Division of Water Quality
Watershed Assessment Team
April 29, 2009

Version 2[a]

Memorandum

To: Trish MacPherson

Through: Steve Kroeger

From: Cathy Tyndall

Subject: Memorandum discusses the results of benthic sampling for:

1. Upstream and downstream of a tomato farm - Rabbit and Cat Creek watershed. Little Tennessee River Basin, Subbasin 01, Macon County. October 2008.
2. Pre-construction conditions for an EEP stream restoration project - Cat Creek. Little Tennessee River Basin, Subbasin 01, Macon County. October 2008.
3. Dalton Creek – residential development concerns. Little Tennessee River Basin, Subbasin 01, Macon County. October 2008.

Introduction

In support of the local watershed planning (LWP) effort in the Franklin to Fontana area, macroinvertebrate sampling was conducted at six sites in October 2008 (Figure 1). The purpose of the sampling was threefold, namely, to sample upstream and downstream of a tomato farm located in the floodplain of Rabbit and Cat Creek (Figure 2), to gather pre-construction conditions for an Ecosystem Enhancement Program (EEP) stream restoration project on Cat Creek that will begin in 2009, and to determine if residential growth in the Dalton Creek watershed was affecting water quality. After the benthic samples were identified, it was obvious that the tomato farm and its impacts on water quality should be brought to the forefront.

Rabbit Creek and two sites on Cat Creek were sampled to determine if impacts from a tomato farm would be evident in the benthic community after one year of tomato production. Rabbit Creek at SR 1504 (# 1) is below the farm and the confluence with Cat Creek. Cat Creek off SR 1504 (# 2) is located just downstream of the tomato farm. The Cat Creek site off SR 1520 (# 3) is located about 50 feet above the tomato farm. Cat Creek was also sampled off SR 1504 at the Waldroop Property (#4) and off SR 1520 at the Seagel Farm (#5) for pre-construction conditions for an EEP stream restoration project that will begin in 2009. The Waldroop property site is within the future restoration project boundaries and the Seagle site is located just upstream of the project. Sampling these two sites on Cat Creek, which are above the tomato farm, provides even more information regarding the impacts from the tomato farm and the conditions in upper Cat Creek. Lastly, Dalton Creek (#6) was sampled due to concerns from residential development in the watershed. Dalton Creek also served as a comparison site for the set of sites sampled.

The Rabbit Creek site at SR 1504 and Cat Creek off SR 1504, both located downstream of the tomato farm, were sampled five months earlier in May 2008 (NC DWQ 2008b). In May, planting had not yet occurred and plastic had not been put in place. However, according to a local resident the tomato farm had applied a white powder to the field the day before the May sampling. This powder was most likely pre-planting soil fumigation which is typically a mixture of methyl bromide and chloropicrin. It is used for

[a] Version 2 includes: a) the addition of Fig 2 showing the location of the tomato farm in Rabbit and Cat Creeks, b) the addition of the sample data obtained in May 2008 was added to the data obtained in October (Table 1), and c) minor rewording of the text.

soil borne diseases, nematodes, and weed control. Although limited activity had occurred at the tomato farm, the May sampling event serves as a comparison to the October sampling, which was after the first growing season.

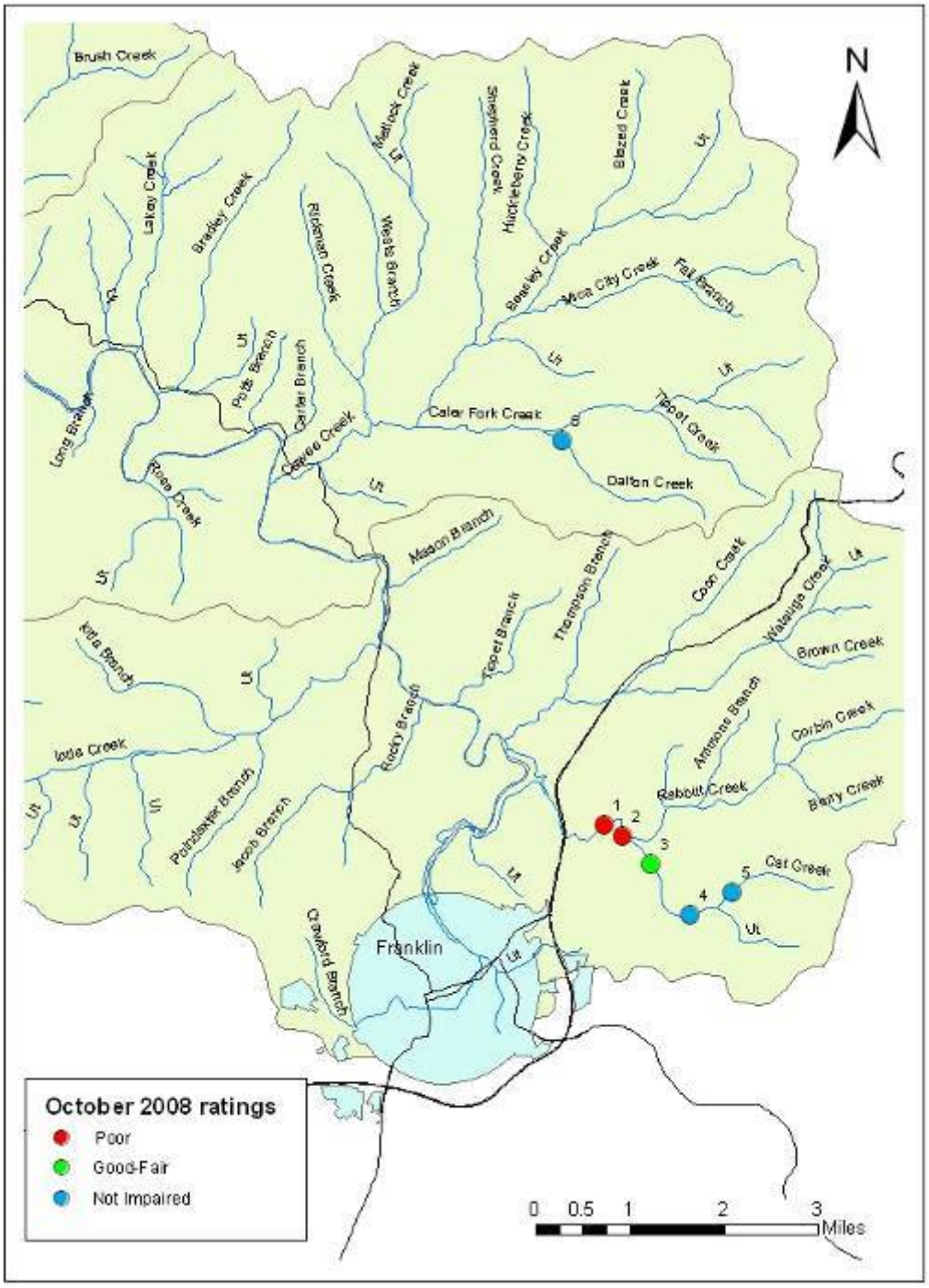

Figure 1. Location of macroinvertebrate sampling locations, October 2008.

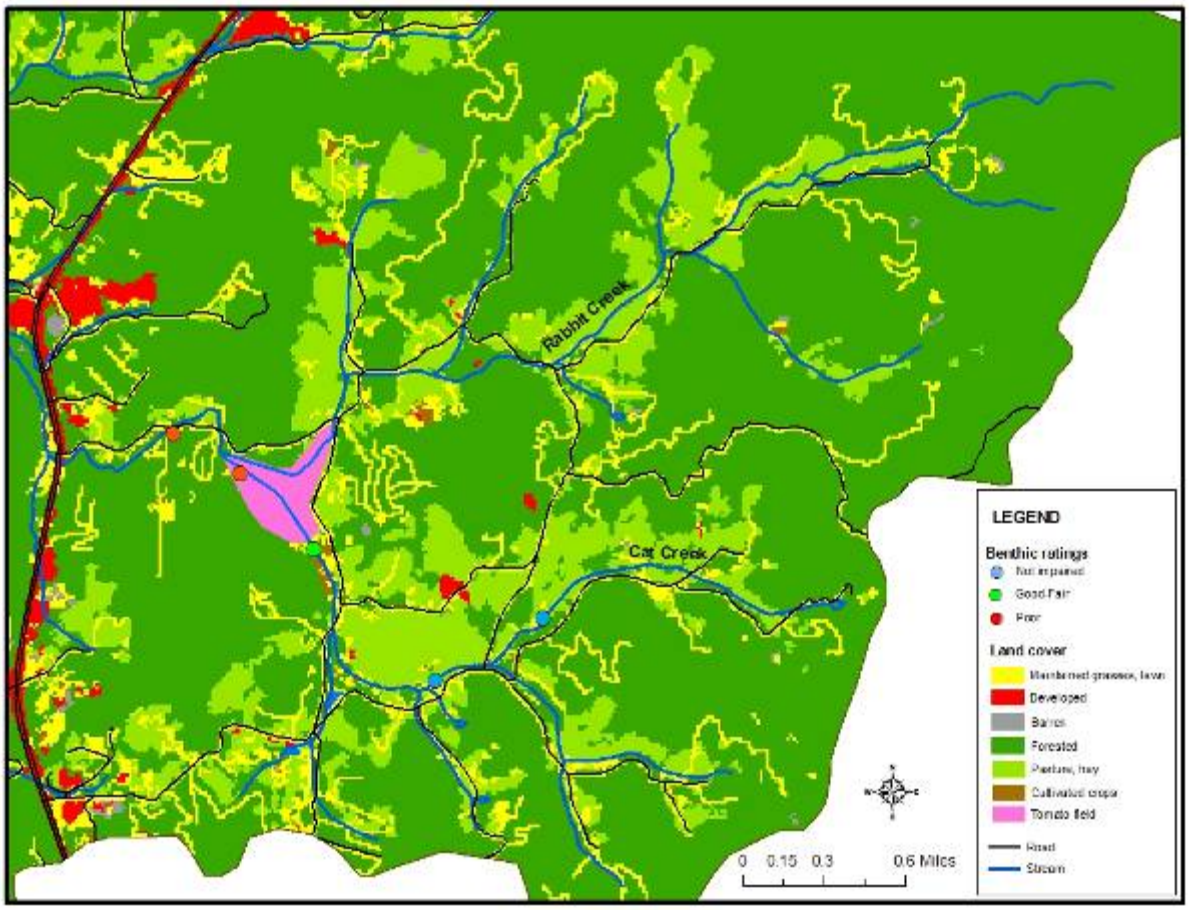

Figure 2. Location of tomato farm in Rabbit and Cat Creek watersheds

Background

There is increasing evidence that the runoff from tomato farms adversely affects benthic communities. In 2003, DWQ conducted the Mud Creek watershed water quality assessment with financing from the Clean Water Management Trust Fund. The study (NC DWQ 2003a) determined that the key stressor for the benthic macroinvertebrate community below a set of tomato fields on Mud Creek was toxicity. The source of this toxicity was most likely tomato pesticides. The macroinvertebrate site above the tomato farms was sampled in October of 2000 and 2001 and it was characteristic of a non-impaired mountain stream, containing both pollution intolerant and tolerant invertebrates including long-lived pollution-sensitive stoneflies. The macroinvertebrate community below the tomato farms was characterized by a community exposed to periodic toxic stress. The downstream site was sampled in 1997, twice in 2000, and again in 2001. In 1997, two EPT taxa were collected. In July 2000, the EPT taxa richness increased to 16. In October 2000, the EPT richness dropped back down to five, indicating a toxic event. By October 2001, the EPT richness increased to 15 (NC DWQ 2003a).

Over the last two decades, biological surveys by DWQ's Biological Assessment Unit (BAU) have documented patterns of decline and recovery below tomato farms, particularly in the lower Mills River (NC DWQ 2003b). Macroinvertebrate communities were rated Good in 1992 and 1993 at SR 1353, which is located below tomato farms and one mile above the confluence with the French Broad River. Steep declines in EPT taxa richness and abundance were noted at this site in 1994. Results from macroinvertebrate sampling led BAU biologists to state that "the 1994 data at SR 1353 clearly indicated a

toxic event at the site". The Poor rating was believed to be associated with runoff from agricultural activities in nearby tomato farming areas. In 1997, the rating at SR 1353 improved to Good-Fair. A sampling site located on the Mills River at SR 1373, above the tomato farms, rated Excellent for macroinvertebrates for all sampling events (7 total) from 1984 through 1997(NC DWQ 1997).

In 2000, the lower Mills River was placed on North Carolina's 303 (d) list of biologically impaired waters. It was suggested that impacts were likely associated with agricultural nonpoint sources of pollution, particularly those associated with pesticides applied on tomato farms (NC DWQ, 2005). However, in 2006 the Mills River was removed from the list because macroinvertebrate sampling in 2002 for a Total Maximum Daily Load (TMDL) study indicated that the entire river was supporting its uses (NC DWQ 2003b) (NC DWQ, 2006a). The 2002 sampling did not specifically sample upstream and downstream of targeted tomato farms, but did sample five locations on the North Fork Mills River, the South Fork Mills River, and the Mills River. All of the 2002 sampling rated Good and Good-Fair. More recent macroinvertebrate sampling in 2007 in the Mills River watershed has made it evident that the 2002 sampling was not an indication of overall improved water quality but was most likely an upward trend in a periodic cycle of stress and recovery. DWQ also conducted pesticide sampling in water samples collected in the Mills River in 2002 during normal and stormflow conditions and none were detected (NC DWQ 2003c). Detection of pesticides in surface water is especially difficult due to the fact that the presence and magnitude of the pesticides are dependent upon the timing of pesticide application in relation to precipitation events (NC DWQ 2009).

In 2007, the Asheville Regional Office (ARO) requested benthic samples from two sites on South Fork Mills River. A tomato farmer had been spraying his fields with pesticides and it is thought that run-off events transported the pesticides into the stream causing a fish kill on July 26, 2007. DWQ water samples showed the presence of Chlorothalonil in field run-off and samples collected from the river. BAU conducted an upstream-downstream benthos study to determine the possible effects of the pesticides on the aquatic macroinvertebrates. There was a definite, measurable difference between the upstream and downstream sites. The upstream site rated Excellent while the downstream site rated Fair. In addition, stoneflies were absent at the downstream location and were plentiful upstream. BAU biologists determined that the results of the sampling were consistent with a slug of pesticides entering the stream. The same downstream location had been sampled for macroinvertebrates in 1993 (Excellent rating), 2002 (Good rating) and had been sampled two months earlier for a fish survey and had rated Good to Excellent (NC DWQ, 2007). In addition to having the classifications of water supply II, trout waters, outstanding resource waters, and high quality waters, the South Fork Mills River is home to a number of rare and endangered species including: the hellbender, the blotched chub and blueside darter, Appalachian elktoe, slippershell mussel, and Tennessee heelsplitter (NC DWQ, 2005).

The Asheville Regional Office's Aquifer Protection Section (APS) conducted a preliminary investigation of agricultural pesticides in the Mills River Watershed during the summer of 2008. This action was prompted by recent and past declines in fish and macroinvertebrate communities as well as a documented releases of pesticides. This was the same release of pesticides that prompted ARO to request BAU macroinvertebrate sampling after the July 2007 fish kill in the South Fork Mills River. A second year of investigation is planned for the summer of 2009 (NC DWQ 2009).

Methods

Benthic Macroinvertebrates

Benthic macroinvertebrates were collected in October using BAU's Qual 4 method. This method is typically used for streams that have a drainage area of three square miles or less and produces a rating of Not Rated or Not Impaired. Due to time constraints and to maintain sample consistency, the Qual 4 method was used for all six sites. For the three sites with drainage areas greater than three square miles, a bioclassification based on the EPT taxa was assigned. This was possible since the collection method for Qual 4 samples and EPT samples is the same.

The Qual 4 collection method is comprised of four samples including the collection of one riffle-kick, one bank/root mat sweep, one leaf pack, and visual collections. These collections are used to inventory the aquatic fauna and produce an indication of the relative abundance for each taxon. Organisms are

identified to the lowest possible taxon and enumerated as Rare (1-2 specimens, denoted by "R" on taxa tables), Common (3-9 specimens, "C"), or Abundant (≥10 specimens, "A").

Several data analysis summaries (metrics) are calculated from the benthic data to facilitate the detection of physical habitat and/or water quality problems. These metrics are based on a long history of observations and studies that show unstressed streams and rivers have higher invertebrate diversity and a relatively high proportion of intolerant species. Taxa within the three EPT insect orders (Ephemeroptera, Plecoptera and Trichoptera) are generally intolerant of many kinds of pollution. Therefore, higher EPT taxa richness values indicate better water quality. Conversely, polluted streams have lower invertebrate diversity and are dominated by tolerant species.

The diversity of the invertebrate fauna is evaluated using taxa richness (i.e. the total number of distinct taxa present); the tolerance of the stream community is evaluated using a Biotic Index (derived from the general response of each taxon to the presence of stressors). Both tolerance values for individual taxa and the final biotic index values have a range of 0-10 with higher numbers indicating more tolerant taxa and more polluted conditions respectively. Criteria for mountain sites were used to assign bioclassifications based upon EPT Richness and NCBI values. Seasonal corrections for EPT richness and NCBI were made as appropriate for October samples.

Bioclassifications can be affected by seasonal differences in taxonomic groups, particularly within the insect order Plecoptera, many of which are present as larvae in streams in winter or spring taxa. It is also sometimes necessary to deduct seasonal mayflies. As seasonal taxa can artificially inflate taxa richness values, seasonal taxa need to be removed from analysis to have ratings that are comparable to those collected during summer months (June-Sept.). It was determined that only the winter stoneflies would be subtracted and they are indicated in the taxa list in Appendix 1. For more information on sampling methods, metrics, and ratings, refer to "*Standard Operating Procedures for Benthic Macroinvertebrates*" (NC DWQ, 2006b).

Habitat Evaluation

Habitat evaluations were conducted at the four new monitoring locations on Cat and Dalton Creeks using the BAU's Habitat Assessment method for Mountain Streams. Habitat assessments had been conducted at Rabbit Creek at SR 1504 and Cat Creek off SR 1504 in May 2008 and it was determined that a second assessment at these two sites was not necessary. The habitat assessment assigns a numerical score from 1-100 for the reach of stream sampled, based on channel modification, instream habitat, bottom substrate, pool variety, riffle habitats, bank stability and vegetation, light penetration, and width of the riparian zone. More specifically, these habitat evaluations assess the quality and quantity of instream habitat, the quality and quantity of the stream's riparian zone, and also evaluate detrimental impacts on stream habitat such as bank erosion and substrate embeddedness. No criteria have been developed to rate habitat scores, but the higher the score, the better the overall habitat. Habitat submetrics are depicted in Table 1.

The two sites below the tomato farm (Rabbit Creek at SR 1504 and Cat Creek off SR 1504) and the site just above the tomato farm scored 47, 42, and 46 respectively. The site above the tomato farm scored slightly higher for instream habitat, but lower in riffle habitat. Riparian buffer zones were minimal at all three sites. The riparian zone was less than six meters at the two Cat Creek sites and between six and twelve meters at the Rabbit Creek site. The Cat Creek site on the Seagle farm upstream of the tomato farm scored 49 in overall habitat. This was mostly due to the cattle pasture setting, the absence of riparian zone, unstable banks, and shade. The Cat Creek site on the Waldroop property scored the highest (62) of the Cat Creek sites. Better bank stability and increased stream shading were the main differences between the Waldroop site and the Seagle Farm site. Dalton Creek scored the highest (74) of all sites for habitat, although deeply incised-steep, straight banks were noted. Dalton Creek scored high for riffle habitat, instream habitat, and substrate composition.

Physical-Chemical
Measurements for pH were collected from each site using an Accumet AP61 meter. Data for temperature, dissolved oxygen, and specific conductance were collected using a YSI-85 multimeter for all sites. Physical measurements are included in Table 1.

At the time of sampling, the physical-chemical measurements were within typical ranges for the area. As expected and consistent with previous measurements collected in Cat and Rabbit Creek, the conductivity values were elevated (ranged from 46 to 51µmhos/cm). The elevated values are most likely due to human land disturbances such as farming. The lowest conductivity values were recorded at the uppermost site on Cat Creek at the Seagle farm (42) µmhos/cm) and in Dalton Creek (31) µmhos/cm). As shown in previous tomato farm macroinvertebrate sampling studies, conductivity measurements collected at the time of sampling are not related to the pesticide toxicity (NC DWQ 2007). Dissolved oxygen and pH values were also within normal ranges.

Table 1. Habitat, Biological, Physical and Chemical Data (May and October 2008)

	October 2008 Sample Results							May 2008 Sample Results		
	*Rabbit Cr at SR 1504	*Cat Cr off SR 1504	Cat Cr above tomato farm	Cat Cr at tWaldroop property	Cat Cr at Seagle Farm	Dalton Cr off Dalton Cr Rd		Cat Cr off SR 1504	Rabbit Cr off SR 1504	Rabbit Cr at SR 1504
Map number (Figure 1)	1	2	3	4	5	6		2		1
Collection Date	10/27	10/27	10/27	10/27	10/28	10/28		5/9	5/8	5/8
Collection Method	Qual 4	Qual 4	Qual 4	Qual 4	Qual 4	Qual 4		EPT	EPT	Full Scale
Drainage area (mi^2)	8.8	3.7	3.7	2.3	1.2	1.4		3.7	4.7	8.8
Biological Community										
Ephemeroptera	2	2	6	6	10	6		15	13	19
Plecoptera	0	0	5	2	4	9		5	6	6
Trichoptera	1	5	11	12	6	9		9	12	12
EPT Richness	3	7	22	20	20	24		29	31	43
Corrected (seasonal) EPT	3	7	21	20	19	21		24	26	37
EPT Abundance	7	11	81	75	88	93		118	137	202
EPT Biotic Index (EPT BI)	5.76	4.53	4.37	3.16	3.73	2.95		4.27	4.19	4.04
NC Biotic Index (NC BI)	6.46	5.89	4.74	4.19	4.31	3.70		-	-	5.39
Bioclassification	Poor	Poor	Good-Fair	Not Impaired	Not Impaired	Not Impaired		Good-Fair	Good-Fair	Good
Habitat Scores										
Channel Modification (5)	2	2	2	2	2	4		2	2	2

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Instream Habitat (20)	8	11	14	15	12	16		11	14	8
Bottom Substrate (15)	5	2	6	12	11	13		2	6	5
Pool variety (10)	8	8	4	4	4	8		8	4	8
Riffle Habitats (16)	14	14	7	14	14	16		14	14	14
Left bank Stability/Vegetation	3	2	3	4	2	3		2	3	3
Right bank Stability/Vegetation	3	2	3	4	2	5		2	2	3
Light Penetration (10)	2	1	5	7	0	7		1	7	2
Left bank riparian zone width (5)	1	0	1	0	1	1		0	2	1
Right bank riparian zone width (5)	1	0	1	0	1	1		0	0	1
Total Habitat Score (out of 100)	47	42	46	62	49	74		42	54	47
Stream Characteristics										
Average stream width (m)	5	2	1	1.5	0.8	1.2				
Average stream depth (m)	0.3	0.1	0.7	0.2	0.2	0.2		2	4	5
Substrate								0.1	0.1	0.3
Boulder	10	0	T	T	T	5				
Rubble	20	30	10	25	20	40		0	0	10
Gravel	20	20	50	35	30	25		30	35	20
Sand	20	30	30	30	30	20		20	30	20
Silt	10	20	10	10	20	10		30	10	20
Bedrock	10	0	0	0	0	0		20	25	10
Physical								0	0	10
Temperature (Celsius)	9.5	10.7	11.6	10.2	9.0	10				
Dissolved oxygen (mg/L)	9.7	9.9	8.5	9.1	9.2	9.4		20	21	21
Conductivity (µmhos/cm)	47	48	51	46	42	31		8.6	8.4	8.8
pH	6.7	6.6	6.8	6.2	6.3	6.5		46	39	41

Study Sites

Rabbit Creek at SR 1504 (photo from May 2008; physical parameters and remarks from Oct. 2008)

Visible land use: Road, forest, pasture and residential.
Width (m): 5.0
Drainage Area (mi^2): 8.8
Depth (m): Average: 0.3
Canopy: minimal-full sun in all but a few areas
Substrate: Mix of boulder, rubble, gravel, sand and silt and 10% bedrock.
Riparian quality: Narrow riparian (6-12meters) with breaks along left bank. Right bank narrow (6-12meters) and with breaks. Sparse mixed vegetation with poor soil binding.
Instream habitat: Rocks common. Sticks, leaves, snags, logs-rare. Undercut banks/rootmats-rare.
Habitat Score (out of 100): 47
Dissolved Oxygen (mg/L): 9.7
Specific conductance (µmhos/cm): 47
Temperature (°C): 9.5
pH: 6.7
Remarks: Slippery rocks, water slightly turbid, very silty, noticeable absence of benthic taxa.

Cat Creek off SR 1504 (photo from May 2008; physical parameters and remarks from Oct. 2008)

Visible land use: Agriculture (tomato farm), residential, forest.
Width (m): 2
Drainage Area (mi^2): 3.7
Depth (m): Average: **0.1?**
Canopy: Minimal-full sun in all but a few areas.
Substrate: Mix of rubble, gravel, sand and silt. Greater than 80% embedded.
Riparian quality: No riparian buffer on both banks. No trees, grasses and shrubs only, no shade. Clearing for tomato farm extends to within several feet of the stream. Sediment from farm entering Cat Creek.
Instream habitat: Rocks common, sticks and leafpacks rare. Undercut banks and root mats common.
Habitat Score (out of 100): 42
Dissolved Oxygen (mg/L): 9.9
Specific conductance (µmhos/cm): 48
Temperature (°C): 10.7
pH: 6.6
Remarks: Channel filled in with sediment. Channelized ditch. Equipment crossings on creek.

Cat Creek above tomato farm

Visible land use: Road, forest, residential, fallow fields
Width (m): 1.0
Drainage Area (mi^2): 3.7
Depth (m): Average: 0.7
Canopy (% cover): full sun to partial shade
Substrate: Substrate mostly gravel and sand, with small amount of silt and cobble. A trace of boulders.
Riparian quality: Narrow riparian (<6 meters) on both banks. Mostly grasses, shrubs, and small trees.
Instream habitat: Rocks abundant. Sticks, undercut banks and root mats common. Snags and logs rare.
Habitat Score (out of 100): 46
Dissolved Oxygen (mg/L): 8.5
Specific conductance (µmhos/cm): 51
Temperature (°C): 11.6
pH: 6.8
Remarks: Site located approximately 50' above tomato farm. Channelized ditch, filled in with sediment.

Cat Creek at Waldroop Property

Visible land use: Road, active pasture, and residential.
Width (m): 1.5
Drainage Area (mi^2): 2.3
Depth (m): Average: 0.2.
Canopy : Sunlight and shading equal.
Substrate: Mostly gravel, sand, and cobble. Some silt and trace of boulder.
Riparian quality: Width <6 meters, with frequent breaks.
Instream habitat:. Rocks abundant, sticks, leafpacks, undercut banks and root mats common. Snags and logs common. Pools infrequent.
Habitat Score (out of 100): 62
Dissolved Oxygen (mg/L): 9.1
Specific conductance (µmhos/cm): 46
Temperature (°C): 10.2
pH: 6.2
Remarks: EEP stream restoration project to begin in 2009. Cow pasture.

Cat Creek at Seagle Farm

Visible land use: Forest, active pasture, residential
Width (m): 0.8
Drainage Area (mi^2): 1.2
Depth (m): Average: 0.15
Canopy: None
Substrate: Gravel (30%), sand (30%), cobble (20%), and silt (20%). Trace of boulders.
Riparian quality: Narrow left and right riparian with breaks. Bank vegetation generally healthy on right bank, left bank mostly grasses. High erosion potential.
Instream habitat: Rocks abundant. Sticks, leafpacks, undercut banks and root mats rare. Snags and logs rare.
Habitat Score (out of 100): 49
Dissolved Oxygen (mg/L): 9.2
Specific conductance (µmhos/cm): 42
Temperature (°C): 9.0
pH: 6.3
Remarks: Cattle pasture with some access to stream, mostly fenced out. Channelized, no woody debris in stream.

Dalton Creek off Dalton Creek Road

Visible land use: Forest and residential.
Width (m): 1.2
Drainage Area (mi^2): 1.4
Depth (m): Average: 0.2
Canopy: Sunlight and shade equal
Substrate: Cobble (45%),gravel (25%), sand (20%) silt (10%), and boulder (5%)
Riparian quality: Left and right riparian <6 meters, some breaks. Erosion areas present. Bank vegetation generally healthy along both banks. Pools frequent.
Instream habitat: Rocks, sticks, leafpacks abundant. Undercut banks, root mats, snags and logs rare.
Habitat Score (out of 100): 74
Dissolved Oxygen (mg/L): 9.4
Specific conductance (µmhos/cm): 31
Temperature (°C): 10
pH: 6.5
Remarks: Deeply incised, steep, straight banks.

Results

Habitat conditions, physical and chemical water data, and geographical coordinates for the study sites are given in Table 1. Summary biological community metrics and resultant bioclassifications are given in Table 1. Taxa identified and the corresponding abundance classifications are shown in Appendix 1.

Rabbit Creek at SR 1504
Sample Type: Q4
EPT Richness: 3
Seasonally Corrected EPT Richness: 3
EPT Biotic Index: 5.76
Bioclassification: Poor

This site is below the tomato farm and the confluence with Cat Creek. The drainage area is 8.8 square miles. Since the drainage area is larger than three square miles, a bioclassification can be derived based on the EPT taxa. The benthic community rated Good in May; in October the rating decreased to Poor. The total EPT in May was 43 and deceased to only 3 taxa in October. In May, a Full Scale sample was conducted and one would expect a higher number of taxa, however, the different sampling method and seasonal differences would not explain the decrease in EPT taxa from 43 to 3. This is an extremely dramatic decrease in taxa and indicates the presence of a toxic stressor in the stream. In May, 19 different taxa of mayflies were collected including intolerant taxa such as *Epeorus vitreous, Heptagenia marginalis*, *Dannella,* and *Leucrocuta*. Six stonefly taxa were collected in May including *Acroneuria abnormis*, which is a long-lived species and should be found anytime, regardless of the season. No stoneflies were collected in October. Only one individual caddisfly, *Ptilostomis*, was collected in October as compared to 18 different caddisfly taxa in May 2008. Two mayfly taxa, *Baetis pluto* and *Baetis intercalaris*) were collected. No crayfish were collected at this site, which is unusual. One salamander was observed. Other taxa that were present were seven midge taxa, and one very tolerant odonate, *Argia.* **The significant decline in EPT taxa richness and the absence of stoneflies indicates the presence of a toxic stressor that is consistent with the effects of pesticides from tomato farms.**

Cat Creek off SR 1504
Sample Type: Q4
EPT Richness: 7
Seasonally Corrected EPT Richness: 7
EPT Biotic Index: 4.53
Bioclassification: Poor

This site on Cat Creek is located just below the tomato farm. This location was previously sampled in May 2008 and 29 EPT taxa were collected, including five stonefly taxa. The bioclassification was Good-Fair. In October, only seven EPT taxa were collected and the rating decreased to Poor. In May, the benthic community was mostly comprised of moderately tolerant to tolerant taxa. Many of the Abundant mayfly and caddisfly taxa were grazing and/or filtering taxa, indicating elevated nutrient levels. Abundant taxa collected at the site in May included the mayflies *Acentrella turbida, Baetis intercalaris, Maccaffertium modestum* and *Isonychia*; the stonefly *Perlesta*; and the caddisflies *Cheumatopsyche, and Dolophilodes.* The intolerant taxa *Drunella cornutella, Isoperla orata,* and *Neophylax consimilis*, and *Chimarra* were also collected. One specimen of a relatively rare mayfly, *Habrophlebiodes*, was noted. This genus is listed as Significantly Rare by the Natural Heritage Program (NC DWQ, 2008a). Of the five stonefly taxa collected in May, one, *Acroneuria abnormis*, is long-lived and should be found year round. However, no stoneflies were collected in October. None of the taxa that were collected in October were Abundant in number; all were either Rare or Common. The seven taxa collected in October were a mixture of tolerant to fairly intolerant taxa. One caddisfly taxa, *Platycentropus*, is considered fairly rare and is mostly found in swamps and mountain streams. No crayfish were collected in October. Seven odonate taxa were collected; all are considered tolerant. This is the only site sampled in October where Chironomous, a very tolerant midge taxa was collected. Chironomous is considered an indicator of organic enrichment. **Similar to the sample collected in Rabbit Creek in October, this is a dramatic**

decrease in EPT taxa richness and diversity that would be indicative of a toxic stressor to the benthic community. The absence of all stonefly taxa in October is another indication of a toxic stressor.

Cat Creek just upstream tomato farm
Sample Type: Q4
EPT Richness: 22
Seasonally Corrected EPT Richness: 21
EPT Biotic Index: 4.37
Bioclassification: Good-Fair

Cat Creek was sampled just upstream of the tomato farm at this location. There was a noticeable difference in the sample collected here and downstream of the tomato farm. At this site, 22 EPT taxa were collected as opposed to 7 taxa below the tomato farm. The bioclassifaction at this site was Good-Fair, based on the EPT taxa collected. Five stonefly taxa were collected, including three long-lived taxa (*Acroneuria abnormis, Pteronarcys spp*, and *Eccoptura xanthenes*). No stoneflies were collected at the two sites downstream of the tomato farm. In addition, caddisflies (*Glossosoma* and *Goera*) that are sensitive to sediment were collected here and none were found downstream. At this location on Cat Creek, six crayfish were counted in the sample and four salamanders were noted. Below the tomato farm, no crayfish were observed and only one salamander was counted. A much more diverse beetle assemblage (six taxa) was present here than downstream of the tomato farm and taxa that are considered indicators of small, clean streams (*Eccoptura xanthenes* and *Diplectrona*) were collected. This sampling site is located approximately 50 feet above the tomato farm. The drainage area is the same (3.7 square miles) as the downstream site and there are no tributaries entering the stream between the two sites. The only difference between the two sites is the influence from the tomato farm. **The benthic fauna at this location was indicative of a stream that is able to support a viable macroinvertebrate community and was not stressed by the same toxic input observed at the sites downstream of the tomato farm.**

Cat Creek at Waldroop property
Sample Type: Q4
EPT Richness: 20
Seasonally Corrected EPT Richness: 20
EPT Biotic Index: 3.16
Bioclassification: Not Impaired

This site was sampled to monitor the benthic community before an EEP restoration project begins in this section of Cat Creek in 2009 and it also strengthens the comparison of the macroinvertebrates upstream and downstream of the tomato farm. The immediate landuse is farm land and pasture with cattle. Twenty EPT taxa were collected at this location on Cat Creek. The rating was Not Impaired, based on the small drainage area (2.3 square miles). Twenty EPT taxa is a high number of taxa for such a small stream. The benthic fauna were a mixture of moderately tolerant (*Baetis pluto, Maccaffertium modestum*, *Ceratopsyche sparna*) and intolerant taxa (*Glossosoma, Dolophilodes*, *Rhyacophila fuscula*, and *Brachycentrous nigrosoma*). The long-lived stonefly, *Acronuria abnormis,* was collected here, indicating good water quality and year round water. A varied assemblage of beetles was collected. This sampling site had the second lowest EPT BI (3.16) after Dalton Creek (2.95), indicating the second most intolerant EPT community of all the sites sampled and the most intolerant EPT fauna of the four Cat Creek sites. The primary difference in this sample and the comparison site was a slightly more tolerant mayfly community here and fewer stonefly taxa. Cows and agriculture are in the Cat Creek watershed, but not in Dalton Creek's watershed. **The benthic fauna at this location was indicative of a stream that is able to support a viable macroinvertebrate community and was not stressed by the toxic input observed at the sites downstream of the tomato farm.**

Cat Creek above restoration project at Seagle property
Sample Type: Q4
EPT Richness: 20
Seasonally Corrected EPT Richness: 19
EPT Biotic Index: 3.73
Bioclassification: Not Impaired

The drainage area of this site on Cat Creek is only 1.2 square miles, but 20 EPT taxa were collected. Similar to the site at the Waldroop property, this is a high number of EPT taxa for such a small stream. This location on Cat Creek is located above where the EEP restoration project will be implemented. The immediate landuse is farm and pasture. There is some cattle access to the stream, although most of the cattle are fenced from the stream. Ten crayfish were counted and numerous salamanders. There is no riparian buffer at the sampling location; only grassy banks. Regardless of the habitat deficiencies, four stonefly taxa, including two long-lived intolerant species (*Acroneuria abnormis* and *Eccoptura xanthenes*) were collected. This demonstrates that the water quality in the upper portion of Cat Creek is able to support intolerant taxa regardless of the habitat. A varied mayfly community was collected at this small site which included *Paraleptophlebia, Ephemerella subvaria*, and *Maccaffertium pudicum*. The EPT BI (3.73) at this site was slightly higher than the Waldroop site (3.16), indicating a slightly more tolerant EPT community than at the Waldroop site. Similar to the Waldroop site on Cat Creek, agriculture and cows influence the watershed and the benthic community. **The benthic fauna at this location was indicative of a stream that is able to support a viable macroinvertebrate community and was not stressed by the toxic input observed at the sites downstream of the tomato farm.**

Dalton Creek, Macon County
Sample Type: Qual 4
EPT Richness: 24
Seasonally Corrected EPT Richness: 21
EPT Biotic Index: 2.95
Bioclassification: Not Impaired

The Little Tennessee Watershed Association has expressed concerns on the impacts of the Wildflower development on this small stream. Dalton Creek was sampled due to these concerns of residential development in its watershed, but served as a comparison site since there are not cows or agriculture in the watershed. The highest number of EPT taxa (24) were collected at this site and it had the lowest EPT BI of the six sites, indicating the most intolerant community. Dalton Creek is notable in that nine different stoneflies were collected in this small stream. This is an unusually high number of stonefly taxa for a stream that has a drainage area of only 1.4 square miles. Three long-lived stonefly taxa were collected in addition to stoneflies that were not found at the other five sites including *Malirekus hastatus, Cultus decisus*, *Tallaperla*, and *Sweltsa*. All of these are intolerant and are indicators of high quality water. *Glossosoma*, a caddisfly that is sensitive to sediment was also collected. As sedimentation increases, *Glossosoma* ceases to be found. However, deep, straight incised banks were noted and the substrate was estimated to contain 30% sand and silt, which would be an indication of land disturbance upstream. **Dalton Creek is experiencing the effects of land disturbance in its watershed, but the high water quality supports an intolerant community. The stream warrants close observation as conditions may start to decline as development increases in the watershed.**

Conclusions and Recommendations

- There was a dramatic difference in the macroinvertebrate community in the Cat Creek sites sampled above and below the tomato farm. When sampling, care was taken to bracket the farm and isolate it from any other possible impacts. The Poor bioclassification of the Rabbit Creek site at SR 1504, which is also downstream of the farm, further strengthens the results. The benthic community results clearly show a toxic impact from the tomato farm after the first year of operation.

- The benthic sampling demonstrated that the water quality in Cat Creek above the tomato farm was significantly better than below the farm even though the upstream sites were located in or below agricultural settings with cattle. In comparison to Dalton Creek, the benthic communities at the upstream Cat Creek sites (above the tomato farm) were more tolerant. These findings indicate that the presence of cows and agriculture tended to create a more tolerant benthic community. Tolerant mayflies that feed mainly by scraping periphyton and attached algae from rocks were collected in Cat Creek and not in Dalton Creek. Nutrients from cows and agriculture, and the reduced riparian shading leading to increased algae growth may create a suitable habitat for such macroinvertebrates. In addition to tolerant taxa, numerous intolerant taxa were also collected at these upstream sites, indicating overall Good-Fair water quality in Cat Creek above the tomato farm. The water quality was able to support more tolerant as well as intolerant invertebrates including sensitive stoneflies. Poor water quality was found below the tomato farm with a greatly impacted benthic fauna and many taxa completely disappeared.

- The difference in the macroinvertebrate community upstream versus downstream of the tomato farm and the differences in the benthic fauna at the downstream sites in May versus October do not appear to be habitat related since the habitat scores are so similar. Rather, a toxic stressor in the watershed appears to have negatively affected the macroinvertebrate community downstream of the tomato farm.

- Not only were the benthic macroinvertebrates impacted downstream of the tomato farm, the occurrence of crayfish and salamanders also appeared to be greatly affected. At the sites located on Cat Creek and Rabbit Creek below the tomato farm, only one salamander was observed and no crayfish.

- The Watershed Assessment Team and the Ecosystem Enhancement Program should consider partnering with the Aquifer Protection Section in 2009 in their second year of tomato farm investigations and bring the Rabbit and Cat Creek watersheds into the study. Benthic sampling is an invaluable tool in determining pesticide stress in surface waters since the effects on the benthic community are relatively long lasting and easier to capture than a pesticide release in a storm water sample.

- Dalton Creek was used as a comparison site based on its water quality and watershed characteristics, especially the absence of cows and agriculture. The benthic fauna was the most intolerant of the six sites sampled. This was evident in the high number (9) of stoneflies collected in this small stream and the low EPT BI. In addition, *Glossosoma*, an intolerant grazing caddisfly that lives on the top of rocks was collected at this site, and at the Cat Creek sites above the tomato farm. It was not collected at the sites below the tomato farm. It is evident that Dalton Creek is affected by development in its watershed by the steep, incised banks and the amount of sand and silt in the substrate estimated at the time of sampling (30%). Presently, Dalton Creek supports an intolerant benthic community including taxa that are sensitive to sediment. However, this small stream warrants close observation as conditions may start to decline as development increases in the watershed.

References

NC DWQ, 1997. Mills River Sampling, Henderson County, French Broad subbasin 03, July 1997. Biological Assessment Unit, Division of Water Quality. (BAU memo B971001)

NC DWQ 2003a. Biological Impairment in the Mud Creek Watershed French Broad River Basin Henderson County. June 2003. http://h2o.enr.state.nc.us/swpu/mudcreek/mcfinal.pdf

NC DWQ. 2003b. Biological Monitoring of Mills River, Henderson County TMDL Study, June 2002. Biological Assessment Unit, Division of Water Quality. (BAU memoB030424)

NC DWQ. 2003c. Mills River Pesticide/Herbicide Sampling French Broad River Basin. Intensive Survey Unit Unit, Division of Water Quality.

NC DWQ 2005. French Broad River Basin Water Quality Plan. Planning Section, Division of Water Quality. http://h2o.enr.state.nc.us/basinwide/index.htmf

NC DWQ 2006a. 2006 North Carolina Water Quality Assessment and Impaired List (2006 Integrated 305(b) and 303(d) Report) Final. Planning Section, Division of Water Quality. http://h2o.enr.state.nc.us/tmdl/General_303d.htm

NC DWQ. 2006b. Standard Operating Procedures for Benthic Macroinvertebrates. Environmental Sciences Branch, Biological Assessment Unit. http://h2o.enr.state.nc.us/esb/BAU.html

NC DWQ. 2007. South Fork Mills River Report; Asheville Regional Office Requested Sampling, Henderson County. Biological Assessment Unit, Division of Water Quality. (BAU memo B070925)

NC DWQ. 2008a. Taxonomy Document. Environmental Sciences Branch, Biological Assessment Unit.

NC DWQ. 2008b. Results of Benthic Sampling from the Little Tennessee Basin Local Watershed Plan area, Little Tennessee Basin, Subbasin 01 and 02, Macon County. Watershed Assessment Team, Division of Water Quality.

NC DWQ 2009. Preliminary Investigation of Agricultural Pesticides in the Mills River Watershed, Henderson County, North Carolina. Aquifer Protection Section, Division of Water Quality.

Appendix 1. Benthic Macroinvertebrates collected from the Little Tennessee Basin LWP. October 2008. (w) denotes winter stonefly

Order	Family	Species	Rabbit Cr at SR 1504	Cat Cr off SR 1504	Cat Crabove tomato farm	Cat Cr at Waldroop property	Cat Cr at Seagle farm	Dalton Cr off Dalton Cr Rd
Ephemeroptera	Baetidae	ACENTRELLA FEMORELLA (WALTZ)					R	
		BAETIS INTERCALARIS	C		R	C	R	
		BAETIS PLUTO	C	C		C	A	C
		PLAUDITUS DUBIUS GR						R
		PSEUDOCLOEON FRONDALE			C	R	C	
	Baetiscidae	BAETISCA CAROLINA		R	R	C	C	C
	Ephemerellidae	EPHEMERELLA SUBVARIA					R	
		SERRATELLA DEFICIENS				R	R	
	Ephemeridae	HEXAGENIA SPP			R			
	Heptageniidae	MACCAFFERTIUM MODESTUM			A	A	C	A
		MACCAFFERTIUM PUDICUM					A	C
		STENACRON PALLIDUM			R			
	Leptophlebiidae	PARALEPTOPHLEBIA SPP					R	C
Plecoptera	Capniidae	ALLOCAPNIA SPP			C	A	A	A
	Chloroperlidae	SWELTSA SPP (w)						R
	Peltoperlidae	TALLAPERLA SPP						R
	Perlidae	ACRONEURIA ABNORMIS			A	C	A	A
		ECCOPTURA XANTHENES			R		C	R
	Perlodidae	CULTUS DECISUS (w)					R	C
		MALIREKUS HASTATUS (w)						R
	Pteronarcyidae	PTERONARCYS BILOBA			R			
		PTERONARCYS SPP						C
	Taeniopterygidae	TAENIOPTERYX SPP (w)			R			R
Trichoptera	Brachycentridae	BRACHYCENTRUS NIGROSOMA				R		R
	Glossosomatidae	GLOSSOSOMA SPP			C	A	R	C
	Goeridae	GOERA SPP			R			
	Hydropsychidae	CERATOPSYCHE BRONTA						C
		CERATOPSYCHE SPARNA			A	A	C	A
		CHEUMATOPSYCHE SPP		C	A	C	C	C
		DIPLECTRONA MODESTA			C	R	C	C
		HYDROPSYCHE BETTENI			A	R	A	C
		HYDROPSYCHE VENULARIS		R				
	Leptoceridae	TRIAENODES IGNITUS			C			
	Limnephilidae	HYDATOPHYLAX SPP			R	R		
		PLATYCENTROPUS		R				
		PYCNOPSYCHE SPP		R	C	R		C
	Philopotamidae	CHIMARRA SPP		R	C	R	A	

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Order	Family	Species	Rabbit Cr at SR 1504	Cat Cr off SR 1504	Cat Crabove tomato farm	Cat Cr at Waldroop property	Cat Cr at Seagle farm	Dalton Cr off Dalton Cr Rd
		DOLOPHILODES SPP				A		A
	Phryganeidae	PTILOSTOMIS SPP	R		R	R		
	Rhyacophilidae	RHYACOPHILA CAROLINA				R		
Odonata	Aeshnidae	BOYERIA GRAFIANA		R	R			
		BOYERIA VINOSA		R	R	C	C	
	Calopterygidae	CALOPTERYX SPP		C	A	C	A	C
	Coenagrionidae	ARGIA SPP	R	R	R			
	Cordulegasteridae	CORDULEGASTER SPP				R	R	R
	Gomphidae	GOMPHUS SPP		R	R	C	R	R
		HAGENIUS BREVISTYLUS				R		
		LANTHUS SPP						R
		OPHIOGOMPHUS SPP		C	R			
	Macromiidae	MACROMIA SPP		R		R		
Megaloptera	Corydalidae	NIGRONIA SERRICORNIS			C		R	
Coleoptera	Dryopidae	HELICHUS SPP			R	C		
	Dytiscidae	LIOPOREUS TRIANGULARIS				R		
	Elmidae	MACRONYCHUS GLABRATUS			R			
		OPTIOSERVUS OVALIS			R	R		
		OPTIOSERVUS SPP		R				
		STENELMIS SPP			C	R	R	R
	Psephenidae	ECTOPRIA NERVOSA					R	
		PSEPHENUS HERRICKI			C	C	A	C
	Ptilodactylidae	ANCHYTARSUS BICOLOR			C	C		
Chironomidae	Chironomidae	BRILLIA SPP				C		
		CHIRONOMUS SPP		C				
		CLINOTANYPUS PINGUIS			R			
		CONCHAPELOPIA GROUP		R	R	R		R
		CRICOTOPUS BICINCTUS		R			R	
		CRICOTOPUS INFUSCATUS					R	
		CRICOTOPUS INFUSCATUS GR	R					
		CRICOTOPUS VIERRIENSIS GR	C			R		
		EUKIEFFERIELLA TIROLENSIS	R					R
		MICROTENDIPES PEDELLUS GR					R	
		NANOCLADIUS SPP	R					
		ODONTOMESA FULVA				R		
		ORTHOCLADIUS OBUMBRATUS GR	R					
		PARAMETRIOCNEMUS SPP			R		R	R
		POLYPEDILUM AVICEPS		R	R	C		R

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Order	Family	Species	Rabbit Cr at SR 1504	Cat Cr off SR 1504	Cat Crabove tomato farm	Cat Cr at Waldroop property	Cat Cr at Seagle farm	Dalton Cr off Dalton Cr Rd
		POLYPEDILUM FLAVUM	C					
		POLYPEDILUM ILLINOENSE GR	R					
		RHEOCRICOTOPUS ROBACKI				A		
		RHEOTANYTARSUS SPP			R			
		STICTOCHIRONOMUS SPP		R				
		THIENEMANIELLA XENA				R		
		TRIBELOS SPP				R		
		TVETENIA BAVARICA GR			R	C	C	R
non-Chironomidae	Ceratopogonidae	PALPOMYIA (COMPLEX)			R			
Diptera	Dixidae	DIXA SPP			C	C	C	
	Simuliidae	SIMULIUM SPP	C	A	C	A	A	R
	Tipulidae	ANTOCHA SPP		R		R	R	R
		TIPULA SPP	A	C	C	C	C	A
Oligochaeta	Lumbriculidae	LUMBRICULIDAE	C					
	Megadrile	MEGADRILE OLIGOCHAETE	R					
	Naididae	NAIS SPP					R	C
Gastropoda	Lymnaeidae	PSEUDOSUCCINEA COLUMELLA		R				
	Physidae	PHYSA SPP	C		C	C		
	Pleuroceridae	ELIMIA SPP	C	C	A	A	R	R
Other	Hydracarina	HYDRACARINA		R				

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