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Boone County Conservation District

Phase I Data Analysis Report for the Gunpowder Creek Watershed Initiative

October 2012

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1. Introduction

1.1 Project Background

The Boone County Conservation District is committed to "…protecting soil, water, and other natural resources…" To that end, in 2009 they applied for and received funding from the U.S. Environmental Protection Agency under §319(h) of the Clean Water Act to develop a watershed plan through the Gunpowder Creek Watershed Initiative. The goal of the Initiative is to understand the source of pollutants that have resulted in Gunpowder Creek being listed on the §303(d) list of impaired waters in Kentucky.

One of the first steps in this process is to develop an understanding of what information is available and what additional information, if any, is needed. This report describes existing information, including who has collected samples throughout the Gunpowder Creek Watershed, where the samples were collected, the environmental conditions observed when the samples were collected, and knowledge gained about pollutant sources from the results of each sampling event.

1.2 Impairments or Pollutants of Concern

Gunpowder Creek and its tributary South Fork Gunpowder Creek have been listed on the Kentucky §303(d) list of impaired waters. Excerpts of the 2010 Integrated Report to Congress on the Condition of Water Resources in Kentucky are located in Appendix A. In the report, impairments of Gunpowder Creek occur between River Mile 15.4 and 17.1, including issues with sedimentation, nutrients, and organic enrichment. Impairment between River Mile 18.9 and 21.6 is attributed to unknown sources. Within the South Fork Gunpowder Creek, impairments between River Mile 0.0 to 2.0 are identified as nutrients, organic enrichment, sedimentation, and turbidity. Fecal Coliform has been identified as an issue between River Mile 4.1 and 6.8. In addition, a Total Maximum Daily Load (TMDL) has been developed for Ethylene Glycol.

1.3 Scope of This Report

This report assists in meeting milestones 3, 4, and 10 as listed in Table 5 of the Boone County Conservation District's Quality Assurance Project Plan for Gunpowder Creek Watershed Initiative Plan effective on April 15, 2011. Data collected and shared by participating partners will be described as well as the weather conditions under which each sample was collected. Information will be provided regarding the location of each sample. For complete details on sample protocols and site characteristics, please refer to the appropriate partners' Quality Assurance Project Plan (QAPP), Standard Operating Procedure (SOP), and/or sample summary report.

This report discusses:

- Who provided sample results
- Summary of weather conditions during sample collection
- Results of sample analysis
- What the sample results indicate about sources of pollutants of concern
- Additional information that is needed

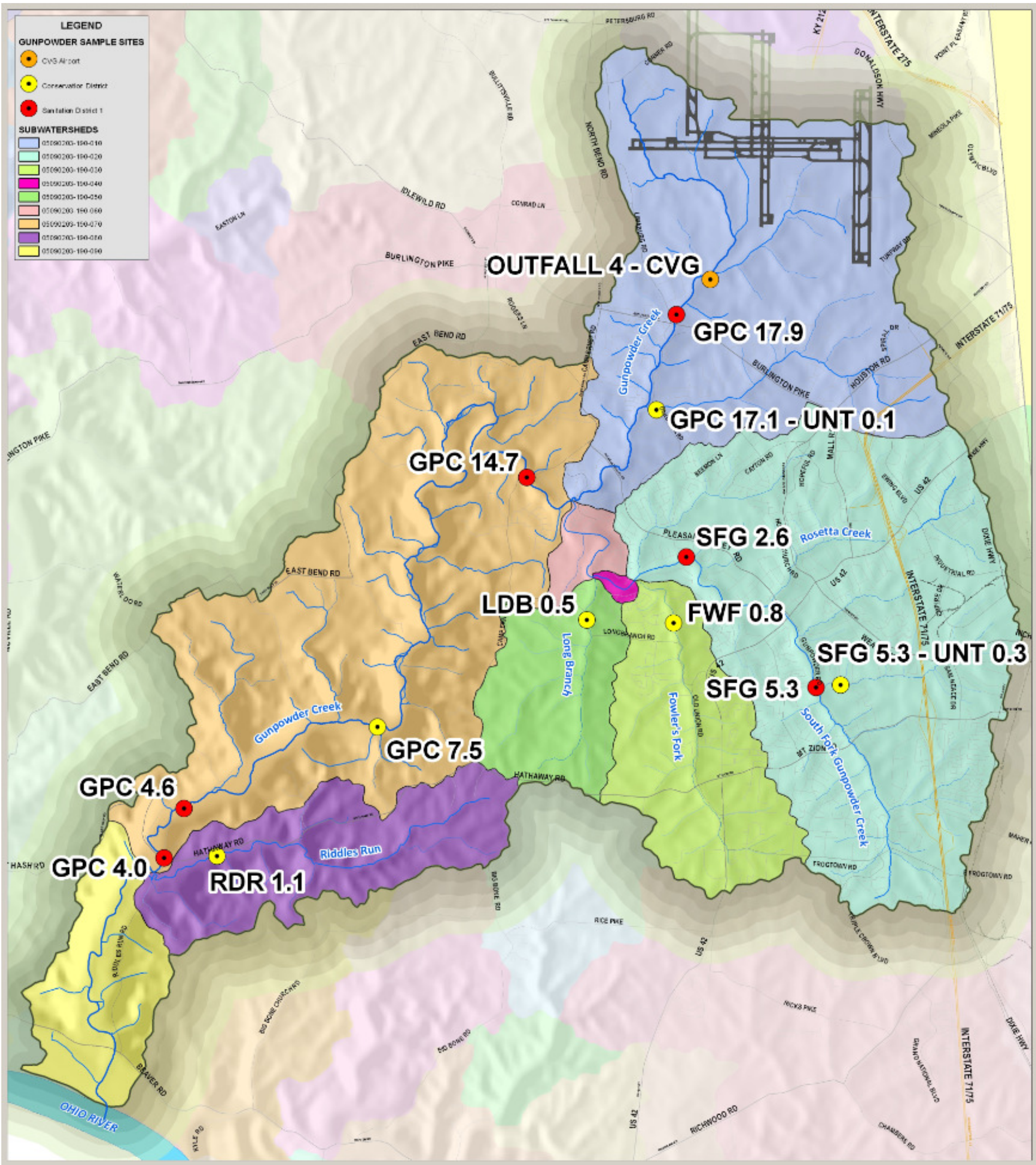
2. Water Quality Sampling Program Summary

2.1 Water Quality Sampling Organizations

Boone County Conservation District has worked collaboratively with the Licking River Watershed Watch, SD1 (formerly known as Sanitation District No. 1 of Northern Kentucky), Thomas More College, and the Kentucky Division of Water (KDOW) to ensure that data from samples collected are representative and reliable. Results from samples collected within the Gunpowder Creek Watershed over the past few years have been shared by SD1 and Kenton County Airport Board. Figure 2-1 shows the location of each sample site. Section 2.2 provides a discussion of each site's location and the surrounding land use. Each site is introduced with the name of the location, as previously communicated with KDOW, the name of the location as used during sample collection, the organization that collected the samples, and the surveyed location of the site in latitude and longitude, Ex. *GPC 7.5 (Site 1 – Boone County Conservation District)* (38˚57'17", 84˚44'46").

Boone County Conservation District collects samples under a KDOW approved QAPP. A copy of the QAPP is located in Appendix B. SD1 collects samples using a QAPP that incorporates United States Environmental Protection Agency (US EPA) requirements, but has not been approved at the state or federal level as of the production of this report. Each QAPP describes procedures to reduce the risk of sample contamination to ensure representative data is collected for analysis. Boone County Conservation District has been collecting water quality samples in the Gunpowder Creek Watershed as part of Phase I of the Gunpowder Creek Watershed Initiative. SD1 has been collecting samples to support their efforts discussed in the Gunpowder Creek Watershed Characterization Report dated January 2009. The Kenton County Airport Board collects monthly samples under a SOP for submission to KDOW documenting compliance with storm water effluent water quality standards.

Figure 2-1 Locations of Sample Sites



2.2 Site Descriptions

GPC 7.5 (Site 1 – Boone County Conservation District) (38˚57’17”, 84˚44’46”)

This sample location is in the wadeable portion of Gunpowder Creek (River Mile 7.5) at the end of Scout Camp Road. In addition to upstream flows, the site receives runoff from rural, undeveloped land including deciduous forests and agriculture. GPC 14.7 is upstream of this site.

GPC 17.1 – UNT 0.1 (Site 2 – Boone County Conservation District) (39˚0’18”, 84˚41’23”)

This sample location is in the headwater portion of an unnamed tributary (UNT) (River Mile 0.1) to Gunpowder Creek (River Mile 17.1) near the intersection of Oakbrook Road and Shady Cove Lane. The site receives runoff from residential and commercial areas as well as a golf course. This is the most upstream site of this tributary.

SFG 5.3 – UNT 0.3 (Site 3 – Boone County Conservation District) (38˚57’40”, 84˚39’26”)

This sample location is in the headwater portion of an unnamed tributary (River Mile 0.3) to South Fork of Gunpowder Creek (River Mile 5.3) near the intersection of Sunnybrook Drive and Tranquility Drive. The site receives runoff from residential and light commercial areas as well as ongoing development. This is the most upstream site of this tributary.

FWF 0.8 (Site 4 – Boone County Conservation District) (38˚58’17”, 84˚41’10”)

This sample location is in the headwater portion of Fowler’s Fork (River Mile 0.8) near the intersection of Fowler Creek Road and Woodcreek Drive. The site receives runoff from agricultural land and is downstream of a pond. This is the most upstream site of Fowlers Fork.

RDR 1.1 (Site 5 – Boone County Conservation District) (38˚56’7”, 84˚46’43”)

This sample location is in the headwater portion of Riddles Run (River Mile 1.1) and is approximately 3,000 feet east of the intersection of Riddles Run Road and Hathaway Road. This site receives runoff from rural, undeveloped land including deciduous forests and agriculture. This is the most upstream site of Riddles Run.

LDB 0.5 (Site 6 – Boone County Conservation District) (38˚58’18”, 84˚42’13”)

This sample location is in the headwater portion of Long Branch (River Mile 0.5) approximately 700 feet south of the intersection of Longbranch Road and Hidden Creek Drive. The site receives runoff from residential areas as well as agriculture and ongoing development. This is the most upstream site of Long Branch.

GPC 14.7 (Site 7 – SD1) (38˚59'39", 84˚42'58")

This sample location is in the wadeable portion of Gunpowder Creek (River Mile 14.7) near the intersection of Camp Ernst Road and Camp Ernst Drive. In addition to upstream flows, the site receives runoff from residential areas as well as agriculture. GPC 17.9 is upstream of this site.

GPC 17.9 (Site 8 – SD1) (39˚1'12", 84˚41'9")

This sample is in the wadeable portion of Gunpowder Creek (River Mile 17.9) near the intersection of Burlington Pike and Limaburg Creek Road. In addition to upstream flows, the site receives runoff from residential, commercial, and industrial areas as well as agriculture and ongoing development. Outfall 4 is upstream of this site.

GPC 4.0 (Site 9 – SD1) (38˚56'1", 84˚47'21")

This sample location is in Gunpowder Creek (River Mile 4.6) near the intersection of Sullivan Road and Hathaway Road. In addition to upstream flows, the site receives runoff from rural, undeveloped land including deciduous forests and agriculture. GPC 4.6 is upstream of this site. Samples were collected at this site only during dry weather and were later changed to GPC 4.6 location as a result of access issues.

GPC 4.6 (Site 10 – SD1) (38˚56'30", 84˚47'7")

This sample location is in Gunpowder Creek (River Mile 4.6) on Sullivan Road approximately 0.5 miles north of Hathaway Road at the end of the bus turnaround lane. In addition to upstream flows, the site receives runoff from rural, undeveloped land including deciduous forests and agriculture. GPC 7.5 is upstream of this site.

SFG 2.6 (Site 11 – SD1) (38˚58'54", 84˚41'1")

This sample location is in the wadeable portion of the South Fork of Gunpowder Creek (River Mile 2.6) near the intersection of Woodcreek Drive and Rollingwood Court. In addition to upstream flows, the site receives runoff from residential and light commercial areas as well as agriculture and ongoing development. FWF 0.8 is upstream of this site.

SFG 5.3 (Site 12 – SD1) (38˚57’42”, 84˚39’8”)

This sample location is in the wadeable portion of the South Fork of Gunpowder Creek (River Mile 5.3) near at the bridge on Gunpowder Road to Grace Fellowship Church. The site receives runoff from residential and light commercial areas as well as ongoing development. SFG 5.3 - UNT 0.3 is upstream of this site.

Outfall 4 (Site 13 –Kenton County Airport Board) (39˚1’32”, 84˚40’45”)

This sample location is at a permitted stormwater pipe near the headwaters of Gunpowder Creek (River Mile 18.4) approximately 1,500 feet east of the intersection of Production Drive and Distribution Drive. The site receives runoff from the airport. This is the most upstream site of Gunpowder Creek.

3. Rain Data

According to the National Weather Service, 2011 was the wettest year on record (http://www.erh.noaa.gov/iln/climo/summaries/wet2011/wet2011.php); receiving almost twice as much rain as is typically seen in northern Kentucky. The National Weather Service has been recording data since its creation as the Weather Bureau in 1870. According to the National Weather Service, the area received twice as much rain as typically falls in June. July and August were at or below average with regard to monthly rainfall totals. Table 3-1 shows rainfall totals collected by the rain gauge located near Big Bone Lick State Park (38˚50'42", 84˚43'15") (http://waterdata.usgs.gov/ky/nwis/uv/?site_no=03277130&PARAmeter_cd=00065,00060,00045,00010,00300,00301,00400,00095,63680). This rain gauge is maintained by the United States Geological Survey (USGS) in cooperation with SD1 and records total rainfall during a 5-minute increment in 0.01 inches. The duration shown is the time between the first recorded measurement and the last measurement. The last measurement of a rain event is followed by a minimum of 6-hours with no rain measurements. Rainfall totals of less than 0.1 inches are not included on this table because those rainfall totals do not typically result in runoff. An additional rain gauge maintained by USGS (38˚59'39", 84˚42'58") (http://waterdata.usgs.gov/ky/nwis/uv/?site_no=03277075&PARAmeter_cd=00065,00060,00045,00010,00300,00301,00400,00095,63680) is within the Gunpowder Creek Watershed. However, the equipment malfunction in June and was not repaired until after the completion of the study.

Table 3-1
Rainfall Totals

Date	Duration (hours)	Total Depth (inches)	Date	Duration (hours)	Total Depth (inches)
6/10/2011	12.25	2.52	7/8/2011	6.00	0.86
6/15/2011	4.75	0.60	7/18/2011	0.25	0.33
6/16/2011	4.50	0.17	7/30/2011	0.75	0.25
6/18/2011	16.75	0.48	8/3/2011	1.25	0.94
6/19/2011	8.00	0.70	8/7/2011	2.00	0.71
6/20/2011	4.25	0.21	8/10/2011	6.00	0.14
6/21/2011	3.25	1.41	8/13/2011	1.00	0.16
6/23/2011	0.25	0.14	8/14/2011	1.25	0.57
6/26/2011	5.75	3.94	8/18/2011	6.25	0.23
6/27/2011	0.75	0.29	9/4/2011	9.00	0.30
7/3/2011	3.50	0.38			

4. Macroinvertebrate Biotic Index

One means of determining water quality, or the health of a water body, is to measure the Macroinvertebrate Biotic Index (MBI). Macroinvertebrates are organisms (insects and crayfish are examples) that spend part or all of their lives in water. Some macroinvertebrates, such as the stonefly and dobsonfly, are extremely sensitive to pollution and low amounts of oxygen in the water. Other species, such as leeches, are very tolerant of pollution. The MBI is a method to give a numeric value to a water body to describe the health, or level of pollution, based on the sensitive species found during a sampling event. Table 4-1 shows the Kentucky MBI. The MBI table is classified into two stream types, wadeable and headwater, as well as four geographic regions. Wadeable streams have a drainage area >10 mi^2 and headwater streams have a drainage area <6 mi^2. Streams with a drainage area between 6-10 mi^2 are classified as either wadeable or headwater based on best professional judgment. The four geographical categories, or ichthyoregions, identified in Table 4-1 and illustrated in Figure 4-1 are "based on the classification of river basins, and ecoregions and the influence of these regions upon river basins". As can be seen in Figure 4-1, Boone County is in the Bluegrass (BG) Region. According to the "Development and Application of the Kentucky Index of Biotic Integrity (KIBI), each region is defined as follows:

> *Mountain* (MT) This region encompasses all river systems (Big Sandy, Cumberland, Kentucky, Licking, Little Sandy, and minor tributaries of the Ohio River) within the boundaries of the Central (69) and Southwestern Appalachian (68) Ecoregions and the Western Allegheny Plateau (70) Ecoregion, except for the Cumberland River above Cumberland Falls.
>
> *Bluegrass* (BG) This region includes all river systems (Kentucky, Licking, Salt, and minor tributaries of the Ohio River) that lie within subecoregions (71d, k, and l) of the Interior Plateau (71).
>
> *Pennyroyal* (PR) This region includes all river systems (Cumberland, Green, Kentucky, Salt, Tradewater, Tennessee, and the minor tributaries of the Ohio River) that lie within subecoregions (71a, b, c, e, f, g, and h) of the Interior Plateau (71), except for the Green River system that lies within subecoregion 71g.
>
> *Mississippi Valley-Interior River* (MVIR) This region encompasses all river systems (Lower Cumberland, Green, Tradewater, Tennessee, minor tributaries of the Mississippi River, and minor tributaries of the Ohio River) within the boundaries of the Interior River Valleys and Hills (72), Mississippi Alluvial Plain (73), and Mississippi Valley Loess Plain (74).

While the macroinvertebrate index provides a good overall indication of water quality it is not directly linked to any particular pollutant or condition in the water body. Macroinvertebrates can also be impaired by modifications to habitat or stream flow. When the community is impaired, as it often was at the sites sampled by Boone County Conservation District, it is not always possible to directly tie that impairment to either a chemical or physical cause; rather it is often the cumulative effect of multiple factors in the streams that produces the macroinvertebrate score.

Table 4-1
Macroinvertebrate Biotic Index for Kentucky by Region

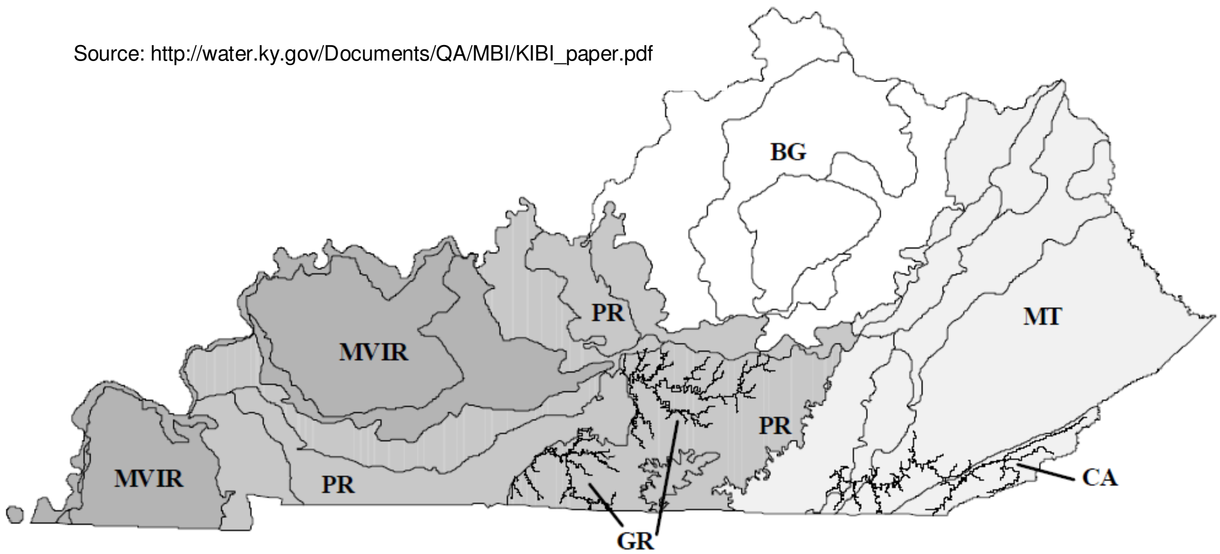
Wadeable	**50th and 5th %ile**	**50th and 5th %ile**	**50th and 5th %ile**	**75th and 25th %ile**
Rating	*Bluegrass*	*Mountain*	*Pennyroyal*	*Mississippi Valley-Interior River*
Excellent	≥70	≥82	≥81	≥58
Good	61-69	75-81	72-80	48-57
Fair	41-60	50-74	49-71	24-47
Poor	21-40	25-49	25-48	13-23
Very Poor	0-20	0-24	0-24	0-12

Headwater

Rating	*Bluegrass*	*Mountain*	*Pennyroyal*	*Mississippi Valley-Interior River*
Excellent	≥58	≥83	≥72	≥63
Good	51-57	72-82	65-71	56-62
Fair	39-50	48-71	43-64	35-55
Poor	19-38	24-47	22-42	19-34
Very Poor	0-18	0-23	0-21	0-18

Figure 4-1 Ichthyoregions of Kentucky

Source: http://water.ky.gov/Documents/QA/MBI/KIBI_paper.pdf



BG= Bluegrass, CA= Cumberland River above Cumberland Falls, GR= Upper Green River, MT= Mountain, MVIR= Mississippi Valley-Interior River, PR= Pennyroyal. Note GR and CA ichthyoregions are river basins within larger ichthyoregions. Solid lines mark Level IV subecoregion boundaries (see Woods et al. 2002).

Table 4-2 lists the macroinvertebrate scores collected at each of the six Boone County sites during this study. Macroinvertebrate scores were collected once during the sampling season. Further discussion of the scores at each site appears in Section 5 on a site-by-site basis. Additional macroinvertebrate sampling in future years would provide a measure of long-term changes in each subwatershed that would be useful to help measure any changes in the stream health.

Table 4-2 Macroinvertebrate Scores Collected during the Boone County 2011 sampling		
Wadeable		
GPC 7.5	40	Poor
Headwater		
GPC 17.1 – UNT 0.1	17	Very Poor
SFG 5.3 – UNT 0.3	18	Very Poor
FWF 0.8	32	Poor
RDR 1.1	40	Fair
LDB 0.5	21	Poor

5. Sampling Results

5.1 Watershed Background Knowledge

5.1.1 Water Uses

Water is used for many uses including agriculture, recreation, and human consumption such as drinking or cooking. The potential use of the stream, river, or lake is used to establish minim quality for that water body, or the water quality standard it must meet. According to the "Watershed Planning Guidebook for Kentucky Communities", there are five designated uses: drinking water, primary contact recreation, secondary contact recreation, outstanding State Resource Water, and either warm or cold water aquatic habitat. Primary contact recreation includes recreational activities such as swimming that create contact between the water and the mucus membranes of humans (mouth, wyes, inside nose) that will allow infection by any pathogens that could be in the water. Secondary contact recreation includes recreation activities such as fishing, wading and boating that create limited human contact with the water in a stream or lake. There are no communities using waters of the Gunpowder Creek Watershed as a drinking water source. Additionally, there are no KDOW designated Outstanding State Resource Waters in the Watershed.

All of the streams within the Gunpowder Creek Watershed are fall under the water quality standards established for warm water aquatic habitat. That means that, provided that flows are sufficient, the streams and creek beds should be capable of supporting native warm water aquatic life such as bass, sunfish, insect larva, and other plants and animals that have been historically found in Northern Kentucky. Water bodies that are designated as cold water aquatic habitat are surface streams that support native aquatic life or self sustaining or reproducing trout populations on a year round basis.

5.1.2 Sample Collection

Samples were collected by trained individuals using the guidelines established in the QAPP as discussed in Section 2.1. Samples are typically collected during both dry and wet weather conditions to identify potential types of sources for the pollutant of concern. A dry weather event is defined as following a seven-day dry period, in which no more than 0.1 inch of precipitation occurs. Dry weather samples help identify direct sources of pollution such as livestock in a creek, pipe discharging in or near a creek, or failing septic tanks (if they are near the water body). A wet weather event is defined as a seven-day antecedent dry period (in which no more than 0.1 inch of precipitation occurs) followed by visible run-off conditions, such as sheet flow on impervious surfaces and visible surface flow in ephemeral channels.

5.1.3 Water Quality and Benchmarks

Water quality standards are required by the Clean Water Act and are established by either the US EPA or KDOW. In this report, the standards for warm water aquatic habitat and primary contact recreation use are shown. Water quality standards in this report were taken from http://lrc.ky.gov/kar/401/010/031.htm.

A bench mark is an acceptable water quality concentration of a given parameter such as nutrients or suspended solids for a healthy stream. It is a water quality goal in lieu of a water quality standard. Bench marks were established by KDOW for the Gunpowder Creek Watershed and shared with the Boone County Conservation District via an email on February 8, 2012.

5.2 Boone County Conservation District Data

5.2.1 GPC 7.5 Results

The site on Gunpowder Creek at River Mile 7.5 is the most downstream site sampled by the Boone County Conservation District and as such totals the output of all of the upstream tributary sites. The results observed at this site are consistent with most of what was sampled upstream. Generally the site water quality for physical chemical variables did not show any extreme indications of pollutants; however, the measurements of *E. coli* and nutrients are indicative of pollutant stressors. Table 5-1 below shows the values measured on the six sampling events conducted by Boone County Conservation District in 2011. The table also lists recently published KDOW benchmarks for some of the variables measured as well as warm water aquatic habitat water quality standards. The benchmarks are based on analysis of the KDOW samples taken at other streams in the watershed and are thresholds set at roughly 75% of the concentrations observed in unimpaired streams. Table 5-2 shows the concentration of *E. coli* samples collected during eight sampling events. Eight sampling events for *E. coli* were conducted to establish the geometric mean of the biological colonies. Water quality standards require five samples being taken during a 30 day period for *E. coli* and Fecal coliform samples. Note that only one sample collected (July 29, 2011) meets the KDOW definition for dry weather sample. This applies to all six sample locations managed by Boone County Conservation District.

Table 5-1
GPC 7.5: Physical and Chemical Data

ANALYSIS	06/20/11	06/24/11	07/07/11	07/29/11	08/04/11	08/18/11	KDOW Benchmark	Standard
Ammonia as Nitrogen (mg/L)	0.05	0.03	0.04	0.04	0.04	0.04	0.025-0.05	0.05
Carbonaceous BOD, 5 day (N) (mg/L)	2	2	2	2	2.8	2	NA	NA
Nitrate-Nitrite as N, by FIA (mg/L)	0.475	0.404	0.1	0.1	0.404	0.1	0.3	1.0
Phosphate, Ortho as P (Dissolved) (mg/L)	0.081	0.111	0.037	0.053	0.093	0.075	NA	NA
Total Kjeldahl Nitrogen (mg/L)	0.882	0.595	0.603	0.673	0.678	0.343	0.3	NA
Total Phosphorus (mg/L)	0.214	0.222	0.112	0.091	0.301	0.141	0.08	NA
Total Suspended Solids (mg/L)	26.5	18	6.4	10.8	49.3	7.43	7.25-10 dry weather	NA
Temperature (degrees C)	20.6	21.3	26.3	28	25.1	23.1	NA	32
pH	7.2	7.7	7.4	7.4	6.6	6.1	NA	6.0 – 9.0
Dissolved Oxygen (mg/L)	8	8.1	6.1	6.8	10.5	7.5	NA	5.0
Specific Conductivity (µS/cm)	422	418	581	625	460	550	522.5	NA
Turbidity (NTU)	ND	34	5	5	96	12	8.3-8.7 dry weather	NA
Flow (cfs)	ND	21.756	3.150	0.146	9.146	0.519	NA	NA

NA = KDOW has not established a value for this parameter.
ND = No data collected during sampling event.

Table 5-2
GPC 7.5: *E. coli* Concentration

ANALYSIS	06/20/11	06/24/11	07/05/11	07/07/11	07/13/11	07/29/11	08/04/11	08/18/11	Standard
E. coli, Colilert QT 2000 (MPN/100 mL)	4611	780	179	359	129	1467	2069	74	130

The measured dissolved oxygen, pH, conductivity and temperature are all within ranges typical of streams in this bioregion. Carbonaceous BOD values are low, which is an indication that direct loading of wastewater (related to potential sewer overflows or septic system failures) is not occurring during the sampled events.

The concentrations of Total Phosphorus (TP) and Total Nitrogen (TN) are typically higher than USEPA proposed guidelines for development of nutrient criteria for this bioregion. KDOW has recently published a benchmark value for TP in this watershed which is based on analysis of KDOW sampling. The TP concentrations measured at this site exceed that threshold. TN is calculated as the sum of Total Kjeldahl Nitrogen (TKN) and Nitrate-Nitrite (N). The KDOW benchmark for TN is 0.6 which is the sum of 0.3 benchmarks for the two constituent parts of TN (TKN and N). All of the samples exceed the threshold for either TKN or N and only the August 18, 2011 sample does not exceed the 0.6 mg/l threshold for TN The elevated nutrient concentrations may be a causative factor in the poor biological ranking measured by the macroinvertebrate sampling. This site scored a 40 on the Macroinvertebrate Biotic Index (MBI) which according to KDOW criteria equals a narrative rating of poor relative to the expected aquatic life uses for wadeable streams in this bioregion.

The Kentucky standard for attainment of Primary Contact Recreation PCR) use measured with *E. coli* is that the geometric mean of no less than five samples in 30 days should not exceed 130cfu/100ml. Of the eight samples collected two sets contain five samples within a 30 day period. The samples between June 20, 2011 and July 13, 2011 and the five samples from July 5, 2011 through August 4, 2011 had geometric mean *E. coli* concentrations of 495 cfu/100 ml and 478 cfu/100ml. The results demonstrate that the recreational use criteria are not met at this site.

Since nutrients and bacteria are both likely to be related to rainfall driven runoff we tabulated rainfall data for the time period of these samples and graphed it with the *E. coli* data in Figure 5-1. As is apparent in the figure the spring of 2011 was very wet and had several storms greater than 0.5 inches, many of which were immediately prior to the sample dates. Of the samples collected at this site only the July 13, July 29 and August 18 dates had 48 hours of dry weather preceding the sample collection. Two of those three dates had the lowest bacteria concentrations sampled. Figure 5-2 shows the Turbidity and Totals Suspended Solids (TSS) data for this site. Note that the three dates with antecedent dry weather represent the lowest values for both of these wet weather related variables. Note that the KDOW benchmarks for these variables are only applicable during demonstrated dry weather events. It appears that most of the samples collected on dry days fall within the range expected by the KDOW benchmarks. The exceedence of the benchmark for specific conductance may also be related to wet weather and KDOW should consider calibration of that benchmark for dry and wet weather days.

Figure 5-1 GPC 7.5: *E. coli*, Colilert QT 2000

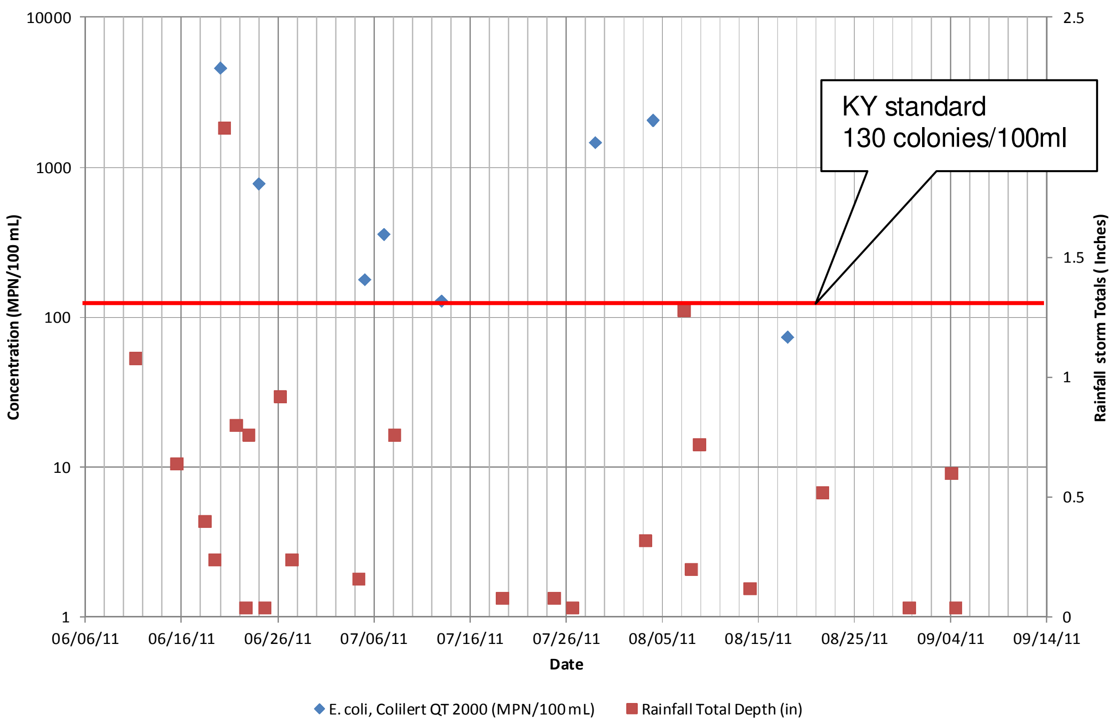
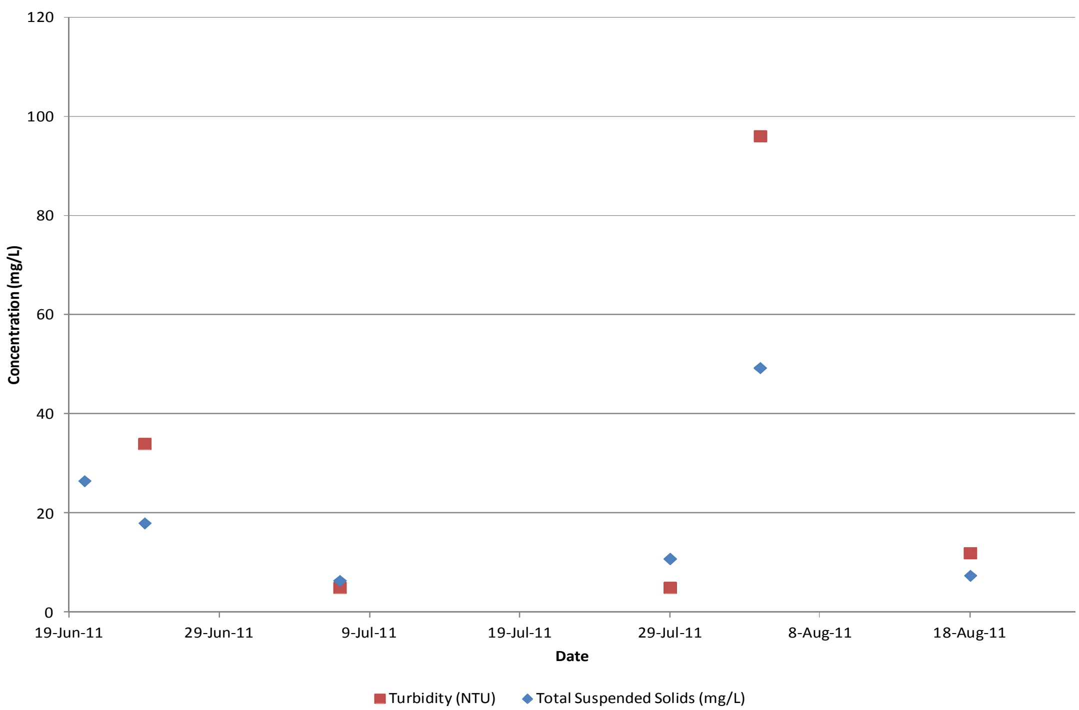


Figure 5-2 GPC 7.5: Turbidity and Total Suspended Solids



GPC 17.1 – UNT 0.1

The results at GPC 17.1 – UNT 0.1 which is an unnamed tributary upstream on Gunpowder Creek are similar to those observed downstream. Table 5.3 summarizes the data collected at that site. Table 5-4 shows the concentration of *E. coli* samples collected during eight sampling events.

Table 5-3
GPC 17.1 – UNT 0.1: Physical and Chemical Data

ANALYSIS	06/20/11	06/24/11	07/07/11	07/29/11	08/04/11	08/18/11	KDOW Benchmarks	Standard
Ammonia as Nitrogen (mg/L)	0.1	0.03	0.03	0.03	0.08	0.03	0.025-0.05	0.05
Carbonaceous BOD, 5 day (N) (mg/L)	6.38	2	2	2	2.62	2	NA	NA
Nitrate-Nitrite as N, by FIA (mg/L)	0.238	0.381	0.1	0.1	0.156	0.529	0.3	1.0
Phosphate, Ortho as P (Dissolved) (mg/L)	0.115	0.095	0.035	0.059	0.089	0.073	NA	NA
Total Kjeldahl Nitrogen (mg/L)	3.65	0.725	0.545	0.468	0.557	0.312	0.3	NA
Total Phosphorus (mg/L)	1.62	0.218	0.076	0.113	0.105	0.391	0.08	NA
Total Suspended Solids (mg/L)	996	37.5	3.2	1.67	6	86.9	7.25-10 dry weather	NA
Temperature (degrees C)	20.2	20.3	25.4	31.6	24.8	24.3	NA	32
pH	8	8.2	8.1	7.7	7.4	6.8	NA	6.0 – 9.0
Dissolved Oxygen (mg/L)	8.3	8.7	7.1	5.8	5.5	8.2	NA	5.0
Specific Conductivity (µS/cm)	210	560	806	785	597	613	522.5	NA
Turbidity (NTU)	ND	31	11	3	7	157	8.3-8.7 dry weather	NA
Flow (cfs)	ND	1.805	0.074	0.024	0.790	0.000*	NA	NA

NA = KDOW has not established a value for this parameter.
ND = No data collected during sampling event.
* = a review of the data makes it appear that depth was not recorded with velocity.

Table 5-4
GPC 17.1 – UNT 0.1: *E. coli* Concentrations

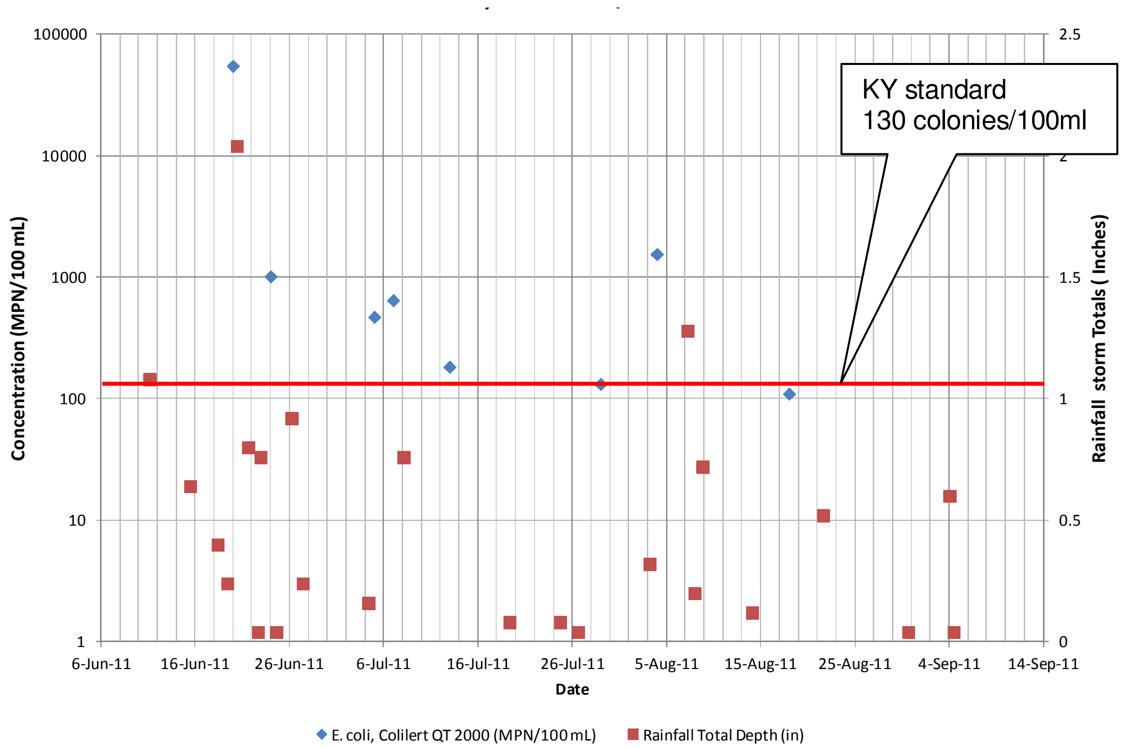
ANALYSIS	06/20/11	06/24/11	07/05/11	07/07/11	07/13/11	07/29/11	08/04/11	08/18/11	Standard
E. coli, Colilert QT 2000 (MPN/100 mL)	54750	1017	471	644	183	132	1549	110	130

The samples again show that dissolved oxygen, pH, conductivity and temperature are within normal ranges. Carbonaceous BOD is low so again there are no indications of wastewater loading. The June 20, 2011 sampling event was preceded by 1.39 inches of precipitation over three days. Possible reasons for the increased colony count include nonpoint source pollution from further away from the stream could have be placed in suspension during this period of excessive rain when compared to precipitation preceding the other sampling events or the higher rain volume could have resulted in the failure of some point source.

The macroinvertebrate survey results indicate an MBI of 17 which is a very poor rating for a headwater stream in this region. The aquatic life is likely impaired by the same factors that are causing high nutrients and high concentrations of fecal bacteria. The macroinvertebrates are dominated by tolerant organisms and the absence of organisms such as mayflies and stoneflies indicative of higher quality water is a strong indicator of the poor water quality.

This site again illustrates exceedances of nutrient targets and recreational use criteria. Bacteria concentrations at this site are higher than at the downstream site which is a possible indication that sources may be concentrated in the headwaters. Nutrients at this site are also present in higher concentrations. Figure 5-3 illustrates the relationship between the *E. coli* concentrations measured and the rainfall totals. At this site the three dates with antecedent dry weather conditions all show the lowest measured concentrations of *E. coli*. At this site the total suspended solids were an order of magnitude higher on June 20, 2011, again a clear indication that the preceding rain events had a significant influence on these measured concentrations.

Figure 5-3 UNT to Gunpowder Creek *E.coli*, Colilert QT 2000



5.2.2 SFG 5.3 – UNT 0.3

The data for SFG 5.3 – UNT 0.3 are presented in Table 5-5. The results from this tributary are similar to those observed at GPC 17.1 - UNT 0.1 and since the tributaries were selected to be comparable in size it is not surprising that the water quality results of the tributary sites turn out to be similar. Table 5-6 shows the concentration of *E. coli* samples collected during eight sampling events.

Table 5-5
SFG 5.3 – UNT 0.3: Physical and Chemical Data

ANALYSIS	06/20/11	06/24/11	07/07/11	07/29/11	08/04/11	08/18/11	KDOW Benchmarks	Standard
Ammonia as Nitrogen (mg/L)	0.1	0.03	0.03	0.05	0.17	0.03	0.025-0.05	0.05
Carbonaceous BOD, 5 day (N) (mg/L)	6.08	2	2	2	2	2	NA	NA
Nitrate-Nitrite as N, by FIA (mg/L)	0.433	0.292	0.1	0.1	0.1	0.1	0.3	1.0
Phosphate, Ortho as P (Dissolved) (mg/L)	0.053	0.065	0.011	0.017	0.067	0.049	NA	NA
Total Kjeldahl Nitrogen (mg/L)	1.98	0.758	0.67	0.94	0.682	0.345	0.3	NA
Total Phosphorus (mg/L)	1.11	0.218	0.06	0.049	0.278	0.051	0.08	NA
Total Suspended Solids (mg/L)	480	32.7	10.6	3.2	43.1	1.5	7.25-10 dry weather	NA
Temperature (degrees C)	19.8	20.3	26.9	27.2	27.2	23.6	NA	32
pH	8	8.1	7.9	7.7	8.1	6.8	NA	6.0 – 9.0
Dissolved Oxygen (mg/L)	8.5	9.4	8.8	5.1	2	7.1	NA	5.0
Specific Conductivity (µS/cm)	422	735	858	1098	607	1036	522.5	NA
Turbidity (NTU)	ND	6	9	2	13	2	8.3-8.7 dry weather	NA
Flow (cfs)	ND	0.673	0.070	DC	0.316	NF	NA	NA

NA = KDOW has not established a value for this parameter.
ND = No data collected during sampling event.
DC = Stream bed dry during sampling event.
NF = No flow in stream during sampling event.

Table 5-6
SFG 5.3 – UNT 0.3: *E. coli* Concentration

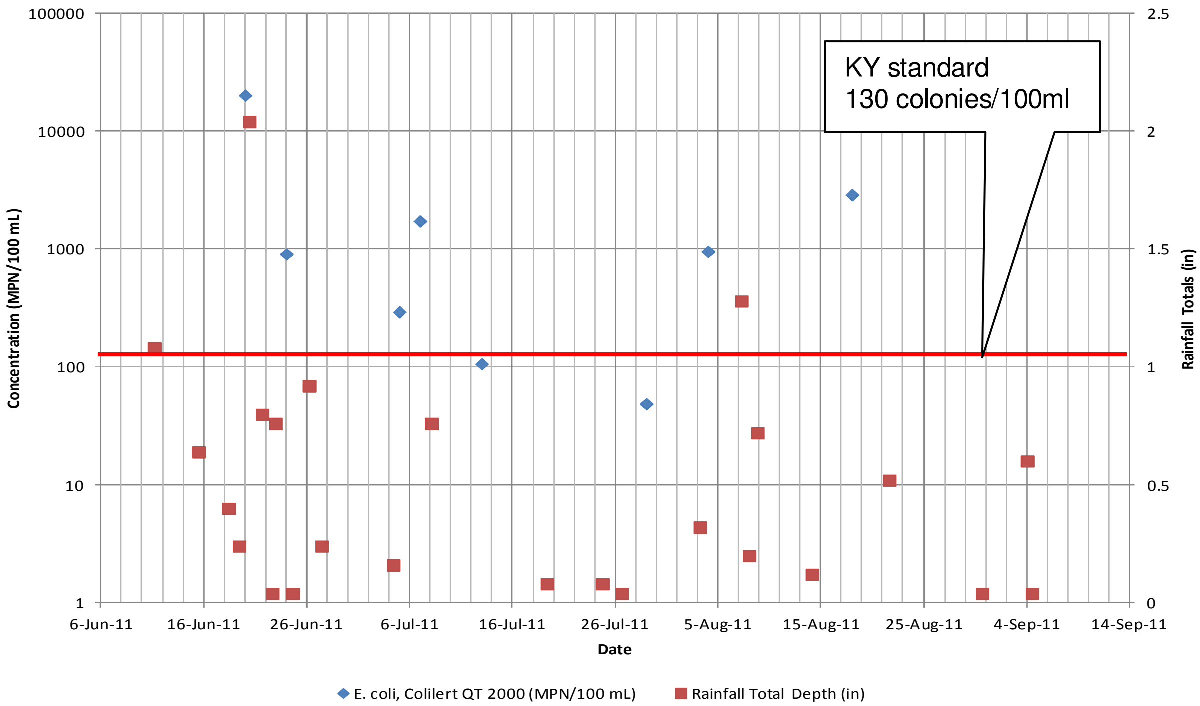
ANALYSIS	06/20/11	06/24/11	07/05/11	07/07/11	07/13/11	07/29/11	08/04/11	08/18/11	Standard
E. coli, Colilert QT 2000 (MPN/100 mL)	20140	906	293	1723	106	48.8	953	2886	130

The samples again largely show that dissolved oxygen, pH, conductivity and temperature are within normal ranges. One sample of dissolved oxygen on August 4 indicates dissolved oxygen did not meet the instantaneous standard for warmwater streams in Kentucky (4.0 mg/l at all times) CBOD is low, so again, there are no indications of wastewater loading. The June 20, 2011 sampling event was preceded by 1.39 inches of precipitation over three days. Possible reasons for the increased colony count include nonpoint source pollution from further away from the stream could have be placed in suspension during this period of excessive rain when compared to precipitation preceding the other sampling events or the higher rain volume could have resulted in the failure of some point source.

The macroinvertebrate survey results indicate an MBI of 18 which is a very poor rating for a headwater stream in this region. The aquatic life is likely impaired by the same factors that are causing high nutrients and high concentrations of fecal bacteria. The macroinvertebrates are dominated by tolerant organisms and the absence of organisms such as mayflies and stoneflies indicative of higher quality water is the same as at the similar tributary at GPC 17.1 - UNT 0.1.

This site again illustrates exceedances of nutrient targets and recreational use criteria. Bacteria concentrations at this site are higher than at the downstream site which is a possible indication that sources may be concentrated in the headwaters. Nutrients at this site are also present in higher concentrations. Figure 5-4 illustrates the relationship between the *E. coli* concentrations measured and the rainfall totals. At this site, two of the three dates with antecedent dry weather conditions show the lowest measured concentrations of *E. coli*. At this site the total suspended solids were an order of magnitude higher than the downstream site on June 20, 2011, again a clear indication that the preceding rain events had a significant influence on these measured concentrations.

Figure 5-4 SFG 5.3 – UNT 0.3: *E.coli*, Colilert QT 2000



5.2.3 FWF 0.8

The Fowlers Fork site collects drainage from a watershed similar in size and land use above SFG 5.3 - UNT 0.3, so the fact that the water quality measured here is similar to the other tributaries is expected. Table 5-7 lists the data collected by Boone County Conservation District at this site. Table 5-8 shows the concentration of *E. coli* samples collected during eight sampling events.

Table 5-7 FWF 0.8: Physical and Chemical Data								
ANALYSIS	**06/20/11**	**06/24/11**	**07/07/11**	**07/29/11**	**08/04/11**	**08/18/11**	**KDOW Benchmarks**	**Standard**
Ammonia as Nitrogen (mg/L)	0.06	0.03	0.04	0.05	0.3	0.05	0.025-0.05	0.05
Carbonaceous BOD, 5 day (N) (mg/L)	2.95	2	2	2	2	2	NA	NA
Nitrate-Nitrite as N, by FIA (mg/L)	0.516	0.562	0.142	0.1	0.1	0.1	0.3	1.0
Phosphate, Ortho as P (Dissolved) (mg/L)	0.099	0.129	0.043	0.055	0.091	0.059	NA	NA
Total Kjeldahl Nitrogen (mg/L)	3.14	0.548	0.696	0.664	0.642	0.475	0.3	NA
Total Phosphorus (mg/L)	1.03	0.161	0.112	0.085	0.118	0.078	0.08	NA
Total Suspended Solids (mg/L)	152	8.67	4.36	9.33	42.4	3.75	7.25-10 dry weather	NA
Temperature (degrees C)	19.9	19	26.4	26.2	27.4	26.4	NA	32
pH	7.9	8	8	7.8	8	6.6	NA	6.0 – 9.0
Dissolved Oxygen (mg/L)	8.2	9	7.8	4.2		9.2	NA	5.0
Specific Conductivity (µS/cm)	459	433	480	961	527	628	522.5	NA
Turbidity (NTU)	107	14	5	2	8	4	8.3-8.7 dry weather	NA
Flow (cfs)	ND	1.778	0.631	0.053	0.138	0.100	NA	NA

NA = KDOW has not established a value for this parameter.
ND = No data collected during sampling event.

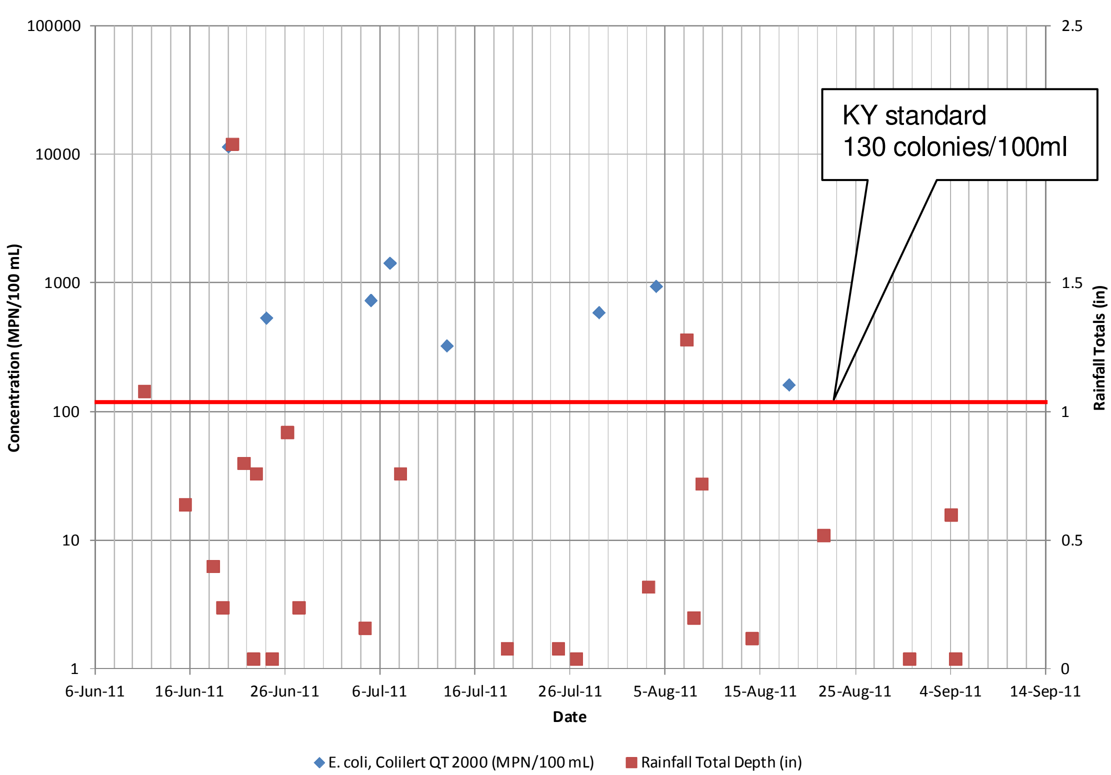
Table 5-8 FWF 0.8: *E. coli* Concentrations									
ANALYSIS	**06/20/11**	**06/24/11**	**07/05/11**	**07/07/11**	**07/13/11**	**07/29/11**	**08/04/11**	**08/18/11**	**Standard**
E. coli, Colilert QT 2000 (MPN/100 mL)	11450	537	733	1430	326	591	944	162	130

The samples largely show that dissolved oxygen, pH, conductivity and temperature are within normal ranges. One sample of dissolved oxygen on July 29 indicates dissolved oxygen barely met the instantaneous standard for warmwater streams in Kentucky (4.0 mg/l at all times) Carbonaceous BOD is low so again there are no indications of wastewater loading.

The macroinvertebrate survey results indicate an MBI of 32 which is a poor rating for a headwater stream in this region. The aquatic life is likely impaired by the same factors that are causing high nutrients and high concentrations of fecal bacteria. The macroinvertebrates are somewhat less dominated by tolerant organisms. Some mayflies indicative of higher quality water are present and the area yielded a more diverse group of organism. It is possible that habitat characteristics at this site lowered the, macroinvertebrate score. None of the other measurements gives a clear indication of why improved macroinvertebrates would be present here.

This site again illustrates exceedances of nutrient targets and recreational use criteria. Bacteria concentrations at this site are higher than at the downstream site which is a possible indication that sources may be concentrated in the headwaters. Nutrients at this site are also present in higher concentrations. Figure 5-5 illustrates the relationship between the *E. coli* concentrations measured and the rainfall totals. At this site, two of the three dates with antecedent dry weather conditions show the lowest measured concentrations of *E. coli* but they are not the same dates as observed downstream or at the South Fork Site. Overall the bacteria geometric means at this site were a bit higher than the previous tributaries which may be an indication of some dry weather source of bacteria such as leaking sewers or septic systems. At this site the total suspended solids were an order of magnitude higher than the downstream site on June 20, 2011, again a clear indication that the preceding rain events had a significant influence on these measured concentrations.

Figure 5-5 FWF 0.8: *E. coli*, Colilert QT 2000



5.2.4 RDR 1.1

The Riddles Run tributary represents a less urban watershed than the upstream tributaries but seems to have largely similar water quality characteristics with a few differences in nutrients and resultant aquatic life. Table 5-9 shows the values measured on six sampling events conducted by Boone County Conservation District in 2011. Table 5-10 shows the concentration of *E. coli* samples collected during eight sampling events.

Table 5-9
RDR 1.1: Physical and Chemical Data

ANALYSIS	06/20/11	06/24/11	07/07/11	07/29/11	08/04/11	08/18/11	KDOW Benchmarks	Standard
Ammonia as Nitrogen (mg/L)	0.03	0.03	0.03	0.03	0.03	0.03	0.025-0.05	0.05
Carbonaceous BOD, 5 day (N) (mg/L)	2	2	2	2	2	2	NA	NA
Nitrate-Nitrite as N, by FIA (mg/L)	0.423	0.232	0.1	0.1	0.2	0.1	0.3	1.0
Phosphate, Ortho as P (Dissolved) (mg/L)	0.089	0.125	0.061	0.109	0.125	0.085	NA	NA
Total Kjeldahl Nitrogen (mg/L)	0.589	0.414	0.33	0.263	0.311	0.239	0.3	NA
Total Phosphorus (mg/L)	0.181	0.134	0.121	0.107	0.107	0.078	0.08	NA
Total Suspended Solids (mg/L)	25.9	17.2	4	2.75	4.75	1.5	7.25-10 dry weather	NA
Temperature (degrees C)	18.6	19.5	23.7	24.1	24.1	20.6	NA	32
pH	7.6	7.9	7.7	7.3	6.5	6.5	NA	6.0 – 9.0
Dissolved Oxygen (mg/L)	8.8	8.8	7.8	2.1	3.7	4.4	NA	5.0
Specific Conductivity (µS/cm)	463	485	565	665	622	623	522.5	NA
Turbidity (NTU)	ND	13	4	5	5	1	8.3-8.7 dry weather	NA
Flow (cfs)	ND	1.386	0.111	0.000	0.034	0.002	NA	NA

NA = KDOW has not established a value for this parameter.
ND = No data collected during sampling event.

Table 5-10
RDR 1.1: *E. coli* Concentration

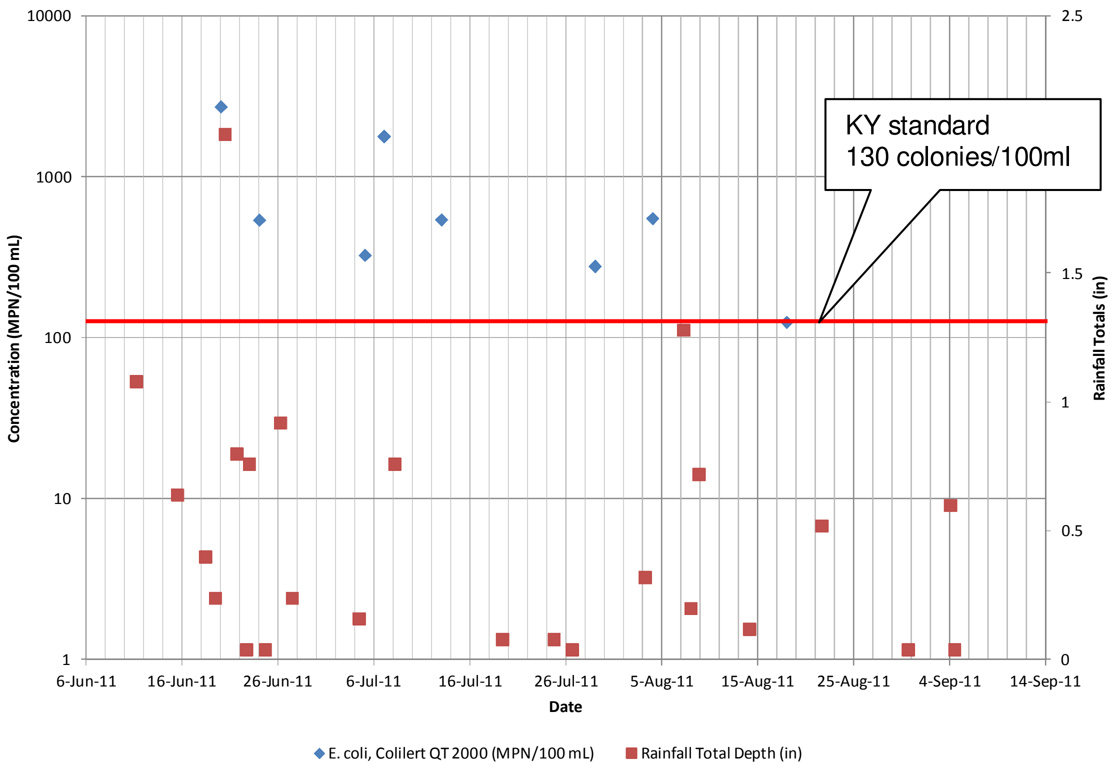
ANALYSIS	06/20/11	06/24/11	07/05/11	07/07/11	07/13/11	07/29/11	08/04/11	08/18/11	Standard
E. coli, Colilert QT 2000 (MPN/100 mL)	2723	538	326	1782	542	278	552	125	130

The samples again largely show that dissolved oxygen, pH, conductivity and temperature are within normal ranges. Two samples of dissolved oxygen on July 29 and August 4 indicate dissolved oxygen did not meet the instantaneous standard for warmwater streams in Kentucky (4.0 mg/l at all times). Carbonaceous BOD is again low so again there are no indications of wastewater loading.

The macroinvertebrate survey results indicate an MBI of 40 which is a fair rating for a headwater stream in this region. The aquatic life is less impaired potentially because nutrient concentrations for both nitrogen and phosphorus are lower at this site. Less eutrophication by nutrients supports more diverse aquatic life. The macroinvertebrates include more mayflies indicative of higher quality water and the area yielded a more diverse group of organism.

The bacteria measured at this site indicate slightly smaller ranges but still consistent exceedances of the recreational use criteria. The high reading on June 20 is only 2723 MPN/100 mL, which is an order of magnitude lower than what was observed on the same date at the other tributary sites. Similar to Fowlers Fork, the bacteria concentration on dry weather days does not go below the standard as they did at the previous sites except for the one sample on August 18. Therefore, it is possible that dry weather sources of bacteria such as livestock or leaking septic systems could be present in this watershed. Figure 5-6 shows the *E. coli* concentration compared to total rainfall. Nutrient targets are met for TN at this site except on June 20 though TP still consistently exceeds those ranges on all dates.

Figure 5-6 RDR 1.1: *E. coli*, Colilert QT 2000



5.2.5 LDB 0.5

The Long Branch Tributary is a slightly smaller headwater stream with land use characteristics that are more transitional (suburban development along Long Branch) than Riddles Run. The water quality measured here is more comparable to that measured in the other three tributaries than it is to what was observed on Riddles Run. Table 5-11 presents the data collected at this site. Table 5-12 shows the concentration of *E. coli* samples collected during eight sampling events.

Table 5-11 LDB 0.5: Physical and Chemical Data								
ANALYSIS	**06/20/11**	**06/24/11**	**07/07/11**	**07/29/11**	**08/04/11**	**08/18/11**	**KDOW Benchmarks**	**Standard**
Ammonia as Nitrogen (mg/L)	0.06	0.03	0.03	0.04	0.03	0.03	0.025-0.05	0.05
Carbonaceous BOD, 5 day (N) (mg/L)	2	2	2	2	2.38	2	NA	NA
Nitrate-Nitrite as N, by FIA (mg/L)	1.13	0.831	0.1	0.1	0.1	0.1	0.3	1.0
Phosphate, Ortho as P (Dissolved) (mg/L)	0.113	0.103	0.053	0.061	0.073	0.125	NA	NA
Total Kjeldahl Nitrogen (mg/L)	0.885	0.526	0.588	0.535	0.777	0.406	0.3	NA
Total Phosphorus (mg/L)	0.361	0.205	0.149	0.157	0.127	0.095	0.08	NA
Total Suspended Solids (mg/L)	70	43.1	5	8.67	8.57	9.25	7.25-10 dry weather	NA
Temperature (degrees C)	18.8	19.8	26.4	29.7	29.3	28.8	NA	32
pH	8	8	8.3	8	8.1	7.2	NA	6.0 – 9.0
Dissolved Oxygen (mg/L)	8.5	7.8	9.2	8.8	3	7.5	NA	5.0
Specific Conductivity (µS/cm)	439	510	453	576	600	808	522.5	NA
Turbidity (NTU)	92	17	11	4	8	5	8.3-8.7 dry weather	NA
Flow (cfs)	ND	0.890	0.022	DC	0.000	NF	NA	NA

NA = KDOW has not established a value for this parameter.
ND = No data collected during sampling event.
DC = Stream bed dry during sampling event.
NF = No flow in stream during sampling event.

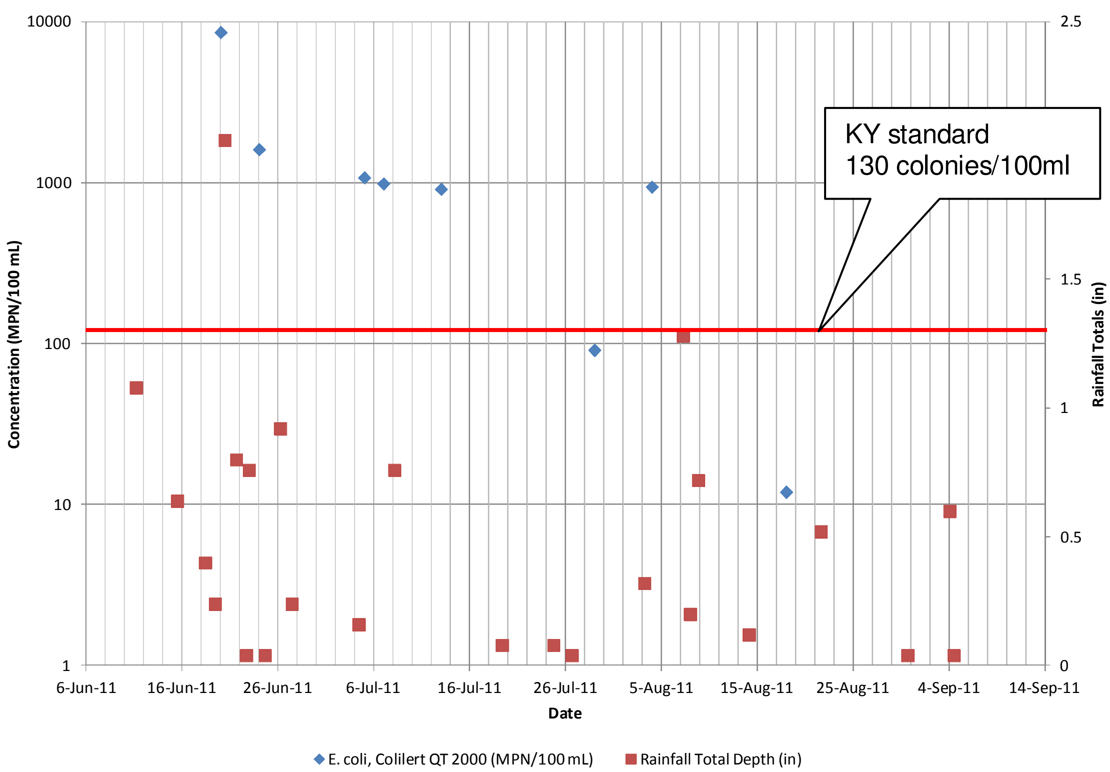
Table 5-12 LDB 0.5: *E. coli* Concentration									
ANALYSIS	**06/20/11**	**06/24/11**	**07/05/11**	**07/07/11**	**07/13/11**	**07/29/11**	**08/04/11**	**08/18/11**	**Standard**
E. coli, Colilert QT 2000 (MPN/100 mL)	8600	1607	1076	988	913	91.2	944	12	130

The samples again largely show that dissolved oxygen, pH, conductivity and temperature are within normal ranges. One sample of dissolved oxygen on August 4 indicates dissolved oxygen did not meet the instantaneous standard for warmwater streams in Kentucky (4.0 mg/l at all times). Carbonaceous BOD is low; therefore, there are no indications of wastewater loading.

The macroinvertebrate survey results indicate an MBI of 21 which is a poor rating for a headwater stream in this region. The aquatic life is likely impaired by the same factors that are causing high nutrients and high concentrations of fecal bacteria. The macroinvertebrates are dominated by tolerant organisms and the absence of organisms such as mayflies and stoneflies indicative of higher quality water is the same as at the similar tributary at GPC 17.1 - UNT 0.1 and SFG 5.3 – UNT 0.3.

This site again illustrates exceedances of nutrient targets and recreational use criteria. Bacteria concentrations at this site are only slightly higher than at the downstream site. Nutrients at this site are also present in higher concentrations. Figure 5-7 illustrates the relationship between the *E. coli* concentrations measured and the rainfall totals. At this site the two of the three dates with antecedent dry weather conditions show the lowest measured concentrations of *E. coli*.

Figure 5-7 LDB 0.5: *E. coli*, Colilert QT 2000



5.3 SD1 Data

The focus of the SD1 data collection effort was on wet weather events. One dry weather sample was collected at each site June 2009 and several samples were collected during wet weather events in May 2009, November 2010 and June 2011. As expected the values for bacteria and nutrients will be higher than expected for dry weather samples. To simplify the descriptions of the SD1 data we have summarized each site into a table of average values. Generally the observations are consistent with what has been measured by Boone County Conservation District and the wet weather problems are primarily bacteria and nutrients. Macroinvertebrate surveys conducted by SD1 are not included in this report.

5.3.1 GPC 14.7

Table 5-13 lists the dry weather data from June 2009 and the averages of the data from the three wet weather events collected at the USGS Gauge on Gunpowder Creek. Table 5-14 shows the concentration of *E. coli* samples averaged during the dry weather data from June 2009 and the averages of the data from the three wet weather events.

Table 5-13
GPC 14.7: Physical and Chemical Data

ANALYSIS	June-2009	May-2010	November-2010	June-2011	KDOW Benchmarks	Standard
Ammonia as Nitrogen (mg/L)	ND	0.09	0.09	0.04	0.25-0.05	0.05
Carbonaceous BOD, 5 day (N) (mg/L)	ND	3.33	5.50	2.32	NA	NA
Dissolved Oxygen (mg/L)	11.11	9.23	11.56	9.65	NA	5.0
Fecal Coliform (CFU/100 mL)	128	15785	22316	7011	NA	200
Hardness as CaCO3 (mg/L)	ND	168	133	186	NA	NA
Nitrate Nitrogen (mg/L)	0.22	0.27	0.03	0.46	0.3	10*
OrthoPhosphate (mg/L)	0.07	0.10	0.12	0.08	NA	NA
pH	8.38	7.92	7.43	8.05	NA	6.0 – 9.0
Specific Conductivity (µS/cm)	643.0	596.5	737.1	637.2	522.5	NA
Temperature (degrees C)	24.61	17.54	9.25	20.38	NA	32
Total Kjeldahl Nitrogen (mg/L)	ND	0.95	0.72	0.77	0.3	NA
Total Nitrogen (mg/L)	ND	1.26	ND	ND	0.6	NA
Total Phosphorus (mg/L)	0.10	0.36	0.25	0.23	0.08	NA
Total Suspended Solids (mg/L)	3.50	121.72	42.74	26.74	7.25- 10 dry weather	NA
Turbidity (NTU)	63.00	175.80	14.00	29.75	8.3-8.5 dry weather	NA

NA = KDOW has not established a value for this parameter.
*Human Health Standard for fish consumption, NA for Aquatic Life
ND = If this parameter was in the sample collected, it was at a concentration below the detection limit of the test.

Table 5-14 GPC 14.7: *E. coli* Concentration					
ANALYSIS	**June-2009**	**May-2010**	**November-2010**	**June-2011**	**Standard**
E. coli, Colilert QT 2000 (MPN/100 mL)	129	6067	55492	3436.88	130

The results are markedly similar to those observed by Boone County Conservation District at sites 1 through 6. Carbonaceous BOD is not high; dissolved oxygen, pH conductivity and temperature are within normal ranges. Metals were measured in the SD1 sampling but generally were present at concentrations slightly above detection limits. Nitrogen in dry weather as measured once in June 2009 does not exceed that threshold. TP exceeded the threshold in the dry weather sample but the concentration of TP was less than half of the average wet weather concentration measured in each event. The nutrients in the wet weather events consistently show values greater than the USEPA target bioregion concentrations.

SD1 measured both *E. coli* and Fecal coliform so samples can be compared to both of the Kentucky standards. It is clear from Table 5-14 that the standard is violated during all three wet weather events. The fecal coliform data show a similar relationship and are also clearly above the KDOW standard for Primary Contact Recreation during wet weather events. The three different wet weather events are similar and the distribution of measurements within each event covers an overlapping range as evidenced by the overlap of the plus or minus one standard deviation interval. More detailed statistical analysis might show that the May 2010 event represents a different mean than the other two events. For the purposes of this review it is more important to note the consistent exceedance of the state standard during wet weather.

5.3.2 GPC 17.9

This site is located upstream of Boone County Conservation District site GPC 17.1 - UNT 0.1 and the observations here are similar to what was observed in the Boone County Conservation District sampling. Table 5-15 shows the average of the three wet weather events and the dry weather sample results from June 2009.

Table 5-15 Average of Three Wet Weather Events and Single Sample Results						
ANALYSIS	**Jun-09**	**May-10**	**Nov-10**	**Jun-11**	**KDOW Benchmarks**	**Standard**
Ammonia as Nitrogen (mg/L)	0.00	0.11	0.09	0.12	0.25-0.05	0.05
Carbonaceous BOD, 5 day (N) (mg/L)	0.00	4.89	7.50	2.60	NA	NA
Dissolved Oxygen (mg/L)	8.32	8.42	11.46	9.26	NA	5.0
Fecal Coliform (CFU/100 mL)	460.	3849.	6598.	4844.	NA	200
Hexavalent Chromium (mg/L)	0.00	0.02	0.09	0.02	NA	0.02
Hardness as CaCO3 (mg/L)	0.00	173.00	134.35	166.00	NA	NA
Nitrate Nitrogen (mg/L)	0.62	0.09	0.02	0.79	0.3	10*
OrthoPhosphate (mg/L)	0.10	0.05	0.06	0.13	NA	NA
pH	8.02	7.80	7.85	7.97	NA	6.0 – 9.0
Specific Conductivity (µS/cm)	527.00	606.33	765.25	612.00	522.5	NA
Temperature (degrees C)	21.53	17.70	9.26	20.49	NA	32
Total Kjeldahl Nitrogen (mg/L)	0.77	0.91	1.53	1.13	0.3	NA
Total Nitrogen (mg/L)	0.00	1.07	0.00	0.00	0.6	NA
Total Phosphorus (mg/L)	0.16	0.17	0.24	0.22	0.08	NA
Total Suspended Solids (mg/L)	24.60	35.20	31.35	30.08	7.25- 10 dry weather	NA
Turbidity (NTU)	86.00	75.92	8.00	13.00	8.3-8.5 dry weather	NA

*Human Health Standard for fish consumption, NA for Aquatic Life
NA = KDOW has not established a value for this parameter.

Table 5-16 Average of Three Wet Weather Events and Single Sample Results					
ANALYSIS	**Jun-09**	**May-10**	**Nov-10**	**Jun-11**	**Standard**
E. coli, Colilert QT 2000 (MPN/100 mL)	404	2357	15061	3358	130

Generally the results show similar patterns to the downstream site at these events. Unlike the Boone County Conservation District sites where the downstream single sample concentration was lower than what was observed for *E. coli,* here the totality of wet weather events sampled showed average bacteria concentration lower than those measured at GPC 14.7. Figure 5-9 shows the log transformed means and standard deviations measured for *E. coli*. These averages show a lower trend at this upstream site than was apparent in the single sample data collected by Boone County

Conservation District. Given that we have observed consistent bacteria loading from all sites during wet weather this is more consistent with our expectations since if all tributaries contribute wet weather loads of bacteria concentrations should not decrease as we move downstream unless sufficient time is available for bacteria die off. This is consistent with our expectation that bacteria concentrations remain constant or increase as we move downstream during a sampling event.

5.3.3 GPC 4.0

Only one sample was collected by SD1 at this site. As a result of access issues, this site was moved to GPC 4.6. After the June 2009 dry weather event all the subsequent samples were taken at GPC 4.6. Table 5-17 lists the data measured at this site.

Table 5-17
Data Measurement

ANALYSIS	Jun-09	KDOW Benchmarks	Standard
Ammonia as Nitrogen (mg/L)	ND	0.25-0.05	0.05
Carbonaceous BOD, 5 day (N) (mg/L)	ND	NA	NA
Dissolved Oxygen (mg/L)	7.05	NA	5.0
Fecal Coliform (CFU/100 mL)	400	NA	200
Hardness as CaCO3 (mg/L)	ND	NA	>20
Nitrate Nitrogen (mg/L)	0.24	0.3	10*
OrthoPhosphate (mg/L)	0.08	NA	NA
pH	8.03	NA	6.0 – 9.0
Specific Conductivity (µS/cm)	551.00	522.5	NA
Temperature (degrees C)	24.64	NA	32
Total Kjeldahl Nitrogen (mg/L)	0.85	0.3	NA
Total Phosphorus (mg/L)	0.17	0.08	NA
Total Suspended Solids (mg/L)	12.00	NA	NA
Turbidity (NTU)	70.00	8.3-8.5 dry weather	NA

*Human Health Standard for fish consumption, NA for Aquatic Life
ND = If this parameter was in the sample collected, it was at a concentration below the detection limit of the test.

Table 5-18 Data Measurement		
ANALYSIS	**Jun-09**	**Standard**
E. coli, Colilert QT 2000 (MPN/100 mL)	241	130

The results are consistent with what was subsequently measured by Boone County Conservation District and show similar concerns for nutrients and bacteria during wet weather. After the dry weather sampling event, this site was relocated 0.6 miles upstream.

5.3.4 GPC 4.6

This site is located downstream of the Boone County Conservation District site GPC 7.5 and just upstream of GPC 4.0. Samples were collected by SD1 during one dry weather event and three wet weather events, during the same dates as collected for sites 7 and 8. Table 5-19 shows the averages of the variables measured during those events.

Table 5-19 Data Measurement			
ANALYSIS	**May-10**	**KDOW Benchmarks**	**Standard**
Ammonia as Nitrogen (mg/L)	0.09	0.25-0.05	0.05
Carbonaceous BOD, 5 day (N) (mg/L)	3.00	NA	NA
Dissolved Oxygen (mg/L)	8.58	NA	5.0
Fecal Coliform (CFU/100 mL)	14000	NA	200
Hardness as CaCO3 (mg/L)	154	NA	>20
Nitrate Nitrogen (mg/L)	0.17	0.3	10*
OrthoPhosphate (mg/L)	0.11	NA	NA
pH	7.69	NA	6.0 – 9.0
Specific Conductivity (µS/cm)	348.00	522.5	NA
Temperature (degrees C)	15.97	NA	32
Total Kjeldahl Nitrogen (mg/L)	2.18	0.3	NA
Total Phosphorus (mg/L)	1.35	0.08	NA
Total Suspended Solids (mg/L)	624.00	NA	NA
Turbidity (NTU)	850.00	8.3-8.5 dry weather	NA

*Human Health Standard for fish consumption, NA for Aquatic Life

Table 5-20 Data Measurement		
ANALYSIS	**May-10**	**Standard**
E. coli, Colilert QT 2000 (MPN/100 mL)	8660	130

Table 5-21 Data Measurement					
ANALYSIS	**May-10**	**Nov-10**	**Jun-11**	**KDOW Benchmarks**	**Standard**
Ammonia as Nitrogen (mg/L)	0.09	0.09	0.03	0.25-0.05	0.05
Carbonaceous BOD, 5 day (N) (mg/L)	2.25	2.75	2.01	NA	NA
Dissolved Oxygen (mg/L)	9.32	11.54	9.01	NA	5.0
Fecal Coliform (CFU/100 mL)	4135	10918	1243	NA	200
Hexavalent Chromium (mg/L)	0.02	0.08	0.02	NA	0.02
Hardness as CaCO3 (mg/L)	210.50	149.75	194.00	NA	>20
Nitrate Nitrogen (mg/L)	0.16	0.02	0.23	0.3	10*
OrthoPhosphate (mg/L)	0.06	0.10	0.08	NA	NA
pH	8.01	7.61	8.07	NA	6.0 – 9.0
Specific Conductivity (µS/cm)	636.44	771.00	586.80	522.5	NA
Temperature	17.82	8.54	20.76	NA	32
Total Kjeldahl Nitrogen (mg/L)	0.72	0.51	0.63	0.3	NA
Total Nitrogen (mg/L)	0.95	0.00	0.00	0.6	NA
Total Phosphorus (mg/L)	0.21	0.23	0.13	0.08	NA
Total Suspended Solids (mg/L)	50.11	16.29	10.63	7.25- 10 dry weather	NA
Turbidity (NTU)	221.65	43.50	25.20	8.3-8.5 dry weather	NA

NA = KDOW has not established a benchmark for this parameter.
*Human Health Standard for fish consumption, NA for Aquatic Life

Table 5-22 Data Measurement				
ANALYSIS	**May-10**	**Nov-10**	**Jun-11**	**Standard**
E. coli, Colilert QT 2000 (MPN/100 mL)	3951	20507	1267	130

The results at this site show similar high nutrient concentrations and bacteria in excess of the KDOW standard. Other pollutants measured do not show any violations of water quality criteria. Carbonaceous BOD continues to be low which indicates a low probability of discharges of sewage during wet weather and high possibility of bacteria being from diffuse sources such as livestock, leaking septic and sewer systems and wildlife sources of bacteria.

5.3.5 SFG 2.6

Table 3-11 shows the data from SFG 2.6. The results from this tributary to the South Fork of Gunpowder Creek do not correspond to any of the sites or tributaries that were subsequently sampled by Boone County Conservation District. Nonetheless, the results of this sampling indicate that the wet weather conditions on this tributary are similar to those tributaries sampled by the Boone County Conservation District.

Table 5-23 South Fork of Gunpowder Creek						
ANALYSIS	**Jun-09**	**May-10**	**Nov-10**	**Jun-11**	**KDOW Benchmarks**	**Standard**
Ammonia as Nitrogen (mg/L)	ND	0.05	0.10	0.09	0.25-0.05	0.05
Carbonaceous BOD, 5 day (N) (mg/L)	ND	3.38	5.00	2.73	NA	NA
Dissolved Oxygen (mg/L)	10.90	9.20	11.36	9.32	NA	5.0
Fecal Coliform (CFU/100 mL)	400	20455	29857	9521	NA	200
Hexavalent Chromium (mg/L)	0.00	0.04	0.12	0.02	NA	0.02
Hardness as CaCO3 (mg/L)	0.00	167.11	123.79	193.00	NA	>20
Nitrate Nitrogen (mg/L)	0.20	0.31	0.17	0.32	0.3	10*
OrthoPhosphate (mg/L)	0.06	0.08	0.14	0.06	NA	NA
pH	8.34	7.86	7.57	8.02	NA	6.0 – 9.0
Specific Conductivity (µS/cm)	780.00	603.11	699.75	846.75	522.5	NA
Temperature (degrees C)	22.78	17.58	8.95	20.04	NA	32
Total Kjeldahl Nitrogen (mg/L)	0.58	1.20	0.71	0.79	0.3	NA
Total Nitrogen (mg/L)	ND	1.42	ND	ND	0.6	
Total Phosphorus (mg/L)	0.10	0.43	0.28	0.22	0.08	NA

Table 5-23 South Fork of Gunpowder Creek						
Total Suspended Solids (mg/L)	2.10	150.00	64.60	51.74	7.25- 10 dry weather	NA
Turbidity (NTU)	101.00	187.00	12.50	22.75	8.3-8.5 dry weather	NA

NA = KDOW has not established a benchmark for this parameter.
*Human Health Standard for fish consumption, NA for Aquatic Life
ND = If this parameter was in the sample collected, it was at a concentration below the detection limit of the test..

Table 5-24
South Fork of Gunpowder Creek

ANALYSIS	Jun-09	May-10	Nov-10	Jun-11	Standard
E. coli, Colilert QT 2000 (MPN/100 mL)	384	9357	64763	6334	130

As in the other sites wet weather nutrients and bacteria are above targets but Carbonaceous BOD is not excessively high. Bacteria are highest during the November 2010 event consistent with the other SD1 sampling events.

5.3.6 SFG 5.3

This site is apparently close to SFG 5.3 - UNT 0.3 sampled by Boone County Conservation District and the results of the SD1 effort are consistent with what was discussed above for the Boone County Conservation District site. Table 5-23 lists the averages of the wet weather events sampled by SD1.

Table 5-25
SFG 5.3 Wet Weather Event Samples

ANALYSIS	Jun-09	May-10	Nov-10	Jun-11	KDOW Benchmarks	Standard
Ammonia as Nitrogen (mg/L)	ND	0.15	0.09	0.05	0.25-0.05	0.05
Carbonaceous BOD, 5 day (N) (mg/L)	ND	4.00	5.13	2.81	NA	NA
Dissolved Oxygen (mg/L)	17.92	9.08	11.01	9.39	NA	5.0
Fecal Coliform (CFU/100 mL)	310	34355	30918	9731	NA	200
Hexavalent Chromium (mg/L)	ND	0.04	0.11	0.02	NA	0.02
Hardness as CaCO3 (mg/L)	ND	151.93	130.90	203.50	NA	>20
Nitrate Nitrogen as N, by FIA (mg/L)	0.29	0.36	0.20	0.36	0.3	10*
OrthoPhosphate (mg/L)	0.11	0.11	0.19	0.09	NA	NA
pH	8.46	7.71	7.35	7.97	NA	6.0 – 9.0
Specific Conductivity (µS/cm)	663.00	479.70	729.50	818.88	522.5	NA
Temperature (degrees C)	24.57	17.34	8.74	19.70	NA	32
Total Kjeldahl Nitrogen (mg/L)	0.64	1.27	0.73	0.90	0.3	NA
Total Phosphorus (mg/L)	0.14	0.43	0.33	0.23	0.08	NA
Total Suspended Solids (mg/L)	2.60	127.17	22.11	49.77	7.25- 10 dry weather	NA
Turbidity (NTU)	69.00	168.66	12.75	23.25	8.3-8.5 dry weather	NA

NA = KDOW has not established a benchmark for this parameter.
*Human Health Standard for fish consumption, NA for Aquatic Life
ND = If this parameter was in the sample collected, it was at a concentration below the detection limit of the test.

Table 5-26
SFG 5.3 Wet Weather Event Samples

ANALYSIS	Jun-09	May-10	Nov-10	Jun-11	Standard
E. coli, Colilert QT 2000 (MPN/100 mL)	265	106	63112	9181	130

This watershed, as with all of the other small watersheds sampled, seems to contribute a similar portion of bacteria and nutrient load to the downstream creek.

5.4 Kenton County Airport Board Data (Outfall 4)

The Airport is required to monitor their outfalls as part of their National Pollutant Discharge Elimination System (NPDES) stormwater permit. The application of deicing agents to runways and aircraft is a potential winter source of toxic glycol byproducts, high biological oxygen demand (BOD) from glycol breakdown and high nitrogen when urea products are used on runways. It is our understanding that urea is not used by the Kenton County Airport Board and the results reported by the airport in their Discharge Monitoring Report (DMR) in Table 3-13 do not indicate excessive nitrogen or ammonia indicative of urea use. The DMR reporting does indicate very high BOD during the sample period in December 2010. No data was apparently reported in January 2010. The measureable presence of glycol compounds in that month indicates that the BOD is very likely caused by glycol degradation. The breakdown of deicing agents in the stream in winter and transport of those daughter products downstream may minimize the effects on summertime BOD which explains why we did not see high Carbonaceous BOD readings at stations on Gunpowder Creek in the June samples.

While we cannot make a direct link, the toxicity of products from the breakdown of glycol may be in part responsible for the low macroinvertebrate indices we see at the downstream sites. Since we also see poor macroinvertebrates in other tributaries it is clearly not the deicing agents from the airport alone that is responsible for impairment of aquatic life in this watershed.

Table 5–27
Excerpt from Kenton County Airport Board DMR Reports

ANALYSIS	10/31/2010 Max	11/30/2010 Max	12/31/2010 Max	3/31/2011 Max	10/31/2011 Max	11/30/2011 Max	12/31/2011 Max	KDOW Benchmarks	Standard
BOD_5 (mg/L)	<2.0	8.8	350.0	5.0	10.0	4.9	5.2	NA	NA
Total Ammonia (mg/L)	0.060	0.160	0.170	4.50	0.05	0.47	1.70	0.25-0.05	NA

6. Conclusions

6.1 Wet Weather

The sampling data reviewed in this report was predominantly wet weather sampling. SD1 focused their efforts on wet weather data and specifically collected wet weather events (a wet weather event is defined as a seven-day antecedent dry period (in which no more than 0.1 inch of precipitation occurs) followed by visible run-off conditions, such as sheet flow on impervious surfaces and visible surface flow in ephemeral channels). Boone County Conservation District collected samples on days when there may have been no active rainfall but many of those days were preceded by significant storms within the previous 24 to 48 hours. Wet weather sampling by both Boone County Conservation District and SD1 provided a clear picture that multiple sources of bacteria and nutrients exist in all of the tributaries. Nutrients and bacteria can come from uncontrollable sources such as wildlife and decay of forest litter. It can also come from sources that can be addressed. In urban areas, the sources may include sewer overflows, failing septic systems, unmanaged pet waste, wildlife in stormwater management structures (i.e. retention ponds), and applying fertilizers to yards or golf courses prior to or during rain events. Sources in rural settings can include livestock in or too close to streams, mismanaged or failing lagoons, wildlife, missing or inadequate buffer strips around row crops, and the application of fertilizers prior to or during rain events.

The widespread nature of high nutrients and bacteria during wet weather suggests that responsible agencies should continue to identify and remove potential sources during wet weather events. Education programs could reduce the practice of applying fertilizers prior to or during wet weather on agricultural land as well as residential and commercial. Continued efforts by SD1 to prevent stormwater from entering the separate sanitary sewer system will reduce the likelihood of overflows. Reenergized partnerships between the Natural Resource Conservation Service and local farmers to create larger buffer strips between livestock and streams will reduce the amount of domestic livestock waste from washing into streams when it rains. Finally, education and enforced leash laws will eliminate solid waste from house pets from impacting waterways.

6.2 Dry Weather

Of the eight dates that samples were collected by Boone County Conservation District only three were possibly dry weather events (a dry weather event is defined as following a seven-day dry period, in which no more than 0.1 inch of precipitation occurs). Since rain data was not collected proximally to each site it is also possible that localized storms may have occurred that could influence flow in the different tributary basins. Generally the dry weather dates did show lower concentrations of pollutants than were observed in the samples that were clearly wet weather related (for both Boone County Conservation District and SD1 samples).

About 60% of bacteria samples collected after 48 hours of apparent dry weather meet KDOW recreational use criteria; the remaining samples show *E. coli* concentrations in excess of that standard. Given the small data set it is difficult to draw firm conclusions about the extent of dry weather source contributions of bacteria to the streams. It is also possible that based on the variability of the bacteria levels, some cases may be a false positive high reading that is not indicative of actual conditions. Future dry weather samples should be taken using the KDOW definition of following a seven-day dry period. A recent study conducted by Malcolm Pirnie/ARCADIS are doing in New York State indicates that the ability to draw conclusions from dry weather bacteria results is significantly enhanced by collecting co-located samples at each site and event for the detection of illicit sources of dry weather bacteria discharge. Given the inherent variability of bacteria data, collecting three or four replicates at each site provides statistical power which helps draw verifiable conclusions about the presence or absence of bacteria sources during dry weather.

Nutrients also were present in the dry weather samples though often at lower concentrations than what was observed during wet weather; however, these levels are still above nutrient targets. Additional dry weather sampling would be needed to confirm that these concentrations are reduced during dry weather periods.

General indications from low Carbonaceous BOD and normal readings for other variables suggest that wastewater (which could commonly originate from sewer overflows or failing septic systems) is not discharged in large quantities. That does not preclude the possibility that storm water induced overflow of sewer systems may be occurring in this watershed. It does suggest that any discharge of sewage is significantly diluted by storm water. Without specific direct measure of sewer overflow and possibly detailed water quality modeling it is difficult to draw more specific conclusions.

Continued evaluation of best management practices (BMPs) and identification of specific sources of bacteria and nutrients should provide means to identify the more significant sources of loading in the watershed and help to identify additional efforts that might be needed to further explore causes and sources of water quality impairment.

6.3 Pollutant Loading

It is difficult to estimate loading relative to variations in both flow and pollutant concentration with data that is not directly linked to rain and flow conditions. A simple method of estimating pollutant loads is to look at USGS Gauge data for Gunpowder and use the mean flow value measured at the gauge. We can then estimate the annual load by using the average instream concentration at GPC 7.5 as representative of all of the sites. If we do that for Total Phosphorus we calculate that on average under 500 lbs of phosphorus leaves the Gunpowder Creek Watershed annually for the 58 square mile watershed this equates to less than 0.02 lbs per acre. For Total Nitrogen the estimate is less than 2500 lb per year, or less than 0.07 lbs per acre. Loading of nutrients from each of the 5 subwatersheds monitored by Boone County Conservation District are comparable and cannot be differentiated statistically.

E coli based on the geometric mean of samples would be 6.11 E+12 Counts (or MPN) per year. These loadings are not extreme for the nutrients, which emphasizes the conservative nature of the USEPA targets that were evaluated in the report. Further sampling would be required to see if this loading is a result of a few concentrated sources of nutrient or of the combination of smaller amounts of excess fertilizer application by landowners. For bacteria this level of loading is not inconsistent with loading from separately sewered areas dominated by storm water from agricultural and residential watersheds. Though the bacteria counts sound high and translate to over 150 million bacteria per acre, it is important to remember that that is the same order of magnitude as bacteria in a very small amount of fecal material, so the combined concentrations of wildlife, domestic animals and leaking sewers or failing septic tanks/leach fields could account for those loadings. To state it another way, it only takes a small amount of fresh excrement to yield high concentrations of bacteria. If the bacteria are from human rather than animal sources, the risk of waterborne disease is significantly greater. Laboratory analysis is available to identify the source as either animal or human, but the tests are expensive. Continued cooperation with SD1 as well as the health department will lead to the reduced risk of human waste entering the Gunpowder Creek Watershed.

Nutrient and bacterial loading in surface water during dry weather conditions (defined in Section 5.1.2) are typically from a single source, such as a failed septic tank on a creek bank or an animal defecating in a stream. This loading during wet weather conditions can also come from non-point sources such as animal waste on a yard or pasture and excess fertilizers applied to fields or fairways. Dry weather samples are typically collected to identify illicit source discharges or to establish background conditions (typical quality of water). Wet weather samples are typically collected to identify and quantify non-point sources of nutrients and bacteria. Samples collected during 2011 were potentially elevated because of residual concentrations after rain events. This can be evaluated after the 2012 sampling program when dry weather samples are collected. An indication that non-point sources are a contributing factor is the elevated concentrations at all sites on June 24, 2011. Samples were collected three days after the area received 1.41 inches of rain in three hours and fifteen minutes. This short duration, high intensity rain typically results in the movement of nutrients from forest and fields into creeks and streams.

6.4 Quality Assurance/Quality Control

The study would benefit by implementation of better system to store data. The use of spreadsheets as data management software increases the potential for transcription and typographical errors. The metadata should also be stored with the data, which cannot typically be done in a spreadsheet. Field chain of custody, photographs, weather data and any field observations should be stored with the sample results. If this program continues over the years a database should be developed to store the field results and metadata. Duplicate data in this study could not be linked to the sites where the duplicates were taken since the metadata linking those values to the sample sites was not included in the spreadsheets provided. The QAPP procedures seem to have been carried out effectively and the data was generally consistent and there were no indications of invalid data.

Appendix A

Final

2010 Integrated Report to Congress on the Condition of Water Resources in Kentucky

Volume II. 303(d) List of Surface Waters

Kentucky Energy and
Environment Cabinet
Division of Water
October 2011

4.2.1.10 Townsend Creek

Stream Name	County	River Miles	Pollutant
Townsend Creek into S. Fk. Licking R.	Harrison	0.0 to 4.9	Fecal Coliform

KDOW, along with the Nature Conservancy, collected pathogen data during the 2006 primary contact recreation season. KDOW is currently developing the pathogen TMDLs which will be submitted for public notice in 2010.

4.2.2 Ohio River Basin

4.2.2.1 Goose Creek Watershed

Stream Name	County	River Miles	Pollutant
Goose Creek into Ohio River	Jefferson	0.3 to 3.6	Fecal Coliform
Goose Creek into Ohio River	Jefferson	0.3 to 3.6	Nutrient/Eutrophication Biological Indicators
Goose Creek into Ohio River	Jefferson	0.3 to 3.6	Organic Enrichment (Sewage) Biological Indicators
Goose Creek into Ohio River	Jefferson	3.6 to 13.0	Fecal Coliform
Goose Creek into Ohio River	Jefferson	3.6 to 13.0	Nutrient/Eutrophication Biological Indicators
Goose Creek into Ohio River	Jefferson	3.6 to 13.0	Organic Enrichment (Sewage) Biological Indicators
Little Goose Creek into Ohio River	Jefferson	0.0 to 9.2	Fecal Coliform

KDOW completed monitoring in 2008. KDOW will pursue development of the nutrient TMDL when nutrient targets are available.

4.2.2.2 Gunpowder Creek Watershed

Stream Name	County	River Miles	Pollutant
Gunpowder Creek into Ohio River	Boone	15.4 to 17.1	Sedimentation/Siltation
Gunpowder Creek into Ohio River	Boone	15.4 to 17.1	Nutrient/Eutrophication Biological Indicators
Gunpowder Creek into Ohio River	Boone	15.4 to 17.1	Organic Enrichment (Sewage) Biological Indicators
Gunpowder Creek into Ohio River	Boone	18.9 to 21.6	Cause Unknown

Stream Name	County	River Miles	Pollutant
South Fork Gunpowder Creek into Gunpowder Creek	Boone	0.0 to 2.0	Nutrient/Eutrophication Biological Indicators
South Fork Gunpowder Creek into Gunpowder Creek	Boone	0.0 to 2.0	Organic Enrichment (Sewage) Biological Indicators
South Fork Gunpowder Creek into Gunpowder Creek	Boone	0.0 to 2.0	Sedimentation/Siltation
South Fork Gunpowder Creek into Gunpowder Creek	Boone	0.0 to 2.0	Turbidity
South Fork Gunpowder Creek into Gunpowder Creek	Boone	4.1 to 6.8	Fecal Coliform

KDOW completed nutrient and pathogen monitoring in 2007. KDOW will pursue development of the nutrient and organic enrichment TMDLs when nutrient targets are available.

Comment [s6]: Deleted the following sentence because this statement may not be true: KDOW will collect additional sediment data and perform geomorphic assessment prior developing the sediment TMDLs.

4.2.2.3 Locust Creek

Stream Name	County	River Miles	Pollutant
Locust Creek into Ohio River	Bracken	0.0 to 4.1	Fecal Coliform

KDOW completed monitoring in 2006.

4.2.2.4 Pond Creek Watershed

Stream Name	County	River Miles	Pollutant
Pond Creek into Ohio River	Oldham	0.0 to 1.5	Chlorine
Pond Creek into Ohio River	Oldham	0.0 to 1.5	Organic Enrichment (Sewage) Biological Indicators
Pond Creek into Ohio River	Oldham	0.0 to 1.5	Nutrient/Eutrophication Biological Indicators
UT to Pond Creek at RM 1.5	Oldham	0.0 to 0.5	Chlorine
UT to Pond Creek at RM 1.5	Oldham	0.0 to 0.5	Organic Enrichment (Sewage) Biological Indicators
UT to Pond Creek at RM 1.5	Oldham	0.0 to 0.5	Nutrient/Eutrophication Biological Indicators

KDOW completed monitoring in 2008. KDOW will pursue development of the nutrient TMDL when nutrient targets are available.

Salt-Licking Basin Unit
Ohio River Basin
Streams

Goose Creek 0.0 to 1.9		Bracken County
Into Locust Creek		Segment Length: 1.9
Impaired Use(s):	Warm Water Aquatic Habitat (Partial Support)	
Pollutant(s):	Cause Unknown	
Suspected Sources:	Natural Sources; Surface Mining	

Gunpowder Creek 0.0 to 15.0		Boone County
Into Ohio River		Segment Length: 15
Impaired Use(s):	Warm Water Aquatic Habitat (Nonsupport)	
Pollutant(s):	Sedimentation/Siltation	
Suspected Sources:	Site Clearance (Land Development or Redevelopment)	

KDOW awarded $501,056 Section 319(h) Grant funds (FFY2009) to the Boone County Conservation District to develop a comprehensive Watershed Based Plan for Gunpowder Creek

Gunpowder Creek 15.4 to 17.1		Boone County
Into Ohio River		Segment Length: 1.7
Impaired Use(s):	Warm Water Aquatic Habitat (Nonsupport)	
Pollutant(s):	Nutrient/Eutrophication Biological Indicators; Organic Enrichment (Sewage) Biological Indicators; Sedimentation/Siltation	
Suspected Sources:	Agriculture; Highway/Road/Bridge Runoff (Non-construction Related); Loss of Riparian Habitat; Site Clearance (Land Development or Redevelopment); Streambank Modifications/destabilization; Unspecified Urban Stormwater	

See Chapter 4, Status of TMDLs Under Development Prior to 2010.

KDOW awarded $501,056 Section 319(h) Grant funds (FFY2009) to the Boone County Conservation District to develop a comprehensive Watershed Based Plan for Gunpowder Creek.

Gunpowder Creek 18.9 to 21.6		Boone County
Into Ohio River		Segment Length: 2.7
Impaired Use(s):	Warm Water Aquatic Habitat (Partial Support)	
Pollutant(s):	Cause Unknown	
Suspected Sources:	Unspecified Urban Stormwater	

See Chapter 4, Status of TMDLs Under Development Prior to 2010.

KDOW awarded $501,056 Section 319(h) Grant funds (FFY2009) to the Boone County Conservation District to develop a comprehensive Watershed Based Plan for Gunpowder Creek.

Laurel Fork 5.8 to 15.9		Lewis County
Into Kinniconick Creek		Segment Length: 10.1
Impaired Use(s):	Warm Water Aquatic Habitat (Partial Support)	
Pollutant(s):	Nutrient/Eutrophication Biological Indicators; Organic Enrichment (Sewage) Biological Indicators; Sedimentation/Siltation; Turbidity	

Salt-Licking Basin Unit
Ohio River Basin
Streams

Montgomery Creek 0.0 to 6.5 — Lewis County
Into Kinniconick Creek — Segment Length: 6.5
Impaired Use(s): Warm Water Aquatic Habitat (Partial Support)
Pollutant(s): Nutrient/Eutrophication Biological Indicators; Organic Enrichment (Sewage) Biological Indicators; Sedimentation/Siltation
Suspected Sources: Crop Production (Crop Land or Dry Land); Dredging (E.g., for Navigation Channels); Grazing in Riparian or Shoreline Zones; Sewage Discharges in Unsewered Areas; Site Clearance (Land Development or Redevelopment)

Salt Lick Creek 0.2 to 7.2 — Lewis County
Into Ohio River — Segment Length: 7
Impaired Use(s): Warm Water Aquatic Habitat (Partial Support)
Pollutant(s): Sedimentation/Siltation
Suspected Sources: Highway/Road/Bridge Runoff (Non-construction Related); Impervious Surface/Parking Lot Runoff; Loss of Riparian Habitat; Runoff from Forest/Grassland/Parkland

Snag Creek 0.5 to 5.5 — Bracken County
Into Ohio River — Segment Length: 5
Impaired Use(s): Primary Contact Recreation Water (Nonsupport)
Pollutant(s): Fecal Coliform
Suspected Sources: Source Unknown

See Chapter 4, Status of TMDLs Under Development Prior to 2010.

South Fork Gunpowder Creek 0.0 to 2.0 — Boone County
Into Ohio River — Segment Length: 2
Impaired Use(s): Warm Water Aquatic Habitat (Nonsupport)
Pollutant(s): Nutrient/Eutrophication Biological Indicators; Organic Enrichment (Sewage) Biological Indicators; Sedimentation/Siltation; Turbidity
Suspected Sources: Agriculture; Package Plant or Other Permitted Small Flows Discharges; Post-development Erosion and Sedimentation; Site Clearance (Land Development or Redevelopment)

See Chapter 4, Status of TMDLs Under Development Prior to 2010.

KDOW awarded $501,056 Section 319(h) Grant funds (FFY2009) to the Boone County Conservation District to develop a comprehensive Watershed Based Plan for Gunpowder Creek.

Salt-Licking Basin Unit
Ohio River Basin
Streams

South Fork Gunpowder Creek 4.1 to 6.8 — Boone County
Into Ohio River — Segment Length: 2.7
Impaired Use(s): Primary Contact Recreation Water (Nonsupport)
Pollutant(s): Fecal Coliform
Suspected Sources: Source Unknown

See Chapter 4, Status of TMDLs Under Development Prior to 2010.

KDOW awarded $501,056 Section 319(h) Grant funds (FFY2009) to the Boone County Conservation District to develop a comprehensive Watershed Based Plan for Gunpowder Creek.

Tenmile Creek 0.05 to 1.15 — Campbell County
Into Ohio River — Segment Length: 1.1
Impaired Use(s): Warm Water Aquatic Habitat (Partial Support)
Pollutant(s): Nutrient/Eutrophication Biological Indicators; Sedimentation/Siltation
Suspected Sources: Crop Production (Crop Land or Dry Land); Livestock (Grazing or Feeding Operations); Site Clearance (Land Development or Redevelopment)

Trace Creek 0.2 to 4.6 — Lewis County
Into Kinniconick Creek — Segment Length: 4.4
Impaired Use(s): Warm Water Aquatic Habitat (Partial Support)
Pollutant(s): Nutrient/Eutrophication Biological Indicators; Organic Enrichment (Sewage) Biological Indicators; Sedimentation/Siltation
Suspected Sources: Crop Production (Crop Land or Dry Land); Dredging (E.g., for Navigation Channels); Grazing in Riparian or Shoreline Zones; Sewage Discharges in Unsewered Areas; Silviculture Activities

Woolper Creek 2.8 to 7.2 — Boone County
Into Ohio River — Segment Length: 4.4
Impaired Use(s): Primary Contact Recreation Water (Nonsupport)
Pollutant(s): Fecal Coliform
Suspected Sources: Agriculture

Woolper Creek 11.9 to 14.0 — Boone County
Into Ohio River — Segment Length: 2.1
Impaired Use(s): Warm Water Aquatic Habitat (Nonsupport); Primary Contact Recreation Water (Nonsupport)
Pollutant(s): Cause Unknown; Fecal Coliform; Nutrient/Eutrophication Biological Indicators; Organic Enrichment (Sewage) Biological Indicators; Total Suspended Solids (TSS)
Suspected Sources: Illegal Dumps or Other Inappropriate Waste Disposal; Impacts from Hydrostructure Flow Regulation/modification; Urban Runoff/Storm Sewers

See Chapter 4, Status of TMDLs Under Development Prior to 2010.

Salt-Licking Basin Unit 303(d) List
Ohio River Basin
Streams

Waterbody & Segment	Total Size	Waterbody ID	8-Digit HUC	County	Assessment Category	Use	Impairment	Suspected Source(s)
Gunpowder Creek 0.0 to 15.0	15 miles	KY493502_01	5090203	Boone	5-NS	WAH	Sedimentation/Siltation	Site Clearance (Land Development or Redevelopment)
Gunpowder Creek 15.4 to 17.1	1.7 miles	KY493502_02	05090203	Boone	5-NS	WAH	Nutrient/ Eutrophication Biological Indicators	Agriculture, Unspecified Urban Stormwater, Site Clearance (Land Development or Redevelopment)
Gunpowder Creek 15.4 to 17.1	1.7 miles	KY493502_02	05090203	Boone	5-NS	WAH	Organic Enrichment (Sewage) Biological Indicators	Agriculture, Unspecified Urban Stormwater
Gunpowder Creek 15.4 to 17.1	1.7 miles	KY493502_02	05090203	Boone	5-NS	WAH	Sedimentation/Siltation	Agriculture, Unspecified Urban Stormwater, Streambank Modifications/destabilization, Site Clearance (Land Development or Redevelopment), Loss of Riparian Habitat, Highway/Road/Bridge Runoff (Non-construction Related)
Gunpowder Creek 18.9 to 21.6	2.7 miles	KY493502_03	5090203	Boone	5-PS	WAH	Cause Unknown	Unspecified Urban Stormwater
Laurel Fork 5.8 to 15.9	10.1 miles	KY513259_01	5090201	Lewis	5-PS	WAH	Nutrient/Eutrophication Biological Indicators	Crop Production (Crop Land or Dry Land), Livestock (Grazing or Feeding Operations), Silviculture Activities
Laurel Fork 5.8 to 15.9	10.1 miles	KY513259_01	5090201	Lewis	5-PS	WAH	Organic Enrichment (Sewage) Biological Indicators	Crop Production (Crop Land or Dry Land), Livestock (Grazing or Feeding Operations), Sewage Discharges in Unsewered Areas
Laurel Fork 5.8 to 15.9	10.1 miles	KY513259_01	5090201	Lewis	5-PS	WAH	Sedimentation/Siltation	Crop Production (Crop Land or Dry Land), Dredging (e.g., for Navigation Channels), Silviculture Activities

Salt-Licking Basin Unit 303(d) List
Ohio River Basin
Streams

Waterbody & Segment	Total Size	Waterbody ID	8-Digit HUC	County	Assessment Category	Use	Impairment	Suspected Source(s)
Montgomery Creek 0.0 to 6.5	6.5 miles	KY498512_01	5090201	Lewis	5-PS	WAH	Sedimentation/Siltation	Crop Production (Crop Land or Dry Land), Dredging (e.g., for Navigation Channels), Site Clearance (Land Development or Redevelopment)
Salt Lick Creek 0.2 to 7.2	7 miles	KY502828_01	5090201	Lewis	5-PS	WAH	Sedimentation/Siltation	Highway/Road/Bridge Runoff (Non-Construction Related), Impervious Surface/Parking Lot Runoff, Loss of Riparian Habitat, Runoff from Forest/Grassland/Parkland
Snag Creek 0.5 to 5.5	5 miles	KY503833_00	5090201	Bracken	5-NS	PCR	Fecal Coliform	Source Unknown
South Fork Gunpowder Creek 0.0 to 2.0	2 miles	KY503926_01	5090203	Boone	5-NS	WAH	Nutrient/Eutrophication Biological Indicators	Agriculture
South Fork Gunpowder Creek 0.0 to 2.0	2 miles	KY503926_01	5090203	Boone	5-NS	WAH	Organic Enrichment (Sewage) Biological Indicators	Agriculture, Package Plant or Other Permitted Small Flows Discharges
South Fork Gunpowder Creek 0.0 to 2.0	2 miles	KY503926_01	5090203	Boone	5-NS	WAH	Sedimentation/Siltation	Agriculture, Post-Development Erosion and Sedimentation, Site Clearance (Land Development or Redevelopment)
South Fork Gunpowder Creek 0.0 to 2.0	2 miles	KY503926_01	05090203	Boone	5-NS	WAH	Turbidity	Agriculture, Site Clearance (Land Development or Redevelopment), Post-development Erosion and Sedimentation, Package Plant or Other Permitted Small Flows Discharges
South Fork Gunpowder Creek 4.1 to 6.8	2.7 miles	KY503926_02	5090203	Boone	5-NS	PCR	Fecal Coliform	Source Unknown

Category 4A (Approved TMDLs)

Waterbody & Segment	Total Size	Waterbody ID	Water Type	Watershed	Basin	8-Digit HUC	County	Use	Impairment
Floyds Fork 11.6 to 24.2	12.6 miles	KY492278_02	River	Salt/ Licking	Salt River	05140102	Jefferson	WAH	Organic Enrichment (Sewage) Biological Indicators
Floyds Fork 24.2 to 34.1	9.9 miles	KY492278_03	River	Salt/ Licking	Salt River	05140102	Jefferson	WAH	Organic Enrichment (Sewage) Biological Indicators
Floyds Fork 34.1 to 61.9	27.8 miles	KY492278_04	River	Salt/ Licking	Salt River	05140102	Shelby	WAH	Organic Enrichment (Sewage) Biological Indicators
Glens Fork 0.0 to 7.1	7.1 miles	KY492907_00	River	Green/ Tradewater	Green River	05110001	Adair	PCR, SCR	Fecal Coliform
Greasy Creek 0.0 to 3.7	3.7 miles	KY493234_00	River	Tenn/Miss/Cumberland	Upper Cumberland	5130101	Bell	PCR	Fecal Coliform
Greasy Creek 3.7 to 11.4	7.7 miles	KY493234_00	River	Upper Cumberland	Upper Cumberland	5130102	Bell	PCR	Fecal Coliform
Gunpowder Creek 15.4 to 17.1	1.7 miles	KY493502_02	River	Salt/ Licking	Ohio River	05090203	Boone	WAH	Ethylene Glycol
Harrods Creek 0.0 to 3.2	3.2 miles	KY493826_01	River	Salt/ Licking	Salt River	05140101	Oldham	WAH	Organic Enrichment (Sewage) Biological Indicators
Hickory Creek 0.0 to 3.9	3.9 miles	KY494122_00	River	Tenn/Miss/Cumberland	Lower Cumberland	5130205	Livingston	PCR	Fecal Coliform
Left Fork Straight Creek 0.0 to 13.1	13.1 miles	KY513326_01	River	Tenn/Miss/Cumberland	Upper Cumberland	5130101	Bell	PCR	Fecal Coliform

Appendix B

QUALITY ASSURANCE PROJECT PLAN

FOR

Gunpowder Creek Watershed Based Plan

DRAFT

Effective Date: April 15, 2011

Revision Date: April 12, 2011

Revision No: Original QAPP

Prepared by:

Sustainable Streams, LLC
2038 Eastern Parkway, Suite 1
Louisville, KY 40204

On behalf of:

Gunpowder Creek Watershed Initiative
Boone County Conservation District
6028 Camp Ernst Road
Burlington, KY 41005

Submitted to:

The Kentucky Energy and Environment Cabinet
Department for Environmental Protection
Division of Water, Nonpoint Source Section
200 Fair Oaks Lane, Fourth Floor
Frankfort, KY 40601

GROUP A ELEMENTS: PROJECT MANAGEMENT

A1: TITLE AND APPROVAL SHEETS

QUALITY ASSURANCE PROJECT PLAN FOR GUNPOWDER CREEK WATERSHED BASED PLAN

April 12, 2011

Boone County Conservation District

APPROVAL SIGNATURES

Boone County Conservation District:

Title	Name	Signature	Date
Project Manager	Mark Jacobs	______________________	__________
QA Officer	Mary Kathryn Dickerson	______________________	__________

Kentucky Division of Water:

Title	Name	Signature	Date
Nonpoint Section Supervisor	Jim Roe	______________________	__________
QA Officer	Lisa Hicks	______________________	__________

REVISION HISTORY

Revision No.	Date of Revision	Page(s) Revised	Revision Explanation
Original QAPP	April 12, 2011	All	Addressing KDOW comments from Pre-approved (reviewable) copy of QAPP

A2: Table of Contents

List of Tables

List of Figures

A3: Distribution List

The purpose of a distribution list is to identify all individuals who should receive a signed copy of the approved Quality Assurance Project Plan (QAPP), either in print or electronic format. The personnel listed in Table 1 should also receive any subsequent revisions to the approved QAPP.

Table 1: QAPP Distribution List

Title	Name	Affiliation	Tel. No.	No. of copies
Project Manager	Mark Jacobs markjacobs@nkcd.org	BCCD[a]	859-586-7903	1
Project QA Officer	Mary Kathryn Dickerson mkdickerson@nkcd.org	BCCD[a]	859-586-7903	1
KDOW Nonpoint Section Supervisor	Jim Roe james.roe@ky.gov	KDOW[b]	502-564-3410	1
KDOW QA Officer	Lisa Hicks lisa.hicks@ky.gov	KDOW[b]	502-564-3410	1
Steering Committee Chair	Tom Comte tecomte@fuse.net	BCCD[a]	859-586-9043	1
Project Technical Adviser	Matt Wooten mwooten@sd1.org	SD1[c]	859-578-6887	1
Project Technical Adviser	Mindy Scott mscott@sd1.org	SD1[c]	859-578-6743	1
Project Technical Adviser	Bob Hawley bob.hawley@sustainablestreams.com	Sustainable Streams[d]	502-718-2912	1
Water Chemistry Lab Manager	Antoinette Rucshman Antoinette@cardinallabs.com	Cardinal Labs[e]	859-341-9989	1
Water Chemistry QA Officer	Krista Line krista@cardinallabs.com	Cardinal Labs[e]	859-341-9989	1
Biological Lab Manager	Marcia Wooton mwooton@thirdrockconsultants.com	Third Rock[f]	859-977-2000	1
Biological Lab QA Officer	Bert Remley bremley@thirdrockconsultants.com	Third Rock[f]	859-977-2000	1

(a) Boone County Conservation District, 6028 Camp Ernst Rd., Burlington, KY 41005
(b) Kentucky Division of Water, Nonpoint Source Section, 200 Fair Oaks Lane, Fourth Floor, Frankfort, KY 40601

[c] Sanitation District No. 1, 1045 Eaton Dr., Fort Wright, KY 41017
[d] Sustainable Streams, LLC, 2038 Eastern Parkway #1, Louisville, KY 40204
[e] Cardinal Laboratories, Inc., 104 North Street, Wilder, KY 41071
[f] Third Rock Consultants, LLC., 2526 Regency Rd. #180, Lexington, KY 40503

A4: PROJECT/TASK ORGANIZATION

A project organizational chart allows one to easily identify the roles and responsibilities of key individuals and hierarchically depicts communication lines between individuals/organizations.

The organizational chart for the Gunpowder Watershed Based Plan QAPP is provided below (Figure 1). Although staff/roles may change during a project, it is important to highlight the responsibilities of the most central positions:

- **Project Manager** (Mark Jacobs): A Project Manager (PM) is responsible for all aspects of the project including quality. They must ensure that all data collection/analysis/ management personnel are properly trained in approved QAPP procedures. A PM also serves as the communication hub, keeping the Kentucky Division of Water (KDOW), steering committee, QA Officer, etc. updated on the project. EPA Guidance notes that a PM may play several other roles in a project (e.g. Chemical Data Collection Manager); however, the PM may NOT serve as the QA Officer. Should the QAPP need to be revised during the project, the PM is responsible for updating and distributing the revised QAPP.

- **Project QA Officer** (Mary Kathryn Dickerson): The purpose of a Project Quality Assurance (QA) Officer is to ensure that the QA procedures outlined in the QAPP are being followed throughout the project. Although the QA officer may have other roles in the broader project (e.g. assisting with Watershed Based Plan), it is essential that the QA officer remain independent of data generation, laboratory analysis, and data management. The QA officer may work with QA officers of other organizations such as subcontracted laboratories to ensure QAPP procedures are being followed by other organizations. The QA Officer has the authority to perform any number of field/lab assessments to ensure QAPP compliance. If at any time the QA Officer discovers significant deviations from required procedures or evidence of systematic failure, the QA Officer has the authority to stop all actions, including those conducted by subcontractors. All findings and recommendations for corrective action will be reported to the Project Manager.

- **KDOW Nonpoint Section Supervisor** (Jim Roe): The nonpoint and basin supervisor is the delegated contact for all project activities related to the 319 program. Responsibilities include:

- Reviewing the QAPP for 319 program elements, or designating appropriate representative (technical advisor)
- Approving the QAPP for use in 319 programs
- Approving and/or reviewing submitted data for completeness and applicability

- **KDOW QA Officer** (Lisa Hicks): The Division QA officer is the delegated manager of the routine QA/QC activities that are implemented as part of normal data collection activities. The Division QA officer provides technical support and reviews and approves QA products. Responsibilities include:
  - Reviewing all externally generated QAPPs and coordinating on any planning related to QAPP elements
  - Communicating with EPA Project Officers and EPA QA personnel on issues related to routine sampling and QA activities
  - Understanding EPA monitoring and QA regulations and guidance, and ensuring staff understand and follow these regulations and guidance
  - Understanding Division QA policy and ensuring staff understand and follow the policy
  - Understanding and ensuring adherence to the QAPP
  - Ensuring that all personnel involved in environmental data collection have access to any training or QA information needed to be knowledgeable in QA requirements, protocols, and technology
  - Recommending required management-level corrective actions

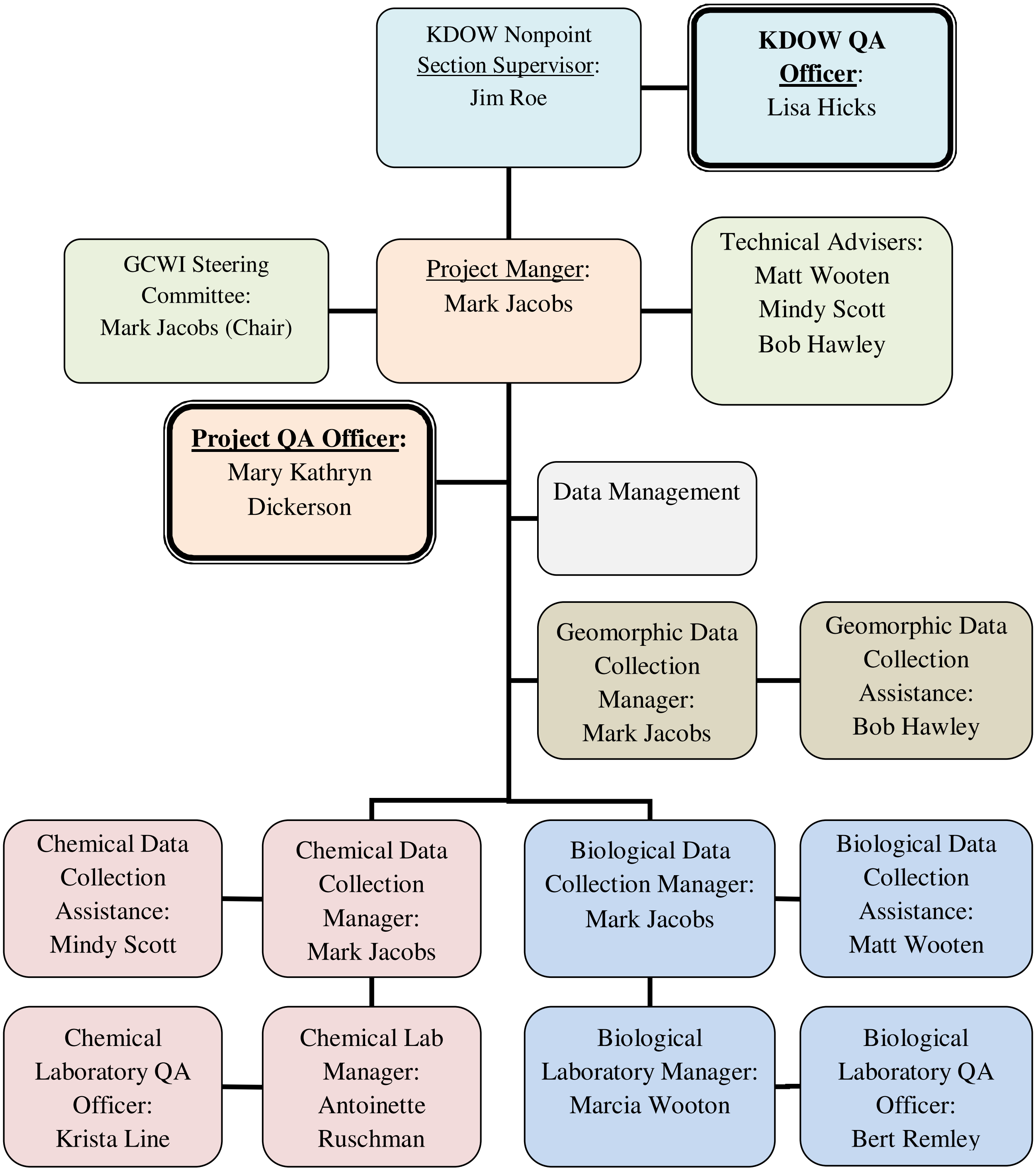


Figure 1: Project Organizational Chart

Central to the success of the overall project is the Gunpowder Creek Watershed Initiative Project Steering Committee (Table 2). The committee is currently chaired by Tom Comte who continues to play an active role in project activities (including the development of this QAPP). The Project Manager and Steering Committee Chair maintain regular communication. The steering committee is regularly updated and asked for feedback during bi-monthly meetings.

Table 2: Gunpowder Creek Watershed Initiative Steering Committee

Name	Affiliation	Tel. No.	Email
Mark Jacobs[a]	Boone Co. Consv. District[b]	859-586-7903	markjacobs@nkcd.org
Steve Divine	N. KY Health Dept. [c]	859-341-4151	Steve.divine@ky.gov
Josh Hunt	City of Florence[d]	859-647-5416	Joshua.hunt@florence-ky.gov
Lajuanda Haight-Maybriar	KY Division of Water[e]	502-564-3410 ext. 4937	Lajuanda.haight-maybriar@ky.gov
Kevin Costello	Boone Co. Planning & Zoning[f]	859-334-9156	kcostello@boonecountyky.org
Greg Sketch	Boone Co. Engineer[g]	(859) 334-3600	gsketch@boonecountyky.org
Yvonne Meichtry	Licking River WW[h]	859-441-9653	ymeichtry@fuse.net
Matt Wooten	Sanitation District No. 1[i]	859-578-6887	mwooten@sd1.org
Donald Chapman	Kenton Co. Airport Board[j]	859-767-7884	dchapman@cvgairport.com
Rick Soper	Boone Co. Consv. District[b]	859-586-7903	N/A
Stacee Hans	KY Dept. Transportation[k]	859-341-2700	Mike.bezold@ky.gov
Mary Kathryn Dickerson	Boone Co. Consv. District[b]	859-586-7903	mkdickerson@nkcd.org

[a] Steering Committee Chairperson
[b] Boone County Conservation District, 6028 Camp Ernst Rd., Burlington, KY 41005
[c] Northern Kentucky District Health Department, 610 Medical Village Dr., Edgewood, KY 41017
[d] City of Florence, 8100 Ewing Blvd., Florence, KY 41042-7588
[e] Kentucky Division of Water, Nonpoint Source Section, 200 Fair Oaks Lane, Fourth Floor, Frankfort, KY 40601
[f] Boone County Planning and Zoning, P.E. Box 958, Burlington, KY 41005
[g] Boone County Engineer, 5645 Idlewild Rd., Burlington, KY 41005-9798
[h] Yvonne Meichtry, Licking River Watershed Watch, 4349 Winters Lane, Cold Springs, KY 41076-9033
[i] Sanitation District No. 1, 1045 Eaton Dr., Fort Wright, KY 41017
[j] Kenton County Airport Board, P.O. Box 752000, Cincinnati, OH 45275
[k] Kentucky Department of Transportation, 421 Buttermilk Pike, Covington, KY 41017

The Boone County Conservation District has contracted with Sustainable Streams, LLC for technical support in developing this QAPP. We have also coordinated with the Licking River Watershed Watch (LRWW), Sanitation District No. 1 (SD1), Thomas More College, Morehead State University, and Kentucky Division of Water (KDOW). This document was informed by EPA (2002a) and KDOW (2010a) guidance, along with QAPPs being used in regional watersheds such as the KDOW-approved QAPP of the neighboring Banklick Creek Watershed

(BWC, 2005) and the draft QAPP of SD1 (2010). A list of potential technical and outreach advisers is provided below (Table 3), along with potential project stakeholders who are also critical for overall project success.

Table 3: Potential Technical Advisers and Stakeholders in the Gunpowder Creek Watershed

Potential Technical Advisers	Potential Stakeholders
1. Kentucky Division of Forestry	1. City of Union
2. Kentucky Department of Fish and Wildlife Resources	2. Northern Kentucky Flyfishers
	3. Hunting and Fishing Clubs
3. Kentucky Division of Water	4. Sierra Club Water Sentinels
4. Boone County Water District	5. Northern Kentucky Home Builders Association
5. Natural Resources Conservation Service	6. Northern Kentucky Cattle Association
6. NKU – Center for Applied Ecology	7. Northern Kentucky Horse Network
7. Northern Kentucky University	8. Boone County Farm Bureau
8. Thomas More College	9. Boone Conservancy
9. University of Kentucky Cooperative Extension Service	10. Northern Kentucky Chamber of Commerce
	11. Boone County Businessmen's Association
10. SD1	12. Boone County Public Schools
11. Sustainable Streams, LLC	13. Boone County Public Library
	14. Boone County Emergency Management – Hazmat Team
	15. Boone County Local Emergency Planning Committee
	16. Citizens of the watershed

Finally, field data collection, laboratory analysis, and data management will be carried out in accordance with the QA procedures outlined herein, regardless of the individual(s) filling those roles. Specific individuals for these roles are unknown at this time.

A5: Problem Definition and Background

The Gunpowder Creek Watershed is located in Boone County (Figure 2), which is Kentucky's second fastest growing county and one of the top 100 in the nation (Census, 2009). From 2000 to 2009, county population was estimated to increase by 38% to 118,576 (Census, 2010). Correspondingly, housing units increased by 35% to 45,043 units from 2000 to 2008 (Census, 2010). This does not take into account commercial development during the same period.

According to Mr. Steve Gay, Director of Boone County GIS Services, approximately 23,680 of these housing units (53% of total) reside in the actual watershed with an estimated population of 59,484 (Pers. Comm., 2009). Mr. Robert Jonas, Boone County GIS Specialist, notes that an additional 12,129 housing units have been approved but not yet built (Pers. Comm., 2009) and municipal plans include commercial development in the watershed, such as the City of Union's "Union Town Plan."

Threats to the water quality of Gunpowder Creek are growing at a rapid pace as Boone County continues to develop. Nonpoint source pollution, due to hydromodification, habitat alteration, and sedimentation, is thought to be the leading cause of impairments in the watershed. Historic land uses such as agriculture also impact the lower portions of the watershed. The Greater Cincinnati/ Northern Kentucky International Airport has a separate TMDL for ethylene glycol. Most of the upper reaches of the watershed have been developed. Development in the county continues to push south and west across the watershed.

Significant impairments have already been identified in the Upper Gunpowder Creek Watershed. The Northern Kentucky/Greater Cincinnati International Airport was identified as a major source of pollution from de-icing operations and has taken mitigating steps in accordance with the approved TMDL developed to address ethylene glycol (KDOW, 1998). Additional TMDLs are under development by KDOW for other pollutants they have assessed and listed as causes of impairments in the creek and its tributaries (Table 4). These are sedimentation/siltation, nutrient/ eutrophication biological indicators, organic enrichment (sewage) biological indicators, and fecal coliform (KDOW, 2008).

These impairments are related to Boone County's rapid growth over the past decade and an increase in storm water runoff. The county will likely continue to grow for the foreseeable future. As a result, the threat to the Gunpowder Creek watershed from nonpoint source pollution will continue to grow. Based on the evidence of this growing threat, it is important that a more clear understanding of the situation facing the watershed be obtained. We intend to do this through the data collection and analysis outlined in this QAPP, which includes a phased approach to monitoring of water chemistry and biological parameters as specified in the KDOW (2010) Guidebook. Because hydromodification (via urban development) is a great concern in this watershed, we also include geomorphic monitoring that is tailored to capture this impairment. All of the data collection and analysis will be in support of developing a Watershed Based Plan (WBP) that will be funded in part through this grant project. .

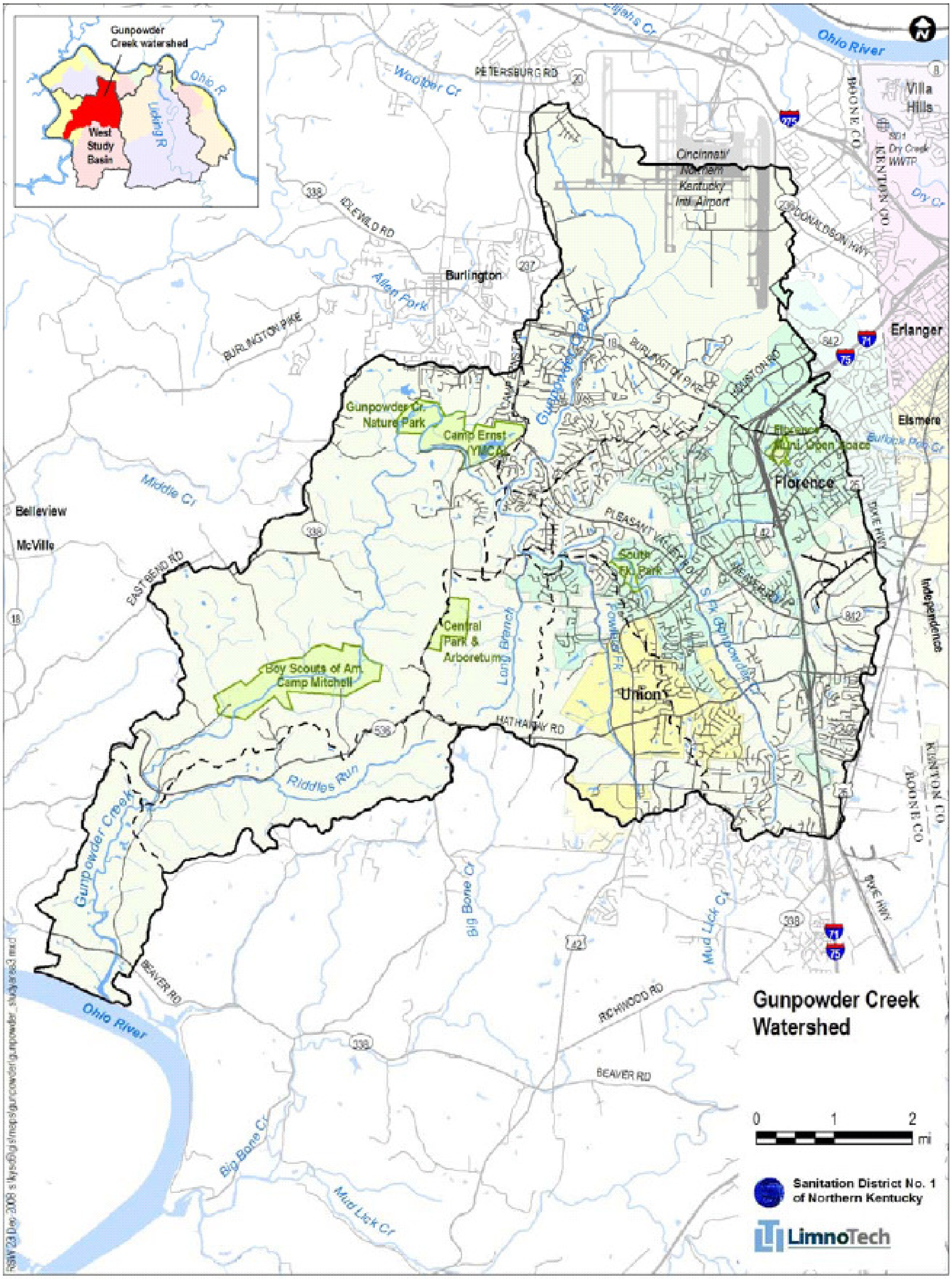


Figure 2: Gunpowder Creek Watershed (LimnoTech, 2009)

Table 4: 303(d)-listed Waterbodies (KDOW, 2008)

Waterbody Segment	Designated uses (Use Support)	Pollutants	Suspected Sources
Gunpowder Ck. RM 0.0 – 15.0	Warm -water Aquatic Habitat (Not supporting)	Sedimentation/siltation	Site Clearance (Land development or redevelopment)
Gunpowder Ck. RM 15.4 – 17.1	Warm -water Aquatic Habitat (Not Supporting)	Sedimentation/siltation; Nutrient/Eutrophication biological indicators Organic enrichment (sewage) biological indicators	Agriculture, Unspecified urban storm water, Streambank modifications/ destabilization, Site clearance (land development or redevelopment), Loss of riparian habitat, Highway/road/bridge runoff (non-construction related)
Gunpowder Ck. RM 18.9 – 21.6	Warm -water Aquatic Habitat (Partially Supporting)	Unknown	Unspecified urban storm water
South Fork Gunpowder Ck. RM 0.0 – 2.0	Warm -water Aquatic Habitat (Not Supporting)	Sedimentation/siltation Turbidity Nutrient/Eutrophication biological indicators Organic enrichment (sewage) biological indicators	Agriculture, Package plant or other permitted small flows discharges, Post-development erosion and sedimentation, Site clearance (land development or redevelopment)
South Fork Gunpowder Ck. RM 4.1 – 6.8	Primary Contact Recreation (Not Supporting)	Fecal coliform	Source unknown

A6: Project/Task Description

The goal of the Gunpowder Creek Watershed Initiative (GCWI) is to improve and/or maintain water quality in the Gunpowder Creek watershed through development of a KDOW-approved WBP. Once the plan is complete and a clearer understanding of the issues facing the watershed is known, appropriate management strategies to mitigate nonpoint source pollution can be identified and selected based on available future funding. Implementation of best management practices (BMPs) will be dictated by the WBP with the goal of making measurable improvements toward water quality standards, such as meeting the designated uses in the watershed of primary contact recreation and warm water aquatic habitat.

Project activities will revolve around meeting EPA's nine criteria (*a – i*) of a WBP (EPA, 2008). Overall project milestones are provided for reference (Table 5); however, the remainder of this document focuses on *criterion a*: *identification of causes of impairments and pollutant sources*.

Table 5: Grant Milestones for the Gunpowder Watershed Initiative

	Milestones	Expected Begin Date		Expected Completion Date	
		Original	Revised	Original	Revised
1	Form Initial Watershed Steering Committee			11/08	
2	Collect water quality related studies from partners	11/08		5/10	
3	Review and assess existing water quality data; identify gaps & develop plan to fill data gaps	11/09		7/10	
4	Submit and obtain QAPP approval from KDOW	5/10		11/10	4/11
5	Develop and submit to NPS staff outreach /educational program materials for approval	3/10		11/13	
6	Submit schedule of outreach/education programs to KDOW	3/10		12/13	
7	Submit advance written notice to KDOW NPS program staff for community meetings and outreach/education events	7/10		12/13	
8	Hold annual community meetings	7/10		12/13	
9	Identify and select needed technical assistance for WBP development	11/10		12/11	
10	Collect water quality data and physical data to fill data gaps	2/10	4/11	12/11	12/12
11	Select tools/models for data analysis	11/09		12/11	12/12
12	Analyze data using approved tools/models	6/10	10/11	5/12	3/13
13	Calculate current pollutant loads	6/10	1/13	10/12	3/13
14	Submit watershed data analysis report including source information, and load calculations to KDOW for review and approval	10/12	1/13	2/13	4/13
15	Estimate load reductions needed and identify, estimate costs of and prioritize needed management measures	2/13		5/13	
16	Identify criteria to determine if load reductions are being achieved and develop a monitoring strategy to evaluate the effectiveness of recommended BMPs, and submit to KDOW for review and approval	2/13		5/13	
17	Develop management measures implementation schedule	7/13		8/13	

Milestones		Expected Begin Date		Expected Completion Date	
		Original	Revised	Original	Revised
18	Submit WBP to NPS Staff for review and approval; incorporate changes suggested	9/13		11/13	
19	Submit WBP to KDOW for final approval	11/13		12/13	
20	Submit 1st Annual Report	10/10		12/10	
21	Submit 2nd Annual Report	10/11		12/11	
22	Submit 3rd Annual Report	10/12		12/12	
23	Submit 4th Annual Report	10/13		12/13	

As seen in Table 5 (Milestones 2 and 3) one of our first tasks was to acquire water quality data that already exists in the Gunpowder Watershed, and subsequently determine what additional data are needed. SD1 has an abundance of data at numerous locations throughout the watershed—all of which have been collected using standard procedures and quality assurance measures that are consistent with those outlined in this QAPP. Five SD1sites that are frequently sampled and spatially distributed in locations that are most consistent with the Phase 1 monitoring guidelines highlighted in KDOW's (2010) Guidebook are indicated by the blue circles in Figure 3. Given that hydromodification due to urban development is a major concern in the watershed, SD1 has also undertaken over three years of fluvial geomorphic monitoring at seven sites in the watershed. LRWW has performed historical monitoring at several sites throughout the watershed and, through a grant from SD1, is planning on conducting water chemistry and biological sampling at six key sites, which is intended to fill the remaining gaps at the HUC14 (Phase 1) level. The monitoring locations are summarized in Figure 3 and Table 6, with a breakdown of the Phase 1 monitoring provided in Table 7.

Table 6: Phase 1 Sampling Locations and Site Names

Site Name (Stream & River Mile)	**Stream Name**	**Site Location** (Decimal Degrees) **Latitude**	**Longitude**
GPC 4.6	Gunpowder Creek	38.933752	-84.789426
GPC 7.5	Gunpowder Creek	38.954653	-84.745833
GPC 14.7	Gunpowder Creek	38.994638	-84.716271
GPC 17.9	Gunpowder Creek	39.015753	-84.687930
GPC 17.1 - UNT 0.1	Unnamed Tributary to Gunpowder Creek	39.005020	-84.689940
SFG 2.6	South Fork of Gunpowder Creek	38.981674	-84.684500
SFG 5.3 - DS	South Fork of Gunpowder Creek	38.961638	-84.657351
SFG 5.3 - US	South Fork of Gunpowder Creek	38.960377	-84.656824
SFG 5.3 - UNT 0.3	Unnamed Tributary to South Fork of Gunpowder Creek	38.961213	-84.656198
FWF 0.8	Fowlers Fork	38.972779	-84.686212
LDB 0.5	Long Branch	38.972507	-84.703982
RDR 1.1	Riddles Run	38.934208	-84.778223

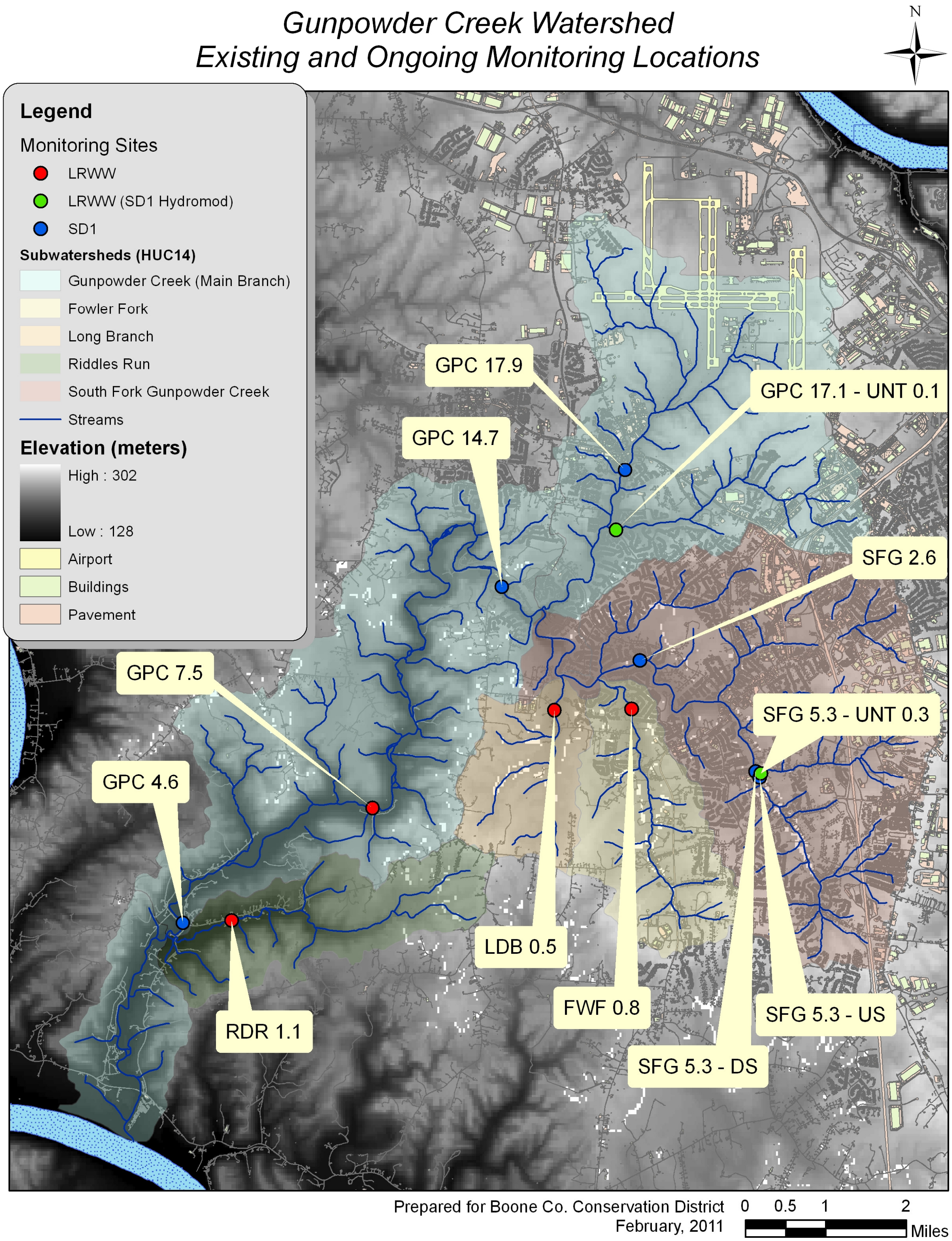


Figure 3: Existing and Ongoing Monitoring Locations in the Gunpowder Creek Watershed

Table 7: Summary of Existing and Proposed Monitoring for Phase 1 Sampling

Phase I Sites[a]	Water Chemistry		Biological		Geomorphic	
	Existing	Proposed[b]	Existing	Proposed[c]	Existing	Proposed[d]
GPC 4.6	SD1	SD1	SD1		SD1	
GPC 7.5	LRWW	LRWW		LRWW		BCCD
GPC 14.7	SD1	SD1	SD1		SD1	
GPC 17.9	SD1	SD1	SD1		SD1	
GPC 17.1 - UNT 0.1		LRWW		LRWW	SD1	
SFG 2.6	SD1	SD1	SD1		SD1	
SFG 5.3 - DS	SD1	SD1			SD1	
SFG 5.3 - US			SD1		SD1	
SFG 5.3 - UNT 0.3		LRWW		LRWW	SD1	
FWF 0.8	LRWW	LRWW		LRWW		BCCD
LDB 0.5	LRWW	LRWW		LRWW		BCCD
RDR 1.1	LRWW	LRWW		LRWW		BCCD

[a]Phase I monitoring locations are distributed in accordance with the KDOW (2010) Guidebook for WBPs, capturing the downstream reach of all HUC 14 watersheds. After completion of the Phase I monitoring and analysis, Phase II sites will be selected to target upstream reaches in priority subwatersheds

[b]Proposed water chemistry sampling includes ongoing dry and wet-weather sampling during the recreational contact season by SD1 with frequencies and parameters designed to inform SD1's ongoing watershed based planning process. LRWW sampling will be performed by students under the supervision of Dr. Chris Lorentz of Thomas More College, with field management by Mark Jacobs of BCCD. They will follow procedures outlined in this QAPP and their sampling frequencies and parameters will be guided by their grant budget.

[c]Proposed biological sampling will be conducted by LRWW for fish and macroinvertebrates, performed by students under the supervision of Dr. Chris Lorentz of Thomas More College, with field management by Mark Jacobs (BCCD) and field assistance from Matt Wooten of SD1. They will follow procedures outlined in this QAPP and their sampling frequencies and parameters will be guided by their grant budget.

[d]Proposed geomorphic monitoring is designed to monitor channel instabilities (e.g. bank and bed erosion) in response to watershed urbanization (i.e. 'hydromodification'). It will be performed by Mark Jacobs (BCCD) and Dr. Bob Hawley (Sustainable Streams) according to the frequency and procedures outlined in this QAPP (which are identical to SD1's geomorphic data collection SOP for regional comparability). In summary, it includes geometric surveys of channel cross sections and profiles as well as bed material pebble counts collected at each proposed location in this year and then repeated at each site during the following year to capture changes in the channel form and bed material. Among other things, the monitoring will be used to develop loads of fine sediment from channel banks as well as directly inform BMP recommendations in the WBP

.It is important to note that although this grant was awarded prior to the release of the KDOW (2010c) Guidelines, the GCWI will make every effort to meet the KDOW sampling goals to the extent possible within confines of the GCWI scope and budget. All agencies and partners recognize the same broad goal of improved water quality of the Gunpowder Creek Watershed.

With additional sampling planned by both SD1 and LRWW, the GCWI plans to continue to collaborate with their regional partners to realize the best usage of monitoring funds for this grant project. After completion of the 2011 sampling season by SD1 and LRWW, we will perform a thorough analysis of the Phase 1 data to identify priority subwatersheds to target in the Phase 2 sampling year (expected to take place 1/2012 – 12/2012). We understand that this depends on coordination with TMDL Staff at KDOW and their subsequent approval of the Phase 2 locations. Therefore, we will plan to meet with KDOW in November/December 2011 to share Phase 1 results from our project partners and arrive at agreed upon Phase 2 sampling locations.

In general, we anticipate sampling in four categories: water quality (chemical), hydrologic (flow), biologic, and geomorphic sampling (Table 8), all of which will be collected in accordance with the QA procedures presented herein.

Table 8: Proposed GCWI Sampling Categories

Category	Sub-Category	Parameter	Reference
Water quality (Chemical)	Bacteria	E. coli (Escherichia coli)	SM9223 B
	Nutrients	NO_3/NO_2 (Nitrate-Nitrite)	EPA 353.2
		NH_3-N (Ammonia-Nitrogen)	SM4500NH3 D
		TKN (Total Kjeldahl Nitrogen)	EPA 351.2
		TP (Total Phosphorus)	EPA 365.1
		OP (Orthophosphate)	EPA 365.3
		CBOD5 (5-day Carbonaceous Biochemical Oxygen Demand)	HACH 10230
	Sediment	TSS (Total Suspended Sediment)	SM2540 D
	Field Data	Turbidity (actual or estimated)	
		pH (Hydronium Ions/Acidity)	
		DO (Dissolved Oxygen)	
		Conductivity (Ionic Content/ TSS)	
		% Saturation (Percentage of DO)	
		Temperature	
Hydrologic	Flow	Volumetric Stream Discharge Rate	(KDOW, 2010b)
Biological	Macroinvertebrates	Taxonomic Identification (lab)	(KDOW, 2009)
	Fish	Taxonomic Identification (field)	(SD1, 2007)
	Habitat	Rapid Bioassessment Protocol	(Barbour et al., 1999)
Geomorphic	Geometric	cross-section and profile surveys	(Harrelson et al., 1994)
	Bed material	pebble counts	(Bunte and Abt, 2001a; 2001b)

A7: Quality Objectives and Criteria

The primary goal of the QAPP is to ensure that the data generated for this project using 319(h) grant funds meet the standards required by KDOW and be usable for this project. Field and lab personnel will follow standard operating procedures (SOP) for sampling and laboratory analyses. Quality objectives and criteria (Table 9) will include a range of Data Quality Indicators (DQIs) for the various sample types.

Table 9: Data Quality Indicators by Sample Type

Sample Type	Precision	Bias	Accuracy	Representativeness	Comparability	Completeness	Sensitivity
Water quality (Chemical)	✓	✓	✓	✓	✓	✓	✓
Hydrologic	✓				✓		✓
Biological	✓			✓	✓	✓	
Geomorphic	✓	✓		✓	✓	✓	

A7.1 – Precision:

Precision is the measure of agreement among repeated measurements (or split samples) under the same/similar conditions (EPA, 2002a). It can be expressed as an absolute measure or the Relative Percent Difference (RPD) between the measurements or replicate/duplicate samples. Precision objectives (Table 10) are summarized below.

Table 10: Precision Objectives by Sample Sub-Category

Category	Sub-Category	Parameter	Field Precision (RPD) Objective	Field Precision (RPD) Method	Analytical Precision (RPD) Objective	Analytical Precision (RPD) Method
Water quality (Chemical)	Bacteria	E. coli	50%	Field Duplicate	40%	Lab Replicate
	Nutrients	NO_3/NO_2	30%	Field Duplicate	20%	Lab Replicate
		NH_3-N	30%	Field Duplicate	20%	Lab Replicate
		TKN	30%	Field Duplicate	20%	Lab Replicate
		TP	30%	Field Duplicate	20%	Lab Replicate
		OP	30%	Field Duplicate	20%	Lab Replicate
		CBOD5	40%	Field Duplicate	20%	Lab Replicate
	Sediment	TSS	30%	Field Duplicate	20%	Lab Replicate
	Field Data	Turbidity pH DO Conductivity % Saturation Temperature	10%	Repeat Reading	N/A	
Hydrologic	Flow	Discharge	10%	Repeat Reading	N/A	
Biological	Macros	Taxa. ID (lab)	N/A		95%	Repeat ID
	Fish	Taxa. ID (field)	95%	Repeat ID	N/A	
Geomorphic	Geometric	cross-section survey	0.5 ft (vert.) 2.0 ft (horz.)	Absolute Diff. Rebar to Rebar[a]	N/A	
	Bed material	pebble count	± ½ phi size	Repeat Measurement	N/A	

[a]Absolute difference at rebar monuments during annually repeated level-tape survey

Water Quality (Chemical)

Precision of water chemistry samples will be estimated via a combination of laboratory replicates and repeated field measurements. Precision of split samples (lab replicates) and field duplicates will be estimated by RPD using the following equation:

$$RPD = \frac{(C_a - C_b)}{\frac{(C_a + C_b)}{2}} \times 100\%$$

Where: C_a = Measured concentration of sample

C_b = Measured concentration of replicate sample

Precision of field data measurements (pH, temp, etc.) will be checked via repeated measurements by independent samplers and estimated using RPD. Water chemistry precision procedures (lab replicates, field duplicates, and repeat field readings) will be performed a minimum of once per event for each parameter. Specifically regarding field duplicates, they will be collected once per event for each parameter at a minimum of 10% of the sampling locations (i.e. one (1) out of every ten (10) locations). For grab samples, field duplicates are defined as two samples of equal volume that are collected simultaneously from the same location at the same time. For bucket and/or churn splitter samples, field duplicates are equal volumes filled from the same bucket/churn splitter sample.

For E. coli samples, KDOW requires field blanks to evaluate contamination levels from ambient conditions, sample containers, or sample storage containers. For grab samples, this means filling an E. coli sample bottle with deionized water and keeping the lid open an equal length of time as the actual sample is exposed to the atmosphere. If using buckets and/or churn splitters, rinsate blanks are required to determine potential contamination from the buckets/churns. A rinsate blank is an E. coli sample bottle that is filled with deionized water that was first passed through the bucket and/or churn splitter. Field blanks (and rinsate blanks if using buckets/churns) will be collected once per event for E. coli samples at 10% of the sampling locations.

Hydrologic

Precision of flow measurements will be estimated by repeat field measurements by a second observer at least once per sampling event.

Biological

Taxonomic precision will be estimated using repeated taxonomic identification by an independent taxonomist. The precision objective is for 95% agreement among all repeated identifications. If taxonomic precision falls below 95% agreement, all samples in the sample group will be re-identified. A third taxonomist will reconcile identification differences.

Geomorphic

Geometric survey precision will be estimated at each cross section (i.e. site) by comparing horizontal and vertical differences observed at the rebar monuments between sample years (i.e. annually repeated surveys). Absolute errors will be kept to ±0.5 ft and ±2.0 ft in the vertical and lateral dimensions, respectively. Standardized errors (by dividing by the length of the cross section) shall be kept ≤ 0.01 ft/ft (vertical) and ≤ 0.025 ft/ft (horizontal). If errors are observed greater than this range, an independent survey between rebar monuments will be performed to estimate which survey year was most accurate.

Bed material precision will be tested through repeated measurements of individual pebbles by a second observer. The objective is for size estimates not to vary by more than ½ phi size on the US SAH-97 (or equivalent) aluminum half-phi template. If a repeated sample varies by greater than ½ phi size, the entire pebble count will be repeated.

A7.2 – Bias:

Bias is the systematic deviation of measured values in one direction (EPA, 2002a). Bias can be tested by comparing replicate data and/or repeated measurements. If regular deviation occurs between replicate/repeat data, skewness will be estimated to determine if the bias is statistically significant. Statistically significant biased data will either be corrected or discarded.

A7.3 – Accuracy:

Accuracy describes how close a measurement is to a known value (EPA, 2002a). Quality objectives for biological and geomorphic metrics are more appropriately classified as precision objectives; however, accuracy in water chemistry laboratory analysis can be estimated using matrix spikes. A matrix spike is when a reference sample of known concentration is added to a field sample and reanalyzed. Accuracy is assessed by estimating the Percent Recovery using the equation below:

$$\%R = \frac{(C_S - C_U)}{C_A} \times 100\%$$

Where: C_S = Measured concentration of spiked sample

C_U = Measured concentration of unspiked sample

C_A = Actual concentration of added spike

For water chemistry samples, the accuracy objective for matrix spikes is a percent recovery of 80 – 120%.

Control samples and laboratory blanks are other methods of assessing accuracy. Laboratory blanks are particularly employed for bacteria (E. coli) analyses and assessed via a presence/absence criteria. Control samples for non-bacteria parameters are assessed via Percent Recovery using the following equation:

$$\%R = \frac{C_M}{C_C} \times 100\%$$

Where: C_M = Measured concentration of control sample

C_C = Actual concentration of control sample

For E. coli samples, the accuracy objective for laboratory control samples is to correctly classify the presence/absence of E. coli in the control sample. Regarding Percent Recovery of non-bacteria control samples that will be used for other water chemistry suites, the accuracy objective is 80 – 120% recovery. The accuracy objectives are summarized below (Table 11).

Table 11: Accuracy Objectives for Water Quality (Chemistry) Laboratory Analyses

Sub-Category	Parameter	Objective	Method
Bacteria	E. coli	Presence/Absence	Laboratory Control Sample
Nutrients	NO_3/NO_2	80-120% Recovery	Laboratory Control Sample/ Matrix Spike
	NH_3-N	80-120% Recovery	Laboratory Control Sample/ Matrix Spike
	TKN	80-120% Recovery	Laboratory Control Sample/ Matrix Spike
	TP	80-120% Recovery	Laboratory Control Sample/ Matrix Spike
	OP	80-120% Recovery	Laboratory Control Sample/ Matrix Spike
	CBOD5	80-120% Recovery	Laboratory Control Sample
Sediment	TSS	80-120% Recovery	Laboratory Control Sample

A7.4 – Representativeness:

Representativeness is the degree to which data accurately and precisely represent a characteristic of a population, variability at a sampling location, and conditions of the environment/process being measured (EPA, 2002a). Sample sites are representative if they encompass a range of conditions that is characteristic of the region being studied. In the case of the Gunpowder Watershed, the key gradient to capturing nonpoint source pollution is representing the range of landuse conditions that result in nonpoint source runoff (e.g. agricultural, urban, suburban) versus more of a reference watershed such as forest or prairie. By locating sample sites near the mouths of all major tributaries (Figure 3), we capture the full range of sub-watershed landuse conditions from undeveloped to fully developed (Figure 2).

Additionally, water chemistry sampling is representative if it is collected across a gradient of runoff conditions. We achieve this by targeting a mix of dry and wet-weather sampling events.

A7.5 – Comparability:

Comparability is the degree to which data collected in this study can be compared with other data across the region (EPA, 2002a). This is ensured by following standard sampling procedures, handling methods, etc. Standard procedures for water chemistry, biological, and hydrologic sampling are well established (Table 8). As geomorphic sampling has been less common in water quality projects, the employed procedures have been more variable.

Particularly in regards to the nonpoint source issue of hydromodification, geomorphic monitoring is designed to capture the physical responses of streams to the altered (developed) flow regime relative to the natural variability observed in undeveloped basins. For example, what types of bed degradation and bank erosion rates are evident in urban basins versus forested basins? Methods used to characterize such change have included quantifiable measurements using bank pins (Rosgen, 2001) and repeated cross-section surveys (Dunne and Leopold, 1978; Henshaw and Booth, 2000) and more qualitative assessments via 'expert' judgment (e.g. Johnson et al., 1999; Pfankuch, 1978; Rosgen, 2007; Simon and Downs, 1995).

Recognizing that quantifiable methods tend to transfer better across different users and agencies, a recent literature review determined that spatially-integrated cross sections and profiles with accompanying pebble counts provided optimum value and precision for capturing the multidimensional effects of hydromodification (Bledsoe et al., 2008; Hawley, 2009). In this light, the Standard Operating Procedure (SOP) of SD1 (2009) entails 100-particle pebble counts after Bunte and Abt (2001a; 2001b) and cross-section and profile surveys after Harrelson *et al.* (1994). For comparability with prior and ongoing SD1 data, we will collect geomorphic data using comparable methods.

A7.6 – Completeness:

Completeness is the amount of usable data acquired compared to the amount of data that was expected from a monitoring plan (EPA, 2002a). Events which may contribute to data being unusable include access/safety issues, sampling container problems, equipment failures, holding time exceedances, sample sorting/damage, noncompliant QA/QC, etc. This project does not have statistical criteria that require a specific degree of completeness; however, our completeness objective is to have 90% of all collected data to be usable.

A7.7 – Sensitivity:

Sensitivity refers to the capacity of a method or instrument to discern different levels of the variable of interest (EPA, 2002a). This is typically referred to as a method/instrument detection limit or a laboratory quantification limit. That is, at what concentration is a pollutant so trace that it becomes undetectable by an instrument and/or differences between sample concentrations indiscernible. Pollutant levels of concern for this project are well above detection limits of industry standard equipment and methods. Depending on what equipment is available to GCWI, detection limits of industry standard equipment is provided below (Table 12).

Table 12: Specification Limits of Industry Standard Equipment and Detection Limits

(a) Field

Parameter	Instrument	Range	Accuracy	Resolution
Temperature	Hydrolab	-5 to 50°C	±0.10°C	0.01°C
	YSI	-5 to 45°C	±0.15°C	0.01°C
pH	Hydrolab	0 to 14 units	±0.2 units	0.01 units
	YSI	0 to 14 units	±0.2 units	0.01 units
Dissolved Oxygen	Hydrolab	0 to 20 mg/L	±0.2 mg/L	0.01 mg/L
	YSI	0 to 20 mg/L	±0.2 mg/L	0.01 mg/L
Conductivity	Hydrolab	0 to 1,000 µS/cm	±0.5% of range	4 digits
	YSI	0 to 1,000 µS/cm	±1% of range	4 digits
Flow	Marsh-McBirney	-0.5 to +20 ft/sec	±2% of reading	±0.05 ft/sec

(b) Laboratory

Sub-Category	Parameter	Reference Method	Reporting Limit	Standard Analytical Procedure (SAP)
Bacteria	E. coli[a]	SM9223 B	4-10 MPN/100 mL	Micro 013
Nutrients	NO_3/NO_2	EPA 353.2	0.013 mg/L	Inorg 045
	NH_3-N	SM4500NH3 D	0.03 mg/L	Inorg 018
	TKN	EPA 351.2	0.144 mg/L	Inorg 040
	TP	EPA 365.1	0.01 mg/L	Inorg 041
	OP[b]	EPA 365.3	0.007 mg/L	Inorg 013
	CBOD5[c]	HACH 10230	2 mg/L	Inorg 014
Sediment	TSS	SM2540 D	1 mg/L	Inorg 007

[a]E. coli depends on dilution range (ND on 25 mL max = <4 MPN/100 mL; ND on 10 mL max = < 10 MPN/100 mL)

[b]Orthophosphate should be field filtered with 0.45 µm membrane filter

[c]5-day Biochemical Oxygen Demand values below current MDL (4.6 mg/L) will be reported as an estimate with J Qualifier

A8: Special Training/Certifications

The GCWI includes steering committee members and project partners that cover a broad range of expertise across all sampling categories with both professional and academic training. This includes:

- Water quality (chemical): Mary Kathryn Dickerson, Mark Jacobs, and Tom Comte (BCCD); Dr. Yvonne Meichtry (LRWW); Lajuanda Haight-Maybriar (KDOW); Mindy Scott and Matt Wooten (SD1); Chris Lorentz (Thomas More); and Bob Hawley (Sustainable Streams)
- Hydrologic: Mindy Scott, Matt Wooten; Scott Fennell (NKU), and Bob Hawley
- Biological: Mary Kathryn Dickerson, Dr. Yvonne Meichtry, Matt Wooten; Scott Fennell, and Chris Lorentz
- Geomorphic: Matt Wooten; Scott Fennell, and Bob Hawley

Sampling technicians and managers will be trained in their respective water quality, hydrologic, biological, and geomorphic sampling procedures described herein (Section B2). Experienced sampling personnel will direct the training and training records will be stored by BCCD and/or their contracted consultants and/or partner agencies where applicable. Laboratories conducting analytical work should have appropriate certifications including:

- Water quality (chemical) laboratory: <u>recommended to have at least one of the following</u>
  - **KY Micro**: Commonwealth of Kentucky Energy and Environment Cabinet Drinking Water Laboratory Certification Program
  - **NELAC**: National Environmental Laboratory Accreditation Conference (Non-profit institute that manages the National Environmental Laboratory Accreditation Program, NELAP)
  - **A2LA**: American Association for Laboratory Accreditation
- Taxonomic Identification (biological) laboratory:
  - **NABS**: North American Benthological Society Taxonomic Certification

A9: Documentation and Records

Data management is discussed in detail in Section B10. Documents and records are described in the subsections below.

A9.1 – Field Documentation and Records

Field data will be collected on paper forms, sample labels, and/or field books. Chain of Custody (COC) sheets will accompany samples to receiving laboratories and returned to BCCD following analysis. Information on sample labels will be entered into electronic databases by the receiving laboratories. Data from field books and forms will be entered into electronic databases at the office. Original paper copies of COC sheets, field forms and field books will be kept by BCCD for no less than five years. At a minimum, field sampling technicians will record the following for each sample:

- Site name/location
- Initials of field technicians
- Date and time of sample

Field books for geomorphic data collection will be used for site sketches, level-tape surveys, and bed material pebble counts (Figure 11).

A9.2 – Laboratory Documentation and Records

Samples requiring laboratory analysis will be delivered to receiving laboratories accompanied by COC sheets. Laboratories will retain COC sheets during their analyses and return them to BCCD upon analytical completion for storage. Information on sample labels will be entered into electronic databases by the receiving laboratories. Analytical results will be summarized via an electronic database and reported to BCCD. The analytical database will include a minimum of the following:

- Sample collection date and time
- Date and time sample was received
- Date and time of sample analysis
- Sample name and location
- Analysis name and method
- Analysis result
- Analysis reporting limit
- Analyst initials performing analysis
- Laboratory QA/QC results/summary

Turnaround times for water chemistry and macroinvertebrate laboratory analysis are expected to be approximately 3 weeks and 30 days, respectively.

A9.3 – QA Reports

Should revisions to this QAPP be determined necessary, the QA Officer and Project Manager will work with the KDOW Project Manager and QA Officer to revise the QAPP. After revisions are approved by KDOW, the Project Manager (Mark Jacobs) will distribute revised copies according to the distribution list (Table 1) and ensure that all project personnel are made aware of the necessary changes (Figure 1). Upon receiving revised QAPP documents, recipients will be instructed to discard older versions (both electronic and hard copies).

A9.4 – Final Reports

Sampling results will be stored in electronic databases (i.e. M.S. Excel) and stored throughout the project at a minimum of two locations. One of the locations will be BCCD and the other location will be a project stakeholder (e.g. SD1). Final results will be summarized in the project's technical report (i.e. Data Analysis Report). Selected results and summaries will also be included in the project's final report (i.e. Watershed Based Plan). The final QA'd version of the database will be stored at a minimum of two locations for a period of no less than ten years. The final project database will also be available to the public and partner agencies upon request (e.g. SD1). It will also be submitted to KDOW in an Excel format that is agreeable to both BCCD and KDOW. All original electronic sampling results will be retained by BCCD and at least one project stakeholder (e.g. SD1) for no less than ten (10) years.

A9.5 – Reports and Deliverables to KDOW

We call out a separate sub-section of specific deliverables for KDOW. They include:

- Quality Assurance Evaluation Report (QER): due at the end of the first data collection for each sampling type (e.g. water chemistry, biological, etc.), or whenever requested by KDOW. KDOW will provide template/example for this report.
- Raw data (in the form of field sheets and calibration records): requested randomly by KDOW and/or at the end of data collection
- Progress reports: due at time of invoicing or an otherwise agreed upon schedule
- Final data in Excel format: specific spreadsheet format to be agreeable to both BCCD and KDOW

GROUP B ELEMENTS: DATA GENERATION AND ACQUISITION

B1: SAMPLING PROCESS DESIGN (EXPERIMENTAL DESIGN)

The first step in developing a Watershed Based Plan that will protect and enhance the water quality of the Gunpowder Creek Watershed is to gather an understanding of the baseline condition of the watershed. Based on data from previous efforts and the current plans of SD1 and LRWW, some additional data collection is expected under the umbrella of this project. GCWI will solicit technical assistance from experienced experts where needed, for example, the Center for Applied Ecology at Northern Kentucky University. If it is determined that additional data are needed, the sampling design will be informed by KDOW (2010c) guidelines and collaboration with project partners to best optimize the sampling that could be collected under this project.

Existing monitoring locations (Figure 3) have been placed near the mouth of all HUC14 watersheds, which is consistent with the placement of "Phase 1" monitoring locations specified in the KDOW (2010c) WBP Guidebook. The GCWI intends to make every effort to meet the KDOW sampling goals to the extent possible within confines of the GCWI scope and budget, despite being planned and awarded prior to the Guidebook release. Following the 2010/2011 sample collection by SD1 and LRWW, GCWI will perform a Phase 1 assessment to identify prioritized sub-watersheds for "Phase 2" monitoring. We intend to meet with KDOW at this time to develop a "Phase 2" Monitoring Plan, which will be approved prior to the collection of "Phase 2" data with this 319(h) grant funding.

Regarding a "Phase 1" Monitoring Plan, a technical subcommittee of the GCWI has convened and identified hydromodification monitoring as a priority for this year's sampling season. SD1 currently collects hydromodification data at seven (7) locations in the Gunpowder Creek watershed (GPC 14.7, GPC 17.9, GPC17.1-UNT0.1, SFG2.6, SFG5.3-DS, SFG5.3-US, SFG5.3-UNT0.3)[1]. The technical subcommittee has arrived at a consensus to pursue hydromodification monitoring at the four (4) LRWW sites (Figure 3) that do not have hydromodification data collected by SD1. This includes: FWF 0.8, GPC 7.5, LDB 0.5, and RDR 1.1. We discussed this and the rest of our Phase 1 sampling plans (Table 7) with KDOW at February 25, 2011 meeting, in which we received positive feedback (pending the approval of this QAPP).

Regardless of what specific sampling is planned/approved for Gunpowder Creek, any additional data that are collected by the GCWI under this 319(h) grant project will use the sampling methods listed below.

[1] SD1 collects hydromodification data at all of their wadeable sites listed above. GPC4.6 is in the backwater of the Ohio River and not a wadeable site, therefore, hydromodification data is not collected at GPC 4.6.

B2: Sampling Methods

B2.1 – Water Quality (Chemical) Sampling

Water quality data may be generated via grab samples from stream banks or bridges, or with auto-samplers. The following methods for water chemistry sampling are primarily informed by and adapted from the KDOW-approved BWC (2005) QAPP for neighboring Banklick Creek Watershed. Table 13 indicates preservation methods and sample holding times for possible sample suites that may be analyzed for this project.

Table 13: Preservation and Holding Time of Potential Water Quality Parameters

Sub-Category	Parameter	Reference Method	Preservation	Holding Time
Bacteria	E. coli[(a)]	SM9223 B	$Na_2S_2O_3$	12 hours[(a)]
Nutrients	NO_3/NO_2	EPA 353.2	H_2SO_4	28 days
	NH_3-N	SM4500NH3 D	H_2SO_4	28 days
	TKN	EPA 351.2	H_2SO_4	28 days
	TP	EPA 365.1	H_2SO_4	28 days
	OP[(b)]	EPA 365.3	Unpreserved	48 hours
	CBOD5	HACH 10230	Unpreserved	48 hours
Sediment	TSS	SM2540 D	Unpreserved	7 days

[(a)]we will make every effort to meet a 6-hour holding time for E.coli samples; however, a 12-hour goal for this project will be needed for watershed size, the number and specifications of field parameters, etc.

[(b)]Orthophosphate should be field filtered with 0.45 µm membrane filter

Sampling from Stream Banks or Bridges/Overpasses

Samples will be collected from stream banks or bridges to minimize safety concerns. The procedures described below assume that a two-person sampling team with some basic knowledge of the accepted procedures used to collect environmental samples will take the samples. The two-person team will have decided before beginning work who will be the “Clean hands” and who will be the “Dirty hands”. The designation will determine the division of labor between them. In general, “Clean Hands” will be in charge of any activities that might involve direct contact with the sample, while “Dirty Hands” will handle equipment, take notes, and any other activities that do not involve direct contact with the sample. The specific duties of each individual are described below.

1. Before arriving on site both team members should have thoroughly washed and dried their hands and forearms. Soap and water should be kept on hand at all times in case a team member's hands become excessively dirty.

2. Immediately upon arriving on site both team members should set-up any necessary safety equipment such as lights or cones. In cases where the bank slope is steep or slippery, or whenever there is a risk of a team member falling, especially if falling could results in being swept away in a fast moving stream, it may be necessary to 'tie-off' to a static object. It is highly recommended that a self-retracting lifeline, with a built in winch, be used to decrease the risk of falling and, if necessary, pull a team member out of the stream and/or up the bank without exposing other team members to the same hazards. It may be necessary to have a third team member available to act as a safety supervisor and lifeline operator.

3. Once all of the necessary equipment is set-up and it is safe to begin work, "Clean Hands" should put on a fresh pair of non-talc latex gloves and begin triple rinsing the pre-cleaned sampling bucket. If metals are among the analtyes to be tested, then the bucket should be made from a non-reactive plastic such as Nalgene; otherwise the bucket should be made from stainless steel.

4. While "Clean Hands" rinses the sampling bucket, "Dirty Hands" should be filling out the necessary field paper work, including preparing the label for the sample bottle(s), and begin taking any environmental readings (temperature, DO, pH, etc.)

5. After the bucket has been properly rinsed and the paperwork completed, "Dirty Hands" should put on a pair of non-talc latex gloves to assist "Clean Hands" in the sample collection.

6. "Dirty Hands" should throw the bucket into the water body, while only holding onto the rope and being careful to not touch the bank, tree branches, or anything else. Once the bucket is filled, "Dirty Hands" may pull in the bucket, being extremely careful not to let the bucket touch the bank, to "Clean Hands" who will empty the bucket back into the water body. This process needs to be repeated twice more to "river rinse" the bucket. This can be a tedious and time-consuming task, so in cases where it is possible to fill and empty the bucket without pulling it back to the bank or having the bucket touch anything, it is recommended to do so.

7. Now that the bucket has been 'river rinsed', the sample can be collected. "Dirty Hands" should follow the same procedure to lower and raise the bucket in Step 6, so that "Clean Hands" can submerge the sample bottle into the bucket to collect the sample while minimizing, to the greatest extent possible, the amount of exposure the sample has to the

open air. Whenever possible, it is preferable that the bucket be submerged and the sample pulled up from beneath the surface.

8. Now that the sample has been collected, "Dirty Hands" should label and store the sample on ice in a clean cooler while "Clean Hands" changes gloves.

9. For analyses that require more than one bottle for sampling to be completed Steps 7 and 8 should be repeated (including the replacement of gloves) until enough volume has been collected.

10. When the sample needs to be composited over time, or if the sample site is not in a good mixing zone and the sample needs to be composited across the stream, it will be necessary to use a churn splitter. In that case, "Clean Hands" will need to have triple washed the churn splitter using deionized water and, if possible, a river rinse from the water body, making sure that all surfaces (including the lid) that may come in contact with the sample are rinsed and purged. The spigot should be purged with each washing.

11. The general process will remain the same when collecting time composited samples except that when "Clean Hands" has control of the sampling bucket, "Clean Hands" will pour the sample into the churn splitter and immediately close the lid. This process will repeat until enough samples have been collected over the specified period of time.

12. In cases where the samples must be composited from aliquots from the left bank, right bank, and middle of the stream, the bucket should be thrown to one section of the stream by "Dirty Hands", pulled across to "Clean Hands", who will pour it directly into the churn splitter and immediately close the lid. This will need to be repeated at the next section until a cross-section of the stream has been collected into the churn splitter.

13. Now that the sample is ready to be collected, "Dirty Hands" should 'churn' the sample using at least ten slow strokes of the churn. It is very important that the churn never breaks the surface of the sample as this can introduce additional oxygen into the sample.

14. "Clean Hands" should purge excess samples before filling the sample bottles. The following guidelines will help reduce the opportunity for contamination to enter the sample:

a. Be sure to position the churn splitter so that it is fairly level and the spigot is not touching anything.

b. Avoid resting the churn splitter under trees, wires, poles etc.

c. Minimize the amount of time the lid of the churn splitter is not secured over the churn splitter.

d. When rinsing the churn splitter, use copious amounts of de-ionized water.

e. Before arriving on site, the churn splitter should have been thoroughly washed and dried. The churn splitter still needs to be triple rinsed once the team has arrived on site. If a bucket will be used to transport sample from the water body, it should also be washed and dried before arriving on site, in addition to being triple rinsed before sampling.

f. If multiple sites are going to be sampled using the same equipment, sample in the order of the site with the lowest expected concentrations to the one with the highest. For example, if samples are going to be taken near a discharge point, the upstream sample should be taken first, then the downstream sample, and finally the sample nearest the discharge point.

g. The churn splitter must be triple rinsed between every sample. It is preferred that it be cleaned as close in time as possible to the collection of the sample.

Collecting Samples Using a Flow Triggered Automatic Sampler

The procedures described below assume that a two-person sampling team with some basic knowledge of the accepted procedures used to collect environmental samples will take the samples. The two-person team will have decided before beginning work who will be the “Clean Hands” and who will be the “Dirty Hands”. The designation will determine the division of labor between them. In general, “Clean Hands” will be in charge of any activities that might involve direct contact with the sample, while “Dirty Hands” will handle equipment, take notes, and any other activities that do not involve direct contact with the sample. The specific duties of each individual are described below. The procedure described in this protocol assumes that the automatic sampler will be left in place at the sampling site and that a sampling team will collect the samples some time after an event is completed.

Please refer to the user manual for information on setting-up and programming specific pieces of equipment.

1. Before arriving on site both team members should have thoroughly washed and dried their hands and forearms. Soap and water should be kept on hand at all times in case a team member’s hands become excessively dirty.

2. Immediately upon arriving on site both team members should set-up any necessary safety equipment such as lights, cones, or traffic barricades.

3. Once all of the necessary equipment is set-up and it is safe to begin work, “Clean Hands” should put on a fresh pair of non-talc latex gloves.

4. “Dirty Hands” should fill out the necessary field paper work, including preparing the label for the sample bottle(s), and begin taking any environmental readings (temperature, DO, pH, etc.) Once that is completed, “Dirty Hands” should put on a fresh pair of non-talc latex gloves to assist in the sample collection.

5. “Dirty Hands” should unlock the sample bottle compartment and open up the automatic sampler so that “Clean Hands” has free and easy access to the sample bottles.

6. “Dirty Hands” should then open the bags containing the automatic sampler bottle caps but should not actually touch the caps. “Clean Hands” should reach into the bags and bring out each cap for the bottles.

7. After all of the sample bottles have been sealed, they can be removed from the automatic sampler, labeled, and stored on ice in a clean cooler.

8. In cases where the sample must be transferred to a “traditional” sample bottle, the sample should be carefully poured from the automatic sampler bottle into the “traditional” sample bottle. At no time should the automatic sampler bottle touch the “traditional” bottle. The use of a funnel is strongly discouraged; however, if it is necessary the funnel should be pre-cleaned thoroughly and stored in at least two airtight bags made of non-reactive plastic.

9. If several bottles are going to be composited for analysis the use of a churn splitter will be necessary. In that case, “Clean Hands” will need to have triple washed the churn splitter using deionized water, paying close attention to be sure that all surfaces, including the lid, that may come in contact with the sample are rinsed and purged the spigot with each washing.

10. The appropriate automatic sampler bottles should be poured into the churn splitter and the lid closed immediately.

11. Now that the sample is ready to be collected, “Dirty Hands” should ‘churn’ the sample using at least ten slow strokes of the churn. It is very important that the churn never breaks the surface of the sample as this can introduce additional oxygen into the sample.

12. “Clean Hands” should purge with excess sample before filling the sample bottles.

The following guidelines will help reduce the opportunity for contamination to enter the sample:

> a. Be sure to position the churn splitter so that it is fairly level and the spigot is not touching anything.
>
> b. Avoid resting the churn splitter under trees, wires, poles etc.

c. Minimize the amount of time the lid of the churn splitter is not secured over the churn splitter.

d. When rinsing the churn splitter, use copious amounts of de-ionized water.

e. Before arriving on site, the churn splitter should have been thoroughly washed and dried. The churn splitter still needs to be triple rinsed once the team has arrived on site. If a bucket will be used to transport sample from the water body, it should also be washed and dried before arriving on site, in addition to being triple rinsed before sampling.

f. If multiple sites are going to be sampled using the same equipment, sample in the order of the site with the lowest expected concentrations to the one with the highest. For example, if samples are going to be taken near a discharge point, the upstream sample should be taken first, then the downstream sample, and finally the sample nearest the discharge point.

g. The churn splitter must be triple rinsed between every sample. It is preferred that it be cleaned as close in time as possible to the collection of the sample.

The following general guidelines should be followed to insure the highest quality results are achieved when using automatic samplers:

a. Automatic samplers should be cleaned and maintained regularly according to their manufacturer's recommendation. Careful attention should be paid to the tubing running to and from the sampler and the pump when being cleaned as they come in direct contact with the sample. In cases where ultra-low detection levels are called for it may be necessary to install pre-cleaned tubing and pump right before sampling is set to begin.

b. The bottles in the automatic sampler should be pre-cleaned before being set-up.

c. The bottle storage compartment should be closed tight enough so that no possible contaminant such as rain, leaves, or other debris could enter the sample bottle.

d. Automatic samplers should be placed to the greatest extent possible in a flat, dry location with the smallest chance of the sampler being submerged.

e. Caps to the automatic sampler bottles can be left in the automatic sampler, or carried with the sampling team. In either case they should be pre-cleaned and stored in at least two airtight bags made from a non-reactive plastic.

f. When opening and closing the sample bottle compartment, be careful not to accidentally knock any dirt or debris that may be attached to the automatic sampler into a sample bottle. Additionally, the top of the automatic sampler should not be placed down so that the bottom rim is in the dirt or mud.

The automatic samplers may be triggered by flow meters that might be used to simultaneously collect stream flow data during sample collection. If collecting flow data with an auto device, data will be downloaded via a laptop computer connection or other device and downloaded using the appropriate software. Flow data should be reviewed in the field to verify that the flow meter is working correctly. Field crews should attempt to correct any malfunctions in the field as soon as possible to return the meter to a calibrated state before leaving the site. If time does not allow for adjustments to be made then the field team should return as soon as possible to address the flow meter.

B2.2 – Hydrologic Sampling

Hydrologic (flow) data will be collected according to the KDOW (2010b) *"Standard Operating Procedure for Measuring Stream Discharge."* As stated in the KDOW (2010c) Guidebook for WBPs, flow data is required for every sample collected. SD1 collects flow data with every dry weather sample[2]. There are also 14 USGS gages across northern KY that record flow at 15-minute intervals. One of those gages is located in Gunpowder Creek (GPC14.7). Continuous gage records can be used to augment flow records at nearby locations using a variety of scaling procedures (e.g. Emmett, 1975; Hawley and Bledsoe, In review; Hey, 1975; Leopold, 1994; Watson et al., 1997). This makes flow measurements by GCWI during high/dangerous flow conditions unnecessary.

The GCWI will collect stream discharge measurements using the following procedures during every water quality (chemical) sampling event where unsafe/hazardous conditions do not exist. The step-by-step procedures below are modeled after the KDOW (2010b) SOP.

Flow Sampling Using a Portable Flow Meter

1. Arrive at site visually inspect the stream current for unsafe conditions. Hazardous flow conditions vary from stream to stream depending on channel slope, confinement, water quality, water depth etc. (e.g. a 2-foot depth in a steep boulder canyon can be very dangerous, whereas a 2-foot depth in a wide flat sand bed channel may not pose as great of a hazard risk). Good judgment should be used to determine if unsafe conditions exist—this includes the sense to abort flow measurements when determined unsafe in the middle of a sample collection.

[2] SD1 does not collect flow data during wet weather sampling events due to the inherent danger of streams during high flow.

2. If unsafe conditions do not exist, string a measuring tape taught across the channel. Rebar/pins may be useful in pulling the tape taught. Determine the width of the active stream flow by measuring from the edge of water on the left bank to the edge of water on the right bank and subtracting any slack water areas.

3. Divide the width of active stream flow by 10 (using a calculator) to determine the width of sample increments[3]. Alternatively, one can select an even/easy increment width (e.g. 2 feet), provided it results in 10 or more total increments across the channel and ends at the edge of water on the right bank.

4. Add the incremental width calculated above to the edge of water on the left bank (see Figure 4). Repeat 9 more times until arriving at the edge of water on the right bank. Record those values on the field sheet—these locations are where flow depth and velocity will be measured.

5. At each incremental location measure the depth of water to the nearest 0.10 feet (or better).

6. Position the velocity probe at 60% of the depth below the water's surface. For example, if the depth is 1.0 feet, the velocity should be measured at 0.6 feet down from the surface (40% or 0.4 feet up from the bottom). Most portable flow meters can be set up to do this somewhat automatically using their setting position.

7. Once the flow probe is in the setting position at 60% of the depth and is facing directly upstream into the flow, observe the velocity over a 10-20 second period. Record a velocity value that best approximates the mean of the observations.

8. Record all width increments, depths, and velocities on the field sheet so that the total volumetric flow can be calculated by a simple spreadsheet program.

[3] If the increment is less than 0.2 ft, divide the total width by a smaller number of increments (e.g. 5) to achieve an increment width that is greater than 0.2 ft.

$$q_4 = v_4 \left[\frac{b_5 - b_3}{2}\right] d_4$$

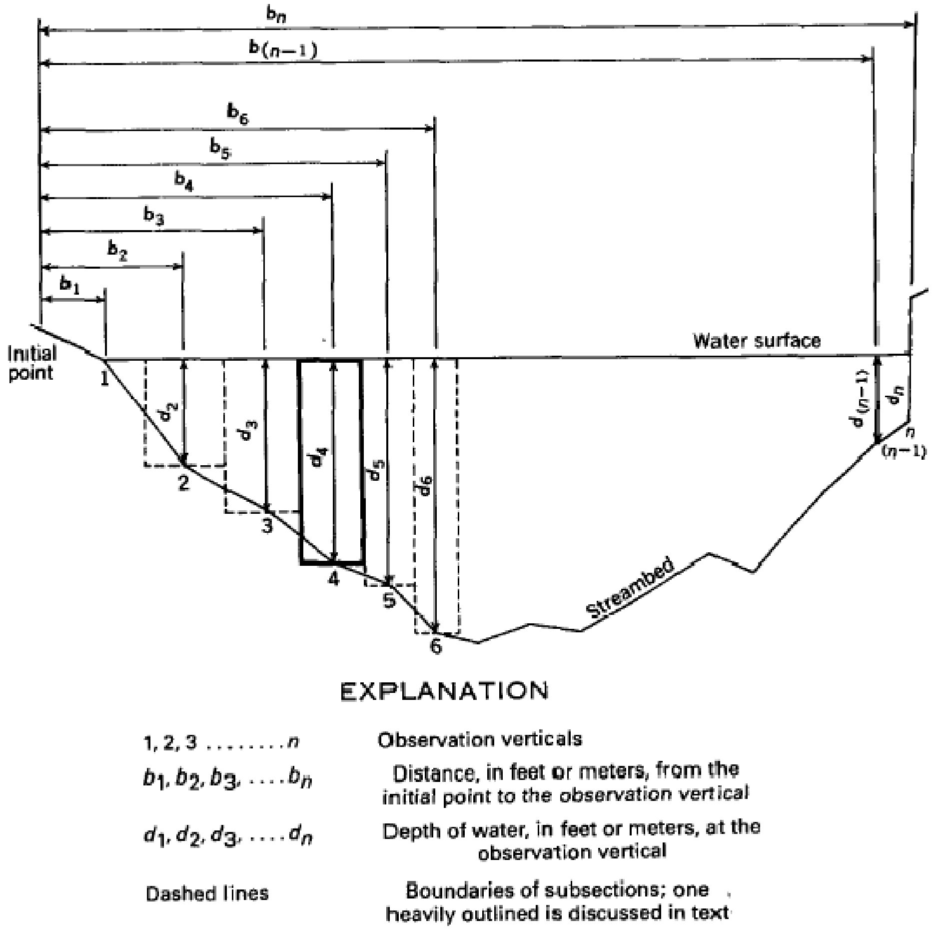


Figure 4: Depth and Velocity Measured at Incremental Locations to Integrate Total Volumetric Flow with Example Calculation after Rantz et al. (1982)

B2.3 – Biological Sampling

Biological sampling will be conducted according to EPA's Rapid Bioassessment Protocols for high gradient streams (Barbour et al. 1999) and *"Methods for Sampling Benthic Macroinvertebrate Communities in Wadeable Waters"* (KDOW 2009). The goal will be to detect ecological differences between sites if such differences exist. The potential types of biological sampling that may be employed on this project include: macroinvertebrates, fish, and habitat (described in detail below). The following methods are primarily informed by and adapted from SD1 (2007) QAPP for Biological and Habitat Surveys to maintain regional consistency/comparability.

Macroinvertebrate Sampling

The macroinvertebrate community will be sampled at all sites using the rapid bioassessment multi-habitat approach (Barbour *et al.* 1999) and modified to reflect KDOW protocol requirements (KDOW 2009). At each site, a riffle sample will be collected, where four (4) 0.25 m^2 samples are taken from mid-riffle or thalweg (path of the deepest thread of water), dislodging benthos by vigorously disturbing 0.25m^2 (20 x 20 in) in front of the 600 micron net. Large rocks should be hand washed into the net. The contents of the net are washed and all four samples are composited into a 600-micron mesh wash bucket and kept separate from all other sub-habitat collections. Additionally, a qualitative multi-habitat sweep sample (using an 800 micron D-frame net) is collected that targets a variety of non-riffle habitats. Each habitat type should be swept three times, whenever possible.

At non-wadeable sites (e.g. backwater of Ohio River), macroinvertebrates will be sampled following the large river approach developed by ORSANCO and refined by SD1 (2007). Typically, a stream reach for this method is 500m in length. Hester-Dendy (HD) multi-plate artificial substrates are deployed at the upstream end of the reach in both shallow (< 1m) water and deep (approximately 3m) water. Additionally, a multi-habitat qualitative sample using a D-frame net is collected in 100m intervals throughout the 500m reach. These six (6) multi-habitat sub-samples are composited to create one sample. The shallow and deep HD samples are preserved independently, for a total of 3 samples per stream reach.

Samples will be sieved in the field using a standard 600-micron sieve to remove small debris and excess sediment. Extremely large debris will be thoroughly washed into the sieve and discarded. Immediately following collection, samples are placed in pre-labeled containers, keeping riffle and multi-habitat samples separate. Additional labels are placed inside all containers to identify the sample in the event the outer label is removed or obliterated. Samples will be immediately preserved in a 70% alcohol solution and shipped to the taxonomic laboratory for processing.

Initially, collected samples will be sieved in the field using a standard 500-micron sieve to remove small debris and excess sediment. Extremely large debris will be thoroughly washed into the sieve and discarded. Immediately following collection, samples will be placed in prelabeled containers. Additional labels will be placed inside all biological samples to identify the sample in the event the outer label is accidentally removed or obliterated. Samples will be immediately preserved in a 70% alcohol solution and shipped to a taxonomic laboratory for processing. All samples collected will be accompanied by chain-of-custody documents.

Biological community sampling and fish shocking will not occur at the same site on the same day in order to avoid sampling disturbed areas.

Fish Sampling

Measurements of the structure and function of the fish community also provide insight to stream health and water quality. At all wadeable sites, fish community structure will be sampled with a backpack type shocking device utilizing the rapid bioassessment multihabitat electrofishing approach (Barbour et al., 1999) and modified to reflect KDOW (2001) protocol requirements at all wadeable sites. The 100-meters of stream identified in the habitat assessment will be the focus of the fish collections. Areas outside of the habitat assessment may be sampled if portions of the habitat assessment area are not accessible with the backpack electrofishing unit. Sampling will occur for one hour over the 100-meter area. A minimum of two riffle areas will be sampled for site segments containing riffles.

At sites that are non-wadeable (e.g. backwater of Ohio River), fish communities will be sampled via night-time boat electrofishing (where applicable) after a protocol developed by ORSANCO and refined by SD1 (2007). Where boat electrofishing is required, a zone will consist of a 500m reach of shoreline, in which a minimum of 1800 shocking seconds will be applied.

Fish will be identified in the field by a trained taxonomist. Fish will be separated in the field by species and counted. The numbers of each species will be recorded and the presence of disease or external anomalies will be noted. Total length will be measured for larger predatory fish species. Following identification and measurement, fish will be immediately released. Any species not identified in the field with certainty will be retained and identified in the laboratory. In the event that a threatened or endangered species is collected, it will be noted and released immediately. A reference fish collection will be created for each stream sampled. The reference collection will be housed at Thomas More College Ohio River Field Station.

Field data from the first sampling event will be evaluated to determine the level of acceptable variability for the number of fish collected. Based on the sampling variability, future collection methods may be altered.

Habitat Sampling

A habitat is defined as "… the quality of the instream and riparian habitat that influences the structure and function of the aquatic community in a stream,"(Barbour et al., 1999). Habitat and biodiversity are closely linked, and a biological community is limited by the quality of the habitat. A habitat assessment evaluates physical and chemical components of the stream along with biotic interactions. Altered habitat can be a major stressor to aquatic systems, and these assessments will help determine if chemical or non-chemical stressors are present. The measurement of physical characteristics and parameters will provide insight to the condition of the biological community.

An initial habitat assessment will be performed at each site by a team of at least two personnel who have been trained in the habitat assessment procedures. Habitat assessments will follow EPA's Rapid Bioassessment Protocols for high gradient streams (Barbour et al., 1999) and *"Methods for Assessing Biological Integrity of Surface Waters"* (KDOW, 2001). Physical Characterization / Water Quality field sheets will be completed for each site. Physical Characterization / Water Quality metrics consist of watershed features (predominant surrounding land use, local watershed non-point source pollution, and erosion), riparian vegetation, in-stream features, large woody debris, aquatic vegetation, water quality, sediment/substrate quality, inorganic substrate components, and organic substrate components (Barbour et al., 1999).

Detailed sketches or photographs of the assessed stream reach for each site will be drawn to scale and include approximate areas of habitat types such as aquatic vegetation (submerged, emergent), inorganic substrate (gravel, cobble, boulder), fallen trees/snags, and undercut banks. This will provide the proportions of each habitat type to be sampled during the benthic macroinvertebrate sampling events.

Habitat Assessment field sheets for high gradient streams will be completed for each station (Barbour et al., 1999). The habitat assessment information will be used to qualitatively characterize the aquatic bottomland communities along the reaches of Northern Kentucky Streams. Habitat parameters include epifaunal substrate/available cover, embeddedness, water velocity and depth regime, sediment deposition, channel flow status, channel alteration, frequency of riffles, bank stability, vegetative protection, and riparian vegetative zone. Habitat observations will include notations of other factors potentially influencing the character and quality of the aquatic communities. A record of the habitat assessment site will be maintained with photographs taken of the 100-meter reach.

Field-measurable parameters of dissolved oxygen (DO), specific conductance (SpCond), water temperature, and pH will be analyzed during each sampling event utilizing a multi-probe water quality meter, or comparable unit.

B2.4 – Geomorphic Sampling

Geomorphic data will be collected using industry standard methods by trained personnel. Geometric data will be informed by Harrelson *et al.* (1994) and pebble counts will be modeled after Bunte and Abt (2001a; 2001b). The procedures are designed to measure the multidimensional effects of hydromodification from the conversion of land from undeveloped to developed and are a result of a recent literature review (Bledsoe et al., 2008; Hawley, 2009). Specifically, the methods are intended to directly quantify how stream channels adjust their cross-sectional and longitudinal (profile) forms, along with their bed material composition, in response to the altered runoff conditions from watershed urbanization. The monitoring and quantification of channel bed and bank erosion directly informs estimates of fine sediment loads from channel sources. The data are also critical for developing tailored recommendations for BMPs to arrest channel instability, mitigate hydromodification, and promote the natural flow and sediment regimes that are necessary for meeting the warm-water aquatic habitat designated use.

The following methods are primarily informed by and adapted from the Water Quality Control Board-Approved QAPP for Hydromodification Assessment and Management in Southern California (Stein, 2007), as well as the Standard Operating Procedures of SD1 (2009) to ensure regional comparability with previously collected hydromodification data in Northern Kentucky.

Channel Geometry Data

Geometric data collection is designed to capture changes in channel form via annually repeated cross-section surveys (Dunne and Leopold, 1978; Henshaw and Booth, 2000) with spatially integrated longitudinal thalweg profiles (Bledsoe et al., 2008; Hawley, 2009; SD1, 2009).

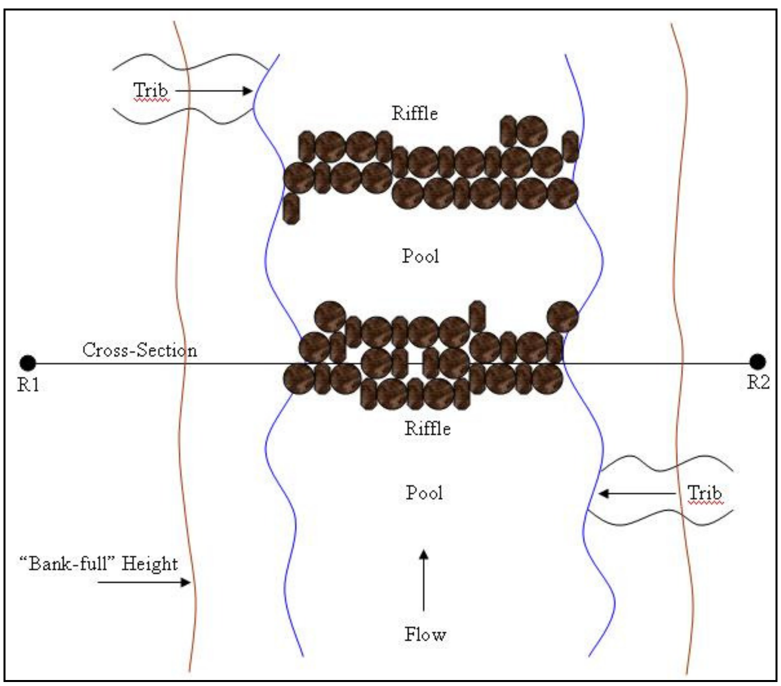


Figure 5: Cross section layout adapted from SD1 (2009) SOP

Cross sections will be located at representative riffle sections and oriented perpendicularly to flow direction at flood stage and extend well into the adjacent floodplain (Figure 5). Semi-permanent (rebar) monuments will be placed at the cross-section bounds and serve as reference points for the annually repeated surveys (SD1, 2009). Each rebar monument will be referenced to three permanent landmarks (e.g. well-established trees, boulders, utility poles, edge of curb or pavement, manholes, etc.). Sketches and measurements to each landmark will be used to triangulate the rebar monuments for future surveys. Approximate GPS coordinates (ca. ±10 feet) will be recorded for each rebar; however, triangulation and a metal detector will be the primary methods for relocating rebar monuments during future surveys.

Surveys will be performed with a level and tape (or equivalent) to ensure regional comparability (SD1, 2009). The tape will be pulled tight between the two rebar pins, ensuring minimal sag. The '0' end of the tape is placed at the rebar on the left side of the channel when looking downstream (i.e. 'R1'). Shots will be taken at a maximum of every 5 meters across the cross section; however, they will normally be spaced much closer to capture all major grade breaks (i.e. changes in slope), depositional surfaces, toes of slopes, channel thalweg, etc. (Harrelson et al., 1994). Spacing will be particularly close at each bank to ensure an accurate representation of bank height and angle.

The longitudinal profile along the channel thalweg will be surveyed over a minimum of three riffle-pool sequences over the site reach or for a distance of up to 100 meters. The tape is laid out from downstream to upstream and should trace the thalweg of the stream. The thalweg is defined as the deepest point in the stream at any given cross section and typically meanders from one side of the channel to the other as one moves up or downstream. It typically parallels the flow direction at flood stage. Survey measurements should be collected at every vertical break in slope (e.g. head of riffle, toe of riffle, knickpoint/headcut, etc.) and at every key horizontal change or feature (e.g. meander bends, thalweg crossings, etc.) (Harrelson et al., 1994). The maximum spacing of profile shots shall be 20 meters. The profile is spatially referenced to the cross section (and thereby the rebar monuments) by noting at what station the profile tape intersects the cross-section tape.

Each survey is documented with a photo of the cross section location (typically looking upstream). A photo of each bank will also be recorded. Either a survey rod or a field technician should be included in each photo for scale.

Throughout the channel geometry surveys, the level bubble of the instrument shall be periodically checked to ensure levelness. If the instrument is found to be out of level or is bumped at any point during the survey, the instrument shall be re-leveled and backsight reshot. If the elevation is off by greater than 2 cm, the data logged since the time of the previous level check will be discarded.

Bed Material Data

Samples of the channel bed material are based on the methodology developed by Bunte and Abt (2001a; 2001b). As employed by SD1, a 100-particle pebble count is sufficient to capture the key size classes and gradations of Northern Kentucky streams (SD1, 2009). A square sampling frame (e.g. 0.25 or 0.5 meter square) is placed at regular intervals (e.g. 0.5 or 1 meter spacing) along complete cross-section transects from the toe of the left bank to the toe of the right bank. If the 100th particle is reached in the middle of a transect, a full transect should be completed before stopping the pebble count to eliminate bias from oversampling one side of the cross section.

At each sample location, the field technician will sample the four pebbles in contact with the sampling frame at each corner. Use of a sampling frame eliminates the bias of Wolman (toe) pebble counts toward larger particles (Bunte and Abt, 2001a). Each pebble will be measured using a US SAH-97 (or equivalent) phi template (Figure 6). Employing phi templates eliminates measurement error that can occur when measuring along the b-axis of a curved particle in a traditional pebble count (Potyondy and Bunte, 2002).

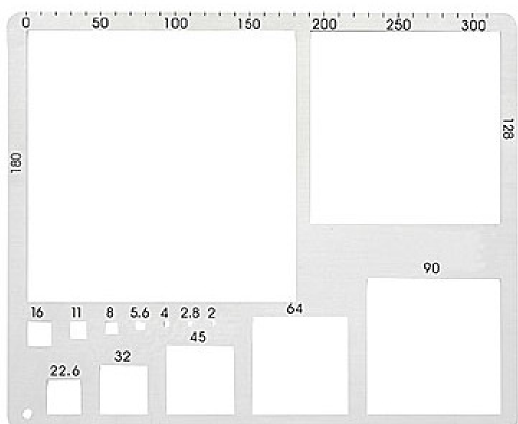


Figure 6: Standard US SAH-97 phi template (i.e. 'gravelometer')–NOT TO SCALE

For cases when the corner of the sampling frame is in contact with fine particles (d < 2 mm), the field technician shall do one of two procedures. If the layer of fine particles is greater than ca. ½ inch thick (approximately one finger width), the measurement shall be recorded as < 2 mm. If the fine particles are in a relatively thin layer (less than ca. ½ inch thick) and are only hiding a larger particle, the buried substrate should be sampled. A breadth of regional experience indicates that fine particles (d < 2 mm) generally do not constitute a substantial fraction of volumetric pebble counts, and sieve sampling is consequently not necessary.

For particles larger than 180 mm, the length of the b-axis should be estimated using the scale on the side of the phi template. Care should be taken to avoid sampling the same particle more than once. For sites where exposed, intact bedrock occupies substantial portions of the channel bed, this may be understandably unavoidable but should be minimized to the extent practicable.

Bed material samples will be collected with a trained, two-person team. One technician will collect and measure the samples and a second observer will record the samples. The second observer will perform repeat measurements of randomly selected particles. The repeat measurements shall not vary by more than ½ phi size. If such an error is observed the sampler(s) will be retrained on bed material sampling procedures and the pebble count shall be repeated.

B3: Sample Handling and Custody

B3.1 – Water Quality (Chemical) Sampling

Water quality samples will be handled via standard chain of custody protocols. All samples will be labeled with standard information (Figure 7). Samples will be kept on ice in coolers during transport. Chain-of-custody sheets will accompany samples to the laboratory where they will be signed by the relinquishing and receiving parties (Figure 8).

Client:	Boone County Conservation District
Sample ID:	
Location:	
Collection Time:	
Collection Date:	
Analysis:	
Preservation:	

Figure 7: Example Sample Label

CHAIN OF CUSTODY RECORD

Boone County Conservation District
6028 Camp Ernst Road
Burlington, KY 41005

Project Location or Number

Results to: Mark Jacobs
Phone #: 859-586-7903
Fax #

Address

Sampler (print)

Cardinal Labs Log In Test Results
Residual Chlorine Check + / - / N/A
pH check >10 / <2 / N (Neutral)
Purchase Order #

Preservative codes
1. HNO_3 7. H_3PO_4
2. NaOH
3. HCl
4. H_2SO_4
5 $Na_2S_2O_3$
6. None Enter #

Cardinal Laboratories
104 North Street
Wilder, KY 41071
859-341-9989
859-341-5081 fax
info@cardinallabs.com

Cardinal Project # ________________

Analytes / Method Number

Sample Location or ID	Date	Time	Matrix	Grab/Comp	# Bottles	E coli	TSS	BOD	TP,NN,TKN,NH3	OP(filtered)								Cardinal Sample ID #
						5	6	6	4	6								
Site 1 Hr 0 - Location 1					5	1	1	1	1	1								
Site 2 Hr 0 - Location 2					5	1	1	1	1	1								
Site 3 Hr 0 - Location 3					5	1	1	1	1	1								
Site 4 Hr 0 - Location 4					5	1	1	1	1	1								
Site 5 Hr 0 - Location 5					5	1	1	1	1	1								
Blank Hr 0					5	1	1	1	1	1								
Duplicate Hr 0					5	1	1	1	1	1								

Field Comments
Turn-Around-Time (TAT): 24 Hr 48 Hr Normal
Shipment Method: **Dropped off - Cooler**
Cooling/Packing Material: **Wet Ice**
Tracking Number: **N/A**
Cooler Temp:
Checked By:
Samples checked by:
Samples distributed/storage time:

Relinquished by Sampler:	Date	Time	Received by Lab Runner:	Date	Time	Samples logged into LIMS by:
Relinquished by Lab Runner:	Date	Time	Received by Laboratory:	Date	Time	Special Instructions:
						Hazards:

Chain Complete? Yes No N/A	Sample Amount Correct? Yes No	Custody Seal Intact? Yes No	Additional Comments:	Problems and/or Corrective Action?
Headspace? Yes No N/A	Correct Bottles? Yes No	Condition of Samples?		Yes (record on back of form) No

Figure 8: Example Chain of Custody Sheet from Cardinal Labs of Northern KY

B3.2 – Hydrologic Sampling

Flow measurements will accompany all samples where/when hazardous conditions do not exist. For comparability, flow will be collected after Rantz et al. (1982), and recorded on SD1's field form (Figure 9). Width, depth, and velocity will be recorded at each incremental location (Figure 4), such that volumetric flow rate can be automatically integrated using a simple spreadsheet model back at the office.

Sanitation District No.1 Flow Data Sheet **Version 2007.1**

Project Name **Date**

Study Basin **Start Time**

Samplers **End Time**

Equipment ID

Project Descriptor

Stream Conditions

Weather Conditions **Air Temp (°F)**

Field Observations

	Distance From Shore Referenc	Panel Number	Panel Width	Water Depth	Velocity Readings			Mean Velocity	Panel Discharge	Time
					20% Dept	60% Dept	80% Dept			
	(feet)		(feet)	(feet)	(fps)	(fps)	(fps)	(fps)	(cfs)	(hh:mm)
1		1						0.0	0.0	
2		2						0.0	0.0	
3		3						0.0	0.0	
4		4						0.0	0.0	
5		5						0.0	0.0	
6		6						0.0	0.0	
7		7						0.0	0.0	
8		8						0.0	0.0	
9		9						0.0	0.0	
10		10						0.0	0.0	
11		11						0.0	0.0	
12		12						0.0	0.0	
13		13						0.0	0.0	
14		14						0.0	0.0	
15		15						0.0	0.0	
16		16						0.0	0.0	
17		17						0.0	0.0	
18		18						0.0	0.0	
19		19						0.0	0.0	
#		20						0.0	0.0	
21										
#							Total Panel Discharge		0.0	cfs

Figure 9: Example Field Form for Measuring Flow (provided by SD1)

B3.3 – Biological Sampling

Biological samples will be handled via standard chain of custody protocols. Field observations will be recorded on standard forms such as Barbour *et al.* (1999) or equivalent, (Figure 10). All samples collected for laboratory analysis will be preserved immediately after collection and transported to the receiving laboratory, accompanied by chain-of-custody documents. When received by the laboratory, chain-of custody documents will be completed and samples will be logged into the laboratory logbook and/or laboratory database. Any further preservation will be conducted at this time. Maximum holding times before analysis, as stated in applicable laboratory method SOPs, will be followed.

BENTHIC MACROINVERTEBRATE FIELD DATA SHEET

STREAM NAME	LOCATION	
STATION #________ RIVERMILE_________	STREAM CLASS	
LAT _____________ LONG _____________	RIVER BASIN	
STOREt #	AGENCY	
INVESTIGATORS		LOT NUMBER
FORM COMPLETED BY	DATE ______ TIME ______ AM PM	REASON FOR SURVEY

HABITAT TYPES	**Indicate the percentage of each habitat type present** ❑ Cobble_____% ❑ Snags_____% ❑ Vegetated Banks_____% ❑ Sand_____% ❑ Submerged Macrophytes_____% ❑ Other ( )_____%
SAMPLE COLLECTION	**Gear used** ❑ D-frame ❑ kick-net ❑ Other ________________________ **How were the samples collected?** ❑ wading ❑ from bank ❑ from boat **Indicate the number of jabs/kicks taken in each habitat type.** ❑ Cobble_____ ❑ Snags_____ ❑ Vegetated Banks_____ ❑ Sand_____ ❑ Submerged Macrophytes_____ ❑ Other ( )_____
GENERAL COMMENTS	

QUALITATIVE LISTING OF AQUATIC BIOTA
Indicate estimated abundance: 0 = Absent/Not Observed, 1 = Rare, 2 = Common, 3= Abundant, 4 = Dominant

Periphyton	0 1 2 3 4	Slimes	0 1 2 3 4
Filamentous Algae	0 1 2 3 4	Macroinvertebrates	0 1 2 3 4
Macrophytes	0 1 2 3 4	Fish	0 1 2 3 4

FIELD OBSERVATIONS OF MACROBENTHOS
Indicate estimated abundance: 0 = Absent/Not Observed, 1 = Rare (1-3 organisms), 2 = Common (3-9 organisms), 3= Abundant (>10 organisms), 4 = Dominant (>50 organisms)

Porifera	0 1 2 3 4	Anisoptera	0 1 2 3 4	Chironomidae	0 1 2 3 4
Hydrozoa	0 1 2 3 4	Zygoptera	0 1 2 3 4	Ephemeroptera	0 1 2 3 4
Platyhelminthes	0 1 2 3 4	Hemiptera	0 1 2 3 4	Trichoptera	0 1 2 3 4
Turbellaria	0 1 2 3 4	Coleoptera	0 1 2 3 4	Other	0 1 2 3 4
Hirudinea	0 1 2 3 4	Lepidoptera	0 1 2 3 4		
Oligochaeta	0 1 2 3 4	Sialidae	0 1 2 3 4		
Isopoda	0 1 2 3 4	Corydalidae	0 1 2 3 4		
Amphipoda	0 1 2 3 4	Tipulidae	0 1 2 3 4		
Decapoda	0 1 2 3 4	Empididae	0 1 2 3 4		
Gastropoda	0 1 2 3 4	Simuliidae	0 1 2 3 4		
Bivalvia	0 1 2 3 4	Tabinidae	0 1 2 3 4		
		Culcidae	0 1 2 3 4		

Figure 10: Example Macroinvertebrate Field Data Sheet after Barbour *et al.* (1999)

B3.4 – Geomorphic Sampling

Geomorphic data, both channel geometry and bed material, will be logged into field books during field data collection (Figure 11). Field book pages will be copied and stored in separate locations upon returning to the office. Data will be logged into electronic databases within one month of data collection. Original copies of field books will be stored at the Boone County Conservation District.

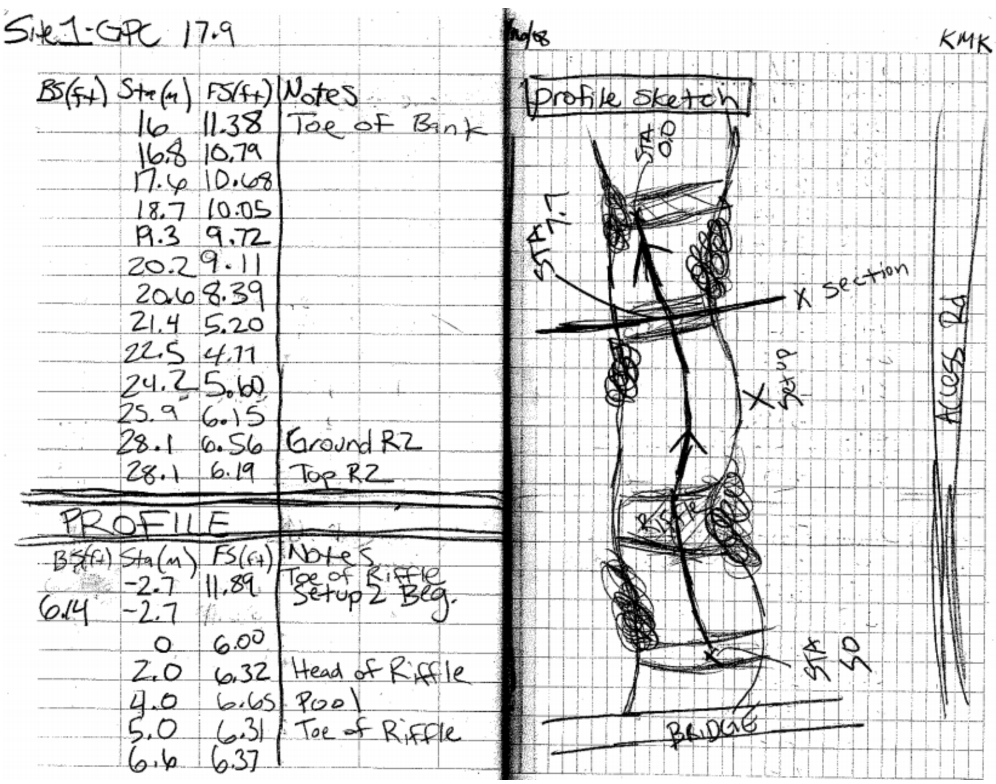


Figure 11: Example Field Book Record of Regional 'Hydromodification' Surveys by SD1

B4: Analytical Methods

All project analytical methods will adhere to industry standard procedures referenced throughout this QAPP. This includes standard EPA methods for water chemistry laboratory analyses (i.e. Table 12), standard EPA methods for biological analyses (Barbour et al., 1999), and industry standard procedures for stream flow (Rantz et al., 1982), channel geometry (Harrelson et al., 1994) and bed material (Bunte and Abt, 2001a; 2001b). As instructed in the KDOW (2010a) QAPP template, analytical methods are subcategorized below into 1) field measurement methods (*water quality field measurements, flow, channel geometry, and bed material*), 2) field analysis methods (*fish taxonomy*), and 3) laboratory analyses methods (*water chemistry and macroinvertebrate taxonomy*).

B4.1 – Field Measurement Methods

In-stream water quality field measurements will be collected with multi-probe sampling instruments with ranges and sensitivities listed in Table 11. Field personnel will be trained in proper multi-probe sampling methods and take measurements according to equipment specifications.

Stream flow will be measured incrementally after Rantz et al. (1982) such that a simple integration of all of the incremental flows will provide an estimate of total stream flow. Personnel will be trained in the use of a portable flow meter and automated spreadsheets will ensure proper integration of the field measurements back at the office.

Channel geometry surveys will be modeled after Harrelson et al. (1994) using a level and tape survey method. Tape shall be 50- to 100-meter fiberglass or equivalent. Level shall be a bubble-level type with 20x magnification or equivalent. Both instrument and rod personnel will be trained in their respective duties and have a comprehensive understanding of basic level-tape survey methodology including instrument setup and leveling, rod sighting, rod reading, rod positioning, rod boots, rod turning, backsighting, foresighting, moving the instrument to a new setup, etc.

Bed material measurements will be taken according to a 100-particle pebble count after Bunte and Abt (2001a; 2001b). Pebble measurements will be made using a US SAH-97 (or equivalent) phi template (Figure 6) after Potyondy and Bunte (2002). The phi template serves as a multi-sized field sieve. Measurements are obtained by recording the smallest phi size a given pebble can pass completely through (i.e. without becoming stuck or lodged).

B4.2 – Field Analysis Methods

Taxonomic identification of fish will be performed in the field using all available and appropriate taxonomic keys and regional distribution records. For the purpose quality assurance/quality control, 10% of the fish specimens from a given site or at least one voucher specimen from each species collected should be re-identified by a qualified fish taxonomist (e.g. Matt Wooten). When needed, independent taxonomic verifications made by recognized experts (based on education and/or experience) are used to confirm suspect identifications. Unknown and voucher fish specimens will be fixed in a 10% formalin solution for at least 2 weeks, rinsed and soaked in tap water for 1-2 days and stored in a 70% ethanol solution.

B4.3 – Laboratory Analyses Methods

Analytical methods for potential water chemistry parameters that may be included in this project will be based on standard EPA methodologies (Table 12). Laboratory taxonomic evaluations for macroinvertebrate samples will be performed according to standard EPA sorting and identification procedures (Barbour et al., 1999). Upon receipt of the benthic samples at laboratory, chain-of-custody forms will be completed and the samples will be inventoried. Samples will be preserved in 70% alcohol solution.

Benthic samples will be sorted and separated into major phylogenetic categories. All organisms will be removed with fine-tipped forceps or a pipette and placed in shell vials containing a 70% isopropyl alcohol solution. All identifications will be performed or verified by experienced taxonomists (e.g. Bert Remley) and verified in accordance with the laboratory QA/QC program. All identifications and enumerations will be recorded on standardized sheets for consistency and ease of data entry. Organisms will be identified to the lowest practical identification level (LPIL). Data will be entered into a database that will be transferred to the Boone County Conservation District upon completion of the analyses.

Subsampling techniques may be necessary in case of large sample volume. This will follow appropriate EPA and KDOW protocols. A comprehensive voucher set will be produced and retained for the duration of all regional projects along with identified specimens.

Turnaround times for water chemistry and macroinvertebrate laboratory analysis are expected to be approximately 3 weeks and 30 days, respectively.

B5: Quality Control

Quality objectives and procedures were described in detail in section A7, with specific objectives listed in Tables 9 and 10. As instructed in the KDOW (2010a) QAPP template, quality control requirements are subcategorized below into 1) field sampling quality control (*water quality and macroinvertebrate sampling*), 2) field measurements /analysis quality control (*water quality field measurements, flow, channel geometry, bed material, and fish taxonomy*), and 3) laboratory analysis quality control (*water chemistry and macroinvertebrate taxonomy*).

B5.1 – Field Sampling Quality Control

Quality in field sampling is best achieved by following proven, industry standard procedures. These protocols were described in detail in section B2. All samples will be collected in teams of two or more with ample time to ensure both safety and quality. Each team member will be trained in proper sampling methods and have the authority to request a re-sample if they observe a potential contamination or accidental protocol breach. The QA Officer also has the authority to provide random site visits to verify that the QA procedures outlined herein are being followed at all times. The goal is that by having fully trained personnel working in teams of two with more than adequate time for sample collection, field quality will be achieved through time-tested sampling techniques prescribed by EPA/KDOW.

Field Sampling Precision will be checked via repeat measurements of field parameters and by collecting field duplicates for water chemistry analysis (Table 9). The frequency of the Field

Sampling QC measures shall be once per event (i.e. one set of duplicate samples and repeat field measurements at one site per sampling event).

B5.2 – Field Measurements/Analysis Quality Control

Water quality field measurements will be collected with multi-probe sampling instruments with ranges and sensitivities listed in Table 11. All field personnel will be trained in proper multi-probe sampling techniques and take measurements according to equipment specifications. All personnel will have the authority to perform independent quality checks on field measurements, which should not vary by more than 10%. If such a deviation is observed, it may be a function of natural variability, instrument, or operator error. In either case, the measurement will be re-measured for a minimum of 30 seconds and re-recorded. If this occurs on more than one occasion during the same sampling event, the instrument should be checked and re-calibrated as needed at the first opportunity. If it is determined not to be instrument error, the field technician will be re-trained in proper field measurement procedures and the data noted as possibly suspect.

Stream flow will be measured using a portable flow meter during all water chemistry sampling events where hazardous conditions do not exist. Once per event, a second observer will perform a repeat measurement of incremental flow (i.e. depth and velocity at one location), which should not vary by more than 10%. Similarly to the water chemistry measurements collected with the multi-probe, the second observer should take steps to determine if the discrepancy is from natural variability, instrument error/calibration, or user error, and take actions accordingly.

Channel geometry surveys after Harrelson et al. (1994) using a level and tape survey method will be checked by the variability between rebar monuments during annually repeated surveys. Absolute errors will be kept to ±0.5 ft (vertical) and ±2.0 ft (horizontal), and standardized errors (by dividing by the length of the cross section) shall be kept ≤ 0.01 ft/ft (vertical) and ≤ 0.025 ft/ft (horizontal). If errors are observed greater than this range, an independent survey between rebar monuments will be performed to estimate which survey year was most accurate.

Quality of bed material measurements after Bunte and Abt (2001a; 2001b) will be checked through repeated measurements of individual pebbles by a second observer. The objective is for size estimates not to vary by more than ½ phi size on the US SAH-97 (or equivalent) aluminum phi template (Figure 6). If a repeated sample varies by greater than ½ phi size, personnel will be re-trained in proper use of a phi template after Potyondy and Bunte (2002) and the entire pebble count will be repeated.

Taxonomic identification of fish will be performed in the field using all available and appropriate taxonomic keys and regional distribution records. For quality control, 10% of the fish specimens from a given site or at least one voucher specimen from each species collected should be re-identified by a qualified fish taxonomist. When needed, independent taxonomic verifications made by recognized experts (based on education and/or experience) are used to confirm suspect identifications. Unknown and voucher fish specimens will be fixed in a 10% formalin solution for at least 2 weeks, rinsed and soaked in tap water for 1-2 days and stored in a 70% ethanol solution. In situations where preservation of specimen is impractical (e.g. 8 pound channel catfish), photos will be an acceptable alternative to voucher specimen.

B5.3 – Laboratory Analysis Quality Control

Analytical quality control for potential water chemistry parameters that may be included in this project will be based on standard EPA methodologies (Table 12). Contracted laboratories will maintain and follow internal QA/QC procedures and pass annual quality inspections by the Commonwealth of Kentucky and/or annual audits by NELAC or A2LA. At a minimum, laboratory analyses will achieve the QA/QC criteria outlined in Tables 9 and 10 regarding laboratory replicates, matrix spikes, percent recoveries, etc. The frequency of water chemistry laboratory QC procedures is outlined in Table 14.

Table 14: Frequency of Laboratory QA/QC Procedures for Water Quality Parameters

Sub-Category	Parameter	Method Blank	Positive Control	Negative Control	Lab Replicate	Lab Control Sample (LCS)	LCS Duplicate	Matrix Spike
Bacteria	E. coli	1 per 20	1 per 20	1 per 20	1 per 20			
Nutrients	NO_3/NO_2	1 per 20				1 per 20	1 per 20[(a)]	1 per 10
	NH_3-N	1 per 20				1 per 20	1 per 20[(b)]	1 per 20
	TKN	1 per 20				1 per 20	1 per 20[(a)]	1 per 10
	TP	1 per 20				1 per 20	1 per 20[(a)]	1 per 10
	OP	1 per 20				1 per 20	1 per 20[(b)]	1 per 20
	CBOD5	1 per 20			1 per 20[(c)]	1 per 20		
Sediment	TSS	1 per 20			1 per 10[(d)]	1 per 20		

[(a)]Can be sample duplicate or Matrix Spike Duplicate

[(b)]Can be lab replicate, sample duplicate, LCS Duplicate, or Matrix Spike Duplicate

[(c)]Sample volume dependent—if not enough sample, LCS Duplicate will be run as an alternative

[(d)]Can be lab replicate, sample duplicate, or LCS Duplicate

Laboratory taxonomic evaluations for macroinvertebrate samples will be performed according to standard EPA sorting and identification procedures (Barbour et al., 1999). QA/QC checks will occur on no less than 10% of the samples processed. A minimum of 10% of all sorted samples will be checked for completeness. Completeness checks will be accomplished by re-sorting the residual sample material by a different technician. If the animals removed from the residual material total 10% or more of the total number of animals in the sample, this constitutes a QC failure, and all samples sorted by that technician shall be resorted back until the time of the last acceptable QC check.

For identification tasks, at least 10% of all identified samples will be checked for identification and enumeration accuracy. Taxonomic checks will be performed by the re-identification of the selected samples by a different taxonomist. A discrepancy of 5% or more constitutes a QC failure and all samples identified by the taxonomist on that project will be reworked.

Data entry will be facilitated by the use of standardized sheets to record organism identifications and counts for each sample. A visual check of all data will be performed by experienced personnel to assure completeness and accuracy of the data.

B6: Instrument/Equipment Testing, Inspection, and Maintenance

As instructed in the KDOW (2010a) QAPP template, instrument/equipment testing, inspection, and maintenance procedures are subcategorized below into 1) field measurement instruments (*water quality field measurements, flow, channel geometry, and bed material*), 2) field instruments/equipment (*fish taxonomy*), and 3) laboratory analysis instruments/equipment (*water chemistry and macroinvertebrate taxonomy*).

B6.1 – Field Measurement Instruments/Equipment

In-stream water quality field measurements and stream flow measurements will be collected with multi-probe sampling instruments and portable flow meters, respectively. Their ranges and sensitivities listed in Table 11. The probe(s) and portable flow meter will be inspected and maintained according to the manufacturer's specifications. Technicians will periodically (i.e. once per month during the sampling season) test the probe(s) in deionized water to ensure proper operation. Probes that do not operate properly after calibration will be sent for manufacturer's inspection/calibration and be either recalibrated or deemed nonrepairable and replaced.

Channel geometry data will be collected using a standard level-tape method using a 20x magnification level (or equivalent). The level will be inspected and maintained according to the manufacturer's specifications and periodically tested with established benchmarks at the Boone County Conservation District Office or at their designated consultant's office at intervals of once per month during the sampling season. If the survey instrument falls out of level and connot be corrected, it will be sent to a survey vendor for calibration where it will be either recalibrated or deemed nonrepairable and replaced.

Pebble measurements will be made using a US SAH-97 (or equivalent) phi template (Figure 6). The phi template will be periodically inspected for damage and compared with a second template. Irreversibly damaged phi templates will be discarded and replaced.

B6.2 – Field Instruments/Equipment

Taxonomic identification of fish will be performed in the field using all available and appropriate taxonomic keys and regional distribution records. The biological sampling manager will periodically check with appropriate authorities to ensure that the team is using the most up-to-

Pebble measurements will be made using a US SAH-97 (or equivalent) phi template (Figure 6), which are calibrated in the factory. The phi template will be periodically inspected for damage. Irreversibly damaged phi templates cannot be recalibrated and will be discarded.

B7.2 – Field Instruments/Equipment

Taxonomic identification of fish will be performed in the field using all available and appropriate taxonomic keys and regional distribution records. Taxonomic keys do not require calibration.

B7.3 – Laboratory Analysis Instruments/Equipment

Laboratory analytical instruments and equipment will be calibrated according to the manufacturer's specifications or whenever testing indicates that the equipment has fallen out of calibration.

Laboratory taxonomic evaluations of macroinvertebrates will be performed according to standard EPA sorting and identification procedures (Barbour et al., 1999) using all available and appropriate taxonomic keys and regional distribution records. Taxonomic keys do not require calibration.

B8: Inspection/Acceptance of Supplies and Consumables

As instructed in the KDOW (2010a) QAPP template, inspection/acceptance of supplies and consumables are subcategorized below into 1) field sampling supplies and consumables (*water quality and macroinvertebrate sampling*), 2) field measurement/analyses supplies and consumables (*water quality field measurements, channel geometry, bed material, and fish taxonomy*), and 3) laboratory analyses supplies and consumables (*water chemistry and macroinvertebrate taxonomy*).

B8.1 – Field Sampling Supplies and Consumables

Water quality and macroinvertebrate sampling requires sample containers that have been certifiably cleaned according to their respective standards. All sample containers will be inspected for defects by the Sampling Manager (Mark Jacobs) or his designated technician, and will only be accepted with a certification of acceptable cleaning. Sample containers will come pre-preserved for the respective parameters with $Na_2S_2O_3$ or H_2SO_4 according to Table 13.

B8.2 – Field Measurement/Analyses Supplies and Consumables

Channel geometry surveys and bed material pebble counts do consume supplies that require QA/QC inspections prior to use. Standard rebar and flagging tape from local hardware stores are generally sufficient.

Water quality field measurements and taxonomic identification of fish also use limited consumables. Supplies requiring special inspection/certification (e.g. non-talc latex gloves) shall be inspected for proper certification.

B8.3 – Laboratory Analyses Supplies and Consumables

Analytical methods for potential water chemistry parameters that may be included in this project will be based on standard EPA methodologies (Table 12). Laboratory taxonomic evaluations for macroinvertebrate samples will be performed according to standard EPA sorting and identification procedures (Barbour et al., 1999). All supplies and consumables for laboratory analyses will be inspected by the Laboratory Manager to verify compliance with laboratory methodologies and standard procedures.

B9: Data Acquisition Requirements for Non-direct Measurements

The purpose of this section is to specify the requirements that the GCWI will use to determine if data collected through non-direct measures may be used for this project. This includes data that were collected by other projects/organizations, data acquired from GIS databases, maps, photographs, scientific literature, historical documents, testimony of residents, etc.

The Gunpowder Creek watershed has an extensive network of active stakeholders, including many agencies that have collected and continue to collect high-quality data. This includes extensive water chemistry, biological, fluvial geomorphic, and GIS databases. The GCWI intends to acquire, inspect, and potentially use as much of the data that are relevant to the project, provided they meet the criteria outlined below (primarily in reference to and adapted from Stein, 2007). Any limitations found regarding a given data set will be recorded and reported to the stakeholder who shared that data.

1. The data should have been collected from streams located in northern Kentucky watersheds.
    a. For water chemistry and biological samples, data should have been collected from within the boundaries of the Gunpowder Creek watershed.
    b. For fluvial geomorphic and hydrologic analyses, data from hydrogeomorphically comparable watersheds in northern Kentucky may be used (with appropriate limitations) to support analytical trends from data within the Gunpowder Creek watershed.
2. The data should have been collected in a way that adequately characterizes the chemical/biological/geomorphic condition of the stream using standard, accepted, and comparable methods to those outlined herein.

3. The data should be relevant to the goals of this study.

4. The data should be readily available.

5. Metadata describing the original purpose and objectives for the data, sampling methods and location, procedures for data collection and analysis, and QA/QC information should accompany the data set or be available through consultation with the data authors.

6. The authors of the data set should be available for consultation about such issues as missing data, filling data gaps, the meaning of zero counts, interpretation of outlier data points, and limitations on interpretation of the data set, including the degree to which the data can be extrapolated from the data-collection sites to other sites for which data do not exist.

7. The data set should be scientifically credible and clear of any controversy about its validity, integrity, and ownership, and it should not be currently withheld from distribution because of legal or proprietary concerns. Consistent data collection and analysis methods and quality assurance procedures should apply to the entire data set.

8. The data should be recent enough to pertain to either existing field conditions or the question at hand.

    a. For the purposes of this study, "recent enough" means that no data more than 15 years old for water chemistry and biological samples. It is assumed that this period is an acceptable interval within which to expect only negligible changes in condition at the site, IF no major impacts (anthropogenic or natural) have occurred (e.g. major flood, fire, change in land use practices).

    b. Regarding fluvial geomorphic and GIS data, historical changes in channel geometry and landuse can provide insights to the project, including—and sometimes especially if—those data are from preceding years. This may even include qualitative descriptions from residents, historic aerial photography, maps, etc. provided that they are used within their qualitative context and not extrapolated to/mixed with present quantitative data.

B10: DATA MANAGEMENT

The purpose of this section is to outline how data generated by this project will be managed, stored, and used. The procedures are consistent with the Boone County Conservation District standard data management procedures. The following is primarily informed by and adapted from Stein (2007).

A systematic naming/numbering system will be developed for unique identification of individual samples, sampling events, and sampling sites. The sample numbering system will contain codes that will allow the computer system to distinguish among several different sample types. This system will be flexible enough to allow changes during the demonstration project, while maintaining a structure that allows easy comprehension of the sample type.

To minimize the errors associated with entry and transcription of data from one medium to another, data will be captured electronically where possible. Clearly stated standard operation procedures will be given to the field crews with respect to the use of the field computer systems and the entry of data in the field. Contingency plans will also be stated explicitly in the event that the field systems fail.

All data collected in the field on paper forms or field books will be entered into an Excel spreadsheet as soon as possible after completion. Data entry will be double checked for data entry or typographical errors. All data will be stored in at least two locations or on a network with regular offsite backups. Original paper copies of field forms and field books will be archived and stored for at least five years.

Data results from analytical testing will be entered into the laboratory's database after an initial review of the data against method criteria. A secondary reviewer then reviews the data before it is released to GCWI. Should errors arise in the laboratory, a non-conformance report/corrective action report is generated. This report identifies the problem or error, gives planned corrective action and corrective action follow-up procedures. This form is reviewed and agreed to by the laboratory section manager, project manager, QA manager, and analyst. All completed forms are kept in the QA Manager's possession.

Upon receipt of the data, GCWI will perform a review of the quality assurance checks and report any variances back to the laboratory for rectification. Should no variances arise, the data will be accepted and used.

All original electronic data files of sample results (e.g. water chemistry sample results) will be retained for at least ten years at BCCD and stored offsite by at least one project partner (e.g. SD1). The final project database will also be available to the public and partner agencies upon request (e.g. SD1, KDOW, etc.), and will be retained by BCCD and at least one project partner (e.g. SD1) for at least ten years.

Group C Elements: Assessment and Oversight

C1: Assessments and Response Actions

Mark Jacobs (Project Manager) will be responsible for the day-to-day oversight of the project. Mary Kathryn Dickerson (QA Officer) will meet with the Project Manager on a quarterly basis to discuss the collection process, field analyses, data management, and the overall status of the project.

Furthermore, the QA Officer has the authority to conduct random audits at any number of sampling locations/events, to ensure that procedures described here are being followed. The project team will discuss procedures and assess errors in measurements at least biannually. Data collection will be repeated if necessary, as determined by the QA officer in consultation with the Project Manager.

C2: Reports to Management

The status of data collection will be reported to the KDOW Project Manager on a annual basis beginning with the onset of data collection and continuing until the completion of all project data collection as a part of the annual project reports required by this 319(h) grant. Additionally, a Data Analysis Report (DAR) and a Watershed Based Plan (WBP) will be prepared by GCWI for this project. All reports will be prepared and submitted by the Project Manager (Mark Jacobs), in consultation with the Project QA Officer (Mary Kathryn Dickerson), the project steering committee, technical advisers, etc.

GROUP D ELEMENTS: DATA VALIDATION AND USABILITY

D1: DATA REVIEW, VERIFICATION, AND VALIDATION

Data review, verification, and validation steps and procedures were guided by KDOW's (2010) QAPP template, Stein's (2007) CA-approved QAPP, and EPA's (2002b) guidance on environmental data verification and validation. Data generated by project activities will be reviewed against the data quality objectives cited in Element A7 and the quality assurance/quality control practices cited in Elements B5 – B8. Data quality flags from the water chemistry laboratory are provided in Figure 12.

Common Laboratory Qualifiers

A	Value reported is the average of two or more determinations.
B	Analyte was detected in both the sample and the associated method blank. Result exhibits the potential for high bias.
B'	Analyte was detected in the associated method blank.
C	LCD was analyzed instead of MSD due to limited sample volume.
D	Duplicate or replicate failed to meet acceptance criteria.
E	Result is reported as less than the Total result.
F	High concentration resulted in required dilution and elevated detection limit.
F'	Limited sample volume, turbidity or other matrix effect resulted in elevated quant limit/reporting limit or other interferences.
G	Analysis results exceed your permit or regulatory limitation.
H	Result exhibits the potential for high bias.
H'	Low response for IS; possible high bias for detected compounds.
I	Matrix interference.
J	Result is estimated below current MDL
K	The fecal coliform or E.coli count is an estimate, based on colony counts outside the optimum range of 20-60 CFU.
L	LCS failed to meet acceptance criteria.
L'	LCD failed to meet acceptance criteria.
M	MS recovery outside of acceptance criteria.
M'	MSD recovery outside of acceptance criteria.
N	Analysis is not covered under NELAP accreditation.
O	An appropriate aliquot of your sample was subcontracted to a NELAP accredited laboratory. The report is attached.
P	BOD or CBOD seed depletion was outside acceptance limits. All other QC passed, so no effect.
P'	BOD/CBOD method blank concentration was high. All other QC passed, so no effect.
Q	Sample was received or analyzed outside of method established holding time.
R	Sample was received warm, was submitted in inappropriate container, or was improperly preserved.
S	One or more surrogate recoveries failed to meet acceptance criteria.
T	Laboratory contamination is suspected.
U	Analyte not detected.
V	Compound(s) in CCV or ICV had a high %R but results are <RL, or below regulatory limitations.
W	The pH,Dissolved Oxygen,and Total Residual Cholrine were measured upon arrival to the laboratory. The Ammonia was preserved upon arrival to the laboratory.
W'	
X	Analysis was not performed.
X'	Analysis was performed, but valid data could not be obtained.
Y	Coliform bacteria are used as indicator organisms. This water yielded no coliform bacteria; therefore, it is potable. Kentucky Certification KY 00053
Z	Coliform Bacteria are used as indicators for possible fecal contamination. This water had a high number of total coliform bacteria, therefore, it is not potable. Disinfection with regular chlorine bleach and resampling are recommended. Kentucky Certification KY 00053
Z'	E. coli NEGATIVE.
NE	No effect on data
RR	Sample will be reanalyzed
(#)	Indicates number of items referenced in qualifier. *Example S(2) would indicate that 2 surrogate recoveries were outside acceptance criteria.*
*	*(project specific comment)*

Common Laboratory Abbreviation

%R	Percent Recovery
CCV	Continuing Calibration Verification.
ICV	Initial Calibration Verification.
LCD	Laboratory Control Sample Duplicate
LCS	Laboratory Control Sample
MB	Method Blank
MDL	Method Detection Limit
MS	Matrix Spike
MSD	Matrix Spike Duplicate
QA	Quality Assurance
QC	Quality Control
RL	Reporting Limit
RPD	Relative Percent Difference

Figure 12: Data Quality Flags and Abbreviations Used by Cardinal Laboratories

Data will be separated into three categories: data meeting all data quality objectives, data failing precision or recovery criteria, and data failing to meet accuracy criteria. Data meeting all data quality objectives, but with failures of quality assurance/quality control practices will be set aside until the impact of the failure on data quality is determined. Once determined, the data will be moved into either the first category or the last category.

Data falling in the first category is considered usable by the project. Data falling in the last category is considered not usable. Data falling in the second category will have all aspects assessed. If sufficient evidence is found supporting data quality for use in this project, the data will be moved to the first category, but will be flagged with a "J" as per EPA specifications.

D2: Verification and Validation Methods

Data collected in the field will be validated and verified by the respective Field Data Collection Manager, including assuring that field QA procedures have been maintained. Field operations personnel will check data sheets for completeness and maintain chain-of-custody forms. The Laboratory Manager shall verify that laboratory data quality assurance procedures have been maintained. Field and laboratory records shall be archived in the project file and retained by GCWI.

Data incorporated in the database will be reviewed and tested by the Project Manager. Results of field data will be uploaded into the project database. The original data sheets will be checked for completeness and correctness. Electronic entries will be compared to the original hardcopy data sheets and any errors in the database will be corrected. The original data field sheets will be retained by the Project Manager. Because errors can arise when manually entering hand-written field book data into electronic databases, the electronic data will not be used until all manually entered data have been checked for completeness and any transcription errors corrected.

The Project Manager and QA officer will conduct a final review of the data to ensure completeness and precision criteria have been met. Any data qualifications or limitations on data use will be noted in the database at this stage.

In addition to quality control measures governing data collection, the electronic database developed to store field data will also incorporate numerous measures to assure accurate data entry and processing. The following measures will be implemented:

1. Each field in the database that requires a value will be checked for null or missing values.
2. Standard codes will be provided in look-up lists for use in populating the data table fields.
3. The entry of duplicate records will be prevented, based on a unique combination of fields that define the primary key.

4. If the record set is related to another table in the database, it will be checked for orphan records (i.e., all parent records have child records and all child records have parent records).

5. All of the sites will be checked for having corresponding records in each data table.

The Project Manager, Mark Jacobs, will be responsible for oversight of data collection and the initial analysis of the raw data obtained from the field and any contracted laboratory. Any data requiring reconciliation and/or corrective action will be done by a committee composed of the Project Manager and the QA Officer. Any corrections require a unanimous agreement that the correction is appropriate. All QA and data verification fields will be included in the final project database. In the case of data verification resulting in a change to data, the Project Manager shall inform all data users and make corrections.

The Project Manager and QA Officer shall be informed if data accuracy, reliability or usability has been reduced as the result of errors in stored data or corrupted data files. All data users shall be notified of data problems and corrections.

D3: Reconciliation with User Requirements

Data collected during this project will provide a means of estimating water quality impairments and sources in the Gunpowder Creek watershed as outlined in Elements A5 and A6 (Problem Definition and Background, and Project/Task Description, respectively). We recognize, however, that even the best QA-approved, validated data may not result in a total understanding of all possible nonpoint source pollutants, their spatial and temporal variability, and their precise/exact sources. As it is the nature of nonpoint source pollution, we recognize that the data collected by and used for this project will have clear limitations.

Furthermore, all project reports will identify limitations of the data and discuss appropriate and inappropriate uses of the data and the resultant WBP that is developed. The goal of the GCWI is to improve and/or maintain water quality in the Gunpowder Creek watershed through development of a KDOW-approved WBP. Once the plan is complete and a clearer understanding of the issues facing the watershed is known, appropriate management strategies to mitigate nonpoint source pollution can be identified and selected based on available future funding. By following the QA procedures and guidance outline herein, any data collected by this project will assist in achieving this goal.

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