# Nonpoint Source Pollution Control Program
# KY Division of Water
# Final Report

# "An Evaluation of Best Management Practices Installed in the Buck Creek Watershed on Stream Water Quality: An Upstream-Downstream Watershed Approach"

Submitted by
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Third Rock Consultants, Inc. identified the macroinvertebrate samples and calculated the indices. Fouser Environmental Services, LTD analyzed the solids samples.

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## Executive Summary

The Buck 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 Buck Creek waters, and second was a monitoring program designed to discern the outcome of the BMP program through the water quality status.

Emphasis, in the Buck 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 Buck Creek watershed project has been 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 BMPs and management systems.

Best Management Practices (BMPs) were installed in four subwatersheds whose drainages flow to Buck Creek. To evaluate the effectiveness of these BMPs two sampling stations, one upstream of the tributaries confluence (BCU; control site) and the other downstream (BCD; impacted site). The results of the four years of sampling indicate that dissolved oxygen, the most important of the water quality attributes, improved significantly and the improvement corresponds to the implementation of BMPs. The reliability of this conclusion is very high. Other attributes measured were less definitive in their support of BMP success with some macroinvertebrate metrics indicating deteriorating conditions, however, the reliability of these conclusions is low.

Buck Creek is a very dynamic hydrologic and hydraulic system. During the five years this study was conducted several storms occurred producing enough streamflow to significantly modify the fluvial geomorphological landscape of the watershed. In addition, the system is continually subject to biological modifications. BCU, the upstream site was repeatedly dammed by beavers, dams that were breached by storms or completely destroyed only to be rebuilt. The downstream site, BCD, was modified repeatedly and dramatically by gravel mining upstream of the sampling site. Both sites were impacted, sometimes significantly, by trees, woody debris or root wads moving through the system. A deposit of this debris traps other materials and can modify the stream hydraulics, producing scour or deposition areas that can alter habitat across the stream potentially affecting macroinvertebrate habitat.

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 Buck Creek to a more 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).

Nonpoint source pollution is the largest cause of water quality impairment in the United States (USEPA, 1995). A multitude of processes or activities may be responsible for this source of pollution. Hydrologic modifications that degrade water quality by accelerating or sustaining the erosion and deposition of sediment, or by producing contaminated runoff, is common in many rural watersheds.

# Materials and Methods

## 1. *Description of the Project Area*

The Buck Creek watershed is located within the Interior Plateau Ecoregion. The geology of the drainage basin is dominated by formations of the Paleozoic era. Devonian and Mississippian sedimentary rock underlies much of the soil of the basin. The upland terraces and ridgetops are mantled with a silty loess or Quaternarian and Tertiary gravelly deposits. Buck Creek is a 5$^{th}$ order stream and has many major tributaries (1$^{st}$, 2$^{nd}$, 3$^{rd}$, and 4$^{th}$ order streams) contributing to the total flow. Buck Creek has a 294.492 square mile drainage area. The flow of the mainstem is north to south from Lincoln County to Pulaski County, KY and terminating at the confluence with the Cumberland River in Pulaski County, KY. Buck Creek is entirely designated by the nine-digit hydrologic unit code 051301030. The study area in Buck Creek, which includes the BMP implementation area, includes 9 different 14-digit hydrologic units (**Table 1)**

**Table 1. Hydrologic unit codes, 14-digit (HUC14) where BMPs are targeted.**

| NAME | ACRES | HUC14 |
|---|---|---|
| Briary Creek | 7,841.4 | 05130103030140 |
| Buck Creek | 2,339.9 | 05130103030150 |
| Whetstone Creek | 1,624.0 | 05130103030160 |
| Buck Creek | 730.8 | 05130103030170 |
| Barney Branch | 4,722.8 | 05130103030180 |
| Clear Creek | 2,273.9 | 05130103030190 |
| Barney Branch | 173.3 | 05130103030200 |
| Buck Creek | 524.5 | 05130103030210 |
| Indian Creek | 3,610.1 | 05130103030220 |

The mainstem of Buck Creek watershed is classified as an Outstanding State Resource Water (OSRW: Kentucky Surface Water Standards (KAR 5:031). The Creek is a Class II canoeing stream from HWY 461 to the confluence with the Cumberland River. Thirty species of mussels occur in this watershed including four that are listed as Federally Endangered Species: Cumberland bean pearly mussel (Villosa trabalis), Cumberland combshell (Epioblasma brevidens), little-wing pearly mussel (Pegias fibula), oyster mussel (Epioblasma capsaeformis) and the fluted kidneyshell are candidates for federal listing.

Freshwater mussels are an indicator of the health of aquatic ecosystems. Populations of the Cumberlandian combshell mussel (*Epioblasma brevidens*), now only found in small portions of the Tennessee and Cumberland River basins in Kentucky, Tennessee and Virginia, have decreased as a result of deteriorating stream quality (Snape II and Ferris, 2004). Silt eroding from agricultural fields, gravel mining, and road construction contribute to storm related increases of suspended solids and turbidity which may cover and/or suffocate mussel beds. The fine silt also fills in the tiny spaces in gravel stream bottoms, ruining them for use by juvenile mussels.

This monitoring effort is designed to evaluate the aquatic health of a short reach of the Buck Creek aquatic ecosystem without the collection of mussels. Instead water chemistry, macroinvertebrates (other than mussels) and diatom algae are used to assess water quality. Care was taken in the sampling process to not collect mussels or disturb habitat where mussel beds were obvious. Overall water quality is good, however, with mussel populations in the Southeastern United States generally in decline (Williams and others 1993) it is prudent to protect this OSRW from the detrimental effects of NPS pollution, resulting primarily from agricultural practices. Detrimental practices include row-cropping in riparian zones, cattle access to streams, gravel mining and channel modifications at stream crossings. A small portion of the mainstem and 2 tributaries to Buck Creek are included on the 2000 Final and 2004 Draft 303(d) List of Impaired Waters.

Both Buck Creek sites have rock, cobble and sand streambeds with intermittent silt deposits. Bed slopes are relatively gentle. Cattle have considerable access to several thousand linear feet of tributary streams from the head waters of the tributaries to near the confluence with Buck Creek. Access to the mainstem of Buck Creek is more restricted, although, some stream banks are scarred where access has been unrestricted.

Based on data from the early to mid-1990's, land use is primarily cropland and pasture (**Table 2** & **Figure 1**) followed by deciduous forest, mixed forest, and evergreen forest in a decreasing order. All other landuses combined total less than 3% of the basin's landuse. **Figure 2** depicts the distribution of landuses in Buck Creek with agriculture land in the river valley with forested uplands. The small areas where urban or residential landuse exists are also along the river.

**Table 2. Landuse areas within the Buck Creek drainage basin.**

| **Land Use Type** | **Sub-Total Area (Acre)** | **%** |
|---|---:|---:|
| CONFINED FEEDING OPS | 113,798 | 0.01 |
| OTHER URBAN OR BUILT-UP | 235,400 | 0.02 |
| COMMERCIAL AND SERVICES | 378,930 | 0.03 |
| STRIP MINES | 2,553,971 | 0.19 |
| TRANS, COMM, UTIL | 3,680,255 | 0.27 |
| TRANSITIONAL AREAS | 5,040,066 | 0.37 |
| RESIDENTIAL | 12,321,707 | 0.90 |
| RESERVOIRS | 14,869,524 | 1.08 |
| EVERGREEN FOREST LAND | 29,221,379 | 2.13 |
| MIXED FOREST LAND | 237,829,800 | 17.35 |
| DECIDUOUS FOREST LAND | 400,416,600 | 29.21 |
| CROPLAND AND PASTURE | 664,283,798 | 48.45 |
| Total | 1,370,945,226 | 100.00 |

The basin is located in south Lincoln county, west Rockcastle County, and north and east Pulaski county, KY. The town of Burnside in Pulaski County is close to the mouth of the drainage basin. **Table 3** displays the geographic information regarding basin location.

**Table 3. Geographic coordinates of the Buck Creek basin.**

| Location in basin | Latitude | Longitude |
|---|---|---|
| Mouth of basin | 36.9771 | -84.4903 |
| Centroid of basin | 37.2241 | -84.4722 |
| Headwaters of basin | 37.4584 | -84.6302 |

Buck Creek watershed was selected to provide a demonstration of BMP implementation within a portion of a watershed. The choices of BMPs will emphasize streamside protection, proper manure handling and utilization, and conversion to rotational grazing or flash grazing systems. An upstream – downstream watershed monitoring network was implemented to evaluate water quality changes associated with the BMP implementation within the targeted subwatersheds. This report documents the first year of the monitoring plan. The Surface Water Standards (401 KAR 5:031) are used to provide the "yardstick" for evaluating BMP performance for three important water quality criteria, water temperature, dissolved oxygen, and pH.. The results of this project will be relevant to other watersheds with similar nonpoint source issues.

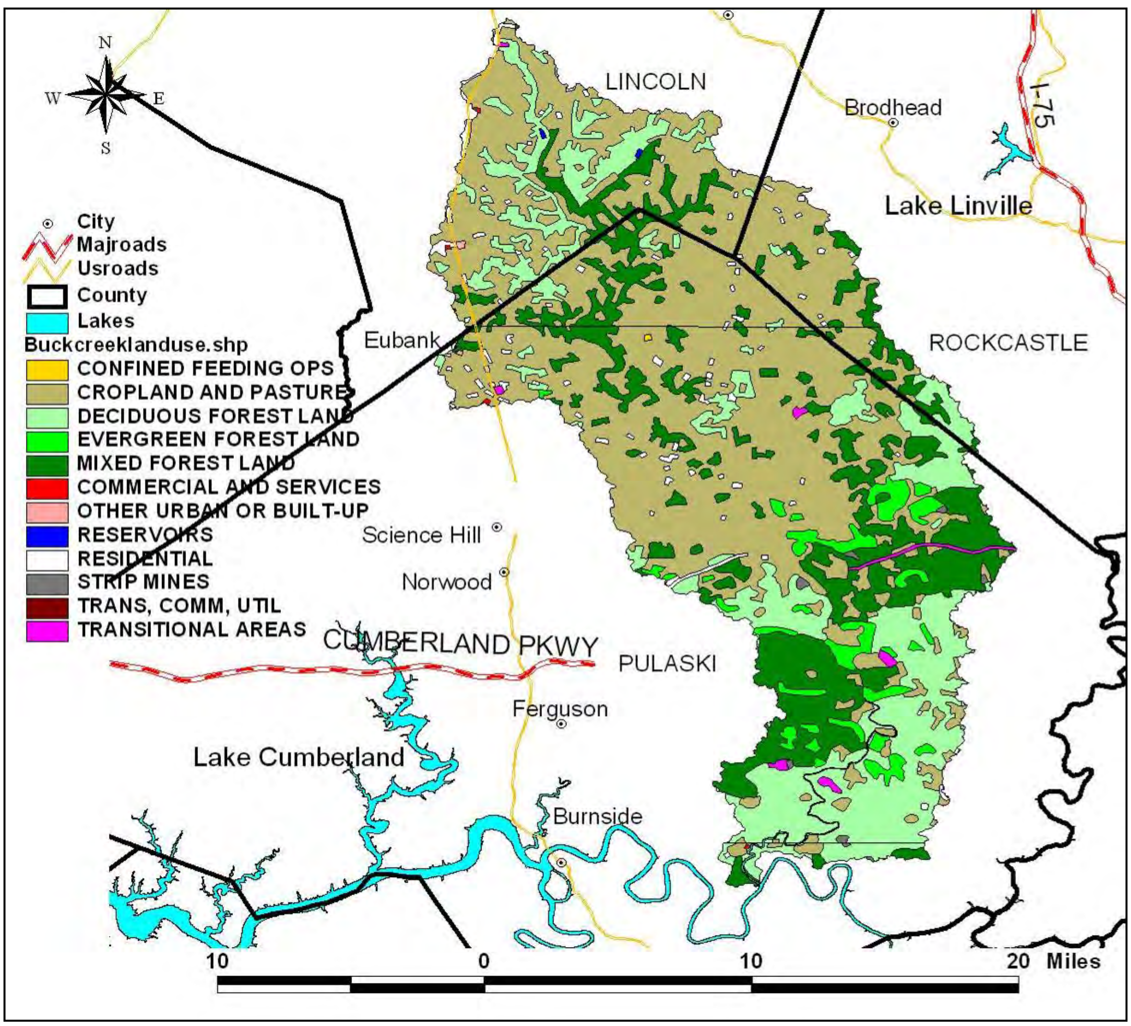


**Figure 1. Distribution of landuses in the Buck Creek drainage basin.**

***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 central portion of the Buck Creek watershed is heavily concentrated with farming operations. The farms are comprised of both full time and part 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, streambank erosion, and animal waste storage. See Appendix C and E.

The Best Management Practices selected by the Watershed Coordinator, 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. All practices installed through this grant and used as match on this grant were installed according to USDA-NRCS standards and specifications.

Since this was a BMP 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 a field day. BMPs were selected that met the needs of the operation while providing the best resource protection. Also, the BMPs that were not demonstrated at the field day were demonstrated through a van tour of three farms in the area on November 3, 2009. After the van tour all BMPs involved with the grant have been demonstrated.

A BMP Implementation Plan (Appendix C) was developed along the lines of the one used in a nearby 319 project – Peyton Creek. A project Oversight Committee was formed at the onset comprised of local farmers from within the watershed, and agency personnel from NRCS, KFWR, UK Extension, and the Conservation District.

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 by the Watershed Coordinator 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:

- Costs for alternative water supplies are only eligible if livestock are excluded from streams or other water bodies.
- The most cost effective water source was utilized as determined by NRCS.
- Pasture and Hayland planting could not exceed 30% of the total farm size.

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.

**Water Quality Monitoring**

The water quality monitoring used in this project was implemented using an upstream-downstream design. The upstream (Control) downstream (Experimental) watershed approach with pre-BMP and post-BMP is a popular approach for evaluating BMPs (Grabow et al. 1998, 1999a, 1999b; KDOW 1993; USEPA 1997; Clausen and Spooner, 1993; Spooner and others 1985). Two sites, Control and Experimental, were selected and were monitored during a 2 year pre-BMP period followed by another 2 year post-BMP monitoring period. An empirical relationship, using ordinary least squares (OLS) regression, was established between each of seven water quality attributes for the pre-BMP data. After the pre-BMP period, BMPs were implemented in the targeted subwatersheds only. Both Control and Experimental sites were subsequently monitored. Watershed responses have been compared with those predicted by regression equations to determine if the BMPs have had an effect, (Schilling and others 2002; Dillaha 1990). 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).

Monitoring was conducted over a five year period, from 2006 through 2010. The first two-year interval (pre-BMP: 2006 – 2007) preceded or was in the early stages of BMP implementation. Monitoring was suspended in 2008 coinciding with the most active period of BMP implementation. The final 2 year period (post-BMP: 2009 – 2010) followed the majority of BMP implementations. More than 550,000 water quality data points have been collected to date in Buck Creek since May, 2006.

**Sampling Strategy**

This project used a combination of continuously recording remote monitors and discrete-monitoring (also called grab-samples) to evaluate water quality (**Table 4**) at the Upstream and Downstream stations. 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 **Table 4**. Data was logged on frequent time intervals (15 minutes). Because the time interval is so short, the monitors are considered "continuous". **Figure 2** provides a photograph of a continuous monitor deployed at the BCU station.

**Table 4. 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 |

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.

**Figure 2. Photograph of continuous monitor deployed at the Upstream monitoring station on Buck Creek.**

Discrete water samples (**Figure 3**) were collected at both sampling locations and transported to Fouser Environmental Services, Ltd in Versailles, KY to be analyzed for total solids, and total suspended solids.


**Figure 3. Discrete samples collected from the Upstream monitoring station on Buck Creek.**

## 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 Buck 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 upstream - downstream 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 Buck 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).

$Y_t = b_0 + b_1X_t + b_2X_e + b_3 X_t X_e + e_t$ **Equation 1**

where:

$Y_t$ = Dependent variable; water quality time series from Downstream Buck Creek
$X_t$ = Independent variable; water quality time series from Upstream Buck Creek
$X_e$ = binomial classification variable where
    $X_e = 0$ = pre-BMP dates
    $X_e = 1$ = post-BMP dates
$e_t$ = unexplained or residual error

$b_0$ = y-intercept of the pre-BMP (calibration) regression line
$b_1$ = slope of the pre-BMP (calibration) regression line
$b_2$ = difference in the y-intercept of the water quality time series between the pre-BMP (calibration) and post-BMP period
$b_3$ = difference in the slope the water quality time series between the pre-BMP (calibration) and post-BMP regression lines
$(b_0 + b_2)$ = intercept of the post-BMP regression line
$(b_1 + b_3)$ = slope of the post-BMP regression line

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.

If the model residuals are not independent the model appears to have more information than is actually available from the dataset. Fifteen-minute data collected over long intervals exhibits strong and complicated autocorrelation relational patterns. Autocorrelation or, as it is often called, serial correlation refers to the relations between a datum and previous data. Previous data referring to data collected at an earlier time step. Certainly the strongest relation is to the immediately preceding datum, referred to as a "1$^{st}$-order" or "lag 1" relation. The continuously monitored data exhibit a lag 1 correlation value of approximately 0.99. This value indicates that each new datum in the time series conveys approximately 1.0% of the information it would if the measured attribute was generated randomly and independently from the population. This implies that the samples we are collecting are information poor as individual values. The consequence of using autocorrelated data is that probability values in the model are overestimated and may appear significant when in fact they aren't. Autocorrelation does not bias our model or estimates of the coefficients of the model. This condition is effectively mitigated by using very large datasets containing tens of thousands of data. The model probabilities for the continuous monitoring data in this report are at a minimum significant to 10 significant digits (0.000000000).

Another method used to confirm the utility of these models was a calculation of the effective sample size ($n_e$), using a correction technique reported by Reckhow and Chapra

(1983; p. 74). This methodology uses the 1st-order autocorrelation coefficient for the model to determine the effective number of samples when calculating the variance of the mean of the model. For example, the 22,200 data used in the model for DO had a very strong autocorrelation with a 1st-order autocorrelation coefficient of 0.99. The effective sample size is $n_e$ = 112. Although, 112 is certainly not as robust as 22,200 it is, nonetheless, a significant sample size considering it is completely independent data.

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.

**Education**

A field day sponsored by the Pulaski County Conservation District (PCCD) was held at Alan Hubble's farm during the summer of 2009. A newspaper article and poster was developed (Appendix D) for the field day. The field day was held on September 15, 2009 with approximately 165 persons in attendance. The activities included six stops. Attendees were transported over the farm on hay wagons. The stops included discussions on the following topics: Corn Silage, Wildlife Management, Cattle Handling Facilities, Best Management Practices and Rotational Grazing, Water Quality, and Hay Wrapping.

The PCCD hosted a Field Tour on three different farms on November 3, 2009. This tour was attended by six people including the project coordinator. There were seven BMPs demonstrated on this tour, which demonstrated all remaining BMPs.

## *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 4**) to collect water quality data for the parameters shown in **Table 5**. Data were logged on frequent time intervals of 15 minutes. Because the time interval is so short, the monitors are considered "continuous".

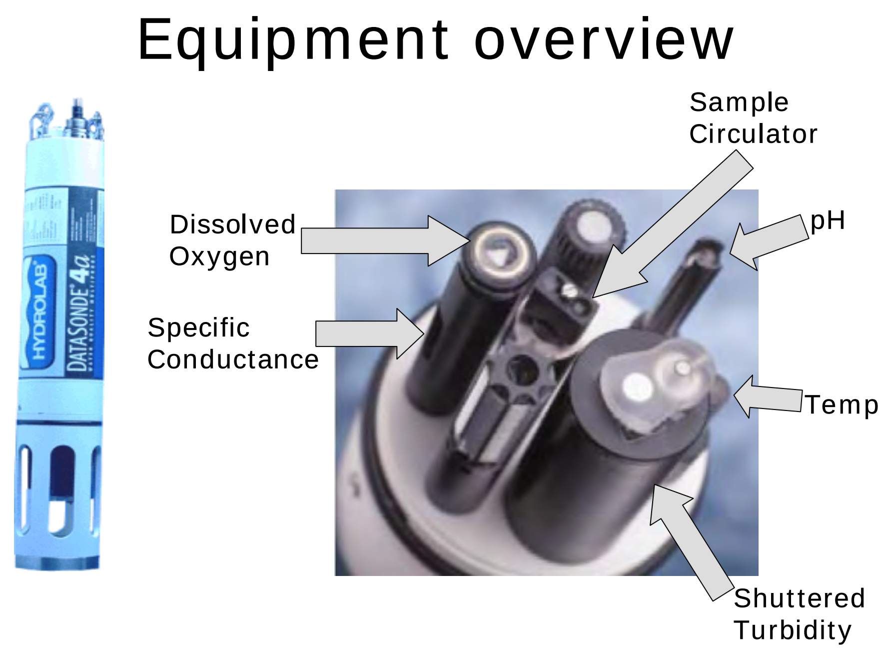


**Figure 4. Overview of one of the continuous monitors that was deployed during this project.**

**Table 5. 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 four two-week intervals (@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. 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

Water quality has improved in the Buck Creek watershed concurrent with the operation of this project. Watershed management practices coupled with water quality monitoring have not only reduced sources of pollutants in the watershed but have made local landowners aware of the actions they can take to improve their environment and maintain profitability.

### *BMP*

BMP installation was very successful in Buck Creek through both the project practices and the match practices. Through relationship building with landowners we were able to understand the production objectives of the landowners and relate that to the resources concerns and the objectives of the project. The number of landowners that we directly dealt with was low compared to the overall landowners of the watershed. However, we feel that we were dealing with quality landowners that have talked to their friends and neighbors about the practices. These landowners have become more aware of the environment and resources related to their land due to the project. Also, due to this the project participants have sparked an interest in other landowners to think about how they are managing the resources on their land.

Fourteen different practices were installed to meet the objectives of the project. Over 20,000 feet of fencing was installed in the watershed restricting livestock access to tributaries of Buck Creek which will go a long way on protecting the water quality, riparian areas, and the overall watershed health. Along with 40 tanks and nearly 22,000 feet of pipeline has provided a proper water source for livestock. Also, over 3,000 square feet of pond access ramps were installed, five spring developments, and four stream crossings to allow for additional water access. These practices have not only been good for the environment; they have enabled pastures to be setup in paddocks and utilized as a rotational grazing system. As part of the development of the rotational grazing 156 acres was setup for prescribed grazing to help operators make the transition to managing forage crops as part of the rotational grazing system. Additionally, over 25,000 square feet of heavy use areas have been installed to situate winter feeding areas in environmentally friendly locations. Three producers had the outlook to see the value of the animal waste and installed animal waste storage structures. These are being utilized to not only contain the waste in a dry location, but more importantly they allow for proper timing of application of the waste. Their was a 1.6 acre critical area treatment and 0.1 acre filter strip establishment, which obtained good dollar efficiency for the project. Finally, 490 linear feet of streambank stabilization was installed which greatly reduced a direct source of sediment to the watershed.

Photos of some of the BMPs are provided in Appendix D.

**Table 6. Quantification of the BMPs installed in the Buck Creek watershed in 2007 and 2008.**

| BMP (units) | NRCS Practice Code | Results | HUC 14 | Lat/Long | Watershed Name |
|---|---|---|---|---|---|
| Animal Waste Storage (#) | 313 | 2 | 05130103030010 | NA* | Indian Creek |
| Animal Waste Storage (#) | 313 | 1 | 05130103030190 | NA | Clear Creek |
| Critical Area Planting (Acres) | 342 | 1.6 | 05130103040030 | NA | Brushy Creek |
| Fence (Linear feet) | 382 | 7,265 | 05130103030010 | NA | Indian Creek |
| Fence (Linear feet) | 382 | 465 | 05130103040020 | NA | Bee Lick Creek |
| Fence (Linear feet) | 382 | 4,592 | 05130103030160 | NA | Whetstone Creek |
| Fence (Linear feet) | 382 | 2,001 | 05130103030140 | NA | Briary Creek |
| Fence (Linear feet) | 382 | 1990 | 05130103030190 | NA | Clear Creek |
| Fence (Linear feet) | 382 | 810 | 05130103030230 | NA | Buck Creek |
| Fence (Linear feet) | 382 | 3,250 | 05130103030110 | NA | Buck Creek |
| Filter Strip (Acres) | 393 | 0.1 | 05130103030210 | NA | Buck Creek |
| Heavy Use Area (Feet² ) | 561 | 4,284 | 05130103040020 | NA | Bee Lick Creek |
| Heavy Use Area (Feet² ) | 561 | 2,520 | 05130103030230 | NA | Buck Creek |
| Heavy Use Area (Feet² ) | 561 | 2,100 | 05130103040020 | NA | Buck Creek |
| Heavy Use Area (Feet² ) | 561 | 10,500 | 05130103040090 | NA | Flat Lick Creek |
| Heavy Use Area (Feet² ) | 561 | 1,260 | 05130103030140 | NA | Briary Creek |
| Heavy Use Area (Feet² ) | 561 | 2,694 | 05130103030160 | NA | Whetstone Creek |
| Heavy Use Area (Feet² ) | 561 | 2,222 | 05130103030190 | NA | Clear Creek |
| Grassed Waterway (Acres) | 412 | 0.5 | 05130103030010 | NA | Indian Creek |
| Grassed Waterway (Acres) | 412 | 1 | 05130103040020 | NA | Bee Lick Creek |
| Pasture & Hayland seeding (Acres) | 512 | 12.7 | 05130103030150 | NA | Buck Creek |
| Pasture & Hayland seeding (Acres) | 512 | 8.1 | 05130103030010 | NA | Indian Creek |
| Pasture & Hayland seeding (Acres) | 512 | 60.5 | 05130103040030 | NA | Brushy Creek |
| Pasture & Hayland seeding (Acres) | 512 | 98 | 05130103040080 | NA | Buck Creek |
| Pasture & Hayland seeding (Acres) | 512 | 60 | 05130103040090 | NA | Flat Lick Creek |
| Pipeline (Linear feet) | 516 | 958 | 05130103030190 | NA | Clear Creek |
| Pipeline (Linear feet) | 516 | 3,510 | 05130103030160 | NA | Whetstone Creek |
| Pipeline (Linear feet) | 516 | 4,258 | 05130103030010 | NA | Indian Creek |
| Pipeline (Linear feet) | 516 | 496 | 05130103030140 | NA | Briary Creek |
| Pipeline (Linear feet) | 516 | 1,715 | 05130103040040 | NA | Clifty Creek |
| Pipeline (Linear feet) | 516 | 2,490 | 05130103040020 | NA | Bee Lick Creek |
| Pipeline (Linear feet) | 516 | 2,535 | 05130103040080 | NA | Buck Creek |
| Pipeline (Linear feet) | 516 | 2,300 | 05130103040030 | NA | Brushy Creek |
| Pipeline (Linear feet) | 516 | 195 | 05130103040020 | NA | Buck Creek |
| Pipeline (Linear feet) | 516 | 2,179 | 05130103040100 | NA | Stewart Branch |
| Pipeline (Linear feet) | 516 | 1,116 | 05130103040090 | NA | Flat Lick Creek |
| Pond Ramp (Feet² ) | 575 | 1,470 | 05130103030160 | NA | Whetstone Creek |
| Pond Ramp (Feet² ) | 575 | 336 | 05130103030140 | NA | Briary Creek |
| Pond Ramp (Feet² ) | 575 | 600 | 05130103030190 | NA | Clear Creek |
| Pond Ramp (Feet² ) | 575 | 600 | 05130103030230 | NA | Buck Creek |
| Prescribed Grazing (Acres) | 528A | 96 | 05130103040080 | NA | BuckCreek |
| Prescribed Grazing (Acres) | 528A | 60 | 05130103080130 | NA | Clift Creek |
| Spring Developments (#) | 574 | 2 | 05130103030140 | NA | Briary Creek |
| Spring Developments (#) | 574 | 2 | 05130103040030 | NA | Brushy Creek |
| Spring Developments (#) | 574 | 1 | 05130103040020 | NA | Bee Lick Creek |
| Stream Crossings (#) | 576 | 2 | 05130103030010 | NA | Indian Creek |
| Stream Crossings (#) | 576 | 1 | 05130103030140 | NA | Briary Creek |
| Stream Crossings (#) | 576 | 1 | 05130103030160 | NA | Whetstone |

| | | | | | |
|---|---|---|---|---|---|
| | | | | | Creek |
| Streambank Stabilization (LF) | 580 | 490 | 05130103030210 | NA | Buck Creek |
| Tank (#) | 614 | 5 | 05130103030140 | NA | Briary Creek |
| Tank (#) | 614 | 3 | 05130103030190 | NA | Clear Creek |
| Tank (#) | 614 | 5 | 05130103030160 | NA | Whetstone Creek |
| Tank (#) | 614 | 4 | 05130103040040 | NA | Clifty Creek |
| Tank (#) | 614 | 7 | 05130103030010 | NA | Indian Creek |
| Tank (#) | 614 | 4 | 05130103040020 | NA | Bee Lick Creek |
| Tank (#) | 614 | 3 | 05130103040030 | NA | Brushy Creek |
| Tank (#) | 614 | 2 | 05130103040080 | NA | Buck Creek |
| Tank (#) | 614 | 1 | 05130103040020 | NA | Buck Creek |
| Tank (#) | 614 | 4 | 05130103040100 | NA | Stewart Branch |
| Tank (#) | 614 | 2 | 05130103040090 | NA | Flat Lick Creek |

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

## Water Quality Results

The annual and monthly distribution of precipitation in the Buck Creek Watershed is approximated using data collected by the USGS at the Rockcastle River gauging station 03406500. Rainfall data from the period January through October of each of the four years sampled 2006 – 2007; Pre-BMP period and 2009 – 2010; Post-BMP period are depicted in **Figure 5**.

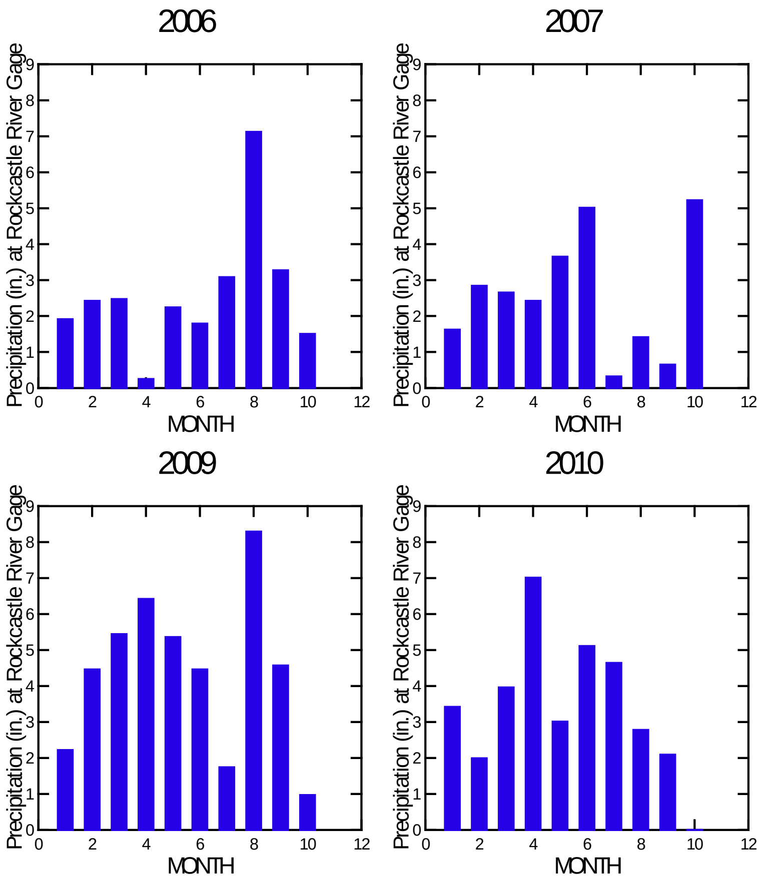


**Figure 5. Precipitation plots for the months January through October for the years 2006 and 2007 and 2009 and 2010. The data was observed at the USGS station 03406500 on the Rockcastle River at Billows, KY. This data is provisional.**

**Figure 6** depicts the monthly flow conditions at the USGS station on the Rockcastle River for the years 2006 – 2007; Pre-BMP period and 2009 – 2010; Post-BMP period. These graphs suggests that the Pre-BMP and Post-BMP hydrology are very similar.

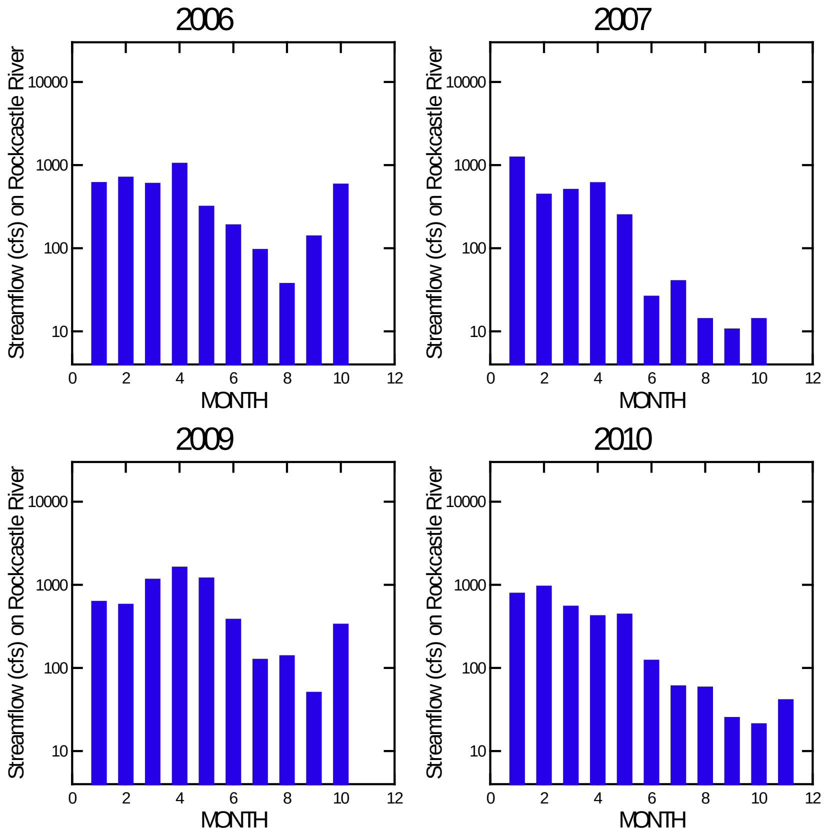


**Figure 6. Monthly average streamflow observed at the USGS station 03406500 on the Rockcastle River at Billows, KY..**

## Quality Assurance and Quality Control Measures

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. A summary of the components of that effort is presented below. **Table 7** 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.

Emphasis was placed on reducing the probability of committing a Type II error concluding that the change in an attribute at BCD between the pre and post-BMP is no different than the change at the reference site BCU when, in fact, it is.

**Table 7. 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 8** 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 8. 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 |
| Upstream | | | | | |
| N of cases | 850 | 847 | 850 | 842 | 850 |
| Minimum | -0.1 | -3.9 | -0.3 | -33.3 | -47.0 |
| Median | 0.0 | -0.2 | 0.1 | -0.3 | -7.4 |
| Mean | 0.0 | -0.3 | 0.1 | 11.2 | 6.9 |
| Maximum | 0.2 | 1.9 | 0.6 | 104.2 | 28.0 |
| C.V. | 1.120 | -0.908 | 0.896 | 4.391 | 0.955 |
| Downstream | | | | | |
| N of cases | 850 | 847 | 850 | 842 | 850 |
| Minimum | -0.1 | -2.7 | -0.2 | -27.3 | -31.0 |
| Median | 0.0 | -0.3 | 0.1 | -0.6 | -6.4 |
| Mean | 0.0 | -0.4 | 0.2 | 9.1 | 2.9 |
| Maximum | 0.1 | 1.6 | 0.5 | 97.1 | 34.0 |
| C.V. | 1.030 | -0.878 | 1.006 | 3.222 | 0.953 |

**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.

**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 are judged to be of high quality and represents the Upstream and Downstream 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.

**Completeness** is a measure of the amount of usable data. Field and laboratory completeness were 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 the continuous monitors and 95% for laboratory analyses, Completeness objectives were met for all samples. **Table 9** presents the percentage of data collected for the continuous monitors and solids samples.

**Table 9. Completeness data calculated as the number of samples collected divided by the number of samples expected to be collected.**

| Attribute | Upstream | Downstream |
|---|---|---|
| Water Temperature (c) | 114% | 107% |
| Dissolved Oxygen (mg/l | 110% | 107% |
| pH (su) | 114% | 107% |
| Turbidity (ntu) | 112% | 99% |
| Specific Electrical Conductance (microsemiens) | 114% | 103% |
| Total Solids (mg/l) | 136% | 134% |
| Total Suspended Solids (mg/l) | 136% | 134% |
| Total Suspended Solids (mg/l) | 136% | 134% |

**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**

A summary of the key findings are presented below. **Table 10** provides a summary of the remotely monitored water quality attributes. This 15-minute time interval data was partitioned into subsets by sample site and by 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 pre-BMP and post-BMP intervals. These differences can potentially obscure the impacts of the BMPs installed in the watershed.

Water temperatures were slightly 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 Downstream (BCD *treatment*) and Upstream (BCU *control*). The variability of both dissolved oxygen and pH, as presented by the coefficient of variation (C.V.), is

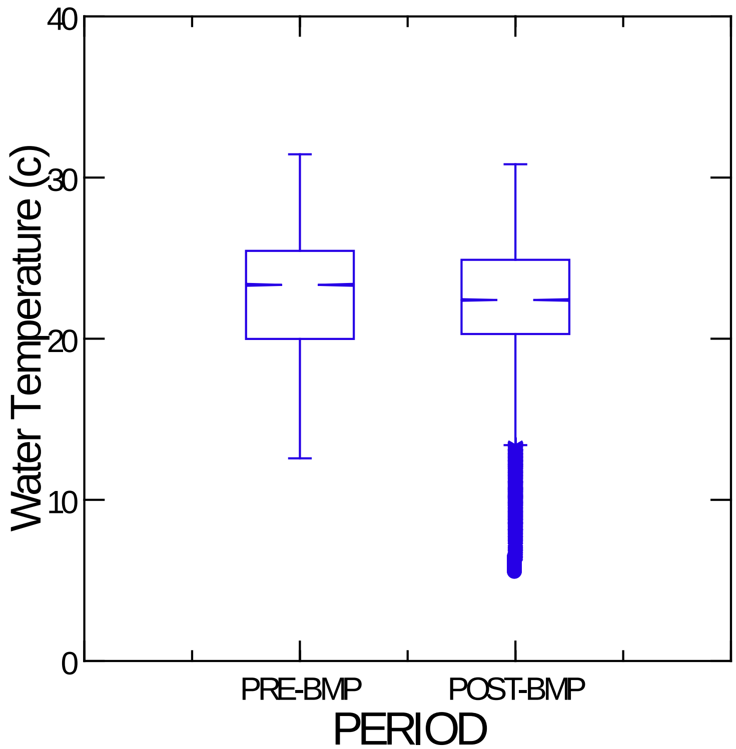


**Figure 7 Comparison of water temperature in the Pre-BMP period versus the Post-BMP period. Water temperatures were slightly higher in the Pre-BMP period.**

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 10. Summary of the continuous monitoring data divided into pre-BMP and post BMP periods.**

| | Water Temperature (Celcius) | | Dissolved Oxygen (mg/l) | | Dissolved Oxygen Deficit (mg/l) | | pH (su) | | Specific Electrical Conductance (microsemiens | |
|---|---|---|---|---|---|---|---|---|---|---|
| | pre-BMP | post-BMP | pre-BMP | post-BMP | pre-BMP | post-BMP | pre-BMP | post-BMP | pre-BMP | post-BMP |
| Upstream Buck Creek | | | | | | | | | | |
| N of cases | 13,214 | 11,213 | 12,446 | 11,204 | 12,446 | 11,204 | 13,214 | 11,213 | 13,214 | 11,213 |
| % of Design | 123 | 104 | 116 | 104 | 116 | 104 | 123 | 104 | 123 | 104 |
| Minimum | 4.00 | 8.35 | 0.21 | 0.50 | -2.28 | -10.33 | 6.69 | 6.56 | 0 | 0 |
| Median | 22.08 | 22.53 | 7.00 | 6.68 | 2.47 | 2.29 | 7.38 | 7.55 | 184 | 171 |
| Mean | 20.51 | 22.71 | 6.19 | 6.87 | 2.96 | 2.05 | 7.54 | 7.61 | 186 | 170 |
| Maximum | 31.44 | 30.82 | 11.62 | 24.29 | 8.84 | 8.17 | 9.28 | 9.86 | 546 | 339 |
| C.V. | 0.296 | 0.172 | 0.466 | 0.340 | 0.808 | 1.145 | 0.083 | 0.064 | 0.211 | 0.270 |
| Downstream Buck Creek | | | | | | | | | | |
| N of cases | 13,213 | 9,797 | 13,213 | 9,791 | 13,213 | 9,791 | 13,213 | 9,976 | 12,366 | 9,746 |
| % of Design | 123 | 91 | 123 | 91 | 123 | 91 | 123 | 93 | 115 | 91 |
| Minimum | 3.95 | 5.49 | 0.12 | 2.60 | -2.99 | -6.48 | 6.19 | 6.82 | 37 | 0 |
| Median | 22.21 | 22.27 | 6.68 | 7.50 | 2.21 | 1.13 | 7.37 | 7.63 | 184 | 177 |
| Mean | 20.37 | 21.64 | 6.25 | 7.59 | 2.92 | 1.37 | 7.38 | 7.70 | 192.6 | 170 |
| Maximum | 29.78 | 28.50 | 14.17 | 24.9 | 9.34 | 7.00 | 9.91 | 9.27 | 557 | 343 |
| C.V. | 0.300 | 0.163 | 0.428 | 0.251 | 0.904 | 1.334 | 0.087 | 0.054 | 0.214 | 0.345 |

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 no violations of the 31.7 c water temperature threshold. 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 15-minute data Downstream (BCD) there were 30 days in violation of the acute dissolved oxygen standard in the pre-BMP period (May through October; 2006 – 2007) this amounted to 20.3% of days sampled for dissolved oxygen. In the post-BMP period (2009 – 2010) dissolved oxygen conditions improved, only 8.3% of the 109 days sampled were in violation of the acute dissolved oxygen standard. Also at BCD there were 29 days (19.6% of the days sampled for dissolved oxygen) in violation of the chronic dissolved oxygen criterion in the pre-BMP years. In the post-BMP interval dissolved oxygen conditions improved considerably with only 8 days or 7.3% of the day's sampled being in violation.

At the Upstream site (BCU) there were 39 days (27.9% of the days sampled) in violation of the acute dissolved oxygen standard in the pre-BMP period versus 28 days (22.6% of the time) in the post-BMP period. There were 35 (25%) days with chronic violations at BCU in the pre-BMP years versus 15 (12.1%) days in the post-BMP interval.

There were no pH violations below pH=6 at any time at either location during the four years of sampling. However, there were 6 days (4.1%) with pH > 9 at BCD in 2006 - 2007 versus an increase to 11 days (11.5%) with exceedences in the post-BMP interval. At BCU there were 7 days (5.4%) with a pH value greater than nine during the pre-BMP period but that increased to 10 days (9.1%) 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.

**ANCOVA Models of Continuous Data**

**The model developed for DO** has an adjusted squared multiple R = 0.593 explaining approximately 60% of the total data variance for the full DO data. N = 22,220 reliable DO sample pairs were collected during the four years of sampling and used in this model. The full model for DO is presented as **Equation 2**

$Y_t = 1.69 + 0.71X_t + 1.92X_e + -0.152\ X_t\ X_e$ **Equation 2**

where:

$Y_t$ = Dependent variable; DO (mg/l) from BCD
$X_t$ = Independent variable; DO (mg/l) from BCU
$X_e$ = binomial classification variable where:
$X_e$ = 0 = pre-BMP dates
$X_e$ = 1 = post-BMP dates
$e_t$ = unexplained or residual error

$b_0$ = y-intercept of the pre-BMP regression line = 1.69 (mg/l)
$b_1$ = slope of the pre-BMP regression line = 0.71 (mg/l)
$b_2$ = difference in the y-intercept, DO (mg/l), between the pre-BMP and post-BMP period = 1.92 (mg/l) with y-intercept of the post-BMP being significantly higher than the pre-BMP period
$b_3$ = difference in the slope, DO (mg/l), between the pre-BMP and post-BMP regression lines = -0.152 (mg/l)
$(b_0 + b_2)$ = intercept of the post-BMP regression line = 1.69 + 1.92 = 3.61 (mg/l)
$(b_1 + b_3)$ = slope of the post-BMP regression line = 0.71 - 0.152 = 0.56 (mg/l)

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

$Y_t = 1.69 + 0.71X_t$ **Equation 3**

**Equation 4** represents the post-BMP period

$Y_t = 1.69 + 1.92 + (0.71 - 0.15)\ X_t$ **Equation 4**

**ANCOVA Results DO Model**

| | |
|---|---|
| Dependent Variable | $Y_t$ |
| N | 22,220 $n_e$ = 112 |
| Multiple R | 0.770 |
| Squared Multiple R | 0.593 |

| | |
|---|---|
| Adjusted Squared Multiple R | 0.593 |
| Standard Error of Estimate | 1.581 |

**Regression Coefficients B = $(X'X)^{-1}X'Y$**

| Effect | | Coefficient | Standard Error | Std. Coefficient | Tolerance | t | p-Value |
|---|---|---|---|---|---|---|---|
| CONSTANT | $b_0$ | 1.687 | 0.034 | 0.000 | . | 50.314 | 0.000000000 |
| $X_t$ | $b_1$ | 0.712 | 0.005 | 0.771 | 0.648 | 144.984 | 0.000000000 |
| $X_e$ | $b_2$ | 1.922 | 0.062 | 0.385 | 0.119 | 31.073 | 0.000000000 |
| $X_t*X_e$ | $b_3$ | -0.152 | 0.009 | -0.236 | 0.105 | -17.896 | 0.000000000 |

**Confidence Interval for Regression Coefficients**

| Effect | | Coefficient | 95.0% Confidence Interval Lower | Upper | VIF |
|---|---|---|---|---|---|
| CONSTANT | $b_0$ | 1.687 | 1.621 | 1.752 | . |
| $X_t$ | $b_1$ | 0.712 | 0.702 | 0.721 | 1.544 |
| $X_e$ | $b_2$ | 1.922 | 1.801 | 2.043 | 8.381 |
| $X_t*X_e$ | $b_3$ | -0.152 | -0.169 | -0.136 | 9.530 |

**Analysis of Variance**

| Source | SS | df | Mean Squares | F-Ratio | p-Value |
|---|---|---|---|---|---|
| Regression | 80,989.882 | 3 | 26,996.627 | 10,801.628 | 0.000000000 |
| Residual | 55,524.690 | 22,216 | 2.499 | | |

The histogram of the model residuals in **Figure 8** indicates a close conformity to the requirement of normal residuals, suggesting that this is an acceptable model.

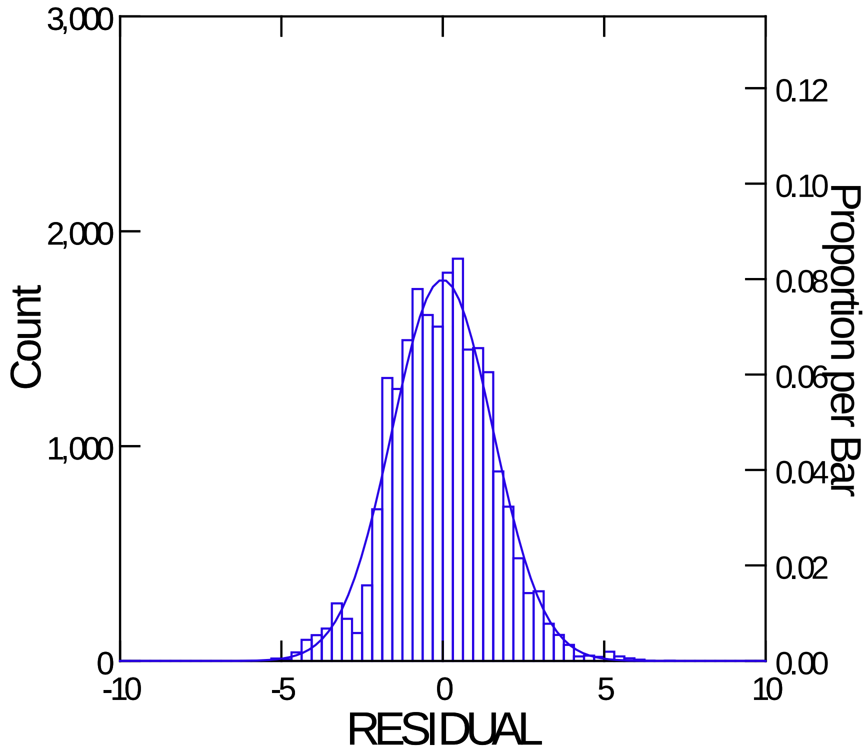


**Figure 8. Histogram of the model residuals and kernal smooth for the normal distribution.**

The statistical significance of a difference in model intercept and slope is revealed in the P-values, with the magnitude of the difference provided by the coefficient values (Grabow and others1998). The P value of the $b_2$ coefficient (0.000000000) indicates that there is a statistically significant difference in the y-intercepts of the pre-BMP period and the post-BMP period. The $b_2$ coefficient 1.922 reveals the magnitude of the difference with the positive sign indicating that the intercept of the post-BMP period is higher than the pre-BMP period documenting that BCD had an increase in DO relative to BCU.

The P value of the $b_3$ coefficient (0.000000000) indicates that there is a statistically significant difference in the slopes of the regression models. The slope of the post-BMP model ($b_3 = -0.152$) is less by 0.152 mg/l than that of the pre-BMP model. The negative nature of the coefficient indicates that the difference is more prominent at upper levels of DO than at the lower levels. This suggests that greater photosynthesis occurred in the post-BMP period. It was noted above that there was a 12.0% decrease in the number of days with acute DO violations at BCD between the post-BMP period relative to the pre-BMP period. BCU decreased by only 5.3%.

The average difference for the 'full' model was derived by setting $X_t$ = average of all the BCU DO data (both calibration and treatment periods). This value can be found from the results as equal to 6.59 mg/l DO. Substituting this value for $X_t$ in **Equations 5** and **6** results in the following functions:

**Equation 5** represents the calibration period

$Y_{tc} = 1.69 + 0.71 * 6.59$ **Equation 5**

$Y_{tc} = 6.37$

**Equation 6** represents the treatment period

$Y_{tt}$ = 1.69 + 1.92 + (0.71 - 1.52)* 6.59 **Equation 6**
$Y_{tt}$ = -1.73

**Equation 7** can be used to estimate the percent increase of DO at BCD relative to the control site BCU.

$1-(10^{Ytt}/10^{Ytc})$ **Equation 7**

substituting results in $1-(10^{-1.73}/10^{6.37})$ = 1.00 or an 100% increase.

A very powerful graphical nonparametric tool reveals the same basic conclusion reached by the statistical model. **Figure 9** demonstrates that DO concentrations were significantly higher in the post-BMP period at BCD than in the pre-BMP period. Differences in the control site, BCU were significantly lower in the post-BMP period.

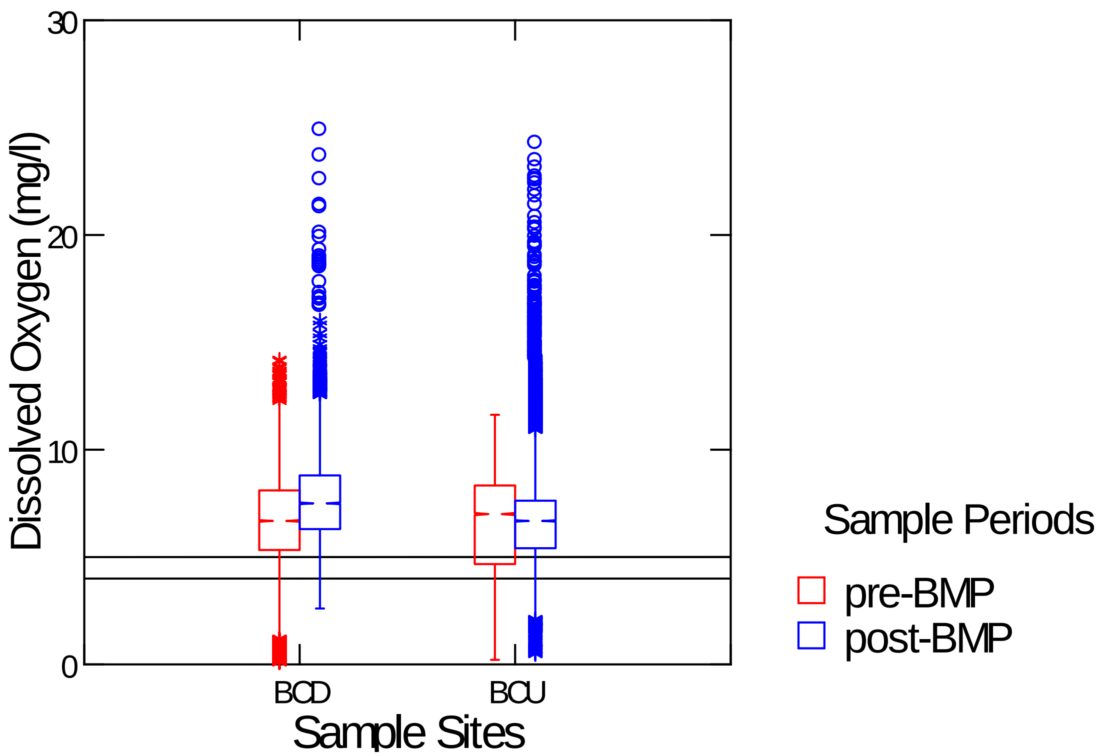


**Figure 9. Notched box plots depicts the difference between the pre-BMP and post-BMP sampling intervals for both sampling sites.**

**The DO deficit (DOD)**, defined as the concentration of oxygen (mg/l) at saturation ($O_s$ ), minus the observed concentration (O; mg/l) of DO (DOD = $O_s$ – O) is commonly used to assess water quality along with DO concentrations (Chapra and Di Toro 1991, Chapra 1997, and Chapra and McBride 2005). This attribute normalizes DO for changes in WT and SEC and provides a good index of the role of photosynthesis and respiration in Buck Creek.

DO deficit, *D* (mg/L), is defined as **Equation 8**:

**Equation 8** DOD = $O_s$ – O

O = concentration of DO
$O_s$ = the concentration of dissolved oxygen in water (mg $O_2$ / l) at equilibrium with the atmosphere

*Cs* is calculated as a function of WT and salinity (**Equation 9**). Water temperature is converted to degrees Kelvin in the equation.

**Equation 9** $O_s$ = EXP (-139.34411 + (1.575701 * 100000 / (WT + 273.15)) - (6.642308 * 10000000 / ((WT + 273.15) * (WT + 273.15))) + (1.2438 * 10000000000/((WT + 273.15)*(WT + 273.15) * (WT +273.15))) - (8.621949 *100000000000 / ((WT +273.15) * (WT + 273.15) * (WT + 273.15) * (WT + 273.15))) - CL * (( 3.1929 * 0.01) - (1.9428 * (10 / (WT + 273.15))) +( 3.8673 * (1000 / ((WT + 273.15) * (WT + 273.15))))))

WT = Water Temperature ($^oC$)
Cl = chlorine = ((5.572 * (0.0001 * $\varpi$) + 2.02 * (0.000000001 * $\varpi^2$)) / 1.80655)
$\varpi$ = Specific Electrical Conductance ( $\mu$S / cm at 25 $^oC$)

The model used 22,220 pairs of data to explain approximately 58% of the system variability with a standard error of the estimate of 1.607 mg/l. Each of the coefficients were significant at the 0.000000000 probability level.

The model developed for DOD has an adjusted squared multiple R = 0.577 explaining approximately 58% of the total data variance for the full DOD data. 22,220 DOD values were calculated and used in this model. The full model for DOD is presented as **Equation 10**

$Y_t = 0.74 + 0.79X_t +-0.46X_e + -0.22\ X_t\ X_e$ **Equation 10**

where:

$Y_t$ = Dependent variable; DOD (mg/l) from Downstream Buck Creek
$X_t$ = Independent variable; DOD (mg/l) from Upstream Buck Creek
$X_e$ = binomial classification variable where:
$X_e$ = 0 = pre-BMP dates
$X_e$ = 1 = post-BMP dates
$e_t$ = unexplained or residual error

$b_0$ = y-intercept of the pre-BMP regression line = 0.74 (mg/l)
$b_1$ = slope of the pre-BMP regression line = 0.79 (mg/l)
$b_2$ = difference in the y-intercept, DOD (mg/l), between the pre-BMP and post-BMP period = -0.46 (mg/l) with y-intercept of the post-BMP being significantly higher than the pre-BMP period
$b_3$ = difference in the slope, DOD (mg/l), between the pre-BMP and post-BMP regression lines = -0.220 (mg/l)
($b_0 + b_2$) = intercept of the post-BMP regression line = 0.74 – 0.46 = 0.28 (mg/l)
($b_1 + b_3$) = slope of the post-BMP regression line = 0.79 - 0.22 = 0.57 (mg/l)

The statistical analysis of the model is presented below. The model coefficients indicate that the model for the calibration period is represented by **Equation 11**

$Y_t = 0.74 + 0.79X_t$ **Equation 11**

**Equation 12** represents the treatment period

$Y_t = 0.74 – 0.46 + (0.79 - 0.22)\ X_t$ **Equation 12**

**ANCOVA Results DOD Model**

| | |
|---|---|
| Dependent Variable | $Y_t$ |
| N | 22,220 $n_e$ = 112 |
| Multiple R | 0.760 |
| Squared Multiple R | 0.577 |
| Adjusted Squared Multiple R | 0.577 |
| Standard Error of Estimate | 1.607 |

**Regression Coefficients B = (X'X)$^{-1}$X'Y**

| Effect | | Coefficient | Standard Error | Std. Coefficient | Tolerance | t | p-Value |
|---|---|---|---|---|---|---|---|
| CONSTANT | $b_0$ | 0.736 | 0.023 | 0.000 | . | 32.069 | 0.000000000 |
| $X_t$ | $b_1$ | 0.791 | 0.006 | 0.780 | 0.540 | 131.312 | 0.000000000 |
| $X_e$ | $b_2$ | -0.458 | 0.031 | -0.092 | 0.489 | -14.755 | 0.000000000 |
| $X_t$*$X_e$ | $b_3$ | -0.220 | 0.009 | -0.163 | 0.413 | -24.007 | 0.000000000 |

**Confidence Interval for Regression Coefficients**

| Effect | | Coefficient | 95.0% Confidence Interval Lower | Upper | VIF |
|---|---|---|---|---|---|
| CONSTANT | $b_0$ | 0.736 | 0.691 | 0.780 | . |
| $X_t$ | $b_1$ | 0.791 | 0.780 | 0.803 | 1.851 |
| $X_e$ | $b_2$ | -0.458 | -0.519 | -0.397 | 2.045 |
| $X_t$*$X_e$ | $b_3$ | -0.220 | -0.237 | -0.202 | 2.422 |

**Analysis of Variance**

| Source | SS | df | Mean Squares | F-Ratio | p-Value |
|---|---|---|---|---|---|
| Regression | 78,262.499 | 3 | 26,087.500 | 10,101.520 | 0.000000000 |
| Residual | 57,373.535 | 22,216 | 2.583 | | |

The histogram of the model residuals in **Figure 10** demonstrates a close conformity to the requirement of normal residuals, suggesting that this is an acceptable model.

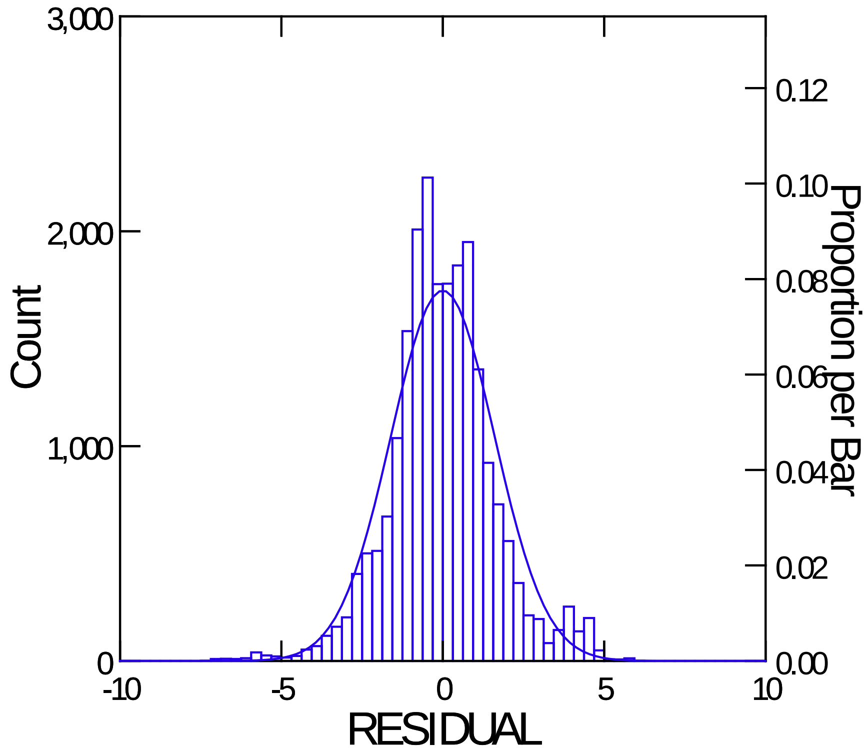


**Figure 10. Histogram of the model residuals and kernal smooth for the normal distribution.**

The P value of the $b_2$ coefficient (0.000000000) indicates that there is a statistically significant difference in the y-intercepts of the calibration period and the treatment period. The $b_2$ coefficient -0.458 reveals the magnitude of the difference with the negative sign indicating that the intercept of the treatment period is lower than the calibration period documenting that BCD had a decrease in DOD relative to BCU.

The P value of the $b_3$ coefficient (0.000000000) indicates that there is a statistically significant difference in the slopes of the regression models. The slope of the treatment model ($b_3 = -0.220$) is less by 0.220 mg/l than that of the calibration model. The negative nature of the coefficient indicates that the difference is more prominent at upper levels of DOD than at the lower levels. This also suggests that greater photosynthesis occurred in the post-BMP period.

The average difference for the 'full' model was derived by setting $X_t$ = average of all the BCU DOD data (both pre-BMP period and post-BMP period). This value can be found from the results as equal to 2.50 mg/l DOD. Substituting this value for $X_t$ in **Equations 13** and **14** results in the following functions:

**Equation 13** represents the calibration period

$Y_{tc} = 0.74 + 0.79*2.50$ **Equation 13**
$Y_{tc} = 2.715$

**Equation 14** represents the treatment period

$Y_{tt} = 0.74 - 0.46 + (0.79-0.22)* 2.50$ **Equation 14**

$Y_{tt} = 1.705$

**Equation 15** can be used to estimate the percent increase of DOD at BCD relative to the control site BCU.

$1\text{-}(10^{Ytt}/10^{Ytc})$ **Equation 15**

substituting results in $1\text{-}(10^{1.71}/10^{2.72}) = 0.90$ or a 90% decrease in DOD.

A very powerful graphical nonparametric tool reveals the same basic conclusion reached by the statistical model. **Figure 11** demonstrates that DOD concentrations were significantly higher in the post-BMP period at BCD than in the pre-BMP period. Differences in the control site, BCU were significant lower in the post-BMP period.

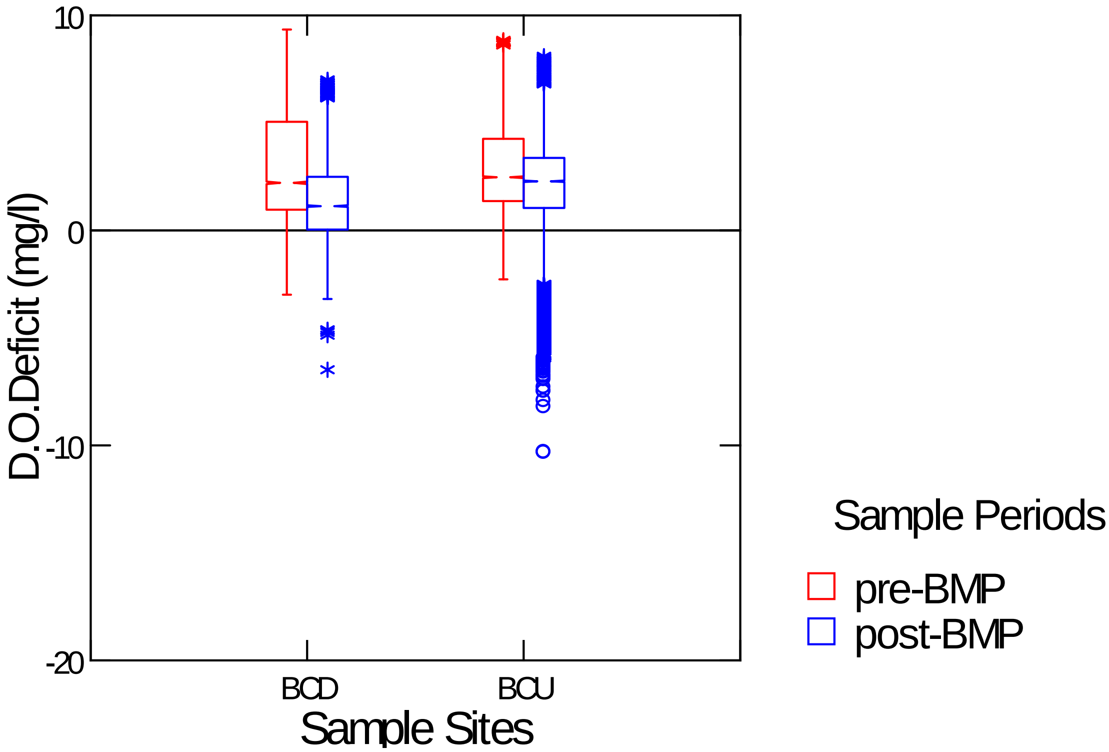


**Figure 11 Notched box plots depicts the difference between the pre-BMP and post-BMP sampling intervals for both sampling sites.**

The model developed for pH is not presented in detail because the adjusted squared multiple R = 0.298. Although the model results were sufficient and reliable the model explains less than 30% of the total data variance for the full pH data. **Figure 12** depicts the relation between pre-BMP and post-BMP periods at BCU and BCD. pH increased during the post-BMP period relative to the pre-BMP period at both stations although slightly more at BCD.

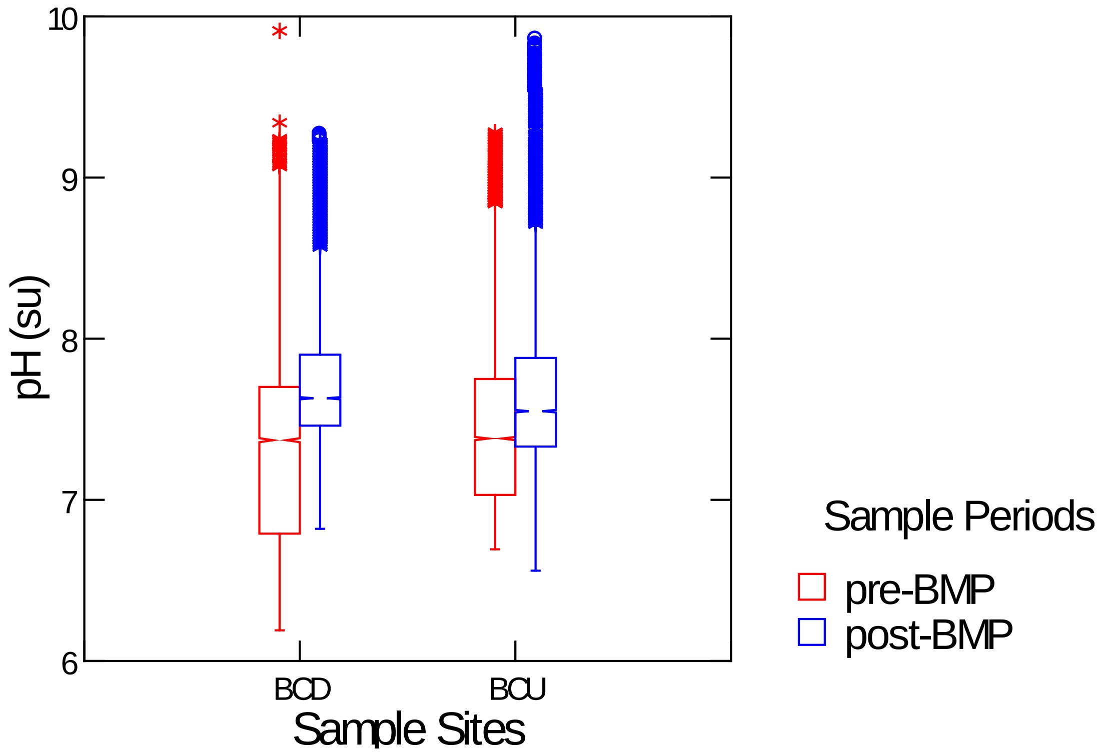


**Figure 12 Notched box plots depicts the difference between the pre-BMP and post-BMP sampling intervals for both sampling sites.**

**The model developed for SEC** has an adjusted squared multiple R = 0.621 explaining approximately 62% of the total data variance for the full SEC data. 22,096 SEC values were calculated and used in this model. The full model for SEC is presented as **Equation 16**

$Y_t = 28.82 + 0.87X_t - 6.78X_e + 0.02\ X_t\ X_e$ **Equation 16**

where:

$Y_t$ = Dependent variable; SEC (umhos) from Downstream Buck Creek
$X_t$ = Independent variable; SEC (umhos) from Upstream Buck Creek
$X_e$ = binomial classification variable where:
$X_e = 0$ = pre-BMP dates
$X_e = 1$ = post-BMP dates
$e_t$ = unexplained or residual error

$b_0$ = y-intercept of the pre-BMP regression line = 28.82 (umhos)
$b_1$ = slope of the pre-BMP regression line = 0.87 (umhos)
$b_2$ = difference in the y-intercept, SEC (umhos), between the pre-BMP and post-BMP period = -6.78 (umhos) with y-intercept of the post-BMP being significantly higher than the pre-BMP period
$b_3$ = difference in the slope, SEC (umhos), between the pre-BMP and post-BMP regression lines = 0.02 (umhos)
$(b_0 + b_2)$ = intercept of the post-BMP regression line = 28.82 – 6.78 = 22.04 (umhos)
$(b_1 + b_3)$ = slope of the post-BMP regression line = 0.87 + 0.02 = 0.89 (umhos)

The statistical analysis of the model is presented below. The model coefficients indicate that the model for the calibration period is represented by **Equation 17**

$Y_t = 28.82 + 0.87X_t$ **Equation 17**

**Equation 18** represents the treatment period

$Y_t = 28.82 – 6.78 + (0.87 + 0.02) X_t$ **Equation 18**

**ANCOVA Results SEC Model**

| | |
|---|---|
| Dependent Variable | SEC |
| N | 22,096 |
| Multiple R | 0.788 |
| Squared Multiple R | 0.621 |
| Adjusted Squared Multiple R | 0.621 |
| Standard Error of Estimate | 31.173 |

**Regression Coefficients B = (X'X)$^{-1}$X'Y**

| Effect | Coefficient | Standard Error | Std. Coefficient | Tolerance | t | p-Value |
|---|---|---|---|---|---|---|
| CONSTANT | 28.815 | 1.331 | 0.000 | . | 21.645 | 0.000000000 |
| USEC | 0.868 | 0.007 | 0.771 | 0.448 | 124.621 | 0.000000000 |
| PERIOD | -6.780 | 1.752 | -0.066 | 0.058 | -3.869 | 0.000109440 |
| XESEC | 0.020 | 0.010 | 0.035 | 0.061 | 2.079 | 0.037594004 |

**Confidence Interval for Regression Coefficients**

| Effect | Coefficient | 95.0% Confidence Interval Lower | Upper | VIF |
|---|---|---|---|---|
| CONSTANT | 28.815 | 26.206 | 31.425 | . |
| USEC | 0.868 | 0.854 | 0.881 | 2.235 |
| PERIOD | -6.780 | -10.215 | -3.346 | 17.208 |
| XESEC | 0.020 | 0.001 | 0.039 | 16.376 |

**Analysis of Variance**

| Source | SS | df | Mean Squares | F-Ratio | p-Value |
|---|---|---|---|---|---|
| Regression | 35,242,067.231 | 3 | 11,747,355.744 | 12,088.805 | 0.000000000 |
| Residual | 21,468,010.429 | 22,092 | 971.755 | | |

The histogram of the model residuals in **Figure 13** demonstrates a near conformity to the requirement of normal residuals, suggesting that this is an acceptable model.

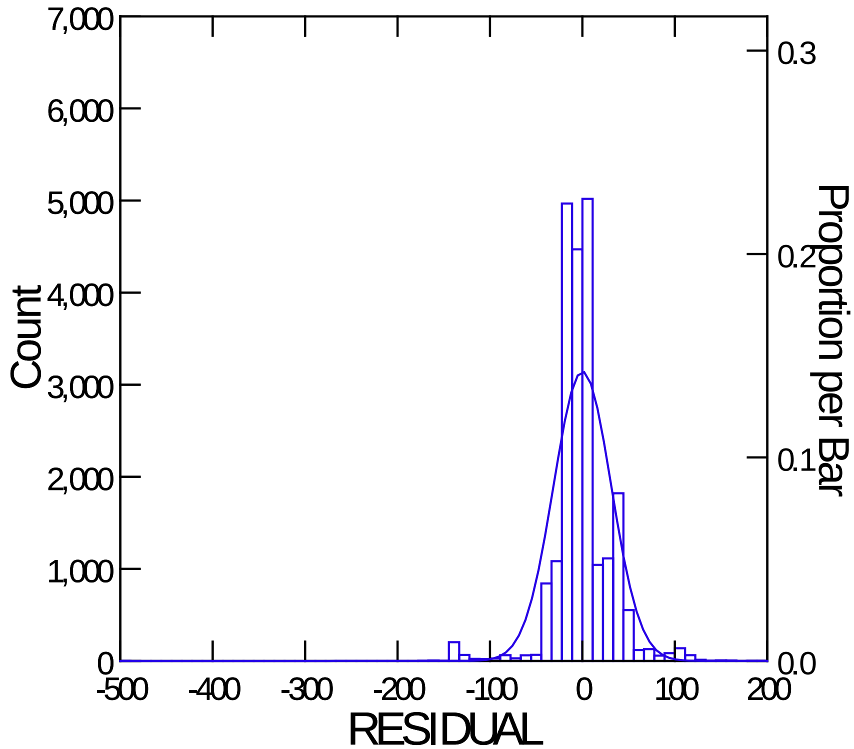


**Figure 13. Histogram of the SEC model residuals and kernal smooth for the normal distribution.**

The P value of the $b_2$ coefficient (0.000000000) indicates that there is a statistically significant difference in the y-intercepts of the calibration period and the treatment period. The $b_2$ coefficient -6.78 reveals the magnitude of the difference with the negative sign indicating that the intercept of the post-BMP period is lower than the pre-BMP period documenting that BCD had a decrease in SEC relative to BCU.

The P value of the $b_3$ coefficient (0.037594004) indicates that the slope of the post-BMP period is different than the pre-BMP period. The slope of the post-BMP model ($b_3$ = 0.02) is different by only 0.02 umhos than the pre-BMP model.

The average difference for the 'full' model was derived by setting $X_t$ = average of all the BCU SEC data (both pre-BMP period and post-BMP period). This value can be found from the results as equal to 178 umhos SEC. Substituting this value for $X_t$ in **Equations 19** and **20** results in the following functions:

**Equation 19** represents the calibration period

$Y_{tc} = 28.82 + 0.87*178$ **Equation 19**
$Y_{tc} = 183.68$

**Equation 20** represents the treatment period

$Y_{tt} = 28.82 – 6.78 + (0.87 + 0.02)*178$ **Equation 20**
$Y_{tt} = 180.46$

**Equation 21** can be used to estimate the percent increase of SEC at BCD relative to the control site BCU.

$1\text{-}(10^{Ytt}/10^{Ytc})$ **Equation 21**

substituting results in $1\text{-}(10^{180.46}/10^{183.68})$ = 0.99 or a near identical decrease in SEC.

A very powerful graphical nonparametric tool reveals the same basic conclusion reached by the statistical model. **Figure 14** demonstrates that SEC concentrations were significantly lower in the post-BMP period at BCD than in the pre-BMP period. Differences in the control site, BCU were significantly lower in the post-BMP period.

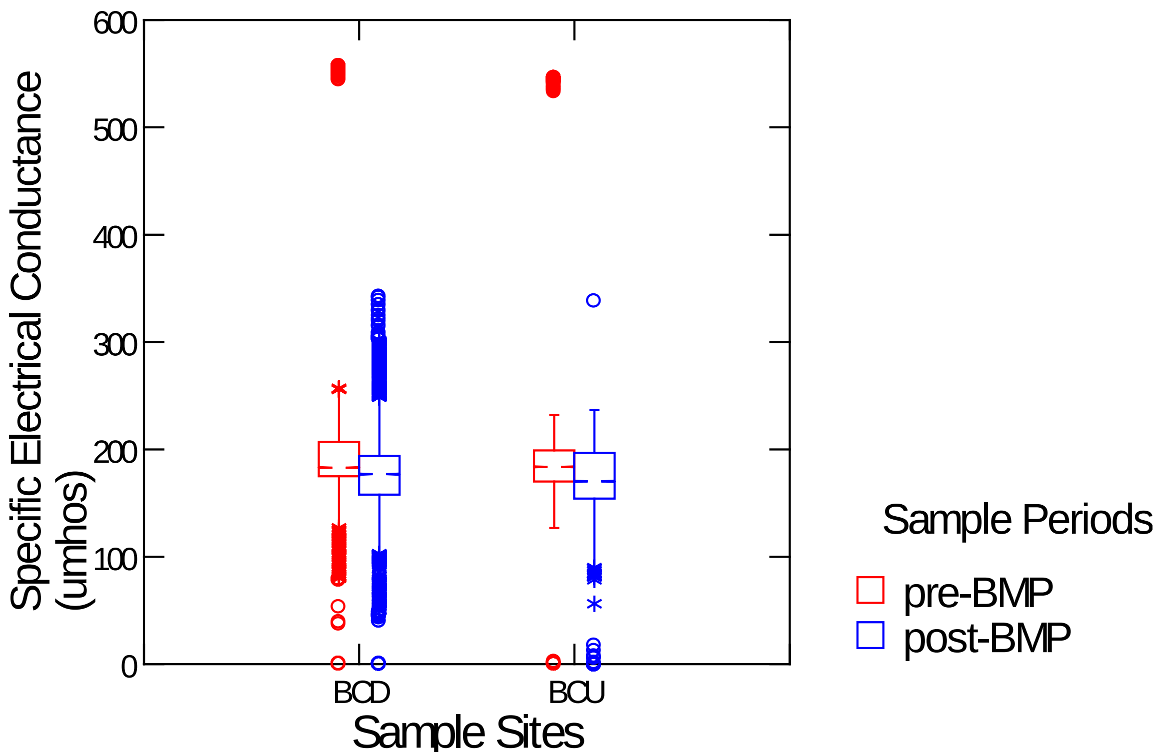


**Figure 14 Notched box plots depicts the difference between the pre-BMP and post-BMP sampling intervals for both sampling sites.**

**The model developed for the $\log_e$ of turbidity** is not presented in detail because the adjusted squared multiple R = 0.119. Although the model results were sufficient and reliable the model explains less than 12% of the total data variance for the full pH data. **Figure 15** depicts the relation between pre-BMP and post-BMP periods at BCU and BCD. Turbidity decreased during the post-BMP period relative to the pre-BMP period at both stations although slightly more at BCD. There is significant evidence that this decrease in turbidity, especially at BCD resulted in increased photosynthetic activity.

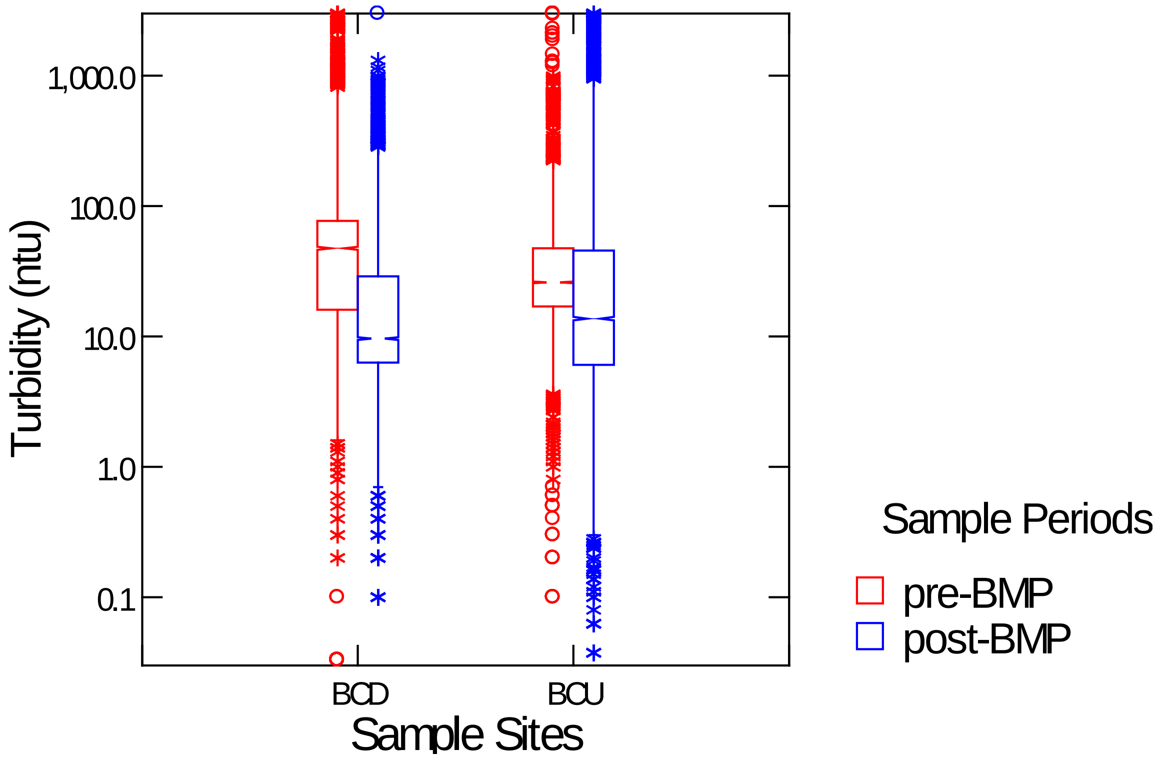


**Figure 15 Notched box plots depicts the difference between the pre-BMP and post-BMP sampling intervals for both sampling sites.**

### Discrete Sampling Program

The objective of the discrete sampling program was to collect 70% of the samples during storm events. However, as is often the case in storm chasing storms didn't materialize after mobilization of the sampling team. Several sampling trips, each year were made to the watershed in anticipation of wet weather yet not every expectation was met.

#### *Total solids*

Fifty-six pairs of reliable total solids samples were collected during the four years of sampling. The untransformed data produced a reliable model. The full model for total solids is presented as **Equation 22**

$Y_t = 0.574 + 0.736X_t + 0.399X_e - 0.182\, X_t\, X_e$ **Equation 22**

where:

$Y_t$ = Dependent variable; TS (mg/l) from Downstream Buck Creek
$X_t$ = Independent variable; TS (mg/l) from Upstream Buck Creek
$X_e$ = binomial classification variable where:
$X_e = 0$ = pre-BMP dates
$X_e = 1$ = post-BMP dates
$e_t$ = unexplained or residual error

$b_0$ = y-intercept of the pre-BMP regression line = 0.574 (mg/l)
$b_1$ = slope of the pre-BMP regression line = 0.736 (mg/l)

$b_2$ = difference in the y-intercept, TS (mg/l), between the pre-BMP and post-BMP period = 0.399 (mg/l) with y-intercept of the post-BMP being significantly higher than the pre-BMP period
$b_3$ = difference in the slope, TS (mg/l), between the pre-BMP and post-BMP regression lines = - 0.182 (mg/l)
$(b_0 + b_2)$ = intercept of the post-BMP regression line = 0.574 + 0.399 = 0.973 (mg/l)
$(b_1 + b_3)$ = slope of the post-BMP regression line = 0.736 - 0.182 = 0.554 (mg/l)

The statistical analysis of the model is presented below. The model coefficients indicate that the model for the pre-BMP period is represented by **Equation 23**

$$Y_t = 0.574 + 0.736X_t \qquad \textbf{Equation 23}$$

**Equation 24** represents the post-BMP period

$$Y_t = 0.574 + 0.399 + (0.736 - 0.182)\ X_t \qquad \textbf{Equation 24}$$

**ANCOVA Results total solids Model**

---

Dep Var: $Y_t$ N: 56 Multiple R: 0.582 Squared multiple R: 0.338

Adjusted squared multiple R: 0.300 Standard error of estimate: 0.192

| Effect | | Coefficient | Std Error | Std Coef | Tolerance | t | P(2 Tail) |
|---|---|---|---|---|---|---|---|
| CONSTANT | $(b_0)$ | 0.574 | 0.469 | 0.000 | . | 1.224 | 0.227 |
| $X_t$ | $(b_1)$ | 0.736 | 0.219 | 0.702 | 0.291 | 3.354 | 0.001 |
| $X_e$ | $(b_2)$ | 0.399 | 0.555 | 0.859 | 0.009 | 0.719 | 0.475 |
| $X_t*X_e$ | $(b_3)$ | -0.182 | 0.262 | -0.824 | 0.009 | -0.696 | 0.489 |

| Effect | Coefficient | Lower < 95%> | Upper |
|---|---|---|---|
| CONSTANT | 0.574 | -0.367 | 1.516 |
| $X_t$ | 0.736 | 0.296 | 1.176 |
| $X_e$ | 0.399 | -0.715 | 1.513 |
| $X_t*X_e$ | -0.182 | -0.707 | 0.343 |

Analysis of Variance

| Source | Sum-of-Squares | df | Mean-Square | F-ratio | P |
|---|---|---|---|---|---|
| Regression | 0.977 | 3 | 0.326 | 8.862 | 0.000 |
| Residual | 1.910 | 52 | 0.037 | | |

The Durbin-Watson D statistic indicates that the model errors are uncorrelated. The Durbin-Watson D statistic for the residuals of the model equals 2.005 is close enough to 2.00 and the First Order Autocorrelation (-0.067) is close to 0.00 autocorrelation highly unlikely to be a problem for the model.

The maximum difference as computed by the K-S test of the Total Solids model is 0.770 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, however, supports the assumption that the residuals are normally distributed (**Figure 16**).

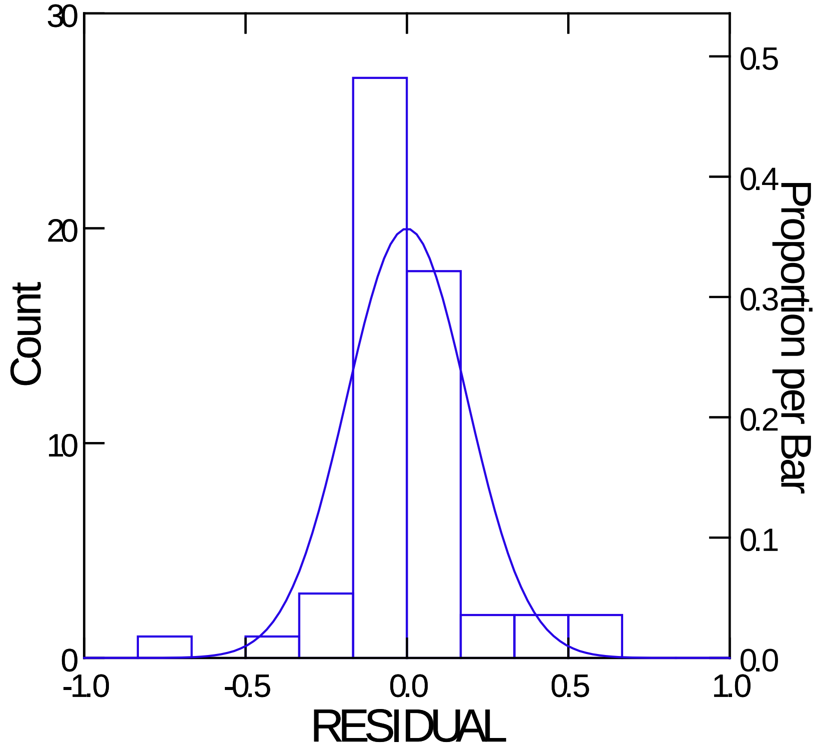


**Figure 16. Distribution of Total Solids residuals relative to the normal distribution. The fit is not acceptable.**

The P value of the $b_2$ and $b_3$ coefficients (0.475 and 0.489 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 warranted.

A very powerful graphical nonparametric tool reveals the same basic conclusion reached by the statistical model. **Figure 17** demonstrates that total solids concentrations were not significantly lower in the post-BMP period at BCD than in the pre-BMP period. Differences in the control, BCU were also not significant between the two periods.

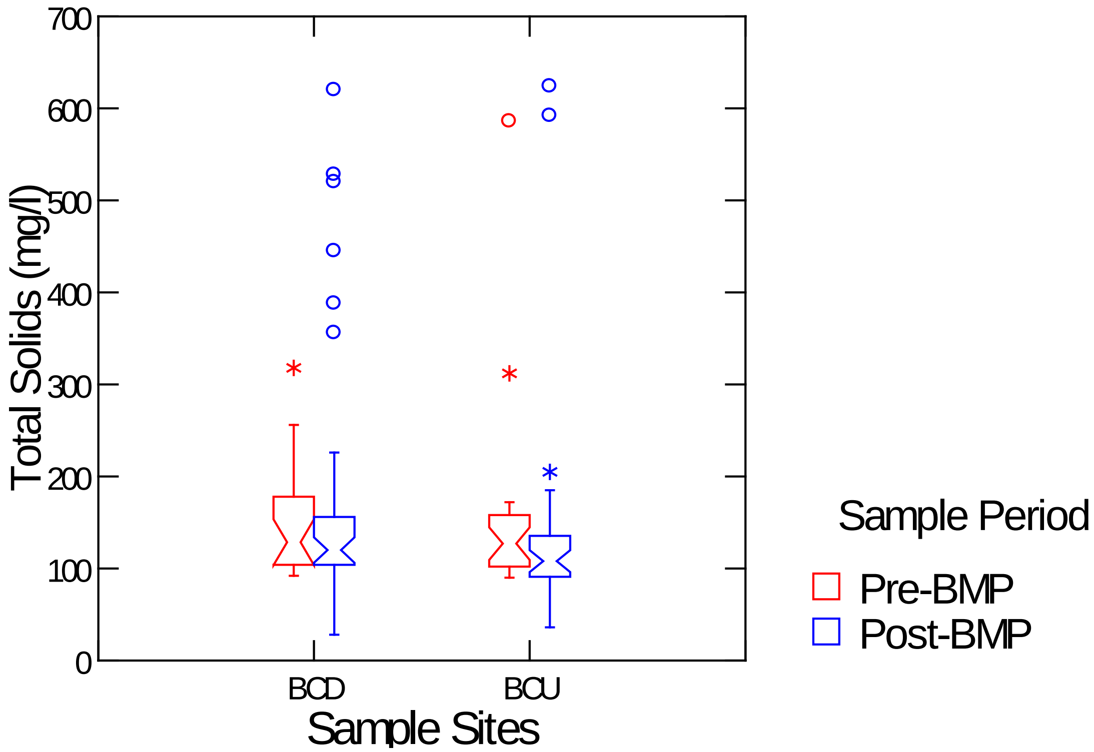


**Figure 17. Notched box plots depict the difference between the pre-BMP and post-BMP sampling intervals for both sample sites.**

### *Total suspended solids*

Fifty-six 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 25**

$Y_t = 0.329 + 0.617X_t - 0.336X_e + 0.390 X_t X_e$ **Equation 25**

where:

$Y_t$ = total suspended solids ($log_{10}$ transformed) from BCD
$X_t$ = total suspended solids ($log_{10}$ transformed) from BCU
$X_e$ = 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.

$b_0$ = y-intercept of the pre-BMP regression line = 0.329 (mg/l)
$b_1$ = slope of the pre-BMP regression line = 0.617 (mg/l)
$b_2$ = difference in the y-intercept, TSS (mg/l), between the pre-BMP and post-BMP period = - 0.336 (mg/l) with y-intercept of the post-BMP being significantly lower than the pre-BMP period
$b_3$ = difference in the slope, TSS (mg/l), between the pre-BMP and post-BMP regression lines = 0.390 (mg/l)
$(b_0 + b_2)$ = intercept of the post-BMP regression line = 0.329 - 0.336 = - 0.070 (mg/l)
$(b_1 + b_3)$ = slope of the post-BMP regression line = 0.617 + 0.390 = 1.007 (mg/l)

The statistical analysis of the model is presented below. The model coefficients indicate that the model for the calibration period is represented by **Equation 26**

$Y_t = 0.329 + 0.617X_t$ **Equation 26**

**Equation 27** represents the treatment period

$Y_t = 0.329 + -0.336 + (0.617+0.390)\, X_t$ **Equation 27**

Dep Var: $Y_t$ N: 56 Multiple R: 0.827 Squared multiple R: 0.684

Adjusted squared multiple R: 0.666 Standard error of estimate: 0.326

| Effect | | Coefficient | Std Error | Std Coef | Tolerance | t | P(2 Tail) |
|---|---|---|---|---|---|---|---|
| CONSTANT | ($b_0$) | 0.329 | 0.172 | 0.000 | . | 1.912 | 0.061 |
| $X_t$ | ($b_1$) | 0.617 | 0.142 | 0.568 | 0.356 | 4.345 | 0.000 |
| $X_e$ | ($b_2$) | -0.336 | 0.220 | -0.294 | 0.165 | -1.530 | 0.132 |
| $X_t$*$X_e$ | ($b_3$) | 0.390 | 0.177 | 0.492 | 0.121 | 2.200 | 0.032 |

| Effect | Coefficient | Lower < 95%> | Upper |
|---|---|---|---|
| CONSTANT | 0.329 | -0.016 | 0.675 |
| $X_t$ | 0.617 | 0.332 | 0.903 |
| $X_e$ | -0.336 | -0.777 | 0.105 |
| $X_t$*$X_e$ | 0.390 | 0.034 | 0.746 |

Analysis of Variance

| Source | Sum-of-Squares | df | Mean-Square | F-ratio | P |
|---|---|---|---|---|---|
| Regression | 11.989 | 3 | 3.996 | 37.578 | 0.000 |
| Residual | 5.530 | 52 | 0.106 | | |

The Durbin-Watson D statistic indicates that the model errors are uncorrelated. The Durbin-Watson D statistic for the residuals of the model equals 2.008 which is close enough to 2.00 and the First Order Autocorrelation (-0.036) is close to 0.00, autocorrelation is not a problem for the model.

The maximum difference as computed by the K-S test of the Total Suspended Solids model is 0.618 with a 2-tailed probability (P) of 0.000. 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 clearly supports the assumption that the residuals are normally distributed (**Figure 18**).

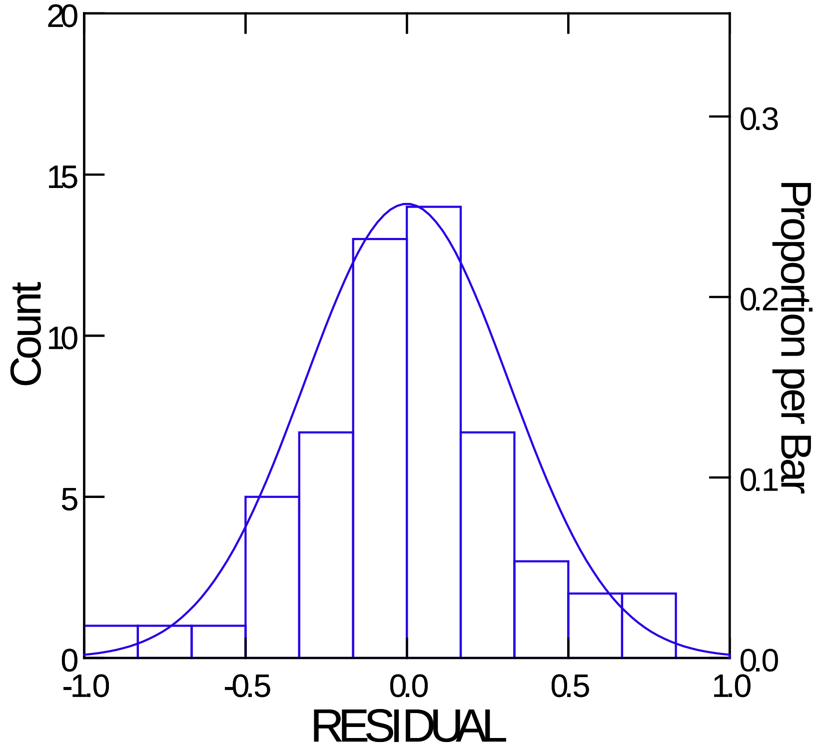


**Figure 18. Distribution of Total Suspended Solids residuals relative to the normal distribution. The normal fit appears to be good for these residuals indicating that this model is acceptable.**

The P value of the $b_2$ coefficient = 0.132 indicate that there is a not statistically significant difference in the y-intercepts of the calibration period and the treatment period. The $b_2$ coefficient -0.336 reveals the magnitude of the difference with the negative sign indicating that the intercept of the post-BMP period is lower than the pre-BMP period documenting that BCD had a decrease in TSS relative to BCU.

The P value of the $b_3$ coefficient = 0.032 indicates that there is a statistically significant difference in the slopes of the regression models. The slope of the post-BMP model ($b_3$ = 0.39) is greater by 0.39 mg/l (0.617 + 0.390 = 1.007) than that of the pre-BMP model. This indicates that a greater reduction of TSS occurred at the lower concentrations of TSS than at the higher, in other words a reduction of base flow TSS.

The average difference for the 'full' model was derived by setting $X_t$ = average of all the BCU TSS data (both pre-BMP period and post-BMP period). This value can be found from the results as equal to 1.13 mg/l TSS. Substituting this value for $X_t$ in **Equations 28** and **27** results in the following functions:

**Equation 28** represents the calibration period

$Y_{tc} = 0.329 + 0.617*1.13$ **Equation 28**
$Y_{tc} = 1.026$

**Equation 29** represents the treatment period

$Y_{tt} = 0.329 – 0.336 + (0.617 + 0.390)*1.13$ **Equation 29**

$Y_{tt} = 1.131$

**Equation 30** can be used to estimate the percent increase of SEC at BCD relative to the control site BCU.

$1\text{-}(10^{Ytt}/10^{Ytc})$ **Equation 30**

substituting results in $1\text{-}(10^{1.131}/10^{1.026}) = -0.27$ or an 27% decrease in TSS.

A very powerful graphical nonparametric tool reveals the same basic conclusion reached by the statistical model. **Figure 19** demonstrates that total suspended solids concentrations were not significantly lower in the post-BMP period in BCD than in the pre-BMP period. Differences in the control watershed, BCU were not significant between the two periods.

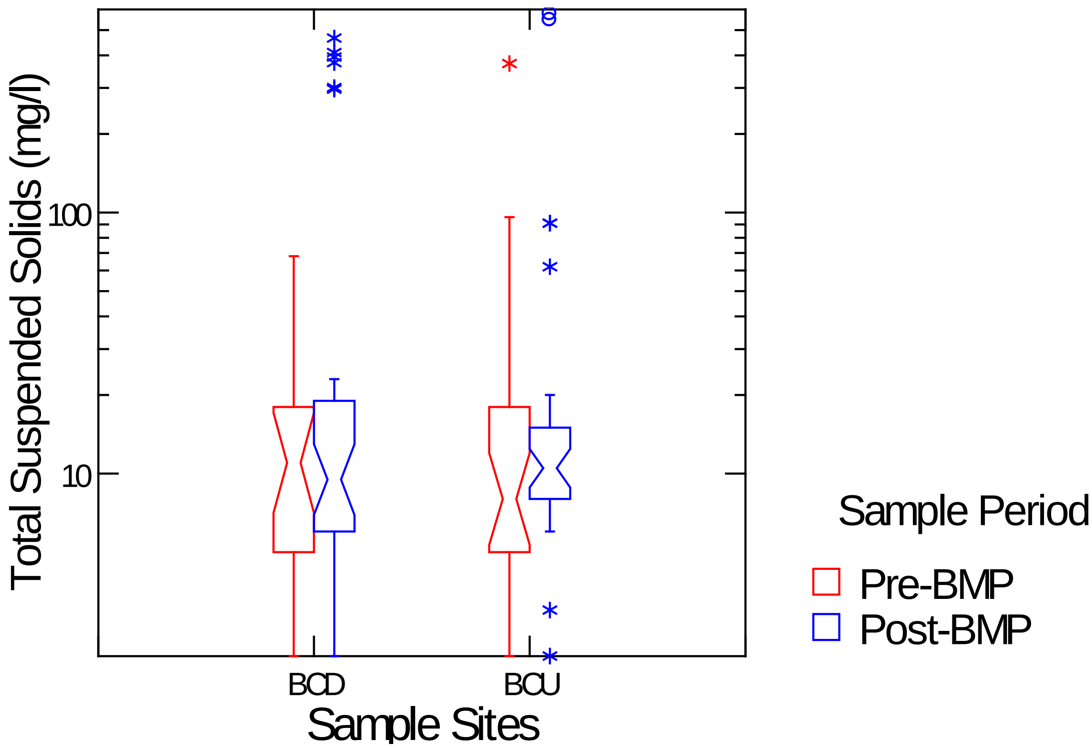


**Figure 19. Notched box plots depict the difference between the pre-BMP and post-BMP sampling intervals for both sample sites. Although, the post-BMP median at BCD is less than the pre-BMP period the difference is not statistically significant.**

### Macroinvertebrates

According to their River Continuum Concept (Vannote and others 1980) the primary energy source in the upstream sections of stream ecosystems (lotic) is material contributed by the terrestrial component of the watershed (allochthonous) because in-stream production (autochthonous ) is suppressed by shading. As stream order increases the trophic system transitions from depending on external energy inputs to more internal production from algal and rooted plant primary productivity. The sampling sites BCU and BCD are located far enough downstream in the watershed that internal production is an important if not dominant component of the stream trophic system. Large amounts of detritus (decomposing organic material), from incomplete utilization upstream, is available throughout the reach between BCU and BCD.

One hundred and eight (108) macroinvertebrate taxa were collected in the semi-quantitative and qualitative sampling combined. Seven indices were calculated to characterize the macroinvertebrate communities at BCU and BCD (**Tables 11**and **12)**.

1. **Taxa Richness** was calculated as the total number of distinct taxa found in the composite sample of both semi-quantitative and qualitative samples. Increasing taxa richness corresponds to improving water quality, habitat diversity and/or habitat suitability.
2. **Ephemeroptera, Plecoptera, Trichoptera Richness (EPT)** was calculated as the total number of Ephemeroptera, Plecoptera, and Trichoptera taxa in those orders. This index value usually increases with improving water quality, habitat diversity and/or habitat suitability.
3. **Modified Hilsenhoff Biotic Index (mHBI)** was evaluated because it is sensitive to general stressors including organic pollution such as sewage effluent or animal waste (Hilsenhoff 1987). The tolerance values used were those reported in appendix D-1, KY Division of Water, 2002
4. **Modified Percent EPT Abundance (m%EPT).** The caddisfly *Cheumatopsyhce* was excluded from the calculation. This value usually increases with improving water quality and/or habitat conditions.
5. **Percent Ephemeroptera (%Ephem).** The relative abundance of mayflies is calculated to assess impacts to the ionic composition of the water including changes in specific electrical conductance.
6. **Percent Chironomidae+Oligochaeta (%Chir+%Olig).** Increasing abundance of these groups suggests decreasing water quality conditions. Zweig and Rabeni, (2001) report results that indicate genus-level identification is necessary for some invertebrates, especially Chironomidae.
7. **Percent Primary Clingers (%Clingers).** Is a habitat metric measure designed to assess the relative abundance of those organisms that need hard, silt-free substrates to "cling" to.

The results of the metric analysis is presented below in table form and graphically using notched box-plots.

**Table 11. Results of metrics for each sample site and date.**

| Sample Site | Sample Period | Date | Taxa Richness | EPT Richness | modified Hilsenhoff Biotic Index | m%EPT |
|---|---|---|---|---|---|---|
| BCU | Pre-BMP | May-06 | 78 | 21 | 5.47 | 29.4% |
| BCU | Pre-BMP | Jul-06 | 81 | 27 | 5.39 | 33.9% |
| BCU | Pre-BMP | May-07 | 75 | 27 | 5.13 | 29.9% |
| BCU | Pre-BMP | Jul-07 | 70 | 10 | 5.83 | 18.2% |
| BCU | Post-BMP | Jun-09 | 60 | 14 | 5.89 | 50.7% |
| BCU | Post-BMP | Aug-09 | 61 | 24 | 5.48 | 11.1% |
| BCU | Post-BMP | May-10 | 46 | 18 | 5.21 | 25.2% |
| BCU | Post-BMP | Jul-10 | 57 | 19 | 5.66 | 44.4% |
| BCD | Pre-BMP | May-06 | 65 | 22 | 5.92 | 35.0% |
| BCD | Pre-BMP | Jul-06 | 68 | 28 | 5.44 | 45.8% |
| BCD | Pre-BMP | May-07 | 54 | 28 | 4.62 | 39.3% |
| BCD | Pre-BMP | Jul-07 | 62 | 21 | 5.53 | 52.0% |
| BCD | Post-BMP | Jun-09 | 62 | 11 | 6.09 | 41.3% |
| BCD | Post-BMP | Aug-09 | 41 | 15 | 5.01 | 20.0% |
| BCD | Post-BMP | May-10 | 24 | 8 | 6.07 | 17.9% |
| BCD | Post-BMP | Jul-10 | 39 | 17 | 5.38 | 70.3% |

Taxa Richness was higher at BCU for every sampling date except the June 2009. Taxa Richness was significantly lower in the post-BMP period than the pre-BMP at both locations (**Figure 20**). This result indicates that the macroinvertebrate community, as defined by Taxa Richness, didn't improve following BMP implementation. The magnitude of the difference increased in the post-BMP but wasn't statistically different.

EPT Richness was greater at BCD for every date of the pre-BMP period. However, the reverse was true in the post-BMP period, with EPT Richness being considerably, higher at BCU. EPT Richness decreased significantly between the pre and post BMP periods at BCD, although not at BCU (**Figure 21**). This indicates that the macroinvertebrate community, as defined by EPT Richness, didn't improve following BMP implementation and may have worsened.

The modified Hilsenhoff Biotic Index didn't exhibit any pattern relative to the pre and post-BMP period at either location (**Figure 22**). There were no significant differences between the BCD and BCU sites indicating that the macroinvertebrate community, as defined by the modified Hilsenhoff Biotic Index, didn't improve following BMP implementation.

**Table 12. Results of metrics for each sample site and date.**

| Sample Site | Sample Period | Date | % Ephemeroptera | %Chir+%Olig | %Clingers |
|---|---|---|---|---|---|
| BCU | Pre-BMP | May-06 | 12.6% | 37.7% | 47.2% |
| BCU | Pre-BMP | Jul-06 | 29.9% | 36.9% | 28.4% |
| BCU | Pre-BMP | May-07 | 14.4% | 16.4% | 63.6% |
| BCU | Pre-BMP | Jul-07 | 16.8% | 23.8% | 18.2% |
| BCU | Post-BMP | Jun-09 | 9.2% | 6.3% | 64.8% |
| BCU | Post-BMP | Aug-09 | 10.3% | 7.8% | 76.1% |
| BCU | Post-BMP | May-10 | 19.6% | 3.8% | 81.1% |
| BCU | Post-BMP | Jul-10 | 41.9% | 23.1% | 28.2% |
| BCD | Pre-BMP | May-06 | 14.5% | 53.3% | 28.7% |
| BCD | Pre-BMP | Jul-06 | 43.8% | 43.0% | 18.5% |
| BCD | Pre-BMP | May-07 | 6.6% | 6.6% | 85.5% |
| BCD | Pre-BMP | Jul-07 | 46.1% | 9.2% | 33.6% |
| BCD | Post-BMP | Jun-09 | 8.5% | 28.0% | 45.5% |
| BCD | Post-BMP | Aug-09 | 19.6% | 12.8% | 67.6% |
| BCD | Post-BMP | May-10 | 15.4% | 46.2% | 30.8% |
| BCD | Post-BMP | Jul-10 | 68.9% | 16.2% | 31.1% |

The modified Percent EPT Abundance didn't exhibit any pattern relative to the pre and post-BMP period at either location (**Figure 23**). There were no significant differences between the BCD and BCU sites indicating that the macroinvertebrate community, as defined by the modified Percent EPT Abundance, didn't improve following BMP implementation.

The Percent Ephemeroptera didn't exhibit any pattern relative to the pre and post-BMP period at either location (**Figure 24**). There were no significant differences between the BCD and BCU sites indicating that the macroinvertebrate community, as defined by the Percent Ephemeroptera, didn't improve following BMP implementation.

The Percent Chironomidae+Oligochaeta decreased significantly at BCU between the pre and post-BMP periods indicating an improvement in water quality or habitat at the reference site (**Figure 25**). At the BCD site no significant change occurred indicating that the macroinvertebrate community, as defined by the Percent Chironomidae+Oligochaeta, didn't improve following BMP implementation.

Percent Primary Clingers didn't exhibit any pattern relative to the pre and post-BMP period at either location (**Figure 26**). There were no significant differences between the BCD and BCU sites indicating that the macroinvertebrate community, as defined by the Percent Primary Clingers, didn't improve following BMP implementation.

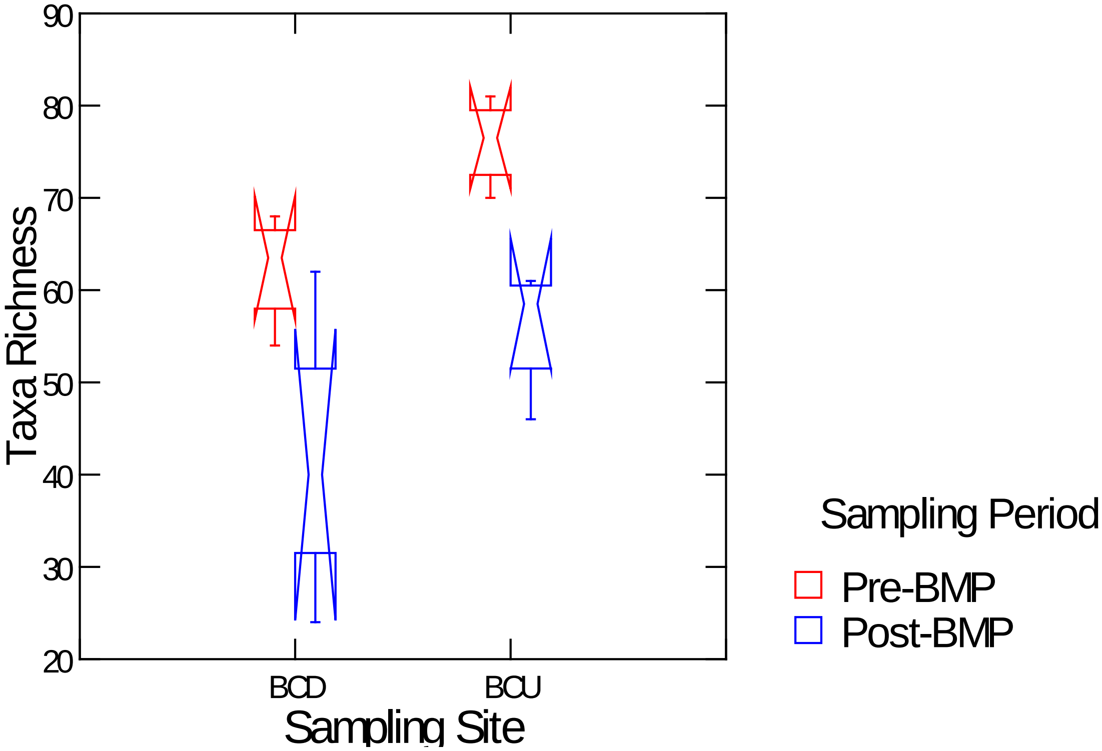


**Figure 20. Notched box plots depict the difference for Taxa Richness between the pre-BMP and post-BMP sampling intervals for both sample sites. The post-BMP median at BCD and BCU is significantly less than the pre-BMP period. The difference is statistically significant.**

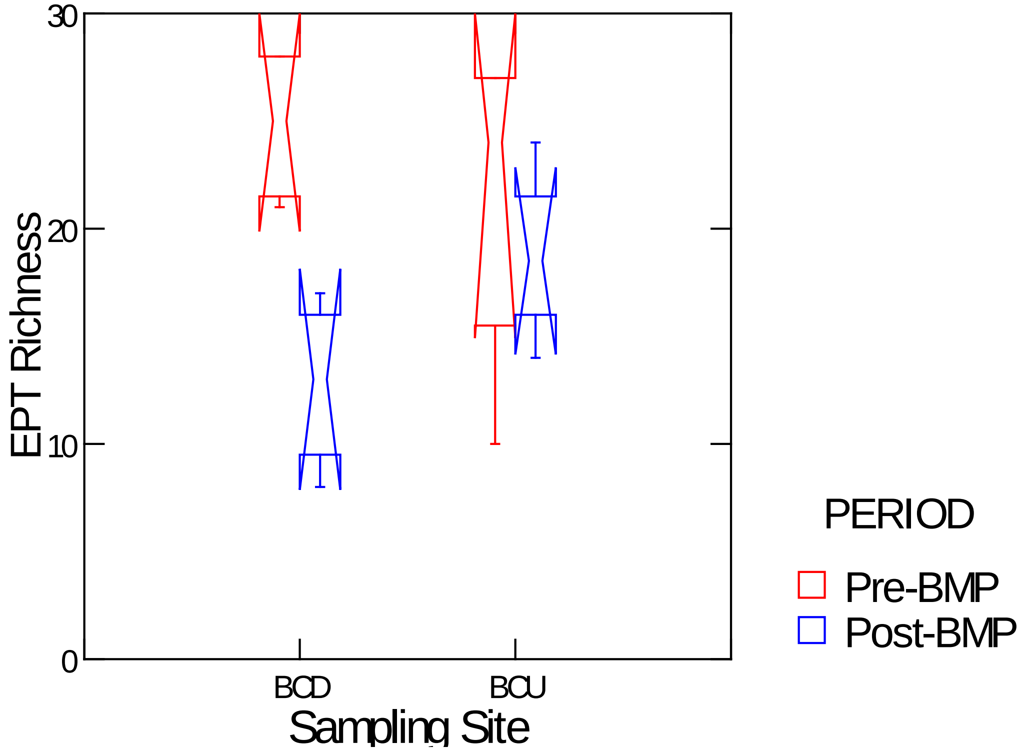


**Figure 21. Notched box plots depict the difference for Ephemeroptera, Plecoptera, Trichoptera Richness between the pre-BMP and post-BMP sampling intervals for both sample sites. The post-BMP median at BCD is significantly less than the pre-BMP period. The difference is statistically significant. The difference wasn't observed at BCU.**

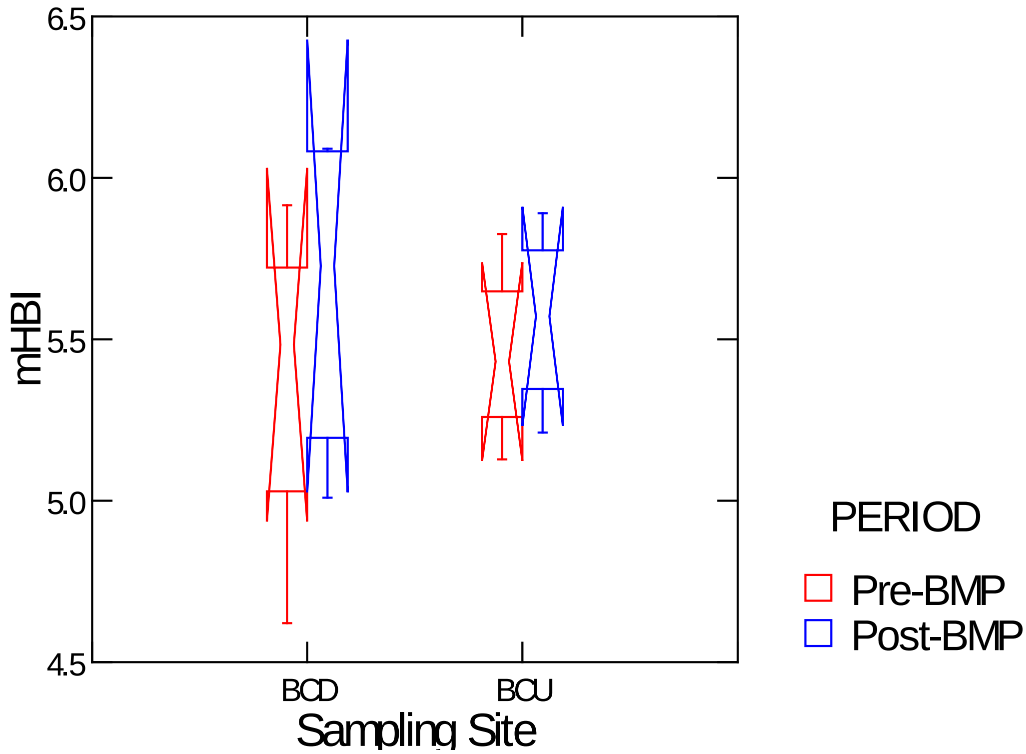


**Figure 22. Notched box plots depict the difference for Modified Hilsenhoff Biotic Index between the pre-BMP and post-BMP sampling intervals for both sample sites. Although, the post-BMP median at BCD is greater than the pre-BMP period the difference is not statistically significant.**

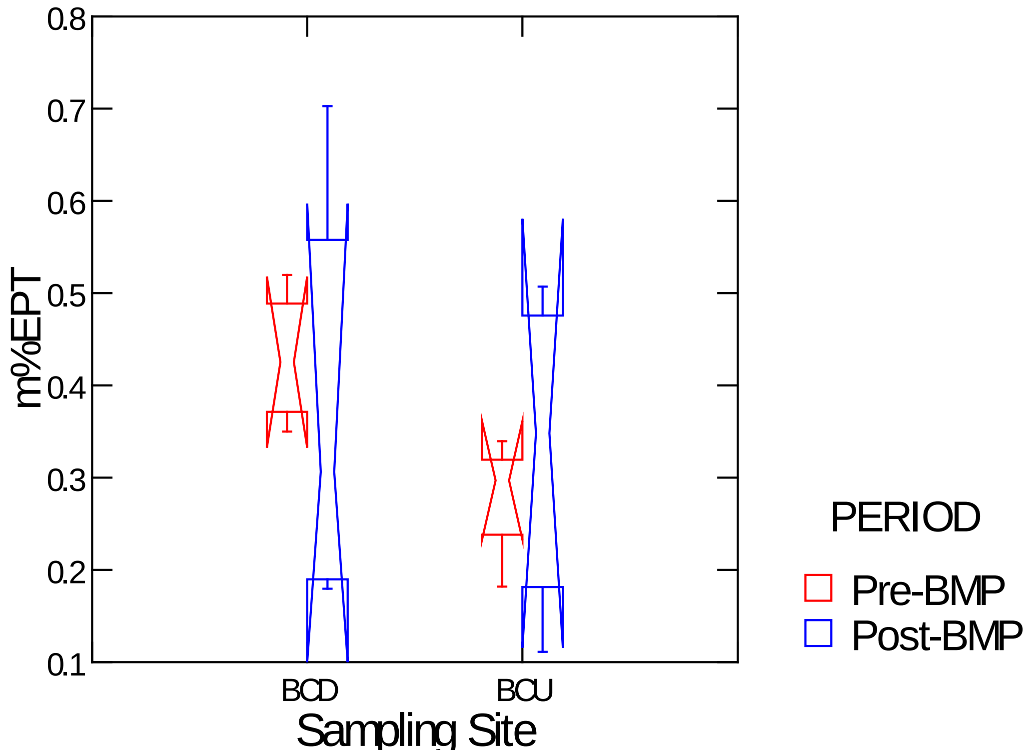


**Figure 23. Notched box plots depict the difference for Modified Percent EPT Abundance between the pre-BMP and post-BMP sampling intervals for both sample sites. Although, the post-BMP median at BCD is less than the pre-BMP period the difference is not statistically significant.**

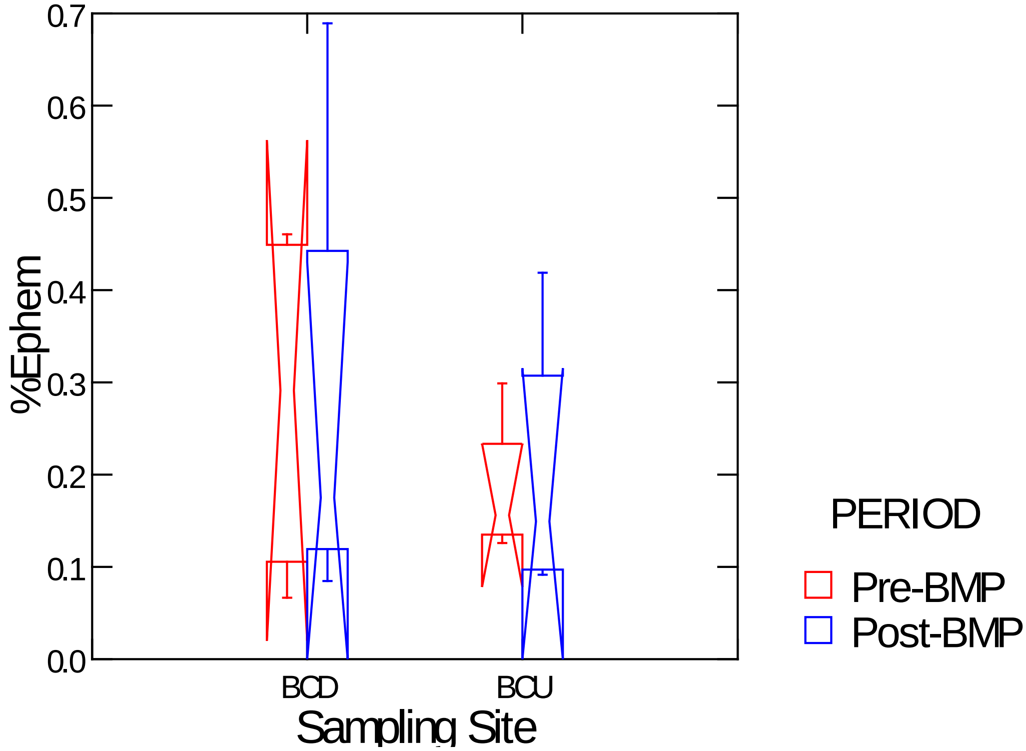


**Figure 24. Notched box plots depict the difference between the pre-BMP and post-BMP sampling intervals for both sample sites. Although, the post-BMP median at BCD is less than the pre-BMP period the difference is not statistically significant.**

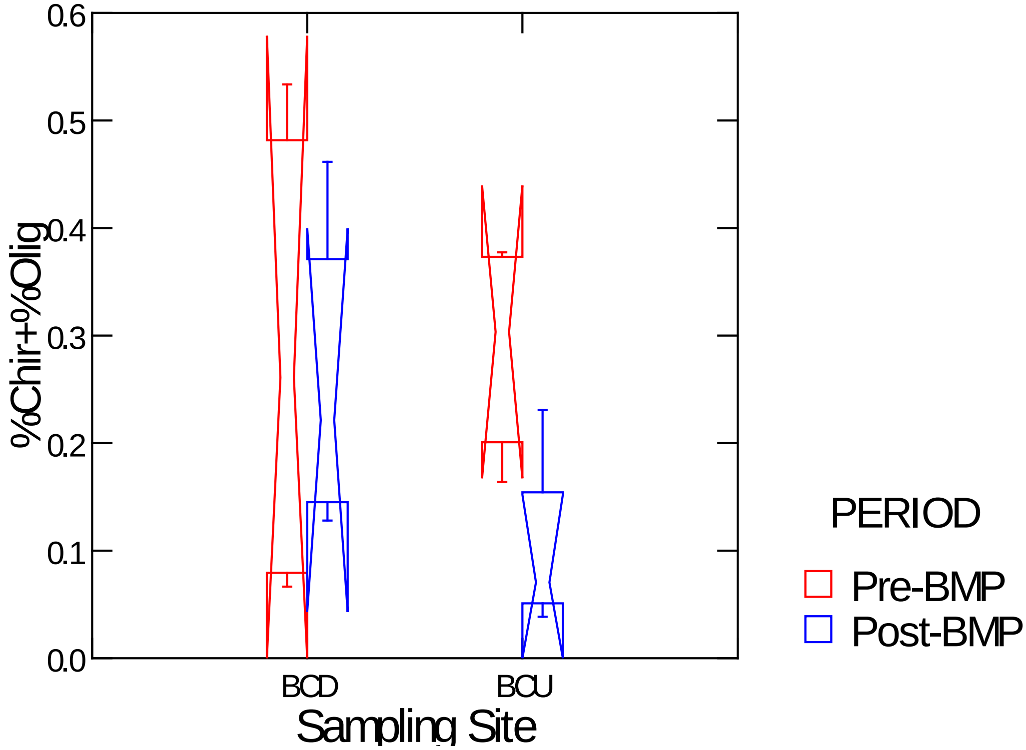


**Figure 25. Notched box plots depict the difference between the pre-BMP and post-BMP sampling intervals for both sample sites. Although, the post-BMP median at BCD is less than the pre-BMP period the difference is not statistically significant.**

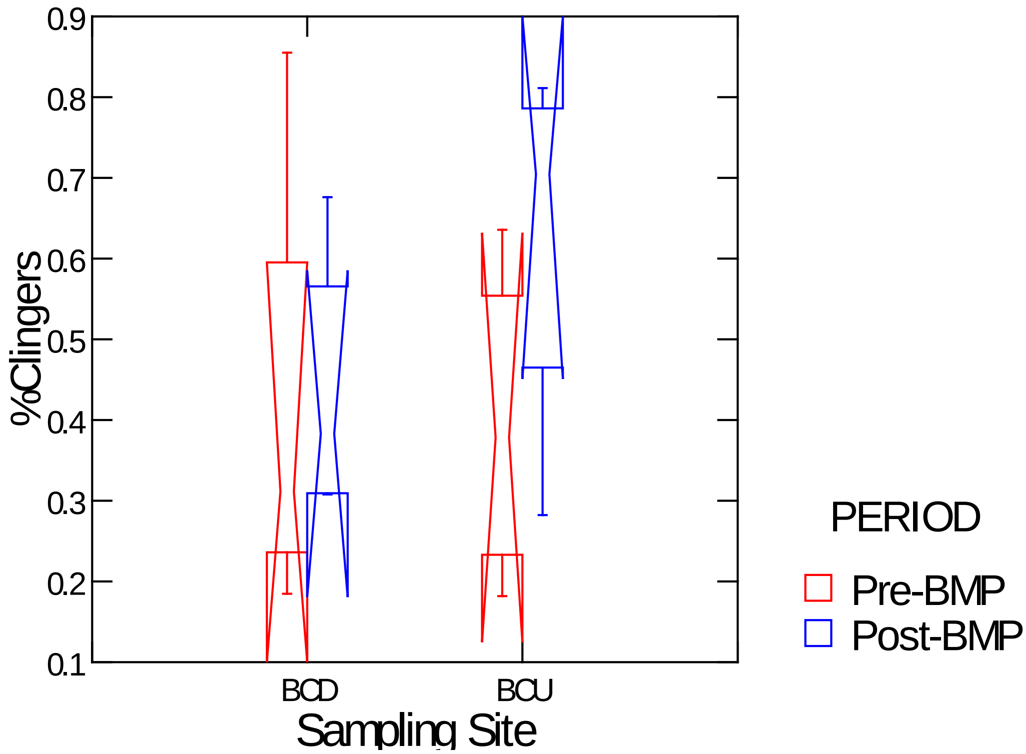


**Figure 26. Notched box plots depict the difference between the pre-BMP and post-BMP sampling intervals for both sample sites. Although, the post-BMP median at BCD is less than the pre-BMP period the difference is not statistically significant.**

## Algae

Algal photosynthesis is the base of the autochthonous food production in streams converting minerals and inorganic carbon to organic foodstuffs for much of the rest of the food chain. Algae frequently play an important role in material and energy fluxes in small stream and river ecosystems. The photosynthetic process also strongly influences the pH and oxygen dynamics in the water column and sediments of streams.

Photosynthesis and respiration are two important metabolic reactions of aquatic environments. The equations defining these reactions are often coupled to demonstrate the relations between them and their dependencies (**Equation 31**).

**Equation 31** $$6CO_2 + 6H_2O \underset{Respiration}{\overset{Photosynthesis}{\rightleftharpoons}} C_6H_{12}O_6 + 6O_2$$

This set of reactions produces oxygen during the day, sometimes to supersaturated levels, and consumes $CO_2$, forcing pH to rise. In some cases, pH can be forced higher than 9.0 pH units (above state water quality criteria). Also important, in the presence of elevated pH and water temperatures, the balance of ionized (ammonium) and un-ionized ammonia nitrogen can be caused to shift. The latter compound is extremely toxic to most aquatic life and, although uncommon under most stream water conditions, can become more common as water temperatures and pH rises.

Primary production by benthic algae and macrophytes, on and within streams and rivers, is a main source of energy and nutrition for higher trophic levels in the food web. In addition, these organisms can be considered biochemical treatment plants because their metabolic activity can modify materials entering the stream system from the terrestrial catchment. This material processing has long been recognized for its filtering effects. Part of the autochthonous organic matter (originating in stream) produced by these autotrophs will be consumed by the organisms themselves, and by all the other bacteria, fungi, and animals of the stream and river community for the maintenance of life, for growth, and reproduction. Another part will be exported downstream in the river ecosystem, or accumulated into organic sediments.

Algal samples were collected from 2.5 $cm^2$ unglazed clay tiles (**Figure 27**) suspended in the water column for 14 days at both locations, BCU and BCD, twice a year for four years for a total of 16 samples. Aufwuchs material was removed from only one 2.5 $cm^2$ surface for each tile. The collected material was rubbed from the surface of the tile into a funnel that directed the flow into a sampling container. By collecting uniform surface areas it was easier to accurately calculate densities and consequently easier to compare sample densities from station to station and date to date.

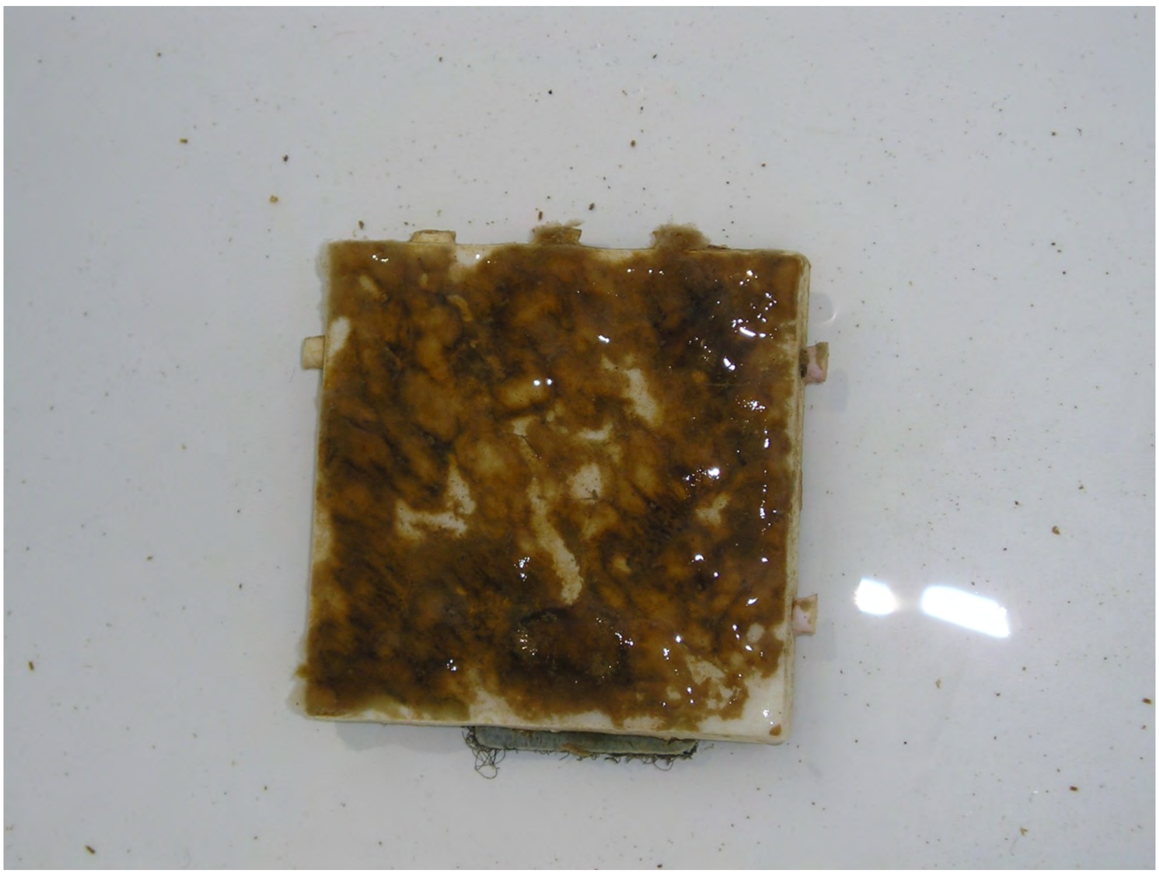

**Figure 27. Aufwuchs community developed on 2.5 $cm^2$ unglazed clay tile after 14 day incubation.**

More than 450 cells per sample for each of the 16 samples were counted and densities calculated. Algal cell densities are affected by numerous factors including nutrients, light current, water temperature, competition, predation, turbidity and scour, and substrate. Clay tiles were used in this study to normalize the substrate effect. Two tiles were composited for each of the 16 samples to reduce between tile differences.

Four indices were calculated for each sample, Shannon's Diversity, Evenness, Taxa Richness, and Relative Density. Four sets of algal samples were collected at each location both Pre- BMP implementation and Post-BMP implementation. These relations are depicted below using notched boxplots.

General evaluation of the boxplots indicate that the four samples collected in each of the four different treatments do not adequately characterize the median of any of the indice's variabilities. Consequently, interpretation of data patterns are not very reliable. Algal diversity depicted in **Figure 28** did not vary significantly between treatment location or treatment period. Diversity at the two locations during the Post-BMP period was very similar. During the Pre-BMP period a single diversity sample at the BCU site influenced that data depiction dramatically. No discernible pattern exists for this data indicating that at the level of sampling conducted for this attribute was inadequate for determining the effectiveness of the BMP program.

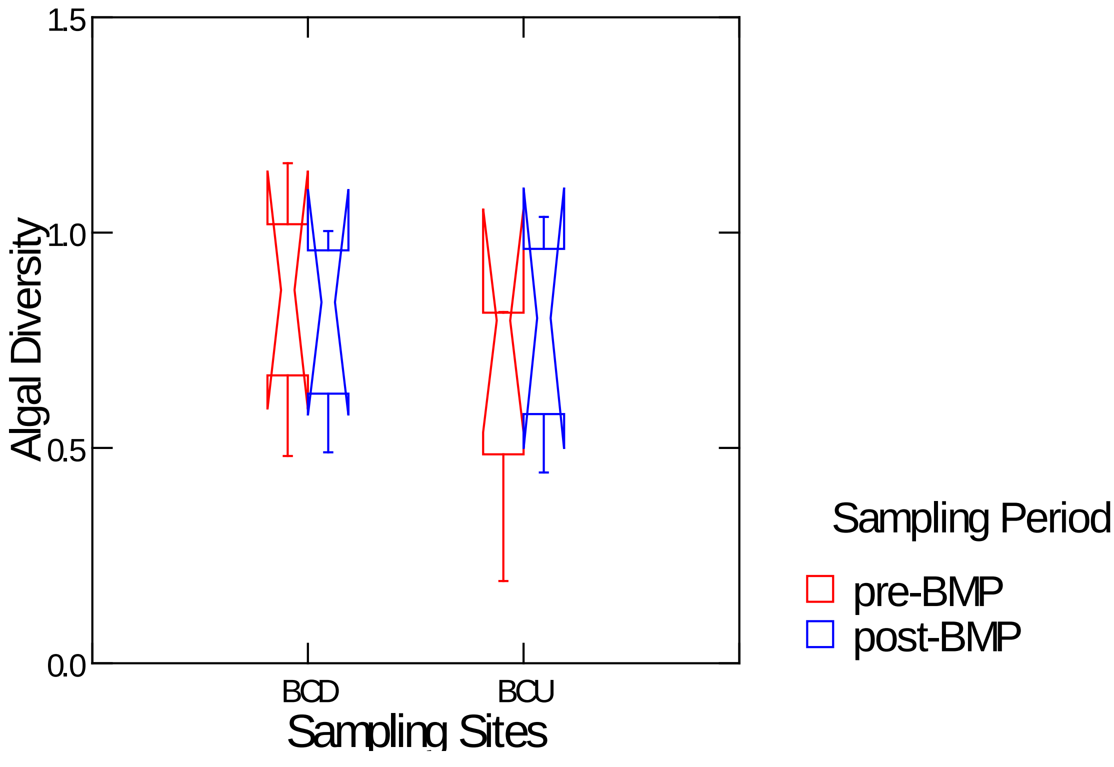


**Figure 28 Shannon Diversity values by treatment location and period.**

Taxa Evenness, depicted in **Figure 29**, did not vary significantly between treatment location or treatment period, however, the median value for both BCU and BCD appeared to increase slightly from the Pre-BMP period to the Post-BMP period. BCU appears to generally be influenced by a few taxa more commonly than BCD which generally exhibits more even taxa distribution. However, the patterns depicted by the boxplots are not statistically significant. Only a slightly discernible pattern exists for this data (although it is not statistically significant) indicating that at the level of sampling conducted for this attribute was inadequate for determining the effectiveness of the BMP program.

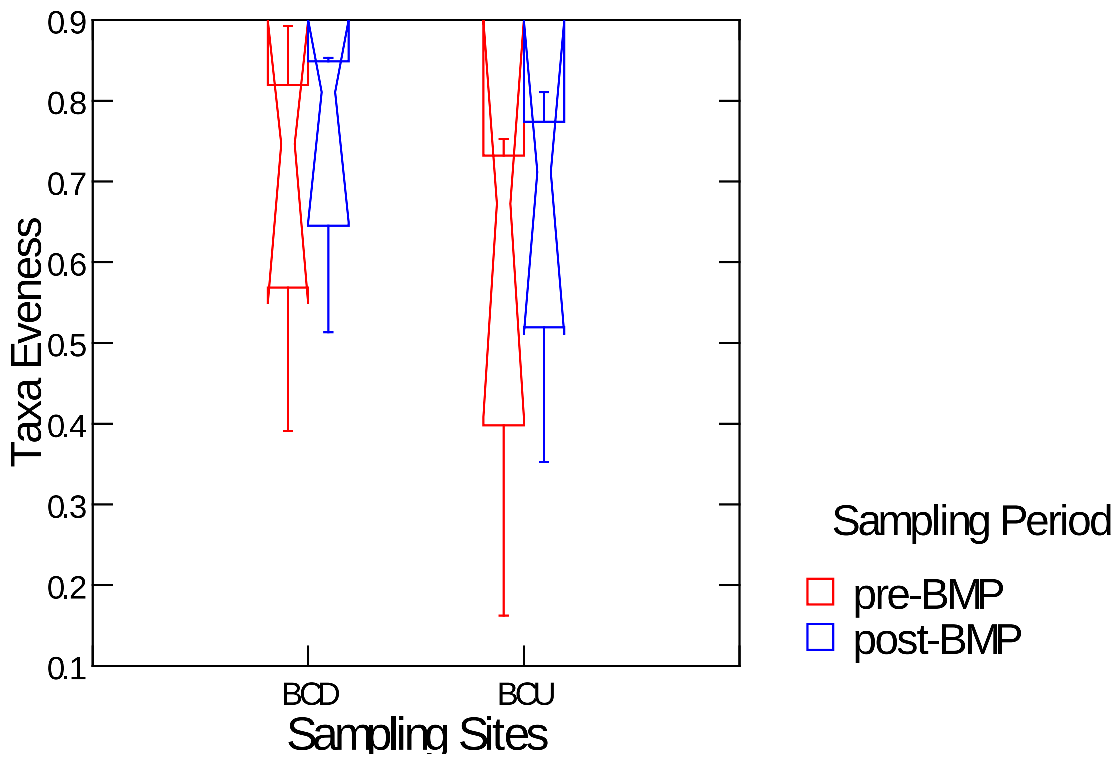


**Figure 29. Taxa Evenness values by treatment location and period.**

Taxa Richness, depicted in **Figure 30**, did not vary significantly between treatment location or treatment period, however, the median value for BCD decreased from the Pre-BMP period to the Post-BMP period while BCU increased during the period. This slightly discernible pattern (although it is not statistically significant) suggests that, at the level of sampling conducted for this attribute, it appears that Taxa Richness declined at the BCD site while slightly increasing at the BCU site. This is not the pattern desired but is likely explained by the physical alteration of stream habitat by the washing away of a major root wad at the BCD site along with gravel mining. It is not believed that the BMPs installed led to the reduction of Taxa Richness at BCU.

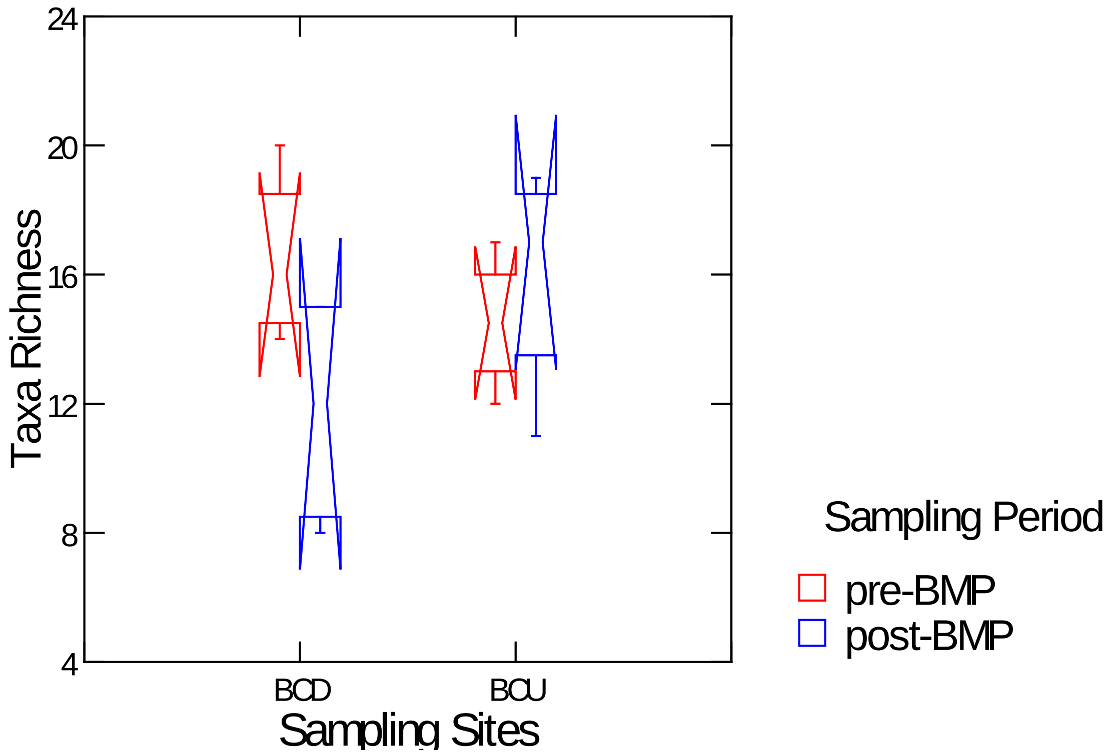


**Figure 30. Taxa Richness values by treatment location and period.**

Relative Density, depicted in **Figure 31**, did not vary significantly between treatment location or treatment period. The median value shows no pattern at all, however, variability was greater in the Pre-BMP period at BCU resulting from the large bloom of Achnanthidium minutissimum (Kützing) Czarnecki during August 2007.

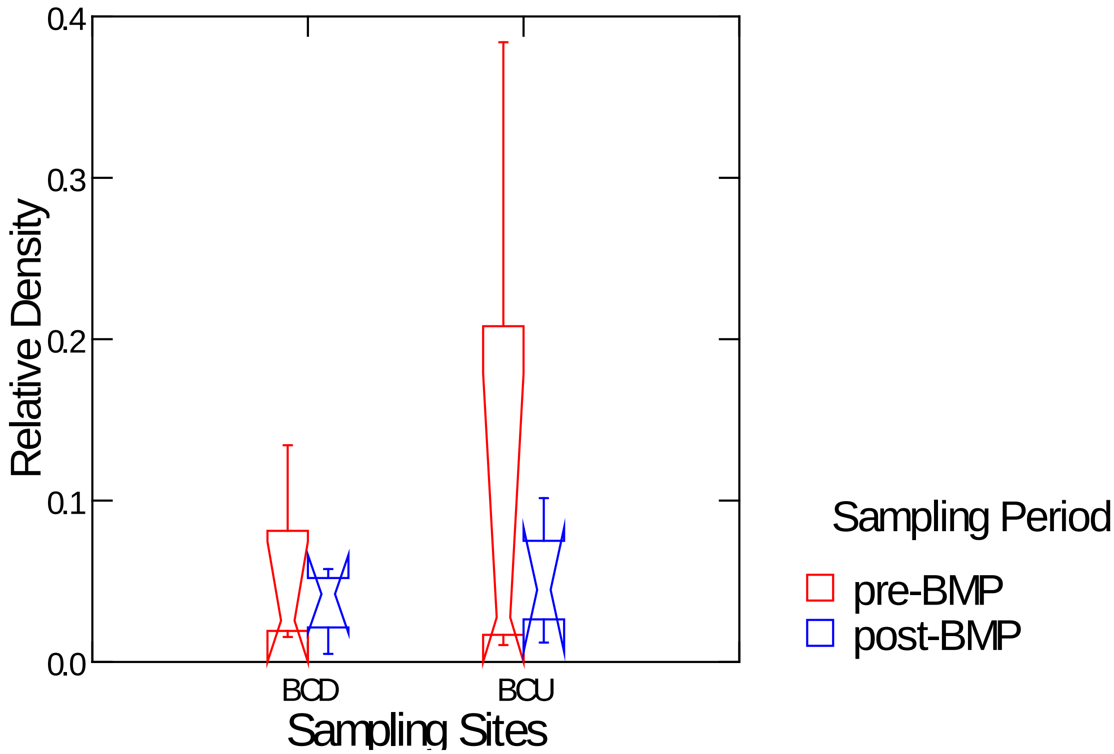


**Figure 31. Relative Density values by treatment location and period.**

**Table 13** lists the 20 most common taxa growing on the tile surface or within the aufwuchs community developed on the tiles.

**Table 13. Twenty most common taxa, from all counts combined, ranked from "Most Common" (top) to the 20th "Most Common" (bottom) and presented with their Cumulative Relative Density. These 20 taxa accounted for 99% of all taxa counted.**

| Rank by Density | Taxa | Cumulative Relative Density |
|---|---|---|
| 1 | Achnanthidium minutissimum (Kützing) Czarnecki | 0.6474 |
| 2 | Achnanthes lanceolata (Brébisson) Grunow | 0.6863 |
| 3 | Melosira varians Agardh | 0.7233 |
| 4 | Cocconeis placentula var lineata (Ehrenberg) Van Heurck | 0.7569 |
| 5 | Gomphonema angustatum (Kützing) Rabenhorst | 0.7886 |
| 6 | Nitzschia palea (Kützing) W. Smith | 0.8195 |
| 7 | Fragilaria vaucheriae var vaucheriae (Kutz.) Peters. | 0.8487 |
| 8 | Navicula capitatoradiata Germain | 0.8712 |
| 9 | Navicula cryptocephala Kützing | 0.8880 |
| 10 | Synedra ulna (Nitzsch) Ehrenberg | 0.9048 |
| 11 | Nitzschia acicularis (Kützing) W. Smith | 0.9209 |
| 12 | Cymbella affinis Kützing | 0.9349 |
| 13 | Achnanthes deflexa Reimer | 0.9462 |
| 14 | Synedra rumpens var rumpens Geitler | 0.9570 |
| 15 | Nitzschia fonticola Grunow | 0.9665 |
| 16 | Achnanthes clevei Grunow | 0.9720 |
| 17 | Achnanthes exigua var elliptica Hustedt | 0.9769 |
| 18 | Nitzschia dissipata var dissipata (Kützing) Grunow | 0.9810 |
| 19 | Diatoma vulgare Bory | 0.9844 |
| 20 | Cymbella minuta Hilse ex Rabenhorst | 0.9869 |

# Conclusions

Best Management Practices (BMPs) were installed in four subwatersheds whose drainages flow to Buck Creek. To evaluate the effectiveness of these BMPs two sampling stations, one upstream of the tributaries confluence (BCU; control site) and the other downstream (BCD; impacted site). The results of the four years of sampling indicate that dissolved oxygen, the most important of the water quality attributes, improved significantly and the improvement corresponds to the implementation of BMPs. The reliability of this conclusion is very high. Other attributes measured were less definitive in their support of BMP success with some macroinvertebrate metrics indicating deteriorating conditions, however, the reliability of these conclusions is low.

Buck Creek is a very dynamic hydrologic and hydraulic system. During the five years this study was conducted several storms occurred producing enough streamflow to significantly modify the fluvial geomorphological landscape of the watershed. In addition, the system is continually subject to biological modifications. BCU, the upstream site was repeatedly dammed by beavers, dams that were breached by storms or completely destroyed only to be rebuilt. The downstream site, BCD, was modified repeatedly and dramatically by gravel mining upstream of the sampling site. Both sites were impacted, sometimes significantly, by trees, woody debris or root wads moving through the system. A deposit of this debris traps other materials and can modify the stream hydraulics, producing scour or deposition areas that can alter habitat across the stream potentially affecting macroinvertebrate habitat.

Extensive water quality and biological monitoring data was statistically analyzed and modeled to evaluate the effectiveness for BMPs implemented in the Buck Creek watershed between BCU and BCD. Over 5,300 hours of in-situ water quality data were collected for water temperature, dissolved oxygen, dissolved oxygen deficit, pH, specific electrical conductance, and turbidity between May of 2006 and October of 2010. This data was by far the most reliable data collected. Confidence in the data and the statistics generated by the data is much higher with this data as can be observed with the numerous notched box plots presented in the text. Notches for the in-situ data are very small, in most cases almost imperceptibly small, whereas with all the other data the notches are very large often extending beyond the interquartile range. This condition exists because the variability of the data is too great for the number of data collected to explain or characterize the variance.

Dissolved oxygen, the most important water quality attribute, improved between 2006 and 2010. Both DO and dissolved oxygen deficit (DOD) were evaluated at the sampling site below the BMPs, BCD, and upstream of the BMPs, BCU. BCD had an increase in DO and a decrease in DOD relative to BCU. Statistical modeling indicates a significant probability that the BMPs contributed to these water quality improvements. Additional evidence of water quality improvement was a 12.0% decrease in the number of days with acute DO violations at BCD during the post-BMP period relative to the pre-BMP period, whereas, BCU decreased by only 5.3% during that period. A 12.3% decrease in chronic DO violations was observed at BCD and a 12.9% decrease at BCU suggesting that the BMPs can't be credited with the decrease in chronic DO violations.

Although, pH increased during the post-BMP period relative to the pre-BMP period it did so at both stations, though slightly more at BCD. Consequently, changes in pH can't be attributed in any significant way to the BMPs.

There was a statistically significant decrease in SEC at BCD relative to BCU, however, the difference of 0.02 umhos is not meaningful and doesn't indicate much of an improvement due to the BMPs.

Turbidity didn't produce a significant model. The decreased turbidity during the post-BMP period relative to the pre-BMP period was observed at both stations, although slightly more at BCD. There is evidence that this decrease in turbidity, especially at BCD resulted in increased photosynthetic activity.

Neither total solids nor total suspended solids were statistically different as a result of BMP activity. These water quality attributes were collected far less frequently than the in-situ attributes discussed above and consequently the results from these analyses are not as reliable. The notched box plots do indicate that these results are more reliable than the results of the biological data which were not collected as frequently.

Seven metrics were used to characterize the macroinvertebrate community response to BMP implementation and four metrics were used to evaluate the algal response. None of the metrics improved in response to BMPs. The macroinvertebrate metric, EPT richness, significantly decreased at BCD relative BCU suggesting poorer environmental conditions.

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 rarely 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." 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 Buck 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 KY and elsewhere has produced several lessons that guided or influenced the design and implementation of the Buck 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. John Burnett a farmer that lives in the Buck Creek 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.

Unpredictable climatic conditions during the monitoring period, beaver activities and gravel mining activities all contributed to the monitoring results. Many of the issues associated with this project and projects such as the Buck Creek 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

Workplan Outputs

**319 Plan Overview**

- Review year 1 Pre-BMP monitoring data.
- Develop landowner participant applications
- Develop application score sheet to base applicant's score on their proximity to streams and other criteria (we did not want the applications to be first come first serve).
- Set a sign-up period for applications.
- Have project advertisement and informative session and/or sessions to inform landowners in the project area, how it is set-up, how to apply, what is available for funding, time line of events, and other similar items.
- Visit landowners that are good potential project participants to further inform them in detail of the project.
- The first sign-up period will begin spring 2007.
- Farm visits will be made to applicants to check to see what practices they will qualify for and to help the landowners brainstorm about what practices they need how they will fit into there existing operations.
- At the end of the sign-up period the POC will score applicants.
- All applicants will be notified as being approved, or being not approved.
- Survey and design of practices for approved applicants.
- Complete Year 2 Pre-BMP monitoring.
- Begin construction and installation of designed practices.
- Perform periodic checkouts during the construction and installation of practices.
- Perform a final engineering checkout to ensure the practice has been installed according to the NRCS standards and specifications.
- Once the practice has been signed off on as being properly installed according to specs the applicant may submit bills and receipts.
- The project coordinator will go through bills and receipts checking for appropriate types and quantities of materials used.
- A payment authorization form will be filled out through this process as well.
- The payment authorization forms will go through the Conservation Board Meetings to keep the Board aware of which landowners are installing what practices. This will allow them a way to better track the progress of BMP installation through this project.
- Then the request for reimbursement will be sent to Division of Conservation.
- Start a new sign-up period if needed to utilize all funds, and follow same steps as listed above.
- Review year 2 Pre-BMP monitoring data.
- Complete installation of all practices.

- Complete all Post-BMP practices including but not limited to: Educational Field Day, Post-BMP monitoring, invoicing, and reports.

Prepared By: John Burnett
Date: 12-7-06

# The Conservation District's Milestones

| | Milestone | Expected Begin Date | Expected End Date | Actual Begin Date | Actual End Date |
|---|---|---|---|---|---|
| 1. | Sign contract. | July 2005 | July 2005 | 1/17/06 | 3/16/06 |
| 2. | Develop and submit a QAPP to the NPS Section for approval prior to performing any water quality monitoring. | July 2005 | July 2005 | May 2005 | 8/3/05 |
| 3. | Form Project Oversight Committee (POC). | July 2006 | Aug. 2006 | June 2006 | 8/24/06 |
| 4. | Initiate pre-BMP monitoring. | May 2006 | Aug. 2008 | 5/4/06 | 10/15/07 |
| 5. | Identify potential cooperators and agree on practices. | Aug. 2006 | Oct. 2006 | 8/9/06 | 4/30/07 |
| 6. | Meet with potential cooperators. | Oct. 2006 | Nov. 2006 | 11/8/06 | 4/30/07 |
| 7. | POC prioritize BMPs. | Nov. 2006 | Nov. 2006 | 10/30/06 | 5/14/07 |
| 8. | Develop and submit BMP Implementation Plan to the NPS Section for approval. | July 2006 | Dec. 2006 | 9/18/06 | 11/27/06 |
| 9. | Submit plans, agendas for DOW approval. | Nov. 2006 | Dec. 2006 | 11/7/06 | 3/12/07 |
| 10. | Submit first annual report. | Nov. 2006 | Dec. 2006 | 11/1/06 | 11/16/06 |
| 11. | POC review BMPs and designs and first year monitoring. | Feb. 2007 | Feb. 2007 | 12/18/06 | 5/14/07 |
| 12. | Design and begin Installation of BMPs. | Jan. 2007 | May 2009 | 5/25/07 | 7/26/10 |
| 13. | Install >25% of BMPs. | July 2007 | Dec. 2007 | 7/17/07 | 12/31/07 |
| 14. | POC review BMPs. | Aug. 2007 | Aug. 2007 | 8/13/07 | 8/13/07 |
| 15. | Submit second annual report. | Nov. 2007 | Dec. 2007 | 12/20/07 | 1/31/08 |
| 16. | POC review BMP implementation and pre-BMP monitoring. | Feb. 2008 | Feb. 2008 | 2/4/08 | 2/4/08 |
| 17. | Install >75% of BMPs. | July 2008 | Dec. 2008 | 1/1/08 | 10/1/09 |
| 18. | POC review BMP implementation. | Aug. 2008 | Aug. 2008 | 9/8/08 | 9/8/08 |
| 19. | Submit third annual report. | Nov. 2008 | Dec. 2008 | 11/3/08 | 11/13/08 |
| 20. | Install = 100% of BMPs. | Dec. 2008 | May 2009 | 10/1/09 | - |
| 21. | POC review BMP implementation. | Feb. 2009 | Feb. 2009 | 6/22/09 | 6/2209 |
| 22. | Begin 1st year post-BMP monitoring. | Mar. 2009 | Dec. 2009 | 6/1/09 | 10/1/09 |
| 23. | POC review post-BMP monitoring and BMP maintenance. | Aug. 2009 | Aug. 2009 | 8/10/09 | 8/10/09 |
| 24. | Submit fourth annual report. | Nov. 2009 | Dec. 2009 | 11/10/09 | 12/16/09 |

| | | | | |
|---|---|---|---|---|
| 25. POC review post-BMP monitoring and watershed health. | Feb. 2010 | Feb. 2010 | 8/10/09 | 8/10/09 |
| 26. Begin 2nd year post-BMP monitoring. | Mar. 2010 | Dec. 2010 | 5/29/10 | 10/29/10 |
| 27. POC review post-BMP monitoring and watershed health. | Aug. 2010 | Aug. 2010 | 8/1/2010 | 12/31/10 |
| 28. Submit fifth annual report. | Nov. 2010 | Dec. 2010 | 11/1/10 | 11/15/10 |
| 29. Prepare and submit three copies of the final report and submit three copies of all products produced by this project. | Jan. 2011 | June 2011 | 1/1/11 | July 2011 |

Budget Summary

## BUDGET INFORMATION

### The Conservation District's Detailed Budget:

| Budget Categories | 319(h) Dollars | Conservation District Match | Total |
|---|---|---|---|
| Personnel | $29,250 | $19,500 | $48,750 |
| Supplies | | | |
| Equipment | | | |
| Travel | | | |
| Contractual<br>• BMPs<br>• Monitoring/Engineering | <br>$200,000<br>$100,844 | <br>$133,333.33<br>$67,229.34 | <br>$333,333.33<br>$168,073.34 |
| Operating Costs | | | |
| Other | | | |
| **TOTAL:** | **$330,094** | **$220,062.67** | **$550,156.67** |
| | ***60.00%*** | ***40.00%*** | ***100%*** |

### The Conservation District's Budget Summary:

| | BMP Implement-ation | Project Management | Education, Training, or Outreach | Monitoring | Technical Assistance (Engineering) | Other | Total |
|---|---|---|---|---|---|---|---|
| Personnel | $29,250 | $19,500 | | | | | $48,750 |
| Supplies | | | | | | | |
| Equipment | | | | | | | |
| Travel | | | | | | | |
| Contractual | $333,333.33 | | | $155,833 | $12,240.34 | | $501,406.67 |
| Operating Costs | | | | | | | |
| Other | | | | | | | |
| **TOTAL:** | **$362,583.33** | **$19,500** | | **$155,833** | **$12,240.34** | | **$550,156.67** |

Original

## REVISED BUDGET INFORMATION

### The Conservation District's Detailed Budget:

| Budget Categories | 319(h) Dollars | Conservation District Match | Total |
|---|---|---|---|
| Personnel | $43,837.51 | $29,225.01 | $73,062.52 |
| Supplies | | | |
| Equipment | | | |
| Travel | | | |
| Contractual<br>• BMPs<br>• Monitoring/Engineering | <br>$192,756.69<br>$93,499.80 | <br>$128,504.46<br>$62,333.20 | <br>$321,261.15<br>$155,833.00 |
| Operating Costs | | | |
| Other | | | |
| **TOTAL:** | **$330,094** | **$220,062.67** | **$550,156.67** |
| | ***60.00%*** | ***40.00%*** | ***100%*** |

### The Conservation District's Budget Summary:

| | BMP Implement-ation | Project Management | Education, Training, or Outreach | Monitoring | Technical Assistance (Engineering) | Other | Total |
|---|---|---|---|---|---|---|---|
| Personnel | $43,837.51 | $29,225.01 | | | | | $73,062.52 |
| Supplies | | | | | | | |
| Equipment | | | | | | | |
| Travel | | | | | | | |
| Contractual | $321,261.15 | | | $155,833 | | | $477,094.15 |
| Operating Costs | | | | | | | |
| Other | | | | | | | |
| **TOTAL:** | **$365,098.66** | **29,225.01** | | **$155,833** | | | **$550,156.67** |

Revised: 4/25/08

The primary reason for this budget revision was to move $12,240.34 out of the Technical Assistance (contractual) category into BMP Implementation (Personnel) and Project Management (Personnel). After getting the project rolling it was decided that USDA-NRCS and the Pulaski Co. Conservation Disctrict would be able to handle any engineering needs without hiring outside support. Also, $12,072.18 was moved from BMP Implementation funds were shifted from contractual to personnel to support the salary of the project coordinator.

## REVISED BUDGET INFORMATION

### The Conservation District's Detailed Budget:

| Budget Categories | 319(h) Dollars | Conservation District Match | Total |
|---|---|---|---|
| Personnel | $61,594.20 | $41,062.80 | $102,657.00 |
| Supplies | | | |
| Equipment | | | |
| Travel | | | |
| Contractual<br>• BMPs<br>• Monitoring/Engineering | <br>$175,000.00<br>$93,499.80 | <br>$116,666.67<br>$62,333.20 | <br>$291,666.67<br>$155,833.00 |
| Operating Costs | | | |
| Other | | | |
| **TOTAL:** | **$330,094** | **$220,062.67** | **$550,156.67** |
| | ***60.00%*** | ***40.00%*** | ***100%*** |

### The Conservation District's Budget Summary:

| | BMP Implement-ation | Project Management | Education, Training, or Outreach | Monitoring | Technical Assistance (Engineering) | Other | Total |
|---|---|---|---|---|---|---|---|
| Personnel | $61,594.20 | $41,062.80 | | | | | $102,657.00 |
| Supplies | | | | | | | |
| Equipment | | | | | | | |
| Travel | | | | | | | |
| Contractual | $291,666.67 | | | $155,833 | | | $447,499.67 |
| Operating Costs | | | | | | | |
| Other | | | | | | | |
| **TOTAL:** | **$353,260.87** | **41,062.80** | | **$155,833** | | | **$550,156.67** |

Revised: 2/12/09

The primary reason for this budget revision was to shift $29,594.48 from BMP Implementation (contractual) into BMP Implementation (personnel) and Project Management (personnel). It was brought to the project coordinators attention that if project has BMP funds available and no one to oversee and administer the program the BMP funds will not get implemented. So, based on the POC recommendation the budget revised was submitted and approved.

## REVISED BUDGET INFORMATION

### The Conservation District's Detailed Budget:

| Budget Categories | 319(h) Dollars | Conservation District Match | Total |
|---|---|---|---|
| Personnel | $66,499.62 | $44,333.08 | $110,832.70 |
| Supplies | | | |
| Equipment | | | |
| Travel | | | |
| Contractual<br>• BMPs<br>• Monitoring/Engineering | <br>$147,304.87<br>$94,155.70 | <br>$98,203.25<br>$62,770.47 | <br>$245,508.12<br>$156,926.17 |
| Operating Costs | | | |
| Other | | | |
| **TOTAL:** | **$307,960.19** | **$205,306.80** | **$513,266.99** |
| | ***60.00%*** | ***40.00%*** | ***100%*** |

### The Conservation District's Budget Summary:

| | BMP Implement-ation | Project Management | Education, Training, or Outreach | Monitoring | Technical Assistance (Engineering) | Other | Total |
|---|---|---|---|---|---|---|---|
| Personnel | $66,499.62 | $44,333.08 | | | | | $110,832.70 |
| Supplies | | | | | | | |
| Equipment | | | | | | | |
| Travel | | | | | | | |
| Contractual | $245,508.12 | | | $156,926.17 | | | $402,434.29 |
| Operating Costs | | | | | | | |
| Other | | | | | | | |
| **TOTAL:** | **$312,007.74** | **44,333.08** | | **$156,926.17** | | | **$513,266.99** |

Revised: 6/30/11

This final budget revision was performed to enable all categories to balance out. In other words the monitoring and personnel went over budget slightly from the last revised budget. So this revision moved $9,268.87 out of the BMP Implementation (contractual), which still left $22,157.81 in this category as unobligated funds. We added $1,093.17 into Monitoring (contractual), and $4,905.42 into BMP Implementation (personnel) and $3,270.28 into Project Management (personnel).

Equipment Summary

There was no equipment purchased through this project.

Special Grant Conditions

There were no Special Grant Conditions placed on this project by EPA.

Appendix B

# QUALITY ASSURANCE / QUALITY CONTROL PLAN FOR REDUCTION OF NON-POINT SOURCE POLLUTION IN BUCK CREEK WATERSHED

**Section 319(h) Nonpoint Source Implementation Program**
**FFY 2005**

For
**Pulaski County Conservation District**

By
**Lynn Jarrett**
**Cumberland Environmental Group, LLC**

7/28/2005

Buck Creek Nonpoint Source Management Project
QAPP Ver. 3.0 Last Rev. 7/28/05 CEG

**QUALITY ASSURANCE PLAN APPROVAL**

| Project Personnel | Approval Signature | Date |
|---|---|---|
| KY Division of Water<br>Quality Assurance Coordinator | | |
| KY Division of Water, NPS Section<br>Project Manager | | |
| KY Division of Conservation<br>Project Manager | | |
| Lynn Jarrett<br>Cumberland Environmental Group, LLC<br>Monitoring Manager | | |

**QUALITY ASSURANCE PROJECT PLAN DISTRIBUTION LIST**

| | |
|---|---|
| Corrine Wells<br>KY Division of Water, NPS Section<br>14 Reilly Road<br>Frankfort, KY 40601<br>Tel: 502-564-3410<br>Email: Corrine.wells@ky.gov | Mike Strunk<br>Nature Conservancy/Pulaski County Conservation District<br>45 Eagle Creek Drive Ste 102<br>Somerset, KY 42503<br>Phone: (606) 678-5416 x 118<br>Fax: (606) 677-9582<br>Email: michael.strunk@ky.usda.gov |
| Rodney Pierce<br>KY Division of Water, NPS Section<br>14 Reilly Road<br>Frankfort, KY 40601<br>Tel: 502-564-3410<br>Email: rodney.pierce@ky.us | Lynn Jarrett, Senior Scientist<br>Cumberland Environmental Group, LLC<br>P.O. Box 446<br>Henryville, IN 47126<br>Tel: 812-294-7618<br>Email: lynn.jarrett@CEG.com |
| Shelly Graves<br>KY Division of Conservation<br>663 Teton Trail<br>Frankfort, KY 40601<br>Tel: 502-564-3080<br>Email: shelly.graves@ky.us | Ellen Fouser, Laboratory Manager<br>Fouser Environmental Services<br>400 Crossfield Drive<br>Versailles, KY 40383<br>Tel: 859-873-6211 |
| Demetrio Zourarkis<br>KY Division of Conservation<br>663 Teton Trail<br>Frankfort, KY 40601 | |

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**TABLES**

**FIGURES**

ACRONYMS AND ABBREVIATIONS

| | |
|---|---|
| ANOVA | Analysis of variance |
| BMP | Best Management Practice |
| CEG | Cumberland Environmental Group, LLC |
| DO | Dissolved Oxygen |
| DOC | (KY) Division of Conservation |
| DOW | (KY) Division of Water |
| DQO | Data Quality Objective |
| EPA | (United States) Environmental Protection Agency |
| FFY | Federal Fiscal Year |
| GIS | Geographic Information System |
| 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 |
| PCCD | Pulaski County Conservation District |
| QAPP | Quality Assurance Project Plan |
| QA/QC | Quality Assurance Quality Control |
| RC&D | Resource Conservation and Development |
| RPD | Relative Percent Difference |
| SEC | Specific Electrical Conductance |
| SOP | Standard Operating Procedure |
| T | Temperature |
| USGS | United States Geological Survey |
| μS/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 Pulaski County Conservation District (PCCD) in Pulaski County, Kentucky have entered into a grant agreement to improve water quality in the Buck Creek Watershed.

The PCCD, and their partners, will implement Best Management Practices (BMPs) throughout the Buck 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 a contracted monitoring manager, Cumberland Environmental Group, LLC (CEG) in cooperation with the PCCD. This 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:** Mike Strunk, Buck Creek Watershed Coordinator of the PCCD 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:** Mike Strunk, will assist BMP implementation, and site selection under the direction of the District Conservationist.

**Monitoring Manager:** CEG will install a monitoring network that consists of 2 continuous monitors and 2 grab sampling sites. CEG will oversee and assist with sample collection, data review and management. CEG will conduct the data analyses.

**Laboratory Manager:** The Fouser Environmental Services laboratory will analyze grab samples for total solids and total suspended solids.

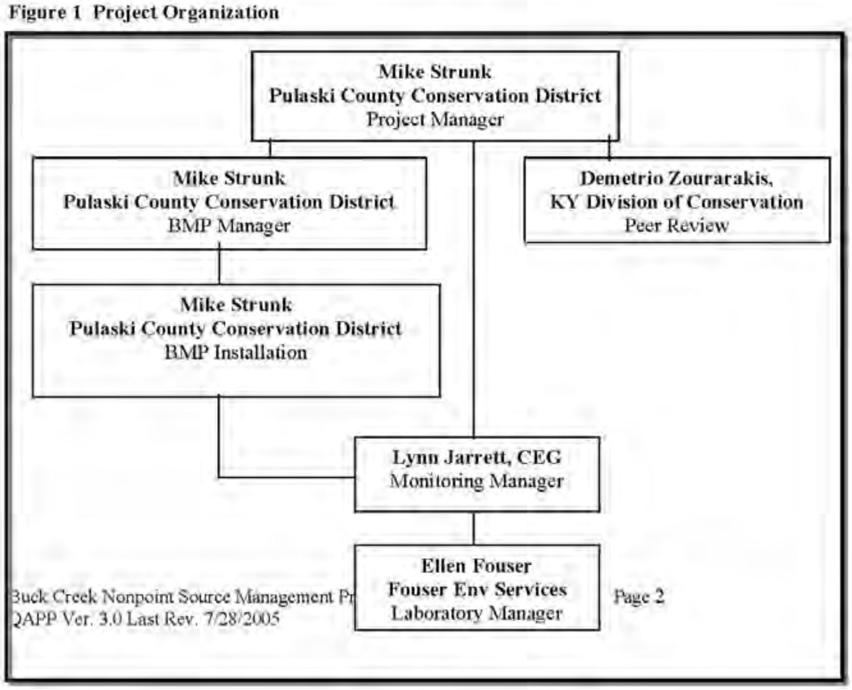
**Peer Review:** The KY Division of Conservation (DOC) will provide independent peer review on this project, including all aspects of data collection, assessment and report generation.

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 1 Project Organization, Roles and Responsibilities**

| Organization | Key Roles | Project Responsibility |
|---|---|---|
| PCCD | Project Manager | Project management<br>• Assist site selection, assist project data management, reporting, final report coordinator<br>• Quality Assurance Manager |
| PCCD | BMP Manager | • Coordinate BMP installation<br>• BMP data management<br>• Assist with site selection<br>• Grab sample collection |
| CEG | Monitoring Manager | • Site selection (continuous & grab)<br>• Continuous monitor installation<br>• Coordinate sampling teams (continuous & grab)<br>• Continuous monitor field work, assist with grab sample collection<br>• Manage, quality assure and assess sampling data<br>• Provide electronic and hard copy interim and final data reports |
| Fouser Environmental Services | Laboratory Manager | • Laboratory analyses |
| KY Division of Conservation | Peer Review | • Peer reviewer<br>• Review all project data and reports |

**Figure 1 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.*

The mainstem of Buck Creek watershed is classified as an Outstanding State Resource Water (OSRW: Kentucky Surface Water Standards (KAR 5:031). The Creek is a Class II canoeing stream from HWY 461 to the confluence with the Cumberland River. Thirty species of mussels occur in this watershed including four that are listed as Federally Endangered Species: Cumberland bean pearly mussel (Villosa trabalis), Cumberland combshell (Epioblasma brevidens), little-wing pearly mussel (Pegias fibula), oyster mussel (Epioblasma capsaeformis) and the fluted kidneyshell is a candidate for federal listing.

Overall water quality is believed to be good, however, mussel populations in the Southeastern United States are on the decline (Williams and others 1993) and protecting this OSRW from the detrimental effects of NPS from agricultural practices is needed. Detrimental practices include row-cropping in riparian zones, cattle access to streams, gravel mining and channel modifications at stream crossings. A small portion of the mainstem and 2 tributaries to Buck Creek are included on the 2000 Final and 2004 Draft 303(d) List of Impaired Waters.

The Buck Creek is tributary to the Cumberland River, with a 294.492 square mile drainage area. Buck Creek is best defined by the nine-digit hydrologic unit code 051301030. The study area in Buck Creek includes where the BMPs will be implemented includes 9 14-digit hydrologic units (Table 2)

**Table 2. Hydrologic unit codes, 14-digit (HUC14) where BMPs are targeted.**

| NAME | ACRES | HUC14 |
|---|---|---|
| Briary Creek | 7,841.4 | 05130103030140 |
| Buck Creek | 2,339.9 | 05130103030150 |
| Whetstone Creek | 1,624.0 | 05130103030160 |
| Buck Creek | 730.8 | 05130103030170 |
| Barney Branch | 4,722.8 | 05130103030180 |
| Clear Creek | 2,273.9 | 05130103030190 |
| Barney Branch | 173.3 | 05130103030200 |
| Buck Creek | 524.5 | 05130103030210 |
| Indian Creek | 3,610.1 | 05130103030220 |

This watershed is located in the Interior Plateau Ecoregion. The geology of the drainage basin is dominated by formations of the Paleozoic era. Devonian and Mississippian sedimentary rock underlies much of the soil of the basin. The upland terraces and ridgetops are mantled with a silty loess or Quaternarian and Tertiary gravelly deposits. Buck Creek is a 5$^{th}$ order stream and has many major tributaries (1$^{st}$, 2$^{nd}$, 3$^{rd}$, and 4$^{th}$ order streams) contributing to the total flow, and the flow of the mainstem is north to south from Lincoln County to Pulaski County, KY and terminating at the confluence with the Cumberland River in Pulaski County, KY.

The majority of the land in the Buck Creek Watershed is in pasture and cropland (Table 3 & Figure 2) followed by deciduous forest, mixed forest, and evergreen forest in a decreasing order. All other landuses combined total less than 3% of the basin's landuse. Figure 2 demonstrates that the distribution of agriculture land is in the river valley and that the uplands are forested. The small areas where urban or residential landuse exists are also along the river.

**Table 3 Landuse areas within the Buck Creek drainage basin.**

| Land Use Type | Sub-Total Area (Acre) | % |
|---|---|---|
| CONFINED FEEDING OPS | 113,798 | 0.01 |
| OTHER URBAN OR BUILT-UP | 235,400 | 0.02 |
| COMMERCIAL AND SERVICES | 378,930 | 0.03 |
| STRIP MINES | 2,553,971 | 0.19 |
| TRANS, COMM, UTIL | 3,680,255 | 0.27 |
| TRANSITIONAL AREAS | 5,040,066 | 0.37 |
| RESIDENTIAL | 12,321,707 | 0.90 |
| RESERVOIRS | 14,869,524 | 1.08 |
| EVERGREEN FOREST LAND | 29,221,379 | 2.13 |
| MIXED FOREST LAND | 237,829,800 | 17.35 |
| DECIDUOUS FOREST LAND | 400,416,600 | 29.21 |
| CROPLAND AND PASTURE | 664,283,798 | 48.45 |
| Total | 1,370,945,226 | 100.00 |

Freshwater mussels are an indicator of the health of aquatic ecosystems. Populations of the Cumberlandian combshell mussel (*Epioblasma brevidens*), now only found in small portions of the Tennessee and Cumberland River basins in Kentucky, Tennessee and Virginia, have decreased as a result of deteriorating stream quality (Snape II and Ferris, 2004). Silt eroding from agricultural fields, gravel mining, and road construction contribute to storm related increases of suspended solids and turbidity, that may cover and/or suffocate mussel beds. The fine silt also fills in the tiny spaces in gravel stream bottoms, ruining them for use by juvenile mussels.

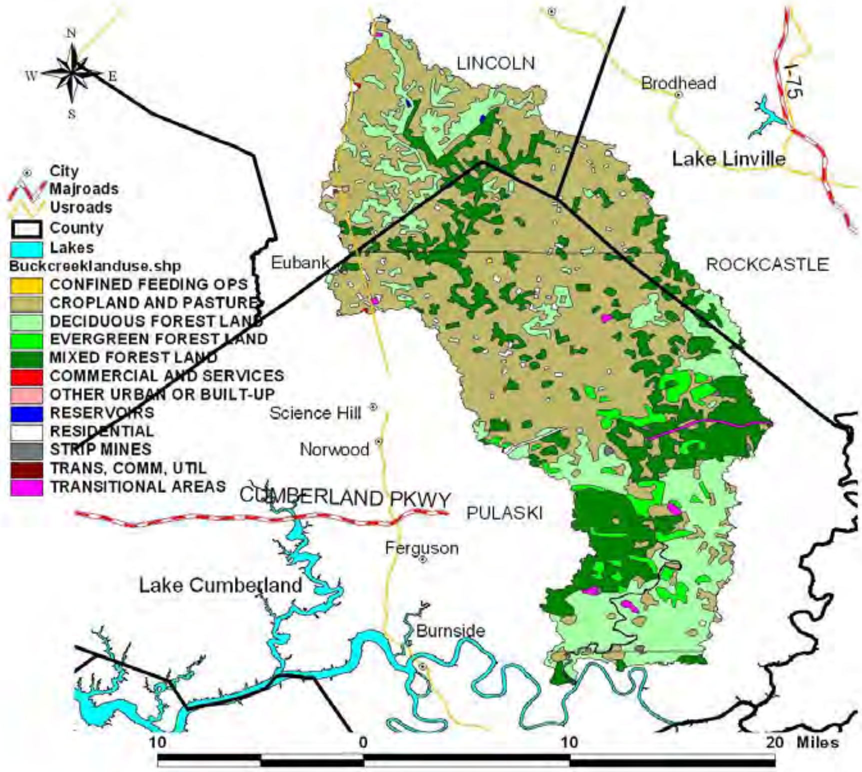



**Figure 2 Distribution of landuses in the drainage basin.**

The basin is located in south Lincoln county, west Rockcastle County, and north and east Pulaski county, KY. The town of Burnside in Pulaski County is close to the mouth of the drainage basin. Table 4 displays the geographic information regarding basin location.

**Table 4 Geographic coordinates of the Buck Creek basin.**

| Location in basin | Latitude | Longitude |
|---|---|---|
| Mouth of basin | 36.9771 | -84.4903 |
| Centroid of basin | 37.2241 | -84.4722 |
| Headwaters of basin | 37.4584 | -84.6302 |

## 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.*

Work To Be Performed

1. Site selection (continuous water quality monitors, grab samples, biological monitoring)
   Product: Geographic Information System (GIS) coverage and map of sampling locations with coordinates accurate to within 20 meters
2. Installation of 2 continuous water quality monitors to collect 6 water quality attributes (See **Overview of Continuous Monitors** for additional information)
   Product: Database of water quality data totaling 5,376 hours of sample data for each of 6 water quality attributes
3. Continuous monitor calibration, servicing and data download
   Product: Improve and account for the accuracy and precision of the database above
4. Grab sample collection for total solids and total suspended solids at 2 locations
   Product: 80 samples of both water quality attributes
5. Laboratory analysis for total solids and total suspended solids concentrations
   Product: Analytical results of water quality totaling 80 samples of each of the water quality attributes.
6. Biological monitoring of macroinvertebrates
   Product: Macroinvertebrate data results (including indices calculations) and voucher specimens for 16 sampling runs
7. Biological monitoring of periphytic algae
   Product: Periphytic algae data results (including indices calculations) and voucher specimens for 16 sampling runs
8. Data quality review for continuous monitors and grab samples Data management
9. Data assessment to evaluate water quality changes associated with BMP implementation
10. Reports and presentations summarizing the dataset and major findings of the monitoring program.
    Product: Three annual data reports summarizing the data and the quality assurance and quality control (QA/QC) results AND a Final Report summarizing all the data and the findings relative to the BMP implementation

Implementation Schedule

Continuous monitors and grab samples will be collected during five-month intervals (May through September) for four years, 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 5. This schedule may be adjusted as needed to ensure that data collection is completed by 1/2010.

**Table 5 Project Schedule**

| Task | Timeframe |
|---|---|
| Pre-BMP Monitoring | 5/2006 – 9/2007 |
| BMP Installation | 5/2007 – 7/2008 |
| BMP Monitoring | 5/2008 – 9/2008 |
| Post-BMP Monitoring | 5/2009 – 9/2009 |
| Data Assessment | 10/2019 – 5/2010 |
| Final Monitoring Report | 6/2010 |

**Overview of Continuous Monitors**

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.

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The continuous monitors used in this project will include probes to collect water quality data the parameters shown in Table 6. Data can be logged or transmitted via satellite on frequent time intervals (e.g., 15 minutes). Because the time interval is so short, the monitors are considered "continuous".

**Table 6 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 35,000 data for each parameter may be collected over 1 year with data logged every 15 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.

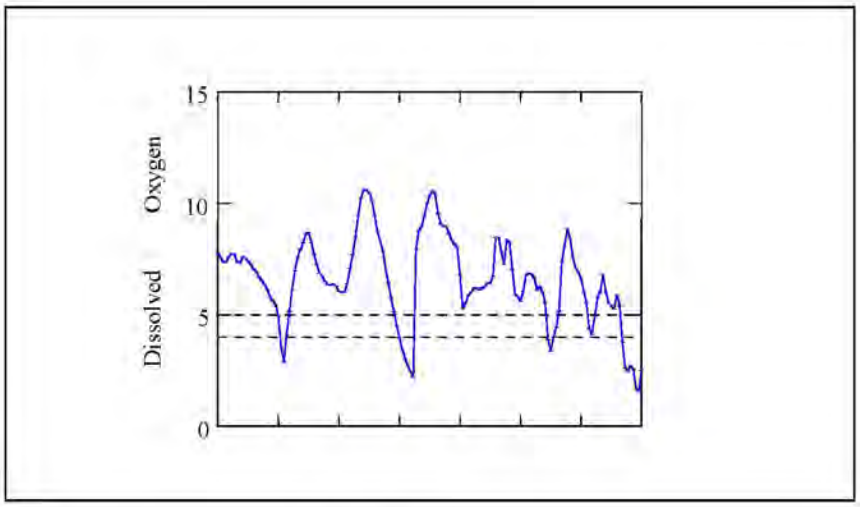


**Figure 3 Continuous Dissolved Oxygen Data**

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 Sondes 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. 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.

**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 in Section 2.5.**

**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 using **Equation 2 in Section 2.5.**

**Representativeness** 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.

**Completeness** 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%.

**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 is 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.
- Authoritative analysis of a subset of the biological samples will be conducted to assure taxanomic accuracy

The water quality criteria and DQOs for this project are summarized in Table 7.

**Table 7 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% |

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**Table 7 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) Temperature**: 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.

### 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 Project Manager, 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 the Monitoring Manager for 3 years after the last invoice is paid and will be transmitted to the Project Manager upon completion of the project. Records will be maintained by the Project Manager, 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, and 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 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 Project Manager and BMP Manager;
- 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 the Buck 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 in the watershed receiving BMPs (Experiment Location). A continuous water quality monitoring station will be installed in a watershed without BMPs (Control Location) as a control site. Grab samples will be collected at 2 locations in the Buck 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 project watershed

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

Season: Continuous monitors will be deployed during 5 months annually (four 2-week intervals) 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%) 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 will be collected at the upstream Control Location as a control. The Control Location land use is agricultural and BMP implementation will not be emphasized in this portion of the watershed.

Macroinvertebrate sampling: Sampling sites will coincide with sites 1 and 3 of the study performed by Moeykin and Schuster (1997). Sampling will be performed twice a year (late May and Mid July) for each of the four years. Sampling methods and dates will conform to those reported in Moeykin and Schuster 1997 for comparability purposes. These methods may be reconciled with section II A. of KDOW 2002 for Wadeable-Moderate/High Gradient streams.

Table 8 identifies site selection considerations which will be evaluated and applied to the degree possible prior to installing continuous monitors.

**Table 8 Factors for Continuous Monitor Site Selection**

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

(From: Wagner and others, 2000)

*Data collection:* Each of the two sites within the watershed (Table 9 and Figure 4) will be instrumented with water quality sampling devices (Hydrolab DataSonde) to facilitate the accurate estimation of time series of water quality parameters. Water quality shelters will be installed at the two watershed sites to house the water quality sampling equipment. Continuous water quality data will be collected for four (2 week) intervals per year and used in conjunction with estimated streamflow to calculate water quality constituent loads. The monitors will be deployed in a common water bath between 2 deployments to characterize the data deviation due to the change of the measures and the time-dependent processes at each of the sites.

Continuous monitor sampling was selected to avoid the expense of large numbers of storm related samples. It is proposed that the monitors, which record water temperature, dissolved oxygen, specific electrical conductance, turbidity, and pH data at fifteen-minute time intervals be used to capture the temporal and spatial variability of the water quality dynamics. Ruhl and Jarrett (1998) demonstrated the utility of this approach in urban watersheds while modeling dissolved oxygen associated with combined sewer overflows. Jarrett and Saffran (1999) report on the instruments enhanced ability to capture process level dynamics with respect to monthly water quality monitoring of nutrients and solids.

**Table 9 Grab sampling site locations.**

| Sample Site # | Location |
|---|---|
| **1** (Upstream) | **Buck Creek above the confluence with Briary Creek** |
| **2** (Downstream) | **Buck Creek below confluence with Indian Creek** |

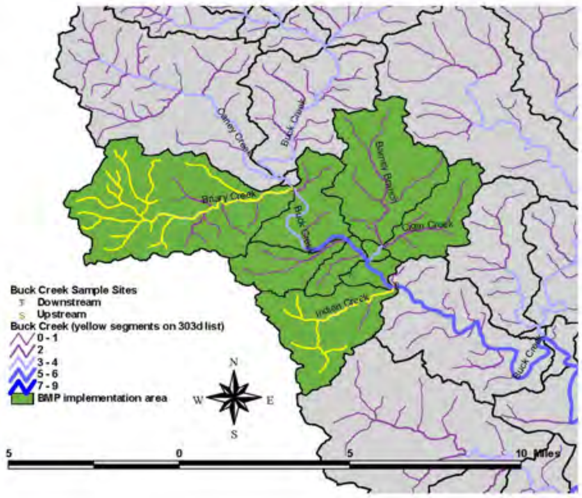


**Figure 4. Sample site locations.**

**Table 10. Monitoring schedule for continuous monitors (M) and grab samples (X).** Grab samples will be collected at the two sites during 7 select storm events and three low flow periods. Biological studies will be conducted during the periods and at the sites indicated with "xx" in the table.

| | May | Jun | Jul | Aug | Sep | May | Jun | Jul | Aug | Sep | May | Jun | Jul | Aug | Sep | May | Jun | Jul | Aug | Sep |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SITE 1 | xx M X | X | xx M X | X M | X M | xx M X | X | xx M X | X M | X M | xx M X | X | xx M X | X M | X M | xx M X | X | xx M X | X M | X M |
| SITE 2 | xx M X | X | xx M X | X M | X M | xx M X | X | xx M X | X M | X M | xx M X | X | xx M X | X M | X M | xx M X | X | xx M X | X M | X M |
| | May | Jun | Jul | Aug | Sep | May | Jun | Jul | Aug | Sep | May | Jun | Jul | Aug | Sep | May | Jun | Jul | Aug | Sep |
| | 2006 | | | | | 2007 | | | | | 2008 | | | | | 2009 | | | | |

*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 11.

**Table 11 Study Parameters**

| STORET Code | Parameter | # of Sites | Sampling Frequency | Project Target # Samples or Datum (1) |
|---|---|---|---|---|
| 00010 | Water Temperature (°C) | 2 | 15 min | 21,504 |
| 00300 | Dissolved oxygen (mg/l) | 2 | 15 min | 21,504 |
| 00301 | Dissolved oxygen (% saturation) | 2 | 15 min | 21,504 |
| 00400 | pH - Water, Whole, Field, S.U. | 2 | 15 min | 53,76 |
| 00095 | Specific Conductivity (uS/cm @ 25 °C) | 2 | 15 min | 21,504 |
| 00076 | Turbidity (NTU) | 2 | 15 min | 21,504 |
| 00500 | Total Solids (mg/l) | 2 | Storm sampling | 80 |
| 00545 | Total Suspended Solids (mg/l) | 2 | Storm sampling | 80 |
| | Total Dissolved Solids (mg/l) | 2 | n/a | 80 |
| 00060 | Stream Discharge **(2)** | | | |
| | Macroinvertebrate studies | 2 | twice/year | 16 |
| | Algae studies | 2 | twice/year | 16 |

**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/hour * 24 hour/day * 56 days/year * 4 monitoring years; # Grab Samples: 2 sites * 10 samples * 4 monitoring intervals

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

*Sampling Schedule:* Continuous monitoring data and grab samples will be collected during four annual 5-month monitoring intervals spanning pre-, during and post-BMP installation. Sampling will occur during the 5-month recreational season (May 1 – Sep 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 5.

Continuous monitors will be serviced (either deployed or recovered) on approximately the 1st and 15th of each month. Seventy percent of the grab samples will be collected during storm events 30% during low to median flow. The 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.

Macroinvertebrate and algal sampling will occur in late May and mid July of each year. The macroinvertebrate sampling will be conducted during a single day. The algal sampling will be conducted over a 3 week period.

***Data Analysis***
Data from this project will be analyzed to evaluate changes in water quality before, during, and after BMP installation. Data from the Experiment Location watershed will be compared to the Control Location watershed. 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 11 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 the Experiment Location and Control Location will be compared.

Using flow data estimated from the nearby, watershed relative USGS Gaging Stations 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 5** 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.

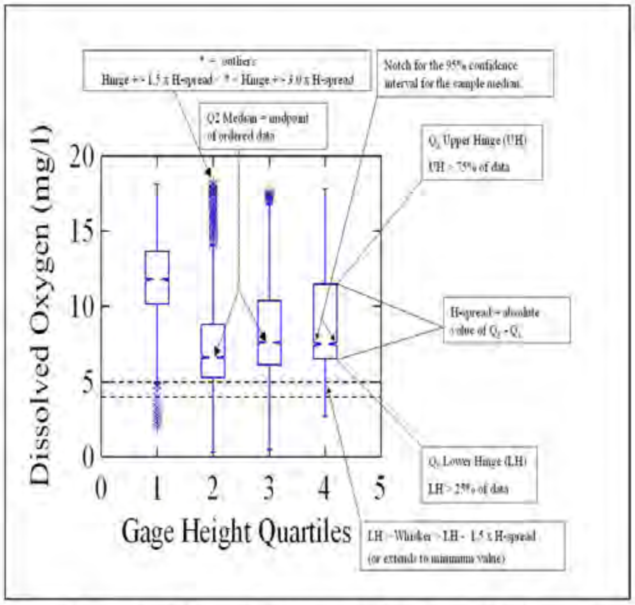


**Figure 5 Dissolved Oxygen Concentration by Gage Height Quartile**

The % DO saturation also provides a valuable indicator of stream ecosystem processes. In the example provided in **Figure 6**, 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 the Experiment Location and Control Location and for each BMP condition. Analysis of covariance will be used to evaluate relationships between several factors (e.g., flow, temp and DO).

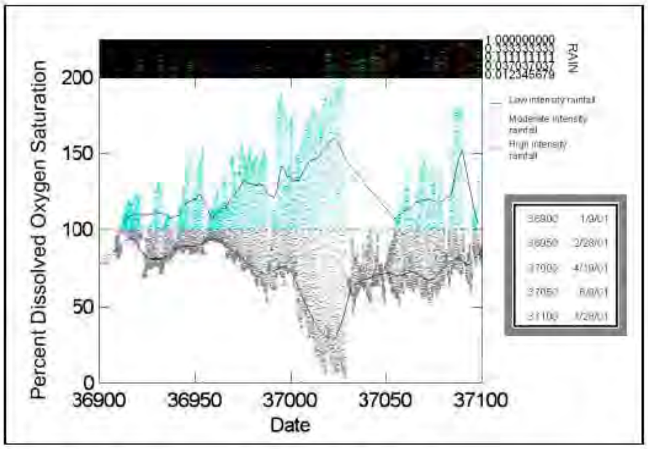


**Figure 6 % DO Saturation with respect to Rainfall**

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 7**.

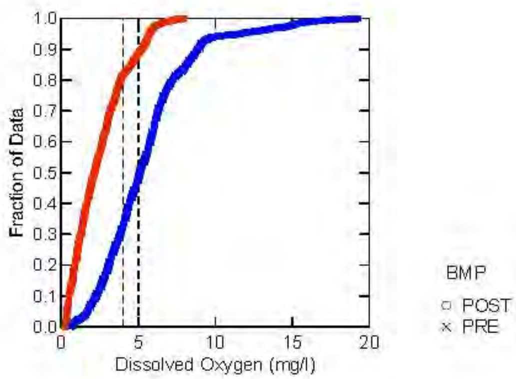


**Figure 7 Comparison of the cumulative frequency distributions of dissolved oxygen data collected before and after BMPs.**

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## 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 after each two week deployment.

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.

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 for the two-week intervals. 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 1.6: 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, 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 12, samples will be collected after 3 rinses with ambient water into clean plastic containers supplied by the laboratory.

**Table 12 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 |

**Macroinvertebrate Samples**: Macroinvertebrate samples will be collected on two dates each year for four years (late May and Mid July) at each of the two sites.

Samples will be collected qualitatively and semi-quantitatively as described by KDOW (1993 & 2002), Moeykin and Schuster (1997), and Plafkin et al. (1989). Qualitative sampling will be conducted at each site to develop a species list and evaluate taxa presence or absence. Multi-habitat sampling will follow the prescription of section IIA.2. of KDOW (2002, pp. 54-55).

Riffle/run sampling will be conducted semi-quantitatively collecting three traveling-kick samples. Collectors will work upstream for three meters in 60 seconds collecting the material in an A-frame dip net with a 600 - 900 μm mesh and a vertical net height of at least 22.6 cm.

Macroinvertebrates with be placed into 70% ethyl alcohol in glass jars for picking and taxonomy. No stains will be applied to samples.

**Algal Samples:** Algal samples will be collected over a two week period two times each year for four years (late May and Mid July) at each of the two sites.

Samples will be collected from unglazed clay tiles (2.5 cm x 2.5 cm) which will be preconditioned and then placed in Buck Creek at the two sampling sites. An aufwuchs community, predominated by algae but also including detritus, sediment and other microorganisms will be allowed to develop on the tiles over a maximum period of 14 days. Five days after the tiles are deployed a subset of the original number of tiles will be collected to represent the community after five days of development. Nine days after the tiles are deployed another subset will be collected to represent the community after nine days of development. The final tiles will be collected at the end of 14 days of deployment.

Aufwuchs material will be removed from only one 2.5 $cm^2$ surface for each tile. The collected material will be rubbed from the surface of the tile into a funnel that directs the flow into a soft plastic sampling container and immediately frozen. By collecting uniform surface areas it is easier to accurately calculate densities and consequently easier to compare sample densities from station to station and date to date.

### 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**.

**Macroinvertebrate Samples:** Macroinvertebrate samples with be placed into 70% ethyl alcohol in glass jars for picking and taxonomy. No stains will be applied to samples.

**Algal Samples:** Aufwuchs material that will include the algal samples will be stored in the dark and frozen until analysis.

### 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 the Laboratory Manager. This laboratory has been certified for drinking water analyses in Kentucky.

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).

**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. 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 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**

$$\%R = \frac{SSR - SR}{SA} X 100$$

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

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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

**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 is 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 6** 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 after every 2 week deployment as described in **Section 2.7**. If problems are detected during field visits or through review of the downloaded data it will be documented and corrected.

**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 13, additional service is not needed.

**Table 13 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 is 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 Project Manager and BMP Manager (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 SQL 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 the Experiment Location and the Control Location.

These reports will be provided to the Project Manager. The Project Manager 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 completed 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 14. (Wagner and others, 2000). Data will be rejected if the in-situ readings are beyond the maximum allowable limits.

**Table 14 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.

**Macroinvertebrate Samples:**

### 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 8). Fouling usually begins at some time after service check and usually does not occur uniformly over the time span between calibration checks.

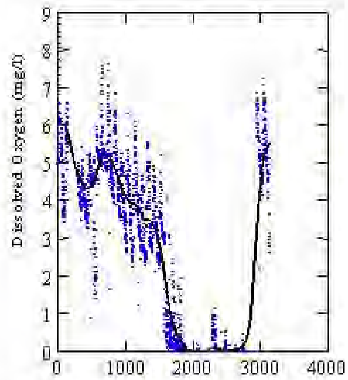


**Figure 8 Example of Fouled Dissolved Oxygen Sensor**

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 9,** 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.

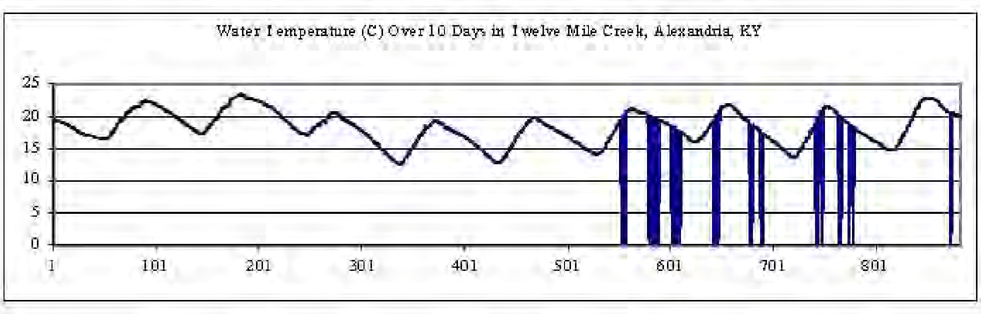

**Figure 9 Example of Data Logging Error**

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 location. This combination of study design attributes will provide a comprehensive dataset and assessment that is uniquely suited to the user 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).

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.

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APPENDIX I

Appendix C

# Buck Creek Watershed
# BMP Implementation Plan

## List of eligible BMP's:

A list of eligible BMP's and items eligible for cost share follows:

| NRCS Practice Name | NRCS Practice Code |
|---|---|
| Critical Area Planning | 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 |

A detailed description of each NRCS Practice can be obtained at the following website:
http://www.nrcs.usda.gov/technical/efotg/
Once, on the website click on Kentucky>Pulaski County. Next, under the eFotg folder click on section IV > conservation practices.

## Other items eligible for funding:

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.
Charger, for electrical fencing limit of 1 charger per cooperator.
Extension of electrical service for water pumps - $1,000.00 maximum.
Flash grazing – only for code 393 (filter strip).
Water meters for municipal water sources – 1 meter per cooperator with a size limit of ¾".
Moving existing heavy use areas away from creek (feeding areas must be at least 150' away from a body of water)
Rental payment for riparian areas will have a contract ending no later than the end of the Grant with an added maintenance time.

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 and only with the implementation of filter strips (393). 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 $15.00/ac the first year, $10.00/ac the second, and $5.00/ac the third. However, there will be a 50 acre maximum limit for prescribed grazing per landowner. Also required will be one mandatory educational training session. This training will be approximately a 6 hour training held at the Pulaski County Extension Building, and conducted by approximately 3-4 forage and beef specialist speakers.

Rental Payments for Riparian Areas. Producers who participate in this practice will receive $100.00/ac per year for three years with an additional three-year maintenance agreement. The minimum width will be 50' and the maximum width 180'.

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 only cost share on: fertilizer and lime applications which are applied according to a soil test, seed from an approved seed list (see attached list), and drill rental. A soil test less than one year old will also be required and the planting may 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 2007 EQIP guidelines. 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 (BMP's) and technologies selected by the watershed Coordinator are oriented around reducing pathogens, nutrients, and sediment. The efforts will be centered primarily on developing the riparian areas, 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 BMP's 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, nearing completion of projects, a farm will be selected for a field day. BMP's will be selected that meet the needs of the operation while providing the best resource protection.

## Relative Treatment Efficiency of BMP's:

The focus of this project is on the adoption of demonstration BMP's that will educate producers on technologies available in protecting water quality. Emphasis will be on the adoption of a management system rather than individual BMP's; therefore, comparison of treatment efficiencies of individual BMP's 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 BMP's and eligible cost share items, as appropriate, funded by 319(h). All BMPs will be installed according to NRCS standards and specifications. Also, all BMPs must comply with the Kentucky Agriculture Water Quality Act and the Forest Conservation Act. BMP's must be maintained for the life of the practice. The closing date of this project is June 30, 2011

## Description of BMP Targeting Process:

Targeting of BMP's 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 of the farming operation, 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, and CRP).

4. Proximity of the landowner to Buck Creek or tributaries.

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 and description of BMPs that have been installed as a part of this project. Specific location information for BMP's 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. Load reductions for each BMP installed through the grant and BMPs used as match will be included in the annual reports submitted to Division of Water and Division of Conservation.

## Financial Plan of Action:

This project will assist these farmers by offering them incentives to install demonstration BMP's. The cost share rate will be 75:25.
This will be accomplished by using "local match" from other state cost share projects, and applying it to the match of producers in the project area.

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

Restrictions:

- Size of ponds will be passed 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. BMP's or systems that are primarily for improving production of efficiency of the producer's operation will not be eligible for funding.

- Costs for alternative water supplies are only eligible if; 1. livestock are excluded from streams or other water bodies, or 2. as part of a rotational grazing system. The most cost effective water facility determined by NRCS will be utilized.

## State Cost Share BMP's Used As Match:

Water Quality BMP's 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";* a copy of the manual can be obtained from the Division of Conservation website: http://www.conservation.ky.gov/ The manual, which sites 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 BMP's will be demonstrated in accordance with guidance provided by the Division of Conservation. The primary State Cost Share BMP boundary for the area to be used as match is the Buck Creek Watershed within Pulaski County, secondary match area is the remaining part of Pulaski County, and the final match area is the remaining part of the Buck Creek Watershed outside of Pulaski County.

## Equal Opportunity Statement:

The United States Department of Agriculture (USDA) prohibits discrimination in its programs and related programs on the basis of race, color, national origin, sex, religion, age, physical or mental disability, sexual orientation, genetic information, political beliefs, and marital or parental status.

Appendix D

Raw Data

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## Certificate of Analysis

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P.O. Box 446
Henryville, Indiana 47126

Project:
Entered By: Lynn Ellis
Date Reported: 07/20/2006
Date Received: 06/30/2006
Date Complete: 07/20/2006

| Test | Method | Result | Units | Date | Initials |
|---|---|---|---|---|---|
| **602767-01** | **BCU** | | **6/30/06 11:00** | | |
| Solids | | | | | |
| Total Solids | SM 2540 B | 131 | mg/L | 07/14/2006 | CB |
| Total Dissolved Solids | SM 2540 C | 120 | mg/L | 07/14/2006 | CB |
| **602767-02** | **BCD** | | **6/30/06 12:30** | | |
| Solids | | | | | |
| Total Solids | SM 2540 B | 136 | mg/L | 07/14/2006 | CB |
| Total Dissolved Solids | SM 2540 C | 134 | mg/L | 07/14/2006 | CB |

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Project:
Entered By: Lynn Ellis
Date Reported: 08/29/2006
Date Received: 08/09/2006
Date Complete: 08/29/2006

| Test | Method | Result | Units | Date | Initials |
|---|---|---|---|---|---|
| **603406-01** | **BCU** | | **8/9/06 12:00** | | |
| Solids | | | | | |
| Total Solids | SM 2540 B | 114 | mg/L | 08/15/2006 | KM |
| Total Suspended Solids | SM 2540 D | 8 | mg/L | 08/14/2006 | CR |
| **603406-02** | **BCD** | | **8/9/06 13:00** | | |
| Solids | | | | | |
| Total Solids | SM 2540 B | 127 | mg/L | 08/15/2006 | KM |
| Total Suspended Solids | SM 2540 D | 11 | mg/L | 08/14/2006 | CR |

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| | |
|---|---|
| Project: | Buck Creek |
| Entered By: | Lynn Ellis |
| Date Reported: | 08/29/2006 |
| Date Received: | 08/25/2006 |
| Date Complete: | 08/29/2006 |

| Test | Method | Result | Units | Date | Initials |
|---|---|---|---|---|---|
| **603620-01** | **BCD** | | **8/24/06 13:15** | | |
| Solids | | | | | |
| Total Solids | SM 2540 B | 106 | mg/L | 08/29/2006 | KM |
| Total Dissolved Solids | SM 2540 C | 94 | mg/L | 08/29/2006 | KM |
| **603620-02** | **BCU** | | **8/24/06 12:40** | | |
| Solids | | | | | |
| Total Solids | SM 2540 B | 106 | mg/L | 08/29/2006 | KM |
| Total Dissolved Solids | SM 2540 C | 90 | mg/L | 08/29/2006 | KM |

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Project:
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Date Reported: 09/14/2006
Date Received: 09/08/2006
Date Complete: 09/14/2006

| Test | Method | Result | Units | Date | Initials |
|---|---|---|---|---|---|
| **603836-04** | **BCD** | | **9/8/06 13:30** | | |

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Project:
Entered By: Lynn Ellis
Date Reported: 09/14/2006
Date Received: 09/08/2006
Date Complete: 09/14/2006

| Test | Method | Result | Units | Date | Initials |
|---|---|---|---|---|---|
| **603836-01** | **BCU** | | **9/8/06 12:30** | | |
| Solids | | | | | |
| Total Solids | SM 2540 B | 92 | mg/L | 09/12/2006 | KM |
| Total Suspended Solids | SM 2540 D | 7 | mg/L | 09/12/2006 | CR |
| **603836-02** | **BCU** | | **9/8/06 12:45** | | |
| Solids | | | | | |
| Total Solids | SM 2540 B | 90 | mg/L | 09/12/2006 | KM |
| Total Suspended Solids | SM 2540 D | 5 | mg/L | 09/12/2006 | CR |
| **603836-03** | **BCD** | | **9/8/06 13:15** | | |
| Solids | | | | | |
| Total Solids | SM 2540 B | 94 | mg/L | 09/12/2006 | KM |
| Total Suspended Solids | SM 2540 D | 5 | mg/L | 09/12/2006 | CR |
| **603836-04** | **BCD** | | **9/8/06 13:30** | | |
| Solids | | | | | |
| Total Solids | SM 2540 B | 102 | mg/L | 09/12/2006 | KM |
| Total Suspended Solids | SM 2540 D | 4 | mg/L | 09/12/2006 | CR |

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Project:
Entered By: Ellen Fouser
Date Reported: 10/04/2006
Date Received: 09/25/2006
Date Complete: 10/04/2006

| Test | Method | Result | Units | Date | Initials |
|---|---|---|---|---|---|
| **604048-07** | **BCU** | | **9/13/06 14:05** | | |
| Solids | | | | | |
| Total Suspended Solids | SM 2540 D | 5 | mg/L | 09/28/2006 | KM |
| **604048-08** | **BCD** | | **9/13/06 13:30** | | |
| Solids | | | | | |
| Total Solids | SM 2540 B | 116 | mg/L | 09/27/2006 | KM |
| Volatile Suspended Solids | EPA 160.4 | 0.002 | mg/L | 09/28/2006 | KM |
| Total Suspended Solids | SM 2540 D | 18 | mg/L | 09/28/2006 | KM |

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Date Received: 09/25/2006
Date Complete: 10/04/2006

| Test | Method | Result | Units | Date | Initials |
|---|---|---|---|---|---|
| **604048-04** | **BCD** | | **9/22/06 10:00** | | |
| Solids | | | | | |
| Volatile Suspended Solids | EPA 160.4 | 0.004 | mg/L | 09/28/2006 | KM |
| Total Suspended Solids | SM 2540 D | 2 | mg/L | 09/28/2006 | CR |
| **604048-05** | **BCD** | | **9/22/06 11:30** | | |
| Solids | | | | | |
| Total Solids | SM 2540 B | 106 | mg/L | 09/27/2006 | KM |
| Volatile Suspended Solids | EPA 160.4 | 0.005 | mg/L | 09/28/2006 | KM |
| Total Suspended Solids | SM 2540 D | 6 | mg/L | 09/28/2006 | CR |
| **604048-06** | **BCD** | | **9/22/06 12:00** | | |
| Solids | | | | | |
| Total Solids | SM 2540 B | 104 | mg/L | 09/27/2006 | KM |
| Volatile Suspended Solids | EPA 160.4 | 0.003 | mg/L | 09/28/2006 | KM |
| Total Suspended Solids | SM 2540 D | 10 | mg/L | 09/28/2006 | KM |
| **604048-07** | **BCU** | | **9/13/06 14:05** | | |
| Solids | | | | | |
| Total Solids | SM 2540 B | 110 | mg/L | 09/27/2006 | KM |
| Volatile Suspended Solids | EPA 160.4 | 0.005 | mg/L | 09/28/2006 | KM |

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Date Reported: 10/04/2006
Date Received: 09/25/2006
Date Complete: 10/04/2006

| Test | Method | Result | Units | Date | Initials |
|---|---|---|---|---|---|
| **604048-01** | **BCU** | | **9/22/06 10:30** | | |
| Solids | | | | | |
| Total Solids | SM 2540 B | 102 | mg/L | 09/27/2006 | KM |
| Volatile Suspended Solids | EPA 160.4 | 0.004 | mg/L | 09/28/2006 | KM |
| Total Suspended Solids | SM 2540 D | 6 | mg/L | 09/28/2006 | CR |
| **604048-02** | **BCU** | | **9/22/06 12:30** | | |
| Solids | | | | | |
| Total Solids | SM 2540 B | 100 | mg/L | 09/27/2006 | KM |
| Volatile Suspended Solids | EPA 160.4 | 0.005 | mg/L | 09/28/2006 | KM |
| Total Suspended Solids | SM 2540 D | 3 | mg/L | 09/28/2006 | CR |
| **604048-03** | **BCU** | | **9/22/06 13:00** | | |
| Solids | | | | | |
| Total Solids | SM 2540 B | 100 | mg/L | 09/27/2006 | KM |
| Volatile Suspended Solids | EPA 160.4 | 0.005 | mg/L | 09/28/2006 | KM |
| Total Suspended Solids | SM 2540 D | 6 | mg/L | 09/28/2006 | CR |
| **604048-04** | **BCD** | | **9/22/06 10:00** | | |
| Solids | | | | | |
| Total Solids | SM 2540 B | 92 | mg/L | 09/27/2006 | KM |

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Project:
Entered By: Lynn Ellis
Date Reported: 11/20/2006
Date Received: 10/17/2006
Date Complete: 11/07/2006

| Test | Method | Result | Units | Date | Initials |
|---|---|---|---|---|---|
| **604431-04** | **BCD** | | **10/17/06 13:55** | | |
| Solids | | | | | |
| Total Solids | SM 2540 B | 178 | mg/L | 10/23/2006 | KM |
| Total Volatile Solids | SM 2540 E | 52 | mg/L | 10/23/2006 | KM |
| Volatile Suspended Solids | SM 2540 E | 27 | mg/L | 10/18/2006 | KM |
| Total Suspended Solids | SM 2540 D | 30 | mg/L | 10/18/2006 | KM |

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Project:
Entered By: Lynn Ellis
Date Reported: 11/20/2006
Date Received: 10/17/2006
Date Complete: 11/07/2006

| Test | Method | Result | Units | Date | Initials |
|---|---|---|---|---|---|
| **604431-01** | **BCU** | | **10/17/06 13:00** | | |
| Solids | | | | | |
| Total Solids | SM 2540 B | 166 | mg/L | 10/23/2006 | KM |
| Total Volatile Solids | SM 2540 E | 48 | mg/L | 10/23/2006 | KM |
| Volatile Suspended Solids | SM 2540 E | 21 | mg/L | 10/18/2006 | KM |
| Total Suspended Solids | SM 2540 D | 48 | mg/L | 10/18/2006 | KM |
| **604431-02** | **BCU** | | **10/17/06 13:43** | | |
| Solids | | | | | |
| Total Solids | SM 2540 B | 158 | mg/L | 10/23/2006 | KM |
| Total Volatile Solids | SM 2540 E | 96 | mg/L | 10/23/2006 | KM |
| Volatile Suspended Solids | SM 2540 E | 25 | mg/L | 10/18/2006 | KM |
| Total Suspended Solids | SM 2540 D | 42 | mg/L | 10/18/2006 | KM |
| **604431-03** | **BCD** | | **10/17/06 13:30** | | |
| Solids | | | | | |
| Total Solids | SM 2540 B | 179 | mg/L | 10/23/2006 | KM |
| Total Volatile Solids | SM 2540 E | 45 | mg/L | 10/23/2006 | KM |
| Volatile Suspended Solids | SM 2540 E | 23 | mg/L | 10/18/2006 | KM |
| Total Suspended Solids | SM 2540 D | 36 | mg/L | 10/18/2006 | KM |

**FES** FOUSER ENVIRONMENTAL SERVICES

165 Camden Avenue, Versailles, Ky. 40383 Phone: 859-873-6211 Fax: 859-873-3715 e-mail: lab@fouser.com

LABORATORY/CONSULTING

## Certificate of Analysis

Cumberland Environmental
Mr. Lynn Jarrett
P.O. Box 446
Henryville, Indiana 47126

Project:
Entered By: Lynn Ellis
Date Reported: 5/17/2007
Date Received: 5/3/2007
Date Complete: 5/16/2007

| Test | Method | Result | Units | Date | Initials |
|---|---|---|---|---|---|
| **701866-01** | **Buck Ck. Upstream** | | **Collection 5/3/07 10:00** | | |
| Nitrate-Nitrite | | | | | |
| Nitrate-N | EPA 300.0 | 0.50 | mg/L | 5/4/2007 | EW |
| Nitrite-N | EPA 300.0 | <0.05 | mg/L | 5/4/2007 | EW |
| Phosphorus | | | | | |
| Phosphorus, Dissolved | EPA 365.3 | 0.05 | mg/L | 5/15/2007 | KM |
| Solids | | | | | |
| Total Solids | SM 2540 B | 104 | mg/L | 5/10/2007 | KM |
| Total Suspended Solids | SM 2540 D | 3 | mg/L | 5/8/2007 | KM |
| **701866-02** | **Buck Ck. Downstream** | | **Collection 5/3/07 11:30** | | |
| Nitrate-Nitrite | | | | | |
| Nitrate-N | EPA 300.0 | 0.50 | mg/L | 5/4/2007 | EW |
| Nitrite-N | EPA 300.0 | <0.05 | mg/L | 5/4/2007 | EW |
| Phosphorus | | | | | |
| Phosphorus, Dissolved | EPA 365.3 | 0.10 | mg/L | 5/15/2007 | KM |
| Solids | | | | | |
| Total Solids | SM 2540 B | 120 | mg/L | 5/10/2007 | KM |
| Total Suspended Solids | SM 2540 D | 4 | mg/L | 5/8/2007 | KM |

Page 1 of 3

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LABORATORY/CONSULTING

## Certificate of Analysis

Cumberland Environmental
Mr. Lynn Jarrett
P.O. Box 446
Henryville, Indiana 47126

Project:
Entered By: Lynn Ellis
Date Reported: 6/26/2007
Date Received: 6/20/2007
Date Complete: 6/22/2007

| Test | Method | Result | Units | Date | Initials |
|---|---|---|---|---|---|
| **702512-03** **BCD** | | **Collection** | **6/19/07 16:15** | | |
| Nitrate-Nitrite | | | | | |
| Nitrate-N | EPA 300.0 | <0.05 | mg/L | 6/20/2007 | EW |
| Nitrite-N | EPA 300.0 | <0.05 | mg/L | 6/20/2007 | EW |
| Phosphorus | | | | | |
| Phosphorus, Total | EPA 365.3 | 0.10 | mg/L | 6/21/2007 | KM |
| Solids | | | | | |
| Total Solids | SM 2540 B | 144 | mg/L | 6/21/2007 | KM |
| Total Suspended Solids | SM 2540 D | 21 | mg/L | 6/21/2007 | CT |

| | | | | | |
|---|---|---|---|---|---|
| **702512-04** **FB1** | | **Collection** | **6/20/07 11:30** | | |
| Nitrate-Nitrite | | | | | |
| Nitrate-N | EPA 300.0 | <0.05 | mg/L | 6/20/2007 | EW |
| Nitrite-N | EPA 300.0 | <0.05 | mg/L | 6/20/2007 | EW |
| Phosphorus | | | | | |
| Phosphorus, Total | EPA 365.3 | 1.10 | mg/L | 6/21/2007 | KM |
| Solids | | | | | |
| Total Solids | SM 2540 B | 236 | mg/L | 6/21/2007 | KM |
| Total Suspended Solids | SM 2540 D | 20 | mg/L | 6/21/2007 | CT |

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# Certificate of Analysis

Cumberland Environmental
Mr. Lynn Jarrett
P.O. Box 446
Henryville, Indiana 47126

Project:
Entered By: Lynn Ellis
Date Reported: 6/26/2007
Date Received: 6/20/2007
Date Complete: 6/22/2007

| Test | | Method | Result | Units | Date | Initials |
|---|---|---|---|---|---|---|
| **702512-01** | **BCU** | | **Collection** | **6/19/07 15:45** | | |
| Nitrate-Nitrite | | | | | | |
| Nitrate-N | | EPA 300.0 | <0.05 | mg/L | 6/20/2007 | EW |
| Nitrite-N | | EPA 300.0 | <0.05 | mg/L | 6/20/2007 | EW |
| Phosphorus | | | | | | |
| Phosphorus, Total | | EPA 365.3 | 1.80 | mg/L | 6/21/2007 | KM |
| Solids | | | | | | |
| Total Solids | | SM 2540 B | 134 | mg/L | 6/21/2007 | KM |
| Total Suspended Solids | | SM 2540 D | 28 | mg/L | 6/21/2007 | CT |
| **702512-02** | **BCU** | | **Collection** | **6/19/07 15:55** | | |
| Nitrate-Nitrite | | | | | | |
| Nitrate-N | | EPA 300.0 | <0.05 | mg/L | 6/20/2007 | EW |
| Nitrite-N | | EPA 300.0 | <0.05 | mg/L | 6/20/2007 | EW |
| Phosphorus | | | | | | |
| Phosphorus, Total | | EPA 365.3 | 0.50 | mg/L | 6/21/2007 | KM |
| Solids | | | | | | |
| Total Solids | | SM 2540 B | 128 | mg/L | 6/21/2007 | KM |
| Total Suspended Solids | | SM 2540 D | 31 | mg/L | 6/21/2007 | CT |

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## Certificate of Analysis

Cumberland Environmental
Mr. Lynn Jarrett
P.O. Box 446
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Project:
Entered By: Lynn Ellis
Date Reported: 6/29/2007
Date Received: 6/25/2007
Date Complete: 6/29/2007

| Test | | Method | Result | Units | Date | Initials |
|---|---|---|---|---|---|---|
| **702563-03** | **BCD** | | **Collection** | **6/25/07 09:30** | | |
| Nitrate-Nitrite | | | | | | |
| Nitrate-N | | EPA 300.0 | <0.05 | mg/L | 6/26/2007 | EW |
| Nitrite-N | | EPA 300.0 | <0.05 | mg/L | 6/26/2007 | EW |
| Phosphorus | | | | | | |
| Phosphorus, Total | | EPA 365.3 | <0.01 | mg/L | 6/26/2007 | KM |
| Solids | | | | | | |
| Total Solids | | SM 2540 B | 136 | mg/L | 6/28/2007 | KM |
| Total Suspended Solids | | SM 2540 D | 12 | mg/L | 6/26/2007 | CT |
| **702563-04** | **PC1** | | **Collection** | **6/25/07 13:00** | | |
| Nitrate-Nitrite | | | | | | |
| Nitrate-N | | EPA 300.0 | <0.05 | mg/L | 6/26/2007 | EW |
| Nitrite-N | | EPA 300.0 | <0.05 | mg/L | 6/26/2007 | EW |
| Phosphorus | | | | | | |
| Phosphorus, Total | | EPA 365.3 | 0.30 | mg/L | 6/26/2007 | KM |
| Solids | | | | | | |
| Total Solids | | SM 2540 B | 273 | mg/L | 6/28/2007 | KM |
| Total Suspended Solids | | SM 2540 D | 27 | mg/L | 6/26/2007 | CT |

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Cumberland Environmental
Mr. Lynn Jarrett
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Henryville, Indiana 47126

Project:
Entered By: Lynn Ellis
Date Reported: 6/29/2007
Date Received: 6/25/2007
Date Complete: 6/29/2007

| Test | | Method | Result | Units | Date | Initials |
|---|---|---|---|---|---|---|
| **702563-01** | **BCU** | | **Collection** | **6/25/07 09:00** | | |
| Nitrate-Nitrite | | | | | | |
| Nitrate-N | | EPA 300.0 | <0.05 | mg/L | 6/26/2007 | EW |
| Nitrite-N | | EPA 300.0 | <0.05 | mg/L | 6/26/2007 | EW |
| Phosphorus | | | | | | |
| Phosphorus, Total | | EPA 365.3 | 0.35 | mg/L | 6/26/2007 | KM |
| Solids | | | | | | |
| Total Solids | | SM 2540 B | 124 | mg/L | 6/28/2007 | KM |
| Total Suspended Solids | | SM 2540 D | 18 | mg/L | 6/26/2007 | CT |
| **702563-02** | **BCV** | | **Collection** | **6/25/07 09:00** | | |
| Nitrate-Nitrite | | | | | | |
| Nitrate-N | | EPA 300.0 | <0.05 | mg/L | 6/26/2007 | EW |
| Nitrite-N | | EPA 300.0 | <0.05 | mg/L | 6/26/2007 | EW |
| Phosphorus | | | | | | |
| Phosphorus, Total | | EPA 365.3 | <0.01 | mg/L | 6/26/2007 | KM |
| Solids | | | | | | |
| Total Solids | | SM 2540 B | 127 | mg/L | 6/28/2007 | KM |
| Total Suspended Solids | | SM 2540 D | 16 | mg/L | 6/26/2007 | CT |

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## Certificate of Analysis

Cumberland Environmental
Mr. Lynn Jarrett
P.O. Box 446
Henryville, Indiana 47126

Project:
Entered By: Lynn Ellis
Date Reported: 8/28/2007
Date Received: 8/22/2007
Date Complete: 8/28/2007

| Test | Method | Result | Units | Date | Initials |
|---|---|---|---|---|---|
| **703465-05** | **BCU** | | **Collection** | **8/21/07 12:45** | |

**Approved By:** [signature]

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Henryville, Indiana 47126

Project:
Entered By: Lynn Ellis
Date Reported: 8/28/2007
Date Received: 8/22/2007
Date Complete: 8/28/2007

| Test | | Method | Result | Units | Date | Initials |
|---|---|---|---|---|---|---|
| **703465-01** | **BCU** | | **Collection** | **8/21/07 12:15** | | |
| Nitrate-Nitrite | | | | | | |
| Nitrate-N | | EPA 300.0 | <0.1 | mg/L | 8/22/2007 | EW |
| Phosphorus | | | | | | |
| Phosphorus, Total | | EPA 365.3 | 3.00 | mg/L | 8/28/2007 | KM |
| Solids | | | | | | |
| Total Solids | | SM 2540 B | 136 | mg/L | 8/23/2007 | KM |
| Total Suspended Solids | | SM 2540 D | 8 | mg/L | 8/23/2007 | KM |
| **703465-02** | **BCU** | | **Collection** | **8/21/07 12:10** | | |
| Solids | | | | | | |
| Total Solids | | SM 2540 B | 136 | mg/L | 8/23/2007 | KM |
| Total Suspended Solids | | SM 2540 D | 2 | mg/L | 8/23/2007 | KM |
| **703465-05** | **BCU** | | **Collection** | **8/21/07 12:45** | | |
| Nitrate-Nitrite | | | | | | |
| Nitrate-N | | EPA 300.0 | <0.1 | mg/L | 8/22/2007 | EW |
| Phosphorus | | | | | | |
| Phosphorus, Total | | EPA 365.3 | 1.00 | mg/L | 8/28/2007 | KM |
| Solids | | | | | | |
| Total Solids | | SM 2540 B | 130 | mg/L | 8/23/2007 | KM |
| Total Suspended Solids | | SM 2540 D | 10 | mg/L | 8/23/2007 | KM |

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# Certificate of Analysis

Cumberland Environmental
Mr. Lynn Jarrett
P.O. Box 446
Henryville, Indiana 47126

Project: Buck Ck.
Entered By: Lynn Ellis
Date Reported: 11/1/2007
Date Received: 10/25/2007
Date Complete: 11/1/2007

| Test | | Method | Result | | Units | Date | Initials |
|---|---|---|---|---|---|---|---|
| **704418-04** | **BCD** | | | **Collection** | **10/23/07 17:45** | | |
| **704418-05** | **BCD** | | | **Collection** | **10/24/07 14:30** | | |
| Solids | | | | | | | |
| Total Solids | | SM 2540 B | 256 | | mg/L | 10/30/2007 | KM |
| Total Suspended Solids | | SM 2540 D | 18 | | mg/L | 10/30/2007 | CT |
| **704418-06** | **BCD** | | | **Collection** | **10/25/07 13:00** | | |
| Solids | | | | | | | |
| Total Solids | | SM 2540 B | 246 | | mg/L | 10/30/2007 | KM |
| Total Suspended Solids | | SM 2540 D | 3 | | mg/L | 10/30/2007 | CT |

**Approved By:** [signature]

**FES** FOUSER ENVIRONMENTAL SERVICES

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LABORATORY/CONSULTING

## Certificate of Analysis

Cumberland Environmental
Mr. Lynn Jarrett
P.O. Box 446
Henryville, Indiana 47126

Project: Buck Ck.
Entered By: Lynn Ellis
Date Reported: 11/1/2007
Date Received: 10/25/2007
Date Complete: 11/1/2007

| Test | | Method | Result | | Units | Date | Initials |
|---|---|---|---|---|---|---|---|
| **704418-01** | **BCU** | | | **Collection** | **10/23/07 17:30** | | |
| Solids | | | | | | | |
| Total Solids | | SM 2540 B | 586 | | mg/L | 10/30/2007 | KM |
| Total Suspended Solids | | SM 2540 D | 372 | | mg/L | 10/30/2007 | CT |
| **704418-02** | **BCU** | | | **Collection** | **10/24/07 14:00** | | |
| Solids | | | | | | | |
| Total Solids | | SM 2540 B | 312 | | mg/L | 10/30/2007 | KM |
| Total Suspended Solids | | SM 2540 D | 96 | | mg/L | 10/30/2007 | CT |
| **704418-03** | **BCU** | | | **Collection** | **10/25/07 12:30** | | |
| Solids | | | | | | | |
| Total Solids | | SM 2540 B | 164 | | mg/L | 10/30/2007 | KM |
| Total Suspended Solids | | SM 2540 D | 7 | | mg/L | 10/30/2007 | CT |
| **704418-04** | **BCD** | | | **Collection** | **10/23/07 17:45** | | |
| Solids | | | | | | | |
| Total Solids | | SM 2540 B | 318 | | mg/L | 10/30/2007 | KM |
| Total Suspended Solids | | SM 2540 D | 68 | | mg/L | 10/30/2007 | CT |

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LABORATORY/CONSULTING

## Certificate of Analysis

Cumberland Environmental
Mr. Lynn Jarrett
P.O. Box 446
Henryville, Indiana 47126

Project: Buck Ck.
Entered By: Lynn Ellis
Date Reported: 11/14/2007
Date Received: 11/2/2007
Date Complete: 11/13/2007

| Test | | Method | Result | | Units | Date | Initials |
|---|---|---|---|---|---|---|---|
| **704500-01** | **BCU** | | | **Collection** | **11/2/07 12:30** | | |
| Solids | | | | | | | |
| Total Solids | | SM 2540 B | 158 | | mg/L | 11/9/2007 | KM |
| Total Suspended Solids | | SM 2540 D | 4 | | mg/L | 11/5/2007 | CT |
| **704500-02** | **BCD** | | | **Collection** | **11/2/07 13:30** | | |
| Solids | | | | | | | |
| Total Solids | | SM 2540 B | 146 | | mg/L | 11/9/2007 | KM |
| Total Suspended Solids | | SM 2540 D | <1 | | mg/L | 11/5/2007 | CT |

**Approved By:** Cody Bremer

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LABORATORY/CONSULTING

## Certificate of Analysis

Cumberland Environmental Group
Mr. Lynn Jarrett
P.O. Box 446
Henryville, IN 47126

Project: Buck Creek
Entered By: Lynn Ellis
Date Reported: 6/12/2009
Date Received: 6/5/2009
Date Complete: 6/12/2009

| Test | Method | Result | Units | Date | Analyst |
|---|---|---|---|---|---|
| **902581-01** | **BCU** | | **6/4/09 13:30** | | |
| Solids | | | | | |
| Total Solids | SM 2540 B | 88 | mg/L | 6/11/2009 | KM |
| Total Dissolved Solids | SM 2540 C | 79 | mg/L | 6/11/2009 | KM |
| **902581-02** | **BCU** | | **6/4/09 13:35** | | |
| Solids | | | | | |
| Total Solids | SM 2540 B | 120 | mg/L | 6/11/2009 | KM |
| Total Dissolved Solids | SM 2540 C | 107 | mg/L | 6/11/2009 | KM |
| **902581-03** | **BCD** | | **6/4/09 14:00** | | |
| Solids | | | | | |
| Total Solids | SM 2540 B | 104 | mg/L | 6/11/2009 | KM |
| Total Dissolved Solids | SM 2540 C | 100 | mg/L | 6/11/2009 | KM |

**Approved By:** Cody Brenneman
Cody Brenneman

Page 1 of 1

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LABORATORY/CONSULTING

## Certificate of Analysis

Pulaski County Conservation District
Mr. John Burnett
45 Eagle Creek Drive
Somerset, KY 42503

Project: Buck Creek
Entered By: Lynn Ellis
Date Reported: 6/16/2010
Date Received: 6/1/2010
Date Complete: 6/16/2010

| Test | Method | Result | Units | PQL | Date | Analyst |
|---|---|---|---|---|---|---|
| **908647-01** | **BCU-A** | | **6/1/10 11:15** | | | |
| Solids | | | | | | |
| Total Solids | SM 2540 B | 76 | mg/L | 10 | 6/4/2010 | KM |
| Total Dissolved Solids | SM 2540 C | 76 | mg/L | 10 | 6/4/2010 | KM |
| **908647-02** | **BCU-B** | | **6/1/10 11:15** | | | |
| Solids | | | | | | |
| Total Solids | SM 2540 B | 92 | mg/L | 10 | 6/4/2010 | KM |
| Total Dissolved Solids | SM 2540 C | 90 | mg/L | 10 | 6/4/2010 | KM |
| **908647-03** | **BCD-A** | | **6/1/10 12:10** | | | |
| Solids | | | | | | |
| Total Solids | SM 2540 B | 108 | mg/L | 10 | 6/4/2010 | KM |
| Total Dissolved Solids | SM 2540 C | 104 | mg/L | 10 | 6/4/2010 | KM |
| **908647-04** | **BCD-B** | | **6/1/10 12:10** | | | |
| Solids | | | | | | |
| Total Solids | SM 2540 B | 108 | mg/L | 10 | 6/4/2010 | KM |
| Total Dissolved Solids | SM 2540 C | 108 | mg/L | 10 | 6/4/2010 | KM |

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LABORATORY/CONSULTING

## Certificate of Analysis

Pulaski County Conservation District
Mr. John Burnett
45 Eagle Creek Drive
Somerset, KY 42503

Project: Buck Creek
Entered By: Lynn Ellis
Date Reported: 6/16/2010
Date Received: 6/1/2010
Date Complete: 6/16/2010

| Test | Method | Result | Units | PQL | Date | Analyst |
|---|---|---|---|---|---|---|
| **908647-04** | **BCD-B** | | **6/1/10 12:10** | | | |

**Approved By:** [signature]
Ray Fouser, P.E.

# FES FOUSER ENVIRONMENTAL SERVICES

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LABORATORY/CONSULTING

## Certificate of Analysis

Pulaski County Conservation District
Mr. John Burnett
45 Eagle Creek Drive
Somerset, KY 42503

Project: Buck Creek
Entered By: Lynn Ellis
Date Reported: 6/25/2010
Date Received: 6/9/2010
Date Complete: 6/25/2010

| Test | Method | Result | Units | PQL | Date | Analyst |
|---|---|---|---|---|---|---|
| **908855-01** | **BCU-A** | | **6/9/10 14:25** | | | |
| Solids | | | | | | |
| Total Solids | SM 2540 B | 106 | mg/L | 1 | 6/15/2010 | KM |
| Total Suspended Solids | SM 2540 D | 10 | mg/L | 2 | 6/15/2010 | KM |
| **908855-02** | **BCU-B** | | **6/9/10 14:25** | | | |
| Solids | | | | | | |
| Total Solids | SM 2540 B | 90 | mg/L | 1 | 6/15/2010 | KM |
| Total Suspended Solids | SM 2540 D | 10 | mg/L | 2 | 6/15/2010 | KM |
| **908855-03** | **BCD-A** | | **6/9/10 13:50** | | | |
| Solids | | | | | | |
| Total Solids | SM 2540 B | 125 | mg/L | 1 | 6/15/2010 | KM |
| Total Suspended Solids | SM 2540 D | 11 | mg/L | 2 | 6/15/2010 | KM |
| **908855-04** | **BCD-B** | | **6/9/10 13:50** | | | |
| Solids | | | | | | |
| Total Solids | SM 2540 B | 130 | mg/L | 1 | 6/15/2010 | KM |
| Total Suspended Solids | SM 2540 D | 10 | mg/L | 2 | 6/15/2010 | KM |

Page 1 of 2

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## Certificate of Analysis

Pulaski County Conservation District
Mr. John Burnett
45 Eagle Creek Drive
Somerset, KY 42503

Project: Buck Creek
Entered By: Lynn Ellis
Date Reported: 6/25/2010
Date Received: 6/9/2010
Date Complete: 6/25/2010

| Test | Method | Result | Units | PQL | Date | Analyst |
|---|---|---|---|---|---|---|
| **908855-04** | **BCD-B** | | **6/9/10 13:50** | | | |

Approved By: ______________
Ray Fouser, P.E.

Page 2 of 2

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# Certificate of Analysis

Cumberland Environmental Group
Mr. Lynn Jarrett
P.O. Box 446
Henryville, IN 47126

Project: Buck Creek
Entered By: Lynn Ellis
Date Reported: 7/15/2009
Date Received: 7/6/2009
Date Complete: 7/15/2009

| Test | Method | Result | Units | Date | Analyst |
|---|---|---|---|---|---|
| **902955-01** | **BCU** | | **7/6/09 11:30** | | |
| Solids | | | | | |
| Total Solids | SM 2540 B | 92 | mg/L | 7/8/2009 | KM |
| Total Dissolved Solids | SM 2540 C | 81 | mg/L | 7/8/2009 | KM |
| **902955-02** | **BCU** | | **7/6/09 11:35** | | |
| Solids | | | | | |
| Total Solids | SM 2540 B | 112 | mg/L | 7/8/2009 | KM |
| Total Dissolved Solids | SM 2540 C | 101 | mg/L | 7/8/2009 | KM |
| **902955-03** | **BCD** | | **7/6/09 12:30** | | |
| Solids | | | | | |
| Total Solids | SM 2540 B | 100 | mg/L | 7/8/2009 | KM |
| Total Dissolved Solids | SM 2540 C | 91 | mg/L | 7/8/2009 | KM |
| **902955-04** | **BCD** | | **7/6/09 12:35** | | |
| Solids | | | | | |
| Total Solids | SM 2540 B | 124 | mg/L | 7/8/2009 | KM |
| Total Dissolved Solids | SM 2540 C | 114 | mg/L | 7/8/2009 | KM |

**FES** FOUSER ENVIRONMENTAL SERVICES
165 Camden Avenue, Versailles, Ky. 40383 Phone: 859-873-6211 Fax: 859-873-3715 e-mail: lab@fouser.com

LABORATORY/CONSULTING

## Certificate of Analysis

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P.O. Box 446
Henryville, IN 47126

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Date Reported: 7/15/2009
Date Received: 7/6/2009
Date Complete: 7/15/2009

| Test | Method | Result | Units | Date | Analyst |
|---|---|---|---|---|---|
| **902955-04** | **BCD** | | **7/6/09 12:35** | | |

Approved By: Cody Brenneman

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LABORATORY/CONSULTING

# Certificate of Analysis

Cumberland Environmental Group
Mr. Lynn Jarrett
P.O. Box 446
Henryville, IN 47126

Project: Buck Creek
Entered By: Lynn Ellis
Date Reported: 7/15/2009
Date Received: 6/26/2009
Date Complete: 7/15/2009

| Test | Method | Result | Units | Date | Analyst |
|---|---|---|---|---|---|
| **902879-01** | **BCU** | | **6/26/09 11:00** | | |
| Solids | | | | | |
| Total Solids | SM 2540 B | 144 | mg/L | 7/2/2009 | KM |
| Total Dissolved Solids | SM 2540 C | 82 | mg/L | 7/2/2009 | KM |
| **902879-02** | **BCUT** | | **6/26/09 11:00** | | |
| Solids | | | | | |
| Total Solids | SM 2540 B | 328 | mg/L | 7/2/2009 | KM |
| Total Dissolved Solids | SM 2540 C | 96 | mg/L | 7/2/2009 | KM |
| **902879-03** | **BCD** | | **6/26/09 12:15** | | |
| Solids | | | | | |
| Total Solids | SM 2540 B | 528 | mg/L | 7/2/2009 | KM |
| Total Dissolved Solids | SM 2540 C | 118 | mg/L | 7/2/2009 | KM |
| **902879-04** | **BCD** | | **6/26/09 12:20** | | |
| Solids | | | | | |
| Total Solids | SM 2540 B | 620 | mg/L | 7/2/2009 | KM |
| Total Dissolved Solids | SM 2540 C | 154 | mg/L | 7/2/2009 | KM |

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Project: Buck Creek
Entered By: Lynn Ellis
Date Reported: 7/15/2009
Date Received: 6/26/2009
Date Complete: 7/15/2009

| Test | Method | Result | Units | Date | Analyst |
|---|---|---|---|---|---|
| **902879-04** | **BCD** | | **6/26/09 12:20** | | |

**Approved By:** [signature]
Cody Brenneman

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## Certificate of Analysis

| | | | |
|---|---|---|---|
| Cumberland Environmental Group | | Project: | Buck Creek |
| Mr. Lynn Jarrett | | Entered By: | Lynn Ellis |
| P.O. Box 446 | | Date Reported: | 7/31/2009 |
| Henryville, IN 47126 | | Date Received: | 7/27/2009 |
| | | Date Complete: | 7/31/2009 |

| Test | Method | Result | Units | Date | Analyst |
|---|---|---|---|---|---|
| **903337-01** | **BCD** | | **7/25/09 13:00** | | |
| Solids | | | | | |
| Total Solids | SM 2540 B | 108 | mg/L | 7/28/2009 | KM |
| Total Dissolved Solids | SM 2540 C | 96 | mg/L | 7/30/2009 | KM |
| **903337-02** | **BCD** | | **7/25/09 13:05** | | |
| Solids | | | | | |
| Total Solids | SM 2540 B | 124 | mg/L | 7/28/2009 | KM |
| Total Dissolved Solids | SM 2540 C | 115 | mg/L | 7/30/2009 | KM |
| **903337-03** | **BCU** | | **7/25/09 14:00** | | |
| Solids | | | | | |
| Total Solids | SM 2540 B | 108 | mg/L | 7/28/2009 | KM |
| Total Dissolved Solids | SM 2540 C | 94 | mg/L | 7/30/2009 | KM |
| **903337-04** | **BCU** | | **7/25/09 14:05** | | |
| Solids | | | | | |
| Total Solids | SM 2540 B | 108 | mg/L | 7/28/2009 | KM |
| Total Dissolved Solids | SM 2540 C | 93 | mg/L | 7/30/2009 | KM |

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P.O. Box 446
Henryville, IN 47126

Project: Buck Creek
Entered By: Lynn Ellis
Date Reported: 7/31/2009
Date Received: 7/27/2009
Date Complete: 7/31/2009

| Test | Method | Result | Units | Date | Analyst |
|---|---|---|---|---|---|
| **903337-04** | **BCU** | | **7/25/09 14:05** | | |

**Approved By:** Cody Brenneman

Cody Brenneman

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Cumberland Environmental Group
Mr. Lynn Jarrett
P.O. Box 446
Henryville, IN 47126

| | |
|---|---|
| Project: | Buck Creek |
| Entered By: | Lynn Ellis |
| Date Reported: | 9/3/2009 |
| Date Received: | 8/20/2009 |
| Date Complete: | 9/3/2009 |

| Test | Method | Result | Units | Date | Analyst |
|---|---|---|---|---|---|
| **903819-01** | **BCU** | | **8/19/09 11:45** | | |
| Solids | | | | | |
| Total Solids | SM 2540 B | 96 | mg/L | 8/25/2009 | KM |
| Total Dissolved Solids | SM 2540 C | 88 | mg/L | 8/25/2009 | KM |
| **903819-02** | **BCU** | | **8/19/09 11:50** | | |
| Solids | | | | | |
| Total Solids | SM 2540 B | 76 | mg/L | 8/25/2009 | KM |
| Total Dissolved Solids | SM 2540 C | 68 | mg/L | 8/25/2009 | KM |
| **903819-03** | **BCD** | | **8/19/09 12:45** | | |
| Solids | | | | | |
| Total Solids | SM 2540 B | 92 | mg/L | 8/25/2009 | KM |
| Total Dissolved Solids | SM 2540 C | 82 | mg/L | 8/25/2009 | KM |
| **903819-04** | **BCD** | | **8/19/09 12:50** | | |
| Solids | | | | | |
| Total Solids | SM 2540 B | 108 | mg/L | 8/25/2009 | KM |
| Total Dissolved Solids | SM 2540 C | 102 | mg/L | 8/25/2009 | KM |

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Henryville, IN 47126

Project: Buck Creek
Entered By: Lynn Ellis
Date Reported: 9/3/2009
Date Received: 8/20/2009
Date Complete: 9/3/2009

| Test | Method | Result | Units | Date | Analyst |
|---|---|---|---|---|---|
| **903819-04** | **BCD** | | **8/19/09 12:50** | | |

**Approved By:** Cody Brenneman

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Mr. Lynn Jarrett
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Henryville, IN 47126

Project: Buck Creek
Entered By: Lynn Ellis
Date Reported: 9/3/2009
Date Received: 8/13/2009
Date Complete: 9/3/2009

| Test | Method | Result | Units | Date | Analyst |
|---|---|---|---|---|---|
| **903669-01** | **BCU** | | **8/12/09 12:00** | | |
| Solids | | | | | |
| Total Solids | SM 2540 B | 104 | mg/L | 8/13/2009 | KM |
| Total Dissolved Solids | SM 2540 C | 94 | mg/L | 8/20/2009 | KM |
| **903669-02** | **BCU** | | **8/12/09 12:10** | | |
| Solids | | | | | |
| Total Solids | SM 2540 B | 140 | mg/L | 8/13/2009 | KM |
| Total Dissolved Solids | SM 2540 C | 128 | mg/L | 8/20/2009 | KM |
| **903669-03** | **BCD** | | **8/12/09 14:20** | | |
| Solids | | | | | |
| Total Solids | SM 2540 B | 124 | mg/L | 8/13/2009 | KM |
| Total Dissolved Solids | SM 2540 C | 120 | mg/L | 8/20/2009 | KM |
| **903669-04** | **BCD** | | **8/12/09 14:30** | | |
| Solids | | | | | |
| Total Solids | SM 2540 B | 120 | mg/L | 8/13/2009 | KM |
| Total Dissolved Solids | SM 2540 C | 114 | mg/L | 8/20/2009 | KM |

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Henryville, IN 47126

Project: Buck Creek
Entered By: Lynn Ellis
Date Reported: 9/3/2009
Date Received: 8/13/2009
Date Complete: 9/3/2009

| Test | Method | Result | Units | Date | Analyst |
|---|---|---|---|---|---|
| **903669-04** | **BCD** | | **8/12/09 14:30** | | |

**Approved By:** [signature]
Cody Brenneman

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Project: Buck Creek
Entered By: Cody Brenneman
Date Reported: 8/13/2009
Date Received: 7/30/2009
Date Complete: 8/13/2009

| Test | Method | Result | Units | Date | Analyst |
|---|---|---|---|---|---|
| **903414-01** | **BCU** | | **7/29/09 12:45** | | |
| Solids | | | | | |
| Total Solids | SM 2540 B | 108 | mg/L | 8/3/2009 | KM |
| Total Dissolved Solids | SM 2540 C | 93 | mg/L | 8/5/2009 | KM |
| **903414-02** | **BCU** | | **7/29/09 14:00** | | |
| Solids | | | | | |
| Total Solids | SM 2540 B | 132 | mg/L | 8/3/2009 | KM |
| Total Dissolved Solids | SM 2540 C | 109 | mg/L | 8/5/2009 | KM |

**Approved By:** Cody Brenneman

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# Certificate of Analysis

Cumberland Environmental Group
Mr. Lynn Jarrett
P.O. Box 446
Henryville, IN 47126

Project: Buck Creek
Entered By: Lynn Ellis
Date Reported: 9/16/2009
Date Received: 8/28/2009
Date Complete: 9/15/2009

| Test | Method | Result | Units | Date | Analyst |
|---|---|---|---|---|---|
| **903940-01** | **BCU** | | **8/28/09 11:00** | | |
| Solids | | | | | |
| Total Solids | SM 2540 B | 132 | mg/L | 9/3/2009 | KM |
| Total Dissolved Solids | SM 2540 C | 125 | mg/L | 9/3/2009 | KM |
| **903940-02** | **BCU** | | **8/28/09 11:05** | | |
| Solids | | | | | |
| Total Solids | SM 2540 B | 108 | mg/L | 9/3/2009 | KM |
| Total Dissolved Solids | SM 2540 C | 100 | mg/L | 9/3/2009 | KM |
| **903940-03** | **BCD** | | **8/28/09 12:30** | | |
| Solids | | | | | |
| Total Solids | SM 2540 B | 116 | mg/L | 9/3/2009 | KM |
| Total Dissolved Solids | SM 2540 C | 110 | mg/L | 9/3/2009 | KM |
| **903940-04** | **BCD** | | **8/28/09 12:25** | | |
| Solids | | | | | |
| Total Solids | SM 2540 B | 124 | mg/L | 9/3/2009 | KM |
| Total Dissolved Solids | SM 2540 C | 115 | mg/L | 9/3/2009 | KM |

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P.O. Box 446
Henryville, IN 47126

Project: Buck Creek
Entered By: Lynn Ellis
Date Reported: 9/16/2009
Date Received: 8/28/2009
Date Complete: 9/15/2009

| Test | Method | Result | Units | Date | Analyst |
|---|---|---|---|---|---|
| **903940-04** | **BCD** | | **8/28/09 12:25** | | |

**Approved By:** Cody Brenneman

Page 2 of 2

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Cumberland Environmental Group
Mr. Lynn Jarrett
P.O. Box 446
Henryville, IN 47126

Project: Buck Creek
Entered By: Lynn Ellis
Date Reported: 10/29/2009
Date Received: 10/9/2009
Date Complete: 10/29/2009

| Test | Method | Result | Units | Date | Analyst |
|---|---|---|---|---|---|
| **904631-01** | **BCU** | | **10/9/09 13:30** | | |
| Solids | | | | | |
| Total Solids | SM 2540 B | 100 | mg/L | 10/15/2009 | KM |
| Total Suspended Solids | SM 2540 D | 3 | mg/L | 10/16/2009 | KM |
| **904631-02** | **BCU** | | **10/9/09 13:35** | | |
| Solids | | | | | |
| Total Solids | SM 2540 B | 60 | mg/L | 10/15/2009 | KM |
| Total Suspended Solids | SM 2540 D | 6 | mg/L | 10/16/2009 | KM |
| **904631-03** | **BCD** | | **10/9/09 14:00** | | |
| Solids | | | | | |
| Total Solids | SM 2540 B | 72 | mg/L | 10/15/2009 | KM |
| Total Suspended Solids | SM 2540 D | 8 | mg/L | 10/16/2009 | KM |
| **904631-04** | **BCD** | | **10/9/09 14:05** | | |
| Solids | | | | | |
| Total Solids | SM 2540 B | 76 | mg/L | 10/15/2009 | KM |
| Total Suspended Solids | SM 2540 D | 8 | mg/L | 10/16/2009 | KM |

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Entered By: Lynn Ellis
Date Reported: 10/29/2009
Date Received: 10/9/2009
Date Complete: 10/29/2009

| Test | Method | Result | Units | Date | Analyst |
|---|---|---|---|---|---|
| **904631-04** | **BCD** | | **10/9/09 14:05** | | |

**Approved By:** Cody Brenneman

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Henryville, IN 47126

Project: Buck Creek
Entered By: Lynn Ellis
Date Reported: 11/13/2009
Date Received: 10/31/2009
Date Complete: 11/13/2009

| Test | Method | Result | Units | Date | Analyst |
|---|---|---|---|---|---|
| **904966-01** | **BCU** | | **10/31/09** | | |
| Solids | | | | | |
| Total Solids | SM 2540 B | 132 | mg/L | 11/6/2009 | KM |
| Total Dissolved Solids | SM 2540 C | 112 | mg/L | 11/6/2009 | KM |
| **904966-02** | **BCD** | | **10/31/09** | | |
| Solids | | | | | |
| Total Solids | SM 2540 B | 28 | mg/L | 11/6/2009 | KM |
| Total Dissolved Solids | SM 2540 C | 26 | mg/L | 11/6/2009 | KM |

Approved By: Cody Brenneman
Cody Brenneman

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LABORATORY/CONSULTING

# Certificate of Analysis

Pulaski County Conservation District
Mr. John Burnett
45 Eagle Creek Drive
Somerset, KY 42503

Project: Buck Creek
Entered By: Lynn Ellis
Date Reported: 7/30/2010
Date Received: 7/27/2010
Date Complete: 7/29/2010

| Test | Method | Result | Units | PQL | Date | Analyst |
|---|---|---|---|---|---|---|
| **909674-01** | **BCU-A** | | **7/21/10 14:56** | | | |
| Solids | | | | | | |
| Total Solids | SM 2540 B | 592 | mg/L | 10 | 7/27/2010 | KM |
| Total Suspended Solids | SM 2540 D | 576 | mg/L | 2 | 7/27/2010 | KM |
| **909674-02** | **BCU-B** | | **7/21/10 14:57** | | | |
| Solids | | | | | | |
| Total Solids | SM 2540 B | 624 | mg/L | 10 | 7/27/2010 | KM |
| Total Suspended Solids | SM 2540 D | 546 | mg/L | 2 | 7/27/2010 | KM |
| **909674-03** | **BCD-A** | | **7/21/10 15:17** | | | |
| Solids | | | | | | |
| Total Solids | SM 2540 B | 520 | mg/L | 10 | 7/27/2010 | KM |
| Total Suspended Solids | SM 2540 D | 394 | mg/L | 2 | 7/27/2010 | KM |
| **909674-04** | **BCD-B** | | **7/21/10 15:18** | | | |
| Solids | | | | | | |
| Total Solids | SM 2540 B | 445 | mg/L | 10 | 7/27/2010 | KM |
| Total Suspended Solids | SM 2540 D | 375 | mg/L | 2 | 7/27/2010 | KM |

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LABORATORY/CONSULTING

## Certificate of Analysis

Pulaski County Conservation District
Mr. John Burnett
45 Eagle Creek Drive
Somerset, KY 42503

Project: Buck Creek
Entered By: Lynn Ellis
Date Reported: 7/30/2010
Date Received: 7/27/2010
Date Complete: 7/29/2010

| Test | Method | Result | Units | PQL | Date | Analyst |
|---|---|---|---|---|---|---|
| 909674-04 | BCD-B | | 7/21/10 15:18 | | | |

Approved By: [signature]

Ray Fouser, P.E.

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LABORATORY/CONSULTING

## Certificate of Analysis

Pulaski County Conservation District
Mr. John Burnett
45 Eagle Creek Drive
Somerset, KY 42503

Project: Buck Creek
Entered By: Ellen Fouser
Date Reported: 7/26/2010
Date Received: 7/20/2010
Date Complete: 7/26/2010

| Test | Method | Result | Units | PQL | Date | Analyst |
|---|---|---|---|---|---|---|
| **909556-01** | **BCU-A** | | **7/14/10 08:00** | | | |
| Solids | | | | | | |
| Total Solids | SM 2540 B | 138 | mg/L | 10 | 7/20/2010 | KM |
| Total Suspended Solids | SM 2540 D | 10 | mg/L | 2 | 7/20/2010 | KM |
| **909556-02** | **BCU-B** | | **7/14/10 08:02** | | | |
| Solids | | | | | | |
| Total Solids | SM 2540 B | 185 | mg/L | 10 | 7/20/2010 | KM |
| Total Suspended Solids | SM 2540 D | 14 | mg/L | 2 | 7/20/2010 | KM |
| **909556-03** | **BCD-A** | | **7/14/10 08:29** | | | |
| Solids | | | | | | |
| Total Solids | SM 2540 B | 177 | mg/L | 10 | 7/20/2010 | KM |
| Total Suspended Solids | SM 2540 D | 19 | mg/L | 2 | 7/20/2010 | KM |
| **909556-04** | **BCD-B** | | **7/14/10 08:30** | | | |
| Solids | | | | | | |
| Total Solids | SM 2540 B | 179 | mg/L | 10 | 7/20/2010 | KM |
| Total Suspended Solids | SM 2540 D | 20 | mg/L | 2 | 7/20/2010 | KM |

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Pulaski County Conservation District
Mr. John Burnett
45 Eagle Creek Drive
Somerset, KY 42503

Project: Buck Creek
Entered By: Ellen Fouser
Date Reported: 7/26/2010
Date Received: 7/20/2010
Date Complete: 7/26/2010

| Test | Method | Result | Units | PQL | Date | Analyst |
|---|---|---|---|---|---|---|
| **909556-04** | **BCD-B** | | **7/14/10 08:30** | | | |

**Approved By:** [signature]
Ray Fouser, P.E.

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## Certificate of Analysis

Pulaski County Conservation District
Mr. John Burnett
45 Eagle Creek Drive
Somerset, KY 42503

Project: Buck Creek
Entered By: Lynn Ellis
Date Reported: 8/17/2010
Date Received: 8/5/2010
Date Complete: 8/17/2010

| Test | Method | Result | Units | PQL | Date | Analyst |
|---|---|---|---|---|---|---|
| **909909-01** | **BCU-A** | | **8/5/10 10:44** | | | |
| Solids | | | | | | |
| Total Solids | SM 2540 B | 79 | mg/L | 10 | 8/11/2010 | KM |
| Total Suspended Solids | SM 2540 D | 7 | mg/L | 2 | 8/9/2010 | KM |
| **909909-02** | **BCU-B** | | **8/5/10 10:45** | | | |
| Solids | | | | | | |
| Total Solids | SM 2540 B | 114 | mg/L | 10 | 8/11/2010 | KM |
| Total Suspended Solids | SM 2540 D | 8 | mg/L | 2 | 8/9/2010 | KM |
| **909909-03** | **BCD-A** | | **8/5/10 10:05** | | | |
| Solids | | | | | | |
| Total Solids | SM 2540 B | 71 | mg/L | 10 | 8/11/2010 | KM |
| Total Suspended Solids | SM 2540 D | 8 | mg/L | 2 | 8/9/2010 | KM |
| **909909-04** | **BCD-B** | | **8/5/10 10:06** | | | |
| Solids | | | | | | |
| Total Solids | SM 2540 B | 83 | mg/L | 10 | 8/11/2010 | KM |
| Total Suspended Solids | SM 2540 D | 7 | mg/L | 2 | 8/9/2010 | KM |

# FES Fouser Environmental Services

165 Camden Avenue, Versailles, Ky. 40383 Phone: 859-873-6211 Fax: 859-873-3715 e-mail: lab@fouser.com

Laboratory/Consulting

## Certificate of Analysis

Pulaski County Conservation District
Mr. John Burnett
45 Eagle Creek Drive
Somerset, KY 42503

Project: Buck Creek
Entered By: Lynn Ellis
Date Reported: 8/17/2010
Date Received: 8/5/2010
Date Complete: 8/17/2010

| Test | Method | Result | Units | PQL | Date | Analyst |
|---|---|---|---|---|---|---|
| **909909-04** | **BCD-B** | | **8/5/10 10:06** | | | |

**Approved By:** Ray Fouser
Ray Fouser, P.E.

# FES Fouser Environmental Services

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Laboratory/Consulting

## Certificate of Analysis

Pulaski County Conservation District
Mr. John Burnett
45 Eagle Creek Drive
Somerset, KY 42503

Project: Buck Creek
Entered By: Lynn Ellis
Date Reported: 8/30/2010
Date Received: 8/25/2010
Date Complete: 8/27/2010

| Test | Method | Result | Units | PQL | Date | Analyst |
|---|---|---|---|---|---|---|
| **910253-01** | **BCU-A** | | **8/20/10 08:00** | | | |
| Solids | | | | | | |
| Total Solids | SM 2540 B | 133 | mg/L | 10 | 8/26/2010 | KM |
| Total Suspended Solids | SM 2540 D | 18 | mg/L | 2 | 8/26/2010 | KM |
| **910253-02** | **BCU-B** | | **8/20/10 08:02** | | | |
| Solids | | | | | | |
| Total Solids | SM 2540 B | 129 | mg/L | 10 | 8/26/2010 | KM |
| Total Suspended Solids | SM 2540 D | 20 | mg/L | 2 | 8/26/2010 | KM |
| **910253-03** | **BCD-A** | | **8/20/10 08:45** | | | |
| Solids | | | | | | |
| Total Solids | SM 2540 B | 135 | mg/L | 10 | 8/26/2010 | KM |
| Total Suspended Solids | SM 2540 D | 17 | mg/L | 2 | 8/26/2010 | KM |
| **910253-04** | **BCD-B** | | **8/20/10 08:47** | | | |
| Solids | | | | | | |
| Total Solids | SM 2540 B | 122 | mg/L | 10 | 8/26/2010 | KM |
| Total Suspended Solids | SM 2540 D | 16 | mg/L | 2 | 8/26/2010 | KM |

**FES** FOUSER ENVIRONMENTAL SERVICES
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LABORATORY/CONSULTING

## Certificate of Analysis

Pulaski County Conservation District
Mr. John Burnett
45 Eagle Creek Drive
Somerset, KY 42503

Project: Buck Creek
Entered By: Lynn Ellis
Date Reported: 8/30/2010
Date Received: 8/25/2010
Date Complete: 8/27/2010

| Test | Method | Result | Units | PQL | Date | Analyst |
|---|---|---|---|---|---|---|
| **910253-04** | **BCD-B** | | **8/20/10 08:47** | | | |

Approved By: [signature]
Ray Fouser, P.E.

**FES** FOUSER ENVIRONMENTAL SERVICES
165 Camden Avenue, Versailles, Ky. 40383 Phone: 859-873-6211 Fax: 859-873-3715 e-mail: lab@fouser.com

LABORATORY/CONSULTING

## Certificate of Analysis

Pulaski County Conservation District
Mr. John Burnett
45 Eagle Creek Drive
Somerset, KY 42503

Project: Buck Creek
Entered By: Lynn Ellis
Date Reported: 9/1/2010
Date Received: 8/19/2010
Date Complete: 8/27/2010

| Test | Method | Result | Units | PQL | Date | Analyst |
|---|---|---|---|---|---|---|
| **910180-01** | **BCU-A** | | **8/19/10 08:50** | | | |
| Solids | | | | | | |
| Total Solids | SM 2540 B | 143 | mg/L | 10 | 8/25/2010 | KM |
| Total Suspended Solids | SM 2540 D | 91 | mg/L | 2 | 8/20/2010 | KM |
| **910180-02** | **BCU-B** | | **8/19/10 08:52** | | | |
| Solids | | | | | | |
| Total Solids | SM 2540 B | 161 | mg/L | 10 | 8/25/2010 | KM |
| Total Suspended Solids | SM 2540 D | 91 | mg/L | 2 | 8/20/2010 | KM |
| **910180-03** | **BCD-A** | | **8/19/10 09:15** | | | |
| Solids | | | | | | |
| Total Solids | SM 2540 B | 356 | mg/L | 10 | 8/25/2010 | KM |
| Total Suspended Solids | SM 2540 D | 301 | mg/L | 2 | 8/20/2010 | KM |
| **910180-04** | **BCD-B** | | **8/19/10 09:17** | | | |
| Solids | | | | | | |
| Total Solids | SM 2540 B | 388 | mg/L | 10 | 8/25/2010 | KM |
| Total Suspended Solids | SM 2540 D | 297 | mg/L | 2 | 8/20/2010 | KM |

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LABORATORY/CONSULTING

## Certificate of Analysis

Pulaski County Conservation District
Mr. John Burnett
45 Eagle Creek Drive
Somerset, KY 42503

Project: Buck Creek
Entered By: Lynn Ellis
Date Reported: 9/1/2010
Date Received: 8/19/2010
Date Complete: 8/27/2010

| Test | Method | Result | Units | PQL | Date | Analyst |
|---|---|---|---|---|---|---|
| **910180-04** | **BCD-B** | | **8/19/10 09:17** | | | |

**Approved By:** Ray Fouser

Ray Fouser, P.E.

Page 2 of 2

**FES** FOUSER ENVIRONMENTAL SERVICES

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LABORATORY/CONSULTING

# Certificate of Analysis

Pulaski County Conservation District
Mr. John Burnett
45 Eagle Creek Drive
Somerset, KY 42503

Project: Buck Creek
Entered By: Lynn Ellis
Date Reported: 10/13/2010
Date Received: 9/23/2010
Date Complete: 10/13/2010

| Test | Method | Result | Units | PQL | Date | Analyst |
|---|---|---|---|---|---|---|
| **910791-01** | **BCU-A** | | **9/23/10 10:35** | | | |
| Solids | | | | | | |
| Total Solids | SM 2540 B | 50 | mg/L | 10 | 9/29/2010 | KM |
| Total Suspended Solids | SM 2540 D | 11 | mg/L | 2 | 9/24/2010 | KM |
| **910791-02** | **BCU-B** | | **9/23/10 10:36** | | | |
| Solids | | | | | | |
| Total Solids | SM 2540 B | 83 | mg/L | 10 | 9/29/2010 | KM |
| Total Suspended Solids | SM 2540 D | 12 | mg/L | 2 | 9/24/2010 | KM |
| **910791-03** | **BCD-A** | | **9/23/10 10:54** | | | |
| Solids | | | | | | |
| Total Solids | SM 2540 B | 104 | mg/L | 10 | 9/29/2010 | KM |
| Total Suspended Solids | SM 2540 D | 7 | mg/L | 2 | 9/24/2010 | KM |
| **910791-04** | **BCD-B** | | **9/23/10 10:55** | | | |
| Solids | | | | | | |
| Total Solids | SM 2540 B | 108 | mg/L | 10 | 9/29/2010 | KM |
| Total Suspended Solids | SM 2540 D | 6 | mg/L | 2 | 9/24/2010 | KM |

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## Certificate of Analysis

Pulaski County Conservation District
Mr. John Burnett
45 Eagle Creek Drive
Somerset, KY 42503

Project: Buck Creek
Entered By: Lynn Ellis
Date Reported: 10/13/2010
Date Received: 9/23/2010
Date Complete: 10/13/2010

| Test | Method | Result | Units | PQL | Date | Analyst |
|---|---|---|---|---|---|---|
| 910791-04 | BCD-B | | 9/23/10 10:55 | | | |

Approved By: [signature]
Ray Fouser, P.E.

Page 2 of 2

**FES** FOUSER ENVIRONMENTAL SERVICES
165 Camden Avenue, Versailles, Ky. 40383 Phone: 859-873-6211 Fax: 859-873-3715 e-mail: lab@fouser.com

LABORATORY/CONSULTING

## Certificate of Analysis

Pulaski County Conservation District
Mr. John Burnett
45 Eagle Creek Drive
Somerset, KY 42503

Project: Buck Creek
Entered By: Lynn Ellis
Date Reported: 11/12/2010
Date Received: 10/29/2010
Date Complete: 11/9/2010

| Test | Method | Result | Units | PQL | Date | Analyst |
|---|---|---|---|---|---|---|
| **911463-01** | **BCU-A** | | **10/27/10 15:20** | | | |
| Solids | | | | | | |
| Total Solids | SM 2540 B | 36 | mg/L | 10 | 11/2/2010 | KM |
| Total Suspended Solids | SM 2540 D | 10 | mg/L | 2 | 11/2/2010 | KM |
| **911463-02** | **BCU-B** | | **10/27/10 15:21** | | | |
| Solids | | | | | | |
| Total Solids | SM 2540 B | 205 | mg/L | 10 | 11/2/2010 | KM |
| Total Suspended Solids | SM 2540 D | 10 | mg/L | 2 | 11/2/2010 | KM |
| **911463-03** | **BCD-A** | | **10/27/10 15:40** | | | |
| Solids | | | | | | |
| Total Solids | SM 2540 B | 226 | mg/L | 10 | 11/2/2010 | KM |
| Total Suspended Solids | SM 2540 D | 7 | mg/L | 2 | 11/2/2010 | KM |
| **911463-04** | **BCD-B** | | **10/27/10 15:41** | | | |
| Solids | | | | | | |
| Total Solids | SM 2540 B | 58 | mg/L | 10 | 11/2/2010 | KM |
| Total Suspended Solids | SM 2540 D | 4 | mg/L | 2 | 11/2/2010 | KM |

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LABORATORY/CONSULTING

## Certificate of Analysis

Pulaski County Conservation District
Mr. John Burnett
45 Eagle Creek Drive
Somerset, KY 42503

Project: Buck Creek
Entered By: Lynn Ellis
Date Reported: 11/12/2010
Date Received: 10/29/2010
Date Complete: 11/9/2010

| Test | Method | Result | Units | PQL | Date | Analyst |
|---|---|---|---|---|---|---|
| **911463-04** | **BCD-B** | | **10/27/10 15:41** | | | |

**Approved By:** [signature]
Ray Fouser, P.E.

Page 2 of 2

BMPs Installed Table

| BMP (units) | NRCS Practice Code | Results | HUC 14 | Lat/Long | Watershed Name |
|---|---|---|---|---|---|
| Animal Waste Storage (#) | 313 | 2 | 05130103030010 | NA* | Indian Creek |
| Animal Waste Storage (#) | 313 | 1 | 05130103030190 | NA | Clear Creek |
| Critical Area Planting (Acres) | 342 | 1.6 | 05130103040030 | NA | Brushy Creek |
| Fence (Linear feet) | 382 | 7,265 | 05130103030010 | NA | Indian Creek |
| Fence (Linear feet) | 382 | 465 | 05130103040020 | NA | Bee Lick Creek |
| Fence (Linear feet) | 382 | 4,592 | 05130103030160 | NA | Whetstone Creek |
| Fence (Linear feet) | 382 | 2,001 | 05130103030140 | NA | Briary Creek |
| Fence (Linear feet) | 382 | 1990 | 05130103030190 | NA | Clear Creek |
| Fence (Linear feet) | 382 | 810 | 05130103030230 | NA | Buck Creek |
| Fence (Linear feet) | 382 | 3,250 | 05130103030110 | NA | Buck Creek |
| Filter Strip (Acres) | 393 | 0.1 | 05130103030210 | NA | Buck Creek |
| Heavy Use Area (Feet$^2$) | 561 | 4,284 | 05130103040020 | NA | Bee Lick Creek |
| Heavy Use Area (Feet$^2$) | 561 | 2,520 | 05130103030230 | NA | Buck Creek |
| Heavy Use Area (Feet$^2$) | 561 | 2,100 | 05130103040020 | NA | Buck Creek |
| Heavy Use Area (Feet$^2$) | 561 | 10,500 | 05130103040090 | NA | Flat Lick Creek |
| Heavy Use Area (Feet$^2$) | 561 | 1,260 | 05130103030140 | NA | Briary Creek |
| Heavy Use Area (Feet$^2$) | 561 | 2,694 | 05130103030160 | NA | Whetstone Creek |
| Heavy Use Area (Feet$^2$) | 561 | 2,222 | 05130103030190 | NA | Clear Creek |
| Grassed Waterway (Acres) | 412 | 0.5 | 05130103030010 | NA | Indian Creek |
| Grassed Waterway (Acres) | 412 | 1 | 05130103040020 | NA | Bee Lick Creek |
| Pasture & Hayland seeding (Acres) | 512 | 12.7 | 05130103030150 | NA | Buck Creek |
| Pasture & Hayland seeding (Acres) | 512 | 8.1 | 05130103030010 | NA | Indian Creek |
| Pasture & Hayland seeding (Acres) | 512 | 60.5 | 05130103040030 | NA | Brushy Creek |
| Pasture & Hayland seeding (Acres) | 512 | 98 | 05130103040080 | NA | Buck Creek |
| Pasture & Hayland seeding (Acres) | 512 | 60 | 05130103040090 | NA | Flat Lick Creek |
| Pipeline (Linear feet) | 516 | 958 | 05130103030190 | NA | Clear Creek |
| Pipeline (Linear feet) | 516 | 3,510 | 05130103030160 | NA | Whetstone Creek |
| Pipeline (Linear feet) | 516 | 4,258 | 05130103030010 | NA | Indian Creek |
| Pipeline (Linear feet) | 516 | 496 | 05130103030140 | NA | Briary Creek |
| Pipeline (Linear feet) | 516 | 1,715 | 05130103040040 | NA | Clifty Creek |
| Pipeline (Linear feet) | 516 | 2,490 | 05130103040020 | NA | Bee Lick Creek |
| Pipeline (Linear feet) | 516 | 2,535 | 05130103040080 | NA | Buck Creek |
| Pipeline (Linear feet) | 516 | 2,300 | 05130103040030 | NA | Brushy Creek |
| Pipeline (Linear feet) | 516 | 195 | 05130103040020 | NA | Buck Creek |
| Pipeline (Linear feet) | 516 | 2,179 | 05130103040100 | NA | Stewart Branch |
| Pipeline (Linear feet) | 516 | 1,116 | 05130103040090 | NA | Flat Lick Creek |
| Pond Ramp (Feet$^2$) | 575 | 1,470 | 05130103030160 | NA | Whetstone Creek |
| Pond Ramp (Feet$^2$) | 575 | 336 | 05130103030140 | NA | Briary Creek |
| Pond Ramp (Feet$^2$) | 575 | 600 | 05130103030190 | NA | Clear Creek |
| Pond Ramp (Feet$^2$) | 575 | 600 | 05130103030230 | NA | Buck Creek |
| Prescribed Grazing (Acres) | 528A | 96 | 05130103040080 | NA | BuckCreek |
| Prescribed Grazing (Acres) | 528A | 60 | 05130103080130 | NA | Clift Creek |
| Spring Developments (#) | 574 | 2 | 05130103030140 | NA | Briary Creek |
| Spring Developments (#) | 574 | 2 | 05130103040030 | NA | Brushy Creek |
| Spring Developments (#) | 574 | 1 | 05130103040020 | NA | Bee Lick Creek |
| Stream Crossings (#) | 576 | 2 | 05130103030010 | NA | Indian Creek |
| Stream Crossings (#) | 576 | 1 | 05130103030140 | NA | Briary Creek |
| Stream Crossings (#) | 576 | 1 | 05130103030160 | NA | Whetstone Creek |

| | | | | | |
|---|---|---|---|---|---|
| Streambank Stabilization (LF) | 580 | 490 | 05130103030210 | NA | Buck Creek |
| Tank (#) | 614 | 5 | 05130103030140 | NA | Briary Creek |
| Tank (#) | 614 | 3 | 05130103030190 | NA | Clear Creek |
| Tank (#) | 614 | 5 | 05130103030160 | NA | Whetstone Creek |
| Tank (#) | 614 | 4 | 05130103040040 | NA | Clifty Creek |
| Tank (#) | 614 | 7 | 05130103030010 | NA | Indian Creek |
| Tank (#) | 614 | 4 | 05130103040020 | NA | Bee Lick Creek |
| Tank (#) | 614 | 3 | 05130103040030 | NA | Brushy Creek |
| Tank (#) | 614 | 2 | 05130103040080 | NA | Buck Creek |
| Tank (#) | 614 | 1 | 05130103040020 | NA | Buck Creek |
| Tank (#) | 614 | 4 | 05130103040100 | NA | Stewart Branch |
| Tank (#) | 614 | 2 | 05130103040090 | NA | Flat Lick Creek |

BMP Photos

Grassed Waterway: Before

Grassed Waterway: After

Waste Storage: Before

Waste Storage: After

Streambank Protection: Before

NOTE: (The gravel mining in the photo is not related to Mr. Beshear's property.)

Streambank Protection: After

Streambank Protection: Before

Streambank Protection: After

Watering Facility: Before

Watering Facility: After

HUA: Before

.

HUA: After

Pond Tank: Before

Pond Tank: After

Woodland Fence: Before

Woodland Fence: After

Stream Fence: Before

Stream Fence: After

HUA: Before

HUA: After

Stream Crossing: Before

Stream Crossing: After

Fence: After

Spring Development: After

Pond Ramp: Before

Pond Ramp: After

Feeding Area/ Waste Storage: Before

Feeding Area/ Waste Storage: After

Stream Crossing: Before

Stream Crossing: After

Stream Fencing: Before

Stream Fencing: After

Watering Facility: Before

Note: (Before livestock was watering directly out of the stream.)

Watering Facility: After

HUA: Before

HUA: After

Fence: Before

Fence: After

Spring Development: Before

Spring Development: After

Stream Crossing: Before

Stream Crossing: After

Pasture and Hayland Planting: Before

Pasture and Hayland Planting: After

Pond Ramp and Fence: Before

Pond Ramp and Fence: After

Pond Ramp and Fence: Before

Pond Ramp and Fence: After

Press Releases

THE PULASKI COUNTY SOIL AND WATER CONSERVATION DISTRICT AND PULASKI COUNTY CATTLEMAN'S ASSOCIATION WILL BE HOSTING AN ON-FARM DEMONSTRATION FIELD DAY TUESDAY, SEPTEMBER 15, 2009. THE EVENT WILL BE HELD ON THE HUBBLE FARM IN THE WHETSTONE CREEK WATERSHED OFF OF HIGHWAY 452, AND WILL BEGIN AT 5:30 P.M. THE DEMONSTRATIONS WILL HIGHLIGHT THE PRIMARY GOAL OF THE GRANT, WHICH IS TO PROTECT AND ENHANCE AGRICULTURAL RESOURCES AND STREAM HABITAT FOR FEDERALLY THREATENED AND ENDANGERED MUSSEL SPECIES THROUGH THE INSTALLATION OF RIPARIAN AGRICULTURAL AND ANIMAL BEST MANAGEMENT PRACTICES. SPEAKERS WILL INCLUDE REPRESENTATIVES FROM CUMBERLAND ENVIRONMENTAL GROUP, KCTCS, TUBLINE MANUFACTORING, PULASKI COUNTY EXTENSION SERVICE, U.S.D.A. NATURAL RESOURCES CONSERVATION SERVICE, AND THE KENTUCKY DEPARTMENT OF FISH AND WILDLIFE. A MEAL WILL ALSO BE SERVED BY THE PULASKI COUNTY CATTLEMANS ASSOCIATION. PLEASE CONTACT THE PULASKI COUNTY CONSERVATION DISTRICT AT (606)678-4842 EXT. 3 BY SEPTEMBER 10TH TO RSVP OR FOR FURTHER INFORMATION.

**"This work was funded in part by a grant from the U.S. Environmental Protection Agency under §319(h) of the Clean Water Act. "**

BUCK CREEK WATERSHED 319 GRANT FIELD DAY

THE PULASKI CO. CONSERVATION DISTRICT AND THE PULASKI COUNTY CATTLEMAN'S ASSOCIATION WILL BE HOSTING AN ON-FARM DEMONSTRATION FIELD DAY TUESDAY, SEPTEMBER 15, 2009. THE EVENT WILL BE HELD ON THE HUBBLE FARM IN THE WHETSTONE CREEK WATERSHED OFF OF HIGHWAY 452, AND WILL BEGIN AT 5:30 P.M. THE DEMONSTRATIONS WILL HIGHLIGHT THE PRIMARY GOAL OF THE GRANT, WHICH IS TO PROTECT AND ENHANCE AGRICULTURAL RESOURCES AND STREAM HABITAT FOR THREATENED AND ENDANGERED MUSSEL SPECIES THROUGH THE INSTALLATION OF RIPARIAN AGRICULTURAL AND ANIMAL MANAGEMENT BMP'S. A MEAL WILL ALSO BE SERVED BY THE PULASKI COUNTY CATTLEMANS ASSOCIATION. PLEASE CONTACT THE PULASKI COUNTY CONSERVATION DISTRICT AT (606)678-4842 EXT. 3 BY SEPTEMBER 10TH TO RSVP OR FOR FURTHER INFORMATION.

**"This work was funded in part by a grant from the U.S. Environmental Protection Agency under §319(h) of the Clean Water Act. "**

Letters

April 2, 2007

Dear Landowner,

The Pulaski County Soil and Water Conservation District is accepting applications for the Buck Creek Watershed Riparian Restoration Project (319 Grant) at your USDA Service Center. The efforts of this grant will be centered primarily on developing the riparian areas (streamside buffers), 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. The installation of these conservation practices will only be on existing operations.

The funding for this grant has been approved for a defined area of the Buck Creek Watershed. The Project Area includes the following drainage areas: **Briary Creek, Whetstone Creek, Indian Creek, Barney Branch, and Clear Creek.** This work was funded in part by a grant from the U.S. Environmental Protection Agency under §319(h) of the Clean Water Act.

**Applications will be accepted from April 2, 2007 through April 30, 2007.**

This Project will allow landowners engaged in livestock or agricultural production on eligible land to receive cost share ranging from 30 to 75 percent on installed practices. All conservation practices implemented through this program must be installed according to NRCS standards and specifications. The project applications will be evaluated and ranked using criteria established by the local Project Oversight Committee.

To apply for this Riparian Restoration Project Grant, or for more information, please contact your local NRCS or Pulaski County Conservation District office at the USDA Service Center, 45 Eagle Creek Drive, Suite 102, Somerset, KY 42503. Or call at (606) 678-4842, extension 3.

Sincerely,

John Burnett, Buck Creek Watershed Coordinator
Pulaski County Conservation District

May 25, 2007
Dear Landowner,

The Pulaski County Soil and Water Conservation District would like to thank you for your interest in the EPA 319 Grant Program. This letter is to inform you that **your application has been approved for funding up to $**. Please notify us of your intent to follow through with the Best Management Practice installation by June 15, 2007 if you are still interested in the installation of practices as discussed with you on the farm visit. Please read and follow the guidelines listed below:

- Maximum funding for this project is 75% cost share or $20,000 whichever is the lesser amount.
- All funds will be disbursed on a reimbursement basis.
- **All practices must be installed according to NRCS standards and specifications.**
- Receipts are required for materials.
- Completed Agricultural Water Quality Act (AWQA) plan on file with the Pulaski County Conservation District.
- Completed current conservation plan.

Remember that April 1, 2008 is the deadline for receipts to be turned in for approved applicants. Also, keep in mind that you may not begin construction of any practices until you have the approved NRCS designs for that particular practice.

If you have any additional questions feel free to contact the Pulaski County Soil and Water Conservation District M-F 8:00 am – 4:30 pm.

Thank you,

John Burnett
Pulaski County Conservation District

This work was funded in part by a grant from the U.S. Environmental Protection Agency under §319(h) of the Clean Water Act through the Kentucky Division of Water to Pulaski County Soil and Water Conservation District through Grant # 05-07.

Brochures

# GUIDELINES FOR
# BUCK CREEK WATERSHED RIPARIAN RESTORATION
# PROJECT 319 GRANT

## Timeline:

- Advertisement Period: March 19, 2007 to April 1, 2007
- Sign-up Period: April 2, 2007 to April 30, 2007
- Applications will be scored, ranked, and approved by May 14, 2007
- **April 1, 2008** deadline for receipts to be turned in for **APPROVED** applicants.

## Contact Information:

- Pulaski County Soil and Water Conservation District, 45 Eagle Creek Drive, Suite 102, Somerset, KY 42503.
- Phone number (606) 678-4842 extension 3.
- Office hours are 8:00a.m. to 4:30p.m.

## General Information:

- Buck Creek Watershed Riparian Restoration Project applications can be picked up during the sign-up period at the Pulaski County Conservation District office. The District's office is located in the U.S.D.A. Service Center and is co-located with the U.S.D.A. – Natural Resources Conservation Service (NRCS) office. This program is funded through an EPA 319 Grant between the Commonwealth of Kentucky and Pulaski County Conservation District.
- Applications received during the sign-up period will be scored, ranked, and funded in priority order until the funds are exhausted. Approved applicants will be notified by letter after May 7, 2007.
- The efforts will be centered primarily on developing the riparian areas, 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. The goal is to keep high quality water in the Buck Creek watershed.

## Sign-up Information:

- Farms must be a minimum of ten acres to apply.
- Incomplete applications will not be accepted and must receive a date, time, and number from the Pulaski County Conservation District when logged in at the office. Also, no late applications will be accepted.
- Farms must be in one of the following drainage areas to be eligible for funding: Briary Creek, Whetstone Creek, Indian Creek, Barney Branch, and Clear Creek.
- No receipts should be turned in with the initial application. Receipts will be turned in later by **APPROVED** applicants only.

## Program Guidelines For Approved Applicants:

- Maximum funding for this project is 75% cost share or $20,000 whichever is the lesser amount.

- All funds will be disbursed on a reimbursement basis.
- All practices must be installed according to NRCS standards and specifications.
- Receipts are required for materials.
- Completed Agricultural Water Quality Act (AWQA) plan on file with the Pulaski County Conservation District.
- Completed current conservation plan.

## Eligible Conservation Practices:

| NRCS Practice Name | NRCS Practice Code |
|---|---|
| • Critical Area Planning | 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 |

## Other items eligible for funding:

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.
Charger, for electrical fencing limit of 1 charger per cooperator.
Extension of electrical service for water pumps - <u>$1,000.00 maximum</u>.
Water meters for municipal water sources – <u>1 meter per cooperator with a ¾" size limit.</u>

Heavy Use Area Protection practice shall be used in only the following areas: gateways, walkways, around tanks, and feeding areas. Moving existing heavy use areas away from creek (feeding areas must be at least 150’ away from a body of water)
Flash grazing – only for code 393 (filter strip). . Flash grazing in riparian areas can occur during two periods in the spring and fall and only with the implementation of filter strips (393). The specific dates are May 1 through May 15, and October 1 through October 15.
Rental payment for riparian areas will have a contract ending no later than the end of the Grant with an added maintenance time. Producers who participate in this practice will receive $100.00/ac per year for three years with an additional three-year maintenance agreement. The minimum width will be 50’ and the maximum width 180’.
Prescribed Grazing incentive payments for prescribed grazing practices shall be $15.00/ac the first year, $10.00/ac the second, and $5.00/ac the third. However, there will be a 50 acre maximum limit for prescribed grazing per landowner. Also required will be one mandatory Beef Quality Assurance Training session; the training dates are as follows: May 17, June 7, or July 26 2007. The trainings will be held at the Pulaski County Extension Office at 6:00 P.M.
The Pasture and Hayland Planting practice shall only cost share on: fertilizer and lime applications which are applied according to a soil test, seed from an approved seed list (see attached list), and drill rental. A soil test less than one year old will also be required and the planting may not exceed 30% of the farm.
Costs for alternative water supplies are only eligible if; 1. livestock are excluded from streams or other water bodies, or 2. as part of a rotational grazing system. The most cost effective water facility determined by NRCS will be utilized.

**This work was funded in part by a grant from the U.S. Environmental Protection Agency under §319(h) of the Clean Water Act through the Kentucky Division of Water to the Pulaski County Soil and Water Conservation District through Grant#05-07.**

**PULASKI COUNTY CONSERVATION DISTRICT**
**BUCK CREEK WATERSHED RIPARIAN RESTORATION PROJECT**

# 319 GRANT

2007

**A. Application Information**

**For Office Use Only:**

Date received: _______

Application Number:

1. Name: ______________________________________________

Address: ______________________________________________

City: _________________ State:_______ Zip Code:_______

2. Phone: ________________________________

Cell Phone: ____________________________

3. Social Security Number: ______________ 4.Farm Number _______ Tract Number_______

5. How many acres are in your farm? _____ (Minimum size farm eligible is 10 acres)

6. Do you have an Ag Water Quality Plan completed? Yes ____ No____

7. Do you have a current conservation plan? Yes____ No____

8. ****All practices 75% cost share unless otherwise noted****

9. All practices installed must meet NRCS standards and specifications.

10. Applicants Request:
The practice(s) is needed on the farm identified above and would not be performed to the extent requested and needed by me without cost-sharing. If cost-sharing is approved for the practice(s) requested, I agree to refund all or part of the cost-share assistance paid to me as determined by the local conservation district, if, before the expiration of the specified practice lifespan, I (a) destroy the approved practice(s), or, (b) relinquish control or title to the land on which the approved practice(s) has been established and the new owner an/or operator of the land does not agree in writing to properly maintain the practice(s) for the remainder of it's lifespan.

11. **I agree to be willing for cost share practices to be part of a field day or demonstration. I understand the maximum cost-share I may receive from this program for all practices installed is $20,000. I understand that before I am eligible for theses funds I must complete the following: 1.) agree upon and sign contract, 2.) receive NRCS designs for approved practices, 3.) install practices according to the designs and specifications, and 4.) sign the practice certification.**

____________________________________ ___________________________

APPLICANTS SIGNATURE DATE

## B. Estimated Quantities:

| A. | B. | C. | D. |
|---|---|---|---|
| **Practice:** | **Unit (ft./ac./ea.)** | **Estimated Total Cost ($):** | **Estimated Cost Share ($):** |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |

**Total Estimated Cost Share: $ ____________________**

**C. Location:**

14-Digit Watershed: ____________________________________

Topo Quad Name: _____________________________________

Latitude (N/S): _________________ Longitude (E/W):____________________

This practice is needed and practical to solve the problem identified and can be installed according to NRCS conservation practice standards and specifications. ____Yes ____ No

**D. Site Information:**

What is the distance in feet from the closest planned BMP to Buck Creek or a major tributary (list tributary)?

______________________________________________________________________

___________________________________________________________

What is the current feedlot ratio? ________# of animal units _______ feedlot area (Acres)

Is applicant willing to establish a riparian area(s)? _____No _____Yes
If yes, list the total acres of riparian area(s)? ____________ Acres

__________________________________________ __________________

**Signature: NRCS Representative** **Date**

__________________________________________ __________________

**Signature: Conservation District Board Chairman** **Date**

__________________________________________ __________________

**Signature: 319 Project Coordinator** **Date**

**C. Verification Information (to be completed by Pulaski County Conservation District Representative)**

1. Practice Components Installed: Complete Exhibit 1 below to identify actual measures installed and costs.

## Exhibit 1

| A. Component Description | B. Units Applied | C. Total Cost ($) |
|---|---|---|
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |

2. Performance Report: Has this practice been performed to the extent requested and does it meet the standards and specifications? ____Yes ____No

Signature: __________________________________________
Pulaski County Conservation District Representative

3. Total Installation Cost: $________________ 4. Cost-Share Payment: $________________

5. C.D. Payment Approval: ________________ 6. Check Number: ______________________

7. Social Security Number of person receiving cost-share funds: ___________________________

**C. Certification and Maintenance.**

1. Did you bear all of the expenses of performing this practice? _____Yes _____No

2. Please attach all receipts.

3. Performance Maintenance Agreement:

I certify that the above information is true and correct. I further certify that the entries in Exhibit 1 show that the practice was performed in accordance with the practice specifications and other program requirements. I hereby apply for payment to the extent that the Conservation District has determined that the practice has been performed. I agree to maintain this practice for at least ___ years following the year the practice is completed. I agree to refund all or part of the cost-share assistance paid to me as determined by the Conservation District if, before the expiration of the practice's life span specified above, I (a) destroy the practice installed, or (b) cease to use the practice for its intended purpose, or c.) voluntarily relinquish control or title to the land on which the installed practice has been established and the new owner and/or operator o the land does not agree, in writing, to properly use and maintain the practice for the remainder of its specified life span.

_________________________________ _________________________
APPLICANTS SIGNATURE DATE

3/22/07

Page Compiled by B. Parmley – bparmley

# Buck Creek Watershed Riparian Restoration Project accepting applications

The Pulaski County Soil and Water Conservation District is accepting applications for the Buck Creek Watershed Riparian Restoration Project (319 Grant) at the USDA Service Center.

**Informational community meeting to be held at the Eubank Fire Department March 29, 2007, at 7 p.m.**

The efforts of this grant will be centered primarily on developing the riparian areas, 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.

The installation of these conservation practices will only be on existing operations.

The funding for this grant has been approved for a defined area of the Buck Creek Watershed. The project area includes the following drainage areas: Briary Creek, Whetstone Creek, Indian Creek, Barney Branch and Clear Creek. This work was funded in part by a grant from the U.S. Environmental Protection Agency under §319(h) of the Clean Water Act.

There will be an informational community meeting held at the Eubank Fire Department on March 29, 2007, at 7 p.m.

Applications will be accepted from April 2, 2007, through April 30, 2007.

This project will allow persons engaged in livestock or agricultural production on eligible land to receive cost share ranging from 30 to 75 percent on installed practices. All conservation practices implemented through this program must be installed according to NRCS standards and specifications.

The project applications will be evaluated and ranked using criteria established by the local Project Oversight Committee.

To apply for this Riparian Restoration Project Grant, or for more information, please contact your local NRCS or Pulaski County Conservation District office at the USDA Service Center, 45 Eagle Creek Drive, Suite 102, Somerset, KY 42503. Or call at (606) 678-4842, ext. 3.

# On-farm Field Day is Sept. 15

The Pulaski County Soil and Water Conservation District and Pulaski County Cattleman's Association will be hosting an On-Farm Demonstration Field Day Tuesday, Sept. 15, 2009.

The event will be held on the Hubble Farm in the Whetstone Creek Watershed off Ky. 452, and will begin at 5:30 p.m.

The demonstrations will highlight the primary goal of the grant, which is to protect and enhance agricultural resources and stream habitat for federally threatened and endangered mussel species through the installation of Riparian Agricultural and Animal Best Management Practices.

Speakers will include representatives from Cumberland Environmental Group, KCTCS, Tubline Manufacturing, Pulaski County Extension Service, USDA Natural Resources Conservation Service, and the Kentucky Department of Fish and Wildlife.

A meal will also be served by the Pulaski County Cattleman's Association.

Contact the Pulaski County Conservation District at (606) 678-4842, Ext. 3, by Sept. 11 to RSVP or for further information.

This work was funded in part by a grant from the U.S. Environmental Protection Agency Under §319(H) of the Clean Water Act.



Posters

# September 15, 2009 Field Day
# Buck Creek Watershed Riparian Restoration Project

- The EPA 319 Grant Project Area is approximately 29,000acres consisting of around 400 landowners.

- The Project area includes the drainage areas of the following Buck Creek tributaries: Briary Creek, Whetstone Creek, Indian Creek, Barney Branch, and Clear Creek.

- The efforts of the grant have been centered primarily on developing the riparian areas, adoption of rotational grazing systems, the development of alternative water supplies or providing limited stream access to cattle, and the construction of well designed sited animal feeding/waste storage areas.

- The goal is to protect and enhance agricultural resources and stream habitat for Federally Threatened and Endangered mussel species through the installation of riparian agricultural and animal management Best Management Practices.

Field Day Partners:

| | |
|---|---|
| Pulaski County Conservation District | Pulaski County Extension Service |
| Pulaski County Cattleman's Association | KY Community & Technical College System |
| Cumberland Environmental Group | KY Department of Fish & Wildlife Resources |
| Natural Resources Conservation Service | KY Division of Conservation |
| KY Division of Water | Tubeline Manufactoring Inc. |

**This work was funded in part by a grant from the U.S. Environmental Protection Agency under §319(h) of the Clean Water Act through the Kentucky Division of Water to the Pulaski County Soil and Water Conservation District (Grant #05-07 ).**