EPA 319(h) Nonpoint Source Project
Phase III Final Report

"An Evaluation of Best Management Practices Installed in the Peyton Creek Watershed on Stream Water Quality: A Paired Watershed Approach"

Submitted by
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227 Morris Drive
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EPA 319(h) Grant # C9994861-02

MOA # M-03098184

Project Period

August 1, 2003 through September 30, 2009

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Funding for this project, Peyton Creek Watershed Phase III was provided in part by a grant from the US Environmental Protection Agency (EPA) through the Kentucky Division of Water, Nonpoint Source Section to Kentucky Heritage Resource Conservation and Development Council, Inc. as authorized by the Clean Water Act Amendments of 1987, §319(h) Nonpoint Source Implementation Grant # C9994861-02. The contents of this document do not necessarily reflect the view and policies of the USEPA, KDOW or the Kentucky Heritage Resource Conservation and Development Council, Inc. nor does the mention of trade names or commercial products constitute endorsement. This document was printed on recycled paper.

Acknowledgements

The Kentucky Heritage Resource Conservation and Development Council, Inc. would like to acknowledge the following organizations and people for their help in making this project a success.

Lynn Jarrett of Cumberland Environmental Group, LLC for his direction, insight, enthusiasm, and water quality monitoring. His dedication to the project, and travels during storm events and professional technical expertise are molded throughout this project.

Paul Jeffries, Watershed Coordinator. Without Paul's knowledge and understanding of technical information, and his skill in working with local producers and understanding their plight, this project would not have been successfully implemented.

Division of Conservation. Angie Wingfield. Angie's assistance and patience in getting our producers and contractors paid is second to none. Angie was always professional and courteous in her work and advise. Kimberly Medley, Field Representative, provided insight and guidance in helping to implement this project through her knowledge of programs and technical expertise.

Division of Water's Corrine Mulberry and Jim Roe. Corrine and Jim were both supportive and knowledgeable in helping get through the endless rules, laws, regulations involved in developing, implementing, and funding this project.

Lincoln County Conservation District. For their forward thinking and recognizing the need to address water quality concerns and issues within Lincoln County. The Lincoln County Conservation District is truly looking out for the local farmer. Shelia Starnes, District Administrative Clerk was instrumental in helping to get producers paid by tracking local cost-share funds. Deborah Messenger was a valuable asset in her computer abilities by developing farm maps and our informational brochures.

USDA-Natural Resources Conservation Service. Bo Renfro, District Conservationist, David Stipes, Area Conservationist, and Tim Hafner, RC&D Program Manager, all who provided immeasurable assistance and patience in getting through all the hoops and meetings to achieve funding and implementation of this project. They take their roles seriously, and provide the best assistance they can.

Lastly, we would like to acknowledge all the producers involved in this project who were willing to take a chance at trying new and innovative technologies on their land in hopes of making our word a better place to live.

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Executive Summary

The Peyton Creek Watershed project had two key components. First was the coordinated implementation of Best Management Practices (BMPs) to reduce the impact of agricultural activities on receiving waters, and second was a monitoring program designed to discern the success of the BMP program.

Emphasis, in the Peyton Creek watershed was on the adoption of a management system for individual landowners rather than individual BMPs. This approach provides a more coherent management strategy that can produce synergistic improvements from the BMPs that are implemented.

The Peyton Creek watershed project has been very successful from the perspective of landowner participation and the quality of the management systems and BMPs installed in the watershed. The water quality monitoring program has provided valuable insight into the effectiveness of the management systems. However, extreme weather conditions have compromised the ability of the monitoring to assess the management systems effectiveness. Indications are that significant reductions in fecal coliform bacteria have been achieved but these may have resulted from the reduced streamflow and lack of runoff into the system. Improvements in dissolved oxygen concentrations may be an even more convincing success given the reduced streamflow and subsequent reduction in mechanical reaeration.

An 86% reduction in fecal coliform bacteria in Peyton Creek was observed relative to the control watershed, Frog Branch. This was partially due to increases in fecal coliform bacteria in Frog Branch.

Visual observations indicate considerable success. During the 2004 and 2005 sampling years neither fish nor crayfish were evident at the Peyton Creek sampling site PC1 although they were always noted in the field log at Frog Branch (FB1). By the summer of 2007 minnows and crayfish were abundant at PC1 during all but the few storm events that were sampled. Exclusion of cattle from the watershed at and upstream of Peyton Creek sampling site PC1 dramatically changed the riparian landscape and the amount of erosion contributing directly to the stream. After 2005 manure was not observed in the stream, whereas before the fencing manure mixed with unconsolidated sediment made fish and crayfish habitat impossible to find.

It will likely require several years for the materials once contributed to the stream network to “flush” out even if new material is excluded. A few good wet years may return Peyton Creek to an ecologically hospitable environment for native aquatic life, although, this will require maintenance of the new management systems and the BMPs that have been installed over the past few years.

Introduction and Background

Nonpoint source (NPS) pollution is the largest cause of water quality impairment in the United States (USEPA, 1995). Agriculture is estimated to be a source for pollution contributed to 48% of all impaired river miles (USEPA 2003). A multitude of processes or activities may be responsible for this source of pollution. The activities of people living in, working in, or traveling through a watershed may have negative water quality impacts. Often the individuals impacting water quality don't understand the consequences of watershed activities on creeks and rivers (Thom, 2002). Educational programs and Best Management Practices (BMPs) are among the most effective tools available to prevent or reduce the impact of human activities on the waters of rural watersheds (USEPA 1997). Kentucky promotes the use of these tools both in a statewide strategy and with local watershed projects to address NPS pollution within the Commonwealth (KDOW 200b).

The Kentucky Heritage Resource Conservation and Development Council, Inc. (KHRC&D) has identified water quality as one of their primary focuses of concern within the ten county RC&D area (**Figure 1**). Beginning in 1992 with the Salt River HUA, the Council has been involved with many NPS projects. After the completion of the HUA, the Council applied for various 319(h) projects. These included the Salt River Riparian Project, the Cedar Creek Watershed, the Spears Creek-Mocks Branch Project, and the Spears Creek-Mocks Branch-Hanging Fork Watershed projects. Many other projects throughout the RC&D area have also been proposed.

The KHRC&D believes the best way to lead is by example. Therefore the 319(h) grant program that demonstrates the implementation of BMPs throughout watershed areas seemed like a logical fit. However, documenting positive results has been difficult with previous projects the KHRC&D has been involved in. The length of the post-BMP monitoring period, the selection of watersheds that are too large, and climatic extremes have constrained the effectiveness of previous monitoring programs. In addition, other factors such as the shifting commitment of landowners to participate in the BMP program, the change in landuse upstream of the monitoring location (independent of the BMP implementation), and changing economic conditions, made it difficult to document the effectiveness of BMPs in projects like Spears Creek - Mocks Branch Watershed project (KHRC&D 2004). These are common problems for many projects (Kingsolver and others; KDOW 2000a).

The Peyton Creek Watershed was chosen for BMP demonstrations for three reasons. 1.) It is a small watershed (3,820 acres) yet important in that it is a sub-watershed of the larger Hanging Fork Creek which is a tributary of the Dix River and ultimately Herrington Lake. 2.) Peyton Creek had documented NPS pollution problems. 3.) The project is in Lincoln County, an economically distressed area with full time farmers who would respond favorably when given assistance to correct water quality problems in the watershed and help maintain sustainable production.

Peyton Creek watershed is made up primarily of full-time farmers whose sole family income is derived from agriculture, and who do not earn supplemental income assistance from a second part-time job. As such, the farmers in this watershed have limited funds available to address water quality issues. Rather, they try to get as much production from their land as is physically possible.

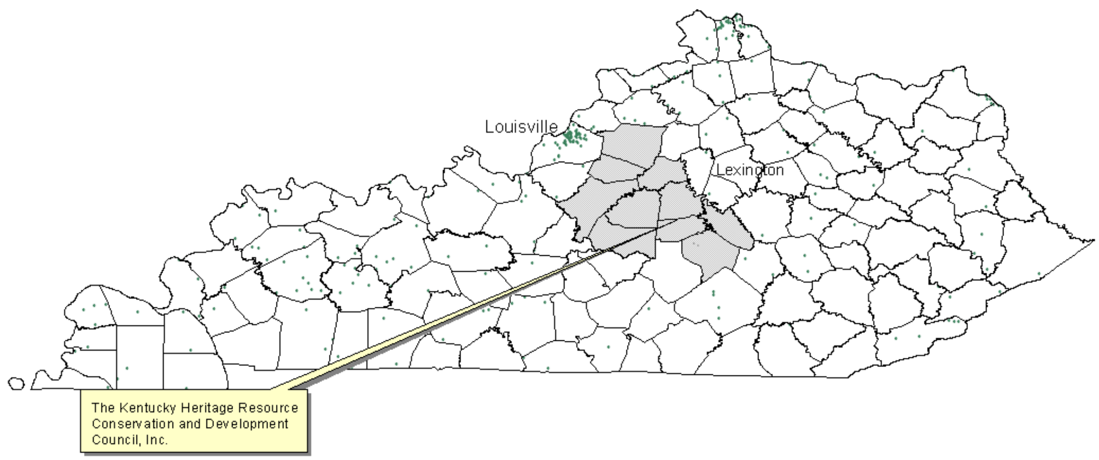

Figure 1. Ten counties served by the Kentucky Heritage Resource Conservation and Development Council, Inc.

In 2003, when this project started beef cattle numbers had been increasing in Lincoln County since the turn of the century (2007 Agricultural Census) reaching the largest numbers in 20 years (**Figure 2**). Weaning lots were over-crowded, cattle had free access to creeks for shade and water, and there were no rotational grazing systems or cross-fencing in riparian areas resulting in improper stocking rates and soil erosion.

This project assisted farmers by offering them incentives to install demonstration BMPs. New concepts were offered and showcased at field days. To improve participation the 60:40 cost share rate was adjusted to 90:10. This was justified by the low per capita income of residents from within this project area. This was accomplished by using "local match" from other state cost share projects, and applying it to the match of producers in Peyton Creek Watershed.

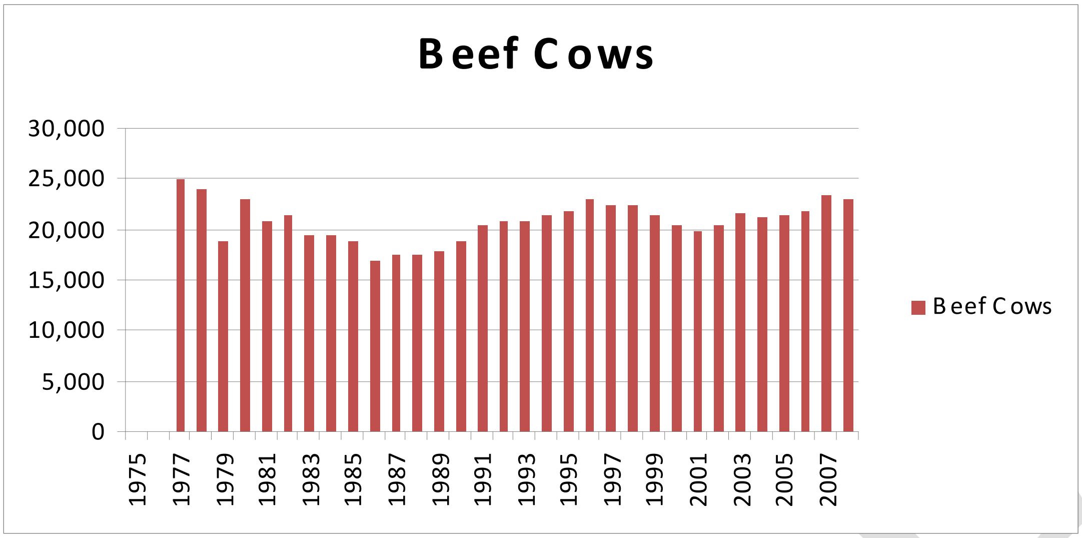

Figure 2. Beef cattle numbers per year in Lincoln County, KY. (Source**:** National Agricultural Statistics Service: http://www.nass.usda.gov/QuickStats/Create_County_All.jsp)

Peyton Creek watershed was selected to provide a demonstration of BMP implementation throughout a watershed to educate producers on technologies available to protect water quality. The BMP Plan was designed to emphasize streamside protection, proper manure handling and utilization and conversion to rotational grazing systems. This was especially needed for farms that include wooded riparian areas, since cattle have been reported to spend more time near shade and water sources (Blackshaw and Blackshaw 1994). Emphasis in the project was placed on the adoption of a management system rather than individual BMPs.

Continuously recording remote water quality monitors and discrete water quality sampling were used within a paired watershed sampling design. The paired watershed sampling design used a *control* watershed, Frog Branch, and a *treatment* watershed, Peyton Creek, to increase the statistical power of the water quality data. The monitoring was initiated prior to BMP (pre-BMP) installation and after BMPs (post-BMP) was installed to evaluate water quality changes associated with BMP implementation within the *treatment* watershed. More than 700,000 water quality data points were collected from the two watersheds.

Materials and Methods

1. *Description of the Project Area*

The Peyton Creek Watershed project is comprised of two small drainage basins, Peyton Creek and Frog Branch (**Figure 3**). BMPs were installed in Peyton Creek watershed (*treatment*) and water quality was monitored at the station PC1. The Frog Branch watershed was used as a *control*, meaning that water quality monitoring was conducted there, at the station FB1, but BMPs were not applied.

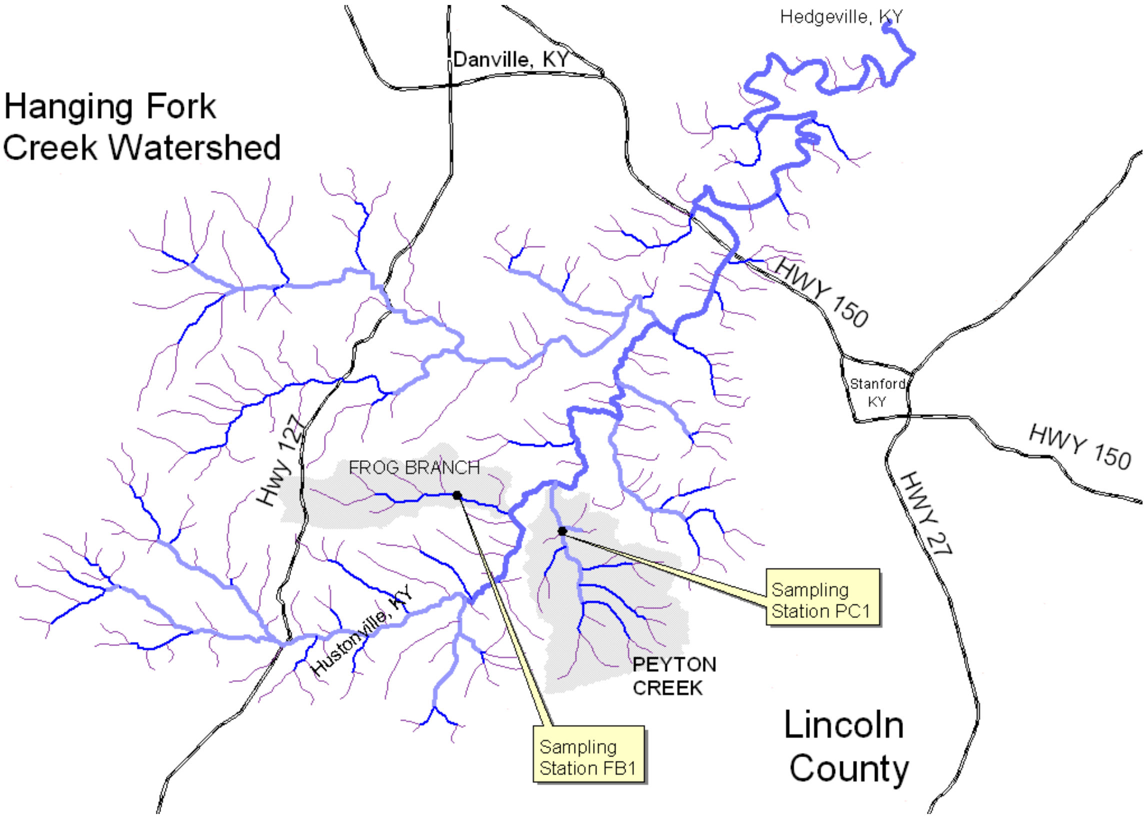

Figure 3. Depiction of *treatment* (Peyton Creek) and *control* (Frog Branch) watersheds within the Hanging Fork Creek watershed.

Peyton Creek, a tributary to Hanging Fork Creek, drains approximately six square miles surface area in Lincoln County, KY (**Table 1**). The watershed is located in the Inner Bluegrass Ecoregion at the edge of the Outer Bluegrass and Knobs Physiographic Regions. It is located near the community of McKinney, Kentucky in rural southern Lincoln County.

The Inner Bluegrass Ecoregion is underlain by Middle Ordovician Lexington limestone. Very fertile Alfisols have developed from the underlying phosphatic limestone (Ecoregions of Kentucky Map). Peyton Creek is a 3rd order stream and the watershed has approximately 27.4 miles of streams.

Table 1. Watershed information for Peyton Creek and Frog Branch. HUC refers to the Hydrologic Unit Code.

Watershed	HUC	Area (Square Miles)
Peyton Creek	05100205180060	5.969
Frog Branch	05100205180040	3.303

Frog Branch, a 3.3 square mile, 2nd order tributary to Hanging Fork served as a control watershed in this project. This watershed has very similar land uses and soils but a slightly steeper topography. BMPs were not implemented in this watershed.

Both creeks have rock, cobble and sand streambeds with intermittent silt deposits. Bed slopes are relatively gentle. The sequence of pool, riffle, run is common at all but high flow and during extreme low flow when the systems are reduced to isolated pools.

Cattle have considerable access to Peyton Creek from the head waters to near the mouth of the stream. Access to Frog Branch is more restricted. The Peyton Creek station where the continuously recording remote monitor is deployed had frequent cattle loafing during the pre-BMP period. The stream banks were scarred where access has been unrestricted (**Figure 4**).

Figure 4. Photos of Peyton Creek sampling station PC1 before BMPs were applied. From left to right on the top, photos taken on July 7, 2004 and August 26, 2004, respectively. From left to right on the bottom photos taken on August 24, 2005 and looking upstream from the sample station on the same date.

Based on data from the early to mid-1990's, land use in Peyton Creek is almost entirely pastureland (~5.5 square miles), with small areas of forest and residential development (**Figure 5**). All residences, in both Peyton Creek and Frog Branch are served by on-site wastewater treatment facilities commonly septic tanks that use leach fields for subsurface disposal of wastewater. There are currently no point source discharges in the Peyton Creek watershed.

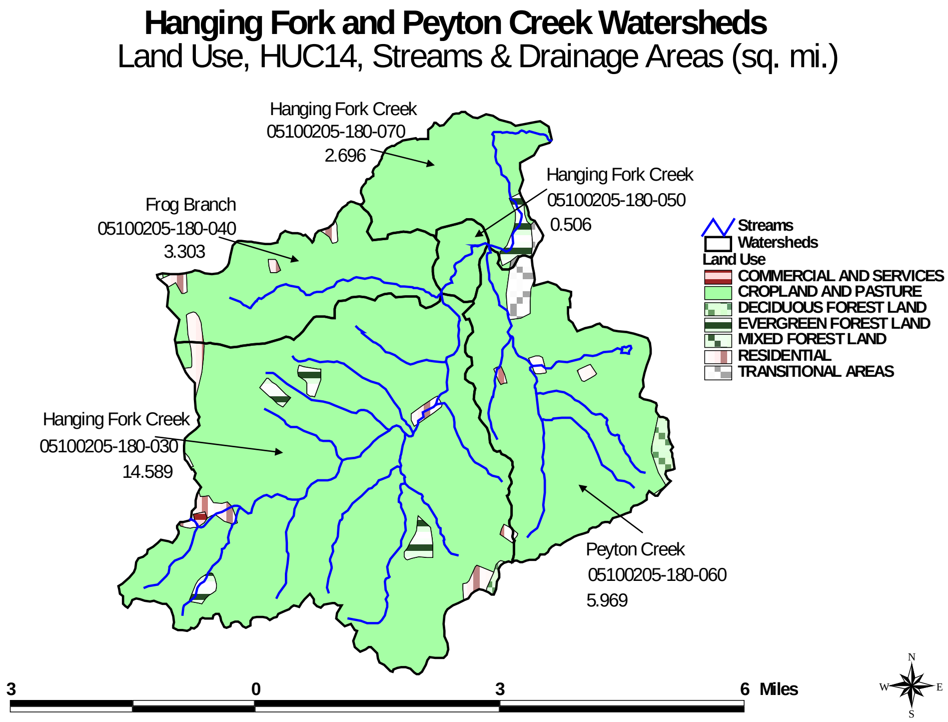

Figure 5. Landuse map of upper Hanging Fork watershed including Peyton Creek and Frog Branch.

Soils are relatively high in phosphorus and their erosion into the stream provides a relatively stable background source of phosphorus to both watersheds' surface drainage systems. Nitrogen is also generally available from soils and organic material being washed into the system.

2. Description of all methods used to obtain the results of the project.

Water Quality BMPs used as match and funded via the Kentucky Soil Erosion and Water Quality Cost Share Program were installed per the current *"Kentucky Soil Erosion and Water Quality Cost-Share Program Manual."* The manual, cites the regulation

> KRS 146.110-121, states the intent of the cost-share program, and describes the eligibility process, application process, selection criteria, operation and maintenance requirements, etc. These BMPs will be demonstrated in accordance with guidance provided by the Division of Conservation.

BMPs

The Peyton Creek watershed is heavily concentrated with farming operations. Most farms are comprised of full time farmers trying to get as much production from their land as physically possible. Resultant environmental problems addressed by this project include: cattle's free access to creeks, lack of fencing/rotational grazing systems, eroded crossings and feeding areas, lack of proper water management, overgrazing and improper stocking rate, poor pasture and hayland management, and soil erosion from cropping practices. See Appendix C and E.

The Best Management Practices and technologies, selected by the Watershed Coordinator and others, were oriented around reducing pathogens, nutrients, and sediment. The efforts were centered primarily on encouraging the adoption of rotational grazing systems, the development of alternative water supplies or providing limited stream access to cattle. The construction of well designed and sited animal feeding/waste storage areas was another primary objective.

Other BMPs that addressed the target pollutants were eligible for systems other than rotational grazing. Since this was a technology based demonstration project with primarily educational objectives, at least one farm needing several of the referenced BMPs was identified to facilitate demonstration of the BMPs by conducting two field days. BMPs were selected that met the needs of the operation while providing the best resource protection.

A BMP Implementation Plan (Appendix C) was developed along the lines of the one used in an adjacent 319 project – Spears Creek/Mocks Branch/Hanging Fork. A project Oversight Committee was formed at the onset comprised of local farmers from within the watershed, and agency personnel from NRCS, DOC, DOW, and the Conservation District.

During the winter of 2003 – 2004, the Watershed Coordinator sent out letters to all farmers in the watershed explaining the purpose and goals of this project. Interested farmers were asked to come in to develop a conservation plan that would address resource concerns in the Peyton Creek Watershed. Once all plans were completed, the Project Oversight Committee met to determine what BMPs should be targeted to get the most water quality benefit with the amount of funds available. Of the 30 active farms in the Peyton Creek watershed nearly 50% participated in improved landscape management.

BMPs were targeted to areas of the watershed that were identified as susceptible to producing water quality impacts. However, the ultimate selection of the BMP locations was based on producer interest. Selection of farms for BMP implementation was based on the following priority factors:

1. Conservation needs were identified that would improve water quality and meet the needs of the cooperating farmer.
2. The ensuing educational benefits that could be realized through educational tours and on farm field days.
3. Cost share contributions from other programs (EQIP, State Cost Share, CRP).
4. Length or percentage of stream protected from unrestricted livestock access (higher percentages and greater lengths were a higher priority).
5. Overall cost of BMPs for rotational grazing systems per stream mile protected.

Some restrictions imposed on the implementation of BMPs included:

- Size of ponds were based on reasonable livestock watering needs. Additional costs associated with larger pond capacity were borne by the producer.
- Any BMP or system receiving funding under this program was reviewed for the potential to improve water quality. BMPs or systems that were primarily for improving production or efficiency of the producer’s operation were not eligible for funding.

- Costs for alternative water supplies are only eligible if livestock are excluded from streams or other water bodies.

This project complements other federal funding programs under which specific BMP locations are protected under the Freedom of Information Act. Specific location information for BMPs funded by this project, matching State Cost Share funds, and/or other funding programs (as appropriate) will be provided to DOC, at a minimum, by 14 digit HUC.

Water Quality Monitoring

The water quality monitoring used in this project was implemented within a paired watershed design (Grabow and others 1998, 1999a, 1999b; Clausen and Spooner, 1993) using the Frog Branch watershed as the *control* and Peyton Creek as the *treatment* watershed. The paired watershed design was combined with pre-BMP and post-BMP monitoring in each watershed to provide a powerful tool for discerning water quality improvements. The statistical analysis of this sample design is often referred to as Before-After Control-Impact analysis (BACI: Murtaugh 2000; McDonald and others 2000; Conquest 2000; Benedetti-Cecchi 2001; Loftis and others 2001). This approach is one of the earliest and most popular approaches for evaluating BMPs (KDOW 1993; USEPA 1997; Spooner and others 1985).

The two watersheds have similar size, soils, topography, and landuse. Monitoring was conducted over a five year period, from 2004 through 2005. The first two-year interval (pre-BMP: 2004 – 2005) preceded or was in the early stages of BMP implementation. Monitoring was suspended in 2006 coinciding with the most active period of BMP implementation. The final 2 year period (post-BMP: 2007 – 2008) followed the majority of BMP implementations. More than 700,000 water quality data points were collected in Peyton Creek and nearby Frog Branch since May, 2004.

Sampling Strategy

This project used a combination of continuously recording remote monitors and discrete-monitoring (also called grab-samples) to evaluate water quality (**Tables 2**) each of the two monitoring stations PC1 and FB1. The remote monitors provide a robust approach to reliably assess water quality criteria and dynamics for dissolved oxygen, pH and temperature. The latter approach produces generally less reliable data but is necessary to assess attributes of water quality that can’t be evaluated with electronic probes.

The continuous monitors used in this project included probes to collect water quality data for the parameters shown in **Tables 2**. Data was logged on frequent time intervals (15 minutes). Because the time interval is so short, the monitors are considered “continuous”. **Figure 6** provides a photograph of a continuous monitor deployed at the Frog Branch station.

Table 2 Water quality criteria and collection methods for monitoring program attributes

Parameter (Units)	Acute Criterion	Chronic Criterion	401 KAR 5:031 Subsection	Collection Method
Continuous monitoring attributes				
Dissolved Oxygen (DO) (mg/l)	≥ 4.0 instantaneous	≥5.0 daily avg.	4 (1)(e) 1	Continuous Monitor
% DO Saturation	NA	NA	NA	Calculated
pH (pH units) **(1)**	≥ 6.0 and ≤ 9.0	n/a	4 (1)(b)	Continuous Monitor
Temperature (°C) **(2)**	31.7	n/a	4 (1)(d)	Continuous Monitor
Specific Conductivity (SC) (uS/cm @ 25 °C)	NA	NA	NA	Continuous Monitor
Turbidity **(3)**	Narrative Criterion		2 (1)(a) & (c)	Continuous Monitor
Discrete monitoring attributes				
Total Solids (TS) (mg/l)	NA	NA	NA	Grab Sample
Total Dissolved Solids (TDS) (mg/l) **(3)**	Narrative Criterion		4 (1)(f)(1)	Calculated
Total Suspended Solids (TSS) (mg/l) **(3)**	Narrative Criterion		4 (1)(f)(2)	Grab Sample
Fecal Coliform (CFU/100 ml) **(4)**	**May 1 – Oct 31:** Geomean ≤ 200 FC/ 100 ml and ≤ 20% of samples ≤ 400 FC/ 100 ml		6 (1)(a)	Grab Sample
	Nov 1 – Apr 30: Geomean ≤ 1000 FC/ 100 ml and ≤ 20% of samples ≤ 2000 FC/ 100 ml			

Table 2 Notes:

(1) pH: in addition to these numerical criteria, 401 KAR 5:031, Section 4(1)(b) also specifies that pH shall not fluctuate more than 1.0 pH units over 24 hours. Unlike grab samples, continuous monitoring data will allow assessment of this aspect of the pH criterion.

(2) Temp: in addition to this numerical criterion, 401 KAR 5:031, Section 4(1)(d)(1) also specifies that the normal daily and seasonal temperature fluctuations that existed before the addition of heat due to other than natural causes shall be maintained. 401 KAR 5:031, Section 4(1)(d)(2) provides for site-specific temperature criteria.

(3) NTU: Nephelometric turbidity units. Narrative criteria for solids: Total dissolved solids shall not be changed to the extent that the indigenous aquatic community is adversely affected. Total suspended solids shall not be changed to the extent that the indigenous aquatic community is adversely affected. Turbidity: Surface waters shall not be aesthetically or otherwise degraded by substances that: (a) Settle to form objectionable deposits; (c) Produce objectionable color, odor, taste, or turbidity.

(4) Fecal Coliform: Geometric mean based on at least 5 samples in 30 days. Fecal coliform criteria are intended to protect human health and are applicable in waters designated for recreational use and apply May 1 through Oct. 31, with less stringent criteria applicable from Nov 1 through Apr. 30.

Figure 6. Photograph of continuous monitor deployed at the Frog Branch monitoring station FB1 with QAQC monitor .

Discrete water samples were collected at both sampling locations (**Figure 7**) and transported to Fouser Environmental Services, Ltd in Versailles, KY to be analyzed for fecal coliform bacteria, total solids, and total suspended solids.

The Surface Water Standards for fecal coliform require collection of 5 or more samples per month with samples analyzed within 6 hours for regulatory purposes. In this project, samples were collected twice per month, analyzed within 24 hours, and the data was used to evaluate pre-and post-BMP conditions. Therefore, fecal coliform data should not be used for regulatory purposes.

Figure 7. Discrete samples collected from Frog Branch monitoring station FB1.

On February 22, 2005 members of the Peyton Creek 319 project team met to discuss the 2004 sampling results as presented in the data report “Peyton Creek Data Report 2004” (CEG 2004). Results from the report indicated that continuous monitoring data provided reliable and interpretable information regarding Peyton Creek ecosystem function and watershed impacts. The data from the continuous monitors also demonstrated that Peyton Creek data could be reliably compared to Frog Branch (the control basin) data. This will make it possible for the Kentucky Heritage RC&D to test the null hypothesis that the two watersheds have changed in the same direction at the same rate. Since best management practices (bmp) are being implemented in Peyton Creek but not in Frog Branch we expect that water quality should improve in Peyton Creek at a faster rate than in Frog Branch.

However, grab sample results did not exhibit the same level of reliability because of the small number of samples designed to be collected. Natural system variability in Peyton Creek and Frog Branch is large because both watersheds are small and relatively steep resulting in rapid response times to storm events. The physiography and demography of the watersheds combined with an abundant and metabolically active aquatic biota contribute to a dynamic watershed drainage system both in terms of water quantity and water quality.

To improve the utility and reliability of the grab sampling the CEG proposed to modify the program. The new program increased the number of samples collected at the stations fitted with the multi-probe monitors, Peyton Creek 1 (PC1) and Frog Branch 1 (FB1) and eliminated sampling at Peyton Creek 2 and Peyton Creek 3 and at Frog Branch 2. A proposal to modify the sampling plan was submitted by the Kentucky Heritage RC&D on March 8, 2005. The modification was approved by letter from the Kentucky Division of Water (KYDOW) on April 7, 2005.

The new sampling program proposed that 22 samples, for each of the three attributes, be collected per year at each station PC1 and FB1. In addition 3 QAQC samples for each attribute should be collected at each station.

Fifteen of the samples, at each station, were to be collected during five different storm events and seven samples were to be collected during non-storm flows. During each of the five storms 3 samples were to be collected for each attribute at each station. An effort was to be made to collect the samples during the rising limb of the storm flow, near the peak of the storm flow and during the receding limb of the storm flow. All protocols specified in the projects Quality Assurance Project Plan (QAPP) were followed.

Lack of precipitation during the 2005, 2007, and 2008 sampling periods made it impossible to achieve the distribution of samples specified in the amendment. All storms that occurred between May and October were sampled, however, there were only five storms and only 2 produced enough runoff to affect streamflow and justify sampling over the hydrograph. Instead of the 25 samples projected to be collected on average only 22 samples were collected because of dry conditions.

Data Analysis

Several approaches were used to assess the large amount of data generated by the monitoring program including; empirical modeling, statistical techniques, and summaries of data relative to water quality standards. The Surface Water Standards (401 KAR 5:031) were used to provide the "yardstick" for evaluating BMP performance for three important water quality criteria, water temperature, dissolved oxygen, and pH. Surface Water Standards have been adopted in Kentucky to protect human health and aquatic life from the adverse effects of water pollution.

The designated uses of Kentucky streams are described in 401 KAR 5:026. Streams in the Peyton Creek watershed are classified as warm water aquatic habitat and primary contact for recreational uses. Numerical and narrative water quality criteria relevant to this project are found at 401 KAR 5:031, Section 2 (Minimum Criteria), Section 4 (Aquatic Life) and Section 6 (Recreational).

Empirical Modeling

The paired watershed design was combined with pre-BMP and post-BMP monitoring in each watershed to provide a powerful tool for discerning water quality improvements. The statistical analysis of this sample design is often referred to as Before-After Control-Impact analysis. An empirical relationship, using ordinary least squares (OLS) regression, was established for five water quality attributes of the pre and post-BMP data. After the pre-BMP period, BMPs were implemented in the Peyton Creek watershed only. Both watersheds were then subsequently monitored. Watershed responses are compared with those predicted by the regression equations (in the general form of **Equation 1**) to determine if the BMPs had an effect, (Grabow and others 1998; Schilling and others 2002; Dillaha 1990).

$Y_t = b_0 + b_1 X_t + b_2 X_e + b_3 X_t X_e + e_t$ **Equation 1**

where:

Y_t = water quality time series from Peyton Creek
X_t = water quality time series from Frog Branch
X_e = indicator variable such that $X_e = 0$ are the pre-BMP dates and $X_e = 1$ are the post-BMP dates
e_t = unexplained or residual error
b_0, b_1, b_2, & b_3 = regression coefficients representing intercept and slope, respectively.

Model residuals were analyzed to assure that the basic assumptions of regression analysis were not violated. Two key assumptions, the independence of the residuals and their normal distribution are critical.

The Durbin-Watson D statistic was used to compute the 1st-order autocorrelation for the variables of interest and to test if the autocorrelation is zero. A D value near 2 indicates that errors are uncorrelated.

Two methods are used to evaluate the assumption of normality. Graphically, histogram plots of the residuals provide a valuable visual assessment of the variables distribution. The histogram of the data has a model of normal data superimposed.

A numerical technique, the Kolmogorov-Smirnov One Sample Test (K-S), is also used to provide an additional tool to evaluate normality. K-S is a nonparametric test of equality of one-dimensional probability distributions. The technique calculates a maximum distance between the empirical distribution function of the sample and the cumulative distribution function of the reference distribution. The statistic is calculated under the null hypothesis that the sample is drawn from the reference distribution.

Graphical Methods

A box plot is a simple graphical display of five number summaries of the sample set. It presents graphically the relative position of the median (or second quartile, Q_2), the minimum and maximum values and the upper and lower quartiles (Q_1 and Q_3) (Tukey 1977). The fraction of the data lying between the upper and lower quartiles (or hinges) is represented by a box. The length of the box along the scale of the data measures the H-spread. Whiskers or lines extend from each end of the box to the extreme values, minimum and maximum. If the extreme values or 'outliers' range too far from the hinges they are considered 'far outliers' and indicated by points (asterisks or circles). Computation of these outliers is performed as follows:

- H - spread = difference between values of hinges;
- Step = 1.5 x H-spread (interquartile range; $Q_3 - Q_1$);
- Inner fences are values 1 (one) Step outside hinges;
- Outer fences are values 2 (two) Steps outside hinges;
- Values between an inner fence and its neighboring outer fence are 'outside' (*);

- Values beyond outer fences are 'far outside' (o).

The box plot provides information concerning symmetry and skewness as well.

Box plots are very simple graphical procedures that provide much information about the distribution of a set of data (**Figure 8**) and they may highlight situations that require special investigation for a process or part of a process.

A useful extension of the box plot is the addition of a *notch* which provides delineation of the 95% confidence interval for the median (McGill et al. 1978). This technique is particularly useful when comparing subsets of data with multiple box plots. Two-way comparisons of the data are similar to the two sample T-test common in classical statistics. However, when more than 2 plots are included in the graphic, the same limitations common to parametric approaches with respect to multiple comparisons apply to the boxplots (Chambers et al. 1983).

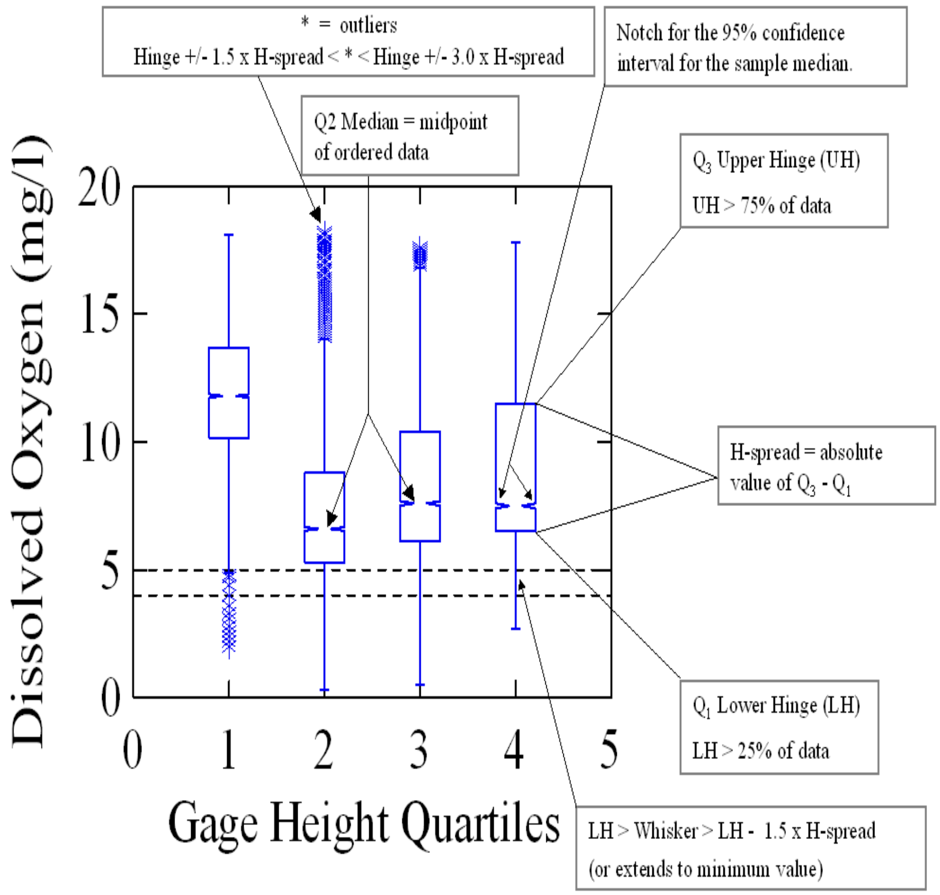

Figure 8. A box plots of dissolved oxygen with respect to gage height (stage). The components of the box plot are defined in terms of an ordered data set.

Because the assumption of normality and independence is so important to the use of parametric techniques, particularly when data sets are to be compared, it is important to have alternative methods of evaluation available or techniques available that reduce or obviate the problem of imperfect normality or non-normality. Techniques of both kinds do exist. The aforementioned nonparametric procedures provide alternative methodologies of data evaluation and will be discussed below. Techniques are also available that will make some non-normal and imperfectly normal data sets suitable for analysis by parametric methods. These techniques are referred to as data transformations, with the logarithmic transformation usually being the most useful.

The logarithmic transformation requires the calculation of the logarithm of each sample value. The transformed variable should generally be equivalent to the untransformed data. If the original sample dataset was derived from a lognormal parent distribution or an imperfect normal distribution with several abnormally high values and very few extremely low values, then the transformed data will simulate a normal distribution. The transformation also has the laudable effect of stabilizing the variance of the sample, making it easier to meet the assumption of homoscedasticity.

The lognormal distribution is commonly used in water quality work. A theoretical justification of the use of the distribution was offered by Chow (1954). He relied on the central limit theorem to demonstrate the normality of the logarithm of x_i when the number of causative agents tended to be infinitely large. Certainly the causes of many water quality effects are sufficiently large to justify this interpretation.

Many reactions in nature proceed at exponential rates; factors such as nutrients (which are influenced by these reactions) may appear and/or disappear at other than simple additive rates. Biologically active elements or compounds such as nitrogen, phosphorus, and carbon are examples of materials that, under strictly abiotic conditions, follow density patterns associated with normal distributions. However, in biologically active environments these elements may exhibit deviations from normality even with very large sample sizes.

Data are commonly collected from independent but overlapping frequency distributions. The quantitative and chemical behaviors of many variables, particularly nutrients, have different controlling factors at different times of the year. For example, independent of sources, phosphorus concentrations are controlled primarily by flow in the late fall, winter, and early spring, and by biological activity in the late spring, summer, and early fall. These two causes, while they are interrelated, follow different probability distributions. Because of this, it is often useful with annual data to analyze it based on seasonal subsets if there is sufficient data. This approach often produces much more normal or log normal distributions and consequently more sufficient estimates of the mean and standard deviation.

Random samples collected from a normal distribution, if collected in sufficient quantity, should exhibit characteristics of a normal or near normal distribution (unimodal and symmetrical about the mode). However, most water quality samples, including the samples in this monitoring program are not randomly collected. Instead, the samples are usually collected systematically. Systematic sampling can introduce considerable bias into the data by selectively sampling only portions of the population distribution. Methods are available for randomizing systematic collections and reducing the bias. The sampling regime of this study was systematic in both space and time. Spatial and temporal bias was evaluated using autocorrelation analysis.

Education

A field day sponsored by the Lincoln County Conservation District (LCCD) was held at Lowell Atwood's farm during the summer of 2007. A brochure was developed (Appendix D) and distributed to surrounding offices, local feed stores, farm stores, Extension Service offices, and mailings. The field day was held on September 20, 2007 with approximately 150 persons in attendance. The activities included four stops. Attendees were transported over the farm on hay wagons. The stops included discussions on the following topics: Cattle Handling Facilities, Nutrient Management, Conservation Practices, Water Quality Monitoring, and Nonpoint Source Pollution.

The LCCD hosted a second Field Day in the Peyton Creek Watershed again at Lowell Atwood's farm on Thursday September 18, 2008 from 10:00 am to noon. The Field Day was attended by FFA students from the Lincoln County High School as well as local farmers and local, state and federal personnel.

3. Description of Specialized Materials

Water Quality Monitoring

An overview of continuous monitors is provided here because this type of sampling is significantly different from typical monthly or quarterly sampling (i.e., grab sampling) used to characterize water quality.

The continuous monitors used in this project included probes (**Figure 9**) to collect water quality data for the parameters shown in **Table 3**. Data were logged on frequent time intervals of 15 minutes. Because the time interval is so short, the monitors are considered "continuous".

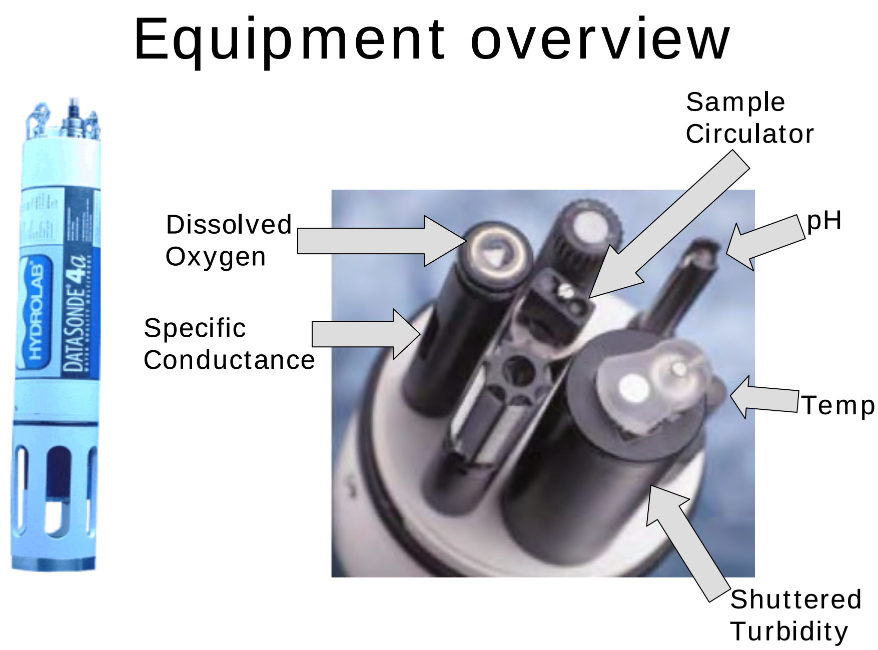

Figure 9. Overview of one of the continuous monitors that was deployed during this project.

Table 3. Continuous monitoring parameters used in this study and their STORET code numbers.

STORET #	Description
00010	Water Temperature (°Celsius)
00300	Dissolved oxygen (mg/l)
00301	Dissolved oxygen (% saturation)
00400	pH - Water, Whole, Field, Standard units
00095	Specific Conductance (micro-siemens /cm @ 25 °C)
00076	Turbidity (NTU)

Approximately 35,040 data for each parameter may be collected over 1 year with data logged every 15 minutes. For this study data was to be collected for a six month interval (@17,520 datapoints) for each of four years. The 15 minute data were then aggregated to hourly intervals by using the average of the four 15-minute data. The resulting target was @4,380 hours of data per year for each of four years. A total of @17,520 hours of data were expected to be collected. When coupled with precipitation data and gage height or other measures of flow, continuous water quality monitors provide resource managers with a very robust dataset to characterize water quality changes and processes in detail through the seasons and through many flow regimes. It may be useful to think of continuous monitors as a "water quality video camera", while collecting grab samples is similar to using a still camera with a timer. Continuous monitors provide data that can be used to clearly evaluate average and instantaneous DO and identify episodes of DO criteria violations that may not have been found using traditional sampling methods.

Although only a few water quality characteristics can be monitored at this frequent time scale, the monitored parameters can be especially important from both a scientific and regulatory perspective. The increased sensitivity of continuous monitoring will highlight water quality changes related to storm events, changes in land use practices and other impacts such as spills, sewer overflows, or bypasses.

It is important to note that continuous monitors require diligent calibration and servicing to minimize problems associated with probe drift, fouling and interference. Each year the monitors were shipped to Hach facilities in CO for refurbishing. These cost were not borne by the project.

In addition, management, analysis and interpretation of the large databases produced by continuous monitors present new challenges. Probes are also available to collect chlorophyll a, ammonia-nitrogen and other parameters. However, data quality may be lower with the probes currently available for these parameters and are not used in this study.

Hydrolab Series 4a, 4x, and 5x Data Sondes were used for this project. Additional information regarding these monitors is available at http://www.hydrolab.com. Detailed procedures for continuous monitors are provided in USGS Water-Resources Investigations Report 00-4252 Guidelines and Standard Procedures for Continuous Water-Quality Monitors: Site Selection, Field Operation, Calibration, Record Computation, and Reporting. (Wagner and others, 2000).

Results and Discussion

The management of the Peyton Creek watershed landscape to protect water quality has been advanced with the implementation of this project. Watershed management practices have reduced sources of pollutants in the watershed and the water quality monitoring has demonstrated to the local landowners that their actions can improve their environment while maintaining profitability.

The proximity of the two watersheds assured that the meteorological conditions would be as similar as could be achieved. The property use and ownership in the Frog Branch watershed suggested that it would be a stable and relatively consistent control for the monitoring program. However, monitoring conducted prior to the pre-BMP monitoring revealed that the Peyton Creek water quality was far more dynamic and variable than the Frog Branch control watershed (**Figure 10**). This indicated that significantly more data than is traditionally collected would be necessary to compare the two systems. Consequently, it was decided that continuous deployment of remote water quality monitors for six month intervals during the four monitoring years was justified.

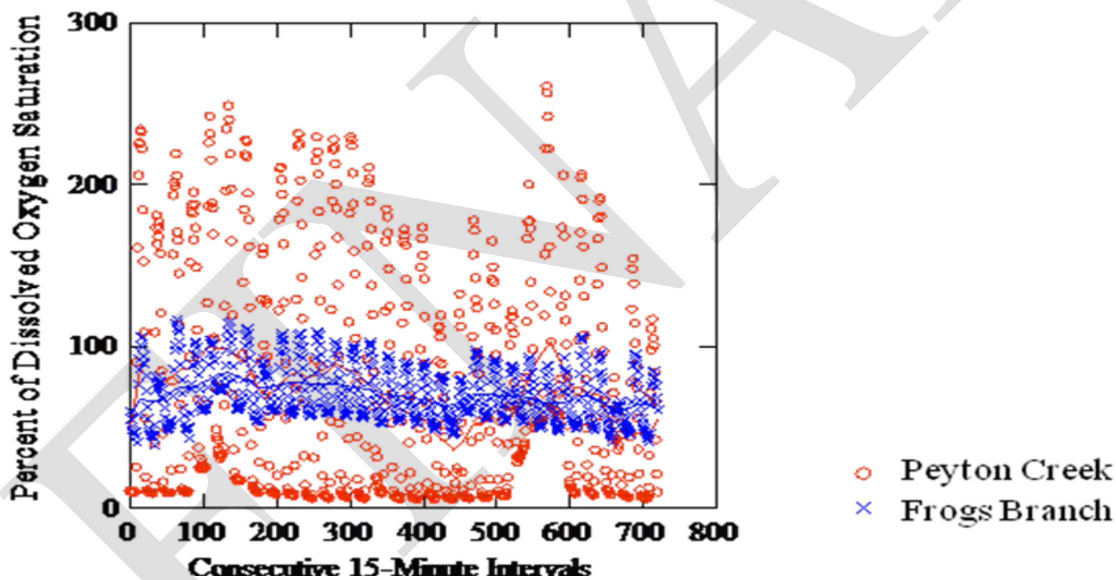

Figure 10. Comparison of percent of dissolved oxygen saturation at Peyton Creek (red) and Frog Branch (blue) for November, 2003.

BMP

BMP installation was very successful in Peyton Creek requiring additional funding, Phases II and III, to meet the needs of the watershed's farmers. Twelve of the 30 active farmers in the watershed participated in the implementation of one or more management practices.

Twelve different practices were installed to meet the management objectives described above. Approximately 14,900 feet of fencing was installed in the watershed restricting access to Peyton Creek. This along with 30 tanks and more than 42,000 feet of pipeline has provided significant protection for the Peyton Creek and has maintained the farmer's profitability (**Table 4**). Over 89,000 square feet of improvements to heavy use areas along with over 4 acres of critical area treatment and nine animal waste storage facilities have reduced erosion and the runoff of manure laden soils significantly. Nearly 250 acres of prescribed grazing and flash grazing has been introduced into the watershed further protecting the Peyton Creek from extensive animal loafing and destruction of important riparian areas.

The overwhelming majority of BMPs were implemented upstream of the water quality monitoring station PC1. Photographs of some of the BMPs are provided in **Appendix D**.

Table 4. Quantification of the BMPs installed in the Peyton Creek watershed between 2005 and 2008 including Phases I - III.

BMP (units)	NRCS Practice Code	Results	HUC 14	Lat/Long	Watershed Name
Animal Waste Storage (#)	313	9	05100205180060	NA*	Peyton Creek
Fence (Linear feet)	382	14,900	05100205180060	NA	Peyton Creek
Critical Area Treatment (# of Acres.)	342	4.5	05100205180060	NA	Peyton Creek
Heavy Use Area (Feet^2)	561	89,500	05100205180060	NA	Peyton Creek
Pipeline (Linear feet)	516	42,318	05100205180060	NA	Peyton Creek
Tank (#)	614	30	05100205180060	NA	Peyton Creek
Spring Developments (#)	574	2	05100205180060	NA	Peyton Creek
Pasture & Hayland seeding (Acres)	512	641	05100205180060	NA	Peyton Creek
Prescribed Grazing (Acres)	528A	206	05100205180060	NA	Peyton Creek
Flash Grazing (Acres)		43	05100205180060	NA	Peyton Creek
Stream Crossings (#)	576	5	05100205180060	NA	Peyton Creek
Livestock exclusion (Acres)		26	05100205180060	NA	Peyton Creek

* NRCS cannot provide these locations because they are protected by the Freedom of Information Act (FOIA).

Water Quality Results

The Hanging Fork Watershed, including Peyton Creek and Frog Branch, were subject to severe drought conditions during the 2005, 2007, and 2008 sampling periods. Loss of flow and stagnant water conditions developed by late July in each of the three years and the creeks were completely dry for much of August, September, and October of each year. Rainfall data from the USGS station 03285000 on the Dix River near Danville, KY and upstream of Herrington Lake is presented in **Figure 11**.

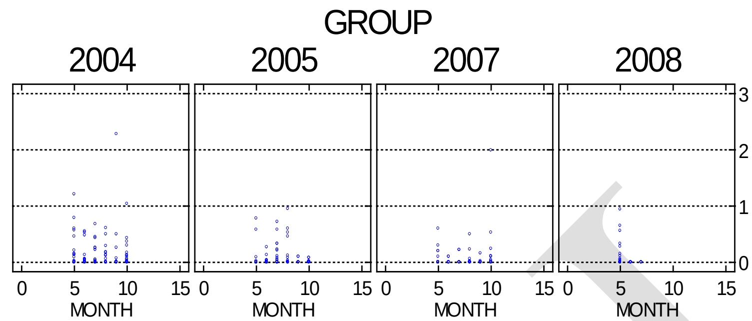

Figure 11. Precipitation plots for the months May through October for the years 2004 through 2008. The data was collected at the USGS station 03285000 on the Dix River near Danville, KY. This data is provisional.

Figure 12 depicts the monthly flow conditions at the USGS station on the Dix River for the drought years relative to the wetter years; 2003 – 2004, and 2006.

Dry periods such as these are often cited as justification for the need for longer term sampling (Richards 2008).

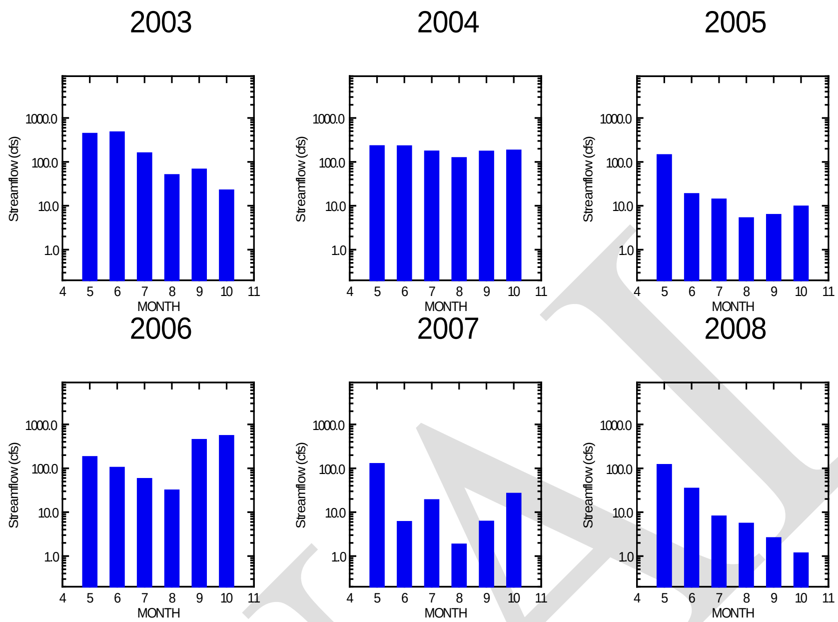

Figure 12. Monthly streamflow May through October at the USGS station 03285000 on the Dix River for the interval 2003 through 2008.

Quality Assurance and Quality Control (QA/QC) Measures

Data quality is a critical component of any database. Two different datasets are used to assess the data quality. First is the QA/QC data collected during the Operation and Maintenance (O&M) activities and described in the Field Meter Calibration section of (Wagner and others, 2000; 2006). These data include paired data collected from the **SITE** meter which has been deployed and a cleaned and calibrated **PORTABLE** meter brought to the site for the O&M actions. These data serve as the Observed (**SITE**) and Expected (**PORTABLE**) data and are used to compute the corrections to the main database. The main database provides the second dataset which is the complete observed data for the continuous monitoring network and the appropriate metadata. Data quality assessment using this dataset is determined by assessment of magnitudes, trends through time, and multivariable relationships.

Several approaches were used to ensure the quality of the data collected in this effort. The Quality Assurance Project Plan is attached with this submission. **Table 5** presents the Data Quality Objectives (DQOs) of the project. While most of the DQOs were met with the large majority of the data some data were outside the range of acceptability and were purged from the database accounting for many of the missing data documented in the evaluation of data Completeness.

Table 5. Data Quality Objectives (DQO) for monitoring program attributes.

Parameter (Units)	MDL/ Range	Accuracy	Precision/ Resolution
Continuous monitoring attributes			
Dissolved Oxygen (DO) (mg/l)	0 to 20 mg/L	±0.2	0.01 mg/L
% DO Saturation			
pH (pH units)	0 to 14	±0.2	0.01 units
Temperature (°C)	-5 to 50	±0.15	0.01°C
Specific Conductivity (SC) (uS/cm @ 25 °C)	0 to 100 uS/cm	±0.5% of range	4 digits
Turbidity	0 to 1000 mg/L	The greater of ± 5 % or 2 NTU	
Discrete monitoring attributes			
Total Solids (TS) (mg/l)	10 – 20,000 mg/L	NA	±30%
Total Dissolved Solids (TDS) (mg/l)	10 – 20,000 mg/L	NA	±30%
Total Suspended Solids (TSS) (mg/l)	4 – 20,000 mg/L	91%	±6%
Fecal Coliform (CFU/100 ml)	$1 – 10^6$ CFU/100 ml	±50%	±10%

<u>Precision</u> is a measure of variance between duplicate samples (i.e., are measurements reproducible?). Precision is often expressed as relative percent difference (RPD) between duplicates. **Table 6** presents a summary of the data collected for the continuous monitors. The data in the table are differences between the field meter and the standard meter used for comparison. The data was collected by deploying the standard meter beside the field meter for up to two hours at the beginning of a deployment and then again at the end of the deployment usually about two weeks. The meters logged 15-minute data from the same environment. At the beginning of a deployment both meters have been cleaned and calibrated and should read approximately the same. At the end of the deployment fouling and/or drift may affect the field meter and it may read different from the standard meter which has been recently cleaned and calibrated. For practical purposes the calculation of the residuals is done by subtracting the standard meter value from the field meter value. If the field meter is underestimating the true value of the water quality attribute the resulting residual value is negative if it is overestimating the true value the residual is positive.

Table 6. Summary statistics of the precision data collected for the four continuous monitors used in this study.

Statistic	Water Temperature	Dissolved Oxygen	pH	Turbidity	Specific Electrical Conductance
	Celsius	mg/l	su	ntu	microsemiens
Peyton Creek					
N of cases	630	626	630	630	630
Minimum	-0.2	-4.4	-0.2	-26.3	-52.0
Median	0.0	-0.6	0.1	-0.3	-8.4
Mean	0.0	-0.4	0.1	9.1	-7.3
Maximum	0.3	2.7	0.8	76.1	10.0
C.V.	1.816	-1.772	1.708	3.090	-1.525
Frog Branch					
N of cases	646	622	646	646	646
Minimum	-0.1	-6.8	-0.3	-26.3	-26.8
Median	0.1	-0.7	0.1	11.8	-5.9
Mean	0.1	-0.5	0.1	19.3	-5.2
Maximum	0.3	7.0	0.6	99.6	14.0
C.V.	1.269	-3.221	1.779	1.598	-1.744

<u>Accuracy</u> is a measure of the ability to correctly determine concentration. The target accuracy of continuous monitors is established by the manufacturer and evaluated in the field through relative percent difference (RPD) of pre- and post-calibration readings. The sign associated with the differences is presented in **Table 7** to depict the pattern of probe performance. Extreme values were large for some of the probes. Some of these extremes were easily repaired by changing membranes on the dissolved oxygen probes or changing the cleaning pad on the turbidity probes.

Table 7. Statistical summary of the Relative Percent Differences of pre- and post-calibration readings.

	Dissolved Oxygen Drift	pH 7.0 Std Drift	pH 10.0 Std Drift	S.E.C. 0 Std Drift	S.E.C. 500 Std Drift	S.E.C. 1,00 Std Drift	Turbidity 0 Std Drift	Turbidity 800 Std Drift
Count	31	31	31	31	31	31	31	31
Min	-47.62	-3.29	-3.00	0.00	-2.60	-1.60	-0.10	-4.00
Median	-2.00	1.57	1.20	0.00	0.80	1.50	0.12	2.13
Mean	-6.77	1.83	1.81	0.35	1.82	4.90	32.98	2.67
Maximum	6.67	11.43	10.00	2.00	11.00	90.10	1000.00	14.25
C.V.	-1.90	1.35	1.29	1.87	1.76	3.27	5.44	1.75

Representativeness expresses the extent to which the analytical data reflect the actual media at the site. Representativeness was evaluated using best professional judgment (BPJ) with respect to general sample management issues including sample documentation, preservation, handling and transport as well as a discussion of representativeness with respect to analytical-method specific issues such as method deviations. The data collected to date is judged to be of high quality and represents the FB1 and PC1 stations adequately.

In order to obtain representative data from grab samples, the monitoring program attempted to emphasize storm events; 70% of samples were to be collected under elevated flow conditions and 30% were to be baseflow samples. However, as has been discussed above severe drought conditions during the 2005, 2007, and 2008 sampling periods made accomplishment of this goal impossible.

Completeness is a measure of the amount of usable data; field and laboratory completeness will be evaluated separately. Completeness may be reduced by flow conditions in the streams, field equipment failure, exceedence of holding times, broken sample containers, etc. The completeness DQO for sample collection was 90%; for laboratory analyses, the completeness DQO was 95% and for the continuous monitors 90%. Completeness objectives were not met because of drought conditions resulting in a loss of flow for much of the summers in 2005, 2007, and 2008. **Table 8** presents the percentage of data collected

Table 8. Completeness data calculated as the number of hourly samples collected divided by the number of sample hours expected to be collected. The number of hourly samples collected are presented in parentheses.

Attribute	Peyton Creek	Frog Branch
Water Temperature (c)	71% (3,117)	72% (3,162)
Dissolved Oxygen (mg/l	65% (2,889)	71% (3,134)
pH (su)	70% (3,102)	72% (3,162)
Turbidity (ntu)	59% (2,618)	72% (3,160)
Specific Electrical Conductance (microsemiens)	71% (3,116)	72% (3,160)
Total Solids (mg/l)	49%	42%
Total Suspended Solids (mg/l)	49%	42%
Fecal Coliform bacteria (cfu/100 ml)	50%	44%

Comparability is a qualitative parameter that expresses the confidence with which one data set can be compared to another. Comparability of the sampling and analytical programs was evaluated separately.

Sampling comparability was evaluated based on the following:

- A consistent approach to sampling was applied throughout the program;

- Sampling was consistent with established methods for the media and analytical procedures;
- Samples were properly handled and preserved.

Analytical comparability was evaluated based upon the following:

- Consistent methods for sample preparation and analysis;
- Sample preparation and analysis was consistent with specific method requirements;
- The analytical results for a given analysis were reported with consistent detection limits and consistent units of measure.

All of the above criteria were met for both the discrete and continuous monitoring programs.

Continuous monitoring

The continuous monitoring data provides high resolution, high quality, definitive information on changes in stream water quality in Peyton Creek and Frog Branch. **Table 9** provides a summary of the water quality attributes remotely monitored at high frequencies (15-minute time intervals) in each watershed and divided into pre-BMP and post-BMP intervals. Inter-annual differences in weather can potentially account for most differences observed in the water quality data between the intervals obscuring the impacts of the BMPs installed in the watershed.

Water temperatures were higher in the post-BMP interval and as presented above conditions were also much dryer. Mean and median dissolved oxygen levels were lower in both Peyton Creek (*treatment*) and in Frog Branch (*control*) watersheds. The variability of both dissolved oxygen and pH, as presented by the coefficient of variation (C.V.), is greater in both watersheds. This variability of these attributes, especially given the large number of data, often indicates greater metabolic activity in the stream system suggesting that nutrients are still abundant in the stream networks. Turbidity is also higher in both watersheds even with lower flow suggesting a biogenic source.

Table 9. Summary of the continuous monitoring data divided into pre-BMP and post BMP periods.

	Water Temperature (Celcius)		Dissolved Oxygen (mg/l)		pH (su)		Specific Electrical Conductance (microsemiens		Turbidity (ntu)	
	pre-BMP	post-BMP	pre-BMP	post-BMP	pre-BMP	post-BMP	pre-BMP	post-BMP	pre-BMP	post-BMP
Peyton Creek										
N of cases	9,054	6,010	8,707	5,496	9,107	5,949	9,103	6,009	8,450	4,670
Minimum	0.0	4.0	0.0	0.1	6.8	3.3	0	16	0	0
Median	20.5	22.4	7.8	6.0	8.0	7.8	389	395	36	198
Mean	17.6	21.7	7.6	6.4	8.0	7.9	389	404	71	250
Maximum	35.4	34.8	20.0	23.0	9.9	9.4	935	607	1,610	3,000
C.V.	0.49	0.27	0.60	0.67	0.05	0.07	0.30	0.16	1.84	1.34
Frog Branch										
N of cases	9,426	6,064	9,268	6,063	9,426	6,064	9,249	6,064	9,298	6,059
Minimum	0.4	2.7	0.0	0.7	6.8	7.2	3	194	0	0
Median	20.4	20.5	8.2	5.1	8.0	7.8	354	379	22	13
Mean	17.2	19.5	8.6	5.7	7.9	7.9	343	382	43	79
Maximum	30.8	29.1	49.8	19.0	9.4	9.9	517	517	905	3,000
C.V.	0.48	0.26	0.52	0.65	0.04	0.06	0.21	0.15	1.57	2.51

Three of the attributes measured are regulated under 401 KAR 5:031 Section 4 Aquatic Life as warmwater aquatic habitat. The regulated attributes are water temperature, dissolved oxygen, and pH. Analysis of the data indicated there were 94 violations of the 31.7 c water temperature threshold, all in Peyton Creek, compared to none in 2004. There are two criteria for dissolved oxygen, chronic and acute. The chronic criterion requires that daily (24 hour) averages cannot be less than 5.0 mg/l while the acute standard states that the waterbody cannot at any time have dissolved oxygen levels below 4.0 mg/l.

Based on the hourly data in Peyton Creek (PC1) there were 142 days in violation of the acute dissolved oxygen standard in the pre-BMP period (May through October; 2004 – 2005) this amounted to 52% of the 273 days sampled for dissolved oxygen. Only 65 days (24%) out of the 273 days were in violation of the acute dissolved oxygen standard in Frog Branch during the pre-BMP period. Also in Peyton Creek there were 102 days (37% of the days sampled for dissolved oxygen) in the pre-BMP years 2004 and 2005 and 61 days in (22%) in Frog Branch.

In the post-BMP period (2007 – 2008) dissolved oxygen conditions worsened in both watersheds. In Peyton Creek 80% (165 days) of the 206 days sampled were in violation of the acute dissolved oxygen standard and increase of 28%. However, in Frog Branch an even more dramatic increase in violations occurred with 65% of the days sampled in Frog Branch in violation of the acute dissolved oxygen standard an increase of 41%. An even more dramatic pattern was observed with respect to the chronic dissolved oxygen violations in the post-BMP interval (2007 – 2008). Chronic dissolved oxygen conditions actually improved slightly in Peyton Creek with 66 days or 32% of the day's sampled being in violation a 5% improvement. In Frog Branch 113 days or 55% of the sampled days were in violation of the chronic dissolved oxygen criterion a 33% increase in violations. Comparisons of the trends in these violations are depicted in **Figures 13 & 14**.

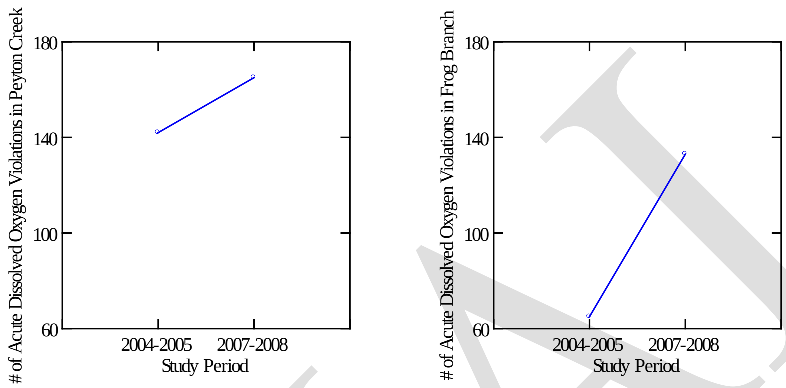

Figure 13. Paired trends of the total pre and post-BMP acute dissolved oxygen criterion violations.

These results clearly indicate an improvement in Peyton Creek relative to Frog Branch even though water quality, in terms of dissolved oxygen, generally worsened in each watershed. The exception being the improvement of chronic dissolved oxygen in Peyton Creek in the post-BMP period.

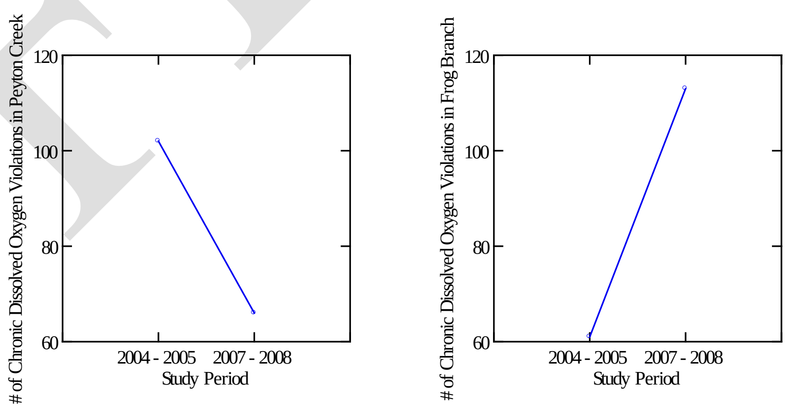

Figure 14. Paired trends of the total pre and post-BMP acute dissolved oxygen criterion violations.

There were no pH violations below pH=6 at any time at either location during the four years of sampling. However, there were 18 days (6.5%) with pH > 9 at PC1 in 2004 - 2005 versus 28 days (13.7%) with exceedences in the post-BMP interval. At FB1 there was 1 day (0.4%) with a pH value greater than nine during the pre-BMP period but that increased to 22 days (14.0%) in the post-BMP period. All of these violations appear to be associated with photosynthesis and respiration not influent materials other than plant nutrients. There were no violations of the 1 standard unit changes in 24 hour criterion for either stream.

Analysis of Covariance Modeling of Continuous Data

Analysis of the continuous monitoring data with the analysis of covariance models was compromised by difficulty in meeting the requirement that the data be Independent (not autocorrelated). All of the continuous monitoring data was highly autocorrelated. A variety of techniques were used to offset this limitation such as data aggregation as recommended by Grabow and others (1998b). Aggregation was attempted by averaging the 15-minute data to hourly, daily, weekly, and monthly values yet all groupings produced seriously impaired results as autocorrelation remained high. Consequently, a strategy was chosen that used daily data which was randomly subsetted and the use of a nonparametric graphical approach which is somewhat equivalent. The graphical approach used notched box plots, as described above and depicted in **Figure 9**, of pre-BMP and post-BMP data for each watershed.

Because autocorrelation was such an issue for the continuous data and because significant results were only identified for the dissolved oxygen data the dissolved oxygen model is the only one presented. Box plots of the relative differences are presented for the other data.

Dissolved Oxygen

Four-hundred eighty-eight reliable pairs of daily average dissolved oxygen values were collected during the four years of sampling. The full model for dissolved oxygen (is presented as **Equation 2**

$Y_t = 2.89 + 0.34X_t + 1.063X_e + -0.06\, X_t\, X_e$ **Equation 2**

where:

Y_t = Dependent variable – dissolved oxygen from Peyton Creek
X_t = dissolved oxygen from Frog Branch
X_e = indicator variable such that $X_e = 0$ are the pre-BMP dates and $X_e = 1$ are the post-BMP dates

b_0, b_1, b_2, & b_3 = regression coefficients.

The statistical analysis of the model is presented below. The model coefficients indicate that the model for the calibration period is represented by **Equation 3**

$Y_t = 2.89 + 0.34X_t$ **Equation 3**

Equation 4 represents the treatment period

$Y_t = 2.89 + 1.063 + (0.34+-0.06)\ X_t$ **Equation 4**

Dependent Variable: Y_t N: 488 Multiple R: 0.395 Squared multiple R: 0.156

Adjusted squared multiple R: 0.151 Standard error of estimate: 2.869

Effect		Coefficient	Std Error	Std Coef	Tolerance	t	P(2 Tail)
CONSTANT	(b_0)	2.885	0.362	0.000	.	7.981	0.000
X_t	(b_1)	0.337	0.043	0.432	0.582	7.892	0.000
X_e	(b_2)	1.063	0.507	0.171	0.263	2.098	0.036
X_t*X_e	(b_3)	-0.062	0.068	-0.075	0.259	-0.913	0.362

Effect	Coefficient	Lower < 95%>	Upper
CONSTANT	2.885	2.175	3.596
X_t	0.337	0.253	0.421
X_e	1.063	0.068	2.059
X_t*X_e	-0.062	-0.196	0.072

Correlation matrix of regression coefficients

	CONSTANT	DOF	EXPERIMENT	DOF
CONSTANT	1.000			
DOF	-0.865	1.000		
EXPERIMENT	-0.714	0.618	1.000	
DOF	0.542	-0.626	-0.852	1.000

Analysis of Variance

Source	Sum-of-Squares	df	Mean-Square	F-ratio	P
Regression	735.115	3	245.038	29.763	0.000
Residual	3984.805	484	8.233		

Durbin-Watson D Statistic 0.331
First Order Autocorrelation 0.831

The Durbin-Watson D statistic indicates that the model errors are still highly correlated. The Durbin-Watson D statistic for the residuals of the model equals 0.331 which is close enough to 2.00 and the First Order Autocorrelation (0.831) is close enough to 1.00 that autocorrelation is a considerable problem for the model and the probability values are inflated and unreliable. However, the model results support results observed with the box plots and analysis of 25 subsets of the daily data all produced the same results although all were autocorrelated as badly as the total model.

Both the analysis of covariance modeling and the box plots of the dissolved data for each watershed indicates improvements in dissolved oxygen at Peyton Creek relative to Frog Branch. Meteorological conditions, common to both watersheds, resulted in decreases in dissolved oxygen in the post-BMP period in the control watershed.

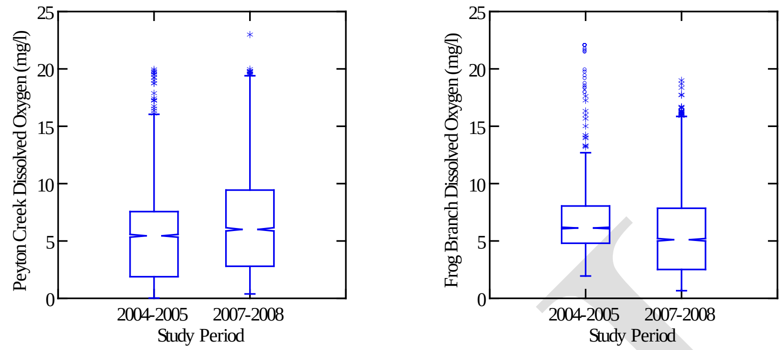

Figure 15. Box plots of the dissolved oxygen data pre and post BMP for each watershed indicates improvements in dissolved oxygen at Peyton Creek while meteorological conditions, common to both watersheds, resulted in decreases in dissolved oxygen in the post-BMP period in the control watershed.

pH levels in both watersheds decreased significantly as heterotrophic activity increased with lower flows.

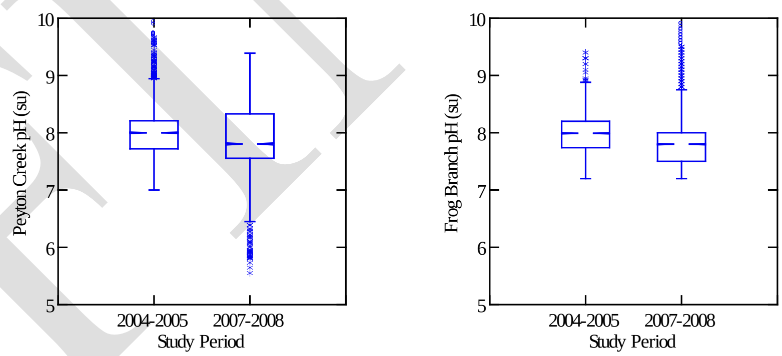

Figure 16. Box plots of the pH data pre and post BMP for each watershed.

Specific Electrical conductance were not significantly different in either watershed during the period although higher spikes were observed Peyton Creek in the pre-BMP as more materials were washed into or deposited in the stream.

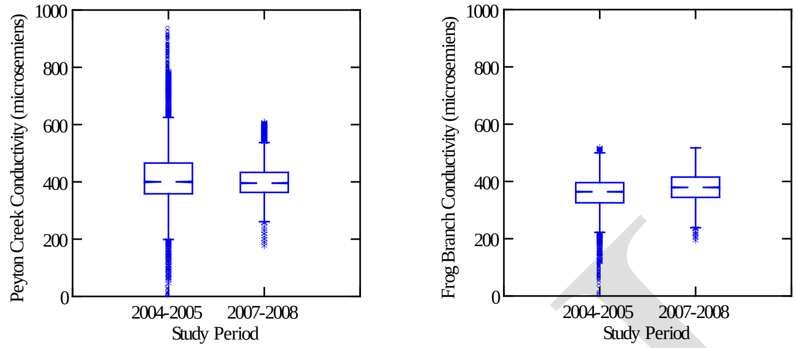

Figure 17. Box plots of the specific electrical conductance data pre and post BMP for each watershed.

Turbidity data was significantly higher in each watershed but the analysis of covariance models indicated that the difference in slopes was insignificant even with the extreme autocorrelation.

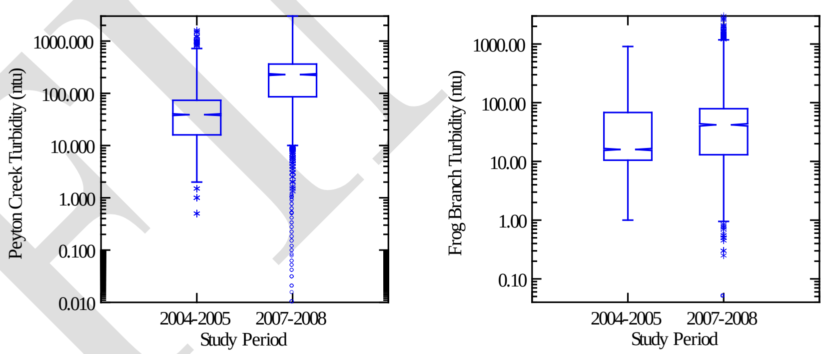

Figure 18. Box plots of the turbidity data pre and post BMP for each watershed.

Discrete Sampling Program

The discrete sampling program was severely affected by the dry conditions experienced in the watershed in 2005, 2007, and 2008. The objective of the program was to collect 70% of the samples during storm events. However, the storms didn't materialize. Several sampling trips, were made each year to the watershed in anticipation of wet weather yet very few expectations were met. The complete loss of flow in Peyton Creek was also unexpected. Local farmers, including Mr. Paul Jeffries, have stated that these are some of the driest conditions they have experienced. In hindsight, more samples might have been collected in May or June when flows were stable. However, as can be seen from the 2003, 2004 and 2006 years it was difficult to anticipate the extreme summer dryness.

Table 10 summarizes the discrete sampling data by watershed and relative to BMP installation. Considerable decreases in all of the solids components and fecal coliform bacteria, in the *treatment* watershed Peyton Creek, may be accounted for by the reduced flow conditions of the post-BMP interval. Similar reductions were observed in the *control* watershed, Frog Branch, although average fecal coliform concentrations increased mainly as a function of the higher maximum values observed. The median value exhibited a decrease similar to the treatment watershed.

An analysis of the fecal coliform bacteria, total solids, and total suspended solids data using the methods of Grabow and other (1998) is excerpted here and will be presented in more detail in the Peyton Creek Water quality report.

Table 10. Summary statistics of the discrete sampling effort. The values outside the parentheses are pre-BMP data and inside the parentheses are post-BMP data.

	Total Solids (mg/l)	Total Suspended Solids (mg/l)	Total Dissolved Solids (mg/l)	Fecal Coliform bacteria (cfu/100 ml)
Peyton Creek				
N of cases	31 (18)	31 (18)	31 (18)	31 (24)
Minimum	29 (208)	1 (1)	28 (168)	880 (40)
Median	288 (283)	25 (10)	263 (243)	9,690 (1,465)
Mean	628 (330)	289 (69)	339 (261)	15,273 (31,882)
Maximum	5,498 (607)	3,580 (397)	1,918 (417)	85,500 (120,000)
C.V.	1.65 (0.34)	2.49 (1.58)	1.00 (0.28)	1.18 (1.64)
Frog Branch				
N of cases	27 (18)	27 (18)	27 (18)	28 (21)
Minimum	167 (204)	1 (1)	159 (184)	60 (70)
Median	243 (234)	13 (12)	232 (215)	2,280 (1,380)
Mean	263 (248)	37 (20)	225 (228)	4,636 (29,212)
Maximum	832 (344)	596 (73)	264 (299)	51,700 (120,000)
C.V.	0.45 (0.16)	3.02 (1.07)	0.12 (.16)	2.07 (1.74)

Fecal coliform bacteria

Forty-six reliable fecal coliform bacteria samples were collected during the four years of sampling. The full model for fecal coliform bacteria ($\log_{10}$ transformed) is presented as **Equation 5**

$Y_t = 3.88 + 0.03X_t + -3.41X_e + 0.75\ X_t\ X_e$ **Equation 5**

where:

$Y_t =$ Dependent variable - fecal coliform bacteria ($\log_{10}$ transformed) from Peyton Creek
X_t = fecal coliform bacteria ($\log_{10}$ transformed) from Frog Branch
X_e = indicator variable such that $X_e = 0$ are the pre-BMP dates and $X_e = 1$ are the post-BMP dates

$b_0, b_1, b_2,$ & b_3 = regression coefficients.

The statistical analysis of the model is presented below. The model coefficients indicate that the model for the calibration period is represented by **Equation 6**

$Y_t = 3.88 + 0.03X_t$ **Equation 6**

Equation 7 represents the treatment period

$Y_t = 3.88 + -3.41 + (0.03+0.75)\ X_t$ **Equation 7**

Dependent Variable: Y_t N: 42   Multiple R: 0.762   Squared multiple R: 0.581
Adjusted squared multiple R: 0.547   Standard error of estimate: 0.524

Effect		Coefficient	Std Error	Std Coef	Tolerance	t	P(2 Tail)
CONSTANT	(b_0)	3.876	0.727	0.000	.	5.335	0.000
X_t	(b_1)	0.029	0.220	0.026	0.271	0.131	0.896
X_e	(b_2)	-3.407	0.882	-2.122	0.037	-3.862	0.000
$X_t * X_e$	(b_3)	0.749	0.259	1.743	0.030	2.896	0.006

Effect	Coefficient	Lower < 95%>	Upper
CONSTANT	3.876	2.405	5.347
X_t	0.029	-0.416	0.473
X_e	-3.407	-5.193	-1.621
$X_t * X_e$	0.749	0.225	1.273

Analysis of Variance

Source	Sum-of-Squares	df	Mean-Square	F-ratio	P
Regression	14.438	3	4.813	17.533	0.000
Residual	10.431	38	0.274		

Durbin-Watson D Statistic   1.697
First Order Autocorrelation   0.119

The Durbin-Watson D statistic indicates that the model errors are uncorrelated. The Durbin-Watson D statistic for the residuals of the model equals 1.697 which is close enough to 2.00 and the First Order Autocorrelation (0.119) is close enough to 0.00 that autocorrelation does not appear to be a problem for the model.

The maximum difference as computed by the K-S test of the fecal coliform bacteria model is 0.185 with a 2-tailed probability (P) of 0.113. P is significantly larger than an alpha of 0.05 suggesting that the null hypothesis that the sample could have been drawn from a normal reference distribution should not be rejected. The graphical assessment supports the assumptions that the residuals are normally distributed (**Figure 19**).

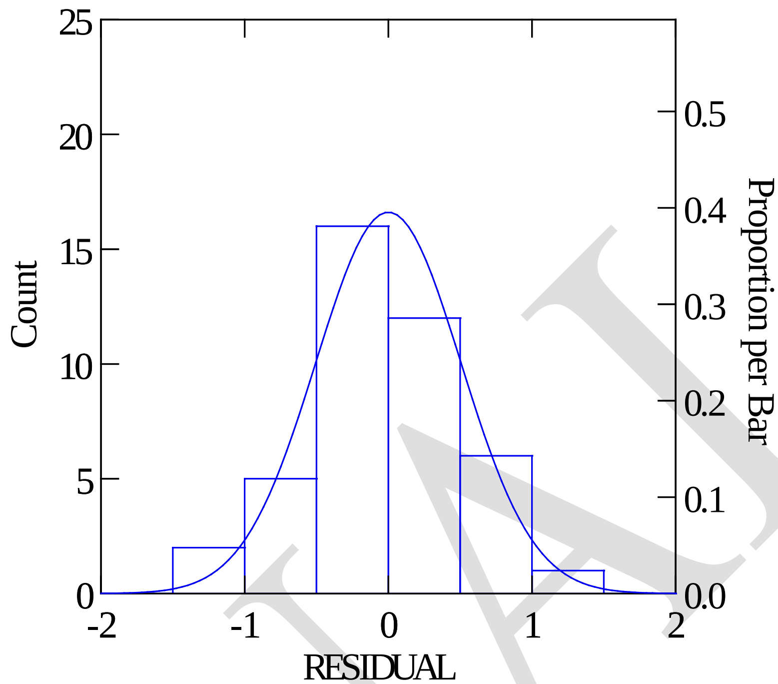

Figure 19 Histogram of the model residuals and kernal smooth for the normal distribution.

The P value of the b_2 coefficient (0.000) indicates that there is a statistically significant difference in the y-intercepts of the calibration period and the treatment period. The b_2 coefficient -3.407 reveals the magnitude of the difference with the negative sign indicating that the intercept of the treatment period is lower than the calibrations period documenting that Peyton Creek had a decrease in fecal coliform bacteria relative to Frog Branch.

The P value of the b_3 coefficient (0.006) indicates that there is a statistically significant difference in the slopes of the regression models. The slope of the treatment model (b_3 = 0.749) is greater by 0.749 log units than that of the calibration model. The positive nature of the coefficient indicates that the difference is more prominent at lower levels of fecal coliform bacteria than at the higher levels.

The average difference for the 'full' model was derived by setting X_t = average of all the Frog Branch fecal coliform data (both calibration and treatment periods). This value can be found from the results as equal to 3.34 $\log_{10}$ fecal coliform bacteria units. Substituting this value for X_t in **Equations 8** and **9** results in the following functions:

Equation 8 represents the calibration period

Y_{tc} = 3.88 + 0.03*3.4 **Equation 8**
Y_{tc} = 3.98

Equation 9 represents the treatment period

Y_{tt} = 3.88 + -3.41 + (0.03+0.75) 3.4 **Equation 9**
Y_{tt} = 3.12

Equation 10 can be used to estimate the percent decrease of fecal coliform bacteria in Peyton Creek relative to the control watershed Frog Branch.

$1-(10^{Ytt}/10^{Ytc})$ **Equation 10**

substituting results in Equation 7 produces $1-(10^{3.12}/10^{3.98}) = 0.86$. This indicates that there was an 86% reduction in fecal coliform bacteria relative to the control watershed, Frog Branch.

A very powerful graphical nonparametric tool reveals the same basic conclusion reached by the statistical model. **Figure 20** indicates that fecal coliform bacteria concentrations *were significantly lower in the post-BMP period in Peyton Creek than in the pre-BMP period.* Differences in the control watershed, Frog Branch were not significant between the two periods.

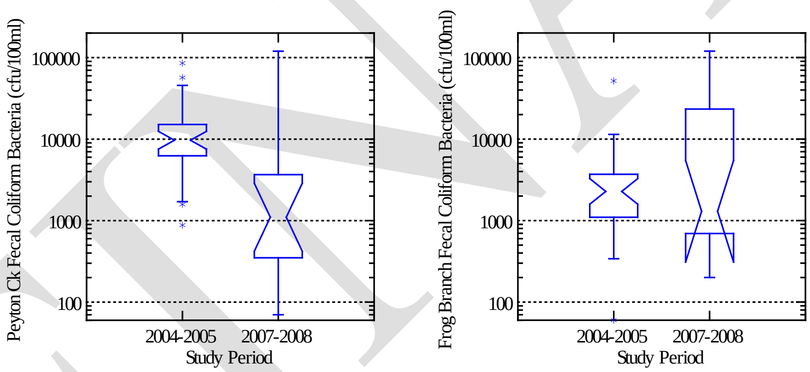

Figure 20 Notched box plots depicts the difference between the pre-BMP and post-BMP sampling intervals for both watersheds.

Total solids

Forty-two pairs of reliable total solids samples were collected during the four years of sampling. Using the log (base 10) transformed data did not produce a reliable model of total solids. However, use of the untransformed data in the model produced even more unreliable results.

The full model for total solids (log_{10} transformed) is presented as **Equation 11**

$Y_t = -0.861 + 1.432X_t + 0.298X_e + -0.151X_t X_e$ **Equation 11**

where:

Y_t = Dependent variable - total solids (log_{10} transformed) from Peyton Creek
X_t = total solids (log_{10} transformed) from Frog Branch
X_e = indicator variable such that $X_e = 0$ are the pre-BMP dates and $X_e = 1$ are the post-BMP dates

b_0, b_1, b_2, & b_3 = regression coefficients.

The statistical analysis of the model is presented below. The model coefficients indicate that the model for the calibration period is represented by **Equation 12**

$Y_t = -0.861 + 1.432X_t$ **Equation 12**

Equation 13 represents the treatment period

$Y_t = -0.861 + 0.298 + (1.432+-0.151)\ X_t$ **Equation 13**

Dependent Variable: Y_t N: 42 Multiple R: 0.433 Squared multiple R: 0.187
Adjusted squared multiple R: 0.123 Standard error of estimate: 0.322

Effect		Coefficient	Std Error	Std Coef	Tolerance	t	P(2 Tail)
CONSTANT	(b_0)	-0.861	1.265	0.000	.	-0.680	0.500
X_t	(b_1)	1.432	0.527	0.422	0.888	2.720	0.010
X_e	(b_2)	0.298	3.826	0.420	0.001	0.078	0.938
X_t*X_e	(b_3)	-0.151	1.602	-0.507	0.001	-0.094	0.925

Effect	Coefficient	Lower < 95%>	Upper
CONSTANT	-0.861	-3.422	1.701
X_t	1.432	0.366	2.498
X_e	0.298	-7.447	8.043
X_t*X_e	-0.151	-3.394	3.093

Analysis of Variance

Source	Sum-of-Squares	df	Mean-Square	F-ratio	P
Regression	0.910	3	0.303	2.916	0.047
Residual	3.952	38	0.104		

Durbin-Watson D Statistic 1.401
First Order Autocorrelation 0.298

The Durbin-Watson D statistic indicates that the model errors are uncorrelated. The Durbin-Watson D statistic for the residuals of the model equals 1.401 which is close enough to 2.00 and the First Order Autocorrelation (0.298) is close to 0.00 but autocorrelation may be a slight problem for the model.

The maximum difference as computed by the K-S test of the total solids model is 0.408 with a 2-tailed probability (P) of 0.0000. P is significantly smaller than an alpha of 0.05 suggesting that the null hypothesis that the sample could have been drawn from a normal reference distribution should be rejected. The graphical assessment supports the assumptions that the residuals are not normally distributed (**Figure 21**).

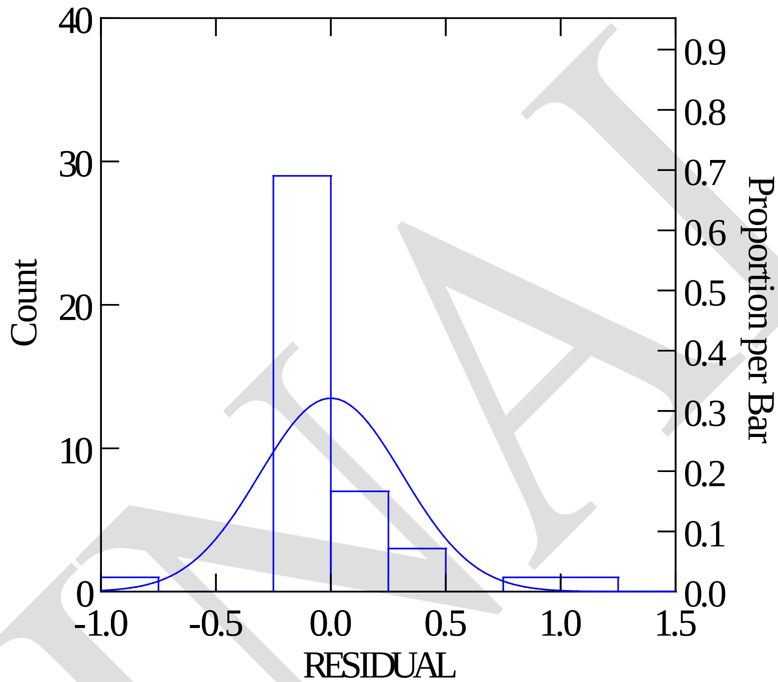

Figure 21 Distribution of residuals relative to the normal distribution. The fit is not as good as for the fecal coliform bacteria data but is still acceptable.

The P value of the b_2 and b_3 coefficients (0.938 and 0.925 respectively) indicates that there are not statistically significant differences in the y-intercepts or slopes of the calibration period and the treatment period. Consequently, evaluation of the coefficients is not advisable.

A very powerful graphical nonparametric tool reveals the same basic conclusion reached by the statistical model. **Figure 22** indicates that total solids concentrations were not significantly lower in the post-BMP period in Peyton Creek than in the pre-BMP period. Differences in the control watershed, Frog Branch were not significant between the two periods.

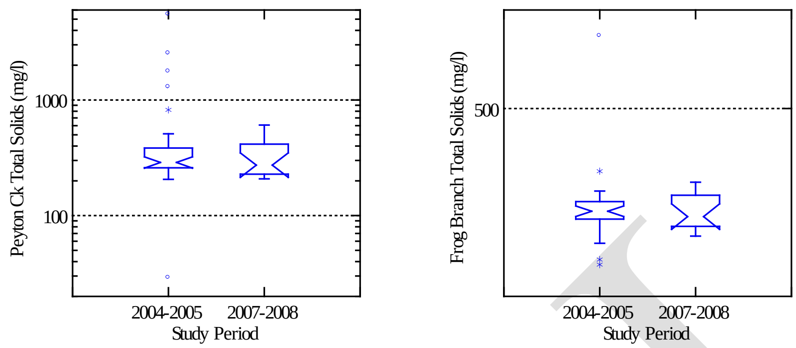

Figure 22. Notched box plots depict the difference between the pre-BMP and post-BMP sampling intervals for both watersheds.

Total suspended solids

Forty-two pairs of reliable total suspended solids samples were collected during the four years of sampling.

The full model for total suspended solids ($\log_{10}$ transformed) is presented as **Equation 14**

$Y_t = 0.842 + 0.734X_t + -0.496X_e + 0.166\ X_t\ X_e$ **Equation 14**

where:

$Y_t =$ Dependent variable - total suspended solids ($\log_{10}$ transformed) from Peyton Creek
$X_t =$ total suspended solids ($\log_{10}$ transformed) from Frog Branch
$X_e =$ indicator variable such that $X_e = 0$ are the pre-BMP dates and $X_e = 1$ are the post-BMP dates

b_0, b_1, b_2, & b_3 = regression coefficients.

The statistical analysis of the model is presented below. The model coefficients indicate that the model for the calibration period is represented by **Equation 15**

$Y_t = 0.842 + 0.734X_t$ **Equation 15**

Equation 16 represents the treatment period

$Y_t = 0.842 + -0.496 + (0.734+0.166)\ X_t$ **Equation 16**

Dependent Variable: Y_t N: 42 Multiple R: 0.528 Squared multiple R: 0.278
Adjusted squared multiple R: 0.221 Standard error of estimate: 0.724

Effect		Coefficient	Std Error	Std Coef	Tolerance	t	P(2 Tail)
CONSTANT	(b_0)	0.842	0.341	0.000	.	2.468	0.018
X_t	(b)	0.734	0.278	0.448	0.657	2.637	0.012
X_e	(b_2)	-0.496	0.568	-0.293	0.168	-0.873	0.388
X_t*X_e	(b_3)	0.166	0.476	0.121	0.158	0.349	0.729

Effect	Coefficient	Lower < 95%>	Upper
CONSTANT	0.842	0.151	1.532
X_t	0.734	0.170	1.298
X_e	-0.496	-1.646	0.654
X_t*X_e	0.166	-0.798	1.130

Analysis of Variance

Source	Sum-of-Squares	df	Mean-Square	F-ratio	P
Regression	7.675	3	2.558	4.886	0.006
Residual	19.894	38	0.524		

Durbin-Watson D Statistic	1.441
First Order Autocorrelation	0.277

The Durbin-Watson D statistic indicates that the model errors are relatively uncorrelated. The Durbin-Watson D statistic for the residuals of the model equals 1.441 which is close enough to 2.00 and the First Order Autocorrelation (0.277) is close to 0.00 but autocorrelation may be a slight problem for the model.

The maximum difference as computed by the K-S test of the total suspended solids model is 0.163 with a 2-tailed probability (P) of 0.292. P is significantly larger than an alpha of 0.05 suggesting that the null hypothesis that the sample could have been drawn from a normal reference distribution should not be rejected. The graphical assessment does not clearly support the assumption that the residuals are normally distributed but is close (**Figure 23**).

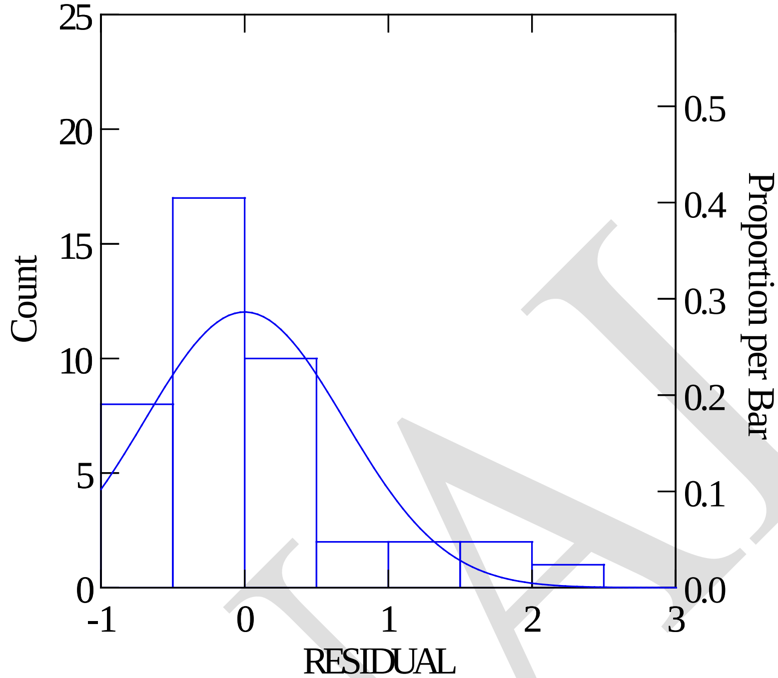

Figure 23 Distribution of residuals relative to the normal distribution. The fit is not good as for these residuals indicating that this model is not acceptable.

The P values of the b_2 and b_3 coefficients (0.388 and 0.729 respectively) indicate that there are not statistically significant differences in the y-intercepts or slopes of the calibration period and the treatment period. Consequently, evaluation of the coefficients is not advisable.

A very powerful graphical nonparametric tool reveals the same basic conclusion reached by the statistical model. **Figure 24** indicates that *total suspended solids concentrations were obviously, though not statistically significantly lower in the post-BMP period in Peyton Creek than in the pre-BMP period. Differences in the control watershed, Frog Branch were not significant between the two periods.*

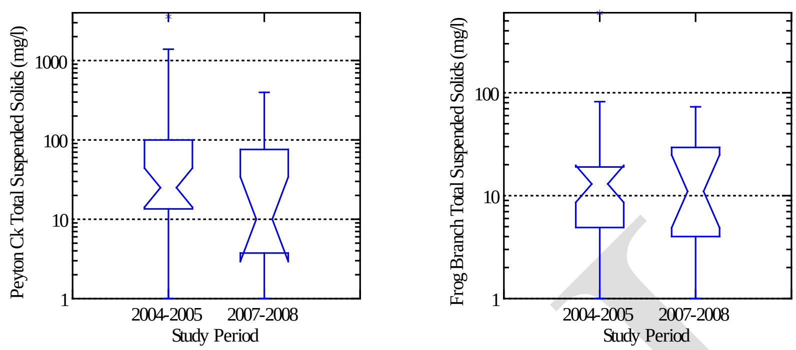

Figure 24 Notched box plots depict the difference between the pre-BMP and post-BMP sampling intervals for both watersheds. Although, the post-BMP median and quartiles are lower than for the pre-BMP period the difference is not statistically significant.

Conclusions

When selecting a watershed for this project, size was an important consideration since it is more likely that results (analytical and social) can be quantified on a smaller watershed within the limited funding and time frame and of the program requirements. However, smaller watersheds means a smaller farm pool from which volunteer farmers can be enticed to cooperate with the BMP program. In addition, smaller watersheds are more severely impacted by weather conditions such as high storm flow and/or drought where the entire creek system may go dry such as occurred in Peyton Creek and Frog Branch in 2005, 2007 and 2008.

As the partners mature in implementing 319 projects, the system tends to run better and all can benefit from lessons learned in the past. One of the inherent difficulties of implementing water quality projects such as this is to document an improvement in water quality given the confines of time, money, and climate. Funding is never enough, the weather never cooperates, and we never have enough time to document positive changes. Richards and others (2008) document that it takes several decades of abundant data “to demonstrate that trends are due to the way we use the land and not just the quirks of the weather.”

The Peyton Creek watershed project has been very successful from the perspective of landowner participation and the quality of the management systems and BMPs installed in the watershed. The water quality monitoring program has provided valuable insight into the effectiveness of the management systems. However, extreme weather conditions have compromised the ability of the monitoring to assess the management systems effectiveness. Indications are that significant reductions in fecal coliform bacteria have been achieved but these may have resulted from the reduced streamflow and lack of runoff into the system. Improvements in dissolved oxygen concentrations may be an even more convincing success given the reduced streamflow and subsequent reduction in mechanical reaeration.

An 86% reduction in fecal coliform bacteria in Peyton Creek was observed relative to the control watershed, Frog Branch. This was partially due to increases in fecal coliform bacteria in Frog Branch.

Visual observations indicate considerable success. During the 2004 and 2005 sampling years neither fish nor crayfish were evident at the Peyton Creek sampling site PC1 although they were always noted in the field log at Frog Branch (FB1). By the summer of 2007 minnows and crayfish were abundant at PC1 during all but the few storm events that were sampled. Exclusion of cattle from the creek at this point and upstream dramatically changed the riparian landscape and the amount of erosion contributing directly to the stream. After 2005 manure was not observed in the stream, whereas before the fencing manure mixed with unconsolidated sediment made fish and crayfish habitat impossible to find.

It will likely require several years for the materials once contributed to the stream network to "flush" out even if any new material is excluded. A few good wet years may return Peyton Creek to an ecologically hospitable environment for native aquatic life, although, this will require maintenance of the new management systems and the BMPs that have been installed over the past few years.

Lessons Learned

The long history of 319(h) projects in Kentucky and elsewhere has produced several lessons that guided or influenced the design and implementation of the Peyton Creek Watershed Project. An important lesson was the need for a committed watershed coordinator for the project (KHRC&D 2004; KDOW 2000a). The selection of Mr. Paul Jeffries a farmer that lives in the Frog Branch watershed was fortuitous because of his relationship with local land owners. His knowledge of the local farming practices and influence with the local farmers obviated many of the BMP implementation problems that have affected other projects such as Spears Creek - Mocks Branch Watershed (KHRC&D 2004).

Other lessons learned:

It is believed that water quality improvements through BMP installation must be those practices that make the most sense to the farmer. The best practices that fit these criteria in this project were: Feeding Pads, Water systems, Fencing streams, and Stream crossings.

The flash grazing practice was not implemented as frequently originally anticipated. The practice did not matter that much to the land owner, but it was a good selling point.

Fencing (a hard to sell practice) needs to be required before land owners area allowed to install other, more desirable practices.

Improvements are needed in engineering and material for feeding pads: size and slope of pad needs to be determined by number of cattle and size of fields; need to raise hay up off the floor of the pad; need better grade bolts; wood is more economical than metal.

Meeting with each farmer led to better implementation. BMPs installed where those that the farmer wanted. This also allowed for the education of the farmer on BMPs and could explain the effects of water quality by the practices they installed.

Engineering plans for feeding pads need to be economical and practical.

Need good watershed coordinator that is trusted, knowledgeable, and is listened to by farmers. Need to be willing to pay for this service.

Oversight committee is critical to successful implementation. These people must come from within the targeted watershed.

Project must be made available to all landowners within the watershed.

Dependable, responsible water quality monitoring company is required.

All agencies involved in project must be cooperative.

And lastly, unpredictable climatic conditions during the monitoring period also contributed to the unexpected results. The sampling period suffered a severe drought. These drought conditions resulted in lower flow, higher temperatures and lower dissolved oxygen concentrations. Many of the issues associated with this project and projects such as the Mocks Branch Watershed project could have been addressed if the project had a longer monitoring period. Many other 319 projects have had similar problems and also concluded that an extended monitoring period, of up to 10 years, would generate better results and provide the data necessary to evaluate the effectiveness of BMPs (Kingsolver and others 2001; KDOW 2000a). The results of this project may also be relevant to other watersheds with similar NPS issues.

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Appendices

Appendix A
Financial and Administrative Closeout

Application Outputs

1. Submit all draft materials to the Cabinet for review and approval.
2. Submit advanced written notice on all workshops, demonstrations, and/or field days to the Cabinet.
3. Execute MOA
4. Project Oversight Committee notified of additional funding.
5. Evaluate post-BMP monitoring dates. Revise/resubmit QAPP o Cabinet for approval.
6. Revised QAPP submitted to Cabinet for approval.
7. Install BMPs.
8. Conduct technology demonstrations fro BMPs to persons outside of Peyton Creek Watershed (within Herrington Lake Watershed).
9. Continue employing Watershed Coordinator.
10. Analyze and interpret water quality and BMP data for Final Report.
11. Upon request of the Division of Water, submit Annual Report and/or participate in the Cabinet sponsored biennial NPS Conference.
12. Submit three copies of the Final Report and submit three copies of all products produced by this project.

Budget Summary
Original Detailed Budget

Budget Categories	Section 319(h)	non-fed match	Total
Personnel	$30,000.00	$20,000.00	$50,000.00
Contractual			
Engineering	$2,500.00	$1,666.67	$4,166.67
BMPs	$200,692.00	$133,794.65	$334,486.65
Data analysis	$5,000.00	$3,333.34	$8,333.34
Final report	$5,000.00	$3,333.34	$8,333.34
TOTAL	$243,192.00	$162,128.00	$405,320.00

DOW approved revised budget

Budget Categories	Section 319(h)	non-fed match	Total
Personnel	$30,000.00	$20,000.00	$50,000.00
Contractual			
Engineering	$2,000.00	$1,333.34	$3,333.34
BMPs	$200,692.00	$133,794.65	$334,486.65
Data analysis	$5,000.00	$3,333.34	$8,333.34
Final report	$5,000.00	$3,333.34	$8,333.34
Field day trans.	$500.00	$333.33	$833.33
TOTAL	$243,192.00	$162,128.00	$405,320.00

This revision was necessary to help fund Lincoln County School System's FFA club's transpiration (school bus use) to field day. $500 was moved from Engineering category to new Field Day Transportation category.

Final Expenditures Budget

Budget Categories	Section 319(h)	non-fed match	Total	Final Expenditures
Personnel	$30,000.00	$20,000.00	$50,000.00	$62,585.44
Contractual				
Engineering	$2,000.00	$1,333.34	$3,333.34	0
BMPs	$200,692.00	$133,794.65	$334,486.65	$332,181.85
Data analysis	$5,000.00	$3,333.34	$8,333.34	$5,066.66
Final report	$5,000.00	$3,333.34	$8,333.34	$5,066.67
Field day trans.	$500.00	$333.33	$833.33	$154.60
TOTAL	$243,192.00	$162,128.00	$405,320.00	$405,055.22

The Kentucky Heritage RC&D Council was reimbursed $405,055.22. A total of $264.78 Federal funds remain unspent. This represents 99.93468% of the budget being spent.

Equipment Summary

No equipment was purchased for this project.

Special Grant Conditions

There were no special grant conditions placed on this project by the United States Environmental Protection Agency.

Appendix B
QAPP for water monitoring

Attached as separate document.

Appendix C
BMP Implementation Plan

Attached as separate document.

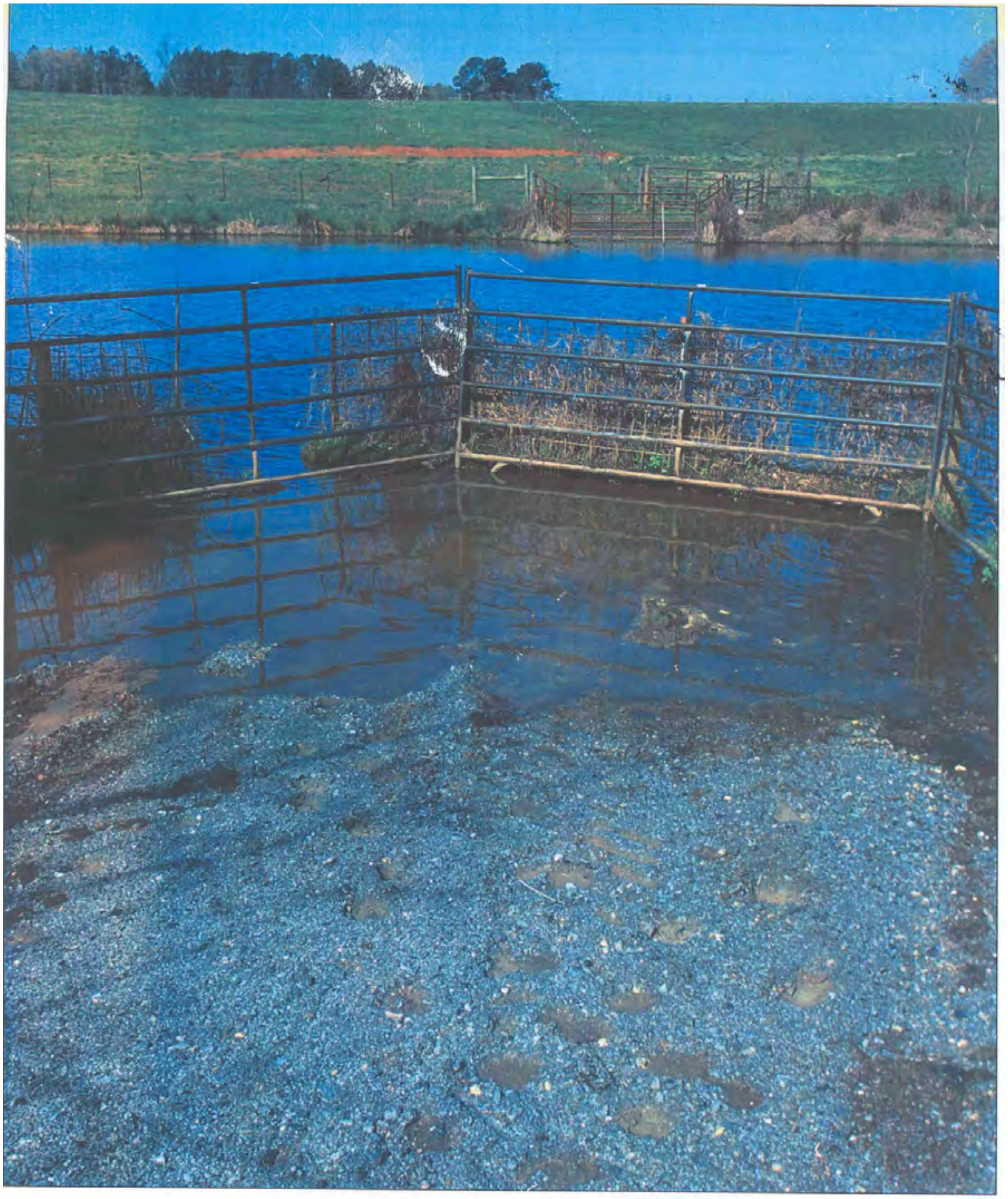
Appendix D
Installed BMPs

Practice	Size/Number
Critical Area Treatment	1.5 acres
Fence	6,100 linear feet
Heavy Use Area	26,700 square feet
Livestock Exclusion	26 acres
Pasture and Hayland Planting	373 acres
Pipeline	25,000 linear feet
Prescribed Grazing	103 acres
Spring Development	1
Stream Crossing	3
Tank	12
Waste Storage Facility	1

Kentucky Heritage RC&D Council Newsletter

Photos of BMPs

Animal Trails & Walkways



Heavy Use Protection Area

Livestock Exclusion

Pasture & Hayland Planting

Pipeline & Tanks

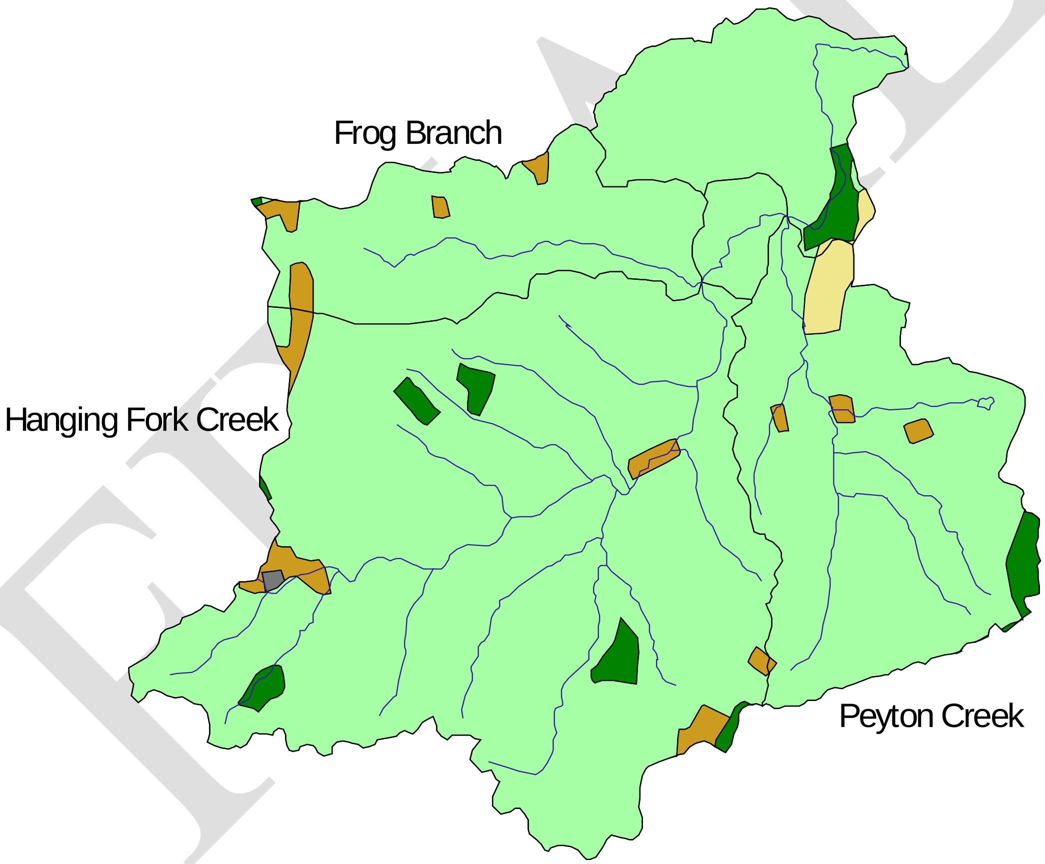

Riparian Buffer

PEYTON CREEK WATERSHED
A SUBPROJECT OF THE HERRINGTON LAKE – DIX RIVER CLEAN WATER ACTION PLAN

Section 319(h) Nonpoint Source Implementation Program
FFY 2002 Cooperative Agreement #C9994861-01

QUALITY ASSURANCE PROJECT PLAN

1/28/2019



J. E. Edinger Associates, Inc.
Research and Applications in Watershed and Waterbody Science

Midwest Regional Office
425 N. Ferguson St, PO Box 446
Henryville, Indiana 47126
tel: 812-294-7618

QUALITY ASSURANCE PLAN APPROVAL

Project Personnel	**Approval Signature**	**Date**
KY Division of Water Quality Assurance Coordinator		
KY Division of Water, NPS Section Project Manager		
KY Division of Conservation Project Manager		
John Overing KY Heritage RC & D Council, Inc. Project Manager		

QUALITY ASSURANCE PROJECT PLAN DISTRIBUTION LIST

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ACRONYMS AND ABBREVIATIONS

ANOVA	Analysis of variance
BMP	Best Management Practice
CFU	Colony Forming Unit (for Fecal Coliform Bacteria)
DO	Dissolved Oxygen
DOC	(KY) Division of Conservation
DOW	(KY) Division of Water
DQO	Data Quality Objective
EPA	(United States) Environmental Protection Agency
FC	Fecal Coliform bacteria
FFY	Federal Fiscal Year
GIS	Geographic Information System
JEEAI	J. E. Edinger Associates, Inc.
KAR	Kentucky Administrative Regulation
KDEP	Kentucky Department for Environmental Protection
Mg/l	Milligrams per liter (equivalent to parts per million)
NEMI	National Environmental Methods Index
NPS	Nonpoint Source
NRCS	Natural Resources Conservation Service
NTU	Nephelometric Turbidity Units
O&M	Operation and Maintenance
QAPP	Quality Assurance Project Plan
QA/QC	Quality Assurance Quality Control
RC&D	Resource Conservation and Development
RPD	Relative Percent Difference
S.C.	Specific Electrical Conductance
SOP	Standard Operating Procedure
T	Temperature
TNTC	Too Numerous To Count (for Fecal Coliform Bacteria)
USGS	United States Geological Survey
uS/cm	Micro-seimens per centimeter

1.0 PROJECT MANAGEMENT

The Kentucky Natural Resources and Environmental Protection Cabinet, Department for Natural Resources, Division of Conservation (DOC) and the Kentucky Heritage Resource Conservation and Development Council, Inc. (RC&D) have entered into a grant agreement to improve water quality in the Peyton Creek Watershed. The Peyton Creek Watershed Project (01-16) is being conducted under the FFY2001 Section 319(h) Nonpoint Source Implementation Program Cooperative Agreement #C9994861-01.

The Kentucky Heritage RC&D, and their partners, will implement Best Management Practices (BMPs) throughout the Peyton Creek watershed. BMPs will emphasize streamside protection, proper manure handling and utilization and conversion to rotational grazing systems. This project includes water quality monitoring to evaluate water quality changes associated with BMP implementation.

This Quality Assurance Project Plan (QAPP) describes quality assurance and quality control for the water quality monitoring network that will be installed by J.E. Edinger Associates, Inc. (JEEAI) in cooperation with the Kentucky Heritage RC&D and the Lincoln County Conservation District in Lincoln County, Kentucky. This Quality Assurance Project Plan (QAPP) is incorporated by reference into the Grant Agreement.

1.1 Project/Task Organization

This QAPP element will identify the individuals and organizations participating in the project and discuss their specific roles and responsibilities. This element also identifies the individual responsible for maintaining the official, approved QA Project Plan.

Project Manager: The Kentucky Heritage RC &D Council, Inc. is responsible for overall management and reporting for this project, oversight of the data collection and assessment components, and maintenance of the approved QAPP.

BMP Manager: The Lincoln County Conservation District will assist BMP implementation, and site selection. The Lincoln County Conservation District may also assist with collecting grab samples. The Lincoln County Conservation District has hired a Watershed Coordinator to assist with BMP implementation, under the direction of the District Conservationist.

Monitoring Manager: J.E. Edinger & Associates, Inc. (JEEAI) will install a monitoring network that consists of 2 continuous monitors and 5 grab sampling sites. JEEAI will oversee and assist with sample collection, data review and management. JEEAI will conduct the data analyses.

Laboratory Manager: The Fouser Environmental Services laboratory will analyze grab samples for total solids, total suspended solids and fecal coliform bacteria.

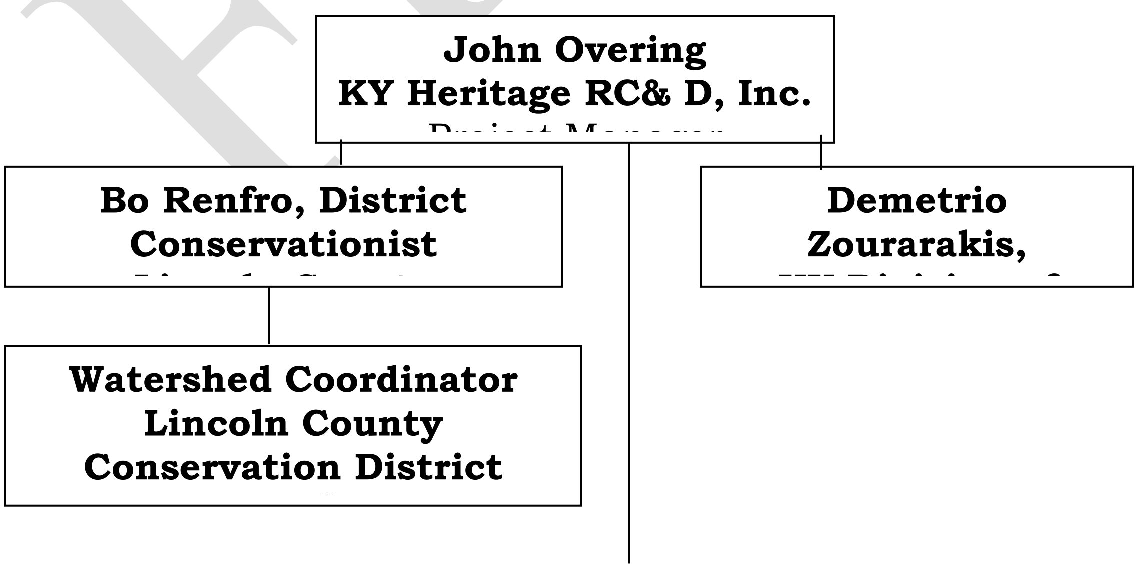
Peer Review: The KY Division of Conservation (DOC) will provide independent peer review on this project, including all aspects of data collection, assessment and report generation.

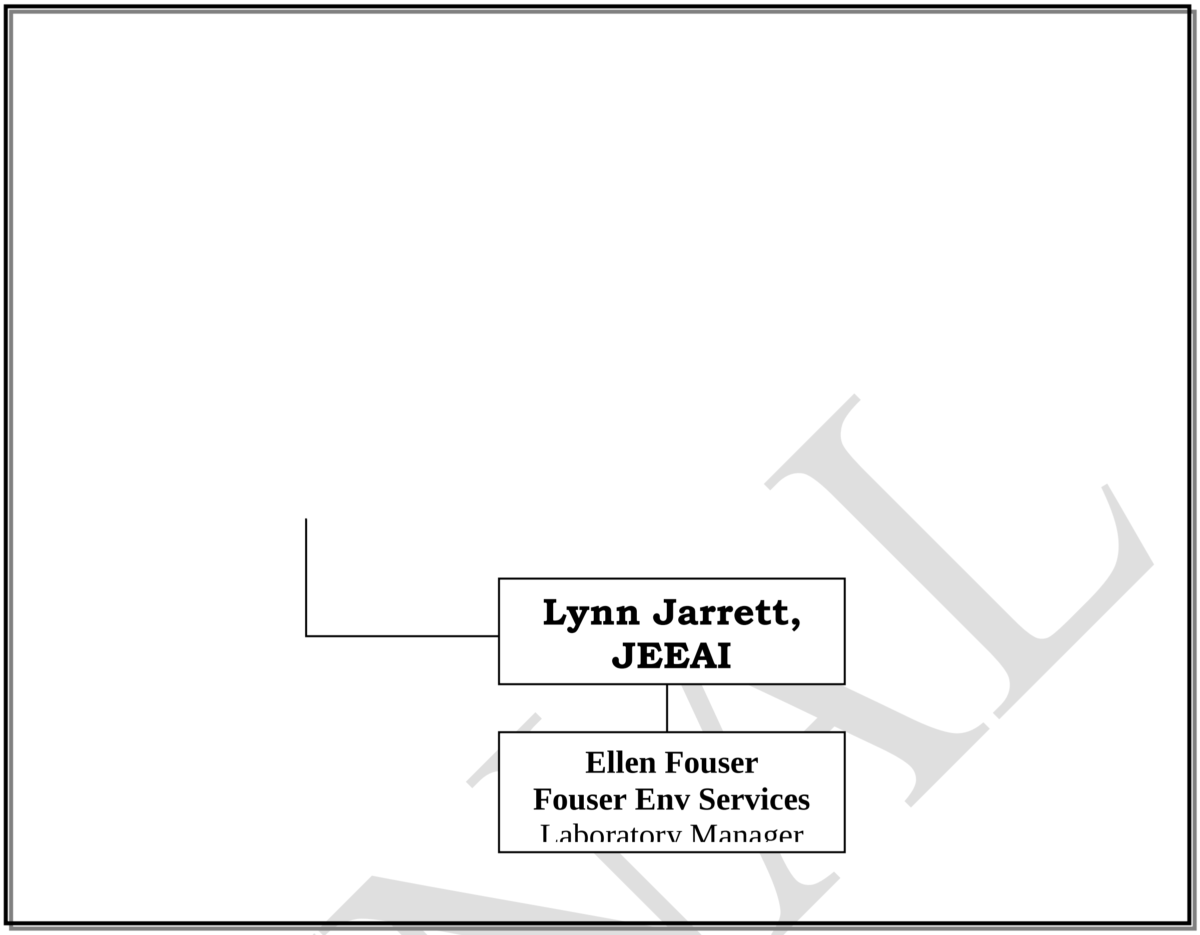
The project team includes engineers, scientists, and technicians with the technical expertise and project management skills necessary to successfully collect water quality and environmental management data. The roles and responsibilities of the personnel working on this project are presented in **Table 1** and illustrated in **Figure 1**.

Table 11: Project Organization, Roles and Responsibilities

Organization	Key Roles	Project Responsibility
Kentucky Heritage RC&D Council, Inc.	Project Manager	• Project management • Site selection, project data management, reporting • Quality Assurance Manager
Lincoln County Conservation District	BMP Manager	• Coordinate BMP installation • BMP data management • Assist with site selection • Grab sample collection
JEEAI	Monitoring Manager	• Site selection (continuous & grab) • Continuous monitor installation • Coordinate sampling teams (continuous & grab) • Continuous monitor field work, assist with grab sample collection • Manage, quality assure and assess sampling data • Provide electronic and hard copy data reports
Fouser Environmental Services	Laboratory Manager	• Laboratory analyses
KY Division of Conservation	Peer Review	• Peer reviewer • Review all project data and reports

Figure 25. Project Organization





1.2 Problem Definition/Background

This QAPP element provides an overview of the specific problem to be solved, decision to be made, or outcome to be achieved, including sufficient background information to provide a historical, scientific, and regulatory perspective for this particular project.

Peyton Creek is tributary to Hanging Fork, with a ~6 square mile drainage area. This watershed is located in the Interior Bluegrass Ecoregion. The Inner Bluegrass Ecoregion is typically underlain by Middle Ordovician Lexington Limestone. Very fertile Alfisols and Mollisols have developed from the underlying phosphatic limestone. (Ecoregions of Kentucky Map). Peyton Creek is a 2nd order stream and the watershed has approximately 27.4 miles of streams.

Based on data from the early to mid-1990's, land use is almost entirely pastureland (~5.5 square miles), with small areas of forest and residential development. (See **Figure 2)** Residential areas have expanded and the new land use data that will be available in the near future through the Kentucky Land Sat project will be incorporated into this project for final site selection and data analysis. There are currently no point source discharges in the Peyton Creek watershed.

The Frog Branch, a 3 square mile, 1st order tributary to Hanging Fork will serve as a control watershed in this project. This watershed has very similar land uses, soils and topography, but BMP implementation will not be emphasized in this watershed.

Peyton Creek watershed was selected to provide a demonstration of BMP implementation throughout a watershed. BMPs will emphasize streamside protection, proper manure handling and utilization and conversion to rotational grazing systems. A monitoring network will be implemented to evaluate water quality changes associated with BMP implementation throughout a small watershed. The Surface Water Standards (401 KAR 5:031) will provide a "yardstick" for this evaluation, however the results will not be used for regulatory purposes. The results of this project may also be relevant to other watersheds with similar nonpoint source issues.

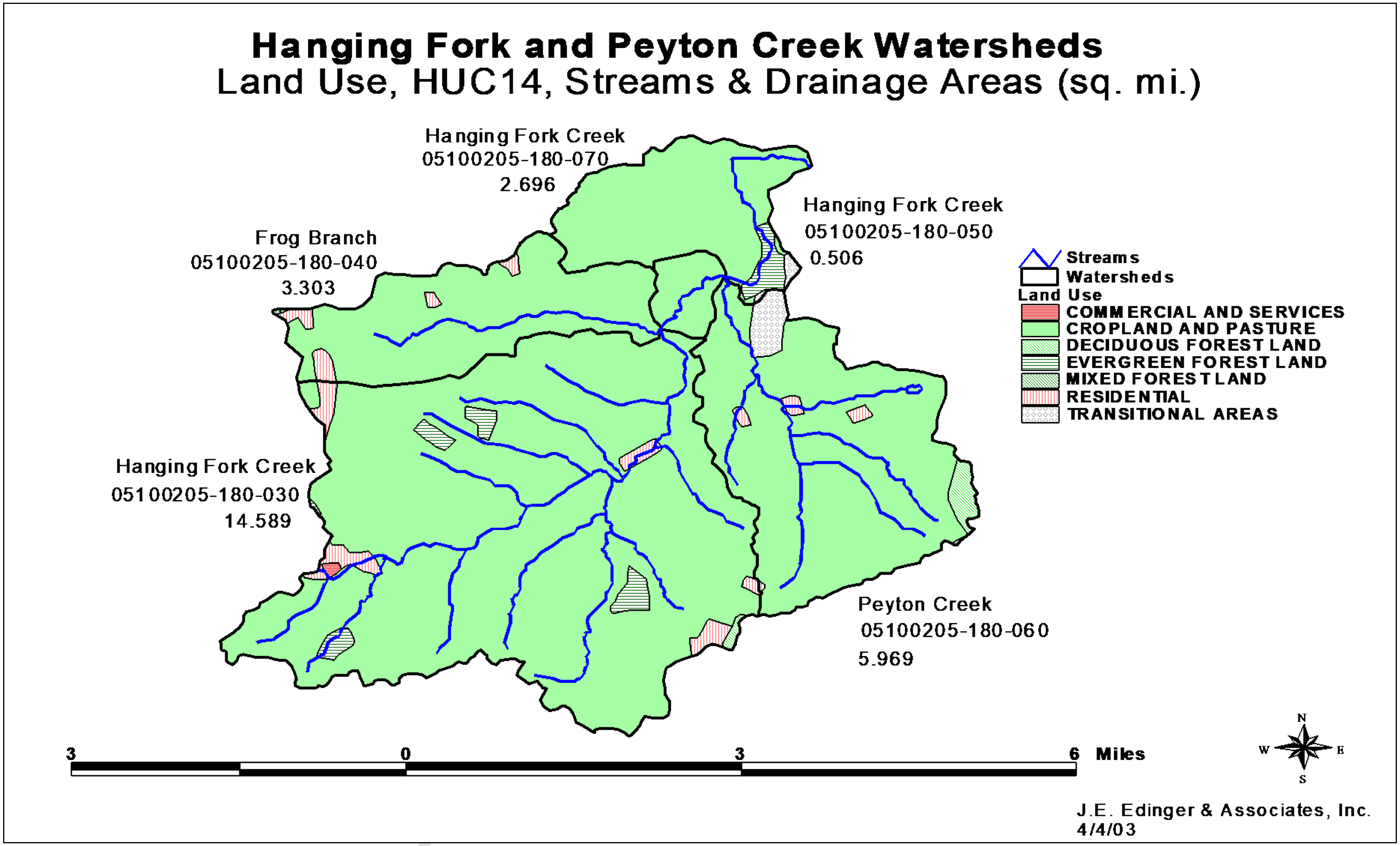


Figure 26: Hanging Fork and Peyton Creek Watersheds

1.3 Project Task Description

This QAPP element provides a summary of all work to be performed, products to be produced, and the schedule for implementation.

<u>Work To Be Performed</u>

- Site selection (continuous water quality monitors, grab samples)
- Installation of 2 continuous water quality monitors to collect 6 water quality parameters (See <u>Overview of Continuous Monitors</u> for additional information)
- Grab sample collection for fecal coliform bacteria, total solids and total suspended solids 5 locations
- Continuous monitor calibration, servicing and data download
- Laboratory analysis for fecal coliform bacteria, total solids and total suspended solids concentrations
- Data quality review for continuous monitors and grab samples
- Data management
- Data assessment to evaluate water quality changes associated with BMP implementation
- Reports and presentations summarizing the dataset and major findings of the monitoring program.

<u>Implementation Schedule</u>

Continuous monitors and grab samples will be collected for four 6-month intervals, spanning pre-BMP through post-BMP implementation. Monitoring will be done concurrently with BMP installation. A project schedule for the monitoring program is provided in **Table 2.** This schedule may be adjusted as needed to ensure that data collection is completed by 9/2006.

Table 12. Project Schedule

Task	Timeframe
Pre-BMP Monitoring	10/2003 – 4/2004
BMP Installation	1/2004 – 5/2006
BMP Monitoring	5/2004 – 5/2006
Post-BMP Monitoring	5/2006 – 9/2006
Data Assessment	1/2006 – 6/2006
Final Monitoring Report	6/2006 – 9/2006

<u>Overview of Continuous Monitors</u>

An overview of continuous monitors is provided here because this type of sampling is significantly different from typical monthly or quarterly sampling (i.e., grab sampling) used to characterize water quality.

The continuous monitors used in this project will include probes to collect water quality data the parameters shown in **Table 3**. Data can be logged or transmitted via satellite on frequent time intervals (e.g., 5 minutes). Because the time interval is so short, the monitors are considered “continuous”.

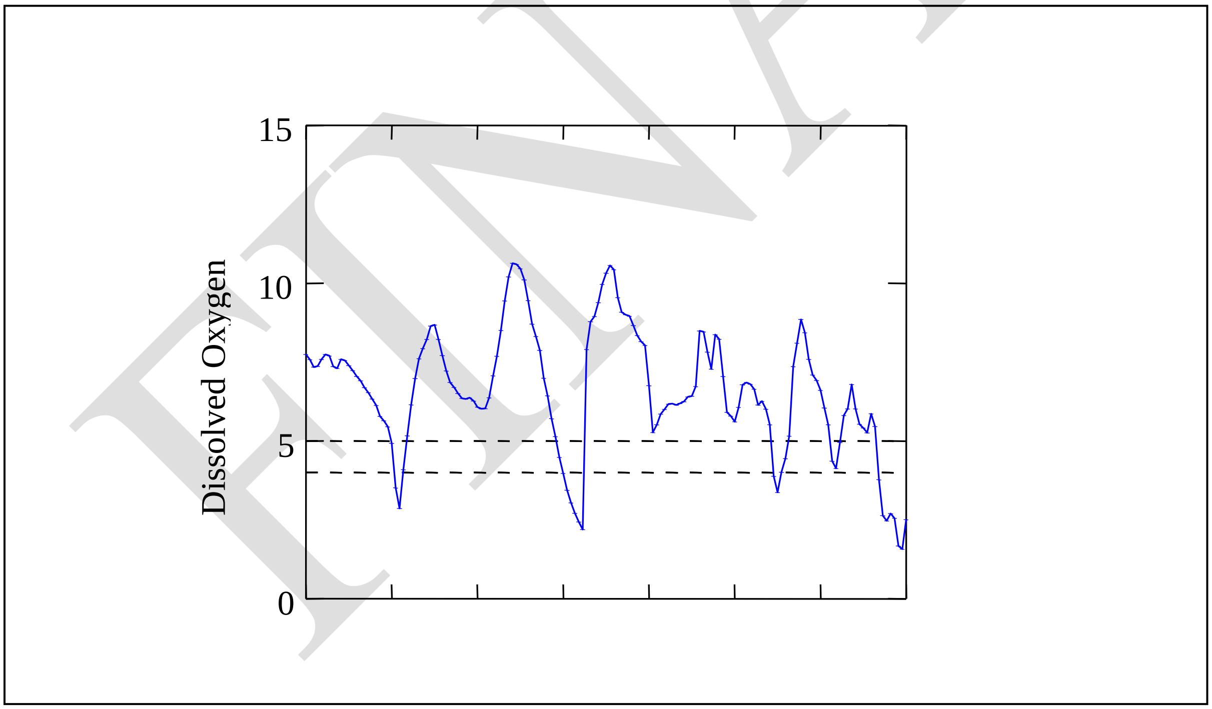
Table 13. Continuous Monitoring Parameters

STORET #	Description

00010	Water Temperature (°Celsius)
00300	Dissolved oxygen (mg/l)
00301	Dissolved oxygen (% saturation)
00400	pH - Water, Whole, Field, Standard units
00095	Specific Conductance (micro-siemens /cm @ 25 °C)
00076	Turbidity (NTU)

Approximately 102,528 data for each parameter may be collected over 1 year with data logged every 5 minutes. When coupled with precipitation data and gage height or other measures of flow, continuous water quality monitors provide resource managers with a very robust dataset to characterize water quality changes and processes in detail through the seasons and through many flow regimes. It may be useful to think of continuous monitors as a “water quality video camera”, while collecting grab samples is similar to using a still camera with a timer. As shown in **Figure 3**, continuous monitors provide data that can be used to clearly evaluate average and instantaneous DO and identify episodes of DO criteria violations that may not have been found using traditional sampling methods.

Figure 27. Continuous Dissolved Oxygen Data



Although only a few water quality characteristics can be monitored at this frequent time scale, the monitored parameters can be especially important from both a scientific and regulatory perspective. The increased sensitivity of continuous monitoring will highlight water quality changes related to storm events, changes in land use practices and other impacts such as spills, sewer overflows, or bypasses.

It is important to note that continuous monitors require diligent calibration and servicing to minimize problems associated with probe drift, fouling and interference. In addition, management, analysis and interpretation of the large databases produced by continuous monitors present new challenges. Probes are also available to collect chlorophyll a, ammonia-nitrogen and other parameters. However, data quality may be lower with the probes currently available for these parameters.

Hydrolab Series 4a Data Sonde's will be used for this project. Additional information regarding these monitors is available at http://www.hydrolab.com. Detailed procedures for continuous monitors are provided in USGS Water-Resources Investigations Report 00-4252 Guidelines and Standard Procedures for Continuous Water-Quality Monitors: Site Selection, Field Operation, Calibration, Record Computation, and Reporting. (Wagner and others, 2000).

1.4 Quality Objectives and Criteria

This QAPP element provides a description of the quality objectives for the project and the performance criteria to achieve those objectives. EPA requires the use of a systematic planning process to define these quality objectives and performance criteria.

Data Quality Objectives (DQOs) are quantitative and qualitative statements that specify the quality of environmental data required to achieve the goals of the program. The quality assurance objectives include precision, accuracy, completeness, representativeness, and comparability. The project goals and attainable data quality for the field and laboratory methods were used to establish the DQOs for this monitoring project. DQOs are defined and established in this section; methods to measure attainment of the DQOs are provided in **Sections 2.5 and 2.6.**

Goals The goals of this monitoring project are to:

- Evaluate changes in water quality associated with BMP implementation
- Evaluate status and trends with respect to Surface Water Standards

Evaluating status with respect to Surface Water Standards requires high quality data to develop accurate estimates of concentrations that are consistent with the averaging periods and other considerations included in the Surface Water Standards.

Surface Water Standards have been adopted in Kentucky to protect human health and aquatic life from the adverse effects of water pollution. The designated uses of Kentucky streams are described in 401 KAR 5:026. Streams in the Peyton Creek watershed are classified as warm water aquatic habitat and primary contact for recreational uses. Numerical and narrative water quality criteria relevant to this project are found at 401 KAR 5:031, Section 2 (Minimum Criteria), Section 4 (Aquatic Life) and Section 6 (Recreational).

This project will use a combination of continuous monitoring, grab samples and calculations to evaluate water quality. These approaches are expected to reliably detect and resolve concentrations to the numerical water quality criteria for dissolved oxygen, pH and temperature.

The Surface Water Standards for fecal coliform require collection of 5 or more samples per month with samples analyzed within 6 hours for regulatory purposes. In this project, samples will be collected twice per month, analyzed within 24 hours, and the data will be used to evaluate pre-and post-BMP conditions. Therefore, fecal coliform data will not be used for regulatory purposes.

<u>Precision</u> is a measure of variance between duplicate samples (i.e., are measurements reproducible?). Precision is often expressed as relative percent difference (RPD) between duplicates and is calculated using **Equation 1** in **Section 2.5.**

<u>Accuracy</u> is a measure of the ability to correctly determine concentration. The target accuracy of continuous monitors is established by the manufacturer and evaluated in the field through relative percent difference (RPD) of pre- and post-calibration readings as described above. To measure laboratory accuracy, samples that have been "spiked" with a known amount of analyte are analyzed. The percent recovery is calculated using **Equation 2** in **Section 2.5.**

<u>Representativeness</u> expresses the extent to which the analytical data reflect the actual media at the site. Representativeness will be evaluated using best professional judgment (BPJ) with respect to general sample management issues including sample documentation, preservation, handling and transport as well as a discussion of representativeness with respect to analytical-method specific issues such as method deviations.

In order to obtain representative data from grab samples, the monitoring program will emphasize storm events; 70% of samples will be collected under elevated flow conditions and 30% will be baseflow samples.

<u>Completeness</u> is a measure of the amount of usable data; field and laboratory completeness will be evaluated separately using **Equation 3** in **Section 2.5**. Completeness may be reduced by field equipment failure, exceedence of holding times, broken sample containers, etc. The completeness DQO for sample collection is 90%; for laboratory analyses, the completeness DQO is 95%.

<u>Comparability</u> is a qualitative parameter that expresses the confidence with which one data set can be compared to another. Comparability of the sampling and analytical programs are evaluated separately.

Sampling comparability will be evaluated based on the following:

- A consistent approach to sampling was applied throughout the program;
- Sampling was consistent with established methods for the media and analytical procedures;
- Samples were properly handled and preserved.

Analytical comparability will be evaluated based upon the following:

- Consistent methods for sample preparation and analysis;
- Sample preparation and analysis was consistent with specific method requirements;
- The analytical results for a given analysis were reported with consistent detection limits and consistent units of measure.

The water quality criteria and DQOs for this project are summarized in **Table 4**.

Table 14: Water Quality Criteria and Data Quality Objectives for Monitoring Program Parameters

Parameter (Units)	Acute Criterion	Chronic Criterion	401 KAR 5:031 Subsection	Collection Method	Analytical Method	MDL/ Range	Accuracy	Precision/ Resolution
Dissolved Oxygen (DO) (mg/l)	≥ 4.0 instantaneous	≥5.0 daily avg.	4 (1)(e) 1	Continuous Monitor	NA	0 to 20 mg/L	±0.2	0.01 mg/L
% DO Saturation	NA	NA	NA	Calculated	NA			
pH (pH units) **(1)**	≥ 6.0 and ≤ 9.0	n/a	4 (1)(b)	Continuous Monitor	NA	0 to 14	±0.2	0.01 units
Temperature (°C) **(2)**	31.7	n/a	4 (1)(d)	Continuous Monitor	NA	-5 to 50	±0.15	0.01°C
Specific Conductivity (SC) (uS/cm @ 25 °C)	NA	NA	NA	Continuous Monitor	NA	0 to 100 uS/cm	±0.5% of range	4 digits
Turbidity **(3)**	Narrative Criterion		2 (1)(a) & (c)	Continuous Monitor	NA	0 to 1000 mg/L	The greater of ± 5 % or 2 NTU	
Total Solids (TS) (mg/l)	NA	NA	NA	Grab Sample	EPA 160.3	10 – 20,000 mg/L	NA	±30%
Total Dissolved Solids (TDS) (mg/l) **(3)**	Narrative Criterion		4 (1)(f)(1)	Calculated	NA	10 – 20,000 mg/L	NA	±30%
Total Suspended Solids (TSS) (mg/l) **(3)**	Narrative Criterion		4 (1)(f)(2)	Grab Sample	EPA 160.2	4 – 20,000 mg/L	91%	±6%
Fecal Coliform (CFU/100 ml) **(4)**	**May 1 – Oct 31:** Geomean ≤ 200 FC/ 100 ml and ≤ 20% of samples ≤ 400 FC/ 100 ml **Nov 1 – Apr 30:** Geomean ≤ 1000 FC/ 100 ml and ≤ 20% of samples ≤ 2000 FC/ 100 ml		6 (1)(a)	Grab Sample	SM 9222D	$1 – 10^6$ CFU/100 ml	±50%	±10%

Table 4 Notes:
(1) pH: in addition to these numerical criteria, 401 KAR 5:031, Section 4(1)(b) also specifies that pH shall not fluctuate more than 1.0 pH units over 24 hours. Unlike grab samples, continuous monitoring data will allow assessment of this aspect of the pH criterion.

(2) Temp: in addition to this numerical criterion, 401 KAR 5:031, Section 4(1)(d)(1) also specifies that the normal daily and seasonal temperature fluctuations that existed before the addition of heat due to other than natural causes shall be maintained. 401 KAR 5:031, Section 4(1)(d)(2) provides for site-specific temperature criteria.

(3) NTU: Nephelometric turbidity units. Narrative criteria for solids: Total dissolved solids shall not be changed to the extent that the indigenous aquatic community is adversely affected. Total suspended solids shall not be changed to the extent that the indigenous aquatic community is adversely affected. Turbidity: Surface waters shall not be aesthetically or otherwise degraded by substances that: (a) Settle to form objectionable deposits; (c) Produce objectionable color, odor, taste, or turbidity.

(4) Fecal Coliform: Geometric mean based on at least 5 samples in 30 days. Fecal coliform criteria are intended to protect human health and are applicable in waters designated for recreational use and apply May 1 through Oct. 31, with less stringent criteria applicable from Nov 1 through Apr. 30.

1.5 Special Training/Certification

This QAPP element provides information regarding specialized training or certifications needed by personnel in order to successfully complete the project or task, including how such training will be provided and how the necessary skills will be assured and documented.

Prior to initiating field work, Field Technicians will receive training from Hydrolab, the monitor unit manufacturer. Field Technicians will review *Guidelines and Standard Procedures for Continuous Water-Quality Monitors: Site Selection, Field Operation, Calibration, Record Computation, and Reporting* (Wagner and others, 2000). This document provides a very detailed description of all aspects of continuous monitor operations. Field Technicians collecting grab samples will be trained on proper field procedures, sample holding times and record-keeping procedures.

All new Field Technicians will be mentored by the Monitoring Manager on several field trips before calibrating and servicing continuous monitors or collecting grab samples alone. Field records will be used to track all field work.

1.6 Documents and Records

This QAPP element provides a description of the process and responsibilities for ensuring the appropriate project personnel have the most current approved version of the QA Project Plan, including version control, updates, distribution, and disposition.

This QAPP element will itemize the information and records which must be included in the data report package and specify the reporting format for hard copy and any electronic forms. Records can include raw *data, data from other sources such as data bases or literature, field logs, sample preparation and analysis logs, instrument printouts, model input and output files, and results of calibration and QC checks.*

This QAPP element will identify any other records and documents applicable to the project that will be produced, such as audit reports, interim progress reports, and final reports. Specify the level of detail of the field sampling, laboratory analysis, literature or data base data collection, or modeling documents or records needed to provide a complete description of any difficulties encountered. Specify or reference all applicable requirements for the final disposition of records and documents, including location and length of retention period.

The QAPP will be maintained by the project's Quality Assurance Officer, the Kentucky Heritage RC&D Council, Inc., which is responsible for updating this document and providing revisions to all project personnel and organizations on the distribution list. To provide unbiased evaluation of quality assurance, the Quality Assurance Officer is independent of the Field Manager and Field Technicians.

All aspects of field operations will be thoroughly documented to track continuous monitor installation, data collection, equipment maintenance, calibration data, and data transfers. Records for all aspects of the field work will be maintained by JEEAI, Henryville, Indiana for 3 years after the last invoice is paid and will be transmitted to the Kentucky Heritage RC&D, Inc. upon completion of the project. Records will be maintained by the Kentucky Heritage RC&D, Inc. for the period specified in the Memorandum of Agreement.

Records will include the following:

- Continuous monitor records will include all information recommended by Wagner and others, 2000, including but not limited to: logs related to supplies, deployment, field calibration sheets, servicing, data download, deviations from procedures, corrective action reports. Each monitor and probe will be tracked by serial number.
  - Maintenance Logs will be used to document maintenance to continuous monitors.
  - Calibration Sheets will be used to document calibration and service on continuous monitors. Standardized forms will be used to document the names of the persons conducting the activity, calibration of probes, equipment used, maintenance data, climatic conditions, and other observations.
  - Corrective Action Reports will be used to document any deviations from the pre-approved field methods. These reports will facilitate data interpretation and make appropriate recommendations for improvements to the monitoring program.
- Grab sample field data sheets, chain of custody, deviations from procedures; corrective action reports;
- Computer databases to store and assess continuous monitor, fecal coliform bacteria, total solids and total suspended solids and GIS (i.e., site locations) data generated in this project;
- Computer databases to manage and assess raw data including continuous monitoring and grab sample data, quality assurance results, USGS flow data, National Weather Service precipitation data, GIS data generated by NREPC and others and BMP implementation data from the KY Heritage RC &D Council, Inc. and Lincoln County Conservation District;

- Hard copy and computer files of all reports and memoranda.

2.0 DATA GENERATION AND ACQUISITION

The elements in this group address all aspects of data generation and acquisition to ensure that appropriate methods for sampling, measurement and analysis, data collection or generation, data handling, and QC activities are employed and documented. The following QA Project Plan elements describe the requirements related to the actual methods or methodology to be used for the collection, handling, and analysis of samples; data obtained from other sources (e.g., contained in a computer data base from previous sampling activities, compiled from surveys, taken from the literature); and the management (i.e., compiling, handling) of the data.

The methods described in these elements should have been summarized earlier in element A6. The purpose here is to provide detailed information on the methods. If the designated methods are well documented and are readily available to all project participants, citations are adequate; otherwise, detailed copies of the methods and/or SOPs must accompany the QA Project Plan either in the text or as attachments.

2.1 Sampling Process Design (Experimental Design)

This QAPP element provides a description of the experimental data generation or data collection design for the project, including as appropriate: the types and numbers of samples required, the design of the sampling network, the sampling locations and frequencies, sample matrices, measurement parameters of interest, and the rationale for the design.

Rationale for Sampling Design: The sampling design for this project considers recommendations in the Standard Operating Procedures for Nonpoint Source Surface Water Monitoring Projects (KDOW, 1995). BMP implementation will be focused on Peyton Creek watershed in this project. In order to evaluate water quality changes associated with BMP installation, a continuous water quality monitoring station will be installed on Peyton Creek above Hanging Fork. A continuous water quality monitoring station will be installed on Frog Branch above Hanging Fork as a control site. Grab samples will be collected at 5 locations in the Peyton Creek watershed, including the continuous monitoring sites. Project partners will assist with final site selection for grab sampling locations. Site selection considerations include anticipated BMP installations, representativeness, typical summer flows, site access and safety. Exact locations of all sample sites will be determined using global positioning system (GPS) units or interpolation from USGS quadrangle maps.

Experimental Design: Experimental design for continuous monitors and grab sample data collection will consider the following:

Site Representativeness: impoundments and confluence backwaters will be avoided, to the extent possible, sites will be well mixed; continuous monitor sites will assess watershed water quality by sampling near confluences; grab sample sites will be distributed across the Peyton Creek watershed

BMP Installation: stream reaches with and without anticipated BMP installation, before and after BMP installation

Season: Continuous monitors will be deployed for 6 months per year during the recreational season (May 1 to Oct. 31) for each of 2 years before and after BMP installation, for a total of 4 years of data collection;

Storm Events: Seven of 10 (70%) of grab samples collected each year will be collected during storm events to better characterize highly variable water quality during storms. For this project, storms will be defined as greater than or equal to 0.5 inches of rain in 24 hours with greater than or equal to 24 hours antecedent dry conditions.

Controls: Continuous monitoring data collected in the Frog Branch as a control. Frog Branch land use is agricultural and BMP implementation will not be emphasized in this watershed.

The following table identifies site selection considerations which will be evaluated and applied to the degree possible prior to installing continuous monitors.

Table 15: Factors for Continuous Monitor Site Selection

Site-design considerations	**Monitor installation**
▪ Representative of cross-sectional variability ▪ Constraints of channel configuration ▪ Range of streamflow (from low flow to flood) ▪ Velocity of streamflow ▪ Turbulence ▪ Avoidance of high-water debris damage ▪ Range of values for water-quality physical properties ▪ Protection from vandalism ▪ Safety hazards	▪ Permits for installation ▪ Type of installation ▪ Difficulty and cost of installation ▪ Ability to install monitor in representative location **Logistics (service requirements)** ▪ Accessibility of site ▪ Frequency of service interval to meet data-quality objectives ▪ Rate of fouling ▪ Proximity to cross-section measuring location ▪ Event related (for example, flooding event) ▪ Proximity to electrical power or telephone service ▪ Need for real-time reporting

(From: Wagner and others, 2000)

Study Parameters: Study parameters that are good indicators of nonpoint source pollution, relevant to Surface Water Standards and are sensitive to changes in watershed conditions were selected. Study parameters, # of sites, sampling frequency and # of samples or datum are shown in **Table 6.**

Table 16: Study Parameters

STORET Code	Parameter	# Sites	Sampling Frequency	Project Target # Samples or Datum (1)
00010	Water Temperature (°C)	2	15 min	138,000
00300	Dissolved oxygen (mg/l)	2	15 min	138,000
00301	Dissolved oxygen (% saturation)	2	n/a	138,000
00400	pH - Water, Whole, Field, S.U.	2	15 min	138,000
00095	Specific Conductivity (uS/cm @ 25 °C)	2	15 min	138,000
00076	Turbidity (NTU)	2	15 min	138,000

STORE T Code	Parameter	# Sites	Sampling Frequency	Project Target # Samples or Datum (1)
	Fecal Coliform (CFU/100 ml)	5	1/15 days	200
00500	Total Solids (mg/l)	5	1/15 days	200
00545	Total Suspended Solids (mg/l)	5	1/15 days	200
	Total Dissolved Solids (mg/l)	5	n/a	200
00060	Stream Discharge **(2)**			

Notes:

(1) Assumes negligible data losses for continuous monitors and grab samples. Does not include Field QC samples. # of Continuous Monitor Datum: 2 sites * 4/hr * 24 hr/day * 180 days * 4 monitoring intervals; # Grab Samples: 5 sites * 10 samples * 4 monitoring intervals

(2) Stream discharge will be interpolated from the a nearby USGS gage or estimated from Herrington Lake precipitation data and interpretation of conductivity and turbidity data.

Sampling Schedule: Continuous monitoring data and grab samples will be collected during four 6-month monitoring intervals spanning pre-, during and post-BMP installation. Sampling will occur during the 6-month recreational season (May 1 – Oct 31) to the extent practical within scheduling constraints. This approach will allow evaluation of a range of water quality conditions while meeting the overall project time-tables given in **Table 2**.

Continuous monitors will be serviced and grab samples collected on approximately the 1st and 15th of each month during deployment. Grab sampling schedule will accommodate holding times (e.g., sample on Monday through Thursday) and will achieve a 70% collection rate for elevated flow samples.

Data Analysis

Data from this project will be analyzed to evaluate changes in water quality before, during, and after BMP installation. Data from the Peyton Creek watershed will be compared to the control watershed, Frog Branch. Both numerical and visual techniques will be used.

Numerical Techniques

For each parameter monitored, summary statistics characterizing data frequency distributions and especially variability will be calculated. The frequency of exceedences of applicable water quality criteria provided in **Table 4** before, during, and after BMP installation will also be characterized. Results will be provided as raw exceedence rates and will also be normalized to the number of data collected for each BMP condition. Frequency of exceedences in Peyton Creek and Frog Branch will be compared.

Using flow data estimated from the USGS gage at Danville, KY (03285000), relationships between water quality parameters and flow will be evaluated as a major indicator of the influence of storms on water quality. An example is shown in **Figure 4** using box and whisker plots of dissolved oxygen concentration by flow quartile. In this example, DO is higher under low flows and declines under higher flows, probably due to the influence of oxygen demanding materials delivered during storms. Because the confidence interval notches for gage height quartiles do not overlap, DO is considered to be significantly different in each flow quartile. Confidence intervals from continuous monitoring data tend to be small because the number of data readings is very large; providing robust data for interpretation.

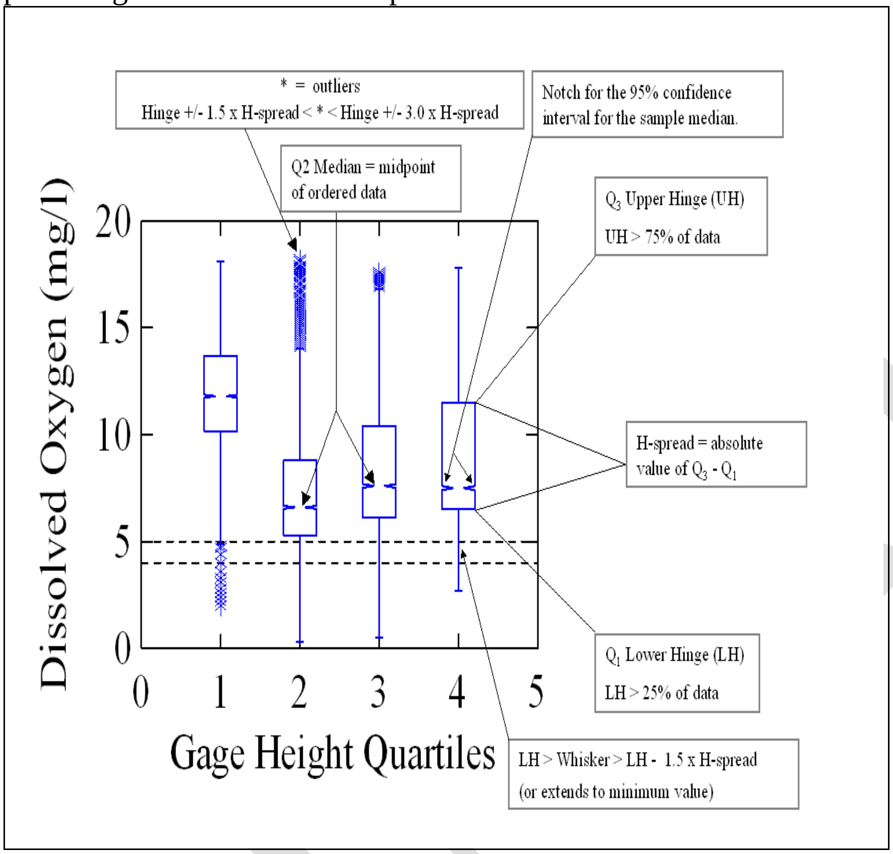


Figure 28 . Dissolved Oxygen Concentration by Gage Height Quartile

The % DO saturation also provides a valuable indicator of stream ecosystem processes. In the example provided in **Figure 5**, the large swings in % DO saturation over the diurnal cycle indicate eutrophication due to nutrient loading.

A simple large sample T-test (Snedecor and Cochran 1989) will be used to test for significant differences between mean concentrations of monitored parameters in Peyton Creek and Frog Branch and for each BMP condition. Analysis of covariance will be used to evaluate relationships between several factors (e.g., flow, temp and DO).

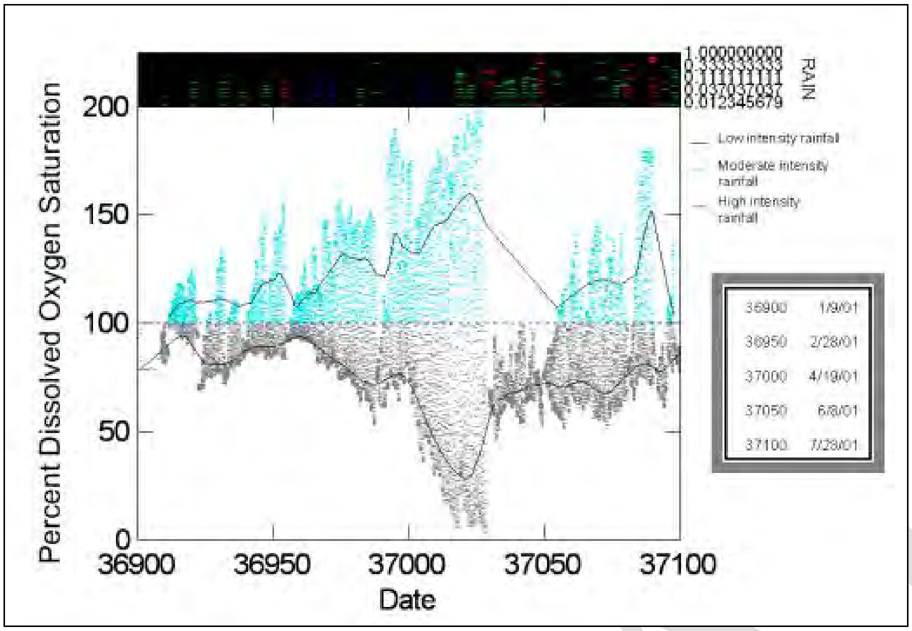


Figure 29. % DO Saturation with respect to Rainfall

Another visual tool very useful for comparing datasets is the quantile plot. BMP performance in the Mocks Branch and Spears Creek 319 Project was evaluated using continuous monitoring data collected by the KY District of the USGS. Before and after datasets were evaluated using quantile plots as well as box-plots and numerical techniques. The ability to distinguish differences is presented in **Figure 6**.

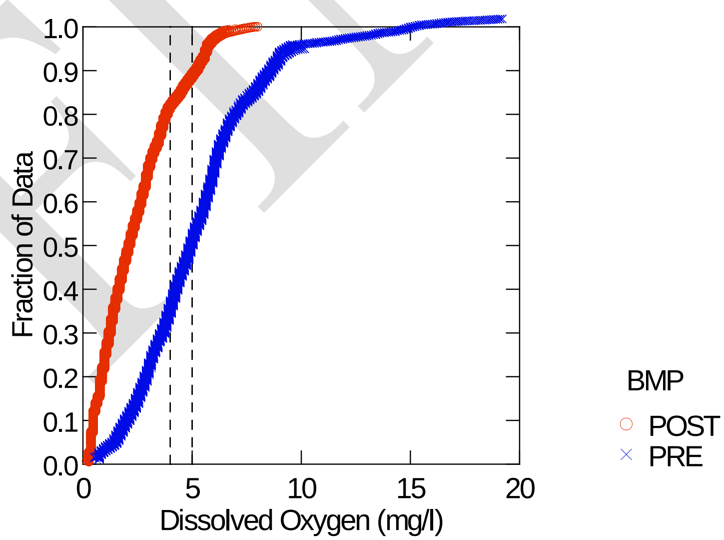


Figure 30. Comparison of the cumulative frequency distributions of dissolved oxygen data collected before and after BMPs.

2.2 Sampling Methods

Describe the procedures for collecting samples and identify the sampling methods and equipment, including any implementation requirements, sample preservation requirements, decontamination procedures, and materials needed for projects involving physical sampling. Where appropriate, identify sampling methods by number, date, and regulatory citation. If a method allows the user to select from various options, then the method citations should state exactly which options are being selected. Describe specific performance requirements for the method. For each sampling method, identify any support facilities needed. The discussion should also address what to do when a failure in the sampling or measurement system occurs, who is responsible for corrective action, and how the effectiveness of the corrective action shall be determined and documented.

Describe the process for the preparation and decontamination of sampling equipment, including the disposal of decontamination by-products; the selection and preparation of sample containers, sample volumes, and preservation methods; and maximum holding times to sample extraction and/or analysis.

Continuous Monitors: The procedures that will be used in this project are described in *Guidelines and Standard Procedures for Continuous Water-Quality Monitors: Site Selection, Field Operation, Calibration, Record Computation, and Reporting.* (Wagner and others, 2000). This USGS document provides a very detailed and useful guide for continuous monitoring systems This document details the site selection, calibration procedures and requirements for each of the water quality attributes measured. It provides descriptions of the field operation and record computations as well and discusses the problems of probe drift, fouling and the use of cross-sectional corrections.

The 2 continuous monitors will be installed to avoid areas of swift currents, depositional areas, and areas where vandalism may occur. The cross-sectional variability of each site location will be evaluated. If sites are not well mixed, data to support cross-sectional corrections will be collected as recommended by USGS. The probe placement will be conducted by Monitoring Manager with guidance from the Project Manager, BMP Manager, KY DOW and KY DOC regarding anticipated BMP installations.

Continuous monitors will be installed in a protective PVC pipe sleeve with holes drilled throughout the sleeve. The sleeves are intended to strike an appropriate balance between allowing free flow and mixing of water around the probes and protecting the instrument. Data will be downloaded from each continuous monitoring unit every 2 weeks. During these visits, the units will be calibrated and serviced as described in **Section 2.7.**

The Monitoring Manager will promptly review the downloaded data and additional services may be performed if the data indicates problems such as solids, biofilm growth, vandalism or other malfunctions. This will ensure the integrity of the continuously measured data under most circumstances.

Continuous monitors are designed and installed for year-round deployment. However units may not function properly if stream velocity falls below 1 foot/ second or if the continuous monitors units are not submerged. Stirrers will be used to minimize the effects of low stream velocity. Monitoring Manager will document periods of probe removal, due to drought or other reasons.

It is anticipated that the continuous monitors will function throughout the life of this project, with regular calibration and service. However, a replacement unit will be deployed if a continuous monitor fails and cannot be calibrated or serviced in the field. Every effort will be made to ensure that the data are continuous. The Field Technician will describe efforts to calibrate and service the probe on the field sheets.

Any deviations from the field procedures described in Wagner and others (2000) will be documented on the field sheets and promptly reported to the Monitoring Manager. The Monitoring Manager will review the procedure, take corrective actions as appropriate and provide a Corrective Action Report to the Project Manager.

The data assessment will evaluate the function of each continuous monitor and probe as well as evaluate each sampling location. New literature and continuous monitor products will also be reviewed. Recommendations to enhance any aspects of this monitoring program that require improvement will be developed annually.

As discussed in **Section 1.5: Documents and Records**, detailed records for installing, calibrating and servicing the continuous monitors and rigorous chain of custody will be used for grab samples.

Grab Samples: Grab samples for fecal coliform bacteria (FC), total solids (TS) and total suspended solids (TSS) will be collected as described in the *Standard Operating Procedures for Nonpoint Source Surface Water Quality Monitoring Projects* (KDOW, 1995). Grab samples will be collected at center of channel from bridges during elevated flow (70% of samples) and via wading at baseflow (30% of samples). As described in **Table 7**, samples will be collected after 3 rinses with ambient water into clean plastic containers supplied by the laboratory. Samples will be stored on ice and delivered promptly to the laboratory to ensure that the 24-hour holding time for fecal coliform samples is met. Note that USEPA requires a 6-hour holding time for regulatory purposes and 24-hour for routine monitoring. (NEMI). Every attempt will be made to meet the 6 hr regulatory holding time.

Table 17. Analytical Methods, Containers and Holding Times

Parameter	**Method**	**Container**	**Preservative**	**Holding Time**
Total Solids (TS)	EPA 160.3	500 ml, plastic	Chill 1C to 4C	7 days
Total Suspended Solids (TSS)	EPA 160.2	500 ml, plastic	Chill 1C to 4C	7 days
Fecal Coliform Bacteria (FC)	SM 9222D	100 ml, plastic	Chill 1C to 4C	24 hours*
* Note: Every attempt will be made to meet the 6 hr regulatory holding time.				

2.3 Sample Handling and Custody

Describe the requirements for sample handling and custody in the field, laboratory, and transport, taking into account the nature of the samples, the maximum allowable sample holding times before extraction or analysis, and available shipping options and schedules for projects involving physical sampling. Sample handling includes packaging, shipment from the site, and storage at the laboratory. Examples of sample labels, custody forms, and sample custody logs should be included.

Continuous Monitors: Not applicable.

Grab Samples: The Laboratory Manager will provide clean sample containers. Chain of custody will be recorded and maintained for all grab samples by field personnel. Sample bottles will be stored on ice until delivered to the laboratory for analysis. All grab samples will be analyzed within holding times recommended by USEPA as shown in **Appendix 1**. Special care will be taken to ensure that FC samples are analyzed within the holding time.

2.4 Analytical Methods

This QAPP element will identify the analytical methods and equipment required and any specific performance requirements for the method. Where appropriate, analytical methods may be identified by number, date, and regulatory citation. Address what to do when a failure in the analytical system occurs, who is responsible for corrective action, and how the effectiveness of the corrective action shall be determined and documented. Specify the laboratory turnaround time needed, if important to the project schedule.

List any method performance standards. If a method allows the user to select from various options, then the method citations should state exactly which options are being selected. For non-standard method applications, such as for unusual sample matrices and situations, appropriate method performance study information is needed to confirm the performance of the method for the particular matrix. If previous performance studies are not available, they must be developed during the project and included as part of the project results.

Continuous Monitors: Not applicable. Continuous monitors do not require analytical methods

Laboratory Samples: Laboratory analyses will be conducted at Fouser Environmental Services laboratory in Versailles, KY. This laboratory has been certified for drinking water analyses in Kentucky.

Water samples will be analyzed for fecal coliform concentrations using Standard Methods 9222D. This method commonly reports elevated concentrations of FC as >6,000 CFU/100 ml. However, these "right-censored" data limit the resource managers' ability to evaluate changes in FC concentration at levels above 60,000 CFU/100 ml. Therefore, additional serial dilutions will be performed as needed to determine the actual concentration of FC in each sample. Water samples will be analyzed for total solids and total suspended solids using EPA Methods 160.3 and 160.2, respectively. Analytical method summaries are provided in **Appendix 1**.

2.5 Quality Control

Identify QC activities needed for each sampling, analysis, or measurement technique. For each required QC activity, list the associated method or procedure, acceptance criteria, and corrective action. Because standard methods are often vague or incomplete in specifying QC requirements, simply relying on the cited method to provide this information is usually insufficient.

QC activities for the field and the laboratory include, but are not limited to, the use of blanks, duplicates, matrix spikes, laboratory control samples, surrogates, or second column confirmation. State the frequency of analysis for each type of QC activity, and the spike compounds sources and levels. State or reference the required control limits for each QC activity and corrective action required when control limits are exceeded and how the effectiveness of the corrective action shall be determined and documented.

Describe or reference the procedures to be used to calculate applicable statistics (e.g., precision and bias). Copies of the formulas are acceptable as long as the accompanying narrative or explanation specifies clearly how the calculations will address potentially difficult situations such as missing data values, "less than" or "greater than" values, and other common data qualifiers.

Continuous Monitors: Quality control procedures for continuous monitors include calibration prior to deployment, field calibration and servicing, prompt evaluation of logged data. These procedures are described in detail in Wagner and others, 2000 and are summarized in **Sections 2.6 and 2.7**.

Grab Samples: Grab samples will be collected using methods described in *Standard Operating Procedures for Nonpoint Source Surface Water Quality Monitoring Projects.* (KDOW, 1995). The FC analysis will include additional serial dilutions as necessary to reduce reporting of right-censored data, usually reported as "too numerous to count" or TNTC.

Precision is a measure of variance between duplicate samples (i.e., are measurements reproducible?). Precision is often expressed as relative percent difference (RPD) between duplicates and is calculated using **Equation 1**. Better precision is reflected in smaller relative percent differences.

Field sampling precision will be estimated using field duplicate samples (1 per 5 samples); laboratory precision will be measured using laboratory duplicates (1 per 10 samples). One field duplicate grab sample will be collected during each sample event, with emphasis placed on fecal coliform sampling since this is the most variable parameter. A fecal coliform field duplicate will be collected during 7 of 10 sample events each year, for a total of 28 field duplicates over the monitoring period. TS and TSS field duplicates will be collected during 3 of 10 sample events each year for a total of 12 field duplicates each for TS and TSS over the monitoring period.

The precision of continuous monitors will be estimated using the RPD between the deployed unit readings upon arrival at the site and after calibration.

Equation 1.

Equation 1: Relative Percent Difference

$$RPD = \frac{|R_X - R_Y|}{0.5(R_X + R_Y)} \times 100$$

where:
R_X = calibrated unit
R_Y = deployed unit (pre-calibration)

=ABS(R_X - R_Y)/((R_X + R_Y)/2)*100 EXCEL Formula

Accuracy is a measure of the ability to correctly determine concentration. The target accuracy of continuous monitors is established by the manufacturer and evaluated in the field through relative percent difference (RPD) of pre- and post-calibration readings as described above. To measure laboratory accuracy, samples that have been "spiked" with a known amount of analyte are analyzed. The percent recovery is calculated by comparing the concentrations of the original sample and the spiked sample using the following equation:

Equation 2. Percent Recovery

$$\%R = \frac{SSR - SR}{SA} X100$$

where:
%R = Recovery (percent);
SSR = Spike sample result (concentration units);
SR = Original sample result (concentration units); and
SA = Spike added (concentration added).

%R=((SSR - SR)/(SA))*100 EXCEL Formula

Accuracy for TS, TSS and FC has not been established by the USEPA for the methods used in this study.

Completeness is a measure of the amount of usable data; field and laboratory completeness will be evaluated separately. Completeness may be reduced by field equipment failure, exceedence of holding times, broken sample containers, etc. The completeness DQO for sample collection is 90%; for laboratory analyses, the completeness DQO is 95%.

Equation 3. Percent Completeness

$$\%C = \frac{(M_V)}{(M_P)} \times 100$$

where
%C= completeness (percent)
MV = number of valid measurements
MP = number of planned measurements

%C=(M_V/ M_P)*100 EXCEL Formula

<u>Comparability</u> is a qualitative parameter that expresses the confidence with which one data set can be compared to another. Comparability of the sampling and analytical programs are evaluated separately.

Sampling comparability will be evaluated based on the following:

- A consistent approach to sampling was applied throughout the program;
- Sampling was consistent with established methods for the media and analytical procedures;
- Samples were properly handled and preserved.

Analytical comparability will be evaluated based upon the following:

- Consistent methods for sample preparation and analysis;
- Sample preparation and analysis was consistent with specific method requirements;
- The analytical results for a given analysis were reported with consistent detection limits and consistent units of measure.

Data that do not meet the DQOs given in **Table 4** will be identified using standard STORET data codes. Monitoring reports will include summary statistics regarding these quality control measures. Corrective actions to minimize the amount of data that do not meet DQOs include, but are not limited to:

- Additional training for field technicians;
- Collection of additional QC grab samples to identify and correct issues;
- More frequent calibration and servicing of continuous monitor units;
- Laboratory visit and evaluation.

2.6 Instrument/Equipment Testing, Inspection and Maintenance

Describe how inspections and acceptance testing of instruments, equipment, and their components affecting quality will be performed and documented to assure their intended use as specified. Identify and discuss the procedure by which final acceptance will be performed by independent personnel (e.g., personnel other than those performing the work) and/or by the EPA project manager. Describe how deficiencies are to be resolved, when re-inspection will be performed, and how the effectiveness of the corrective action shall be determined and documented.

Describe or reference how periodic preventive and corrective maintenance of measurement or test equipment or other systems and their components affecting quality shall be performed to ensure availability and satisfactory performance of the systems. Identify the equipment and/or systems requiring periodic maintenance. Discuss how the availability of critical spare parts, identified in the operating guidance and/or design specifications of the systems, will be assured and maintained.

Continuous Monitors: The Field Technician will calibrate continuous monitors to within acceptable limits provided in **Section 2.7** upon receipt from supplier and prior to deployment in the field. Additionally, field staff will perform routine operation maintenance checks approximately every 2 weeks as described in **Section 2.7**. If problems are detected during field visits or through review of the downloaded data, more frequent field servicing may be performed.

Laboratory Samples: All equipment associated with laboratory analyses will be maintained in accordance with requirements for certified laboratories, including autoclaves and incubators. The Laboratory Manager will immediately report any contamination issues or equipment failures to the Monitoring Manager. Sample collection will be suspended until the laboratory can document that the issues have been addressed.

2.7 Instrument/Equipment Calibration and Frequency

The continuous monitors will be calibrated against calibration standards and serviced (as needed) every 2 weeks. If the continuous monitor readings for calibration standards are within the tolerances recommended by Wagner and others, 2000 and given in **Table 7**, additional service is not needed.

Table 18: Continuous Monitoring Tolerances

Water Quality Parameter	Continuous Monitoring Tolerances
Temperature	± 0.2 °C
Specific Conductance	The greater of ± 5 uS/cm or ±3% of the measured value
Dissolved Oxygen	± 0.3 mg/L
pH	± 0.2 pH unit
Turbidity	The greater of ± 2 NTU or ± 5% of the measured value

If inspection of the continuous monitor indicates fouling, the probes will be cleaned. The difference between the pre- and post- cleaning readings measures the effects of fouling. If the continuous monitor readings are not within the USGS tolerances after cleaning, the probes will be recalibrated. The difference between the pre-and post-calibration readings provides a measure of probe drift.

Each step in this servicing and calibrating process will be documented on the calibration sheets. Any deviations to the procedures given in Wagner and others, 2000 will be documented, reviewed and a Corrective Action report will be prepared. Field visits will be conducted more frequently if field calibration sheets and/or review of logged data indicate that one or more probes have significantly drifted, fouled or otherwise varied from normal monitoring activity.

2.8 Inspection/Acceptance of Supplies and Consumables

Describe how and by whom supplies and consumables (e.g., standard materials and solutions, sample bottles, calibration gases, reagents, hoses, deionizer water, potable water, electronic data storage media) shall be inspected and accepted for use in the project. State acceptance criteria for such supplies and consumables.

Continuous Monitors: The Monitoring Manager will document the receipt and use of supplies and consumables (e.g., standard calibration solutions). Permanent records will be maintained to document receipt and acceptance for the project, as well as the expiration date. The Monitoring Manager is responsible for ensuring adequate supplies and consumables. Expired products will not be used in this project.

Laboratory Samples: The Laboratory Manager will maintain all required records for receipt and use of supplies and consumables. Expired products will not be used in this project.

2.9 Non-Direct Measurements

Identify any types of data needed for project implementation or decision making that are obtained from non-measurement sources such as computer data bases, programs, literature files, and historical data bases. Describe the intended use of the data. Define the acceptance criteria for the use of such data in the project and specify any limitations on the use of the data.

Non-direct measurements in this project will be obtained from the USGS (gage height and/or stream discharge) and the National Weather Service (precipitation). Non-direct data will also be obtained from KY Department for Environmental Protection (GIS), the KY Heritage RC&D, Inc. and Lincoln County Conservation District (BMP implementation). These agencies maintain rigorous quality assurance programs. These non-direct data will be obtained electronically and reviewed by Monitoring Manager. Any anomalies will be discussed with appropriate agency managers prior to use for data assessments. Data quality concerns will be documented in reports to the Project Manager.

2.10 Data Management

Describe the project data management process, tracing the path of the data from their generation to their final use or storage (e.g., the field, the office, the laboratory). Describe or reference the standard record-keeping procedures, document control system, and the approach used for data storage and retrieval on electronic media. Discuss the control mechanism for detecting and correcting errors and for preventing loss of data during data reduction, data reporting, and data entry to forms, reports, and databases. Provide examples of any forms or checklists to be used.

Identify and describe all data handling equipment and procedures to process, compile, and analyze the data. This includes procedures for addressing data generated as part of the project as well as data from other sources. Include any required computer hardware and software and address any specific performance requirements for the hardware/software configuration used. Describe the procedures that will be followed to demonstrate acceptability of the hardware/software configuration required. Describe the process for assuring that applicable information resource management requirements are satisfied.

Describe the process for assuring that applicable Agency information resource management requirements (EPA Directive 2100) are satisfied (EPA QA Project Plans only). If other Agency data management requirements are applicable, such as the Chemical Abstract Service Registry Number Data Standard (EPA Order 2180.1), Data Standards for the Electronic Transmission of Laboratory Measurement Results (EPA Order 2180.2), the Minimum Set of Data Elements for Ground-Water Quality (EPA Order 7500.1A), or new data standards as they are issued by EPA, discuss how these requirements are addressed.

The Monitoring Manager will maintain all numerical data generated by continuous monitors and laboratory samples in this project. Continuous monitoring and laboratory data will include raw data downloaded from continuous monitors, records of data validation, transformations, reductions and analysis. Continuous monitor data will be maintained in a Sequel Server database; laboratory data will be maintained in Excel. Spatial data will be maintained in ArcView 3.2 or ArcView 8. the Monitoring Manager will maintain all documents associated with the monitoring and assessment portion of this

319(h) project in MS-Office. All electronic data and documents will be periodically backed up on CD-ROM and copies will be provided to the Project Manager. The Laboratory Manager will maintain all laboratory records as required.

3.0 ASSESSMENT AND OVERSIGHT

The elements in this group address the activities for assessing the effectiveness of project implementation and associated QA and QC activities. The purpose of assessment is to ensure that the QA Project Plan is implemented as prescribed.

3.1 Assessments and Response Actions

Describe each assessment to be used in the project including the frequency and type. Assessments include, but are not limited to, surveillance, management systems reviews, readiness reviews, technical systems audits, performance evaluations, audits of data quality, and data quality assessments. Discuss the information expected and the success criteria (i.e., goals, performance objectives, acceptance criteria specifications, etc.) for each assessment proposed. List the approximate schedule of assessment activities. For any planned self-assessments (utilizing personnel from within the project groups), identify potential participants and their exact relationship within the project organization. For independent assessments, identify the organization and person(s) that shall perform the assessments if this information is available. Describe how and to whom the results of each assessment shall be reported.

Define the scope of authority of the assessors, including stop work orders, and when assessors are authorized to act.

Discuss how response actions to assessment findings, including corrective actions for deficiencies and other non-conforming conditions, are to be addressed and by whom. Include details on how the corrective actions will be verified and documented.

The Project Manager will arrange and oversee systems audits to review all aspects of the data production process, including data collection, management and assessment. Since there is a gap between pre- and post- BMP monitoring periods, the audits will be conducted for each monitoring period. The audit will ensure that all field personnel are trained, and that field and record-keeping procedures for continuous monitors conform to those documented in Wagner and others, 2000. The systems audit for grab samples will address sample collection, laboratory certification and analyses, data management. Any aspects of the project that do not conform to this QAPP will be documented, corrective actions will be identified and implemented prior to initiating sampling and the results will be included in the subsequent progress report.

Continuous Monitors: The Monitoring Manager will promptly review calibration sheets after each field visit as a quality control check. Any deviations from USGS procedures will be identified by Field Technicians and reviewed by the Monitoring Manager. If needed, corrective actions will be taken and a Corrective Action Report will be prepared. The Monitoring Manager will promptly review the logged data obtained from each field visit; any issues that require attention of the Field Technicians will be conveyed to the Monitoring Manager. No additional work will be performed until appropriate corrective action has been implemented and documented in a Corrective Action Report.

At the conclusion of each monitoring event, field data sheets and calibration sheets will be promptly reviewed by the Monitoring Manager to assess the adequacy of the quality control checks for continuous monitors and grab samples. All quality control documents will be contained within a file for each monitored event.

The Field Technicians and Laboratory Manager will be responsible for reporting any suspected nonconformance or deficiencies to the Monitoring Manager. The Monitoring Manager will be responsible for assessing the suspected problems in consultation with the Project Manager to review the sampling protocols and provide additional training if necessary. If it is determined that the situation warrants a corrective action, then a Corrective Action Report will be issued by the Monitoring Manager.

Equipment, instruments, tools, gauges, and other items requiring preventative maintenance will be serviced in accordance with the manufacturer's specified recommendation and procedures outlined in Wagner and others, 2000. Logs will be established to record maintenance and service procedures and schedules. All maintenance records will be documented and traceable to the specific equipment, instruments, tools, and gauges. When the vendor services an instrument, it is recorded in the maintenance log. The paperwork is then filed and can be tracked by date.

3.2 Reports to Management

Identify the frequency and distribution of reports issued to inform management (EPA or otherwise) of the project status; for examples, reports on the results of performance evaluations and system audits; results of periodic data quality assessments; and significant quality assurance problems and recommended solutions. Identify the preparer and the recipients of the reports, and any specific actions recipients are expected to take as a result of the reports.

The Monitoring Manager will prepare quarterly reports summarizing continuous monitor deployment, grab sample collection, data completeness, quality assurance issues and corrective actions. A final report summarizing data collection and major findings will be prepared. The final report will include an interpretation of changes in water quality associated with BMP installation in this watershed and a comparison of Peyton Creek (study watershed) and Frog Branch (control watershed).

These reports will be provided to the KY Heritage RC&D Council, Inc. Project Manager and will supplement the Project Managers' reports to KY DOC Project Manager. In addition, monitoring project results will be presented at 1 farm day and in a public form (e.g., NPS conference) at the request of the Project Manager and state agency officials.

Field system audits will be performed as described above and the results will be provided to the Project Manager. The results of all audits will be summarized in written reports, with copies retained in the Project Files. The audit reports will be competed for field system audits according to the general outline described below.

All audit reports will include the following sections:

- Introduction – provides background of the project, program element, description of personnel and affiliation of all staff involved, the name of the auditor, the time and date of the audit, and a description of the activities audited.
- Audit Findings – describes the results of the audit including a deficiency report identifying all instances where the procedures in the QAPP were not being followed.
- Conclusions – summarizes the results of the audit and includes recommended actions to address any noted deficiencies.

4.0 DATA VALIDATION AND USABILITY

The elements in this group address the QA activities that occur after the data collection phase of the project is completed. Implementation of these elements determines whether or not the data conform to the specified criteria, thus satisfying the project objectives.

4.1 Data Review, Verification, and Validation

State the criteria used to review and validate -- that is, accept, reject, or qualify -- data, in an objective and consistent manner.

Continuous Monitors: The Monitoring Manager will review data from continuous monitors. The review will include calibration data and comparison of each reading to the previous and subsequent readings. Rigorous calibration and servicing are needed to minimize drift, fouling and perform cross-section corrections. USGS procedures in Wagner and others, 2000 will be used to "correct" the data. Data will only be corrected if the degree and type of correction required is known; in all cases the procedures used to generate corrected data will be thoroughly documented.

USGS has determined that corrections are inaccurate if the in-situ readings differ from the calibrated portable meter readings by more than the "maximum allowable limits" shown in **Table 9.** (Wagner and others, 2000). Data will be rejected if the in-situ readings are beyond the maximum allowable limits.

Table 19: Maximum Allowable Limits for Continuous Water-Quality Monitoring Sensors

Water Quality Parameter	Maximum Allowable Limits for Water-Quality Sensor Values
Temperature	± 2.0 °C
Specific Conductance	± 30%
Dissolved Oxygen	The greater of ± 2.0 mg/L or 20 %
pH	± 2.0 pH units
Turbidity	± 30%

Laboratory Samples: The Laboratory Manager will be responsible for identifying acceptable data (i.e., quality control samples were within limits specified by the lab); rejected data (i.e., quality control criteria were not met) and qualified data (i.e., some aspects of quality control were exceeded). STORET data qualifiers will be included in the electronic data transmission to the Technical Manager.

4.2 Verification and Validation Methods

Describe the process to be used for verifying and validating data, including the chain-of-custody for data throughout the life of the project or task. Discuss how issues shall be resolved and the authorities for *resolving such issues. Describe how the results are conveyed to data users. Precisely define and interpret how validation issues differ from verification issues for this project. Provide examples of any forms or checklists to be used. Identify any project-specific calculations required.*

The Monitoring Manager will review calibration sheets for continuous monitors, chain of custody sheets for grab samples and corrective action reports to identify questionable data. Quality assurance issues will be coded and tracked in the database. The Monitoring Manager will be responsible for final decisions regarding data validation, based on consultation with the Field Technician and Laboratory Manager.

Continuous Monitors: Data from continuous monitors will be evaluated for sensor fouling, drift, and data-logging errors. Fouling is caused by biofilms and sediments accumulating on the sensor and may cause sensor failure. Electronic (meter) drift is caused by a decrease in probe sensitivity over time. Data logging errors can be caused by electronic interferences (e.g., radio towers, power lines) and loss of power to the data logging unit.

Fouling may be related to environmental conditions (e.g., rapid growth of biofilms in warm, nutrient-enriched waters) or specific events (e.g., storms, sewage bypasses). Fouling can cause large deviations from the expected value **(Figure 7).** Fouling usually begins at some time after service check and usually does not occur uniformly over the time span between calibration checks.

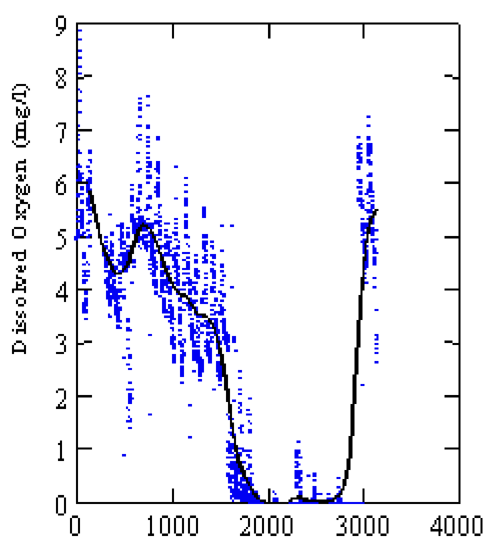


Figure 7. Example Of Fouled Dissolved Oxygen Sensor

Frequent routine maintenance and prompt review of downloaded data are the best way to reduce fouling problems. Fouling is typically manifested in the data record by gradual change in scale of the measurement followed by a recovery to expected values, usually following cleaning. Recovery may follow removal of material by natural processes such as increased flow, thus highlighting the need for detailed and accurate field and maintenance logs.

Data collected from fouled probes should be distinguished from electronic drift due to loss of probe sensitivity. Electronic drift occurs from the last time the sensor was calibrated and is estimated by comparing calibration solution readings from the cleaned continuous monitor. Because drift is assumed to occur uniformly between two service dates, drift can be adjusted for by applying a linear interpolation over the time between calibration checks.

As shown in **Figure 5,** data logging errors caused by electronics malfunction may also occur, resulting periodic loss of data. As per Wagner and others, 2000, missing values will not be calculated. The amount of missing data will be documented through % completeness.

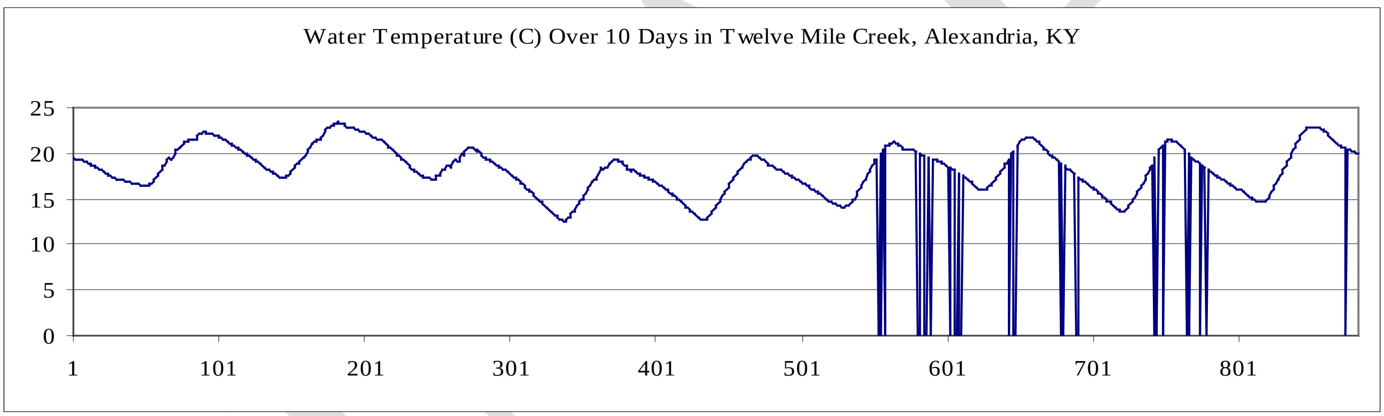


Figure 8. Example of Data Logging Error

Whitfield and Wade (1993) note that timing errors in the data-loggers may produce artifacts in the database. They evaluated signals from two field instruments deployed together, one newly calibrated the other having been deployed for a period of time and found differences in how each unit recorded the same process. The primary differences were related to the timing of the process. Data logging errors will be minimized through use of smoothing techniques whereby data collected at 15 minute intervals will be aggregated to hourly. Although this results in a reduction in the number of datum, it also decreases bias.

4.3 Reconciliation with User Requirements

Describe how the results obtained from the project or task will be reconciled with the requirements defined by the data user or decision maker. Outline the proposed methods to analyze the data and determine possible anomalies or departures from assumptions established in the planning phase of data collection. Describe how reconciliation with user requirements will be documented, issues will be resolved, and how limitations on the use of the data will be reported to decision makers.

This monitoring program has been designed to meet the data quality objectives related to evaluating water quality status and effectiveness of BMPs. The collection and analysis of over 400,000 data points will support very robust analyses of water quality changes associated with BMP installation in this watershed. Use of continuous monitors will provide detailed data regarding water quality changes over a wide range of hydrologic conditions. The study design includes a control watershed (Frogs Branch). This combination of study design attributes will provide a comprehensive dataset and assessment that is uniquely suited to the users requirements for analysis of the effectiveness of nonpoint source management measures.

The study design used for grab samples attempts to provide data that will be able to distinguish statistically significant changes in water quality associated with BMP implementation by focusing sampling on storm events (70% of samples). Fecal coliform analysis will include serial dilutions minimize right-censored data. However, given the wide variability in fecal coliform data it may not possible to distinguish statistically significant differences.

A system of audits and quality assurance measures will ensure high quality data are collected in this project. The results of these audits will be used to improve the design, implementation and data assessments associated with this monitoring program.

5.0 REFERENCES

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APPENDIX I

Peyton Creek Watershed
BMP Implementation Plan

List of eligible BMPs:
Cost share rate: 90:10

A list of eligible BMPs and items eligible for cost share follows:

NRCS Practice Name	NRCS Practice Code
Critical Area Planting	342
Diversion	362
Fence	382
Filter Strip	393
Grassed Waterway	412
Heavy Use Area Protection	561
Livestock Exclusion	472
Livestock Shade Structure	717
Nutrient Management	590
Pasture and Hayland Planting	512
Pipeline	516
Pond	378
Prescribed Grazing	528A
Riparian Forest Buffer	391A
Roof Runoff Management	558
Sinkhole Protection	725
Spring Development	574
Streambank and Shoreline Protection	580
Stream Crossing	576
Tank	614
Tree/Shrub Establishment	612
Waste Management System	312
Waste Storage Facility	313
Waste Treatment Lagoon	359
Waste Utilization	633
Well	642

<u>Other items eligible for funding:</u>

Pumps, for transmission of water from ponds, wells, springs or streams to troughs or watering devices.
Ponds, must be fenced with a trough, or fenced with limited access area.
Chargers, for electrical fencing.
Extension of electrical service for water pumps.
Flash grazing.
Water meters for municipal water sources.

Moving feeding areas away from creek.
Rental payment for riparian areas.

In some instances, greater definition of practices is required for this project than what is available in the FOTG. The following is a list of clarifications to BMP practices as they relate to this project.

Flash Grazing. Flash grazing in riparian areas can occur during two periods in the spring and fall. The specific dates are May 1 through May 15, and October 1 through October 15.

Prescribed Grazing. Incentive payments for prescribed grazing practices shall be $15 per acre per year for three years.

Rental Payments for Riparian Areas. Producers who participate in this practice will receive $100 per acre per year.

Heavy Use Area Protection. This practice shall be used in only the following areas: gateways, walkways, around tanks, and feeding areas.

Pasture and Hayland Planting. This practice shall include the requirement that reestablishment shall not exceed 30% of the farm.

Permanent Fencing. Permanent fencing is defined as barbed wire, woven wire, or high tensile wire. If high tensile wire is used, two strands must be energized.

Fencing. For the purpose of this project, fencing of riparian areas will follow EQIPguidelines. In addition, in situations where fencing setbacks result in areas unusable to the producer, the Watershed Coordinator can expand the setback to the best use of the producer.

Description of the BMP selection process:

Best Management Practices (BMPs) and technologies selected by the Watershed Coordinator are oriented around reducing pathogens, nutrients, and sediment. The efforts will be centered primarily around encouraging the adoption of rotational grazing systems, the development of alternative water supplies or providing limited stream access to cattle, and the construction of well designed and sited animal feeding/waste storage areas. Other BMPs that address the target pollutants will be eligible for systems other than rotational grazing. Since this is a technology based demonstration project with primarily educational objectives, at least one farm needing several of the referenced BMPs will be identified to facilitate demonstration of the BMPs by conducting a field day. BMPs will be selected that meet the needs of the operation while providing the best resource protection.

Relative Treatment Efficiency of BMPs

The focus of this project is on the adoption of demonstration BMPs that will educate producers on technologies available in protecting water quality. Emphasis will be on the adoption of a management system rather than individual BMPs; therefore, comparison of treatment efficiencies of individual BMPs is not needed.

Operation and Maintenance

The project will complement other state and federal funding programs in the watershed. Operation and maintenance agreements are required for both EQIP and State Cost Share funding. These agreements will be adopted for BMPs and eligible cost share items, as appropriate, funded by 319(h). BMPs must be maintained for the life of the project. The closing date of this project is September 30, 2008.

Description of BMP Targeting Process

Targeting of BMPs will be based on producer interest. Selection of farms for BMP implementation will be selected based on the following priority factors:

1. Conservation needs identified by the Watershed Coordinator in order to improve water quality, meet the needs, and receive the cooperation from the participating farmer.

2. The ensuing educational benefits that can be realized through educational tours and on farm field days.

3. Cost share contributions from other programs (EQIP, State Cost Share, CRP).

4. Length or percentage of stream protected from unrestricted livestock access (higher percentages and greater lengths are higher priority).

5. Overall cost of BMPs for rotational grazing systems per stream mile protected.

This project complements other federal funding programs under which specific BMP locations are protected under the Freedom of Information Act. Therefore, the cooperating Conservation District will maintain the specific location of BMPs. Specific location information for BMPs funded by this project, matching State Cost Share funds, and/or other funding programs (as appropriate) will be provided to DOC, at a minimum, by 14 digit HUC.

Financial Plan of Action:

Peyton Creek Watershed is made up primarily of full-time farmers whose sole family income is derived from agriculture, and who do not earn supplemental income assistance from a second part-time job. As such, the farmers in this watershed have limited funds available to address water quality issues. Rather, they try to get as much production from their land as is physically possible. Weaning lots are over crowded, cattle have free access to creeks for shade and water, there are no rotational grazing systems or cross-fencing leading to improper stocking rates and soil erosion.

This project will assist these farmers by offering them incentives to install demonstration BMPs. New concepts will be offered and showcased at field days. The 60:40 cost share rate will be adjusted to 90:10 due to the low per capita income of residents from within this project area. This will be accomplished by using "local match" from other state cost share projects, and applying it to the match of producers in Peyton Creek Watershed.

Existing state and federal programs will be utilized to the maximum extent possible with most of these paying 75% of the cost of the BMPs. Funds for this project will primarily be used to provide cost share for practices not covered by existing programs, or producers' inability to participate.

Restrictions:

- Size of ponds will be based on reasonable livestock watering needs. Additional costs associated with larger pond capacity will be borne by the producer.

- Any BMP or system considered for funding under this program must be reviewed for the potential to improve water quality. BMPs or systems that are primarily for improving production or efficiency of the producer's operation will not be eligible for funding.

- Costs for alternative water supplies are only eligible if livestock are excluded from streams or other water bodies.

State Cost Share BMPs used as match:

Water Quality BMPs used as match and funded via the Kentucky Soil Erosion and Water Quality Cost Share Program will be installed per the current *"Kentucky Soil Erosion and Water Quality Cost-Share Program Manual."* The manual, which cites the regulation
KRS 146.110-121, states the intent of the cost-share program, and describes the eligibility process, application process, selection criteria, operation and maintenance requirements, etc. These BMPs will be demonstrated in accordance with guidance provided by the Division of Conservation.