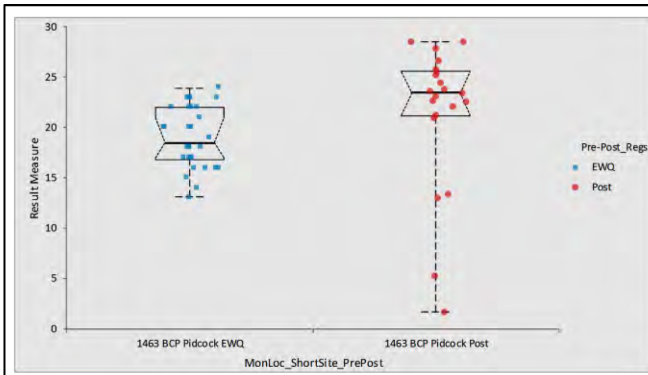
Chloride, Total mg/l

Existing Water Quality (Table 2X):

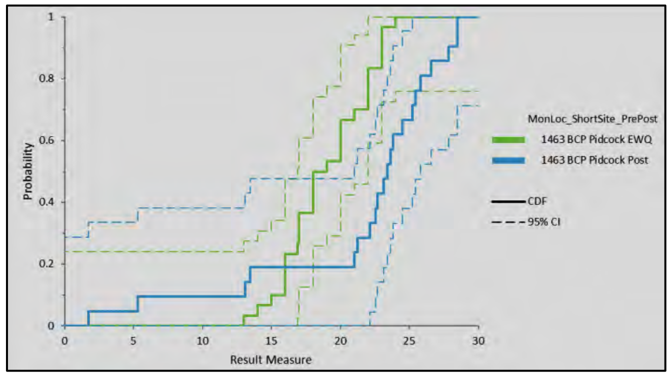
Median 19 mg/l
Lower 95% Confidence Interval 17 mg/l
Upper 95% Confidence Interval 21 mg/l
Defined in regulations as a flow-related parameter







N	51					
Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1463 BCP Pidcock EWQ	13.0	16.8	18.5	22.0	24.0	5.2
1463 BCP Pidcock Post	1.7	21.2	23.4	25.6	28.5	4.4



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1463 BCP Pidcock EWQ	30	842.7	28.09
1463 BCP Pidcock Post	21	1203.9	57.33

H statistic	9.28
X^2 approximation	9.28
DF	1
p-value	0.0023 [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.

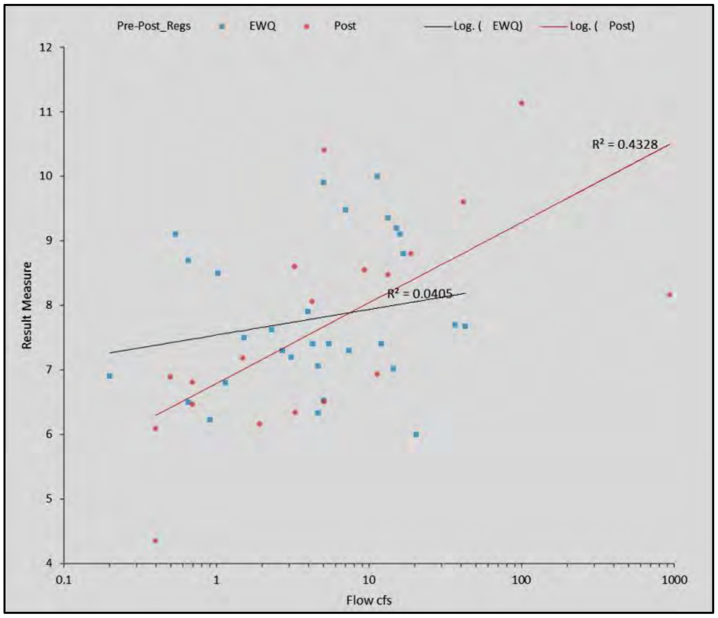
Water quality degradation is evident. Chloride concentrations increased by about 5 mg/l between the two periods. Post-EWQ median concentration rose above the EWQ upper 95% confidence interval. 2011 data varied most widely. The unusually low concentrations on the annual plot in 2011 were from samples taken under high flow or flood conditions. Flow is plotted on a logarithmic scale.

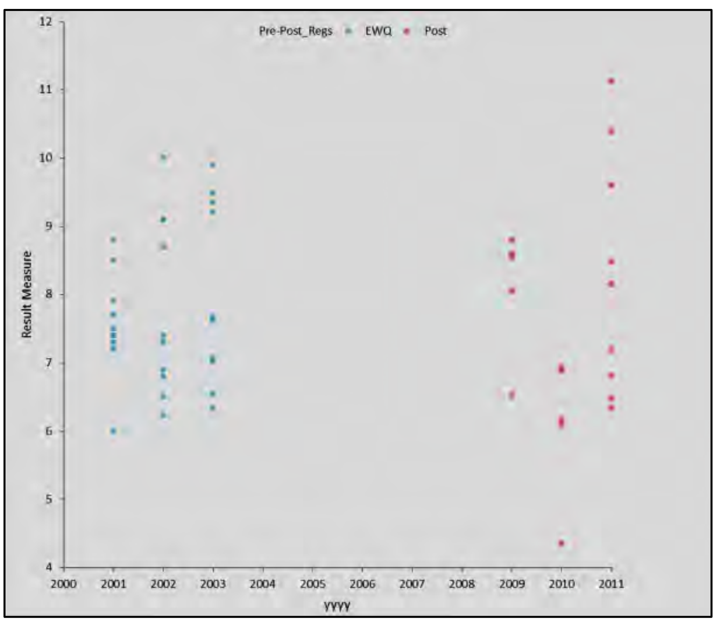
Chapter 3: 1463 BCP
Pidcock Creek, PA

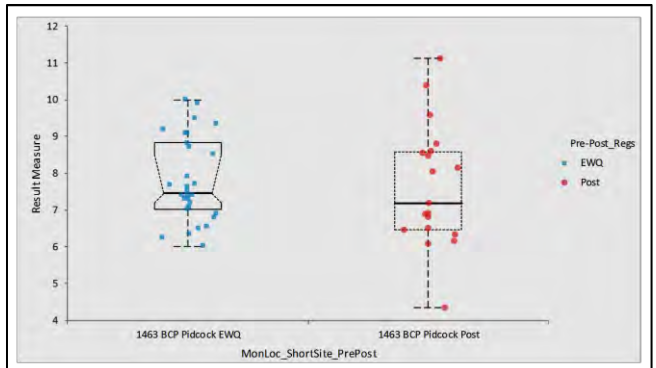
Dissolved Oxygen (DO) mg/l

Existing Water Quality (Table 2X):

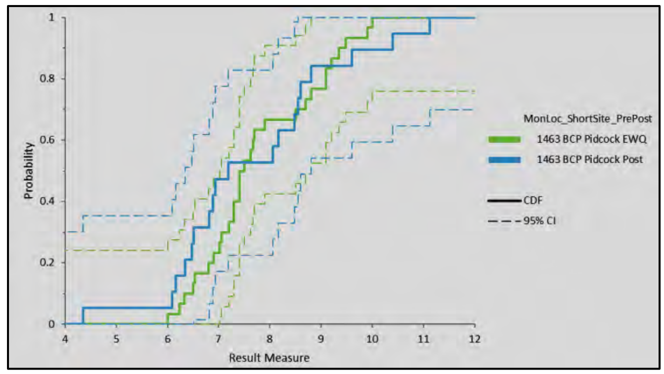
Median 7.45 mg/l
Lower 95% Confidence Interval 7.2 mg/l
Upper 95% Confidence Interval 8.5 mg/l







N	49					
Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1463 BCP Pidcock EWQ	6.0	7.0	7.5	8.8	10.0	1.8
1463 BCP Pidcock Post	4.4	6.5	7.2	8.6	11.1	2.1



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1463 BCP Pidcock EWQ	30	35.2	1.17
1463 BCP Pidcock Post	19	55.6	2.93

H statistic	0.44
X^2 approximation	0.44
DF	1
p-value	0.5048 [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.

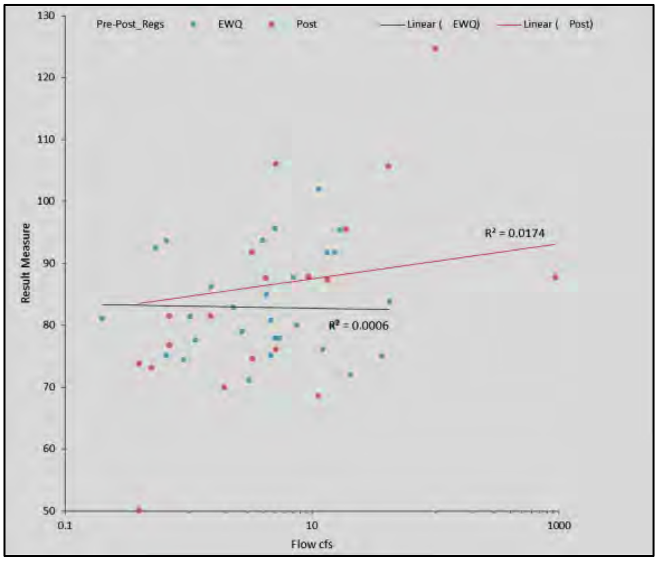
No water quality degradation is indicated. No measurable change took place between the EWQ and Post-EWQ periods. There was one sample in 2010 that violated PA dissolved oxygen criteria. In June 2010, DO concentration was 4.35 mg/l at mid-day. This occurred during extreme low-flow conditions, when only standing pools were visible in the stream. There was no flow across riffles; only interstitial flow between pools. There was probably enough decomposing material in the stream to create substantial oxygen demand that was not offset by primary production. DO saturation for this sample was 50.1%. Flow is plotted on a logarithmic axis.

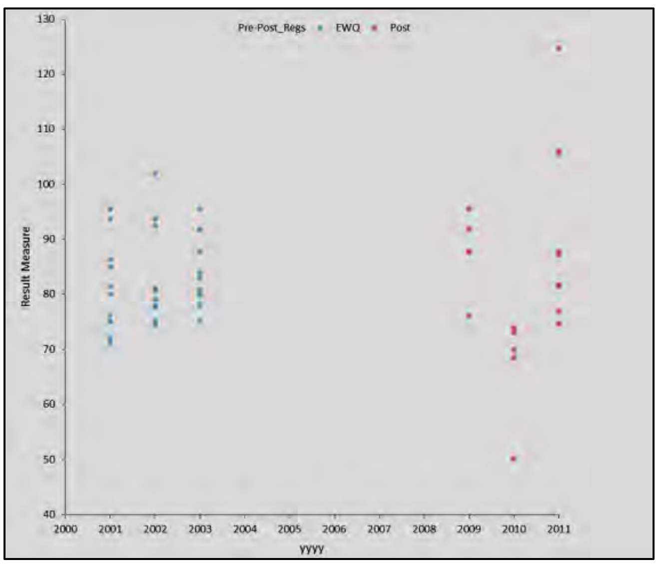
Chapter 3: 1463 BCP
Pidcock Creek, PA

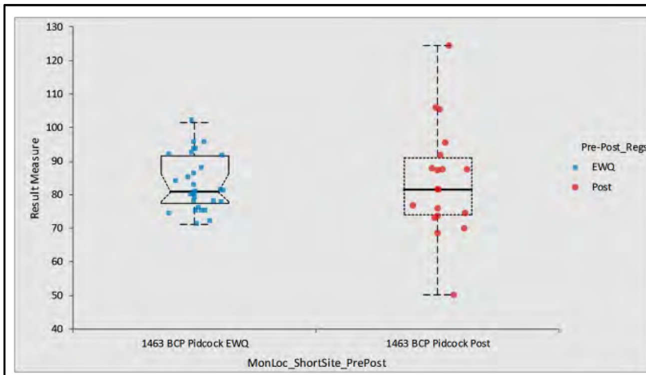
Dissolved Oxygen Saturation %

Existing Water Quality (Table 2X):

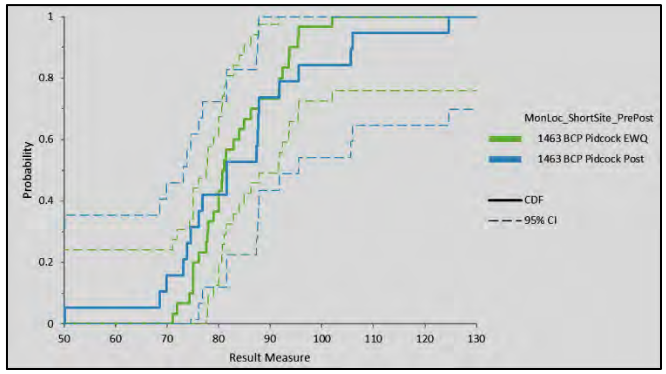
Median 81%
Lower 95% Confidence Interval 78%
Upper 95% Confidence Interval 86%







N	49					
Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1463 BCP Pidcock EWQ	71.1	77.5	80.9	91.7	102.0	14.2
1463 BCP Pidcock Post	50.1	73.9	81.5	91.1	124.6	17.2



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1463 BCP Pidcock EWQ	30	0.3	0.01
1463 BCP Pidcock Post	19	0.5	0.02

H statistic	0.00
X^2 approximation	0.00
DF	1
p-value	0.9509 [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.

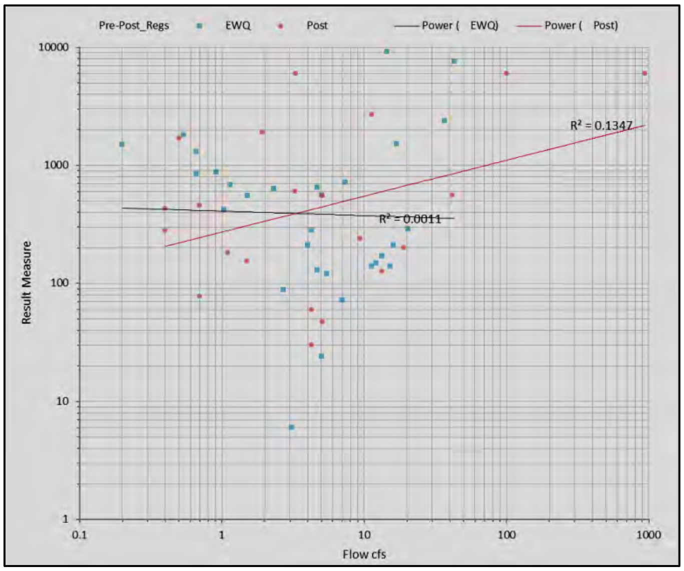
No water quality degradation is indicated. Dissolved Oxygen Saturation is unrelated to flow, and did not measurably change between the EWQ and post-EWQ periods. In terms of DO and DO%, water quality is not optimal at this location. Optimally, there is a balance between oxygen produced by plants and oxygen demand by decomposing materials in the stream, and DO% should be around 100%. As a rule of thumb, DO% below 80% indicates excessive oxygen demand, and over 120% indicates over-production of algae and plant material. Note that flow is plotted on a logarithmic scale.

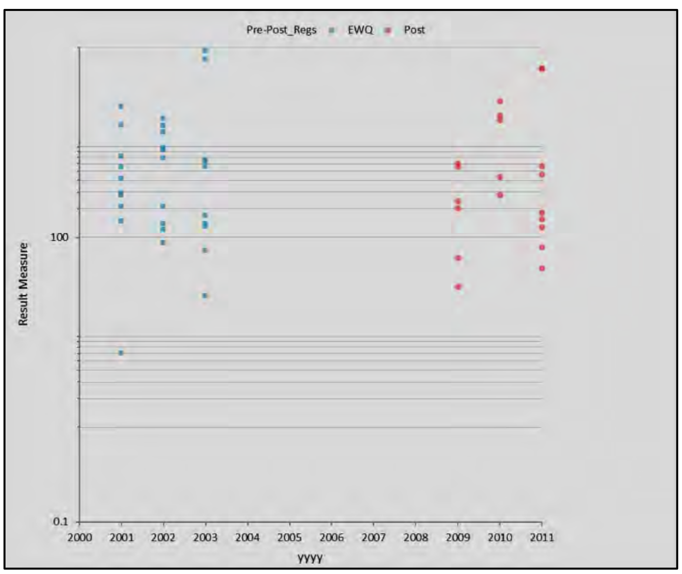
Chapter 3: 1463 BCP
Pidcock Creek, PA

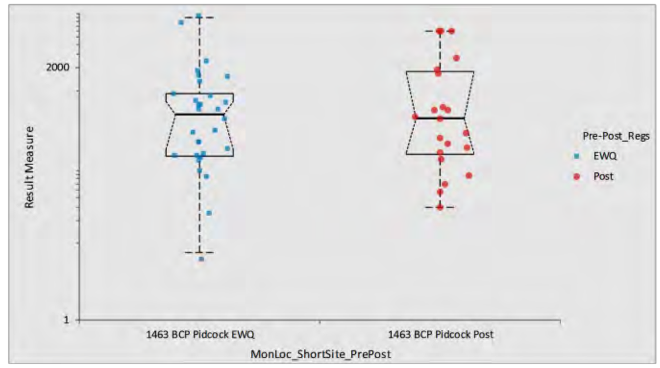
Enterococcus colonies/100 ml

Existing Water Quality (Table 2X):

Median 485/100 ml
Lower 95% Confidence Interval 170/100 ml
Upper 95% Confidence Interval 720/100 ml

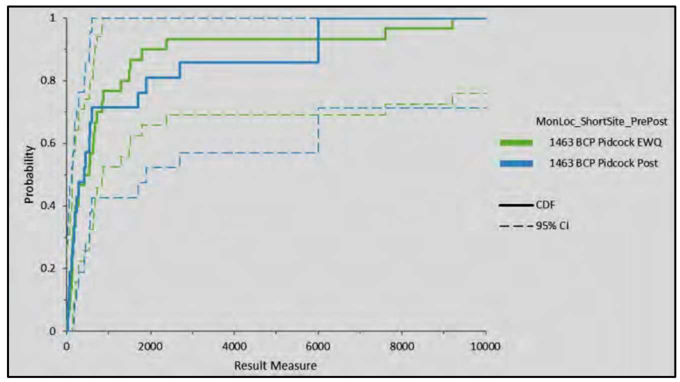






N 51

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1463 BCP Pidcock EWQ	6	140	485	915	9,200	775
1463 BCP Pidcock Post	30	146	430	1,767	6,000	1,621



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1463 BCP Pidcock EWQ	30	0.4	0.01
1463 BCP Pidcock Post	21	0.6	0.03

H statistic	0.00
X² approximation	0.00
DF	1
p-value	0.9466 [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.

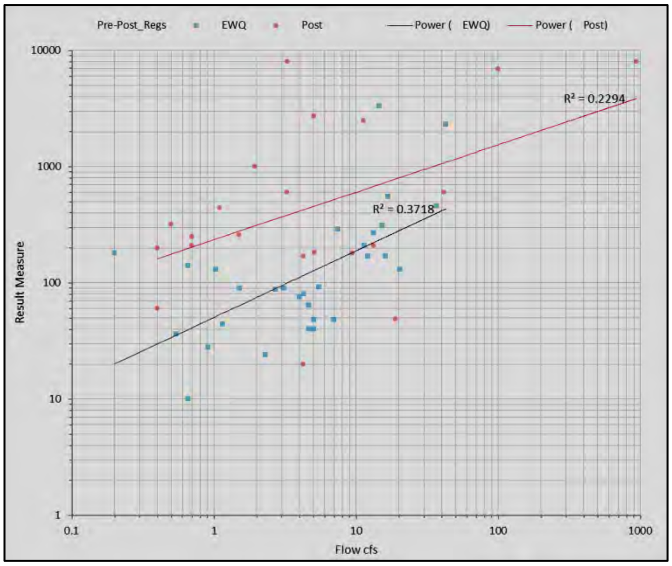
No water quality degradation is evident. Enterococci did not measurably change between the EWQ and Post-EWQ periods. Sources of analytical uncertainty included potential laboratory artifacts and insufficient post-EWQ sampling (n=21). Enterococcus concentrations are unrelated to flow in both data sets. Note that concentrations and flows are plotted on a logarithmic scale.

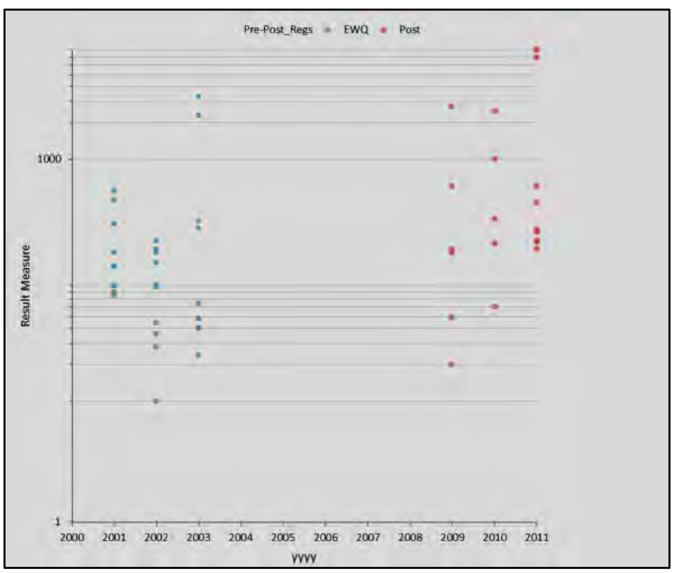
Chapter 3: 1463 BCP
Pidcock Creek, PA

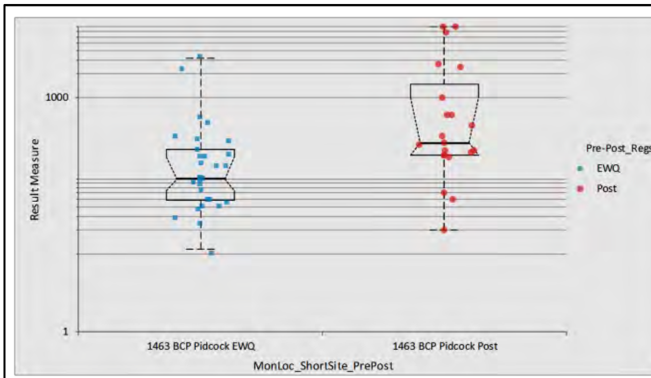
Escherichia coli colonies/100 ml

Existing Water Quality (Table 2X):

Median 91/100 ml
Lower 95% Confidence Interval 64/100 ml
Upper 95% Confidence Interval 170/100 ml
Defined in regulations as a flow-related parameter

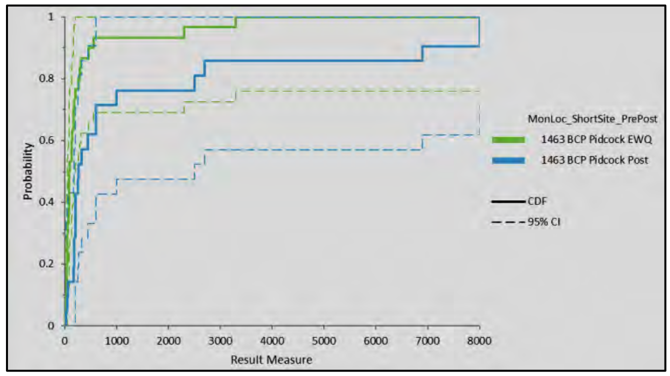






N | 51

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1463 BCP Pidcock EWQ	10	48	91	215	3,300	167
1463 BCP Pidcock Post	20	181	260	1,500	8,000	1,319



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1463 BCP Pidcock EWQ	30	896.5	29.88
1463 BCP Pidcock Post	21	1280.8	60.99

H statistic	9.86
X^2 approximation	9.86
DF	1
p-value	0.0017 [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.

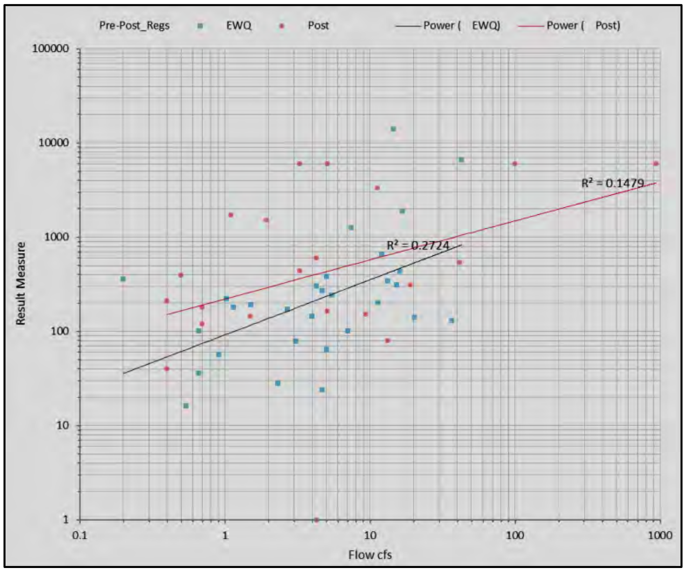
Water quality degradation is evident. E. coli concentrations apparently rose between the EWQ and Post-EWQ periods. Sources of analytical uncertainty included potential laboratory artifacts and insufficient post-EWQ sampling (n=21). Note that concentrations and flows are plotted on a logarithmic scale. No independent data were available at this site to validate DRBC's conclusion. The increase is reported as such in the summary matrix, but confidence in the conclusion is low because of low N and high variability. The reason for the increase remains unexplained.

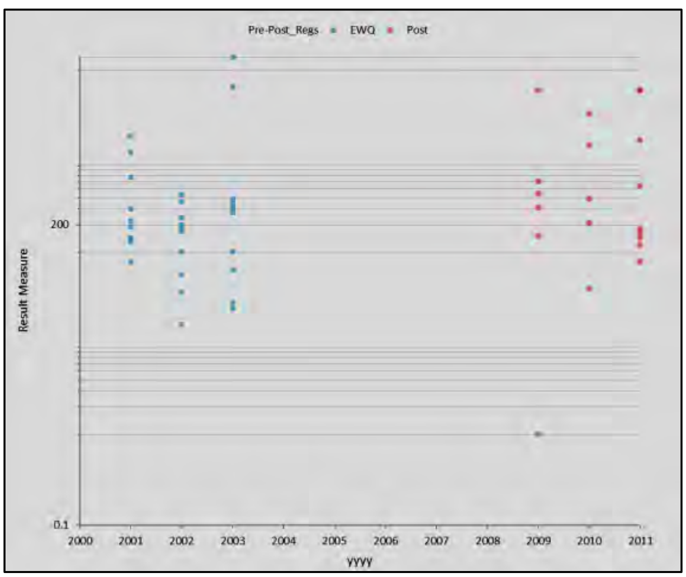
Chapter 3: 1463 BCP
Pidcock Creek, PA

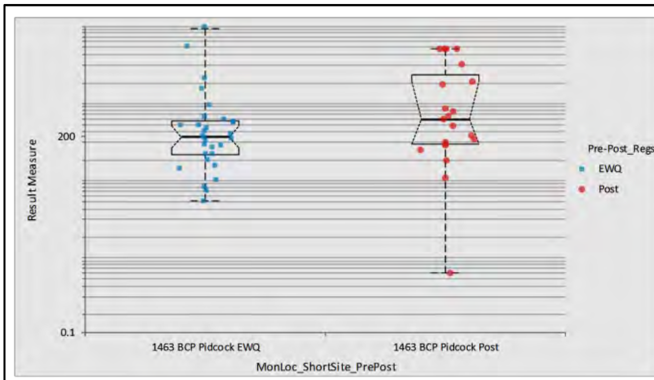
Fecal coliform colonies/100 ml

Existing Water Quality (Table 2X):

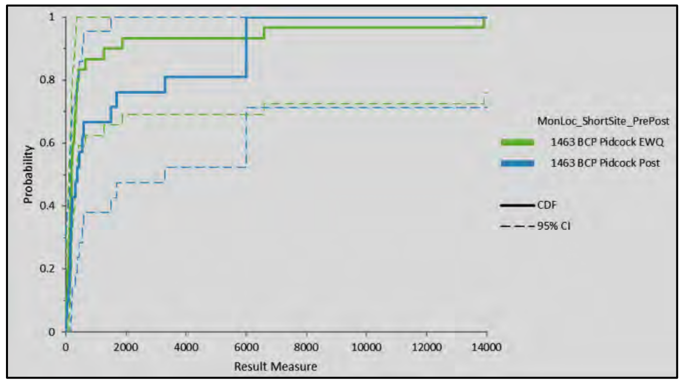
Median 195/100 ml
Lower 95% Confidence Interval 130/100 ml
Upper 95% Confidence Interval 310/100 ml
Defined in regulations as a flow-related parameter







N	51					
Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1463 BCP Pidcock EWQ	16	98	195	362	13,900	264
1463 BCP Pidcock Post	1	148	390	2,233	6,000	2,085



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1463 BCP Pidcock EWQ	30	232.4	7.75
1463 BCP Pidcock Post	21	332.0	15.81

H statistic	2.56
X^2 approximation	2.56
DF	1
p-value	0.1099 [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.

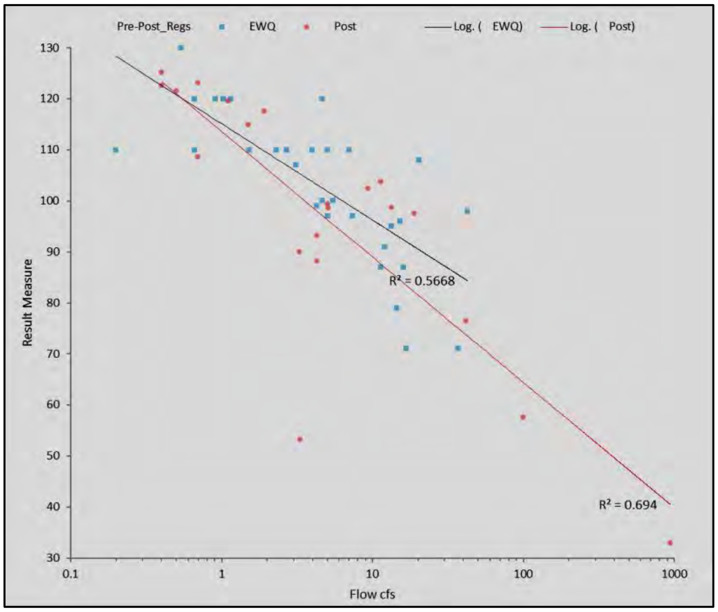
No water quality degradation is evident. Fecal coliform concentrations apparently did not measurably change between the EWQ and post-EWQ periods. Sources of analytical uncertainty included potential laboratory artifacts and insufficient post-EWQ sampling (n=21). Fecal coliform concentrations are positively but weakly related to flow. Post-EWQ median concentrations were above the EWQ upper 95% confidence interval, but the data are so variable that no statistical difference was detectable. Note that concentrations and flows are plotted on a logarithmic scale.

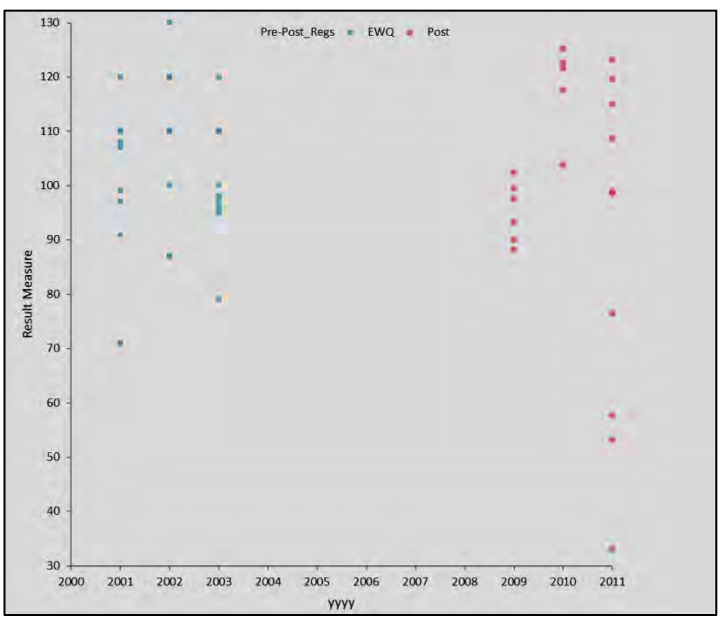
Chapter 3: 1463 BCP
Pidcock Creek, PA

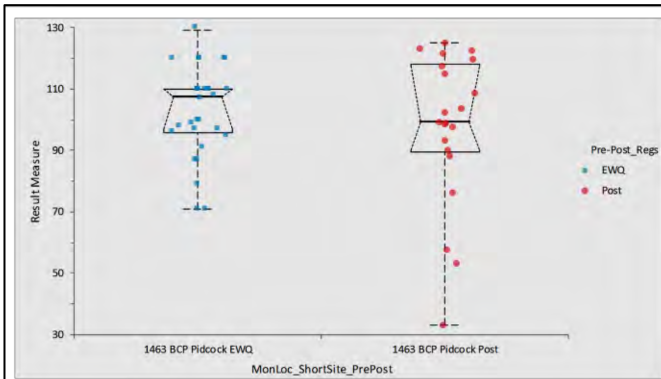
Hardness as CaCO3, Total mg/l

Existing Water Quality (Table 2X):

Median 108 mg/l
Lower 95% Confidence Interval 97 mg/l
Upper 95% Confidence Interval 110 mg/l
Defined in regulations as a flow-related parameter

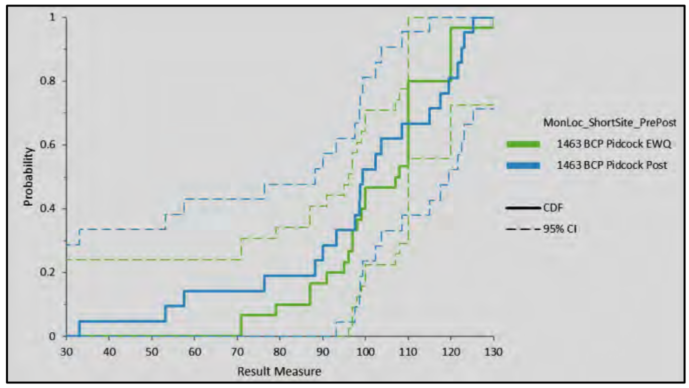






N 51

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1463 BCP Pidcock EWQ	71.0	95.9	107.5	110.0	130.0	14.1
1463 BCP Pidcock Post	33.0	89.4	99.4	118.3	125.2	28.9



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1463 BCP Pidcock EWQ	30	14.7	0.49
1463 BCP Pidcock Post	21	21.0	1.00

H statistic	0.16
X^2 approximation	0.16
DF	1
p-value	0.6870[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.

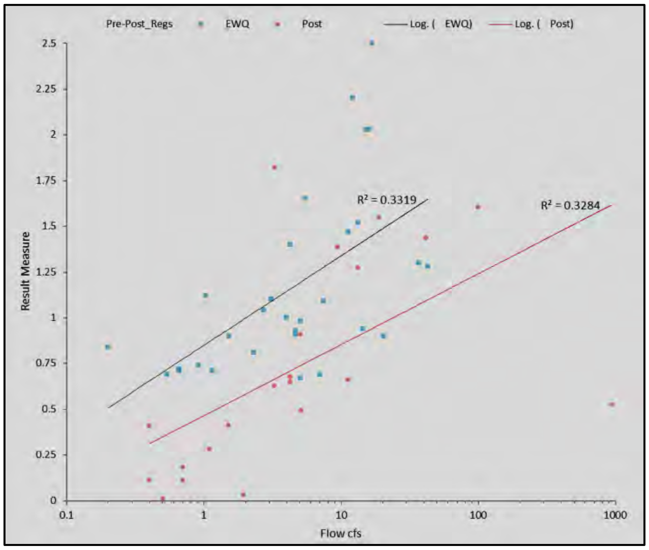
No water quality degradation is evident. Hardness did not measurably change between the EWQ and post-EWQ periods. Sources of analytical uncertainty included potential laboratory artifacts and insufficient post-EWQ sampling (n=21). Hardness is inversely related to flow. Post-EWQ median hardness fell within the EWQ 95% confidence intervals. The unusually low values observed in the post-EWQ period were sampled during high-flow or flood events. Note that flows are plotted on a logarithmic scale.

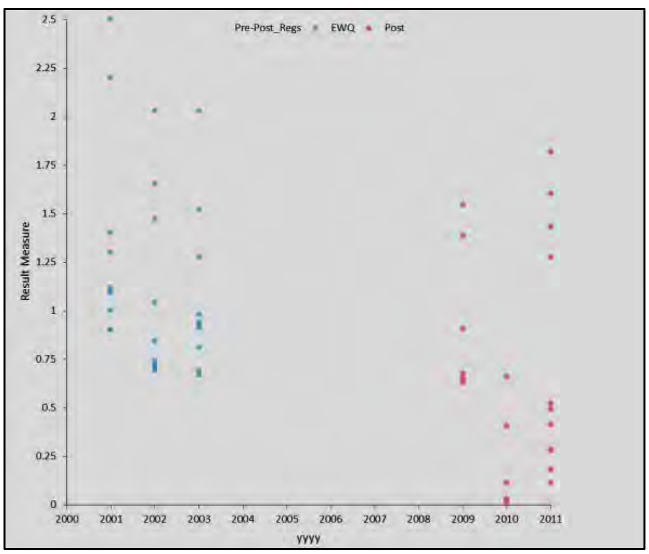
Chapter 3: 1463 BCP
Pidcock Creek, PA

Nitrate + Nitrite as N, Total mg/l

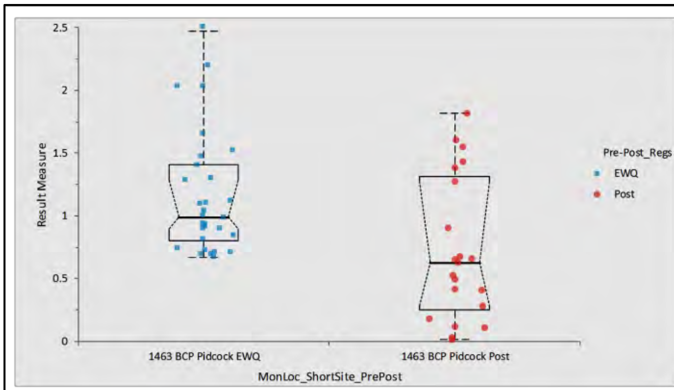
Existing Water Quality (Table 2X):

Median 0.99 mg/l
Lower 95% Confidence Interval 0.90 mg/l
Upper 95% Confidence Interval 1.28 mg/l



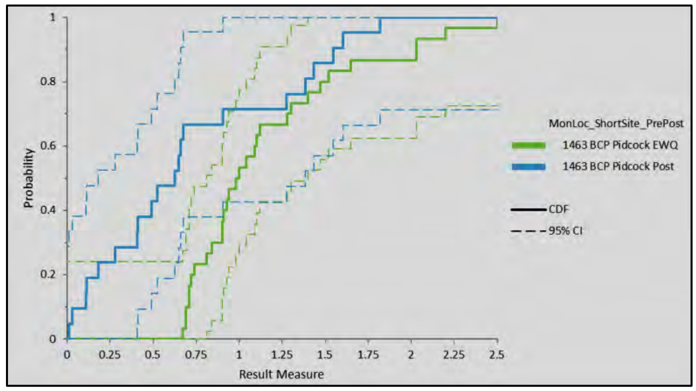


No water quality degradation is evident. Nitrate concentrations apparently declined between the EWQ and post-EWQ periods. However, there are potential laboratory artifacts and detection limit differences that introduce uncertainty in the conclusion. Nitrate is positively but weakly related to flow.



N 51

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1463 BCP Pidcock EWQ	0.670	0.804	0.990	1.406	2.500	0.602
1463 BCP Pidcock Post	0.012	0.248	0.627	1.311	1.819	1.063



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1463 BCP Pidcock EWQ	30	874.8	29.16
1463 BCP Pidcock Post	21	1249.7	59.51

H statistic	9.61
X^2 approximation	9.61
DF	1
p-value	0.0019 [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.

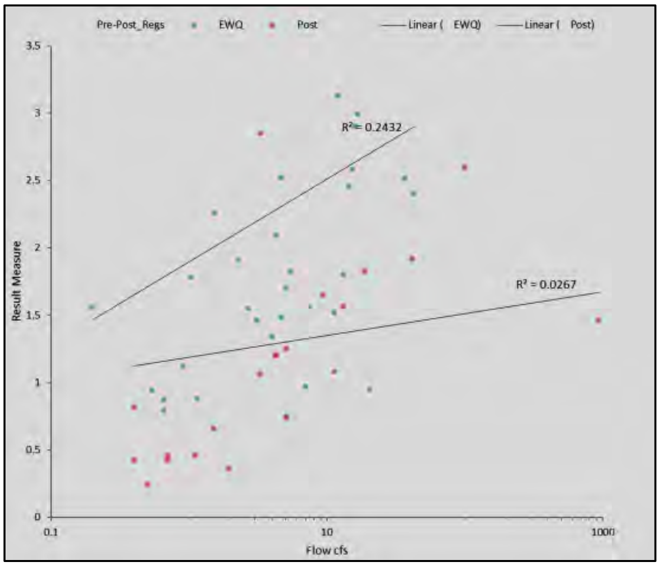
On the annual plot, 2002-2003 EWQ nitrates appear to match well with post-EWQ nitrate + nitrite for 2009. Nitrate + Nitrite concentrations are assumed to be equivalent for comparison with EWQ nitrate concentrations, since EWQ nitrite concentrations were never detected. Note that flows are plotted on a logarithmic scale. Independent data were not available for validation of the apparent decline. Post-EWQ median nitrate + nitrite concentrations fell below the EWQ lower 95% confidence interval.

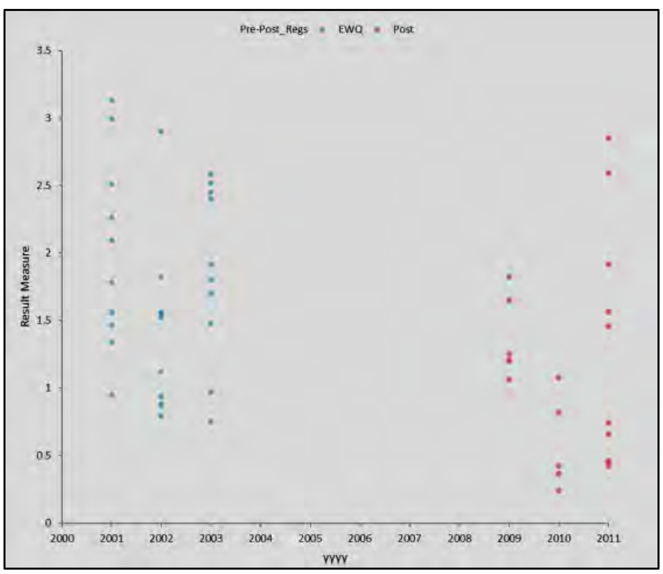
Chapter 3: 1463 BCP
Pidcock Creek, PA

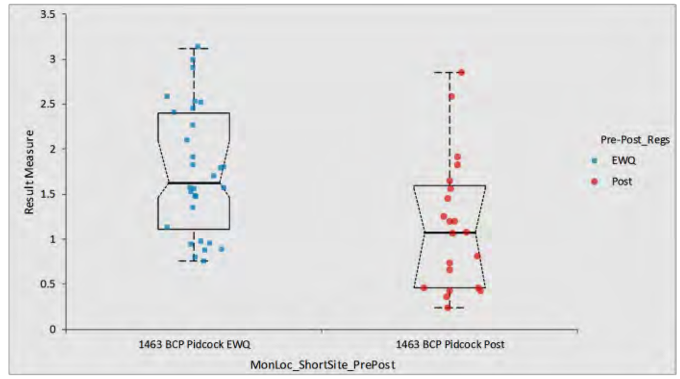
Nitrogen as N, Total (TN) mg/l

Existing Water Quality (Table 2X):

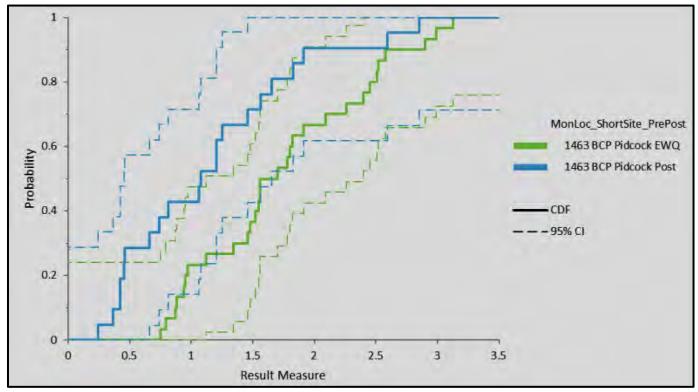
Median 1.63 mg/l
Lower 95% Confidence Interval 1.46 mg/l
Upper 95% Confidence Interval 2.09 mg/l







N	51					
Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1463 BCP Pidcock EWQ	0.750	1.108	1.630	2.404	3.130	1.297
1463 BCP Pidcock Post	0.242	0.458	1.076	1.593	2.850	1.135



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1463 BCP Pidcock EWQ	30	681.6	22.72
1463 BCP Pidcock Post	21	973.8	46.37

H statistic	7.49
X^2 approximation	7.49
DF	1
p-value	0.0062 [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.

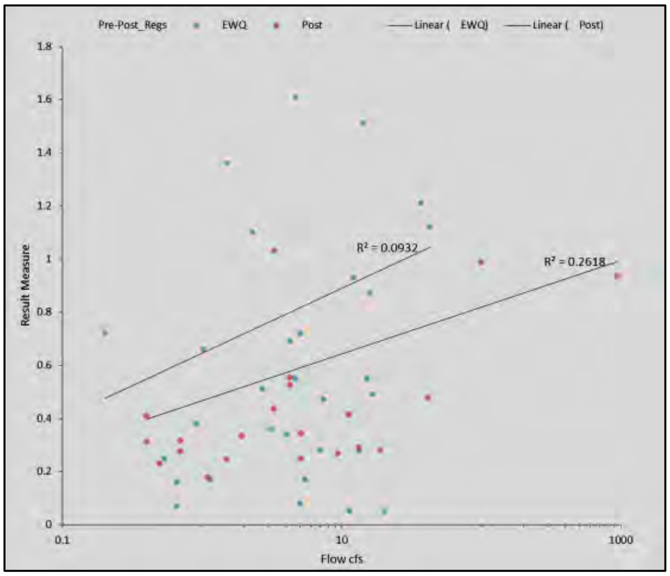
No water quality degradation is evident. Total Nitrogen concentrations apparently declined between the EWQ and post-EWQ periods. However, differences in detection limits and laboratory artifacts introduced uncertainty in such a conclusion. TN is weakly related to flow in the EWQ period, but unrelated to flow in the post-EWQ period. Note that flows are plotted on a logarithmic scale. DRBC results could not be independently validated. Post-EWQ median TN concentrations fell below the EWQ lower 95% confidence interval.

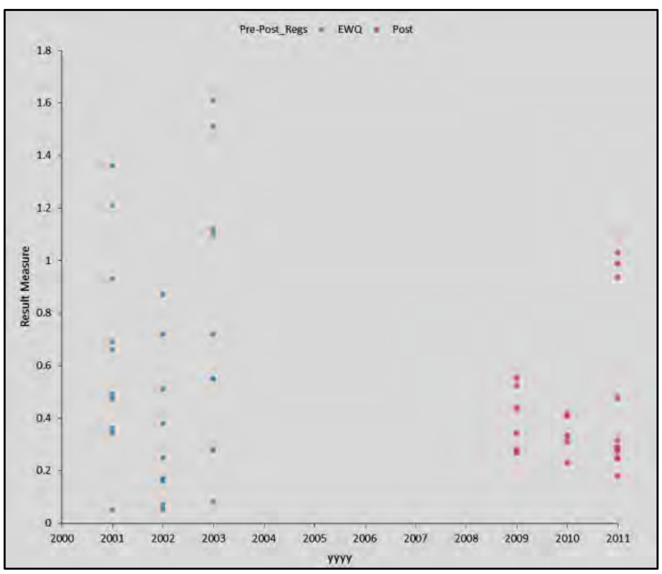
Chapter 3: 1463 BCP
Pidcock Creek, PA

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

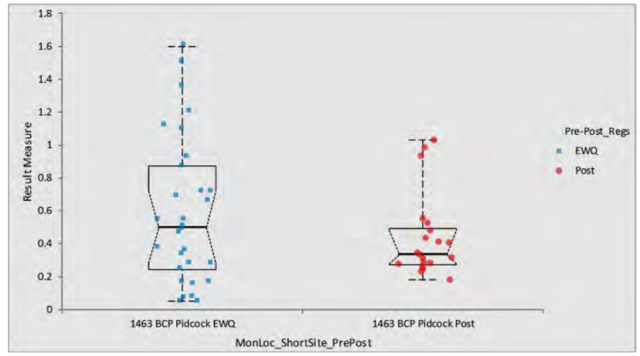
Existing Water Quality (Table 2X):

Median 0.50 mg/l
Lower 95% Confidence Interval 0.28 mg/l
Upper 95% Confidence Interval 0.72 mg/l



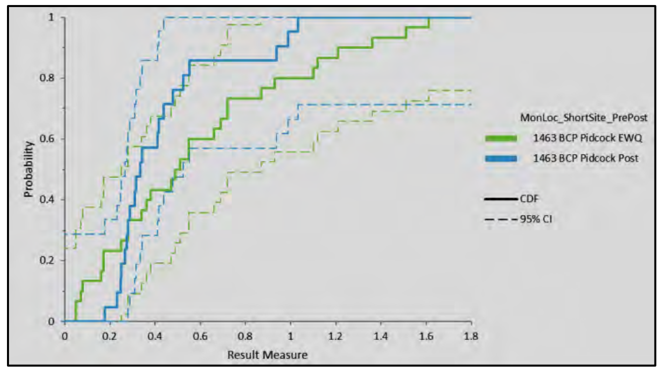


No water quality degradation is evident. No measurable change occurred in TKN concentrations between the EWQ and post-EWQ periods. However, potential laboratory artifacts and insufficient post-EWQ sampling (n=21) introduced analytical uncertainty.



N 51

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1463 BCP Pidcock EWQ	0.050	0.243	0.500	0.875	1.610	0.632
1463 BCP Pidcock Post	0.178	0.272	0.334	0.494	1.031	0.222



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1463 BCP Pidcock EWQ	30	93.6	3.12
1463 BCP Pidcock Post	21	133.8	6.37

H statistic	1.03
X^2 approximation	1.03
DF	1
p-value	0.3104 [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.

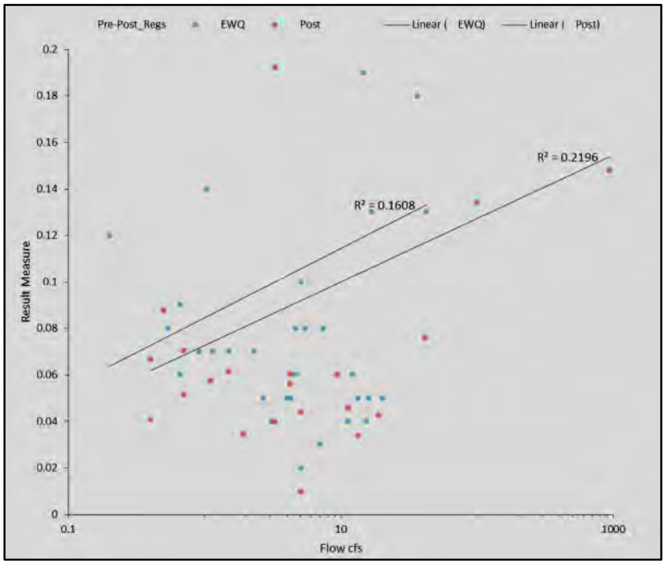
TKN concentration is unrelated to flow in the EWQ data sets, and weakly related in the post-EWQ data set. TKN ranges less widely in the post-EWQ data set. Note that flows are plotted on a logarithmic scale. Post-EWQ median TKN fell within EWQ 95% confidence intervals, but very near the lower 95% confidence interval. Though there was no statistical difference between EWQ and post-EWQ TKN, concentrations appeared to fall somewhat and were far more stable. Unlike nitrate + nitrite and other parameters, the TKN data sets are more directly comparable since there are no discrepancies in detection limits throughout the two periods, and the flow regime is well represented in both periods.

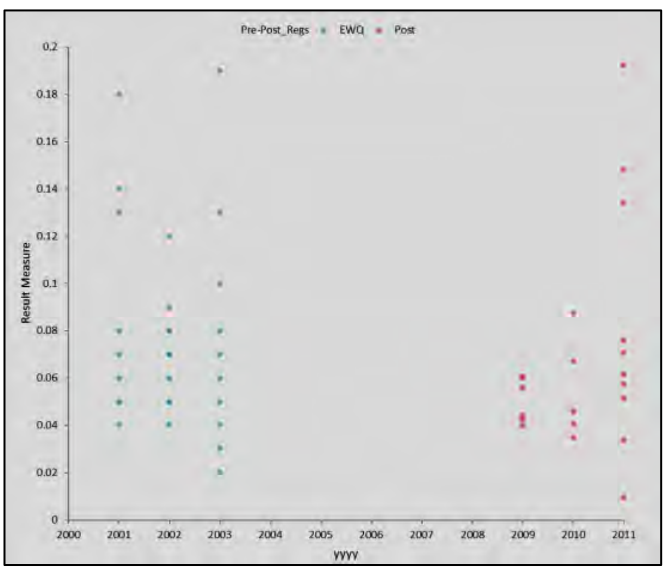
Chapter 3: 1463 BCP
Pidcock Creek, PA

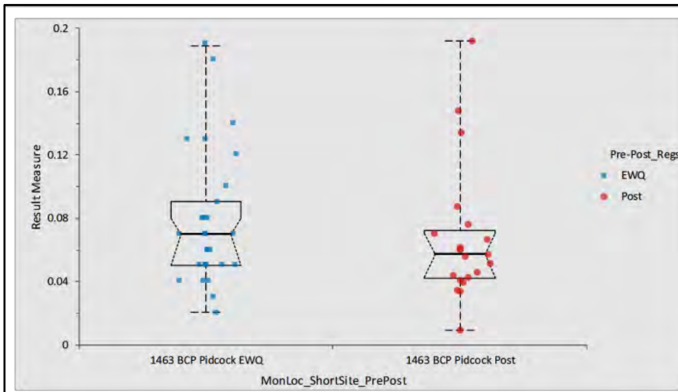
Orthophosphate as P, Total mg/l

Existing Water Quality (Table 2X):

Median 0.07 mg/l
Lower 95% Confidence Interval 0.05 mg/l
Upper 95% Confidence Interval 0.08 mg/l

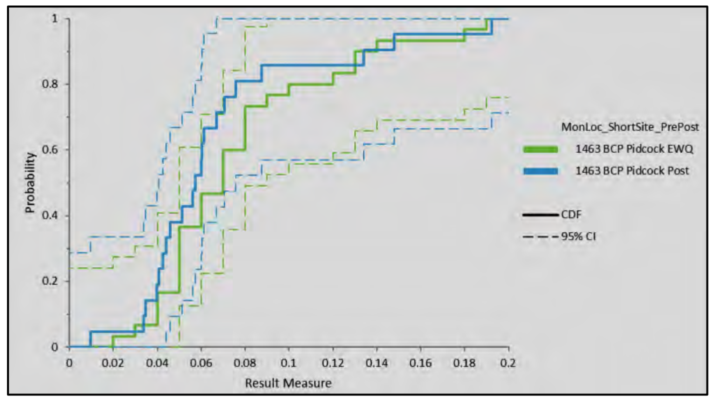






N 51

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1463 BCP Pidcock EWQ	0.020	0.050	0.070	0.091	0.190	0.041
1463 BCP Pidcock Post	0.010	0.042	0.057	0.072	0.192	0.030



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1463 BCP Pidcock EWQ	30	108.3	3.61
1463 BCP Pidcock Post	21	154.7	7.37

H statistic	1.19
X^2 approximation	1.19
DF	1
p-value	0.2746 [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.

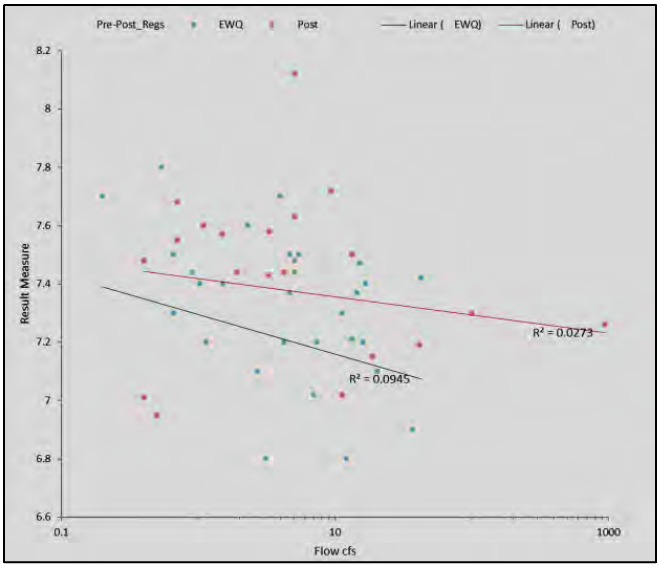
No water quality degradation is evident. Orthophosphate concentrations did not measurably change between the EWQ and post-EWQ periods. However, potential laboratory artifacts and insufficient post-EWQ sampling (n=21) introduced analytical uncertainty. Orthophosphate is very weakly related to flow in both data sets. Note that flows are plotted on a logarithmic scale. Post-EWQ median orthophosphate fell within EWQ 95% confidence intervals, but very near the lower 95% confidence interval. There were no independent data to confirm DRBC results. DRBC detection limits improved between the two periods, but there were no undetected results in either data set.

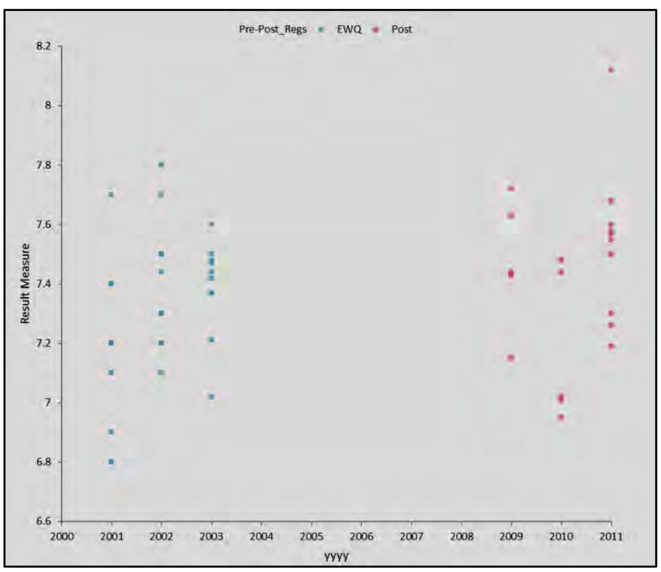
Chapter 3: 1463 BCP
Pidcock Creek, PA

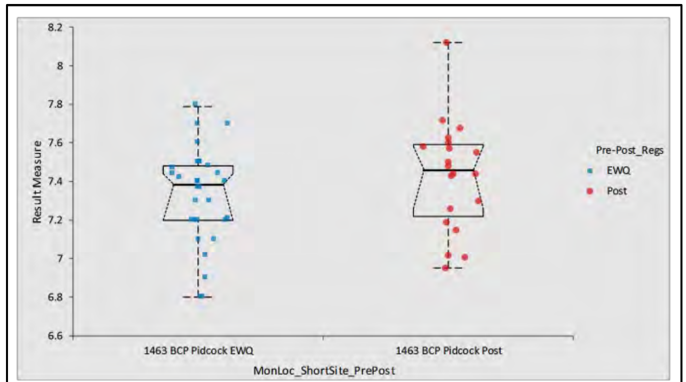
pH, units

Existing Water Quality (Table 2X):

Median 7.39 standard units
Lower 95% Confidence Interval 7.20 standard units
Upper 95% Confidence Interval 7.44 standard units

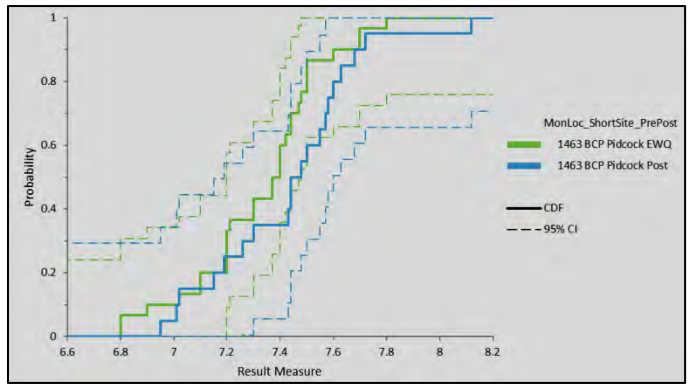






N 50

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1463 BCP Pidcock EWQ	6.80	7.20	7.39	7.48	7.80	0.28
1463 BCP Pidcock Post	6.95	7.22	7.46	7.59	8.12	0.37



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1463 BCP Pidcock EWQ	30	154.1	5.14
1463 BCP Pidcock Post	20	231.2	11.56

H statistic	1.82
X² approximation	1.82
DF	1
p-value	0.1776 [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.

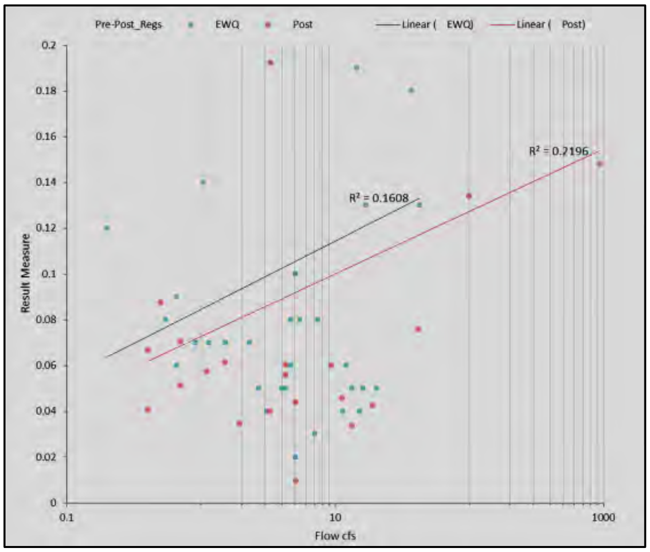
No water quality degradation is indicated. pH did not measurably change between the EWQ and post-EWQ periods. Under higher flow conditions, pH tends toward neutral, though pH is unrelated to flow in both data sets. Post-EWQ median pH fell within the EWQ 95% confidence intervals. Note that flows are plotted on a logarithmic scale.

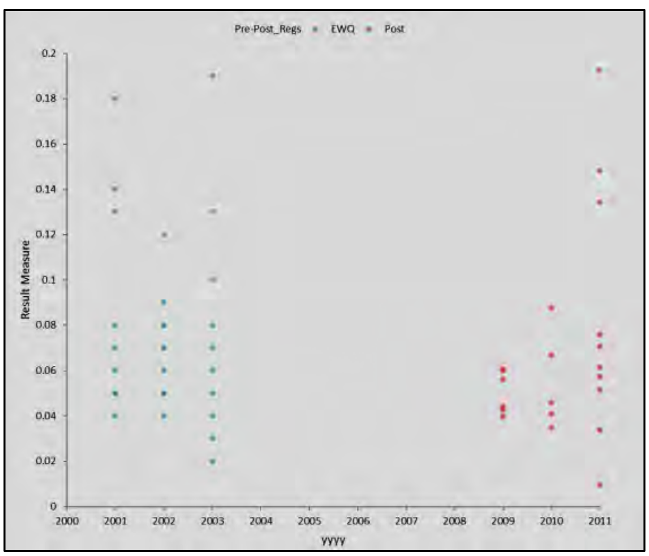
Chapter 3: 1463 BCP
Pidcock Creek, PA

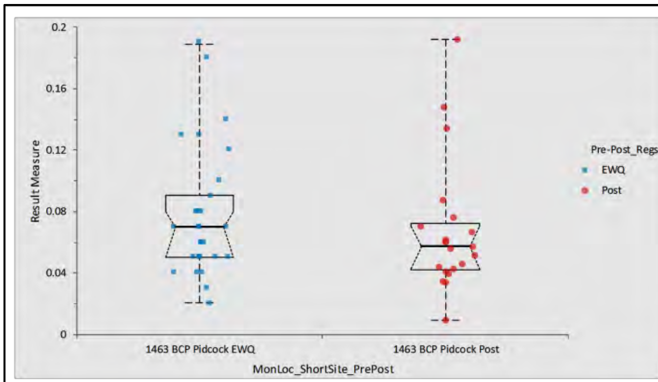
Phosphorus as P, Total (TP) mg/l

Existing Water Quality (Table 2X):

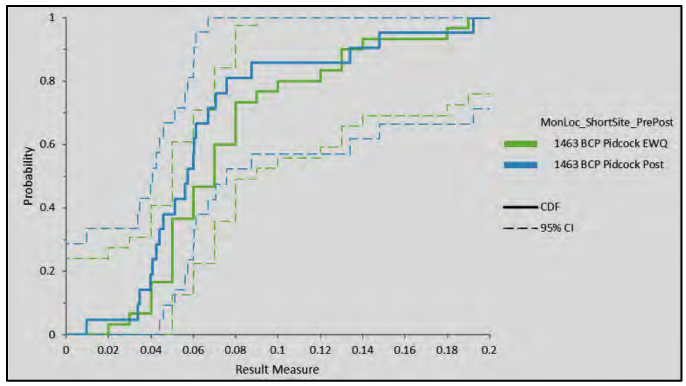
Median 0.10 mg/l
Lower 95% Confidence Interval 0.08 mg/l
Upper 95% Confidence Interval 0.12 mg/l







N	51					
Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1463 BCP Pidcock EWQ	0.020	0.050	0.070	0.091	0.190	0.041
1463 BCP Pidcock Post	0.010	0.042	0.057	0.072	0.192	0.030



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1463 BCP Pidcock EWQ	30	108.3	3.61
1463 BCP Pidcock Post	21	154.7	7.37

H statistic	1.19
X² approximation	1.19
DF	1
p-value	0.2746 [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.

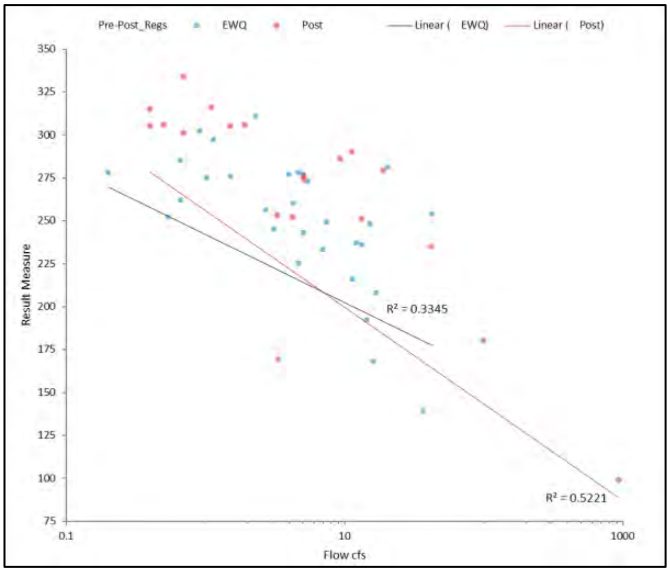
No water quality degradation is indicated. Total Phosphorus (TP) concentrations did not measurably change between the EWQ and post-EWQ periods. However, potential laboratory artifacts and insufficient post-EWQ sampling (n=21) introduced analytical uncertainty. Post-EWQ median total phosphorus fell below the EWQ lower 95% confidence interval, but there were insufficient data for a statistically significant decline. TP is unrelated to flow in both data sets. Note that flows are plotted on a logarithmic scale. No independent data were available to confirm these results.

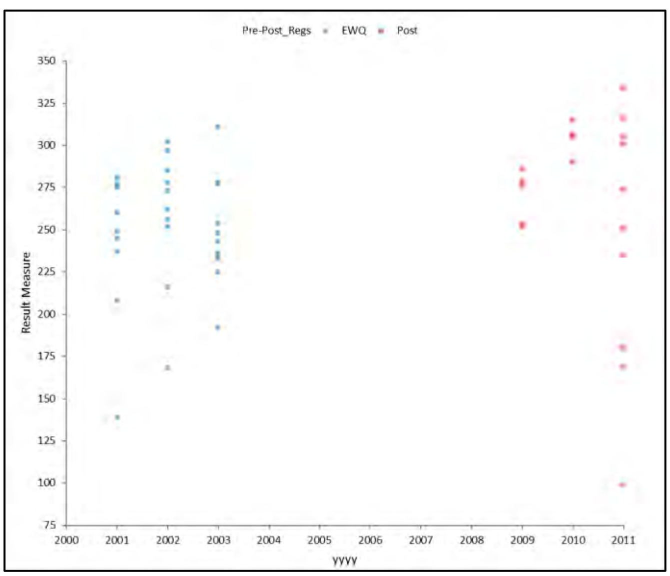
Chapter 3: 1463 BCP
Pidcock Creek, PA

Specific Conductance µmho/cm

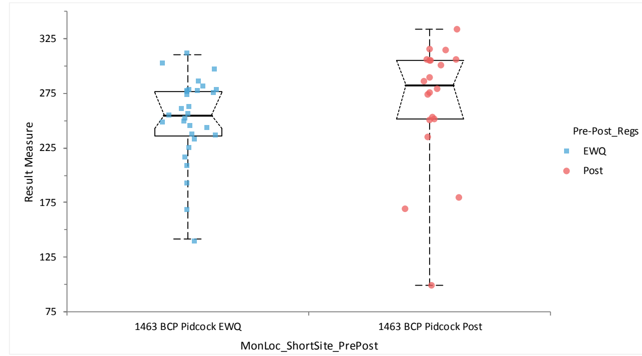
Existing Water Quality (Table 2X):

Median 255 µmho/cm
Lower 95% Confidence Interval 243 µmho/cm
Upper 95% Confidence Interval 276 µmho/cm
Defined in regulations as a flow-related parameter



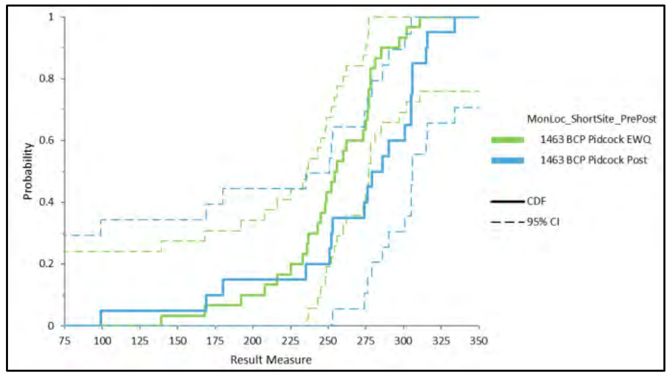


Evidence of water quality degradation is indicated. Specific conductance rose by about 27 µmho/cm, which is above the EWQ upper 95% confidence interval. In both data sets, specific conductance is inversely related to flow.



N 50

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1463 BCP Pidcock EWQ	139	235.8	255.0	277.1	311	41.3
1463 BCP Pidcock Post	99	251.4	282.5	305.6	334	54.2



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1463 BCP Pidcock EWQ	30	360.5	12.02
1463 BCP Pidcock Post	20	540.8	27.04

H statistic	4.24
X^2 approximation	4.24
DF	1
p-value	0.0394 [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.

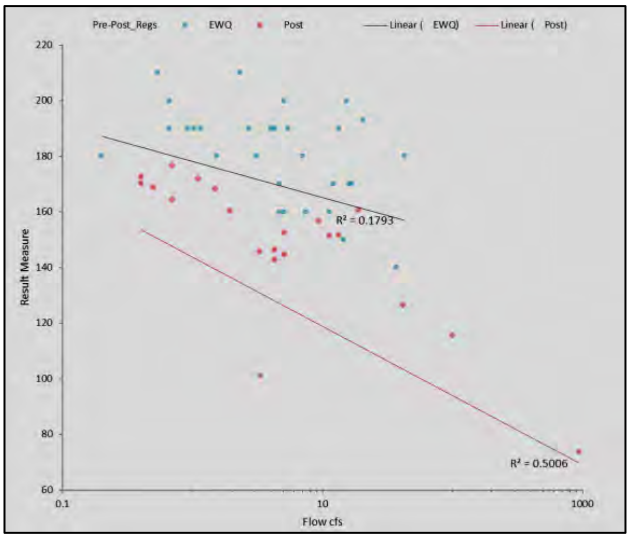
In the post-EWQ data, a single outlier drives the regression, but the flow relationship remains strong even so. The outlier was a sample taken during flood conditions. Note that flows are plotted on a logarithmic scale. The rise in specific conductance may be attributable to the concurrent rise in chloride concentrations. No new dischargers are present in the watershed. Specific conductance has risen from a median of 255 µmho/cm, which was around the upper limit of typical concentration for a relatively undeveloped Piedmont stream. It is now 282 µmho/cm, which is a significant increase in a short time.

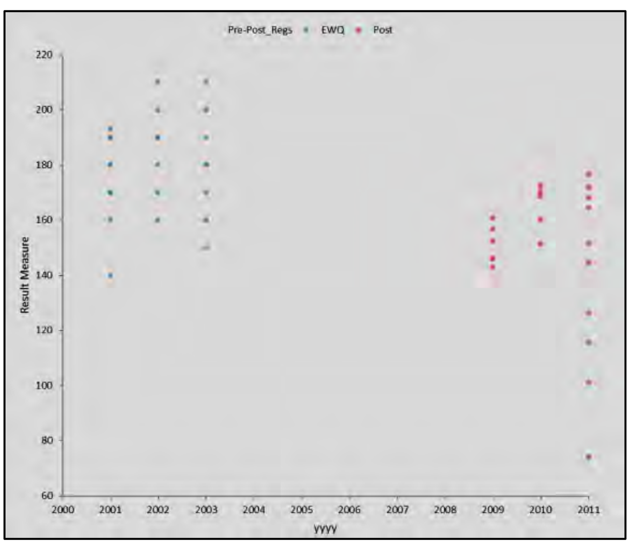
Chapter 3: 1463 BCP
Pidcock Creek, PA

Total Dissolved Solids (TDS) mg/l

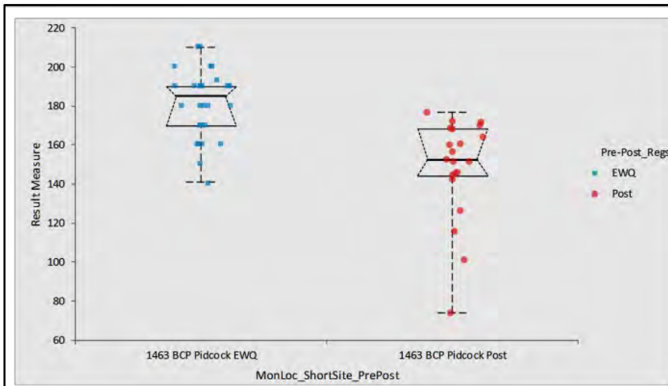
Existing Water Quality (Table 2X):

Median 185 mg/l
Lower 95% Confidence Interval 170 mg/l
Upper 95% Confidence Interval 190 mg/l
Defined in regulations as a flow-related parameter



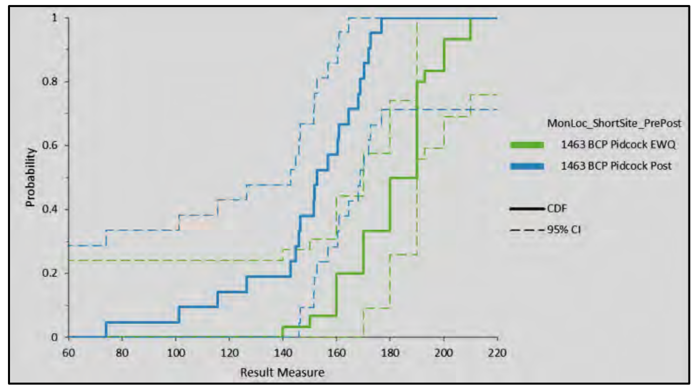


No water quality degradation is evident. TDS apparently declined between the EWQ and post-EWQ periods. However, potential laboratory artifacts introduced uncertainty in this conclusion.



N | 51

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1463 BCP Pidcock EWQ	140.0	170.0	185.0	190.0	210.0	20.0
1463 BCP Pidcock Post	73.9	144.1	152.6	168.3	176.6	24.2



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1463 BCP Pidcock EWQ	30	1809.6	60.32
1463 BCP Pidcock Post	21	2585.2	123.10

H statistic	20.04
X^2 approximation	20.04
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.

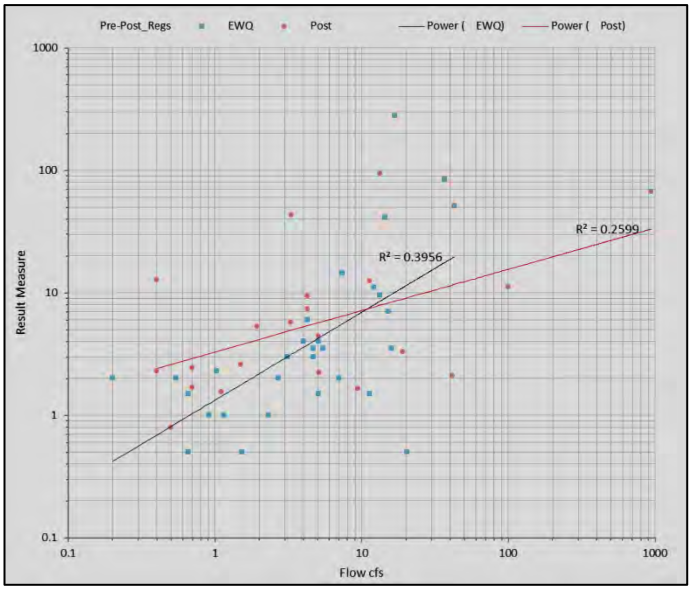
TDS is inversely related to flow, though weakly in the EWQ data set. Stream flows were not significantly different between the two periods. Post-EWQ median TDS was well below the EWQ 95% lower confidence interval. Post-EWQ detection limits were lower than EWQ detection limits, though there were no non-detect results at any time. Unusually low TDS values in the post-EWQ data are all high flow or flood samples, though TDS was generally lower in the post-EWQ data throughout the entire data distribution. Note that flows are plotted on a logarithmic scale.

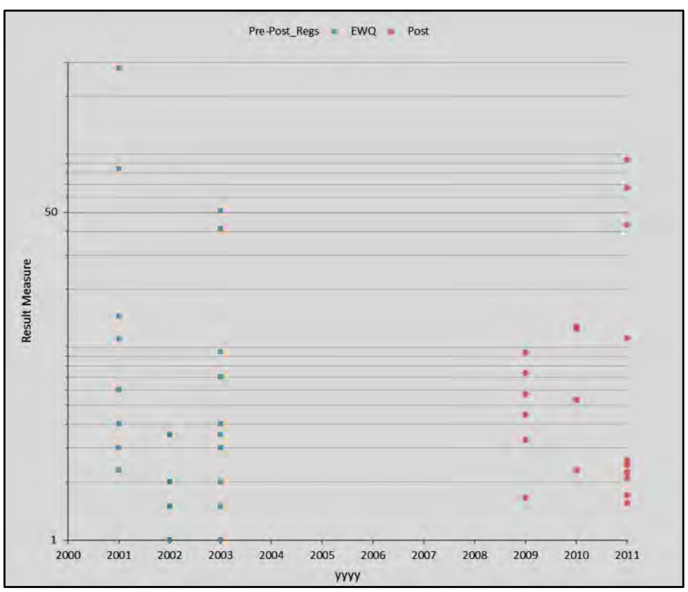
Chapter 3: 1463 BCP
Pidcock Creek, PA

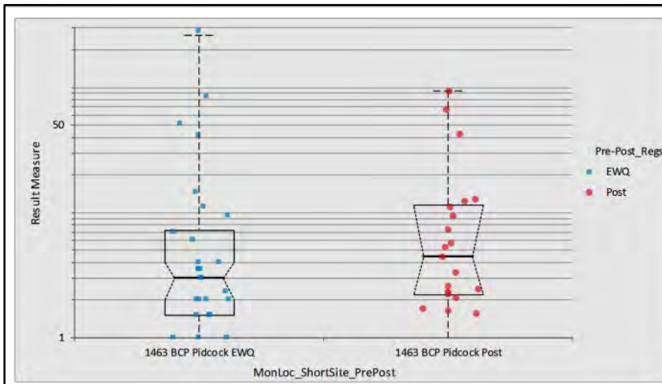
Total Suspended Solids (TSS) mg/l

Existing Water Quality (Table 2X):

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

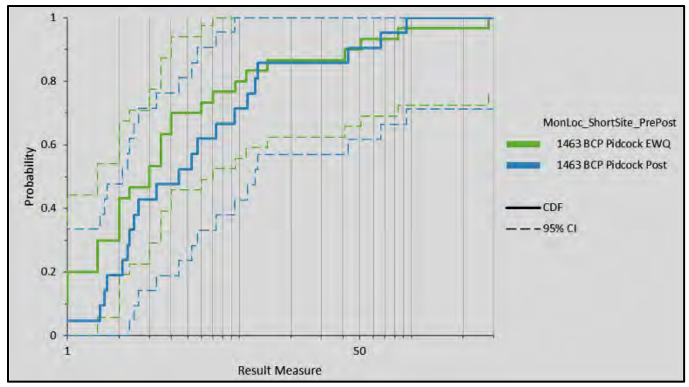






N 51

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1463 BCP Pidcock EWQ	0.5	1.5	3.0	7.2	280.0	5.7
1463 BCP Pidcock Post	0.8	2.2	4.4	11.6	94.0	9.4



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1463 BCP Pidcock EWQ	30	149.6	4.99
1463 BCP Pidcock Post	21	213.8	10.18

H statistic	1.65
X^2 approximation	1.65
DF	1
p-value	0.1994 [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.

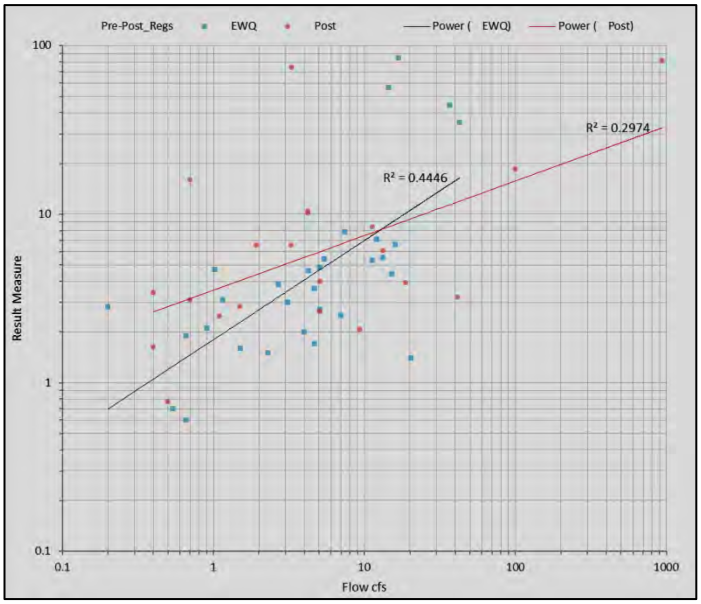
No water quality degradation is evident. TSS did not measurably change between the EWQ and post-EWQ periods. However, potential laboratory artifacts and insufficient post-EWQ sampling (n=21) introduced analytical uncertainty. TSS is positively though weakly related to flow in both data sets. Post-EWQ median TSS was slightly above the EWQ upper 95% confidence interval, but the difference was not statistically significant. Both distributions were similarly shaped. Note that both flow and concentration are plotted on a logarithmic scale.

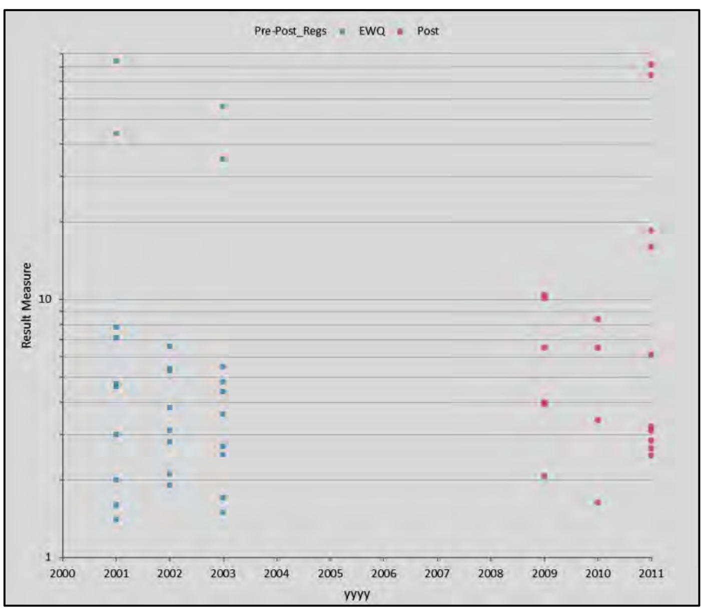
Chapter 3: 1463 BCP
Pidcock Creek, PA

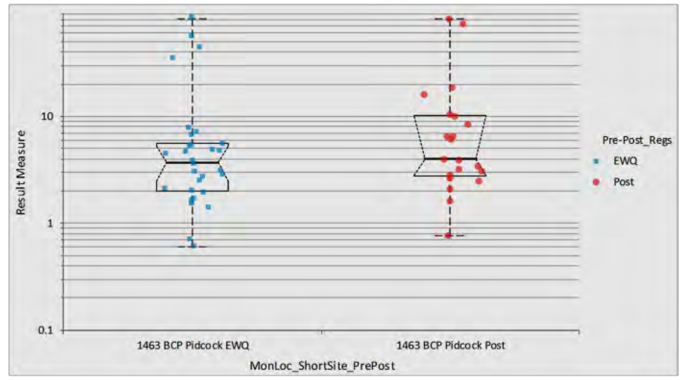
Turbidity NTU

Existing Water Quality (Table 2X):

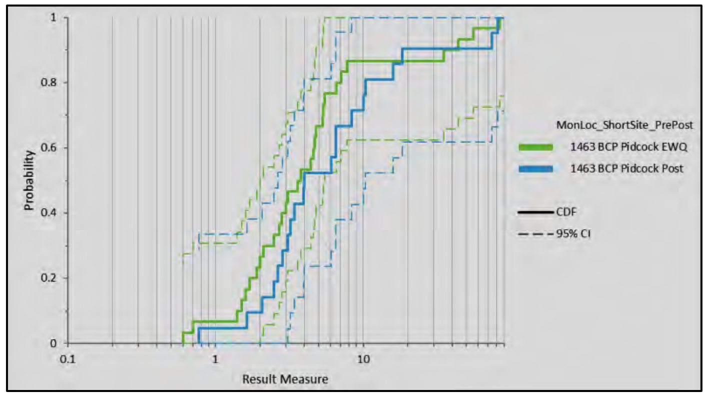
Median 3.7 NTU
Lower 95% Confidence Interval 2.5 NTU
Upper 95% Confidence Interval 5.3 NTU
Defined in regulations as a flow-related parameter







N	51					
Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1463 BCP Pidcock EWQ	0.6	2.0	3.7	5.6	84.0	3.6
1463 BCP Pidcock Post	0.8	2.8	4.0	10.2	81.5	7.4



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1463 BCP Pidcock EWQ	30	126.1	4.20
1463 BCP Pidcock Post	21	180.1	8.58

H statistic	1.39
X² approximation	1.39
DF	1
p-value	0.2392 [1]

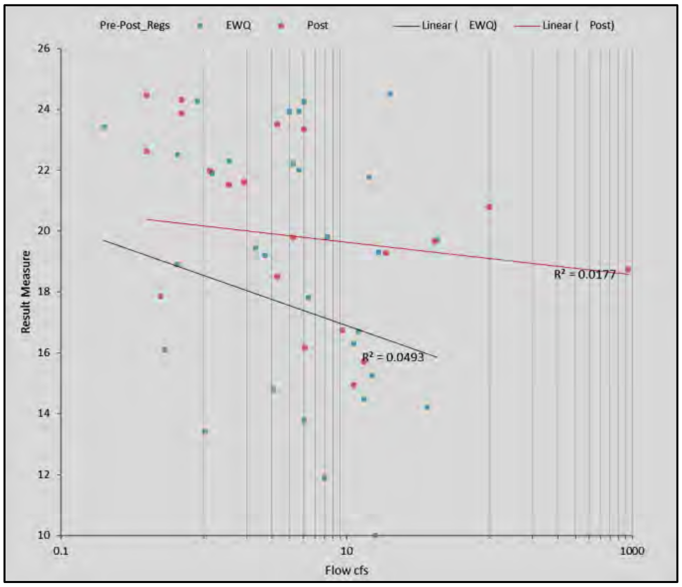
H0: $\theta_1 = \theta_2 = \theta_{...}$
The median of the populations are all equal.
H1: $\theta_i \neq \theta_j$ for at least one i,j
The median of the populations are not all equal.
[1] Do not reject the null hypothesis at the 5% significance level.

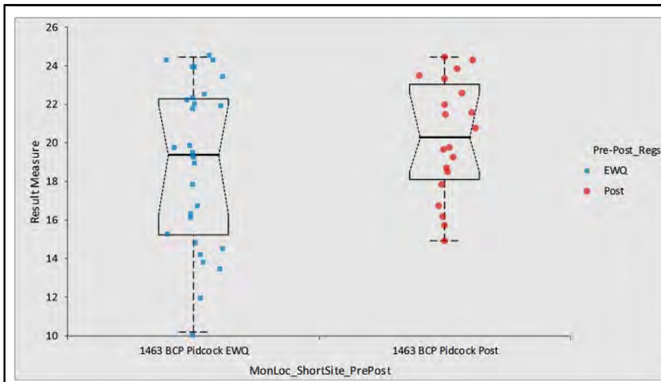
No water quality degradation is evident. Turbidity did not measurably change between the EWQ and post-EWQ periods. The post-EWQ median turbidity fell within the EWQ 95% confidence intervals of the median. In both data sets, the turbidity vs. flow relationship is positive, though the post-EWQ relationship is weak and driven by a single outlier sample taken during a major flood. Note that both concentration and flow is represented on logarithmic scales in all charts.

Chapter 3: 1463 BCP
Pidcock Creek, PA

Water Temperature, degrees C

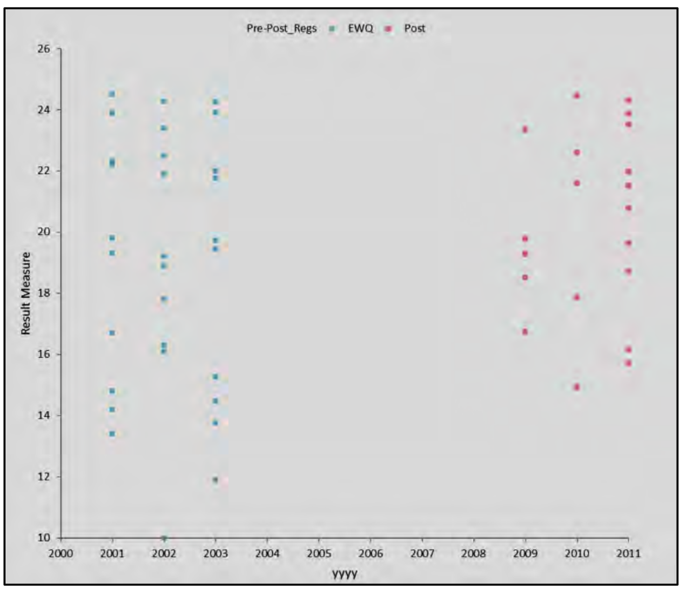
Not included in DRBC Existing Water Quality rules

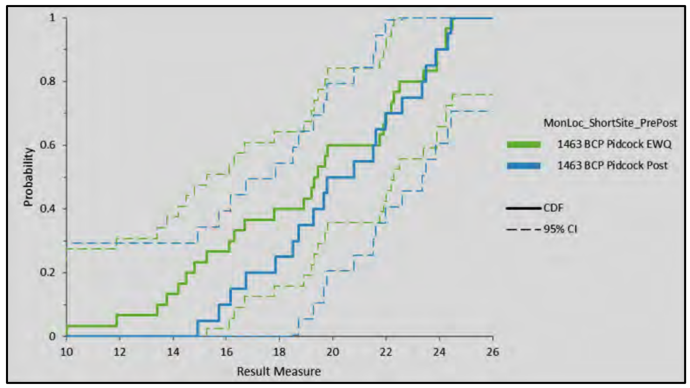




N 50

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1463 BCP Pidcock EWQ	10.0	15.2	19.4	22.3	24.5	7.1
1463 BCP Pidcock Post	14.9	18.1	20.3	23.0	24.5	4.9





Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1463 BCP Pidcock EWQ	30	76.8	2.56
1463 BCP Pidcock Post	20	115.2	5.76

H statistic	0.90
X^2 approximation	0.90
DF	1
p-value	0.3418 [1]

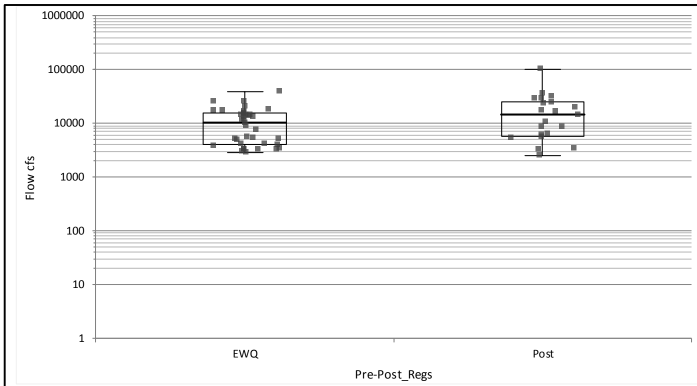
H0: $\theta_1 = \theta_2 = \theta ...$
The median of the populations are all equal.
H1: $\theta_i \neq \theta_j$ for at least one i,j
The median of the populations are not all equal.
[1] Do not reject the null hypothesis at the 5% significance level.

No water quality degradation is evident. Water temperature did not measurably change between the EWQ and post-EWQ periods. Water temperature is not related to flow in either data set. There were less cool temperatures in the post-EWQ data set. Note that flows are plotted on a logarithmic scale.

Chapter 4: 1487 ICP Delaware River at Lambertville/New Hope Bridge, NJ/PA

1487 ICP
Delaware River at Lambertville Bridge

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



N | 58

Flow cfs by Pre-Post_Regs	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
EWQ	2,835	3,987	10,286	15,373	38,963	11,386
Post	2,473	5,862	14,483	25,551	100,496	19,689

Kruskal-Wallis test

Flow cfs by Pre-Post_Regs	n	Rank sum	Mean rank
EWQ	37	318.2	8.60
Post	21	560.6	26.69

H statistic	3.08
X^2 approximation	3.08
DF	1
p-value	0.0792 [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.

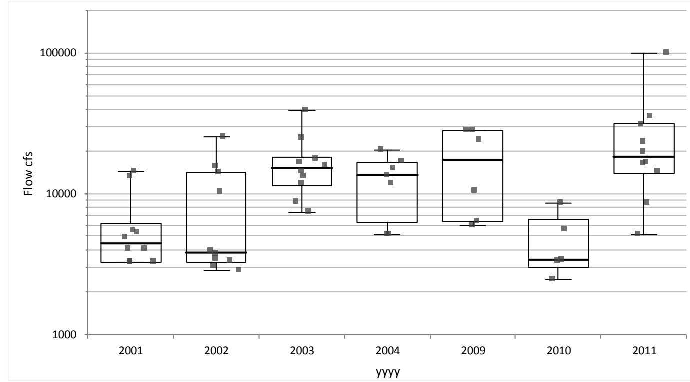
Flow was not statistically different between the two periods at this location, though EWQ flow was normal for the May to September period and post-EWQ flow was generally above-normal.

Upstream ICP: Delaware River at Bulls Island 1554 ICP
Downstream ICP: Delaware River at Washington Crossing 1418 ICP

Tributary BCP Watersheds in Upstream Reach:

Alexauken Creek, NJ – 1495 BCP (new, EWQ definition in progress)
Wickecheoke Creek, NJ – 1525 BCP
Lockatong Creek, NJ – 1540 BCP

All other tributaries to the upstream reach are less than 20 square miles drainage area, possess no wastewater discharges, and are expected to exert very little water quality influence upon the Delaware River.



N | 58

Flow cfs by yyyy	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
2001	3,245	3,284	4,450	6,157	14,474	2,872
2002	2,835	3,274	3,818	14,233	25,471	10,959
2003	7,346	11,473	15,201	18,099	38,963	6,626
2004	5,114	6,236	13,501	16,826	20,471	10,590
2009	5,990	6,315	17,341	28,178	28,178	21,863
2010	2,473	3,025	3,389	6,618	8,641	3,593
2011	5,153	13,987	18,277	31,487	100,496	17,500

Annual flow statistics are plotted above. Flow is plotted on a logarithmic scale. These are May to September flow measurements associated with the time of each water quality sample. Flow is estimated at this location using drainage area weighting based on the USGS continuous stream gage at Trenton, NJ. “Normal” flow is about 10,000 cfs at this location on the Delaware River.

Chapter 4: 1487 ICP

Delaware River at Lambertville/New Hope Bridge, NJ/PA

Alkalinity as CaCO3, Total mg/l

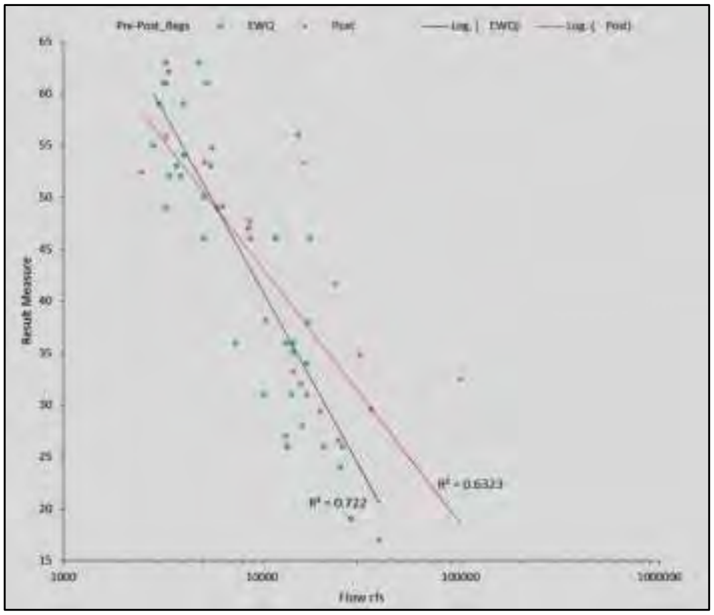
Existing Water Quality (Table 2W):

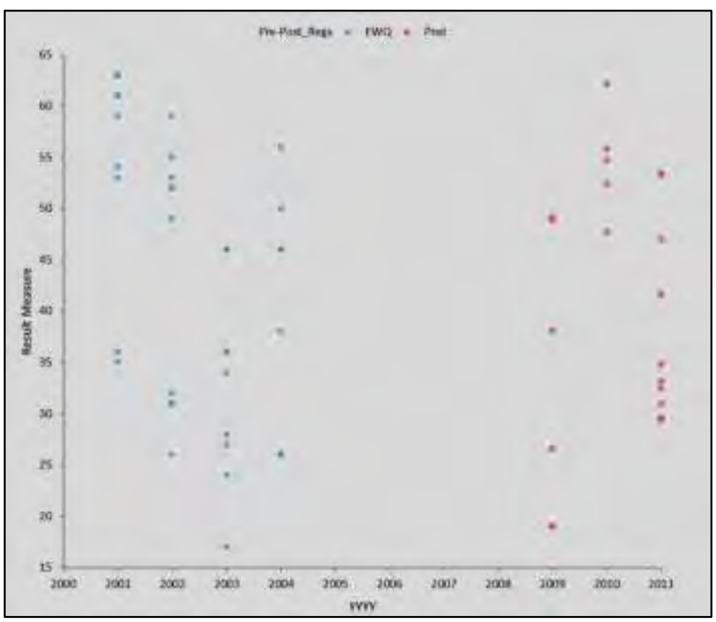
Median 46 mg/l

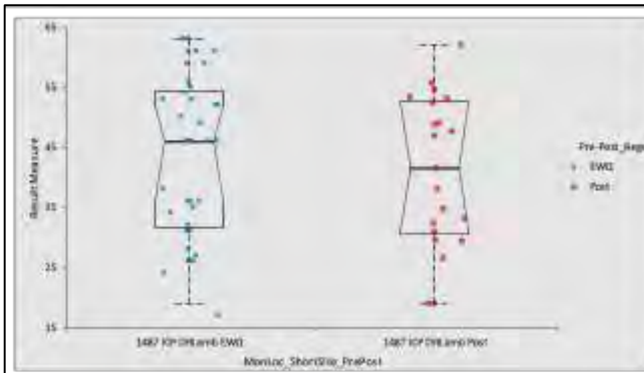
Lower 95% Confidence Interval 36 mg/l

Upper 95% Confidence Interval 52 mg/l

Defined in regulations as a flow-related parameter

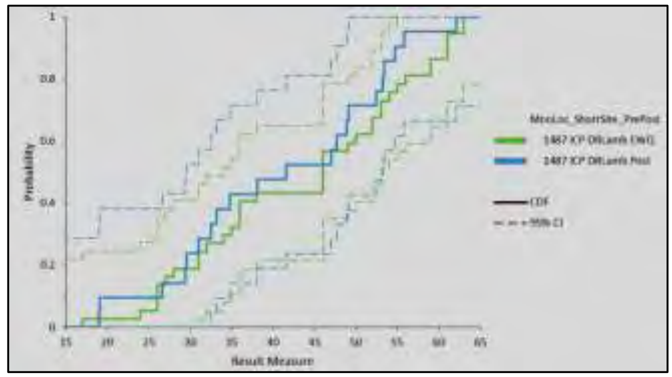






N | 58

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1487 ICP DRLamb EWQ	17.0	31.7	46.0	54.3	63.0	22.7
1487 ICP DRLamb Post	19.0	30.5	41.6	52.7	62.1	22.2



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1487 ICP DRLamb EWQ	37	44.3	1.20
1487 ICP DRLamb Post	21	78.1	3.72

H statistic	0.43
X^2 approximation	0.43
DF	1
p-value	0.5120 [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.

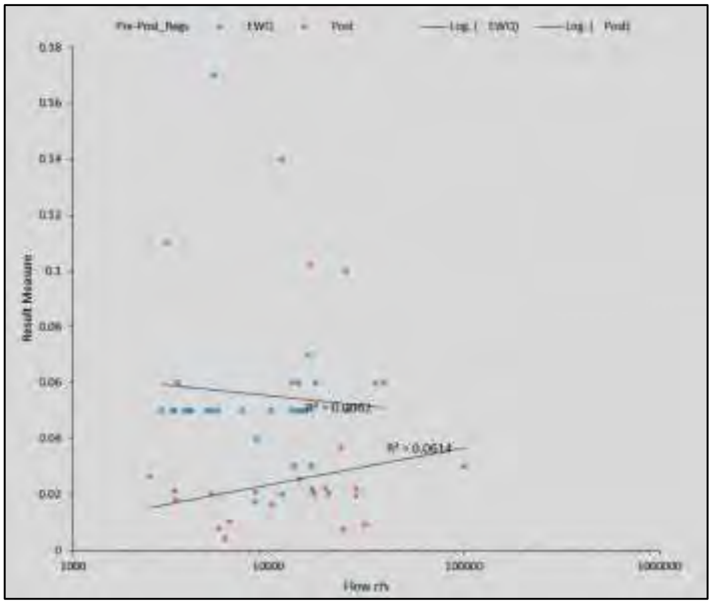
No water quality degradation is evident. Alkalinity did not measurably change between the EWQ and post-EWQ periods. Alkalinity is inversely related to flow. Post-EWQ median alkalinity fell within the EWQ 95% confidence intervals. The overall distributions were closely matched. Note that flow is plotted on a logarithmic scale.

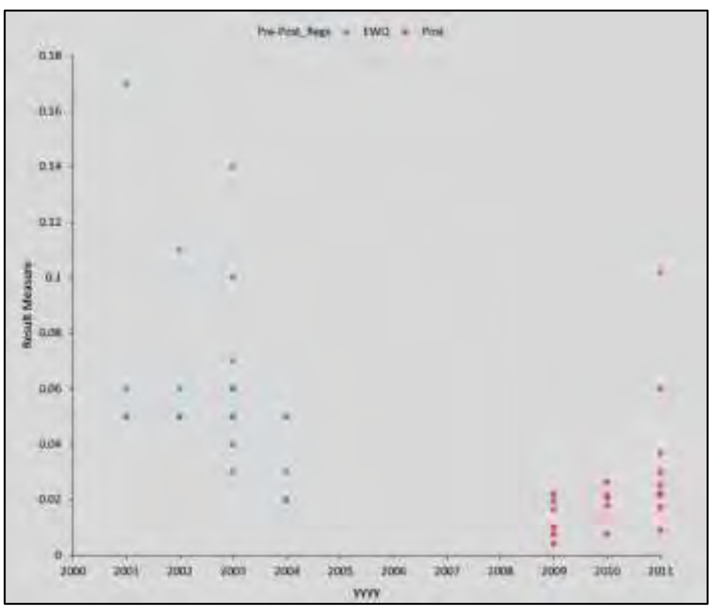
Chapter 4: 1487 ICP
Delaware River at Lambertville/New Hope Bridge, NJ/PA

Ammonia Nitrogen as N, Total mg/l

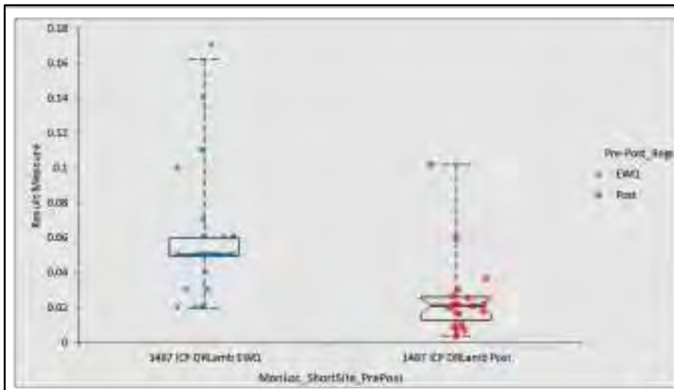
Existing Water Quality (Table 2W):

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



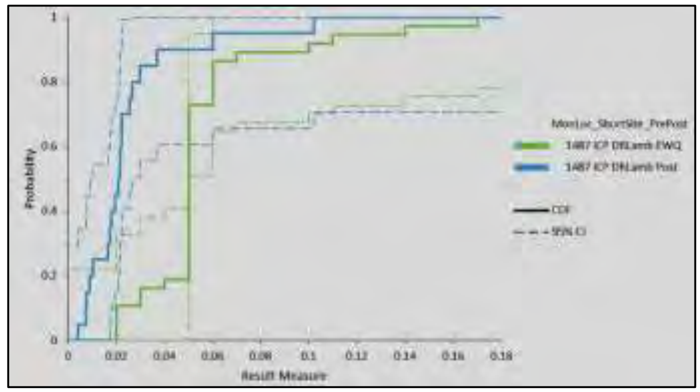


No water quality degradation is evident. Ammonia concentrations apparently declined. However, differences in detection limits and potential laboratory artifacts introduced uncertainty in the conclusion. No independent data were available to validate results.



N	57

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1487 ICP DRLamb EWQ	0.020	0.050	0.050	0.060	0.170	0.010
1487 ICP DRLamb Post	0.004	0.013	0.021	0.026	0.102	0.013



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1487 ICP DRLamb EWQ	37	1948.4	52.66
1487 ICP DRLamb Post	20	3604.6	180.23

H statistic	21.10
X^2 approximation	21.10
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.

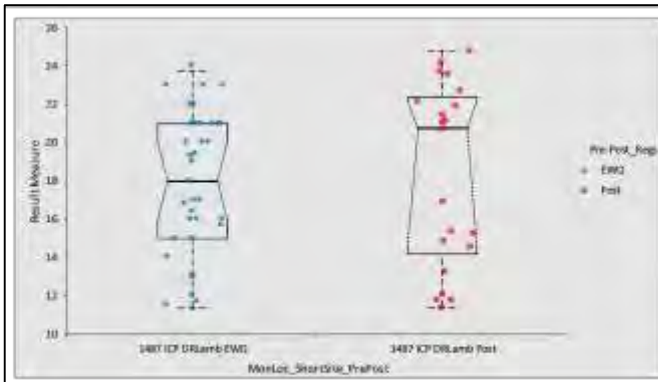
The post-EWQ detection limit (0.004-0.006 mg/l) was much lower than the EWQ period (0.05 mg/l 2002-2003; 0.02 mg/l in 2004). The EWQ data set possessed 24/37 undetected results, which interfered with estimation of the median concentration. Under lower detection levels there was only one non-detect result in the post-EWQ period. Only 10% (2/20) of post-EWQ results were above 0.05 mg/l, where 27% (10/37) of EWQ results were above 0.05 mg/l. This may represent a water quality improvement.

Chapter 4: 1487 ICP
Delaware River at Lambertville/New Hope Bridge, NJ/PA

Chloride, Total mg/l

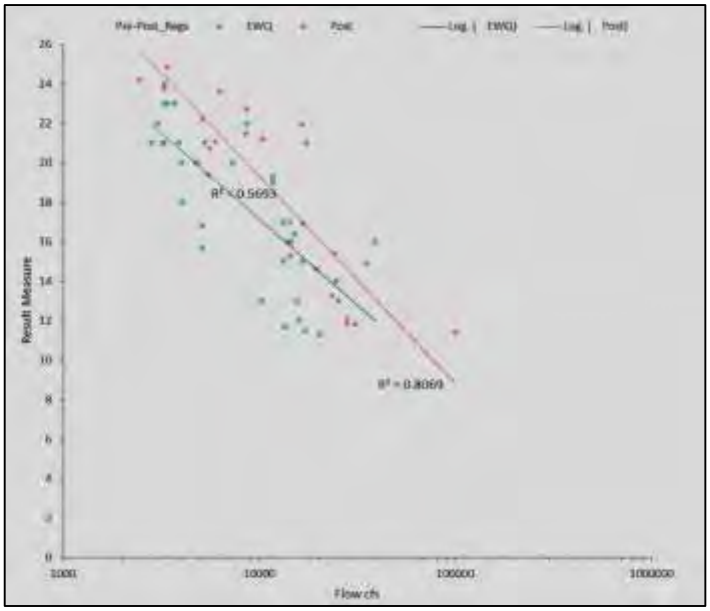
Existing Water Quality (Table 2W):

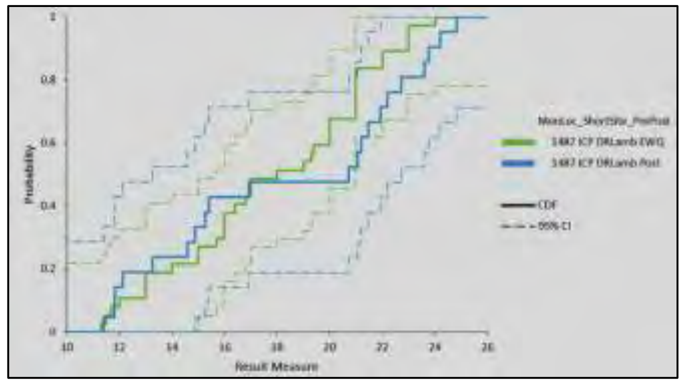
Median 18 mg/l
Lower 95% Confidence Interval 16 mg/l
Upper 95% Confidence Interval 20 mg/l
Defined in regulations as a flow-related parameter



N 58

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1487 ICP DRLamb EWQ	11.3	15.0	18.0	21.0	24.0	6.0
1487 ICP DRLamb Post	11.4	14.2	20.7	22.4	24.8	8.2



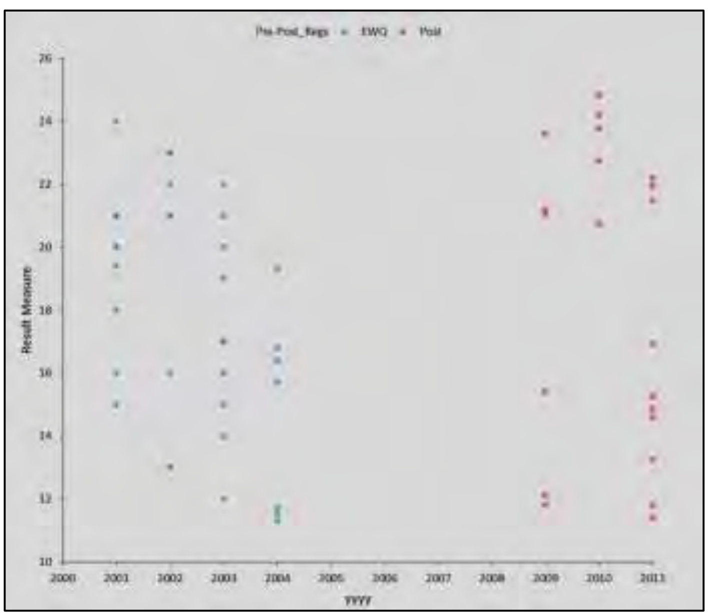


Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1487 ICP DRLamb EWQ	37	48.8	1.32
1487 ICP DRLamb Post	21	86.0	4.10

H statistic	0.47
X^2 approximation	0.47
DF	1
p-value	0.4913 [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.



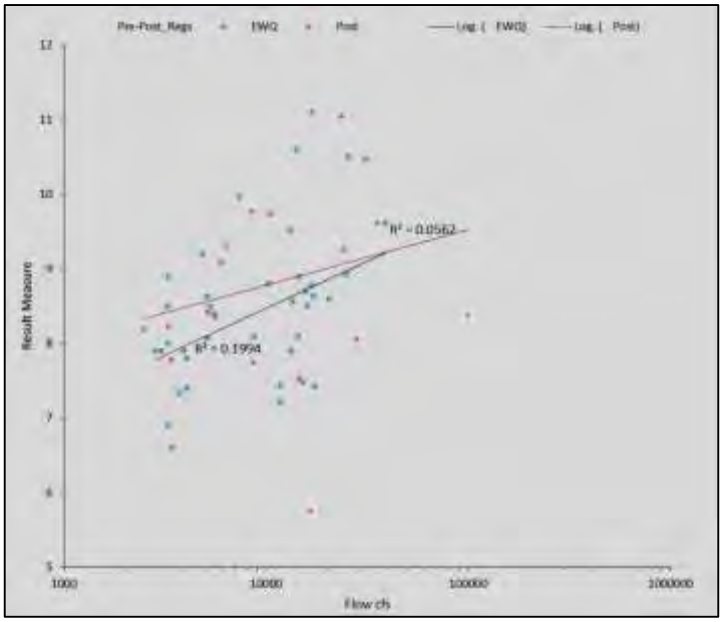
Some evidence exists of water quality degradation. Chloride concentrations apparently did not measurably change between the two periods. Sources of analytical uncertainty included potential laboratory artifacts and insufficient post-EWQ sampling (n=21). Post-EWQ median concentration was above the upper EWQ 95% confidence interval, but there were too few post-EWQ data (n=21) for a significant difference. Both sets are strongly related to flow, which is plotted on a logarithmic scale.

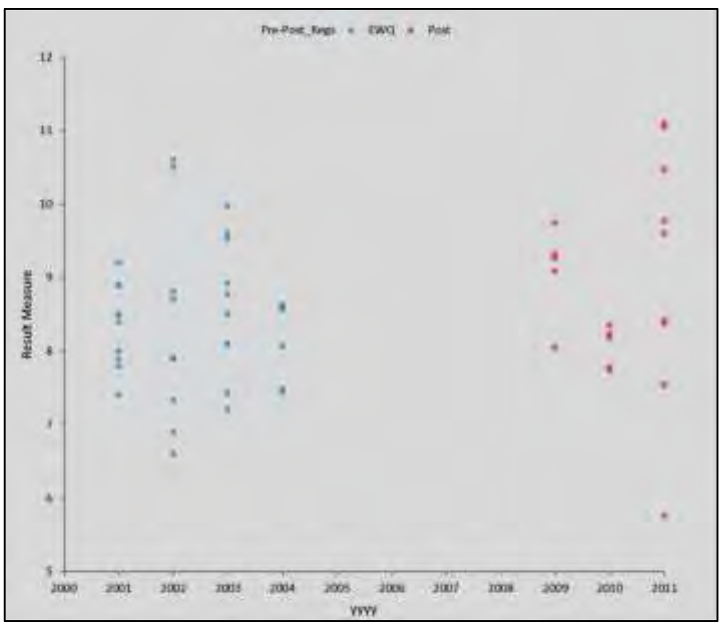
Chapter 4: 1487 ICP
Delaware River at Lambertville/New Hope Bridge, NJ/PA

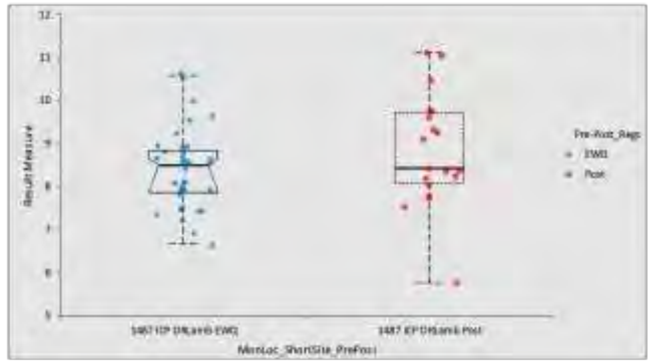
Dissolved Oxygen (DO) mg/l

Existing Water Quality (Table 2W):

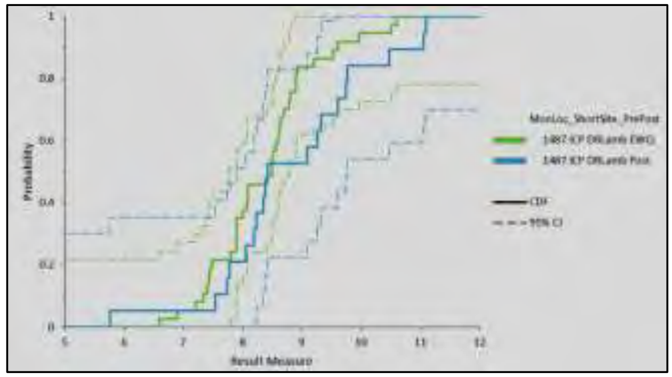
Median 8.50 mg/l
Lower 95% Confidence Interval 7.90 mg/l
Upper 95% Confidence Interval 8.63 mg/l







	N	56				
Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1487 ICP DRLamb EWQ	6.6	7.9	8.5	8.8	10.6	1.0
1487 ICP DRLamb Post	5.8	8.1	8.4	9.7	11.1	1.6



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1487 ICP DRLamb EWQ	37	164.4	4.44
1487 ICP DRLamb Post	19	320.2	16.85

H statistic	1.82
X^2 approximation	1.82
DF	1
p-value	0.1770 [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.

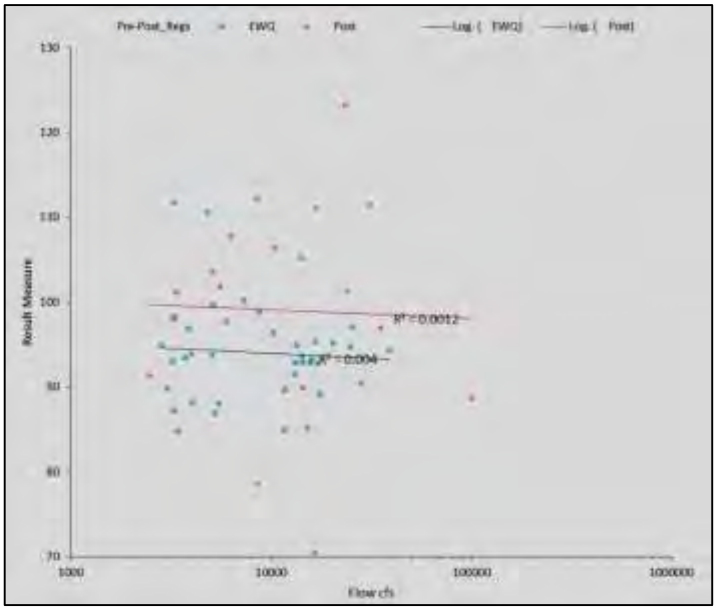
No water quality degradation is evident. No measurable change took place between the EWQ and Post-EWQ periods. Post-EWQ dissolved oxygen concentrations fell within the EWQ 95% confidence intervals. Note that flow is plotted on a logarithmic scale for best view of the data. DO is unrelated to flow.

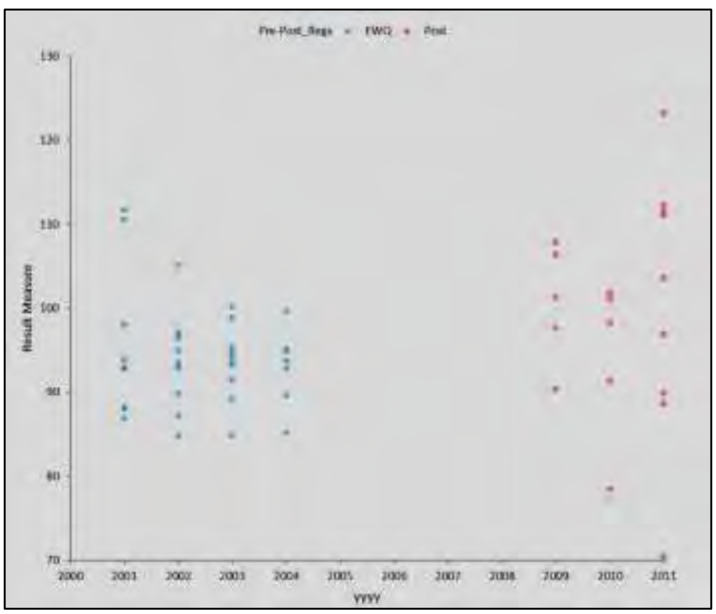
Chapter 4: 1487 ICP
Delaware River at Lambertville/New Hope Bridge, NJ/PA

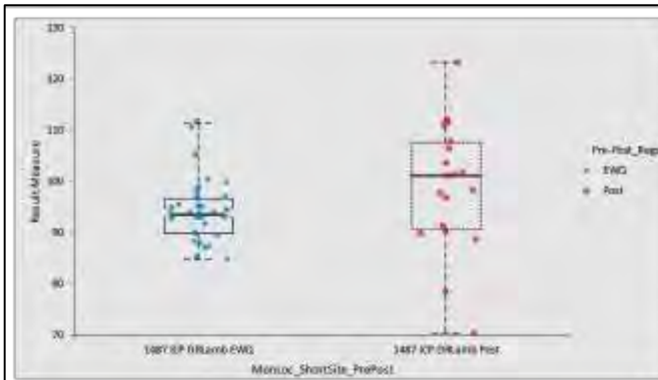
Dissolved Oxygen Saturation %

Existing Water Quality (Table 2W):

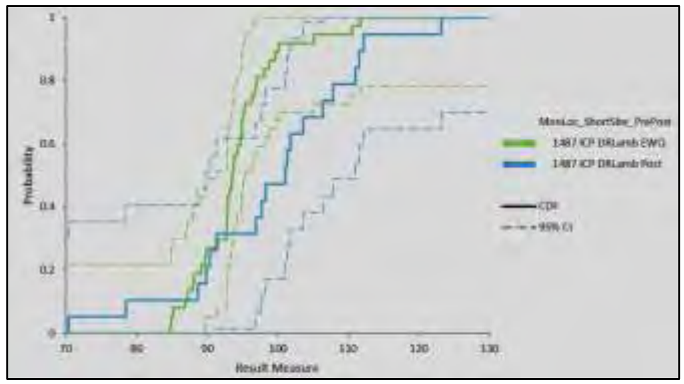
Median 94%
Lower 95% Confidence Interval 93%
Upper 95% Confidence Interval 95%







N	56					
Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1487 ICP DRLamb EWQ	84.8	89.8	93.6	96.5	111.7	6.8
1487 ICP DRLamb Post	70.4	90.6	101.1	107.6	123.2	17.0



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1487 ICP DRLamb EWQ	37	439.4	11.87
1487 ICP DRLamb Post	19	855.6	45.03

H statistic	4.87
X^2 approximation	4.87
DF	1
p-value	0.0274 [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.

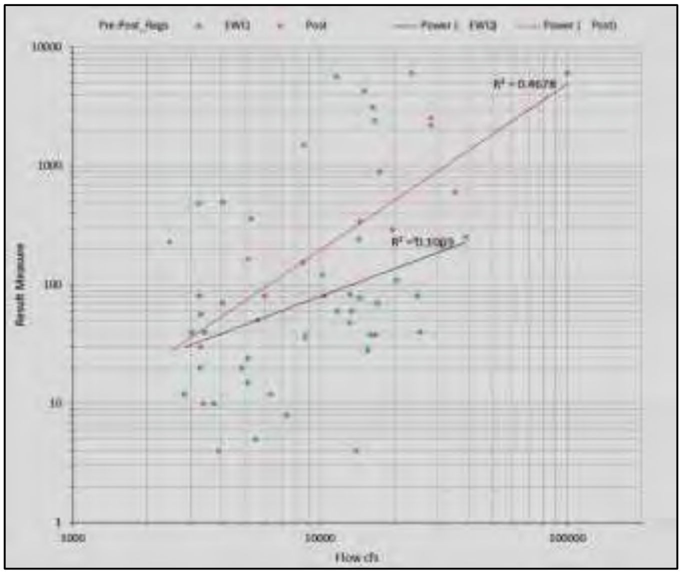
No water quality degradation is evident. Dissolved Oxygen Saturation increased between the EWQ and post-EWQ periods. The main driver of the change was that DO saturation ranged widely in 2011, indicating higher than usual primary productivity by algae and plant activity that summer. Post-EWQ median DO saturation rose above the EWQ upper 95% confidence interval. Post-EWQ minimum DO saturation, at 70%, indicates unusually high oxygen demand during one of the sampling events. Overall post-EWQ DO saturation rose to “normal” levels for a wide, shallow, highly productive river. Dissolved Oxygen Saturation is unrelated to flow. Flow is plotted on a logarithmic scale.

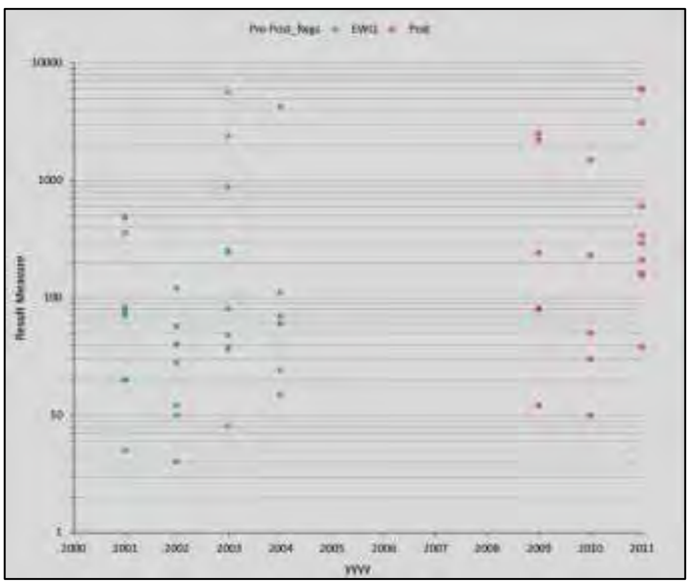
Chapter 4: 1487 ICP
Delaware River at Lambertville/New Hope Bridge, NJ/PA

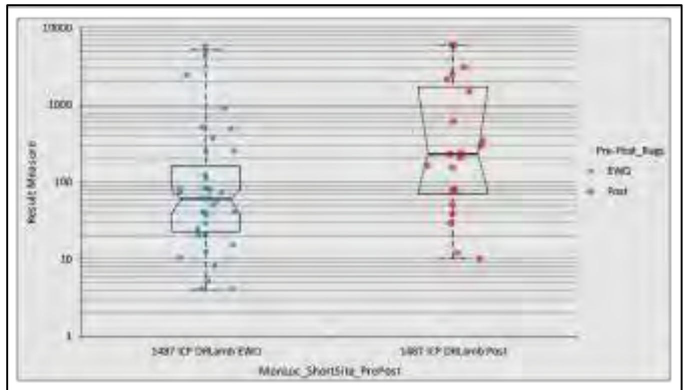
Enterococcus colonies/100 ml

Existing Water Quality (Table 2W):

Median 60/100 ml
Lower 95% Confidence Interval 38/100 ml
Upper 95% Confidence Interval 80/100 ml

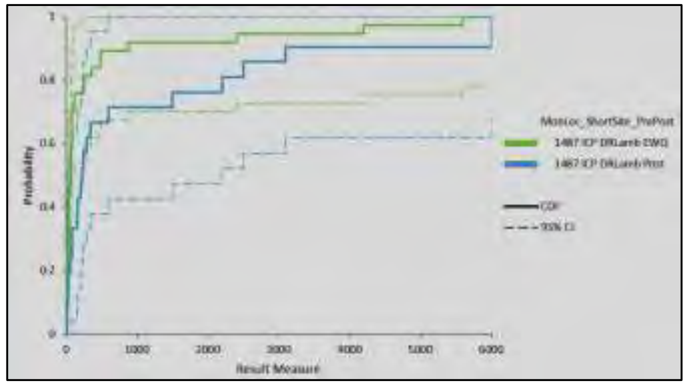






	N
	58

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1487 ICP DRLamb EWQ	4	23	60	160	5,600	137
1487 ICP DRLamb Post	10	70	230	1,733	6,000	1,663



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1487 ICP DRLamb EWQ	37	653.5	17.66
1487 ICP DRLamb Post	21	1151.4	54.83

H statistic	6.33
X^2 approximation	6.33
DF	1
p-value	0.0118[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.

Weak evidence of degradation exists. Enterococci apparently rose between the two periods, and the post-EWQ median was higher than the EWQ upper 95% confidence interval. Sources of analytical uncertainty included potential laboratory artifacts and insufficient post-EWQ sampling (n=21). Enterococcus concentrations are positively related to flow in the post-EWQ data set, but the regression is driven by a single outlier sample taken during flood conditions. Note that concentrations and flows are plotted on a logarithmic scale.

Chapter 4: 1487 ICP

Delaware River at Lambertville/New Hope Bridge, NJ/PA

Escherichia coli colonies/100 ml

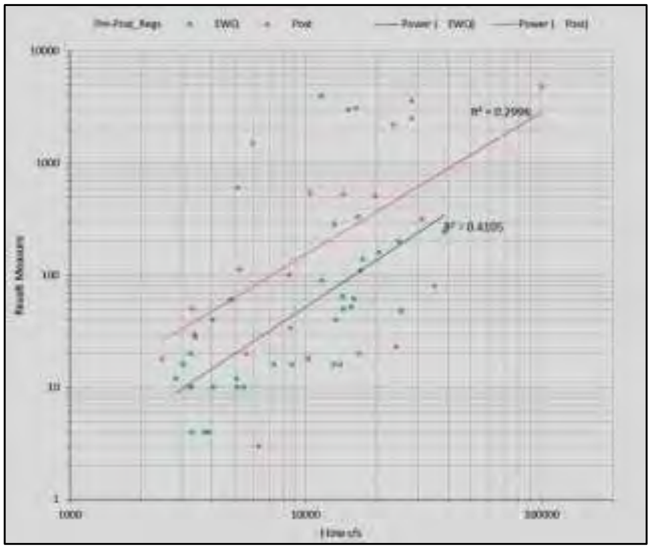
Existing Water Quality (Table 2W):

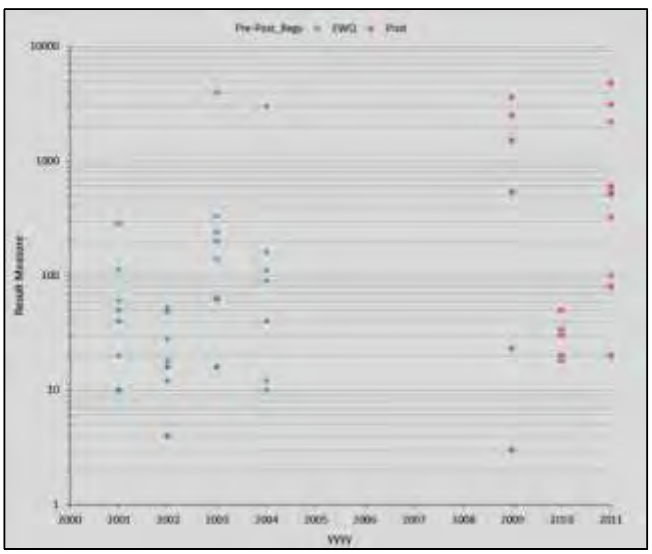
Median 40/100 ml

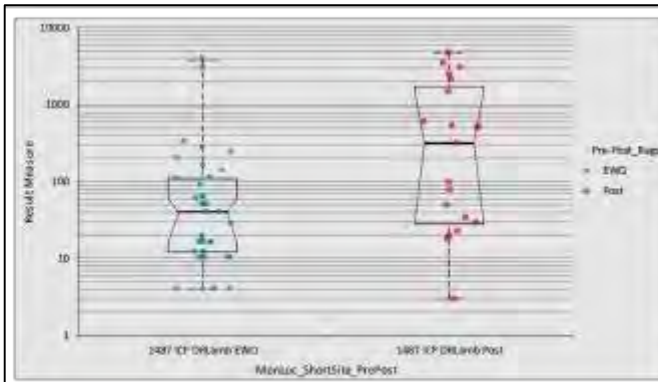
Lower 95% Confidence Interval 16/100 ml

Upper 95% Confidence Interval 62/100 ml

Defined in regulations as a flow-related parameter

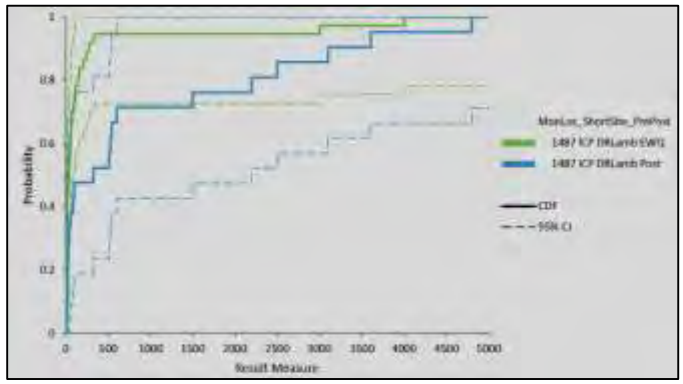






N | 58

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1487 ICP DRLamb EWQ	4	12	40	111	4,000	99
1487 ICP DRLamb Post	3	28	320	1,733	4,800	1,706



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1487 ICP DRLamb EWQ	37	832.4	22.50
1487 ICP DRLamb Post	21	1466.7	69.84

H statistic	8.08
X^2 approximation	8.08
DF	1
p-value	0.0045 [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.

Weak evidence of water quality degradation exists. E. coli concentrations apparently rose above the EWQ upper 95% confidence interval. Sources of analytical uncertainty included potential laboratory artifacts and insufficient post-EWQ sampling (n=21).

E. coli concentrations are positively related to flow, but the relationship is weak in the post-EWQ data. No independent data from other agencies were available at this site to validate DRBC’s conclusion. The reason for the increase remains unexplained other than the prevalence of higher flow conditions in the post-EWQ period.

Chapter 4: 1487 ICP

Delaware River at Lambertville/New Hope Bridge, NJ/PA

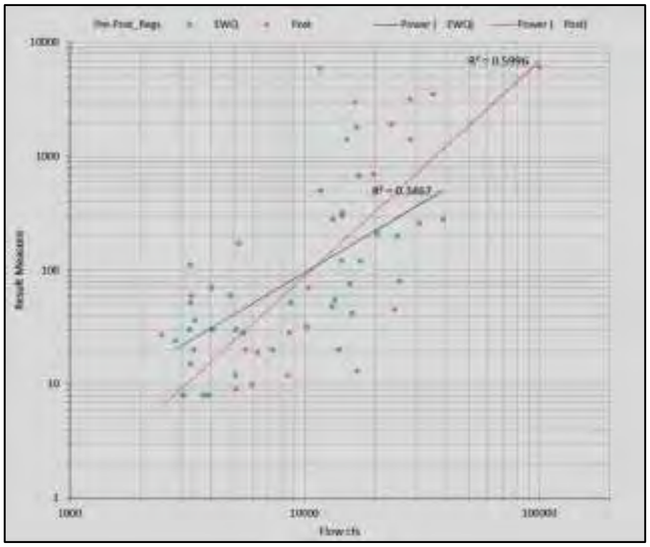
Fecal coliform colonies/100 ml

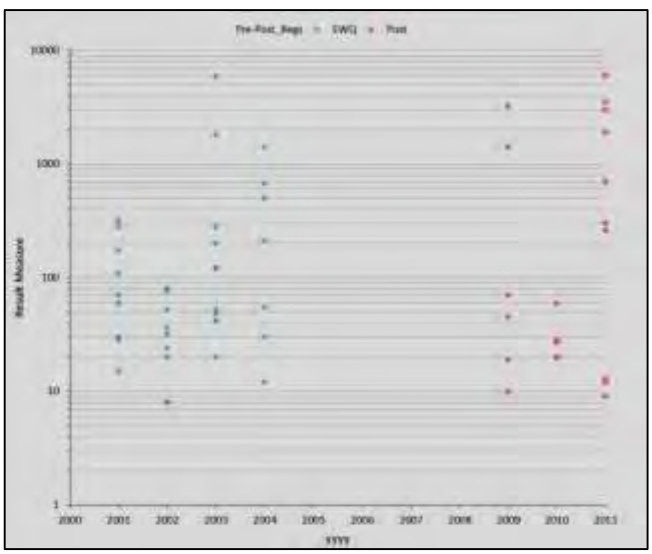
Existing Water Quality (Table 2W):

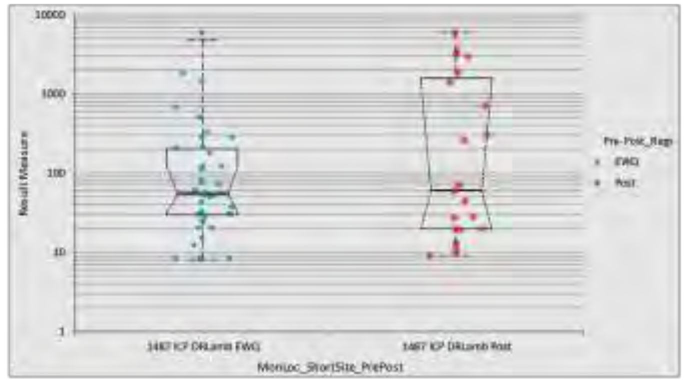
Median 55/100 ml

Lower 95% Confidence Interval 32/100 ml

Upper 95% Confidence Interval 120/100 ml

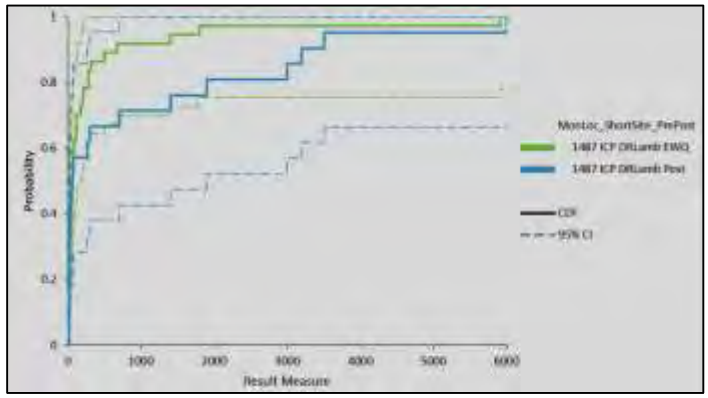






N	58

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1487 ICP DRLamb EWQ	8	29	55	203	5,900	174
1487 ICP DRLamb Post	9	20	60	1,567	6,000	1,547



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1487 ICP DRLamb EWQ	37	14.3	0.39
1487 ICP DRLamb Post	21	25.2	1.20

H statistic	0.14
X^2 approximation	0.14
DF	1
p-value	0.7097 [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. Fecal coliform concentrations 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=21). Fecal coliform concentrations are positively related to flow. Post-EWQ median concentrations fell within the EWQ 95% confidence intervals. As with the EWQ data set in 2003-2004, post-EWQ high concentrations are most likely during wet weather conditions as seen in 2009 and 2011. Note that both concentrations and flows are presented on a logarithmic scale.

Chapter 4: 1487 ICP

Delaware River at Lambertville/New Hope Bridge, NJ/PA

Hardness as CaCO3, Total mg/l

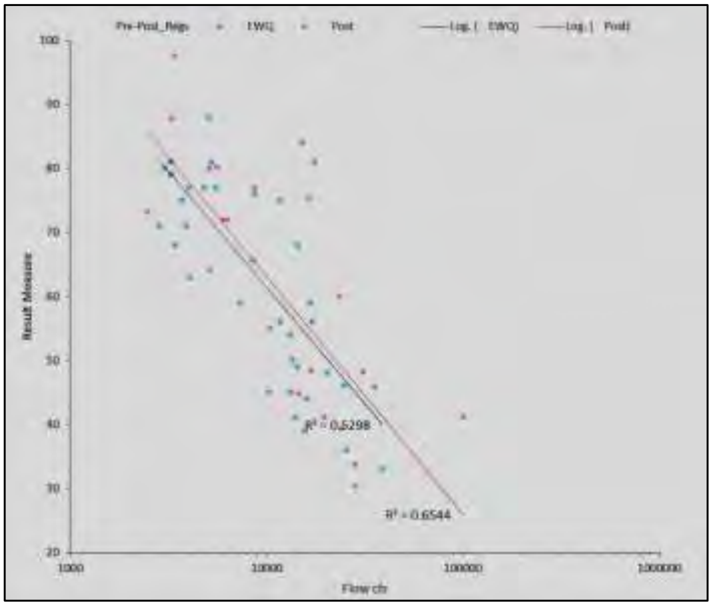
Existing Water Quality (Table 2W):

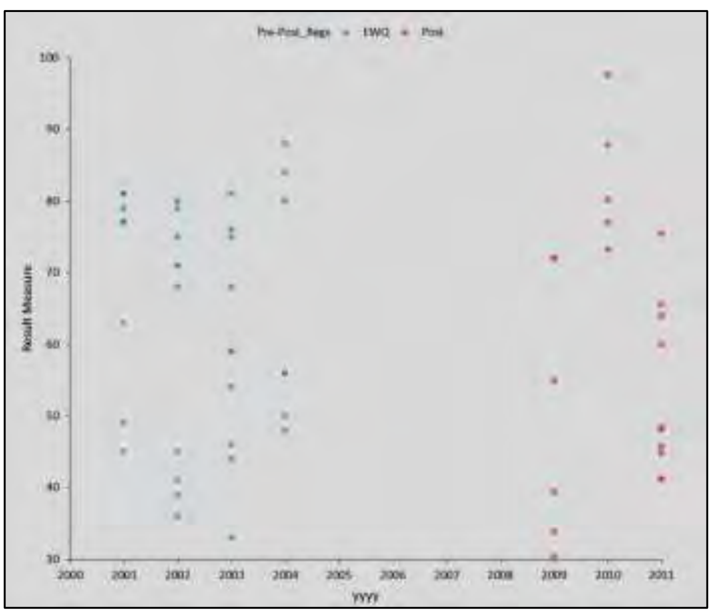
Median 68 mg/l

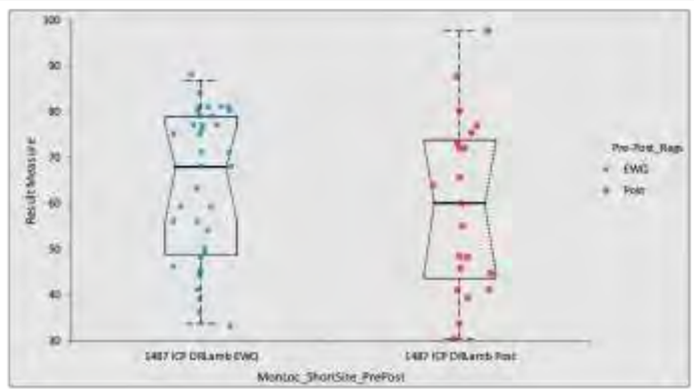
Lower 95% Confidence Interval 56 mg/l

Upper 95% Confidence Interval 77 mg/l

Defined in regulations as a flow-related parameter

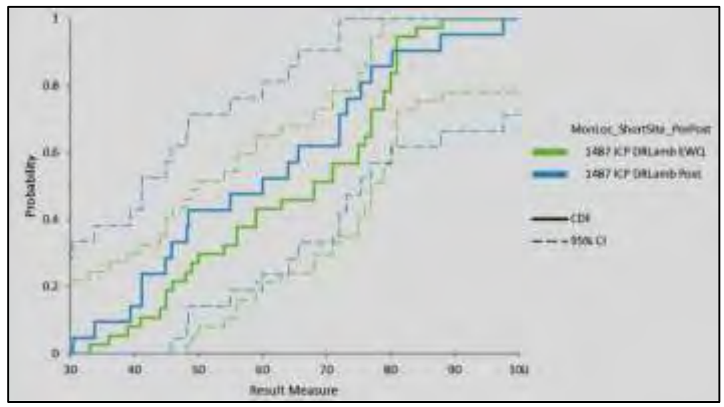






N	58

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1487 ICP DRLamb EWQ	33.0	48.7	68.0	79.0	88.0	30.3
1487 ICP DRLamb Post	30.4	43.6	60.0	73.9	97.6	30.3



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1487 ICP DRLamb EWQ	37	128.7	3.48
1487 ICP DRLamb Post	21	226.7	10.80

H statistic	1.25
X^2 approximation	1.25
DF	1
p-value	0.2640 [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 indicated. Hardness 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=21). Hardness is inversely related to flow. Post-EWQ median hardness fell within the EWQ 95% confidence intervals. Flow is plotted on a logarithmic scale.

Chapter 4: 1487 ICP

Delaware River at Lambertville/New Hope Bridge, NJ/PA

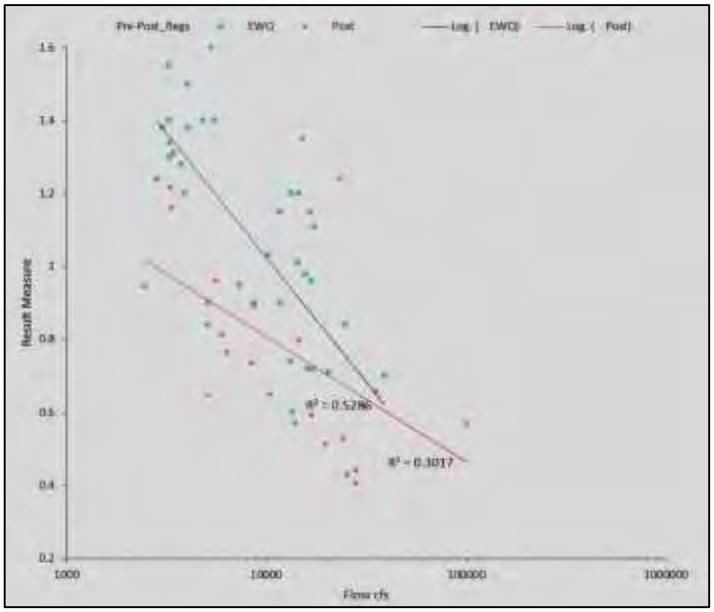
Nitrate + Nitrite as N, Total mg/l

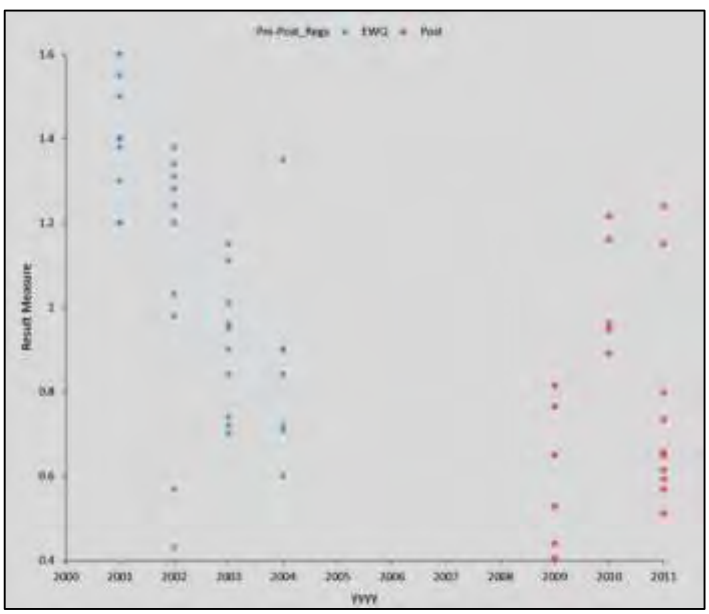
Existing Water Quality (Table 2W):

Median 1.11 mg/l

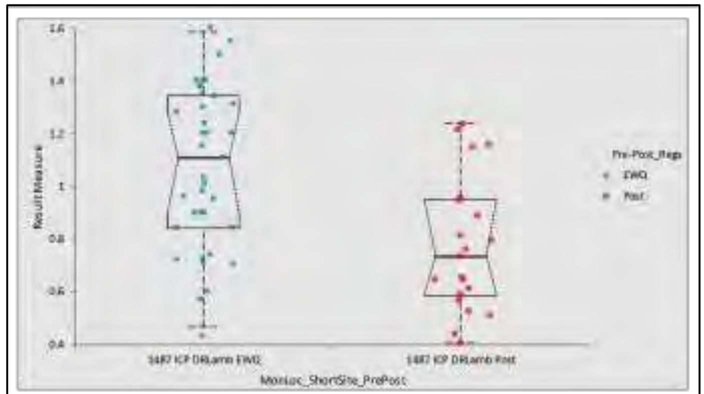
Lower 95% Confidence Interval 0.90 mg/l

Upper 95% Confidence Interval 1.28 mg/l



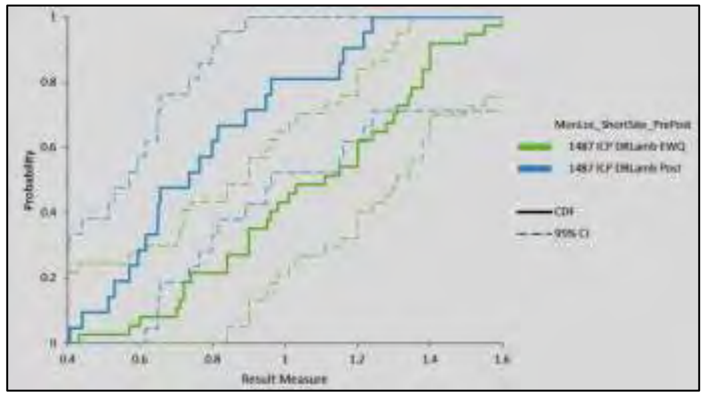


No water quality degradation is evident. Nitrate concentrations apparently declined between the EWQ and post-EWQ periods. However, potential laboratory artifacts and insufficient post-EWQ sampling produced analytical uncertainty.



N 58

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1487 ICP DRLamb EWQ	0.430	0.840	1.110	1.343	1.600	0.503
1487 ICP DRLamb Post	0.405	0.585	0.735	0.952	1.240	0.366



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1487 ICP DRLamb EWQ	37	1243.5	33.61
1487 ICP DRLamb Post	21	2191.0	104.33

H statistic	12.05
X² approximation	12.05
DF	1
p-value	0.0005 [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.

The annual plot shows a declining trend in concentration within the EWQ period that appears to stabilize into the post-EWQ period. 2002-2004 EWQ nitrates appear to match with post-EWQ nitrate + nitrite. Nitrate + Nitrite concentrations were assumed equivalent with EWQ nitrate alone, since EWQ nitrite concentrations were never detected at this site. Note that flow is plotted on a logarithmic scale. Independent data were not available for comparison. Post-EWQ median nitrate + nitrite concentrations fell below the EWQ lower 95% confidence interval. There were no undetected results in either data set.

Chapter 4: 1487 ICP

Delaware River at Lambertville/New Hope Bridge, NJ/PA

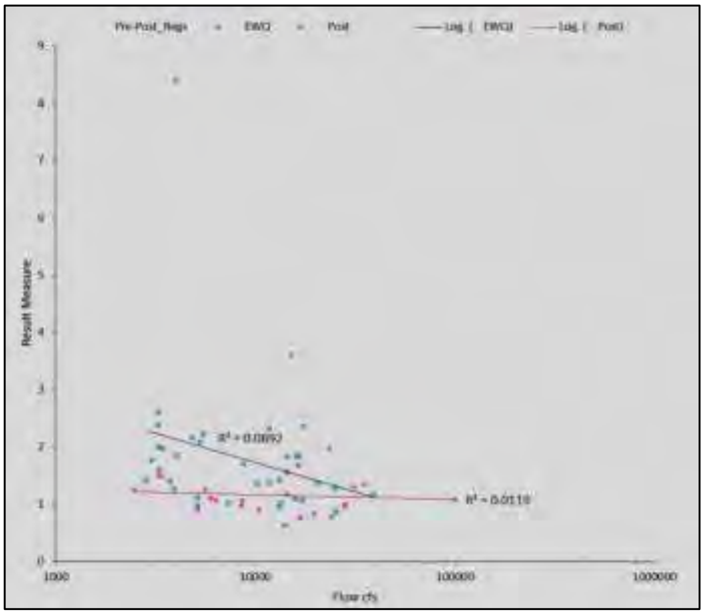
Nitrogen as N, Total (TN) mg/l

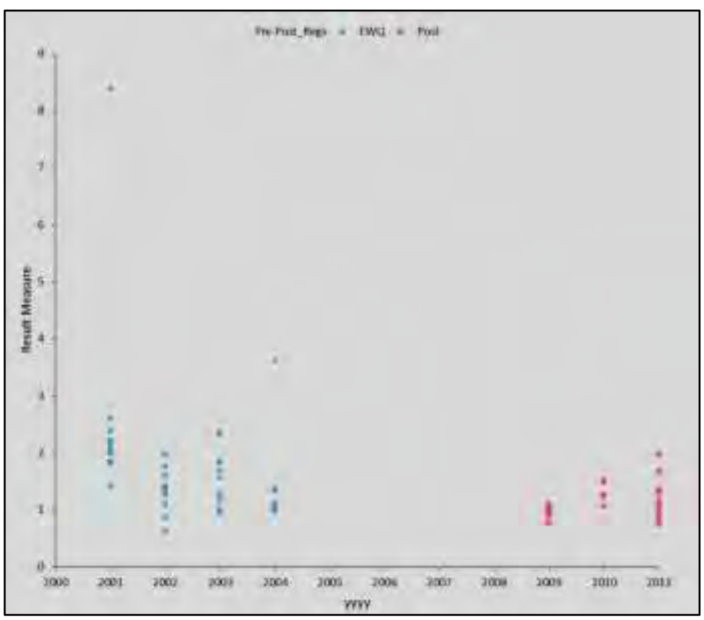
Existing Water Quality (Table 2W):

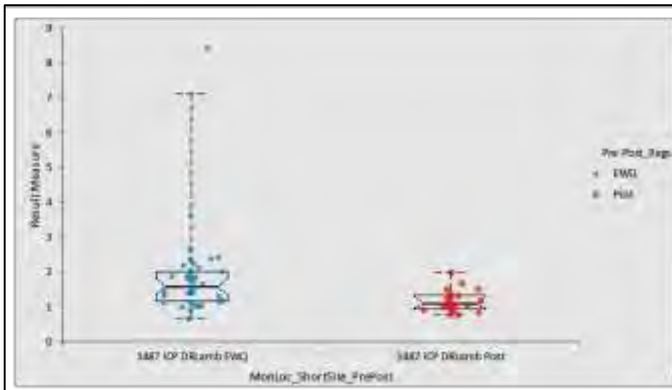
Median 1.56 mg/l

Lower 95% Confidence Interval 1.36 mg/l

Upper 95% Confidence Interval 1.84 mg/l

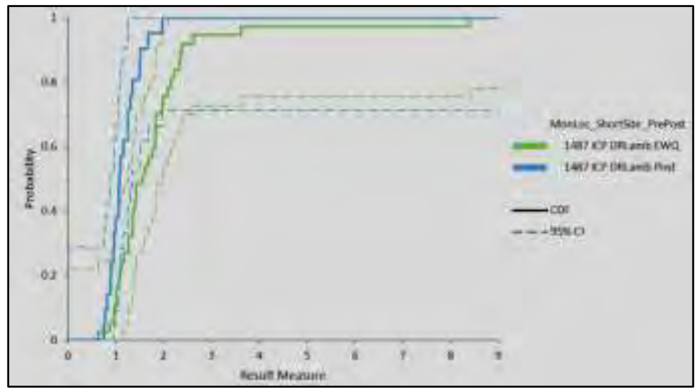






N 58

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1487 ICP DRLamb EWQ	0.620	1.150	1.560	2.020	8.400	0.870
1487 ICP DRLamb Post	0.748	0.939	1.077	1.317	1.969	0.378



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1487 ICP DRLamb EWQ	37	1174.9	31.75
1487 ICP DRLamb Post	21	2070.1	98.58

H statistic	11.38
X^2 approximation	11.38
DF	1
p-value	0.0007[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.

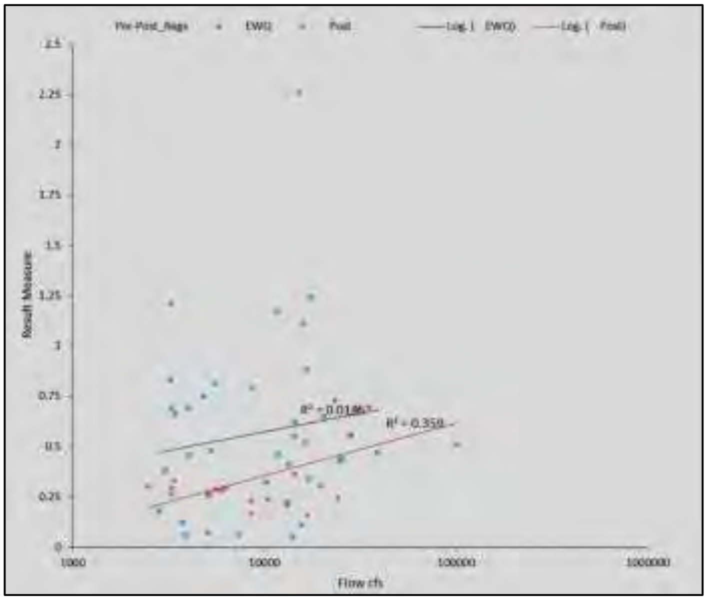
No water quality degradation is evident. Total Nitrogen concentrations apparently declined between the EWQ and post-EWQ periods. However, potential laboratory artifacts weaken the conclusion. TN is unrelated to flow in both periods. The EWQ data overall are more variable than the post-EWQ data. DRBC results could not be independently validated.

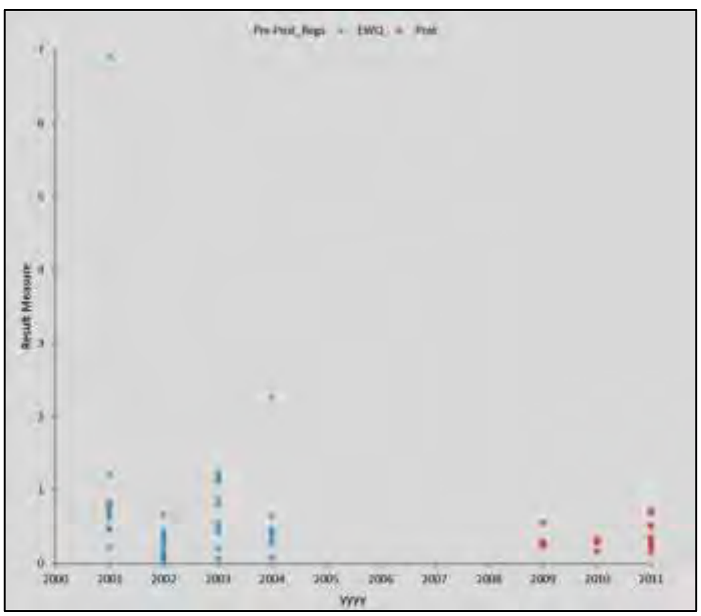
Post-EWQ median TN concentrations fell below the EWQ lower 95% confidence interval, which may indicate a water quality improvement.

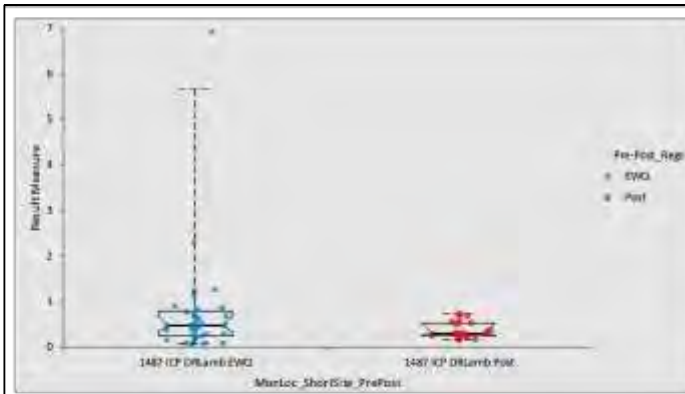
Nitrogen, Kjeldahl as N, Total (TKN) mg/l

Existing Water Quality (Table 2W):

Median 0.46 mg/l
Lower 95% Confidence Interval 0.34 mg/l
Upper 95% Confidence Interval 0.66 mg/l

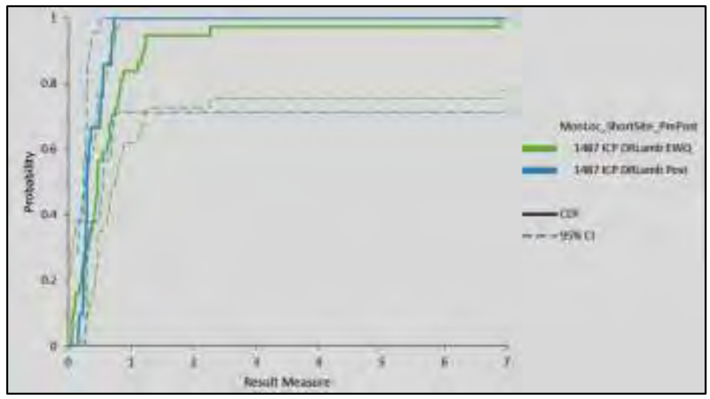






N 58

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1487 ICP DRLamb EWQ	0.050	0.247	0.460	0.797	6.900	0.550
1487 ICP DRLamb Post	0.155	0.249	0.301	0.529	0.729	0.280



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1487 ICP DRLamb EWQ	37	202.2	5.47
1487 ICP DRLamb Post	21	356.3	16.97

H statistic	1.96
X^2 approximation	1.96
DF	1
p-value	0.1617 [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.

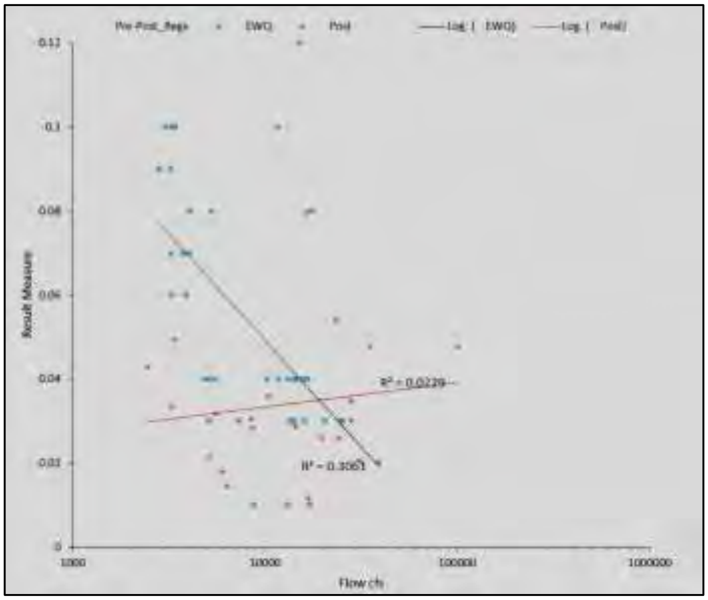
No water quality degradation is evident. No apparent measurable change occurred in TKN concentrations between the EWQ and post-EWQ periods. However, potential laboratory artifacts and insufficient post-EWQ sampling produced analytical uncertainty. TKN concentration is unrelated to flow in EWQ data, but positively related in post-EWQ data. Post-EWQ TKN was less variable than EWQ TKN. The plots look strange due to an unusually high unexplained measurement taken in 2001 (6.9 mg/l, removed in the flow relationship plot for better visibility of all other data). Post-EWQ median TKN fell below the EWQ lower 95% confidence interval.

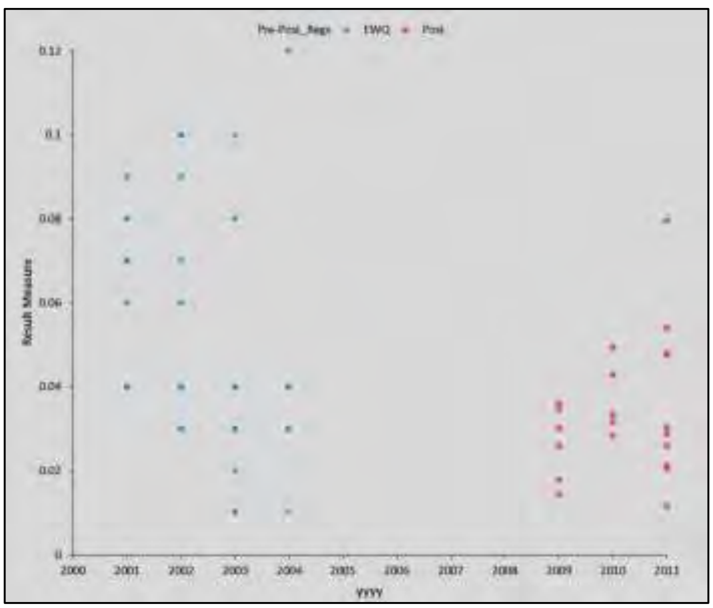
Chapter 4: 1487 ICP
Delaware River at Lambertville/New Hope Bridge, NJ/PA

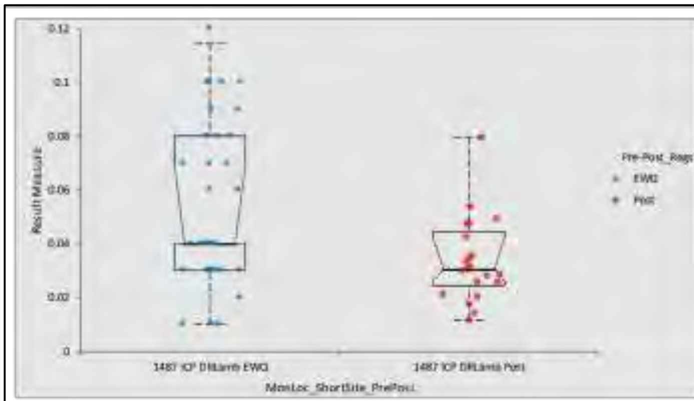
Orthophosphate as P, Total mg/l (OP)

Existing Water Quality (Table 2W):

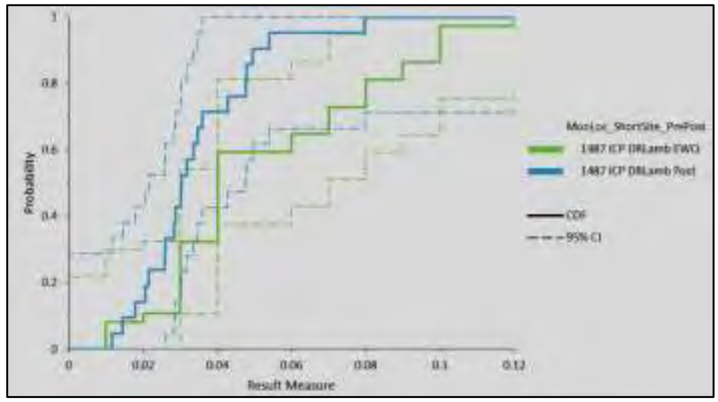
Median 0.04 mg/l
Lower 95% Confidence Interval 0.04 mg/l
Upper 95% Confidence Interval 0.07 mg/l







N	58					
Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1487 ICP DRLamb EWQ	0.010	0.030	0.040	0.080	0.120	0.050
1487 ICP DRLamb Post	0.012	0.024	0.030	0.044	0.080	0.020



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1487 ICP DRLamb EWQ	37	580.1	15.68
1487 ICP DRLamb Post	21	1022.0	48.67

H statistic	5.67
X^2 approximation	5.67
DF	1
p-value	0.0173 [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.

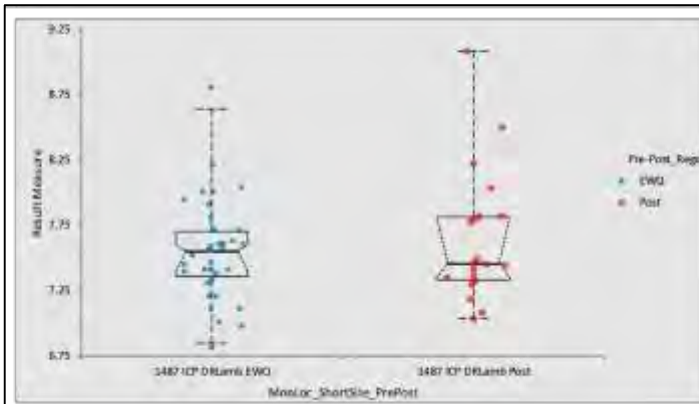
No water quality degradation is evident. OP concentrations appeared to decline between the EWQ and post-EWQ periods. However, differences in detection limits and potential laboratory artifacts produced uncertainty. Post-EWQ median OP fell below the EWQ lower 95% confidence interval, though that interval was established around the detection limit. Orthophosphate is unrelated to flow in the post-EWQ data, but inversely and weakly related to flow in the EWQ data set. Flow is plotted on a logarithmic scale. There were no independent data to confirm DRBC results.

Chapter 4: 1487 ICP
Delaware River at Lambertville/New Hope Bridge, NJ/PA

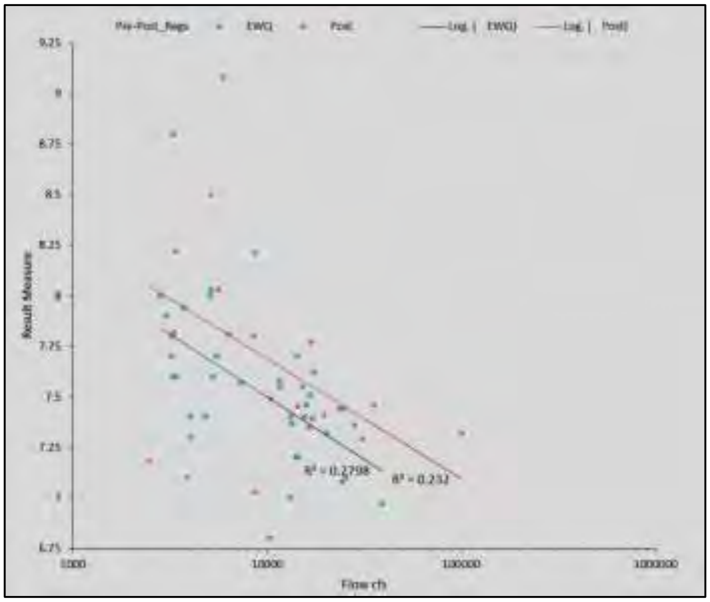
pH

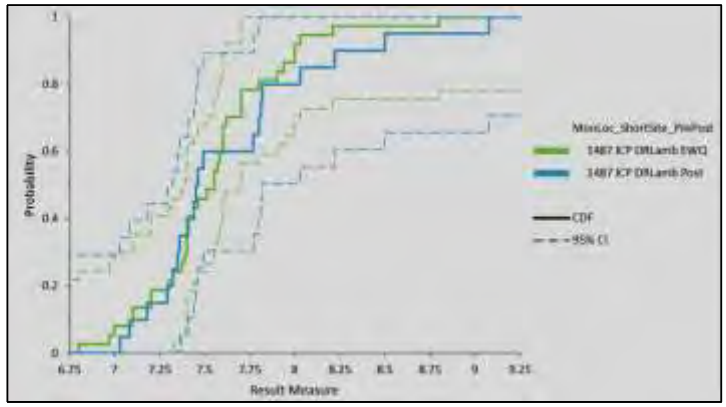
Existing Water Quality (Table 2W):

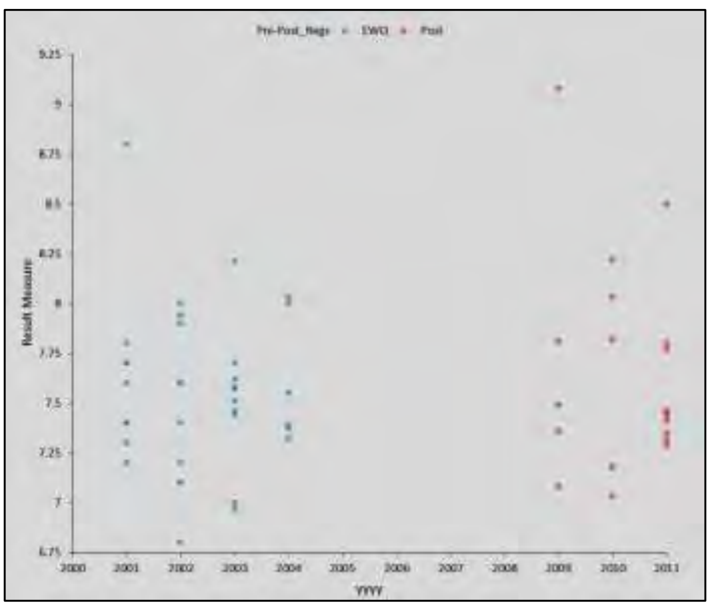
Median 7.55 standard units
Lower 95% Confidence Interval 7.40 standard units
Upper 95% Confidence Interval 7.60 standard units



Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
N	57					
1487 ICP DRLamb EWQ	6.80	7.35	7.55	7.70	8.80	0.35
1487 ICP DRLamb Post	7.03	7.33	7.46	7.82	9.08	0.48







Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1487 ICP DRLamb EWQ	37	7.4	0.20
1487 ICP DRLamb Post	20	13.6	0.68

H statistic	0.08
X^2 approximation	0.08
DF	1
p-value	0.7825 [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. pH did not measurably change between the EWQ and post-EWQ periods. Post-EWQ median pH fell between the EWQ 95% confidence intervals. Under higher flow conditions, pH tends toward neutral. During low flow and high primary productivity periods, pH criteria are occasionally exceeded at this location. Flow is plotted on a logarithmic scale.

Chapter 4: 1487 ICP

Delaware River at Lambertville/New Hope Bridge, NJ/PA

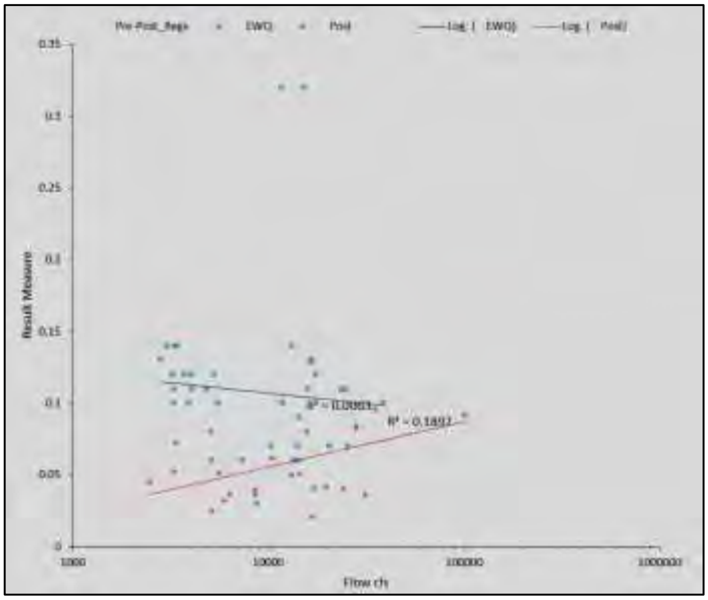
Phosphorus as P, Total (TP) mg/l

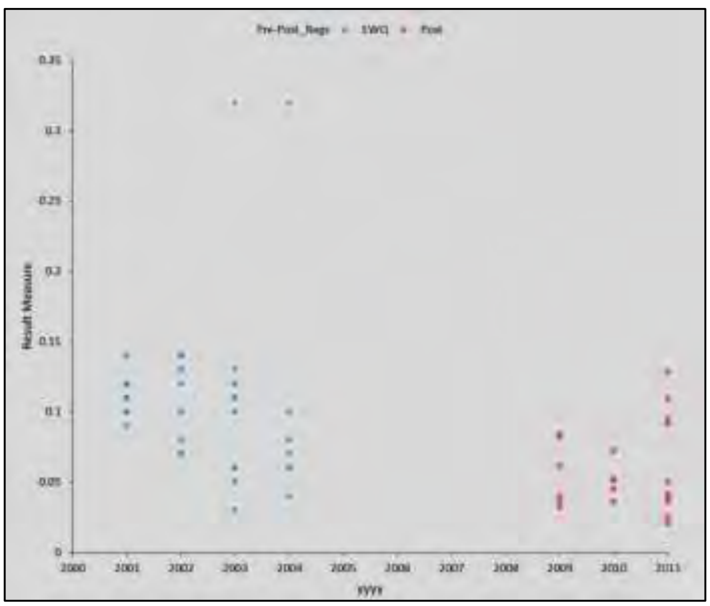
Existing Water Quality (Table 2W):

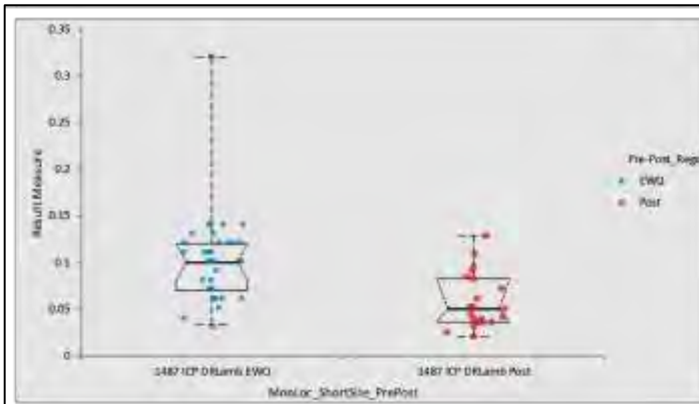
Median 0.10 mg/l

Lower 95% Confidence Interval 0.08 mg/l

Upper 95% Confidence Interval 0.12 mg/l

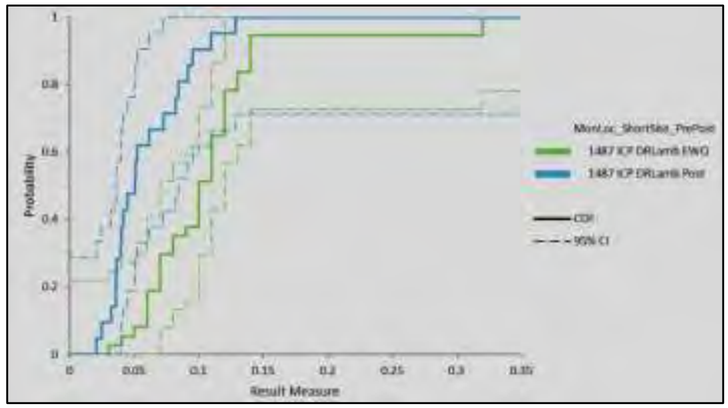






N 58

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1487 ICP DRLamb EWQ	0.030	0.070	0.100	0.120	0.320	0.050
1487 ICP DRLamb Post	0.020	0.036	0.050	0.083	0.129	0.047



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1487 ICP DRLamb EWQ	37	1675.7	45.29
1487 ICP DRLamb Post	21	2952.4	140.59

H statistic	16.28
X^2 approximation	16.28
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.

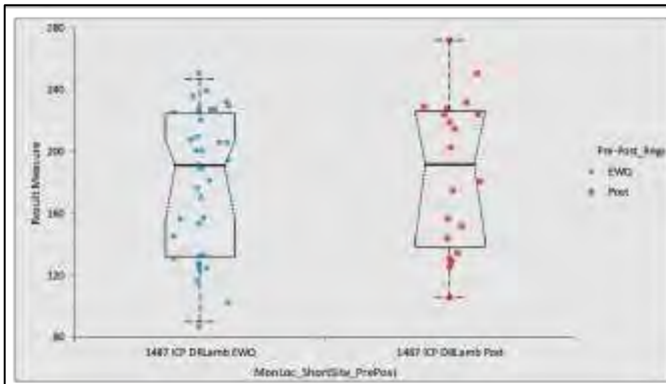
No water quality degradation is evident. Total Phosphorus (TP) concentrations apparently declined between the EWQ and post-EWQ periods. However, differences in detection limits and potential laboratory artifacts introduced uncertainty. Post-EWQ median TP fell below the EWQ lower 95% confidence interval. TP is unrelated to flow in both data sets. No independent data were available to confirm these results.

Chapter 4: 1487 ICP
Delaware River at Lambertville/New Hope Bridge, NJ/PA

Specific Conductance µmho/cm

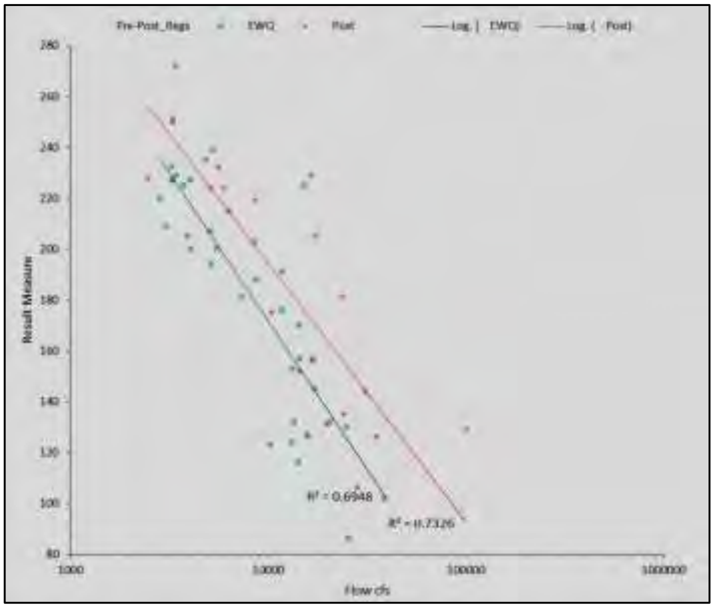
Existing Water Quality (Table 2W):

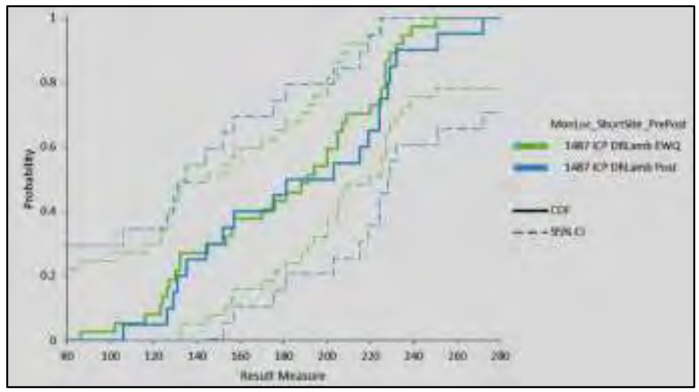
Median 191 µmho/cm
Lower 95% Confidence Interval 156 µmho/cm
Upper 95% Confidence Interval 207 µmho/cm
Defined in regulations as a flow-related parameter



N	57

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1487 ICP DRLamb EWQ	86	132	191	225	250	93
1487 ICP DRLamb Post	106	139	192	226	272	88



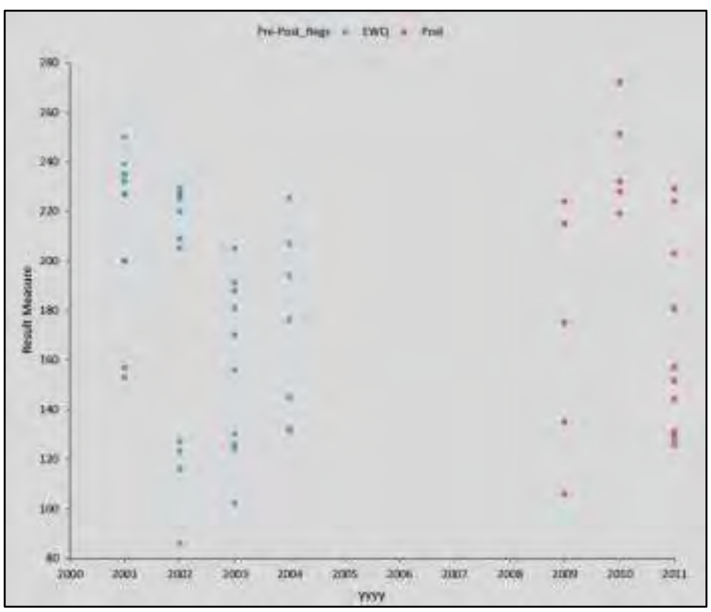


Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1487 ICP DRLamb EWQ	37	22.0	0.59
1487 ICP DRLamb Post	20	40.6	2.03

H statistic	0.23
X^2 approximation	0.23
DF	1
p-value	0.6336 [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.



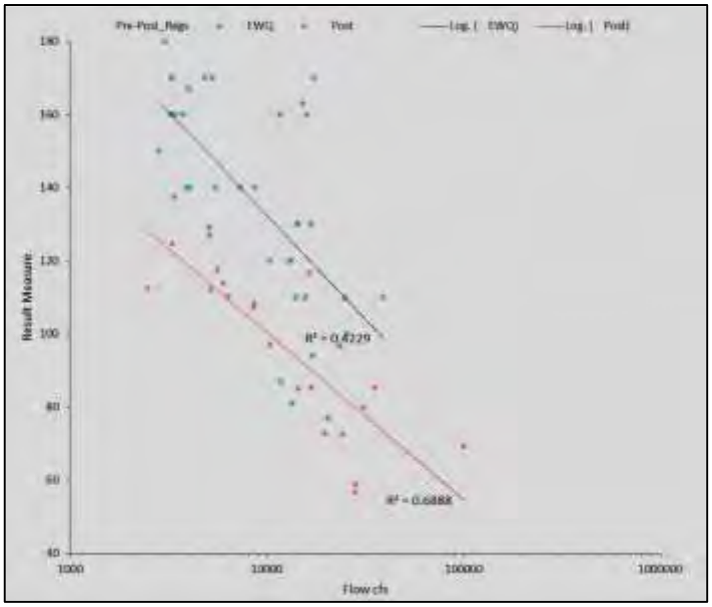
No water quality degradation is evident. Specific conductance did not measurably change between the EWQ and post-EWQ periods. Cumulative frequency distributions of both data sets are nearly identical. In both data sets, specific conductance is inversely related to flow. Post-EWQ median specific conductance fell within the EWQ 95% confidence intervals. Flow is plotted on a logarithmic scale.

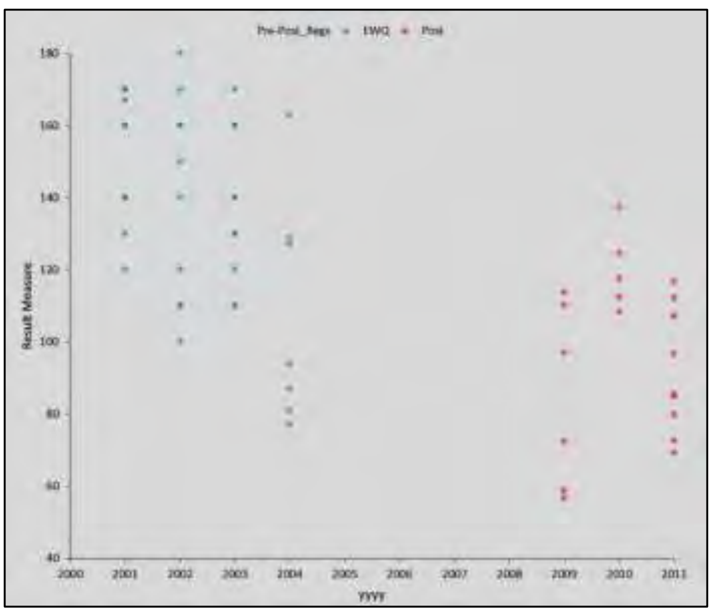
Chapter 4: 1487 ICP
Delaware River at Lambertville/New Hope Bridge, NJ/PA

Total Dissolved Solids (TDS) mg/l

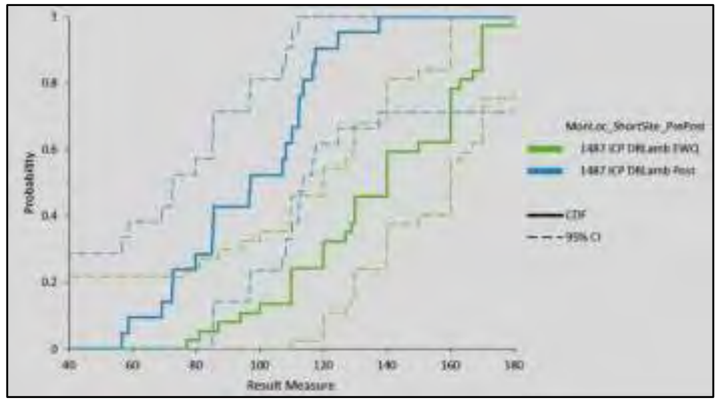
Existing Water Quality (Table 2W):

Median 140 mg/l
Lower 95% Confidence Interval 127 mg/l
Upper 95% Confidence Interval 160 mg/l
Defined in regulations as a flow-related parameter





N	58					
Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1487 ICP DRLamb EWQ	77.0	116.7	140.0	160.0	180.0	43.3
1487 ICP DRLamb Post	56.6	77.4	97.1	112.8	137.5	35.4



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1487 ICP DRLamb EWQ	37	2126.5	57.47
1487 ICP DRLamb Post	21	3746.7	178.41

H statistic	20.65
X^2 approximation	20.65
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.

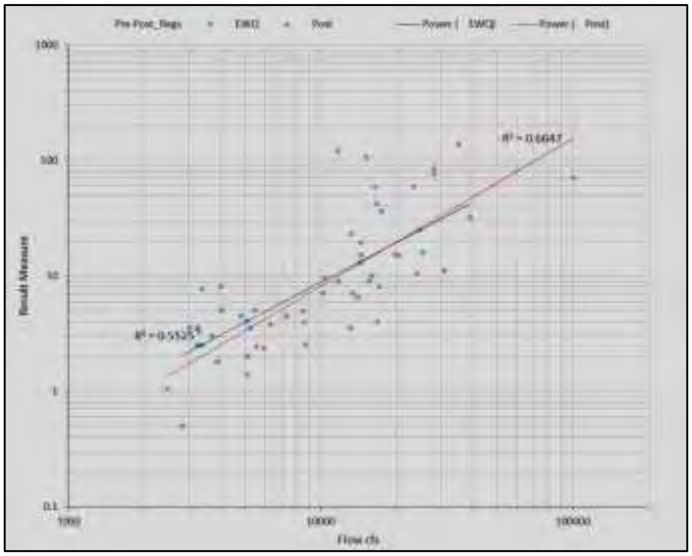
No water quality degradation is evident. TDS apparently declined between the EWQ and post-EWQ periods. However, flow condition differences and potential laboratory artifacts introduced uncertainty. TDS is inversely related to flow, which is plotted on a logarithmic scale. As fewer post-EWQ samples were low-flow samples, the decline in TDS may be explained partly by flow effects. Post-EWQ median TDS was below the EWQ 95% lower confidence interval. There were no undetected results in either data set.

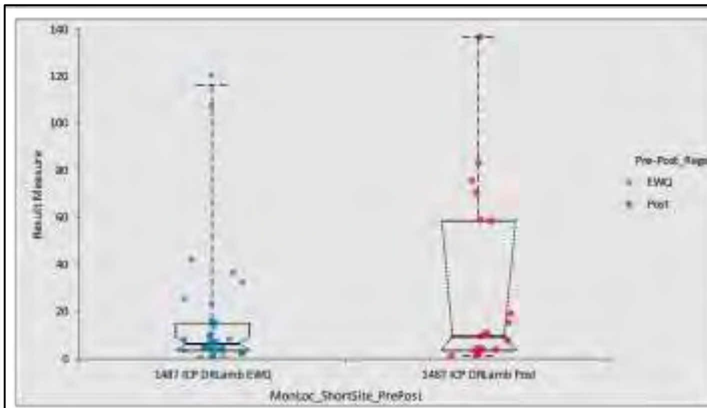
Chapter 4: 1487 ICP
Delaware River at Lambertville/New Hope Bridge, NJ/PA

Total Suspended Solids (TSS) mg/l

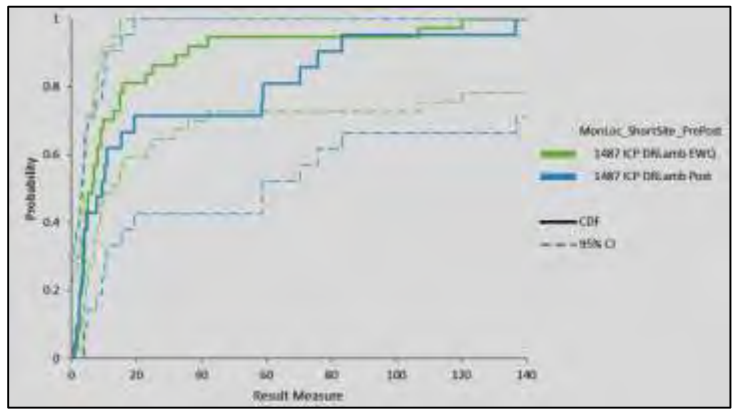
Existing Water Quality (Table 2W):

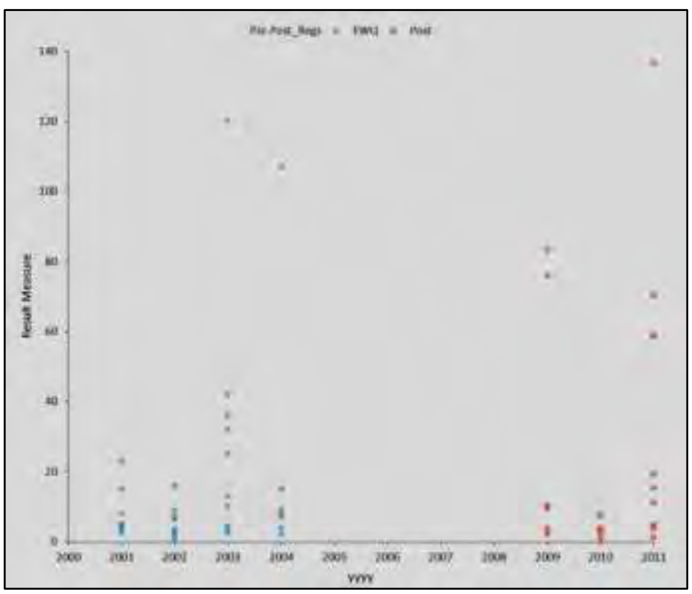
Median 6.5 mg/l
Lower 95% Confidence Interval 3.5 mg/l
Upper 95% Confidence Interval 9.0 mg/l
Defined in regulations as a flow-related parameter





N	58					
Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1487 ICP DRLamb EWQ	0.5	3.5	6.5	15.0	120.0	11.5
1487 ICP DRLamb Post	1.1	3.6	9.5	58.7	136.6	55.1





Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1487 ICP DRLamb EWQ	37	71.7	1.94
1487 ICP DRLamb Post	21	126.3	6.01

H statistic	0.70
X^2 approximation	0.70
DF	1
p-value	0.4045 [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.

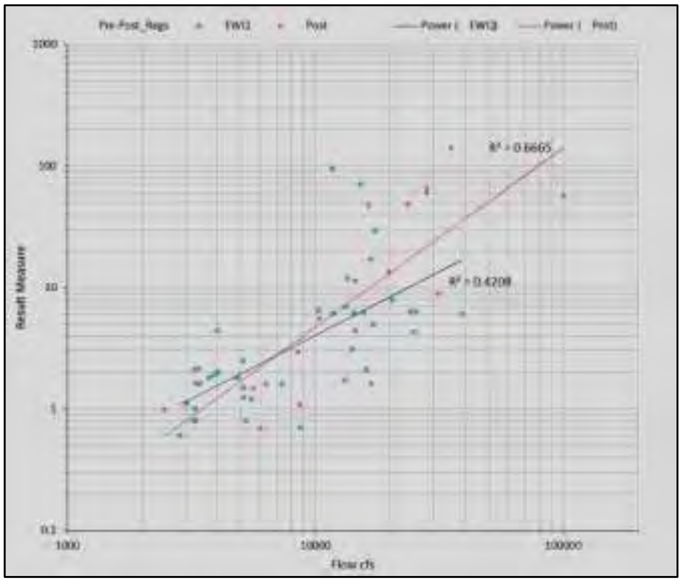
No water quality degradation is evident. TSS did not measurably change between the EWQ and post-EWQ periods. However, potential laboratory artifacts and insufficient post-EWQ sampling produced analytical uncertainty. TSS is positively related to flow in both data sets. Post-EWQ median TSS was above the EWQ upper 95% confidence interval, but the differences appear to be flow-related, as there were fewer dry weather samples in the post-EWQ data set. Flow and concentrations are plotted on a logarithmic scale.

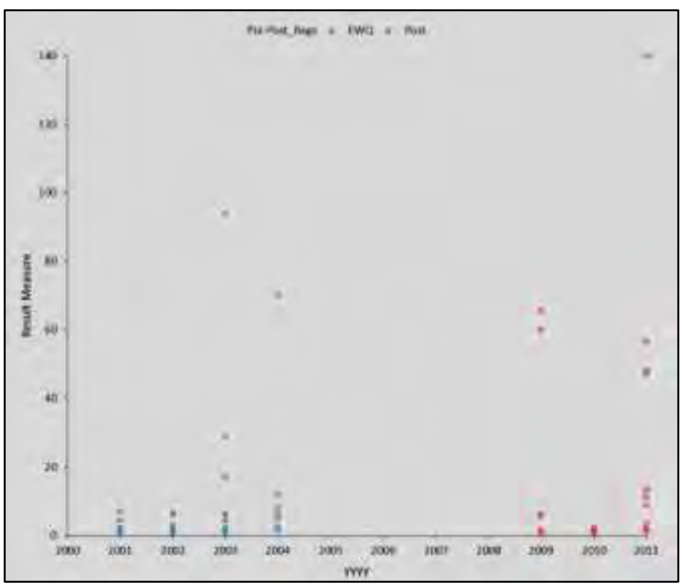
Chapter 4: 1487 ICP
Delaware River at Lambertville/New Hope Bridge, NJ/PA

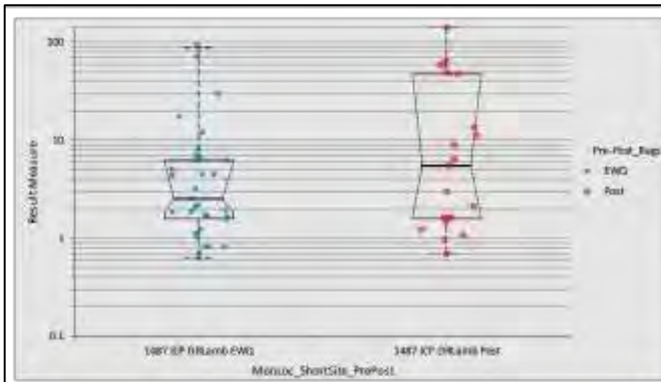
Turbidity NTU

Existing Water Quality (Table 2W):

Median 2.5 NTU
Lower 95% Confidence Interval 1.8 NTU
Upper 95% Confidence Interval 6.0 NTU
Defined in regulations as a flow-related parameter

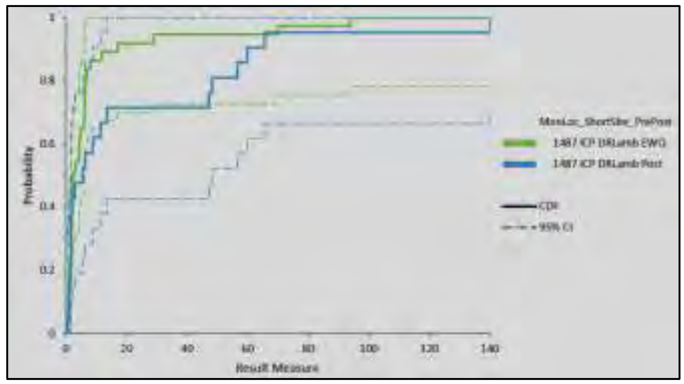






N	58

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1487 ICP DRLamb EWQ	0.6	1.6	2.5	6.2	94.0	4.7
1487 ICP DRLamb Post	0.7	1.6	5.5	47.6	140.0	46.0



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1487 ICP DRLamb EWQ	37	136.2	3.68
1487 ICP DRLamb Post	21	240.0	11.43

H statistic	1.32
X² approximation	1.32
DF	1
p-value	0.2506 [1]

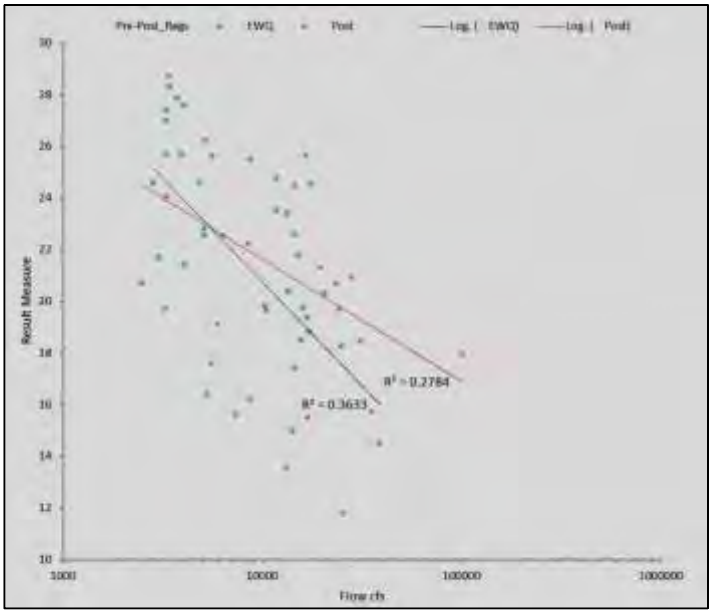
H0: $\theta_1 = \theta_2 = \theta_{...}$
The median of the populations are all equal.
H1: $\theta_i \neq \theta_j$ for at least one i,j
The median of the populations are not all equal.
[1] Do not reject the null hypothesis at the 5% significance level.

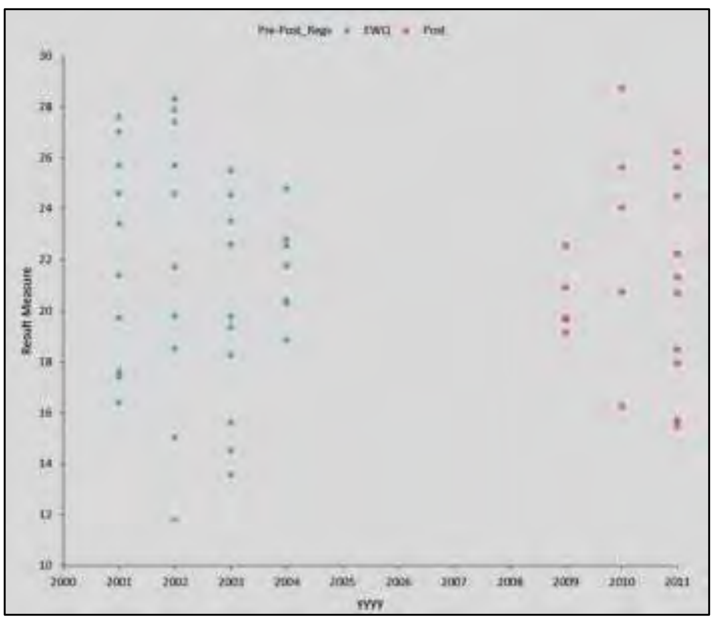
No water quality degradation is evident. All but five post-EWQ turbidity results were within the expected EWQ range of 0-15. All five were taken during high flow conditions. The post-EWQ median turbidity was within but near the EWQ upper 95% confidence interval, but overall turbidity did not measurably change. Turbidity is positively related to flow. Post-EWQ N was far less than EWQ N, and dry-weather samples were under-represented in the post-EWQ data set. Both concentration and flow are represented on a logarithmic scale.

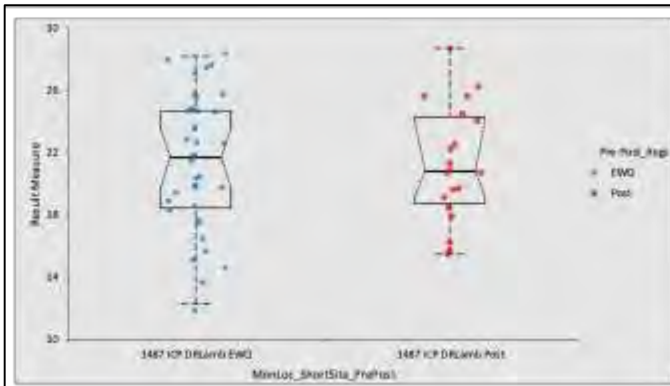
Chapter 4: 1487 ICP
Delaware River at Lambertville/New Hope Bridge, NJ/PA

Water Temperature, degrees C

Not included in DRBC Existing Water Quality rules

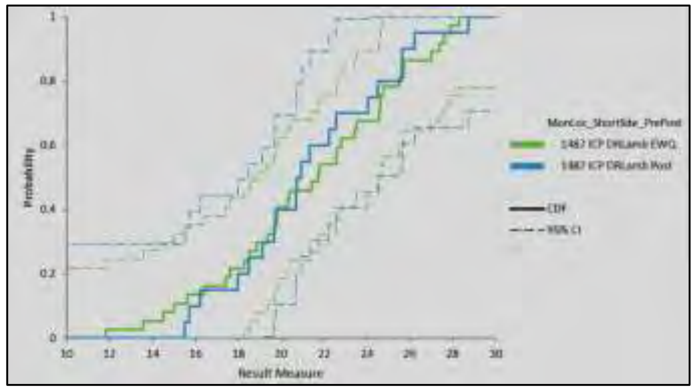






N 57

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1487 ICP DRLamb EWQ	11.8	18.4	21.7	24.7	28.3	6.2
1487 ICP DRLamb Post	15.5	18.7	20.8	24.3	28.7	5.6



Kruskal-Wallis test

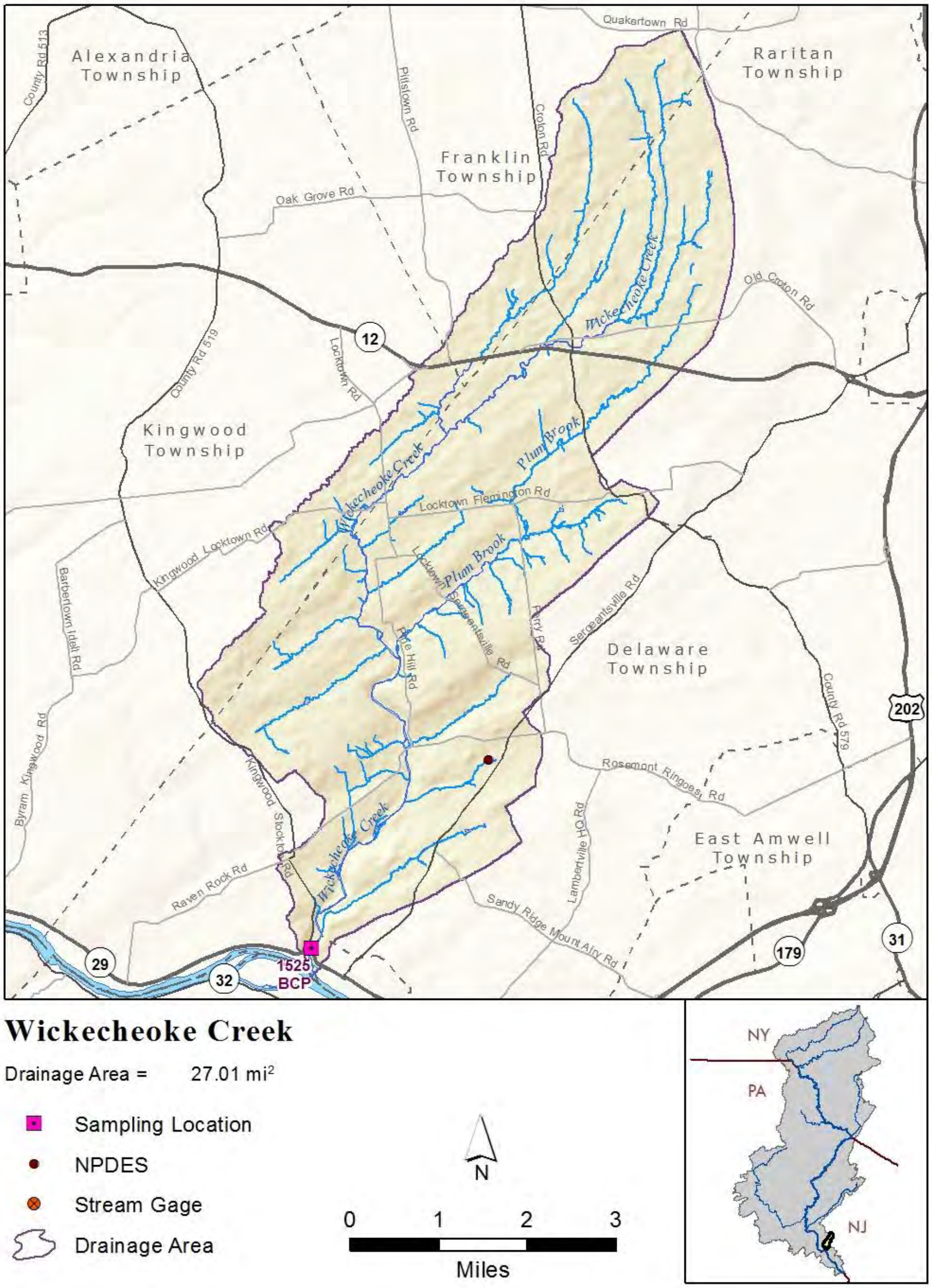
Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1487 ICP DRLamb EWQ	37	6.5	0.18
1487 ICP DRLamb Post	20	12.0	0.60

H statistic	0.07
X^2 approximation	0.07
DF	1
p-value	0.7955 [1]

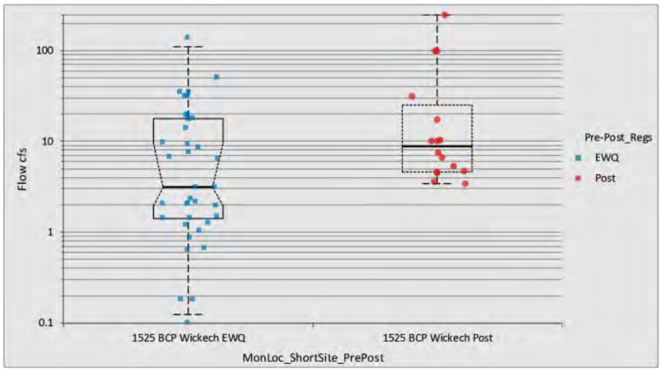
H0: $\theta_1 = \theta_2 = \theta...$
The median of the populations are all equal.
H1: $\theta_i \neq \theta_j$ for at least one i,j
The median of the populations are not all equal.
[1] Do not reject the null hypothesis at the 5% significance level.

No water quality degradation is evident. Water temperature did not measurably change between the EWQ and post-EWQ periods. Water temperature is inversely related to flow, though the relationship is weak. The distributions were almost identical, except post-EWQ minimum and maximum temperatures were higher than EWQ temperatures.

Chapter 5: 1525 BCP Wickecheoke Creek, Hunterdon County, NJ



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



N | 54

Flow cfs by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1525 BCP Wickech EWQ	0.10	1.40	3.12	17.98	135.33	16.58
1525 BCP Wickech Post	3.40	4.64	8.75	25.33	250.00	20.69

Kruskal-Wallis test

Flow cfs by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1525 BCP Wickech EWQ	38	318.4	8.38
1525 BCP Wickech Post	16	756.3	47.27

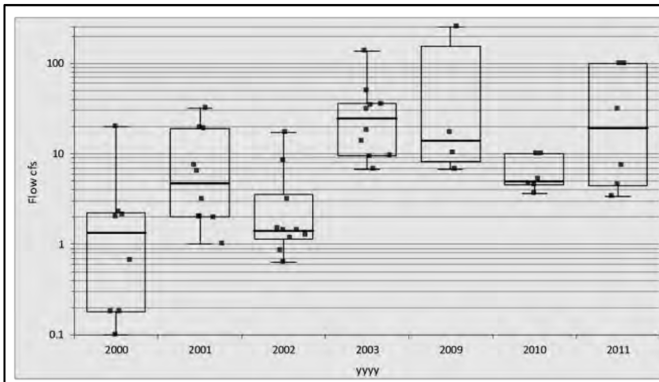
H statistic	4.34
X^2 approximation	4.34
DF	1
p-value	0.0372 [1]

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.

Flow was higher during the post-EWQ period. Numerous samples were collected in the EWQ period when the flow was less than 3 cfs. The minimum flow sampled in the post-EWQ period was 3.4 cfs. This has a major effect upon analysis of within-site water quality changes between the two periods, especially for those parameters that are flow-related.

The 27 square mile watershed is about 48% forested, with less than 1% urban land cover. There is no carbonate bedrock in the watershed.

Wickecheoke Creek is captured by the Delaware and Raritan Canal and is used as public water supply, exported outside the Delaware River Basin via the New Jersey Water Supply Authority. Its water quality influence upon the Delaware River is minimal except during high-flow conditions.



N | 54

Flow cfs by yyyy	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
2000	0.1	0.2	1.4	2.2	19.8	2.0
2001	1.0	2.0	4.7	19.0	31.6	17.0
2002	0.6	1.2	1.4	3.6	17.2	2.4
2003	6.7	9.6	24.5	36.1	135.3	26.5
2009	6.7	8.2	13.9	153.1	250.0	144.9
2010	3.6	4.5	5.0	10.0	10.0	5.5
2011	3.4	4.4	19.3	98.9	98.9	94.5

Annual May to September flow statistics are plotted above. Flow is plotted on a logarithmic scale. These are flow measurements or sometimes estimates associated with the time of each water quality sample. "Normal" annual median flow is about 29 cfs at this location, but the summer seasonal flow is much less. The geology of this watershed is such that almost all rainfall runs off almost immediately. Very little water infiltrates into groundwater to be held back as baseflow to the stream. Like several other Piedmont streams of the Lower Delaware, this "flashy" condition means that for most of the summer there is very little water in what appears to be an over-sized channel. When it rains, the channel fills quickly but not for a long duration. Unless it rains frequently, normal flow conditions are not sustained. Thus in the figure above, only during the relatively wet summers of 2003, 2009 and 2011 were near-normal flow conditions represented by these samples.

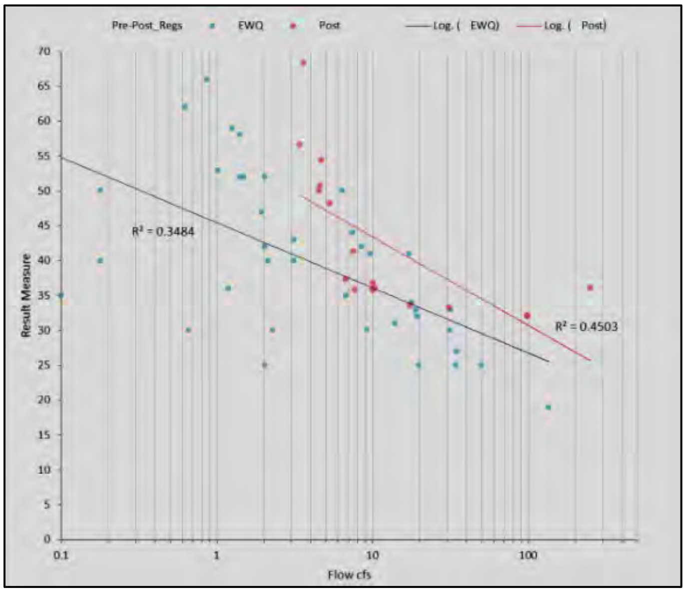
Upstream ICP: Delaware River at Bulls Island 1554 ICP
Downstream ICP: Delaware River at Lambertville 1487 ICP

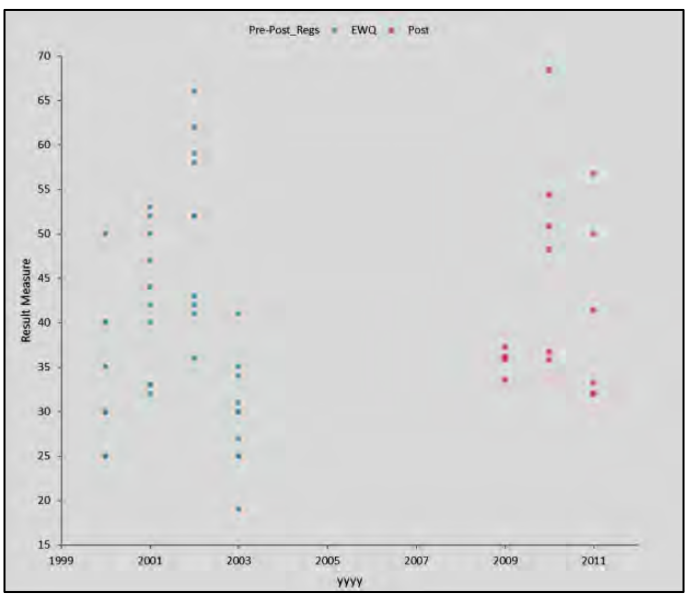
Chapter 5: 1525 BCP Wickecheoke Creek, NJ

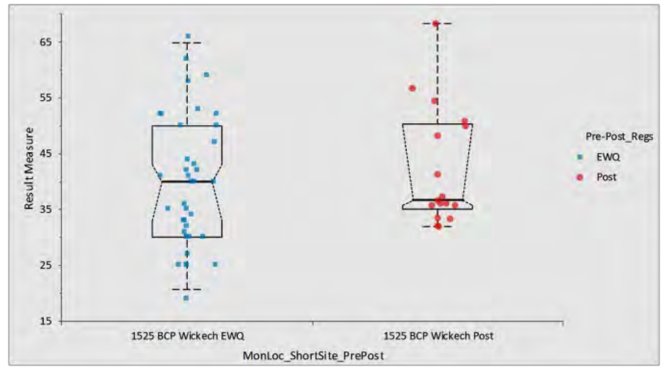
Alkalinity as CaCO3, Total mg/l

Existing Water Quality (Table 2V):

Median 40 mg/l
Lower 95% Confidence Interval 33 mg/l
Upper 95% Confidence Interval 43 mg/l
Defined in regulations as a flow-related parameter

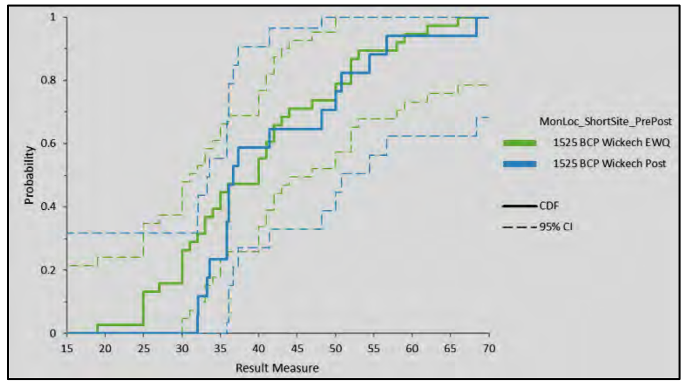






N | 55

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1525 BCP Wickech EWQ	19.0	30.0	40.0	50.0	66.0	20.0
1525 BCP Wickech Post	32.0	35.1	36.7	50.3	68.4	15.2



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1525 BCP Wickech EWQ	38	67.1	1.77
1525 BCP Wickech Post	17	150.0	8.82

H statistic	0.85
X^2 approximation	0.85
DF	1
p-value	0.3574 [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.

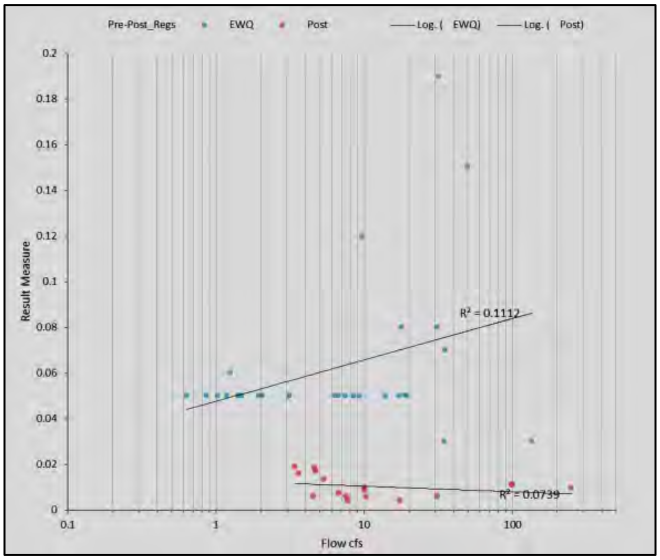
No water quality degradation is evident. Alkalinity did not measurably change between the EWQ and post-EWQ periods. Alkalinity is inversely related to flow in both data sets. Post-EWQ median alkalinity fell within EWQ 95% confidence intervals, and the post-EWQ data were under-represented by dry weather samples. Flow is plotted on a logarithmic axis.

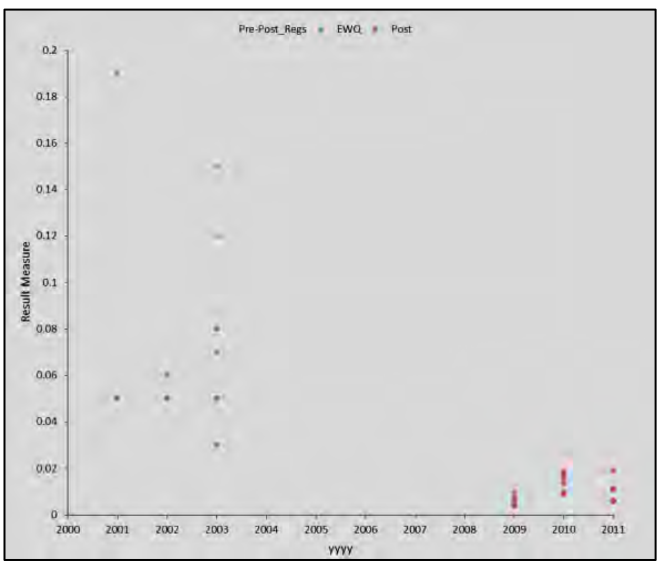
Chapter 5: 1525 BCP Wickecheoke Creek, NJ

Ammonia Nitrogen as N, Total mg/l

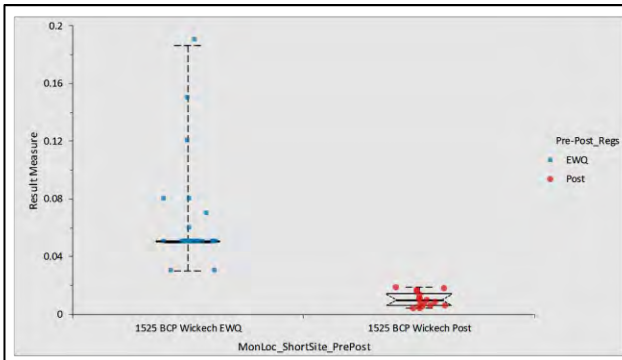
Existing Water Quality (Table 2V):

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

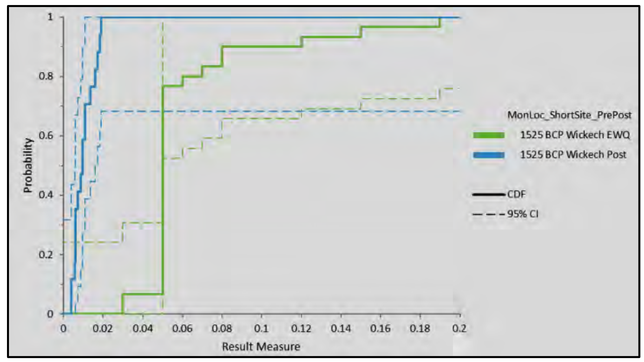




No water quality degradation is evident. Ammonia concentrations apparently declined. However, differences in flow conditions, detection limits, potential laboratory artifacts and too few post-EWQ samples introduced uncertainty to conclusions.



N	47					
Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1525 BCP Wickech EWQ	0.030	0.050	0.050	0.051	0.190	0.001
1525 BCP Wickech Post	0.004	0.006	0.010	0.014	0.019	0.008



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1525 BCP Wickech EWQ	30	2167.5	72.25
1525 BCP Wickech Post	17	3825.0	225.00

H statistic	35.01
X^2 approximation	35.01
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.

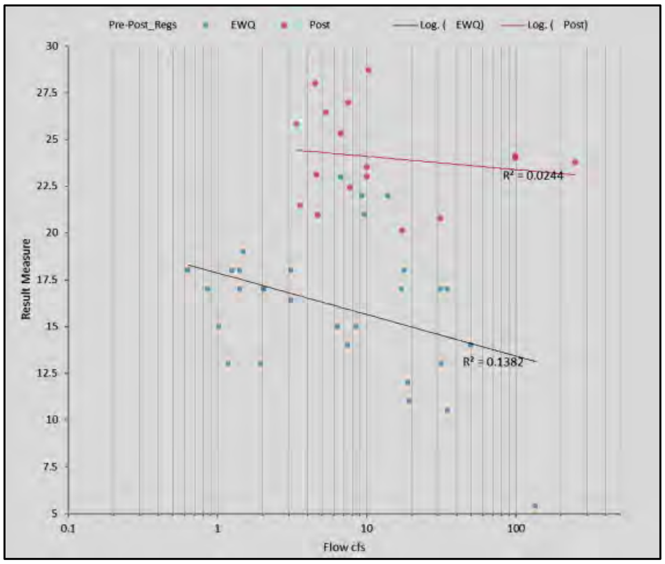
Post-EWQ median ammonia concentration was below the EWQ lower 95% confidence interval. No independent data were readily available to validate the decline. DRBC's post-EWQ detection limit was lower than during the EWQ period. EWQ data possessed high frequencies of non-detect results (23 of 30 samples). Thus EWQ was established as "less than" 0.05 mg/l, which was the detection limit at the time. Even with lower detection levels for post-EWQ samples, there were still 5 out of 17 non-detect results. The decline in concentration at least partially is due to adoption of more sensitive laboratory methods rather than a real change in ambient Wickecheoke Creek concentrations.

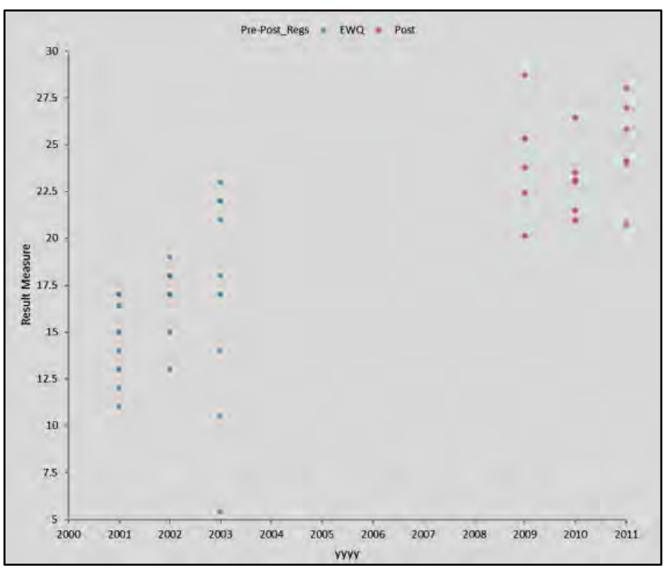
Chapter 5: 1525 BCP Wickecheoke Creek, NJ

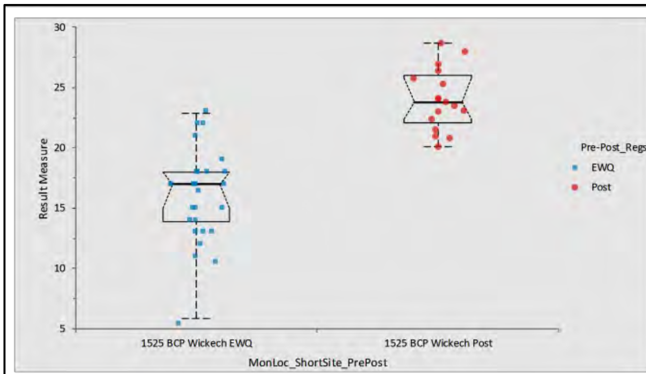
Chloride, Total mg/l

Existing Water Quality (Table 2V):

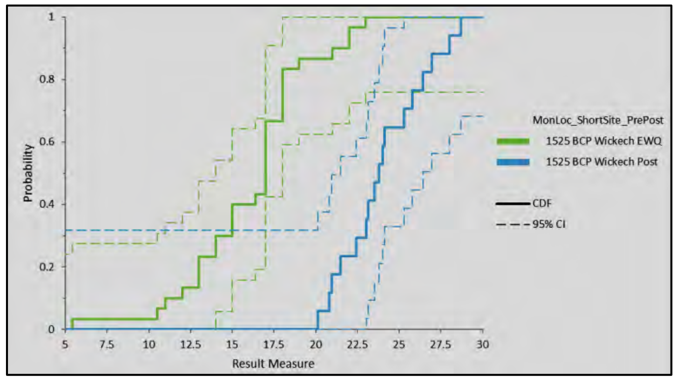
Median 17 mg/l
Lower 95% Confidence Interval 15 mg/l
Upper 95% Confidence Interval 18 mg/l
Defined in regulations as a flow-related parameter







N	47					
Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1525 BCP Wickech EWQ	5.4	13.9	17.0	18.0	23.0	4.1
1525 BCP Wickech Post	20.1	22.1	23.8	26.0	28.7	3.9



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1525 BCP Wickech EWQ	30	1904.0	63.47
1525 BCP Wickech Post	17	3360.1	197.65

H statistic	28.14
X^2 approximation	28.14
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.

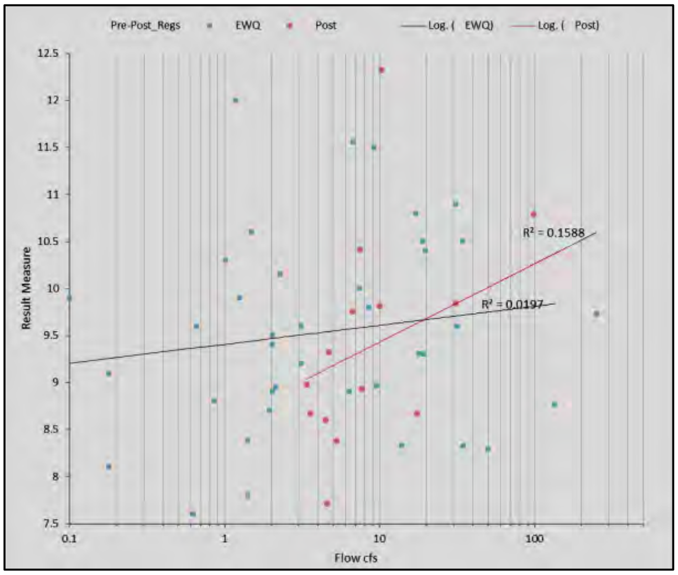
Water quality degradation is evident. Chloride concentrations increased by 6.8 mg/l (40%) between the two periods. Post-EWQ median concentration rose above the EWQ upper 95% confidence interval. Flow is plotted on a logarithmic scale. With no new discharge permits issued in the watershed, we suspect that other sources such as winter road salting may be the main reason for the increase.

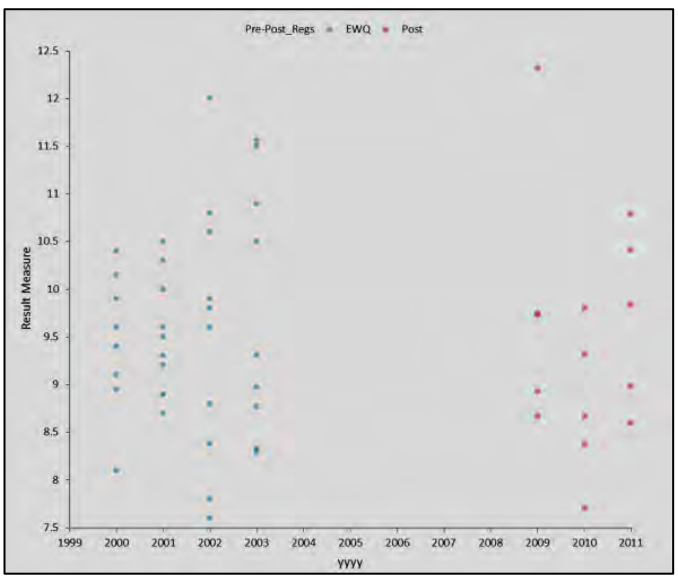
Chapter 5: 1525 BCP Wickecheoke Creek, NJ

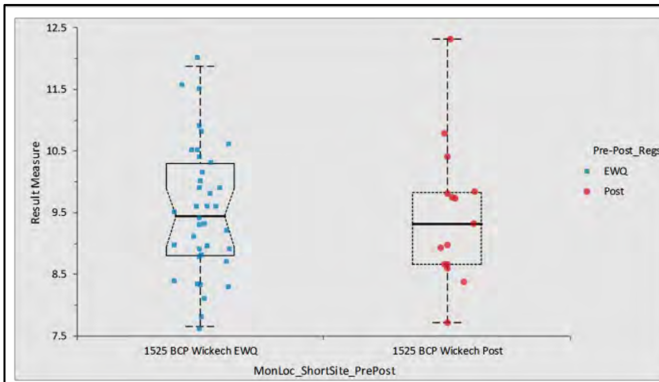
Dissolved Oxygen (DO) mg/l

Existing Water Quality (Table 2V):

Median 9.45 mg/l
Lower 95% Confidence Interval 8.95 mg/l
Upper 95% Confidence Interval 9.90 mg/l

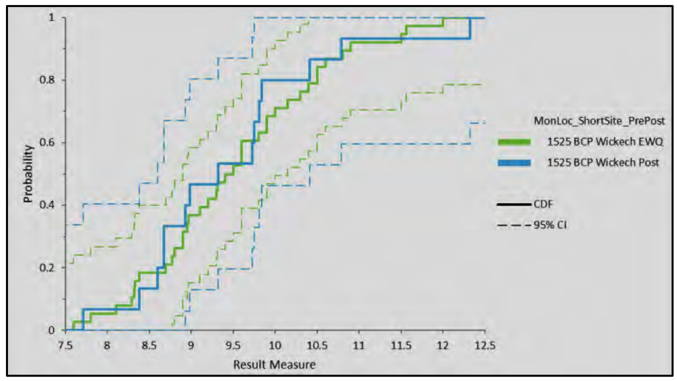






N | 53

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1525 BCP Wickech EWQ	7.60	8.80	9.45	10.31	12.00	1.51
1525 BCP Wickech Post	7.71	8.67	9.32	9.84	12.32	1.17



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1525 BCP Wickech EWQ	38	8.1	0.21
1525 BCP Wickech Post	15	20.4	1.36

H statistic	0.12
X^2 approximation	0.12
DF	1
p-value	0.7296 [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.

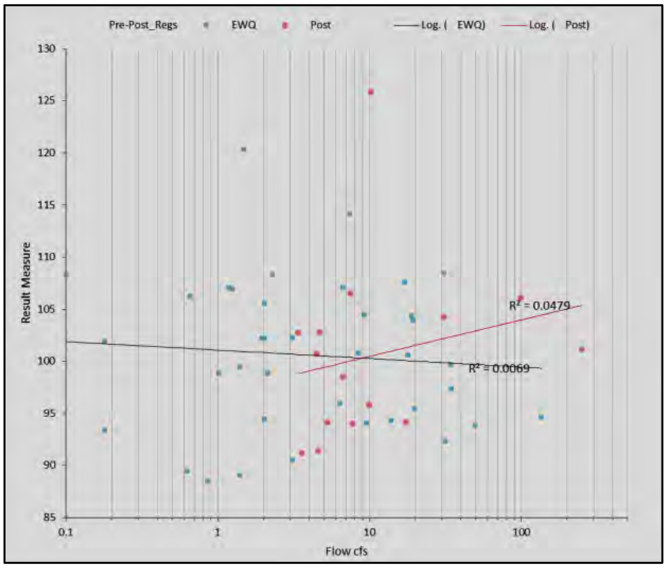
No water quality degradation is evident. No measurable change took place between the EWQ and Post-EWQ periods. Post-EWQ median DO concentration was within the EWQ 95% confidence intervals. Flow is plotted on a logarithmic scale. DO concentration is unrelated to flow in both data sets.

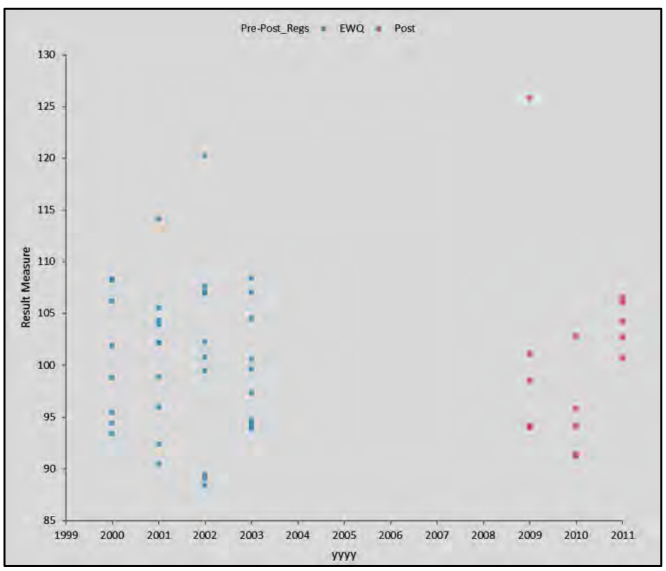
Chapter 5: 1525 BCP Wickecheoke Creek, NJ

Dissolved Oxygen Saturation %

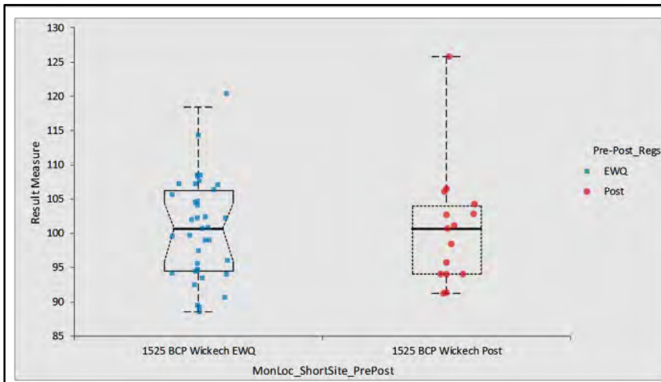
Existing Water Quality (Table 2V):

Median 101%
Lower 95% Confidence Interval 96%
Upper 95% Confidence Interval 104%



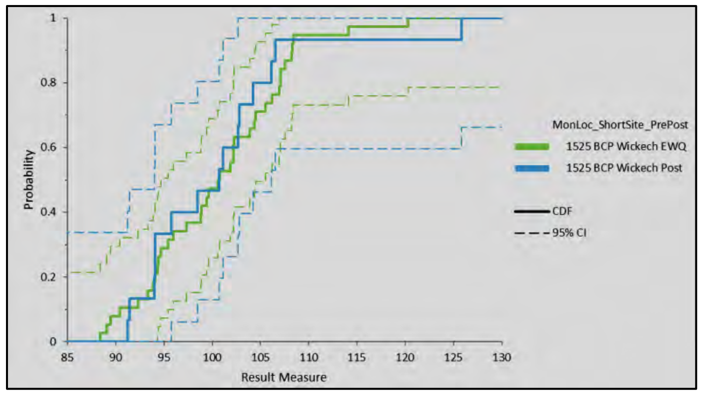


No water quality degradation is evident. Dissolved Oxygen Saturation is unrelated to flow, and did not measurably change between the EWQ and post-EWQ periods. Flow is plotted on a logarithmic scale.



N 53

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1525 BCP Wickech EWQ	88.4	94.4	100.7	106.3	120.3	11.9
1525 BCP Wickech Post	91.2	94.1	100.7	104.0	125.8	9.9



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1525 BCP Wickech EWQ	38	11.6	0.31
1525 BCP Wickech Post	15	29.4	1.96

H statistic	0.17
X² approximation	0.17
DF	1
p-value	0.6784 [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.

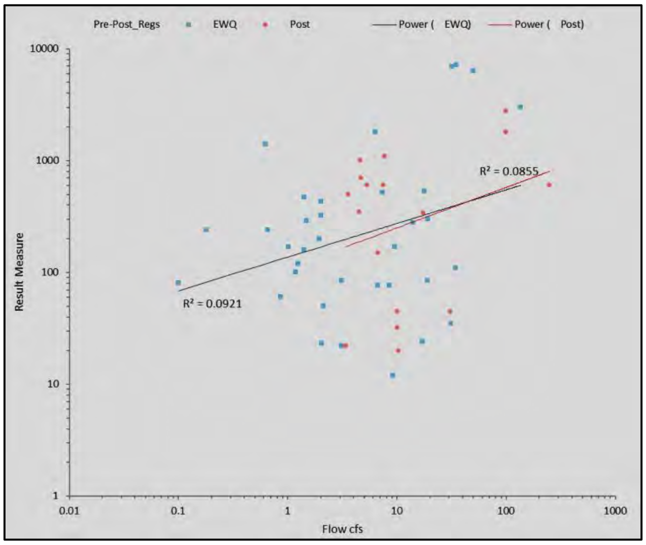
Dissolved oxygen saturation is nicely balanced in Wickecheoke Creek, rarely dipping below 90% or rising above 120%. There are some algae blooms, as indicated by the highest saturation levels, but the blooms never appear to last long. The short duration of algae blooms is probably due to washout by storms. Even a small rain event can scour the Wickecheoke Creek stream bottom of excess algal growth.

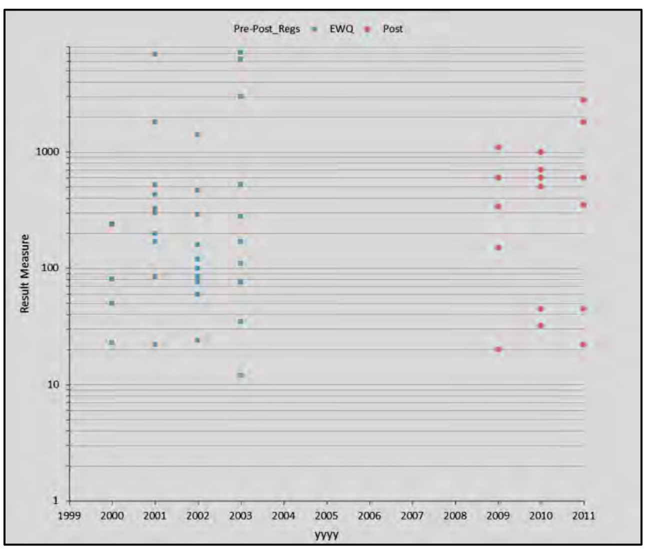
Chapter 5: 1525 BCP Wickecheoke Creek, NJ

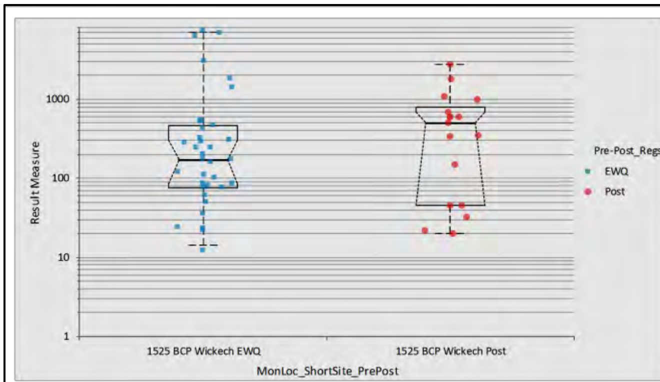
Enterococcus colonies/100 ml

Existing Water Quality (Table 2V):

Median 170/100 ml
Lower 95% Confidence Interval 84/100 ml
Upper 95% Confidence Interval 300/100 ml

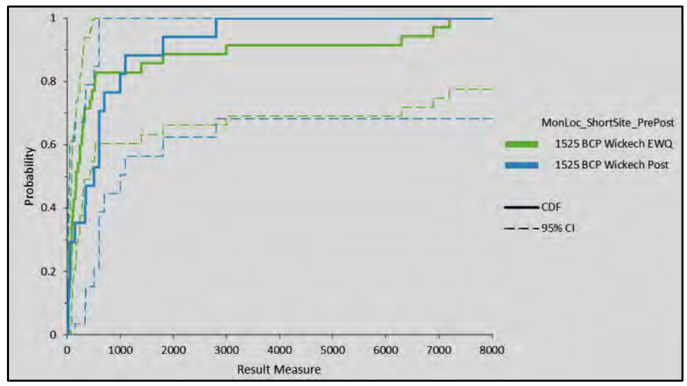






N 52

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1525 BCP Wickech EWQ	12	77	170	463	7,200	387
1525 BCP Wickech Post	20	45	500	800	2,800	755



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1525 BCP Wickech EWQ	35	61.8	1.77
1525 BCP Wickech Post	17	127.2	7.48

H statistic	0.82
X^2 approximation	0.82
DF	1
p-value	0.3643[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 indicated. Enterococci did not measurably change between the EWQ and Post-EWQ periods. Sources of analytical uncertainty included potential laboratory artifacts, insufficient post-EWQ sampling (n=17), and poor post-EWQ representation of the flow regime. Enterococcus concentrations are very weakly related to flow in both data sets, but results are highly variable.

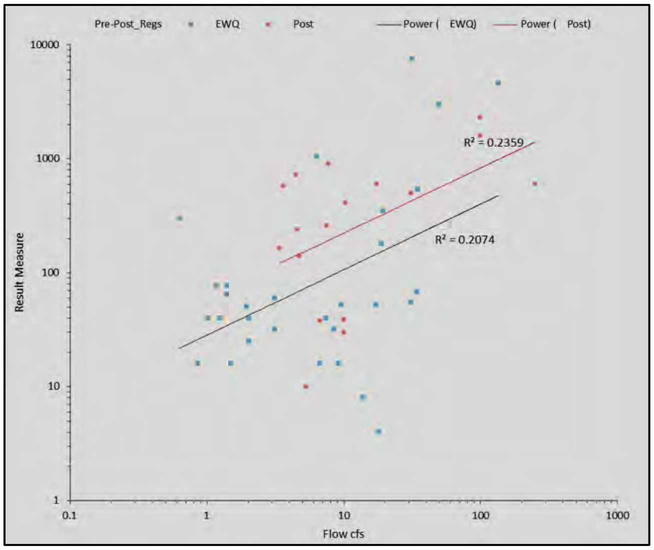
Post-EWQ median enterococcus concentrations were well above the EWQ upper 95% confidence interval, but variability is so high that the rise is statistically meaningless.

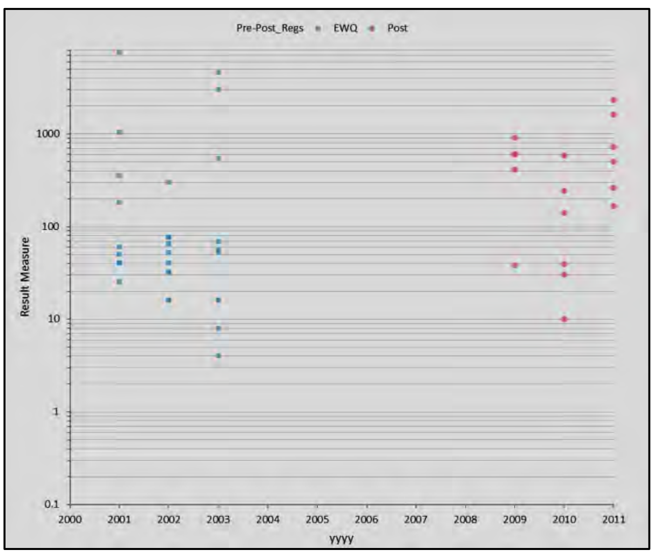
Chapter 5: 1525 BCP
Wickecheoke Creek, NJ

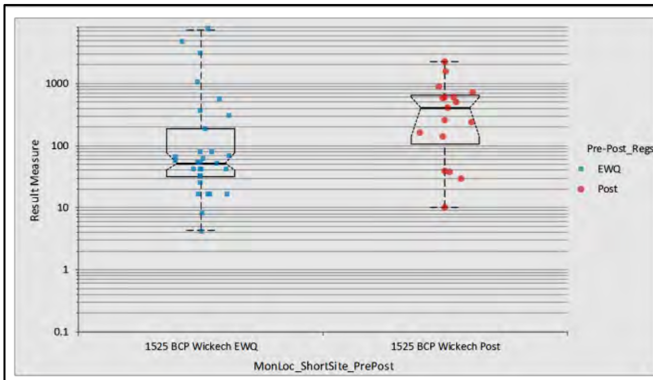
Escherichia coli colonies/100 ml

Existing Water Quality (Table 2V):

Median 52/100 ml
Lower 95% Confidence Interval 40/100 ml
Upper 95% Confidence Interval 76/100 ml

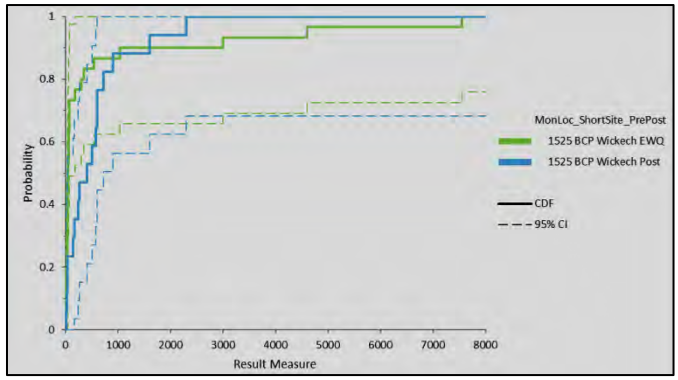






N 47

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1525 BCP Wickech EWQ	4	31	52	190	7544	159
1525 BCP Wickech Post	10	106	410	640	2300	534



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1525 BCP Wickech EWQ	30	307.2	10.24
1525 BCP Wickech Post	17	542.1	31.89

H statistic	4.52
X^2 approximation	4.52
DF	1
p-value	0.0334 [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.

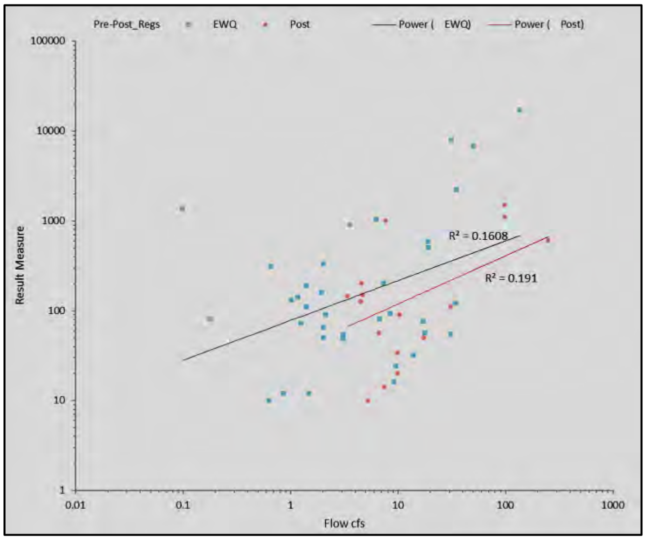
Some evidence of water quality degradation is indicated. E. coli concentrations apparently rose between the EWQ and Post-EWQ periods. Sources of analytical uncertainty included potential laboratory artifacts, insufficient post-EWQ sampling (n=17), and poor post-EWQ representation of the flow regime. No independent data were available at this site to validate DRBC results. The increase is reported as such in the summary matrix, but confidence in the conclusion is low because of low N and high variability.

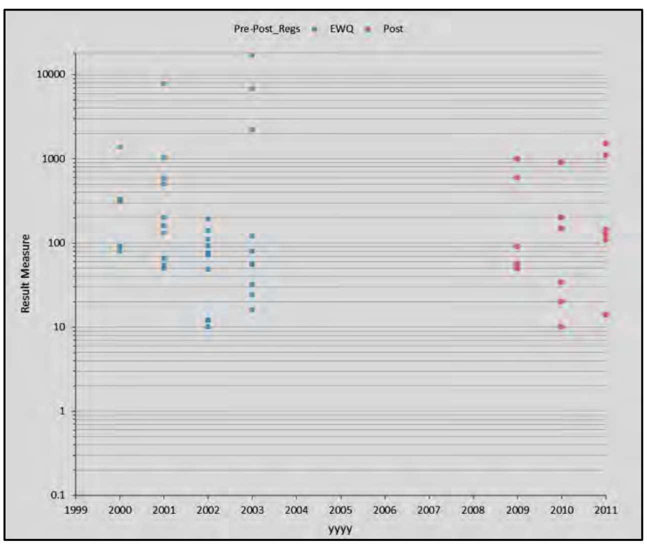
Chapter 5: 1525 BCP Wickecheoke Creek, NJ

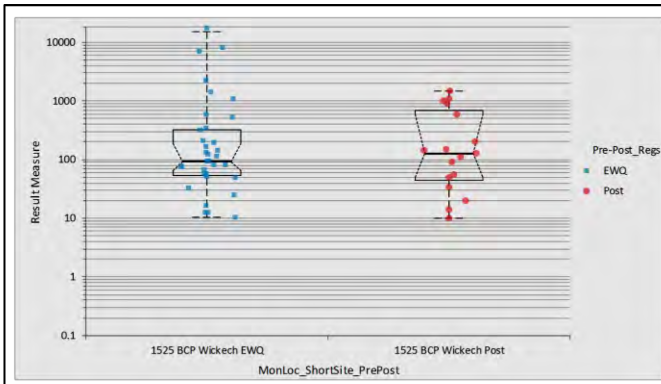
Fecal coliform colonies/100 ml

Existing Water Quality (Table 2V):

Median 92/100 ml
Lower 95% Confidence Interval 65/100 ml
Upper 95% Confidence Interval 190/100 ml

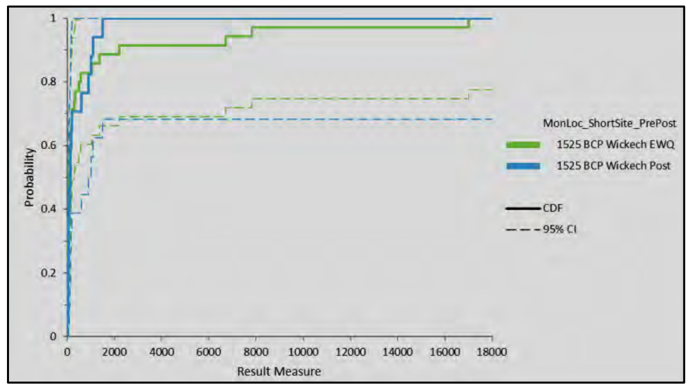






N 52

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1525 BCP Wickech EWQ	10	54	92	327	17000	273
1525 BCP Wickech Post	10	45	127	700	1500	655



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1525 BCP Wickech EWQ	35	0.7	0.02
1525 BCP Wickech Post	17	1.5	0.09

H statistic	0.01
X^2 approximation	0.01
DF	1
p-value	0.9223 [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.

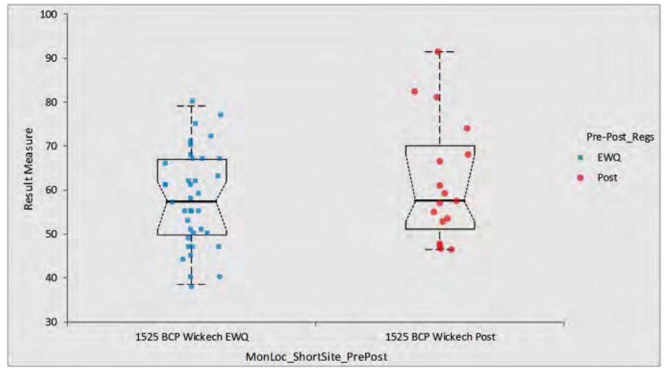
No water quality degradation is indicated. Fecal coliform concentrations did not measurably change between the EWQ and post-EWQ periods. Sources of analytical uncertainty included potential laboratory artifacts, insufficient post-EWQ sampling (n=17), and poor post-EWQ representation of the flow regime. Fecal coliform concentrations are positively but weakly related to flow. Post-EWQ median concentrations fell within the EWQ 95% confidence intervals, but the data were naturally variable and N was low. Note that concentrations and flows are plotted on a logarithmic scale.

Chapter 5: 1525 BCP Wickecheoke Creek, NJ

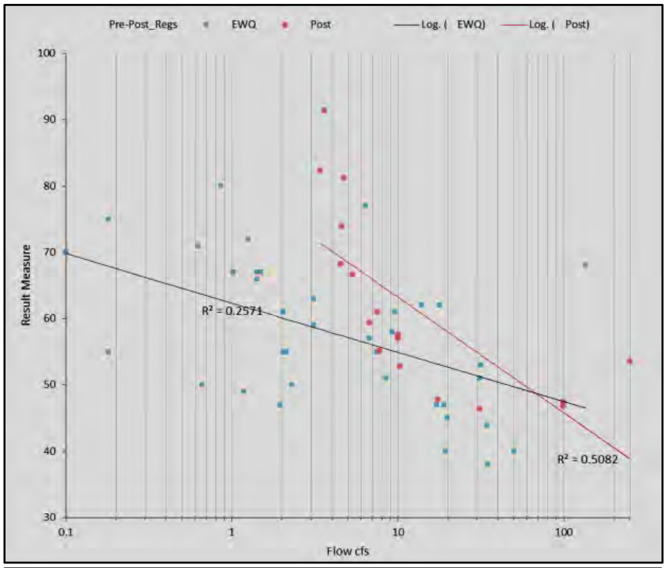
Hardness as CaCO3, Total mg/l

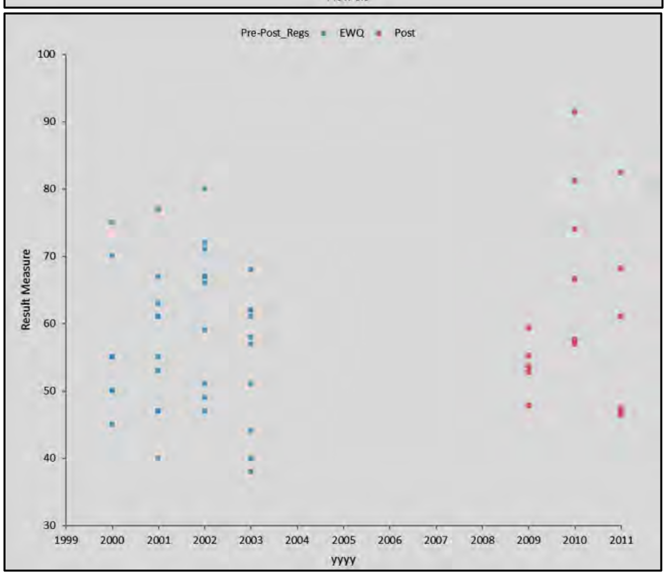
Existing Water Quality (Table 2V):

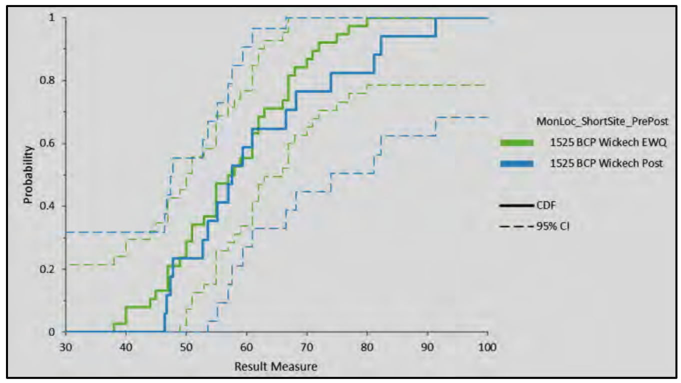
Median 58 mg/l
Lower 95% Confidence Interval 51 mg/l
Upper 95% Confidence Interval 62 mg/l
Defined in regulations as a flow-related parameter



N	55					
Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1525 BCP Wickech EWQ	38.0	49.9	57.5	67.0	80.0	17.1
1525 BCP Wickech Post	46.4	51.1	57.6	70.1	91.4	19.0







Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1525 BCP Wickech EWQ	38	38.0	1.00
1525 BCP Wickech Post	17	84.9	5.00

H statistic	0.48
X² approximation	0.48
DF	1
p-value	0.4886 [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.

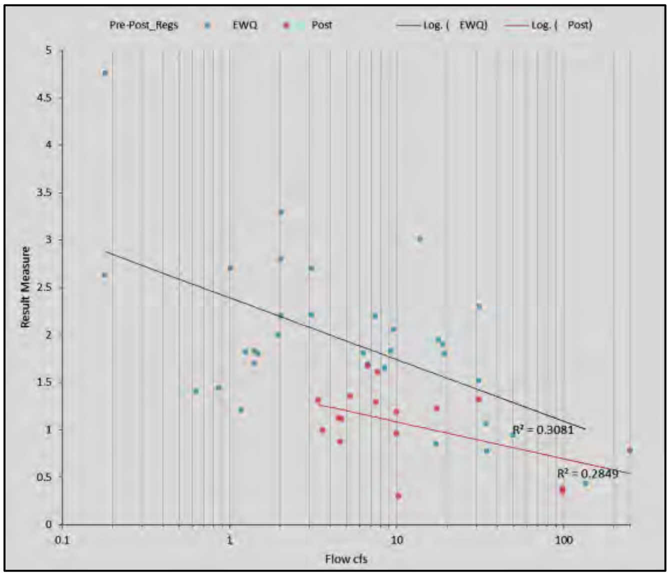
No water quality degradation is indicated. Hardness did not measurably change between the EWQ and post-EWQ periods. Sources of analytical uncertainty included potential laboratory artifacts, insufficient post-EWQ sampling (n=17), and poor post-EWQ representation of the flow regime. Hardness is inversely related to flow. Post-EWQ median hardness fell within the EWQ 95% confidence intervals. Note that flows are plotted on a logarithmic scale.

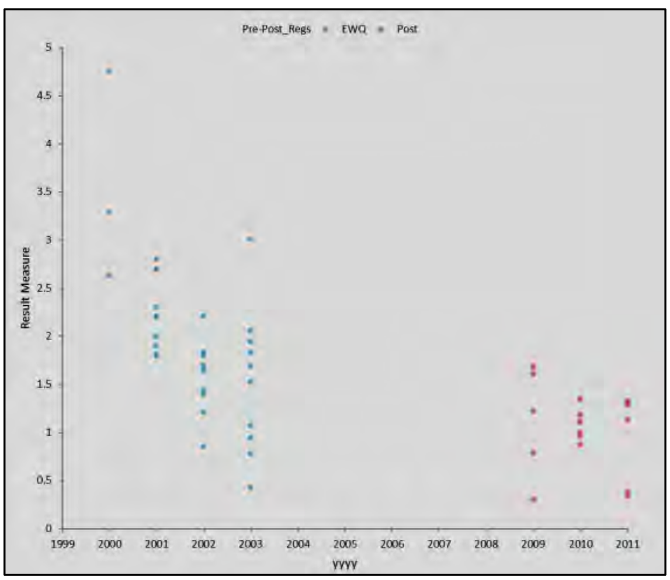
Chapter 5: 1525 BCP Wickecheoke Creek, NJ

Nitrate + Nitrite as N, Total mg/l

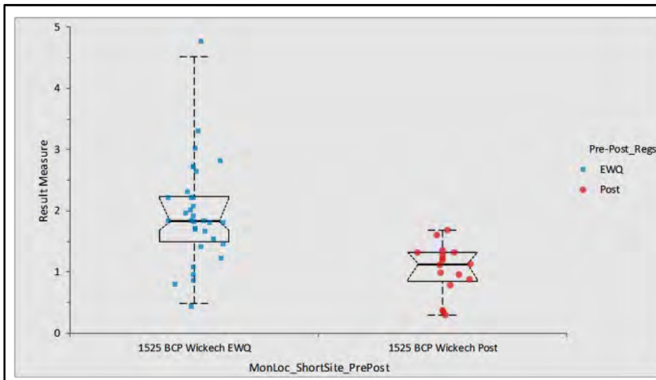
Existing Water Quality (Table 2V, as Nitrate only):

Median 1.83 mg/l
Lower 95% Confidence Interval 1.69 mg/l
Upper 95% Confidence Interval 2.20 mg/l



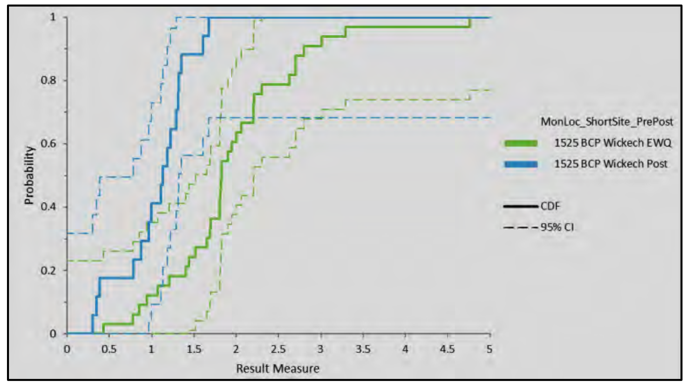


No water quality degradation is indicated. Nitrate concentrations apparently declined between the EWQ and post-EWQ periods. However, differences in flow conditions and potential laboratory artifacts introduced uncertainty. In both data sets, nitrate is inversely but weakly related to flow. On the annual plot, 2002-2003 EWQ nitrates appear to match well with post-EWQ nitrate + nitrite for 2009.



N 50

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1525 BCP Wickech EWQ	0.430	1.493	1.830	2.240	4.760	0.747
1525 BCP Wickech Post	0.303	0.845	1.129	1.316	1.678	0.471



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1525 BCP Wickech EWQ	33	1254.9	38.03
1525 BCP Wickech Post	17	2436.0	143.29

H statistic	17.37
X^2 approximation	17.37
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.

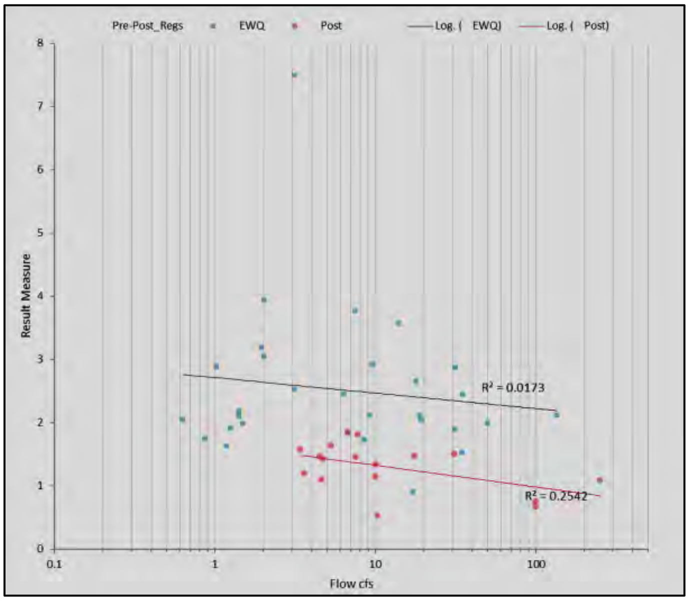
Nitrate + Nitrite concentrations are assumed to be equivalent for comparison with EWQ nitrate concentrations, since EWQ nitrite concentrations were never detected. Note that flows are plotted on a logarithmic scale. Independent data were not available for validation of the apparent decline in concentrations shown by DRBC. Post-EWQ median nitrate + nitrite concentrations fell below the EWQ lower 95% confidence interval. There was no interference by undetected values in either data set.

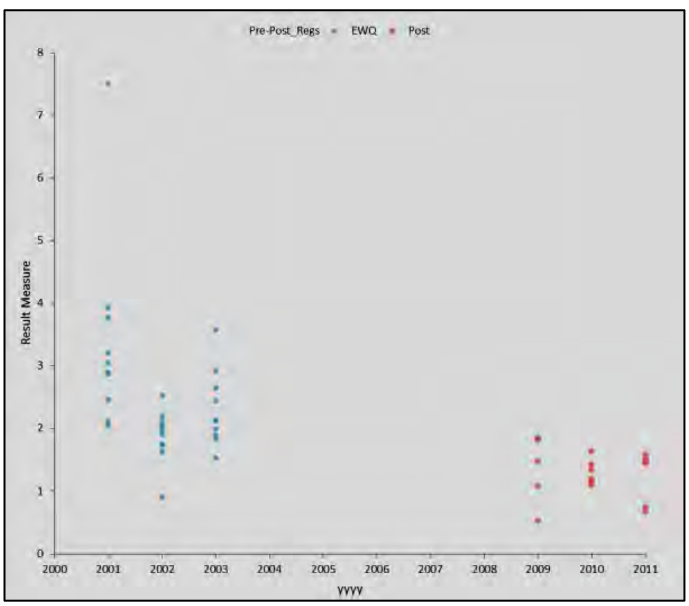
Chapter 5: 1525 BCP Wickecheoke Creek, NJ

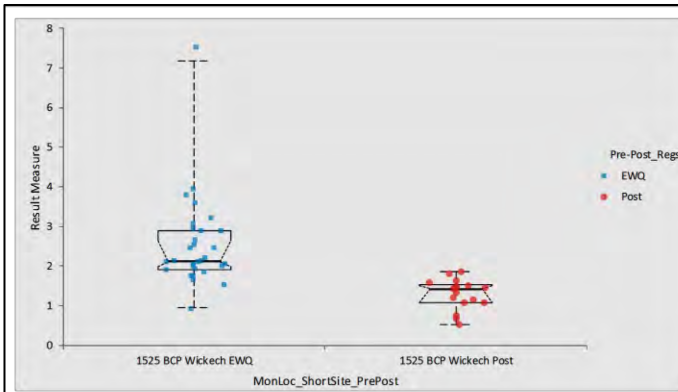
Nitrogen as N, Total (TN) mg/l

Existing Water Quality (Table 2V):

Median 2.12 mg/l
Lower 95% Confidence Interval 1.99 mg/l
Upper 95% Confidence Interval 2.65 mg/l

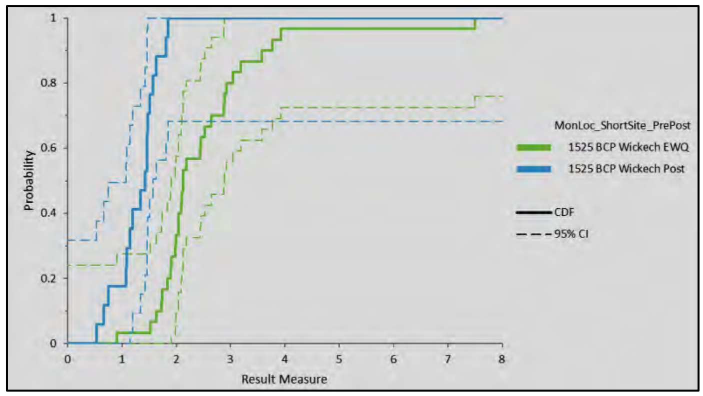






N 47

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1525 BCP Wickech EWQ	0.900	1.908	2.120	2.883	7.500	0.975
1525 BCP Wickech Post	0.527	1.087	1.425	1.527	1.851	0.440



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1525 BCP Wickech EWQ	30	1748.0	58.27
1525 BCP Wickech Post	17	3084.8	181.46

H statistic	25.71
X² approximation	25.71
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.

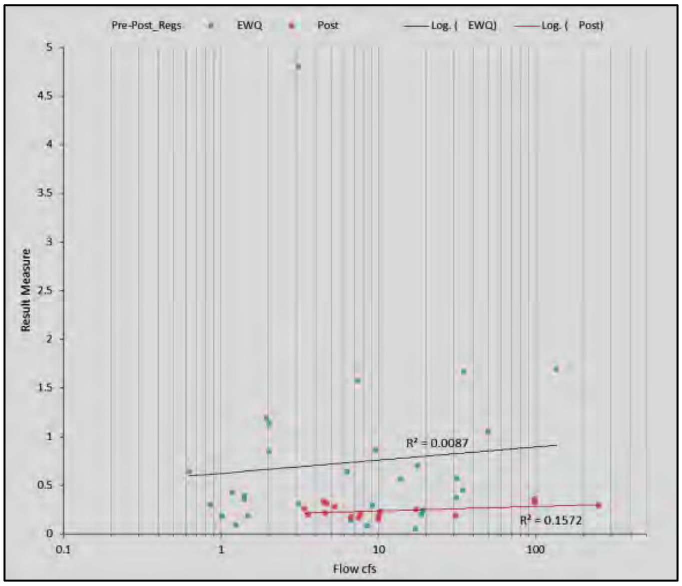
No water quality degradation is indicated. TN apparently declined between the EWQ and post-EWQ periods. However, flow differences and potential laboratory artifacts introduced uncertainty in conclusions. TN is weakly related to flow in the post-EWQ period, but unrelated to flow in the EWQ period due to skewing of the regression by an outlier sample. Note that flows are plotted on a logarithmic scale. DRBC results could not be independently validated. Post-EWQ median TN concentrations fell below the EWQ lower 95% confidence interval.

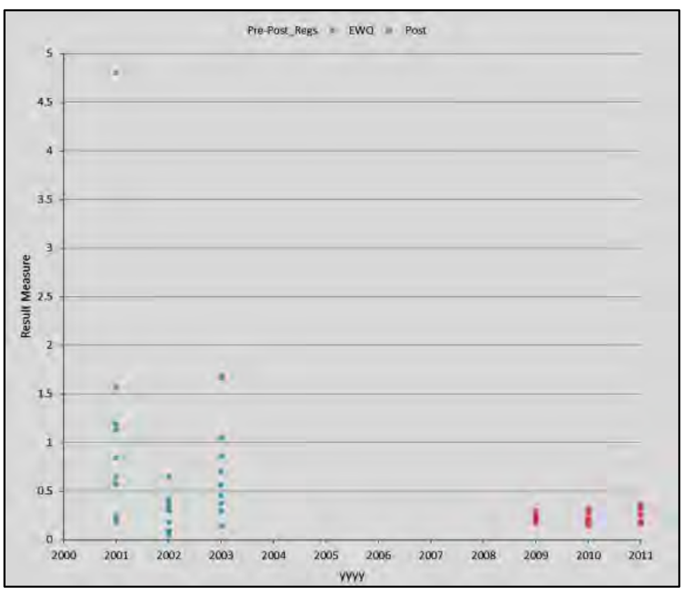
Chapter 5: 1525 BCP Wickecheoke Creek, NJ

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

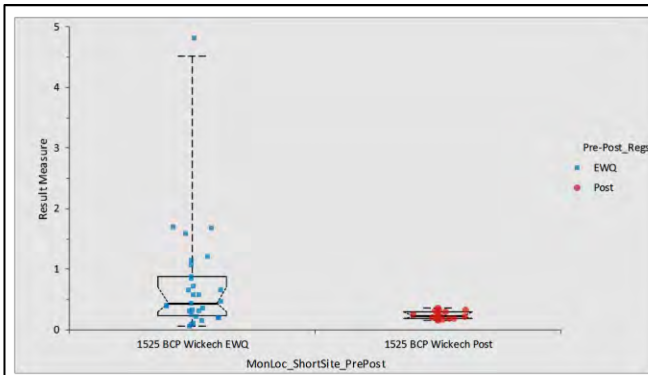
Existing Water Quality (Table 2V):

Median 0.44 mg/l
Lower 95% Confidence Interval 0.30 mg/l
Upper 95% Confidence Interval 0.70 mg/l

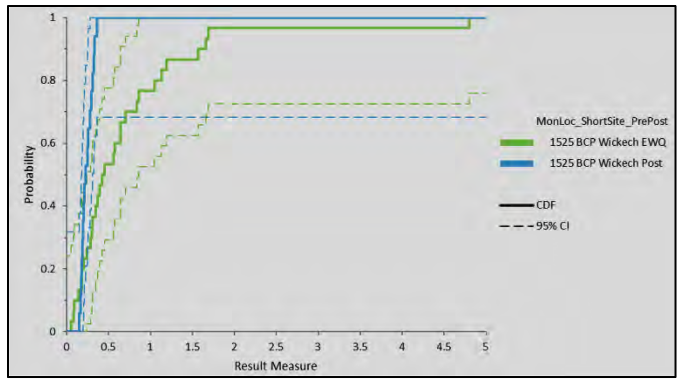




No water quality degradation is indicated. TKN concentrations apparently declined between the EWQ and post-EWQ periods. However, flow differences and potential laboratory artifacts introduced uncertainty in conclusions. TKN concentration is unrelated to flow in both data sets.



N	47					
Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1525 BCP Wickech EWQ	0.050	0.237	0.435	0.876	4.800	0.639
1525 BCP Wickech Post	0.149	0.184	0.223	0.300	0.360	0.116



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1525 BCP Wickech EWQ	30	546.1	18.20
1525 BCP Wickech Post	17	963.8	56.69

H statistic	8.03
X^2 approximation	8.03
DF	1
p-value	0.0046 [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.

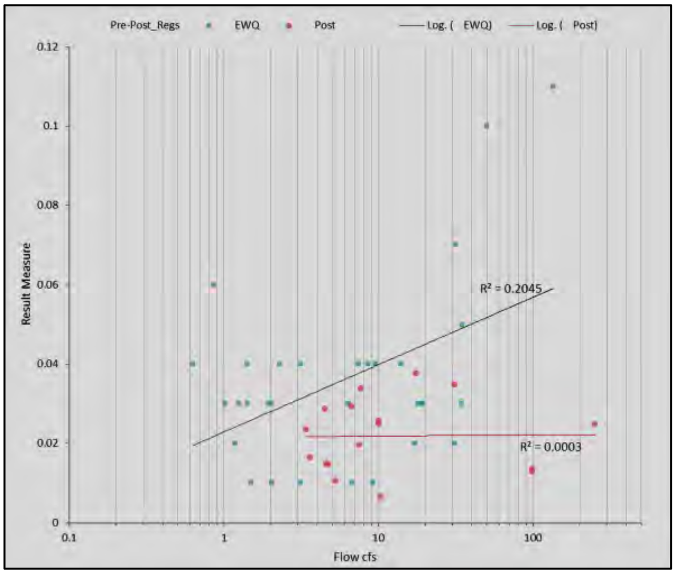
TKN ranges less widely and is less variable in the post-EWQ data set. Post-EWQ median TKN fell below the EWQ lower 95% confidence interval. Unlike nitrate + nitrite and other parameters, the TKN data sets are more directly comparable since there are no discrepancies in detection limits throughout the two periods. The main difference was that there were less dry weather post-EWQ TKN samples. Because of method stability, the decrease in concentrations may indicate a real improvement in water quality.

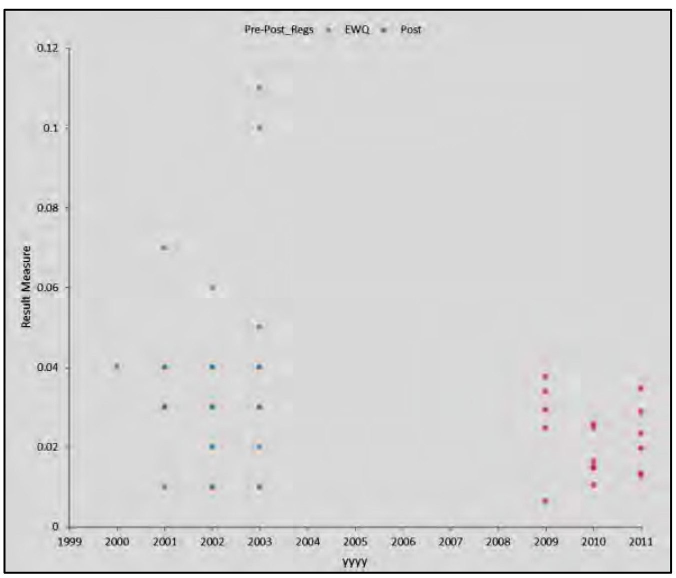
Chapter 5: 1525 BCP Wickecheoke Creek, NJ

Orthophosphate as P, Total mg/l

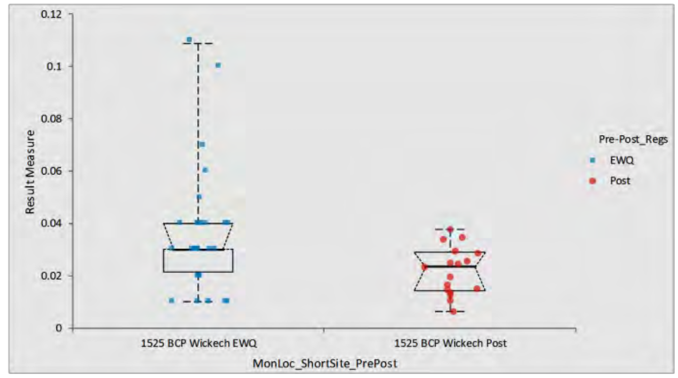
Existing Water Quality (Table 2V):

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



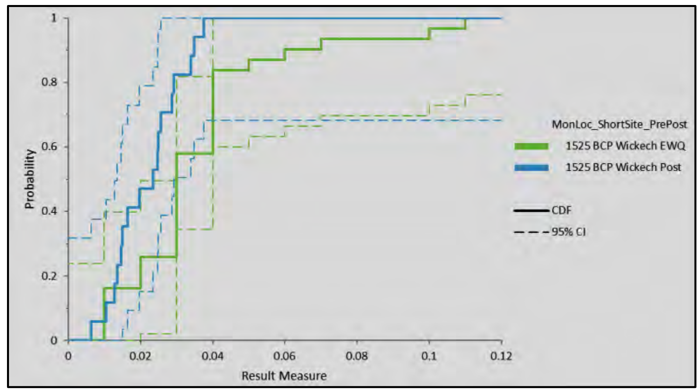


No water quality degradation is indicated. Orthophosphate concentrations apparently declined between the EWQ and post-EWQ periods. However, flow differences and potential laboratory artifacts introduced uncertainty in conclusions.



N 48

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1525 BCP Wickech EWQ	0.010	0.022	0.030	0.040	0.110	0.018
1525 BCP Wickech Post	0.006	0.014	0.023	0.029	0.038	0.015



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1525 BCP Wickech EWQ	31	516.2	16.65
1525 BCP Wickech Post	17	941.3	55.37

H statistic	7.55
X² approximation	7.55
DF	1
p-value	0.0060 [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.

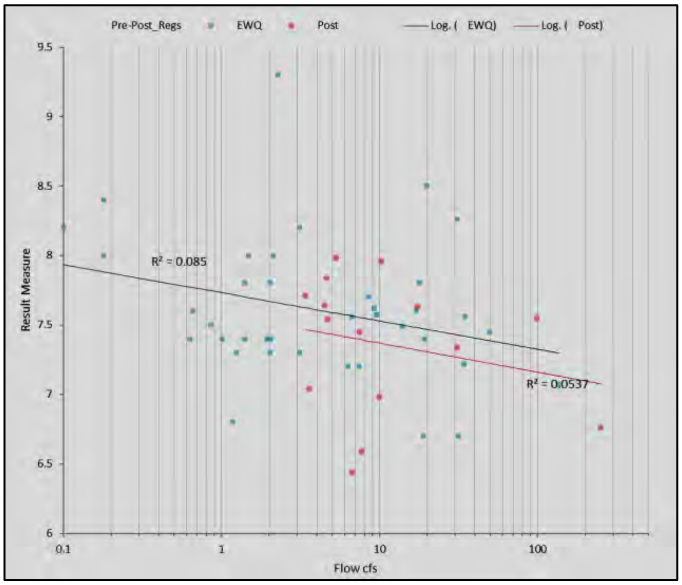
Orthophosphate is weakly related to flow in the EWQ data set, but unrelated to flow in the post-EWQ data set. Note that flows are plotted on a logarithmic scale. Post-EWQ median orthophosphate fell below the EWQ lower 95% confidence interval. There were no independent data to confirm DRBC results. DRBC detection limits improved between the two periods, but there was no interference in calculation of the median by non-detect results. Some improvement in water quality may be evident in that there are no values above 0.04 mg/l in the post-EWQ data set.

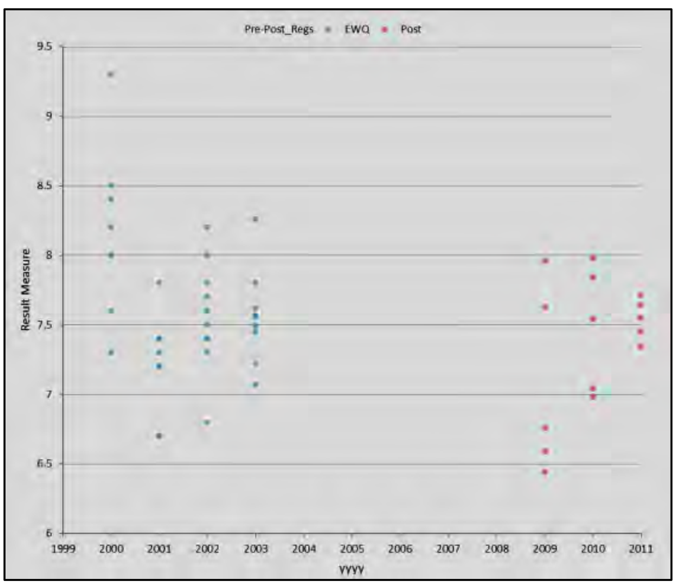
Chapter 5: 1525 BCP Wickecheoke Creek, NJ

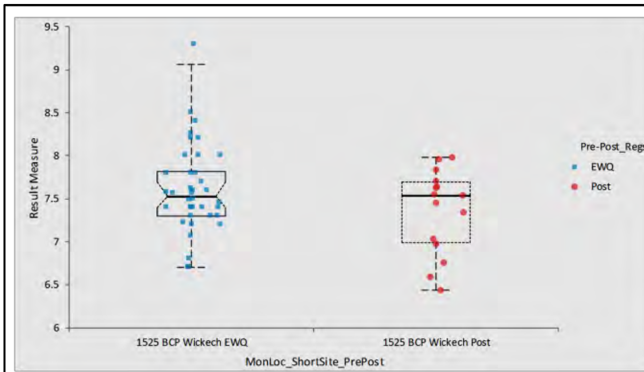
pH, units

Existing Water Quality (Table 2V):

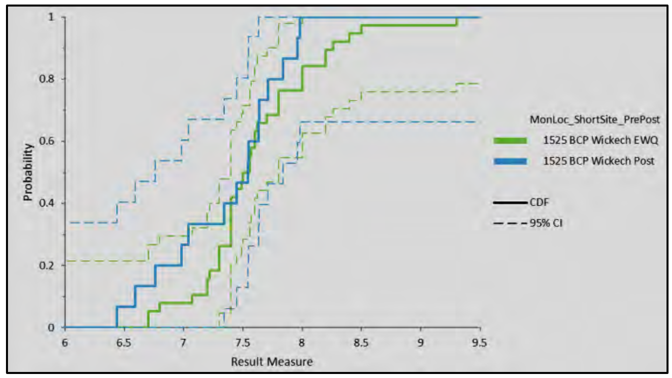
Median 7.53 standard units
Lower 95% Confidence Interval 7.40 standard units
Upper 95% Confidence Interval 7.70 standard units







N	53					
Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1525 BCP Wickech EWQ	6.70	7.30	7.53	7.82	9.30	0.52
1525 BCP Wickech Post	6.44	6.99	7.54	7.70	7.98	0.71



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1525 BCP Wickech EWQ	38	64.5	1.70
1525 BCP Wickech Post	15	163.4	10.89

H statistic	0.96
X^2 approximation	0.96
DF	1
p-value	0.3279 [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.

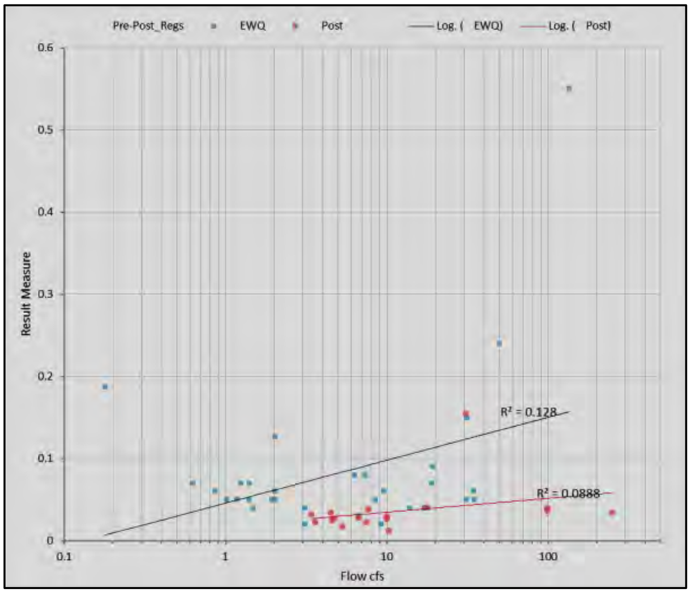
No water quality degradation is indicated. pH did not measurably change between the EWQ and post-EWQ periods. Under higher flow conditions, pH tends toward neutral, though pH is unrelated to flow in both data sets. Post-EWQ median pH fell within the EWQ 95% confidence intervals. Note that flows are plotted on a logarithmic scale.

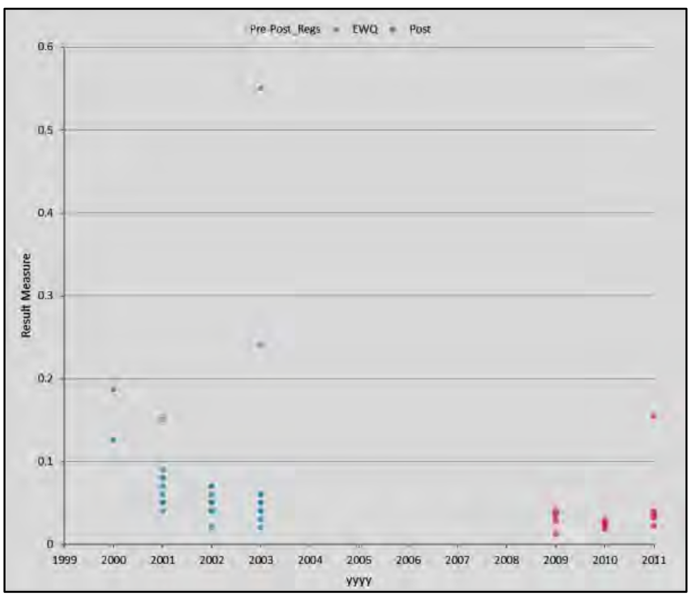
Chapter 5: 1525 BCP Wickecheoke Creek, NJ

Phosphorus as P, Total (TP) mg/l

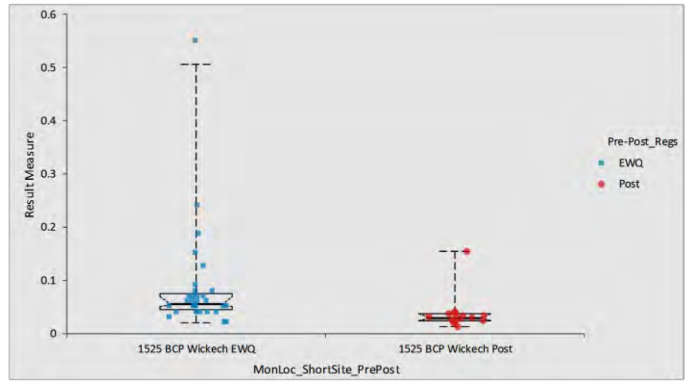
Existing Water Quality (Table 2V):

Median 0.06 mg/l
Lower 95% Confidence Interval 0.05 mg/l
Upper 95% Confidence Interval 0.07 mg/l



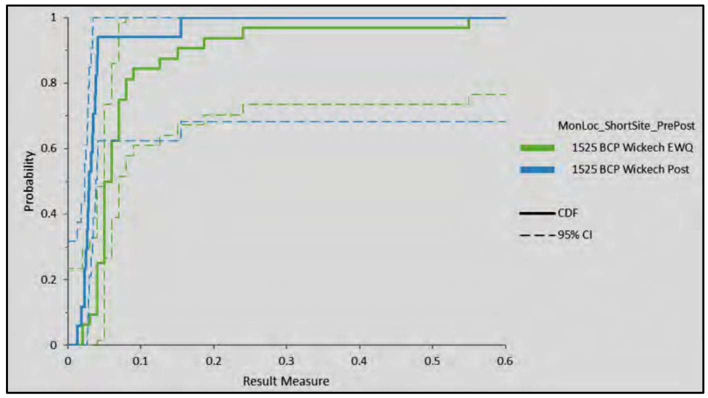


No water quality degradation is indicated. Total Phosphorus (TP) concentrations apparently declined between the EWQ and post-EWQ periods. However, flow differences and potential laboratory artifacts introduced uncertainty in conclusions.



N 49

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1525 BCP Wickech EWQ	0.020	0.044	0.055	0.076	0.550	0.032
1525 BCP Wickech Post	0.013	0.024	0.029	0.037	0.155	0.013



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1525 BCP Wickech EWQ	32	1287.8	40.24
1525 BCP Wickech Post	17	2424.1	142.59

H statistic	18.30
X^2 approximation	18.30
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.

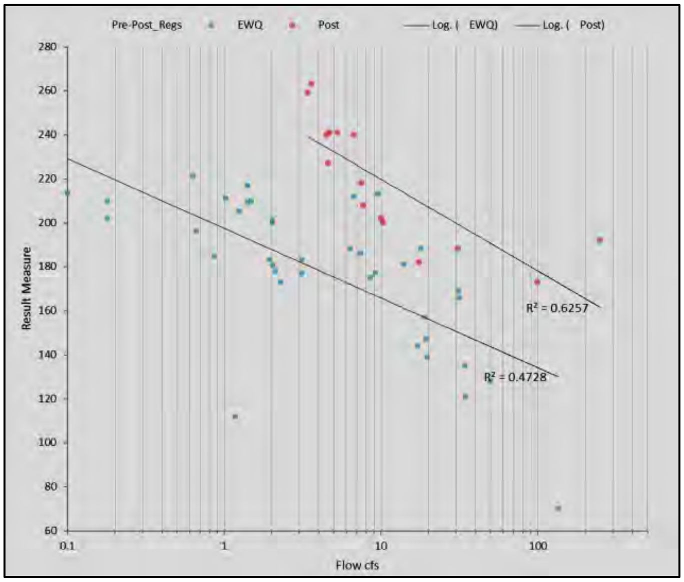
Post-EWQ median total phosphorus fell below the EWQ lower 95% confidence interval. TP is unrelated to flow in both data sets. Note that flows are plotted on a logarithmic scale. No independent data were available to confirm these results. The compressed appearance of data on these graphs is caused by a single high outlier value from a sample taken in September 2003 (0.55 mg/l). The cause for the high value is unknown.

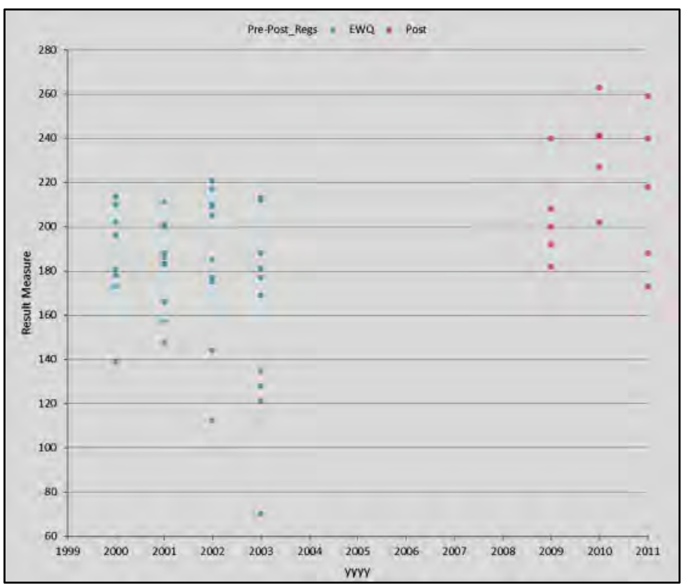
Chapter 5: 1525 BCP Wickecheoke Creek, NJ

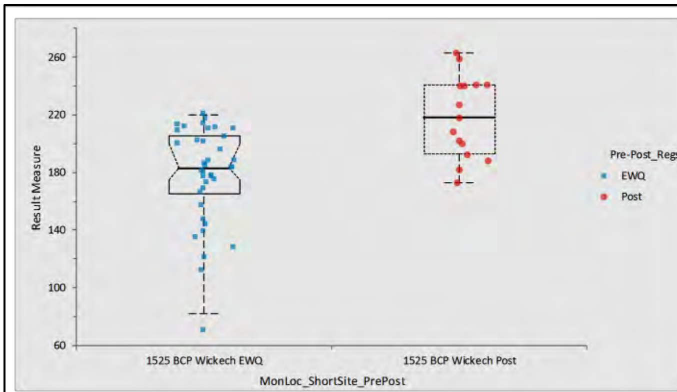
Specific Conductance µmho/cm

Existing Water Quality (Table 2V):

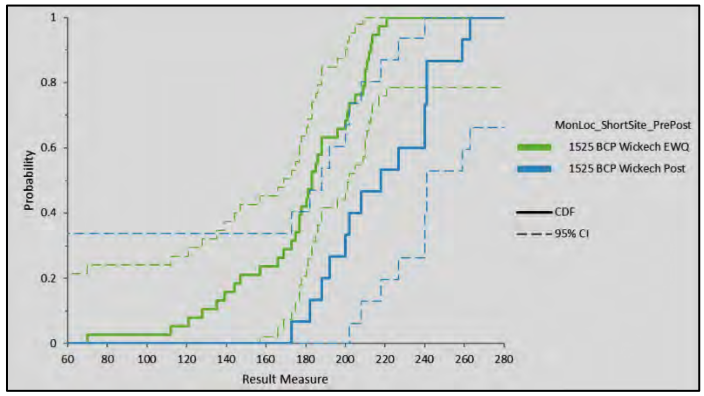
Median 183 µmho/cm
Lower 95% Confidence Interval 175 µmho/cm
Upper 95% Confidence Interval 200 µmho/cm
Defined in regulations as a flow-related parameter







N	53					
Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1525 BCP Wickech EWQ	70.0	165.3	183.0	205.3	221.0	40.1
1525 BCP Wickech Post	173.0	193.3	218.0	240.8	263.0	47.5



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1525 BCP Wickech EWQ	38	819.8	21.57
1525 BCP Wickech Post	15	2076.8	138.45

H statistic	12.15
X^2 approximation	12.15
DF	1
p-value	0.0005 [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.

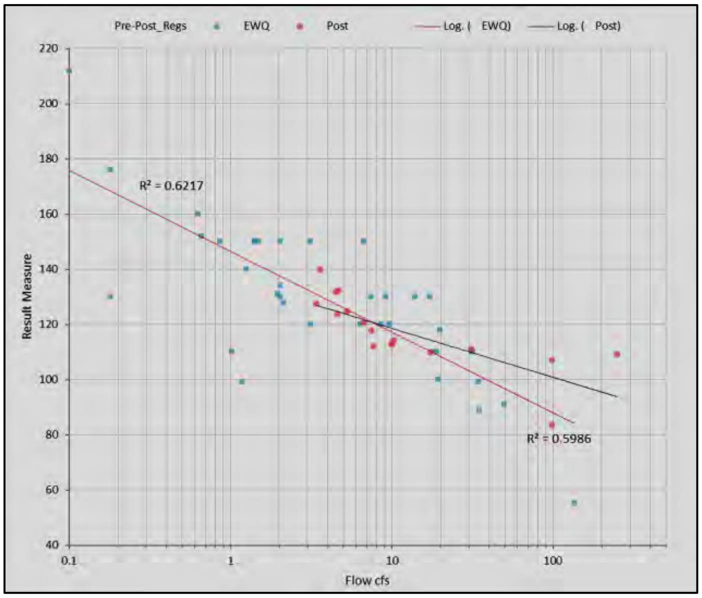
Water quality degradation is evident. Specific conductance rose above the EWQ upper 95% confidence interval between the EWQ and post-EWQ periods. In both data sets, specific conductance is inversely related to flow. Note that flows are plotted on a logarithmic scale. The rise in specific conductance may be attributable to the concurrent rise in chloride concentrations. No new dischargers are present in the watershed. Specific conductance has risen from a median of 183 µmho/cm to 218 µmho/cm, a 19% increase in a short time span.

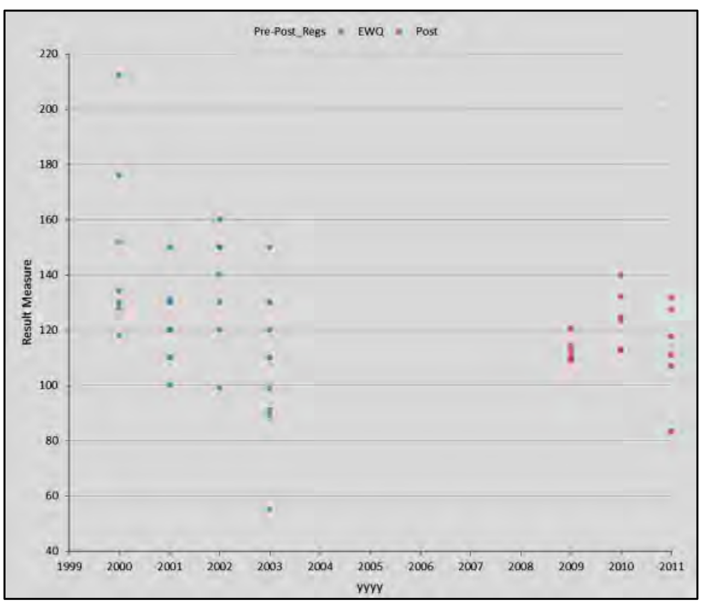
Chapter 5: 1525 BCP
Wickecheoke Creek, NJ

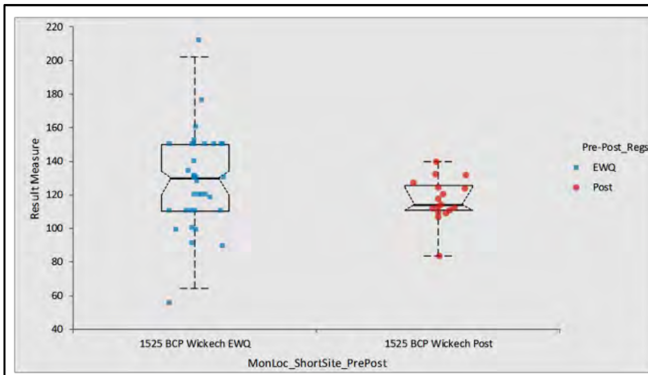
Total Dissolved Solids (TDS) mg/l

Existing Water Quality (Table 2V):

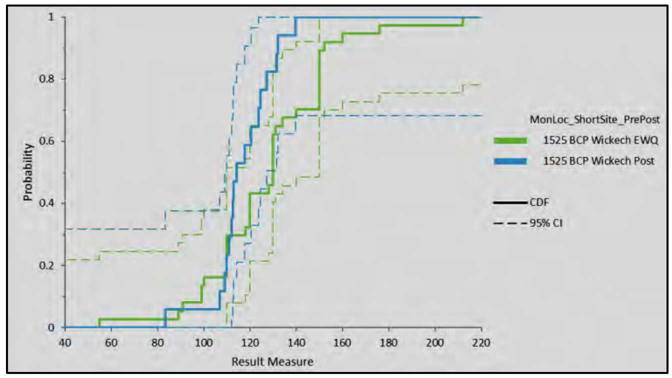
Median 130 mg/l
Lower 95% Confidence Interval 120 mg/l
Upper 95% Confidence Interval 134 mg/l
Defined in regulations as a flow-related parameter







N	54					
Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1525 BCP Wickech EWQ	55	110	130	150	212	40
1525 BCP Wickech Post	83	111	114	126	140	15



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1525 BCP Wickech EWQ	37	231.3	6.25
1525 BCP Wickech Post	17	503.3	29.61

H statistic	2.98
X^2 approximation	2.98
DF	1
p-value	0.0842 [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.

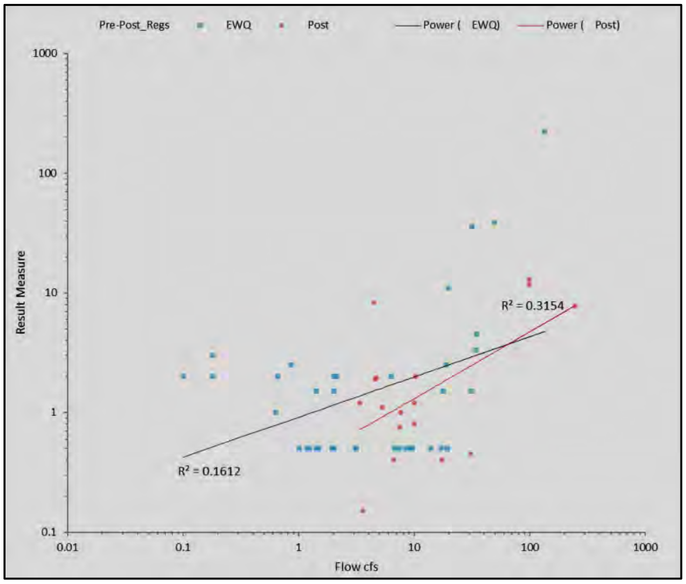
No water quality degradation is evident. TDS did not measurably change between the EWQ and post-EWQ periods. TDS is inversely and strongly related to flow in both data sets. Stream flows were different between the two periods, so flow accounts for some of the apparent decline in TDS even though the decline was not statistically significant. Post-EWQ median TDS was below the EWQ 95% lower confidence interval. Post-EWQ detection limits were lower than EWQ detection limits, though there were no non-detect results at any time. Note that flows are plotted on a logarithmic scale.

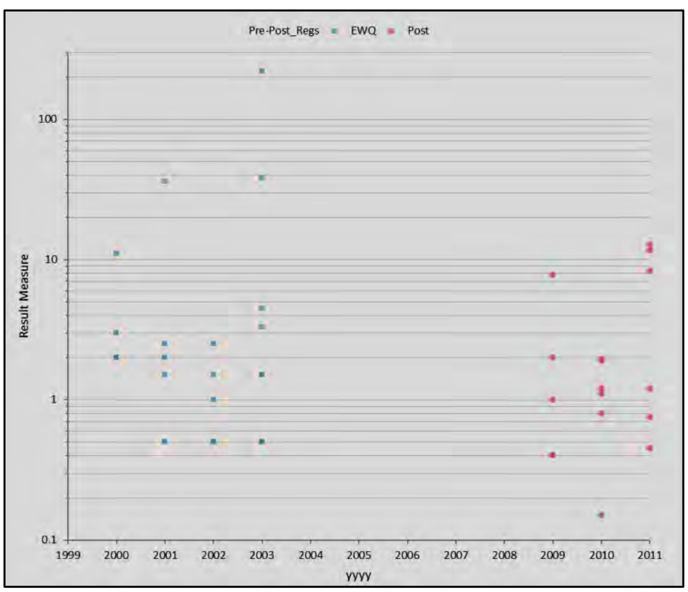
Chapter 5: 1525 BCP Wickecheoke Creek, NJ

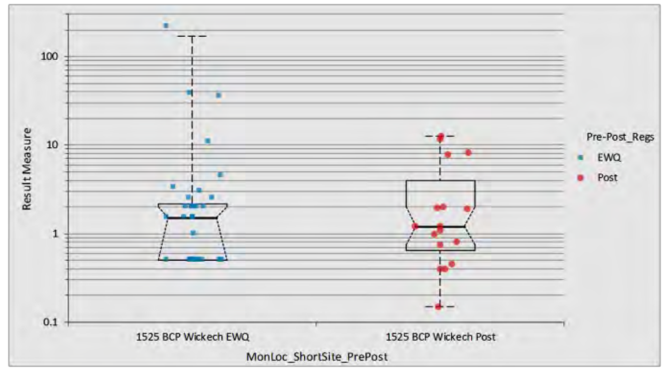
Total Suspended Solids (TSS) mg/l

Existing Water Quality (Table 2V):

Median 1.0 mg/l
Lower 95% Confidence Interval <0.5 mg/l
Upper 95% Confidence Interval 1.5 mg/l
Defined in regulations as a flow-related parameter

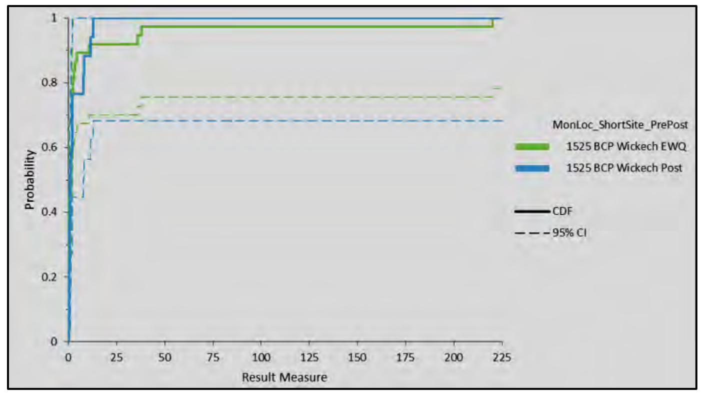






N | 54

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1525 BCP Wickech EWQ	0.5	0.5	1.5	2.2	220.0	1.7
1525 BCP Wickech Post	0.2	0.6	1.2	3.9	12.8	3.3



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1525 BCP Wickech EWQ	37	1.1	0.03
1525 BCP Wickech Post	17	2.5	0.15

H statistic	0.02
X² approximation	0.02
DF	1
p-value	0.9020 [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.

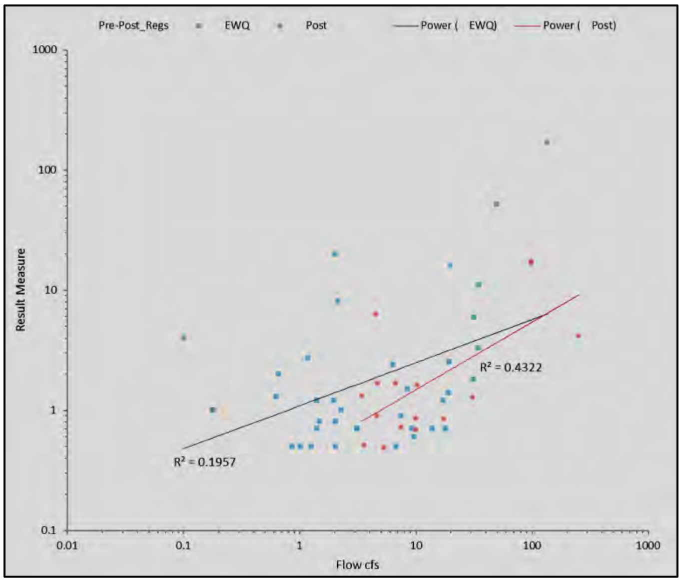
No water quality degradation is evident. TSS did not measurably change between the EWQ and post-EWQ periods. TSS is positively related to flow in both data sets, though the relationship is weaker in the EWQ data because of numerous non-detect results in the data that were estimated at the detection limit concentration (22 of 39 samples). Post-EWQ median TSS was within the EWQ 95% confidence intervals. Note that both flow and concentration are plotted on a logarithmic scale.

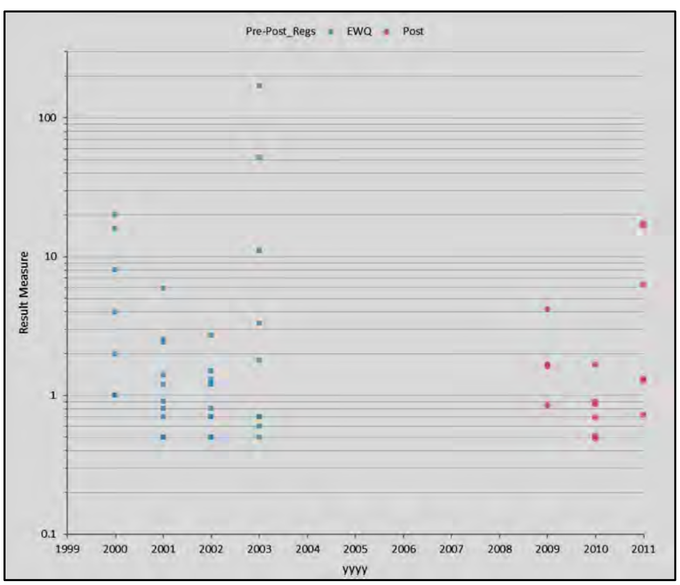
Chapter 5: 1525 BCP Wickecheoke Creek, NJ

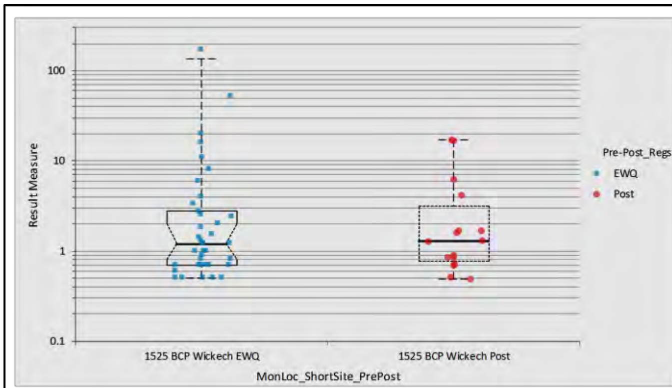
Turbidity NTU

Existing Water Quality (Table 2V):

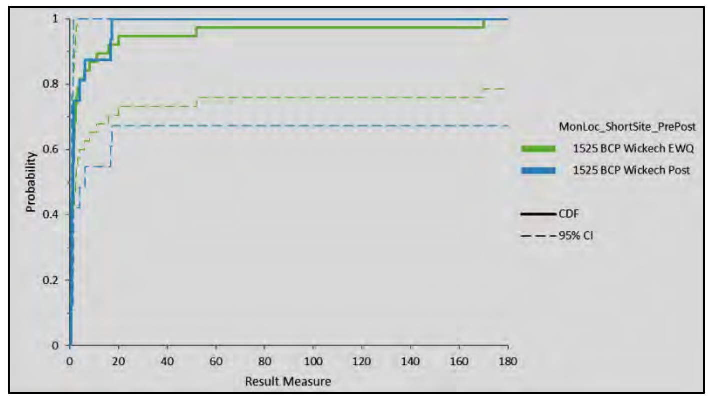
Median 1.2 NTU
Lower 95% Confidence Interval 0.7 NTU
Upper 95% Confidence Interval 2.0 NTU
Defined in regulations as a flow-related parameter







N	54					
Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1525 BCP Wickech EWQ	0.5	0.7	1.2	2.8	170.0	2.1
1525 BCP Wickech Post	0.5	0.8	1.3	3.1	17.3	2.3



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1525 BCP Wickech EWQ	38	2.4	0.06
1525 BCP Wickech Post	16	5.6	0.35

H statistic	0.03
X^2 approximation	0.03
DF	1
p-value	0.8570[1]

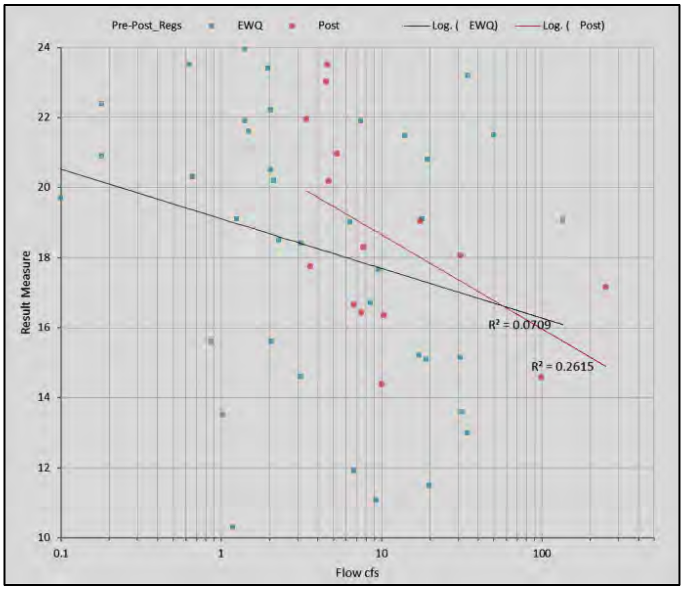
H0: $\theta_1 = \theta_2 = \theta$...
The median of the populations are all equal.
H1: $\theta_i \neq \theta_j$ for at least one i,j
The median of the populations are not all equal.
[1] Do not reject the null hypothesis at the 5% significance level.

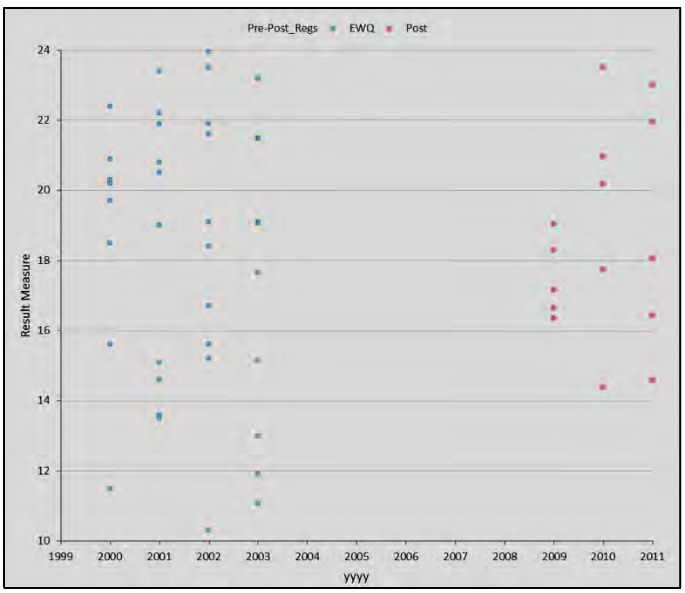
No water quality degradation is evident. Turbidity did not measurably change between the EWQ and post-EWQ periods. The post-EWQ median turbidity fell within the EWQ 95% confidence intervals of the median. In both data sets, the turbidity vs. flow relationship is positive, though the EWQ relationship is weak. Note that both concentration and flow are represented on logarithmic scales.

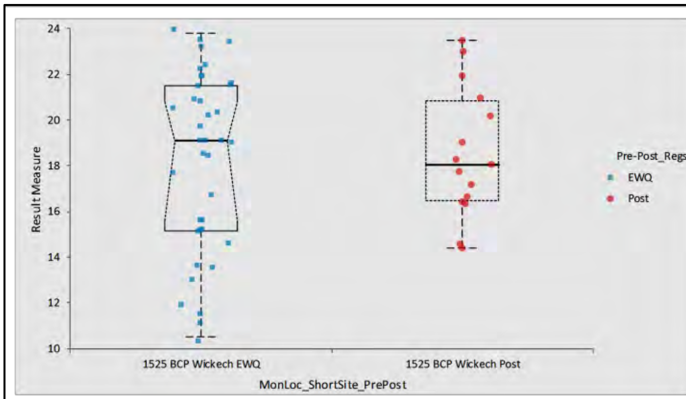
Chapter 5: 1525 BCP Wickecheoke Creek, NJ

Water Temperature, degrees C

Not included in DRBC Existing Water Quality rules

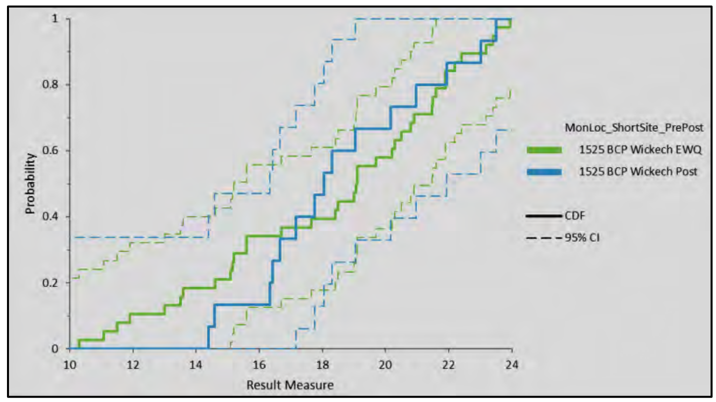






N | 53

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1525 BCP Wickech EWQ	10.3	15.1	19.1	21.5	23.9	6.4
1525 BCP Wickech Post	14.4	16.5	18.1	20.8	23.5	4.4



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1525 BCP Wickech EWQ	38	0.2	0.01
1525 BCP Wickech Post	15	0.6	0.04

H statistic	0.00
X² approximation	0.00
DF	1
p-value	0.9528 [1]

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

The median of the populations are all equal.

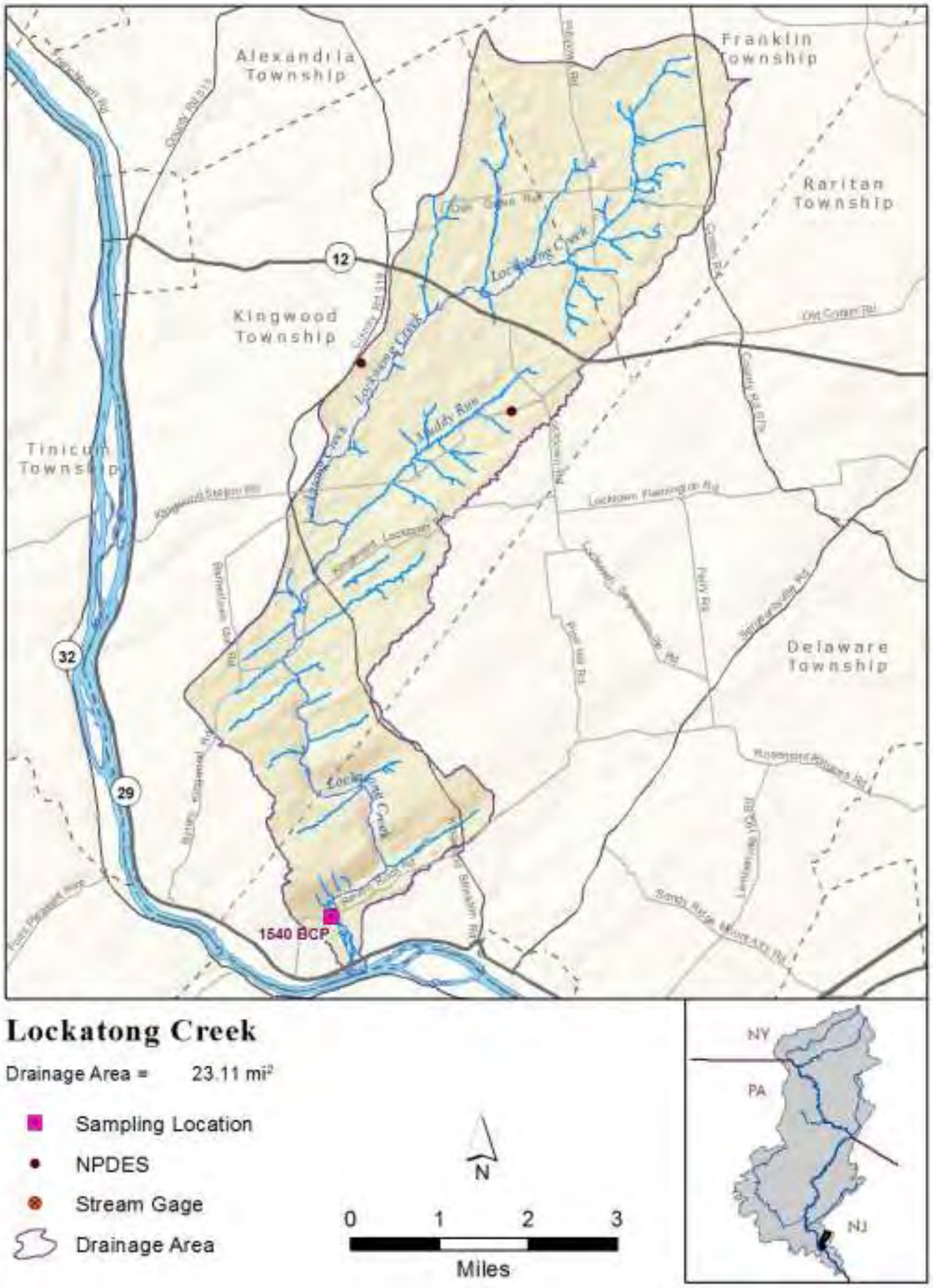
H1: $\theta_i \neq \theta_j$ for at least one i,j

The median of the populations are not all equal.

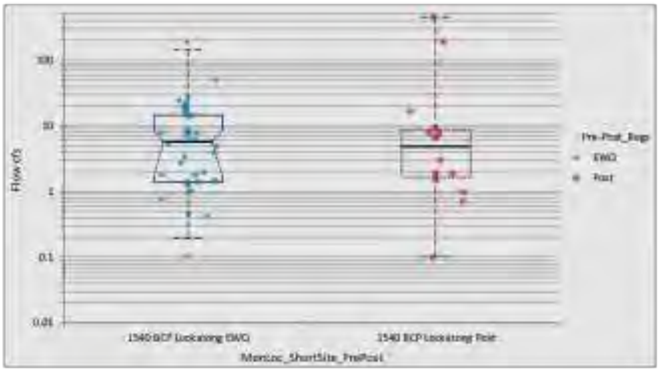
[1] Do not reject the null hypothesis at the 5% significance level.

No water quality degradation is evident. Water temperature did not measurably change between the EWQ and post-EWQ periods. Water temperature is not related to flow in the EWQ data set, but inversely and weakly related to flow in the post-EWQ data set. There were less cool temperatures in the post-EWQ data set. Note that flows are plotted on a logarithmic scale.

Chapter 6: 1540 BCP Lockatong Creek, Hunterdon County, NJ



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



N	54

Flow cfs by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1540 BCP Lockatong EWQ	0.10	1.39	5.72	14.57	180.30	13.19
1540 BCP Lockatong Post	0.10	1.67	4.90	8.65	451.90	6.98

Kruskal-Wallis test

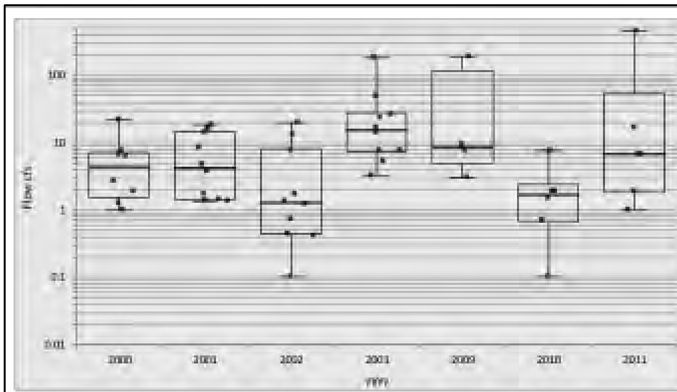
Flow cfs by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1540 BCP Lockatong EWQ	38	4.8	0.13
1540 BCP Lockatong Post	16	11.4	0.71

H statistic	0.07
X^2 approximation	0.07
DF	1
p-value	0.7981 [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.

Flow was roughly the same between the EWQ and post-EWQ periods. Fewer samples were collected in the post-EWQ period, but the range of flow conditions sampled was wider. Both data sets contain samples taken at minimum flow, when only standing pools were present and much of the channel was dry. Flow is plotted on a logarithmic scale.

The 23.1 square mile Lockatong Creek watershed is about 41% forested, with less than 1% urban land cover. There is no carbonate bedrock in the watershed. Lockatong Creek is captured by the Delaware and Raritan Canal and provides public water supply via the New Jersey Water Supply Authority. Its influence upon the Delaware River is minimal except during high-flow conditions.



N	54

Flow cfs by yyyy	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
2000	0.99	1.52	4.41	7.24	22.21	5.72
2001	1.33	1.44	4.29	14.57	18.75	13.14
2002	0.10	0.44	1.28	8.14	19.72	7.71
2003	3.32	7.46	15.62	28.36	180.30	20.90
2009	3.10	4.98	8.50	115.92	192.00	110.94
2010	0.10	0.65	1.70	2.38	7.60	1.73
2011	1.00	1.83	6.70	53.24	451.90	51.42

Annual May to September flow statistics are plotted above. Flow is plotted on a logarithmic scale. These are flow measurements or sometimes estimates associated with the time of each water quality sample. “Normal” annual median flow is about 47 cfs at this location, but the summer seasonal flow is around 29 cfs (USGS gage 01460880, 2006-2012 data). Though a wide range of flows were sampled by DRBC, these data sets appear to be most representative of low flow conditions. EWQ samples were taken when there was no USGS gage on the Lockatong Creek, and flows were estimated based upon a DRBC rating curve built at the same location where the USGS gage now resides. When available, USGS continuous flow records were used to match flow with DRBC water quality samples in the post-EWQ period of 2009-2011.

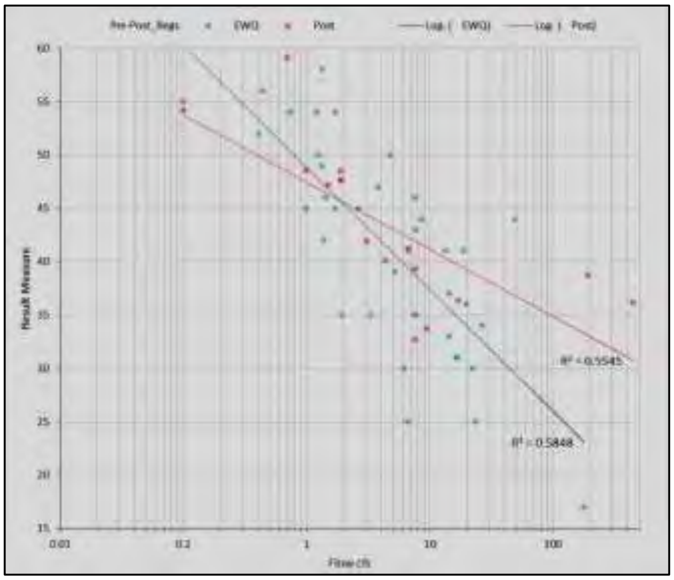
Upstream ICP: Delaware River at Bulls Island
Downstream ICP: Delaware River at Lambertville

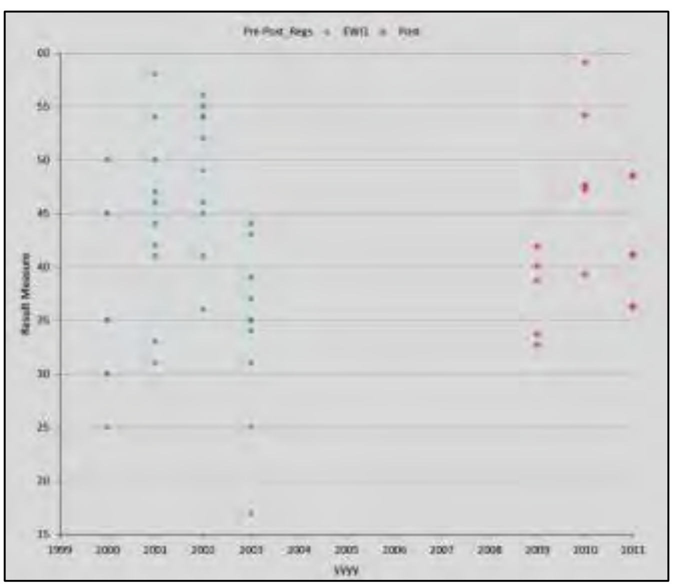
Chapter 6: 1540 BCP Lockatong Creek, NJ

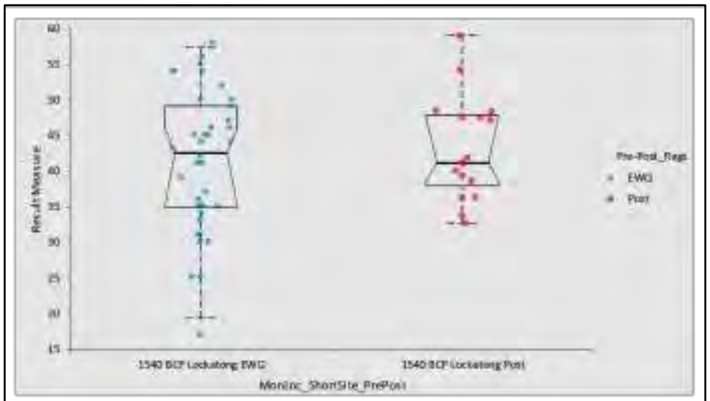
Alkalinity as CaCO3, Total mg/l

Existing Water Quality (Table 2U):

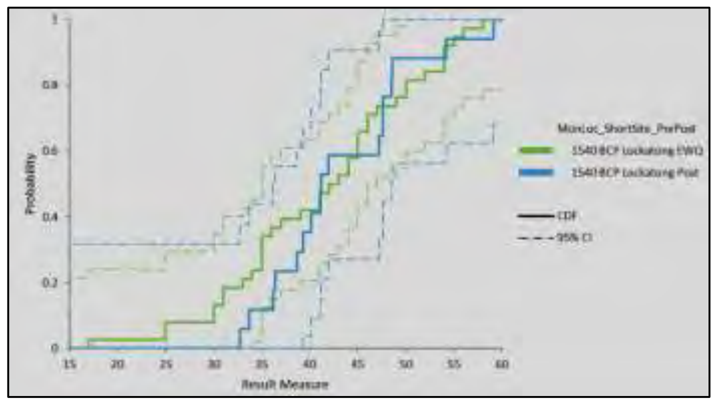
Median 43 mg/l
Lower 95% Confidence Interval 35 mg/l
Upper 95% Confidence Interval 46 mg/l
Defined in regulations as a flow-related parameter







N	55					
Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1540 BCP Lockatong EWQ	17.0	34.9	42.5	49.1	58.0	14.2
1540 BCP Lockatong Post	32.7	37.9	41.2	47.9	59.1	10.0



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1540 BCP Lockatong EWQ	38	30.4	0.80
1540 BCP Lockatong Post	17	68.0	4.00

H statistic	0.38
X^2 approximation	0.38
DF	1
p-value	0.5356 [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.

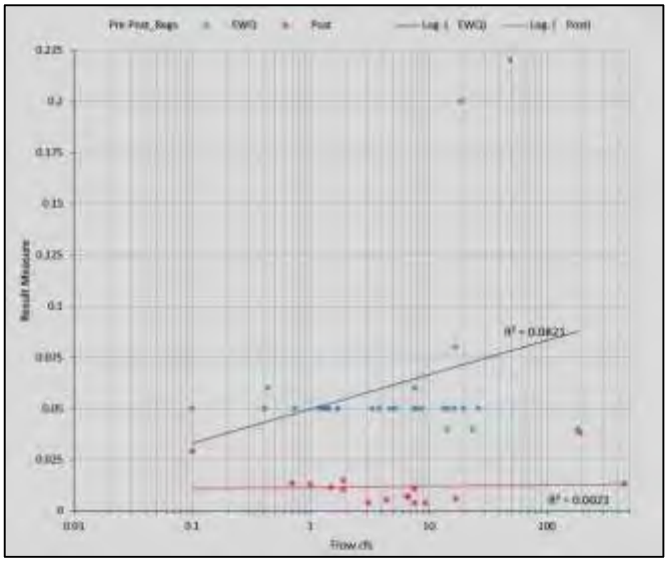
No water quality degradation is evident. Alkalinity did not measurably change between the EWQ and post-EWQ periods. Alkalinity is inversely related to flow in both data sets. Post-EWQ median alkalinity fell within EWQ 95% confidence intervals. Flow is plotted on a logarithmic axis.

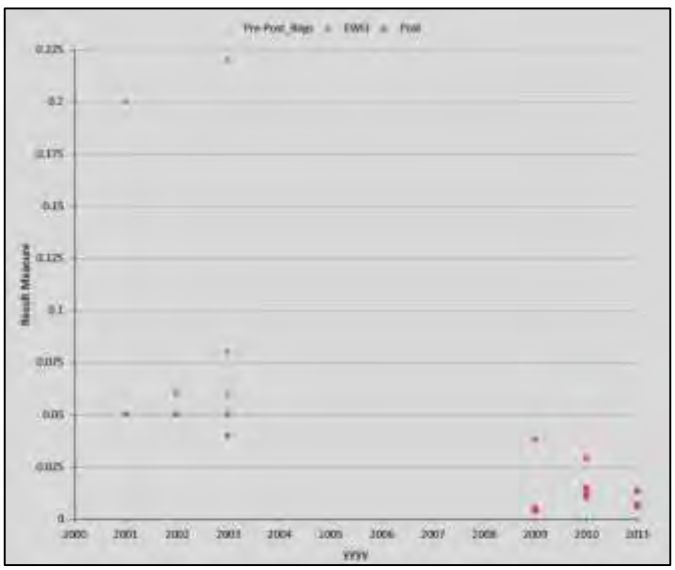
Chapter 6: 1540 BCP Lockatong Creek, NJ

Ammonia Nitrogen as N, Total mg/l

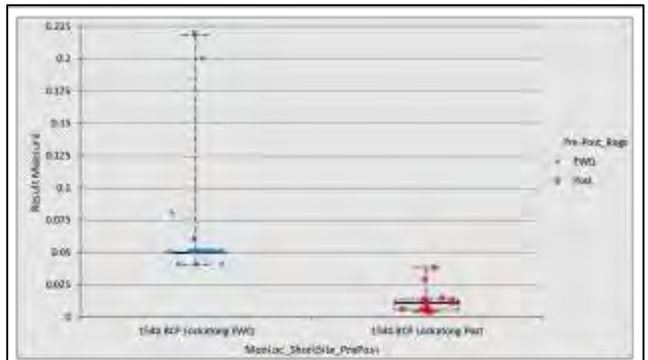
Existing Water Quality (Table 2U):

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



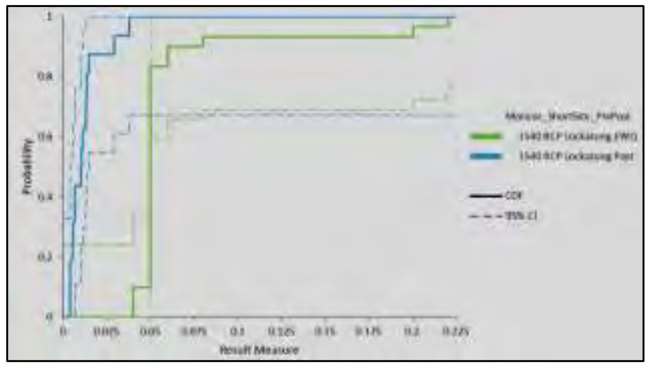


No water quality degradation is evident. Ammonia concentrations apparently declined between the two periods. However, differences in detection limits, potential laboratory artifacts, and too few post-EWQ samples introduced uncertainty in conclusions. Post-EWQ median ammonia concentration was below the EWQ lower 95% confidence interval.



N 46

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1540 BCP Lockatong EWQ	0.040	0.050	0.050	0.050	0.220	0.000
1540 BCP Lockatong Post	0.004	0.006	0.011	0.014	0.038	0.008



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1540 BCP Lockatong EWQ	30	1920.0	64.00
1540 BCP Lockatong Post	16	3600.0	225.00

H statistic	34.42
X^2 approximation	34.42
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.

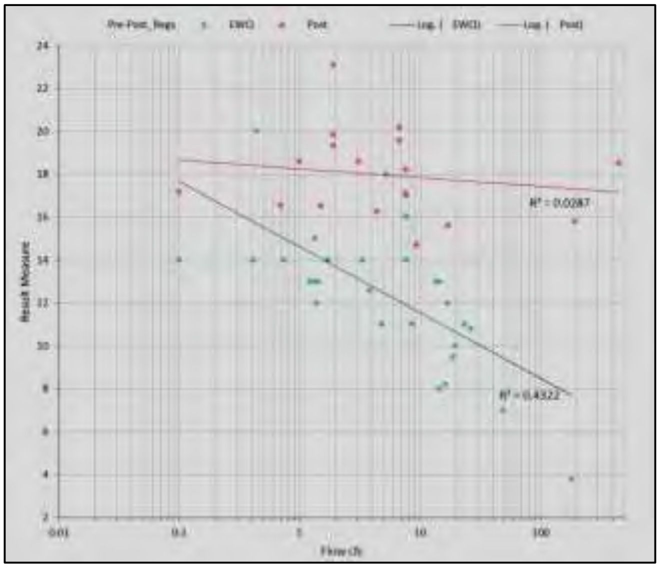
No independent data were readily available to validate results. EWQ data possessed 25/30 undetected results, interfering with calculation of the median. Thus EWQ was established as <0.05 mg/l; the detection limit at the time. At lower detection limits there were still 5 undetected results in post-EWQ data. We are now able to measure ambient Lockatong Creek concentrations (median 0.011 mg/l), which are certainly less than 0.05 mg/l. Some improvement possibly took place, as the post-EWQ data contained no concentrations higher than 0.004 mg/l.

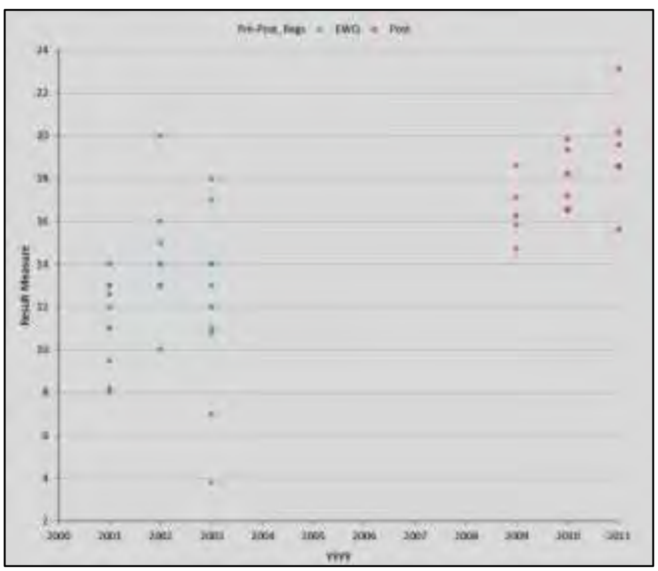
Chapter 6: 1540 BCP Lockatong Creek, NJ

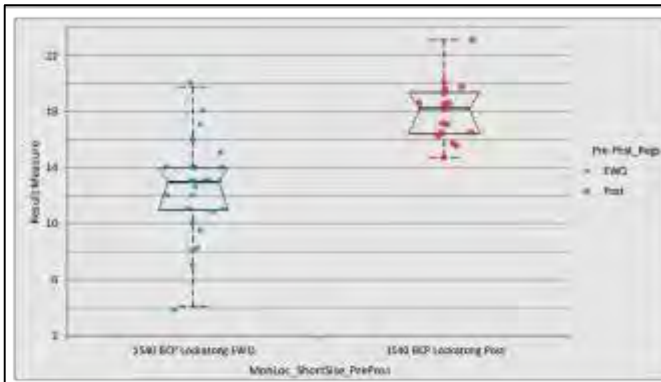
Chloride, Total mg/l

Existing Water Quality (Table 2U):

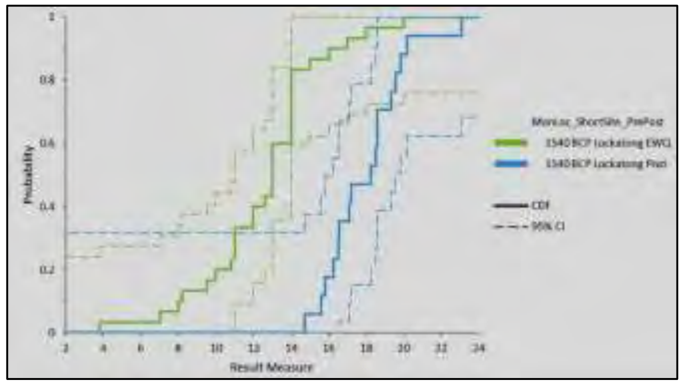
Median 13 mg/l
Lower 95% Confidence Interval 11 mg/l
Upper 95% Confidence Interval 14 mg/l
Defined in regulations as a flow-related parameter







N	47					
Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1540 BCP Lockatong EWQ	3.8	11.0	13.0	14.0	20.0	3.0
1540 BCP Lockatong Post	14.7	16.4	18.2	19.4	23.1	3.0



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1540 BCP Lockatong EWQ	30	1642.8	54.76
1540 BCP Lockatong Post	17	2899.1	170.53

H statistic	24.27
X² approximation	24.27
DF	1
p-value	<0.0001 [1]

H0: $\theta_1 = \theta_2 = \theta_{\dots}$
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.

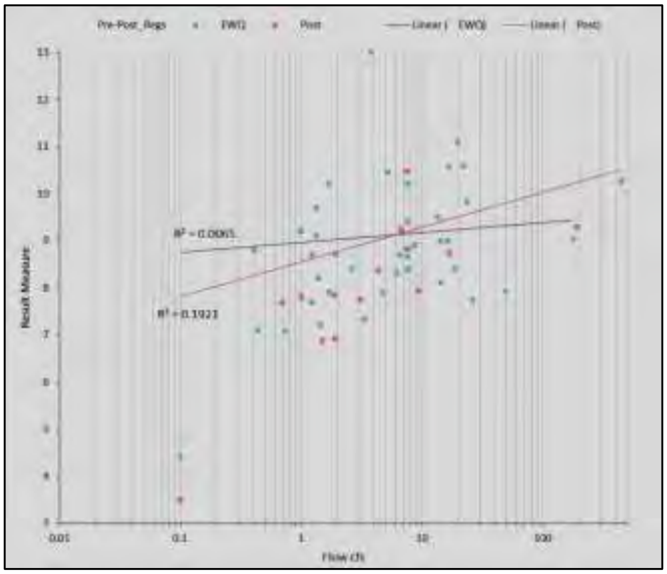
Water quality degradation is evident. Chloride concentrations apparently increased between the two periods. However, analytical uncertainty included potential laboratory artifacts and insufficient post-EWQ sampling (n=17). Post-EWQ median concentration rose above the EWQ upper 95% confidence interval. EWQ chloride was inversely related to flow, but post-EWQ chloride was not flow-related, probably due to insufficient post-EWQ sampling.

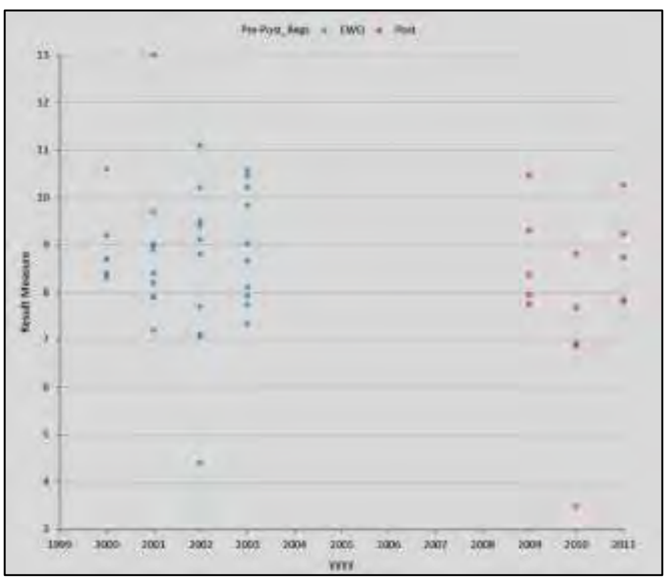
Chapter 6: 1540 BCP Lockatong Creek, NJ

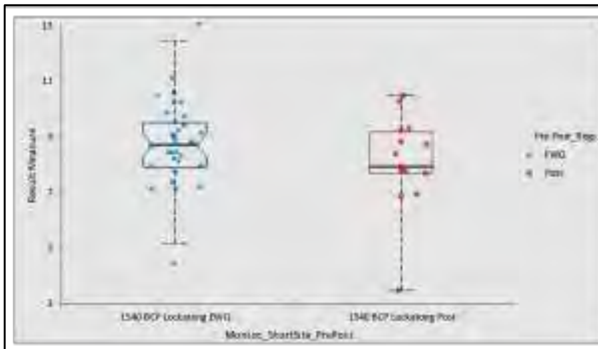
Dissolved Oxygen (DO) mg/l

Existing Water Quality (Table 2U):

Median 8.70 mg/l
Lower 95% Confidence Interval 8.30 mg/l
Upper 95% Confidence Interval 9.10 mg/l

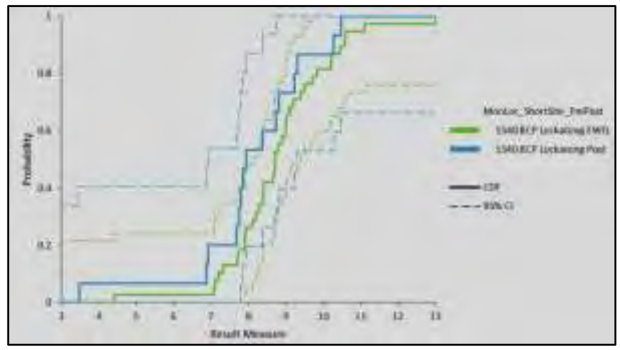






N 53

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1540 BCP Lockatong EWQ	4.40	7.92	8.70	9.52	13.00	1.60
1540 BCP Lockatong Post	3.48	7.69	7.94	9.16	10.48	1.47



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1540 BCP Lockatong EWQ	38	136.4	3.59
1540 BCP Lockatong Post	15	345.6	23.04

H statistic	2.02
X^2 approximation	2.02
DF	1
p-value	0.1550[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. No measurable change took place between the EWQ and Post-EWQ periods. Post-EWQ median DO concentration fell below the EWQ lower 95% confidence interval, but there were too few post-EWQ samples for a significant comparison.

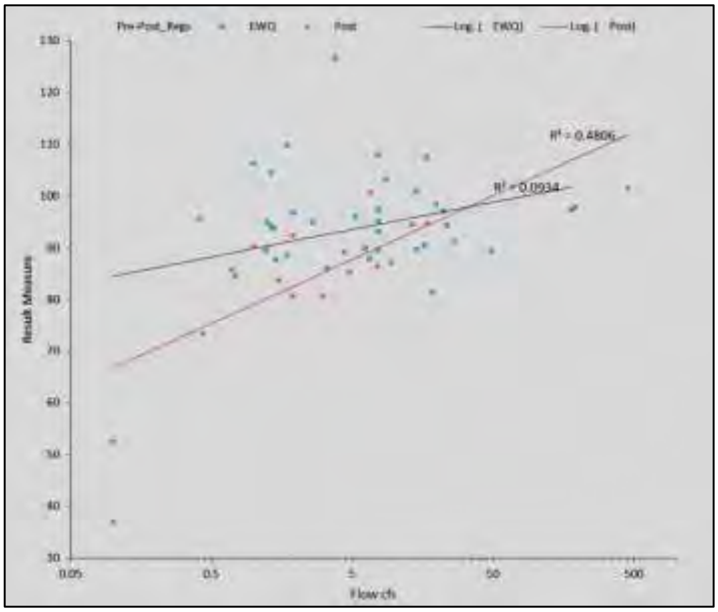
Sampling time of day may have slightly biased the post-EWQ data; average sample time was 10:00 AM for post-EWQ samples compared with 11:00 AM for EWQ samples. DO concentrations typically increase during the day; an hour in time difference can be meaningful. Flow is plotted on a logarithmic scale. DO is unrelated to flow in both data sets. There are extreme low DO values in both data sets. Those measurements were taken from standing pools during dry conditions in 2002 and 2010 when there was no observable flow in Lockatong Creek. The pools were full of decomposing leaves that drove DO concentrations below 5 mg/l.

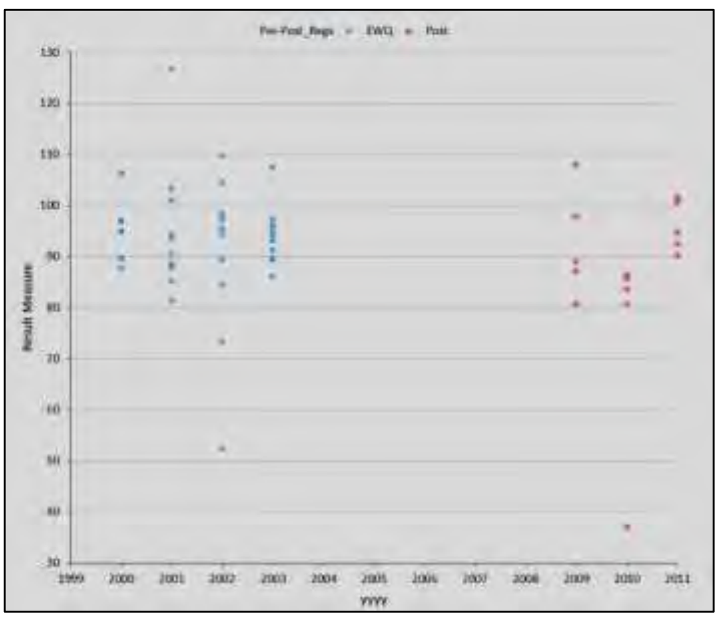
Chapter 6: 1540 BCP Lockatong Creek, NJ

Dissolved Oxygen Saturation %

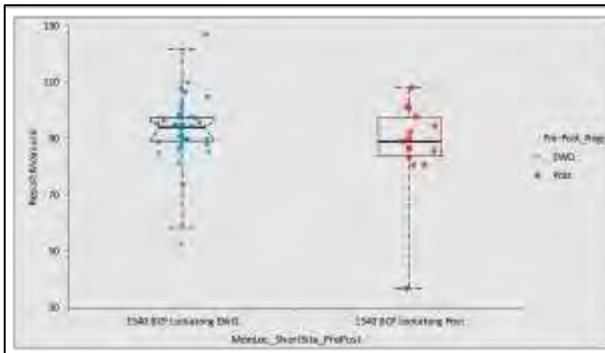
Existing Water Quality (Table 2U):

Median 94%
Lower 95% Confidence Interval 90%
Upper 95% Confidence Interval 96%

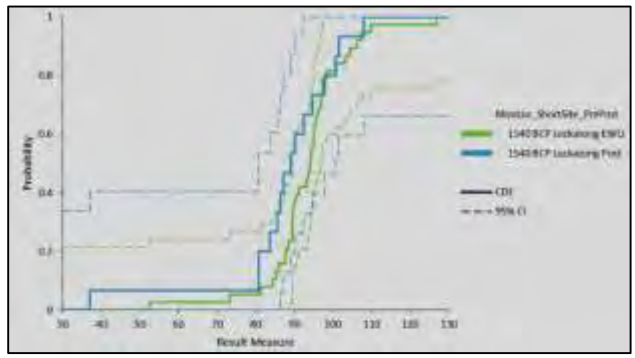




No water quality degradation is evident. Dissolved Oxygen Saturation is unrelated to flow, and did not measurably change between the EWQ and post-EWQ periods. The apparent post-EWQ flow relationship is skewed by a single low outlier value.



Result Measure by MonLoc_ShortSite_PrePost	N	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
	53						
1540 BCP Lockatong EWQ		52	89	94	97	127	8
1540 BCP Lockatong Post		37	84	89	97	108	13



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1540 BCP Lockatong EWQ	38	136.4	3.59
1540 BCP Lockatong Post	15	345.6	23.04

H statistic	2.02
X^2 approximation	2.02
DF	1
p-value	0.1551 [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.

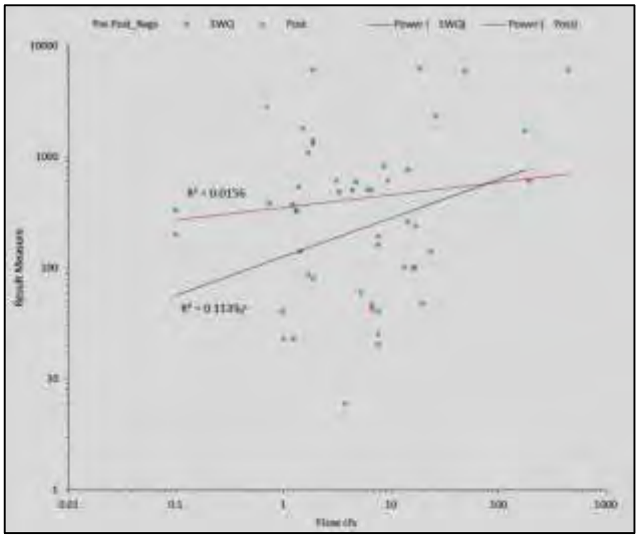
Post-EWQ median DO saturation fell below the EWQ lower 95% confidence interval, but not significantly. Dissolved oxygen saturation is slightly imbalanced in Lockatong Creek, tending between 80% and 110%. One algae bloom was detected in 2001 as indicated by the highest saturation level near 130%. There is some oxygen demand that suppresses DO saturation but it rarely drops below 80% except for on two occasions when the stream dried up and left standing pools in 2002 and 2010. Decomposing leaves and organic matter in the pools suppressed concentrations below 5 mg/l and saturation levels near or below 50%.

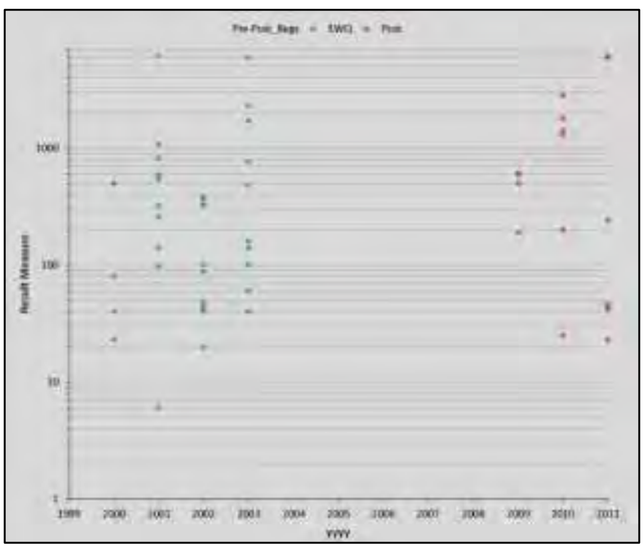
Chapter 6: 1540 BCP Lockatong Creek, NJ

Enterococcus colonies/100 ml

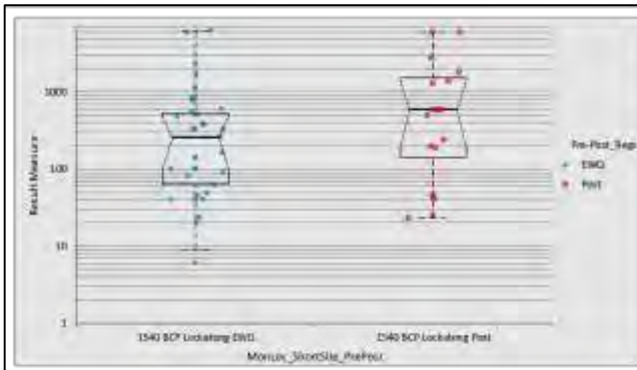
Existing Water Quality (Table 2U):

Median 260/100 ml
Lower 95% Confidence Interval 98/100 ml
Upper 95% Confidence Interval 480/100 ml

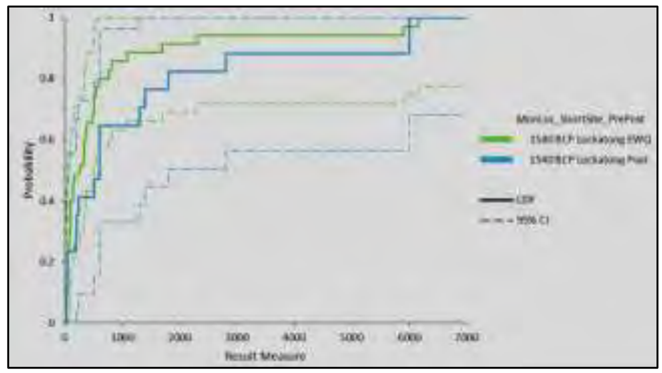




No water quality degradation is indicated. Enterococci did not measurably change between the EWQ and Post-EWQ periods. Enterococcus concentrations are unrelated related to flow in both data sets. Note that concentrations and flows are plotted on a logarithmic scale.



N	52					
Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1540 BCP Lockatong EWQ	6	63	260	533	6,164	470
1540 BCP Lockatong Post	23	142	600	1,533	6,000	1,391



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1540 BCP Lockatong EWQ	35	165.0	4.72
1540 BCP Lockatong Post	17	339.8	19.99

H statistic	2.20
X^2 approximation	2.20
DF	1
p-value	0.1381 [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.

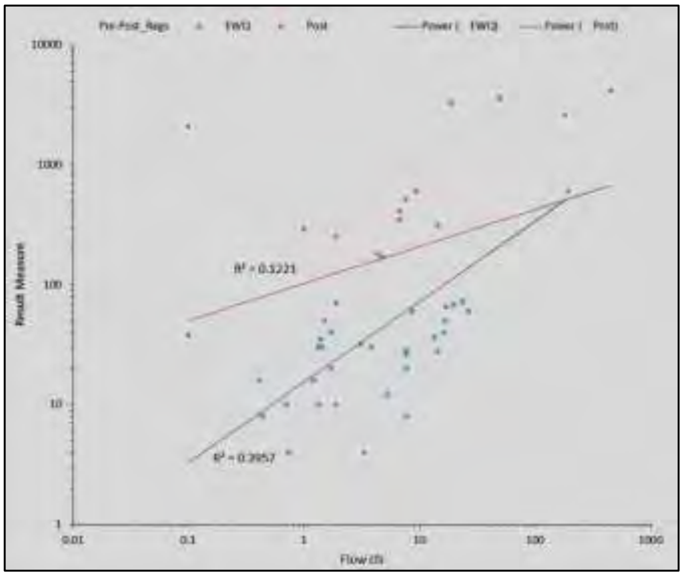
Sources of analytical uncertainty included potential laboratory artifacts and insufficient post-EWQ sampling (n=17). Post-EWQ median enterococcus concentrations were above the EWQ upper 95% confidence interval, but variability is so high and post-EWQ N so low that the rise is meaningless.

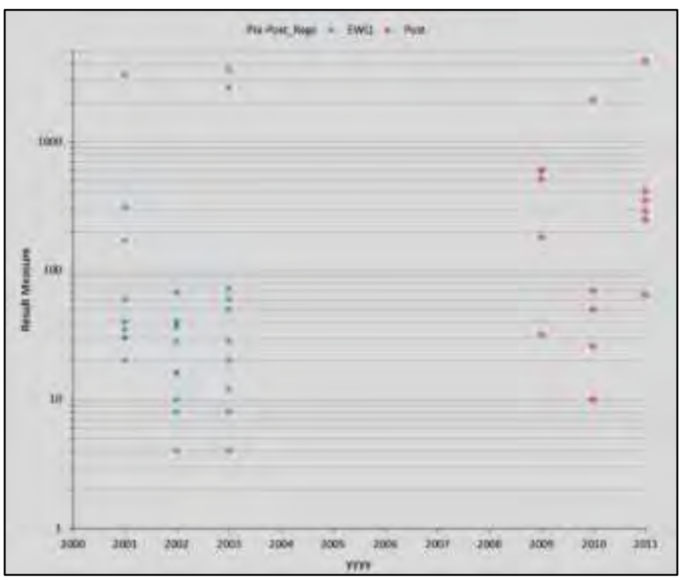
Chapter 6: 1540 BCP Lockatong Creek, NJ

Escherichia coli colonies/100 ml

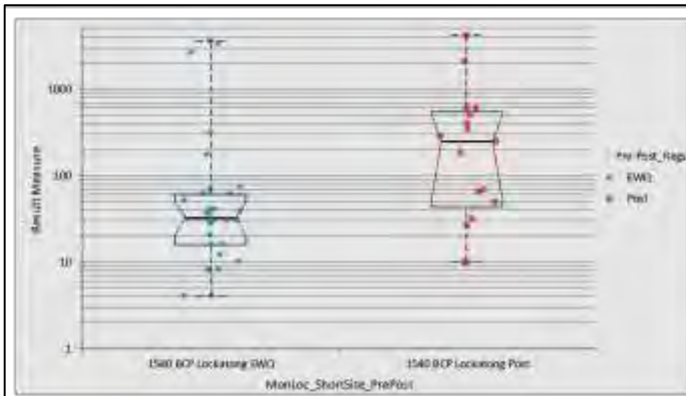
Existing Water Quality (Table 2U):

Median 33/100 ml
Lower 95% Confidence Interval 20/100 ml
Upper 95% Confidence Interval 50/100 ml
Defined in regulations as a flow-related parameter



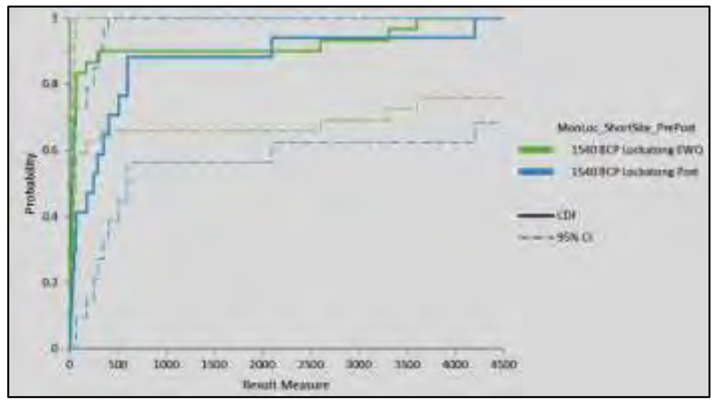


Water quality degradation is evident. E. coli concentrations apparently rose between the EWQ and Post-EWQ periods. Post-EWQ median E. coli rose above the EWQ upper 95% confidence interval.



N | 47

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1540 BCP Lockatong EWQ	4	16	33	61	3,600	45
1540 BCP Lockatong Post	10	44	250	540	4,200	496



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1540 BCP Lockatong EWQ	30	452.4	15.08
1540 BCP Lockatong Post	17	798.4	46.96

H statistic	6.66
X^2 approximation	6.66
DF	1
p-value	0.0099 [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.

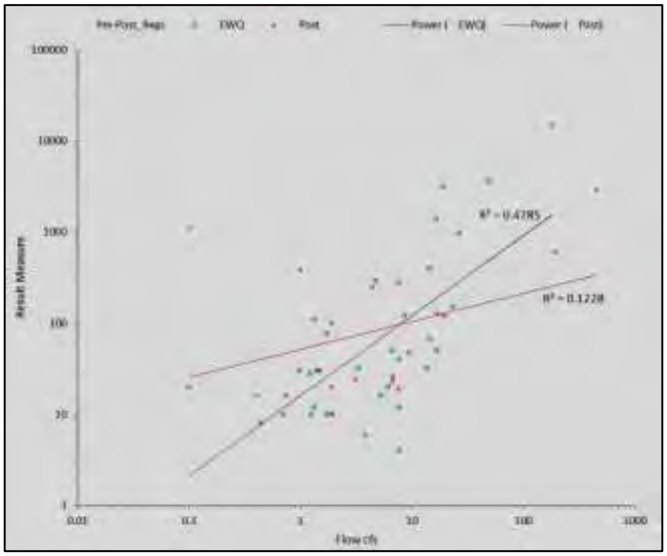
Analytical uncertainty included potential laboratory artifacts and insufficient post-EWQ sampling (n=17). No independent data were available at this site to validate DRBC's conclusion. The increase is reported as such in the summary matrix, but confidence in the conclusion is low because of low N and high variability.

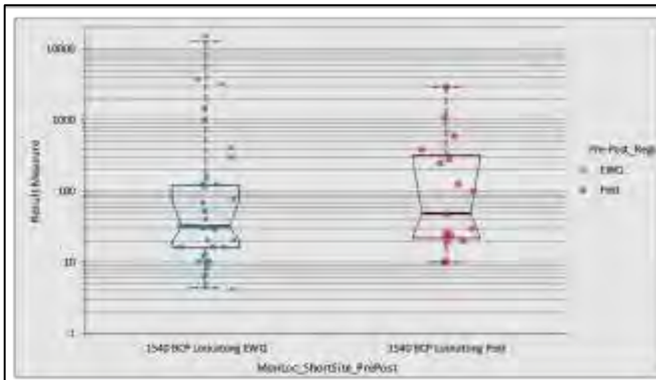
Chapter 6: 1540 BCP Lockatong Creek, NJ

Fecal coliform colonies/100 ml

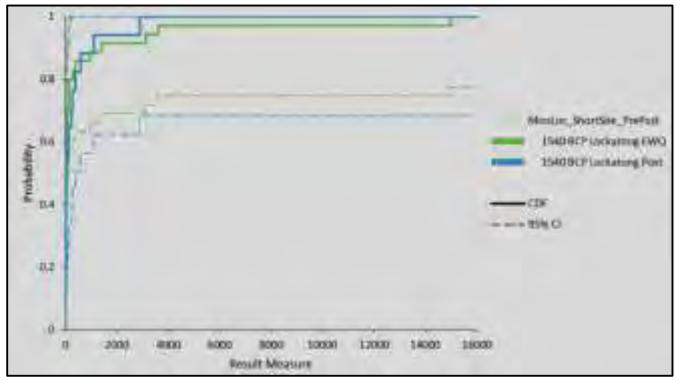
Existing Water Quality (Table 2U):

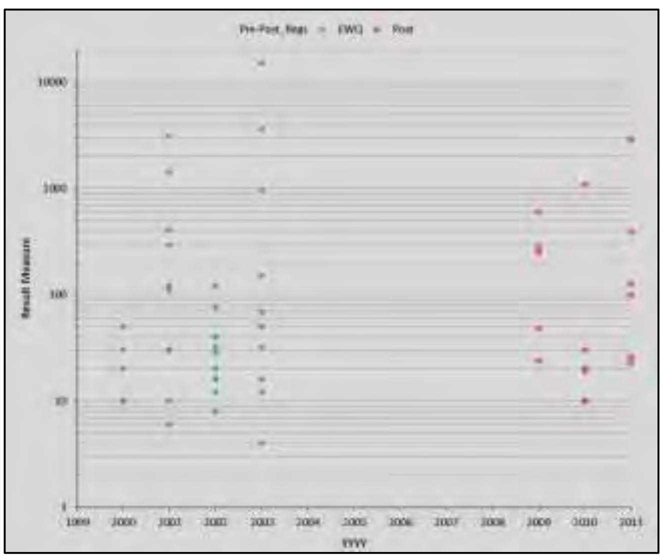
Median 32/100 ml
Lower 95% Confidence Interval 20/100 ml
Upper 95% Confidence Interval 76/100 ml
Defined in regulations as a flow-related parameter





	N	52				
Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1540 BCP Lockatong EWQ	4	16	32	120	15,000	104
1540 BCP Lockatong Post	10	22	48	317	2,900	295





Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1540 BCP Lockatong EWQ	35	41.3	1.18
1540 BCP Lockatong Post	17	84.9	5.00

H statistic	0.55
X² approximation	0.55
DF	1
p-value	0.4581 [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.

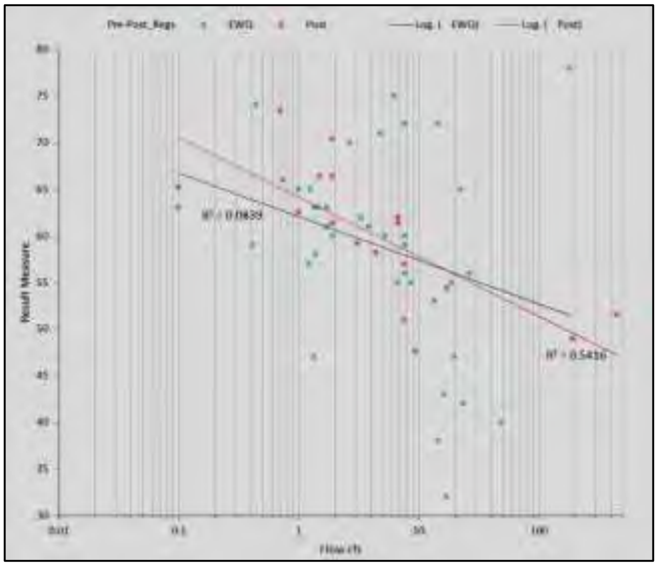
No water quality degradation is evident. Fecal coliform concentrations did not measurably change between the EWQ and post-EWQ periods. Fecal coliform concentrations are positively related to flow in both data sets, but weakly so in the post-EWQ data. Post-EWQ median concentrations fell within the EWQ 95% confidence intervals, but the data were naturally variable and post-EWQ N was low. Note that concentrations and flows are plotted on a logarithmic scale.

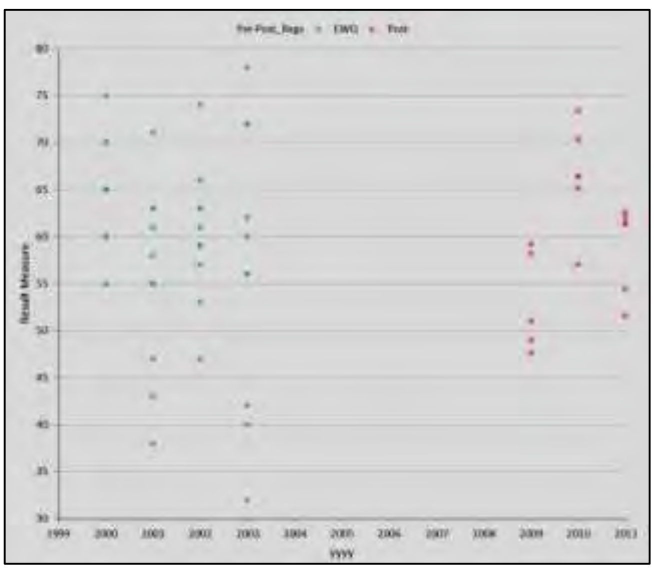
Chapter 6: 1540 BCP Lockatong Creek, NJ

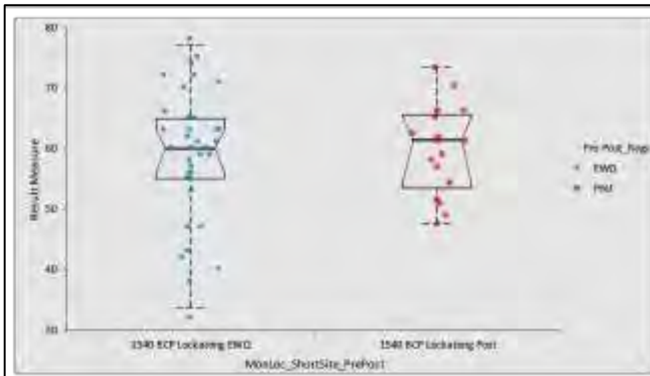
Hardness as CaCO3, Total mg/l

Existing Water Quality (Table 2U):

Median 60 mg/l
Lower 95% Confidence Interval 56 mg/l
Upper 95% Confidence Interval 63 mg/l

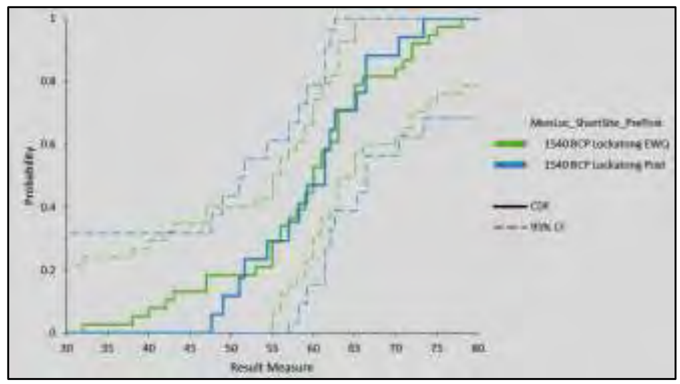






N | 55

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1540 BCP Lockatong EWQ	32	55	60	65	78	10
1540 BCP Lockatong Post	48	53	61	66	73	12



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1540 BCP Lockatong EWQ	38	1.3	0.03
1540 BCP Lockatong Post	17	2.9	0.17

H statistic	0.02
X^2 approximation	0.02
DF	1
p-value	0.8985 [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.

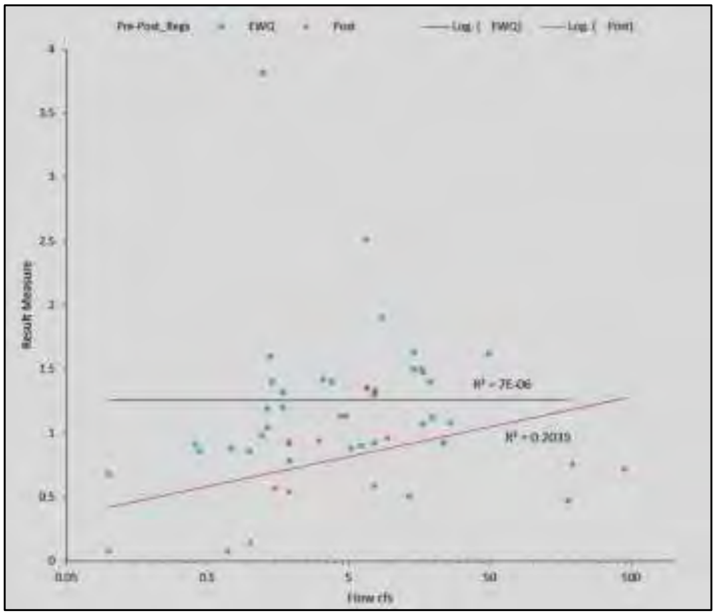
We found no evidence of water quality degradation. Hardness did not measurably change between the EWQ and post-EWQ periods. Hardness is inversely related to flow in the post-EWQ data, but unrelated to flow in the EWQ data. Post-EWQ median hardness fell within the EWQ 95% confidence intervals. Note that flows are plotted on a logarithmic scale.

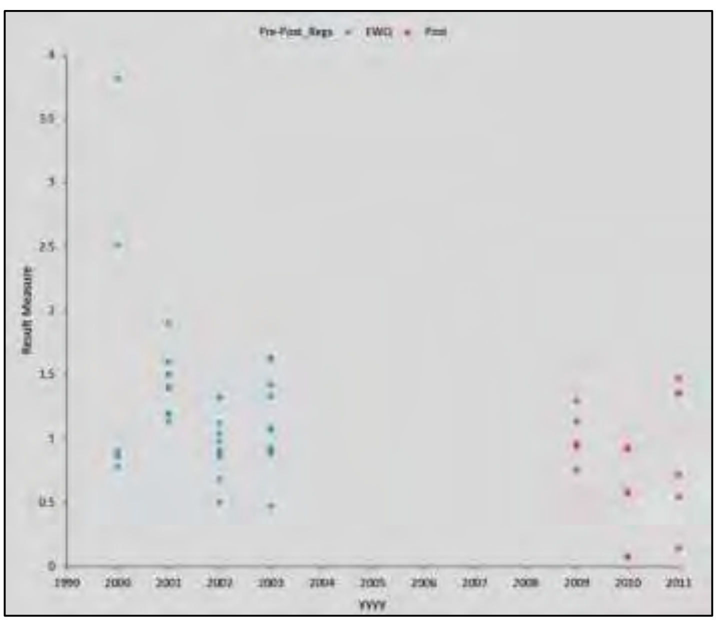
Chapter 6: 1540 BCP Lockatong Creek, NJ

Nitrate + Nitrite as N, Total mg/l

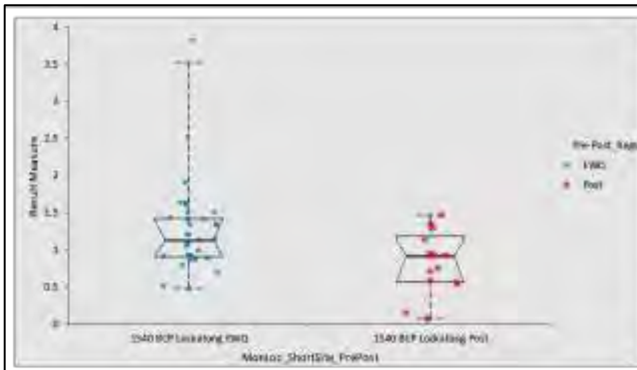
Existing Water Quality (Table 2U, as Nitrate only):

Median 1.13 mg/l
Lower 95% Confidence Interval 0.92 mg/l
Upper 95% Confidence Interval 1.40 mg/l

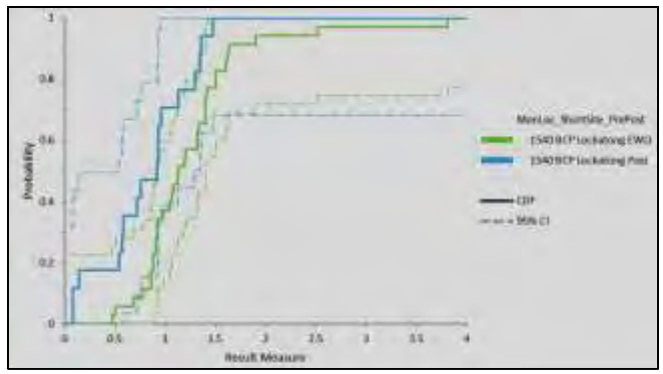




No water quality degradation is evident. Nitrate concentrations apparently declined between the EWQ and post-EWQ periods. However, potential laboratory artifacts and too few post-EWQ samples introduced uncertainty in conclusions.



N	52					
Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1540 BCP Lockatong EWQ	0.47	0.90	1.13	1.42	3.81	0.52
1540 BCP Lockatong Post	0.08	0.56	0.92	1.19	1.47	0.63



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1540 BCP Lockatong EWQ	35	475.5	13.58
1540 BCP Lockatong Post	17	978.9	57.58

H statistic	6.34
X^2 approximation	6.34
DF	1
p-value	0.0118[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.

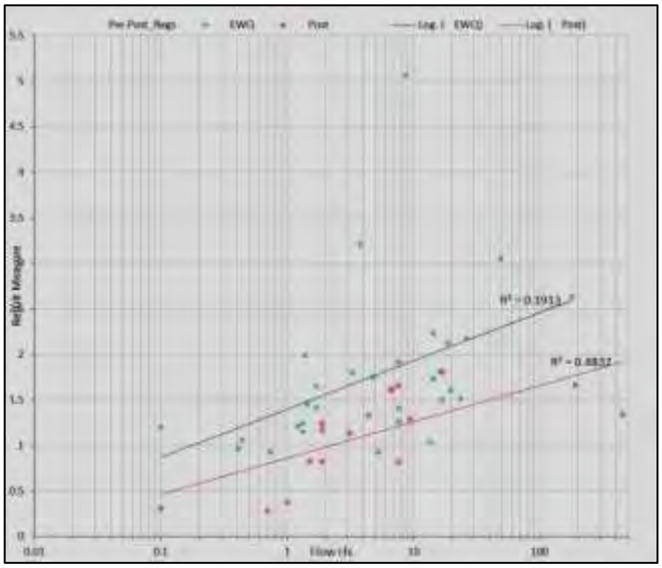
In both data sets, nitrate is unrelated to flow. On the annual plot, 2002-2003 EWQ nitrates appear to match well with post-EWQ nitrate + nitrite for 2009-2011. Post-EWQ Nitrate + Nitrite concentrations are assumed equivalent with EWQ nitrate concentrations, since EWQ nitrite concentrations were never detected. Independent data were not available for validation of results. Post-EWQ median nitrate + nitrite concentrations fell to the EWQ lower 95% confidence interval. Water quality may have improved, as there were no non-detect results to cloud a statistical comparison.

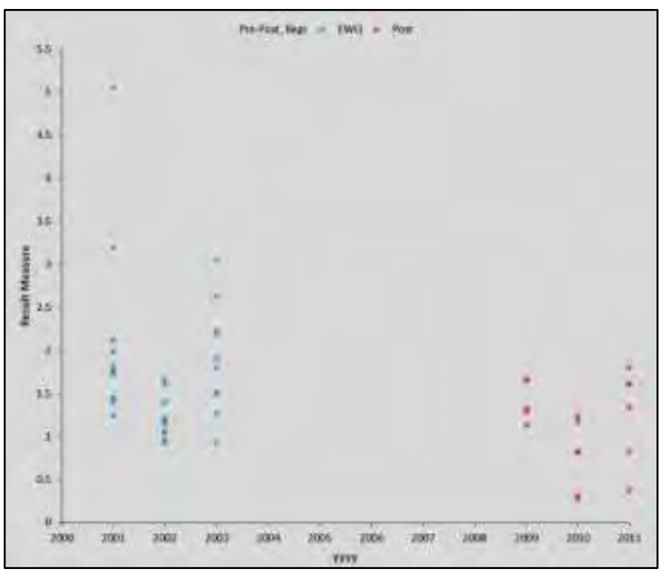
Chapter 6: 1540 BCP Lockatong Creek, NJ

Nitrogen as N, Total (TN) mg/l

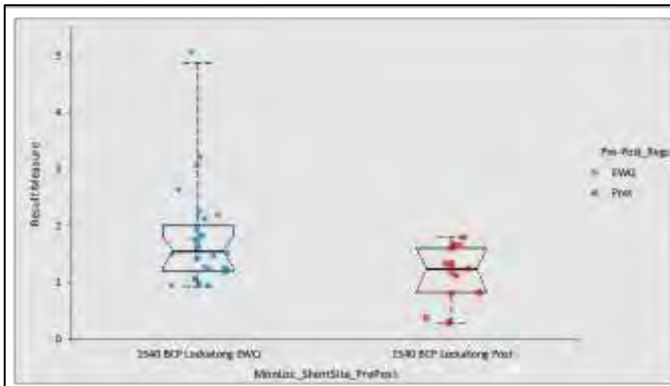
Existing Water Quality (Table 2U):

Median 1.56 mg/l
Lower 95% Confidence Interval 1.26 mg/l
Upper 95% Confidence Interval 1.81 mg/l



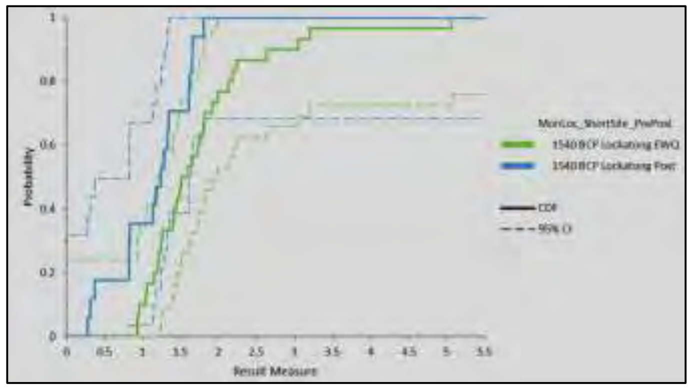


No water quality degradation is evident. Total Nitrogen concentrations apparently declined between the EWQ and post-EWQ periods. However, potential laboratory artifacts and too few post-EWQ samples introduced uncertainty in conclusions.



N 47

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1540 BCP Lockatong EWQ	0.93	1.21	1.56	2.00	5.06	0.79
1540 BCP Lockatong Post	0.28	0.82	1.24	1.61	1.80	0.79



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1540 BCP Lockatong EWQ	30	472.0	15.73
1540 BCP Lockatong Post	17	833.0	49.00

H statistic	6.94
X^2 approximation	6.94
DF	1
p-value	0.0084 [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.

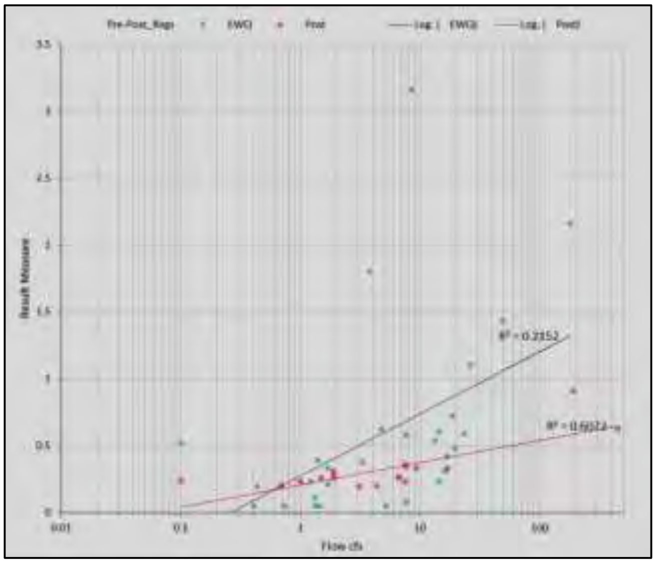
TN is strongly related to flow in the post-EWQ period, but weakly related to flow in the EWQ period due to skewing of the regression by some outlier samples. Note that flows are plotted on a logarithmic scale. DRBC results could not be independently validated. Post-EWQ median TN concentrations fell just below the EWQ lower 95% confidence interval.

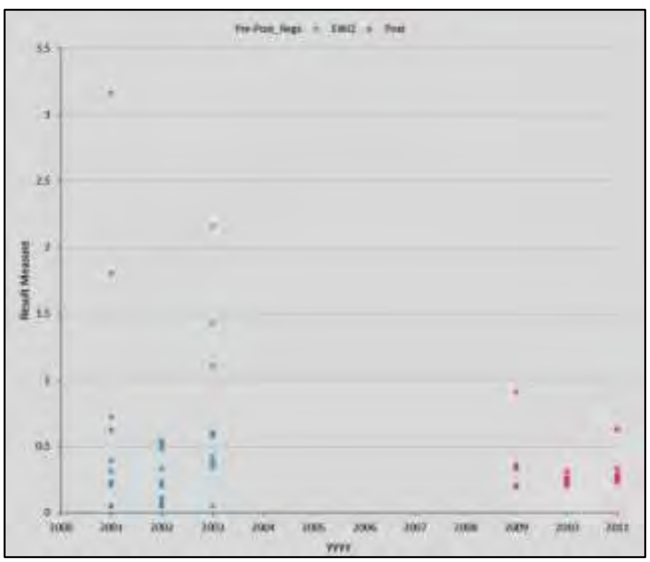
Chapter 6: 1540 BCP Lockatong Creek, NJ

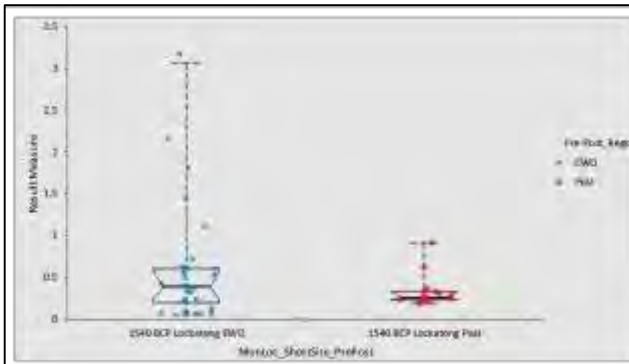
Nitrogen, Kjeldahl as N, Total (TKN) mg/l

Existing Water Quality (Table 2U):

Median 0.39 mg/l
Lower 95% Confidence Interval 0.23 mg/l
Upper 95% Confidence Interval 0.58 mg/l

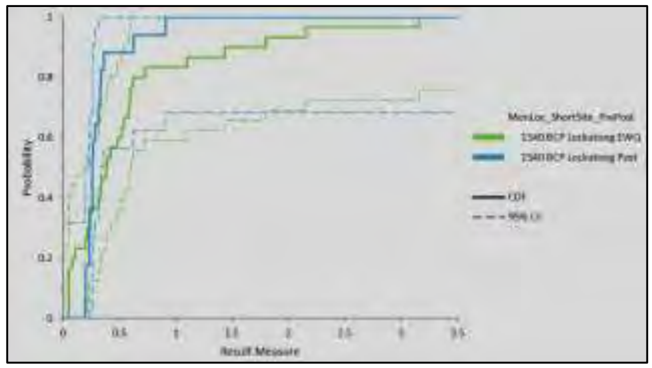






N 47

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1540 BCP Lockatong EWQ	0.05	0.19	0.39	0.60	3.16	0.41
1540 BCP Lockatong Post	0.20	0.23	0.26	0.33	0.91	0.10



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1540 BCP Lockatong EWQ	30	67.5	2.25
1540 BCP Lockatong Post	17	119.1	7.01

H statistic	0.99
X^2 approximation	0.99
DF	1
p-value	0.3188 [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. TKN concentrations apparently declined between the two periods. However, potential laboratory artifacts and too few post-EWQ samples introduced uncertainty in conclusions. TKN concentration is related to flow in both data sets, though weakly so in the EWQ data because of some high values that skew the regression.

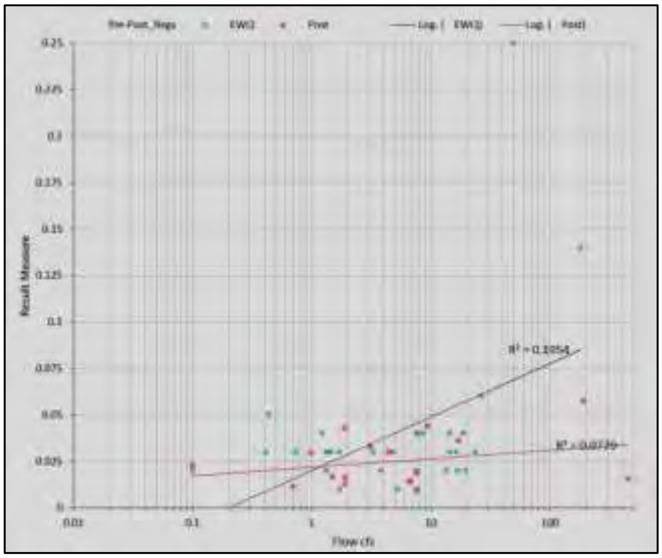
TKN ranges less widely and is less variable in the post-EWQ data set. Post-EWQ median TKN fell to just above the EWQ lower 95% confidence interval. There are no discrepancies in detection limits between the two data sets. Although results may indicate a water quality improvement, there still could be differences attributable to separate laboratories, which is unaccounted because no split sampling was conducted upon laboratory changes.

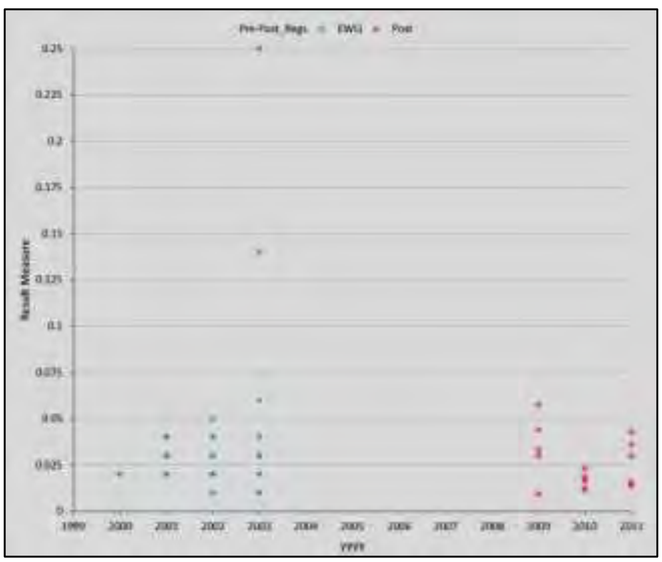
Chapter 6: 1540 BCP Lockatong Creek, NJ

Orthophosphate as P, Total mg/l (OP)

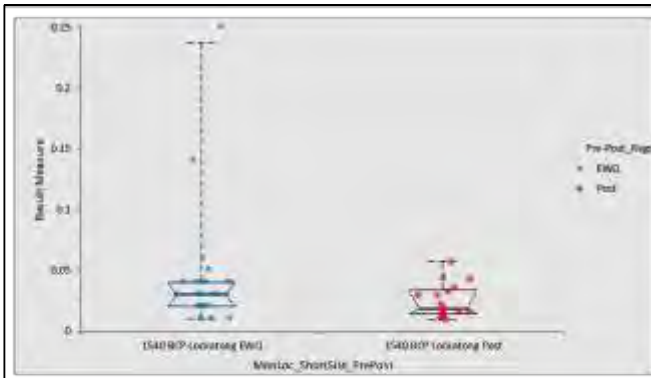
Existing Water Quality (Table 2U):

Median 0.03 mg/l
Lower 95% Confidence Interval 0.02 mg/l
Upper 95% Confidence Interval 0.04 mg/l



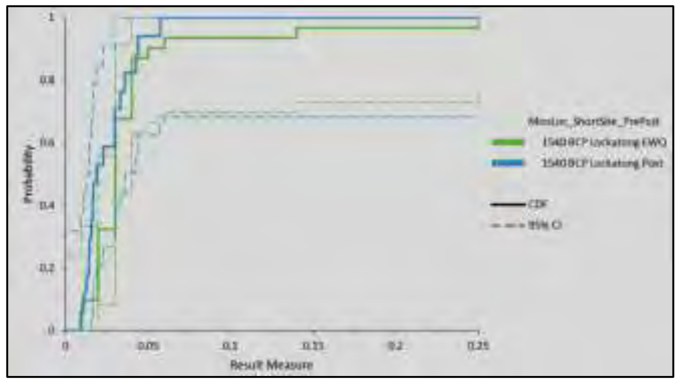


No water quality degradation is evident. OP apparently did not change between the two periods. Analytical uncertainty included potential laboratory artifacts, insufficient post-EWQ sampling (n=17), and detection limit differences. Orthophosphate is weakly related to flow in EWQ data, but unrelated to flow in post-EWQ data.



N 48

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1540 BCP Lockatong EWQ	0.01	0.02	0.03	0.04	0.25	0.02
1540 BCP Lockatong Post	0.01	0.01	0.02	0.03	0.06	0.02



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1540 BCP Lockatong EWQ	31	235.8	7.61
1540 BCP Lockatong Post	17	430.0	25.29

H statistic	3.46
X^2 approximation	3.46
DF	1
p-value	0.0630 [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.

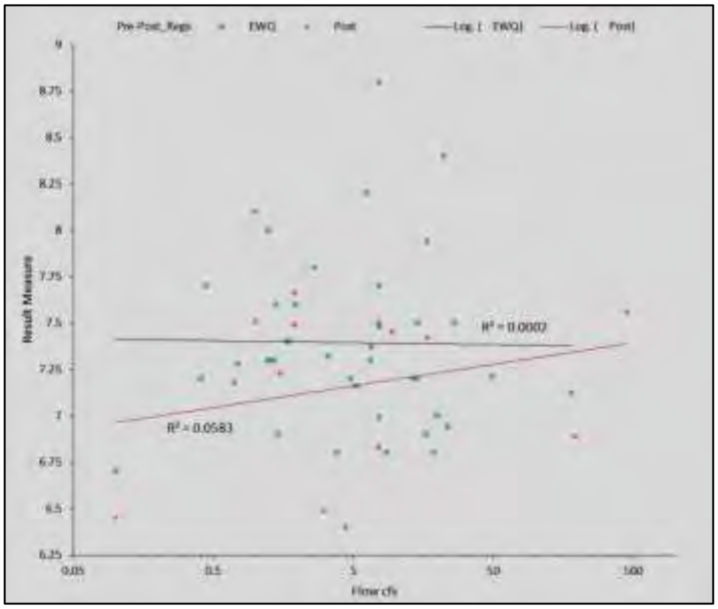
Post-EWQ median orthophosphate was within the EWQ 95% confidence intervals. There were no independent data to confirm DRBC results. DRBC detection limits improved between the two periods, but there were only three non-detect results in EWQ data and there were no non-detect results in post-EWQ data. Thus there was no interference in estimation of the median in either data set. Some improvement in water quality may be evident in that there are no values above 0.05 mg/l in the post-EWQ data set, but there was insufficient post-EWQ data (n=17) to conclusively document such an improvement.

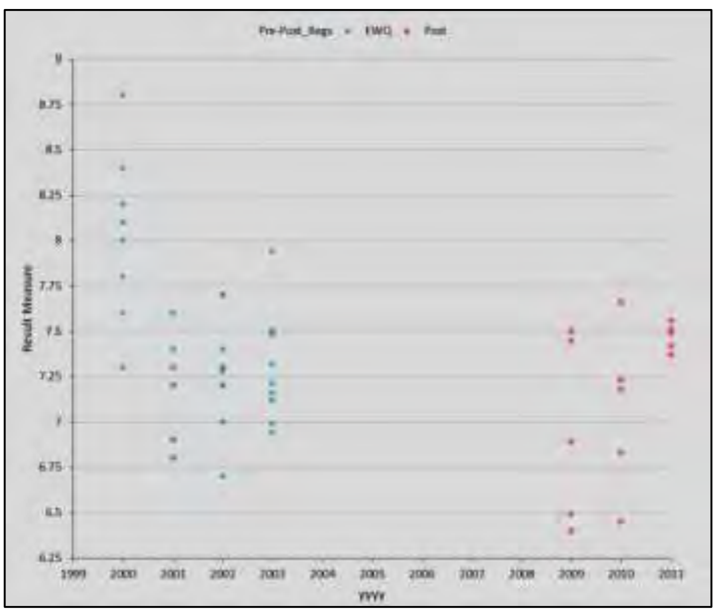
Chapter 6: 1540 BCP Lockatong Creek, NJ

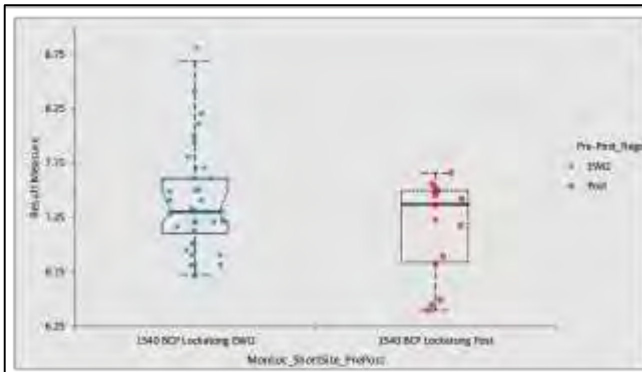
pH, units

Existing Water Quality (Table 2U):

Median 7.30 standard units
Lower 95% Confidence Interval 7.20 standard units
Upper 95% Confidence Interval 7.50 standard units

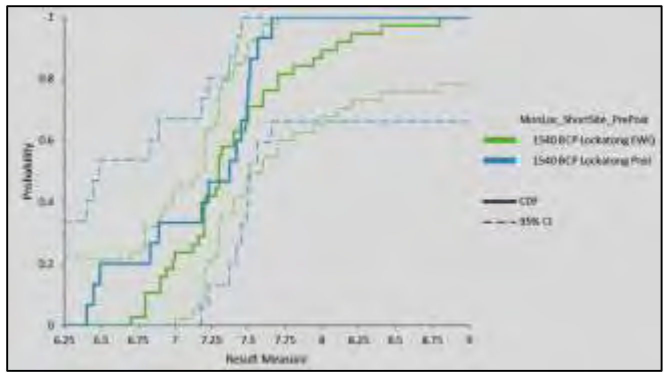






N 53

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1540 BCP Lockatong EWQ	6.70	7.11	7.30	7.61	8.80	0.50
1540 BCP Lockatong Post	6.40	6.84	7.37	7.50	7.66	0.66



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1540 BCP Lockatong EWQ	38	55.7	1.47
1540 BCP Lockatong Post	15	141.1	9.40

H statistic	0.83
X^2 approximation	0.83
DF	1
p-value	0.3634 [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.

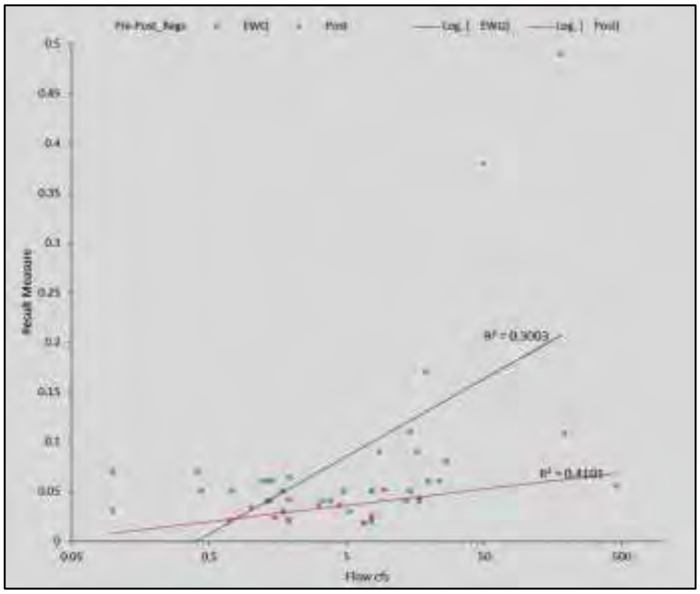
No water quality degradation is evident. pH did not measurably change between the EWQ and post-EWQ periods. pH is unrelated to flow in both data sets. Post-EWQ median pH was within the EWQ 95% confidence intervals. Note that flows are plotted on a logarithmic scale.

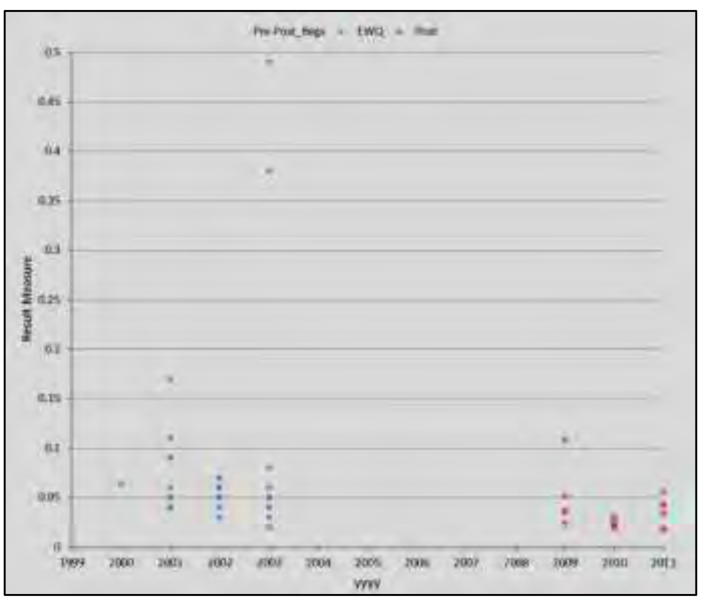
Chapter 6: 1540 BCP Lockatong Creek, NJ

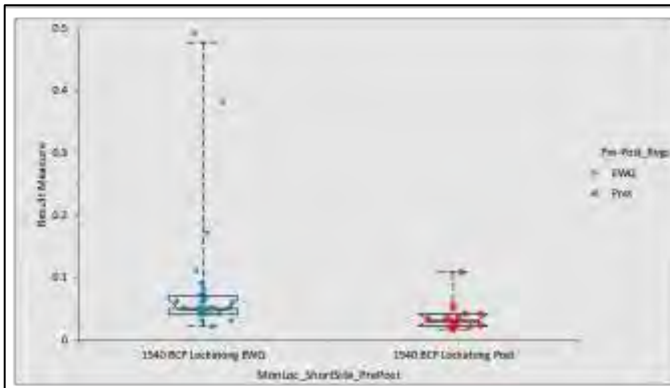
Phosphorus as P, Total (TP) mg/l

Existing Water Quality (Table 2U):

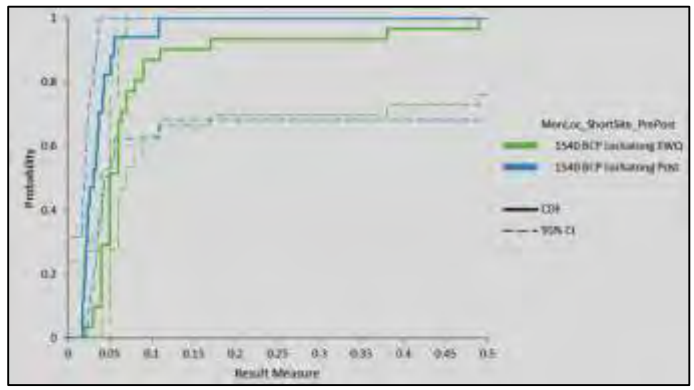
Median 0.05 mg/l
Lower 95% Confidence Interval 0.05 mg/l
Upper 95% Confidence Interval 0.06 mg/l







N	48					
Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1540 BCP Lockatong EWQ	0.020	0.040	0.050	0.070	0.490	0.030
1540 BCP Lockatong Post	0.018	0.021	0.031	0.042	0.108	0.021



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1540 BCP Lockatong EWQ	31	926.8	29.90
1540 BCP Lockatong Post	17	1690.0	99.41

H statistic	13.43
X^2 approximation	13.43
DF	1
p-value	0.0002 [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. Total Phosphorus (TP) concentrations apparently declined between the EWQ and post-EWQ periods. However, potential laboratory artifacts and too few post-EWQ samples introduced uncertainty in conclusions.

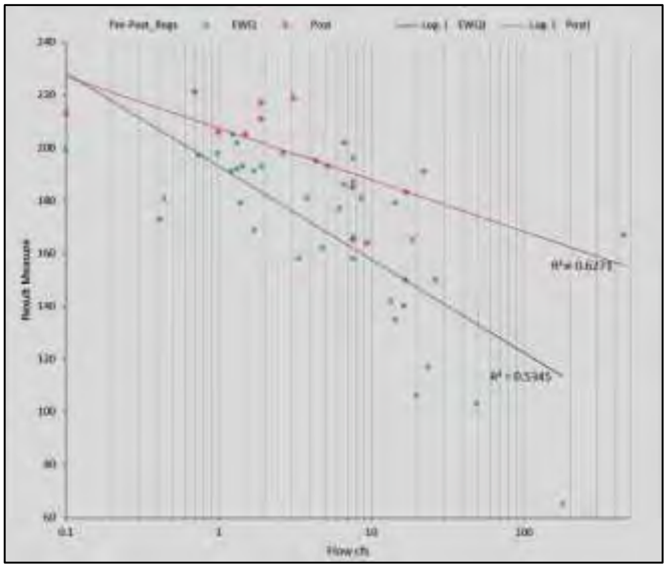
Post-EWQ median total phosphorus fell below the EWQ lower 95% confidence interval. TP is positively related to flow in both data sets, though TP was not designated as such in DRBC water quality regulations. The EWQ flow relationship is skewed by two high outlier values from samples taken in July and September 2003. Note that flows are plotted on a logarithmic scale. No independent data were available to confirm these results.

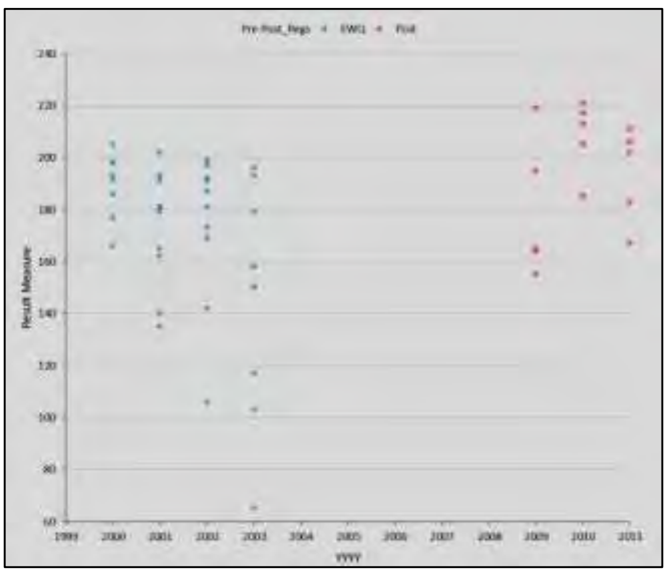
Chapter 6: 1540 BCP Lockatong Creek, NJ

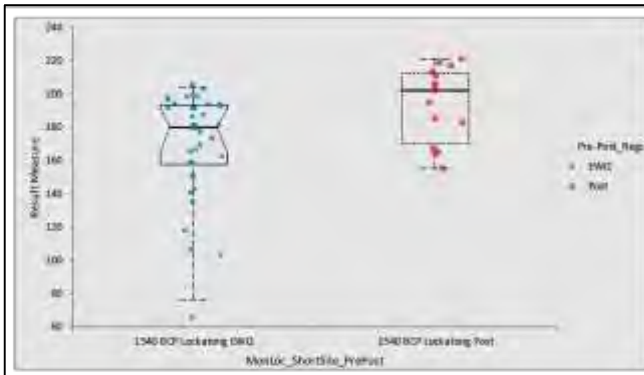
Specific Conductance µmho/cm

Existing Water Quality (Table 2U):

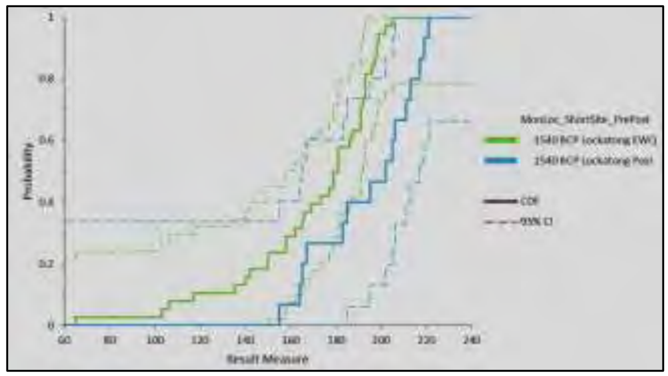
Median 180 µmho/cm
Lower 95% Confidence Interval 165 µmho/cm
Upper 95% Confidence Interval 191 µmho/cm
Defined in regulations as a flow-related parameter







Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
N	53					
1540 BCP Lockatong EWQ	65	157	180	193	205	36
1540 BCP Lockatong Post	155	170	202	213	221	43



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1540 BCP Lockatong EWQ	38	512.1	13.48
1540 BCP Lockatong Post	15	1297.4	86.49

H statistic	7.59
X² approximation	7.59
DF	1
p-value	0.0059 [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.

Water quality degradation is evident. Specific conductance rose above the EWQ upper 95% confidence interval between the EWQ and post-EWQ periods. In both data sets, specific conductance is inversely related to flow.

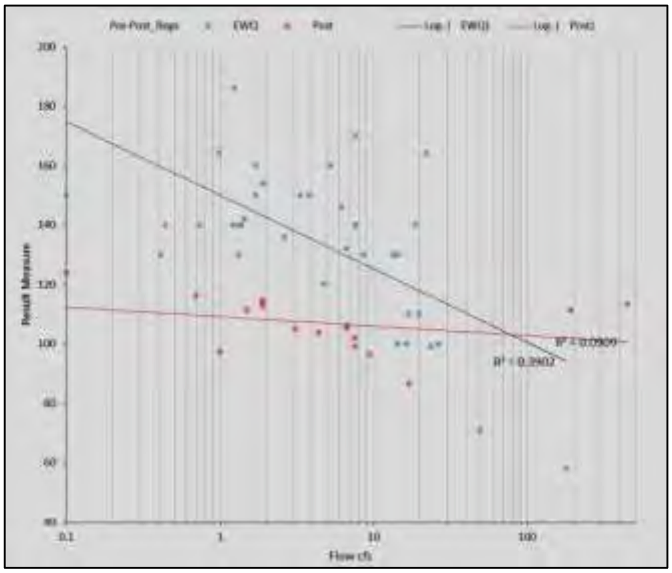
Note that flow is plotted on a logarithmic scale. The rise in specific conductance may be attributable to the concurrent rise in chloride concentrations. No new dischargers are present in the watershed. Median specific conductance rose from 180 to 202 µmho/cm, a 12% increase.

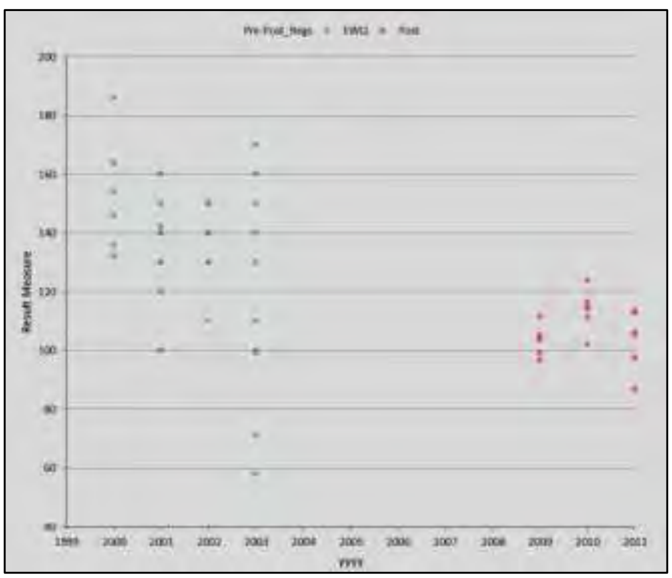
Chapter 6: 1540 BCP Lockatong Creek, NJ

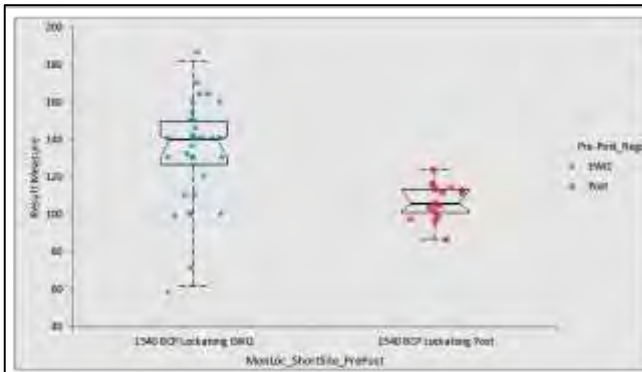
Total Dissolved Solids (TDS) mg/l

Existing Water Quality (Table 2U):

Median 140 mg/l
Lower 95% Confidence Interval 130 mg/l
Upper 95% Confidence Interval 142 mg/l
Defined in regulations as a flow-related parameter

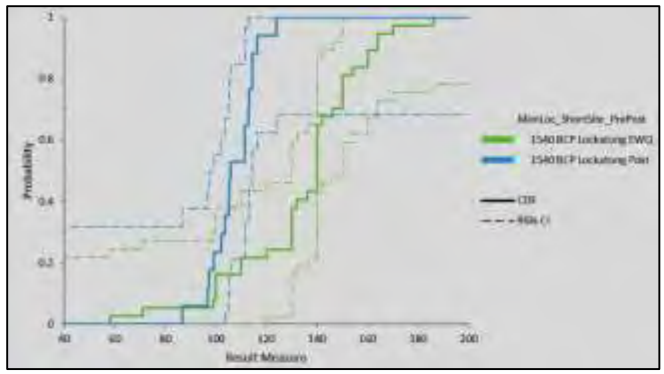






N 54

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1540 BCP Lockatong EWQ	58	127	140	150	186	23
1540 BCP Lockatong Post	87	101	106	114	124	13



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1540 BCP Lockatong EWQ	37	1197.6	32.37
1540 BCP Lockatong Post	17	2606.5	153.32

H statistic	15.44
X^2 approximation	15.44
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. TDS apparently declined between the EWQ and post-EWQ periods. However, potential laboratory artifacts and too few post-EWQ samples introduced uncertainty in conclusions.

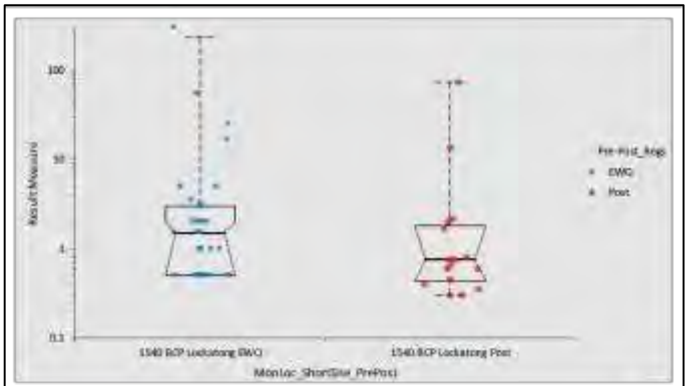
TDS is inversely and strongly related to flow in the EWQ data set, but unrelated to flow in the post-EWQ data set. Post-EWQ TDS varied very little because both high and low flow conditions were not well-represented – there were too few post-EWQ samples taken to cover the flow regime (n=17). Post-EWQ median TDS was well below the EWQ 95% lower confidence interval. Detection limit differences did not influence the data, and there were no non-detect results at any time. Note that flows are plotted on a logarithmic scale.

Chapter 6: 1540 BCP Lockatong Creek, NJ

Total Suspended Solids (TSS) mg/l

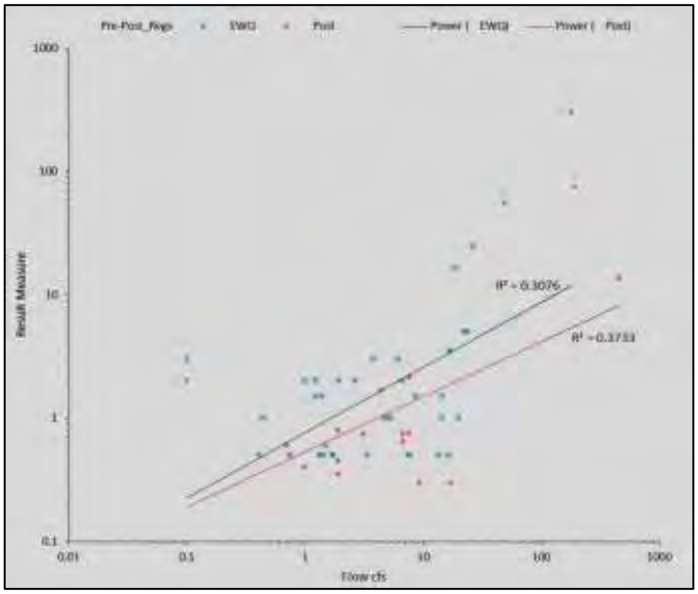
Existing Water Quality (Table 2U):

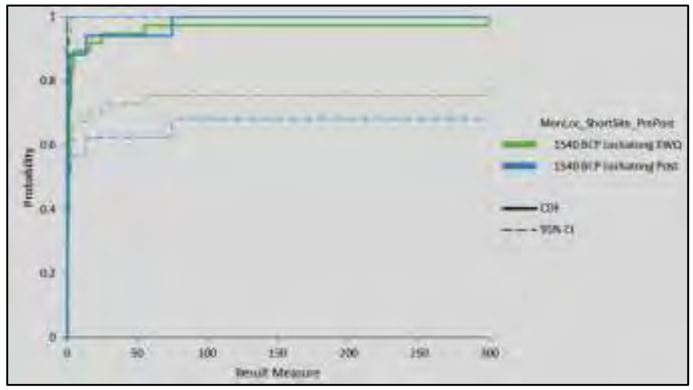
Median 1.0 mg/l
Lower 95% Confidence Interval 0.5 mg/l
Upper 95% Confidence Interval 2.0 mg/l
Defined in regulations as a flow-related parameter

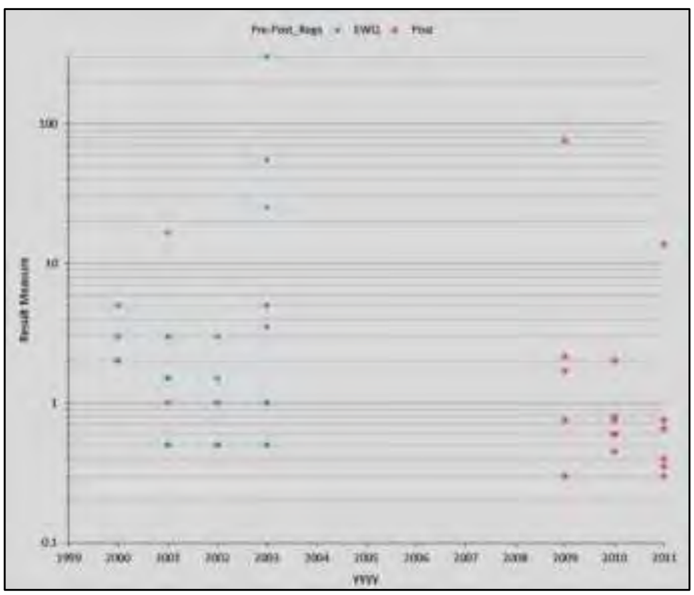


N 54

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1540 BCP Lockatong EWQ	0.50	0.50	1.50	3.00	300.00	2.50
1540 BCP Lockatong Post	0.30	0.43	0.75	1.80	74.55	1.37







Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1540 BCP Lockatong EWQ	37	166.5	4.50
1540 BCP Lockatong Post	17	362.5	21.32

H statistic	2.17
X^2 approximation	2.17
DF	1
p-value	0.1405 [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.

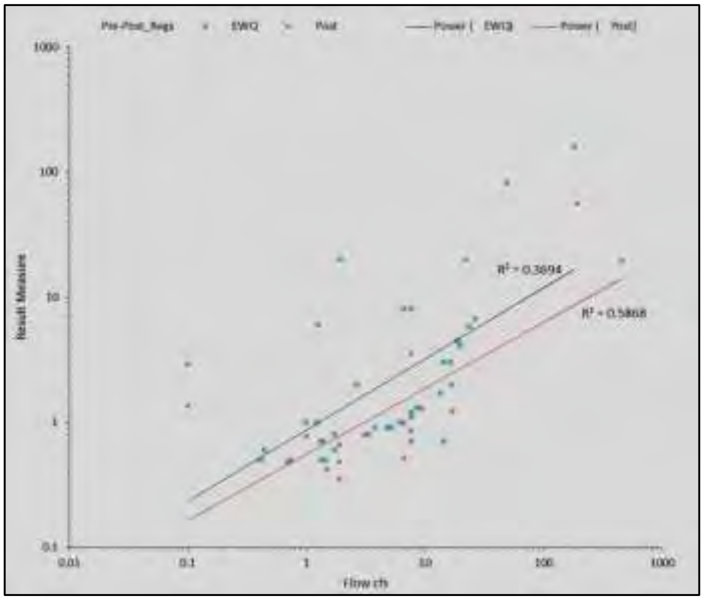
No water quality degradation is evident. TSS did not measurably change between the EWQ and post-EWQ periods. TSS is positively related to flow in both data sets. Post-EWQ median TSS was within the EWQ 95% confidence intervals. Note that both flow and concentration are plotted on a logarithmic scale.

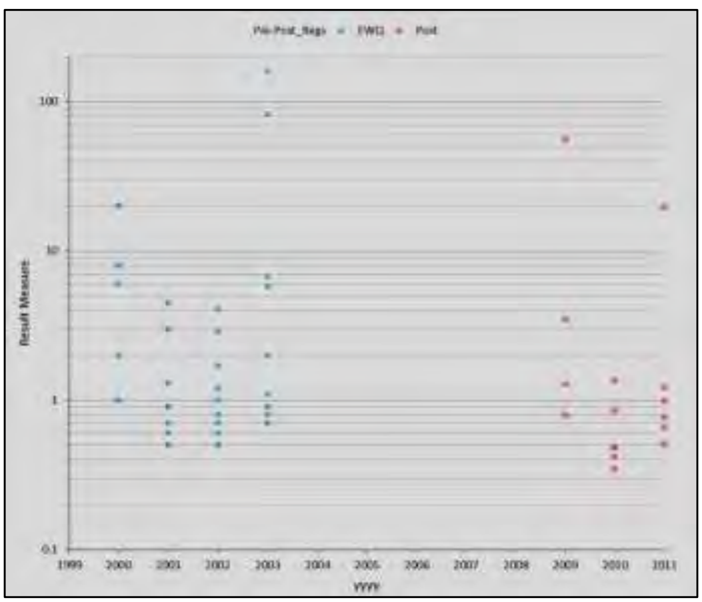
Chapter 6: 1540 BCP Lockatong Creek, NJ

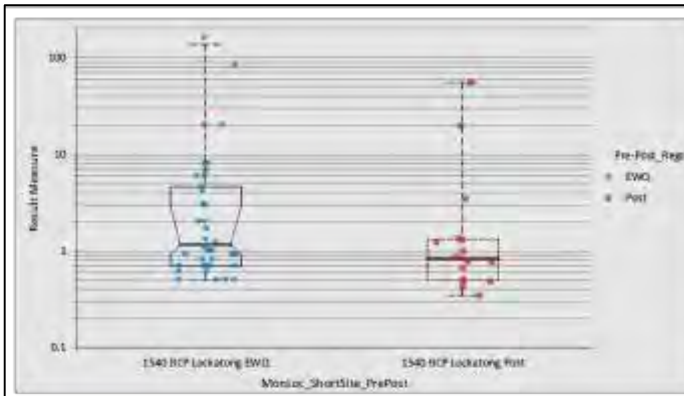
Turbidity NTU

Existing Water Quality (Table 2U):

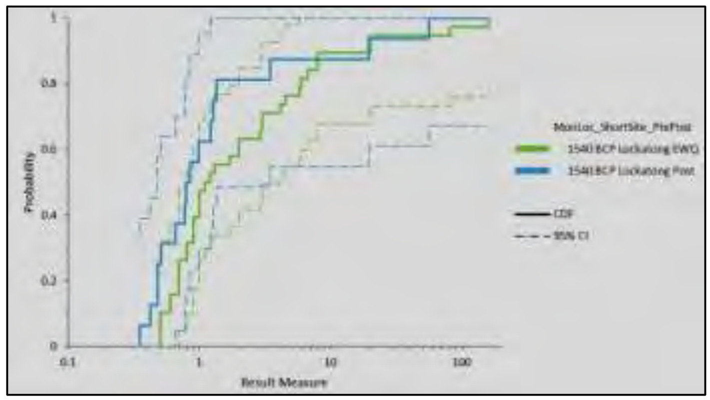
Median 1.2 NTU
Lower 95% Confidence Interval 0.8 NTU
Upper 95% Confidence Interval 3.0 NTU
Defined in regulations as a flow-related parameter







N	54					
Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1540 BCP Lockatong EWQ	0.5	0.7	1.2	4.6	160.0	3.9
1540 BCP Lockatong Post	0.4	0.5	0.8	1.3	56.1	0.8



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1540 BCP Lockatong EWQ	38	208.4	5.49
1540 BCP Lockatong Post	16	495.1	30.94

H statistic	2.85
X^2 approximation	2.85
DF	1
p-value	0.0916 [1]

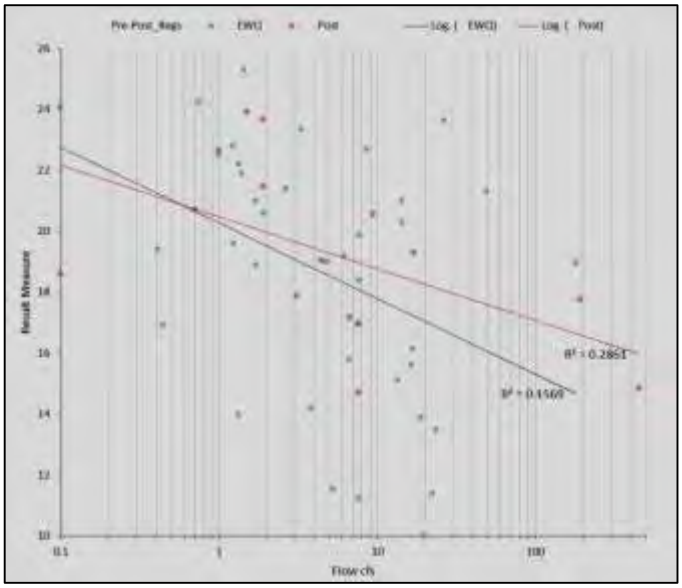
H0: $\theta_1 = \theta_2 = \theta_{...}$
The median of the populations are all equal.
H1: $\theta_i \neq \theta_j$ for at least one i,j
The median of the populations are not all equal.
[1] Do not reject the null hypothesis at the 5% significance level.

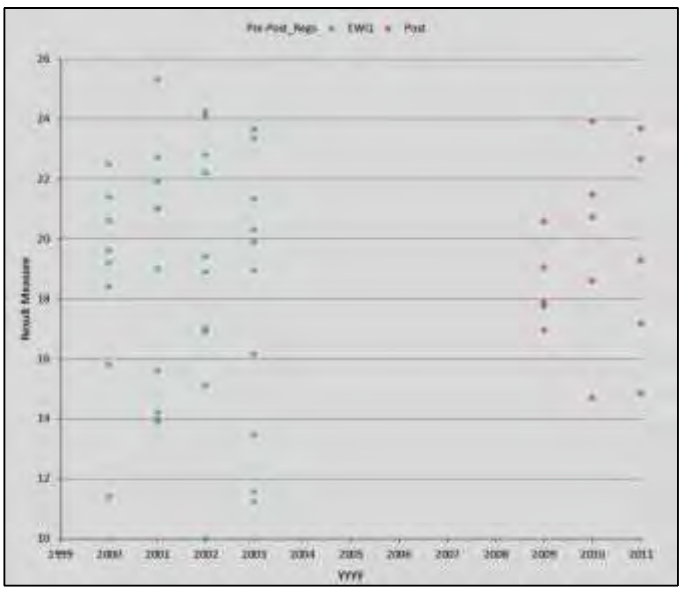
No water quality degradation is evident. Turbidity did not measurably change between the EWQ and post-EWQ periods. The post-EWQ median turbidity fell within the EWQ 95% confidence intervals of the median. In both data sets, the turbidity vs. flow relationship is positive. Note that both concentration and flow is represented on logarithmic scales in all charts.

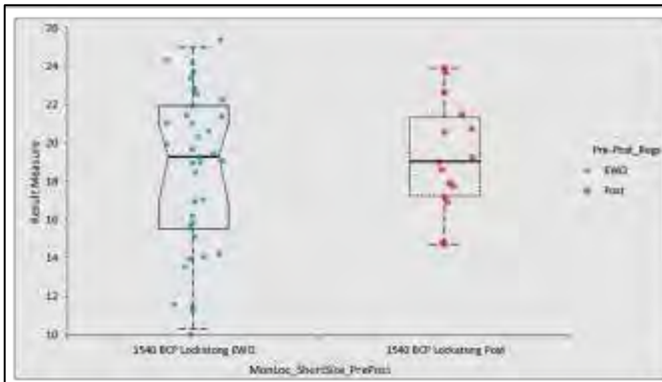
Chapter 6: 1540 BCP Lockatong Creek, NJ

Water Temperature, degrees C

Not included in DRBC Existing Water Quality rules

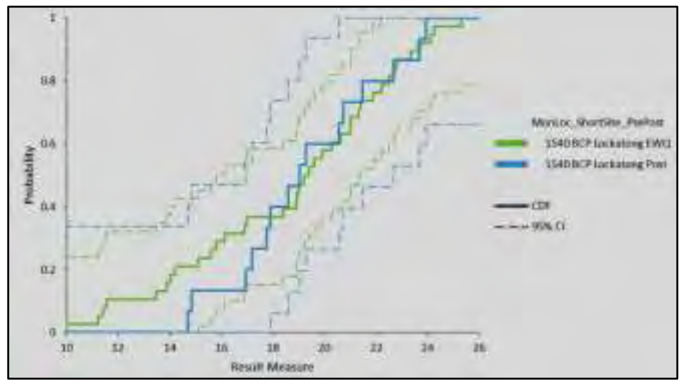






N	53

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1540 BCP Lockatong EWQ	10.0	15.6	19.3	21.9	25.3	6.4
1540 BCP Lockatong Post	14.7	17.3	19.0	21.4	23.9	4.1



Kruskal-Wallis test

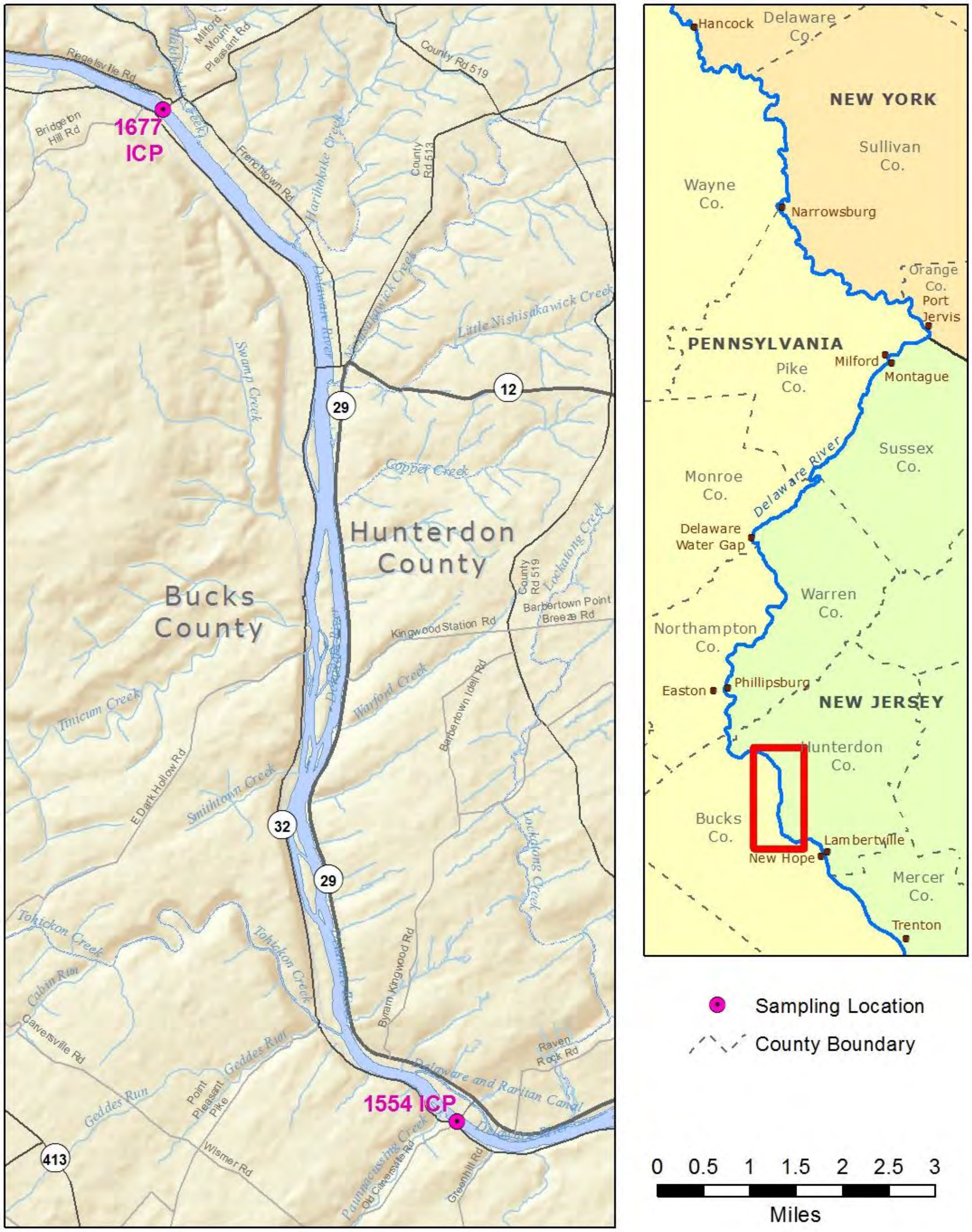
Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1540 BCP Lockatong EWQ	38	5.2	0.14
1540 BCP Lockatong Post	15	13.1	0.87

H statistic	0.08
X^2 approximation	0.08
DF	1
p-value	0.7822[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.

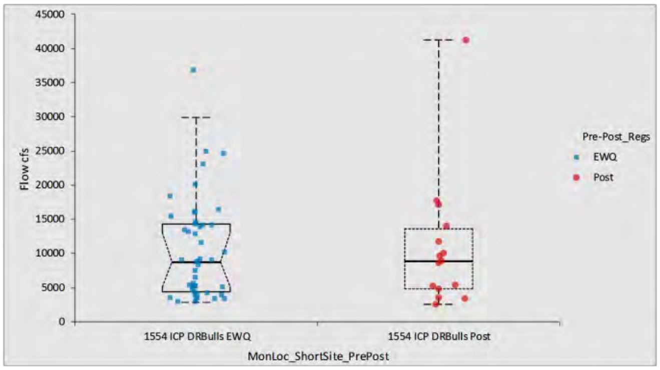
No water quality degradation is evident. Water temperature did not measurably change between the EWQ and post-EWQ periods. Water temperature is inversely but weakly related to flow in both data sets. Note that flows are plotted on a logarithmic scale.

Chapter 7: 1554 ICP Delaware River at Bulls Island Foot Bridge, NJ/PA



1554 ICP
Delaware River at Bull's Island Foot Bridge

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



N	64

Flow cfs by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1554 ICP DRBulls EWQ	2,767	4,415	8,766	14,231	36,680	9,816
1554 ICP DRBulls Post	2,559	4,858	8,846	13,640	41,262	8,783

Flow was not different between the two periods at this location, though EWQ flow was normally distributed and well-represented for the May to September period and post-EWQ flow was less representative of above-normal conditions due to too few post-EWQ water quality samples.

Kruskal-Wallis test

Flow cfs by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1554 ICP DRBulls EWQ	49	0.1	0.00
1554 ICP DRBulls Post	15	0.4	0.03

H statistic	0.00
X^2 approximation	0.00
DF	1
p-value	0.9684 [1]

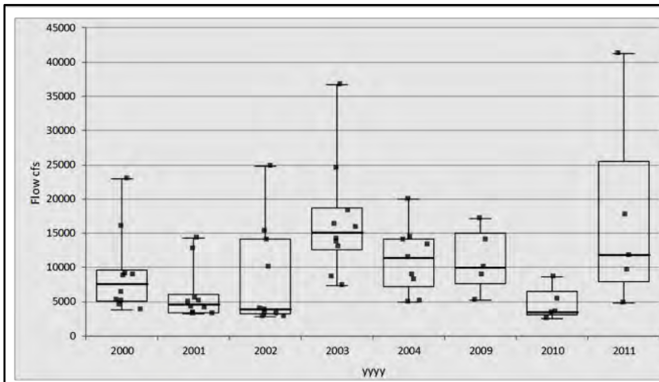
H0: $\theta_1 = \theta_2 = \theta\ldots$

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.



N	64

Flow cfs by yyyy	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
2000	3,799	5,059	7,537	9,670	22,967	4,611
2001	3,235	3,403	4,582	6,070	14,280	2,667
2002	2,767	3,261	3,829	14,104	24,762	10,844
2003	7,317	12,613	15,026	18,745	36,680	6,132
2004	4,983	7,187	11,458	14,123	20,040	6,936
2009	5,255	7,649	10,024	15,051	17,128	7,402
2010	2,559	3,065	3,474	6,452	8,690	3,387
2011	4,778	7,957	11,775	25,561	41,262	17,604

Annual flow statistics are plotted above. These are May to September flow measurements associated with the time of each water quality sample. Flow is estimated at this location using drainage area weighting based on the USGS continuous stream gage at Trenton, NJ. "Normal" flow is about 10,000 cfs at this location on the Delaware River.

Upstream ICP: Delaware River at Milford 1677 ICP
Downstream ICP: Del. River at Lambertville 1487 ICP

Tributary BCP Watersheds in Upstream Reach:

Paunnacussing Creek, PA – 1556 BCP
Tohickon Creek, PA – 1570 BCP
Tinicum Creek, PA – 1616 BCP
Nishisakawick Creek, NJ – 1641 BCP
Hakihokake Creek, NJ – 1672 BCP (new; EWQ def. in progress.)

All other tributaries to the upstream reach are less than 20 square miles drainage area, are not expected to have significant influence upon Delaware River water quality, and possess no wastewater discharges.

Chapter 7: 1554 ICP

Delaware River at Bulls Island Foot Bridge, NJ/PA

Alkalinity as CaCO3, Total mg/l

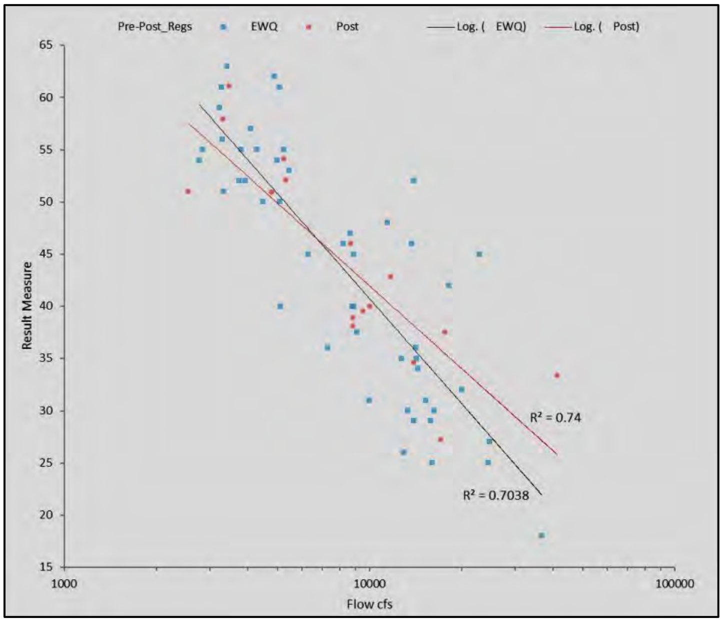
Existing Water Quality (Table 2T):

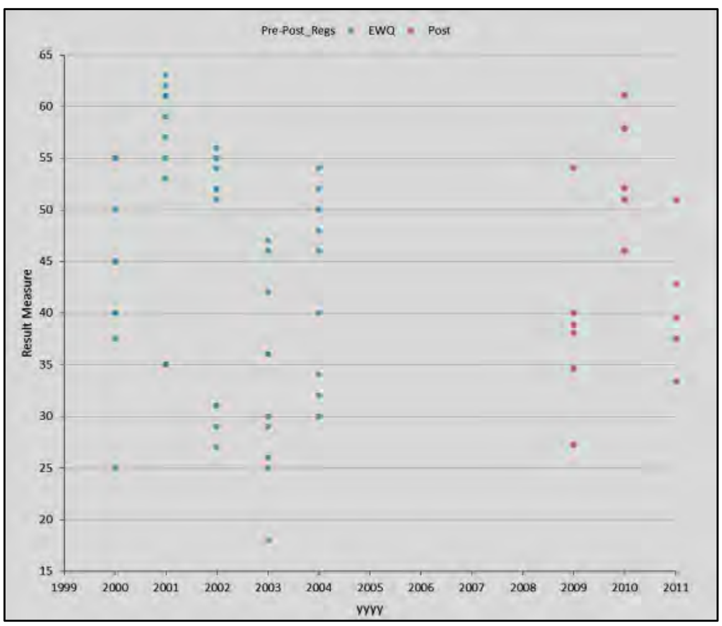
Median 45 mg/l

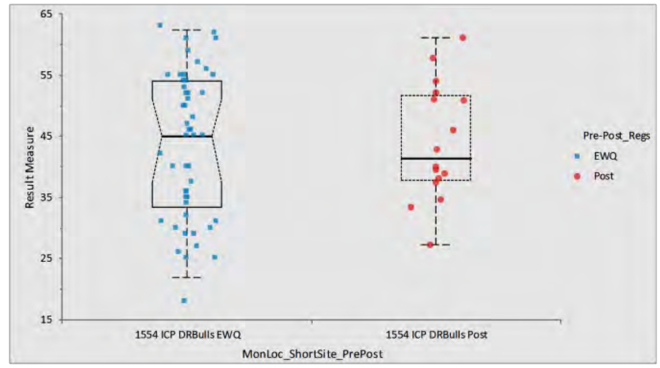
Lower 95% Confidence Interval 38 mg/l

Upper 95% Confidence Interval 51 mg/l

Defined in regulations as a flow-related parameter

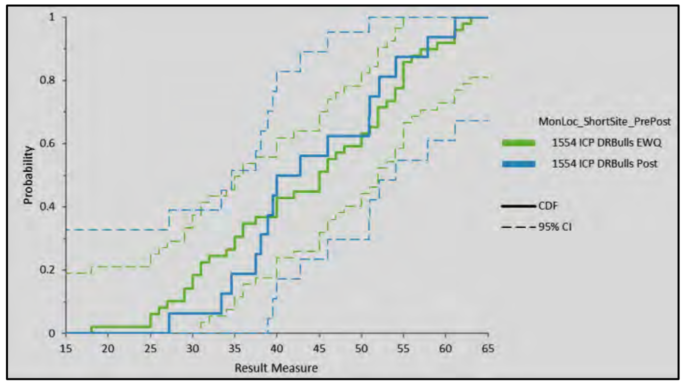






N 65

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1554 ICP DRBulls EWQ	18	33	45	54	63	21
1554 ICP DRBulls Post	27	38	41	52	61	14



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1554 ICP DRBulls EWQ	49	0.2	0.01
1554 ICP DRBulls Post	16	0.8	0.05

H statistic	0.00
X^2 approximation	0.00
DF	1
p-value	0.9575 [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.

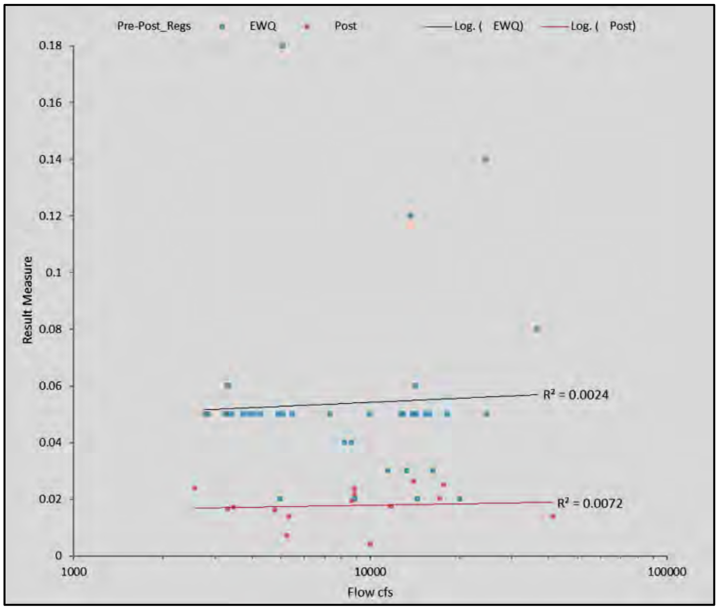
No water quality degradation is indicated. Alkalinity did not measurably change between the EWQ and post-EWQ periods. Alkalinity is inversely related to flow. Post-EWQ median alkalinity fell within the EWQ 95% confidence intervals. The overall distributions were closely matched.

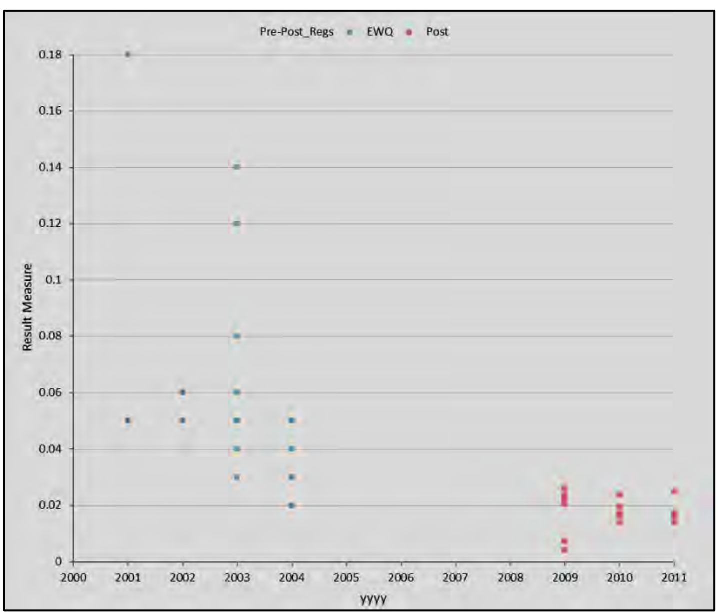
Chapter 7: 1554 ICP
Delaware River at Bulls Island Foot Bridge, NJ/PA

Ammonia Nitrogen as N, Total mg/l

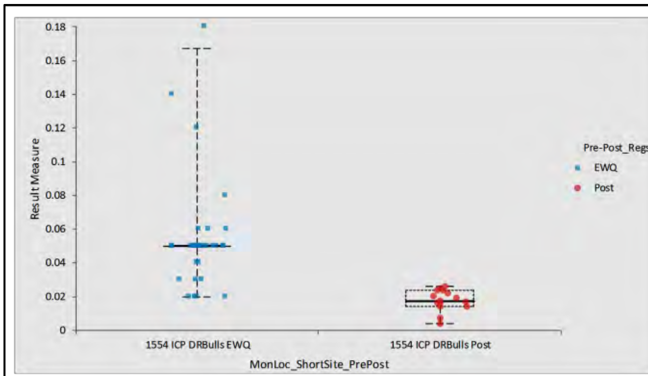
Existing Water Quality (Table 2T):

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



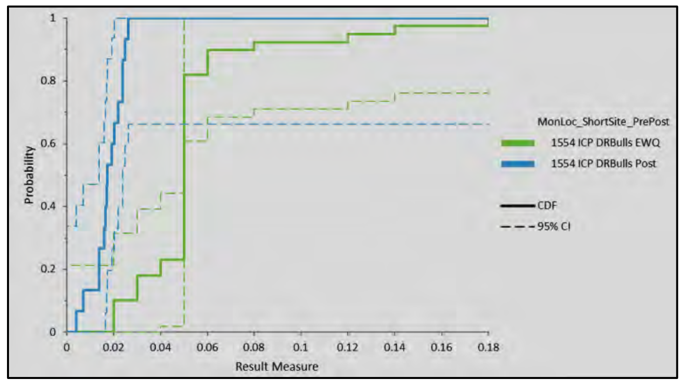


No water quality degradation is indicated. Ammonia concentrations apparently declined significantly. However, detection level differences and potential laboratory artifacts introduced uncertainty to conclusions.



N 54

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1554 ICP DRBulls EWQ	0.020	0.050	0.050	0.050	0.180	0.000
1554 ICP DRBulls Post	0.004	0.014	0.017	0.024	0.026	0.009



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1554 ICP DRBulls EWQ	39	1848.5	47.40
1554 ICP DRBulls Post	15	4806.2	320.41

H statistic	29.16
X^2 approximation	29.16
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 independent data were available to validate results. The post-EWQ detection limit (0.004-0.006 mg/l) was much lower than during the EWQ period (0.05 mg/l 2002-2003; 0.02 mg/l in 2004). EWQ data included 27/39 undetected results, interfering with calculation of the median. Under 2009-2011 lower detection levels there was one undetected result. Thus the result found by DRBC may not be a real change in ambient river concentrations, but simply that we now have defined the real concentrations below the EWQ 0.05 mg/l. No post-EWQ results were above 0.026 mg/l, where 18% (7/39) of EWQ results were above 0.05 mg/l. This implies a water quality improvement.

Chapter 7: 1554 ICP

Delaware River at Bulls Island Foot Bridge, NJ/PA

Chloride, Total mg/l

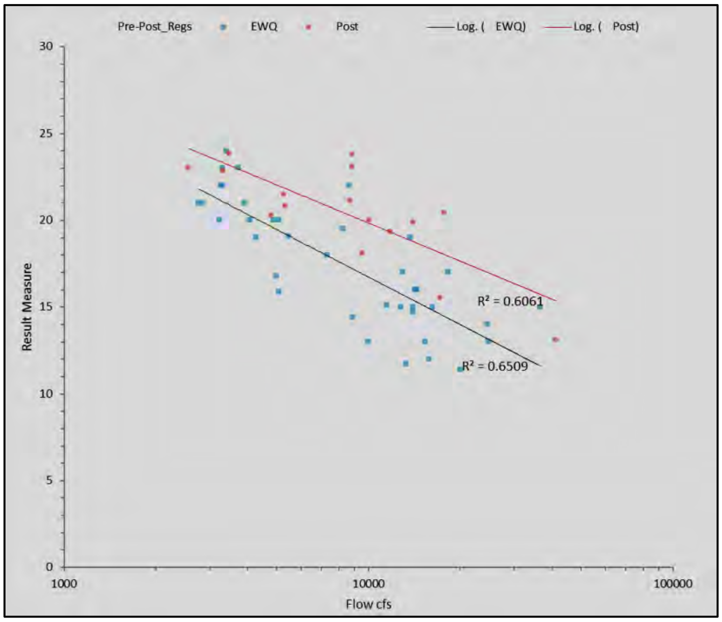
Existing Water Quality (Table 2T):

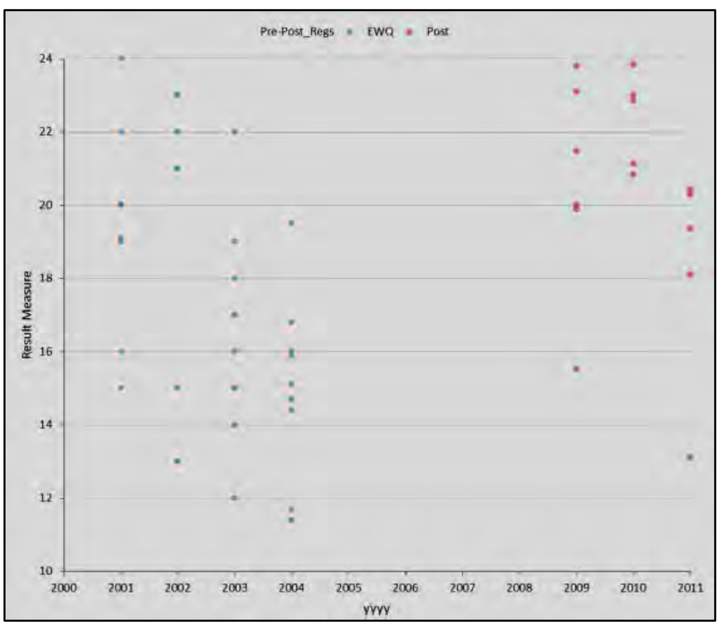
Median 17 mg/l

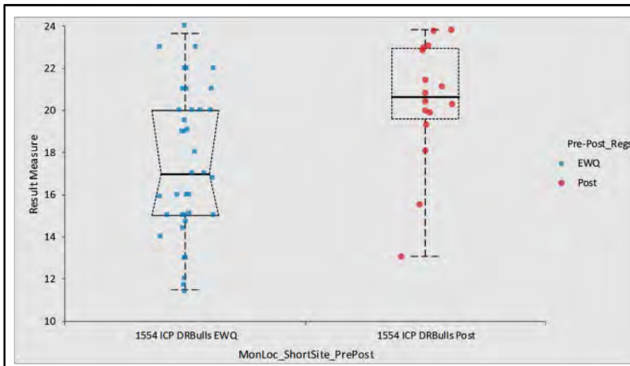
Lower 95% Confidence Interval 15 mg/l

Upper 95% Confidence Interval 20 mg/l

Defined in regulations as a flow-related parameter

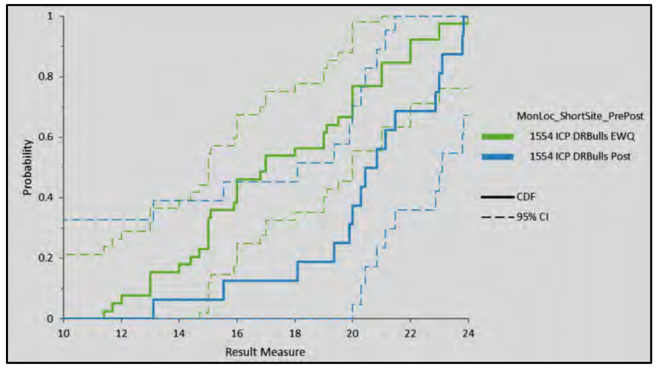






N | 55

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1554 ICP DRBulls EWQ	11.4	15.0	17.0	20.0	24.0	5.0
1554 ICP DRBulls Post	13.1	19.6	20.6	22.9	23.8	3.4



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1554 ICP DRBulls EWQ	39	592.4	15.19
1554 ICP DRBulls Post	16	1444.0	90.25

H statistic	7.95
X^2 approximation	7.95
DF	1
p-value	0.0048 [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.

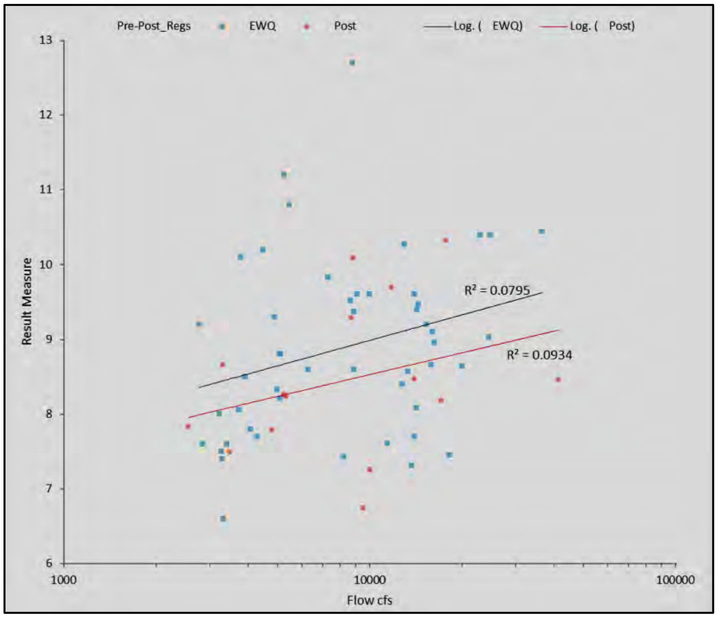
Evidence indicates water quality degradation. Chloride concentrations increased by about 3.6 mg/l (21%) between the two periods. Too few post-EWQ samples introduced some uncertainty in the conclusion, yet the difference still was significant. Post-EWQ median concentration was above the EWQ upper 95% confidence interval. Both sets are strongly related to flow. This is the furthest downstream Delaware River location where the increase in chloride concentrations was significant and above the upper Existing Water Quality target. Of course, more frequent sampling at Trenton, Washington Crossing and Lambertville might have produced a measurable difference downstream of this location, where smaller increases were measured.

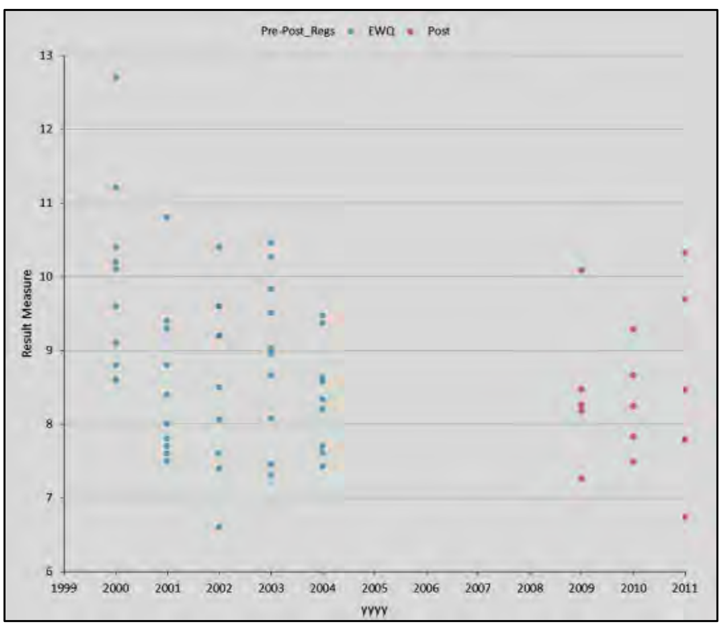
Chapter 7: 1554 ICP
Delaware River at Bulls Island Foot Bridge, NJ/PA

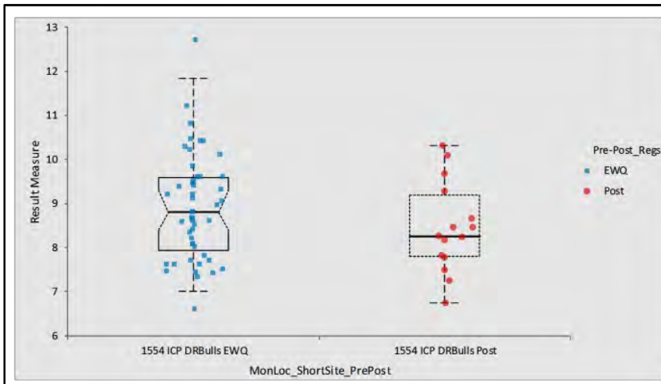
Dissolved Oxygen (DO) mg/l

Existing Water Quality (Table 2T):

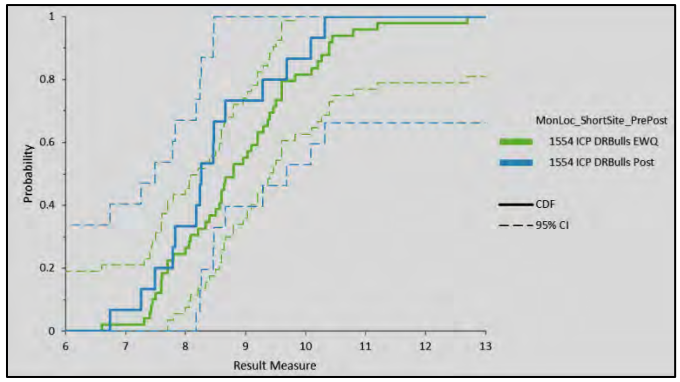
Median 8.80 mg/l
Lower 95% Confidence Interval 8.40 mg/l
Upper 95% Confidence Interval 9.30 mg/l







	N	64				
Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1554 ICP DRBulls EWQ	6.60	7.93	8.80	9.60	12.70	1.67
1554 ICP DRBulls Post	6.74	7.80	8.26	9.19	10.32	1.39



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1554 ICP DRBulls EWQ	49	124.2	2.53
1554 ICP DRBulls Post	15	405.6	27.04

H statistic	1.53
X^2 approximation	1.53
DF	1
p-value	0.2163[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. No measurable DO change took place between the EWQ and Post-EWQ periods. Post-EWQ dissolved oxygen concentrations fell below the EWQ lower 95% confidence interval, but overall the data distributions were not significantly different. There were too few measurements taken in the post-EWQ period. Bi-weekly instead of monthly sampling is recommended to improve statistical comparisons. DO concentration was unrelated to flow in both data sets.

Chapter 7: 1554 ICP

Delaware River at Bulls Island Foot Bridge, NJ/PA

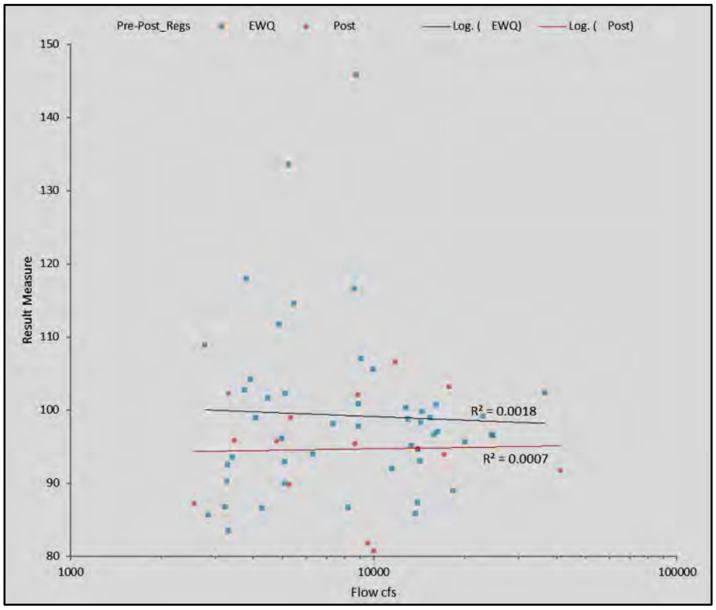
Dissolved Oxygen Saturation %

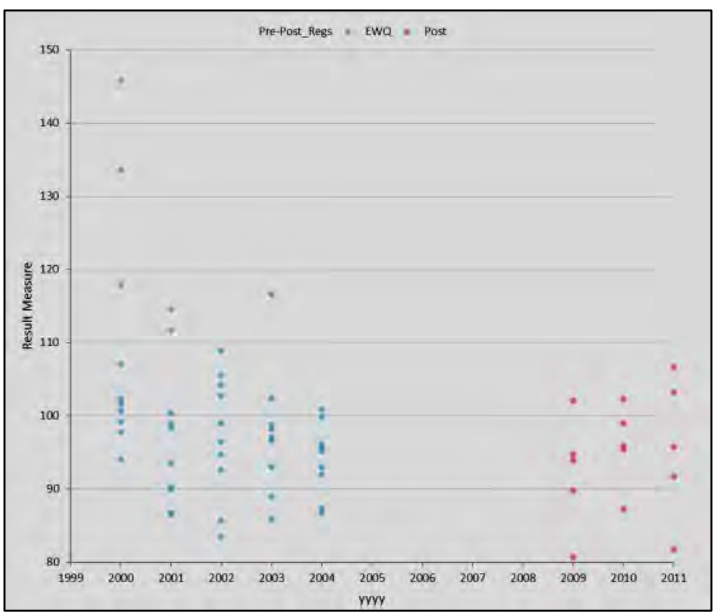
Existing Water Quality (Table 2T):

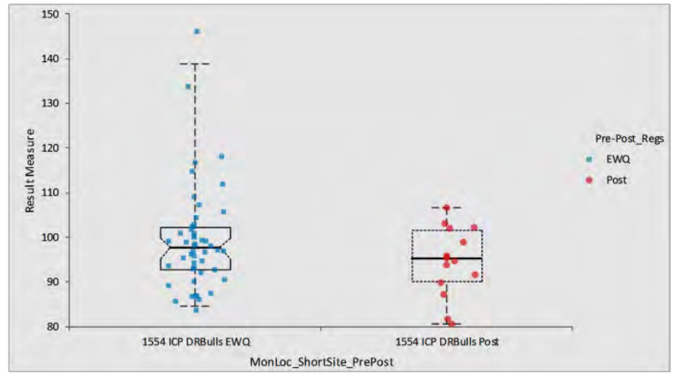
Median 98%

Lower 95% Confidence Interval 95%

Upper 95% Confidence Interval 100%

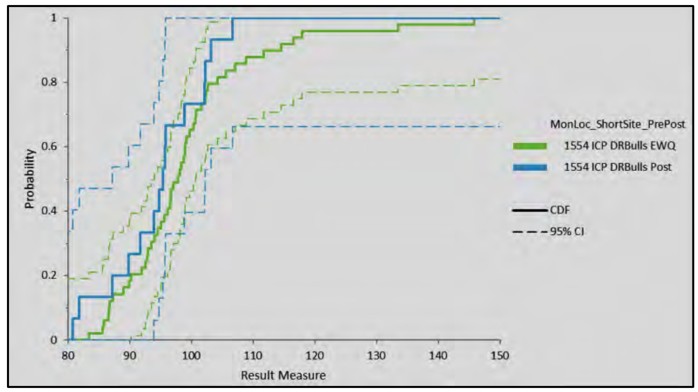






N 64

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1554 ICP DRBulls EWQ	83	93	98	102	146	9
1554 ICP DRBulls Post	81	90	95	102	107	11



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1554 ICP DRBulls EWQ	49	113.3	2.31
1554 ICP DRBulls Post	15	370.0	24.67

H statistic	1.39
X^2 approximation	1.39
DF	1
p-value	0.2377 [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.

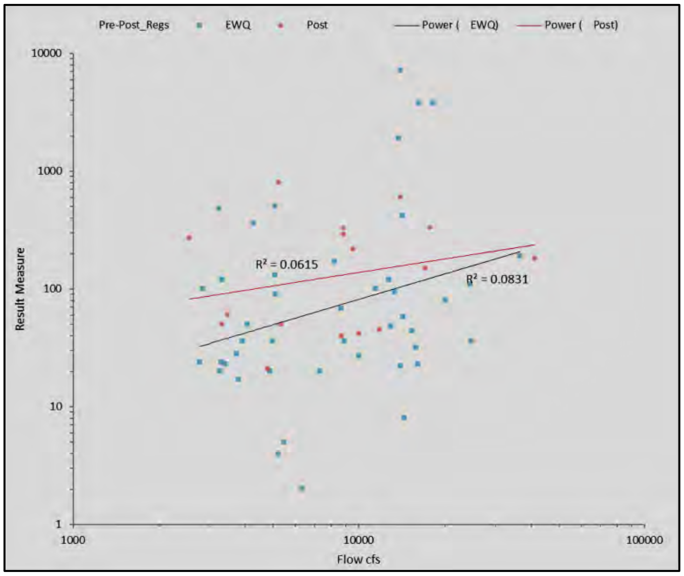
No water quality degradation is evident. Dissolved Oxygen Saturation did not measurably change between the EWQ and post-EWQ periods. Post-EWQ median DO saturation was within the EWQ 95% confidence intervals. Dissolved Oxygen Saturation is unrelated to flow.

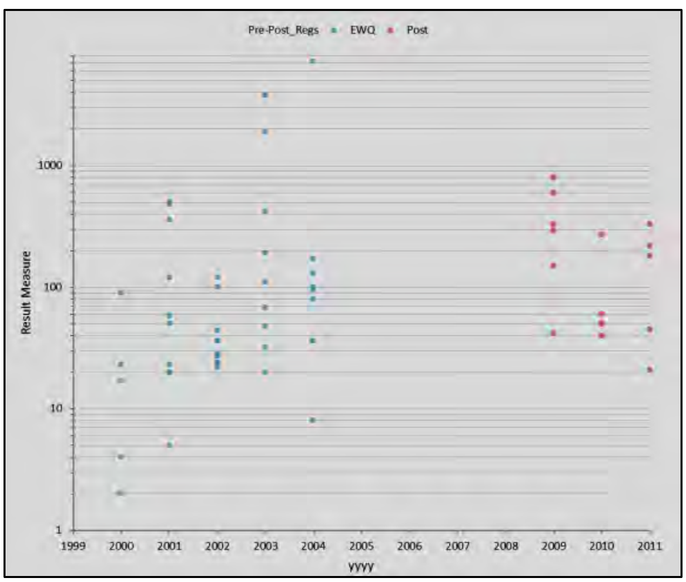
Chapter 7: 1554 ICP
Delaware River at Bulls Island Foot Bridge, NJ/PA

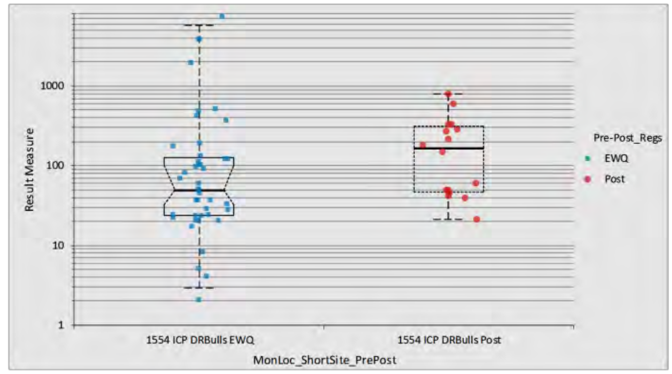
Enterococcus colonies/100 ml

Existing Water Quality (Table 2T):

Median 49/100 ml
Lower 95% Confidence Interval 32/100 ml
Upper 95% Confidence Interval 100/100 ml

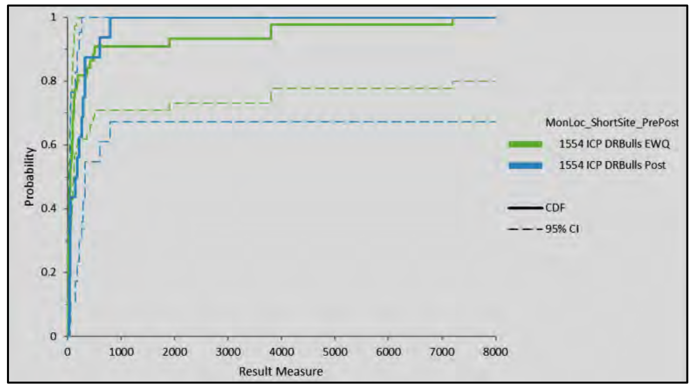






N 60

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1554 ICP DRBulls EWQ	2	23	49	126	7200	102
1554 ICP DRBulls Post	21	47	166	313	800	266



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1554 ICP DRBulls EWQ	44	300.6	6.83
1554 ICP DRBulls Post	16	826.6	51.66

H statistic	3.70
X^2 approximation	3.70
DF	1
p-value	0.0545 [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.

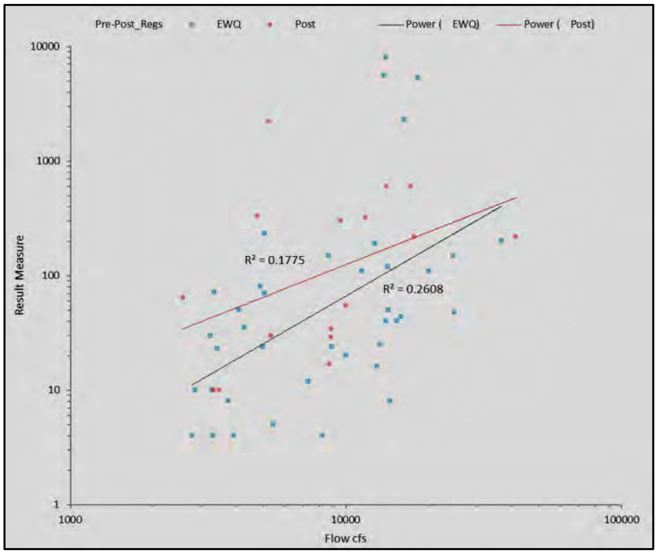
No water quality degradation is evident. Enterococci did not measurably change between the EWQ and Post-EWQ periods, though the median for the post-EWQ period was higher than the upper 95% confidence interval established in the rules. There were too few measurements taken in the post-EWQ period. Bi-weekly instead of monthly sampling is recommended to improve statistical comparisons. Enterococcus concentrations are unrelated to flow in both data sets. Note that concentrations and flows are plotted on a logarithmic scale.

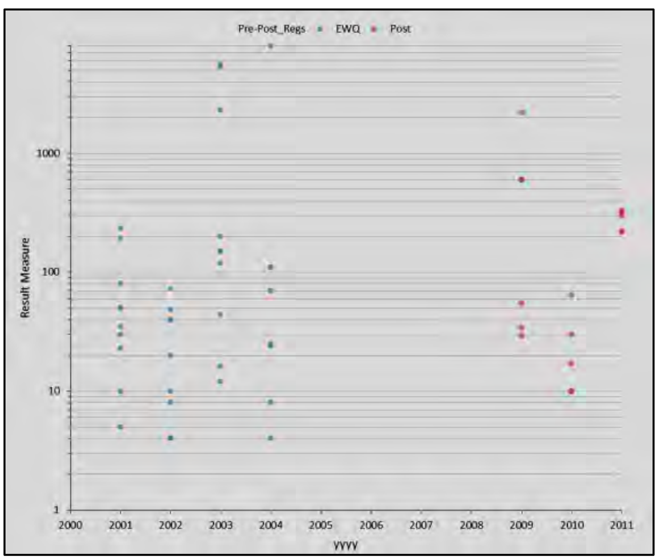
Chapter 7: 1554 ICP
Delaware River at Bulls Island Foot Bridge, NJ/PA

Escherichia coli colonies/100 ml

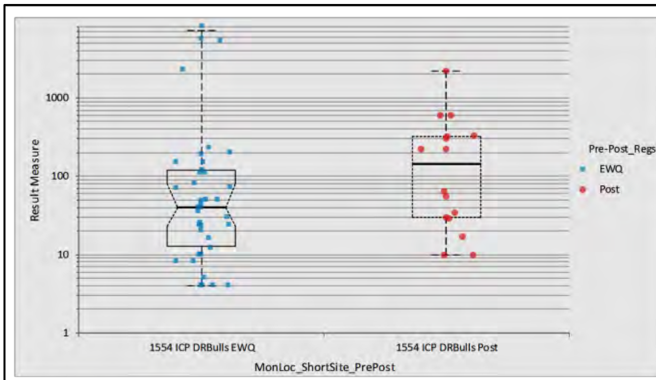
Existing Water Quality (Table 2T):

Median 40/100 ml
Lower 95% Confidence Interval 23/100 ml
Upper 95% Confidence Interval 80/100 ml

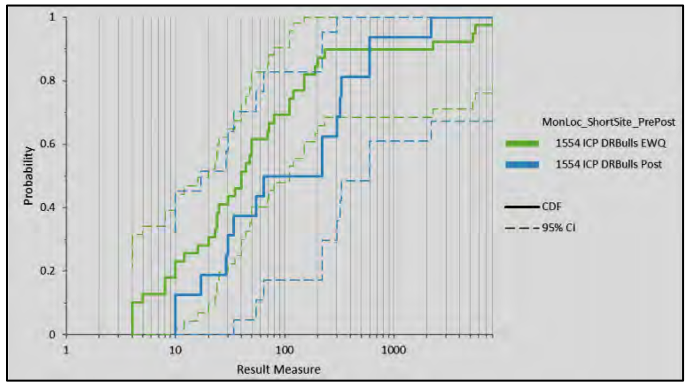




Slight evidence of water quality degradation is evident. E. coli concentrations did not measurably change between the EWQ and Post-EWQ periods, though post-EWQ median E. coli fell above the EWQ upper 95% confidence interval.



N	55					
Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1554 ICP DRBulls EWQ	4	13	40	118	8000	106
1554 ICP DRBulls Post	10	29	142	326	2200	296



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1554 ICP DRBulls EWQ	39	210.0	5.38
1554 ICP DRBulls Post	16	511.9	31.99

H statistic	2.82
X^2 approximation	2.82
DF	1
p-value	0.0934[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.

E. coli results are extremely variable, as are the other bacteria parameters, especially since too few samples were taken in the post-EWQ period (n=16). E. coli concentrations are weakly related to flow in both data sets. Note that concentrations and flow are plotted on a logarithmic scale. No independent data from other agencies were available at this site to validate DRBC's conclusion.

Chapter 7: 1554 ICP

Delaware River at Bulls Island Foot Bridge, NJ/PA

Fecal coliform colonies/100 ml

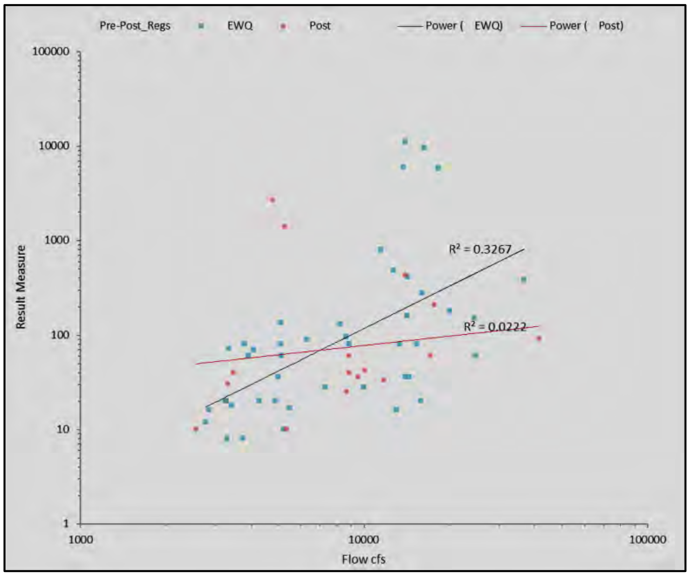
Existing Water Quality (Table 2T):

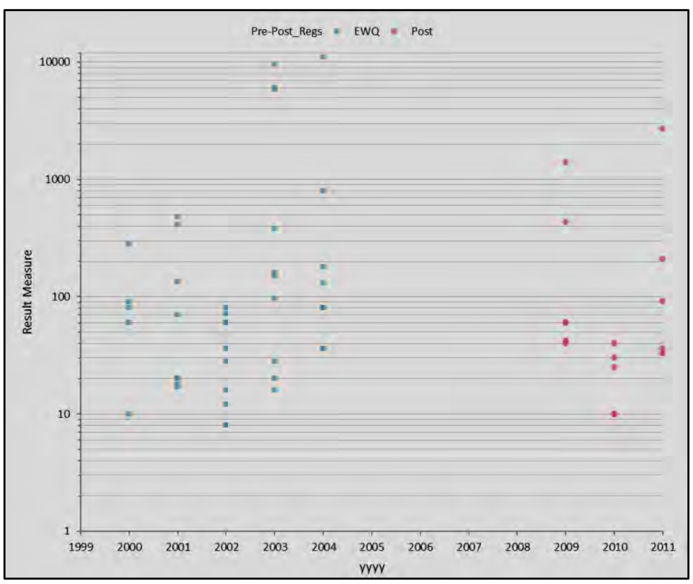
Median 71/100 ml

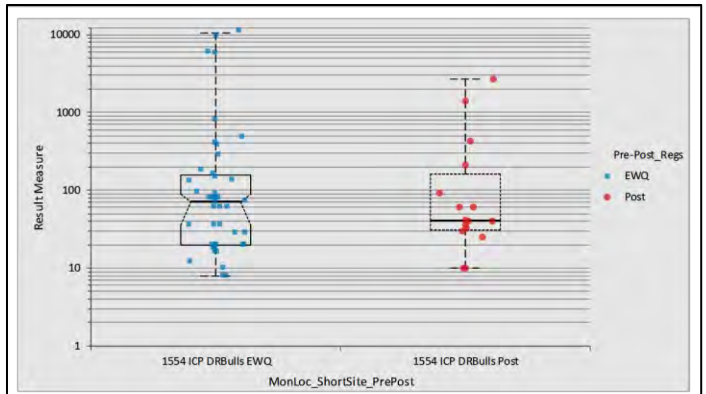
Lower 95% Confidence Interval 36/100 ml

Upper 95% Confidence Interval 90/100 ml

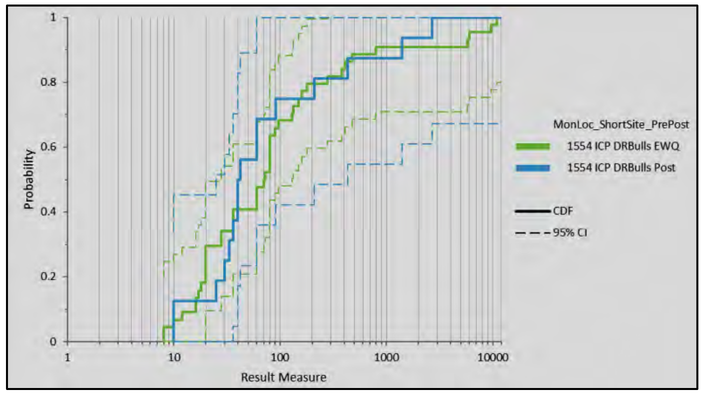
Defined in regulations as a flow-related parameter







N	60					
Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1554 ICP DRBulls EWQ	8	20	71	156	11000	136
1554 ICP DRBulls Post	10	31	41	160	2700	129



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1554 ICP DRBulls EWQ	44	3.6	0.08
1554 ICP DRBulls Post	16	9.8	0.61

H statistic	0.04
X^2 approximation	0.04
DF	1
p-value	0.8343 [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. Fecal coliform concentrations did not measurably change between the EWQ and post-EWQ periods. EWQ fecal coliform concentrations are positively but weakly related to flow, but post-EWQ data are unrelated to flow, probably because of too few post-EWQ samples (n=16). Post-EWQ median concentrations fell within the EWQ 95% confidence intervals. Note that both concentrations and flows are presented on a logarithmic scale.

Chapter 7: 1554 ICP

Delaware River at Bulls Island Foot Bridge, NJ/PA

Hardness as CaCO3, Total mg/l

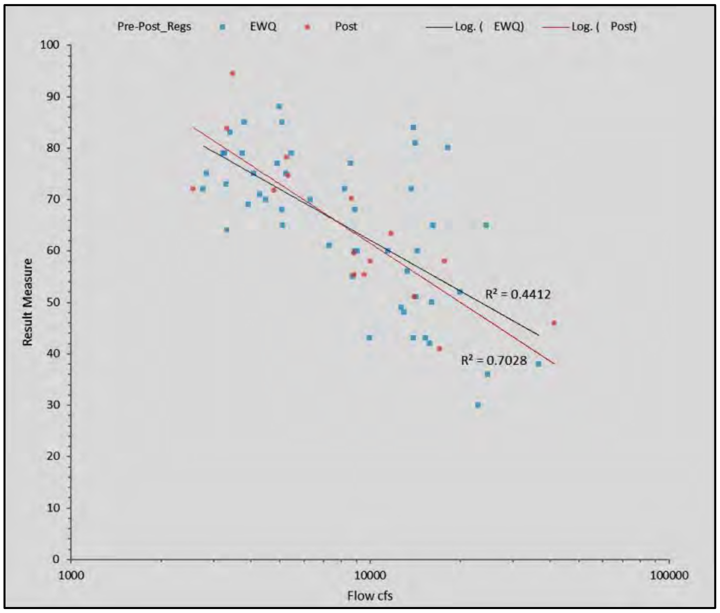
Existing Water Quality (Table 2T):

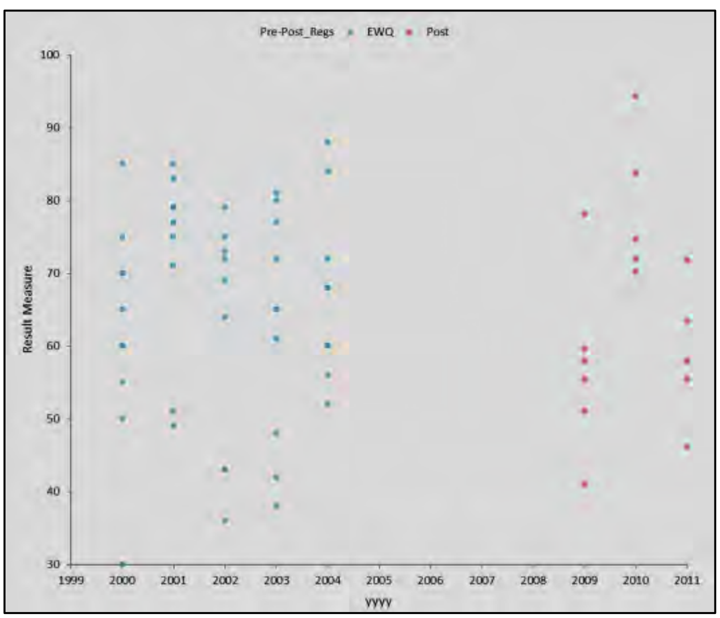
Median 68 mg/l

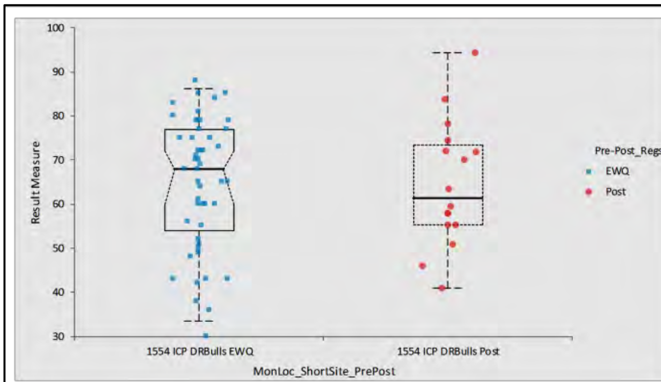
Lower 95% Confidence Interval 60 mg/l

Upper 95% Confidence Interval 72 mg/l

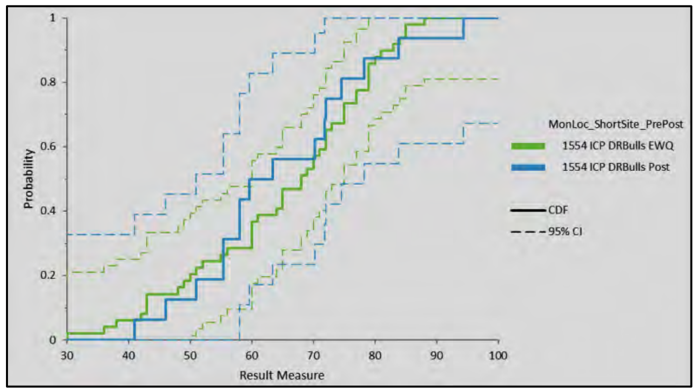
Defined in regulations as a flow-related parameter







Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
N	65					
1554 ICP DRBulls EWQ	30	54	68	77	88	23
1554 ICP DRBulls Post	41	55	62	74	94	18



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1554 ICP DRBulls EWQ	49	20.9	0.43
1554 ICP DRBulls Post	16	64.0	4.00

H statistic	0.24
X^2 approximation	0.24
DF	1
p-value	0.6258 [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.

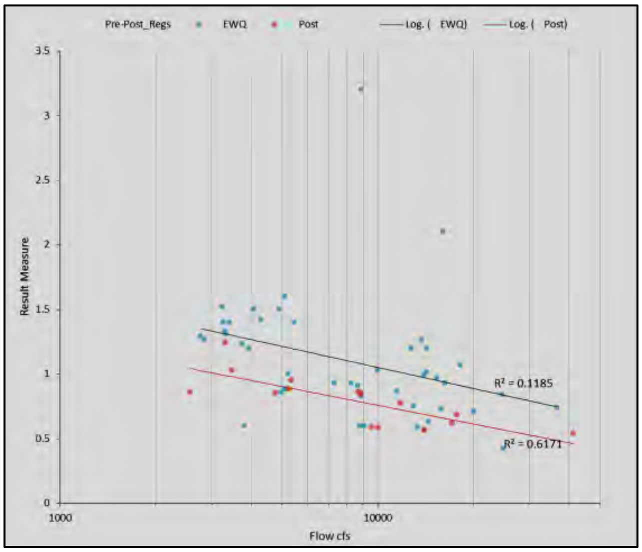
No water quality degradation is indicated. Hardness did not measurably change between the EWQ and post-EWQ periods. Hardness is inversely related to flow. Post-EWQ median hardness fell within the EWQ 95% confidence intervals.

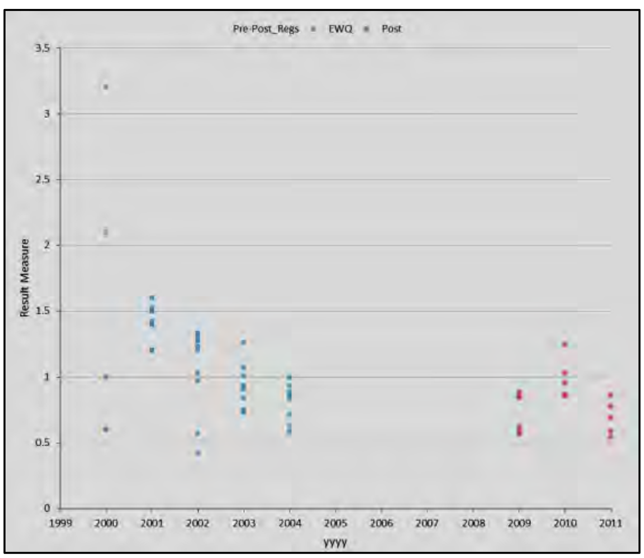
Chapter 7: 1554 ICP
Delaware River at Bulls Island Foot Bridge, NJ/PA

Nitrate + Nitrite as N, Total mg/l

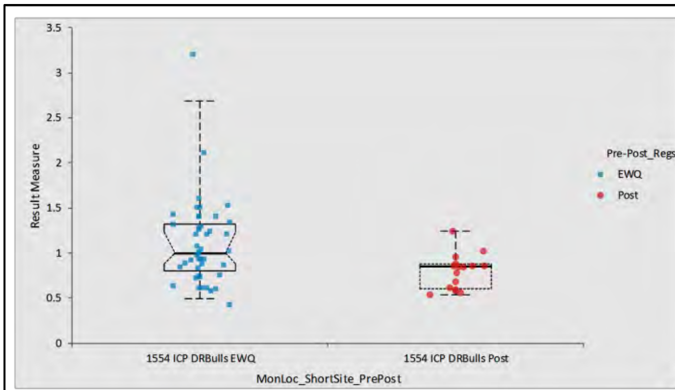
Existing Water Quality (Table 2T as Nitrate):

Median 1.00 mg/l
Lower 95% Confidence Interval 0.88 mg/l
Upper 95% Confidence Interval 1.23 mg/l

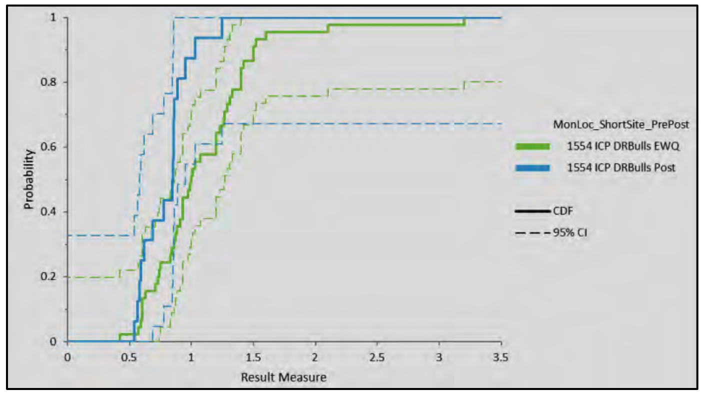




No water quality degradation is indicated. Nitrate concentrations apparently declined between the EWQ and post-EWQ periods. On the annual plot there is a declining trend in concentration within the EWQ period that appears to stabilize in the post-EWQ period. 2002-2004 EWQ nitrates appear to match well with post-EWQ nitrate + nitrite.



N	61					
Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1554 ICP DRBulls EWQ	0.42	0.80	1.00	1.32	3.20	0.51
1554 ICP DRBulls Post	0.54	0.60	0.85	0.88	1.25	0.27



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1554 ICP DRBulls EWQ	45	672.8	14.95
1554 ICP DRBulls Post	16	1892.3	118.27

H statistic	8.14
X^2 approximation	8.14
DF	1
p-value	0.0043 [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.

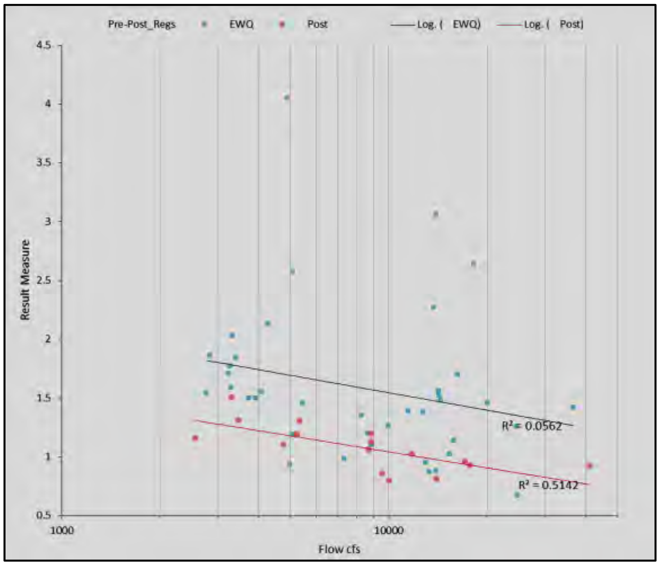
The data may be affected by laboratory artifacts that produce uncertainty in conclusions. Nitrate + Nitrite concentrations are assumed equivalent for comparison with EWQ nitrate concentrations, since EWQ nitrite concentrations were never detected. Note that flow is plotted on a logarithmic scale. Independent data were not available for validation of the apparent decline. Post-EWQ median concentrations fell just below the EWQ lower 95% confidence interval. There were no undetected results in either data set.

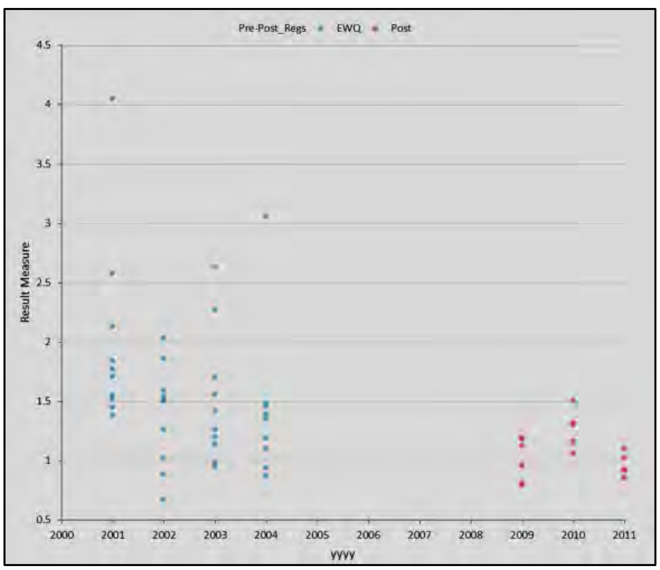
Chapter 7: 1554 ICP
Delaware River at Bulls Island Foot Bridge, NJ/PA

Nitrogen as N, Total (TN) mg/l

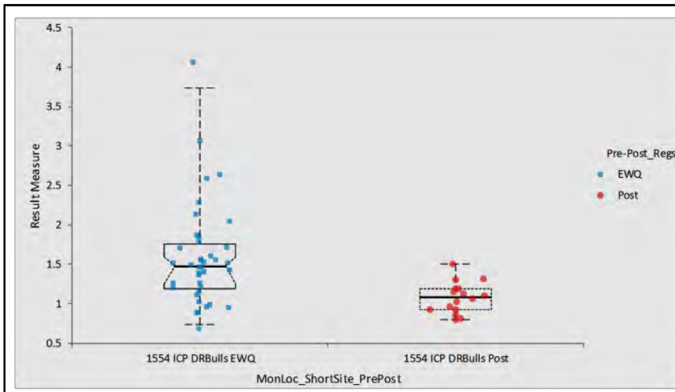
Existing Water Quality (Table 2T):

Median 1.48 mg/l
Lower 95% Confidence Interval 1.26 mg/l
Upper 95% Confidence Interval 1.59 mg/l

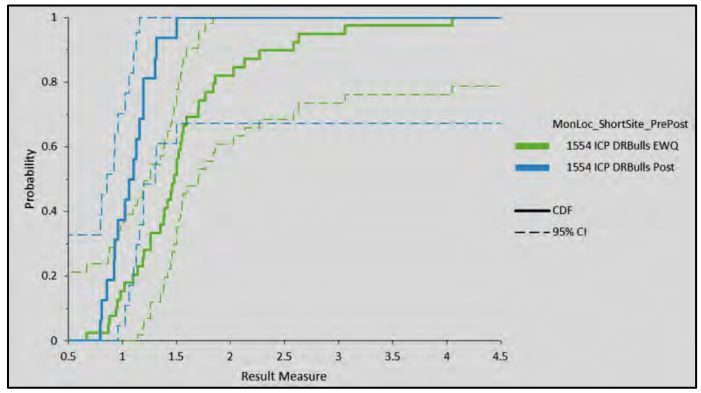




No water quality degradation is evident. Total Nitrogen concentrations apparently declined between the EWQ and post-EWQ periods. However, potential laboratory artifacts produced uncertainty in conclusions.



N	55					
Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1554 ICP DRBulls EWQ	0.67	1.19	1.48	1.76	4.05	0.57
1554 ICP DRBulls Post	0.80	0.92	1.08	1.19	1.51	0.27



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1554 ICP DRBulls EWQ	39	935.4	23.98
1554 ICP DRBulls Post	16	2280.1	142.50

H statistic	12.53
X^2 approximation	12.53
DF	1
p-value	0.0004 [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.

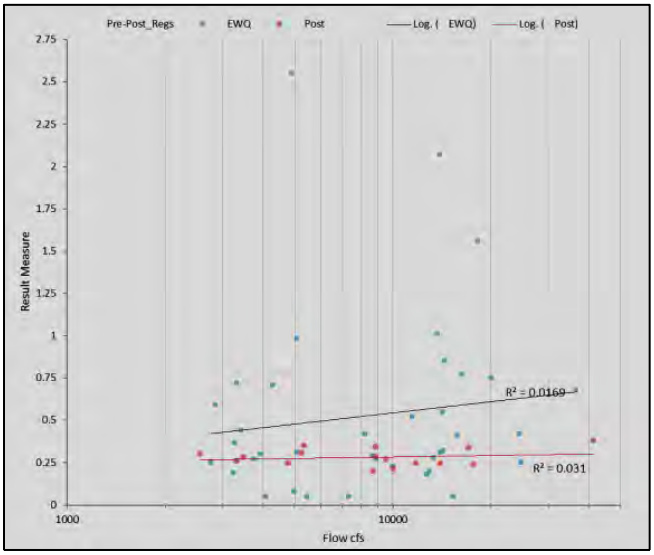
TN is unrelated to flow in the EWQ period, but strongly related to flow in the post-EWQ period. The flow relationship may be false because of insufficient post-EWQ samples (n=16) which were not fully representative of flow conditions in the post-EWQ period. The EWQ data overall are far more variable than the post-EWQ data. DRBC results could not be independently validated. Post-EWQ median TN concentrations fell below the EWQ lower 95% confidence interval.

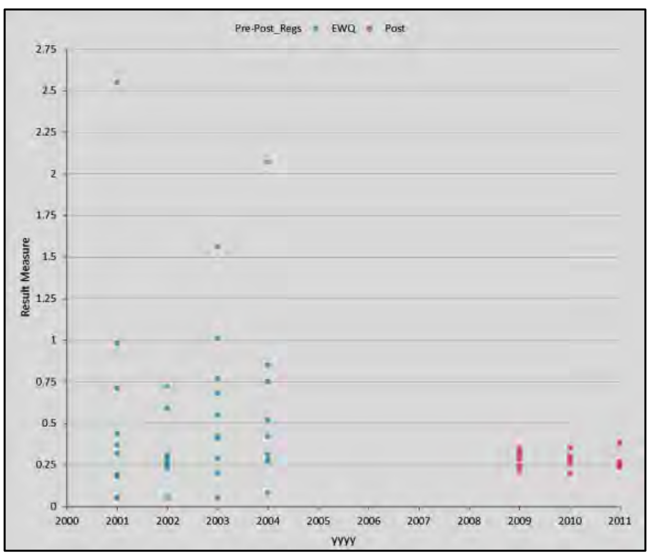
Chapter 7: 1554 ICP
Delaware River at Bulls Island Foot Bridge, NJ/PA

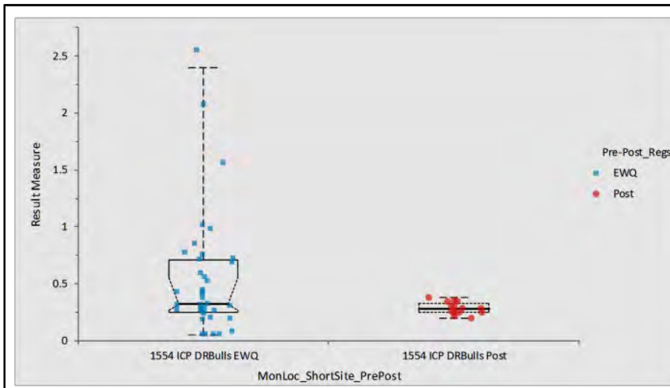
Nitrogen, Kjeldahl as N, Total (TKN) mg/l

Existing Water Quality (Table 2T):

Median 0.32 mg/l
Lower 95% Confidence Interval 0.27 mg/l
Upper 95% Confidence Interval 0.55 mg/l

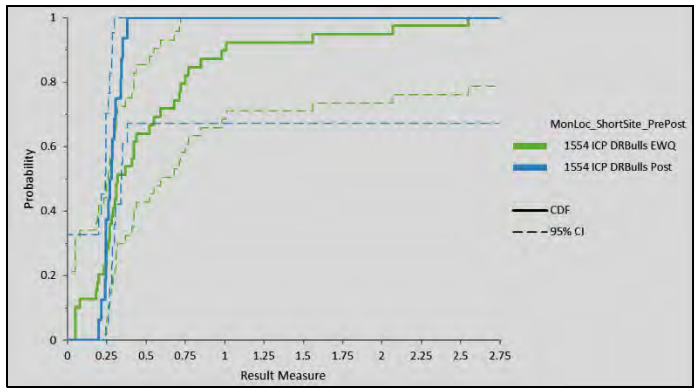






N 55

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1554 ICP DRBulls EWQ	0.05	0.25	0.32	0.71	2.55	0.46
1554 ICP DRBulls Post	0.20	0.25	0.28	0.33	0.38	0.08



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1554 ICP DRBulls EWQ	39	226.6	5.81
1554 ICP DRBulls Post	16	552.3	34.52

H statistic	3.04
X² approximation	3.04
DF	1
p-value	0.0814 [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. No measurable change occurred in TKN concentrations between the EWQ and post-EWQ periods. TKN concentration is unrelated to flow in both data sets. Post-EWQ TKN was far less variable than EWQ TKN.

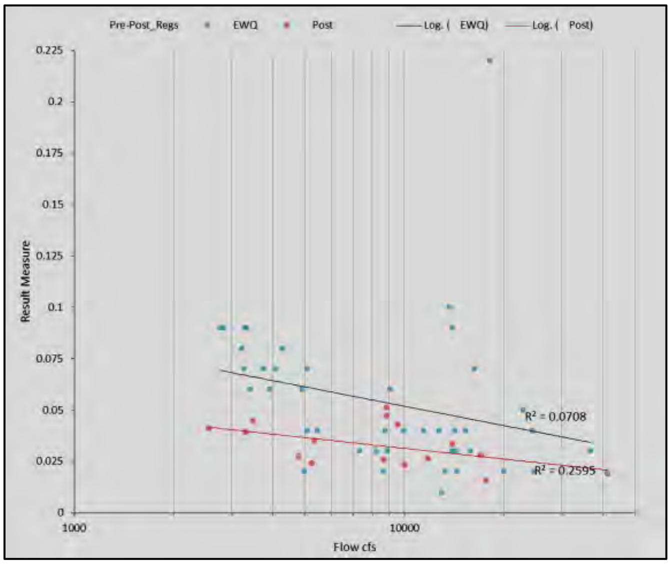
Post-EWQ median TKN fell within the EWQ 95% confidence intervals. Though there was no statistical difference between EWQ and post-EWQ TKN, concentrations fell and were much more stable. This may be a laboratory artifact rather than a real trend. However, unlike nitrate + nitrite and other parameters, the TKN data sets should be directly comparable since there are no discrepancies in detection limits. The main differences were that post-EWQ TKN samples were less numerous and not as fully representative of flow conditions.

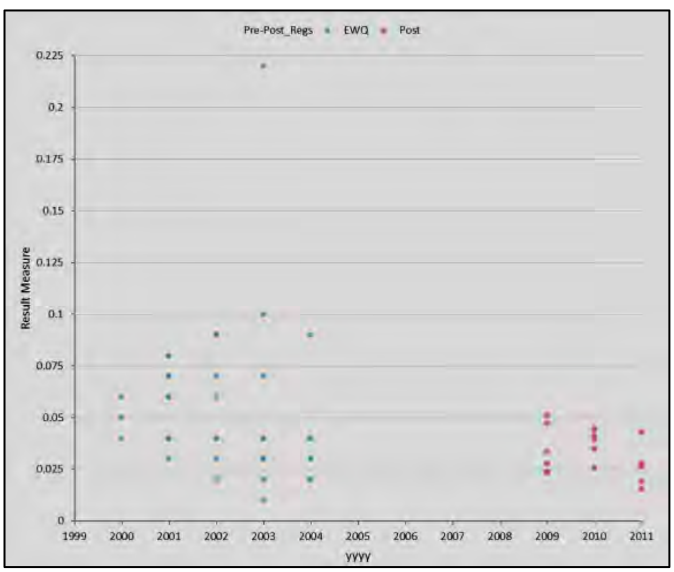
Chapter 7: 1554 ICP
Delaware River at Bulls Island Foot Bridge, NJ/PA

Orthophosphate as P, Total mg/l (OP)

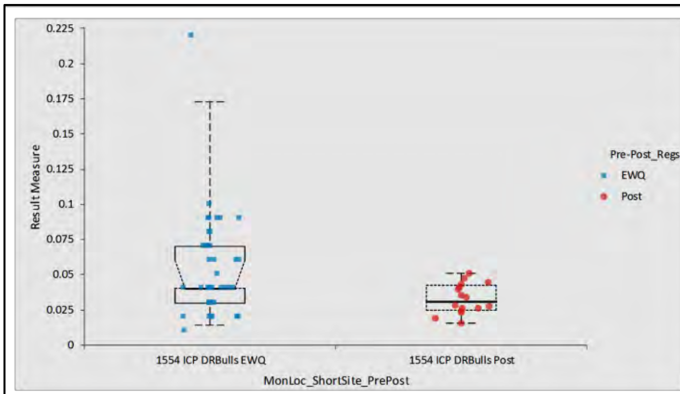
Existing Water Quality (Table 2T):

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

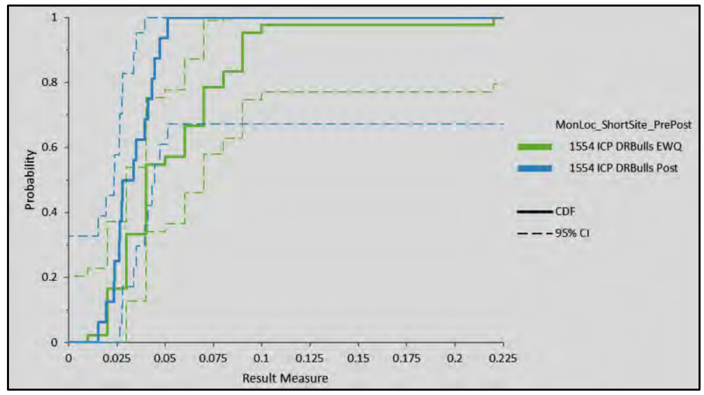




No water quality degradation is evident. Orthophosphate concentrations apparently declined between the EWQ and post-EWQ periods. However, potential laboratory artifacts and differences in flow condition representativeness introduced uncertainty to conclusions.



N	58					
Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1554 ICP DRBulls EWQ	0.01	0.03	0.04	0.07	0.22	0.04
1554 ICP DRBulls Post	0.02	0.02	0.03	0.04	0.05	0.02



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1554 ICP DRBulls EWQ	42	427.5	10.18
1554 ICP DRBulls Post	16	1122.3	70.14

H statistic	5.48
X² approximation	5.48
DF	1
p-value	0.0192 [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.

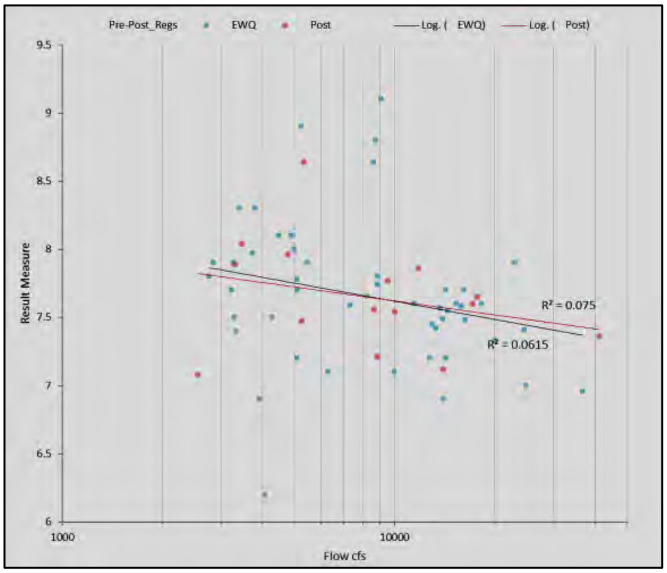
Post-EWQ median orthophosphate fell below the EWQ lower 95% confidence interval, though the interval was established around the detection limit. OP is unrelated to flow in EWQ data, but weakly related to flow in post-EWQ data. Flow is plotted on logarithmic scale. There were no independent data to confirm DRBC results. DRBC detection limits improved between the two periods, but this had no bearing on the results since there was only one non-detect result in the EWQ data set and none in the post-EWQ data set. There may be a water quality improvement, as there are no post-EWQ concentrations higher than 0.05 mg/l.

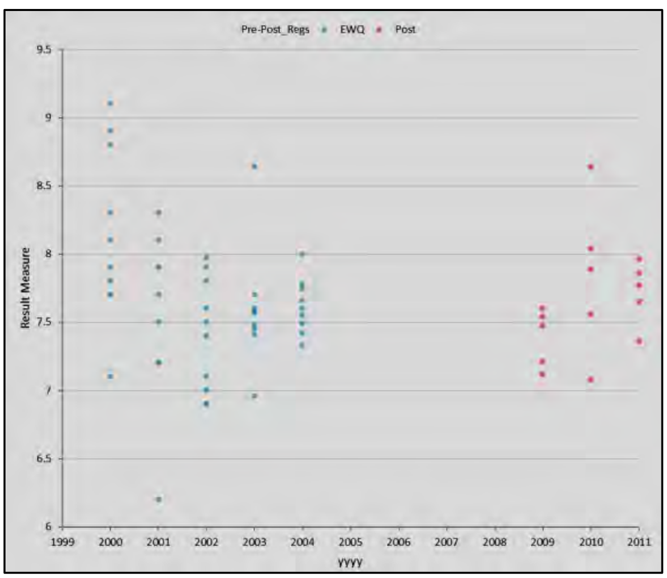
Chapter 7: 1554 ICP
Delaware River at Bulls Island Foot Bridge, NJ/PA

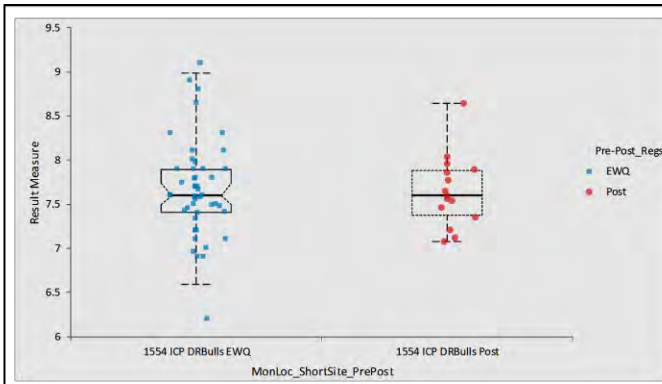
pH, units

Existing Water Quality (Table 2T):

Median 7.60 standard units
Lower 95% Confidence Interval 7.50 standard units
Upper 95% Confidence Interval 7.74 standard units

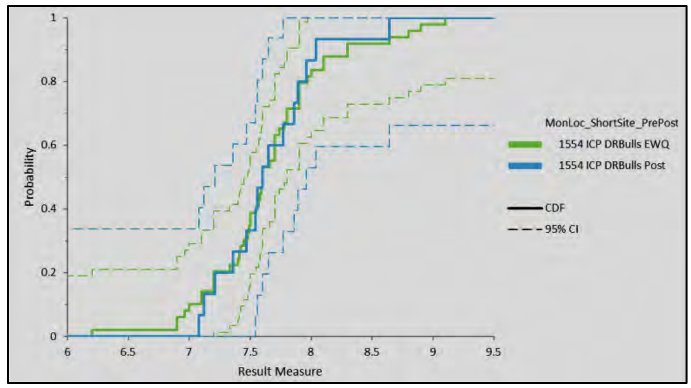






N 64

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1554 ICP DRBulls EWQ	6.20	7.41	7.60	7.90	9.10	0.49
1554 ICP DRBulls Post	7.08	7.38	7.60	7.89	8.64	0.51



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1554 ICP DRBulls EWQ	49	0.1	0.00
1554 ICP DRBulls Post	15	0.4	0.03

H statistic	0.00
X^2 approximation	0.00
DF	1
p-value	0.9684 [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.

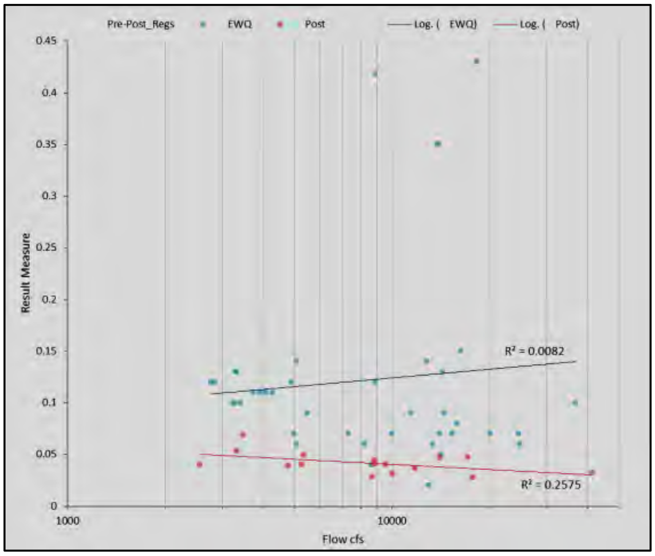
No water quality degradation is evident. pH did not measurably change between the EWQ and post-EWQ periods. Post-EWQ median pH fell between the EWQ 95% confidence intervals. Under higher flow conditions, pH tends toward neutral. During low flow and high primary productivity periods, pH criteria are occasionally exceeded at this location. Flow is plotted on a logarithmic scale.

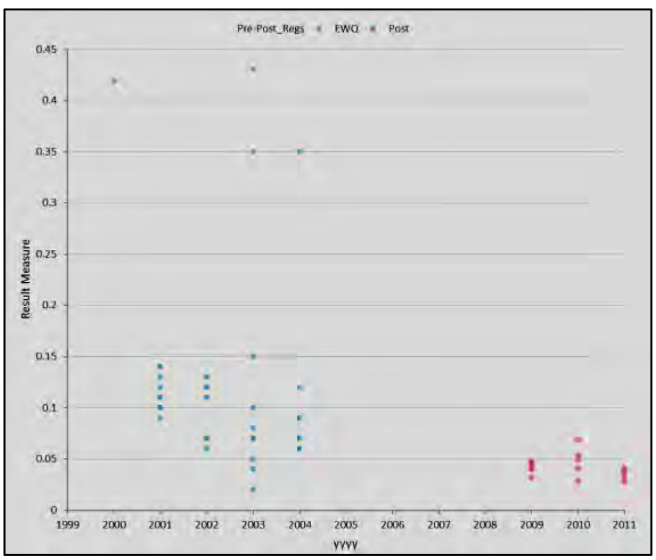
Chapter 7: 1554 ICP
Delaware River at Bulls Island Foot Bridge, NJ/PA

Phosphorus as P, Total (TP) mg/l

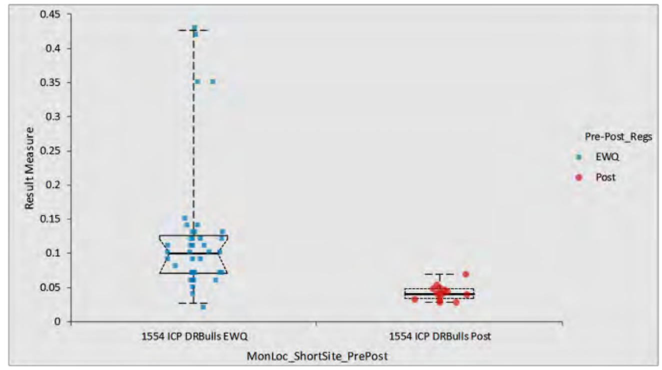
Existing Water Quality (Table 2T):

Median 0.10 mg/l
Lower 95% Confidence Interval 0.07 mg/l
Upper 95% Confidence Interval 0.12 mg/l



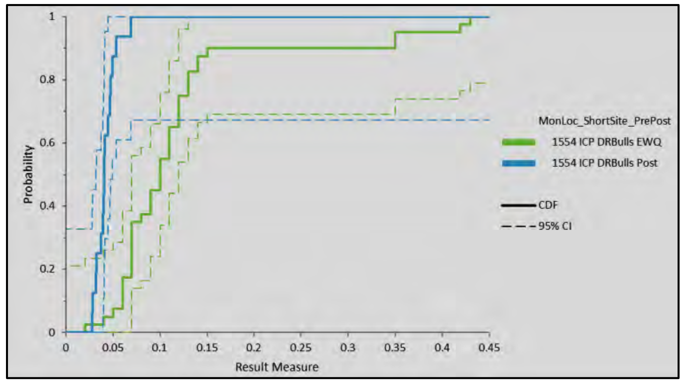


No water quality degradation is indicated. Total Phosphorus (TP) concentrations apparently declined between the EWQ and post-EWQ periods. However, potential laboratory artifacts and insufficient post-EWQ data (n=16) produced uncertainty to conclusions.



N | 56

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1554 ICP DRBulls EWQ	0.02	0.07	0.10	0.13	0.43	0.06
1554 ICP DRBulls Post	0.03	0.03	0.04	0.05	0.07	0.01



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1554 ICP DRBulls EWQ	40	2073.6	51.84
1554 ICP DRBulls Post	16	5184.0	324.00

H statistic	27.38
X^2 approximation	27.38
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 TP fell below the EWQ lower 95% confidence interval. TP is unrelated to flow in the EWQ data set, and weakly related to flow in the post-EWQ data set. The decline in concentration may be partially attributable to improved laboratory detection limits or method sensitivity, although all results were well above the detection limits. No independent data were available to confirm these results.

Chapter 7: 1554 ICP

Delaware River at Bulls Island Foot Bridge, NJ/PA

Specific Conductance µmho/cm

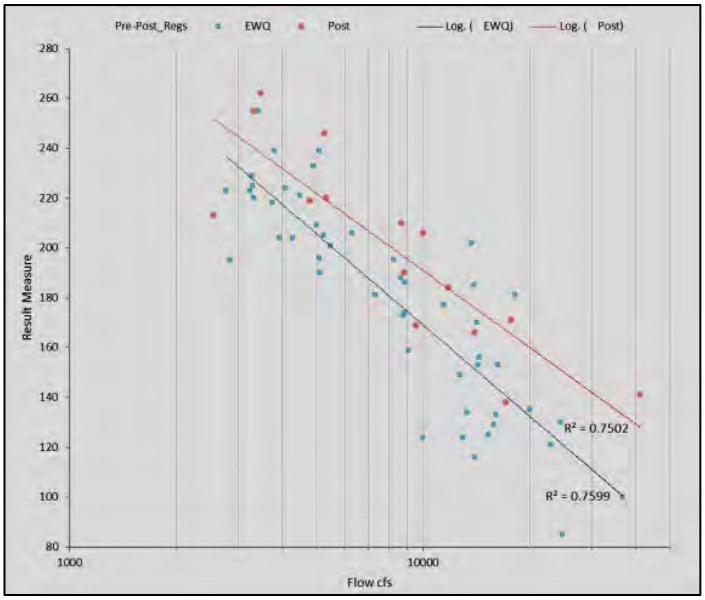
Existing Water Quality (Table 2T):

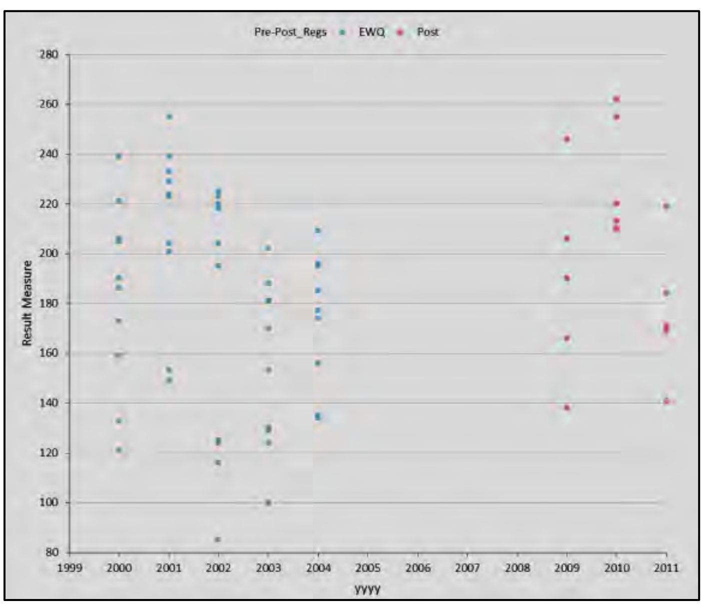
Median 186 µmho/cm

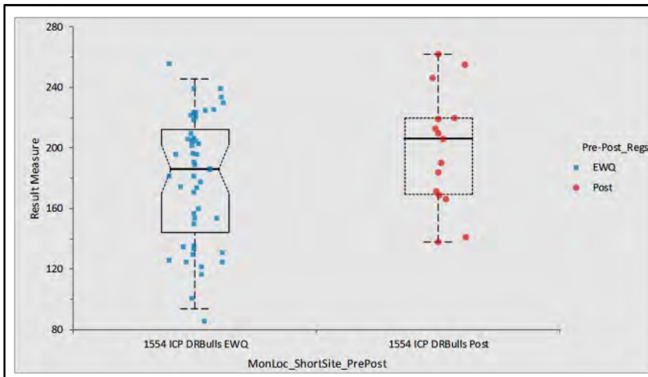
Lower 95% Confidence Interval 170 µmho/cm

Upper 95% Confidence Interval 202 µmho/cm

Defined in regulations as a flow-related parameter

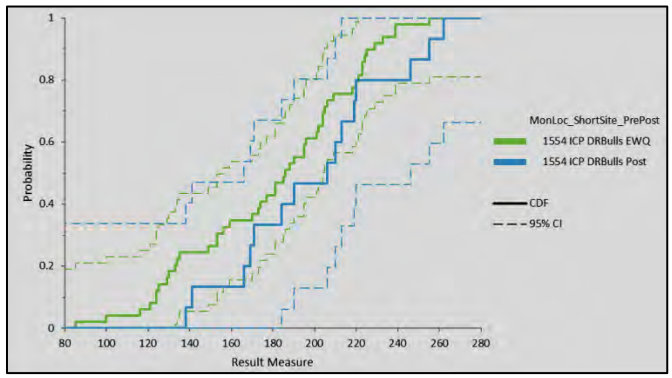






N 64

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1554 ICP DRBulls EWQ	85	144	186	212	255	68
1554 ICP DRBulls Post	138	169	206	220	262	51



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1554 ICP DRBulls EWQ	49	163.5	3.34
1554 ICP DRBulls Post	15	534.0	35.60

H statistic	2.01
X^2 approximation	2.01
DF	1
p-value	0.1560 [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.

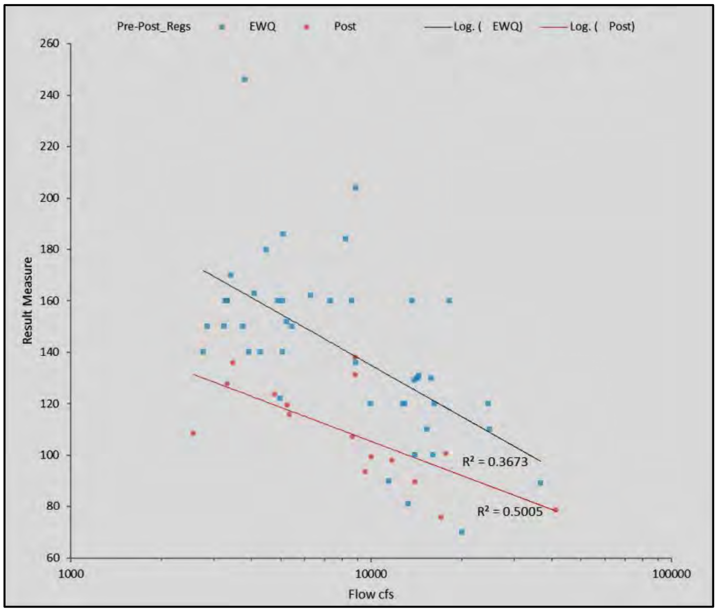
Slight evidence indicates water quality degradation. Specific conductance did not measurably change between the EWQ and post-EWQ periods. However, there were too few post-EWQ data (n=15) for reliable statistical comparison. In both data sets, specific conductance is strongly and inversely related to flow. Post-EWQ median specific conductance rose above the EWQ upper 95% confidence interval, but the overall distribution was not significantly different. Flow is plotted on a logarithmic scale.

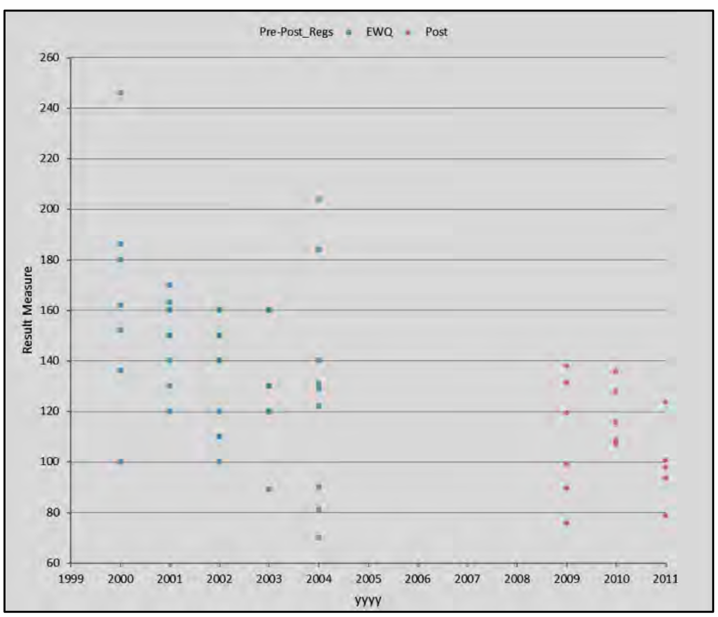
Chapter 7: 1554 ICP
Delaware River at Bulls Island Foot Bridge, NJ/PA

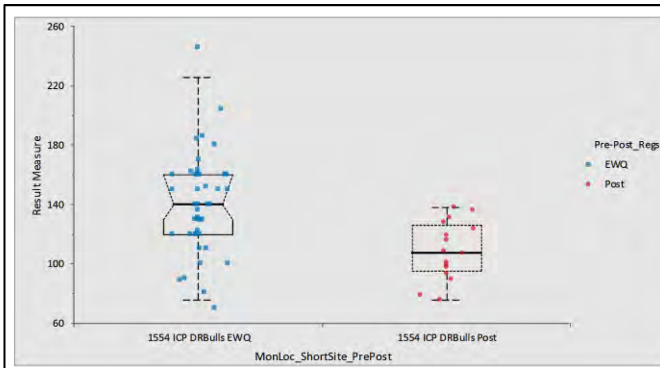
Total Dissolved Solids (TDS) mg/l

Existing Water Quality (Table 2T):

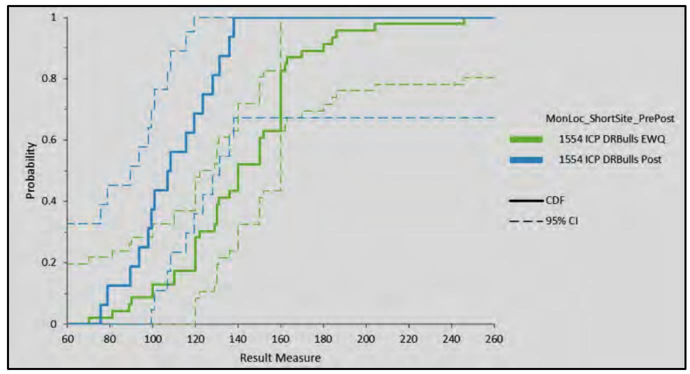
Median 140 mg/l
Lower 95% Confidence Interval 130 mg/l
Upper 95% Confidence Interval 160 mg/l
Defined in regulations as a flow-related parameter







N	62					
Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1554 ICP DRBulls EWQ	70	120	140	160	246	40
1554 ICP DRBulls Post	76	95	108	126	138	31



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1554 ICP DRBulls EWQ	46	913.6	19.86
1554 ICP DRBulls Post	16	2626.6	164.16

H statistic	10.92
X^2 approximation	10.92
DF	1
p-value	0.0010[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. TDS measurably declined between the EWQ and post-EWQ periods. However, potential laboratory artifacts and insufficient post-EWQ data produced uncertainty in conclusions. TDS is inversely related to flow in the EWQ data set, but unrelated to flow in the post-EWQ data set – probably due to insufficient sampling not fully representative of flow conditions. Post-EWQ median TDS was well below the EWQ 95% lower confidence interval. Post-EWQ detection limits were lower than EWQ detection limits, though there were no non-detect results in either data set. Flow is plotted on a logarithmic scale.

Chapter 7: 1554 ICP

Delaware River at Bulls Island Foot Bridge, NJ/PA

Total Suspended Solids (TSS) mg/l

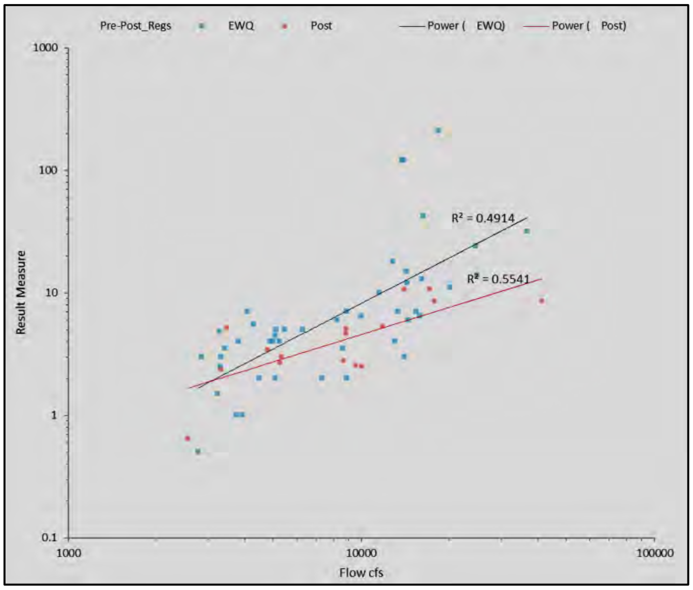
Existing Water Quality (Table 2T):

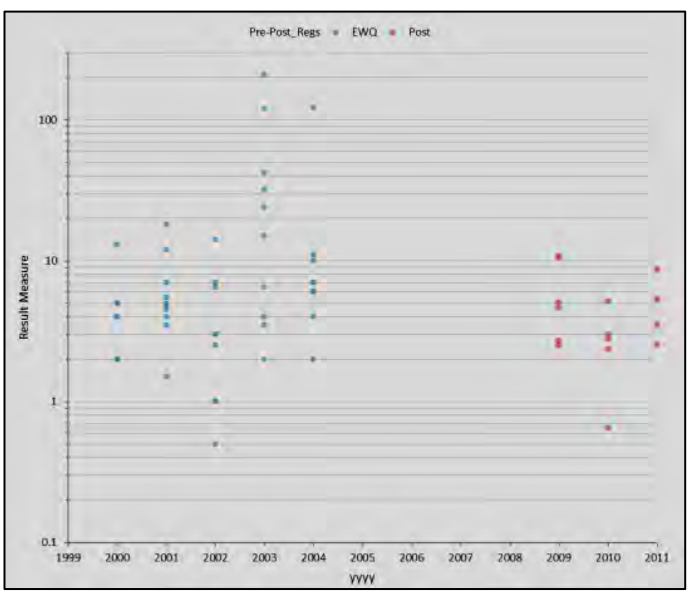
Median 5.0 mg/l

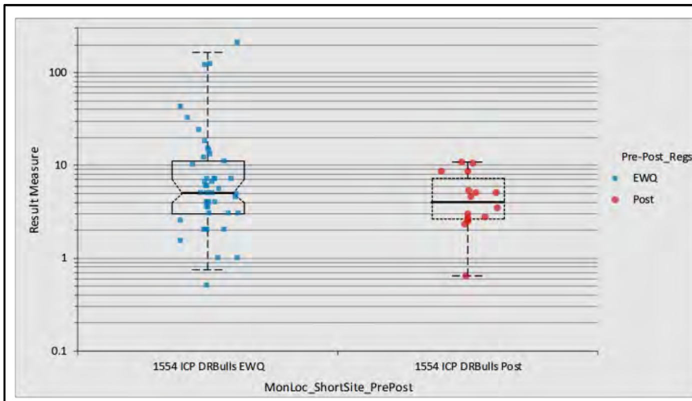
Lower 95% Confidence Interval 4.0 mg/l

Upper 95% Confidence Interval 7.0 mg/l

Defined in regulations as a flow-related parameter

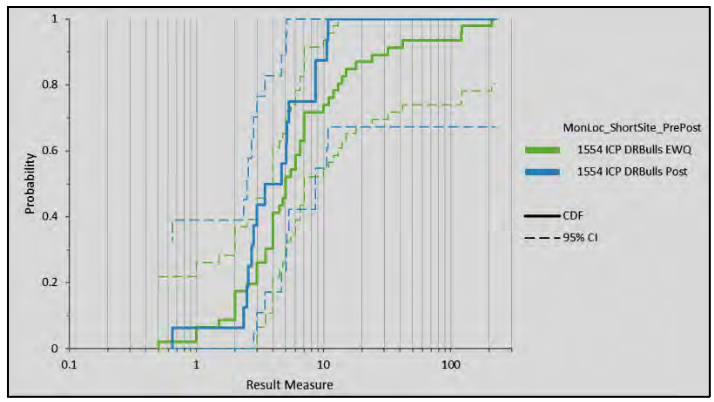






N | 62

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1554 ICP DRBulls EWQ	0.5	3.0	5.0	11.1	210.0	8.1
1554 ICP DRBulls Post	0.7	2.6	4.1	7.2	10.8	4.6



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1554 ICP DRBulls EWQ	46	119.0	2.59
1554 ICP DRBulls Post	16	342.3	21.39

H statistic	1.42
X^2 approximation	1.42
DF	1
p-value	0.2336[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.

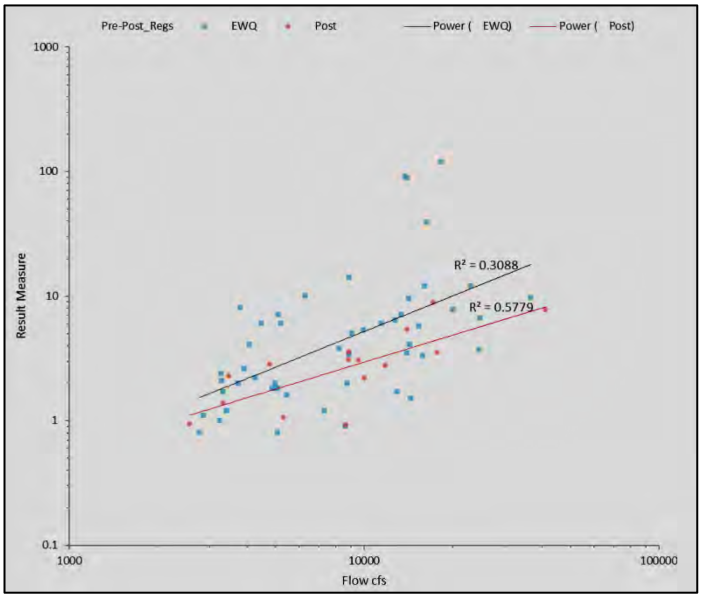
No water quality degradation is evident. TSS did not measurably change between the EWQ and post-EWQ periods. TSS is positively related to flow in both data sets. Post-EWQ median TSS was within the EWQ 95% confidence intervals. Flow and concentrations are plotted on a logarithmic scale, and the regressions are power equations.

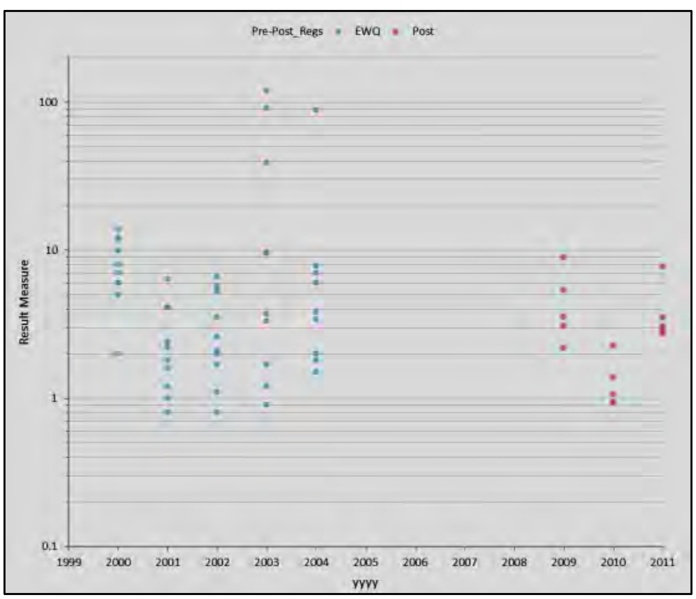
Chapter 7: 1554 ICP
Delaware River at Bulls Island Foot Bridge, NJ/PA

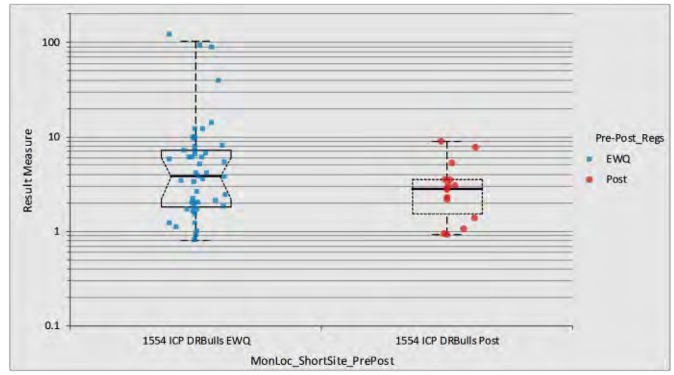
Turbidity NTU

Existing Water Quality (Table 2T):

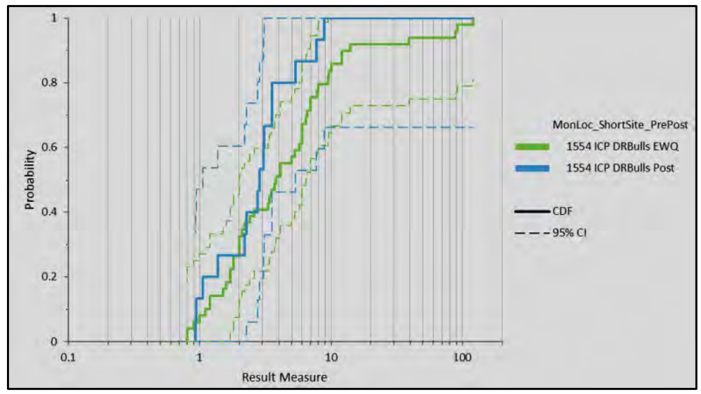
Median 3.8 NTU
Lower 95% Confidence Interval 2.2 NTU
Upper 95% Confidence Interval 6.0 NTU







N	64					
Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1554 ICP DRBulls EWQ	0.8	1.8	3.8	7.3	120.0	5.5
1554 ICP DRBulls Post	0.9	1.5	2.8	3.6	8.9	2.0



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1554 ICP DRBulls EWQ	49	145.7	2.97
1554 ICP DRBulls Post	15	476.0	31.73

H statistic	1.79
X² approximation	1.79
DF	1
p-value	0.1804 [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.

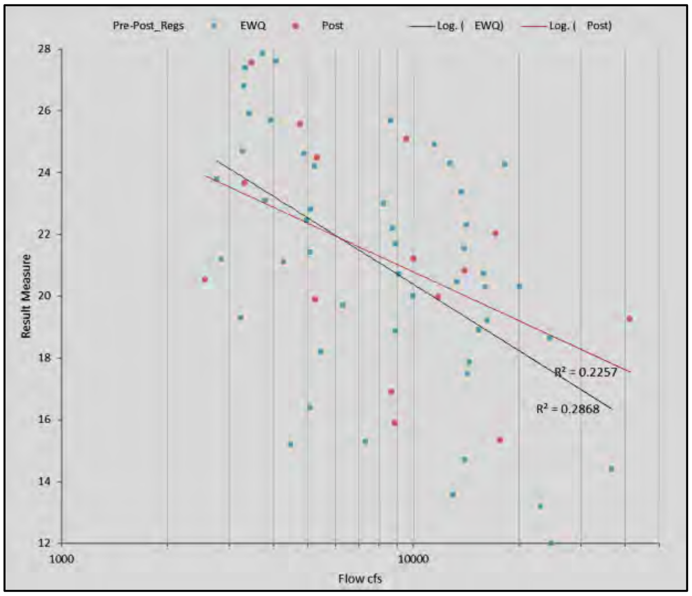
No water quality degradation is evident. Turbidity did not measurably change between the EWQ and post-EWQ periods. All post-EWQ turbidity results were below 9 NTU. The post-EWQ median turbidity was within the EWQ 95% confidence intervals. In the EWQ data set, the turbidity vs. flow relationship is weakly positive, and strongly positive in the post-EWQ data set. Both concentration and flow are represented on a logarithmic scale.

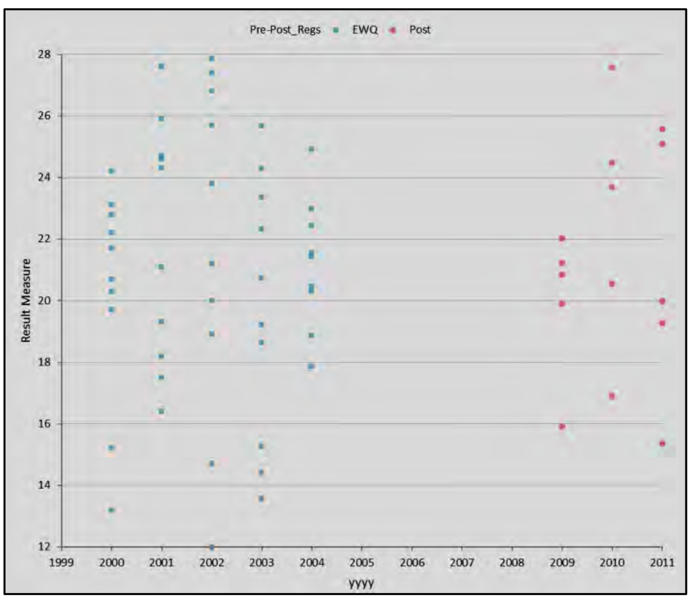
Chapter 7: 1554 ICP

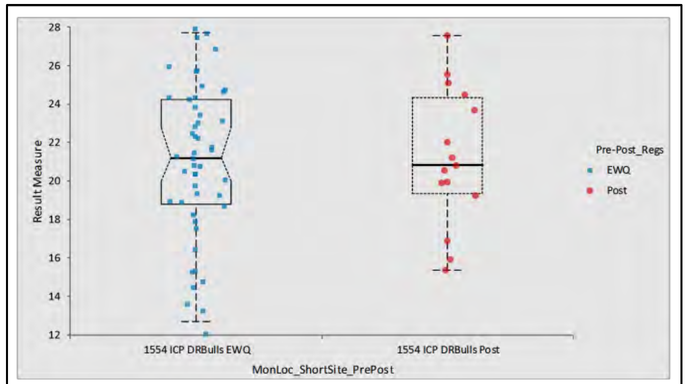
Delaware River at Bulls Island Foot Bridge, NJ/PA

Water Temperature, degrees C

Not included in DRBC Existing Water Quality rules

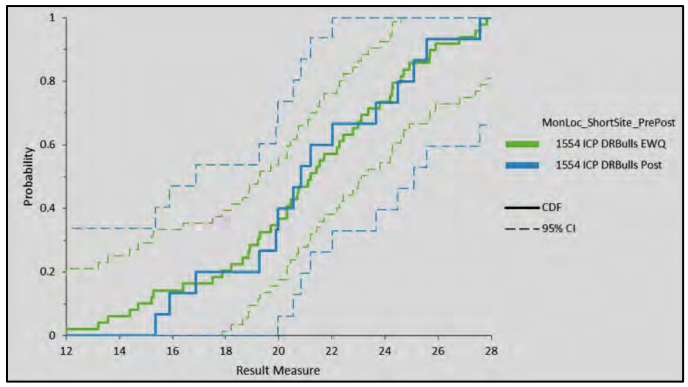






N | 64

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1554 ICP DRBulls EWQ	12.0	18.8	21.2	24.2	27.9	5.4
1554 ICP DRBulls Post	15.4	19.4	20.8	24.3	27.6	5.0



Kruskal-Wallis test

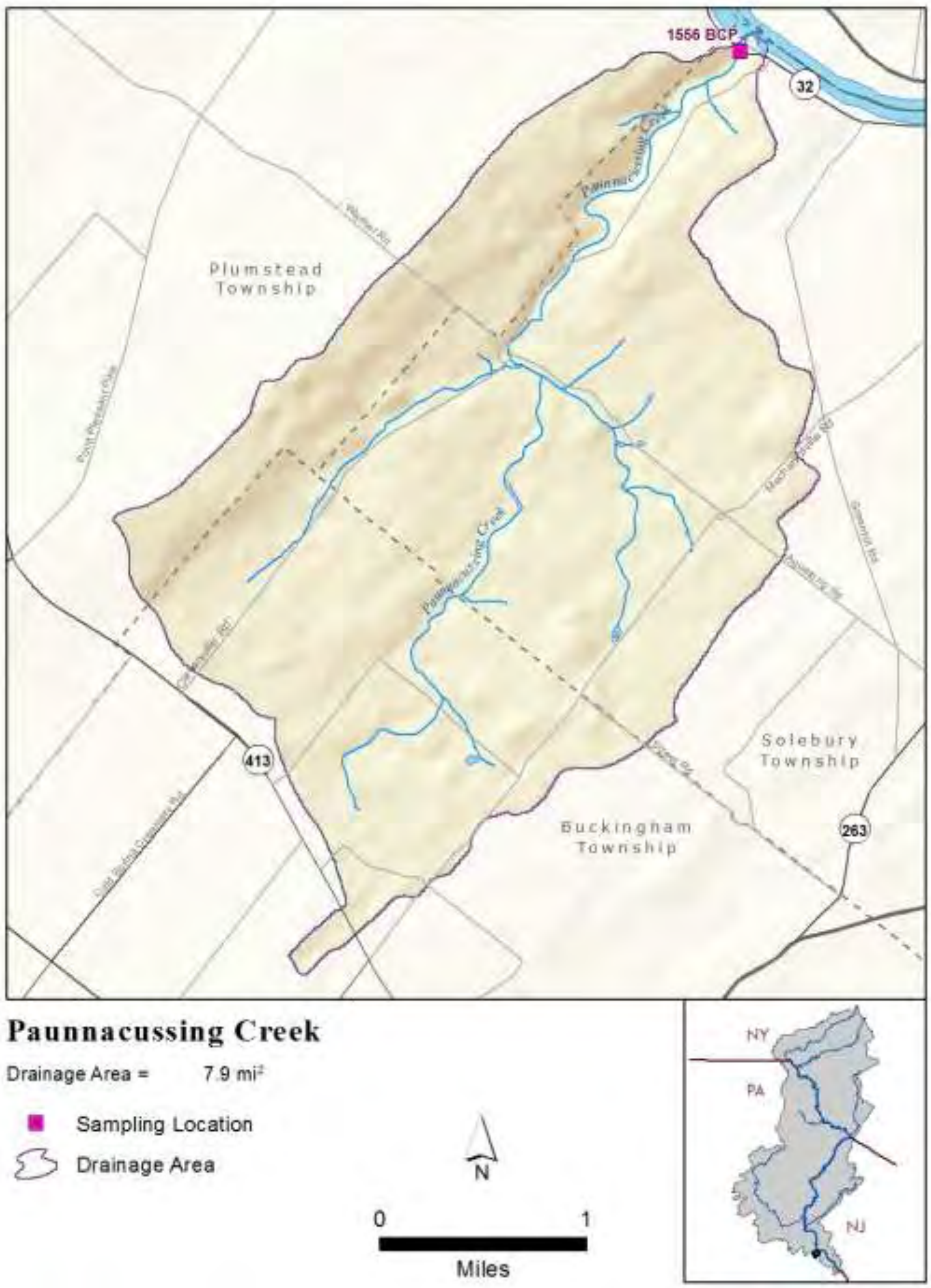
Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1554 ICP DRBulls EWQ	49	0.6	0.01
1554 ICP DRBulls Post	15	2.0	0.13

H statistic	0.01
X^2 approximation	0.01
DF	1
p-value	0.9305 [1]

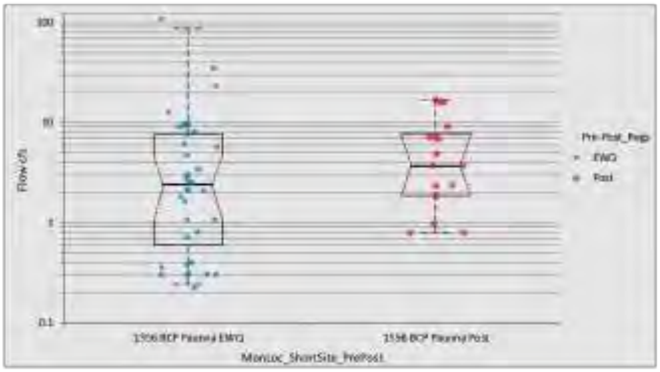
H0: $\theta_1 = \theta_2 = \theta_{...}$
The median of the populations are all equal.
H1: $\theta_i \neq \theta_j$ for at least one i,j
The median of the populations are not all equal.
[1] Do not reject the null hypothesis at the 5% significance level.

No water quality degradation is evident. Water temperature did not measurably change between the EWQ and post-EWQ periods. Water temperature is inversely related to flow, though the relationship is weak. The distributions were almost identical.

Chapter 8: 1556 BCP Paunacussing Creek, Bucks County, PA



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



N	54

Flow cfs by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1556 BCP Paunna EWQ	0.22	0.60	2.38	7.60	107.19	7.00
1556 BCP Paunna Post	0.80	1.87	3.68	7.80	16.80	5.94

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

Kruskal-Wallis test

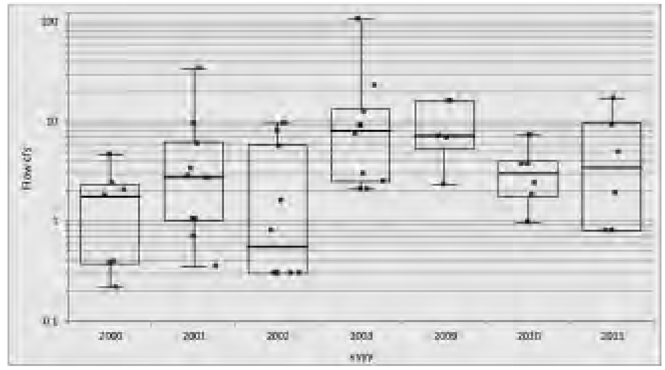
Flow cfs by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1556 BCP Paunna EWQ	37	134.3	3.63
1556 BCP Paunna Post	17	292.4	17.20

H statistic	1.73
X^2 approximation	1.73
DF	1
p-value	0.1889 [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.

The 7.9 square mile Paunacussing Creek watershed was included within the Wild and Scenic designation of the Lower Delaware. The watershed is about 50% forested, and less than 1% urban land cover. There is no carbonate bedrock in the watershed, so water quality should be similar to other Piedmont streams.

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



N	54

Flow cfs by yyyy	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
2000	0.22	0.37	1.77	2.32	4.62	1.95
2001	0.35	1.01	2.77	6.24	34.13	5.23
2002	0.30	0.30	0.55	5.80	9.60	5.50
2003	2.10	2.47	8.10	13.34	107.19	10.88
2009	2.32	5.29	7.18	16.03	16.03	10.74
2010	0.97	1.73	3.04	3.97	7.20	2.24
2011	0.80	0.80	3.40	9.66	16.80	8.86

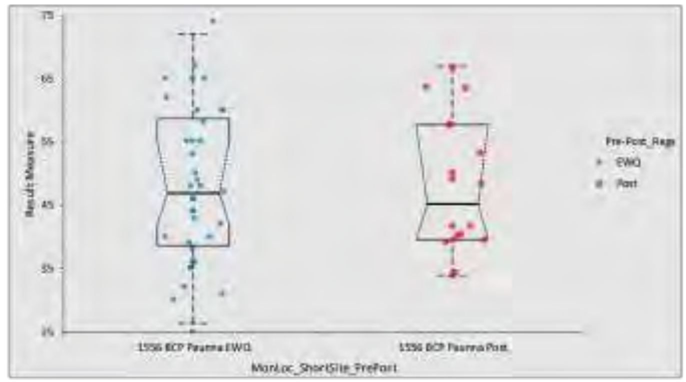
Annual May to September flow statistics are plotted above. Flow is plotted on a logarithmic scale. These are flow measurements or sometimes estimates associated with the time of each water quality sample. “Normal” annual median flow is about 7.1 cfs at this location, but the summer seasonal flow is around 5 cfs. Though a wide range of flows were sampled by DRBC, these data sets appear to be most representative of low flow conditions. EWQ samples (2000-2003) were taken using a DRBC gage and rating curve established for Paunacussing Creek, but the rating was too difficult to maintain because of channel instability and bridge reconstruction. 2009-2011 flows corresponding to each water quality sample were estimated using the USGS BaSE program (Stuckey, M.H., Koerkle, E.H., and Ulrich, J.E., 2012, Estimation of baseline daily mean streamflows for ungaged locations on Pennsylvania streams, water years 1960–2008: U.S. Geological Survey Scientific Investigations Report 2012–5142, 61 p.). DRBC benchmarked water surface elevation measurements are still used to check BaSE estimates.

Chapter 8: 1556 BCP Paunacussing Creek, PA

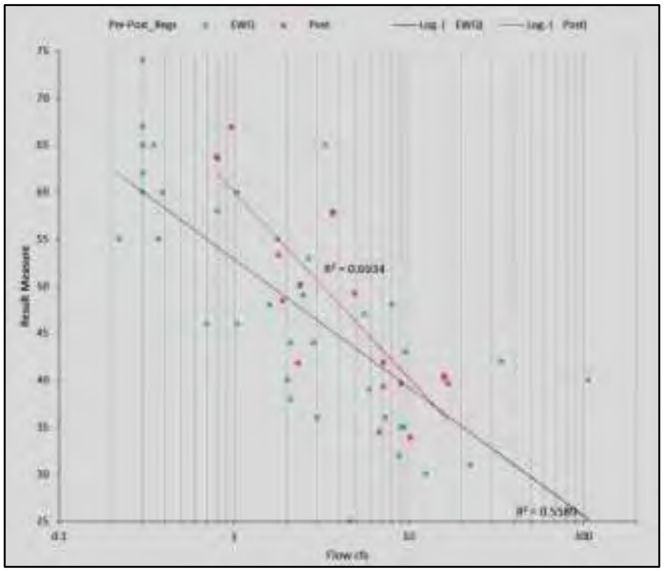
Alkalinity as CaCO3, Total mg/l

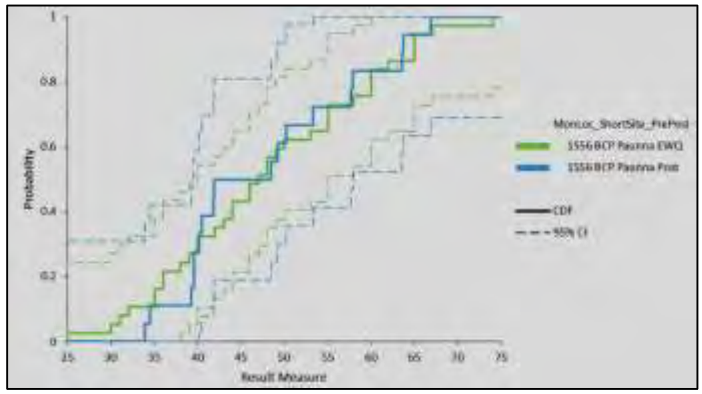
Existing Water Quality (Table 2S):

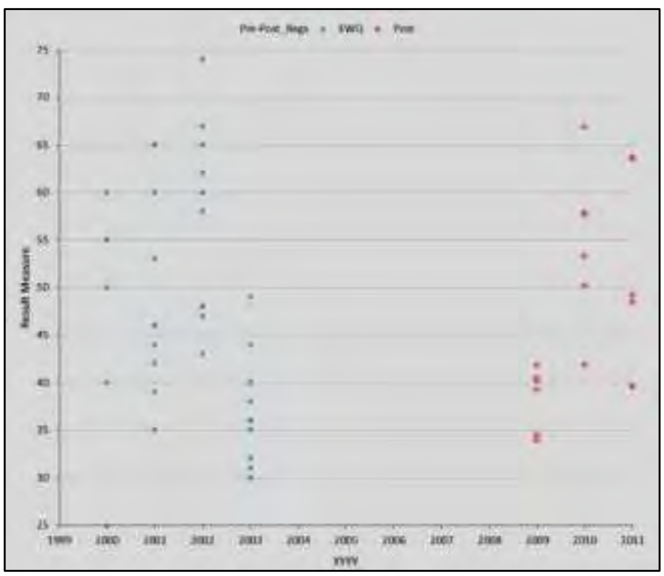
Median 47 mg/l
Lower 95% Confidence Interval 42 mg/l
Upper 95% Confidence Interval 55 mg/l
Defined in regulations as a flow-related parameter



N	55					
Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1556 BCP Paunna EWQ	25	39	47	59	74	20
1556 BCP Paunna Post	34	40	45	58	67	18







Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1556 BCP Paunna EWQ	37	0.4	0.01
1556 BCP Paunna Post	18	0.9	0.05

H statistic	0.01
X^2 approximation	0.01
DF	1
p-value	0.9428 [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.

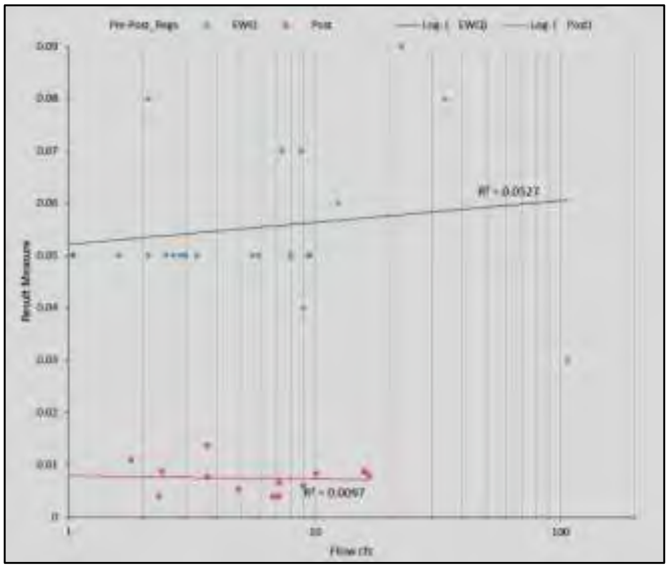
No water quality degradation is evident. Alkalinity did not measurably change between the EWQ and post-EWQ periods. Alkalinity is inversely related to flow in both data sets. Post-EWQ median alkalinity fell within EWQ 95% confidence intervals. Flow is plotted on a logarithmic scale.

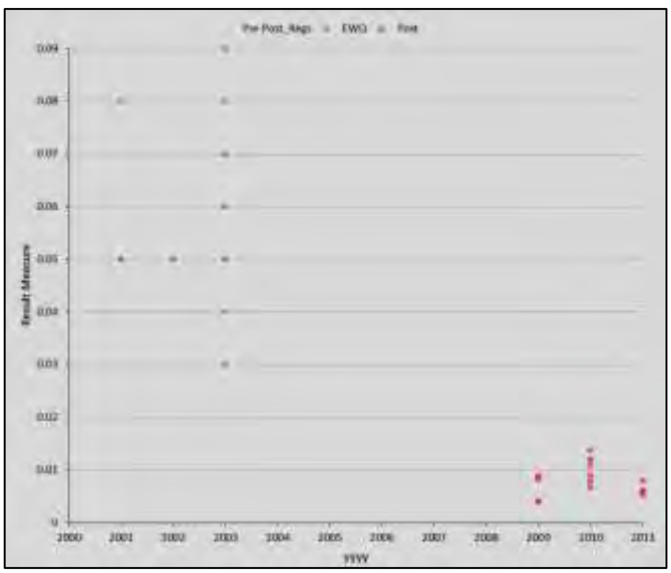
Chapter 8: 1556 BCP Paunacussing Creek, PA

Ammonia Nitrogen as N, Total mg/l

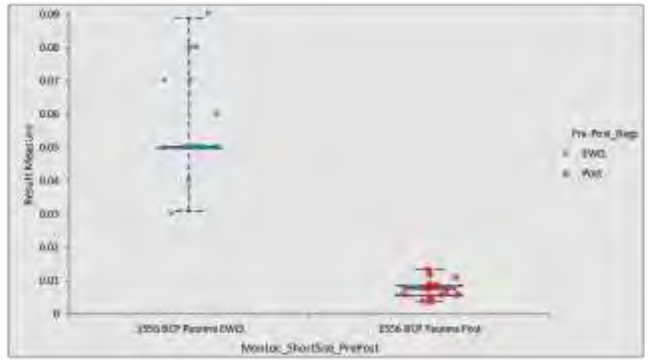
Existing Water Quality (Table 2S):

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



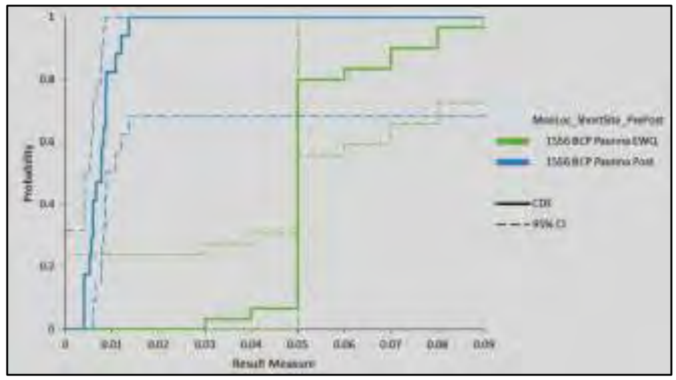


No water quality degradation is evident. Ammonia concentrations apparently declined. However, detection limit differences, potential laboratory artifacts, and insufficient post-EWQ sampling (n=17) introduced uncertainty to conclusions.



N	47

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1556 BCP Paunna EWQ	0.03	0.05	0.05	0.05	0.09	0.00
1556 BCP Paunna Post	0.00	0.01	0.01	0.01	0.01	0.00



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1556 BCP Paunna EWQ	30	2167.5	72.25
1556 BCP Paunna Post	17	3825.0	225.00

H statistic	35.53
X^2 approximation	35.53
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.

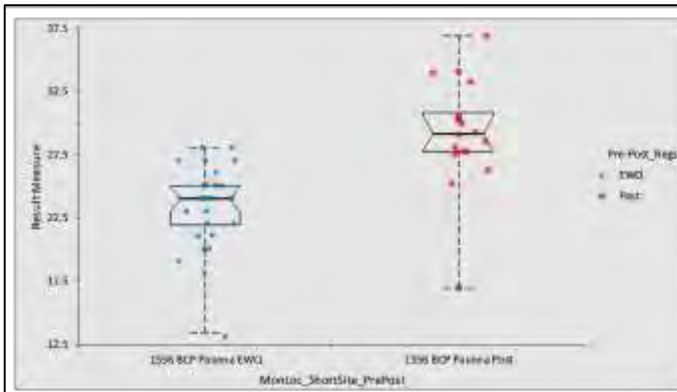
Post-EWQ median concentration was below the EWQ lower 95% confidence interval. No independent data were available to validate the decline. DRBC's post-EWQ detection limit was lower than during the EWQ period. EWQ data set possessed many non-detect results (24 of 30 samples). Thus EWQ was established as "less than" 0.05 mg/l, the detection limit at the time. From 2009-2011 there were 4/17 non-detect results at detection limits of 0.004-0.006 mg/l. Now we can see what the real concentrations are, well-below 0.05 mg/l. Post-EWQ concentrations measured no higher than 0.014 mg/l, suggesting water quality improvement.

Chapter 8: 1556 BCP Paunacussing Creek, PA

Chloride, Total mg/l

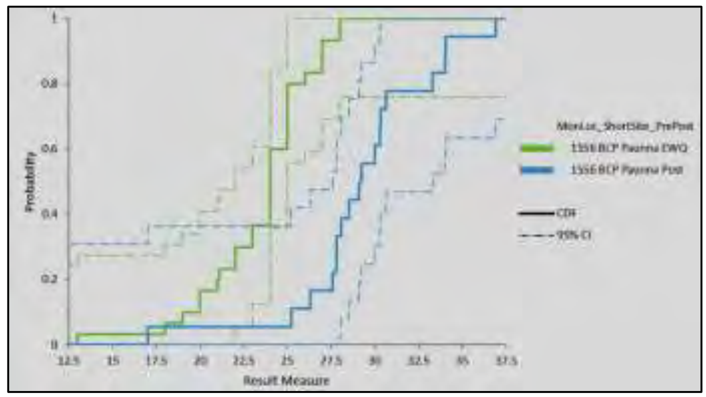
Existing Water Quality (Table 2S):

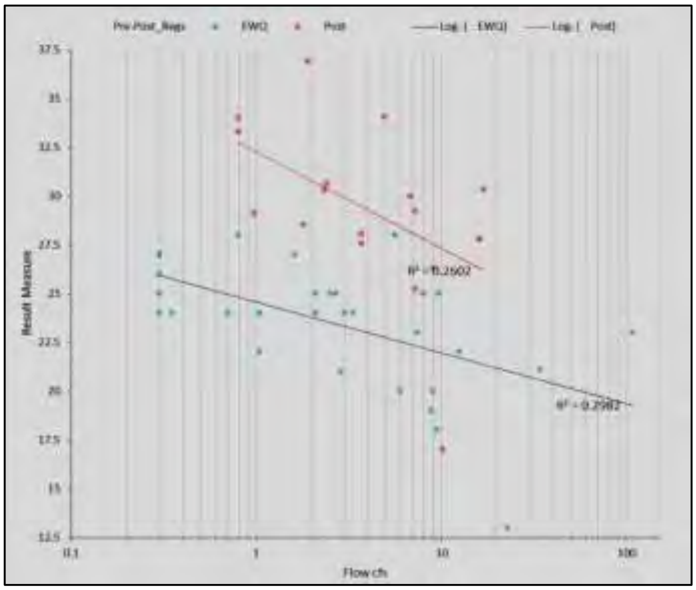
Median 24 mg/l
Lower 95% Confidence Interval 23 mg/l
Upper 95% Confidence Interval 25 mg/l
Defined in regulations as a flow-related parameter

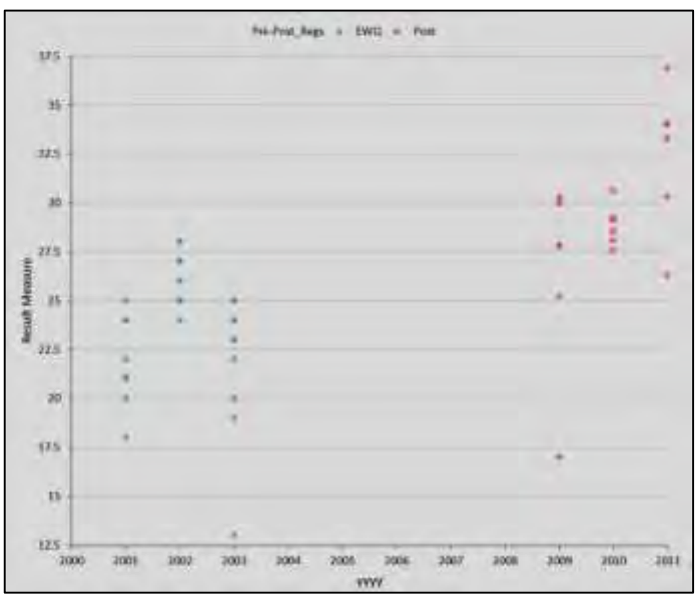


N | 48

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1556 BCP Paunna EWQ	13	22	24	25	28	3
1556 BCP Paunna Post	17	28	29	31	37	3







Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1556 BCP Paunna EWQ	30	1672.5	55.75
1556 BCP Paunna Post	18	2787.6	154.86

H statistic	22.88
X^2 approximation	22.88
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.

Water quality degradation is evident. Chloride concentrations increased by 5 mg/l between the two periods. Post-EWQ median concentration rose above the EWQ upper 95% confidence interval.

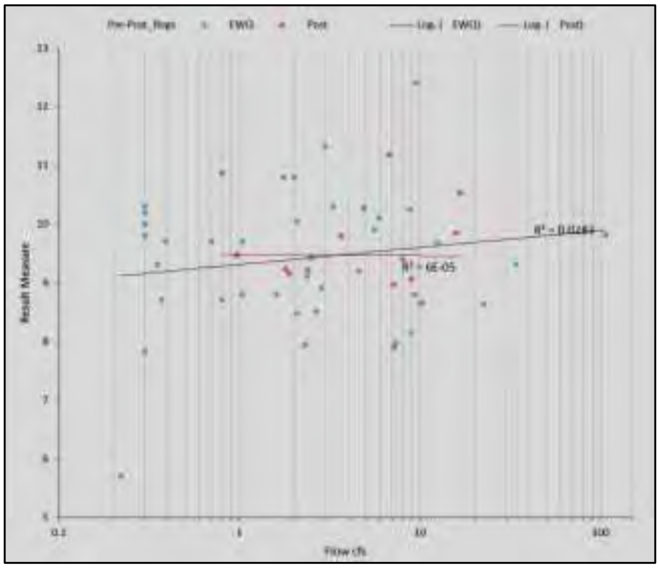
Chloride concentrations are weakly and inversely related to flow. We can only speculate at the reason for increasing chloride concentrations. There are no new discharge permits in the watershed. While these concentrations are far better than water quality criteria levels, such a large increase in so short a time deserves further investigation in this designated Wild and Scenic watershed.

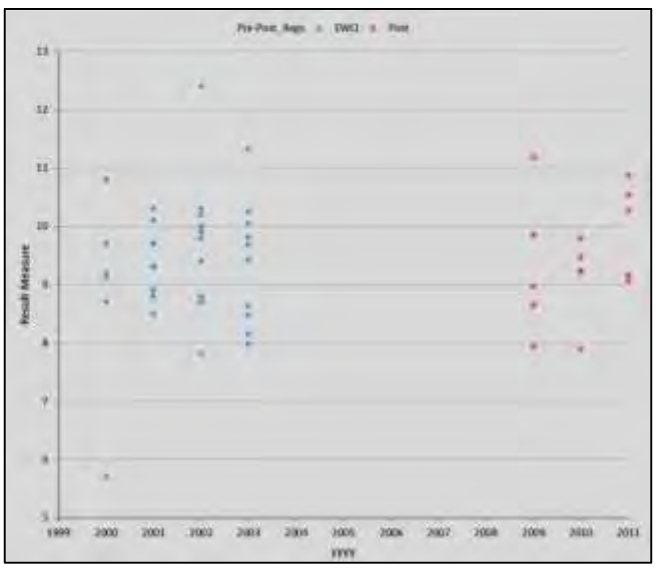
Chapter 8: 1556 BCP Paunacussing Creek, PA

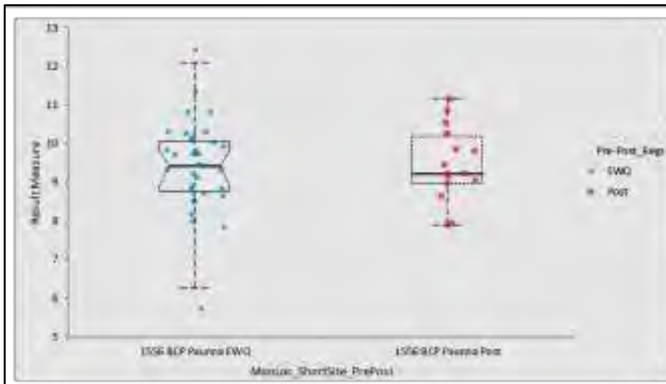
Dissolved Oxygen (DO) mg/l

Existing Water Quality (Table 2S):

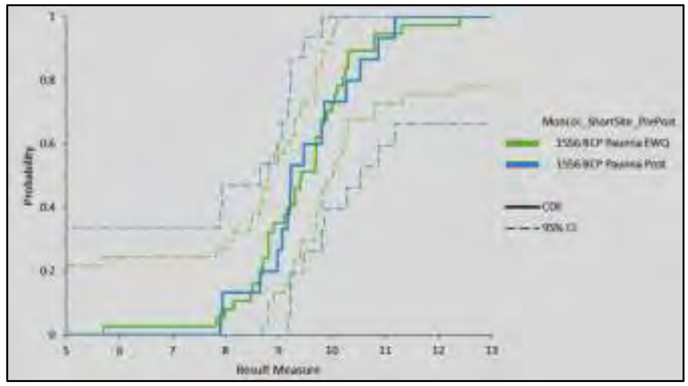
Median 9.42 mg/l
Lower 95% Confidence Interval 8.90 mg/l
Upper 95% Confidence Interval 9.81 mg/l







N	52					
Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1556 BCP Paunna EWQ	5.70	8.77	9.42	10.07	12.40	1.30
1556 BCP Paunna Post	7.90	8.99	9.23	10.20	11.18	1.22



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1556 BCP Paunna EWQ	37	0.7	0.02
1556 BCP Paunna Post	15	1.7	0.11

H statistic	0.01
X^2 approximation	0.01
DF	1
p-value	0.9195 [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.

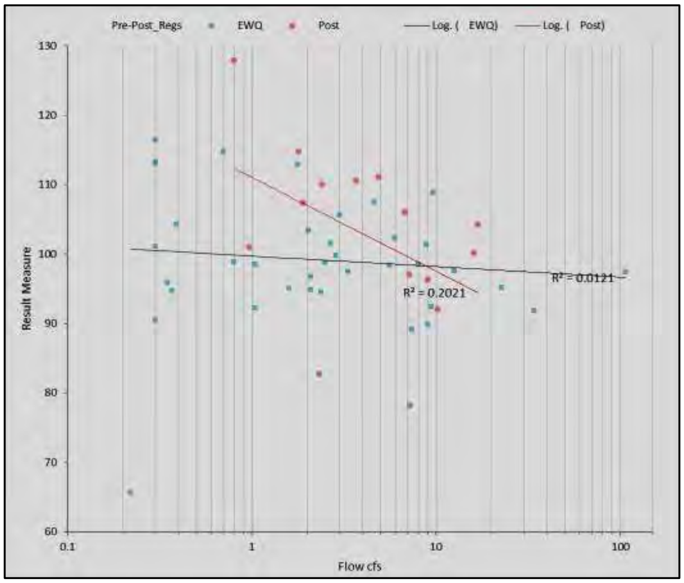
No water quality degradation is indicated. No measurable change took place between the EWQ and Post-EWQ periods. Post-EWQ median DO concentration fell within the EWQ 95% confidence intervals. Flow is plotted on a logarithmic scale. DO concentration is unrelated to flow in both data sets. There was an extreme low DO value in the EWQ data set. That measurement was taken from a standing pool during dry conditions in July 2000 when flow in Paunacussing Creek was 0.2 cfs. The pool was full of decomposing organic matter that drove DO concentration to 5.7 mg/l.

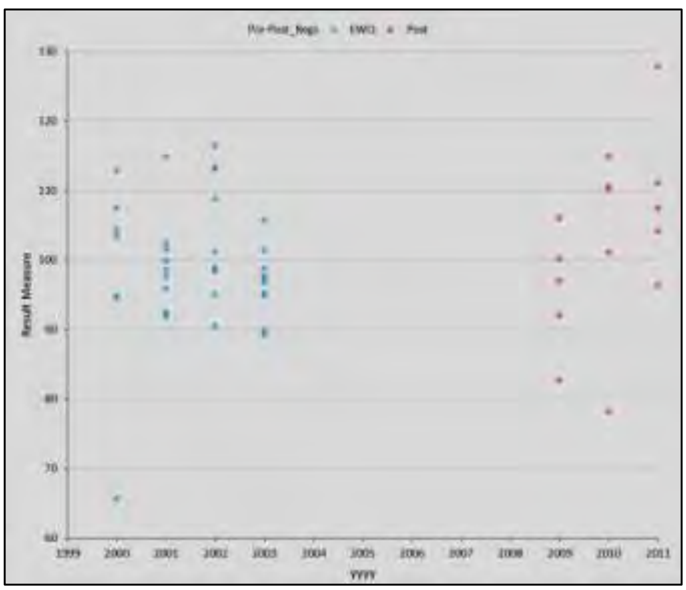
Chapter 8: 1556 BCP Paunacussing Creek, PA

Dissolved Oxygen Saturation %

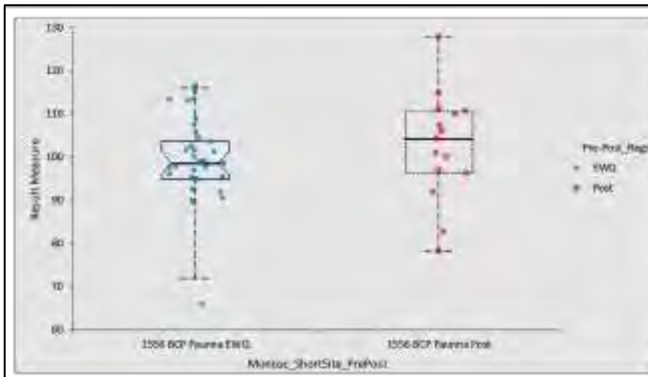
Existing Water Quality (Table 2S):

Median 98%
Lower 95% Confidence Interval 96%
Upper 95% Confidence Interval 101%



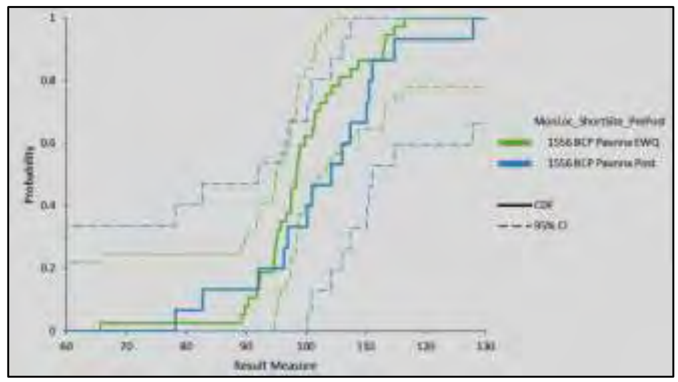


No water quality degradation is indicated. DO Saturation is unrelated to flow, and did not measurably change between the EWQ and post-EWQ periods. Post-EWQ median DO saturation rose to the EWQ upper 95% confidence interval, but not significantly. Flow is plotted on a logarithmic scale.



N 52

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1556 BCP Paunna EWQ	66	95	98	104	116	9
1556 BCP Paunna Post	78	96	104	111	128	14



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1556 BCP Paunna EWQ	37	95.7	2.59
1556 BCP Paunna Post	15	236.0	15.73

H statistic	1.44
X^2 approximation	1.44
DF	1
p-value	0.2295 [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.

Some riparian trees were removed during bridge reconstruction between the EWQ and post-EWQ periods. This may account for the slight increase in DO saturation. Upon tree removal more light strikes the stream and promotes algal production. During mid-day hours the plants produce oxygen super-saturation conditions, thus the observed median value of 104%.

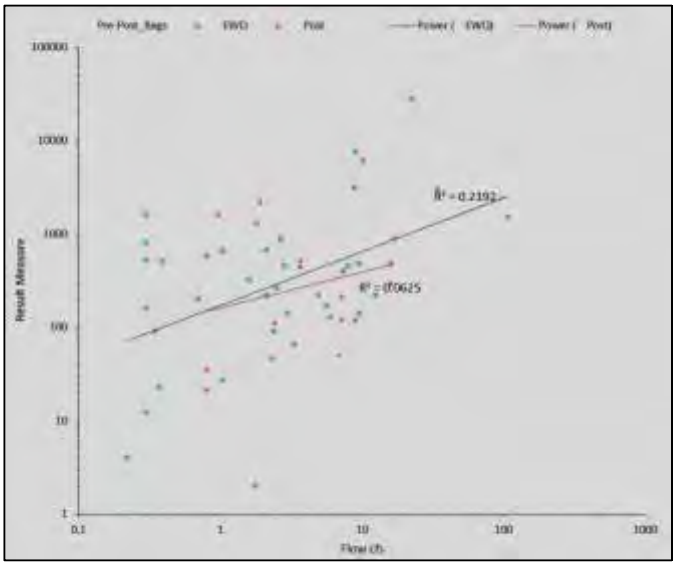
There was an extreme low DO saturation value in the EWQ data set. That measurement was taken from a standing pool during dry conditions in July 2000 when flow in Paunacussing Creek was estimated at 0.2 cfs. The pool contained decomposing organic matter that drove DO to 5.7 mg/l, and DO saturation to 65%.

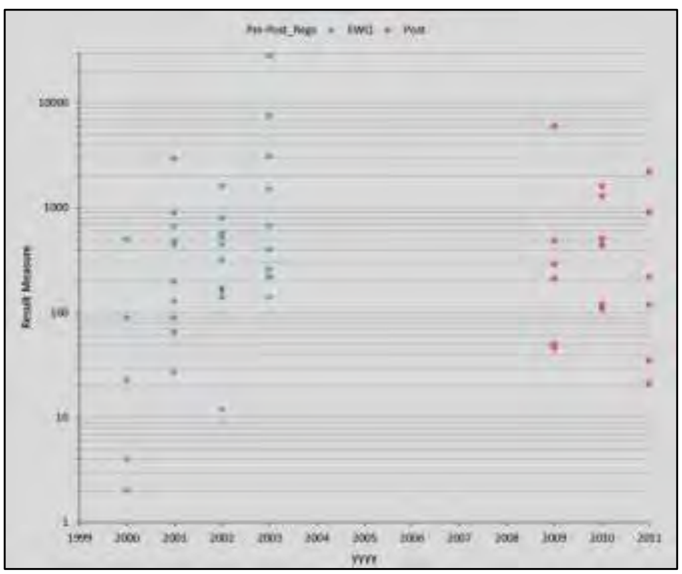
Chapter 8: 1556 BCP Paunacussing Creek, PA

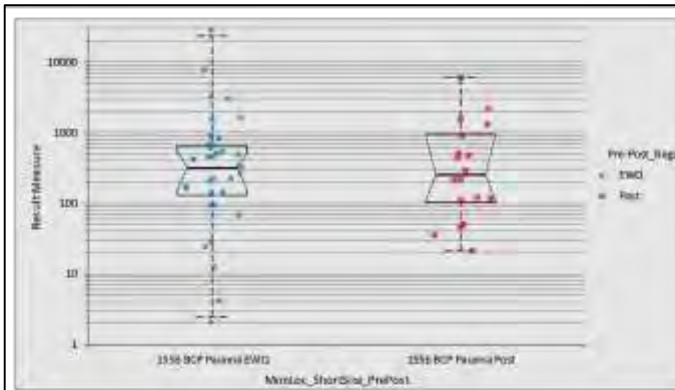
Enterococcus colonies/100 ml

Existing Water Quality (Table 2S):

Median 320/100 ml
Lower 95% Confidence Interval 160/100 ml
Upper 95% Confidence Interval 520/100 ml

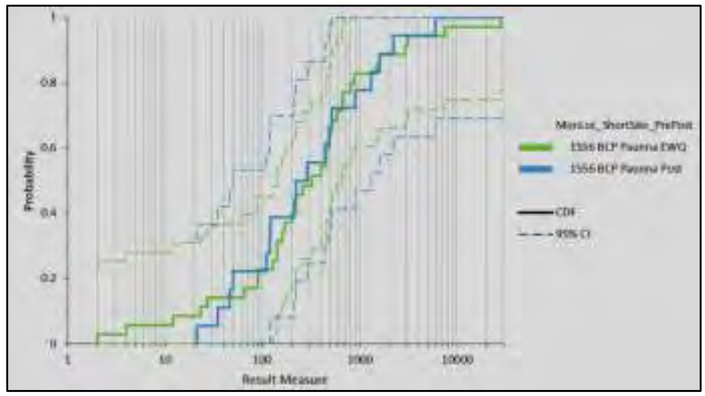






N	53

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1556 BCP Paunna EWQ	2	130	320	668	28,000	538
1556 BCP Paunna Post	21	105	255	933	6,000	828



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1556 BCP Paunna EWQ	35	3.5	0.10
1556 BCP Paunna Post	18	6.7	0.37

H statistic	0.04
X^2 approximation	0.04
DF	1
p-value	0.8363[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.

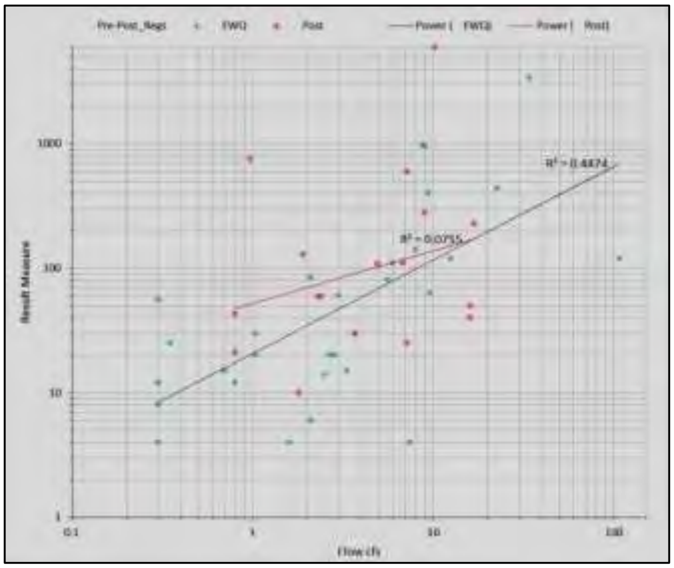
No water quality degradation is evident. Enterococci did not measurably change between the EWQ and Post-EWQ periods. Enterococcus concentrations are unrelated to flow in both data sets. Note that concentrations and flows are plotted on a logarithmic scale. Post-EWQ median enterococcus concentrations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

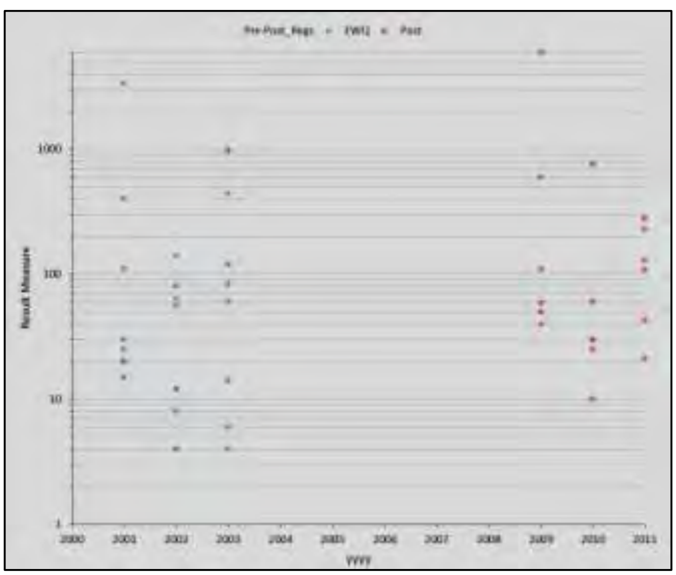
Chapter 8: 1556 BCP Paunacussing Creek, PA

Escherichia coli colonies/100 ml

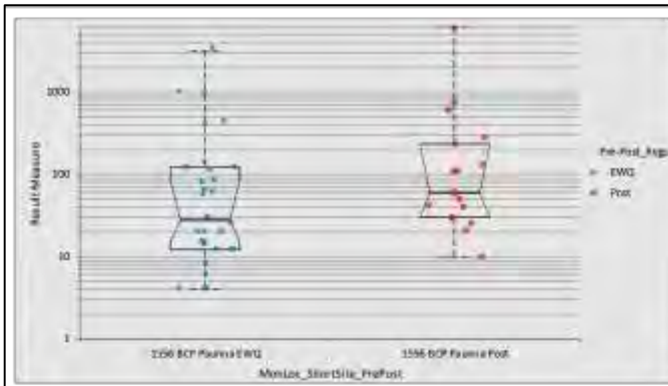
Existing Water Quality (Table 2S):

Median 28/100 ml
Lower 95% Confidence Interval 15/100 ml
Upper 95% Confidence Interval 84/100 ml
Defined in regulations as a flow-related parameter



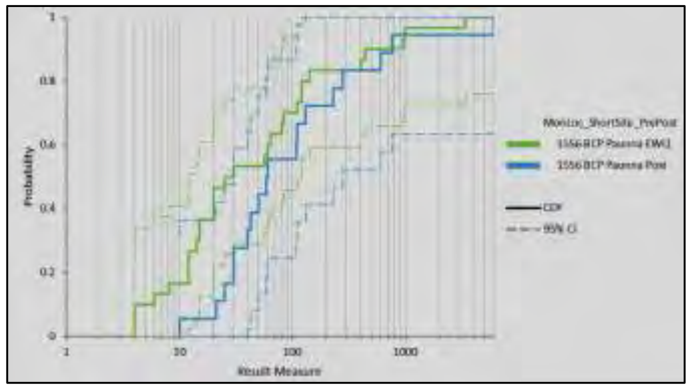


No water quality degradation is evident. E. coli concentrations did not measurably change between the EWQ and Post-EWQ periods. Post-EWQ median E. coli fell within the EWQ 95% confidence intervals.



N 48

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1556 BCP Paunna EWQ	4	12	28	120	3400	108
1556 BCP Paunna Post	10	30	60	234	6000	204



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1556 BCP Paunna EWQ	30	200.2	6.67
1556 BCP Paunna Post	18	333.7	18.54

H statistic	2.73
X^2 approximation	2.73
DF	1
p-value	0.0987 [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.

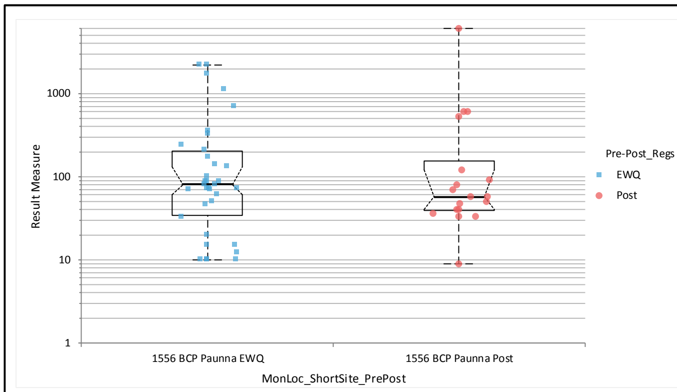
E. coli concentrations were positively related to flow in the EWQ data set, but unrelated to flow in the post-EWQ data set – possibly due to too few post-EWQ samples (n=18). No independent data from other agencies were available at this site to validate DRBC's conclusion.

Chapter 8: 1556 BCP Paunacussing Creek, PA

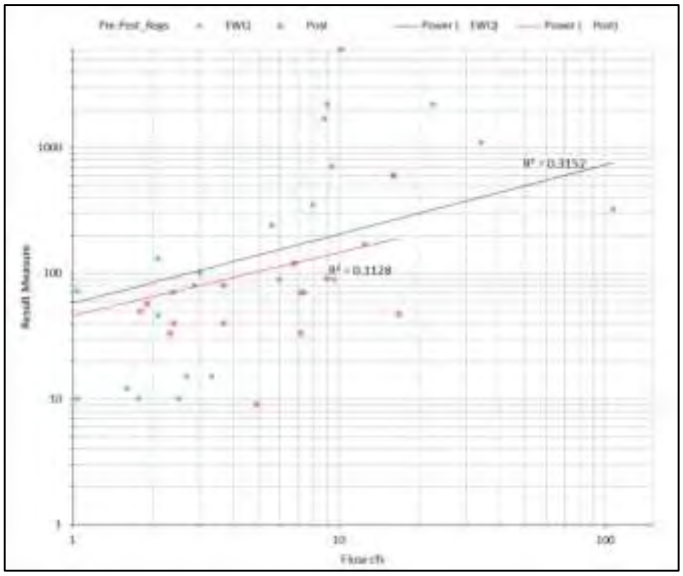
Fecal coliform colonies/100 ml

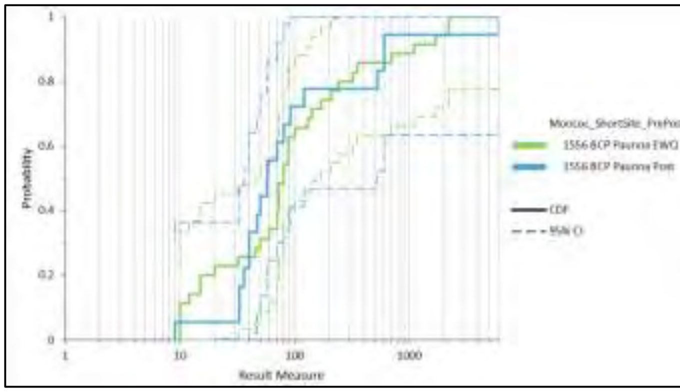
Existing Water Quality (Table 2S):

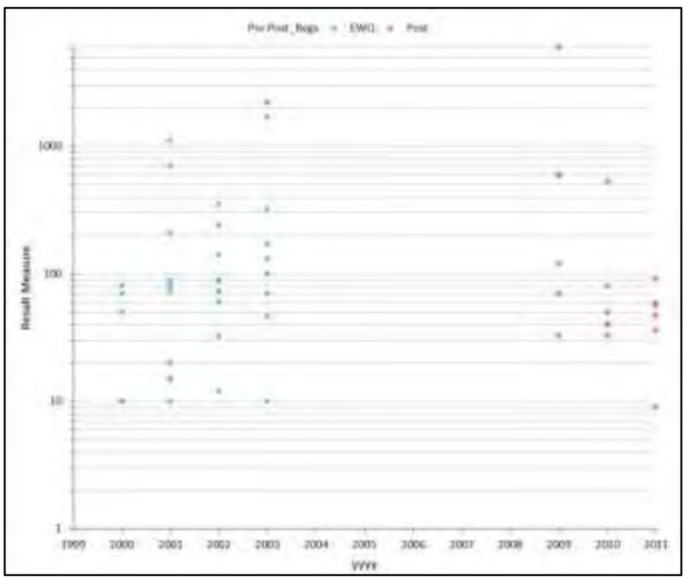
Median 80/100 ml
Lower 95% Confidence Interval 60/100 ml
Upper 95% Confidence Interval 130/100 ml
Defined in regulations as a flow-related parameter



N	53					
Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1556 BCP Paunna EWQ	10	34	80	203	2200	169
1556 BCP Paunna Post	9	40	58	154	6000	115







Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1556 BCP Paunna EWQ	35	20.1	0.57
1556 BCP Paunna Post	18	39.0	2.17

H statistic	0.25
X^2 approximation	0.25
DF	1
p-value	0.6185 [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. Fecal coliform concentrations did not measurably change between the EWQ and post-EWQ periods. Fecal coliform concentrations are positively related to flow in the EWQ data set, but not in the post-EWQ data set - because of too few post-EWQ samples (n=18).

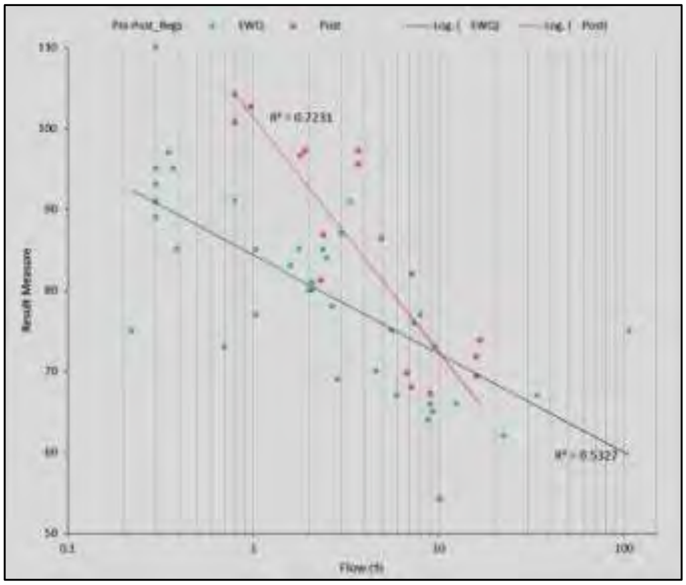
Post-EWQ median concentrations fell just below the EWQ lower 95% confidence interval, but the data were naturally variable and post-EWQ N was low so no real change could be measured. Note that concentrations and flows are plotted on a logarithmic scale.

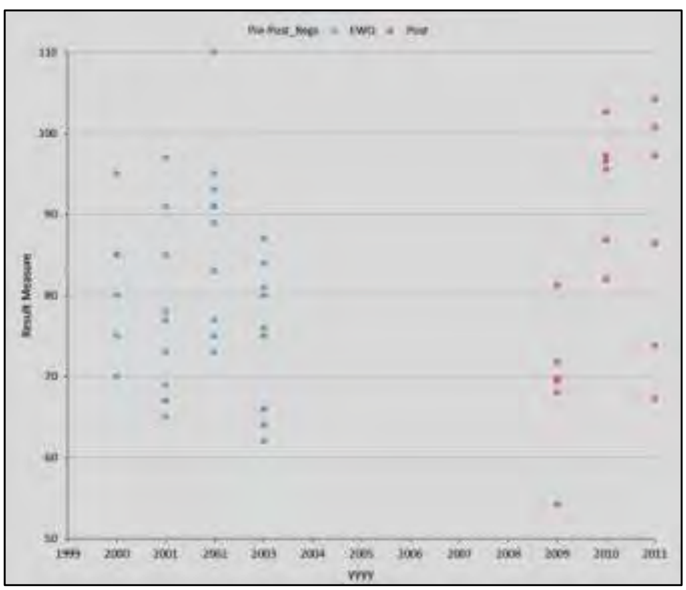
Chapter 8: 1556 BCP Paunacussing Creek, PA

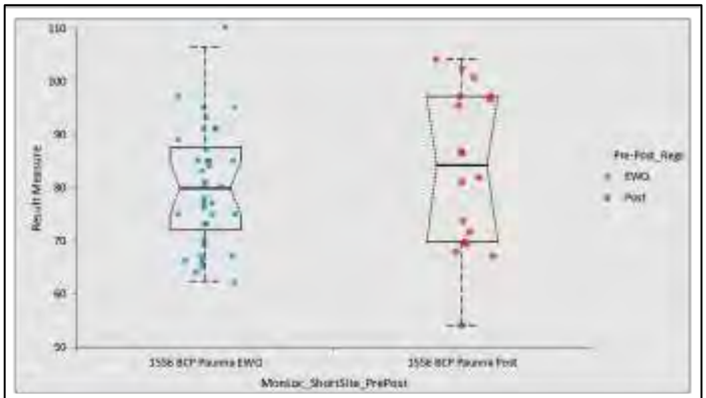
Hardness as CaCO3, Total mg/l

Existing Water Quality (Table 2S):

Median 80 mg/l
Lower 95% Confidence Interval 75 mg/l
Upper 95% Confidence Interval 85 mg/l
Defined in regulations as a flow-related parameter

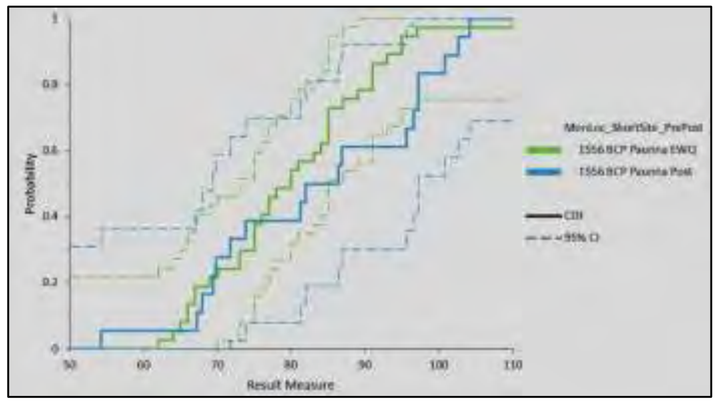






N	55

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1556 BCP Paunna EWQ	62	72	80	88	110	16
1556 BCP Paunna Post	54	70	84	97	104	27



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1556 BCP Paunna EWQ	37	107.3	2.90
1556 BCP Paunna Post	18	220.5	12.25

H statistic	1.28
X^2 approximation	1.28
DF	1
p-value	0.2582 [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.

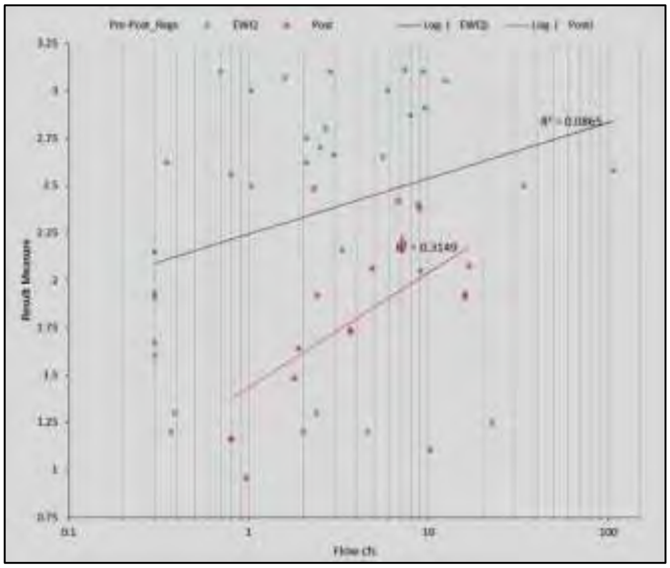
No water quality degradation is evident. Hardness did not measurably change between the EWQ and post-EWQ periods. Hardness is inversely related to flow in both data sets. Post-EWQ median hardness fell within the EWQ 95% confidence intervals. Note that flows are plotted on a logarithmic scale.

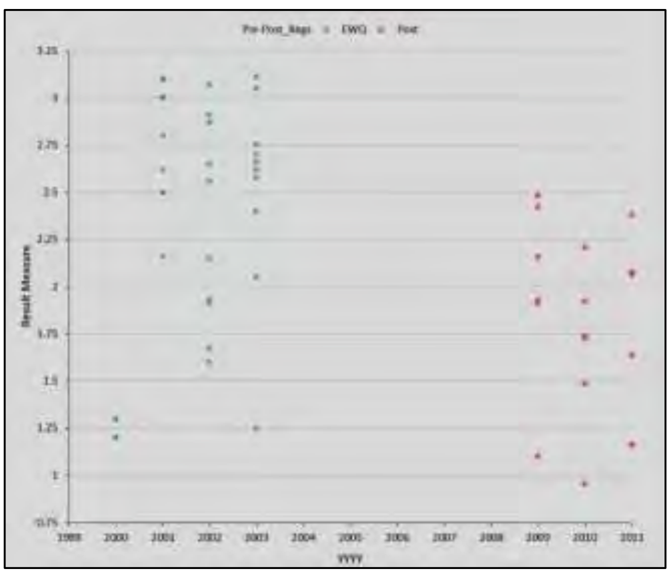
Chapter 8: 1556 BCP Paunacussing Creek, PA

Nitrate + Nitrite as N, Total mg/l

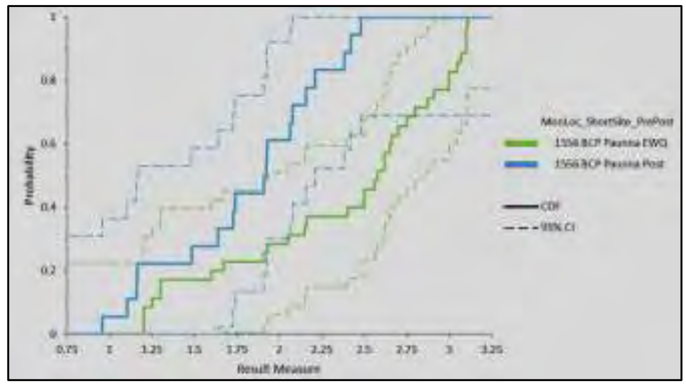
Existing Water Quality (Table 2S, as Nitrate only):

Median 2.58 mg/l
Lower 95% Confidence Interval 2.15 mg/l
Upper 95% Confidence Interval 2.75 mg/l





Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
N 53						
1556 BCP Paunna EWQ	1.20	1.91	2.58	2.90	3.11	0.99
1556 BCP Paunna Post	0.96	1.46	1.92	2.16	2.48	0.70



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1556 BCP Paunna EWQ	35	845.3	24.15
1556 BCP Paunna Post	18	1643.6	91.31

H statistic	10.44
X^2 approximation	10.44
DF	1
p-value	0.0012 [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. Nitrate concentrations apparently declined between the EWQ and post-EWQ periods. However, analytical uncertainty sources included potential laboratory artifacts, insufficient post-EWQ sampling (n=18), and under-representation of post-EWQ flow conditions.

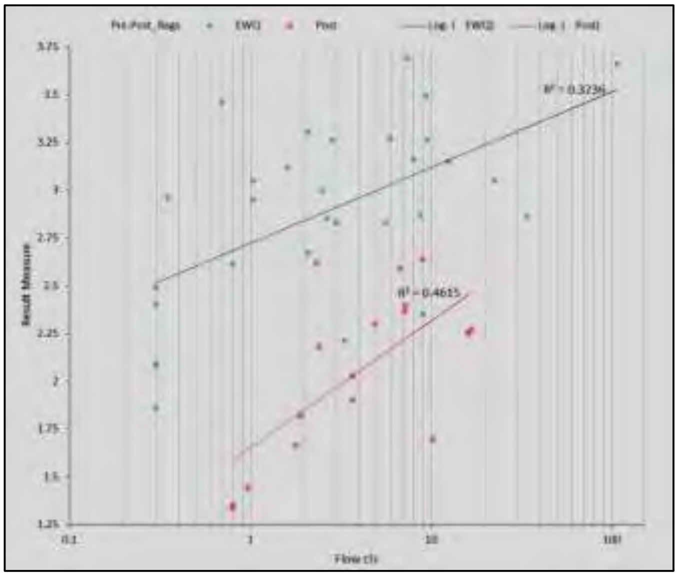
Nitrate is unrelated related to flow in the EWQ data set, but positively related to flow in the post-EWQ data set. Post-EWQ nitrate + nitrite concentrations were assumed equivalent for comparison with EWQ nitrate concentrations since EWQ nitrite concentrations were never detected. Flow is plotted on a logarithmic scale. Independent data were not available for validation of results. Post-EWQ median nitrate + nitrite concentrations fell below the EWQ lower 95% confidence interval.

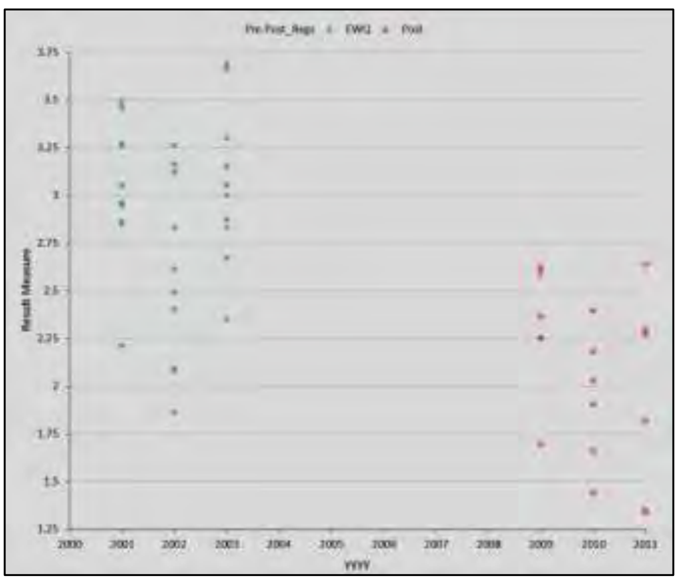
Chapter 8: 1556 BCP Paunacussing Creek, PA

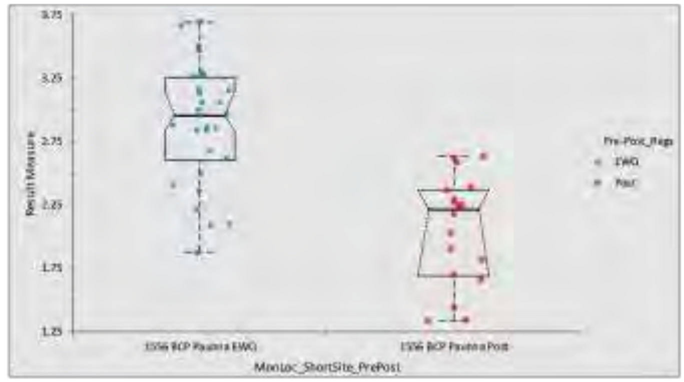
Nitrogen as N, Total (TN) mg/l

Existing Water Quality (Table 2S):

Median 2.96 mg/l
Lower 95% Confidence Interval 2.83 mg/l
Upper 95% Confidence Interval 3.15 mg/l

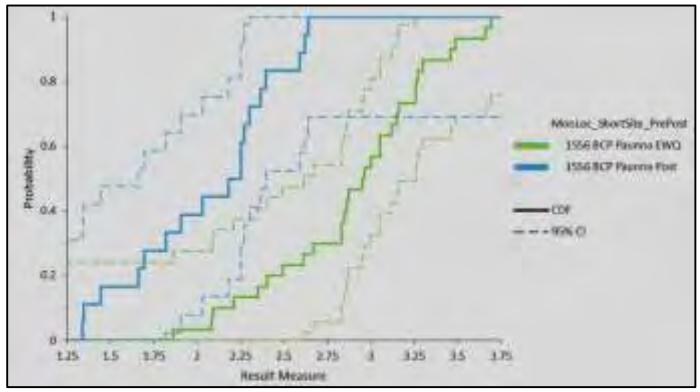






N	48

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1556 BCP Paunna EWQ	1.86	2.60	2.96	3.26	3.69	0.66
1556 BCP Paunna Post	1.34	1.69	2.22	2.37	2.64	0.67



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1556 BCP Paunna EWQ	30	1555.2	51.84
1556 BCP Paunna Post	18	2592.0	144.00

H statistic	21.16
X^2 approximation	21.16
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.

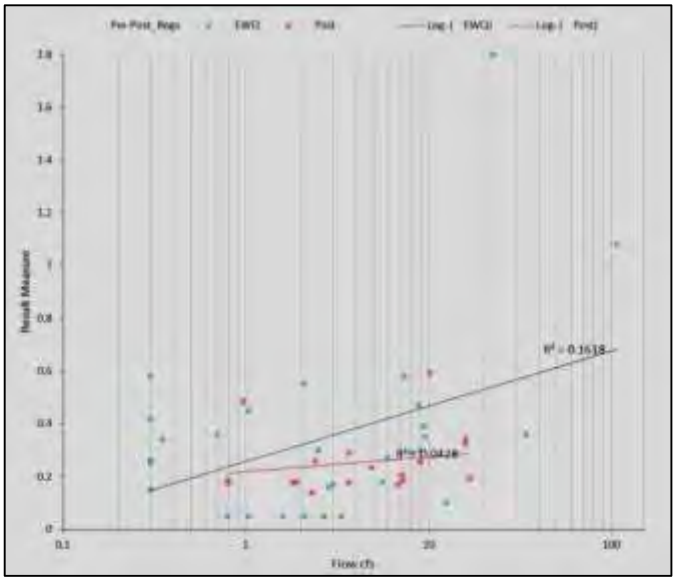
No water quality degradation is evident. Total Nitrogen concentrations declined between the EWQ and post-EWQ periods. However, potential laboratory artifacts introduce uncertainty into conclusions. TN is positively related to flow in both data sets. TN should have been designated as a flow-related parameter for this site in Table 2S of DRBC water quality regulations. Note that flows are plotted on a logarithmic scale. DRBC results could not be independently validated. Post-EWQ median TN concentrations fell well below the EWQ lower 95% confidence interval.

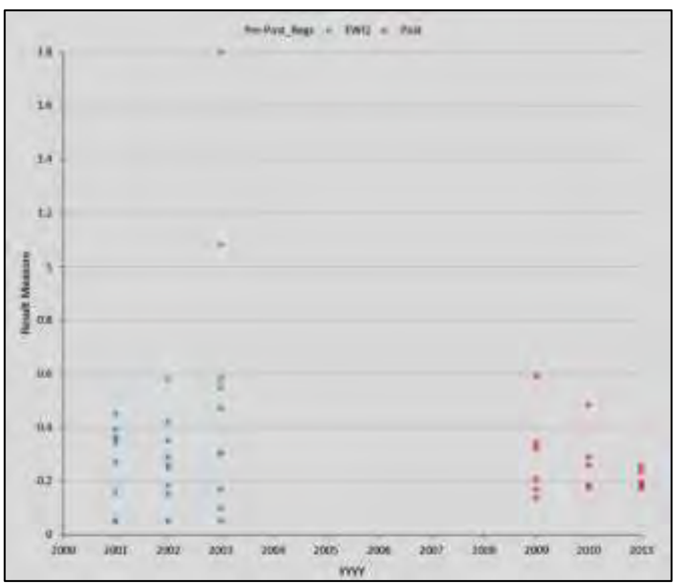
Chapter 8: 1556 BCP Paunacussing Creek, PA

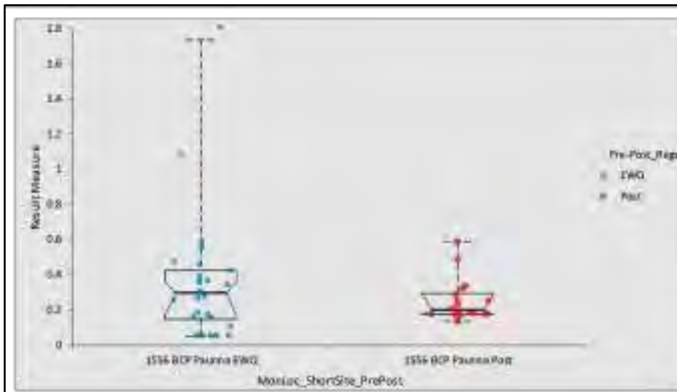
Nitrogen, Kjeldahl as N, Total (TKN) mg/l

Existing Water Quality (Table 2S):

Median 0.30 mg/l
Lower 95% Confidence Interval 0.17 mg/l
Upper 95% Confidence Interval 0.36 mg/l

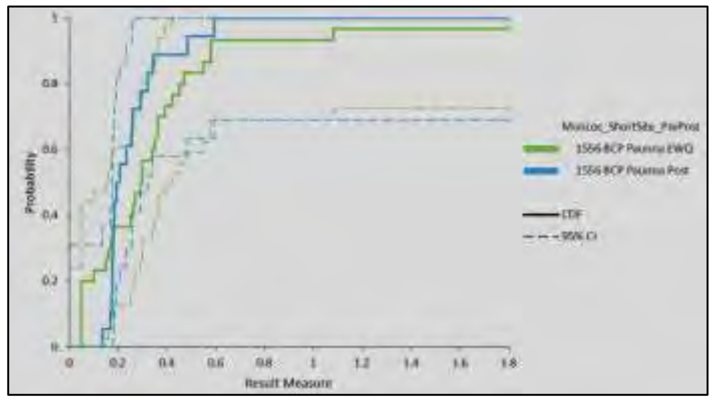






N 48

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1556 BCP Paunna EWQ	0.05	0.15	0.30	0.42	1.80	0.28
1556 BCP Paunna Post	0.14	0.18	0.20	0.29	0.59	0.12



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1556 BCP Paunna EWQ	30	36.3	1.21
1556 BCP Paunna Post	18	60.5	3.36

H statistic	0.49
X^2 approximation	0.49
DF	1
p-value	0.4818 [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.

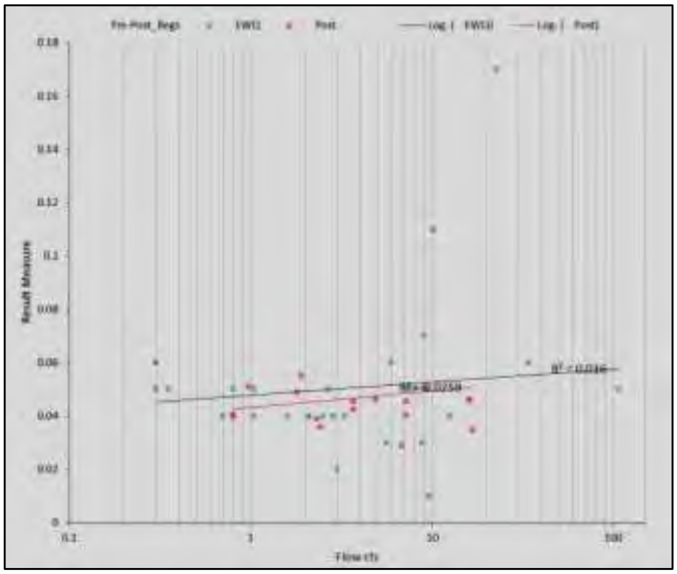
No water quality degradation is evident. TKN concentrations did not measurably change between the EWQ and post-EWQ periods. Potential laboratory artifacts introduce some uncertainty into stronger conclusions. TKN concentration is unrelated to flow in both data sets. TKN ranges less widely and is less variable in the post-EWQ data set. Note that flows are plotted on a logarithmic scale. Post-EWQ median TKN fell to just above the EWQ lower 95% confidence interval, though the decline was statistically insignificant due to insufficient post-EWQ data (n=18).

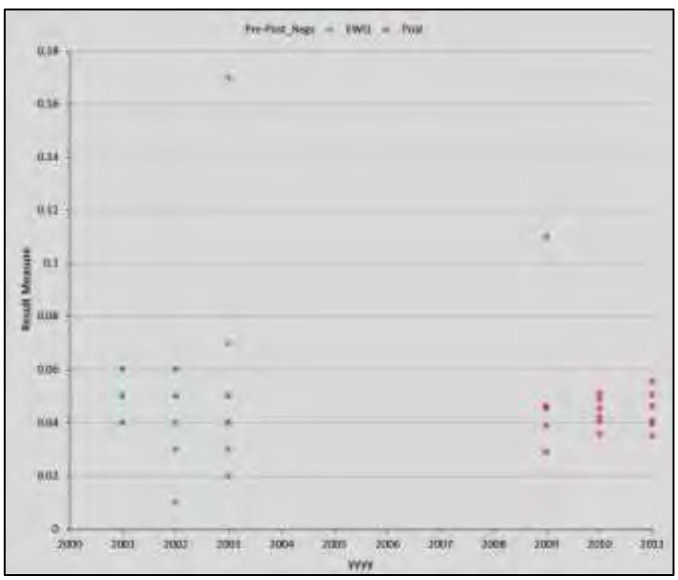
Chapter 8: 1556 BCP Paunacussing Creek, PA

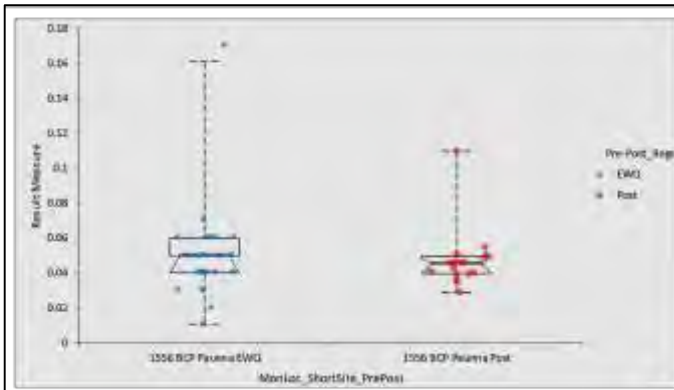
Orthophosphate as P, Total mg/l

Existing Water Quality (Table 2S):

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

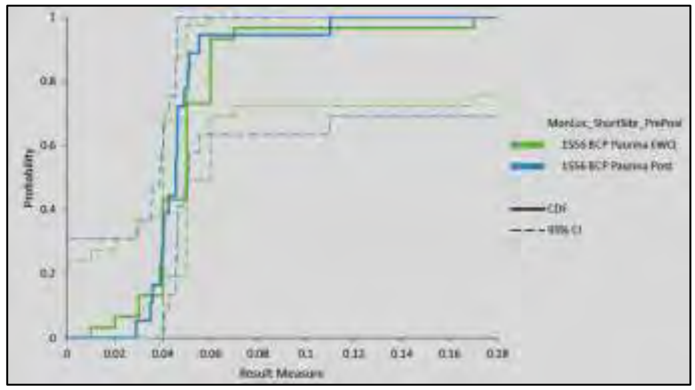






N	48

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1556 BCP Paunna EWQ	0.01	0.04	0.05	0.06	0.17	0.02
1556 BCP Paunna Post	0.03	0.04	0.05	0.05	0.11	0.01



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1556 BCP Paunna EWQ	30	53.3	1.78
1556 BCP Paunna Post	18	88.9	4.94

H statistic	0.74
X^2 approximation	0.74
DF	1
p-value	0.3907 [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.

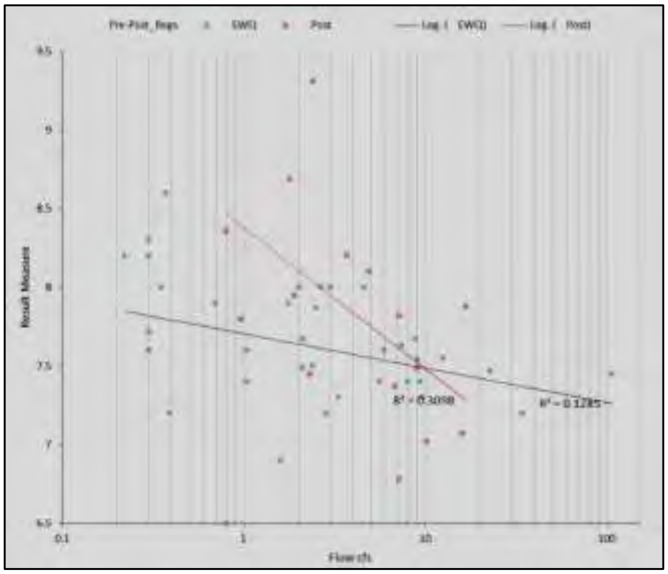
No water quality degradation is evident. Orthophosphate concentrations did not change between the EWQ and post-EWQ periods. Potential laboratory artifacts and insufficient post-EWQ sampling frequency produced uncertainty in conclusions. Orthophosphate is unrelated to flow in both data sets. Note that flows are plotted on a logarithmic scale. Post-EWQ median orthophosphate was within EWQ 95% confidence intervals. There were no independent data to confirm DRBC results.

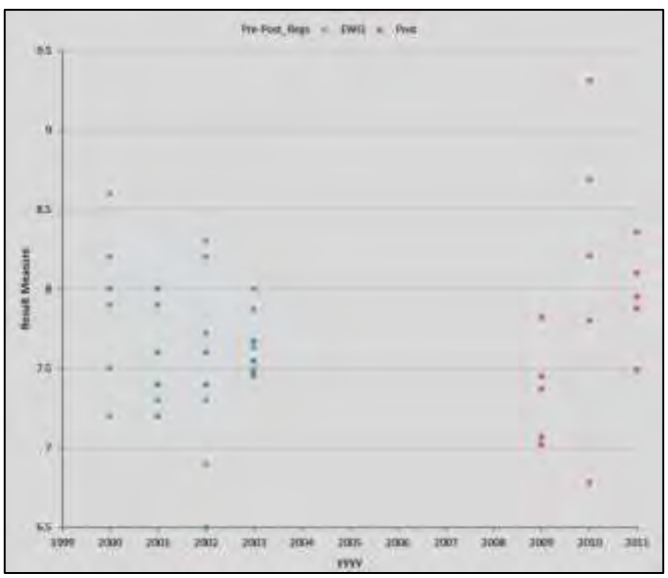
Chapter 8: 1556 BCP Paunacussing Creek, PA

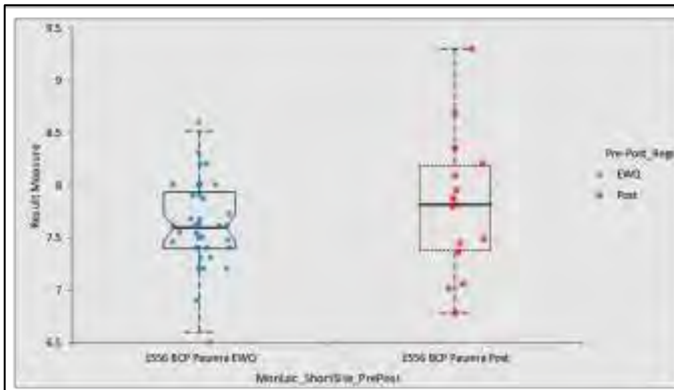
pH, units

Existing Water Quality (Table 2S):

Median 7.60 standard units
Lower 95% Confidence Interval 7.47 standard units
Upper 95% Confidence Interval 7.72 standard units

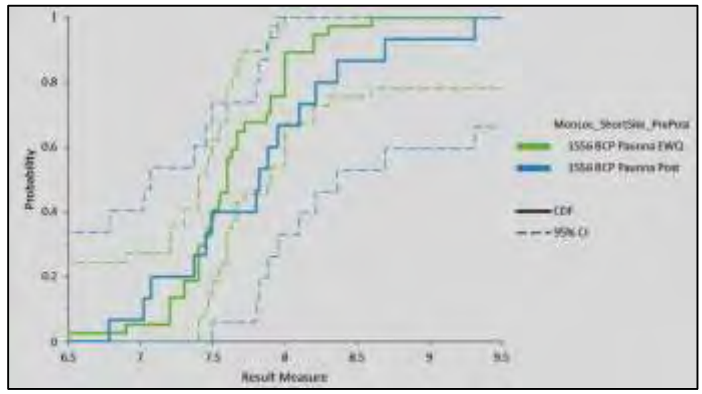






N 52

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1556 BCP Paunna EWQ	6.50	7.40	7.60	7.93	8.60	0.53
1556 BCP Paunna Post	6.78	7.38	7.82	8.19	9.31	0.81



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1556 BCP Paunna EWQ	37	46.5	1.26
1556 BCP Paunna Post	15	114.8	7.65

H statistic	0.70
X^2 approximation	0.70
DF	1
p-value	0.4014 [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.

Slight evidence is shown of water quality degradation, though pH did not measurably change between the EWQ and post-EWQ periods. pH is unrelated to flow in the EWQ data set, and weakly related to flow in the post-EWQ data set, tending toward neutral during higher flow conditions.

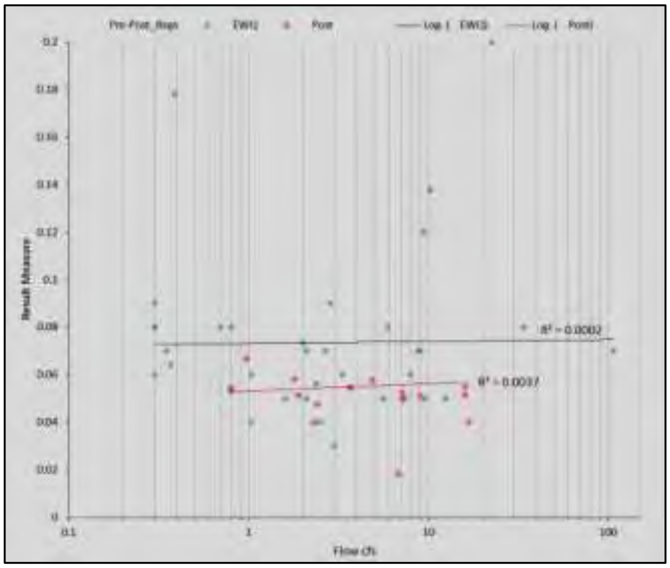
Post-EWQ median pH was just above the EWQ upper 95% confidence interval, but the increase was not significant due to insufficient post-EWQ data (n=15). pH ranged more widely in the post-EWQ data set, where minimum and maximum values occurred in the dry 2010 season. The wide range displayed in 2010 indicates higher algal productivity and less scouring away of the algae by storms. Without regular scouring events, the algal biomass can build up to problematic levels. In the post-EWQ data, increased algal activity is also associated with removal of riparian trees for bridge reconstruction, which increased sunlight to the stream.

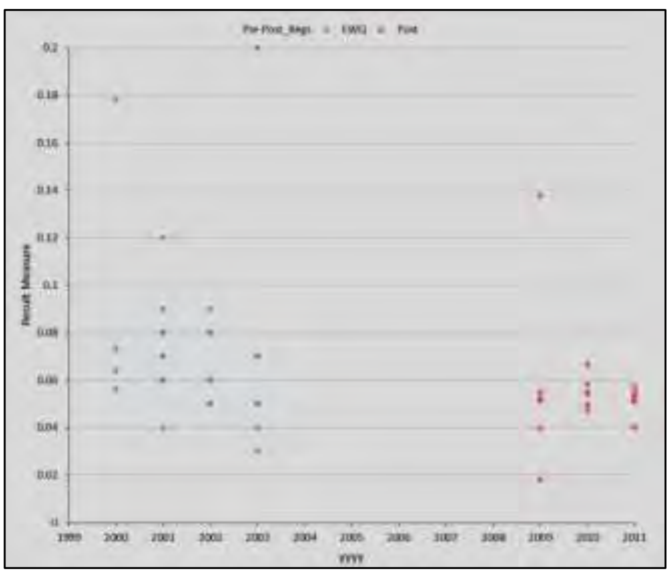
Chapter 8: 1556 BCP Paunacussing Creek, PA

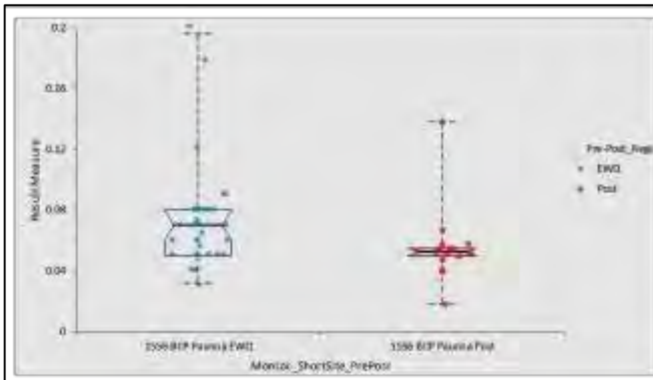
Phosphorus as P, Total (TP) mg/l

Existing Water Quality (Table 2S):

Median 0.07 mg/l
Lower 95% Confidence Interval 0.06 mg/l
Upper 95% Confidence Interval 0.08 mg/l

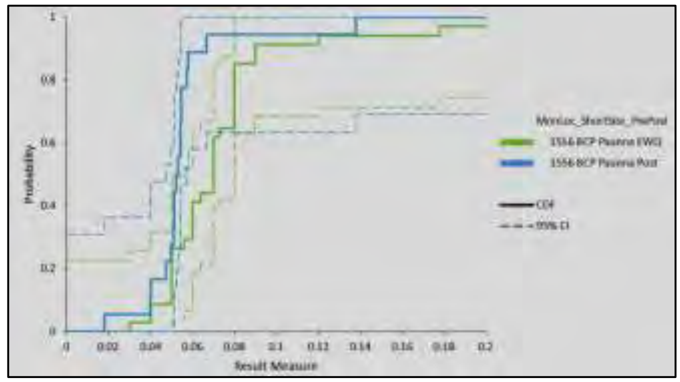






N 52

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1556 BCP Paunna EWQ	0.03	0.05	0.07	0.08	0.20	0.03
1556 BCP Paunna Post	0.02	0.05	0.05	0.05	0.14	0.01



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1556 BCP Paunna EWQ	34	644.2	18.95
1556 BCP Paunna Post	18	1216.9	67.60

H statistic	8.15
X^2 approximation	8.15
DF	1
p-value	0.0043 [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.

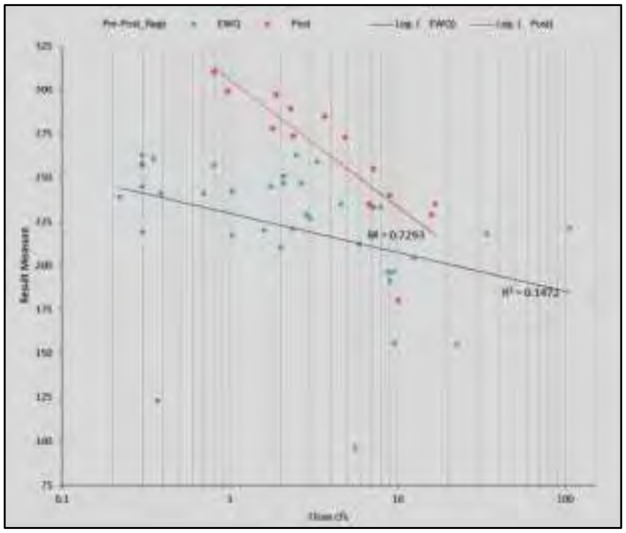
No water quality degradation is evident. Total Phosphorus (TP) concentrations declined between the EWQ and post-EWQ periods. However, potential laboratory artifacts and insufficient post-EWQ sampling frequency produced uncertainty in conclusions. Post-EWQ median total phosphorus fell below the EWQ lower 95% confidence interval. TP is unrelated to flow in both data sets. Note that flows are plotted on a logarithmic scale. No independent data were available to confirm these results.

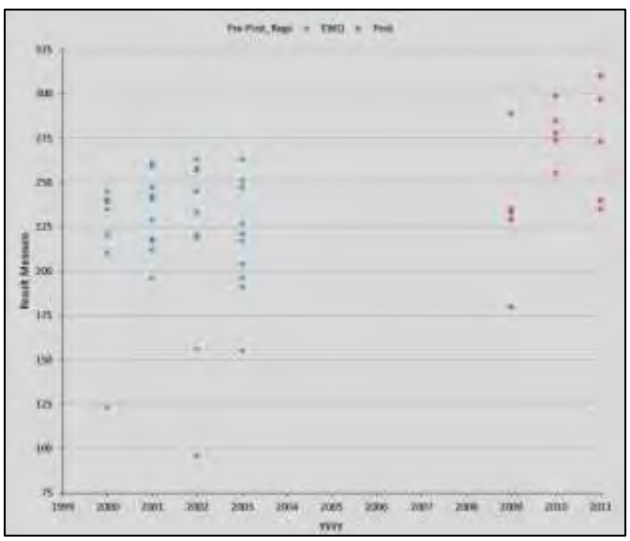
Chapter 8: 1556 BCP Paunacussing Creek, PA

Specific Conductance µmho/cm

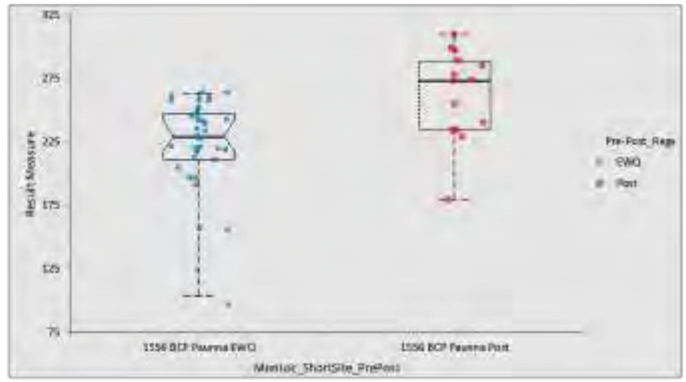
Existing Water Quality (Table 2S):

Median 229 µmho/cm
Lower 95% Confidence Interval 218 µmho/cm
Upper 95% Confidence Interval 242 µmho/cm
Defined in regulations as a flow-related parameter



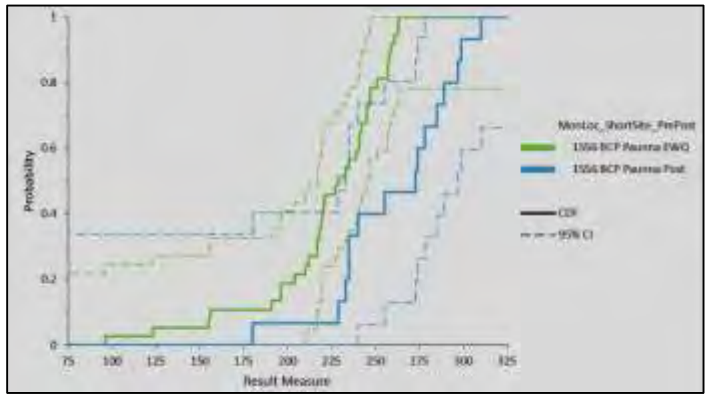


Water quality degradation is evident. Specific conductance rose above the EWQ upper 95% confidence interval between the EWQ and post-EWQ periods. Specific conductance is inversely related to flow in the post-EWQ data set. Note that flows are plotted on a logarithmic scale.



N 52

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1556 BCP Paunna EWQ	96	211	229	247	263	36
1556 BCP Paunna Post	180	235	273	288	310	53



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1556 BCP Paunna EWQ	37	636.8	17.21
1556 BCP Paunna Post	15	1570.8	104.72

H statistic	9.62
X^2 approximation	9.62
DF	1
p-value	0.0019 [1]

H0: $\theta_1 = \theta_2 = \theta_{\dots}$
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.

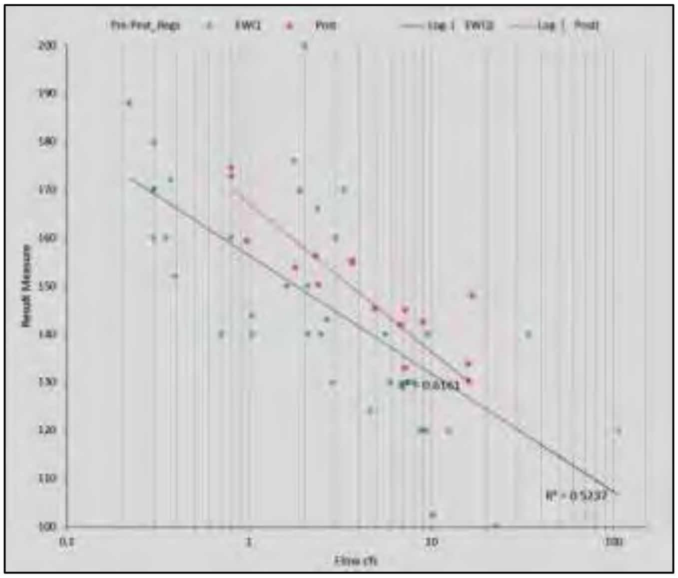
Specific conductance was defined as a flow-related parameter in the EWQ data set (DRBC water quality regulations Table 2S), even though the relationship was very weak at this site. The rise in specific conductance may be attributable to the concurrent rise in chloride concentrations. No new dischargers are present in the watershed. We speculate that winter application of road salt may have contributed to the increase. Median specific conductance has risen from 229 to 273 µmhos/cm, a 19% increase.

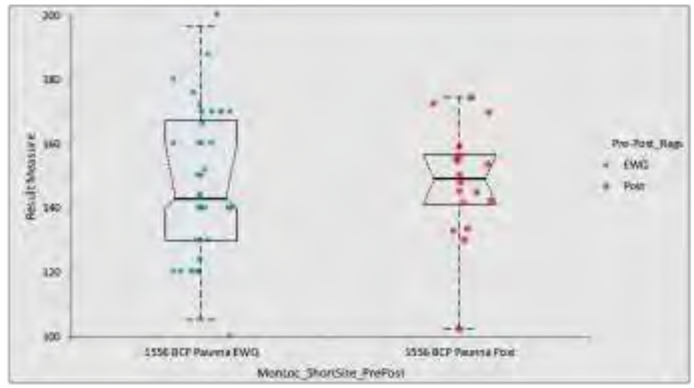
Chapter 8: 1556 BCP Paunacussing Creek, PA

Total Dissolved Solids (TDS) mg/l

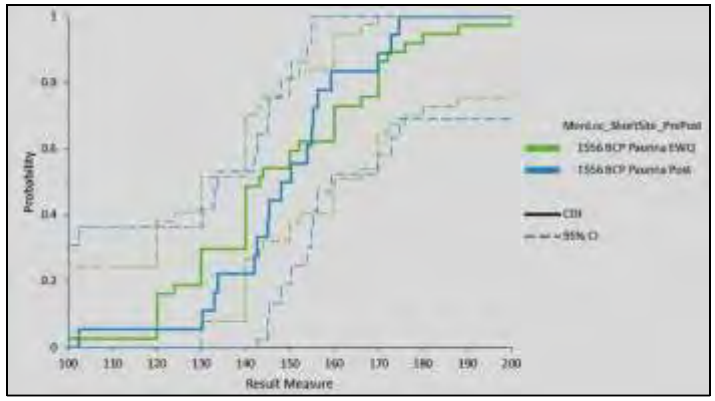
Existing Water Quality (Table 2S):

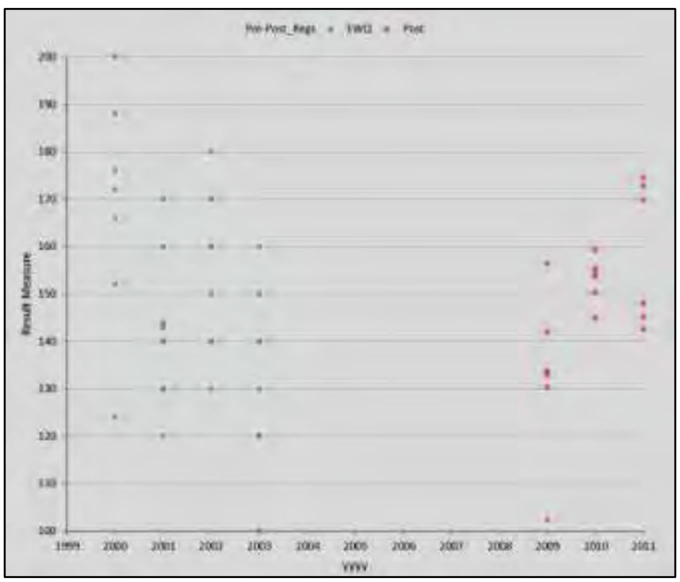
Median 130 mg/l
Lower 95% Confidence Interval 120 mg/l
Upper 95% Confidence Interval 144 mg/l
Defined in regulations as a flow-related parameter





Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
N	55					
1556 BCP Paunna EWQ	100	130	143	167	200	37
1556 BCP Paunna Post	102	141	149	157	175	15





Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1556 BCP Paunna EWQ	37	21.2	0.57
1556 BCP Paunna Post	18	43.6	2.42

H statistic	0.25
X^2 approximation	0.25
DF	1
p-value	0.6148 [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.

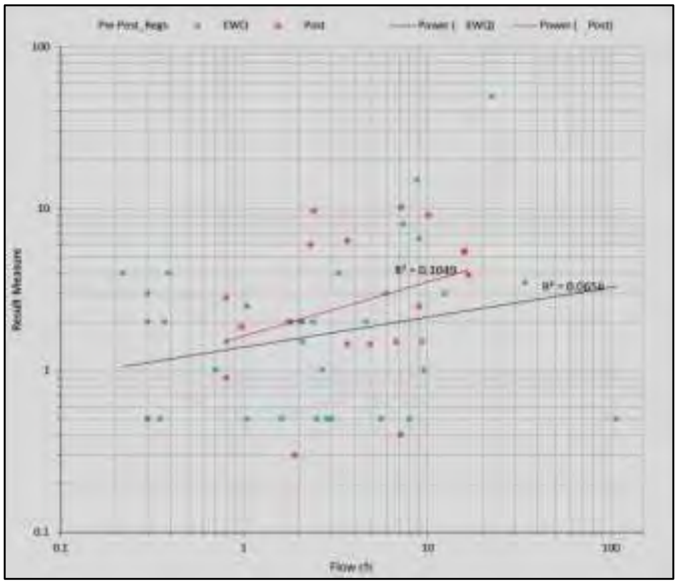
No water quality degradation is evident. TDS did not measurably change between the EWQ and post-EWQ periods. Potential laboratory artifacts produced uncertainty in comparisons. TDS is inversely and strongly related to flow in both data sets. Post-EWQ median TDS was above the EWQ upper 95% lower confidence interval, but the increase was not statistically significant. Post-EWQ detection limits were lower than EWQ detection limits, though there were no non-detect results at any time. Note that flows are plotted on a logarithmic scale.

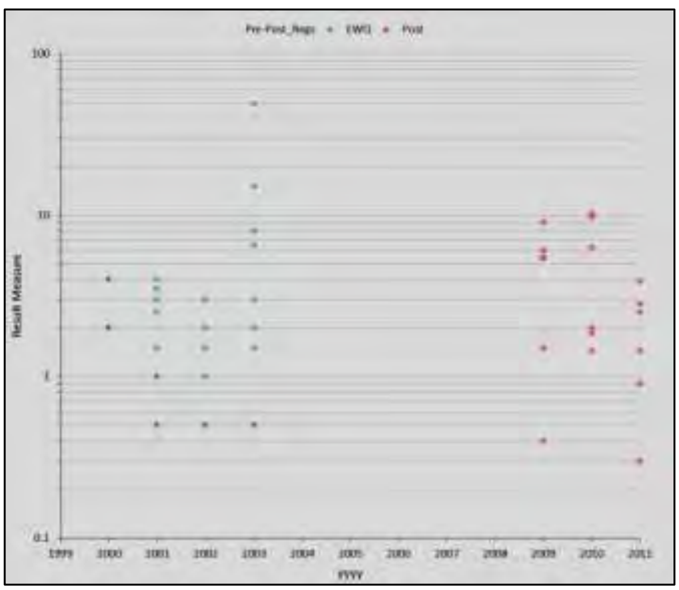
Chapter 8: 1556 BCP Paunacussing Creek, PA

Total Suspended Solids (TSS) mg/l

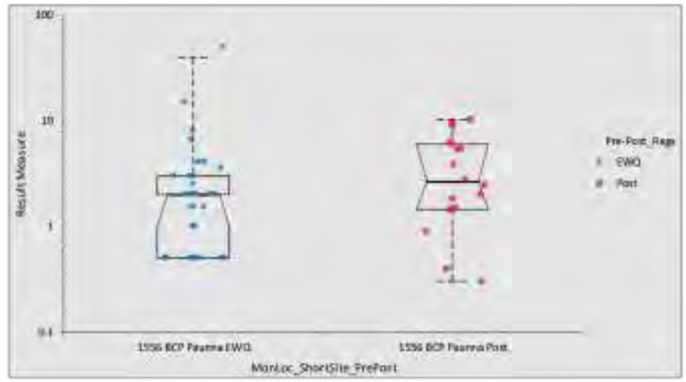
Existing Water Quality (Table 2S):

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



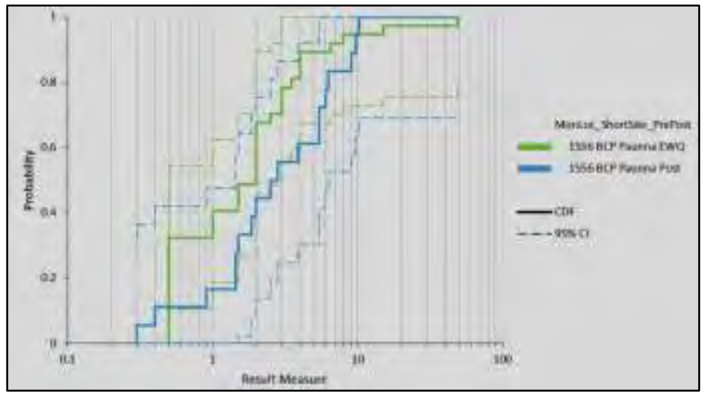


No water quality degradation is evident. TSS did not measurably change between the EWQ and post-EWQ periods. TSS is unrelated to flow in both data sets.



N 55

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1556 BCP Paunna EWQ	0.5	0.5	2.0	3.0	49.0	2.5
1556 BCP Paunna Post	0.3	1.4	2.6	6.0	10.2	4.6



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1556 BCP Paunna EWQ	37	209.3	5.66
1556 BCP Paunna Post	18	430.2	23.90

H statistic	2.52
X^2 approximation	2.52
DF	1
p-value	0.1121 [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 TSS was above the EWQ upper 95% confidence interval, but the increase was statistically insignificant.

Note: in DRBC water quality regulations Table 2S, the published median and confidence intervals are incorrect, and should read:

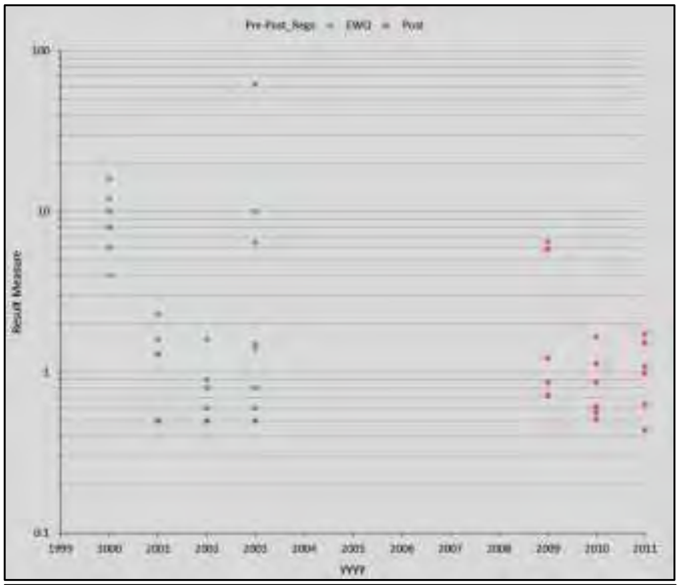
Median 2.0 mg/l (not 1.0 mg/l)
Lower 95% confidence interval 1.0 mg/l
Upper 95% confidence interval 2.0 mg/l

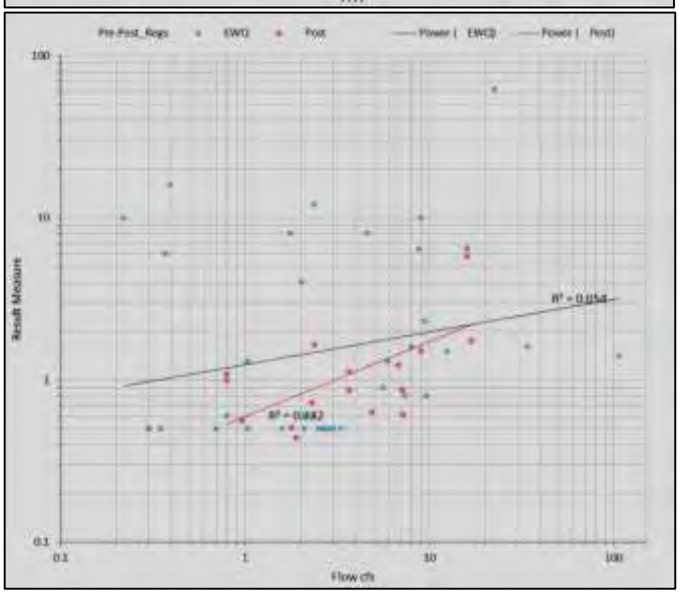
Chapter 8: 1556 BCP Paunacussing Creek, PA

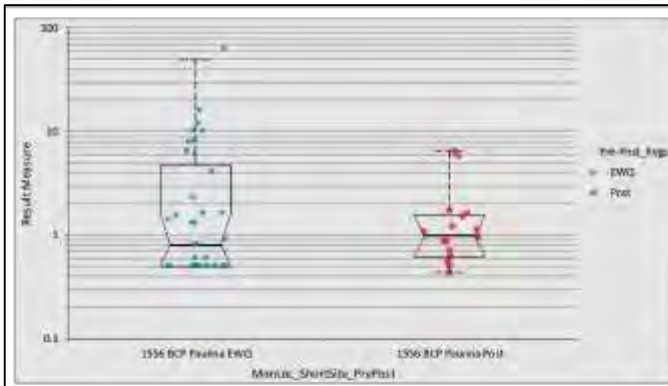
Turbidity NTU

Existing Water Quality (Table 2S):

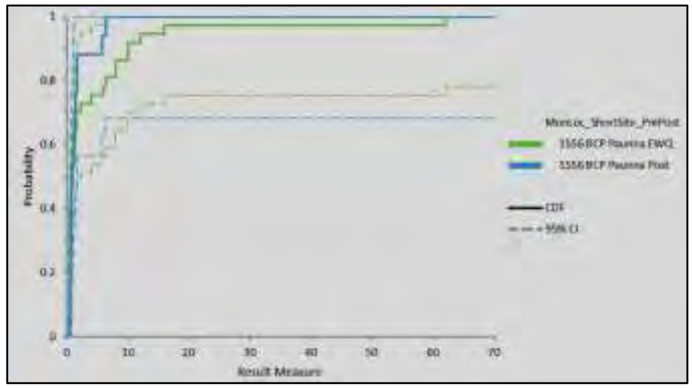
Median 0.8 NTU
Lower 95% Confidence Interval 0.5 NTU
Upper 95% Confidence Interval 1.6 NTU







N	54					
Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1556 BCP Paunna EWQ	0.5	0.5	0.8	4.7	62.0	4.2
1556 BCP Paunna Post	0.4	0.6	1.0	1.6	6.5	0.9



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1556 BCP Paunna EWQ	37	9.3	0.25
1556 BCP Paunna Post	17	20.1	1.18

H statistic	0.12
X^2 approximation	0.12
DF	1
p-value	0.7276[1]

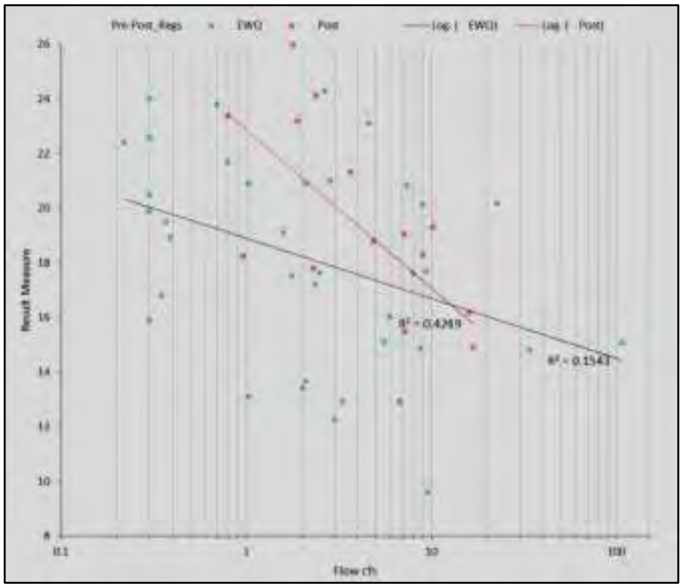
H0: $\theta_1 = \theta_2 = \theta\ldots$
The median of the populations are all equal.
H1: $\theta_i \neq \theta_j$ for at least one i,j
The median of the populations are not all equal.
[1] Do not reject the null hypothesis at the 5% significance level.

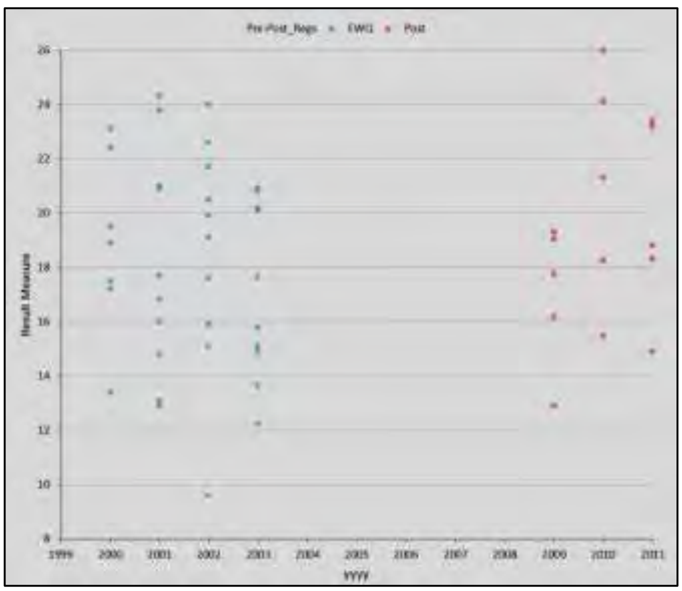
No water quality degradation is evident. Turbidity did not measurably change between the EWQ and post-EWQ periods. The post-EWQ median turbidity fell within the EWQ 95% confidence intervals of the median. Turbidity is related to flow in the post-EWQ data set, but unrelated to flow in the EWQ data set. There were insufficient post-EWQ data to fully represent Paunacussing Creek's flow regime (n=17). Note that concentration and flow is represented on logarithmic scale.

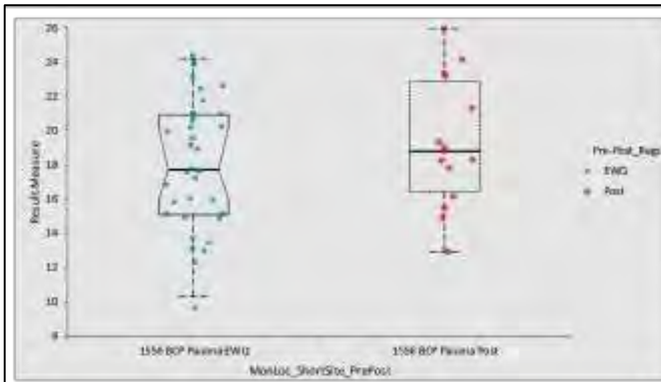
Chapter 8: 1556 BCP Paunacussing Creek, PA

Water Temperature, degrees C

Not included in DRBC Existing Water Quality rules

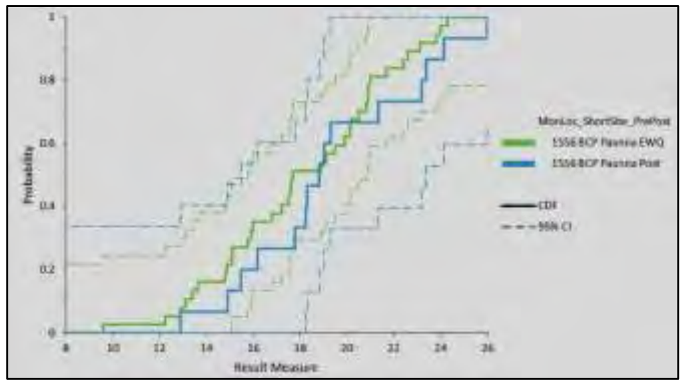






N 52

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1556 BCP Paunna EWQ	9.6	15.1	17.7	20.9	24.3	5.8
1556 BCP Paunna Post	12.9	16.4	18.8	22.9	26.0	6.4



Kruskal-Wallis test

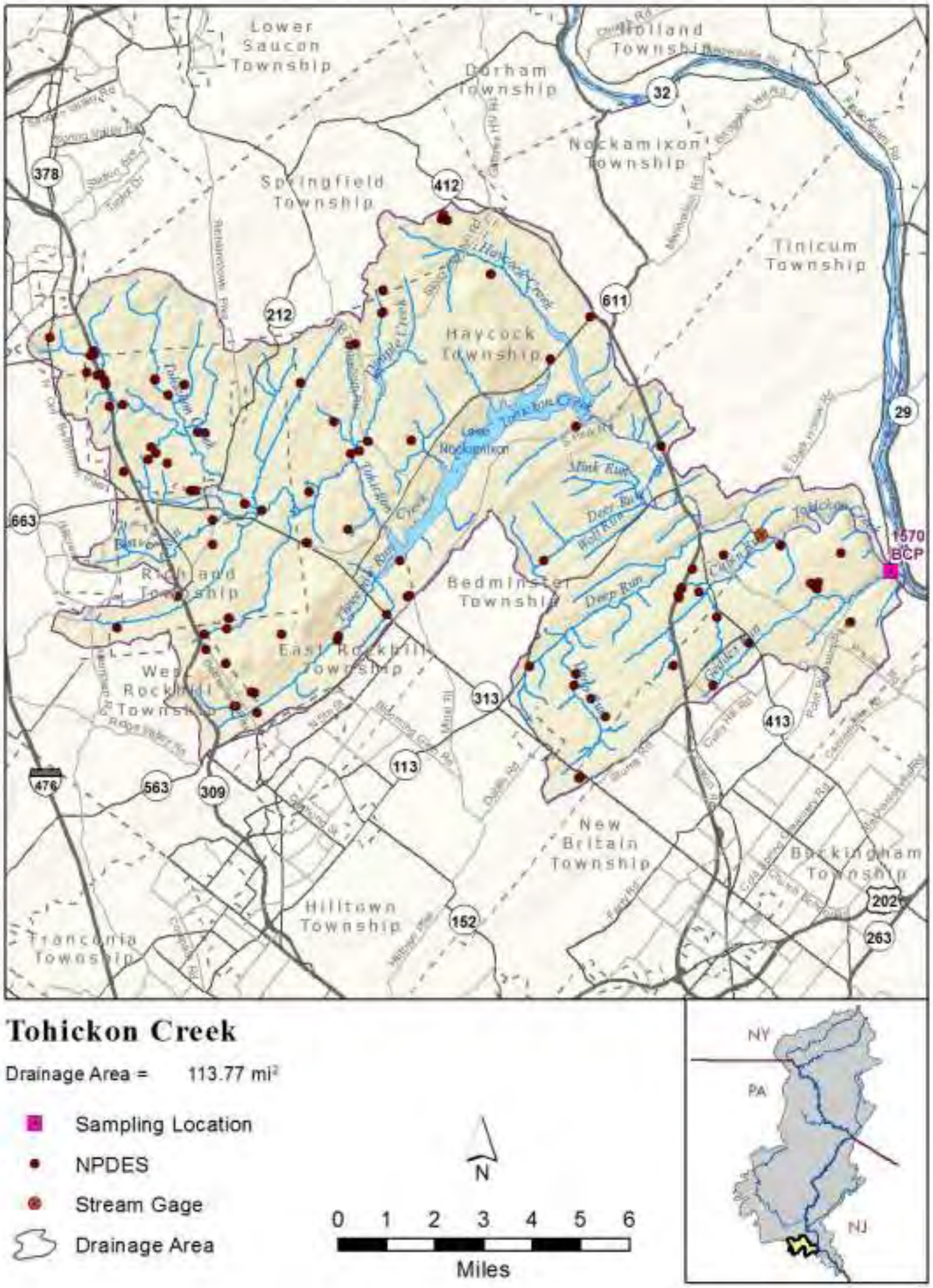
Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1556 BCP Paunna EWQ	37	52.3	1.41
1556 BCP Paunna Post	15	129.1	8.60

H statistic	0.79
X² approximation	0.79
DF	1
p-value	0.3742 [1]

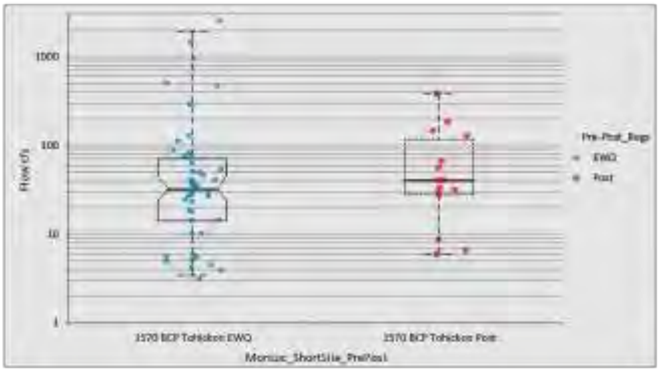
H0: $\theta_1 = \theta_2 = \theta_{...}$
The median of the populations are all equal.
H1: $\theta_i \neq \theta_j$ for at least one i,j
The median of the populations are not all equal.
[1] Do not reject the null hypothesis at the 5% significance level.

No water quality degradation is evident. Water temperature did not measurably change between the EWQ and post-EWQ periods. Water temperature is related to flow in both data sets, though weakly related in the EWQ data set. There were less cool temperatures and less temperature measurements overall in the post-EWQ data set (n=15). Some temperature increase may be attributed to riparian tree removal discussed previously. Note that flows are plotted on a logarithmic scale.

Chapter 9: 1570 BCP Tohickon Creek, Bucks County, PA



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



N	62

Flow cfs by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1570 BCP Tohickon EWQ	3.0	14.0	32.3	71.4	2500.2	57.5
1570 BCP Tohickon Post	5.9	27.9	40.4	118.7	382.2	90.8

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

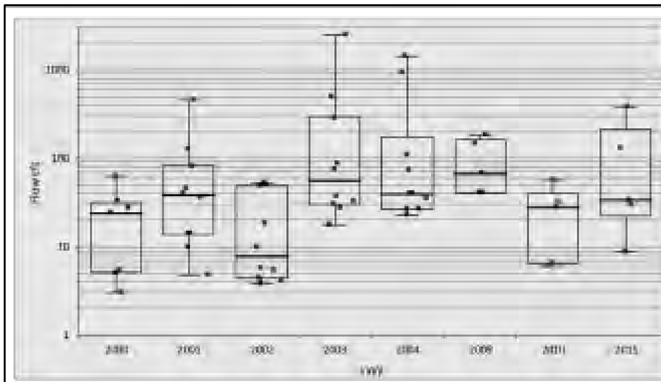
Kruskal-Wallis test

Flow cfs by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1570 BCP Tohickon EWQ	47	67.9	1.45
1570 BCP Tohickon Post	15	212.8	14.19

H statistic	0.86
X^2 approximation	0.86
DF	1
p-value	0.3530 [1]

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

The 114 square mile Tohickon Creek watershed is one of the larger tributaries to the Delaware River within the narrow, confined river valley below the Lehigh River confluence. It was included in the Lower Delaware Wild and Scenic designation for its spectacular scenery, good water quality, and recreational value. The Tohickon watershed is about 57% forested, and about 4.4% urban land cover. There is no underlying carbonate bedrock, but water quality is influenced by Lake Nockamixon that controls flow and acts as a pollutant sink for much of the urban influences within the watershed.



N	62

Flow cfs by yyyy	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
2000	3.0	5.1	23.9	31.2	62.1	26.1
2001	4.7	13.6	37.9	83.9	459.0	70.3
2002	3.8	4.4	7.7	48.6	52.2	44.3
2003	17.6	29.9	55.1	299.1	2500.2	269.3
2004	23.0	26.2	39.3	176.3	1409.2	150.1
2009	40.4	40.4	67.0	161.2	185.9	120.8
2010	5.9	6.4	27.7	39.7	56.6	33.3
2011	8.7	22.2	33.5	213.4	382.2	191.2

Annual May to September flow statistics associated with water quality measurements are plotted above. Flow is plotted on a logarithmic scale. These are flow measurements or sometimes estimates associated with the time of each water quality sample. "Normal" annual median flow for the years that Lake Nockamixon has controlled the flow (1973-Present) is about 173 cfs at this location, but the May-September summer seasonal flow is around 107 cfs. Though a wide range of flows were sampled by DRBC, these data sets appear to be most representative of low to low-normal flow conditions. Flows corresponding to each water quality sample were estimated using flow records for the time of each sample taken from continuous data at the USGS stream gage at Pipersville, PA (USGS 01459500) times a drainage area weighting factor.

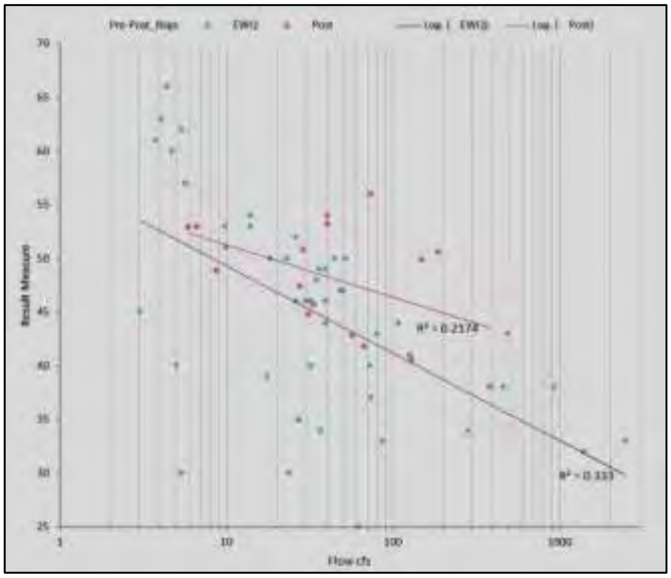
Upstream ICP: Delaware River at Milford 1677 ICP
Downstream ICP: Del. River at Bulls Island 1554 ICP

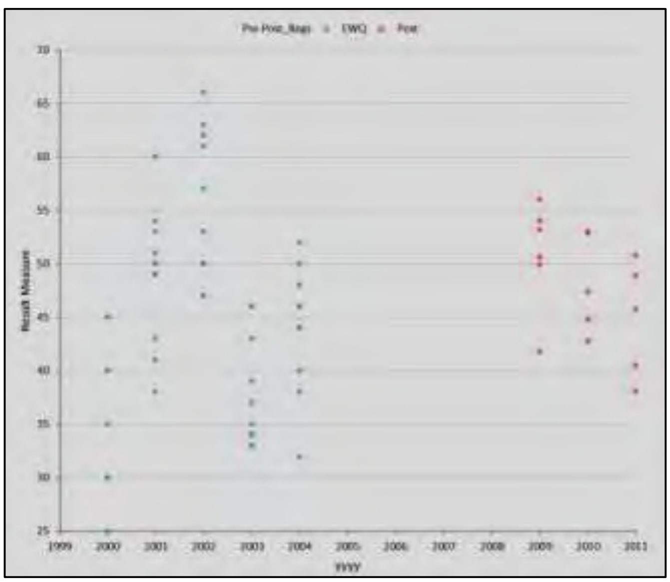
Chapter 9: 1570 BCP Tohickon Creek, PA

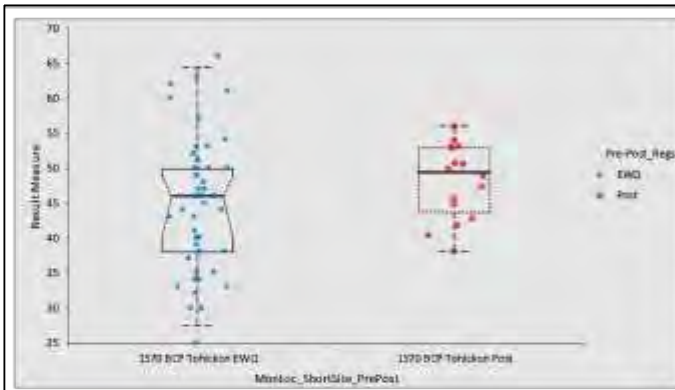
Alkalinity as CaCO3, Total mg/l

Existing Water Quality (Table 2R):

Median 46 mg/l
Lower 95% Confidence Interval 40 mg/l
Upper 95% Confidence Interval 49 mg/l
Defined in regulations as a flow-related parameter

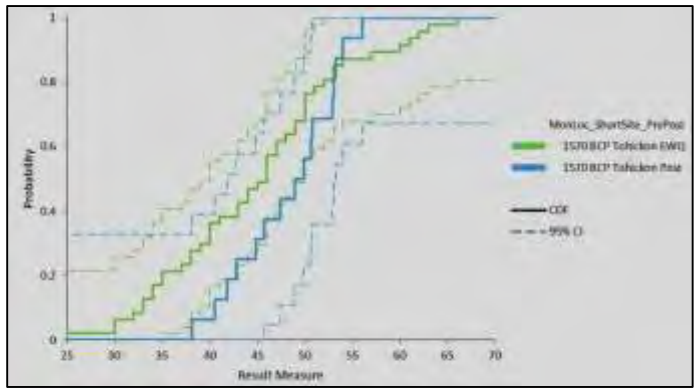






N 63

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1570 BCP Tohickon EWQ	25	38	46	50	66	12
1570 BCP Tohickon Post	38	44	49	53	56	9



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1570 BCP Tohickon EWQ	47	198.1	4.22
1570 BCP Tohickon Post	16	582.0	36.38

H statistic	2.32
X^2 approximation	2.32
DF	1
p-value	0.1274 [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.

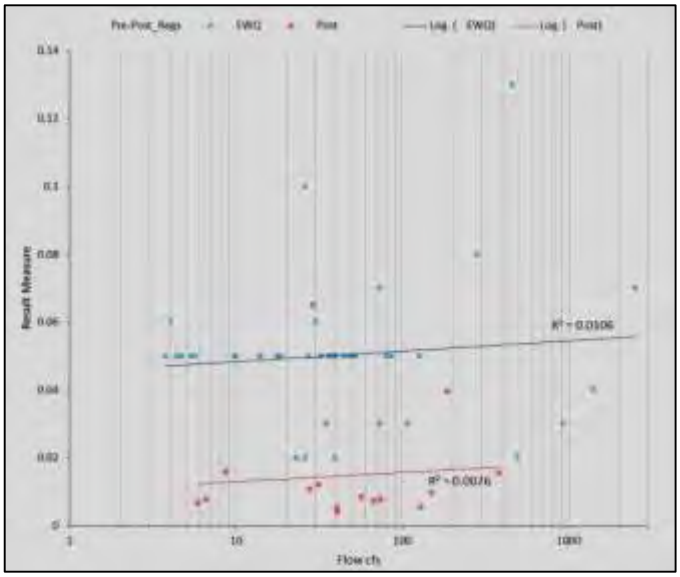
No water quality degradation is evident. Alkalinity did not measurably change between the EWQ and post-EWQ periods. Alkalinity is inversely related to flow in both data sets. Post-EWQ median alkalinity fell within EWQ 95% confidence intervals. Flow is plotted on a logarithmic scale.

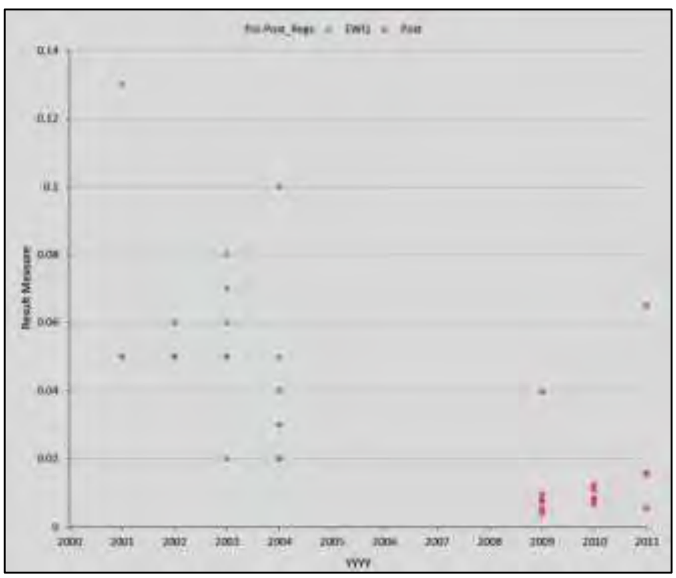
Chapter 9: 1570 BCP Tohickon Creek, PA

Ammonia Nitrogen as N, Total mg/l

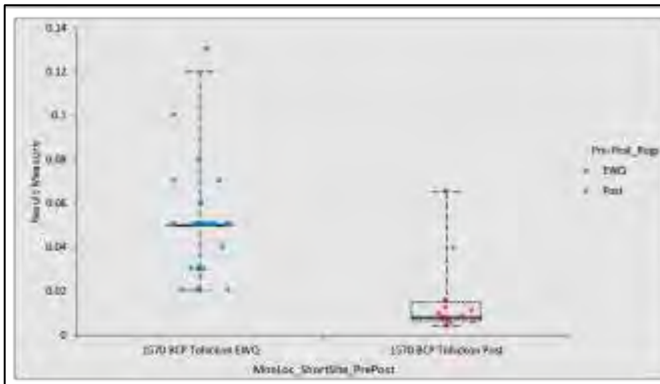
Existing Water Quality (Table 2R):

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



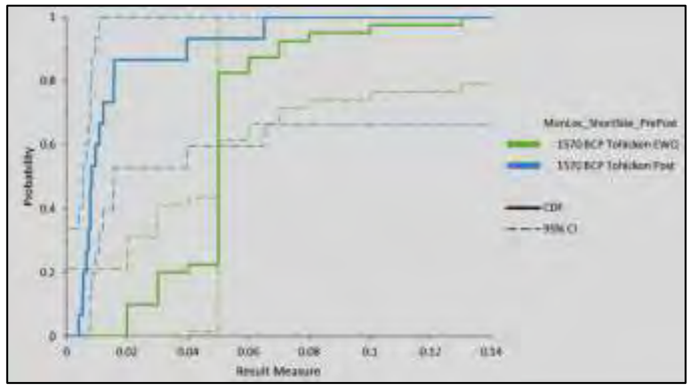


No water quality degradation is evident. Ammonia concentrations apparently declined. However, differences in detection limits, potential laboratory artifacts, and insufficient post-EWQ sampling frequency contributed uncertainty to conclusions. Post-EWQ median ammonia concentration was below the EWQ lower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



N 55

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1570 BCP Tohickon EWQ	0.020	0.050	0.050	0.050	0.130	0.000
1570 BCP Tohickon Post	0.004	0.007	0.008	0.015	0.065	0.008



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1570 BCP Tohickon EWQ	40	1651.2	41.28
1570 BCP Tohickon Post	15	4403.3	293.55

H statistic	25.75
X^2 approximation	25.75
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.

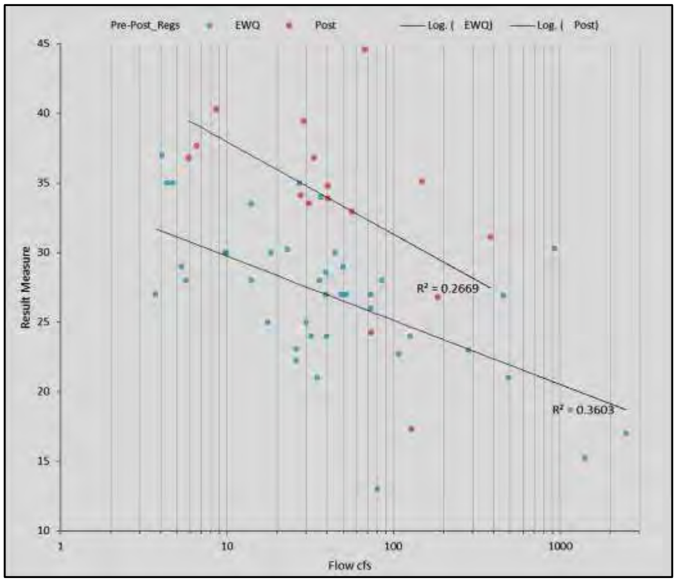
No independent data were available to validate the decline. Post-EWQ detection limits were lower than EWQ limits. EWQ data contain numerous non-detect results (25/40 samples) that interfered with estimation of the median. Thus EWQ was established as <0.05 mg/l, the detection limit at the time. In the 2009-2011 period there was 1/15 non-detect result. So we now know what the concentrations really are. Possible evidence for water quality improvement is indicated by post-EWQ concentrations no greater than 0.065 mg/l.

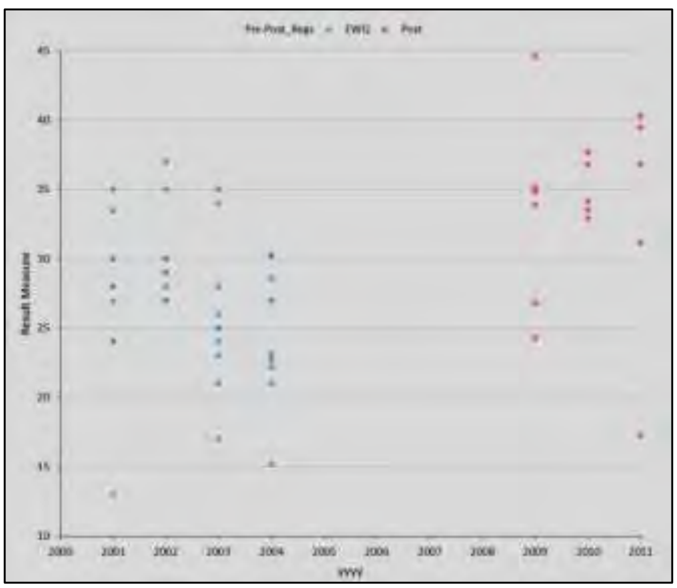
Chapter 9: 1570 BCP Tohickon Creek, PA

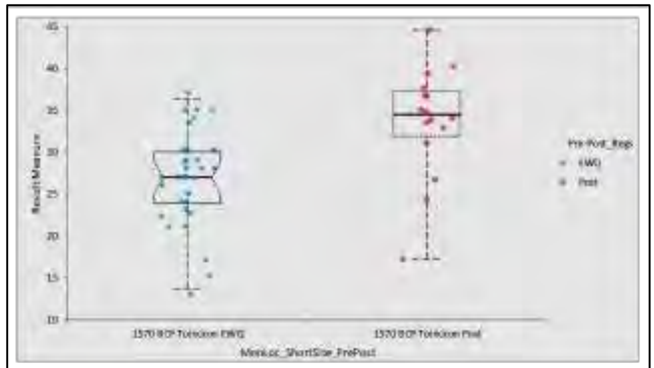
Chloride, Total mg/l

Existing Water Quality (Table 2R):

Median 27 mg/l
Lower 95% Confidence Interval 25 mg/l
Upper 95% Confidence Interval 29 mg/l
Defined in regulations as a flow-related parameter

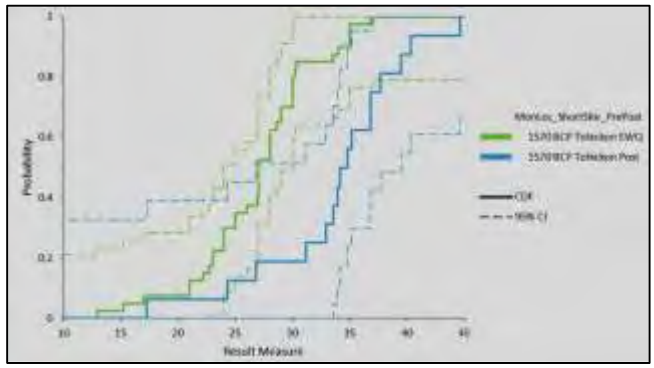






N	56

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1570 BCP Tohickon EWQ	13	24	27	30	37	6
1570 BCP Tohickon Post	17	32	34	37	45	5



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1570 BCP Tohickon EWQ	40	970.2	24.26
1570 BCP Tohickon Post	16	2425.6	151.60

H statistic	12.79
X^2 approximation	12.79
DF	1
p-value	0.0003 [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.

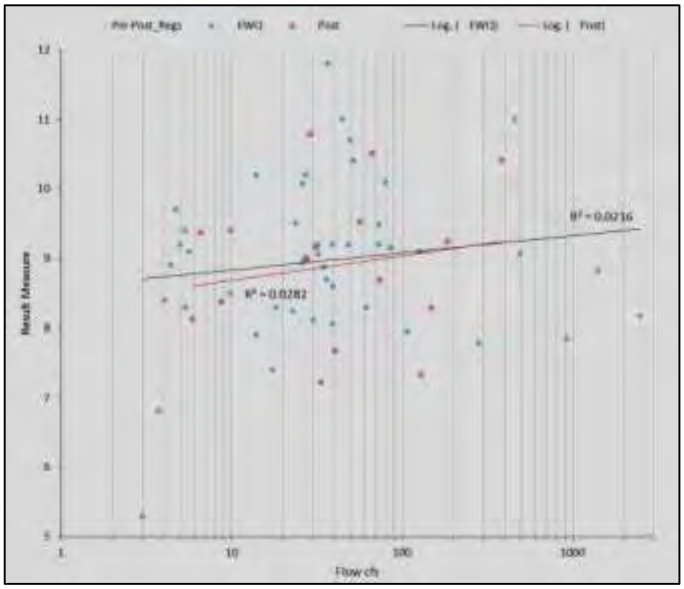
Water quality degradation is evident. Chloride concentrations increased by 7 mg/l between the two periods. Post-EWQ median concentration rose above the EWQ upper 95% confidence interval. The entire northern U.S. has experienced rising chlorides in fresh waters. Although chloride concentrations in Tohickon Creek remain far better than water quality criteria levels, such an increase over such a short time is problematic given that this is a designated Wild and Scenic watershed.

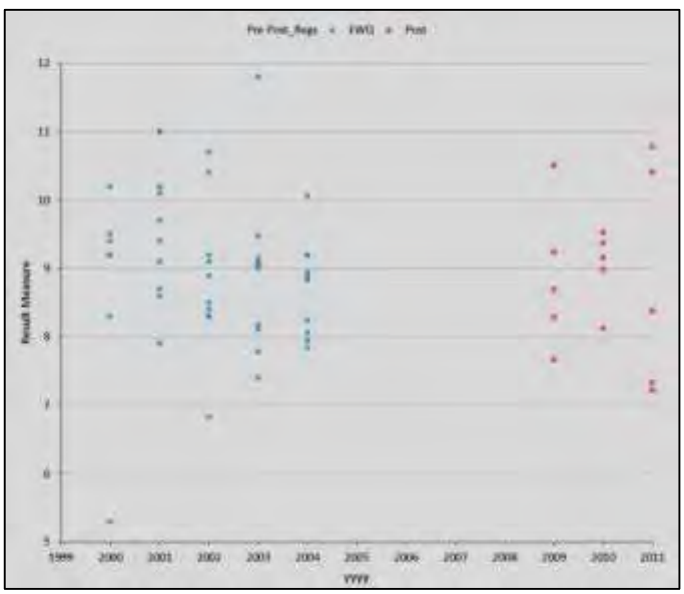
Chapter 9: 1570 BCP Tohickon Creek, PA

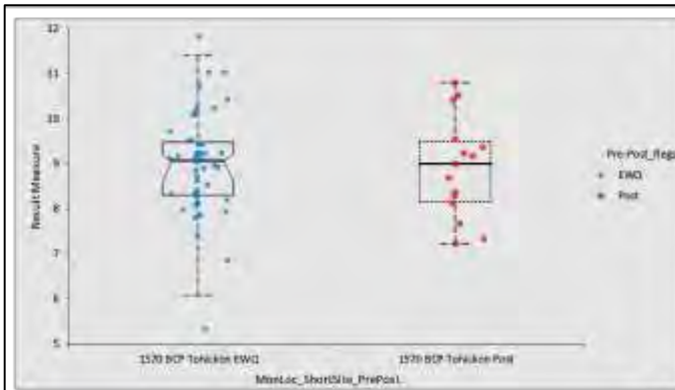
Dissolved Oxygen (DO) mg/l

Existing Water Quality (Table 2R):

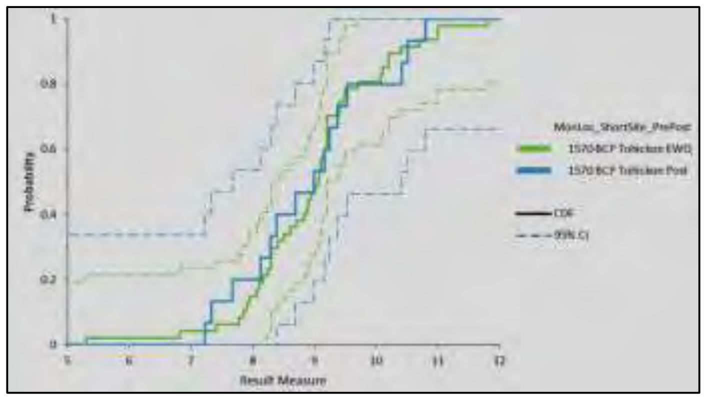
Median 9.06 mg/l
Lower 95% Confidence Interval 8.60 mg/l
Upper 95% Confidence Interval 9.20 mg/l







N	62					
Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1570 BCP Tohickon EWQ	5.30	8.30	9.06	9.47	11.80	1.17
1570 BCP Tohickon Post	7.22	8.16	8.99	9.50	10.79	1.35



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1570 BCP Tohickon EWQ	47	2.8	0.06
1570 BCP Tohickon Post	15	8.8	0.59

H statistic	0.04
X^2 approximation	0.04
DF	1
p-value	0.8500[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.

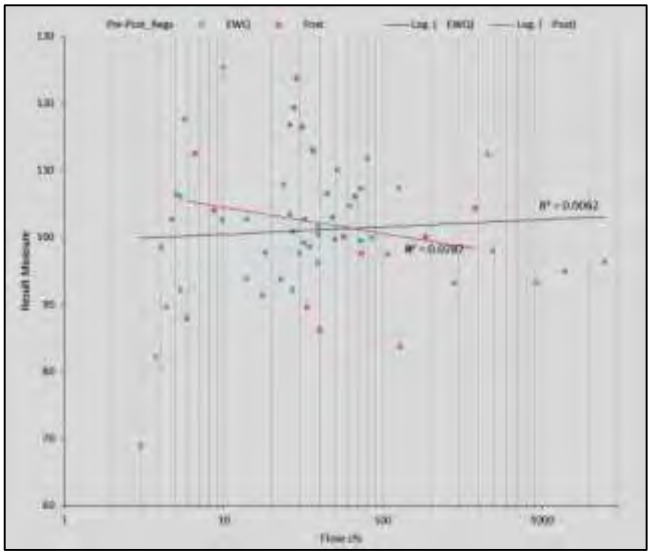
No water quality degradation is evident. No measurable change took place between the EWQ and Post-EWQ periods. Post-EWQ median DO concentration fell within the EWQ 95% confidence intervals. Flow is plotted on a logarithmic scale. DO concentration is unrelated to flow in both data sets. There was an extreme low DO value in the EWQ data set. That measurement was taken during dry conditions in July 2000 when flow in Tohickon Creek was 3 cfs. There was insufficient flow to wash away decomposing organic matter that drove DO concentration to 5.3 mg/l.

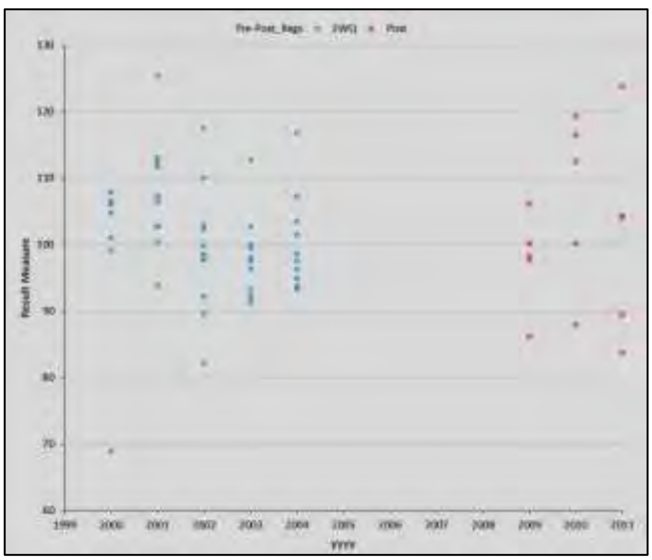
Chapter 9: 1570 BCP Tohickon Creek, PA

Dissolved Oxygen Saturation %

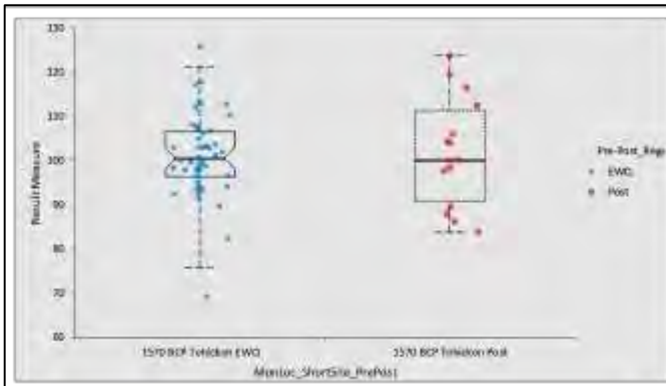
Existing Water Quality (Table 2R):

Median 100%
Lower 95% Confidence Interval 98%
Upper 95% Confidence Interval 103%



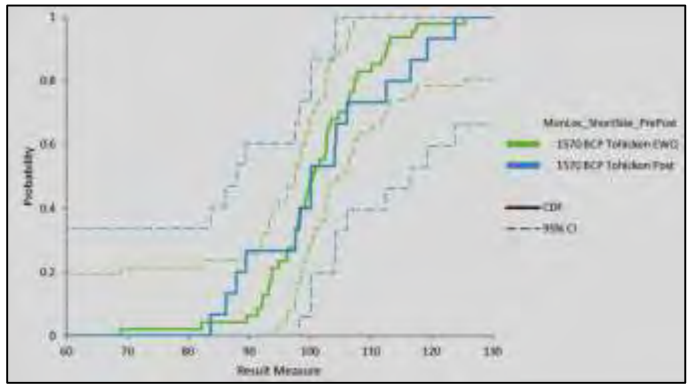


No water quality degradation is evident. Dissolved Oxygen Saturation is unrelated to flow, and did not measurably change between the EWQ and post-EWQ periods. Post-EWQ median DO saturation was within the EWQ 95% confidence intervals. Flow is plotted on a logarithmic scale.



N	62

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1570 BCP Tohickon EWQ	69	96	100	106	125	10
1570 BCP Tohickon Post	84	91	100	111	124	21



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1570 BCP Tohickon EWQ	47	1.9	0.04
1570 BCP Tohickon Post	15	6.0	0.40

H statistic	0.02
X^2 approximation	0.02
DF	1
p-value	0.8759 [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.

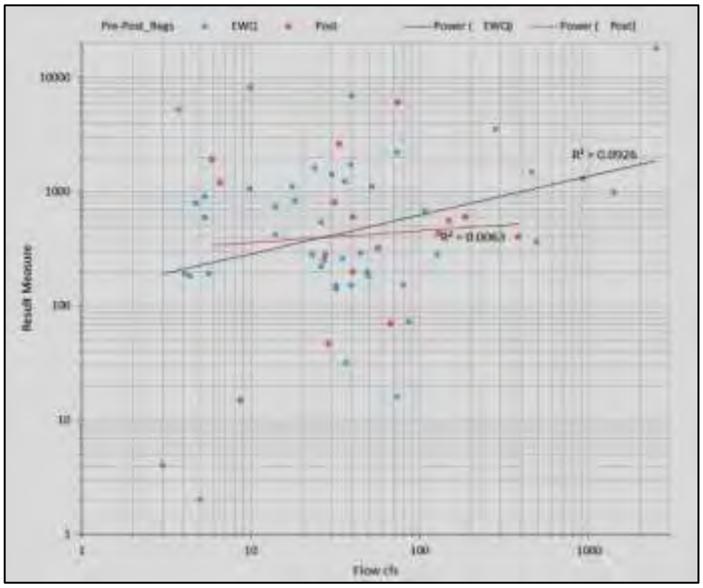
Tohickon Creek is wide and shallow, without full shading by riparian vegetation in many locations. This promotes increased algal production. During mid-day hours the algae and aquatic plants produce oxygen super-saturation conditions, with frequently observed saturation values over 120%. There was an extreme low DO saturation value in EWQ data. That was taken during dry conditions in July 2000 when flow was an estimated 3 cfs. The flow was probably insufficient to wash out decomposing organic matter that drove DO concentration to 5.7 mg/l, and DO saturation to 68%.

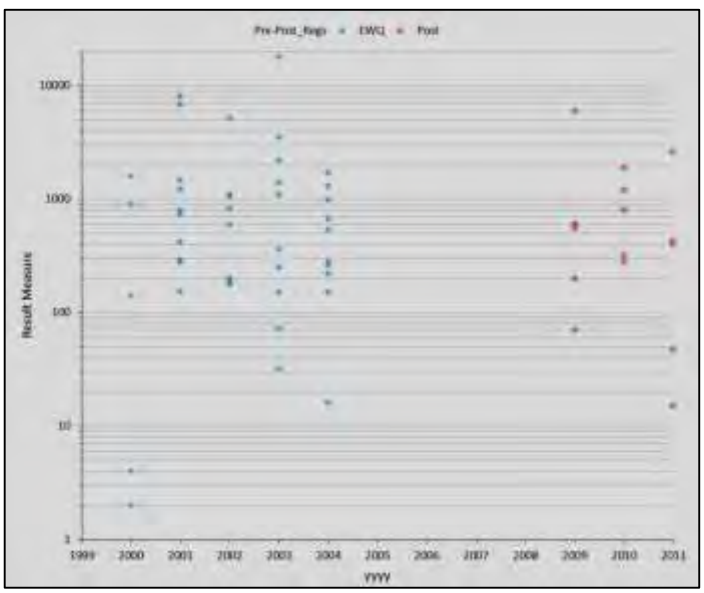
Chapter 9: 1570 BCP Tohickon Creek, PA

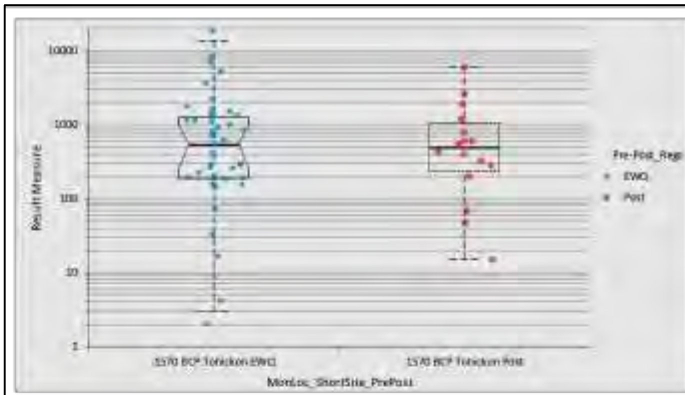
Enterococcus colonies/100 ml

Existing Water Quality (Table 2R):

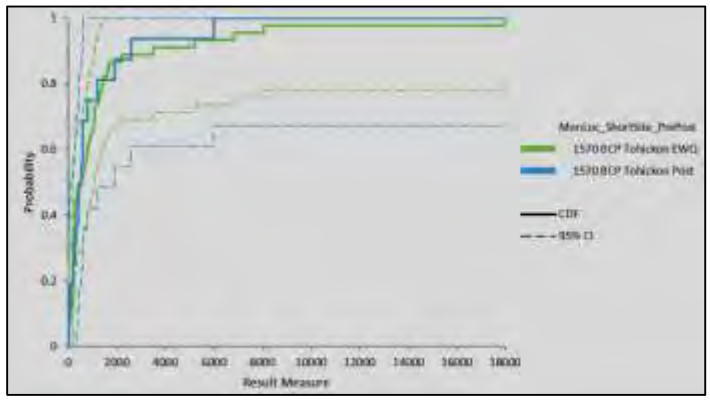
Median 540/100 ml
Lower 95% Confidence Interval 250/100 ml
Upper 95% Confidence Interval 980/100 ml







	N	61				
Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1570 BCP Tohickon EWQ	2	187	540	1247	18000	1060
1570 BCP Tohickon Post	15	233	490	1033	6000	800



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1570 BCP Tohickon EWQ	45	0.3	0.01
1570 BCP Tohickon Post	16	0.8	0.05

H statistic	0.00
X^2 approximation	0.00
DF	1
p-value	0.9542 [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.

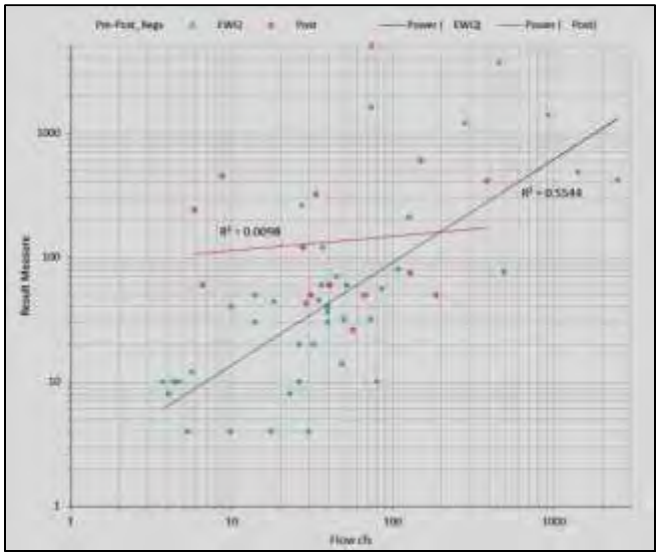
No water quality degradation is evident. Enterococci did not measurably change between the EWQ and Post-EWQ periods. Enterococcus concentrations are unrelated to flow in both data sets. Note that concentrations and flows are plotted on a logarithmic scale. Post-EWQ median enterococcus concentrations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

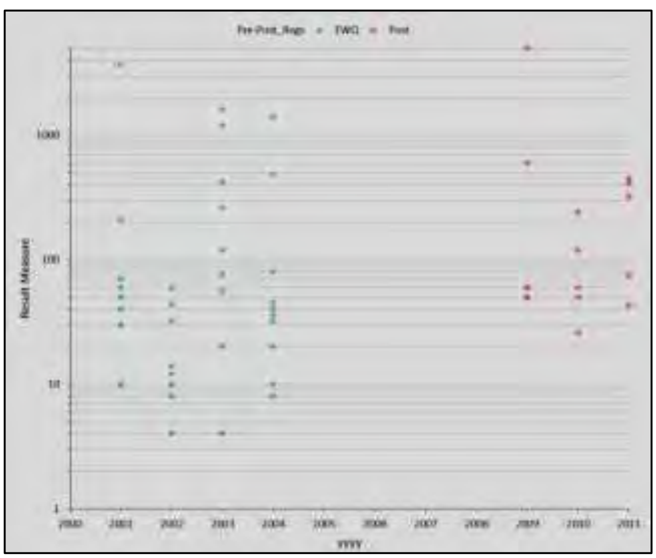
Chapter 9: 1570 BCP Tohickon Creek, PA

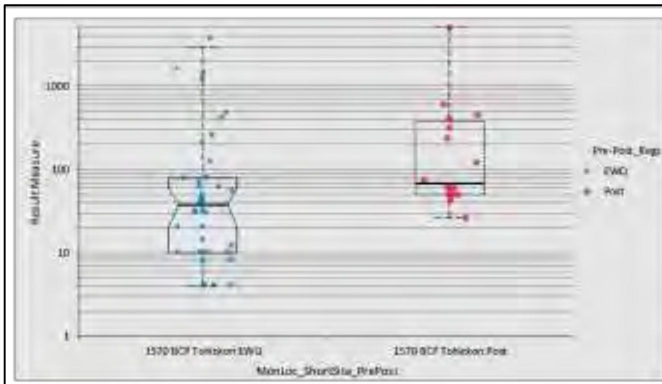
Escherichia coli colonies/100 ml

Existing Water Quality (Table 2R):

Median 38/100 ml
Lower 95% Confidence Interval 20/100 ml
Upper 95% Confidence Interval 60/100 ml
Defined in regulations as a flow-related parameter

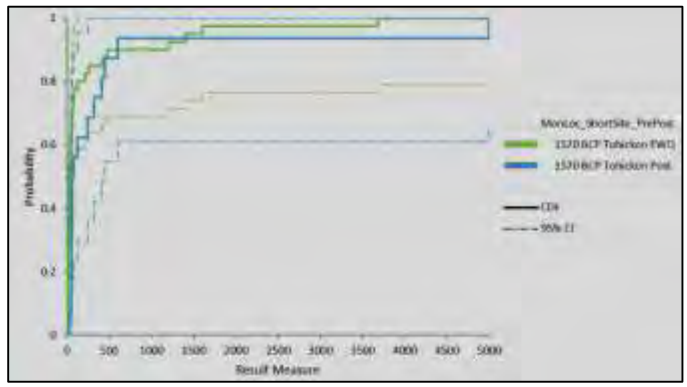






N 56

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1570 BCP Tohickon EWQ	4	10	38	78	3680	68
1570 BCP Tohickon Post	26	50	68	373	5000	323



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1570 BCP Tohickon EWQ	40	518.4	12.96
1570 BCP Tohickon Post	16	1296.0	81.00

H statistic	6.84
X^2 approximation	6.84
DF	1
p-value	0.0089 [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.

Water quality degradation is evident here. E. coli concentrations apparently increased between the EWQ and Post-EWQ periods. However, potential laboratory artifacts and insufficient post-EWQ sampling frequency introduced uncertainty into conclusions. Post-EWQ median E. coli rose above the EWQ upper 95% confidence interval.

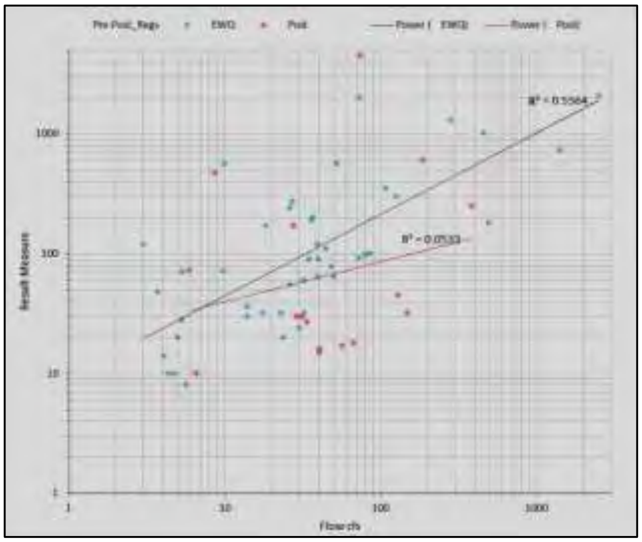
Note that concentrations and flows are plotted on a logarithmic scale. E. coli concentrations were positively related to flow in the EWQ data set, but unrelated to flow in the post-EWQ data set – possibly due to too few post-EWQ samples (n=16). No independent data from other agencies were available at this site to validate DRBC's conclusion.

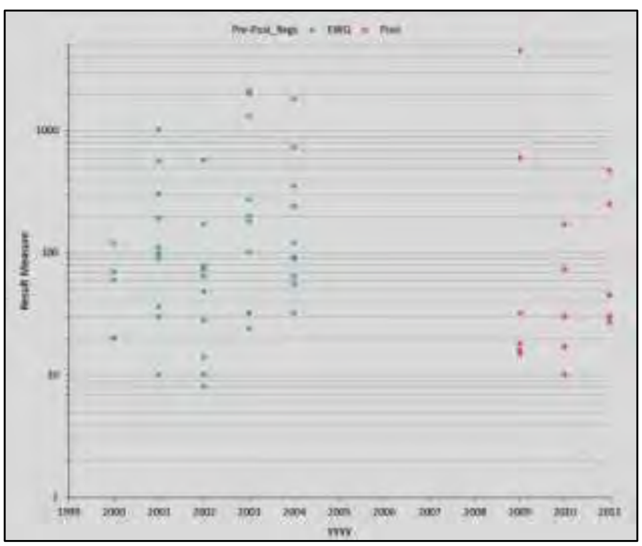
Chapter 9: 1570 BCP Tohickon Creek, PA

Fecal coliform colonies/100 ml

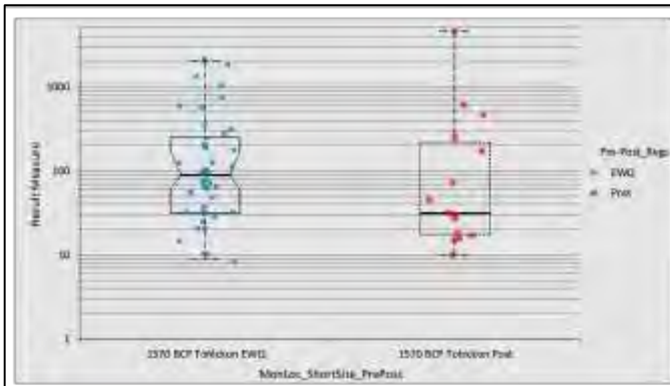
Existing Water Quality (Table 2R):

Median 90/100 ml
Lower 95% Confidence Interval 60/100 ml
Upper 95% Confidence Interval 170/100 ml
Defined in regulations as a flow-related parameter



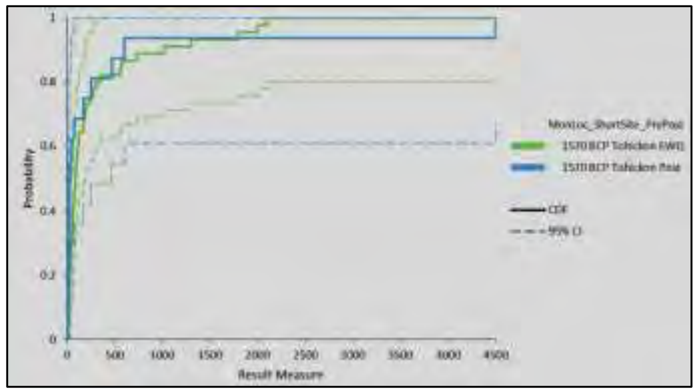


No water quality degradation is evident. Fecal coliform concentrations did not measurably change between the EWQ and post-EWQ periods. Fecal coliform concentrations are positively related to flow in the EWQ data set, but unrelated to flow in the post-EWQ data set - probably because of too few post-EWQ samples (n=16).



N 61

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1570 BCP Tohickon EWQ	8	32	90	250	2100	218
1570 BCP Tohickon Post	10	17	31	217	4500	199



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1570 BCP Tohickon EWQ	45	180.0	4.00
1570 BCP Tohickon Post	16	506.3	31.64

H statistic	2.18
X^2 approximation	2.18
DF	1
p-value	0.1399 [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.

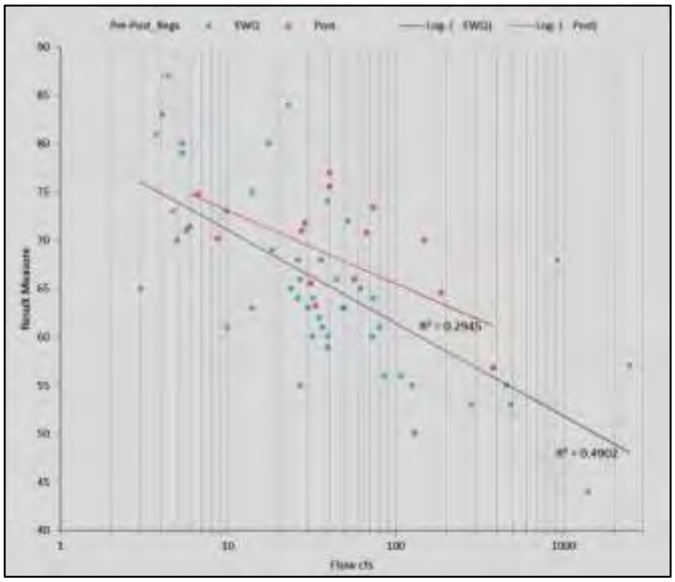
Insufficient sampling frequency and potential laboratory artifacts introduced uncertainty into conclusions. Post-EWQ median concentrations fell below the EWQ lower 95% confidence interval, but the data were naturally variable and post-EWQ N was low so no real change occurred. Note that concentrations and flows are plotted on a logarithmic scale.

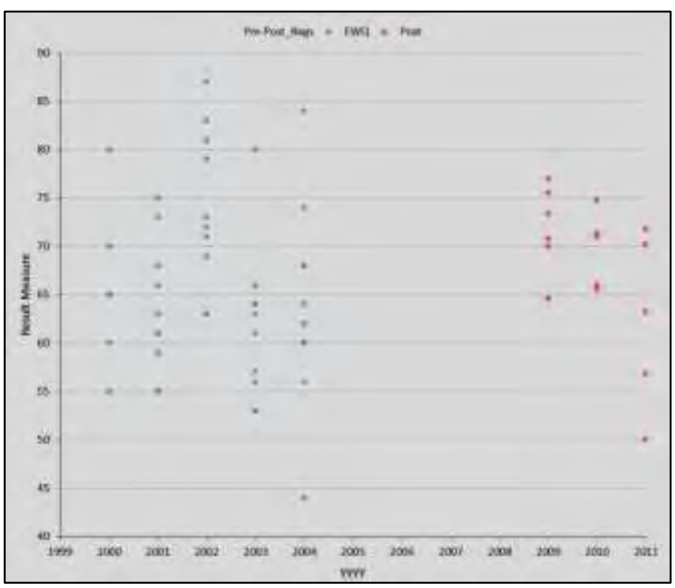
Chapter 9: 1570 BCP Tohickon Creek, PA

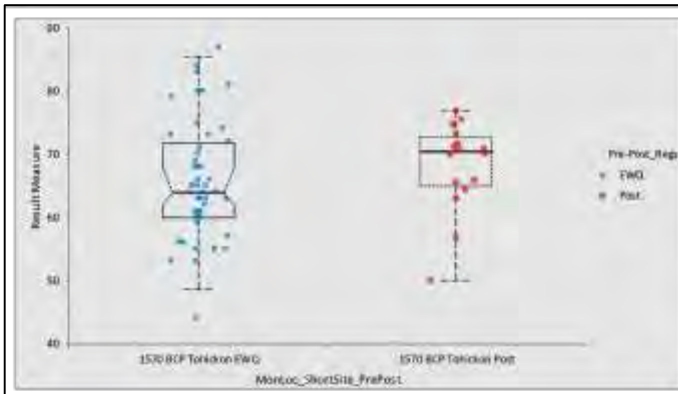
Hardness as CaCO3, Total mg/l

Existing Water Quality (Table 2R):

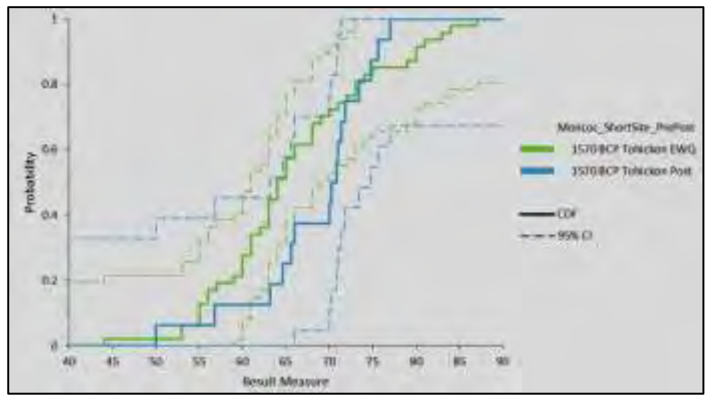
Median 64 mg/l
Lower 95% Confidence Interval 62 mg/l
Upper 95% Confidence Interval 68 mg/l
Defined in regulations as a flow-related parameter







N	63					
Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1570 BCP Tohickon EWQ	44	60	64	72	87	12
1570 BCP Tohickon Post	50	65	71	73	77	8



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1570 BCP Tohickon EWQ	47	196.1	4.17
1570 BCP Tohickon Post	16	576.0	36.00

H statistic	2.30
X^2 approximation	2.30
DF	1
p-value	0.1293 [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.

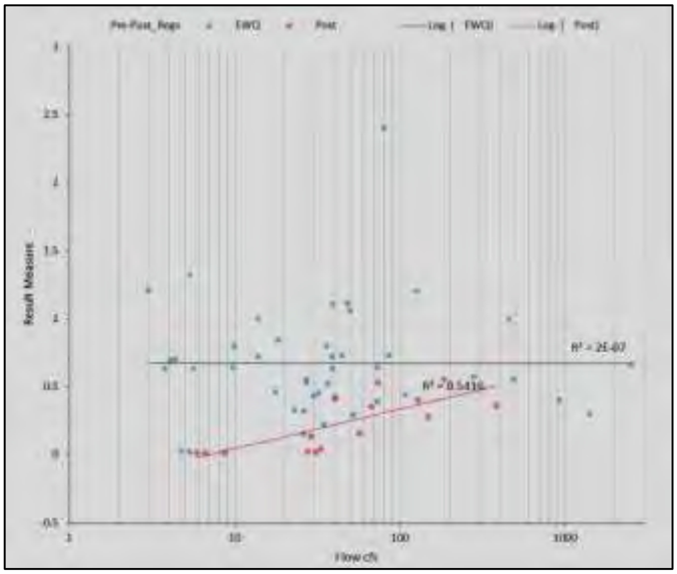
No water quality degradation is evident. Hardness did not measurably change between the EWQ and post-EWQ periods. Hardness is inversely related to flow in both data sets. Post-EWQ median hardness was above the EWQ upper 95% confidence interval, but the increase was not significant because too few post-EWQ samples were taken (n=16) to be able to distinguish a real difference between the two periods. Note that flows are plotted on a logarithmic scale.

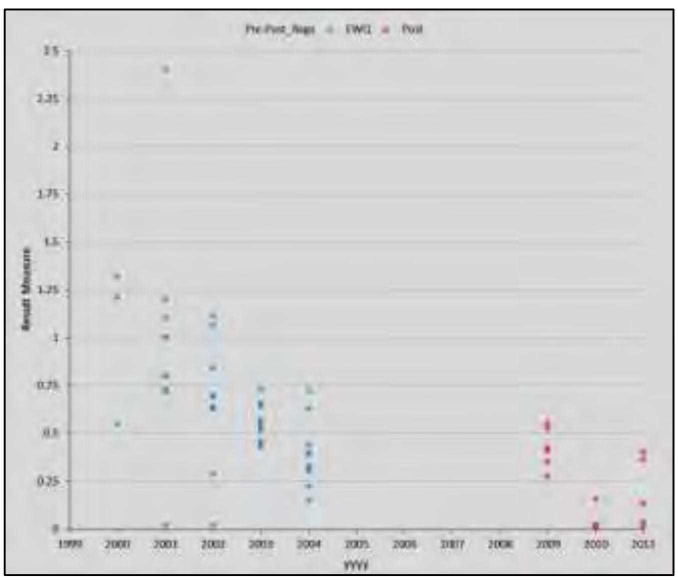
Chapter 9: 1570 BCP Tohickon Creek, PA

Nitrate + Nitrite as N, Total mg/l

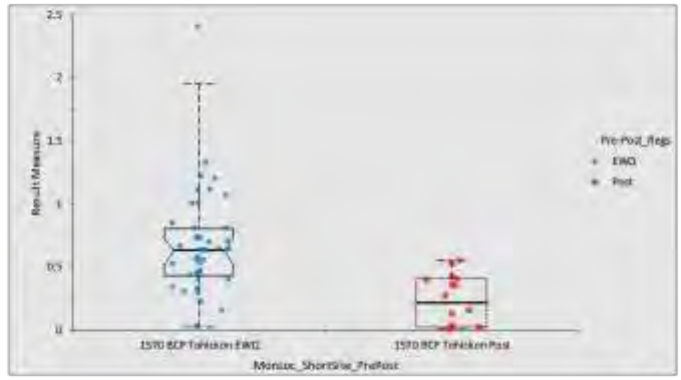
Existing Water Quality (Table 2R, as Nitrate only):

Median 0.63 mg/l
Lower 95% Confidence Interval 0.52 mg/l
Upper 95% Confidence Interval 0.72 mg/l



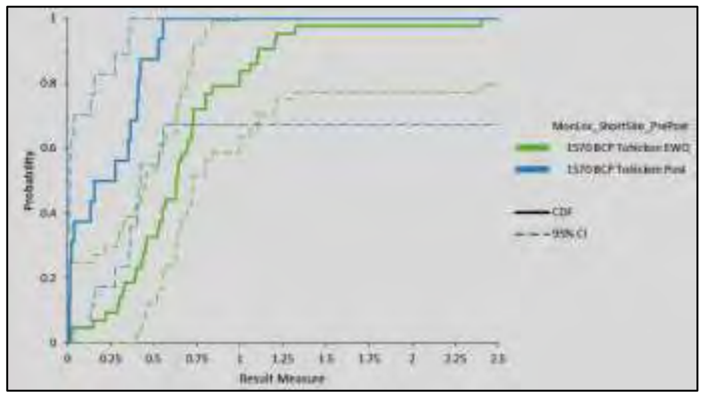


No water quality degradation is evident. Nitrate concentrations apparently declined between the EWQ and post-EWQ periods. However, insufficient sampling frequency and potential laboratory artifacts introduced uncertainty into conclusions. Nitrate is unrelated related to flow in the EWQ data set, but positively related to flow in the post-EWQ data set.



N 59

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1570 BCP Tohickon EWQ	0.02	0.43	0.63	0.80	2.40	0.37
1570 BCP Tohickon Post	0.01	0.02	0.22	0.41	0.55	0.39



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1570 BCP Tohickon EWQ	43	1476.8	34.35
1570 BCP Tohickon Post	16	3969.0	248.06

H statistic	18.47
X^2 approximation	18.47
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.

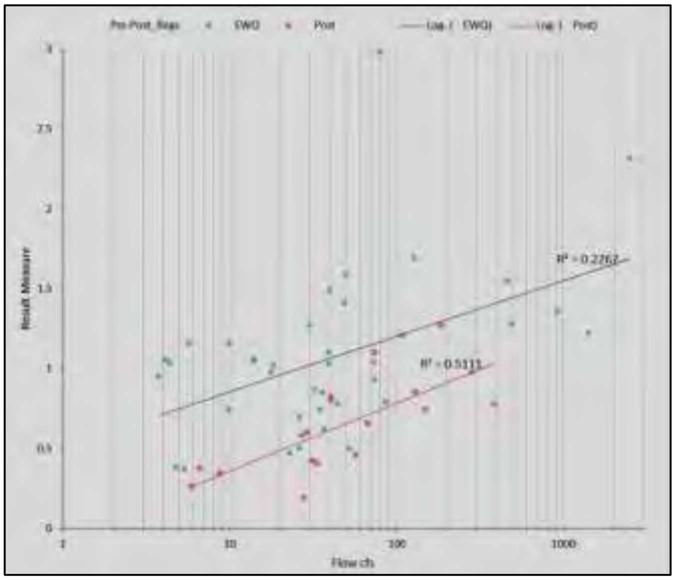
Post-EWQ nitrate + nitrite concentrations were assumed equivalent for comparison with EWQ nitrate concentrations since EWQ nitrite concentrations were never detected. Note that flows are plotted on a logarithmic scale. Independent data were not available for validation of the apparent decline. Tohickon Creek possesses the lowest nitrate + nitrite concentrations among all of the tributaries to the Lower Delaware. This is probably due to sequestration of nutrients by Lake Nockamixon, which is located well upstream of the sampling site.

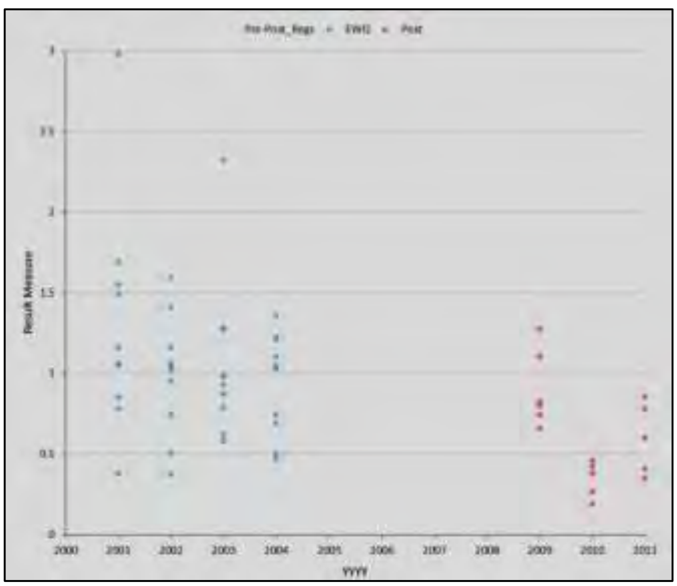
Chapter 9: 1570 BCP Tohickon Creek, PA

Nitrogen as N, Total (TN) mg/l

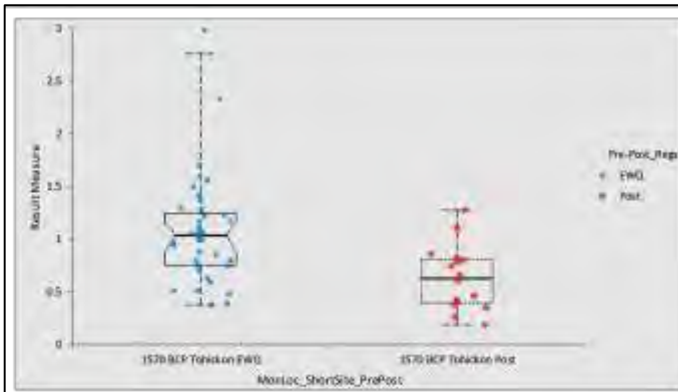
Existing Water Quality (Table 2R):

Median 1.03 mg/l
Lower 95% Confidence Interval 0.87 mg/l
Upper 95% Confidence Interval 1.16 mg/l

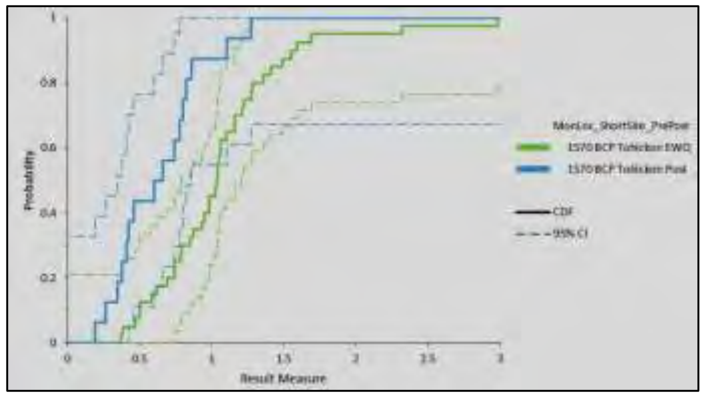




No water quality degradation is evident. Total Nitrogen concentrations apparently declined between the EWQ and post-EWQ periods. However, insufficient sampling frequency and potential laboratory artifacts introduced uncertainty into conclusions.



N	56					
Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1570 BCP Tohickon EWQ	0.37	0.76	1.04	1.25	2.98	0.49
1570 BCP Tohickon Post	0.19	0.39	0.63	0.81	1.27	0.42



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1570 BCP Tohickon EWQ	40	864.9	21.62
1570 BCP Tohickon Post	16	2162.3	135.14

H statistic	11.38
X^2 approximation	11.38
DF	1
p-value	0.0007[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.

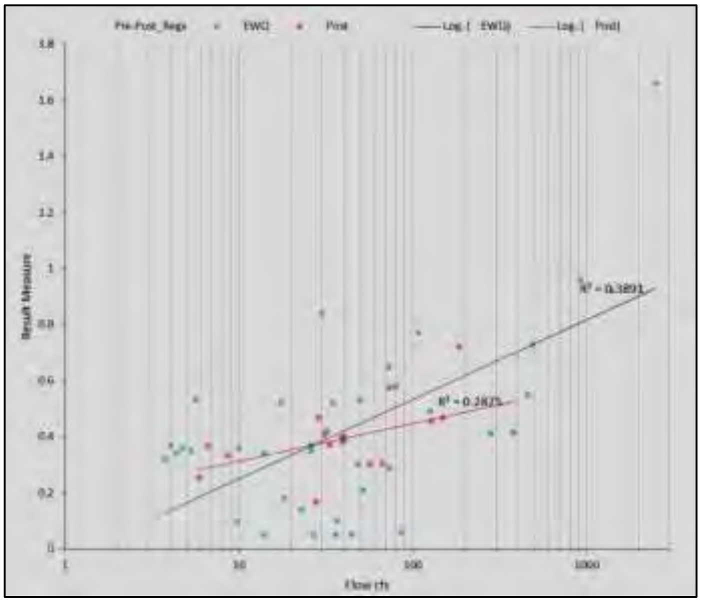
TN is positively related to flow in both data sets, though weakly so in the EWQ data set. Note that flows are plotted on a logarithmic scale. DRBC results could not be independently validated. Post-EWQ median TN concentrations fell well below the EWQ lower 95% confidence interval.

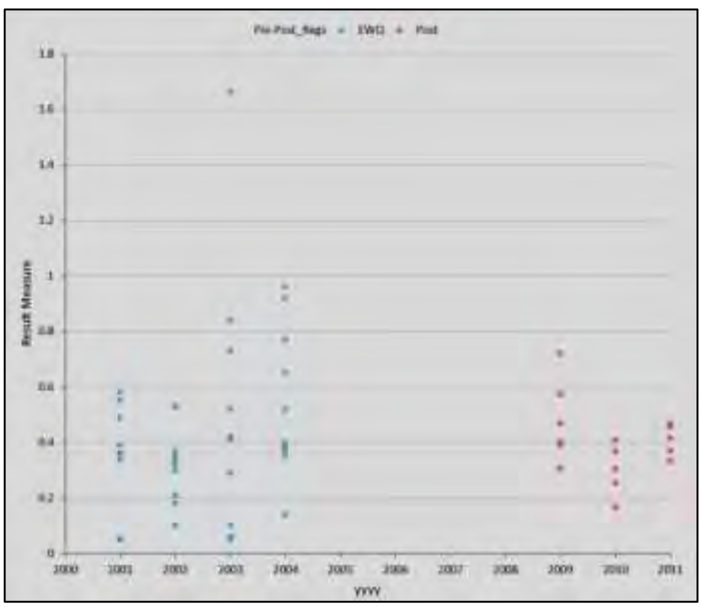
Chapter 9: 1570 BCP Tohickon Creek, PA

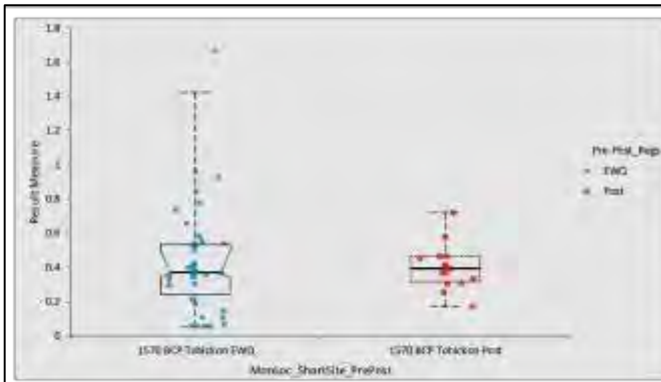
Nitrogen, Kjeldahl as N, Total (TKN) mg/l

Existing Water Quality (Table 2R):

Median 0.37 mg/l
Lower 95% Confidence Interval 0.34 mg/l
Upper 95% Confidence Interval 0.49 mg/l

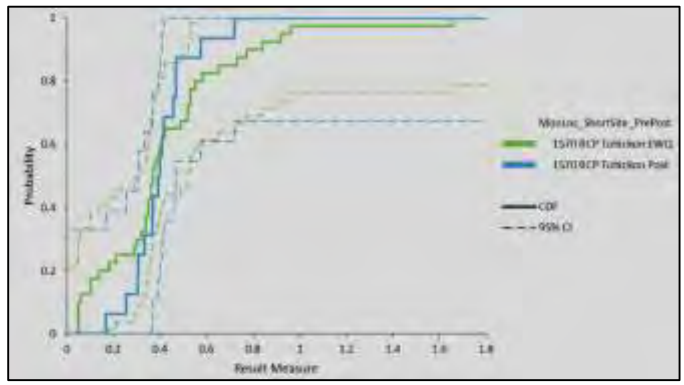






N	56

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1570 BCP Tohickon EWQ	0.05	0.24	0.37	0.53	1.66	0.29
1570 BCP Tohickon Post	0.17	0.32	0.40	0.46	0.72	0.14



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1570 BCP Tohickon EWQ	40	5.6	0.14
1570 BCP Tohickon Post	16	14.1	0.88

H statistic	0.07
X^2 approximation	0.07
DF	1
p-value	0.7855 [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.

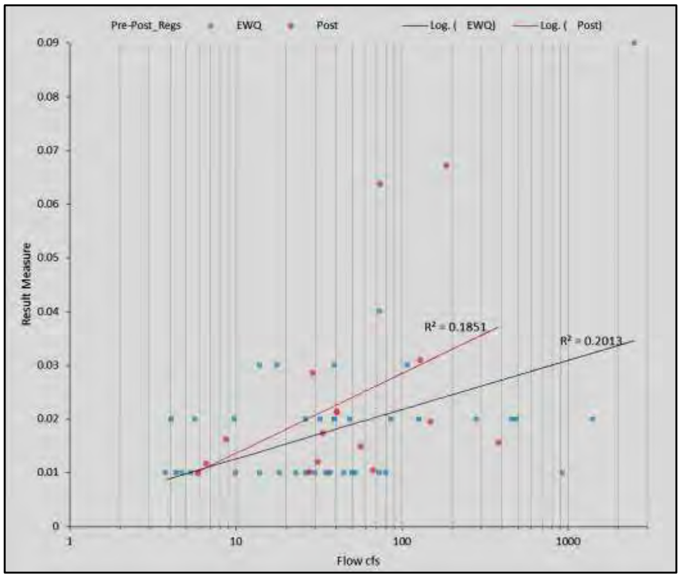
No water quality degradation is evident. TKN concentrations did not measurably change between the EWQ and post-EWQ periods. TKN concentration is related to flow in both data sets, though more weakly related in the post-EWQ data set, which is probably due to fewer samples (n=16). TKN ranges less widely and is less variable in the post-EWQ data set, though this pattern may be attributable to laboratory artifacts. Note that flows are plotted on a logarithmic scale. Post-EWQ median TKN was within the EWQ 95% confidence intervals.

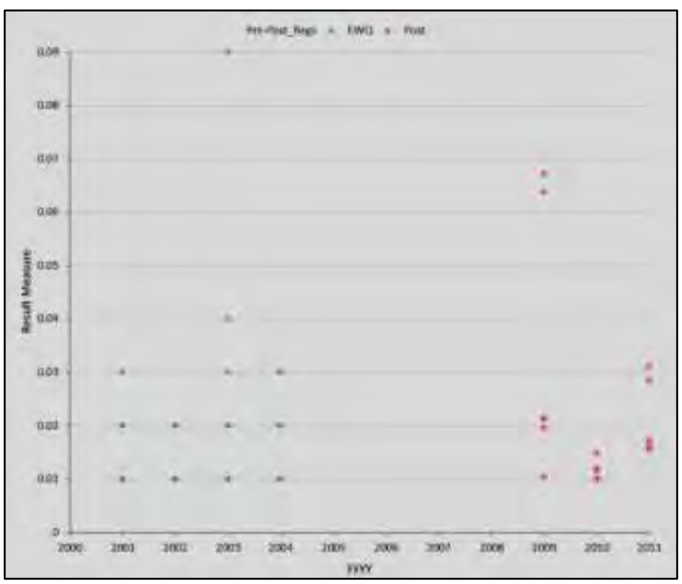
Chapter 9: 1570 BCP Tohickon Creek, PA

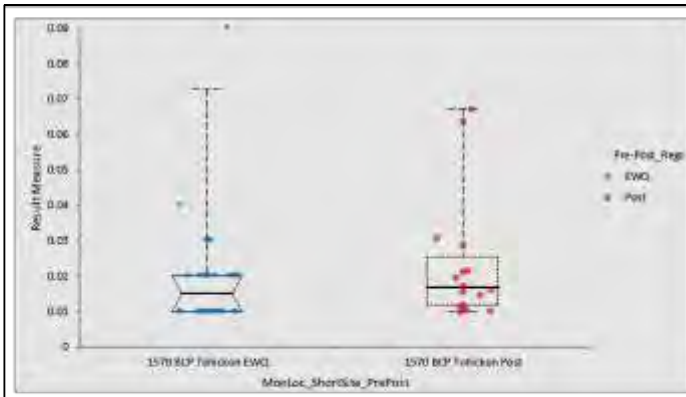
Orthophosphate as P, Total mg/l

Existing Water Quality (Table 2R):

Median 0.015 mg/l
Lower 95% Confidence Interval 0.010 mg/l
Upper 95% Confidence Interval 0.020 mg/l

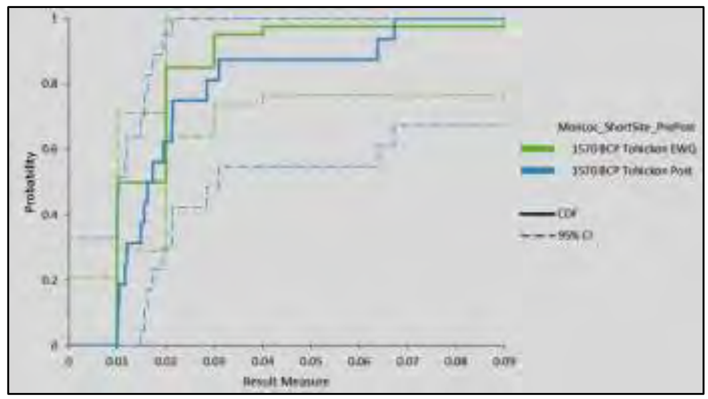






N 56

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1570 BCP Tohickon EWQ	0.010	0.010	0.015	0.020	0.090	0.010
1570 BCP Tohickon Post	0.010	0.012	0.017	0.026	0.067	0.014



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1570 BCP Tohickon EWQ	40	152.1	3.80
1570 BCP Tohickon Post	16	380.3	23.77

H statistic	2.13
X^2 approximation	2.13
DF	1
p-value	0.1442 [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. Orthophosphate concentrations did not change between the EWQ and post-EWQ periods. Detection limit differences, laboratory artifacts, and insufficient sampling frequency introduced uncertainty into conclusions.

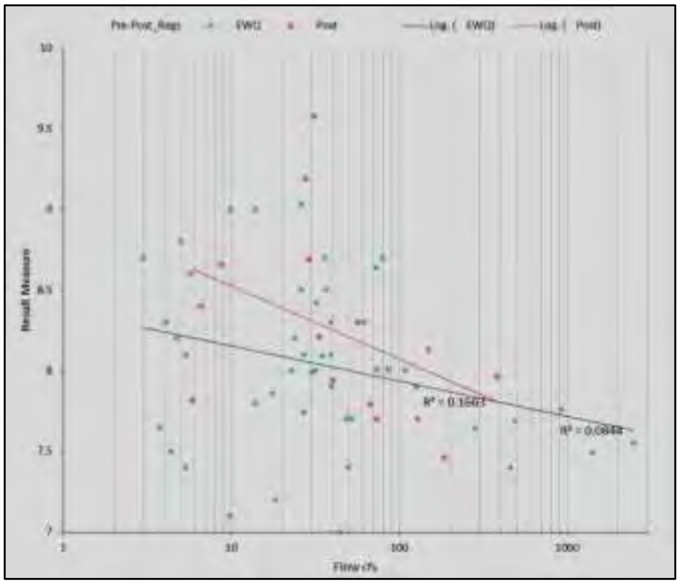
Orthophosphate is very weakly related to flow in both data sets. Post-EWQ median orthophosphate was within the EWQ 95% confidence intervals. The post-EWQ data describe actually orthophosphate concentrations better than the EWQ data, which had 12 non-detect results. There were no undetected results in the post-EWQ data, as detection limits were lower in that data set. There were no independent data to confirm DRBC results.

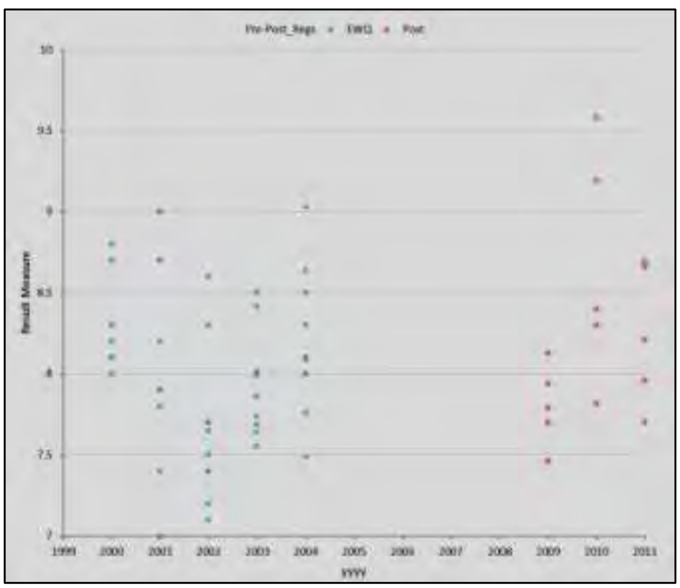
Chapter 9: 1570 BCP Tohickon Creek, PA

pH, units

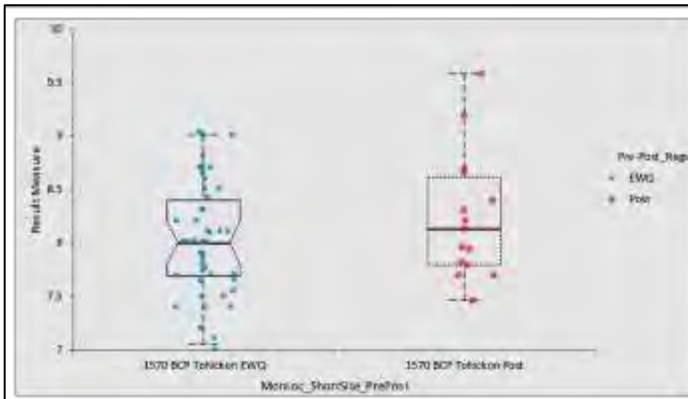
Existing Water Quality (Table 2R):

Median 8.00 standard units
Lower 95% Confidence Interval 7.80 standard units
Upper 95% Confidence Interval 8.20 standard units



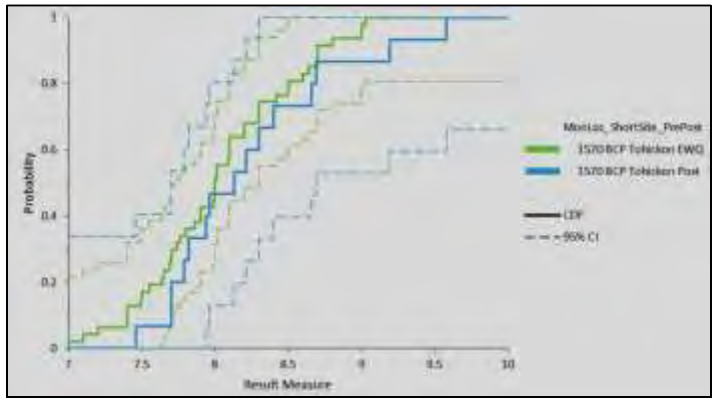


No water quality degradation is evident. pH did not measurably change between the EWQ and post-EWQ periods. pH is unrelated to flow in both data sets, but tends toward neutral during higher flow conditions. Post-EWQ median pH was within the EWQ 95% confidence intervals.



N 62

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1570 BCP Tohickon EWQ	7.00	7.69	8.00	8.40	9.03	0.71
1570 BCP Tohickon Post	7.46	7.80	8.13	8.62	9.58	0.82



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1570 BCP Tohickon EWQ	47	69.1	1.47
1570 BCP Tohickon Post	15	216.6	14.44

H statistic	0.88
X^2 approximation	0.88
DF	1
p-value	0.3486[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.

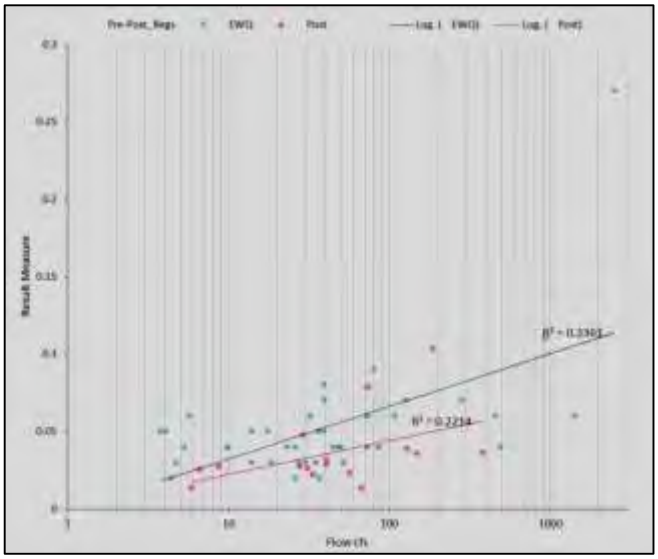
pH is a bit higher in Tohickon Creek compared to other Delaware River tributaries, which is not surprising given that the Tohickon Creek is more wide, shallow and exposed to sunlight than other tributaries. Algal productivity is high in Tohickon Creek, and in the dry year of 2010 there were two sample results over pH 9.

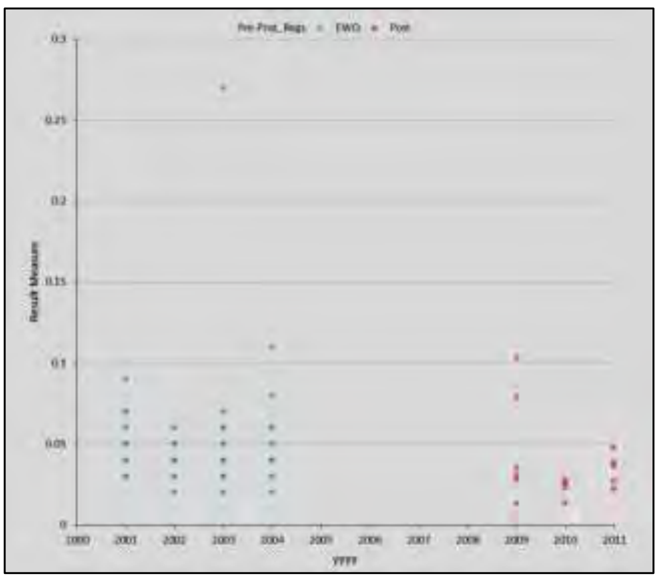
Chapter 9: 1570 BCP Tohickon Creek, PA

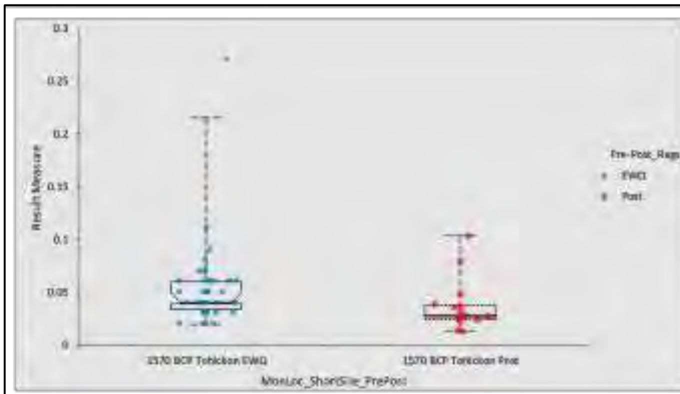
Phosphorus as P, Total (TP) mg/l

Existing Water Quality (Table 2R):

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

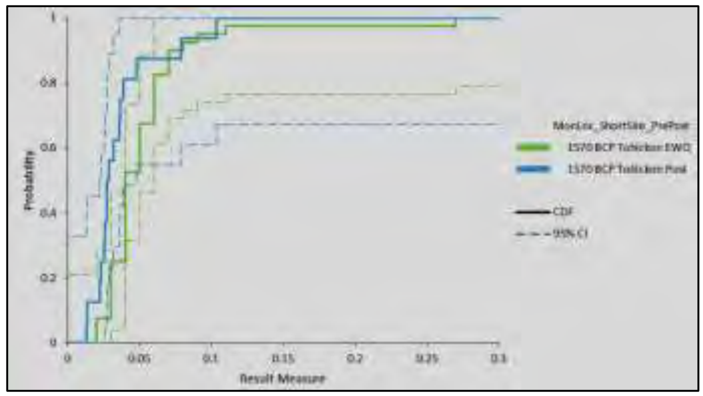






N | 56

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1570 BCP Tohickon EWQ	0.02	0.03	0.04	0.06	0.27	0.03
1570 BCP Tohickon Post	0.01	0.02	0.03	0.04	0.10	0.01



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1570 BCP Tohickon EWQ	40	672.4	16.81
1570 BCP Tohickon Post	16	1681.0	105.06

H statistic	8.96
X^2 approximation	8.96
DF	1
p-value	0.0028 [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.

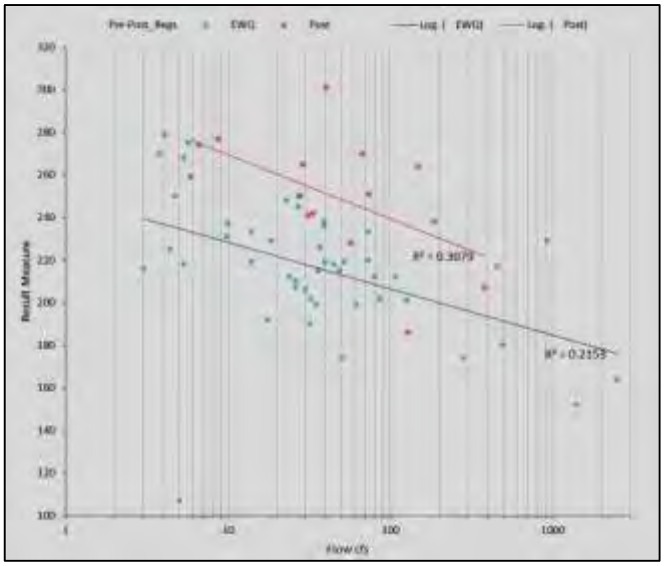
No water quality degradation is evident. Total Phosphorus (TP) apparently declined between the EWQ and post-EWQ periods. However, insufficient sampling frequency and potential laboratory artifacts introduced uncertainty into conclusions. Post-EWQ median total phosphorus fell below the EWQ lower 95% confidence interval. TP is weakly related to flow in both data sets. In EWQ data the relationship to flow appears stronger, but the regression is skewed by a single high outlier sample taken in August 2003. No independent data were available to confirm these results.

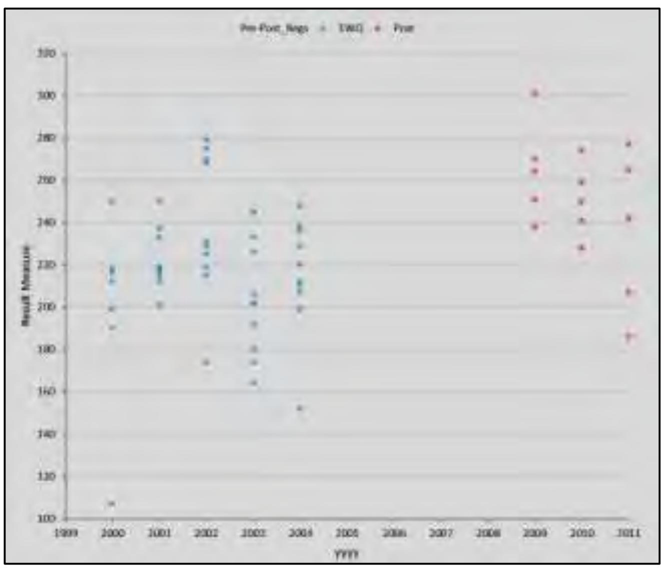
Chapter 9: 1570 BCP Tohickon Creek, PA

Specific Conductance µmho/cm

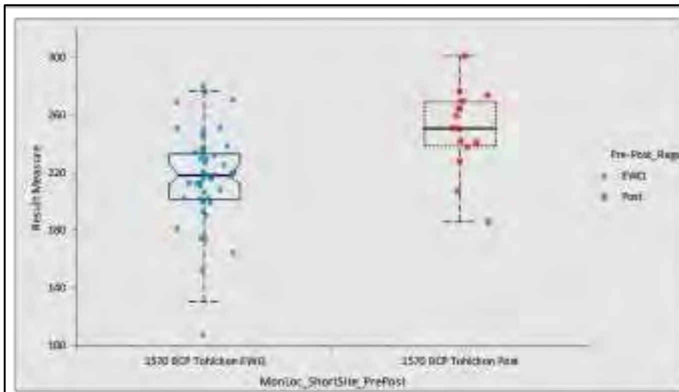
Existing Water Quality (Table 2R):

Median 218 µmho/cm
Lower 95% Confidence Interval 212 µmho/cm
Upper 95% Confidence Interval 226 µmho/cm
Defined in regulations as a flow-related parameter



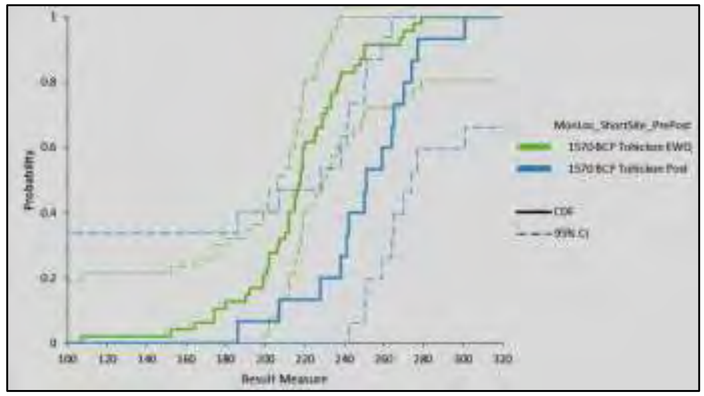


Water quality degradation is indicated here. Specific conductance rose above the EWQ upper 95% confidence interval between the EWQ and post-EWQ periods. Specific conductance is weakly and inversely related to flow in both data sets.



N 62

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1570 BCP Tohickon EWQ	107	202	218	233	279	31
1570 BCP Tohickon Post	186	239	251	269	301	31



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1570 BCP Tohickon EWQ	47	956.3	20.35
1570 BCP Tohickon Post	15	2996.3	199.75

H statistic	12.15
X^2 approximation	12.15
DF	1
p-value	0.0005 [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.

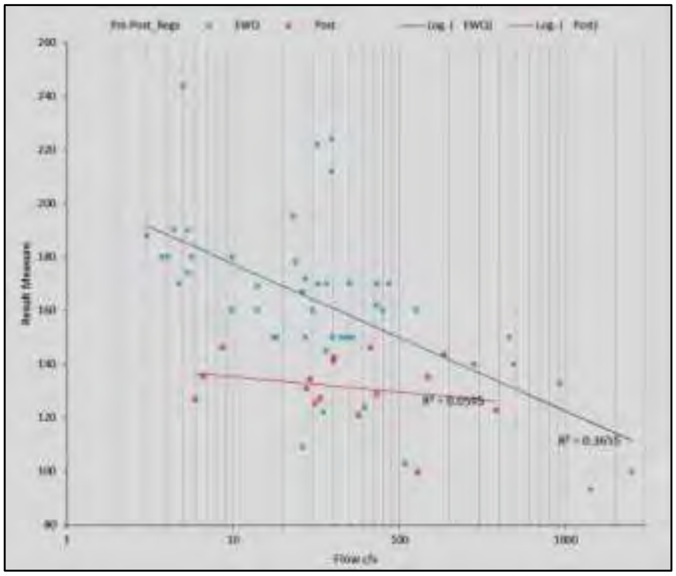
Specific conductance was defined as a flow-related parameter in the EWQ data set (DRBC water quality regulations Table 2R), even though the relationship was very weak at this site. Post-EWQ sampling frequency was insufficient. Rising specific conductance may be attributable to the concurrent rise in chloride concentrations. In this Wild and Scenic designated stream, median specific conductance has risen from 218 to 251 µmho/cm, a 15% increase over a short time period.

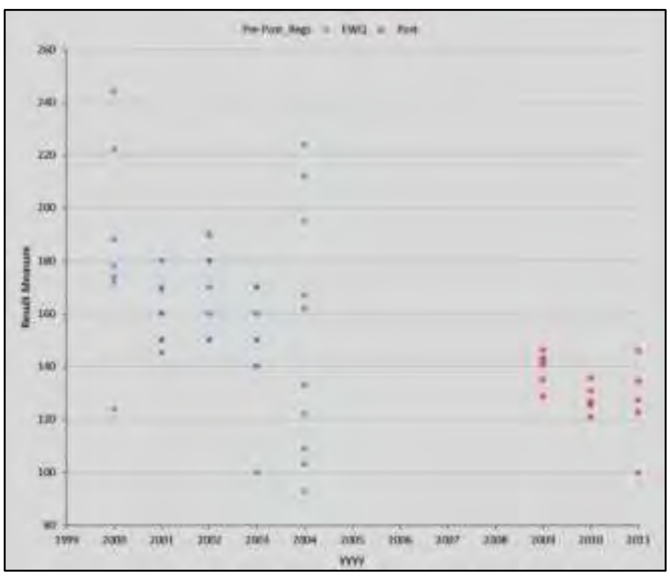
Chapter 9: 1570 BCP Tohickon Creek, PA

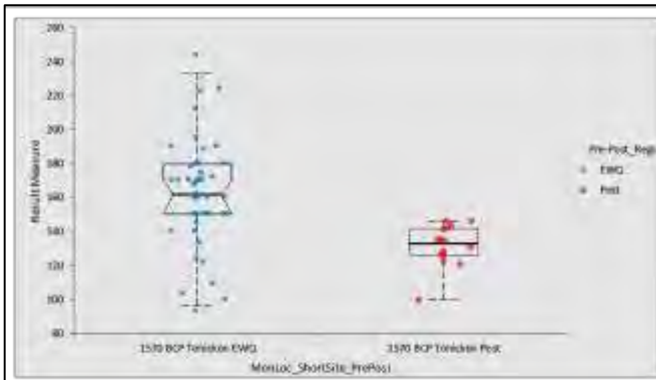
Total Dissolved Solids (TDS) mg/l

Existing Water Quality (Table 2R):

Median 162 mg/l
Lower 95% Confidence Interval 150 mg/l
Upper 95% Confidence Interval 170 mg/l
Defined in regulations as a flow-related parameter

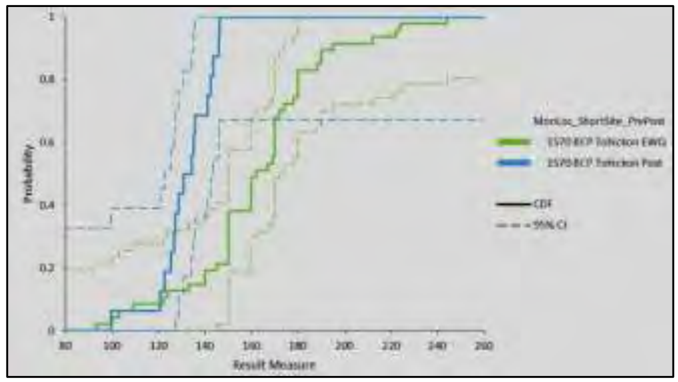






N 63

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1570 BCP Tohickon EWQ	93	150	162	180	244	30
1570 BCP Tohickon Post	100	126	133	142	146	16



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1570 BCP Tohickon EWQ	47	1528.2	32.51
1570 BCP Tohickon Post	16	4489.0	280.56

H statistic	17.97
X^2 approximation	17.97
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.

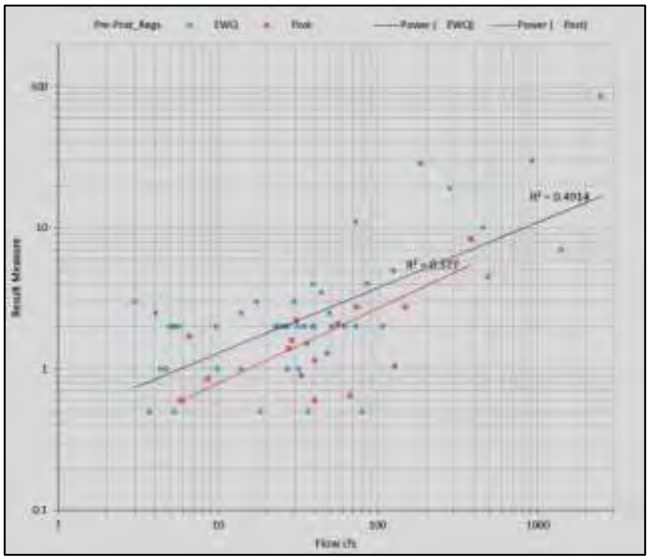
No water quality degradation is evident. TDS apparently declined between the EWQ and post-EWQ periods. However, potential laboratory artifacts and insufficient post-EWQ sampling frequency introduced uncertainty into conclusions. TDS is inversely related to flow in the EWQ data set, but unrelated to flow in the post-EWQ data set. Post-EWQ median TDS fell below the EWQ lower 95% lower confidence interval. Post-EWQ detection limits were lower than EWQ detection limits, though there were no non-detect results at any time.

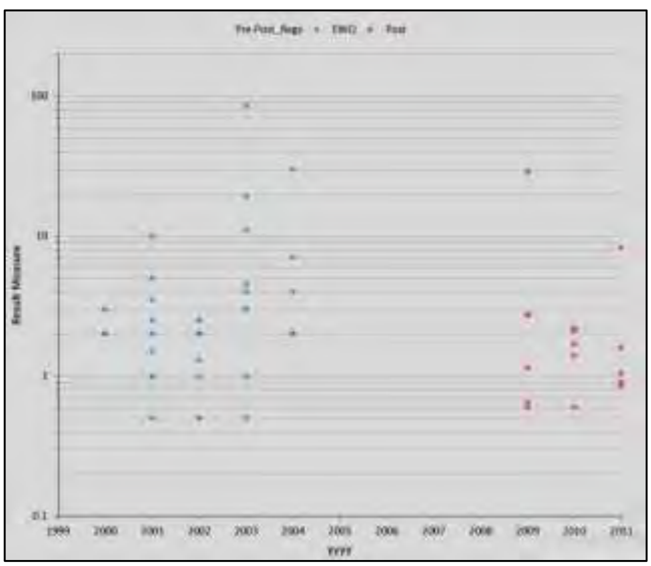
Chapter 9: 1570 BCP Tohickon Creek, PA

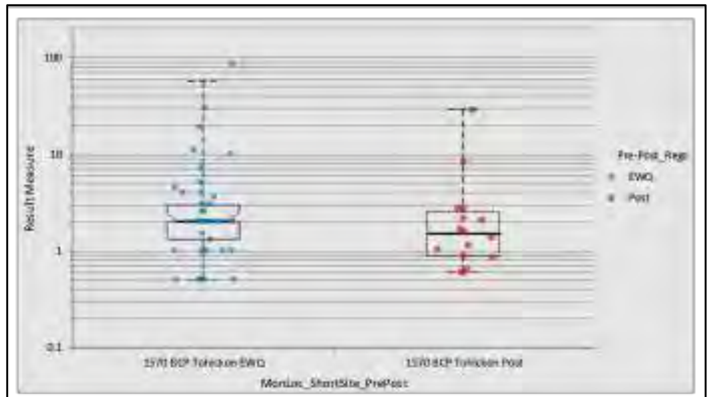
Total Suspended Solids (TSS) mg/l

Existing Water Quality (Table 2R):

Median 2.0 mg/l*
Lower 95% Confidence Interval 1.0 mg/l
Upper 95% Confidence Interval 2.5 mg/l
*Should have been designated in rules as flow-related

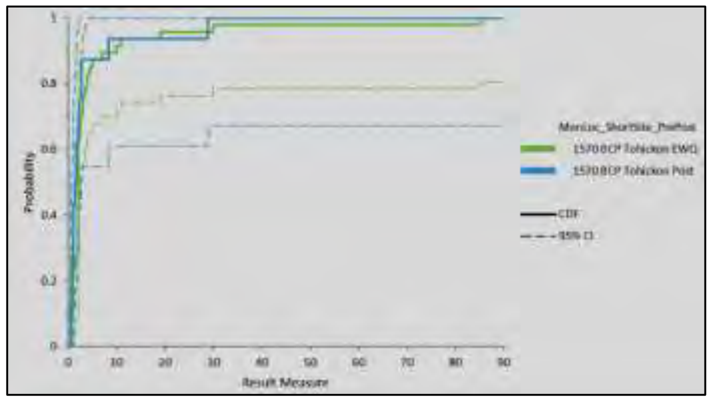






N 63

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1570 BCP Tohickon EWQ	0.50	1.33	2.00	3.00	85.00	1.67
1570 BCP Tohickon Post	0.60	0.87	1.50	2.52	28.80	1.65



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1570 BCP Tohickon EWQ	47	129.4	2.75
1570 BCP Tohickon Post	16	380.3	23.77

H statistic	1.55
X^2 approximation	1.55
DF	1
p-value	0.2132 [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. TSS did not measurably change between the EWQ and post-EWQ periods. TSS is positively related to flow in both data sets. Post-EWQ median TSS was within the EWQ 95% confidence intervals. Note that both flow and concentration are plotted on a logarithmic scale.

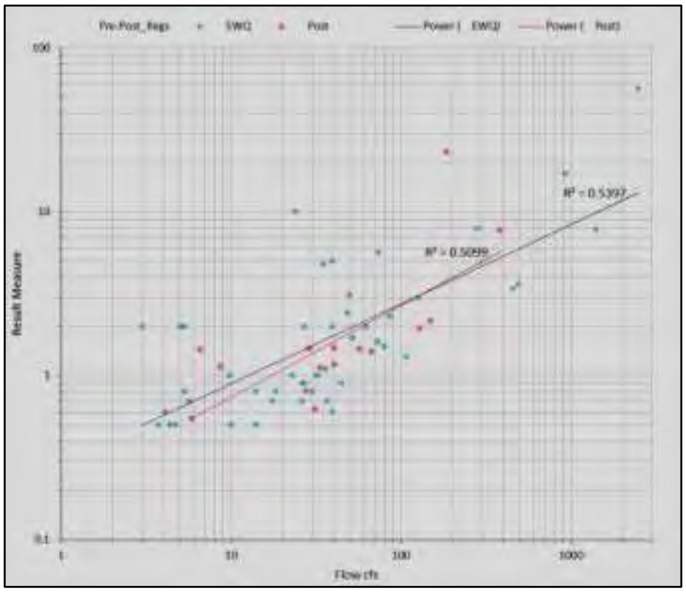
Note: In the DRBC water quality regulations Table 2R, TSS should have been designated as a flow-related parameter for Tohickon Creek.

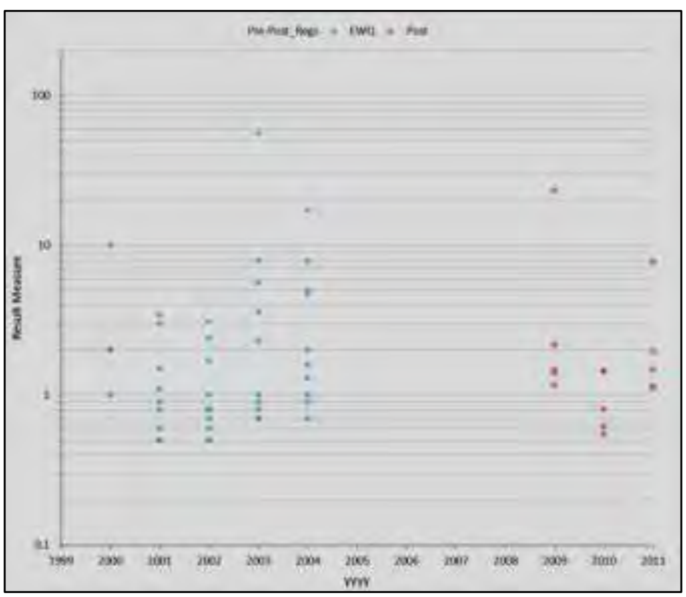
Chapter 9: 1570 BCP Tohickon Creek, PA

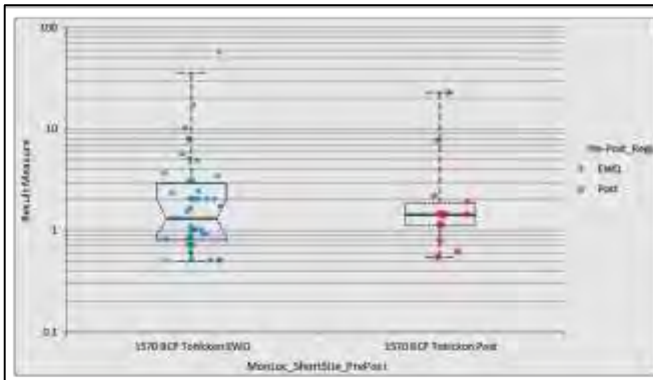
Turbidity NTU

Existing Water Quality (Table 2R):

Median 1.3 NTU
Lower 95% Confidence Interval 0.9 NTU
Upper 95% Confidence Interval 2.0 NTU
Defined in regulations as a flow-related parameter

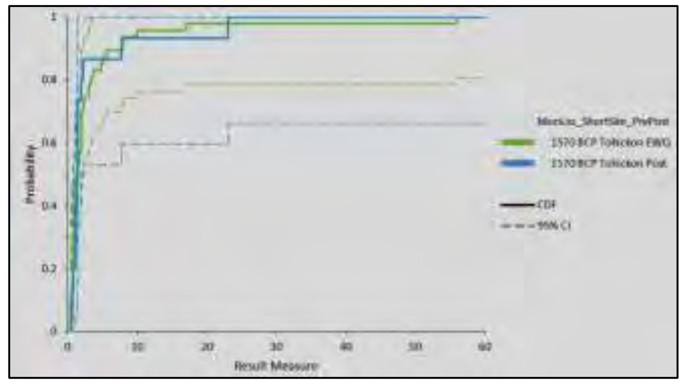






N | 62

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1570 BCP Tohickon EWQ	0.5	0.8	1.3	2.9	56.0	2.1
1570 BCP Tohickon Post	0.6	1.1	1.4	1.9	23.1	0.7



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1570 BCP Tohickon EWQ	47	2.8	0.06
1570 BCP Tohickon Post	15	8.8	0.59

H statistic	0.04
X² approximation	0.04
DF	1
p-value	0.8499 [1]

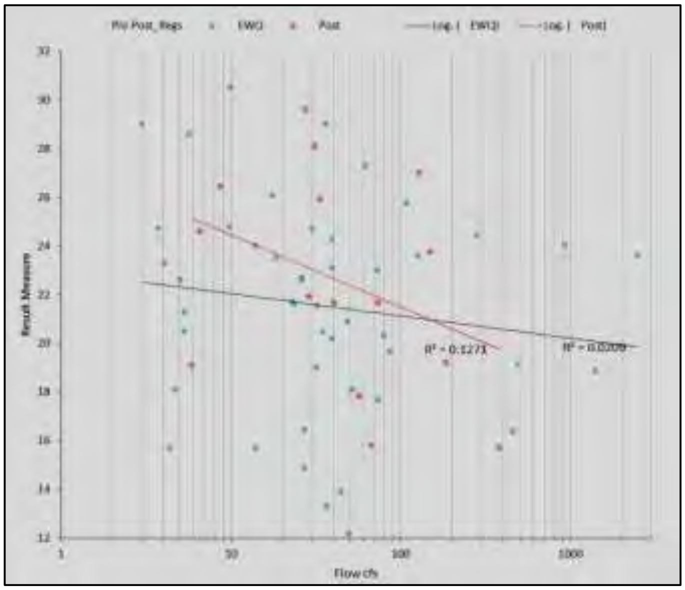
H0: $\theta_1 = \theta_2 = \theta_{\ldots}$
The median of the populations are all equal.
H1: $\theta_i \neq \theta_j$ for at least one i,j
The median of the populations are not all equal.
[1] Do not reject the null hypothesis at the 5% significance level.

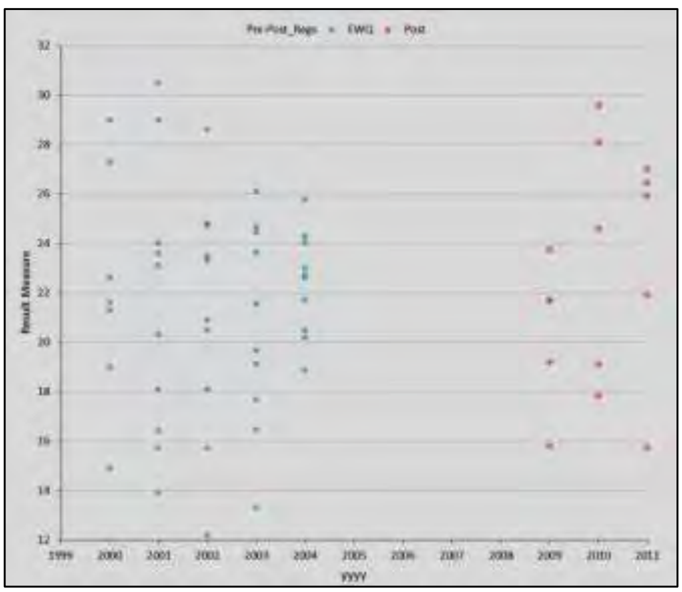
No water quality degradation is evident. Turbidity did not measurably change between the EWQ and post-EWQ periods. The post-EWQ median turbidity fell within the EWQ 95% confidence intervals of the median. Turbidity is related to flow in both data sets. Note that concentration and flow is represented on logarithmic scale.

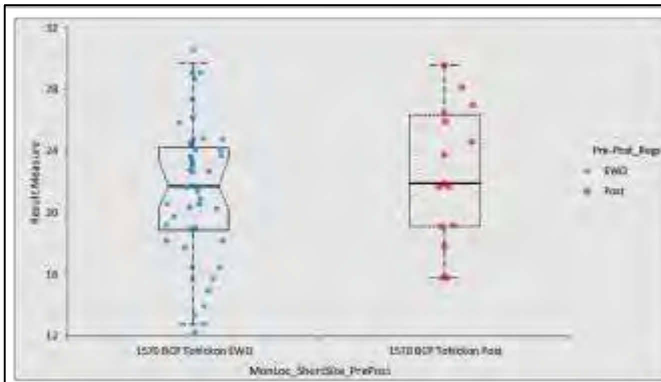
Chapter 9: 1570 BCP Tohickon Creek, PA

Water Temperature, degrees C

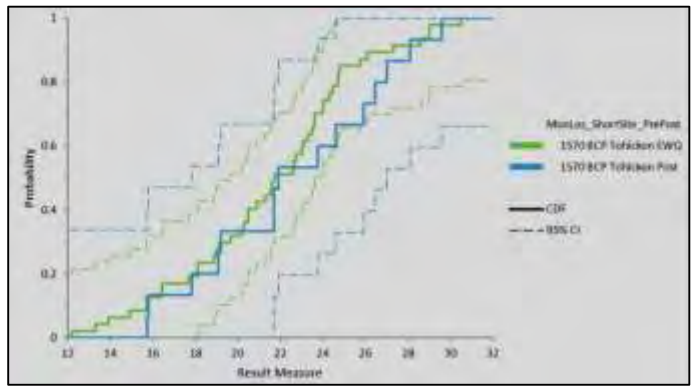
Not included in DRBC Existing Water Quality rules







N	62					
Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1570 BCP Tohickon EWQ	12.2	18.9	21.7	24.2	30.5	5.4
1570 BCP Tohickon Post	15.7	19.1	21.9	26.4	29.6	7.3



Kruskal-Wallis test

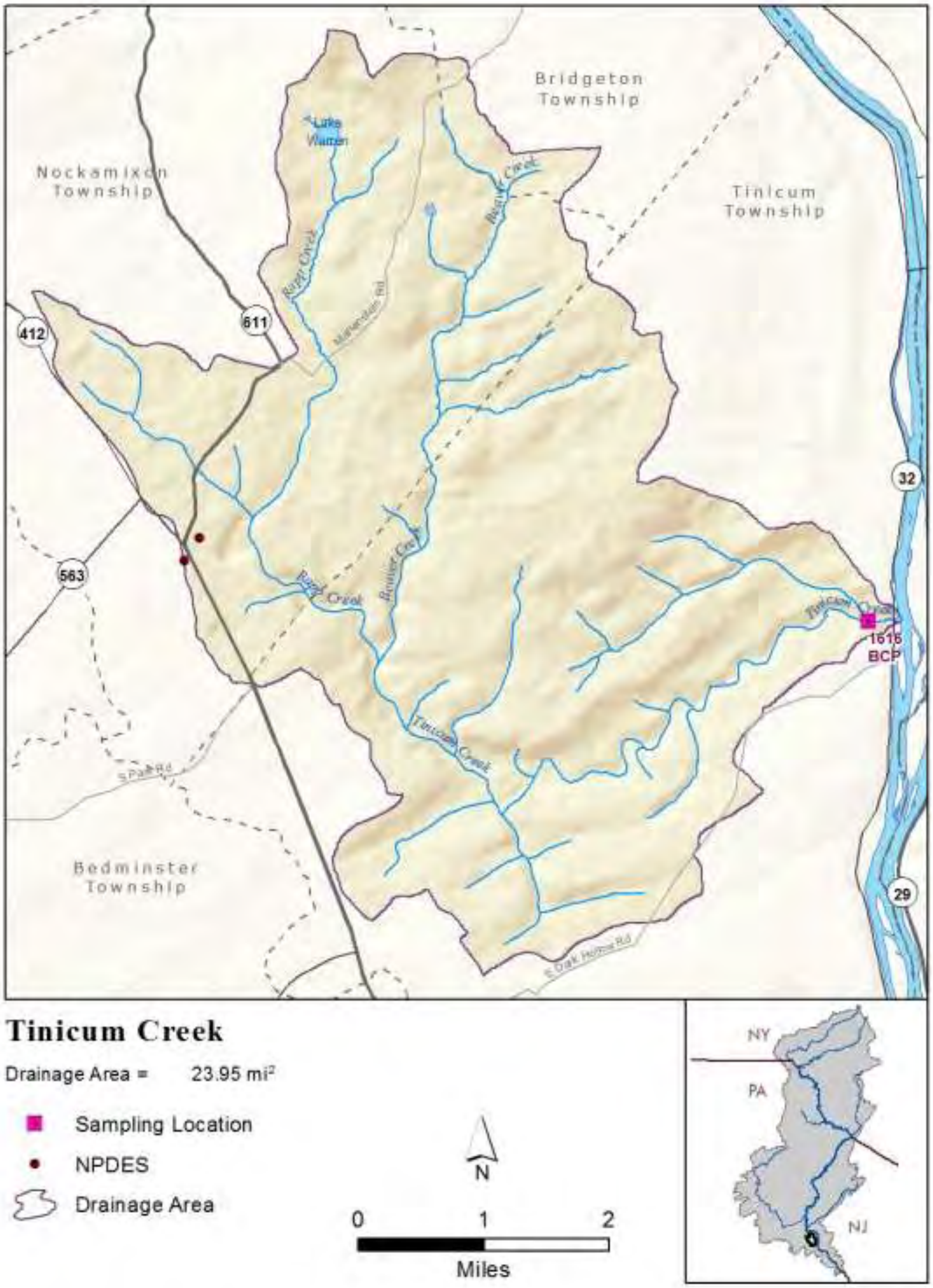
Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1570 BCP Tohickon EWQ	47	52.1	1.11
1570 BCP Tohickon Post	15	163.4	10.89

H statistic	0.66
X^2 approximation	0.66
DF	1
p-value	0.4158[1]

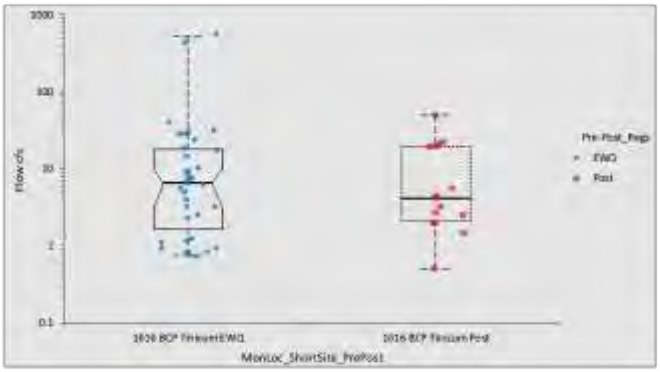
H0: $\theta_1 = \theta_2 = \theta_{...}$
The median of the populations are all equal.
H1: $\theta_i \neq \theta_j$ for at least one i,j
The median of the populations are not all equal.
[1] Do not reject the null hypothesis at the 5% significance level.

No water quality degradation is evident. Water temperature did not measurably change between the EWQ and post-EWQ periods. Water temperature is unrelated to flow in both data sets. Note that flows are plotted on a logarithmic scale.

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



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



N	51

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

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

Kruskal-Wallis test

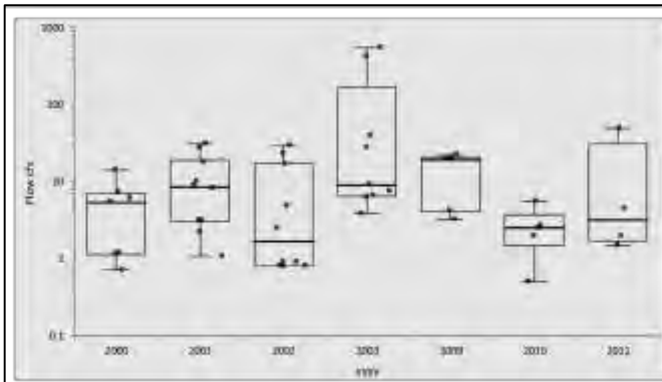
Flow cfs by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1616 BCP Tinicum EWQ	36	9.5	0.26
1616 BCP Tinicum Post	15	22.8	1.52

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

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

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

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



N	51

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

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

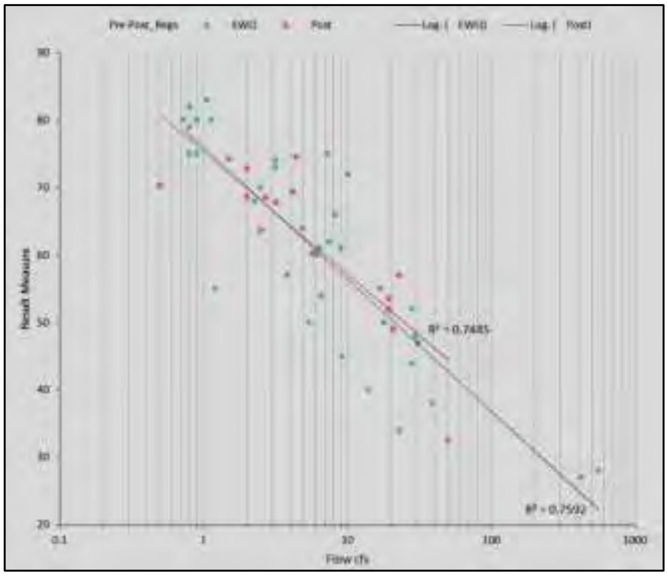
*Stuckey, M.H., Koerkle, E.H., and Ulrich, J.E., 2012, Estimation of baseline daily mean streamflows for ungaged locations on Pennsylvania streams, water years 1960–2008: U.S. Geological Survey Scientific Investigations Report 2012–5142, 61 p.)

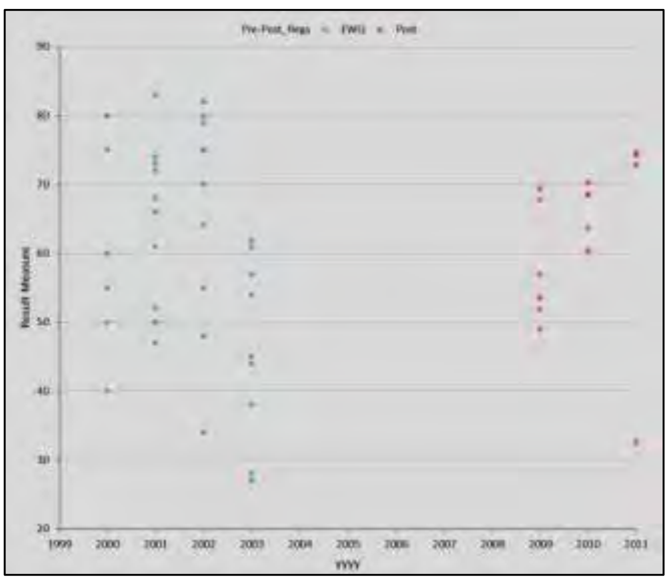
Chapter 10: 1616 BCP Tinicum Creek, PA

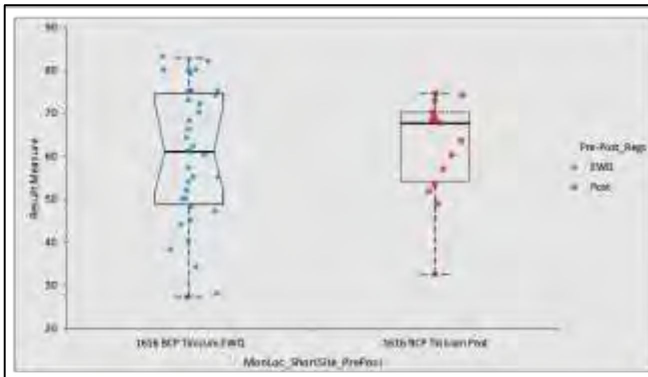
Alkalinity as CaCO3, Total mg/l

Existing Water Quality (Table 2Q):

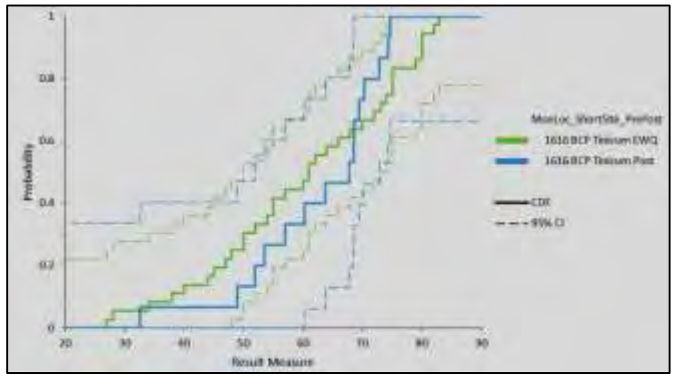
Median 61 mg/l
Lower 95% Confidence Interval 52 mg/l
Upper 95% Confidence Interval 72 mg/l
Defined in regulations as a flow-related parameter







N	51					
Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1616 BCP Tinicum EWQ	27	49	61	75	83	26
1616 BCP Tinicum Post	33	54	68	70	75	16



Kruskal-Wallis test

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

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

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

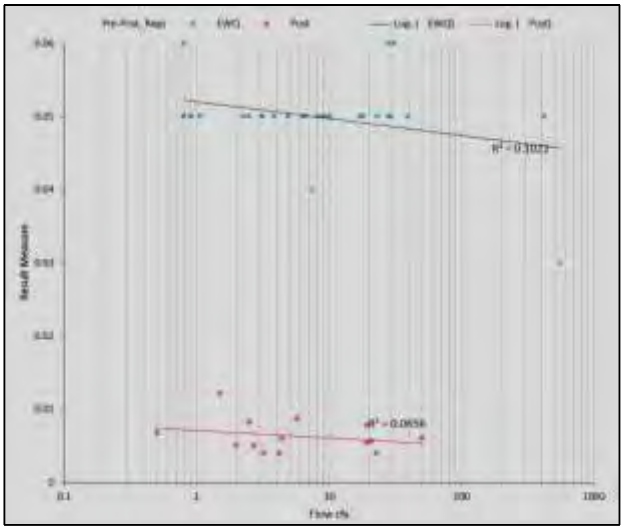
No water quality degradation is evident here. Alkalinity did not measurably change between the EWQ and post-EWQ periods. Alkalinity is inversely related to flow in both data sets. Post-EWQ median alkalinity fell within EWQ 95% confidence intervals. Flow is plotted on a logarithmic scale.

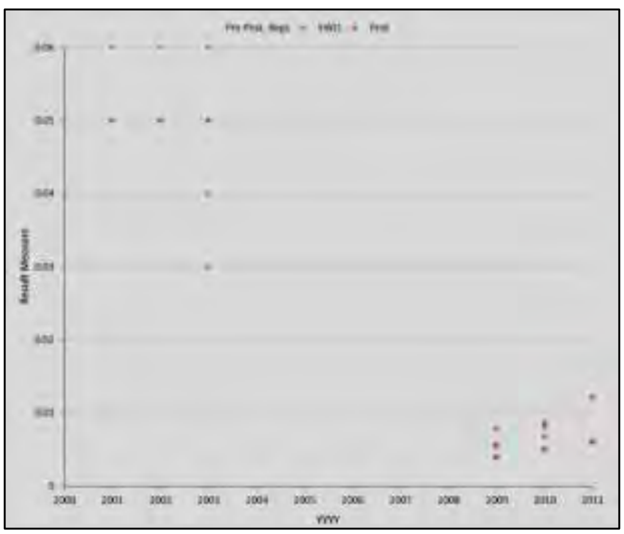
Chapter 10: 1616 BCP Tinicum Creek, PA

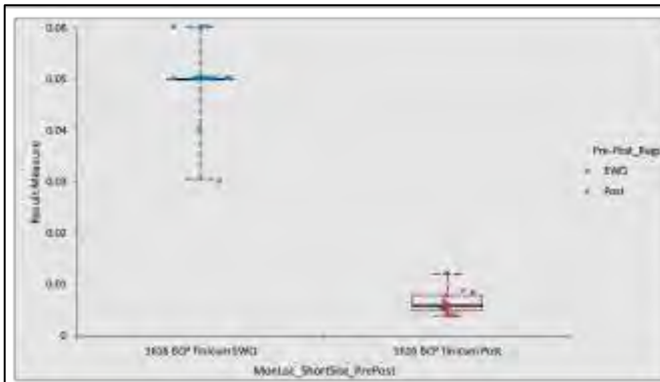
Ammonia Nitrogen as N, Total mg/l

Existing Water Quality (Table 2Q):

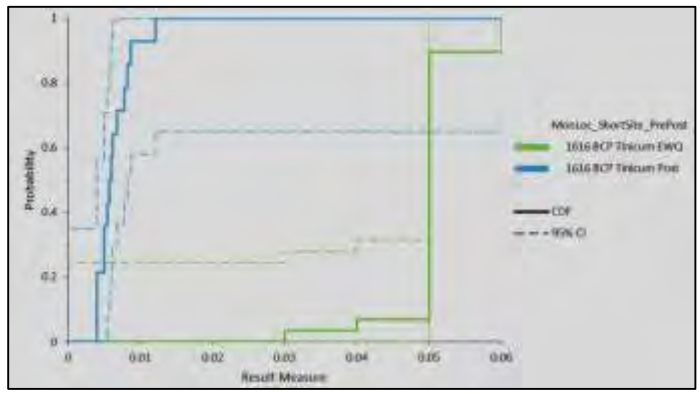
Median <0.05 mg/l
Lower 95% Confidence Interval <0.05 mg/l
Upper 95% Confidence Interval <0.05 mg/l







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



Kruskal-Wallis test

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

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

H0: $\theta_1 = \theta_2 = \theta\ldots$
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. Ammonia concentrations apparently declined. Post-EWQ median ammonia concentration was below the EWQ lower 95% confidence interval. However, potential laboratory artifacts, detection limit differences, and insufficient post-EWQ sampling frequency introduced uncertainty into conclusions.

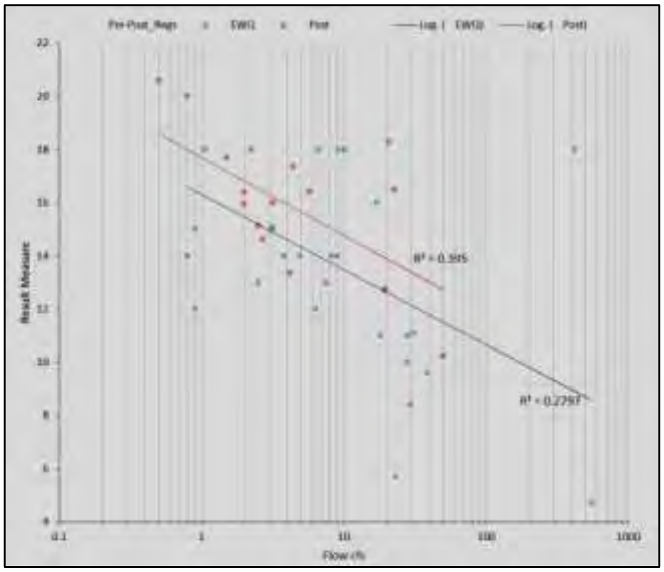
No independent data were available to validate results. EWQ data possessed 26/29 undetected results, which interfered with calculation of the median. Thus EWQ was established as <0.05 mg/l, the detection limit at the time. Post-EWQ 2009-2011 lower detection levels of 0.004-0.006 mg/l still resulted in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

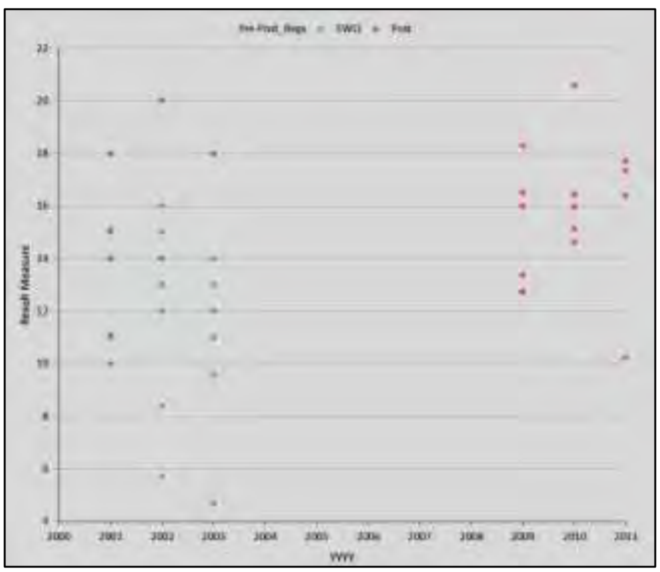
Chapter 10: 1616 BCP Tinicum Creek, PA

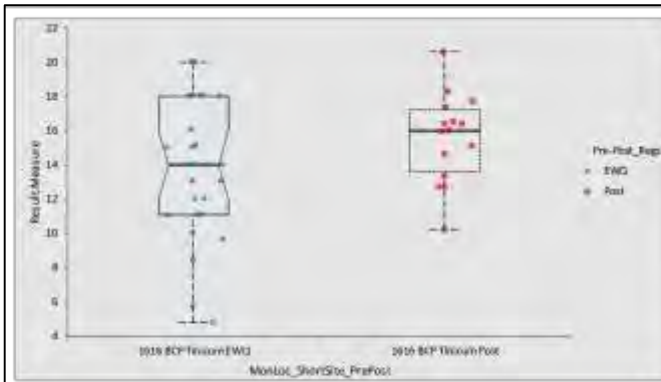
Chloride, Total mg/l

Existing Water Quality (Table 2Q):

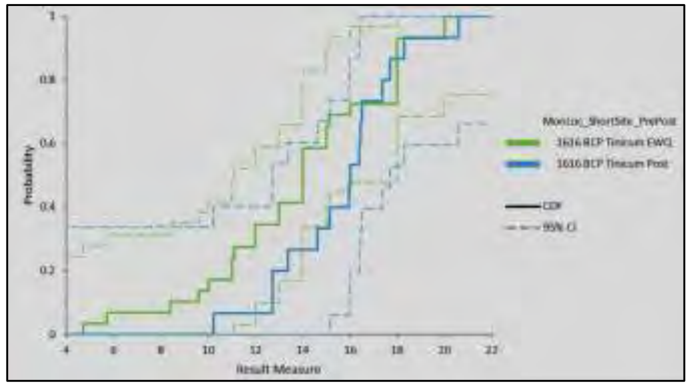
Median 14 mg/l
Lower 95% Confidence Interval 12 mg/l
Upper 95% Confidence Interval 16 mg/l







N	44					
Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1616 BCP Tinicum EWQ	5	11	14	18	20	7
1616 BCP Tinicum Post	10	14	16	17	21	4



Kruskal-Wallis test

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

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

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

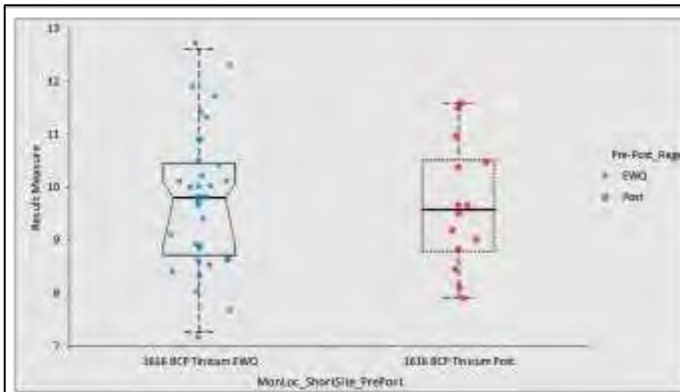
No water quality degradation is evident here. Chloride concentrations did not measurably change between the two periods. Post-EWQ median concentration rose to the EWQ upper 95% confidence interval. Flow is plotted on a logarithmic scale.

Chapter 10: 1616 BCP Tinicum Creek, PA

Dissolved Oxygen (DO) mg/l

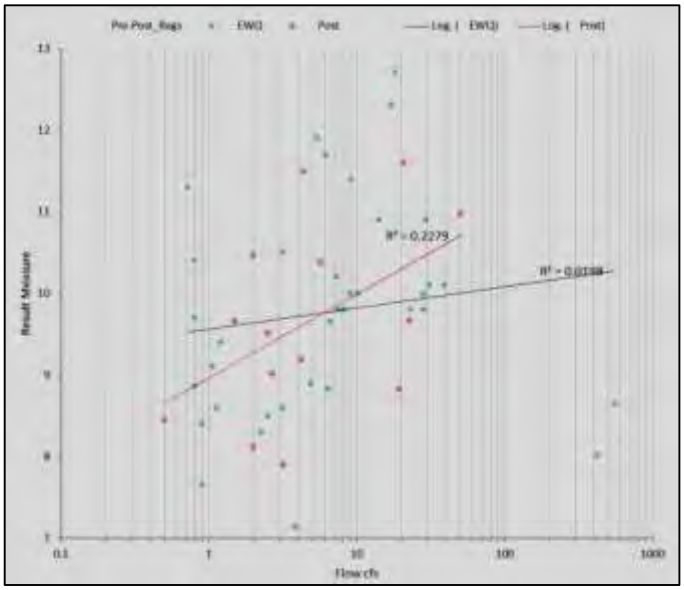
Existing Water Quality (Table 2Q):

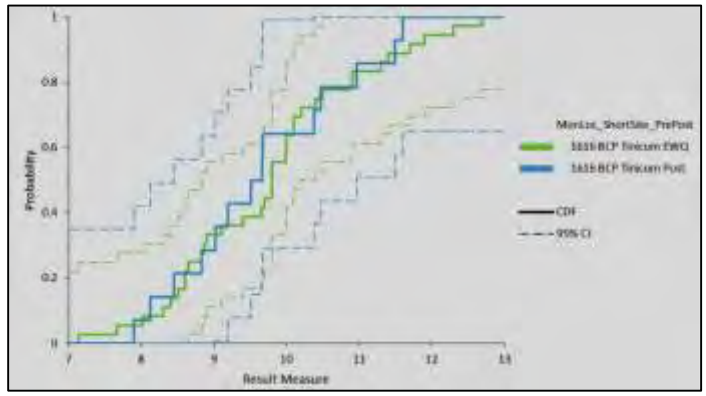
Median 9.80 mg/l
Lower 95% Confidence Interval 8.90 mg/l
Upper 95% Confidence Interval 10.10 mg/l

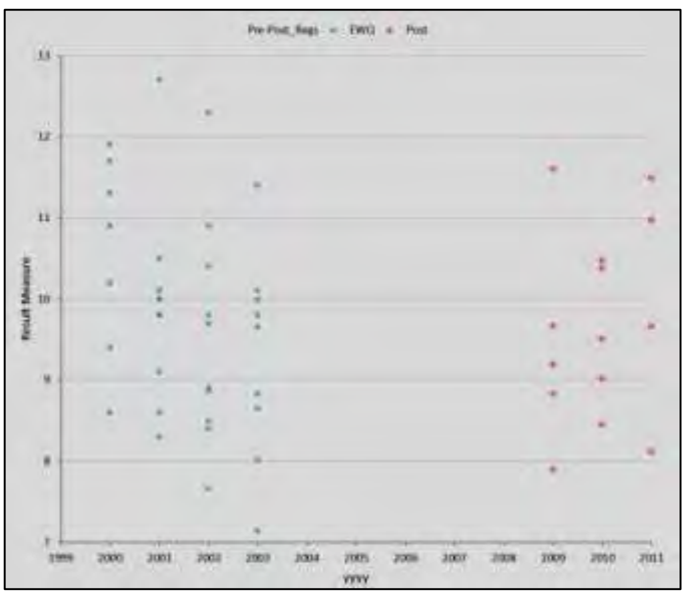


N 50

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







Kruskal-Wallis test

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

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

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

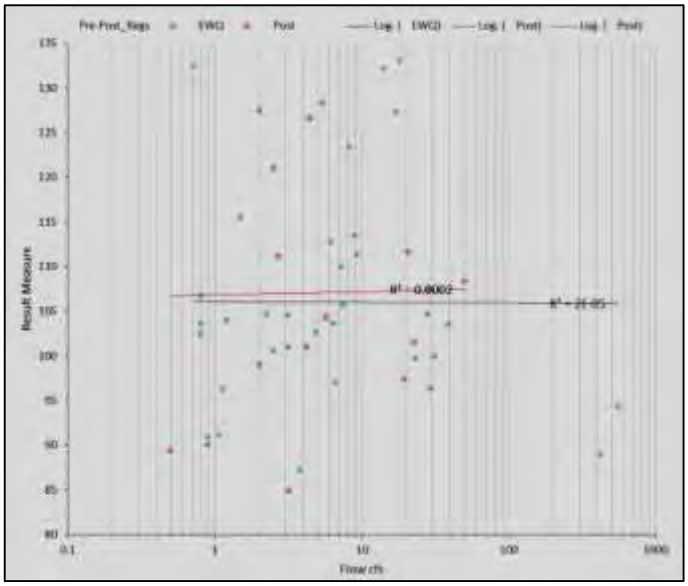
No water quality degradation is evident here. No measurable change took place between the EWQ and Post-EWQ periods. Post-EWQ median DO concentration fell within the EWQ 95% confidence intervals. Flow is plotted on a logarithmic scale. DO concentration is unrelated to flow in both data sets.

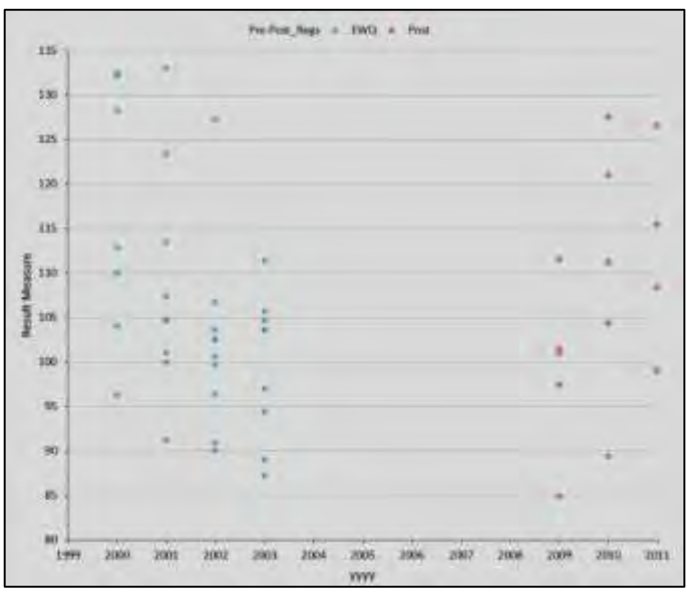
Chapter 10: 1616 BCP Tinicum Creek, PA

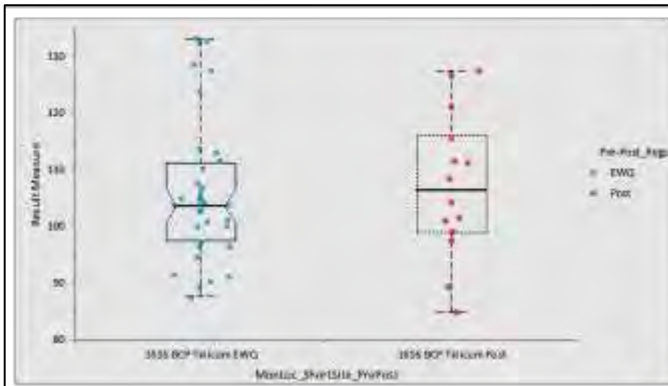
Dissolved Oxygen Saturation %

Existing Water Quality (Table 2Q):

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

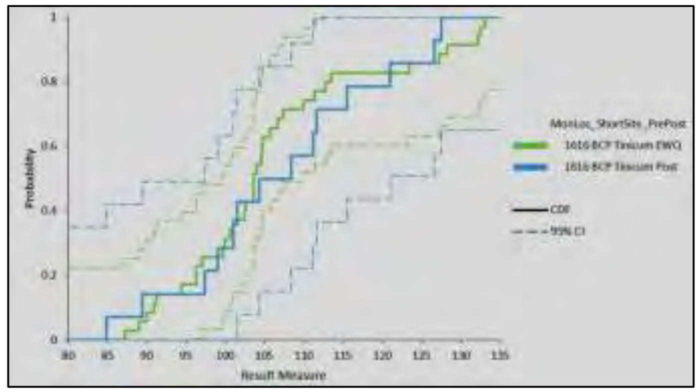






N	49

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



Kruskal-Wallis test

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

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

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

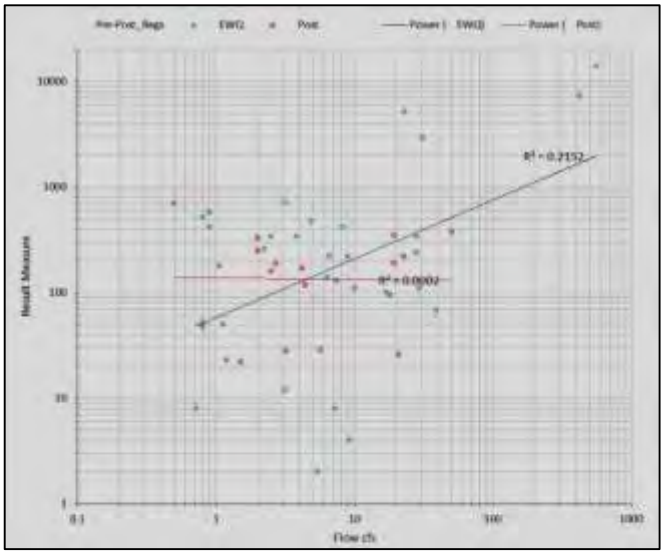
No water quality degradation is evident here. Dissolved Oxygen Saturation is unrelated to flow, and did not measurably change between the EWQ and post-EWQ periods. Post-EWQ median DO saturation was within the EWQ 95% confidence intervals. Flow is plotted on a logarithmic scale. Tinicum Creek is wide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

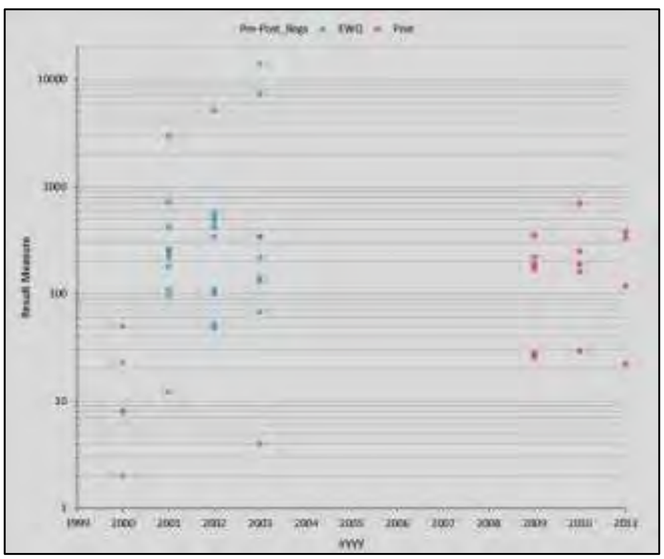
Chapter 10: 1616 BCP Tinicum Creek, PA

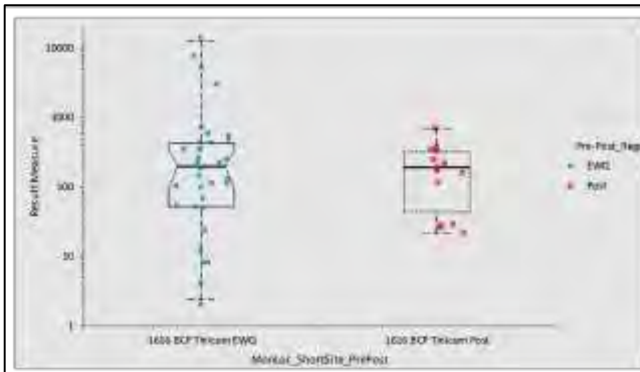
Enterococcus colonies/100 ml

Existing Water Quality (Table 2Q):

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

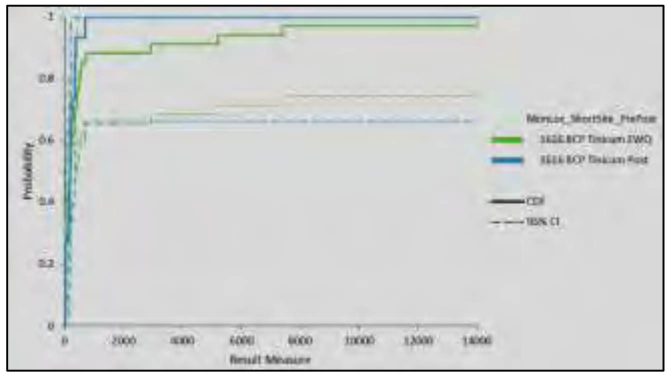






N 49

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



Kruskal-Wallis test

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

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

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

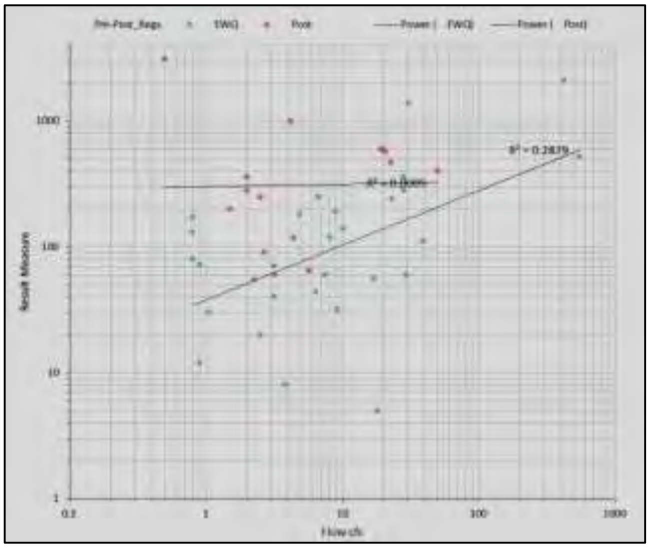
No water quality degradation is evident here. Enterococci did not measurably change between the EWQ and Post-EWQ periods. Enterococcus concentrations are unrelated to flow in both data sets. Concentrations and flows are plotted on a logarithmic scale, and regressions are power relationships. Post-EWQ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

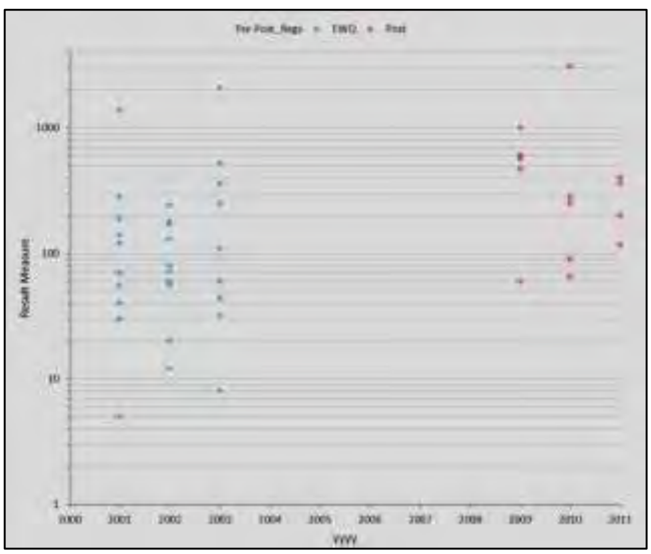
Chapter 10: 1616 BCP Tinicum Creek, PA

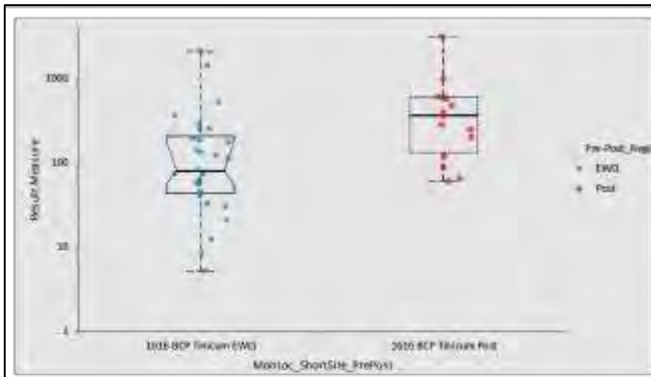
Escherichia coli colonies/100 ml

Existing Water Quality (Table 2Q):

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

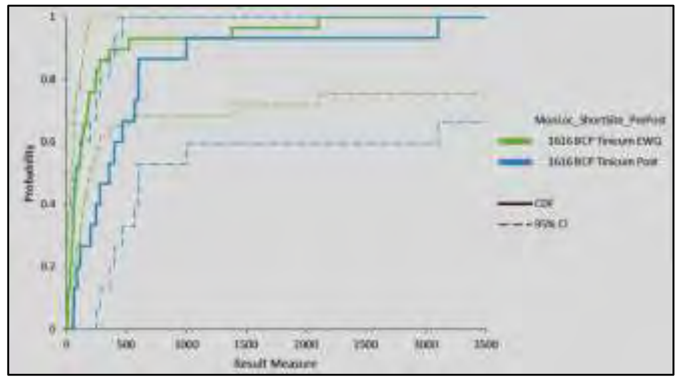






N 44

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



Kruskal-Wallis test

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

H statistic	8.98
X² approximation	8.98
DF	1
p-value	0.0027 [1]

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

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

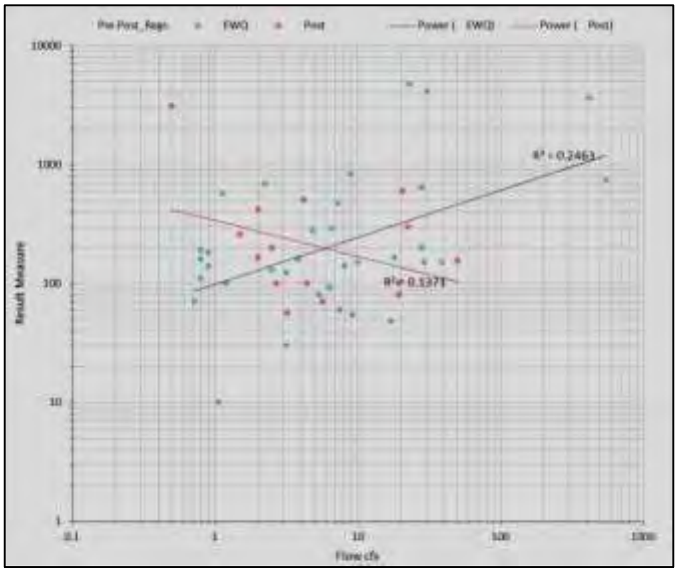
Concentrations and flows are plotted on logarithmic scale and regressions are power relationships. E. coli concentrations were positively but weakly related to flow in the EWQ data set, but unrelated to flow in the post-EWQ data set – possibly due to too few post-EWQ samples (n=15). No independent data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

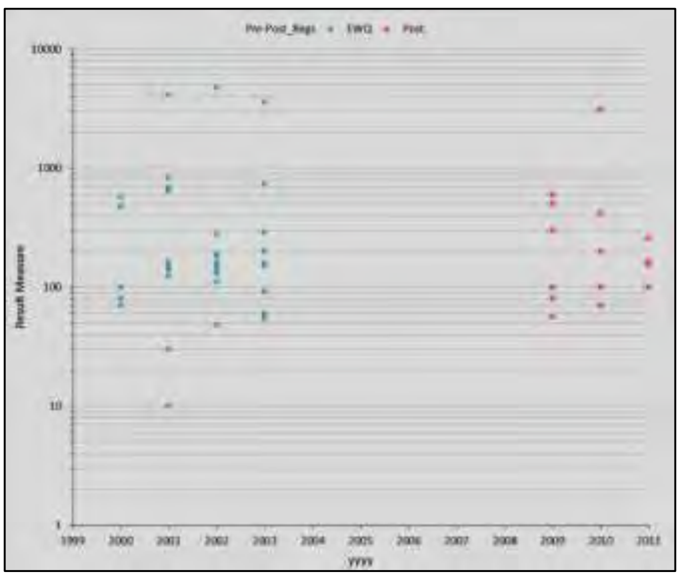
Chapter 10: 1616 BCP Tinicum Creek, PA

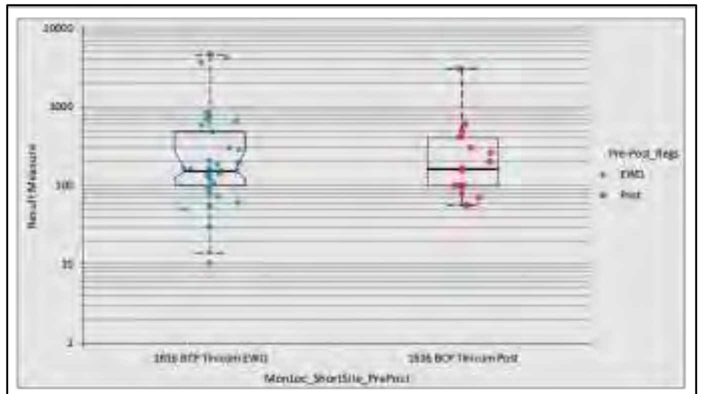
Fecal coliform colonies/100 ml

Existing Water Quality (Table 2Q):

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

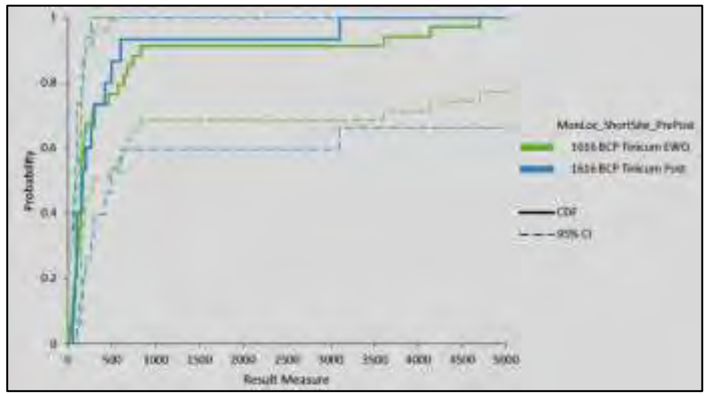






N 49

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



Kruskal-Wallis test

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

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

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

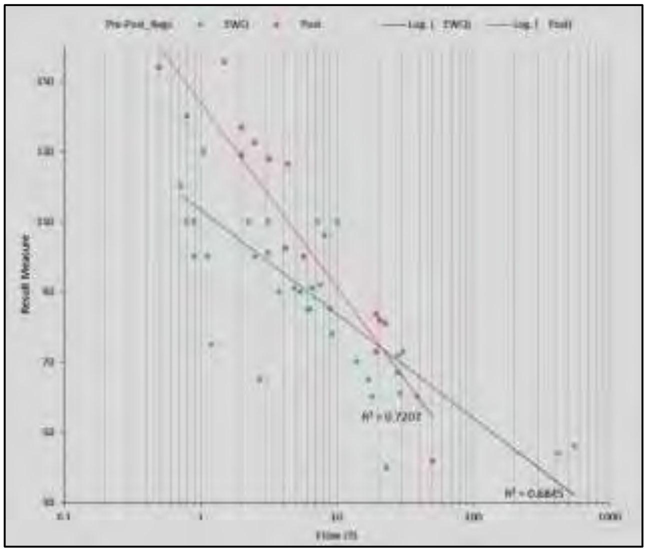
No water quality degradation is evident here. Fecal coliform concentrations did not measurably change between the EWQ and post-EWQ periods. Fecal coliform concentrations are unrelated to flow in both data sets. Post-EWQ median concentrations were within the EWQ 95% confidence intervals. Concentrations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

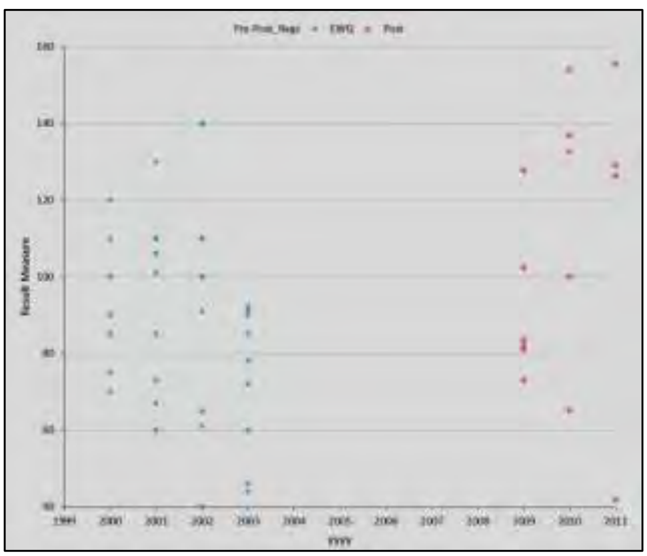
Chapter 10: 1616 BCP Tinicum Creek, PA

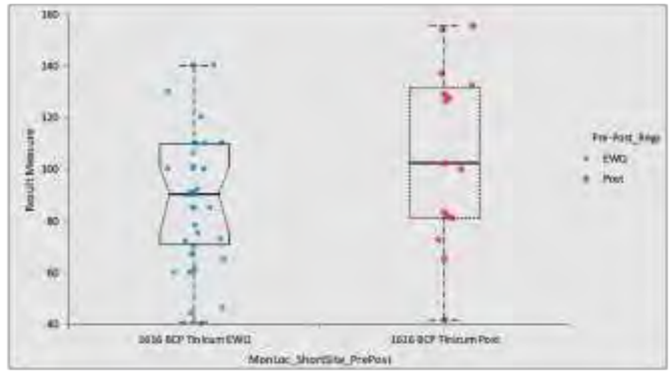
Hardness as CaCO3, Total mg/l

Existing Water Quality (Table 2Q):

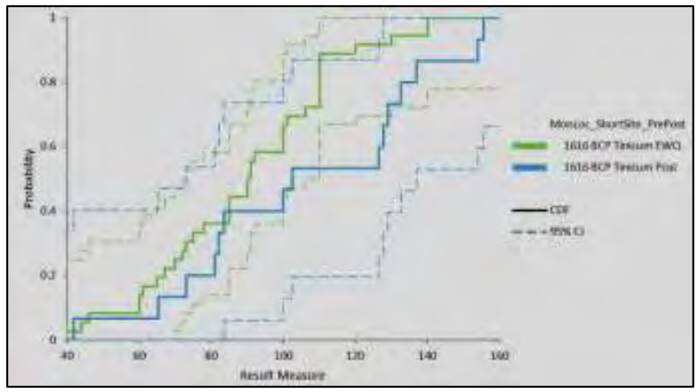
Median 91 mg/l
Lower 95% Confidence Interval 75 mg/l
Upper 95% Confidence Interval 101 mg/l
Defined in regulations as a flow-related parameter







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



Kruskal-Wallis test

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

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

H0: $\theta_1 = \theta_2 = \theta_{...}$
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.

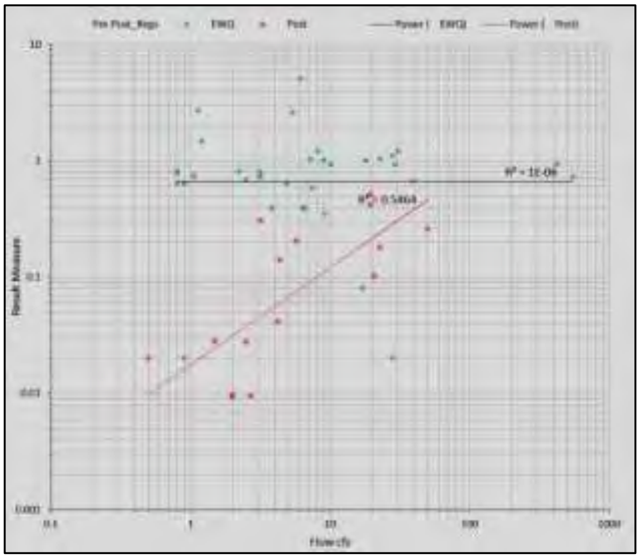
No water quality degradation is evident here. Hardness did not measurably change between the EWQ and post-EWQ periods. Hardness is inversely related to flow in both data sets. Post-EWQ median hardness was above the EWQ upper 95% confidence interval, but the increase was not significant because too few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

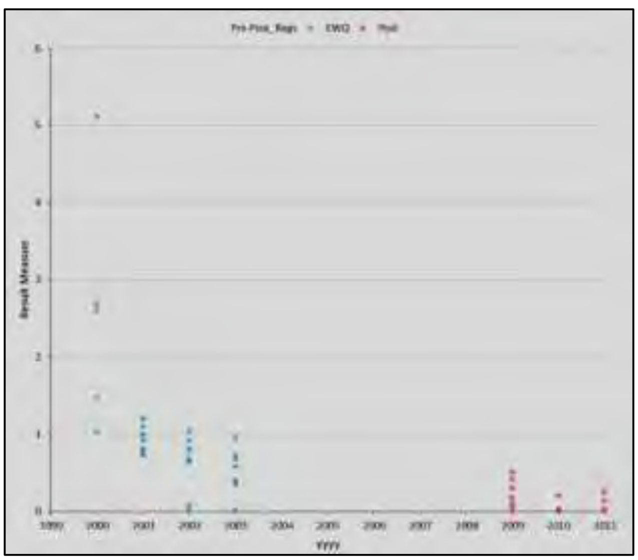
Chapter 10: 1616 BCP Tinicum Creek, PA

Nitrate + Nitrite as N, Total mg/l

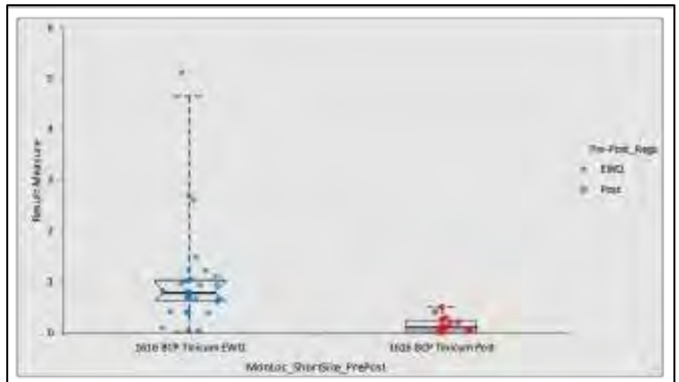
Existing Water Quality (Table 2Q, as Nitrate only):

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



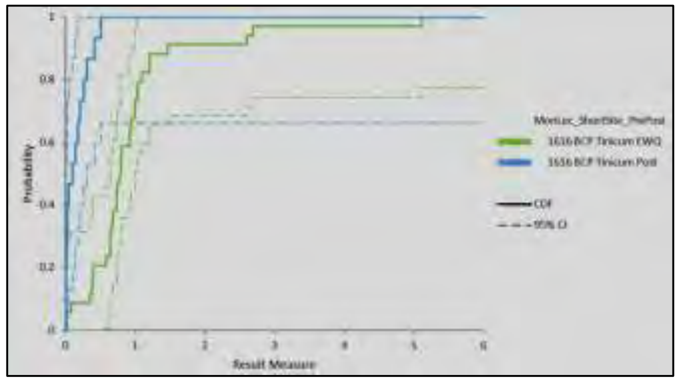


No water quality degradation is evident here. Nitrate concentrations apparently declined between the EWQ and post-EWQ periods. However, this conclusion is uncertain because of potential laboratory artifacts and insufficient post-EWQ sampling frequency. Nitrate is unrelated related to flow in the EWQ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



N | 49

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



Kruskal-Wallis test

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

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

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

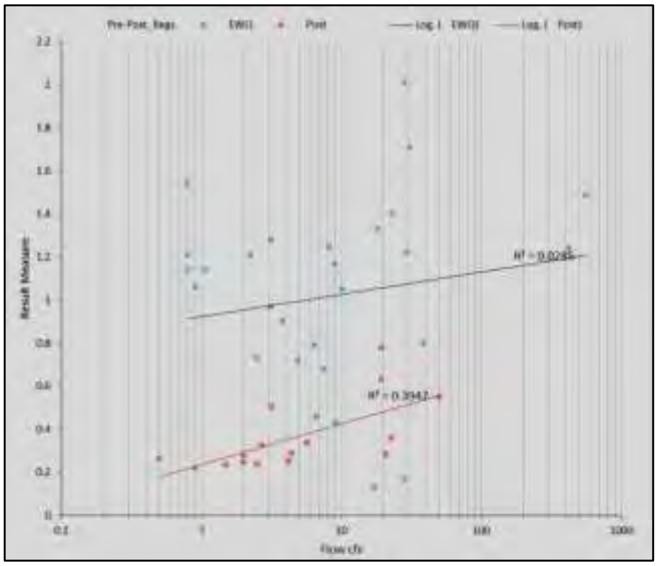
Due to the small number of post-EWQ data, flow conditions are not fully represented. Post-EWQ nitrate + nitrite concentrations were assumed equivalent for comparison with EWQ nitrate concentrations since EWQ nitrite concentrations were never detected. Independent data were not available for validation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

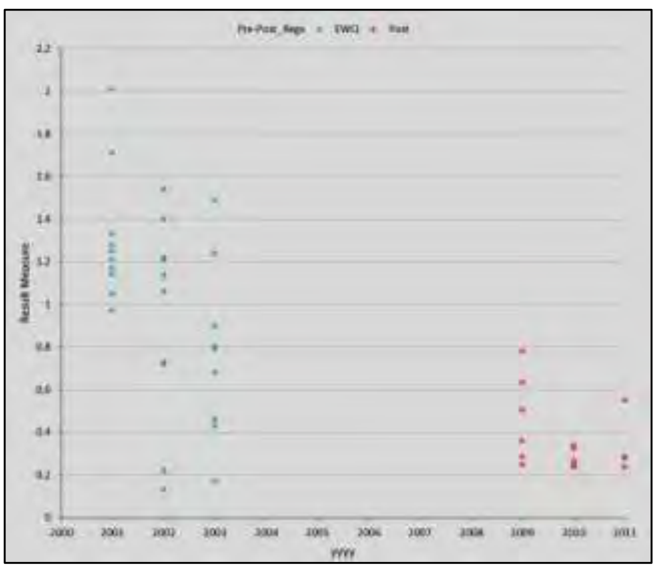
Chapter 10: 1616 BCP Tinicum Creek, PA

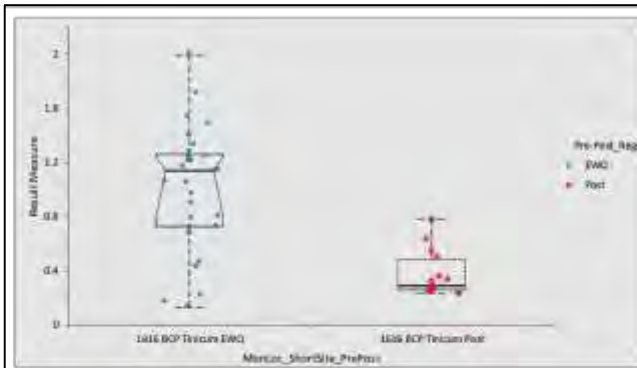
Nitrogen as N, Total (TN) mg/l

Existing Water Quality (Table 2Q):

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

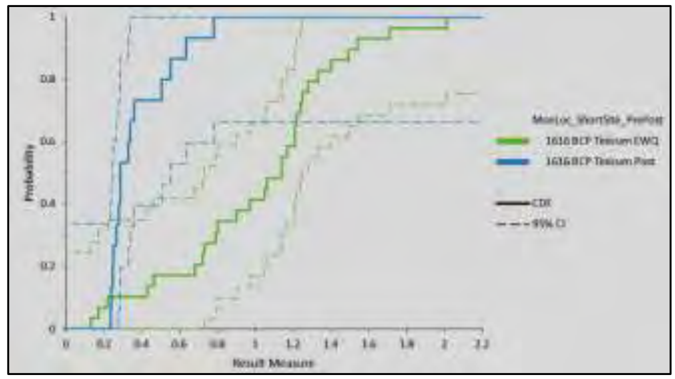






N	44

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



Kruskal-Wallis test

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

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

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

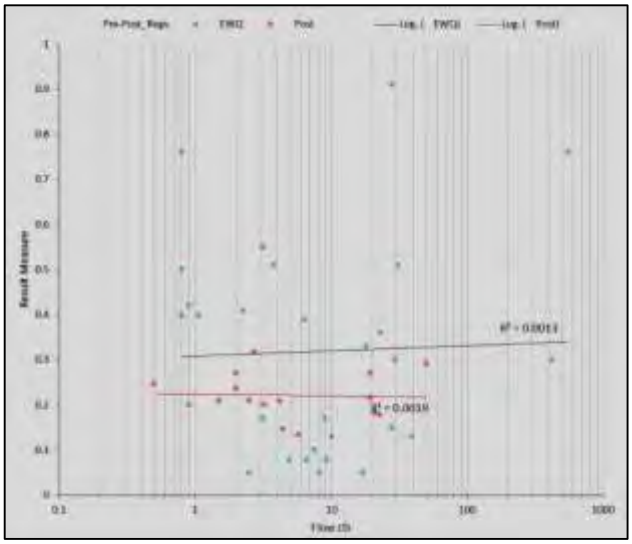
No water quality degradation is evident here. Total Nitrogen concentrations apparently declined between the EWQ and post-EWQ periods. Such a conclusion is uncertain because of potential laboratory artifacts and insufficient post-EWQ sampling frequency. TN is positively related to flow in the post-EWQ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

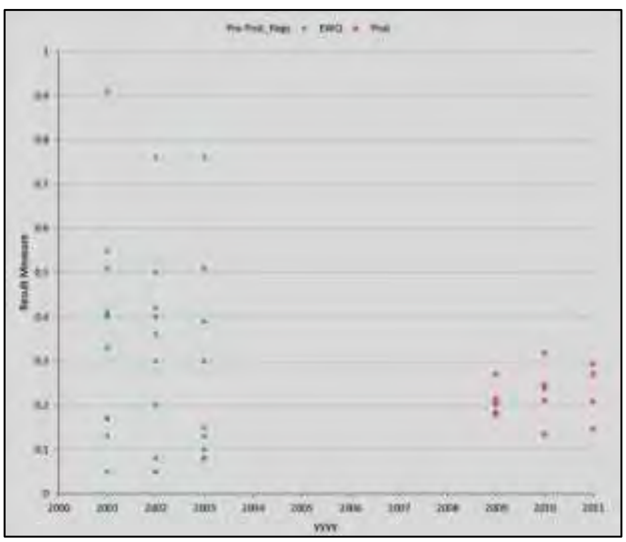
Chapter 10: 1616 BCP Tinicum Creek, PA

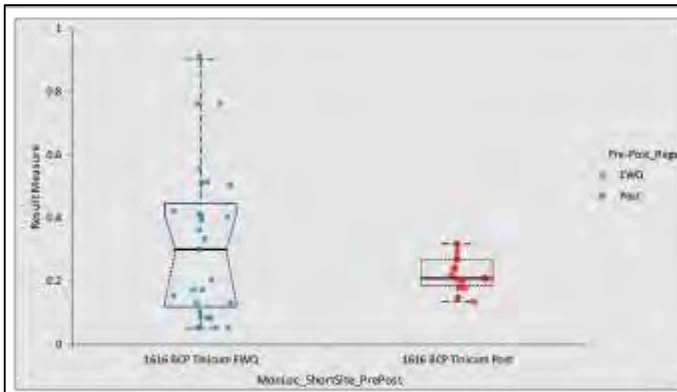
Nitrogen, Kjeldahl as N, Total (TKN) mg/l

Existing Water Quality (Table 2Q):

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

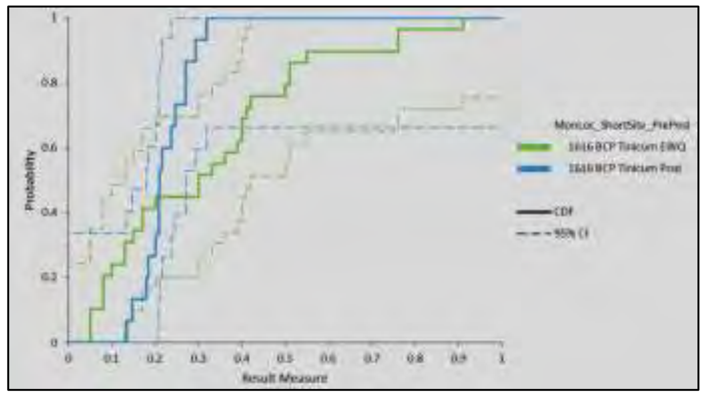






N 44

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



Kruskal-Wallis test

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

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

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

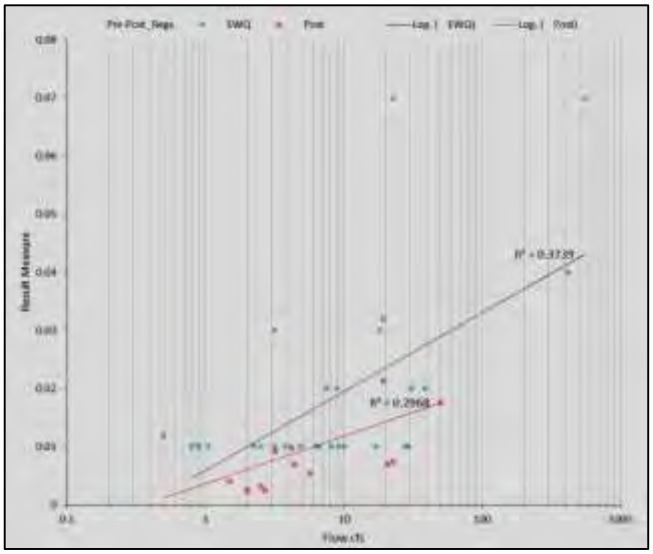
No water quality degradation is evident here. TKN concentrations did not measurably change between the EWQ and post-EWQ periods. Potential laboratory artifacts introduced uncertainty into apparently obvious trends. TKN concentration is unrelated to flow in both data sets. TKN ranges less widely and is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

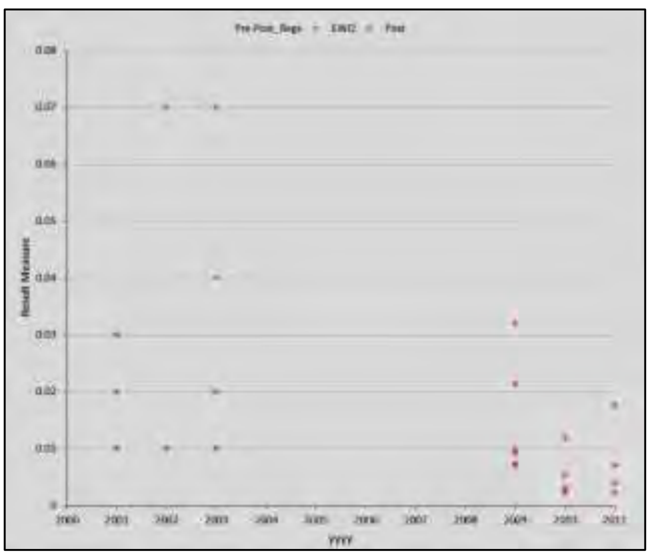
Chapter 10: 1616 BCP Tinicum Creek, PA

Orthophosphate as P, Total mg/l

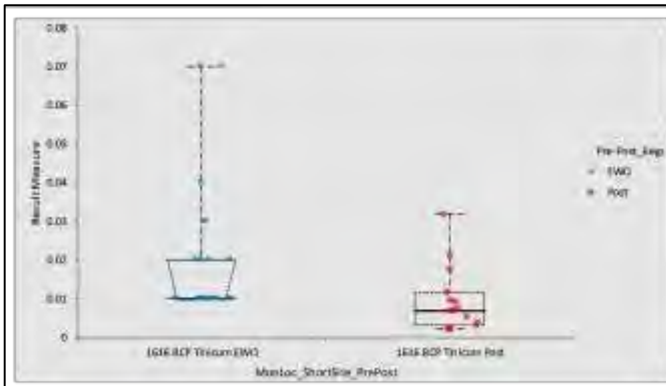
Existing Water Quality (Table 2Q):

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



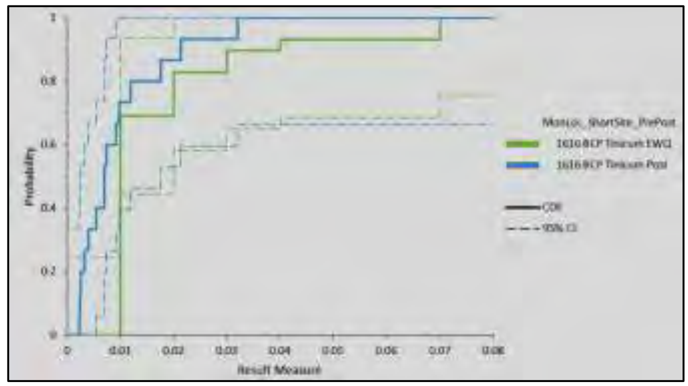


No water quality degradation is evident here. Orthophosphate concentrations apparently declined between the EWQ and post-EWQ periods. Detection limit differences, potential laboratory artifacts and insufficient post-EWQ sampling frequency introduced uncertainty into conclusions.



N 44

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



Kruskal-Wallis test

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

H statistic	11.01
X² approximation	11.01
DF	1
p-value	0.0009 [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.

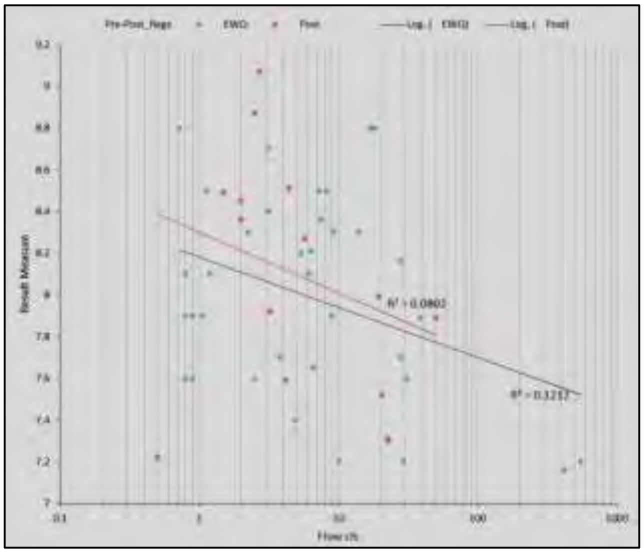
Orthophosphate is weakly related to flow in both data sets. Flow is plotted on logarithmic scale. Post-EWQ median orthophosphate fell below the EWQ lower 95% confidence interval. Post-EWQ data describe actual orthophosphate concentrations better than the EWQ data, where 19/29 undetected results interfered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

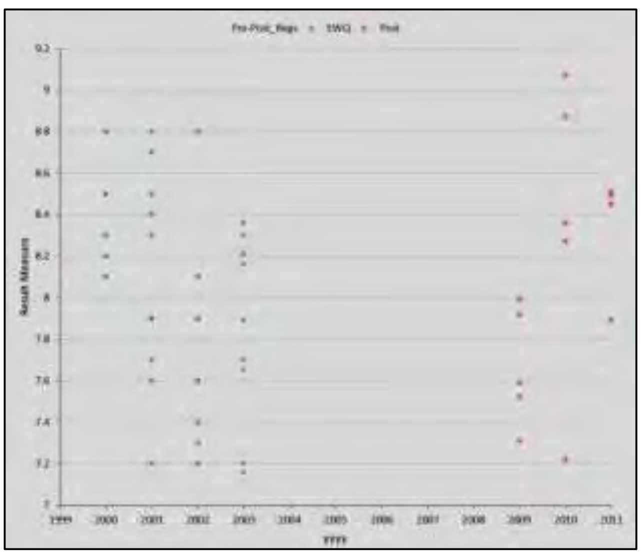
Chapter 10: 1616 BCP Tinicum Creek, PA

pH, units

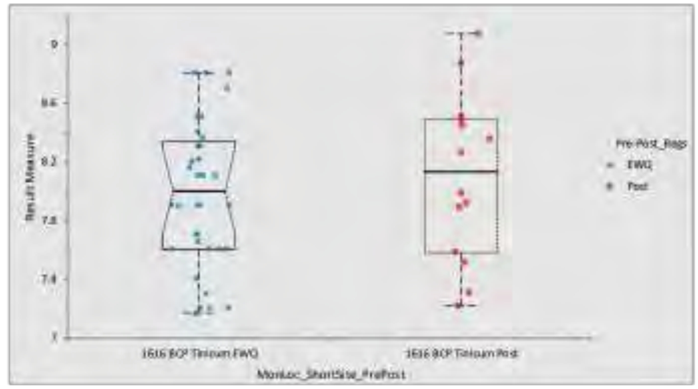
Existing Water Quality (Table 2Q):

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



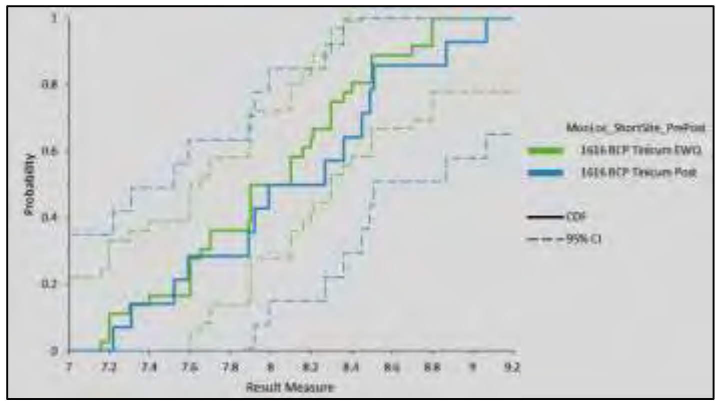


No water quality degradation is evident here. pH did not measurably change between the EWQ and post-EWQ periods. pH is unrelated to flow in both data sets. pH tends toward neutral during higher flow conditions. Flow is plotted on logarithmic scale. Post-EWQ median pH was within the EWQ 95% confidence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



N 50

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



Kruskal-Wallis test

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

H statistic	0.48
X² approximation	0.48
DF	1
p-value	0.4889[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.

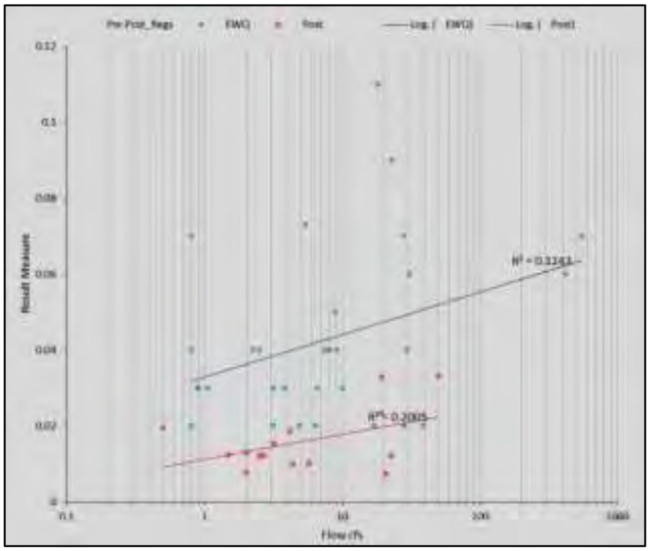
In Tinicum Creek, mid-day pH tends to run higher than some other watersheds due to its wide, shallow channel. There is high algae production at the DRBC monitoring site driving up the mid-day pH. Pennsylvania pH criteria occasionally are exceeded here.

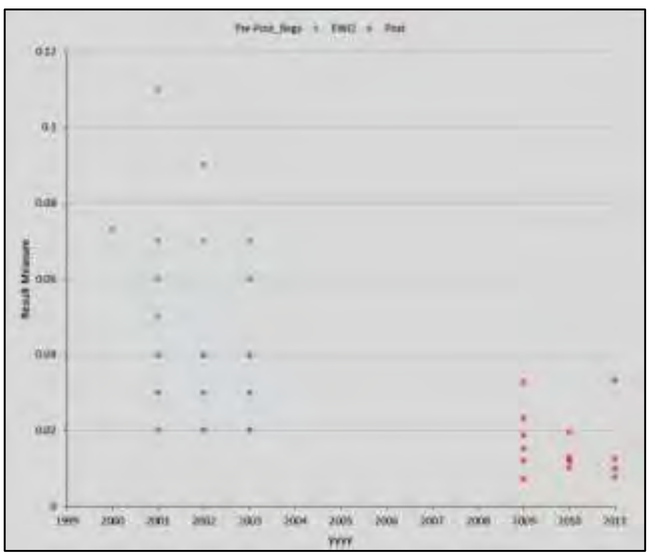
Chapter 10: 1616 BCP Tinicum Creek, PA

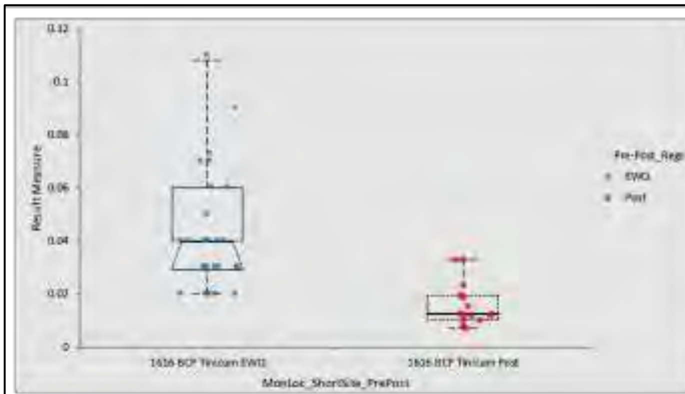
Phosphorus as P, Total (TP) mg/l

Existing Water Quality (Table 2Q):

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

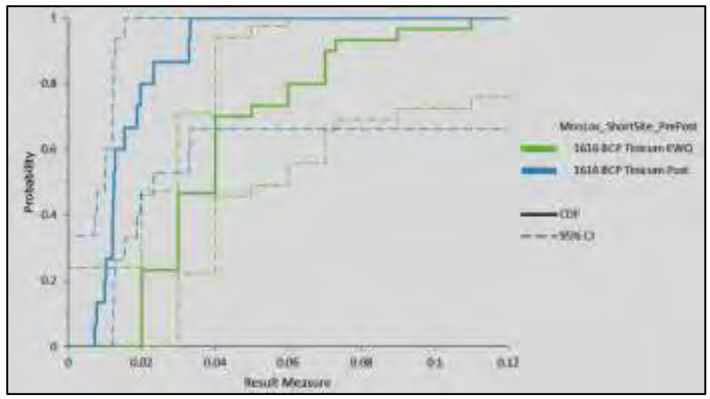






N	45

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



Kruskal-Wallis test

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

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

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

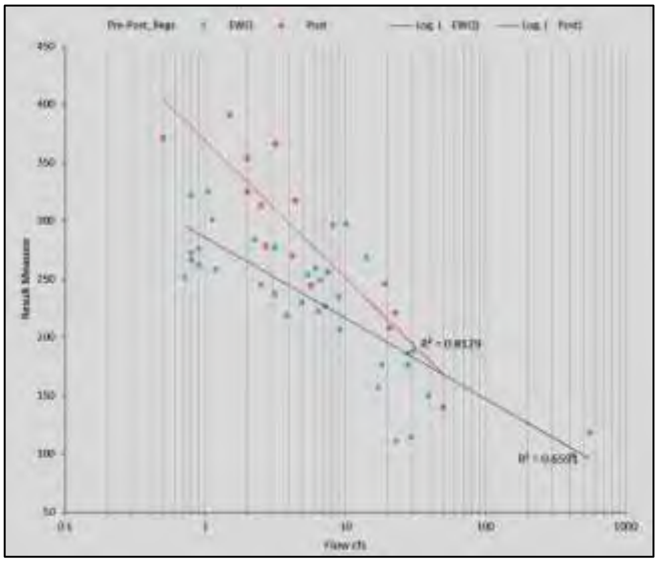
No water quality degradation is evident here. Total Phosphorus (TP) concentrations apparently declined between the EWQ and post-EWQ periods. However, detection limit differences, potential laboratory artifacts and insufficient post-EWQ sampling frequency introduced uncertainty into conclusions. Post-EWQ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

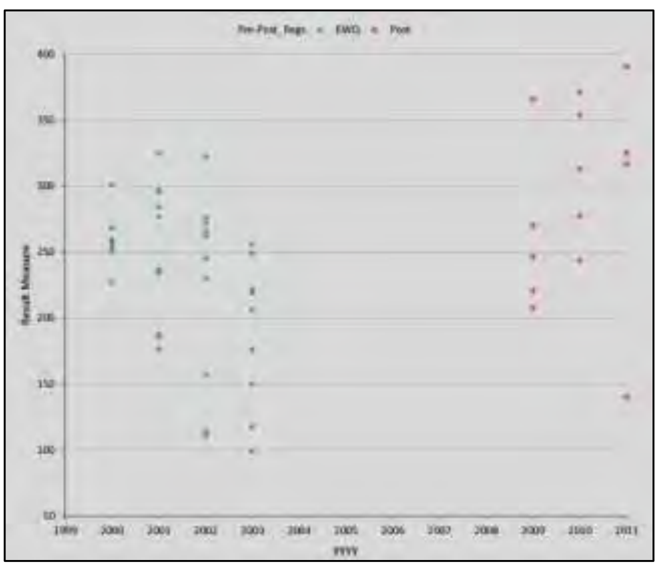
Chapter 10: 1616 BCP Tinicum Creek, PA

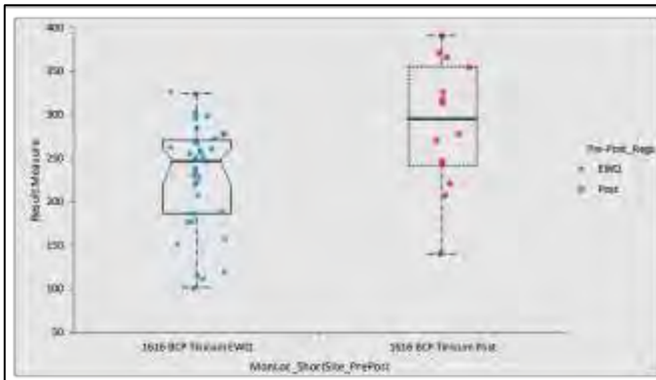
Specific Conductance µmho/cm

Existing Water Quality (Table 2Q):

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

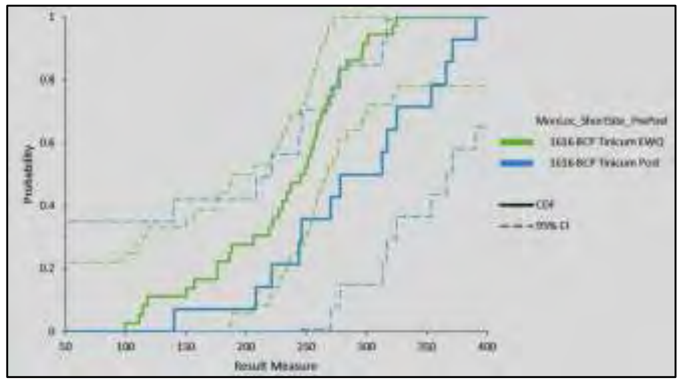






N 50

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



Kruskal-Wallis test

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

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

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

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

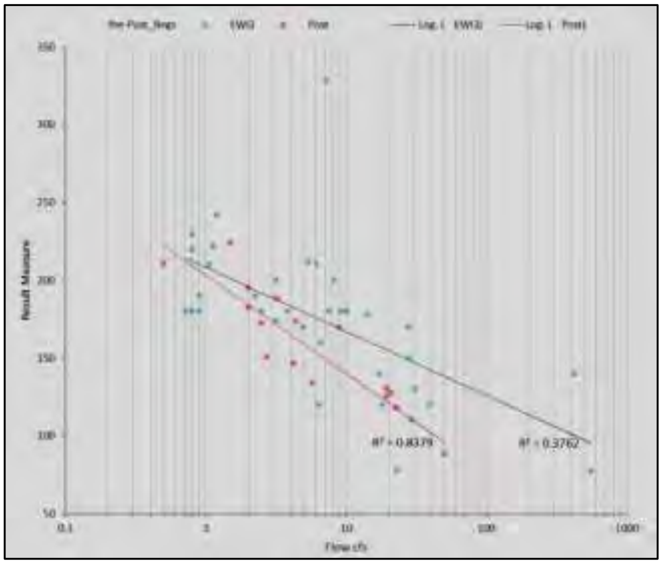
The rise in specific conductance may be partially attributable to the concurrent rise in chloride concentrations. Median specific conductance has risen from 247 to 296 µmhos/cm, a 20% increase.

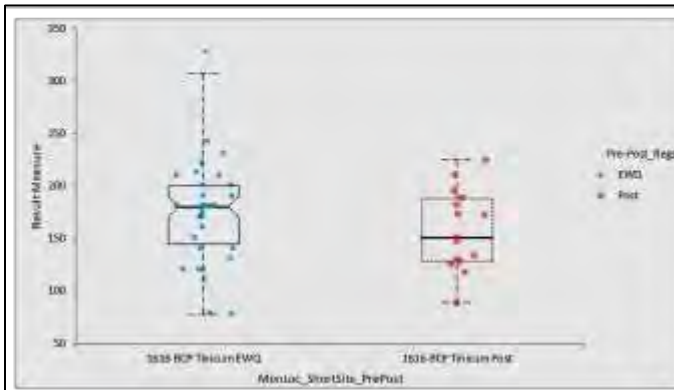
Chapter 10: 1616 BCP Tinicum Creek, PA

Total Dissolved Solids (TDS) mg/l

Existing Water Quality (Table 2Q):

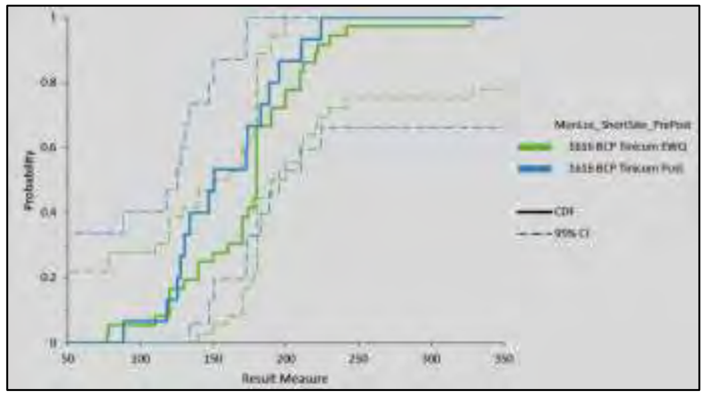
Median 180 mg/l
Lower 95% Confidence Interval 170 mg/l
Upper 95% Confidence Interval 190 mg/l
Defined in regulations as a flow-related parameter

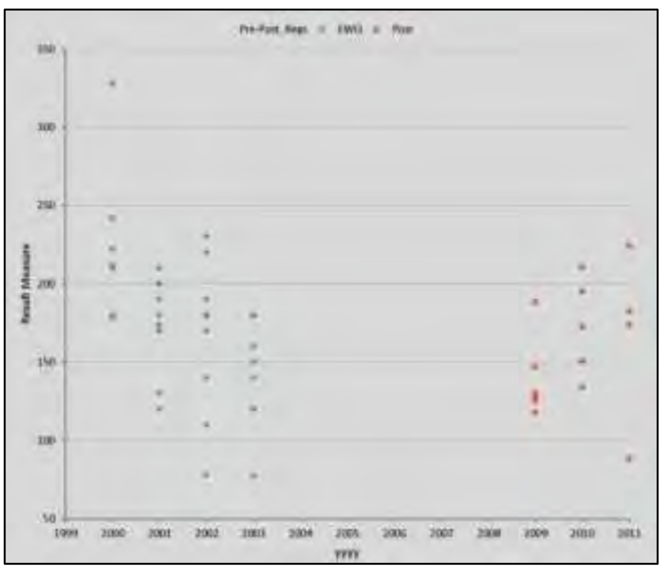




N 51

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





Kruskal-Wallis test

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

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

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

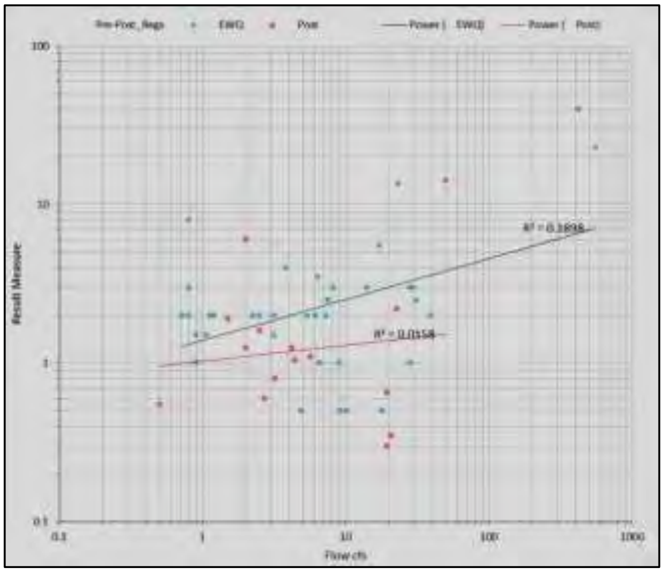
No water quality degradation is evident here. TDS apparently declined between the EWQ and post-EWQ periods, but not significantly. Conclusions are uncertain because of potential laboratory artifacts. TDS is inversely related to flow in both data sets. Post-EWQ median TDS fell below the EWQ lower 95%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

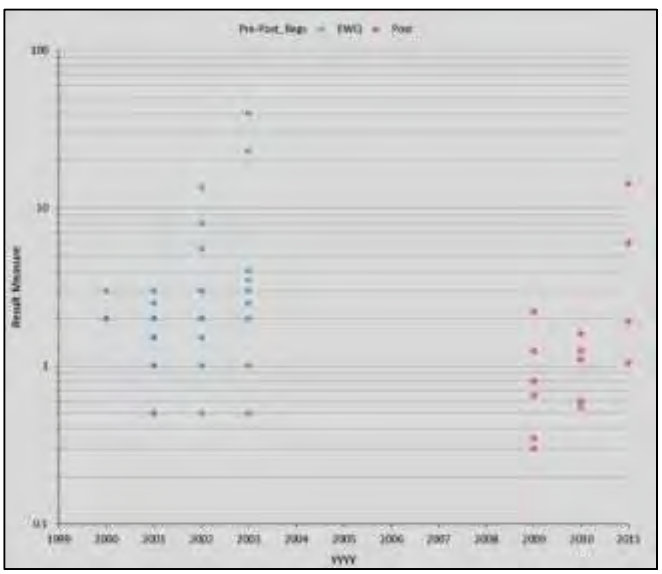
Chapter 10: 1616 BCP Tinicum Creek, PA

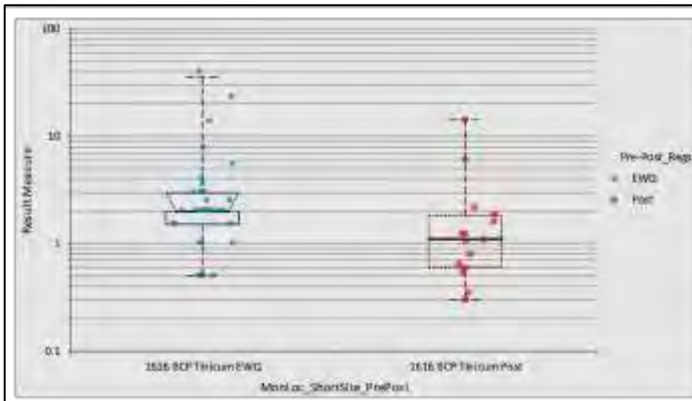
Total Suspended Solids (TSS) mg/l

Existing Water Quality (Table 2Q):

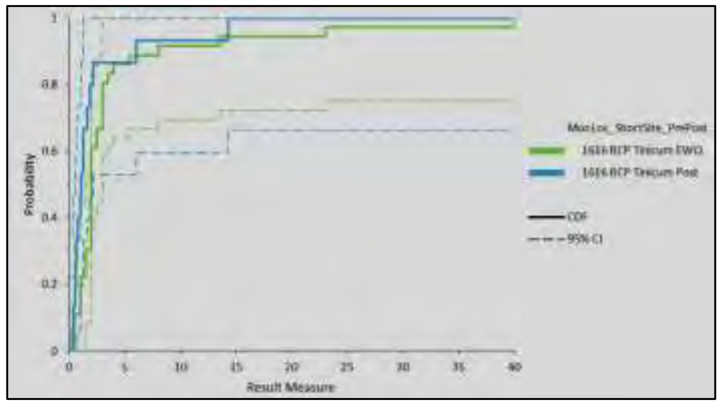
Median 2.0 mg/l
Lower 95% Confidence Interval 1.0 mg/l
Upper 95% Confidence Interval 3.0 mg/l







N	51					
Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1616 BCP Tinicum EWQ	0.5	1.5	2.0	3.0	40.0	1.5
1616 BCP Tinicum Post	0.3	0.6	1.1	1.8	14.3	1.2



Kruskal-Wallis test

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

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

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

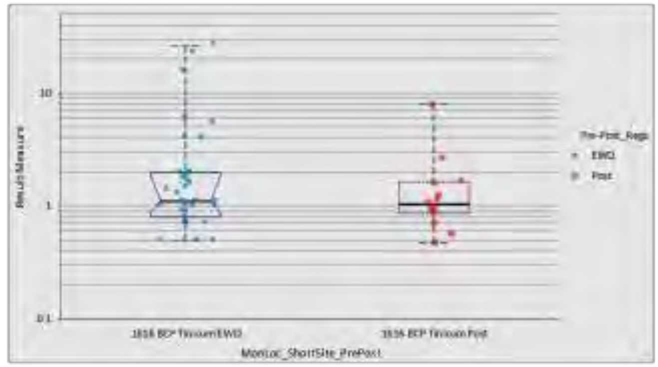
No water quality degradation is evident here. TSS apparently declined between the EWQ and post-EWQ periods. Sources of uncertainty included potential laboratory artifacts and insufficient post-EWQ sampling (n=15). TSS is unrelated to flow in both data sets, mainly because it is unsafe to sample Tinicum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

Chapter 10: 1616 BCP Tinicum Creek, PA

Turbidity NTU

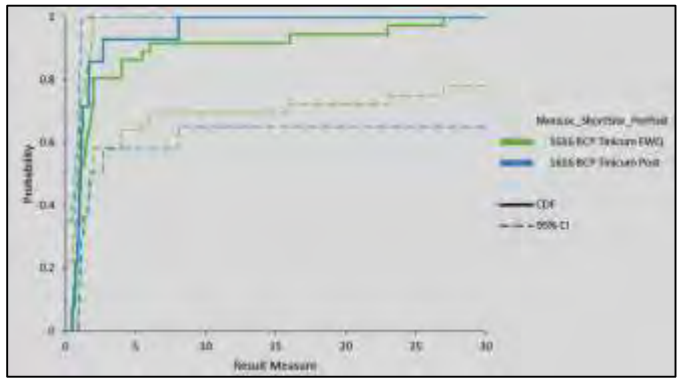
Existing Water Quality (Table 2Q):

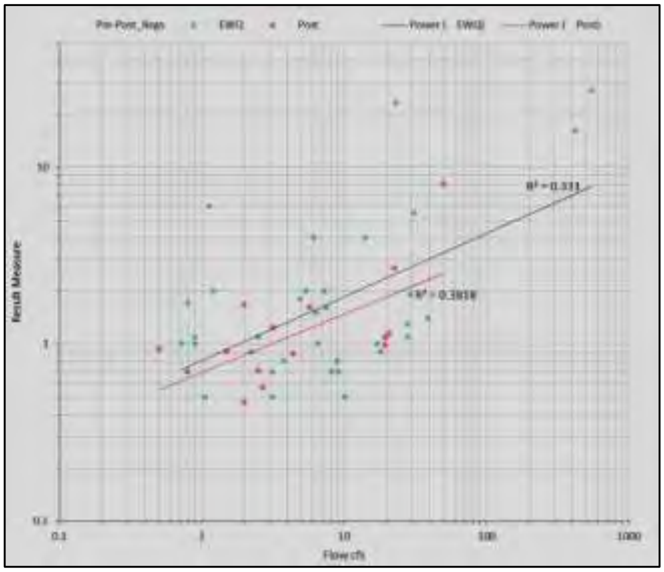
Median 1.1 NTU
Lower 95% Confidence Interval 0.9 NTU
Upper 95% Confidence Interval 1.8 NTU
Defined in regulations as a flow-related parameter

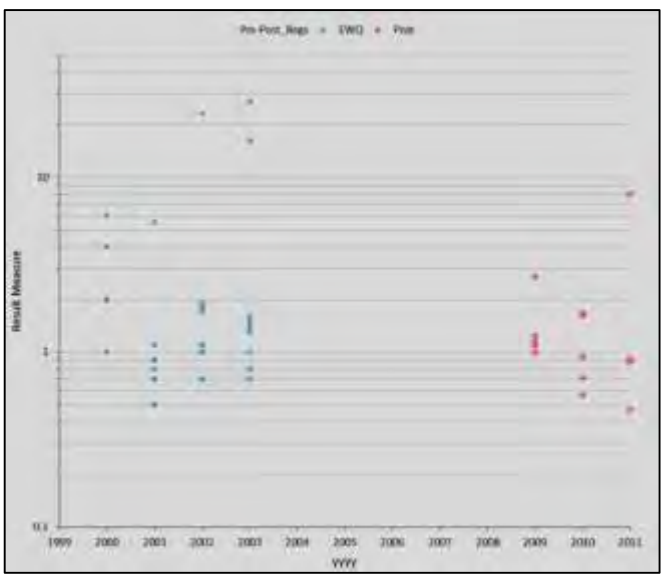


N | 50

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







Kruskal-Wallis test

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

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

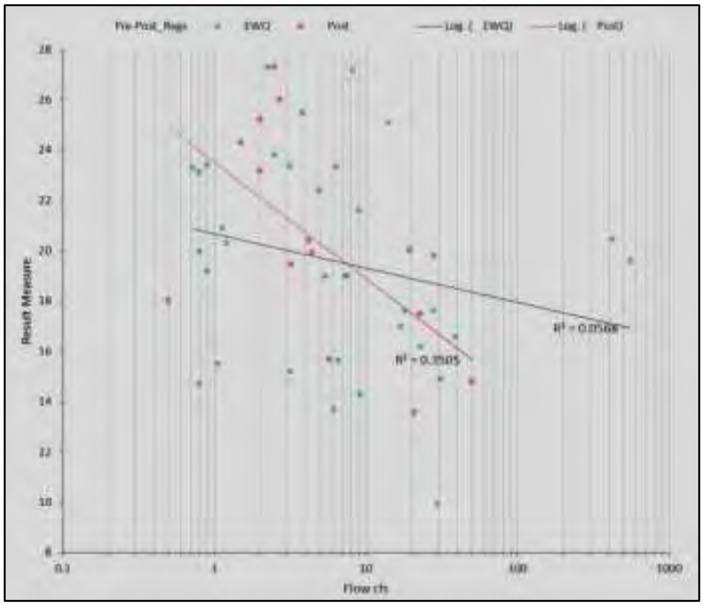
H0: $\theta_1 = \theta_2 = \theta ...$
The median of the populations are all equal.
H1: $\theta_i \neq \theta_j$ for at least one i,j
The median of the populations are not all equal.
[1] Do not reject the null hypothesis at the 5% significance level.

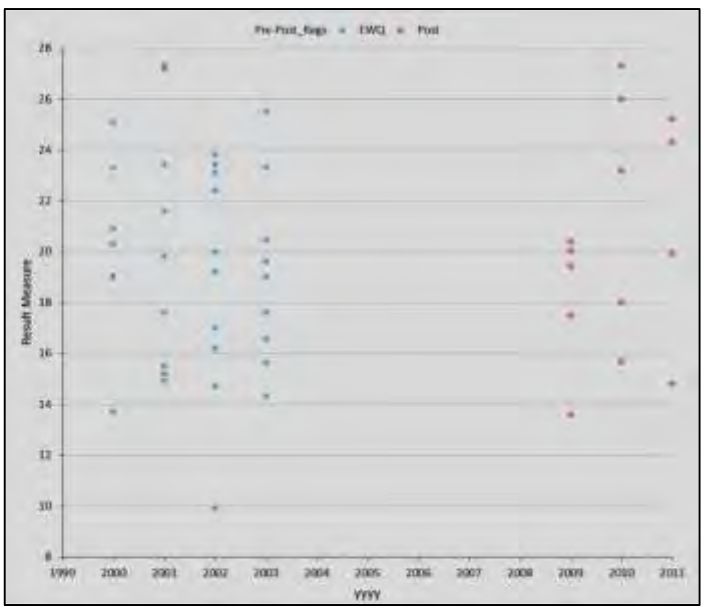
No water quality degradation is evident here. Turbidity did not measurably change between the EWQ and post-EWQ periods. Analytical uncertainty was introduced by insufficient post-EWQ sampling (n=14). Post-EWQ median turbidity fell within the EWQ 95% confidence intervals. Turbidity is related to flow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

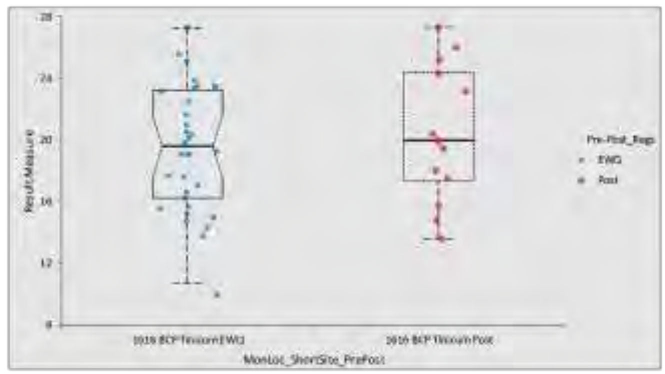
Chapter 10: 1616 BCP Tinicum Creek, PA

Water Temperature, degrees C

Not included in DRBC Existing Water Quality rules

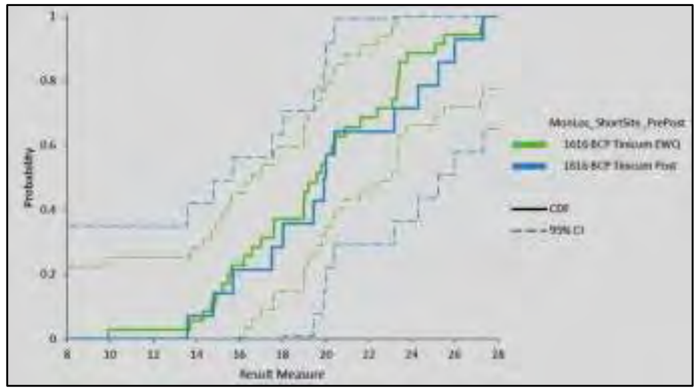






N | 49

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



Kruskal-Wallis test

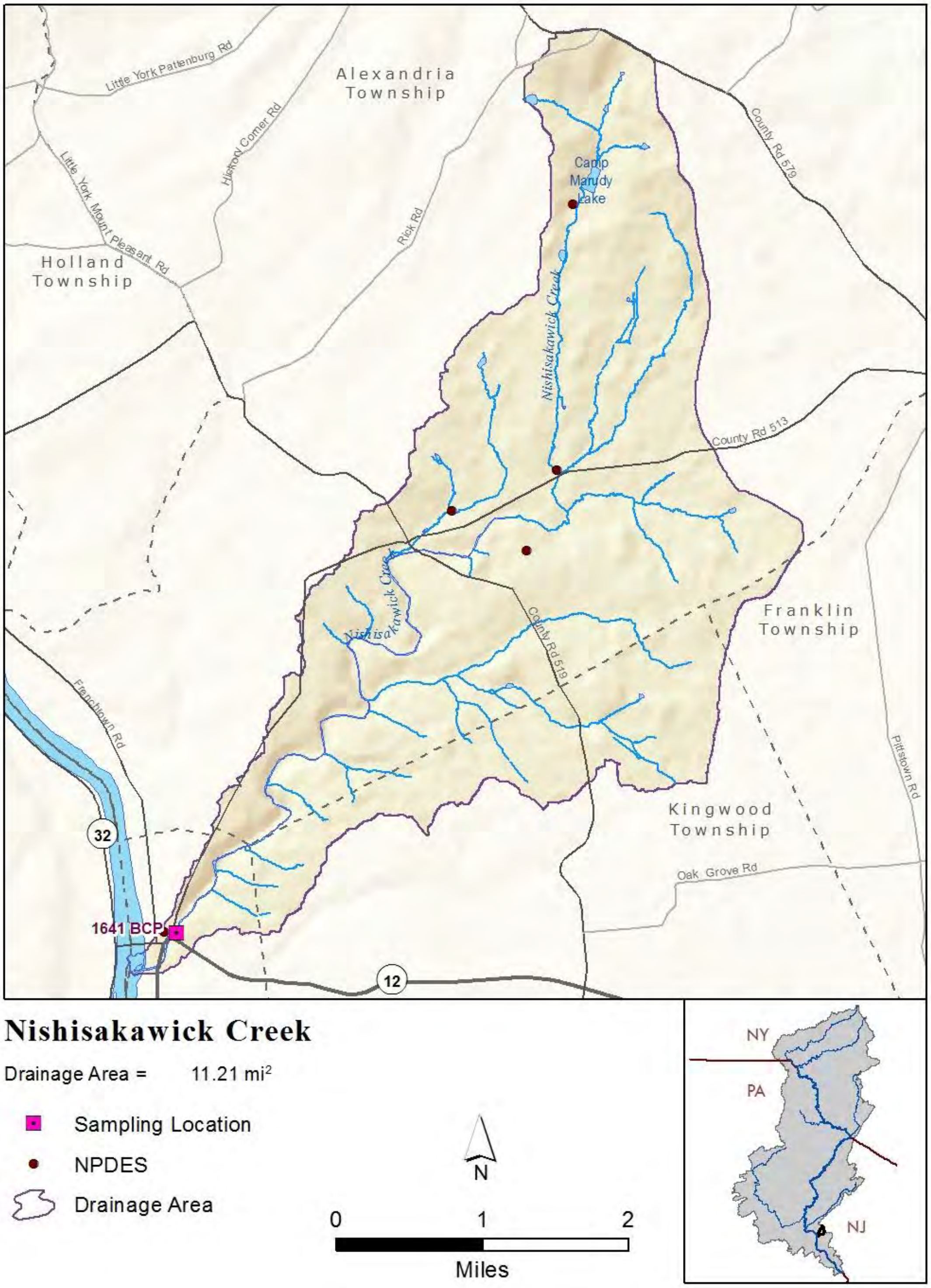
Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1616 BCP Tinicum EWQ	35	19.3	0.55
1616 BCP Tinicum Post	14	48.3	3.45

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

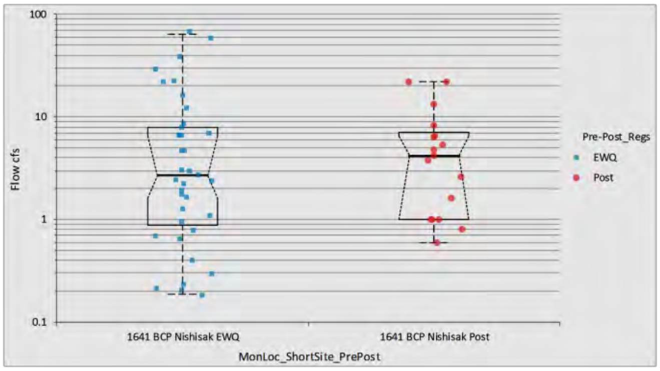
H0: $\theta_1 = \theta_2 = \theta$...
The median of the populations are all equal.
H1: $\theta_i \neq \theta_j$ for at least one i,j
The median of the populations are not all equal.
[1] Do not reject the null hypothesis at the 5% significance level.

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

Chapter 11: 1641 BCP Nishisakawick Creek, Hunterdon County, NJ



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



N | 54

Flow cfs by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1641 BCP Nishisak EWQ	0.18	0.883	2.680	7.987	66.43	7.103
1641 BCP Nishisak Post	0.60	1.000	4.200	7.100	22.07	6.100

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

Kruskal-Wallis test

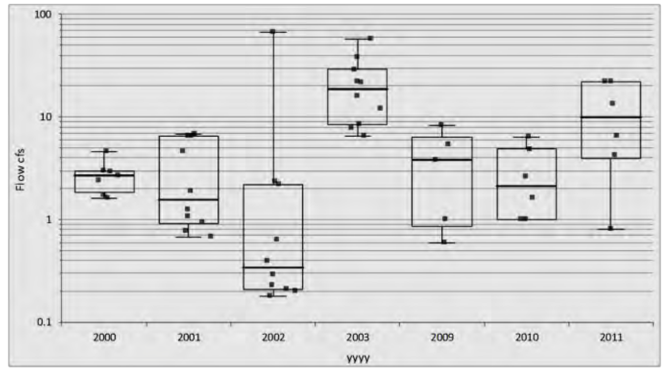
Flow cfs by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1641 BCP Nishisak EWQ	37	10.3	0.28
1641 BCP Nishisak Post	17	22.4	1.32

H statistic	0.13
X^2 approximation	0.13
DF	1
p-value	0.7164 [1]

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

The 11.2 square mile Nishisakawick Creek watershed is about 30% forested and contains about 2.8% urban land cover. There is no underlying carbonate bedrock in the watershed, so water quality is expected to be typical of a Piedmont stream with some agricultural influences.

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



N | 54

Flow cfs by yyyy	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
2000	1.62	1.847	2.680	2.973	4.63	1.127
2001	0.67	0.926	1.570	6.510	6.76	5.584
2002	0.18	0.209	0.340	2.204	66.43	1.995
2003	6.46	8.366	18.690	29.400	57.65	21.034
2009	0.60	0.867	3.800	6.367	8.30	5.500
2010	1.00	1.000	2.100	4.933	6.40	3.933
2011	0.80	3.917	9.950	22.070	22.07	18.153

Annual May to September flow statistics associated with water quality measurements are plotted above. Flow is plotted on logarithmic scale. These are flow measurements or sometimes estimates associated with the time of each water quality sample. Mean annual flow is about 16.7 cfs; and harmonic mean flow is about 4.53 cfs (USGS StreamStats retrieval February 2014) which is more typical of summer flow conditions. Though DRBC sampled a wide range of flows, these data sets appear most representative of low to low-normal flow conditions except for high-flow years of 2003 and 2011. Flows corresponding to each water quality sample were estimated using either a gage-discharge rating constructed by DRBC or a Delaware River Basin adaptation of the USGS BaSE*program. There was an excellent correspondence between sample flows determined by the DRBC gage and BaSE-derived estimates, so DRBC intends to use the BaSE program for future flow estimates. DRBC's gages have too often been disrupted by storms, and maintaining a gage at DRBC's monitoring site is not economically viable. DRBC continues to use bridge benchmark readings to relate and check with BaSE estimates.

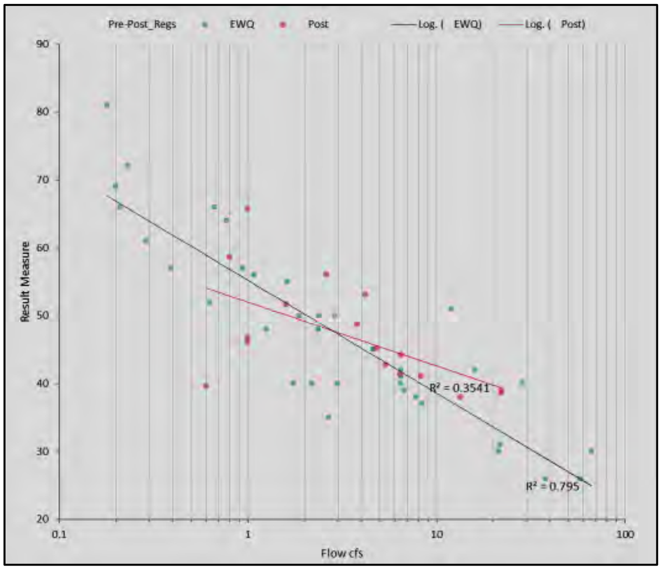
*Stuckey, M.H., Koerkle, E.H., and Ulrich, J.E., 2012, Estimation of baseline daily mean streamflows for ungaged locations on Pennsylvania streams, water years 1960–2008: U.S. Geological Survey Scientific Investigations Report 2012–5142, 61 p.)

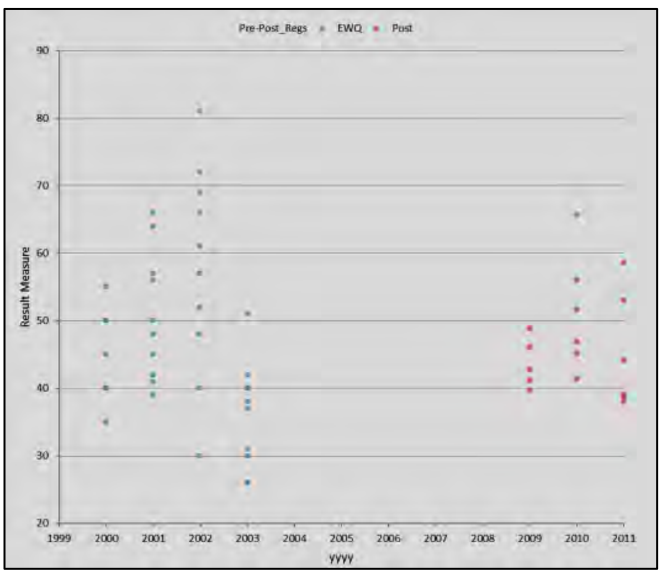
Chapter 11: 1641 BCP Nishisakawick Creek, NJ

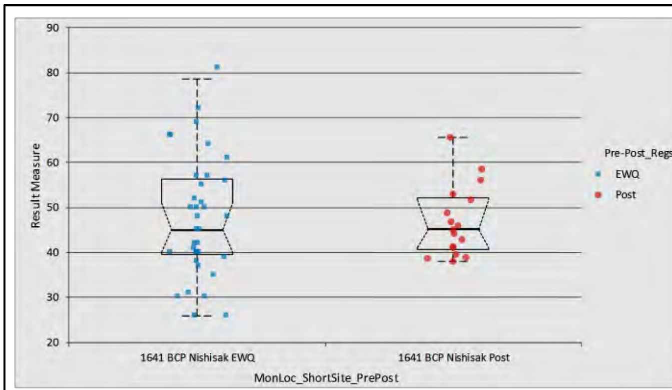
Alkalinity as CaCO3, Total mg/l

Existing Water Quality (Table 2P):

Median 45 mg/l
Lower 95% Confidence Interval 40 mg/l
Upper 95% Confidence Interval 51 mg/l
Defined in regulations as a flow-related parameter

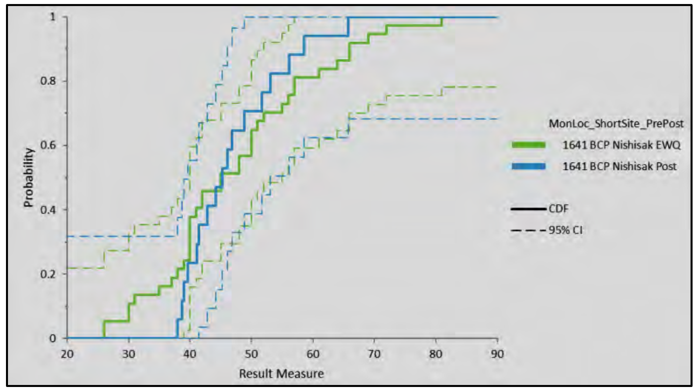






N | 54

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1641 BCP Nishisak EWQ	26.0	39.67	45.00	56.33	81.0	16.67
1641 BCP Nishisak Post	38.0	40.63	45.20	52.17	65.7	11.53



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1641 BCP Nishisak EWQ	37	0.1	0.00
1641 BCP Nishisak Post	17	0.1	0.01

H statistic	0.00
X^2 approximation	0.00
DF	1
p-value	0.9777 [1]

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

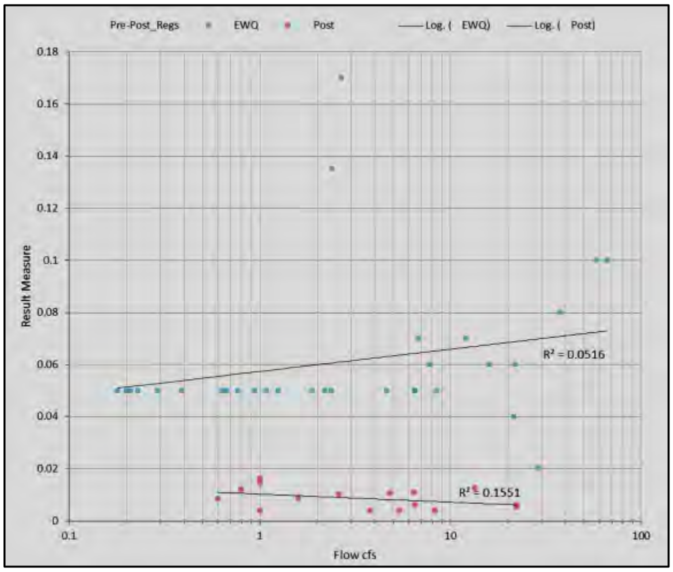
No water quality degradation is evident here. Alkalinity did not measurably change between the EWQ and post-EWQ periods. Sources of analytical uncertainty included potential laboratory artifacts and insufficient post-EWQ sampling (n=17). Alkalinity is inversely related to flow in both data sets. Post-EWQ median alkalinity fell within EWQ 95% confidence intervals. Flow is plotted on logarithmic scale.

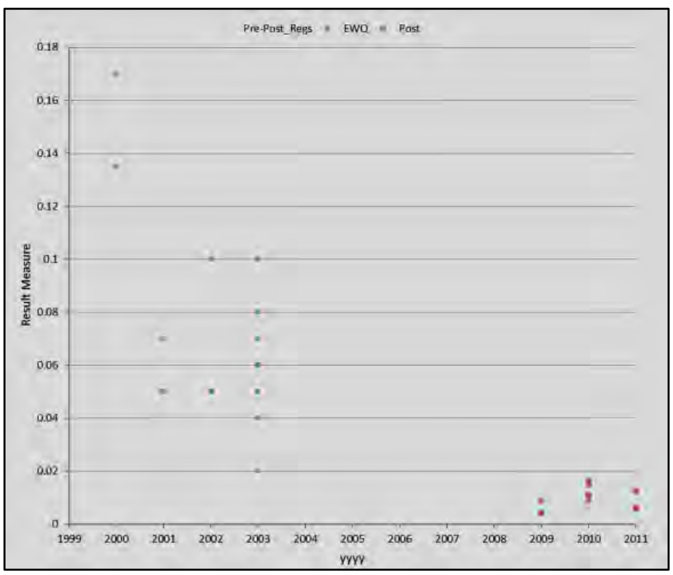
Chapter 11: 1641 BCP Nishisakawick Creek, NJ

Ammonia Nitrogen as N, Total mg/l

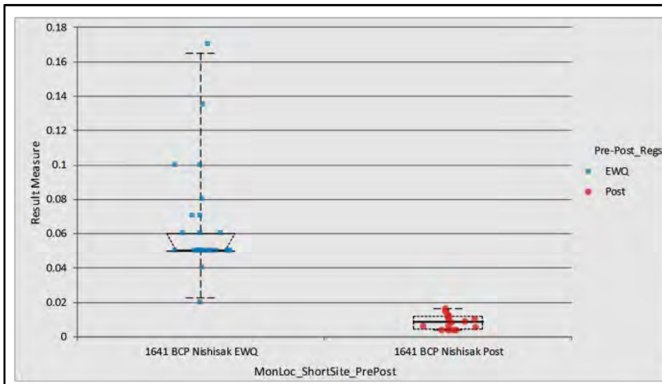
Existing Water Quality (Table 2P):

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

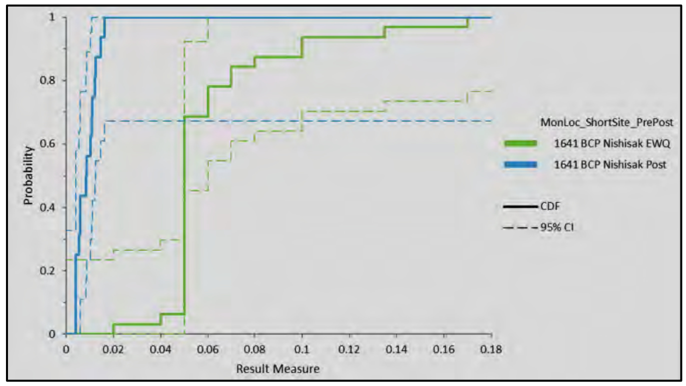




No water quality degradation is evident here. Ammonia concentrations apparently declined. However, different detection limits, potential laboratory artifacts, insufficient post-EWQ sampling frequency, and under-representation of the post-EWQ flow conditions introduced analytical uncertainty. Post-EWQ median ammonia concentration was below the EWQ lower 95% confidence interval.



N	48					
Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1641 BCP Nishisak EWQ	0.020	0.050	0.050	0.060	0.170	0.010
1641 BCP Nishisak Post	0.004	0.005	0.009	0.012	0.016	0.007



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1641 BCP Nishisak EWQ	32	2048.0	64.00
1641 BCP Nishisak Post	16	4096.0	256.00

H statistic	33.82
X^2 approximation	33.82
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.

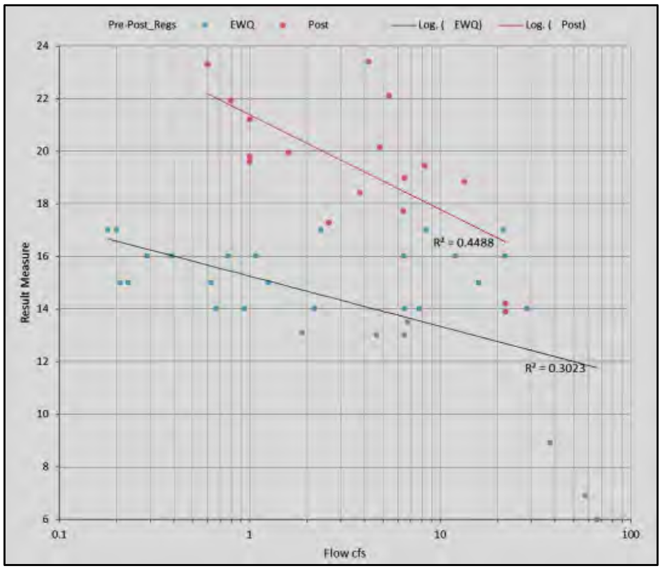
EWQ data possessed numerous non-detect results (22 of 32 samples) that interfered with calculation of the median. Thus EWQ was established as <0.05 mg/l, the detection limit at the time. Under 2009-2011 lower detection levels there still were 6/16 undetected results. So DRBC post-EWQ results show actual concentrations. Some water quality improvement possibly took place, as the post-EWQ data contained no concentrations greater than 0.016 mg/l. Flow is plotted on logarithmic scale. Too few independent data were available to validate results.

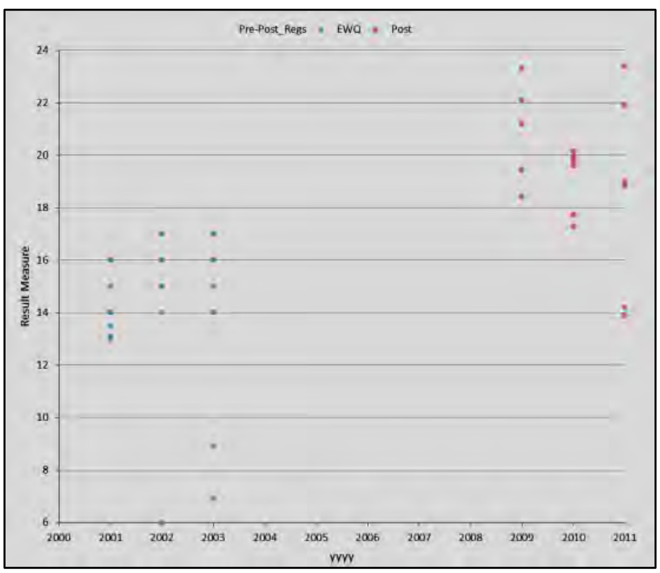
Chapter 11: 1641 BCP Nishisakawick Creek, NJ

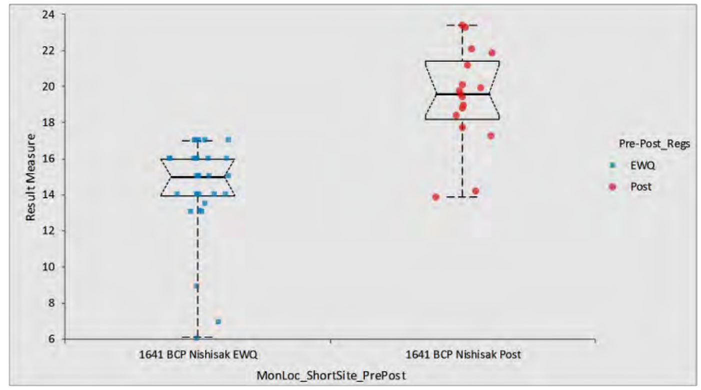
Chloride, Total mg/l

Existing Water Quality (Table 2P):

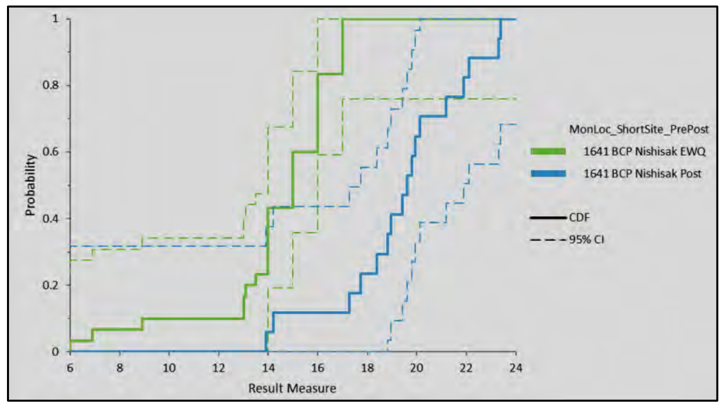
Median 15 mg/l
Lower 95% Confidence Interval 14 mg/l
Upper 95% Confidence Interval 16 mg/l







N	47					
Result Measure by MonLoc_ShortSite_PrePost	**Minimum**	**1st Quartile**	**Median**	**3rd Quartile**	**Maximum**	**Inter-quartile range**
1641 BCP Nishisak EWQ	6.0	14.0	15.0	16.0	17.0	2.0
1641 BCP Nishisak Post	13.9	18.2	19.6	21.4	23.4	3.3



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1641 BCP Nishisak EWQ	30	1540.8	51.36
1641 BCP Nishisak Post	17	2719.1	159.95

H statistic	22.83
X^2 approximation	22.83
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.

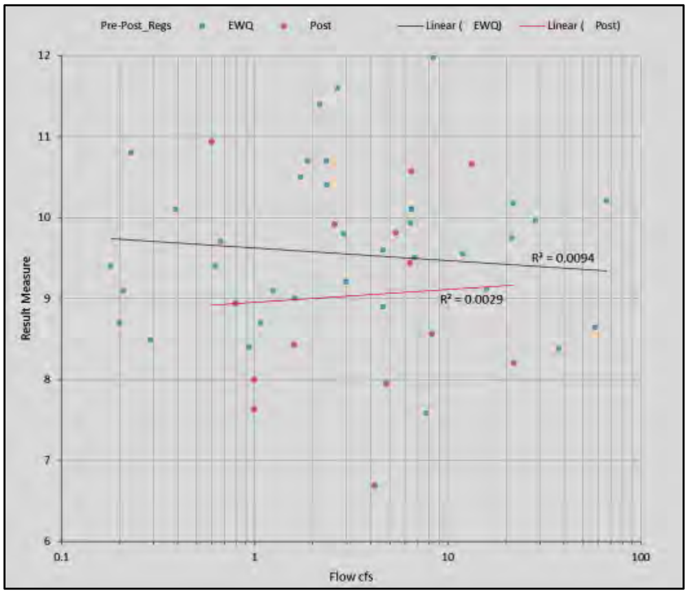
Water quality degradation is evident here. Chloride concentrations measurably rose between the two periods. Potential laboratory artifacts and insufficient post-EWQ sampling introduced analytical uncertainty. Post-EWQ median concentration rose above the EWQ upper 95% confidence interval. Flow is plotted on logarithmic scale.

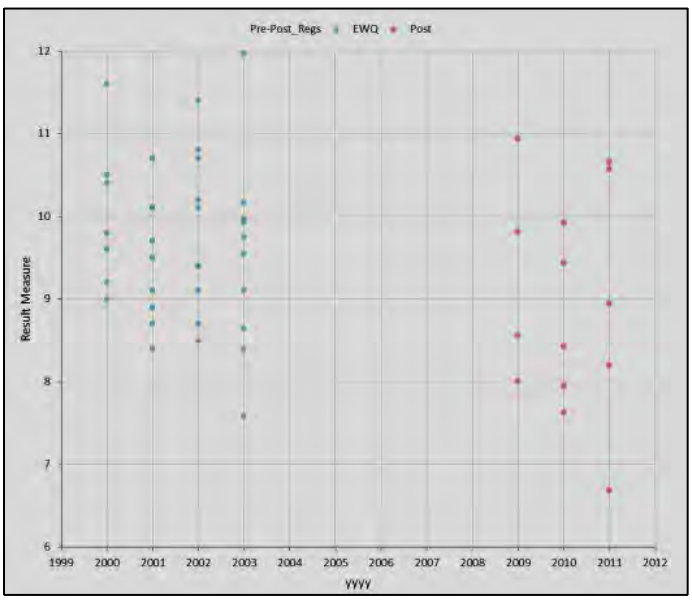
Chapter 11: 1641 BCP Nishisakawick Creek, NJ

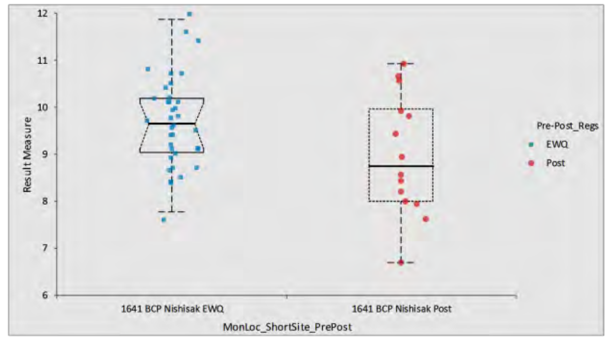
Dissolved Oxygen (DO) mg/l

Existing Water Quality (Table 2P):

Median 9.65 mg/l
Lower 95% Confidence Interval 9.11 mg/l
Upper 95% Confidence Interval 10.10 mg/l

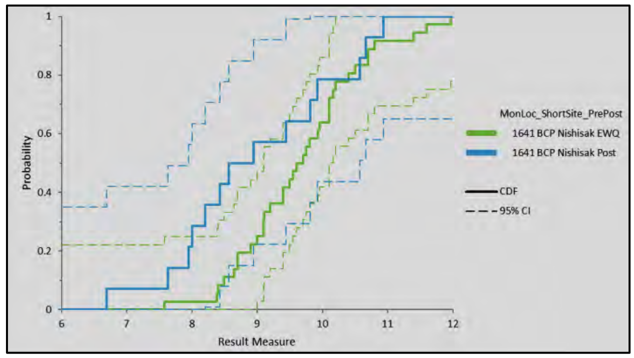






N 50

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1641 BCP Nishisak EWQ	7.58	9.04	9.65	10.19	11.97	1.15
1641 BCP Nishisak Post	6.69	8.00	8.75	9.97	10.94	1.98



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1641 BCP Nishisak EWQ	36	191.4	5.32
1641 BCP Nishisak Post	14	492.1	35.15

H statistic	3.22
X² approximation	3.22
DF	1
p-value	0.0729 [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.

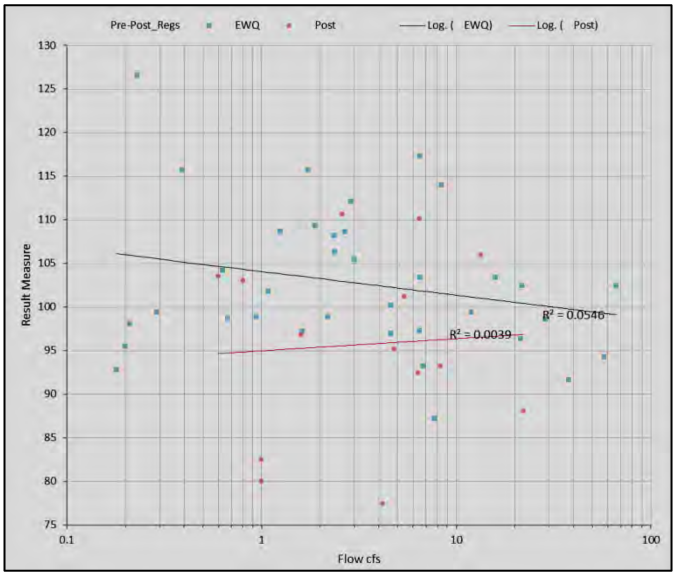
Slight evidence of water quality degradation is indicated. No measurable change took place between the EWQ and Post-EWQ periods. Post-EWQ median DO concentration fell below the EWQ 95% lower confidence interval, but the difference insignificant due to insufficient post-EWQ data (n=14). Flow is plotted on a logarithmic scale. DO concentration is unrelated to flow in both data sets.

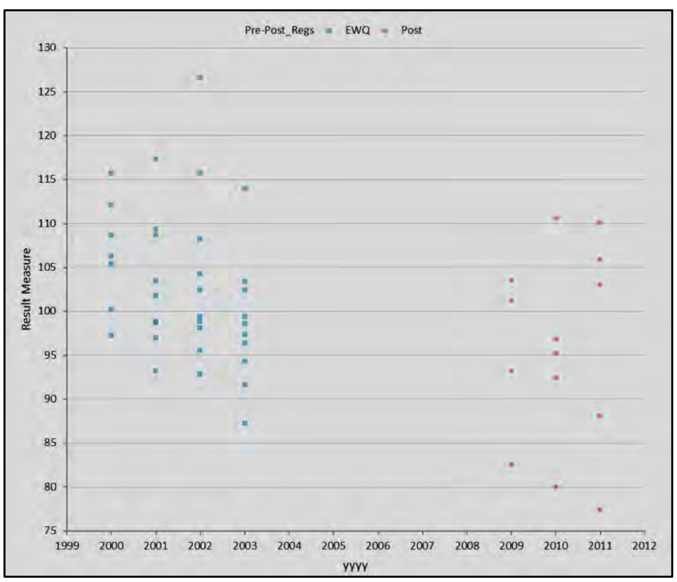
Chapter 11: 1641 BCP Nishisakawick Creek, NJ

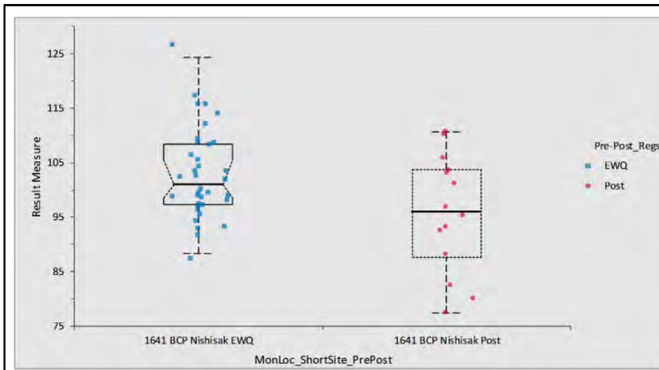
Dissolved Oxygen Saturation %

Existing Water Quality (Table 2P):

Median 101%
Lower 95% Confidence Interval 99%
Upper 95% Confidence Interval 105%

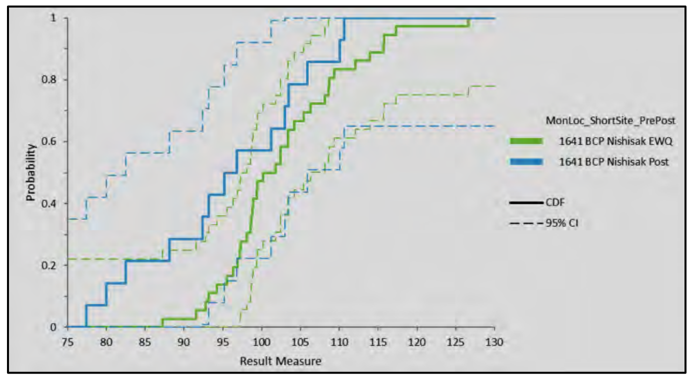






N 50

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1641 BCP Nishisak EWQ	87.2	97.2	101.0	108.4	126.6	11.2
1641 BCP Nishisak Post	77.4	87.6	96.0	103.7	110.6	16.1



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1641 BCP Nishisak EWQ	36	205.4	5.71
1641 BCP Nishisak Post	14	528.3	37.73

H statistic	3.45
X^2 approximation	3.45
DF	1
p-value	0.0631[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.

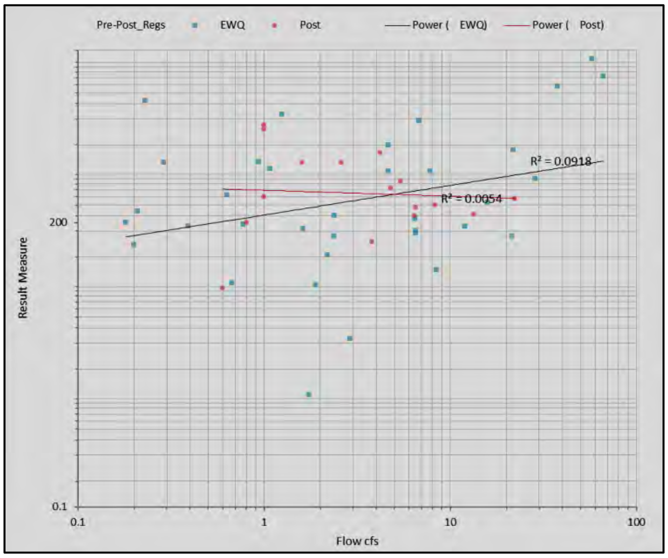
Some evidence of water quality degradation is indicated. Dissolved Oxygen Saturation is unrelated to flow, and did not measurably change between the EWQ and post-EWQ periods. Post-EWQ median DO saturation fell below the lower EWQ 95% confidence interval, though the difference was insignificant due to insufficient post-EWQ data (n=14). Post-EWQ data contain four values of DO saturation below 90%, where EWQ data contained one value below 90%. There may be a source of oxygen demand in the watershed that did not previously exist.

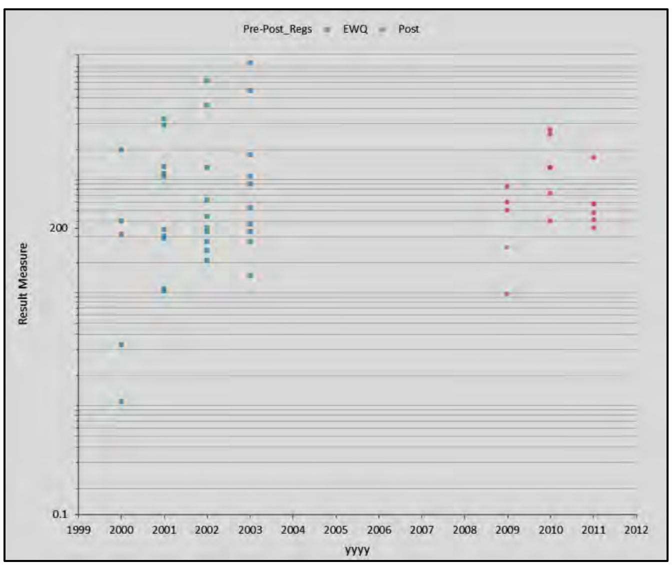
Chapter 11: 1641 BCP Nishisakawick Creek, NJ

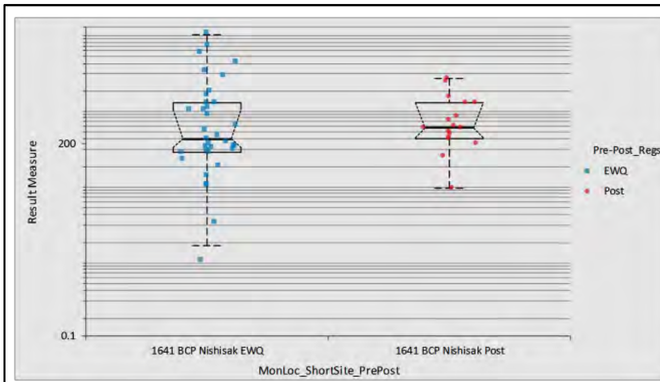
Enterococcus colonies/100 ml

Existing Water Quality (Table 2P):

Median 240/100 ml
Lower 95% Confidence Interval 170/100 ml
Upper 95% Confidence Interval 790/100 ml

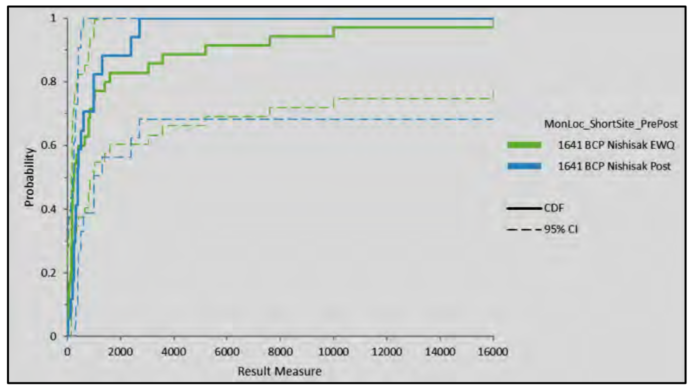






N | 52

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1641 BCP Nishisak EWQ	2	142	240	1,008	16,000	866
1641 BCP Nishisak Post	35	247	380	1,000	2,700	753



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1641 BCP Nishisak EWQ	35	42.4	1.21
1641 BCP Nishisak Post	17	87.2	5.13

H statistic	0.56
X² approximation	0.56
DF	1
p-value	0.4525 [1]

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

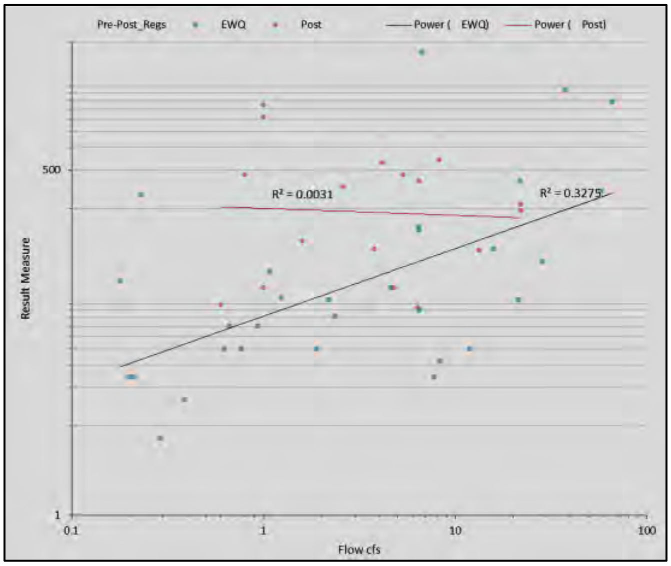
No water quality degradation is evident here. Enterococci apparently did not measurably change between the EWQ and Post-EWQ periods. Potential laboratory artifacts and insufficient post-EWQ sampling introduced analytical uncertainty. Enterococcus concentrations are unrelated to flow in both data sets. Note that concentrations and flows are plotted on a logarithmic scale. Post-EWQ median enterococcus concentrations were within the EWQ 95% confidence intervals.

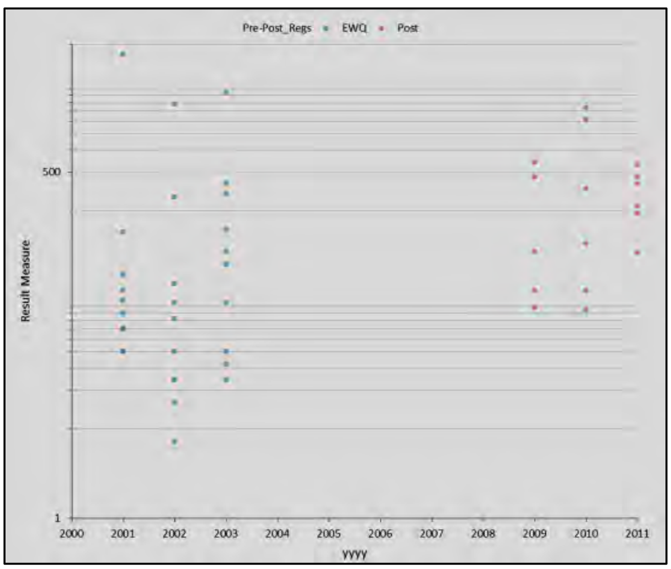
Chapter 11: 1641 BCP Nishisakawick Creek, NJ

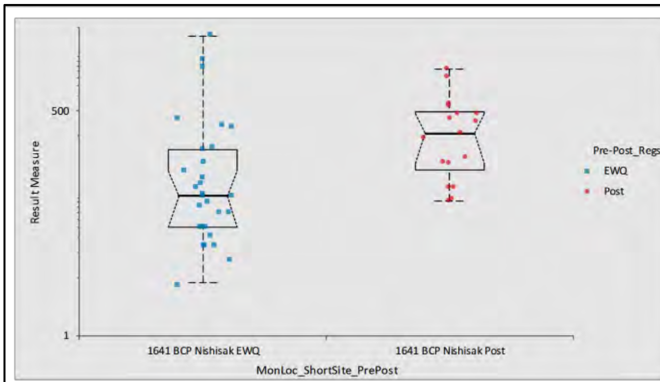
Escherichia coli colonies/100 ml

Existing Water Quality (Table 2P):

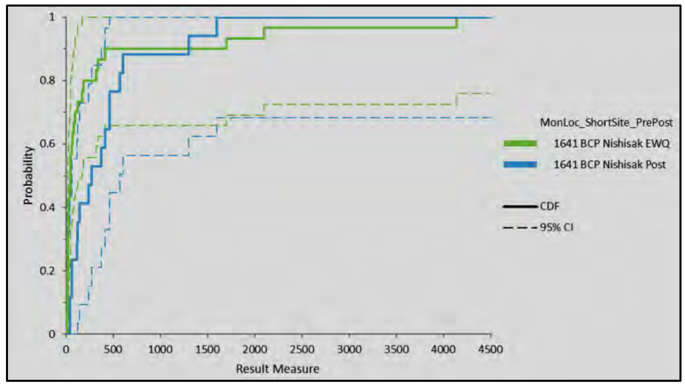
Median 48/100 ml
Lower 95% Confidence Interval 20/100 ml
Upper 95% Confidence Interval 96/100 ml
Defined in regulations as a flow-related parameter







N	47					
Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1641 BCP Nishisak EWQ	4	20	48	171	4140	151
1641 BCP Nishisak Post	42	99	270	497	1600	398



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1641 BCP Nishisak EWQ	30	607.5	20.25
1641 BCP Nishisak Post	17	1072.1	63.06

H statistic	8.95
X^2 approximation	8.95
DF	1
p-value	0.0028[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.

Evidence of water quality degradation is indicated. E. coli concentrations apparently increased between the EWQ and Post-EWQ periods. Post-EWQ median E. coli rose above the EWQ upper 95% confidence interval. Potential laboratory artifacts may introduce uncertainty into conclusions.

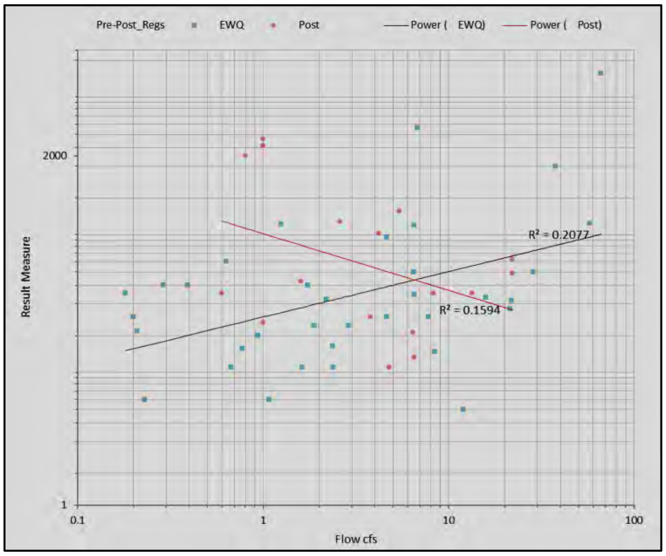
E. coli concentrations were positively but weakly related to flow in the EWQ data set, but unrelated to flow in the post-EWQ data set – possibly due to insufficient post-EWQ sampling frequency (n=17). No independent data were available at this site to validate DRBC's conclusion. The increase in E. coli concentrations may be related to the decline in dissolved oxygen saturation noted earlier if there is a source in the watershed.

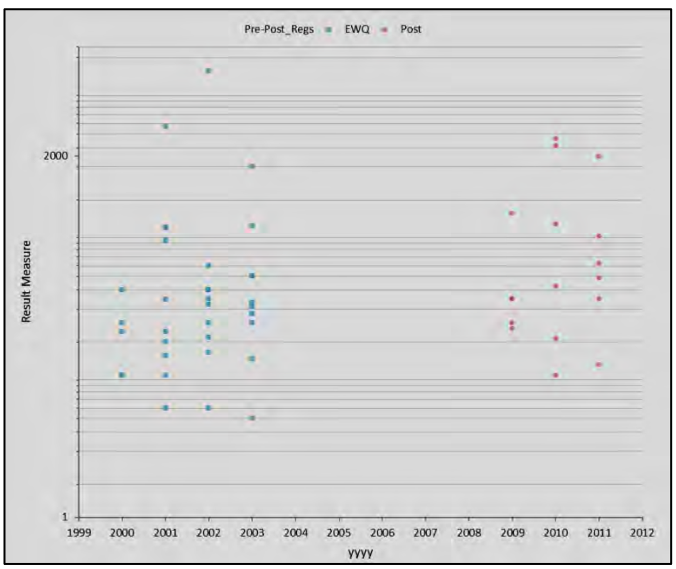
Chapter 11: 1641 BCP Nishisakawick Creek, NJ

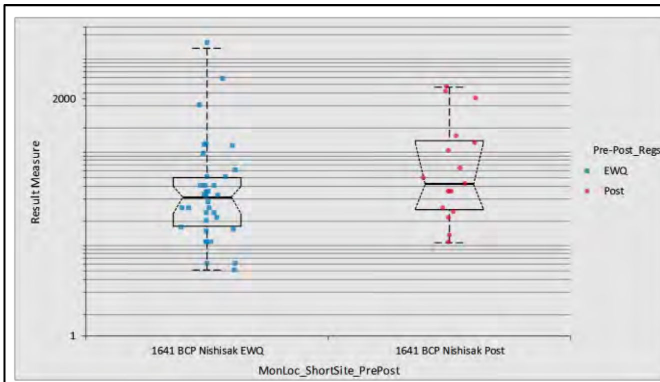
Fecal coliform colonies/100 ml

Existing Water Quality (Table 2P):

Median 85/100 ml
Lower 95% Confidence Interval 50/100 ml
Upper 95% Confidence Interval 120/100 ml

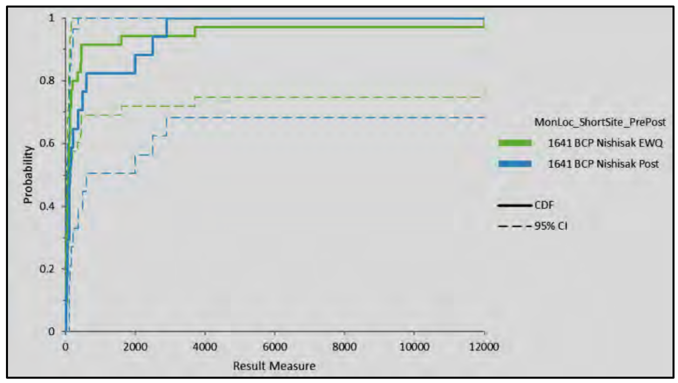






N 52

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1641 BCP Nishisak EWQ	8	33	85	160	12000	127
1641 BCP Nishisak Post	20	58	130	520	2900	462



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1641 BCP Nishisak EWQ	35	206.4	5.90
1641 BCP Nishisak Post	17	425.0	25.00

H statistic	2.75
X^2 approximation	2.75
DF	1
p-value	0.0970[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.

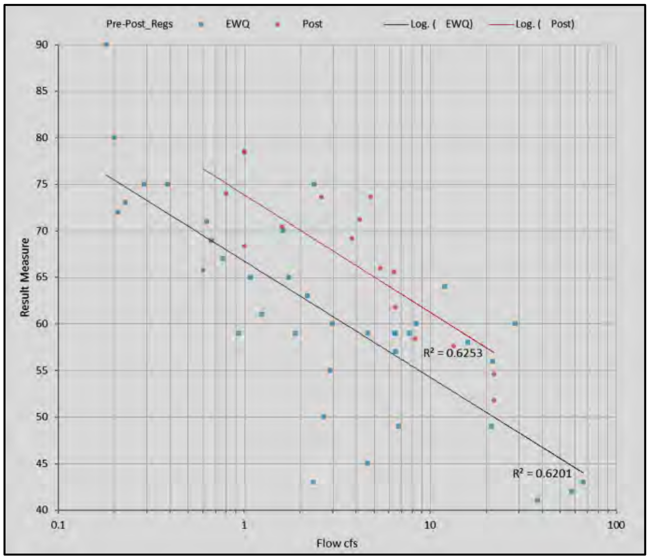
No water quality degradation is evident here. Fecal coliform concentrations apparently did not measurably change between the EWQ and post-EWQ periods. Potential laboratory artifacts and insufficient post-EWQ sampling introduced analytical uncertainty. Fecal coliform concentrations are unrelated to flow in both data sets. Post-EWQ median concentrations were within the EWQ 95% confidence intervals. Note that concentrations and flows are plotted on a logarithmic scale.

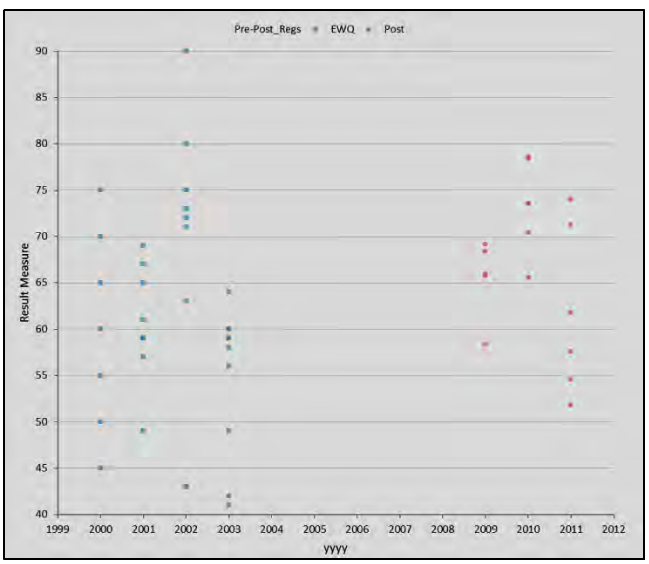
Chapter 11: 1641 BCP Nishisakawick Creek, NJ

Hardness as CaCO3, Total mg/l

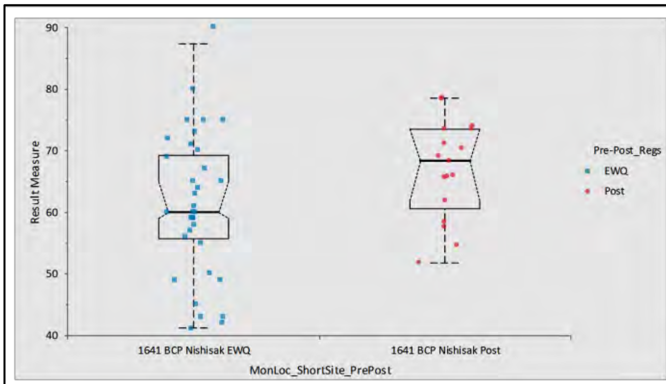
Existing Water Quality (Table 2P):

Median 60 mg/l
Lower 95% Confidence Interval 59 mg/l
Upper 95% Confidence Interval 65 mg/l
Defined in regulations as a flow-related parameter



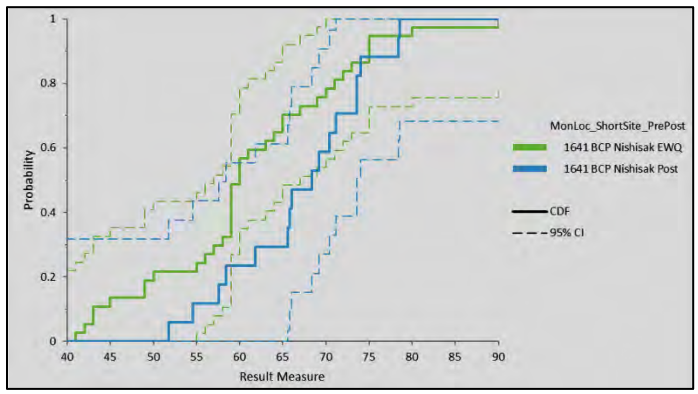


Weak evidence of water quality degradation is indicated. Hardness apparently did not measurably change between the EWQ and post-EWQ periods.



N 54

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1641 BCP Nishisak EWQ	41	56	60	69	90	14
1641 BCP Nishisak Post	52	61	68	74	79	13



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1641 BCP Nishisak EWQ	37	295.1	7.98
1641 BCP Nishisak Post	17	642.4	37.79

H statistic	3.79
X^2 approximation	3.79
DF	1
p-value	0.0514 [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.

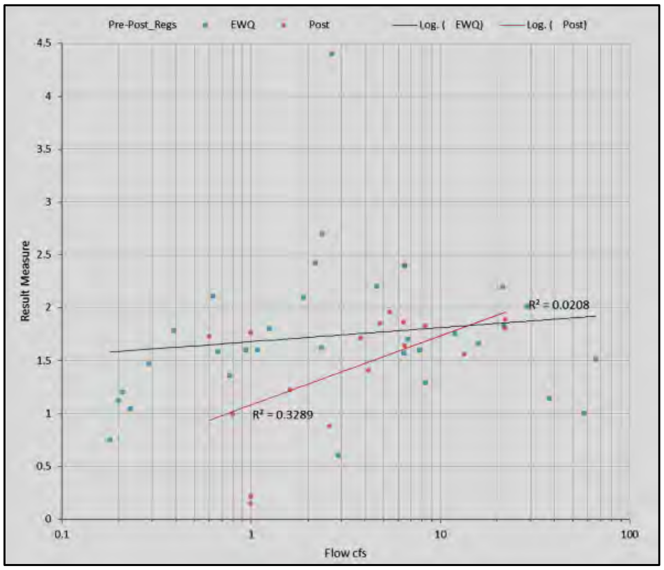
Potential laboratory artifacts and insufficient post-EWQ sampling introduced analytical uncertainty. Hardness is inversely related to flow in both data sets. Post-EWQ median hardness was above the EWQ upper 95% confidence interval, but the increase insignificant. As hardness is usually geologically sourced, the increase may be related to the flow conditions sampled unless there is an unknown new source in the watershed.

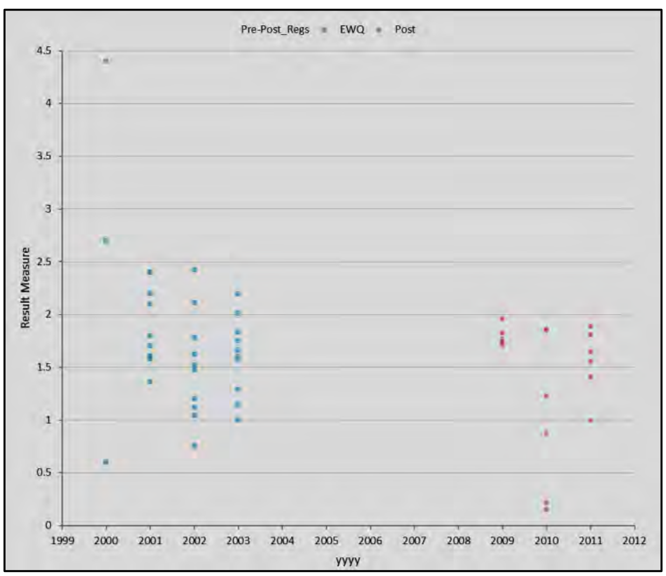
Chapter 11: 1641 BCP Nishisakawick Creek, NJ

Nitrate + Nitrite as N, Total mg/l

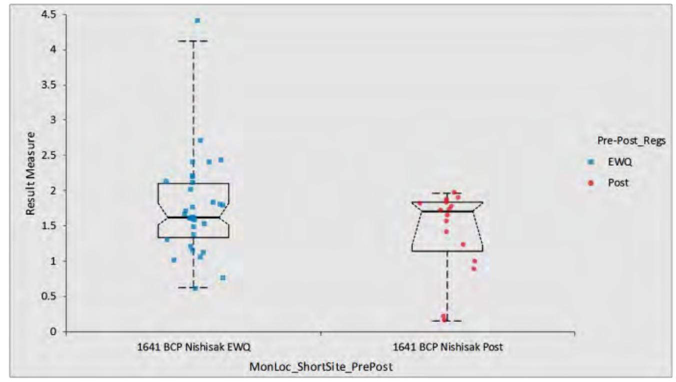
Existing Water Quality (Table 2P, as Nitrate only):

Median 1.62 mg/l
Lower 95% Confidence Interval 1.52 mg/l
Upper 95% Confidence Interval 1.83 mg/l



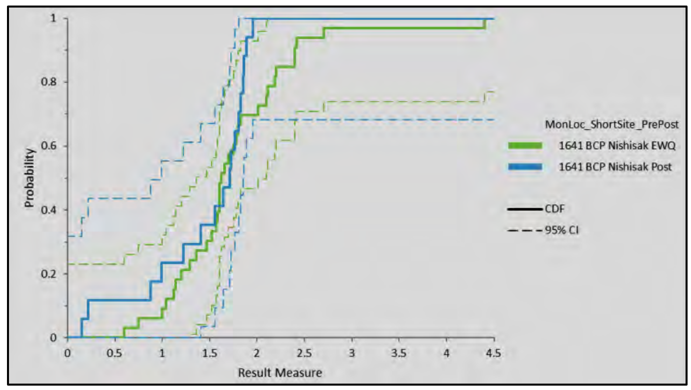


No water quality degradation is evident here. Nitrate concentrations did not measurably change between the EWQ and post-EWQ periods. Potential laboratory artifacts, insufficient post-EWQ sampling, and under-representation of post-EWQ flow conditions introduced analytical uncertainty.



N 50

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1641 BCP Nishisak EWQ	0.60	1.34	1.62	2.10	4.40	0.77
1641 BCP Nishisak Post	0.15	1.15	1.71	1.84	1.96	0.69



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1641 BCP Nishisak EWQ	33	44.9	1.36
1641 BCP Nishisak Post	17	87.2	5.13

H statistic	0.62
X² approximation	0.62
DF	1
p-value	0.4304 [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.

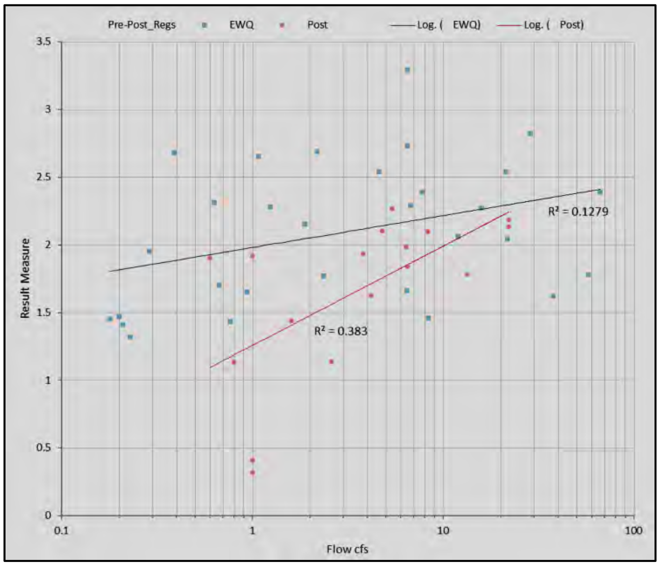
Nitrate is unrelated related to flow in the EWQ data set, but positively related to flow in the post-EWQ data set. Post-EWQ nitrate + nitrite concentrations were assumed equivalent for comparison with EWQ nitrate concentrations since EWQ nitrite concentrations were never detected. Independent data were not available for validation of DRBC data. 2001-2003 data were most comparable with post-EWQ data.

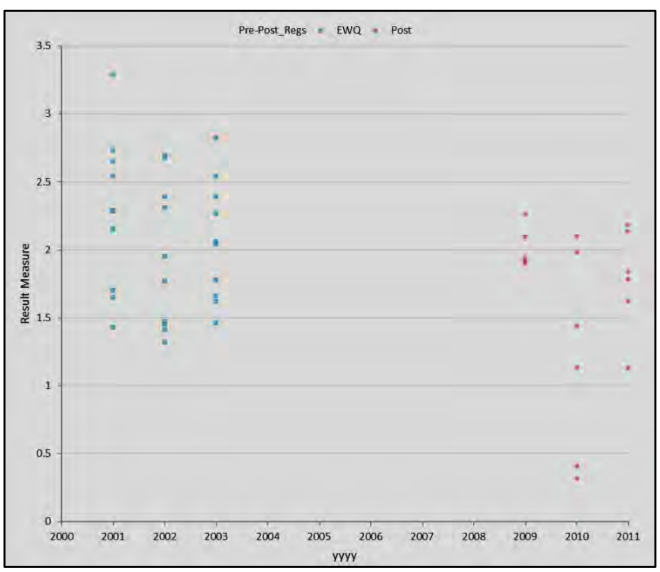
Chapter 11: 1641 BCP Nishisakawick Creek, NJ

Nitrogen as N, Total (TN) mg/l

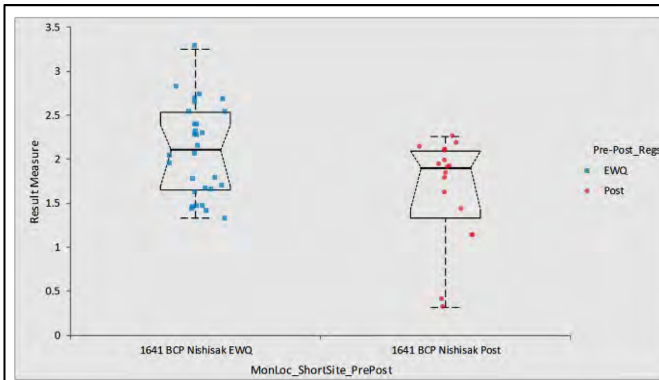
Existing Water Quality (Table 2P):

Median 2.09 mg/l
Lower 95% Confidence Interval 1.70 mg/l
Upper 95% Confidence Interval 2.39 mg/l



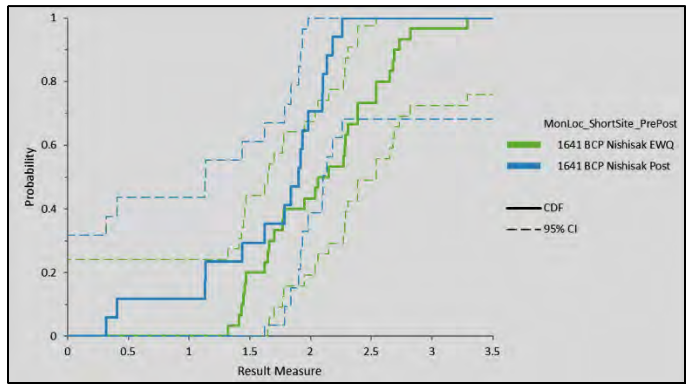


No water quality degradation is evident here. Total Nitrogen concentrations apparently declined between the EWQ and post-EWQ periods. Potential laboratory artifacts and insufficient post-EWQ sampling frequency introduced uncertainty into conclusions.



N 47

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1641 BCP Nishisak EWQ	1.32	1.65	2.11	2.54	3.29	0.89
1641 BCP Nishisak Post	0.31	1.34	1.90	2.10	2.26	0.76



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1641 BCP Nishisak EWQ	30	300.8	10.03
1641 BCP Nishisak Post	17	530.9	31.23

H statistic	4.42
X² approximation	4.42
DF	1
p-value	0.0354 [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.

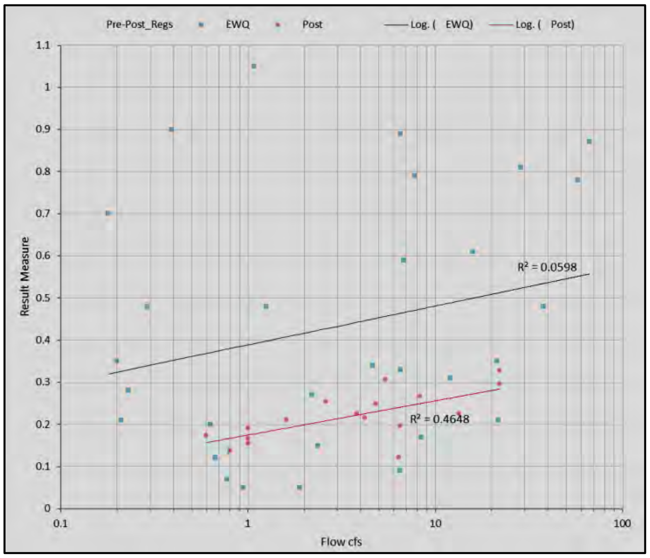
TN is positively related to flow in the post-EWQ data set, but unrelated to flow in the EWQ data set. DRBC results could not be independently validated. Post-EWQ median TN concentrations fell within the EWQ 95% confidence intervals, but the decline in concentrations was significant.

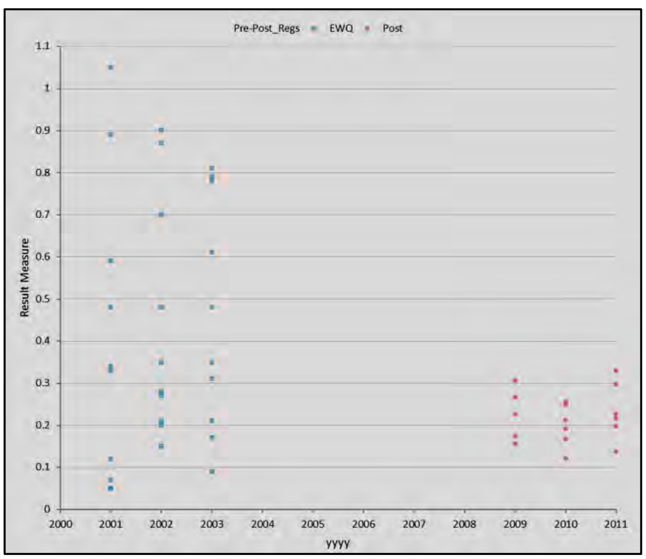
Chapter 11: 1641 BCP Nishisakawick Creek, NJ

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

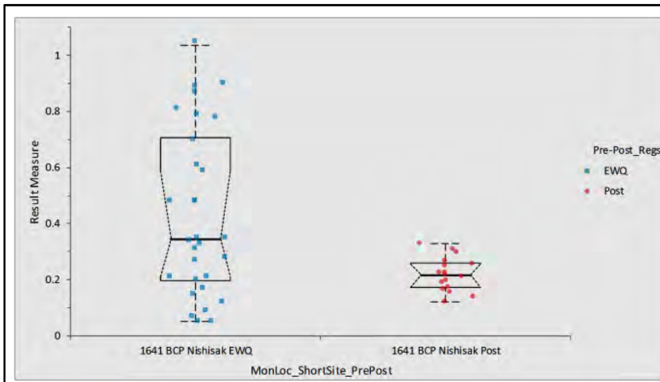
Existing Water Quality (Table 2P):

Median 0.35 mg/l
Lower 95% Confidence Interval 0.21 mg/l
Upper 95% Confidence Interval 0.59 mg/l



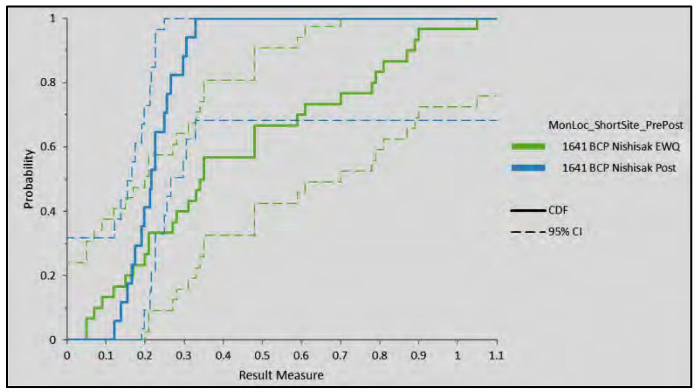


No water quality degradation is evident here. TKN concentrations apparently declined between the EWQ and post-EWQ periods. However, potential laboratory artifacts and insufficient post-EWQ sampling frequency introduced uncertainty into conclusions.



N 47

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1641 BCP Nishisak EWQ	0.05	0.20	0.35	0.71	1.05	0.51
1641 BCP Nishisak Post	0.12	0.17	0.22	0.26	0.33	0.09



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1641 BCP Nishisak EWQ	30	367.5	12.25
1641 BCP Nishisak Post	17	648.5	38.15

H statistic	5.41
X^2 approximation	5.41
DF	1
p-value	0.0201 [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.

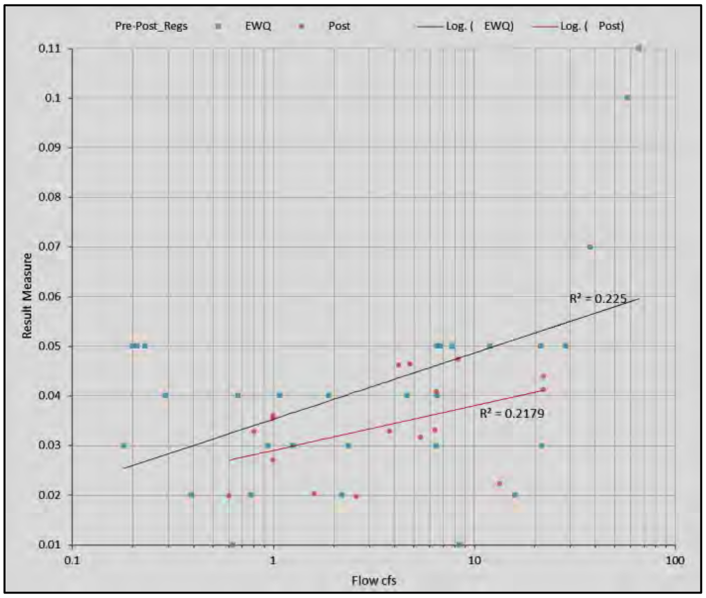
TKN concentration is unrelated to flow in the EWQ data set, but positively related to flow in the post-EWQ data set. TKN ranges much less widely and is less variable in the post-EWQ data set. Note that flows are plotted on a logarithmic scale. Post-EWQ median TKN was within the EWQ 95% confidence intervals, but the decline was significant.

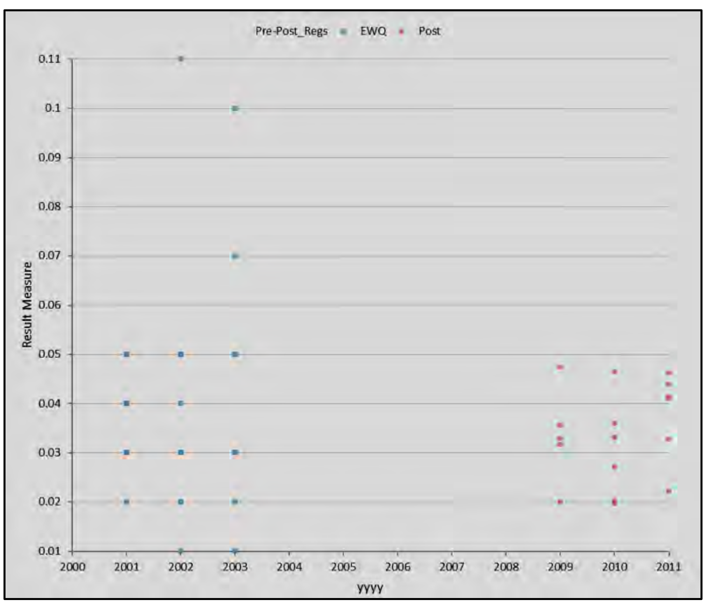
Chapter 11: 1641 BCP Nishisakawick Creek, NJ

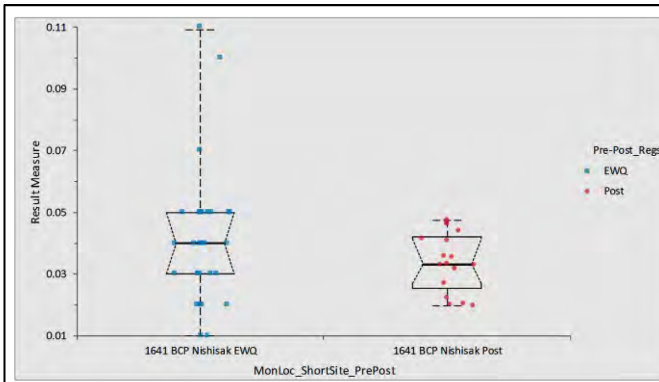
Orthophosphate as P, Total mg/l

Existing Water Quality (Table 2P):

Median 0.04 mg/l
Lower 95% Confidence Interval 0.03 mg/l
Upper 95% Confidence Interval 0.05 mg/l

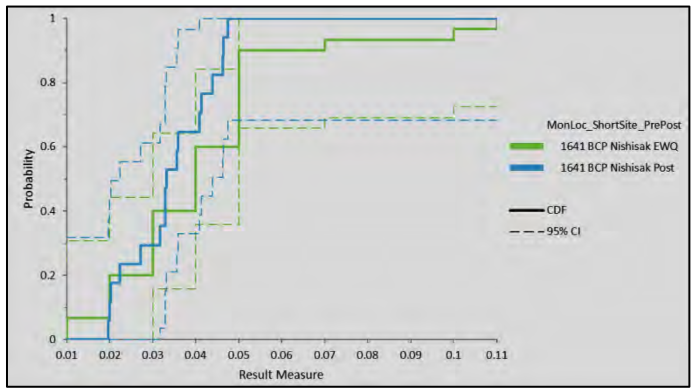






N 47

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1641 BCP Nishisak EWQ	0.01	0.03	0.04	0.05	0.11	0.02
1641 BCP Nishisak Post	0.02	0.03	0.03	0.04	0.05	0.02



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1641 BCP Nishisak EWQ	30	93.6	3.12
1641 BCP Nishisak Post	17	165.2	9.72

H statistic	1.39
X^2 approximation	1.39
DF	1
p-value	0.2379 [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.

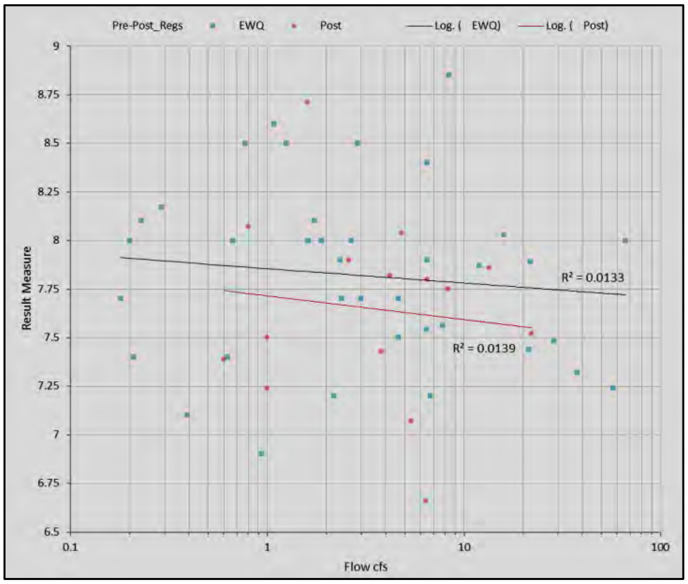
No water quality degradation is evident here. Orthophosphate apparently did not change between the EWQ and post-EWQ periods. Potential laboratory artifacts, detection limit differences, and insufficient post-EWQ sampling frequency introduced uncertainty into data comparisons. Orthophosphate is weakly related to flow in both data sets. Flows is plotted on logarithmic scale. Post-EWQ median orthophosphate fell within the EWQ 95% confidence intervals. There were no independent data to confirm DRBC results.

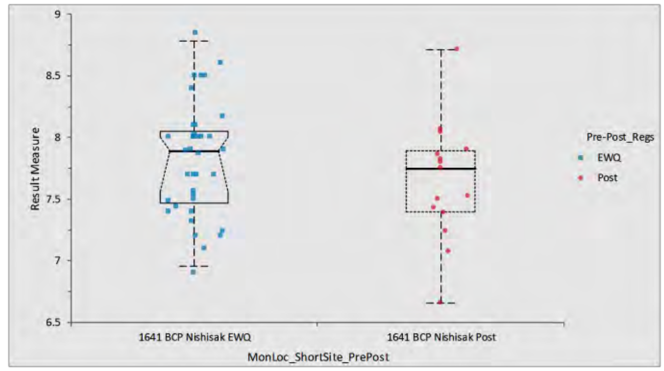
Chapter 11: 1641 BCP Nishisakawick Creek, NJ

pH

Existing Water Quality (Table 2P):

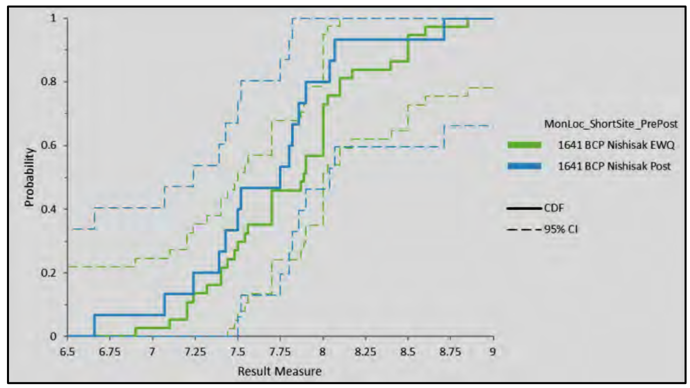
Median 7.89 standard units
Lower 95% Confidence Interval 7.56 standard units
Upper 95% Confidence Interval 8.00 standard units

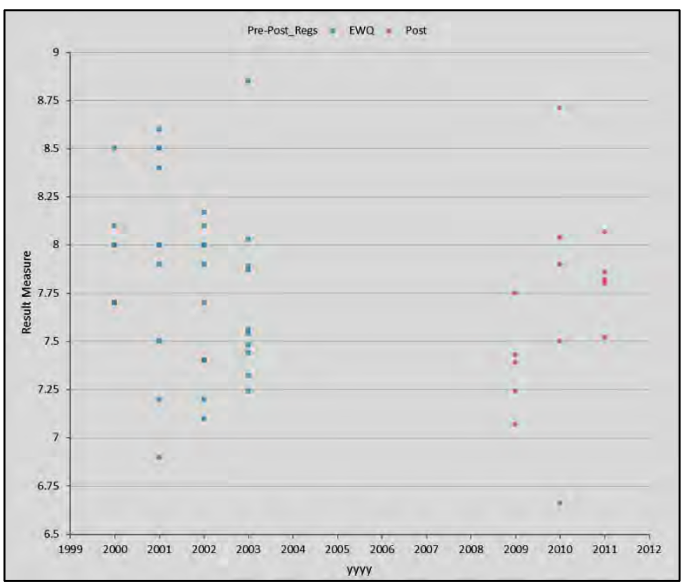




N 52

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1641 BCP Nishisak EWQ	6.90	7.47	7.89	8.05	8.85	0.59
1641 BCP Nishisak Post	6.66	7.40	7.75	7.89	8.71	0.50





Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1641 BCP Nishisak EWQ	37	86.3	2.33
1641 BCP Nishisak Post	15	212.8	14.19

H statistic	1.31
X^2 approximation	1.31
DF	1
p-value	0.2532 [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.

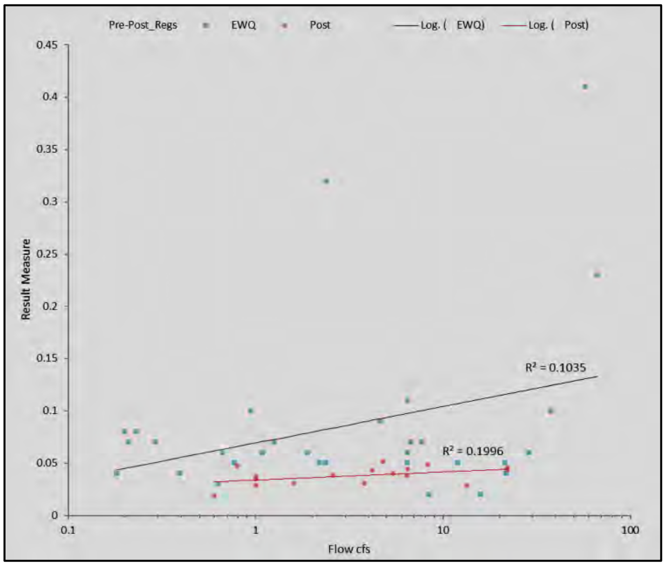
No water quality degradation is evident here. pH did not measurably change between the EWQ and post-EWQ periods. Analytical uncertainty was introduced by insufficient post-EWQ sampling (n=15). pH is unrelated to flow in both data sets. Flow is plotted on logarithmic scale. Post-EWQ median pH was within the EWQ 95% confidence intervals.

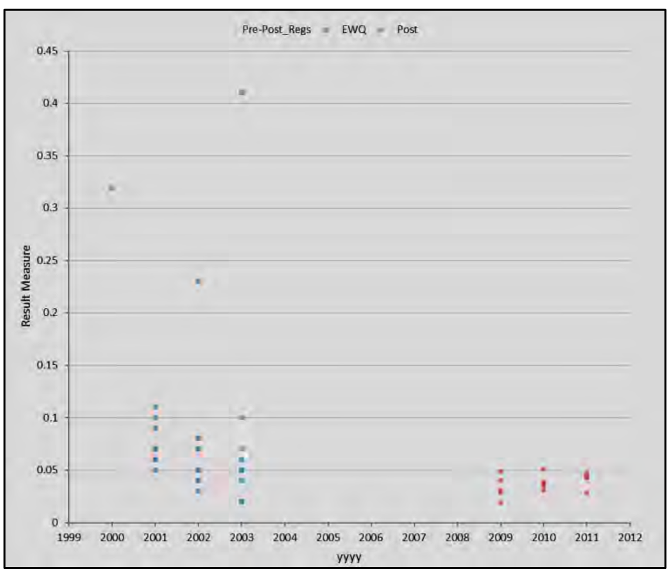
Chapter 11: 1641 BCP Nishisakawick Creek, NJ

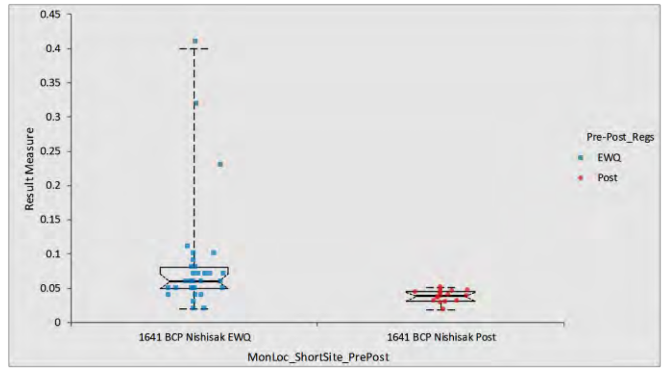
Phosphorus as P, Total (TP) mg/l

Existing Water Quality (Table 2P):

Median 0.06 mg/l
Lower 95% Confidence Interval 0.05 mg/l
Upper 95% Confidence Interval 0.07 mg/l

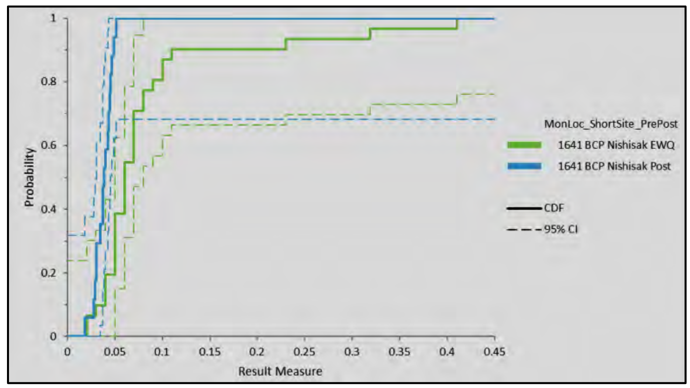






N 48

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1641 BCP Nishisak EWQ	0.020	0.050	0.060	0.080	0.410	0.030
1641 BCP Nishisak Post	0.019	0.031	0.038	0.045	0.051	0.014



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1641 BCP Nishisak EWQ	31	1134.1	36.58
1641 BCP Nishisak Post	17	2068.0	121.65

H statistic	16.41
X^2 approximation	16.41
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.

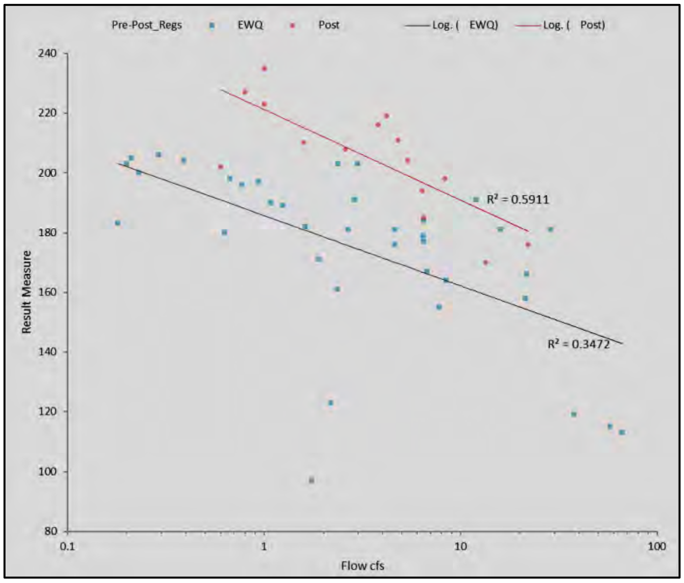
No water quality degradation is evident here. Total Phosphorus (TP) concentrations apparently declined between the EWQ and post-EWQ periods. However, potential laboratory artifacts and insufficient post-EWQ sampling frequency (n=17) introduced uncertainty into data comparisons. Post-EWQ median total phosphorus fell below the EWQ lower 95% confidence interval. TP is very weakly related to flow in both data sets. Flow is plotted on logarithmic scale. No independent data were available to confirm these results.

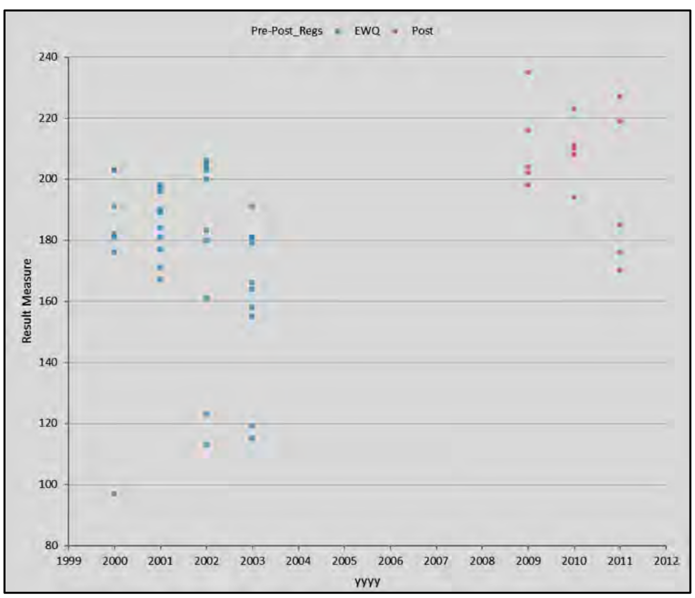
Chapter 11: 1641 BCP Nishisakawick Creek, NJ

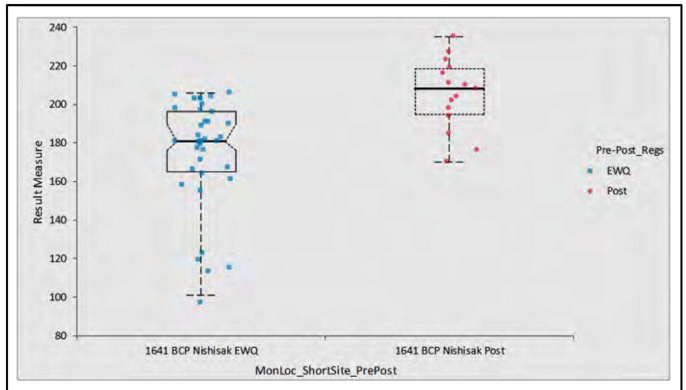
Specific Conductance µmho/cm

Existing Water Quality (Table 2P):

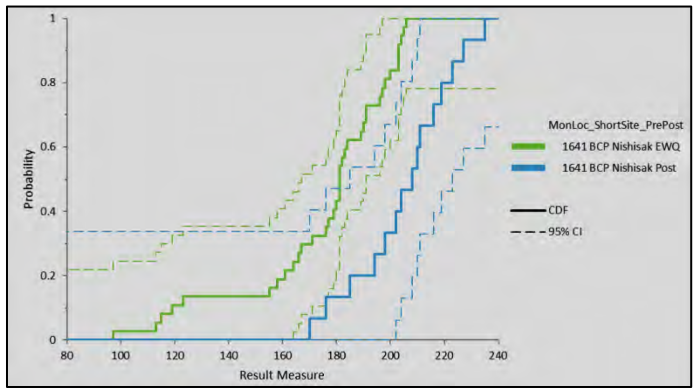
Median 181 µmho/cm
Lower 95% Confidence Interval 176 µmho/cm
Upper 95% Confidence Interval 190 µmho/cm
Defined in regulations as a flow-related parameter







N	52					
Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1641 BCP Nishisak EWQ	97	165	181	196	206	31
1641 BCP Nishisak Post	170	195	208	219	235	24



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1641 BCP Nishisak EWQ	37	945.1	25.54
1641 BCP Nishisak Post	15	2331.3	155.42

H statistic	14.28
X^2 approximation	14.28
DF	1
p-value	0.0002 [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.

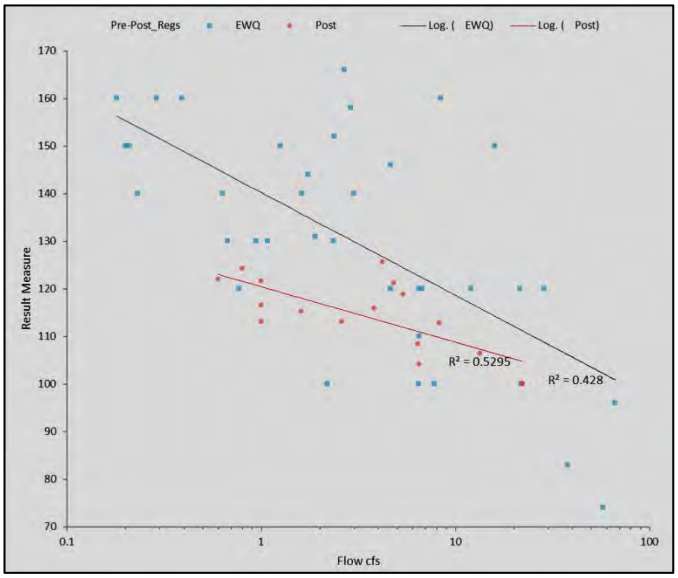
Water quality degradation is indicated here. Specific conductance rose above the EWQ upper 95% confidence interval between the EWQ and post-EWQ periods. However, insufficient post-EWQ sampling frequency (n=17) and under-representation of post-EWQ flow conditions introduced uncertainty into data comparisons. Specific conductance is inversely related to flow in both data sets. Flow is plotted on logarithmic scale. The rise in specific conductance may be partially attributable to the concurrent rise in chloride concentrations. Median specific conductance has risen from 181 to 208 µmhos/cm; a 15% increase.

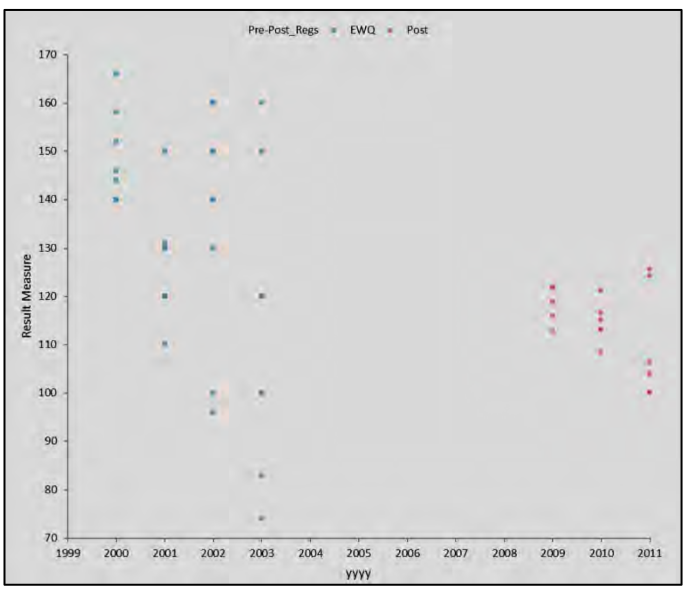
Chapter 11: 1641 BCP Nishisakawick Creek, NJ

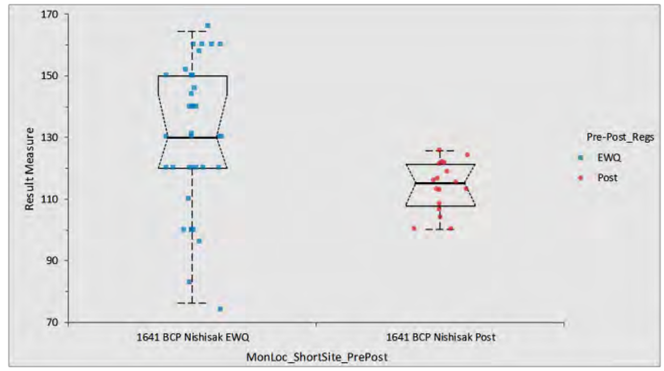
Total Dissolved Solids (TDS) mg/l

Existing Water Quality (Table 2P):

Median 130 mg/l
Lower 95% Confidence Interval 120 mg/l
Upper 95% Confidence Interval 144 mg/l
Defined in regulations as a flow-related parameter

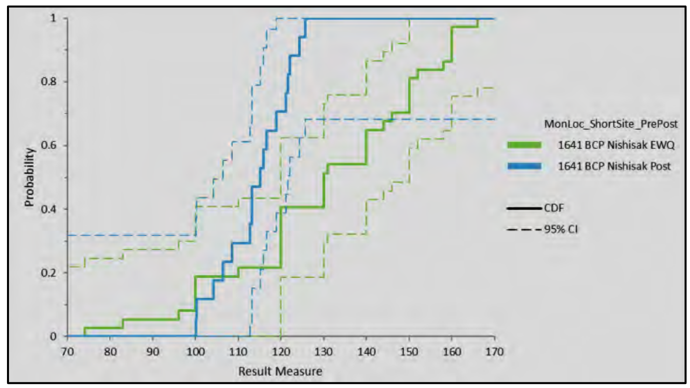






N | 54

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1641 BCP Nishisak EWQ	74	120	130	150	166	30
1641 BCP Nishisak Post	100	108	115	121	126	14



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1641 BCP Nishisak EWQ	37	596.0	16.11
1641 BCP Nishisak Post	17	1297.2	76.31

H statistic	7.68
X² approximation	7.68
DF	1
p-value	0.0056 [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. TDS apparently declined between the EWQ and post-EWQ periods. Potential laboratory artifacts, insufficient post-EWQ sampling frequency (n=17) and under-representation of post-EWQ flow conditions introduced uncertainty into data comparisons.

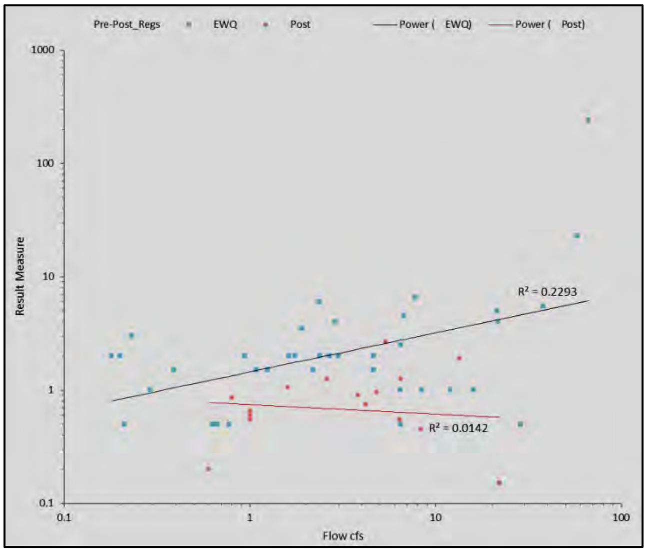
TDS is inversely related to flow in both data sets. Post-EWQ median TDS fell below the EWQ lower 95% lower confidence interval, and was much less variable than the baseline samples as well. Post-EWQ detection limits were lower than EWQ detection limits, though there were no non-detect results at any time.

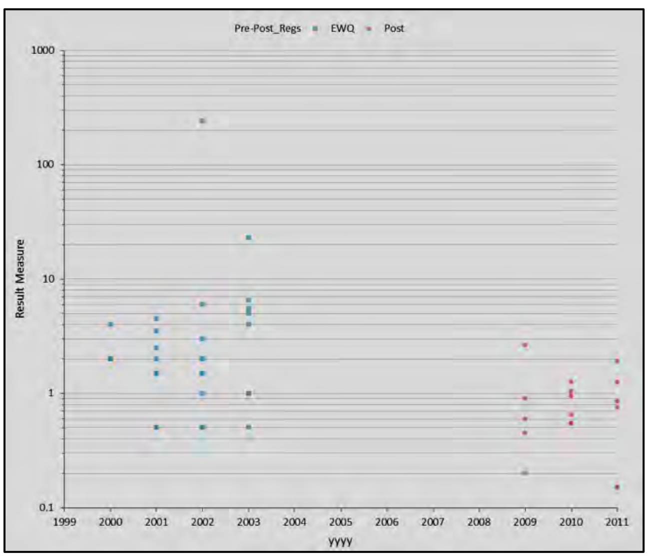
Chapter 11: 1641 BCP Nishisakawick Creek, NJ

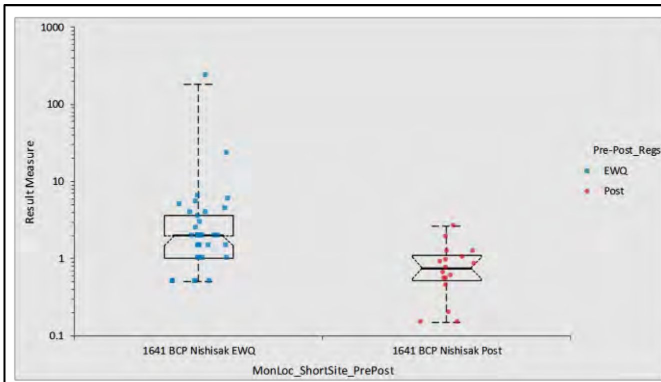
Total Suspended Solids (TSS) mg/l

Existing Water Quality (Table 2P):

Median 1.5 mg/l
Lower 95% Confidence Interval 1.0 mg/l
Upper 95% Confidence Interval 2.0 mg/l

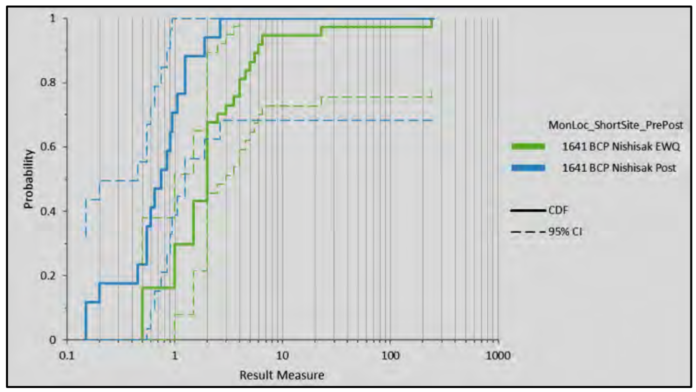






N 54

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1641 BCP Nishisak EWQ	0.5	1.0	2.0	3.7	240.0	2.7
1641 BCP Nishisak Post	0.1	0.5	0.8	1.1	2.7	0.6



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1641 BCP Nishisak EWQ	37	991.1	26.79
1641 BCP Nishisak Post	17	2157.2	126.89

H statistic	12.82
X^2 approximation	12.82
DF	1
p-value	0.0003 [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. TSS apparently declined between EWQ and post-EWQ periods. Potential laboratory artifacts, insufficient post-EWQ sampling frequency (n=17) and under-representation of post-EWQ flow conditions introduced uncertainty into data comparisons. TSS is unrelated to flow in both data sets.

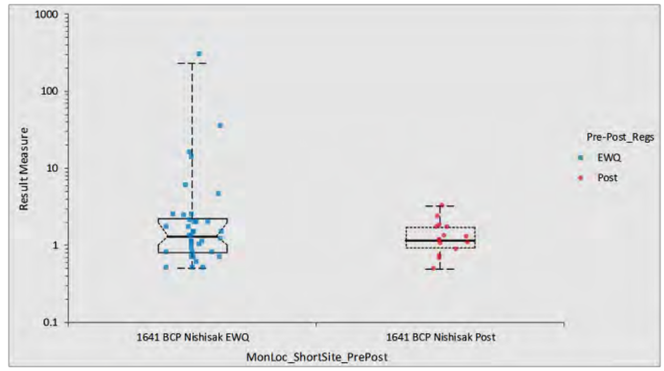
Post-EWQ median TSS fell below the lower EWQ 95% confidence interval and the difference in median concentrations was significant. Flows and concentrations are plotted on logarithmic scale. TSS should be related to flow, so it appears that too few samples were taken in both periods to fully characterize TSS for Nishisakawick Creek.

Chapter 11: 1641 BCP Nishisakawick Creek, NJ

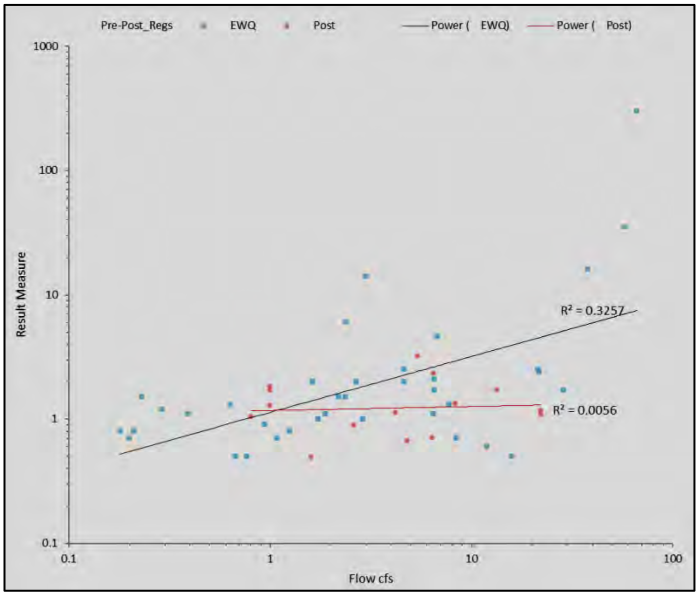
Turbidity NTU

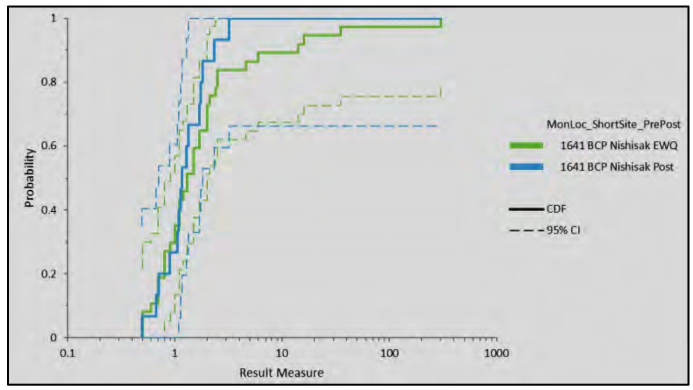
Existing Water Quality (Table 2P):

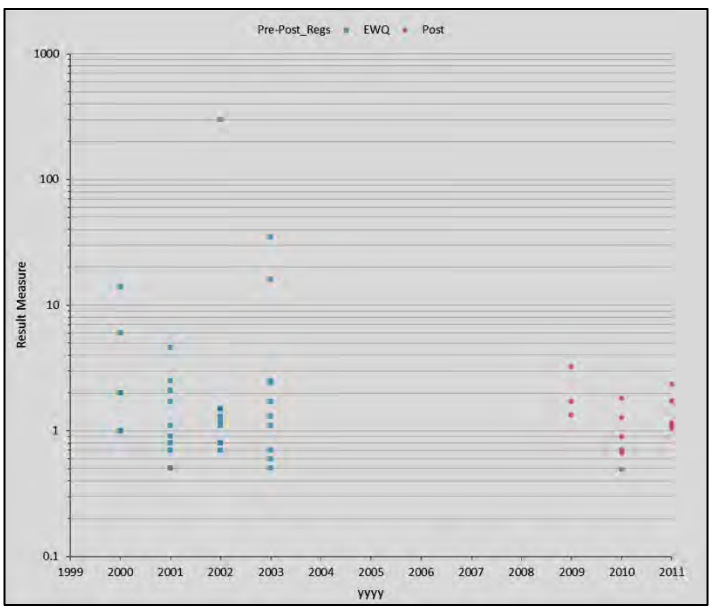
Median 1.3 NTU
Lower 95% Confidence Interval 0.9 NTU
Upper 95% Confidence Interval 2.0 NTU
Defined in regulations as a flow-related parameter



Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
N	52					
1641 BCP Nishisak EWQ	0.50	0.80	1.30	2.20	300.00	1.40
1641 BCP Nishisak Post	0.49	0.92	1.16	1.73	3.21	0.81







Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1641 BCP Nishisak EWQ	37	28.5	0.77
1641 BCP Nishisak Post	15	70.4	4.69

H statistic	0.43
X^2 approximation	0.43
DF	1
p-value	0.5113[1]

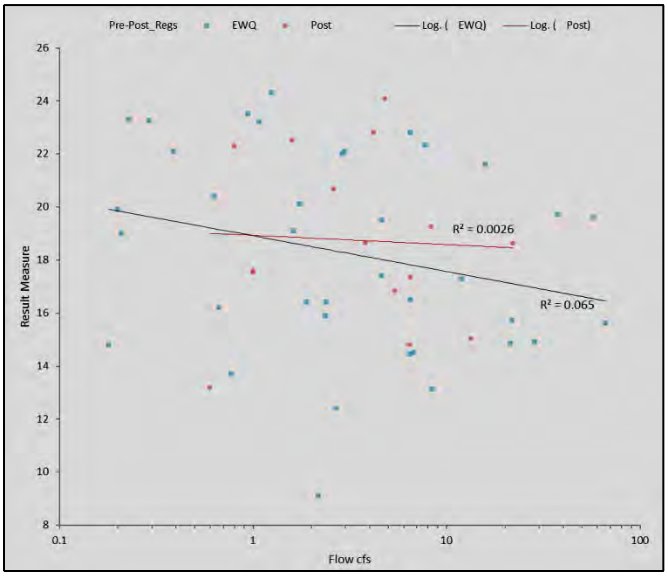
H0: $\theta_1 = \theta_2 = \theta_{...}$
The median of the populations are all equal.
H1: $\theta_i \neq \theta_j$ for at least one i,j
The median of the populations are not all equal.
[1] Do not reject the null hypothesis at the 5% significance level.

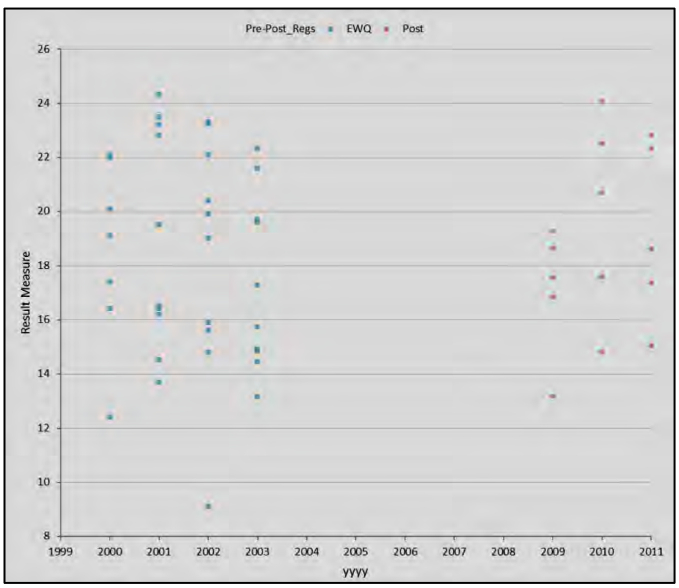
No water quality degradation is evident here. Turbidity did not measurably change between the EWQ and post-EWQ periods. The post-EWQ median turbidity fell within the EWQ 95% confidence intervals of the median. Turbidity is weakly related to flow in the EWQ data set and unrelated to flow in the post-EWQ data set. There were too few samples taken in the post-EWQ period, and post-EWQ flow conditions were not fully represented. Concentrations and flows are represented on logarithmic scale.

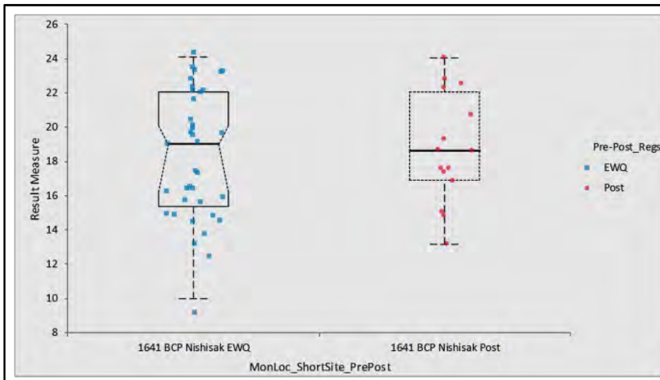
Chapter 11: 1641 BCP Nishisakawick Creek, NJ

Water Temperature, degrees C

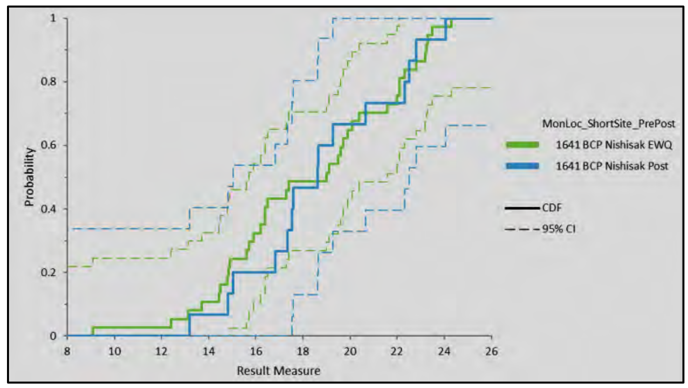
Not included in DRBC Existing Water Quality rules







Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
N	52					
1641 BCP Nishisak EWQ	9.1	15.4	19.0	22.0	24.3	6.7
1641 BCP Nishisak Post	13.2	16.9	18.6	22.0	24.1	5.1



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1641 BCP Nishisak EWQ	37	12.5	0.34
1641 BCP Nishisak Post	15	30.8	2.05

H statistic	0.19
X² approximation	0.19
DF	1
p-value	0.6641 [1]

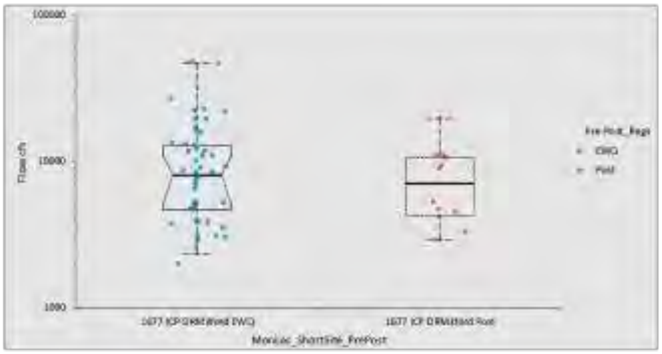
H0: $\theta_1 = \theta_2 = \theta ...$
The median of the populations are all equal.
H1: $\theta_i \neq \theta_j$ for at least one i,j
The median of the populations are not all equal.
[1] Do not reject the null hypothesis at the 5% significance level.

No water quality degradation is evident here. Water temperature did not measurably change between the EWQ and post-EWQ periods. There were too few post-EWQ samples (n=15). Water temperature is unrelated to flow in both data sets. Flow is plotted on logarithmic scale.

Chapter 12: 1677 ICP Delaware River at Milford/Upper Black Eddy

1677 ICP
Delaware River at Upper Black Eddy Bridge

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



N	62

Flow cfs by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1677 ICP DRMilford EWQ	1985	4661	8056	12887	47384	8226
1677 ICP DRMilford Post	2889	4262	7026	10651	19576	6389

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

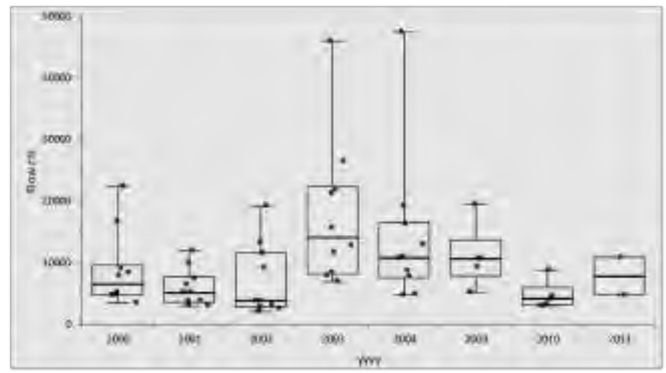
Kruskal-Wallis test

Flow cfs by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1677 ICP DRMilford EWQ	50	33.6	0.67
1677 ICP DRMilford Post	12	140.1	11.67

H statistic	0.53
X^2 approximation	0.53
DF	1
p-value	0.4651

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.

For many of the water quality parameters to follow, there were an insufficient number of samples taken to set up a good statistical comparison between the two periods. For the next assessment round biweekly instead of monthly sampling is recommended.



N	62

Flow cfs by yyyy	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
2000	3,460	4,661	6,513	9,556	22,379	4,895
2001	2,995	3,650	5,138	7,637	11,983	3,987
2002	1,985	2,828	3,794	11,681	19,196	8,854
2003	6,919	8,240	14,122	22,268	45,946	14,028
2004	4,723	7,500	10,756	16,449	47,384	8,950
2009	5,242	7,903	10,541	13,678	19,576	5,775
2010	2,889	3,122	4,113	5,916	8,809	2,795
2011	4,621	4,621	7,722	10,823	10,823	6,202

Annual flow statistics are plotted above. These are May to September flow measurements associated with the time of each water quality sample. Flow is interpolated at this location using drainage area weighting based on the USGS continuous stream gage at Trenton, NJ. "Normal" flow is about 9,000 cfs at this location on the Delaware River, but median summer flows are typically around 5,000 cfs.

Upstream ICP: Delaware River at Riegelsville 1748 ICP
Downstream ICP: Del. River at Bulls Island 1554 ICP

Tributary BCP Watersheds in Upstream Reach:

Musconetcong River, NJ – 1746 BCP
Cooks Creek, PA – 1737 BCP

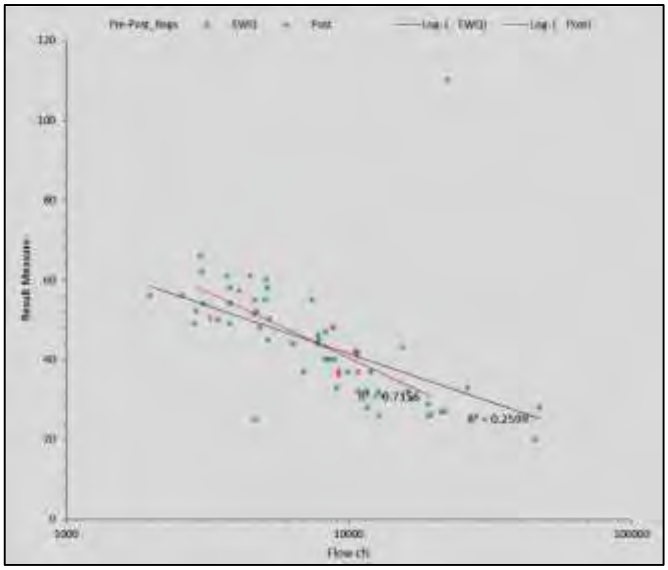
All other tributary watersheds are less than 20 square miles and have little effect upon the Delaware River.

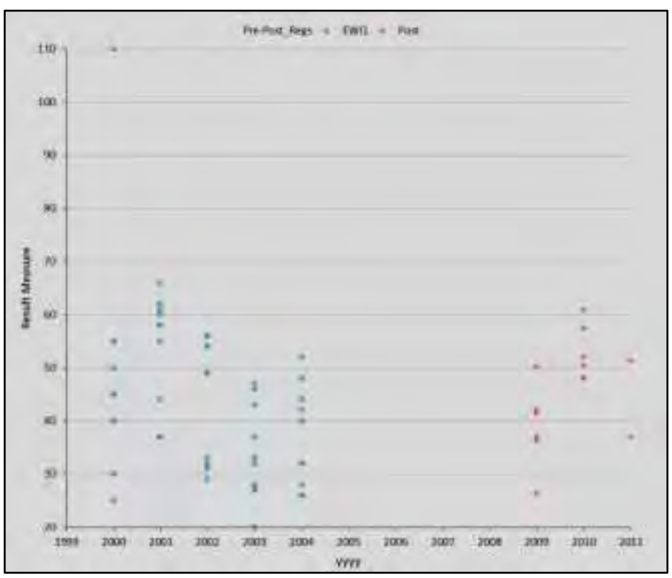
Chapter 12: 1677 ICP
Delaware River at Milford/Upper Black Eddy NJ/PA

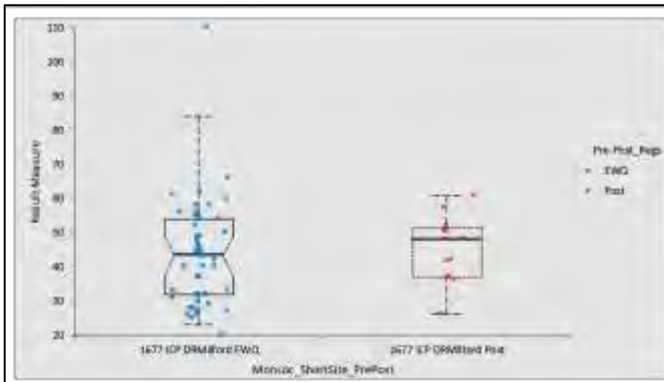
Alkalinity as CaCO3, Total mg/l

Existing Water Quality (Table 2O):

Median 44 mg/l
Lower 95% Confidence Interval 37 mg/l
Upper 95% Confidence Interval 49 mg/l
Defined in regulations as a flow-related parameter

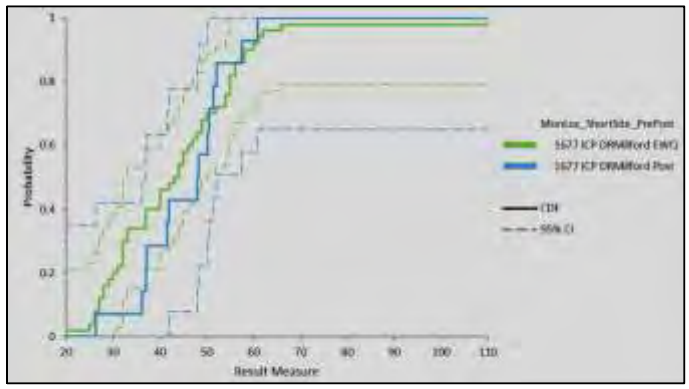






N 64

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1677 ICP DRMilford EWQ	20	32	44	54	110	22
1677 ICP DRMilford Post	26	37	48	51	61	14



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1677 ICP DRMilford EWQ	50	49.0	0.98
1677 ICP DRMilford Post	14	175.0	12.50

H statistic	0.65
X^2 approximation	0.65
DF	1
p-value	0.4213[1]

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

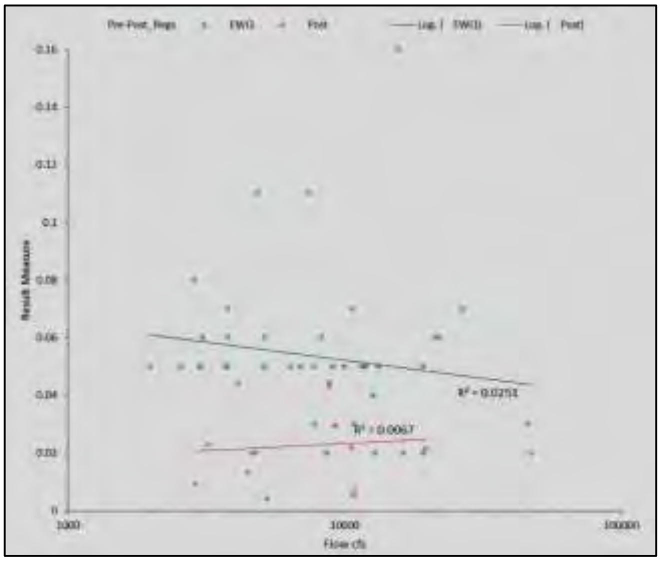
No water quality degradation is evident here. Alkalinity apparently did not measurably change between the EWQ and post-EWQ periods. Potential laboratory artifacts and insufficient post-EWQ sampling introduced analytical uncertainty. Alkalinity is inversely related to flow in both data sets. Post-EWQ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

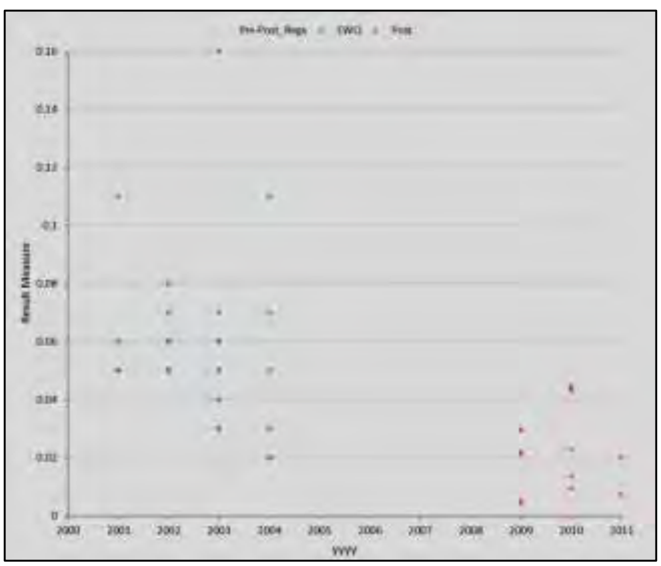
Chapter 12: 1677 ICP
Delaware River at Milford/Upper Black Eddy NJ/PA

Ammonia Nitrogen as N, Total mg/l

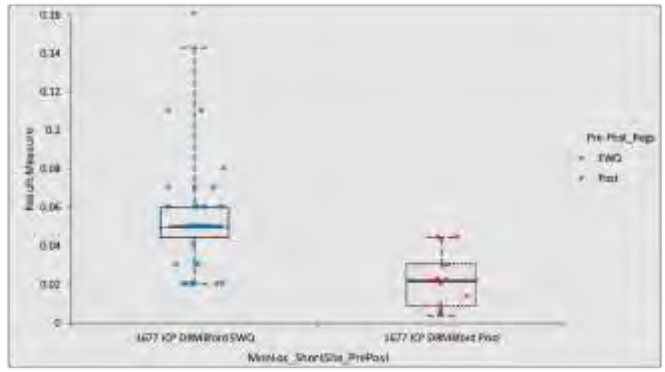
Existing Water Quality (Table 2O):

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



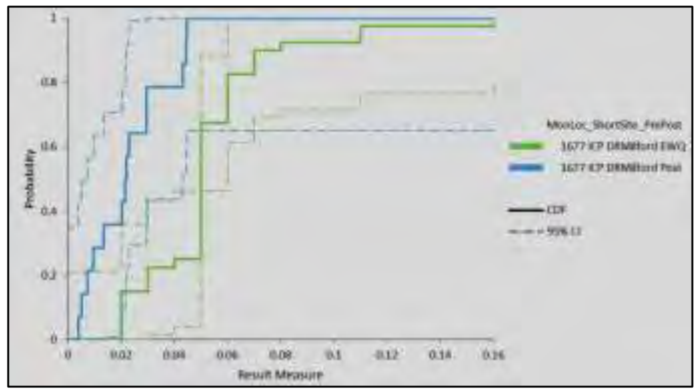


No water quality degradation is evident here. Ammonia concentrations apparently declined. However, potential laboratory artifacts, detection limit differences, and insufficient post-EWQ sampling frequency (n=14) introduced analytical uncertainty.



N	54

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1677 ICP DRMilford EWQ	0.02	0.04	0.05	0.06	0.16	0.02
1677 ICP DRMilford Post	0.00	0.01	0.02	0.03	0.04	0.02



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1677 ICP DRMilford EWQ	40	1144.9	28.62
1677 ICP DRMilford Post	14	3271.1	233.65

H statistic	18.47
X^2 approximation	18.47
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.

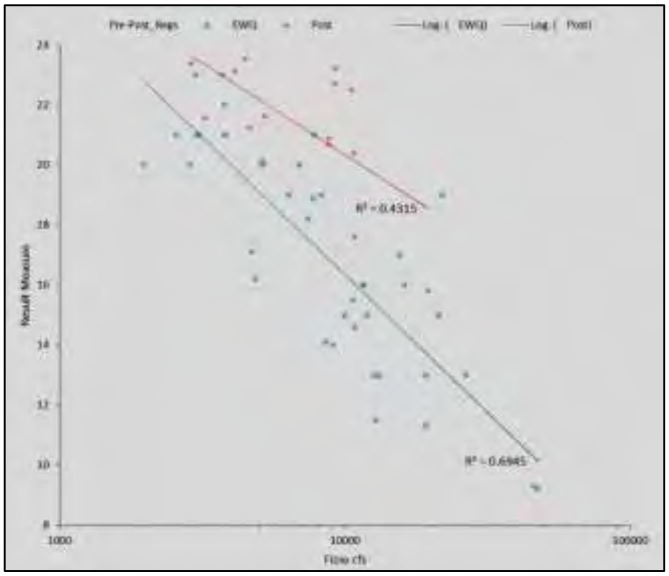
Post-EWQ median ammonia concentration was below the EWQ lower 95% confidence interval. No independent data were available to validate results. EWQ data possessed 25/40 undetected results which interfered with calculation of the median value. Thus EWQ was established as <0.05 mg/l. Under 2009-2011 lower detection levels there was only one undetected result, revealing actual low-level ammonia concentrations. Some evidence for water quality improvement exists as post-EWQ data contained no concentrations above 0.04 mg/l. Flow is plotted on a logarithmic scale.

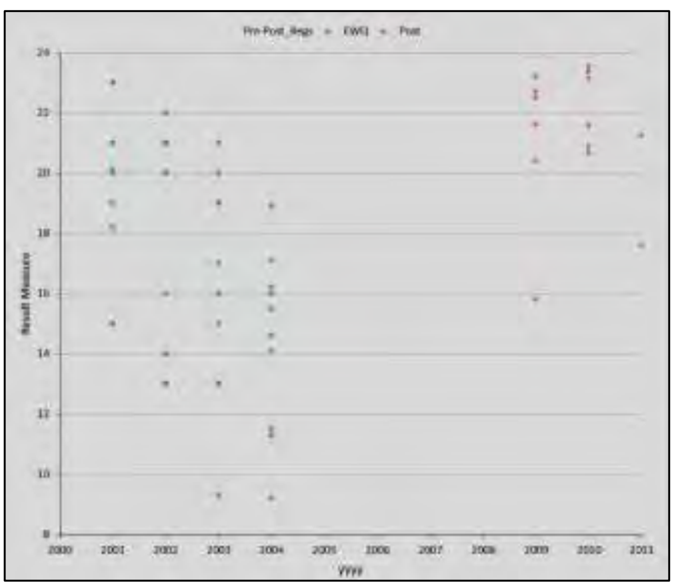
Chapter 12: 1677 ICP
Delaware River at Milford/Upper Black Eddy NJ/PA

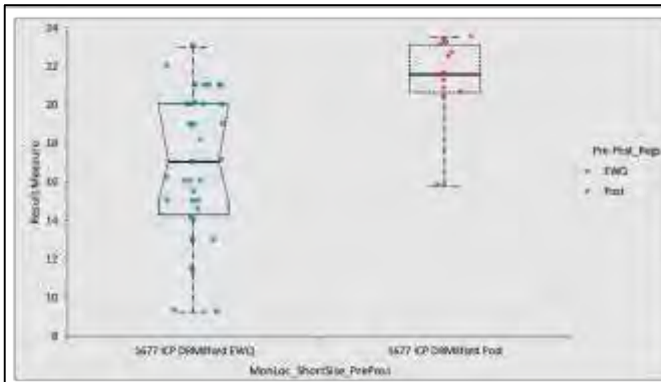
Chloride, Total mg/l

Existing Water Quality (Table 2O):

Median 17 mg/l
Lower 95% Confidence Interval 15 mg/l
Upper 95% Confidence Interval 20 mg/l
Defined in regulations as a flow-related parameter

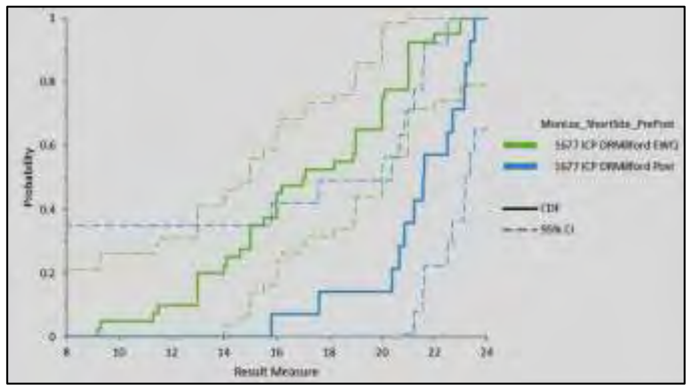






N 54

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1677 ICP DRMilford EWQ	9	14	17	20	23	6
1677 ICP DRMilford Post	16	21	22	23	24	2



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1677 ICP DRMilford EWQ	40	960.4	24.01
1677 ICP DRMilford Post	14	2744.0	196.00

H statistic	15.01
X^2 approximation	15.01
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.

Water quality degradation is evident here. Chloride concentrations apparently rose by about 5 mg/l between the two periods. Potential laboratory artifacts and insufficient post-EWQ sampling frequency (n=14) introduced analytical uncertainty. Post-EWQ median concentration rose above the EWQ upper 95% confidence interval. Both data sets are inversely flow-related. The post-EWQ data are not fully representative of flow conditions, as few samples were collected under high flow conditions. Bi-weekly instead of monthly sampling is recommended for the next assessment.

Chapter 12: 1677 ICP

Delaware River at Milford/Upper Black Eddy NJ/PA

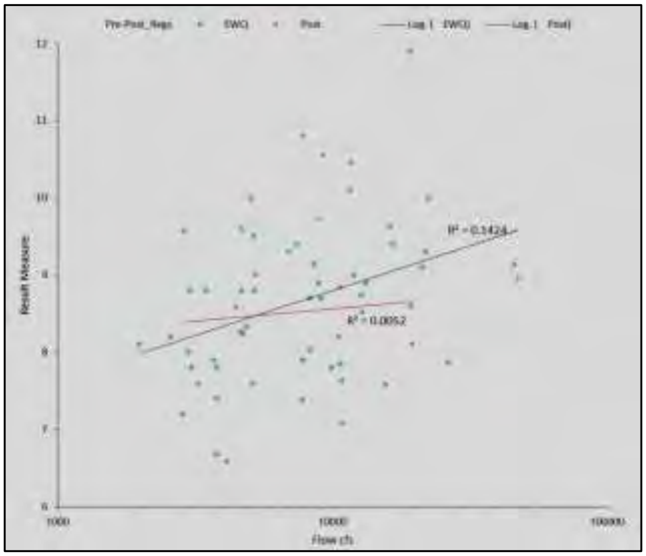
Dissolved Oxygen (DO) mg/l

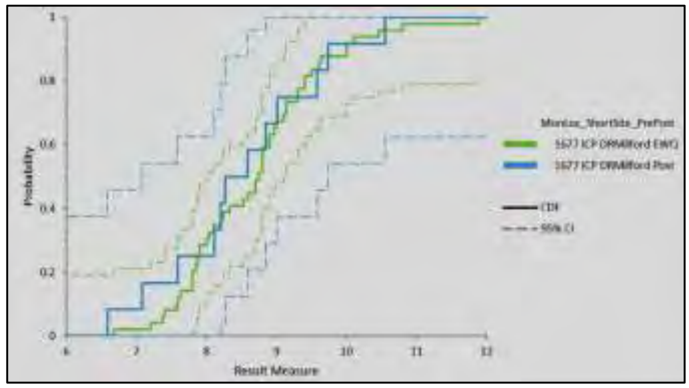
Existing Water Quality (Table 2O):

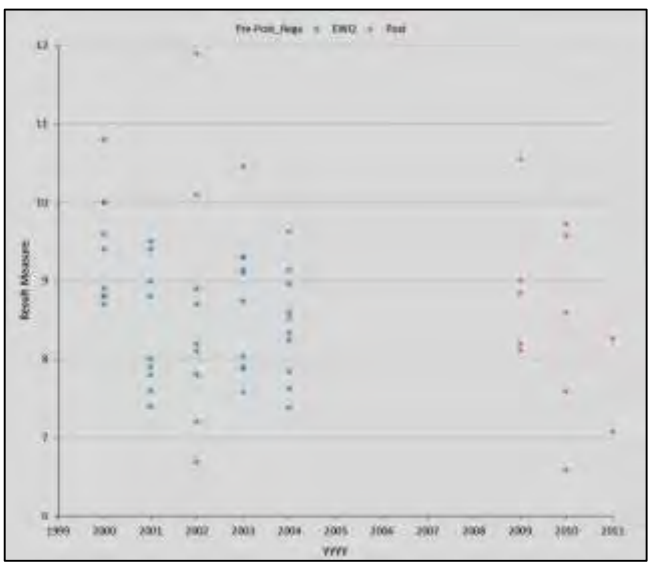
Median 8.74 mg/l
Lower 95% Confidence Interval 8.20 mg/l
Upper 95% Confidence Interval 8.96 mg/l

N	61

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1677 ICP DRMilford EWQ	6.68	7.89	8.74	9.30	11.90	1.41
1677 ICP DRMilford Post	6.59	7.81	8.43	9.34	10.55	1.54







Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1677 ICP DRMilford EWQ	49	8.6	0.18
1677 ICP DRMilford Post	12	35.0	2.92

H statistic	0.14
X^2 approximation	0.14
DF	1
p-value	0.7099 [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.

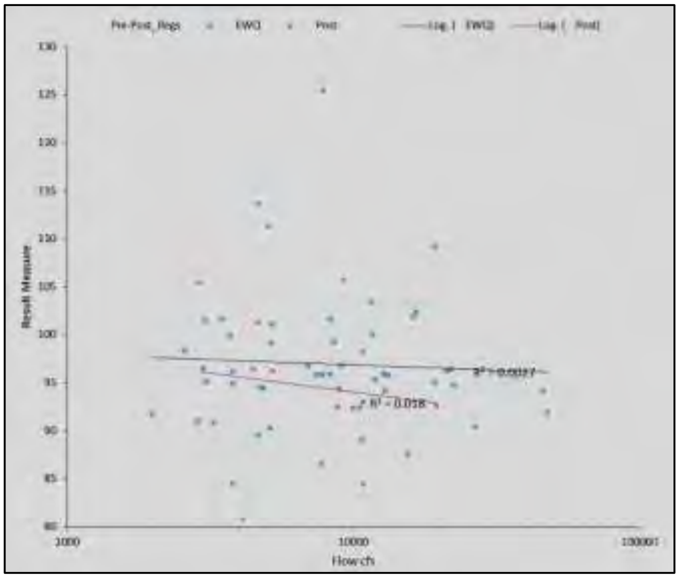
No water quality degradation is evident here. No measurable change took place between the EWQ and Post-EWQ periods. There were too few post-EWQ samples (n=12). Post-EWQ median DO concentration fell within the EWQ 95% confidence intervals. Flow is plotted on a logarithmic scale. DO concentration is unrelated to flow in both data sets.

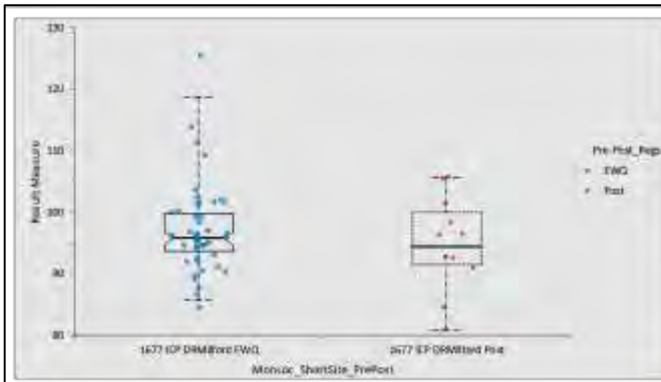
Chapter 12: 1677 ICP
Delaware River at Milford/Upper Black Eddy NJ/PA

Dissolved Oxygen Saturation %

Existing Water Quality (Table 2O):

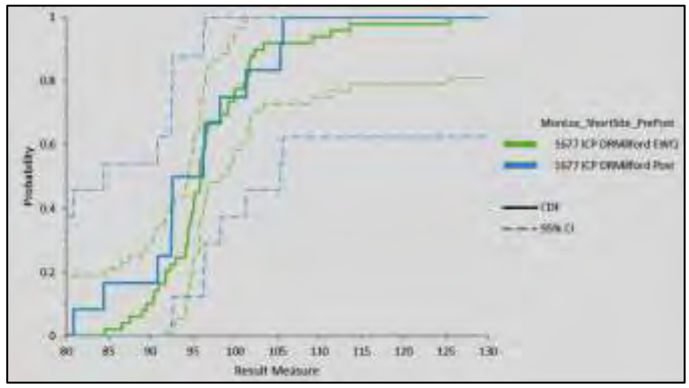
Median 96%
Lower 95% Confidence Interval 95%
Upper 95% Confidence Interval 97%

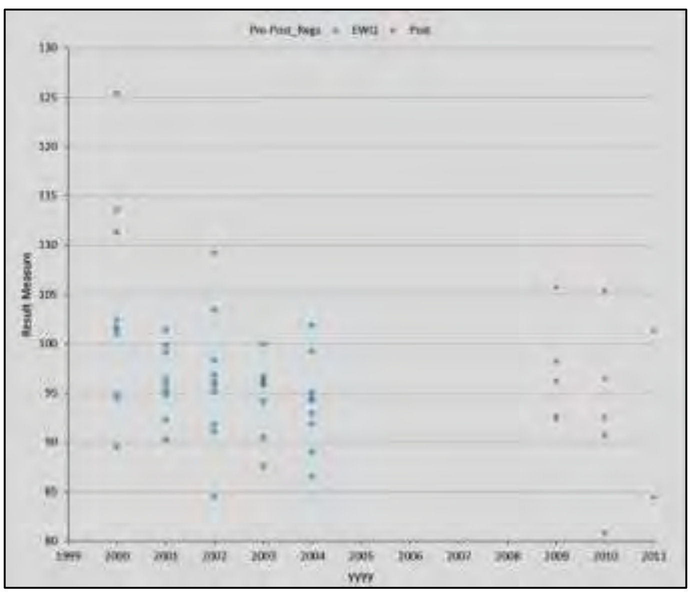




N 61

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1677 ICP DRMilford EWQ	84	94	96	100	125	6
1677 ICP DRMilford Post	81	91	94	100	106	9





Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1677 ICP DRMilford EWQ	49	25.0	0.51
1677 ICP DRMilford Post	12	102.1	8.51

H statistic	0.40
X^2 approximation	0.40
DF	1
p-value	0.5254[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.

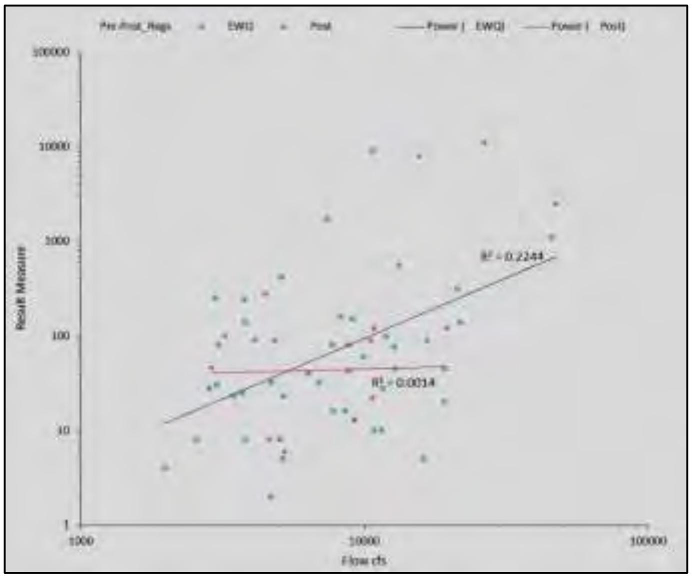
No water quality degradation is evident here. Dissolved Oxygen Saturation is unrelated to flow, and did not measurably change between the EWQ and post-EWQ periods. Post-EWQ median DO saturation fell below the lower EWQ 95% confidence interval, though the difference was not significant due to insufficient post-EWQ sampling (n=12). Flow is plotted on a logarithmic scale.

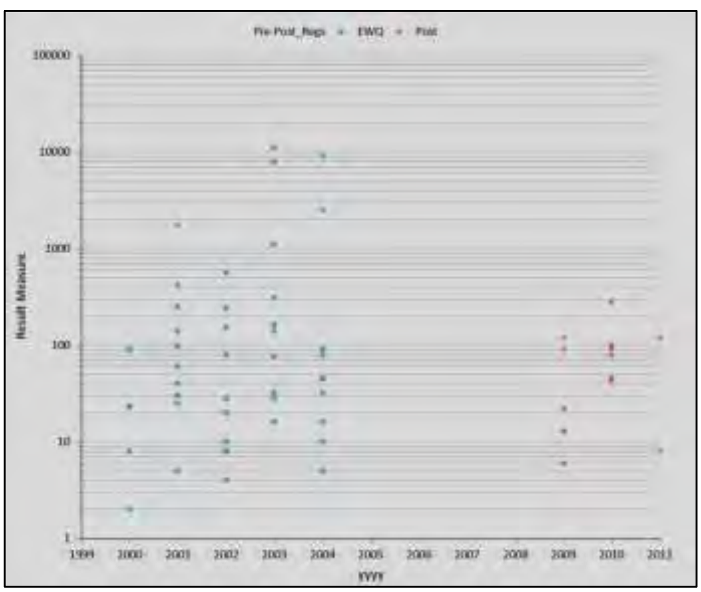
Chapter 12: 1677 ICP
Delaware River at Milford/Upper Black Eddy NJ/PA

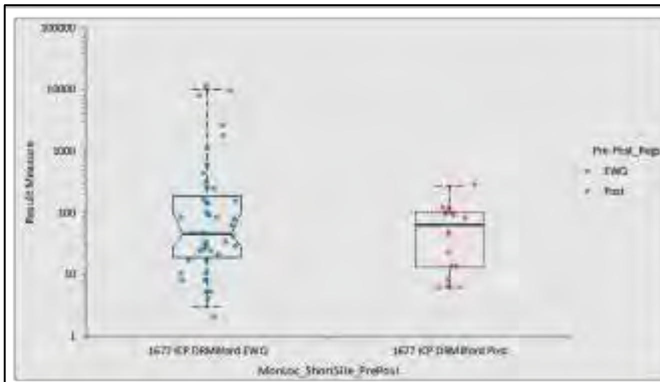
Enterococcus colonies/100 ml

Existing Water Quality (Table 2O):

Median 45/100 ml
Lower 95% Confidence Interval 28/100 ml
Upper 95% Confidence Interval 98/100 ml

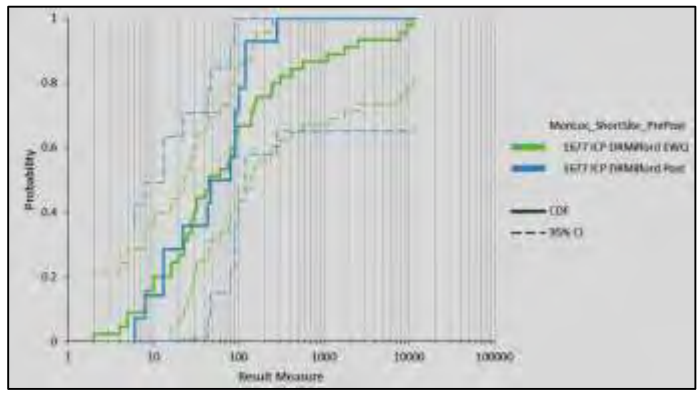






N 59

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1677 ICP DRMilford EWQ	2	19	45	187	11000	168
1677 ICP DRMilford Post	6	13	63	102	280	89



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1677 ICP DRMilford EWQ	45	11.3	0.25
1677 ICP DRMilford Post	14	36.2	2.58

H statistic	0.16
X^2 approximation	0.16
DF	1
p-value	0.6884 [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.

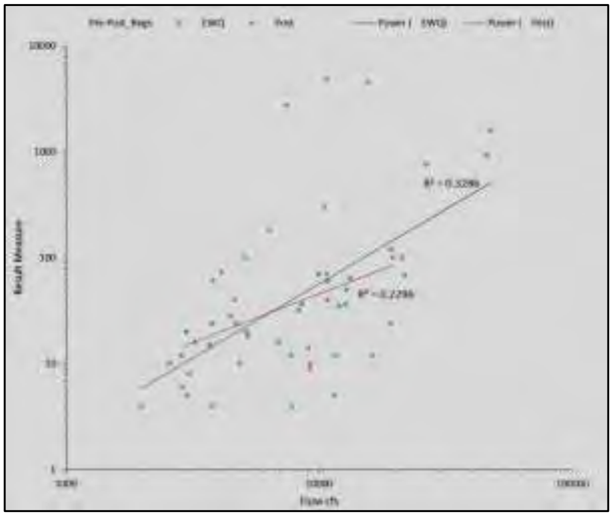
No water quality degradation is evident here. Enterococci did not measurably change between the EWQ and Post-EWQ periods. Uncertainty is introduced into comparisons by potential laboratory artifacts and insufficient post-EWQ sampling frequency. Both data sets are unrelated to flow. Post-EWQ samples were not representative of the full range of flow conditions. Note that concentrations and flows are plotted on a logarithmic scale. Post-EWQ median enterococcus concentrations fell within the EWQ 95% confidence intervals.

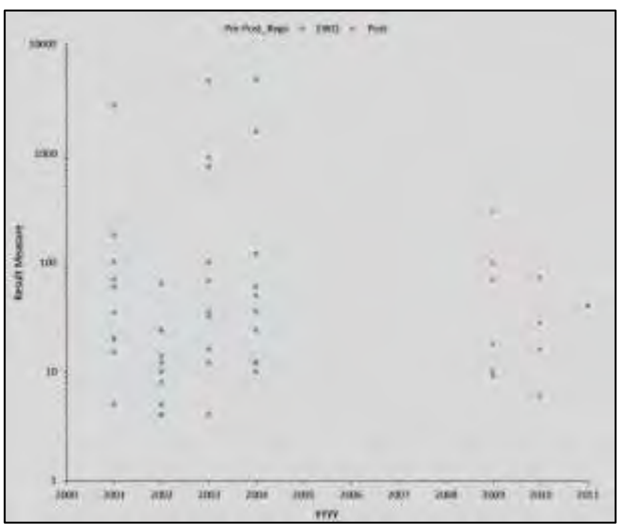
Chapter 12: 1677 ICP
Delaware River at Milford/Upper Black Eddy NJ/PA

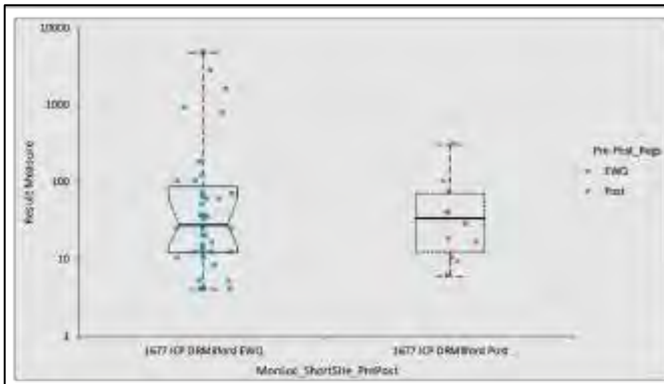
Escherichia coli colonies/100 ml

Existing Water Quality (Table 2O):

Median 28/100 ml
Lower 95% Confidence Interval 15/100 ml
Upper 95% Confidence Interval 60/100 ml
Defined in regulations as a flow-related parameter

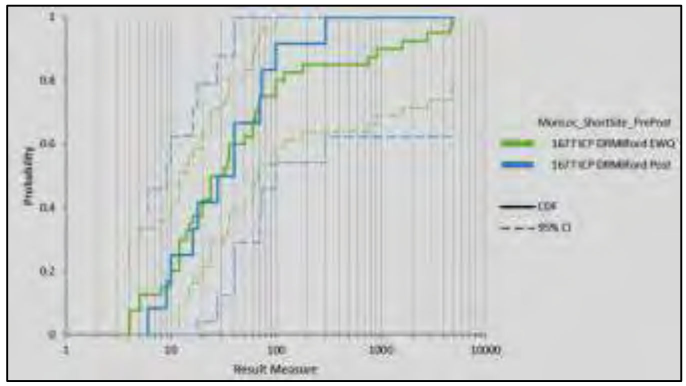






N | 52

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1677 ICP DRMilford EWQ	4	12	28	88	4800	76
1677 ICP DRMilford Post	6	13	34	72	300	59



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1677 ICP DRMilford EWQ	40	0.0	0.00
1677 ICP DRMilford Post	12	0.0	0.00

H statistic	0.00
X^2 approximation	0.00
DF	1
p-value	1.0000 [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. E. coli concentrations apparently did not change between the EWQ and Post-EWQ periods. Uncertainty is introduced into comparisons by potential laboratory artifacts and insufficient post-EWQ sampling frequency (n=12). Post-EWQ median E. coli fell within the EWQ 95% confidence intervals. Note that concentrations and flows are plotted on a logarithmic scale.

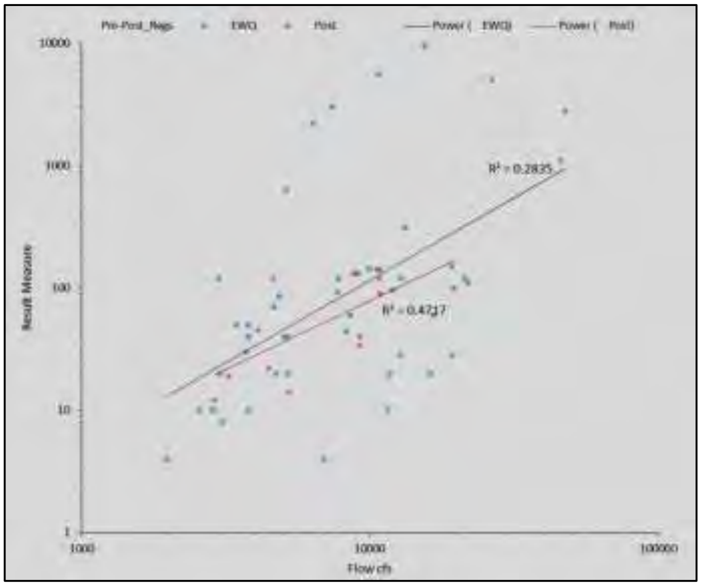
E. coli concentrations were positively but weakly related to flow in the EWQ data set, but unrelated to flow in the post-EWQ data set. Post-EWQ data were not fully representative of flow conditions. No independent data were available for validation.

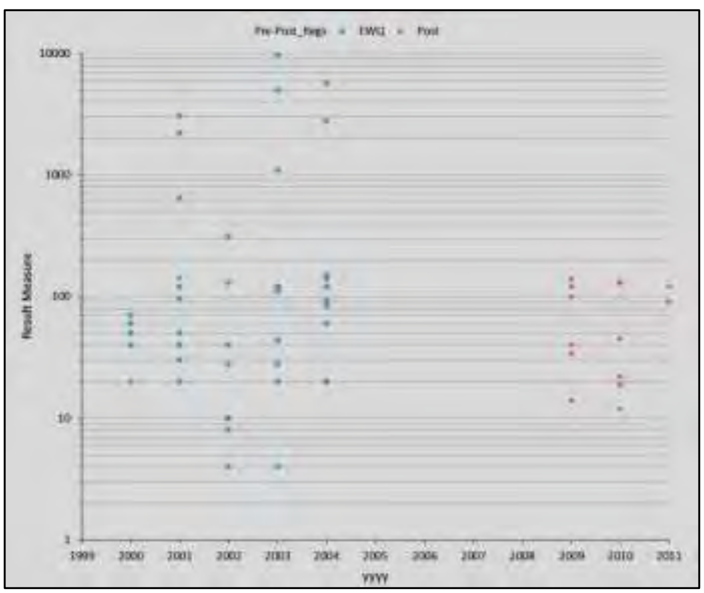
Chapter 12: 1677 ICP
Delaware River at Milford/Upper Black Eddy NJ/PA

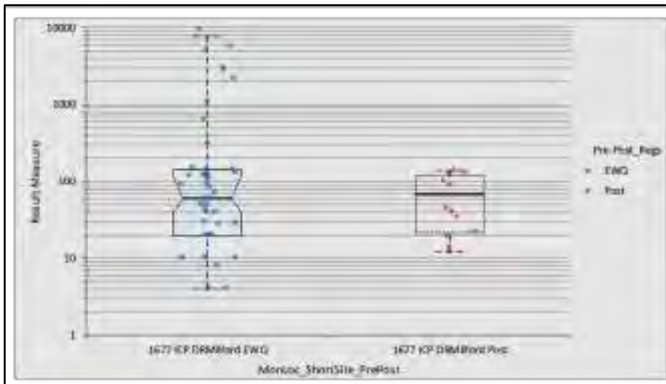
Fecal coliform colonies/100 ml

Existing Water Quality (Table 2O):

Median 60/100 ml
Lower 95% Confidence Interval 40/100 ml
Upper 95% Confidence Interval 120/100 ml
Defined in regulations as a flow-related parameter

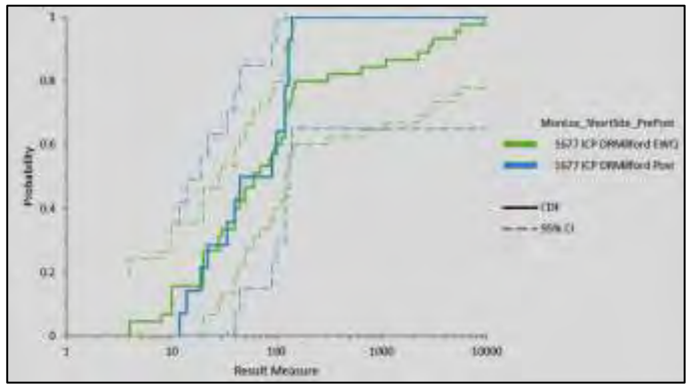






N	59

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1677 ICP DRMilford EWQ	4	20	60	141	9600	121
1677 ICP DRMilford Post	12	22	68	121	140	99



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1677 ICP DRMilford EWQ	45	9.8	0.22
1677 ICP DRMilford Post	14	31.5	2.25

H statistic	0.14
X^2 approximation	0.14
DF	1
p-value	0.7079 [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. Fecal coliform concentrations apparently did not measurably change between the EWQ and post-EWQ periods. Uncertainty is introduced into comparisons by potential laboratory artifacts and insufficient post-EWQ sampling frequency (n=14). Fecal coliform concentrations are weakly related to flow in the EWQ data set, and positively related to flow in the post-EWQ data set. Post-EWQ median concentrations were within the EWQ 95% confidence intervals. Note that concentrations and flows are plotted on a logarithmic scale.

Chapter 12: 1677 ICP

Delaware River at Milford/Upper Black Eddy NJ/PA

Hardness as CaCO3, Total mg/l

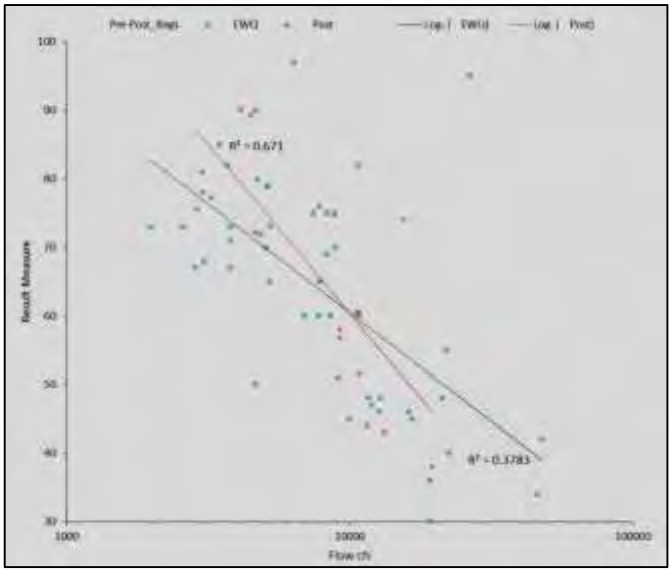
Existing Water Quality (Table 2O):

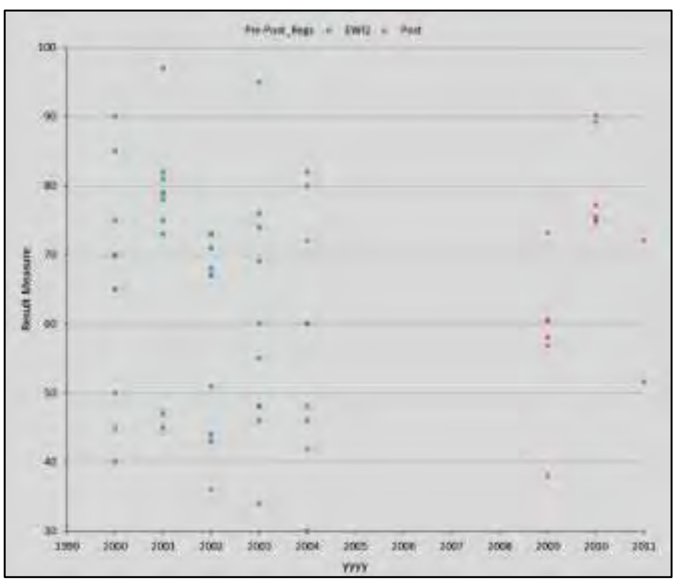
Median 67 mg/l

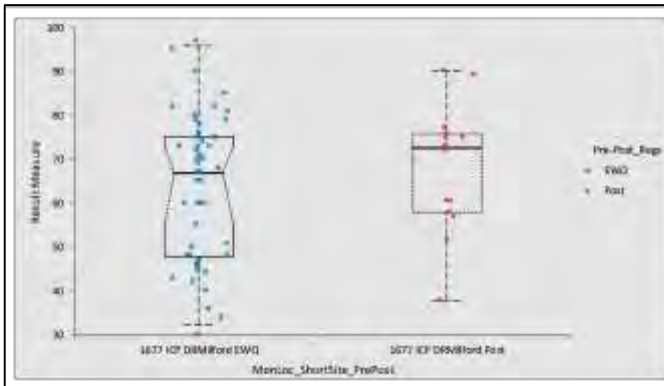
Lower 95% Confidence Interval 55 mg/l

Upper 95% Confidence Interval 73 mg/l

Defined in regulations as a flow-related parameter

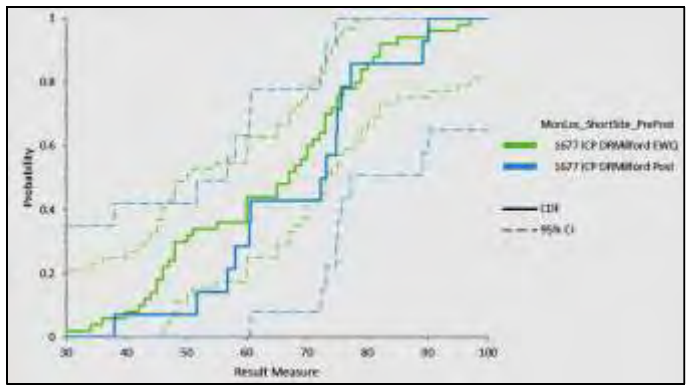






N	64

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1677 ICP DRMilford EWQ	30	48	67	75	97	27
1677 ICP DRMilford Post	38	58	73	76	90	18



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1677 ICP DRMilford EWQ	50	76.9	1.54
1677 ICP DRMilford Post	14	274.6	19.61

H statistic	1.01
X^2 approximation	1.01
DF	1
p-value	0.3138[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. Uncertainty is introduced into comparisons by potential laboratory artifacts and insufficient post-EWQ sampling frequency (n=14). Hardness is inversely related to flow in both data sets. Post-EWQ median hardness was at the EWQ upper 95% confidence interval, but the increase was not significant. Flows are plotted on a logarithmic scale.

Chapter 12: 1677 ICP

Delaware River at Milford/Upper Black Eddy NJ/PA

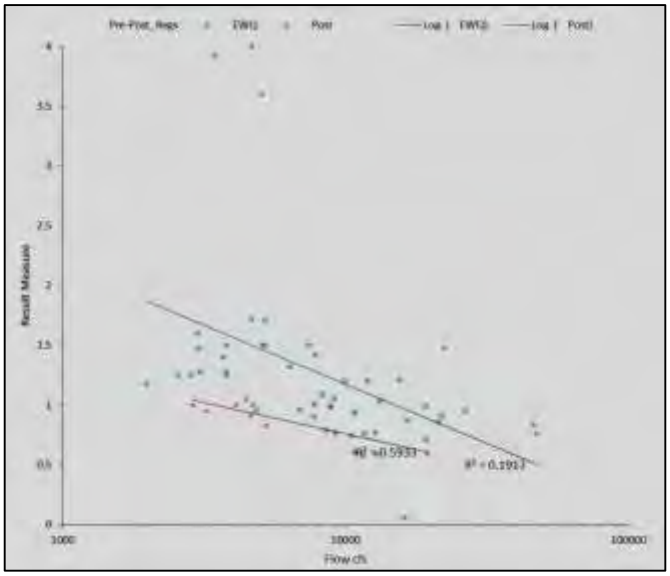
Nitrate + Nitrite as N, Total mg/l

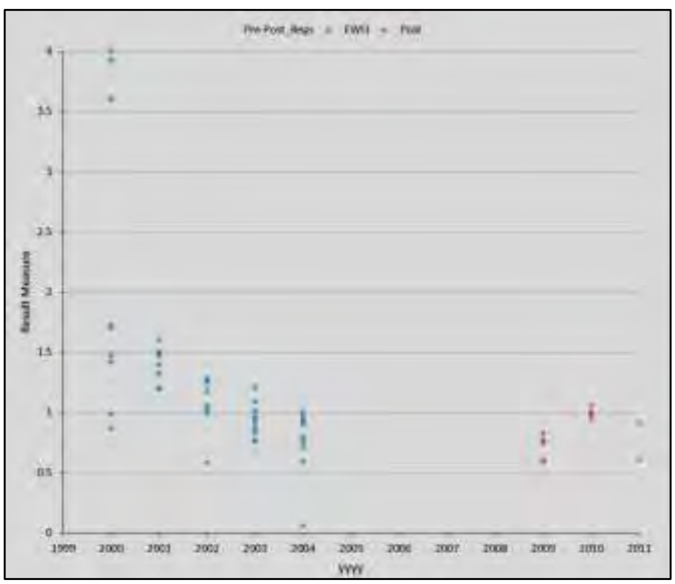
Existing Water Quality (Table 2O, as Nitrate only):

Median 1.09 mg/l

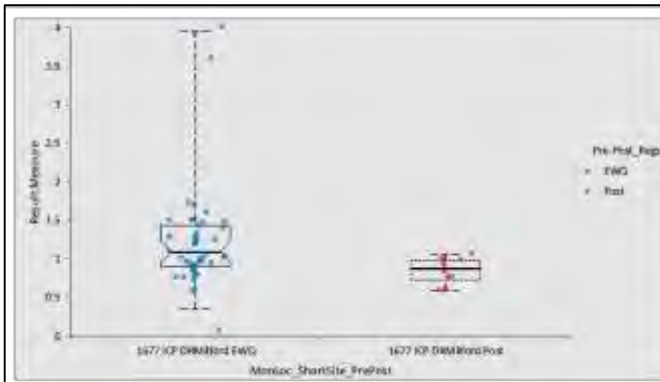
Lower 95% Confidence Interval 0.96 mg/l

Upper 95% Confidence Interval 1.25 mg/l



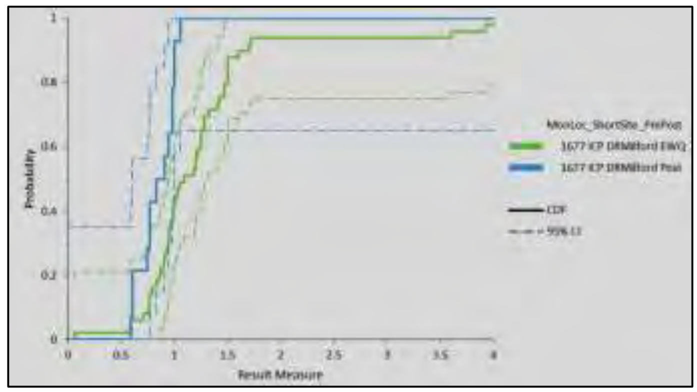


No water quality degradation is evident here. Nitrate concentrations apparently declined between the EWQ and post-EWQ periods. Uncertainty is introduced into comparisons by potential laboratory artifacts, different detection limits and insufficient post-EWQ sampling frequency (n=14).



N 63

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1677 ICP DRMilford EWQ	0.06	0.91	1.09	1.44	4.00	0.53
1677 ICP DRMilford Post	0.59	0.73	0.87	0.99	1.05	0.25



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1677 ICP DRMilford EWQ	49	668.6	13.64
1677 ICP DRMilford Post	14	2340.1	167.15

H statistic	8.96
X^2 approximation	8.96
DF	1
p-value	0.0028 [1]

H0: $\theta_1 = \theta_2 = \theta_{\dots}$

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 related to flow in the EWQ data set, but inversely related to flow in the post-EWQ data set. Post-EWQ concentrations fell below the EWQ lower 95% confidence interval. Post-EWQ nitrate + nitrite concentrations were assumed equivalent for comparison with EWQ nitrate concentrations since EWQ nitrite concentrations were never detected. Flow is plotted on a logarithmic scale. Independent data were not available for validation of DRBC data.

Chapter 12: 1677 ICP

Delaware River at Milford/Upper Black Eddy NJ/PA

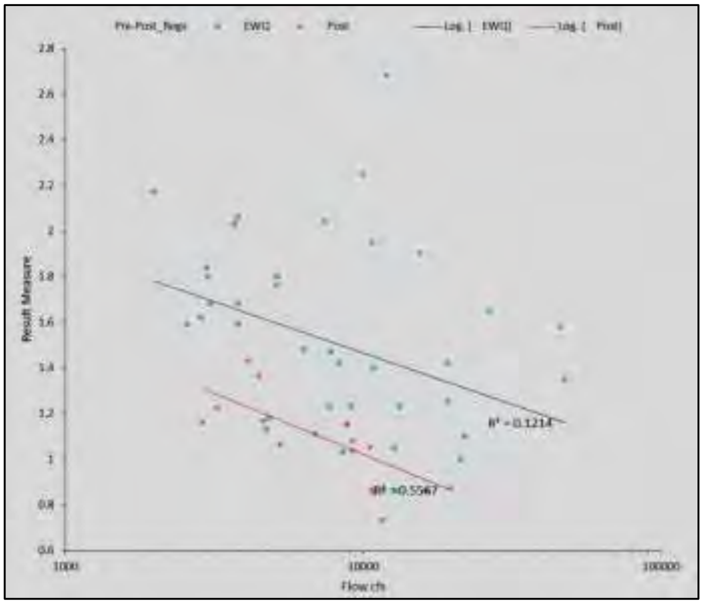
Nitrogen as N, Total (TN) mg/l

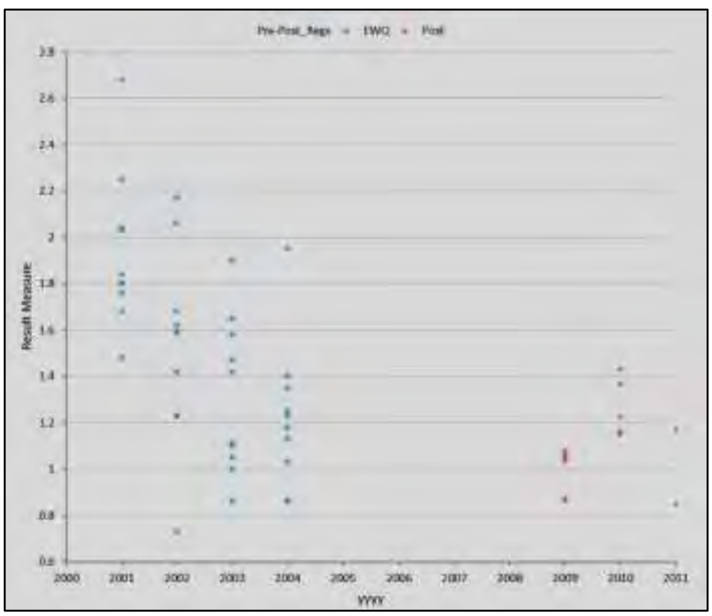
Existing Water Quality (Table 2O):

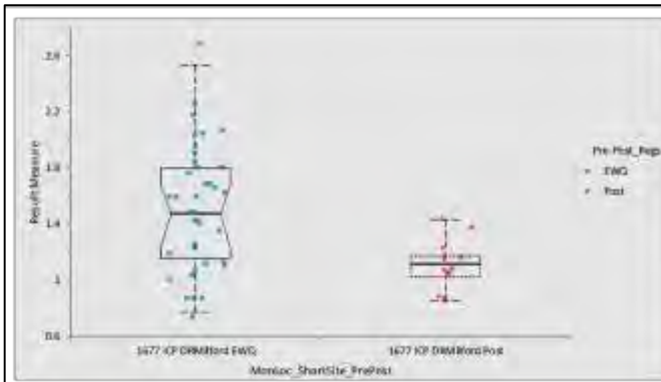
Median 1.48 mg/l

Lower 95% Confidence Interval 1.23 mg/l

Upper 95% Confidence Interval 1.68 mg/l

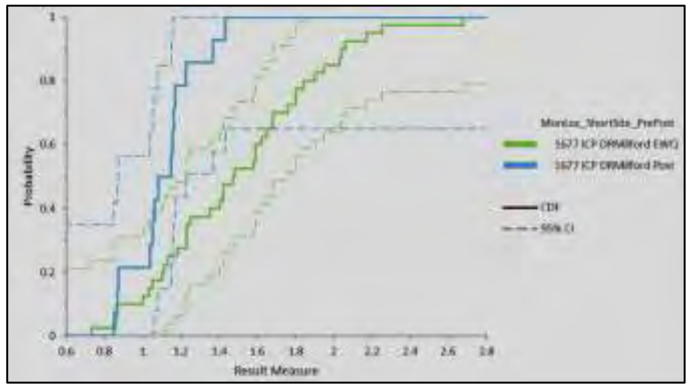






N 54

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1677 ICP DRMilford EWQ	0.73	1.15	1.48	1.80	2.68	0.65
1677 ICP DRMilford Post	0.85	1.02	1.11	1.17	1.43	0.15



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1677 ICP DRMilford EWQ	40	624.1	15.60
1677 ICP DRMilford Post	14	1783.1	127.37

H statistic	9.73
X² approximation	9.73
DF	1
p-value	0.0018[1]

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

The median of the populations are all equal.

H1: $\theta_i \neq \theta_j$ for at least one i,j

The median of the populations are not all equal.

[1] Reject the null hypothesis in favour of the alternative hypothesis at the 5% significance level.

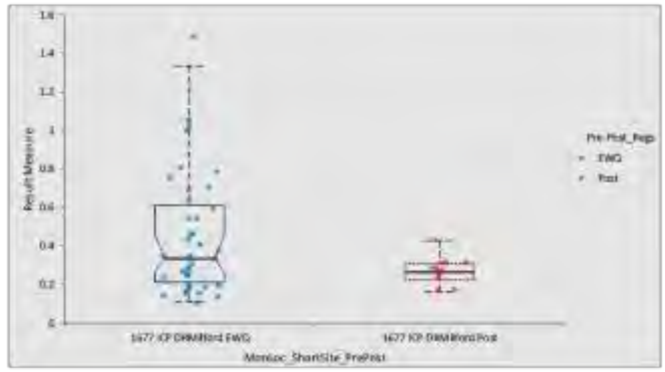
No water quality degradation is evident here. Total Nitrogen concentrations apparently declined between the EWQ and post-EWQ periods. Uncertainty is introduced into comparisons by potential laboratory artifacts, different detection limits and insufficient post-EWQ sampling frequency (n=14). TN is inversely related to flow in the post-EWQ data set, but unrelated to flow in the EWQ data set. Flow is plotted on a logarithmic scale. DRBC results could not be independently validated. Post-EWQ median TN concentrations fell below the EWQ lower 95% confidence interval.

Chapter 12: 1677 ICP
Delaware River at Milford/Upper Black Eddy NJ/PA

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

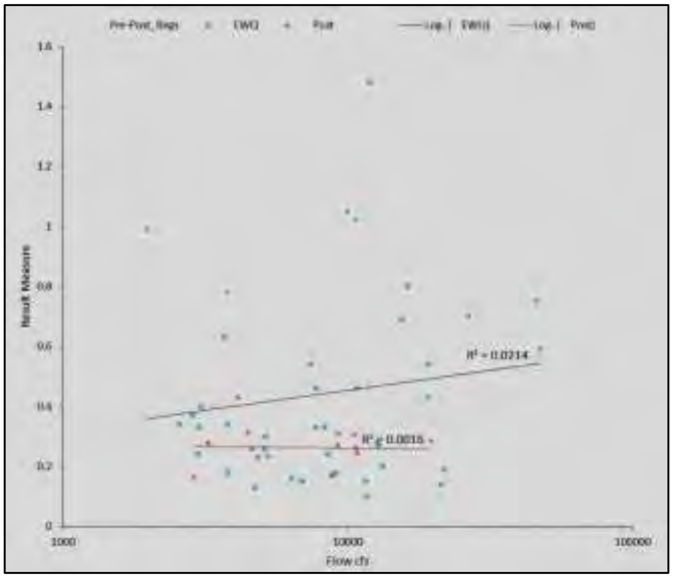
Existing Water Quality (Table 2O):

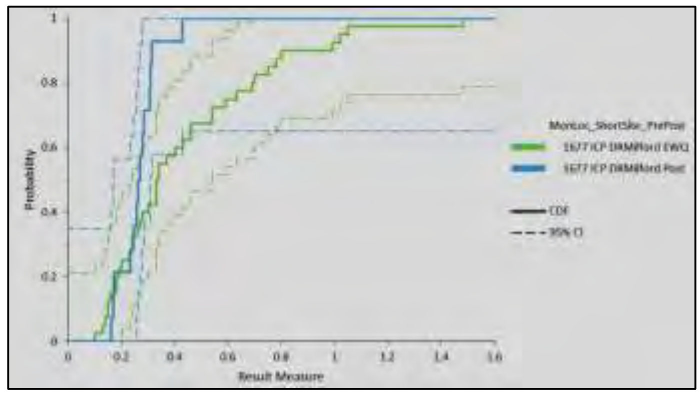
Median 0.34 mg/l
Lower 95% Confidence Interval 0.26 mg/l
Upper 95% Confidence Interval 0.46 mg/l

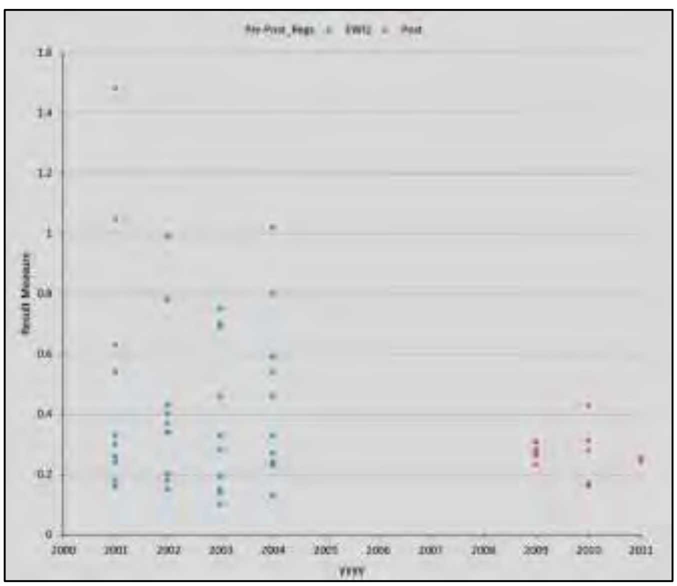


N 54

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1677 ICP DRMilford EWQ	0.10	0.21	0.34	0.61	1.48	0.40
1677 ICP DRMilford Post	0.16	0.23	0.27	0.31	0.43	0.08







Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1677 ICP DRMilford EWQ	40	207.0	5.18
1677 ICP DRMilford Post	14	591.5	42.25

H statistic	3.23
X^2 approximation	3.23
DF	1
p-value	0.0724 [1]

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

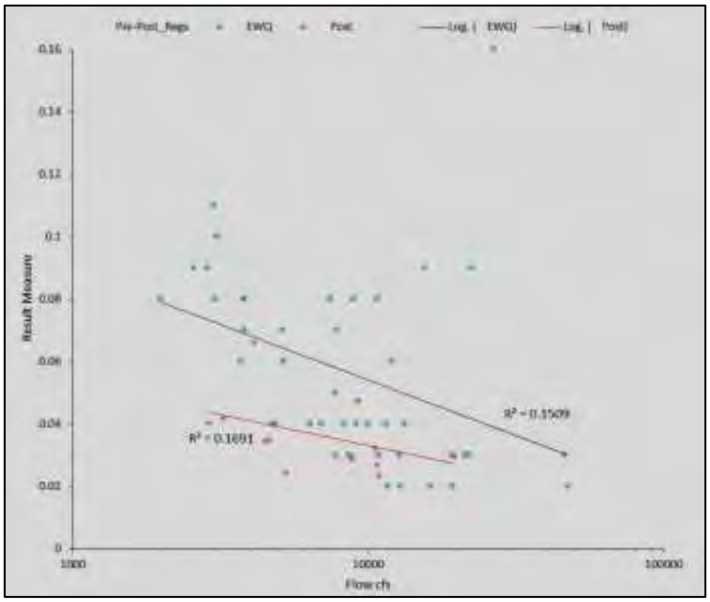
No water quality degradation is evident here. TKN concentrations apparently did not measurably change between the EWQ and post-EWQ periods, though the post-EWQ range was far narrower and all concentrations were less than 0.5 mg/l. Uncertainty is introduced into comparisons by potential laboratory artifacts and insufficient post-EWQ sampling frequency (n=14). TKN concentration is unrelated to flow in both data sets. Flow is plotted on a logarithmic scale. Post-EWQ median TKN was within the EWQ 95% confidence intervals but very near the lower interval.

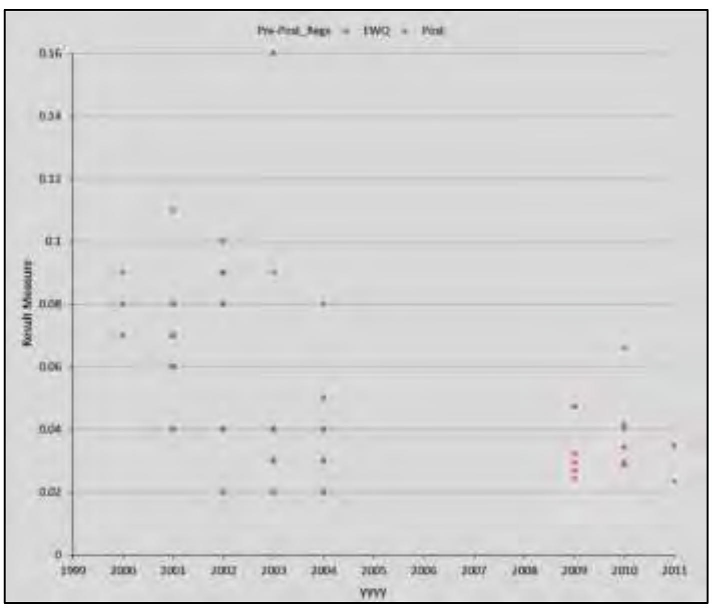
Chapter 12: 1677 ICP
Delaware River at Milford/Upper Black Eddy NJ/PA

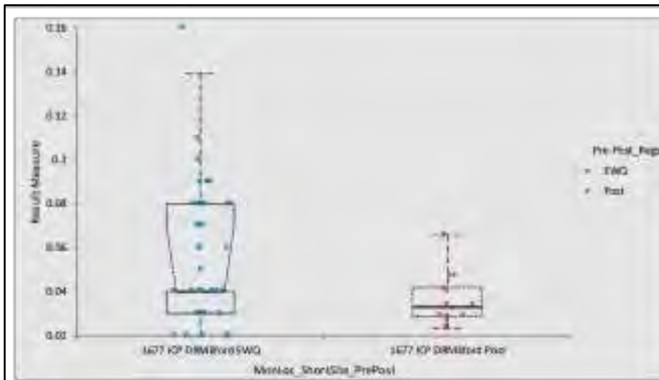
Orthophosphate as P, Total mg/l

Existing Water Quality (Table 2O):

Median 0.04 mg/l
Lower 95% Confidence Interval 0.04 mg/l
Upper 95% Confidence Interval 0.07 mg/l

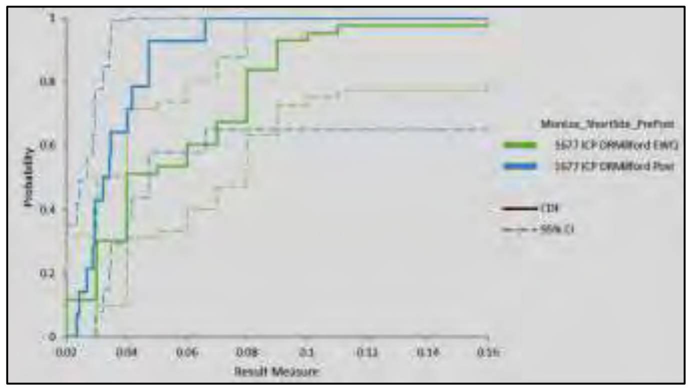






N 57

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1677 ICP DRMilford EWQ	0.02	0.03	0.04	0.08	0.16	0.05
1677 ICP DRMilford Post	0.02	0.03	0.03	0.04	0.07	0.01



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1677 ICP DRMilford EWQ	43	323.8	7.53
1677 ICP DRMilford Post	14	994.6	71.04

H statistic	4.83
X^2 approximation	4.83
DF	1
p-value	0.0279 [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.

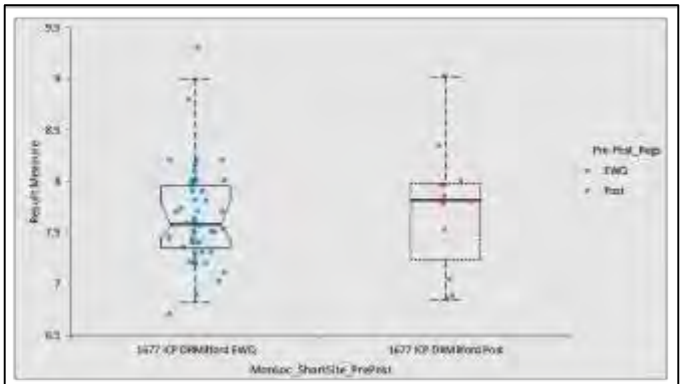
No water quality degradation is evident here. Orthophosphate concentrations apparently declined. Uncertainty in comparisons was introduced by potential laboratory artifacts, declining detection limits and insufficient post-EWQ sampling frequency. Both data sets are weakly and inversely related to flow. Post-EWQ median orthophosphate fell below the EWQ lower 95% confidence interval. A water quality improvement is evidenced in that there were no post-EWQ concentrations higher than 0.07 mg/l. There were no independent data to confirm DRBC results.

Chapter 12: 1677 ICP
Delaware River at Milford/Upper Black Eddy NJ/PA

pH

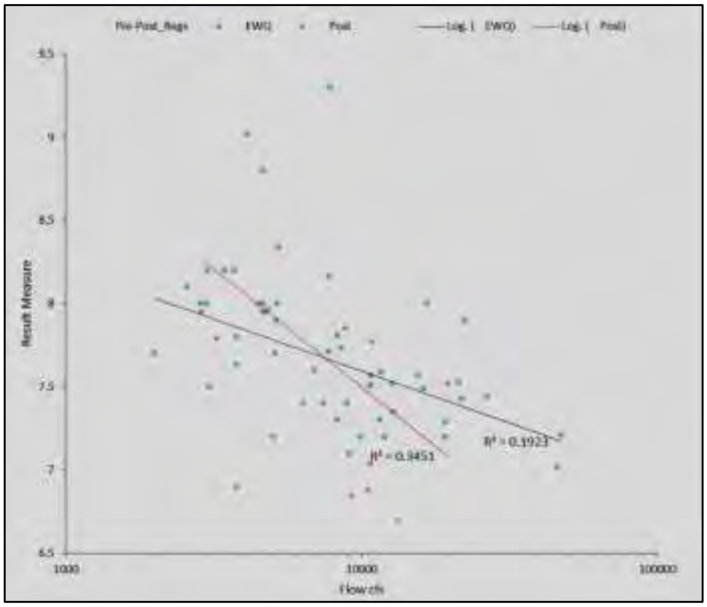
Existing Water Quality (Table 2O):

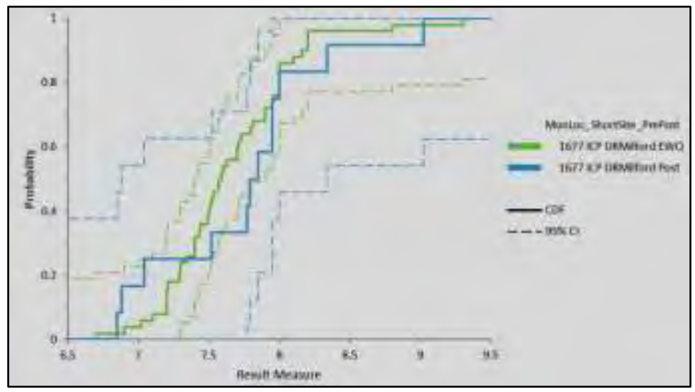
Median 7.58 standard units
Lower 95% Confidence Interval 7.44 standard units
Upper 95% Confidence Interval 7.80 standard units

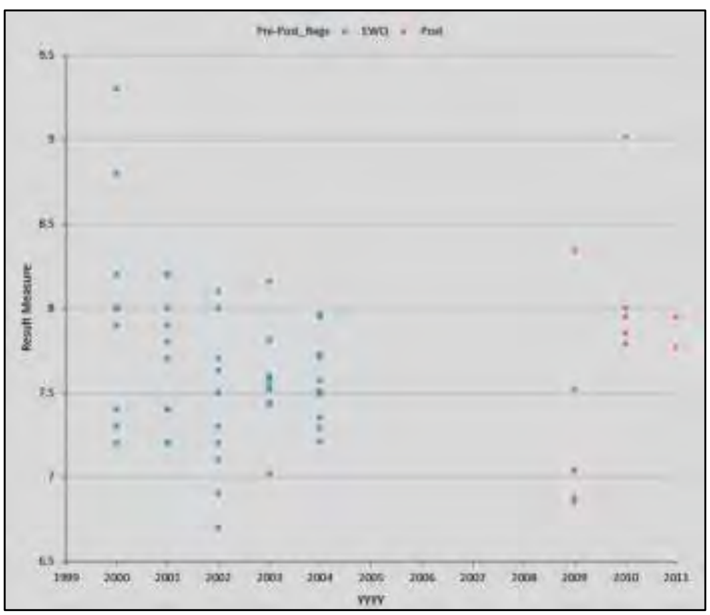


N 62

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1677 ICP DRMilford EWQ	6.70	7.35	7.58	7.96	9.30	0.62
1677 ICP DRMilford Post	6.85	7.24	7.82	7.98	9.02	0.74







Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1677 ICP DRMilford EWQ	50	24.5	0.49
1677 ICP DRMilford Post	12	102.1	8.51

H statistic	0.39
X^2 approximation	0.39
DF	1
p-value	0.5326 [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.

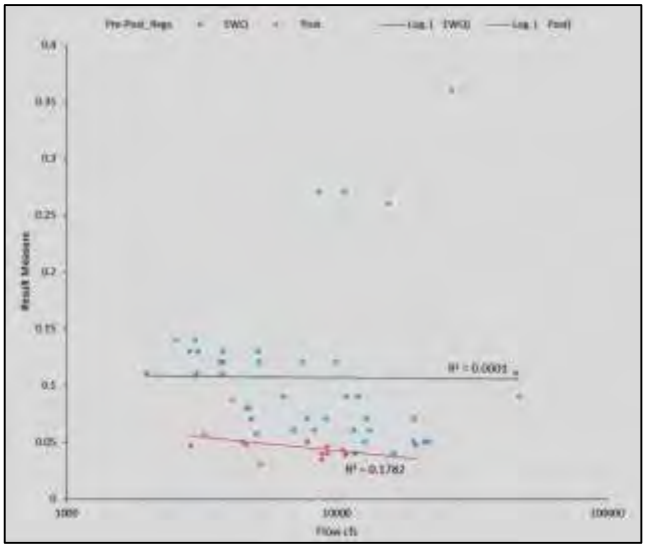
No water quality degradation is evident here. pH did not measurably change between the EWQ and post-EWQ periods. pH is weakly related to flow in both data sets. Note that flows are plotted on a logarithmic scale. Post-EWQ median pH was just above the EWQ upper 95% confidence interval, but the increase was statistically insignificant. There were too few samples collected in the post-EWQ period. This is a wide, shallow reach of the Delaware, where primary productivity is high – indicated by occasional spikes above pH 9.

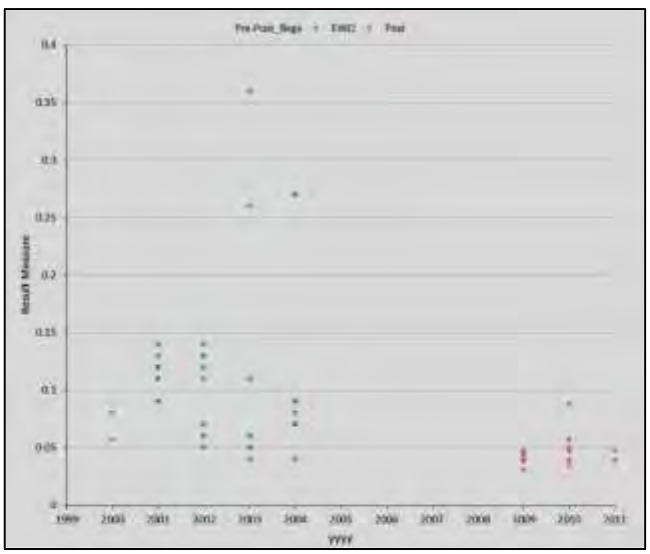
Chapter 12: 1677 ICP
Delaware River at Milford/Upper Black Eddy NJ/PA

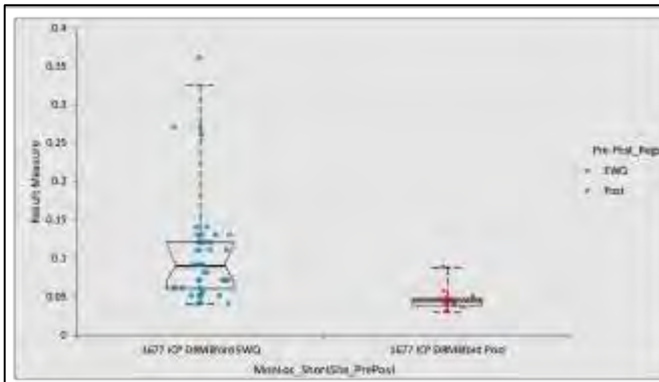
Phosphorus as P, Total (TP) mg/l

Existing Water Quality (Table 2O):

Median 0.09 mg/l
Lower 95% Confidence Interval 0.07 mg/l
Upper 95% Confidence Interval 0.12 mg/l

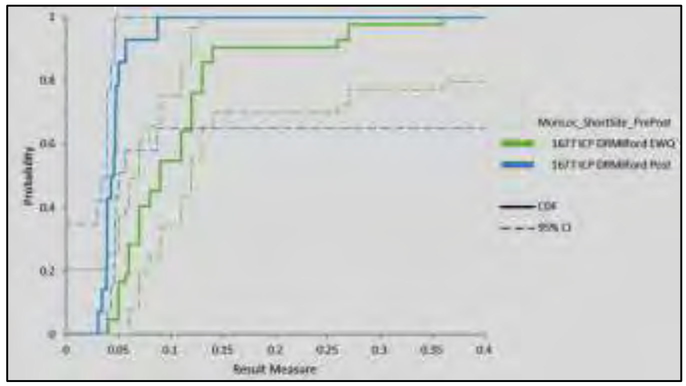






N 56

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1677 ICP DRMilford EWQ	0.04	0.06	0.09	0.12	0.36	0.06
1677 ICP DRMilford Post	0.03	0.04	0.04	0.05	0.09	0.01



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1677 ICP DRMilford EWQ	42	1530.1	36.43
1677 ICP DRMilford Post	14	4590.2	327.87

H statistic	23.10
X^2 approximation	23.10
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.

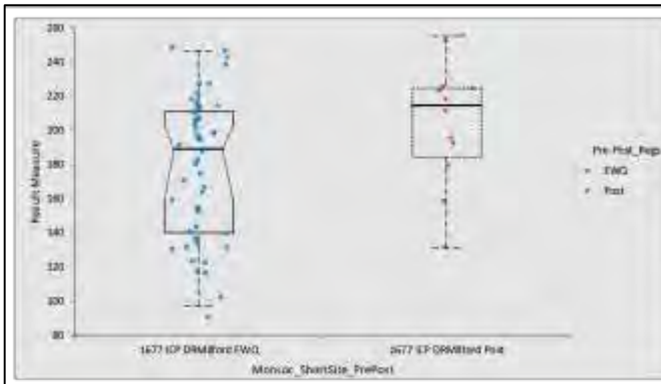
No water quality degradation is evident here. Total Phosphorus (TP) concentrations apparently declined between the EWQ and post-EWQ periods. Uncertainty in comparisons was introduced by potential laboratory artifacts, declining detection limits and insufficient post-EWQ sampling frequency (n=14). Post-EWQ median total phosphorus fell below the EWQ lower 95% confidence interval. TP is unrelated to flow in both data sets. Flow is plotted on a logarithmic scale. No independent data were available to confirm these results.

Chapter 12: 1677 ICP
Delaware River at Milford/Upper Black Eddy NJ/PA

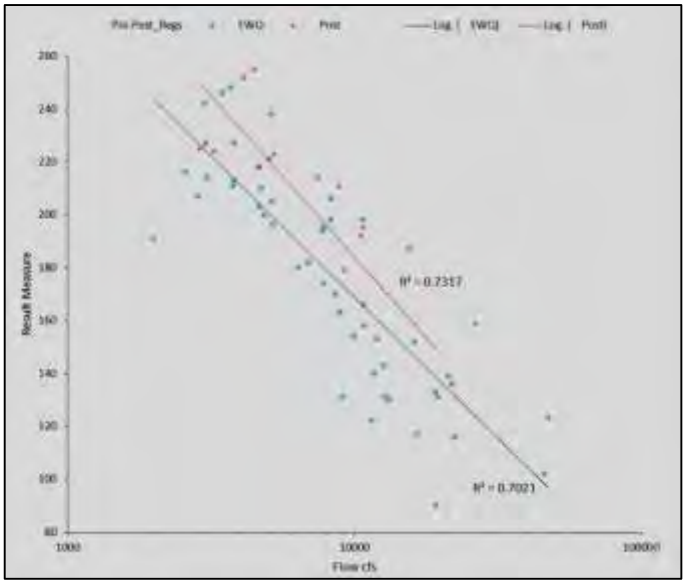
Specific Conductance µmho/cm

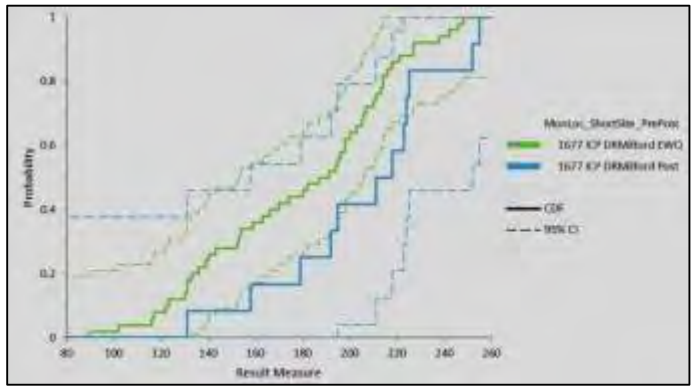
Existing Water Quality (Table 2O):

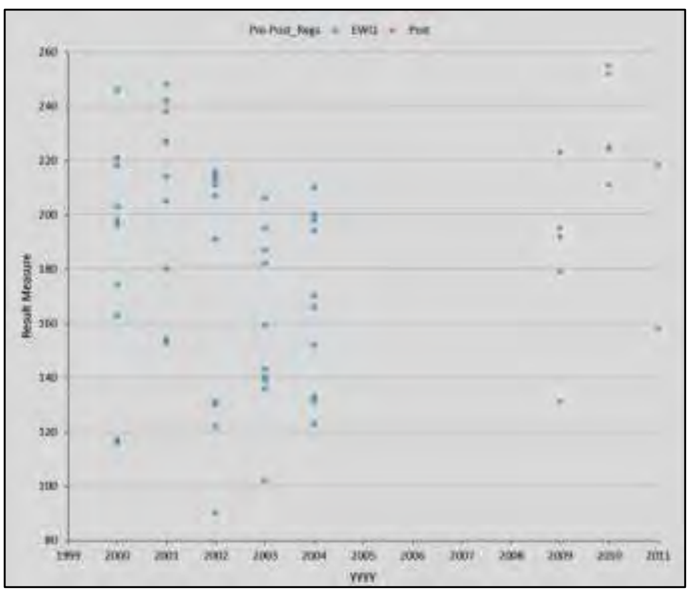
Median 189 µmho/cm
Lower 95% Confidence Interval 159 µmho/cm
Upper 95% Confidence Interval 203 µmho/cm
Defined in regulations as a flow-related parameter



N	62					
Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1677 ICP DRMilford EWQ	90	140	189	211	248	71
1677 ICP DRMilford Post	131	184	215	225	255	40







Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1677 ICP DRMilford EWQ	50	253.1	5.06
1677 ICP DRMilford Post	12	1054.7	87.89

H statistic	4.02
X^2 approximation	4.02
DF	1
p-value	0.0450[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.

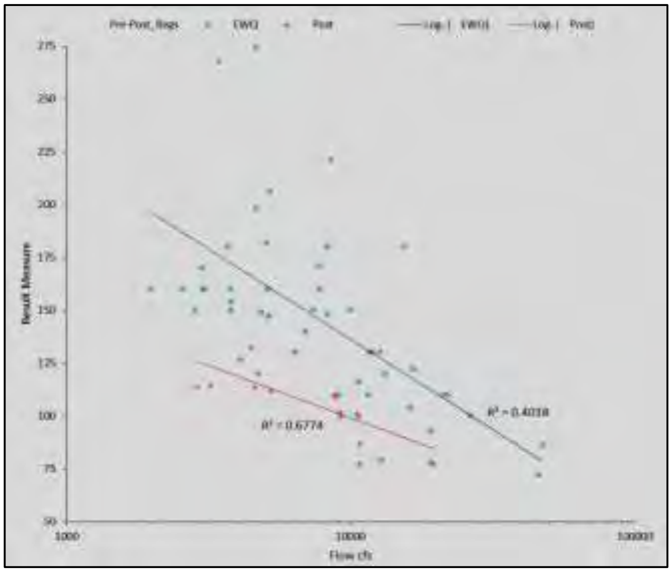
Water quality degradation is evident here. Specific conductance rose by 26 µmhos/cm; above the EWQ upper 95% confidence interval. However, uncertainty is introduced by insufficient post-EWQ sampling frequency and under-sampling of the full range of flow conditions. Specific conductance is inversely related to flow in both data sets. Flow is plotted on logarithmic scale. The rise in specific conductance may be associated with the concurrent rise in chloride concentrations. Median specific conductance has risen from 189 to 215 µmhos/cm; a 14% increase.

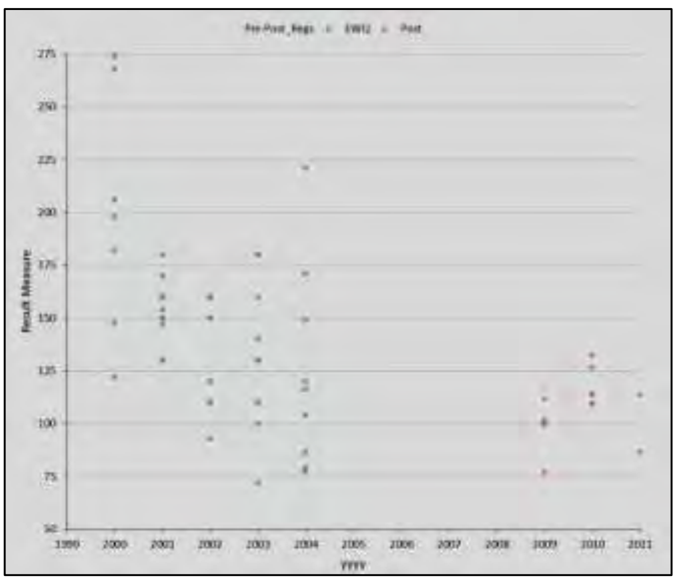
Chapter 12: 1677 ICP
Delaware River at Milford/Upper Black Eddy NJ/PA

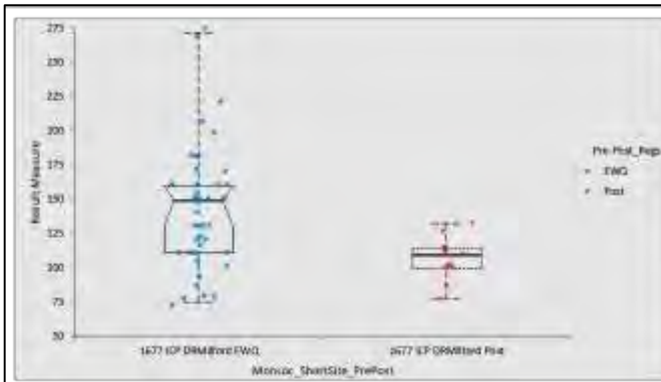
Total Dissolved Solids (TDS) mg/l

Existing Water Quality (Table 2O):

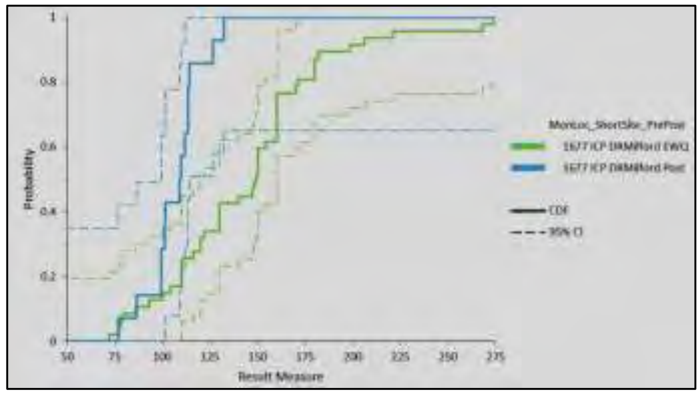
Median 149 mg/l
Lower 95% Confidence Interval 130 mg/l
Upper 95% Confidence Interval 160 mg/l
Defined in regulations as a flow-related parameter







	N	61				
Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1677 ICP DRMilford EWQ	72	111	149	160	274	49
1677 ICP DRMilford Post	77	99	109	114	132	14



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1677 ICP DRMilford EWQ	47	825.7	17.57
1677 ICP DRMilford Post	14	2772.1	198.01

H statistic	11.44
X² approximation	11.44
DF	1
p-value	0.0007[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.

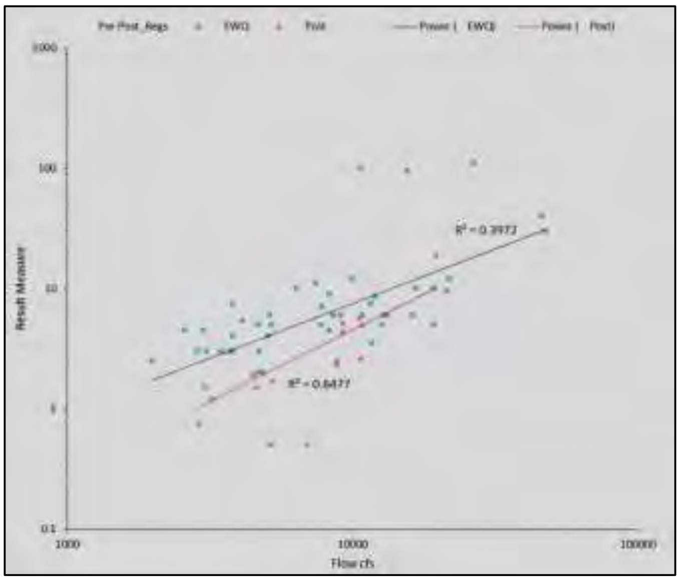
No water quality degradation is evident here. TDS apparently declined between the EWQ and post-EWQ periods. Uncertainty in comparisons was introduced by potential laboratory artifacts and insufficient post-EWQ sampling frequency (n=14). TDS is inversely related to flow in both data sets. Post-EWQ median TDS fell below the EWQ lower 95% lower confidence interval. Post-EWQ TDS was much less variable than the baseline samples as well. There were no undetected results at any time. Flow is plotted on a logarithmic scale.

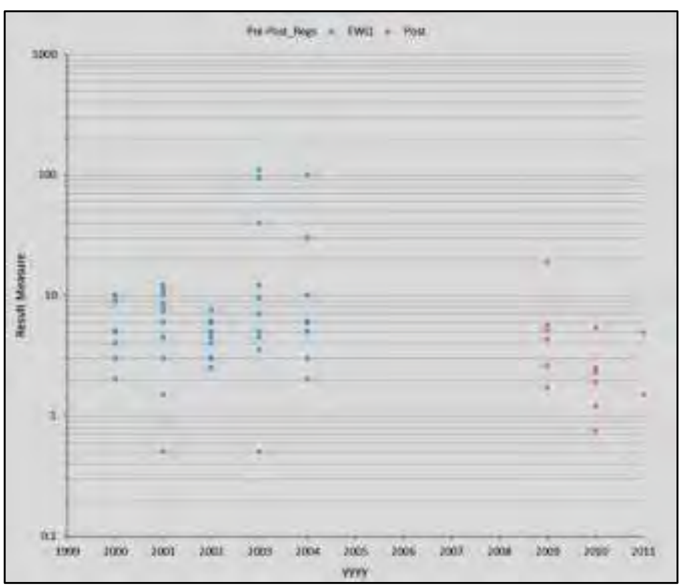
Chapter 12: 1677 ICP
Delaware River at Milford/Upper Black Eddy NJ/PA

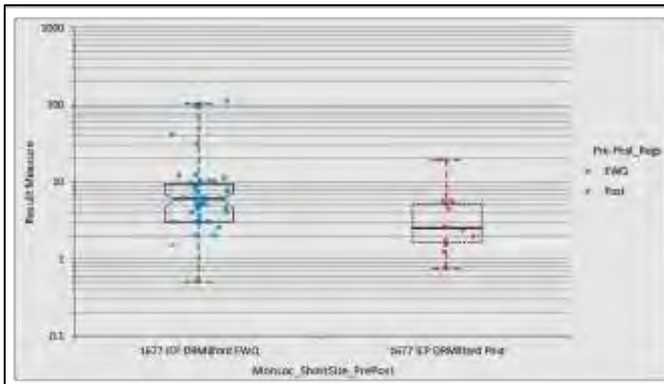
Total Suspended Solids (TSS) mg/l

Existing Water Quality (Table 2O):

Median 6.0 mg/l
Lower 95% Confidence Interval 4.5 mg/l
Upper 95% Confidence Interval 7.0 mg/l
Defined in regulations as a flow-related parameter

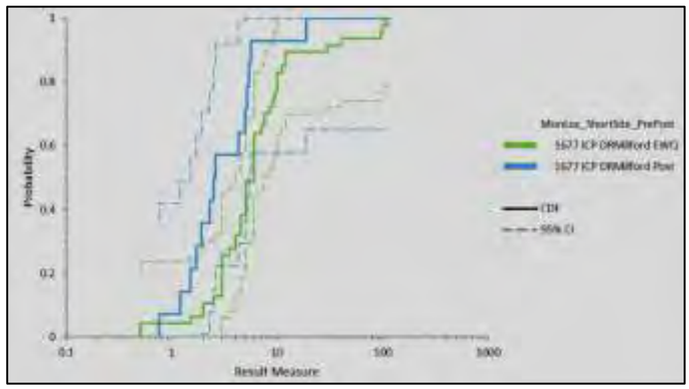






N 61

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1677 ICP DRMilford EWQ	0.5	3.1	6.0	9.4	110.0	6.3
1677 ICP DRMilford Post	0.8	1.7	2.6	5.2	18.8	3.5



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1677 ICP DRMilford EWQ	47	511.2	10.88
1677 ICP DRMilford Post	14	1716.1	122.58

H statistic	7.09
X^2 approximation	7.09
DF	1
p-value	0.0078 [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.

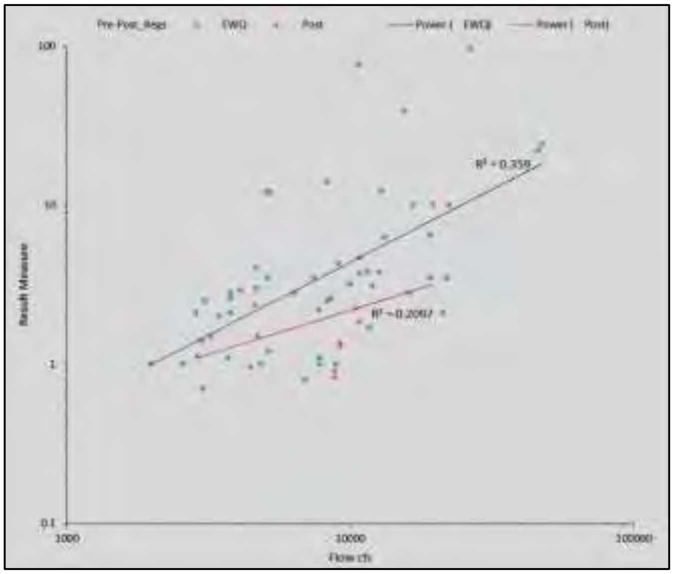
No water quality degradation is evident here. TSS apparently declined between EWQ and post-EWQ periods. Uncertainty in comparisons was introduced by potential laboratory artifacts, insufficient post-EWQ sampling frequency, and under-representation of post-EWQ flow conditions. TSS is positively related to flow in both data sets. Post-EWQ median TSS fell below the lower EWQ 95% confidence interval. Both flow and concentration are plotted on a logarithmic scale.

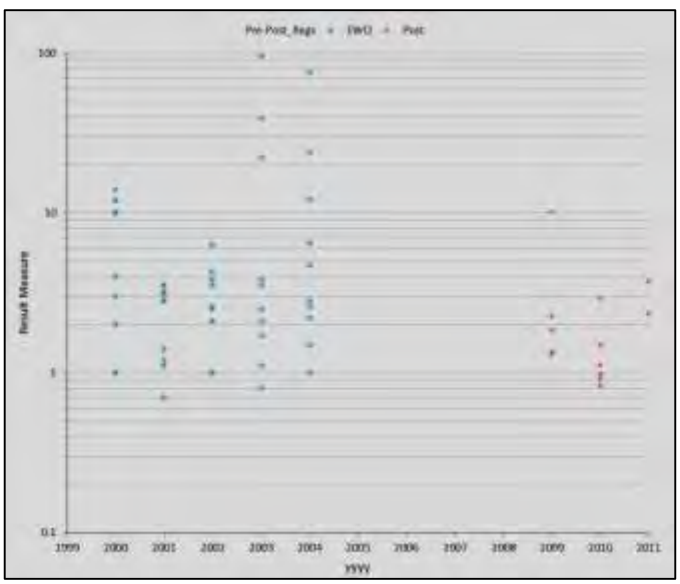
Chapter 12: 1677 ICP
Delaware River at Milford/Upper Black Eddy NJ/PA

Turbidity NTU

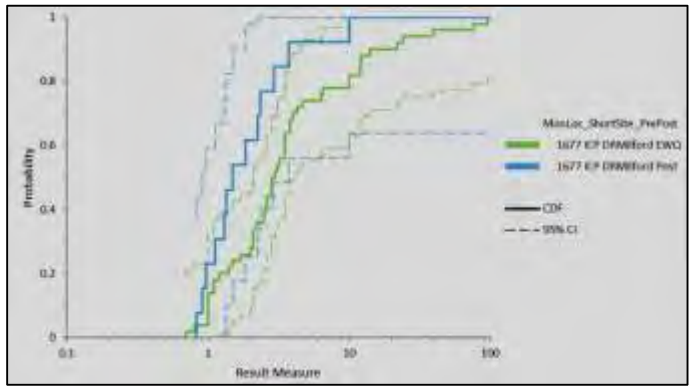
Existing Water Quality (Table 2O):

Median 2.9 NTU
Lower 95% Confidence Interval 2.2 NTU
Upper 95% Confidence Interval 3.8 NTU
Defined in regulations as a flow-related parameter





N	63					
Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1677 ICP DRMilford EWQ	0.7	1.7	2.9	6.3	96.0	4.6
1677 ICP DRMilford Post	0.8	1.1	1.5	2.5	10.1	1.5



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1677 ICP DRMilford EWQ	50	348.5	6.97
1677 ICP DRMilford Post	13	1340.3	103.10

H statistic	5.03
X^2 approximation	5.03
DF	1
p-value	0.0249 [1]

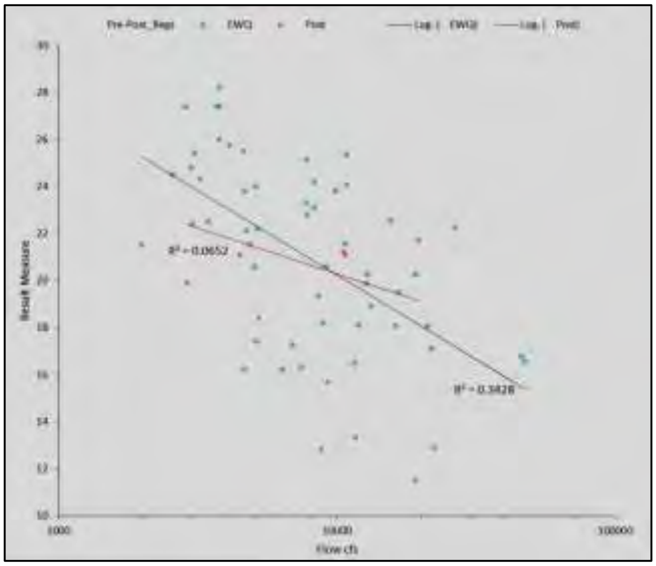
H0: $\theta_1 = \theta_2 = \theta ...$
The median of the populations are all equal.
H1: $\theta_i \neq \theta_j$ for at least one i,j
The median of the populations are not all equal.
[1] Reject the null hypothesis in favour of the alternative hypothesis at the 5% significance level.

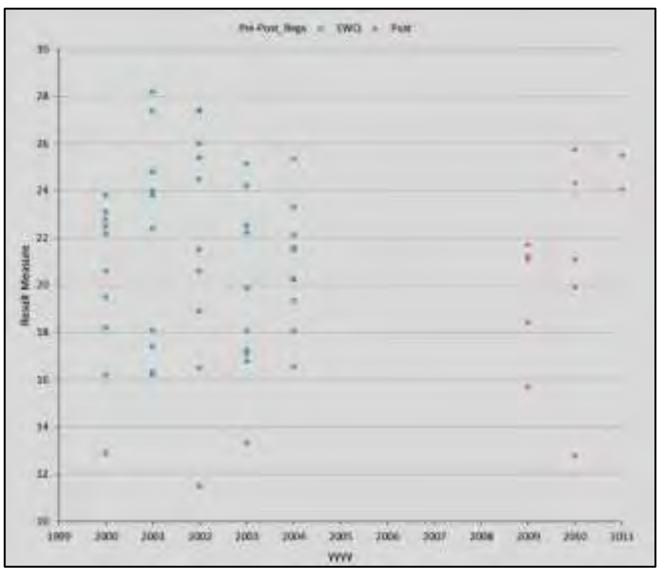
No water quality degradation is evident here. Turbidity appeared to decline between the EWQ and post-EWQ periods. Uncertainty in comparisons was introduced by insufficient post-EWQ sampling frequency (n=13). Post-EWQ median turbidity fell below the EWQ 95% confidence interval. Turbidity is weakly related to flow in both data sets. Both concentration and flow are represented on logarithmic scales.

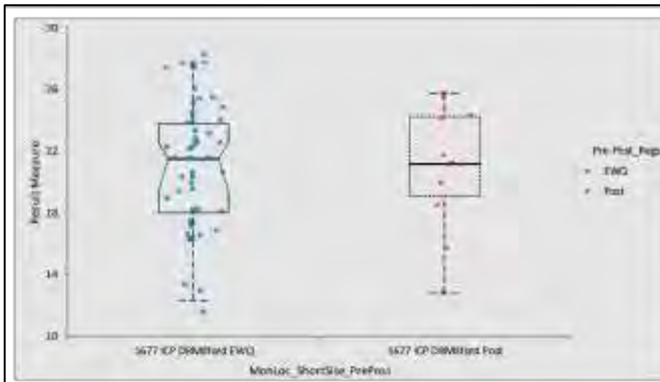
Chapter 12: 1677 ICP
Delaware River at Milford/Upper Black Eddy NJ/PA

Water Temperature, degrees C

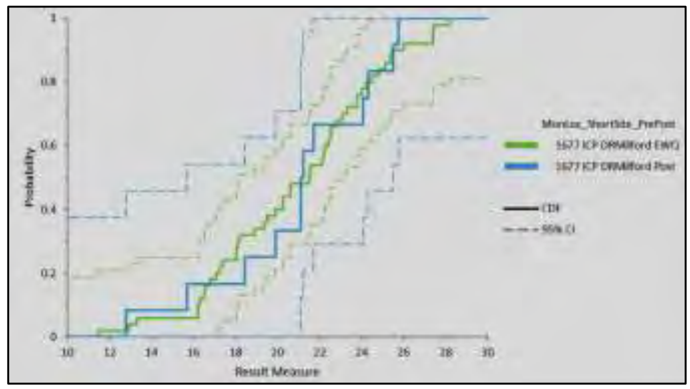
Not included in DRBC Existing Water Quality rules







N	62					
Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1677 ICP DRMilford EWQ	11.5	18.0	21.5	23.8	28.2	5.8
1677 ICP DRMilford Post	12.8	19.0	21.2	24.2	25.8	5.2



Kruskal-Wallis test

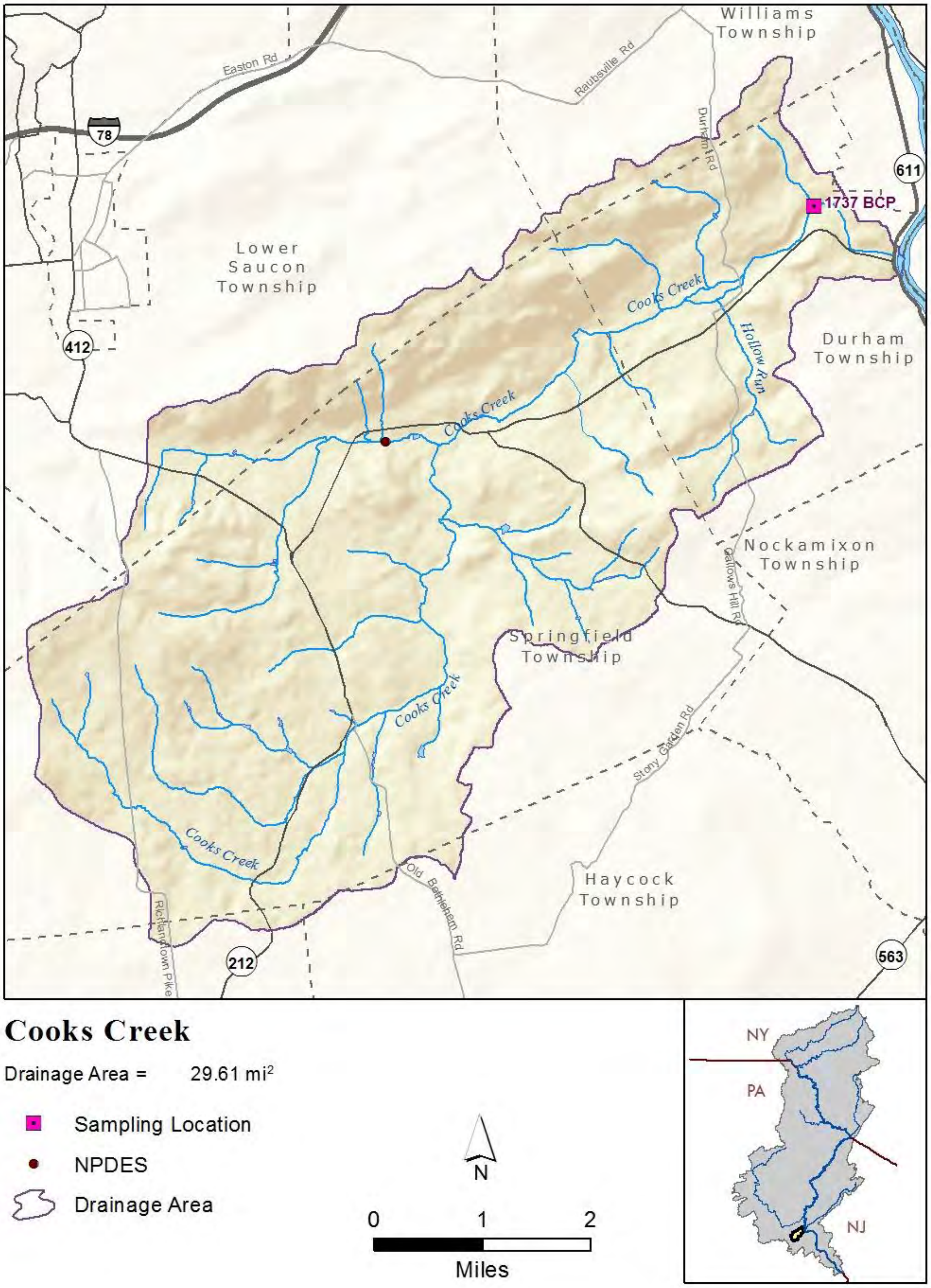
Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1677 ICP DRMilford EWQ	50	1.3	0.03
1677 ICP DRMilford Post	12	5.3	0.44

H statistic	0.02
X^2 approximation	0.02
DF	1
p-value	0.8866 [1]

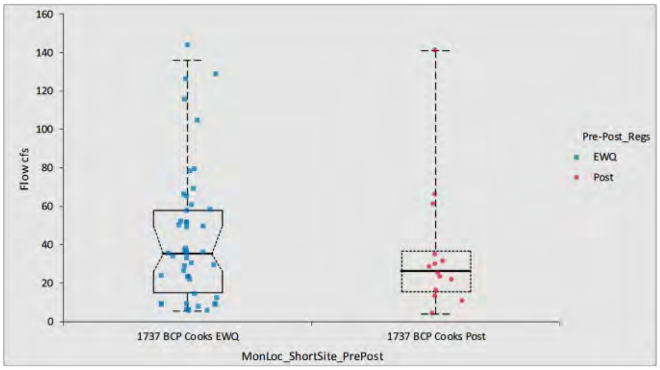
H0: $\theta_1 = \theta_2 = \theta\ldots$
The median of the populations are all equal.
H1: $\theta_i \neq \theta_j$ for at least one i,j
The median of the populations are not all equal.
[1] Do not reject the null hypothesis at the 5% significance level.

No water quality degradation is evident here. Water temperature did not measurably change between the EWQ and post-EWQ periods. Uncertainty in comparisons was introduced by insufficient post-EWQ sampling frequency (n=12). Water temperature is weakly related to flow in both data sets. Flow is plotted on a logarithmic scale.

Chapter 13: 1737 BCP Cooks Creek, Bucks & Northampton Counties, PA



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



N 61

Flow cfs by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1737 BCP Cooks EWQ	5.70	15.2	35.3	57.8	143.8	42.6
1737 BCP Cooks Post	4.00	15.7	26.5	36.7	141.0	21.1

Flow was roughly the same between the EWQ and post-EWQ periods. Fewer samples were collected in the post-EWQ period. Although the range of flow conditions sampled was equal, fewer samples were collected within the 40 to 140 cfs range. Flow is plotted on a logarithmic scale.

Kruskal-Wallis test

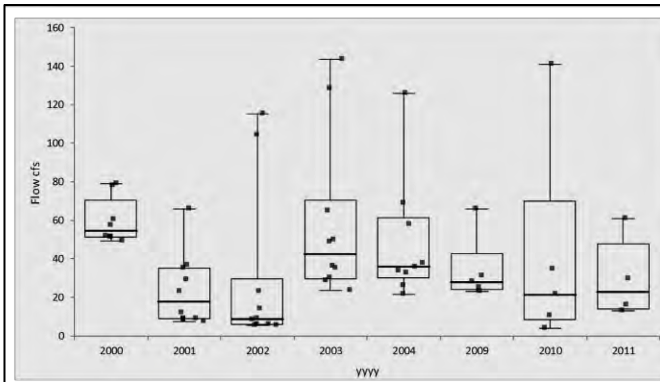
Flow cfs by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1737 BCP Cooks EWQ	47	64.4	1.37
1737 BCP Cooks Post	14	216.1	15.43

H statistic	0.89
X^2 approximation	0.89
DF	1
p-value	0.3455[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.

An insufficient number of samples were collected in the post-EWQ period (n=14). In the future, bi-weekly instead of monthly sampling is recommended.

At the Red Bridge Road site, the upstream Cooks Creek watershed area is 29.6 square miles. The watershed is about 60% forested, and 1.3% urban land cover. The watershed is about 36% underlain by carbonate bedrock, so expected water quality includes significant limestone influence.



N 61

Flow cfs by yyyy	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
2000	49.2	51.6	54.4	70.5	79.0	19.0
2001	7.4	8.8	17.7	35.4	65.9	26.7
2002	5.7	6.0	8.8	29.8	115.5	23.8
2003	23.9	29.8	42.6	70.4	143.8	40.6
2004	21.7	30.3	35.9	61.6	125.9	31.3
2009	23.0	24.3	28.0	42.6	65.9	18.3
2010	4.0	8.3	21.4	70.0	141.0	61.7
2011	13.0	14.2	22.8	48.0	61.0	33.8

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 is about 44.5 cfs; and harmonic mean flow is about 24.1 cfs (USGS StreamStats retrieval February 2013) which is more typical of summer flow conditions. Though DRBC sampled a wide range of flows, these data appear to be most representative of low to normal flow conditions. Flows corresponding to each water quality sample were estimated using either a gage-discharge rating constructed by DRBC or a Delaware River Basin adaptation of the USGS BaSE* program once DRBC stopped maintaining the gage. There was an excellent correspondence between sample flows determined by the DRBC gage and BaSE-derived estimates. Maintaining a gage at DRBC's monitoring site is not economically viable.

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

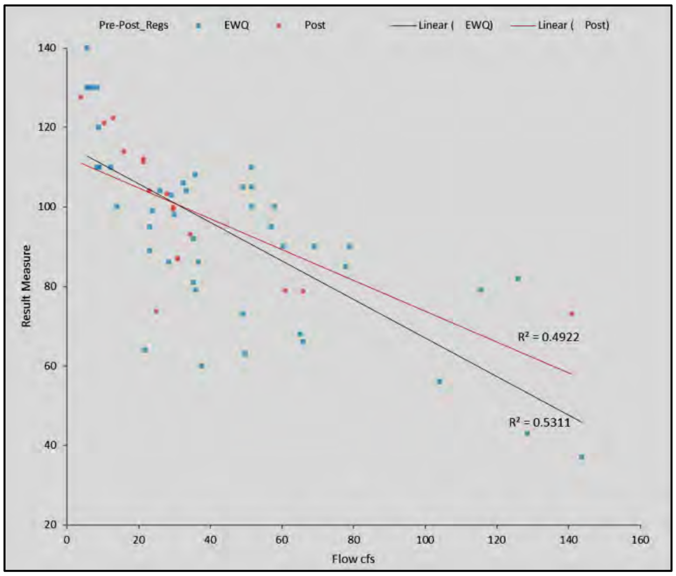
Upstream ICP: Delaware River at Riegelsville 1748 ICP
Downstream ICP: Delaware River at Milford 1677 ICP

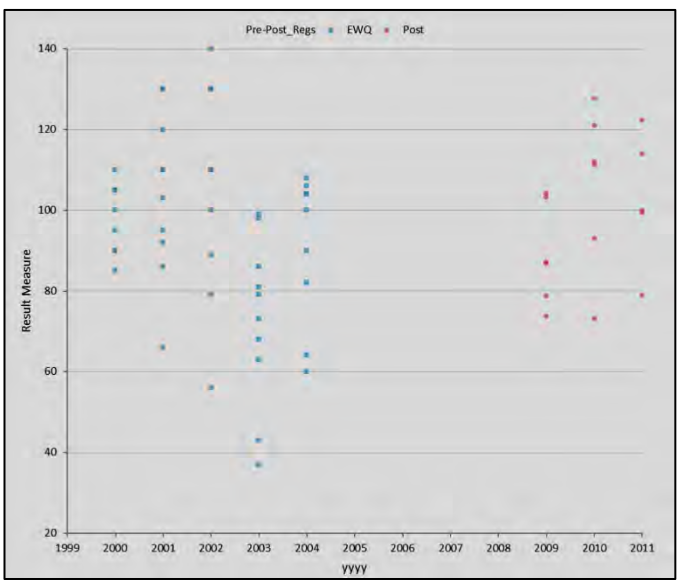
Chapter 13: 1737 BCP Cooks Creek, PA

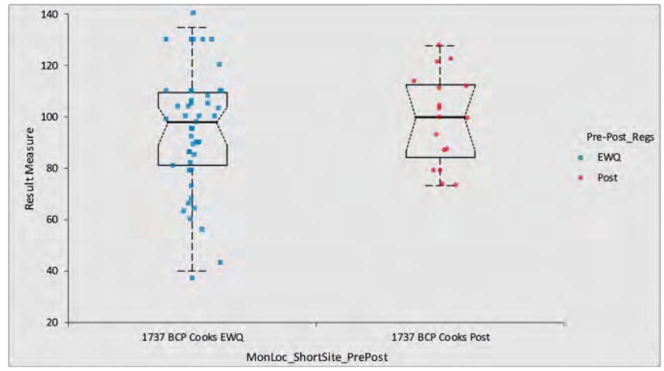
Alkalinity as $CaCO_3$, Total mg/l

Existing Water Quality (Table 2N):

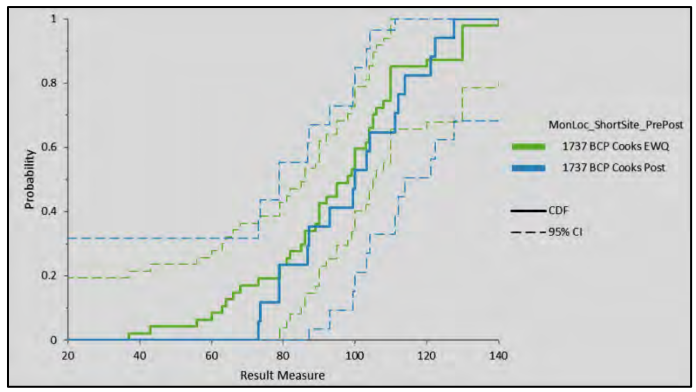
Median 98 mg/l
Lower 95% Confidence Interval 89 mg/l
Upper 95% Confidence Interval 104 mg/l
Defined in regulations as a flow-related parameter







N	64					
Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1737 BCP Cooks EWQ	37	81	98	110	140	29
1737 BCP Cooks Post	73	84	100	113	128	28



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1737 BCP Cooks EWQ	47	38.4	0.82
1737 BCP Cooks Post	17	106.3	6.25

H statistic	0.42
X^2 approximation	0.42
DF	1
p-value	0.5180 [1]

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

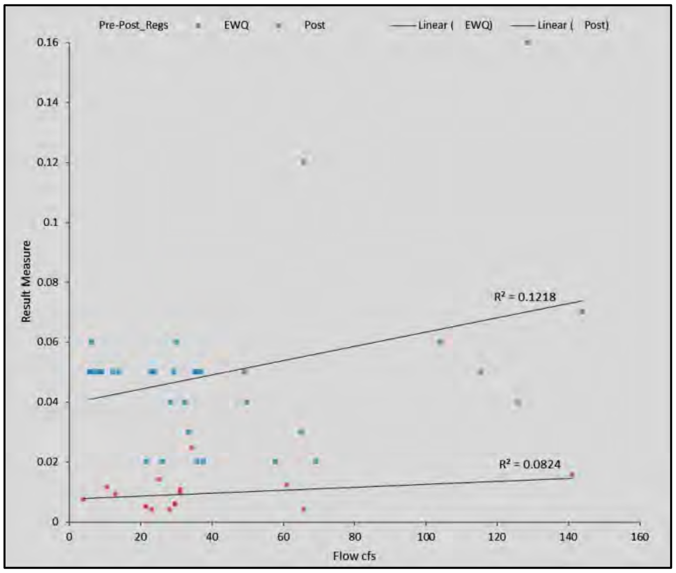
No water quality degradation is evident here. Alkalinity did not measurably change between the EWQ and post-EWQ periods. Uncertainty was introduced into comparisons by potential laboratory artifacts and insufficient post-EWQ sampling frequency. Alkalinity is inversely related to flow in both data sets. Post-EWQ median alkalinity fell within EWQ 95% confidence intervals. Flow and concentration are plotted directly with no transformations.

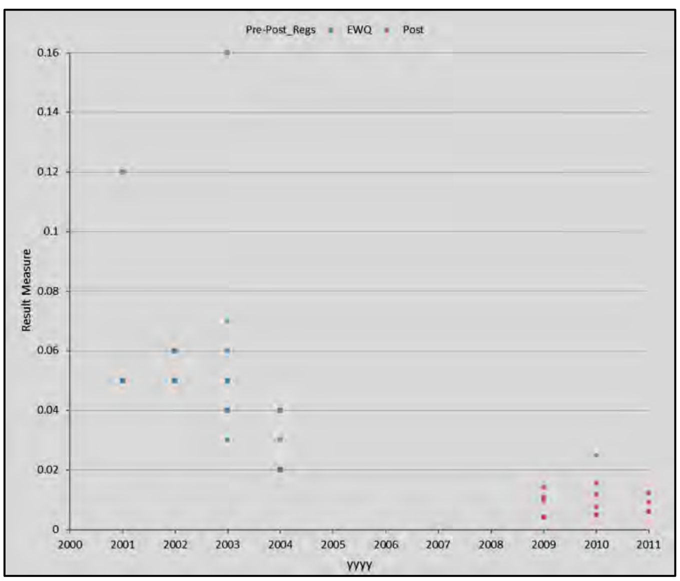
Chapter 13: 1737 BCP Cooks Creek, PA

Ammonia Nitrogen as N, Total mg/l

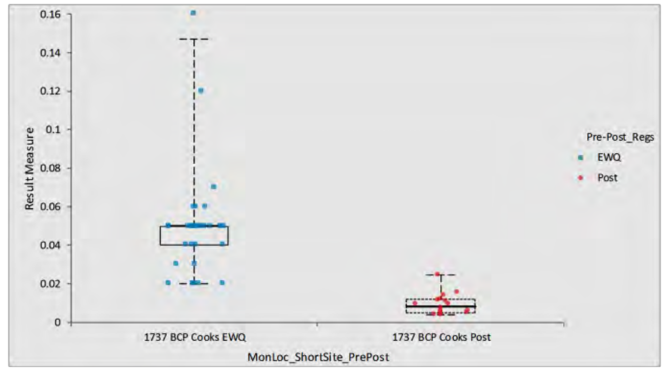
Existing Water Quality (Table 2N):

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



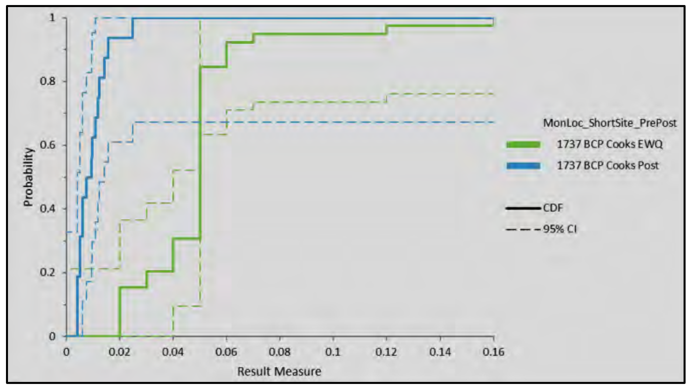


No water quality degradation is evident here. Ammonia concentrations apparently declined. Uncertainty was introduced into comparisons by potential laboratory artifacts, declining detection limits and insufficient post-EWQ sampling frequency. Post-EWQ median ammonia concentration was below the EWQ lower 95% confidence interval.



N 55

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1737 BCP Cooks EWQ	0.02	0.04	0.05	0.05	0.16	0.01
1737 BCP Cooks Post	0.00	0.01	0.01	0.01	0.02	0.01



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1737 BCP Cooks EWQ	39	2400.9	61.56
1737 BCP Cooks Post	16	5852.3	365.77

H statistic	34.12
X² approximation	34.12
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.

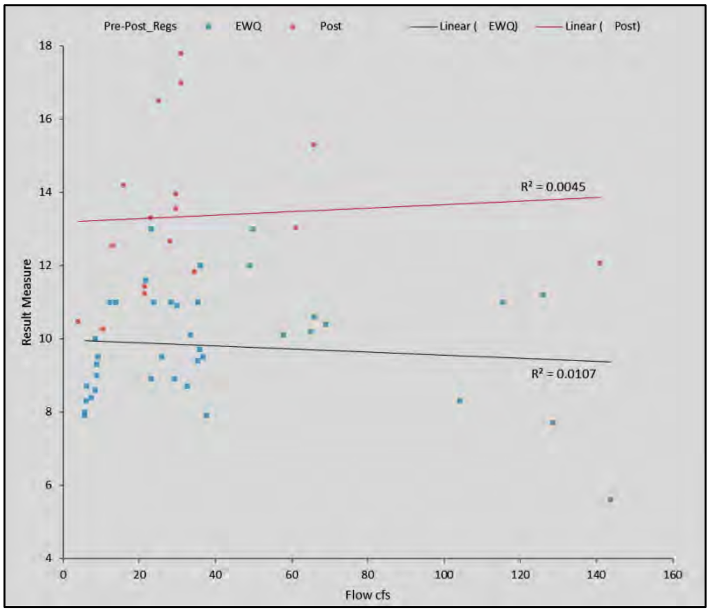
No independent data were available to validate results. EWQ data possessed 30/39 undetected results, which interfered with calculation of the median. Thus EWQ was established as <0.05 mg/l, the detection limit at the time. 2009-2011 detection levels were very low (0.004-0.006 mg/l), yet there were still 7/16 undetected results. Thus we may have measured actual very low concentrations rather than a real change in ambient concentrations. Evidence of water quality improvement may be indicated where the post-EWQ data contained no concentrations higher than 0.02 mg/l, unless this is a laboratory artifact.

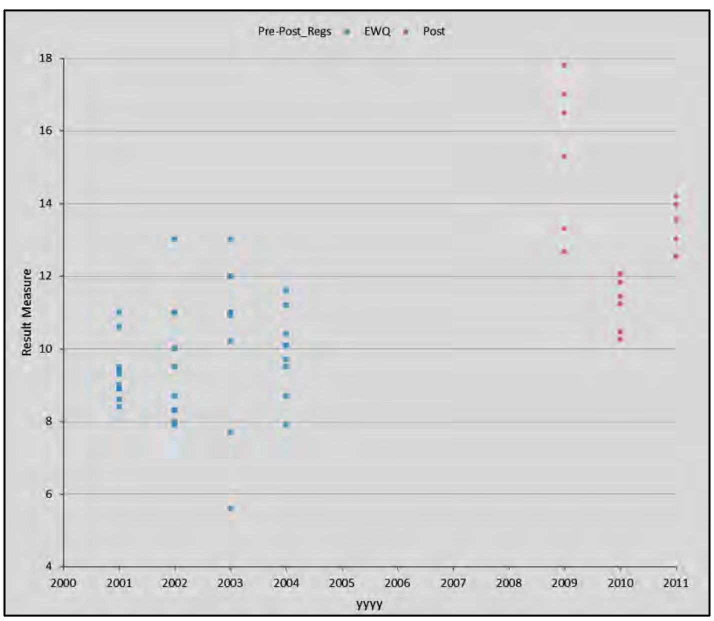
Chapter 13: 1737 BCP Cooks Creek, PA

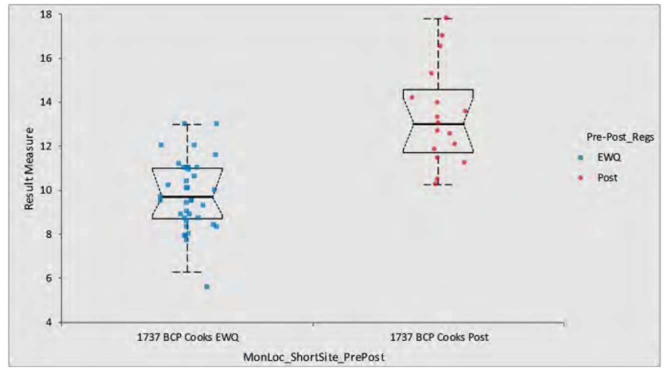
Chloride, Total mg/l

Existing Water Quality (Table 2N):

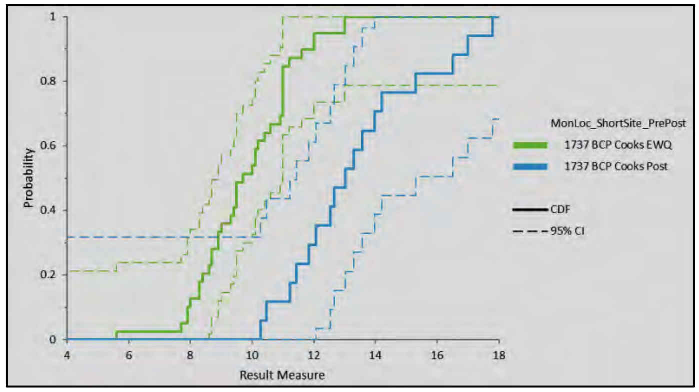
Median 9.7 mg/l
Lower 95% Confidence Interval 8.9 mg/l
Upper 95% Confidence Interval 10.9 mg/l







N	56					
Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1737 BCP Cooks EWQ	5.6	8.7	9.7	11.0	13.0	2.3
1737 BCP Cooks Post	10.3	11.7	13.0	14.6	17.8	2.9



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1737 BCP Cooks EWQ	39	2046.3	52.47
1737 BCP Cooks Post	17	4694.5	276.15

H statistic	25.38
X^2 approximation	25.38
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.

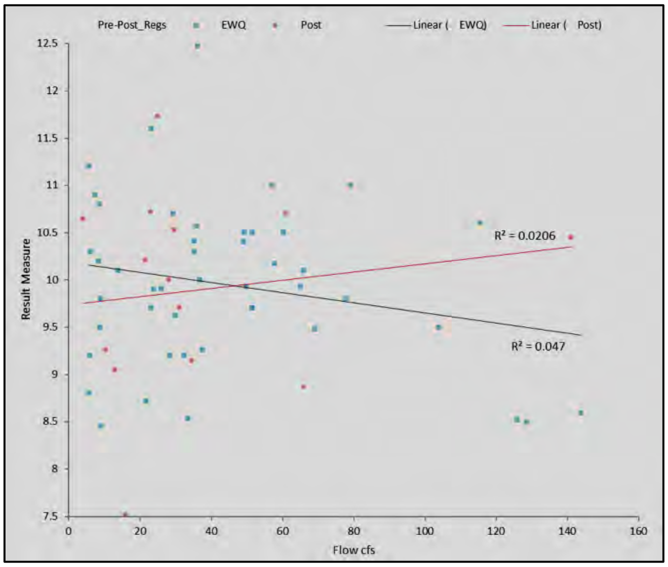
Water quality degradation is evident here. Chloride concentrations apparently rose by about 3 mg/l between the two periods. Post-EWQ median concentration rose above the EWQ upper 95% confidence interval. Chloride concentration is unrelated to flow in this data set. Uncertainty was introduced into comparisons by potential laboratory artifacts and insufficient post-EWQ sampling frequency. No new discharge permits were issued in this watershed to account for an increase, so other sources should be investigated in this high quality watershed.

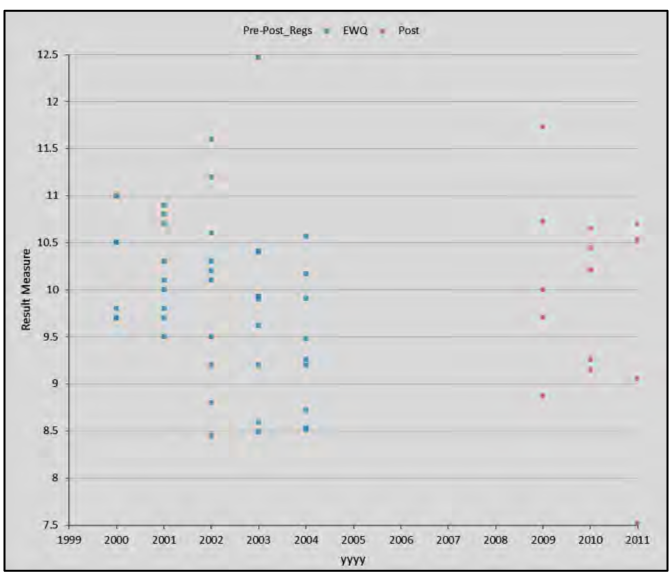
Chapter 13: 1737 BCP Cooks Creek, PA

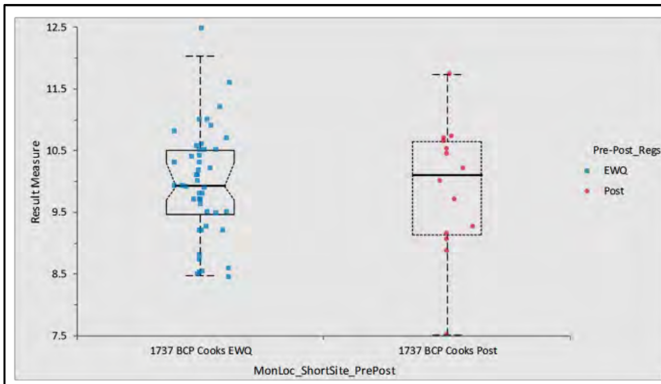
Dissolved Oxygen (DO) mg/l

Existing Water Quality (Table 2N):

Median 9.93 mg/l
Lower 95% Confidence Interval 9.70 mg/l
Upper 95% Confidence Interval 10.30 mg/l

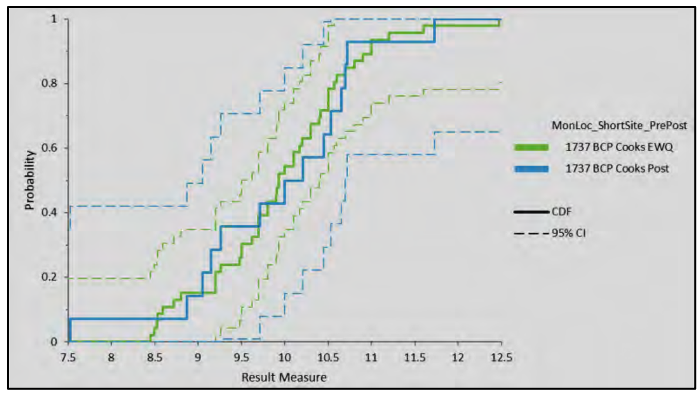






N | 60

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1737 BCP Cooks EWQ	8.45	9.46	9.93	10.50	12.47	1.04
1737 BCP Cooks Post	7.52	9.14	10.11	10.65	11.73	1.51



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1737 BCP Cooks EWQ	46	2.4	0.05
1737 BCP Cooks Post	14	7.9	0.56

H statistic	0.03
X^2 approximation	0.03
DF	1
p-value	0.8544 [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.

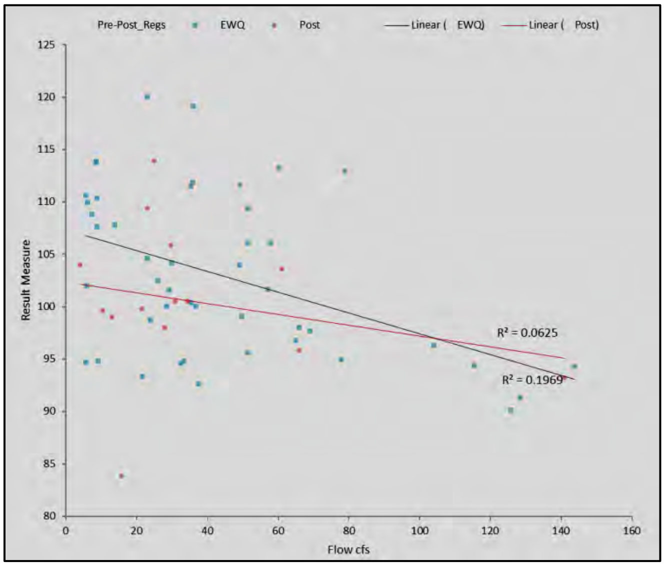
No water quality degradation is evident here. No measurable change took place between the EWQ and Post-EWQ periods. Uncertainty was introduced into comparisons by insufficient post-EWQ sampling frequency. Post-EWQ median DO concentration fell within the EWQ 95% confidence intervals. DO concentration is unrelated to flow in both data sets.

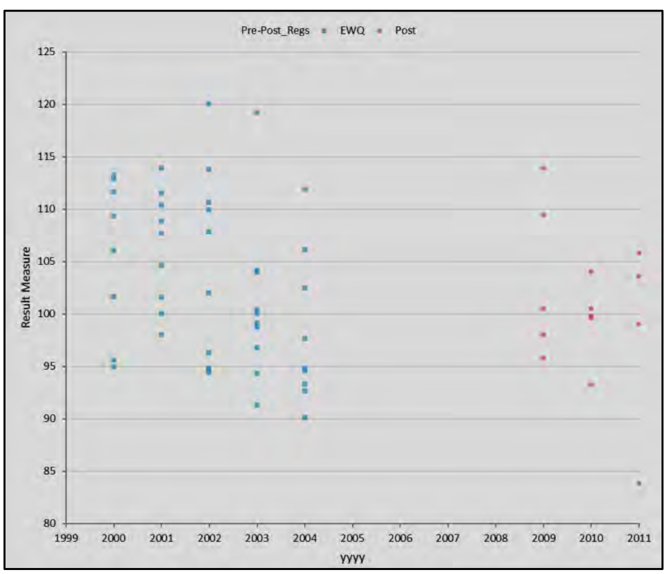
Chapter 13: 1737 BCP Cooks Creek, PA

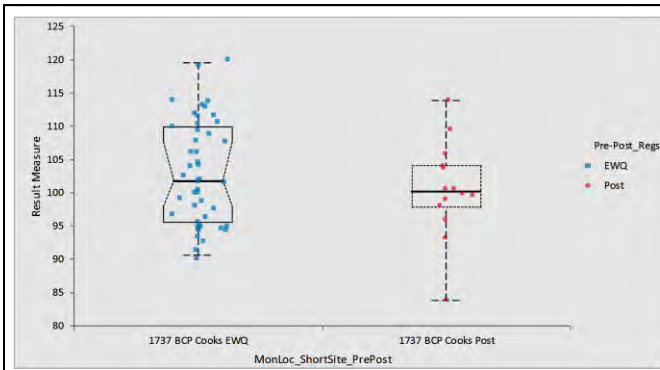
Dissolved Oxygen Saturation %

Existing Water Quality (Table 2N):

Median 102%
Lower 95% Confidence Interval 98%
Upper 95% Confidence Interval 108%

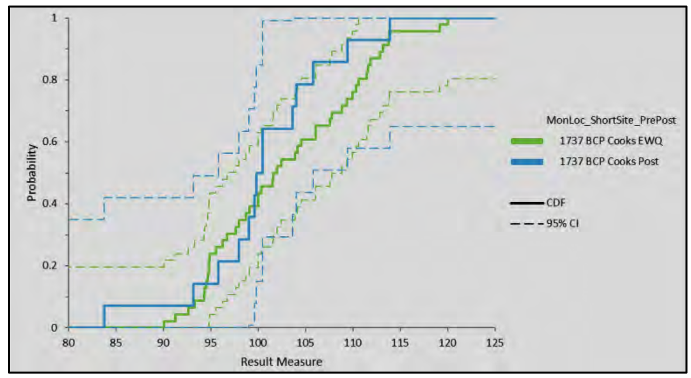






N 60

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1737 BCP Cooks EWQ	90	96	102	110	120	14
1737 BCP Cooks Post	84	98	100	104	114	6



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1737 BCP Cooks EWQ	46	34.8	0.76
1737 BCP Cooks Post	14	114.3	8.16

H statistic	0.49
X^2 approximation	0.49
DF	1
p-value	0.4845[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.

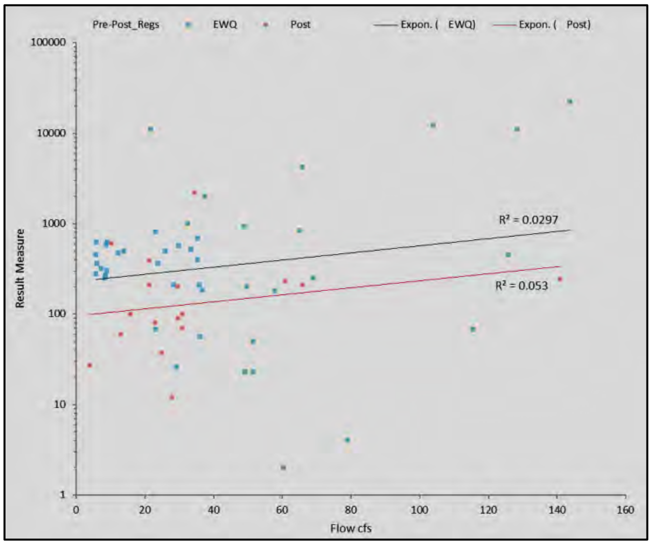
No water quality degradation is evident here. Dissolved Oxygen Saturation is unrelated to flow, and did not measurably change between the EWQ and post-EWQ periods. Uncertainty was introduced into comparisons by insufficient post-EWQ sampling frequency. Post-EWQ median DO saturation fell within the EWQ 95% confidence intervals.

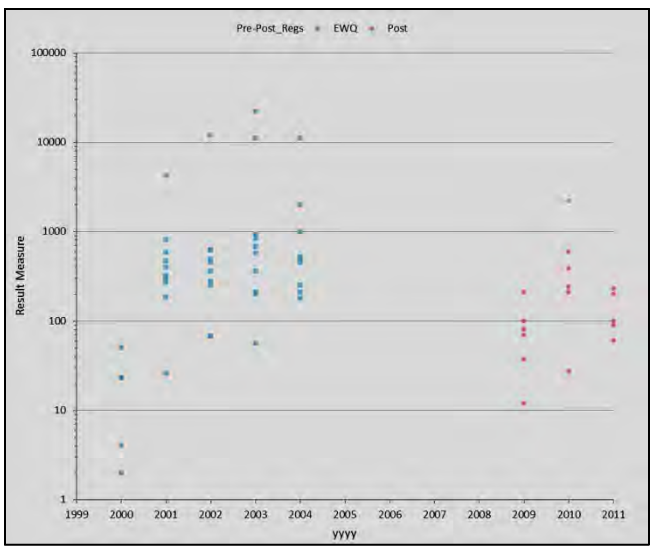
Chapter 13: 1737 BCP Cooks Creek, PA

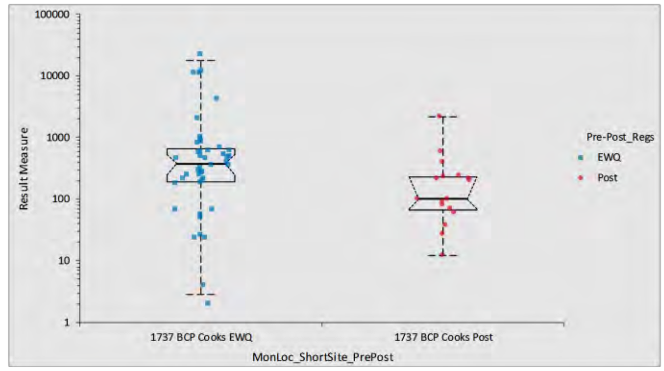
Enterococcus colonies/100 ml

Existing Water Quality (Table 2N):

Median 380/100 ml
Lower 95% Confidence Interval 250/100 ml
Upper 95% Confidence Interval 520/100 ml

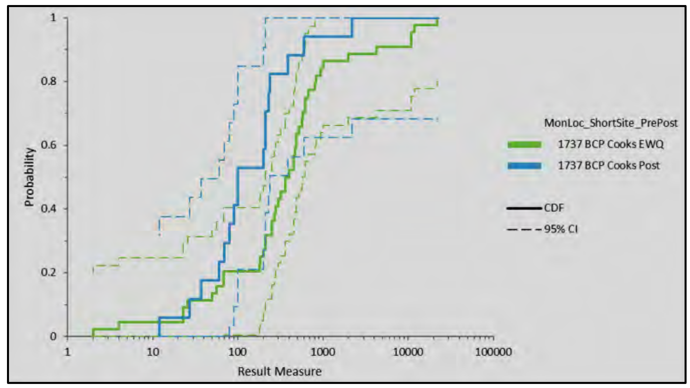






N	61					

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1737 BCP Cooks EWQ	2	191	380	655	22000	464
1737 BCP Cooks Post	12	67	100	233	2200	167



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1737 BCP Cooks EWQ	44	528.6	12.01
1737 BCP Cooks Post	17	1368.0	80.47

H statistic	6.02
X² approximation	6.02
DF	1
p-value	0.0141 [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.

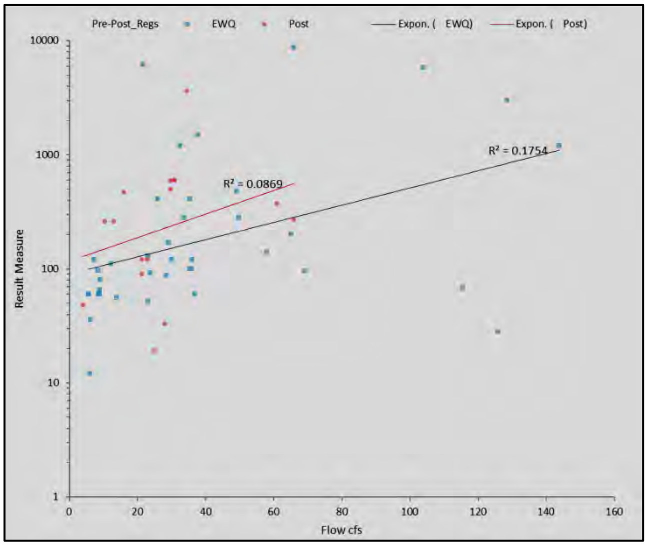
No water quality degradation is evident here. Enterococci apparently declined between the EWQ and Post-EWQ periods. Uncertainty was introduced into comparisons by potential laboratory artifacts and insufficient post-EWQ sampling frequency. Enterococcus concentrations are unrelated to flow in both data sets. Note that concentrations are plotted on a logarithmic scale, and the regression is an exponential relationship. Post-EWQ median enterococcus concentrations fell below the lower EWQ 95% confidence interval.

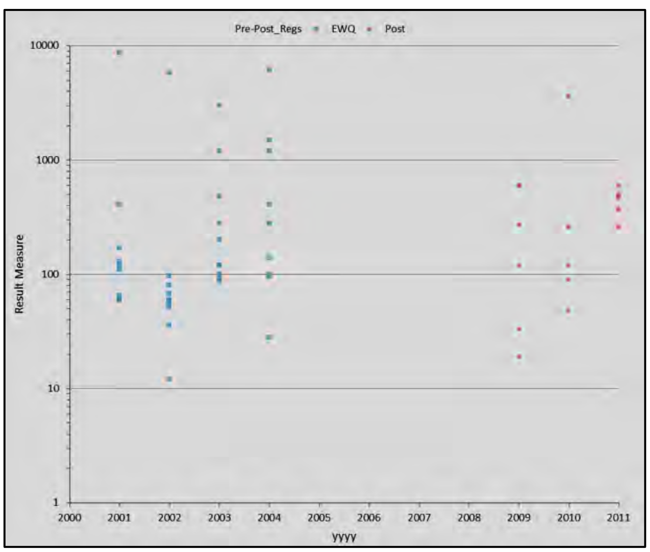
Chapter 13: 1737 BCP Cooks Creek, PA

Escherichia coli colonies/100 ml

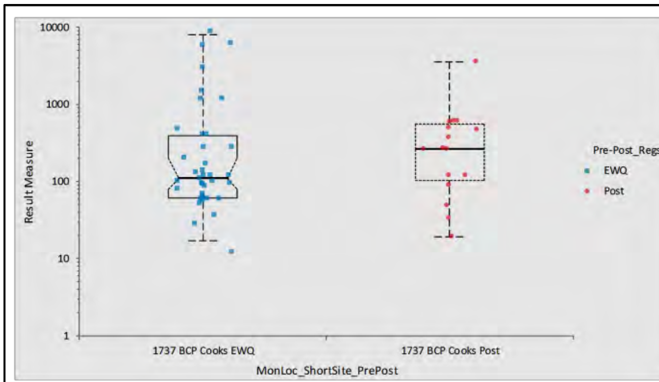
Existing Water Quality (Table 2N):

Median 110/100 ml
Lower 95% Confidence Interval 80/100 ml
Upper 95% Confidence Interval 200/100 ml
Defined in regulations as a flow-related parameter



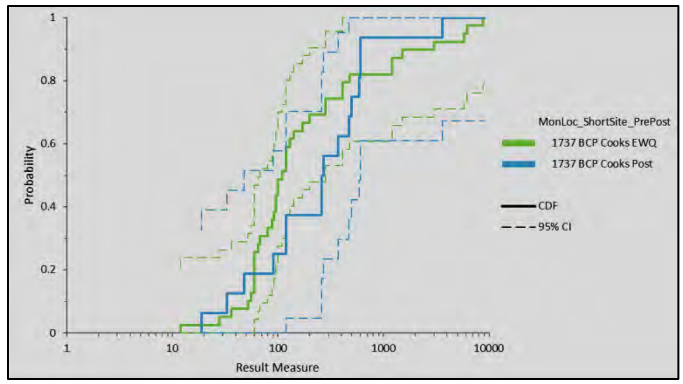


Water quality degradation is evident here. E. coli concentrations appeared to measurably increase between the EWQ and Post-EWQ periods. Uncertainty was introduced into comparisons by potential laboratory artifacts and insufficient post-EWQ sampling frequency.



N 55

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1737 BCP Cooks EWQ	12	61	110	388	8740	328
1737 BCP Cooks Post	19	103	265	553	3600	450



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1737 BCP Cooks EWQ	39	80.4	2.06
1737 BCP Cooks Post	16	196.0	12.25

H statistic	1.08
X² approximation	1.08
DF	1
p-value	0.2990 [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.

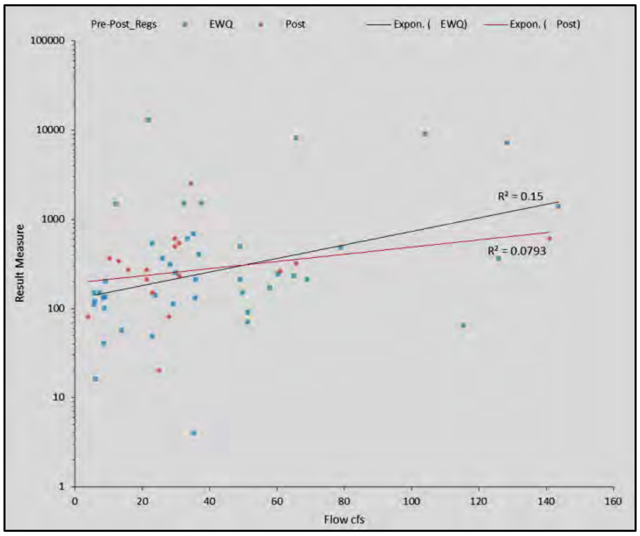
Post-EWQ median E. coli rose above the EWQ 95% confidence interval, but the post-EWQ data set contained no high-flow samples. Note that concentrations are plotted on a logarithmic scale. E. coli concentrations are unrelated to flow in both data sets, and <u>should not have been classified as flow-related in EWQ rules</u>. Insufficient independent data were available at this site to validate results.

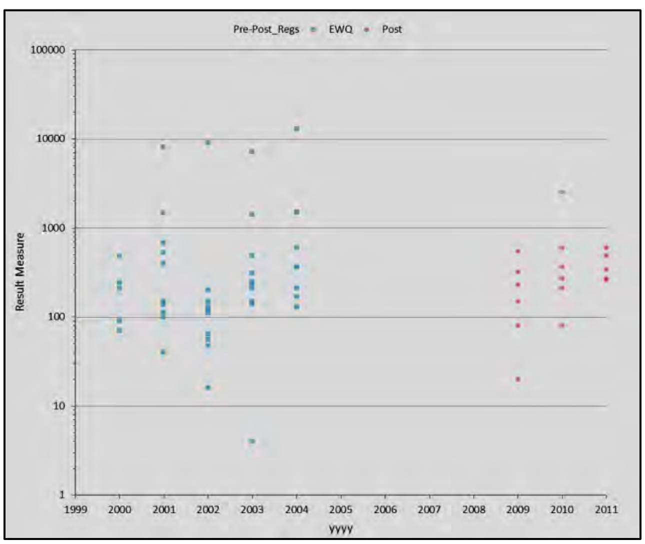
Chapter 13: 1737 BCP Cooks Creek, PA

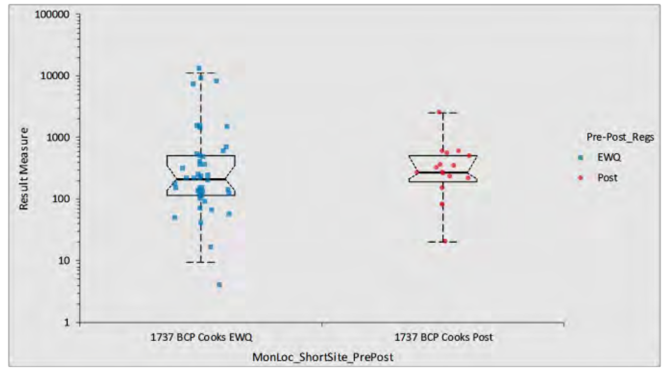
Fecal coliform colonies/100 ml

Existing Water Quality (Table 2N):

Median 210/100 ml
Lower 95% Confidence Interval 140/100 ml
Upper 95% Confidence Interval 360/100 ml

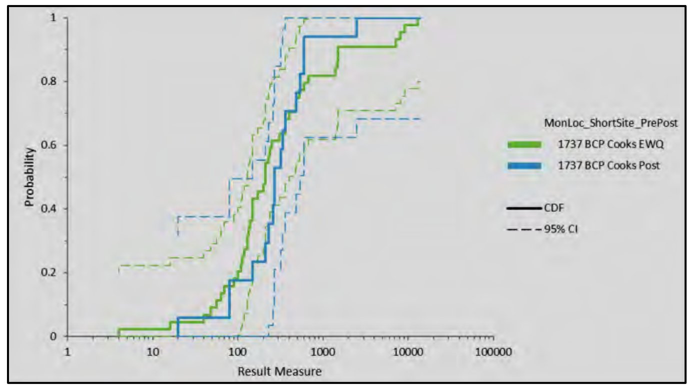






N	61

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1737 BCP Cooks EWQ	4	115	210	513	13000	398
1737 BCP Cooks Post	20	190	270	507	2500	317



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1737 BCP Cooks EWQ	44	52.4	1.19
1737 BCP Cooks Post	17	135.5	7.97

H statistic	0.60
X^2 approximation	0.60
DF	1
p-value	0.4398 [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.

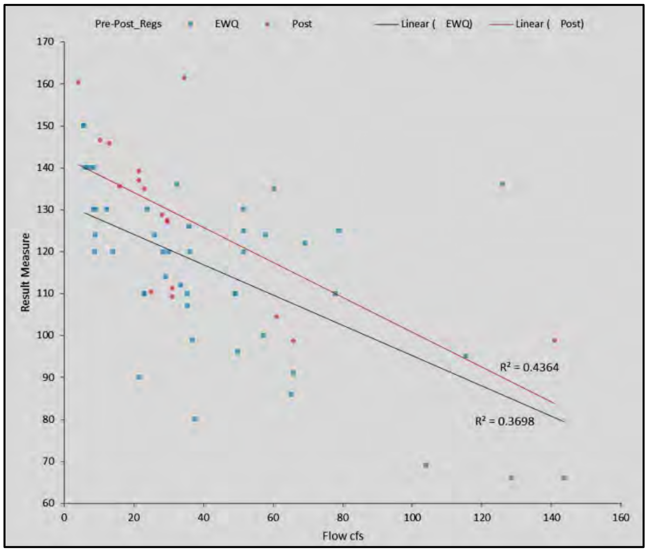
No water quality degradation is evident here. Fecal coliform concentrations did not measurably change between the EWQ and post-EWQ periods. Uncertainty was introduced into comparisons by potential laboratory artifacts and insufficient post-EWQ sampling frequency. Fecal coliform concentrations are unrelated to flow in both data sets. Post-EWQ median concentrations were within the EWQ 95% confidence intervals. Concentrations are plotted on a logarithmic scale.

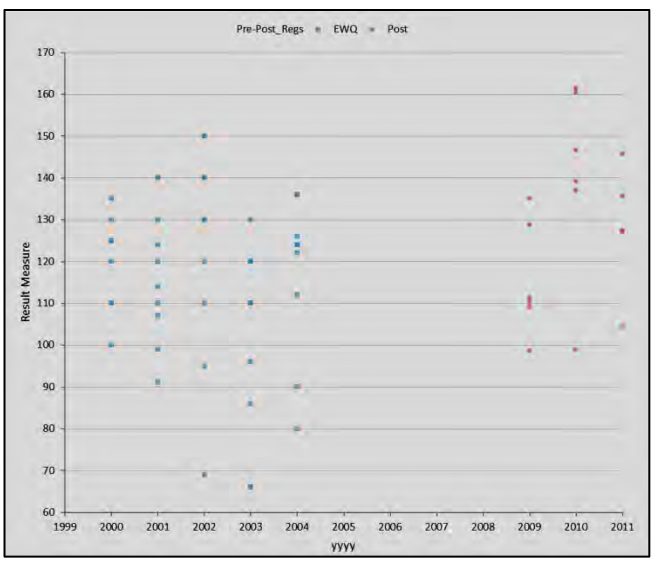
Chapter 13: 1737 BCP Cooks Creek, PA

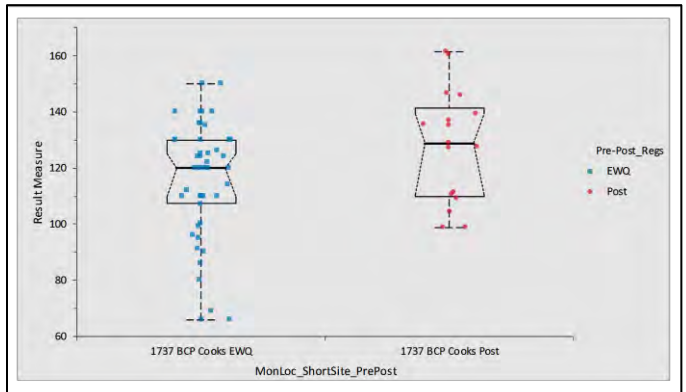
Hardness as CaCO3, Total mg/l

Existing Water Quality (Table 2N):

Median 120 mg/l
Lower 95% Confidence Interval 110 mg/l
Upper 95% Confidence Interval 125 mg/l
Defined in regulations as a flow-related parameter

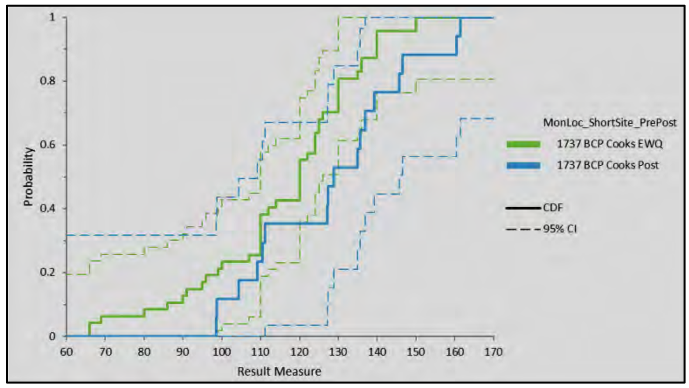






N | 64

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1737 BCP Cooks EWQ	66	108	120	130	150	23
1737 BCP Cooks Post	99	110	129	141	161	31



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1737 BCP Cooks EWQ	47	306.4	6.52
1737 BCP Cooks Post	17	847.1	49.83

H statistic	3.34
X² approximation	3.34
DF	1
p-value	0.0678 [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.

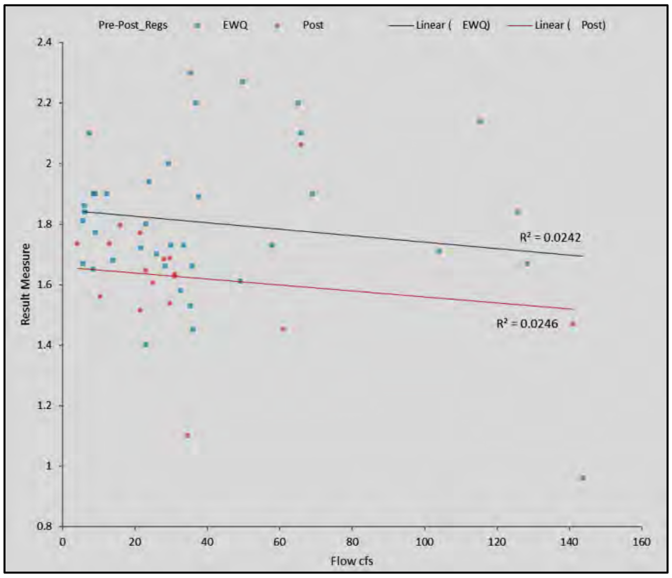
No water quality degradation is evident here. Hardness did not measurably change between the EWQ and post-EWQ periods. Uncertainty was introduced into comparisons by potential laboratory artifacts and insufficient post-EWQ sampling frequency. Hardness is inversely related to flow in both data sets. Post-EWQ median hardness rose above the EWQ upper 95% confidence interval, but the increase was not significant because too few post-EWQ samples were taken (n=17) to be able to distinguish a real difference between the two periods.

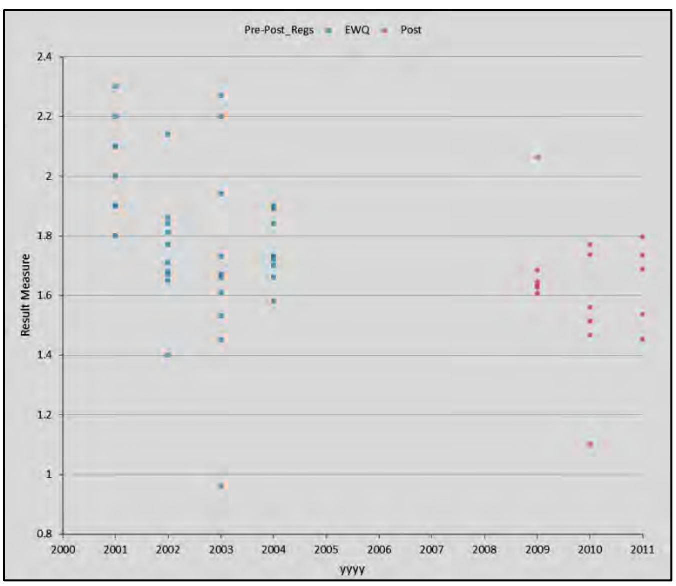
Chapter 13: 1737 BCP Cooks Creek, PA

Nitrate + Nitrite as N, Total mg/l

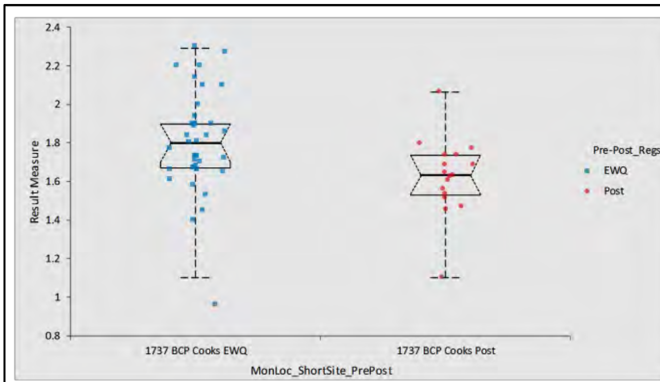
Existing Water Quality (Table 2N, as Nitrate only):

Median 1.80 mg/l
Lower 95% Confidence Interval 1.70 mg/l
Upper 95% Confidence Interval 1.90 mg/l



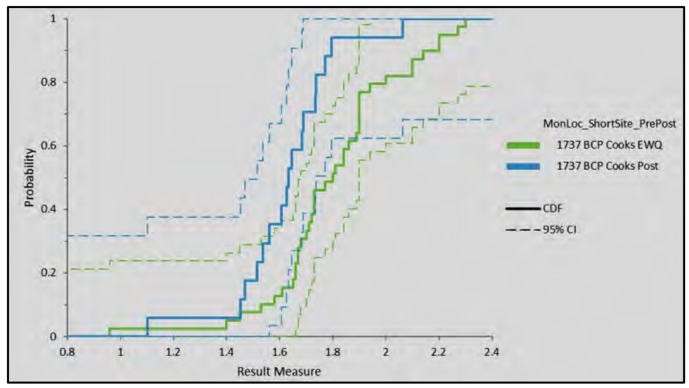


No water quality degradation is evident here. Nitrate concentrations apparently declined between the EWQ and post-EWQ periods. Uncertainty was introduced into comparisons by potential laboratory artifacts and insufficient post-EWQ sampling frequency. Nitrate is unrelated related to flow in both data sets.



N 56

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1737 BCP Cooks EWQ	0.96	1.67	1.80	1.90	2.30	0.23
1737 BCP Cooks Post	1.10	1.53	1.63	1.74	2.06	0.21



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1737 BCP Cooks EWQ	39	660.5	16.94
1737 BCP Cooks Post	17	1515.3	89.14

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

H0: $\theta_1 = \theta_2 = \theta_{\dots}$
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.

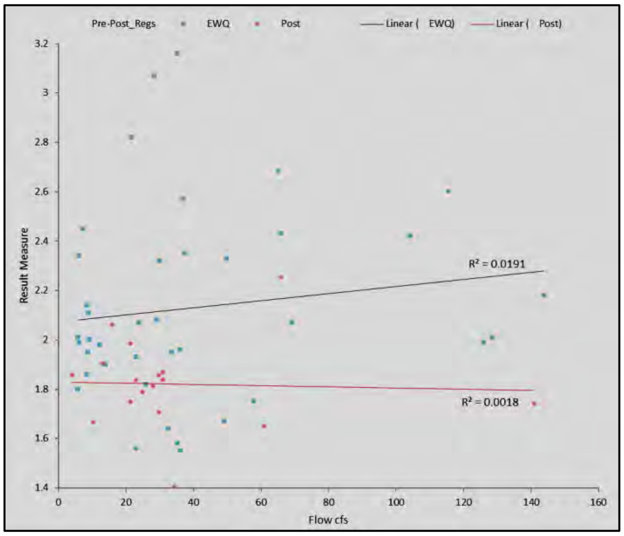
Post-EWQ concentrations fell below the EWQ lower 95% confidence interval. Post-EWQ nitrate + nitrite concentrations were assumed equivalent for comparison with EWQ nitrate concentrations since EWQ nitrite concentrations were never detected. Independent data were not available for validation of results. At other sites where concentrations are lower, there was a problem interpreting the data due to changing detection limits. Concentrations are sufficiently high in Cooks Creek that problems with interpretation did not arise; so the decline may represent an improvement in water quality.

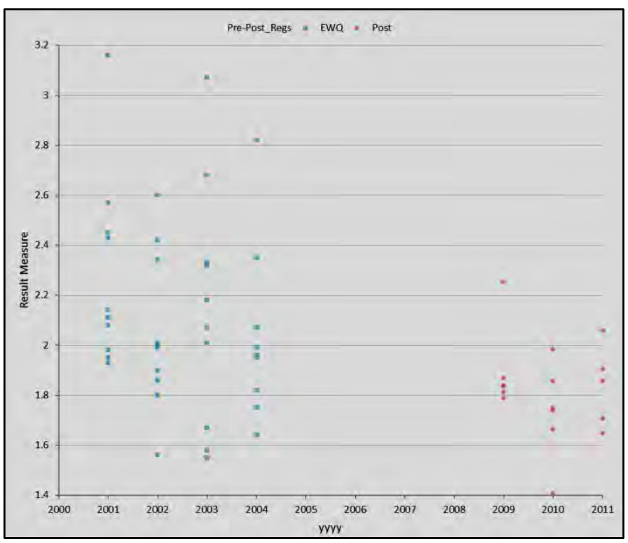
Chapter 13: 1737 BCP Cooks Creek, PA

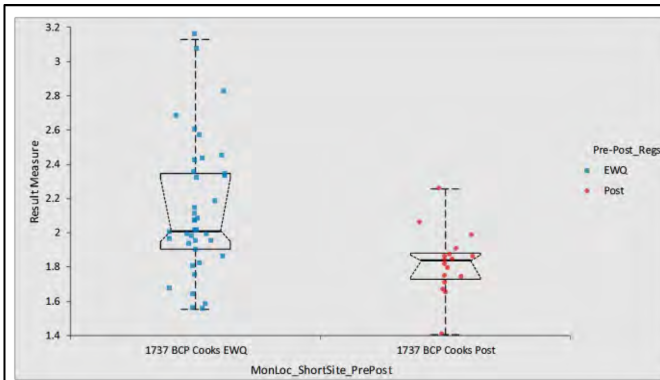
Nitrogen as N, Total (TN) mg/l

Existing Water Quality (Table 2N):

Median 2.01 mg/l
Lower 95% Confidence Interval 1.95 mg/l
Upper 95% Confidence Interval 2.32 mg/l

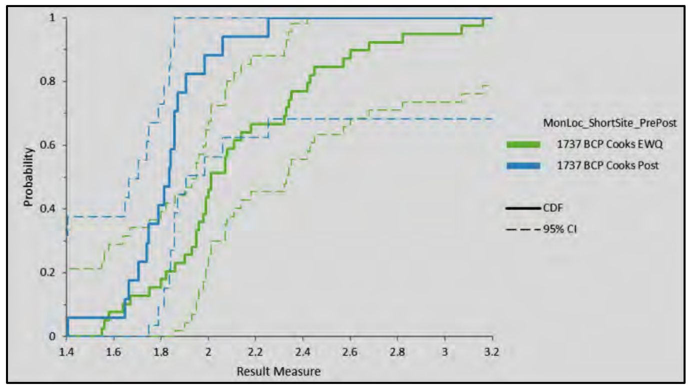






N 56

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1737 BCP Cooks EWQ	1.55	1.91	2.01	2.35	3.16	0.44
1737 BCP Cooks Post	1.41	1.73	1.84	1.88	2.25	0.15



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1737 BCP Cooks EWQ	39	863.4	22.14
1737 BCP Cooks Post	17	1980.7	116.51

H statistic	10.69
X^2 approximation	10.69
DF	1
p-value	0.0011[1]

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

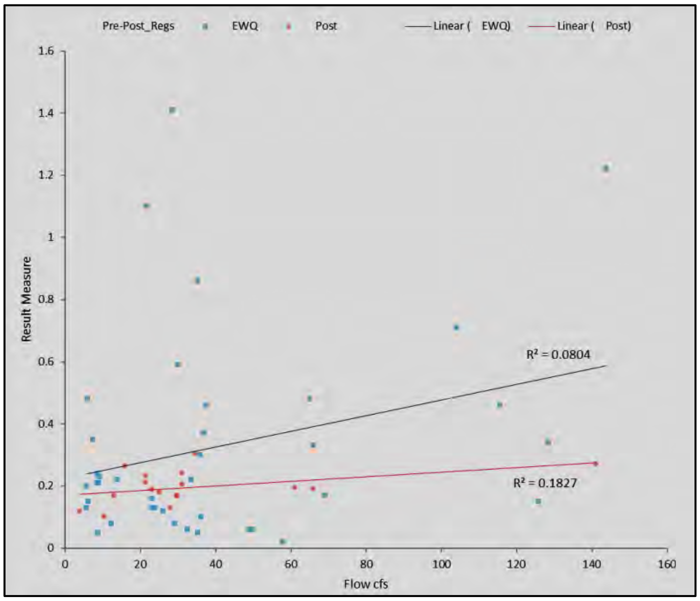
No water quality degradation is evident here. Total Nitrogen concentrations apparently declined between the EWQ and post-EWQ periods. Uncertainty was introduced into comparisons by potential laboratory artifacts and insufficient post-EWQ sampling frequency. TN is unrelated to flow in both data sets. DRBC results could not be independently validated. Post-EWQ median TN concentrations fell below the EWQ lower 95% confidence intervals.

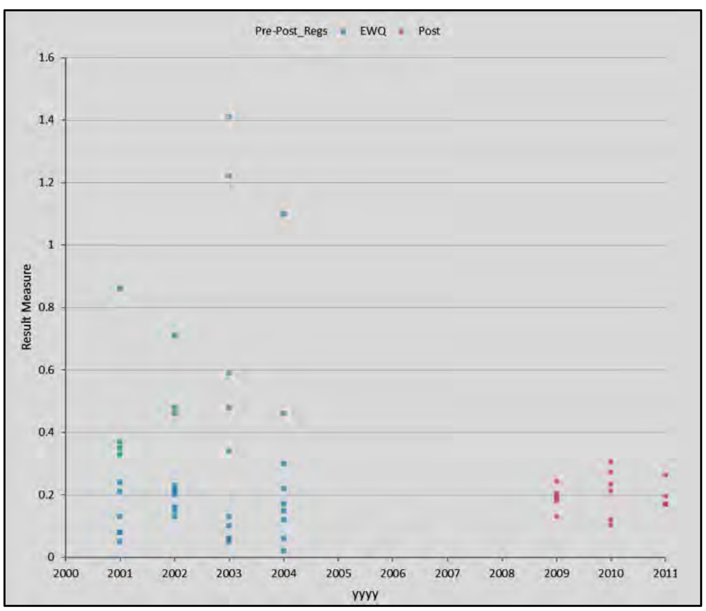
Chapter 13: 1737 BCP Cooks Creek, PA

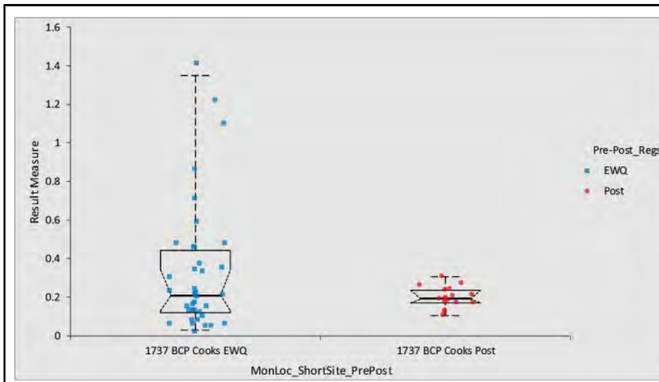
Nitrogen, Kjeldahl as N, Total (TKN) mg/l

Existing Water Quality (Table 2N):

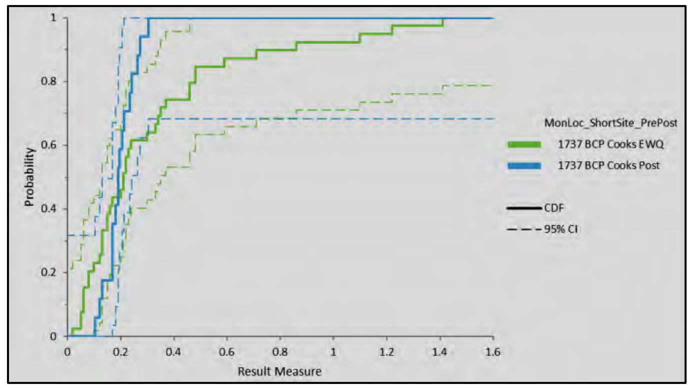
Median 0.21 mg/l
Lower 95% Confidence Interval 0.13 mg/l
Upper 95% Confidence Interval 0.34 mg/l







	N	56				
Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1737 BCP Cooks EWQ	0.02	0.12	0.21	0.45	1.41	0.32
1737 BCP Cooks Post	0.10	0.17	0.19	0.24	0.31	0.07



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1737 BCP Cooks EWQ	39	20.8	0.53
1737 BCP Cooks Post	17	47.8	2.81

H statistic	0.26
X² approximation	0.26
DF	1
p-value	0.6115 [1]

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

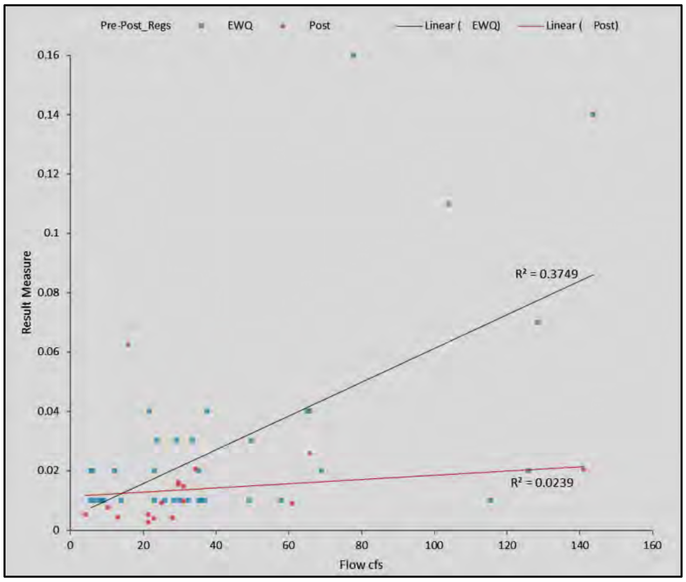
No water quality degradation is evident here. TKN concentrations apparently did not measurably change between the EWQ and post-EWQ periods, though the post-EWQ range was far narrower and all concentrations were less than 0.4 mg/l. Uncertainty was introduced into comparisons by potential laboratory artifacts and insufficient post-EWQ sampling frequency. TKN concentration is unrelated to flow in both data sets. Post-EWQ median TKN was within the EWQ 95% confidence intervals.

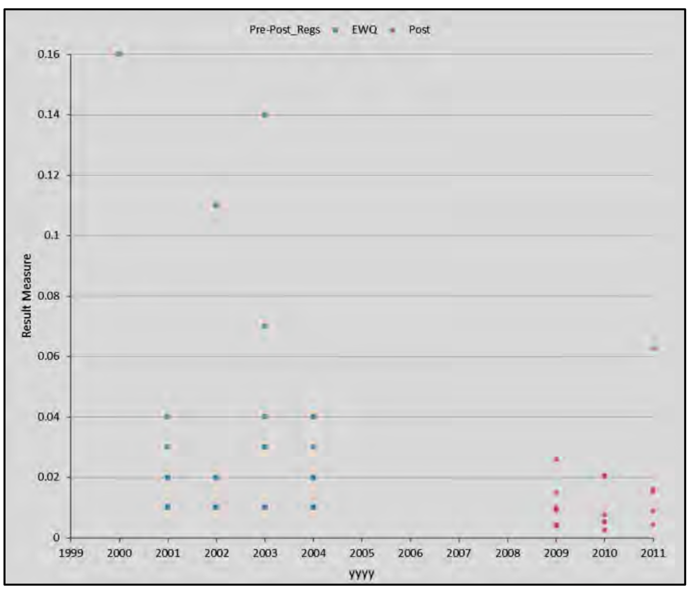
Chapter 13: 1737 BCP Cooks Creek, PA

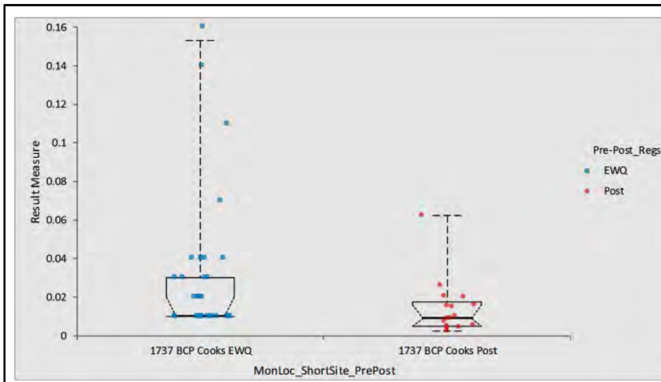
Orthophosphate as P, Total mg/l (OP)

Existing Water Quality (Table 2N):

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

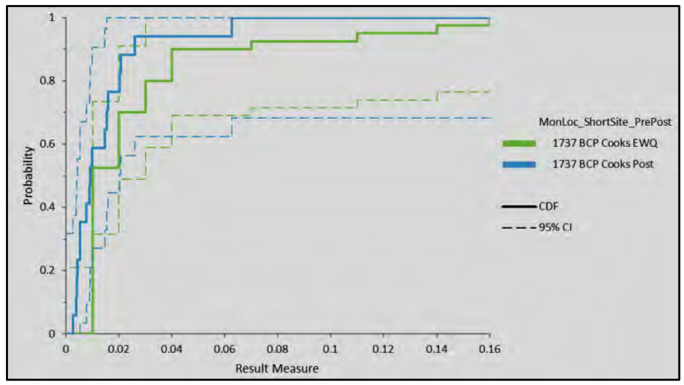






N | 57

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1737 BCP Cooks EWQ	0.010	0.010	0.010	0.030	0.160	0.020
1737 BCP Cooks Post	0.003	0.005	0.009	0.017	0.063	0.013



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1737 BCP Cooks EWQ	40	616.2	15.41
1737 BCP Cooks Post	17	1449.9	85.29

H statistic	7.91
X² approximation	7.91
DF	1
p-value	0.0049 [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.

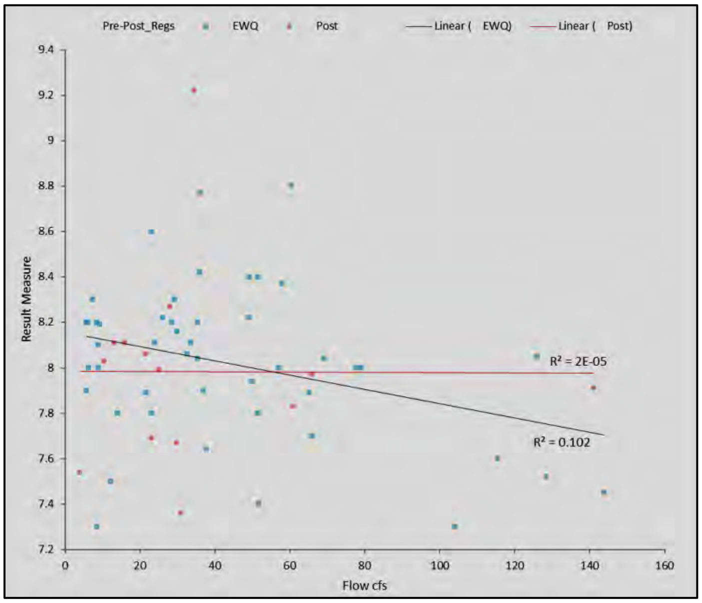
No water quality degradation is evident here. OP concentrations apparently declined between the EWQ and post-EWQ periods. Uncertainty was introduced into comparisons by potential laboratory artifacts, declining detection limits and insufficient post-EWQ sampling frequency. OP is weakly related to flow in the EWQ data set, but unrelated to flow in the post-EWQ data set. Post-EWQ median orthophosphate fell below the EWQ lower 95% confidence interval. Evidence for a water quality improvement is that there were no post-EWQ concentrations higher than 0.07 mg/l. There were no independent data to confirm results.

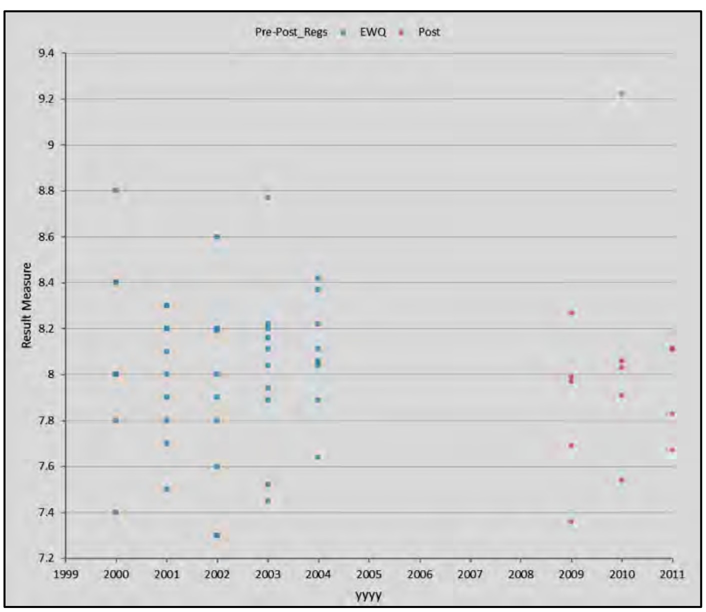
Chapter 13: 1737 BCP Cooks Creek, PA

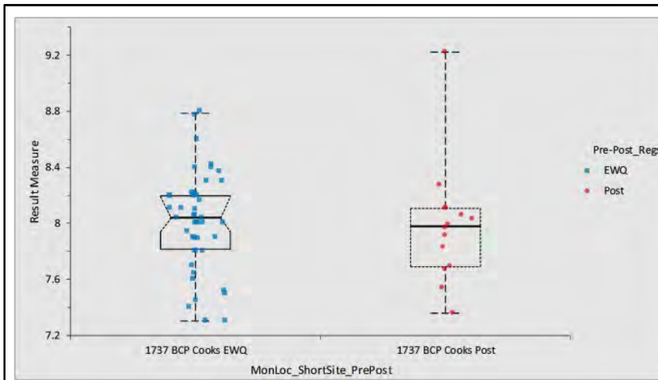
pH

Existing Water Quality (Table 2N):

Median 8.04 standard units
Lower 95% Confidence Interval 7.94 standard units
Upper 95% Confidence Interval 8.19 standard units

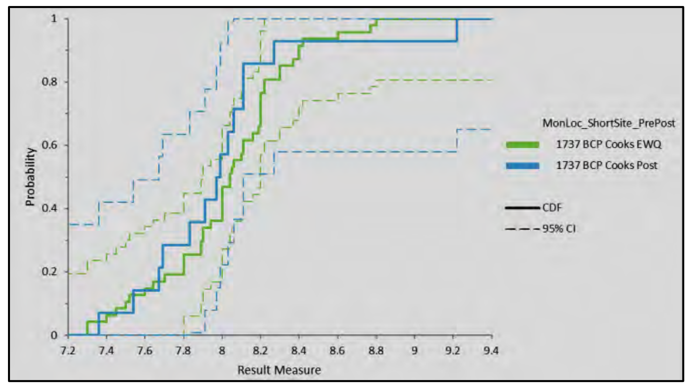






N | 61

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1737 BCP Cooks EWQ	7.30	7.82	8.04	8.20	8.80	0.39
1737 BCP Cooks Post	7.36	7.69	7.98	8.11	9.22	0.42



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1737 BCP Cooks EWQ	47	63.2	1.34
1737 BCP Cooks Post	14	212.2	15.15

H statistic	0.88
X² approximation	0.88
DF	1
p-value	0.3495 [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.

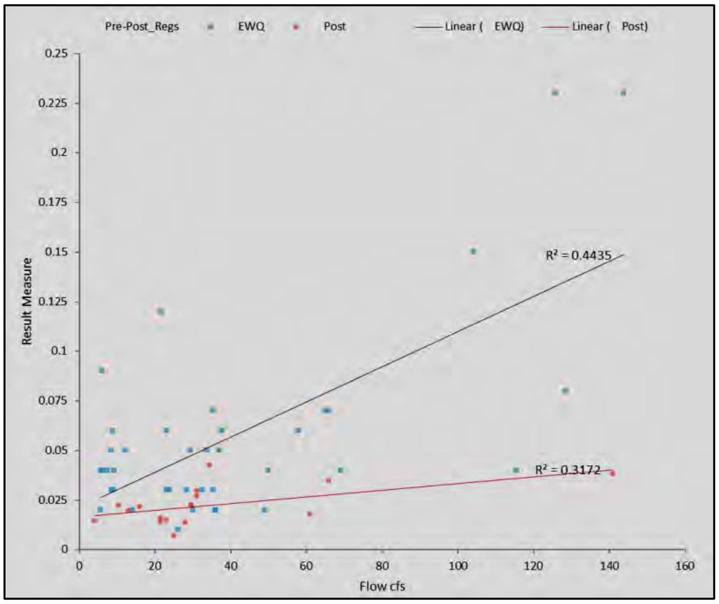
No water quality degradation is evident here. pH did not measurably change between the EWQ and post-EWQ periods. Uncertainty was introduced into comparisons by insufficient post-EWQ sampling frequency. pH is unrelated to flow in both data sets. Post-EWQ median pH was within the EWQ 95% confidence intervals. In 2010 there was one spike above pH 9, indicating high algal productivity during that sampling period.

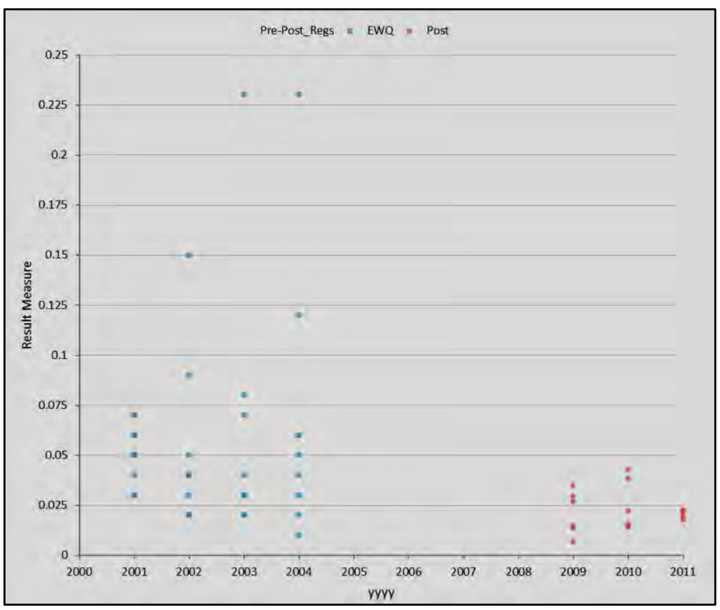
Chapter 13: 1737 BCP Cooks Creek, PA

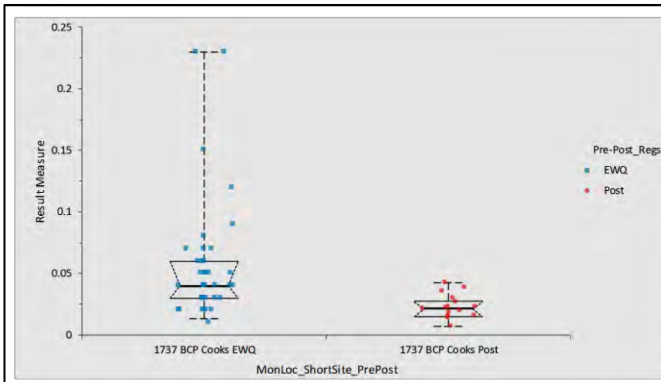
Phosphorus as P, Total (TP) mg/l

Existing Water Quality (Table 2N):

Median 0.04 mg/l
Lower 95% Confidence Interval 0.03 mg/l
Upper 95% Confidence Interval 0.06 mg/l

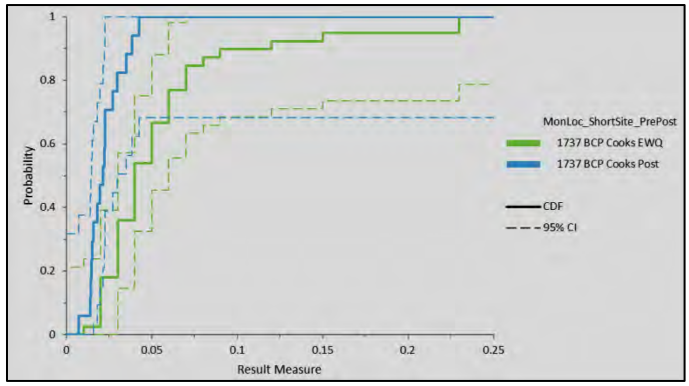






N 56

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1737 BCP Cooks EWQ	0.010	0.030	0.040	0.060	0.230	0.030
1737 BCP Cooks Post	0.007	0.015	0.022	0.028	0.043	0.013



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1737 BCP Cooks EWQ	39	1398.0	35.85
1737 BCP Cooks Post	17	3207.2	188.66

H statistic	17.42
X^2 approximation	17.42
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.

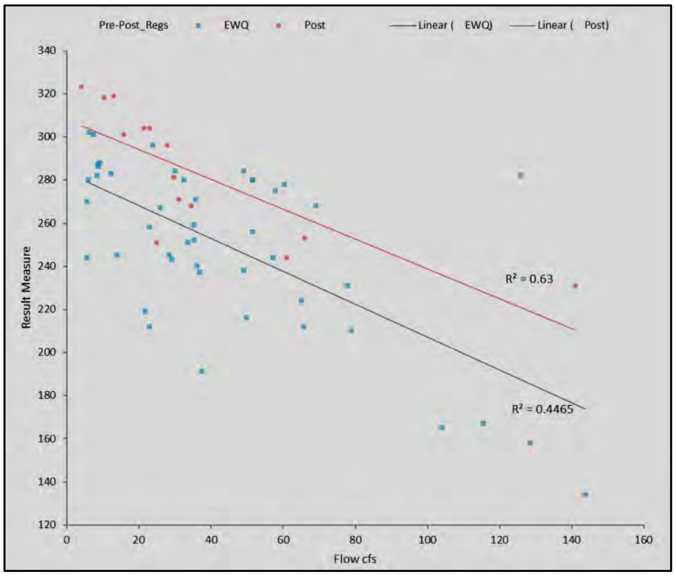
No water quality degradation is evident here. Total Phosphorus (TP) concentrations apparently declined between the EWQ and post-EWQ periods. Uncertainty was introduced into comparisons by potential laboratory artifacts, declining detection limits and insufficient post-EWQ sampling frequency. Post-EWQ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

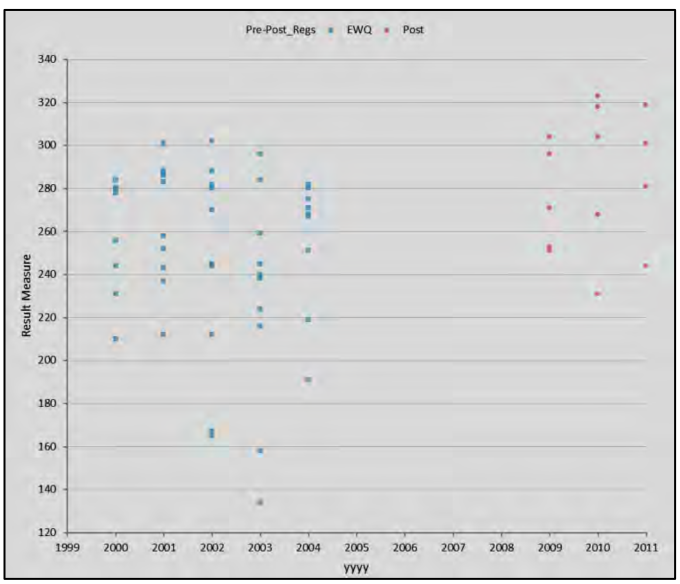
Chapter 13: 1737 BCP Cooks Creek, PA

Specific Conductance µmho/cm

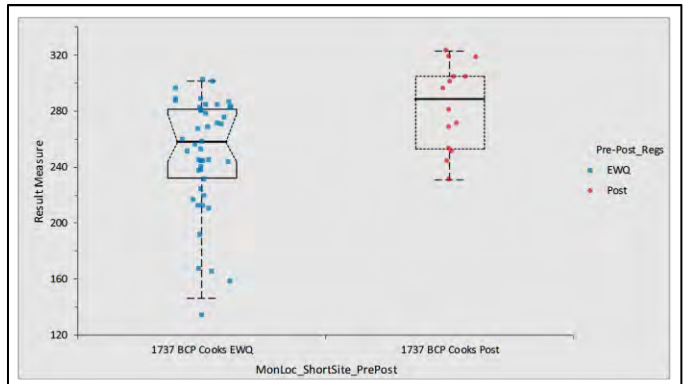
Existing Water Quality (Table 2N):

Median 258 µmho/cm
Lower 95% Confidence Interval 244 µmho/cm
Upper 95% Confidence Interval 278 µmho/cm
Defined in regulations as a flow-related parameter



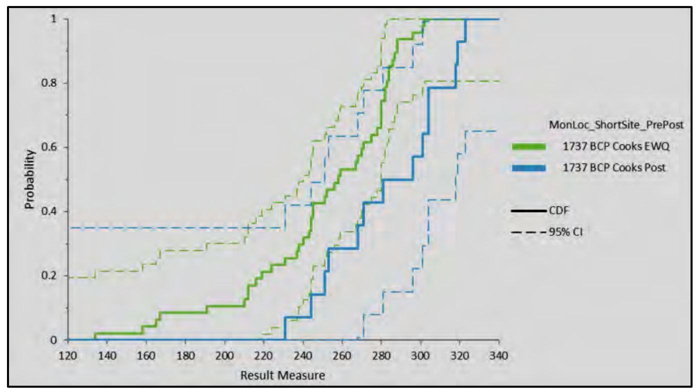


Water quality degradation is evident here. Specific conductance rose by 31 µmho/cm; above the EWQ upper 95% confidence interval. Uncertainty was introduced into comparisons by insufficient post-EWQ sampling frequency.



N | 61

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1737 BCP Cooks EWQ	134	232	258	282	302	50
1737 BCP Cooks Post	231	253	289	305	323	52



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1737 BCP Cooks EWQ	47	524.4	11.16
1737 BCP Cooks Post	14	1760.6	125.76

H statistic	7.26
X^2 approximation	7.26
DF	1
p-value	0.0071 [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.

Specific conductance is inversely related to flow in both data sets. Part of the increase may be attributable to fewer high-flow samples taken in the post-EWQ period. Unrelated to the increase, limestone-influenced streams like Cooks Creek generally possess higher specific conductance, alkalinity and hardness than the Piedmont watersheds downstream.

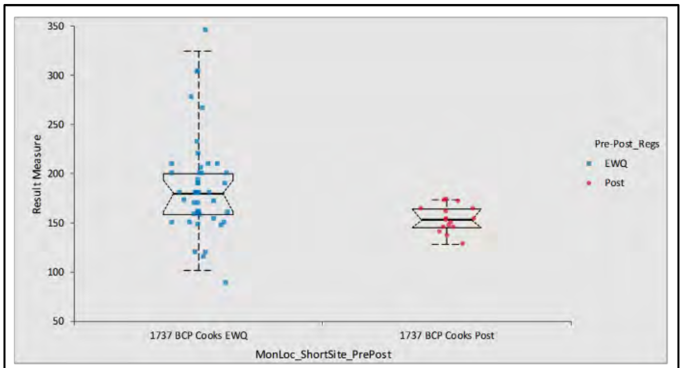
The rise in specific conductance may be partially attributable to the concurrent rise in chloride concentrations. Median specific conductance has risen from 258 to 289 µmhos/cm, which is a 12% increase in a few years' time.

Chapter 13: 1737 BCP Cooks Creek, PA

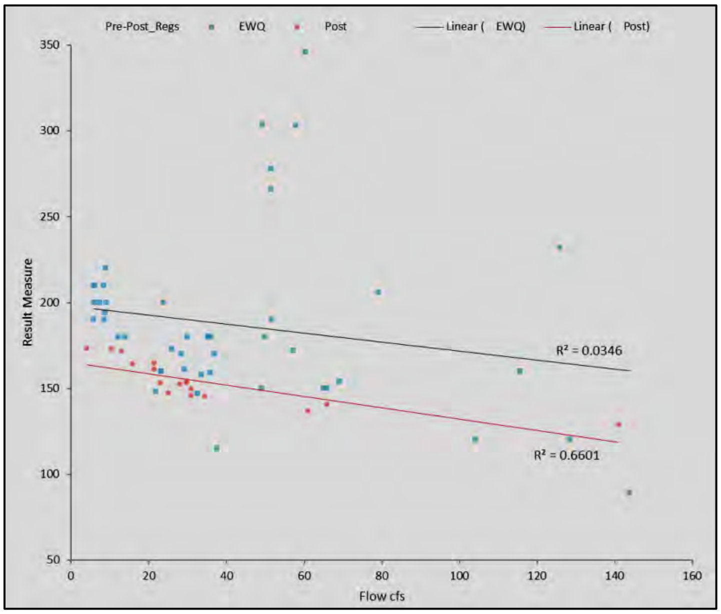
Total Dissolved Solids (TDS) mg/l

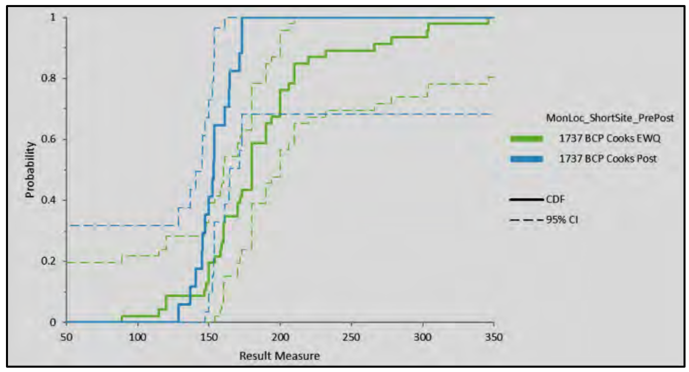
Existing Water Quality (Table 2N):

Median 180 mg/l
Lower 95% Confidence Interval 161 mg/l
Upper 95% Confidence Interval 194 mg/l
Defined in regulations as a flow-related parameter



Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
N	63					
1737 BCP Cooks EWQ	89	159	180	201	346	42
1737 BCP Cooks Post	129	146	153	164	173	19



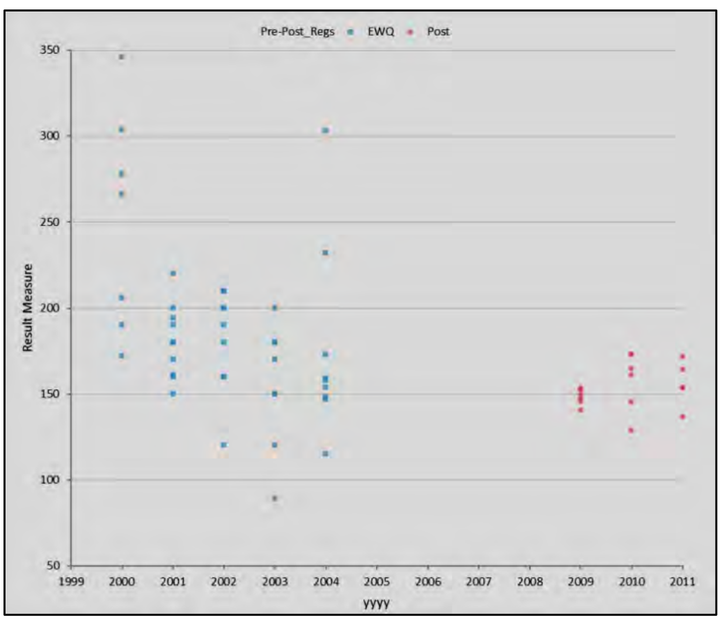


Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1737 BCP Cooks EWQ	46	1052.2	22.87
1737 BCP Cooks Post	17	2847.1	167.47

H statistic	11.63
X^2 approximation	11.63
DF	1
p-value	0.0006[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.



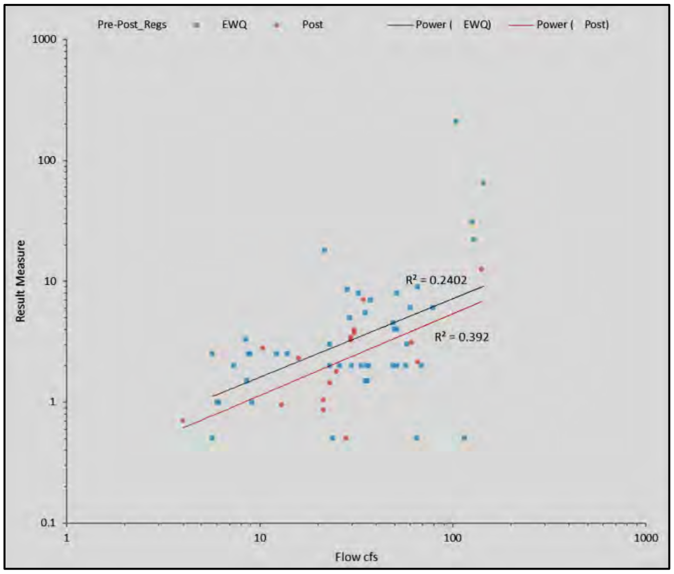
No water quality degradation is evident here. TDS apparently declined between the two periods. Uncertainty was introduced into comparisons by potential laboratory artifacts and insufficient post-EWQ sampling frequency. EWQ TDS is unrelated to flow though TDS was designated in the rules as flow related. Post-EWQ TDS is inversely related to flow though the regression is driven by a single high-flow sample. Post-EWQ median TDS fell below the EWQ lower 95% lower confidence interval. Post-EWQ TDS was much 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.

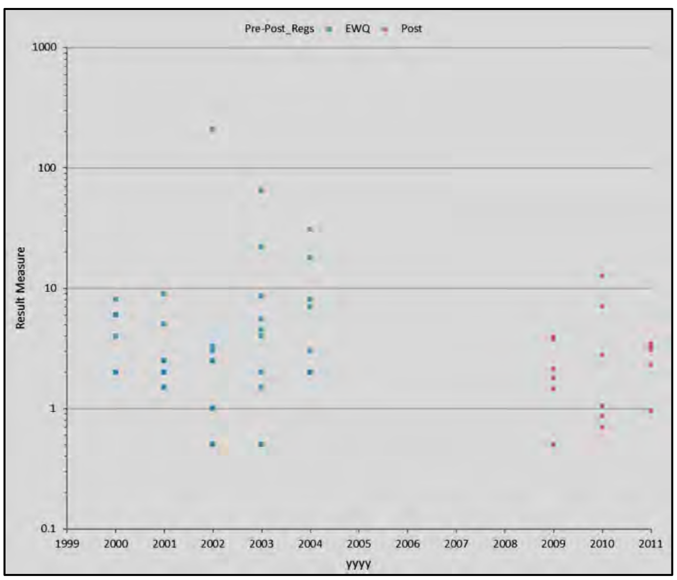
Chapter 13: 1737 BCP Cooks Creek, PA

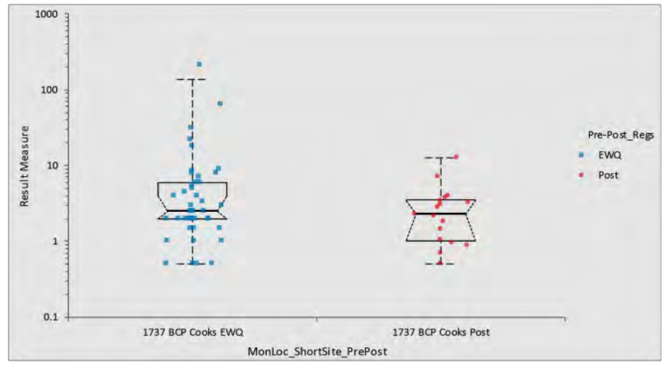
Total Suspended Solids (TSS) mg/l

Existing Water Quality (Table 2N):

Median 2.5 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

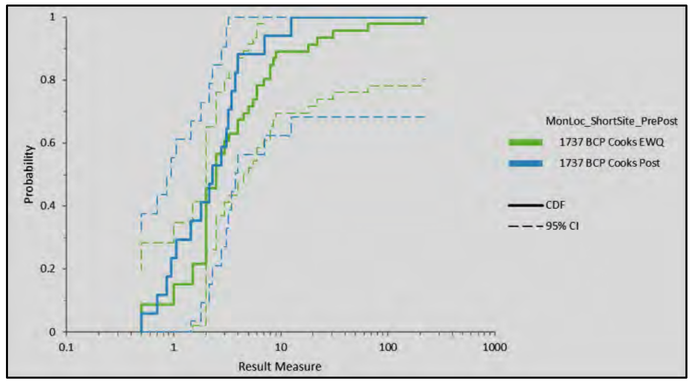






	N
	63

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1737 BCP Cooks EWQ	0.5	2.0	2.5	6.0	210.0	4.0
1737 BCP Cooks Post	0.5	1.0	2.3	3.6	12.6	2.5



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1737 BCP Cooks EWQ	46	94.7	2.06
1737 BCP Cooks Post	17	256.2	15.07

H statistic	1.05
X^2 approximation	1.05
DF	1
p-value	0.3053[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.

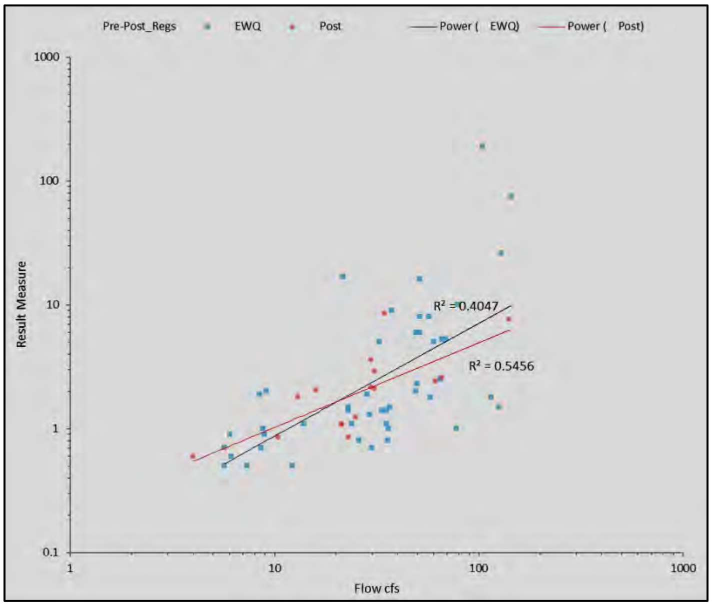
No water quality degradation is evident here. TSS did not measurably change between the EWQ and post-EWQ periods. Uncertainty was introduced into comparisons by potential laboratory artifacts and insufficient post-EWQ sampling frequency. TSS is positively related to flow in both data sets. Post-EWQ median TSS fell within the EWQ 95% confidence intervals. Both flow and concentration are plotted on a logarithmic scale.

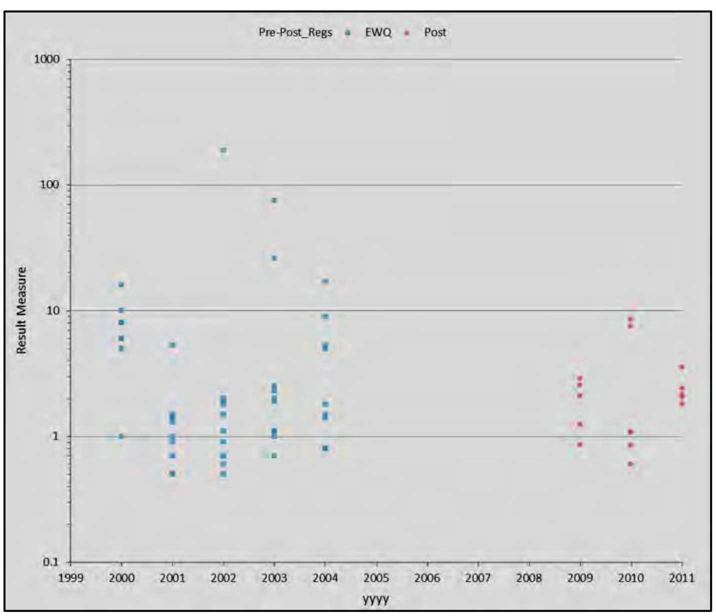
Chapter 13: 1737 BCP Cooks Creek, PA

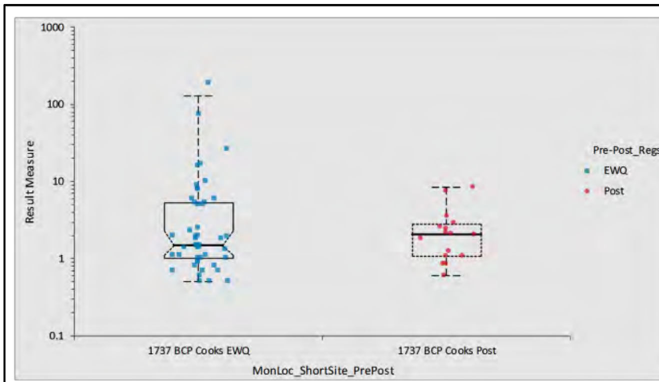
Turbidity NTU

Existing Water Quality (Table 2N):

Median 1.5 NTU
Lower 95% Confidence Interval 1.1 NTU
Upper 95% Confidence Interval 2.3 NTU
Defined in regulations as a flow-related parameter

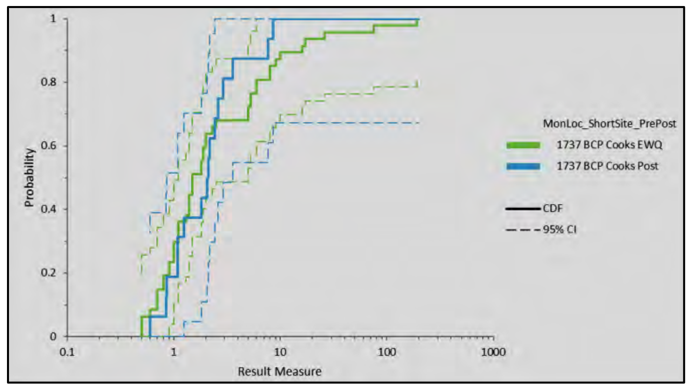






N 63

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1737 BCP Cooks EWQ	0.50	1.00	1.50	5.30	190.00	4.30
1737 BCP Cooks Post	0.60	1.08	2.09	2.78	8.56	1.69



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1737 BCP Cooks EWQ	47	2.8	0.06
1737 BCP Cooks Post	16	8.3	0.52

H statistic	0.03
X² approximation	0.03
DF	1
p-value	0.8558 [1]

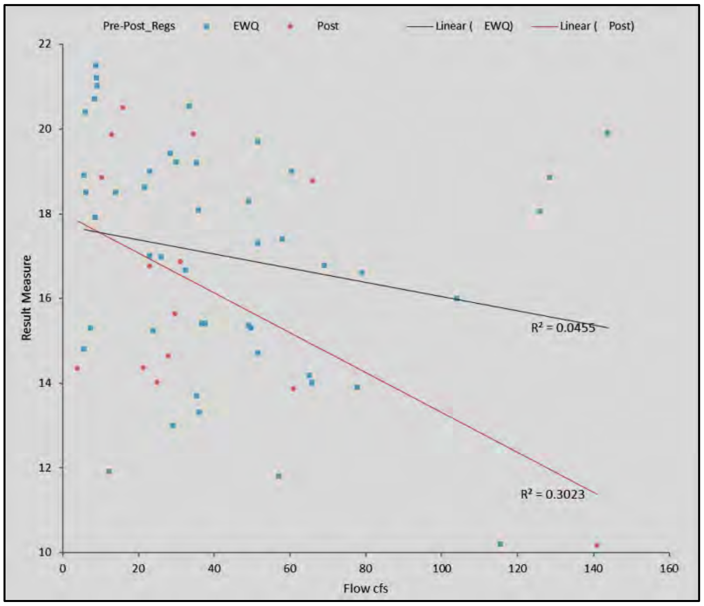
H0: $\theta_1 = \theta_2 = \theta_{...}$
The median of the populations are all equal.
H1: $\theta_i \neq \theta_j$ for at least one i,j
The median of the populations are not all equal.
[1] Do not reject the null hypothesis at the 5% significance level.

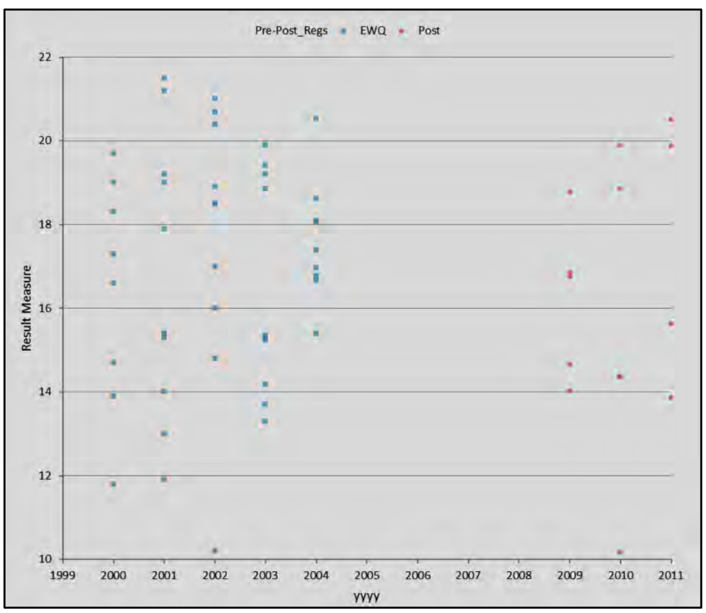
No water quality degradation is evident here. Turbidity did not measurably change between the EWQ and post-EWQ periods. Uncertainty was introduced into comparisons by insufficient post-EWQ sampling frequency. Post-EWQ median turbidity fell within the EWQ 95% confidence intervals of the median. Turbidity is positively related to flow in both data sets. Both concentration and flow is represented on logarithmic scale, and the regression is a power relationship.

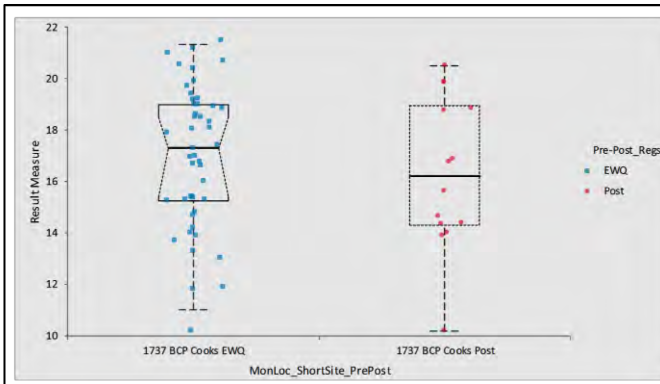
Chapter 13: 1737 BCP Cooks Creek, PA

Water Temperature, degrees C

Not included in DRBC Existing Water Quality rules

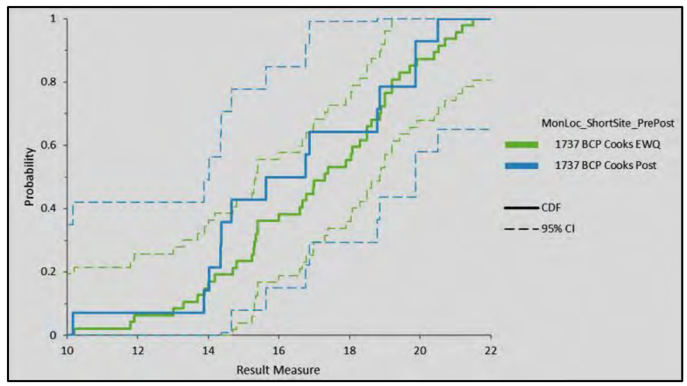






N	61

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1737 BCP Cooks EWQ	10.2	15.2	17.3	19.0	21.5	3.8
1737 BCP Cooks Post	10.2	14.3	16.2	18.9	20.5	4.6



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1737 BCP Cooks EWQ	47	40.3	0.86
1737 BCP Cooks Post	14	135.2	9.65

H statistic	0.56
X^2 approximation	0.56
DF	1
p-value	0.4556[1]

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

The median of the populations are all equal.

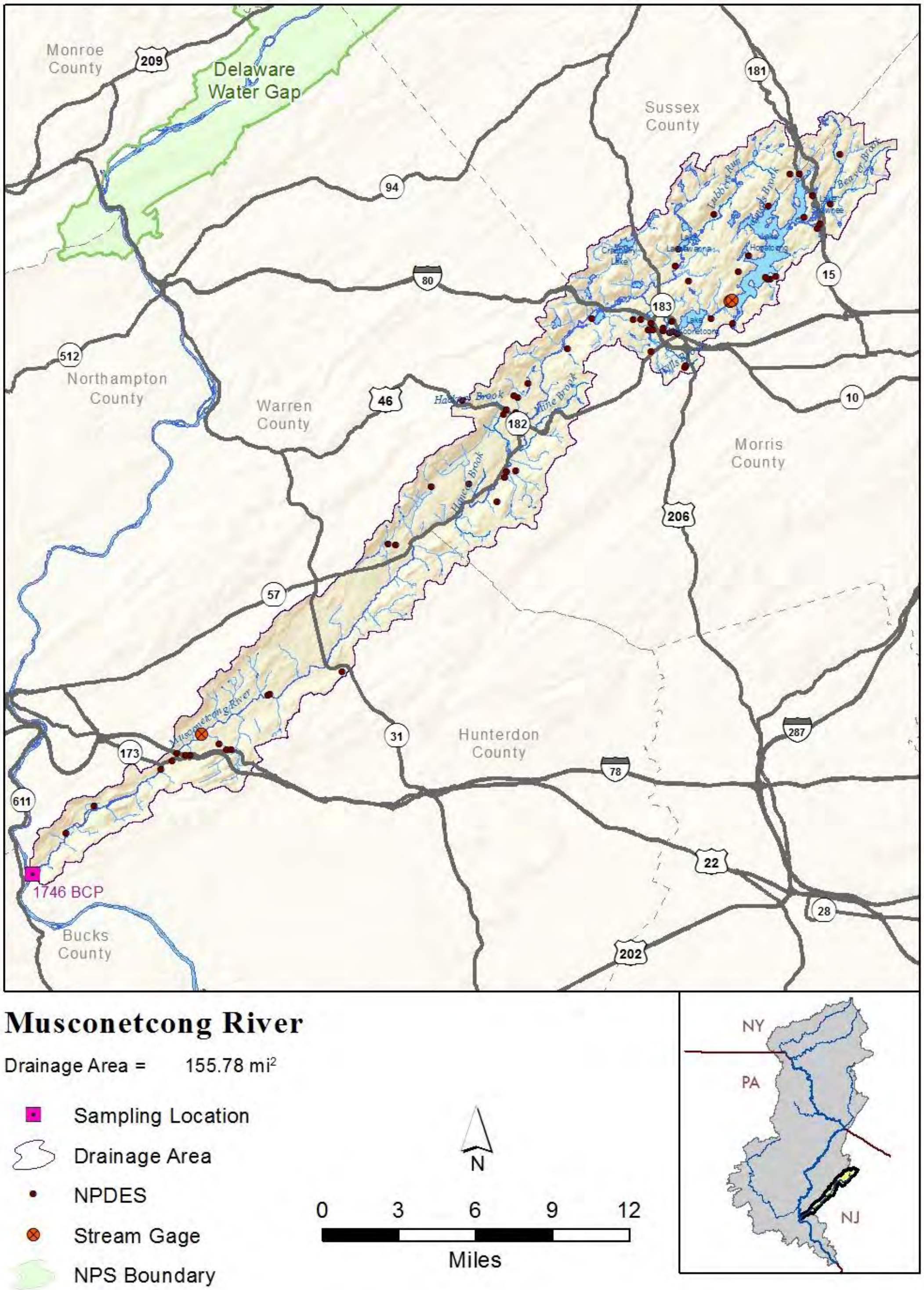
H1: $\theta_i \neq \theta_j$ for at least one i,j

The median of the populations are not all equal.

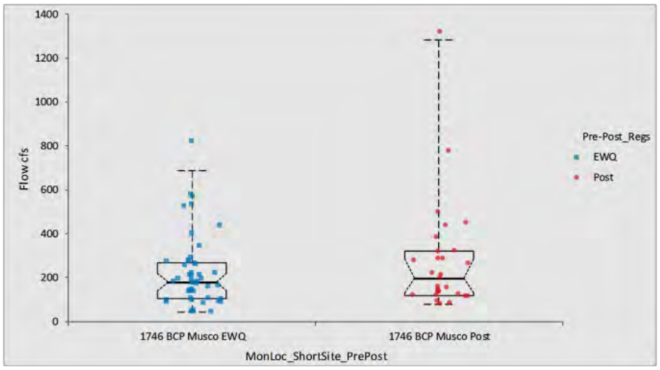
[1] Do not reject the null hypothesis at the 5% significance level.

No water quality degradation is evident here. Water temperature did not measurably change between the EWQ and post-EWQ periods. Uncertainty was introduced into comparisons by insufficient post-EWQ sampling frequency. Water temperature is unrelated to flow in the EWQ data set, but weakly and inversely related to flow in the post-EWQ data set. Flows is plotted on a logarithmic scale.

Chapter 14: 1746 BCP Musconetcong River, Hunterdon, Warren, Sussex and Morris Counties, NJ



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



N | 77

Flow cfs by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1746 BCP Musco EWQ	44.0	104.3	179.2	269.3	819.0	165.1
1746 BCP Musco Post	79.0	120.0	197.0	319.3	1317.0	199.3

Flow was roughly the same between the EWQ and post-EWQ periods. Fewer samples were collected in the post-EWQ period. The range of flow conditions sampled was wider in the post-EWQ period, but there were fewer samples taken during low-flow conditions.

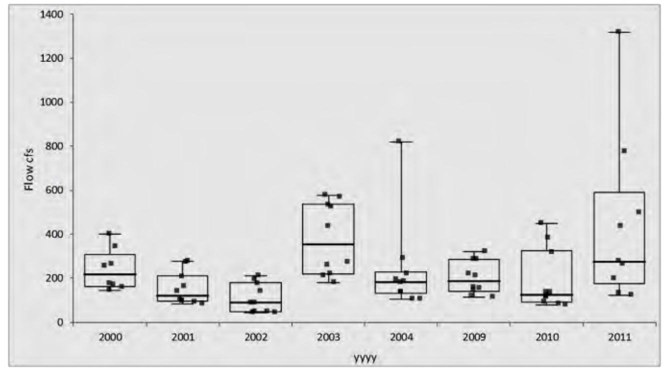
Kruskal-Wallis test

Flow cfs by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1746 BCP Musco EWQ	48	94.9	1.98
1746 BCP Musco Post	29	157.1	5.42

H statistic	0.50
X^2 approximation	0.50
DF	1
p-value	0.4779 [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.

The 155.9 square mile Musconetcong River watershed is a large tributary to the Delaware River, and has been designated in the federal Wild and Scenic River system. The watershed is about 58% forested, and contains 11.3% urban land cover – one of the more urbanized watersheds in the Lower Delaware. The watershed is about 25% underlain by carbonate bedrock, and about 48% influenced by glacial activity. There are numerous municipal and industrial dischargers in the watershed, and significant agriculture in the valley. Human activity in the watershed is sufficiently complex that the Musconetcong is a good candidate for construction of a watershed water quality model to assess cumulative effects, particularly since the Musconetcong presently deteriorates downstream Delaware River water quality.



N | 77

Flow cfs by yyyy	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
2000	145.9	163.2	215.8	309.9	399.4	146.7
2001	82.5	94.4	119.8	212.0	277.1	117.7
2002	44.0	46.6	88.5	179.1	212.4	132.5
2003	180.5	220.8	355.6	536.3	577.4	315.5
2004	103.0	131.7	182.0	227.8	819.0	96.1
2009	115.0	141.8	185.5	284.0	320.0	142.2
2010	79.0	93.1	127.0	324.5	449.0	231.4
2011	121.0	175.3	277.0	590.3	1317.0	415.0

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 is about 302 cfs; and harmonic mean flow is about 187 cfs (USGS Stream Stats retrieval, Feb. 2014) which is more typical of summer flow conditions. Though a wide range of flows were sampled by DRBC, these data appear to be most representative of low to normal flow conditions. Flows corresponding to each water quality sample were estimated using instantaneous data from the USGS gage No. 01457000 on the Musconetcong River near Bloomsbury times a drainage area weighting factor.

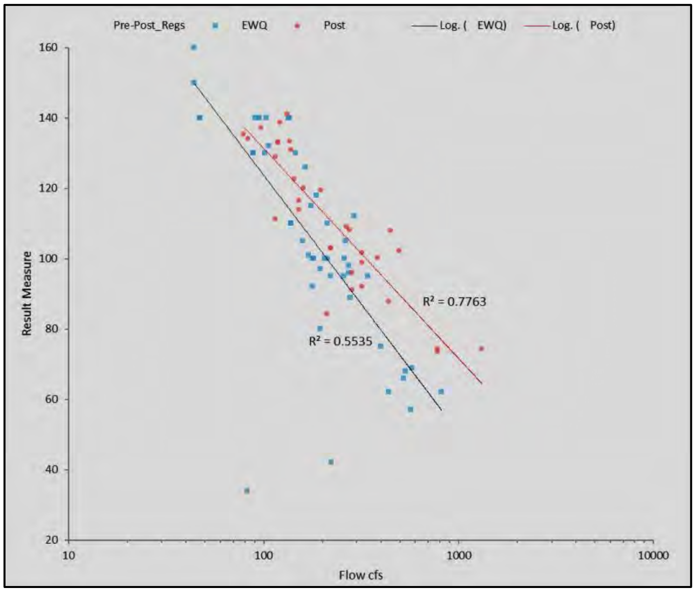
Upstream ICP: Delaware River at Riegelsville 1748 ICP
Downstream ICP: Delaware River at Milford 1677 ICP

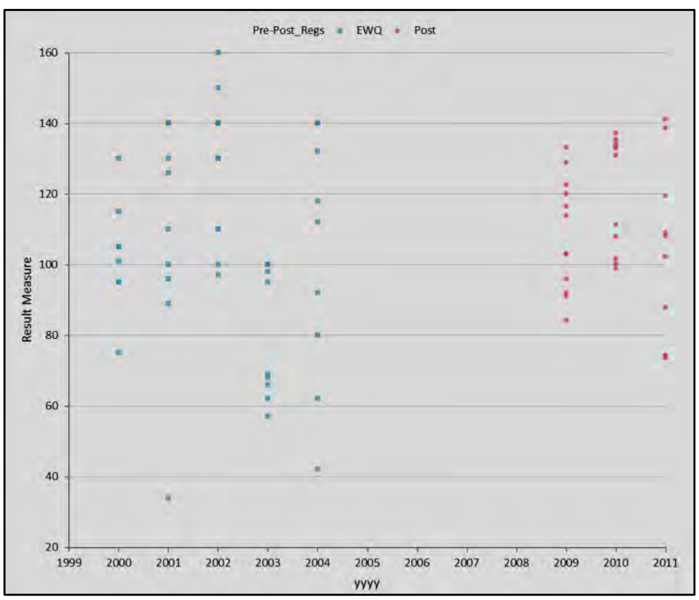
Chapter 14: 1746 BCP Musconetcong River, NJ

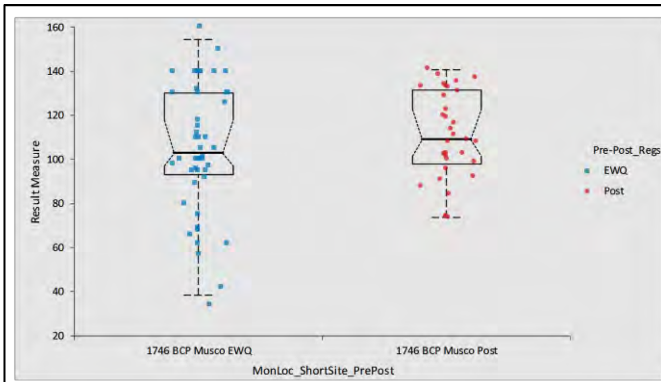
Alkalinity as CaCO3, Total mg/l

Existing Water Quality (Table 2M):

Median 103 mg/l
Lower 95% Confidence Interval 97 mg/l
Upper 95% Confidence Interval 118 mg/l
Defined in regulations as a flow-related parameter

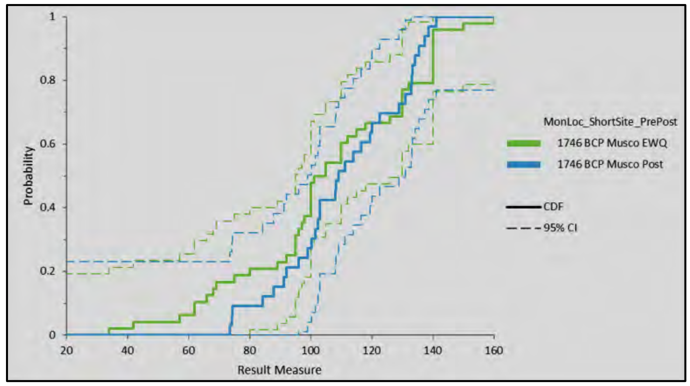






N | 81

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1746 BCP Musco EWQ	34	93	103	130	160	37
1746 BCP Musco Post	74	98	109	132	141	34



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1746 BCP Musco EWQ	48	112.5	2.34
1746 BCP Musco Post	33	163.7	4.96

H statistic	0.50
X² approximation	0.50
DF	1
p-value	0.4796 [1]

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

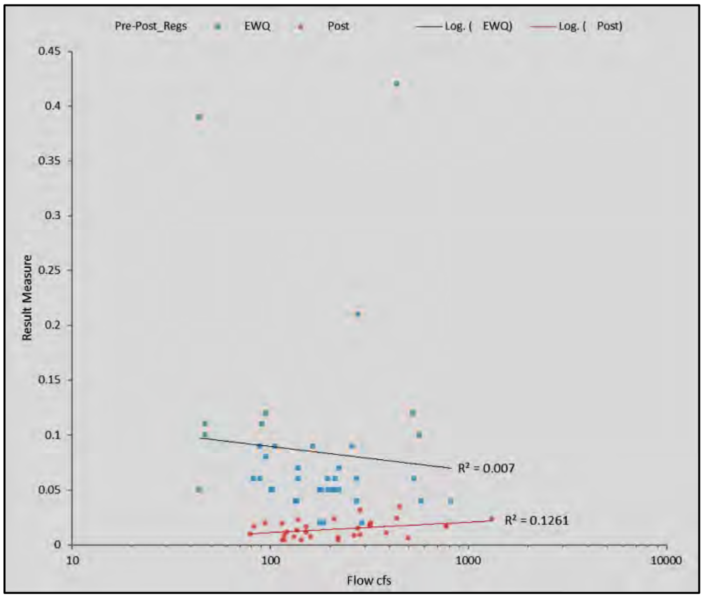
No water quality degradation is evident here. Alkalinity did not measurably change between the EWQ and post-EWQ periods. Uncertainty was introduced into comparisons by potential laboratory artifacts. Alkalinity is inversely related to flow in both data sets. Post-EWQ median alkalinity fell within EWQ 95% confidence intervals. Flow is plotted on a logarithmic scale. Limestone-influences are apparent at these alkalinity concentrations.

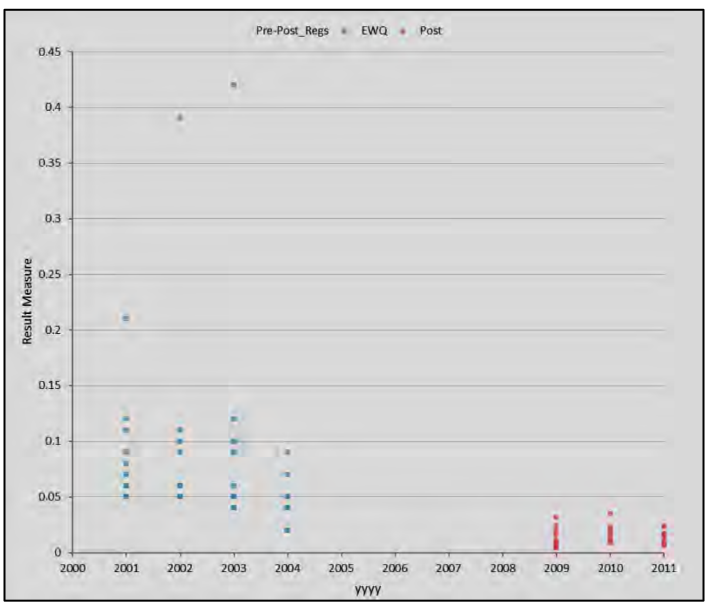
Chapter 14: 1746 BCP Musconetcong River, NJ

Ammonia Nitrogen as N, Total mg/l

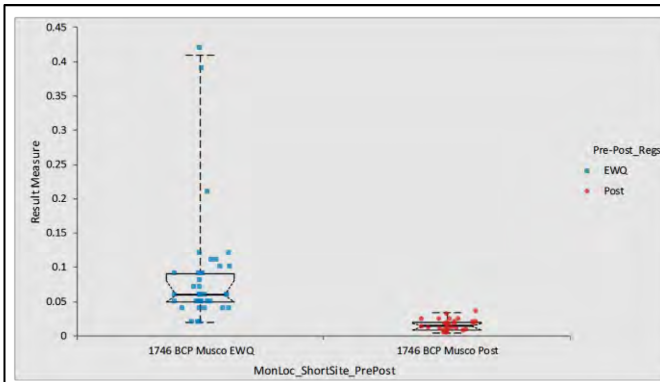
Existing Water Quality (Table 2M):

Median 0.06 mg/l
Lower 95% Confidence Interval 0.05 mg/l
Upper 95% Confidence Interval 0.08 mg/l

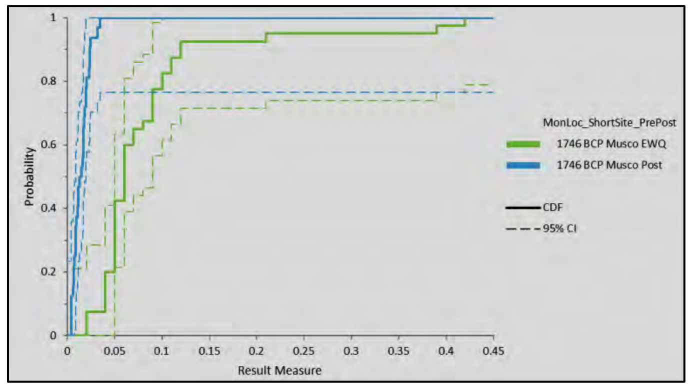




No water quality degradation is evident here. Ammonia concentrations apparently declined. Uncertainty was introduced into comparisons by potential laboratory artifacts and declining detection limits. Post-EWQ median ammonia concentration was below the EWQ lower 95% confidence interval. New Jersey and USGS data were available and validated these results.



N	72					
Result Measure by MonLoc_ShortSite_PrePost	**Minimum**	**1st Quartile**	**Median**	**3rd Quartile**	**Maximum**	**Inter-quartile range**
1746 BCP Musco EWQ	0.020	0.050	0.060	0.090	0.420	0.040
1746 BCP Musco Post	0.004	0.008	0.014	0.020	0.035	0.012



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1746 BCP Musco EWQ	40	9625.5	240.64
1746 BCP Musco Post	32	12031.9	376.00

H statistic	49.63
X^2 approximation	49.63
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.

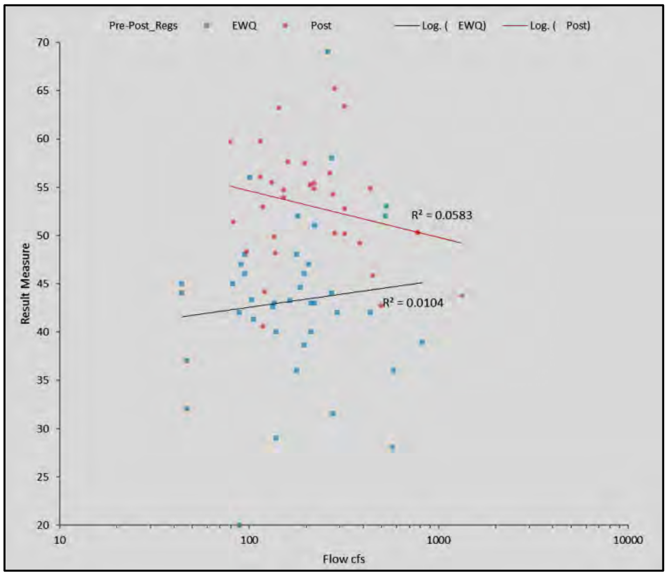
Flow is plotted on a logarithmic scale. DRBC's post-EWQ detection limit was much lower than during the EWQ period. EWQ data possessed 12/40 undetected results out of 40 samples at detection limits of 0.02-0.05 mg/l. 2009-2011 detection levels were 0.004-0.006 mg/l, and there were still 5/32 undetected results. So rather than a real change in ambient concentrations data may show actual low-level concentrations. Evidence of water quality improvement is possible as post-EWQ DRBC, NJDEP and USGS data contained no concentrations over 0.035 mg/l.

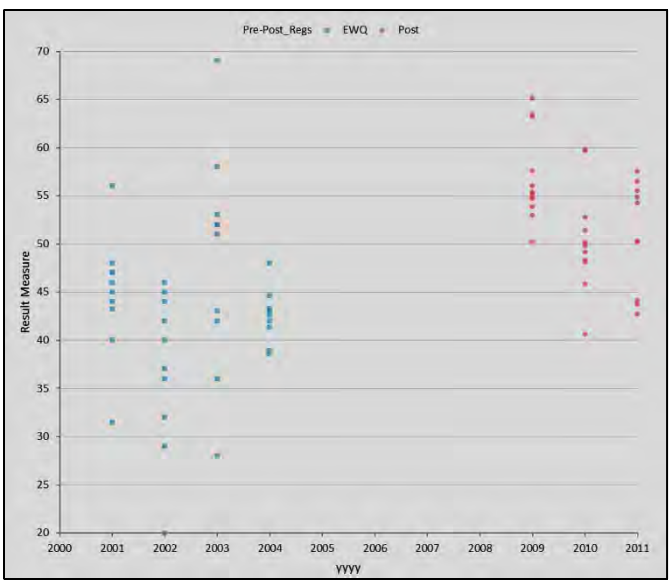
Chapter 14: 1746 BCP Musconetcong River, NJ

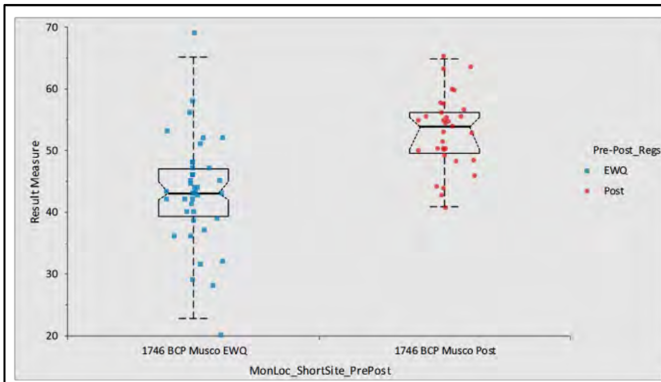
Chloride, Total mg/l

Existing Water Quality (Table 2M):

Median 43 mg/l
Lower 95% Confidence Interval 42 mg/l
Upper 95% Confidence Interval 45 mg/l

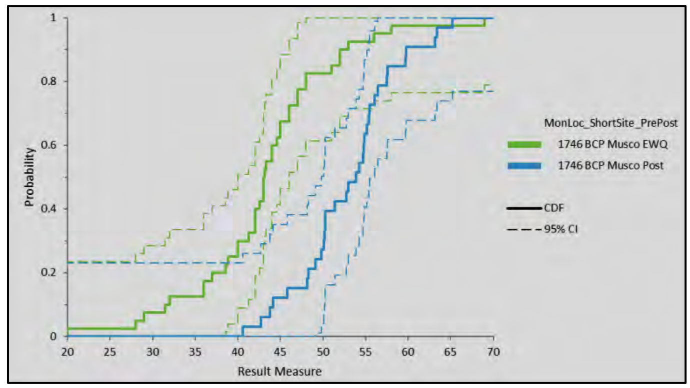






N 73

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1746 BCP Musco EWQ	20.0	39.4	43.1	47.0	69.0	7.6
1746 BCP Musco Post	40.6	49.6	53.9	56.2	65.2	6.6



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1746 BCP Musco EWQ	40	5175.6	129.39
1746 BCP Musco Post	33	6273.5	190.11

H statistic	25.44
X^2 approximation	25.44
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.

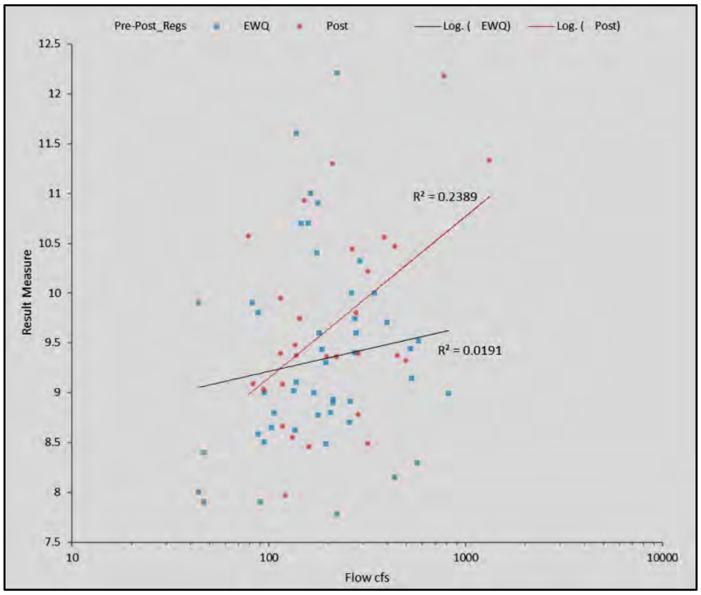
Water quality degradation is evident here. Chloride concentrations apparently rose by about 11 mg/l between the two periods, a 25% increase. Uncertainty was introduced into comparisons by potential laboratory artifacts. Post-EWQ median concentration rose above the EWQ upper 95% confidence interval. Chloride concentration is unrelated to flow in this data set. Note that flow is plotted on a logarithmic scale. NJDEP and USGS data validated this conclusion.

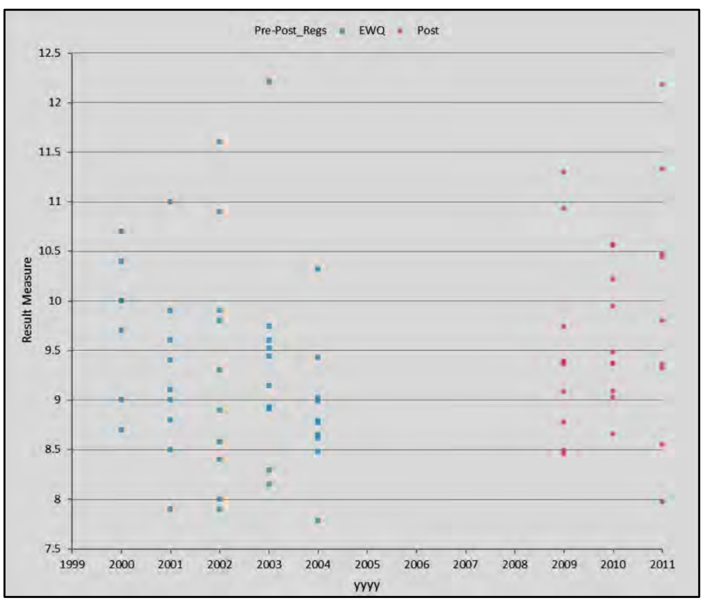
Chapter 14: 1746 BCP Musconetcong River, NJ

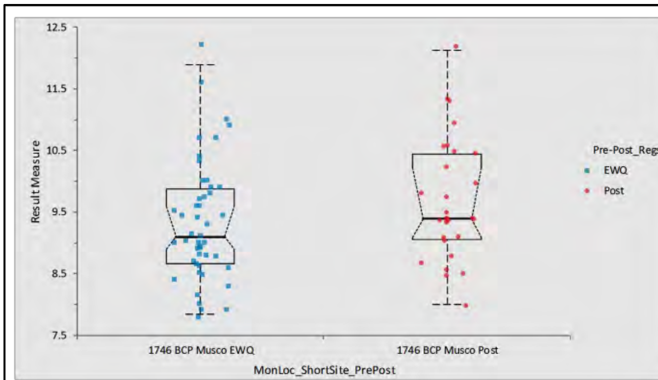
Dissolved Oxygen (DO) mg/l

Existing Water Quality (Table 2M):

Median 9.10 mg/l
Lower 95% Confidence Interval 8.90 mg/l
Upper 95% Confidence Interval 9.60 mg/l

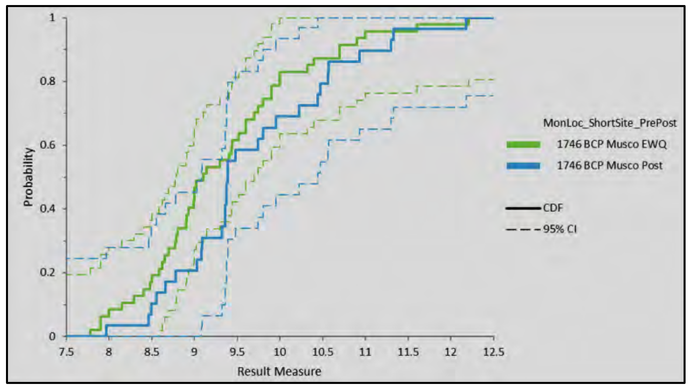






N 76

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1746 BCP Musco EWQ	7.78	8.66	9.10	9.88	12.21	1.23
1746 BCP Musco Post	7.97	9.06	9.39	10.45	12.18	1.39



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1746 BCP Musco EWQ	47	414.0	8.81
1746 BCP Musco Post	29	671.0	23.14

H statistic	2.23
X^2 approximation	2.23
DF	1
p-value	0.1358 [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.

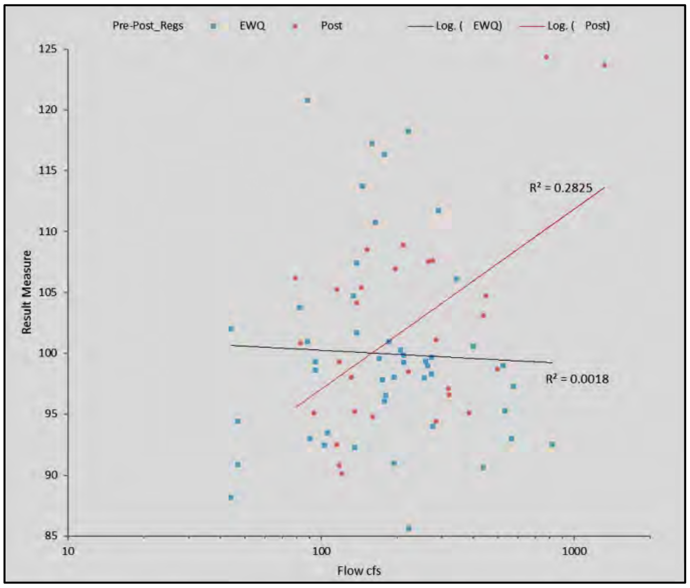
No water quality degradation is evident here. No measurable change took place between the EWQ and Post-EWQ periods. Post-EWQ median DO concentration fell within the EWQ 95% confidence intervals. DO concentration is unrelated to flow in both data sets. Note that flow is plotted on a logarithmic scale.

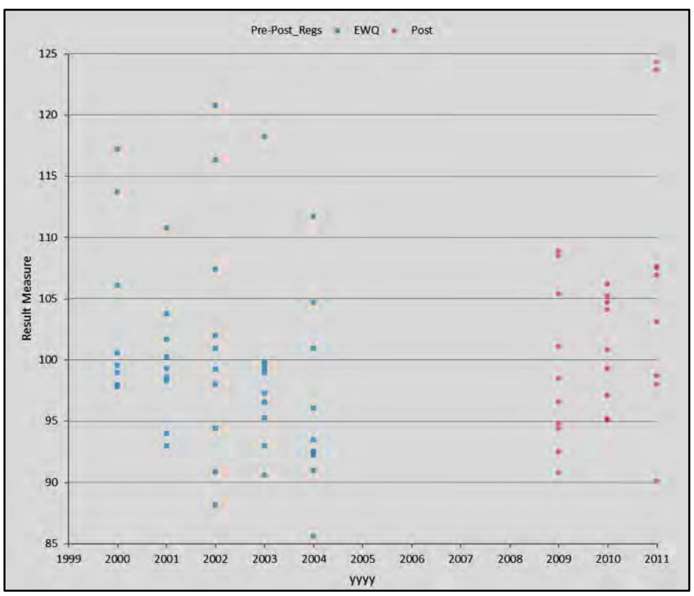
Chapter 14: 1746 BCP Musconetcong River, NJ

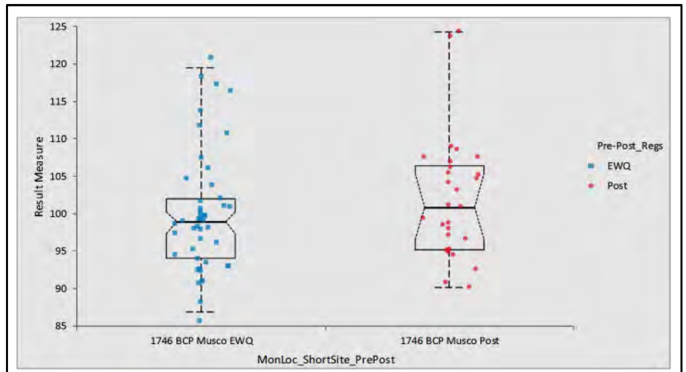
Dissolved Oxygen Saturation %

Existing Water Quality (Table 2M):

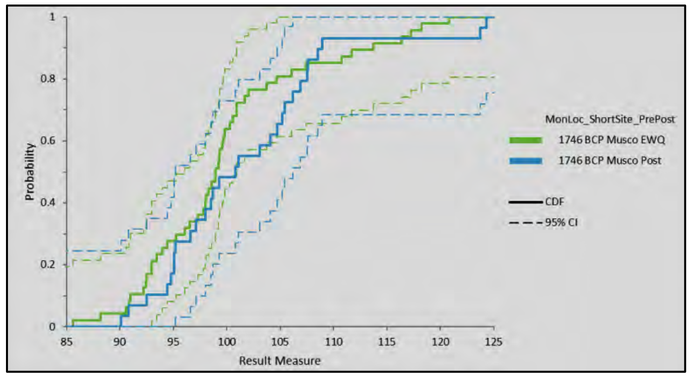
Median 99%
Lower 95% Confidence Interval 97%
Upper 95% Confidence Interval 100%







N	76					
Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1746 BCP Musco EWQ	86	94	99	102	121	8
1746 BCP Musco Post	90	95	101	106	124	11



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1746 BCP Musco EWQ	47	210.6	4.48
1746 BCP Musco Post	29	341.4	11.77

H statistic	1.13
X^2 approximation	1.13
DF	1
p-value	0.2873[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.

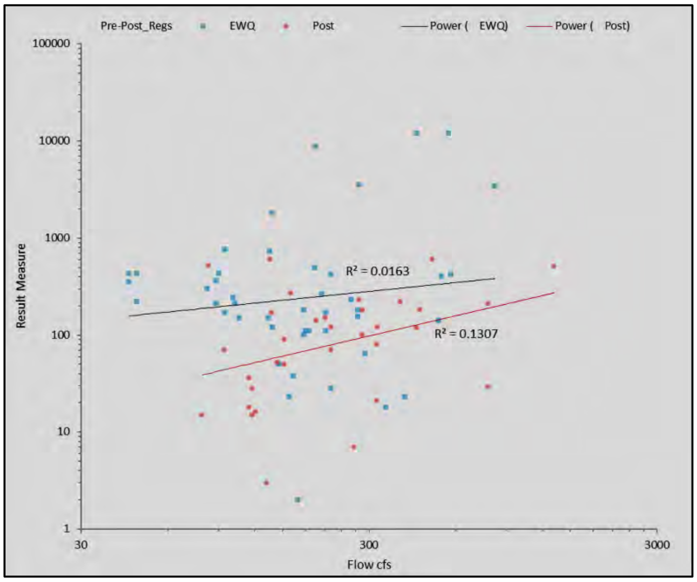
No water quality degradation is evident here. Dissolved Oxygen Saturation is unrelated to flow, and did not measurably change between the EWQ and post-EWQ periods. Post-EWQ median DO saturation increased above the upper EWQ 95% confidence interval but the increase was not significant. An increase in DO saturation would represent a water quality improvement anyway.

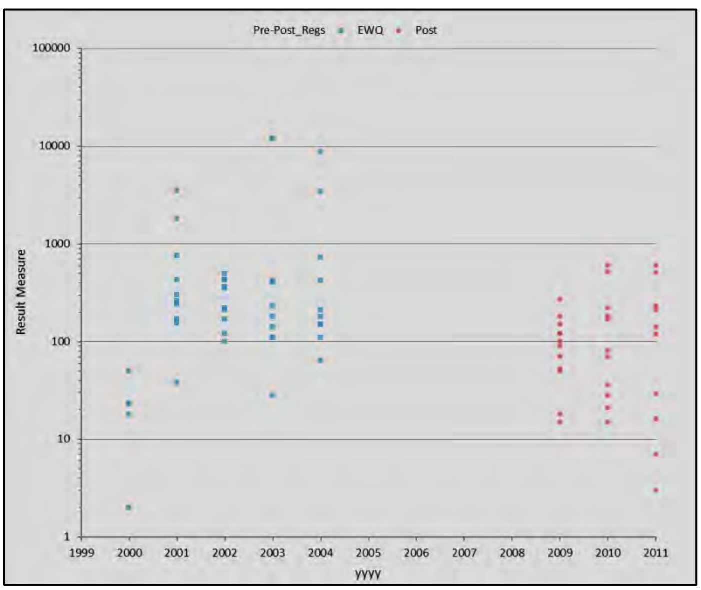
Chapter 14: 1746 BCP Musconetcong River, NJ

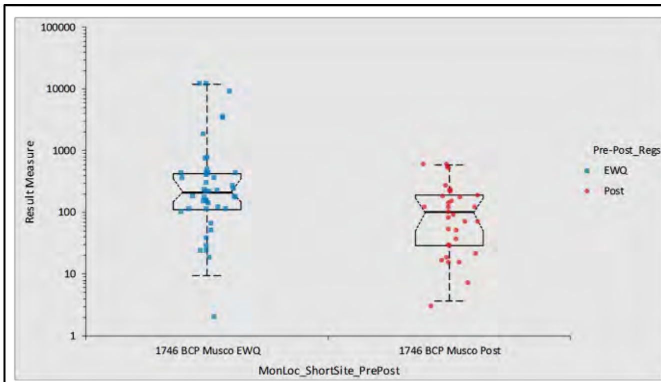
Enterococcus colonies/100 ml

Existing Water Quality (Table 2M):

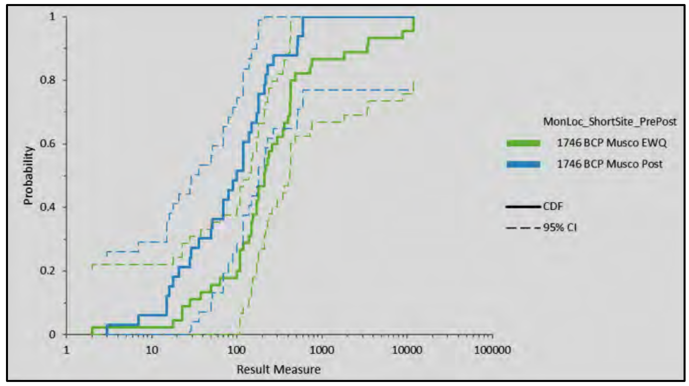
Median 210/100 ml
Lower 95% Confidence Interval 150/100 ml
Upper 95% Confidence Interval 360/100 ml







N	78					
Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1746 BCP Musco EWQ	2	110	210	430	12000	320
1746 BCP Musco Post	3	29	100	191	600	163



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1746 BCP Musco EWQ	45	1947.0	43.27
1746 BCP Musco Post	33	2655.0	80.46

H statistic	8.97
X^2 approximation	8.97
DF	1
p-value	0.0027 [1]

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

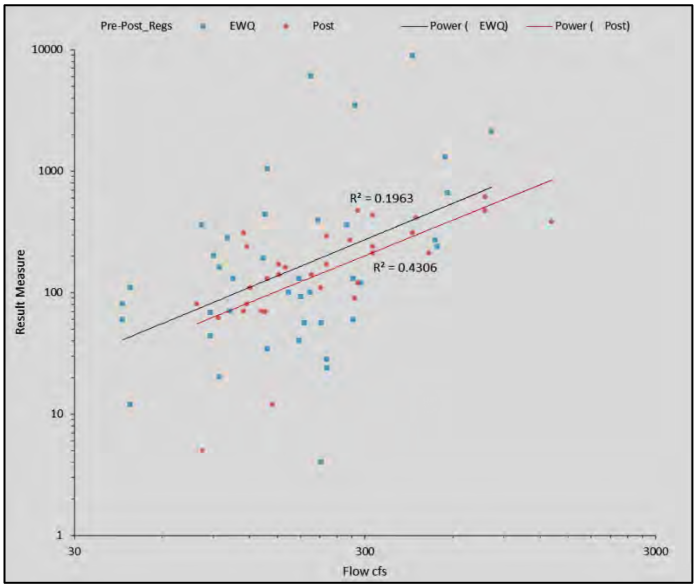
No water quality degradation is evident here. Enterococci apparently declined between the EWQ and Post-EWQ periods. Uncertainty was introduced into comparisons by potential laboratory artifacts. Enterococcus concentrations are unrelated to flow in both data sets. Note that concentrations and flows are plotted on a logarithmic scale, and the regression is a power relationship. Post-EWQ median enterococcus concentrations fell below the lower EWQ 95% confidence interval.

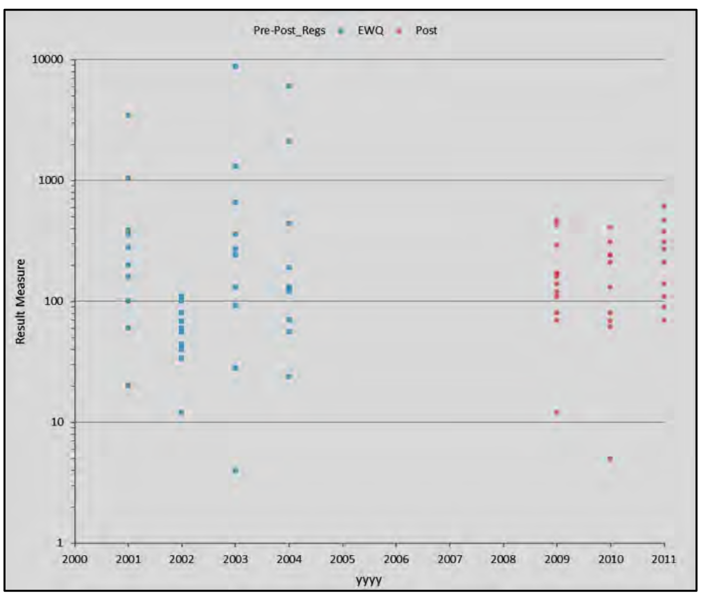
Chapter 14: 1746 BCP Musconetcong River, NJ

Escherichia coli colonies/100 ml

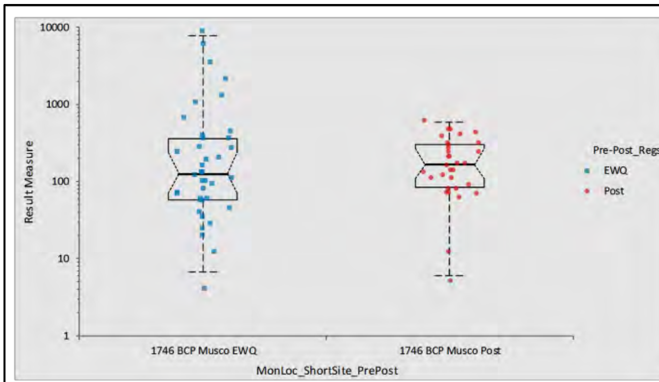
Existing Water Quality (Table 2M):

Median 125/100 ml
Lower 95% Confidence Interval 70/100 ml
Upper 95% Confidence Interval 240/100 ml



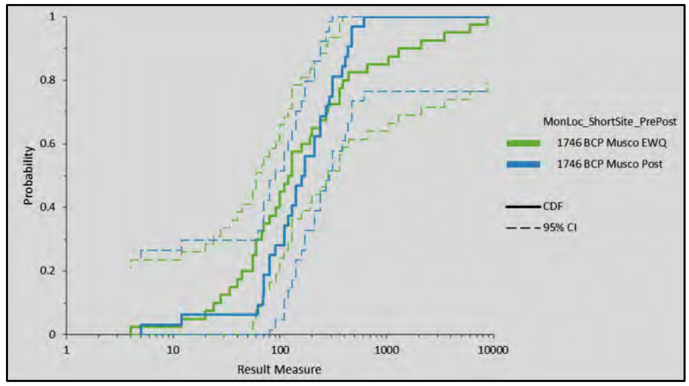


No water quality degradation is evident here. E. coli concentrations did not measurably change between the EWQ and Post-EWQ periods. Uncertainty was introduced into comparisons by potential laboratory artifacts.



N 72

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1746 BCP Musco EWQ	4	58	125	360	8800	302
1746 BCP Musco Post	5	84	165	302	610	218



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1746 BCP Musco EWQ	40	113.9	2.85
1746 BCP Musco Post	32	142.4	4.45

H statistic	0.59
X^2 approximation	0.59
DF	1
p-value	0.4442 [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.

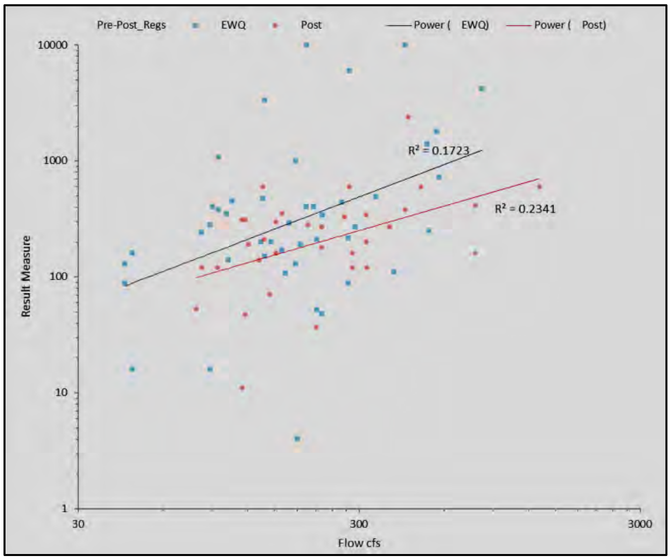
Post-EWQ median E. coli fell within the EWQ 95% confidence intervals. Note that concentrations and flows are plotted on a logarithmic scale. E. coli concentrations are unrelated to flow in the EWQ data set, but positively related to flow in the post-EWQ data set. New Jersey DEP and USGS data validated results and were virtually identical with DRBC data.

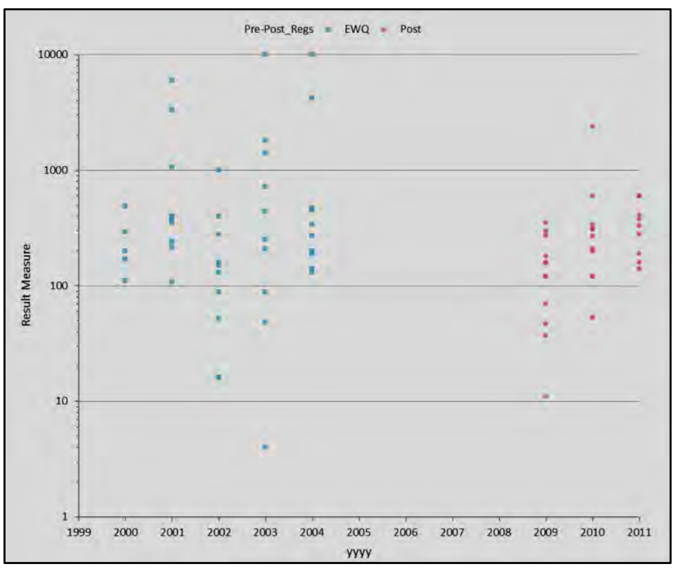
Chapter 14: 1746 BCP Musconetcong River, NJ

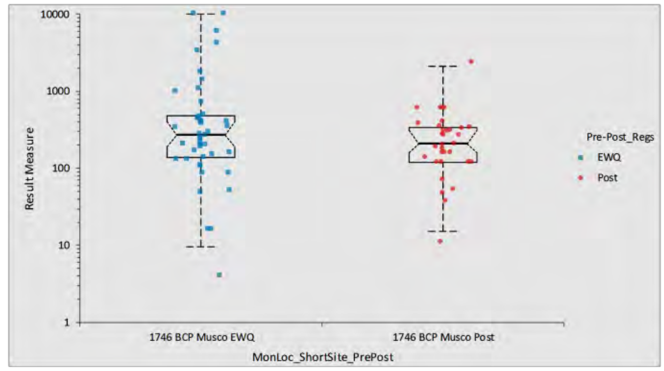
Fecal coliform colonies/100 ml

Existing Water Quality (Table 2M):

Median 270/100 ml
Lower 95% Confidence Interval 190/100 ml
Upper 95% Confidence Interval 400/100 ml

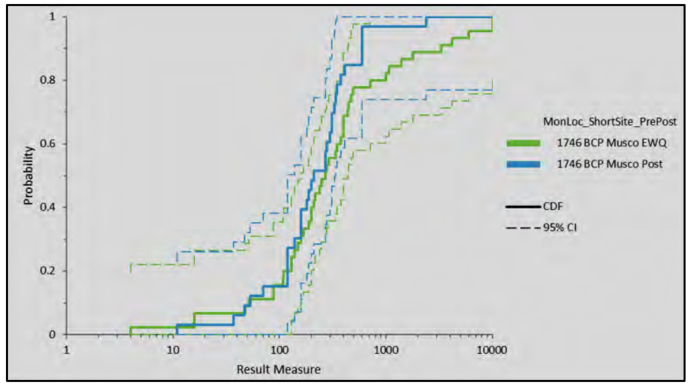






N | 78

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1746 BCP Musco EWQ	4	137	270	477	10000	340
1746 BCP Musco Post	11	120	210	343	2400	223



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1746 BCP Musco EWQ	45	281.3	6.25
1746 BCP Musco Post	33	383.5	11.62

H statistic	1.30
X^2 approximation	1.30
DF	1
p-value	0.2550 [1]

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

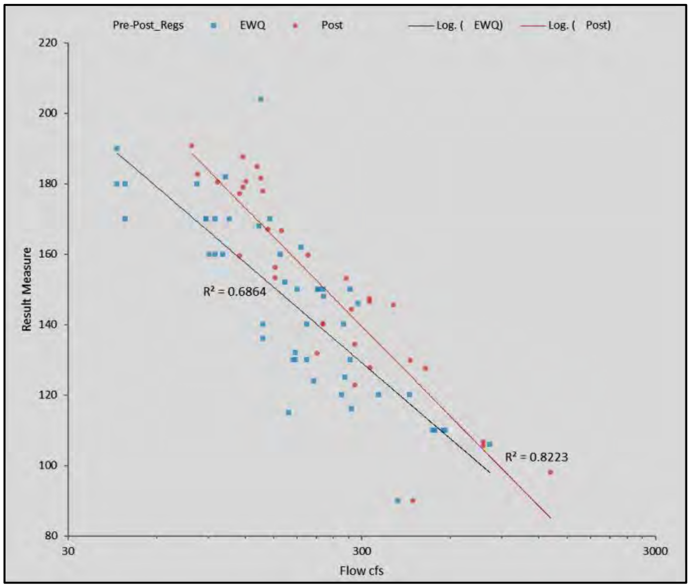
No water quality degradation is evident here. Fecal coliform concentrations did not measurably change between the EWQ and post-EWQ periods. Uncertainty was introduced into comparisons by potential laboratory artifacts. Four sample results were truncated at upper quantification levels by the laboratory, but these did not interfere with comparisons. Fecal coliform concentrations are unrelated to flow in both data sets. Post-EWQ median concentrations were within the EWQ 95% confidence intervals. Note that concentrations and flows are plotted on a logarithmic scale. NJDEP and USGS data validated DRBC results.

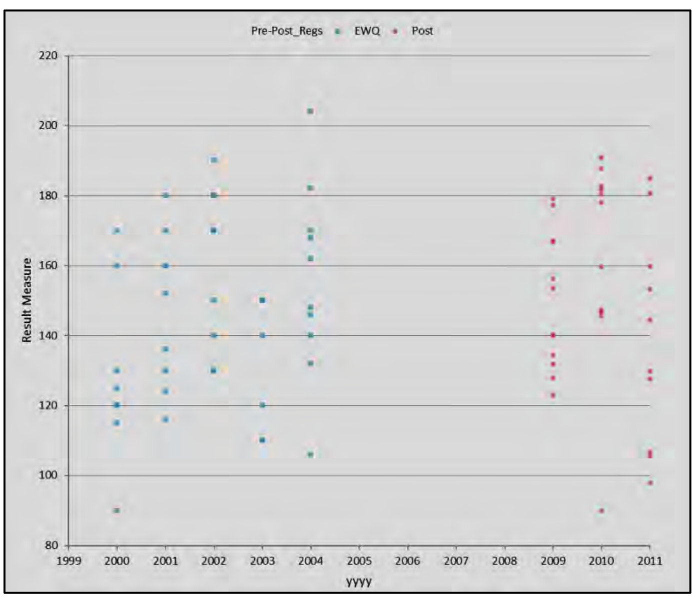
Chapter 14: 1746 BCP Musconetcong River, NJ

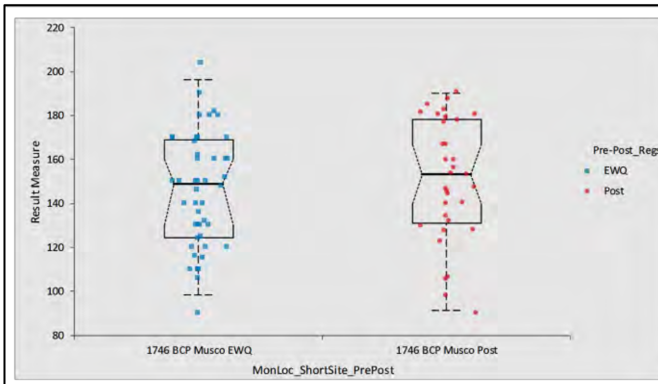
Hardness as CaCO3, Total mg/l

Existing Water Quality (Table 2M):

Median 149 mg/l
Lower 95% Confidence Interval 130 mg/l
Upper 95% Confidence Interval 160 mg/l
Defined in regulations as a flow-related parameter

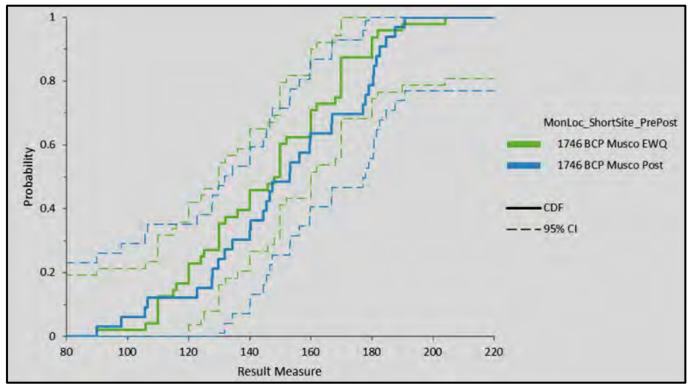






N 81

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1746 BCP Musco EWQ	90	124	149	169	204	45
1746 BCP Musco Post	90	131	153	178	191	47



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1746 BCP Musco EWQ	48	192.0	4.00
1746 BCP Musco Post	33	279.3	8.46

H statistic	0.85
X^2 approximation	0.85
DF	1
p-value	0.3559 [1]

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

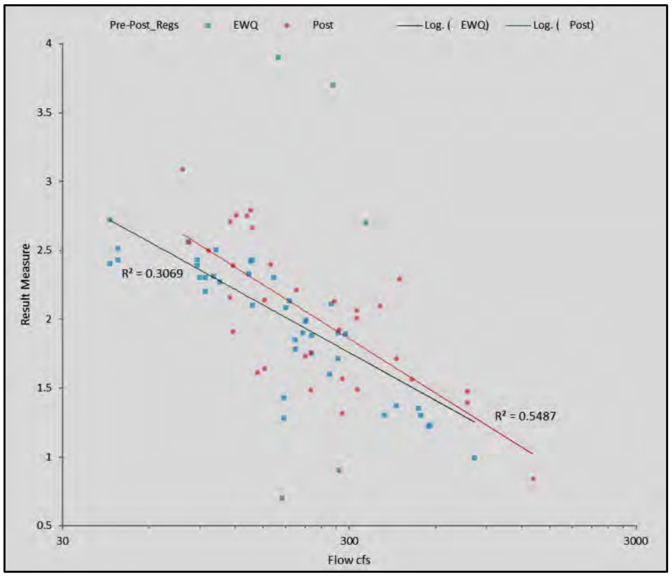
No water quality degradation is evident here. Hardness did not measurably change between the EWQ and post-EWQ periods. Uncertainty was introduced into comparisons by potential laboratory artifacts. Hardness is inversely related to flow in both data sets. Post-EWQ median hardness fell within the EWQ 95% confidence intervals. Flow is plotted on a logarithmic scale. USGS data validated DRBC results. These hardness concentrations reflect limestone influences.

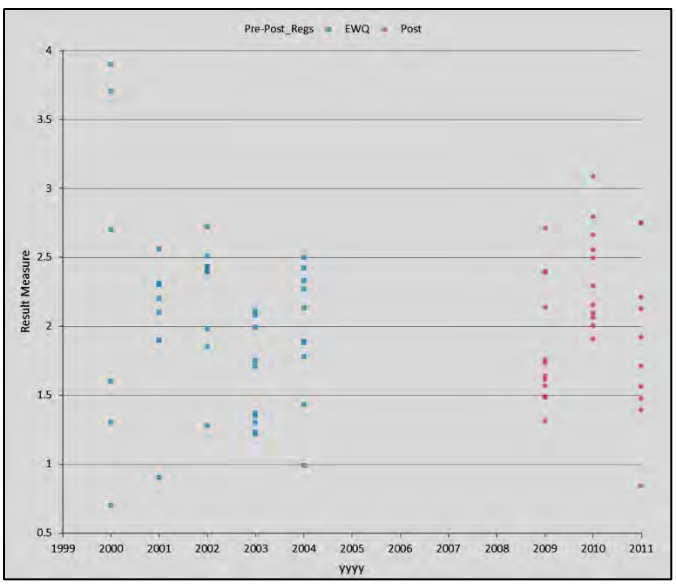
Chapter 14: 1746 BCP Musconetcong River, NJ

Nitrate + Nitrite as N, Total mg/l

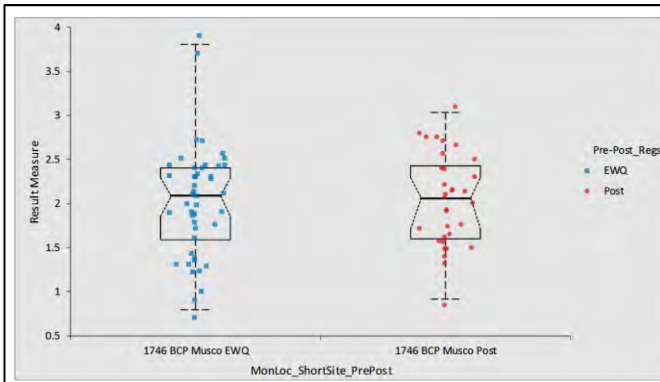
Existing Water Quality (Table 2M, as Nitrate only):

Median 2.09 mg/l
Lower 95% Confidence Interval 1.85 mg/l
Upper 95% Confidence Interval 2.30 mg/l



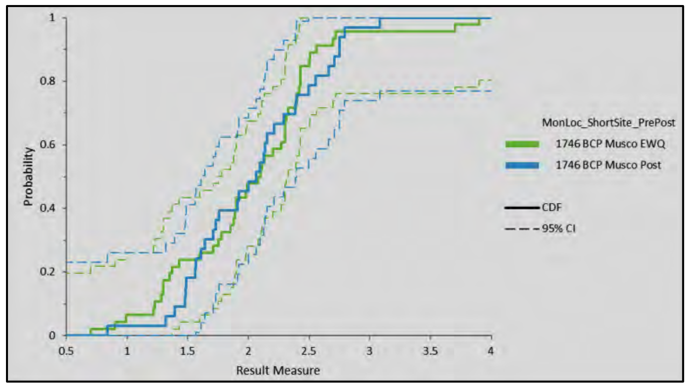


No water quality degradation is evident here. Nitrate concentrations, somewhat high in the Musconetcong, apparently did not change between the EWQ and post-EWQ periods. Uncertainty was introduced into comparisons by potential laboratory artifacts.



N | 79

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1746 BCP Musco EWQ	0.70	1.59	2.09	2.40	3.90	0.82
1746 BCP Musco Post	0.84	1.60	2.06	2.43	3.09	0.83



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1746 BCP Musco EWQ	46	14.7	0.32
1746 BCP Musco Post	33	20.5	0.62

H statistic	0.07
X^2 approximation	0.07
DF	1
p-value	0.7960[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.

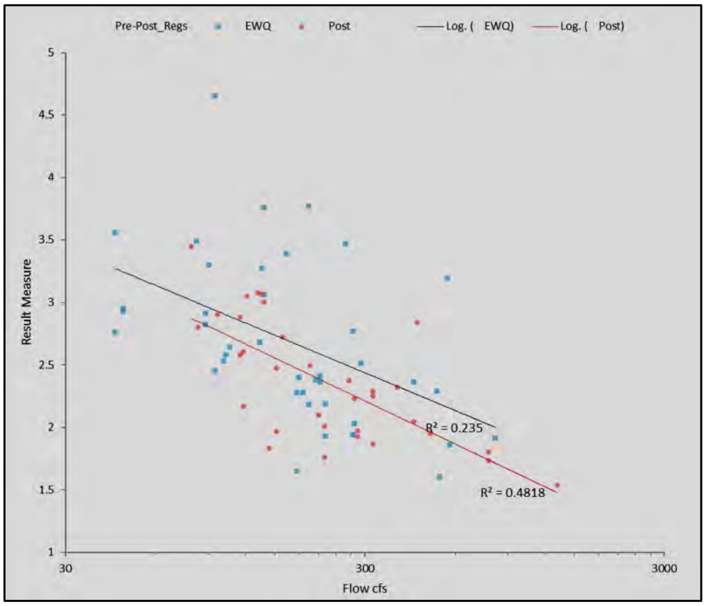
Both data sets are inversely related to flow. EWQ and post-EWQ data distributions were nearly identical. Post-EWQ nitrate + nitrite concentrations were assumed equivalent for comparison with EWQ nitrate concentrations since EWQ nitrite concentrations were never detected. Independent data were not available for validation of results (USGS measures dissolved instead of total nitrate). At other sites where concentrations are lower data interpretation was problematic due to changing detection limits. Concentrations are sufficiently high in the Musconetcong River that no such problems arose.

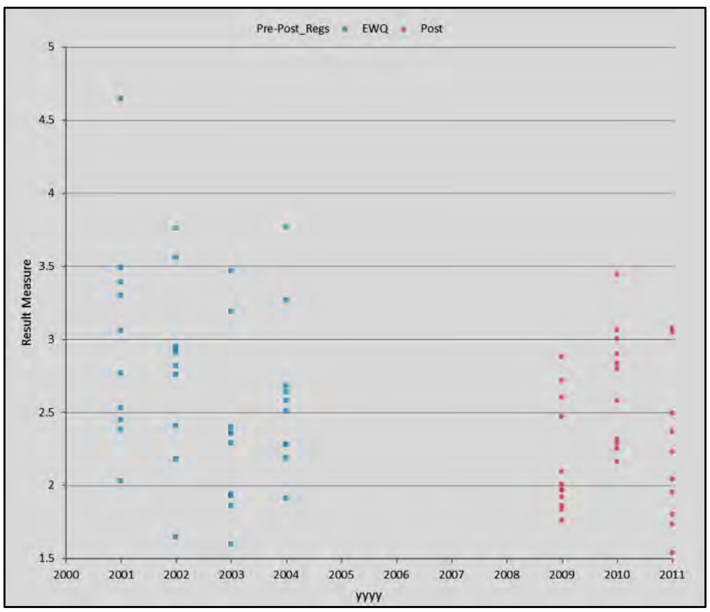
Chapter 14: 1746 BCP Musconetcong River, NJ

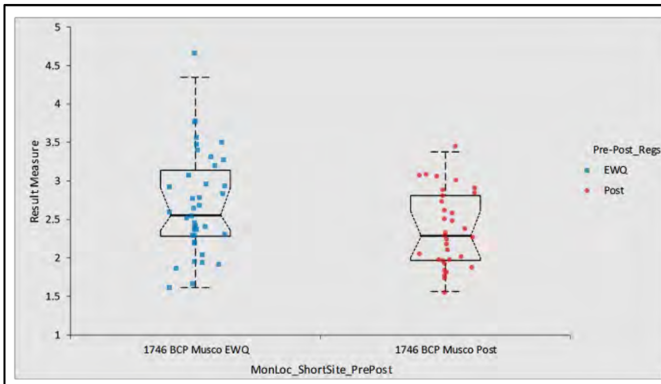
Nitrogen as N, Total (TN) mg/l

Existing Water Quality (Table 2M):

Median 2.56 mg/l
Lower 95% Confidence Interval 2.36 mg/l
Upper 95% Confidence Interval 2.91 mg/l

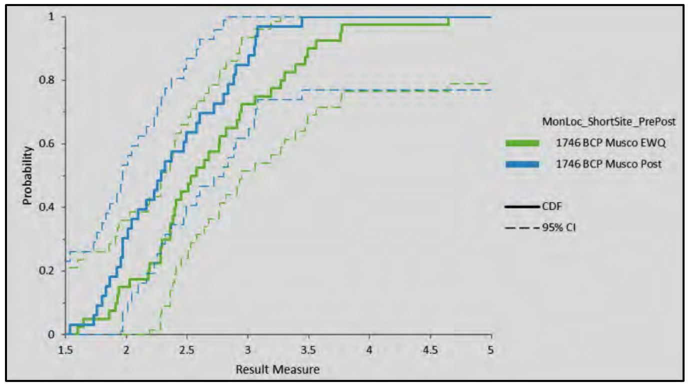






N 73

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1746 BCP Musco EWQ	1.60	2.28	2.56	3.14	4.65	0.86
1746 BCP Musco Post	1.54	1.96	2.29	2.81	3.44	0.85



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1746 BCP Musco EWQ	40	902.5	22.56
1746 BCP Musco Post	33	1093.9	33.15

H statistic	4.43
X² approximation	4.43
DF	1
p-value	0.0352 [1]

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

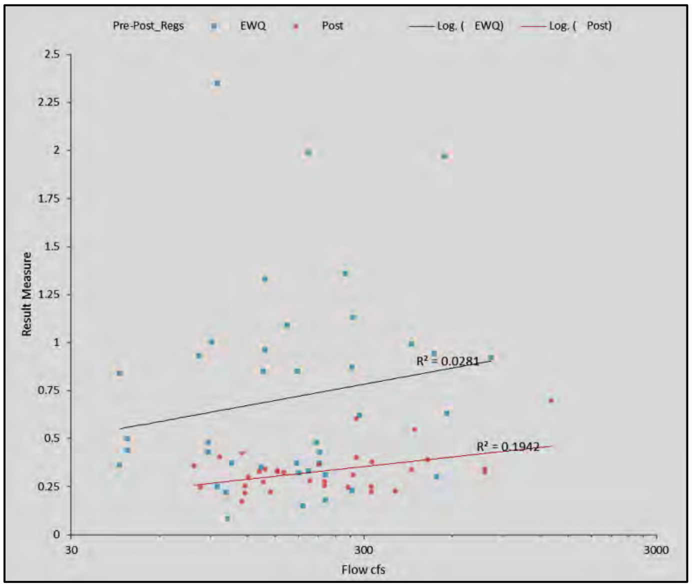
No water quality degradation is evident here. Total Nitrogen concentrations apparently declined between the EWQ and post-EWQ periods. Uncertainty was introduced into comparisons by potential laboratory artifacts. TN is weakly related to flow in the EWQ data, but inversely related to flow in the post-EWQ data. USGS data displayed a similar decline but were too few in number for statistical significance. Post-EWQ median TN concentrations fell below the EWQ lower 95% confidence intervals, possibly indicating a water quality improvement. Musconetcong River Total Nitrogen concentrations remain among the highest in comparison with other Delaware River tributaries.

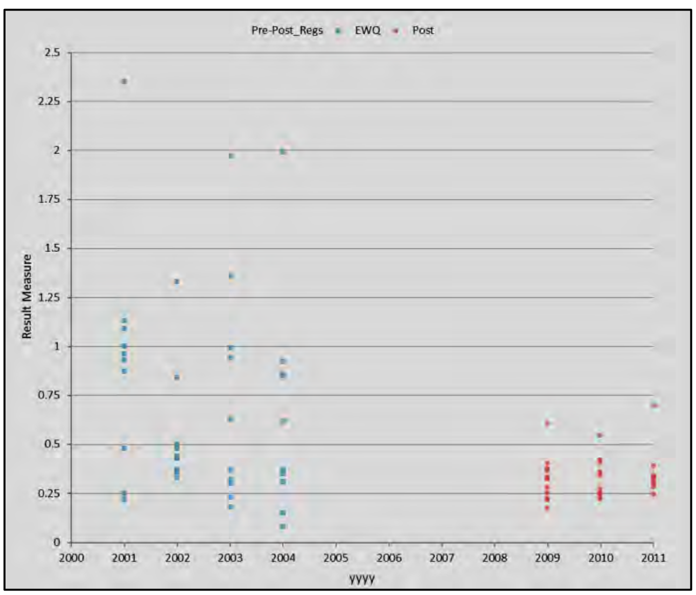
Chapter 14: 1746 BCP Musconetcong River, NJ

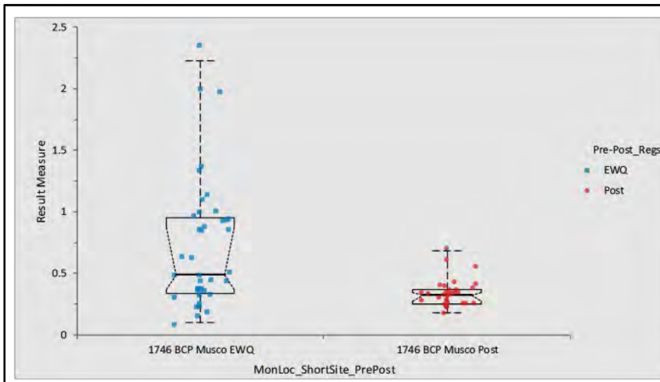
Nitrogen, Kjeldahl as N, Total (TKN) mg/l

Existing Water Quality (Table 2M):

Median 0.49 mg/l
Lower 95% Confidence Interval 0.37 mg/l
Upper 95% Confidence Interval 0.87 mg/l

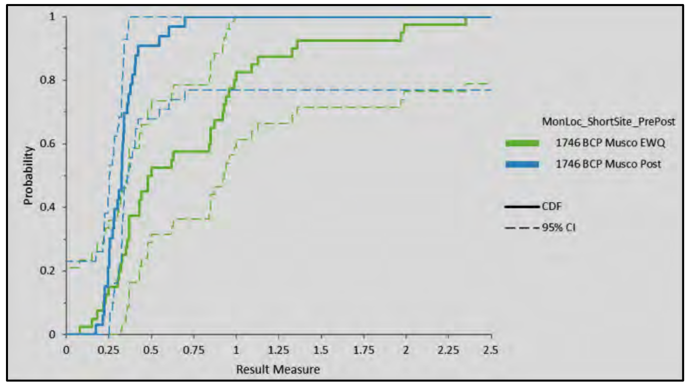






N | 73

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1746 BCP Musco EWQ	0.08	0.34	0.49	0.95	2.35	0.61
1746 BCP Musco Post	0.17	0.25	0.32	0.37	0.70	0.12



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1746 BCP Musco EWQ	40	2958.4	73.96
1746 BCP Musco Post	33	3585.9	108.66

H statistic	14.54
X² approximation	14.54
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.

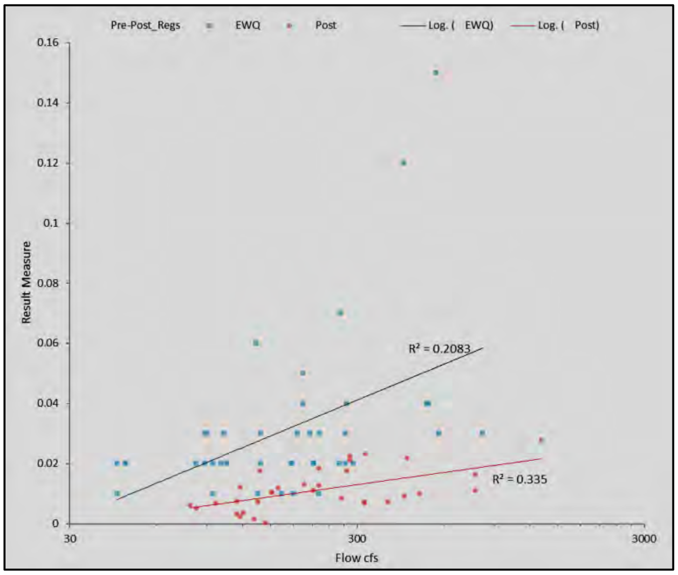
No water quality degradation is evident here. TKN concentrations apparently declined between the EWQ and post-EWQ periods. Uncertainty was introduced into comparisons by potential laboratory artifacts. The post-EWQ range was far narrower and all concentrations were less than 0.75 mg/l. TKN concentration is unrelated to flow in both data sets. Post-EWQ median TKN fell below the lower EWQ 95% confidence interval. There were insufficient USGS data to confirm DRBC results.

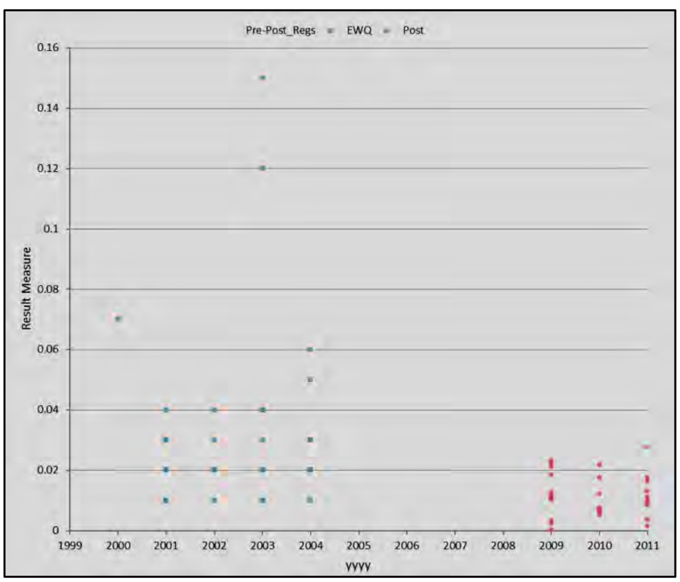
Chapter 14: 1746 BCP Musconetcong River, NJ

Orthophosphate as P, Total mg/l

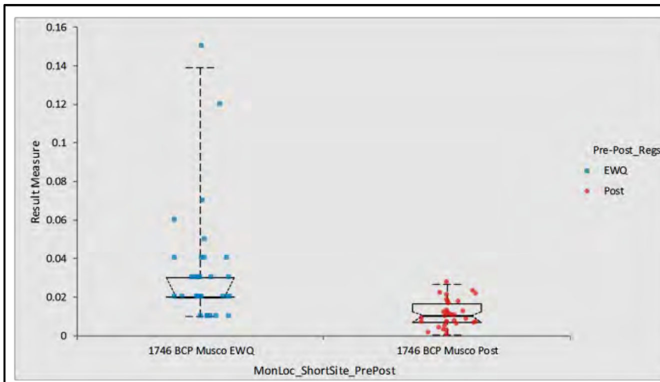
Existing Water Quality (Table 2M):

Median 0.02 mg/l
Lower 95% Confidence Interval 0.02 mg/l
Upper 95% Confidence Interval 0.03 mg/l



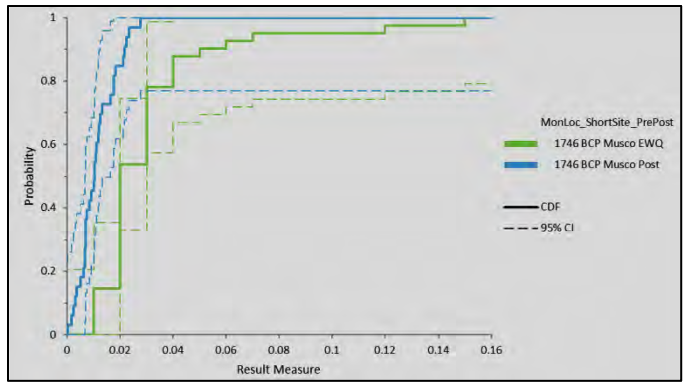


No water quality degradation is evident here. Orthophosphate concentrations apparently declined between the EWQ and post-EWQ periods. Uncertainty was introduced into comparisons by potential laboratory artifacts and detection limit differences.



N 74

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1746 BCP Musco EWQ	0.010	0.020	0.020	0.030	0.150	0.010
1746 BCP Musco Post	0.000	0.007	0.010	0.017	0.028	0.010



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1746 BCP Musco EWQ	41	5892.0	143.71
1746 BCP Musco Post	33	7320.4	221.83

H statistic	28.96
X² approximation	28.96
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.

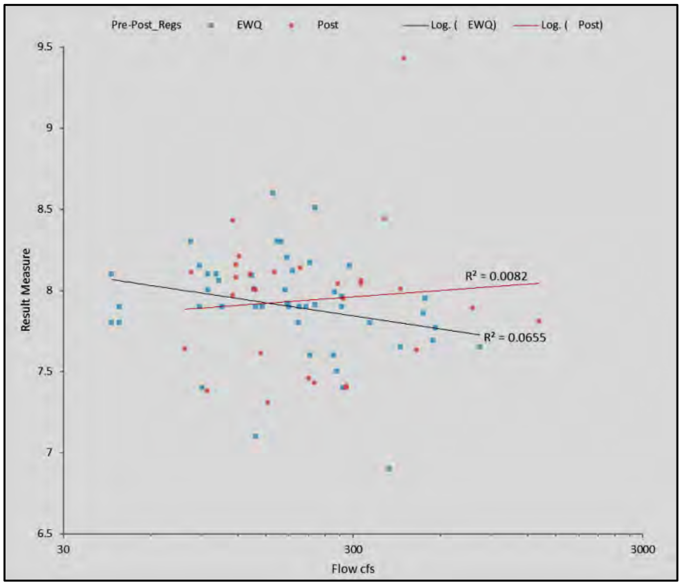
Orthophosphate is weakly related to flow in both data sets. Post-EWQ median orthophosphate fell below the EWQ lower 95% confidence interval. This has little to do with the improvement in detection limits because there were only 4 non-detect results in the EWQ data. A possible water quality improvement is indicated in that there were no post-EWQ concentrations higher than 0.03 mg/l, though this may be a laboratory artifact. Post-EWQ orthophosphate also ranged much less widely than EWQ data. There were no independent data to confirm DRBC results.

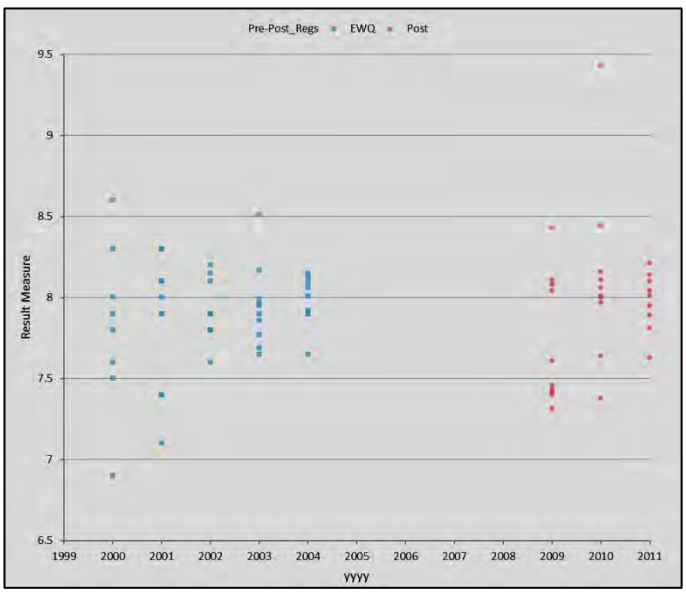
Chapter 14: 1746 BCP Musconetcong River, NJ

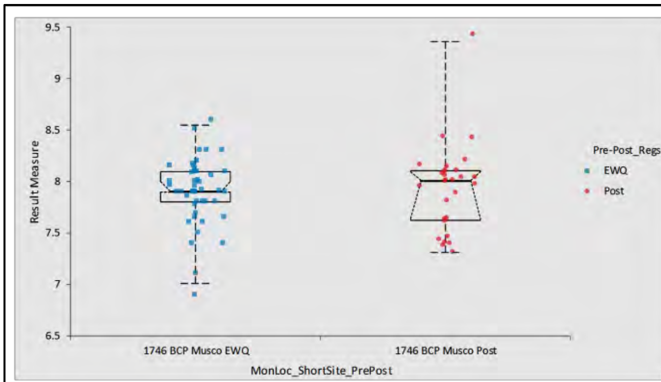
pH

Existing Water Quality (Table 2M):

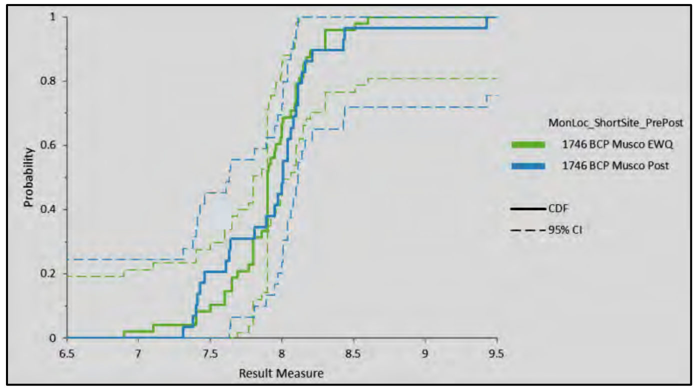
Median 7.90 standard units
Lower 95% Confidence Interval **7.80*** standard units
Upper 95% Confidence Interval 8.00 standard units
* Typographical error (7.90) in regulations







N	77					
Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1746 BCP Musco EWQ	6.90	7.80	7.90	8.10	8.60	0.30
1746 BCP Musco Post	7.31	7.62	8.01	8.11	9.43	0.49



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1746 BCP Musco EWQ	48	27.8	0.58
1746 BCP Musco Post	29	45.9	1.58

H statistic	0.15
X² approximation	0.15
DF	1
p-value	0.7009 [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.

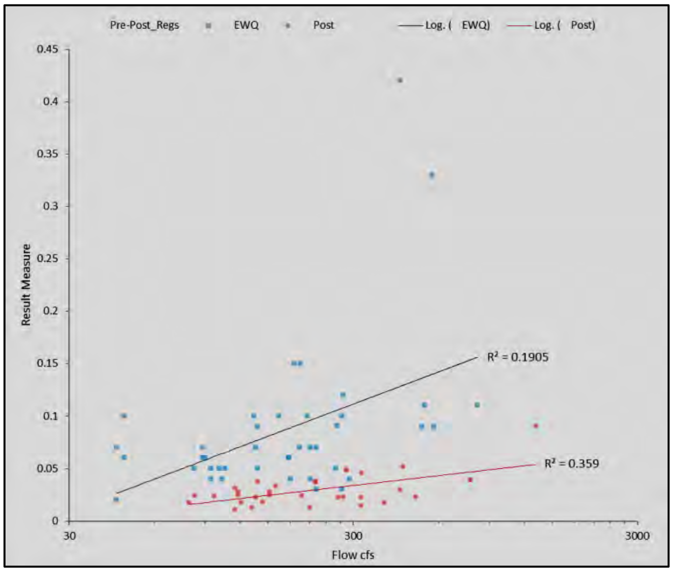
No water quality degradation is evident here. pH did not measurably change between the EWQ and post-EWQ periods. pH is unrelated to flow in both data sets. Post-EWQ median pH was above the upper EWQ 95% confidence interval, but the result was not statistically significant. In 2010 there was one spike above pH 9, indicating high algal productivity during that dry sampling period. USGS data confirm these results.

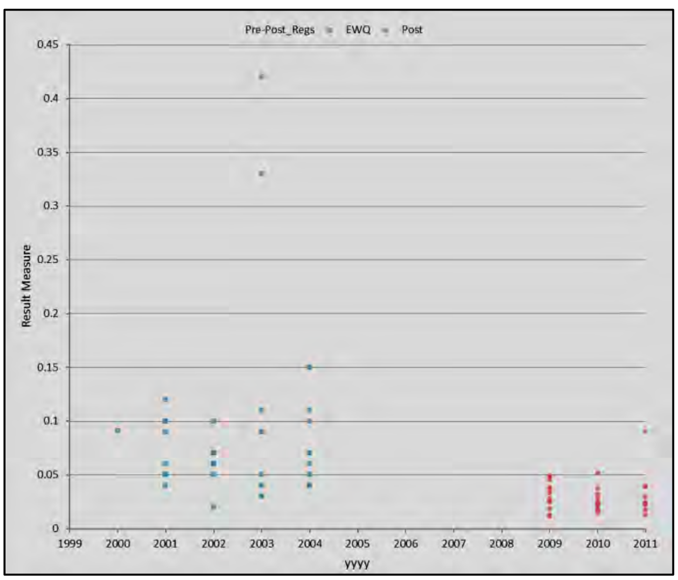
Chapter 14: 1746 BCP Musconetcong River, NJ

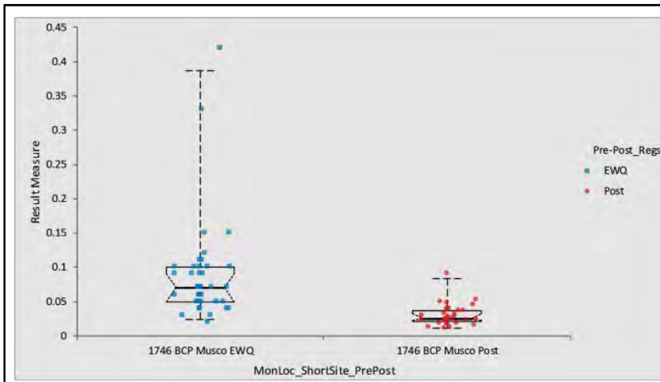
Phosphorus as P, Total (TP) mg/l

Existing Water Quality (Table 2M):

Median 0.07 mg/l
Lower 95% Confidence Interval 0.05 mg/l
Upper 95% Confidence Interval 0.09 mg/l

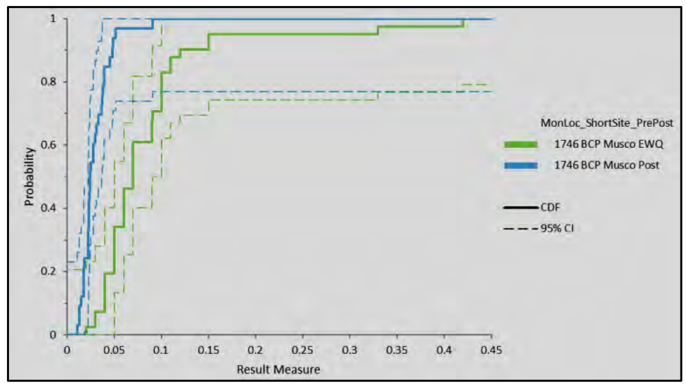






N 74

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1746 BCP Musco EWQ	0.02	0.05	0.07	0.10	0.42	0.05
1746 BCP Musco Post	0.01	0.02	0.02	0.04	0.09	0.02



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1746 BCP Musco EWQ	41	8106.2	197.71
1746 BCP Musco Post	33	10071.3	305.19

H statistic	39.38
X^2 approximation	39.38
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.

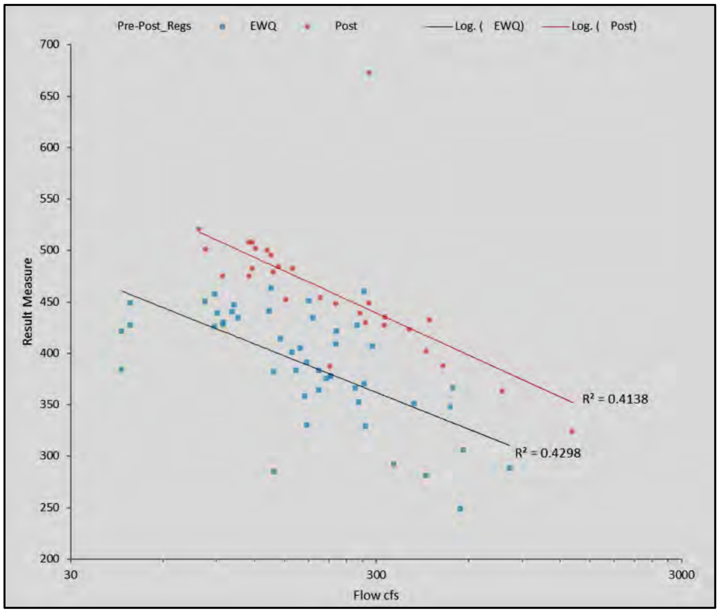
No water quality degradation is evident here. Total Phosphorus (TP) concentrations apparently declined between the EWQ and post-EWQ periods. No water quality degradation is evident here. Uncertainty was introduced into comparisons by potential laboratory artifacts and detection limit differences. Post-EWQ median total phosphorus fell below the EWQ lower 95% confidence interval. TP is weakly related to flow in both data sets. USGS data confirm DRBC results, though not strongly. Some decline in concentrations is shown in USGS data, but only the DRBC post-EWQ data line up with USGS results. It appears that, in the EWQ period, DRBC results were more variable than USGS data.

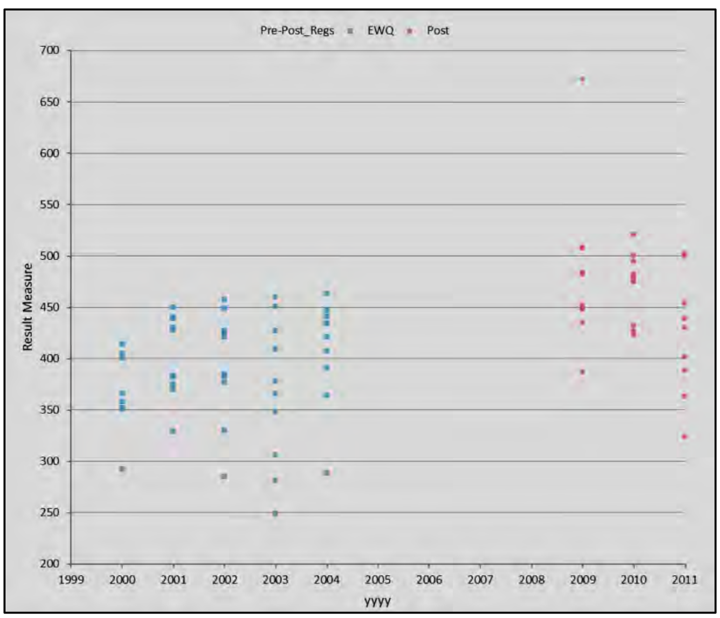
Chapter 14: 1746 BCP Musconetcong River, NJ

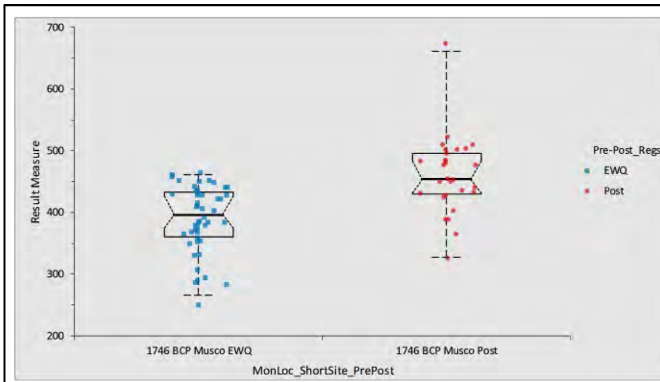
Specific Conductance µmho/cm

Existing Water Quality (Table 2M):

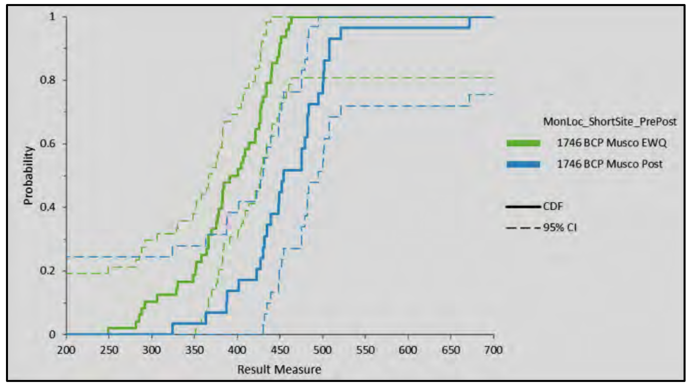
Median 396 µmho/cm
Lower 95% Confidence Interval 375 µmho/cm
Upper 95% Confidence Interval 426 µmho/cm
Defined in regulations as a flow-related parameter







N	77					
Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1746 BCP Musco EWQ	249	361	396	432	463	72
1746 BCP Musco Post	324	429	454	497	672	68



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1746 BCP Musco EWQ	48	4246.9	88.48
1746 BCP Musco Post	29	7029.4	242.39

H statistic	22.53
X² approximation	22.53
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.

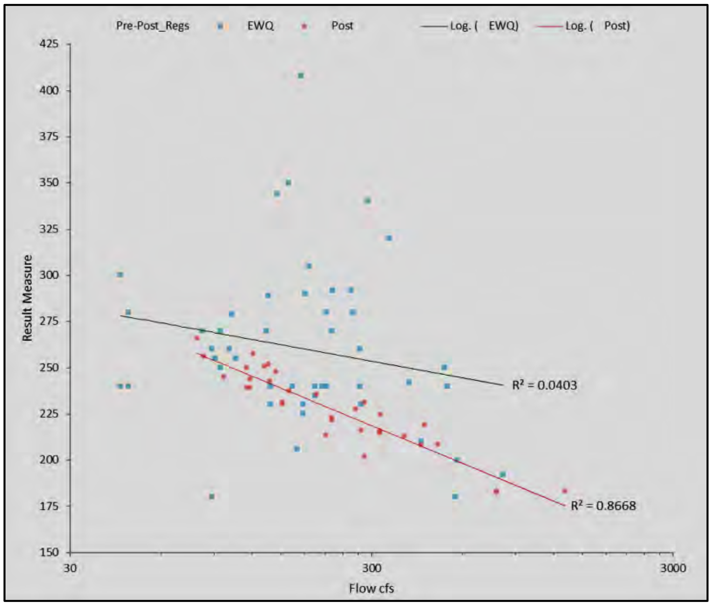
Water quality degradation is evident here. Specific conductance rose by 58 µmho/cm; well above the EWQ upper 95% confidence interval. Specific conductance is inversely related to flow in both data sets. The rise in specific conductance may be partially attributable to the concurrent rise in chloride concentrations. Median specific conductance has risen from 396 to 454 µmhos/cm; a 15% increase in a few years' time. Further investigation is recommended, as 454 µmho/cm is high even for limestone streams in the region. USGS data confirm DRBC results.

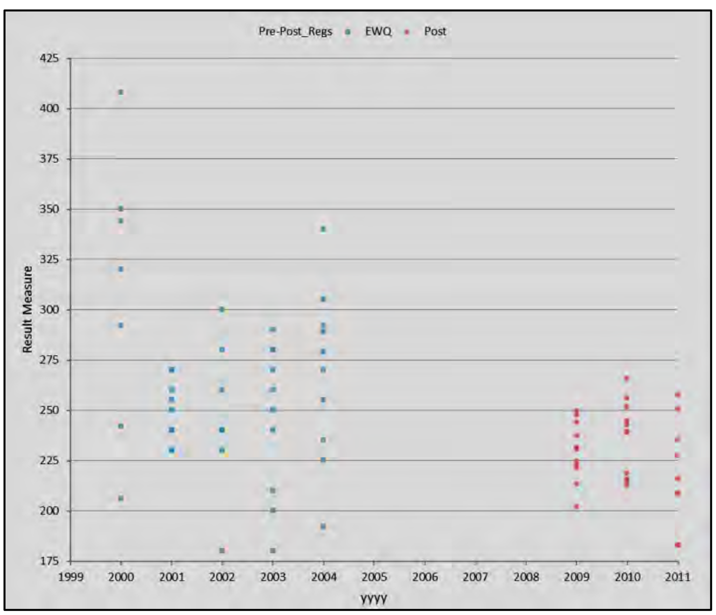
Chapter 14: 1746 BCP Musconetcong River, NJ

Total Dissolved Solids (TDS) mg/l

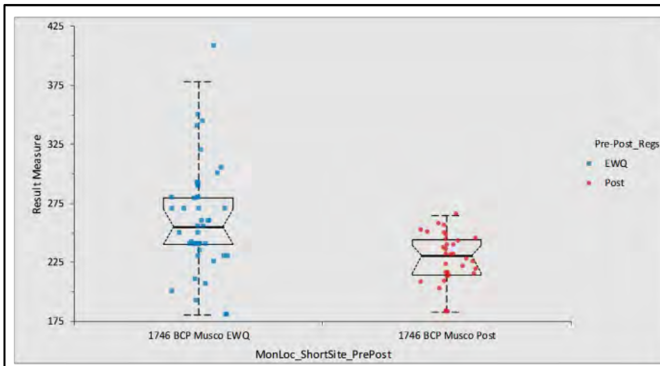
Existing Water Quality (Table 2M):

Median 255 mg/l
Lower 95% Confidence Interval 240 mg/l
Upper 95% Confidence Interval 270 mg/l
Defined in regulations as a flow-related parameter



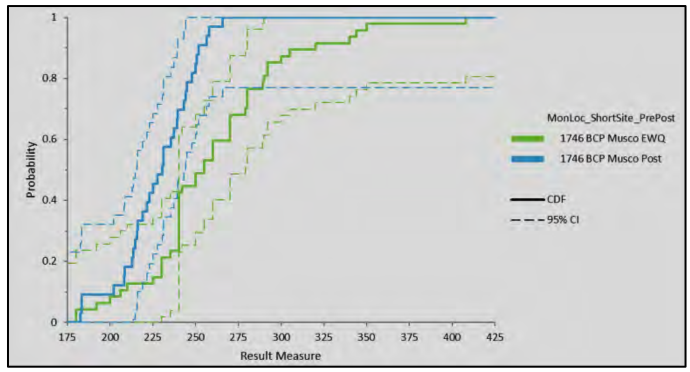


No water quality degradation is evident here. TDS apparently declined between the EWQ and post-EWQ periods.   Uncertainty was introduced into comparisons by potential laboratory artifacts.



N 80

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1746 BCP Musco EWQ	180	240	255	280	408	40
1746 BCP Musco Post	183	214	231	244	266	30



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1746 BCP Musco EWQ	47	3261.1	69.39
1746 BCP Musco Post	33	4644.6	140.75

H statistic	14.67
X² approximation	14.67
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.

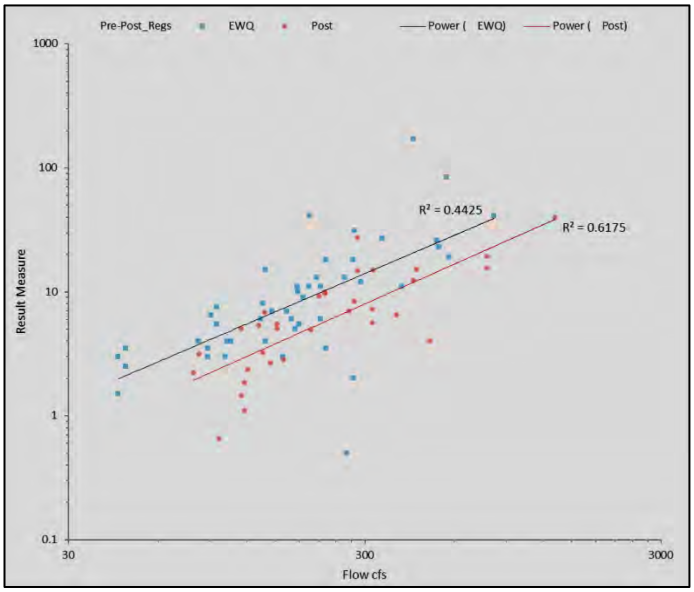
TDS is unrelated to flow in the EWQ data set, though it was designated in the rules as flow related. TDS was inversely related to flow in the post-EWQ data set. Post-EWQ median TDS fell below the EWQ lower 95% lower confidence interval, and was much less variable than the baseline samples as well. Post-EWQ detection limits were lower than EWQ detection limits, though there were no non-detect results at any time. USGS data ranged similarly with DRBC data, but the decline was not evident. The USGS TDS slightly increased, which is logical given the increases in chlorides and specific conductance. DRBC EWQ data were more variable, so perhaps the decline shown in these results is a laboratory artifact rather than a real water quality improvement.

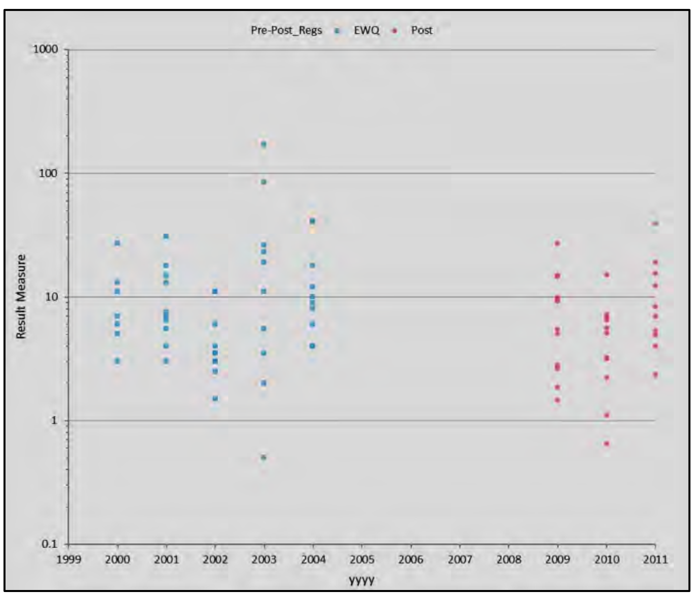
Chapter 14: 1746 BCP Musconetcong River, NJ

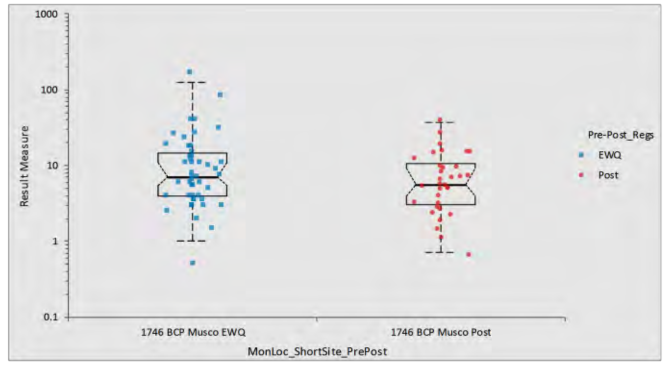
Total Suspended Solids (TSS) mg/l

Existing Water Quality (Table 2M):

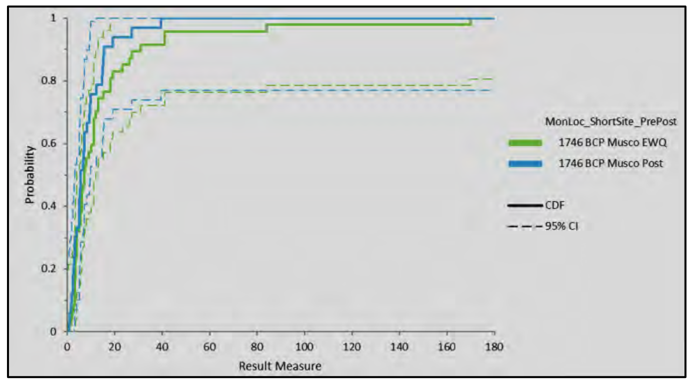
Median 7.0 mg/l
Lower 95% Confidence Interval 5.5 mg/l
Upper 95% Confidence Interval 11.0 mg/l
<u>Should have been designated in rules as flow-related</u>







N	80					
Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1746 BCP Musco EWQ	0.5	4.0	7.0	14.7	170.0	10.7
1746 BCP Musco Post	0.7	3.0	5.6	10.7	39.5	7.6



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1746 BCP Musco EWQ	47	379.2	8.07
1746 BCP Musco Post	33	540.1	16.37

H statistic	1.70
X^2 approximation	1.70
DF	1
p-value	0.1919[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.

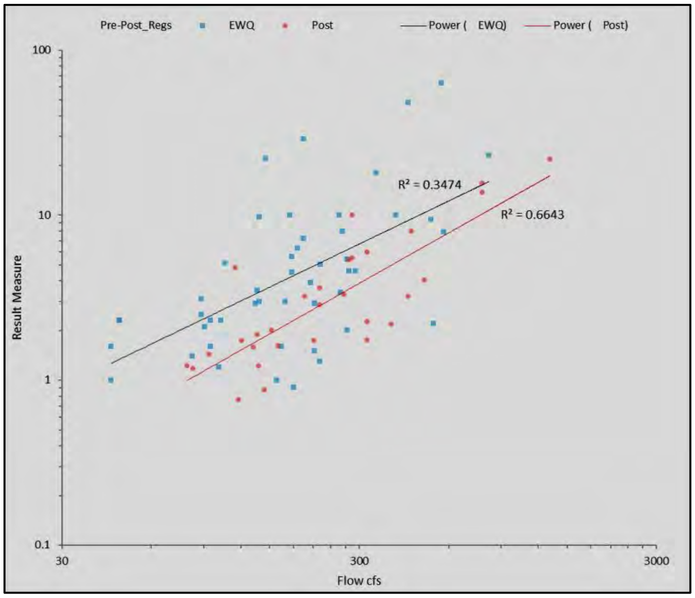
No water quality degradation is evident here. TSS did not measurably change between the EWQ and post-EWQ periods. Uncertainty was introduced into comparisons by potential laboratory artifacts. TSS is positively related to flow in both data sets. Post-EWQ median TSS fell within the EWQ 95% confidence intervals, though post-EWQ median TSS was near the lower EWQ 95% confidence interval. Both flow and concentration are plotted on a logarithmic scale, and the regression is a power relationship. USGS data were too few for trend evaluation, but closely resembled DRBC results.

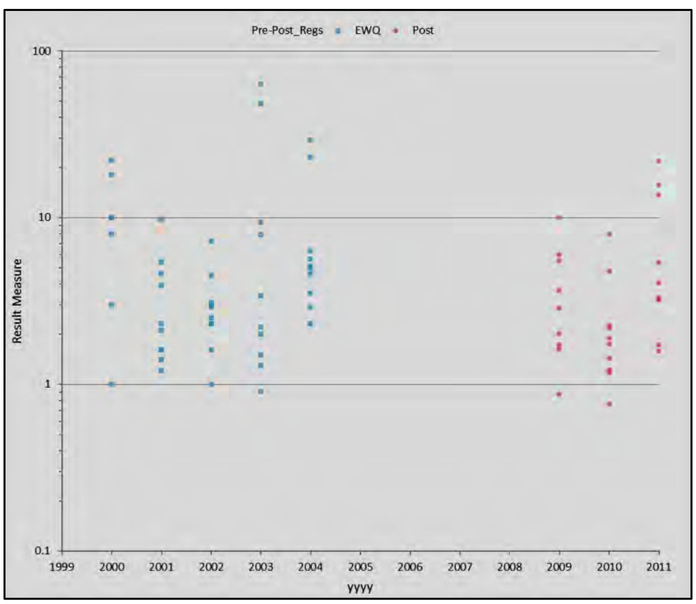
Chapter 14: 1746 BCP Musconetcong River, NJ

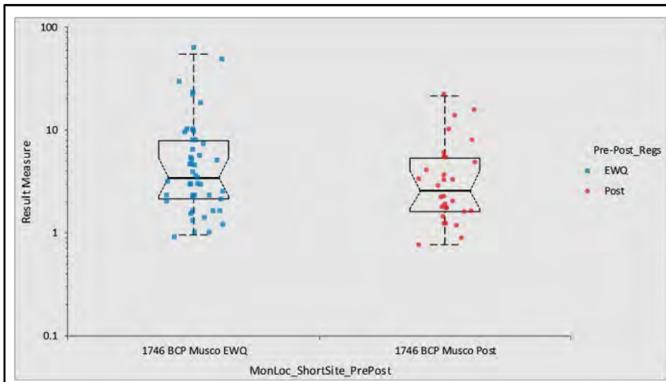
Turbidity NTU

Existing Water Quality (Table 2M):

Median 3.5 NTU
Lower 95% Confidence Interval 2.3 NTU
Upper 95% Confidence Interval 5.4 NTU
Defined in regulations as a flow-related parameter

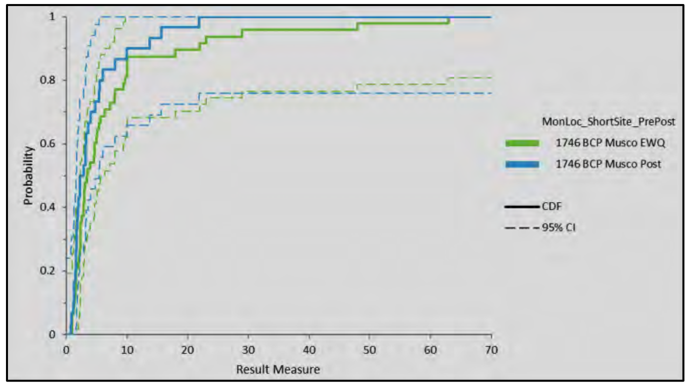






N 78

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1746 BCP Musco EWQ	0.9	2.1	3.5	8.0	63.0	5.8
1746 BCP Musco Post	0.8	1.6	2.6	5.4	21.9	3.8



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1746 BCP Musco EWQ	48	438.0	9.13
1746 BCP Musco Post	30	700.8	23.36

H statistic	2.22
X² approximation	2.22
DF	1
p-value	0.1364 [1]

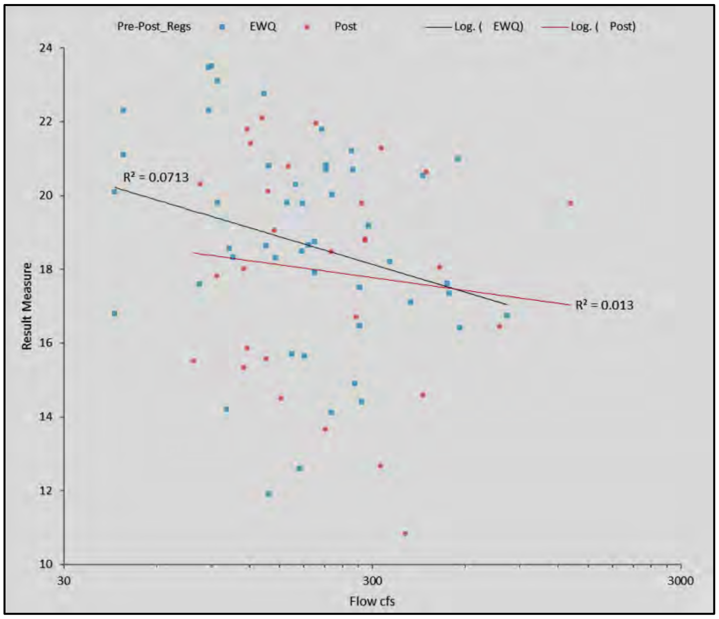
H0: $\theta_1 = \theta_2 = \theta_{\ldots}$
The median of the populations are all equal.
H1: $\theta_i \neq \theta_j$ for at least one i,j
The median of the populations are not all equal.
[1] Do not reject the null hypothesis at the 5% significance level.

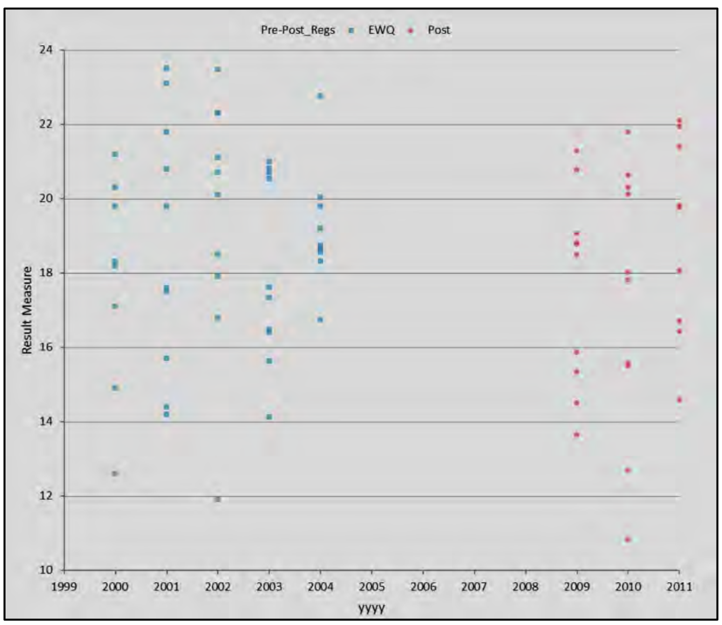
No water quality degradation is evident here. Turbidity did not measurably change between the EWQ and post-EWQ periods. The post-EWQ median turbidity fell within the EWQ 95% confidence intervals of the median. Turbidity is positively related to flow in both data sets. Both concentration and flow are presented on logarithmic scale, and the regression is a power relationship. There were very few USGS data available for comparison with DRBC results, but USGS and DRBC results ranged similarly.

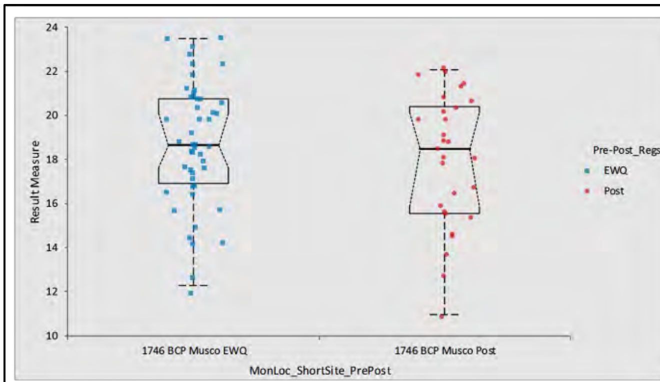
Chapter 14: 1746 BCP Musconetcong River, NJ

Water Temperature, degrees C

Not included in DRBC Existing Water Quality rules

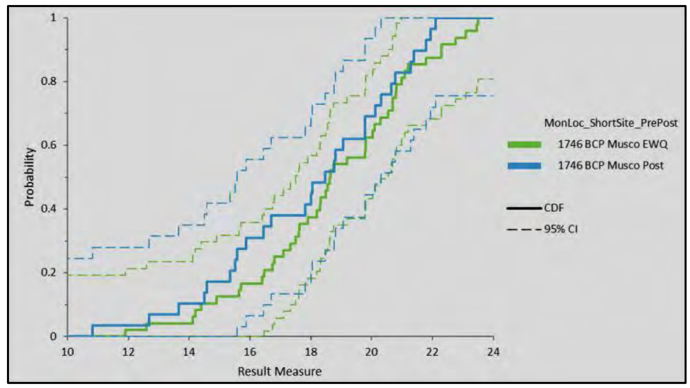






	N
	77

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1746 BCP Musco EWQ	11.9	16.9	18.6	20.8	23.5	3.8
1746 BCP Musco Post	10.8	15.6	18.5	20.4	22.1	4.9



Kruskal-Wallis test

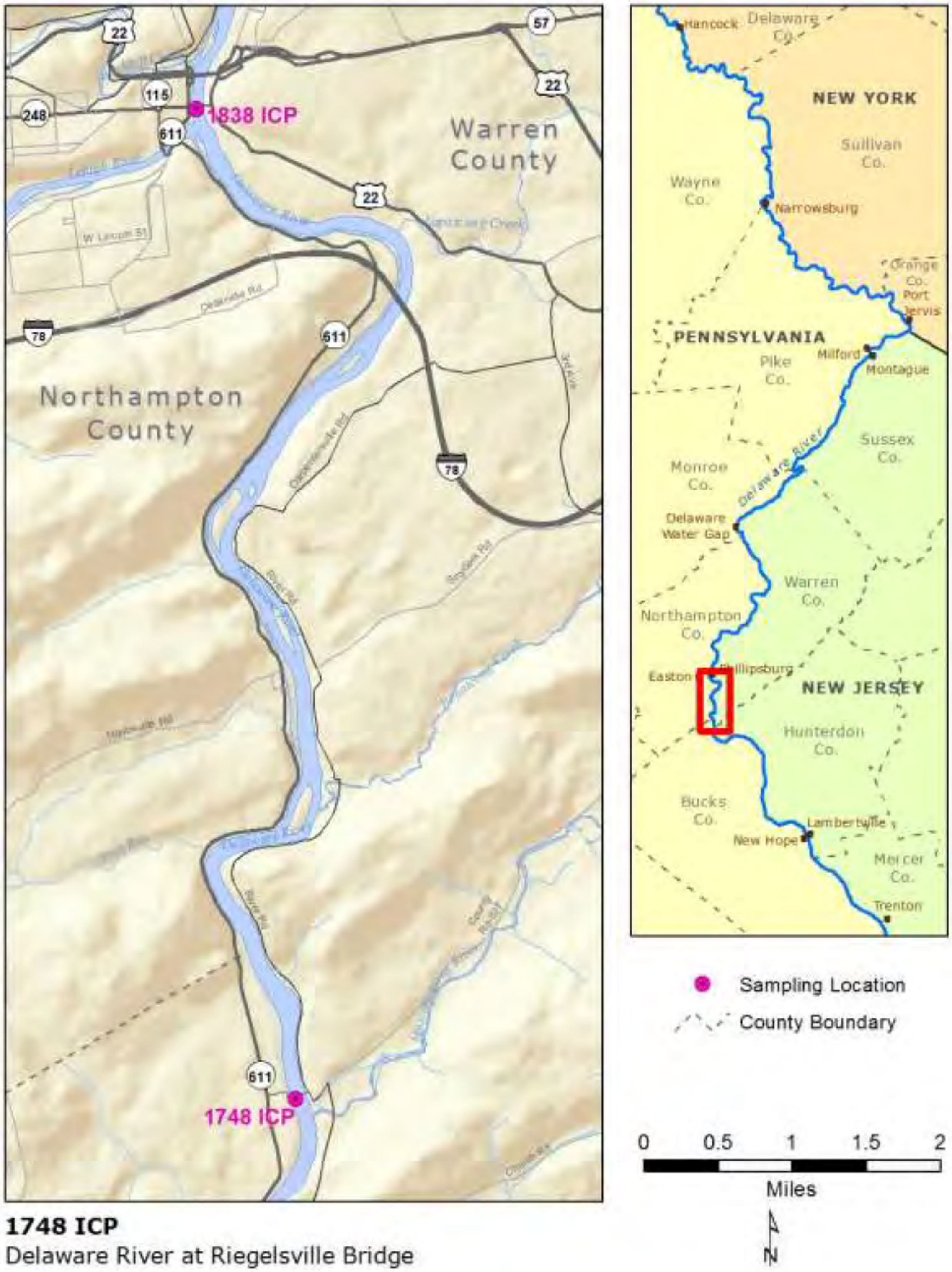
Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1746 BCP Musco EWQ	48	161.3	3.36
1746 BCP Musco Post	29	267.0	9.21

H statistic	0.86
X^2 approximation	0.86
DF	1
p-value	0.3549 [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.

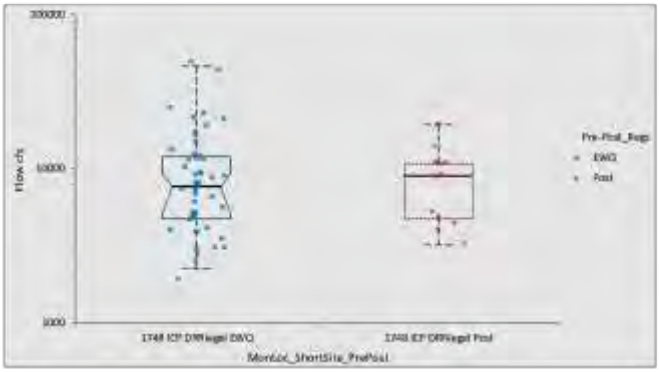
No water quality degradation is evident here. Water temperature did not measurably change between the EWQ and post-EWQ periods. Water temperature is unrelated to flow in both data sets. Flows are plotted on a logarithmic scale. DRBC data did not differ from NJDEP and USGS results, though there were more DRBC data in the May to September period.

Chapter 15: 1748 ICP Delaware River at Riegelsville



1748 ICP
Delaware River at Riegelsville Bridge

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



N	63					
Flow cfs by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1748 ICP DRRiegel EWQ	1,925	4,686	7,635	11,926	48,931	7,240
1748 ICP DRRiegel Post	3,183	4,719	9,053	10,826	19,227	6,107

Flow was roughly the same between the EWQ and post-EWQ periods. Too few samples were collected in the post-EWQ period (n=13) for confident statistical comparisons. 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.

Kruskal-Wallis test

Flow cfs by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1748 ICP DRRiegel EWQ	50	2.9	0.06
1748 ICP DRRiegel Post	13	11.1	0.85

H statistic	0.04
X^2 approximation	0.04
DF	1
p-value	0.8385 [1]

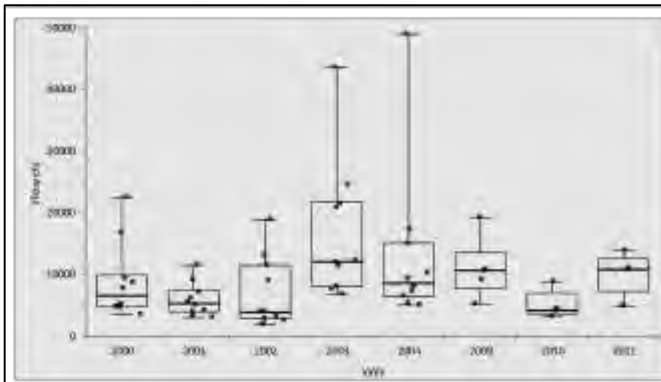
H0: $\theta_1 = \theta_2 = \theta\ldots$
The median of the populations are all equal.
H1: $\theta_i \neq \theta_j$ for at least one i,j
The median of the populations are not all equal.
[1] Do not reject the null hypothesis at the 5% significance level.

Upstream ICP: Delaware River at Easton 1838 ICP
Downstream ICP: Delaware River at Milford 1677 ICP

Tributary BCP Watersheds in Upstream Reach:

Lehigh River, PA – 1837 BCP
Lopatcong Creek, NJ – 1820 BCP (see Appendix A)
Pohatcong Creek, NJ – 1774 BCP

All other tributaries are less than 20 square miles drainage area and have little effect upon the Delaware River.



N	63					
Flow cfs by yyyy	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
2000	3460	4686	6445	9918	22469	5232
2001	2985	3896	5273	7301	11396	3405
2002	1925	2764	3859	11540	18950	8777
2003	6779	7934	12057	21666	43619	13732
2004	4956	6354	8625	15124	48931	8770
2009	5199	7768	10547	13564	19227	5796
2010	3183	3541	4219	6960	8792	3420
2011	4881	7281	10827	12646	13813	5366

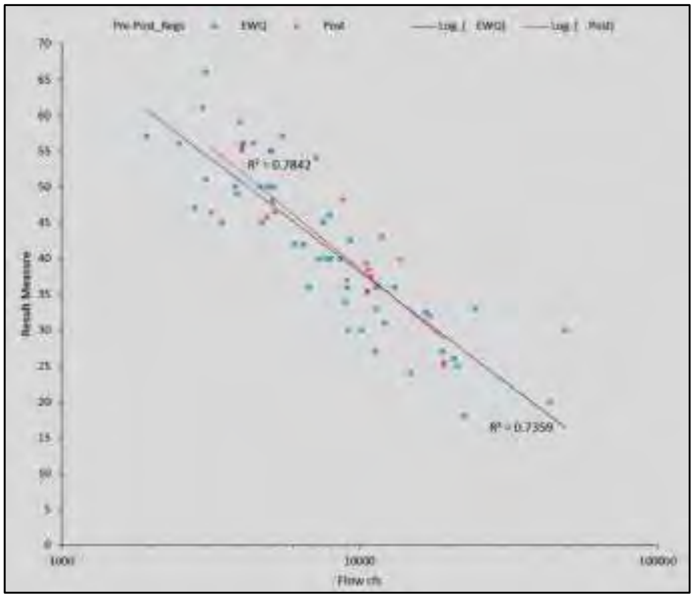
Annual May to September flow statistics associated with water quality measurements are plotted above. These are flow measurements or sometimes estimates associated with the time of each water quality sample. Mean annual flow is about 9,000 cfs; and harmonic mean flow is about 5,000 cfs which is more typical of summer flow conditions. Though a wide range of flows were sampled by DRBC, these data appear to be most representative of low to normal flow conditions. Flows corresponding to each water quality sample were calculated using instantaneous water stage data from the USGS gage No. 01457500 on the Delaware River at Riegelsville.

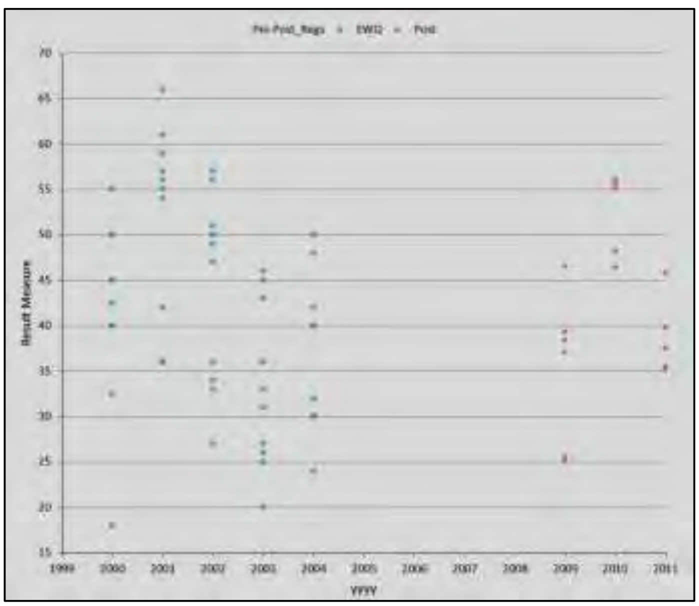
Chapter 15: 1748 ICP Delaware River at Riegelsville

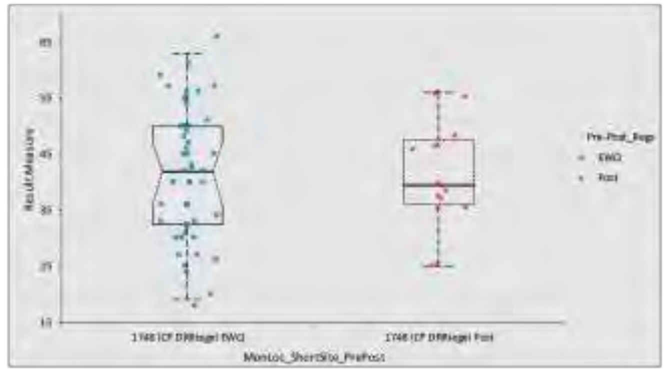
Alkalinity as CaCO3, Total mg/l

Existing Water Quality (Table 2L):

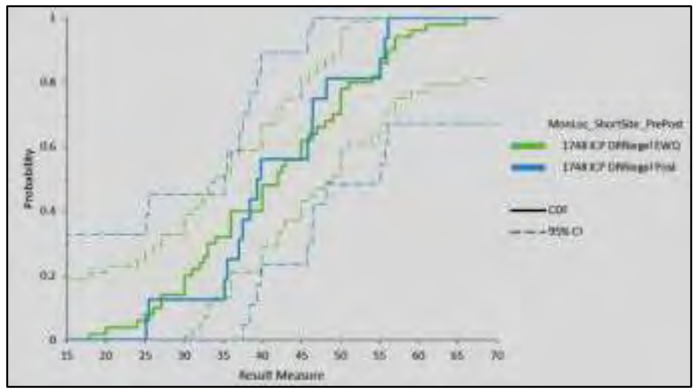
Median 42 mg/l
Lower 95% Confidence Interval 36 mg/l
Upper 95% Confidence Interval 48 mg/l
Defined in regulations as a flow-related parameter







N	66					
Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1748 ICP DRRiegel EWQ	18	32	42	50	66	18
1748 ICP DRRiegel Post	25	36	40	47	56	11



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1748 ICP DRRiegel EWQ	50	0.0	0.00
1748 ICP DRRiegel Post	16	0.0	0.00

H statistic	0.00
X^2 approximation	0.00
DF	1
p-value	1.0000 [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.

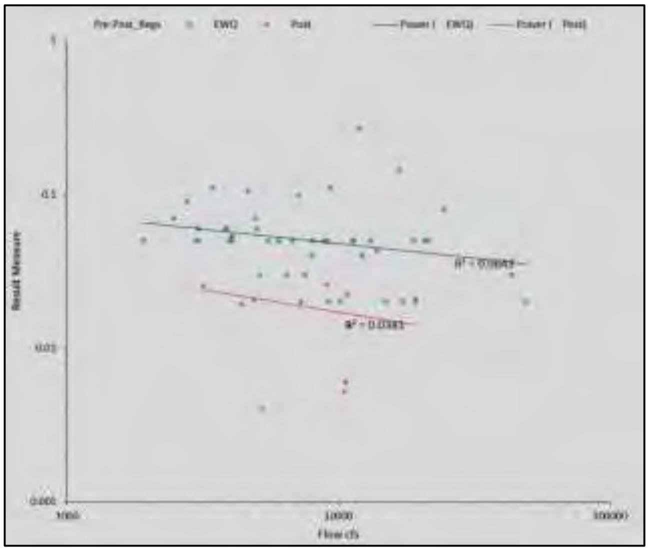
No water quality degradation is evident here. Alkalinity apparently did not measurably change between the EWQ and post-EWQ periods. Uncertainty was introduced into comparisons by potential laboratory artifacts and insufficient post-EWQ sampling frequency. Alkalinity is inversely related to flow in both data sets. Post-EWQ median alkalinity fell within EWQ 95% confidence intervals. Flow is plotted on a logarithmic scale. One outlier value of 180 mg/l was removed from the data set (sample taken 5/22/2000). The full flow regime was not well-represented in the post-EWQ data set, as noted by the short regression line in the flow vs. concentration plot.

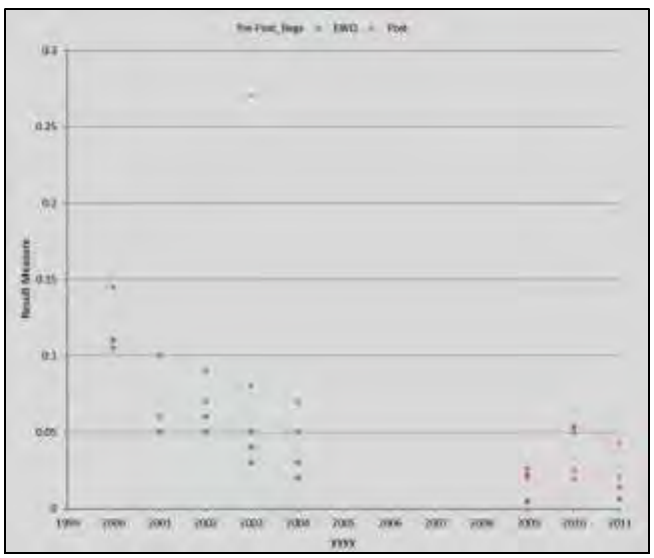
Chapter 15: 1748 ICP Delaware River at Riegelsville

Ammonia Nitrogen as N, Total mg/l

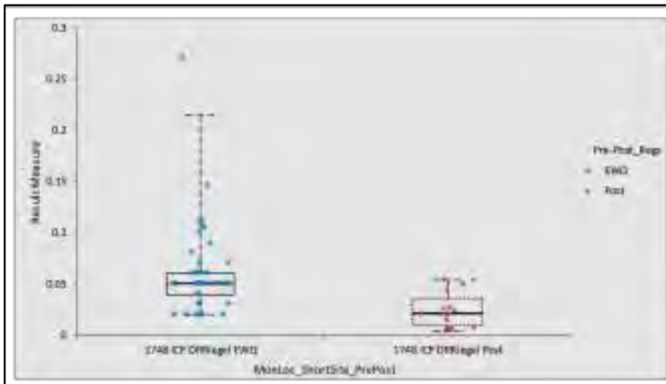
Existing Water Quality (Table 2L):

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



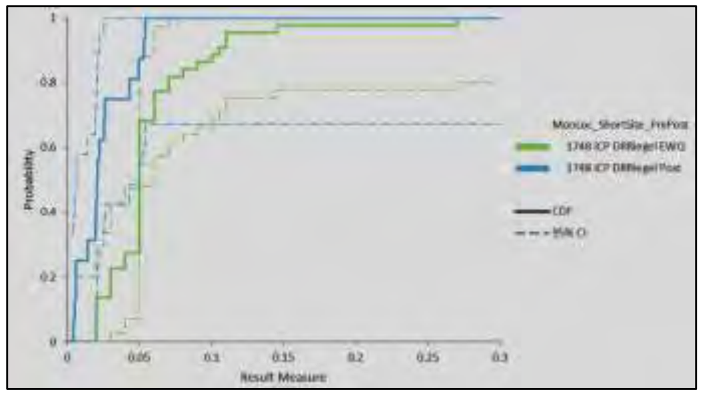


No water quality degradation is evident here. Ammonia concentrations apparently declined. Uncertainty was introduced into comparisons by potential laboratory artifacts, detection limit differences and insufficient post-EWQ sampling frequency. Post-EWQ median ammonia concentration was below the EWQ lower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



N	60

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1748 ICP DRRiegel EWQ	0.020	0.040	0.050	0.060	0.270	0.020
1748 ICP DRRiegel Post	0.004	0.009	0.021	0.036	0.054	0.027



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1748 ICP DRRiegel EWQ	44	1255.1	28.53
1748 ICP DRRiegel Post	16	3451.6	215.72

H statistic	15.90
X^2 approximation	15.90
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.

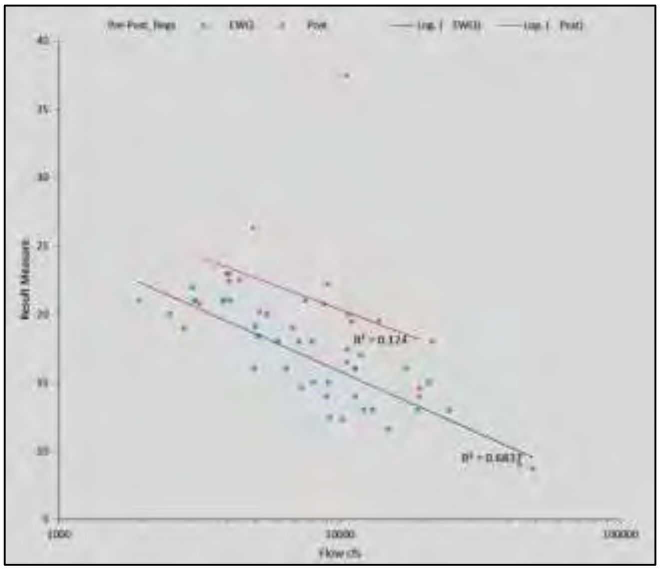
Too few independent data were available to validate these results. Flow and concentration are plotted on a logarithmic scale. DRBC's post-EWQ detection limit (0.004-0.006 mg/l) was much lower than during the EWQ period (0.02-0.05 mg/l). EWQ data included 29/44 undetected results, interfering with calculation of the median. Under 2009-2011 lower detection levels, there were 3/16 undetected results. So rather than a real change in ambient concentrations it is likely that we are now able to measure actual low-level concentrations. Evidence of possible water quality improvement is that post-EWQ DRBC and USGS data contained no concentrations higher than 0.054 mg/l.

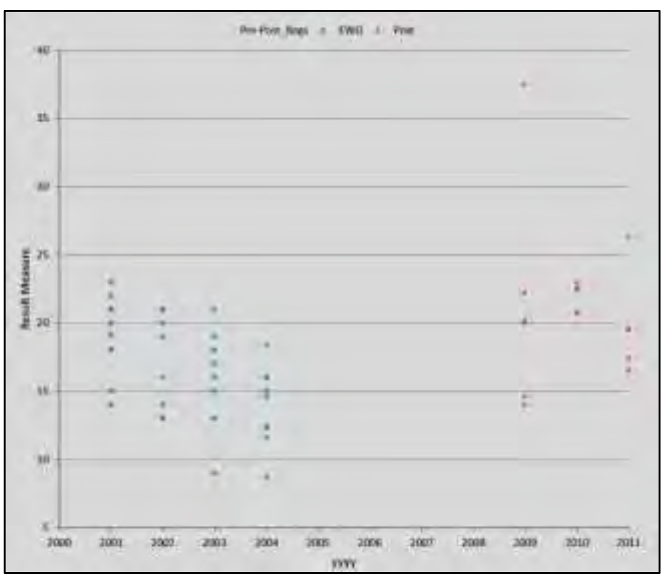
Chapter 15: 1748 ICP Delaware River at Riegelsville

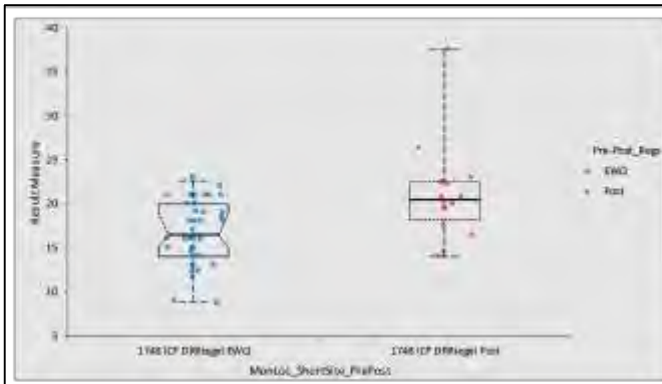
Chloride, Total mg/l

Existing Water Quality (Table 2L):

Median 17 mg/l
Lower 95% Confidence Interval 15 mg/l
Upper 95% Confidence Interval 19 mg/l
Defined in regulations as a flow-related parameter

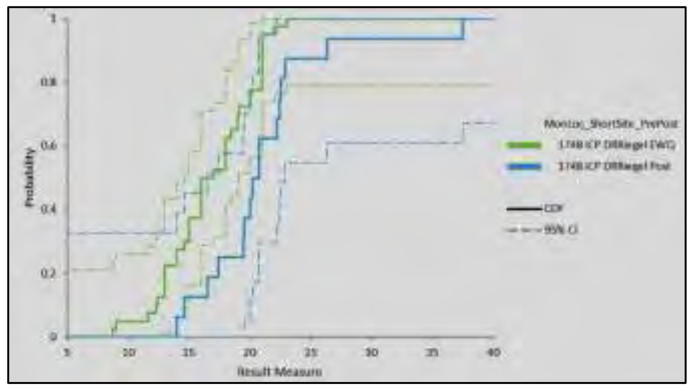






N 56

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1748 ICP DRRiegel EWQ	9	14	17	20	23	6
1748 ICP DRRiegel Post	14	18	20	22	38	4



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1748 ICP DRRiegel EWQ	40	636.0	15.90
1748 ICP DRRiegel Post	16	1590.0	99.38

H statistic	8.40
X^2 approximation	8.40
DF	1
p-value	0.0038 [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.

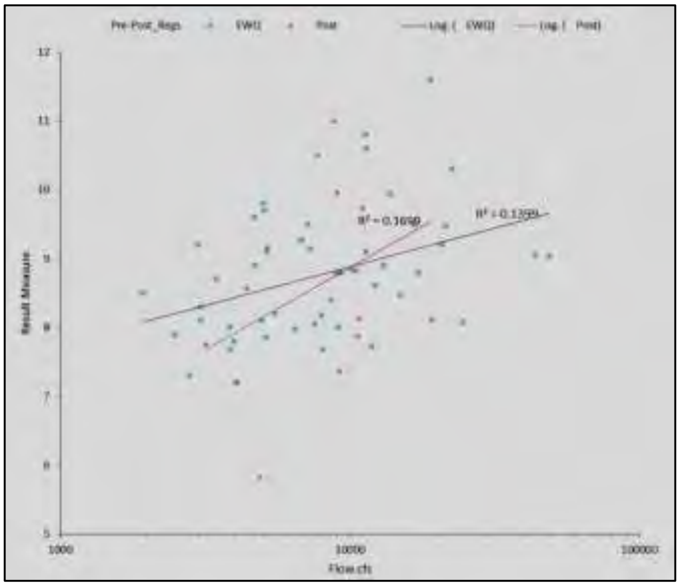
Water quality degradation is evident here. Chloride concentrations apparently rose by about 3 mg/l between the two periods. Uncertainty was introduced into comparisons by potential laboratory artifacts and insufficient post-EWQ sampling frequency. Post-EWQ median concentration rose above the EWQ upper 95% confidence interval. Chloride concentration is related to flow in the EWQ data, but unrelated to flow in the post-EWQ data due to insufficient data (n=16). Note that flow is plotted on a logarithmic scale. No other data were available to validate this conclusion.

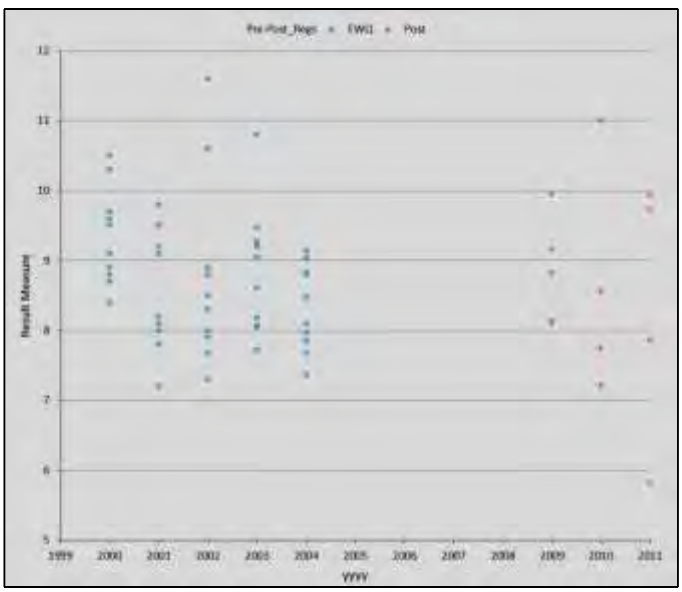
Chapter 15: 1748 ICP Delaware River at Riegelsville

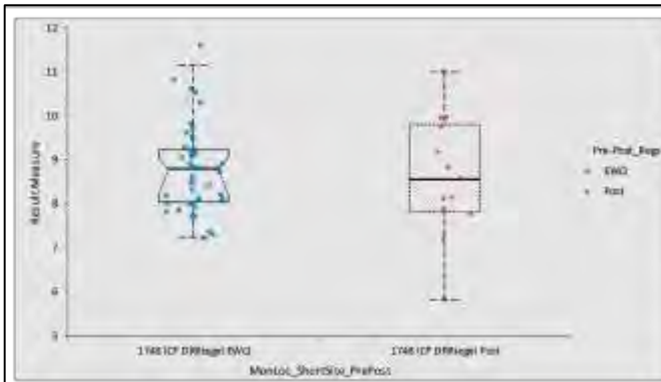
Dissolved Oxygen (DO) mg/l

Existing Water Quality (Table 2L):

Median 8.80 mg/l
Lower 95% Confidence Interval 8.20 mg/l
Upper 95% Confidence Interval 9.05 mg/l

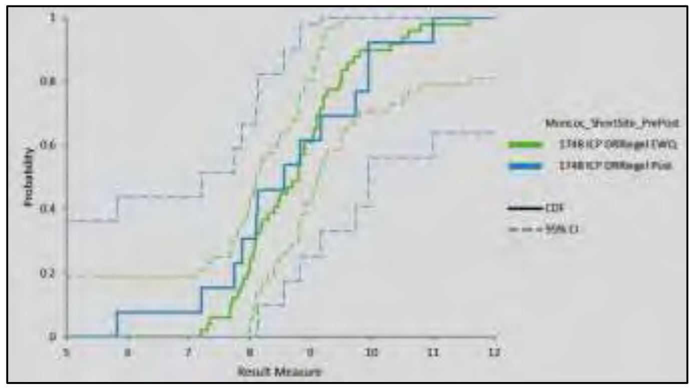






N 62

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1748 ICP DRRiegel EWQ	7.20	8.03	8.80	9.22	11.60	1.19
1748 ICP DRRiegel Post	5.82	7.83	8.56	9.80	11.00	1.97



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1748 ICP DRRiegel EWQ	49	1.5	0.03
1748 ICP DRRiegel Post	13	5.6	0.43

H statistic	0.02
X^2 approximation	0.02
DF	1
p-value	0.8831[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.

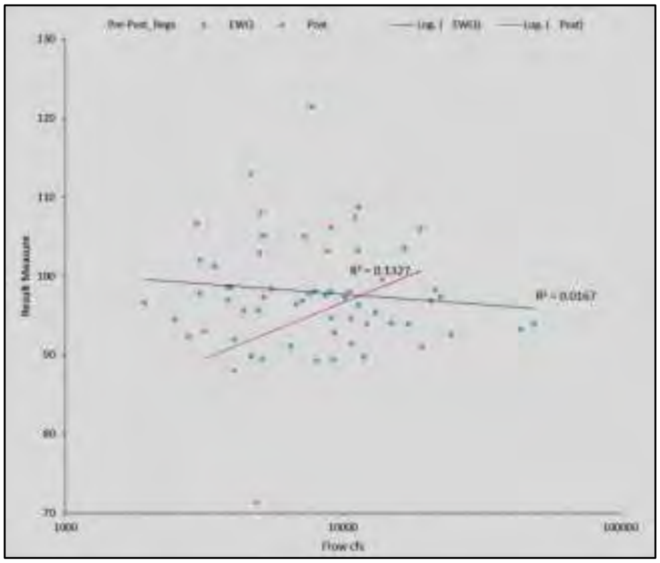
No water quality degradation is evident here. No measurable change took place between the EWQ and Post-EWQ periods. Uncertainty was introduced into comparisons by insufficient post-EWQ sampling frequency. Post-EWQ median DO concentration fell within the EWQ 95% confidence intervals. DO concentration is unrelated to flow in both data sets. Flow is plotted on a logarithmic scale. One 2011 sample result was less than 6 mg/l, which might have been a measurement probe malfunction. However, there are treatment plants upstream that historically had problems, so the low result might have been a sporadic pollution event.

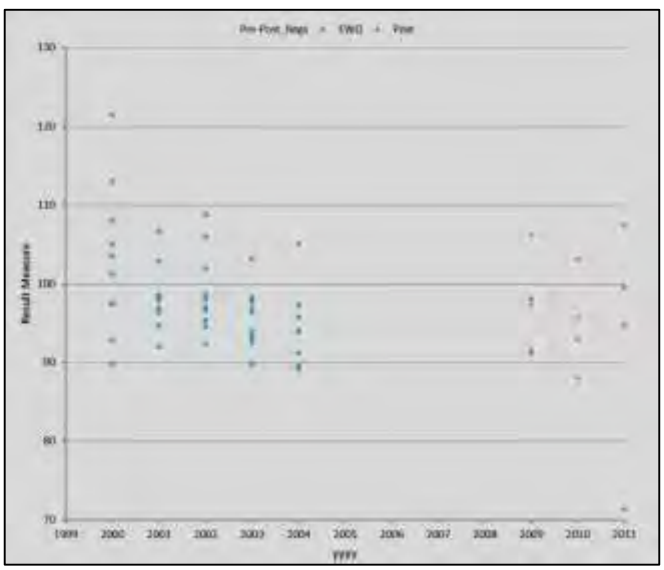
Chapter 15: 1748 ICP Delaware River at Riegelsville

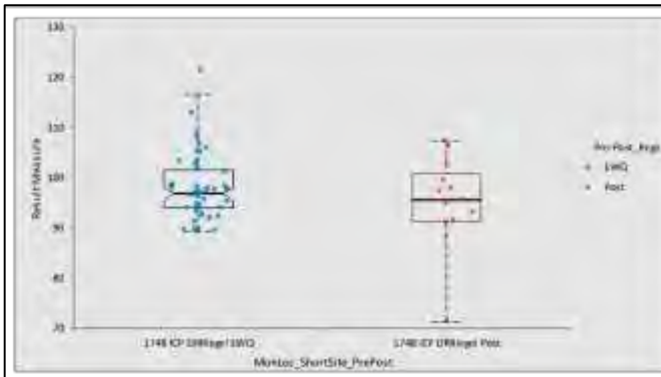
Dissolved Oxygen Saturation %

Existing Water Quality (Table 2L):

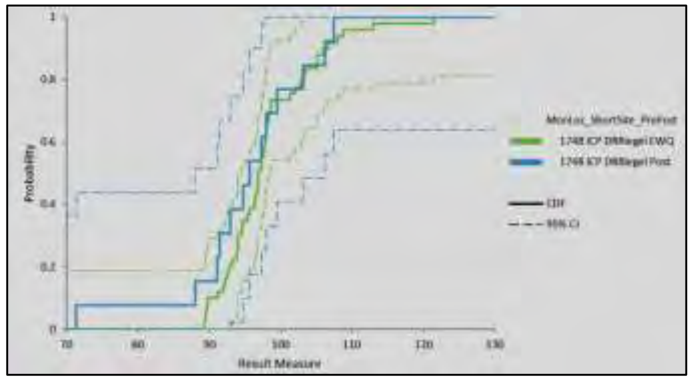
Median 97%
Lower 95% Confidence Interval 95%
Upper 95% Confidence Interval 98%







N	62					
Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1748 ICP DRRiegel EWQ	89	94	97	101	121	8
1748 ICP DRRiegel Post	71	91	96	101	107	9



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1748 ICP DRRiegel EWQ	49	33.5	0.68
1748 ICP DRRiegel Post	13	126.2	9.71

H statistic	0.49
X² approximation	0.49
DF	1
p-value	0.4837[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.

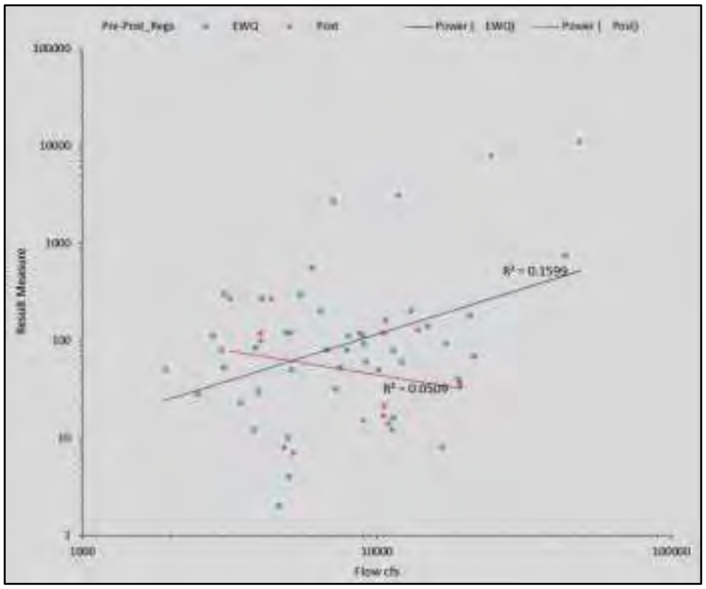
No water quality degradation is evident here. DO Saturation is unrelated to flow, and apparently did not measurably change between the EWQ and post-EWQ periods. Uncertainty was introduced into comparisons by insufficient post-EWQ sampling frequency. Post-EWQ median DO saturation fell within the EWQ 95% confidence intervals. There was one low saturation value of 71.3% found in August 2011 that possibly was a probe malfunction. However, USGS data contain multiple readings around 80%. This site historically had problems with an oxygen deficit due to uncontrolled upstream wastewater treatment. Such problems are no longer frequent. Biweekly instead of monthly sampling is recommended here.

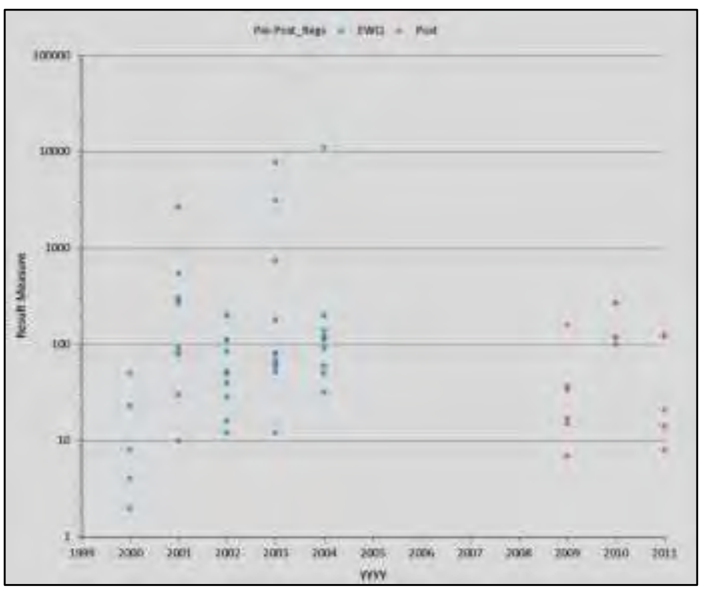
Chapter 15: 1748 ICP Delaware River at Riegelsville

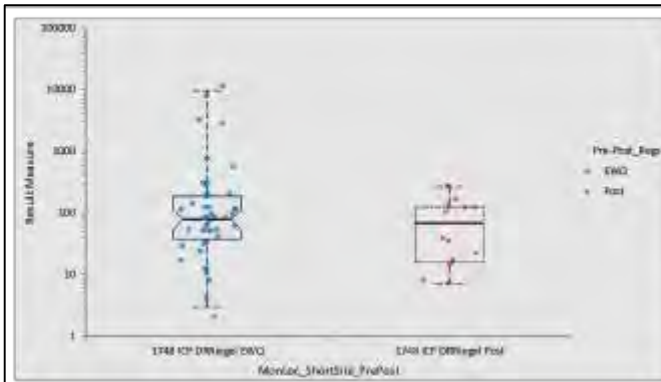
Enterococcus colonies/100 ml

Existing Water Quality (Table 2L):

Median 80/100 ml
Lower 95% Confidence Interval 52/100 ml
Upper 95% Confidence Interval 110/100 ml

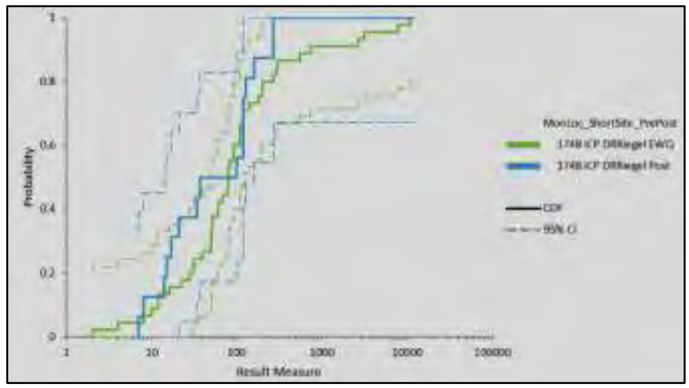






N	61

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1748 ICP DRRiegel EWQ	2	37	80	187	11000	149
1748 ICP DRRiegel Post	7	16	69	124	270	108



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1748 ICP DRRiegel EWQ	45	56.7	1.26
1748 ICP DRRiegel Post	16	159.4	9.96

H statistic	0.69
X^2 approximation	0.69
DF	1
p-value	0.4075 [1]

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

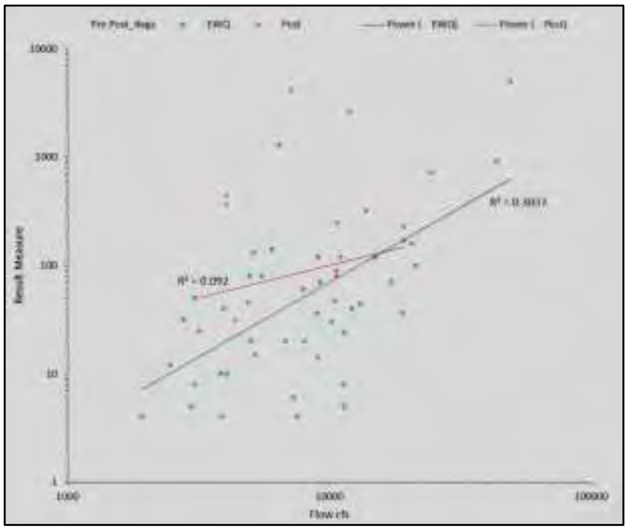
No water quality degradation is evident here. Enterococci apparently did not measurably change between the EWQ and Post-EWQ periods. Uncertainty was introduced into comparisons by potential laboratory artifacts and insufficient post-EWQ sampling frequency. Enterococcus concentrations are unrelated to flow in both data sets. Concentrations and flows are plotted on a logarithmic scale, and the regression is a power relationship. Post-EWQ median enterococcus concentrations fell within the EWQ 95% confidence intervals.

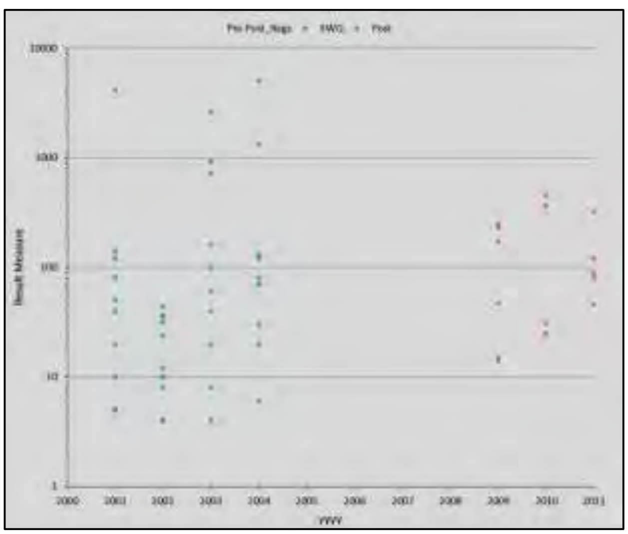
Chapter 15: 1748 ICP Delaware River at Riegelsville

Escherichia coli colonies/100 ml

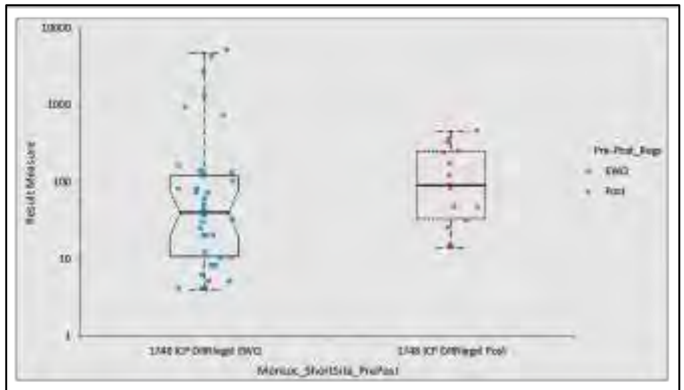
Existing Water Quality (Table 2L):

Median 40/100 ml
Lower 95% Confidence Interval 20/100 ml
Upper 95% Confidence Interval 80/100 ml
Defined in regulations as a flow-related parameter

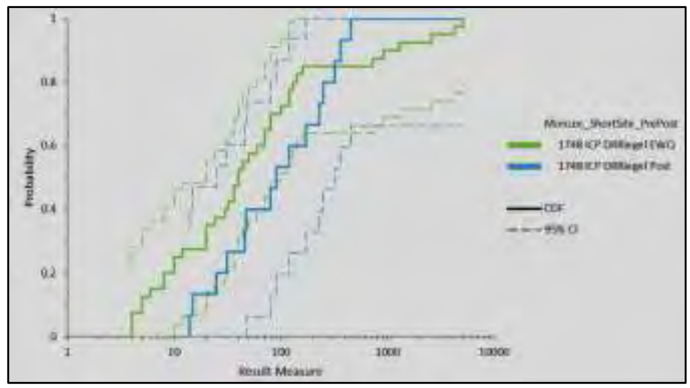




No water quality degradation is evident here. Median E. coli concentrations increased but did not measurably change between the EWQ and Post-EWQ periods. Uncertainty was introduced into comparisons by potential laboratory artifacts and insufficient post-EWQ sampling frequency. Post-EWQ median E. coli rose above the upper EWQ 95% confidence interval, but there were too few samples for statistical difference.



N	55					
Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1748 ICP DRRiegel EWQ	4	11	40	120	5000	109
1748 ICP DRRiegel Post	14	34	90	247	450	213



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1748 ICP DRRiegel EWQ	40	184.9	4.62
1748 ICP DRRiegel Post	15	493.1	32.87

H statistic	2.64
X^2 approximation	2.64
DF	1
p-value	0.1040 [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.

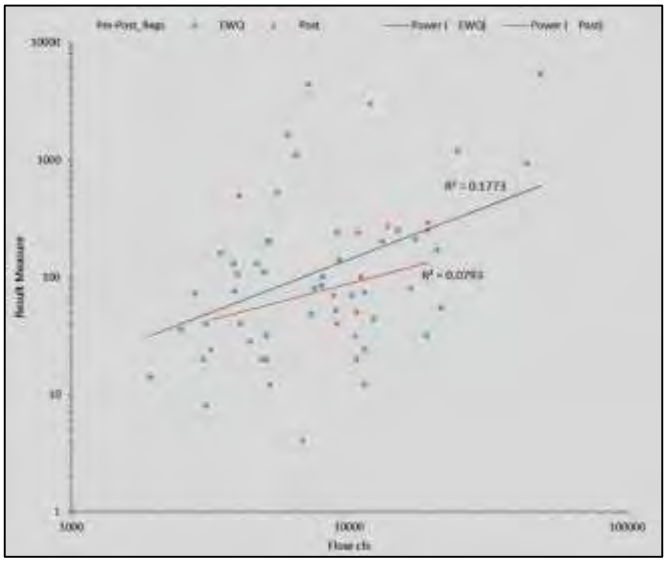
Concentrations and flows are plotted on a logarithmic scale. E. coli concentrations are related to flow in the EWQ data set, but unrelated to flow in the post-EWQ data set – probably because of the narrower range of flow conditions sampled. New Jersey DEP and USGS data were available but too few in number to fully validate DRBC data.

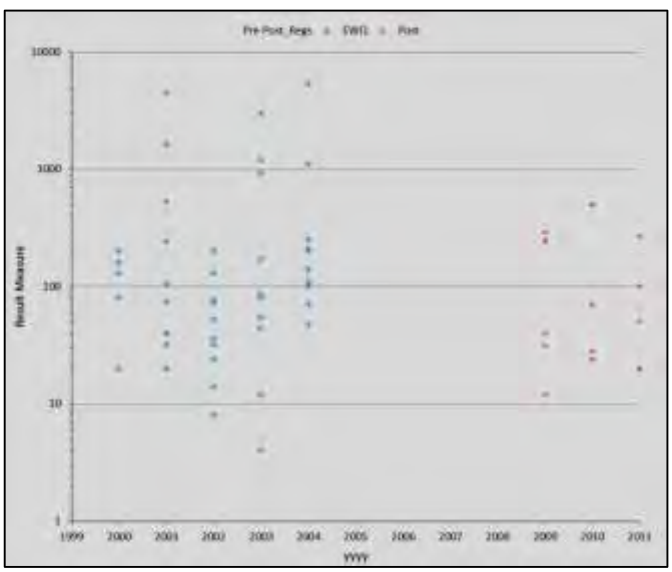
Chapter 15: 1748 ICP Delaware River at Riegelsville

Fecal coliform colonies/100 ml

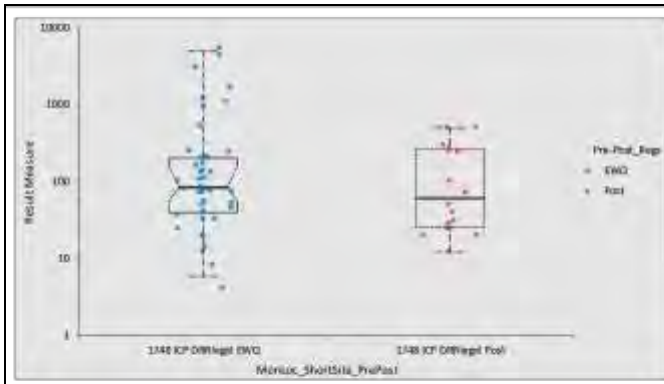
Existing Water Quality (Table 2L):

Median 84/100 ml
Lower 95% Confidence Interval 54/100 ml
Upper 95% Confidence Interval 160/100 ml
Defined in regulations as a flow-related parameter*



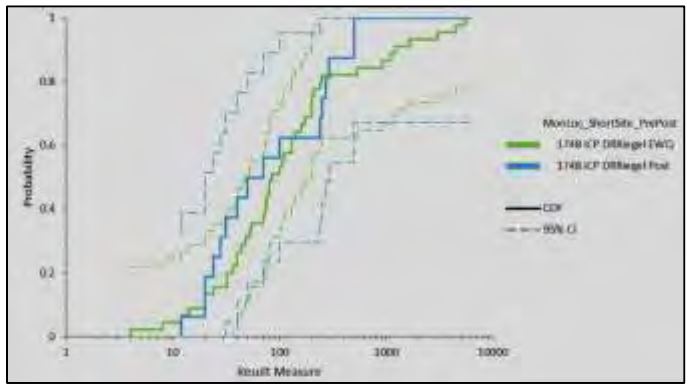


*Fecal coliform were erroneously identified in DRBC water quality regulations as flow-related. The relationship to flow does not hold true at Riegelsville, and the language should be removed from Table 2L.



N 61

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1748 ICP DRRiegel EWQ	4	40	84	203	5400	163
1748 ICP DRRiegel Post	12	26	60	262	500	236



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1748 ICP DRRiegel EWQ	45	39.2	0.87
1748 ICP DRRiegel Post	16	110.3	6.89

H statistic	0.47
X^2 approximation	0.47
DF	1
p-value	0.4909[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.

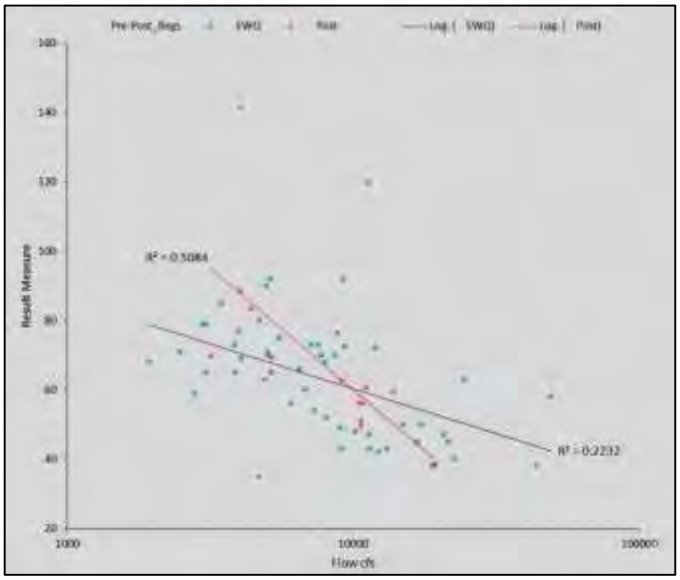
No water quality degradation is evident here. Fecal coliform concentrations apparently did not measurably change between the EWQ and post-EWQ periods. Uncertainty was introduced into comparisons by potential laboratory artifacts and insufficient post-EWQ sampling frequency. Post-EWQ data contained fewer high results and were not fully representative of flow conditions. Fecal coliform concentrations are unrelated to flow in both data sets. Post-EWQ median concentrations were within the EWQ 95% confidence intervals. NJDEP and USGS data showed a statistically significant decline in concentrations, and validated DRBC results.

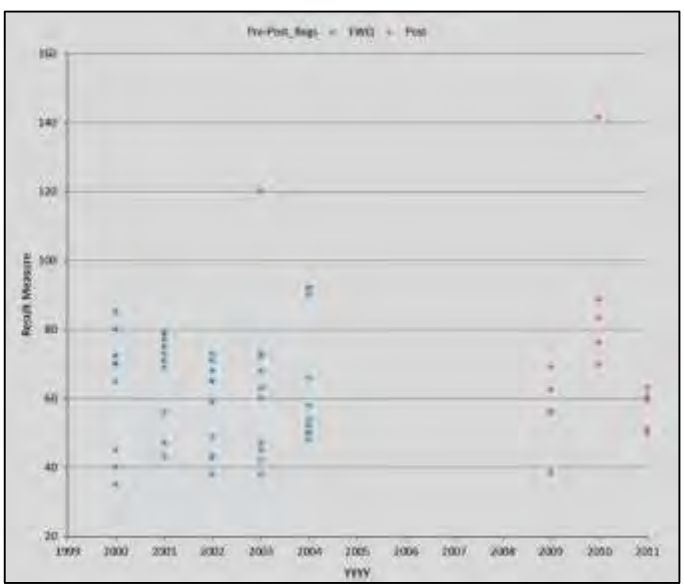
Chapter 15: 1748 ICP Delaware River at Riegelsville

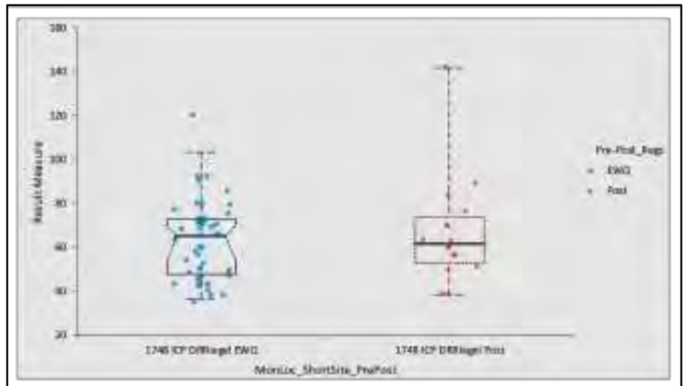
Hardness as CaCO3, Total mg/l

Existing Water Quality (Table 2L):

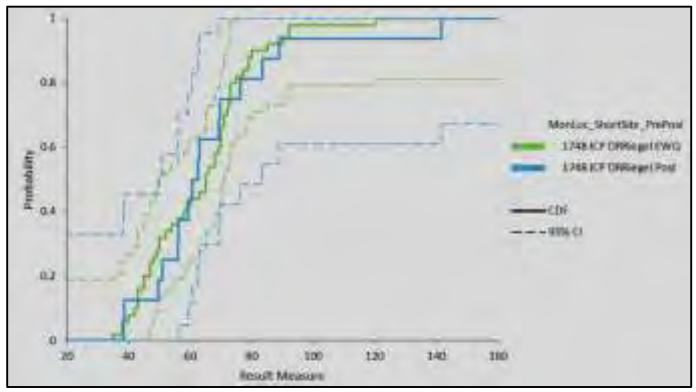
Median 65 mg/l
Lower 95% Confidence Interval 54 mg/l
Upper 95% Confidence Interval 70 mg/l
Defined in regulations as a flow-related parameter







N		66					
Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1748 ICP DRRiegel EWQ	35	48	65	73	120	25
1748 ICP DRRiegel Post	38	53	62	74	142	20



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1748 ICP DRRiegel EWQ	50	0.2	0.00
1748 ICP DRRiegel Post	16	0.6	0.04

H statistic	0.00
X^2 approximation	0.00
DF	1
p-value	0.9642[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.

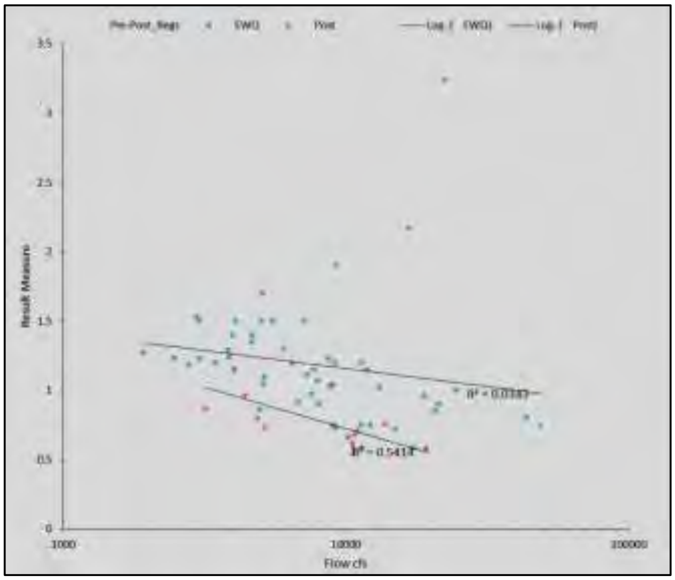
No water quality degradation is evident here. Hardness apparently did not measurably change between the EWQ and post-EWQ periods. Uncertainty was introduced into comparisons by potential laboratory artifacts and insufficient post-EWQ sampling frequency. Hardness is inversely related to flow in both data sets, though weakly so in the EWQ data. Post-EWQ median hardness fell within the EWQ 95% confidence intervals. Flow is plotted on a logarithmic scale. USGS data were available for comparison with DRBC results, and validated DRBC conclusions.

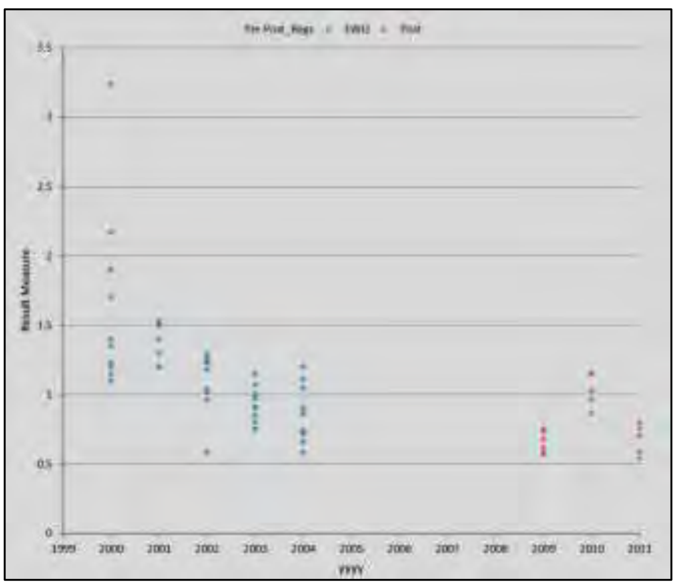
Chapter 15: 1748 ICP Delaware River at Riegelsville

Nitrate + Nitrite as N, Total mg/l

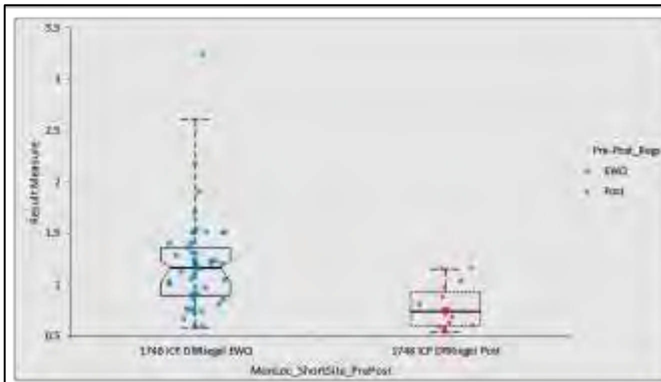
Existing Water Quality (Table 2L, as Nitrate only):

Median 1.17 mg/l
Lower 95% Confidence Interval 1.02 mg/l
Upper 95% Confidence Interval 1.23 mg/l



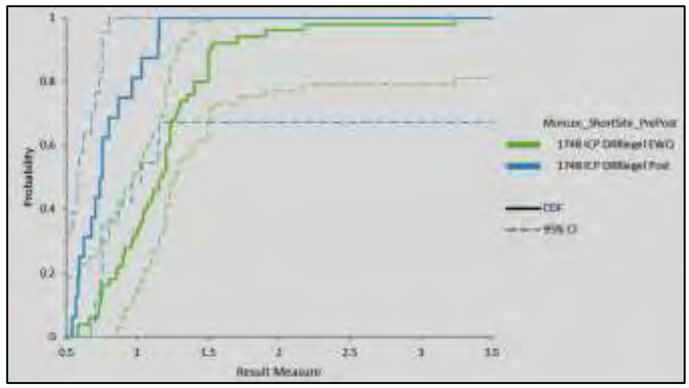


No water quality degradation is evident here. Nitrate concentrations apparently declined between the EWQ and post-EWQ periods. Uncertainty was introduced into comparisons by potential laboratory artifacts, detection limit differences and insufficient post-EWQ sampling frequency. Nitrate is unrelated to flow in the EWQ data and inversely related in the post-EWQ data.



N 66

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1748 ICP DRRiegel EWQ	0.58	0.90	1.17	1.35	3.24	0.45
1748 ICP DRRiegel Post	0.54	0.60	0.74	0.92	1.15	0.32



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1748 ICP DRRiegel EWQ	50	1425.8	28.52
1748 ICP DRRiegel Post	16	4455.6	278.47

H statistic	15.97
X^2 approximation	15.97
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.

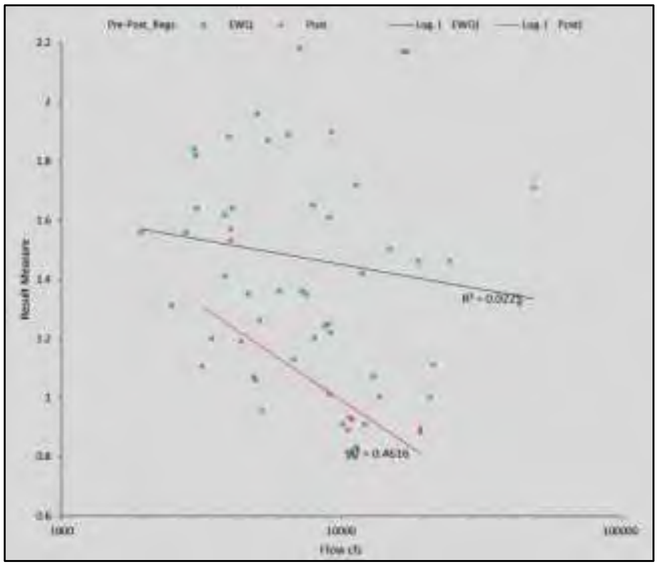
Post-EWQ nitrate concentrations fell below the lower EWP 95% confidence interval. Post-EWQ nitrate + nitrite concentrations were assumed equivalent for comparison with EWQ nitrate concentrations since EWQ nitrite concentrations were never detected. Independent data were not available for validation of DRBC data, as USGS measures dissolved nitrate while DRBC measures total nitrate. At other sites where concentrations are lower, there was a problem interpreting the data due to changing detection limits. Concentrations are sufficiently high for the Delaware River at Riegelsville interpretive problems did not arise.

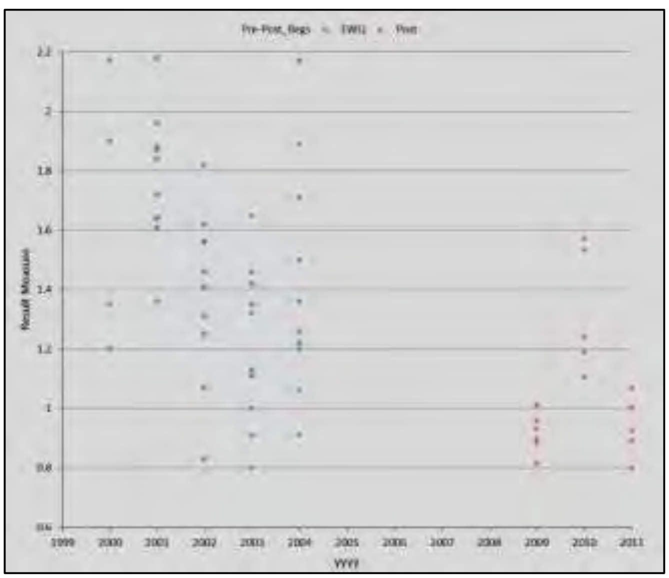
Chapter 15: 1748 ICP Delaware River at Riegelsville

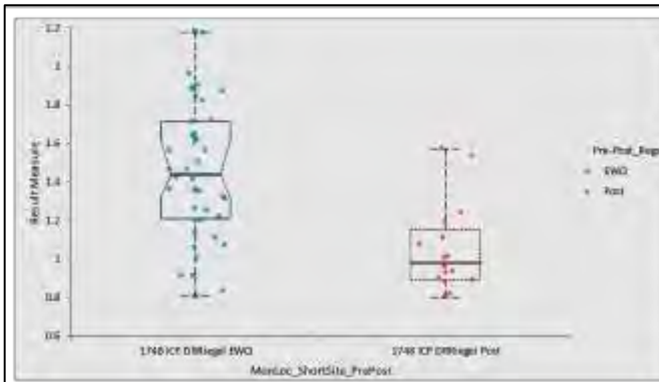
Nitrogen as N, Total (TN) mg/l

Existing Water Quality (Table 2L):

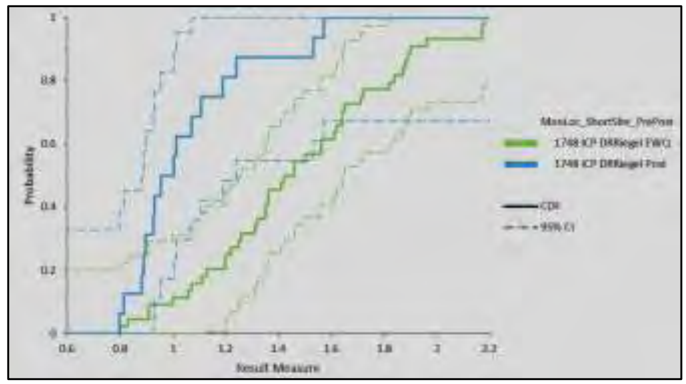
Median 1.44 mg/l
Lower 95% Confidence Interval 1.31 mg/l
Upper 95% Confidence Interval 1.62 mg/l







N	60					
Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1748 ICP DRRiegel EWQ	0.80	1.21	1.44	1.72	2.18	0.51
1748 ICP DRRiegel Post	0.80	0.89	0.98	1.15	1.57	0.26



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1748 ICP DRRiegel EWQ	44	1265.8	28.77
1748 ICP DRRiegel Post	16	3481.0	217.56

H statistic	15.57
X^2 approximation	15.57
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.

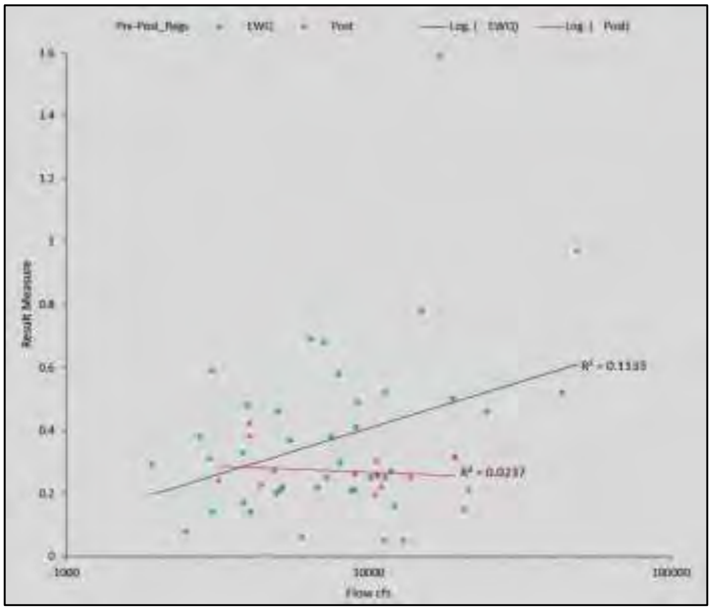
No water quality degradation is evident here. Total Nitrogen concentrations apparently declined between the EWQ and post-EWQ periods. Uncertainty was introduced into comparisons by potential laboratory artifacts, detection limit differences and insufficient post-EWQ sampling frequency. TN is unrelated to flow in the EWQ data, but inversely related to flow in the post-EWQ data. USGS data displayed a similar decline but were too few in number for statistical significance. Post-EWQ median TN concentrations fell below the EWQ lower 95% confidence intervals.

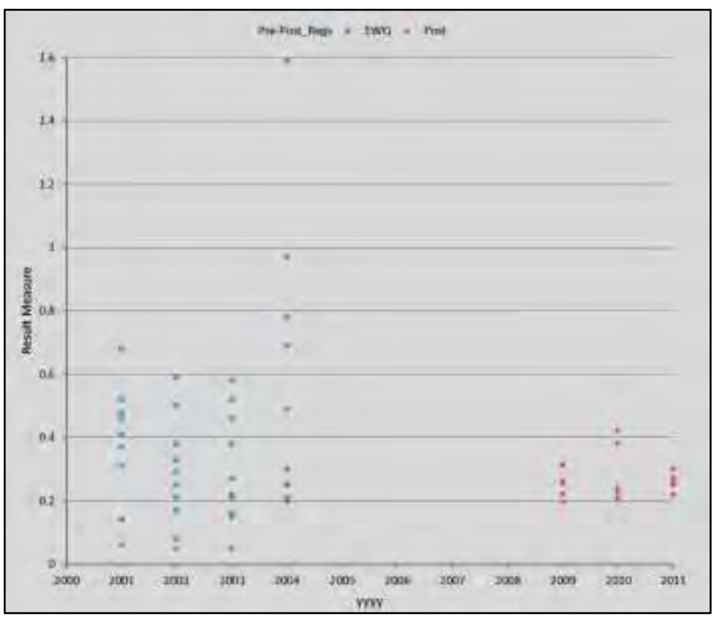
Chapter 15: 1748 ICP Delaware River at Riegelsville

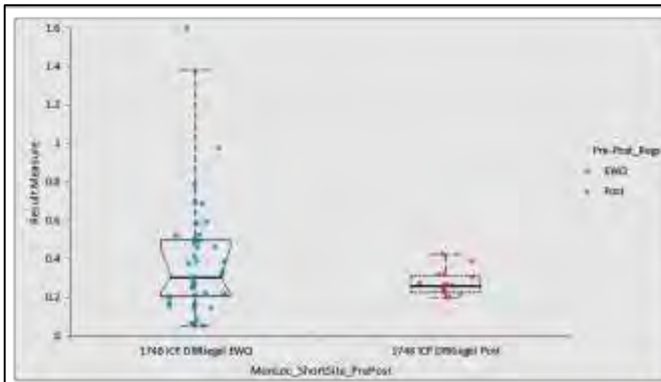
Nitrogen, Kjeldahl as N, Total (TKN) mg/l

Existing Water Quality (Table 2L):

Median 0.31 mg/l
Lower 95% Confidence Interval 0.22 mg/l
Upper 95% Confidence Interval 0.46 mg/l

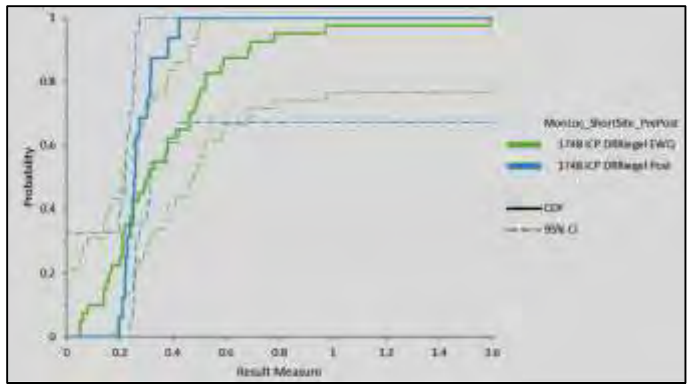






N 56

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1748 ICP DRRiegel EWQ	0.05	0.20	0.31	0.50	1.59	0.29
1748 ICP DRRiegel Post	0.20	0.22	0.26	0.31	0.42	0.09



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1748 ICP DRRiegel EWQ	40	60.0	1.50
1748 ICP DRRiegel Post	16	150.1	9.38

H statistic	0.79
X^2 approximation	0.79
DF	1
p-value	0.3741 [1]

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

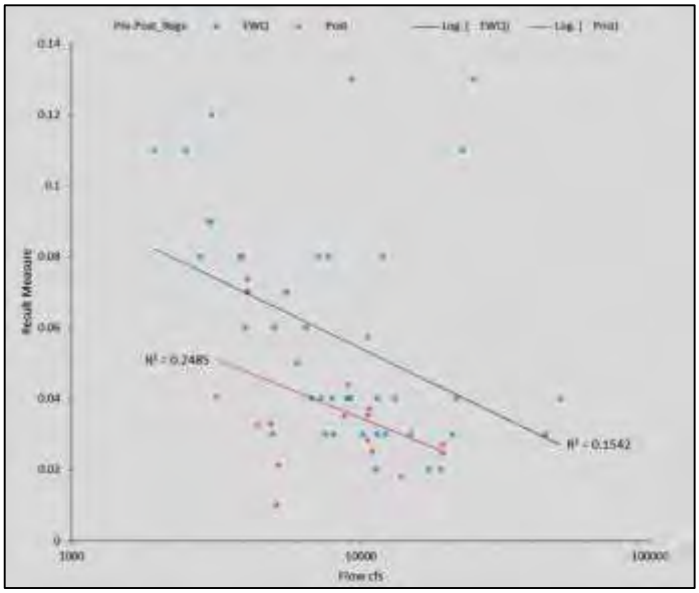
No water quality degradation is evident here. TKN concentrations apparently did not measurably change between the EWQ and post-EWQ periods, though the post-EWQ range was far narrower and all concentrations were less than 0.5 mg/l. Uncertainty was introduced into comparisons by potential laboratory artifacts and insufficient post-EWQ sampling frequency. TKN concentration is unrelated to flow in both data sets. Post-EWQ median TKN fell within the EWQ 95% confidence intervals. There were insufficient USGS data (n=4) to confirm DRBC results.

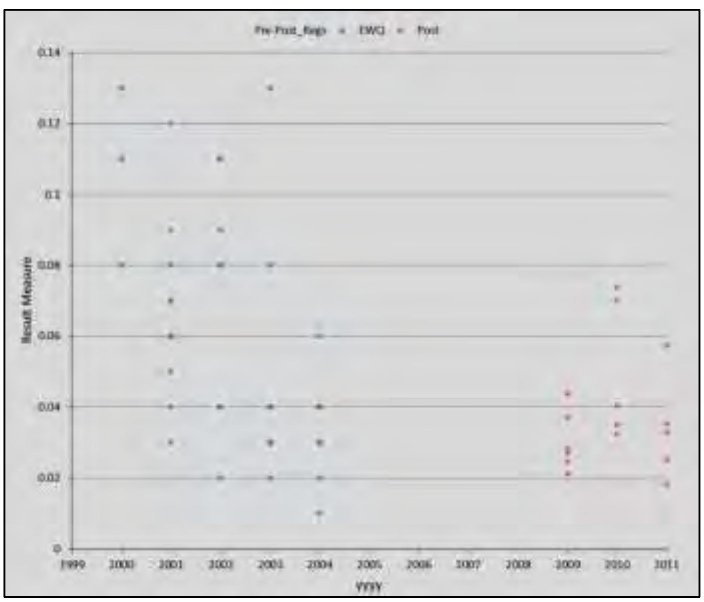
Chapter 15: 1748 ICP Delaware River at Riegelsville

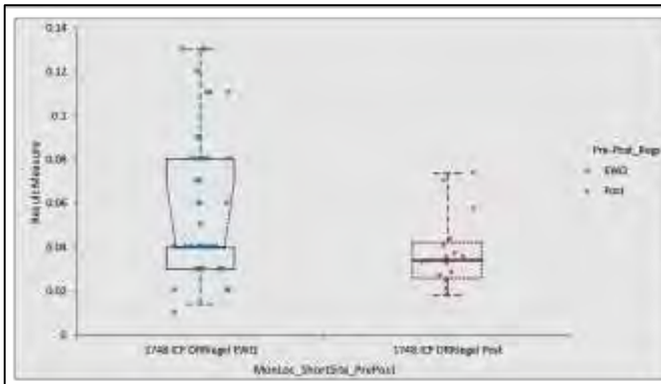
Orthophosphate as P, Total mg/l (OP)

Existing Water Quality (Table 2L):

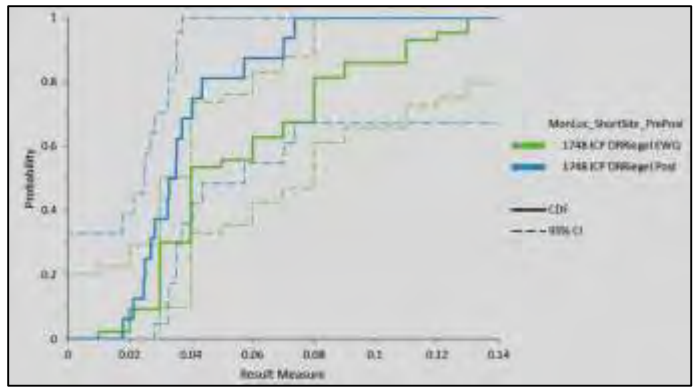
Median 0.04 mg/l
Lower 95% Confidence Interval <0.04 mg/l
Upper 95% Confidence Interval 0.07 mg/l







N	59					
Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1748 ICP DRRiegel EWQ	0.01	0.03	0.04	0.08	0.13	0.05
1748 ICP DRRiegel Post	0.02	0.03	0.03	0.04	0.07	0.02



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1748 ICP DRRiegel EWQ	43	393.0	9.14
1748 ICP DRRiegel Post	16	1056.3	66.02

H statistic	4.96
X^2 approximation	4.96
DF	1
p-value	0.0259 [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. OP concentrations apparently declined between the EWQ and post-EWQ periods. Uncertainty was introduced into comparisons by potential laboratory artifacts, detection limit differences and insufficient post-EWQ sampling frequency.

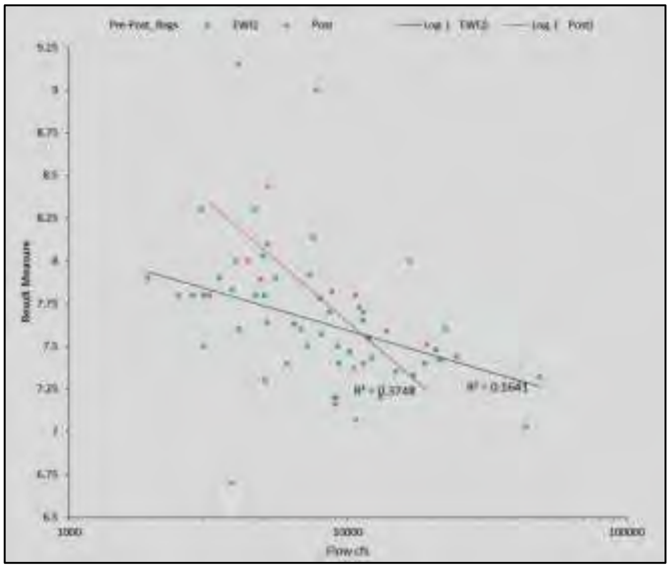
OP is weakly related to flow in both data sets. Post-EWQ median OP fell to the EWQ lower 95% confidence interval and the upper quartile of data decreased significantly. This may be due to an improvement in detection limits, or may be a water quality improvement as there were no post-EWQ concentrations higher than 0.08 mg/l. Post-EWQ OP ranged much less widely than EWQ data. There were no independent data to confirm DRBC results.

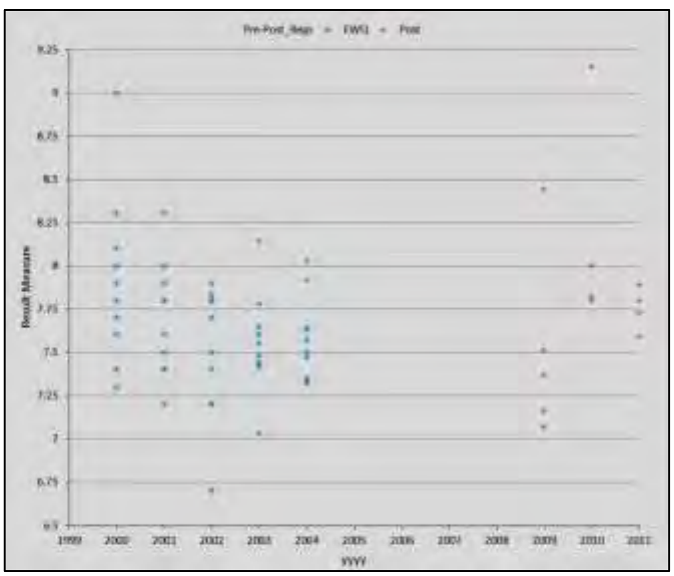
Chapter 15: 1748 ICP Delaware River at Riegelsville

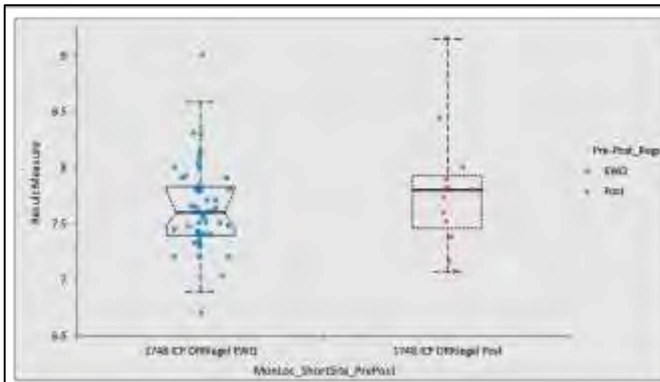
pH

Existing Water Quality (Table 2L):

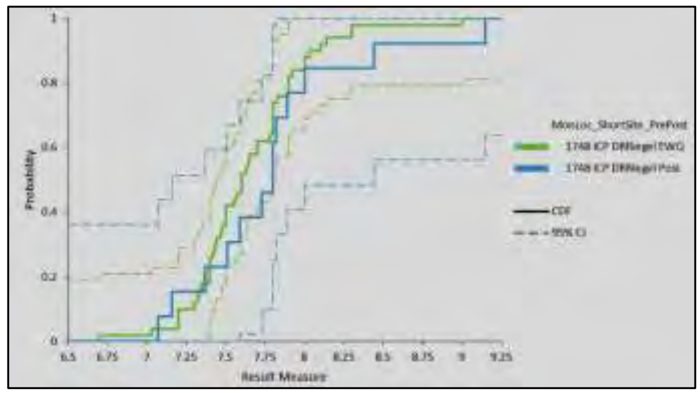
Median 7.60 standard units
Lower 95% Confidence Interval 7.48 standard units
Upper 95% Confidence Interval 7.80 standard units







N	63					
Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1748 ICP DRRiegel EWQ	6.70	7.40	7.60	7.84	9.00	0.44
1748 ICP DRRiegel Post	7.07	7.46	7.80	7.93	9.15	0.46



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1748 ICP DRRiegel EWQ	50	48.0	0.96
1748 ICP DRRiegel Post	13	184.7	14.21

H statistic	0.69
X² approximation	0.69
DF	1
p-value	0.4048 [1]

H0: $\theta_1 = \theta_2 = \theta_{\dots}$
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.

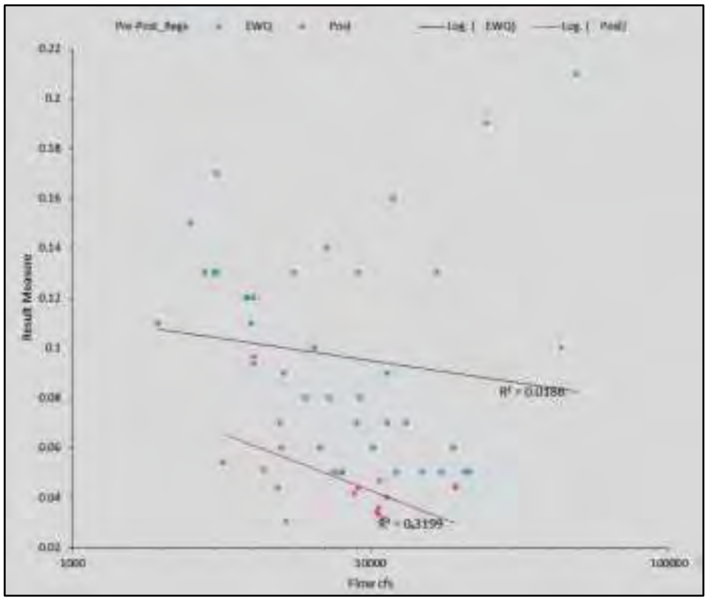
No water quality degradation is evident here. pH did not measurably change between the EWQ and post-EWQ periods. Uncertainty was introduced into comparisons by insufficient post-EWQ sampling frequency. pH is weakly related to flow in both data sets, tending toward neutral at higher flow conditions. Post-EWQ median pH was at the upper EWQ 95% confidence interval, but the result was not statistically significant. In 2010 there was one spike above pH 9, indicating high algal productivity during that dry sampling period. USGS data confirm these results.

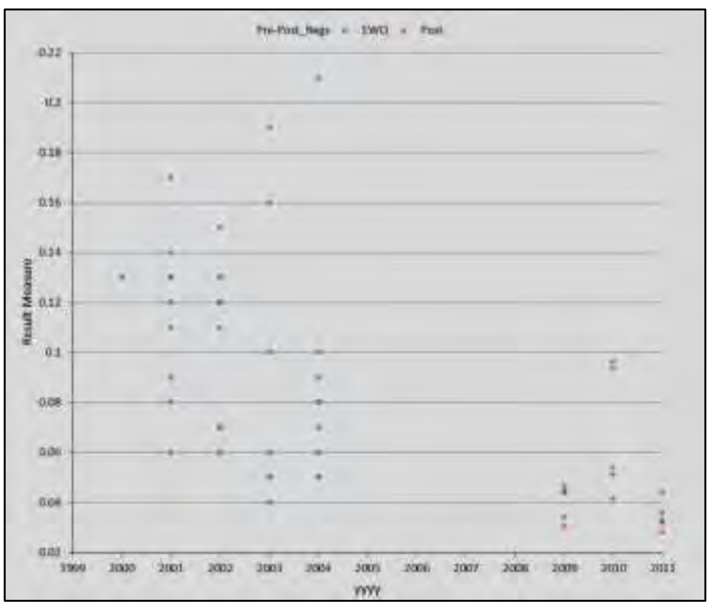
Chapter 15: 1748 ICP Delaware River at Riegelsville

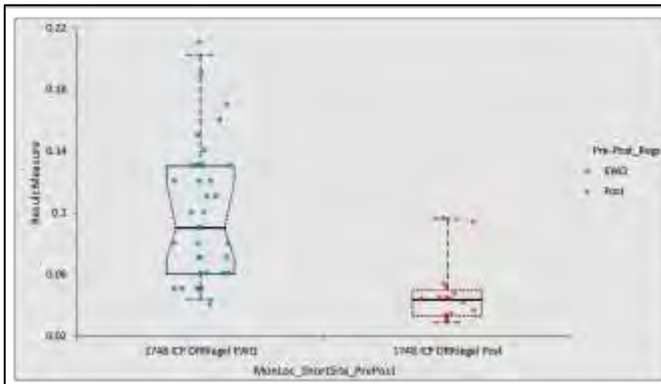
Phosphorus as P, Total (TP) mg/l

Existing Water Quality (Table 2L):

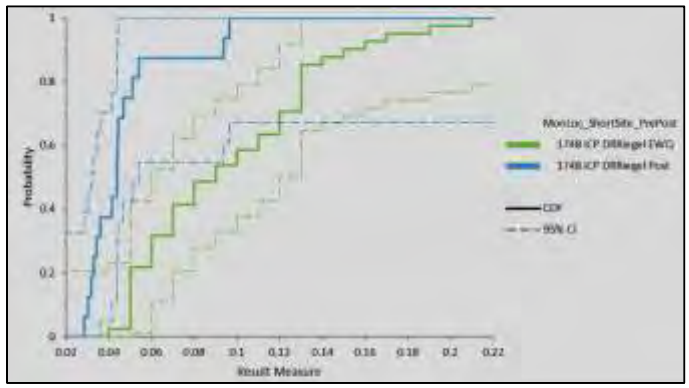
Median 0.09 mg/l
Lower 95% Confidence Interval 0.07 mg/l
Upper 95% Confidence Interval 0.12 mg/l







N	57					
Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1748 ICP DRRiegel EWQ	0.04	0.06	0.09	0.13	0.21	0.07
1748 ICP DRRiegel Post	0.03	0.03	0.04	0.05	0.10	0.02



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1748 ICP DRRiegel EWQ	41	1648.8	40.21
1748 ICP DRRiegel Post	16	4225.0	264.06

H statistic	21.42
X^2 approximation	21.42
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.

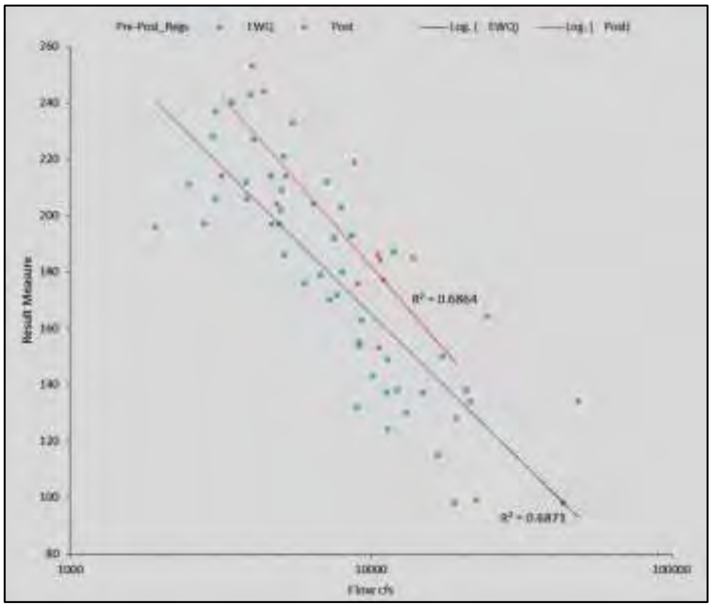
No water quality degradation is evident here. Total Phosphorus (TP) concentrations apparently declined between the EWQ and post-EWQ periods. Uncertainty was introduced into comparisons by potential laboratory artifacts, detection limit differences and insufficient post-EWQ sampling frequency. Post-EWQ median TP fell below the EWQ lower 95% confidence interval. TP is unrelated to flow in the EWQ data, and weakly related in post-EWQ data. USGS data confirm DRBC results though not strongly. A decline in concentrations is shown in USGS data (n=19), but only DRBC post-EWQ data line up well with USGS results. DRBC EWQ results were more variable than USGS data.

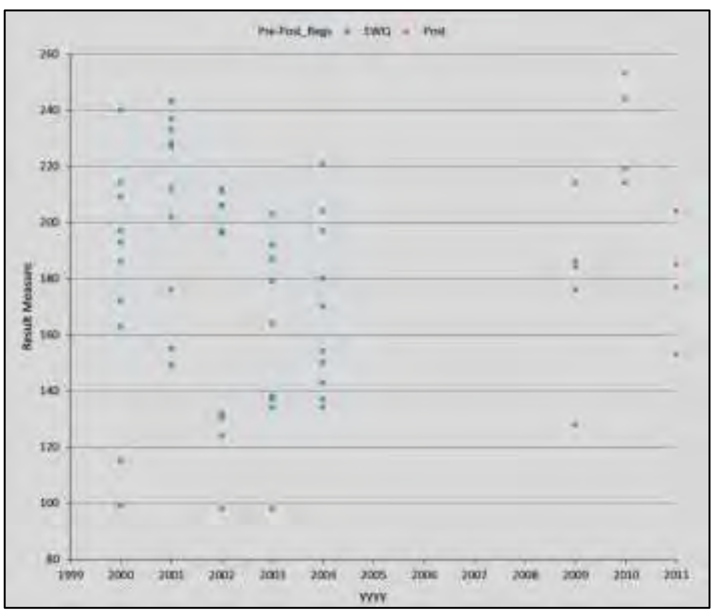
Chapter 15: 1748 ICP Delaware River at Riegelsville

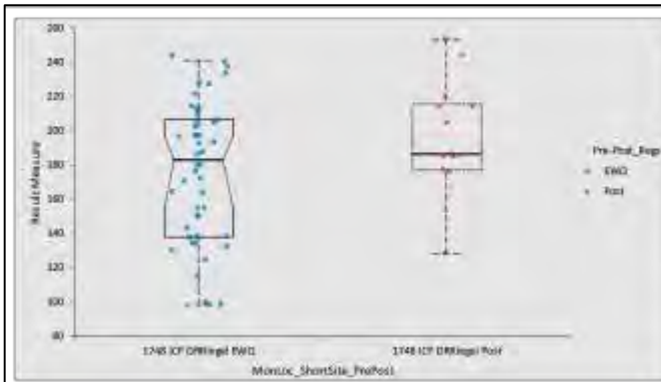
Specific Conductance µmho/cm

Existing Water Quality (Table 2L):

Median 183 µmho/cm
Lower 95% Confidence Interval 155 µmho/cm
Upper 95% Confidence Interval 197 µmho/cm
Defined in regulations as a flow-related parameter

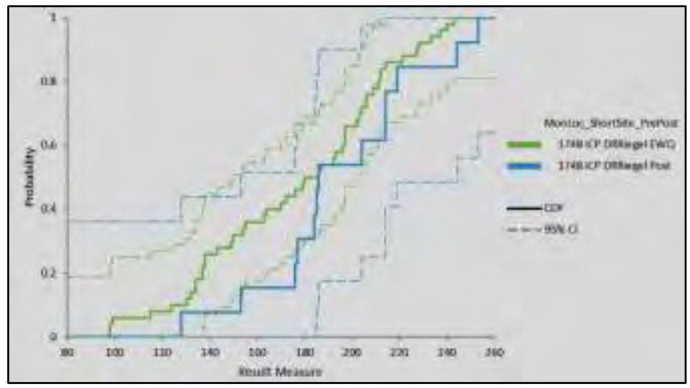






N	63

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1748 ICP DRRiegel EWQ	98	138	183	206	243	68
1748 ICP DRRiegel Post	128	177	186	216	253	39



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1748 ICP DRRiegel EWQ	50	129.6	2.59
1748 ICP DRRiegel Post	13	498.5	38.34

H statistic	1.87
X^2 approximation	1.87
DF	1
p-value	0.1715[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.

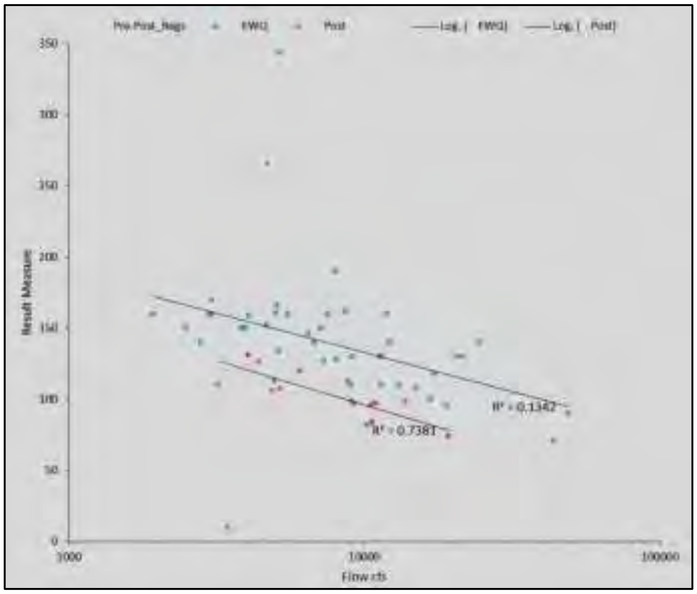
No water quality degradation is evident here. Specific conductance did not measurably change between the EWQ and post-EWQ period. Post-EWQ median specific conductance fell within the EWQ 95% confidence intervals. Specific conductance is inversely related to flow in both data sets. The rise in specific conductance seen elsewhere is not apparent here; probably because the full flow regime is not well-represented in the post-EWQ data. USGS data (n=19) show a larger increase between the two periods, but there are insufficient data for statistical significance of the result. DRBC results compare well with USGS results.

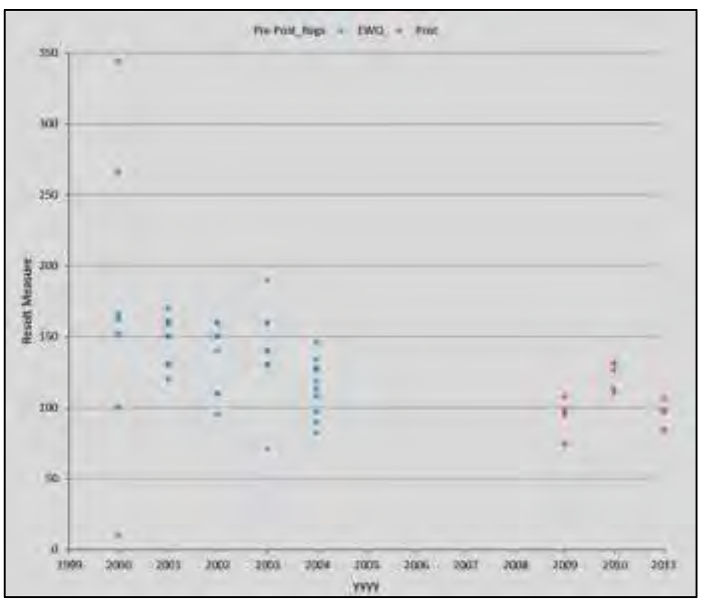
Chapter 15: 1748 ICP Delaware River at Riegelsville

Total Dissolved Solids (TDS) mg/l

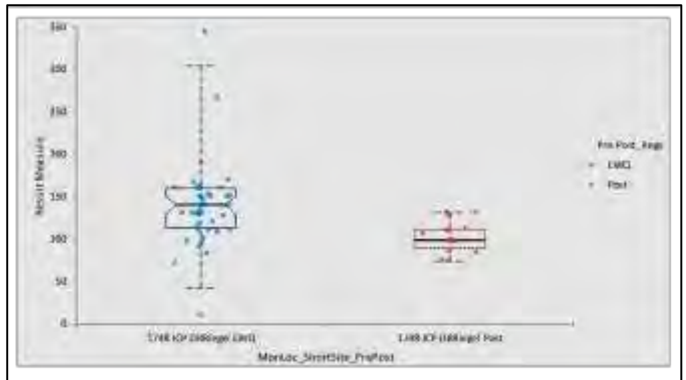
Existing Water Quality (Table 2L):

Median 140 mg/l
Lower 95% Confidence Interval 130 mg/l
Upper 95% Confidence Interval 150 mg/l
Defined in regulations as a flow-related parameter



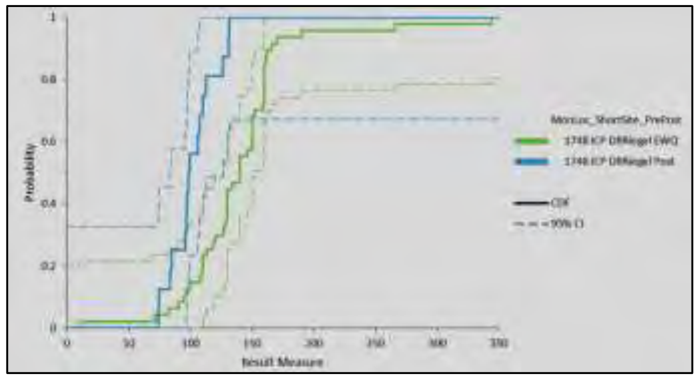


No water quality degradation is evident here. TDS apparently declined between the EWQ and post-EWQ periods. Uncertainty was introduced into comparisons by potential laboratory artifacts and insufficient post-EWQ sampling frequency.



N 63

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1748 ICP DRRiegel EWQ	10	114	140	160	344	46
1748 ICP DRRiegel Post	74	89	99	112	132	23



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1748 ICP DRRiegel EWQ	47	1287.6	27.40
1748 ICP DRRiegel Post	16	3782.3	236.39

H statistic	15.12
X^2 approximation	15.12
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.

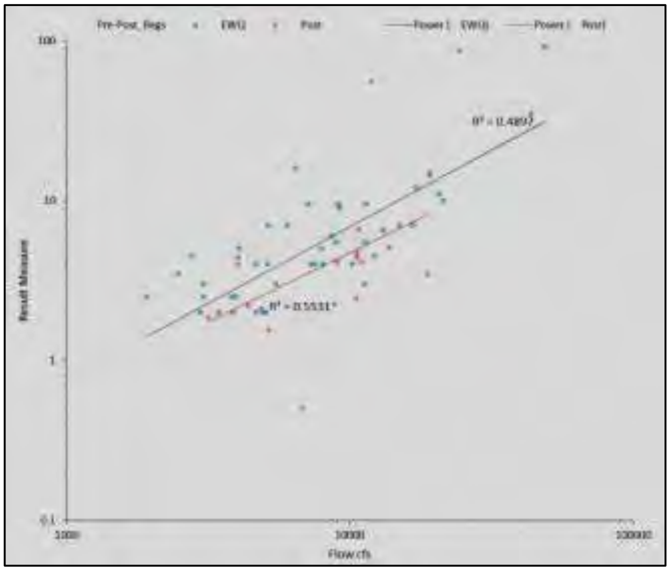
TDS is unrelated to flow in EWQ data, though TDS was designated in the rules as flow related and is inversely related to flow in post-EWQ data. Post-EWQ median TDS fell below the EWQ lower 95% lower confidence interval and was much less variable than the baseline samples as well. Post-EWQ detection limits were lower than EWQ detection limits, though there were no non-detect results at any time. USGS data were within the same range as DRBC data, but the TDS decline was not evident in USGS data. The USGS data displayed a slight increase in TDS, which is logical given the increases in chlorides and specific conductance. This supports the notion that there may be laboratory artifacts in DRBC's TDS data.

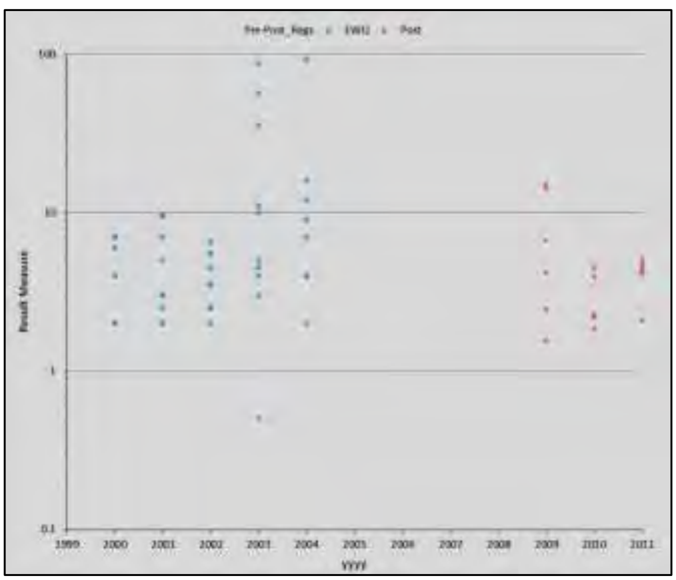
Chapter 15: 1748 ICP Delaware River at Riegelsville

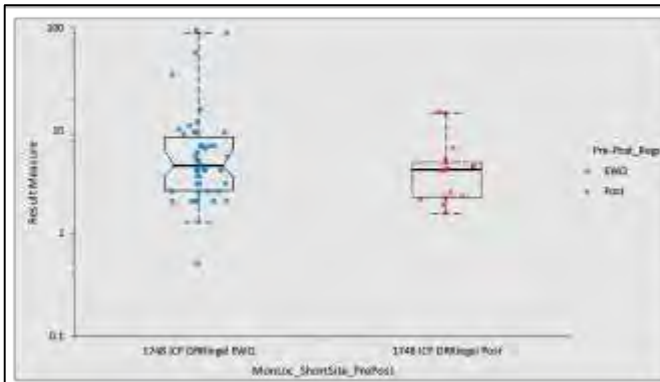
Total Suspended Solids (TSS) mg/l

Existing Water Quality (Table 2L):

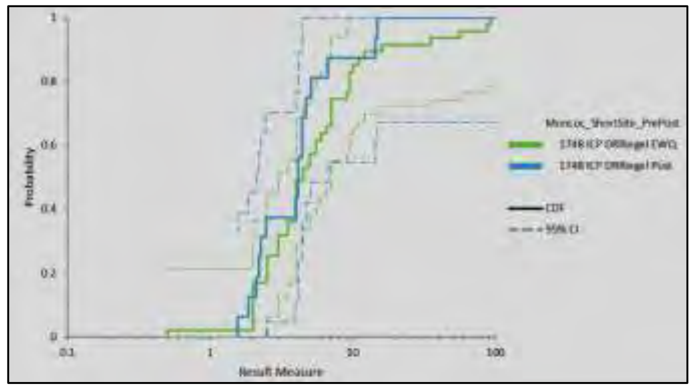
Median 4.5 mg/l
Lower 95% Confidence Interval 3.5 mg/l
Upper 95% Confidence Interval 6.5 mg/l
Defined in regulations as a flow-related parameter







Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
N	63					
1748 ICP DRRiegel EWQ	0.5	2.6	4.5	8.7	92.0	6.1
1748 ICP DRRiegel Post	1.6	2.2	4.1	4.9	14.9	2.7



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1748 ICP DRRiegel EWQ	47	92.7	1.97
1748 ICP DRRiegel Post	16	272.3	17.02

H statistic	1.09
X^2 approximation	1.09
DF	1
p-value	0.2966 [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.

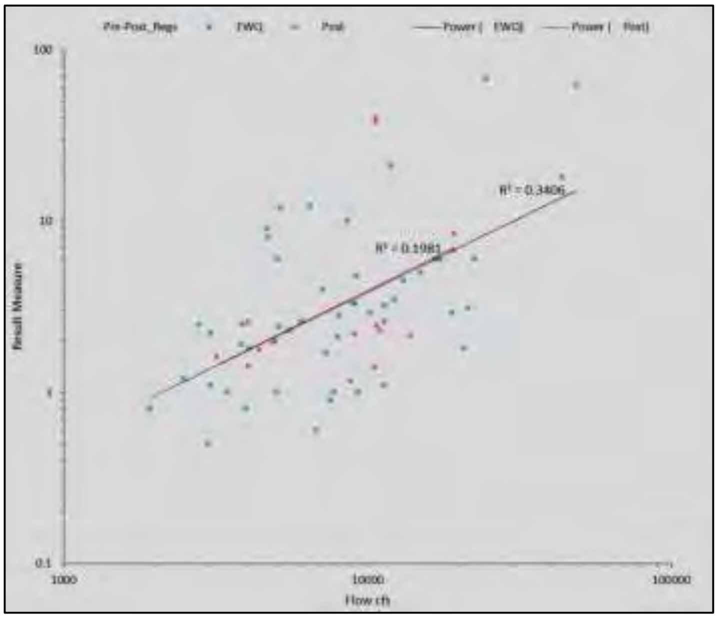
No water quality degradation is evident here. TSS apparently did not measurably change between the EWQ and post-EWQ periods. Uncertainty was introduced into comparisons by potential laboratory artifacts and insufficient post-EWQ sampling frequency. TSS is positively related to flow in both data sets. Post-EWQ median TSS fell within the EWQ 95% confidence intervals. Both flow and concentration are plotted on a logarithmic scale, and the regression is a power relationship. USGS data were too few for trend evaluation, but closely resembled DRBC results.

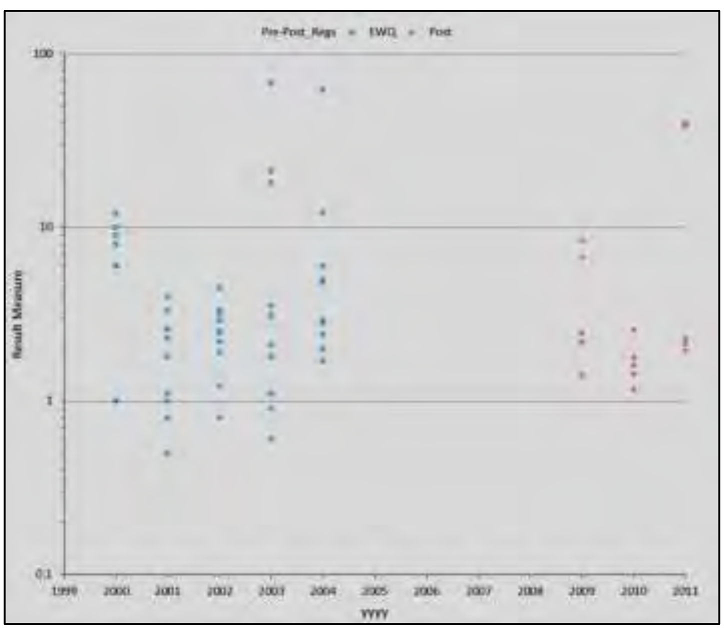
Chapter 15: 1748 ICP Delaware River at Riegelsville

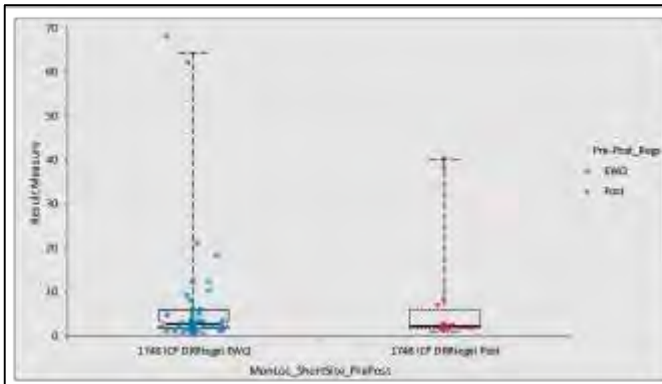
Turbidity NTU

Existing Water Quality (Table 2L):

Median 2.7 NTU
Lower 95% Confidence Interval 2.1 NTU
Upper 95% Confidence Interval 3.5 NTU
Defined in regulations as a flow-related parameter

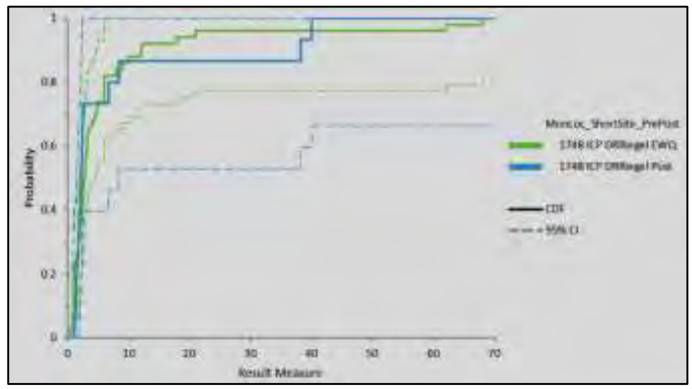






N 65

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1748 ICP DRRiegel EWQ	0.5	1.7	2.7	6.0	68.0	4.3
1748 ICP DRRiegel Post	1.2	1.6	2.2	6.0	40.0	4.4



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1748 ICP DRRiegel EWQ	50	8.4	0.17
1748 ICP DRRiegel Post	15	28.0	1.87

H statistic	0.10
X^2 approximation	0.10
DF	1
p-value	0.7495 [1]

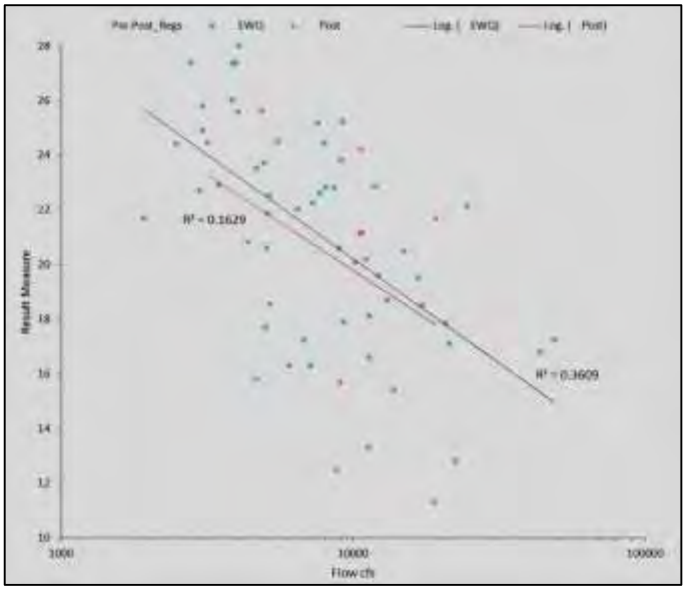
H0: $\theta_1 = \theta_2 = \theta ...$
The median of the populations are all equal.
H1: $\theta_i \neq \theta_j$ for at least one i,j
The median of the populations are not all equal.
[1] Do not reject the null hypothesis at the 5% significance level.

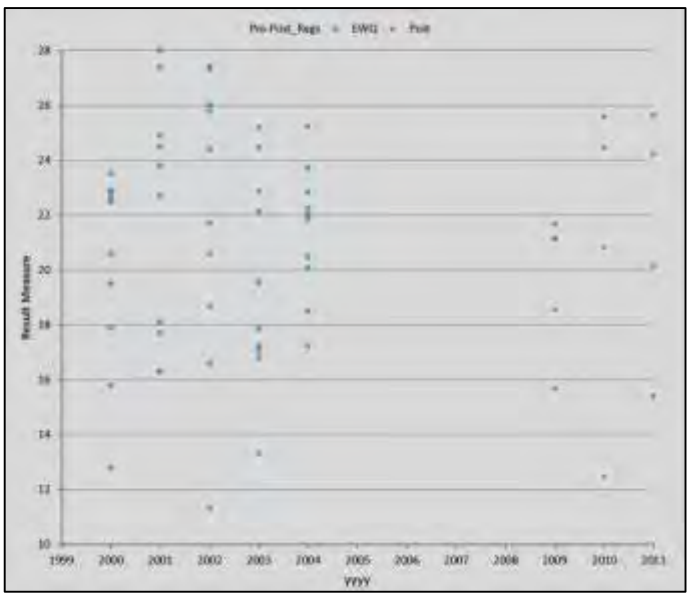
No water quality degradation is evident here. Turbidity apparently did not measurably change between the EWQ and post-EWQ periods. Uncertainty was introduced into comparisons by insufficient post-EWQ sampling frequency. Post-EWQ median turbidity fell within the EWQ 95% confidence intervals of the median. Turbidity is positively related to flow in both data sets, and the power regression lines actually overlay one another. Concentration and flow are represented on logarithmic scales. There were very few USGS data available for comparison with DRBC results, but USGS and DRBC results were similar.

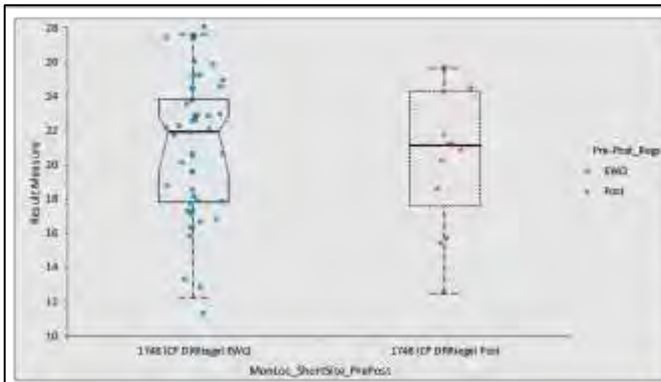
Chapter 15: 1748 ICP Delaware River at Riegelsville

Water Temperature, degrees C

Not included in DRBC Existing Water Quality rules

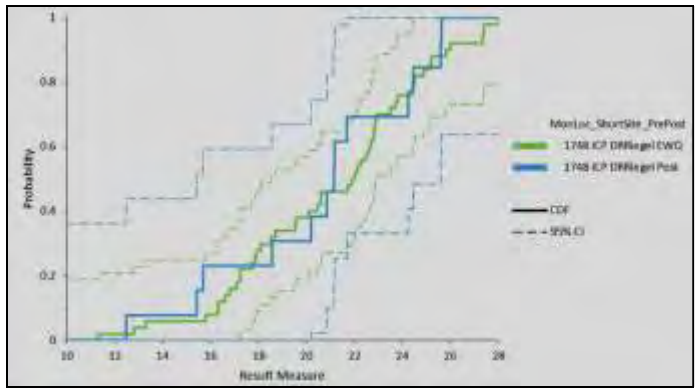






N | 63

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1748 ICP DRRiegel EWQ	11.3	17.8	21.9	23.9	28.0	6.0
1748 ICP DRRiegel Post	12.5	17.6	21.1	24.3	25.6	6.7



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1748 ICP DRRiegel EWQ	50	11.5	0.23
1748 ICP DRRiegel Post	13	44.3	3.41

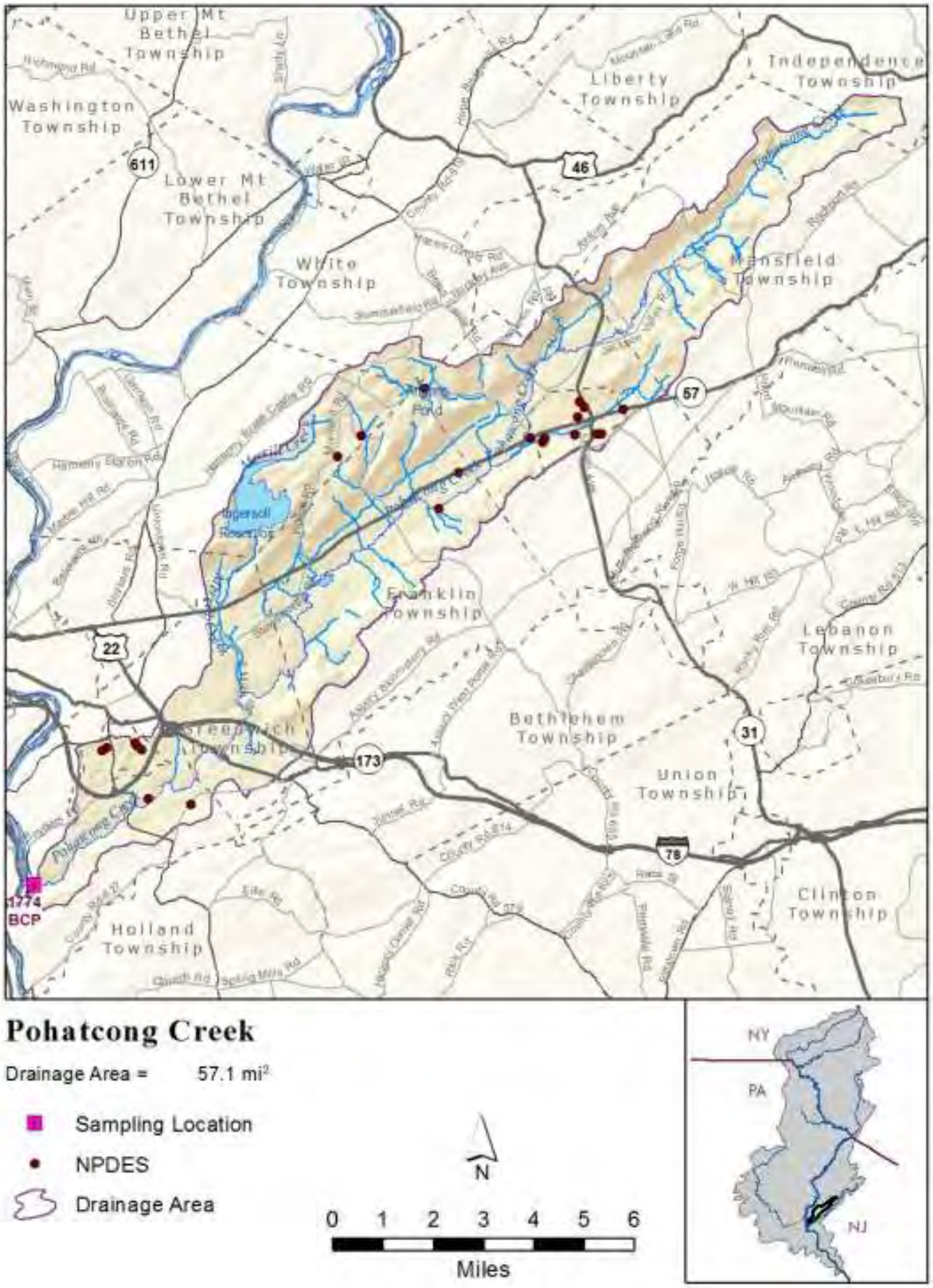
H statistic	0.17
X² approximation	0.17
DF	1
p-value	0.6835 [1]

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.

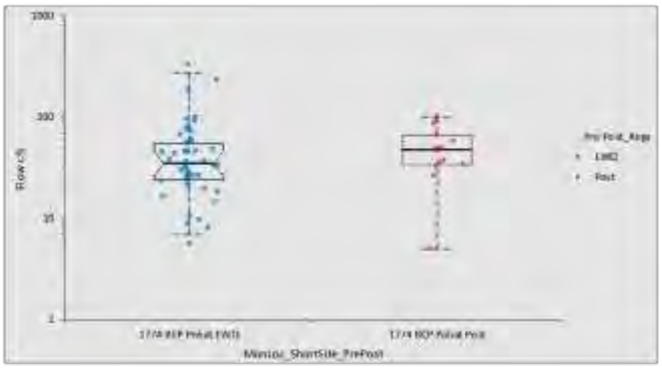
[1] Do not reject the null hypothesis at the 5% significance level.

No water quality degradation is evident here. Water temperature did not measurably change between the EWQ and post-EWQ periods. Uncertainty was introduced into comparisons by insufficient post-EWQ sampling frequency. Water temperature is weakly and inversely related to flow in both data sets. Flow is plotted on a logarithmic scale. DRBC data closely resembled NJDEP and USGS results.

Chapter 16: 1774 BCP Pohatcong Creek, Warren County, NJ



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



N	62					
Flow cfs by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1774 BCP Pohat EWQ	5.6	23.8	34.7	55.2	329.4	31.5
1774 BCP Pohat Post	5.0	34.0	47.4	67.2	101.0	33.3

Flow was roughly the same between the EWQ and post-EWQ periods. Fewer samples were collected in the post-EWQ period. The range of flow conditions sampled was wider in the EWQ period, and the post-EWQ data contain fewer samples taken at high and low flow conditions. This is a deficiency that possibly affects the measurable change analyses for those parameters that are flow-related. There were too few samples taken in the post-EWQ period at Pohatcong Creek; sampling should have been biweekly instead of monthly.

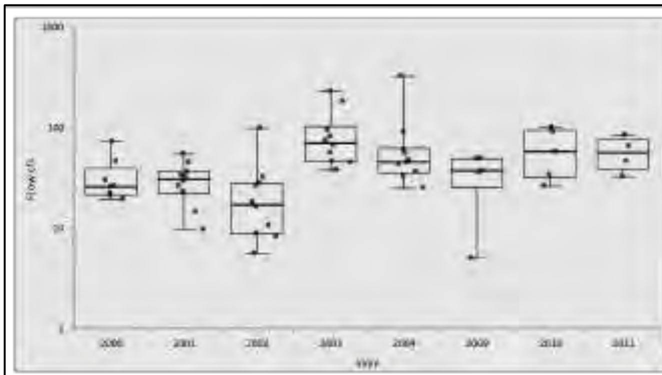
Kruskal-Wallis test

Flow cfs by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1774 BCP Pohat EWQ	48	130.0	2.71
1774 BCP Pohat Post	14	445.8	31.84

H statistic	1.77
X^2 approximation	1.77
DF	1
p-value	0.1835[1]

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

The 57.1 square mile Pohatcong Creek watershed is about 49% forested and about 8% urban land cover. Less than 1% of the watershed was affected by glacial activity. About 47% of the watershed is underlain by carbonate bedrock; limestone influence upon water quality is significant. Limestone streams possess high alkalinity, hardness and specific conductance. The watershed has urban and agricultural influences upon water quality as well. DRBC samples at the River Road Bridge near the Delaware River confluence.



N	62					
Flow cfs by yyyy	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
2000	19.4	21.5	25.8	39.1	73.2	17.6
2001	9.7	22.1	31.0	36.6	54.8	14.5
2002	5.6	8.8	17.0	28.0	97.4	19.3
2003	37.5	45.7	70.3	102.1	231.8	56.4
2004	25.2	35.6	45.8	62.2	329.4	26.6
2009	5.0	25.5	37.3	48.9	49.4	23.4
2010	26.0	31.4	57.5	94.1	101.0	62.7
2011	32.5	38.2	55.9	76.9	85.0	38.7

Annual May to September flow statistics associated with water quality measurements are plotted above. These are measurements or estimates associated with the time of each water quality sample. Mean annual flow is about 97.3 cfs; and harmonic mean flow is about 73.6 cfs (USGS Stream Stats retrieval, Feb. 2014) which is more typical of summer flow conditions. Though a wide range of flows were sampled by DRBC, these data appear to be most representative of low to normal flow conditions. Flows corresponding to each water quality sample were estimated using a DRBC-constructed rating curve using a benchmark established on the bridge over River Road. In the 2009-2011 time periods many flow estimates were derived from the USGS BaSE* program. There was excellent correspondence between DRBC estimates and BaSE-derived estimates.

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

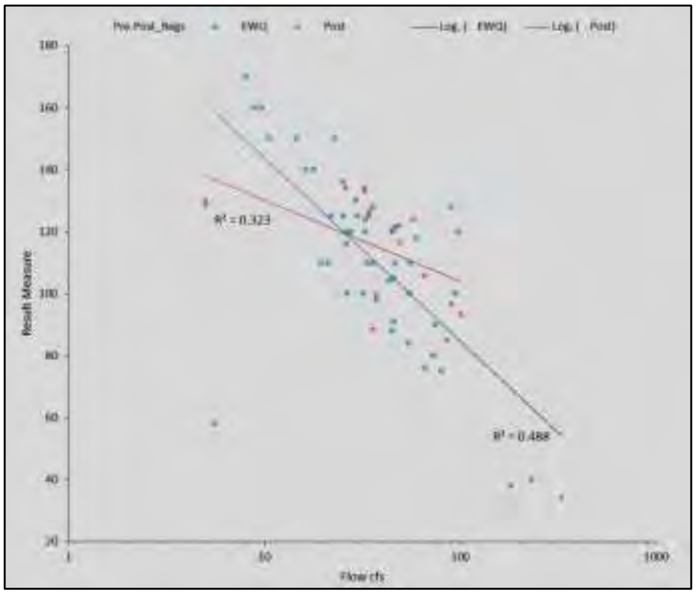
Upstream ICP: Delaware River at Easton 1838 ICP
Downstream ICP: Del. River at Riegelsville 1748 ICP

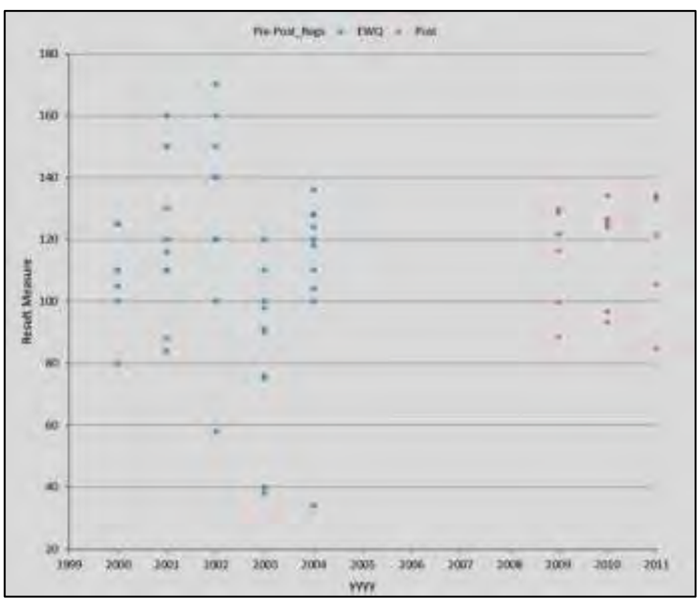
Chapter 16: 1774 BCP Pohatcong Creek, NJ

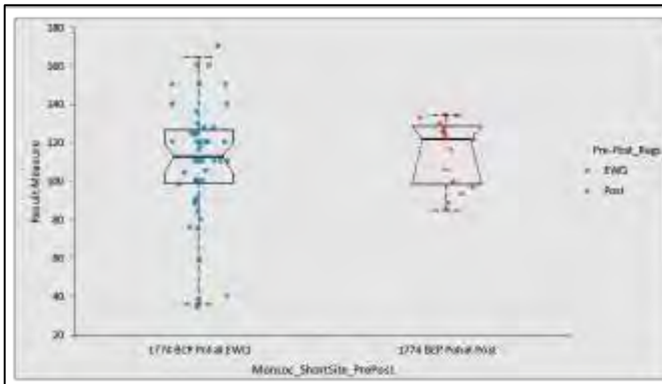
Alkalinity as CaCO3, Total mg/l

Existing Water Quality (Table 2K):

Median <u>113</u> mg/l (typo. error in rules 116 m/l)
Lower 95% Confidence Interval 104 mg/l
Upper 95% Confidence Interval 120 mg/l
Defined in regulations as a flow-related parameter

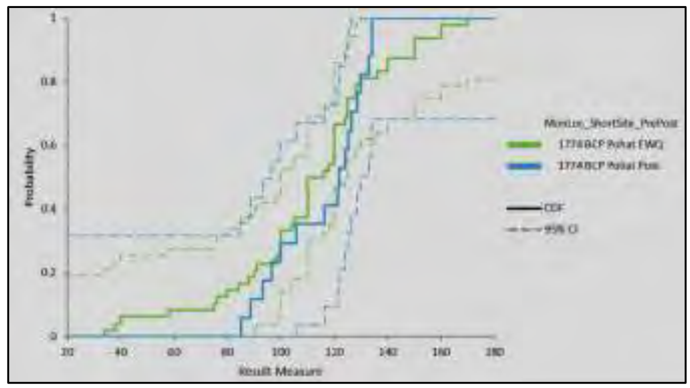






N 65

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1774 BCP Pohat EWQ	34	99	113	127	170	28
1774 BCP Pohat Post	85	99	122	129	134	30



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1774 BCP Pohat EWQ	48	46.0	0.96
1774 BCP Pohat Post	17	129.9	7.64

H statistic	0.49
X^2 approximation	0.49
DF	1
p-value	0.4825 [1]

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

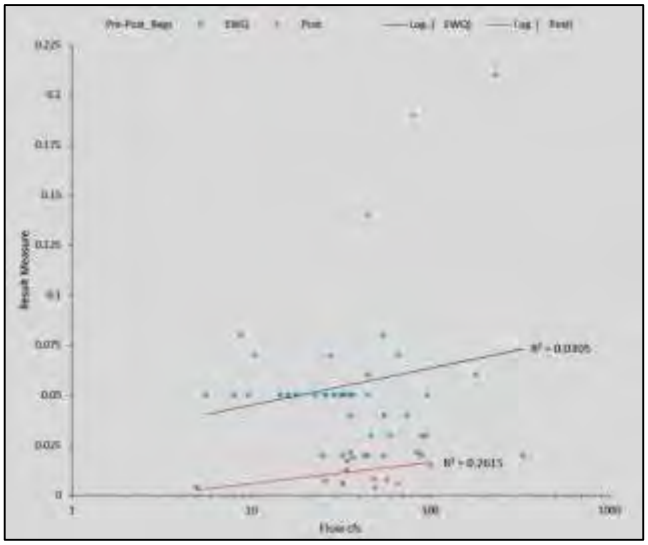
No water quality degradation is evident here. Alkalinity apparently did not measurably change between the EWQ and post-EWQ periods. However, uncertainty is introduced into this conclusion because of potential laboratory artifacts, insufficient post-EWQ sampling frequency, and flow differences. Alkalinity is inversely related to flow in both data sets. Post-EWQ median alkalinity rose above the upper EWQ 95% confidence interval, but there were insufficient data for statistical significance. There were too few data in the post-EWQ data set to fully represent the flow regime of Pohatcong Creek – there were too few samples taken under high-flow conditions.

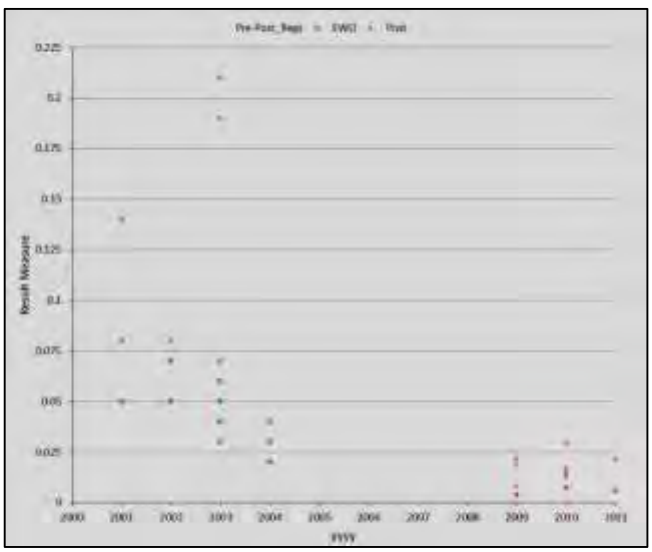
Chapter 16: 1774 BCP Pohatcong Creek, NJ

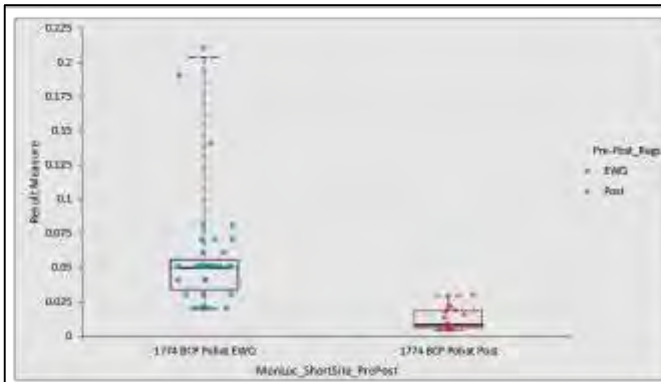
Ammonia Nitrogen as N, Total mg/l

Existing Water Quality (Table 2K):

Median <0.05 mg/l
Lower 95% Confidence Interval <0.05 mg/l
Upper 95% Confidence Interval <0.05 mg/l
Designated in DRBC rules as flow-related

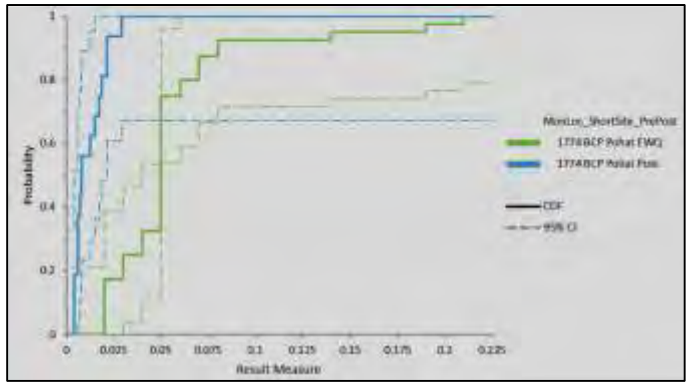






N 56

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1774 BCP Pohat EWQ	0.02	0.03	0.05	0.06	0.21	0.02
1774 BCP Pohat Post	0.00	0.01	0.01	0.02	0.03	0.01



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1774 BCP Pohat EWQ	40	2235.0	55.88
1774 BCP Pohat Post	16	5587.6	349.22

H statistic	30.34
X² approximation	30.34
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. Ammonia concentrations apparently declined. However, uncertainty is introduced into this conclusion because of detection limit differences, potential laboratory artifacts, insufficient post-EWQ sampling frequency, and flow differences. Post-EWQ median ammonia concentration was below the EWQ lower 95% confidence interval.

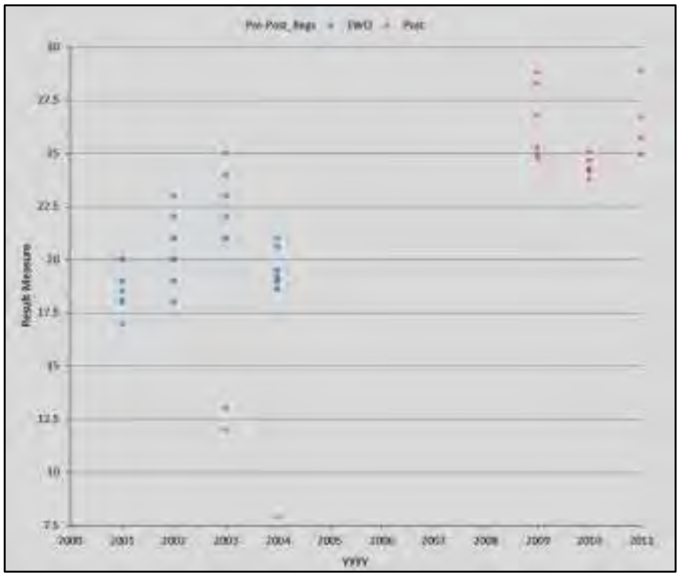
No independent data were available to validate results. DRBC's post-EWQ detection limit (0.004-0.006 mg/l) was much lower than during the EWQ period (0.02-0.05 mg/l). EWQ data possessed many undetected results (27 of 40 samples), which interfered with calculation of the median. Under 2009-2011 lower detection levels there were still 6/16 undetected results, but the median calculation was unaffected. So rather than a real change in ambient concentrations we are better able to measure actual concentrations. Some water quality improvement may be indicated as the post-EWQ data contained no concentrations greater than 0.03 mg/l.

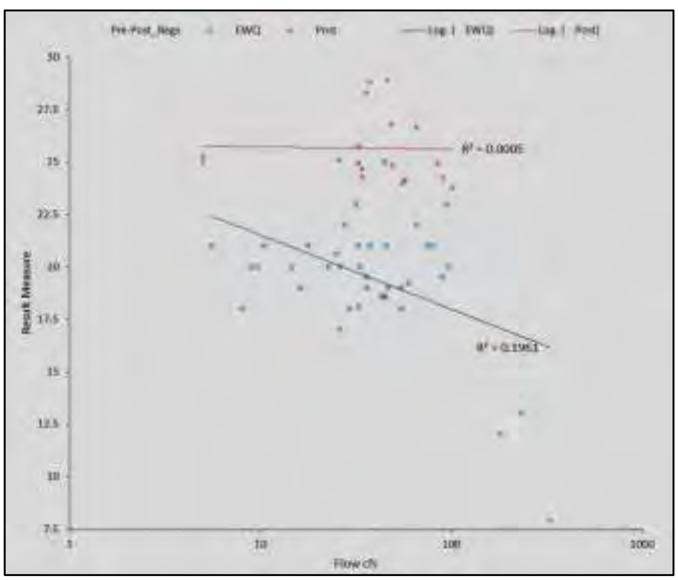
Chapter 16: 1774 BCP Pohatcong Creek, NJ

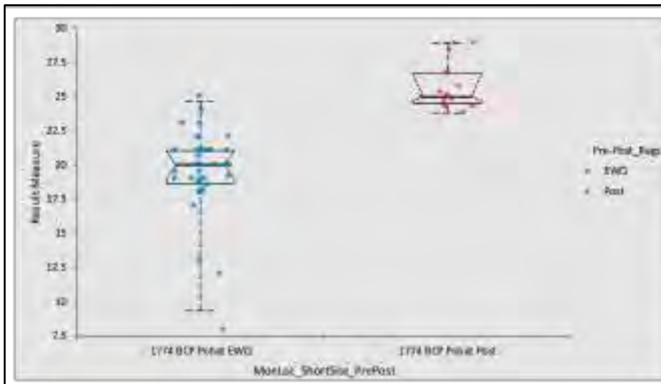
Chloride, Total mg/l

Existing Water Quality (Table 2K):

Median 20 mg/l
Lower 95% Confidence Interval 19 mg/l
Upper 95% Confidence Interval 21 mg/l

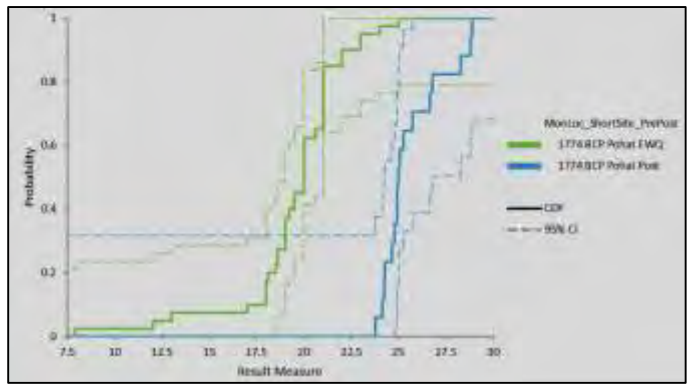






N 57

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1774 BCP Pohat EWQ	8	19	20	21	25	2
1774 BCP Pohat Post	24	25	25	27	29	2



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1774 BCP Pohat EWQ	40	2722.5	68.06
1774 BCP Pohat Post	17	6405.9	376.82

H statistic	33.31
X^2 approximation	33.31
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.

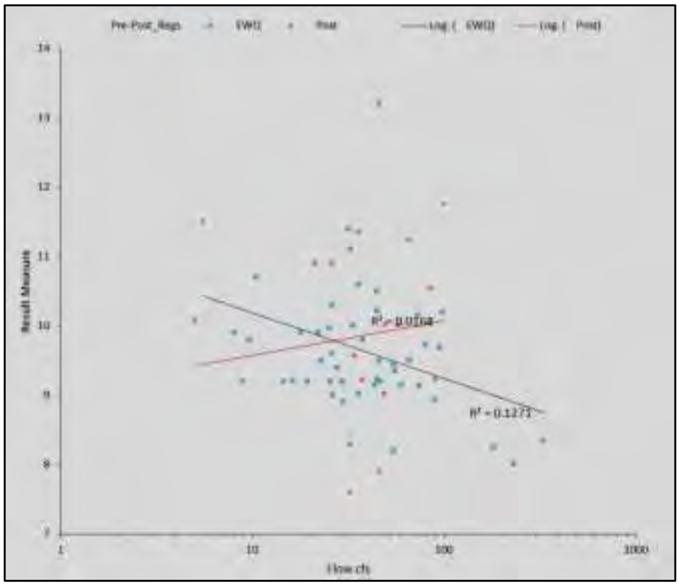
Water quality degradation is evident here. Chloride concentrations apparently rose by about 5 mg/l. However, uncertainty is introduced into this conclusion by potential laboratory artifacts, insufficient post-EWQ sampling frequency, and flow differences. Post-EWQ median concentration rose above the EWQ upper 95% confidence interval. Chloride concentration is unrelated to flow in this data set. No independent data were available to validate these results.

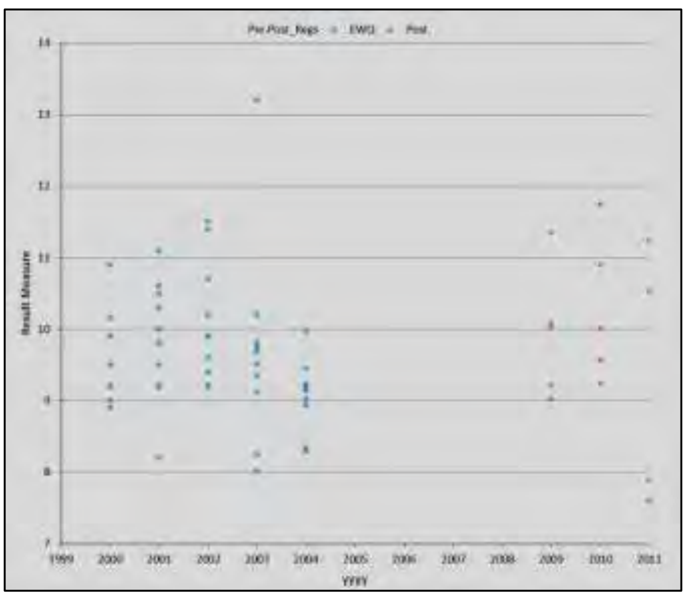
Chapter 16: 1774 BCP Pohatcong Creek, NJ

Dissolved Oxygen (DO) mg/l

Existing Water Quality (Table 2K):

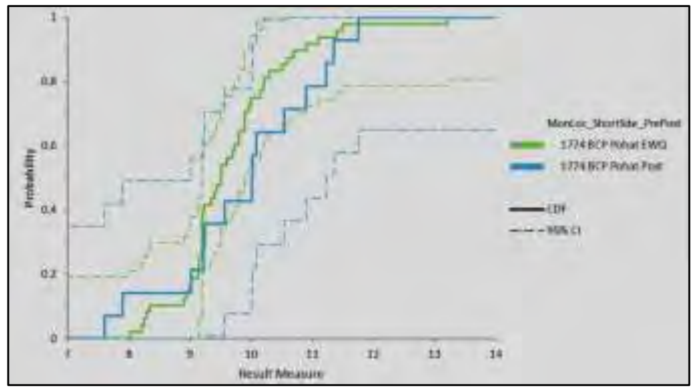
Median 9.50 mg/l
Lower 95% Confidence Interval 9.20 mg/l
Upper 95% Confidence Interval 9.90 mg/l





N | 62

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1774 BCP Pohat EWQ	8.01	9.17	9.50	10.09	13.20	0.92
1774 BCP Pohat Post	7.60	9.20	10.02	10.93	11.75	1.72



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1774 BCP Pohat EWQ	48	93.5	1.95
1774 BCP Pohat Post	14	320.6	22.90

H statistic	1.27
X^2 approximation	1.27
DF	1
p-value	0.2591 [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.

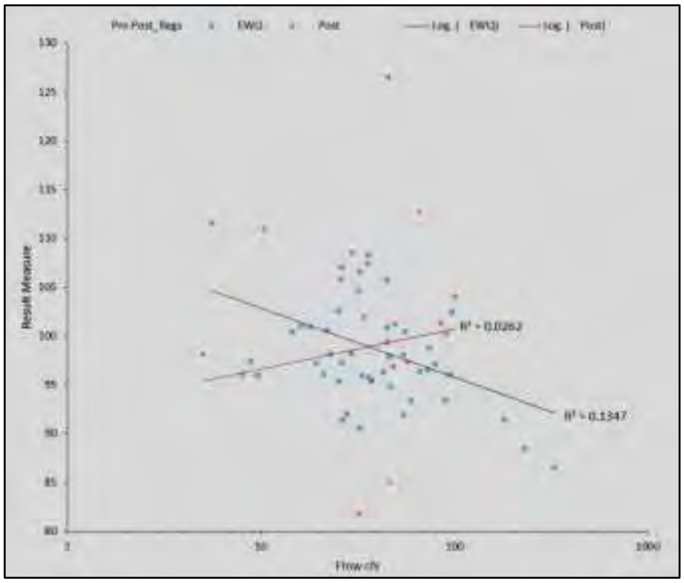
No water quality degradation is evident here. No measurable change took place between the EWQ and Post-EWQ periods. Uncertainty is introduced into this conclusion by insufficient post-EWQ sampling frequency and flow differences. Post-EWQ median DO concentration was above the EWQ upper 95% confidence interval but the increase was not statistically significant due to too few post-EWQ samples. Such an increase would represent an improvement to water quality anyway. DO concentration is unrelated to flow in both data sets.

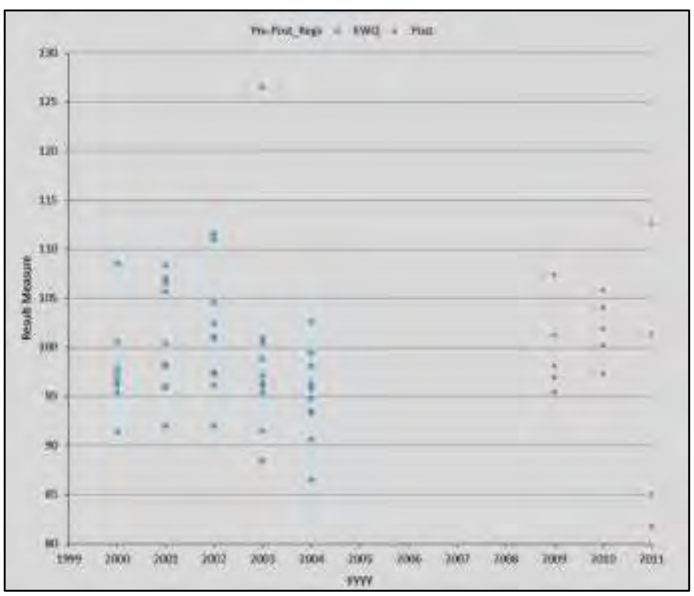
Chapter 16: 1774 BCP Pohatcong Creek, NJ

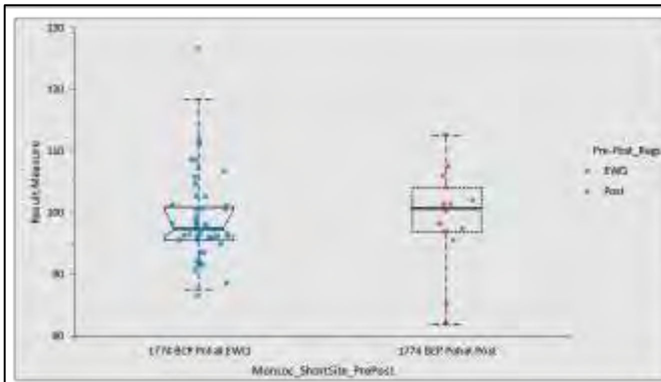
Dissolved Oxygen Saturation %

Existing Water Quality (Table 2K):

Median 97%
Lower 95% Confidence Interval 96%
Upper 95% Confidence Interval 100%

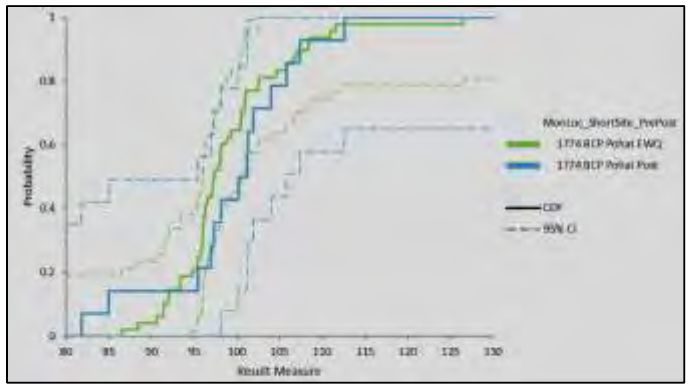






N 62

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1774 BCP Pohat EWQ	86	96	97	101	126	5
1774 BCP Pohat Post	82	97	101	104	113	7



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1774 BCP Pohat EWQ	48	77.5	1.62
1774 BCP Pohat Post	14	265.8	18.98

H statistic	1.05
X^2 approximation	1.05
DF	1
p-value	0.3044 [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.

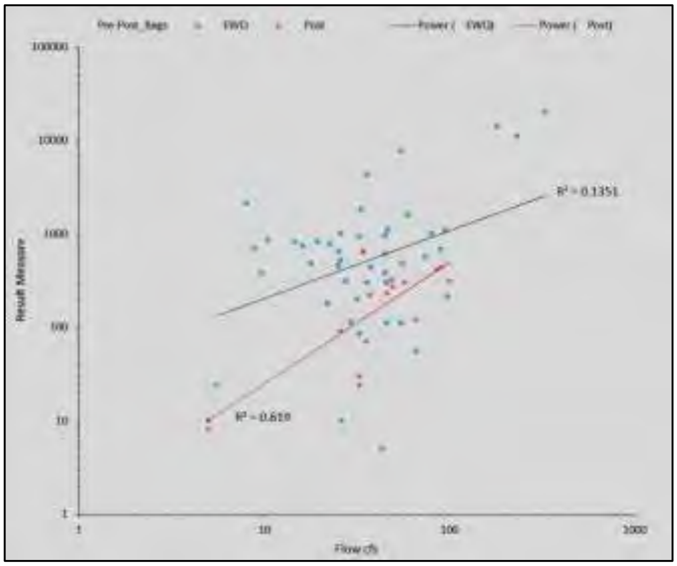
No water quality degradation is evident here. Dissolved Oxygen Saturation is unrelated to flow, and did not measurably change between the EWQ and post-EWQ periods. Uncertainty is introduced into this conclusion by insufficient post-EWQ sampling frequency and flow differences. Post-EWQ median DO saturation increased above the upper EWQ 95% confidence interval but the increase was not statistically significant due to too few post-EWQ samples. An increase in DO saturation would represent a water quality improvement anyway.

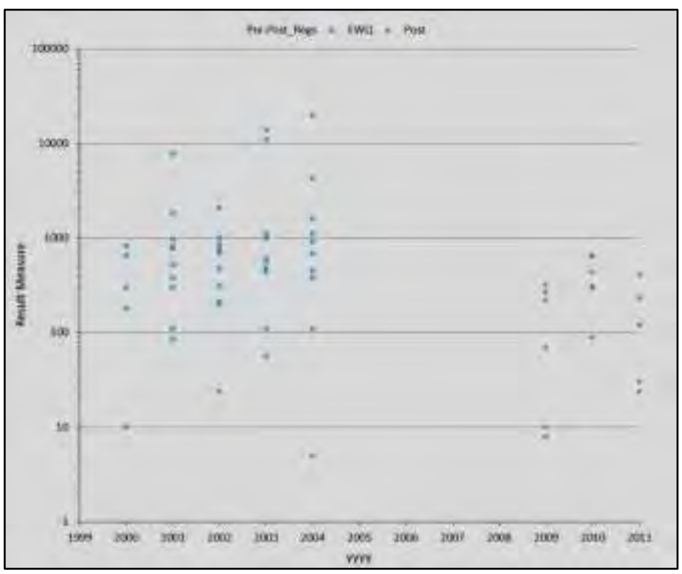
Chapter 16: 1774 BCP Pohatcong Creek, NJ

Enterococcus colonies/100 ml

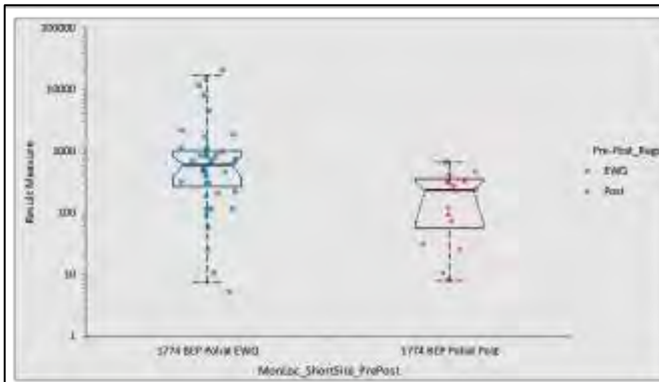
Existing Water Quality (Table 2K):

Median 610/100 ml
Lower 95% Confidence Interval 380/100 ml
Upper 95% Confidence Interval 820/100 ml

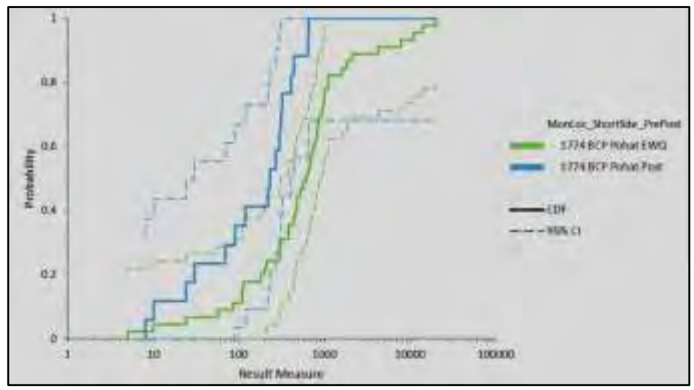




Pohatcong Creek possesses among the highest bacteria concentrations throughout the Lower Delaware. No water quality degradation is evident here. Enterococci apparently declined between the EWQ and Post-EWQ periods.



N	62					
Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1774 BCP Pohat EWQ	5	270	610	1000	20000	730
1774 BCP Pohat Post	8	57	230	350	650	293



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1774 BCP Pohat EWQ	45	947.6	21.06
1774 BCP Pohat Post	17	2508.4	147.55

H statistic	10.62
X^2 approximation	10.62
DF	1
p-value	0.0011 [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.

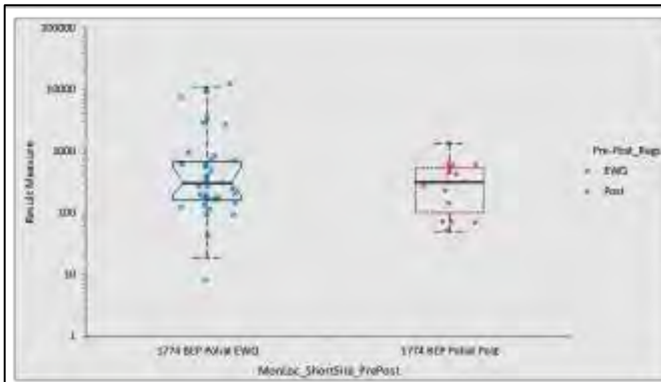
Uncertainty is introduced into this conclusion by potential laboratory artifacts, insufficient post-EWQ sampling frequency and flow differences. Enterococcus concentrations are weakly related to flow in the EWQ data set, but positively related to flow in the post-EWQ data – but only because of a pair of influential low values. Concentrations and flows are plotted on a logarithmic scale, and the regression is a power relationship. Post-EWQ median enterococcus concentrations fell below the lower EWQ 95% confidence interval.

Chapter 16: 1774 BCP Pohatcong Creek, NJ

Escherichia coli colonies/100 ml

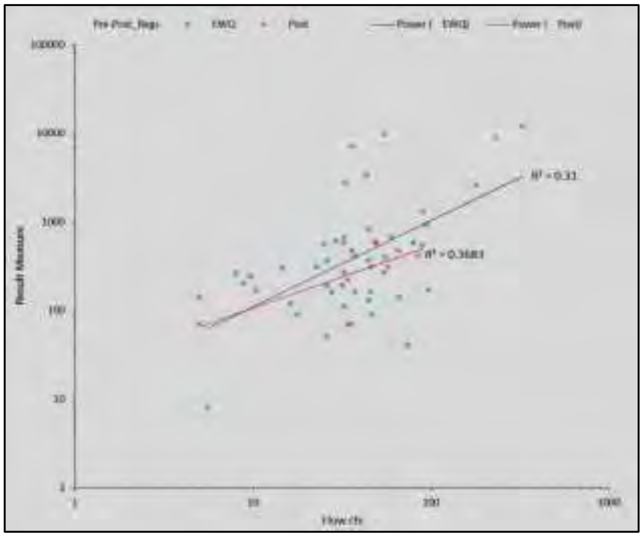
Existing Water Quality (Table 2K):

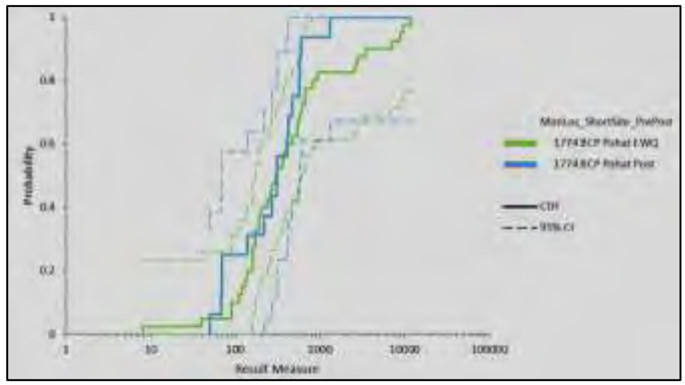
Median 305/100 ml
Lower 95% Confidence Interval 190/100 ml
Upper 95% Confidence Interval 550/100 ml
Designated in DRBC rules as flow-related

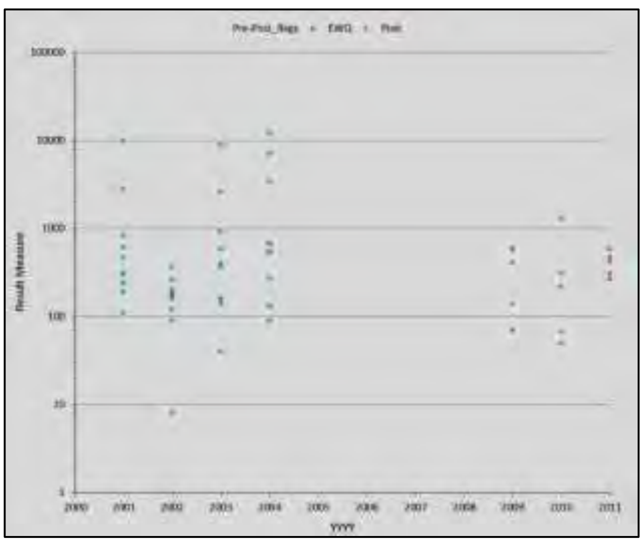


N 56

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1774 BCP Pohat EWQ	8	160	305	670	12000	510
1774 BCP Pohat Post	50	99	310	528	1300	429







Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1774 BCP Pohat EWQ	40	42.0	1.05
1774 BCP Pohat Post	16	105.1	6.57

H statistic	0.55
X^2 approximation	0.55
DF	1
p-value	0.4570[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. E. coli concentrations apparently did not measurably change between the EWQ and Post-EWQ periods. Uncertainty is introduced into this conclusion by potential laboratory artifacts, insufficient post-EWQ sampling frequency and flow differences.

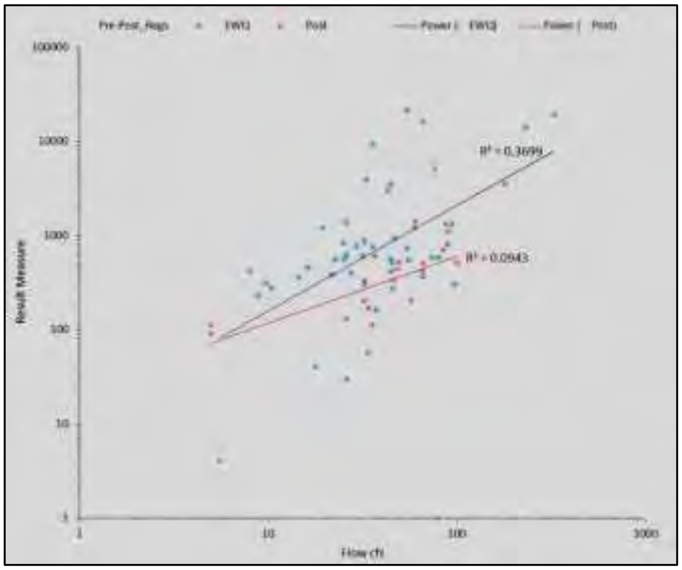
Post-EWQ median E. coli fell within the EWQ 95% confidence intervals. Concentrations and flows are plotted on a logarithmic scale. E. coli concentrations are weakly related to flow in both data sets. No independent data were available to validate these results.

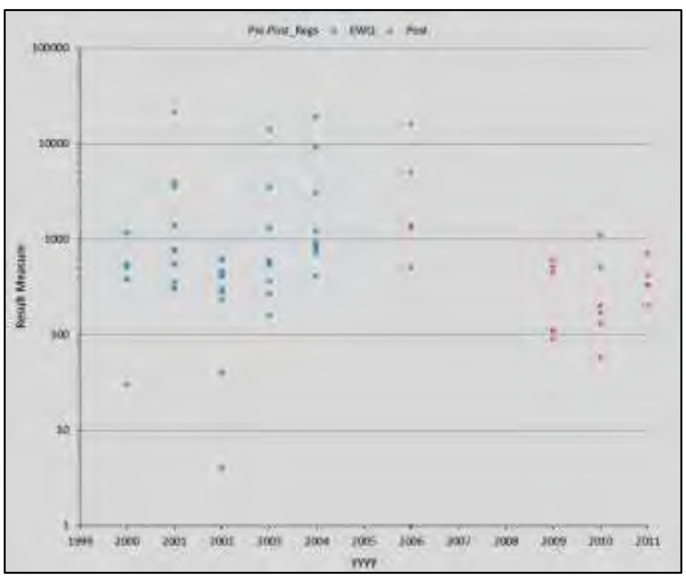
Chapter 16: 1774 BCP Pohatcong Creek, NJ

Fecal coliform colonies/100 ml

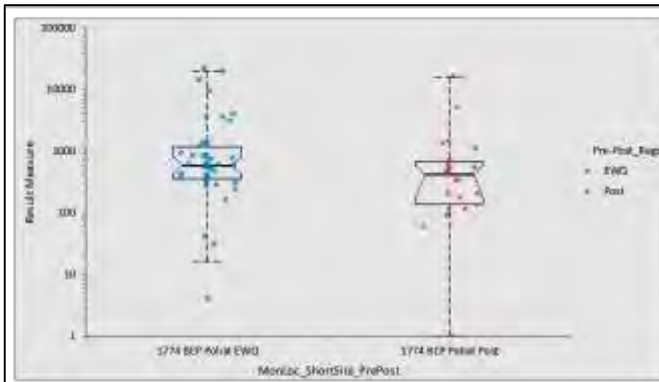
Existing Water Quality (Table 2K):

Median 580/100 ml
Lower 95% Confidence Interval 420/100 ml
Upper 95% Confidence Interval 810/100 ml



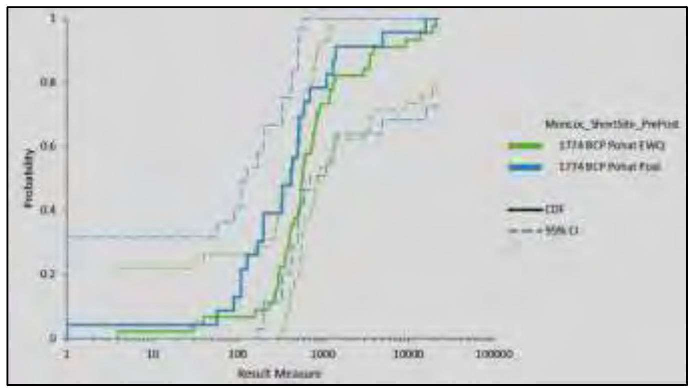


Fecal coliform concentrations apparently did not measurably change between the EWQ and post-EWQ periods, though there were fewer high results in the post-EWQ data set. Uncertainty is introduced into this conclusion by potential laboratory artifacts, insufficient post-EWQ sampling frequency and flow differences.



N	68

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1774 BCP Pohat EWQ	4	358	580	1187	21200	828
1774 BCP Pohat Post	1	137	420	683	16000	547



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1774 BCP Pohat EWQ	45	476.9	10.60
1774 BCP Pohat Post	23	933.1	40.57

H statistic	3.61
X^2 approximation	3.61
DF	1
p-value	0.0575 [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.

Fecal coliform concentrations are weakly related to flow in the EWQ data set, but unrelated to flow in the post-EWQ data. Post-EWQ median concentrations were within the EWQ 95% confidence intervals. Concentrations and flows are plotted on a logarithmic scale.

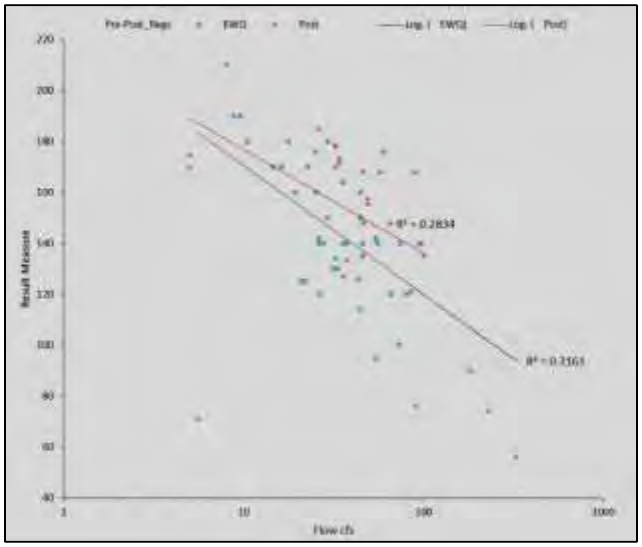
NJDEP 2006 data were comparable with DRBC data and included in the post-EWQ data set in order to increase the number of post-EWQ results.

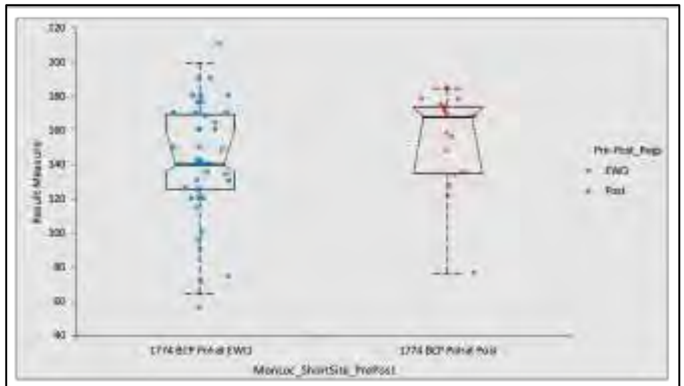
Chapter 16: 1774 BCP Pohatcong Creek, NJ

Hardness as CaCO3, Total mg/l

Existing Water Quality (Table 2K):

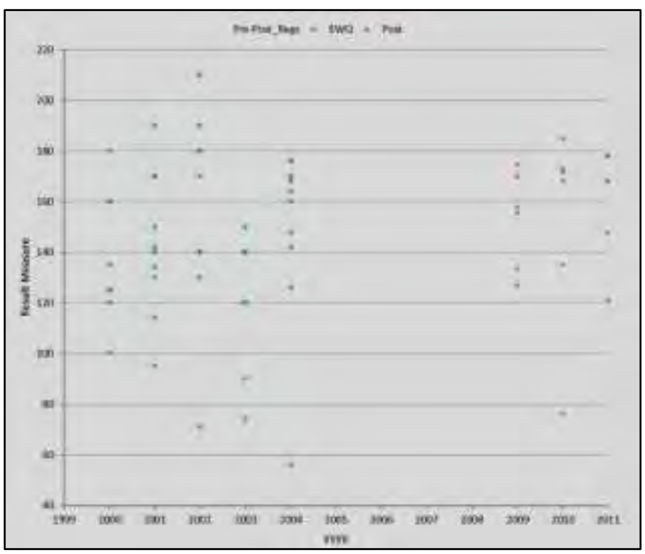
Median 140 mg/l
Lower 95% Confidence Interval 135 mg/l
Upper 95% Confidence Interval 160 mg/l
Defined in regulations as a flow-related parameter

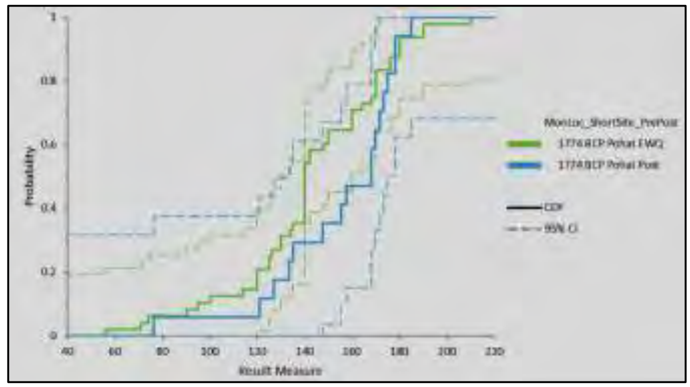




N	65

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1774 BCP Pohat EWQ	56	125	140	169	210	44
1774 BCP Pohat Post	76	134	168	174	185	39





Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1774 BCP Pohat EWQ	48	192.0	4.00
1774 BCP Pohat Post	17	542.1	31.89

H statistic	2.06
X² approximation	2.06
DF	1
p-value	0.1512 [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.

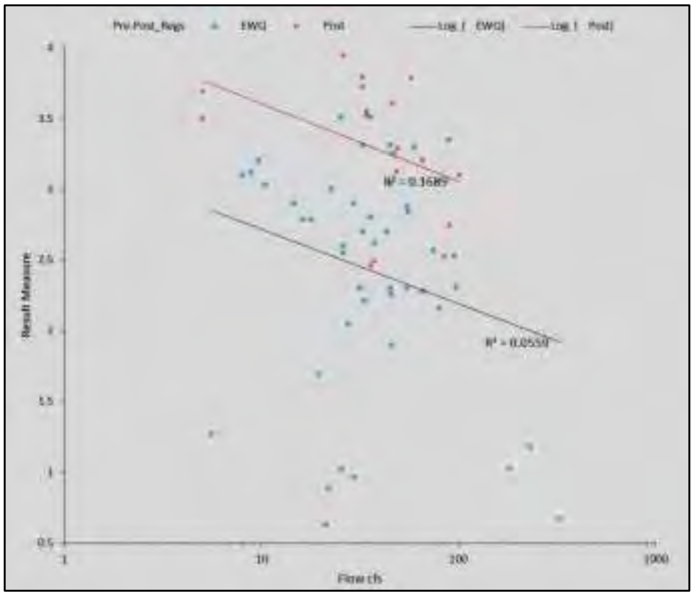
No water quality degradation is evident here. Hardness apparently did not measurably change between the EWQ and post-EWQ periods. Uncertainty is introduced into this conclusion by potential laboratory artifacts, insufficient post-EWQ sampling frequency and flow differences. Hardness is inversely but weakly related to flow in both data sets. Post-EWQ median hardness was above the EWQ upper 95% confidence interval, but the rise was not statistically significant due to insufficient post EWQ samples (n=17). Flow is plotted on a logarithmic scale. No data were available to validate DRBC conclusions. These high concentrations reflect natural limestone influence upon water quality.

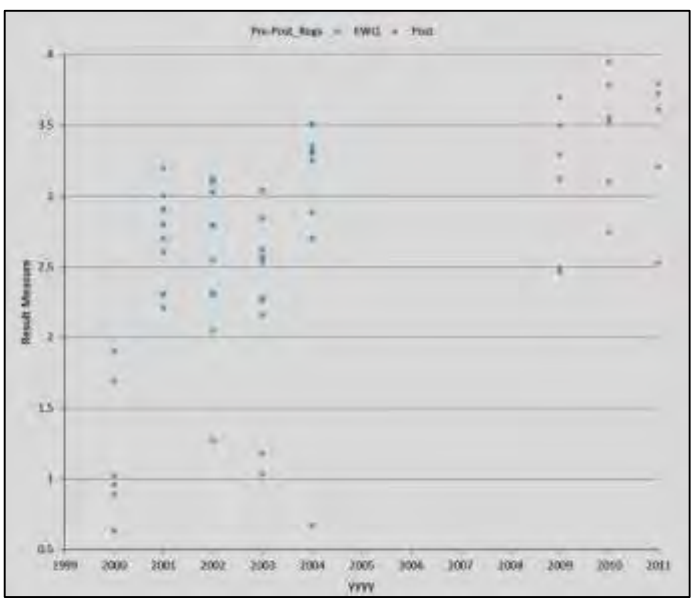
Chapter 16: 1774 BCP Pohatcong Creek, NJ

Nitrate + Nitrite as N, Total mg/l

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

Median 2.61 mg/l
Lower 95% Confidence Interval 2.30 mg/l
Upper 95% Confidence Interval 2.88 mg/l

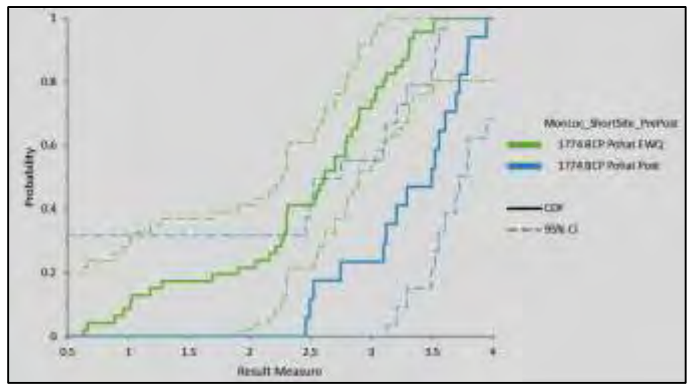




Water quality degradation is evident here. Nitrate concentrations, already high in the Pohatcong, apparently increased. Uncertainty is introduced into conclusions by potential laboratory artifacts, insufficient post-EWQ sampling frequency and flow differences.

N	63

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1774 BCP Pohat EWQ	0.63	2.15	2.61	3.03	3.51	0.88
1774 BCP Pohat Post	2.46	2.98	3.50	3.70	3.95	0.72



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1774 BCP Pohat EWQ	46	1435.8	31.21
1774 BCP Pohat Post	17	3885.2	228.54

H statistic	15.84
X^2 approximation	15.84
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.

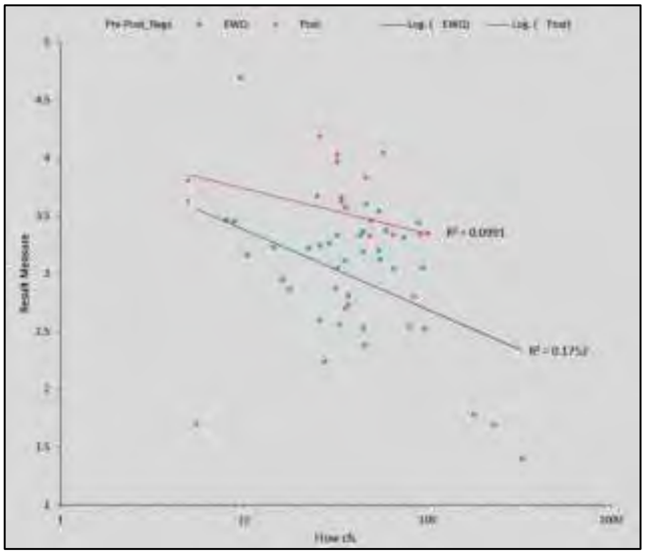
Nitrate is unrelated to flow in both data sets. Post-EWQ median concentration exceeded the EWQ upper 95% confidence interval. Post-EWQ nitrate + nitrite concentrations were assumed equivalent for comparison with EWQ nitrate concentrations since EWQ nitrite concentrations were never detected. Independent data were not available for validation of results. At other sites where concentrations are lower, there was a problem interpreting the data due to changing detection limits. Concentrations are sufficiently high in Pohatcong Creek that no uncertainty was introduced by detection limit differences.

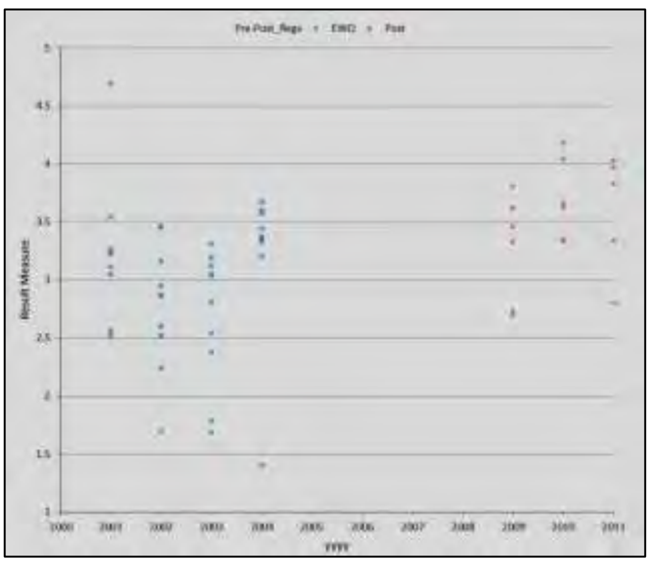
Chapter 16: 1774 BCP Pohatcong Creek, NJ

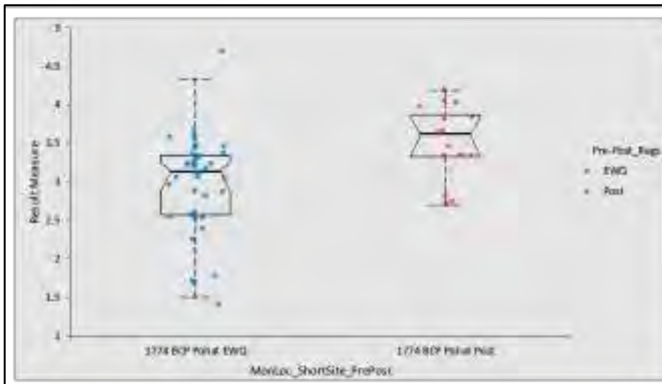
Nitrogen as N, Total (TN) mg/l

Existing Water Quality (Table 2K):

Median 3.14 mg/l
Lower 95% Confidence Interval 2.87 mg/l
Upper 95% Confidence Interval 3.26 mg/l

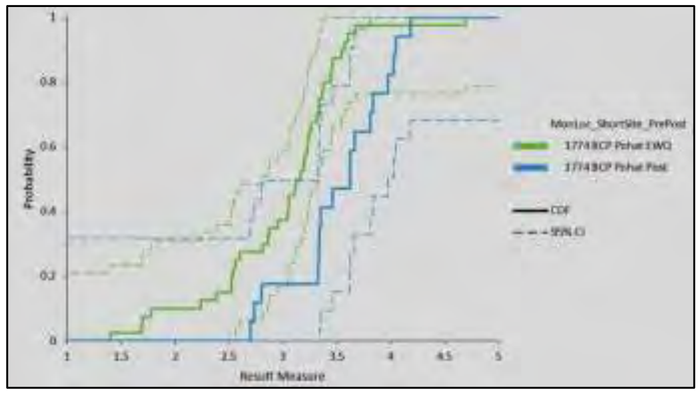






N 57

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1774 BCP Pohat EWQ	1.40	2.58	3.14	3.35	4.69	0.77
1774 BCP Pohat Post	2.70	3.33	3.62	3.88	4.18	0.55



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1774 BCP Pohat EWQ	40	936.1	23.40
1774 BCP Pohat Post	17	2202.5	129.56

H statistic	11.39
X^2 approximation	11.39
DF	1
p-value	0.0007[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.

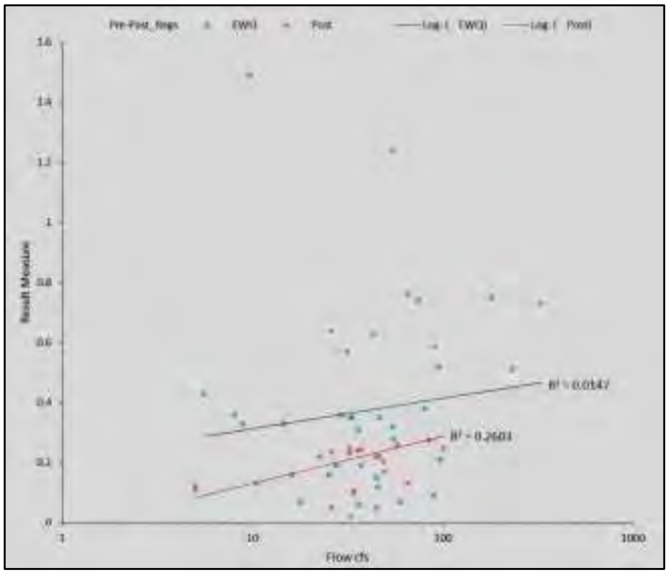
Water quality degradation is evident here. Total Nitrogen concentrations apparently increased. Uncertainty is introduced into conclusions by potential laboratory artifacts, insufficient post-EWQ sampling frequency and flow differences. TN is unrelated to flow in both data sets. No independent data were available to validate results. Post-EWQ median TN concentration exceeded the EWQ upper 95% confidence interval. Pohatcong Creek Total Nitrogen concentrations remain among the highest in comparison with other Delaware River tributaries.

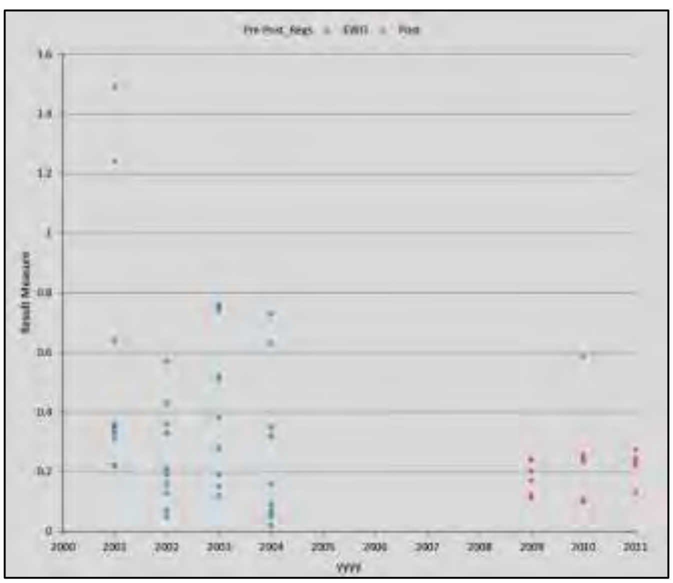
Chapter 16: 1774 BCP Pohatcong Creek, NJ

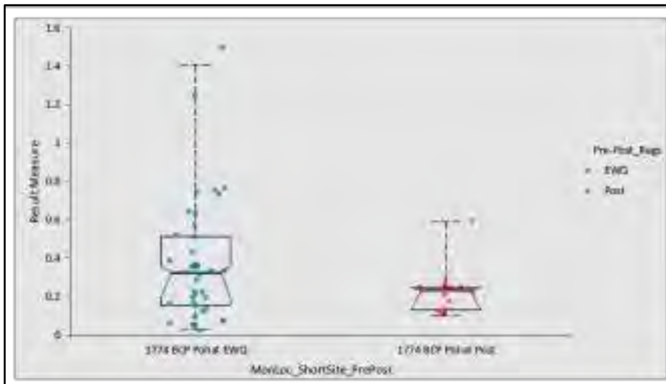
Nitrogen, Kjeldahl as N, Total (TKN) mg/l

Existing Water Quality (Table 2K):

Median 0.33 mg/l
Lower 95% Confidence Interval 0.19 mg/l
Upper 95% Confidence Interval 0.36 mg/l

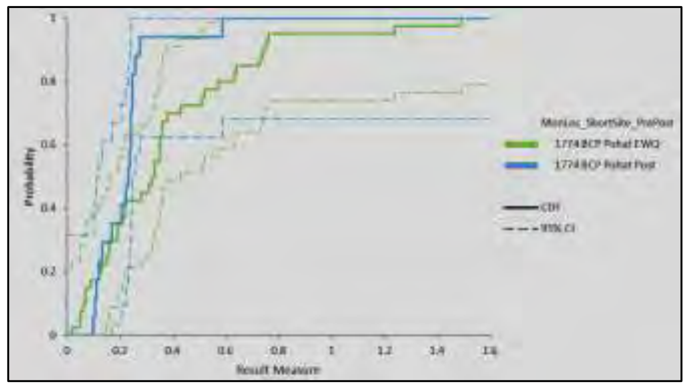






N	57

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1774 BCP Pohat EWQ	0.02	0.15	0.33	0.52	1.49	0.36
1774 BCP Pohat Post	0.10	0.13	0.23	0.25	0.59	0.12



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1774 BCP Pohat EWQ	40	207.0	5.18
1774 BCP Pohat Post	17	487.1	28.65

H statistic	2.52
X^2 approximation	2.52
DF	1
p-value	0.1124 [1]

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

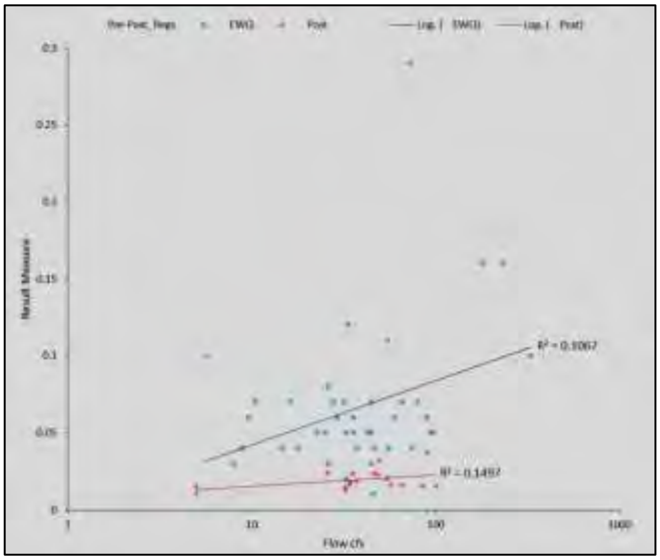
No water quality degradation is evident here. TKN concentrations apparently did not measurably change. Uncertainty is introduced into conclusions by potential laboratory artifacts, insufficient post-EWQ sampling frequency and flow differences. The post-EWQ range was far narrower and all concentrations were less than 0.6 mg/l – reflecting either a water quality improvement or laboratory artifacts. TKN concentration is unrelated to flow in both data sets. Post-EWQ median TKN fell within the EWQ 95% confidence intervals. There were no independent data to confirm DRBC results.

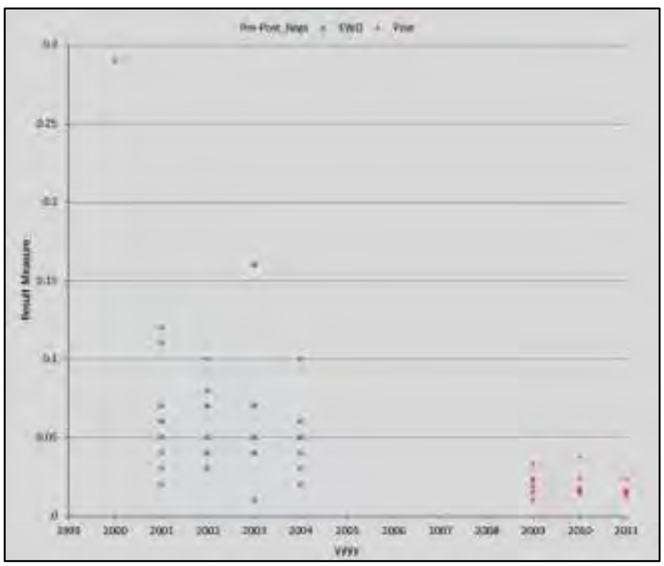
Chapter 16: 1774 BCP Pohatcong Creek, NJ

Orthophosphate as P, Total mg/l (OP)

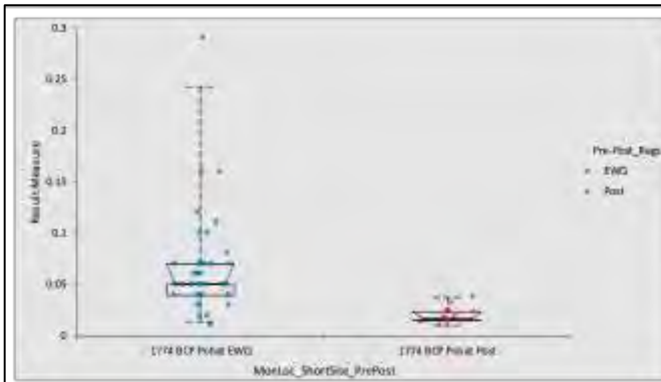
Existing Water Quality (Table 2K):

Median 0.05 mg/l
Lower 95% Confidence Interval 0.05 mg/l
Upper 95% Confidence Interval 0.07 mg/l



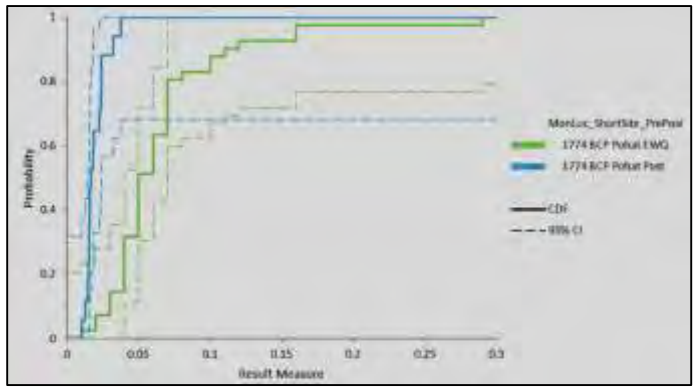


No water quality degradation is evident here. OP concentrations apparently declined between the EWQ and post-EWQ periods. Uncertainty is introduced into conclusions by potential laboratory artifacts, insufficient post-EWQ sampling frequency, and flow differences.



N 58

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1774 BCP Pohat EWQ	0.01	0.04	0.05	0.07	0.29	0.03
1774 BCP Pohat Post	0.01	0.02	0.02	0.02	0.04	0.01



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1774 BCP Pohat EWQ	41	2397.1	58.47
1774 BCP Pohat Post	17	5781.3	340.08

H statistic	28.88
X^2 approximation	28.88
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.

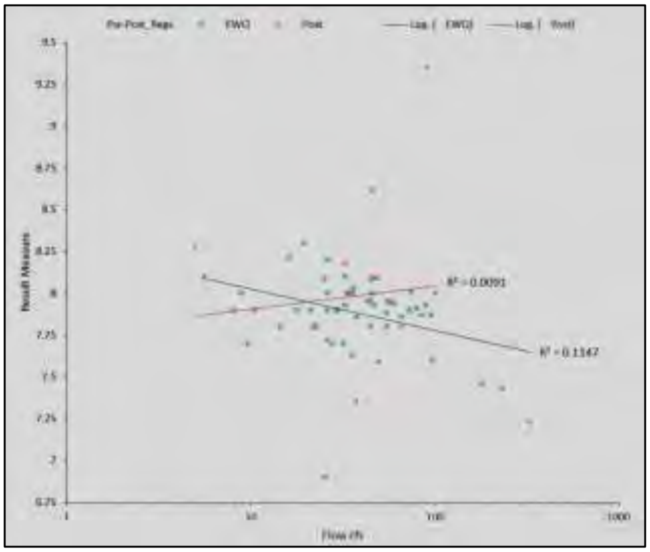
OP is unrelated to flow in both data sets. Post-EWQ median OP fell below the EWQ lower 95% confidence interval. Unlike in other watersheds, there were no undetected results in the EWQ or post-EWQ data, so this analysis contained no interference by differences between detection limits. Post-EWQ orthophosphate ranged less widely than EWQ data and no concentrations were higher than 0.04 mg/l, possibly indicating water quality improvement or laboratory artifacts. There were no independent data to confirm DRBC results.

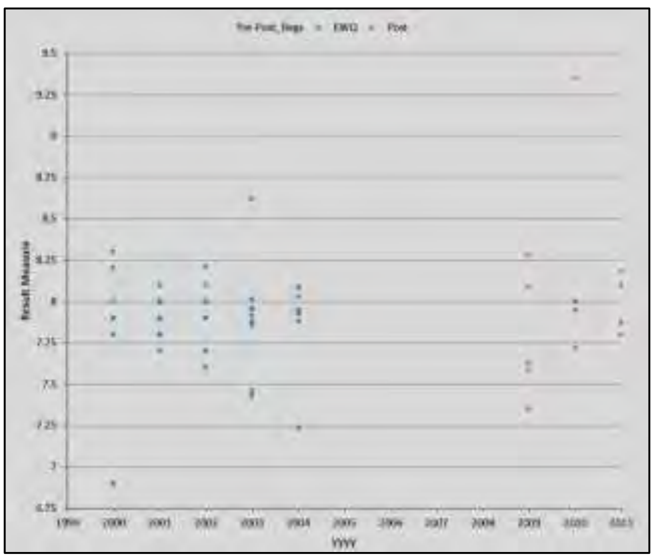
Chapter 16: 1774 BCP Pohatcong Creek, NJ

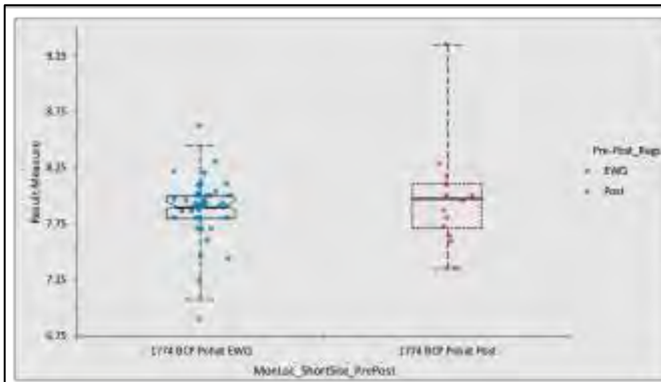
pH

Existing Water Quality (Table 2K):

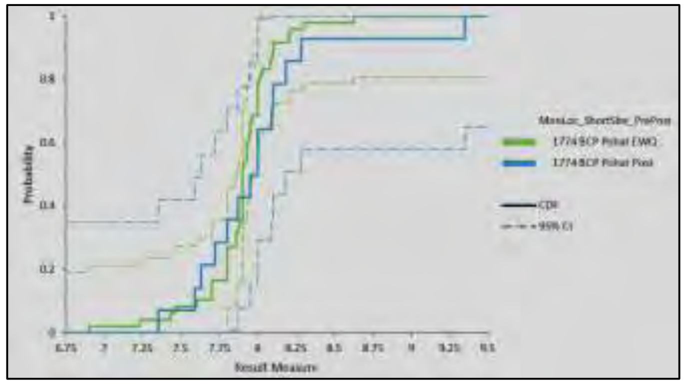
Median 7.90 standard units
Lower 95% Confidence Interval 7.88 standard units
Upper 95% Confidence Interval 7.95 standard units







N	62					
Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1774 BCP Pohat EWQ	6.90	7.80	7.90	8.00	8.62	0.20
1774 BCP Pohat Post	7.35	7.71	7.98	8.11	9.35	0.39



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1774 BCP Pohat EWQ	48	23.4	0.49
1774 BCP Pohat Post	14	80.2	5.73

H statistic	0.32
X^2 approximation	0.32
DF	1
p-value	0.5718[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.

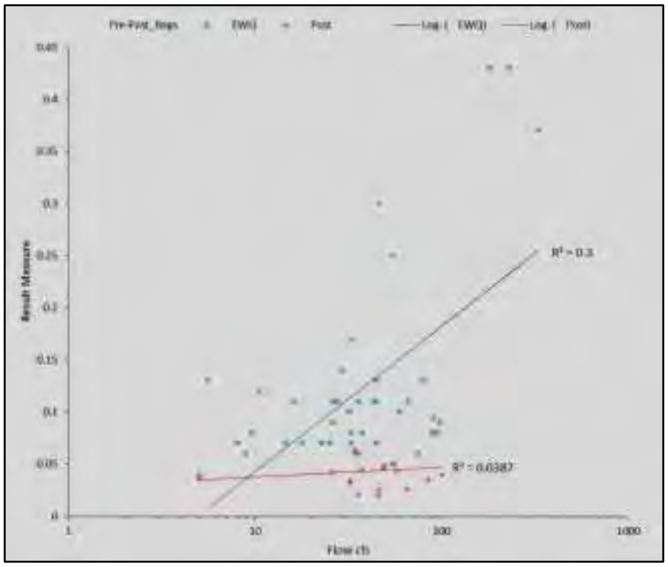
No water quality degradation is evident here. pH did not measurably change between the EWQ and post-EWQ periods. Uncertainty is introduced into conclusions by insufficient post-EWQ sampling frequency and flow differences. pH is unrelated to flow in both data sets. Post-EWQ median pH was above the upper EWQ 95% confidence interval, but the result was not statistically significant due to insufficient post-EWQ data (n=14). In 2010 there was one spike above pH 9, indicating high algal productivity during that dry sampling period. No additional data were available to confirm DRBC results.

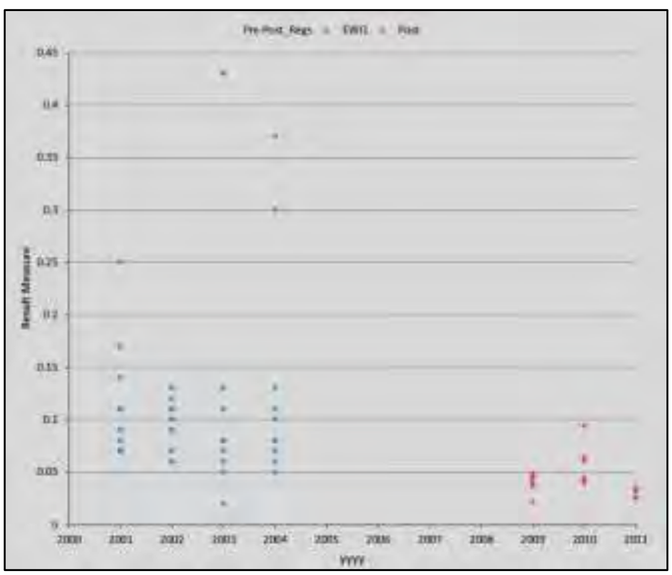
Chapter 16: 1774 BCP Pohatcong Creek, NJ

Phosphorus as P, Total (TP) mg/l

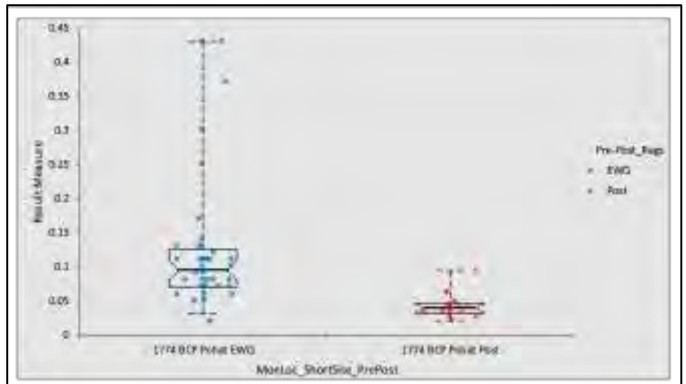
Existing Water Quality (Table 2K):

Median 0.10 mg/l
Lower 95% Confidence Interval 0.08 mg/l
Upper 95% Confidence Interval 0.11 mg/l



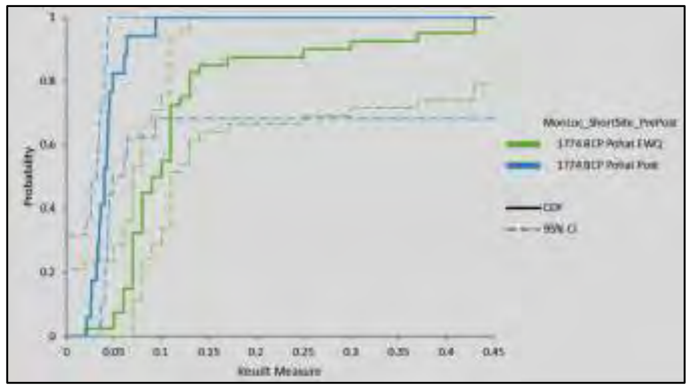


No water quality degradation is evident here. Total Phosphorus (TP) concentrations apparently declined between the EWQ and post-EWQ periods. Uncertainty is introduced into conclusions by potential laboratory artifacts, detection limit differences, insufficient post-EWQ sampling frequency, and flow differences.



N 57

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1774 BCP Pohat EWQ	0.02	0.07	0.10	0.13	0.43	0.06
1774 BCP Pohat Post	0.02	0.03	0.04	0.05	0.09	0.01



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1774 BCP Pohat EWQ	40	2160.9	54.02
1774 BCP Pohat Post	17	5084.5	299.09

H statistic	26.42
X^2 approximation	26.42
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.

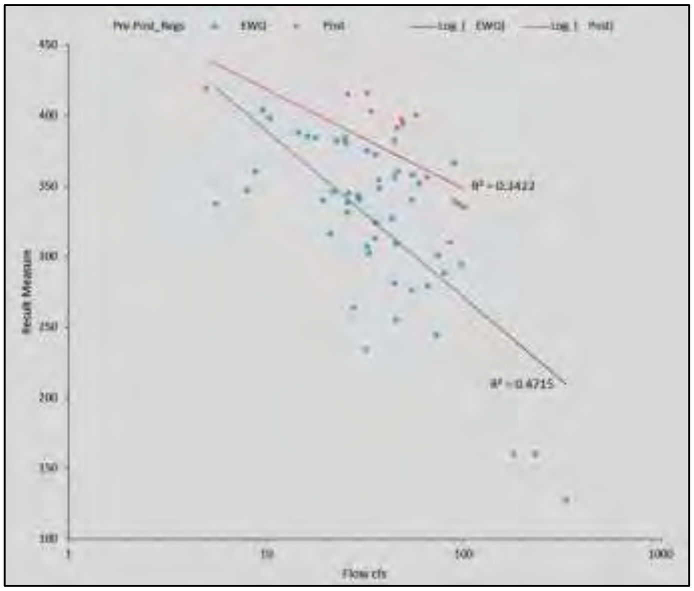
Post-EWQ median total phosphorus fell below the EWQ lower 95% confidence interval. TP is unrelated to flow in both data sets. The weak relationship to flow indicated in the EWQ data were driven by a few high outlier values. No additional data were available to confirm DRBC results. EWQ results were more variable than post-EWQ data, which contained no concentrations higher than 0.1 mg/l. This may constitute a water quality improvement unless it reflects only laboratory artifacts.

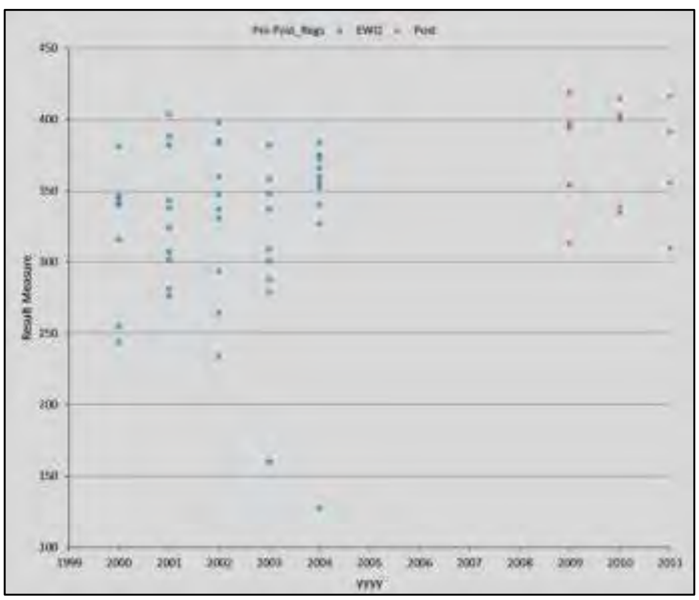
Chapter 16: 1774 BCP Pohatcong Creek, NJ

Specific Conductance µmho/cm

Existing Water Quality (Table 2K):

Median 340 µmho/cm
Lower 95% Confidence Interval 316 µmho/cm
Upper 95% Confidence Interval 352 µmho/cm
Defined in regulations as a flow-related parameter

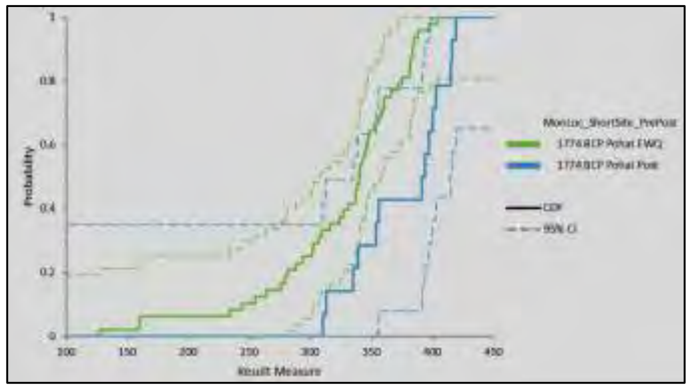




Water quality degradation is evident here. Specific conductance apparently increased above the EWQ upper 95% confidence interval. Uncertainty is introduced into conclusions by insufficient post-EWQ sampling frequency and flow differences.

N 62

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1774 BCP Pohat EWQ	127	297	340	364	404	67
1774 BCP Pohat Post	310	339	393	404	419	65



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1774 BCP Pohat EWQ	48	671.3	13.98
1774 BCP Pohat Post	14	2301.4	164.39

H statistic	9.13
X² approximation	9.13
DF	1
p-value	0.0025 [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.

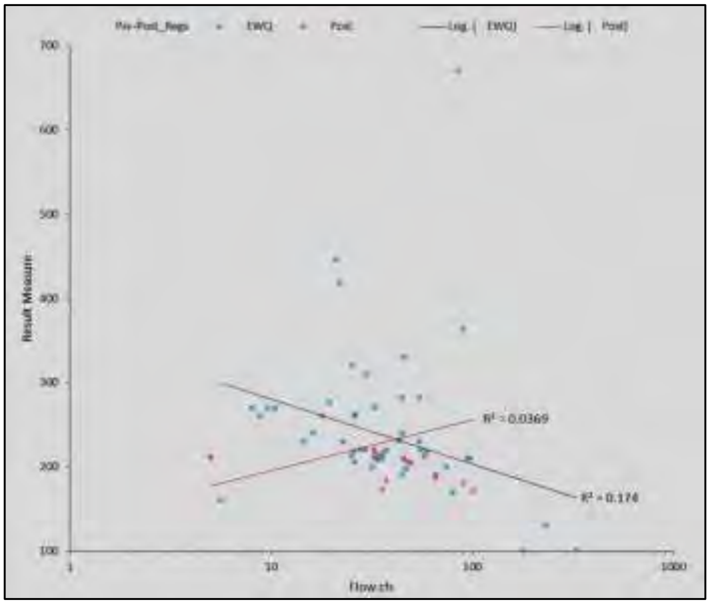
Specific conductance is inversely related to flow in both data sets. Higher flow conditions were not well represented in the post-EWQ data, and the significant increase may be partially attributable to this. The rise in specific conductance may be partially attributable to the concurrent rise in chloride concentrations. Median specific conductance has risen from 340 to 393 µmhos/cm; a 16% increase in a few years' time. Further investigation is recommended. No additional data were available to confirm DRBC results.

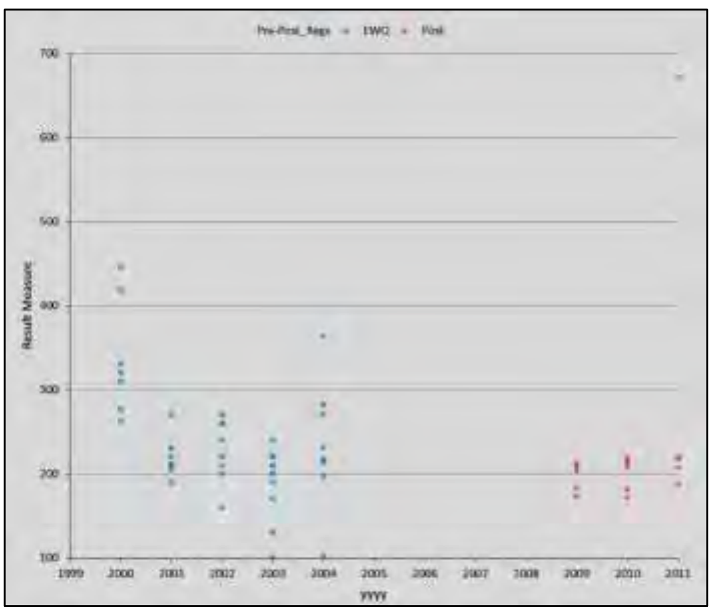
Chapter 16: 1774 BCP Pohatcong Creek, NJ

Total Dissolved Solids (TDS) mg/l

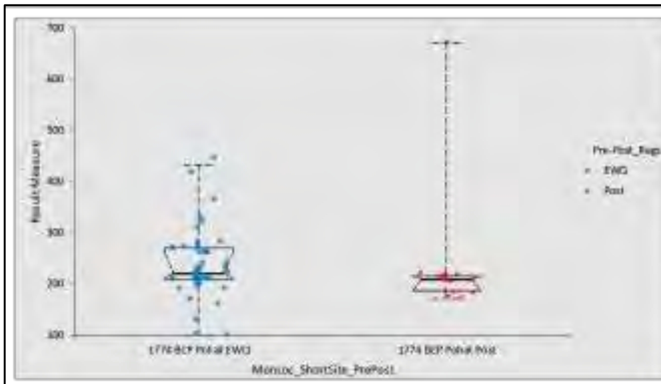
Existing Water Quality (Table 2K):

Median 220 mg/l
Lower 95% Confidence Interval 211 mg/l
Upper 95% Confidence Interval 260 mg/l
Defined in regulations as a flow-related parameter

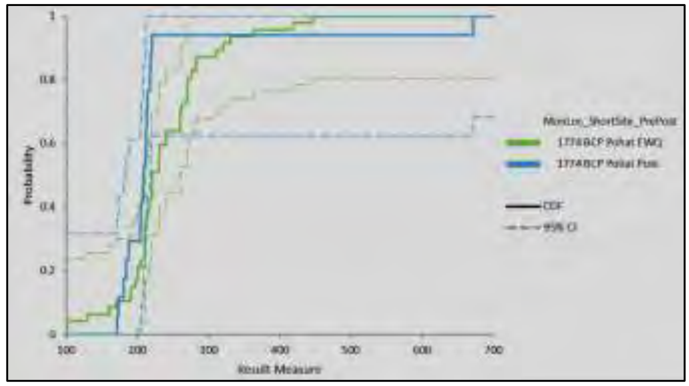




No water quality degradation is evident here. TDS apparently declined. Uncertainty is introduced into conclusions by potential laboratory artifacts, insufficient post-EWQ sampling frequency, and flow differences.



N	64					
Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1774 BCP Pohat EWQ	100	210	220	270	446	60
1774 BCP Pohat Post	171	186	208	215	671	29



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1774 BCP Pohat EWQ	47	494.8	10.53
1774 BCP Pohat Post	17	1368.0	80.47

H statistic	5.38
X^2 approximation	5.38
DF	1
p-value	0.0204 [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.

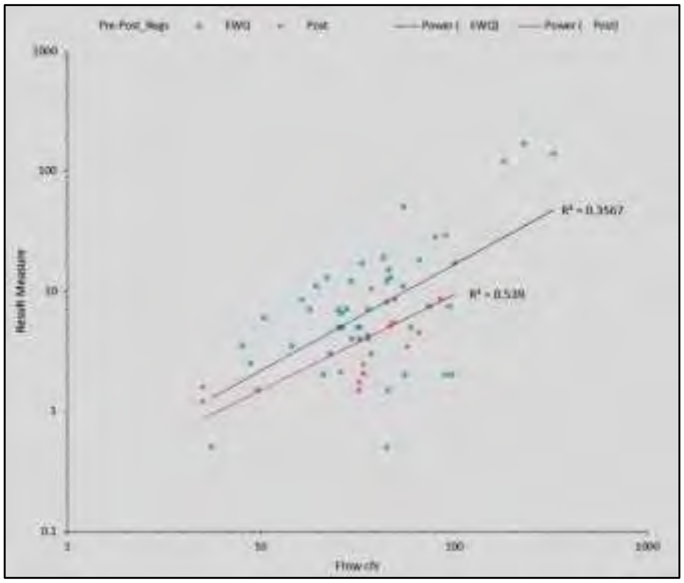
TDS is unrelated to flow in both data sets, though TDS was designated in the rules as flow related. Post-EWQ median TDS fell below the EWQ lower 95% lower confidence interval. Post-EWQ TDS was much less variable than the baseline samples as well except for a single unexplained high outlier measurement (5/17/11, normal flow conditions). Post-EWQ detection limits were lower than EWQ detection limits, though there were no non-detect results at any time. No additional data were available to confirm DRBC results.

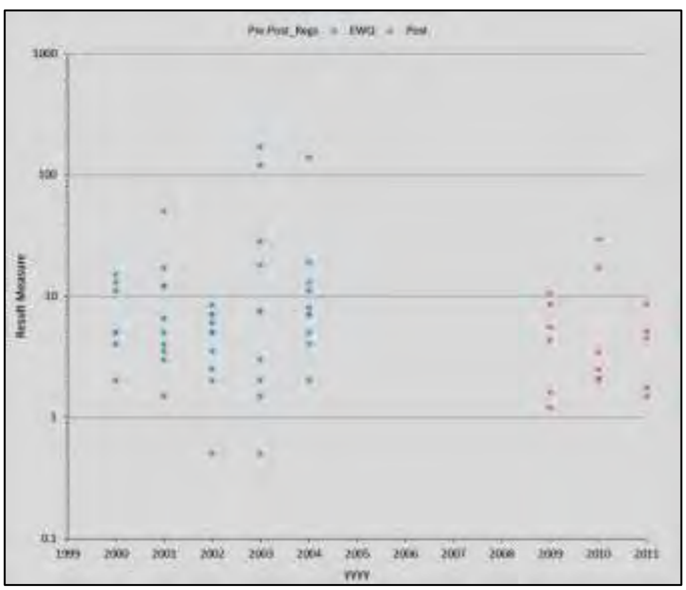
Chapter 16: 1774 BCP Pohatcong Creek, NJ

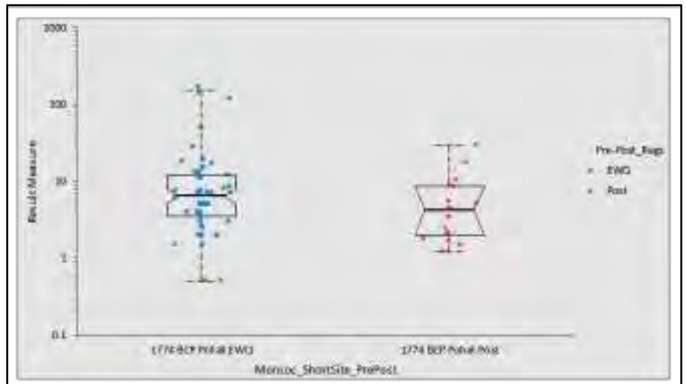
Total Suspended Solids (TSS) mg/l

Existing Water Quality (Table 2K):

Median 6.5 mg/l
Lower 95% Confidence Interval 5.0 mg/l
Upper 95% Confidence Interval 8.0 mg/l
<u>Should have been designated in rules as flow-related</u>

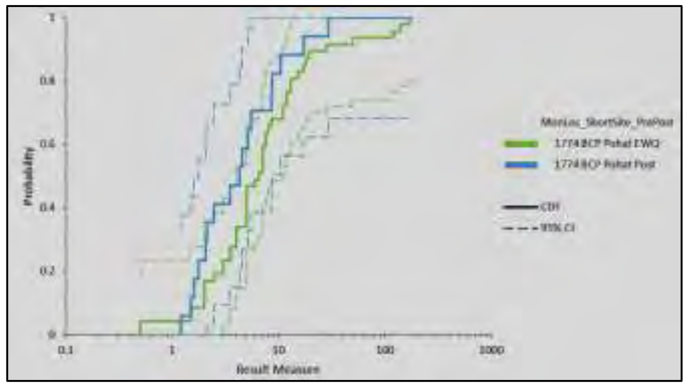






N 64

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1774 BCP Pohat EWQ	0.5	3.5	6.5	12.0	170.0	8.5
1774 BCP Pohat Post	1.2	2.0	4.3	8.6	29.2	6.6



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1774 BCP Pohat EWQ	47	194.0	4.13
1774 BCP Pohat Post	17	536.5	31.56

H statistic	2.11
X^2 approximation	2.11
DF	1
p-value	0.1463 [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.

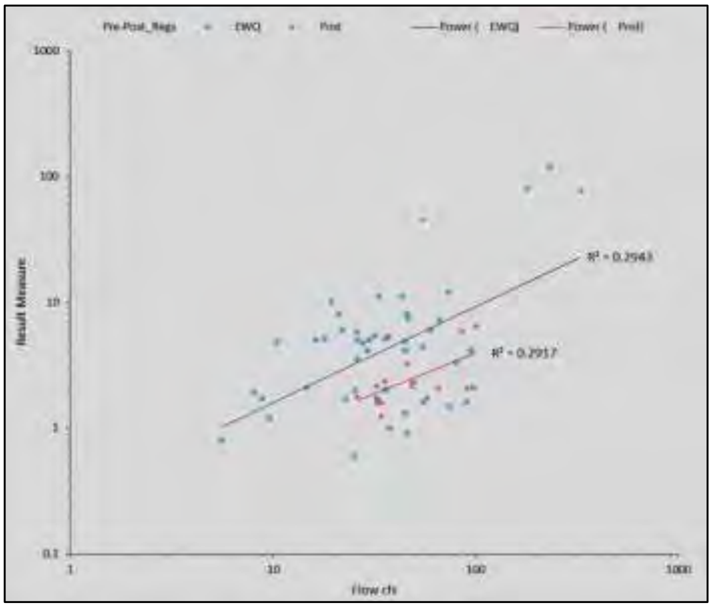
No water quality degradation is evident here. TSS apparently did not measurably change between the EWQ and post-EWQ periods. Uncertainty is introduced into conclusions by potential laboratory artifacts, insufficient post-EWQ sampling frequency, and flow differences. TSS is positively related to flow in both data sets. Post-EWQ median TSS fell below the EWQ lower 95% confidence interval, but the decline was not statistically significant due to too few post-EWQ samples taken under higher flow conditions. Flow and concentration are plotted on a logarithmic scale, and the regression is a power relationship. No additional data were available to confirm DRBC results.

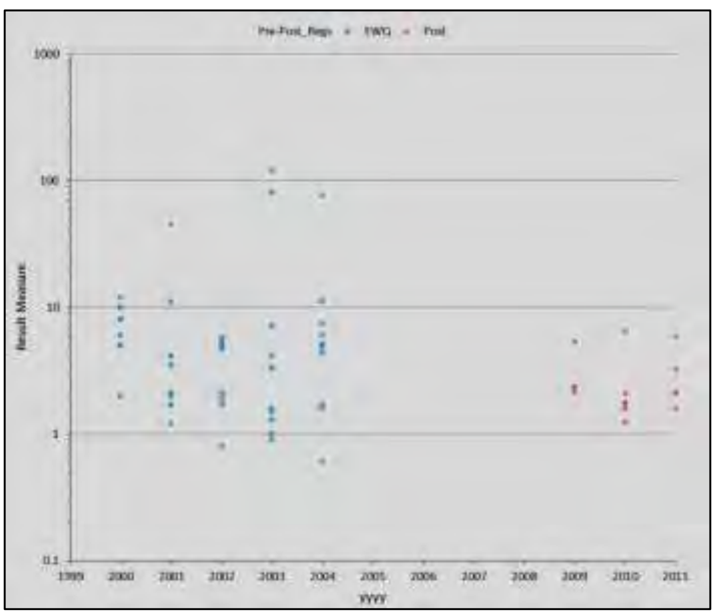
Chapter 16: 1774 BCP Pohatcong Creek, NJ

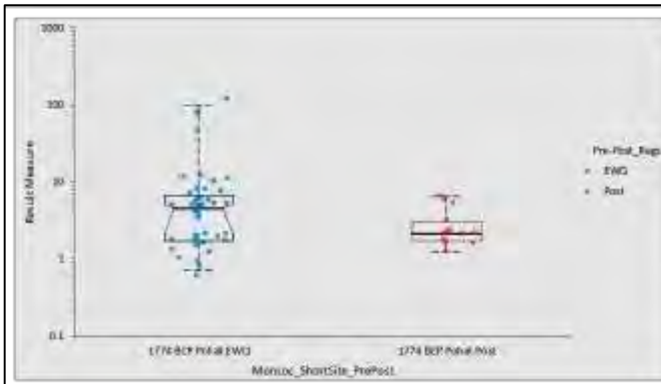
Turbidity NTU

Existing Water Quality (Table 2K):

Median 4.6 NTU
Lower 95% Confidence Interval 2.1 NTU
Upper 95% Confidence Interval 5.1 NTU
Defined in regulations as a flow-related parameter

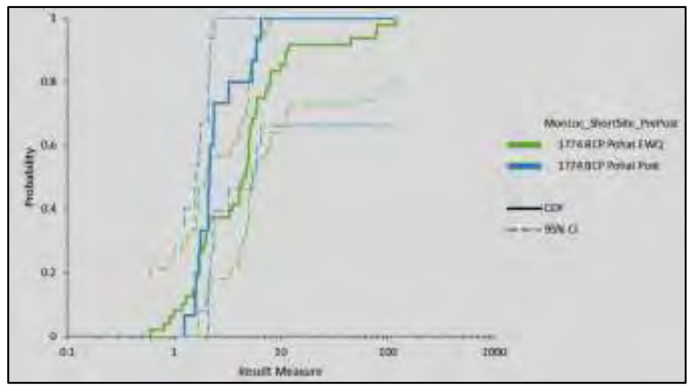






N 63

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1774 BCP Pohat EWQ	0.6	1.7	4.6	6.6	120.0	4.9
1774 BCP Pohat Post	1.2	1.7	2.1	3.1	6.5	1.4



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1774 BCP Pohat EWQ	48	172.5	3.59
1774 BCP Pohat Post	15	552.1	36.80

H statistic	2.16
X^2 approximation	2.16
DF	1
p-value	0.1418 [1]

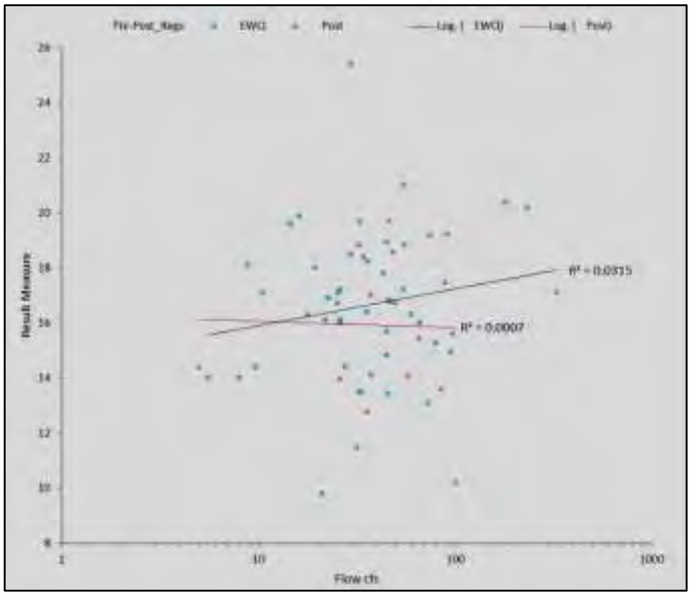
$H0: \theta_1 = \theta_2 = \theta...$
The median of the populations are all equal.
$H1: \theta_i \neq \theta_j$ for at least one i,j
The median of the populations are not all equal.
[1] Do not reject the null hypothesis at the 5% significance level.

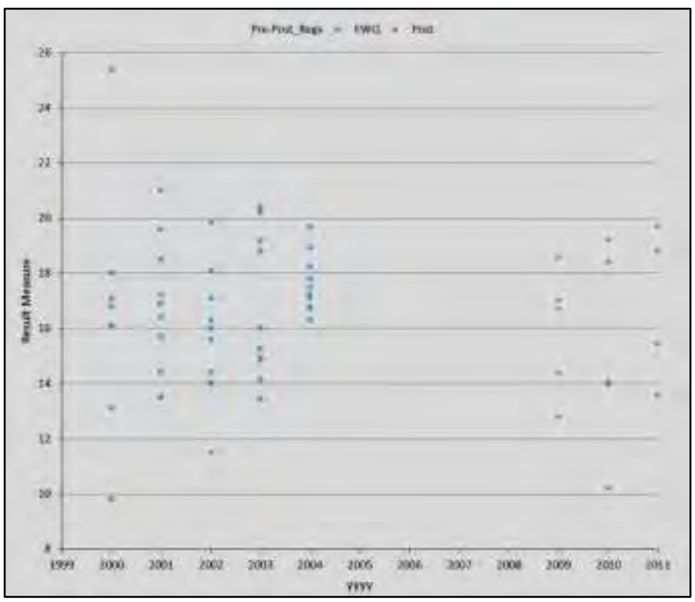
No water quality degradation is evident here. Turbidity apparently did not measurably change between the EWQ and post-EWQ periods. Uncertainty is introduced into conclusions by insufficient post-EWQ sampling frequency and flow differences. Post-EWQ median turbidity fell within the EWQ 95% confidence intervals. Turbidity is positively but weakly related to flow in both data sets. Concentration and flow are represented on logarithmic scale. There were no additional data available for comparison with DRBC results. As with other flow-related parameters at this site, high-flow conditions were under-represented in the sample set, probably causing the apparent decline in turbidity.

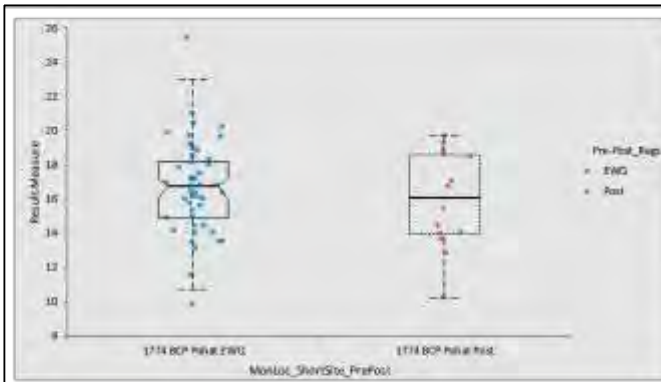
Chapter 16: 1774 BCP Pohatcong Creek, NJ

Water Temperature, degrees C

Not included in DRBC Existing Water Quality rules

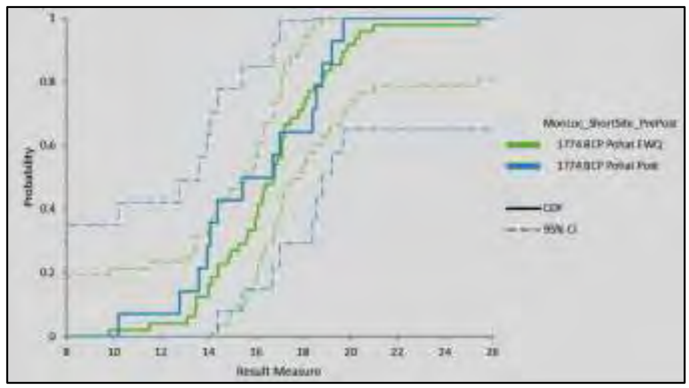






N 62

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1774 BCP Pohat EWQ	9.8	14.9	16.8	18.2	25.4	3.3
1774 BCP Pohat Post	10.2	13.9	16.1	18.6	19.7	4.7



Kruskal-Wallis test

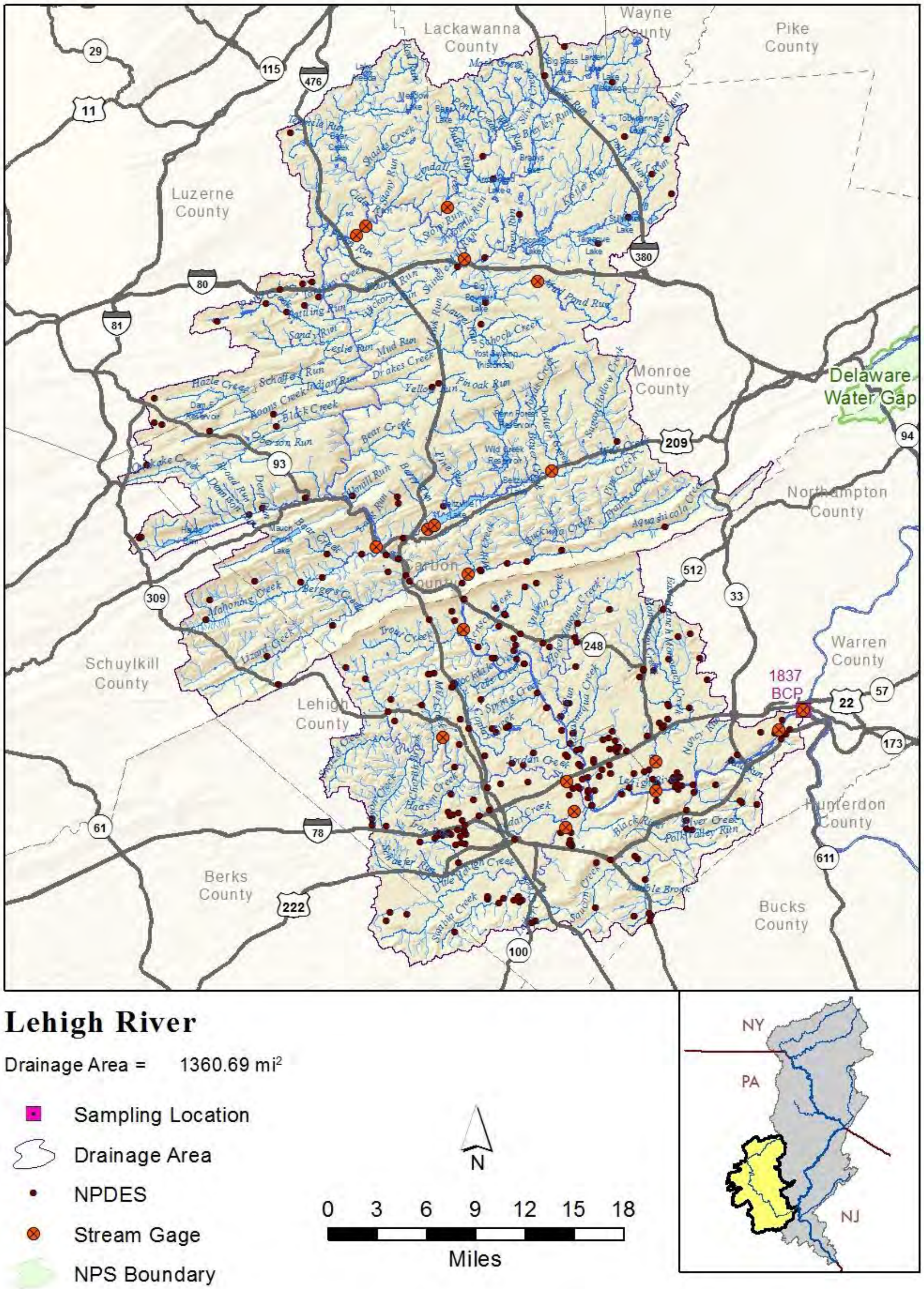
Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1774 BCP Pohat EWQ	48	37.6	0.78
1774 BCP Pohat Post	14	129.0	9.22

H statistic	0.51
X^2 approximation	0.51
DF	1
p-value	0.4742[1]

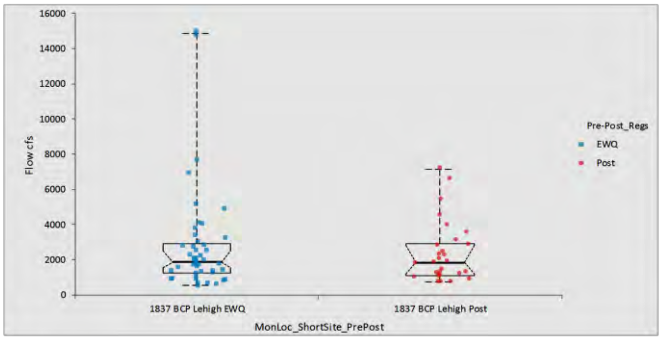
H0: $\theta_1 = \theta_2 = \theta$…
The median of the populations are all equal.
H1: $\theta_i \neq \theta_j$ for at least one i,j
The median of the populations are not all equal.
[1] Do not reject the null hypothesis at the 5% significance level.

No water quality degradation is evident here. Water temperature apparently did not measurably change between the EWQ and post-EWQ periods. Uncertainty is introduced into conclusions by insufficient post-EWQ sampling frequency and flow differences. Water temperature is unrelated to flow in both data sets. Flow is plotted on a logarithmic scale. No additional data were available to confirm DRBC data.

Chapter 17: 1837 BCP Lehigh River, Multiple Counties, PA



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



N	77

Flow cfs by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1837 BCP Lehigh EWQ	493	1263	1859	2935	14960	1671
1837 BCP Lehigh Post	733	1113	1850	2940	7180	1827

Flow was roughly the same between the EWQ and post-EWQ periods. Fewer samples were collected in the post-EWQ period. The range of flow conditions sampled was wider in the EWQ period, but not so much so that the water quality analyses were affected. In both periods there were sufficient samples to fully represent the Lehigh River flow regime.

Kruskal-Wallis test

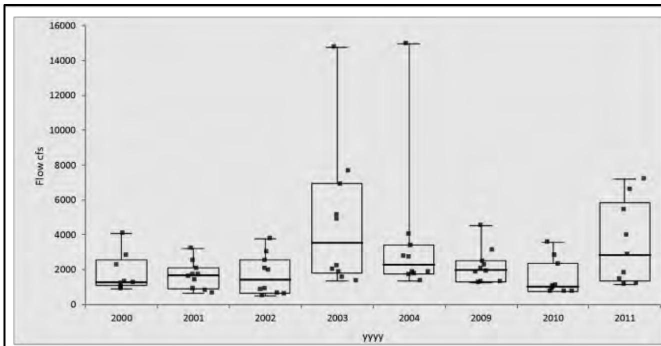
Flow cfs by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1837 BCP Lehigh EWQ	48	6.8	0.14
1837 BCP Lehigh Post	29	11.2	0.39

H statistic	0.04
X^2 approximation	0.04
DF	1
p-value	0.8499[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.

The Lehigh River is the largest and most populous tributary to the Lower Delaware River, so it affects water quality of the Delaware River the most of any tributary and masks the effects of other downstream tributaries. The 1361 square mile watershed is about 60% forested, contains 9.9% urban land cover, and about 16% of the watershed is underlain by carbonate bedrock. About 28% of the watershed was affected by glacial activity (USGS StreamStats retrieval, Feb. 2014).

Numerous new and renewed discharge permits have been issued here under the DRBC Special Protection Waters rules. DRBC has a water quality model of the Lehigh River and uses it to implement discharge permits under Special Protection Waters rules.



N	77

Flow cfs by yyyy	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
2000	909	1098	1266	2577	4077	1479
2001	665	893	1671	2120	3202	1227
2002	493	657	1415	2560	3773	1903
2003	1350	1819	3533	6962	14777	5142
2004	1340	1735	2284	3403	14960	1668
2009	1270	1318	1965	2524	4520	1207
2010	733	764	1024	2372	3570	1608
2011	1130	1357	2850	5823	7180	4467

Pennsylvania DEP maintains a long term water quality monitoring (WQN) station nearby, so there are independent data available to compare with DRBC results. DRBC collects samples from the Route 611 Bridge near the Lehigh River confluence with the Delaware River.

Annual May to September flow statistics associated with water quality measurements are plotted above. These are measurements or estimates associated with the time of each water quality sample. Mean annual flow is about 2520 cfs; and harmonic mean flow is about 1250 cfs (USGS Stream Stats retrieval, Feb. 2014) which is more typical of summer flow conditions. Though a wide range of flows were sampled by DRBC, these data appear to be most representative of low to normal flow conditions. Flows corresponding to each water quality sample were estimated using instantaneous readings at the USGS gage 01454720 on the Lehigh River at Glendon, PA. Those reading are adjusted to account for the slight drainage area difference between the gage and the sampling site.

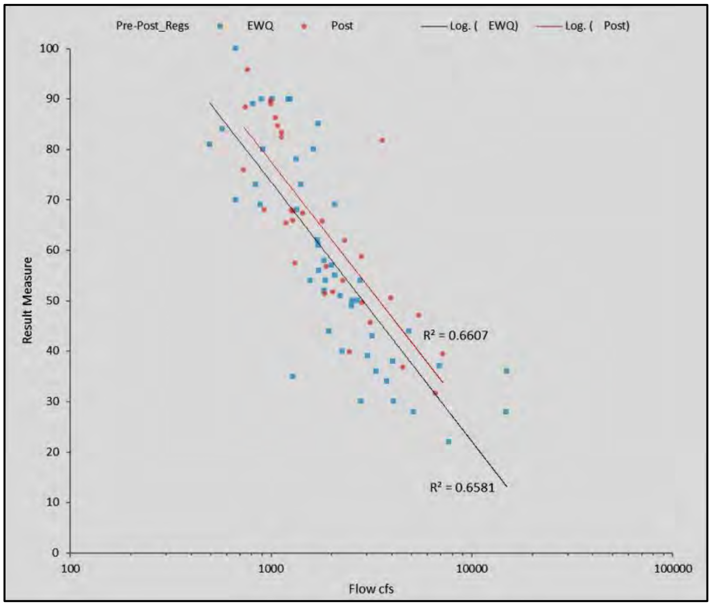
Upstream ICP: Delaware River at Easton 1838 ICP
Downstream ICP: Del. River at Riegelsville 1748 ICP

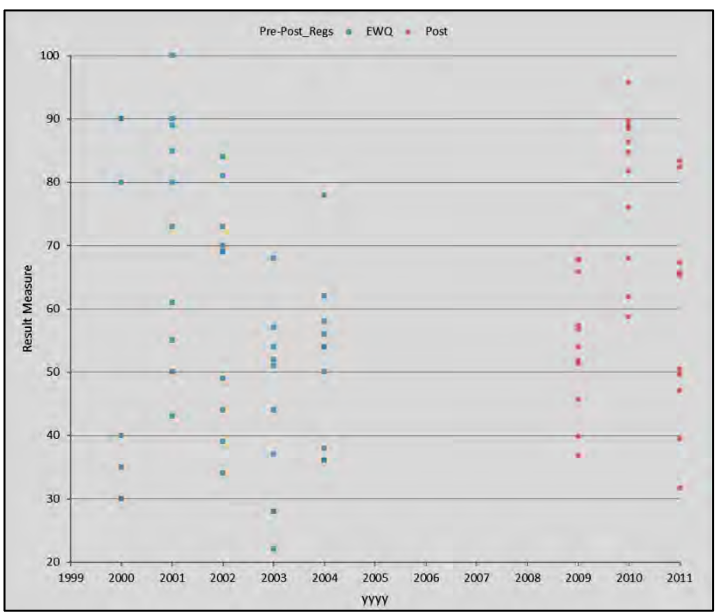
Chapter 17: 1837 BCP Lehigh River, PA

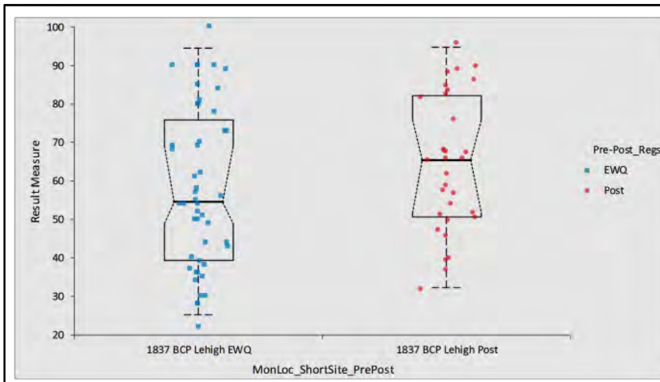
Alkalinity as CaCO3, Total mg/l

Existing Water Quality (Table 2J):

Median 55 mg/l
Lower 95% Confidence Interval 49 mg/l
Upper 95% Confidence Interval 69 mg/l
Defined in regulations as a flow-related parameter

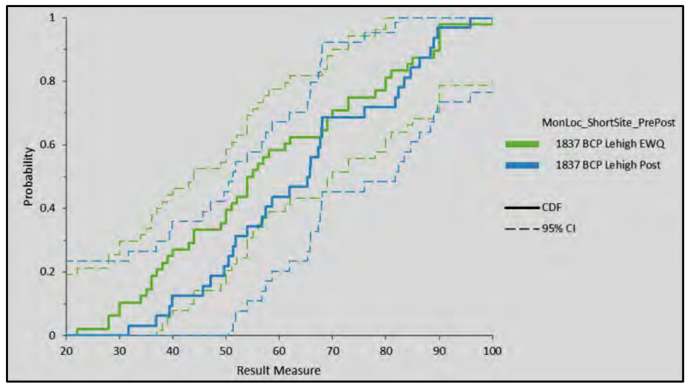






N | 80

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1837 BCP Lehigh EWQ	22	39	55	76	100	37
1837 BCP Lehigh Post	32	51	66	82	96	31



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1837 BCP Lehigh EWQ	48	376.9	7.85
1837 BCP Lehigh Post	32	565.3	17.67

H statistic	1.75
X² approximation	1.75
DF	1
p-value	0.1865 [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.

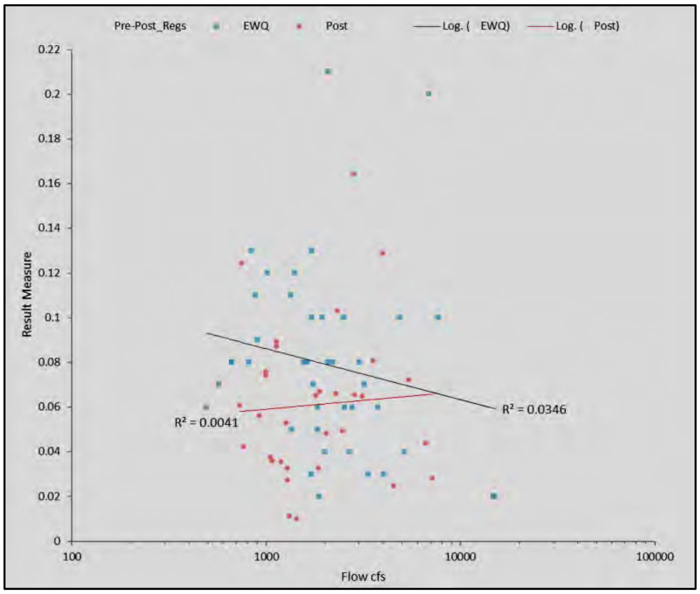
No water quality degradation is evident here. Alkalinity apparently did not measurably change between the EWQ and post-EWQ periods. Uncertainty is introduced into analyses by potential laboratory artifacts. Alkalinity is inversely related to flow in both data sets. Post-EWQ median alkalinity was within the EWQ 95% confidence intervals. Flow is plotted on a logarithmic scale. PADEP samples compared well with DRBC data, though there were only 11 WQN results which were insufficient data for statistical comparisons.

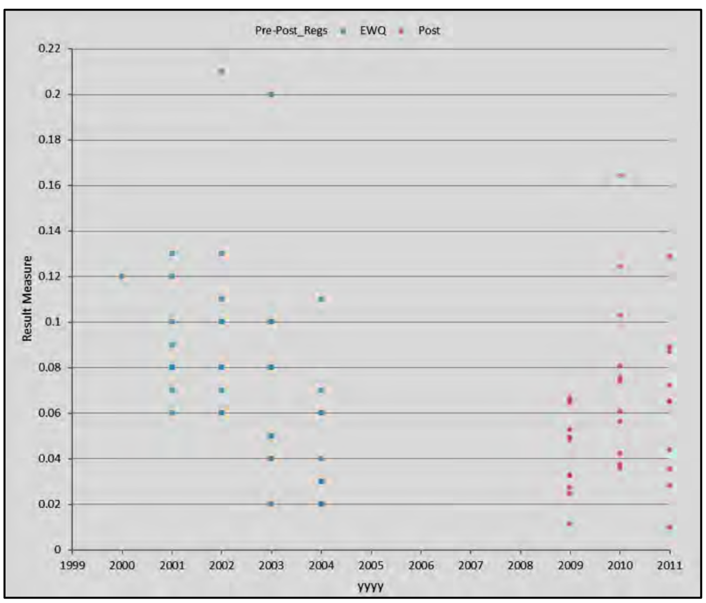
Chapter 17: 1837 BCP Lehigh River, PA

Ammonia Nitrogen as N, Total mg/l

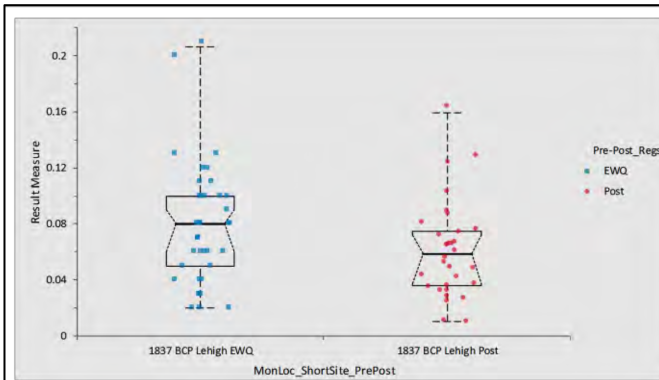
Existing Water Quality (Table 2J):

Median 0.08 mg/l
Lower 95% Confidence Interval 0.06 mg/l
Upper 95% Confidence Interval 0.09 mg/l

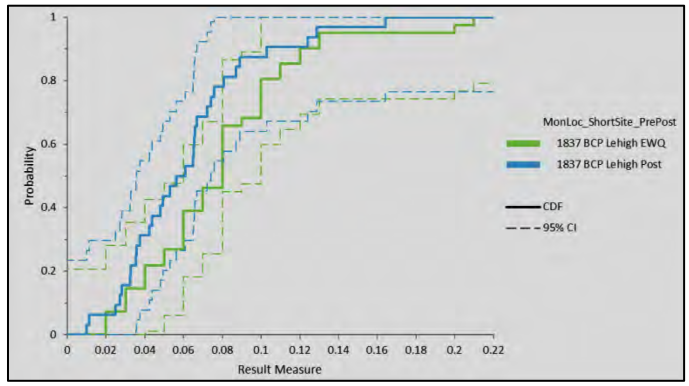




No water quality degradation is evident here. Ammonia concentrations apparently declined slightly. Uncertainty is introduced into analyses by potential laboratory artifacts. Post-EWQ median ammonia concentration was just below the EWQ lower 95% confidence interval.



N	73					
Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1837 BCP Lehigh EWQ	0.02	0.05	0.08	0.10	0.21	0.05
1837 BCP Lehigh Post	0.01	0.04	0.06	0.08	0.16	0.04



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1837 BCP Lehigh EWQ	41	781.5	19.06
1837 BCP Lehigh Post	32	1001.3	31.29

H statistic	3.97
X² approximation	3.97
DF	1
p-value	0.0463 [1]

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

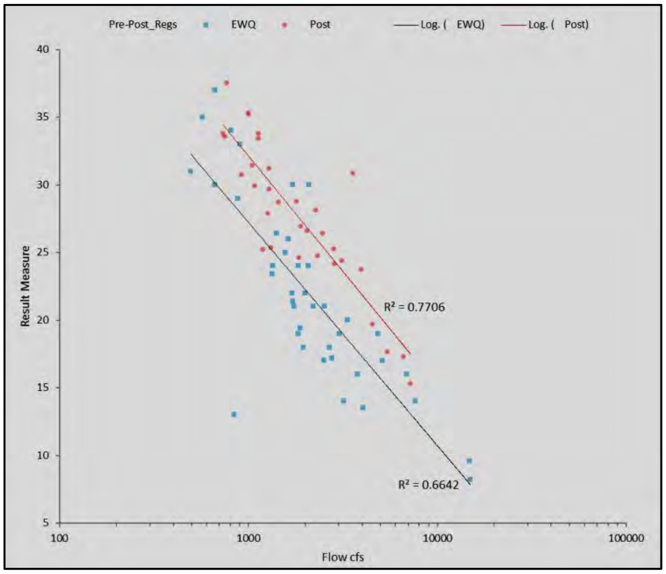
There were no post-EWQ PADEP data available for comparison with DRBC data. Ammonia is unrelated to flow in both data sets. Flow is plotted on a logarithmic scale. DRBC's post-EWQ detection limit (0.004-0.006 mg/l) was much lower than during the EWQ period (0.02-0.05 mg/l). EWQ data possessed 8/41 undetected results, so EWQ estimation of the median concentration was unaffected. In the post-EWQ data there were no undetected results. Thus the result found by DRBC may be a decline in ambient concentrations unless laboratory artifacts interfered. However, ammonia concentrations are still high in the Lehigh River.

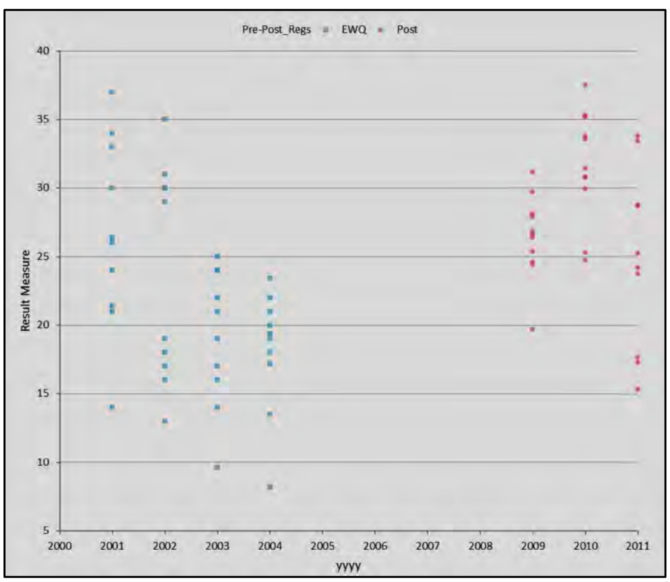
Chapter 17: 1837 BCP Lehigh River, PA

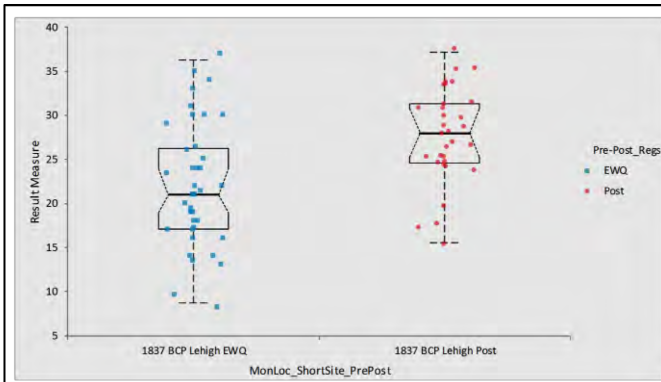
Chloride, Total mg/l

Existing Water Quality (Table 2J):

Median 21 mg/l
Lower 95% Confidence Interval 19 mg/l
Upper 95% Confidence Interval 24 mg/l
Defined in regulations as a flow-related parameter

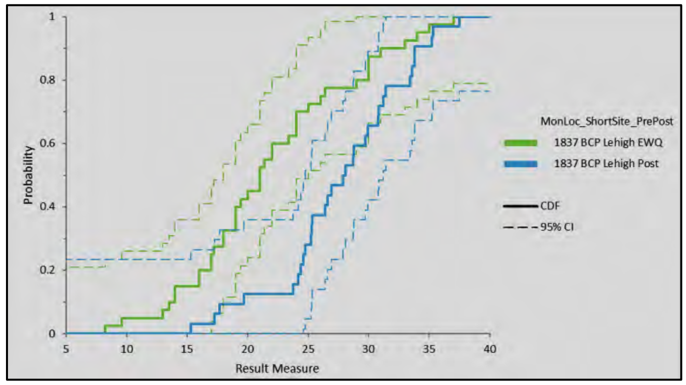






N | 72

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1837 BCP Lehigh EWQ	8	17	21	26	37	9
1837 BCP Lehigh Post	15	25	28	31	38	7



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1837 BCP Lehigh EWQ	40	2520.2	63.00
1837 BCP Lehigh Post	32	3150.2	98.44

H statistic	12.95
X^2 approximation	12.95
DF	1
p-value	0.0003 [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.

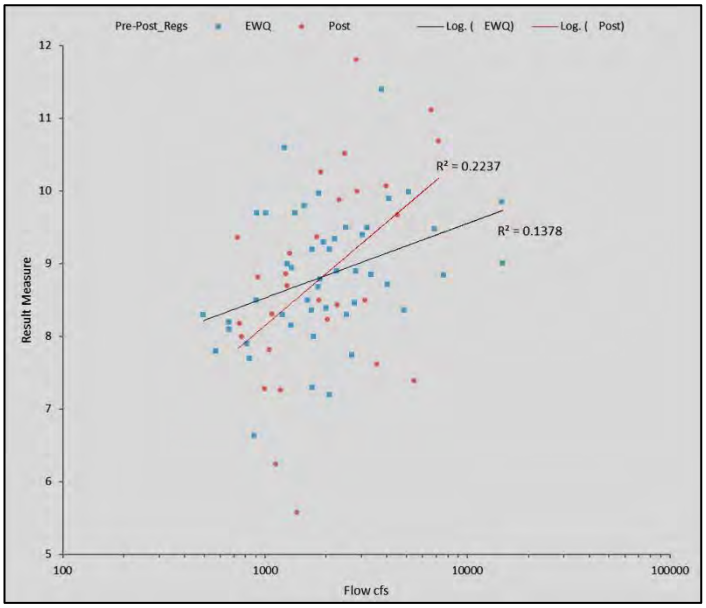
Water quality degradation is evident here. Chloride concentrations apparently rose by about 7 mg/l between the two periods. Uncertainty is introduced into analyses by potential laboratory artifacts. Post-EWQ median concentration rose above the EWQ upper 95% confidence interval. Chloride concentration is inversely related to flow in both data sets. Flow is plotted on a logarithmic scale. Only 3 PADEP samples were available to validate this conclusion, and all were 2009 samples that matched the higher concentration range of the post-EWQ period.

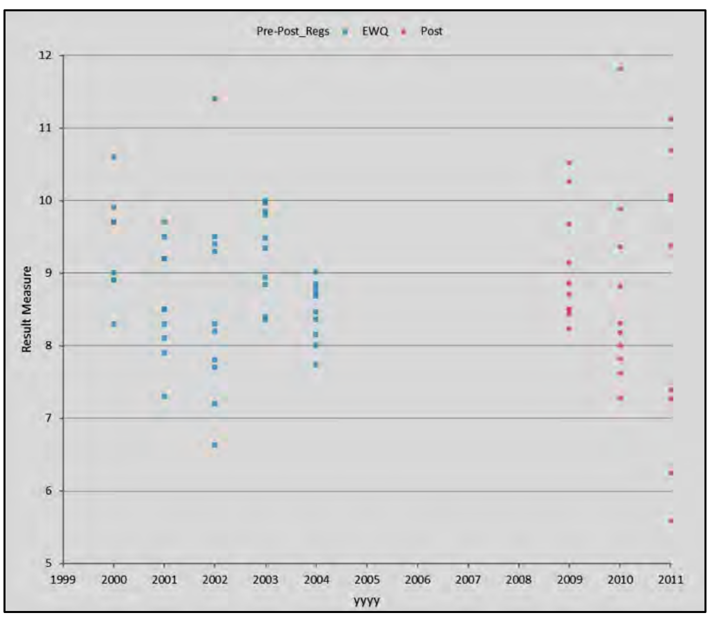
Chapter 17: 1837 BCP Lehigh River, PA

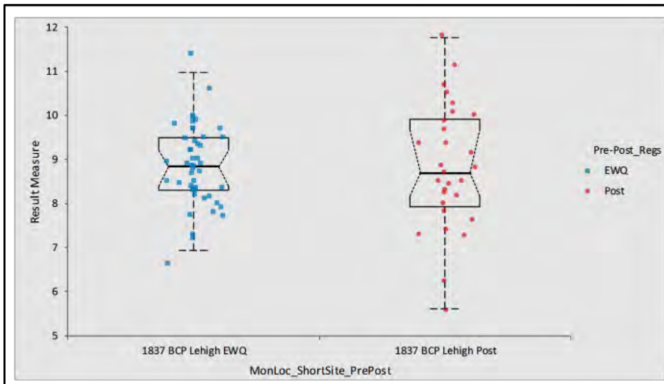
Dissolved Oxygen (DO) mg/l

Existing Water Quality (Table 2J):

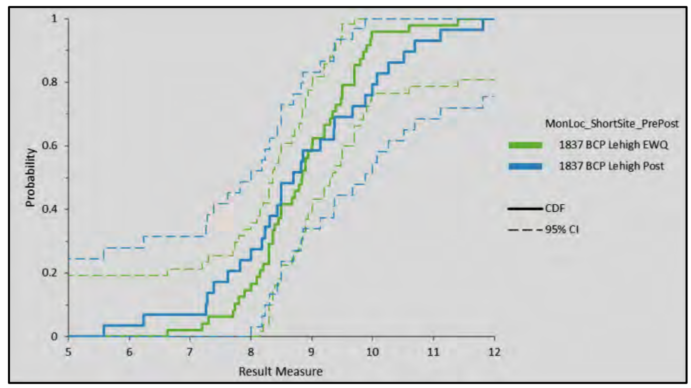
Median 8.85 mg/l
Lower 95% Confidence Interval 8.39 mg/l
Upper 95% Confidence Interval 9.20 mg/l







N	77					
Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1837 BCP Lehigh EWQ	6.63	8.30	8.85	9.49	11.40	1.19
1837 BCP Lehigh Post	5.58	7.94	8.70	9.92	11.81	1.98



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1837 BCP Lehigh EWQ	48	1.5	0.03
1837 BCP Lehigh Post	29	2.5	0.09

H statistic	0.01
X^2 approximation	0.01
DF	1
p-value	0.9288 [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 DO was within the EWQ 95% confidence intervals, though it ranged more widely. DO concentration is unrelated to flow in both data sets. Flow is plotted on a logarithmic scale. There were two results of 6 mg/l or below in the post-EWQ data – these were taken at a time of day when DO concentrations should be near maximum. Thus there may be instances of uncontrolled sewage or other oxygen-reducing materials in the Lehigh. Both samples were taken in July 2011 under low/normal flow conditions. PADEP data generally match DRBC results, though no data were available in the July 2011 period for comparison.

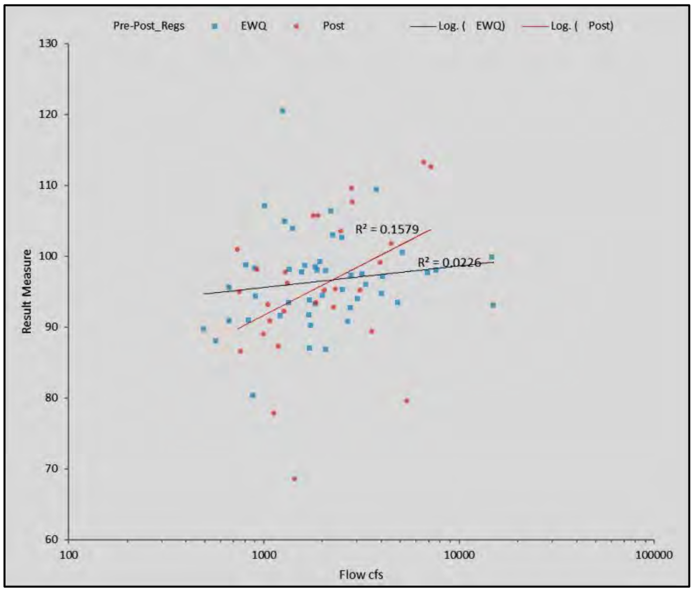
No water quality degradation is evident here. No measurable change took place between the EWQ and Post-EWQ periods. There was no known uncertainty introduced by uncontrolled variables.

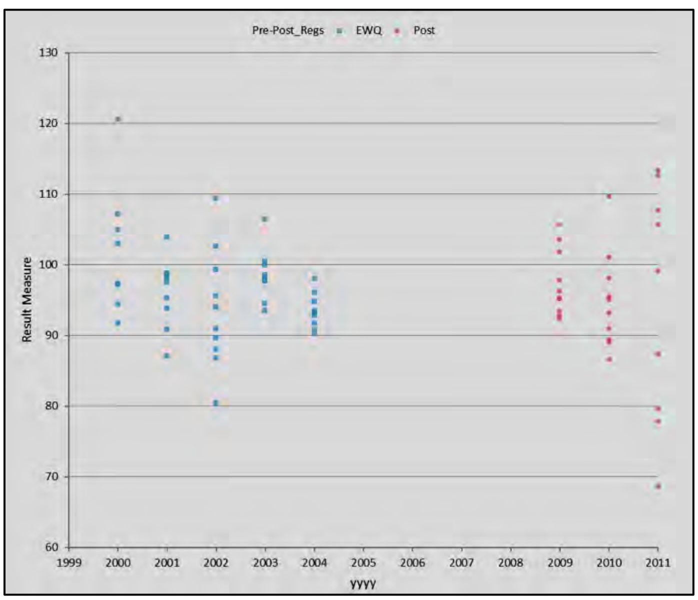
Chapter 17: 1837 BCP Lehigh River, PA

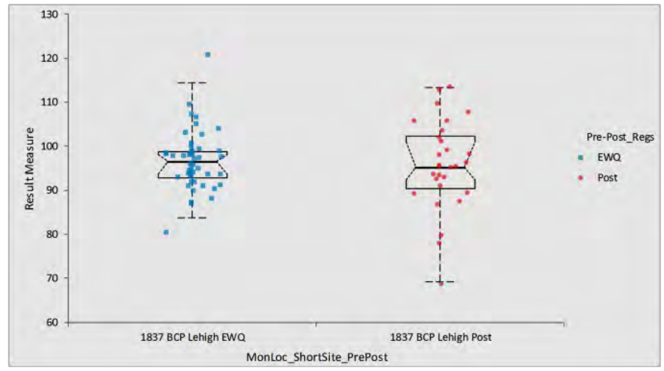
Dissolved Oxygen Saturation %

Existing Water Quality (Table 2J):

Median 97%
Lower 95% Confidence Interval 94%
Upper 95% Confidence Interval 98%

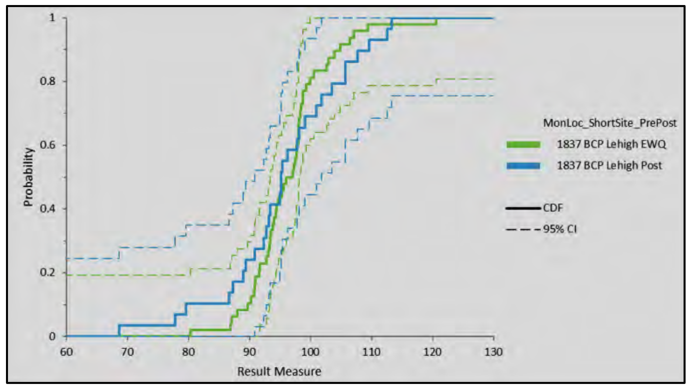






N	77

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1837 BCP Lehigh EWQ	80.4	92.9	96.6	98.8	120.5	5.9
1837 BCP Lehigh Post	68.6	90.4	95.2	102.4	113.3	12.0



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1837 BCP Lehigh EWQ	48	10.1	0.21
1837 BCP Lehigh Post	29	16.7	0.58

H statistic	0.05
X^2 approximation	0.05
DF	1
p-value	0.8171 [1]

H0: $\theta_1 = \theta_2 = \theta_{\dots}$
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.

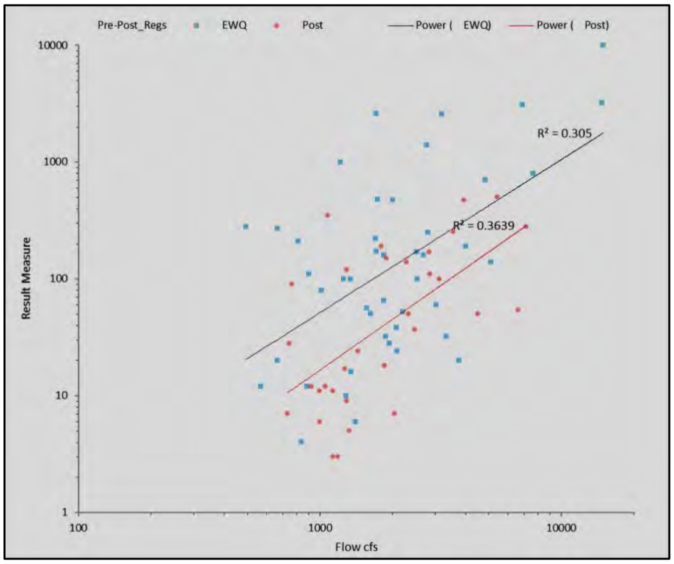
No water quality degradation is evident here. Dissolved Oxygen Saturation is unrelated to flow, and did not measurably change between the EWQ and post-EWQ periods. No known analytical uncertainty was introduced by uncontrolled variables. Post-EWQ median DO saturation fell within the EWQ 95% confidence intervals. Flow is plotted on a logarithmic scale. Three measurements fell below 80% saturation, indicating an excess of oxygen-reducing material at certain times. As a rule of thumb, 80-120% is considered “normal”; in that range a balance exists between oxygen demand and supply. No PADEP data were readily available to confirm DRBC results.

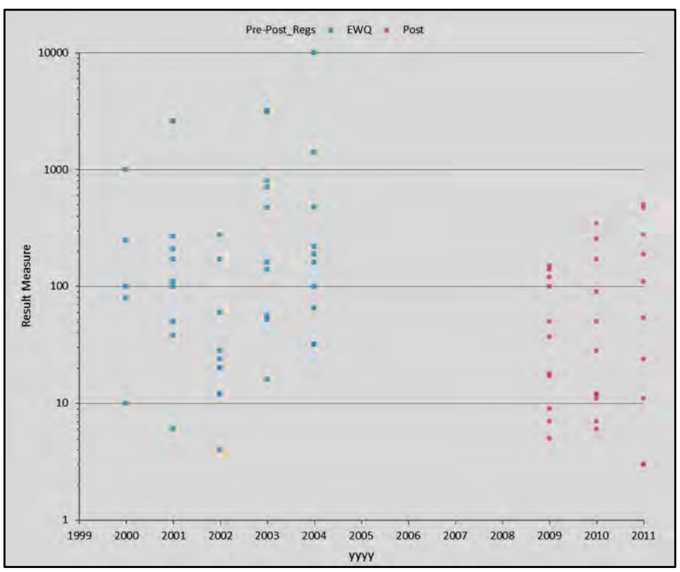
Chapter 17: 1837 BCP Lehigh River, PA

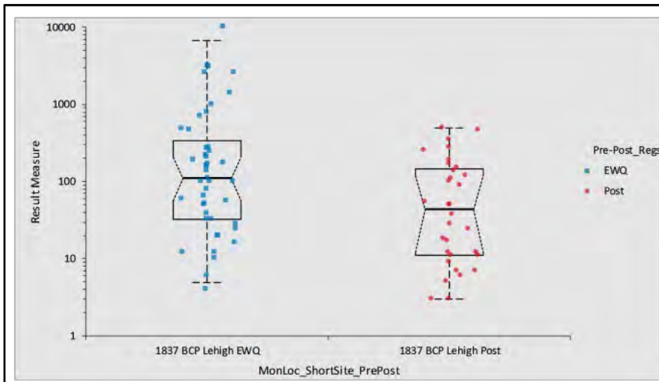
Enterococcus colonies/100 ml

Existing Water Quality (Table 2J):

Median 110/100 ml
Lower 95% Confidence Interval 56/100 ml
Upper 95% Confidence Interval 210/100 ml

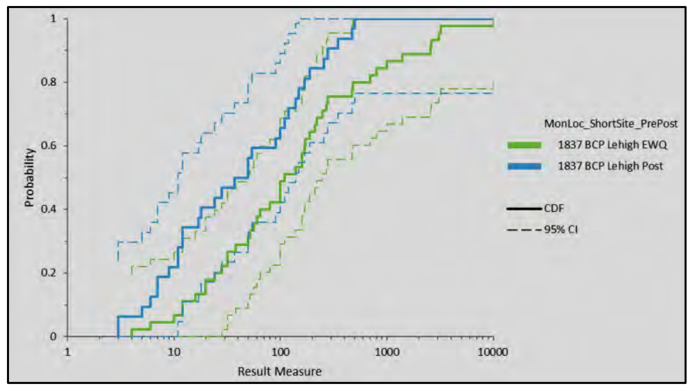






N 77

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1837 BCP Lehigh EWQ	4	32	110	343	10000	311
1837 BCP Lehigh Post	3	11	44	146	500	135



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1837 BCP Lehigh EWQ	45	1456.4	32.36
1837 BCP Lehigh Post	32	2048.0	64.00

H statistic	7.01
X^2 approximation	7.01
DF	1
p-value	0.0081 [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.

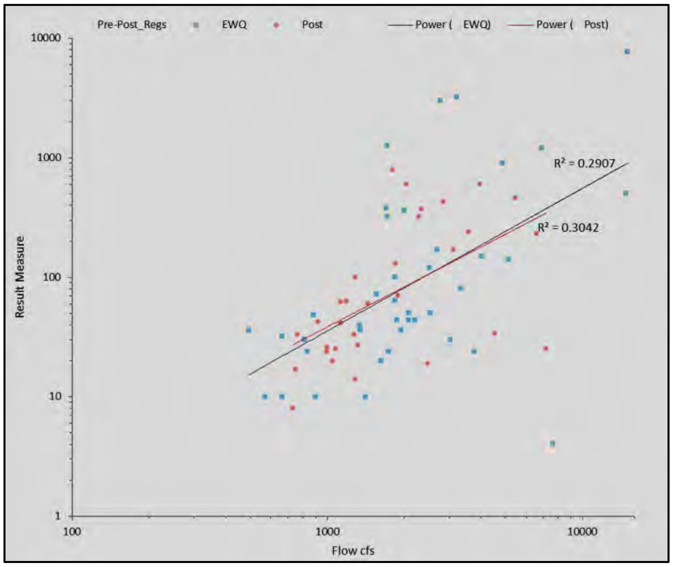
No water quality degradation is evident here. Enterococci apparently declined between the EWQ and Post-EWQ periods. Uncertainty is introduced into analyses by potential laboratory artifacts. Enterococcus concentrations are weakly related to flow in both data sets. Concentrations and flows are plotted on a logarithmic scale, and the regression is a power relationship. Post-EWQ median enterococcus concentrations fell below the lower EWQ 95% confidence interval, indicating either a water quality improvement or potential laboratory artifacts.

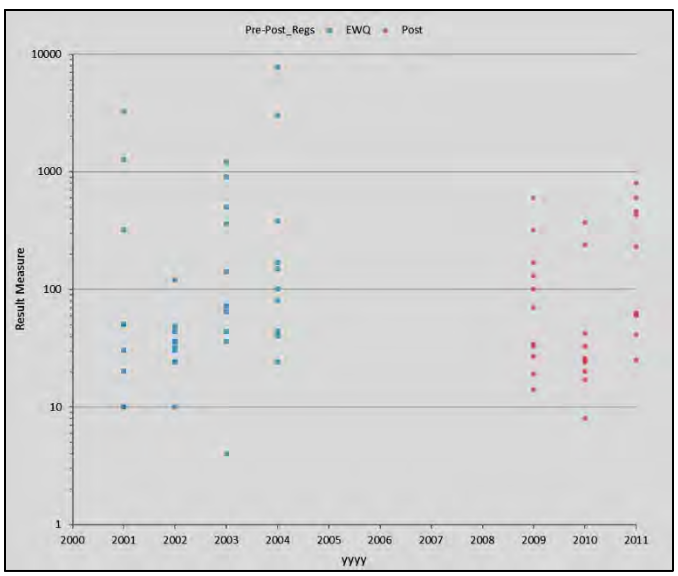
Chapter 17: 1837 BCP Lehigh River, PA

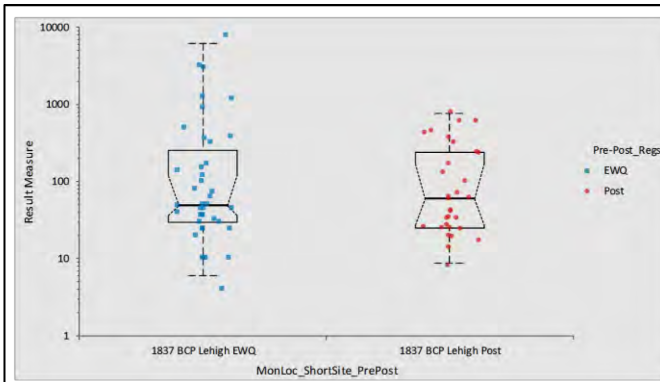
Escherichia coli colonies/100 ml

Existing Water Quality (Table 2J):

Median 49/100 ml
Lower 95% Confidence Interval 36/100 ml
Upper 95% Confidence Interval 120/100 ml
Designated in DRBC rules as flow-related

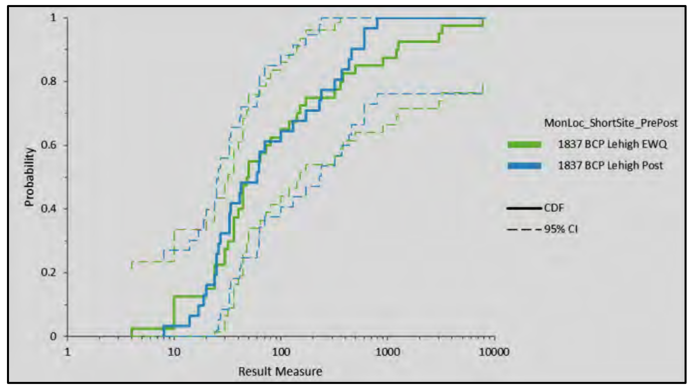






N 71

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1837 BCP Lehigh EWQ	4	30	49	258	7700	228
1837 BCP Lehigh Post	8	25	60	238	800	213



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1837 BCP Lehigh EWQ	40	16.3	0.41
1837 BCP Lehigh Post	31	21.0	0.68

H statistic	0.09
X^2 approximation	0.09
DF	1
p-value	0.7674[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. E. coli concentrations apparently did not measurably change between the EWQ and Post-EWQ periods. Uncertainty is introduced into analyses by potential laboratory artifacts.

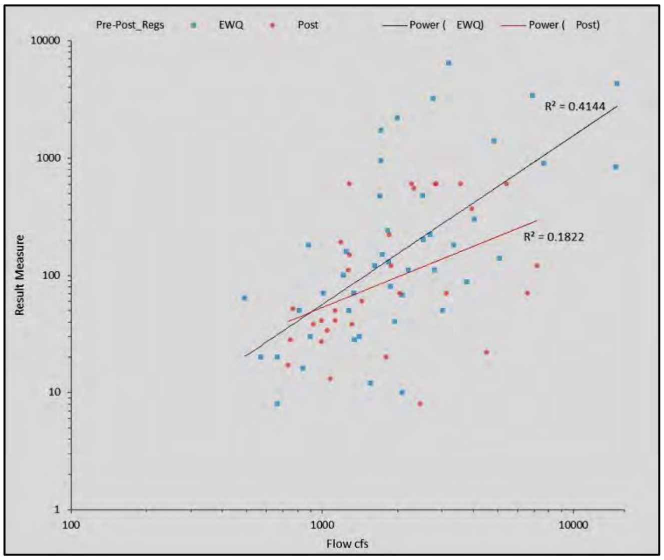
Post-EWQ median E. coli fell within the EWQ 95% confidence intervals. Concentrations and flows are plotted on a logarithmic scale, and regressions are power relationships. E. coli concentrations are weakly related to flow in both data sets. Pennsylvania DEP or USGS data were not available to validate DRBC results.

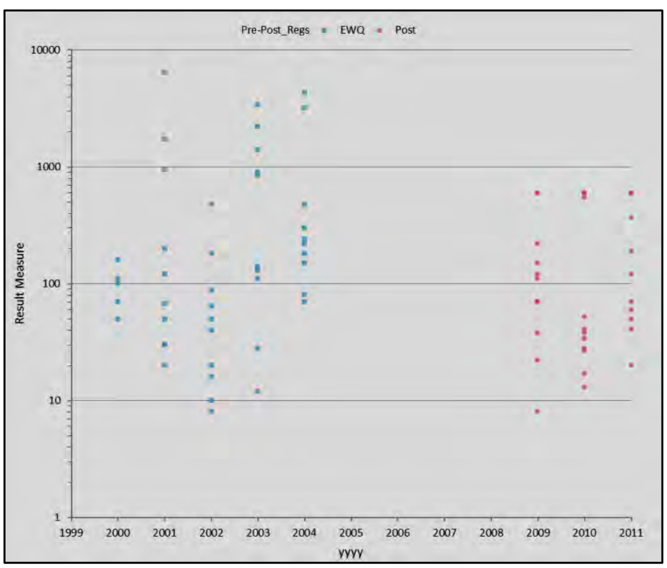
Chapter 17: 1837 BCP Lehigh River, PA

Fecal coliform colonies/100 ml

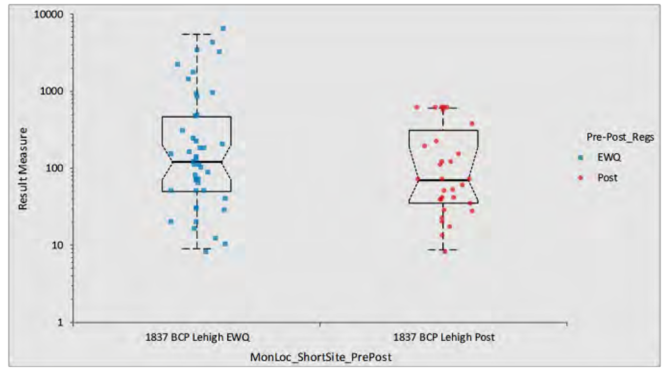
Existing Water Quality (Table 2J):

Median 120/100 ml
Lower 95% Confidence Interval 70/100 ml
Upper 95% Confidence Interval 200/100 ml
Designated in DRBC rules as flow-related



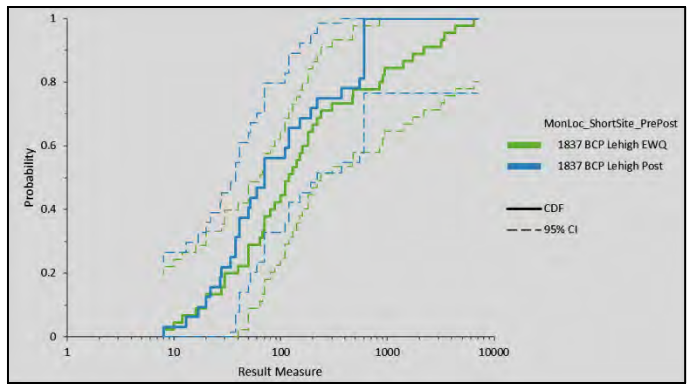


No water quality degradation is evident here. Fecal coliform concentrations apparently did not measurably change between the EWQ and post-EWQ periods. There were fewer high results in the post-EWQ data set due to 3 truncated laboratory upper quantitation limits, though these did not affect comparisons.



N 77

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1837 BCP Lehigh EWQ	8	50	120	473	6440	423
1837 BCP Lehigh Post	8	36	70	308	600	272



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1837 BCP Lehigh EWQ	45	361.3	8.03
1837 BCP Lehigh Post	32	508.0	15.88

H statistic	1.74
X^2 approximation	1.74
DF	1
p-value	0.1873 [1]

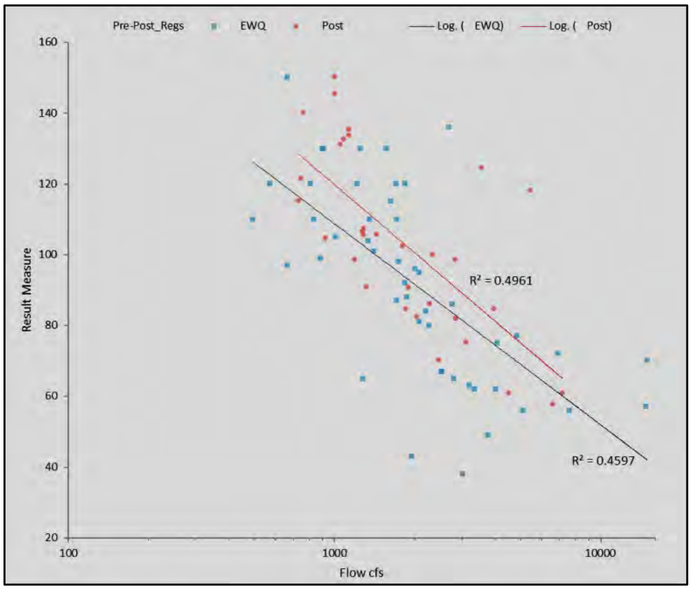
H0: $\theta_1 = \theta_2 = \theta ...$
The median of the populations are all equal.
H1: $\theta_i \neq \theta_j$ for at least one i,j
The median of the populations are not all equal.
[1] Do not reject the null hypothesis at the 5% significance level.

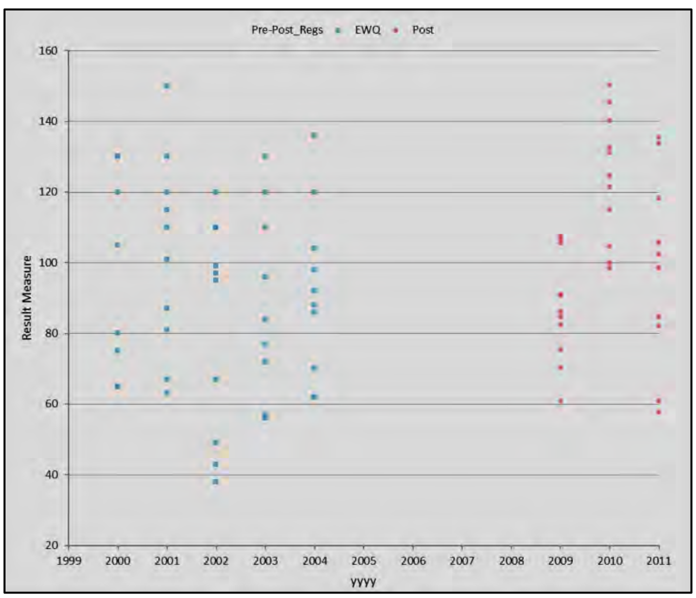
Uncertainty is introduced into analyses by potential laboratory artifacts. Fecal coliform concentrations are weakly related to flow in the EWQ data set, but unrelated to flow in the post-EWQ data. Post-EWQ median concentrations were within the EWQ 95% confidence intervals. Concentrations and flows are plotted on a logarithmic scale, and regressions are power relationships. There were insufficient PADEP data for comparison with DRBC results.

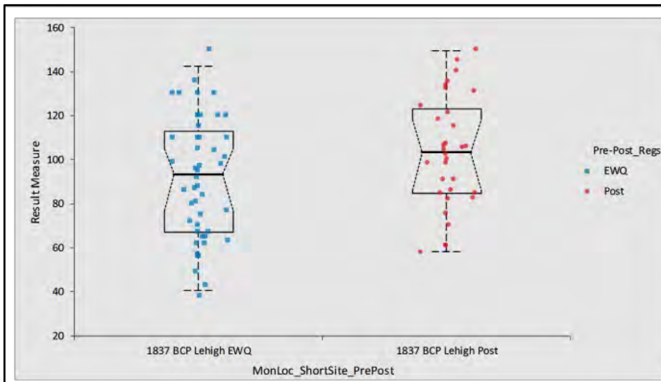
Hardness as CaCO3, Total mg/l

Existing Water Quality (Table 2J):

Median 94 mg/l
Lower 95% Confidence Interval 77 mg/l
Upper 95% Confidence Interval 105 mg/l
Defined in regulations as a flow-related parameter

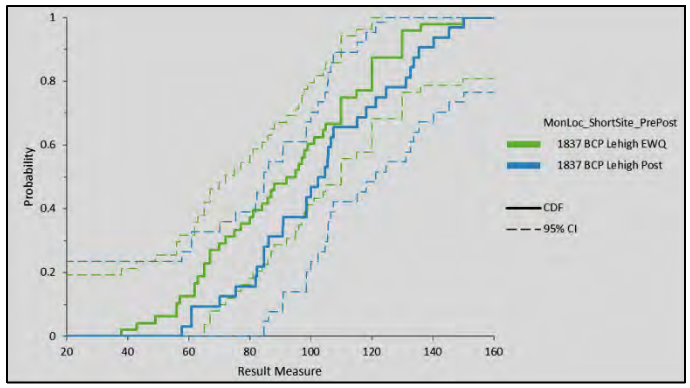






N 80

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1837 BCP Lehigh EWQ	38	67	94	113	150	46
1837 BCP Lehigh Post	58	85	104	123	150	39



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1837 BCP Lehigh EWQ	48	697.7	14.54
1837 BCP Lehigh Post	32	1046.5	32.70

H statistic	3.23
X^2 approximation	3.23
DF	1
p-value	0.0722 [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.

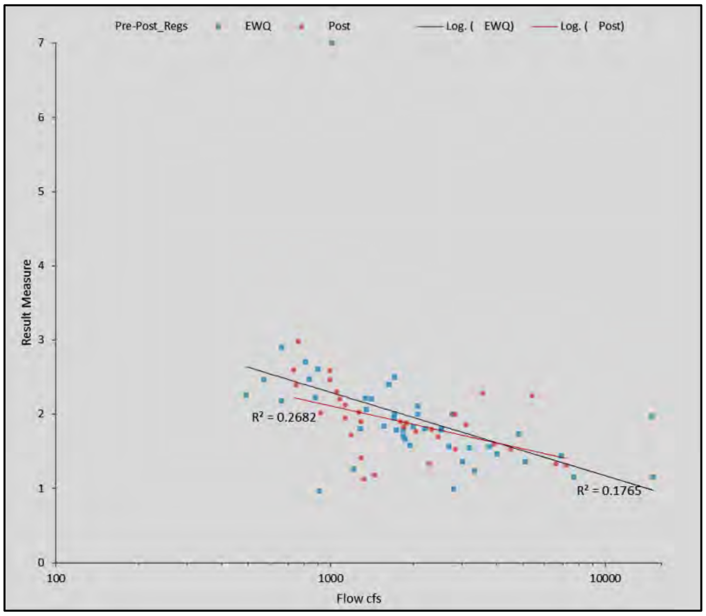
No water quality degradation is evident here. Hardness apparently did not measurably change between the EWQ and post-EWQ periods. Uncertainty is introduced into analyses by potential laboratory artifacts. Hardness is inversely related to flow in both data sets. Post-EWQ median hardness was within the EWQ 95% confidence intervals. Flow is plotted on a logarithmic scale. PADEP data were similar to DRBC results.

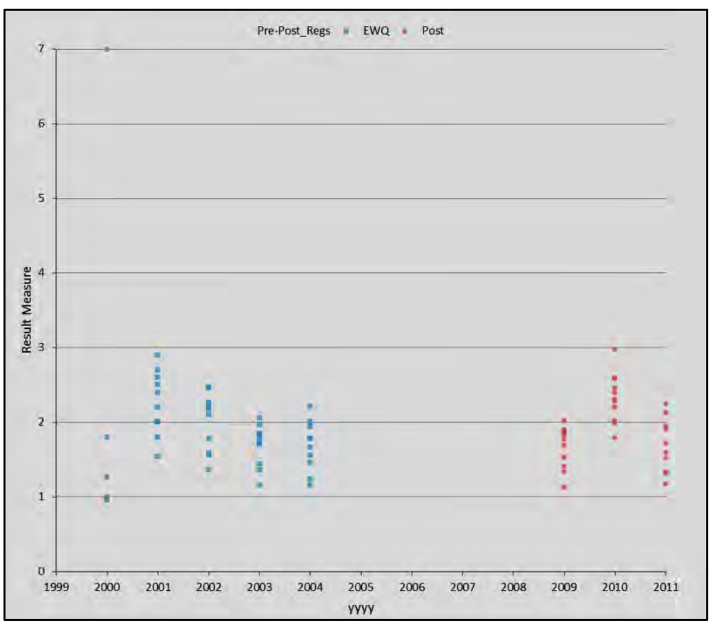
Chapter 17: 1837 BCP Lehigh River, PA

Nitrate + Nitrite as N, Total mg/l

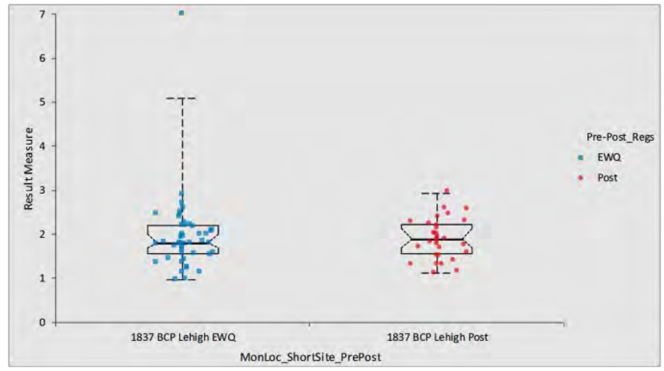
Existing Water Quality (Table 2J, as Nitrate only):

Median 1.80 mg/l
Lower 95% Confidence Interval 1.70 mg/l
Upper 95% Confidence Interval 2.00 mg/l



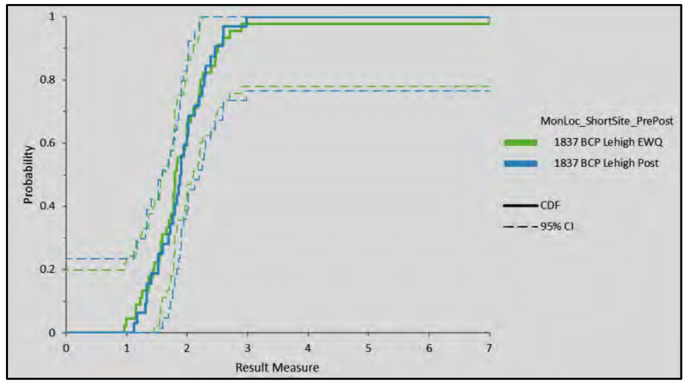


No water quality degradation is evident here. Nitrate concentrations apparently did not measurably change between the EWQ and post-EWQ periods. Nitrate is unrelated to flow in both data sets.



N 77

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1837 BCP Lehigh EWQ	0.96	1.55	1.80	2.20	7.00	0.65
1837 BCP Lehigh Post	1.12	1.55	1.89	2.23	2.98	0.67



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1837 BCP Lehigh EWQ	45	17.4	0.39
1837 BCP Lehigh Post	32	24.5	0.77

H statistic	0.08
X² approximation	0.08
DF	1
p-value	0.7722 [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.

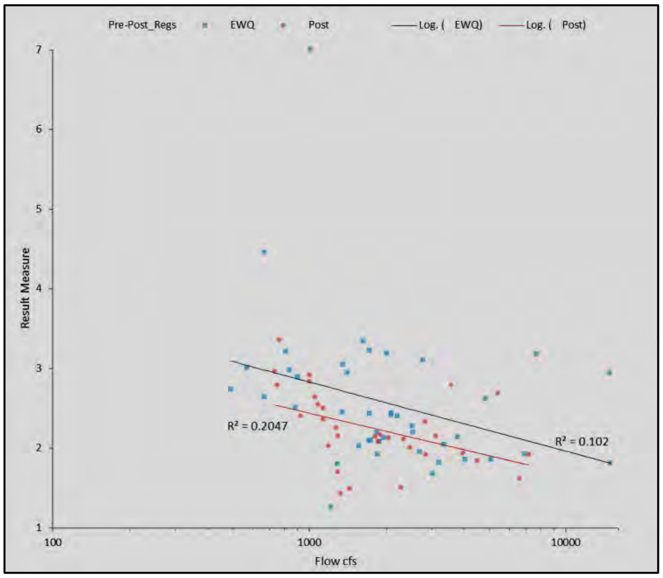
Uncertainty is introduced into analyses by potential laboratory artifacts. Post-EWQ median concentrations fell within the EWQ 95% confidence intervals. Post-EWQ nitrate + nitrite concentrations were assumed equivalent for comparison with EWQ nitrate concentrations since EWQ nitrite concentrations were never detected. PADEP results validated DRBC data. At other sites where concentrations are lower, there was a problem interpreting the data due to changing detection limits. Concentrations are sufficiently high in the Lehigh River that no such interpretive problems arose.

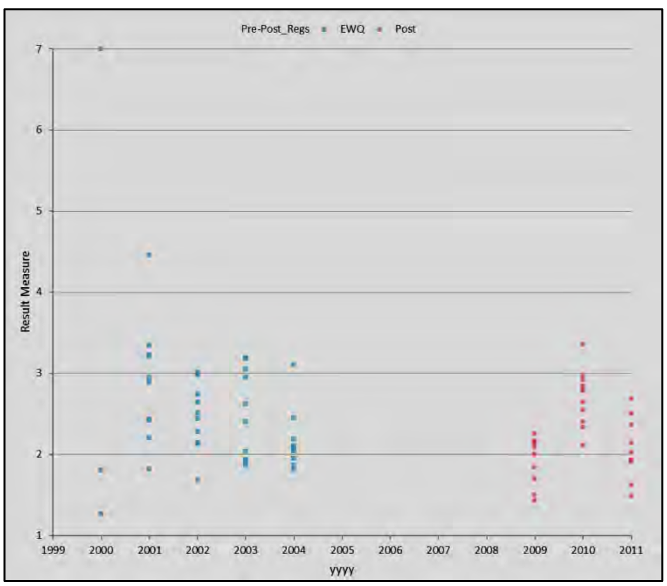
Chapter 17: 1837 BCP Lehigh River, PA

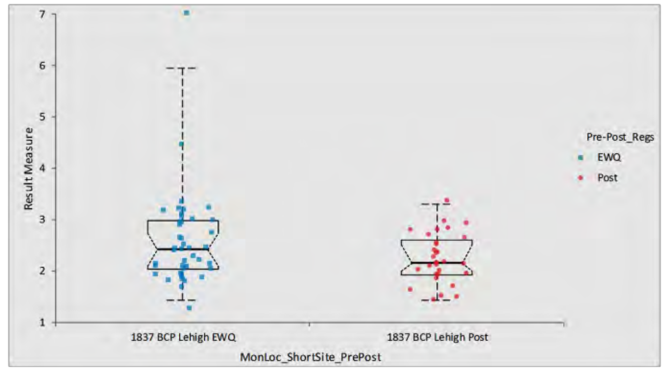
Nitrogen as N, Total (TN) mg/l

Existing Water Quality (Table 2J):

Median 2.43 mg/l
Lower 95% Confidence Interval 2.13 mg/l
Upper 95% Confidence Interval 2.74 mg/l

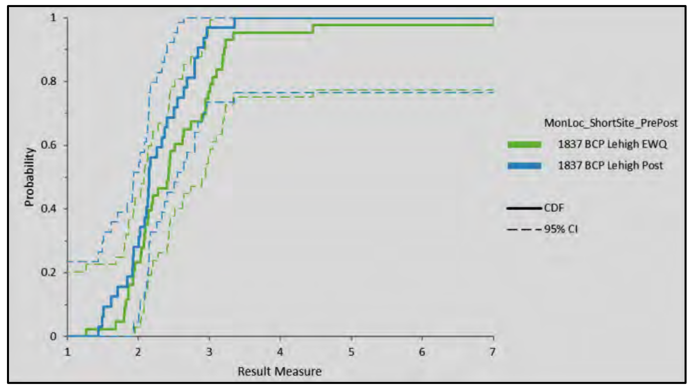






N 75

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1837 BCP Lehigh EWQ	1.26	2.03	2.42	2.98	7.00	0.94
1837 BCP Lehigh Post	1.43	1.93	2.15	2.60	3.36	0.67



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1837 BCP Lehigh EWQ	43	489.0	11.37
1837 BCP Lehigh Post	32	657.0	20.53

H statistic	2.41
X^2 approximation	2.41
DF	1
p-value	0.1204 [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.

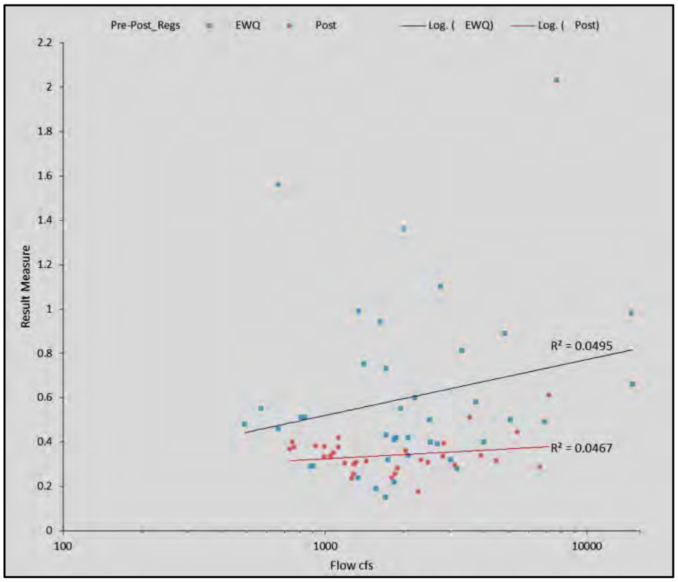
No water quality degradation is evident here. Total Nitrogen concentrations apparently did not measurably change between the EWQ and post-EWQ periods. Uncertainty is introduced into analyses by potential laboratory artifacts. TN is unrelated to flow in both data sets. Post-EWQ PADEP data were comparable to DRBC results, though there were insufficient PADEP data from the EWQ period for comparison with DRBC data. Post-EWQ median TN concentration fell within the EWQ 95% confidence intervals.

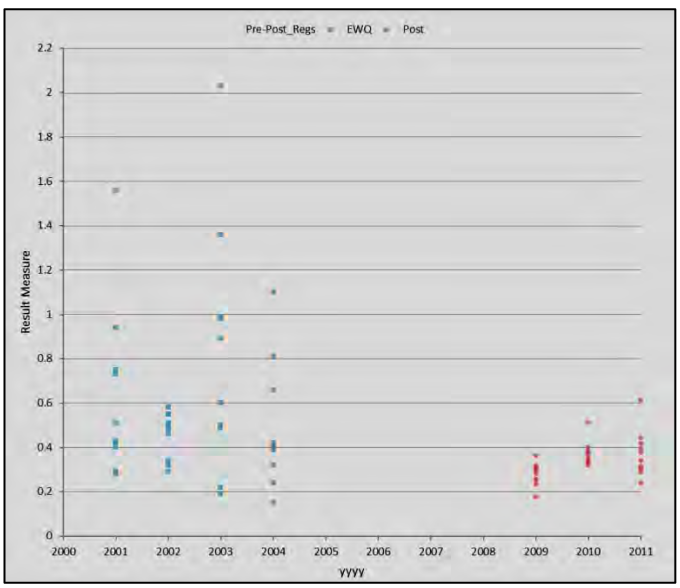
Chapter 17: 1837 BCP Lehigh River, PA

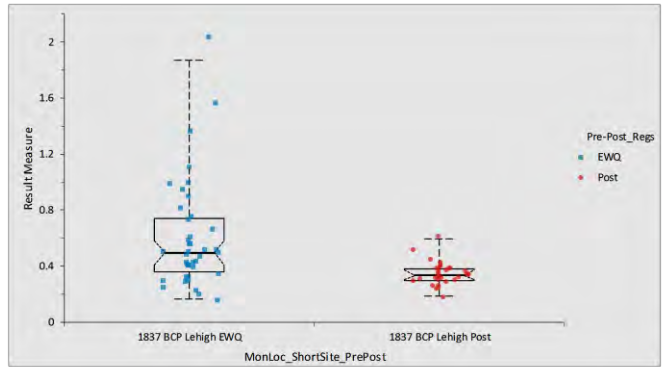
Nitrogen, Kjeldahl as N, Total (TKN) mg/l

Existing Water Quality (Table 2J):

Median 0.50 mg/l
Lower 95% Confidence Interval 0.41 mg/l
Upper 95% Confidence Interval 0.58 mg/l

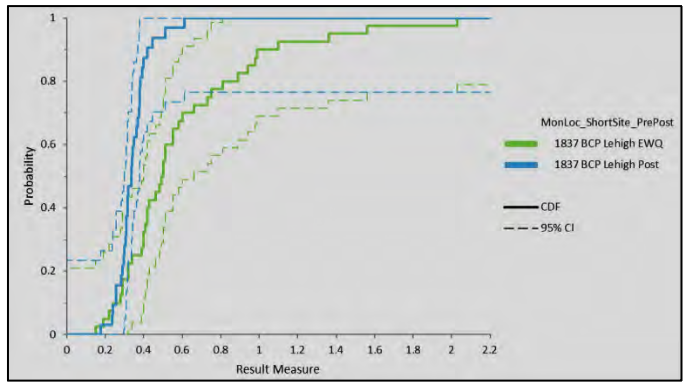






N 72

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1837 BCP Lehigh EWQ	0.15	0.36	0.50	0.74	2.03	0.38
1837 BCP Lehigh Post	0.18	0.30	0.33	0.38	0.61	0.08



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1837 BCP Lehigh EWQ	40	3010.2	75.26
1837 BCP Lehigh Post	32	3762.8	117.59

H statistic	15.47
X² approximation	15.47
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.

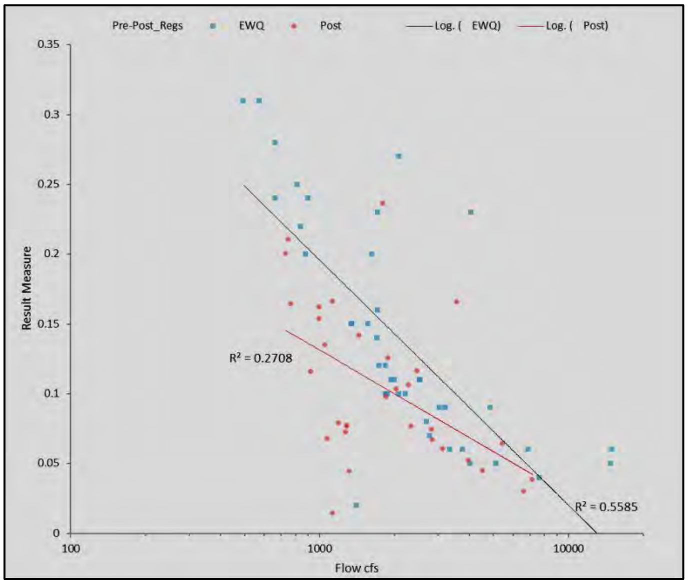
No water quality degradation is evident here. TKN concentrations apparently declined between the EWQ and post-EWQ periods. Uncertainty is introduced into analyses by potential laboratory artifacts. The post-EWQ range was far narrower and all concentrations were less than 0.6 mg/l. TKN concentration is unrelated to flow in both data sets. Post-EWQ median TKN fell below the lower EWQ 95% confidence interval. The TKN decline was enough to offset the slight rise in nitrate, thus the slight improvement in total nitrogen concentrations. There were no additional data to confirm DRBC results.

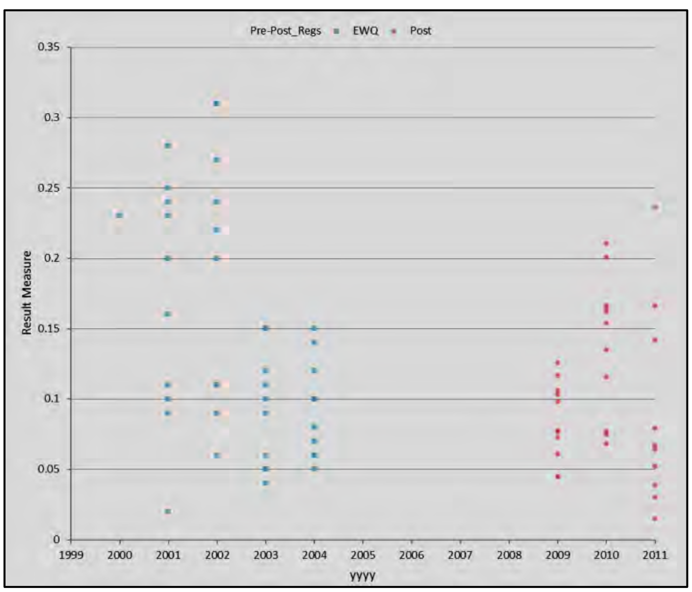
Chapter 17: 1837 BCP Lehigh River, PA

Orthophosphate as P, Total mg/l (OP)

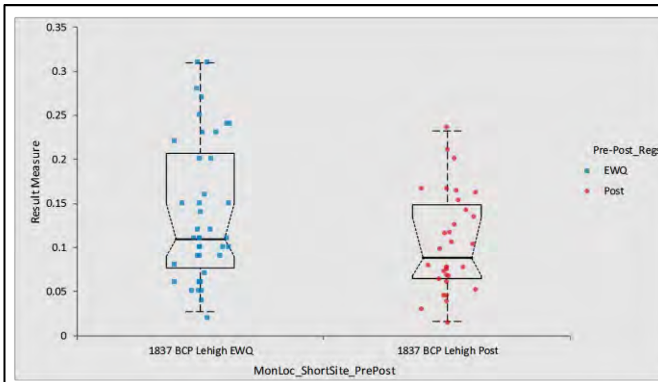
Existing Water Quality (Table 2J):

Median 0.11 mg/l
Lower 95% Confidence Interval 0.09 mg/l
Upper 95% Confidence Interval 0.15 mg/l



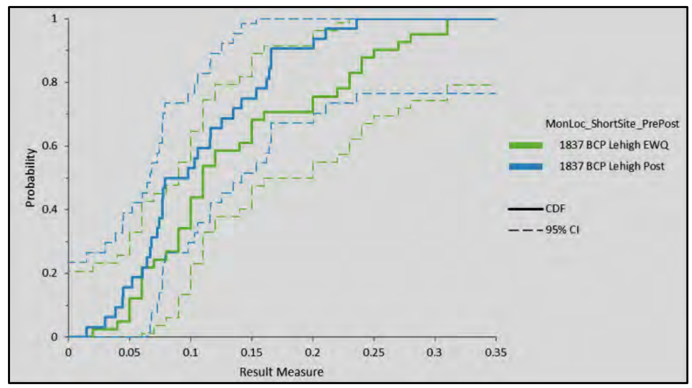


No water quality degradation is evident here. Orthophosphate concentrations did not measurably change between the EWQ and post-EWQ periods. Uncertainty is introduced into analyses by potential laboratory artifacts.



N 73

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1837 BCP Lehigh EWQ	0.02	0.08	0.11	0.21	0.31	0.13
1837 BCP Lehigh Post	0.01	0.07	0.09	0.15	0.24	0.08



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1837 BCP Lehigh EWQ	41	491.8	12.00
1837 BCP Lehigh Post	32	630.1	19.69

H statistic	2.49
X² approximation	2.49
DF	1
p-value	0.1143 [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.

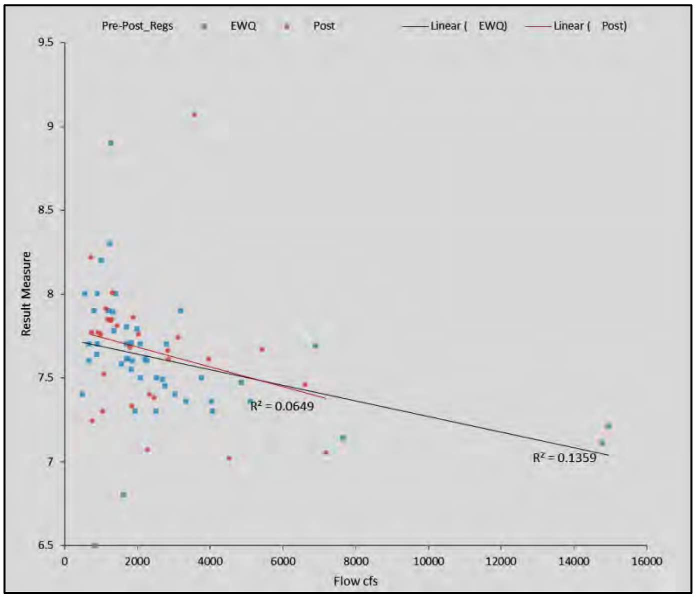
Orthophosphate is inversely related to flow in both data sets, though the relationship is weak in the post-EWQ data. Post-EWQ median orthophosphate fell within the EWQ 95% confidence intervals. Unlike in other watersheds, there were no undetected results in the EWQ or post-EWQ data, so this analysis contained no interference by differences between detection limits. PADEP data were comparable but inconsistent with DRBC results. The PADEP data indicated an increase in orthophosphate concentrations, though there were too few data for statistical significance.

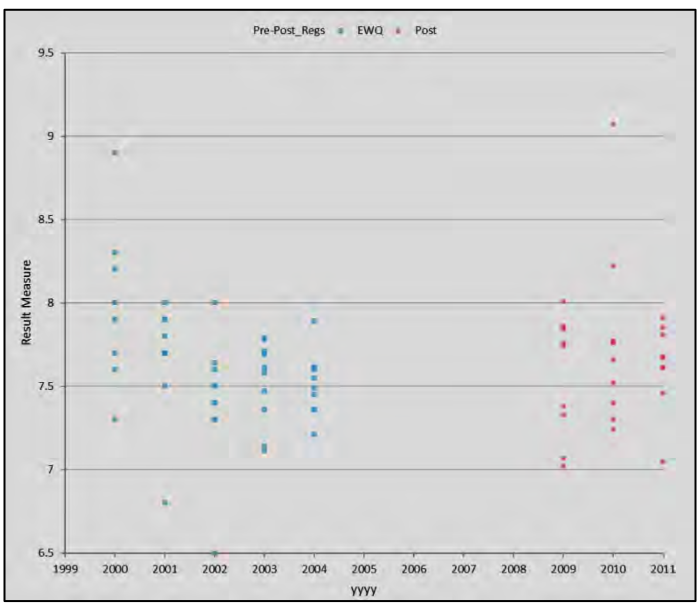
Chapter 17: 1837 BCP Lehigh River, PA

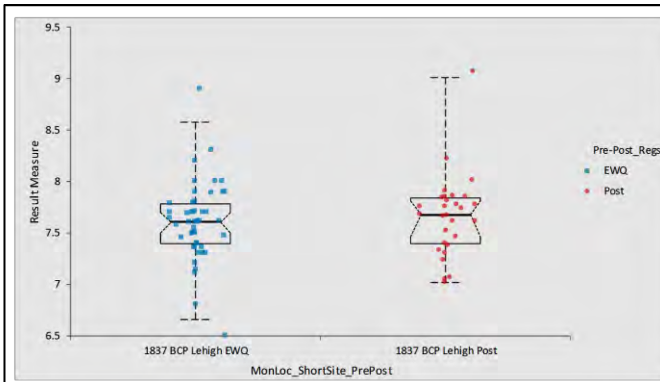
pH

Existing Water Quality (Table 2J):

Median 7.61 standard units
Lower 95% Confidence Interval 7.50 standard units
Upper 95% Confidence Interval 7.70 standard units

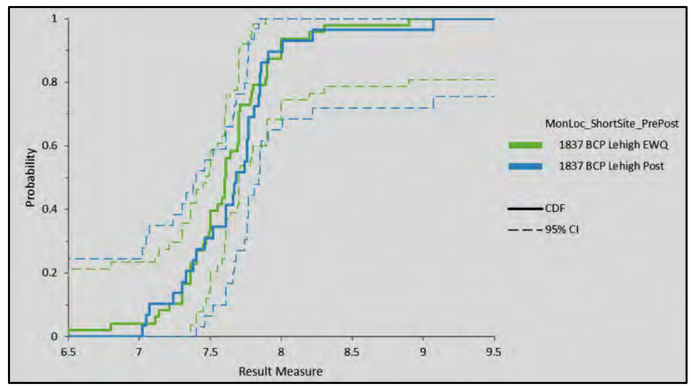






N	77

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1837 BCP Lehigh EWQ	6.50	7.40	7.61	7.79	8.90	0.39
1837 BCP Lehigh Post	7.02	7.39	7.68	7.84	9.07	0.45



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1837 BCP Lehigh EWQ	48	92.1	1.92
1837 BCP Lehigh Post	29	152.5	5.26

H statistic	0.49
X² approximation	0.49
DF	1
p-value	0.4843 [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.

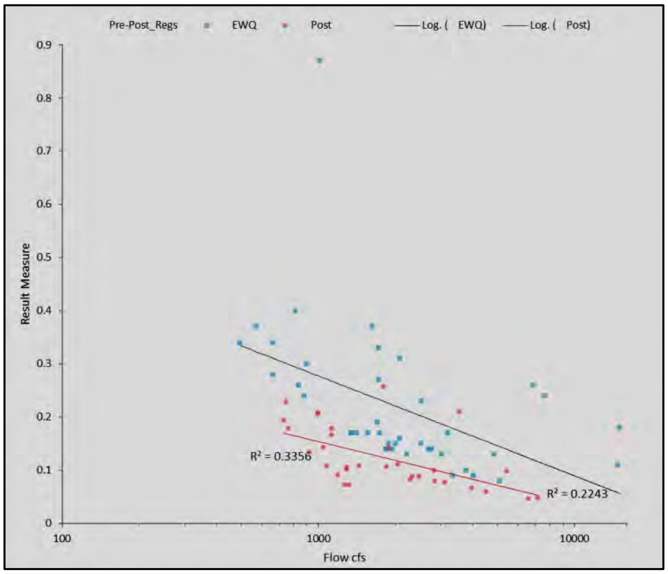
No water quality degradation is evident here. pH did not measurably change between the EWQ and post-EWQ periods. There were no known uncontrolled variables in these data, and so minimal uncertainty about results. pH is unrelated to flow in both data sets. Post-EWQ median pH was within the EWQ 95% confidence intervals. In July 2010 there was one spike above pH 9, indicating high algal productivity during that sampling period. PADEP and USGS data confirmed DRBC results.

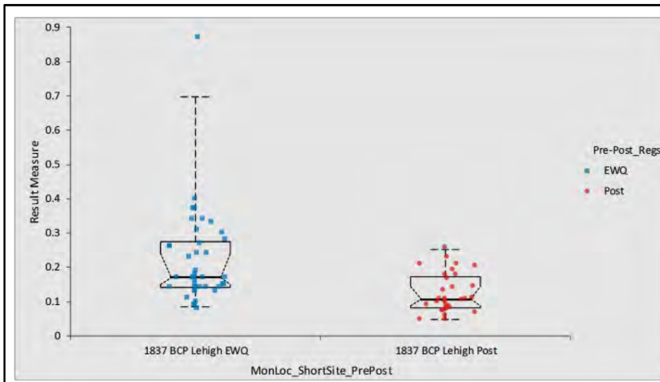
Chapter 17: 1837 BCP Lehigh River, PA

Phosphorus as P, Total (TP) mg/l

Existing Water Quality (Table 2J):

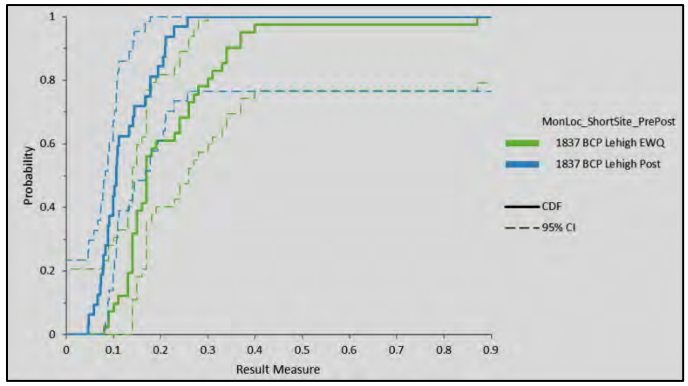
Median 0.17 mg/l
Lower 95% Confidence Interval 0.15 mg/l
Upper 95% Confidence Interval 0.24 mg/l

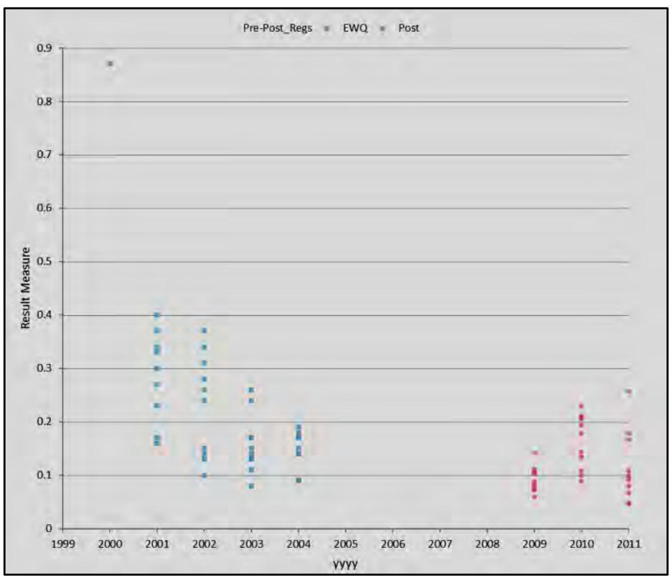




N | 73

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1837 BCP Lehigh EWQ	0.08	0.14	0.17	0.27	0.87	0.13
1837 BCP Lehigh Post	0.05	0.08	0.11	0.17	0.26	0.09





Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1837 BCP Lehigh EWQ	41	3321.0	81.00
1837 BCP Lehigh Post	32	4255.0	132.97

H statistic	16.85
X^2 approximation	16.85
DF	1
p-value	<0.0001 [1]

H0: $\theta_1 = \theta_2 = \theta_{\dots}$
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.

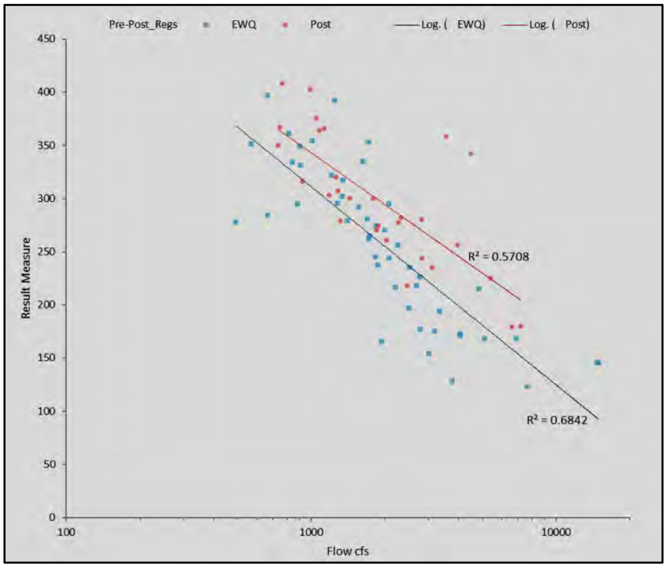
No water quality degradation is evident here. Total Phosphorus (TP) concentrations apparently declined between the EWQ and post-EWQ periods. Uncertainty is introduced into analyses by potential laboratory artifacts. Post-EWQ median total phosphorus fell below the EWQ lower 95% confidence interval. TP is weakly related to flow in both data sets. No additional data were available to confirm DRBC results. EWQ results were more variable than post-EWQ data, which contained no concentrations higher than 0.25 mg/l. This may constitute a water quality improvement; or may be reflective of laboratory artifacts.

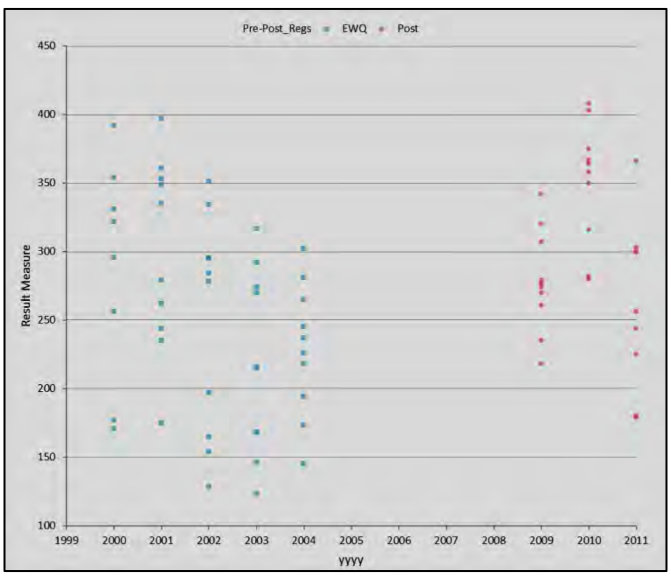
Chapter 17: 1837 BCP Lehigh River, PA

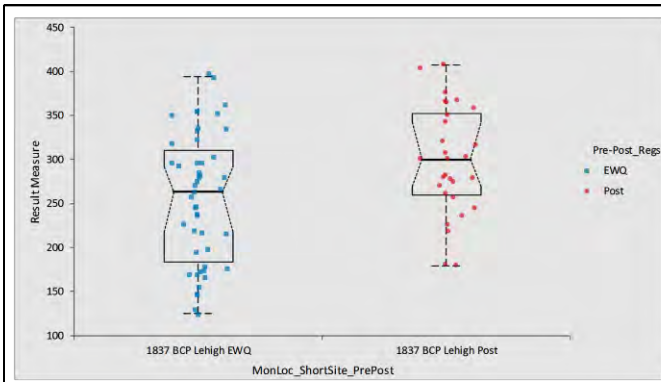
Specific Conductance µmho/cm

Existing Water Quality (Table 2J):

Median 264 µmho/cm
Lower 95% Confidence Interval 218 µmho/cm
Upper 95% Confidence Interval 292 µmho/cm
Defined in regulations as a flow-related parameter

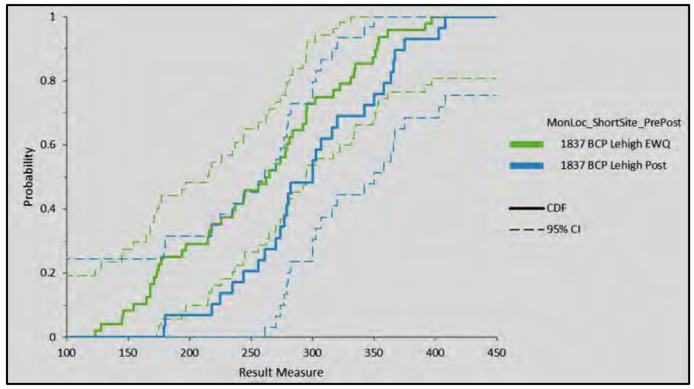






N 77

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1837 BCP Lehigh EWQ	123	184	264	311	397	127
1837 BCP Lehigh Post	179	259	300	353	408	93



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1837 BCP Lehigh EWQ	48	1155.4	24.07
1837 BCP Lehigh Post	29	1912.4	65.95

H statistic	6.13
X² approximation	6.13
DF	1
p-value	0.0133 [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.

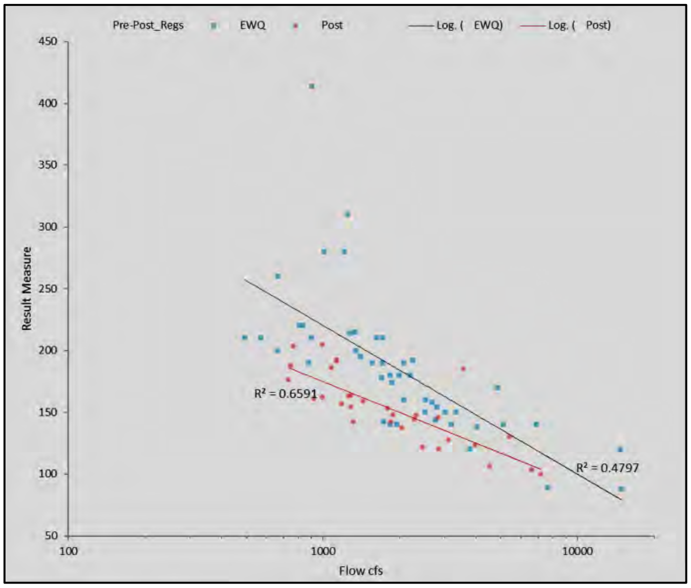
Water quality degradation is evident here. Specific conductance increased 36 µmho/cm; rising above the EWQ upper 95% confidence interval. There were no known uncontrolled variables and thus minimal analytical uncertainty in these data. Specific conductance is inversely related to flow in both data sets. The rise in specific conductance may be partially attributable to the concurrent rise in chloride concentrations. Median specific conductance has risen from 264 to 300 µmho/cm; a 14% increase in a few years' time. Further investigation is underway. PADEP and USGS data confirmed DRBC results.

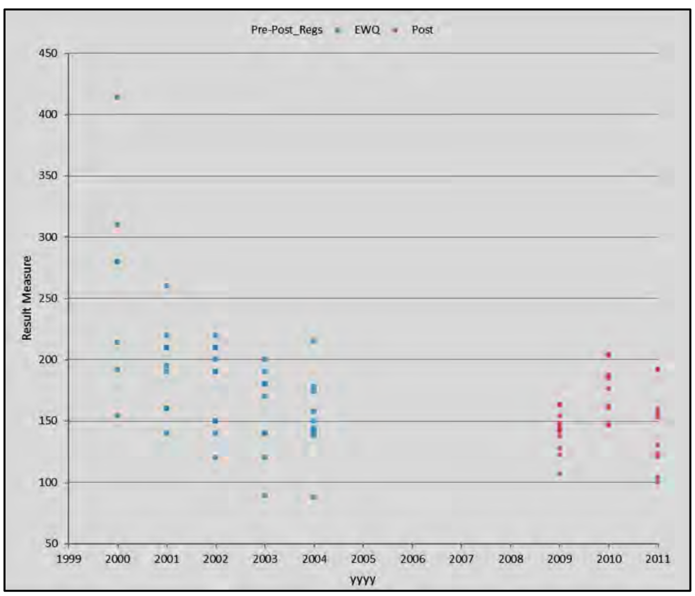
Chapter 17: 1837 BCP Lehigh River, PA

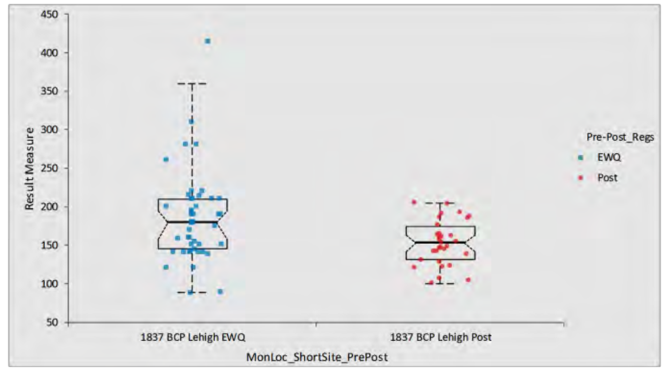
Total Dissolved Solids (TDS) mg/l

Existing Water Quality (Table 2J):

Median 180 mg/l
Lower 95% Confidence Interval 158 mg/l
Upper 95% Confidence Interval 195 mg/l
Defined in regulations as a flow-related parameter

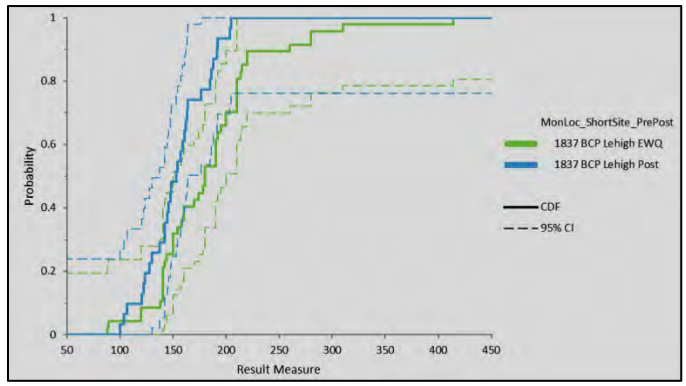






N | 78

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1837 BCP Lehigh EWQ	88	145	180	210	414	65
1837 BCP Lehigh Post	100	132	153	174	204	43



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1837 BCP Lehigh EWQ	47	1522.5	32.39
1837 BCP Lehigh Post	31	2308.3	74.46

H statistic	7.47
X^2 approximation	7.47
DF	1
p-value	0.0063 [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.

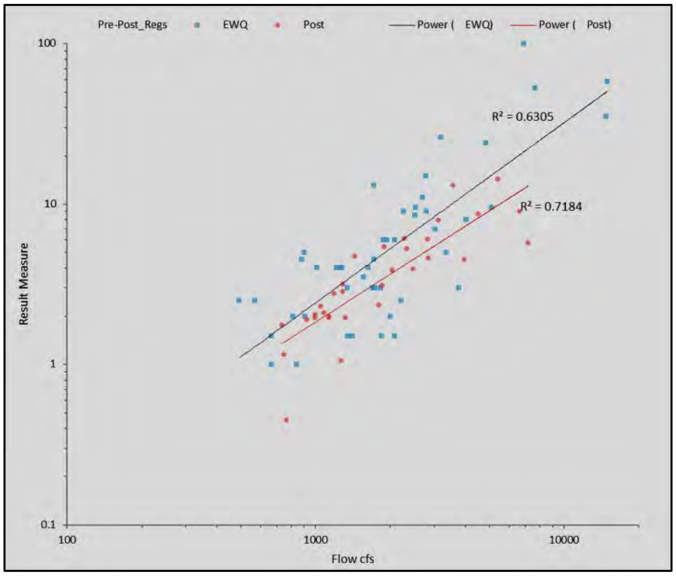
No water quality degradation is evident here. TDS apparently declined between the EWQ and post-EWQ periods. Uncertainty is introduced into analyses by potential laboratory artifacts. TDS is inversely related to flow in both data sets. Post-EWQ median TDS fell below the EWQ lower 95% lower confidence interval, and was 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. PADEP data showed an increase between the two periods – results were comparable with DRBC data in the post-EWQ period, but DRBC EWQ data were more variable, especially in the 2000 data set.

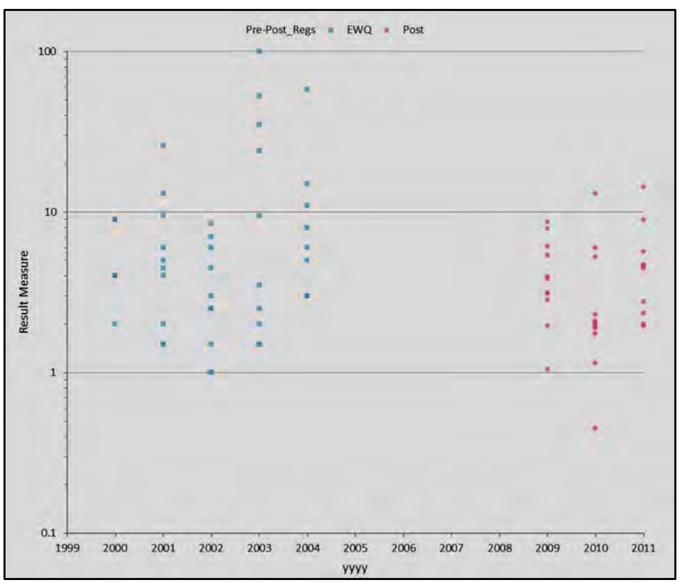
Chapter 17: 1837 BCP Lehigh River, PA

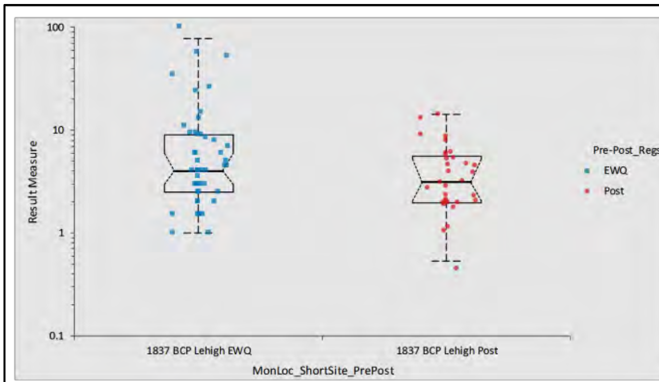
Total Suspended Solids (TSS) mg/l

Existing Water Quality (Table 2J):

Median 4.0 mg/l
Lower 95% Confidence Interval 3.0 mg/l
Upper 95% Confidence Interval 6.0 mg/l
<u>Should have been designated in rules as flow-related</u>

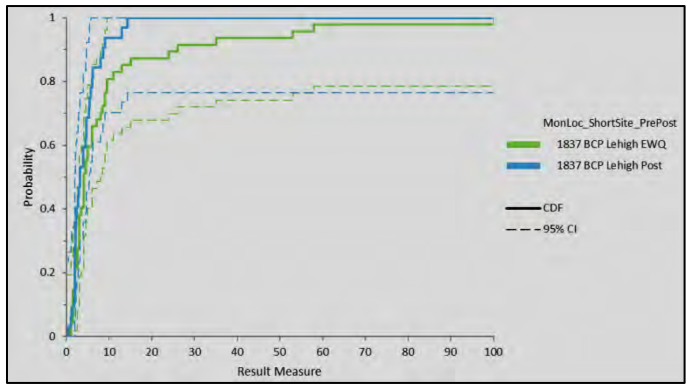






N 79

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1837 BCP Lehigh EWQ	1.0	2.5	4.0	9.0	100.0	6.5
1837 BCP Lehigh Post	0.4	2.0	3.1	5.6	14.3	3.6



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1837 BCP Lehigh EWQ	47	531.1	11.30
1837 BCP Lehigh Post	32	780.1	24.38

H statistic	2.49
X^2 approximation	2.49
DF	1
p-value	0.1144 [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.

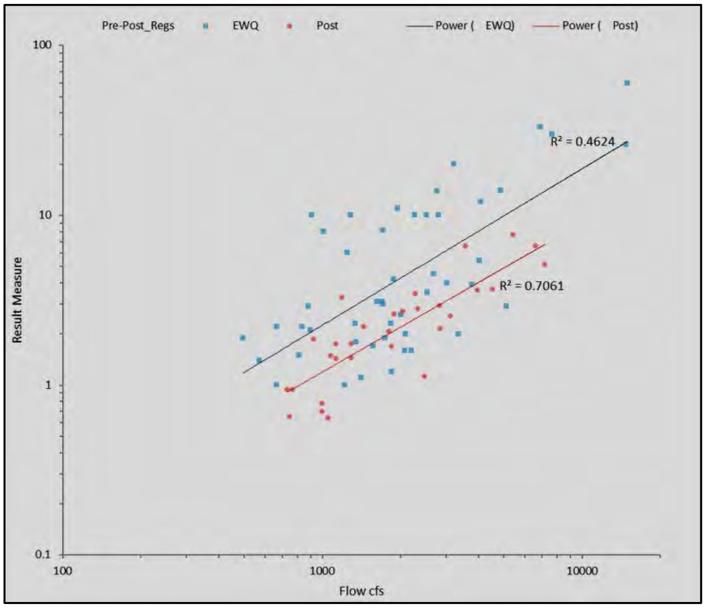
No water quality degradation is evident here. TSS apparently did not measurably change between the EWQ and post-EWQ periods. Uncertainty is introduced into analyses by potential laboratory artifacts. TSS is positively related to flow in both data sets. Post-EWQ median TSS fell near the EWQ lower 95% confidence interval. Flows and concentrations are plotted on a logarithmic scale, and regressions are power relationships. There were insufficient PADEP data available to confirm DRBC results.

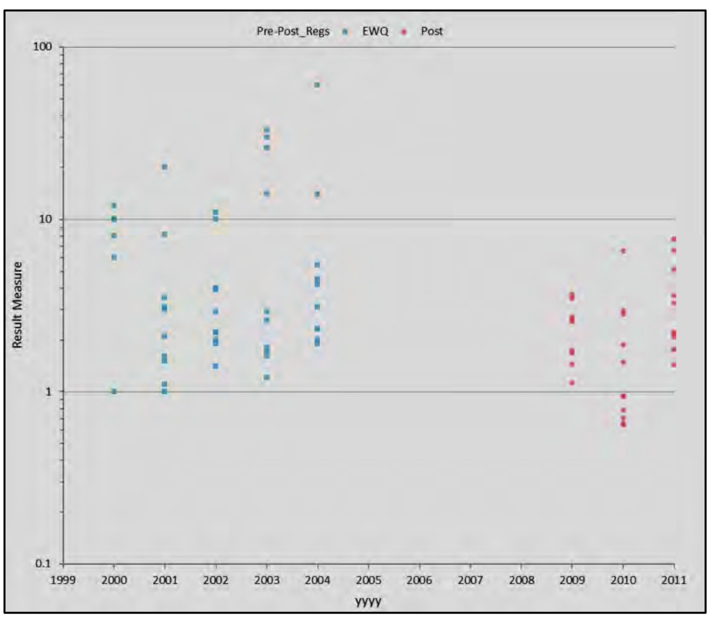
Chapter 17: 1837 BCP Lehigh River, PA

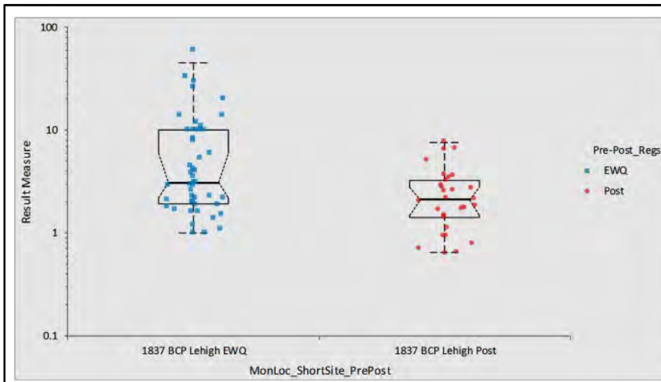
Turbidity NTU

Existing Water Quality (Table 2J):

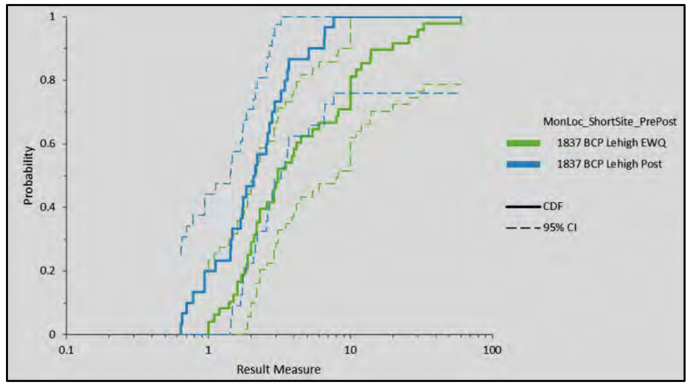
Median 3.1 NTU
Lower 95% Confidence Interval 2.2 NTU
Upper 95% Confidence Interval 6.0 NTU
Defined in regulations as a flow-related parameter







N	78					
Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1837 BCP Lehigh EWQ	1.0	1.9	3.1	10.0	60.0	8.1
1837 BCP Lehigh Post	0.6	1.4	2.1	3.3	7.7	1.9



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1837 BCP Lehigh EWQ	48	1764.2	36.75
1837 BCP Lehigh Post	30	2822.7	94.09

H statistic	8.94
X^2 approximation	8.94
DF	1
p-value	0.0028 [1]

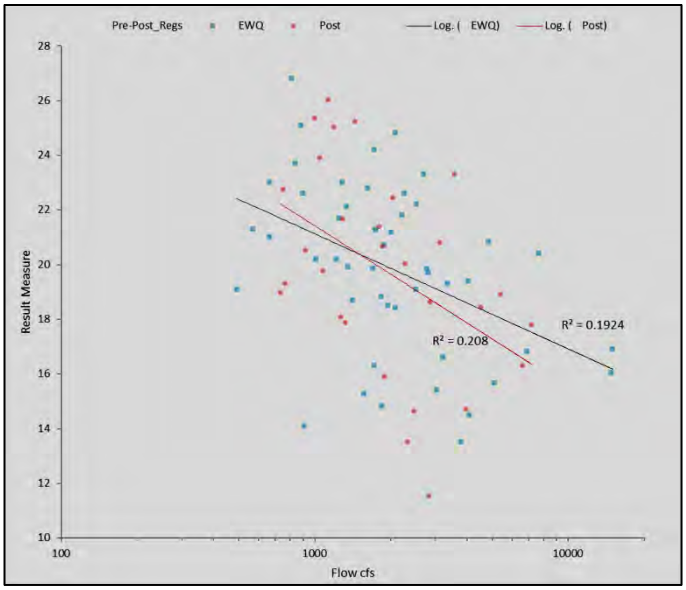
H0: $\theta_1 = \theta_2 = \theta_{...}$
The median of the populations are all equal.
H1: $\theta_i \neq \theta_j$ for at least one i,j
The median of the populations are not all equal.
[1] Reject the null hypothesis in favour of the alternative hypothesis at the 5% significance level.

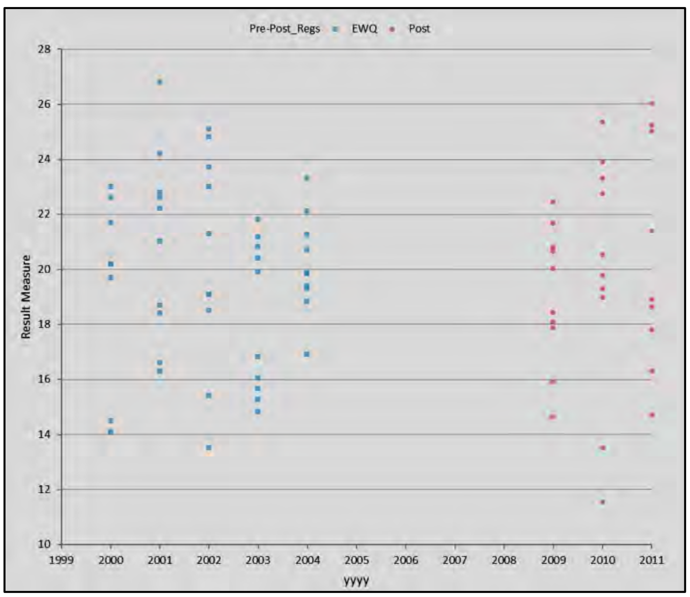
No water quality degradation is evident here. Turbidity measurably declined between the EWQ and post-EWQ periods. Uncertainty in this conclusion was introduced by relatively fewer post-EWQ high-flow samples. The post-EWQ median turbidity fell below the lower EWQ 95% confidence interval. Turbidity is positively related to flow in both data sets. Concentrations and flows are represented on logarithmic scale, and regressions are power relationships. There were no additional data available for comparison with DRBC results. High-flow conditions were under-represented in the post-EWQ sample set, so the apparent decline in turbidity may be because fewer high-flow samples were taken.

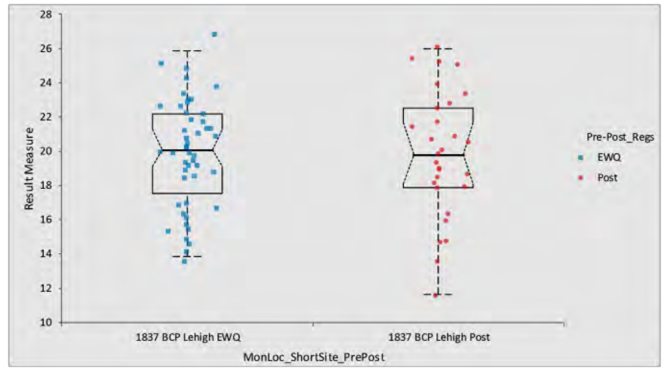
Chapter 17: 1837 BCP Lehigh River, PA

Water Temperature, degrees C

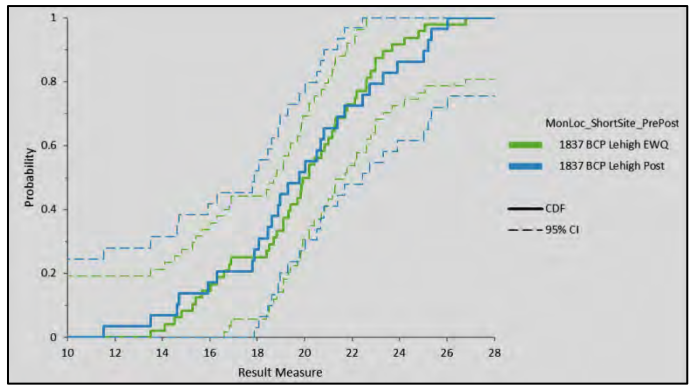
Not included in DRBC Existing Water Quality rules







N	77					
Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1837 BCP Lehigh EWQ	13.5	17.5	20.1	22.2	26.8	4.6
1837 BCP Lehigh Post	11.5	17.9	19.8	22.5	26.0	4.7



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1837 BCP Lehigh EWQ	48	7.1	0.15
1837 BCP Lehigh Post	29	11.8	0.41

H statistic	0.04
X² approximation	0.04
DF	1
p-value	0.8458 [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.

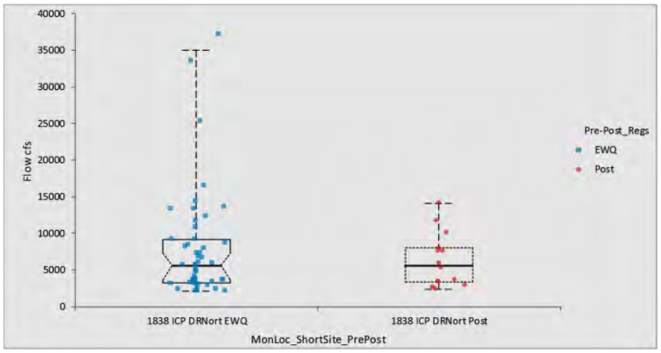
[1] Do not reject the null hypothesis at the 5% significance level.

No water quality degradation is evident here. Water temperature did not measurably change between the EWQ and post-EWQ periods. There were no known uncontrolled variables in these data, so there is minimal analytical uncertainty. Water temperature is weakly related to flow in both data sets. Flow is plotted on a logarithmic scale. PADEP and USGS data were available and confirmed DRBC results.

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.

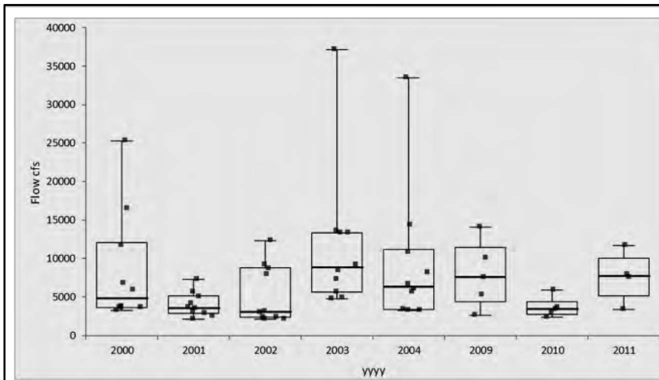
Kruskal-Wallis test

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

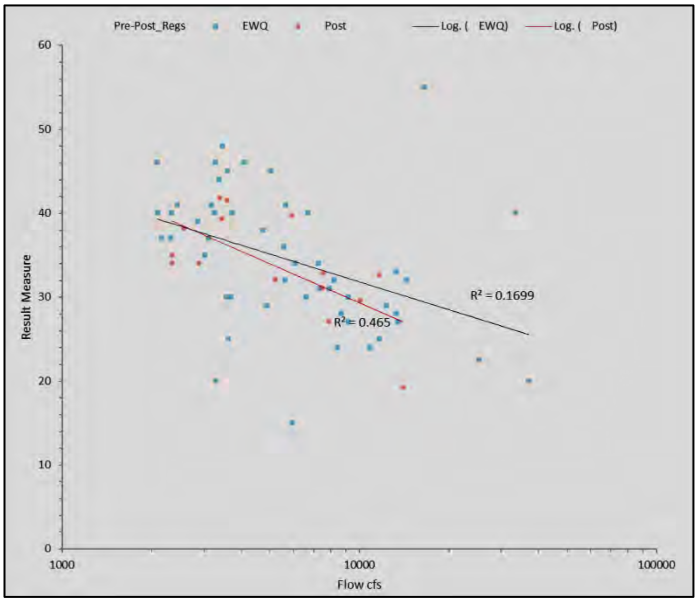
Remaining upstream tributaries are less than 20 square miles watershed size, and are not expected to have major water quality effects upon the Delaware River.

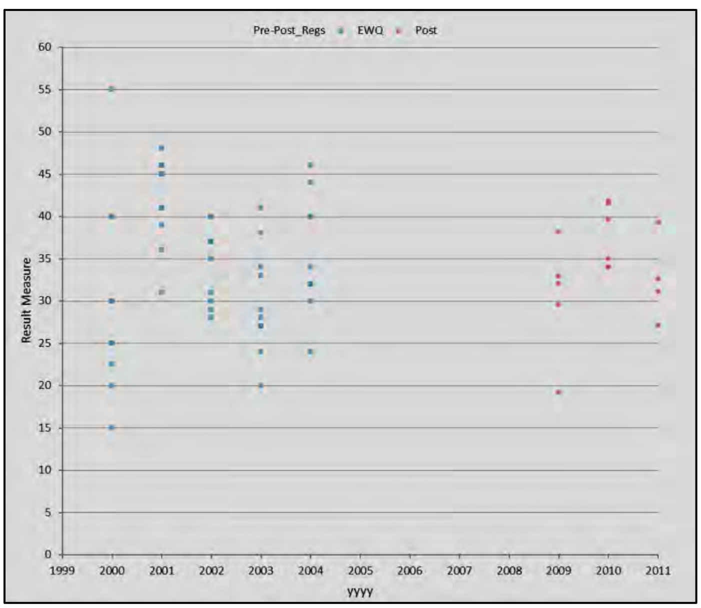
Chapter 18: 1838 ICP Delaware River at Easton

Alkalinity as CaCO3, Total mg/l

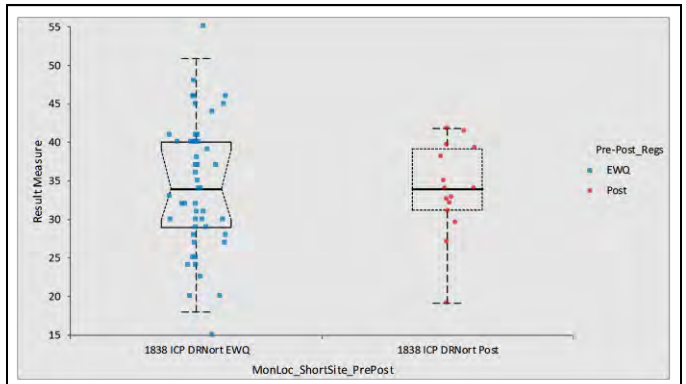
Existing Water Quality (Table 2I):

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



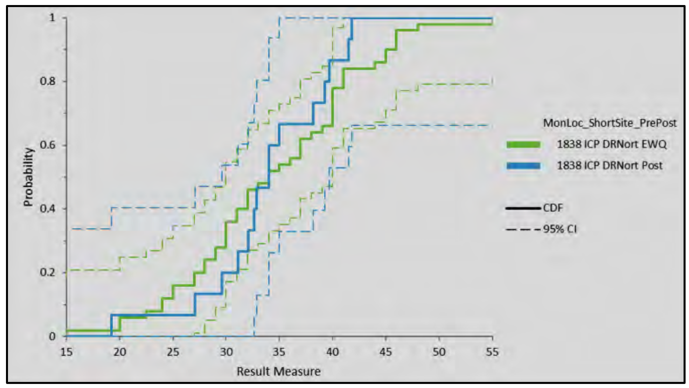


No water quality degradation is evident here. Alkalinity apparently did not measurably change between the EWQ and post-EWQ periods.



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
X² approximation	0.00
DF	1
p-value	0.9689 [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.

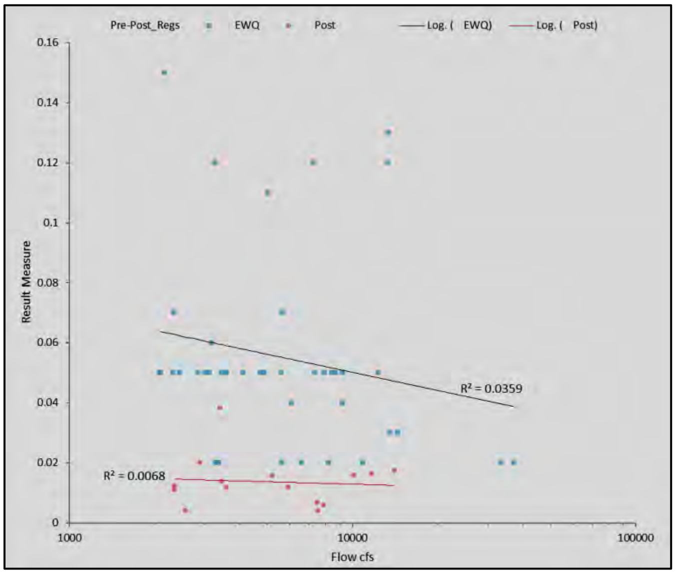
Sources of analytical uncertainty included potential laboratory artifacts, insufficient post-EWQ sampling frequency, and post-EWQ under-representation of flow conditions. Alkalinity is inversely related to flow in both data sets, though weakly in the EWQ period. Post-EWQ median alkalinity fell within 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.

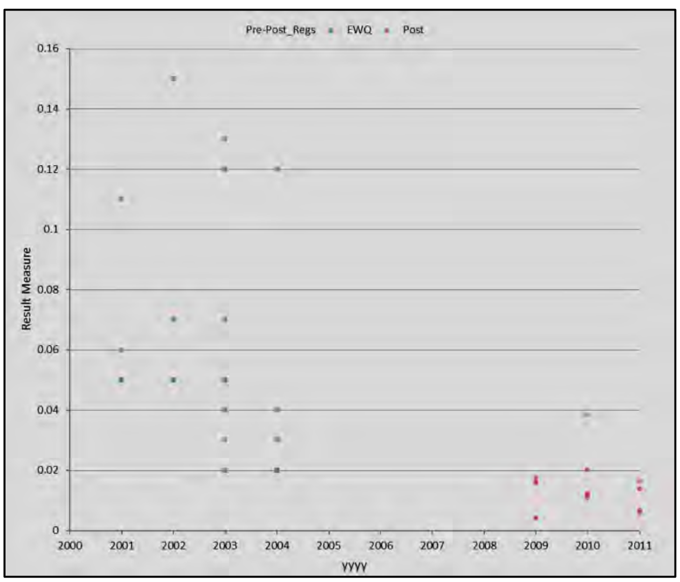
Chapter 18: 1838 ICP Delaware River at Easton

Ammonia Nitrogen as N, Total mg/l

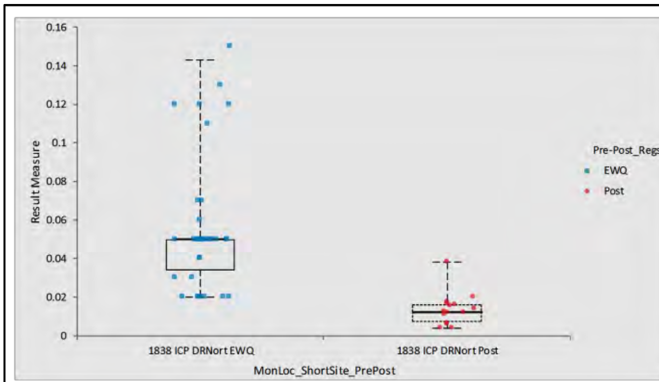
Existing Water Quality (Table 2I):

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



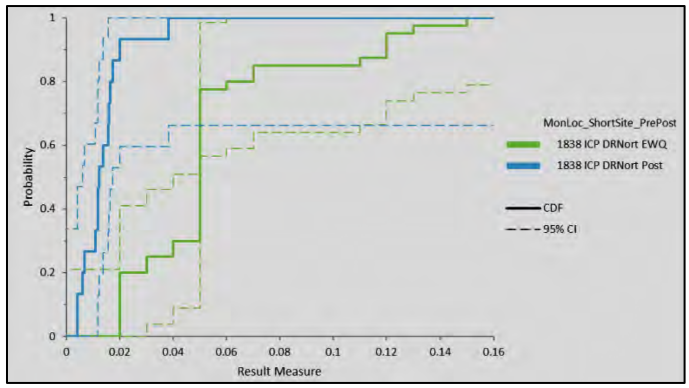


No water quality degradation is evident here. Ammonia concentrations apparently declined. Sources of analytical uncertainty included potential laboratory artifacts, detection limit differences, insufficient post-EWQ sampling frequency, and post-EWQ under-representation of flow conditions.



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
X^2 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.

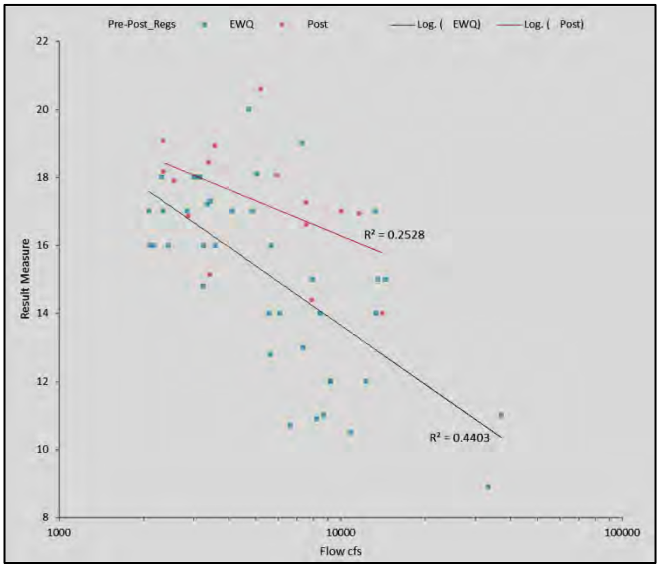
Post-EWQ median ammonia concentration was below the EWQ lower 95% confidence interval. We were better able to measure ammonia in the post-EWQ period due to improved detection limits. No independent data were available to validate DRBC results. Flow is plotted on a logarithmic scale. EWQ data possessed 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.

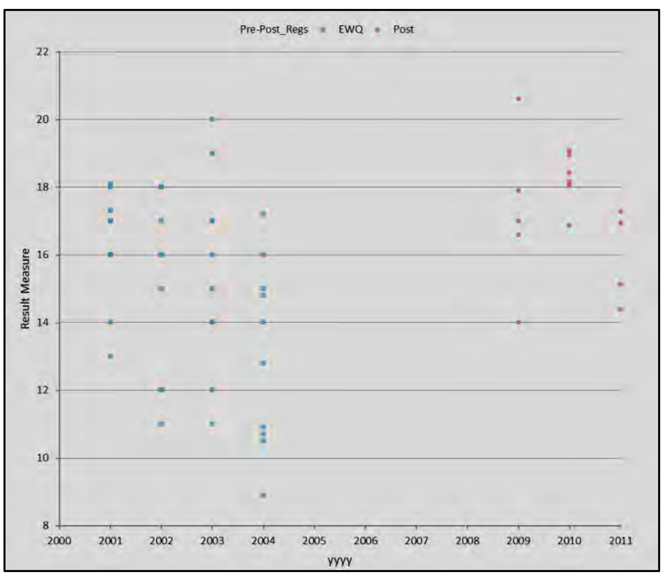
Chapter 18: 1838 ICP Delaware River at Easton

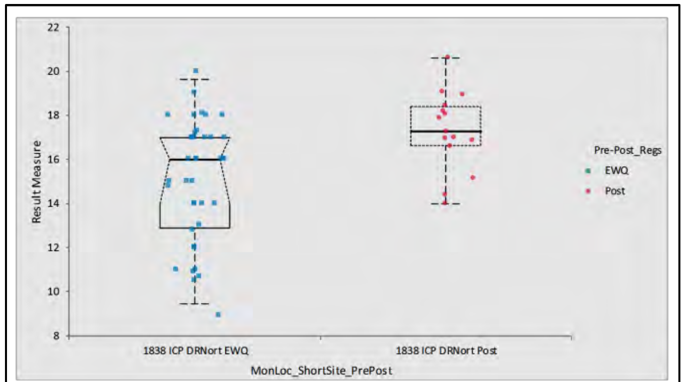
Chloride, Total mg/l

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

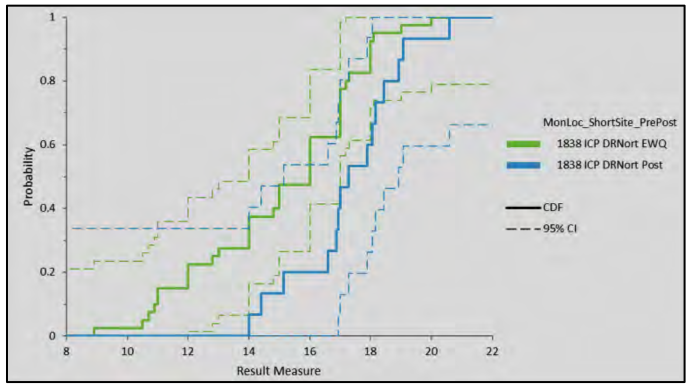






N 55

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.

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.

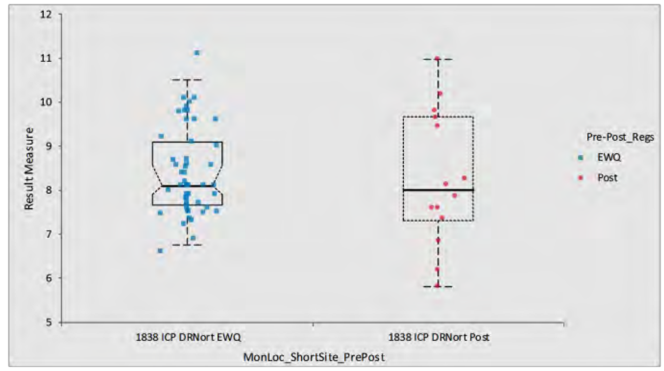
Post-EWQ median chlorides rose to the EWQ upper 95% confidence interval. Chloride concentration is related to flow in the EWQ data, but weakly related to flow in the post-EWQ data due to too few post-EWQ samples (n=15). Higher flow conditions were not well-represented in post-EWQ data, so there were 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

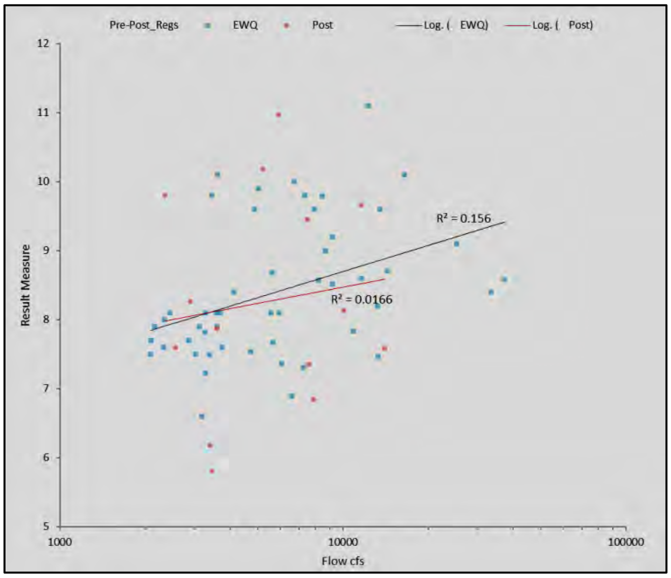
Dissolved Oxygen (DO) mg/l

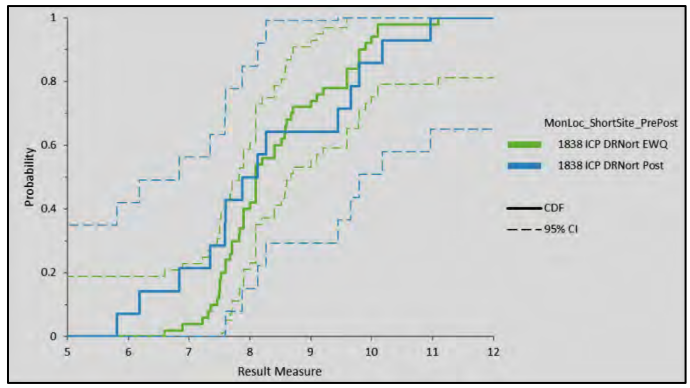
Existing Water Quality (Table 2I):

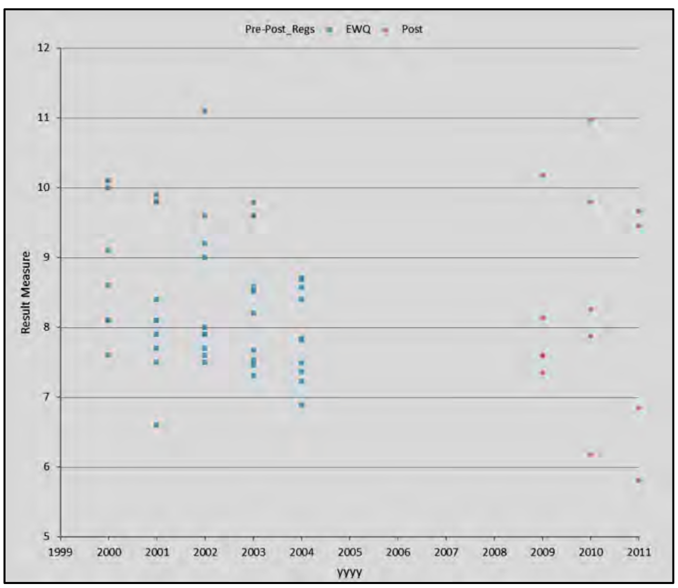
Median 8.10 mg/l
Lower 95% Confidence Interval 7.90 mg/l
Upper 95% Confidence Interval 8.58 mg/l



Result Measure by MonLoc_ShortSite_PrePost	N	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
	64						
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
X² approximation	0.22
DF	1
p-value	0.6375 [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.

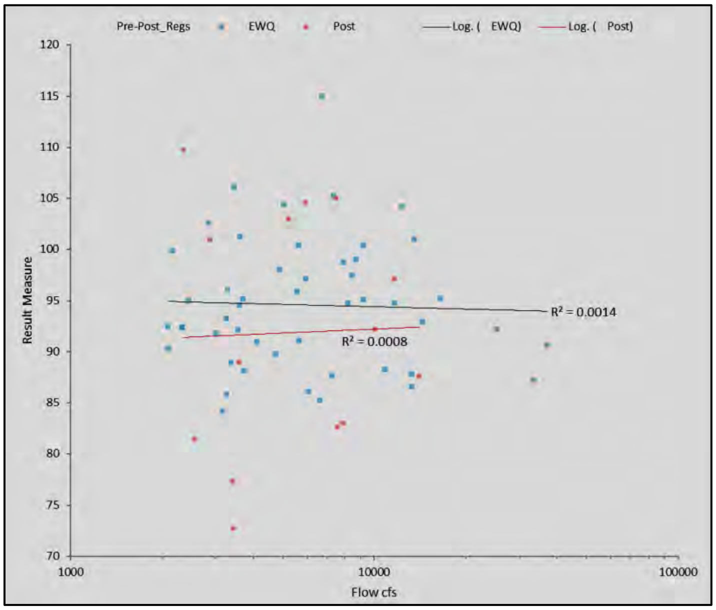
No water quality degradation is evident here. No measurable change took place between the EWQ and Post-EWQ periods. Post-EWQ median DO concentration fell within the EWQ 95% confidence intervals. There were too few post-EWQ samples collected (n=14). DO concentration is unrelated to flow in both data sets.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

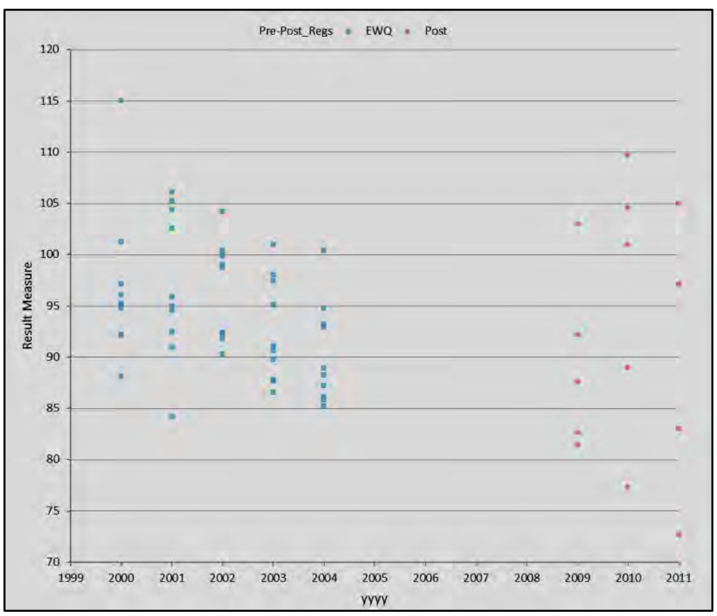
Chapter 18: 1838 ICP Delaware River at Easton

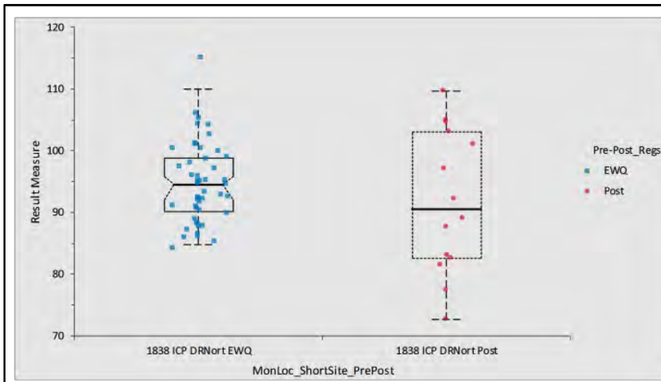
Dissolved Oxygen Saturation %

Existing Water Quality (Table 2I):

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

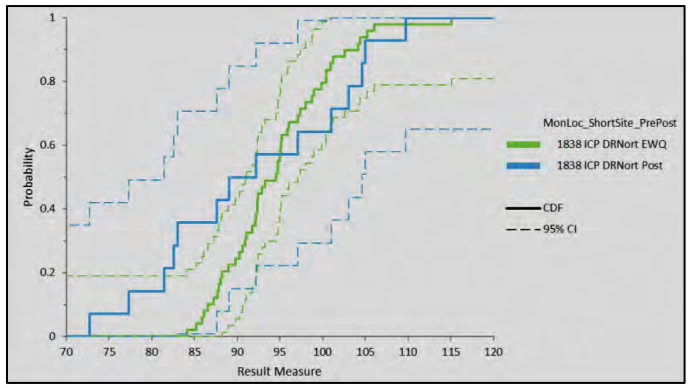






N | 63

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
X² approximation	0.63
DF	1
p-value	0.4275 [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.

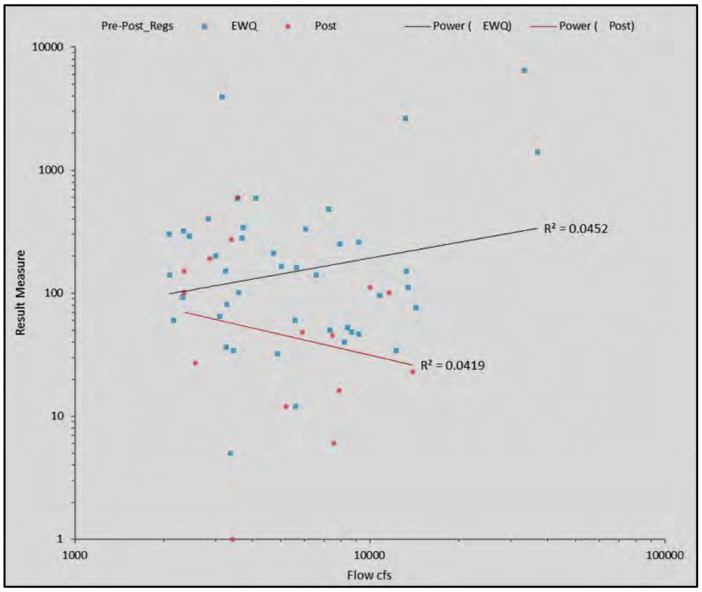
No water quality degradation is evident here. Dissolved Oxygen Saturation is unrelated to flow, and did not measurably change between the EWQ and post-EWQ periods. Analytical uncertainty sources included insufficient post-EWQ sampling frequency. Post-EWQ median DO saturation fell below the lower EWQ 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.

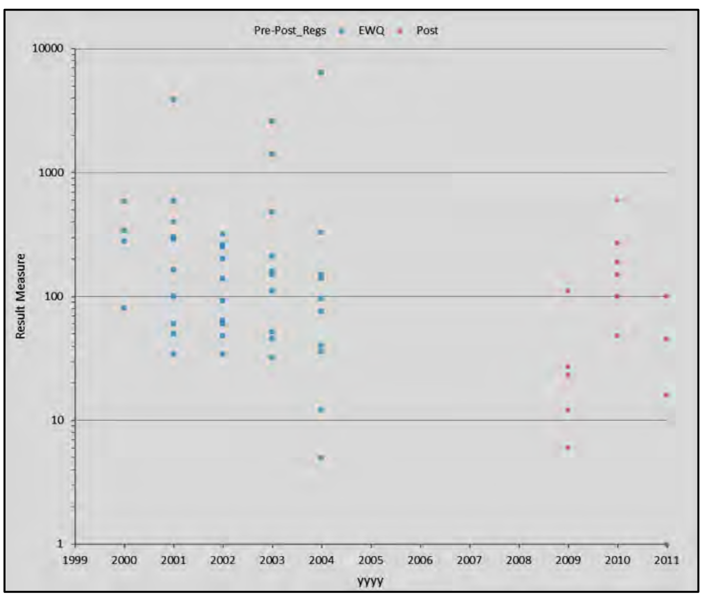
Chapter 18: 1838 ICP Delaware River at Easton

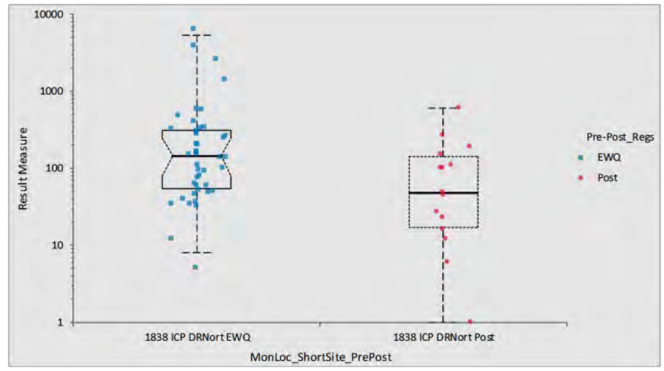
Enterococcus colonies/100 ml

Existing Water Quality (Table 2I):

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

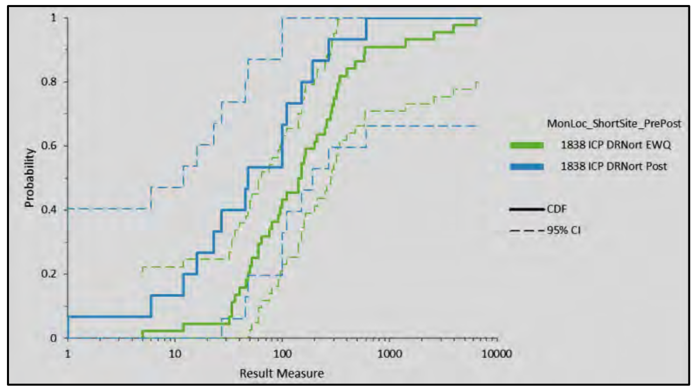






N 59

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
X² 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.

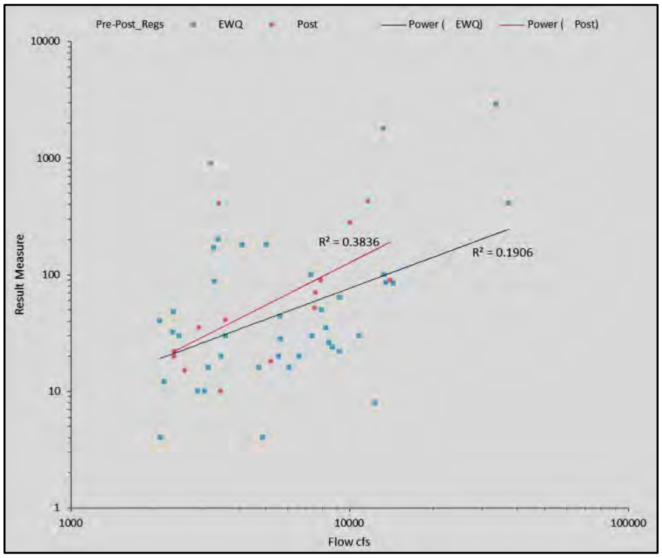
No water quality degradation is evident here. Enterococci apparently declined between the EWQ and Post-EWQ periods. Analytical uncertainty sources included potential laboratory artifacts, insufficient post-EWQ sampling frequency, and flow differences. Enterococcus concentrations are unrelated to flow 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.

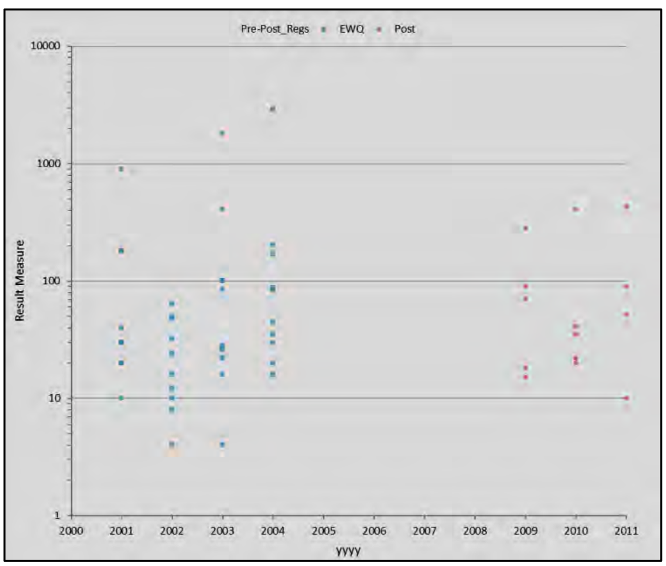
Chapter 18: 1838 ICP Delaware River at Easton

Escherichia coli colonies/100 ml

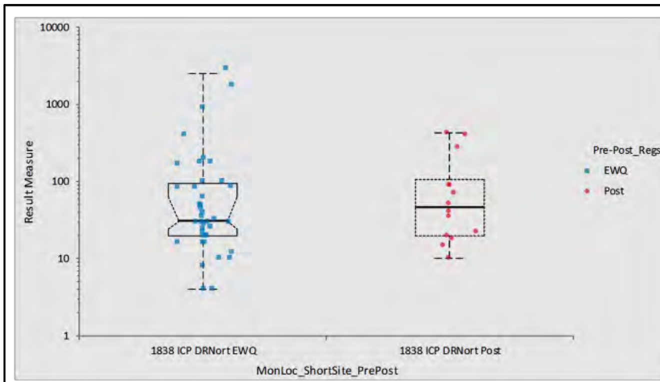
Existing Water Quality (Table 2I):

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



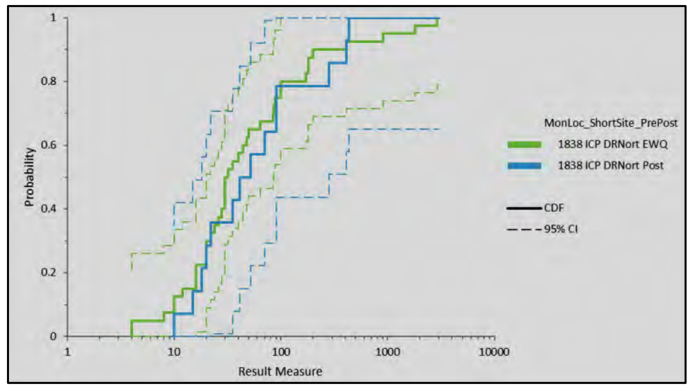


No water quality degradation is evident here. E. coli concentrations apparently did not measurably change between the EWQ and Post-EWQ periods. Analytical uncertainty sources included potential laboratory artifacts, insufficient post-EWQ sampling frequency, and flow differences.



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
X^2 approximation	0.33
DF	1
p-value	0.5668 [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.

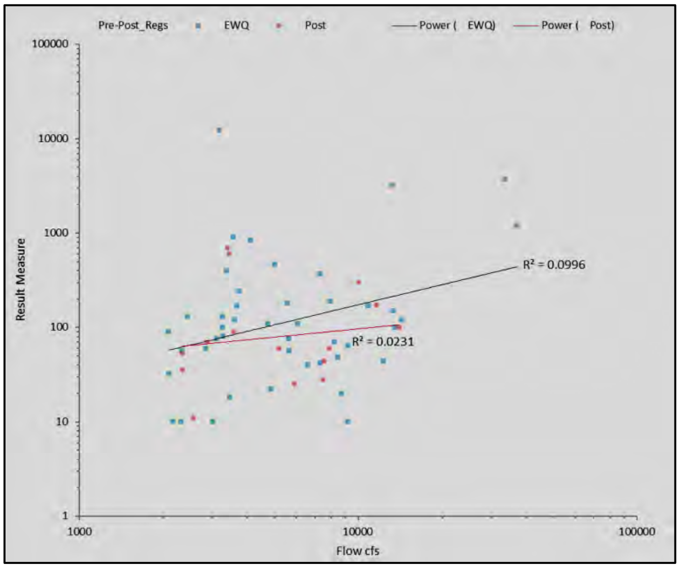
Post-EWQ median E. coli fell within the EWQ 95% confidence intervals. Concentrations and flows are plotted on logarithmic scale, and regressions are power relationships. E. coli concentrations are very weakly related to flow in the EWQ data set, but positively related to flow in the post-EWQ data set.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

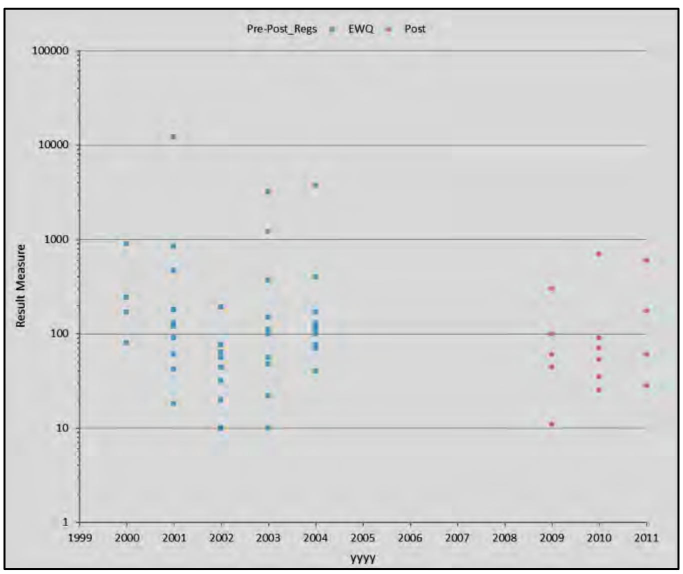
Chapter 18: 1838 ICP Delaware River at Easton

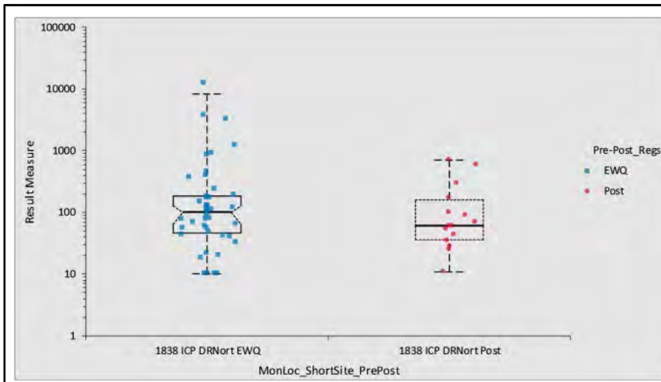
Fecal coliform colonies/100 ml

Existing Water Quality (Table 2I):

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

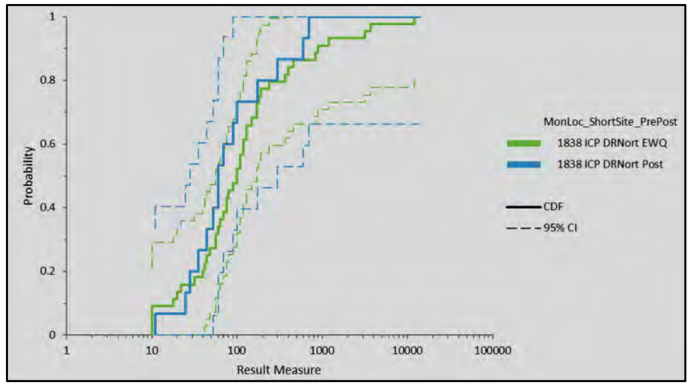






N 59

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
X² 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.

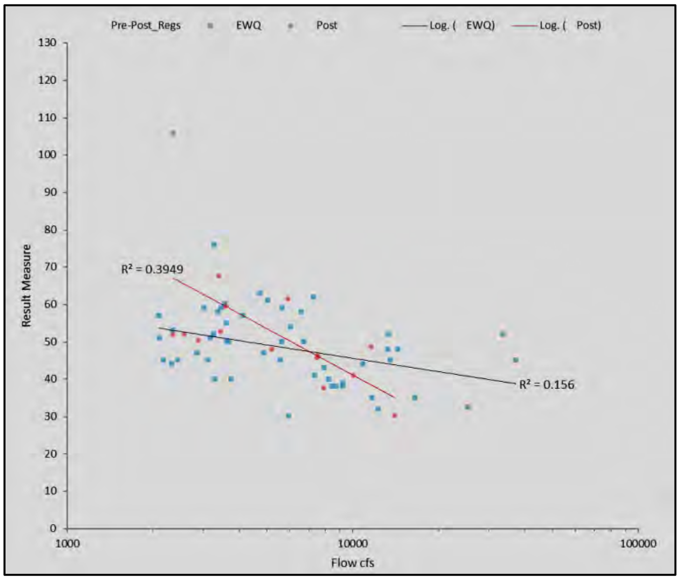
No water quality degradation is evident here. Fecal coliform concentrations apparently fell below the lower EWQ 95% confidence interval, but did not measurably change between the EWQ and post-EWQ periods. Analytical uncertainty sources included laboratory artifacts, insufficient post-EWQ sampling frequency (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.

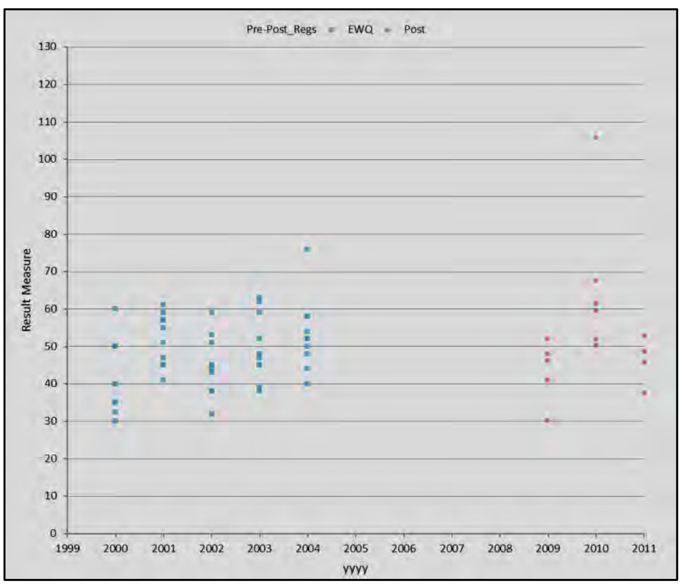
Chapter 18: 1838 ICP Delaware River at Easton

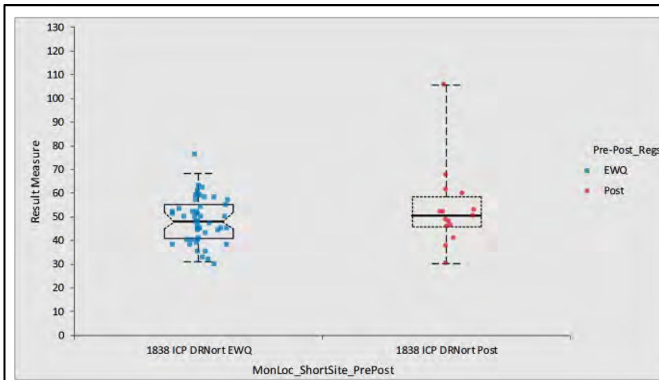
Hardness as CaCO3, Total mg/l

Existing Water Quality (Table 2I):

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

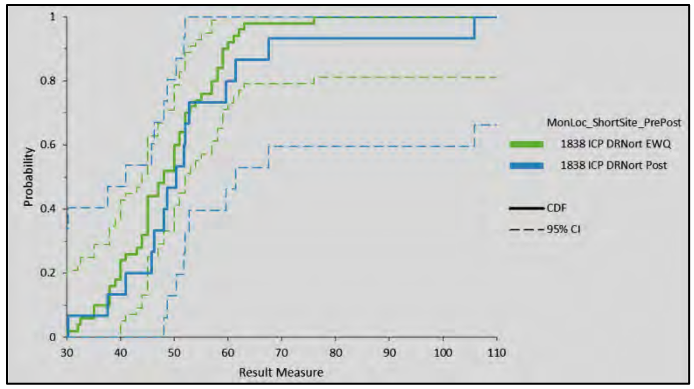






N 65

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
X^2 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.

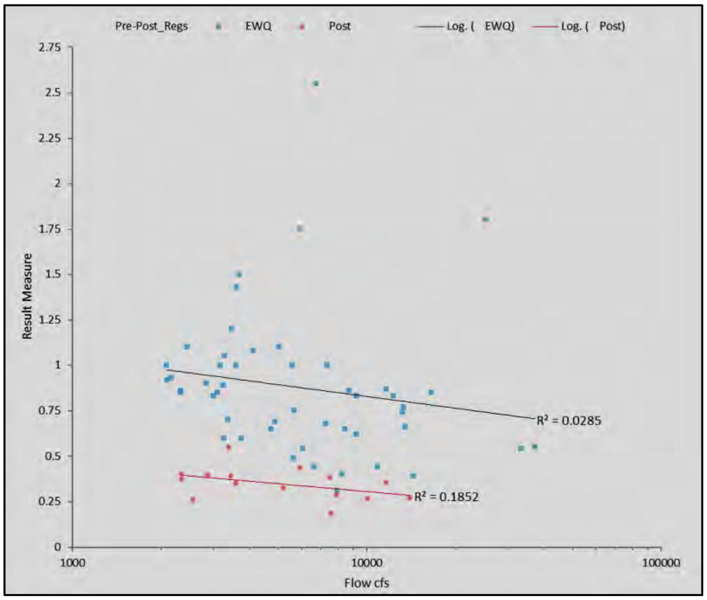
No water quality degradation is evident here. Hardness apparently did not measurably change between the EWQ and post-EWQ periods. Analytical uncertainty sources included potential laboratory artifacts, insufficient post-EWQ sampling frequency, and flow differences. Hardness is weakly related to flow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

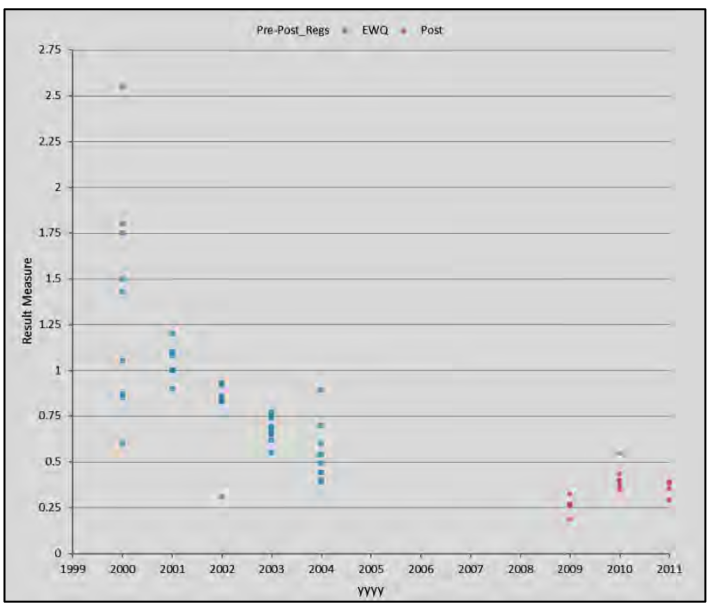
Chapter 18: 1838 ICP Delaware River at Easton

Nitrate + Nitrite as N, Total mg/l

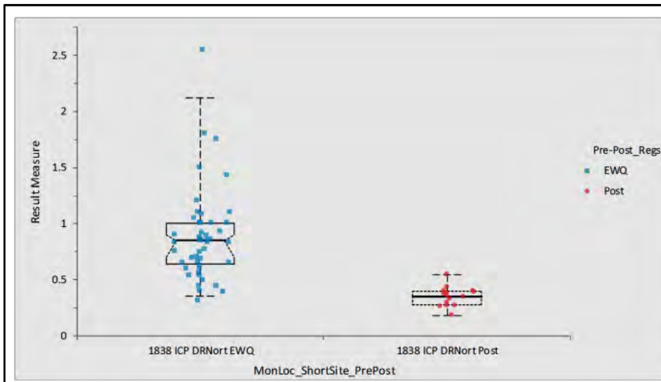
Existing Water Quality (Table 2I, as Nitrate only):

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



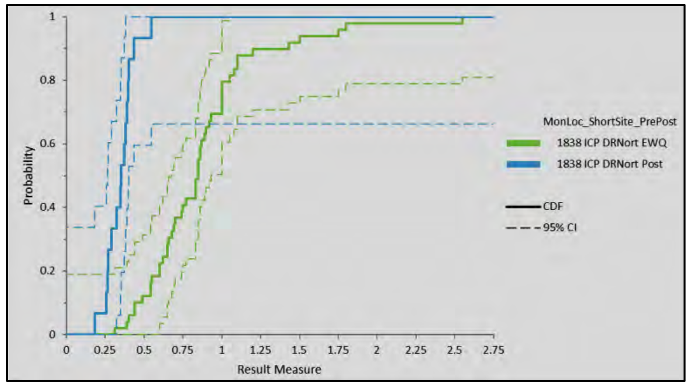


No water quality degradation is evident here. Nitrate concentrations apparently declined between the EWQ and post-EWQ periods. Analytical uncertainty sources included potential laboratory artifacts, detection limit differences, insufficient post-EWQ sampling frequency, and flow differences.



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.

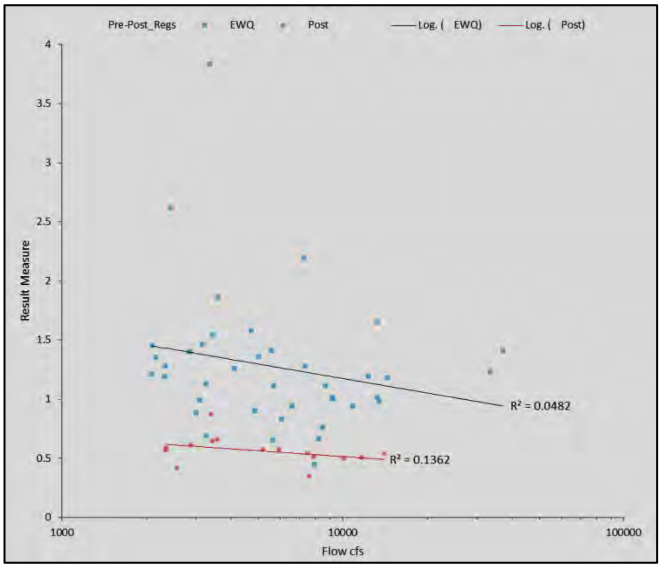
Nitrate is unrelated to flow in both data sets. Post-EWQ nitrate concentrations fell below the lower EWQ 95% confidence interval. Post-EWQ nitrate + nitrite concentrations were assumed equivalent for comparison with EWQ nitrate concentrations since EWQ nitrite concentrations were never detected. Independent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

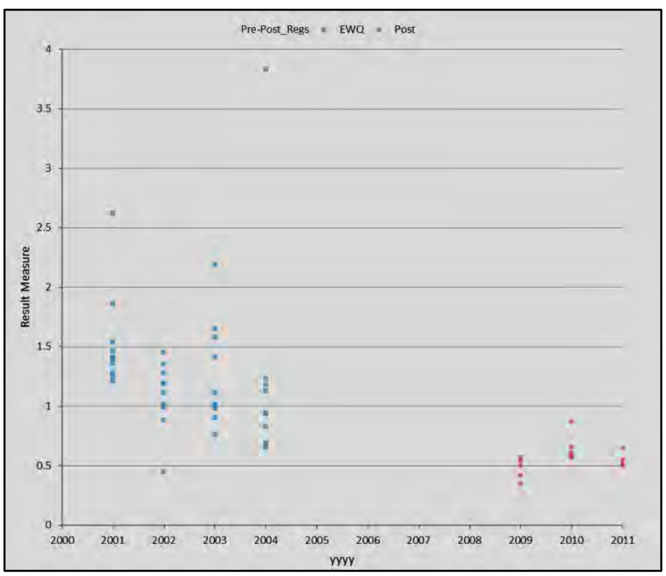
Chapter 18: 1838 ICP Delaware River at Easton

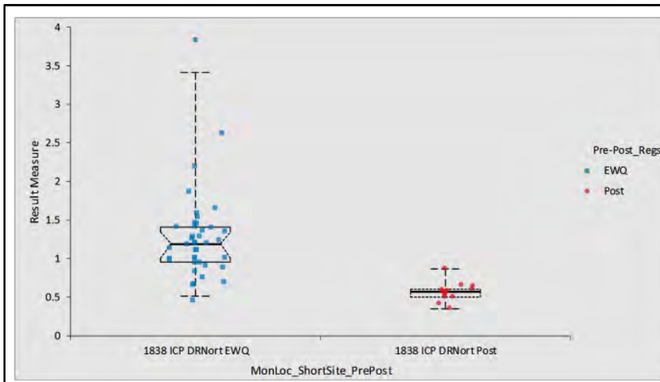
Nitrogen as N, Total (TN) mg/l

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

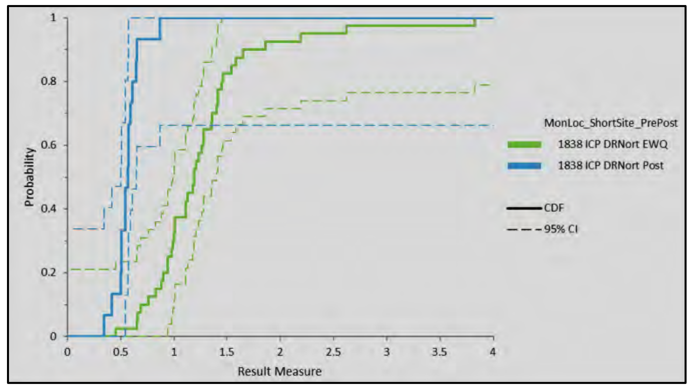






N 55

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
X^2 approximation	28.21
DF	1
p-value	<0.0001 [1]

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

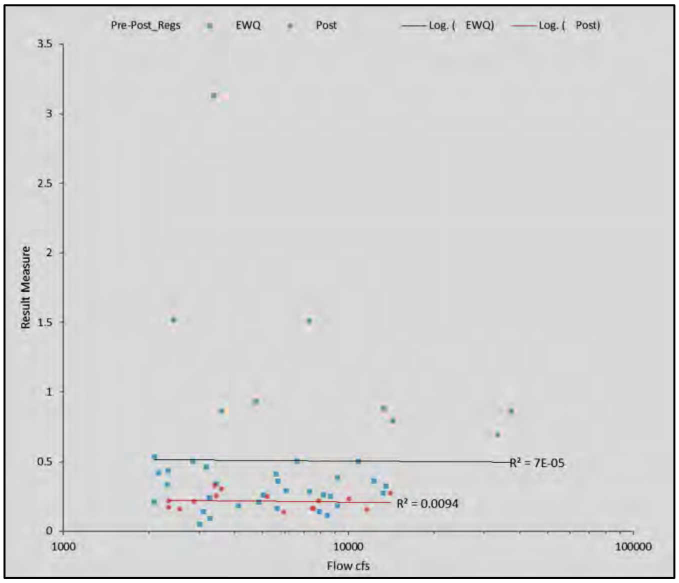
No water quality degradation is evident here. Total Nitrogen concentrations apparently declined between the EWQ and post-EWQ periods. Analytical uncertainty sources included potential laboratory artifacts, detection limit differences, insufficient post-EWQ sampling frequency, and flow differences. TN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

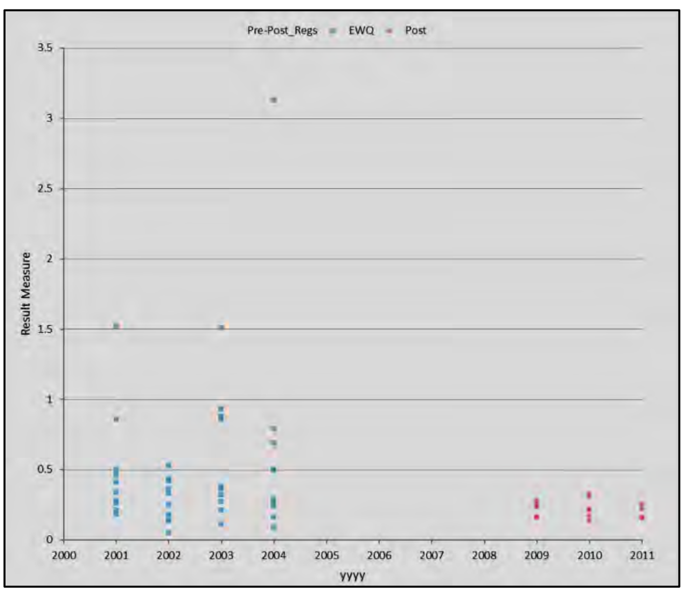
Chapter 18: 1838 ICP Delaware River at Easton

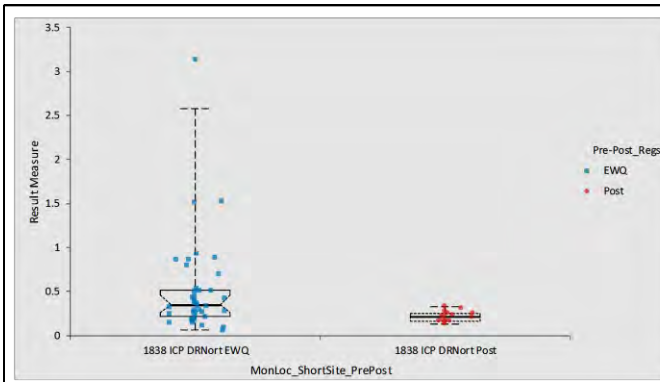
Nitrogen, Kjeldahl as N, Total (TKN) mg/l

Existing Water Quality (Table 2I):

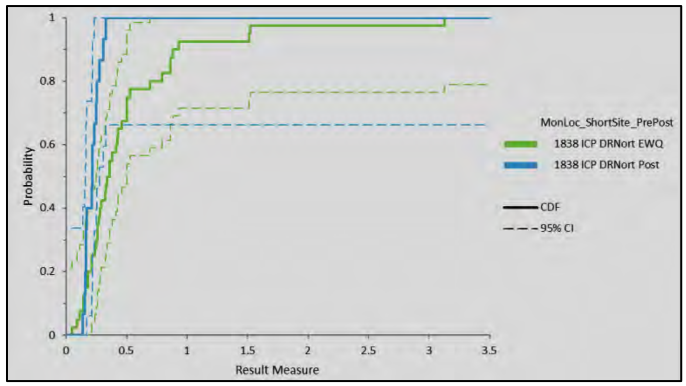
Median 0.35 mg/l
Lower 95% Confidence Interval 0.26 mg/l
Upper 95% Confidence Interval 0.46 mg/l







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.

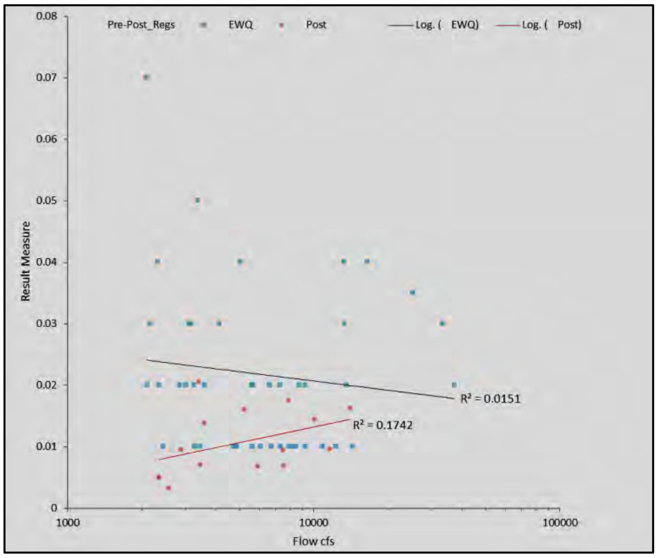
No water quality degradation is evident here. TKN concentrations apparently declined between the EWQ and post-EWQ periods. However, analytical uncertainty sources included potential laboratory artifacts, insufficient post-EWQ sampling frequency, and flow differences. The post-EWQ range was far narrower 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.

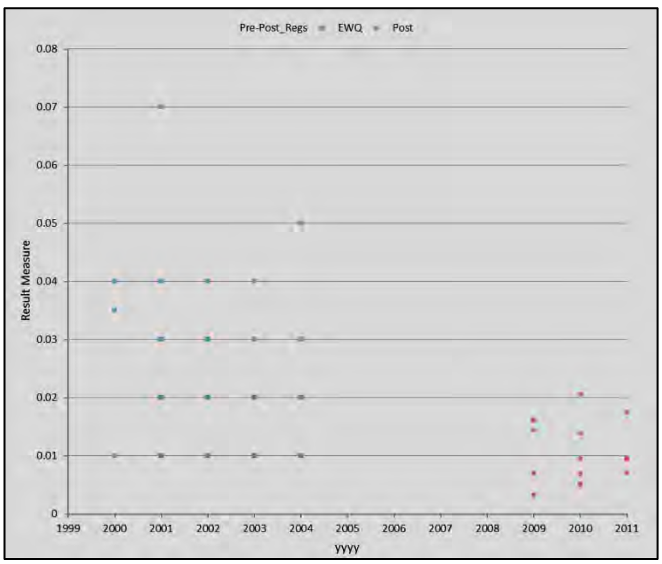
Chapter 18: 1838 ICP Delaware River at Easton

Orthophosphate as P, Total mg/l (OP)

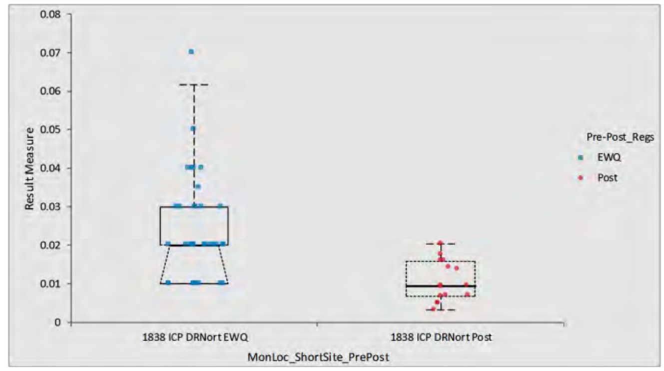
Existing Water Quality (Table 2I):

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



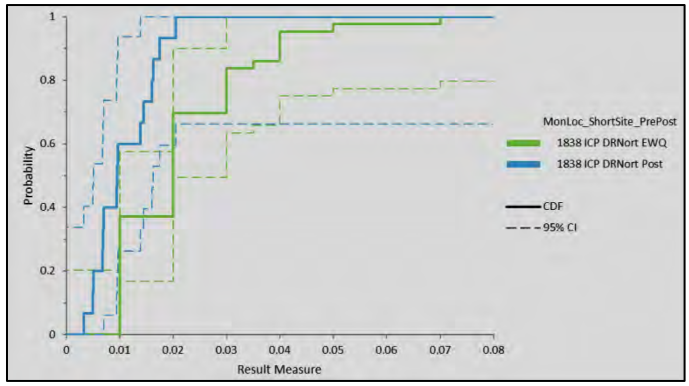


No water quality degradation is evident here. OP concentrations apparently declined between the EWQ and post-EWQ periods. However, analytical uncertainty sources included potential laboratory artifacts, detection limit differences, insufficient post-EWQ sampling frequency, and flow differences.



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.

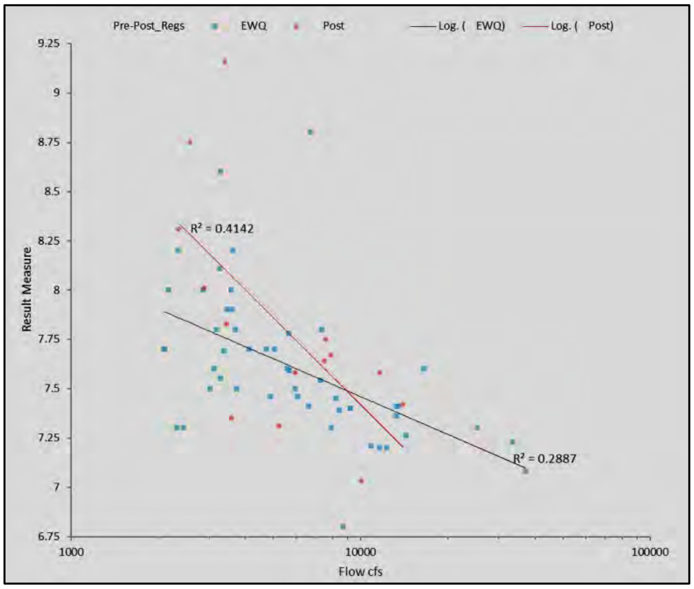
OP is unrelated to flow in both data sets. Post-EWQ median orthophosphate fell to the EWQ lower 95% confidence interval. This may indicate a water quality improvement in that there were no post-EWQ concentrations higher than 0.02 mg/l, but could also be a laboratory artifact. The EWQ orthophosphate undetected 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.

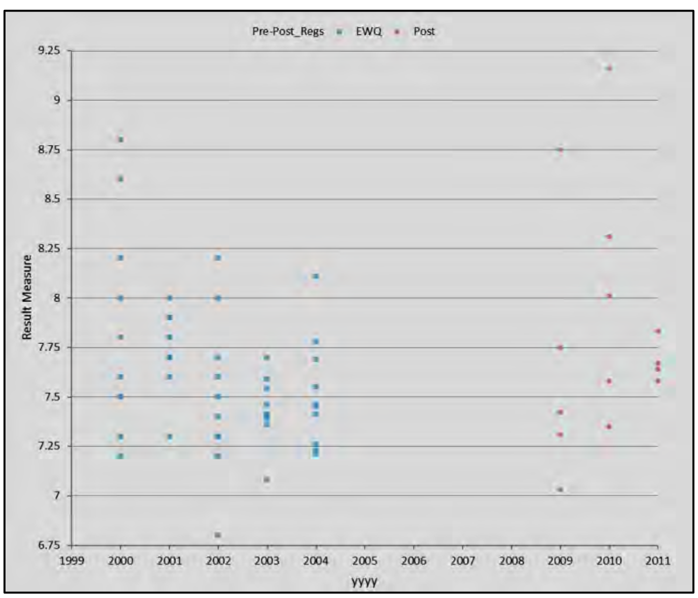
Chapter 18: 1838 ICP Delaware River at Easton

pH

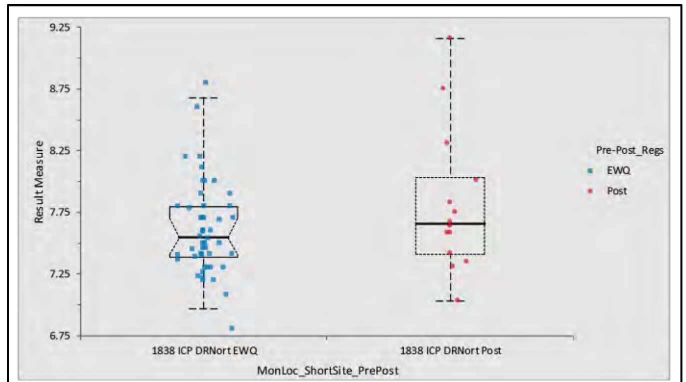
Existing Water Quality (Table 2I):

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



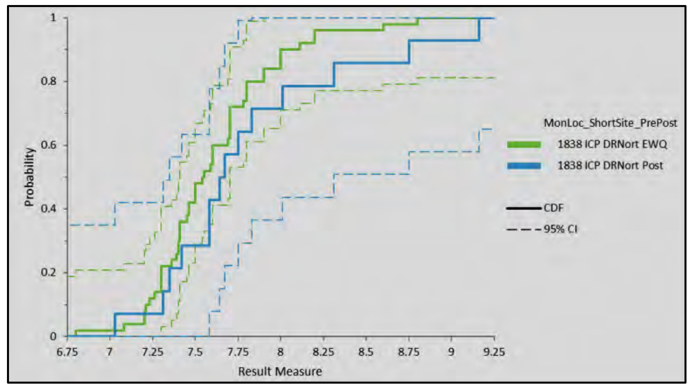


No water quality degradation is evident here. pH apparently did not measurably change between the EWQ and post-EWQ periods. However, analytical uncertainty sources included insufficient post-EWQ sampling frequency and flow differences.



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
X² 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.

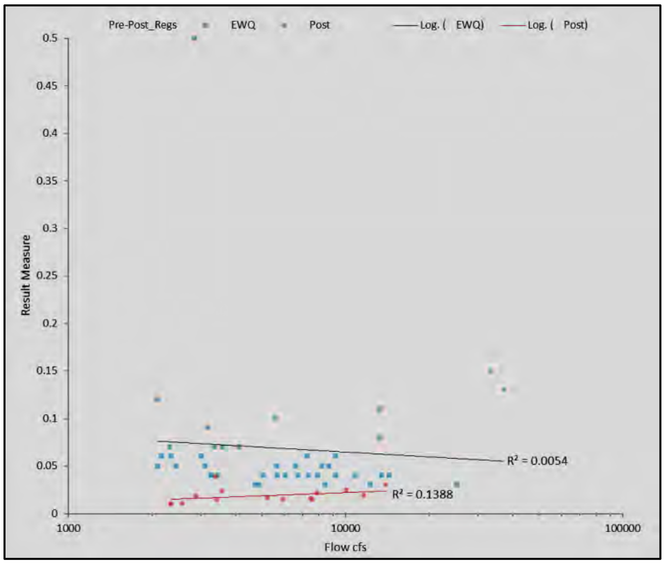
pH is weakly related to flow in the EWQ data set and inversely related to flow in the post-EWQ data. pH tends toward neutral at higher flow conditions. Post-EWQ median pH was near the upper EWQ 95% confidence interval, but there were too few data (n=14) to measure a true difference. In July 2010 there 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.

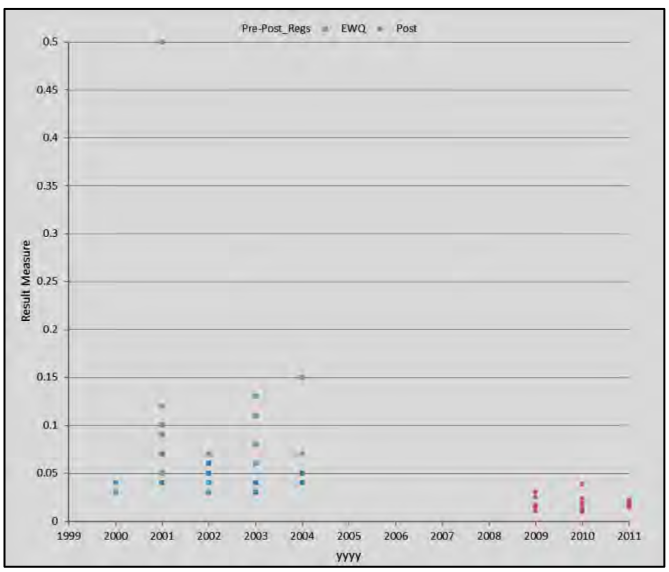
Chapter 18: 1838 ICP Delaware River at Easton

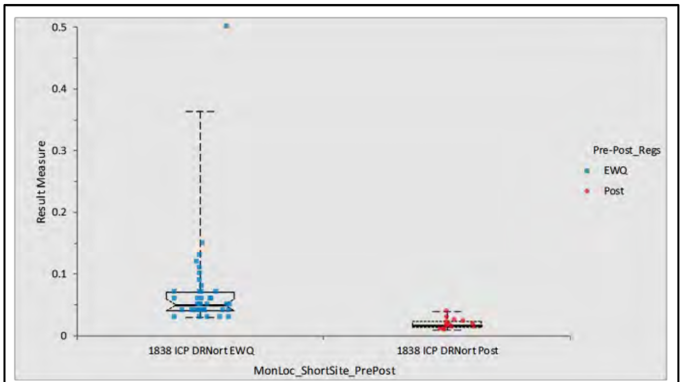
Phosphorus as P, Total (TP) mg/l

Existing Water Quality (Table 2I):

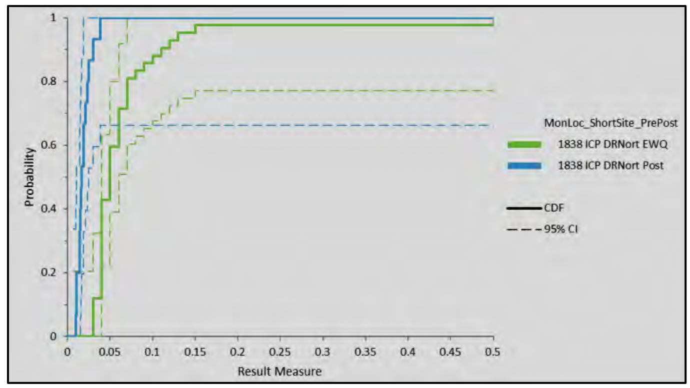
Median 0.05 mg/l
Lower 95% Confidence Interval 0.04 mg/l
Upper 95% Confidence Interval 0.06 mg/l







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.

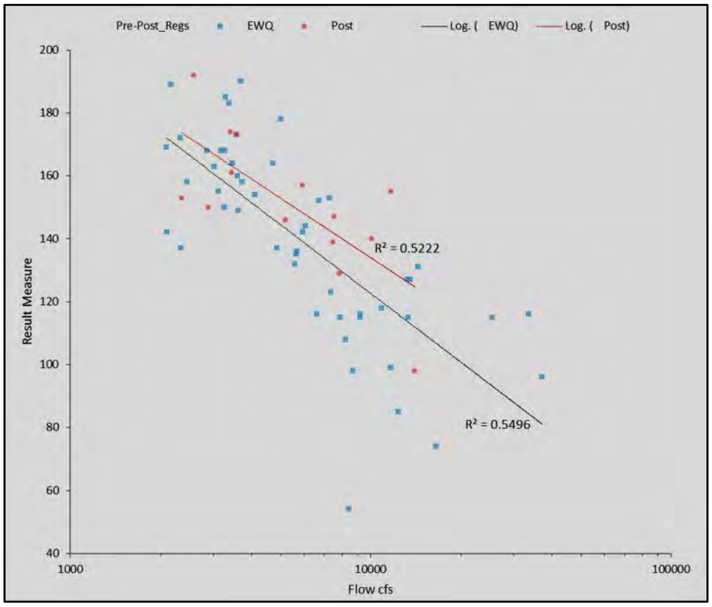
No water quality degradation is evident here. Total Phosphorus (TP) concentrations apparently declined between the EWQ and post-EWQ periods. However, analytical uncertainty sources included potential laboratory artifacts, detection limit differences, insufficient post-EWQ sampling frequency, and flow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

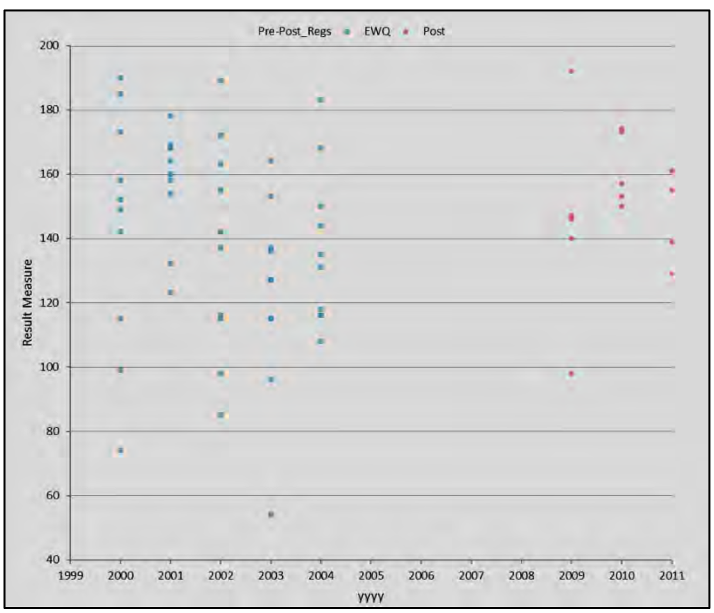
Chapter 18: 1838 ICP Delaware River at Easton

Specific Conductance µmho/cm

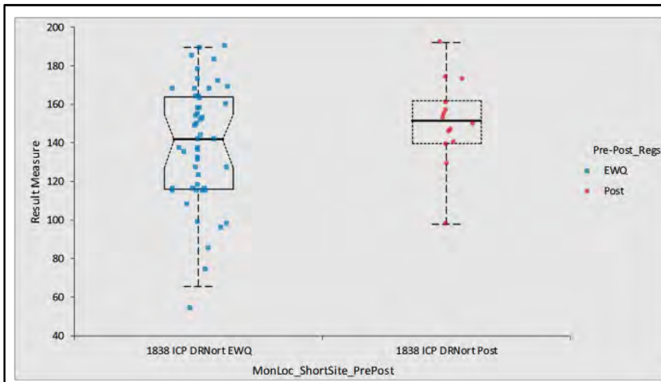
Existing Water Quality (Table 2I):

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



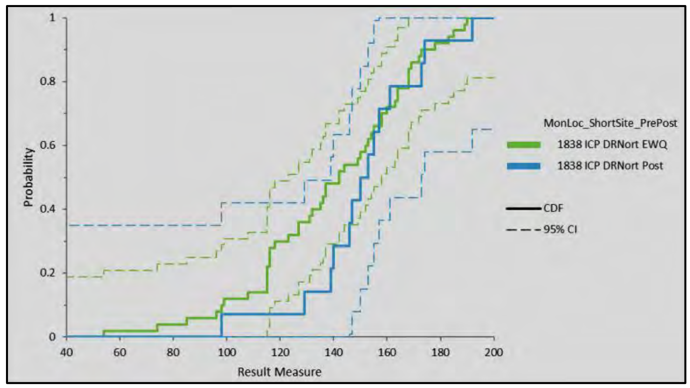


No water quality degradation is evident here. Specific conductance apparently did not measurably change between the EWQ and post-EWQ periods. However, analytical uncertainty sources included insufficient post-EWQ sampling frequency and flow differences.



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
X^2 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.

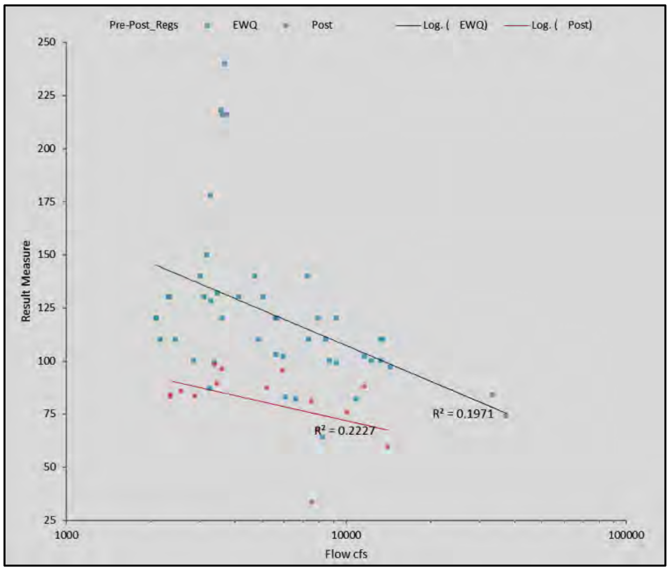
Post-EWQ median specific conductance fell within the EWQ 95% confidence intervals. Specific conductance is inversely related to flow in both data sets. The rise in specific conductance seen elsewhere is not apparent here; probably because the full flow regime is not well-represented in the post-EWQ data. 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.

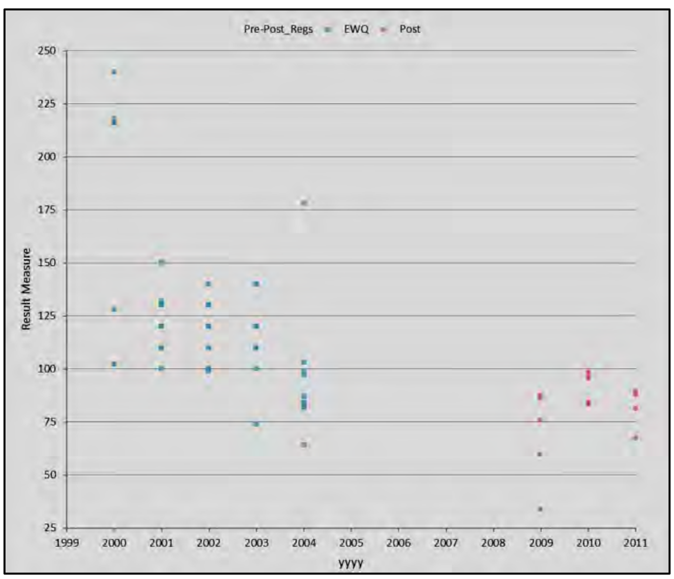
Chapter 18: 1838 ICP Delaware River at Easton

Total Dissolved Solids (TDS) mg/l

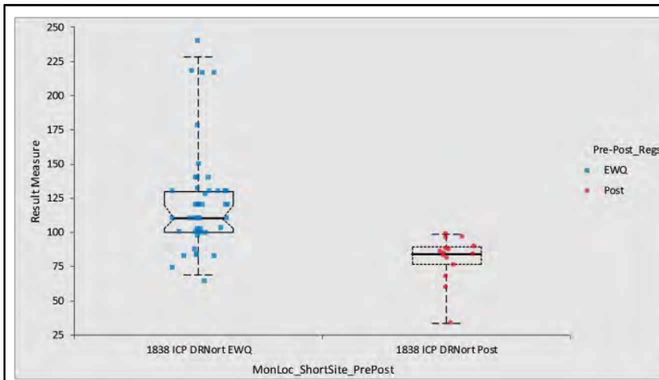
Existing Water Quality (Table 2I):

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



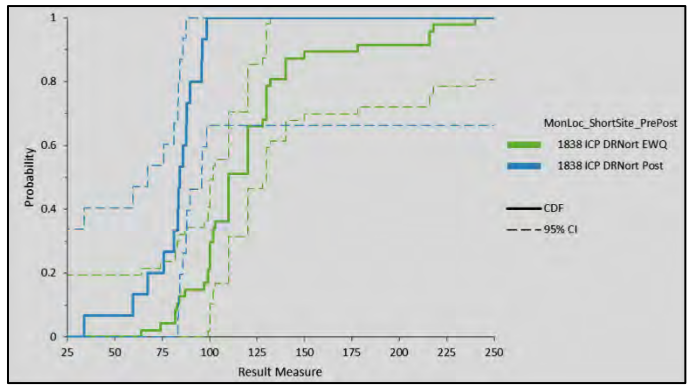


No water quality degradation is evident here. TDS apparently declined between the EWQ and post-EWQ periods. However, analytical uncertainty sources included potential laboratory artifacts, detection limit differences, insufficient post-EWQ sampling frequency, and flow differences. TDS is unrelated to 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
X^2 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.

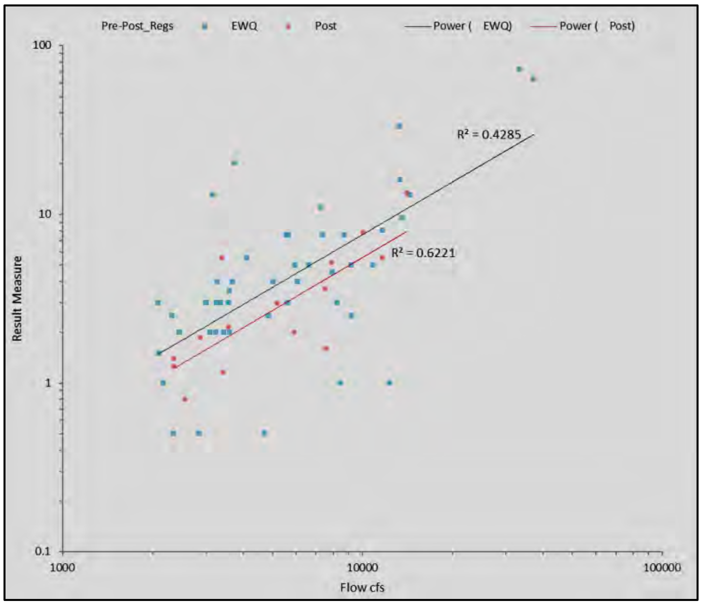
Post-EWQ median TDS fell below the EWQ lower 95% lower confidence interval, and were less variable than the baseline samples as well. Post-EWQ detection limits were lower than EWQ detection limits, though there were no non-detect results at any time. Perhaps this decline is not real but an artifact of 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.

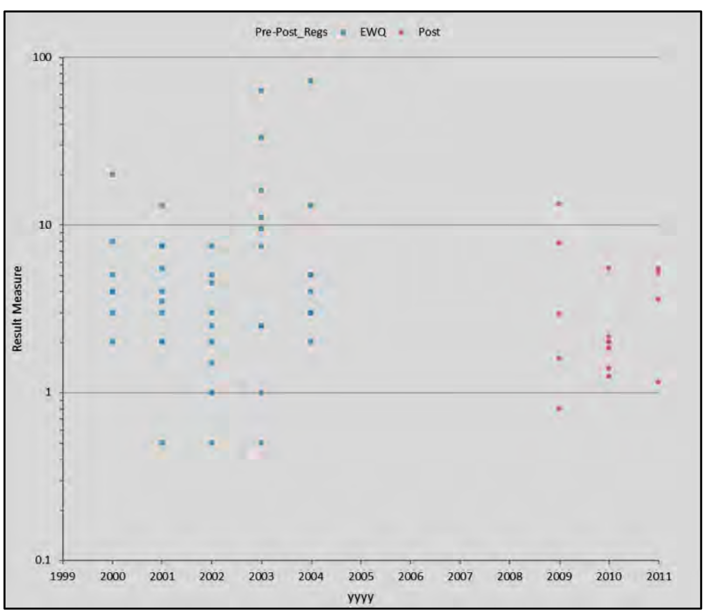
Chapter 18: 1838 ICP Delaware River at Easton

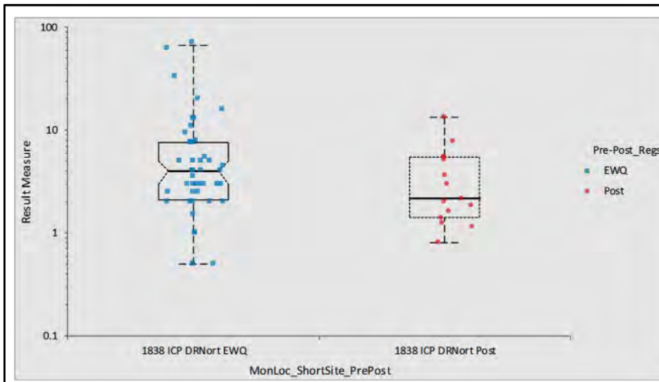
Total Suspended Solids (TSS) mg/l

Existing Water Quality (Table 2I):

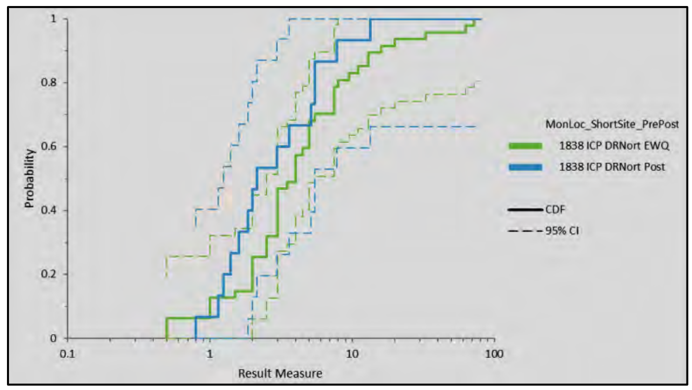
Median 4.0 mg/l
Lower 95% Confidence Interval 3.0 mg/l
Upper 95% Confidence Interval 5.0 mg/l
Defined in regulations as a flow-related parameter







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.

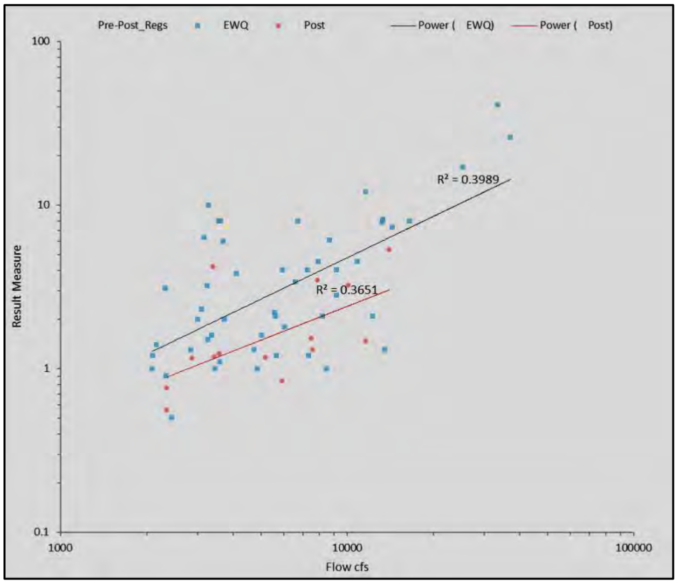
No water quality degradation is evident here. TSS apparently did not measurably change between the EWQ and post-EWQ periods. However, analytical uncertainty sources included potential laboratory artifacts, insufficient post-EWQ sampling frequency, and flow differences. TSS is positively related to flow 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.

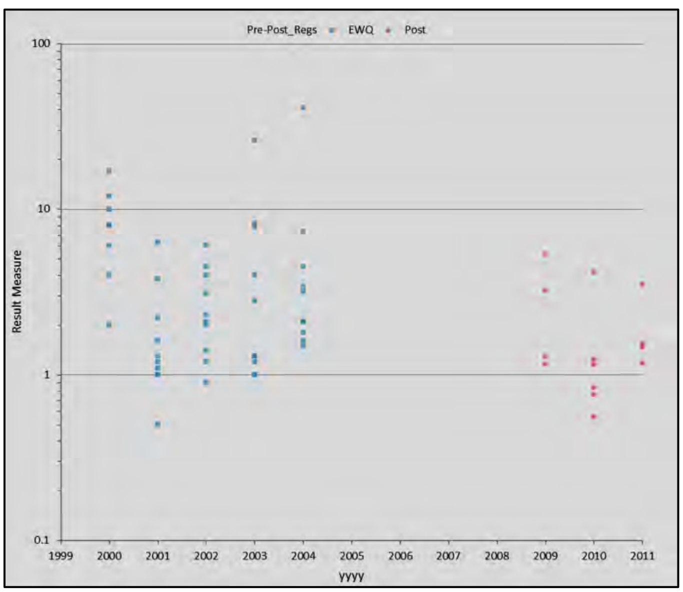
Chapter 18: 1838 ICP Delaware River at Easton

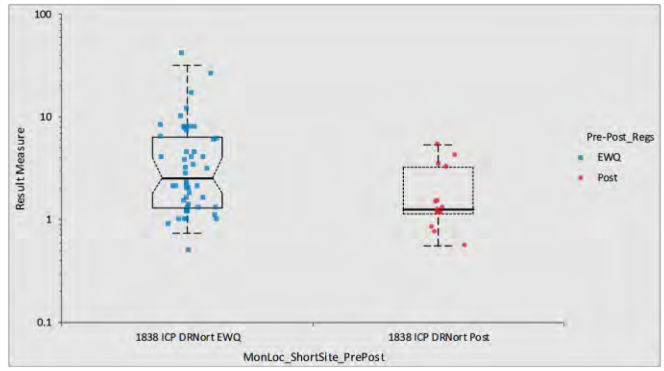
Turbidity NTU

Existing Water Quality (Table 2I):

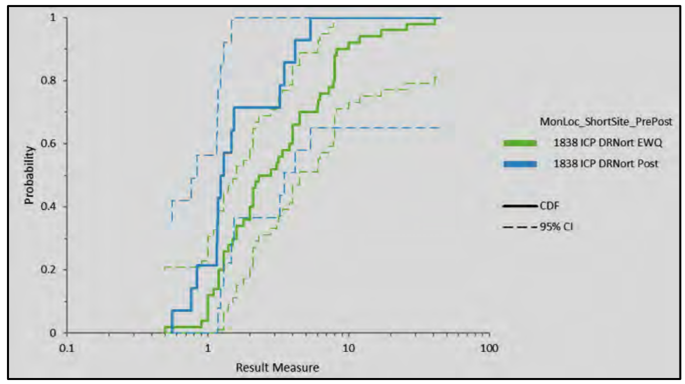
Median 2.6 NTU
Lower 95% Confidence Interval 1.8 NTU
Upper 95% Confidence Interval 4.0 NTU
Defined in regulations as a flow-related parameter







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]

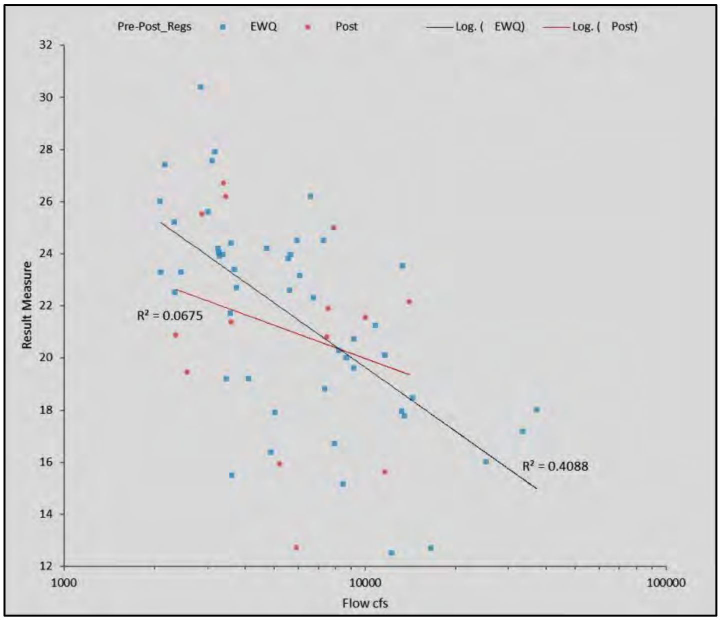
H0: $\theta_1 = \theta_2 = \theta_{...}$
The median of the populations are all equal.
H1: $\theta_i \neq \theta_j$ for at least one i,j
The median of the populations are not all equal.
[1] Reject the null hypothesis in favour of the alternative hypothesis at the 5% significance level.

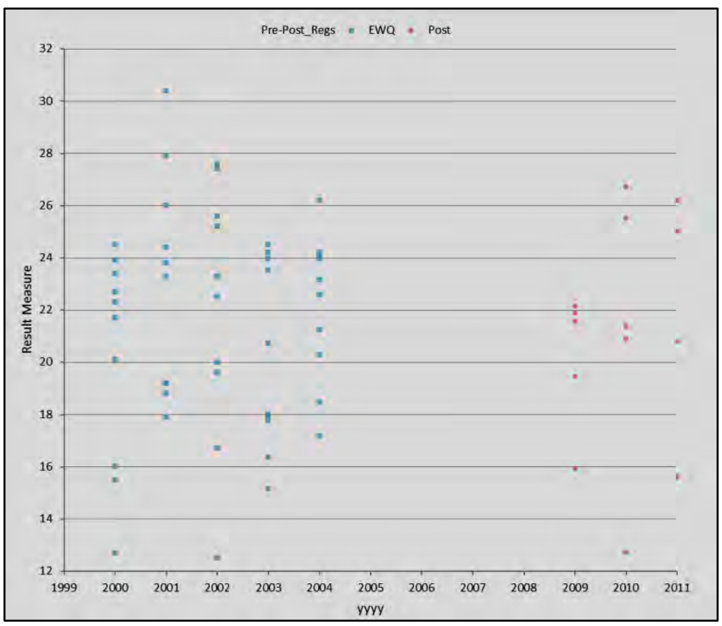
No water quality degradation is evident here. Turbidity apparently declined between the EWQ and post-EWQ periods. However, analytical uncertainty sources included insufficient post-EWQ sampling frequency, and flow differences. Post-EWQ median turbidity fell below the lower EWQ 95% confidence interval 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.

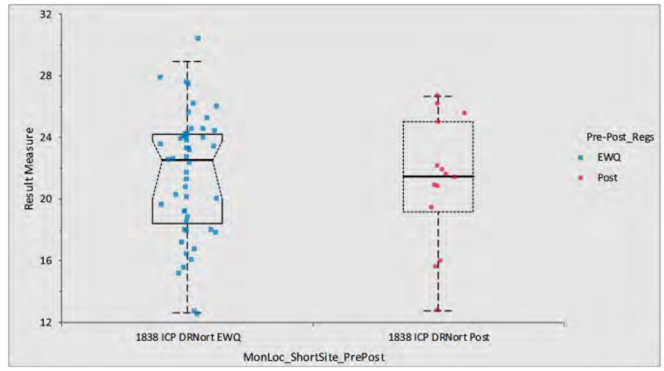
Chapter 18: 1838 ICP Delaware River at Easton

Water Temperature, degrees C

Not included in DRBC Existing Water Quality rules

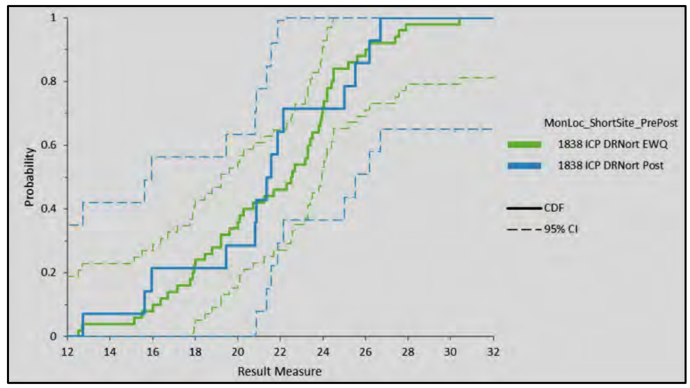






N | 64

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

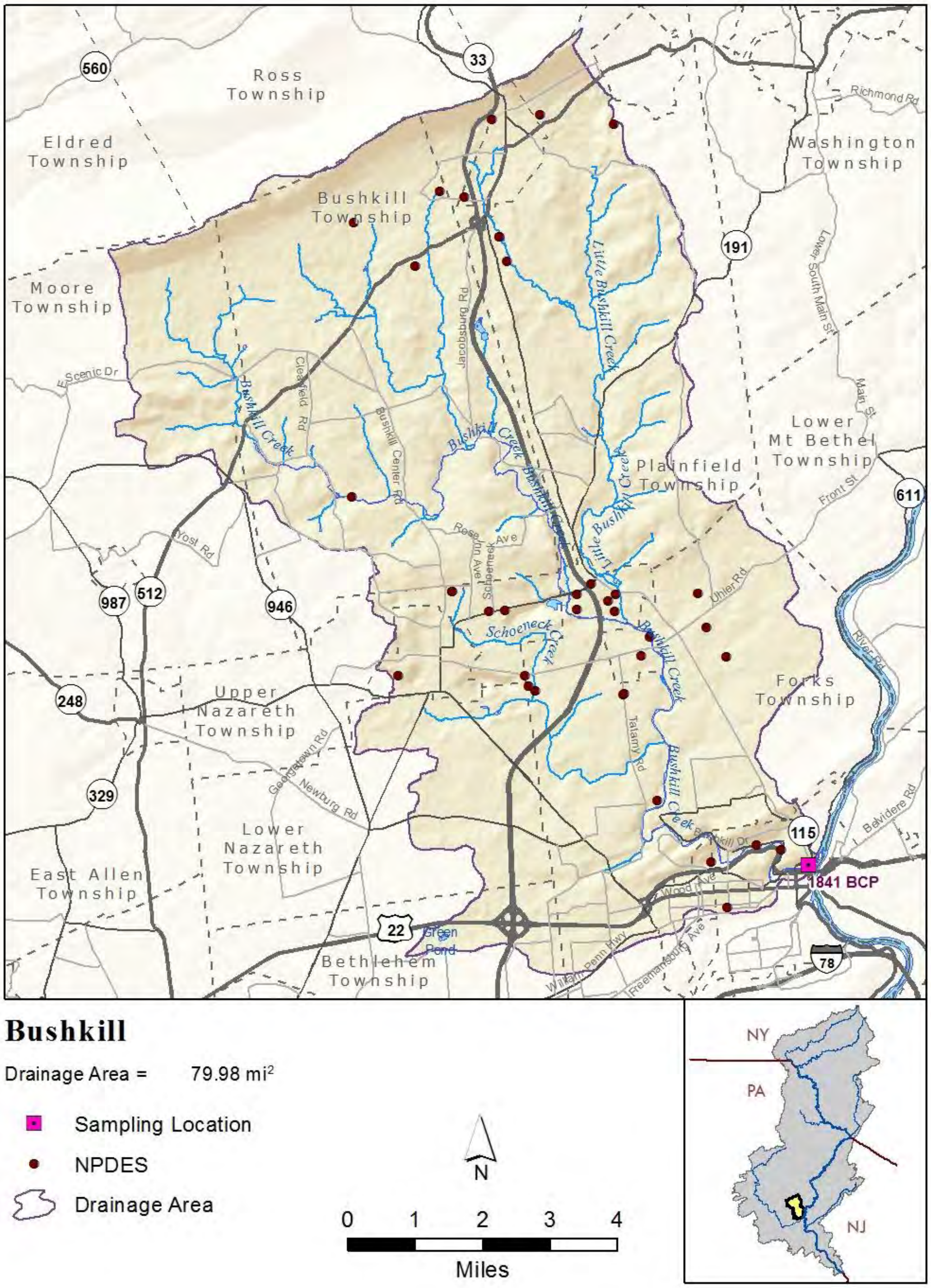
Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1838 ICP DRNort EWQ	50	5.1	0.10
1838 ICP DRNort Post	14	18.3	1.31

H statistic	0.07
X^2 approximation	0.07
DF	1
p-value	0.7950[1]

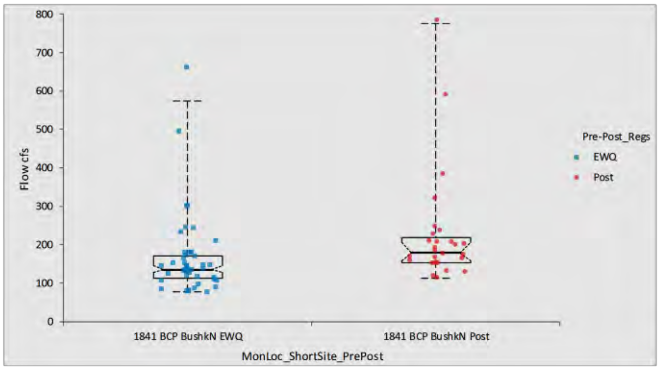
H0: $\theta_1 = \theta_2 = \theta$...
The median of the populations are all equal.
H1: $\theta_i \neq \theta_j$ for at least one i,j
The median of the populations are not all equal.
[1] Do not reject the null hypothesis at the 5% significance level.

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.

Chapter 19: 1841 BCP Bushkill Creek, Northampton County, PA



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



N	75

Flow cfs by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1841 BCP BushkN EWQ	76.0	112.8	135.7	171.3	659.9	58.5
1841 BCP BushkN Post	112.0	153.0	179.6	218.8	784.4	65.8

Post-EWQ flow was higher than baseline EWQ flow by about 45 cfs. Fewer samples were collected in the post-EWQ period. The range of flow conditions sampled was roughly equal, so water quality analyses should not be affected except for comparisons of water quality at very low flow conditions (<112 cfs).

Kruskal-Wallis test

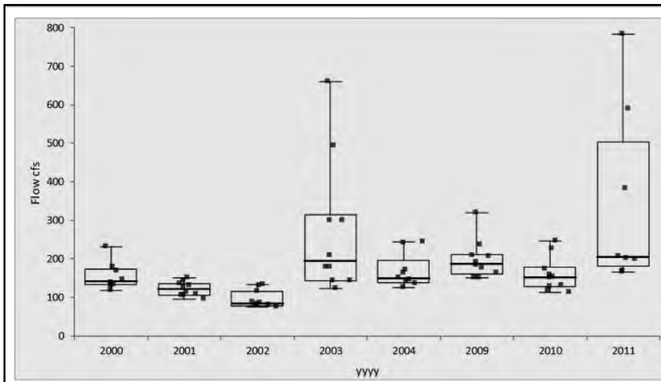
Flow cfs by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1841 BCP BushkN EWQ	47	2165.1	46.07
1841 BCP BushkN Post	28	3634.3	129.80

H statistic	12.21
X^2 approximation	12.21
DF	1
p-value	0.0005 [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.

The 80 square mile Bushkill Creek watershed is about 31% forested and about 15% urban land cover (USGS StreamStats, accessed Feb. 2014). About 38% of the watershed is underlain by carbonate bedrock, and this limestone naturally affects water quality. The watershed was not affected by glacial activity. The upper part of the watershed is an excellent trout fishery of good water quality. The creek is captured and then pumped back to the stream by a large quarry (Goodwin Pumps 2003*), which changes stream water quality and largely controls the downstream flow regime. In the summers of 2000-2002, many samples taken consisted almost exclusively of quarry discharge. Bushkill Creek would have been nearly dry those summers but for the constant 65 cfs pumped to the stream from the quarry bottom. Below the quarry are some large dischargers that further affect the stream, until by the time the Bushkill enters the Delaware River, overall water quality is poor.

*Goodwin Pumps. 2003. Case History: Hercules Cement Plant Case Study: Between a Rock and a Fluid Place. Case History Vol. 4, No. 2, Goodwin Pumps of America, Inc., Bridgeport, NJ.



N	75

Flow cfs by yyyy	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
2000	117.0	132.1	141.7	174.6	230.4	42.6
2001	94.7	104.3	120.7	136.3	150.0	32.0
2002	76.0	77.4	83.8	116.4	133.1	39.0
2003	124.2	142.9	194.6	314.6	659.9	171.7
2004	126.4	138.7	149.8	195.3	243.4	56.6
2009	151.9	161.9	186.8	211.4	319.8	49.5
2010	112.0	127.8	153.3	178.6	245.4	50.8
2011	167.2	181.5	204.5	503.4	784.4	321.9

There are no independent data available to compare with DRBC results at this site. There is a USGS gage in the watershed, but it is located in the upper portion of the watershed, above the quarry. The gage is located too far from the Rt. 611 monitoring site to be of use for flow estimation. Lafayette College maintains a useful stream gage at Cemetery Road just upstream of Easton, PA (David Brandes, Lafayette College, personal communication). Under backwater conditions at Rt. 611, DRBC samples water at the Cemetery Road location.

Annual May to September flow statistics associated with water quality measurements are plotted above. These are measurements or estimates associated with the time of each water quality sample. Mean annual flow is about 121 cfs; and harmonic mean flow is about 73 cfs (USGS Stream Stats retrieval, Feb. 2014). Stream Stats flow statistics must be adjusted to include the constant quarry discharge – when the quarry pumps are in operation, which is most of the time, there are no true low-flow conditions. Though a wide range of flows were sampled by DRBC, these data appear to be most representative of slightly above-normal flow conditions. Flows corresponding to each water quality sample were estimated using the USGS BaSE model with an adjustment for quarry discharge. DRBC intends to use the Lafayette College data when available, and the BaSE program otherwise for future flow estimates.

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

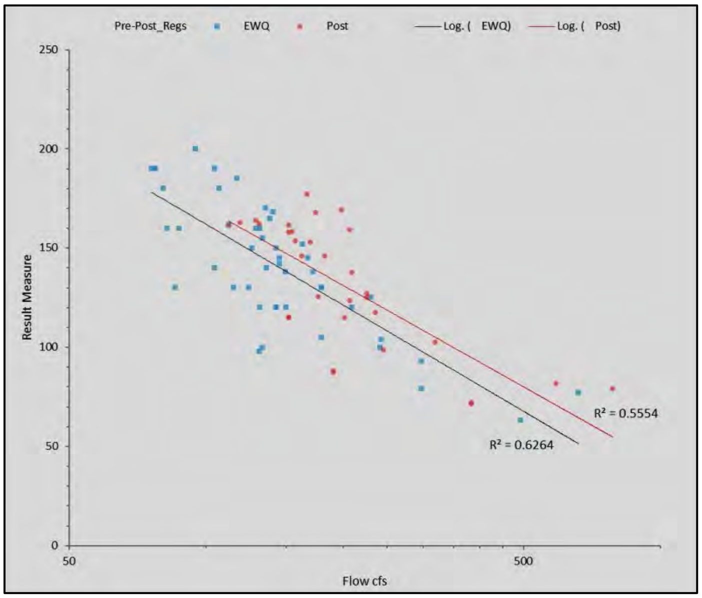
Upstream ICP: Delaware River at Belvidere 1978 ICP
Downstream ICP: Delaware River at Easton 1838 ICP

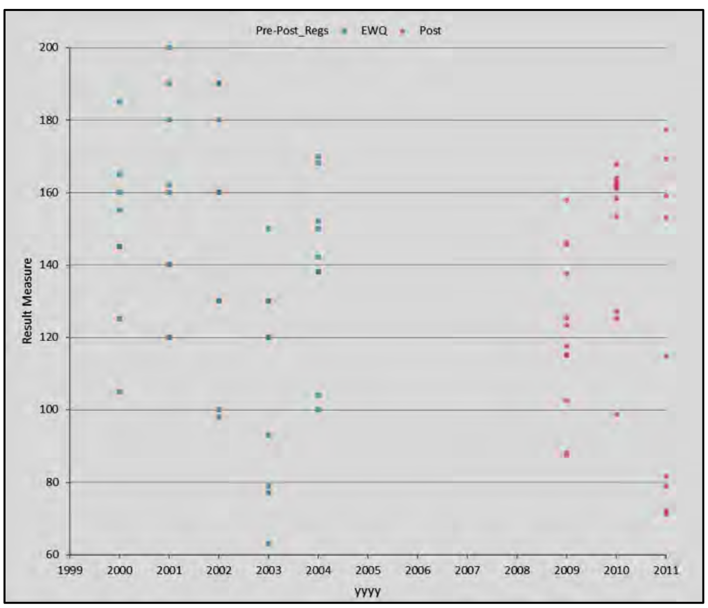
Chapter 19: 1841 BCP Bushkill Creek, PA

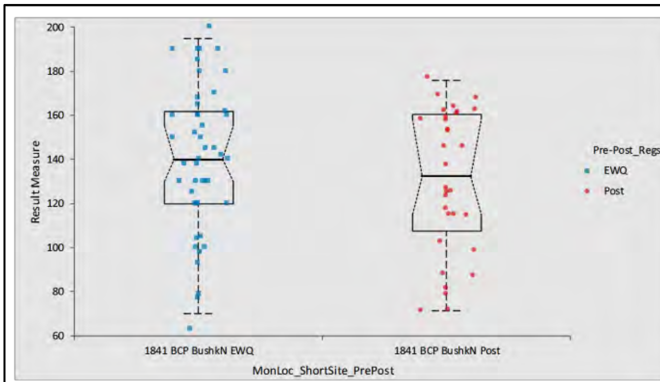
Alkalinity as CaCO3, Total mg/l

Existing Water Quality (Table 2H):

Median 140 mg/l
Lower 95% Confidence Interval 130 mg/l
Upper 95% Confidence Interval 155 mg/l
Defined in regulations as a flow-related parameter

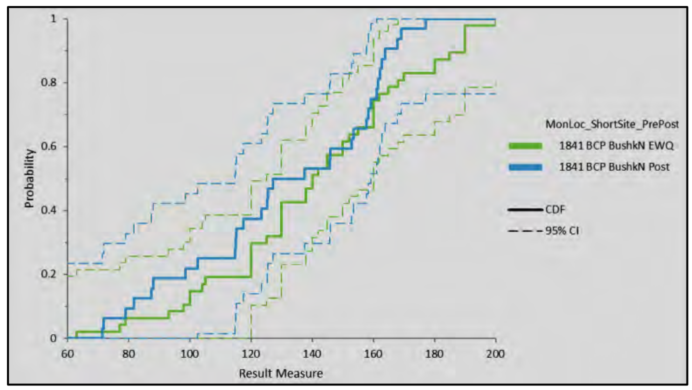






N | 79

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1841 BCP BushkN EWQ	63	120	140	162	200	42
1841 BCP BushkN Post	71	108	132	160	177	53



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1841 BCP BushkN EWQ	47	271.7	5.78
1841 BCP BushkN Post	32	399.0	12.47

H statistic	1.27
X^2 approximation	1.27
DF	1
p-value	0.2589 [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.

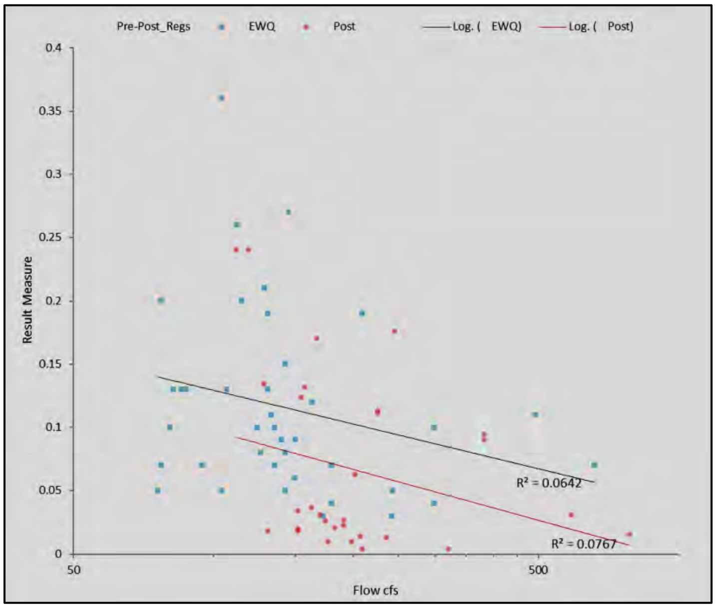
No water quality degradation is evident here. Alkalinity apparently did not measurably change between the EWQ and post-EWQ periods. However, analytical uncertainty was introduced by potential laboratory artifacts and insufficient post-EWQ samples taken under very low flow conditions. Alkalinity is inversely related to flow in both data sets. Post-EWQ median alkalinity was within the EWQ 95% confidence intervals. Flow is plotted on a logarithmic scale. These alkalinities are typical of limestone streams.

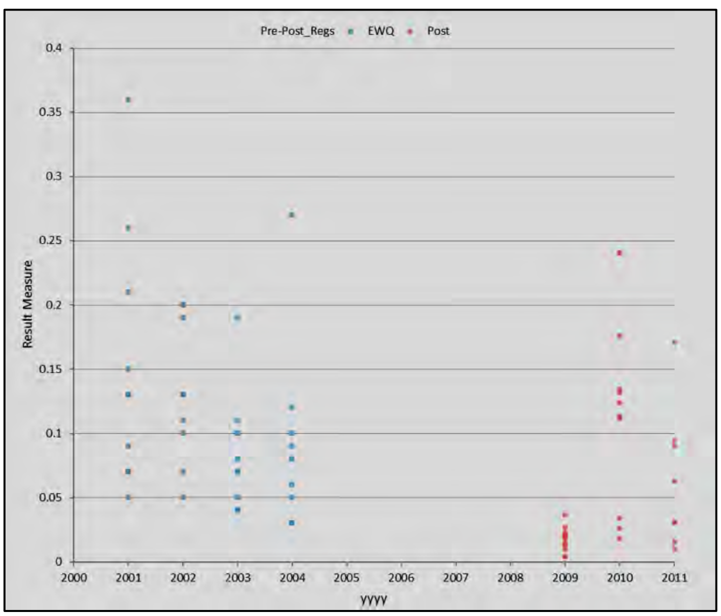
Chapter 19: 1841 BCP Bushkill Creek, PA

Ammonia Nitrogen as N, Total mg/l

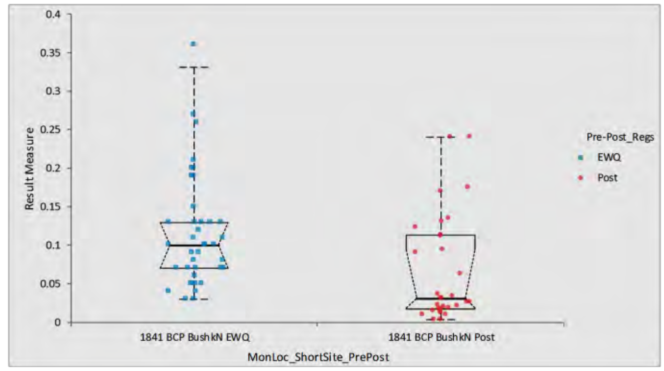
Existing Water Quality (Table 2H):

Median 0.10 mg/l
Lower 95% Confidence Interval 0.07 mg/l
Upper 95% Confidence Interval 0.13 mg/l



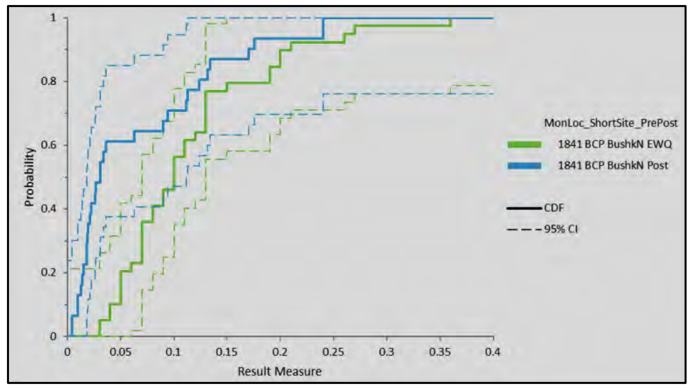


No water quality degradation is evident here. Ammonia concentrations apparently declined. However, analytical uncertainty was introduced by potential laboratory artifacts, detection limit differences, and insufficient post-EWQ low-flow samples.



N | 70

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1841 BCP BushkN EWQ	0.03	0.07	0.10	0.13	0.36	0.06
1841 BCP BushkN Post	0.00	0.02	0.03	0.11	0.24	0.09



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1841 BCP BushkN EWQ	39	2090.0	53.59
1841 BCP BushkN Post	31	2629.4	84.82

H statistic	11.41
X^2 approximation	11.41
DF	1
p-value	0.0007 [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.

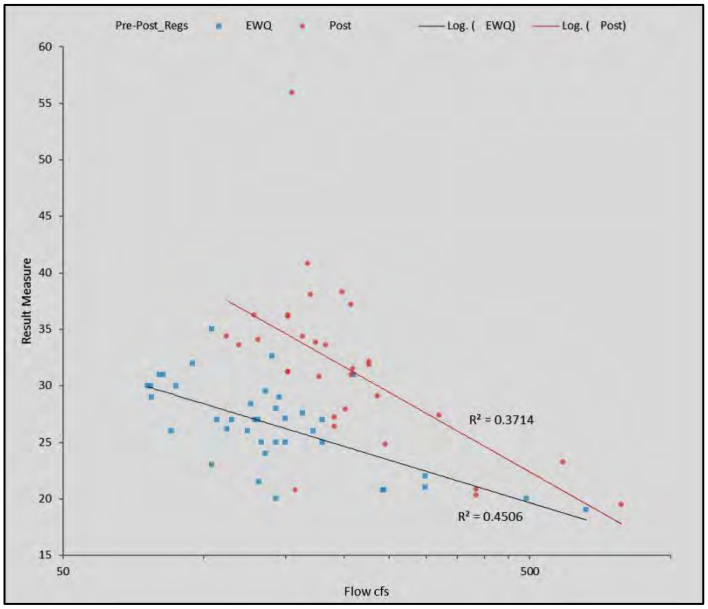
Post-EWQ median ammonia concentration was below the EWQ lower 95% confidence interval. No independent data were available for comparison with DRBC results. Ammonia is unrelated to flow in both data sets. DRBC's post-EWQ detection limit was much lower than during the EWQ period, but concentrations in the Bushkill typically are high enough that there is no interference in the results. EWQ data had 2/39 undetected results. Under post-EWQ very low detection levels there were 2/31 undetected results. Ambient concentrations apparently improved, at least in 2009, unless this is simply a laboratory artifact. There are still numerous high-concentration sample results.

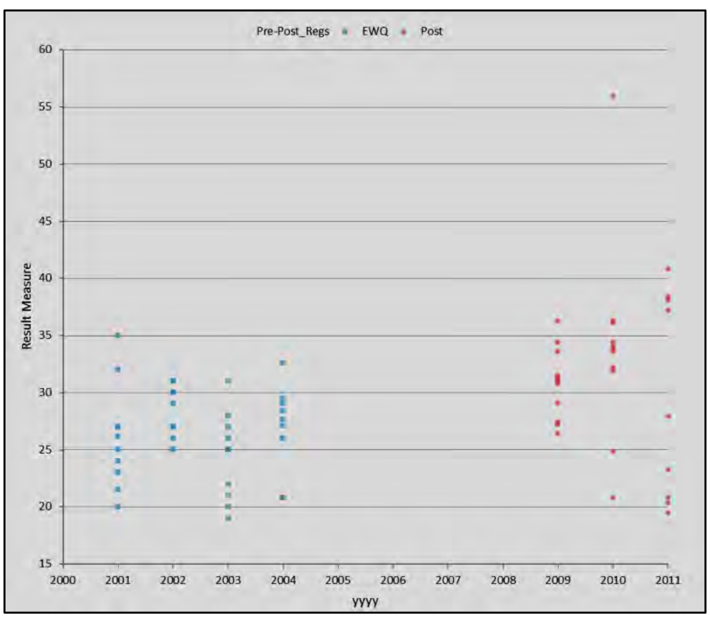
Chapter 19: 1841 BCP Bushkill Creek, PA

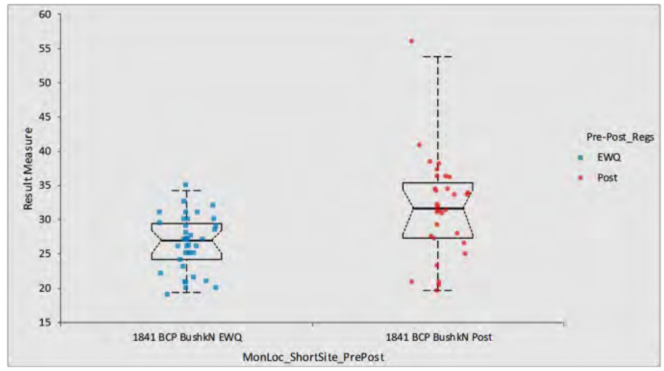
Chloride, Total mg/l

Existing Water Quality (Table 2H):

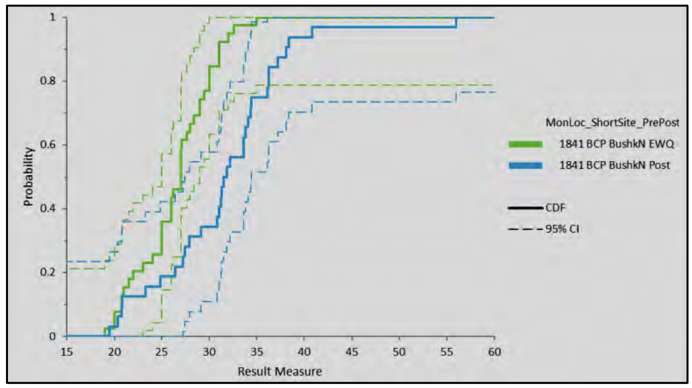
Median 27.0 mg/l
Lower 95% Confidence Interval 25.0 mg/l
Upper 95% Confidence Interval 28.4 mg/l
Defined in regulations as a flow-related parameter







N	71					
Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1841 BCP BushkN EWQ	19.0	24.2	27.0	29.4	35.0	5.3
1841 BCP BushkN Post	19.5	27.3	31.7	35.4	55.9	8.1



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1841 BCP BushkN EWQ	39	2568.5	65.86
1841 BCP BushkN Post	32	3130.4	97.82

H statistic	13.39
X^2 approximation	13.39
DF	1
p-value	0.0003 [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.

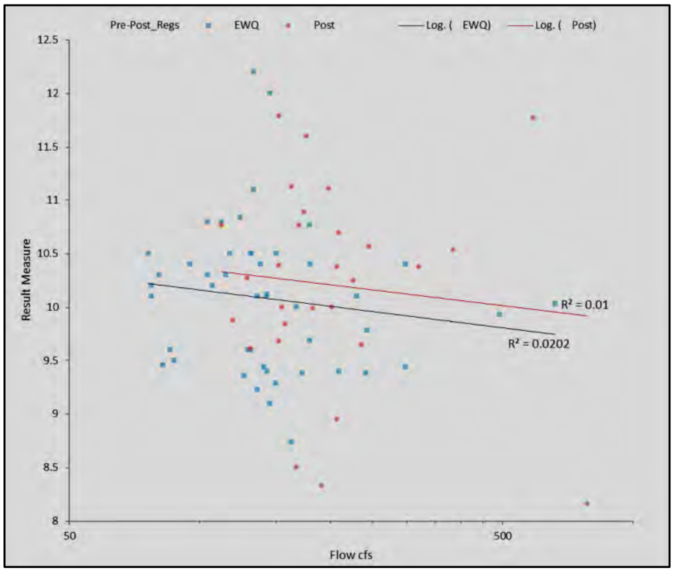
Water quality degradation is evident here. Chloride concentrations apparently rose between the two periods. However, analytical uncertainty was introduced by potential laboratory artifacts and insufficient post-EWQ low-flow samples. Post-EWQ median concentration rose above the EWQ upper 95% confidence interval. Chloride concentration is inversely related to flow in both data sets. No independent data were available for comparison with DRBC results.

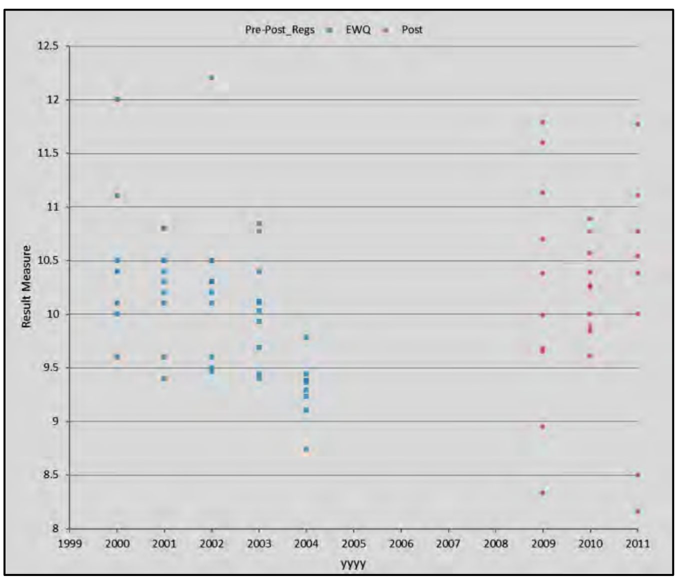
Chapter 19: 1841 BCP Bushkill Creek, PA

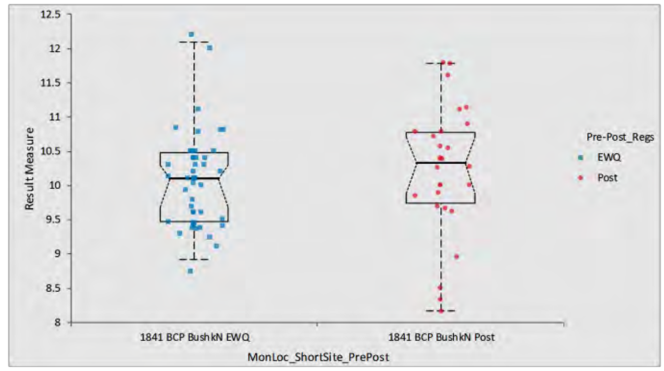
Dissolved Oxygen (DO) mg/l

Existing Water Quality (Table 2H):

Median 10.10 mg/l
Lower 95% Confidence Interval 9.69 mg/l
Upper 95% Confidence Interval 10.30 mg/l

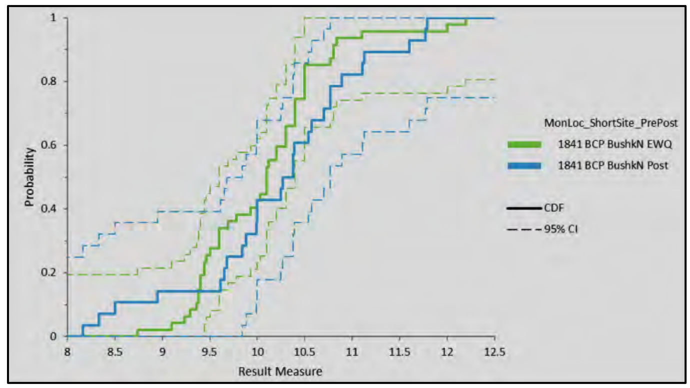






N 75

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1841 BCP BushkN EWQ	8.74	9.47	10.10	10.48	12.20	1.02
1841 BCP BushkN Post	8.16	9.75	10.33	10.77	11.79	1.02



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1841 BCP BushkN EWQ	47	230.1	4.90
1841 BCP BushkN Post	28	386.3	13.80

H statistic	1.30
X^2 approximation	1.30
DF	1
p-value	0.2544 [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.

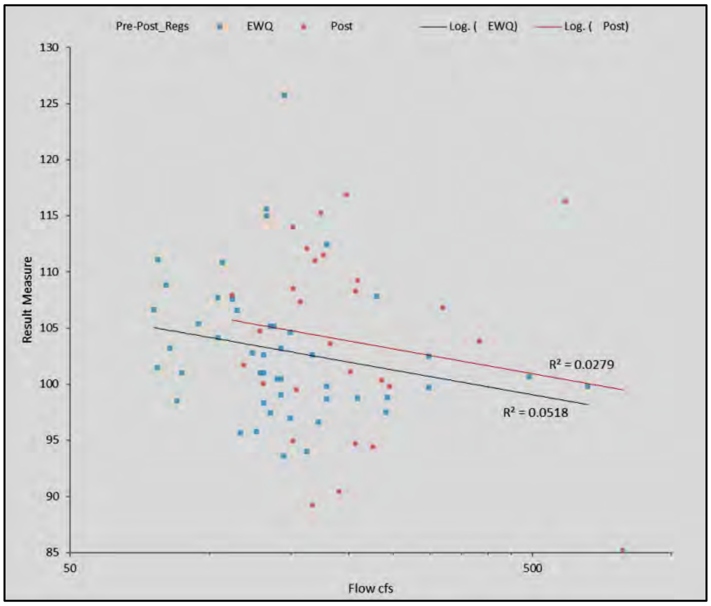
No water quality degradation is evident here. No measurable change took place between the EWQ and Post-EWQ periods. However, analytical uncertainty was introduced by insufficient post-EWQ low-flow samples. Post-EWQ median DO concentration was above the upper EWQ 95% confidence interval but the difference was not statistically significant. Such an increase would constitute a water quality improvement anyway. DO concentration is unrelated to flow in both data sets. No independent data were available for comparison with DRBC results.

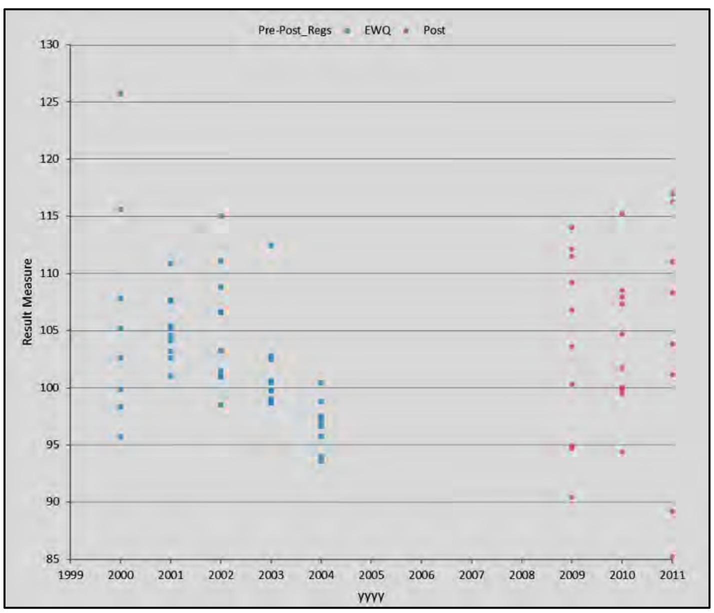
Chapter 19: 1841 BCP Bushkill Creek, PA

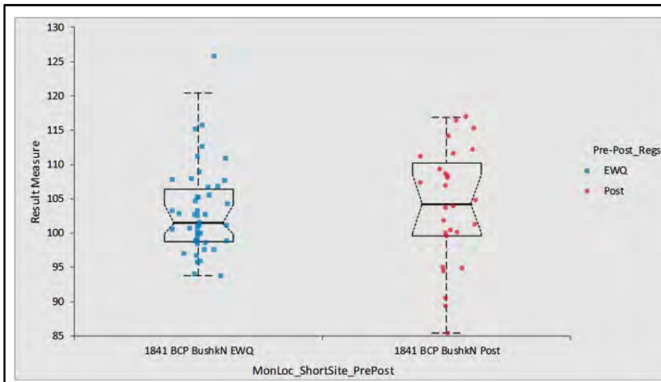
Dissolved Oxygen Saturation %

Existing Water Quality (Table 2H):

Median 102%
Lower 95% Confidence Interval 100%
Upper 95% Confidence Interval 104%

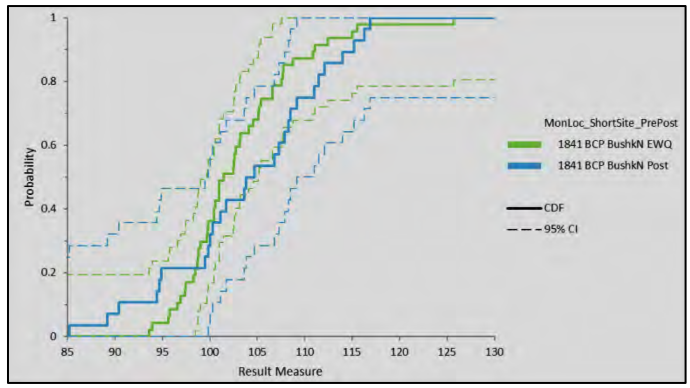






N 75

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1841 BCP BushkN EWQ	94	99	101	106	126	8
1841 BCP BushkN Post	85	100	104	110	117	11



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1841 BCP BushkN EWQ	47	192.0	4.09
1841 BCP BushkN Post	28	322.3	11.51

H statistic	1.08
X² approximation	1.08
DF	1
p-value	0.2981 [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 was introduced by insufficient post-EWQ low-flow samples. Post-EWQ median DO saturation matched the upper EWQ 95% confidence interval. There were no measurements that caused concern about an excess of oxygen-reducing material. As a rule of thumb, 80-120% is considered “normal”; in that range a balance exists between oxygen demand and supply. No independent data were available to corroborate DRBC results.

Chapter 19: 1841 BCP Bushkill Creek, PA

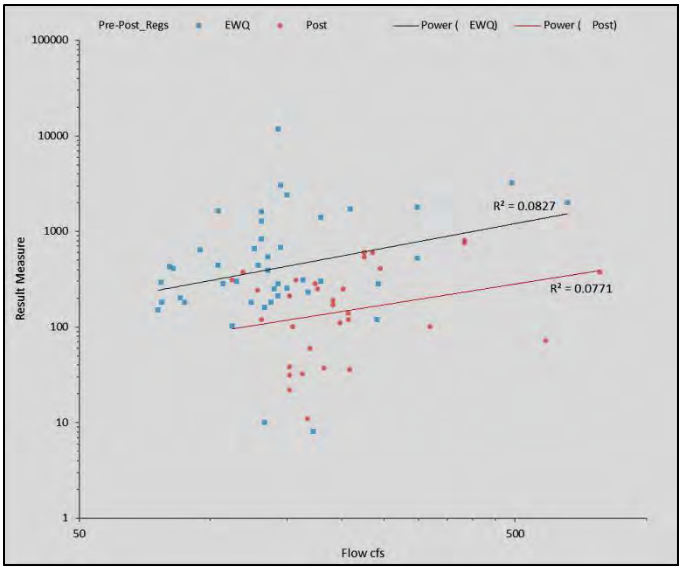
Enterococcus colonies/100 ml

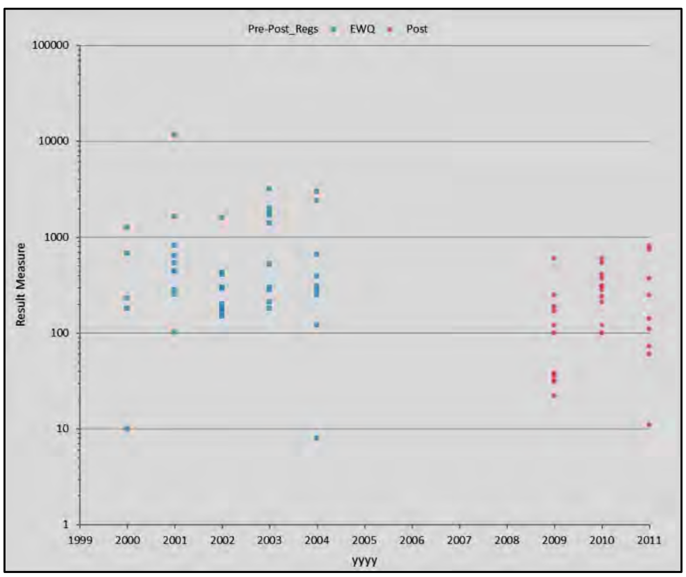
Existing Water Quality (Table 2H):

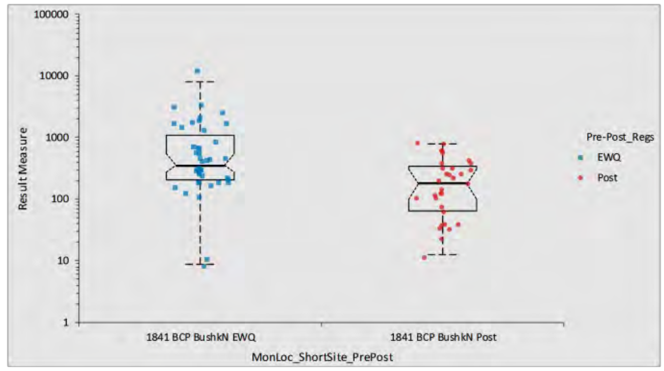
Median 350/100 ml

Lower 95% Confidence Interval 280/100 ml

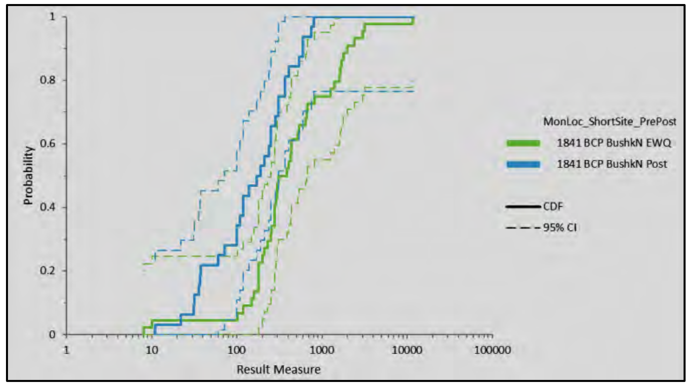
Upper 95% Confidence Interval 540/100 ml







N	76					
Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1841 BCP BushkN EWQ	8	204	350	1084	11700	880
1841 BCP BushkN Post	11	65	180	345	800	280



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1841 BCP BushkN EWQ	44	2349.1	53.39
1841 BCP BushkN Post	32	3230.1	100.94

H statistic	11.45
X^2 approximation	11.45
DF	1
p-value	0.0007 [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.

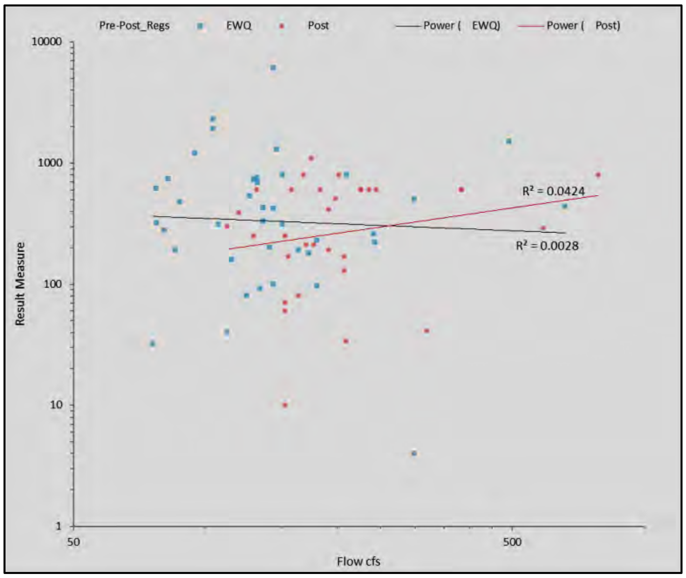
No water quality degradation is evident here. Enterococci apparently declined between the EWQ and Post-EWQ periods. However, analytical uncertainty was introduced by laboratory artifacts and insufficient post-EWQ low-flow samples. Enterococcus concentrations are unrelated to flow in both data sets. Concentrations 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.

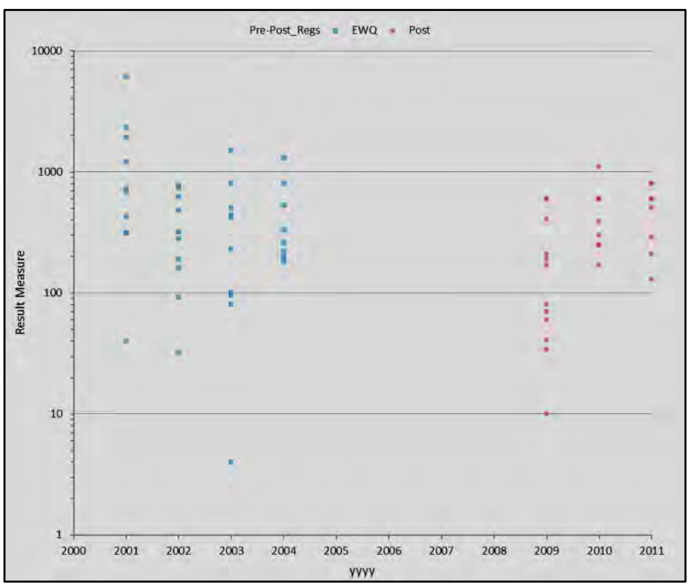
Chapter 19: 1841 BCP Bushkill Creek, PA

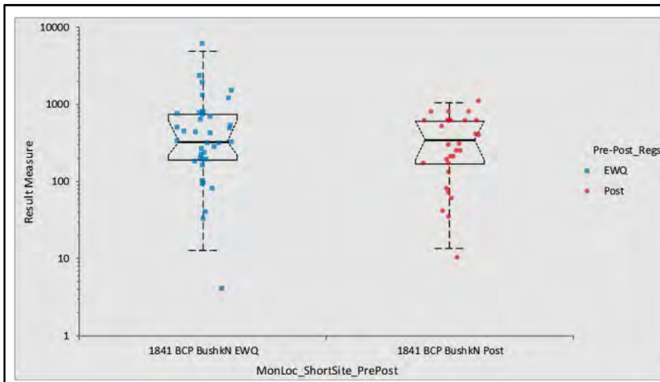
Escherichia coli colonies/100 ml

Existing Water Quality (Table 2H):

Median 330/100 ml
Lower 95% Confidence Interval 220/100 ml
Upper 95% Confidence Interval 620/100 ml
EWQ exceeds federally recommended criteria

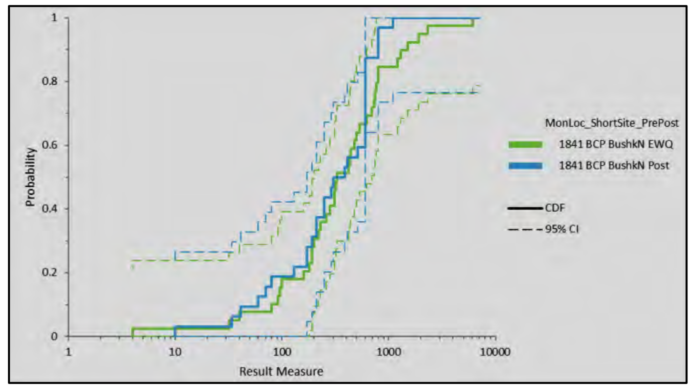






N 71

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1841 BCP BushkN EWQ	4	190	330	738	6100	548
1841 BCP BushkN Post	10	170	345	600	1100	430



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1841 BCP BushkN EWQ	39	103.4	2.65
1841 BCP BushkN Post	32	126.0	3.94

H statistic	0.54
X² approximation	0.54
DF	1
p-value	0.4625 [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.

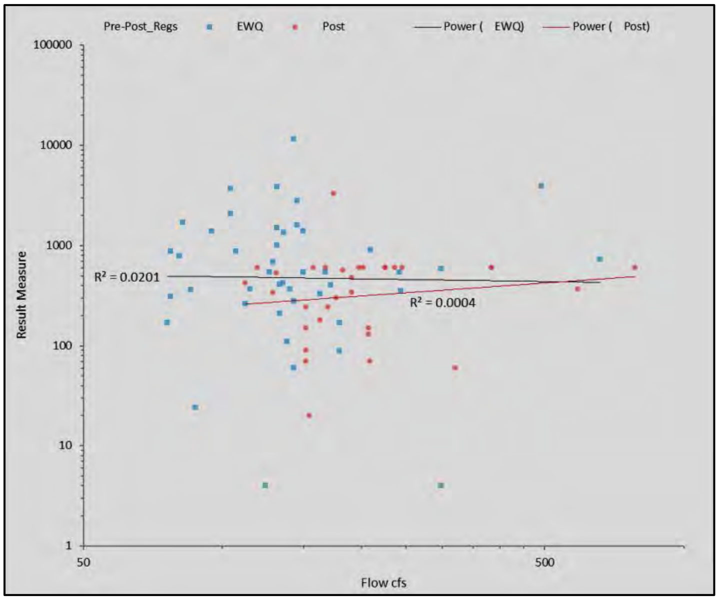
No water quality degradation is evident here. E. coli apparently did not measurably change between the EWQ and Post-EWQ periods. Analytical uncertainty was introduced by potential laboratory artifacts and insufficient post-EWQ low-flow samples. High values (9) were laboratory truncated to upper quantification limits, which affected the comparison above the 75th percentile. 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 unrelated to flow in both data sets. No independent data were available to validate DRBC results.

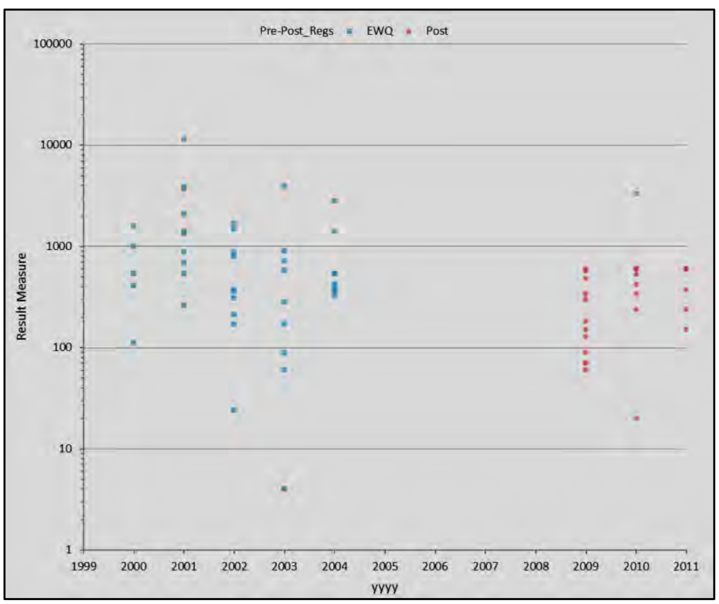
Chapter 19: 1841 BCP Bushkill Creek, PA

Fecal coliform colonies/100 ml

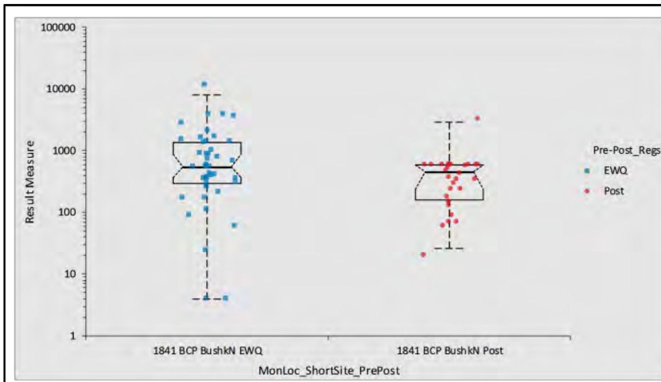
Existing Water Quality (Table 2H):

Median 540/100 ml
Lower 95% Confidence Interval 370/100 ml
Upper 95% Confidence Interval 880/100 ml



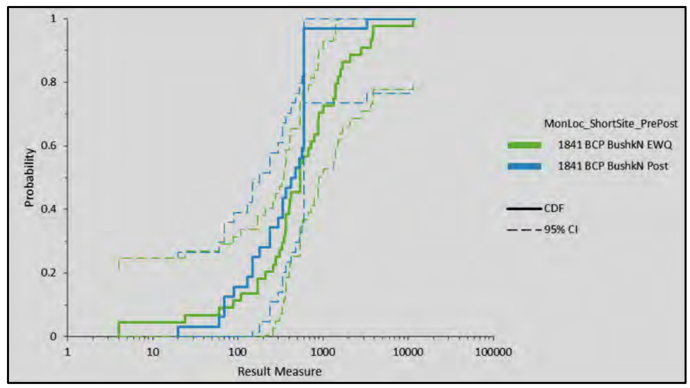


No water quality degradation is evident here. Fecal coliform apparently did not measurably change between the EWQ and post-EWQ periods, though lack of post-EWQ results over 1000 colonies/100ml were due to the laboratory truncating high results (n=10) to upper quantification limits.



N | 76

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1841 BCP BushkN EWQ	4	293	540	1375	11520	1083
1841 BCP BushkN Post	20	163	450	600	3300	438



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1841 BCP BushkN EWQ	44	618.8	14.06
1841 BCP BushkN Post	32	850.8	26.59

H statistic	3.03
X^2 approximation	3.03
DF	1
p-value	0.0819 [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.

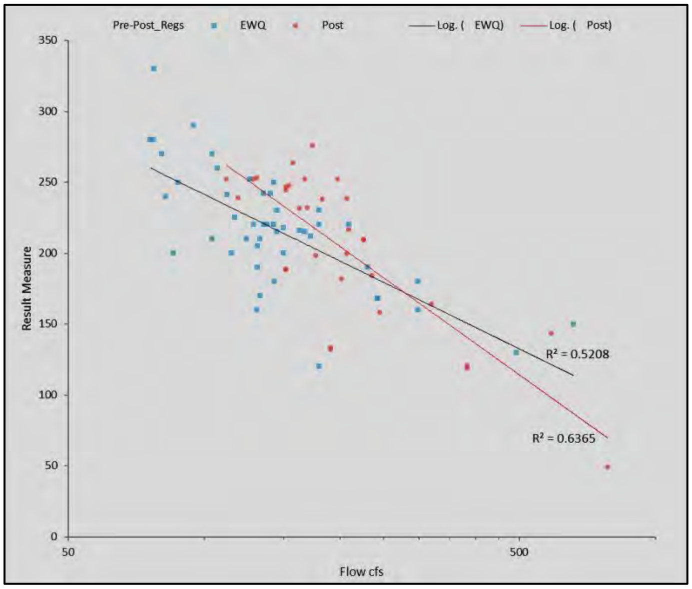
Truncation of results to UQL's affected the comparison above the 70th percentile. Analytical uncertainty was introduced by laboratory artifacts and insufficient post-EWQ low-flow samples. Fecal coliform concentrations are unrelated to flow in both data sets. Post-EWQ median concentrations were within the EWQ 95% confidence intervals. Concentrations and flows are plotted on logarithmic scale, and regressions are power relationships. There were no independent data for comparison with DRBC results.

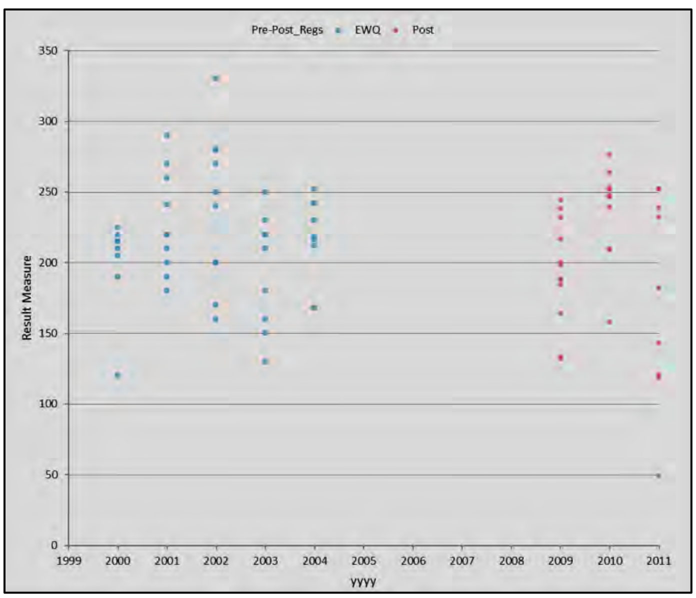
Chapter 19: 1841 BCP Bushkill Creek, PA

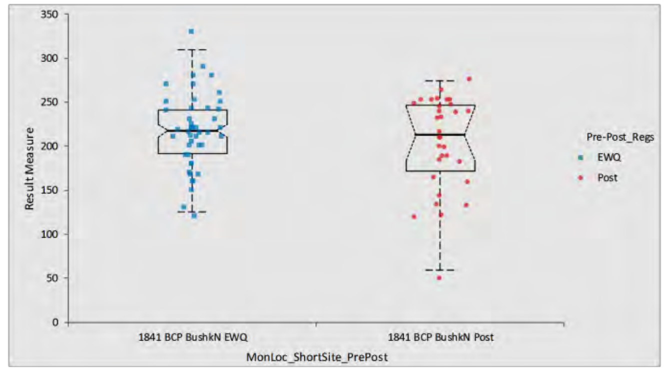
Hardness as CaCO3, Total mg/l

Existing Water Quality (Table 2H):

Median 218 mg/l
Lower 95% Confidence Interval 210 mg/l
Upper 95% Confidence Interval 225 mg/l
Defined in regulations as a flow-related parameter

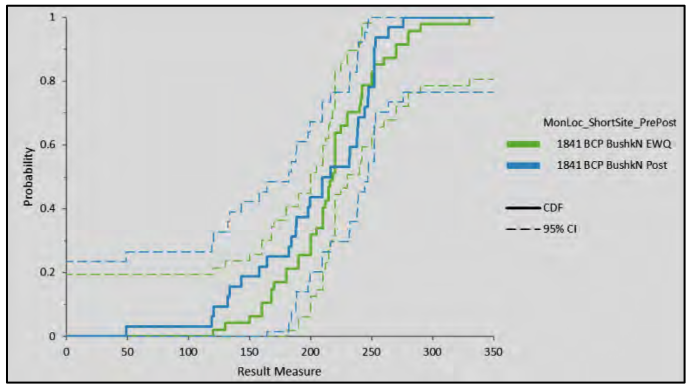






N 79

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1841 BCP BushkN EWQ	120	192	218	242	330	50
1841 BCP BushkN Post	49	172	213	247	276	76



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1841 BCP BushkN EWQ	47	72.8	1.55
1841 BCP BushkN Post	32	106.9	3.34

H statistic	0.34
X^2 approximation	0.34
DF	1
p-value	0.5589[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. However, analytical uncertainty was introduced by potential laboratory artifacts and insufficient post-EWQ low-flow samples. Hardness is inversely related to flow in both data sets. Post-EWQ median hardness was within the EWQ 95% confidence intervals. Flow is plotted on a logarithmic scale. No independent data were available for comparison with DRBC results.

Chapter 19: 1841 BCP Bushkill Creek, PA

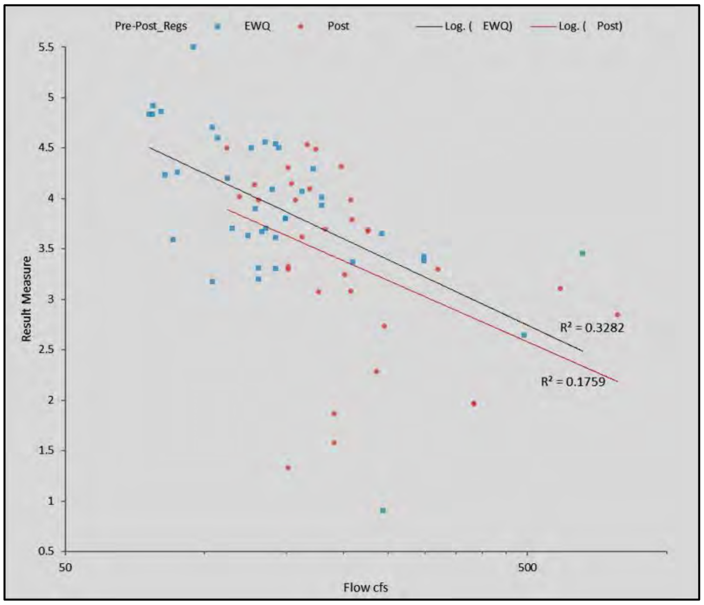
Nitrate + Nitrite as N, Total mg/l

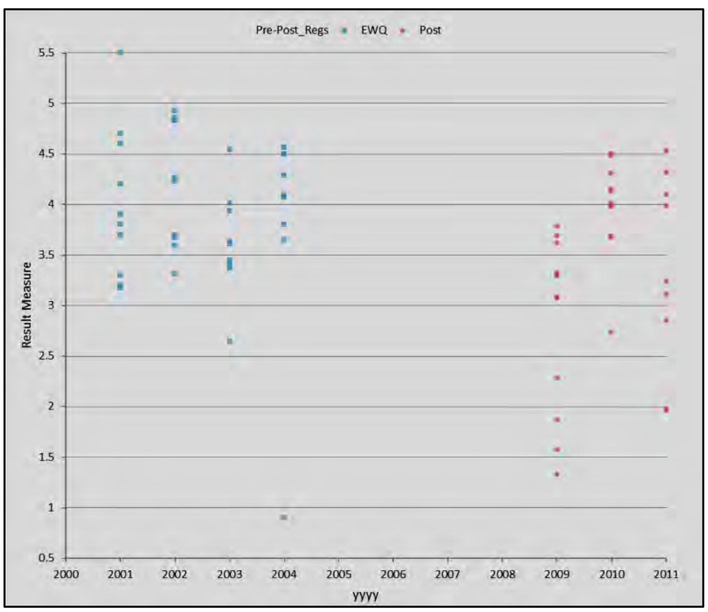
Existing Water Quality (Table 2H, as Nitrate only):

Median 3.90 mg/l

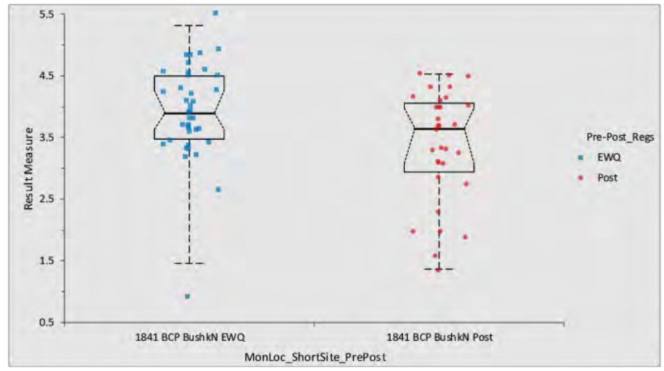
Lower 95% Confidence Interval 3.63 mg/l

Upper 95% Confidence Interval 4.26 mg/l



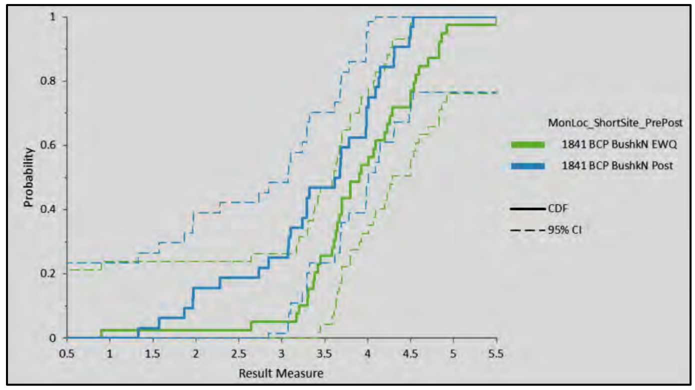


No water quality degradation is evident here. Nitrate concentrations apparently declined between the EWQ and post-EWQ periods. However, analytical uncertainty was introduced by potential laboratory artifacts and insufficient post-EWQ low-flow samples.



N 71

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1841 BCP BushkN EWQ	0.90	3.47	3.90	4.50	5.50	1.03
1841 BCP BushkN Post	1.33	2.94	3.65	4.06	4.53	1.12



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1841 BCP BushkN EWQ	39	1185.3	30.39
1841 BCP BushkN Post	32	1444.5	45.14

H statistic	6.17
X² approximation	6.17
DF	1
p-value	0.0130 [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.

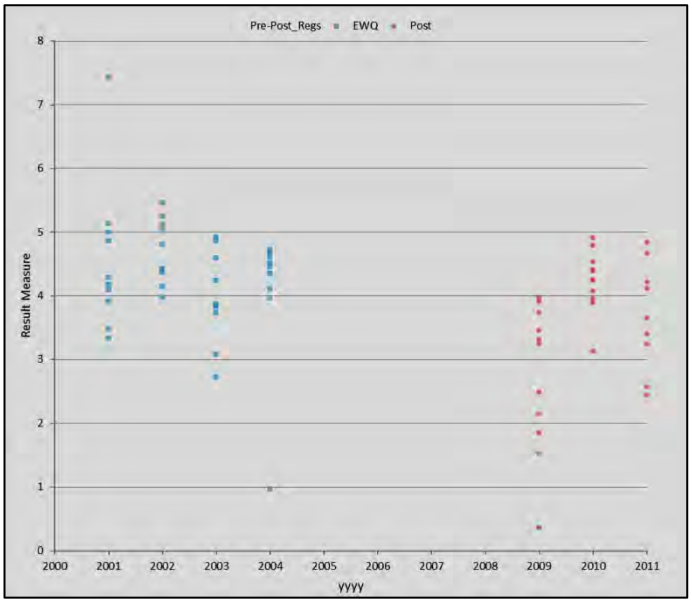
Nitrate is weakly related to flow in both data sets. Post-EWQ median concentrations fell near to the lower EWQ 95% confidence interval. Post-EWQ nitrate + nitrite concentrations were assumed equivalent for comparison with EWQ nitrate concentrations since EWQ nitrite concentrations were never detected. No independent data were available to compare with DRBC results. At other sites where concentrations are lower, there was a problem interpreting the data due to changing detection limits. Concentrations are sufficiently high in Bushkill Creek that problems with interpretation did not arise. This stream contains the highest nitrate concentrations in the Lower Delaware.

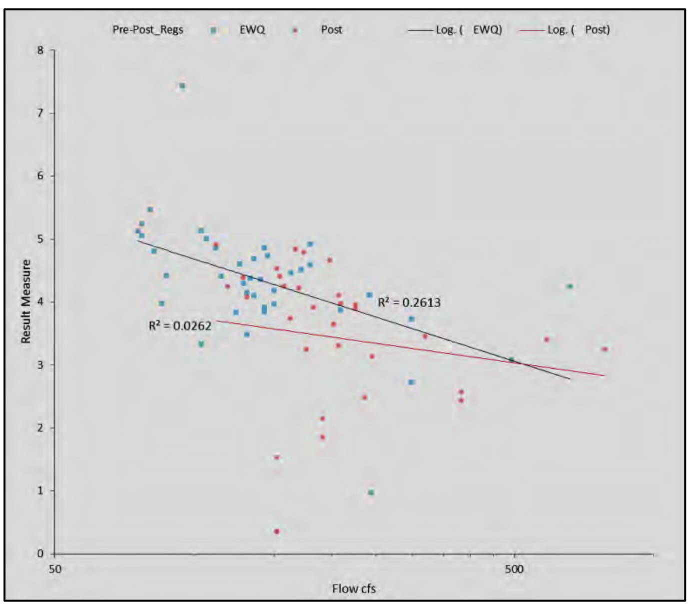
Chapter 19: 1841 BCP Bushkill Creek, PA

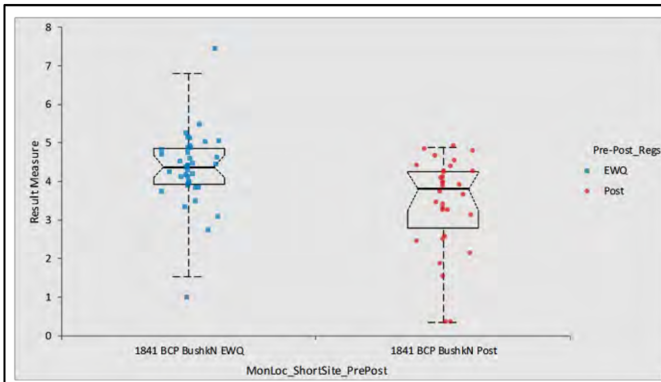
Nitrogen as N, Total (TN) mg/l

Existing Water Quality (Table 2H):

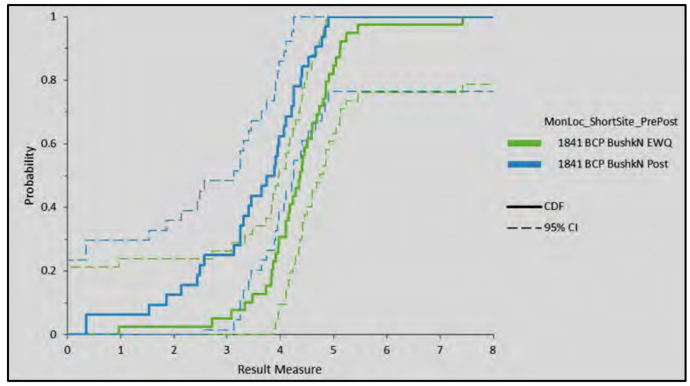
Median 4.41 mg/l (should read <u>4.37</u>)
Lower 95% Confidence Interval 4.11 mg/l
Upper 95% Confidence Interval 4.73 mg/l







N	71					
Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1841 BCP BushkN EWQ	0.97	3.92	4.37	4.85	7.43	0.93
1841 BCP BushkN Post	0.35	2.80	3.81	4.25	4.91	1.44



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1841 BCP BushkN EWQ	39	2178.8	55.87
1841 BCP BushkN Post	32	2655.4	82.98

H statistic	11.35
X^2 approximation	11.35
DF	1
p-value	0.0008 [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.

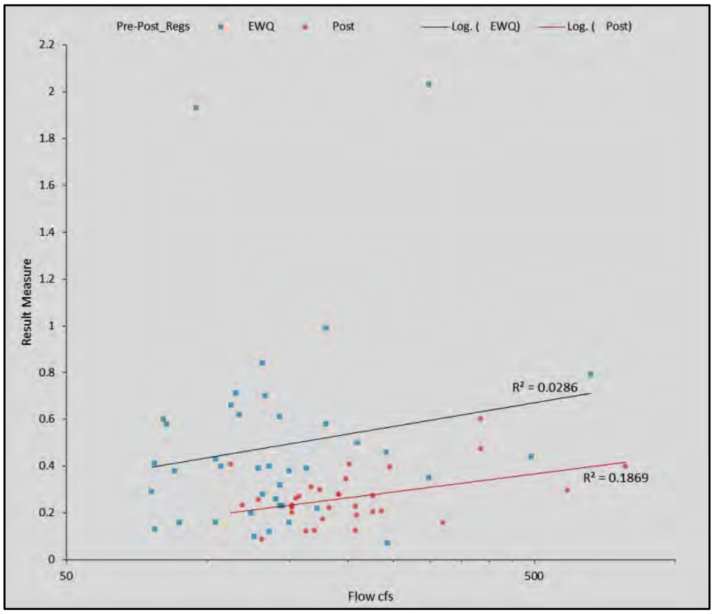
No water quality degradation is evident here. Total Nitrogen concentrations apparently declined between the EWQ and post-EWQ periods. However, analytical uncertainty was introduced by potential laboratory artifacts and insufficient post-EWQ low-flow samples. TN is unrelated to flow in both data sets. No independent data were available to compare with DRBC results. Post-EWQ median TN concentration fell below the lower EWQ 95% confidence interval. Even though TN apparently declined, concentrations in Bushkill Creek are still the highest in all the Lower Delaware.

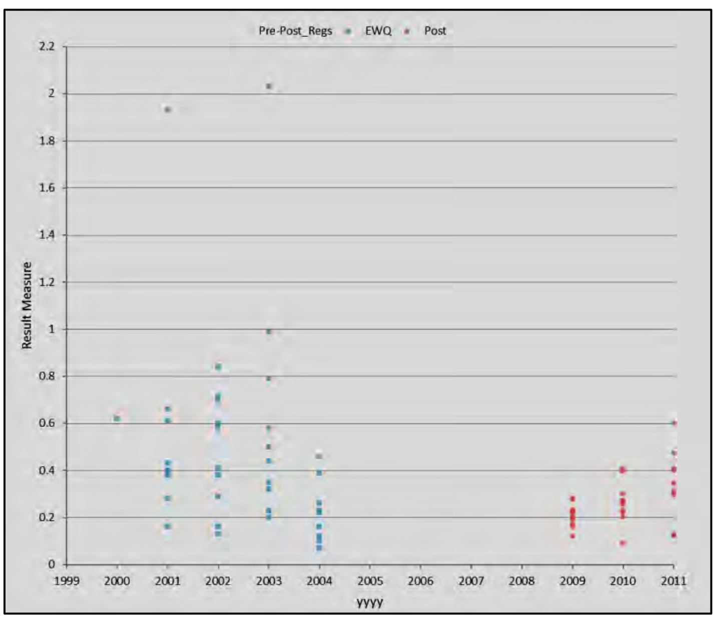
Chapter 19: 1841 BCP Bushkill Creek, PA

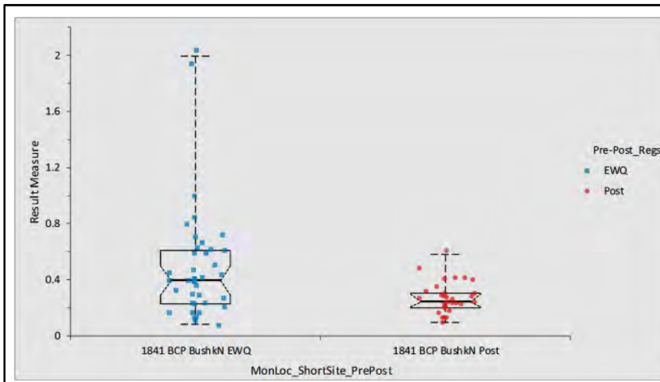
Nitrogen, Kjeldahl as N, Total (TKN) mg/l

Existing Water Quality (Table 2H):

Median 0.40 mg/l
Lower 95% Confidence Interval 0.29 mg/l
Upper 95% Confidence Interval 0.50 mg/l

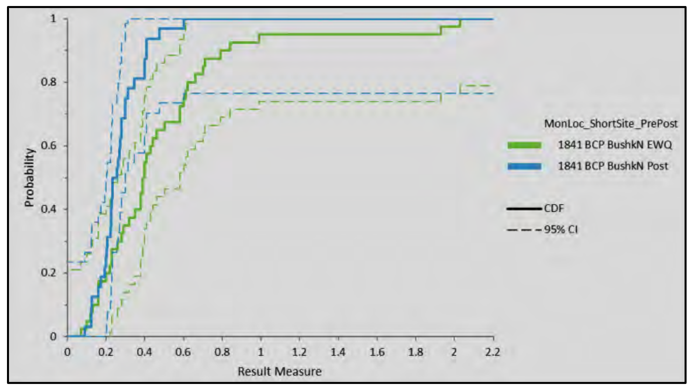






N 72

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1841 BCP BushkN EWQ	0.07	0.23	0.40	0.61	2.03	0.38
1841 BCP BushkN Post	0.09	0.20	0.24	0.31	0.60	0.10



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1841 BCP BushkN EWQ	40	1716.1	42.90
1841 BCP BushkN Post	32	2145.1	67.04

H statistic	8.82
X^2 approximation	8.82
DF	1
p-value	0.0030 [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.

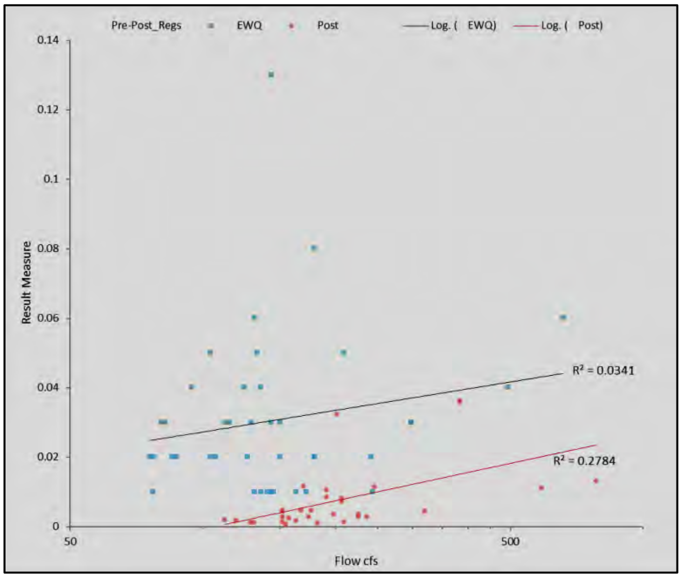
No water quality degradation is evident here. TKN concentrations apparently declined between the EWQ and post-EWQ periods. However, analytical uncertainty was introduced by potential laboratory artifacts and insufficient post-EWQ low-flow samples. The post-EWQ range was far narrower and all concentrations were less than 0.6 mg/l. TKN concentration is unrelated to flow in both data sets. Post-EWQ median TKN fell below the lower EWQ 95% confidence interval, unless the decline is merely a laboratory artifact. The TKN decline contributed to the improvement in total nitrogen concentrations. There were no additional data to confirm DRBC results.

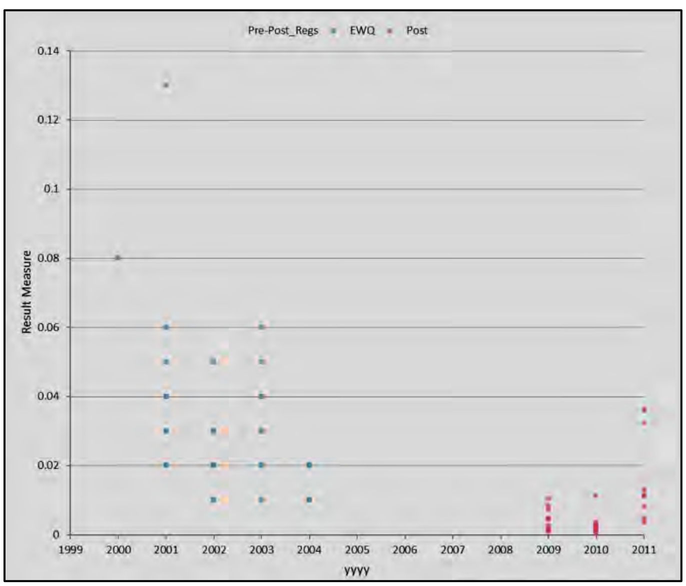
Chapter 19: 1841 BCP Bushkill Creek, PA

Orthophosphate as P, Total mg/l (OP)

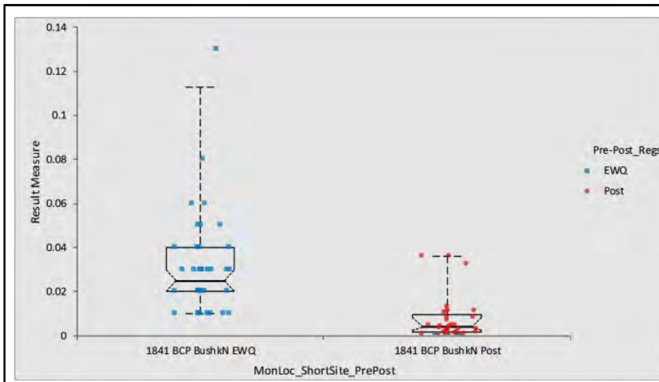
Existing Water Quality (Table 2H):

Median 0.02 mg/l
Lower 95% Confidence Interval 0.02 mg/l
Upper 95% Confidence Interval 0.03 mg/l

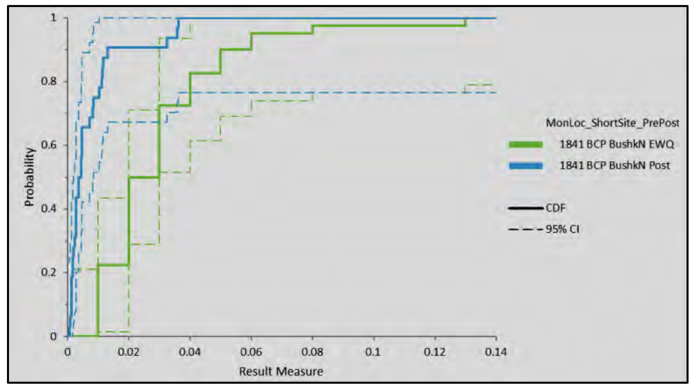




No water quality degradation is evident here. OP concentrations apparently declined between the EWQ and post-EWQ periods. However, analytical uncertainty was introduced by potential laboratory artifacts, detection limit differences and insufficient post-EWQ low-flow samples.



N	72					
Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1841 BCP BushkN EWQ	0.010	0.020	0.025	0.040	0.130	0.020
1841 BCP BushkN Post	0.001	0.002	0.004	0.010	0.036	0.008



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1841 BCP BushkN EWQ	40	6451.6	161.29
1841 BCP BushkN Post	32	8064.5	252.02

H statistic	33.40
X^2 approximation	33.40
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.

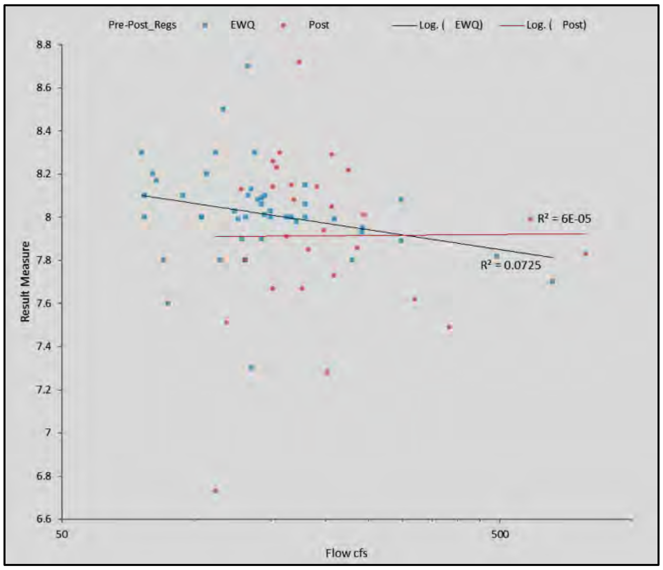
OP is unrelated to flow in both data sets, though there is a weakly positive relationship in the post-EWQ data. Post-EWQ median orthophosphate fell below the lower EWQ 95% confidence interval. Post-EWQ data were far less variable than EWQ data, and there were no post-EWQ measurements higher than 0.04 mg/l. EWQ data were highly variable and contained interference by detection limits, with 9 non-detect results out of 40 tests. There were no undetected results in the post-EWQ data, allowing a clearer picture of actual orthophosphate concentrations contributed by the Bushkill watershed. There were no independent data available for comparison with DRBC results.

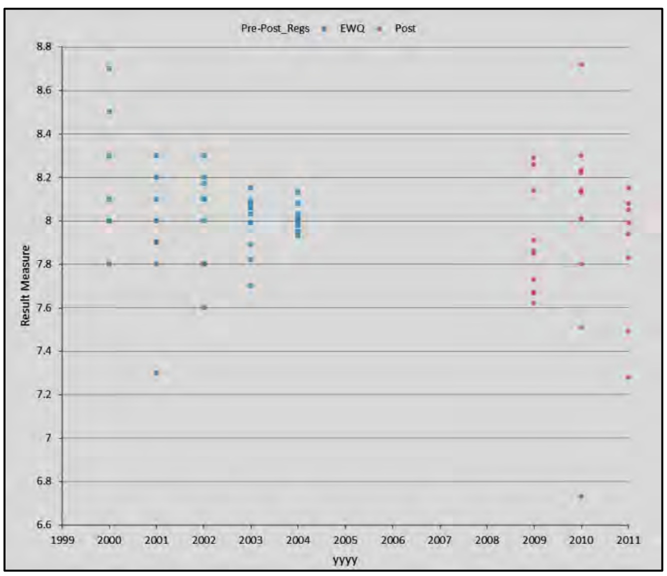
Chapter 19: 1841 BCP Bushkill Creek, PA

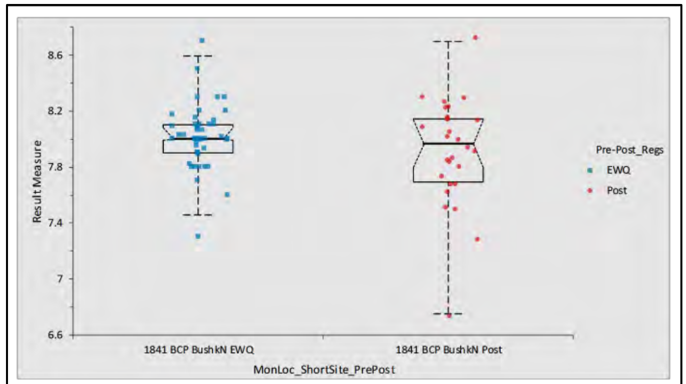
pH

Existing Water Quality (Table 2H):

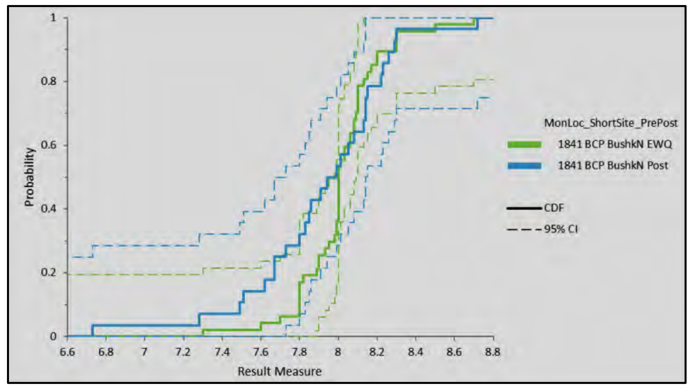
Median 8.00 standard units
Lower 95% Confidence Interval 7.99 standard units
Upper 95% Confidence Interval 8.08 standard units







N	75					
Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1841 BCP BushkN EWQ	7.30	7.91	8.00	8.10	8.70	0.19
1841 BCP BushkN Post	6.73	7.70	7.97	8.15	8.72	0.45



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1841 BCP BushkN EWQ	47	131.1	2.79
1841 BCP BushkN Post	28	220.1	7.86

H statistic	0.74
X^2 approximation	0.74
DF	1
p-value	0.3893 [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.

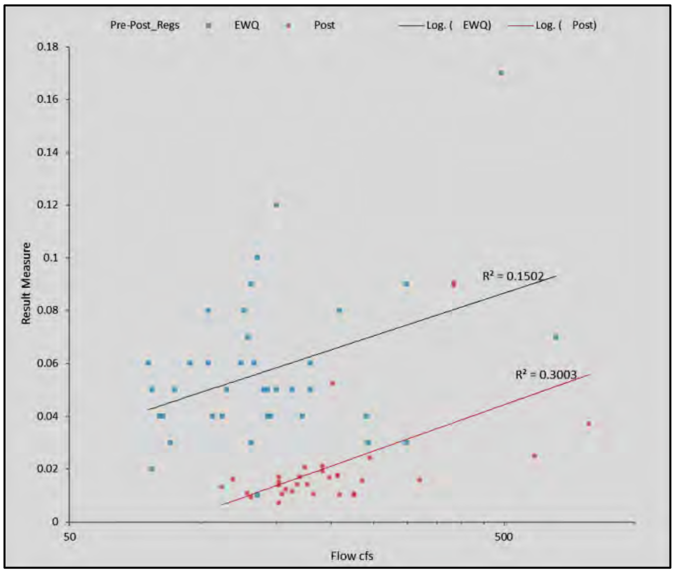
No water quality degradation is evident here. pH apparently did not measurably change between the EWQ and post-EWQ periods. However, analytical uncertainty was introduced by insufficient post-EWQ low-flow samples. pH is unrelated to flow in both data sets. Post-EWQ median pH was within the EWQ 95% confidence intervals. Bushkill Creek median pH is a bit higher than most streams but not unusually so. Median values of 8.0 (EWQ) and 7.95 (post-EWQ) reflect the natural limestone influence and groundwater content pumped from the quarry. The low value of 6.7 observed in 2010 was probably a probe malfunction.

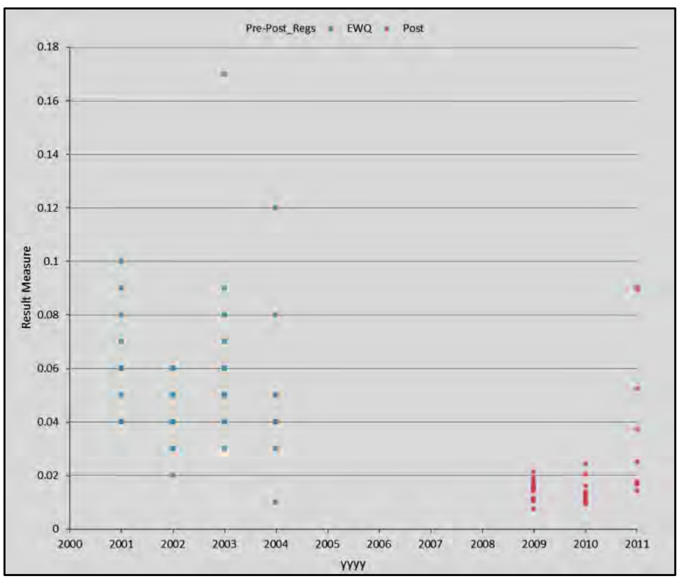
Chapter 19: 1841 BCP Bushkill Creek, PA

Phosphorus as P, Total (TP) mg/l

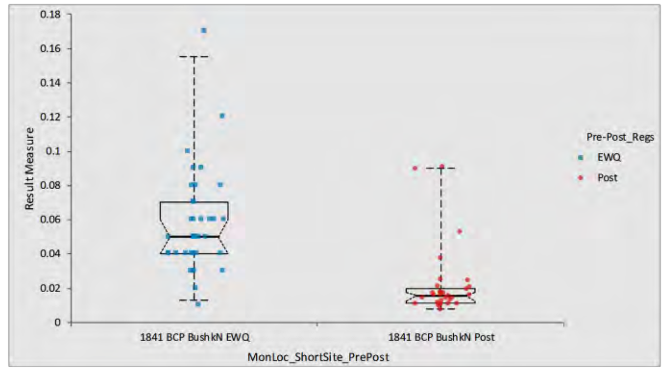
Existing Water Quality (Table 2H):

Median 0.05 mg/l
Lower 95% Confidence Interval 0.04 mg/l
Upper 95% Confidence Interval 0.06 mg/l (<u>0.07</u> recalc*)



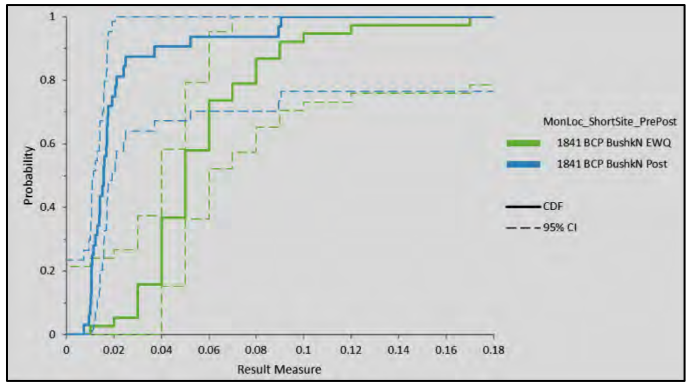


*The data set was recalculated upon removal of a single high outlier value of 0.61 mg/l from July 2001, a suspected data entry error. Inclusion of that data point distorted the view of remaining data. Its exclusion has no influence upon the median or percentile values other than reducing the overall number of data by 1.



N | 70

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1841 BCP BushkN EWQ	0.010	0.040	0.050	0.070	0.170	0.030
1841 BCP BushkN Post	0.007	0.011	0.016	0.020	0.090	0.009



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1841 BCP BushkN EWQ	38	6126.5	161.22
1841 BCP BushkN Post	32	7275.2	227.35

H statistic	32.48
X^2 approximation	32.48
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.

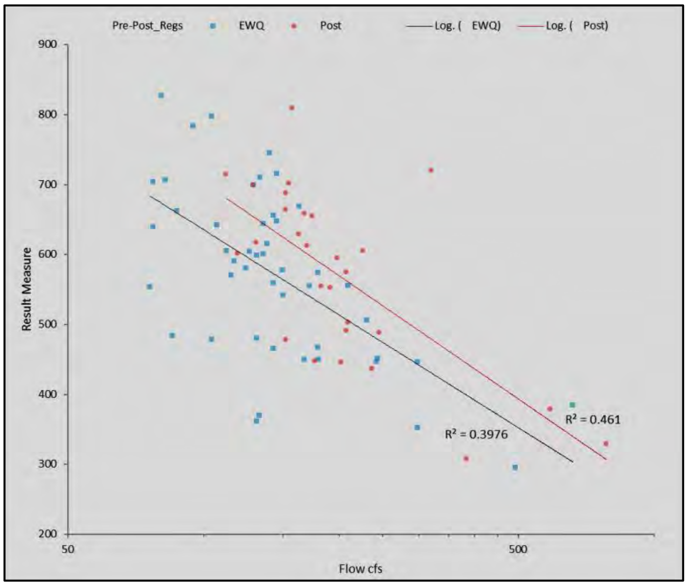
No water quality degradation is evident here. Total Phosphorus (TP) concentrations apparently declined between the EWQ and post-EWQ periods. However, analytical uncertainty was introduced by potential laboratory artifacts, detection limit differences and insufficient post-EWQ low-flow samples. Post-EWQ median total phosphorus fell below the EWQ lower 95% confidence interval. TP is weakly related to flow in both data sets. No additional data were available to confirm DRBC results. EWQ results were more variable than post-EWQ data, which contained no concentrations higher than 0.09 mg/l. This suggests either a water quality improvement or laboratory artifacts.

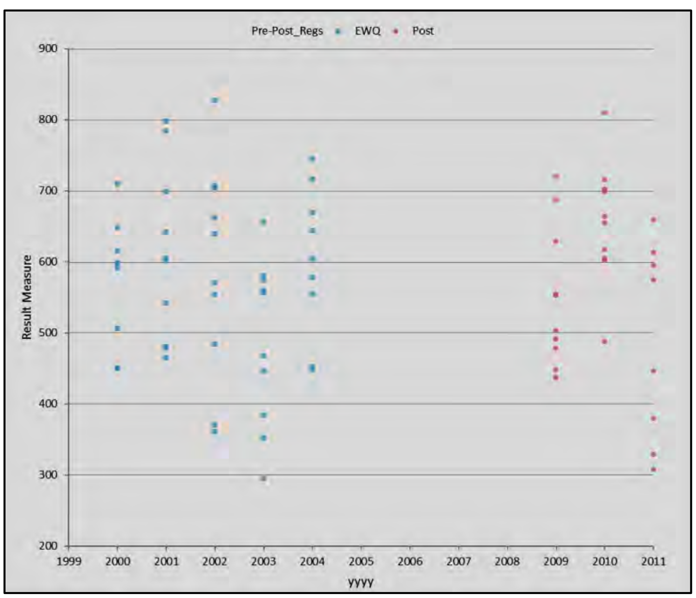
Chapter 19: 1841 BCP Bushkill Creek, PA

Specific Conductance µmho/cm

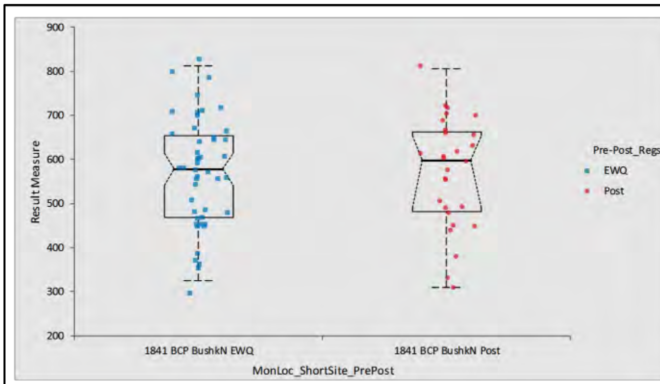
Existing Water Quality (Table 2H):

Median 578 µmho/cm
Lower 95% Confidence Interval 542 µmho/cm
Upper 95% Confidence Interval 615 µmho/cm
Defined in regulations as a flow-related parameter

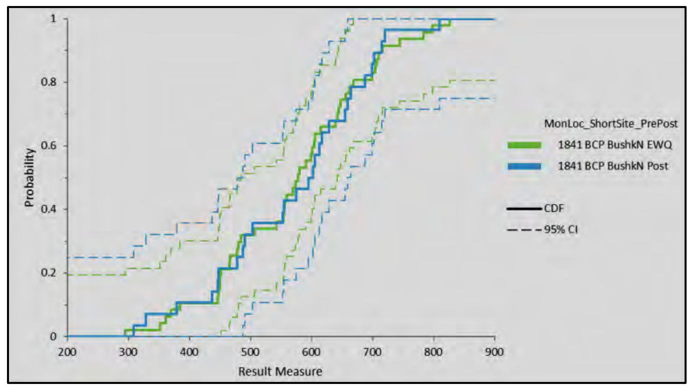




Water quality degradation may have occurred here. Specific conductance apparently increased but did not rise above the EWQ upper 95% confidence interval. However, analytical uncertainty was introduced by insufficient post-EWQ low-flow samples.



N	75					
Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1841 BCP BushkN EWQ	295	469	578	655	827	186
1841 BCP BushkN Post	308	482	599	662	810	180



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1841 BCP BushkN EWQ	47	2.8	0.06
1841 BCP BushkN Post	28	4.7	0.17

H statistic	0.02
X² approximation	0.02
DF	1
p-value	0.8998 [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.

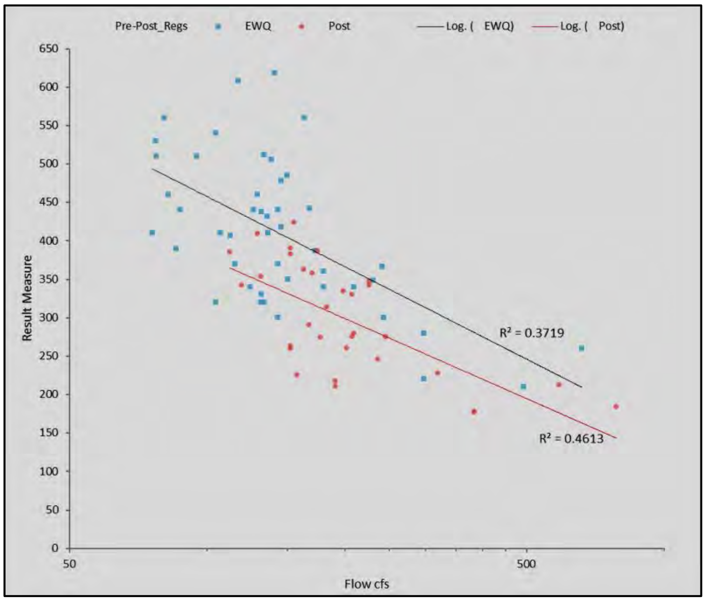
Specific conductance is inversely related to flow in both data sets. If median flow between the two data sets were equal, the increase would have been significant. Since post-EWQ median flow was 45 cfs greater than EWQ median flow, specific conductance did not measurably change. However, the difference is apparent on the plot of concentration vs. flow. The rise in specific conductance may be partially attributable to the concurrent rise in chloride concentrations. Median specific conductance has risen from 578 to 599 µmho/cm; a 10% increase in a few years' time. No data were available to confirm DRBC results.

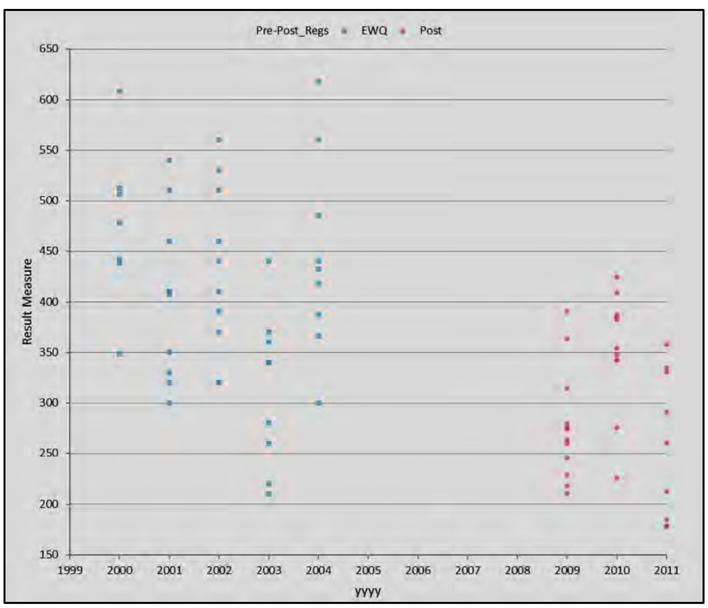
Chapter 19: 1841 BCP Bushkill Creek, PA

Total Dissolved Solids (TDS) mg/l

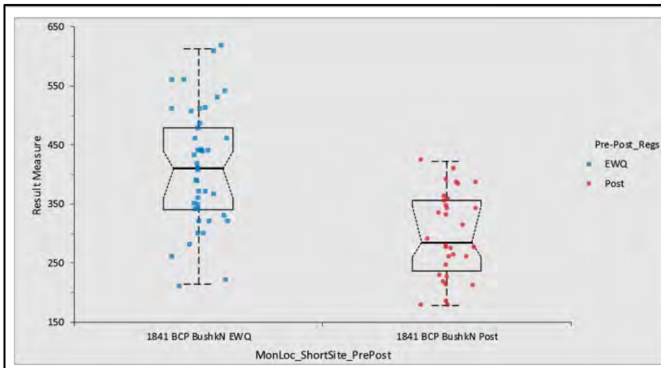
Existing Water Quality (Table 2H):

Median 410 mg/l
Lower 95% Confidence Interval 360 mg/l
Upper 95% Confidence Interval 440 mg/l
Defined in regulations as a flow-related parameter



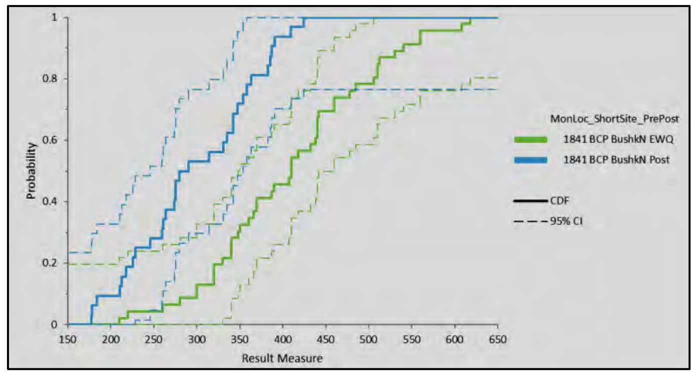


No water quality degradation is evident here. TDS apparently declined. However, analytical uncertainty was introduced by potential laboratory artifacts and insufficient post-EWQ low-flow samples.



N	78

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1841 BCP BushkN EWQ	210	340	410	479	618	139
1841 BCP BushkN Post	178	236	285	356	424	121



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1841 BCP BushkN EWQ	46	4720.8	102.63
1841 BCP BushkN Post	32	6786.1	212.07

H statistic	22.41
X^2 approximation	22.41
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.

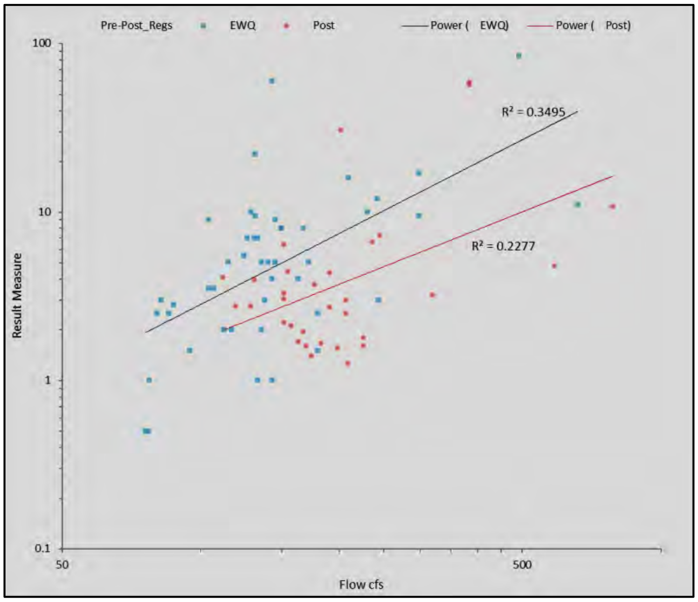
TDS is inversely related to flow in both data sets. Post-EWQ median TDS fell below the EWQ lower 95% lower confidence interval. Post-EWQ TDS was slightly less variable than the baseline samples as well. Post-EWQ detection limits were lower than EWQ detection limits, though there were no undetected results at any time.

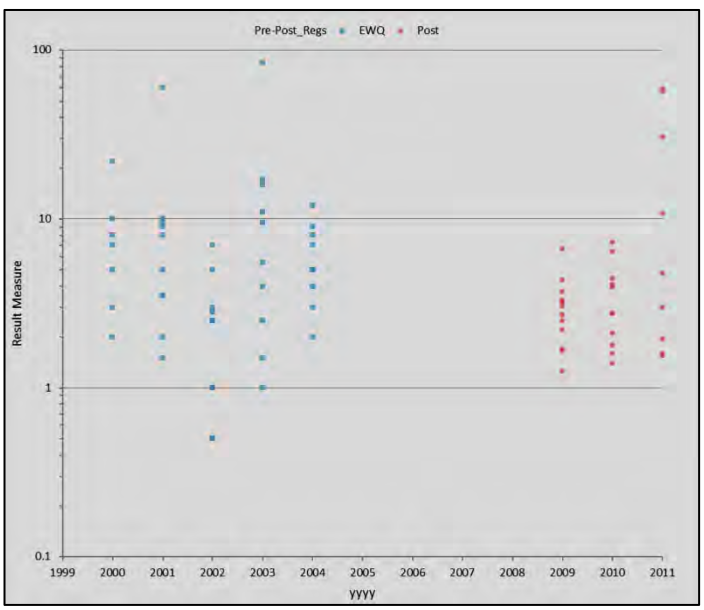
Chapter 19: 1841 BCP Bushkill Creek, PA

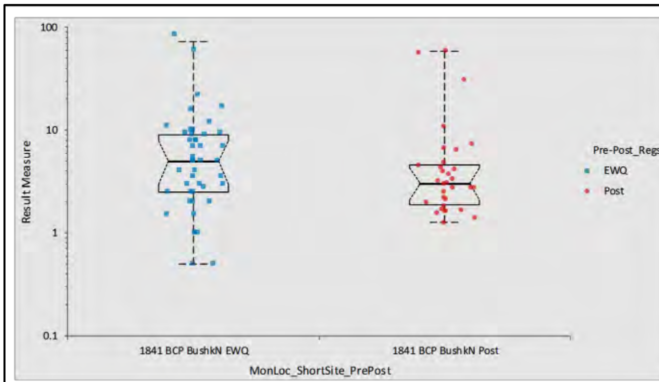
Total Suspended Solids (TSS) mg/l

Existing Water Quality (Table 2H):

Median 5.0 mg/l
Lower 95% Confidence Interval 3.0 mg/l
Upper 95% Confidence Interval 8.0 mg/l
<u>Should have been designated in rules as flow-related</u>

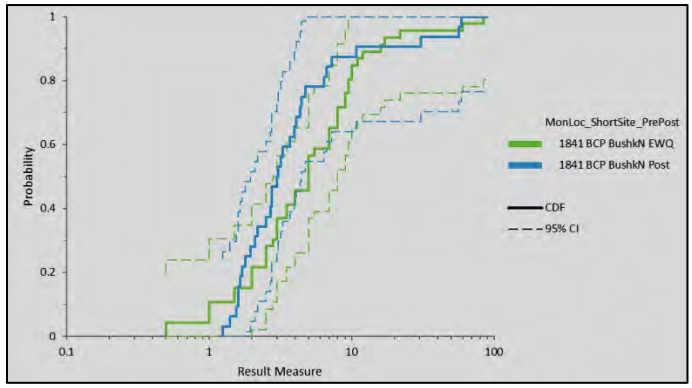






N 78

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1841 BCP BushkN EWQ	0.5	2.5	5.0	9.0	84.0	6.5
1841 BCP BushkN Post	1.3	1.9	3.0	4.6	58.8	2.8



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1841 BCP BushkN EWQ	46	577.6	12.56
1841 BCP BushkN Post	32	830.3	25.95

H statistic	2.74
X² approximation	2.74
DF	1
p-value	0.0976 [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.

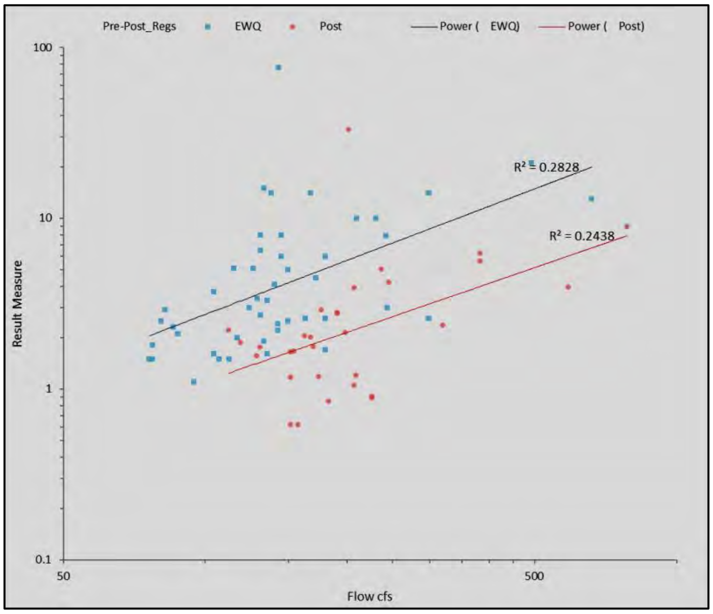
No water quality degradation is evident here. TSS apparently did not measurably change between the EWQ and post-EWQ periods. However, analytical uncertainty was introduced by potential laboratory artifacts and insufficient post-EWQ low-flow samples. TSS is positively but weakly related to flow in both data sets. Post-EWQ median TSS fell to the EWQ lower 95% confidence interval, which is expected given the higher flow conditions sampled in the post-EWQ data set. Flows and concentrations are plotted on logarithmic scale, and regressions are power relationships. There were no independent data available to confirm DRBC results.

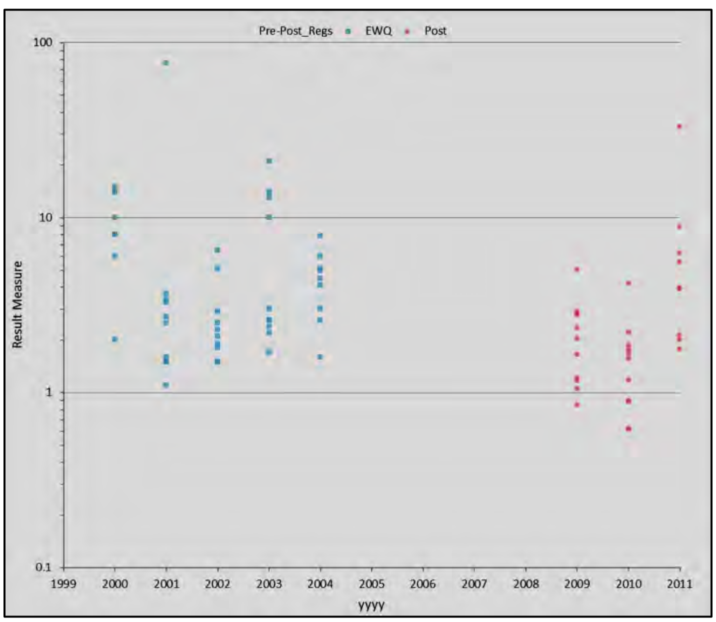
Chapter 19: 1841 BCP Bushkill Creek, PA

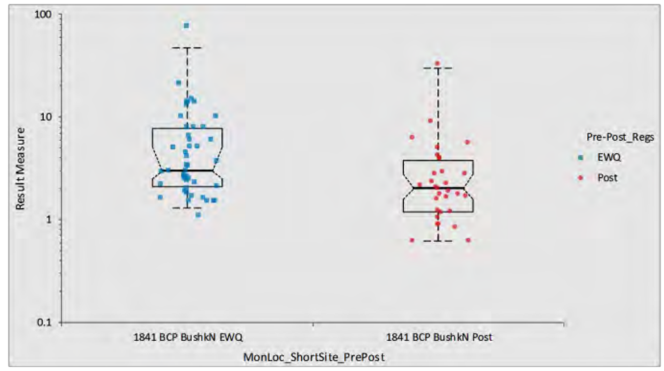
Turbidity NTU

Existing Water Quality (Table 2H):

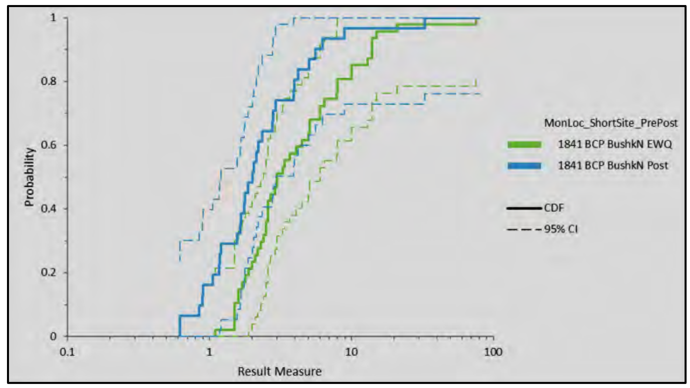
Median 3.0 NTU
Lower 95% Confidence Interval 2.5 NTU
Upper 95% Confidence Interval 5.1 NTU







	N	78				
Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1841 BCP BushkN EWQ	1.1	2.1	3.0	7.7	76.0	5.6
1841 BCP BushkN Post	0.6	1.2	2.0	3.7	32.9	2.6



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1841 BCP BushkN EWQ	47	1845.3	39.26
1841 BCP BushkN Post	31	2797.8	90.25

H statistic	9.04
X² approximation	9.04
DF	1
p-value	0.0026 [1]

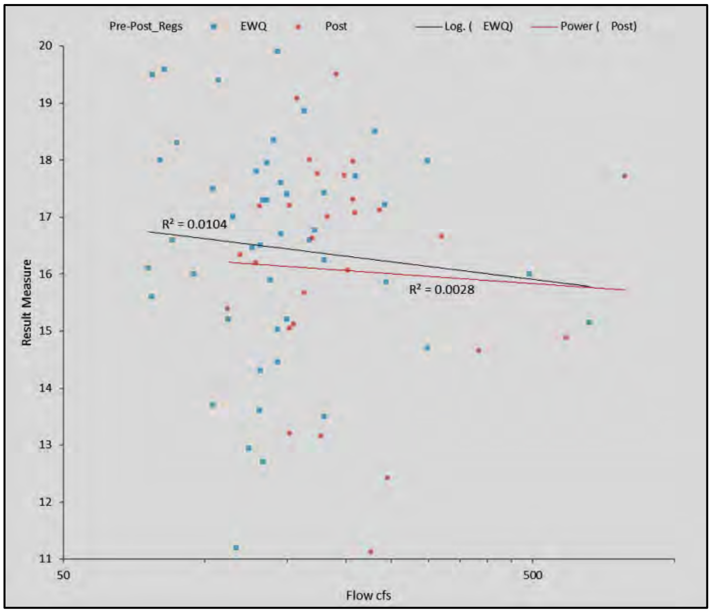
H0: $\theta_1 = \theta_2 = \theta ...$
The median of the populations are all equal.
H1: $\theta_i \neq \theta_j$ for at least one i,j
The median of the populations are not all equal.
[1] Reject the null hypothesis in favour of the alternative hypothesis at the 5% significance level.

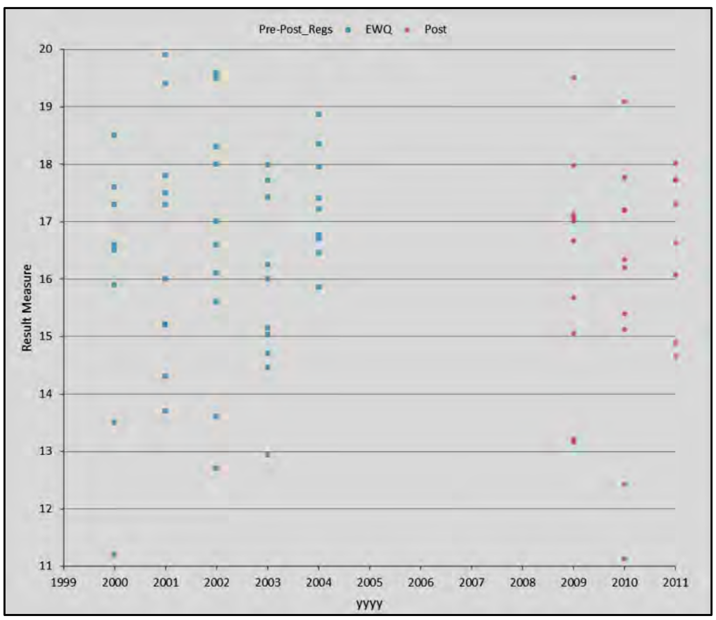
No water quality degradation is evident here. Turbidity apparently declined between the EWQ and post-EWQ periods. However, analytical uncertainty was introduced by insufficient post-EWQ low-flow samples. The post-EWQ median turbidity fell below the lower EWQ 95% confidence interval. Turbidity is positively but weakly related to flow in both data sets. Flows and concentrations are represented on logarithmic scale, and regressions are power relationships. There were no additional data available for comparison with DRBC results.

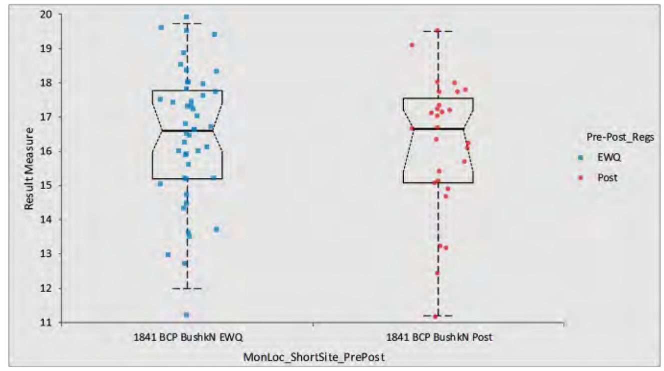
Chapter 19: 1841 BCP Bushkill Creek, PA

Water Temperature, degrees C

Not included in DRBC Existing Water Quality rules

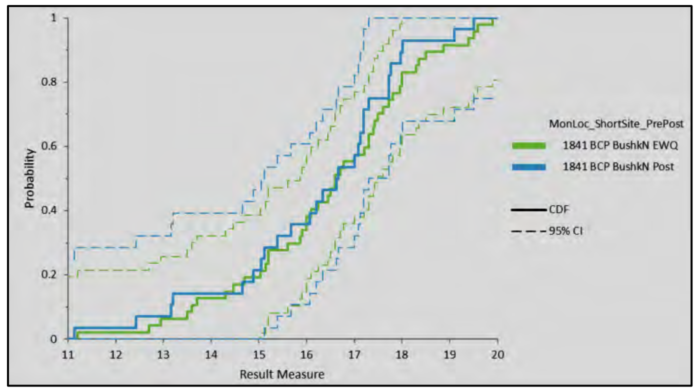






N | 75

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1841 BCP BushkN EWQ	11.2	15.2	16.6	17.8	19.9	2.6
1841 BCP BushkN Post	11.1	15.1	16.7	17.5	19.5	2.5



Kruskal-Wallis test

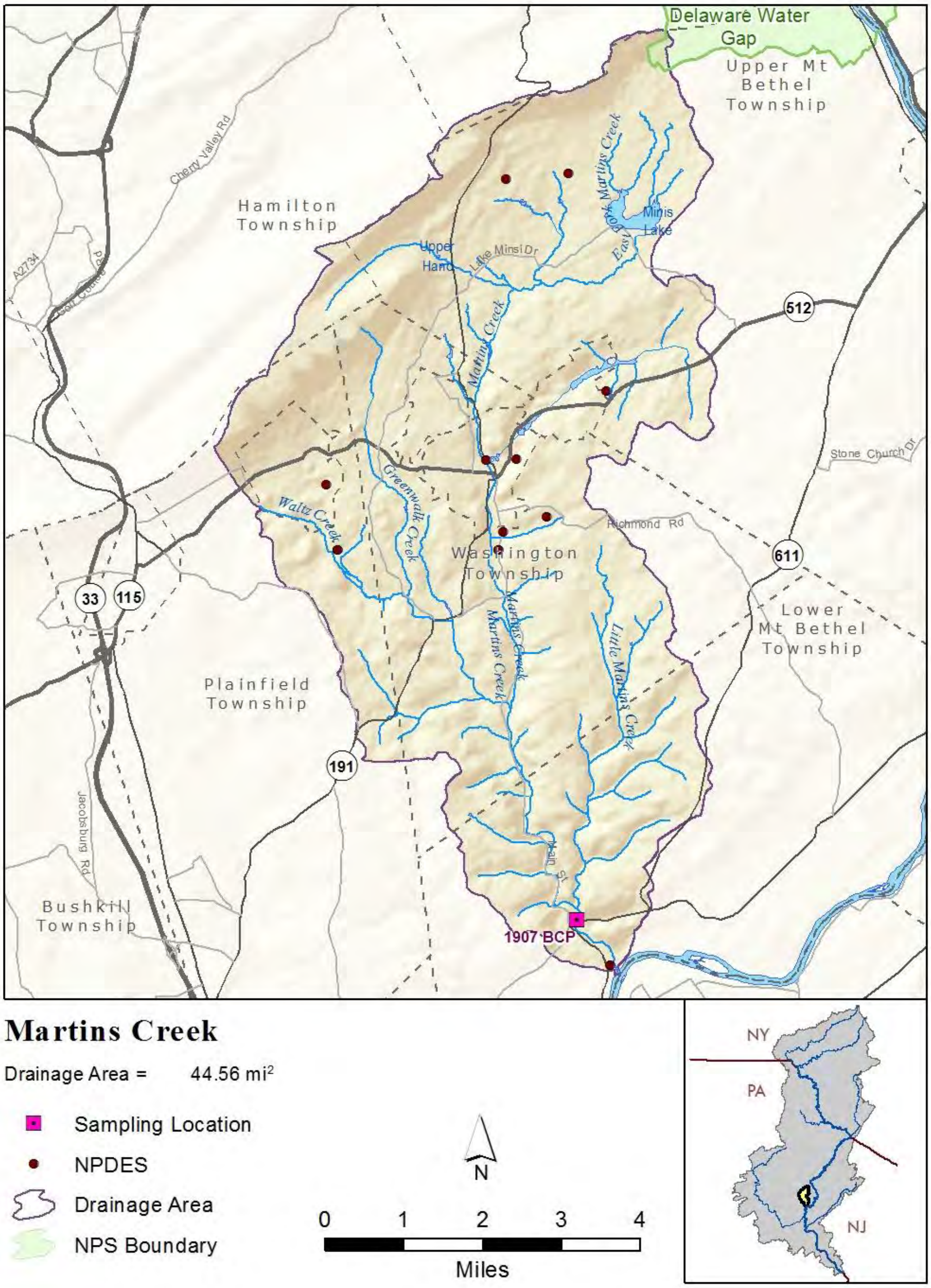
Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1841 BCP BushkN EWQ	47	50.0	1.06
1841 BCP BushkN Post	28	84.0	3.00

H statistic	0.28
X^2 approximation	0.28
DF	1
p-value	0.5952 [1]

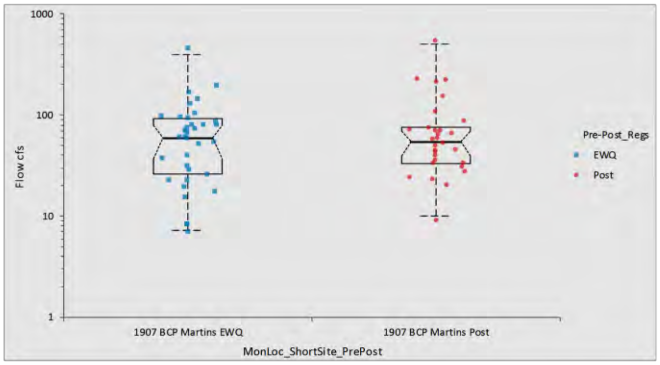
H0: $\theta_1 = \theta_2 = \theta_{...}$
The median of the populations are all equal.
H1: $\theta_i \neq \theta_j$ for at least one i,j
The median of the populations are not all equal.
[1] Do not reject the null hypothesis at the 5% significance level.

No water quality degradation is evident here. Water temperature appears identical between the EWQ and post-EWQ periods. However, analytical uncertainty was introduced by insufficient post-EWQ low-flow samples. Water temperature is unrelated to flow in both data sets. No independent data were available to confirm DRBC results.

Chapter 20: 1907 BCP Martins Creek, Northampton County, PA



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
1907 BCP Martins EWQ	7	26	59	92	453	66
1907 BCP Martins Post	9	33	54	76	536	43

Flow conditions associated with the EWQ and post-EWQ sampling periods were similar. The range of flow conditions sampled was also roughly equal, so water quality comparisons should not be affected by unequal flow conditions.

Kruskal-Wallis test

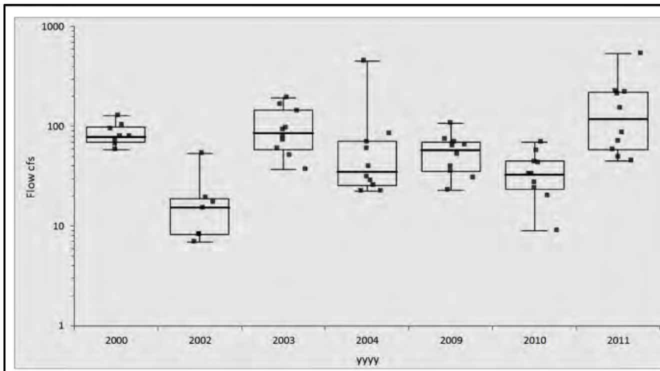
Flow cfs by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1907 BCP Martins EWQ	35	0.1	0.00
1907 BCP Martins Post	30	0.1	0.00

H statistic	0.00
X^2 approximation	0.00
DF	1
p-value	0.9790[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.

Martins Creek is a good-quality cold-water creek possessing naturally reproducing trout populations. The watershed was about 38% glaciated, 8% urban, and contains significant agricultural lands. Overall watershed area is about 44.5 square miles, and it is about 55% forested. Only 1.5% of the watershed is covered by carbonate bedrock. In comparison, the neighboring Bushkill Creek watershed is 38% carbonate bedrock, and the Lehigh River watershed contains 16%. So limestone is not a major determinant of water quality here compared with the Bushkill and Lehigh.

Upstream ICP: Delaware River at Belvidere 1978 ICP
Downstream ICP: Delaware River at Easton 1838 ICP



N 65

Flow cfs by yyyy	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
2000	58.5	69.8	78.9	99.0	128.3	29.2
2002	6.9	8.3	15.1	18.8	53.6	10.5
2003	36.7	58.5	85.9	145.4	194.2	86.9
2004	22.6	25.3	35.3	70.8	452.9	45.6
2009	23.1	35.2	57.7	69.3	107.5	34.1
2010	8.9	23.4	32.8	45.1	69.2	21.6
2011	45.4	58.1	119.6	220.1	536.0	162.0

There are few dischargers in the Martins Creek watershed. There are no independent data sources available to compare with DRBC results at this site. There is a USGS gage in the watershed, but it is located in the upper portion of the watershed and is too far from the Little Creek Road monitoring site to be of use for flow estimation.

Annual May to September flow statistics associated with water quality measurements are plotted above. These are measurements or estimates associated with the time of each water quality sample. Mean annual flow is about 76 cfs; and harmonic mean flow is about 24 cfs (USGS Stream Stats retrieval, Feb. 2014) which is more typical of summer flow conditions. Among the wide range of flows sampled by DRBC, these data appear to be most representative of harmonic mean to mean annual flow conditions. In the EWQ period, flows were measured using a DRBC-constructed benchmark gage and gage-discharge rating. Because of shifting gravel bars near the Little Creek Road site, it proved too expensive to continue maintenance of the rating curve. Post-EWQ flows corresponding to each water quality sample were estimated using the USGS BaSE model, but still compared with DRBC benchmark gage height measurements. BaSE estimates and rating curve measurements were comparable. DRBC intends to use the BaSE program for future flow estimates.

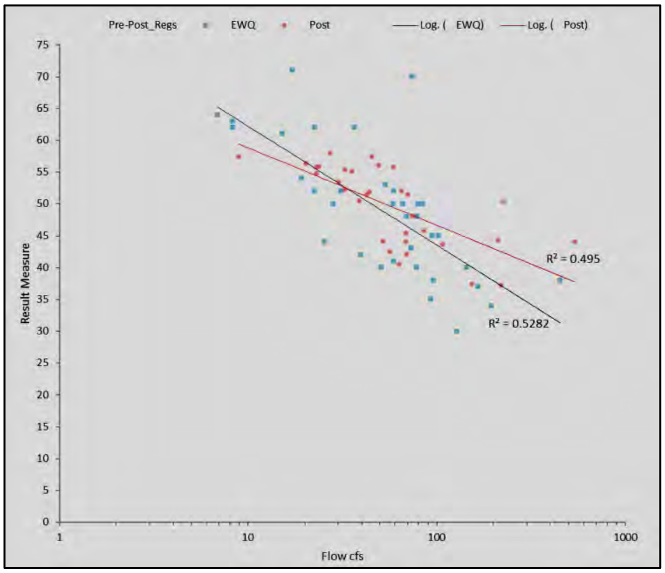
*Stuckey, M.H., Koerkle, E.H., and Ulrich, J.E., 2012, Estimation of baseline daily mean streamflows for ungaged locations on Pennsylvania streams, water years 1960–2008: U.S. Geological Survey Scientific Investigations Report 2012–5142, 61 p.)

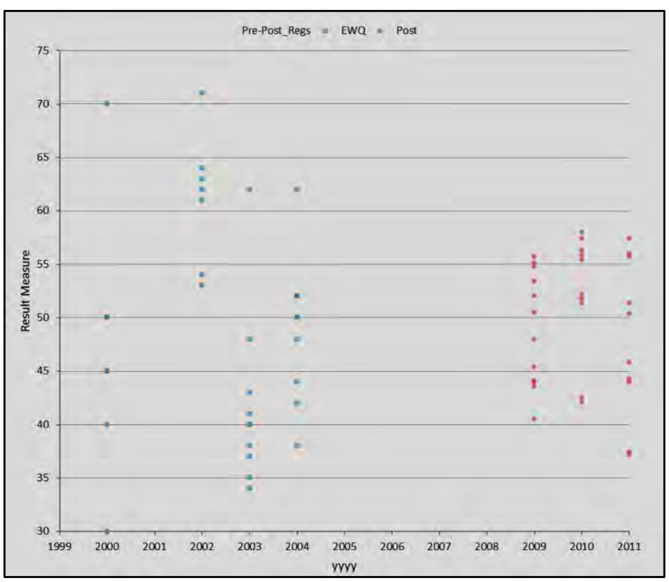
Chapter 20: 1907 BCP Martins Creek, PA

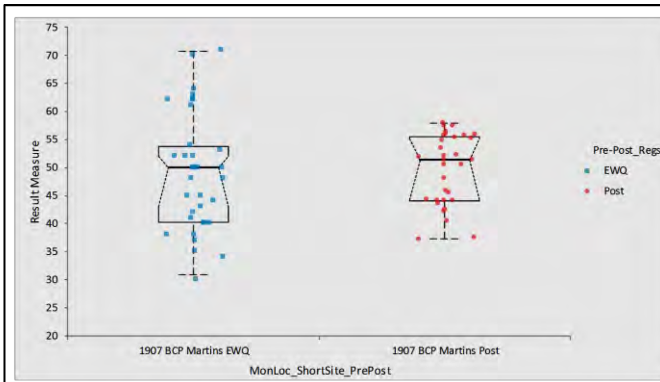
Alkalinity as CaCO3, Total mg/l

Existing Water Quality (Table 2G):

Median 50 mg/l
Lower 95% Confidence Interval 43 mg/l
Upper 95% Confidence Interval 52 mg/l
Defined in regulations as a flow-related parameter

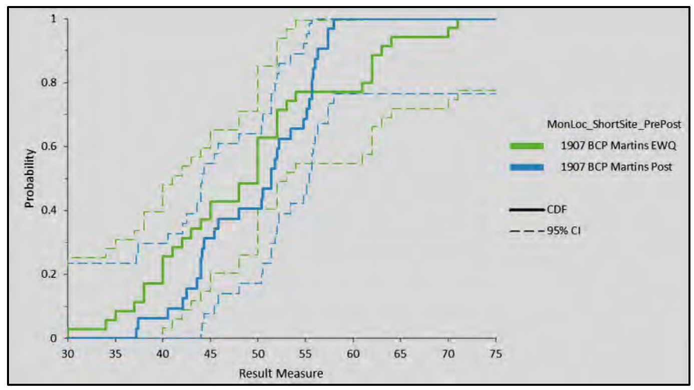






N 67

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1907 BCP Martins EWQ	30	40	50	54	71	14
1907 BCP Martins Post	37	44	51	56	58	12



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1907 BCP Martins EWQ	35	138.0	3.94
1907 BCP Martins Post	32	150.9	4.72

H statistic	0.76
X^2 approximation	0.76
DF	1
p-value	0.3828 [1]

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

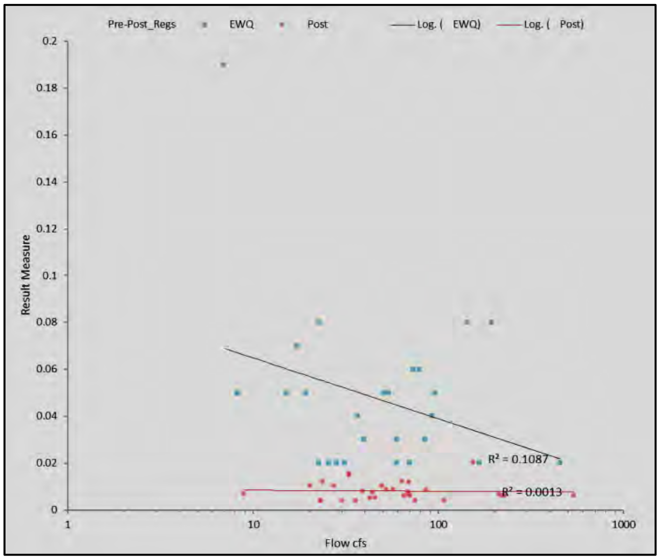
No water quality degradation is evident here. Alkalinity apparently did not measurably change between the EWQ and post-EWQ periods. However, analytical uncertainty was introduced by potential laboratory artifacts. Alkalinity is inversely related to flow in both data sets. Post-EWQ median alkalinity was within the EWQ 95% confidence intervals. Flow is plotted on a logarithmic scale.

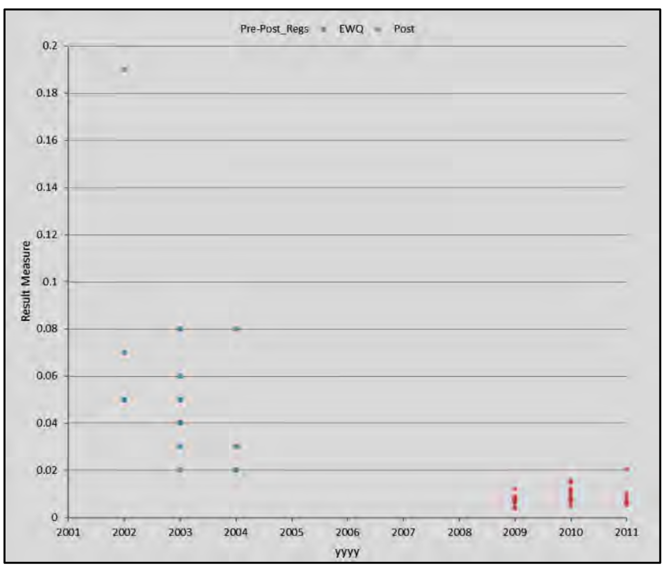
Chapter 20: 1907 BCP Martins Creek, PA

Ammonia Nitrogen as N, Total mg/l

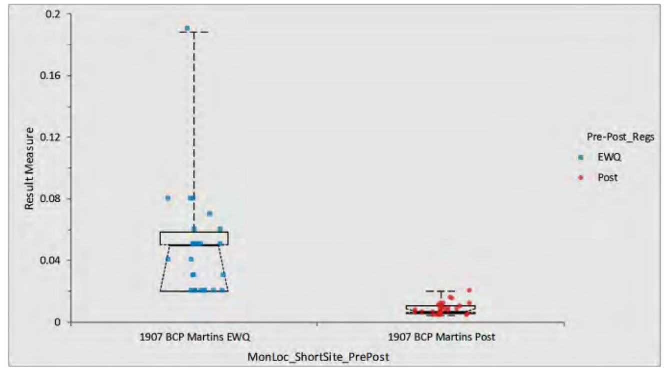
Existing Water Quality (Table 2G):

Median <0.05 mg/l
Lower 95% Confidence Interval 0.02* mg/l
Upper 95% Confidence Interval 0.05 mg/l
*based on estimated values below detection limit



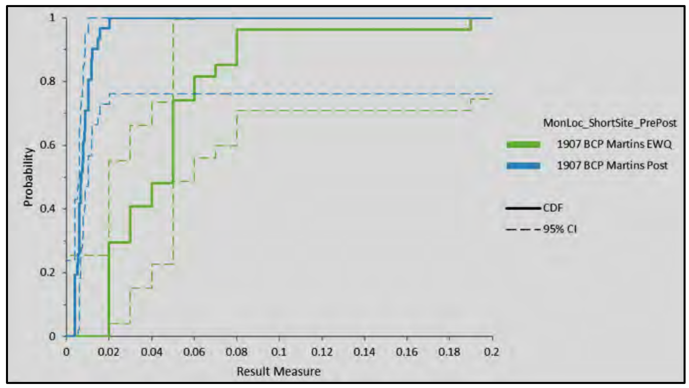


No water quality degradation is evident here. Ammonia concentrations appear to have declined significantly. However, analytical uncertainty was introduced by potential laboratory artifacts and detection limit differences.



N 58

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1907 BCP Martins EWQ	0.020	0.020	0.050	0.058	0.190	0.038
1907 BCP Martins Post	0.004	0.006	0.007	0.010	0.020	0.005



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1907 BCP Martins EWQ	27	6241.1	231.15
1907 BCP Martins Post	31	5435.8	175.35

H statistic	41.20
X^2 approximation	41.20
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.

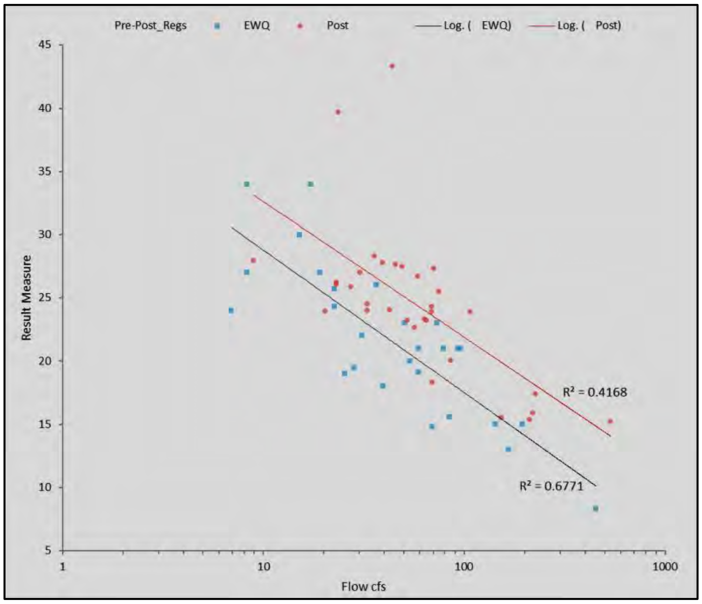
Post-EWQ median ammonia concentration was below the EWQ lower 95% confidence interval. There were no independent data available for comparison with DRBC results. Ammonia is unrelated to flow in both data sets. Flow is plotted on a logarithmic scale. EWQ data contained 18 undetected results out of 27 tests. EWQ results above the detection limit were highly variable. Under 2009-2011 lower detection levels there were still 12/31 undetected results. Post-EWQ results above detection levels were less variable – no result was higher than 0.02 mg/l. True ammonia concentrations are now measurable in this high-quality stream.

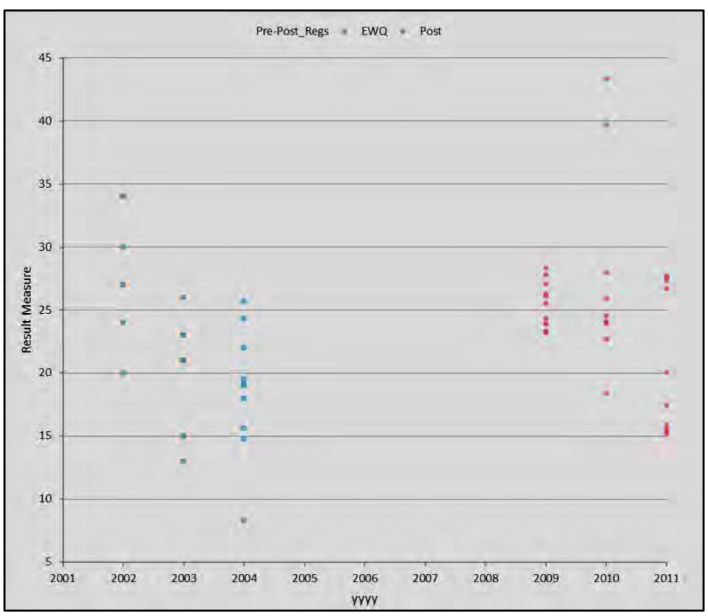
Chapter 20: 1907 BCP Martins Creek, PA

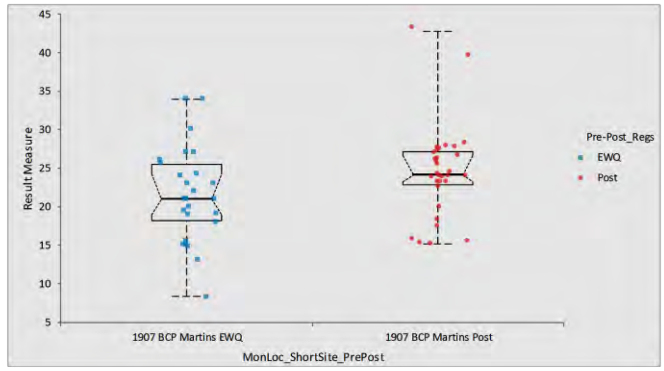
Chloride, Total mg/l

Existing Water Quality (Table 2G):

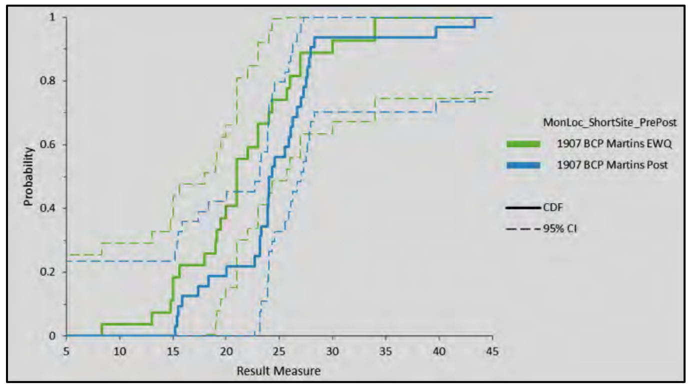
Median 21.0 mg/l
Lower 95% Confidence Interval 19.0 mg/l
Upper 95% Confidence Interval 24.3 mg/l
Defined in regulations as a flow-related parameter







N	59					
Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1907 BCP Martins EWQ	8.3	18.2	21.0	25.5	34.0	7.3
1907 BCP Martins Post	15.2	22.9	24.2	27.2	43.3	4.3



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1907 BCP Martins EWQ	27	757.4	28.05
1907 BCP Martins Post	32	639.0	19.97

H statistic	4.74
X^2 approximation	4.74
DF	1
p-value	0.0295 [1]

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

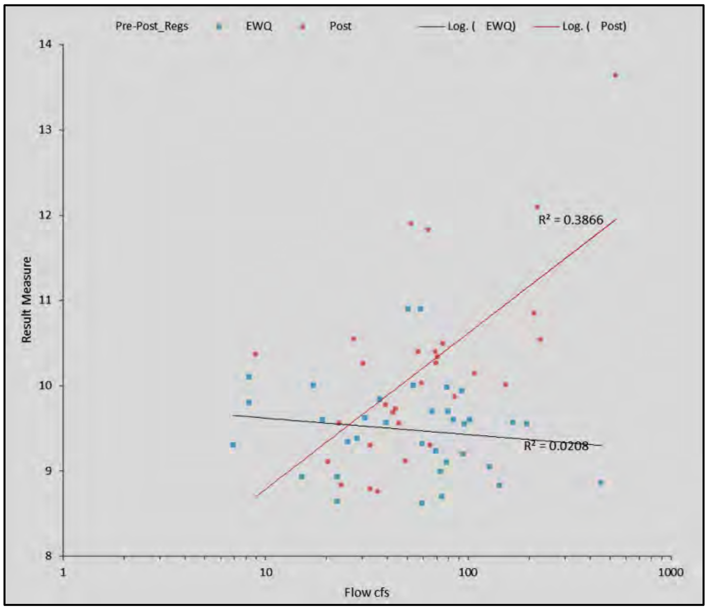
There is evidence of water quality degradation here. Chloride concentrations apparently rose by about 3 mg/l between the two periods. However, analytical uncertainty was introduced by potential laboratory artifacts. Post-EWQ median concentration rose to the EWQ upper 95% confidence interval. Chloride concentration is inversely related to flow in both data sets. Note that flow is plotted on a logarithmic scale. No independent data were available for comparison with DRBC results.

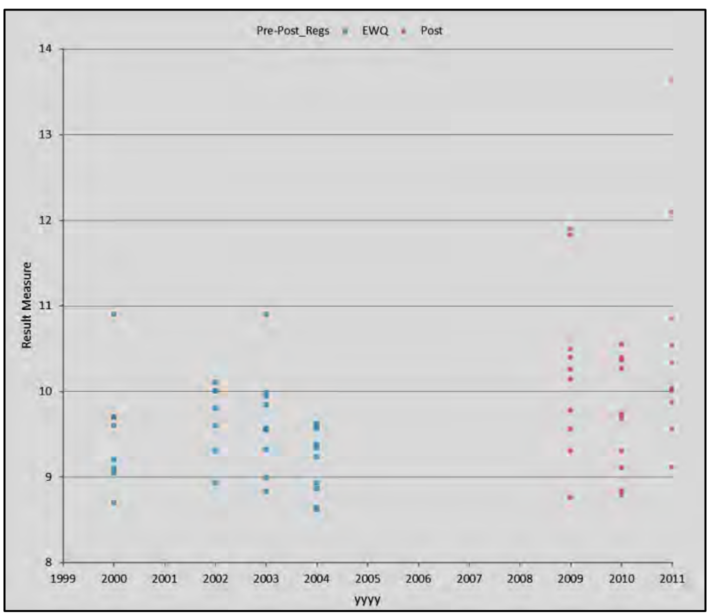
Chapter 20: 1907 BCP Martins Creek, PA

Dissolved Oxygen (DO) mg/l

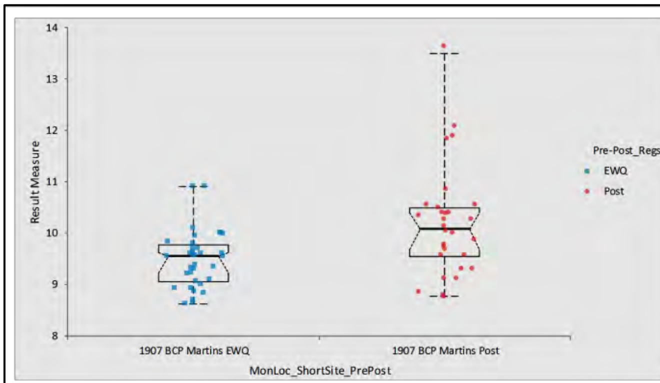
Existing Water Quality (Table 2G):

Median 9.55 mg/l
Lower 95% Confidence Interval 9.23 mg/l
Upper 95% Confidence Interval 9.62 mg/l

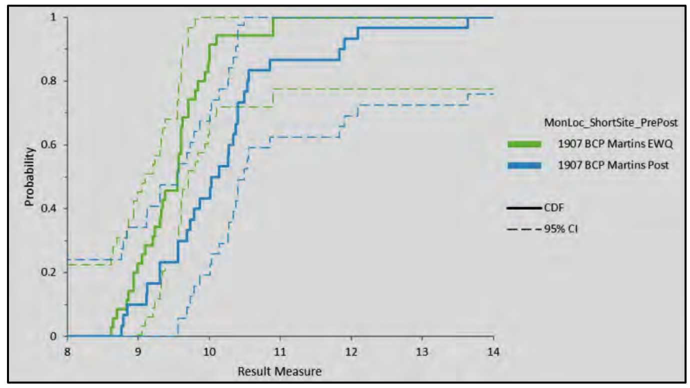




No water quality degradation is evident here. Dissolved oxygen concentrations increased between the EWQ and Post-EWQ periods. There were no known sources of analytical uncertainty in these data.



N	65					
Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1907 BCP Martins EWQ	8.62	9.06	9.55	9.78	10.90	0.73
1907 BCP Martins Post	8.76	9.54	10.09	10.49	13.64	0.96



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1907 BCP Martins EWQ	35	1604.8	45.85
1907 BCP Martins Post	30	1872.3	62.41

H statistic	9.73
X² approximation	9.73
DF	1
p-value	0.0018 [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.

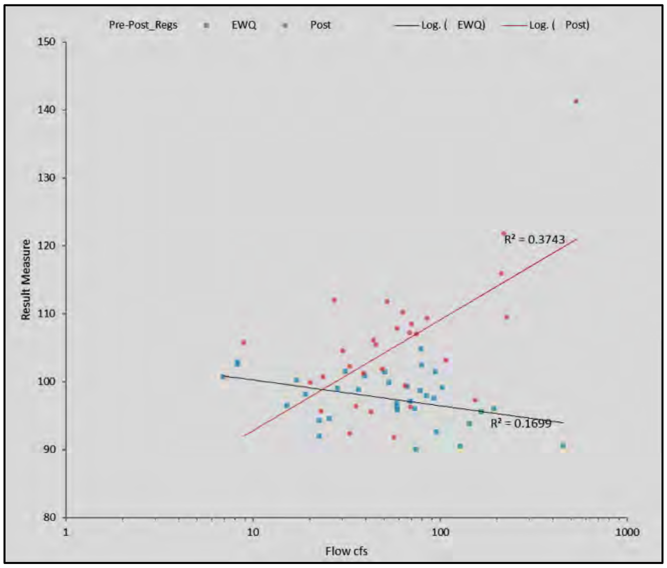
Post-EWQ median DO concentration was above the upper EWQ 95% confidence interval. Such an increase constitutes a water quality improvement. DO concentration is unrelated to flow in the EWQ data set. DO is positively related to flow in the post-EWQ data, apparently driven by a few high measurements taken in 2009 and 2011. Unless there was a change in water temperatures (none) or increased algal activity (possible), the relationship may not be real. Flow is plotted on a logarithmic scale. No independent data were available for comparison with DRBC results.

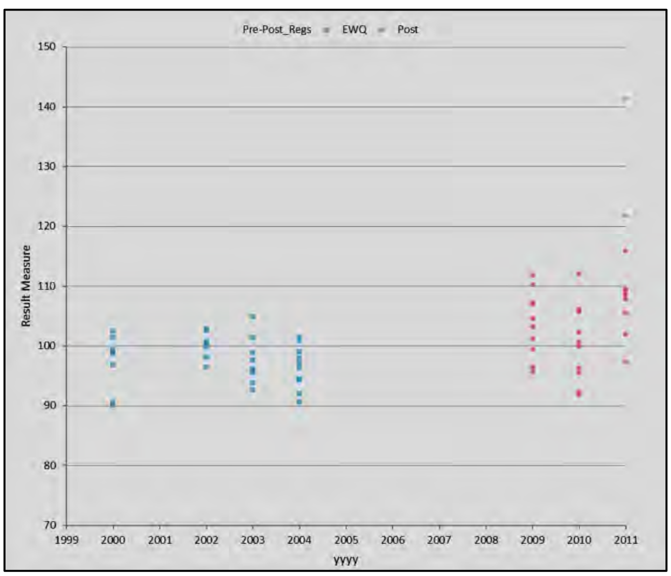
Chapter 20: 1907 BCP Martins Creek, PA

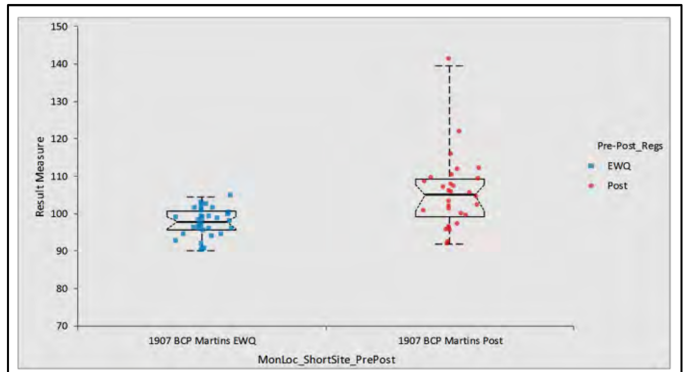
Dissolved Oxygen Saturation %

Existing Water Quality (Table 2G):

Median 98%
Lower 95% Confidence Interval 96%
Upper 95% Confidence Interval 99%

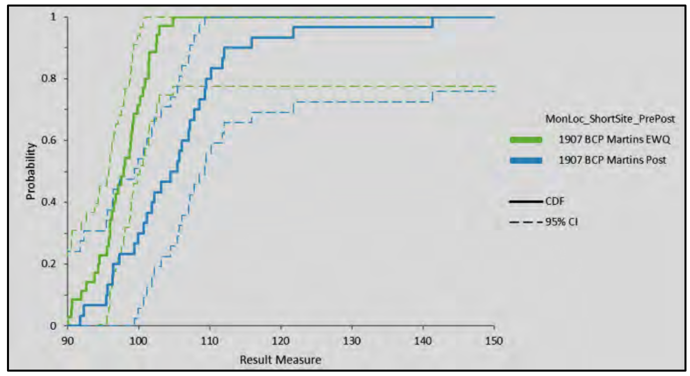






N 65

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1907 BCP Martins EWQ	90	96	98	101	105	5
1907 BCP Martins Post	92	99	105	109	141	10



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1907 BCP Martins EWQ	35	2571.4	73.47
1907 BCP Martins Post	30	3000.0	100.00

H statistic	15.58
X^2 approximation	15.58
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. Dissolved oxygen saturation increased between the EWQ and post-EWQ periods. There were no known sources of analytical uncertainty in these data. Post-EWQ median DO saturation rose above the upper EWQ 95% confidence interval.

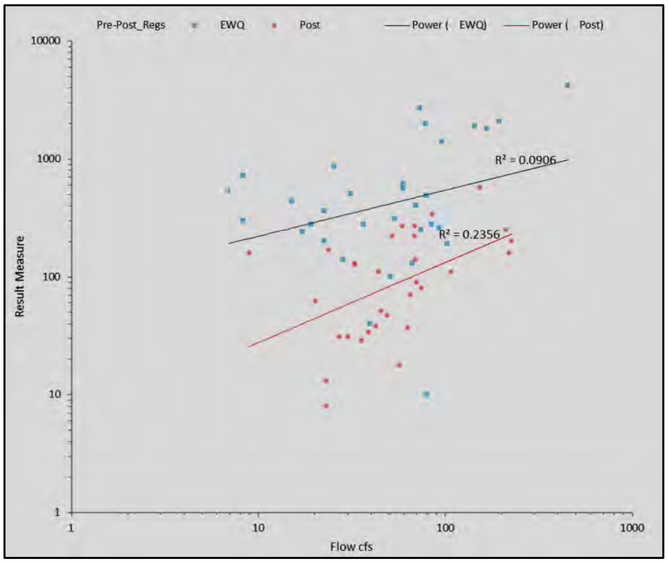
Flow is plotted on a logarithmic scale. DO saturation is not usually flow-related, but there is a weakly positively relationship in the post-EWQ data that was not shown in the baseline EWQ data (see DO discussion above). There were no measurements below 80%, so there is no concern about an excess of oxygen-reducing material. However, there are two values over 120% which indicated super-saturation conditions that are often associated with high algal production. As a rule of thumb, 80-120% is considered “normal”; in that range a balance exists between oxygen demand and supply. No independent data were available to confirm results.

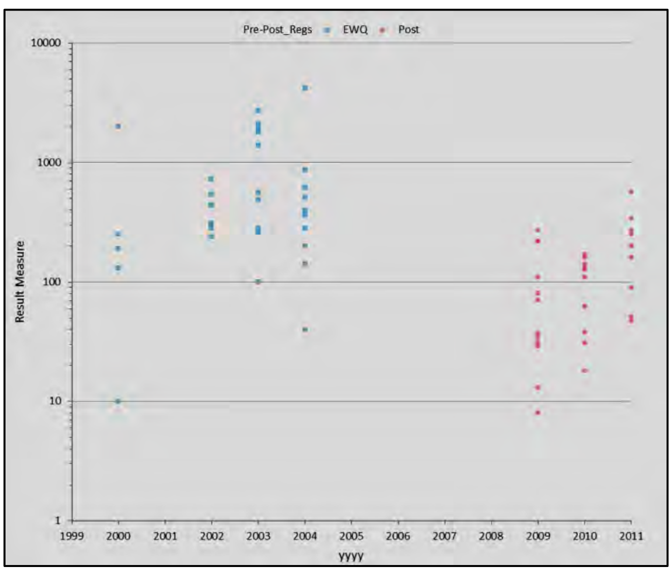
Chapter 20: 1907 BCP Martins Creek, PA

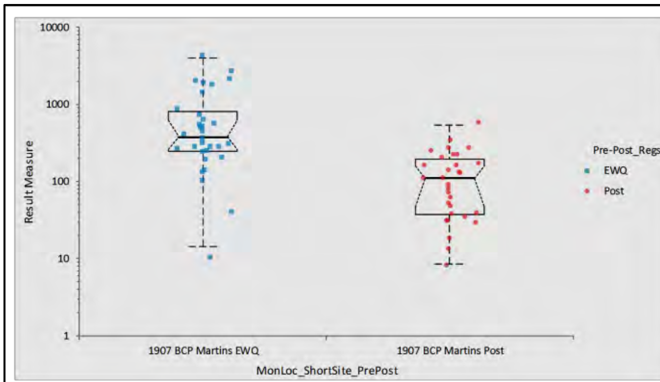
Enterococcus colonies/100 ml

Existing Water Quality (Table 2G):

Median 380/100 ml
Lower 95% Confidence Interval 260/100 ml
Upper 95% Confidence Interval 620/100 ml

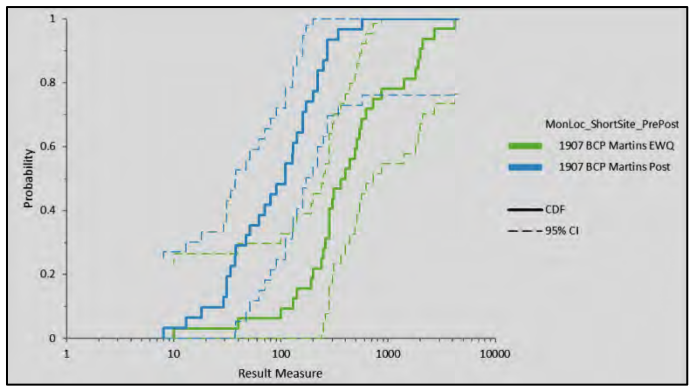






N 63

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1907 BCP Martins EWQ	10	244	380	808	4200	563
1907 BCP Martins Post	8	37	110	195	570	158



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1907 BCP Martins EWQ	32	4005.1	125.16
1907 BCP Martins Post	31	4134.3	133.37

H statistic	24.23
X^2 approximation	24.23
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.

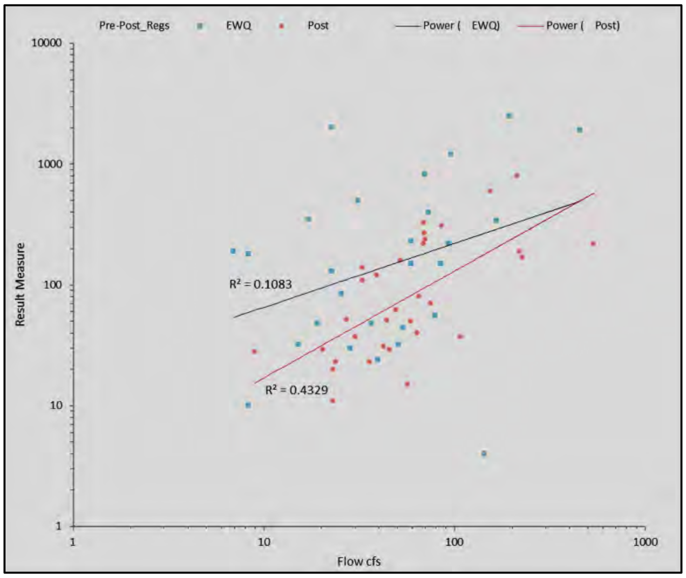
No water quality degradation is evident here. Enterococci apparently declined between the EWQ and Post-EWQ periods. However, analytical uncertainty was introduced by potential laboratory artifacts. There was no truncation of high values in post-EWQ data. Enterococcus concentrations are unrelated to flow 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.

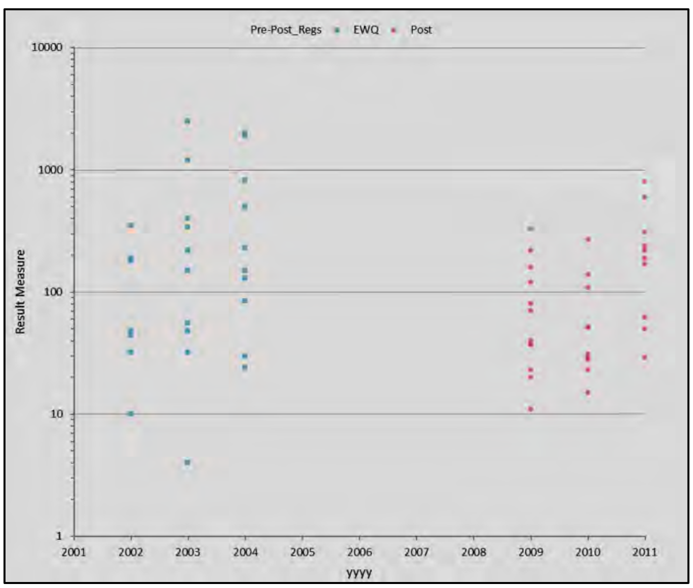
Chapter 20: 1907 BCP Martins Creek, PA

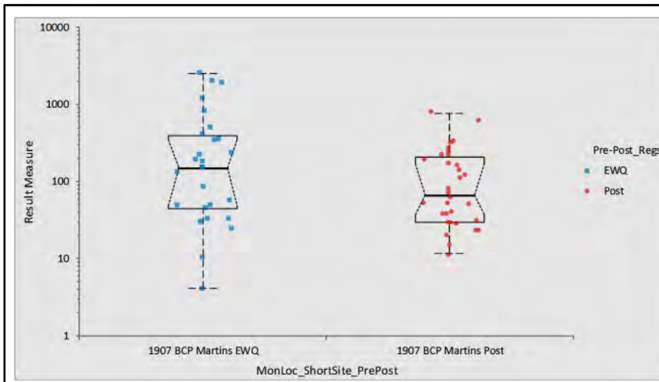
Escherichia coli colonies/100 ml

Existing Water Quality (Table 2G):

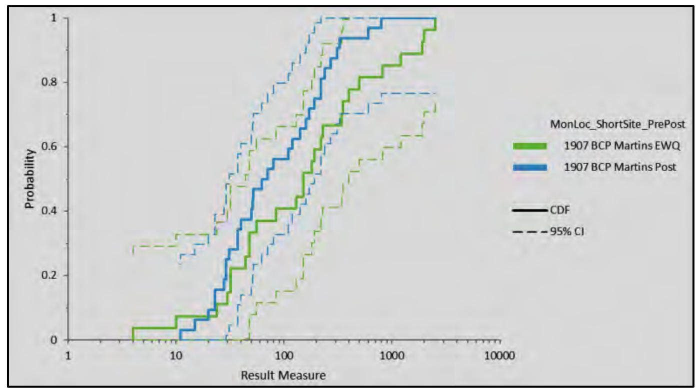
Median 150/100 ml
Lower 95% Confidence Interval 48/100 ml
Upper 95% Confidence Interval 350/100 ml







	N	59				
Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1907 BCP Martins EWQ	4	45	150	392	2500	347
1907 BCP Martins Post	11	30	66	208	800	178



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1907 BCP Martins EWQ	27	428.0	15.85
1907 BCP Martins Post	32	361.1	11.29

H statistic	2.68
X^2 approximation	2.68
DF	1
p-value	0.1019[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.

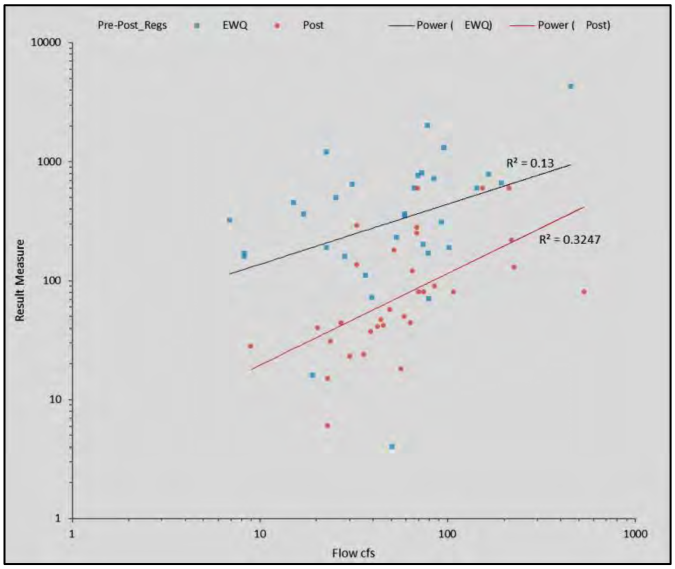
No water quality degradation is evident here. E. coli concentrations apparently did not measurably change between the two periods. However, analytical uncertainty was introduced by potential laboratory artifacts, though there was no truncation of high values in post-EWQ data. Post-EWQ median E. coli fell within EWQ 95% confidence intervals. Flows and concentrations are plotted on logarithmic scale, and regressions are power relationships. E. coli was unrelated to flow in EWQ data, but positively related to flow in post-EWQ data. No independent data were available to validate DRBC results.

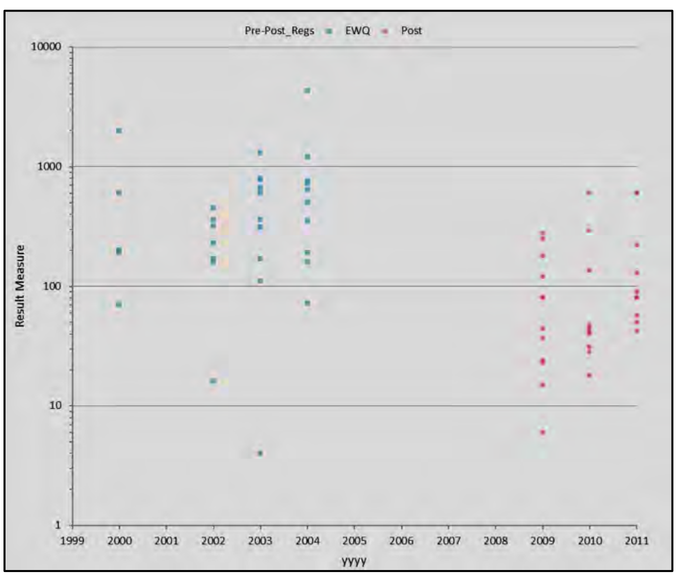
Chapter 20: 1907 BCP Martins Creek, PA

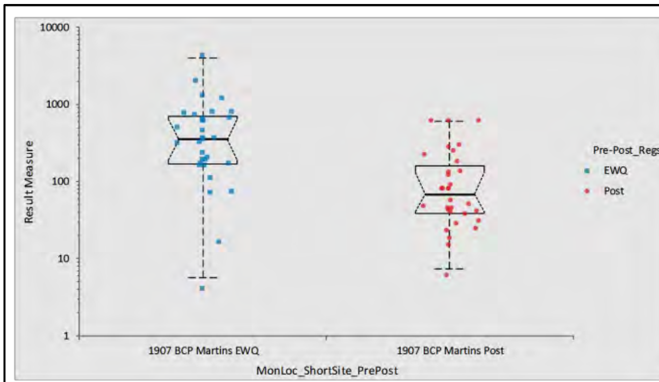
Fecal coliform colonies/100 ml

Existing Water Quality (Table 2G):

Median 355/100 ml
Lower 95% Confidence Interval 190/100 ml
Upper 95% Confidence Interval 640/100 ml

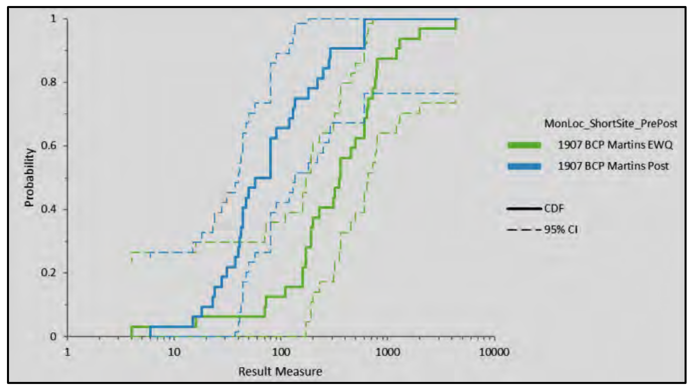






N	64

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1907 BCP Martins EWQ	4	170	355	695	4300	525
1907 BCP Martins Post	6	38	69	162	600	123



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1907 BCP Martins EWQ	32	3280.5	102.52
1907 BCP Martins Post	32	3280.5	102.52

H statistic	18.94
X^2 approximation	18.94
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.

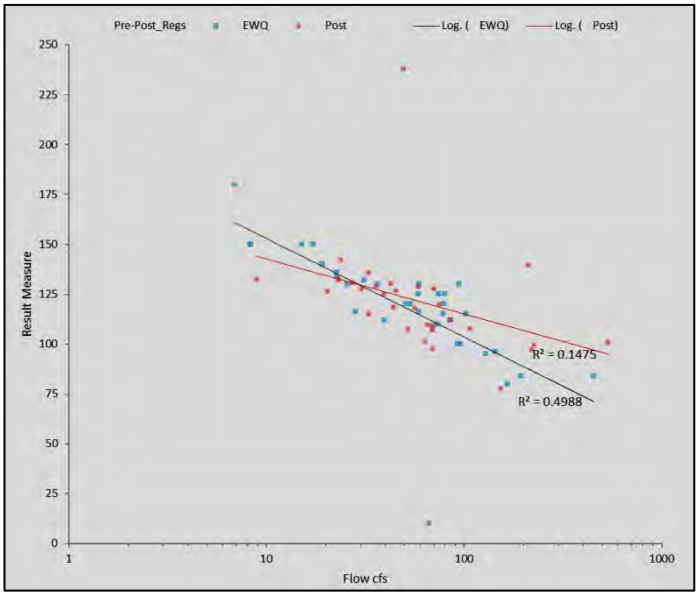
No water quality degradation is evident here. Fecal coliform concentrations apparently declined between the two periods. However, analytical uncertainty was introduced by laboratory artifacts. Fecal coliform concentrations are unrelated to flow in EWQ data, but weakly related in post-EWQ data. Post-EWQ median concentrations fell below the lower EWQ 95% confidence interval. Concentrations and flows are plotted on logarithmic scale, and regressions are power relationships. There were no independent data to confirm results.

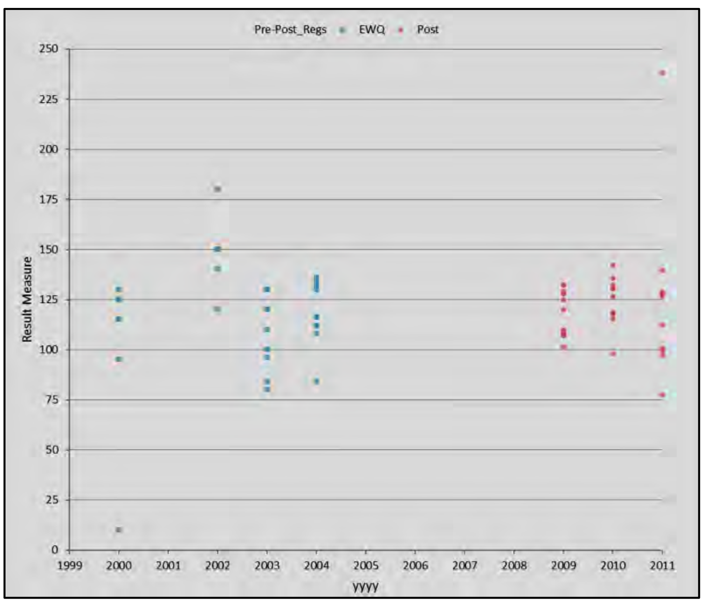
Chapter 20: 1907 BCP Martins Creek, PA

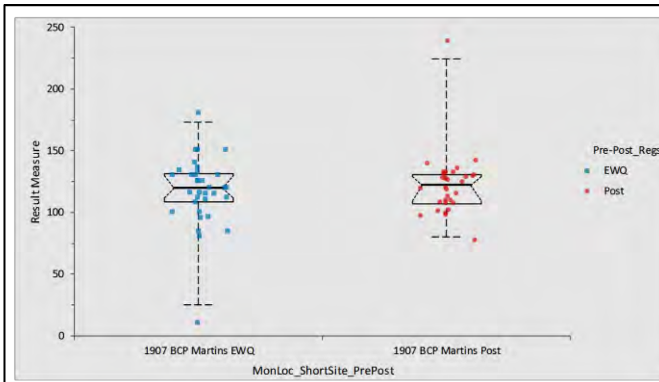
Hardness as CaCO3, Total mg/l

Existing Water Quality (Table 2G):

Median 120 mg/l
Lower 95% Confidence Interval 112 mg/l
Upper 95% Confidence Interval 130 mg/l
Defined in regulations as a flow-related parameter

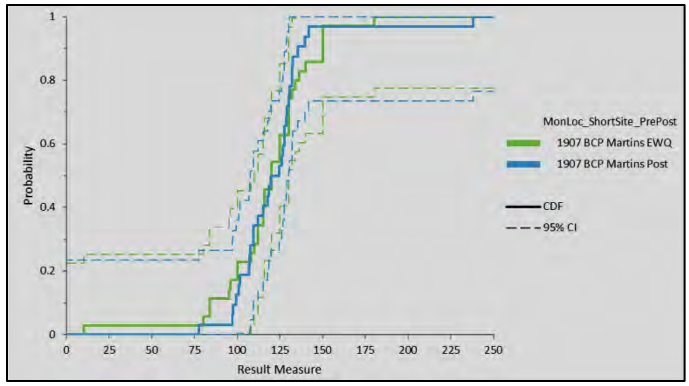






N | 67

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1907 BCP Martins EWQ	10	108	120	132	180	23
1907 BCP Martins Post	77	107	122	130	238	23



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1907 BCP Martins EWQ	35	0.3	0.01
1907 BCP Martins Post	32	0.3	0.01

H statistic	0.00
X^2 approximation	0.00
DF	1
p-value	0.9700 [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.

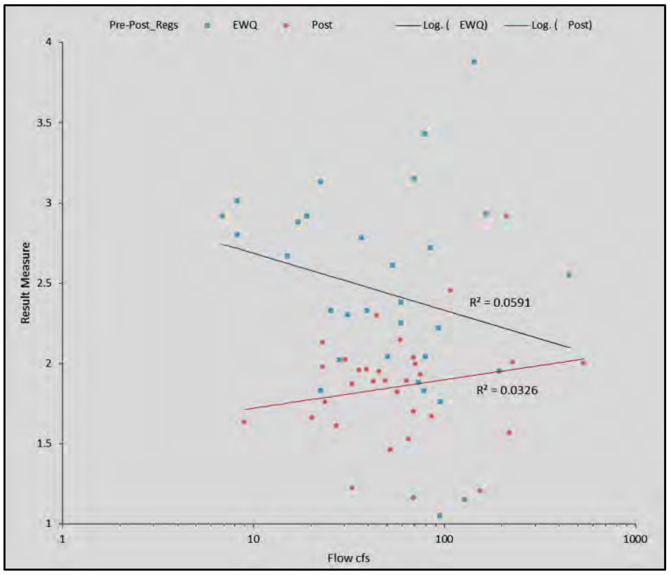
No water quality degradation is evident here. Hardness apparently did not measurably change between the EWQ and post-EWQ periods. However, analytical uncertainty was introduced by potential laboratory artifacts. Hardness is inversely related to flow in the EWQ data set, but unrelated to flow in the post-EWQ data set. Post-EWQ median hardness was within the EWQ 95% confidence intervals. Flow is plotted on a logarithmic scale. No independent data were available for comparison with DRBC results.

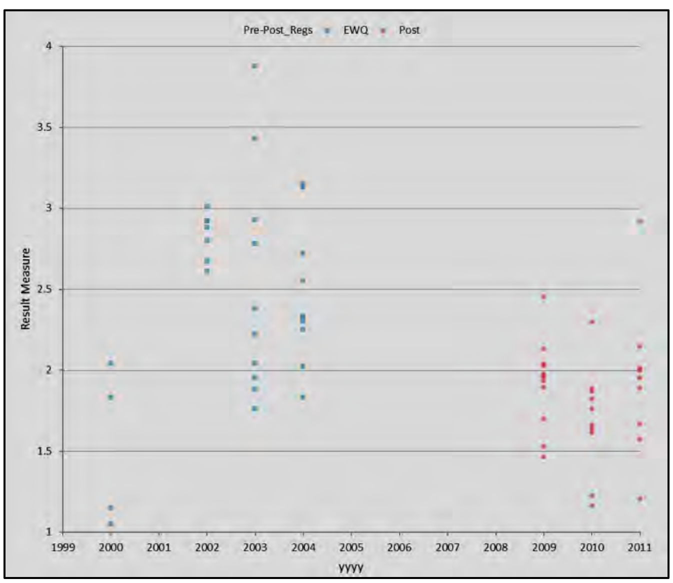
Chapter 20: 1907 BCP Martins Creek, PA

Nitrate + Nitrite as N, Total mg/l

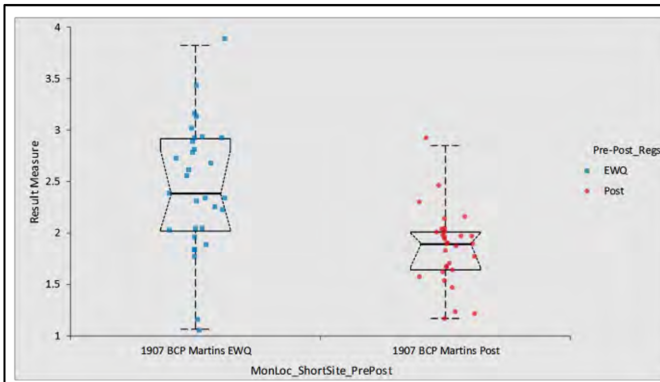
Existing Water Quality (Table 2G, as Nitrate only):

Median 2.38 mg/l
Lower 95% Confidence Interval 2.04 mg/l
Upper 95% Confidence Interval 2.80 mg/l



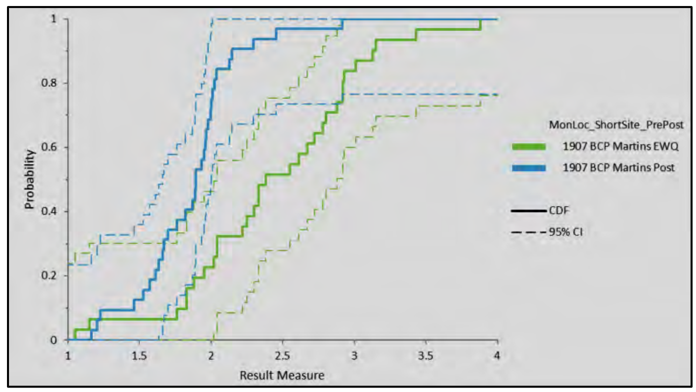


No water quality degradation is evident here. Nitrate concentrations apparently declined between the EWQ and post-EWQ periods. However, analytical uncertainty was introduced by potential laboratory artifacts. Nitrate is unrelated to flow in both data sets.



N	63					

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1907 BCP Martins EWQ	1.05	2.02	2.38	2.91	3.88	0.89
1907 BCP Martins Post	1.16	1.65	1.89	2.01	2.92	0.36



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1907 BCP Martins EWQ	31	2961.6	95.53
1907 BCP Martins Post	32	2869.0	89.66

H statistic	17.35
X^2 approximation	17.35
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.

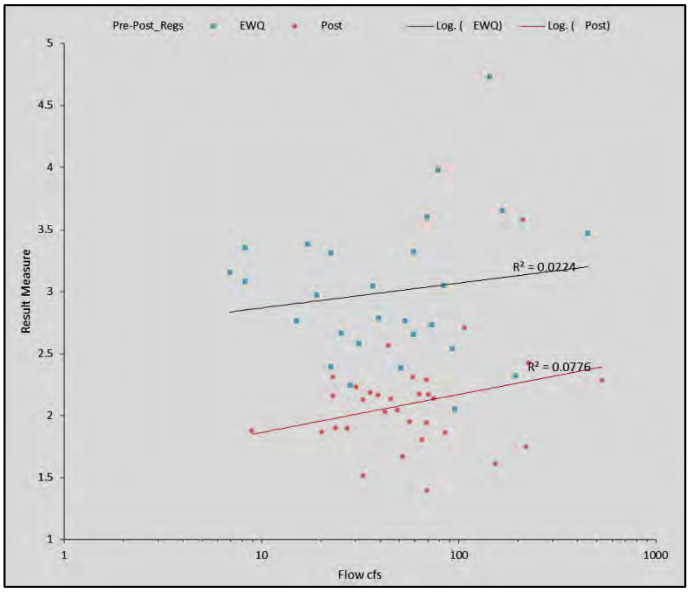
Post-EWQ median concentrations fell below the lower EWQ 95% confidence interval. Post-EWQ nitrate + nitrite results were assumed equivalent with EWQ nitrate results since EWQ nitrite results were never detected. No independent data were available to compare with DRBC results. At other sites where concentrations are lower, there was a problem interpreting the data due to changing detection limits. Concentrations are sufficiently high in Martins Creek that problems with interpretation did not arise. There were no undetected results in either data set.

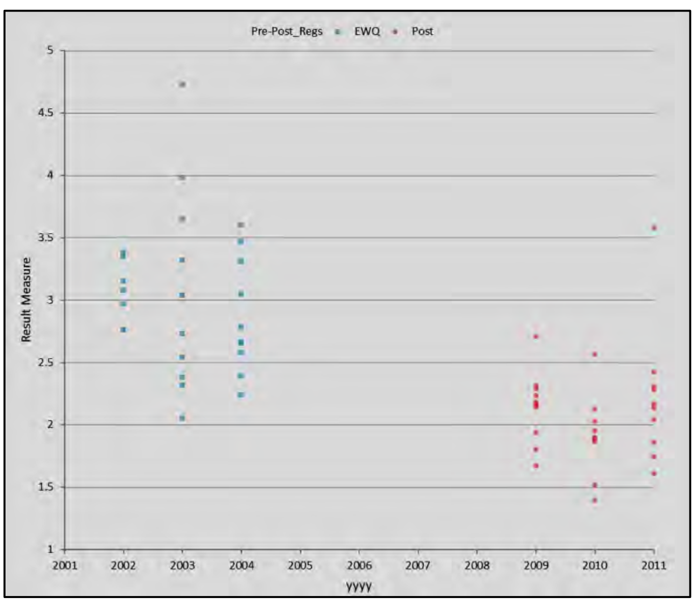
Chapter 20: 1907 BCP Martins Creek, PA

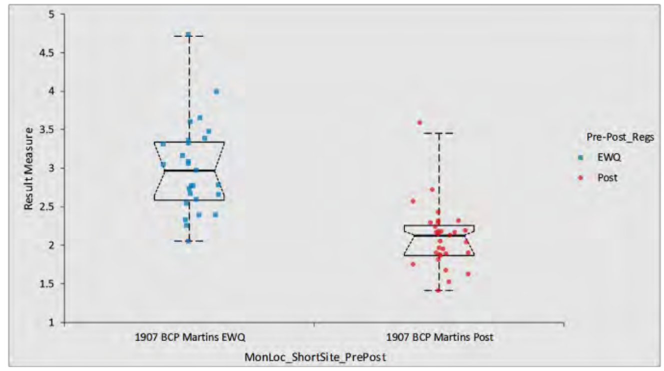
Nitrogen as N, Total (TN) mg/l

Existing Water Quality (Table 2G):

Median 2.95 mg/l
Lower 95% Confidence Interval 2.65 mg/l
Upper 95% Confidence Interval 3.32 mg/l

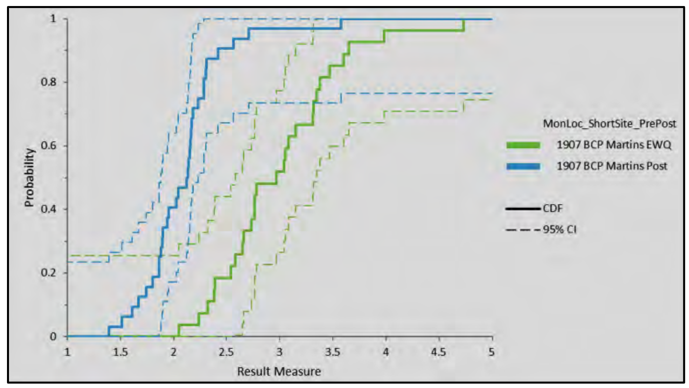






N 59

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1907 BCP Martins EWQ	2.05	2.59	2.97	3.35	4.73	0.75
1907 BCP Martins Post	1.40	1.87	2.13	2.26	3.58	0.39



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1907 BCP Martins EWQ	27	5125.3	189.83
1907 BCP Martins Post	32	4324.5	135.14

H statistic	32.03
X² approximation	32.03
DF	1
p-value	<0.0001 [1]

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

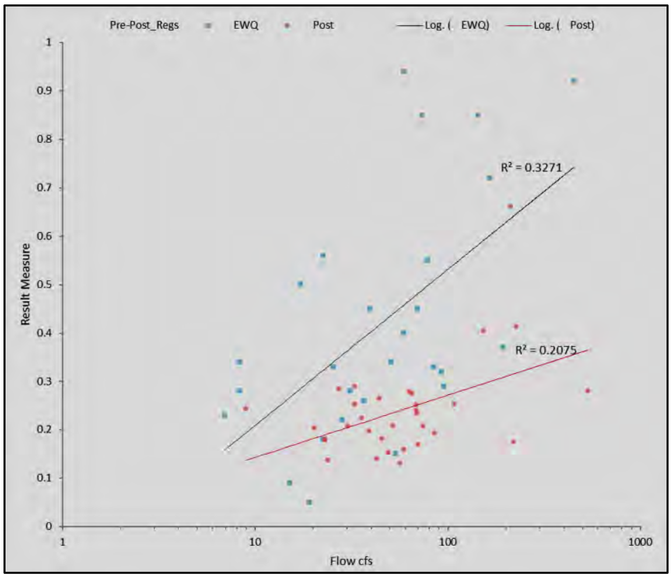
No water quality degradation is evident here. Total Nitrogen concentrations apparently declined between the EWQ and post-EWQ periods. However, analytical uncertainty was introduced by potential laboratory artifacts. TN is unrelated to flow in both data sets. No independent data were available to compare with DRBC results. Post-EWQ median TN concentration fell below the lower EWQ 95% confidence interval. Even though TN apparently declined (unless the decline is actually a laboratory artifact), concentrations are still fairly high.

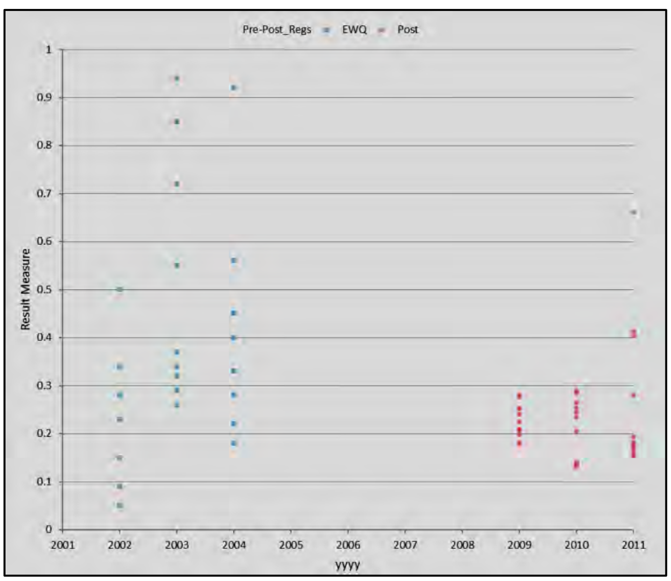
Chapter 20: 1907 BCP Martins Creek, PA

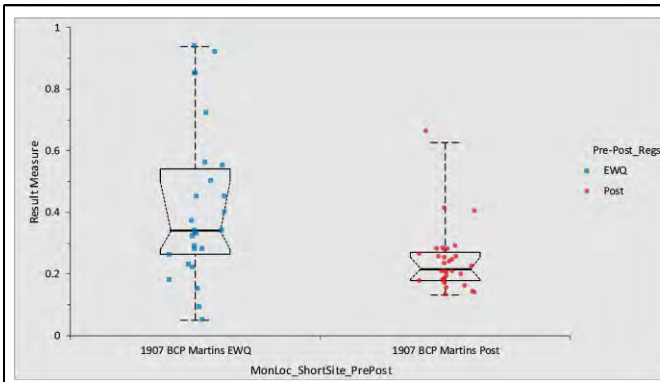
Nitrogen, Kjeldahl as N, Total (TKN) mg/l

Existing Water Quality (Table 2G):

Median 0.34 mg/l
Lower 95% Confidence Interval 0.28 mg/l
Upper 95% Confidence Interval 0.50 mg/l
Defined in regulations as a flow-related parameter

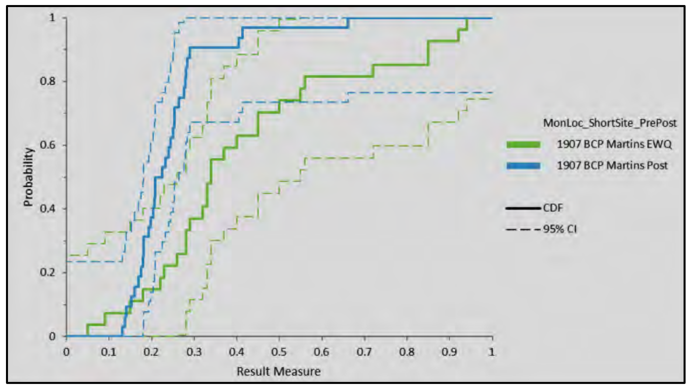






N 59

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1907 BCP Martins EWQ	0.05	0.26	0.34	0.54	0.94	0.28
1907 BCP Martins Post	0.13	0.18	0.22	0.27	0.66	0.09



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1907 BCP Martins EWQ	27	2028.0	75.11
1907 BCP Martins Post	32	1711.1	53.47

H statistic	12.68
X^2 approximation	12.68
DF	1
p-value	0.0004 [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.

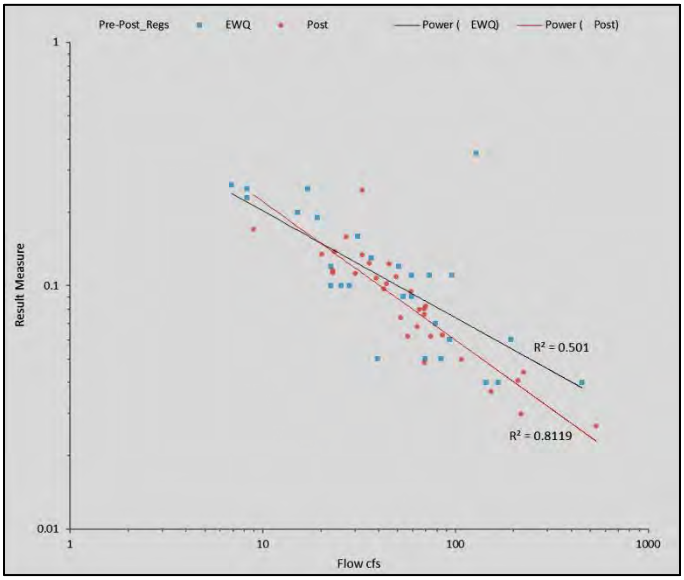
No water quality degradation is evident here. TKN concentrations apparently declined between the EWQ and post-EWQ periods. However, analytical uncertainty was introduced by potential laboratory artifacts. The post-EWQ range was far narrower and all concentrations except one were less than 0.42 mg/l. TKN concentration is weakly related to flow in both data sets. Post-EWQ median TKN fell below the lower EWQ 95% confidence interval. The TKN decline contributed to the apparent improvement in total nitrogen concentrations. There were no additional data to confirm DRBC results.

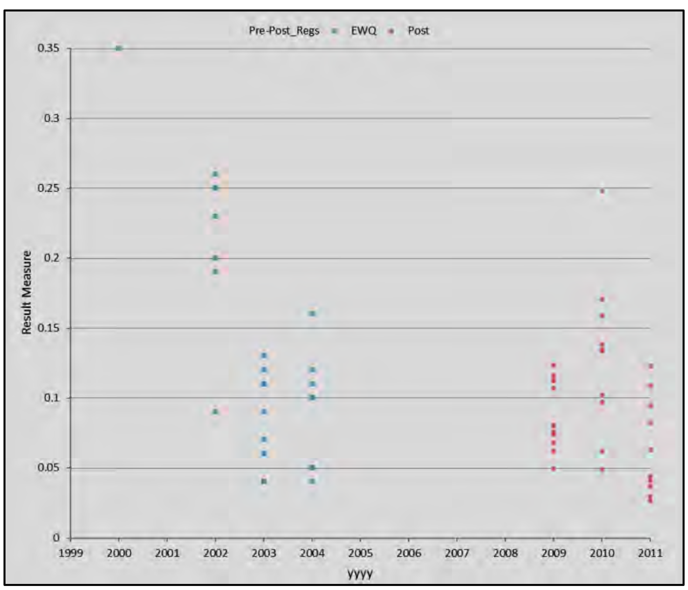
Chapter 20: 1907 BCP Martins Creek, PA

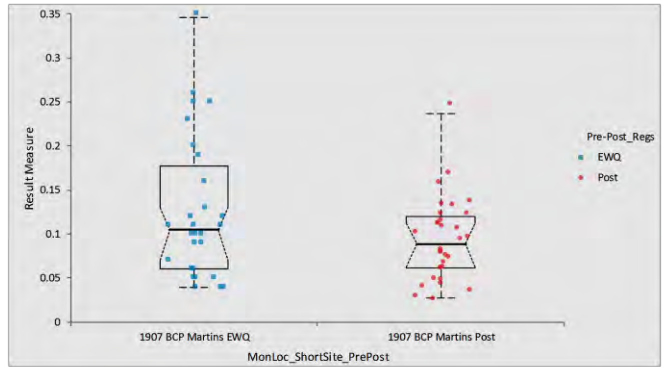
Orthophosphate as P, Total mg/l (OP)

Existing Water Quality (Table 2G):

Median 0.11 mg/l
Lower 95% Confidence Interval 0.07 mg/l
Upper 95% Confidence Interval 0.13 mg/l
Should have been designated in rules as flow-related

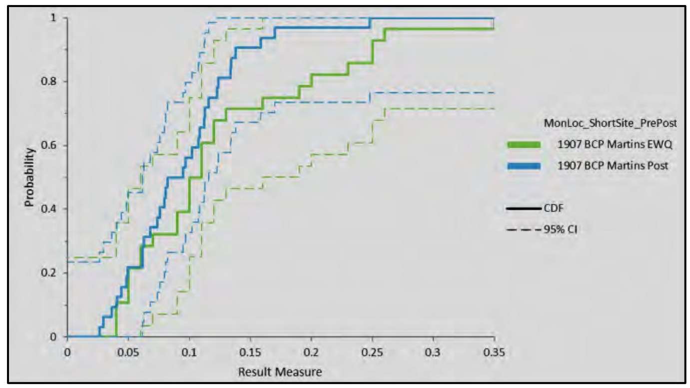






N 60

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1907 BCP Martins EWQ	0.04	0.06	0.11	0.18	0.35	0.12
1907 BCP Martins Post	0.03	0.06	0.09	0.12	0.25	0.06



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1907 BCP Martins EWQ	28	234.3	8.37
1907 BCP Martins Post	32	205.0	6.41

H statistic	1.44
X^2 approximation	1.44
DF	1
p-value	0.2299 [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.

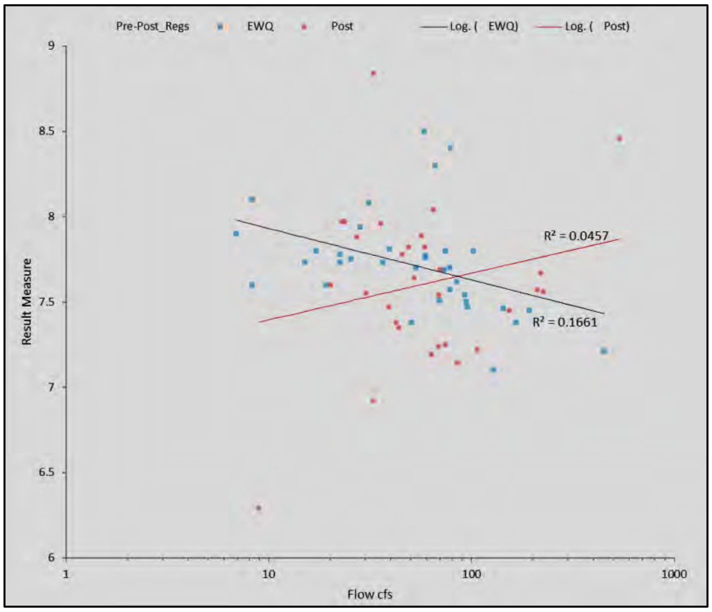
No water quality degradation is evident here. OP concentrations apparently did not measurably change between the EWQ and post-EWQ periods. However, analytical uncertainty was introduced by potential laboratory artifacts. OP is inversely related to flow in both data sets, and should have been designated as such in DRBC water quality rules. Post-EWQ median orthophosphate fell within the EWQ 95% confidence intervals. There was no interference by detection limits in either data set, as concentrations are well-above detection levels. There were no independent data available for comparison with DRBC results.

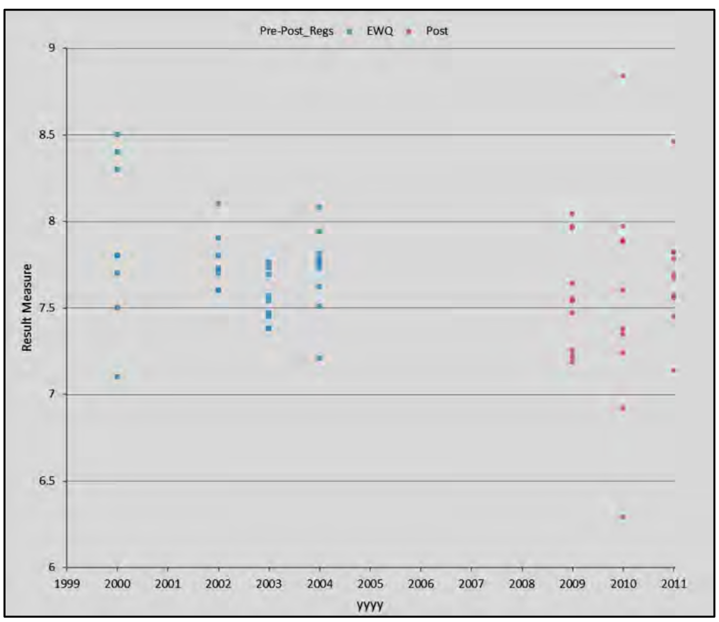
Chapter 20: 1907 BCP Martins Creek, PA

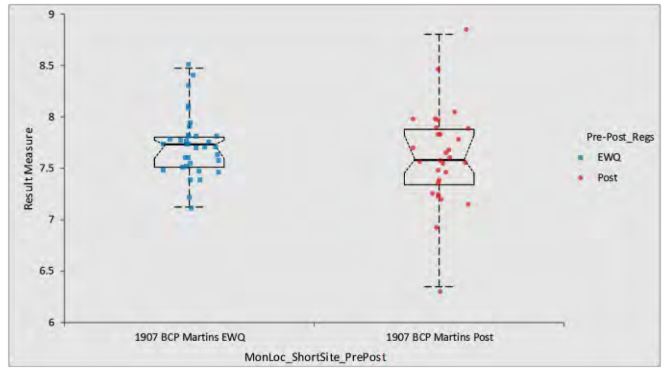
pH

Existing Water Quality (Table 2G):

Median 7.73 standard units
Lower 95% Confidence Interval 7.60 standard units
Upper 95% Confidence Interval 7.78 standard units

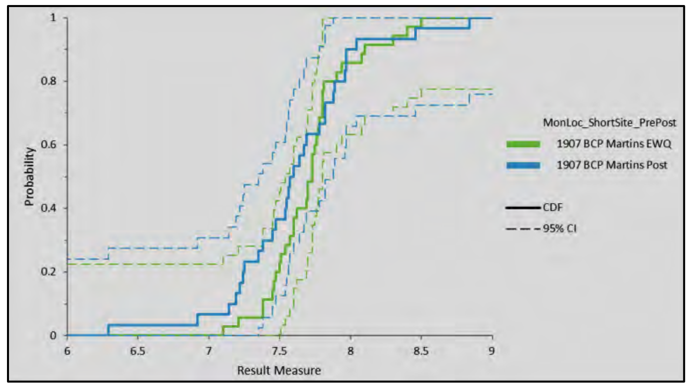






N 65

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1907 BCP Martins EWQ	7.10	7.52	7.73	7.80	8.50	0.29
1907 BCP Martins Post	6.29	7.34	7.59	7.88	8.84	0.54



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1907 BCP Martins EWQ	35	192.1	5.49
1907 BCP Martins Post	30	224.1	7.47

H statistic	1.16
X^2 approximation	1.16
DF	1
p-value	0.2804 [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.

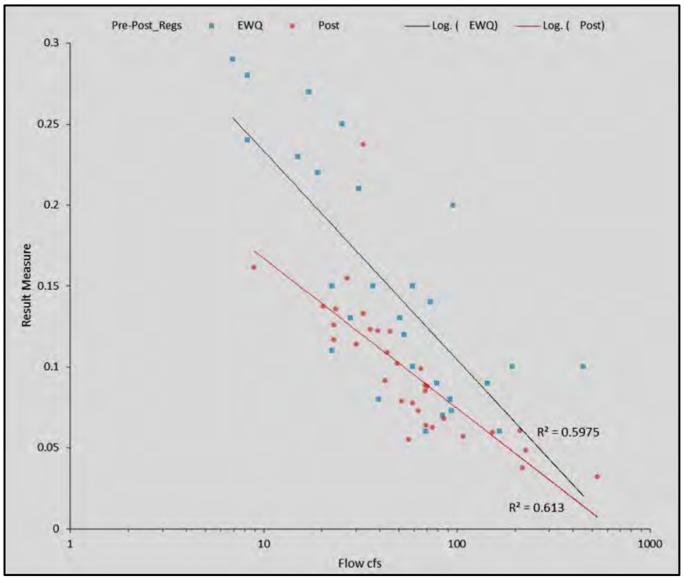
No water quality degradation is evident here. pH did not measurably change between the EWQ and post-EWQ periods. There were no known sources of analytical uncertainty in these data. pH is unrelated to flow in both data sets. Post-EWQ median pH was just below the lower EWQ 95% confidence interval, but the decline was not significant. The result below pH 6.5 taken in 2010 was probably a probe malfunction. There are no independent data available for comparison with DRBC results.

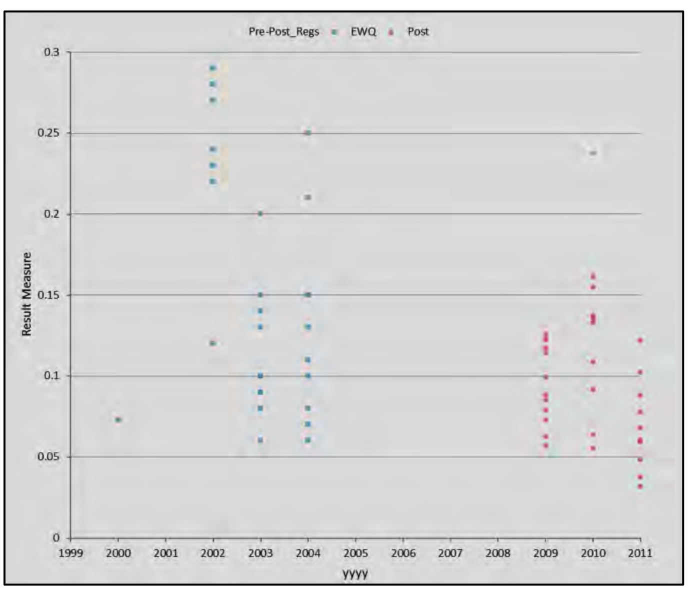
Chapter 20: 1907 BCP Martins Creek, PA

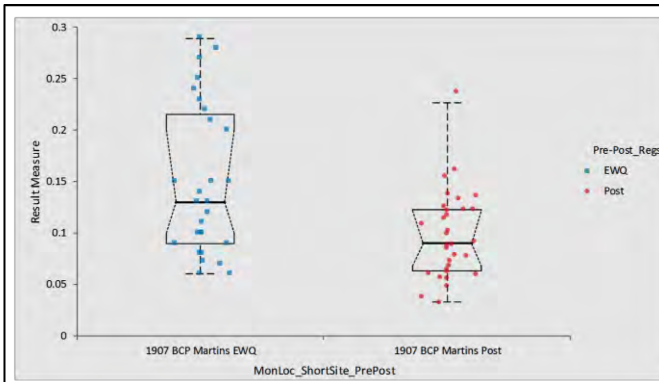
Phosphorus as P, Total (TP) mg/l

Existing Water Quality (Table 2G):

Median 0.13 mg/l
Lower 95% Confidence Interval 0.10 mg/l
Upper 95% Confidence Interval 0.20 mg/l
TP should have been designated in rules as flow-related

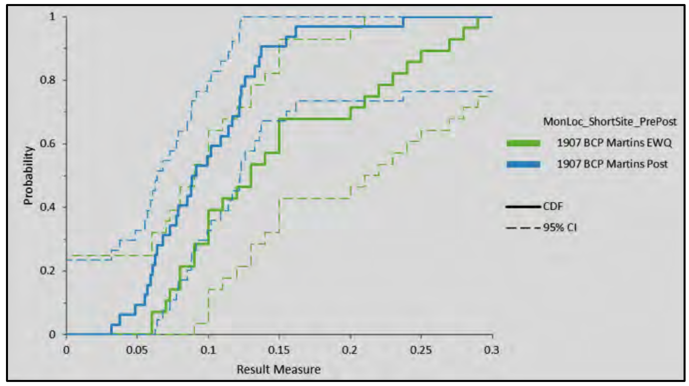






N 60

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1907 BCP Martins EWQ	0.06	0.09	0.13	0.22	0.29	0.13
1907 BCP Martins Post	0.03	0.06	0.09	0.12	0.24	0.06



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1907 BCP Martins EWQ	28	1302.9	46.53
1907 BCP Martins Post	32	1140.0	35.63

H statistic	8.01
X^2 approximation	8.01
DF	1
p-value	0.0046 [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.

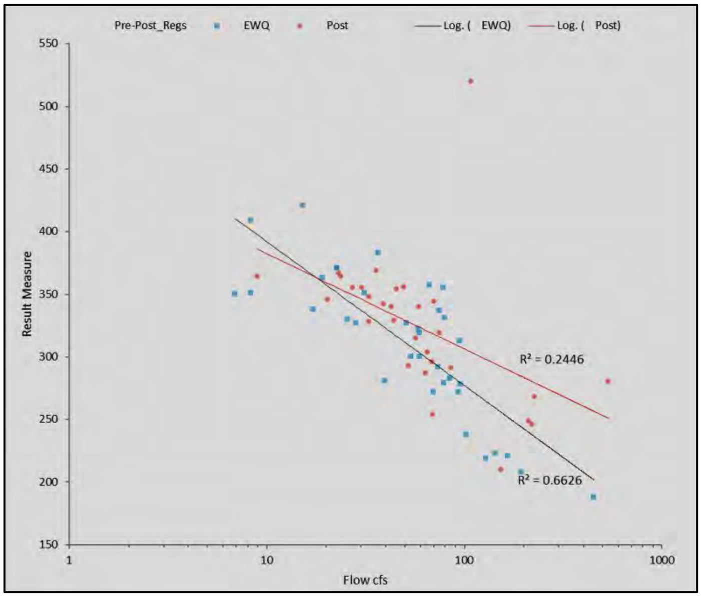
No water quality degradation is evident here. Total Phosphorus (TP) concentrations apparently declined between the EWQ and post-EWQ periods. However, analytical uncertainty was introduced by potential laboratory artifacts. Post-EWQ median total phosphorus fell below the EWQ lower 95% confidence interval. TP is inversely related to flow in both data sets. No additional data were available to confirm DRBC results. There were no undetected results in either data set.

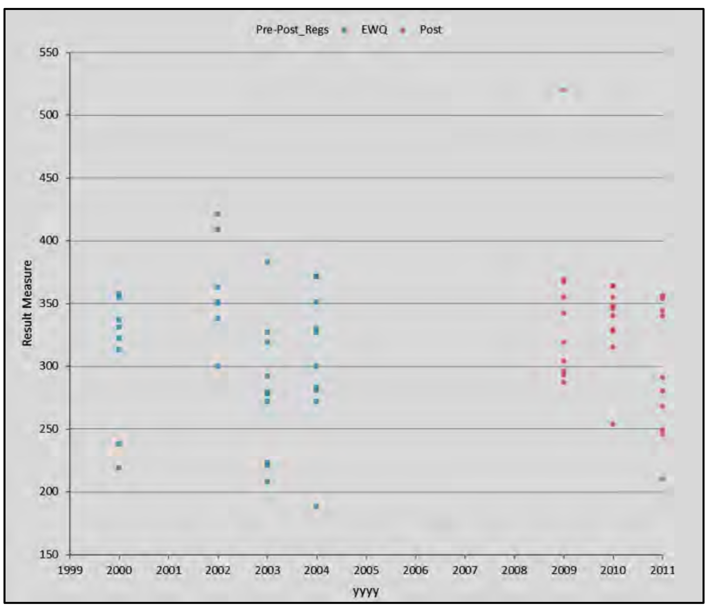
Chapter 20: 1907 BCP Martins Creek, PA

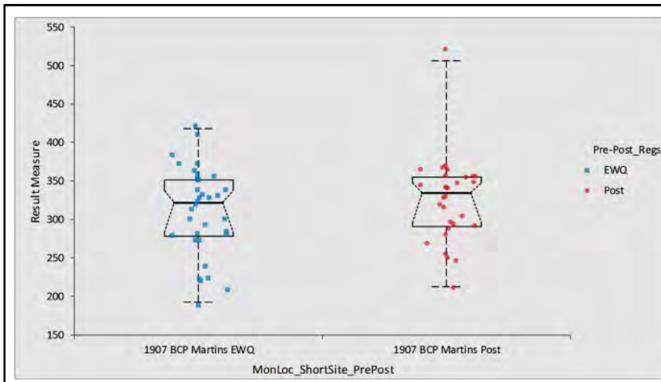
Specific Conductance µmho/cm

Existing Water Quality (Table 2G):

Median 322 µmho/cm
Lower 95% Confidence Interval 283 µmho/cm
Upper 95% Confidence Interval 338 µmho/cm
Defined in regulations as a flow-related parameter

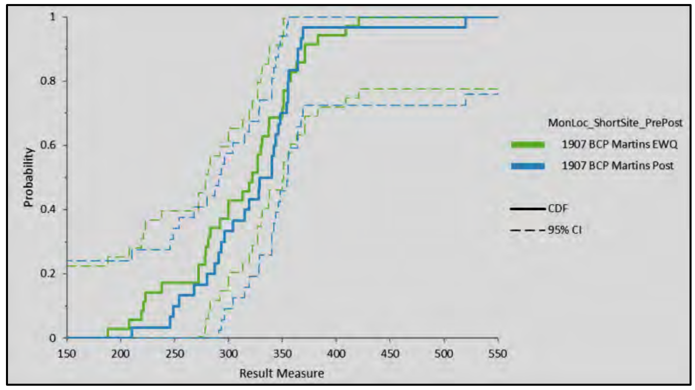






N 65

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1907 BCP Martins EWQ	188	278	322	351	421	73
1907 BCP Martins Post	210	291	335	355	520	64



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1907 BCP Martins EWQ	35	94.5	2.70
1907 BCP Martins Post	30	110.2	3.67

H statistic	0.57
X^2 approximation	0.57
DF	1
p-value	0.4492 [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.

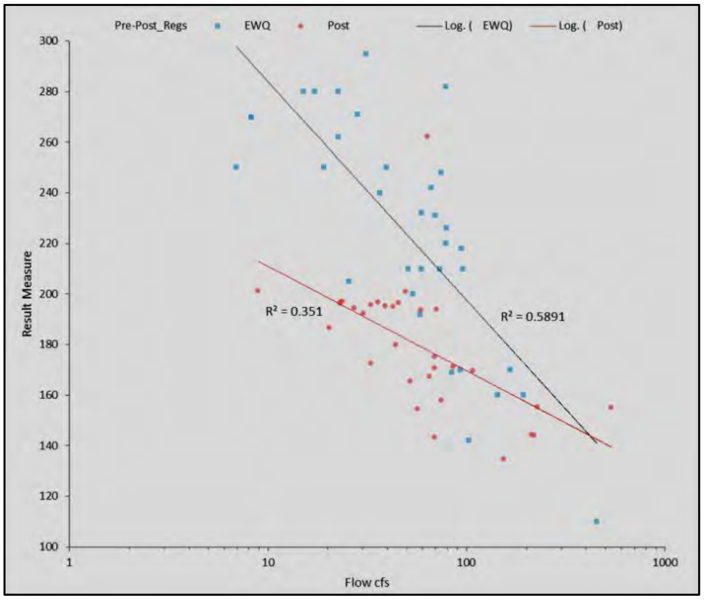
Some evidence of water quality degradation was found here. Specific conductance increased, but not above the EWQ upper 95% confidence interval. Specific conductance is inversely related to flow in both data sets. The rise in specific conductance may be partially attributable to the concurrent rise in chloride concentrations. Median specific conductance increased from 322 to 335 µmho/cm; a 4% rise that was not as severe as other Lower Delaware watersheds. No data were available to confirm DRBC results.

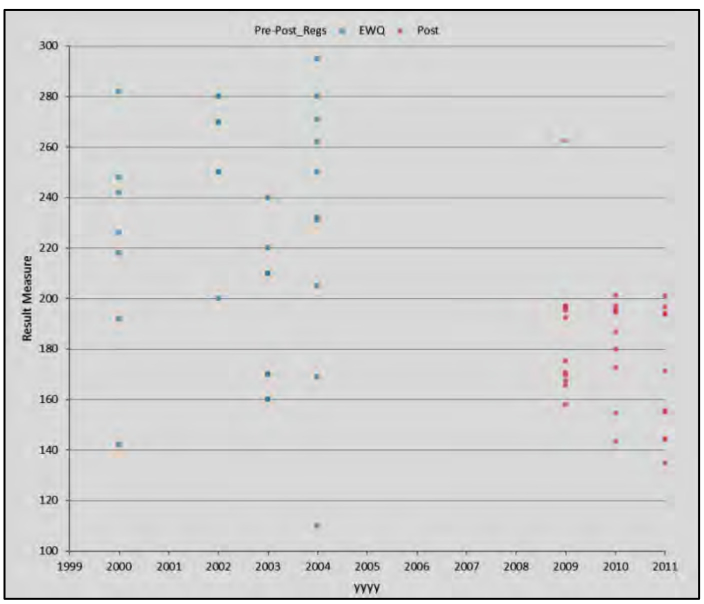
Chapter 20: 1907 BCP Martins Creek, PA

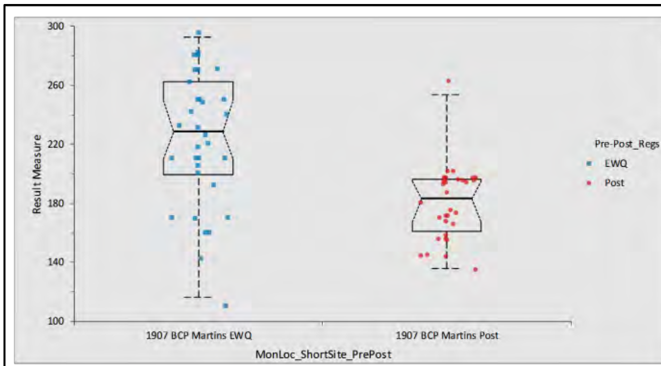
Total Dissolved Solids (TDS) mg/l

Existing Water Quality (Table 2G):

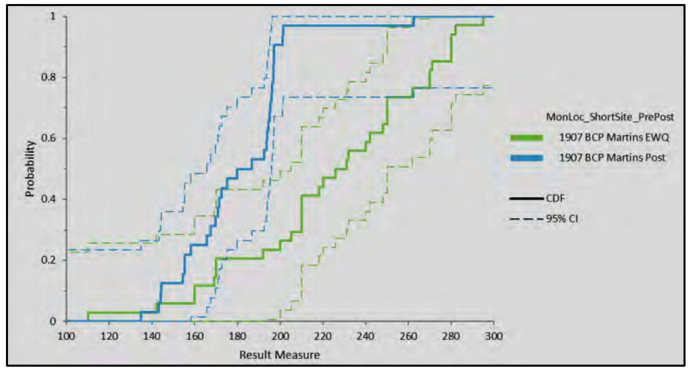
Median 229 mg/l
Lower 95% Confidence Interval 210 mg/l
Upper 95% Confidence Interval 250 mg/l
Defined in regulations as a flow-related parameter







N	66					
Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1907 BCP Martins EWQ	110	199	229	263	295	63
1907 BCP Martins Post	135	161	183	196	262	35



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1907 BCP Martins EWQ	34	3281.1	96.50
1907 BCP Martins Post	32	3486.1	108.94

H statistic	18.37
X² approximation	18.37
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.

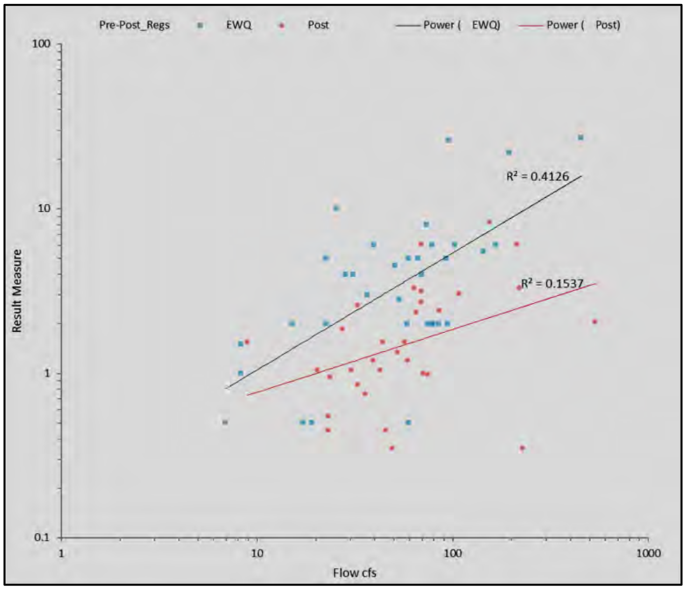
No water quality degradation is evident here. TDS apparently declined between the two periods. However, analytical uncertainty was introduced by potential laboratory artifacts. TDS is inversely related to flow in both data sets. Post-EWQ median TDS fell below the EWQ lower 95% lower confidence interval, and was 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.

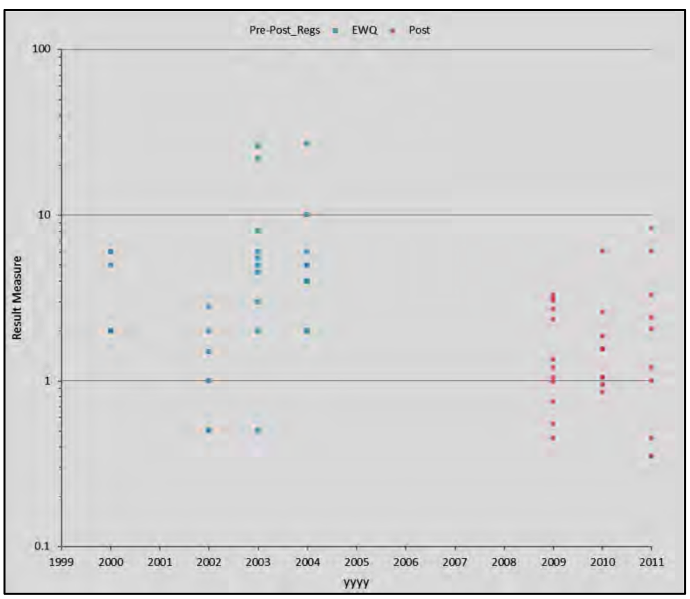
Chapter 20: 1907 BCP Martins Creek, PA

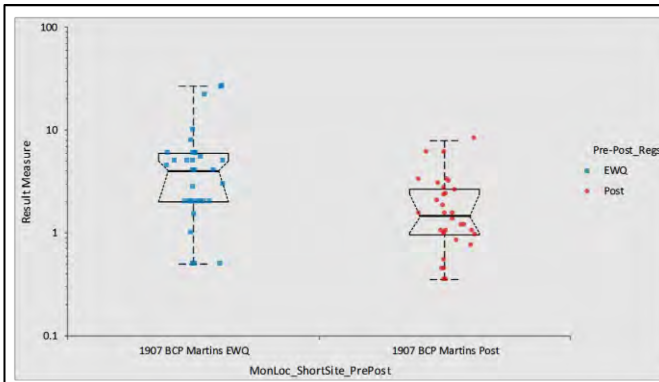
Total Suspended Solids (TSS) mg/l

Existing Water Quality (Table 2G):

Median 4.0 mg/l
Lower 95% Confidence Interval 2.0 mg/l
Upper 95% Confidence Interval 5.0 mg/l
<u>Should have been designated in rules as flow-related</u>

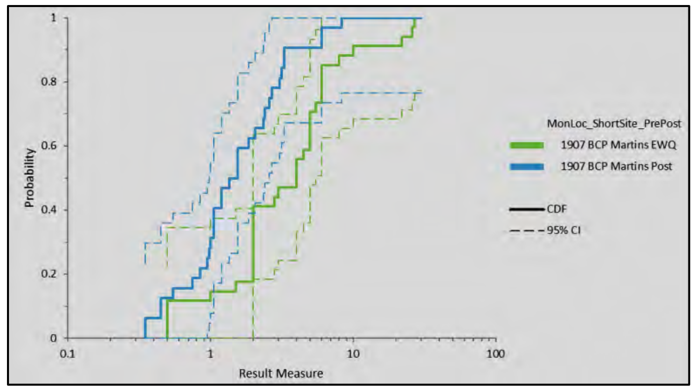






N 66

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1907 BCP Martins EWQ	0.5	2.0	4.0	6.0	27.0	4.0
1907 BCP Martins Post	0.4	1.0	1.4	2.7	8.3	1.7



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1907 BCP Martins EWQ	34	1751.1	51.50
1907 BCP Martins Post	32	1860.5	58.14

H statistic	9.83
X^2 approximation	9.83
DF	1
p-value	0.0017 [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.

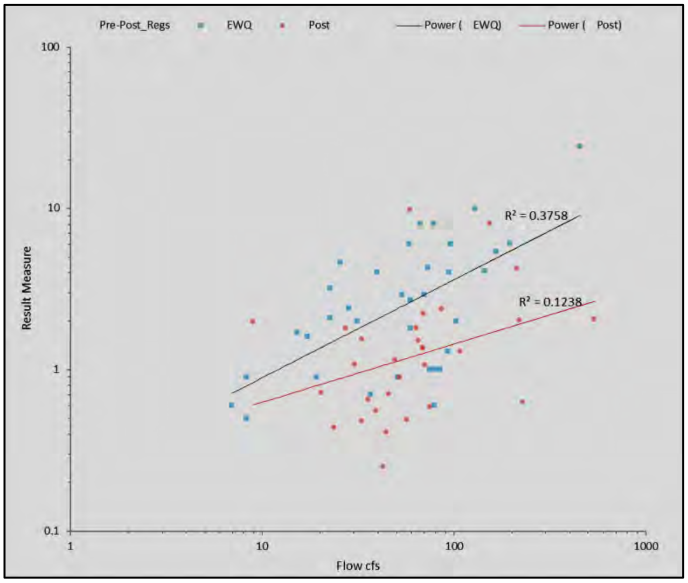
No water quality degradation is evident here. TSS concentrations apparently declined between the EWQ and post-EWQ periods. However, analytical uncertainty was introduced by potential laboratory artifacts. TSS is positively but weakly related to flow in both data sets, and should have been designated as flow-related in DRBC water quality rules. Post-EWQ median TSS fell below the EWQ lower 95% confidence interval. Flows and concentrations are plotted on logarithmic scale, and regressions are power relationships. There were no independent data available to confirm DRBC results.

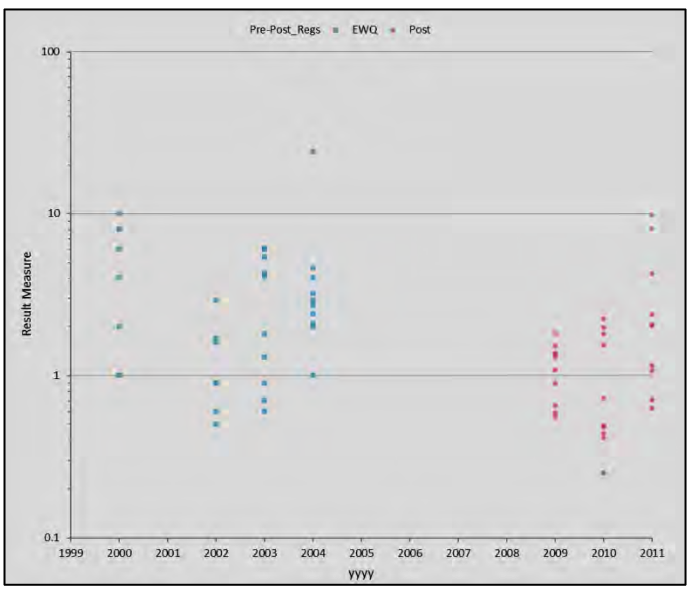
Chapter 20: 1907 BCP Martins Creek, PA

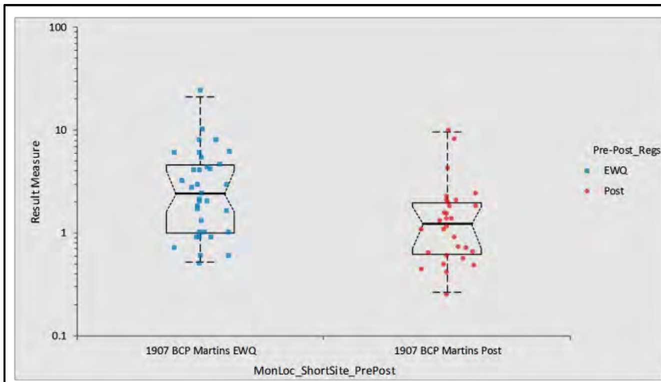
Turbidity NTU

Existing Water Quality (Table 2G):

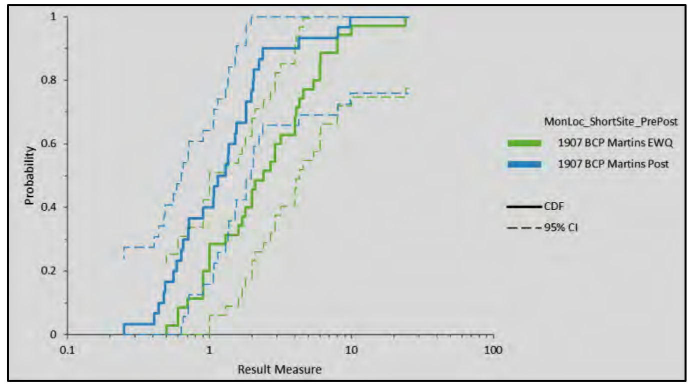
Median 2.4 NTU
Lower 95% Confidence Interval 1.6 NTU
Upper 95% Confidence Interval 4.0 NTU
Defined in regulations as a flow-related parameter







N	65					
Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1907 BCP Martins EWQ	0.5	1.0	2.4	4.6	24.0	3.6
1907 BCP Martins Post	0.3	0.6	1.2	2.0	9.8	1.4



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1907 BCP Martins EWQ	35	1382.9	39.51
1907 BCP Martins Post	30	1613.3	53.78

H statistic	8.38
X^2 approximation	8.38
DF	1
p-value	0.0038 [1]

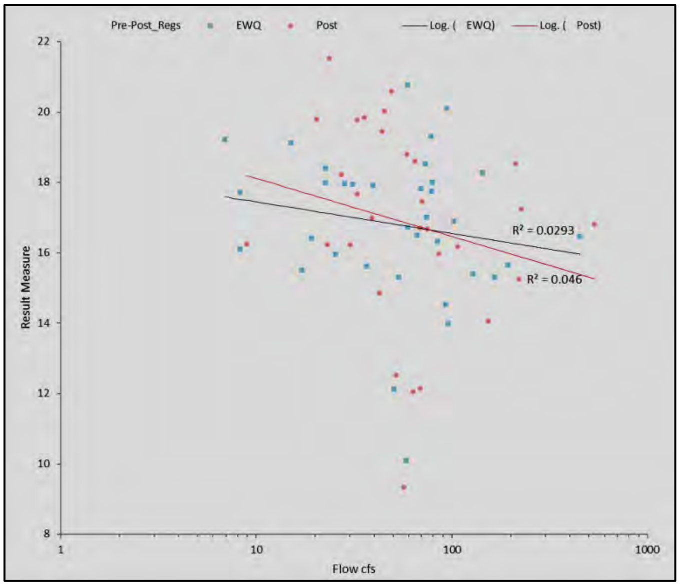
H0: $\theta_1 = \theta_2 = \theta\ldots$
The median of the populations are all equal.
H1: $\theta_i \neq \theta_j$ for at least one i,j
The median of the populations are not all equal.
[1] Reject the null hypothesis in favour of the alternative hypothesis at the 5% significance level.

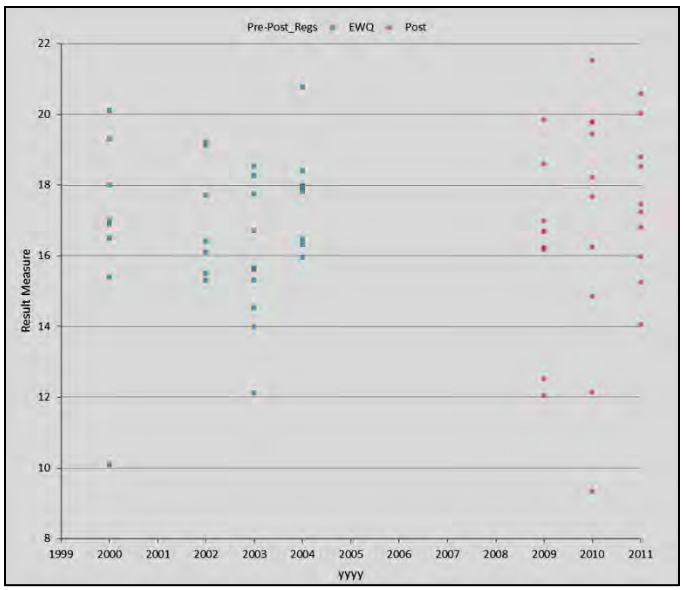
No water quality degradation is evident here. Turbidity measurably declined between the EWQ and post-EWQ periods. There were no known sources of analytical uncertainty in these results. The post-EWQ median turbidity fell below the lower EWQ 95% confidence interval. Turbidity is positively but weakly related to flow in both data sets. Concentrations and flows are represented on logarithmic scale, and regressions are power relationships. There were no additional data available for comparison with DRBC results.

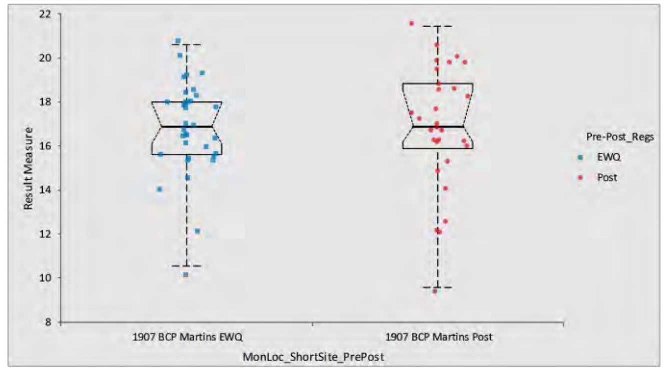
Chapter 20: 1907 BCP Martins Creek, PA

Water Temperature, degrees C

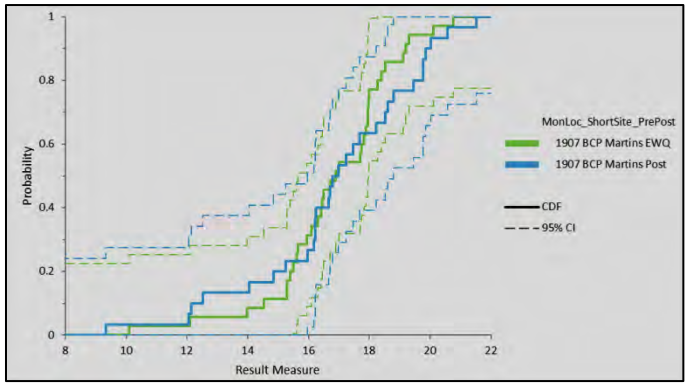
Not included in DRBC Existing Water Quality rules







N	65					
Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1907 BCP Martins EWQ	10.1	15.6	16.9	18.0	20.8	2.4
1907 BCP Martins Post	9.3	15.9	16.9	18.8	21.5	2.9



Kruskal-Wallis test

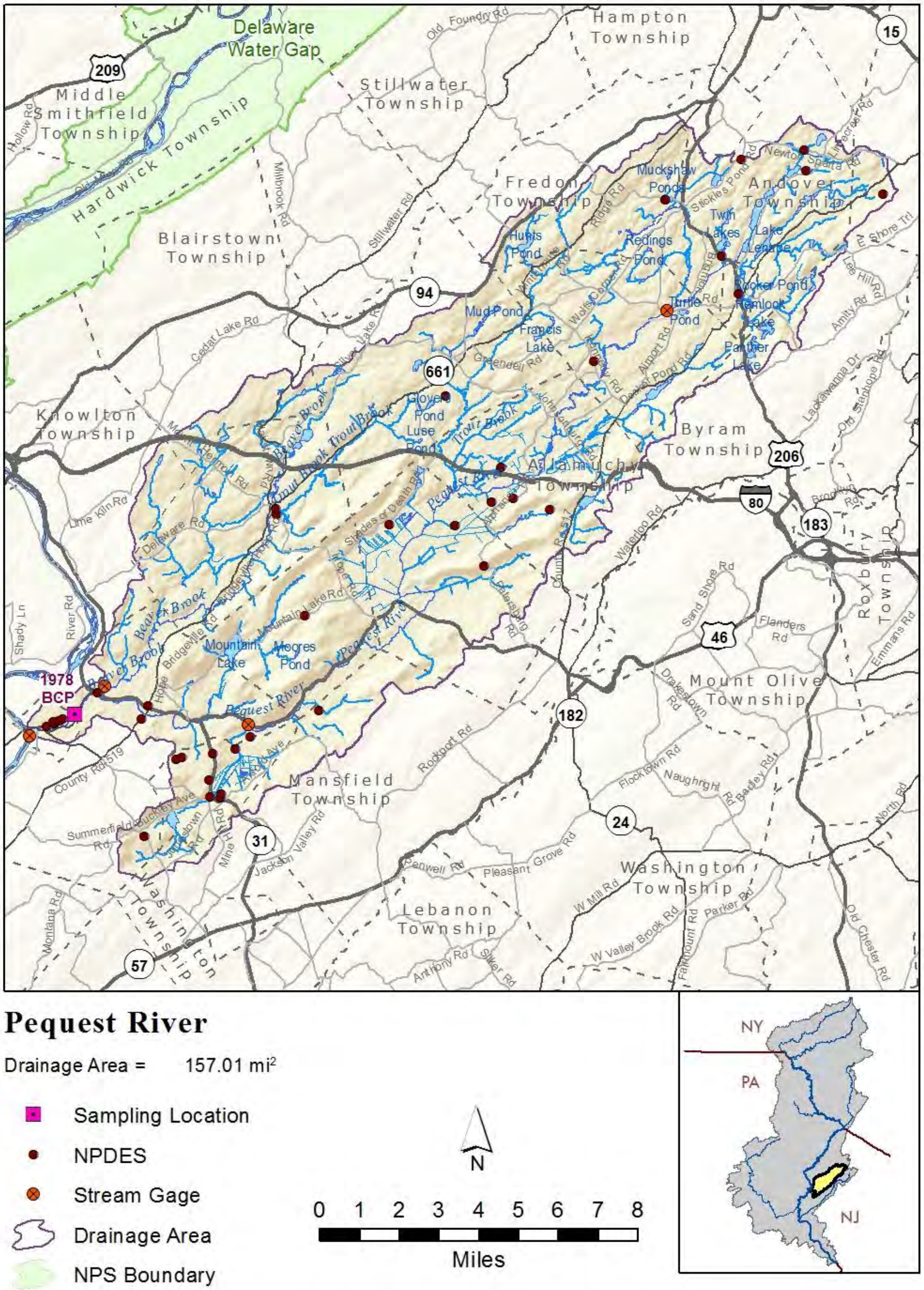
Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1907 BCP Martins EWQ	35	17.9	0.51
1907 BCP Martins Post	30	20.8	0.69

H statistic	0.11
X^2 approximation	0.11
DF	1
p-value	0.7422[1]

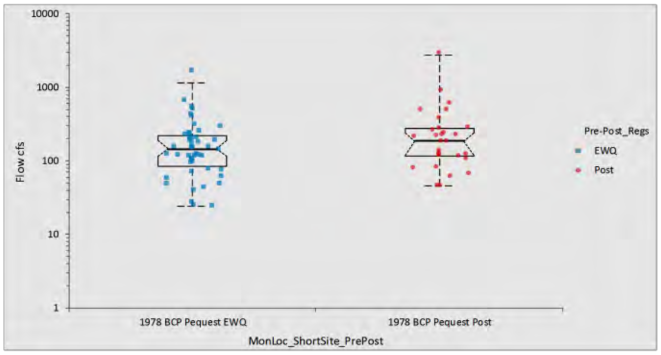
H0: $\theta_1 = \theta_2 = \theta\ldots$
The median of the populations are all equal.
H1: $\theta_i \neq \theta_j$ for at least one i,j
The median of the populations are not all equal.
[1] Do not reject the null hypothesis at the 5% significance level.

No water quality degradation is evident here. Water temperature was nearly identical between the EWQ and post-EWQ periods. There were no known sources of analytical uncertainty in these results. Water temperature is unrelated to flow in both data sets. Note that flows are plotted on a logarithmic scale. No independent data were available to confirm DRBC results.

Chapter 21: 1978 BCP Pequest River, Warren & Sussex Counties, NJ



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



N 78

Flow cfs by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1978 BCP Pequest EWQ	24	85	146	221	1697	136
1978 BCP Pequest Post	46	115	185	281	2918	166

Median post-EWQ flow was 44 cfs higher than EWQ median flow, though this difference did not affect water quality analyses except those at extreme low flow conditions. The range of flow conditions sampled was also roughly equal, but the post-EWQ data are under-represented by values less than 46 cfs. This is taken into account in each water quality analysis, particularly for flow-related parameters.

Kruskal-Wallis test

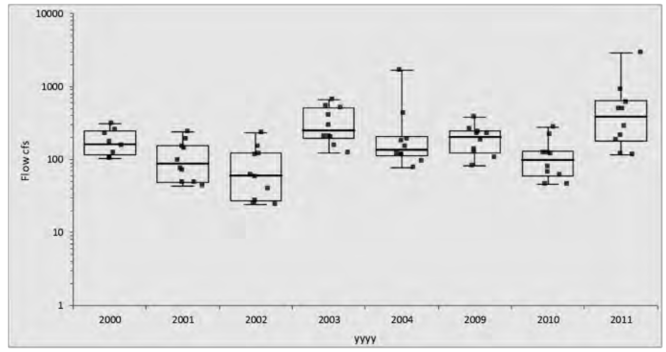
Flow cfs by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1978 BCP Pequest EWQ	48	344.0	7.17
1978 BCP Pequest Post	30	550.4	18.35

H statistic	1.74
X^2 approximation	1.74
DF	1
p-value	0.1868[1]

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

The Pequest River is a good-quality cold-water creek possessing naturally reproducing trout populations. The watershed was about 93% glaciated, there is some agriculture, and small towns comprise 4.5% of the watershed area. Overall watershed area is about 157 square miles, and it is about 58% forested. 93% of the watershed is underlain by carbonate bedrock, and limestone has a major effect upon water quality.

Upstream ICP: Delaware River at Belvidere 1978 ICP
Downstream ICP: Delaware River at Easton 1838 ICP



N 78

Flow cfs by yyyy	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
2000	104	115	164	244	308	129
2001	43	49	88	154	237	105
2002	24	27	60	124	230	97
2003	123	196	250	513	667	317
2004	77	114	135	210	1697	95
2009	81	124	204	245	379	120
2010	46	60	99	131	281	71
2011	116	182	392	640	2918	459

There are a few major dischargers in the Pequest watershed. There are NJDEP and USGS data available for comparison with DRBC results at this site. There is USGS gage 01446400 located upstream of the Orchard Road sampling site, and the gage is used for flow estimation by drainage area weighting.

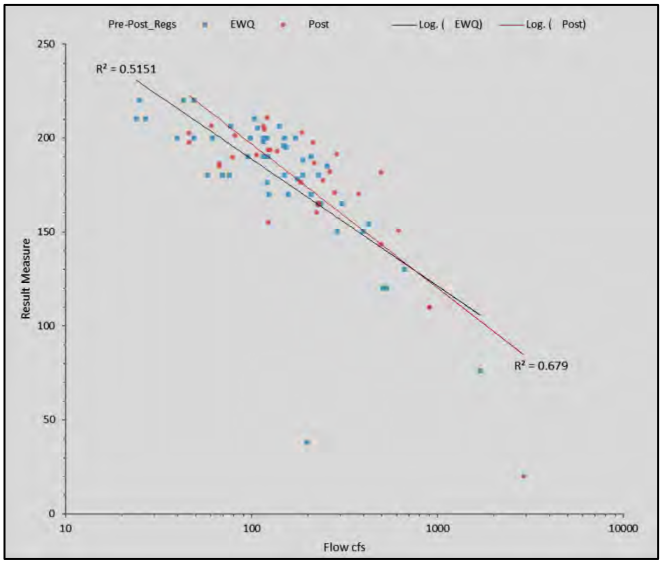
Annual May to September flow statistics associated with water quality measurements are plotted above. These are measurements or estimates associated with the time of each water quality sample. Mean annual flow is about 268 cfs; and harmonic mean flow is about 209 cfs (USGS Stream Stats retrieval, Feb. 2014) which is more typical of summer flow conditions. Though a wide range of flows were sampled by DRBC, these data appear to be most representative of low to harmonic mean flow conditions.

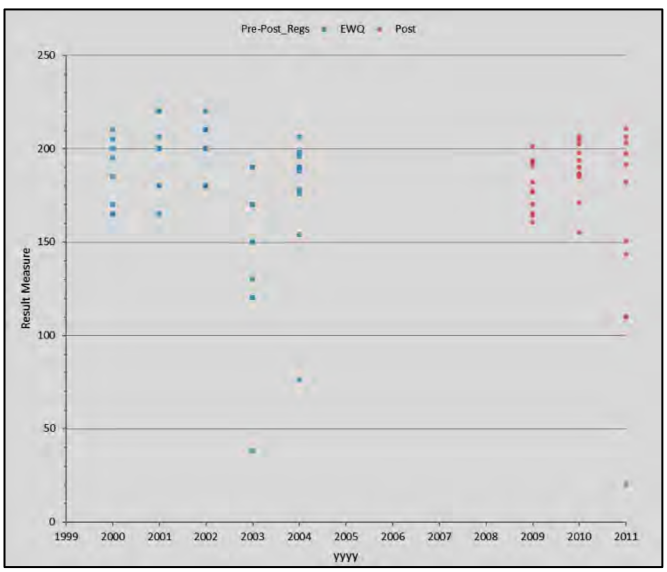
Chapter 21: 1978 BCP Pequest River, NJ

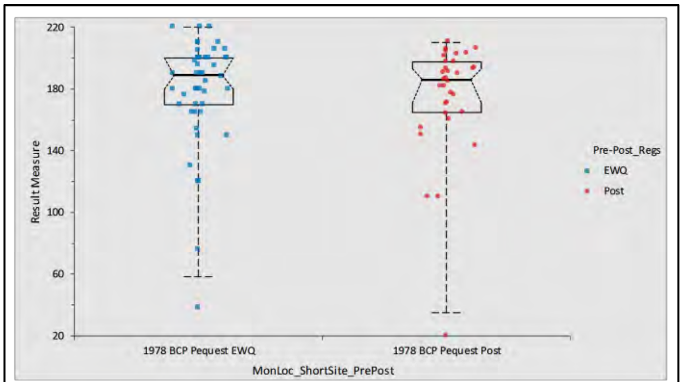
Alkalinity as CaCO3, Total mg/l

Existing Water Quality (Table 2F):

Median 189 mg/l
Lower 95% Confidence Interval 180 mg/l
Upper 95% Confidence Interval 200 mg/l
Defined in regulations as a flow-related parameter

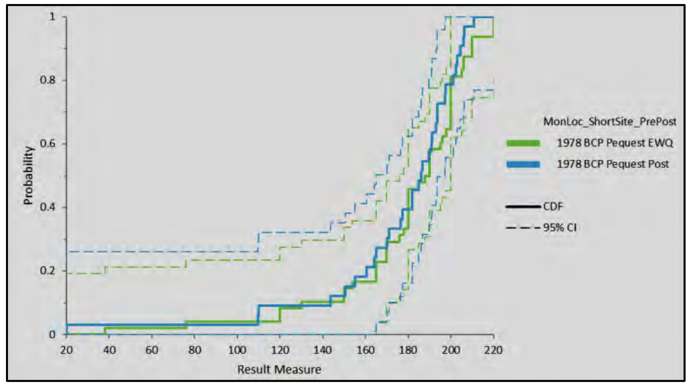






N 81

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1978 BCP Pequest EWQ	38	170	189	200	220	30
1978 BCP Pequest Post	20	165	186	197	211	33



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1978 BCP Pequest EWQ	48	81.4	1.70
1978 BCP Pequest Post	33	118.4	3.59

H statistic	0.36
X^2 approximation	0.36
DF	1
p-value	0.5477 [1]

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

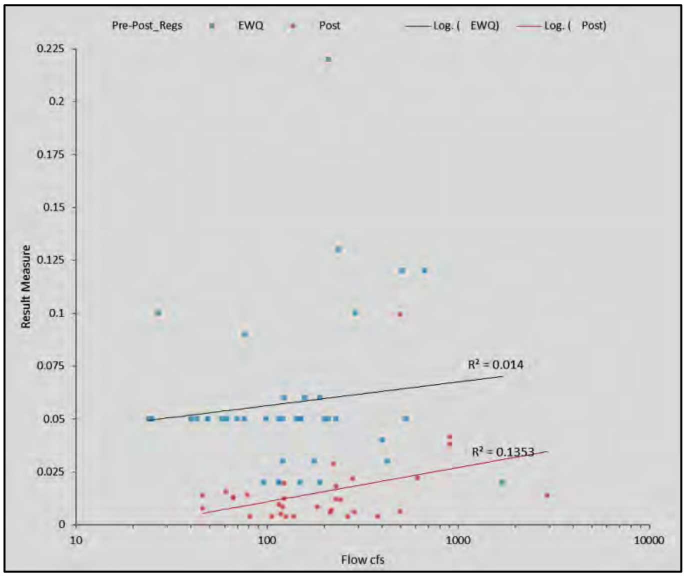
No water quality degradation is evident here. Alkalinity apparently did not measurably change between the EWQ and post-EWQ periods. However, sources of analytical uncertainty included potential laboratory artifacts and under-representation of extreme low flow conditions. Alkalinity is inversely related to flow in both data sets. Post-EWQ median alkalinity was within the EWQ 95% confidence intervals. Flow is plotted on a logarithmic scale.

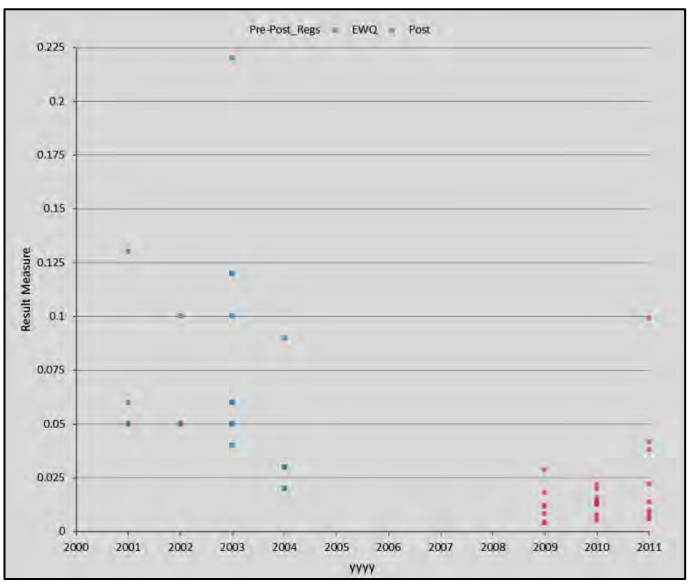
Chapter 21: 1978 BCP Pequest River, NJ

Ammonia Nitrogen as N, Total mg/l

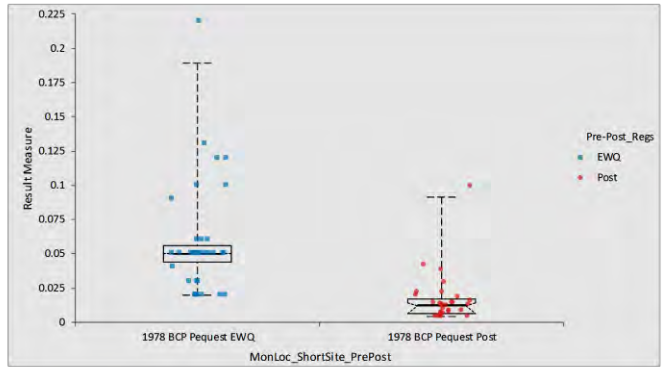
Existing Water Quality (Table 2F):

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



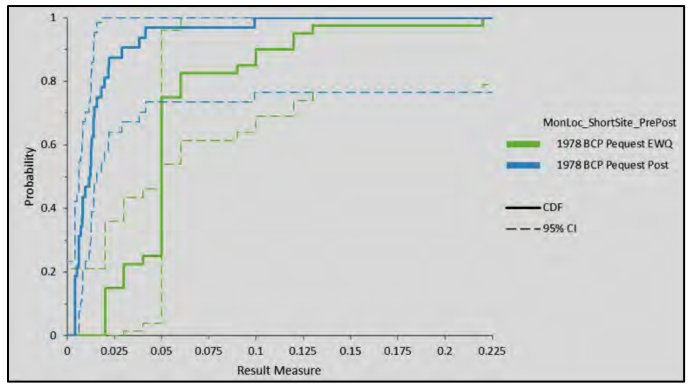


No water quality degradation is evident here. Ammonia concentrations appear to have declined. However, sources of analytical uncertainty included potential laboratory artifacts, detection limit differences, and under-representation of extreme low flow conditions. Post-EWQ median ammonia concentration was below the EWQ lower 95% confidence interval.



N 72

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1978 BCP Pequest EWQ	0.020	0.044	0.050	0.056	0.220	0.012
1978 BCP Pequest Post	0.004	0.006	0.012	0.017	0.099	0.011



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1978 BCP Pequest EWQ	40	8094.0	202.35
1978 BCP Pequest Post	32	10117.5	316.17

H statistic	42.54
X^2 approximation	42.54
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.

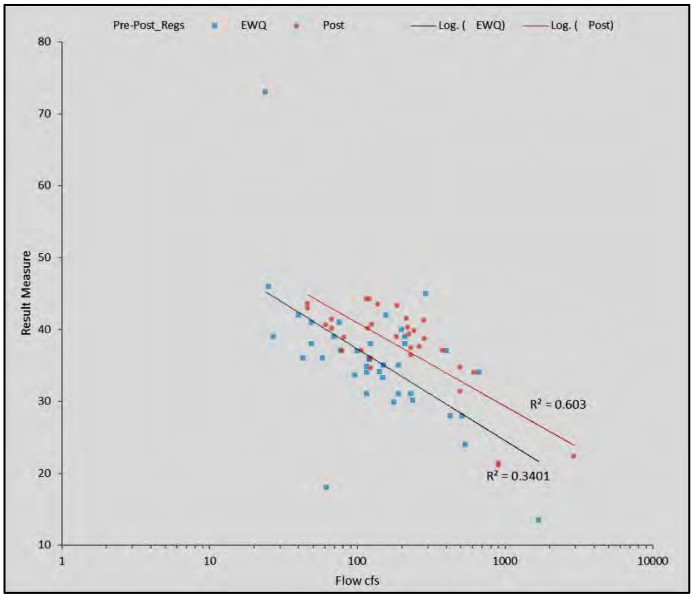
Ammonia is unrelated to flow in both data sets. Flow is plotted on logarithmic scale. EWQ data contained 27/40 undetected results, which interfered with calculation of the median. Because of this EWQ was defined at “less than 0.05 mg/l” in DRBC rules. EWQ results above the detection limit were variable. Under 2009-2011 lower detection levels there were still 9/32 undetected results, and no interference with the median. Post-EWQ results above detection levels were less variable and only one result was higher than 0.04 mg/l. Ambient concentrations appear to have improved (unless this is a laboratory artifact), but true ammonia concentrations are now better known in the Pequest River. USGS/NJ post-EWQ data were comparable with results.

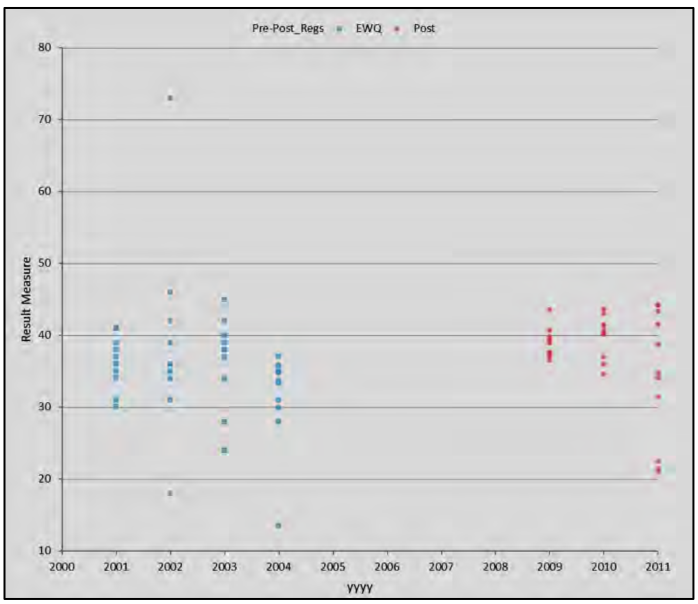
Chapter 21: 1978 BCP Pequest River, NJ

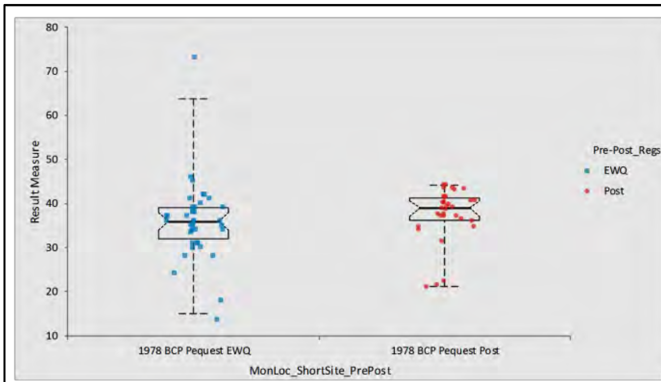
Chloride, Total mg/l

Existing Water Quality (Table 2F):

Median 35.9 mg/l
Lower 95% Confidence Interval 34.0 mg/l
Upper 95% Confidence Interval 38.0 mg/l
Defined in regulations as a flow-related parameter

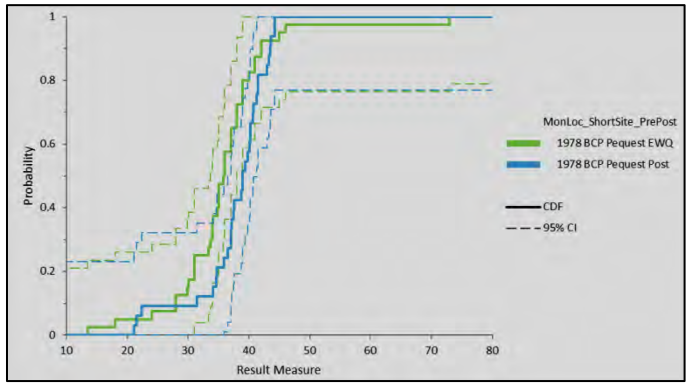






N | 73

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1978 BCP Pequest EWQ	13.5	32.0	35.9	39.0	73.0	7.0
1978 BCP Pequest Post	21.1	36.3	39.0	41.4	44.2	5.0



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1978 BCP Pequest EWQ	40	1155.6	28.89
1978 BCP Pequest Post	33	1400.8	42.45

H statistic	5.68
X^2 approximation	5.68
DF	1
p-value	0.0171 [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.

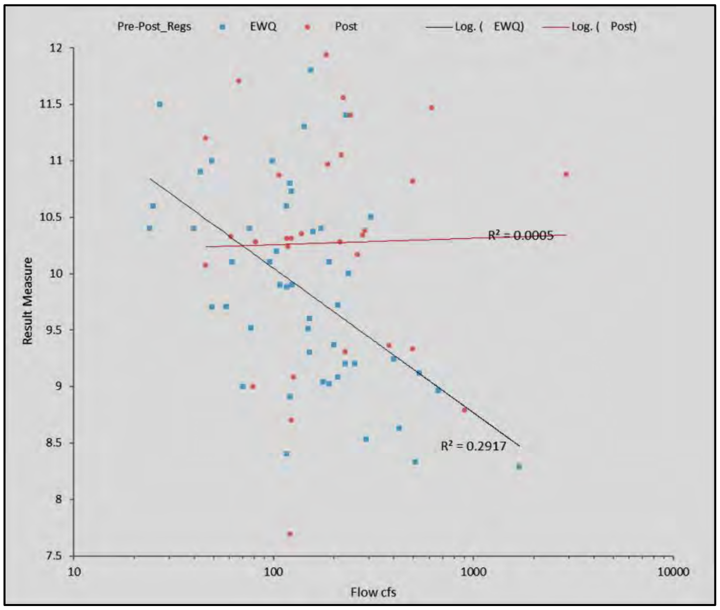
Water quality degradation is evident here. Chloride concentrations apparently rose by about 3 mg/l between the two periods. However, sources of analytical uncertainty included potential laboratory artifacts and under-representation of extreme low flow conditions. Post-EWQ median concentration rose above the EWQ upper 95% confidence interval. Chloride concentration is inversely related to flow in both data sets. Flow is plotted on a logarithmic scale. USGS measured dissolved chloride while DRBC measured total chloride. Even so, there were insufficient data to show any change in USGS dissolved chloride concentrations.

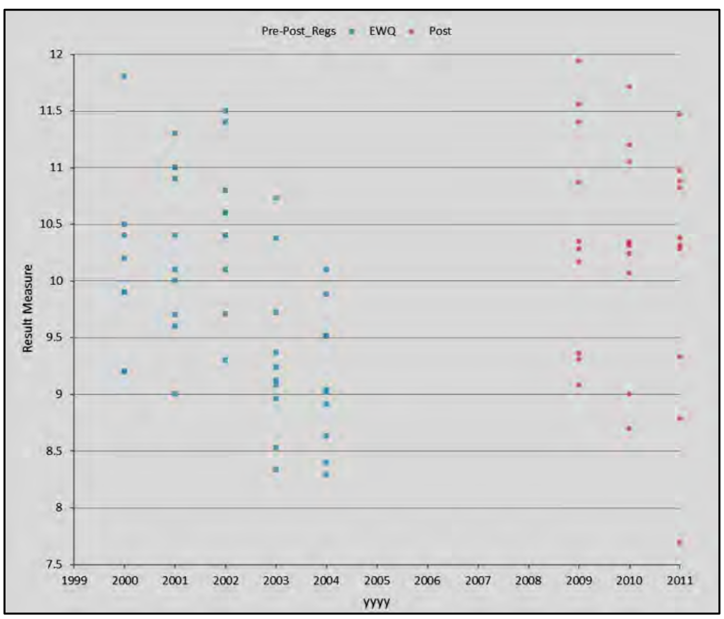
Chapter 21: 1978 BCP Pequest River, NJ

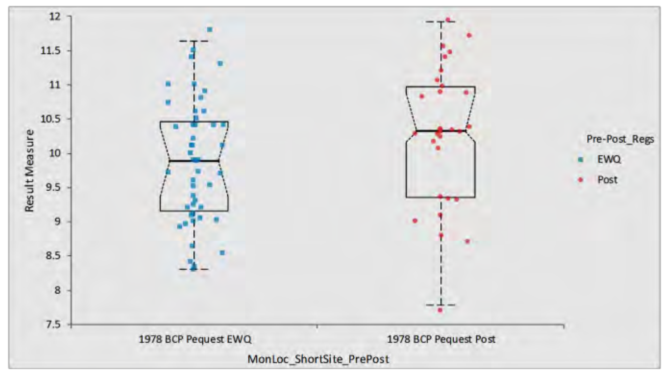
Dissolved Oxygen (DO) mg/l

Existing Water Quality (Table 2F):

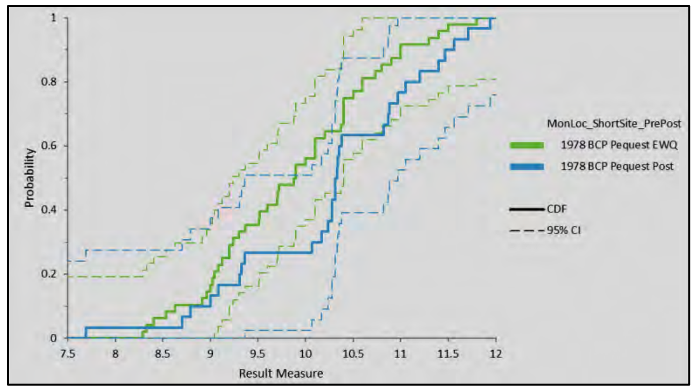
Median 9.89 mg/l
Lower 95% Confidence Interval 9.37 mg/l
Upper 95% Confidence Interval 10.37 mg/l







N	78					
Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1978 BCP Pequest EWQ	8.29	9.15	9.89	10.46	11.80	1.31
1978 BCP Pequest Post	7.69	9.36	10.32	10.98	11.94	1.62



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1978 BCP Pequest EWQ	48	671.3	13.98
1978 BCP Pequest Post	30	1074.0	35.80

H statistic	3.40
X² approximation	3.40
DF	1
p-value	0.0652 [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.

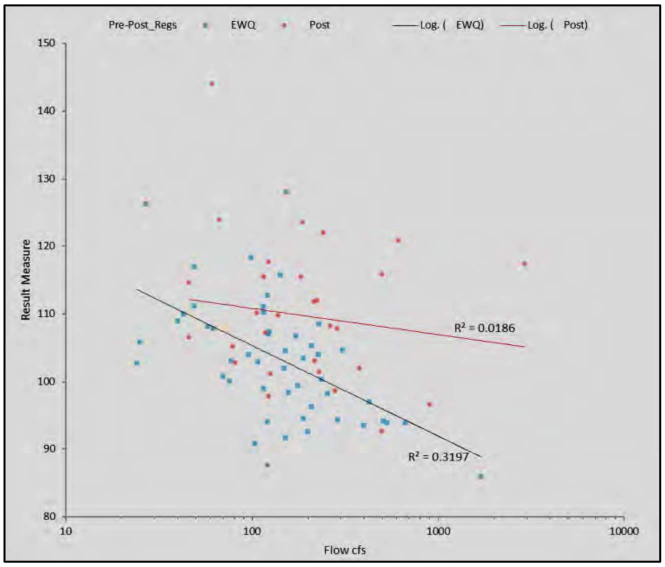
No water quality degradation is evident here. Dissolved oxygen concentrations increased slightly between the EWQ and Post-EWQ periods, but not significantly. There were no known sources of analytical uncertainty in these data. Post-EWQ median DO concentration was near the upper EWQ 95% confidence interval. DO concentration is unrelated to flow in both data sets. Flow is plotted on a logarithmic scale. USGS data, though less numerous (n=10 EWQ, n=11 post-EWQ), indicated a similar increase and were comparable to DRBC results. Both data sets are mid-day grab sample measurements, so they represent maximum daily DO concentrations.

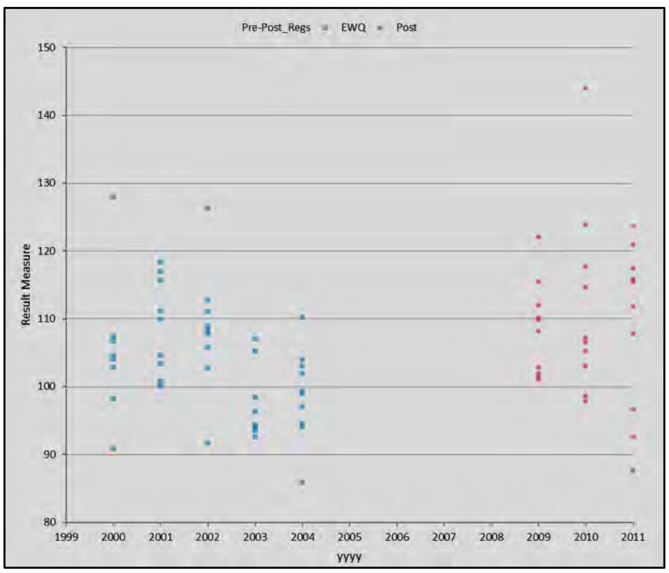
Chapter 21: 1978 BCP Pequest River, NJ

Dissolved Oxygen Saturation %

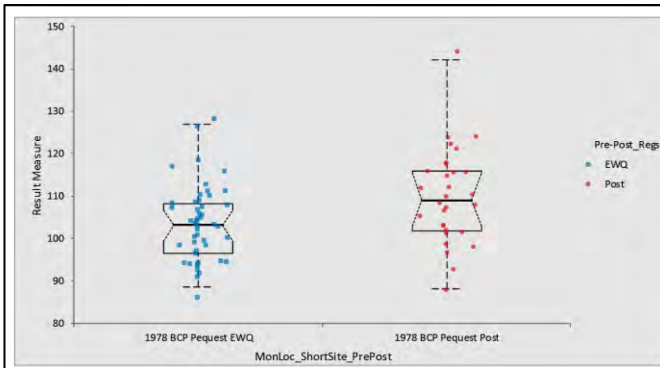
Existing Water Quality (Table 2F):

Median 103%
Lower 95% Confidence Interval 99%
Upper 95% Confidence Interval 107%



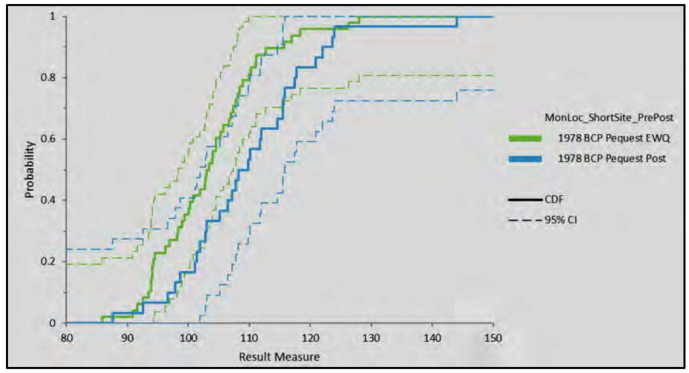


No water quality degradation is evident here. DO saturation increased. There were no known sources of analytical uncertainty in these data. Post-EWQ median DO saturation rose above the upper EWQ 95% confidence interval. DO saturation is not usually flow-related, but there is a weakly inverse relationship in the EWQ data not shown in post-EWQ data.



N	78

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1978 BCP Pequest EWQ	86	97	103	108	128	12
1978 BCP Pequest Post	88	102	109	116	144	14



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1978 BCP Pequest EWQ	48	1302.1	27.13
1978 BCP Pequest Post	30	2083.3	69.44

H statistic	6.59
X^2 approximation	6.59
DF	1
p-value	0.0102[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.

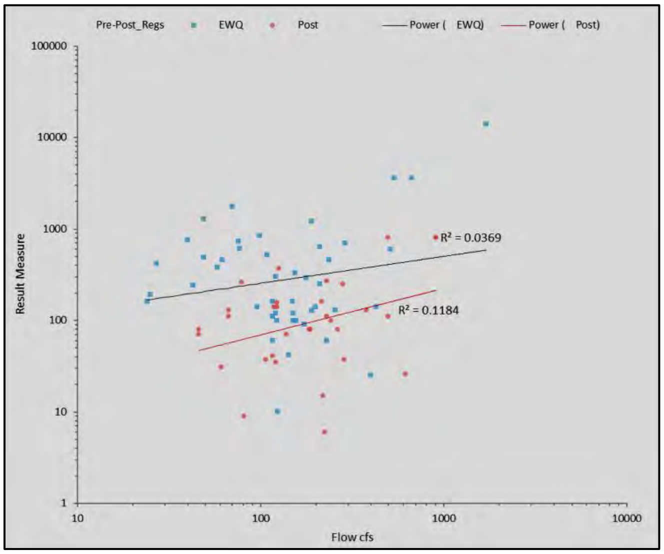
Two possibilities can explain the difference: less organic pollution (less oxygen demand) or increased algal and aquatic plant activity at this site. There were no measurements below 80%, so no concern about excess oxygen-reducing material. However, several values over 120% indicated super-saturation conditions associated with high algal production. As a rule of thumb, 80-120% is considered “normal”; in that range a balance exists between oxygen demand and supply. This location on the Pequest River is a shallow, wide channel that receives abundant sunlight, and abundant algae and aquatic plants. Perhaps there were more aquatic plants in the post-EWQ period, or less storms to scour away plant growth. USGS data were available and corroborated DRBC results.

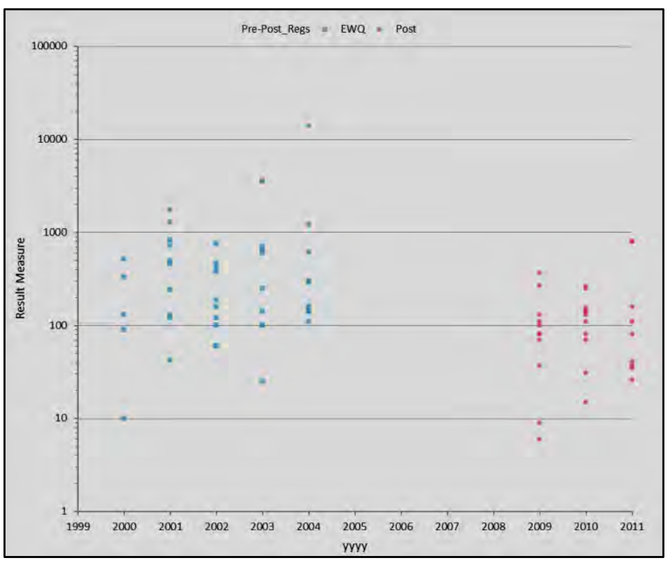
Chapter 21: 1978 BCP Pequest River, NJ

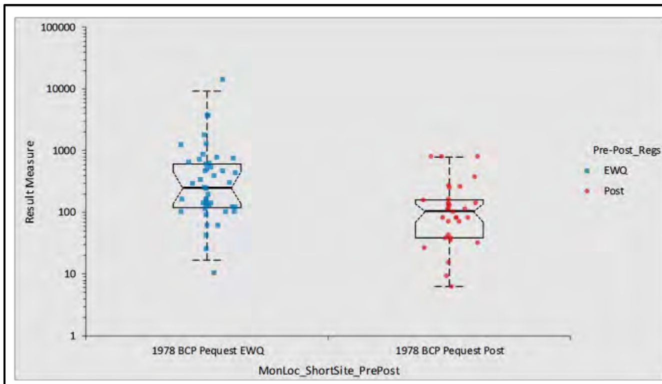
Enterococcus colonies/100 ml

Existing Water Quality (Table 2F):

Median 250/100 ml
Lower 95% Confidence Interval 140/100 ml
Upper 95% Confidence Interval 460/100 ml

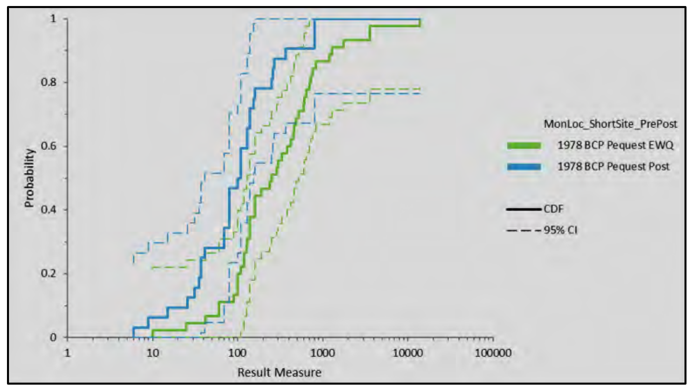






N 77

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1978 BCP Pequest EWQ	10	120	250	620	14000	500
1978 BCP Pequest Post	6	39	105	158	800	119



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1978 BCP Pequest EWQ	45	2553.8	56.75
1978 BCP Pequest Post	32	3591.3	112.23

H statistic	12.29
X² approximation	12.29
DF	1
p-value	0.0005[1]

H0: $\theta_1 = \theta_2 = \theta_{\dots}$
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.

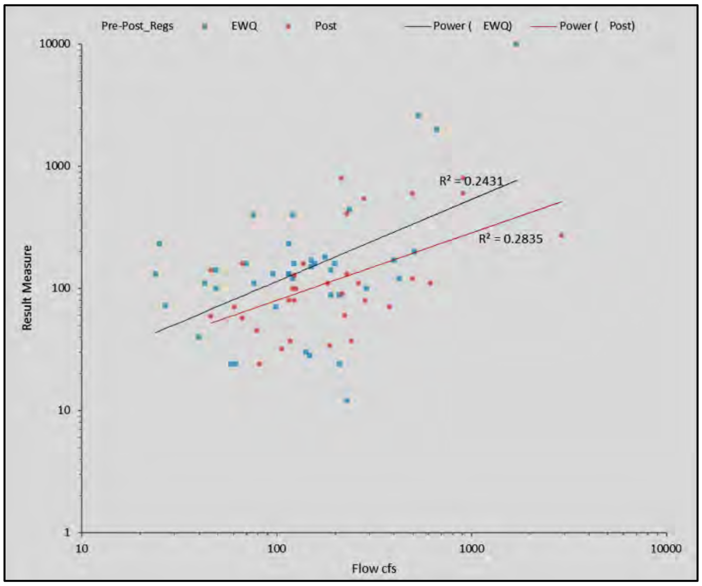
No water quality degradation is evident here. Enterococci apparently declined between the two periods. However, sources of analytical uncertainty included potential laboratory artifacts and under-representation of extreme low flow conditions. Enterococcus concentrations are unrelated to flow in both 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. USGS and NJDEP data were available for comparison with DRBC results. Most of the USGS/NJDEP data were taken during the EWQ period, and compared well with DRBC results.

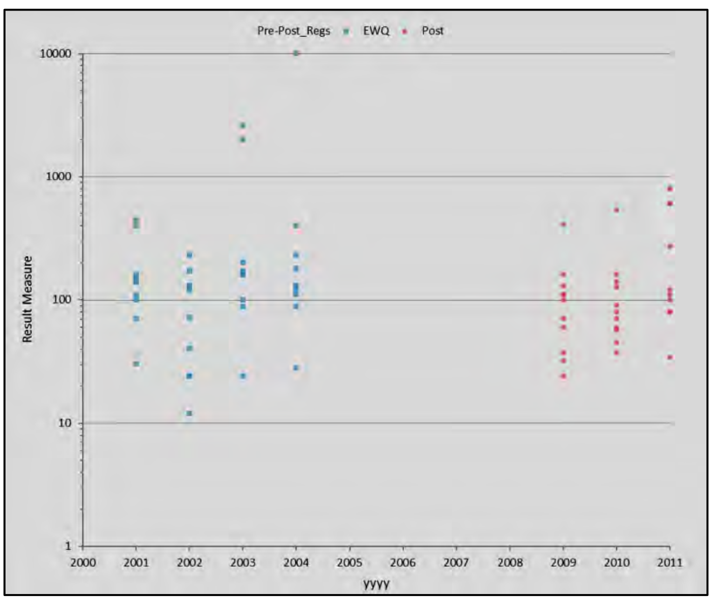
Chapter 21: 1978 BCP Pequest River, NJ

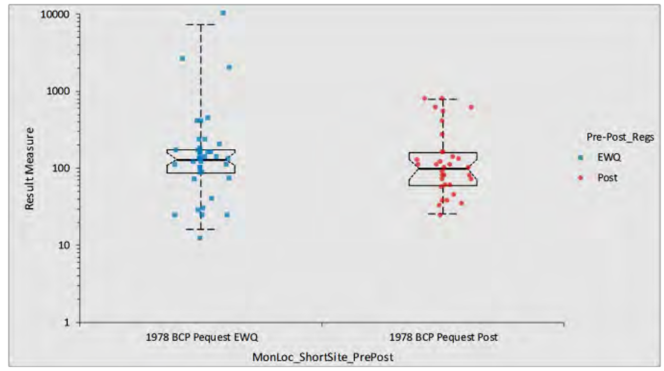
Escherichia coli colonies/100 ml

Existing Water Quality (Table 2F):

Median 130/100 ml
Lower 95% Confidence Interval 110/100 ml
Upper 95% Confidence Interval 160/100 ml

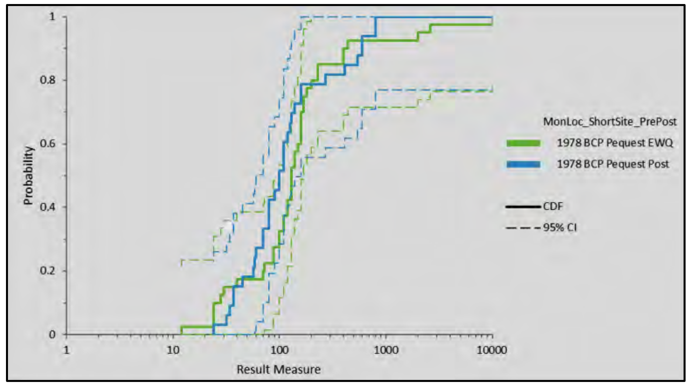






N 73

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1978 BCP Pequest EWQ	12	88	130	176	10000	88
1978 BCP Pequest Post	24	60	100	160	800	100



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1978 BCP Pequest EWQ	40	278.3	6.96
1978 BCP Pequest Post	33	337.3	10.22

H statistic	1.37
X^2 approximation	1.37
DF	1
p-value	0.2418 [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.

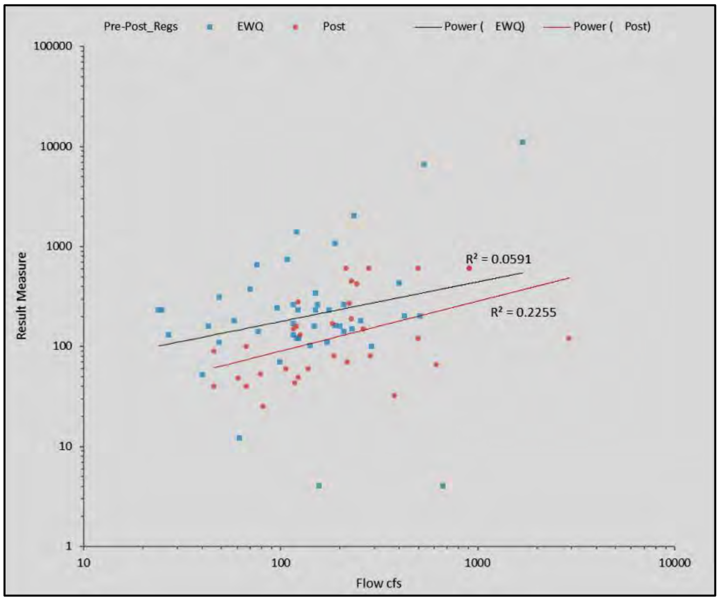
No water quality degradation is evident here. E. coli concentrations did not measurably change between the two periods. However, sources of analytical uncertainty included potential laboratory artifacts and under-representation of extreme low flow conditions. Four high values were laboratory truncated to upper quantification limits, but did not affect the comparison. Post-EWQ median E. coli fell below the lower EWQ 95% confidence interval, but not significantly. Concentrations and flows are plotted on logarithmic scale, and regressions are power relationships. E. coli concentrations are weakly related to flow in both data sets.

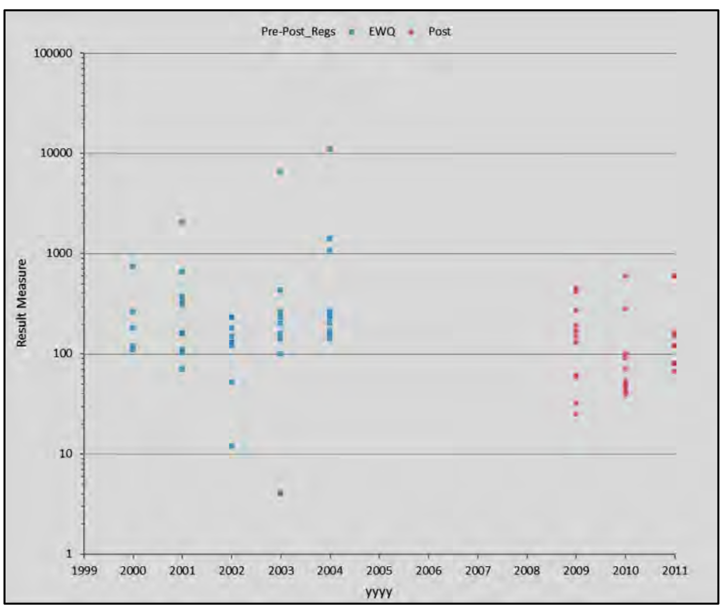
Chapter 21: 1978 BCP Pequest River, NJ

Fecal coliform colonies/100 ml

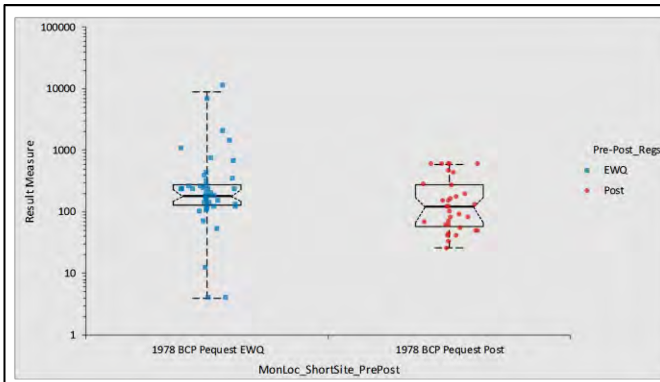
Existing Water Quality (Table 2F):

Median 180/100 ml
Lower 95% Confidence Interval 150/100 ml
Upper 95% Confidence Interval 230/100 ml



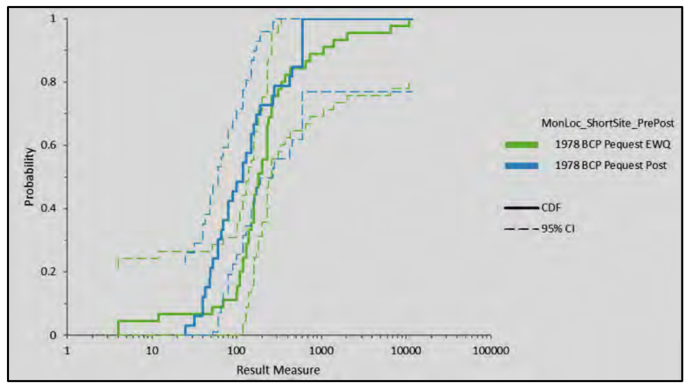


No water quality degradation is evident here. Fecal coliform concentrations apparently declined between the two periods. However, sources of analytical uncertainty included potential laboratory artifacts and under-representation of extreme low flow conditions.



N 78

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1978 BCP Pequest EWQ	4	127	180	277	11000	150
1978 BCP Pequest Post	25	58	120	273	600	216



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1978 BCP Pequest EWQ	45	1110.1	24.67
1978 BCP Pequest Post	33	1513.7	45.87

H statistic	5.11
X^2 approximation	5.11
DF	1
p-value	0.0237[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.

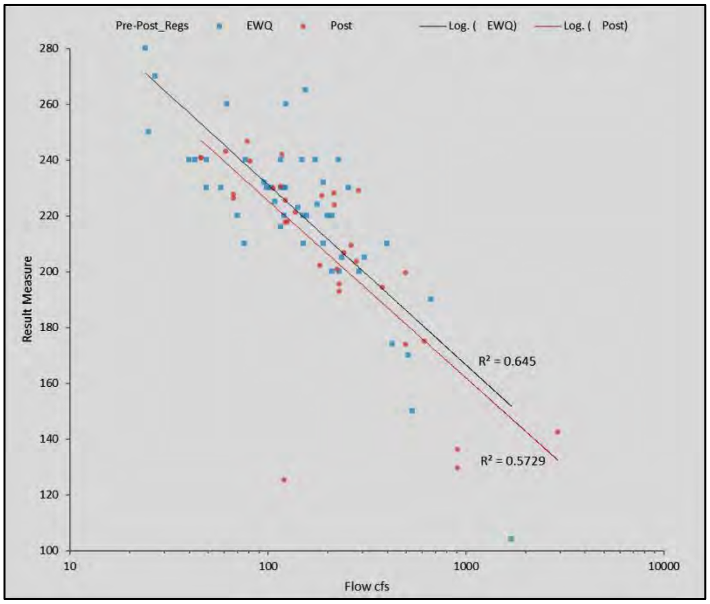
Five high values were laboratory truncated to upper quantification limits, but did not affect the comparison above the 85th percentile. Fecal coliform concentrations are unrelated to flow in the EWQ data set, but weakly related to flow in the post-EWQ data set. Post-EWQ median concentrations fell below the lower EWQ 95% confidence interval. Concentrations and flows are plotted on logarithmic scale, and regressions are power relationships. NJDEP and USGS results verify those of DRBC.

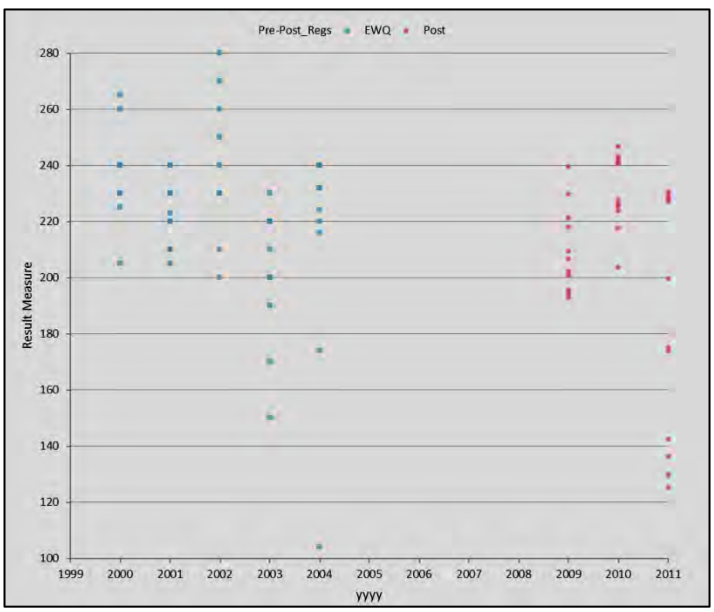
Chapter 21: 1978 BCP Pequest River, NJ

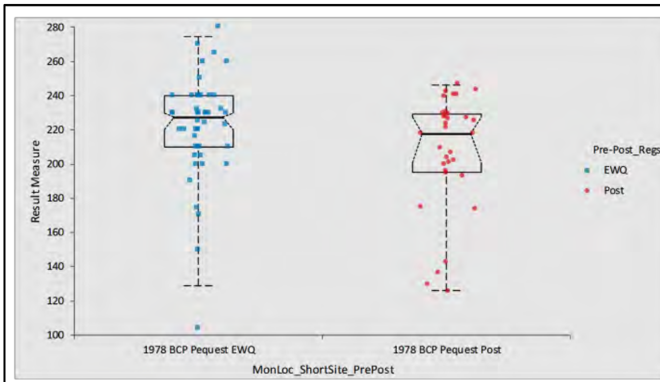
Hardness as CaCO3, Total mg/l

Existing Water Quality (Table 2F):

Median 228 mg/l
Lower 95% Confidence Interval 220 mg/l
Upper 95% Confidence Interval 230 mg/l
Defined in regulations as a flow-related parameter

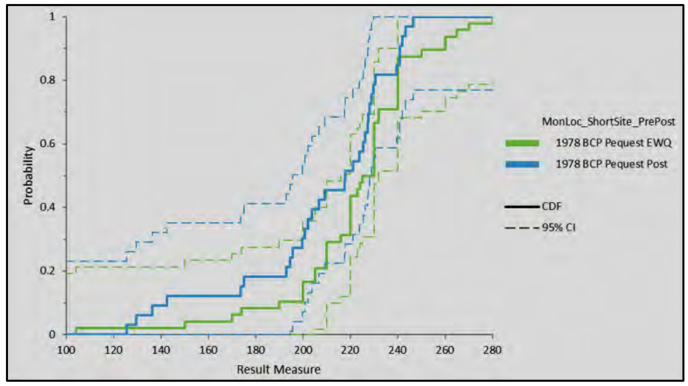






N | 81

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1978 BCP Pequest EWQ	104	210	228	240	280	30
1978 BCP Pequest Post	125	195	218	229	247	34



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1978 BCP Pequest EWQ	48	833.3	17.36
1978 BCP Pequest Post	33	1212.1	36.73

H statistic	3.70
X² approximation	3.70
DF	1
p-value	0.0543 [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.

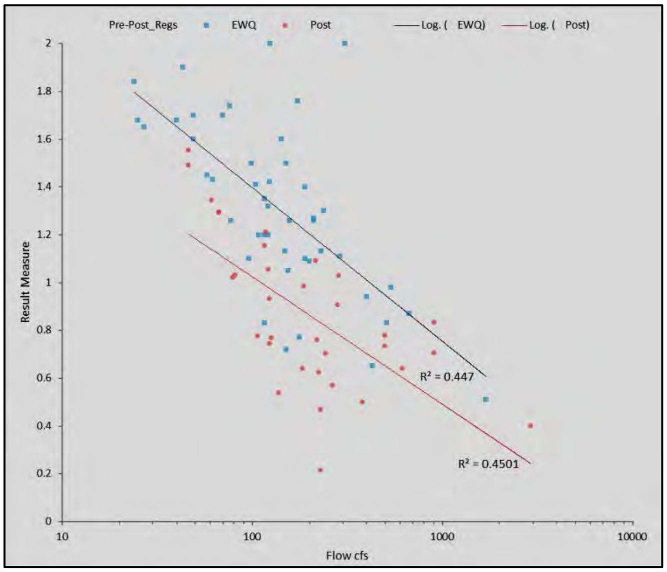
No water quality degradation is evident here. Hardness apparently did not measurably change between the EWQ and post-EWQ periods. However, sources of analytical uncertainty included potential laboratory artifacts and under-representation of extreme low flow conditions. Hardness is inversely related to flow in both data sets. Post-EWQ median hardness fell below the lower EWQ 95% confidence intervals, but not significantly and the differences were in low flow conditions. Flow is plotted on a logarithmic scale. USGS data were comparable with DRBC results.

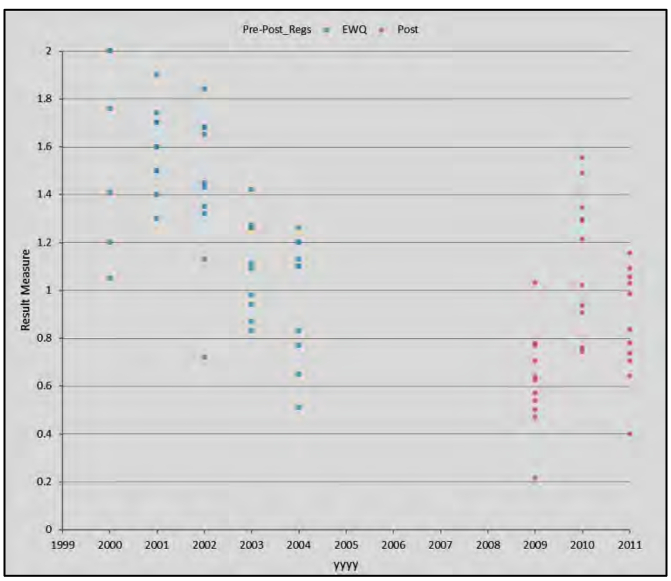
Chapter 21: 1978 BCP Pequest River, NJ

Nitrate + Nitrite as N, Total mg/l

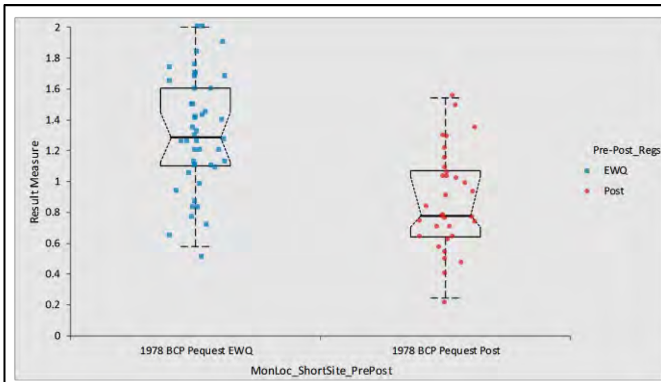
Existing Water Quality (Table 2F, as Nitrate only):

Median 1.29 mg/l
Lower 95% Confidence Interval 1.13 mg/l
Upper 95% Confidence Interval 1.45 mg/l

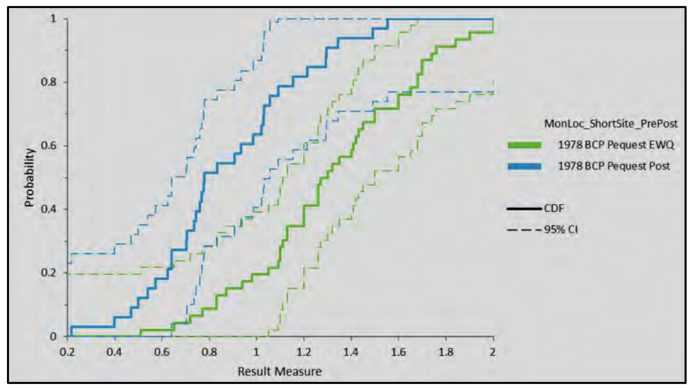




No water quality degradation is evident here. Nitrate concentrations apparently declined between the EWQ and post-EWQ periods. However, sources of analytical uncertainty included potential laboratory artifacts and under-representation of extreme low flow conditions. Nitrate is inversely related to flow in both data sets, and should have been designated as such in DRBC rules.



N	79					
Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1978 BCP Pequest EWQ	0.51	1.10	1.29	1.60	2.00	0.51
1978 BCP Pequest Post	0.22	0.64	0.78	1.07	1.55	0.43



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1978 BCP Pequest EWQ	46	5071.5	110.25
1978 BCP Pequest Post	33	7069.4	214.22

H statistic	23.06
X^2 approximation	23.06
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.

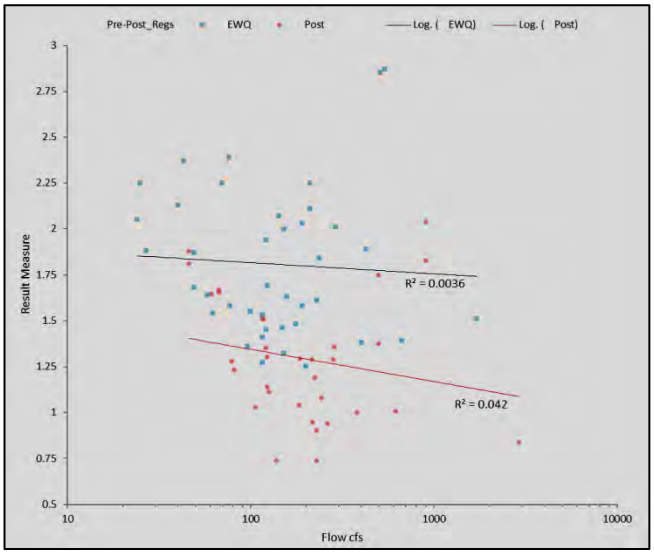
Post-EWQ median concentrations fell below the lower EWQ 95% confidence interval. Post-EWQ nitrate + nitrite concentrations were assumed equivalent with EWQ nitrate concentrations since EWQ nitrite concentrations were never detected. USGS data compared with results, with a similar decline. With no undetected results in either data set, concentrations are sufficiently high in the Pequest River that detection limit differences did not interfere with data analysis.

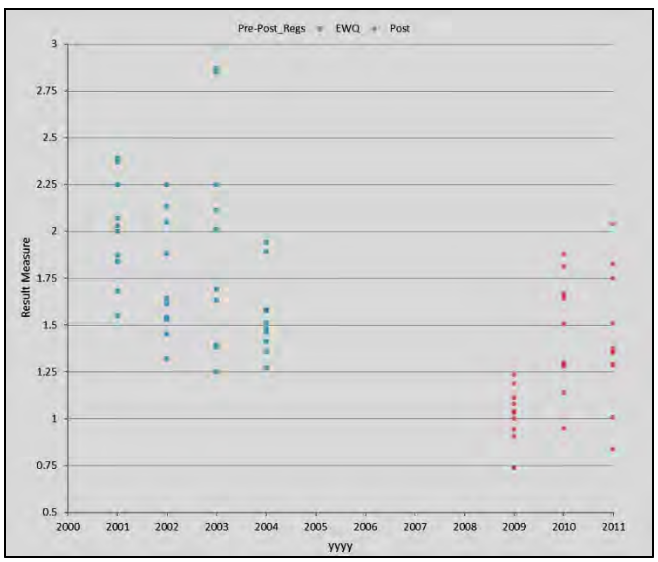
Chapter 21: 1978 BCP Pequest River, NJ

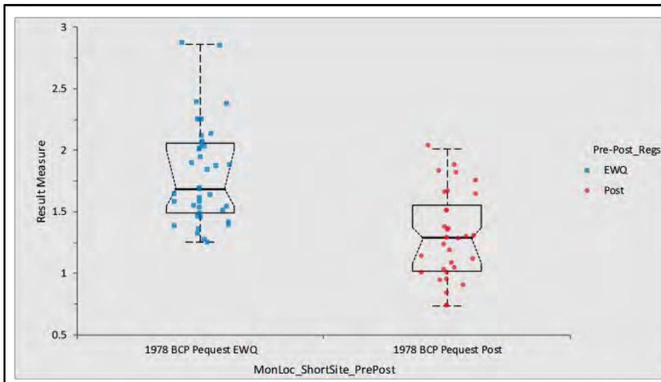
Nitrogen as N, Total (TN) mg/l

Existing Water Quality (Table 2F):

Median 1.69 mg/l
Lower 95% Confidence Interval 1.54 mg/l
Upper 95% Confidence Interval 2.00 mg/l

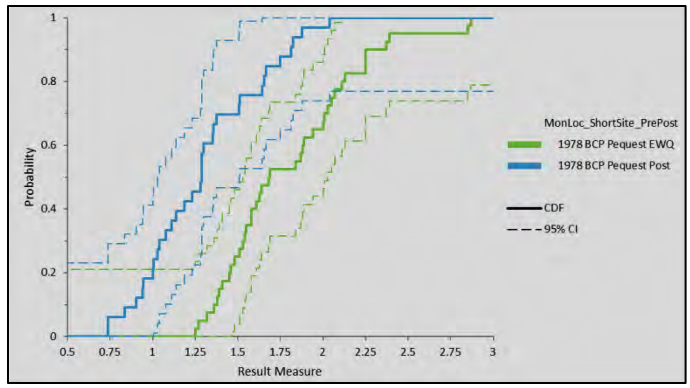






N 73

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1978 BCP Pequest EWQ	1.25	1.49	1.69	2.06	2.87	0.57
1978 BCP Pequest Post	0.74	1.02	1.29	1.55	2.04	0.53



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1978 BCP Pequest EWQ	40	5006.4	125.16
1978 BCP Pequest Post	33	6068.4	183.89

H statistic	24.60
X^2 approximation	24.60
DF	1
p-value	<0.0001 [1]

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

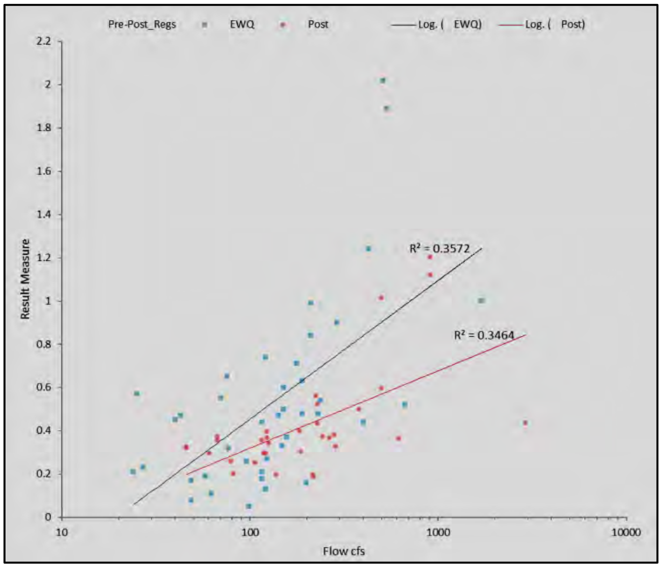
No water quality degradation is evident here. Total Nitrogen concentrations apparently declined between the EWQ and post-EWQ periods. However, sources of analytical uncertainty included potential laboratory artifacts and under-representation of extreme low flow conditions. TN is unrelated to flow in both data sets. USGS data confirmed and were very similar to DRBC results. Post-EWQ median TN concentration fell below the lower EWQ 95% confidence interval.

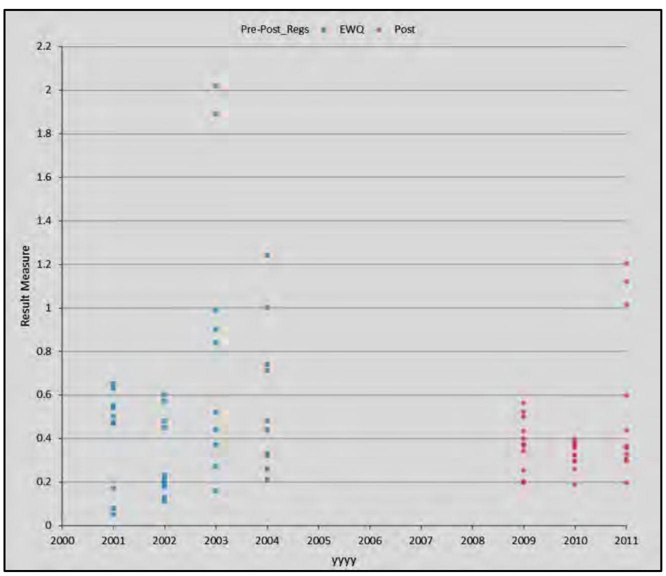
Chapter 21: 1978 BCP Pequest River, NJ

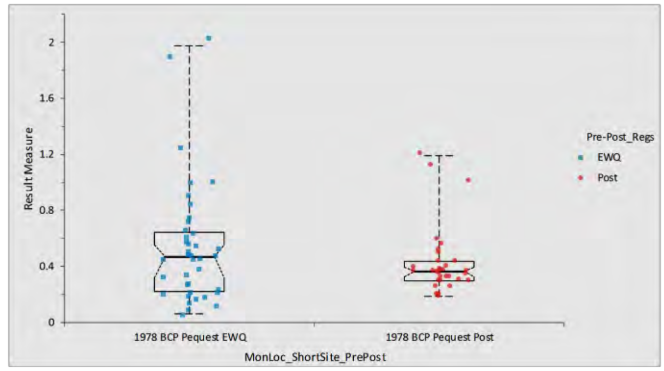
Nitrogen, Kjeldahl as N, Total (TKN) mg/l

Existing Water Quality (Table 2F):

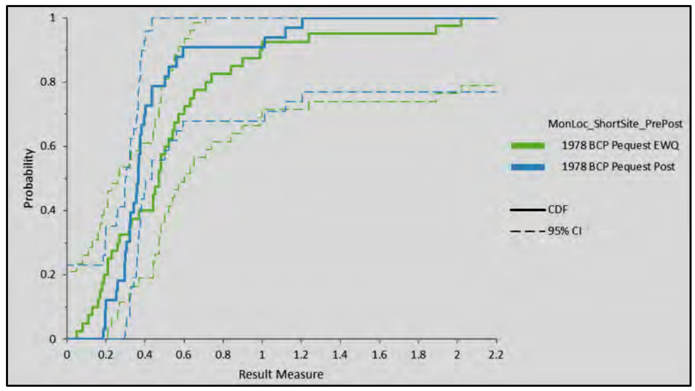
Median 0.47 mg/l
Lower 95% Confidence Interval 0.32 mg/l
Upper 95% Confidence Interval 0.55 mg/l
Defined in regulations as a flow-related parameter







N	73					
Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1978 BCP Pequest EWQ	0.05	0.22	0.47	0.64	2.02	0.42
1978 BCP Pequest Post	0.19	0.30	0.36	0.44	1.20	0.14



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1978 BCP Pequest EWQ	40	230.4	5.76
1978 BCP Pequest Post	33	279.3	8.46

H statistic	1.13
X^2 approximation	1.13
DF	1
p-value	0.2873 [1]

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

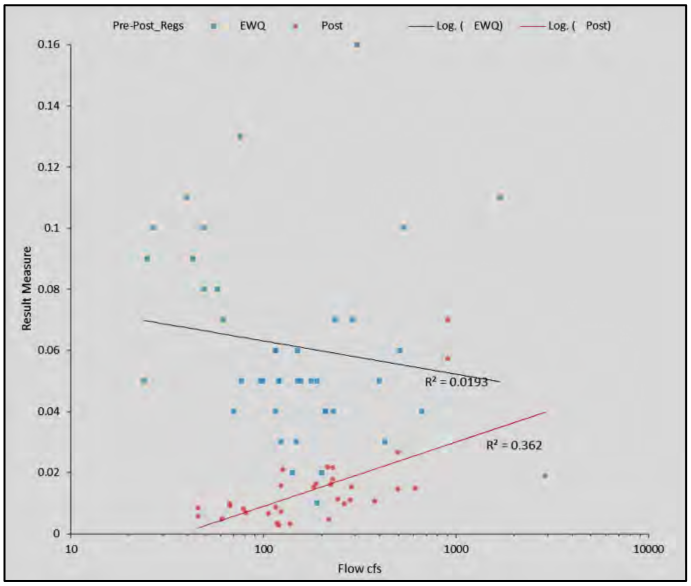
No water quality degradation is evident here. TKN concentrations apparently declined between the EWQ and post-EWQ periods, but not significantly. Sources of analytical uncertainty included potential laboratory artifacts and under-representation of extreme low flow conditions. The post-EWQ range of values was narrower. TKN concentration is weakly related to flow in both data sets. Post-EWQ median TKN fell near the lower EWQ 95% confidence interval. There were too few USGS data to confirm DRBC results.

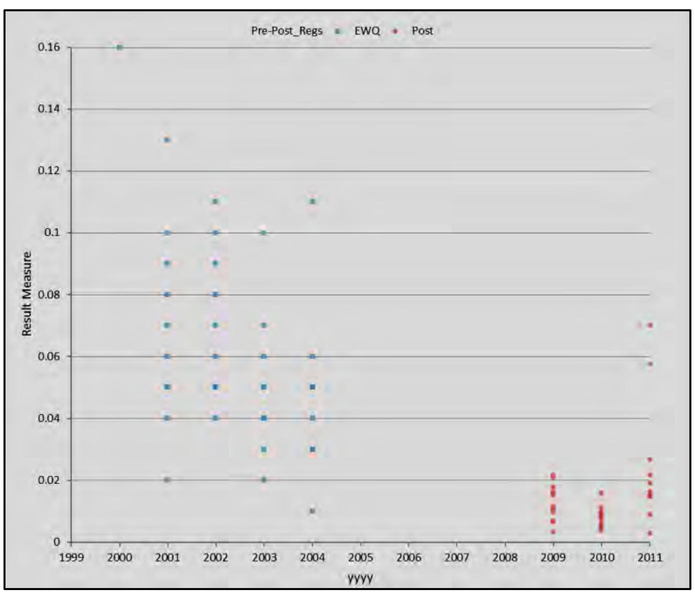
Chapter 21: 1978 BCP Pequest River, NJ

Orthophosphate as P, Total mg/l (OP)

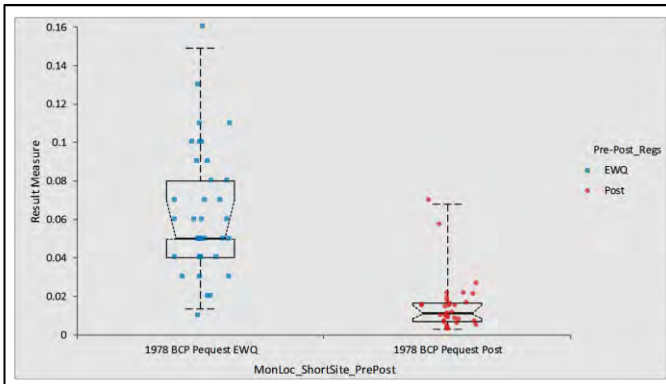
Existing Water Quality (Table 2F):

Median <0.05 mg/l
Lower 95% Confidence Interval 0.05 mg/l
Upper 95% Confidence Interval 0.07 mg/l



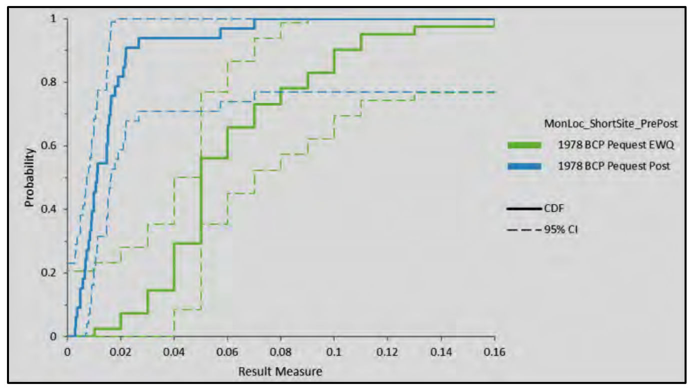


No water quality degradation is evident here. OP concentrations apparently declined between the EWQ and post-EWQ periods. However, sources of analytical uncertainty included potential laboratory artifacts and under-representation of extreme low flow conditions.



N 74

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1978 BCP Pequest EWQ	0.010	0.040	0.050	0.080	0.160	0.040
1978 BCP Pequest Post	0.003	0.007	0.011	0.017	0.070	0.010



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1978 BCP Pequest EWQ	41	8765.9	213.80
1978 BCP Pequest Post	33	10890.9	330.03

H statistic	42.68
X² approximation	42.68
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.

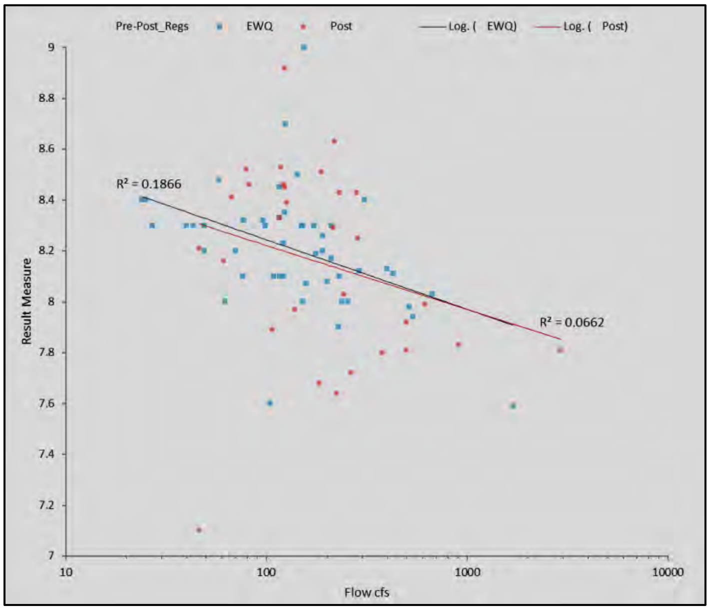
Orthophosphate is unrelated to flow in both data sets. Post-EWQ median orthophosphate fell below the lower EWQ 95% confidence interval. There was no interference by detection limits in either data set, as only a single result was below detection levels. USGS measures dissolved orthophosphate while DRBC measures total orthophosphate, but results were comparable. USGS data were most similar to DRBC post-EWQ results. DRBC EWQ data were more variable, wider-ranging, and generally higher in concentration.

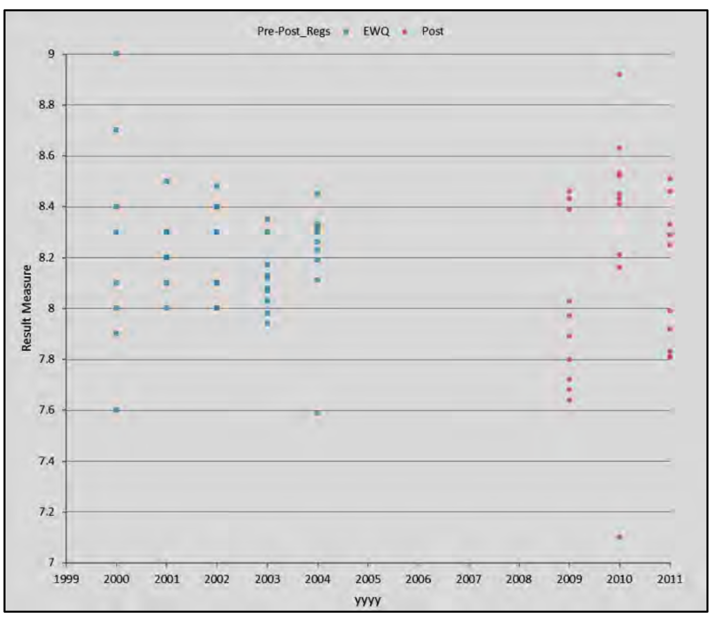
Chapter 21: 1978 BCP Pequest River, NJ

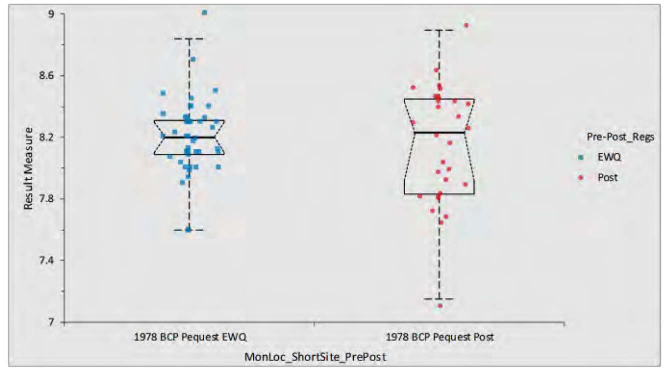
pH

Existing Water Quality (Table 2F):

Median 8.20 standard units
Lower 95% Confidence Interval 8.10 standard units
Upper 95% Confidence Interval 8.30 standard units

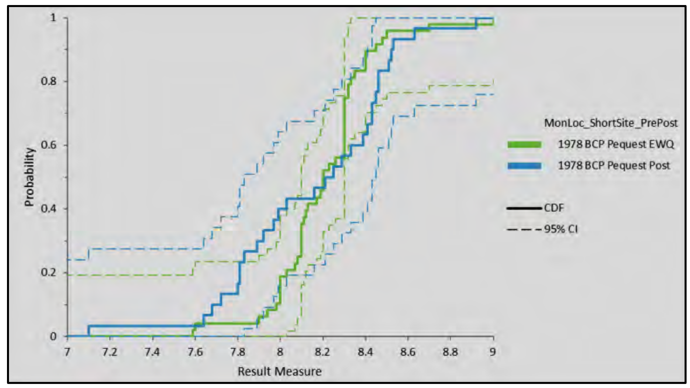






N	78

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1978 BCP Pequest EWQ	7.59	8.09	8.20	8.31	9.00	0.22
1978 BCP Pequest Post	7.10	7.83	8.23	8.45	8.92	0.62



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1978 BCP Pequest EWQ	48	4.4	0.09
1978 BCP Pequest Post	30	7.0	0.23

H statistic	0.02
X^2 approximation	0.02
DF	1
p-value	0.8815 [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.

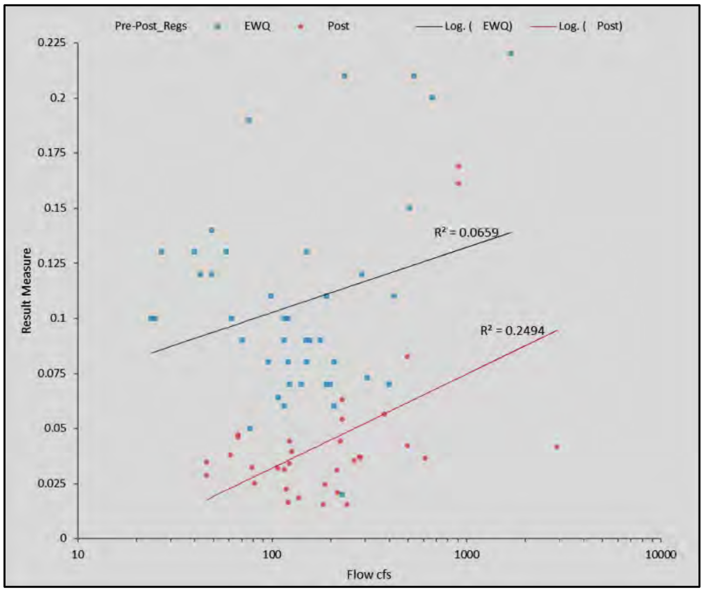
No water quality degradation is evident here. pH did not measurably change between the EWQ and post-EWQ periods. There were no known sources of analytical uncertainty in these data. pH is unrelated to flow in both data sets. Post-EWQ median pH was within the EWQ 95% confidence intervals. The result below pH 7.2 taken in 2010 was probably a probe malfunction. USGS data were less numerous but matched DRBC results.

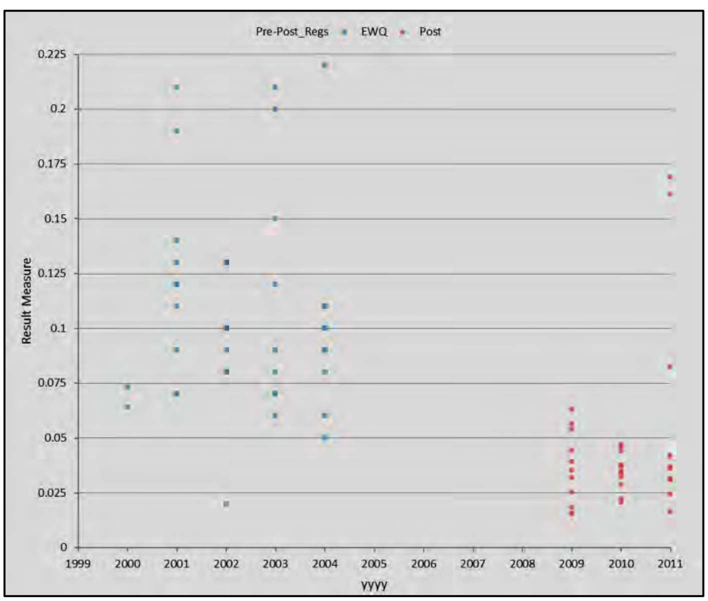
Chapter 21: 1978 BCP Pequest River, NJ

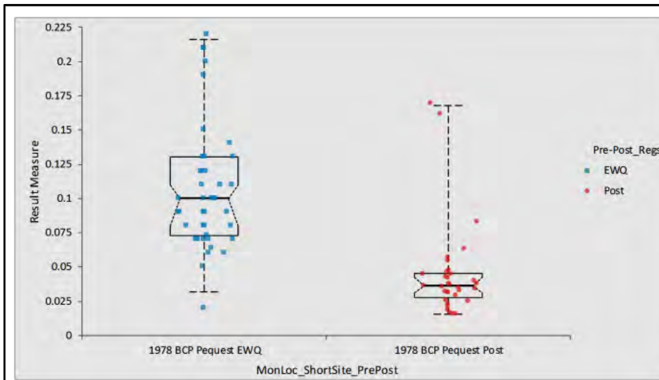
Phosphorus as P, Total (TP) mg/l

Existing Water Quality (Table 2F):

Median 0.10 mg/l
Lower 95% Confidence Interval 0.08 mg/l
Upper 95% Confidence Interval 0.11 mg/l

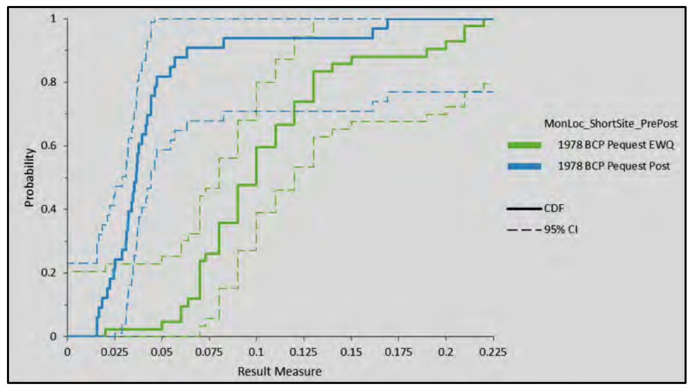






N 75

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1978 BCP Pequest EWQ	0.02	0.07	0.10	0.13	0.22	0.06
1978 BCP Pequest Post	0.02	0.03	0.04	0.04	0.17	0.02



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1978 BCP Pequest EWQ	42	7817.4	186.13
1978 BCP Pequest Post	33	9949.4	301.50

H statistic	37.45
X² approximation	37.45
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.

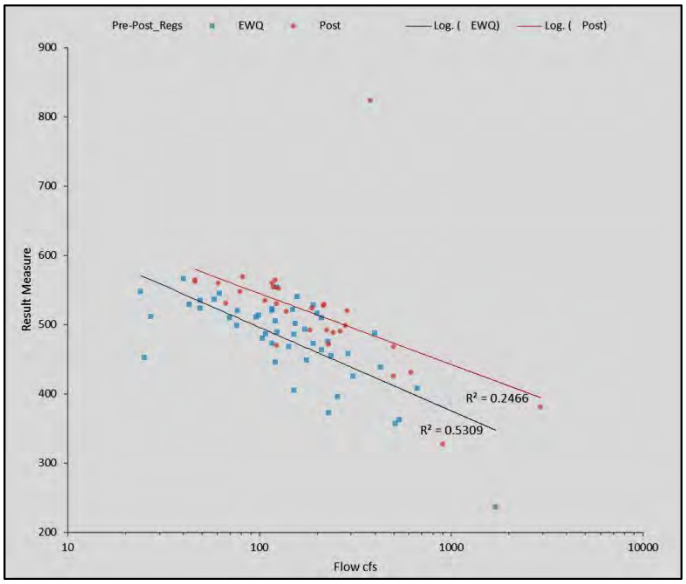
No water quality degradation is evident here. Total Phosphorus (TP) concentrations apparently declined between the EWQ and post-EWQ periods. However, sources of analytical uncertainty included potential laboratory artifacts, detection limit differences, and under-representation of extreme low flow conditions. Post-EWQ median total phosphorus fell below the EWQ lower 95% confidence interval. TP is unrelated to flow in both data sets. USGS data were less numerous but confirmed DRBC results. It appears that New Jersey Total Phosphorus criteria may no longer be exceeded at this location, unless the decline is simply a laboratory artifact.

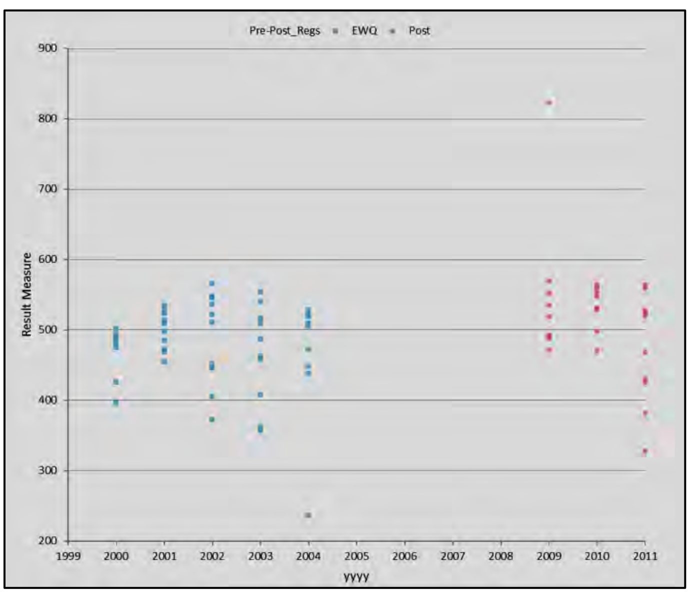
Chapter 21: 1978 BCP Pequest River, NJ

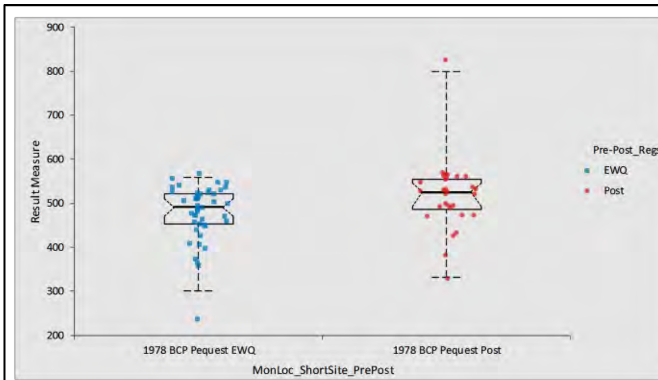
Specific Conductance µmho/cm

Existing Water Quality (Table 2F):

Median 491 µmho/cm
Lower 95% Confidence Interval 472 µmho/cm
Upper 95% Confidence Interval 511 µmho/cm
Defined in regulations as a flow-related parameter

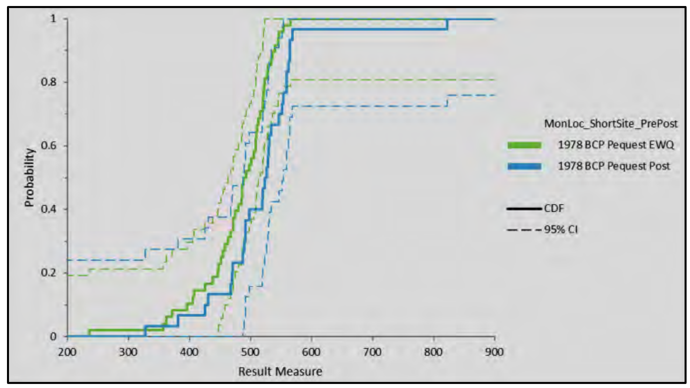






N 78

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1978 BCP Pequest EWQ	236	453	491	521	566	67
1978 BCP Pequest Post	327	487	525	554	823	68



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1978 BCP Pequest EWQ	48	1281.3	26.69
1978 BCP Pequest Post	30	2050.1	68.34

H statistic	6.49
X² approximation	6.49
DF	1
p-value	0.0109 [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.

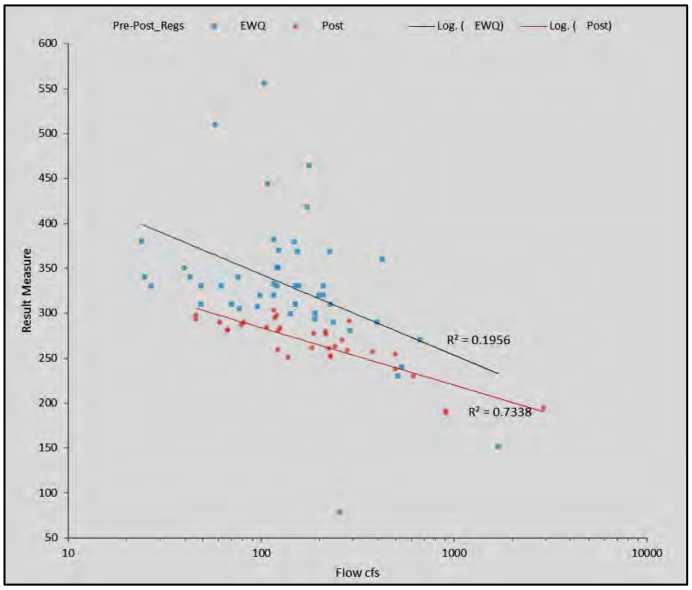
Water quality degradation is evident here. Specific conductance increased by 7%, or 34 µmho/cm, which is above the EWQ upper 95% confidence interval. There are no known sources of analytical uncertainty in these data. Specific conductance is inversely related to flow in both data sets. There was a single extremely high result (823 µmho/cm) taken in June 2009 in normal flow conditions; its cause was unknown. The rise in specific conductance may be partially attributable to the concurrent rise in chloride concentrations. USGS data were similar to DRBC results.

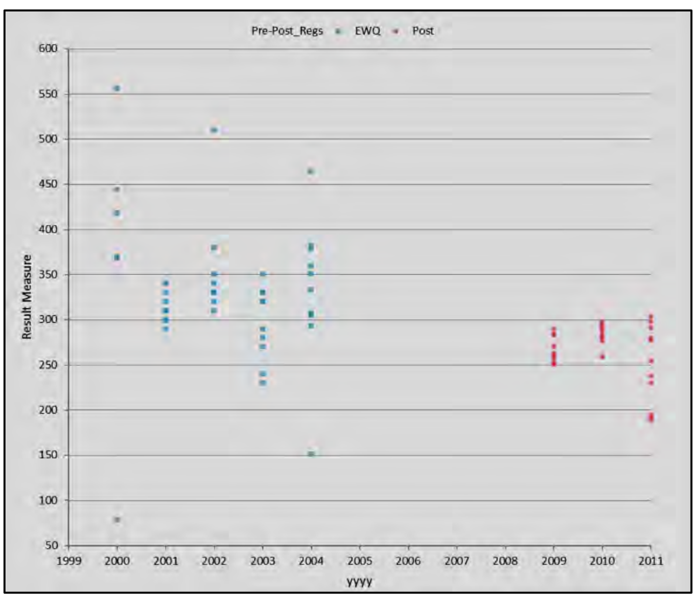
Chapter 21: 1978 BCP Pequest River, NJ

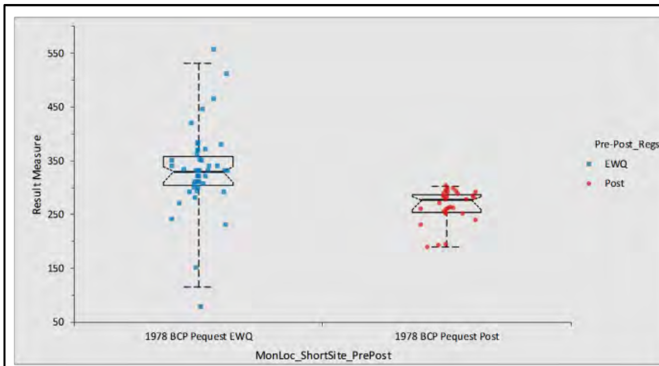
Total Dissolved Solids (TDS) mg/l

Existing Water Quality (Table 2F):

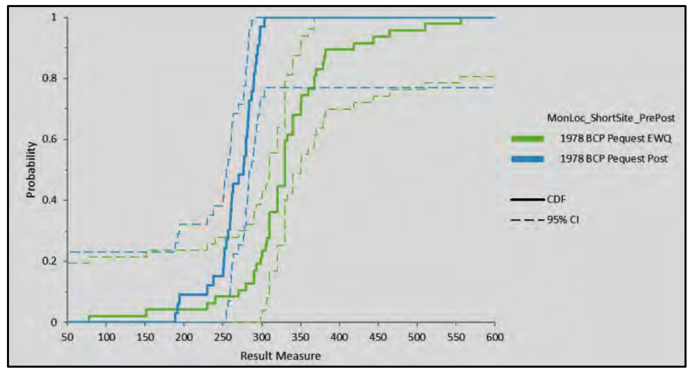
Median 330 mg/l
Lower 95% Confidence Interval 310 mg/l
Upper 95% Confidence Interval 340 mg/l
Defined in regulations as a flow-related parameter







N	80					
Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1978 BCP Pequest EWQ	78	305	330	359	556	53
1978 BCP Pequest Post	189	253	277	288	303	34



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1978 BCP Pequest EWQ	47	7723.5	164.33
1978 BCP Pequest Post	33	11000.2	333.34

H statistic	34.71
X^2 approximation	34.71
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.

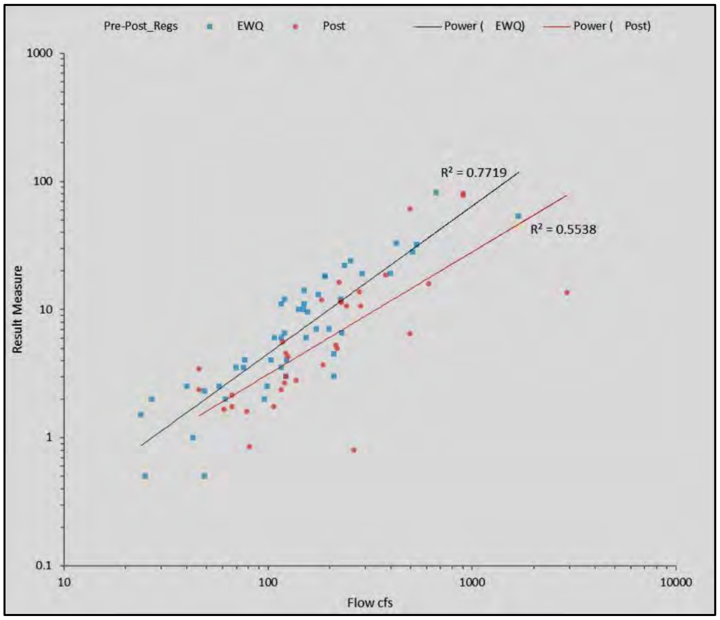
No water quality degradation is evident here. TDS apparently declined between the two periods. However, sources of analytical uncertainty included potential laboratory artifacts and under-representation of extreme low flow conditions. TDS is inversely related to flow in both data sets, though the relationship is weak in the EWQ data. 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 undetected results at any time. USGS data over the period show no decline, and compare best with DRBC post-EWQ data only. DRBC EWQ results were generally higher and more variable than USGS data of the time.

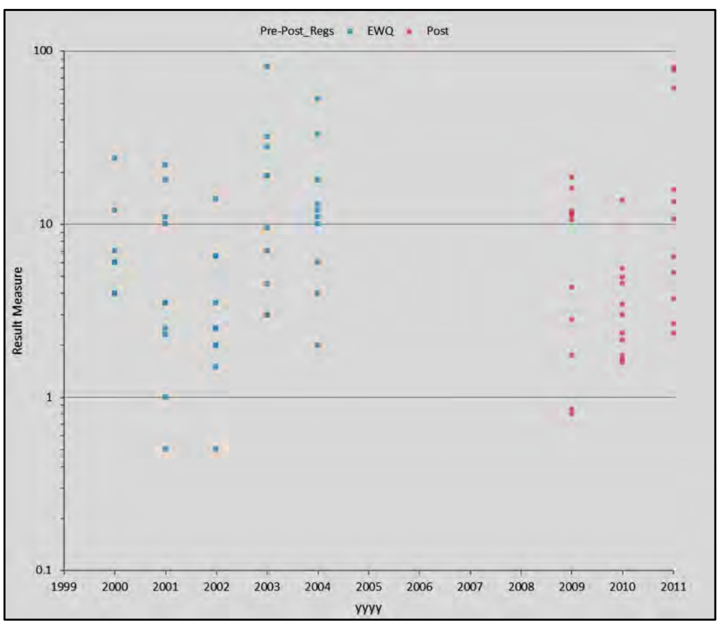
Chapter 21: 1978 BCP Pequest River, NJ

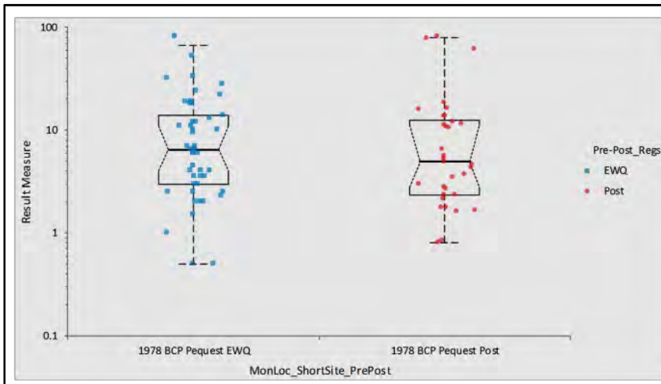
Total Suspended Solids (TSS) mg/l

Existing Water Quality (Table 2F):

Median 6.5 mg/l
Lower 95% Confidence Interval 4.0 mg/l
Upper 95% Confidence Interval 11.0 mg/l
<u>Should have been designated in rules as flow-related</u>

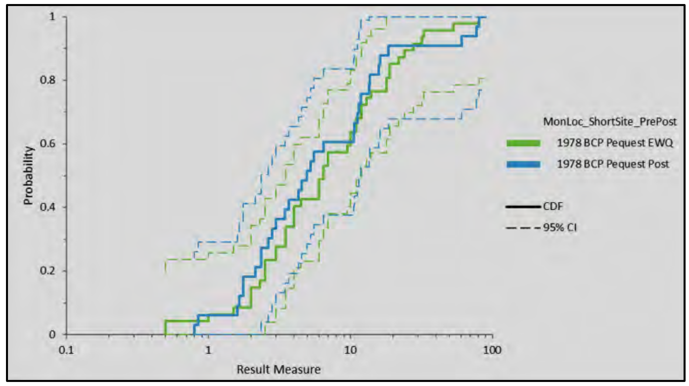






N | 80

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1978 BCP Pequest EWQ	0.5	3.0	6.5	13.8	81.0	10.8
1978 BCP Pequest Post	0.8	2.4	5.0	12.4	80.8	10.1



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1978 BCP Pequest EWQ	47	111.8	2.38
1978 BCP Pequest Post	33	159.3	4.83

H statistic	0.50
X² approximation	0.50
DF	1
p-value	0.4785 [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.

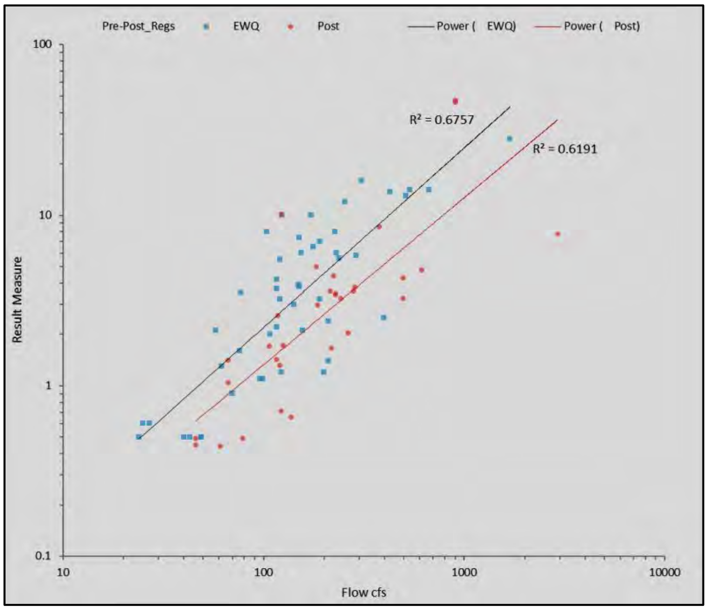
No water quality degradation is evident here. TSS concentrations apparently did not measurably change between the EWQ and post-EWQ periods. However, sources of analytical uncertainty included potential laboratory artifacts and under-representation of extreme low flow conditions. TSS is positively related to flow in both data sets, and should have been designated as flow-related in DRBC water quality rules. Post-EWQ median TSS fell within the EWQ 95% confidence intervals. Flows and concentrations are plotted on logarithmic scale, and regressions are power relationships. USGS data were comparable with DRBC results.

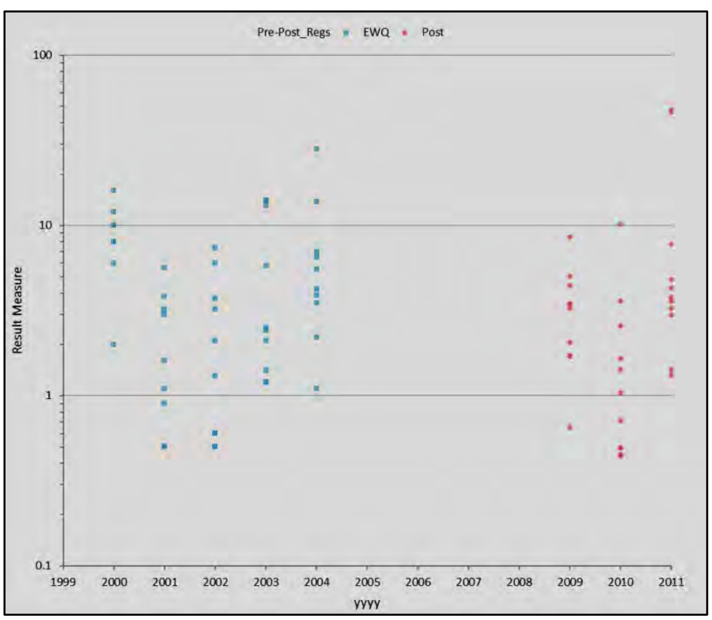
Chapter 21: 1978 BCP Pequest River, NJ

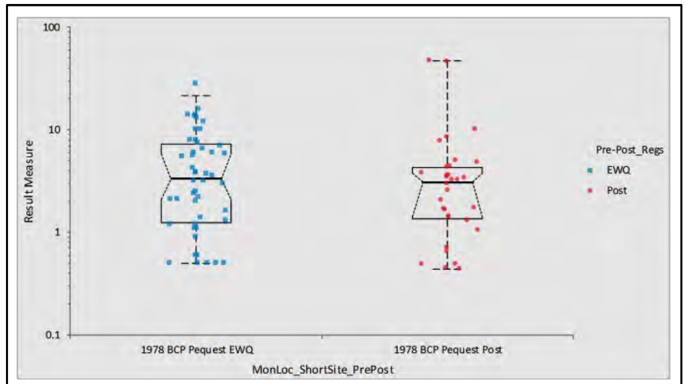
Turbidity NTU

Existing Water Quality (Table 2F):

Median 3.4 NTU
Lower 95% Confidence Interval 2.1 NTU
Upper 95% Confidence Interval 5.8 NTU
Defined in regulations as a flow-related parameter

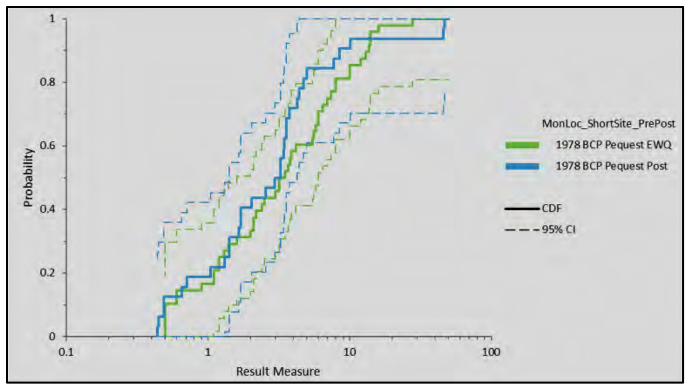






N | 80

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
1978 BCP Pequest EWQ	0.5	1.2	3.4	7.2	28.0	6.0
1978 BCP Pequest Post	0.4	1.4	3.1	4.4	47.1	3.0



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1978 BCP Pequest EWQ	48	212.5	4.43
1978 BCP Pequest Post	32	318.8	9.96

H statistic	0.98
X² approximation	0.98
DF	1
p-value	0.3212 [1]

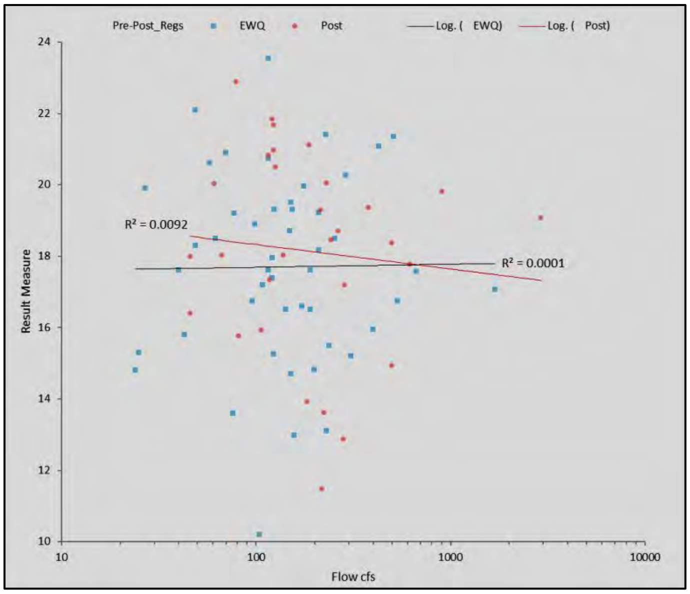
H0: $\theta_1 = \theta_2 = \theta_{\ldots}$
The median of the populations are all equal.
H1: $\theta_i \neq \theta_j$ for at least one i,j
The median of the populations are not all equal.
[1] Do not reject the null hypothesis at the 5% significance level.

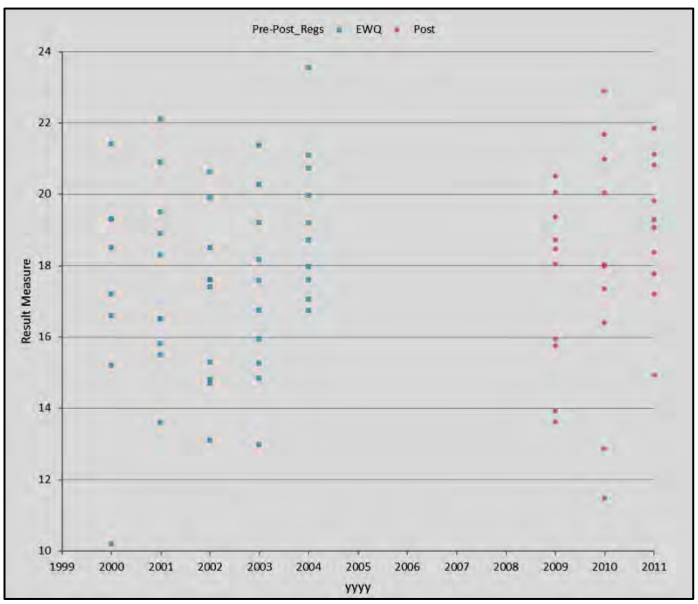
No water quality degradation is evident here. Turbidity did not measurably change between the EWQ and post-EWQ periods. There were no known sources of analytical uncertainty in these data. The post-EWQ median turbidity fell within the EWQ 95% confidence intervals. Turbidity is positively related to flow in both data sets. Concentrations and flows are represented on logarithmic scale, and regressions are power relationships. There were too few USGS data (n=8) available for comparison with DRBC results, but concentrations were in the same range.

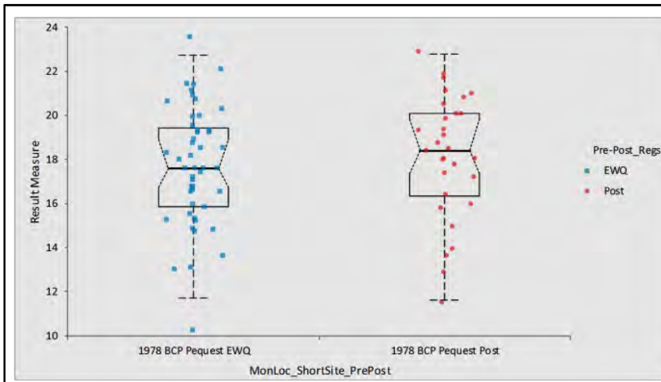
Chapter 21: 1978 BCP Pequest River, NJ

Water Temperature, degrees C

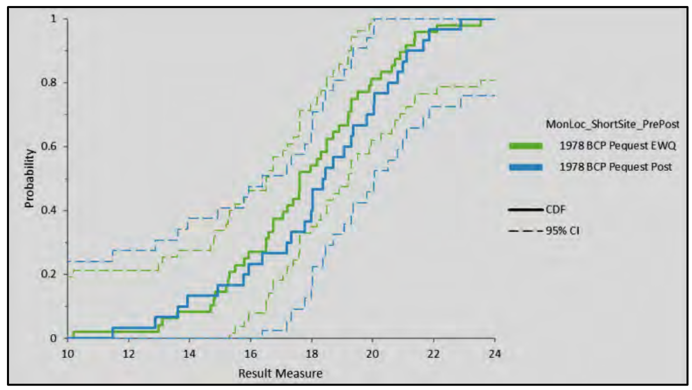
Not included in DRBC Existing Water Quality rules







N	78					
Result Measure by MonLoc_ShortSite_PrePost	**Minimum**	**1st Quartile**	**Median**	**3rd Quartile**	**Maximum**	**Inter-quartile range**
1978 BCP Pequest EWQ	10.2	15.9	17.6	19.4	23.5	3.6
1978 BCP Pequest Post	11.5	16.4	18.4	20.1	22.9	3.7



Kruskal-Wallis test

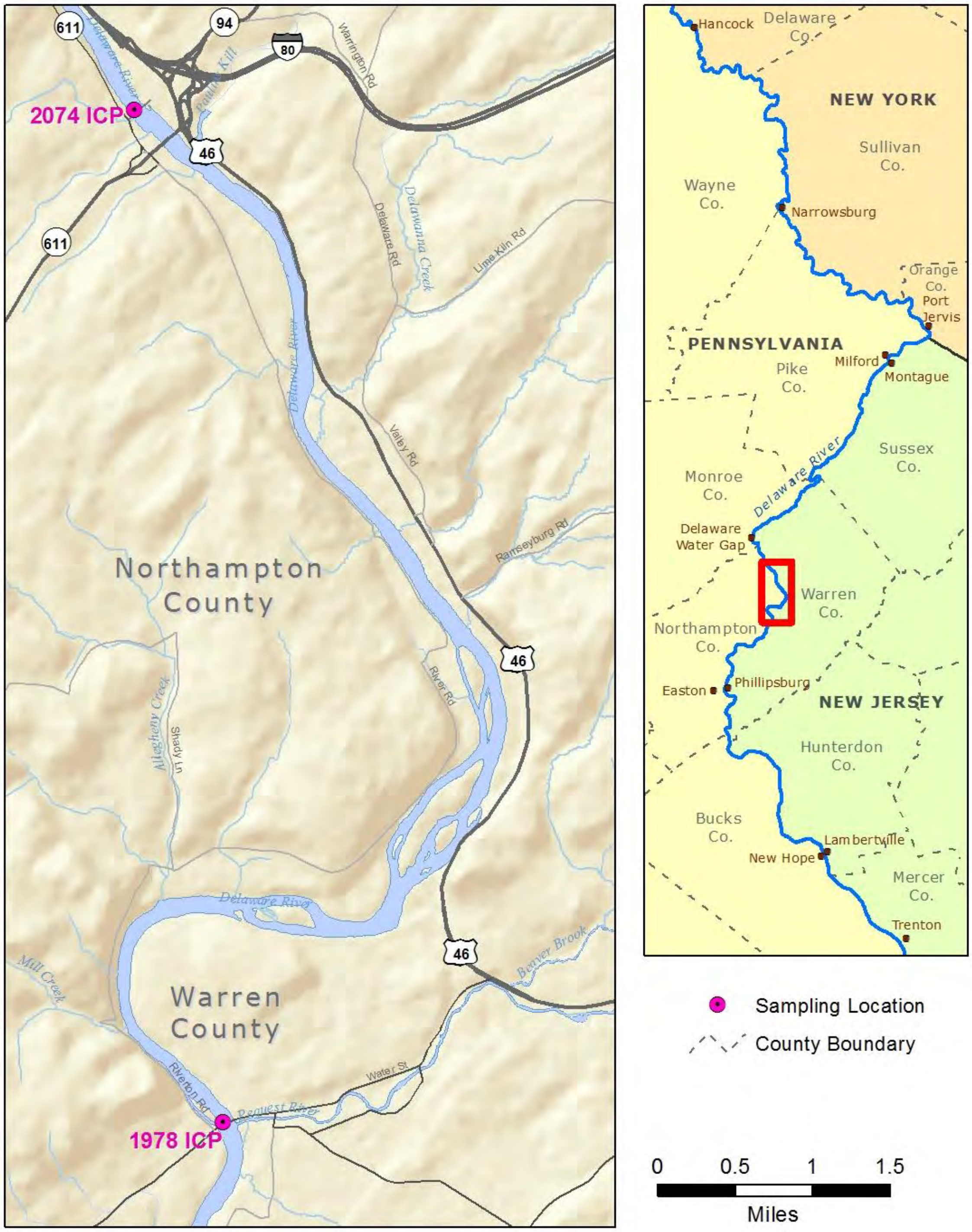
Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1978 BCP Pequest EWQ	48	155.9	3.25
1978 BCP Pequest Post	30	249.4	8.31

H statistic	0.79
X^2 approximation	0.79
DF	1
p-value	0.3743 [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.

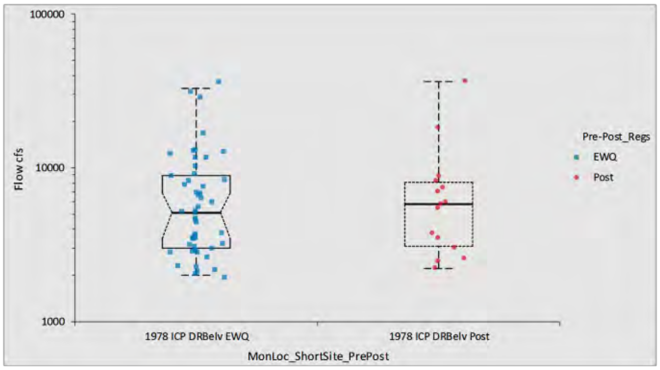
No water quality degradation is evident here. Water temperature was not significantly different between the EWQ and post-EWQ periods, but there was about a 1 degree C increase throughout the post-EWQ data distribution. There were no known sources of analytical uncertainty in these data. Since warmer water holds less oxygen, the dissolved oxygen saturation increase noted earlier is verifiably not due to temperature differences between the data sets. Water temperature is unrelated to flow in both data sets. Note that flows are plotted on a logarithmic scale. NJDEP and USGS data were comparable with DRBC results.

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

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.

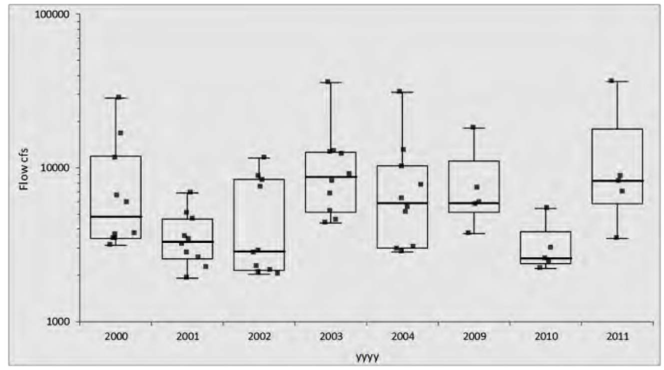
[1] Do not reject the null hypothesis at the 5% significance level.

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.

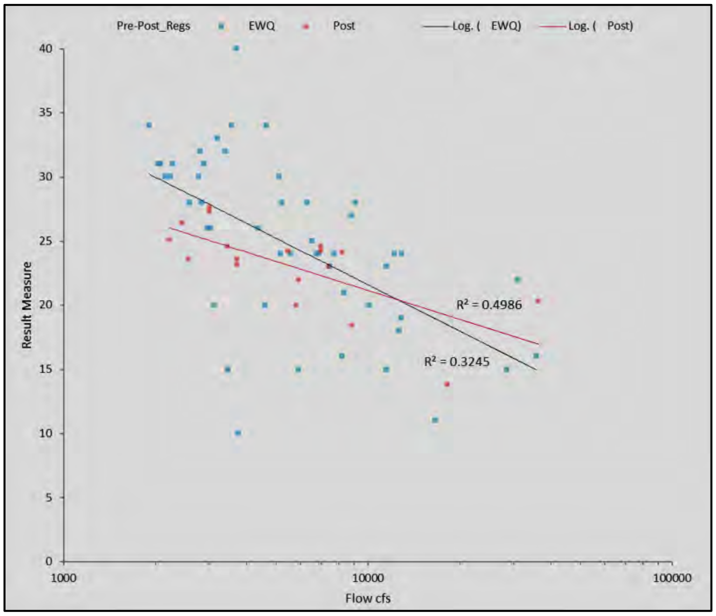
USGS and PADEP maintain a long-term water quality monitoring station at this site. They sample once per quarter every year, whereas DRBC samples twice per month from May through September for three to four year periods. DRBC uses the PADEP/USGS data to check its own results and to supplement the long-term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

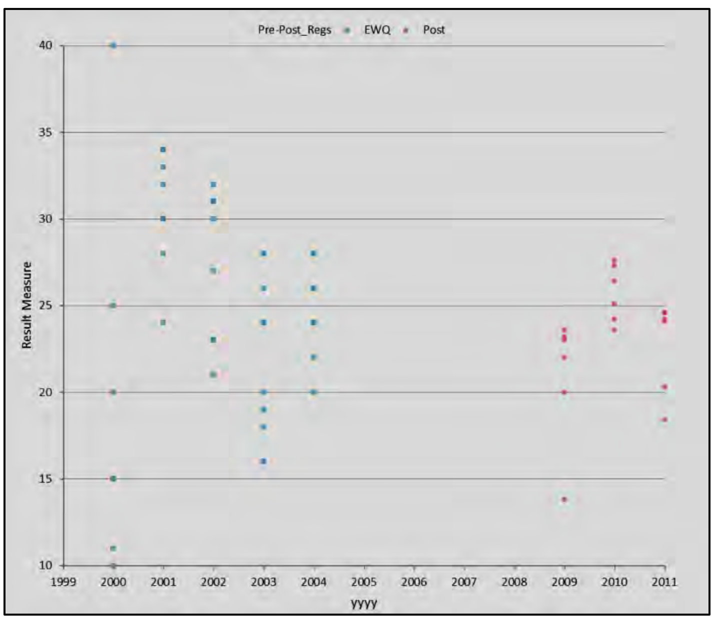
Chapter 22: 1978 ICP Delaware River at Belvidere

Alkalinity as CaCO3, Total mg/l

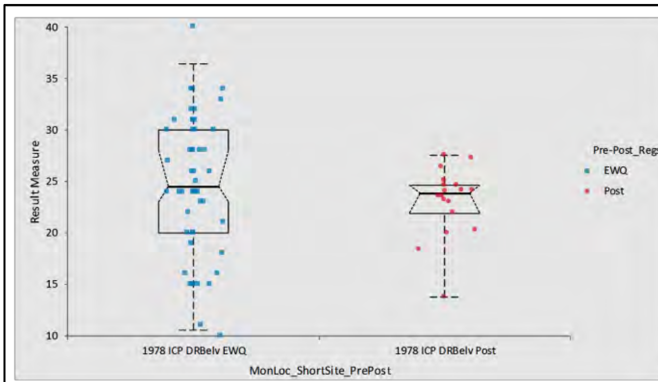
Existing Water Quality (Table 2E):

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

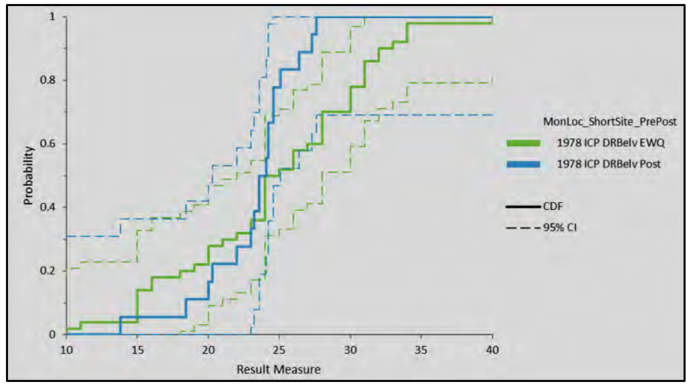




No water quality degradation is evident here. Alkalinity apparently did not measurably change between the EWQ and post-EWQ periods.



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.

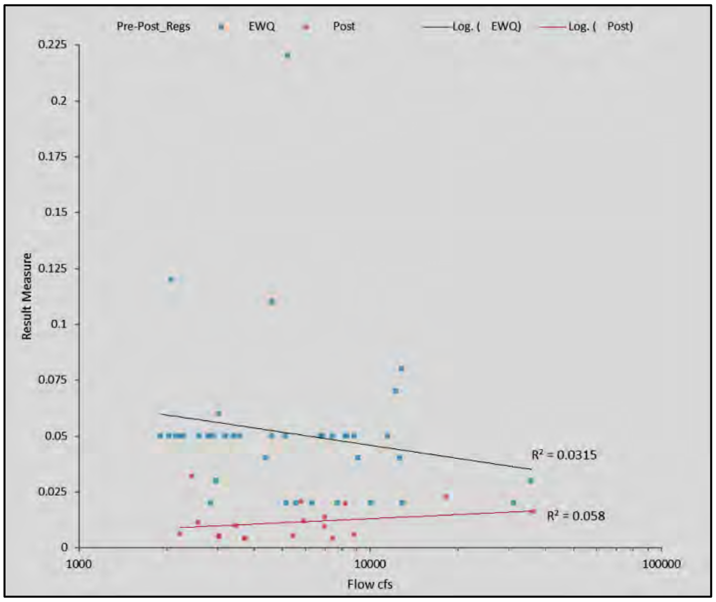
However, sources of analytical uncertainty included potential laboratory artifacts, insufficient post-EWQ sampling (n=18), and insufficient representation of flow conditions. Alkalinity is inversely related to flow in both data sets. Post-EWQ median alkalinity fell within EWQ 95% confidence intervals. 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.

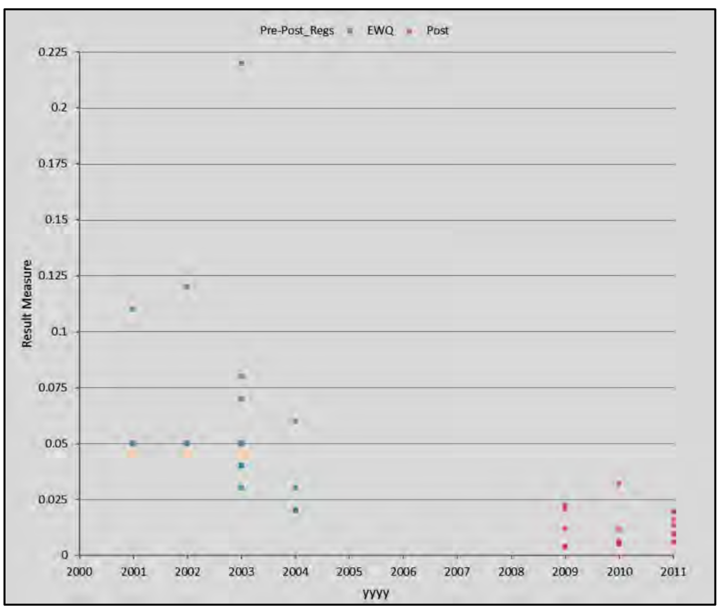
Chapter 22: 1978 ICP Delaware River at Belvidere

Ammonia Nitrogen as N, Total mg/l

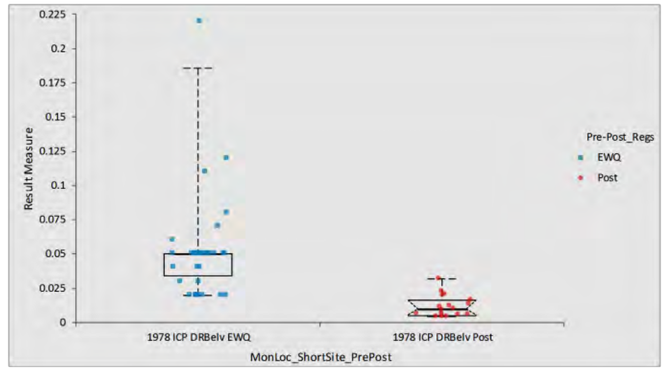
Existing Water Quality (Table 2E):

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



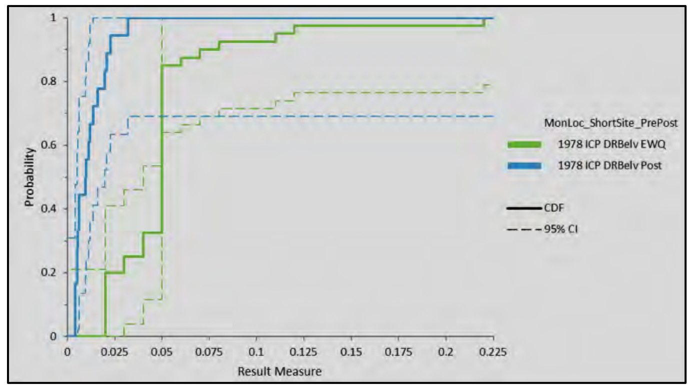


No water quality degradation is evident here. Ammonia concentrations apparently declined. However, sources of analytical uncertainty included potential laboratory artifacts, insufficient post-EWQ sampling (n=18), and insufficient representation of flow conditions.



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.

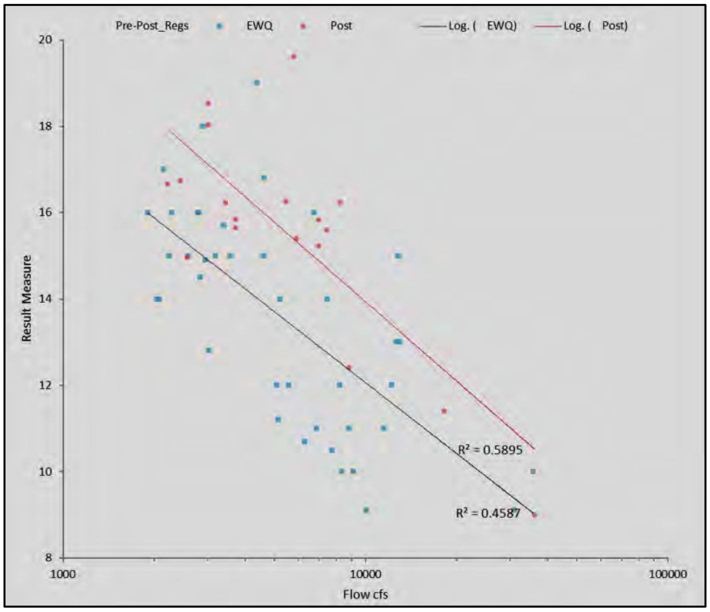
Post-EWQ median ammonia concentration was below the EWQ lower 95% confidence interval. PADEP/USGS data were comparable to DRBC results, with high non-detect frequency and similar concentrations. Flow is plotted on a logarithmic scale. EWQ data included high frequency of undetected results (33 of 40 samples), 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.

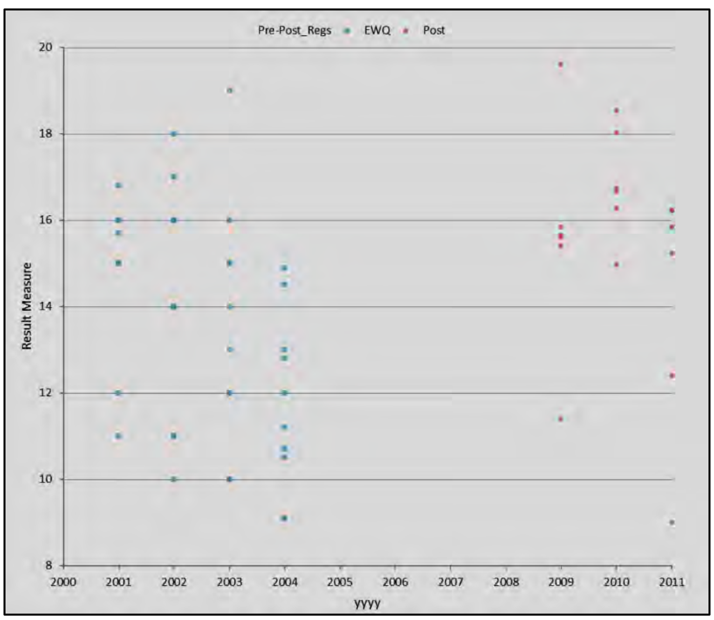
Chapter 22: 1978 ICP Delaware River at Belvidere

Chloride, Total mg/l

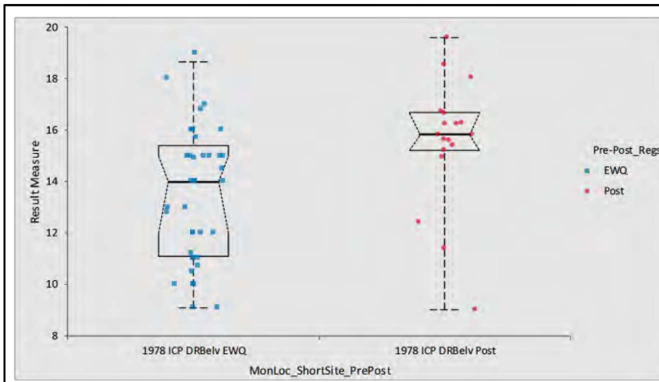
Existing Water Quality (Table 2E):

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



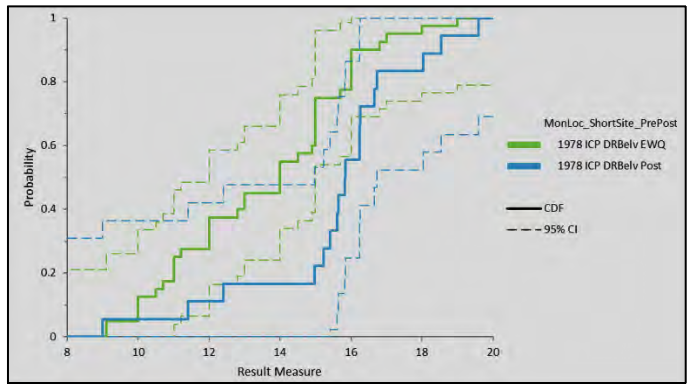


Water quality degradation is evident here. Median chloride concentrations apparently rose by 1.8 mg/l between the two periods.



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.

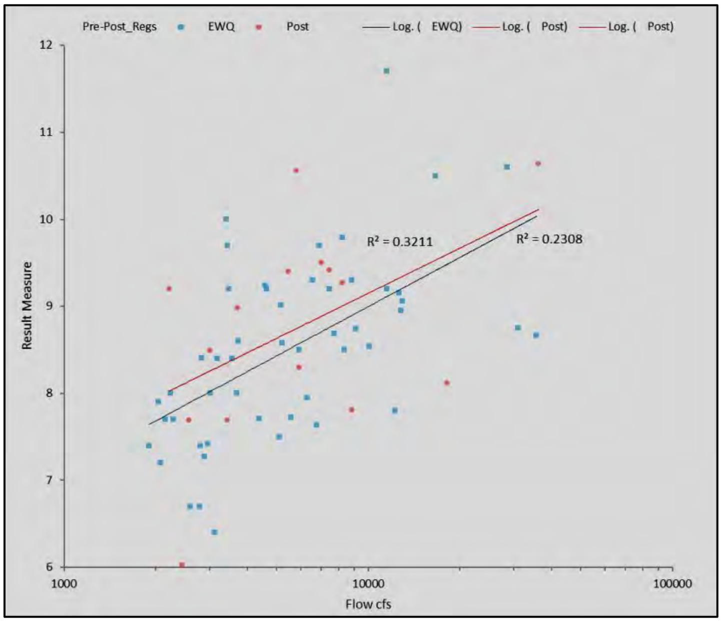
However, sources of analytical uncertainty included potential laboratory artifacts, insufficient post-EWQ sampling (n=18), and insufficient representation of flow conditions. Post-EWQ median concentration rose to just above the EWQ upper 95% confidence interval. There is an obvious separation of about 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.

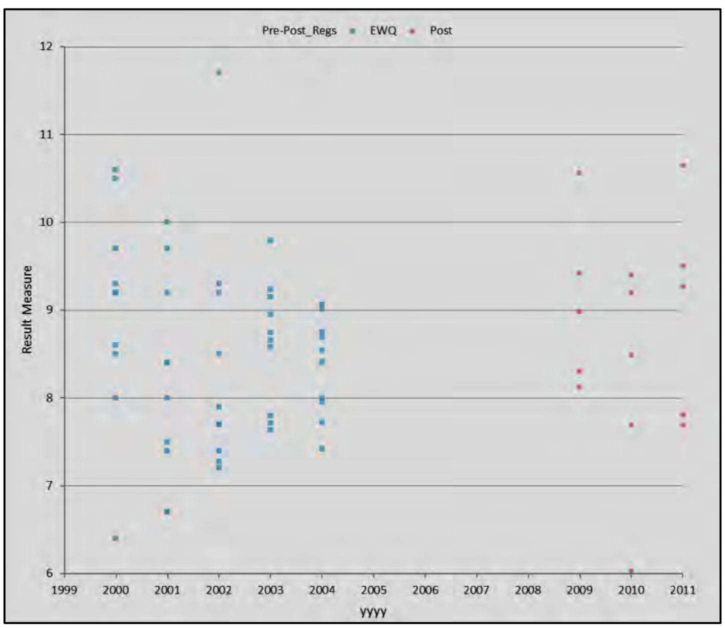
Chapter 22: 1978 ICP Delaware River at Belvidere

Dissolved Oxygen (DO) mg/l

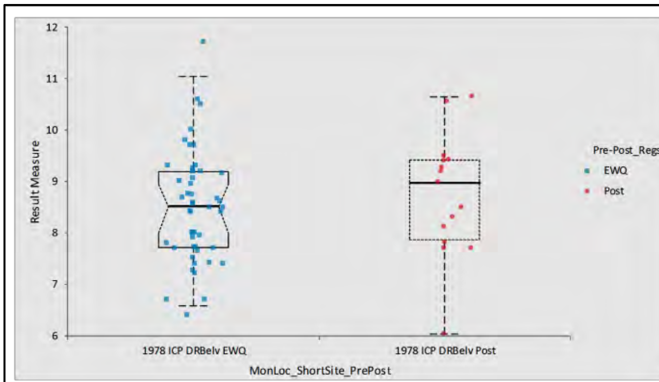
Existing Water Quality (Table 2E):

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



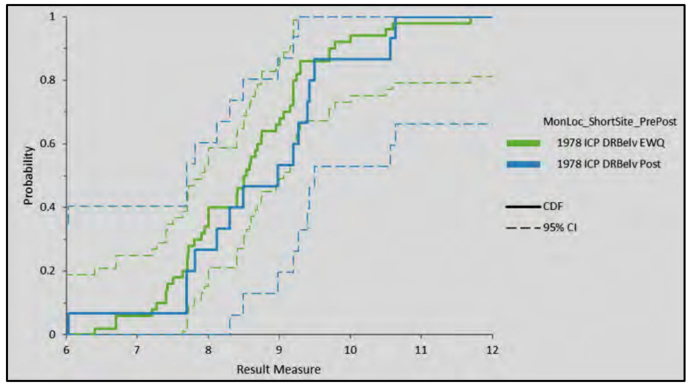


No water quality degradation is evident here. No measurable change took place between the EWQ and Post-EWQ periods.



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
X² approximation	0.90
DF	1
p-value	0.3421 [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.

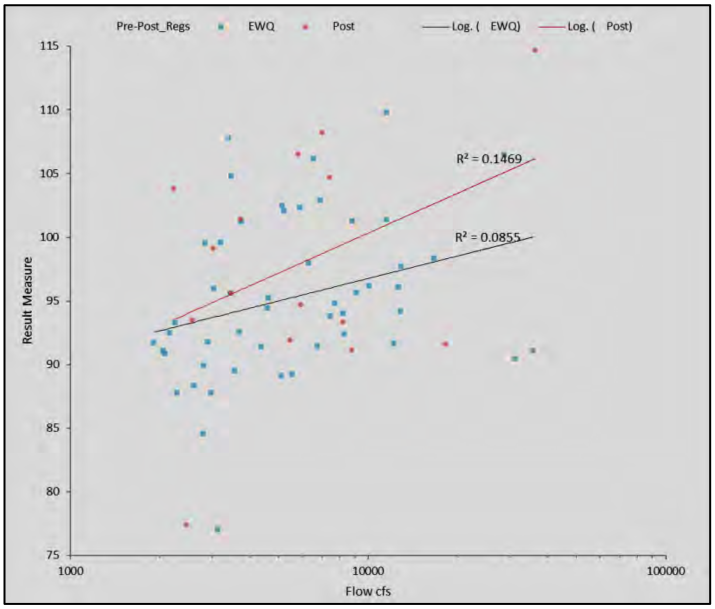
However, analytical uncertainty included insufficient post-EWQ sampling (n=18). Post-EWQ median DO was above the upper EWQ 95% confidence interval, but the increase was not significant and implies water quality improvement. DO is weakly related to flow in both data sets. The site is located on a large 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.

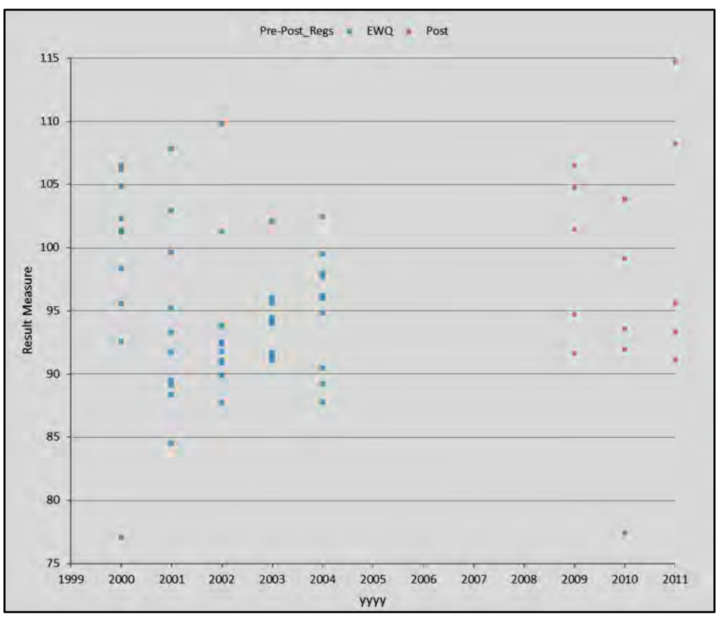
Chapter 22: 1978 ICP Delaware River at Belvidere

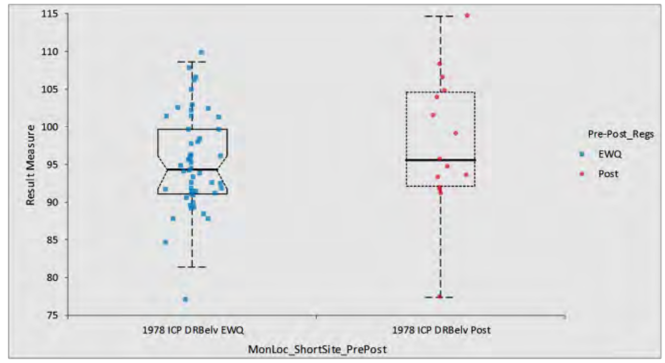
Dissolved Oxygen Saturation %

Existing Water Quality (Table 2E):

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

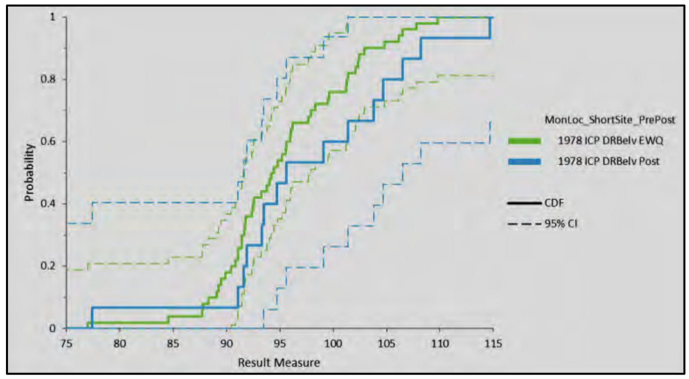






N 65

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.

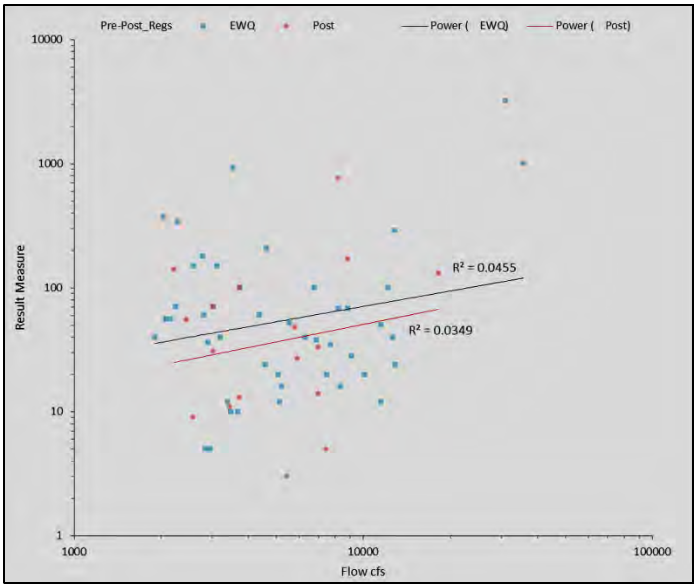
No water quality degradation is evident here. Dissolved Oxygen Saturation is unrelated to flow, and did not measurably change between the EWQ and post-EWQ periods. However, analytical uncertainty included insufficient post-EWQ sampling (n=18). Post-EWQ median DO saturation fell within the EWQ 95% confidence 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.

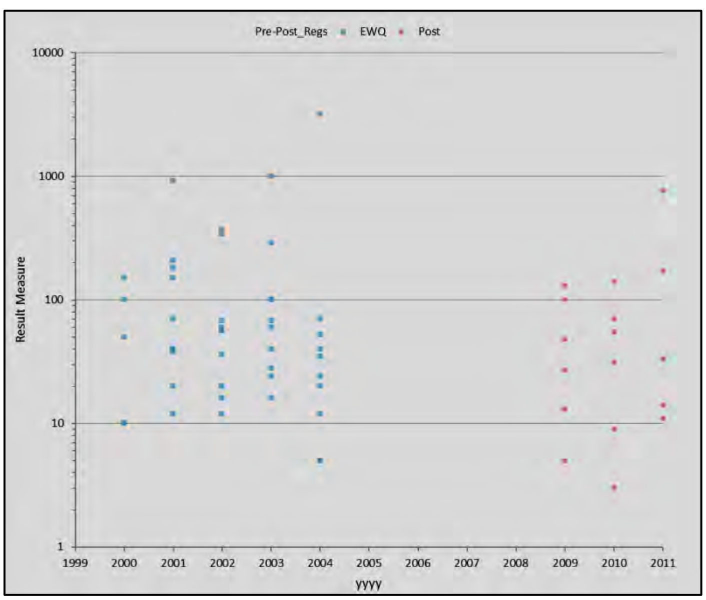
Chapter 22: 1978 ICP Delaware River at Belvidere

Enterococcus colonies/100 ml

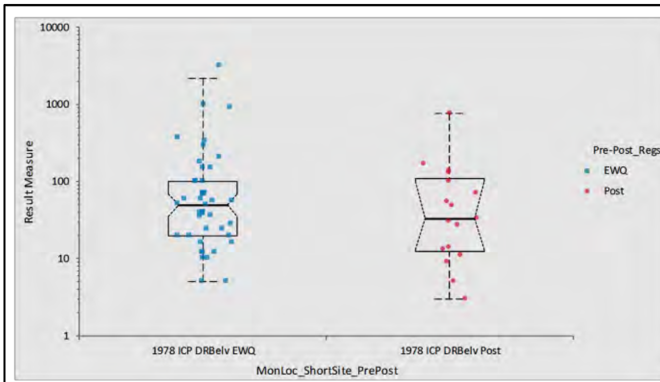
Existing Water Quality (Table 2E):

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



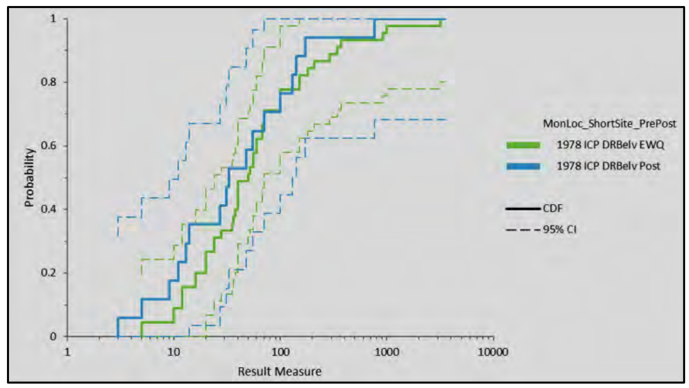


No water quality degradation is evident here. Enterococci apparently declined between the EWQ and Post-EWQ periods, but not significantly.



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.

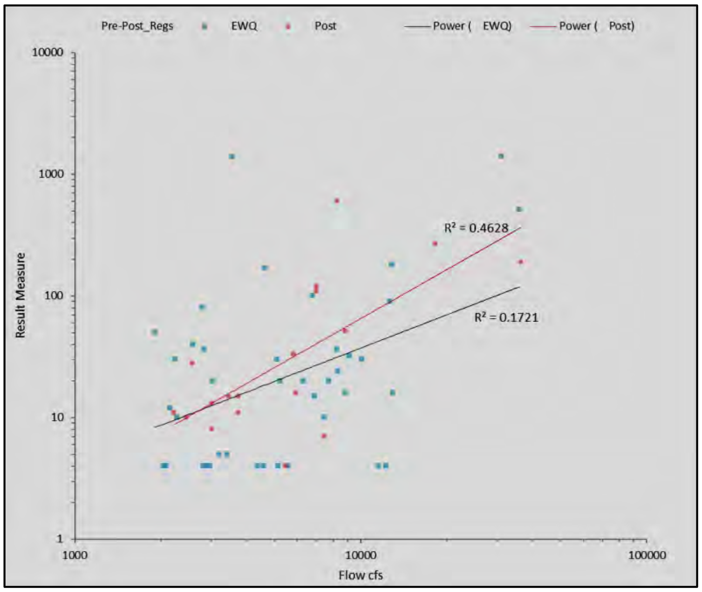
However, sources of analytical uncertainty included potential laboratory artifacts, insufficient post-EWQ sampling (n=18), and insufficient representation of flow conditions. Biweekly instead of monthly sampling is recommended. Enterococcus concentrations are unrelated to flow in both data sets. Concentrations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

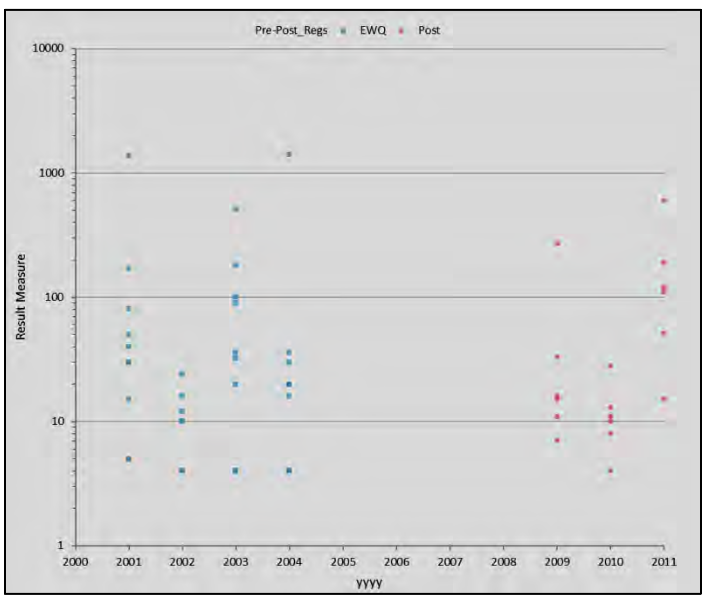
Chapter 22: 1978 ICP Delaware River at Belvidere

Escherichia coli colonies/100 ml

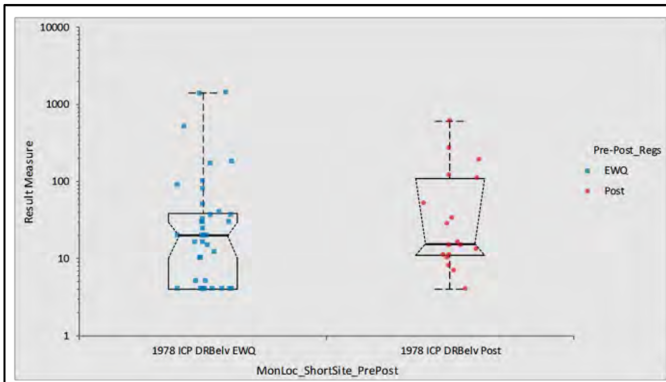
Existing Water Quality (Table 2E):

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



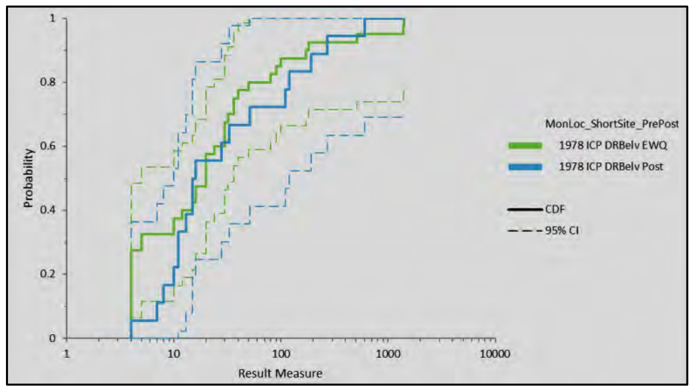


No water quality degradation is evident here. E. coli concentrations apparently did not measurably change between the EWQ and Post-EWQ periods.



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.

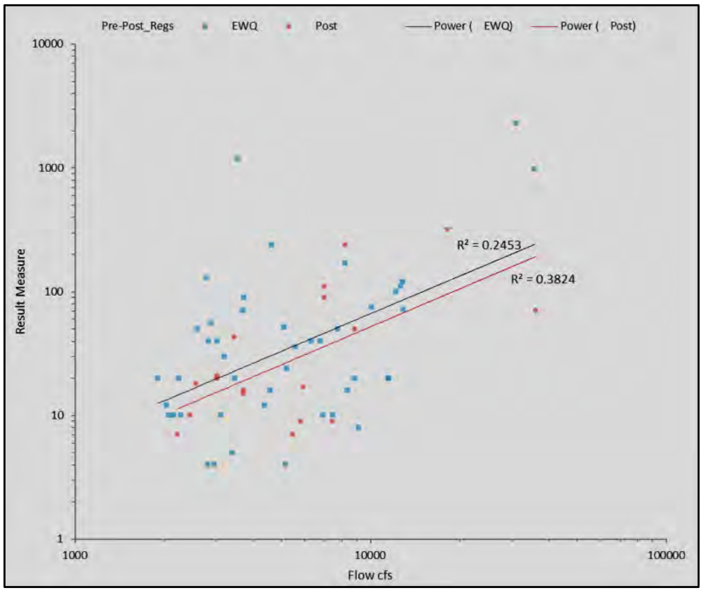
However, sources of analytical uncertainty included potential laboratory artifacts, insufficient post-EWQ sampling (n=18), and insufficient representation of flow conditions. Post-EWQ median E. coli fell within the EWQ 95% confidence intervals. Concentrations and flows are plotted on logarithmic scale, 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.

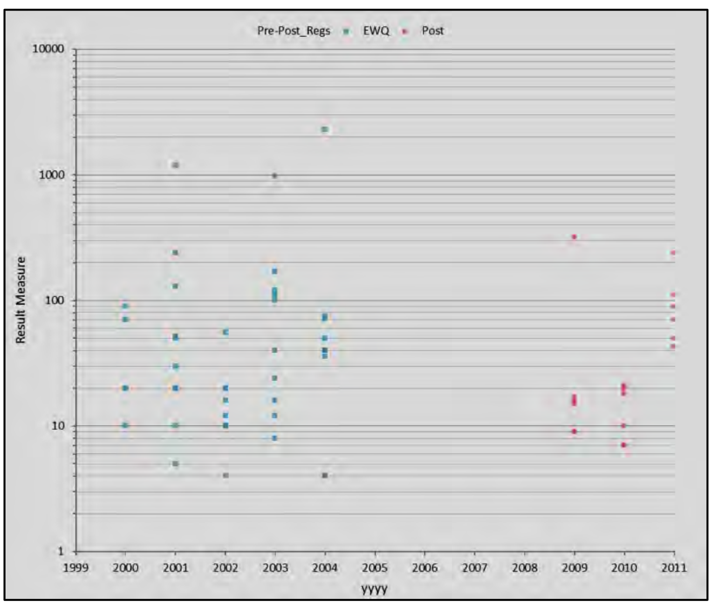
Chapter 22: 1978 ICP Delaware River at Belvidere

Fecal coliform colonies/100 ml

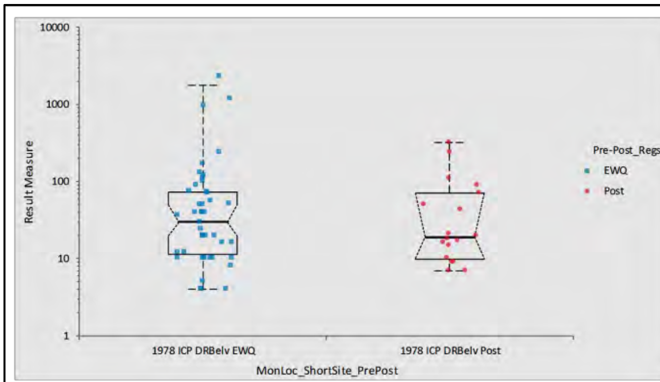
Existing Water Quality (Table 2E):

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



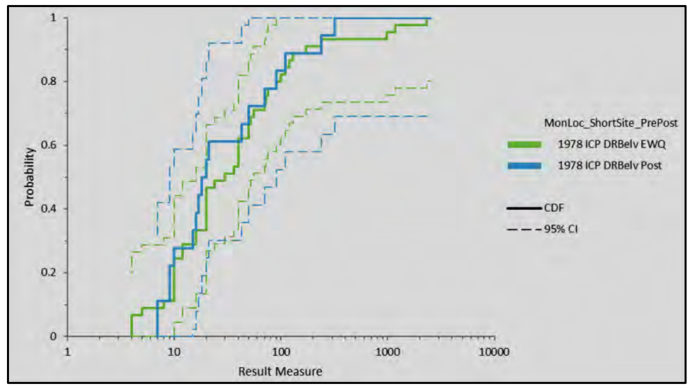


No water quality degradation is evident here. Fecal coliform concentrations fell below the lower EWQ 95% confidence interval, but apparently did not measurably change between the EWQ and post-EWQ periods.



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
X^2 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.

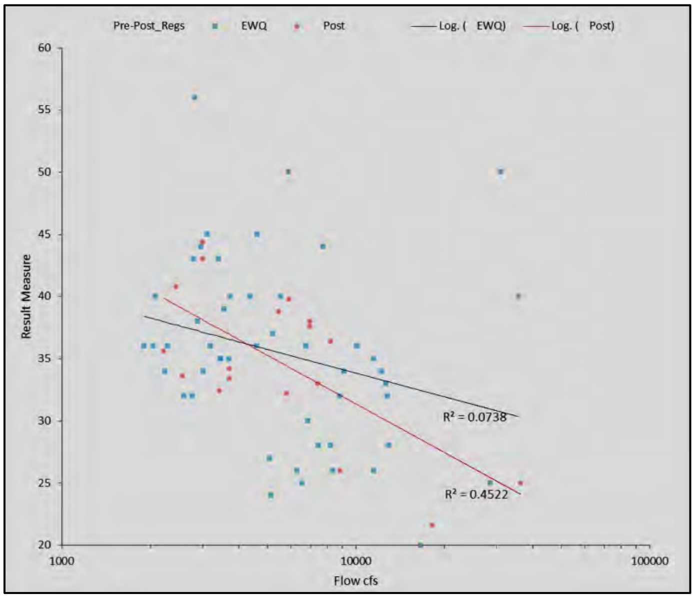
However, sources of analytical uncertainty included potential laboratory artifacts, insufficient post-EWQ sampling (n=18), and insufficient representation of flow conditions. Fecal coliform concentrations are weakly related to flow in both data sets. Biweekly instead of monthly sampling is recommended.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

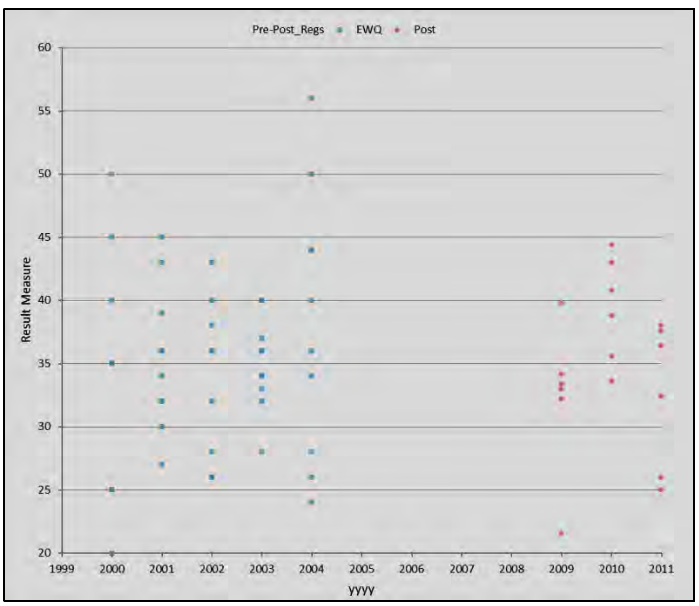
Chapter 22: 1978 ICP Delaware River at Belvidere

Hardness as CaCO3, Total mg/l

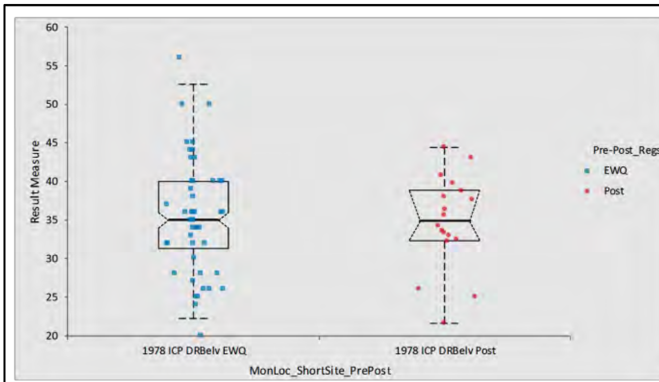
Existing Water Quality (Table 2E):

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



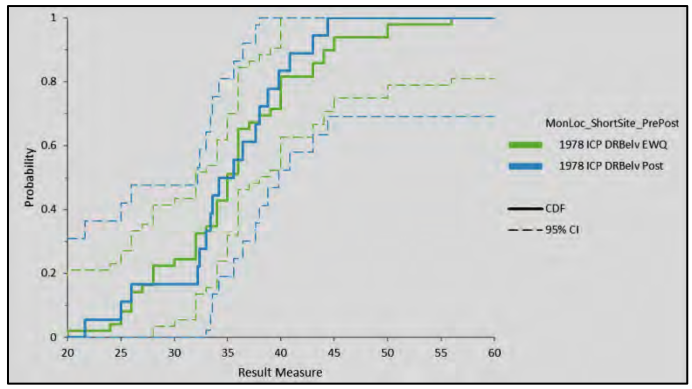


No water quality degradation is evident here. Hardness apparently did not measurably change between the EWQ and post-EWQ periods.



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: $\theta_1 = \theta_2 = \theta_{...}$
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.

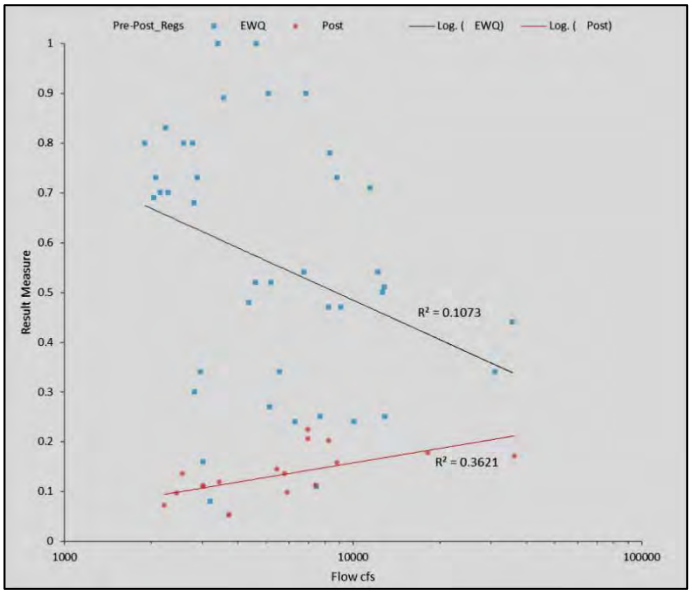
However, sources of analytical uncertainty included potential laboratory artifacts, insufficient post-EWQ sampling (n=18), and insufficient representation of flow conditions. Hardness is unrelated to flow in the EWQ data set, but inversely related to flow in the post-EWQ data set. The strength of the 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.

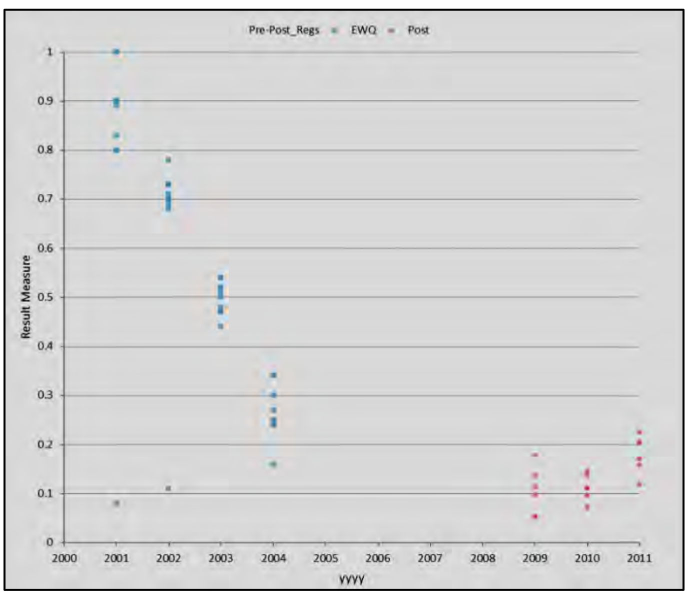
Chapter 22: 1978 ICP Delaware River at Belvidere

Nitrate + Nitrite as N, Total mg/l

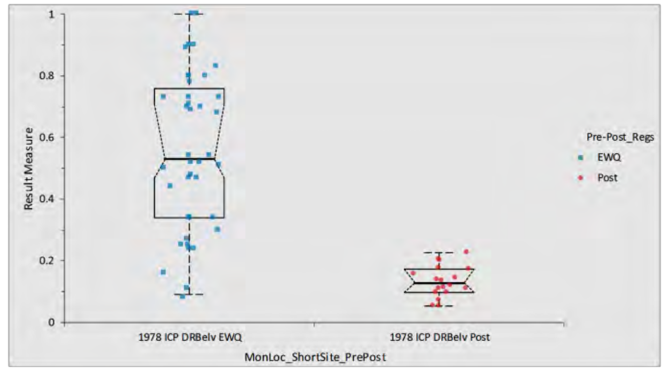
Existing Water Quality (Table 2E, as Nitrate only):

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



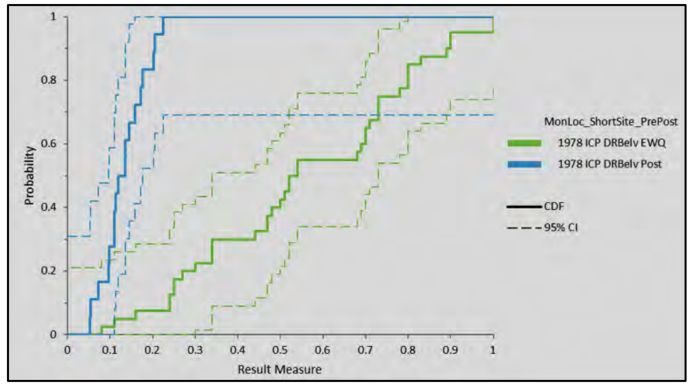


No water quality degradation is evident here. Nitrate concentrations apparently declined between the two periods. Sources of analytical uncertainty included potential laboratory artifacts, insufficient post-EWQ sampling (n=18), and under-representation of flow conditions.



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.

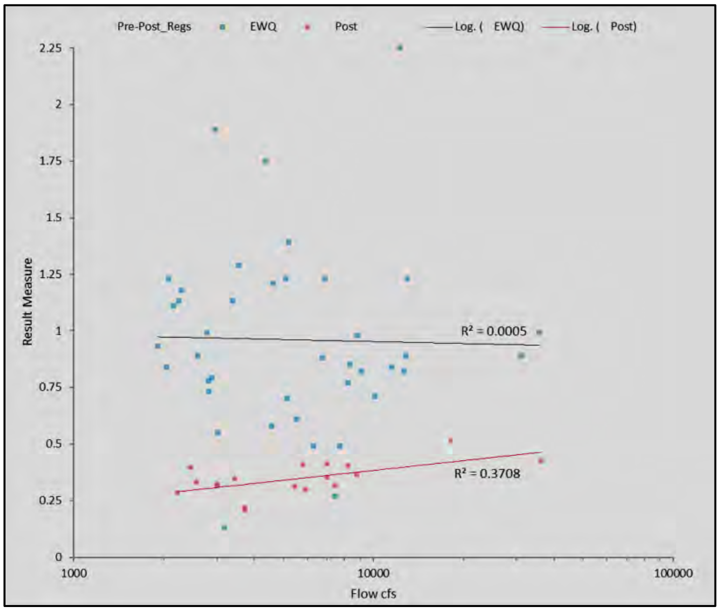
Nitrate is unrelated to flow in EWQ data, but weakly related to flow in post-EWQ data. Post-EWQ nitrate concentrations fell below the lower EWQ 95% confidence interval, and were less variable than EWQ nitrate. Post-EWQ nitrate + nitrite concentrations were assumed equivalent with EWQ nitrate concentrations 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.

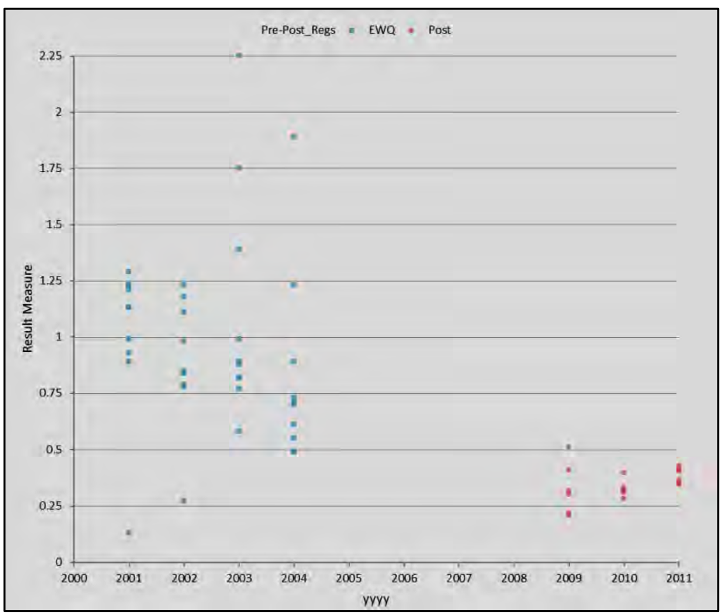
Chapter 22: 1978 ICP Delaware River at Belvidere

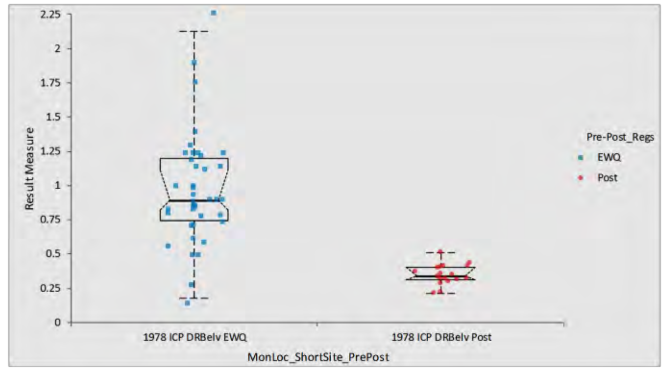
Nitrogen as N, Total (TN) mg/l

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

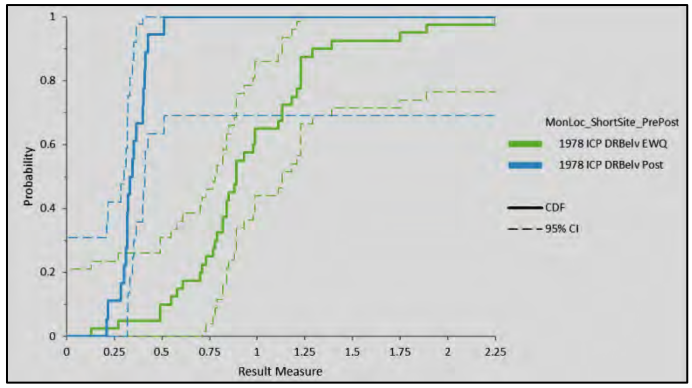






N	58

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.

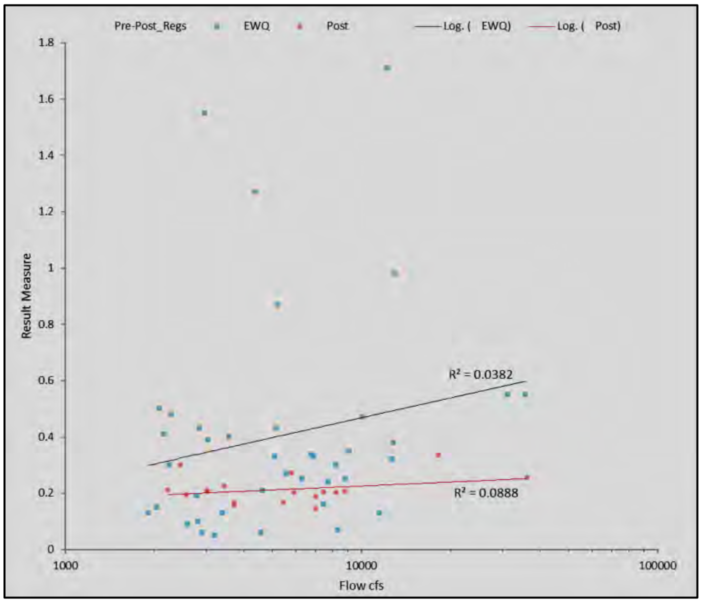
No water quality degradation is evident here. TN apparently declined between the two periods. Sources of analytical uncertainty included potential laboratory artifacts, insufficient post-EWQ sampling (n=18), and under-representation of flow conditions. TN is unrelated to flow in EWQ data but weakly related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

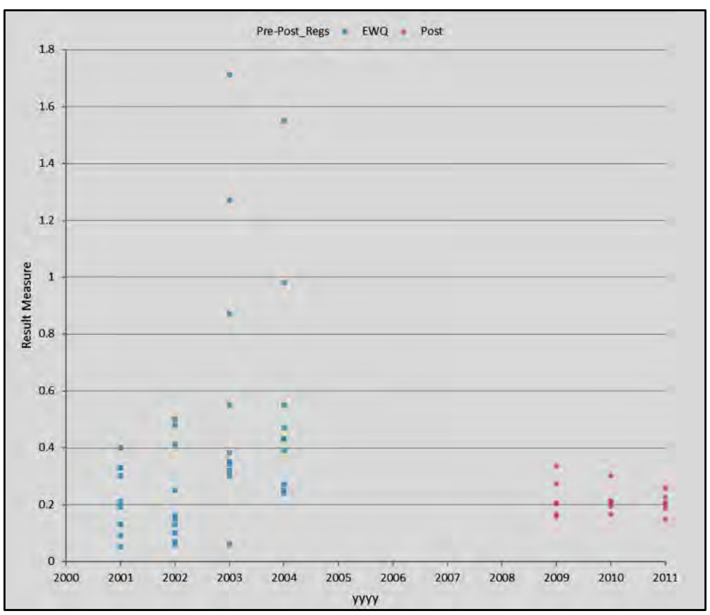
Chapter 22: 1978 ICP Delaware River at Belvidere

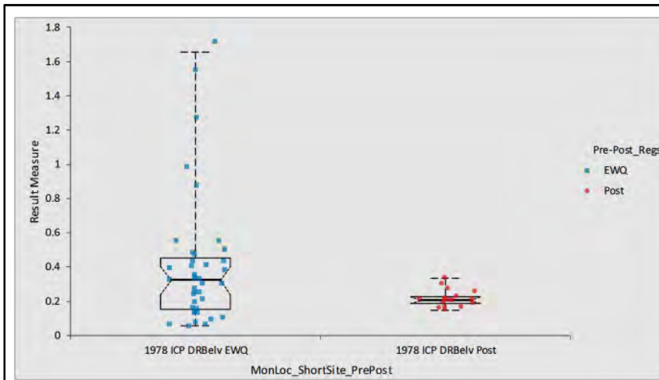
Nitrogen, Kjeldahl as N, Total (TKN) mg/l

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

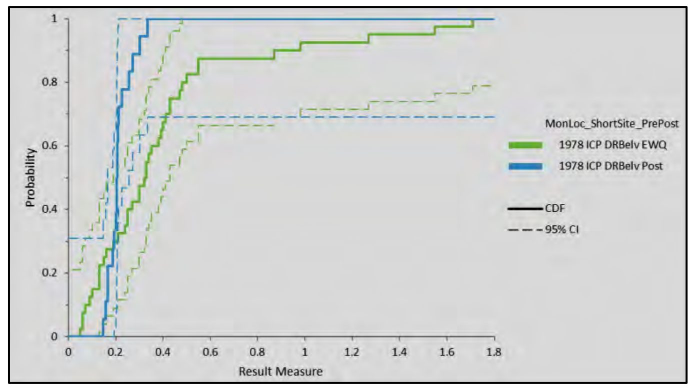






N | 58

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.

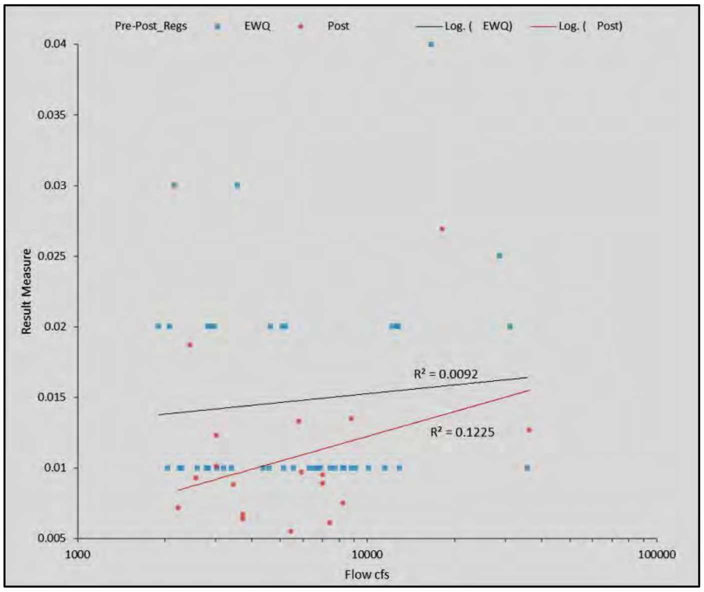
No water quality degradation is evident here. TKN apparently declined between the two periods. Sources of analytical uncertainty included potential laboratory artifacts, insufficient post-EWQ sampling (n=18), and under-representation of flow conditions. The post-EWQ range was far narrower and all concentrations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

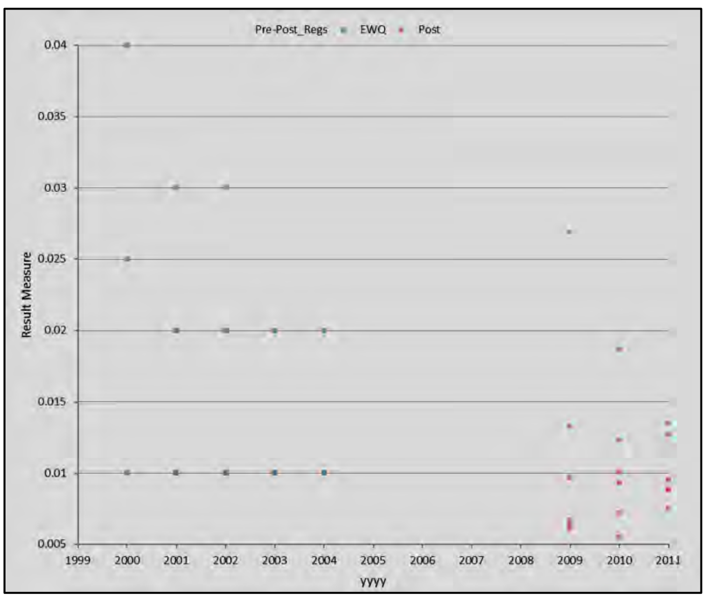
Chapter 22: 1978 ICP Delaware River at Belvidere

Orthophosphate as P, Total mg/l (OP)

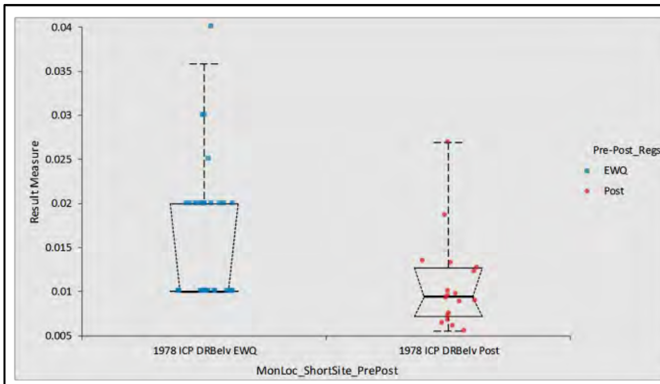
Existing Water Quality (Table 2E):

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



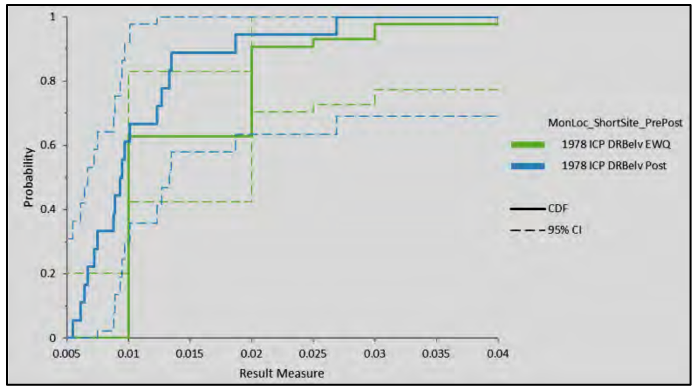


No water quality degradation is evident here. OP apparently declined between the two periods. Sources of analytical uncertainty included potential laboratory artifacts, detection limit differences, insufficient post-EWQ sampling (n=18), and under-representation of flow conditions.



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.

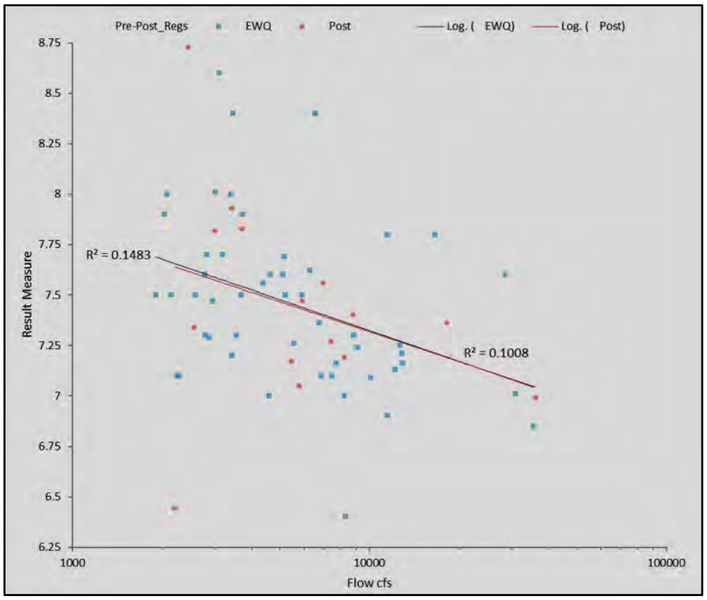
OP is unrelated to flow in both data sets. Post-EWQ median orthophosphate fell below the EWQ lower 95% confidence interval, and the upper quartile of data decreased significantly. This may be due to laboratory artifacts, but perhaps indicates a water quality improvement in that there were no post-EWQ 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.

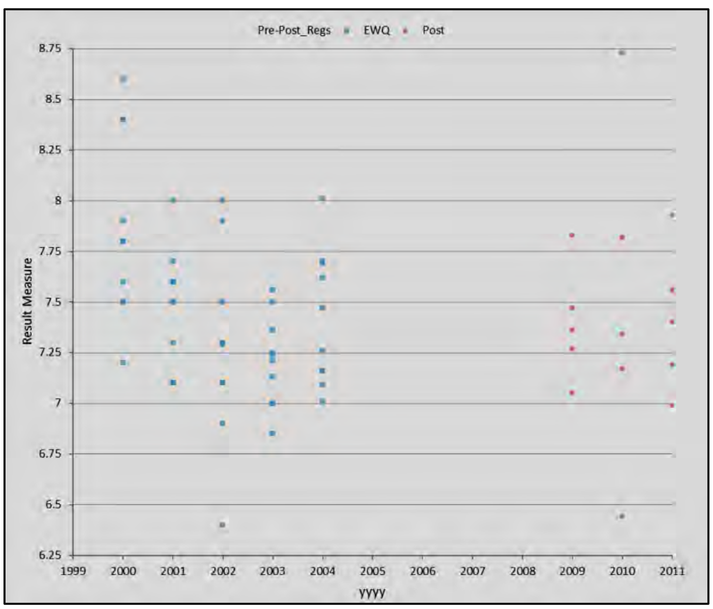
Chapter 22: 1978 ICP Delaware River at Belvidere

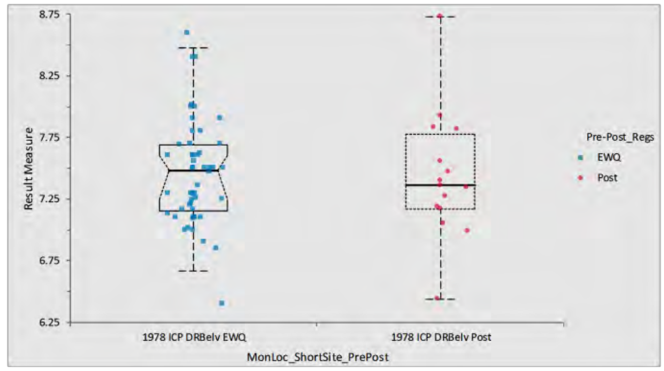
pH

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

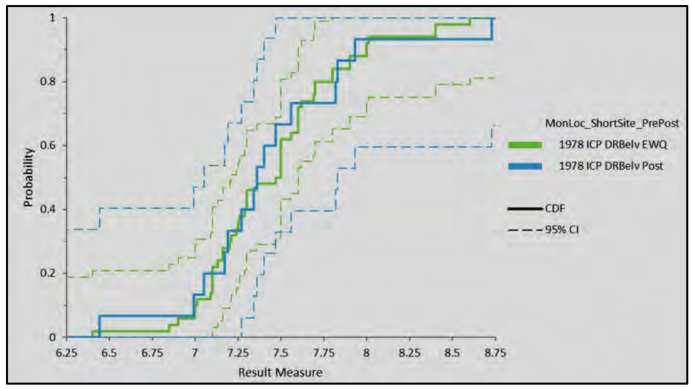






N 65

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
X^2 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.

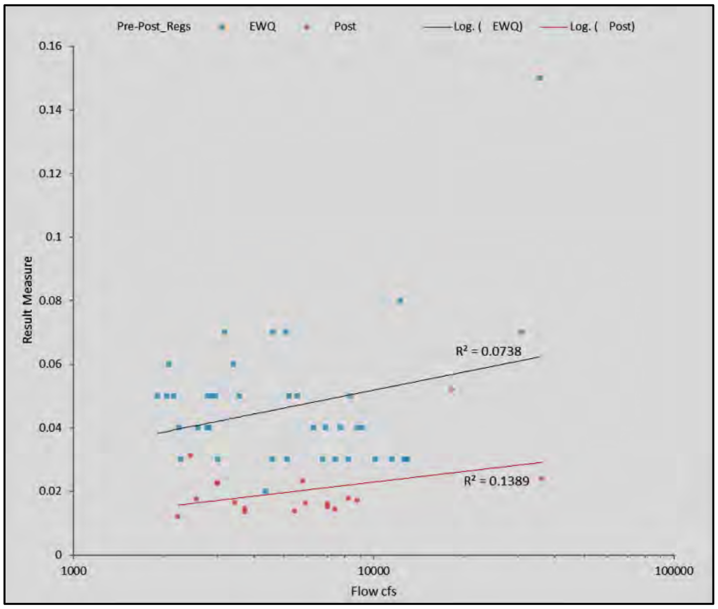
No water quality degradation is evident here. pH apparently did not measurably change between the EWQ and post-EWQ periods. Analytical uncertainty included insufficient post-EWQ sampling (n=18). pH is unrelated to flow in both data sets, but tends toward neutral as flow increases. Post-EWQ median pH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

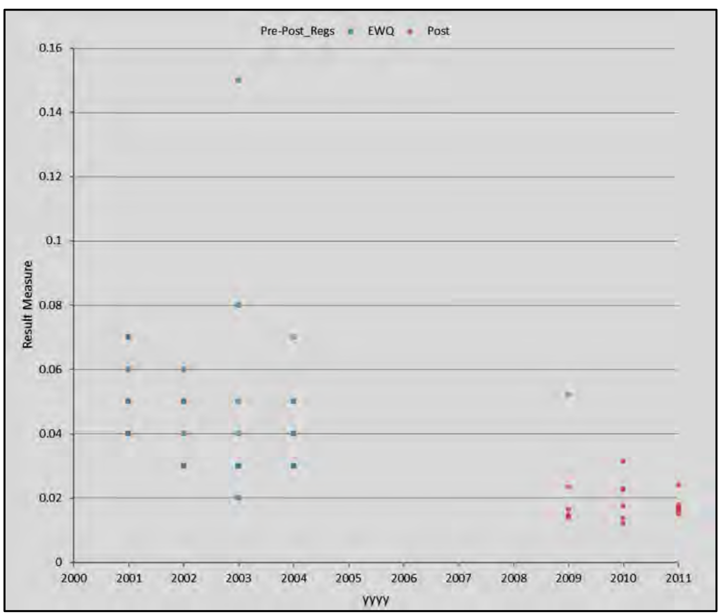
Chapter 22: 1978 ICP Delaware River at Belvidere

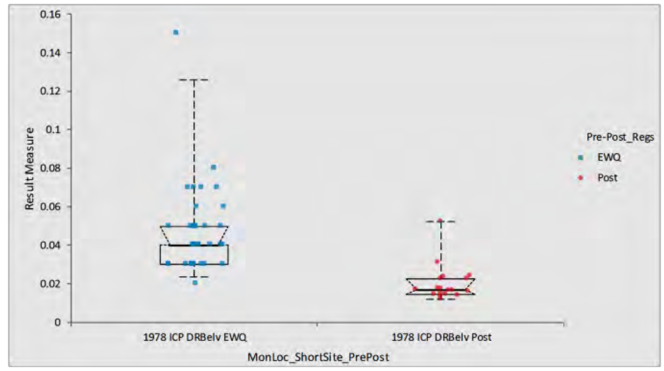
Phosphorus as P, Total (TP) mg/l

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

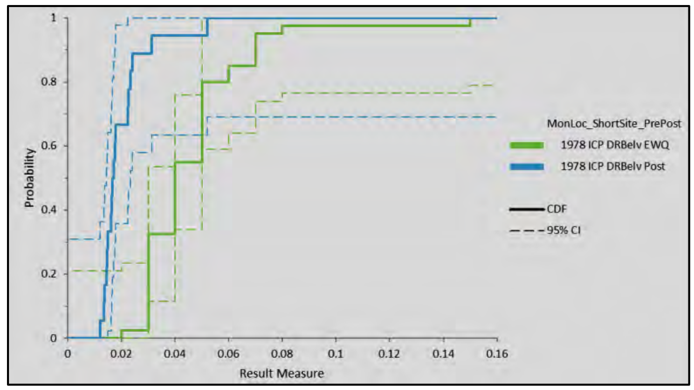






N | 58

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
X^2 approximation	27.82
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.

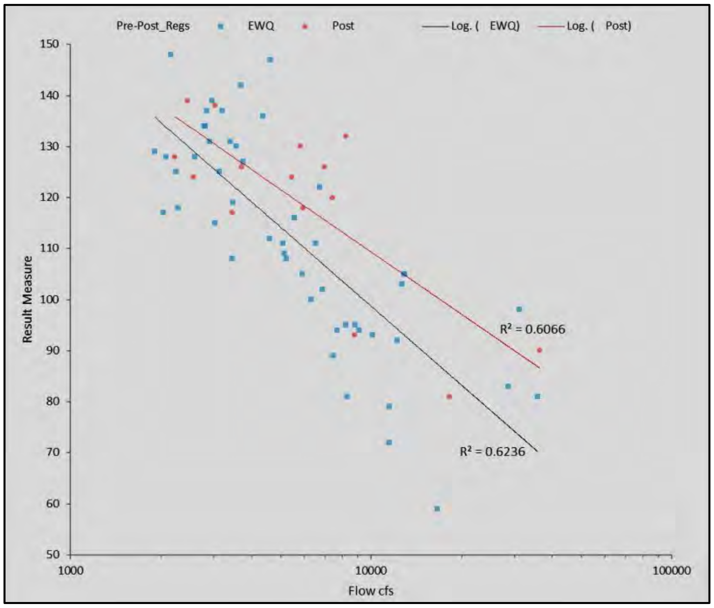
No water quality degradation is evident here. TP apparently declined between the two periods. Sources of analytical uncertainty included potential laboratory artifacts, detection limit differences, insufficient post-EWQ sampling (n=18), and under-representation of flow conditions. Post-EWQ median total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

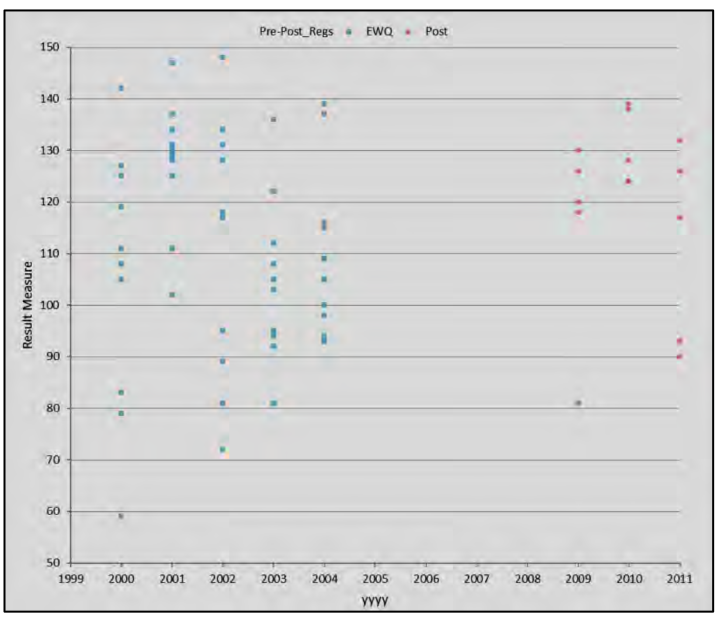
Chapter 22: 1978 ICP Delaware River at Belvidere

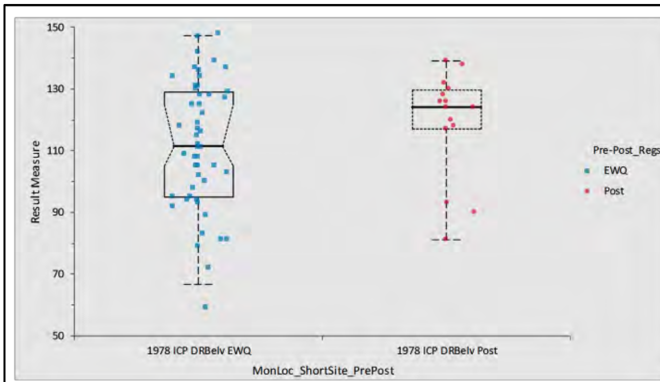
Specific Conductance µmho/cm

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

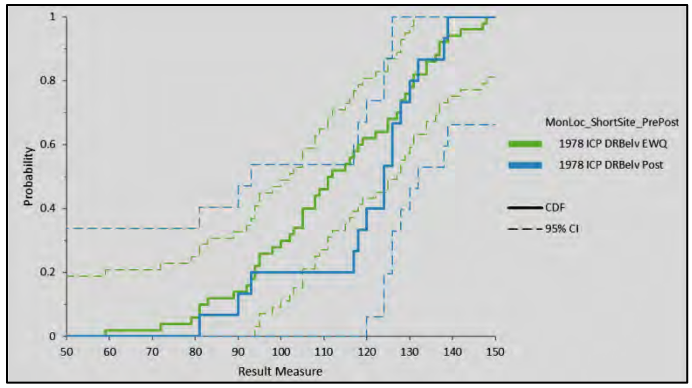






N | 65

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.

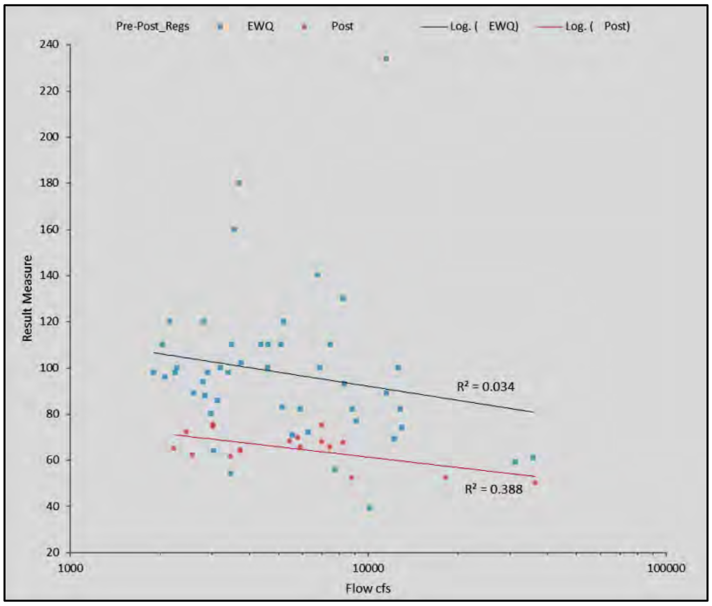
There is slight evidence here of water quality degradation. Specific conductance increased (by about 12 µmho/cm) between the two periods. Analytical uncertainty included insufficient post-EWQ sampling (n=18), and under-representation of flow conditions. Post-EWQ median specific conductance increased 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.

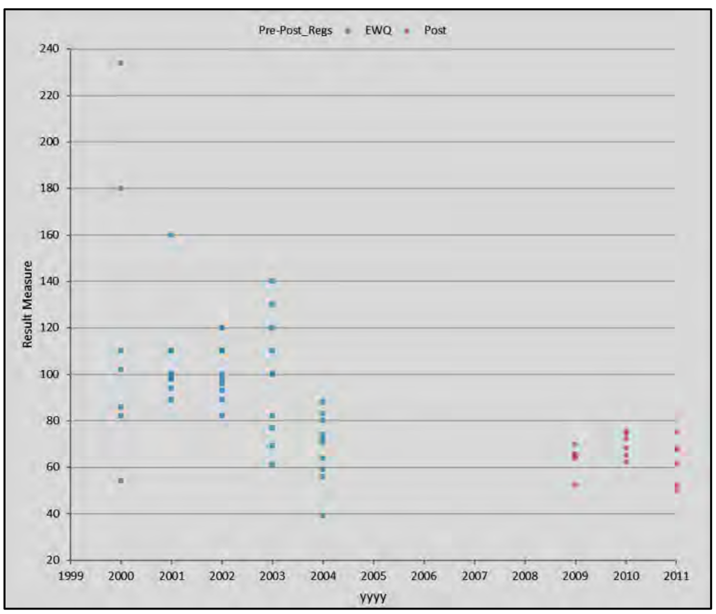
Chapter 22: 1978 ICP Delaware River at Belvidere

Total Dissolved Solids (TDS) mg/l

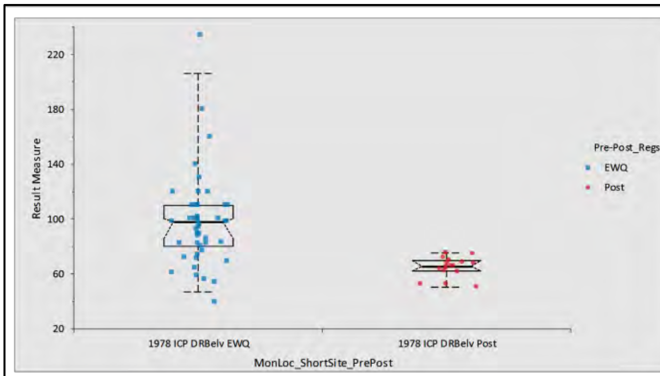
Existing Water Quality (Table 2E):

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



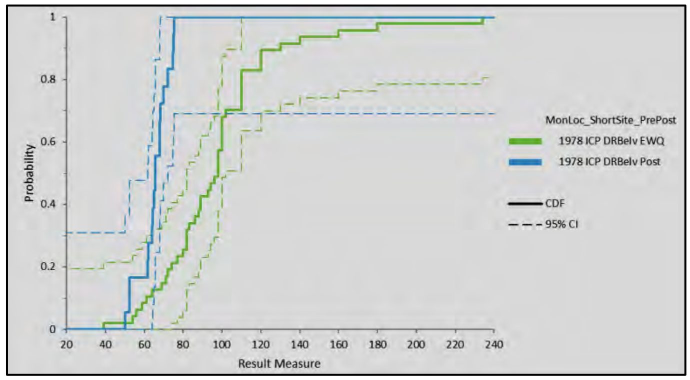


No water quality degradation is evident here. TDS apparently declined between the two periods. Sources of analytical uncertainty included potential laboratory artifacts, insufficient post-EWQ sampling (n=18), and under-representation of flow conditions.



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: $\theta_1 = \theta_2 = \theta_{...}$
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.

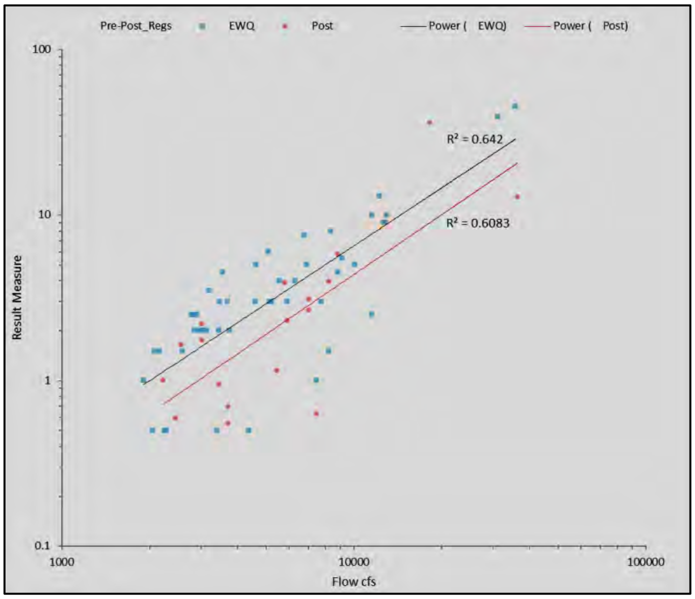
TDS is unrelated to flow in EWQ data but weakly and inversely related in post-EWQ data. Post-EWQ median TDS fell below the EWQ lower 95% lower confidence interval, and was less variable than the baseline samples. Detection limits were different though there were no undetected results at any time. Perhaps 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.

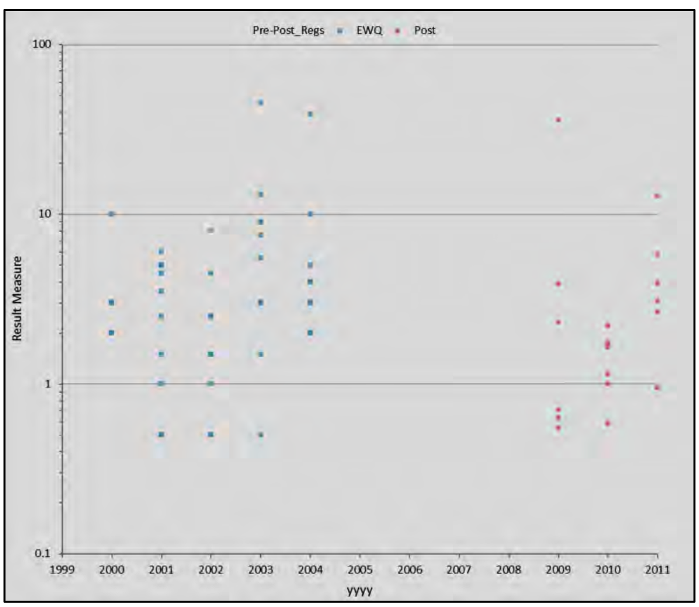
Chapter 22: 1978 ICP Delaware River at Belvidere

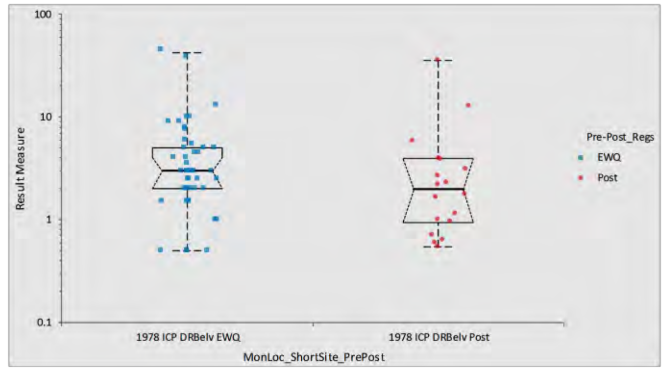
Total Suspended Solids (TSS) mg/l

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

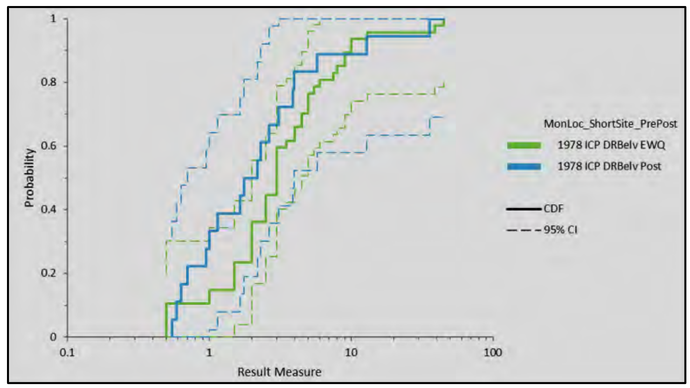






N 65

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
X² approximation	2.03
DF	1
p-value	0.1544 [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.

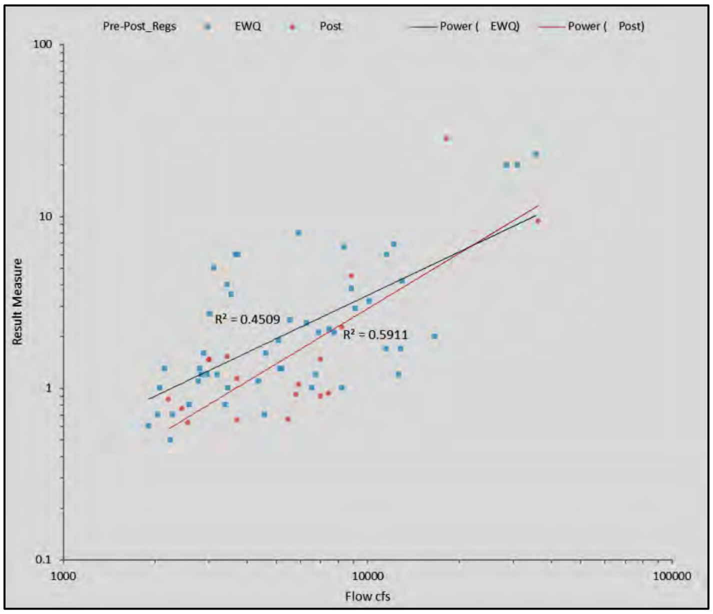
No water quality degradation is evident here. TSS apparently did not measurably change between the EWQ and post-EWQ periods. Sources of analytical uncertainty included potential laboratory artifacts and insufficient post-EWQ sampling (n=18). TSS is positively related to flow in both data sets. Post-EWQ 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.

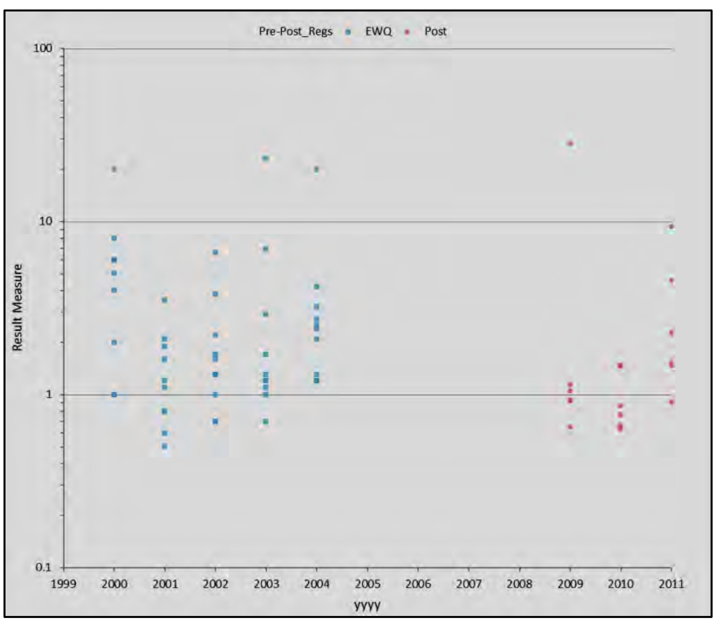
Chapter 22: 1978 ICP Delaware River at Belvidere

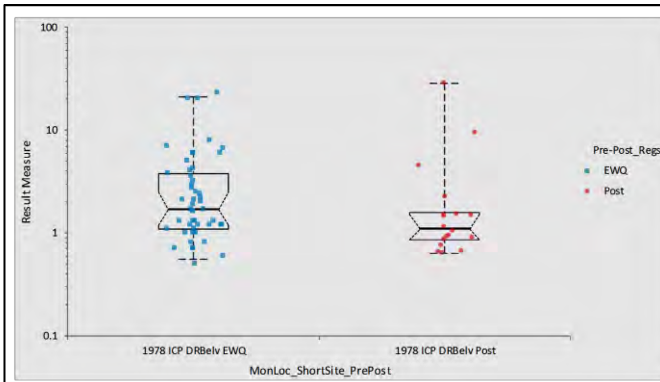
Turbidity NTU

Existing Water Quality (Table 2E):

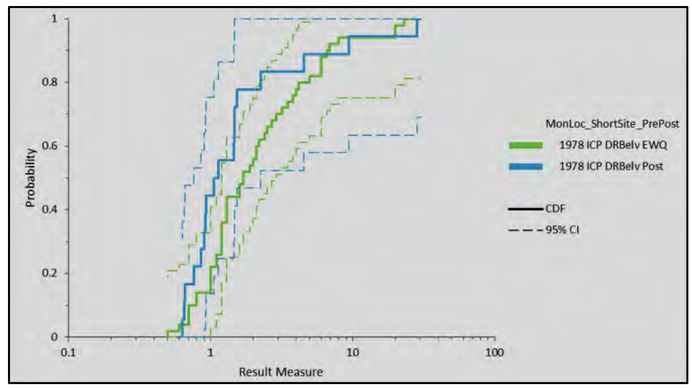
Median 1.7 NTU
Lower 95% Confidence Interval 1.2 NTU
Upper 95% Confidence Interval 2.5 NTU
Defined in regulations as a flow-related parameter







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
X^2 approximation	3.32
DF	1
p-value	0.0685 [1]

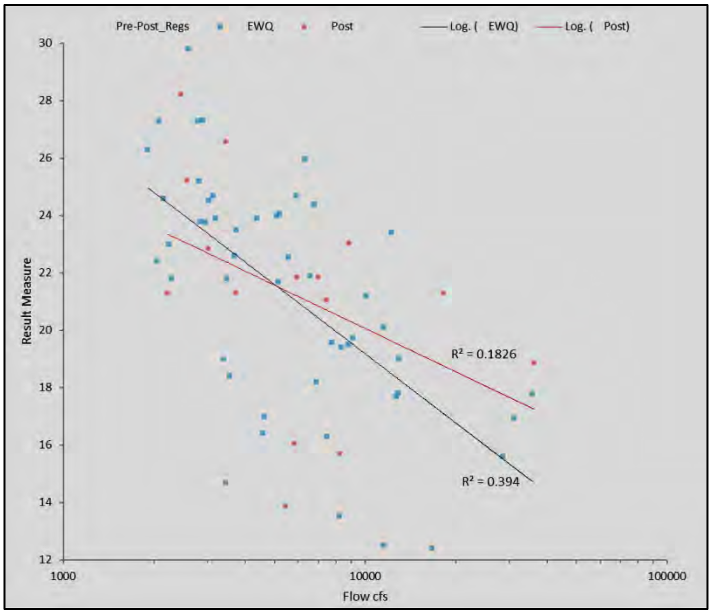
H0: $\theta_1 = \theta_2 = \theta ...$
The median of the populations are all equal.
H1: $\theta_i \neq \theta_j$ for at least one i,j
The median of the populations are not all equal.
[1] Do not reject the null hypothesis at the 5% significance level.

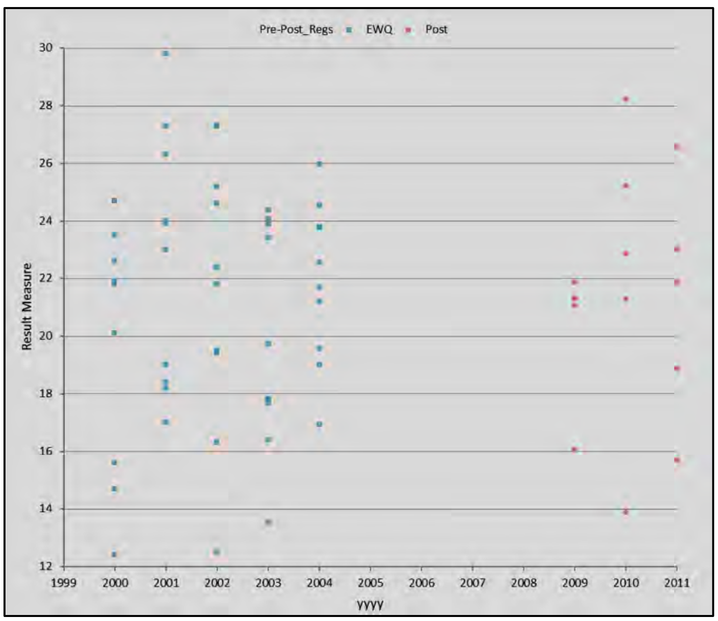
No water quality degradation is evident here. Turbidity apparently declined between the EWQ and post-EWQ periods, but not significantly due to an insufficient number of post-EWQ samples (n=18). The post-EWQ median turbidity fell below the lower EWQ 95% confidence interval. Turbidity is positively related 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.

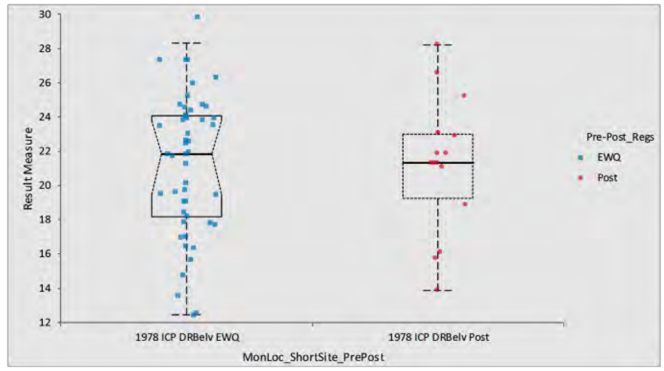
Chapter 22: 1978 ICP Delaware River at Belvidere

Water Temperature, degrees C

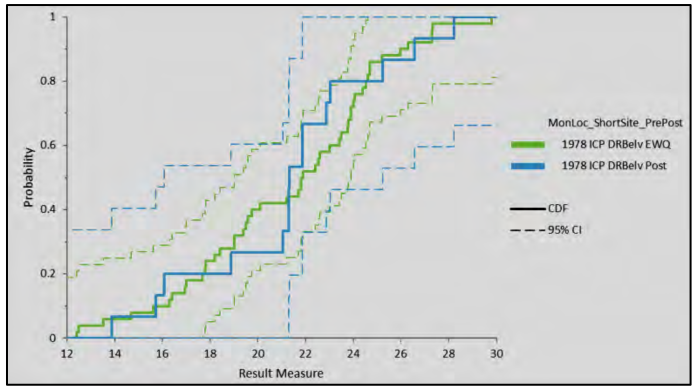
Not included in DRBC Existing Water Quality rules







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

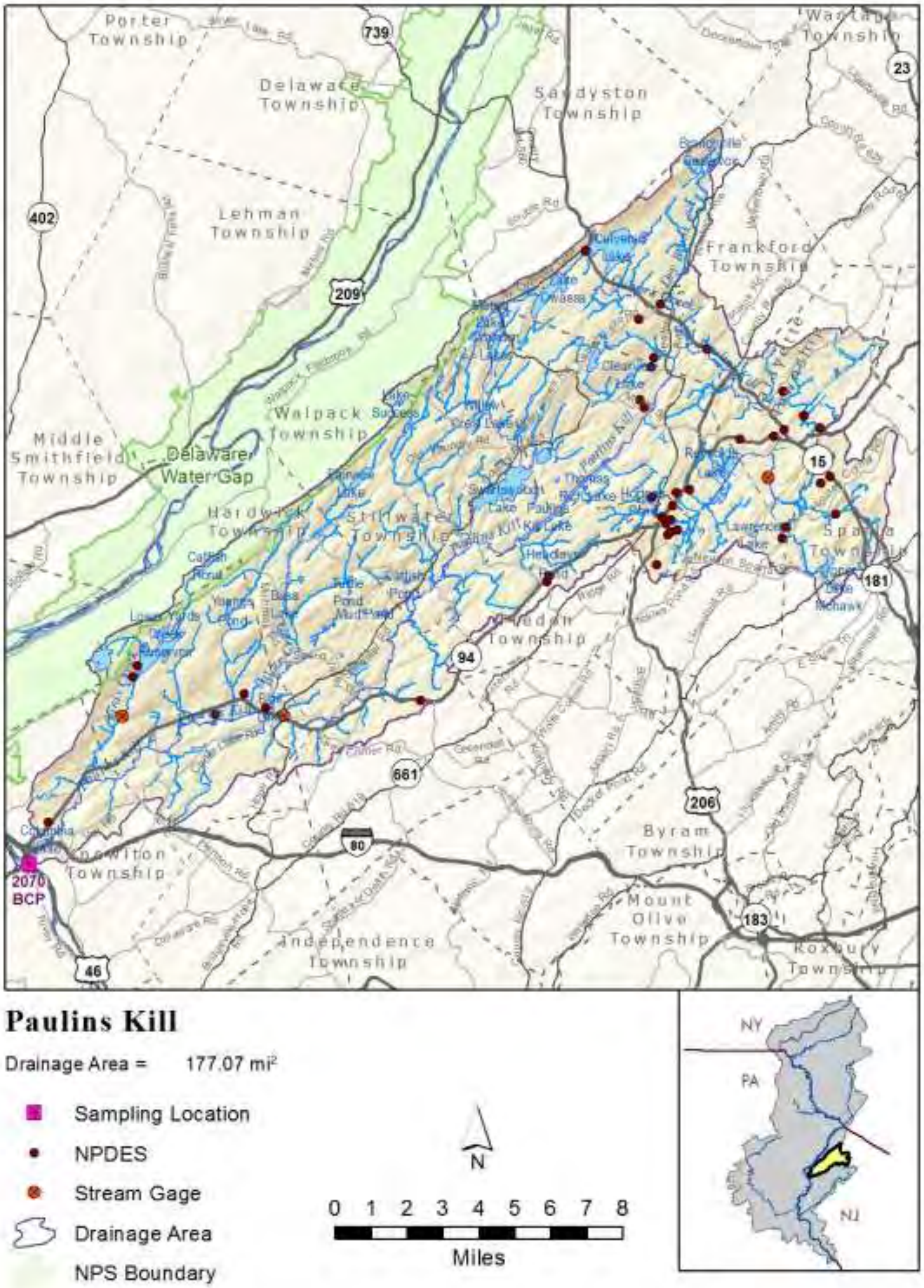
Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
1978 ICP DRBelv EWQ	50	3.4	0.07
1978 ICP DRBelv Post	15	11.3	0.75

H statistic	0.04
X² approximation	0.04
DF	1
p-value	0.8396 [1]

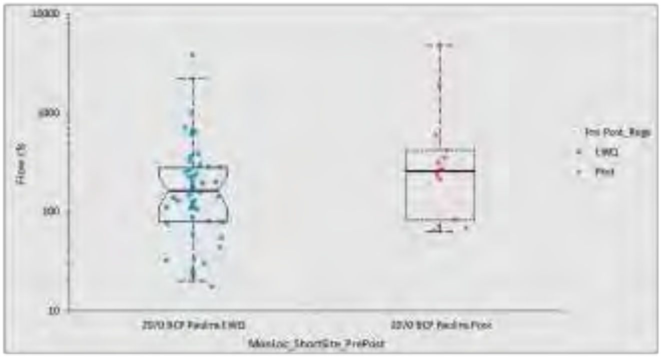
H0: $\theta_1 = \theta_2 = \theta_{...}$
The median of the populations are all equal.
H1: $\theta_i \neq \theta_j$ for at least one i,j
The median of the populations are not all equal.
[1] Do not reject the null hypothesis at the 5% significance level.

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.

Chapter 23: 2070 BCP Paulins Kill River, Warren & Sussex Counties, NJ



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



N	62					
Flow cfs by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
2070 BCP Paulins EWQ	17	81	165	280	3778	199
2070 BCP Paulins Post	63	82	261	426	4846	344

Post-EWQ median flow of the Paulins Kill was about 96 cfs higher than EWQ median flow. Too few samples were collected in the post-EWQ period (n=14). Sampling of the middle to upper range of flow conditions was about the same, but low-flow conditions were not well-represented in post-EWQ data. As a result it is possible that water quality differences can be falsely interpreted as significant when they really are not. This point is closely considered in each analysis to follow.

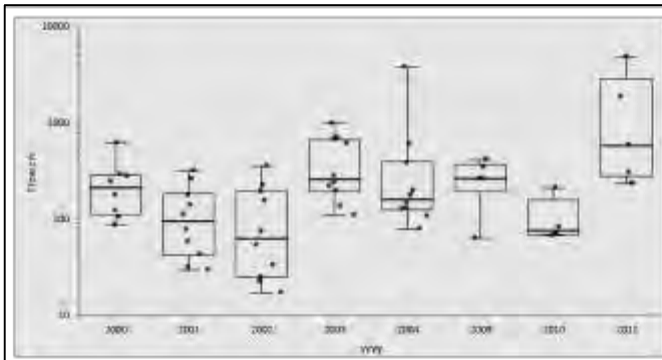
Kruskal-Wallis test

Flow cfs by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
2070 BCP Paulins EWQ	48	165.0	3.44
2070 BCP Paulins Post	14	565.8	40.41

H statistic	2.25
X^2 approximation	2.25
DF	1
p-value	0.1340[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.

Watershed facts derived from USGS StreamStats website (accessed February 2014): The Paulins Kill watershed is about 62% forested; was entirely glaciated; about 5.9% urban land, 7.8% covered by lakes and ponds (including two hydroelectric dams); and is about 29% underlain by carbonate bedrock. The carbonate bedrock percentage is sufficient to produce limestone stream water quality effects, such as high alkalinity, conductivity, hardness, and well-buffered pH. There are numerous dischargers in the watershed.



N	62					
Flow cfs by yyyy	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
2000	86	112	211	285	623	173
2001	30	42	94	184	317	143
2002	17	25	63	196	351	171
2003	110	192	259	665	976	474
2004	78	125	160	396	3778	271
2009	63	193	263	370	412	177
2010	67	69	77	158	212	90
2011	232	280	579	2861	4846	2581

Annual May to September flow statistics associated with water quality measurements are plotted above. Mean annual flow at this location is about 295 cfs; harmonic mean flow is 164 cfs; and average May to September flow is about 147 cfs, which is most typical of summer flow conditions. Though a wide range of flows were sampled by DRBC, the EWQ data are most representative of summer flow conditions, while low flow conditions are not well represented in post-EWQ data. Flows estimates were obtained using instantaneous water discharge data from the USGS gage No. 01443500 on the Paulins Kill at Blairstown. Estimation of stream flow is complicated by the presence of the Columbia Lake hydroelectric generating station that discharges just upstream of the monitoring location. This alters natural flow of the Paulins Kill, so DRBC relates gage height measurements to upstream Blairstown flows then converts Blairstown flow with drainage area weighting to estimate flow at Rt. 46. If the hydropower plant remains operational we recommend that a stream gage be installed upon the next renewal of the power plant’s FERC license. At 177 square miles, the Paulins Kill is a major tributary to the Delaware River, and its hydropower impacts upon the Delaware River should be known and accounted.

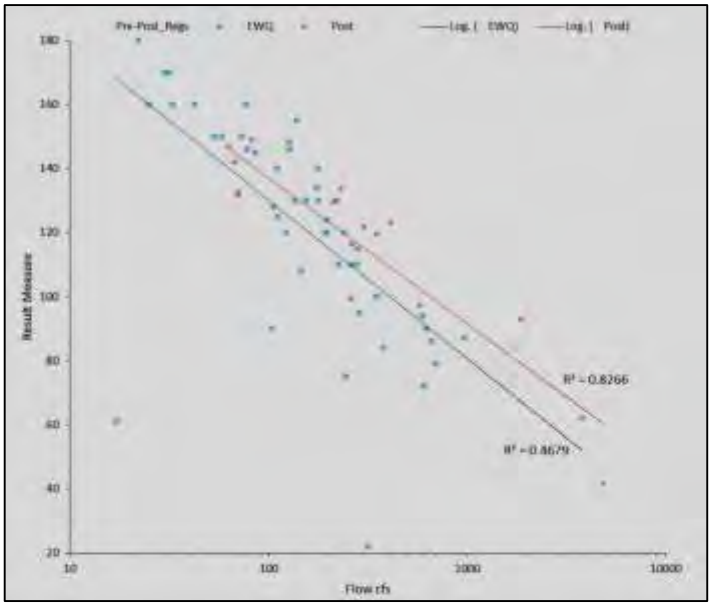
Upstream ICP: Delaware River at Portland 2070 ICP
Downstream ICP: Delaware River at Belvidere 1978 ICP

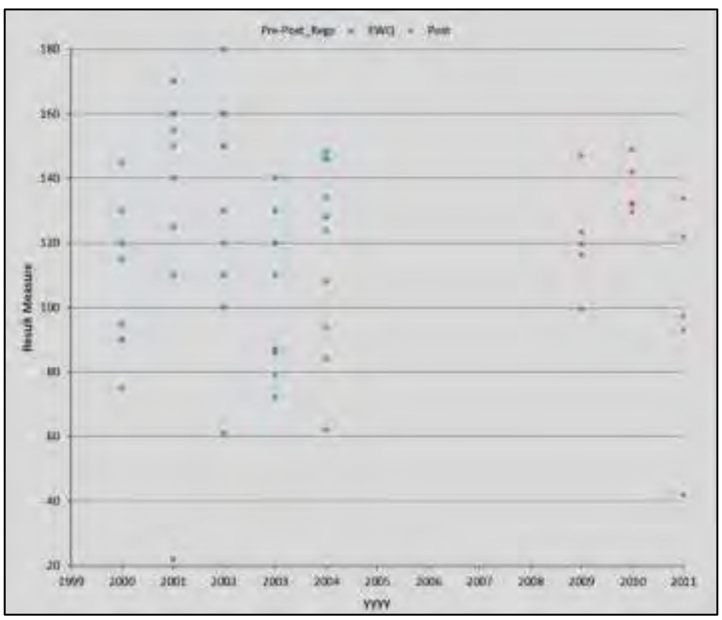
Chapter 23: 2070 BCP Paulins Kill at Rt. 46, NJ

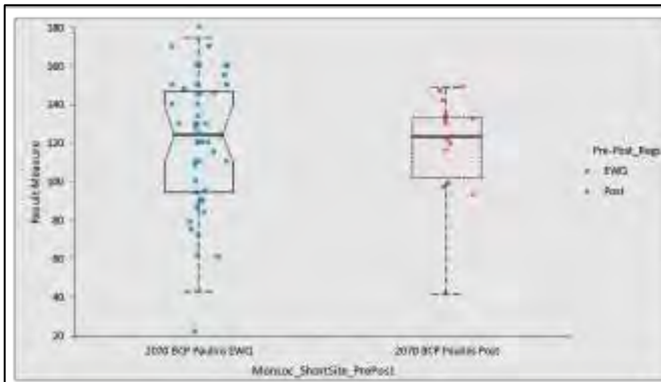
Alkalinity as CaCO3, Total mg/l

Existing Water Quality (Table 2D):

Median 125 mg/l
Lower 95% Confidence Interval 110 mg/l
Upper 95% Confidence Interval 140 mg/l
Defined in regulations as a flow-related parameter

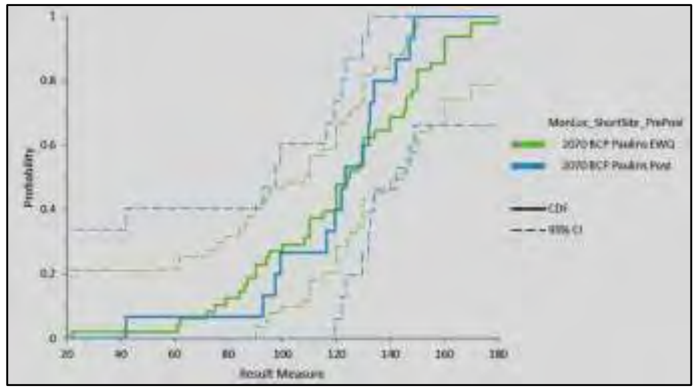






N	63

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
2070 BCP Paulins EWQ	22	94	125	147	180	53
2070 BCP Paulins Post	42	102	123	134	149	31



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
2070 BCP Paulins EWQ	48	5.3	0.11
2070 BCP Paulins Post	15	17.1	1.14

H statistic	0.07
X^2 approximation	0.07
DF	1
p-value	0.7962[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.

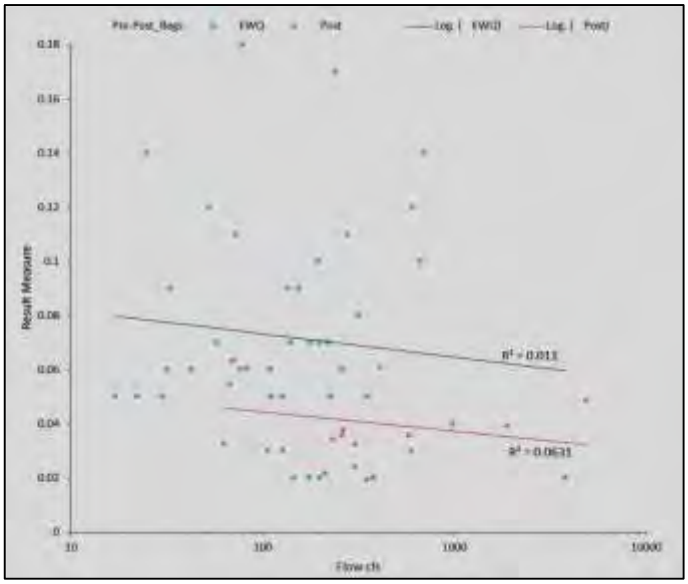
No water quality degradation is evident here. Alkalinity apparently did not measurably change between the EWQ and post-EWQ periods. However, analytical uncertainty was introduced by potential laboratory artifacts, insufficient post-EWQ sampling rate, and low flow differences. Alkalinity is inversely related to flow in both data sets. Median alkalinity over 100 mg/l generally indicates that the stream is influenced by limestone geology. Post-EWQ median alkalinity fell within EWQ 95% confidence intervals. Flow is plotted on logarithmic scale. There were too few samples in the post-EWQ data set. No independent samples were available for comparison with DRBC results.

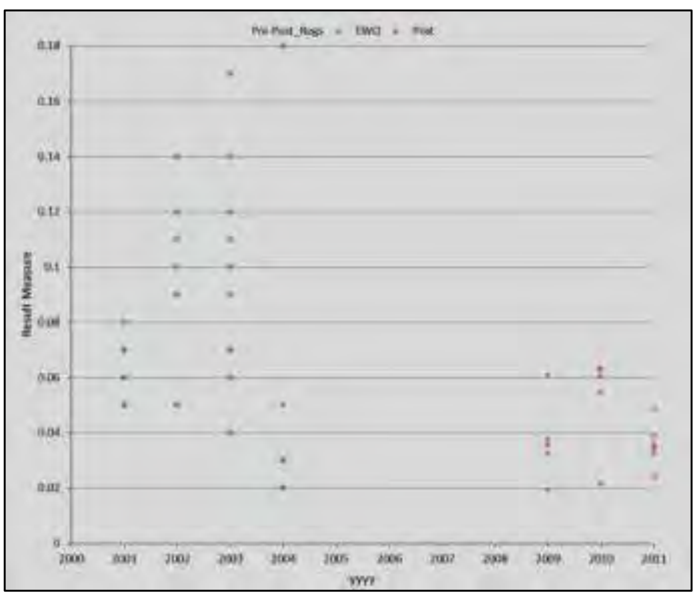
Chapter 23: 2070 BCP Paulins Kill at Rt. 46, NJ

Ammonia Nitrogen as N, Total mg/l

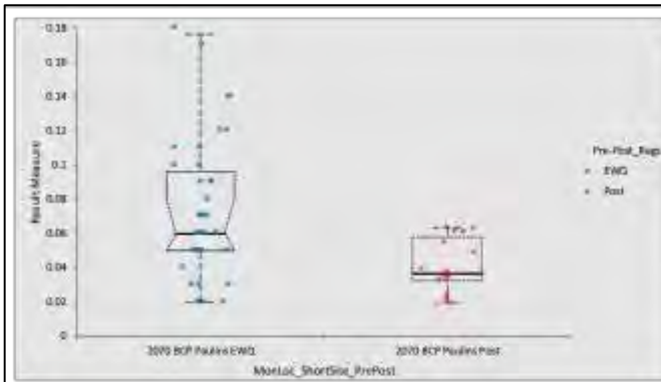
Existing Water Quality (Table 2D):

Median 0.06 mg/l
Lower 95% Confidence Interval <u>0.05*</u> mg/l
Upper 95% Confidence Interval 0.08 mg/l
*corrected value – rules showed 0.04 mg/l



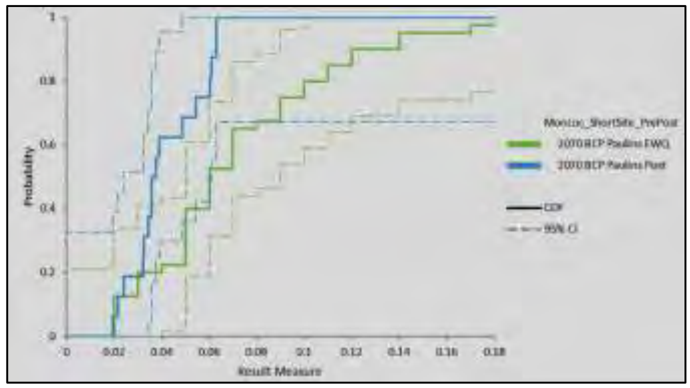


No water quality degradation is evident here. Ammonia concentrations apparently declined. However, analytical uncertainty included potential laboratory artifacts and insufficient post-EWQ sampling rate.



N 56

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
2070 BCP Paulins EWQ	0.020	0.050	0.060	0.096	0.180	0.046
2070 BCP Paulins Post	0.019	0.032	0.037	0.058	0.063	0.026



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
2070 BCP Paulins EWQ	40	525.6	13.14
2070 BCP Paulins Post	16	1314.1	82.13

H statistic	6.95
X^2 approximation	6.95
DF	1
p-value	0.0084 [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.

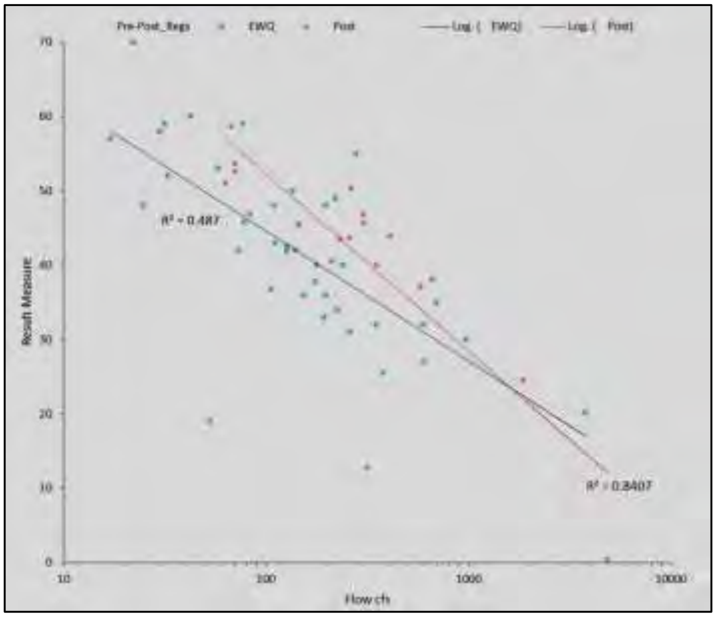
Post-EWQ median ammonia concentration was below the EWQ lower 95% confidence interval. Undetected results did not interfere with estimation of the median and its confidence intervals. EWQ data contained 12 undetected results out of 40 samples. Under 2009-2011 lower detection levels there were no undetected results out of 16 samples. Ammonia is unrelated to flow. Possible water quality improvement is indicated by post-EWQ concentrations no greater than 0.063 mg/l, though this result may be due to laboratory artifacts. There were no independent data available for comparison with DRBC results.

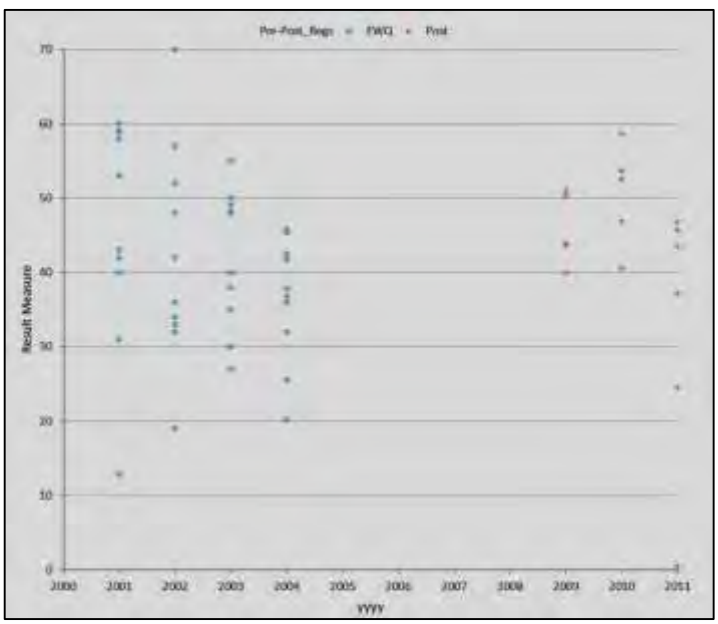
Chapter 23: 2070 BCP Paulins Kill at Rt. 46, NJ

Chloride, Total mg/l

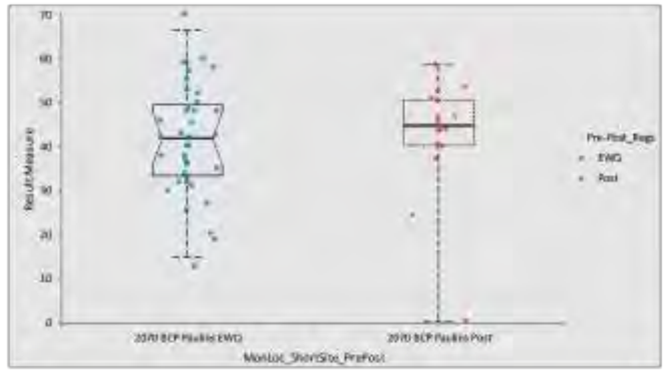
Existing Water Quality (Table 2D):

Median 42 mg/l
Lower 95% Confidence Interval 36 mg/l
Upper 95% Confidence Interval 48 mg/l
Defined in regulations as a flow-related parameter



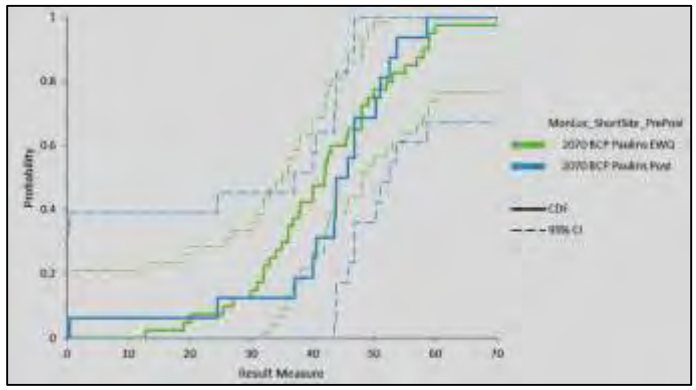


No water quality degradation is evident. Chloride apparently did not change between the two periods, though there were too few post-EWQ data for certainty.



N 56

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
2070 BCP Paulins EWQ	12.8	33.4	41.9	49.6	70.0	16.2
2070 BCP Paulins Post	0.4	40.2	44.8	50.7	58.7	10.5



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
2070 BCP Paulins EWQ	40	55.2	1.38
2070 BCP Paulins Post	16	138.1	8.63

H statistic	0.73
X^2 approximation	0.73
DF	1
p-value	0.3939 [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.

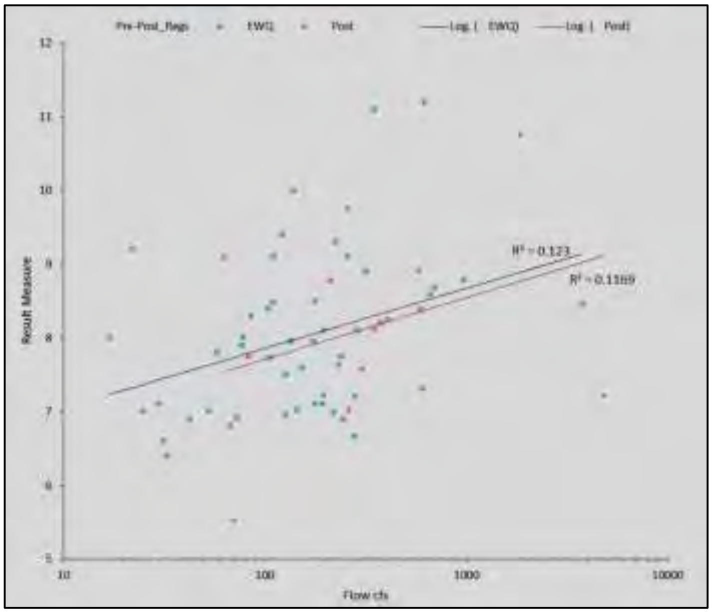
Analytical uncertainty was introduced by potential laboratory artifacts, insufficient post-EWQ sampling rate, and low flow differences. Post-EWQ median concentration fell within the EWQ 95% confidence intervals, rising 2.9 mg/l. Chloride concentration is inversely related to flow in both data sets. No independent data were available to validate results. Note a single extremely low result in 2011 – taken under the highest flow conditions sampled, when the Paulins Kill was running at nearly 5,000 cfs. Some chlorides may be sequestered by Columbia Lake, as the increase here was not as significant as in other watersheds.

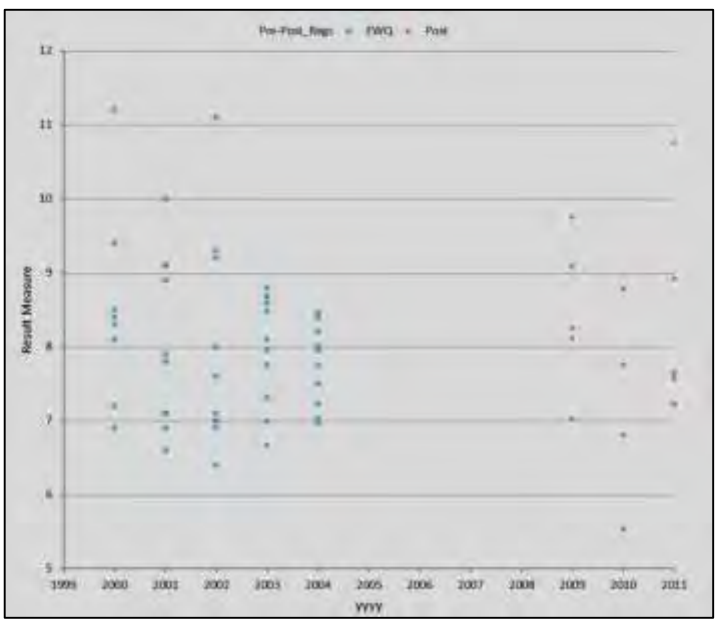
Chapter 23: 2070 BCP Paulins Kill at Rt. 46, NJ

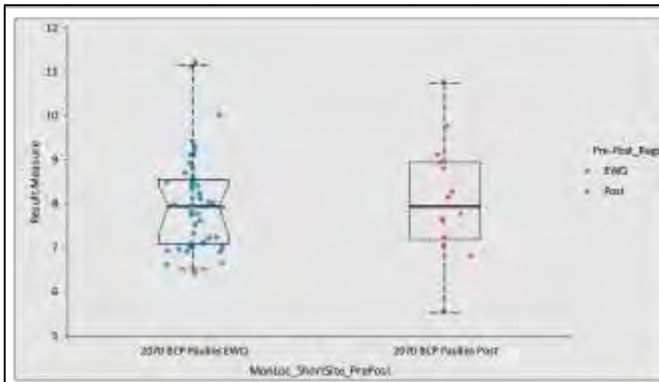
Dissolved Oxygen (DO) mg/l

Existing Water Quality (Table 2D):

Median 7.95 mg/l
Lower 95% Confidence Interval 7.31 mg/l
Upper 95% Confidence Interval 8.39 mg/l

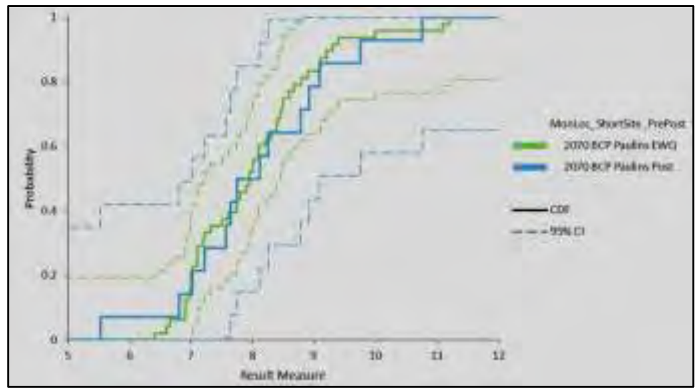






N | 62

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
2070 BCP Paulins EWQ	6.40	7.10	7.95	8.55	11.20	1.45
2070 BCP Paulins Post	5.53	7.20	7.94	8.93	10.76	1.73



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
2070 BCP Paulins EWQ	48	7.1	0.15
2070 BCP Paulins Post	14	24.4	1.75

H statistic	0.10
X^2 approximation	0.10
DF	1
p-value	0.7554 [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.

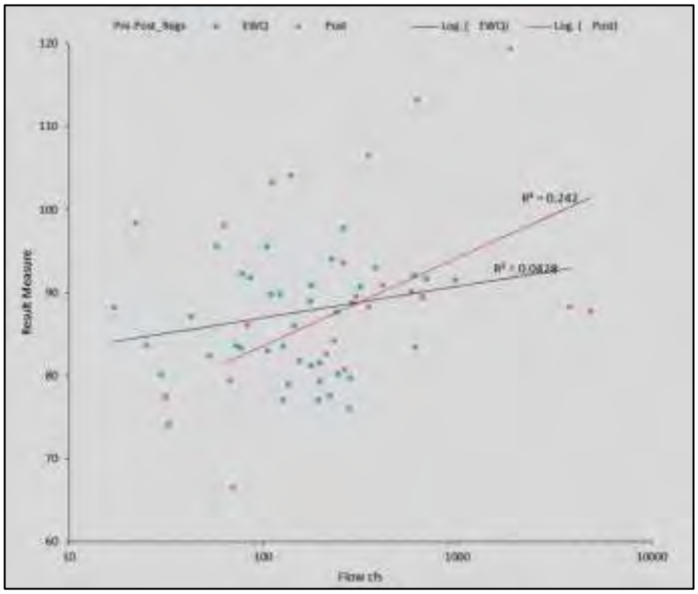
No water quality degradation is evident here. No measurable change took place between the EWQ and Post-EWQ periods. Analytical uncertainty was introduced by insufficient post-EWQ sampling rate. Post-EWQ median DO concentration was within the EWQ 95% confidence intervals. DO concentration is unrelated to flow in both data sets. The low reading of 5.53 mg/l in 2010 was probably a probe malfunction, as low DO was observed at two adjacent sites on the same day. No independent data were available to confirm DRBC results.

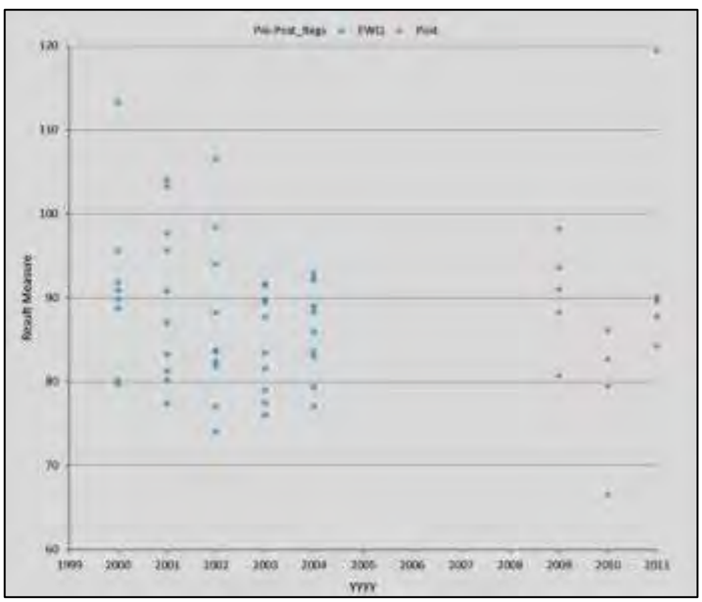
Chapter 22: 1978 ICP Delaware River at Belvidere

Dissolved Oxygen Saturation % (DO%)

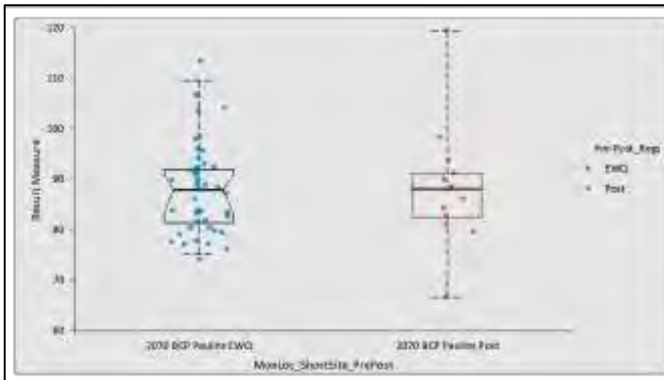
Existing Water Quality (Table 2D):

Median 88%
Lower 95% Confidence Interval 83%
Upper 95% Confidence Interval 91%



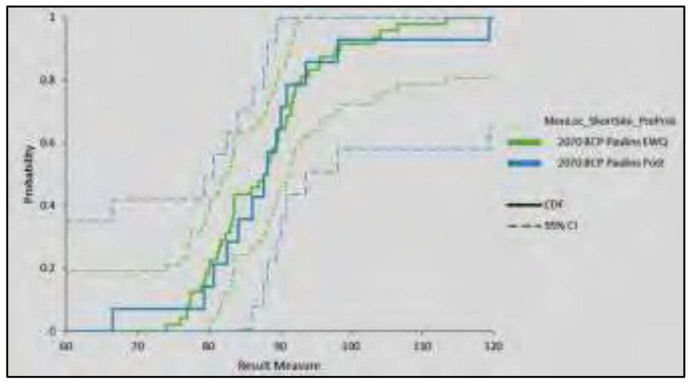


No water quality degradation is evident here. DO% is unrelated to flow, and did not measurably change between the two periods.



N	62

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
2070 BCP Paulins EWQ	74	81	88	92	113	11
2070 BCP Paulins Post	67	82	88	91	119	9



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
2070 BCP Paulins EWQ	48	4.1	0.09
2070 BCP Paulins Post	14	14.0	1.00

H statistic	0.06
X^2 approximation	0.06
DF	1
p-value	0.8137[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.

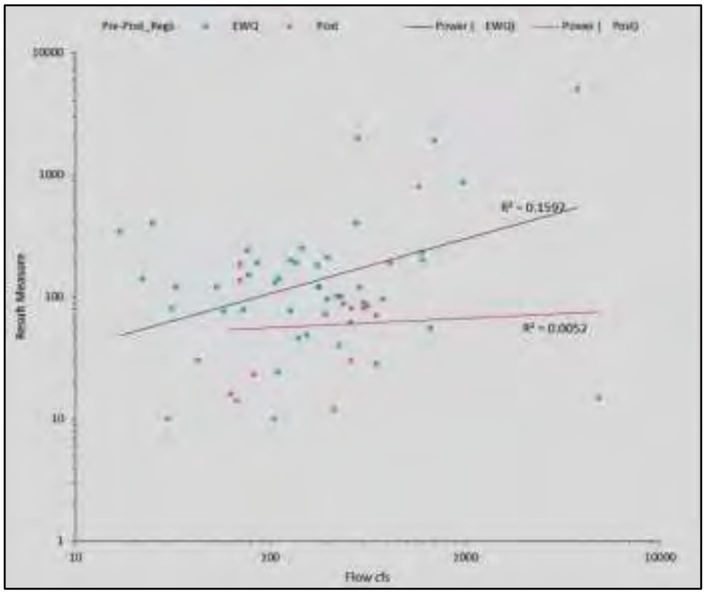
Analytical uncertainty was introduced by insufficient post-EWQ sampling rate. The weakly positive relationship to flow in the post-EWQ data was driven by two outlier values – one high and one low. The low value was probably a probe malfunction, as two adjacent sites showed such low values on the same date. Post-EWQ median DO% fell within EWQ 95% confidence intervals. There are frequent low saturation values (below 80%) at this site, which probably has to do with Columbia Lake's hydropower release structure. Biweekly or continuous sampling is recommended for this location. No independent data were available for comparison with DRBC results.

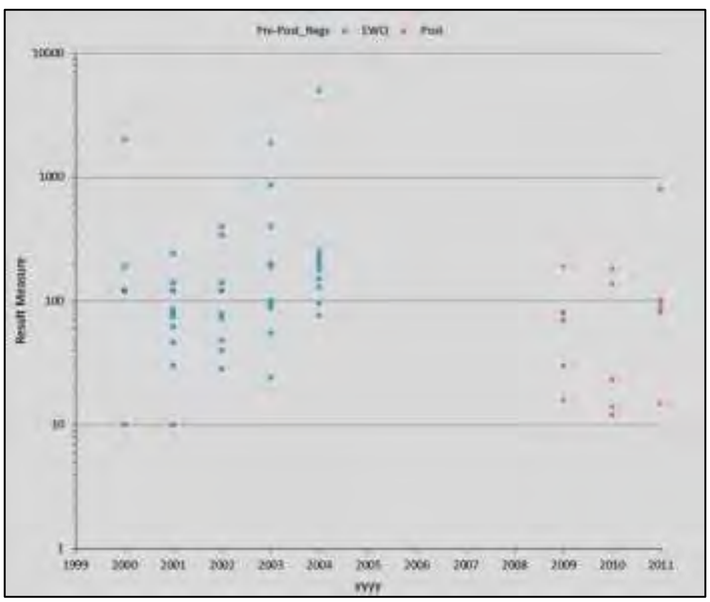
Chapter 23: 2070 BCP Paulins Kill at Rt. 46, NJ

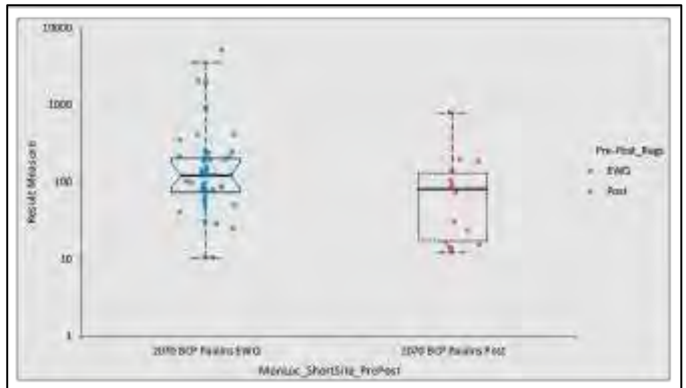
Enterococcus colonies/100 ml

Existing Water Quality (Table 2D):

Median 120/100 ml
Lower 95% Confidence Interval 84/100 ml
Upper 95% Confidence Interval 180/100 ml

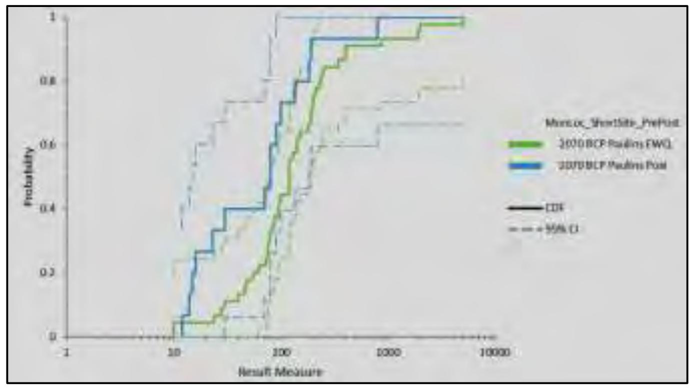






N 60

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
2070 BCP Paulins EWQ	10	74	120	203	5000	129
2070 BCP Paulins Post	12	17	80	130	800	113



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
2070 BCP Paulins EWQ	45	317.3	7.05
2070 BCP Paulins Post	15	952.0	63.47

H statistic	4.17
X^2 approximation	4.17
DF	1
p-value	0.0412 [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.

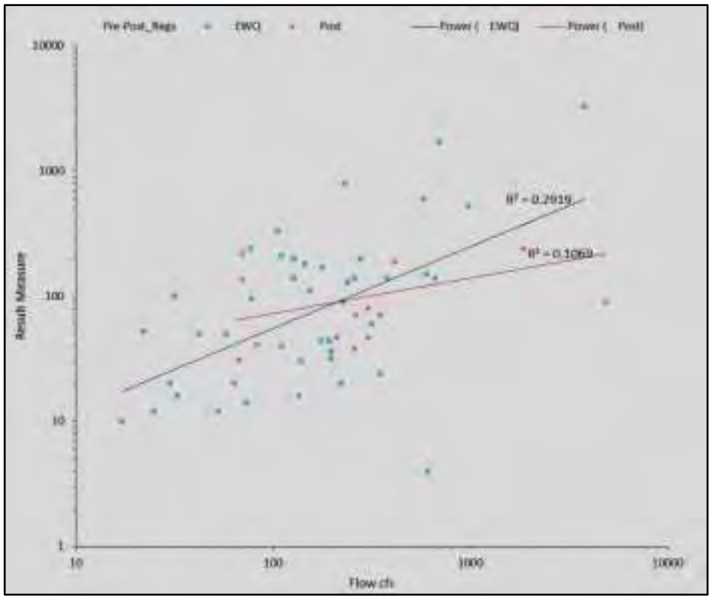
No water quality degradation is evident here. Enterococci apparently declined between the two periods. Analytical uncertainty was introduced by potential laboratory artifacts and insufficient post-EWQ sampling rate. Biweekly sampling is recommended to improve the strength of statistical comparisons. 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.

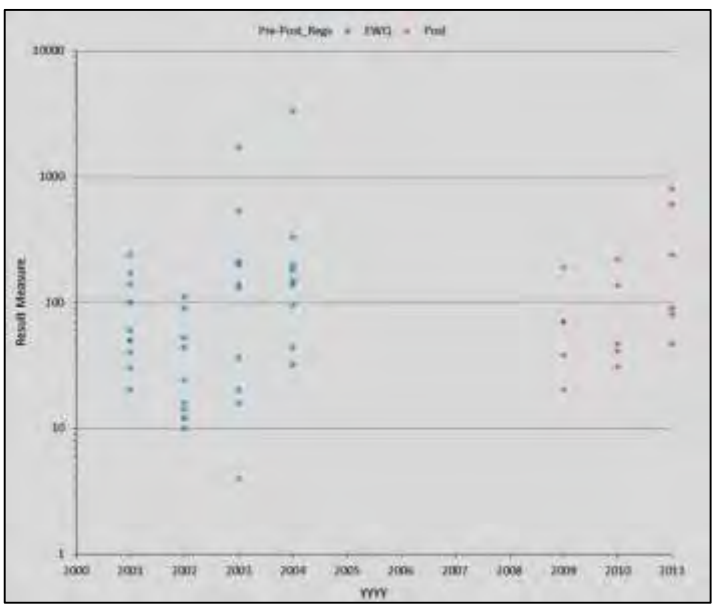
Chapter 23: 2070 BCP Paulins Kill at Rt. 46, NJ

Escherichia coli colonies/100 ml

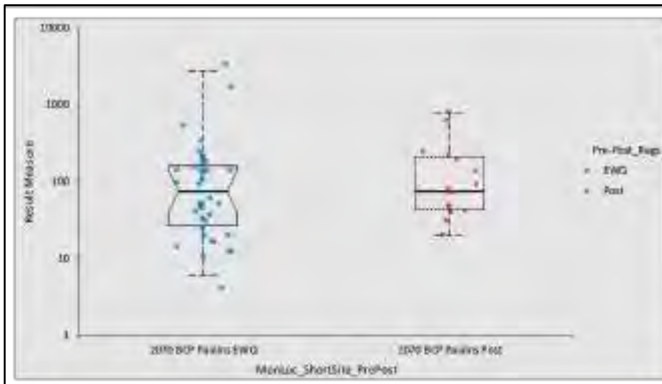
Existing Water Quality (Table 2D):

Median 75/100 ml
Lower 95% Confidence Interval 40/100 ml
Upper 95% Confidence Interval 140/100 ml
Defined in regulations as a flow-related parameter



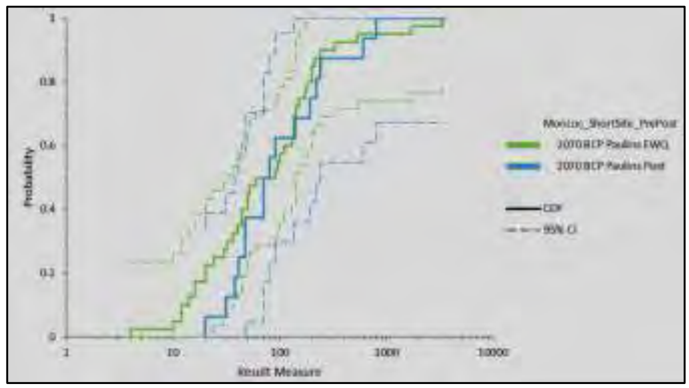


No water quality degradation is evident here. E. coli apparently did not measurably change between the two periods.



N | 56

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
2070 BCP Paulins EWQ	4	27	75	162	3300	135
2070 BCP Paulins Post	20	44	75	208	800	164



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
2070 BCP Paulins EWQ	40	44.1	1.10
2070 BCP Paulins Post	16	110.3	6.89

H statistic	0.58
X^2 approximation	0.58
DF	1
p-value	0.4460 [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.

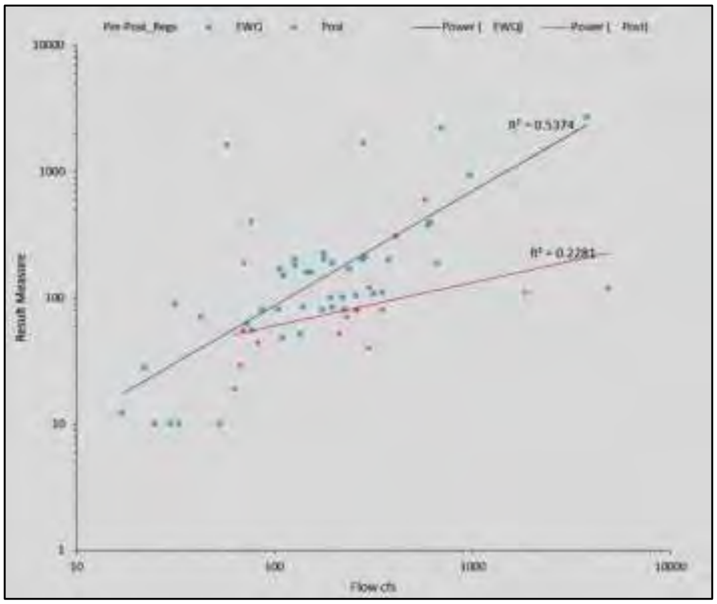
Analytical uncertainty was introduced by potential laboratory artifacts and insufficient post-EWQ sampling rate. Post-EWQ median E. coli fell within the EWQ 95% confidence intervals. Concentrations and flows are plotted on logarithmic scale, and regressions are power relationships. An insufficient number of samples were taken in the post-EWQ period (n=16). Biweekly instead of monthly sampling is recommended. E. coli concentrations are weakly related to flow in EWQ data, but unrelated in post-EWQ data. No independent data were available to validate DRBC results at this location.

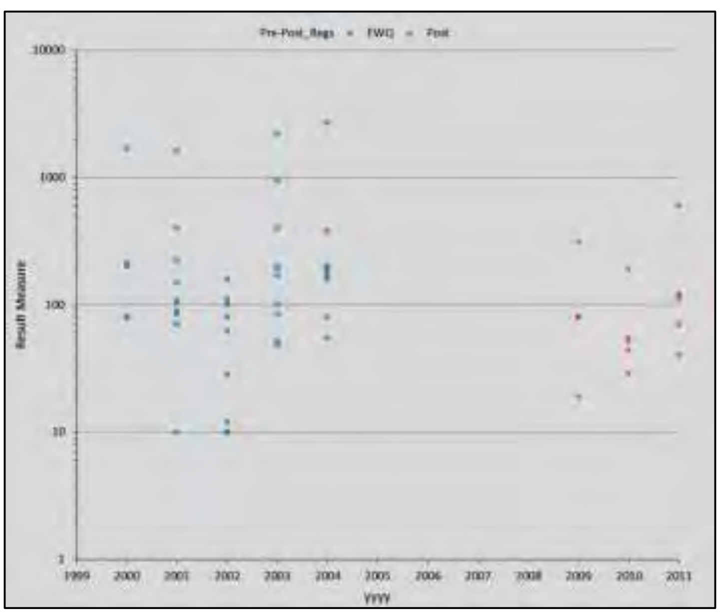
Chapter 23: 2070 BCP Paulins Kill at Rt. 46, NJ

Fecal coliform colonies/100 ml

Existing Water Quality (Table 2D):

Median 110/100 ml
Lower 95% Confidence Interval 84/100 ml
Upper 95% Confidence Interval 190/100 ml
Defined in regulations as a flow-related parameter

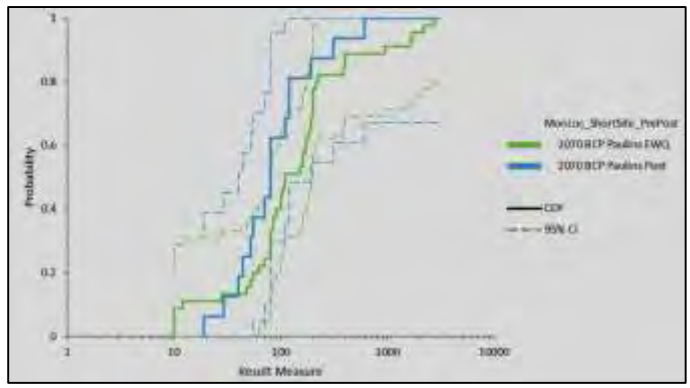




No water quality degradation is evident here. Fecal coliform concentrations apparently fell below the lower EWQ 95% confidence interval, but did not measurably change between the two periods.

N 61

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
2070 BCP Paulins EWQ	10	77	110	200	2700	123
2070 BCP Paulins Post	19	47	80	120	600	73



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
2070 BCP Paulins EWQ	45	200.6	4.46
2070 BCP Paulins Post	16	564.1	35.25

H statistic	2.43
X² approximation	2.43
DF	1
p-value	0.1189 [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.

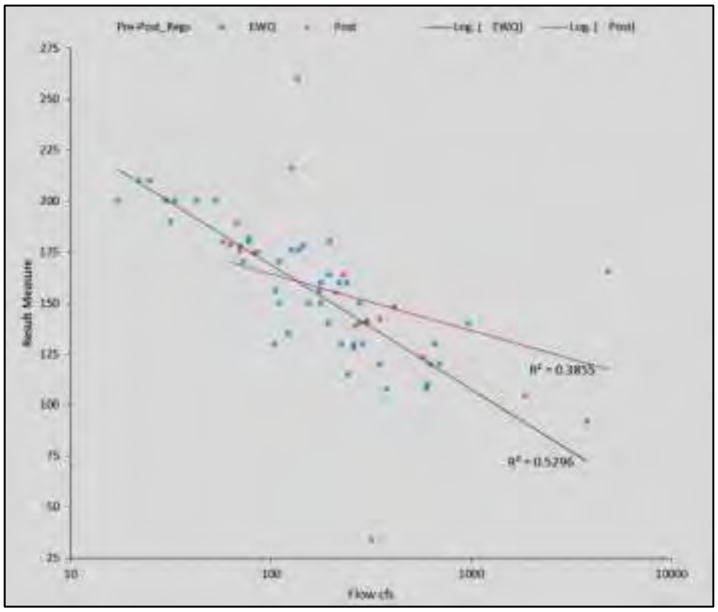
Analytical uncertainty was introduced by potential laboratory artifacts and insufficient post-EWQ sampling rate. There were fewer high results in the post-EWQ data set, but insufficient data to indicate significant change. Fecal coliform concentrations are related to flow in both data sets, though weakly so in post-EWQ data. 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.

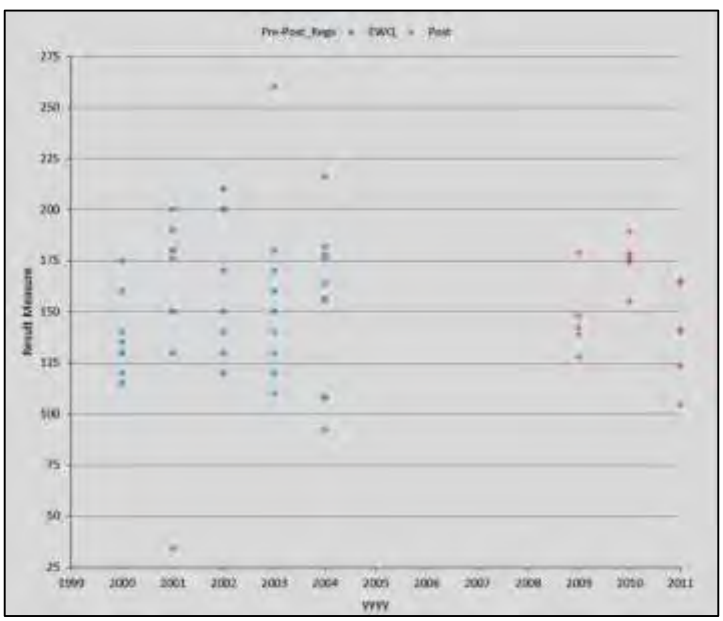
Chapter 23: 2070 BCP Paulins Kill at Rt. 46, NJ

Hardness as CaCO3, Total mg/l

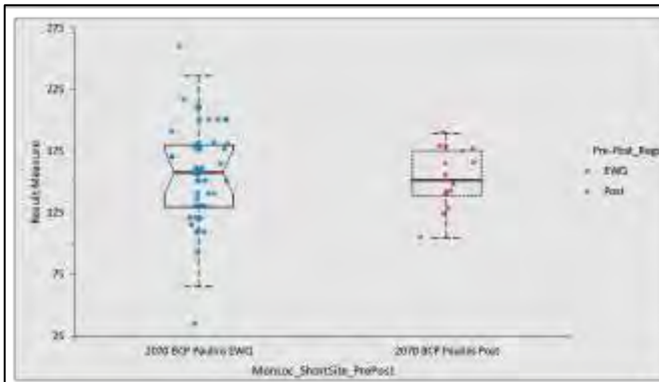
Existing Water Quality (Table 2D):

Median 158 mg/l
Lower 95% Confidence Interval 140 mg/l
Upper 95% Confidence Interval 176 mg/l
Defined in regulations as a flow-related parameter



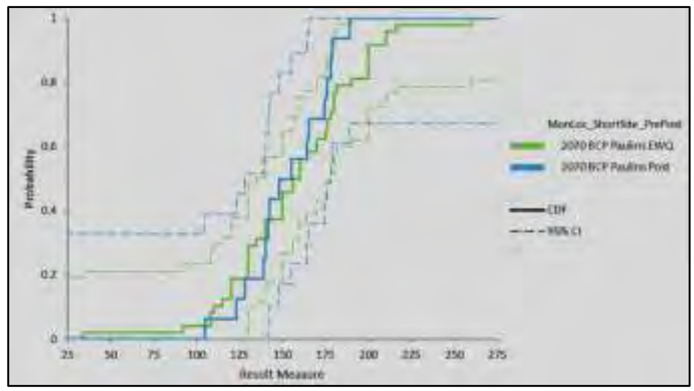


No water quality degradation is evident here. Hardness apparently did not measurably change between the EWQ and post-EWQ periods.



N 64

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
2070 BCP Paulins EWQ	34	130	158	180	260	50
2070 BCP Paulins Post	105	139	152	175	189	36



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
2070 BCP Paulins EWQ	48	24.1	0.50
2070 BCP Paulins Post	16	72.3	4.52

H statistic	0.28
X² approximation	0.28
DF	1
p-value	0.5978 [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.

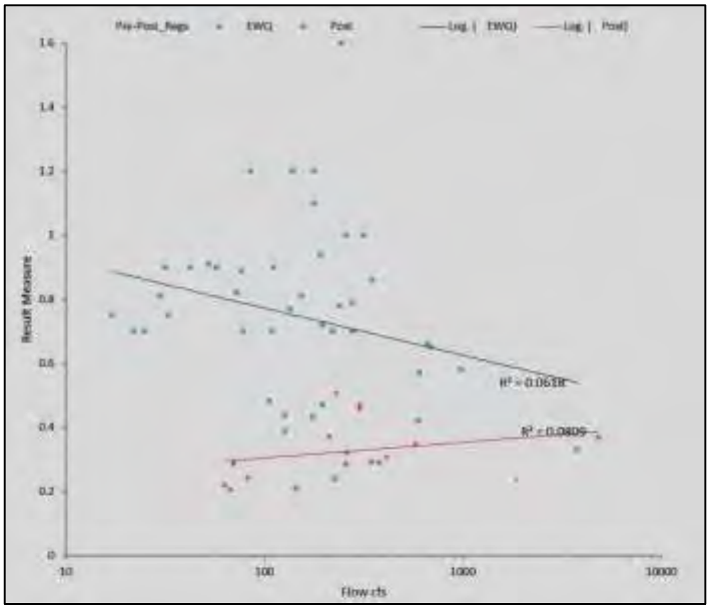
Analytical uncertainty was introduced by potential laboratory artifacts and insufficient post-EWQ sampling rate. Hardness is inversely related to flow in both data sets. The strength of the relationship in the post-EWQ data is weakened by too few data across the full range of flow, so the relationship 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. No independent data were available for comparison with DRBC results. The high concentrations observed are typical of limestone-influenced streams.

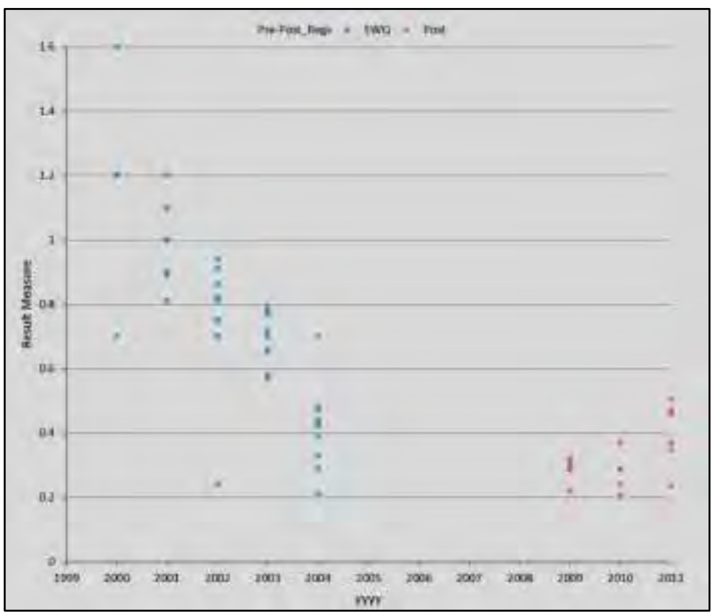
Chapter 23: 2070 BCP Paulins Kill at Rt. 46, NJ

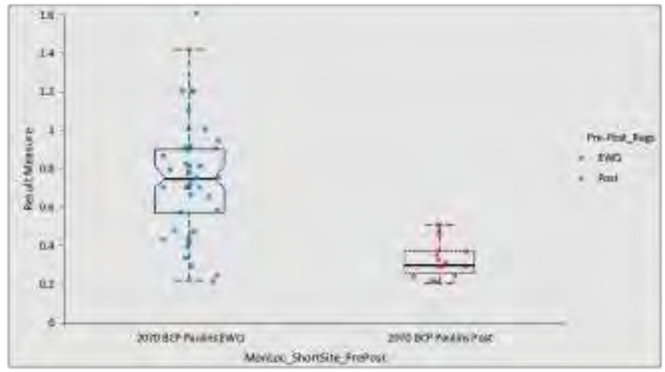
Nitrate + Nitrite as N, Total mg/l

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

Median 0.75 mg/l
Lower 95% Confidence Interval 0.70 mg/l
Upper 95% Confidence Interval 0.86 mg/l

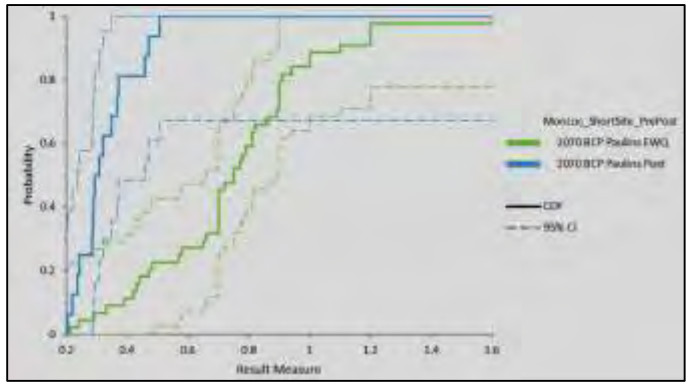






N	60

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
2070 BCP Paulins EWQ	0.21	0.57	0.75	0.90	1.60	0.33
2070 BCP Paulins Post	0.21	0.26	0.30	0.37	0.51	0.11



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
2070 BCP Paulins EWQ	44	1977.8	44.95
2070 BCP Paulins Post	16	5439.1	339.94

H statistic	24.35
X^2 approximation	24.35
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.

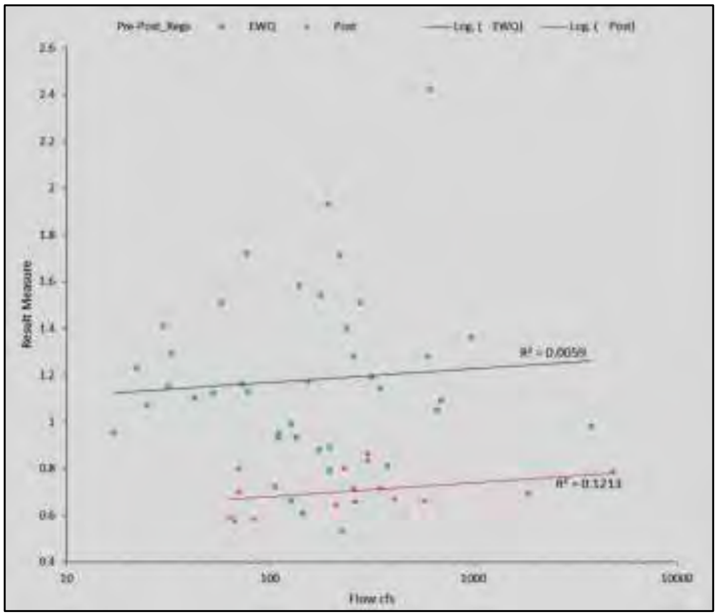
No water quality degradation is evident here. Nitrate concentrations apparently declined between the EWQ and post-EWQ periods. Analytical uncertainty was introduced by potential laboratory artifacts and insufficient post-EWQ sampling rate. Nitrate is unrelated to flow in both data sets. Post-EWQ nitrate 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. No independent data were available for comparison with DRBC results.

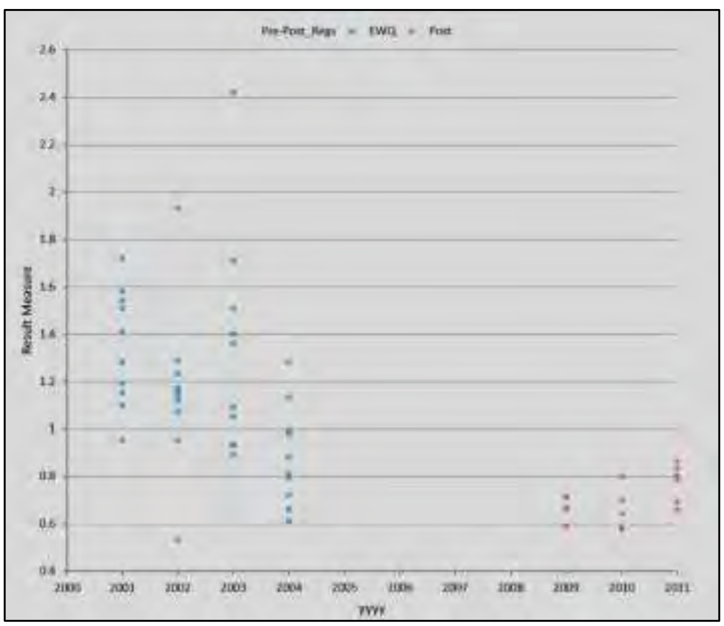
Chapter 23: 2070 BCP Paulins Kill at Rt. 46, NJ

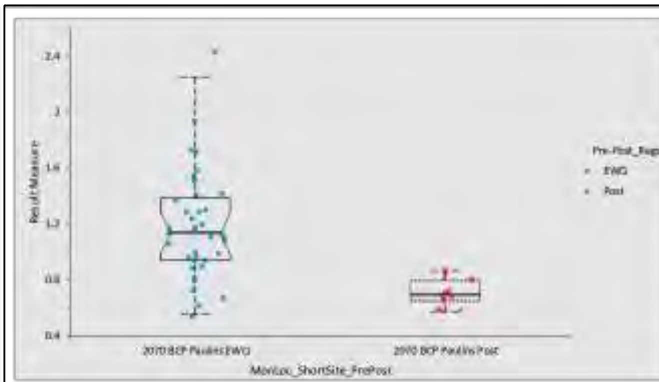
Nitrogen as N, Total (TN) mg/l

Existing Water Quality (Table 2D):

Median 1.13 mg/l
Lower 95% Confidence Interval 0.99 mg/l
Upper 95% Confidence Interval 1.28 mg/l

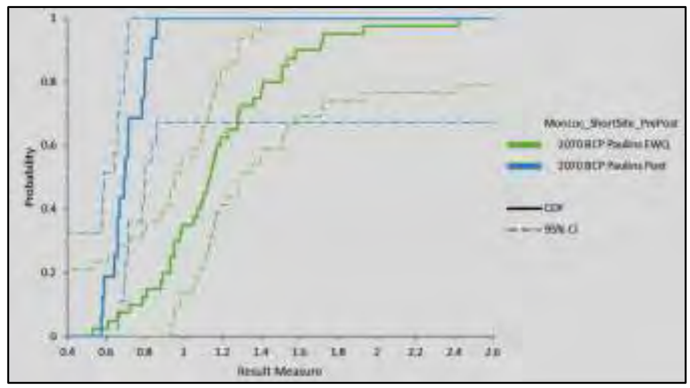






N 56

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
2070 BCP Paulins EWQ	0.53	0.94	1.14	1.38	2.42	0.45
2070 BCP Paulins Post	0.58	0.65	0.69	0.79	0.86	0.14



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
2070 BCP Paulins EWQ	40	1809.0	45.23
2070 BCP Paulins Post	16	4522.6	282.66

H statistic	23.80
X^2 approximation	23.80
DF	1
p-value	<0.0001 [1]

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

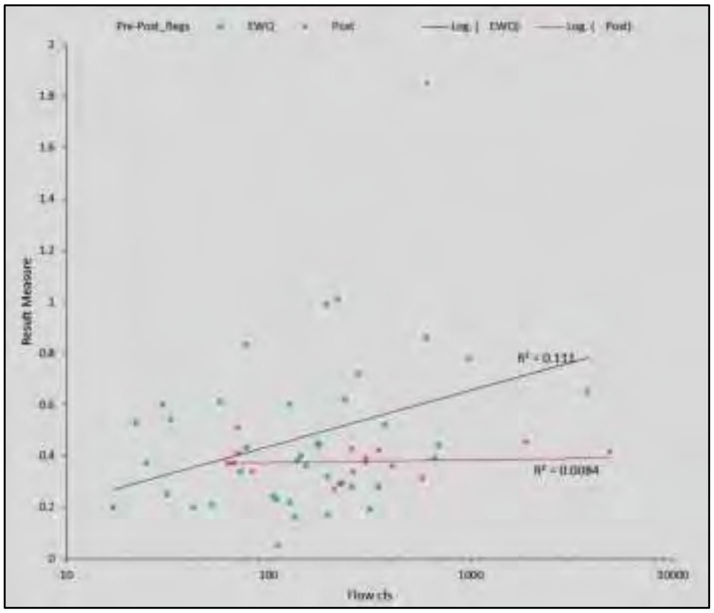
No water quality degradation is evident here. Total Nitrogen concentrations apparently declined between the two periods. Analytical uncertainty was introduced by potential laboratory artifacts and insufficient post-EWQ sampling rate. TN is unrelated to flow in both data sets. Post-EWQ median TN concentrations fell below the EWQ lower 95% confidence intervals. There were no independent data available to confirm DRBC results.

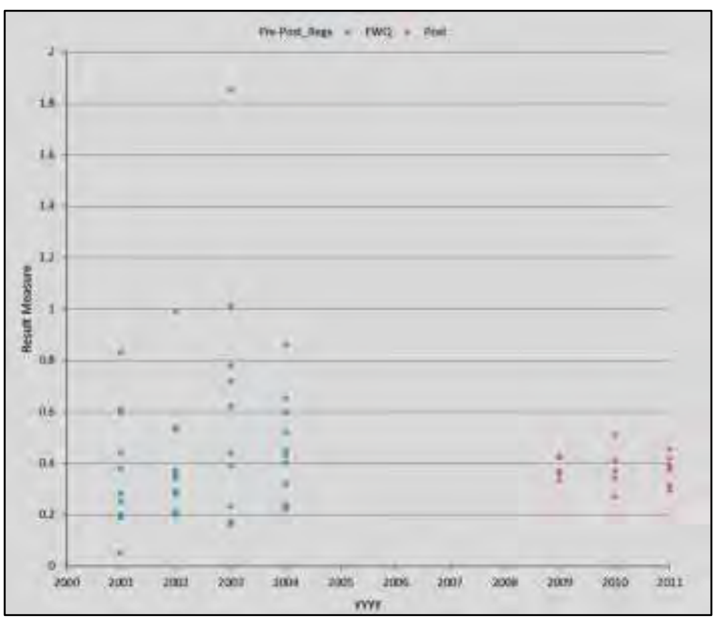
Chapter 23: 2070 BCP Paulins Kill at Rt. 46, NJ

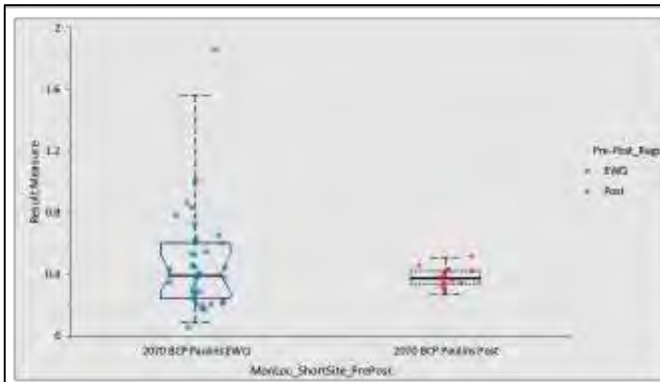
Nitrogen, Kjeldahl as N, Total (TKN) mg/l

Existing Water Quality (Table 2D):

Median 0.39 mg/l
Lower 95% Confidence Interval 0.29 mg/l
Upper 95% Confidence Interval 0.53 mg/l

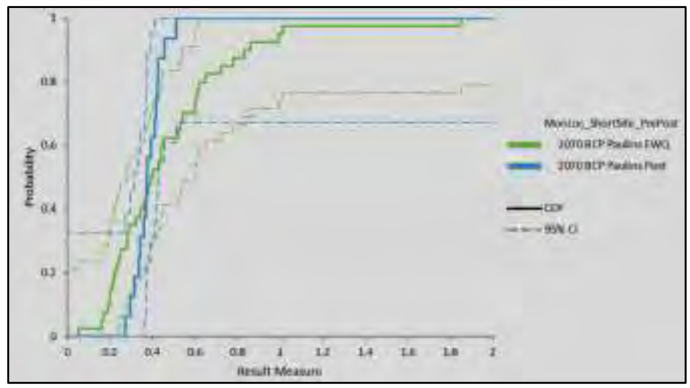






N 56

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
2070 BCP Paulins EWQ	0.05	0.24	0.40	0.61	1.85	0.36
2070 BCP Paulins Post	0.27	0.34	0.37	0.42	0.51	0.08



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
2070 BCP Paulins EWQ	40	19.6	0.49
2070 BCP Paulins Post	16	49.0	3.06

H statistic	0.26
X² approximation	0.26
DF	1
p-value	0.6115[1]

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

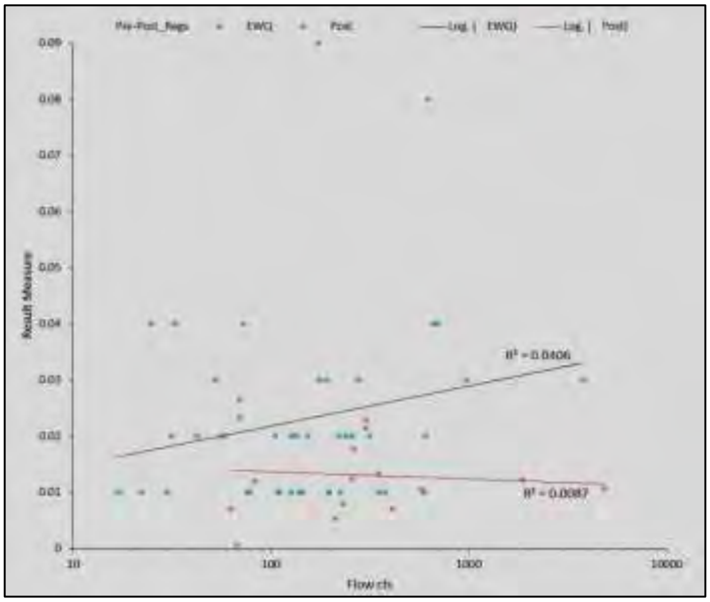
No water quality degradation is evident here. TKN median concentrations apparently did not measurably change between the EWQ and post-EWQ periods. Analytical uncertainty was introduced by potential laboratory artifacts and insufficient post-EWQ sampling rate. The post-EWQ range was far narrower and all concentrations were less than 0.51 mg/l, but post-EWQ median TKN concentration fell within EWQ 95% confidence intervals. TKN concentration is unrelated to flow in both data sets. There were no independent data to confirm DRBC results.

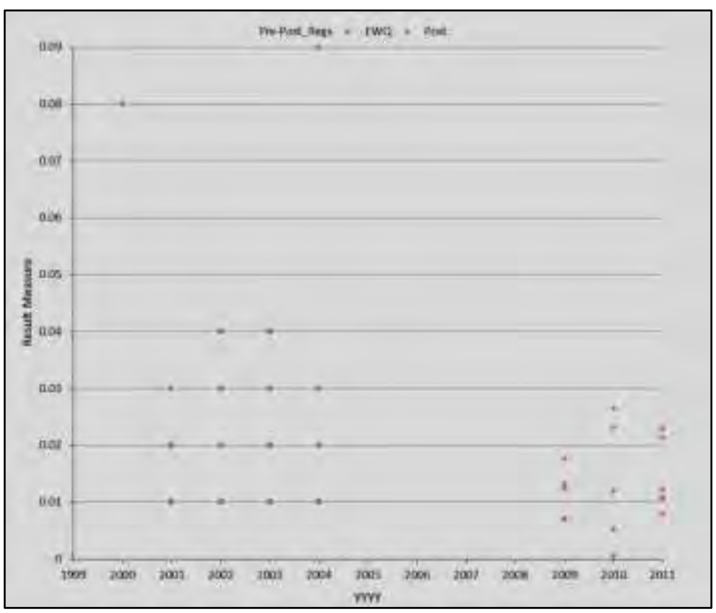
Chapter 23: 2070 BCP Paulins Kill at Rt. 46, NJ

Orthophosphate as P, Total mg/l (OP)

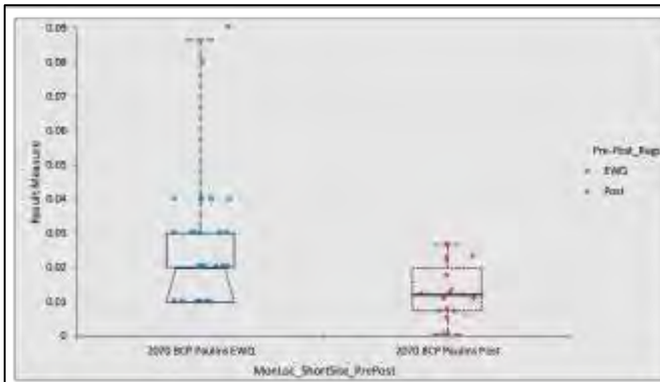
Existing Water Quality (Table 2D):

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



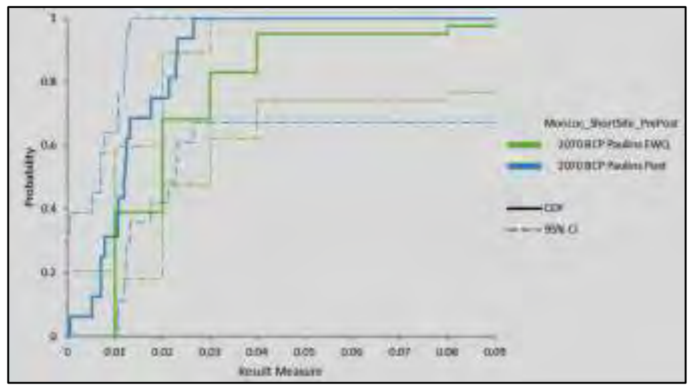


No water quality degradation is evident here. Orthophosphate concentrations apparently declined between the EWQ and post-EWQ periods.



N 57

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
2070 BCP Paulins EWQ	0.010	0.010	0.020	0.030	0.090	0.020
2070 BCP Paulins Post	0.001	0.007	0.012	0.020	0.027	0.012



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
2070 BCP Paulins EWQ	41	263.8	6.43
2070 BCP Paulins Post	16	676.0	42.25

H statistic	3.53
X^2 approximation	3.53
DF	1
p-value	0.0603 [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.

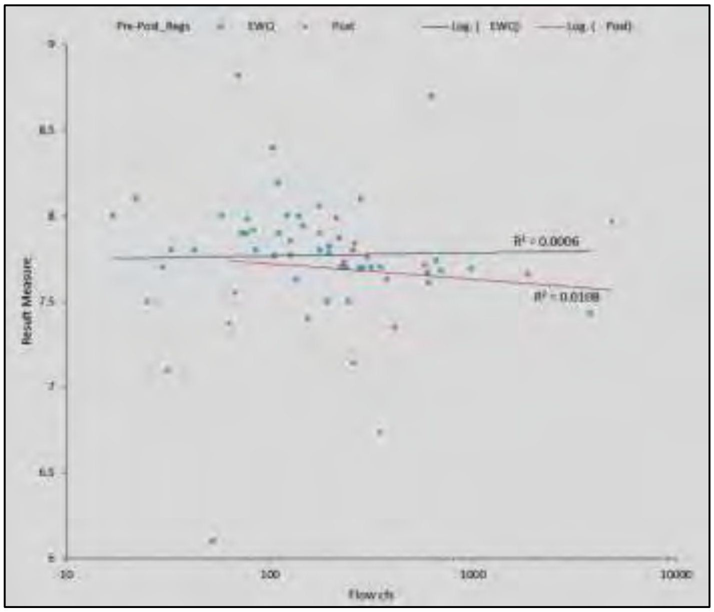
Analytical uncertainty was introduced by potential laboratory artifacts, detection limit differences, and insufficient post-EWQ sampling rate (n=16). OP is unrelated to flow in both data sets. Post-EWQ median OP fell near the EWQ lower 95% confidence interval. Detection limits improved between the two periods. There were no post-EWQ undetected concentrations, and no results higher than 0.027 mg/l. The EWQ non-detection rate was 16 out of 41 samples, so the undetected results did not interfere with estimation of the median. Post-EWQ orthophosphate ranged less widely than EWQ data. There were no independent data available to confirm DRBC results.

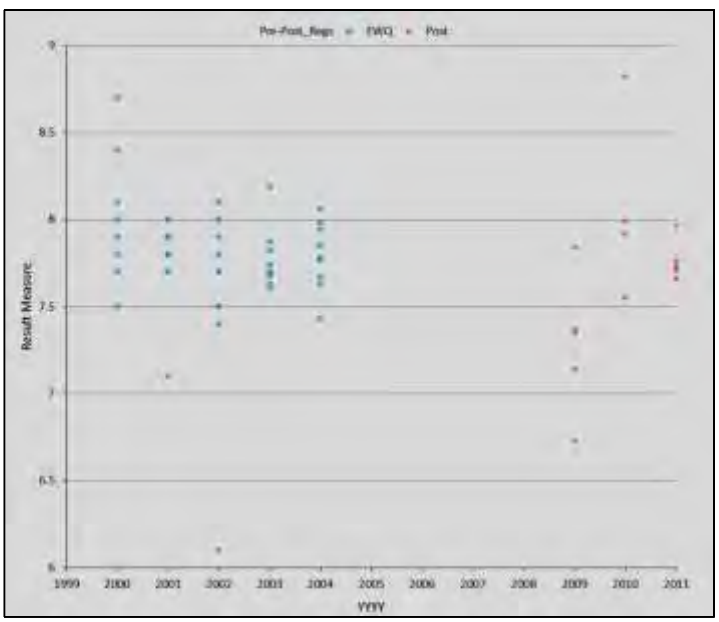
Chapter 23: 2070 BCP Paulins Kill at Rt. 46, NJ

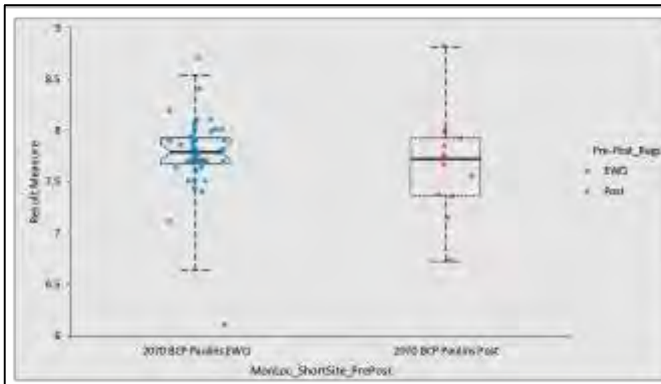
pH

Existing Water Quality (Table 2D):

Median 7.79 standard units
Lower 95% Confidence Interval 7.70 standard units
Upper 95% Confidence Interval 7.87 standard units

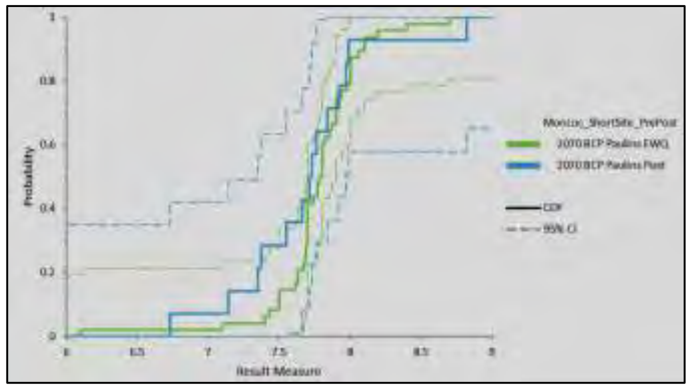






N 62

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
2070 BCP Paulins EWQ	6.10	7.68	7.79	7.92	8.70	0.24
2070 BCP Paulins Post	6.73	7.37	7.72	7.92	8.82	0.56



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
2070 BCP Paulins EWQ	48	80.1	1.67
2070 BCP Paulins Post	14	274.6	19.61

H statistic	1.09
X^2 approximation	1.09
DF	1
p-value	0.2961 [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.

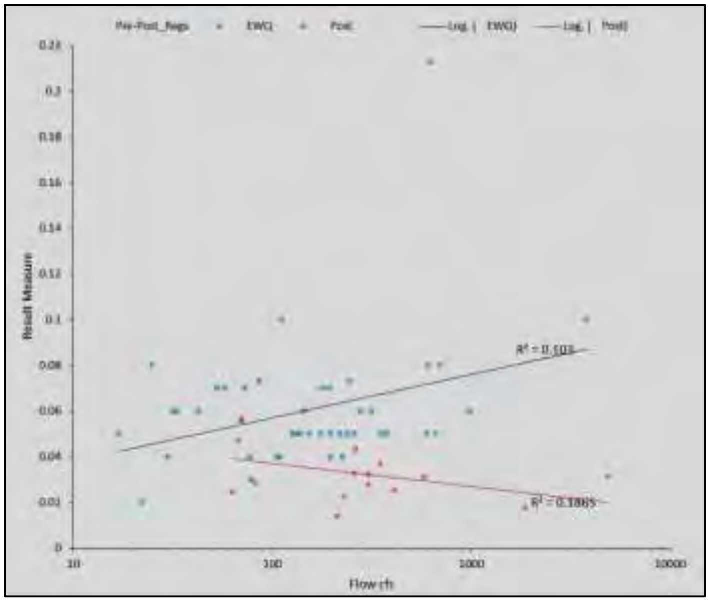
No water quality degradation is evident here. pH apparently did not measurably change between the EWQ and post-EWQ periods. Analytical uncertainty was introduced by insufficient post-EWQ sampling rate (n=14). pH is unrelated to flow in both data sets. Post-EWQ median pH was within the EWQ 95% confidence intervals. No independent data were available to confirm DRBC results.

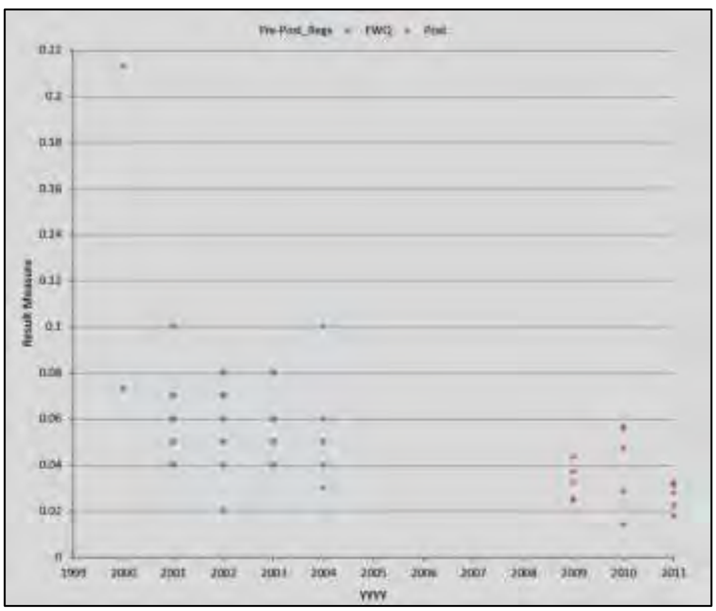
Chapter 23: 2070 BCP Paulins Kill at Rt. 46, NJ

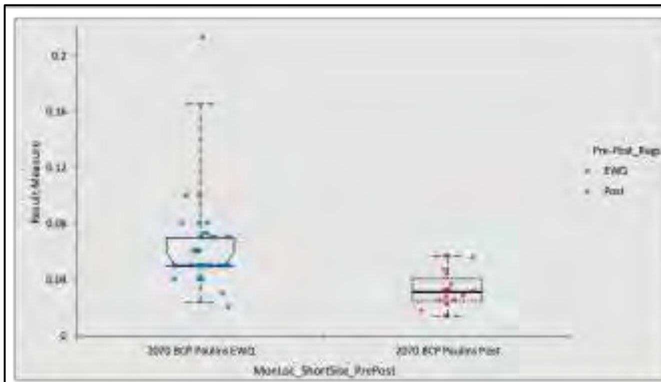
Phosphorus as P, Total (TP) mg/l

Existing Water Quality (Table 2D):

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

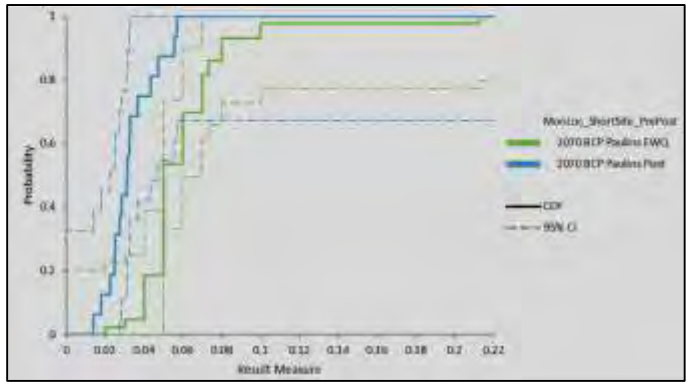






N 59

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
2070 BCP Paulins EWQ	0.020	0.050	0.050	0.070	0.213	0.020
2070 BCP Paulins Post	0.014	0.025	0.031	0.041	0.057	0.016



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
2070 BCP Paulins EWQ	43	1657.9	38.56
2070 BCP Paulins Post	16	4455.6	278.47

H statistic	21.14
X^2 approximation	21.14
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.

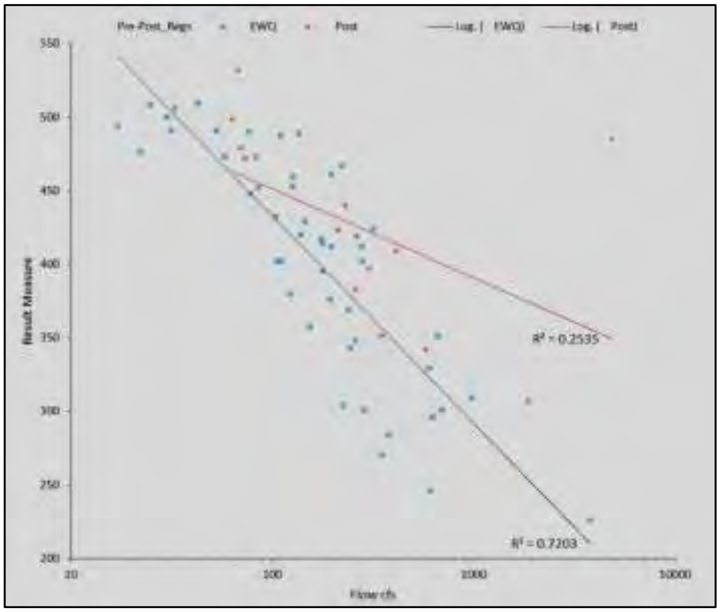
No water quality degradation is evident here. Total Phosphorus (TP) concentrations apparently declined between the EWQ and post-EWQ periods. Analytical uncertainty was introduced by potential laboratory artifacts and insufficient post-EWQ sampling rate (n=16). Post-EWQ median total phosphorus fell below the EWQ lower 95% confidence interval. TP is unrelated to flow in both data sets. There were no undetected results in either data set. No independent data were available to confirm DRBC results.

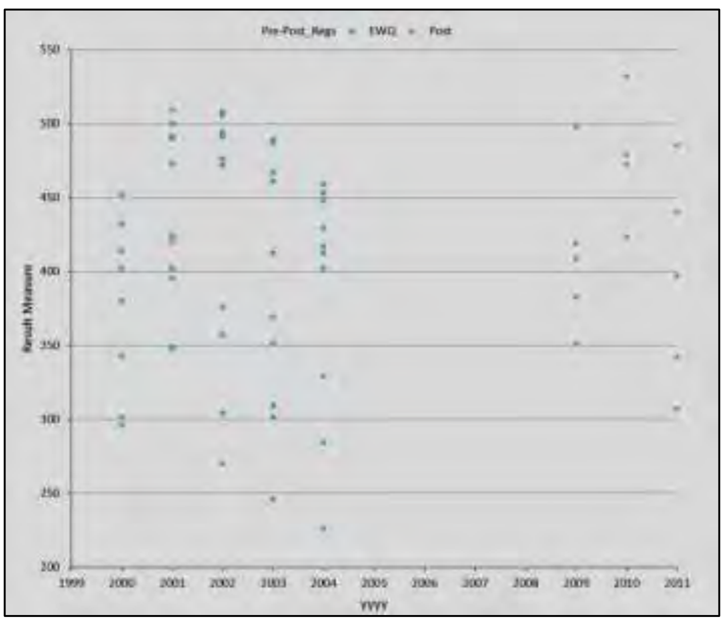
Chapter 23: 2070 BCP Paulins Kill at Rt. 46, NJ

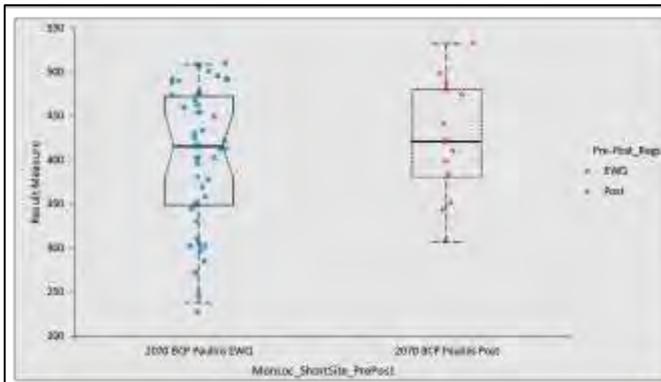
Specific Conductance µmho/cm

Existing Water Quality (Table 2D):

Median 416 µmho/cm
Lower 95% Confidence Interval 380 µmho/cm
Upper 95% Confidence Interval 453 µmho/cm
Defined in regulations as a flow-related parameter

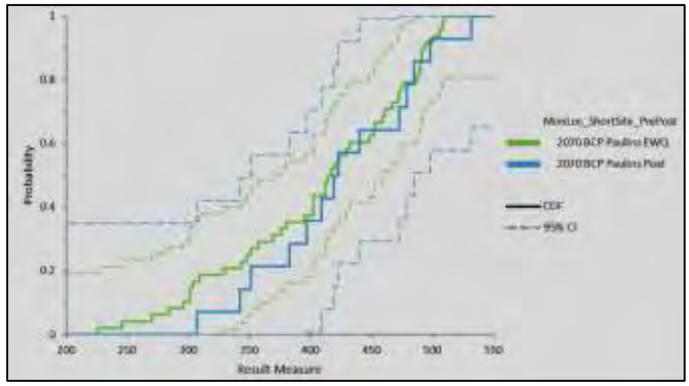






N		62

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
2070 BCP Paulins EWQ	226	349	416	473	509	123
2070 BCP Paulins Post	307	380	421	480	532	99



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
2070 BCP Paulins EWQ	48	25.5	0.53
2070 BCP Paulins Post	14	87.5	6.25

H statistic	0.35
X² approximation	0.35
DF	1
p-value	0.5556 [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.

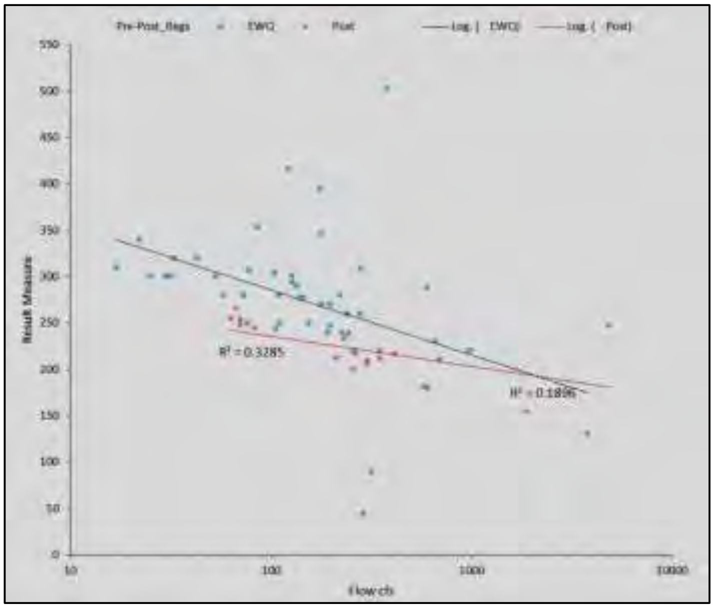
No water quality degradation is evident here. Specific conductance increased by only 5 µmho/cm between the EWQ and post-EWQ periods which was well within the EWQ 95% confidence intervals. There were an insufficient number of samples taken in the post-EWQ time frame (n=14). Biweekly instead of monthly sampling is recommended at this site. Specific conductance is inversely related to flow in both data sets, but due to too few samples the post-EWQ relationship is disrupted by a single unusual and unexplained value. The rise in specific conductance seen elsewhere is not apparent here. There were no available independent data to confirm results.

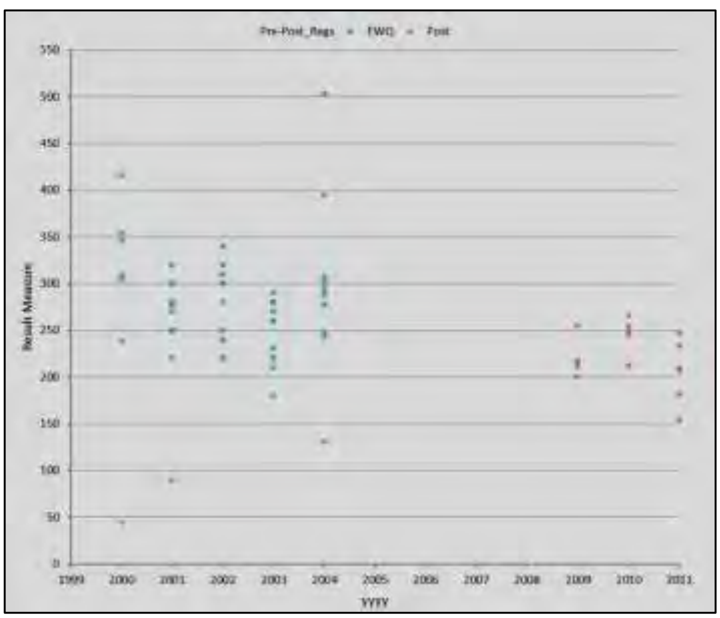
Chapter 23: 2070 BCP Paulins Kill at Rt. 46, NJ

Total Dissolved Solids (TDS) mg/l

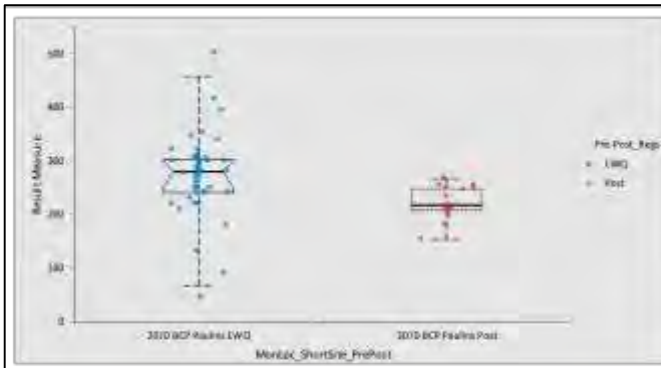
Existing Water Quality (Table 2D):

Median 280 mg/l
Lower 95% Confidence Interval 250 mg/l
Upper 95% Confidence Interval 300 mg/l
Defined in regulations as a flow-related parameter



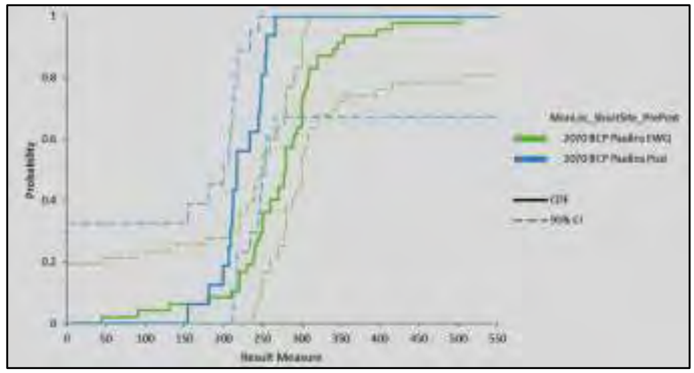


No water quality degradation is evident here. TDS apparently declined between the two periods.



N	63

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
2070 BCP Paulins EWQ	44	241	280	304	503	63
2070 BCP Paulins Post	154	208	217	248	266	40



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
2070 BCP Paulins EWQ	47	1175.0	25.00
2070 BCP Paulins Post	16	3451.6	215.72

H statistic	13.78
X^2 approximation	13.78
DF	1
p-value	0.0002[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.

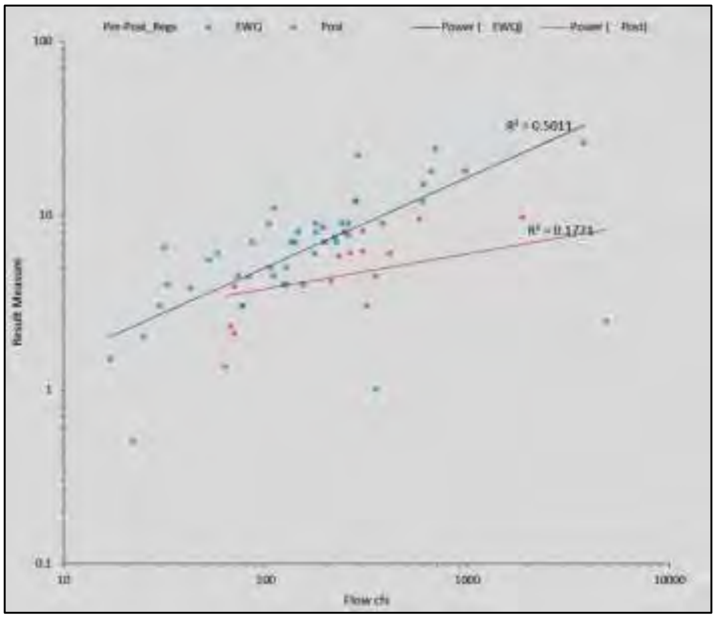
Analytical uncertainty was introduced by potential laboratory artifacts, insufficient post-EWQ sampling rate (n=16), and low-flow differences. TDS is weakly related to flow in both data sets. Post-EWQ median TDS fell below the EWQ lower 95% lower confidence interval, and was less variable than the baseline samples as well. Post-EWQ detection limits were lower than EWQ detection limits, though there were no undetected results at any time. Perhaps this decline is not real but an artifact of different laboratories. It should be noted that the 2003 data are comparable to 2009-2011 data, so some reduction shown here may be real. There were no independent data available for comparison with DRBC results.

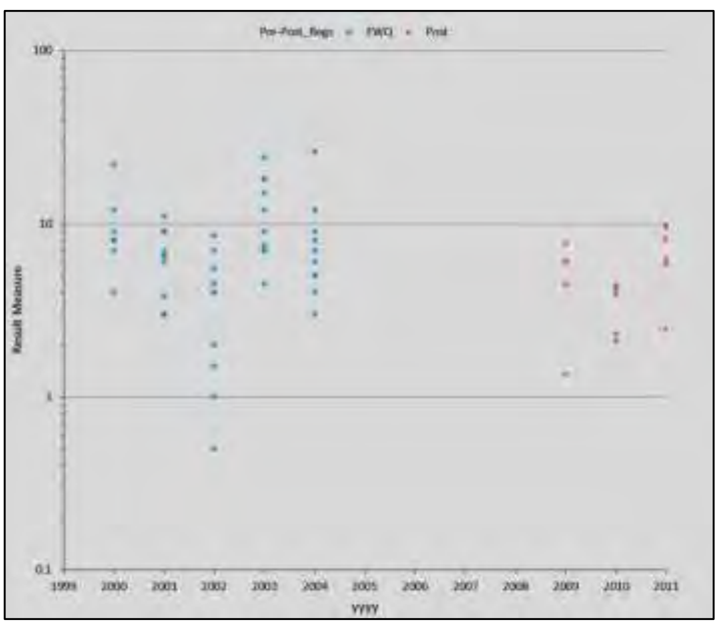
Chapter 23: 2070 BCP Paulins Kill at Rt. 46, NJ

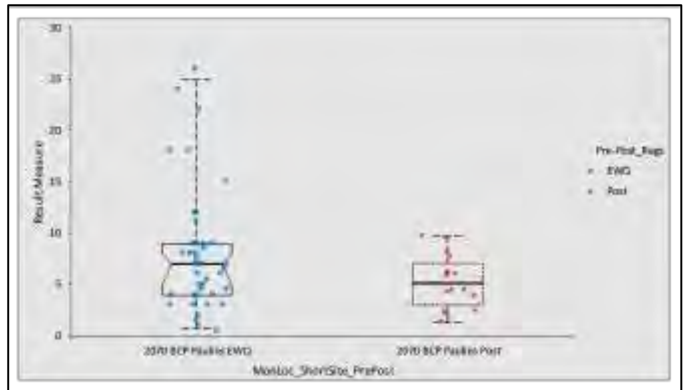
Total Suspended Solids (TSS) mg/l

Existing Water Quality (Table 2D):

Median 7.0 mg/l
Lower 95% Confidence Interval 5.0 mg/l
Upper 95% Confidence Interval 8.0 mg/l
*Should have been designated as flow-related in rules

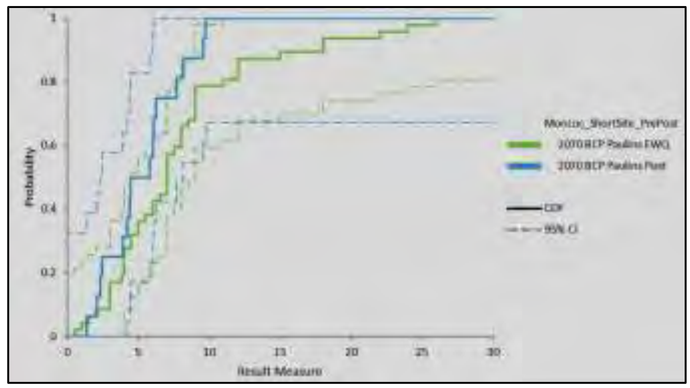






N | 63

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
2070 BCP Paulins EWQ	0.5	4.0	7.0	9.0	26.0	5.0
2070 BCP Paulins Post	1.3	3.1	5.1	7.1	9.7	4.0



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
2070 BCP Paulins EWQ	47	225.7	4.80
2070 BCP Paulins Post	16	663.1	41.44

H statistic	2.65
X² approximation	2.65
DF	1
p-value	0.1035 [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.

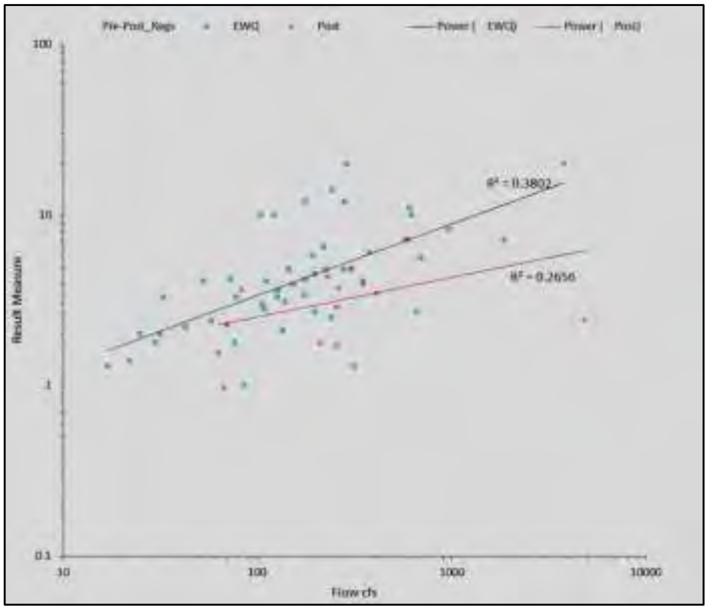
No water quality degradation is evident here. TSS apparently did not measurably change between the EWQ and post-EWQ periods. Analytical uncertainty was introduced by potential laboratory artifacts, insufficient post-EWQ sampling rate (n=16), and low-flow differences. TSS is positively related to flow in both data sets, though the post-EWQ relationship is very weak because of insufficient sampling (n=16). Post-EWQ median TSS fell near the lower EWQ 95% confidence interval. Flows and concentrations are plotted on logarithmic scale, and regressions are power relationships. There were no independent data available for comparison with DRBC results.

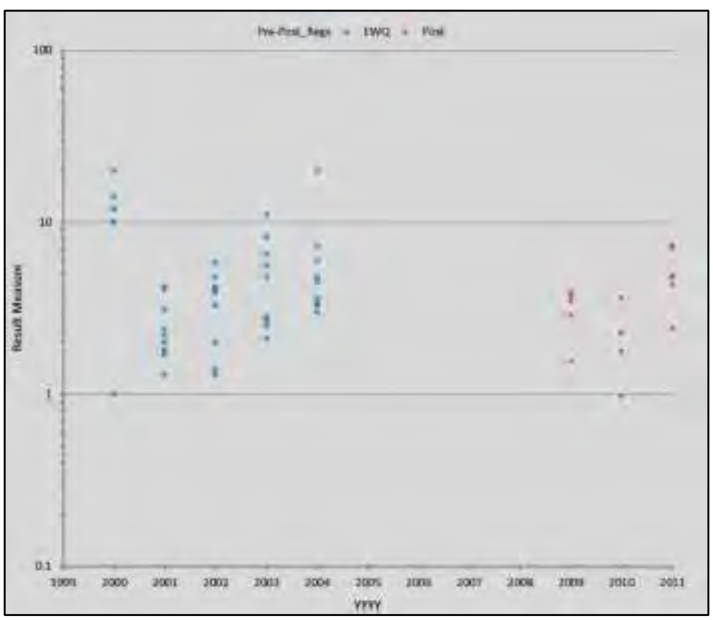
Chapter 23: 2070 BCP Paulins Kill at Rt. 46, NJ

Turbidity NTU

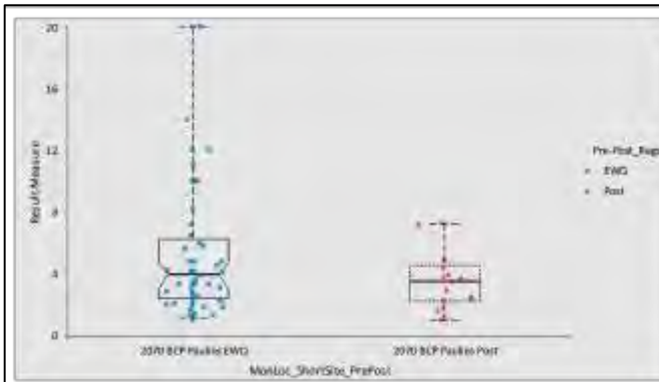
Existing Water Quality (Table 2D):

Median 4.0 NTU
Lower 95% Confidence Interval 3.0 NTU
Upper 95% Confidence Interval 4.8 NTU
Defined in regulations as a flow-related parameter



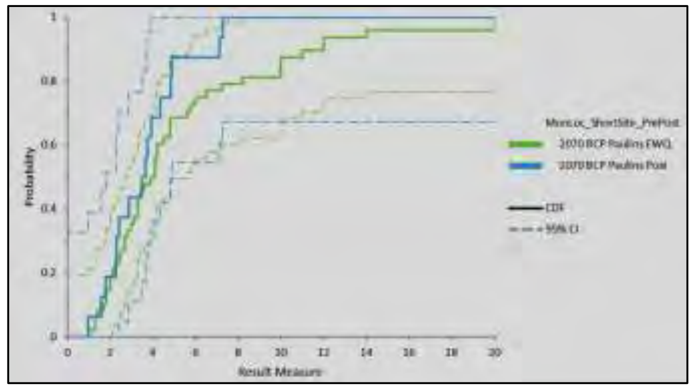


No water quality degradation is evident here. Turbidity apparently did not measurably change between the EWQ and post-EWQ periods.



N	64

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
2070 BCP Paulins EWQ	1.0	2.4	4.0	6.3	20.0	3.9
2070 BCP Paulins Post	1.0	2.3	3.6	4.6	7.3	2.3



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
2070 BCP Paulins EWQ	48	82.7	1.72
2070 BCP Paulins Post	16	248.1	15.50

H statistic	0.95
X^2 approximation	0.95
DF	1
p-value	0.3286 [1]

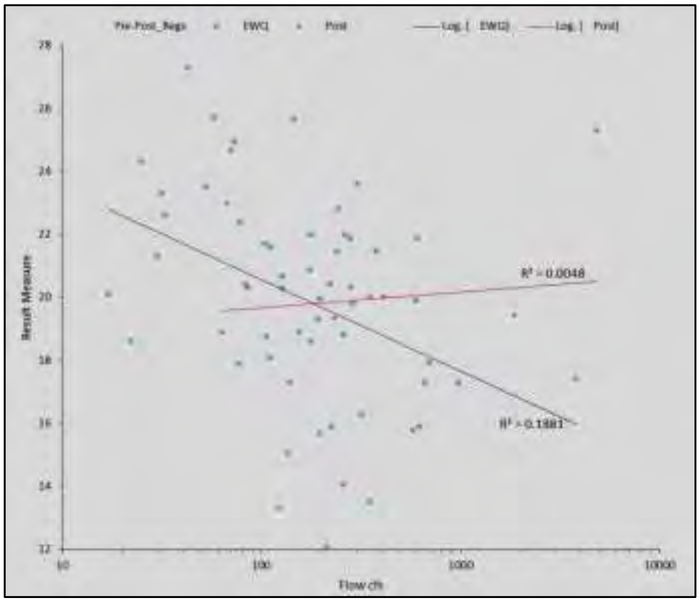
H0: $\theta_1 = \theta_2 = \theta ...$
The median of the populations are all equal.
H1: $\theta_i \neq \theta_j$ for at least one i,j
The median of the populations are not all equal.
[1] Do not reject the null hypothesis at the 5% significance level.

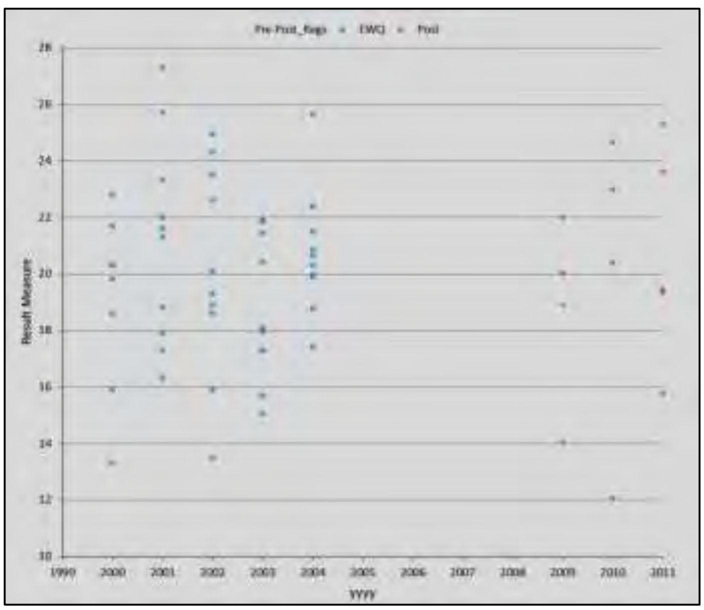
There were an insufficient number of post-EWQ samples (n=16), and too few samples taken under low-flow conditions. Post-EWQ median turbidity fell within the EWQ 95% confidence intervals of the median. Turbidity is positively related to flow in both data sets. The post-EWQ regression is weak because of the low sample number and insufficient range of flow conditions sampled. Concentrations and flows are represented on logarithmic scale, and regressions are power relationships. There were no independent data available for comparison with DRBC results. Biweekly instead of monthly sampling is recommended at this location.

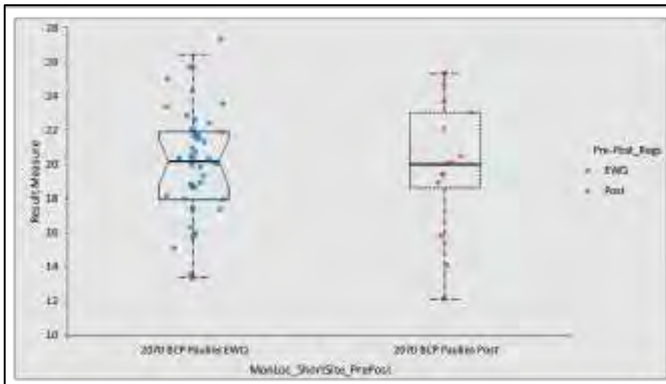
Chapter 23: 2070 BCP Paulins Kill at Rt. 46, NJ

Water Temperature, degrees C

Not included in DRBC Existing Water Quality rules

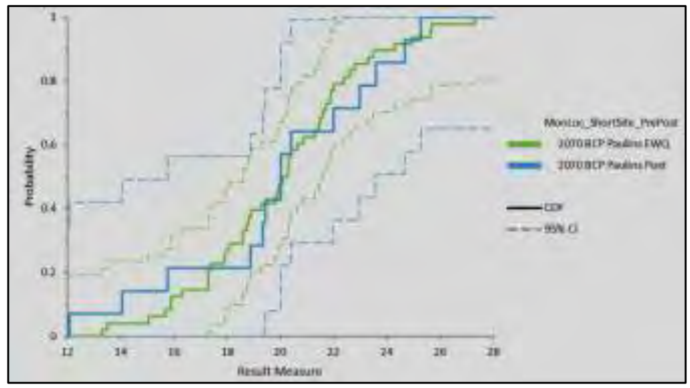






N 62

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
2070 BCP Paulins EWQ	13.3	17.9	20.2	21.9	27.3	4.0
2070 BCP Paulins Post	12.1	18.6	20.0	23.0	25.3	4.4



Kruskal-Wallis test

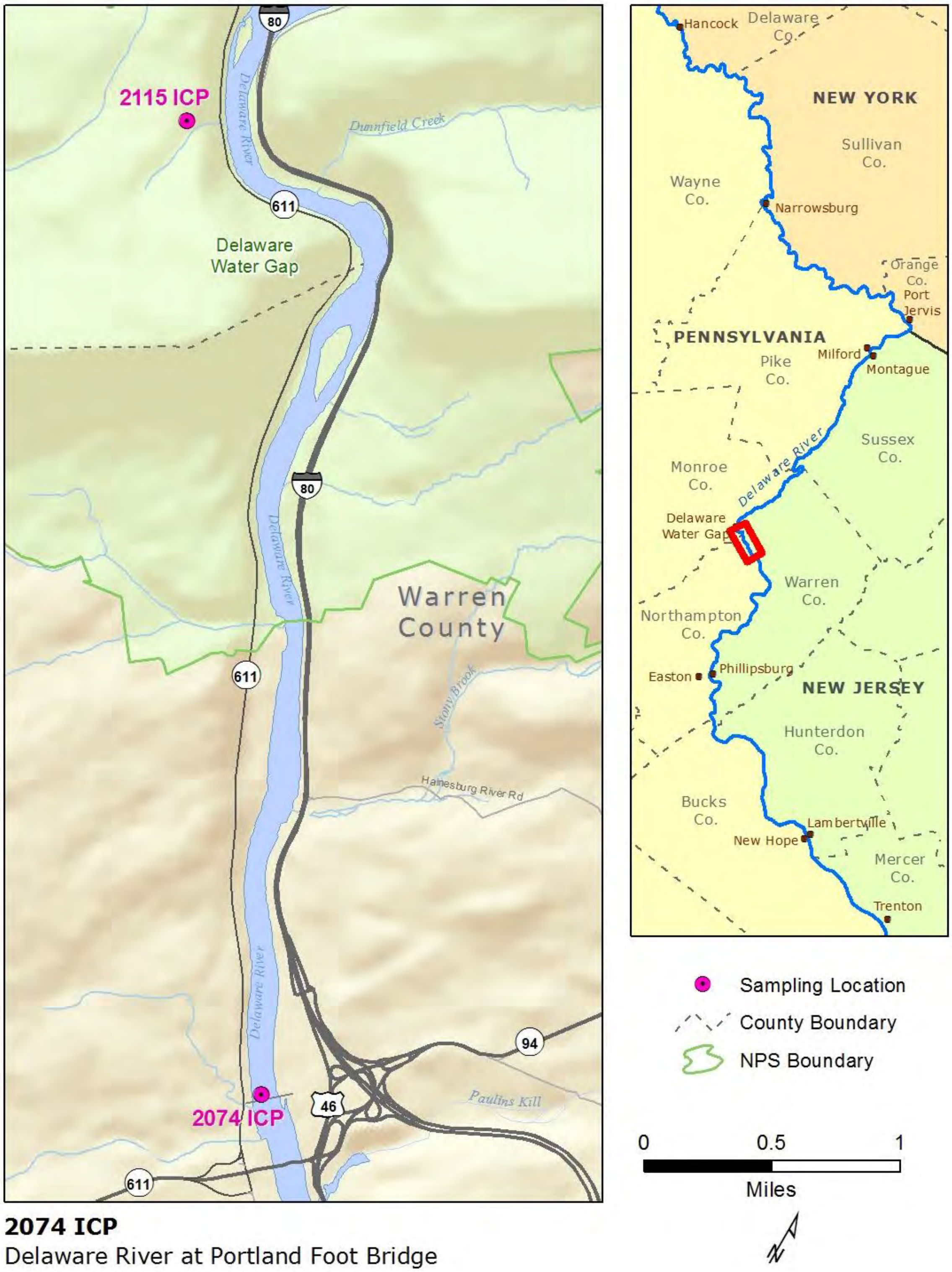
Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
2070 BCP Paulins EWQ	48	2.8	0.06
2070 BCP Paulins Post	14	9.4	0.67

H statistic	0.04
X^2 approximation	0.04
DF	1
p-value	0.8465 [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.

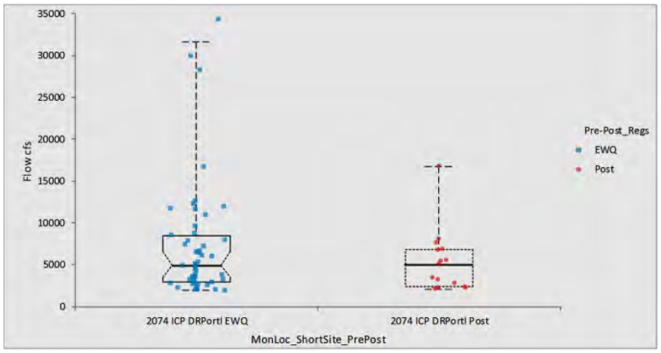
No water quality degradation is evident here. Water temperature did not measurably change between the EWQ and post-EWQ periods. There were an insufficient number of post-EWQ samples (n=14), and too few samples taken under low-flow conditions. Water temperature is unrelated to flow in either data set. Note that flows are plotted on logarithmic scale. No independent data were available for comparison with DRBC results.

Chapter 24: 2074 ICP Delaware River at Portland



2074 ICP
Delaware River at Portland Foot 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
2074 ICP DRPortl EWQ	1896	2920	4907	8463	34245	5543
2074 ICP DRPortl Post	2039	2409	5015	6813	16715	4404

Flow was roughly the same between the EWQ and post-EWQ periods, with a median difference of about 100 cfs. Too few samples were collected in the post-EWQ period (n=15). Considering the under-representation of the flow regime in post-EWQ data, it is possible that water quality differences can falsely be 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
2074 ICP DRPortl EWQ	50	40.5	0.81
2074 ICP DRPortl Post	15	135.0	9.00

H statistic	0.49
X^2 approximation	0.49
DF	1
p-value	0.4835[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.

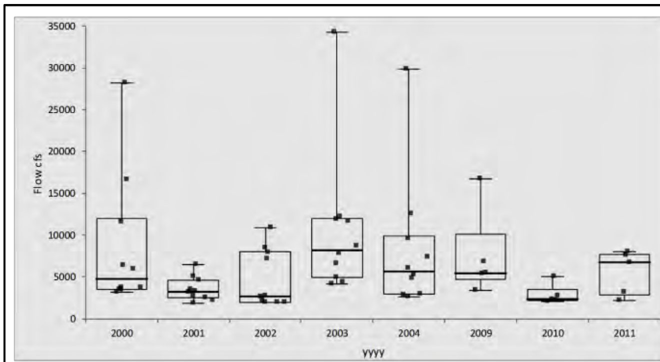
[1] Do not reject the null hypothesis at the 5% significance level.

Upstream ICP: Del. River at Kittatinny Visitor Center 2115 ICP
Downstream ICP: Del. River at Belvidere 1978 ICP

Tributary BCP Watersheds in Upstream Reach:

Slateford Creek, PA – 2095 BCP (new, see Appendix A)
Dunnfield Creek, NJ – 2114 BCP (Middle Delaware)

Both are small tributaries that do not have a major effect on the Delaware River.



N | 65

Flow cfs by yyyy	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
2000	3173	3524	4819	11993	28181	8469
2001	1896	2526	3207	4606	6534	2080
2002	1944	2011	2654	7977	10861	5966
2003	4136	4916	8232	11968	34245	7052
2004	2660	2920	5679	9852	29907	6932
2009	3416	4696	5446	10127	16715	5431
2010	2039	2168	2342	3502	5015	1335
2011	2190	2830	6714	7724	7999	4894

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 7,410 cfs; harmonic mean flow is about 6,850 cfs; and average May to September flow is about 5,300 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 then estimated at Portland by applying a drainage area weighting factor.

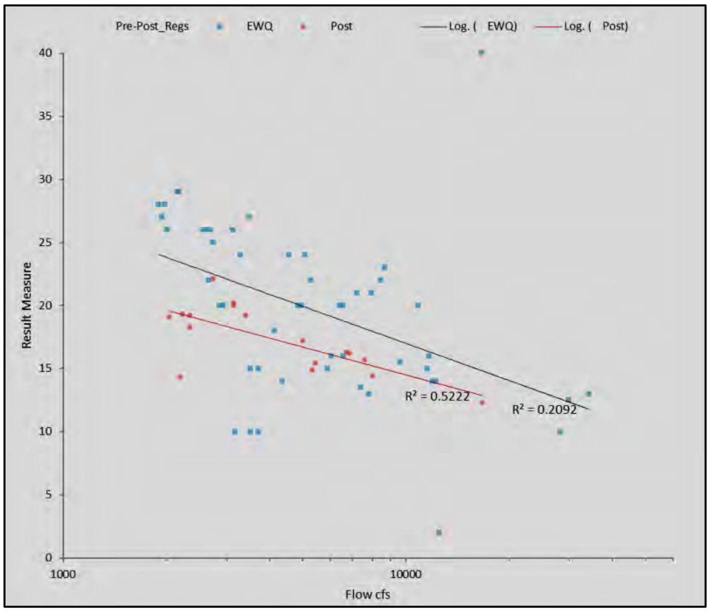
USGS and NJDEP have also monitored water quality monitoring at this site. They sample once per quarter every year, whereas DRBC samples twice per month from May through September for selected multi-year study periods. DRBC uses the NJDEP/USGS data to check its own results and to supplement the long-term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

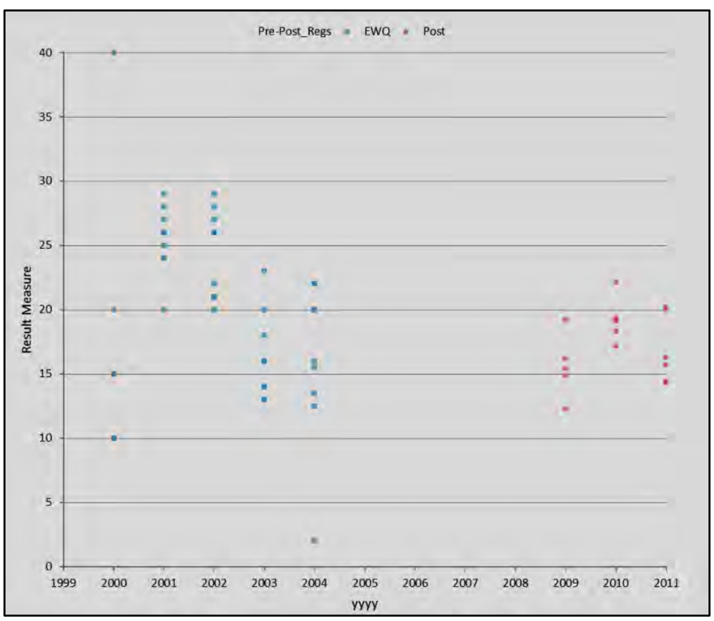
Chapter 24: 2074 ICP Delaware River at Portland

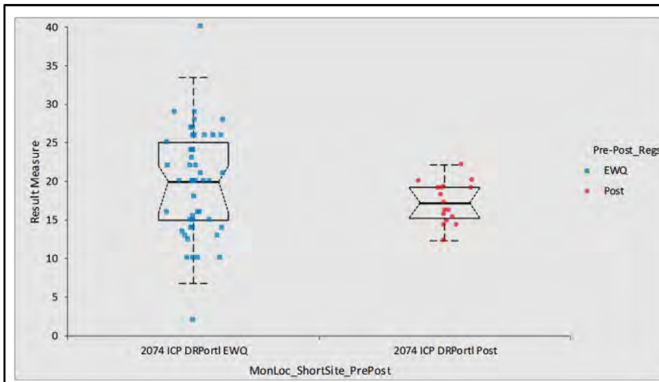
Alkalinity as CaCO3, Total mg/l

Existing Water Quality (Table 2C):

Median 20 mg/l
Lower 95% Confidence Interval 16 mg/l
Upper 95% Confidence Interval 22 mg/l
Defined in regulations as a flow-related parameter

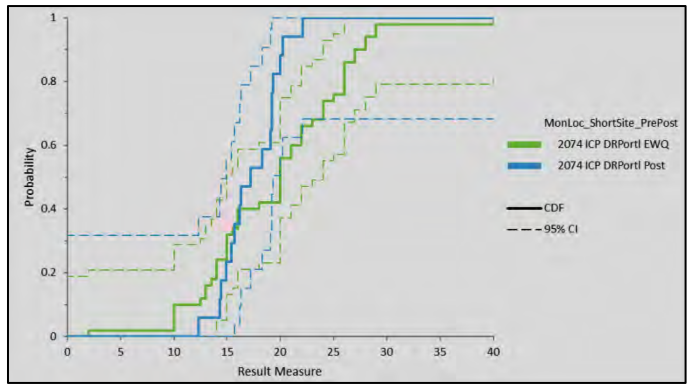






N 67

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
2074 ICP DRPortl EWQ	2	15	20	25	40	10
2074 ICP DRPortl Post	12	15	17	19	22	4



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
2074 ICP DRPortl EWQ	50	202.0	4.04
2074 ICP DRPortl Post	17	594.1	34.95

H statistic	2.10
X^2 approximation	2.10
DF	1
p-value	0.1470 [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.

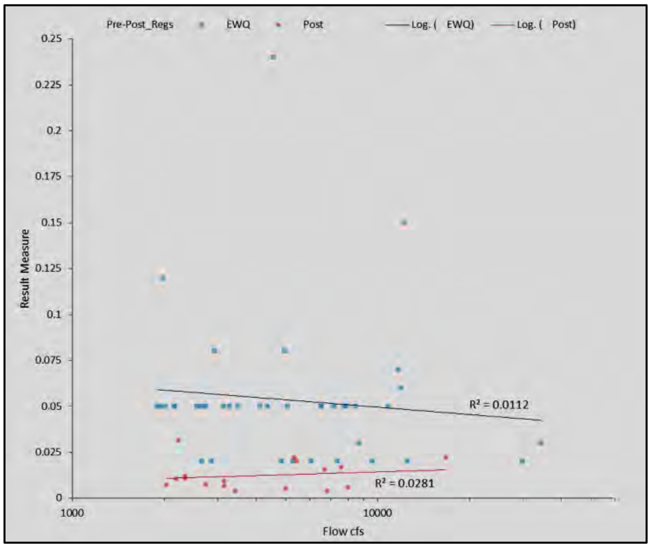
No water quality degradation is evident here. Alkalinity apparently did not measurably change between the EWQ and post-EWQ periods. However, sources of analytical uncertainty include potential laboratory artifacts, insufficient post-EWQ sampling frequency (n=17), and possible under-representation of 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. NJDEP/USGS data were comparable with DRBC results.

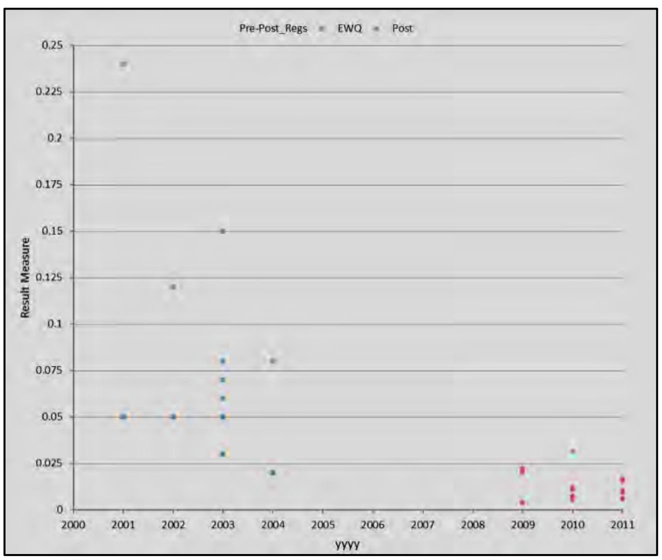
Chapter 24: 2074 ICP Delaware River at Portland

Ammonia Nitrogen as N, Total mg/l

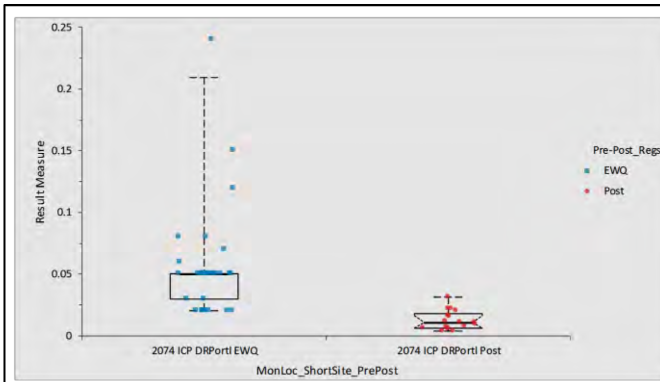
Existing Water Quality (Table 2C):

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

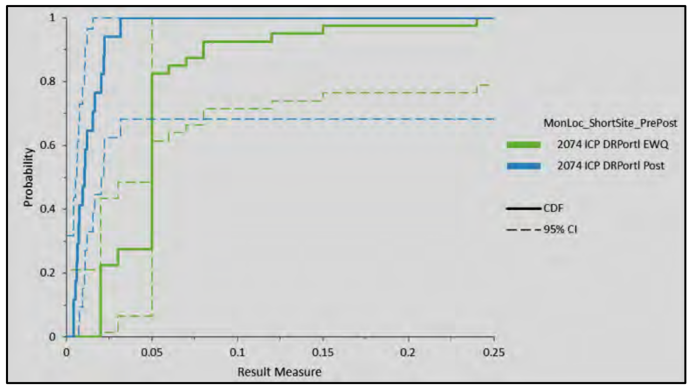




No water quality degradation is evident here. Ammonia concentrations apparently declined; or at least we now know what ammonia concentrations are at Portland. Sources of analytical uncertainty include potential laboratory artifacts, detection limit differences, and insufficient post-EWQ sampling frequency (n=17).



N	57					
Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
2074 ICP DRPortl EWQ	0.020	0.030	0.050	0.050	0.240	0.020
2074 ICP DRPortl Post	0.004	0.006	0.011	0.018	0.032	0.012



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
2074 ICP DRPortl EWQ	40	2280.1	57.00
2074 ICP DRPortl Post	17	5364.9	315.58

H statistic	29.56
X^2 approximation	29.56
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.

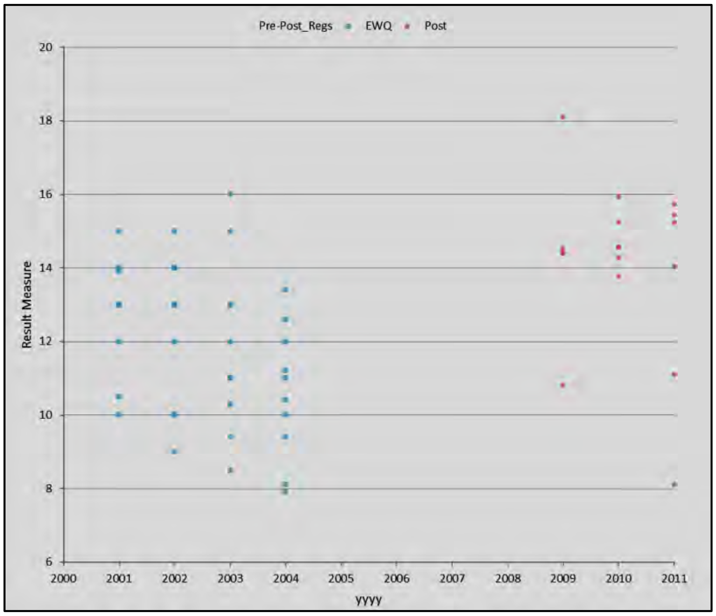
Post-EWQ median ammonia concentration was below the EWQ lower 95% confidence interval. Ammonia is unrelated to flow in both data sets. EWQ data contained 33/40 undetected results that interfered with calculation of the median (thus EWQ <0.05 mg/l). Under 2009-2011 lower detection levels there were 3/17 undetected results and it was possible to see the true median. Perhaps some water quality improvement took place, as post-EWQ data contained concentrations no greater than 0.032 mg/l. NJDEP/USGS data were comparable to DRBC results, with high non-detect frequency and similar concentrations.

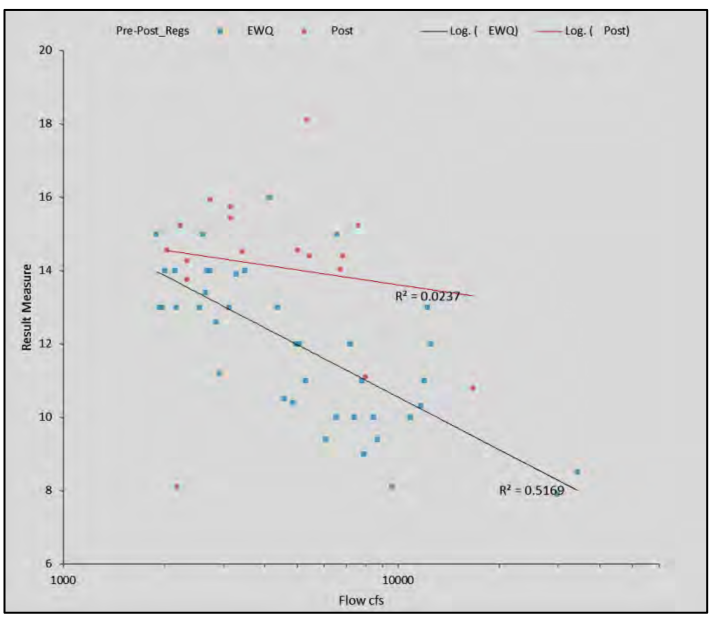
Chapter 24: 2074 ICP Delaware River at Portland

Chloride, Total mg/l

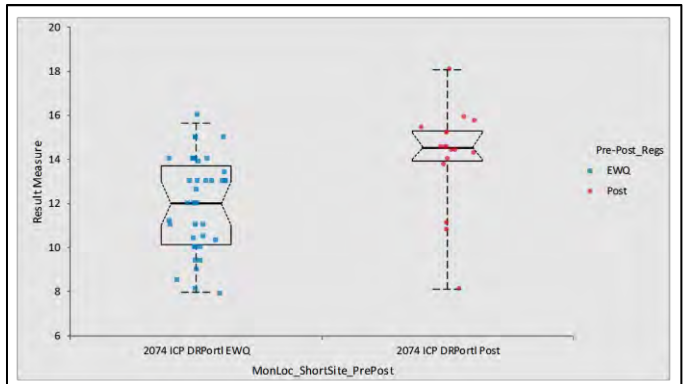
Existing Water Quality (Table 2C):

Median 12 mg/l
Lower 95% Confidence Interval 11 mg/l
Upper 95% Confidence Interval 13 mg/l
Defined in regulations as a flow-related parameter

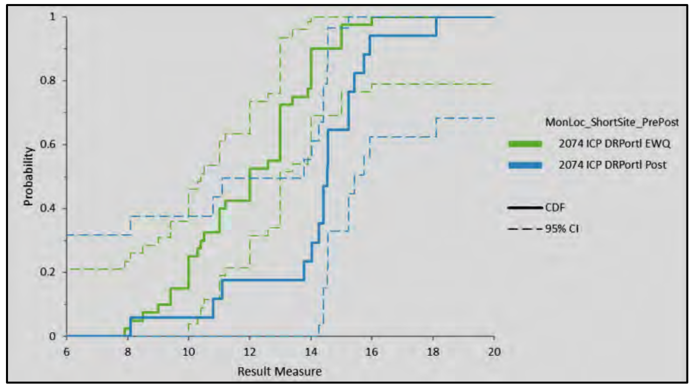




Water quality degradation is evident here. Median chloride concentrations apparently rose by 3 mg/l between the two periods.



	N	57				
Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
2074 ICP DRPortl EWQ	8	10	12	14	16	4
2074 ICP DRPortl Post	8	14	15	15	18	1



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
2074 ICP DRPortl EWQ	40	1076.4	26.91
2074 ICP DRPortl Post	17	2532.7	148.98

H statistic	13.15
X^2 approximation	13.15
DF	1
p-value	0.0003 [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.

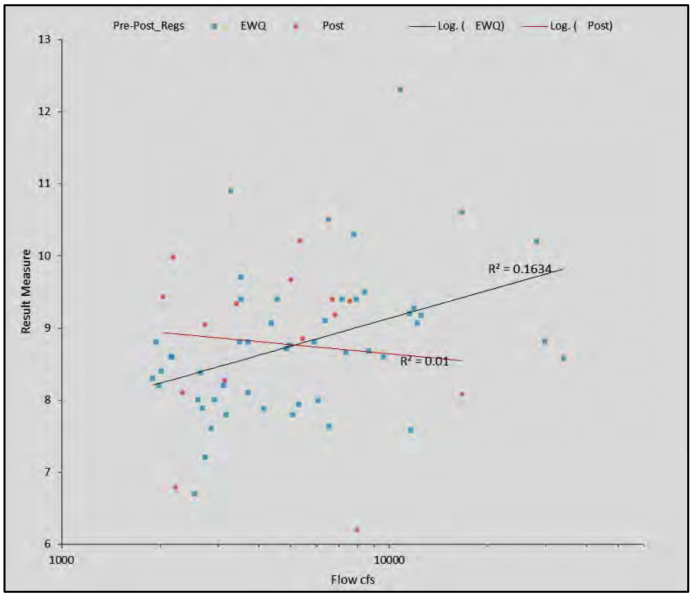
Sources of analytical uncertainty include potential laboratory artifacts, insufficient post-EWQ sampling frequency (n=17), and under-representation of flow conditions. Post-EWQ median concentration rose above the EWQ upper 95% confidence interval. Chloride concentration is inversely related to flow in EWQ data, but unrelated in post-EWQ data. NJDEP and USGS data were similar to DRBC results; displayed a slight increase in chloride concentrations (sampling dissolved rather than DRBC's total chlorides).

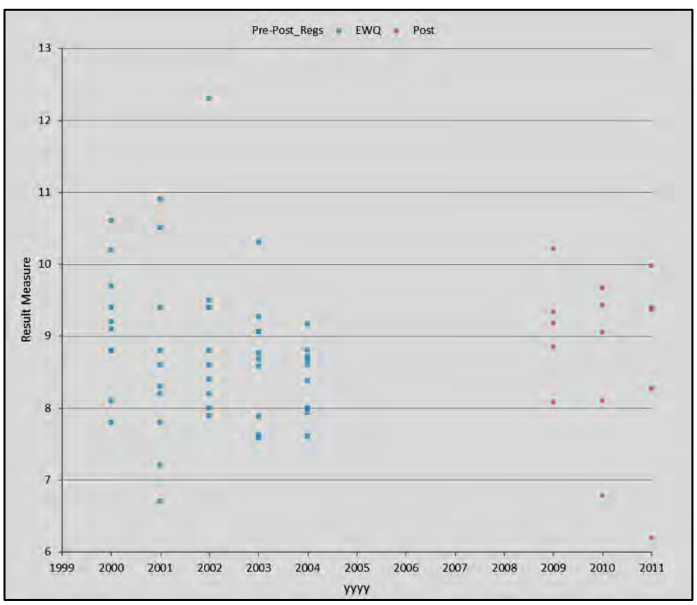
Chapter 24: 2074 ICP Delaware River at Portland

Dissolved Oxygen (DO) mg/l

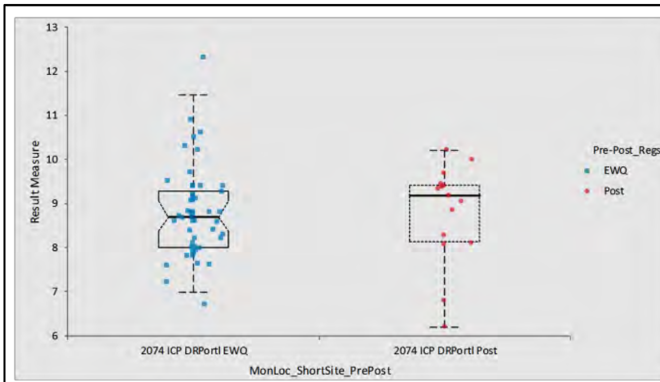
Existing Water Quality (Table 2C):

Median 8.70 mg/l
Lower 95% Confidence Interval 8.38 mg/l
Upper 95% Confidence Interval 9.06 mg/l



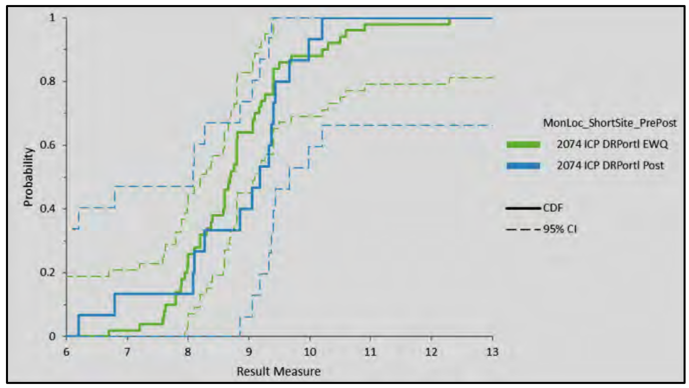


No water quality degradation is evident here. No measurable change took place between the EWQ and Post-EWQ periods. Sources of analytical uncertainty include insufficient post-EWQ sampling frequency (n=15) and under-representation of flow conditions.



N 65

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
2074 ICP DRPortl EWQ	6.70	8.00	8.70	9.28	12.30	1.28
2074 ICP DRPortl Post	6.20	8.13	9.18	9.43	10.21	1.30



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
2074 ICP DRPortl EWQ	50	68.4	1.37
2074 ICP DRPortl Post	15	228.2	15.21

H statistic	0.83
X^2 approximation	0.83
DF	1
p-value	0.3622 [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.

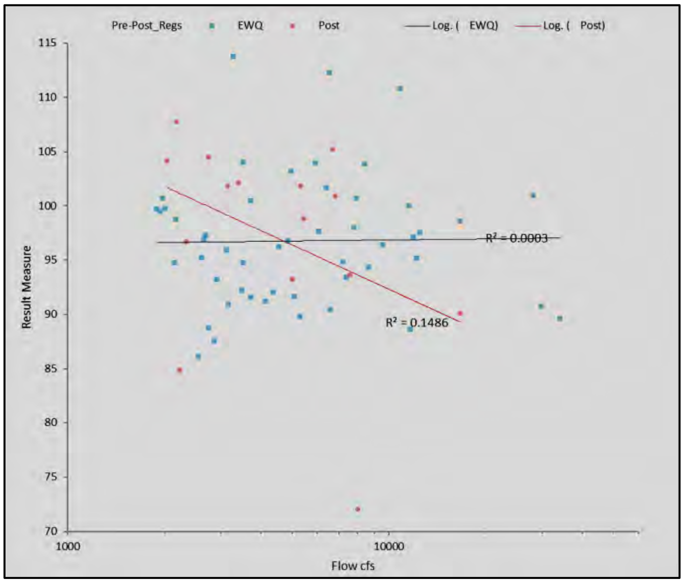
Post-EWQ median DO concentration was above the upper EWQ 95% confidence interval, but the increase was not significant due to an insufficient number of post-EWQ samples (n=15). DO concentration is unrelated to flow in both data sets. The low reading below 7 mg/l in 2010 was probably a probe malfunction. The low reading near 6 mg/l in 2011 could also have been a probe malfunction or may have been real, as other meter readings that day were within expected ranges. NJDEP/USGS data were comparable to DRBC results.

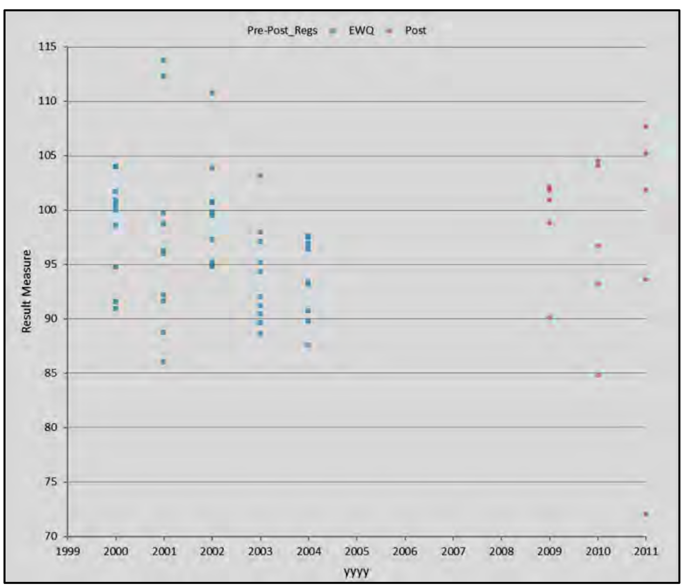
Chapter 24: 2074 ICP Delaware River at Portland

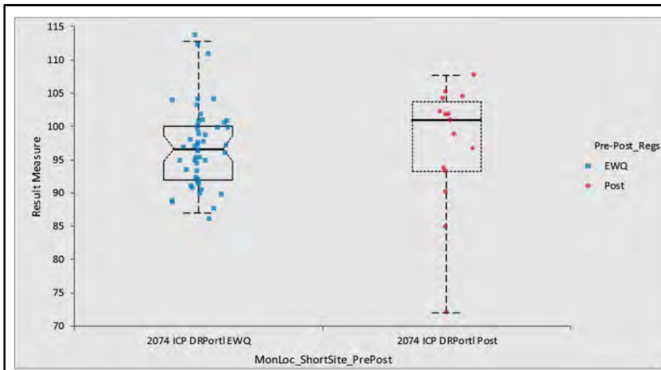
Dissolved Oxygen Saturation %

Existing Water Quality (Table 2C):

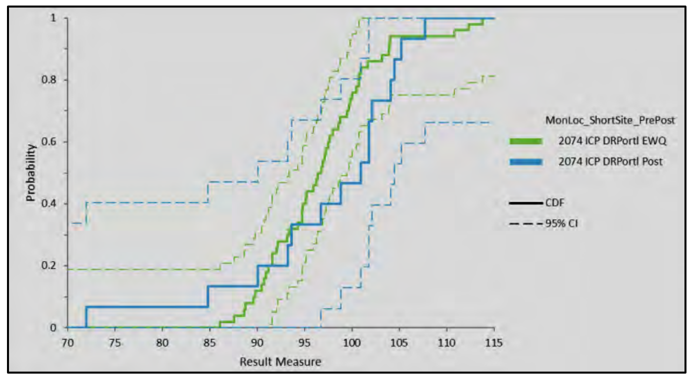
Median 97%
Lower 95% Confidence Interval 95%
Upper 95% Confidence Interval 99%







N	65					
Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
2074 ICP DRPortl EWQ	86	92	97	100	114	8
2074 ICP DRPortl Post	72	93	101	104	108	11



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
2074 ICP DRPortl EWQ	50	124.8	2.50
2074 ICP DRPortl Post	15	416.1	27.74

H statistic	1.51
X^2 approximation	1.51
DF	1
p-value	0.2187[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.

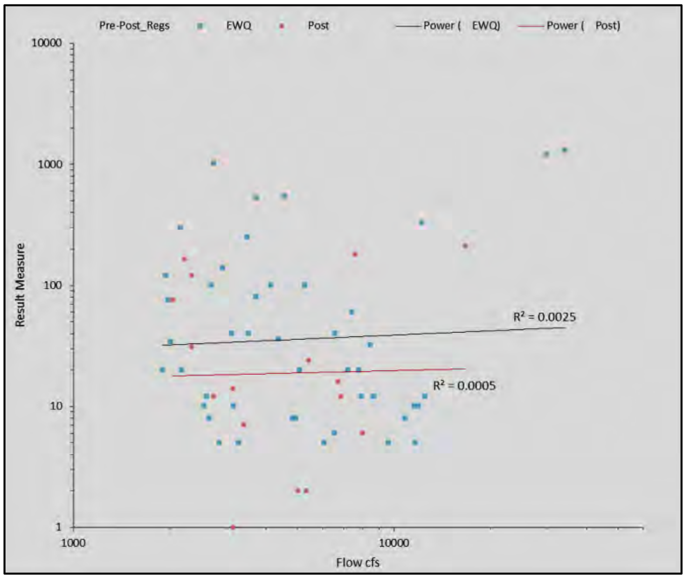
No water quality degradation is evident here. Dissolved Oxygen Saturation is unrelated to flow, and did not measurably change between the EWQ and post-EWQ periods. Sources of analytical uncertainty include insufficient post-EWQ sampling frequency (n=15) and under-representation of flow conditions. Post-EWQ median DO saturation was above the upper EWQ 95% confidence interval, but the difference was not significant due to an insufficient number of post-EWQ samples (n=15). There was a low saturation values of 72% measured in July 2011, which was possibly a probe malfunction. Biweekly instead of monthly sampling is recommended for this location. NJDEP/USGS data were similar to DRBC results.

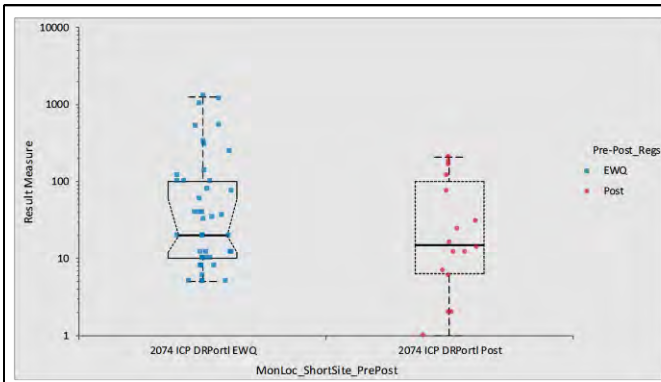
Chapter 24: 2074 ICP Delaware River at Portland

Enterococcus colonies/100 ml

Existing Water Quality (Table 2C):

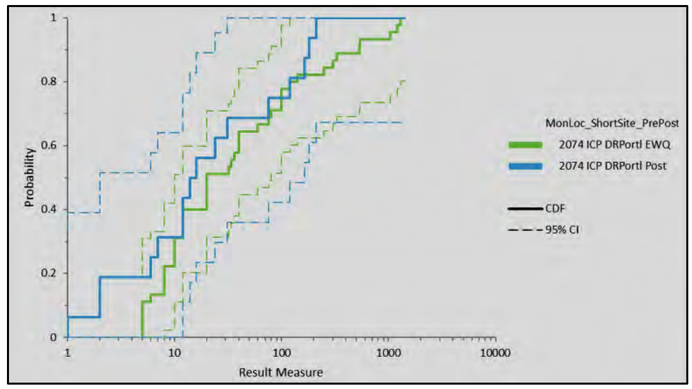
Median 20/100 ml
Lower 95% Confidence Interval 12/100 ml
Upper 95% Confidence Interval 60/100 ml

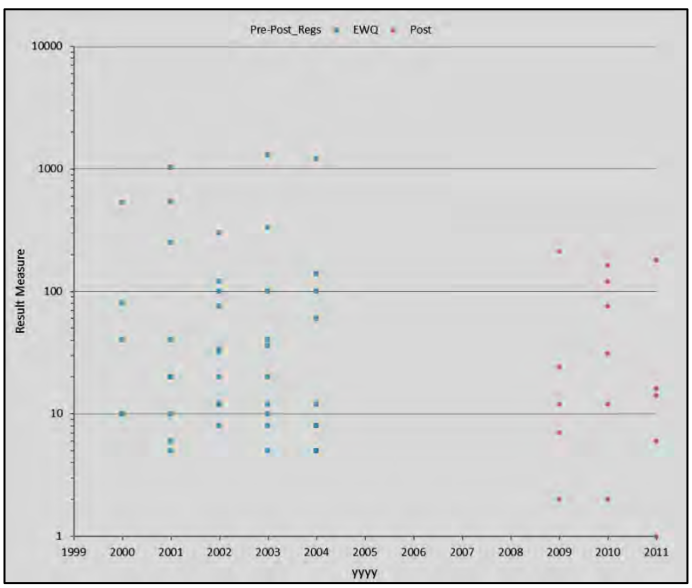




N 61

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
2074 ICP DRPortl EWQ	5	10	20	100	1300	90
2074 ICP DRPortl Post	1	6	15	102	210	95





Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
2074 ICP DRPortl EWQ	45	73.5	1.63
2074 ICP DRPortl Post	16	206.6	12.92

H statistic	0.89
X² approximation	0.89
DF	1
p-value	0.3451 [1]

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

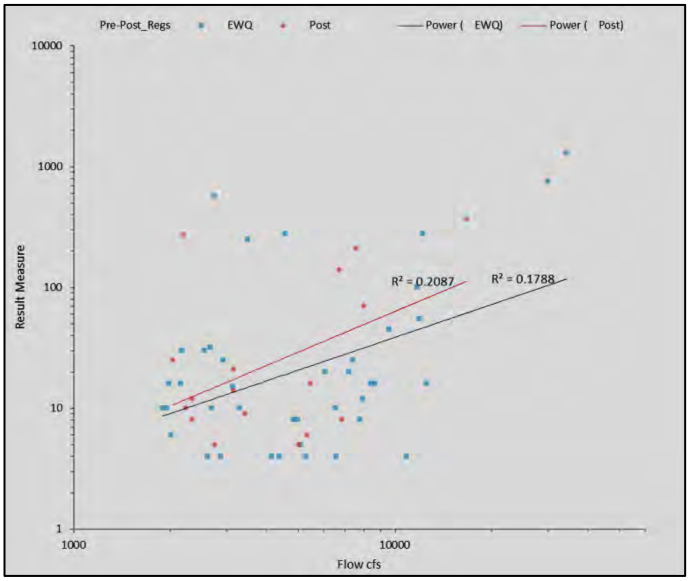
No water quality degradation is evident here. Enterococci apparently did not measurably change between the EWQ and Post-EWQ periods. Sources of analytical uncertainty include potential laboratory artifacts and insufficient post-EWQ sampling frequency (n=17). Biweekly instead of monthly sampling is recommended. Enterococcus concentrations are unrelated to flow in both data sets. Post-EWQ median enterococcus concentrations fell slightly but remained within the EWQ 95% confidence intervals. NJDEP/USGS data were slightly higher than DRBC results, but displayed a similar slight decline in concentration.

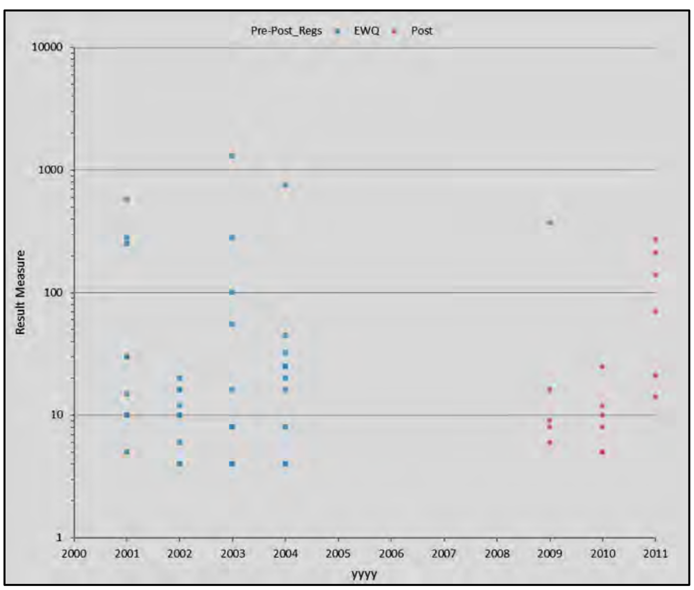
Chapter 24: 2074 ICP Delaware River at Portland

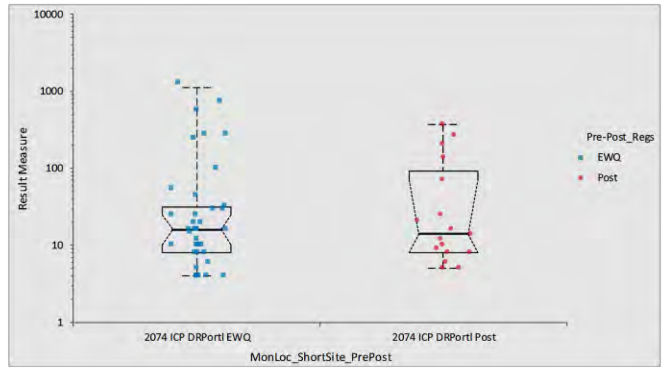
Escherichia coli colonies/100 ml

Existing Water Quality (Table 2C):

Median 16/100 ml
Lower 95% Confidence Interval 8/100 ml
Upper 95% Confidence Interval 25/100 ml
This was defined in rules as a flow-related parameter

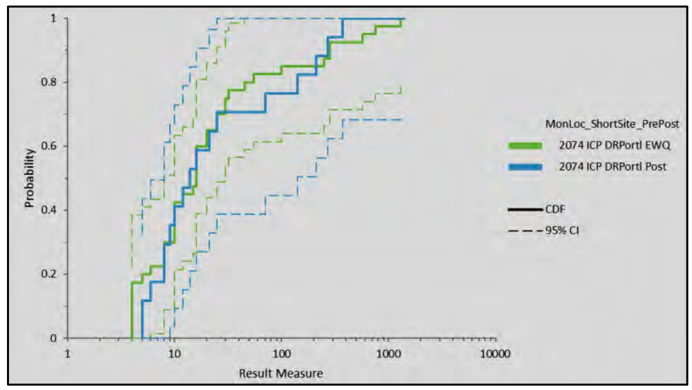






N 57

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
2074 ICP DRPortl EWQ	4	8	16	31	1300	23
2074 ICP DRPortl Post	5	8	14	93	370	85



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
2074 ICP DRPortl EWQ	40	4.9	0.12
2074 ICP DRPortl Post	17	11.5	0.68

H statistic	0.06
X² approximation	0.06
DF	1
p-value	0.8066 [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.

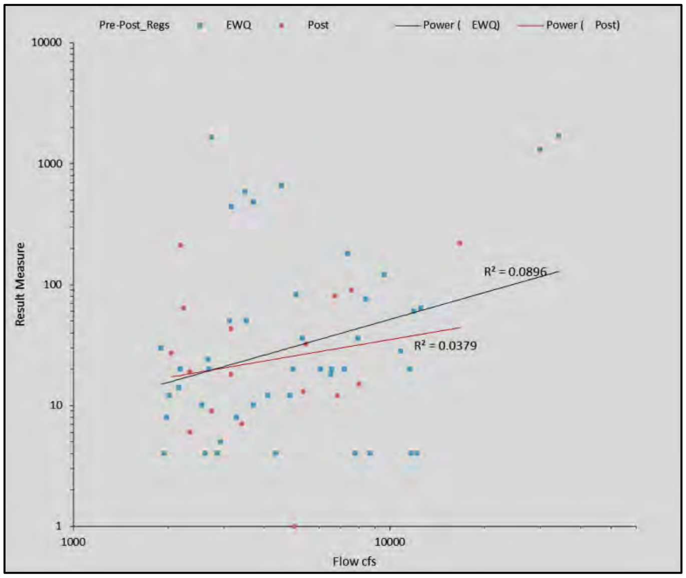
No water quality degradation is evident here. E. coli concentrations apparently did not measurably change between the two periods. Sources of analytical uncertainty include potential laboratory artifacts and insufficient post-EWQ sampling frequency (n=17). Post-EWQ median E. coli fell within the EWQ 95% confidence intervals. Biweekly instead of monthly sampling is recommended. E. coli concentrations are weakly related to flow in both data sets. NJDEP/USGS data were similar to DRBC results at this location.

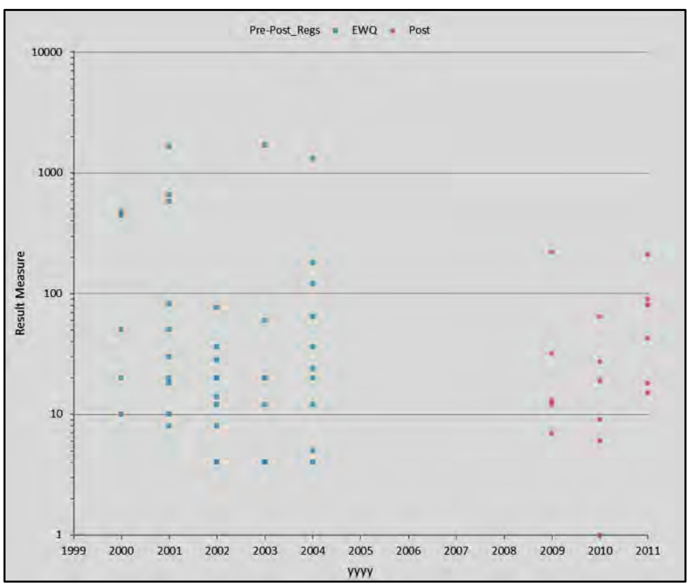
Chapter 24: 2074 ICP Delaware River at Portland

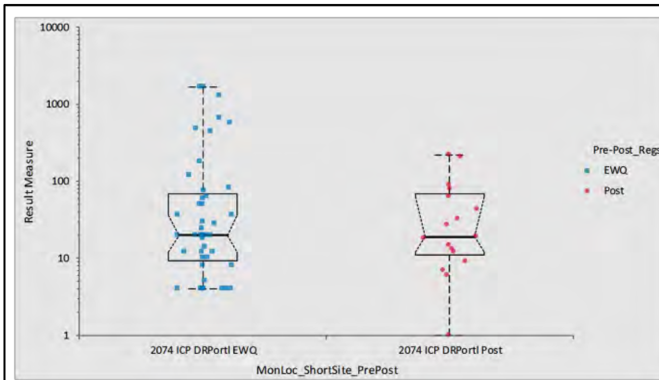
Fecal coliform colonies/100 ml

Existing Water Quality (Table 2C):

Median 20/100 ml
Lower 95% Confidence Interval 12/100 ml
Upper 95% Confidence Interval 36/100 ml
*Erroneously defined in regulations as a flow-related

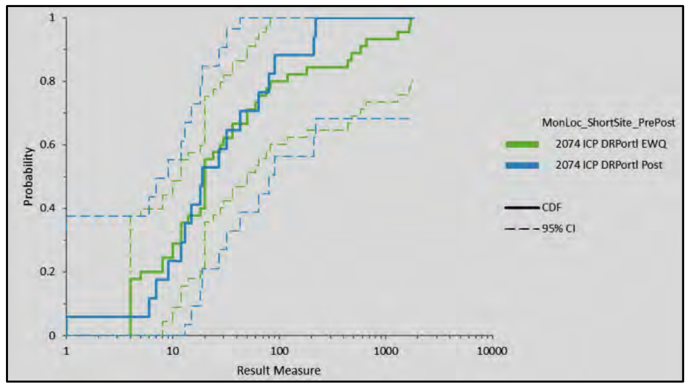






N | 62

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
2074 ICP DRPortl EWQ	4	9	20	68	1700	59
2074 ICP DRPortl Post	1	11	19	69	220	58



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
2074 ICP DRPortl EWQ	45	0.8	0.02
2074 ICP DRPortl Post	17	2.1	0.12

H statistic	0.01
X^2 approximation	0.01
DF	1
p-value	0.9244 [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.

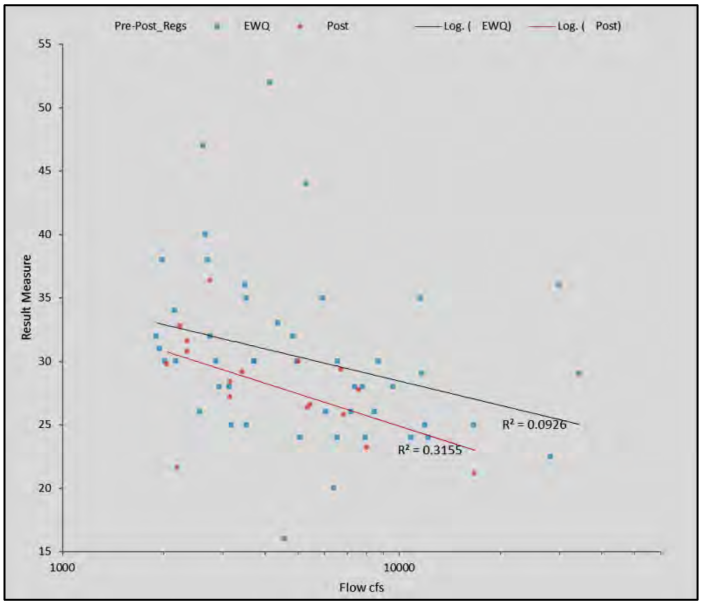
No water quality degradation is evident here. Fecal coliform concentrations apparently did not measurably change between the EWQ and post-EWQ periods. Sources of analytical uncertainty include potential laboratory artifacts and insufficient post-EWQ sampling frequency (n=17). There were fewer high results in the post-EWQ data set, but insufficient data to indicate a significant change. Fecal coliform concentrations are unrelated to flow in both data sets. Biweekly instead of monthly sampling is recommended. NJDEP/USGS data were similar to DRBC results, but possessed a high frequency of undetected results.

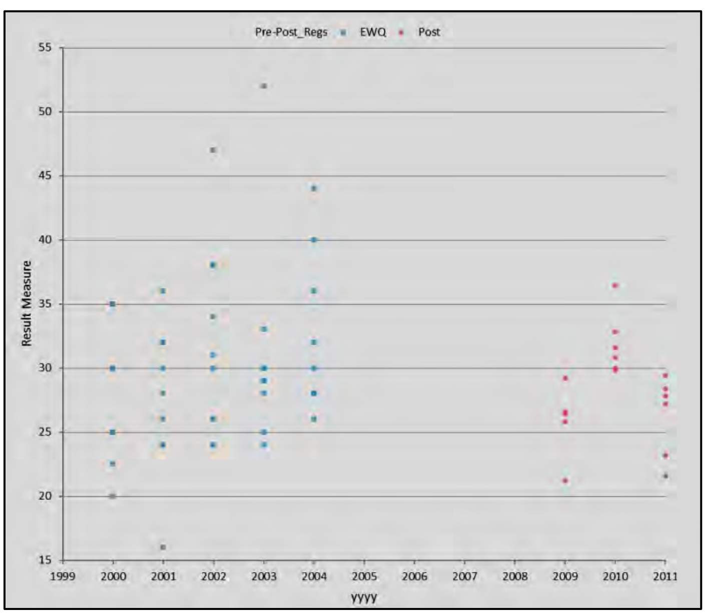
Chapter 24: 2074 ICP Delaware River at Portland

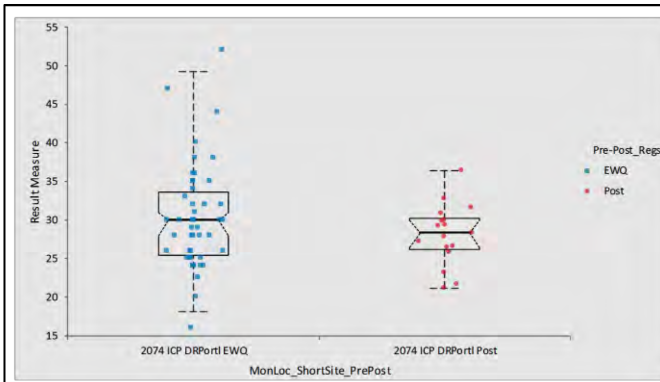
Hardness as CaCO3, Total mg/l

Existing Water Quality (Table 2C):

Median 30 mg/l
Lower 95% Confidence Interval 28 mg/l
Upper 95% Confidence Interval 31 mg/l

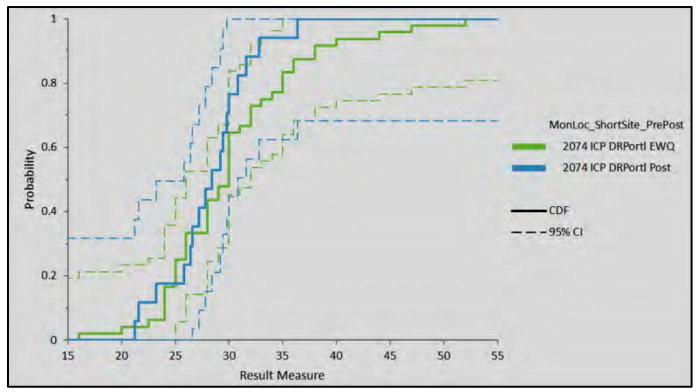






N 65

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
2074 ICP DRPortl EWQ	16	25	30	34	52	8
2074 ICP DRPortl Post	21	26	28	30	36	4



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
2074 ICP DRPortl EWQ	48	96.3	2.01
2074 ICP DRPortl Post	17	272.0	16.00

H statistic	1.03
X^2 approximation	1.03
DF	1
p-value	0.3091 [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.

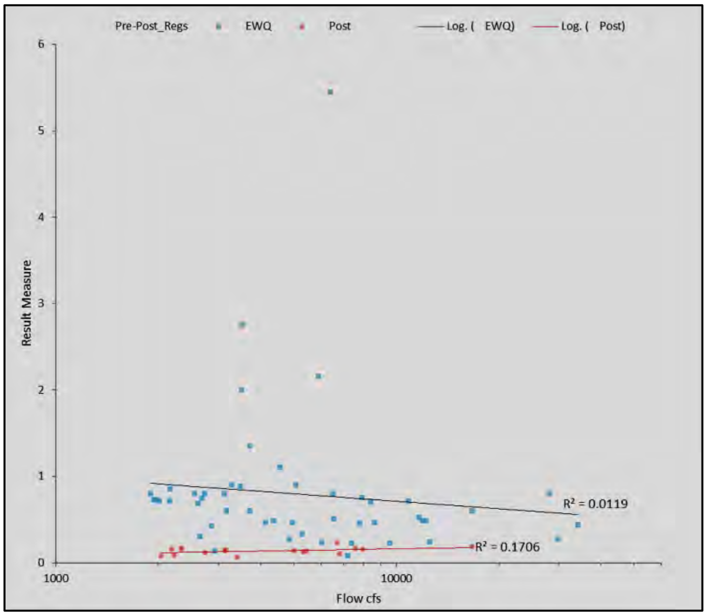
No water quality degradation is evident here. Hardness apparently did not measurably change between the EWQ and post-EWQ periods. Sources of analytical uncertainty include potential laboratory artifacts and insufficient post-EWQ sampling frequency (n=17). Hardness is unrelated to flow in the EWQ data set, but weakly and inversely related to flow in the post-EWQ data set. Post-EWQ median hardness fell within the EWQ 95% confidence intervals. USGS/NJDEP data were comparable with DRBC results.

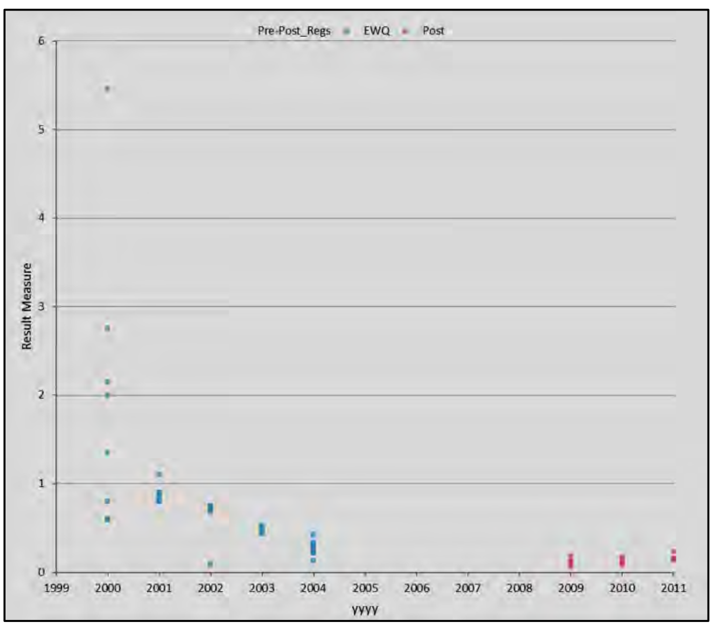
Chapter 24: 2074 ICP Delaware River at Portland

Nitrate + Nitrite as N, Total mg/l

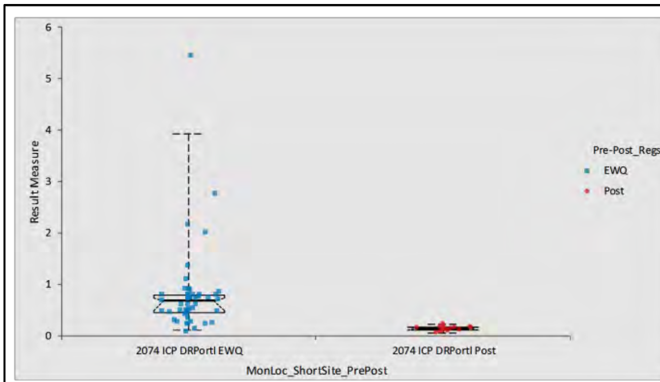
Existing Water Quality (Table 2C, as Nitrate only):

Median 0.68 mg/l
Lower 95% Confidence Interval 0.48 mg/l
Upper 95% Confidence Interval 0.74 mg/l



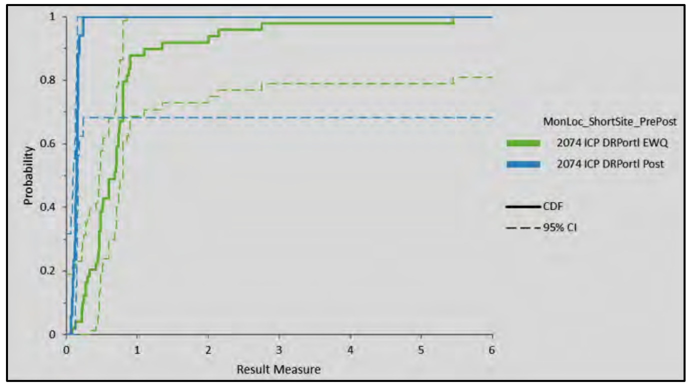


No water quality degradation is evident here. Nitrate concentrations apparently declined between the two periods.



N 66

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
2074 ICP DRPortl EWQ	0.080	0.447	0.680	0.800	5.450	0.353
2074 ICP DRPortl Post	0.060	0.111	0.142	0.163	0.231	0.052



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
2074 ICP DRPortl EWQ	49	3064.4	62.54
2074 ICP DRPortl Post	17	8832.7	519.57

H statistic	32.32
X^2 approximation	32.32
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.

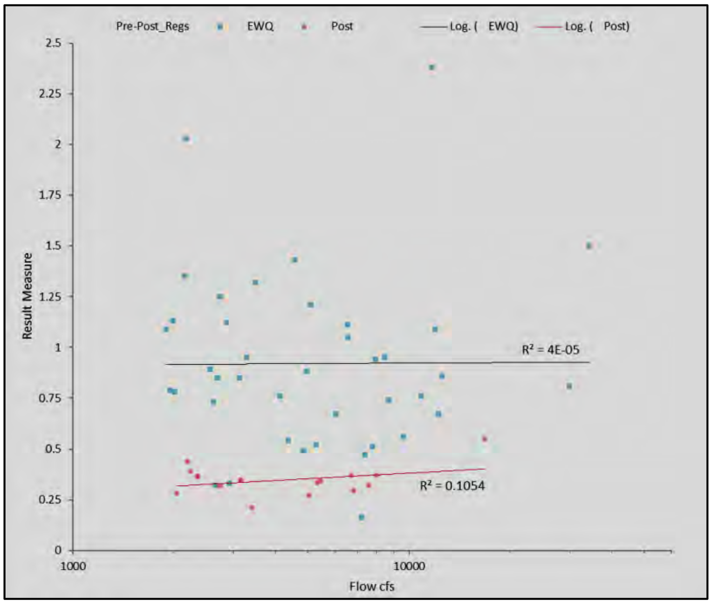
Sources of analytical uncertainty include potential laboratory artifacts and insufficient post-EWQ sampling frequency (n=17). Nitrate is unrelated to flow in either data set. The entire concentration scale is thrown off by the extremely variable results in 2000. Post-EWQ nitrate concentrations fell below the lower EWQ 95% confidence interval, and were less variable than EWQ nitrate. Post-EWQ nitrate + nitrite samples were assumed equivalent with EWQ nitrate samples since EWQ nitrite results were never detected. USGS/NJDEP data were most similar to DRBC 2003-2011 data, and did not display such a precipitous decline in concentrations.

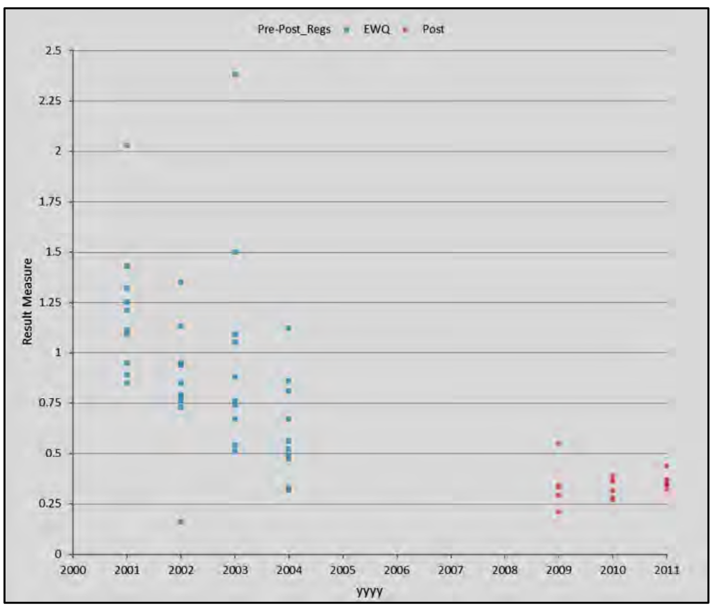
Chapter 24: 2074 ICP Delaware River at Portland

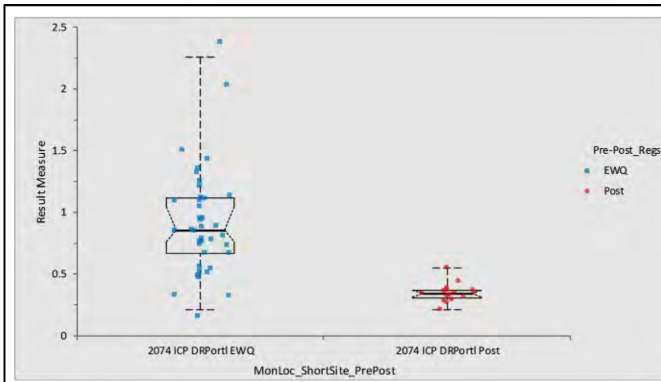
Nitrogen as N, Total (TN) mg/l

Existing Water Quality (Table 2C):

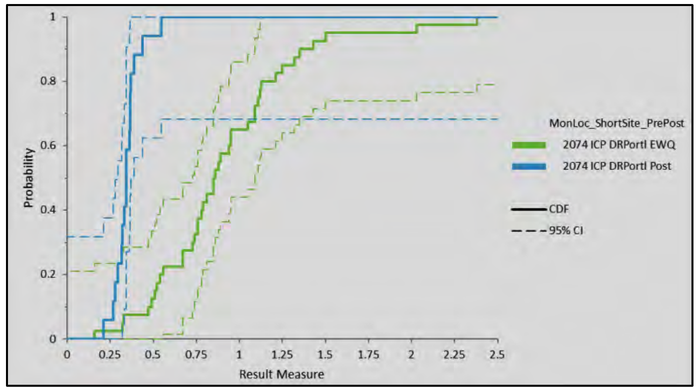
Median 0.86 mg/l
Lower 95% Confidence Interval 0.74 mg/l
Upper 95% Confidence Interval 1.05 mg/l







N	57					
Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
2074 ICP DRPortl EWQ	0.160	0.670	0.855	1.116	2.380	0.446
2074 ICP DRPortl Post	0.210	0.308	0.344	0.368	0.548	0.060



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
2074 ICP DRPortl EWQ	40	2175.6	54.39
2074 ICP DRPortl Post	17	5119.1	301.12

H statistic	26.48
X^2 approximation	26.48
DF	1
p-value	<0.0001 [1]

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

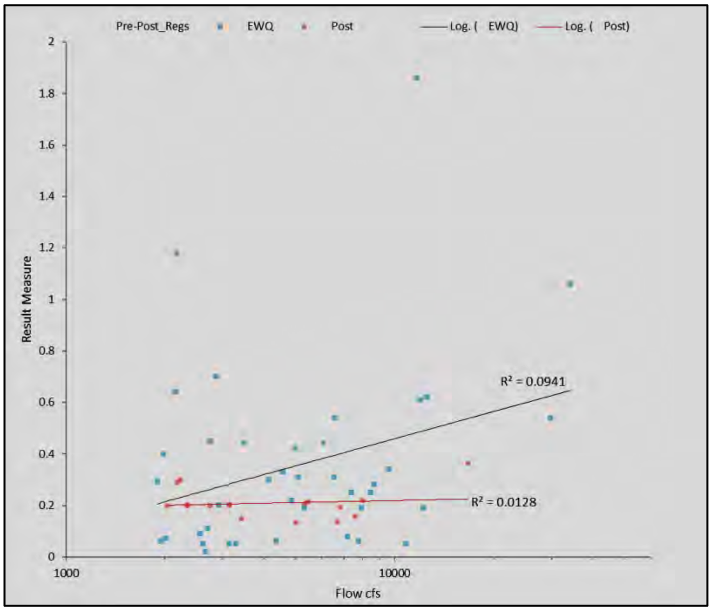
No water quality degradation is evident here. Total Nitrogen concentrations apparently declined between the EWQ and post-EWQ periods. Sources of analytical uncertainty include potential laboratory artifacts and insufficient post-EWQ sampling frequency (n=17). TN is unrelated to flow in both data sets. Post-EWQ median TN concentrations fell below the EWQ lower 95% confidence intervals. USGS/NJDEP data were similar to DRBC 2003-2011 results, showing a significant decline in concentrations but not as drastic as DRBC results indicate.

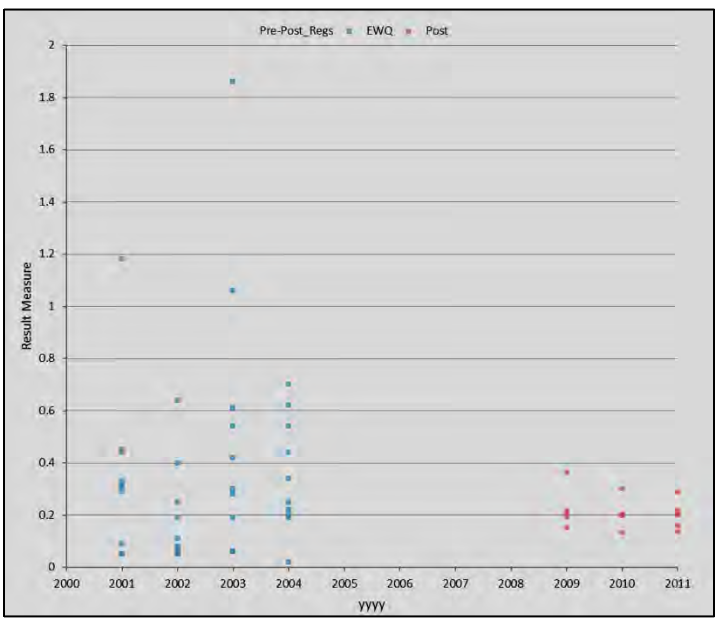
Chapter 24: 2074 ICP Delaware River at Portland

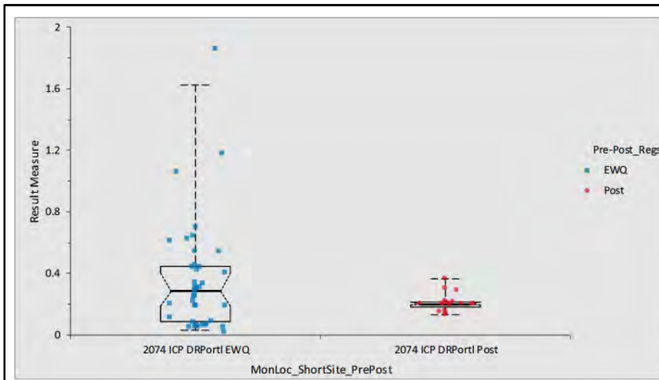
Nitrogen, Kjeldahl as N, Total (TKN) mg/l

Existing Water Quality (Table 2C):

Median 0.29 mg/l
Lower 95% Confidence Interval 0.19 mg/l
Upper 95% Confidence Interval 0.40 mg/l

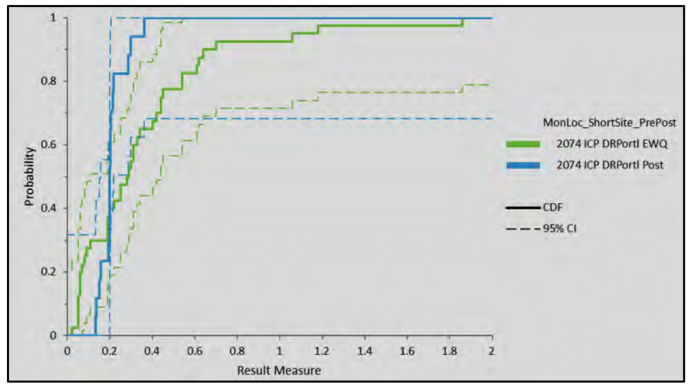






N | 57

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
2074 ICP DRPortl EWQ	0.020	0.084	0.285	0.446	1.860	0.362
2074 ICP DRPortl Post	0.133	0.181	0.200	0.216	0.363	0.035



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
2074 ICP DRPortl EWQ	40	115.6	2.89
2074 ICP DRPortl Post	17	272.0	16.00

H statistic	1.41
X^2 approximation	1.41
DF	1
p-value	0.2354 [1]

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

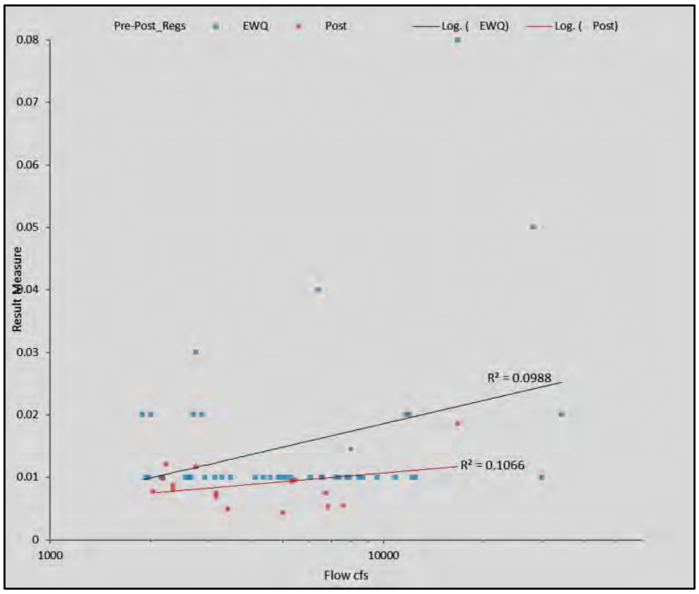
No water quality degradation is evident here. TKN concentrations apparently did not measurably decline between the EWQ and post-EWQ periods. Sources of analytical uncertainty include potential laboratory artifacts and insufficient post-EWQ sampling frequency (n=17). The post-EWQ range was far narrower and all concentrations were less than 0.36 mg/l. TKN concentration is unrelated to flow in both data sets. Post-EWQ median TKN fell below the lower EWQ 95% confidence interval, but there were insufficient post-EWQ samples (n=17) to detect significant change. USGS/NJDEP values were similar to DRBC results.

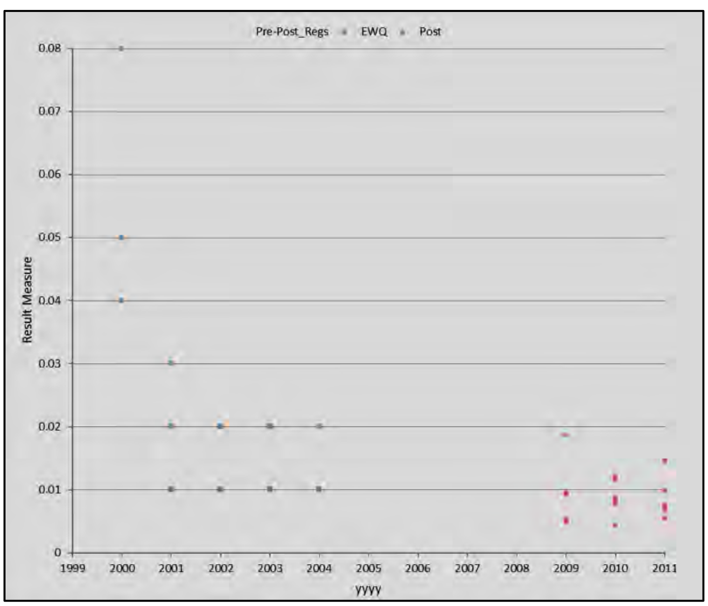
Chapter 24: 2074 ICP Delaware River at Portland

Orthophosphate as P, Total mg/l (OP)

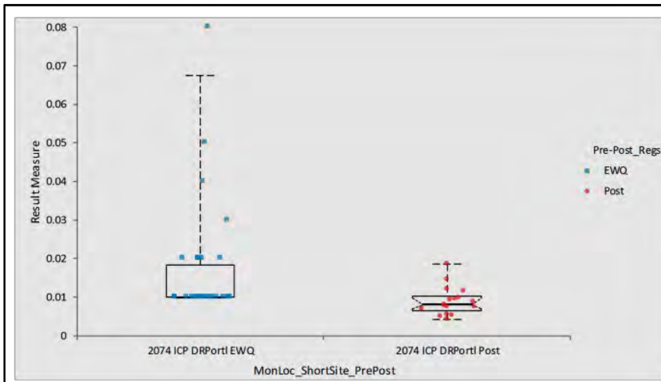
Existing Water Quality (Table 2C):

Median 0.01 mg/l
Lower 95% Confidence Interval 0.005 (<0.01) mg/l*
Upper 95% Confidence Interval 0.01 mg/l
*Used ½ the detection limit as estimate; actually <0.01



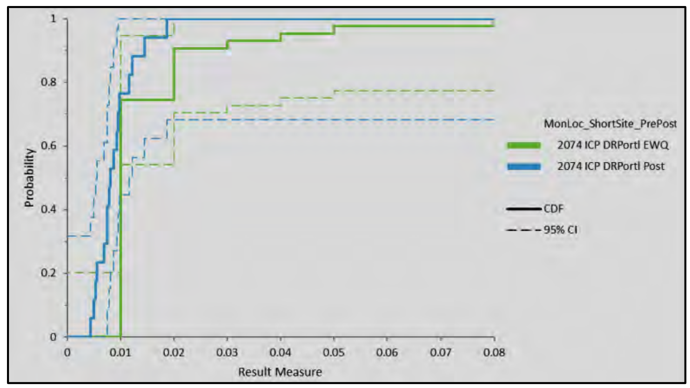


No water quality degradation is evident here. OP concentrations apparently declined between the EWQ and post-EWQ periods.



N 60

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
2074 ICP DRPortl EWQ	0.010	0.010	0.010	0.018	0.080	0.008
2074 ICP DRPortl Post	0.004	0.006	0.008	0.010	0.019	0.004



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
2074 ICP DRPortl EWQ	43	1311.8	30.51
2074 ICP DRPortl Post	17	3318.0	195.18

H statistic	17.93
X^2 approximation	17.93
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.

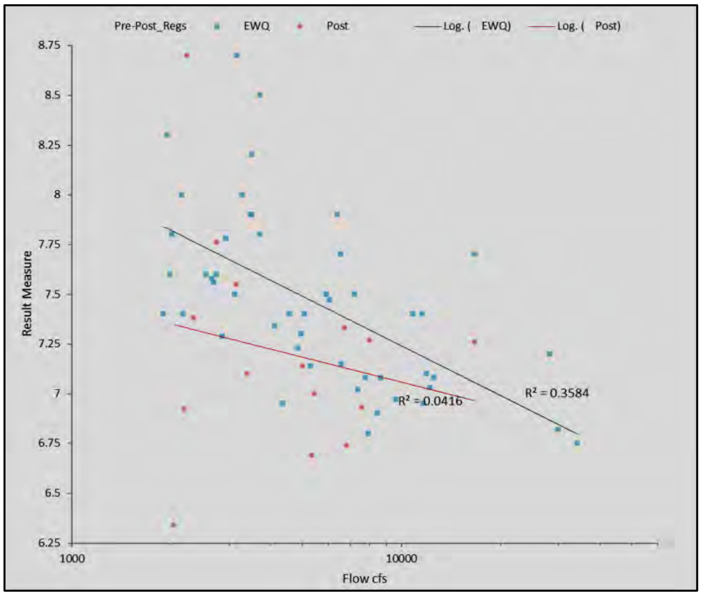
Sources of analytical uncertainty include potential laboratory artifacts, detection limit differences and insufficient post-EWQ sampling (n=17). OP is unrelated to flow in both data sets. Post-EWQ median OP fell below the EWQ lower 95% confidence interval. No post-EWQ concentrations were higher than 0.019 mg/l. The EWQ non-detection rate was 32/43 samples, interfering with estimation of the median. There were no post-EWQ undetected results, and a narrower range. USGS/NJDEP analyzes dissolved rather than total OP, but their results were similar to DRBC, with a high rate of undetected results in the EWQ period and gradually improving method sensitivity.

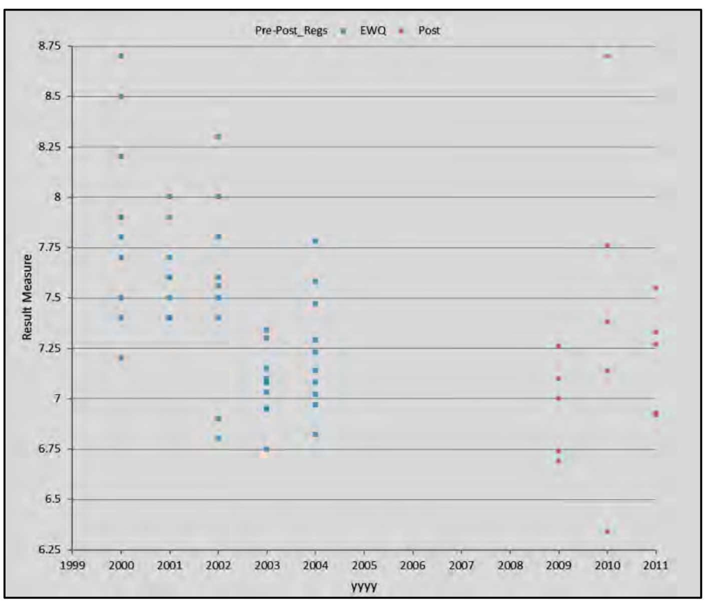
Chapter 24: 2074 ICP Delaware River at Portland

pH

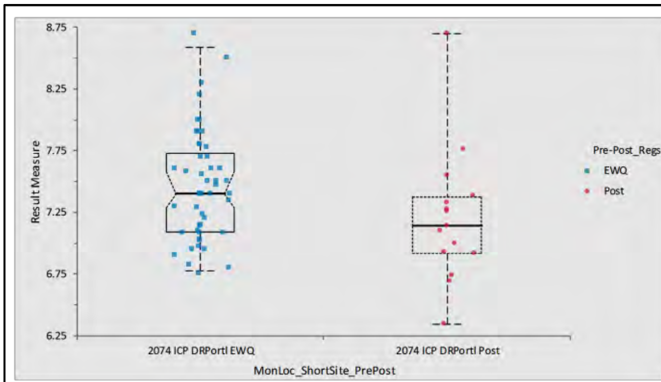
Existing Water Quality (Table 2C):

Median 7.40 standard units
Lower 95% Confidence Interval 7.29 standard units
Upper 95% Confidence Interval 7.58 standard units



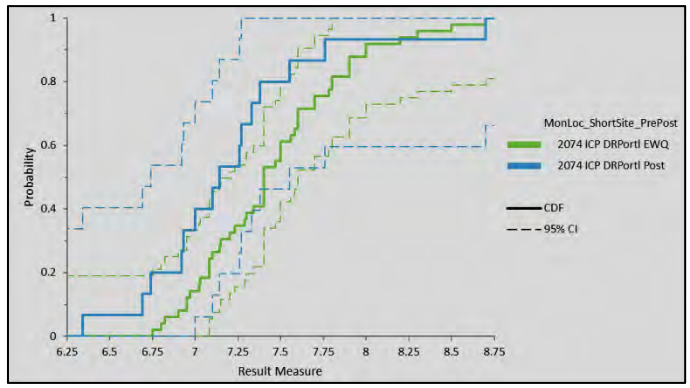


No water quality degradation is evident here. pH apparently declined between the two periods. Sources of analytical uncertainty include insufficient post-EWQ sampling (n=15). pH is inversely related to flow in EWQ data but unrelated in post-EWQ data.



N 64

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
2074 ICP DRPortl EWQ	6.75	7.09	7.40	7.73	8.70	0.63
2074 ICP DRPortl Post	6.34	6.92	7.14	7.37	8.70	0.45



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
2074 ICP DRPortl EWQ	49	388.7	7.93
2074 ICP DRPortl Post	15	1269.6	84.64

H statistic	4.79
X^2 approximation	4.79
DF	1
p-value	0.0286 [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.

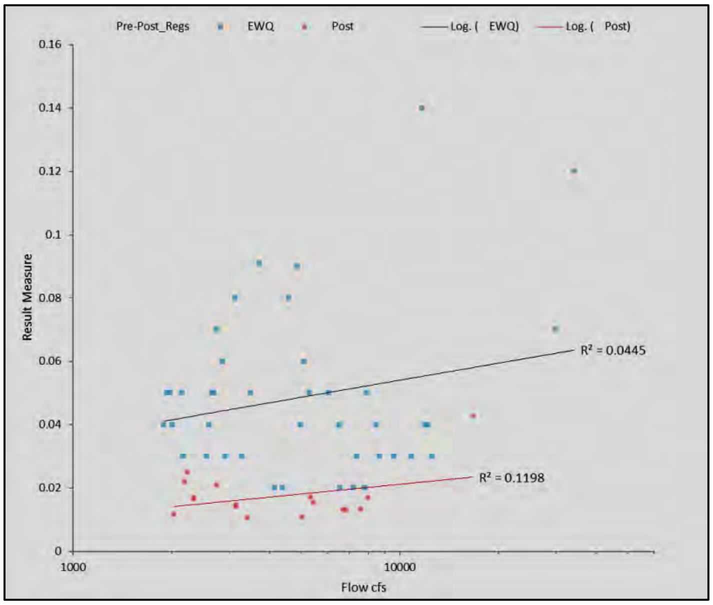
Post-EWQ median pH was below the lower EWQ 95% confidence interval. USGS/NJDEP data also showed a slight decline, mainly because post-EWQ pH was less wide-ranging and stayed nearer pH 7 during wet years. In dry, low-flow years, algae and aquatic plant growth in the Delaware River at Portland is much greater than during wet years when plants cannot grow thickly without being occasionally scoured away. If post-EWQ DRBC sampling were more representative of the entire range of flow conditions, there probably would not have been a significant difference in pH values. Biweekly instead of monthly sampling is recommended.

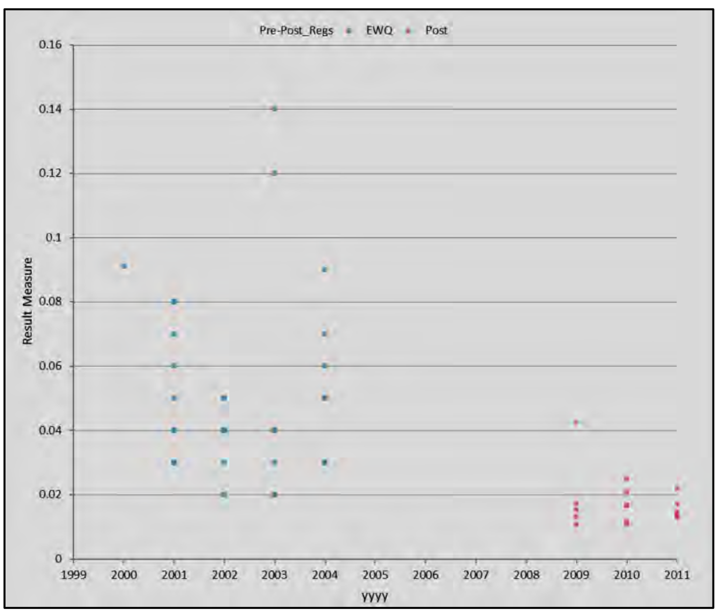
Chapter 24: 2074 ICP Delaware River at Portland

Phosphorus as P, Total (TP) mg/l

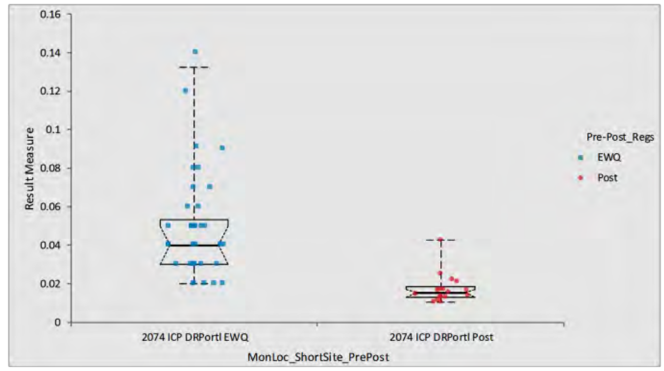
Existing Water Quality (Table 2C):

Median 0.04 mg/l
Lower 95% Confidence Interval 0.03 mg/l
Upper 95% Confidence Interval 0.05 mg/l



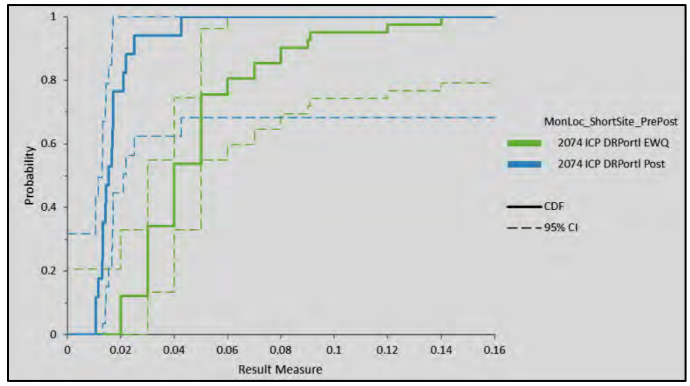


No water quality degradation is evident here. Total Phosphorus (TP) concentrations apparently declined between the EWQ and post-EWQ periods.



N 58

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
2074 ICP DRPortl EWQ	0.020	0.030	0.040	0.053	0.140	0.023
2074 ICP DRPortl Post	0.011	0.013	0.015	0.018	0.043	0.005



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
2074 ICP DRPortl EWQ	41	2366.6	57.72
2074 ICP DRPortl Post	17	5707.8	335.75

H statistic	28.62
X^2 approximation	28.62
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.

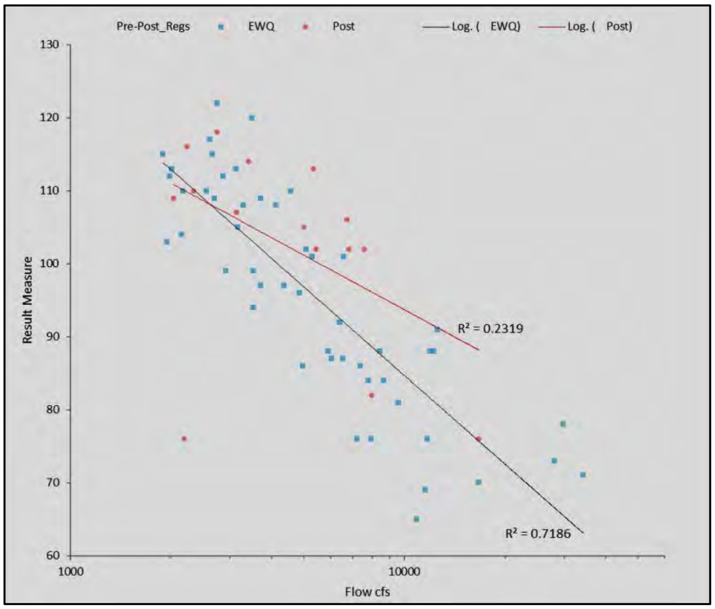
Sources of analytical uncertainty include potential laboratory artifacts, detection limit differences and insufficient post-EWQ sampling (n=17). Post-EWQ median total phosphorus fell below the EWQ lower 95% confidence interval. TP is unrelated to flow in both data sets. USGS/NJDEP data were comparable with DRBC post-EWQ results, though no decline in concentrations was apparent. USGS/NJDEP data during the EWQ period ranged from 0.01 to 0.06 mg/l. This was not very different from DRBC results, but DRBC EWQ data varied more widely.

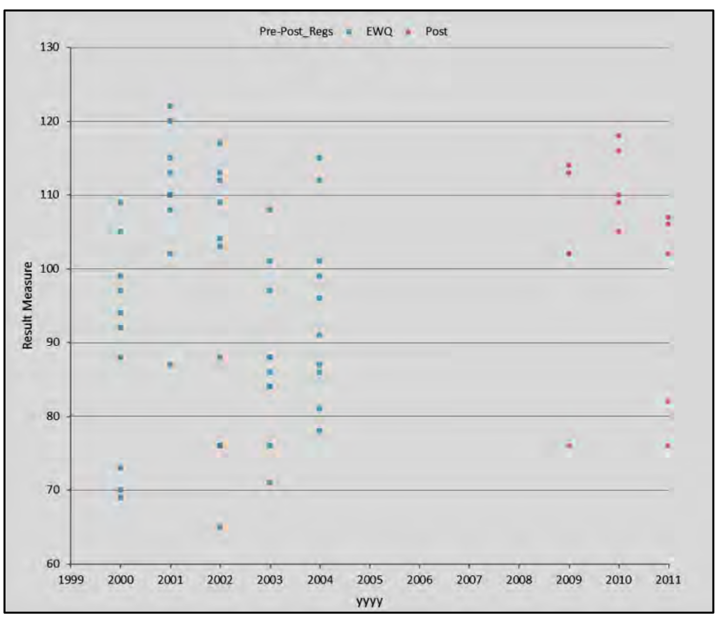
Chapter 24: 2074 ICP Delaware River at Portland

Specific Conductance µmho/cm

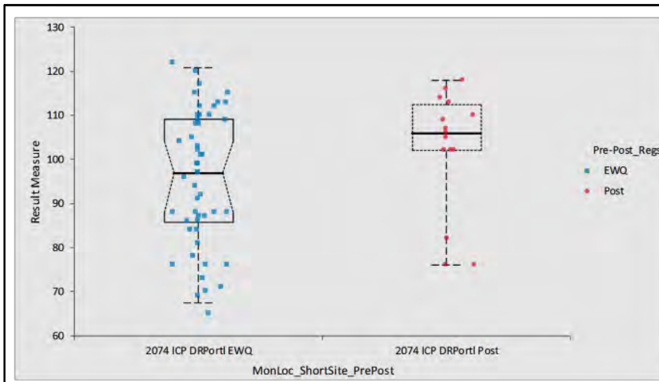
Existing Water Quality (Table 2C):

Median 97 µmho/cm
Lower 95% Confidence Interval 88 µmho/cm
Upper 95% Confidence Interval 104 µmho/cm
Defined in regulations as a flow-related parameter

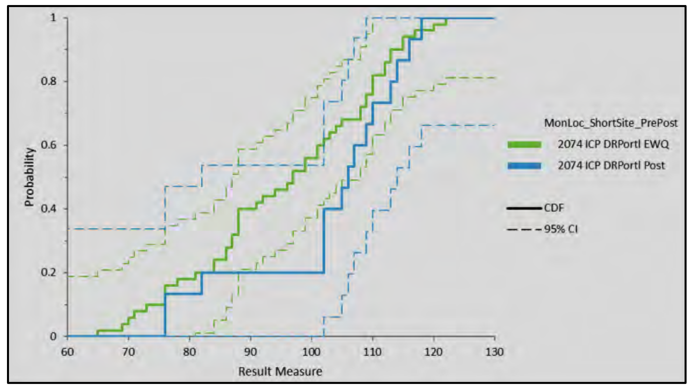




No water quality degradation is evident here. Specific conductance increased by 9 µmho/cm between the EWQ and post-EWQ periods, but the increase was not significant.



Result Measure by MonLoc_ShortSite_PrePost	N	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
	65						
2074 ICP DRPortl EWQ		65	86	97	109	122	23
2074 ICP DRPortl Post		76	102	106	113	118	11



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
2074 ICP DRPortl EWQ	50	206.0	4.12
2074 ICP DRPortl Post	15	686.8	45.79

H statistic	2.50
X² approximation	2.50
DF	1
p-value	0.1138 [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.

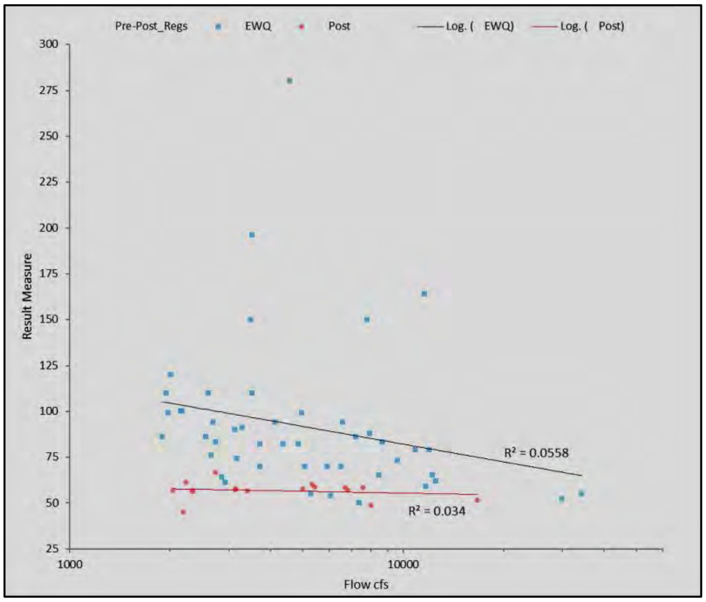
Analytical uncertainty included insufficient post-EWQ sampling (n=15) and possible flow differences. Post-EWQ median specific conductance increased near the upper EWQ 95% confidence interval. Biweekly instead of monthly sampling is recommended. Specific conductance is inversely related to flow in both data sets. Post-EWQ data were not representative of the full range of flow conditions, rendering a weak flow relationship. It is probable that, if more samples were taken under higher flow conditions, there might not have been any increase in specific conductance. USGS/NJDEP data were similar to DRBC results, also showing a slight increase in concentration.

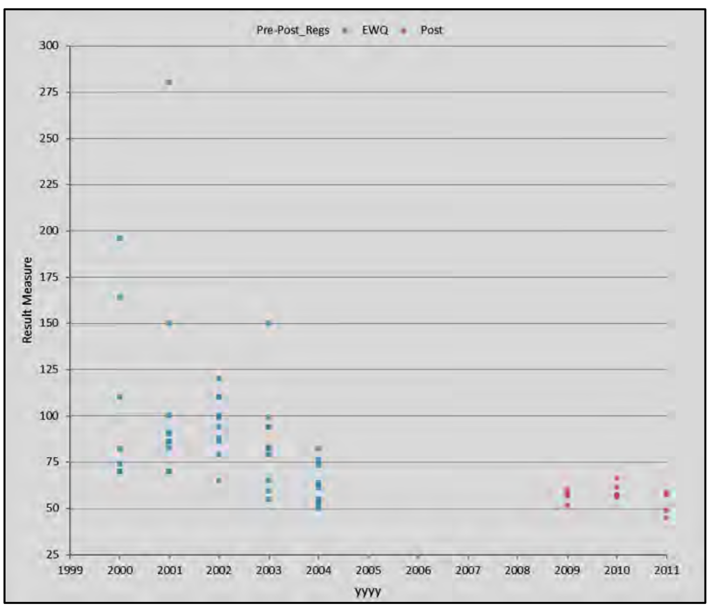
Chapter 24: 2074 ICP Delaware River at Portland

Total Dissolved Solids (TDS) mg/l

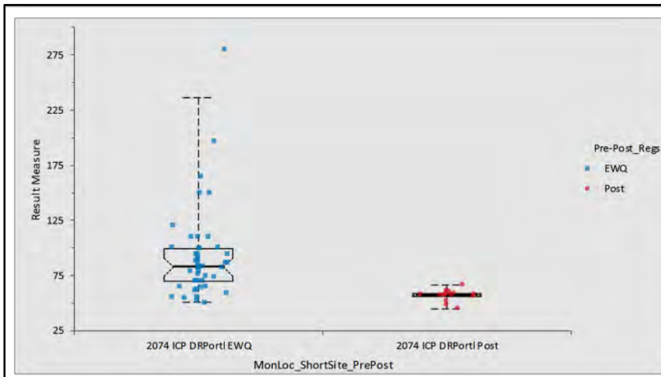
Existing Water Quality (Table 2C):

Median 83 mg/l
Lower 95% Confidence Interval 74 mg/l
Upper 95% Confidence Interval 91 mg/l

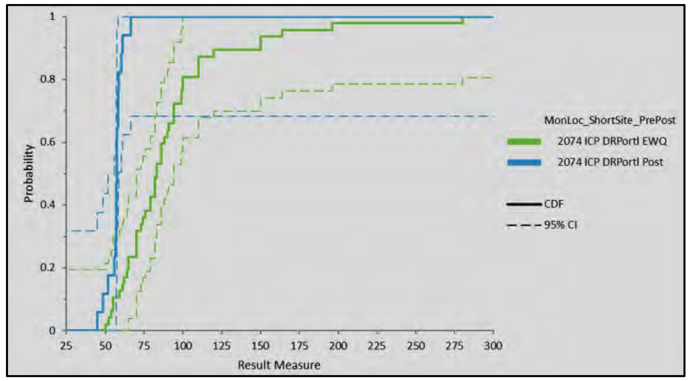




No water quality degradation is evident here. TDS declined between the two periods. Sources of analytical uncertainty include potential laboratory artifacts, detection limit differences and insufficient post-EWQ sampling (n=17).



N	64					
Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
2074 ICP DRPortl EWQ	50	70	83	99	280	29
2074 ICP DRPortl Post	45	56	57	58	66	2



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
2074 ICP DRPortl EWQ	47	2171.9	46.21
2074 ICP DRPortl Post	17	6004.7	353.22

H statistic	23.60
X^2 approximation	23.60
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.

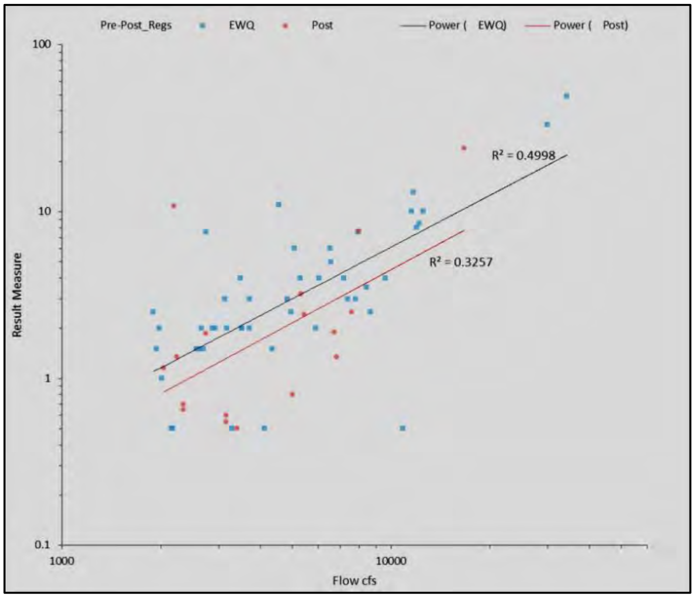
TDS is unrelated to flow in either data set. Post-EWQ median TDS fell below the EWQ lower 95% lower confidence interval, and was less variable than the baseline samples as well. Post-EWQ detection limits were lower than EWQ detection limits, though there were no undetected results at any time. Perhaps this decline is not real but an artifact of using different laboratories. EWQ 2003-2004 data are most similar to post-EWQ 2009-2011 data. USGS/NJDEP data are comparable to DRBC 2003-2011 results but do not show a declining trend. The USGS/NJDEP data actually show a slight but insignificant increase.

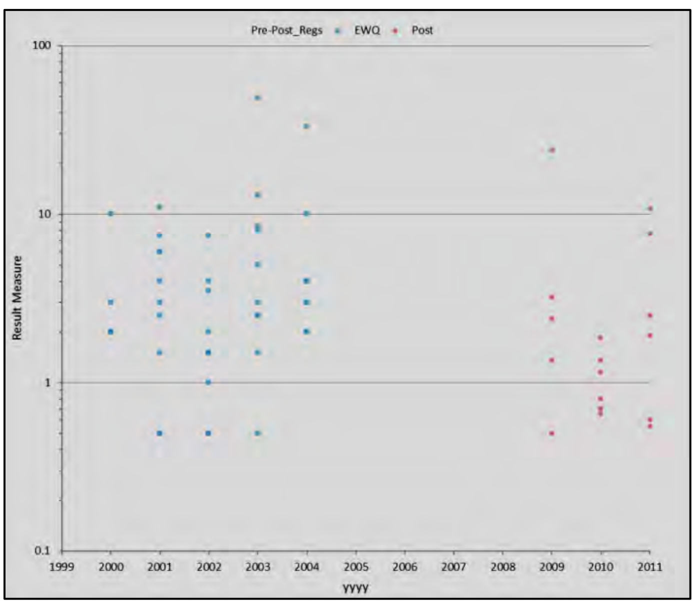
Chapter 24: 2074 ICP Delaware River at Portland

Total Suspended Solids (TSS) mg/l

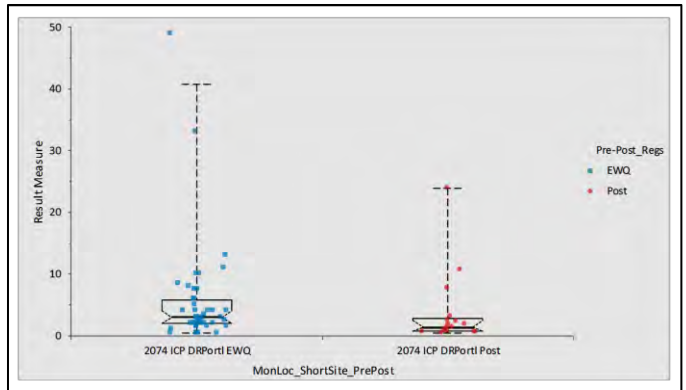
Existing Water Quality (Table 2C):

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



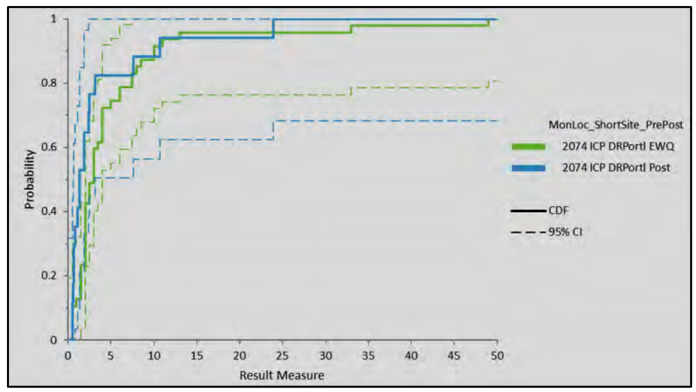


No water quality degradation is evident here. TSS apparently declined between the EWQ and post-EWQ periods, but the decline appears due to insufficient post-EWQ sampling of the full range of flow conditions.



N | 64

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
2074 ICP DRPortl EWQ	0.5	2.0	3.0	5.8	49.0	3.8
2074 ICP DRPortl Post	0.5	0.7	1.3	2.7	23.9	2.0



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
2074 ICP DRPortl EWQ	47	414.0	8.81
2074 ICP DRPortl Post	17	1144.7	67.34

H statistic	4.52
X^2 approximation	4.52
DF	1
p-value	0.0335 [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.

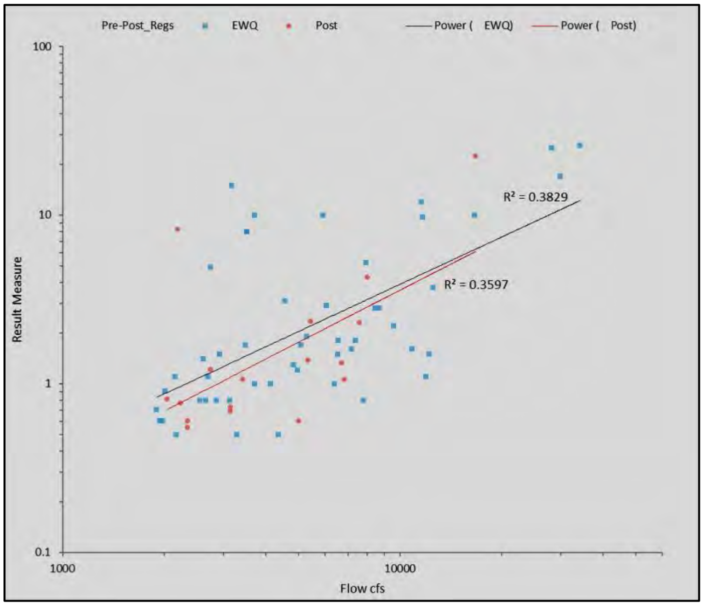
Sources of analytical uncertainty include potential laboratory artifacts and insufficient post-EWQ sampling (n=17). TSS is positively related to flow in both data sets. Post-EWQ median TSS fell below the lower EWQ 95% confidence interval, though higher flow conditions are not represented in the comparison. Biweekly instead of monthly sampling is recommended. USGS/NJDEP data also displayed a significant decline in TSS for the same reason as the DRBC results. If the full range of flow conditions were better represented, there might have been much less concentration difference between the two periods.

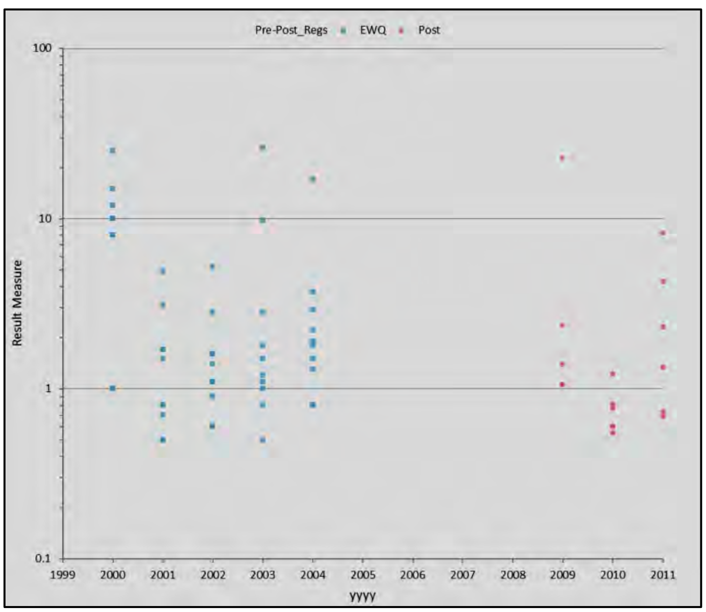
Chapter 24: 2074 ICP Delaware River at Portland

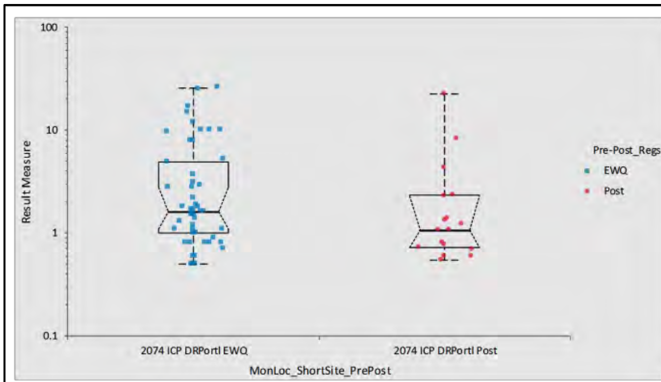
Turbidity NTU

Existing Water Quality (Table 2C):

Median 1.6 NTU
Lower 95% Confidence Interval 1.1 NTU
Upper 95% Confidence Interval 2.8 NTU
Defined in regulations as a flow-related parameter

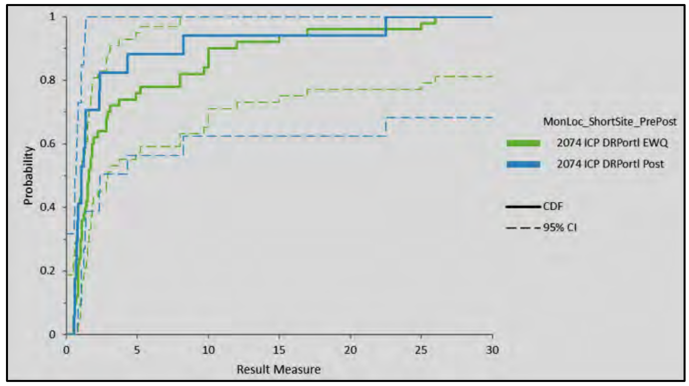






N | 67

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
2074 ICP DRPortl EWQ	0.5	1.0	1.6	4.9	26.0	3.9
2074 ICP DRPortl Post	0.6	0.7	1.1	2.3	22.5	1.6



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
2074 ICP DRPortl EWQ	50	229.0	4.58
2074 ICP DRPortl Post	17	673.5	39.62

H statistic	2.38
X^2 approximation	2.38
DF	1
p-value	0.1229 [1]

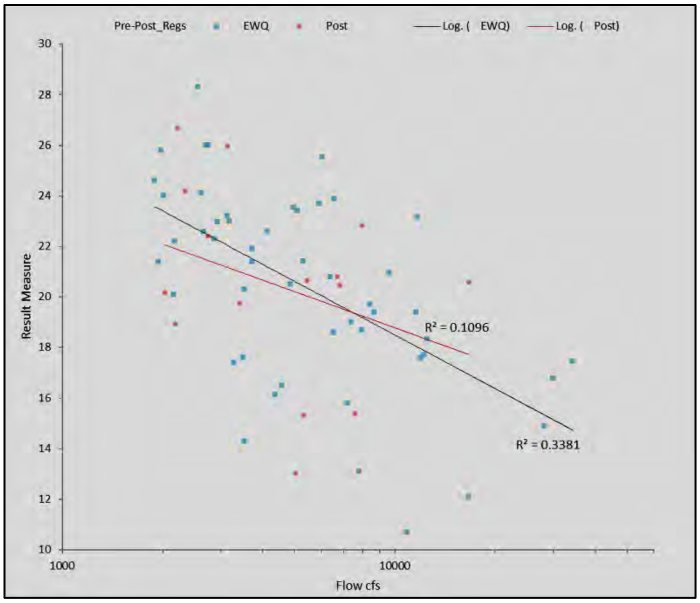
H0: $\theta_1 = \theta_2 = \theta$...
The median of the populations are all equal.
H1: $\theta_i \neq \theta_j$ for at least one i,j
The median of the populations are not all equal.
[1] Do not reject the null hypothesis at the 5% significance level.

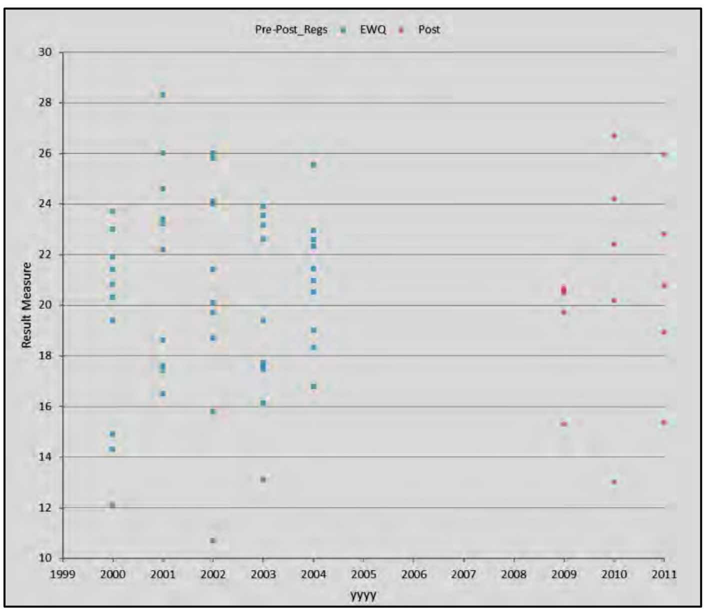
No water quality degradation is evident here. Turbidity apparently did not measurably change between the EWQ and post-EWQ periods. However, an insufficient number of post-EWQ samples (n=17) were taken and the full range of flow conditions was not represented. The post-EWQ median turbidity fell to the lower EWQ 95% confidence interval of the median but only because of too few samples at higher flow. Turbidity is positively related to flow in both data sets, power regression lines are shown. There were very few USGS/NJDEP data available for comparison with DRBC results, but results were similar. Biweekly instead of monthly sampling is recommended at this location.

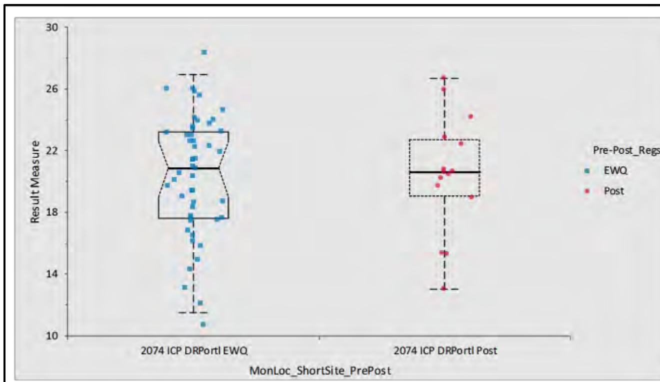
Chapter 24: 2074 ICP Delaware River at Portland

Water Temperature, degrees C

Not included in DRBC Existing Water Quality rules

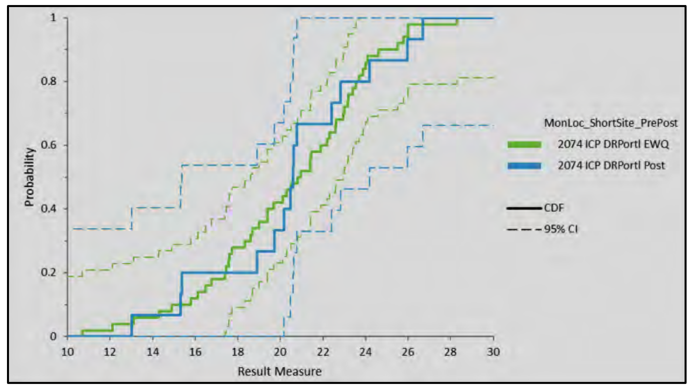






N	65

Result Measure by MonLoc_ShortSite_PrePost	Minimum	1st Quartile	Median	3rd Quartile	Maximum	Inter-quartile range
2074 ICP DRPortl EWQ	10.7	17.6	20.9	23.2	28.3	5.6
2074 ICP DRPortl Post	13.0	19.1	20.6	22.8	26.7	3.7



Kruskal-Wallis test

Result Measure by MonLoc_ShortSite_PrePost	n	Rank sum	Mean rank
2074 ICP DRPortl EWQ	50	0.1	0.00
2074 ICP DRPortl Post	15	0.3	0.02

H statistic	0.00
X^2 approximation	0.00
DF	1
p-value	0.9752 [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, an insufficient number of post-EWQ samples (n=15) were taken and the full range of flow conditions was not represented. Water temperature is weakly and inversely related to flow. USGS/NJDEP data were comparable with DRBC results.

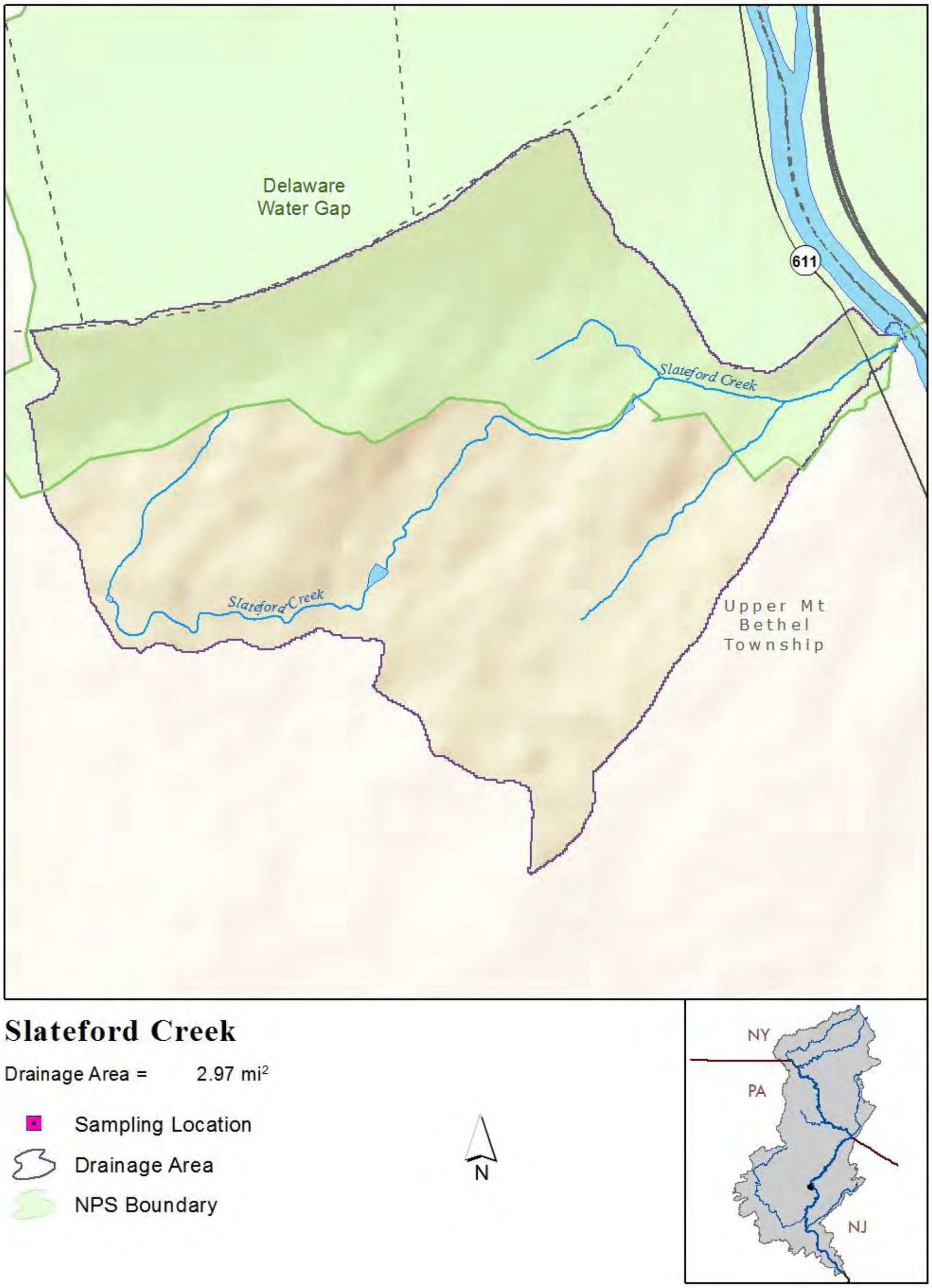
Lower Delaware Scenic and Recreational River Significant Resource Waters

Appendix A:

New and Recommended Future Sites for Inclusion in DRBC Special Protection Waters Rules

Contents

2095 BCP Slateford Creek at National Park Drive, PA



2095 BCP Slateford Creek at National Park Road

Northampton County, PA. Latitude 40.946735 Longitude -75.115074 by GPS NAD83 decimal degrees.
No monitoring by any other agencies
Population 2000 = 173   Population 2010 = 283   Change = +110

Drainage Area at site: 2.95 square miles, tributary to Delaware River Zone 1E

Site Specific EWQ defined by DRBC 2011-2013.

This watershed is tributary to the Lower Delaware Scenic and Recreational River (LDEL)
Classified by DRBC as Significant Resource Waters.

Nearest upstream Interstate Control Point: 2115 ICP Delaware River at I-80 Kittatinny Visitor Center
Nearest downstream Interstate Control Point: 2074 ICP Delaware River at Portland Foot Bridge
Known dischargers within watershed: Unknown.

Watershed is 89.2% forested; urban land cover is 0.1%. Watershed was 100% glaciated, and is not underlain by carbonate bedrock. Mean annual precipitation 47 inches. (http://water.usgs.gov/osw/streamstats/, accessed 2013).

Flow Statistics (USGS BaSE Model):

Max Flow (CFS)	90% Flow (CFS)	75% Flow (CFS)	60% Flow (CFS)	50% Flow (CFS)	40% Flow (CFS)	25% Flow (CFS)	10% Flow (CFS)	Min Flow (CFS)
353	9.78	5.22	3.83	3.10	2.73	1.67	0.72	0.11

StreamStats Low-Flow Stream Statistics

M7D2Y (ft^3/s)	0.51
M30D2Y (ft^3/s)	0.67
M7D10Y (ft^3/s)	0.24
M30D10Y (ft^3/s)	0.31
M90D10Y (ft^3/s)	0.46

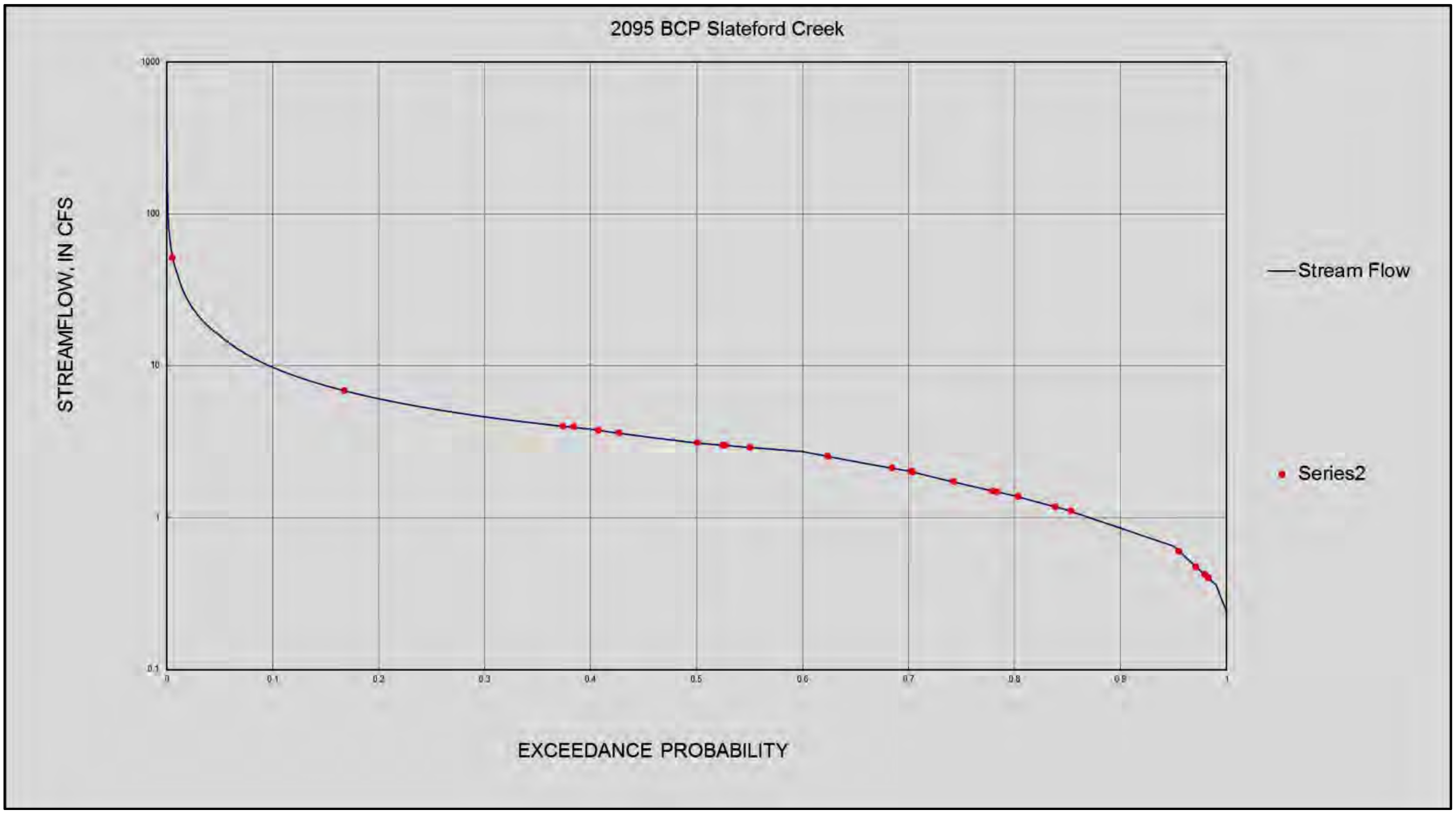
StreamStats Mean/Baseflow Stream Statistics

QA (ft^3/s)	5.34
QAH (ft^3/s)	1.44
BF10YR (ft^3/s)	2.57
BF25YR (ft^3/s)	2.31
BF50YR (ft^3/s)	2.16

StreamStats Peak-Flow Stream Statistics

PK2 (ft^3/s)	153
PK5 (ft^3/s)	274
PK10 (ft^3/s)	373
PK50 (ft^3/s)	641
PK100 (ft^3/s)	778
PK500 (ft^3/s)	1,160

Slateford Creek Flow Regime Represented in SRMP 2011-2013 Samples



The 30 samples taken by DRBC are plotted on the flow exceedance curve above.

Though high flow events are under-represented in our data, we were able to cover almost 100% of the flow regime. Low and normal flow conditions are the best represented by our water quality data. The flow exceedance curve above was prepared using the USGS BaSE model.

Slateford Creek is located at the southern terminus of the Delaware Water Gap National Recreation Area (shown in green on the map). DRBC took 30 samples from the National Park Drive road crossing for the May to September period of three years: 2011-2013. The watershed is only 2.97 square miles, and was chosen for EWQ establishment not because of the stream's potential influence upon the Delaware River, which is small, but because of pending development in the watershed and for the watershed's partial location within the Delaware Water Gap National Recreation Area.

The watershed is 89.1% forest, about 3.6% lakes and ponds, but only 0.07% urban land cover (USGS Stream Stats retrieval February 2013). Slateford Creek possesses excellent water quality. It is steeply sloped, and was never completely dry during the sampling period. Average annual flow is 5.34 cfs, and harmonic mean flow is 1.44 cfs (USGS BaSE model estimates).

Existing Water Quality: 2095 BCP Slateford Creek at National Park Drive, PA

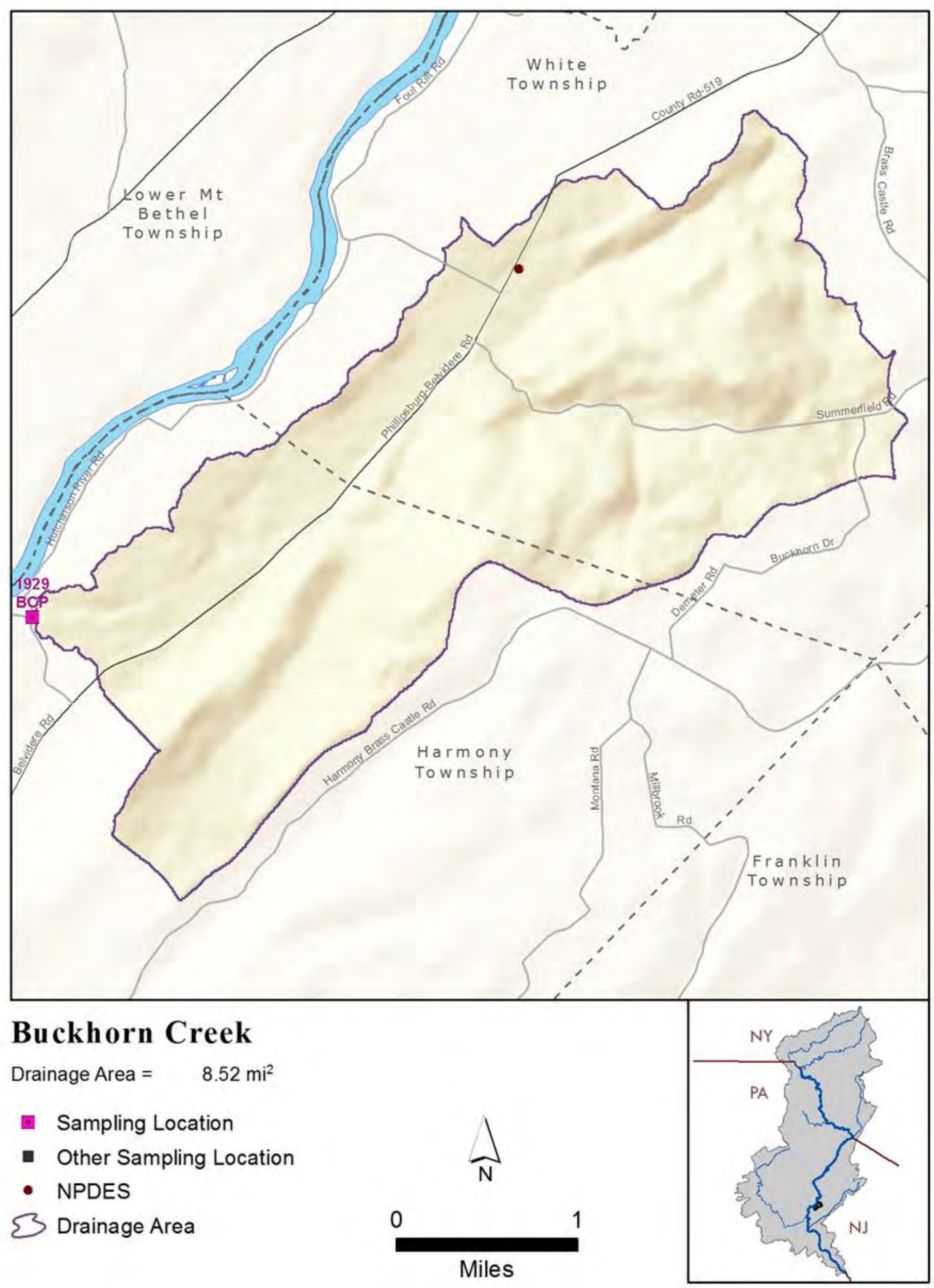
Parameter	N	median	L95CL	U95CL	Flow Relation	Period of Record (May-Sep data)
Alkalinity as CaCO3, Total mg/l	30	51.5	45	62	Inverse	SRMP 2011-2013
Ammonia-Nitrogen as N, Total mg/l	30	<0.006	<0.006	<0.006	None	SRMP 2011-2013 (26/30 ND)
Chloride, Total mg/l	30	7.4	6.1	8.1	Inverse	SRMP 2011-2013
Dissolved Oxygen (DO) mg/l	28	9.40	8.83	9.71	None	SRMP 2011-2013 mid-day
Dissolved Oxygen Saturation %	28	96.7	95.5	99.2	None	SRMP 2011-2013 mid-day
Enterococcus #/100ml {1}	7	30	11	240	None	SRMP 2011 – insufficient data
Escherichia coli #/100ml {2}	8	16	6	180	Positive	SRMP 2011 – insufficient data
Fecal coliform #/100ml	8	17	1	270	Positive	SRMP 2011 – insufficient data
Hardness as CaCO3, Total mg/l	30	78.3	67.4	83.2	Inverse	SRMP 2011-2013
Nitrate+Nitrite as N, Total mg/l	30	0.250	0.171	0.283	None	SRMP 2011-2013
Nitrogen as N, Total mg/l	30	0.398	0.365	0.440	None	SRMP 2011-2013
Nitrogen, Kjeldahl as N, Total mg/l	30	0.149	0.126	0.197	None	SRMP 2011-2013
pH units	28	7.74	7.68	7.85	None	SRMP 2011-2013 mid-day
Phosphate as P, Total mg/l	30	0.009	0.007	0.014	None	SRMP 2011-2013
Phosphorus as P, Total mg/l	30	0.013	0.010	0.017	Positive	SRMP 2011-2013
Specific Conductance µmhos/cm	28	180	153	204	Inverse	SRMP 2011-2013
Temperature, Water, degrees C	28	17.1	16.3	18.2	None	SRMP 2011-2013 mid-day
Total Dissolved Solids (TDS) mg/l	30	105	89	112	Inverse	SRMP 2011-2013
Total Suspended Solids (TSS) mg/l	30	2.0	1.0	3.3	None	SRMP 2011-2013
Turbidity NTU	47	1.56	1.25	2.20	Positive	SRMP 2011-2013

Two-tailed 95% (Lower and Upper) confidence limits were used for these EWQ targets

Note: All data are May to September season. Additional data are available for the October to April “non-seasonal” period, but data are insufficient in number for establishment of site-specific existing water quality targets.

ND = non-detect

1929 BCP Buckhorn Creek at Hutchinson Road (RESERVED)



1929 BCP Buckhorn Creek at Hutchinson Road (RESERVED)

Warren County, NJ. Latitude 40.771667 Longitude -75.130806 by GPS NAD83 decimal degrees.
NJDEP Site No. 01446568
Population 2000 =   Population 2010 =   Change =

Drainage Area: 11.8 square miles, tributary to Delaware River Zone 1D

Site Specific EWQ undefined. NJDEP data available; high-quality stream; recommended for confirmatory monitoring and establishment of EWQ.

This watershed is tributary to the Lower Delaware Scenic and Recreational River (LDEL)
Classified by DRBC as Significant Resource Waters.

Nearest upstream Interstate Control Point: 1978 ICP Delaware River at Belvidere
Nearest downstream Interstate Control Point: 1891 ICP Delaware River at Sandts Eddy Access
Known dischargers within watershed: Undefined.

Watershed is 55.1% forested; urban land cover is 0.75%. Watershed was not glaciated, and is 39.1% underlain by carbonate bedrock. Mean annual precipitation 46.9 inches. (http://water.usgs.gov/osw/streamstats/, accessed 2012).

Flow Statistics (USGS BaSE Model):

Max Flow (CFS)	**90% Flow (CFS)**	**75% Flow (CFS)**	**60% Flow (CFS)**	**50% Flow (CFS)**	**40% Flow (CFS)**	**25% Flow (CFS)**	**10% Flow (CFS)**	**Min Flow (CFS)**
935	34.1	21.1	15.7	12.8	12.2	8.48	4.97	1.91

StreamStats Low-Flow Stream Statistics

M7D2Y (ft^3/s)	5.27
M30D2Y (ft^3/s)	5.96
M7D10Y (ft^3/s)	3.51
M30D10Y (ft^3/s)	3.83
M90D10Y (ft^3/s)	4.31

StreamStats Mean/Baseflow Stream Statistics

QA (ft^3/s)	19.2
QAH (ft^3/s)	11.0
BF10YR (ft^3/s)	10.6
BF25YR (ft^3/s)	9.42
BF50YR (ft^3/s)	8.74

StreamStats Peak-Flow Stream Statistics

PK2 (ft^3/s)	543
PK5 (ft^3/s)	944
PK10 (ft^3/s)	1,270
PK50 (ft^3/s)	2,130
PK100 (ft^3/s)	2,560
PK500 (ft^3/s)	3,760

Existing Water Quality: 1929 BCP Buckhorn Creek at Hutchinson Road (RESERVED)

Placeholder for Existing Water Quality Table

1891 ICP Delaware River at Sandts Eddy Access

1891 ICP
Delaware River at Sandt's Eddy Access

1891 ICP Delaware River at Sandts Eddy Access

Latitude 40.758252 Longitude -75.187719 by GPS NAD83 decimal degrees.
No USGS or State monitoring sites nearby.

Drainage Area: 4,610 square miles, Delaware River Zone 1D

Site Specific EWQ defined 2009-2013 by the DRBC/NPS Scenic Rivers Monitoring Program.

This site is located in the Lower Delaware Scenic and Recreational River.
Classified by DRBC as Significant Resource Waters

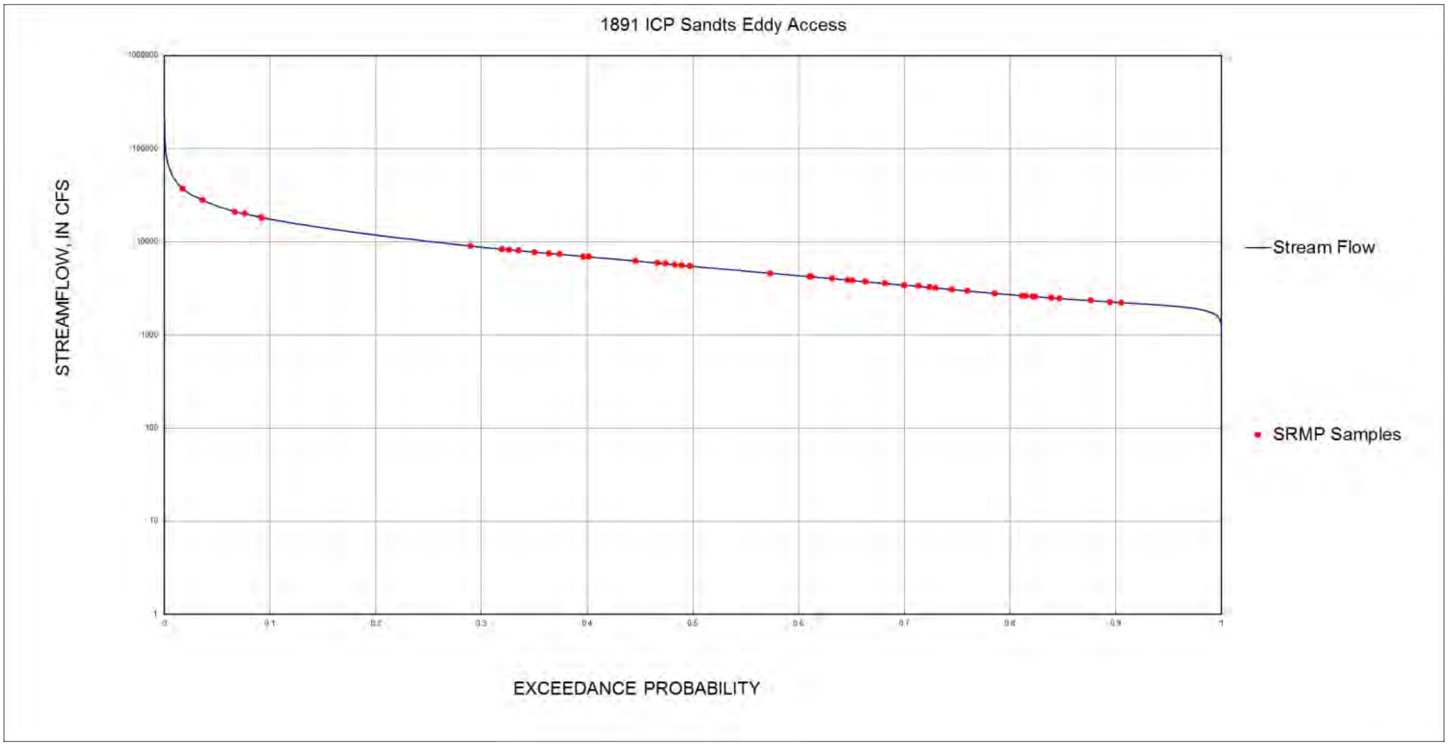
Nearest upstream Interstate Control Point: 1978 ICP Delaware River at Belvidere
Nearest downstream Interstate Control Point: 1838 ICP Delaware River at Easton
Known dischargers within watershed: Undefined
Tributaries to upstream reach: Major tributaries 1978 BCP Pequest River, NJ; 1907 BCP Martins Creek, PA; small tributaries 197.5 Pophandusing Brook, NJ; , 194.1 Oughoughton Creek, PA; 1929 BCP Buckhorn Creek, NJ.

No Stream Stats web site data available.

Flow Statistics Associated with Water Quality Samples (calculated by drainage area weighting from USGS gage data):

Max Flow (CFS)	**90% Flow (CFS)**	**75% Flow (CFS)**	**60% Flow (CFS)**	**50% Flow (CFS)**	**40% Flow (CFS)**	**25% Flow (CFS)**	**10% Flow (CFS)**	**Min Flow (CFS)**
214,500	17,400	10,100	6,920	5,430	4,320	3,030	2,240	1,150

1891 ICP Delaware River at Sandts Eddy SRMP Samples vs. Flow Exceedance Curve



For commonly sampled parameters (up to 48 samples taken), the SRMP data cover about 85% of the flow regime. Flow of the Delaware River is controlled, so extreme low flow conditions (>90% exceedance) are never encountered. High flow conditions (<30% exceedance) are not well represented by these water quality data. Some parameters such as bacteria (enterococcus, E. coli and fecal coliform) were not sampled every year and were not as representative of the full range of flow conditions. See discussions of individual parameters below.

The drainage area above Sandts Eddy access is about 4610 square miles, and median flow is about 7000 cfs. The median flow among SRMP samples is about 5430 cfs, so these water quality data best represent low to normal flow conditions.

This monitoring location was added to the monitoring program because we needed a site that is located between two major influential tributaries – Pequest River and Bushkill Creek. Prior to establishment of the Sandts Eddy site, there was a 14-mile unmonitored gap between SRMP sites at Belvidere and Easton, with multiple tributaries contributing to the reach. With the Sandts Eddy site it is now easier to account the effects of each tributary upon the Delaware River. Under low and normal flow, center-channel grab samples are collected. At high flow, samples are collected near the Pennsylvania shore.

Existing Water Quality: 1891 ICP Delaware River at Sandts Eddy Access

Parameter	N	median	L95CL	U95CL	Flow Relation	Period of Record (May-Sep data)
Alkalinity as CaCO3, Total mg/l	49	36.1	33.1	38.1	None	2009-2013 SRMP
Aluminum, Dissolved mg/l	14	0.006	0.005	0.009	None	2009-2010 SRMP archived*
Ammonia-Nitrogen as N, Total mg/l	47	0.009	0.006	0.011	None	2009-2013 SRMP (14 non-detect)
Barium, Dissolved mg/l	14	0.017	0.012	0.023	None	2009-2010 SRMP archived*
Calcium, Dissolved mg/l	14	8.66	7.18	9.77	None	2009-2010 SRMP archived*
Chloride, Total mg/l	49	16.8	15.8	17.2	Inverse	2009-2013 SRMP
Dissolved Oxygen (DO) mg/l	47	9.35	8.85	9.55	None	2009-2013 SRMP mid-day
Dissolved Oxygen Saturation %	46	106.8	100.5	109.8	None	2009-2013 SRMP mid-day
Enterococcus #/100ml **{1}**	28	47	27	90	None	2009-2011 SRMP
Escherichia coli #/100ml	29	21	14	50	Positive	2009-2011 SRMP
Fecal coliform #/100ml	29	29	20	50	Positive	2009-2011 SRMP
Hardness as CaCO3, Total mg/l	49	52	48.8	55	None	2009-2013 SRMP
Iron, Dissolved µg/l	14	3.8	2.0	5.8	Positive	2009-2010 SRMP archived*
Magnesium, Dissolved mg/l	14	3.04	1.89	3.55	Inverse	2009-2010 SRMP archived*
Manganese, Dissolved µg/l	14	2.6	1.4	4.5	Positive	2009-2010 SRMP archived*
Nitrate + Nitrite as N, Total mg/l	49	0.323	0.286	0.429	None	2009-2013 SRMP
Nitrogen, Kjeldahl as N, Total mg/l	49	0.229	0.217	0.251	None	2009-2013 SRMP
Nitrogen as N, Total mg/l	49	0.605	0.521	0.680	None	2009-2013 SRMP
Orthophosphate as P, Total mg/l	49	0.018	0.016	0.021	None	2009-2013 SRMP
pH units	47	7.96	7.75	8.20	Inverse	2009-2013 SRMP mid-day
Phosphorus as P, Total mg/l	49	0.028	0.024	0.031	None	2009-2013 SRMP
Potassium, Dissolved mg/l	14	0.95	0.70	1.10	Inverse	2009-2010 SRMP archived*
Sodium, Dissolved mg/l	14	8.79	6.79	9.29	Inverse	2009-2010 SRMP archived*
Specific Conductance µmho/cm	47	166	159	172	Inverse	2009-2013 SRMP mid-day
Strontium, Dissolved mg/l	14	0.045	0.035	0.05	Inverse	2009-2010 SRMP archived*
Sulfate as SO4, Total mg/l	14	9.39	6.67	11.30	Inverse	2009-2010 SRMP archived*
Temperature, Water, degrees C	47	21.4	20.6	22.5	None	2009-2013 SRMP mid-day
Total Dissolved Solids (TDS) mg/l	49	83	81	87	None	2009-2013 SRMP
Total Suspended Solids (TSS) mg/l	49	1.8	1.5	3.0	Positive	2009-2013 SRMP
Turbidity NTU	70	1.10	0.99	1.38	Positive	2009-2013 SRMP

Two-tailed 95% lower (L95CL) and upper (U95CL) confidence limits were used for these EWQ targets

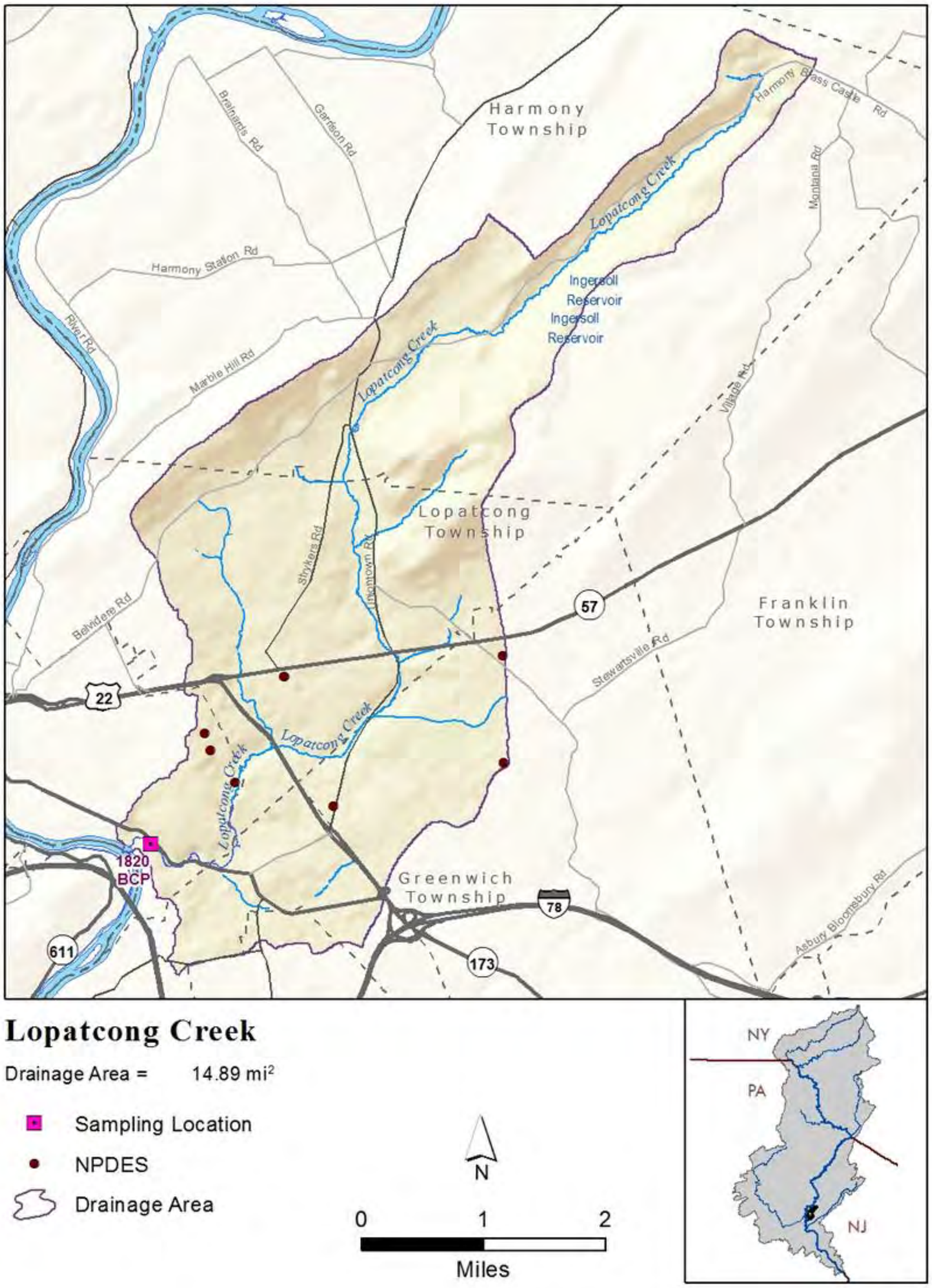
Note: All data are May to September season.

Note: Parameters denoted “archived” were 2009-2010 frozen samples analyzed in 2011 in anticipation of establishing background water quality conditions prior to natural gas development.

*Insufficient number of data to establish Existing Water Quality.

{1}: Median enterococcus concentrations exceed outdated NJ freshwater criterion.

1820 BCP Lopatcong Creek above Phillipsburg WWTP



1820 BCP Lopatcong Creek above Phillipsburg WWTP

Warren County, NJ. Latitude 40.67949 Longitude -75.17499 by GPS NAD83 decimal degrees.
USGS Sites 01455100, 01455099; NJDEP Site No. 01455099
Population 2000 = 11,262 Population 2010 = 14,540 Change = +3,278

Drainage Area at site: 14.7 square miles, tributary to Delaware River Zone 1E

Site Specific EWQ defined by the DRBC/NPS Scenic Rivers Monitoring Program 2009-2013; with additional USGS and NJDEP data from various time periods.

This watershed is tributary to the Lower Delaware Scenic and Recreational River (LDEL)
Classified by DRBC as Significant Resource Waters.

Nearest upstream Interstate Control Point: 1838 ICP Delaware River at Easton
Nearest downstream Interstate Control Point: 1748 ICP Delaware River at Riegelsville
Known dischargers within watershed: Some, undefined. For total Lopatcong Creek effect upon the Delaware River, add loadings produced by Phillipsburg WWTP, located downstream of the monitoring site.

Watershed is 32.8% forested; urban land cover is 17%. Watershed was not glaciated, and is 63% underlain by carbonate bedrock. Mean annual precipitation 45.5 inches. (http://water.usgs.gov/osw/streamstats/, accessed 2012).

Flow Statistics (USGS BaSE Model):

Max Flow (CFS)	90% Flow (CFS)	75% Flow (CFS)	60% Flow (CFS)	50% Flow (CFS)	40% Flow (CFS)	25% Flow (CFS)	10% Flow (CFS)	Min Flow (CFS)
975	36.6	23.1	17.7	14.3	13.7	10.5	7.36	2.18

StreamStats Low-Flow Stream Statistics

M7D2Y (ft^3/s)	12.2
M30D2Y (ft^3/s)	12.8
M7D10Y (ft^3/s)	9.56
M30D10Y (ft^3/s)	9.65
M90D10Y (ft^3/s)	9.94

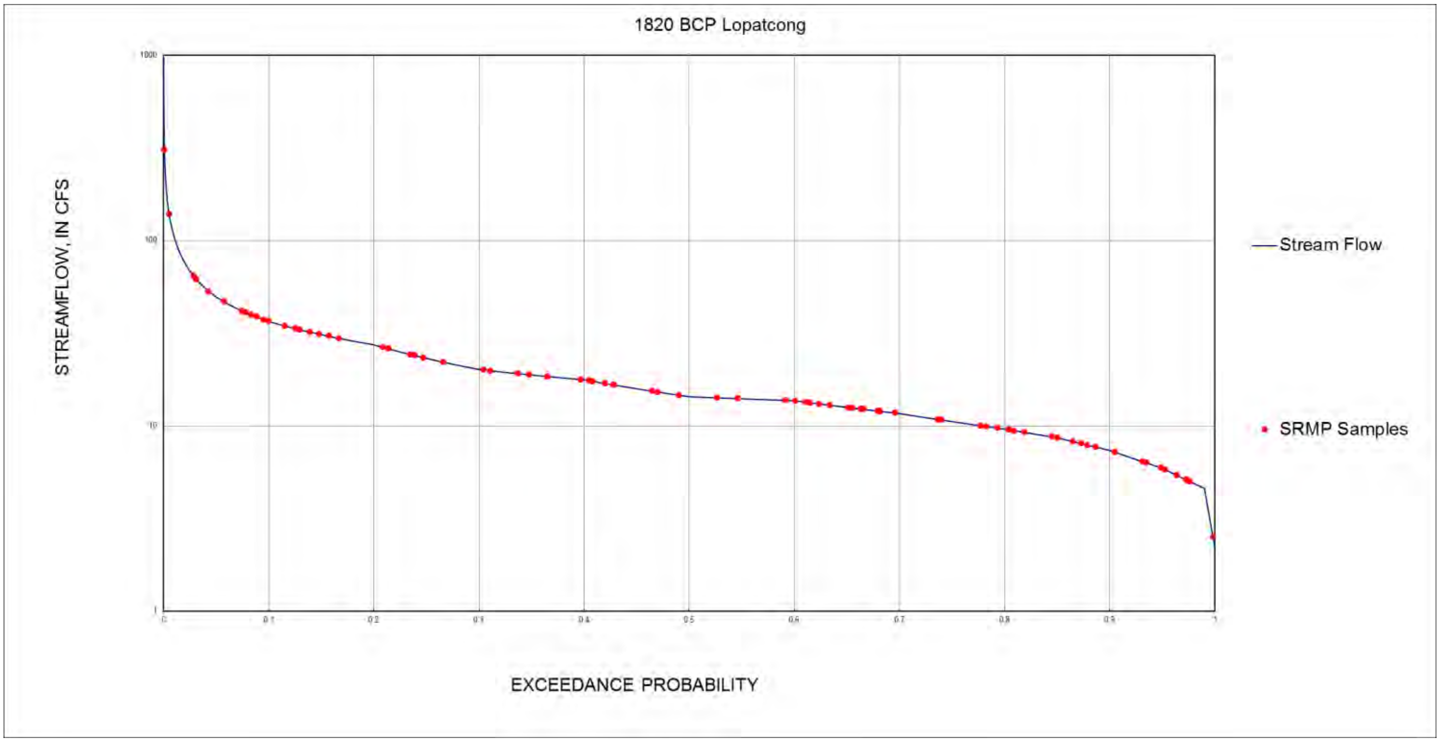
StreamStats Mean/Baseflow Stream Statistics

QA (ft^3/s)	22.2
QAH (ft^3/s)	18.2
BF10YR (ft^3/s)	12.4
BF25YR (ft^3/s)	11.0
BF50YR (ft^3/s)	10.2

StreamStats Peak-Flow Stream Statistics

PK2 (ft^3/s)	707
PK5 (ft^3/s)	1,220
PK10 (ft^3/s)	1,630
PK50 (ft^3/s)	2,720
PK100 (ft^3/s)	3,260
PK500 (ft^3/s)	4,750

1820 BCP Lopatcong Creek SRMP Samples vs. Flow Exceedance Curve



For commonly sampled parameters (up to 82 samples taken), the SRMP data cover almost 100% of Lopatcong Creek's flow regime. However, some parameters such as bacteria (enterococcus, E. coli and fecal coliform) were not sampled every year and were not so representative of the full range of flow conditions. See discussions of individual parameters below.

According to the USGS Stream Stats website (accessed February 2013), the 14.9 square mile Lopatcong Creek watershed is 32.8% forest, 17% urban land cover, and 63% underlain by carbonate bedrock. The watershed was not affected by glacial activity. The watershed was chosen for establishment of Existing Water Quality because of discharge permit activity, and the watershed's high urban land cover as well as high limestone content. All of these make Lopatcong Creek water quality unlike other Lower Delaware tributaries.

The monitoring location is upstream of the City of Phillipsburg's wastewater treatment facility outfall that is located on Lopatcong Creek very close to its confluence with the Delaware River. It proved difficult to access the creek downstream of the treatment plant. As a result, the treatment plant effluent must be balanced with these water quality data in order to determine the effects of Lopatcong Creek upon the downstream portion of the Delaware River.

Existing Water Quality: 1820 BCP Lopatcong Creek above WWTP, NJ

Parameter	N	median	L95CL	U95CL	Flow Relation	Period of Record (May-Sep data)
Alkalinity as CaCO3, Total mg/l	74	150	140	156	None	1980-2000 USGS; 2009-2013 SRMP
Ammonia-Nitrogen as N, Total mg/l	58	<0.006	<0.006	0.007	None	1999-2013 SRMP (50 non-detect)
Chloride, Total mg/l	61	36.8	36.0	37.1	None	2000, 2009-2013 SRMP
Dissolved Oxygen (DO) mg/l	57	10.04	9.80	10.26	None	2000, 2009-2013 SRMP
Dissolved Oxygen Saturation %	61	97.5	96.3	100.3	None	1999-2000, 2009-2013 SRMP
Enterococcus #/100ml **{1}**	40	195	140	340	None	1999-2000, 2009-2011 SRMP
Escherichia coli #/100ml **{2}**	31	270	170	370	None	2009-2011 SRMP
Fecal coliform #/100ml	32	240	180	330	None	2009-2011 SRMP
Hardness as CaCO3, Total mg/l	61	214	202	222	None	2000, 2009-2013 SRMP
Nitrate + Nitrite as N, Total mg/l	54	4.43	4.23	4.65	None	2009-2013 SRMP
Nitrogen as N, Total mg/l	53	4.47	4.31	4.79	Inverse	2009-2013 SRMP
Nitrogen, Kjeldahl as N, Total mg/l	60	0.100	0.097	0.133	None	2000, 2009-2013 SRMP
Orthophosphate as P, Total mg/l	54	0.005	0.003	0.008	None	2000, 2009-13 SRMP (16 non-detect)
pH units	61	7.90	7.82	7.96	None	1999-2000, 2009-2013 SRMP
Phosphorus as P, Total mg/l	58	0.014	0.012	0.017	None	2000, 2009-2013 SRMP
Specific Conductance µmho/cm	61	499	454	516	None	1999-2000, 2009-2013 SRMP
Temperature, Water, degrees C	61	14.2	13.8	14.6	None	1999-2000, 2009-2013 SRMP
Total Dissolved Solids (TDS) mg/l	60	275	269	284	None	2000, 2009-2013 SRMP
Total Suspended Solids (TSS) mg/l	60	2.5	1.7	3.2	None	2000, 2009-2013 SRMP
Turbidity NTU	79	1.57	1.15	1.81	None	2000, 2009-2013 SRMP

Two-tailed 95% lower and upper confidence limits were used for these EWQ targets

Note: All data are May to September season. Additional data are available for the October to April "non-seasonal" period, but data are insufficient in number for establishment of site-specific existing water quality targets.

Note: Hydroqual study 2006-2007 results not included in this data set but were used in model for project development.

Note: Sample results do not incorporate City of Phillipsburg WWTP discharge, which is about 200 meters downstream of monitoring point and just upstream of Lopatcong Creek confluence with the Delaware River.

{1}: Enterococcus concentrations exceed outdated NJ freshwater criterion of 33 #/100 ml.

{2}: Escherichia coli concentrations exceed NJ freshwater criterion of 126 #/100 ml.

1672 BCP Hakihokake Creek at Bridge St. (RESERVED)

1672 BCP Hakihokake Creek at Bridge St. (RESERVED)

Hunterdon County, NJ. Latitude 40.568444 Longitude -75.095167 by GPS NAD83 decimal degrees.
USGS Site No. 01458100; NJDEP Site No. 01458100
Population 2000 =   Population 2010 =   Change =

Drainage Area at site: 17.5 square miles, tributary to Delaware River Zone 1E

Site Specific EWQ monitoring began 2014 by DRBC/NPS Scenic Rivers Monitoring Program; supplementing USGS/NJDEP long-term quarterly and special studies data.

This watershed is tributary to the Lower Delaware Scenic and Recreational River (LDEL)
Classified by DRBC as Significant Resource Waters.

Nearest upstream Interstate Control Point: 1677 ICP Delaware River at Upper Black Eddy Bridge
Nearest downstream Interstate Control Point: 1554 ICP Delaware River at Bulls Island Footbridge
Known dischargers within watershed: Some, undefined.

Watershed is 53.7% forested; urban land cover is 5.8%. Watershed was not glaciated, and is 1.5% underlain by carbonate bedrock. Mean annual precipitation 46.9 inches. (http://water.usgs.gov/osw/streamstats/, accessed 2012).

Flow Statistics (USGS BaSE Model):

Max Flow (CFS)	90% Flow (CFS)	75% Flow (CFS)	60% Flow (CFS)	50% Flow (CFS)	40% Flow (CFS)	25% Flow (CFS)	10% Flow (CFS)	Min Flow (CFS)
1,909	56.9	30.8	22.5	18.5	18.2	12.8	7.35	2.91

StreamStats Low-Flow Stream Statistics

M7D2Y (ft^3/s)	6.89
M30D2Y (ft^3/s)	8.10
M7D10Y (ft^3/s)	3.91
M30D10Y (ft^3/s)	4.63
M90D10Y (ft^3/s)	5.94

StreamStats Mean/Baseflow Stream Statistics

QA (ft^3/s)	28.5
QAH (ft^3/s)	8.84
BF10YR (ft^3/s)	11.9
BF25YR (ft^3/s)	10.6
BF50YR (ft^3/s)	9.79

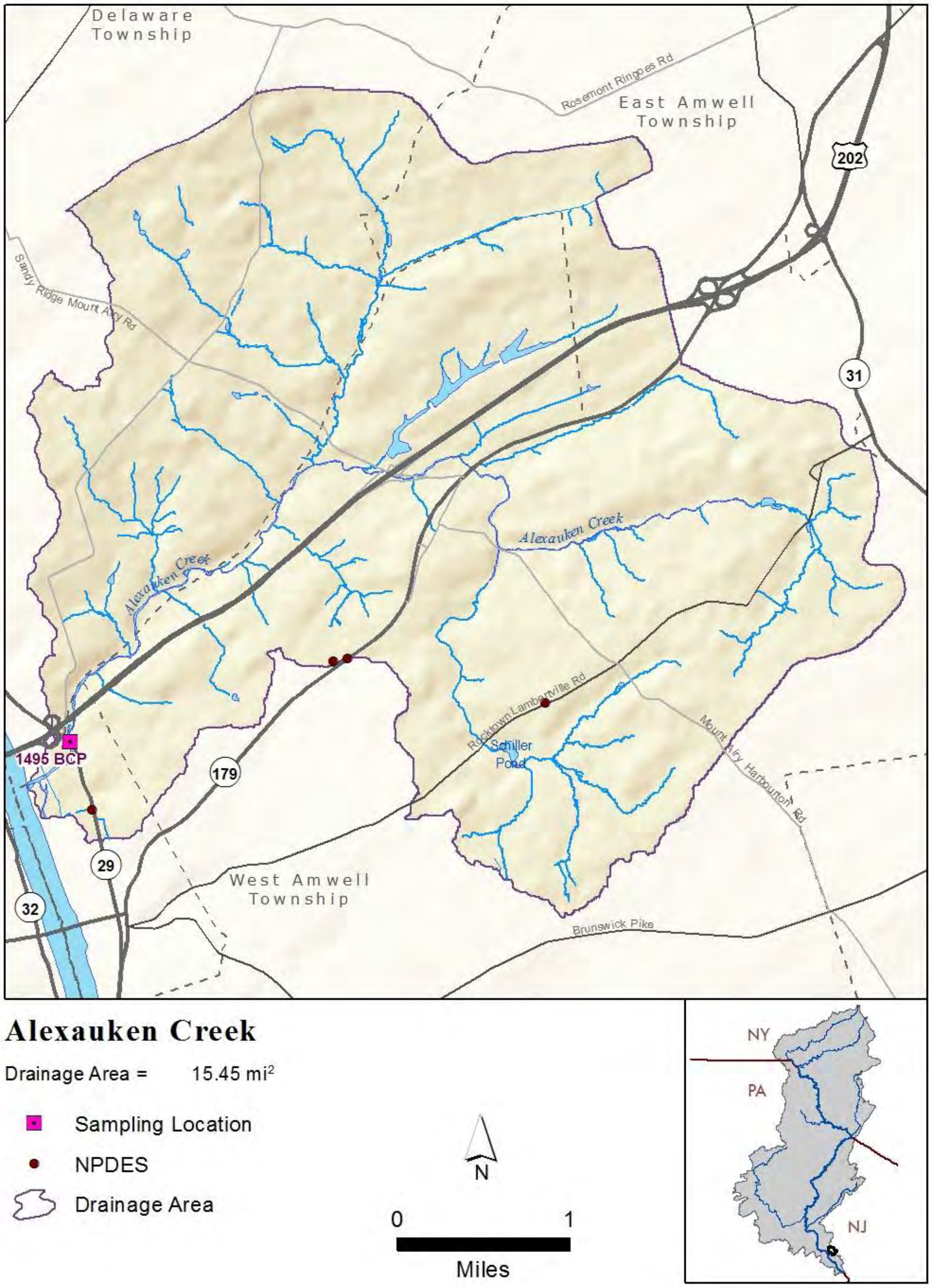
StreamStats Peak-Flow Stream Statistics

PK2 (ft^3/s)	763
PK5 (ft^3/s)	1,310
PK10 (ft^3/s)	1,750
PK50 (ft^3/s)	2,930
PK100 (ft^3/s)	3,530
PK500 (ft^3/s)	5,170

Existing Water Quality: 1672 BCP Hakihokake Creek at Bridge St. (RESERVED)

Placeholder for Existing Water Quality Table

1495 BCP Alexauken Creek at Rt. 29 (RESERVED)



1495 BCP Alexauken Creek at Rt. 29 (RESERVED)

Hunterdon County, NJ. Latitude 40.3806 Longitude -74.947961 by GPS NAD83 decimal degrees.
USGS Site No. 01461900; NJDEP Site No. 01461900
Population 2000 = 2,409 Population 2010 = 2,496 Change = +87

Drainage Area at site: 15.0 square miles, tributary to Delaware River Zone 1E

Site Specific EWQ monitoring began 2014 by DRBC/NPS Scenic Rivers Monitoring Program; supplementing USGS/NJDEP long-term quarterly and special studies data.

This watershed is tributary to the Lower Delaware Scenic and Recreational River (LDEL)
Classified by DRBC as Significant Resource Waters.

Nearest upstream Interstate Control Point: 1554 ICP Delaware River at Bulls Island Footbridge
Nearest downstream Interstate Control Point: 1487 ICP Delaware River at Lambertville
Known dischargers within watershed: Some, undefined.

Watershed is 44.3% forested; urban land cover is 1.56%. Watershed was not glaciated, and is not underlain by carbonate bedrock. Mean annual precipitation 45.1 inches. (http://water.usgs.gov/osw/streamstats/, accessed 2012).

Flow Statistics (USGS BaSE Model):

Max Flow (CFS)	90% Flow (CFS)	75% Flow (CFS)	60% Flow (CFS)	50% Flow (CFS)	40% Flow (CFS)	25% Flow (CFS)	10% Flow (CFS)	Min Flow (CFS)
1,750	45.3	21.9	16.7	14.1	11.8	6.92	3.28	0.54

StreamStats Low-Flow Stream Statistics

M7D2Y (ft^3/s)	1.93
M30D2Y (ft^3/s)	2.70
M7D10Y (ft^3/s)	0.81
M30D10Y (ft^3/s)	1.17
M90D10Y (ft^3/s)	2.07

StreamStats Mean/Baseflow Stream Statistics

QA (ft^3/s)	20.6
QAH (ft^3/s)	5.76
BF10YR (ft^3/s)	8.43
BF25YR (ft^3/s)	7.38
BF50YR (ft^3/s)	6.79

StreamStats Peak-Flow Stream Statistics

PK2 (ft^3/s)	670
PK5 (ft^3/s)	1,160
PK10 (ft^3/s)	1,550
PK50 (ft^3/s)	2,600
PK100 (ft^3/s)	3,130
PK500 (ft^3/s)	4,590

Existing Water Quality: 1495 BCP Alexauken Creek at Rt. 29 (RESERVED)

Placeholder for Existing Water Quality Table

Appendix B: Statistical Plots Generated by Analyse-It

All of the following statistical procedures were performed as part of each water quality and streamflow evaluation. We used an add-in package for Microsoft Excel called Analyse-It (http://www.analyse-it.com). DRBC's water quality database contains many columns that classify results by location, pre- or post-EWQ status, date and time, and flow categories. These were used as nominal variables in Analyse-It that set up comparisons and plots for the continuous variables ResultValue and Flow_cfs. Sites and parameters were filtered, and the resulting data were run through the mill of summary statistics, scatter plots, box plots, cumulative distribution functions, and comparative tests.

Analyse-It was labor intensive, requiring close examination of and often reformatting of resulting plots for best display in this document. Now that the water quality database has grown to over 200,000 records, Excel has become slow to use and Analyse-It plotting and testing almost like mind-numbing factory work. Almost 3,000 iterations of this assessment were essentially completed by hand. The painful process was beneficial in that it forced us to examine every piece of data, identify and attempt to control sources of uncertainty in our conclusions, and document in detail the steps necessary to complete a full measurable change assessment. Now that we've documented the process, however, it's time to become more efficient by programming the process. For this we plan to use Access or SQL Server to host the database, and the R Statistical packages for more rapid analyses and customized plotting.

The descriptions below were copied from the Analyse-It help facility, supplied with the software by Analyse-it Software Ltd., Leeds, UK. We found them helpful in negotiating the assessment process and understanding the limitations of our data and the statistics in general.

Summary Statistics

Summary presents a statistical and visual overview of a sample. A histogram and a combined dot-, box-, mean-, percentile- and SD- plot give a visual summary and statistics such as the mean, standard deviation skewness, kurtosis and median, percentiles summarize the sample numerically.

Normality of the distribution of the sample can be visually assessed with the histogram, or normal quantile plot or statistically using a normality test.

The requirements of the test are:

- A sample measured on a continuous scale.

Using the test

The report shows the number of observations analyzed and summary statistics.

A frequency histogram, box plot, and mean plot are shown in addition to a normal quantile plot and Shapiro-Wilk normality test (see below).

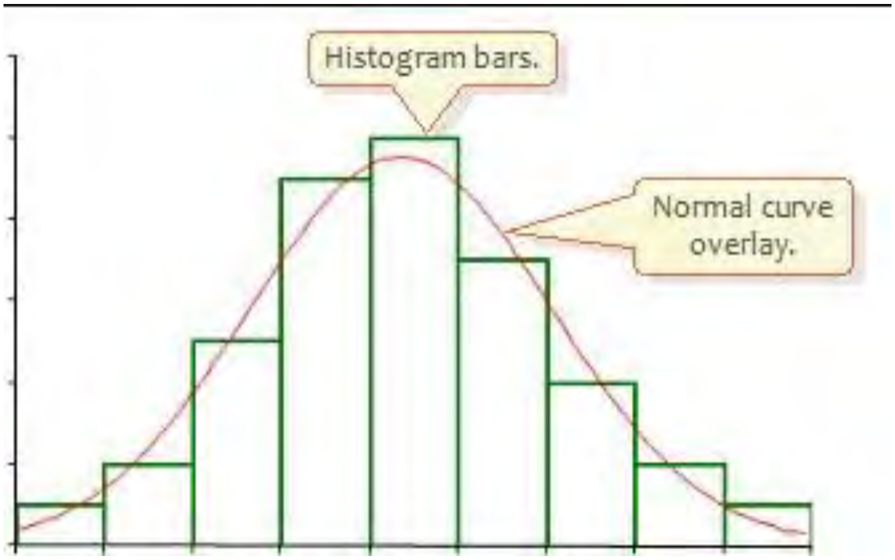
The mean is a measure of the central location of the sample and the standard deviation is a measure of the dispersion of observations. The shape of the distribution is described by the skewness, a measure of the asymmetry, and kurtosis, a measure of the peakedness.

The median is a measure of the central location of the sample with half the observations above and half below the median. The percentile table shows the minimum, maximum and quartiles in addition to any other percentiles shown on the percentile plot (see below).

METHOD Percentiles are calculated using Tukey's method which approximates the percentiles as:
(i - 1/3) / (n + 1/3) (see [4] and [5]).

Confidence intervals are calculated for the mean, median and standard deviation.

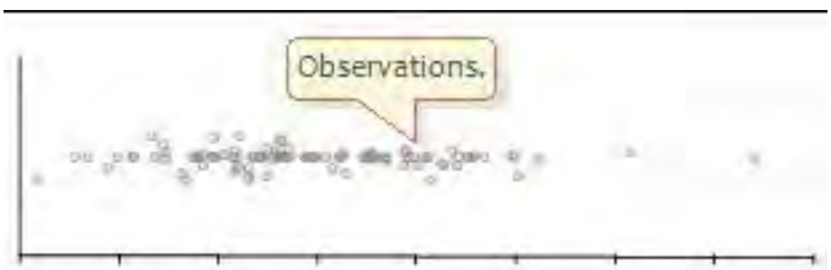
Frequency Histogram



The frequency histogram shows the distribution of the sample. The bins used are chosen automatically, based on the number and range of the observations, or can be entered manually.

Normality can be visually assessed by comparing the height of the frequency histogram bars to a normal curve.

Examining the observations with a dot plot

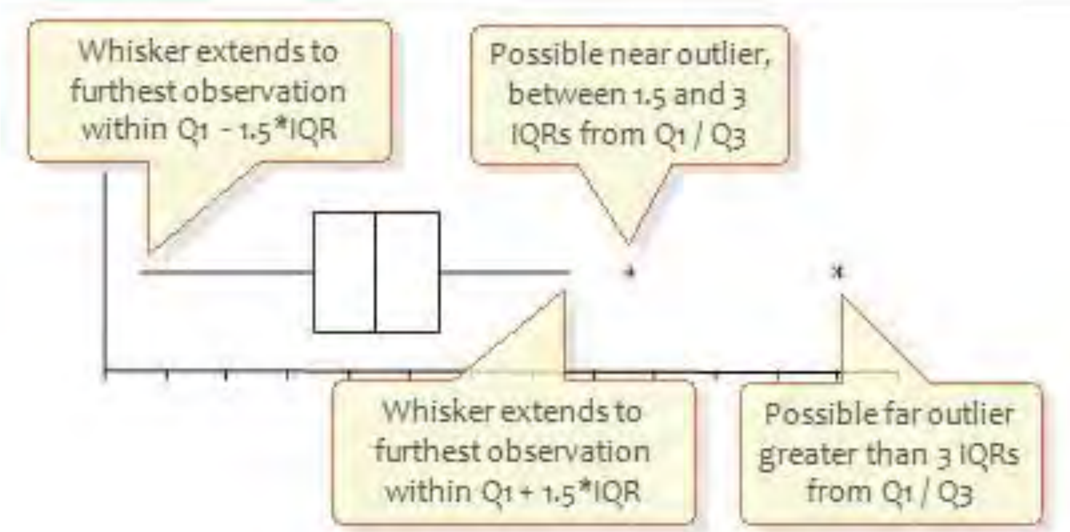


Dot plots show the observations to allow visual assessment of the distribution and clustering of observations, and to spot possible outliers or data entry errors. Observations are jittered (Y axis) to minimize overlapping points.

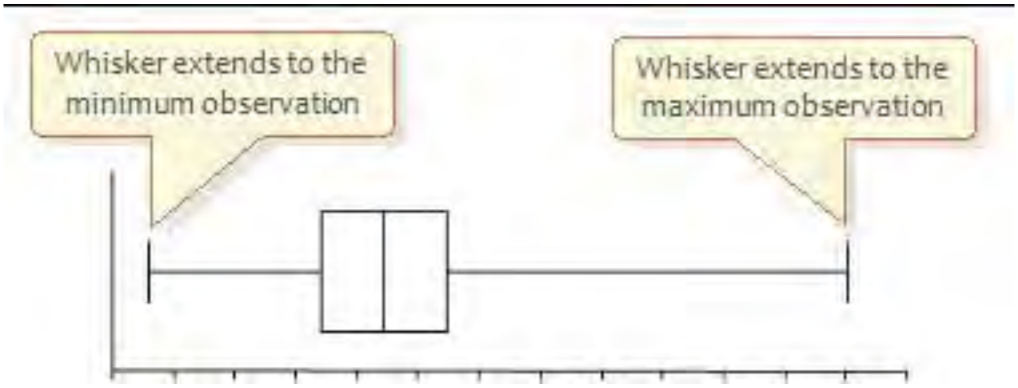
Box and percentile plots

Box and percentile plots show the non-parametric central tendency, dispersion and distribution shape of the sample. Box plot styles vary between publications with the most common styles differing mainly in how the whiskers are drawn.

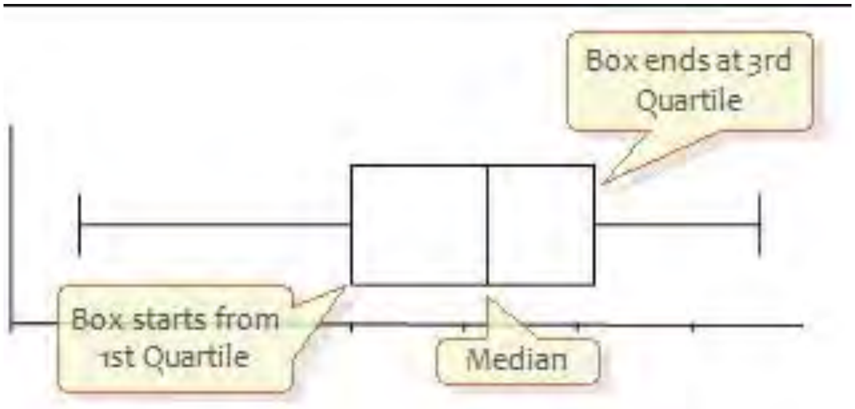
The box plot styles are:



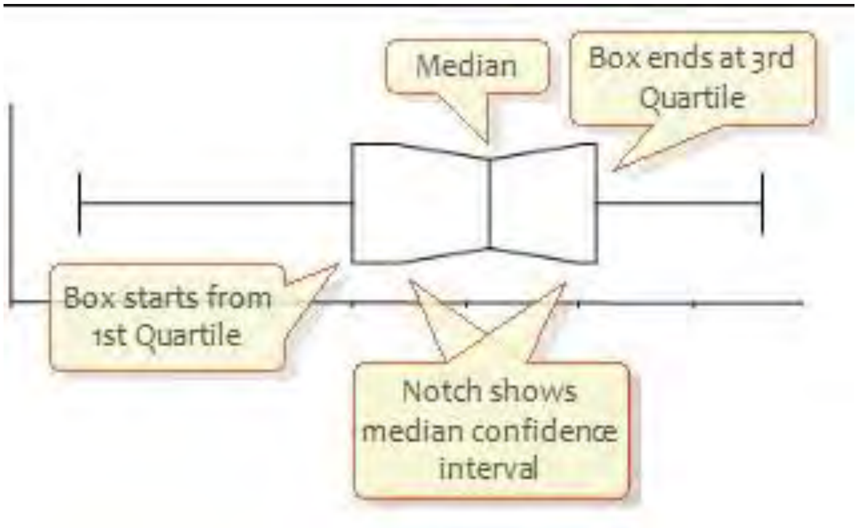
Outlier box plots show whiskers extending to the furthest observations within ±1.5 IQR (interquartile ranges) of the 1st or 3rd quartile. Observations outside 1.5 IQRs are marked as near outliers (+), and those outside 3.0 IQRs are marked as far outliers (*, see below).



Skeletal box plots show whiskers extending to the minimum and maximum observations (see below).

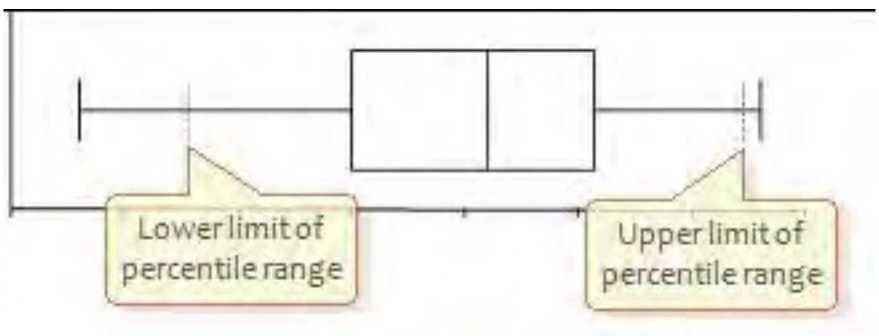


Basic box plots show a simple rectangular box-plot, from the first to the third quartile, with the median marked in the center (see below).



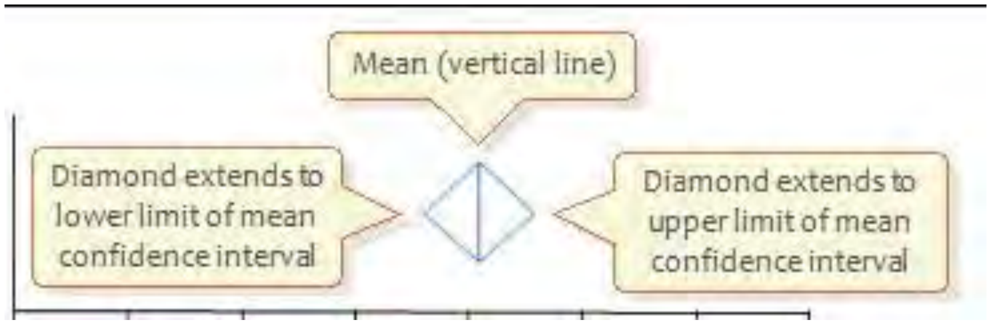
Notched box plots show a basic box plot as above, with the addition of a notched (pinched or indented) section for the confidence interval around the median (see below).

Percentile plots (see below) show the range within which a percentage of the observations lie. The calculated percentiles are also shown in the percentile table.

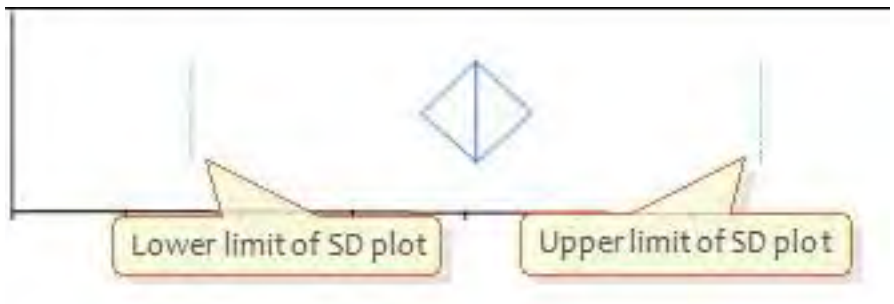


Mean and Standard Deviation plots

Mean and SD plots show the parametric central tendency and dispersion.



The mean plot (left) shows the mean as a vertical line, and optionally, the confidence interval for the mean as a diamond shape.



SD plots (left) are similar to non-parametric percentile plots, but show the parametric dispersion of the sample.

Assessing Normality

Normality can be visually assessed from the frequency histogram, or a Normal Quantile plot and a statistical hypothesis test can be used.

The normality tests available are:

- ***Shapiro-Wilk***, recommended for sample sizes of up to 4000 observations.

METHOD The Shapiro Wilk test uses the modified Shapiro-Wilk method and so is suitable for moderate sample sizes (see [4]).

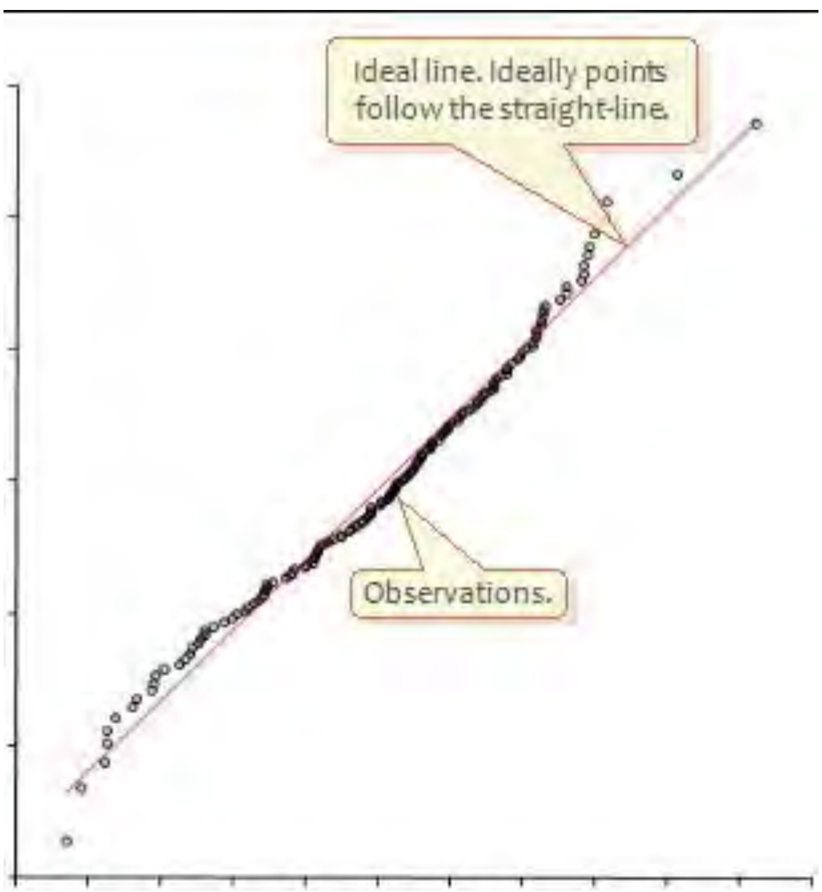
- ***Anderson-Darling***, recommended for sample sizes larger than 4000 observations.

METHOD The Anderson-Darling goodness-of-fit test, modified for unknown population mean and variance, is used (see [2]).

- ***Kolmogorov-Smirnov***, not recommend, mainly for historical interest.

METHOD The Kolmogorov-Smirnov goodness-of-fit test, modified for unknown population mean and variance, is used (see [2]).

The normality test statistic and hypothesis test are shown. The *p*-value is the probability of rejecting the null hypothesis, that the sample is from a normally distributed population, when it is in fact true. A significant p-value implies that the sample is from a non-normally distributed population.



The Normal quantile plot shows the observations of the sample against the expected normal quantile. The expected quantile is the number of SDs from the mean where such an observation would be expected to lie in normal distribution with the sample mean and standard deviation. When the sample is normally distributed the points will form a straight-line. Deviation from the line indicates non-normality.

Correlation and association

Correlation explores the association between two or more variables and makes inferences about the strength of the relationship.

For example, a teacher may want to examine the correlation between the number of hours sleeping and studying for a group of students. A sociologist may want to examine the association between height and self-esteem. Similarly, a medical researcher may want to examine the relationship between hemoglobin and packed cell volume in two groups of women.

Note: The terms correlation and association are often used interchangeably. Technically, association refers to any relationship between two variables, whereas correlation is often used to refer only to a linear relationship between two variables. The terms are used interchangeably in this guide, as is common in most statistics texts.

- Correlation coefficient
  A correlation coefficient measures the association between two variables.

- Scatter plot
  A scatter plot shows the association between variables.

- Inferences about association
  A bivariate random sample of data drawn from a population can be used to make inferences about the association between the variables in the population.

Scatter Plots (Annual Plots)

A scatter plot shows the association between variables.

You can use the plot to determine the type of association between variables. If the variables tend to increase and decrease together, the association is positive. If one variable tends to increase as the other decreases, the association is negative. When a straight line describes the relationship between the variables, the association is linear. When a constantly increasing or decreasing nonlinear function describes the relationship, the association is monotonic. Other relationships may be nonlinear or non-monotonic.

The type of relationship determines the statistical measures and tests of association that are appropriate. A bivariate normal density ellipse summarizes the correlation between variables when the relationship is linear. The narrower the ellipse, the greater the correlation between the variables. The wider and more round it is, the more the variables are uncorrelated.

If the association is nonlinear, it is worth trying to transform the data to make the relationship linear as there are more statistics for analysing linear relationships and their interpretation is generally easier.

You can also use a scatter plot to spot outliers. An individual observation on each of the variables may be perfectly reasonable on its own, but appear as an outlier when plotted on a scatter plot. Avoid outliers as they badly affect the Pearson product-moment correlation coefficient. Other correlation coefficients are more robust to outliers.

Fit model

Fit model describes the relationship between a response variable and one or more predictor variables.

Fits many models including simple linear regression, multiple linear regression, analysis of variance (ANOVA), analysis of covariance (ANCOVA), and binary logistic regression.

For example, an engineer may want to determine the relationship between fuel consumption and various vehicle factors. An economist may be interested in examining the link between employee salary and years in education using a linear regression with an exponential fit. Or a scientist may study the effect of the dose of a drug for different age groups using a logistic regression.

You can fit different types of model to the data:

- Simple regression models
- Advanced models

The tasks available depend on the type of analysis.

- Linear fit
  A linear model describes the relationship between a response variable and the explanatory variables using a linear function.
- Logistic fit
  A logistic model describes the relationship between a categorical response variable and the explanatory variables using a logistic function. The model is formulated in terms of the log odds ratio (the logit) of the probability of the outcome of interest as a function of the explanatory variables.

Simple regression models

Simple regression models describe the relationship between a single predictor variable and a response variable.

Line	Fit the model Y = b0 + b1 x. Fit a straight line.
Polynomial	Fit the model Y = b0 + b1 x + b1 x2.... Polynomials are useful when the function is smooth but not straight. Any smooth function can be estimated by a polynomial of a high-enough degree. Polynomials are generally used as approximations and rarely represent a physical model.
Logarithmic	Fit the model Y = b0 + b1 Log(x). Fit a logarithmic function curve.
Exponential	Fit the model Y = a * b1x Fit an exponential function curve.
Power	Fit the model Y = a * x b1. Fit a power function curve.
Logistic	Fit the model Y = b0 + b1 x where x is the logit.

Linear fit

A linear model describes the relationship between a response variable and the explanatory variables using a linear function.

- Scatter plot
  A scatter plot shows the relationship between variables.
- Parameter estimates
  Parameter estimates (also called coefficients, or beta coefficients) are the change in the response associated with a one-unit change of the predictor, all other predictors being held constant.
- Summary of fit
  R^2 and similar statistics examine how well the model fits the data.
- Lack of Fit
  An F-test or X2-test formally tests whether the model fits the data.
- Effect of model hypothesis test
  An F-test formally tests the hypothesis of whether the model fits the data better than no model.
- Predicted against actual Y plot
  An effect of model plot shows the observed response against the response predicted by the model.
- Effect of terms hypothesis test
  An F-test formally tests whether a term contributes to the model.
- Effect leverage plot
  An effect leverage plot, also known as added variable plot or partial regression leverage plot, shows the unique effect of a term in the model.
- Residual plot
  A residual plot shows the residuals (the difference between the observed response and the fitted response values) against the predictor variable. Normality, sequence and lag plots of the residuals show additional information about their behaviour.
- Outlier and influence plot
  An influence plot shows the outlyingness, leverage, and influence of each case.
- Prediction
  Predict the value of an individual future observation or to predict the population mean at specific values of the predictors.

Summary of fit

R^2 and similar statistics examine how well the model fits the data.

R^2 is the proportion of variability in the response explained by the model. It is 1 when the model fits the data perfectly, though it can only attain this value when all observations for the predictors are different. Zero indicates the model fits no better than the null model. R^2 should not be used when the model does not include a constant term, as the interpretation is undefined.

For models with more than a single term, R^2 can be deceptive as it increases as more parameters are added to the model, eventually reaching saturation at 1 when the number of parameters equals the number of observations. Adjusted R^2 is a modification of R^2 that adjusts for the number of parameters in the model. It only increases when the terms added to the model improve the fit more than would be expected by chance. It is preferred when building and comparing models with a different number of parameters.

For example, if we fit a straight-line model, and then add an additional term to produce a quadratic polynomial model, the value of R^2 will increase. If we continued to increase the polynomial order to the same as the number of observations, then the R^2 value would be 1. The adjusted R^2 statistic is designed to take into account the number of parameters in the model and ensures that adding the new term has some useful purpose rather than simply due to the number of parameters approaching saturation.

In cases where there is more than a single set of predictors with the same value it may be impossible for the R^2 statistic to reach 1. A statistic called the maximum attainable R^2 indicates the maximum value that R^2 can achieve even if the model fitted perfectly. It is related to the pure error discussed in the lack of fit test

The standard error (SE) of the fit, also known as root mean square error (RMSE), is an estimate of the standard deviation of the true unknown random error. If the model fitted is not the correct model, the standard error will be larger than the true random error, as it includes the error due to lack of fit of the model as well as the random errors.

Frequency distribution

A frequency distribution reduces a large amount of data into a more easily understandable form.

A simple table of the frequencies may be all that is needed. Alternatively, there are a number of plots that highlight different aspects of the distribution.

- Cumulative distribution function plot
  A cumulative distribution function (CDF) plot shows the empirical cumulative distribution function of the data.

- Histogram
  A histogram shows the distribution of the data.

Cumulative Distribution Functions

A cumulative distribution function (CDF) plot shows the empirical cumulative distribution function of the data.

The empirical CDF is defined as the proportion of values less than or equal to X. It is an increasing step function that has a vertical jump of 1/N at each value of X equal to an observed value. You can use the plot to see the shape of the distribution of the data, or to compare the shape of the distributions for different sets of data.

Equality of means / medians hypothesis test

A hypothesis test for equality of means/medians formally tests if the populations the samples represent have different central location parameters.

The hypotheses to test depend on the number of groups to be tested.

- For 2 groups, the null hypothesis states that the difference between the mean/medians of the groups is equal to a hypothesized value (0 indicating no difference), against the alternative hypothesis that it is not equal to (or less-than / greater-than) the hypothesized value.
- For more than 2 groups, the null hypothesis states that the means/medians of the groups are equal, against the alternative hypothesis that at least one group is different.

When the test p-value is small, you can reject the null hypothesis and conclude that the groups differ in central location.

It is important to remember that a statistically significant test tells you nothing about the practical importance of what was observed. For a large sample, the difference detected by a statistically significant hypothesis test may be so small as to be practically useless. Conversely, although there may be some evidence of a difference, the sample size may be too small to reach statistical significance, and you may miss an opportunity to discover a true, meaningful difference. For these reasons, it is essential that the p-value is always interpreted together with an estimate of the effect size, so both statistical significance and practical importance can be evaluated.

Kruskal-Wallis	Test if the medians of 2 or more groups are equal. Assumes the population distributions are identically shaped, except for a possible shift in central locations.
Wilcoxon-Mann-Whitney	Test if the shift in location between 2 groups is equal to a hypothesized value. When the population distributions are identically shaped, except for a possible shift in central location, the hypothesis can be stated as testing for a difference in medians. When the population distributions are not identically shaped the hypothesis can be stated as a test whether the samples come from populations such that the probability is 0.5 that a random observation from one group is greater than a random observation from another group.
Student t (commonly used in the past)	Test if the difference in mean between 2 groups is equal to a hypothesized value. Assumes the populations are normally distributed. Due to the central limit theorem the test may still be useful when the assumption is violated if the sample sizes are equal, moderate size, and the distributions have similar shape. However, in this situation the Wilcoxon-Mann-Whitney test may be more powerful. Assumes the population variances are equal. The assumption can be tested using the Levene test. The test may still be useful when the assumption is violated if the sample sizes are equal. However, in this situation the Welch t-test may be preferred.

References to further reading

1. Handbook of Parametric and Nonparametric Statistical Procedures (3rd edition)
   David J. Sheskin, ISBN 1-58488-440-1 2003.

2. Goodness of Fit Techniques
   Ralph D'Agostino, Michael Stephens, ISBN 0-8247-7487-6 1986.

3. Approximating the Shapiro-Wilk W-test for non-normality
   Royston P, Journal Statistics and Computing, Vol 2 No. 3 1992; 117-119.

4. Some Implementations of the Boxplot
   Michael Frigge, David C. Hoaglin, Boris Iglewicz, The American Statistician Vol 41, No. 1 1989; 50-55.

5. Sample Quantiles in Statistical Packages
   Rob J. Hyndman, Yanan Fan. The American Statistician, Vol. 50, No. 4 1996, 361-365.

Appendix C: Flow Estimation and Measurement Techniques of the Scenic Rivers Monitoring Program

Eric Wentz and Robert Limbeck

Ungaged Stream Flow Estimation

Two USGS computer applications were used by DRBC to assign estimates of stream flow to our ungaged, unregulated streams. These estimates were used to classify each of our water quality samples by their flow conditions. Using a combination of StreamStats and BaSE from USGS, we were able, with acceptable confidence, to associate a stream flow on a specific date to an ungaged stream in the Delaware River Basin. StreamStats is a Web-based Geographic Information System (GIS) that provides users with access to an assortment of analytical tools that are useful for water-resources planning and management as well as allows users to easily obtain streamflow statistics, drainage-basin characteristics, and other information for user-selected sites on streams (http://water.usgs.gov/osw/streamstats/). Daily mean streamflow is estimated in BaSE using a methodology that equates streamflow as a percentile from a flow duration curve for a particular day at an ungaged location with streamflow as a percentile from the flow duration curve for the same day at a reference stream gage that is considered to be hydrologically similar to the ungaged location (Stuckey, M.H., Koerkle, E.H., and Ulrich, J.E., 2012, Estimation of baseline daily mean streamflows for ungaged locations on Pennsylvania streams, water years 1960–2008: U.S. Geological Survey Scientific Investigations Report 2012–5142, 61 p.). We made use of a beta-version of BaSE specifically adapted to the Delaware River Basin.

Using these two programs, estimation of streamflow has multiple steps. The first step was to identify the stream to have its flow estimated. Our sample sites were GPS located and coordinates were input into StreamStats using the Zoom to Latitude/Longitude function. This puts a crosshair onto the map at the precise location to use the Delineation Tool in StreamStats. This delineates the selected watershed upstream from the selected GPS coordinates. Once the delineation was complete the basin characteristic statistics were populated in StreamStats. These statistics were then downloaded as a Microsoft Database file (.mdb).

Switching over to the BaSE program, the database file is directly imported into the BaSE application to compute baseline stream flow. By default we let the BaSE application choose the reference gage of the most hydrologically similar to the ungaged site. However, these needed to be closely checked for geographic proximity. Often the best reference gages are located far from the ungaged location, meaning that localized summer thunderstorms are missed. It is frequently possible to select a different reference gage that is closer to and gets the same local weather conditions as the ungaged location.

BaSE creates an excel report that includes streamflow data, exceedance probabilities, basin characteristics, and hydrographs for the ungaged site. The data output from BaSE estimates baseline streamflow at a daily time scale for ungaged streams in the Delaware River Basin using data collected during water years 1960– 2008. However, for data outside these water years (2009-Current), we looked at the daily flow from the reference gage and compared that flow to the flow of the ungaged stream for the previous water years and used the associated flow.

With sample dates and the flow associated with the dates we were able to plot the points along the flow duration curve generated by BaSE. We did this in order to see if our sampling occurred throughout the entire flow duration curve or if we unintentionally targeted high or low flow. This was useful also for identifying regulated streams such as the Mongaup River, Paulins Kill, and Bushkill Creek – it appeared as if our sampling did not cover the low end of the flow duration curve, but only because flow was almost always supplemented by reservoir releases or flow augmentation. This situation occurred on the Mongaup River in New York, where three reservoirs control flow for electric hydropower generation. Also, Bushkill Creek in Northampton County, PA is regulated by a large quarry operation that captures the stream and pumps it back out using a series of large quarry dewatering pumps (see Figure 1 & 2). On these streams, BaSE estimates of low flow do not apply because their flow is artificially supported by augmentation measures. For the Mongaup we could not use BaSE. For the Bushkill we could shift the flow duration curve by the constant 65 cfs supplied by the quarry dewatering pumps.

Gaged Stream Flow Estimation

For streams that have a USGS continuously monitored flow gage, we accessed the flow of the specific date and time that was sampled and record that flow for the sample. This flow is used where the stream gage was in close proximity to our sample site. Where instantaneous flow was captured some distance above or below the sample site we used Drainage Area Weighting (DAW) to estimate the stream flow at the sample site. This required using the USGS program StreamStats again to delineate the watershed at the point where the gage was located and at the sample point. In most instances where we used DAW, the sample location was further down the watershed than the stream gage but not so far down as to not be useful in estimating the stream flow (i.e. within 20% of drainage area size). If the difference in drainage area between the gage location and the sample site exceeded 20%, DAW was either not used to estimate flow, or checked against the BaSE method for agreement (see Figure 3).

To check continuity of this method and the BaSE method, flow duration curves were produced from the gaged data with DAW applied and the BaSE data that was generated. To minimize discrepancies between the two sets of data, the same period of record was used along with average daily flow, which is a standard in the BaSE generated file. These two flow duration curves by different methods were placed on the same excel graph and showed exceptional agreement when the period of record from BaSE and USGS were identical (see example in Figure 4). Some disparity was seen on streams with regulated flows, a sample site that encompassed twice as much watershed as the gage, or on sites where the period of record was not similar.

Stream Flow from Gage Height / Discharge Relationship

This was our long practice of many years, setting up sites with gage height benchmarks and creating gage/discharge relationships using USGS field methods. Whenever we sampled water quality a measurement was taken from the benchmark to the top of the water. These streams were separately visited periodically through the year to take discharge measurements along with the water level height from the gage height marker. Using many measurements at the full range of flows, it was possible to assign a stream flow to a sample event by creating a site specific gage height / discharge relationship. We generated site specific stream flow equations (best fit linear, power or exponential regressions) to calculate the sample stream flow.

In using this method for the past 20 years, we found that in streams with stable channels we could retain the rating from year to year with minimal adjustments by taking a few stream discharge measurements and adding a correction value. Unfortunately, for the majority of the streams we monitored, we had to completely recreate the rating curve every year (and sometimes after every big storm). The stream channels were too unstable, and we could not create stabilization structures to maintain the gages. We also could not afford the staff time it took to create new rating curves so often. Due to the expense in field time that it takes to maintain gages, this method was abandoned at problematic monitoring sites in favor of a BaSE or DAW approach. The BaSE and DAW estimation methods are somewhat less accurate, but are sufficient for our requirement of classifying water quality samples to determine flow relationships. So we sacrificed some accuracy for the savings of thousands of hours of staff time, yet still were able to achieve our data quality objectives. We also gained valuable insight about the heroic efforts required by the U.S. Geological Survey to maintain our stream gage network.

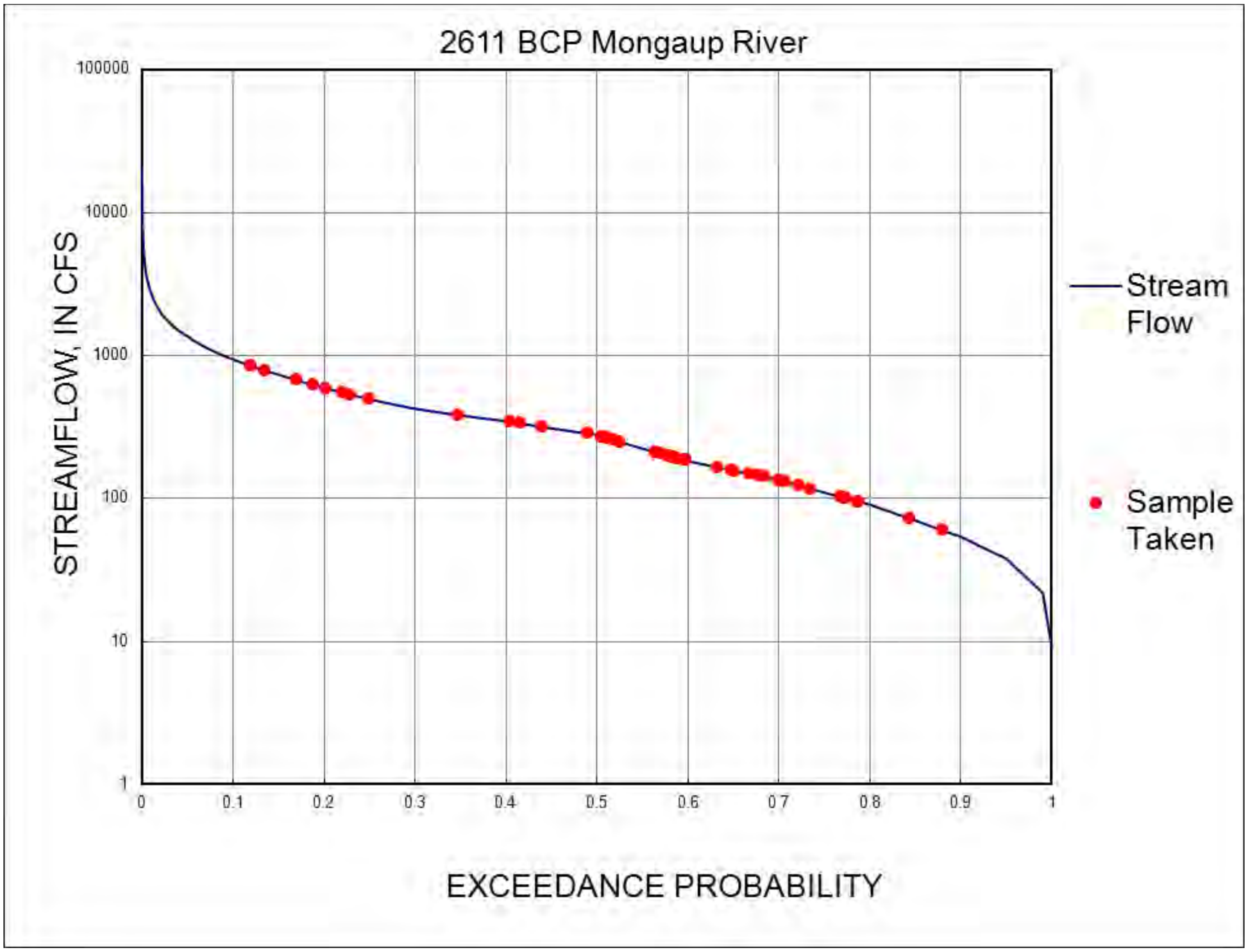
Special Circumstance: Mongaup Stream Flow Estimation

This streamflow was difficult or impossible to estimate using previous methods. We could not use BaSE as the Mongaup is controlled upstream by a hydropower dam, the Rio system. We could not use DAW on the Mongaup from the upstream gage for the same reason. A gage discharge relationship was not reliable because high flows would not be measureable due to dangerous conditions.

We used a combination of methods to estimate flow. We looked at reports from the Delaware River Master to see what the daily release was from the Rio system. We also looked at the flow above and below the influence of the Mongaup with DAW and tried to calculate the Mongaup influence. We also knew that the Mongaup has a minimum flow of 100 cfs, 60 cfs in drought conditions, required for their operations and agreement with NYSDEC. Finally, we looked at notes supplied by our sampling team as to the visual assessment of the stream flow conditions. Using these multiple sources we could crosscheck and determine if the sample was taken during the releases reported to the river master or at the minimum flow.

Luckily for future assessment there is a USGS stream flow gage on the Mongaup River below the Rio system which will provide stream flow reporting without the use of any flow estimation tools.

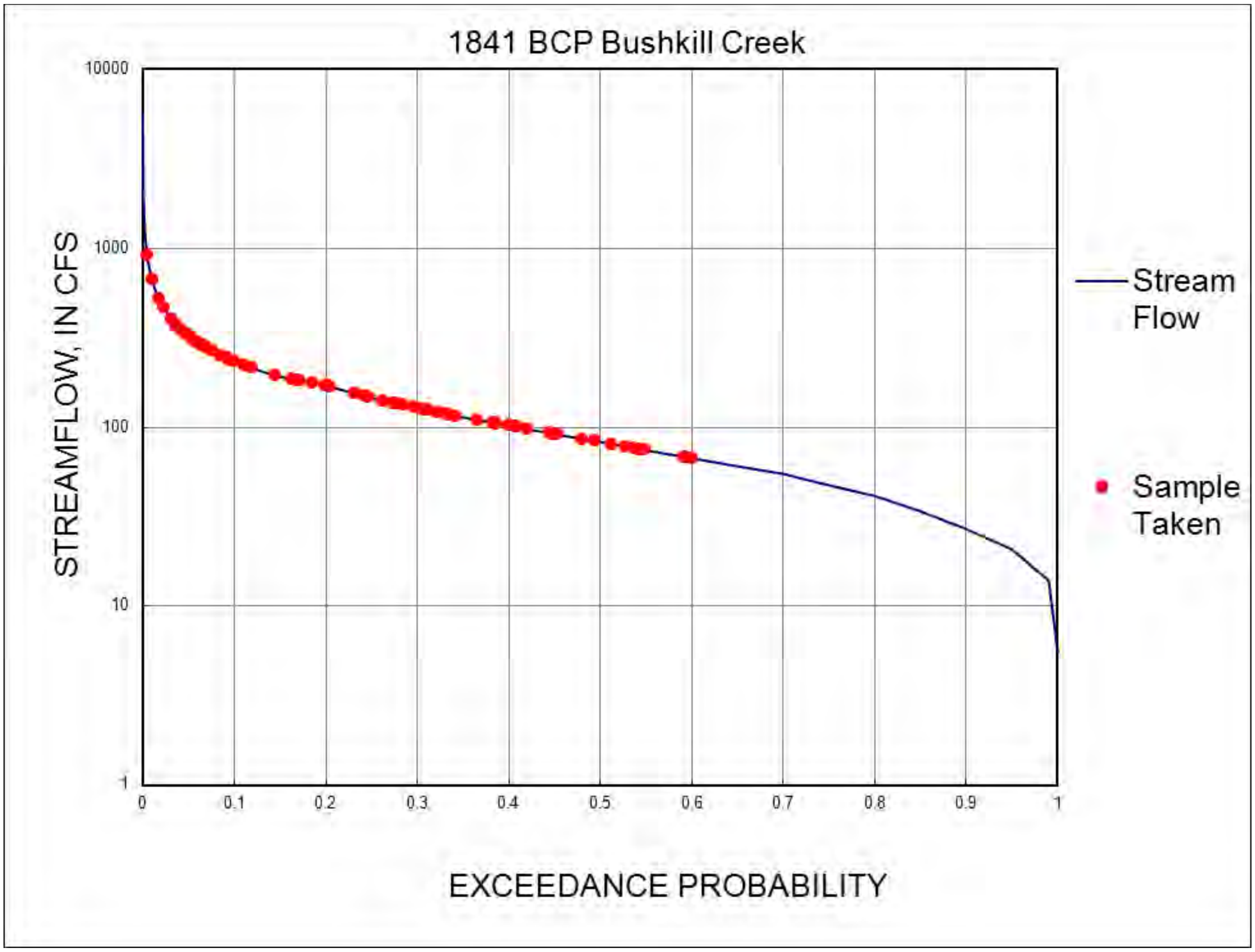
Figure 1



As stipulated by the Rio hydroelectric power plant operating license, a minimum flow must be passed in the reach of the Mongaup River between the Rio Dam and the Rio Powerhouse to maintain aquatic habitat. The minimum flow is 100 cfs unless it can be shown that inflow to the reservoir is less in which case the flow may be reduced but not below 60 cfs per FERC license requirements and agreement with the New York State Department of Environmental Conservation (NYSDEC). The existing Rio Project utilizes 870 cfs and has a capacity to generate 10 MW. The minimum flow unit will utilize 100 cfs (12% increase) and the installed generating capacity will be increased by 600-900 kW (DOCKET NO. D-2011-020 CP-1).

Hydropower flow downstream at our BCP site should be around 970 cfs at maximum power discharge.

Figure 2

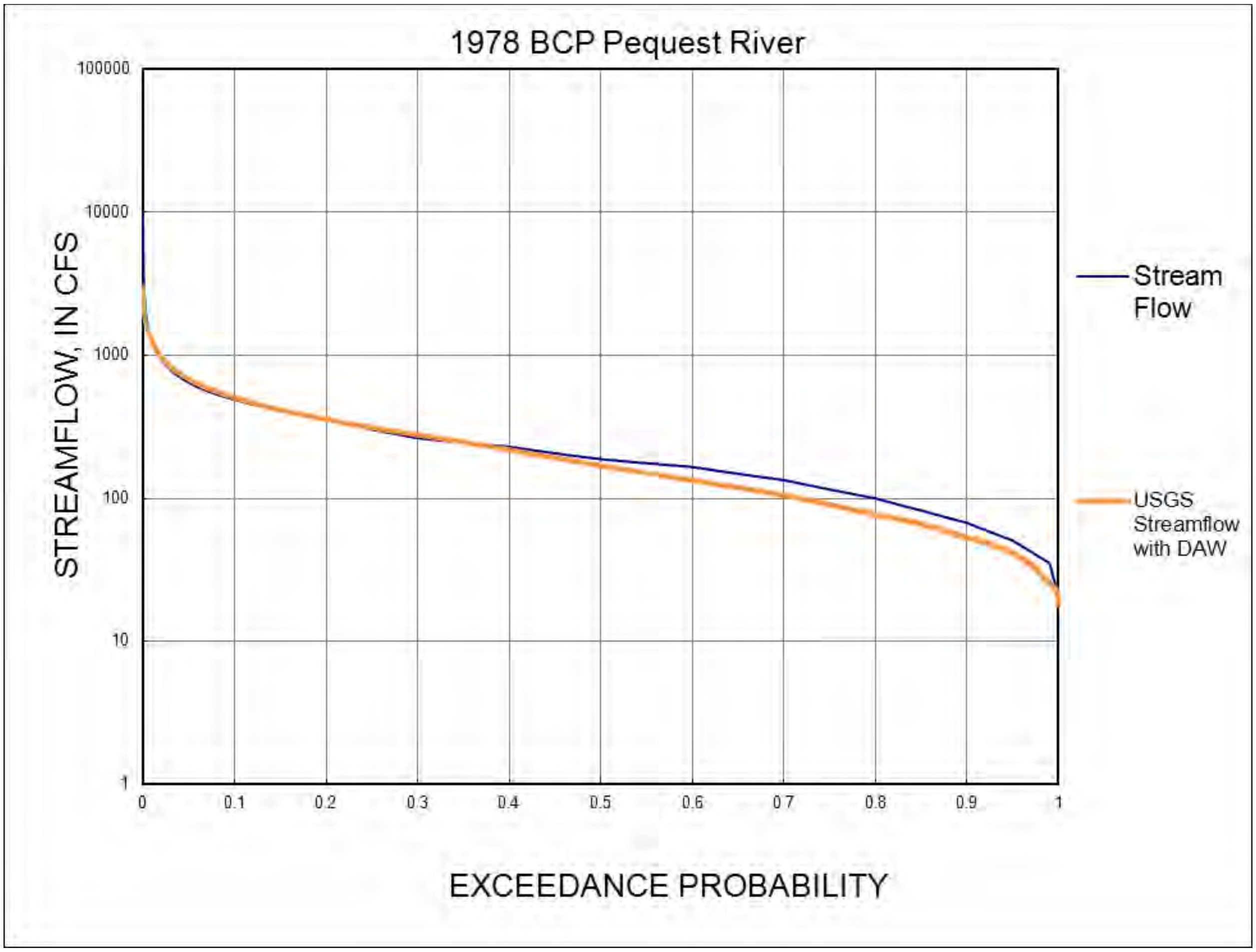


Hercules Cement Plant is located in the mid-reaches of the Bushkill Creek watershed and changes flow of the Bushkill Creek downstream of its location.

John Michael Paz, president of Godwin Pumps comments, “One of the real benefits we brought to Hercules is our diligence. For instance, Godwin mechanics make each client feel that their project is a top priority. Our chief road mechanic, Paul Natalino, provided regular service on the pumps at Hercules every other week, and as a result everything ran smoothly. When a client needs to pump 40 to 45 mgd to keep their operation going, like Hercules does, they can’t tolerate a lack of service or delays in delivery of equipment.” (Case History GODWIN PUMPS OF AMERICA, INC. Vol. 4 No. 2 http://www.pacificpumpandpower.com/pdf/HerculesCH.pdf)

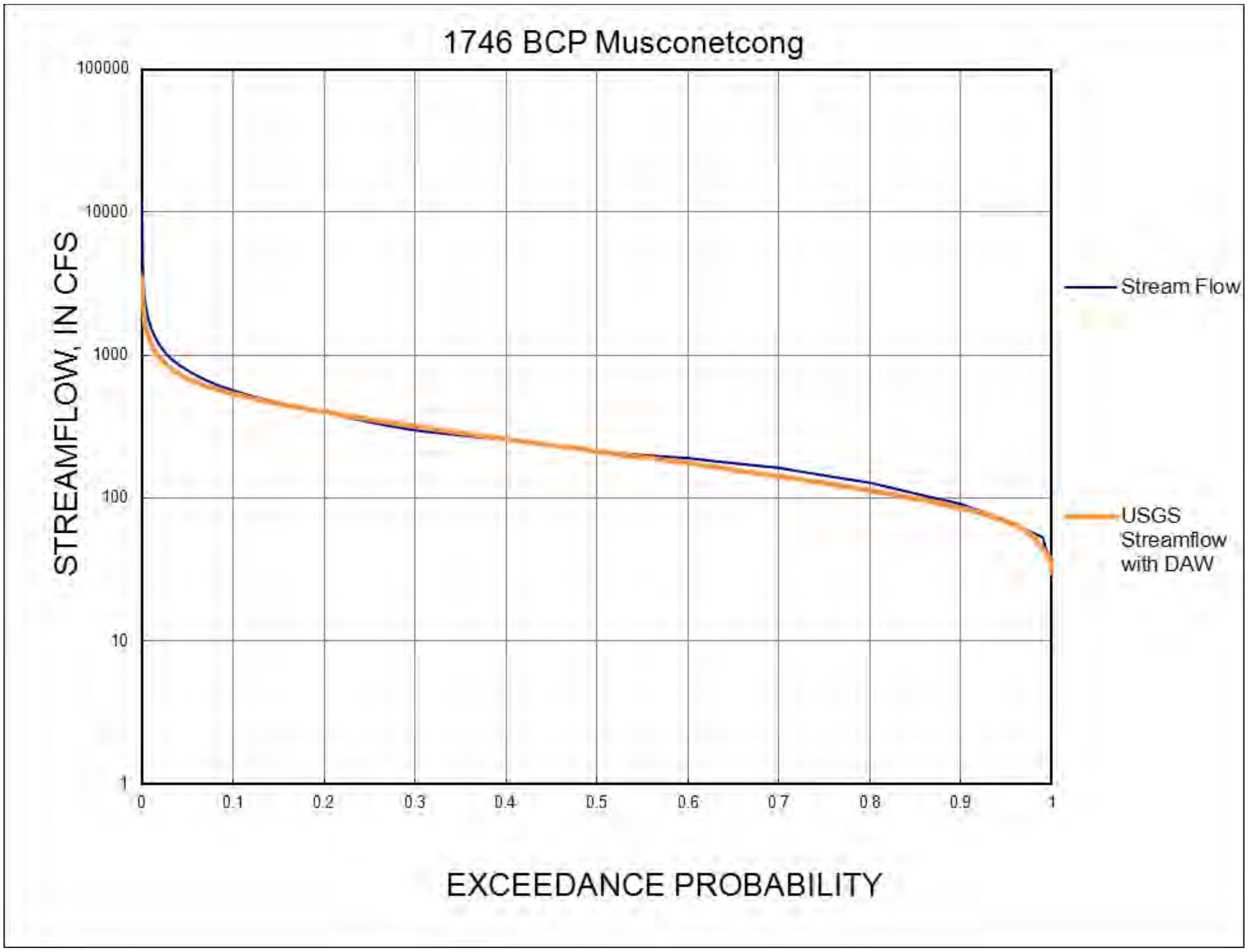
We converted 40-45 mgd to 62-70 cfs - the bottom limit of flow that our sampling has captured, which is almost entirely quarry dewatering discharge. If those pumps fail then Bushkill Creek goes dry from Tatamy to Easton, PA.

Figure 3



The DRBC sample site on the Pequest River has a drainage area of 157 square miles, and the USGS gage has a drainage area of 106 square miles. This difference is 32.5% which is greater than our 20% cutoff for DAW but when comparing with BaSE we see excellent agreement among the higher flow events and sufficient agreement for our data quality needs in the lower flow events. In this case, BaSE had less standard error of prediction at lower flow than other watersheds where gages are far from sites.

Figure 4



The sample site on the Musconetcong has a drainage area of 156 square miles, and the USGS gage has a drainage area of 141 square miles. This difference of 10% is within our 20% cutoff for use of DAW estimation technique, and shows excellent agreement between BaSE and DAW throughout the flow duration curve.