Public Outreach Summary Document
Gunpowder Creek Watershed Plan

Prepared by
Boone County Conservation District
& Sustainable Streams for the
Gunpowder Creek Watershed Initiative
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Public Outreach Summary Document

1.0 Introduction

The Gunpowder Creek Watershed is the largest drainage catchment in Boone County, draining 58.2 square miles of land into Gunpowder Creek and its tributaries, ultimately draining into to the Ohio River. The watershed includes a mix of rural areas, from forests and farms, to developed areas such as the Northern Kentucky Airport, Florence Mall, residential subdivisions, and parts of the cities of Florence and Union. Since 1980, Boone County has been one of Kentucky's fastest growing counties, and development is expected to expand farther into the watershed in the coming years. Every two years, the Kentucky Division of Water (KDOW) publishes its *303(d) List for Impaired Waters*, and Gunpowder Creek has been listed for the impairments of sediment, bacteria, and nutrients. One of the primary causes of these impairments is suspected to be inadequate management of stormwater runoff. Without adequate controls, excess stormwater runoff from impervious surfaces, such as rooftops and roadways, can cause water quality concerns, amplify flooding, increase stream bank erosion, and degrade biological communities, including amphibians, fish, and the insects that they depend on, such as mayflies and stoneflies (**Figure 1**).

Two-Lined Salamander

Great Blue Heron

Spotted Bass

Morphed mayfly with wings

Dragonfly

Crayfish

Figure 1: Examples of aquatic life found in and around Gunpowder Creek
Photos courtesy of Mark Jacobs at Boone County Conservation District

To reverse the degradation of Gunpowder Creek and work towards its restoration, the Boone County Conservation District (BCCD), in association with the Gunpowder Creek Watershed Initiative (GCWI), has obtained federal grant funding to develop a Watershed Plan. The purpose of the *Gunpowder Creek Watershed Plan* is to better understand the impairments in Gunpowder Creek and develop a plan of action to restore the watershed to a healthy, functioning resource. The following stakeholders have been an integral part of the plan's development.

- Kentucky Division of Water
- Sanitation District No. 1 of Northern Kentucky
- Boone County Planning Commission
- Northern Kentucky University (NKU) Center for Environmental Restoration
- Boone County Fiscal Court
- City of Florence, Kentucky
- City of Union, Kentucky
- Kentucky Transportation Cabinet
- Kenton County Airport Board
- Northern Kentucky Area Development District
- Northern Kentucky Health Department

2.0 Exploring the Gunpowder Creek Watershed

The Gunpowder Creek Watershed is composed of the main Gunpowder Creek Watershed and four smaller sub-watersheds: South Fork Gunpowder, Fowler Fork, Long Branch, and Riddles Run (**Figure 2**). Current land use within the sub-watersheds ranges from urban and industrial in the headwaters near the Interstate 71/75 corridor to more suburban and agricultural within the middle sub-watersheds to rural in the downstream portions. Part of the Greater Cincinnati/Northern Kentucky International Airport (CVG), the City of Florence, and the City of Union are included within Gunpowder's borders. The main branch of Gunpowder Creek begins near CVG and flows approximately 36 miles to the southwest where it joins the Ohio River. Approximately 143 miles of blue line streams are found within the watershed.

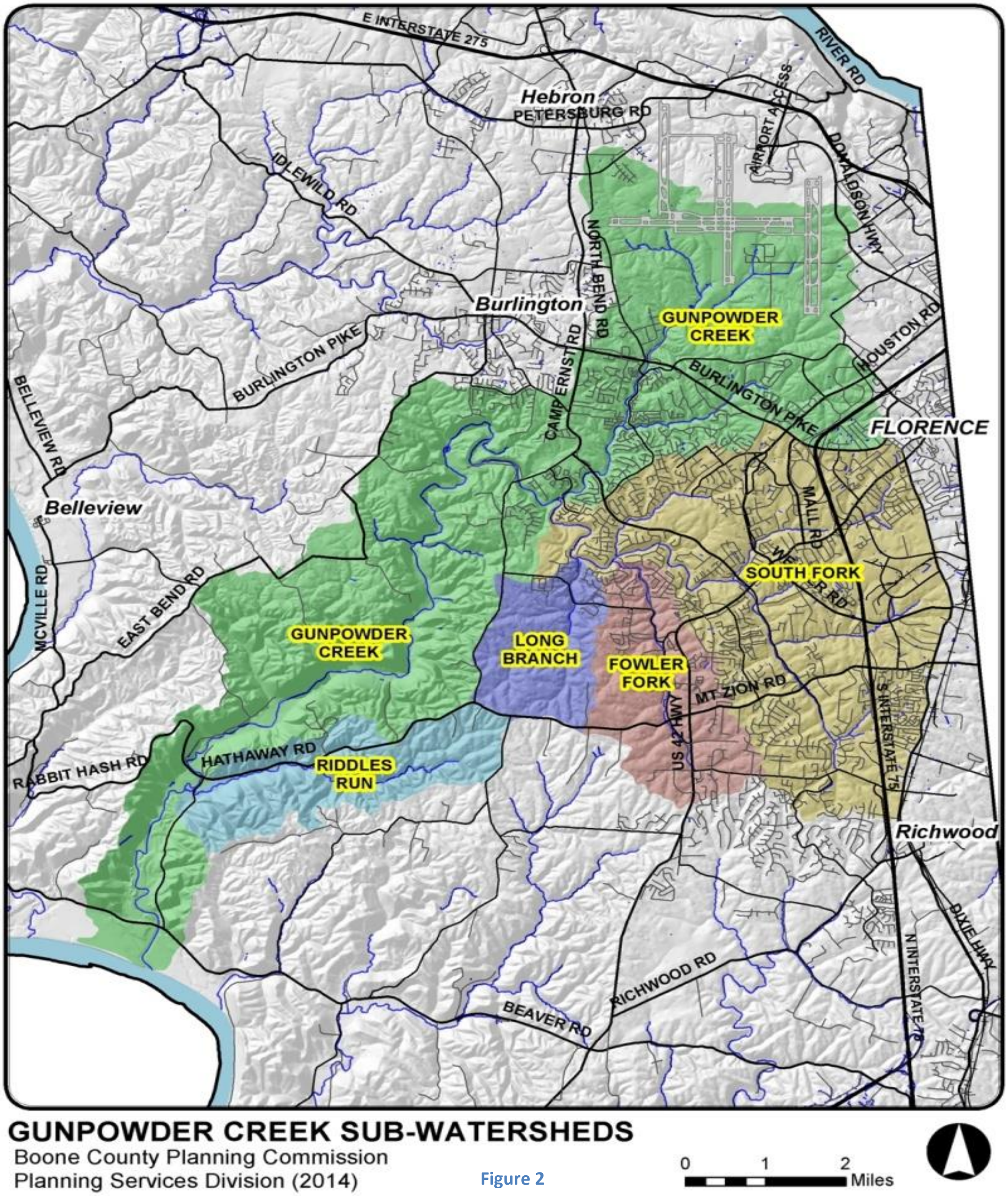

E INTERSTATE 275
RIVER RD
Hebron
PETERSBURG RD
AIRPORT ACCESS
DONALDSON HWY
IDLEWILD RD
NORTH BEND RD
Burlington
GUNPOWDER CREEK
HOUSTON RD
BURLINGTON PIKE
CAMP ERNST RD
BURLINGTON PIKE
FLORENCE
BELLEVIEW RD
Belleview
MALL RD
SOUTH FORK
MCVILLE RD
EAST BEND RD
GUNPOWDER CREEK
LONG BRANCH
FOWLER FORK
MT ZION RD
US 42 HWY
S INTERSTATE 75
HATHAWAY RD
RIDDLES RUN
RABBIT HASH RD
Richwood
DIXIE HWY
N INTERSTATE 75
RICHWOOD RD
BEAVER RD
GUNPOWDER CREEK SUB-WATERSHEDS
Boone County Planning Commission
Planning Services Division (2014)
0
1
2
Miles

Figure 2

Historically, the area of Boone County has been inhabited for quite some time. Native Americans have been in the region since at least 9,500 B.C. (Pollack, 2008). These semi-nomadic people moved seasonally, hunting, gathering, and fishing where resources allowed. Gunpowder Creek was used as a transportation route as well as a source of food and water. As trading and farming expanded, campsites and semi-permanent villages formed in the lower Gunpowder. By A.D. 1,000, permanent villages had been established along the Ohio River and large streams.

Lower Gunpowder had several prehistoric sites, with a series of Fort Ancient villages, linked also to villages in Big Bone and Mud Lick. The archaeological legacy left by these villages includes structure foundations, cemeteries, storage and trash pits, tools and pottery, such as that in **Figure 3**. As farmers, the people of the Fort Ancient villages preferred to settle in areas with broad floodplains, such as those in the lower Gunpowder. Archaeologists think that the Fort Ancient villages lasted until about the time of European settlement in the mid to late 1700s.

Figure 3: Typical decorated pottery of the Fort Ancient Culture

The first Europeans began to explore this area in the mid-1700s, and by the late 1780s, after the French & Indian Wars when the French lost control of the Ohio Valley, the first settlers made their way down the river into the area (Warminski, 2002). As the dominant transportation corridor for people and goods until the late 19^{th} Century, flatboats, skiffs, and (later) riverboats used the Ohio River (and its tributaries) and ferries connected neighboring towns on the opposite shores.

Boone County was established in 1799 with a population of 1,500. Streams such as Woolper Creek, Big Bone Creek, and Gunpowder Creek were charted to their headwaters and settlement, resource extraction, and land clearing/planting was in full swing. Nineteenth century agricultural activity in Boone County was largely subsistence in nature; many of the narrow floodplains and terraces along the middle and lower Gunpowder were cleared and cultivated, as were the rolling uplands in the eastern watershed. Farms diversified to include row crops, livestock, and tobacco, as well as the occasional mill, distillery, rope walk, or other cottage industry.

Gunpowder Creek's hydraulic power was harnessed as early as 1817, when the stream was dammed, excavated, and otherwise altered to create mills (**Figure 4**) (Kreinbrink, 2006). As commerce expanded in the area, roads were constructed and the mill became the center of the community for the local

Figure 4: Stonework and water wheel of one mill, known locally as "The Grand Water Power"

farmers. The population of lower Gunpowder grew, probably to a larger population than currently resides in this portion of the watershed.

Today's Gunpowder Watershed is much different than it was historically. Lower Gunpowder's roadways and communities are now undeveloped, but other areas of the watershed have been drastically impacted by urbanization. Boone County's growth rate recently began expanding rapidly (**Figure 5**). Census records show that from 1950 to 2010 the county's population grew from about 10,000 to 120,000, with the highest growth rate of 38.2% between 2000 and 2010 (BCPC, 2010). Rates of development are not anticipated to slow for the foreseeable future.

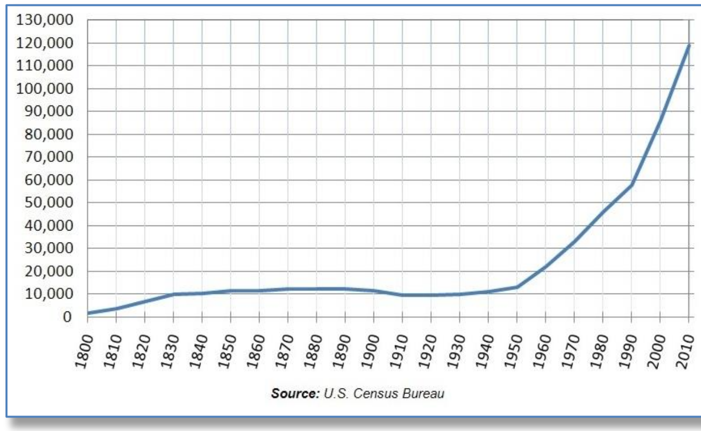


Figure 5: Boone County Population 1800 to 2010

Even so, as of 2009, 53% of the watershed remains undeveloped. These areas include woodlands, as well as recreational and agricultural lands. Residential uses occupy about 30% of the watershed, with dense development covering nearly 20% (**Figure 6**). South Fork is by far the most urban sub-watershed, with over 1,700 acres of industrial/commercial areas and over half of all the suburban density residential area within the entire Gunpowder Creek Watershed (BCPC, 2010).

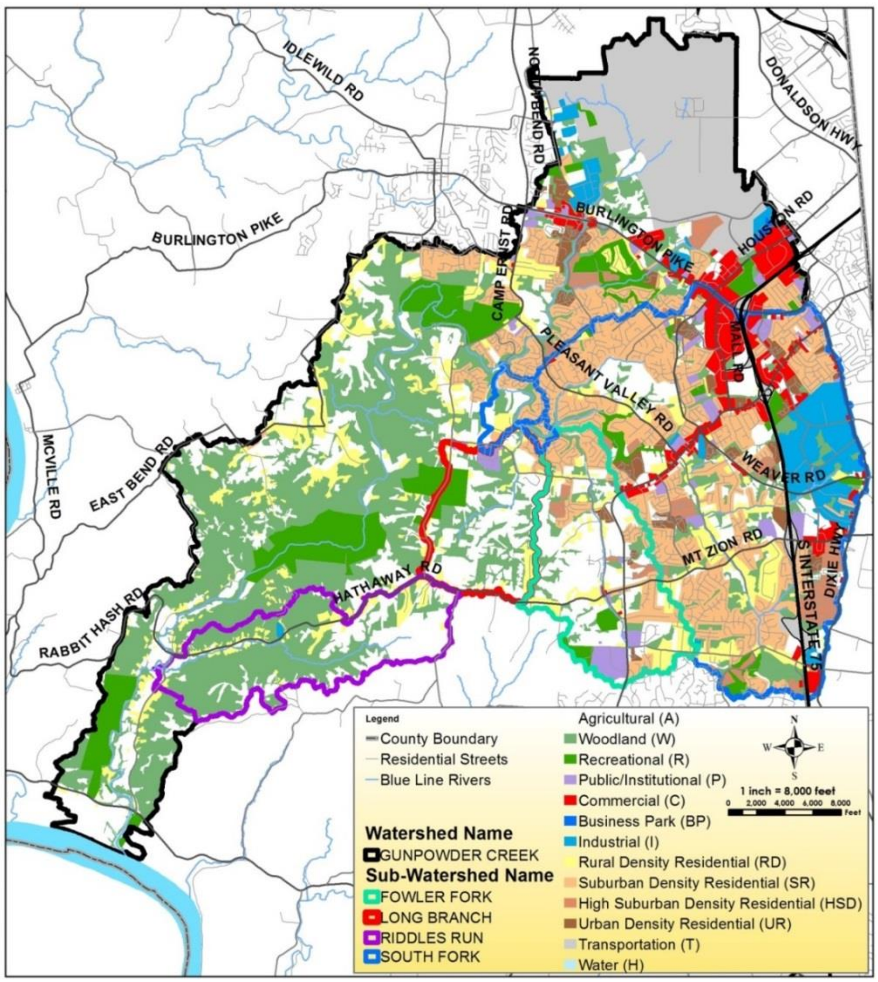


Figure 6: Current Land Use in the Gunpowder Creek Watershed

In beginning to understand the ways that the current land use has impacted Gunpowder Creek and to identify possible sources of impairments from the watershed, the GCWI reviewed some historic stream monitoring data provided by the Sanitation District No. 1 of Northern Kentucky (SD1), an active project partner. The SD1 data revealed high levels of bacteria, degraded biological conditions, severe bank erosion, and hydromodification issues. This data identified improperly managed stormwater runoff as a dominant cause of these impacts.

3.0 Learning More and Monitoring

To gather a complete picture on the current conditions in Gunpowder Creek, the GCWI conducted a two-phased monitoring program. Phase 1 was completed in 2011, an extremely wet year with record rainfall, and Phase 2 was completed in 2012. The difference in rainfall during these two years allowed for a comparison of the types of pollutants contributing to stream degradation during wet versus dry weather. Monitoring and sampling included:

The monitoring program was designed to assess all aspects of stream integrity including biological health, chemical composition, physical habitat, stream flow, and land use.

- Stream flow monitoring: Individual current velocity and depth measurements and continuous flow data from the USGS gauge at Camp Ernst Road near Union, Kentucky.
- Geomorphic surveys: Surveys of the sizes of the rocks in the stream beds and measurements of stream geometry designed to measure the rates of channel erosion.
- Habitat assessments: Assessments of stream habitat elements such as the frequency of fast-flowing riffle habitats, amount of sediment deposition, and the quality of riparian vegetation adjacent to the stream bank.
- Water quality samples: Field and laboratory measurements for parameters such as bacteria, nutrients, pH, temperature, and sediment.
- Biological assessments: Sampling of fish and aquatic insects (i.e., macroinvertebrates) to quantify the diversity of the biologic community (**Figure 7**).

Figure 7: Conducting biological sampling in Gunpowder Creek

GCWI's monitoring was conducted at a total of nine sites located at the mouth of the sub-watersheds, along the main branch, and on some un-named tributaries. Six sites had all the above sampling completed at them (orange triangles, **Figure 8**), and three additional sites were included to expand the hydromodification surveying database (green circles, **Figure 8**).

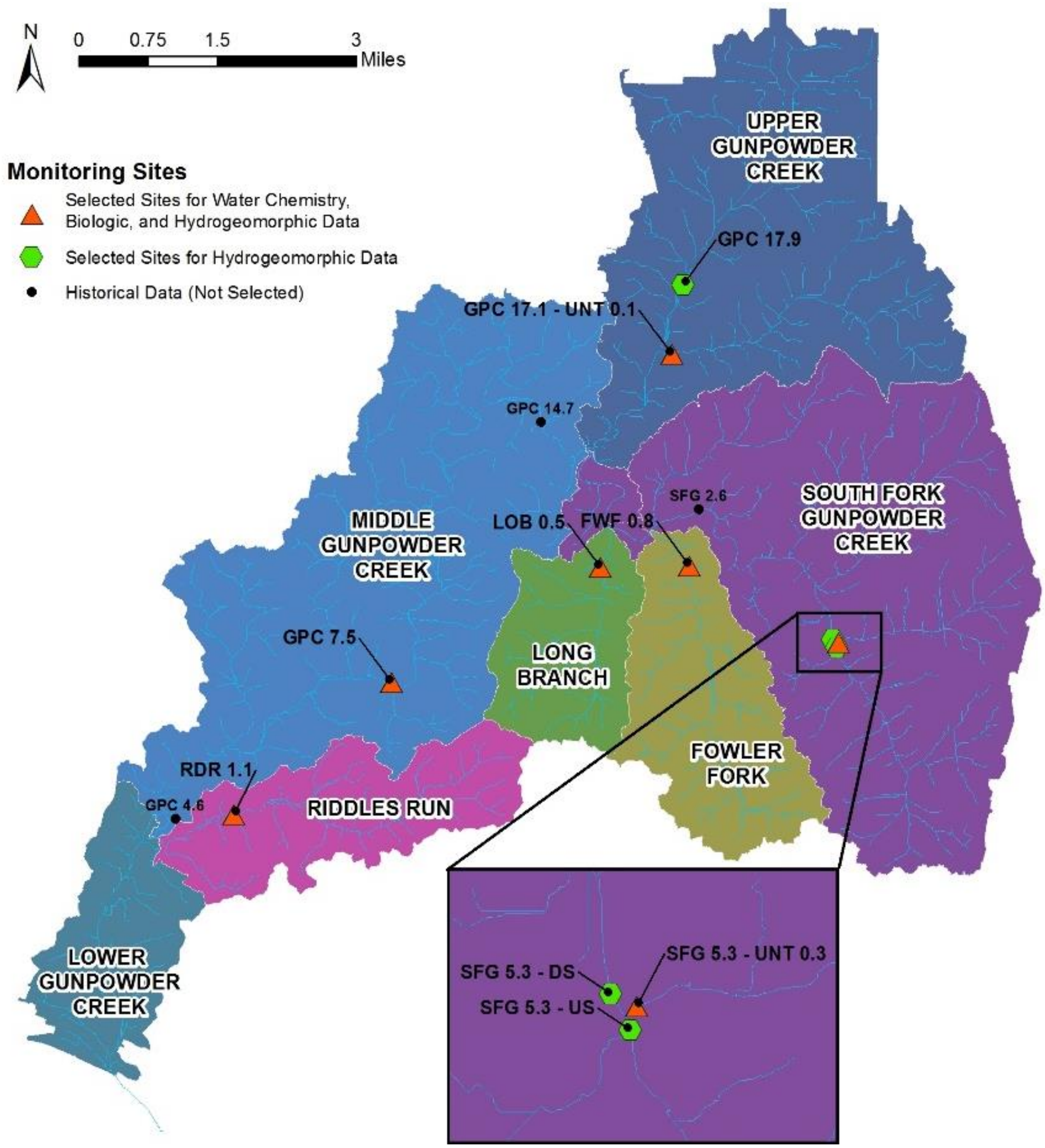


Figure 8: GCWI Monitoring Sites

4.0 Analyzing Results

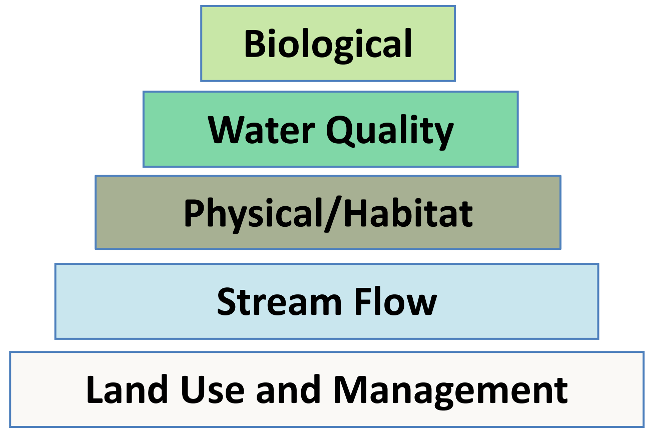


Figure 9: Stream Function Pyramid
Adapted from Center of Watershed Protection (2011)

The stream function pyramid in **Figure 9** shows how the different components of stream and watershed health are related. The foundation of a stream system is the land uses and management within the surrounding watershed. Through proper management of the land, the other parameters remain intact. When land uses are not adequately managed, stream flows can be altered by increased rates of stormwater runoff, which can often be polluted by nutrients and bacteria. The alterations to stream flow will impact the physical habitat within the stream. As these characteristics change, the water quality changes accordingly. An example of this interdependence would be unmanaged development that creates excess runoff to the stream, increasing flows. These increased flows erode the stream, increasing fine sediment loads (i.e. total suspended solids).

Total suspended solids (e.g. loads of fine sediment) and bacteria are the most concerning pollutants based on monitoring data, especially in the developed sub-watersheds.

The monitoring results indicate that sediment, as measured by total suspended solids (TSS), and bacteria, as measured by *E.coli*, are the biggest pollutants of concern, particularly throughout the developed headwaters of the watershed. As to be expected based on the stream function pyramid, **Figure 9**, the biology was found to be the worst in the same sub-watersheds, as erosive flows have altered the habitat, impaired the water quality, and lowered the biologic integrity. The following sections present a brief summary of the results of each aspect of GCWI's monitoring program.

Stream Flow Results

Flows at three sites in the watershed were compared. These sites ranged in development from mostly developed, to partly developed, to undeveloped. The results indicated that for a given rain event the flows and depth of water at the site receiving runoff from the developed area were the highest. In addition, the flows were "flashier," meaning that the changes in flow and water depth were experienced quicker than those in less developed watersheds. These flashy, large flows can cause increased erosion, water quality impairments, degraded habitat conditions, and increased flooding potential.

Stormwater runoff in the developed headwaters makes stream flow rise and fall very rapidly and can cause flooding and stream bank erosion.

They are often considered a safety hazard by engineers because the rates of change in the water depth can occur so quickly that they may catch a child wading in a creek by surprise.

Geomorphic Results

The geomorphic survey data identified stream instability and bank erosion as concerns throughout the watershed, but especially in the most developed sub-watersheds including the South Fork Gunpowder and the headwaters of Gunpowder Creek. The results of the hydrogeomorphic monitoring data were consistent with a separate study of over 40 Northern Kentucky streams, which showed that stream channel enlargement, widening, and deepening are linked to watershed development (Hawley *et al.,* 2013). The following three case studies highlight the unstable nature of the stream systems throughout the most developed portions of the Gunpowder Creek Watershed.

> ***The presence of development has been linked to a larger cross-sectional area of the channel, indicating erosion of the banks.***

<u>*South Fork Gunpowder Creek – SFG 5.3-DS*</u>

The results of the geomorphic survey at Site SFG 5.3-DS, located in the southeastern portion of the watershed (**Figure 8**), identified loss of trees, bedrock incision, and compromised storm sewer infrastructure. At this site the channel slope has become flatter, the bedrock has been fractured and mobilized, and erosive flows have pushed a storm sewer from its headwall. The two pictures in **Figure 10** highlight the loss of trees (red) and the incised bedrock (yellow).

Figure 10: Comparison of geomorphology over 4 year period highlighting incised bedrock (yellow) and tree loss (red)

<u>*South Fork Gunpowder Creek – SFG 5.3-UNT 0.1*</u>

Bank failure was also documented at Site SFG 5.3-UNT 0.1, in South Fork Gunpowder Creek. **Figure 11** highlights a continuous crack along the entire bank length that will eventually lead to bank collapse and stream widening. A good riparian buffer with thick vegetation can help to stabilize banks like this because plants can develop deeper roots that increase the bank's resistance to erosion.

Figure 11: SFG 5.3-UNT 0.1 Tension Crack Bank Failure

<u>*Gunpowder Creek – GPC 17.1-UNT 0.1*</u>

The hydromodification conditions at this site are visible in the pictures in **Figure 12**. The flows generated from this watershed continue to damage the tree and move the large woody debris. The presence of the log in the photograph from 2012 shows that the flows in the channel were large enough to move it.

2010 2011 2012

Figure 12: Erosive flows at GPC 17.1-UNT 0.1 Transport Large Woody Debris and Damage Tree

Habitat Results

The physical stability of a stream strongly influences the habitat conditions such that the most unstable site in the South Fork Gunpowder sub-watershed (SFG5.3-UNT0.1) had the most degraded habitat score of all sites. Other habitat impacts induced by stream erosion include exposing large areas of bedrock, scouring longer and deeper pools, and creating shorter riffle habitats, which are important habitat areas for many aquatic insects and fishes.

Habitat quality decreases as bank erosion increases.

Water Quality Results

One of the ways that the water quality monitoring data was analyzed was to compare the pollutant levels to "benchmark" values from the region's healthy streams provided by KDOW. The comparison allows us to gather a sense of the scale of the problem and helps to prioritize watersheds for restoration efforts. For each site, the exceedances of the benchmark values for each parameter were identified for both dry weather and wet weather conditions.

Sediment and bacteria are the most concerning pollutants in Gunpowder Creek, especially in the developed watersheds.

At all six water quality monitoring sites, sediment, as measured by TSS, and bacteria, as measured by *E.coli*, have the highest ratio of loads when compared to benchmark levels (**Figure 13**), meaning that loads of sediment and bacteria going into the creek are more concerning than the other parameters such as nitrogen or phosphorus. Moreover, sediment and bacteria loads seem to be most concerning in the most developed regions of the watershed. In the South Fork Gunpowder, sediment loads are 30 times higher than benchmark levels. In the headwaters of the main branch, sediment loads are more than 60 times higher than reference conditions.

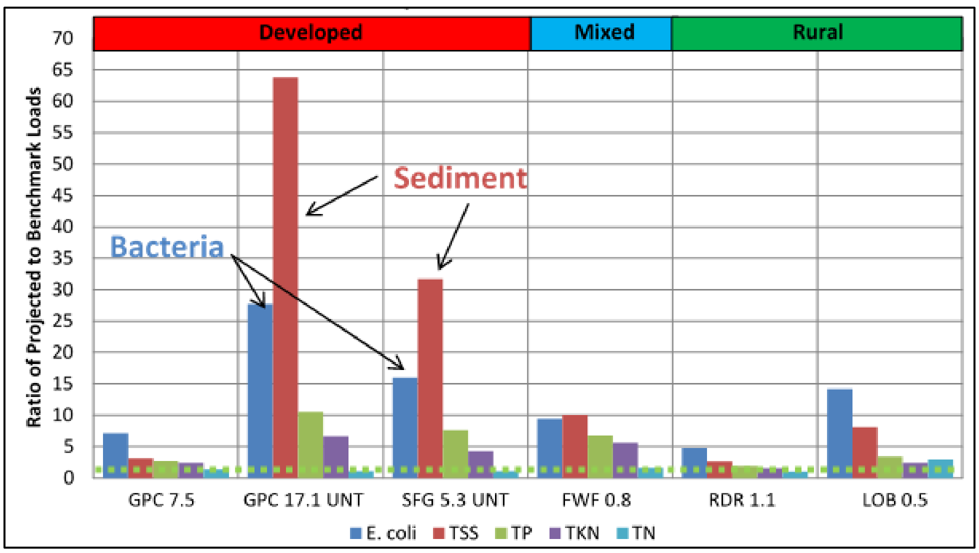


Figure 13: Ratio of Annual Projected Loads to Annual Benchmark Loads

Furthermore, stream bank erosion was found to be a dominant source of the sediment in the developed watersheds, as measured rates of bank erosion through the geomorphic surveys typically could account for 100% of the TSS load measured in the water.

One of the most noticeable benefits of development was evident from the fact that bacteria loads were relatively low in the developed watersheds during dry weather. This indicates that sanitary sewers, which go hand in hand with development, have done a good job of keeping human waste out of streams under these conditions. The fact that wet-weather bacteria loads were exceptionally high in the developed watersheds could be explained by a combination of pet waste and other bacteria from stormwater runoff, as well as potential sanitary sewer overflows that may have occurred during 2011. However, it is important to note that the installation of the Western Regional Wastewater Treatment

Plant and newly installed interceptor sewer that became fully implemented in 2012 has greatly reduced the potential for future sanitary sewer overflows.

The opposite was true in rural areas, where relatively high levels of bacteria were found to be present during dry weather monitoring. This leads to the conclusion that septic systems and/or livestock in the stream could be sources of bacteria loads, as they can directly deliver bacteria to streams during dry weather.

Biological Results

As shown in the stream function pyramid (Figure 9), the biological health of the creek is dependent on the other four factors discussed above. Consistent with the rest of the data analysis, development lowers the biological integrity of Gunpowder Creek. For example, the site with the greatest percentage of impervious area, SFG 5.3-UNT 0.1, had the lowest scores when evaluating two different indices of biologic health.

Watersheds with high levels of impervious areas, such as roads and rooftops, generally have poorer stream health than rural watersheds.

Potential Sources of Pollutants

The watersheds can be classified into three land use categories to highlight the most and least concerning pollutants, along with likely sources and possible causes. The three types of watersheds are: **developed** (20-40% impervious) on the eastern side of the Gunpowder Creek Watershed, **rural** (2-4% impervious) on the western portion of the Gunpowder Creek Watershed, and **mixed** (developed/rural, 12% impervious).

In wet weather, **developed watersheds** have the highest concentrations of bacteria and suspended sediment, most likely caused by animal waste and eroding banks, respectively. The root cause of both of these impairments in developed watersheds is improperly controlled stormwater runoff. Specific conductance was found to be elevated during dry weather flow, with a possible source being point source discharges upstream in the watershed. As discussed above, dry weather bacteria loads were least concerning in developed

Most Concerning	Likely Sources	Possible Causes
Bacteria (Wet Weather)	Stormwater runoff	Animal Waste
Suspended Sediment (Wet Weather)	Bank Erosion	Erosive Flows Unvegetated Banks
Specific Conductance (Dry Weather)	Point Sources?	Point Source Treatment

Least Concerning	Likely Reason	Prevented Pollutant
Bacteria (Dry Weather)	Sanitary Sewers	Human Waste

Figure 14: Concerning pollutants with likely sources and possible causes in developed watersheds

watersheds, which underscore the benefits of sanitary sewers in developed areas. See Figure 14.

Figure 15 shows that during dry weather bacteria, nutrients, and specific conductance are the most concerning pollutants for **rural watersheds**. Bacteria and nutrients are possibly due to poor maintenance of septic systems and/or inadequate livestock fencing, allowing animals direct access to the stream. Specific conductance could be from septic systems, point source discharges, or natural sources. Nutrients from wet weather events are the least concerning pollutant in rural watersheds.

Most Concerning	Likely Sources	Possible Causes
Bacteria & Nutrients (Dry Weather)	Septic Systems Animal (direct)	Septic maintenance Cattle/Horse Fencing
Specific Conductance (Dry Weather)	Septic Systems Point Sources?	Septic maintenance Point Source Treatment

Least Concerning	Likely Reason	Prevented Pollution
Nutrients (Wet Weather)	Fertilizer Management	Excess Algae

Figure 15: Concerning pollutants with likely sources and possible causes in rural watersheds

In **mixed use watersheds**, as displayed in Figure 16, wet weather events create a bacteria problem in the creek, likely from animal waste in stormwater runoff. During dry weather, both specific conductance and nutrients are concerning. The likely sources and possible causes are the same as in rural watersheds. Bacteria during dry weather flow is the least concerning pollutant in Gunpowder's mixed use watersheds.

Most Concerning	Likely Sources	Possible Causes
Bacteria (Wet Weather)	Stormwater runoff	Animal Waste
Specific Conductance (Dry Weather)	Septic Systems Point Sources?	Septic maintenance Point Source Treatment
Nutrients (Dry Weather)	Septic Systems Animal (direct)	Septic maintenance Cattle/Horse Fencing

Least Concerning	Likely Reason	Prevented Pollutant
Bacteria (Dry Weather)	Sanitary Sewers	Human Waste

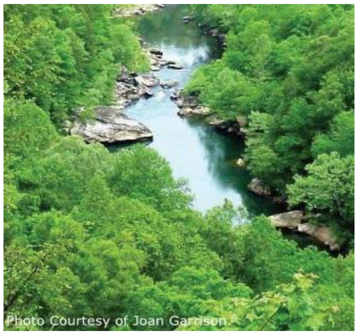
Figure 16: Concerning pollutants with likely sources and possible causes in mixed use watersheds

Prioritization

South Fork Gunpowder and the developed headwaters in the main branch are the reaches of greatest concern within the entire Gunpowder Creek Watershed. This conclusion was drawn after ranking the sub-watersheds in numerous ways, including the number of water quality samples exceeding the benchmark concentration, average sample concentrations, projected annual pollutant loads, and pollutant yields. The results of GCWI's rankings match the findings in KDOW's 2010 *303(d) List of Impaired Waters*. While these areas have been identified as the priority regions of the watershed, an integral aspect of the GCWI's plan is to work with local stakeholders and regional partners to implement smart, cost-effective projects wherever opportunities make sense for stream health improvement.

5.0 Finding Solutions

The next logical step to improving the Gunpowder Creek Watershed is to evaluate the various ways to fix the stream impairments and protect the areas in good condition. Water quality impairments can be mitigated in many ways, using both structural and non-structural Best Management Practices (BMPs). Structural BMPs require construction to be implemented and include items such as detention basins, rain barrels, and fencing. Education would be considered a non-structural BMP in that it does not require construction but aims to extend the life of structural BMPs and gain watershed support for projects. Examples of BMPs are shown in **Figure 17**.



Healthy riparian zones help filter sediments and nutrients from runoff, stabilize streamside soils, and provide shade, food, and habitat for the aquatic systems and aquatic life of a waterway.

Seeding or covering bare soil with mulch, blankets, mats, and other erosion prevention products as soon as possible is the cheapest way to prevent erosion. Grass seeding alone can can reduce erosion by more than 90%.

Rain barrels collect and store stormwater runoff from rooftops. This water can then be used to irrigate gardens and lawns.

Fencing livestock out of streams and providing alternative water results in pathogen reduction, stream bank protection, and clean water for livestock.

Rain gardens are shallow, depressed gardens that collect stormwater runoff from rooftops or other hard surfaces. These rain gardens help filter pollutants and act as beautiful landscape features.

Figure 17: Examples of Structural BMPs

In determining the most appropriate BMPs to implement, let's recap the known facts.

- TSS is the most concerning pollutant in the Gunpowder Creek Watershed.
- TSS was found to be worst in the most developed sub-watersheds.
- The major source of TSS is suspected to be bank erosion, which is caused by the excessively erosive flows in the creek from stormwater runoff.

From these facts, it is clear that stormwater controls must be a key BMP implemented in the watershed in order to mitigate erosive flows and improve stream health. To handle the magnitude of stormwater generated in the developed areas of the watershed, volume-based stormwater controls are the most effective BMP. Examples of volume-based controls include extended detention basins, bioretention basins, and constructed wetlands. In addition to TSS, these controls should lessen bacteria and nutrient impairments as well.

In addition to stormwater runoff from the developed areas of Gunpowder Creek, the watershed plan also includes BMPs for other land uses that have unique impairments and sources of impairments as discussed above, including rural and agricultural areas.

6.0 Strategy for Success

The *Gunpowder Creek Watershed Plan* is the result of a lot of hard work by staff and volunteers from many local stakeholder groups. Yet, our work is not nearly complete. The final and most important stages are to implement the BMPs identified in the document, monitor their performance, and reassess the benefits of those BMPs (**Figure 18**). While data gathering, analysis, and BMP evaluation are necessary, it would all be for naught without properly implementing the developed strategies. By monitoring and reassessing the projects after implementation, we can increase the effectiveness of the plan by continuing to prioritize the strategies that show the best results in our watershed.

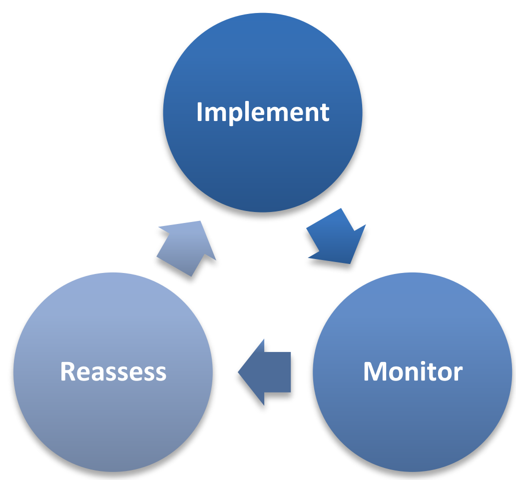


Figure 18: GCWI Watershed Plan Approach

The general public continues to be one of the most important groups to the success of the plan. Six public meetings held during the project were strongly attended by people who live and work in the Gunpowder Creek Watershed. Several of these meetings had close to 100 attendants. Public input from the three public roundtable discussions (**Figure 19**) was directly incorporated into the plan document.

Figure 19: One of Several Well-attended Public Meetings on the Gunpowder Creek Watershed Initiative

Table 1 is a summary of the five questions that were asked to the roundtable groups. Development is obviously a concerning land use within the watershed. Stormwater runoff was the leading problem and priority issue for the roundtable groups, and consequently, the most highly recommended BMPs were detention and retention basins to better control stormwater runoff. Education and more responsible development practices and/or revised ordinances were also recommended by more than half of the roundtable groups.

Table 1: Questions and Dominant Responses from 11 Roundtable Groups with Approximately 70 Participants

Question	Dominant Responses[1]
1. **Why is a clean healthy stream important to you?**	Recreation (73%), Aesthetics (66%), Quality of Life/Health (54%)
2. **What land uses in the watershed are you most concerned about?**	Development (100%)
3. **What do you think are the most common problems?**	Runoff (73%), Flooding/Safety (66%)
4. **What BPMs do you consider feasible in Gunpowder Creek?**	Detention/Retention (82%), Education (66%), Responsible Development/Ordinances (55%)
5. **What issues in Gunpowder Creek do you consider a priority?**	Stormwater Runoff (66%), Flooding (55%)

[1]Responses that were listed by more than half of the groups.

Sub-watershed Prioritization

Sub-watersheds were prioritized for implementation, according to the list below, based on the extent of the impairment and number of identified opportunities within each sub-watershed, cost, and feasibility. However, GCWI intends to evaluate all opportunities for measurable improvement in Gunpowder Creek as they arise in order to leverage the most benefit with the available funding. For these reasons, the priority sub-watersheds may be rearranged as implementation progresses and opportunities become available in the watershed.

1. South Fork (developed headwaters)
2. Riddles Run (agricultural headwaters)
3. Lower Gunpowder (undeveloped bottomlands)
4. Fowler Fork (mixed rural/developed headwaters)
5. Upper Gunpowder (developed headwaters)
6. Long Branch (agricultural headwaters)

Overall Watershed BMPs

The following BMPs are considered appropriate measures to implement throughout the watershed.

- Training and technical support program
- Coordination with NKU's Stream and Wetland Restoration Program
- Watershed coordinator position
- Review and Revision of Rules and Regulations
- Success monitoring and analysis
- Stewardship programs
- Riparian plantings (**Figure 20**)

Figure 20: Example of riparian plantings

Training and technical support for local designers and contractors can provide education on the various BMPs and implementation strategies within the watershed while applying to other watersheds as well. The education component pairs nicely with NKU's existing program, which stabilizes degraded stream reaches and restores habitat after developments or other projects physically alter streams. The training may lessen the need for the NKU restoration program, by educating designers and contractors on cost-effective methods of achieving the desired outcomes while caring for stream health. Creating a watershed coordinator position would provide a staff member to manage and coordinate the implementation efforts, including coordination between regional agencies such that local flood control projects in Florence or the Whispering Trails Subdivision are implemented in a way that also improves channel erosion and water quality in the stream network.

The roundtable discussions brought up the need to review and revise the region's stormwater Rules and Regulations. Adapting the BMP Manual that was developed by SD1 and the City of Florence could incorporate the lessons learned from our monitoring effort such that stormwater controls are designed to do a better job of mitigating channel erosion.

Success monitoring and analysis calls on both the GCWI and SD1 as well, to continue water quality and hydromodification monitoring within the watershed in order to track progress and reassess our BMP strategies as we gain more information on their effectiveness. Stewardship programs could be led by the watershed coordinator and would educate and provide outreach programs for homeowners as well as large corporate and institutional properties. Lastly, installation of riparian plantings could buffer overland stormwater runoff prior to entering the creek.

Developed Headwaters BMPs

The developed sub-watersheds have the greatest pollutant loads for TSS and bacteria along with the worst biological indicators. The developed areas were also the biggest areas of concerns for the public, with known stormwater, flooding, and erosion issues. These sub-watersheds are the highest priority for focused efforts to mitigate erosive flows that have altered the habitat, impaired the water quality, and lowered the biologic integrity. The following BMPs are considered appropriate measures to implement in the developed headwater sub-watersheds.

- Bioretention
- Detention basin retrofits (**Figure 21**)
- Detention basins
- Wetland creation/restoration
- Pet waste program

Figure 21: Detention basin retrofit at Northern Kentucky site after installation (top) and detaining stormwater during rain event (bottom)

Many of the BMPs identified for the developed sub-watersheds are stormwater controls, which will be implemented to mitigate erosive flows. While the implementation methods may differ between each, these volume-based BMPs will detain stormwater runoff and improve the treatment of sediment, bacteria, and nutrients from the runoff. Infiltration-style BMPs are generally limited in our region due to the prevalence of clay soils that restrict infiltration rates.

Of the volume-based BMPs that have been selected, costs and siting restraints will impact how and where they are implemented. Retrofitting existing detention basins is 10 to 100 times more cost-effective than creating new detention basins, but will not work where basins do not currently exist. Retrofits improve existing detention facilities as they hold back more water during relatively small rainfall events to improve water quality treatment and reduce stream erosion, while allowing larger events to pass through the basin as originally designed. New detention will be focused in areas with large amounts of impervious area that are currently not detained and will likely require coordination with private property owners. Bioretention could also be installed in these situations and will be evaluated on an individual basis. Wetland creation and restoration may be utilized in low-lying areas adjacent to the channel.

Implementation of a pet waste program, specifically in areas with high dog-walking traffic, could have a significant impact on bacteria in the stream (**Figure 22**).

Figure 22: Effective pet waste program educational signage

Agricultural BMPs

For cattle and horse farms, livestock exclusion fencing has been considered an appropriate measure to implement. In addition to removing cattle from the stream, this effort will create riparian buffer zones, which will help in filtering cattle waste in overland runoff.

Undeveloped Areas/Forestry BMPs

In undeveloped and forested areas, conservation of open space has been considered an appropriate measure. At the rate that Boone County is developing, identifying and preserving green space is vital to protecting the quality of the county's water resources. The GCWI has already identified publicly owned undeveloped lands that can be targeted for conservation practices.

7.0 Making It Happen

The efforts completed to date would mean nothing if the plan was not well executed, and this section highlights the "who" and "how" for implementing the *Gunpowder Creek Watershed Plan*.

Mark Jacobs from BCCD has done a phenomenal job to date, serving as the Watershed Coordinator, and the GCWI Steering Committee has elected to have him continue in this role. Mr. Jacobs, along with members of the Technical Sub-committee, will be the implementation undertakers. The Steering Committee, outlined in Section 1.0, will continue to meet at least every other month to guide implementation efforts.

Public outreach has been integral to the plan's success so far and will continue. The media campaign, presentations, and public meetings have been valuable. Continued efforts will continue in these realms, including articles in the Conservation District's and County's newsletters. Fundraising will be important to continuing efforts. The funding to date has been primarily through a FFY 2009 Kentucky Nonpoint Source Pollution Control Program grant and many non-Federal sources. This funding will not cover implementation. A grant request has been submitted for FFY 2014 for $1,000,000. The local match portion of $400,000 would likely come from BCCD, SD1, Boone County Fiscal Court, the City of Florence, Boone County Parks, and volunteer time. Additional funding for the GCWI will be sought through local and regional private foundations as well as local, State, and Federal grant sources that may be identified.

Highlighted in **Figure 18**, monitoring and evaluating the in-stream success of the implementation efforts are priorities for the GCWI. GCWI will develop a KDOW-approved monitoring plan and Quality Assurance Project Plan (QAPP) to continue to monitor at the established stations. Success will be measured via implementation rate and water quality results from a KDOW-approved in-stream success monitoring program. The plan will be evaluated and updated as implementation efforts continue.

A big thank you must be expressed to everyone who had a hand in the development and ongoing implementation of the *Gunpowder Creek Watershed Plan*. While there is still plenty to do, your involvement and interest to date, along with the project stakeholders, has been greatly appreciated. Moving forward, we ask you to continue to be stewards of the watershed, diligently looking for any opportunity that may make a considerable impact on today's conditions of Gunpowder Creek. We must capitalize on the existing resources and piggyback on both existing and upcoming efforts to be successful. A heartfelt thank you goes out to all.

Glossary of Terms

Blue line streams: A stream that appears in blue on a USGS topographic map

Dry weather: Event that experienced less than or equal to 0.7 inches of rainfall within 48 hours prior to of the sample date (for purposes of this document)

Geomorphology: The study of landforms and topography, with an emphasis on geologic/topographic formation and movement.

Nutrients: Nitrogen and phosphorus (for purposes of this document). High levels of nutrients in the stream can lead to excess growth of algae and other aquatic plants, altered stream habitat, and degraded biological conditions.

Point Source: A specific source of pollution that can be identified and monitored, such as a pipe discharging into the stream.

Specific Conductance: A measure of the amount of ions in the water, which indicates how well the water can conduct electricity. Typically, high levels of specific conductance are related to high levels of dissolved solids in the stream.

Wet weather event: Event that experienced over 0.7 inches of rainfall within 48 hours prior to of the sample date (for purposes of this document)

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