LYNCHBURG COLLEGE - FRESHWATER ECOLOGY CLASS OF SPRING 2012

Lynchburg Area Stream Health

A water quality assessment of Blackwater Creek Watershed

5/4/2012

ABSTRACT

The purpose of this study was to examine the water quality in the Blackwater Creek watershed and assess any potential land-use impacts that may be occurring. In order to do so, we broke the study into four sections (physical, chemical, macroinvertebrate, and fish) so as to test water quality based on those four parameters. Seven locations were analyzed in relation to state government land-use records, with the intent of deciphering any notable impacts. Overall, the Blackwater Creek watershed has showed a decline in water quality throughout the duration of this study. Continued urbanization shows a trend with this water quality degradation, so best management practices were suggested. The study concludes with a tie-in to the Lynchburg College campus and its concerns regarding College Lake.

INTRODUCTION

Due to rapid urbanization and increased development, there has been a strong concern regarding the water quality of the Blackwater Creek watershed in Lynchburg, Virginia. This concern has prompted a study of the water quality of the Blackwater Creek watershed by Lynchburg College students, to be compared to studies conducted from previous years.

The means by which we utilize the land around us have a strong impact on water quality, adversely affecting all living systems within that watershed. An example of an unfavorable land-use practice is the use of impervious surfaces, such as parking lots. Impervious surfaces do not provide proper water infiltration, preventing water from properly filtering through the ground and into nearby streams. Instead, the runoff of water empties into streams at a much quicker pace, causing stream levels to rise and even adding pollutants.

The measurement of stream health and its response to a variety of environmental stressors, including land use, requires well tested indicators of ecological integrity (Allan, 2004). Composite measure, such as IBI, fish count, water chemistry and physical characteristics are very useful in detecting overall stream degradation.

According to a recent study in Argentina, macroinvertebrates were good indicators of land-use impact and water quality conditions, making them useful tools in identifying disturbances in streams (Miserendino et al., 2011). In this assessment, macroinvertebrate metrics will be calculated and used as water quality indicators.

Urbanization compromises the biotic integrity and health of streams. Indicators of integrity loss, such as macroinvertebrates and fishes are necessary to identify urban effects (Walters et al., 2009). In addition to macroinvertebrates, we will also collect and identify fish samples and use the index of biological integrity (IBI) to assess water quality.

This study also examines the physical characteristics and water chemical make-up of the Blackwater Creek watershed. Inputs of phosphorus and nitrogen to freshwaters can cause excessive aquatic plant growth, depletion of oxygen, and detrimental changes in diversity of aquatic life (Chambers et al., 2010). By conducting chemical tests of the Blackwater Creek watershed, phosphorus and nitrogen levels will be analyzed, along with levels of pH, conductivity, and other properties.

By determining the fish and macroinvertebrate species present and by evaluating water samples, a well-supported assessment of the water quality in the Blackwater Creek watershed can be reached. This assessment can then be compared to previous years' studies of the watershed to determine any trends of improvement or decline. Examples of best management practices (BMPs) can be suggested in order to improve future water quality in the Blackwater Creek watershed.

The Blackwater Creek watershed is located in south-central Virginia and covers an area of roughly 42,000 acres. It consists of three jurisdictions responsible for land management: Lynchburg City, Bedford County and Campbell County (Shahady, 2006). Seven subwatersheds that make up the Blackwater Creek watershed include Upper Ivy, Middle Ivy, Lower Ivy, Lower Blackwater, Burton, Dreaming Creek, and Tomahawk. An eighth subwatershed, Middle Blackwater, was not included in our study.

The Upper Ivy subwatershed is located in the northwest area of the Blackwater Creek watershed (Figure 1). Chaffin Farm was used as the sampling site for this subwatershed. Upper Ivy is characterized by 53% forest, 42% agricultural, and 5% commercial land use.

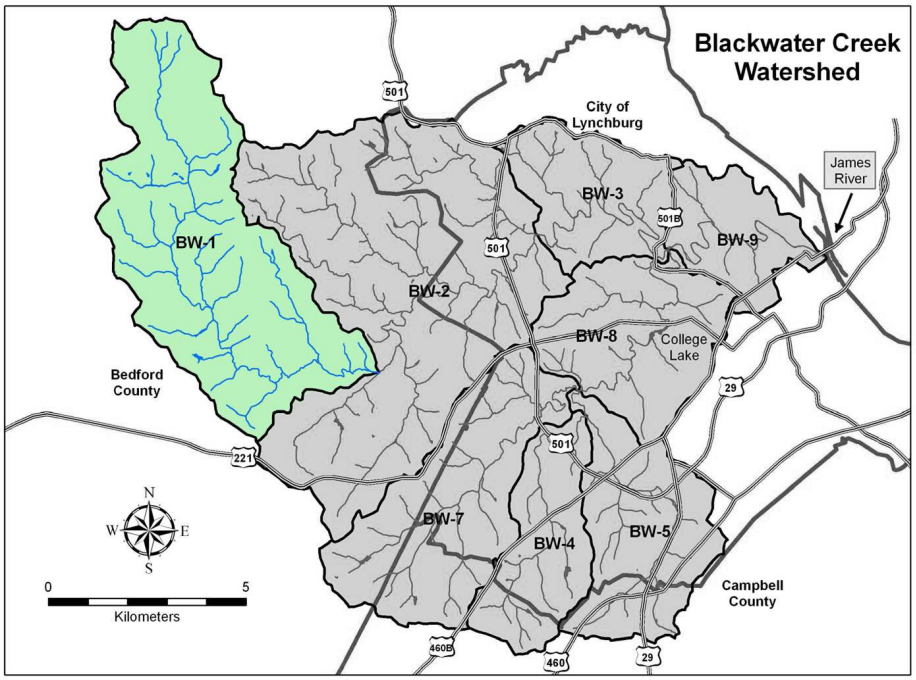

Figure 1. Upper Ivy subwatershed

The Middle Ivy subwatershed is located southeast of Upper Ivy and is characterized by 45% forest, 35% agricultural, 14% commercial, and 6% residential land use. (Figure 2). Hooper Road was the sampling site for Middle Ivy.

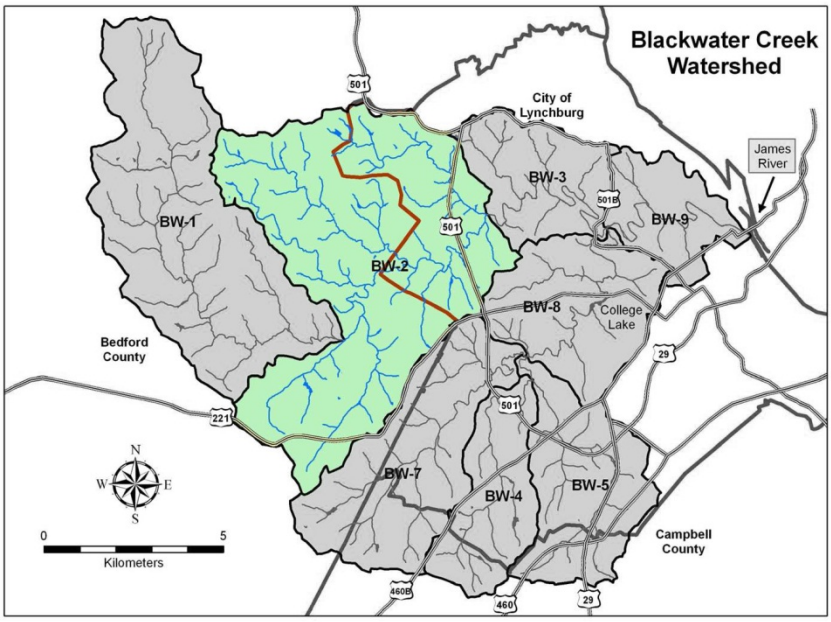

Figure 2. Middle Ivy subwatershed

In the north east portion of the Blackwater Creek watershed is the Lower Ivy subwatershed (Figure 3). Lower Ivy is characterized by 60% residential, 29% forest, 5% agricultural, 4% commercial, and 1% high residential land use. Peaks View Park was the sampling site for this area.

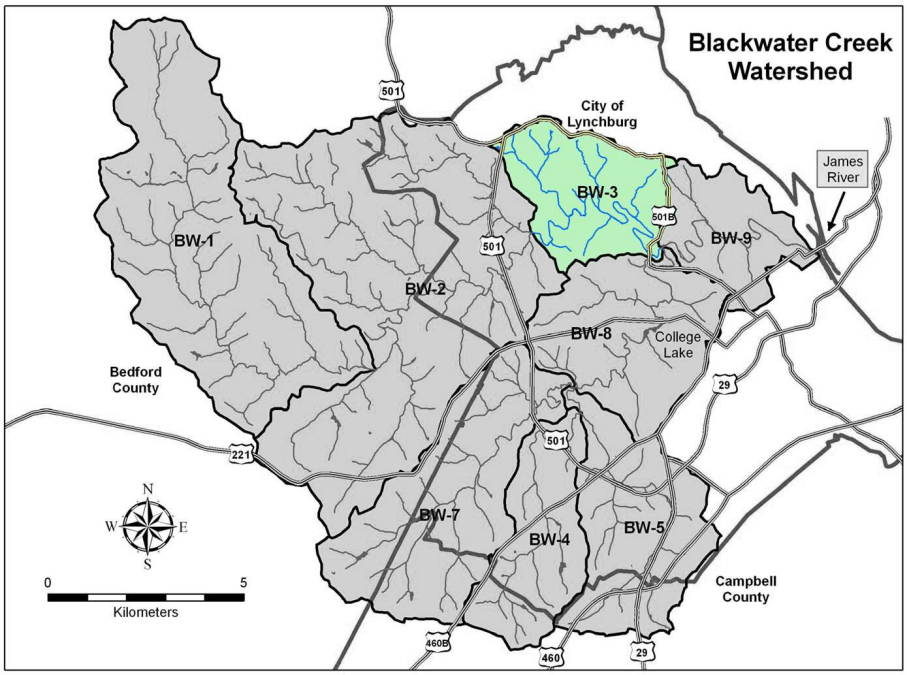

Figure 3. Lower Ivy subwatershed

The Lower Blackwater subwatershed is located on the very north east portion of the Blackwater Creek watershed (Figure 4). It is characterized by 44% residential, 34% forest, 18% commercial, 2% agricultural, and 2% high residential land use. Hollins Mill was the sampling site for Lower Blackwater.

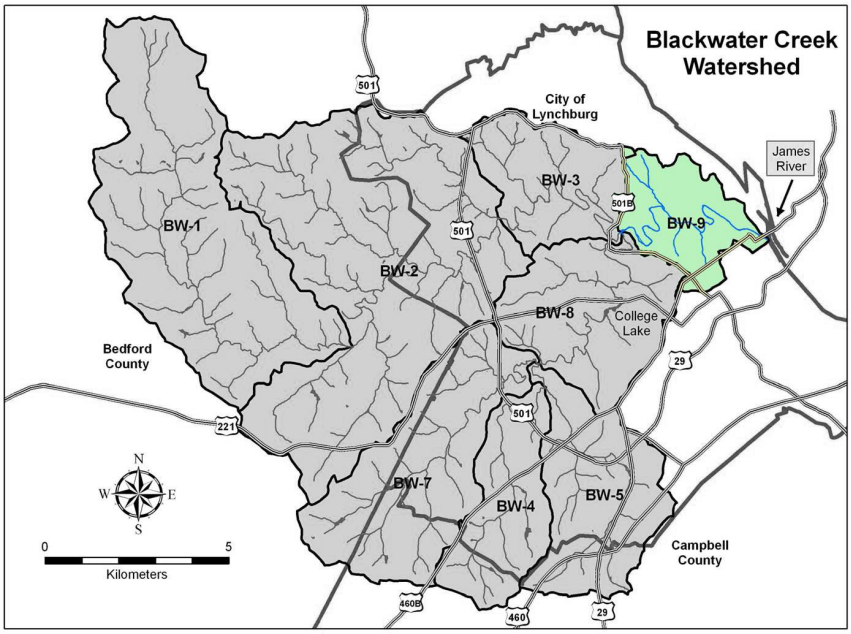

Figure 4. Lower Blackwater subwatershed

In the south east area of the Blackwater Creek watershed is the Burton subwatershed (Figure 5). It is characterized by 37% commercial, 31% residential, 23% forest, 7% agricultural, and 2% high residential land use. Rock Castle Creek was sampled for this subwatershed.

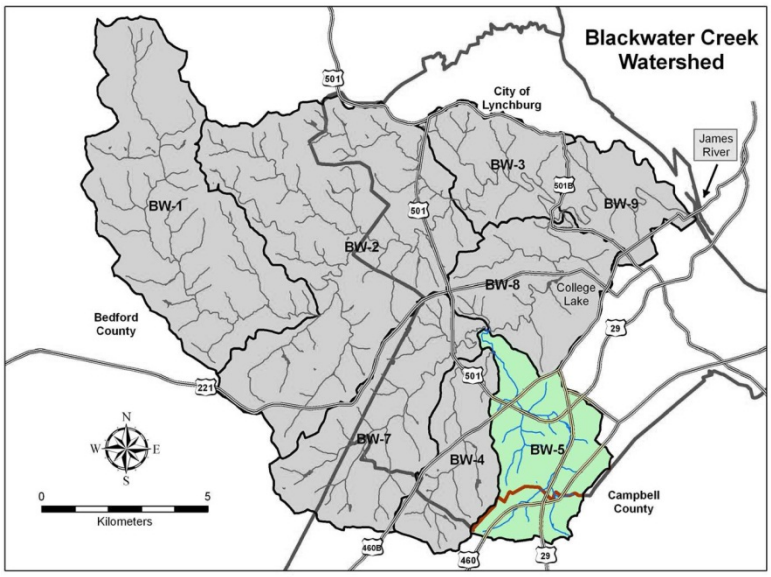

Figure 5. Burton subwatershed

Dreaming Creek was sampled in representation of the Dreaming Creek subwatershed, which is located in the lower-middle area of the Blackwater Creek watershed (Figure 6). Dreaming Creek is characterized by 36% residential, 25% commercial, 20%forest, 17% agricultural, and 2% high residential land use.

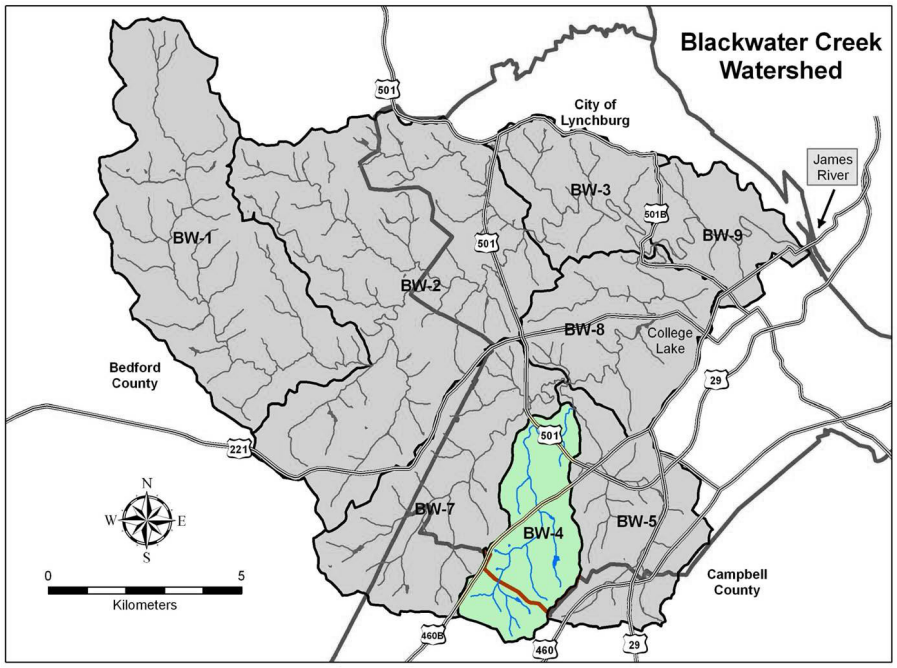

Figure 6. Dreaming Creek subwatershed

Tomahawk Creek was sampled as part of the Tomahawk Creek subwatershed, which is located just west of Dreaming Creek (Figure 7). It is characterized by 37% commercial, 27% agricultural, 21% forest, and 15% high residential land use.

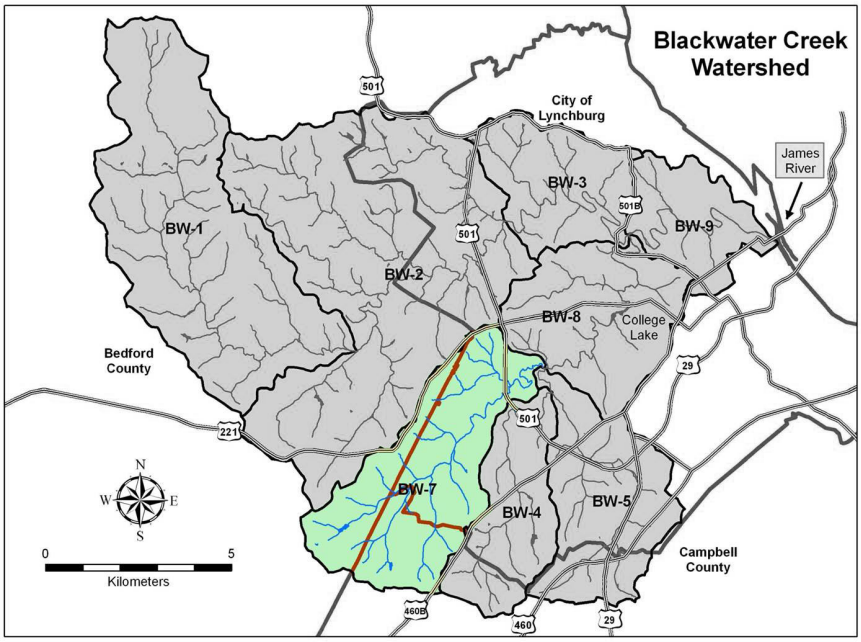

Figure 7. Tomahawk Creek subwatershed

From 2003-2008, Chaffin Farm was found to have the best water quality overall. However, in 2010 Hollins Mill was rated the best in water quality, even though it was the most urbanized area. This improvement is thought to be due to the implementation of best management practices (BMP's) in the Hollins Mill area.

METHODS

Physical

Stream Transect - A stream transect was established at all seven of our sampling locations and the same procedure was followed each time. This was done to provide temporal data on the stream bed condition as well as water level. First, the self-leveling laser transit was set up on the stream bank. To measure the width of the stream at the cross section we used a standard metric tape measure. We then would attach the transit indicator to the meter stick and at half meter or one meter intervals, (depending on the channel width), obtain a stream channel bottom measurement. A GPS unit was used to mark the location of our cross section.

Reach Condition Index (RCI) - To determine the RCI, we first had to establish the reach that we would be surveying. The reach is defined as 30 times the width of the stream channel being surveyed. From our transect we would walk half of the reach distance downstream and half of the reach distance upstream, marking each end of the reach with the GPS unit. While walking the reach sections, we completed the USM Stream Assessment Form for use on streams in Virginia provided by the Virginia DEQ. The RCI is a quantitative tool used to analyze the physical condition of the stream and immediate surrounding area. We use observations as well as qualitative assessment of the streams and surrounding area in order to formulate the basis for the numerical value assigned. The RCI is broken down into 4 Condition Indices which consider channel condition, riparian buffers, surrounding land use, in-stream habitat, and channel alteration which stem from our observation and analysis of the reach.

Chemical

Seven different water quality tests were performed on seven streams in the Blackwater/Ivy Creek watershed. Testing was completed on April 3, 2012. pH testing was completed using a pH meter. Percent dissolved oxygen (%DO), conductivity, and temperature (°C) were all taken using the YSI-85 meter. Sample bottles were also filled at each site to test for phosphorous and nitrate levels in the lab. A separate sample bottle was used so that fecal coliform could be tested at each site as well. At Chaffin farm, the sample was taken at the bridge in juxtaposition to a cow pasture. . At Hollins Mill, the sample collections occurred downstream of the waterfall on the bike path near a parking lot. Hopper Road's test was conducted in a forested area adjacent to a road. Peaksviews sampling occurred at Peaksview Park across a footbridge next to two soccer fields. Dreaming Creek was sampled downstream of a bridge and road. Rockcastle sampling was done off of Wards road near the parking lot of Cracker Barrel.

Sample bottles were hand dipped directly into the stream. A smaller sample bottle used for fecal coliform was filled to the 100 ml mark with water from each sample site.

The fecal coliform (*E. Coli*) was tested using the collilerts method. Auger was added to quantra grid cells along with each sampe and sealed using a quantra tray sealing device. After an incubation period of 18 hours, the trays were viewed under a black light. The number of florescent cells was counted and correlated to an *E. Coli* colony estimation table.

Nitrate and total phosphorous were calculated by using an autoanalyzer. Each sample was digested and standards of 5 ppm and 2.5 ppm nitrate and phosphorous were created. Each digested sample and standard was placed in the autoanlyzer and phosphorous/nitrate levels were calculated by the autoanalyzer using the absorbance curve of the standards.

Macroinvertebrate

Two different sampling methods were used to collect macroinvertebrates, one was by Kick net and the other was by Hess Sampler. To use the Kick net, an area was chosen and then the net was placed up against the stream floor. Then disturbance was created upstream just in front of the Kick net allowing macroinvertebrates to flow downstream into the net. Once the net seemed full it was removed and observed to collect the macroinvertebrates. The Hess Sampler was used differently as it sampled a surface area of 0.1 m^2 per sample. Locating a riffle the Hess was placed firmly on the stream floor with the net facing downstream and the water screen facing upstream. As the sampler was twisted into the streambed; the water and streambed were disturbed allowing the macroinvertebrates and sediment to flow into container cup. The samples from both sampling methods were then put into jars and labeled by site, sample number and sample method. Once in classroom the macroinvertebrates were then put under microscopes and examined and put into their family. Once all macroinvertebrates were counted they were

computed and gave us the stream score. The stream score was based from three categories EPT, PMA and FBI. These measurements take in account the numbers of macroinvertebrates and the type of species. EPT measures the numbers of Families of Ephemeroptera (mayflies), Plecoptera (stoneflies) and Tricoptera (caddisflies) which are indicators of pollution and generally accepted as clean-water specimens. PMA is the measurement of similarity to a non-impacted or target stream based on abundance of the macroinvertebrates family types. FBI measures the sensitivity of water on the macroinvertebrates.

Fish

In conducting our water quality study the fish team used the following materials: waders, 1 – Smith – Root LR-24 Electrofisher Backpack, 4 nets, five gallon buckets, Freshwater Fishes of the Carolinas, Maryland & Delaware, pencil, paper, and a stopwatch. We had four people on our team. One person operated the Smith – Root LR-24 Electrofisher Backpack, two members walked just behind and alongside the shocker with nets to catch fish. Dr. Shahady walked behind the tail with a net and a bucket to temporarily store samples. One person used a stop watch to monitor the eclipsed time. We sampled seven streams. Four were sampled for thirty minutes each: Peaks View, Hollins Mill, Chaffin Farm, and Hooper Road. The total number of fish caught was multiplied by 2 to give us the Catch per Unit Effort (CPUE) score. Three streams were sampled for twenty minutes each: Tomahawk Creek, Dreaming Creek, and Rock Castle Creek. For these sites the total number of fish caught was multiplied by 3 to calculate the CPUE. We walked up stream and sampled both sides of the stream bank as well as the middle riffle habitat where present. Special attention was given to ideal fish habitat to ensure we were able to accurately collect a representative sample. After time expired, three members identified each fish

by species and the fourth wrote down the results. The results were used to determine The Index of Biological Integrity (IBI) score for each stream (Shahady, 90-92).

RESULTS

Physical

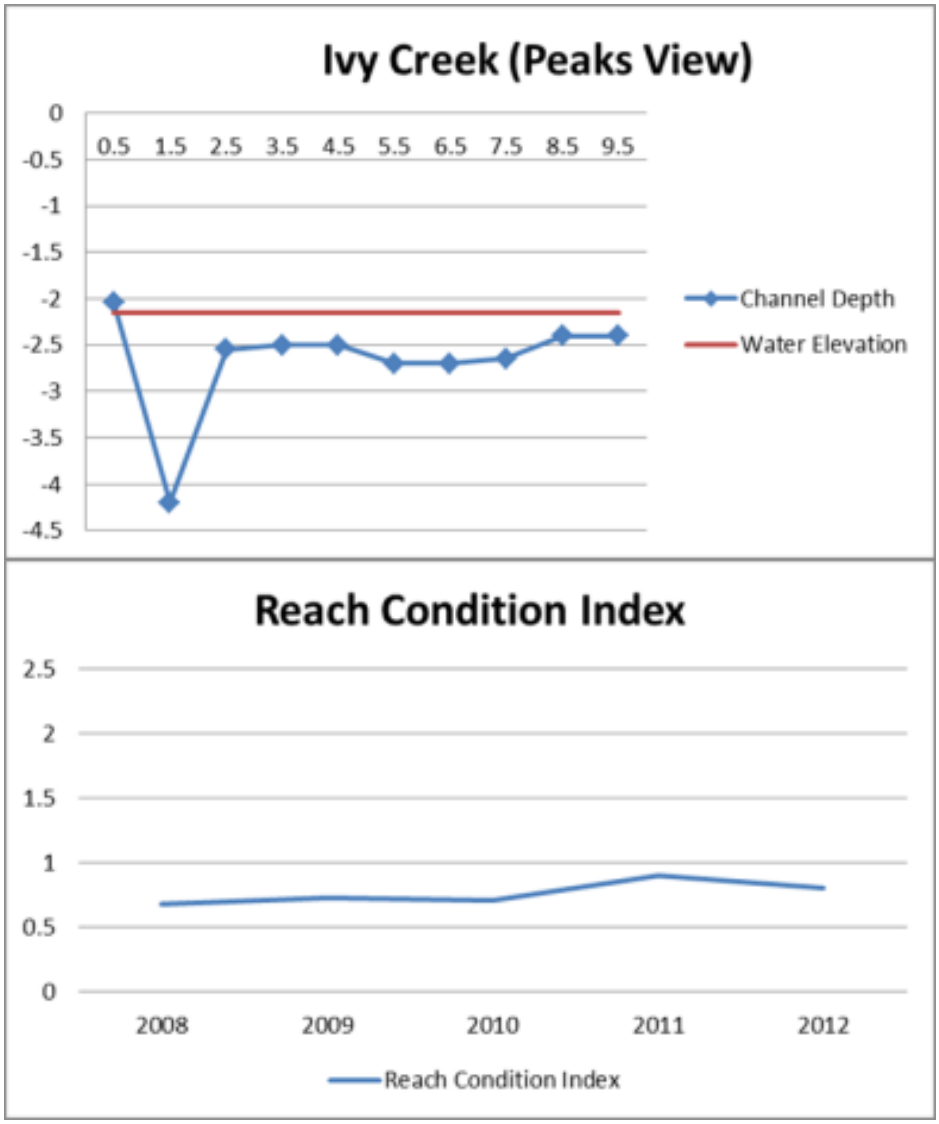

Figure 8. Ivy Creek at Peaks View Park

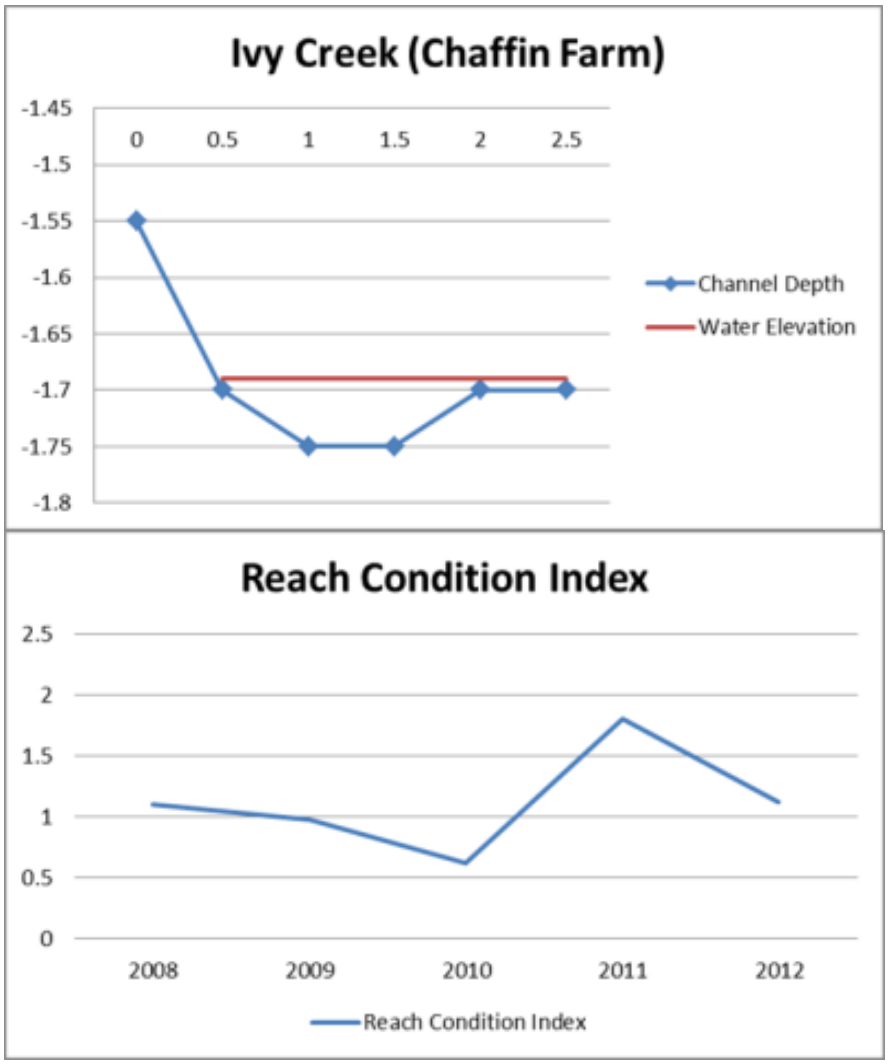

Figure 9. Ivy Creek at Chaffin Farm

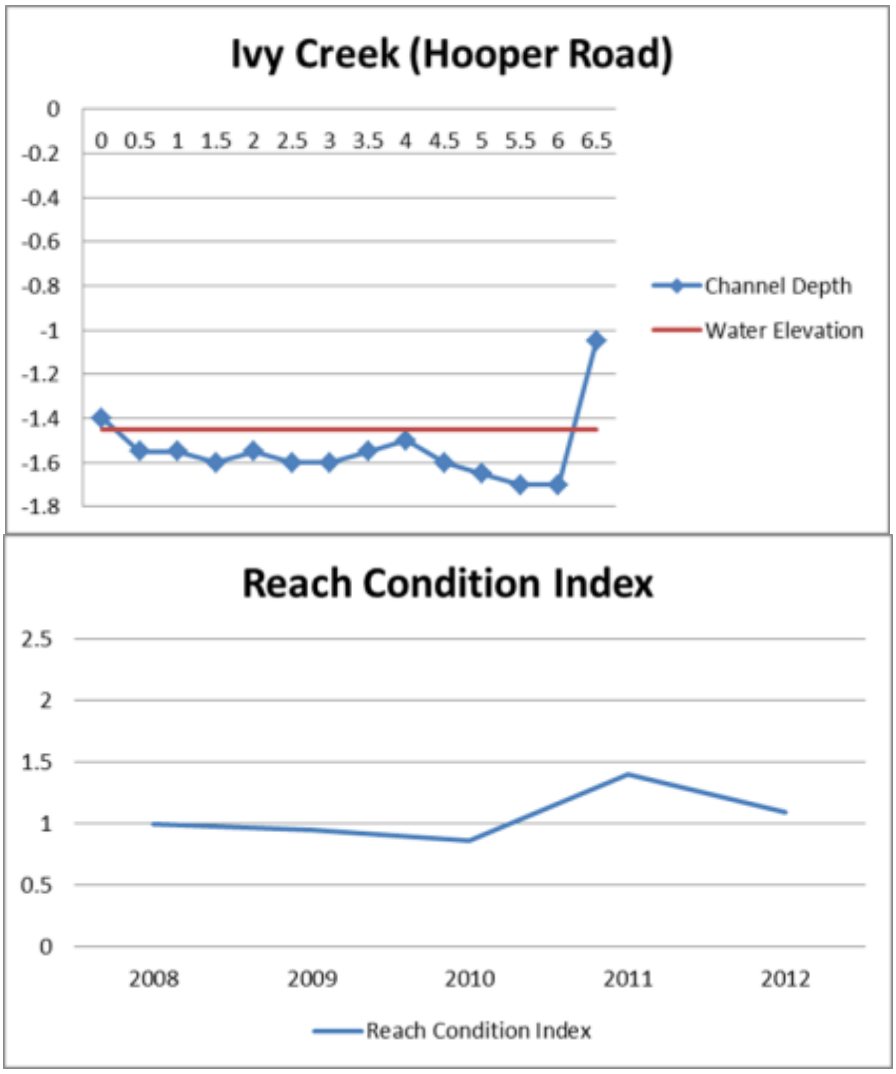

Figure 10. Ivy Creek at Hooper Road

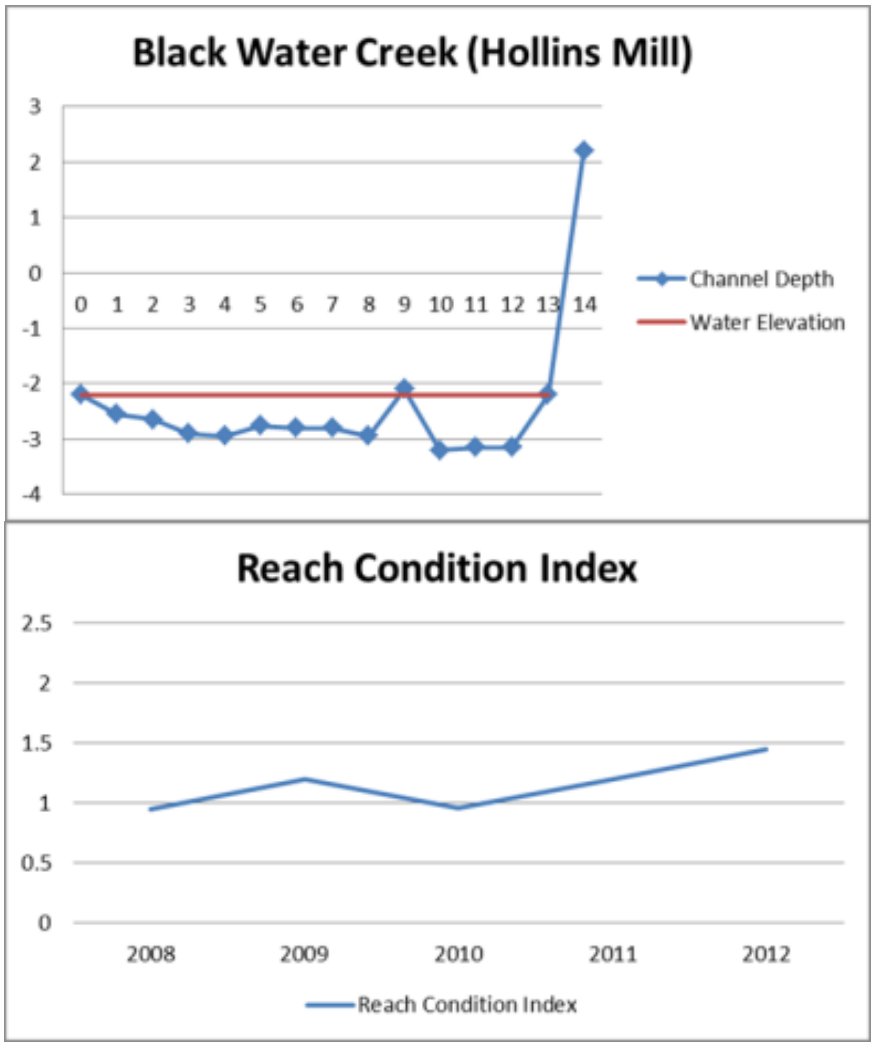

Figure 11. Blackwater Creek at Hollins Mill Dam

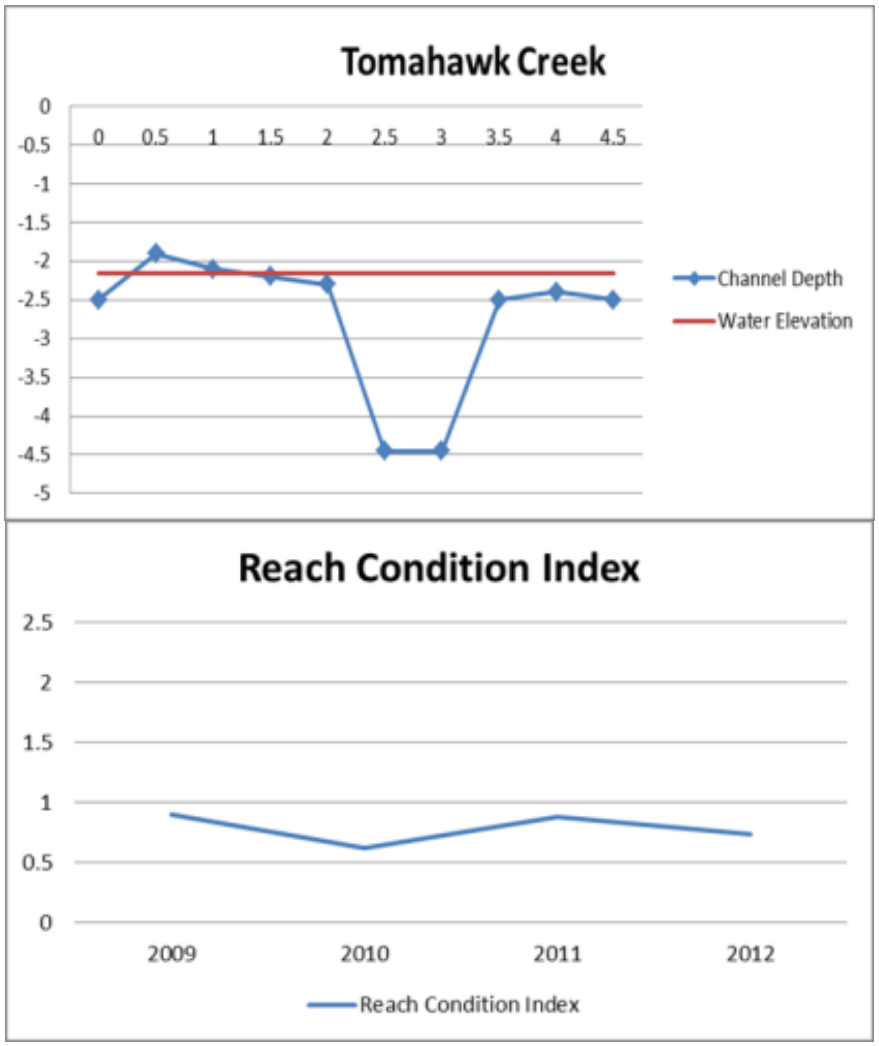

Figure 12. Tomahawk Creek

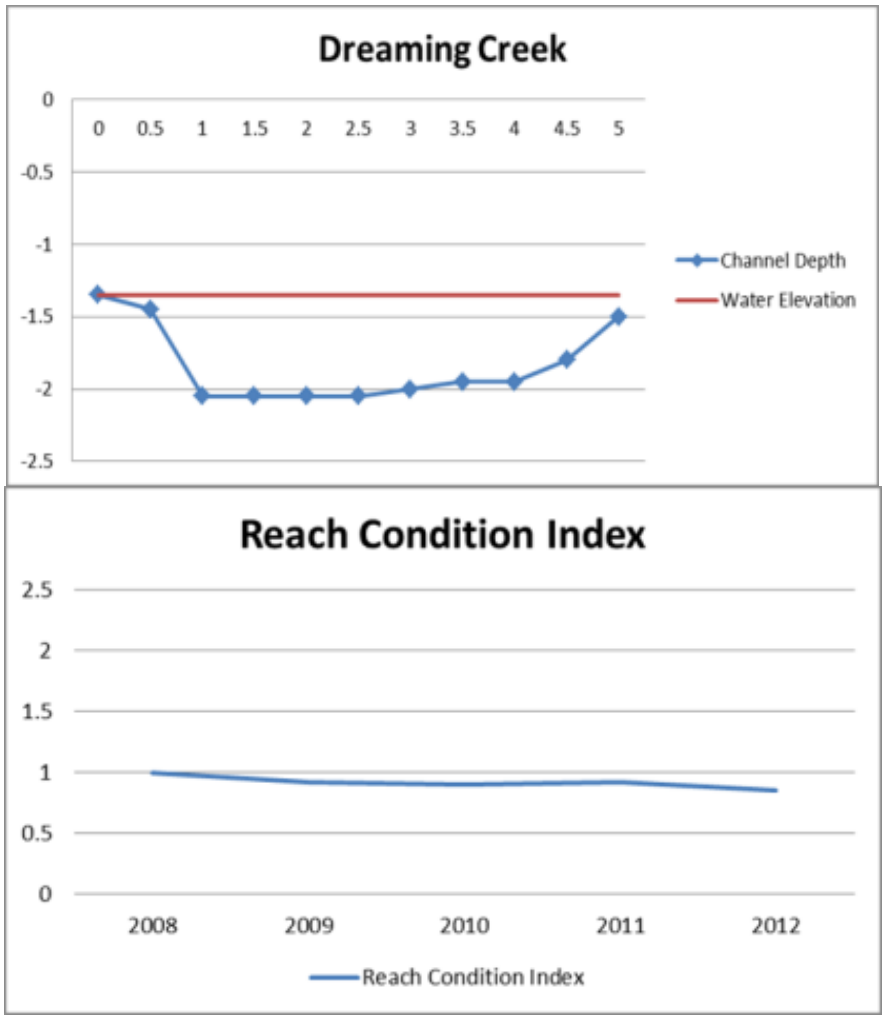

Figure 13. Dreaming Creek

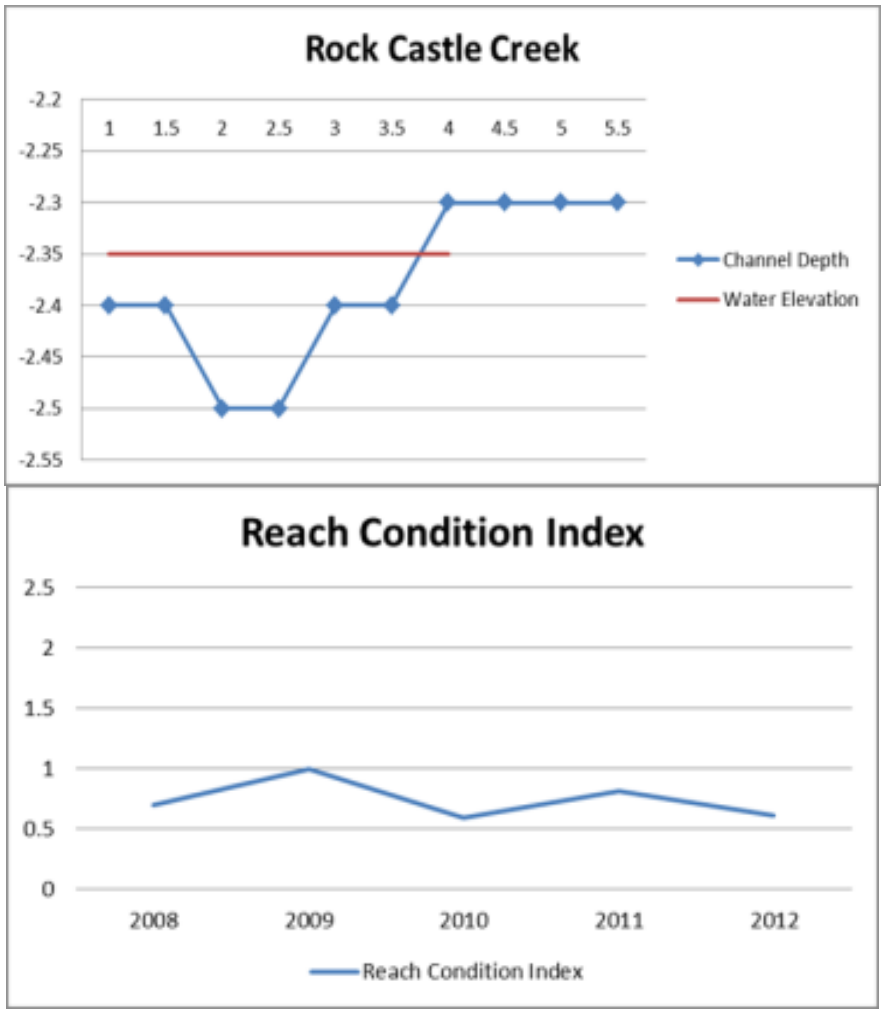

Figure 14. Rock Castle Creek

Site	Reach Condition Index	2008	2009	2010	2011	2012
Rock Castle Creek (Cracker Barrel)		0.7	1	0.59	0.81	0.61
Tomahawk			0.9	0.62	0.88	0.74
Ivy Creek Chaffin Farm		1.1	0.98	0.62	1.8	1.12
Ivy Creek (Peaks View Park)		0.68	0.73	0.71	0.9	0.8
Ivy Creek (Hooper Rd.)		1	0.95	0.86	1.4	1.09
Dreaming Creek (Heritage Funeral Home)		1	0.92	0.9	0.92	0.85
Black Water Creek (Hollins Mill Dam)		0.95	1.2	0.96	1.2	1.45

These values are based on the USM Stream Assessment Form which takes Channel Condition, Riparian Buffers, In-stream Habitat, and Channel Alteration into consideration.

Figure 15. RCI values

The RCI values in our assessment are shown in figure 15, along with the temporal data available. We see that overall, there have been some significant changes to the conditions of the streams. We can categorize the RCI of the streams into three major categories; decreasing in quality, maintaining quality, and improving in quality. The distinctions will be that those that are decreasing have an RCI that is greater than 0.2 less than the previous years' RCI. Those that are maintaining quality are those that have an RCI that is within ~0.1 of the previous years' RCI. Those that are improving in quality are streams with RCI values greater than the RCI value of the previous year. The streams that are decreasing in quality are Rock Castle Creek, Ivy Creek at Chaffin Farm and Ivy Creek at Hooper Road. The streams that are maintaining quality are Tomahawk Creek, Dreaming Creek, and Ivy Creek at Peaks View Park. The stream that is showing an improvement in quality is Blackwater Creek at Hollins Mill Dam.

Some of the factors that appeared to lead to a significant decrease in RCI were increased incision and erosion of stream banks, decreased quality in riparian buffers, loss of in-stream habitat, and changes and alterations in the channel as a result of surrounding land use. The streams within the study that maintained their quality according to RCI have not degraded further, nor showed significant improvement. Conditions have maintained consistent according to the quantitative data on the Stream Assessment Form. This suggests that the efforts to improve local water quality have not aided or threatened stream health. The single stream to show improvement was Blackwater Creek at Hollins Mill Dam. Riparian buffers at this site helped to stabilize banks and provide adequate vegetation protection to the stream. A wide variety of in-stream habitat such as extremely strong riffles and the presence of woody debris throughout the run and pool sections of the stream were present. This data supports that the local measures taken to protect and improve water quality have been at least somewhat successful.

Chemical

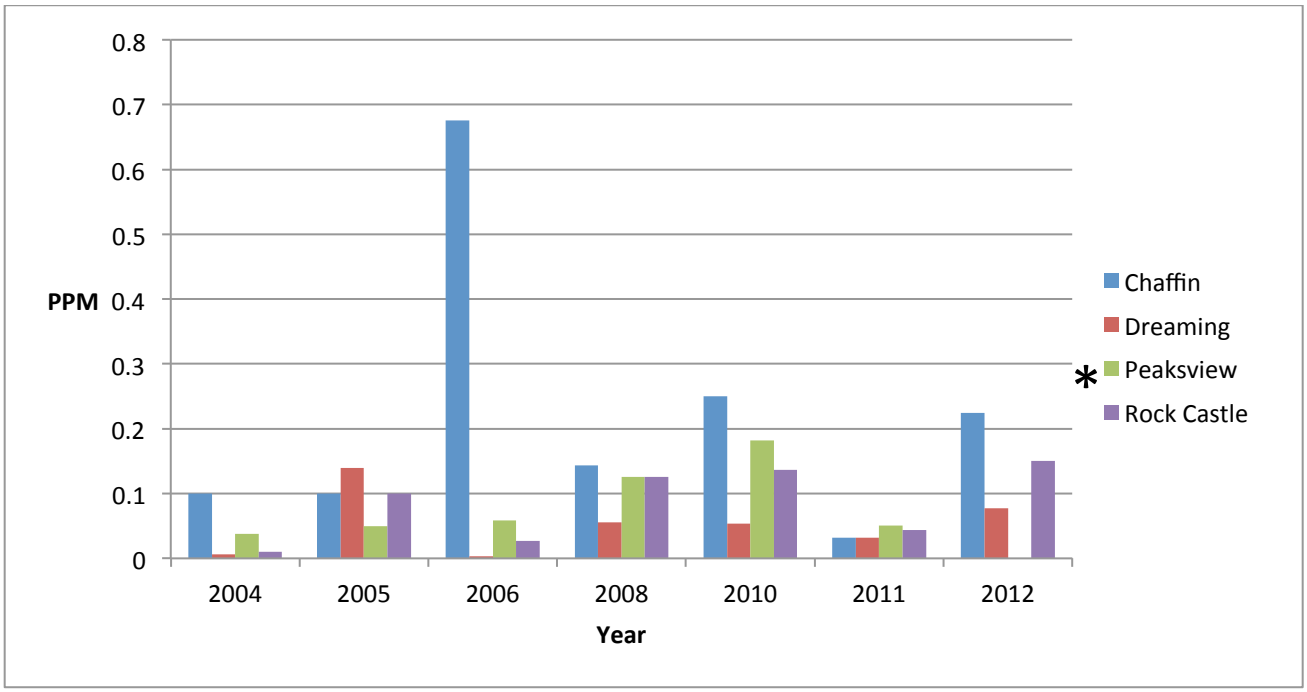

Figure 16: Phosphate (ppm) at selected sites from 2004 to 2012

Four streams were compared when looking at phosphate levels (Figure 16). From 2011 to 2012 phosphate has increased in Chaffin, Dreaming, and Rock Castle creeks. Peaksview Creek does not have a sample due to an improper phosphate digestion.

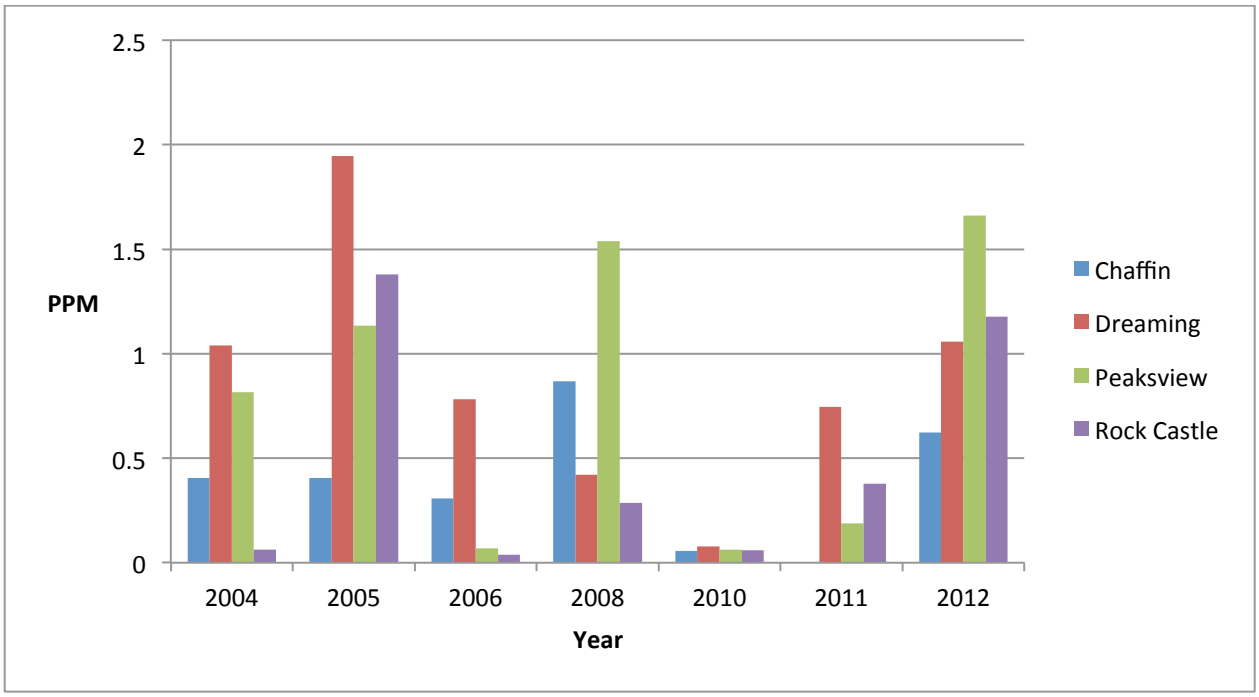

Figure 17: Nitrate (ppm) at selected sites from 2004 to 2012

The same four streams were compared when looking at nitrate levels. Nitrate levels are on the rise for all four streams starting in 2010.

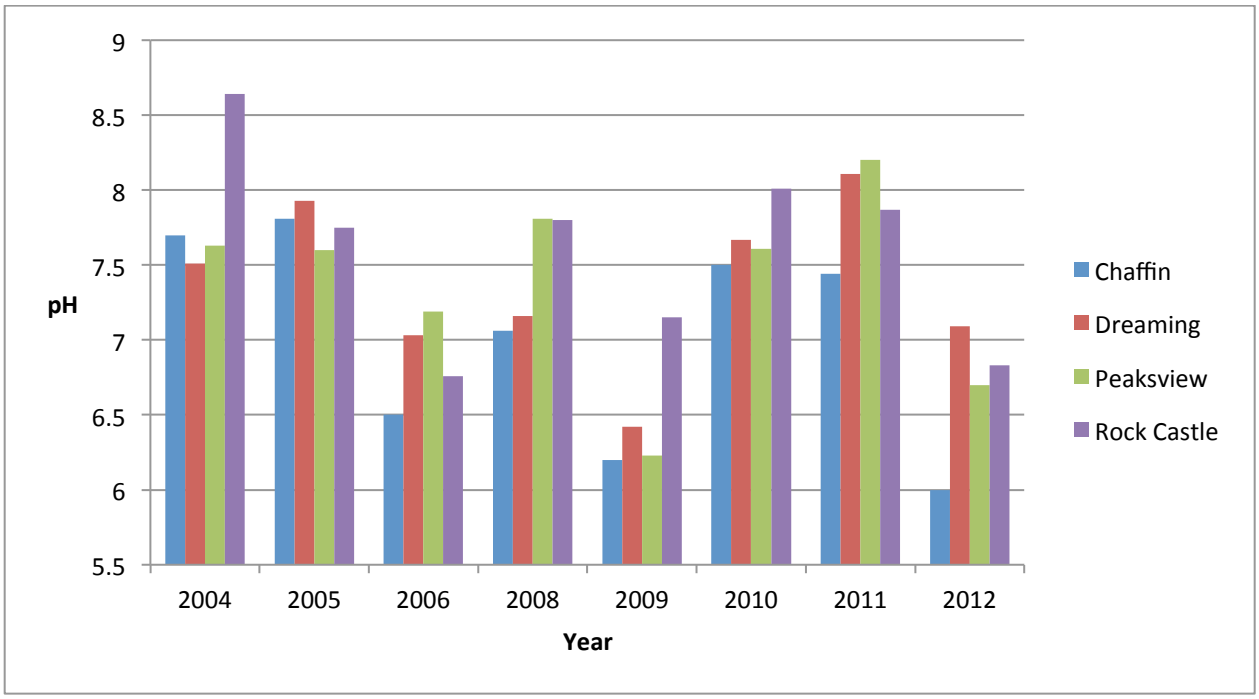

Figure 18: ph Levels from 2004 to 2012 at selected sites

pH levels have varied for all years tested, but stay within the guideline between 6 through 9 pH. pH was lower this year than it has been since 2009.

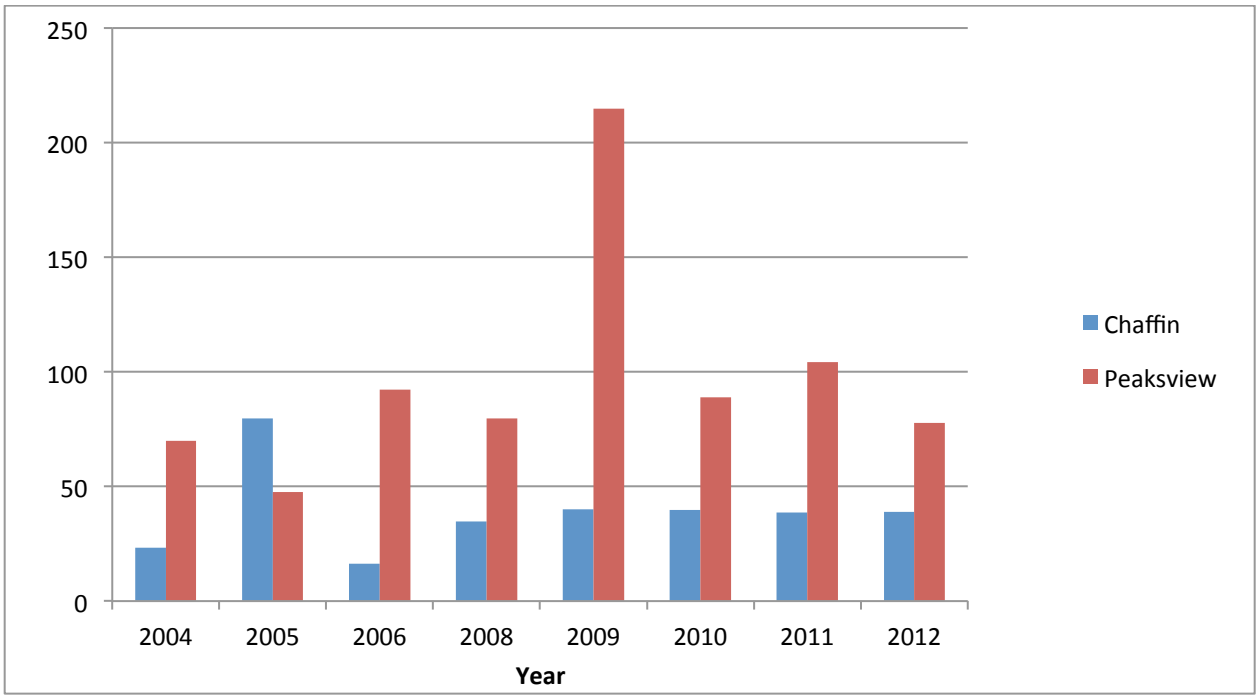

Figure 19: Conductivity (µ S/cm) at Chaffin and Peaksview from 2004 to 2012

A comparison in conductivity between Chaffin and Peaksview shows a consistent level of conductivity for Chaffin while Peaksview is much more inconsistent, going up and down on a yearly basis.

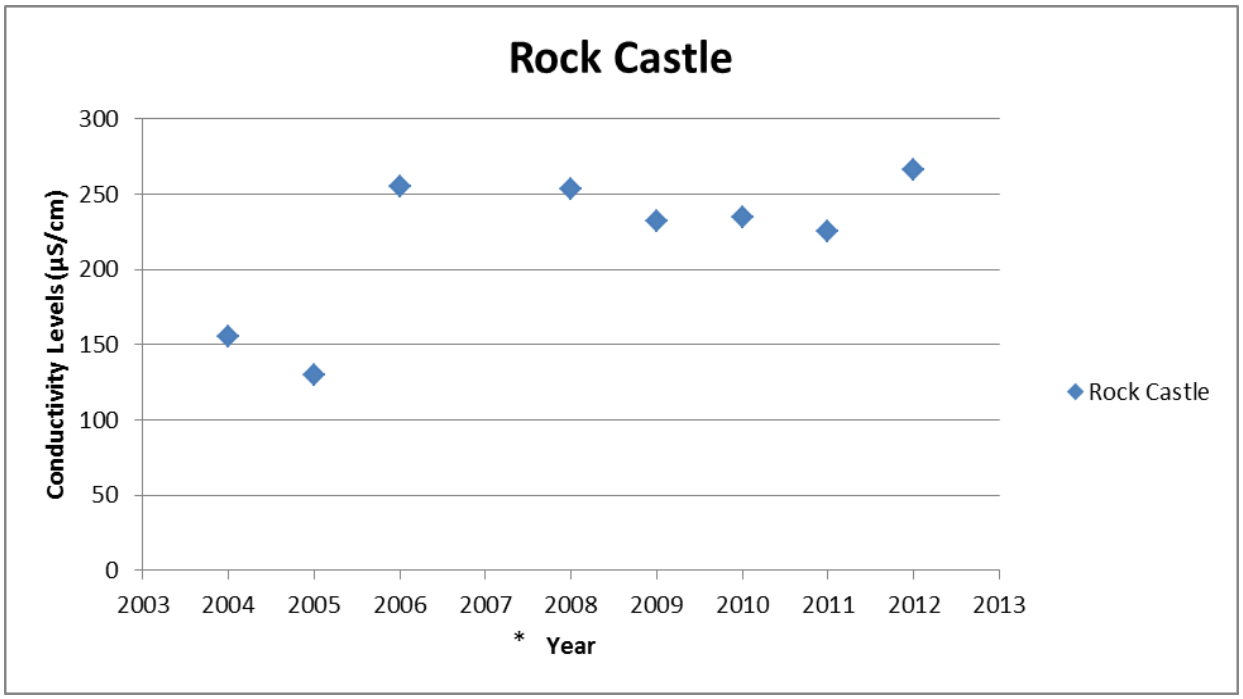

Figure 20: Conductivity Levels at Rock Castle Creek

Rock Castle creek's conductivity level increased substantially in 2006 and 2008, but was on a downward trajectory until 2012.

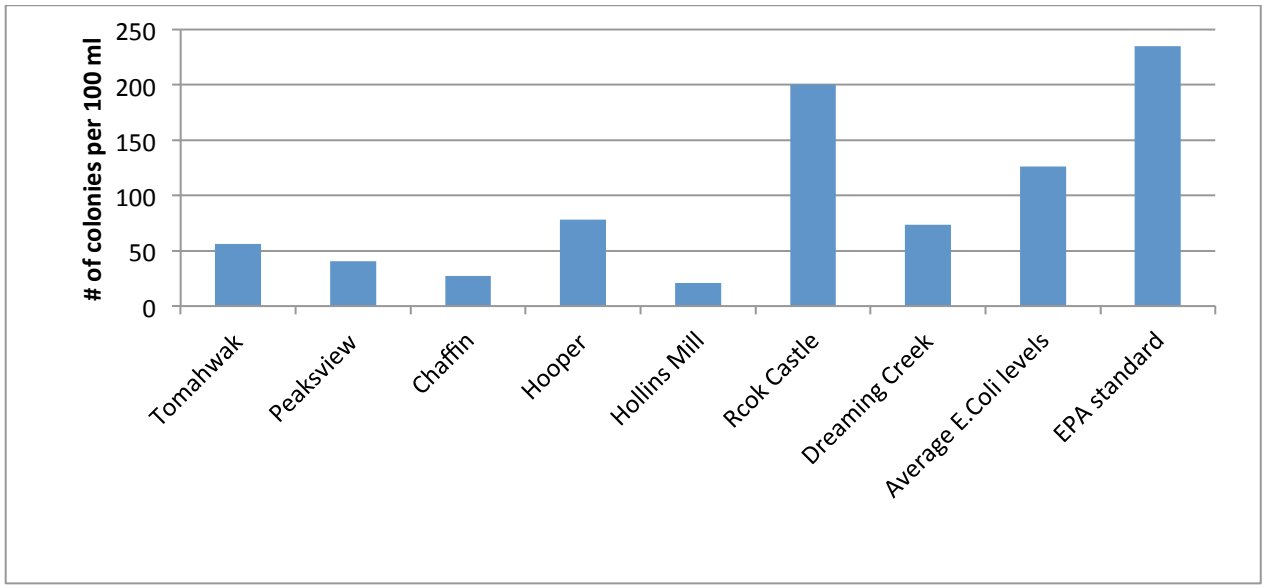

Figure 21: *E. coli* for sample sites compared to EPA standards and average number of colonies

*This was the first year *E.coli* was tested. Levels were all under EPA standards.

Macroinvertebrate

Looking at (Table 1) Ivy Creek at Chaffin Farm draws conclusions of having very healthy water quality by the three categories, EPT, PMA and FBI. With the low number rating of FBI gives the stream pristine water quality allowing species to be vast in numbers. EPT numbers were also excellent as there was great numbers of the families that represent the scale. Along with EPT is PMA, as it too has a high rating of excellent. Based on those numbers presented, Chaffin is our best stream of water quality and over the past years since 2004, Chaffin's water quality has stayed positive and is steadily rising.

Table 1. FBI, EPT and PMA numbers for Subwatershed BW-1 Upper Ivy: Chaffin Farm

Water Quality	FBI	EPT	PMA
Excellent	.00-3.75	>10	>64
Very Good	3.76-4.25	-	-
Good	4.26-5.00	6-9	50-64
Fair	5.01-5.75	2-5	35-49
Fairly Poor	5.76-6.5	-	-
Poor	6.51-7.25	0-1	<35
Very Poor	7.26-10	-	-

Moving ahead to (Table 2) Ivy Creek at Hooper Road showed similar numbers to that of Chaffin farm. Even though the three categories ranked the same with excellent water quality; the numbers did shift in small measurements by EPT, PMA and FBI. Hooper has seen a huge amount of change in water quality since 2011. The stream site is on a huge rise in EPT, PMA and FBI.

Table 2. FBI, EPT and PMA numbers for Subwatershed BW-2 Middle Ivy: Hooper Road

Water Quality	FBI	EPT	PMA
Excellent	.00-3.75	>10	>64
Very Good	3.76-4.25	-	-
Good	4.26-5.00	6-9	50-64
Fair	5.01-5.75	2-5	35-49
Fairly Poor	5.76-6.5	-	-
Poor	6.51-7.25	0-1	<35
Very Poor	7.26-10	-	-

In (Table 3) Blackwater Creek at Hollins Mill, shows a drop in EPT while PMA and FBI numbers stay relatively close with Chaffin and Hooper sites. The reason for the drop in EPT means out of the three species one or even two of them were not of equivalent numbers across the board. Meaning some pollutants in water quality, as these species are very sensitive to pollutants. This numbers run true through the years as in 2012. PMA and FBI have been getting better as the EPT drops more since 2004.

Table 3. FBI, EPT and PMA numbers for Subwatershed BW-9 Lower Blackwater: Hollins Mill Dam

Water Quality	**FBI**	**EPT**	**PMA**
Excellent	.00-3.75	>10	>64
Very Good	3.76-4.25	-	-
Good	4.26-5.00	6-9	50-64
Fair	5.01-5.75	2-5	35-49
Fairly Poor	5.76-6.5	-	-
Poor	6.51-7.25	0-1	<35
Very Poor	7.26-10	-	-

As streams get into more residential and commercial areas numbers start to drop. Seen in (Table 4) Peaks View Park saw changed in two areas, EPT and FBI. EPT went back from very good to excellent water while FBI numbers started to fall as the water saw impact from pollution. Being that it is in a heavy residential area is common for drop in water quality. Yearly the stream has seen an up and down fluctuation in one particular are and that is EPT. FBI and PMA have had a steady pattern in the numbers over the years.

Table 4. FBI, EPT and PMA numbers for Subwatershed BW-3 Lower Ivy: Peaks View Park

Water Quality	FBI	EPT	PMA
Excellent	.00-3.75	>10	>64
Very Good	3.76-4.25	-	-
Good	4.26-5.00	6-9	50-64
Fair	5.01-5.75	2-5	35-49
Fairly Poor	5.76-6.5	-	-
Poor	6.51-7.25	0-1	<35
Very Poor	7.26-10	-	-

Dreaming Creek and Tomahawk Creek are similar in many ways included some of their data. Looking at their numbers (Table 5) being Dreaming Creek (Table 6) being Tomahawk Creek, they have identical numbers of EPT. Being relatively close in location and having similar surroundings, FBI AND PMA ratings change as the water flows downstream. FBI climbed back up to excellent from very good but PMA dropped more to fair. Looking at yearly numbers these two streams have no steady rise or decline, they are very unstable. Here is our first bad overall rating on the watershed.

Table 5. FBI, EPT and PMA numbers for Subwatershed BW-4 Dreaming Creek

Water Quality	FBI	EPT	PMA
Excellent	.00-3.75	>10	>64
Very Good	3.76-4.25	-	-
Good	4.26-5.00	6-9	50-64
Fair	5.01-5.75	2-5	35-49
Fairly Poor	5.76-6.5	-	-
Poor	6.51-7.25	0-1	<35
Very Poor	7.26-10	-	-

Table 6. FBI, EPT and PMA numbers for Subwatershed BW-7 Tomahawk

Water Quality	FBI	EPT	PMA
Excellent	.00-3.75	>10	>64
Very Good	3.76-4.25	-	-
Good	4.26-5.00	6-9	50-64
Fair	5.01-5.75	2-5	35-49
Fairly Poor	5.76-6.5	-	-
Poor	6.51-7.25	0-1	<35
Very Poor	7.26-10	-	-

As the area changes to more commercial, our number ratings start to drop and never looks back. (Table 7) Rock Castle Creek shows all three EPT, PMA and FBI below fair water quality. This stream hasn't change much looking from 2004-2012. However since 2009 the stream has completely reversed numbers making the spike drastically worse in water quality.

Table 7. FBI, EPT and PMA numbers for Subwatershed BW-5 Rock Castle Creek

Water Quality	FBI	EPT	PMA
Excellent	.00-3.75	>10	>64
Very Good	3.76-4.25	-	-
Good	4.26-5.00	6-9	50-64
Fair	5.01-5.75	2-5	35-49
Fairly Poor	5.76-6.5	-	-
Poor	6.51-7.25	0-1	<35
Very Poor	7.26-10	-	-

Fish

Hollins Mill - Water quality at Hollins Mill has slowly improved over time (figure 15). Total IBI in 2005 equals 27. 2012 represents the highest IBI score to date 38.5. Overall we can see an increase in the total number of fish species and an improvement in diversity among populations. Areas for concern include total number of fish species (measurement 1) and total number of darter species / relative percent of darter species to the total (measurement 2).For a middle size stream we should ideally have between 15-30 different fish species. We were able to collect 18 different fish species. While this number is within our ideal range it is on the low end of the scale it is cause for alarm and should be tracked individually in future studies to determine species richness.

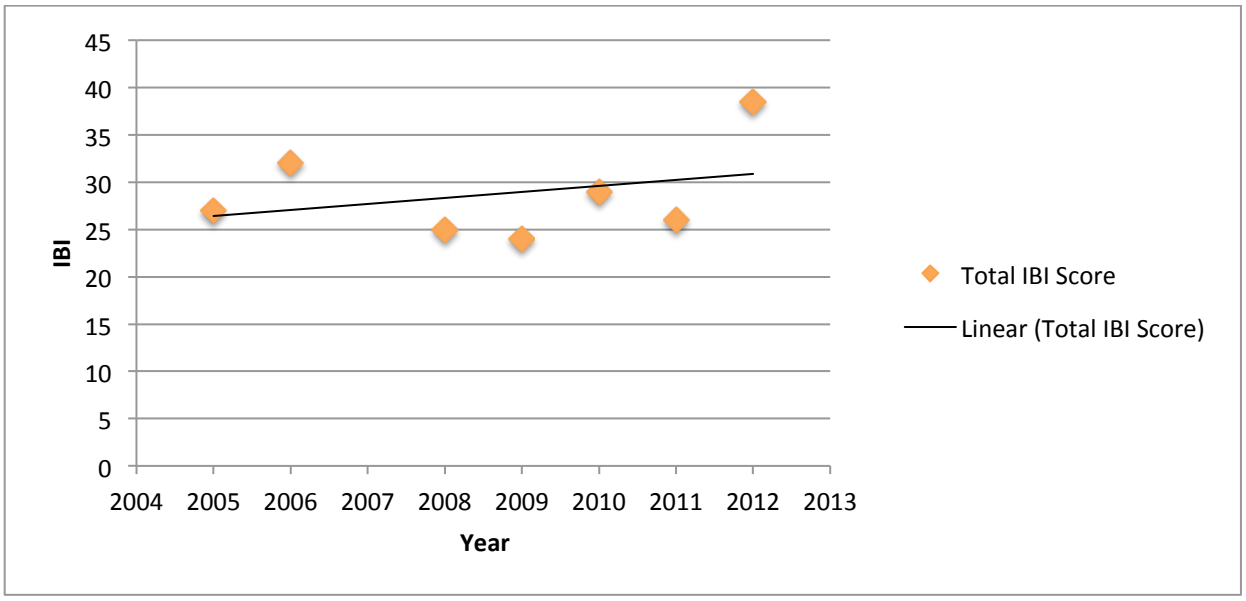

Figure 22: Shows temporal change according to total IBI score for Hollins Mill 2005-2012

Chaffin Farm - Better land management on the farm surrounding our sample site at Chaffin Creek has led to an improvement in fish habitat. Since 2005 the total number of fish species has increased. We have a healthy diverse population of darters indicating riffle habitat is improving. We have also seen a decrease in the percentage of water column insectivores. This is another indication that prior channelization is improving in addition to the return of riffle habitat. The abundance of omnivores or generalist feeders indicates the presence of substantial quantities of plant and animal materials. Improving the riparian buffers should reduce the amount of animal material present in the stream.

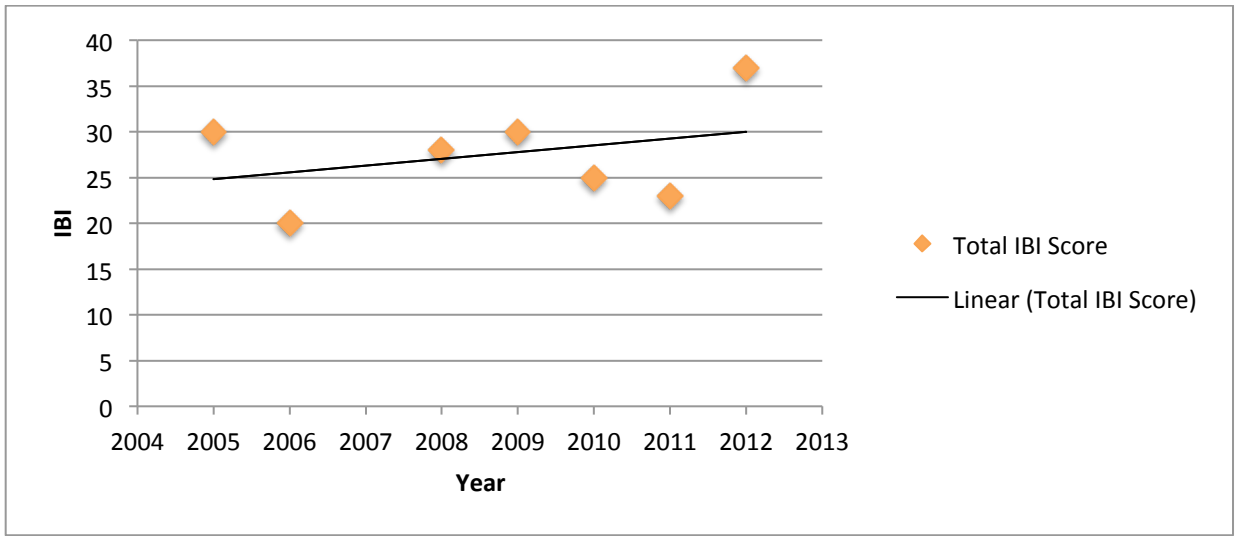

Figure 23: Shows temporal change according to total IBI score for Chaffin Farm 2005-2012

Rock Castle Creek - This streams quality is higher than it had been in the past. This may have been because of ideal weather conditions; which was a warmer winter and we were sampling during a dry period of three weeks of no rain. There was a good concentration of Darters. Darter numbers are important to the indication of stream health because they are an intolerant species and are very sensitive to pollution and stress. So if the stream is unstressed you expect to see high numbers of intolerant species such as darters. There were three scores we had concern about in this stream. One was the number of Top carnivores, high number of omnivore species and higher than ideal water column insectivores. While shocking we found no top carnivores. Top carnivores are essential to the biodiversity of an aquatic environment. Another aspect of the stream that was a concern was the high concentration of omnivores. A high concentration of omnivores suggests lack of competition in the habitat. This plays off of the lack of biodiversity shown also in the lacking of top carnivores. These top carnivores can help to keep omnivores in check. Omnivores have a very large niche space and are very tolerant making them very competitive to specialized species; which have a narrow niche space along with typically being intolerant. An additional aspect that is noted in this stream is a high concentration of water

column insectivores. Sunfish species for example demonstrate a lack of prey diversity. Sunfish are known to feed on insects coming from outside of the stream system which could suggest low concentration of in-stream prey.

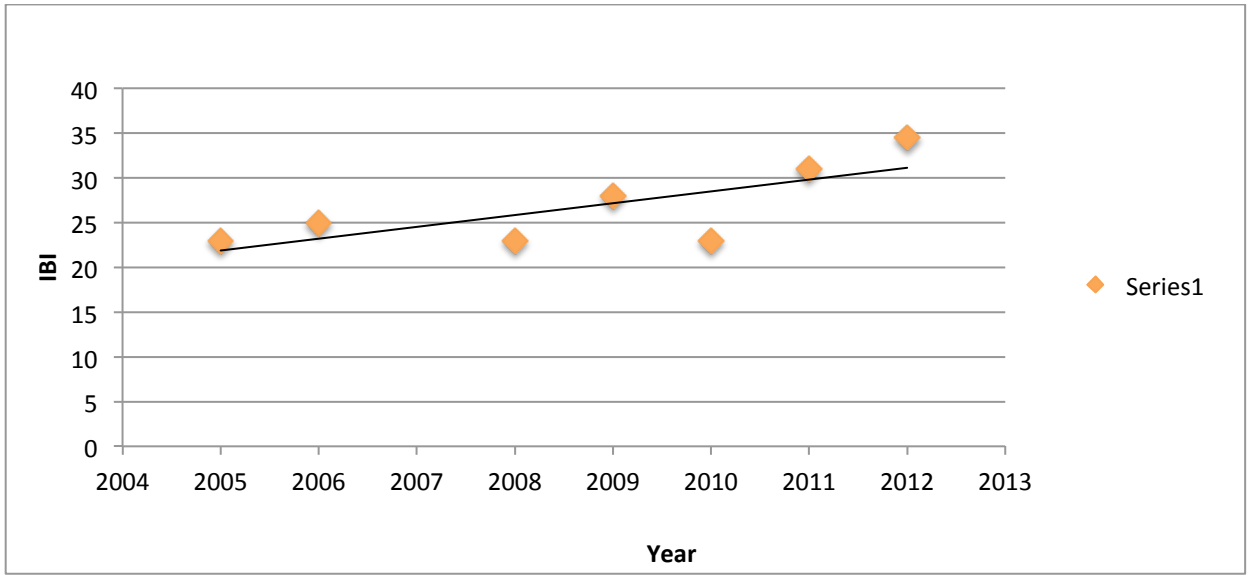

Figure 24: Shows temporal change according to total IBI score for Rock Castle Creek 2005-2012

Hooper Road - The IBI results for Hooper creek are close to ideal across the board. This well balanced IBI score suggests competition and biodiversity. According to our data there is 32.48% intolerant and 17.52% tolerant fish species. We can see from these numbers that the intolerant species are competing well with tolerant fish species. Within the intolerant species measured we had a high diversity of minnow and darter species. Darter and minnow species are found in areas of good riffle habitat. This suggests the riffle habitat has not been degraded by sedimentation. Also in the tolerant species we had good diversity with suckers, and chubs. According to our IBI data presented in the graph below Hooper creek is consistently improving over time.

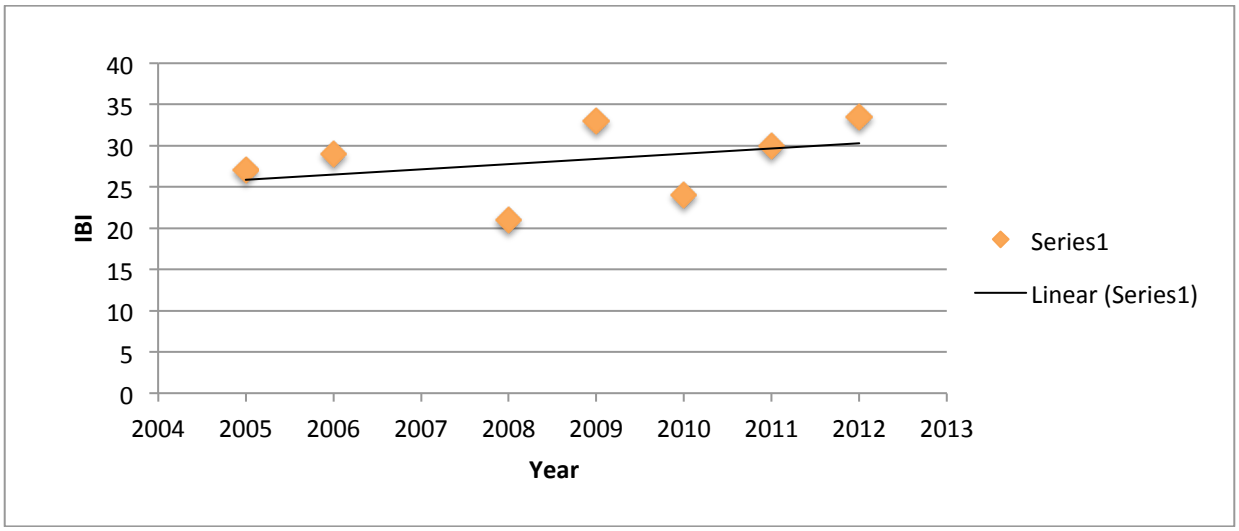

Figure 25: Shows temporal change according to total IBI score for Hooper Road 2005-2012

Peaks View - Peaks View stream's IBI is still showing a decline is water quality. The total amount of fish caught was low, as well as the diversity, that mainly consisted of omnivores and water column insectivores. Water column insectivores are typically feeding on prey that comes in from outside the stream system. A buildup of water column insectivore shows that there is little variety in food available in the stream. When comparing the ideal stream numbers with Peaks View the numbers are very different (Table 8). There were zero suckers found and the number of sunfish deviated from the ideal number by 69%. The lack of fish may be due to the very few riffles that were found; primarily, the fish caught were around debris found in the stream. The very few riffles found and a continuing IBI score decline over the years may be evidence that sedimentation buildup is getting worse and worse. There is very little buffer region around the stream to stop any runoff.

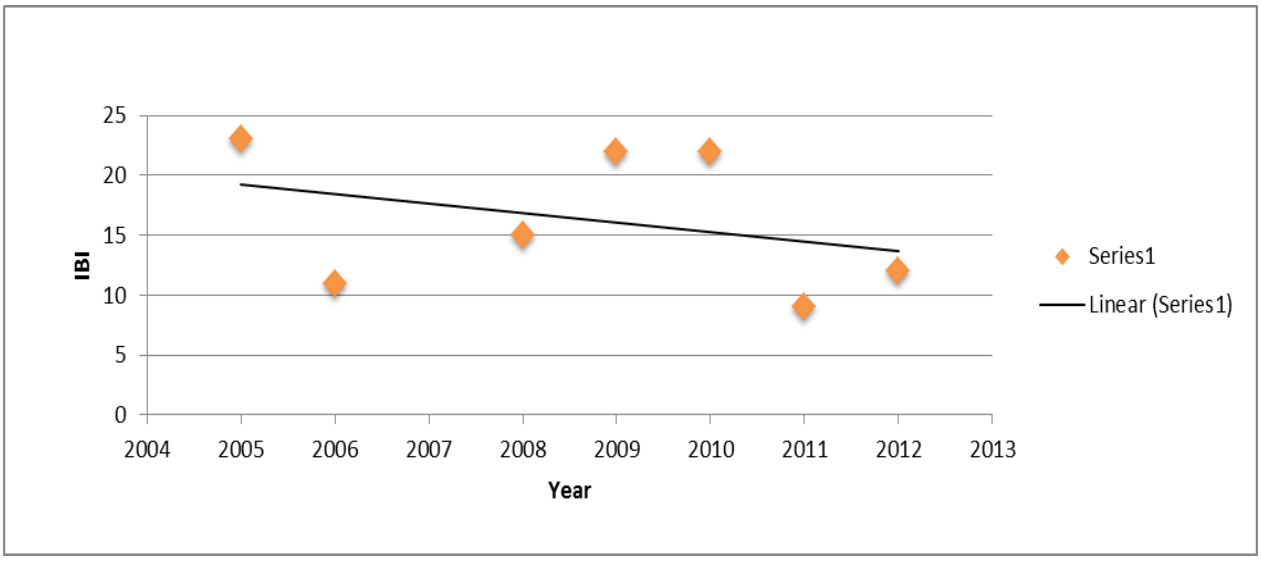

Figure 26: Shows temporal change according to total IBI score for Peaks View 2005-2012. This indicates a decline in water quality over the past seven years

Table 8: Comparison of IBI scores between Peaks View and an ideal stream

	Minnows	*Percids*	*Sunfish*	*Suckers*	*Catfish*
Ideal Stream	40	24	17	12	7
Peaks View	9	4	85.4	0	0

Tomahawk - Tomahawk shows an increase in water quality as well as fish diversity. The ratio between tolerant species and intolerant species is identical; this shows that the biodiversity and competition in the stream is healthy. There was also a decent amount of darters found; darters are found in the riffles of streams. Although there was evidence of some sediment buildup, the amount of riffle habitat was high. Tomahawk has a surrounding area consisting of forest; this provides a good buffer from the residential area that also resides around Tomahawk. The deviation from ideal stream numbers was off; however, there was a lot of diversity among species. The IBI score for 2012 was a 35 which is a good indication that Tomahawk is resilient, and since 2010, Tomahawk's water quality has been increasing.

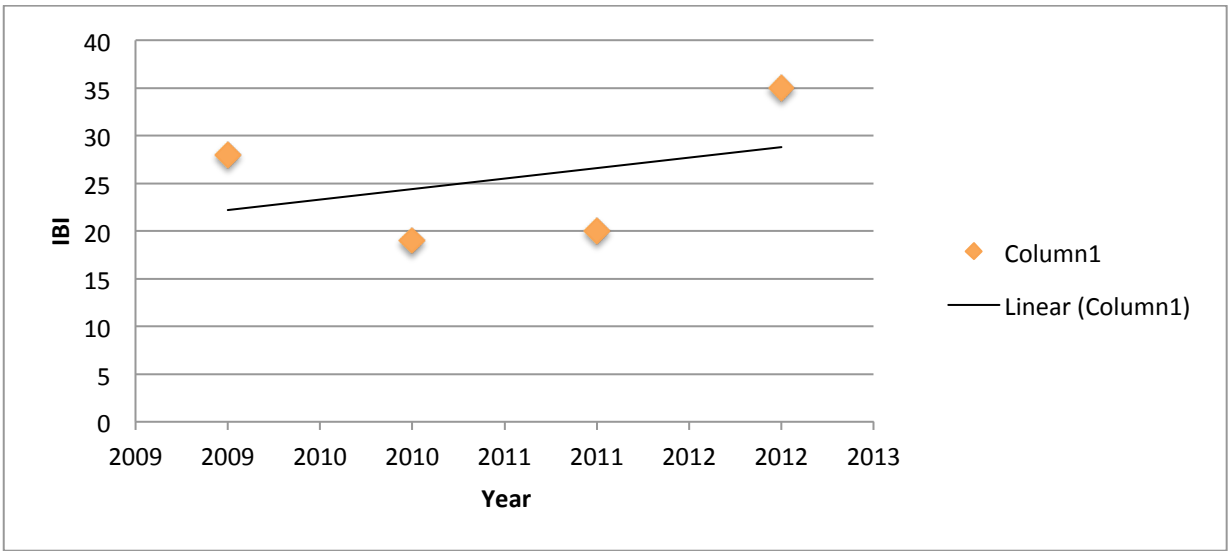

Figure 27: Shows temporal change according to total IBI score for Tomahawk Creek 2005-2012

Dreaming Creek - Dreaming Creek's IBI score has slowly and steadily risen since 2008. In 2012 the IBI score is higher than it has ever been before at 30. This is a highly forested area with a large buffer region and overhead cover. This highly forested area gave way to debris for fish habitat. However, Dreaming had a very high amount of sedimentation buildup which led to low riffle habitat. There were no carnivores found, this causes less competition leading to less biodiversity.

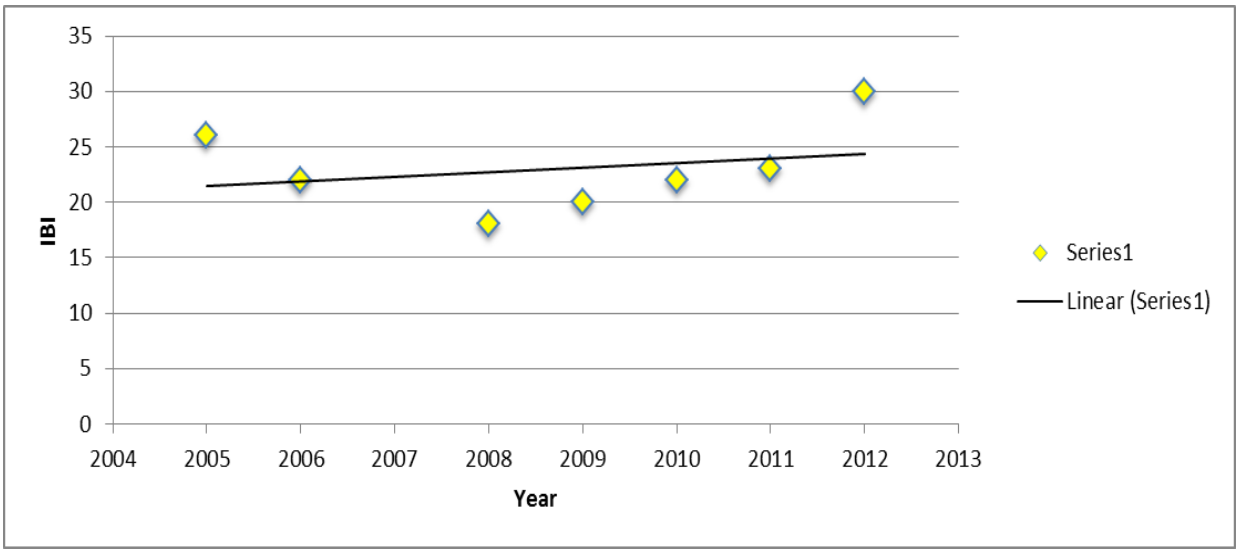

Figure 28: Shows temporal change according to total IBI score for Dreaming Creek 2005-2012

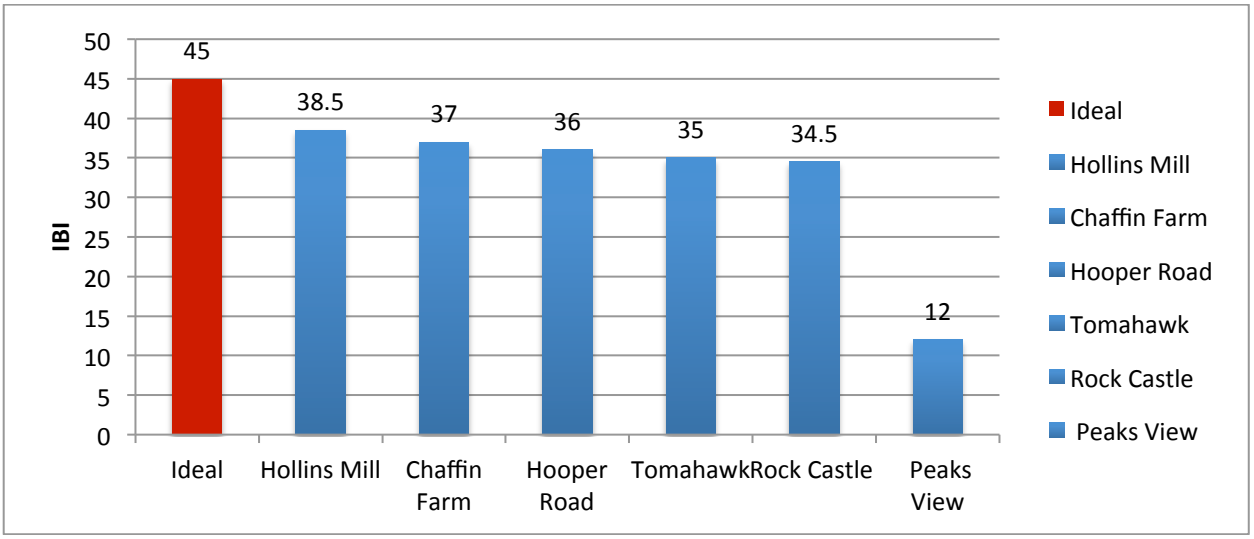

Figure 29: shows total IBI score for 2012 for each stream in comparison to an ideal stream

Table 9: 2012 Fish count totals

	Peaks View	*Hollins Mill*	*Chaffin Farm*	*Hooper Road*	*Tomahawk*	*Dreaming*	*Rock Castle*
Total Fish Species	6.00	18.00	13.00	13.00	12.00	16.00	17.00
Total # Fish Caught	82.00	212.00	438.00	234.00	150.00	321.00	369.00
% Percids	2.44	21.23	11.42	17.52	7.33	5.92	11.38
% Suckers	0.00	3.30	5.25	4.27	1.33	5.92	1.63
% Cyprinidae	4.88	14.62	32.42	20.94	21.33	19.94	17.89
% Catfishes	0.00	1.42	0.00	4.27	2.00	0.00	0.00
% Sunfish	42.68	9.43	0.91	2.56	1.33	1.56	2.44
% WC Insectivores	42.68	9.43	0.91	2.56	1.33	1.56	2.71
% Pool Insectivores	2.44	24.06	20.55	25.64	12.67	13.40	16.26
% Omnivores	4.88	14.62	27.17	21.79	19.33	18.07	13.82
% Carnivores	0.00	0.00	.23	0.00	0.00	0.00	0.00
Total # WC Insectivores	35.00	20.00	4.00	6.00	2.00	5.00	10.00
Total # Pool Insectivores	2.00	55.00	96.00	60.00	19.00	44.00	60.00
% Tolerant	47.56	18.87	19.86	17.52	16.67	19.94	10.57
% Intolerant	2.44	31.13	30.14	32.48	16.67	13.40	22.76

Table 10: IBI Measurements for 2012 Sampling. Possible score 9-45

Measurements	*Peaks View*	*Hollins Mill*	*Chaffin Farm*	*Hooper Road*	*Tomahawk*	*Dreaming*	*Rock Castle*
Total Number of Species	3.5	4	5	5	5	4	5
Total Number / Relative percent of Darter Species	1	4	4	4	3	3	3
Total Number / Relative percent of Water Column Insectivores	0	5	5	4	5	5	5
Total Number / Relative percent of Pool-Benthic Insectivores	1	5	4.5	5	3	3	4
Total Number / Relative percent of Intolerant Species	1	5	4.5	4	5	3	4
Relative abundance of Tolerant Species	0	4.5	4.5	4	5	3	4
Relative abundance of Omnivores or Generalist Feeders	1	5	3.5	4	3	3	3.5
Relative abundance of Top Carnivores	1	1	1	1	1	1	1
Deviation from ideal or number of individuals in sample	1	5	5	5	5	5	5
Total IBI Score	**9.5**	**38.5**	**37**	**36**	**35**	**30**	**34.5**
Grade	Poor	Good	Good	Good	Good	Fair	Good

CONCLUSION

Physical

This study supports the idea that land use has a significant effect on water quality of streams in the area. The amount and type of land use in an area proves to be highly influential in the water quality and general health of nearby streams. The use of Best Management Practices, such as riparian buffers, have aided the water quality in local streams. These BMPs can dramatically reduce the potential for further stream and water quality degradation. Therefore, we

conclude that being proactive about stream health is superior to being reactive. In other words, prevention is always preferred over mitigation.

Chemical

It is important to first note that testing was done during a three week dry period. Wet weather leads to higher amounts of stormwater runoff in streams and high levels of nutrients (Mallin and Johnson, 2009). The lack of gives lower than normal nutrient amounts. Urban stormwater is the leading source of phosphate, nitrate, and e.coli in streams (Mallin and Johnson, 2009). The main source of phosphate and nitrogen in stormwater come from phosphate and nitrogen based fertilizers, pet and animal manure storage areas, wastewater treatment plants, and cleaning agents (Shahady, 2012; Mallin and Johnson, 2009). An increase in phosphate, as seen at Peaksview, can lead to a low dissolved oxygen and eventual stream eutrophication. High amounts of nitrate may also lead to the same problems (Shahady, 2012). The levels of phosphate and nitrate are within the guidelines of the EPA. They are as follows:

pH: 6-9
Temperature: Maximum 32°C
Nitrate: 10 ppm maximum (standard for drinking water)
Phospate: 0.1 ppm
*For Peaks View, there is no data for phosphate because the test was run incorrectly.

The consistency of pH levels over time are a good indication of the health of the riparian buffer around a stream (Shahady, 2012). While the pH levels in the streams tested are all within the guidelines, Rock Castle and Chaffin both have high amounts of fluctuation over time. Rock Castle has experience a high amount of development since 2007 seven which is changing its riparian buffer, therefore explaining the changes. Chaffin put a cattle fence around the stream, preventing livestock from entering it. In both streams the pH was increasing but now shows a

downward trend. pH increases with less organic matter in the streams, which makes sense with less development and sedimentation. The downward trend is a sign towards better stream health.

The difference in conductivity levels between Chaffin and Peaksview can be attributed to the higher amount of sedimentation in Peaksview creek. Peaksview is in a more developed area surrounded by parks and trails. There is a higher amount of stormwater runoff from the developed neighborhoods around it, allowing for higher amounts of sedimentation. The increase in conductivity at Rock Castle can be attributed to the higher amounts of development seen there since 2007.

Lastly there is this years *E.coli* testing. The test shows higher than desired *e.coli* across the board. Stormwater runoff is the leading contributor of fecal coliform to streams (Mallin and Johnson, 2009). The fecal matter gets in the stormwater from livestock manure, seen at Chaffin, septic systems seen in more rural areas, and any type of wastewater leakage. When looking at the *e.coli* levels, Rock Castle creek is dangerously close to exceeding the EPA standard, especially considering the test was done during a dry period. Since Rock Castle creek is in a highly developed area lacking septic systems or agricultural contributors, it is strange the level is so high. Watershed development and impervious surface cover are both correlated with *e.coli* levels (Mallin and Johnson, 2009), but the exact source at Rock Castle creek needs to be identified. The all-around high levels of *e.coli* in each stream is of concerned and needs further monitoring.

Based on the water quality conditions of the streams overall, a stronger, better maintained riparian buffer will increase overall stream health. The riparian buffer will prevent the direct movement of phosphorus and nitrate into water system through phytoremediation. Healthy living plants will reduce the amount of debris in streams, lowing conductivity. pH level become more

consistent if the buffer is maintained well, and *e.coli* will no longer be able to travel directly off of impervious surfaces during stormwater events.

Macroinvertebrate

Our ideal stream in the watershed is Chaffin farm. This stream is located in a very rural setting with agricultural surrounding the flow of stream. Having a secluded location gives the stream stability and thriving conditions for our macroinvertebrates. As our numbers showed once the stream moves downstream into residential and commercial areas the water quality decreases in vast numbers. The reason is urbanization occurring all around the lower half of watershed. Looking at yearly numbers overall the watershed is getting worse once it hits the Peaks View Park, Tomahawk Creek, Dreaming Creek and mostly the Rock Castle Creek area.

Fish

While conducting a fish study of the Blackwater Creek watershed we decided to focus on three points: temporal changes, biodiversity, and the percentage of tolerant versus intolerant species. Temporal trends allow you to look at the data in a format that assesses overall change as opposed to year to year fluctuation including inclement weather and bias. These results provide information that can be used in determining if water quality is actually improving or declining over time. Making this determination is an important criterion to judge which stream restoration projects yield the best results under certain conditions.

Freshwater biodiversity is in crisis and 32% of the world's amphibian species are threatened with extension (Dudgeon, 166). Dudgeon states that "conservation and management of inland waters are critical to the interests of all nations and governments (Dudgeon, 174-775)". In the case where large lake and river systems exist in "pristine" conditions; immediate steps can be taken to preserve those areas. In other areas scientists, policy makers, and stake holders need

to learn that nature and man can co-exist in a state that is mutually beneficial and strive to achieve that balance. Continuing efforts to collect data and identify species must continue; however “the broader community does not have to wait until all possible information is in hand before taking action" (Dudgeon, 175). Lastly identifying keystone species can play a large role in conservation. In providing a habitat for that species to thrive; others will also. Hollins Mill is currently the stream least impacted by human influence. Protections need to be in place to ensure it does not degrade further. Peaks View has been impacted greatly by surrounding land use and should serve as a cautionary tale as to what can happen if we let our streams decline over several decades. As current stakeholders of the Blackwater Creek Watershed we may not have created the problems that affect its current state, but we do have a responsibility to ensure that it is available for environmental services by future generations.

General

The trend in the Blackwater Creek watershed is that water quality with the exception of Hollins Mill, continues to degrade as urbanization continues. The jurisdictions within the watershed need to examine those sites that are most at risk and determine which best management practices (BMP) are most cost effective and will yield the most improvement in the health of the streams.

Our recommendation is that best management practices be implemented such as; reshaping slopes, retention basins, riprap, planting vegetation, creating or maintaining riparian corridors and increasing woody debris were needed. Reshaping slopes involves altering more incised and eroded banks, so that the slope is more gradual down to the water’s edge. Retention basins fully contain a particular storm event, using infiltration as the primary means of disposal (Travis & Mays, 2008). Riprap is when a layer of various-sized rocks are used to protect a

stream bank from erosion. Planting vegetation and maintaining and/or creating riparian corridors involves determining which plants and trees are best suited to the stream's edge and will enhance the quality of marine life. The Lower Blackwater watershed at Hollins Mill is a great example to what BMPs can accomplish. The City of Lynchburg did extensive work within this watershed.

Another example is College Lake. Rather than attempt to maintain College Lake as a lake, we believe that it would be better utilized as a retention basin. Since the lake is more of a wetland than a lake anyway, repurposing it as a retention basin to contain storm water would be more effective.

All of the above mentioned BMPs will aid in slowing stormwater runoff and help in filtering pollutant before they reach the stream, such as nitrogen. Also the BMPs will lower the total suspended sediment which would have multiple benefits. These include lessen turbidity, less alteration of bottom habitat (macroinvertebrates), enhance die off of fecal bacteria, lower phosphorus loading and better oxygenation of water (Mallin et al., 2009).

As a whole the class recommended that riparian buffers be restored around the most impacted stream sites such as, Peaks View and Rock Castle. This would slow the rate of infiltration from runoff and minimize the amount of nitrogen entering into the stream. The riparian buffers would also aid in lowering water temperature and providing habitat for marine life and wildlife.

The research teams also believe there is a need to educate the public in the role that the Blackwater Creek watershed has in their community. In this process, education on the new Total Maximum Daily Loads (TMDL) regulations being set by the federal and state government can be introduced and explained as well. The citizens need to be informed about the new load regulations. The citizens also need to be informed of who made these new regulations. With

this information and then the current information of how the TMDLs are being met now and the expected cost of meeting the new regulations the citizens will have a better appreciation of the money allotted for BMPs within their watershed.

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