Seven Years of Volunteer Biomonitoring in Western North Carolina Streams

Stream Monitoring Information Exchange

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EXECUTIVE SUMMARY

This report details the 2011 results of the Stream Monitoring Information Exchange (SMIE), a volunteer water quality monitoring program in western North Carolina. This program began sampling in the spring of 2005 and there are now 31 active sites. The SMIE program is collaboration between various nonprofit organizations, educational institutions, and local, state, and federal agencies with an interest in water quality issues. The SMIE program uses volunteers to collect benthic macroinvertebrate data to evaluate water quality. Volunteer stream monitoring data are being increasingly used by government agencies for planning and review purposes. The SMIE benthic macroinvertebrate protocol is designed to mimic NC Division of Water Quality (DWQ) collection techniques to facilitate comparisons between the data. The data are being shared with DWQ to identify streams in the process of environmental degradation or improvement.

Eleven volunteers attended a training session on September 24, 2011. No spring training was held in 2011 due to lack of funding. Monitoring was conducted in Buncombe, Haywood, Madison, Mitchell, and Yancey Counties in streams ranging from third to fifth order. Sites were selected, when possible, as Volunteer Water Information Network (VWIN) sites or DWQ sampling sites (as identified from DWQ's Basinwide Assessment reports). Samples were collected using kick net, leaf pack, and visual search methods. Nineteen sites were sampled in the spring and 31 in the fall; established sites not sampled in the spring were primarily due to lack of funding.

The total number of organisms in a sample varied, with some sites having less than 200 organisms in the sample. This threshold is used as an indication of sampling effort. Due to low numbers, the results should be considered conservatively because of their effect on data interpretation. Taxa richness ranged from eight to 20 taxa of 43 possible. Sites with greater taxa richness are considered to have better water quality. The EPT taxa (Ephemeroptera = mayflies, Plecoptera =stoneflies, and Trichoptera = caddisflies) richness ranged from three to 13 of 19 possible. EPT taxa are generally recognized as the most pollution sensitive, thus sites with greater number of EPT taxa are presumed to have better water quality. The Izaak Walton League (IWL) scores ranged from nine to 34; most sites were considered *Good* or *Excellent*. The Virginia Save Our Streams scores ranged from two to twelve with most sites being considered *Acceptable*. Both metrics did have seasonal variation, though.

The efforts of SMIE program volunteers appear to indicate that streams in Buncombe, Haywood, Madison, Mitchell, and Yancey Counties are impacted by rainfall and multiple land use factors. These factors include human encroachment, replacement of native riparian buffer vegetation with impervious surfaces, exotic and invasive species, and erosion that lead to sedimentation of stream substrates. Based on SMIE biomonitoring results, the five highest quality sites in 2011 were the East Fork of the Pigeon River, Cane Creek at Miller Road, Ashworth Creek, Bent Creek, and Reems Creek. The five lowest quality sites were the Pigeon River downstream of Canton, Smith Mill Creek, Reed Creek, Newfound Creek, and the Swannanoa River downstream of Beetree Creek.

The SMIE program works with professional biologists to develop an effective evaluation tool to rate streams. The SMIE program aims to continue improving the skills of volunteers and building a database of biomonitoring results. Additional goals include further development of information available on the website (www.eqilab.org), targeted training based on QAQC results, and analysis of biological data with land use and water chemistry. Pending funding, simultaneous side-by-side comparisons of DWQ and SMIE protocols will be conducted at five sites in 2012.

TABLE OF CONTENTS

EXECUTIVE SUMMARY .... **ii**
Acknowledgments **4**
1.0 INTRODUCTION **4**
List of SMIE Monitoring Sites 5
Map of SMIE Monitoring Sites 6
2.0 METHODS **6**
2.1 Instruction and Training 6
2.2 Sampling 7
2.3 Information Output 8
3.0 RESULTS and DISCUSSION **9**
3.1 Training Sessions 9
Volunteer and biologist proportional similarity 10
3.2 Stream Monitoring Summary 10
3.3 Site Descriptions and Sampling Summaries 13
4.0 SUMMARY **25**
5.0 LITERATURE CITED **27**
Cumulative taxa richness values for all spring seasons. 29
Cumulative taxa richness values for all fall seasons. 29
Cumulative EPT taxa richness values for all spring seasons. 30
Cumulative EPT taxa richness values for all fall seasons. 30
Cumulative Izaak Walton League scores for all spring seasons. 31
Cumulative Izaak Walton League scores for all fall seasons. 31
SMIE summary data (richness, abundance, VASOS, and IWL) 32
SMIE summary data (ecological ratios, diversity, and density) 34
Cumulative SMIE data (spring 2005 – fall 2011) 36
Appendix A. Biological monitoring data sheet 42

Acknowledgments

We wish to thank the Pigeon River Fund of the Community Foundation of Western North Carolina for their financial support of this work. SMIE is based on strong collaboration going back to 2004, when over a dozen local, state, and federal agencies, local and regional non-profit organizations, and educational institutions worked together to develop this program to support improvements to surface water quality. We thank those stakeholders who have supported the work and use the data to improve water quality in western North Carolina. The work of Eric Romaniszn and Jason Robinson has been crucial to establishment of data analysis and reporting methods. Now, more than ever, there is an urgent need for well-educated, engaged community volunteers. The volunteers continue to provide very high levels of in-kind support and have kept the program going even in times of little to no funding. The volunteer donations of time and effort allow funding to be directed towards quality control and expansion of monitoring sites. Special thanks go to our group leaders who undergo extra training and take on additional sampling responsibilities.

1.0 INTRODUCTION

This report details the results of the Stream Monitoring Information Exchange volunteer water quality monitoring program from the spring and fall of 2011. Protocols were developed by Jason Robinson (Kanugalihi Biological Consulting), the NC DWQ, and the SMIE program itself, which is collaboration between regional organizations, educational institutions, and government agencies with an interest in water quality issues. SMIE, coordinated by the Environmental Quality Institute (EQI), has assumed responsibility for designing and implementing a program to train volunteers to implement standardized protocols for benthic macroinvertebrate monitoring in western North Carolina.

Biological stream monitoring is a way to measure the effects of the chemical and physical impacts in a watershed. It is particularly useful due to the time constraints and high cost of laboratory testing for organic pollutants, such as pesticides. Aquatic insect communities are excellent indicators of toxic substances in streams, since they are in the water constantly and have specific tolerance levels to pollutants. If a stream has good chemical ratings, but poor biological scores, it could mean that unmeasured toxic substances are getting into the water periodically.

Volunteer stream monitoring data are being used increasingly by government agencies for planning and review purposes. The NC DWQ is operating on an increasingly restrictive budget, and looking to collaborate with environmental organizations who share their mission to protect and enhance water quality. SMIE helps provide more frequent sampling at a variety of sites in the region and helps DWQ identify streams that may be degrading or in threat of degradation. The data can be used to raise red flags so that DWQ can provide an in-depth survey of pollution sources and stressors. The core SMIE program currently conducts biannual sampling at 31 sites, while the Environmental and Conservation Organization (ECO) samples 23 additional sites in Henderson County following the SMIE protocol (Romaniszyn 2011). Table 1 is a list of all SMIE monitoring sites in Haywood, Buncombe, Madison, Mitchell, and Yancey Counties. Figure 1 depicts the locations of sites in the region.

This protocol is specifically designed to mimic DWQ collection techniques in order to facilitate comparisons between those data. The advanced level of identification (often to species) used by DWQ precludes anything but general comparisons with SMIE data, as the volunteer monitoring protocol identifies only to the family levels (at best). This information is valuable to researchers as well as other volunteer monitoring groups. It is available through technical reports and a data spreadsheet, which can be accessed at www.eqilab.org or by request. This website also has online SMIE training videos, which cover basic stream ecology, macroinvertebrate identification, sampling protocols, and habitat assessment.

Table 1. List of SMIE Monitoring Sites

Site #	Description
Haywood County	
1	East Fork of Pigeon River
2	Pigeon River downstream of Canton
3	Raccoon Creek
4	Richland Creek upstream of Hyatt Creek Rd
5	Crabtree Creek
6	Jonathan Creek at Coleman Mtn Rd
7	Jonathan Creek upstream of Moody Farm Bridge
8	Lower Fines Creek
Buncombe County	
9	Cane Creek at Miller Rd
10	Ashworth Creek
11	Cane Creek at Ashworth Creek
12	Bent Creek
13	Hominy Creek
14	Swannanoa River downstream of Beetree Ck
15	Swannanoa River upstream of Bull Creek
16	Smith Mill Creek
17	Reed Creek at Botanical Gardens
18	Lower Newfound Creek
19	Reems Creek
20	Sandymush Creek
Madison County	
21	California Creek at Radford Rd
22	California Creek at Beech Glen
23	East Fork Bull Creek
24	Little Ivy River at Forks of Ivy
25	Big Ivy River at Forks of Ivy
26	Shelton Laurel Creek
27	Puncheon Fork Creek
28	Big Laurel Creek
Mitchell County	
29	Cane Creek at Bakersville
30	North Toe River
Yancey County	
31	Cane River

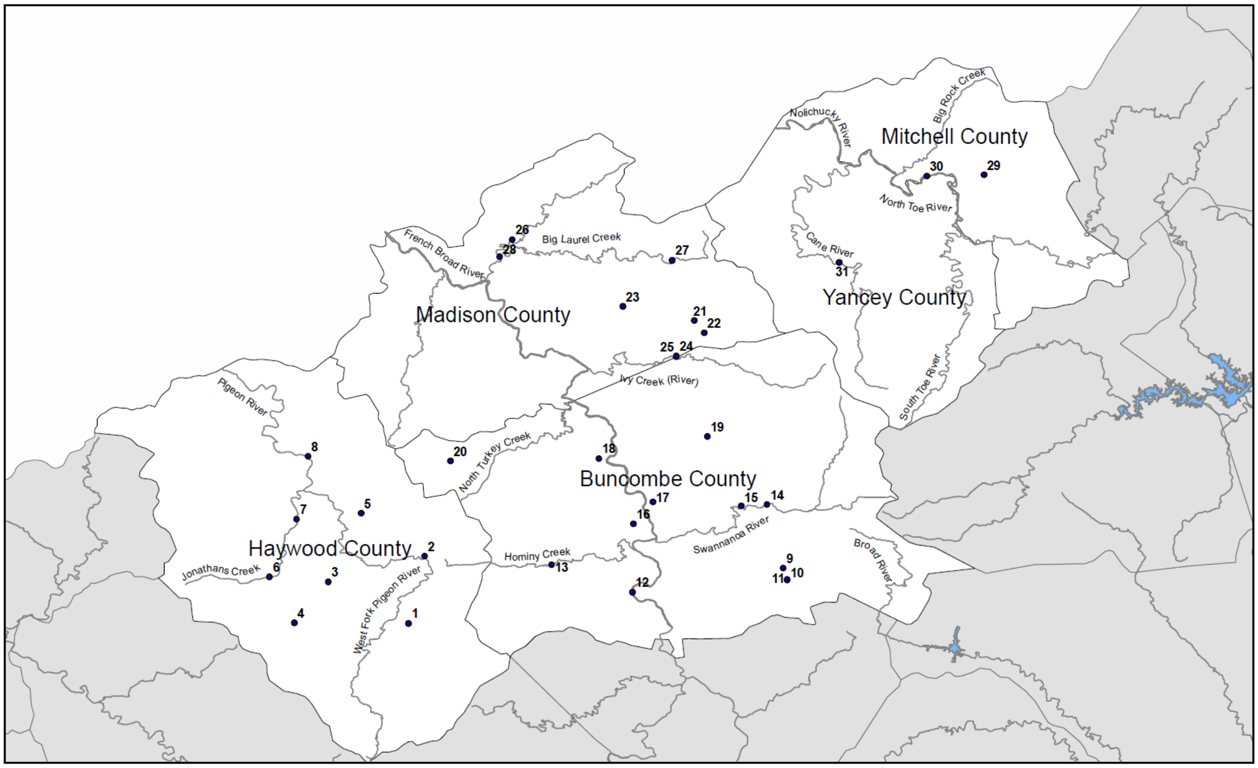

Figure 1. Map of SMIE Monitoring Sites

2.0 METHODS

2.1 Instruction and Training

Volunteers are solicited through participating SMIE organizations as well as through public outreach. The spring 2011 training was cancelled due to lack of funding, but eleven volunteers attended the fall event. Tim Forrest from the University of North Carolina-Asheville was instrumental in providing classroom resources to host a training session on September 24, 2011.

Volunteers were instructed in general stream ecology principles, the theory behind sampling streams for water quality, and the common groups of insects used in the protocol. Microscopes greatly facilitated this process, but the protocol is designed such that microscopic evaluation is not necessary for field identifications. Microsoft PowerPoint©, a projector, and chalkboards were valuable instructional tools. Volunteers received packets containing information on basic stream ecology (including a dichotomous key), the SMIE sampling protocol, and a laminated identification sheet.

The effectiveness of each training session is evaluated using several methods: (1) a brief five question pre- and post-survey of general knowledge of invertebrate identification and sampling concepts; (2) after several hours of identification training, a 15-question quiz to test identification skills; and (3) an evaluation of the instructor, methods and materials, individual performance, and overall efficacy of the training.

Group leaders are responsible for overseeing the implementation of the protocol at all sampling sites, assisting with logistics, and having the final say on identification of specimens. SMIE provides additional training for group leaders, which includes evaluations of both macroinvertebrate identification and protocol proficiency. The volunteer must score 93% in order to complete both requirements. In addition to the initial competency verification, group leaders must preserve all specimens from one site per season to be analyzed by the SMIE biologist. Anyone with less than 85% similarity to the biologist's counts and identifications is required to attend a refresher training session.

2.2 Sampling

All stream sampling followed the SMIE stream monitoring protocols (Robinson 2004). At least one group leader or the SMIE biologist was in charge of leading each group. Sites were selected, when possible, as Volunteer Water Information Network (VWIN) sites (a chemical water monitoring program, also coordinated by EQI) or DWQ sampling sites as identified from the French Broad Basinwide Water Quality Plans and Assessment Reports (NCDENR-DWQ-BPU 2011, NCDENR-DWQ-ESS 2008). Samples were collected using kick net, leaf pack, and visual search methods.

Riffles are the primary habitat for benthic macroinvertebrate collection. Riffles are loosely defined as areas greater than 15 ft^2 with relatively shallow water depth (5-40 cm) and visible current. Benthic macroinvertebrates are collected using a kick net (mesh size 500 μm). Sampling consisted of overturning stones (by feet or hands) for one minute within a 15ft^2 area upstream of the net. All organisms are picked from the net, identified, and recorded separately from the leaf pack and visual collections.

Leaf packs are collected at each site within riffle habitats. Volunteers collect about 600 to 700 cm^3 of leaf material in a leaf pack sample. This material is washed and poured through a kick net several times to isolate insects and reduce the volume of material to be searched. Organisms are picked from the net or leaf material, identified, and recorded separately from the kick net and visual collections.

The visual survey is performed by someone with a working knowledge of different types of habitats and insects; in most instances, this will be the group leader. Searchable habitats include pools, riffles, runs, aquatic macrophytes, submerged mosses, undercut banks, large logs and boulders, and sand bars. This method often yields taxa not collected in the other two samples and provides a total estimate of taxa richness at a site. These organisms are identified and recorded separately from the kick net and leaf pack collections.

Several habitat characteristics are evaluated as part of each sampling event, including:
- What type of barriers to fish movement may be present (i.e., waterfalls, culverts);
- The location of leaf packs, which gives an indication of riparian buffer quality and quantity;
- What substrates are available for aquatic invertebrates to inhabit (i.e., bedrock, boulder, cobble, gravel, sand, clay, algae, woody debris);
- Water color to give an indication of such problems as sedimentation or nuisance algal blooms;
- The composition of streambank vegetation; a healthy riparian buffer of trees and shrubs provides adequate shade to keep water temperatures cool and a supply of leaf litter inputs that are important for the base of the food chain;
- If any litter or trash is observed; and
- The effort it took to sample the riffle habitat. If a lot of effort was made, this is an indication of severe sedimentation. Substrates that are extremely embedded are poor habitat for aquatic organisms. Many taxa inhabit the underside of rocks for protection, searching for food, or predation. The undersides of rocks cannot be accessed if the spaces between the rocks are filled in with sediment. Excess sediment also inhibits fish and amphibian reproduction by

covering the area where many of those organisms lay their eggs, and may smother the eggs themselves.

This habitat description helps interpret what natural or manmade factors are affecting the benthic macroinvertebrate community. The presence or absence of fish is also noted. Streams that support a greater diversity of organisms are generally considered healthier streams.

2.3 Information Output

Microsoft Excel© spreadsheet software is used to summarize and manage data. Data are used to calculate several metrics that help interpret the level of water quality and potential sources of impairment.

Total Taxa Richness: Sites with greater taxa richness are considered to have higher water quality (Rosenberg and Resh 1996). There are 43 possible taxa identified in the SMIE methods.

EPT Taxa Richness: It is generally considered that EPT taxa (Ephemeroptera = mayflies, Plecoptera =stoneflies, and Trichoptera = caddisflies) are the most pollution-sensitive aquatic invertebrates (Resh 1993), thus sites with greater number of EPT taxa are considered to have better water quality. It is important to note that many EPT taxa exhibit natural trends in their life cycle, such that many organisms observed in spring may not be observed in fall, and vice versa. There are 19 possible EPT taxa in the SMIE methods.

Total Number of Organisms: This metric is merely a sum of all the benthic macroinvertebrates collected in the kick net and leaf pack samples. With good species diversity, high total numbers can indicated good water quality. If total numbers are high but species diversity low, the stream may be impaired and only those species that can tolerate the pollutant(s) are flourishing. The stream may also be impaired if low numbers are collected (i.e., chemical contamination, recent flooding). Low numbers may also indicate inadequate sampling techniques or there just happened to be few macroinvertebrates in the collection area. This latter phenomenon is called ‘patchiness’, a natural property of many living (plant and animal) communities. Low numbers pose a very real problem to the interpretation of data, so SMIE aims to collect approximately 200 individuals per site. The total number of organisms is used as the index of sampling effort, since volunteers may have slightly different sampling abilities.

Virginia Save Our Streams (VASOS) multi-metric index: The VASOS index calculates six metrics, which are then used to produce an *Acceptable* or *Unacceptable* ecological condition rating. The six metrics are percent EPT (excluding the net-spinning caddisflies), percent net-spinning (Hydropsychidae) caddisflies, percent lunged snail, percent beetle, percent tolerant organisms, and percent non-insects. The VASOS method scores sites on a scale of 1 to 12 with *Acceptabl*e between 7 and 12 and *Unacceptable* between 0 and 6.

Izaak Walton League (IWL) multi-metric index: The IWL rating uses the presence of various macroinvertebrate groups, combined with estimated tolerance values for these groups, to calculate an index of water quality. The IWL narrative score ranges are <11 *Poor*; 11-16 *Fair*; 17-22 *Good*, and >22 *Excellent*. There is no upper limit for the *Excellent* range.

P/R (Production/Respiration): This metric is calculated as the ratio of ‘scrapers’, which scrape algae off rocks, to ‘filterers’ and ‘collectors’, which filter organic matter floating in the water column. Scores greater than 0.75 indicates the stream may be autotrophic or could have significant organic pollution; less than 0.75 indicates stream may be heterotrophic. Heterotrophic sites may be receiving less nutrients (i.e., nitrogen or phosphorus from agricultural activities or leaking septic systems) than autotrophic sites, and thus could be “respiring” communities. This means they are using the available nutrients before they build up and cause nuisance plant and algae blooms. Collector-gatherers and filterers tend to be abundant in these cases. Nutrient pollution can lead to significant environmental degradation (Laws 1993) and conditions unsuitable for healthy benthic macroinvertebrate and fish communities, such as low dissolved oxygen, high temperature, and lack of suitable substrate.

Leaf Input: The leaf input metric evaluates the importance of woody vegetation to stream food webs. It is calculated as the ratio of ‘shredders’, which feed on decomposing leaves, to ‘filterers’ and ‘collectors’, which filter organic matter floating in the water column. Scores greater than 0.25 in spring and summer and 0.5 in winter and autumn indicate the stream is more heterotrophic. Scores less than those values indicate the stream may be impaired, most likely from riparian buffer alterations. The riparian buffer can be disrupted by human encroachment (i.e., road, homes, agriculture). Healthy streams have adequate supplies of woody vegetation inputs to support a healthy macroinvertebrate population.

Top-Down: This metric is calculated as the ratio of predators to shredders, scrapers, collectors, and filterers. Lower scores mean more plant eating trophic groups are present and an indication that water quality is better. Ratios greater than 0.15 may indicate predators are controlling macroinvertebrate distributions. Predators that are effective colonizers may potentially limit the colonization of other invertebrates, particularly at sites with severe natural disturbances where ‘natural’ communities have been altered or destroyed.

The Simpson’s Diversity and Taxa Density indices are designed to evaluate how the total numbers of organisms found in the sample are distributed among the number of species collected. Low values suggest pollution or recent benthic macroinvertebrate colonization, such as after flooding or drought. Due to the way the metrics are calculated, taxa density values are lower than Simpson’s diversity. There are no standards for what indicates impairment but values from the SMIE program in other counties indicate Simpson’s diversity values greater than 0.75 and taxa density values greater than 0.15 are an indication that numbers are fairly evenly distributed among the taxa collected.

The use of these metrics is widespread. A summary of standard ecological metrics can be found in Hauer and Lamberti (2000) and Rosenberg and Resh (1996). It should be noted that the SMIE protocol was designed to include VASOS and IWL collection strategies nested within the collection procedure, but slight deviations from those procedures are necessarily expected (e.g., the relaxing of the requirement that the kick net collect >200 organisms). Relationships between the metrics calculated are being explored in an effort to determine which metrics best explain water quality and habitat quality at each site.

3.0 RESULTS and DISCUSSION

3.1 Training Sessions

All training participants complete an evaluation of the instructor, methods and materials, overall efficacy of the training, and individual performance. Evaluations from 2011 showed that about half of participants had little or no prior experience monitoring streams and the other half had at least some college-level instruction. All participants felt the SMIE training improved their monitoring skills and knowledge. All participants felt they had maintained or improved their knowledge of threats to water quality, and all felt more empowered to address threats to water quality.

The pre- and post-survey of the fall SMIE training found all participants either maintained or improved (by at least one question) their comprehension of basic stream ecology and water quality assessment concepts, and all maintained or improved their basic invertebrate identification skills after completing the training sessions. Notably for this group, all but two of the 14 participants scored perfectly (5 out of 5) on the basic identification portion of the post-survey, showing exceptional proficiency in distinguishing between five major classes of insects. The average taxonomy score on the identification quiz was 10.5 out of 15 (70%), also an exceptionally high score for new volunteers.

As a continuing check on the volunteer skills, the SMIE biologist checks the identifications and counts of preserved specimens for one site per group leader each season. SMIE used a proportional similarity calculation for the fall 2011 data to compare the volunteer field identifications and biologist re-identifications of the samples quantitatively (Garey and Smock 2007). The 2011 median similarity for kick nets was 89.9% (range: 81-94%) and for leaf packs was 85.8% (range: 77-94%). Similarity values less than 85% indicate that the group leader needs to attend a refresher training session. Some differences may also be due to the lack of notes on the data sheet that could indicate if individuals were discarded prior to preservation, which is usually due to large size or predatory habits. Additionally, we calculated the VASOS and IWL scores to see if these ecological metrics changed. Table 2 shows that while all VASOS scores were *Acceptable*, the IWL scores at two sites changed from *Good* for the biologist to *Excellent* for the volunteers.

Table 2. Volunteer and biologist proportional similarity for kick net (KN) and leaf pack (LP) data, with comparisons of VASOS and IWL scores.

	% similarity		VASOS				IWL			
Stream	**KN**	**LP**	**Vol**		**Biol**		**Vol**		**Biol**	
Sandymush	94.4	91.9	7	A	7	A	14	F	14	F
Asheworth	92.3	93.4	8	A	7	A	**25**	**E**	**19**	**G**
Little Ivy	91.0	**80.0**	8	A	8	A	19	G	20	G
Shelton Laurel	**81.1**	**76.8**	9	A	10	A	25	E	24	E
Hominy	93.5	93.6	8	A	8	A	34	E	28	E
Cane River	87.1	**79.0**	9	A	8	A	**27**	**E**	**22**	**G**
Mean:	89.9	85.8	A=Acceptable, U=Unacceptable				E=Excellent, G=Good, F=Fair			

3.2 Stream Monitoring Summary

Tables 3 and 4 summarize the collection data from 2011. The results from sites where very low numbers were collected should be interpreted conservatively. Low numbers significantly affect data interpretation and can explain many of the discrepancies between metrics. Collecting 200 organisms is generally considered the minimum number for good quality data interpretation (Barbour et al. 1999). Previous comparative analysis of SMIE and NC DWQ data showed the predictive power of SMIE data improves considerably when a minimum of 200 organisms are collected.

Monitoring was conducted at 19 sites in the spring of 2011. Eleven sites were not sampled due to the lack of funding, which resulted in reduced time for coordination and no new volunteer recruitment or training. By fall of 2011, SMIE had regained funding and expanded the program to 31 sites. The following descriptions summarize the overall results in each season.

<u>Total Taxa Richness and EPT Taxa Richness</u>
Spring: Taxa richness ranged from ten (Richland Creek, California Creek at Radford Rd, and Big Laurel Creek) to 20 (Bent Creek) of 43 possible. EPT (<u>E</u>phemeroptera = mayflies, <u>P</u>lecoptera

=stoneflies, and Trichoptera = caddisflies) taxa richness ranged from five (Reed Creek, California Creek at Radford Rd, Little Ivy River, and Big Ivy River) to thirteen (Shelton Laurel Creek) of 19 possible.

Fall: Taxa richness ranged from eight (Newfound Creek and Smith Mill Creek) to 20 taxa (East Fork of Pigeon River, Ashworth Creek, Cane Creek at Ashworth Creek, Swannanoa River downstream of Beetree Creek, and Hominy Creek) of 43 possible. EPT richness ranged from three (Newfound Creek, Pigeon River downstream of Canton, Reed Creek, and Smith Mill Creek) to eleven (Bent Creek) of 19 possible.

Higher taxa diversity was generally observed in the spring, which follows known trends in benthic macroinvertebrate life histories (Allan 1995). Also, even though the sites with the highest diversity had less than half of the total possible, several taxa are rare and/or hard to find (i.e., roach shredder stoneflies, sand and stick cased caddisflies, sand snail case caddisflies, alderflies, predator beetles, fat-head craneflies, red midges, leeches, sowbugs, scuds, round right face snails, and clams/mussels). Taxa richness in some of the highest quality SMIE-sampled streams ranges from 15 to 20 and rarely over 20. In addition, not finding tolerant taxa typical of only poorer water quality can be a positive sign (i.e., oligochaetes, leeches, clams, some damselflies, blackflies, red midges, coiled left face snails).

Figures 2 and 3 are box-and-whisker plots for total taxa richness and EPT taxa richness over all years of monitoring at each site. The "a" figures show data from the spring, and the "b" figures show data from the fall. The horizontal bar in the middle of the "boxes" represents the median for each site, while the upper and lower edges of the box represent the 25th and 75th percentiles respectively. The "whiskers" show the range of the data, with outliers indicated by dots. Box plots are helpful to identify samples with extreme characteristics, or a particular skew to the data. Outliers are often the most information-rich part of the dataset, as they may indicate ecological disturbances.

Total Number of Organisms

Spring: The total number of organisms collected ranged from a high of 808 (Cane Creek at Ashworth Creek) to eight sites having less than 200.

Fall: The total number of organisms collected ranged from a high of 418 (Newfound Creek) to eight sites having less than 200.

Between both seasons, approximately half of the samples had more than 200 organisms observed, 82% had more than 150 organisms, and 8% had less than 100 organisms observed.

VASOS and IWL (Figure 4)

Spring: The IWL scores ranged from 12 (California Creek at Radford Rd) to 29 (Cane Creek at Ashworth Creek); nine sites were rated *Excellent*, six were *Good*, and four were *Fair*. The VASOS scores ranged from six to twelve, with 18 of 19 sites rated as *Acceptable* and one as *Unacceptable* (Reed Creek). With one exception (Reed Creek; see site description), the IWL and VASOS scores corresponded to each other. Sites with higher IWL scores tended to have higher VASOS scores.

Fall: The IWL scores ranged from nine (Newfound Creek) to 34 (Hominy Creek); 13 of 31 sites were rated *Excellent*, 11 were *Good*, six were *Fair*, and one was *Poor* (Newfound Creek). The VASOS scores ranged from two to 12, with 26 sites rated as *Acceptable* and four as *Unacceptable* (Newfound Creek, Pigeon River downstream of Canton, Swannanoa River downstream of Beetree Creek, and Swannanoa River upstream of Bull Creek). With one exception (Swannanoa River upstream of Bull Creek), the IWL and VASOS scores corresponded to each other.

Figure 4a and 4b are box-and-whisker plots for the IWL scores at the monitoring sites over all years of monitoring. The “a” figure shows data from the spring, and the “b” figure shows data from the fall. It should be noted that IWL and VASOS do not consider the same parameters when calculating the final score. For example, stoneflies, mayflies, and caddisflies are separated in the IWL calculation but are lumped together for VASOS. In addition, both calculate their metrics using only the kick net data, so additional organisms collected in leaf packs or visually, particularly EPT taxa, are not included, which can explain discrepancies with other metrics.

P/R

Spring: All but two sites were characterized as heterotrophic (P/R < 0.75). The P/R ratios ranged from 0.02 (Reed Creek) to 3.6 (Richland Creek). Big Laurel Creek was the only other site with a value greater than 0.75, and thus could be receiving excessive organic enrichment.

Fall: Smith Mill Creek was the only stream to be characterized as autotrophic, receiving excessive organic enrichment.

Heterotrophic sites may be receiving less nutrients (i.e., nitrogen or phosphorus) than autotrophic sites, and thus could be “respiring” communities, meaning they are using up the available nutrients before they build up and cause nuisance plant and algae blooms.

Leaf Input

Spring: Scores ranged from 0.00 (California Creek at Radford Rd and North Toe River) to 1.33 (Richland Creek). All but one of the 19 samples had scores indicating possible water quality impairment (<0.25).

Fall: Scores ranged from 0.0 (Pigeon River downstream of Canton, Newfound Creek, and Swannanoa River downstream of Beetree Creek) to 0.90 (East Fork of Bull Creek). All but two of the 31 samples had scores indicating possible water quality impairment (<0.50).

Scores less than the 0.25 in the spring and 0.50 in the fall suggests leaf litter was limited, because of either the leaf inputs being consumed or broken down, or a disruption in riparian buffer condition. Sites with scores of 0.00 indicate an absence of shredders.

Top-Down

Spring: This ratio ranged from 0.02 (Reed Creek) to 0.57 (Bent Creek). It was considered high (>0.15) at eight of 19 sites and suggests predator abundance may influence the composition of macroinvertebrate assemblages.

Fall: This ratio ranged from 0.00 (Newfound Creek) to 0.78 (Reems Creek), and was high at 17 of 31 sites.

Samples with scores less than 0.15 are characterized by more herbivores, signaling that water quality is suitable.

Simpson’s Diversity and Taxa Density

Spring: Simpson values ranged from 0.40 (Ashworth Creek) to 0.87 (Shelton Laurel Creek and North Toe River). Taxa density numbers ranged from 0.02 (Cane Creek at Ashworth Creek) to 0.24 (North Toe River). Five of 19 sites had Simpson values greater than 0.75, which suggests that the numbers were well distributed among the taxa collected.

Fall: Simpson values ranged from 0.14 (Newfound Creek) to 0.85 (Puncheon Fork Creek). Taxa density numbers ranged from 0.02 (Newfound Creek) to 0.16 (Jonathan Creek at Moody Farm

Bridge and Smith Mill Creek). Many sites had Simpson values greater than 0.75.

3.3 Site Descriptions and Sampling Summaries

The following section describes the location and habitat of each SMIE monitoring site. The sites are grouped by subbasin and watershed and are described from upstream to downstream, not necessarily by numerical order. Unique SMIE site identification numbers have been assigned to each site, but corresponding DWQ and VWIN site identifications are specified if available. A description of the benthic macroinvertebrate data is also provided. References to the right and left side of the stream correspond to the right and left sides when facing downstream. Overall water quality patterns for many of the streams or their parent watersheds are described in the NC Department of Environment and Natural Resources basinwide reports for the French Broad River basin (NCDENR-DWQ-BPU 2011, NCDENR- DWQ-ESS 2008). Volunteer observations are also critical in documenting habitat and water characteristics at specific sites.

The monitored streams are all tributaries in the French Broad River Basin, and are located in the Pigeon River, Upper French Broad River, and Nolichucky River subbasins. Henderson and Buncombe Counties have experienced more rapid population growth than surrounding areas in western North Carolina. The valleys along with the Upper French Broad River have provided suitable land for development and agriculture throughout the region, bringing nonpoint sources of pollution in close proximity to the streams. Drought conditions can have severe impacts on streams by reducing aquatic habitats, providing less water to dilute point source pollution, and reducing nonpoint source pollution between rainfall events. The area experienced an extreme drought that lasted approximately two years from 2007 to 2009. Since then, rainfall has mostly been normal, with some abnormally dry conditions during the parts of 2010 and 2011 (Drought Management Advisory Council 2012).

Pigeon River Subbasin (Haywood County)

The Pigeon River is the main artery through Haywood County and is a large tributary to the French Broad River in Tennessee. The headwaters of the Pigeon River are located in southern Haywood County.

Site #1 – East Fork of Pigeon River

The East Fork of the Pigeon River flows through southeastern Haywood County, which is largely comprised of forested public land. This monitoring site is located approximately 100 meters upstream of the bridge on SR 276 over the East Fork, near the junction with Max Thompson Road (SR1105). It corresponds to the discontinued VWIN site Y2, near Bethel. Trees and shrubs dominate the banks, and the substrate is made up of gravel, cobblestones, and bedrock.

This site was first sampled in the fall of 2005. While not sampled in the spring of 2011, the fall IWL score was *Excellent*. It had a fall taxa richness of 20, making it one of the four highest scoring sites. This site has one of the four highest spring median values for taxa richness and EPT taxa richness. In the fall of 2011, net-spinning caddisflies (52%) dominated the sample. The leaf input metric indicates impairment of the riparian buffer. The top-down metric scores were high, indicating a higher than natural proportion of predators in the community. Both the diversity and taxa density metrics show that the site does not have an even distribution among the taxa. The East Fork of the Pigeon River typically shows excellent water quality based on VWIN chemical monitoring, and is comparable with relatively undisturbed areas.

Site #2 – Pigeon River downstream of Canton

This site is located on the Pigeon River just downstream of the Blue Ridge Paper Products Mill in Canton. It is located near Fiberville Street off NC215 in Canton, and is very close to VWIN site Y4.

The riparian zone is comprised mostly of trees and shrubs, with some grass. The substrate is mostly gravel and cobblestones. Volunteers have noted that the water was tea-colored during 88% of the sampling events.

The Pigeon River was first sampled here in the fall of 2006. It was not sampled in the spring of 2011, but it had an IWL rating of *Fair* in the fall. The median fall IWL score over all years is the lowest of all sites. It also had the lowest VASOS score in 2011, and was one of the few sites with an *Unacceptable* rating. It had one of the five lowest EPT taxa richness scores in 2011, with one of the four lowest fall medians. Net-spinning caddisflies (63%) were the dominant taxa in the fall, along with clams and mussels (19%) and coiled left face snails (9%). Some species of these abundant taxa are known to have high tolerance to pollution. This location has one of the three lowest leaf input scores, showing a disruption to the riparian buffer. The top-down metric indicates that predators do not control the community. Both distribution indices show an imbalance among taxa. VWIN data show exceedingly high conductivity, alkalinity, orthophosphate, and ammonia-nitrogen at this site, while turbidity and total suspended solids are usually in the normal range. DWQ finds benthic macroinvertebrate communities largely comprised of pollution tolerant taxa just downstream of the mill and the City of Waynesville's Wastewater Treatment Plant (WWTP).

Site #4 – Richland Creek

Richland Creek runs through Waynesville, into and out of Lake Junaluska, then into the Pigeon River. SMIE samples this creek in Waynesville, upstream of Lake Junaluska and Raccoon Creek. The site is approximately 200 meters upstream of Hyatt Creek Road at Exit 98 on US 23/74, near the upper end of the Wal-Mart parking lot. The VWIN site Y10 is approximately two miles upstream. The stream resembles a long straight channel with little riffle formation or bank heterogeneity. The riparian zone is highly modified by both a large parking lot and residential homes. The substrate is mostly gravel and cobblestone, with sand present.

Richland Creek was first sampled in the spring of 2005. The IWL ratings were *Good* in the spring and *Fair* in the fall of 2011, although there was only one point difference between the scores. The spring taxa richness was relatively low, with 10 taxa observed. Flattened scraper mayflies (42%) and small head caddisflies (23%) were the most abundant taxa in the spring. Net-spinning caddisflies (44%), flattened scraper mayflies (21%), and small head caddisflies (11%) were prevalent in the fall. Water pennies, which are pollution-sensitive organisms, comprised 9% of the fall sample. This site had the highest P/R ratio of all sites, pointing to an autotrophic environment caused by excessive nutrients. The leaf input score was adequate in the spring, but showed impairment in the fall. The top-down ratios from both seasons show a predator-controlled community. VWIN analysis shows excellent water quality. DWQ is finding improved benthic macroinvertebrate communities at various sites along this creek (with bioclassifications from *Good-Fair* to *Good*), attributed mainly to the repair of leaking sewer lines in the watershed.

Site #3 – Raccoon Creek

Raccoon Creek is a tributary to Richland Creek in western Haywood County, upstream of Lake Junaluska. The watershed suffers from a lack of riparian buffers and is vulnerable to erosion from row crops and livestock. This site is located in Waynesville, downstream of the first bridge on Howell Mill Road at the intersection with Business 23 (Old Asheville Highway). It corresponds with VWIN site Y25. Due to safety issues, the site was moved 400 yards upstream of the Business 23 bridge at Jonathan Valley Elementary School. The riparian zone consists of trees, shrubs, and grassy areas, and the substrate is mainly gravel and cobblestones.

Raccoon Creek was first sampled in the spring of 2008. The IWL ratings for both spring and fall 2011 were *Good*. This site had relatively high EPT taxa richness, with the highest spring median of all sites. Taxa richness and EPT taxa richness have improved in the past two years at this site.

Round headed swimmer mayflies (51%) and spiny crawler mayflies (13%) were the main taxa in the spring. In the fall, round headed swimmer mayflies (24%), net-spinning caddisflies (19%), fat-head craneflies (14%), and flattened scraper mayflies (12%) were the most numerous taxa. Coiled right face snails, which are pollution-sensitive organisms, were present in the fall sample. Both seasons exhibited low leaf input metrics, indicating a disturbed riparian zone. Diversity and taxa density indices gave mixed results. The top-down ratio was better in the spring than the fall. VWIN samples exhibit high turbidity, total suspended solids, and nitrate-nitrogen.

Site #5 – Crabtree Creek
Crabtree Creek is a tributary of the Pigeon River in eastern Haywood County. The SMIE monitoring site is located approximately fifty meters below the first bridge on Upper Crabtree Creek Road, which is less than a mile upstream of where Crabtree Creek flows under Hwy 209. This site corresponds to a VWIN site (Y26) near the confluence with the Pigeon River. The substrate consists of gravel, cobblestones, bedrock, and boulders, with a riparian zone of trees and shrubs.

Crabtree Creek was first sampled in the spring of 2005. It was not sampled in the spring of 2011, but the fall IWL rating was *Good*. The fall sample was dominated by net-spinning caddisflies (38%) and round headed swimmer mayflies (23%). One giant shredder stonefly was observed, indicating a good habitat with course particulate matter available as a food source. The leaf input metric shows riparian impairment and the top-down ratio indicates a predator-controlled community. The VWIN data show above average levels of turbidity, total suspended solids, conductivity, and orthophosphate. DWQ cites cattle as likely sources of sediment and nutrients to the rural stream.

Site #7 – Jonathan Creek at Moody Farm Bridge
Jonathan Creek originates west of Maggie Valley and flows northwest into the Pigeon River. This site is located in Maggie Valley, downstream of the Maggie Valley WWTP, and approximately 50 meters downstream of the first bridge on Moody Farm Road (SR 1307). It is near the junction with SR 19 and across from the Maggie Valley Country Club golf course. It corresponds with VWIN site Y27. The riparian zone is mostly trees and shrubs, with a roadway and houses paralleling the stream. The dominant substrates are gravel, cobblestones, and sand.

This site on Jonathan Creek was first sampled in the spring of 2005, but not in the spring of 2011. In the fall, the IWL rating was *Good*. Taxa richness (17) and EPT taxa richness (10) were high relative to other sites, although only 108 individuals were captured. Quick crawling predators (21%), flattened scraper mayflies (17%), round headed swimmers (14%), and watersnipes (14%), were the prevalent taxa, along with giant shredder stoneflies, which suggest good water quality. Diversity and taxa density indices show a good distribution of taxa. The leaf input metric indicates impairment of the riparian buffer, and the top-down metric points to a predator-controlled community. VWIN shows median levels of most parameters less than the regional medians. However, this site shows slightly higher maximum chemical and sediment concentrations than the downstream site, perhaps due to stormwater runoff in Maggie Valley or the proximity to the Maggie Valley WWTP.

Site #6 – Jonathan Creek at Coleman Mountain Rd
This SMIE monitoring site is located approximately 50 meters downstream of the Coleman Mountain Road (SR 1364) bridge near the junction with SR 276. It corresponds with VWIN site Y12, is between DWQ sites EB240 (at SR1322) and EB241 (at SR1349), and is downstream of SMIE site #7. The riparian zone consists of mostly grasses, with very few trees present. Mobile homes and commercial properties line both sides of the stream. The substrate consists of gravel, cobblestone, and sand.

This downstream site on Jonathan Creek was first sampled in the spring of 2005, but not in the spring of 2011. The fall IWL rating was *Excellent*, with the highest IWL score recorded for this site so far. Net-spinning caddisflies (23%), quick crawling predator stoneflies (15%), flattened scraper mayflies (15%), and round headed swimmer mayflies (15%) were the dominant taxa in the fall. Giant shredder stoneflies, coiled right face snails, and 15 water pennies were also counted, all of which are pollution-sensitive taxa. However, only 116 individuals were collected, the leaf input metric shows riparian impairment, the P/R ratio indicates nutrient enrichment, and the top-down metric shows a predator-controlled community. DWQ has given both of their nearby sites *Good* bioclassifications, with declines in EPT taxa attributed to effluent from the Maggie Valley WWTP discharge during drought conditions.

Site #8 – Lower Fines Creek
Fines Creek is a tributary to the Pigeon River in northeastern Haywood County. This site is located near the Fines Creek bridge on SR 1355 near the junction with SR 1338, approaching the confluence with the Pigeon River. It corresponds to VWIN site Y7 and DWQ site EB231 at SR1355. The right side of the stream is mostly trees and shrubs, but the left side is mainly grass with a road in close proximity to the stream. The substrate is a mix of gravel, cobblestone, boulders, and bedrock with a substantial amount of sand present.

Fines Creek was first sampled in the spring of 2005. It was missed in the spring of 2011, but the IWL rating was *Good* in the fall. Round headed swimmer mayflies (39%), net-spinning caddisflies (31%), and quick crawling predator stoneflies (11%) were abundant in the fall. The leaf input metric indicates riparian buffer impairment, the top-down metric shows a predator-controlled community, and the taxa density shows low diversity. DWQ gives this site a *Good* bioclassification, with steep slopes in the upper reaches and dairy farms in the valleys causing the most impact to water quality. VWIN indicates that this site has below average water quality, largely due to high levels of sediment and nutrients.

<u>Upper French Broad River Subbasin (Buncombe and Madison Counties)</u>
The French Broad River originates in Transylvania County and flows through Henderson, Buncombe, and Madison Counties in North Carolina before entering into Tennessee.

Site #9 - Cane Creek at Miller Rd
Cane Creek flows through southeast Buncombe County (Fairview) and north Henderson County before its confluence with the French Broad River. This site is near the Cane Creek cemetery and Fairview School. The sample is collected off US-74 near the bridge where Miller Road crosses Cane Creek (below where Ballard Creek comes in). The site corresponds to DWQ monitoring site EB67 at SR2800. The riparian zone is mainly trees and shrubs, while the stream substrate is composed of gravel and cobblestones.

This upstream site on Cane Creek was first sampled in the spring of 2008, but not in the spring of 2011. The fall IWL rating was *Excellent*, with the highest IWL score from this site so far. This site shows one of the two highest fall medians for taxa richness values, and one of the four highest spring medians for EPT taxa richness. Net-spinning caddisflies (49%) and fragile detritivore stoneflies (14%) are the two most abundant taxa. The leaf input metric indicates a disturbed riparian zone. The top-down metric shows the presence of multiple trophic groups, suggesting suitable water quality. There is concern that construction on the Cliffs at High Carolina golf course community could impact water quality in Cane Creek.

Site #11 – Cane Creek at Ashworth Creek
This site on Cane Creek is approximately 50 meters upstream of the US 74 bridge, near the confluence with Ashworth Creek and less than a mile downstream of the SMIE sites #9 at Miller Rd. It corresponds with VWIN site B15A. The riparian zone is mostly made up of trees and shrubs,

but is also disturbed by a parking lot and driveway. The substrate is composed of gravel and cobblestone.

Cane Creek was first sampled near Ashworth Creek in the spring of 2005. The IWL ratings for the spring and fall of 2011 were *Excellent*, with the highest spring score of all sites that season. Taxa richness is relatively high, and the fall score was one of the highest that season. Spiny crawler mayflies (65%) and quick crawling predator stoneflies (16%) were prevalent in the spring, along with several water pennies, which are sensitive to pollution. In the spring, net-spinning caddisflies (26%), fragile detritivore stoneflies (25%), and flattened scraper mayflies (14%) were the most abundant taxa, with a sensitive giant shredder stonefly also observed. The leaf input metric for the spring indicated riparian zone disruption, although the fall sampling had an acceptable fall score. Both seasons had top-down scores that indicated a predator-controlled community. VWIN analysis shows significant stream sedimentation during storm events in this portion of Cane Creek.

Site #10 – Ashworth Creek

Ashworth Creek originates in Fairview near the border with Henderson County and flows northwest into Cane Creek. The SMIE monitoring site is located approximately 30 meters upstream of the confluence with Cane Creek at the US 74 bridge. It is just downstream of VWIN site B15B. The riparian zone is primarily composed of trees and shrubs with a road running parallel to the stream. The substrate is gravel and cobblestone, which are loosely embedded.

Ashworth Creek was first sampled in the spring of 2005. The IWL ratings were *Excellent* for both the spring and fall of 2011. This site has one of the two highest spring median IWL score. It also has one of the highest fall taxa richness scores. While 400 individuals were collected in the spring, only 143 individuals were collected in the fall. Spiny crawler mayflies (77%) were the predominant taxa in the spring, with coiled right face snails present indicating high quality habitat. In the spring, net-spinning caddisflies (44%) and fragile detritivore stoneflies (22%) were the most abundant groups. Both seasons have a leaf input metric that indicates impairment of the riparian zone. The top-down metrics show a community with balanced trophic groups. While the spring taxa density and diversity measures are low, the fall measures show an even distribution among the observed taxa. VWIN monitoring finds that sedimentation is a problem in this stream.

Site #12 – Bent Creek

Bent Creek is a tributary to the French Broad River located in southwest Buncombe County. This site is located in the Asheville Arboretum near the Hard Times Road parking lot just past the main entrance. The sampling area was approximately 10 meters upstream of the trail bridge before a debris dam changed the habitat to a pool, so it was subsequently moved approximately 100 yards upstream of the trail bridge. The site is just upstream of VWIN site B12A, and about one mile downstream of DWQ site EB359 on FSR479. The riparian zone is relatively intact at this site, consisting of trees and shrubs. The stream bottom habitat is mainly gravel and cobblestones that are loosely embedded.

Bent Creek was first sampled in the spring of 2005. The IWL ratings for both seasons in 2011 were *Excellent*, with the fall exhibiting its highest score so far at this site. The spring counts showed the highest taxa richness of all sites that season. The fall EPT taxa richness was also the highest of all sites that season, with this site having one of the four highest spring medians. Quick crawling predators (26%), spiny crawler mayflies (24%), and net-spinning caddisflies (12%) were the most abundant taxa in the spring sample. In the fall, quick crawling predator stoneflies (31%) and net-spinning caddisflies (31%) tied for dominance in the sample. Giant shredder stoneflies and coiled right face snails were present in the fall sample, demonstrating favorable water quality. The 2011 leaf input metrics indicate impairment of the riparian zone, and top-down metrics show an over-abundance of predators. Simpson's diversity indicates a good distribution of taxa in the samples;

however, the taxa density metric does not support that conclusion. VWIN monitoring shows excellent water quality here, with all chemical parameters below the regional average. DWQ gives this site a *Good* bioclassification.

Site #13 – Hominy Creek

Hominy Creek also drains southwest Buncombe County and empties into the French Broad River. This monitoring site is located approximately 100 meters upstream of the confluence with South Hominy Creek, off NC151. It corresponds to a discontinued VWIN site (B11A) and DWQ site EB103 at NC151. The riparian zone consists of trees, shrubs, grasses, and some exotic plants. The substrate is composed of gravel, cobblestones, and sand. Volunteers regularly report eroding streambanks. They also have reported muddy water during 36% of all samples, but the last three samples since the fall of 2010 have been clear.

Hominy Creek was first sampled in the spring of 2005. Both seasons in 2011 received an *Excellent* IWL rating, with the fall score being the highest score of any site in 2011. Taxa richness in the fall was one of the four highest that season. The IWL and taxa richness measures appear to have improved since 2008. In the spring, 244 individuals were captured, while only 148 were collected in the fall. Spiny crawler mayflies (53%) and net-spinning caddisflies were the most abundant taxa in the fall. Net-spinning caddisflies (31%), round headed swimmer mayflies (18%), and water-worms (17%) were prevalent in the spring. Coiled right face snails were observed in both seasons, indicating high quality water. Leaf input scores for both seasons indicate an impaired riparian zone, while the top-down metric indicates a balance between trophic groups. Diversity and taxa density indices were poor in the spring, but improved in the fall. DWQ gives this site a *Good-Fair* bioclassification, with the stream showing elevated conductivity and silt on the substrate.

Site #14 – Swannanoa River downstream of Beetree Creek

The Swannanoa River is a major tributary to the French Broad River, flowing west from Black Mountain through Swannanoa and Asheville. This site is located off Warren Wilson Road at Charles D. Owen Park, below the confluence with Beetree Creek. It corresponds to VWIN site B9B, and is located upstream of DWQ site EB142 on SR2416. The immediate riparian zone is mostly trees and shrubs. Past this narrow buffer on the right side of the stream are a large public park and lake, with residential land use on the left. The substrate is mostly gravel and cobblestones, with some sand.

This monitoring site was first sampled in the spring of 2005. It received a *Fair* IWL rating in both the spring and fall of 2011. In the fall was one of the few sites to receive an *Unacceptable* VASOS rating in 2011. Taxa richness and EPT taxa richness were both relatively low, with the fall EPT taxa richness having one of the five lowest values in 2011 (only three EPT taxa observed). Just 99 individuals were collected in the spring, with 186 collected in the fall. Net-spinning caddisflies (24%), round headed swimmer mayflies (22%), spiny crawler mayflies (20%), and water-worms (18%) were prevalent in the spring. Seventy-four percent of the fall sample was comprised of net-spinning caddisflies, which along with several clams/mussels and the absence of stoneflies from the sample indicate poor water quality. The spring leaf input metric did not indicate impairment of the riparian zone; however, the fall value was one of the three lowest in that season. The top-down metric demonstrated a balance of trophic groups in the community. While the Simpson's diversity measure in the spring of 2011 showed a good distribution of taxa, the fall measure and both taxa density values were uneven. VWIN monitoring at this site shows high turbidity and total suspended solids values during rain events. DWQ has assigned a site approximately 5 miles upstream a *Fair* bioclassification.

Site #15 – Swannanoa River upstream of Bull Creek

Downstream of SMIE site #14, this Swannanoa River monitoring site is located near Old Farm

School Road at Wykle Drive, just above the confluence with Bull Creek on the Warren Wilson College campus. It corresponds to VWIN site B38, and is located downstream of DWQ site EB142 on SR2416. The riparian zone is made up of trees and shrubs, and the substrate is gravel, cobblestones, and sand. The streambed is covered with silt and algae. Volunteers have reported a muddy or green color to the water in 25% of the samples, but not since 2009.

This SMIE site was first sampled in the spring of 2005. The IWL rating for the spring of 2011 was *Excellent*, and *Good* for the fall. However, the fall sampling yielded an *Unacceptable* VASOS rating, likely due to the abundance of pollution-tolerant taxa. Spiny crawler mayflies (56%) and net-spinning caddisflies (14%) dominate the spring sample. Net-spinning caddisflies (43%), coiled left face snails (21%), and flattened scraper mayflies (11%) were abundant in the fall. While the pollution-tolerant taxa of coiled right face snails and several clams/mussels may indicate poor water quality, coiled right face snails and two giant shredder stoneflies were also observed, supporting the opposite. The leaf input metrics showed riparian zone impairment in both seasons, while the top-down ratios indicated a good balance between the trophic groups observed. The diversity and taxa density measures indicated that the taxa are not distributed equally in the sample. VWIN monitoring detects high sediment concentrations during rain events at this site.

Site #16 – Smith Mill Creek
Most of the Smith Mill Creek watershed is located in urban West Asheville. This site is located at Louisiana Boulevard off Patton Avenue, just over a mile from its confluence with the French Broad River. The stream flows inside culverts for long sections along Patton Avenue. It corresponds to VWIN site B35. The riparian zone consists of some trees, shrubs, and grasses, as well as typical urban development. The substrate is mostly sand, with some gravel and cobblestones that are extremely embedded. Volunteers reported tea-colored water was at one of the three samples taken so far.

Smith Mill Creek was first sampled in the spring of 2009, and was not sampled in the spring of 2011. The fall IWL rating was *Fair*, with this site having the lowest spring median IWL score. The fall sample had one of the lowest taxa richness and EPT taxa richness values, with this site having some of the lowest taxa richness and EPT taxa richness medians for both seasons. This site has shown consistently low numbers of individuals captured, with only 51 individuals collected in the fall sample. Flattened scraper mayflies (59%) and oligochaetes (20%) were the dominant taxa in the fall. Additionally, no stoneflies were captured, indicating poor water quality. It was the only autotrophic site in the fall, with a P/R ratio of 1.86, and indicating excessive nutrient input. The leaf input metric supports the observed disruption of the riparian zone. The top-down metric was adequate due to the presence of plant-eaters. While the Simpson's diversity was not very high, the taxa density had one of the highest values. However, this should be interpreted cautiously considering the relatively few organisms recorded. VWIN data show elevated sediment, nitrates, conductivity, and zinc, which are typical of urban streams.

Site #17 – Reed Creek at Botanical Gardens
Reed Creek is a tributary of the French Broad River that flows through downtown Asheville. This site is located in the Botanical Gardens of Asheville near UNCA at the corner of Weaver Boulevard and Broadway Street. The sample is taken below the confluence with Glenn Creek. It is downstream of VWIN sites B7A and B7B, which are both above the confluence. The riparian zone includes trees, shrubs, and grass, landscaped within the Botanical Garden's property, which is surrounded by an urban setting. The substrate is composed of gravel and cobblestones, which are loosely embedded.

Reed Creek was first sampled in the spring of 2005. The IWL rating for the spring of 2011 was

Good, and the fall rating was *Excellent*. Conversely, this site had an *Unacceptable* VASOS rating in the spring, likely due to the prevalence of pollution-tolerant taxa. EPT taxa richness is poor here, with some of the lowest seasonal values and median values in both the spring and fall seasons. Taxa richness, EPT taxa richness, and IWL scores have shown some improvements since the fall of 2009. Net-spinning caddisflies (77%) and chironomid midges (13%) were the most abundant spring taxa. Round headed swimmer mayflies (40%) and net-spinning caddisflies (27%) were dominant in the fall. Midges and blackfly larvae observed in these samples, and the non-detection of any stoneflies, indicate inadequate water quality. The leaf input metric shows impairment of the riparian zone. The top-down metric displays a good balance of predators and herbivores in the community. Diversity and taxa density indices show an uneven distribution of taxa within the samples. While this creek shows low impacts from sedimentation, other VWIN parameters are excessively high, such as zinc, nitrates, orthophosphate, and conductivity.

Site #18 – Lower Newfound Creek
Newfound Creek flows through western Buncombe County and its watershed is largely rural with significant agricultural land use. This site is less than a mile from its confluence with the French Broad River, approximately 50 meters upstream of the bridge at Jenkins Valley Road and Rhymer Road. It corresponds to VWIN site B4 and is near DWQ site EB129, which is upstream on SR1622 (Rhymer Rd). Trees, shrubs, and grass are prevalent in the buffer zone of this stream. Gravel and cobblestones make up the substrate, with lots of silt and algae covering the rocks. The water was reportedly muddy for 82% of the samples taken at this site.

Newfound Creek was first sampled in the fall of 2005, and was not sampled in the spring of 2011. This site had the lowest IWL score of any site in 2011, resulting in a *Poor* rating. It was also one of the few sites to receive an *Unacceptable* VASOS rating. The taxa richness score is one of the lowest two scores, and the EPT taxa richness score is one of the lowest five scores in 2011. Taxa richness, EPT taxa richness, and IWL scores have been declining since the spring of 2010. Net-spinning caddisflies comprised 91% of the fall sample. No pollution-sensitive taxa were observed (i.e. stoneflies, water pennies, riffle beetles, etc.), and other taxa present included the tolerant clams/mussels, oligochaetes, and coiled left face snails. The leaf input metric is one of the three lowest scores, indicating riparian disruption. Diversity and taxa density scores are the lowest of all sites in 2011. Newfound Creek receives a *Poor* rating from the VWIN program, with excessively high turbidity, total suspended solids, nitrates, conductivity, and fecal coliform, largely due to erosion and livestock throughout the watershed. DWQ gives the nearby site a *Fair* bioclassification.

Site #19 – Reems Creek
Reems Creek flows through northeastern Buncombe County and into the French Broad River. This site is located just below the confluence of Reems and Ox Creeks in Weaverville (just behind the residence at 23 Ox Creek Rd.) and is just downstream of VWIN sites B5A (Ox Creek) and B5B (Reems Creek). The riparian zone consists of trees and shrubs, and the substrate is gravel, cobblestones, and sand.

Sampling started in the fall of 2007 on Reems Creek. This site has an *Excellent* IWL rating for both spring and fall of 2011, and has the highest fall median IWL score. It also has one of the four highest fall median taxa richness values. Spiny crawler mayflies (37%) and quick crawling predator stoneflies (31%) were the dominant spring taxa, with sensitive giant shredder stoneflies and many water pennies present. In the fall, quick crawling predator stoneflies (33%) and net-spinning caddisflies (26%) were abundant, with nine giant shredder stoneflies counted. The leaf input metric indicates an impaired riparian zone. The top-down ratio shows a predator-controlled community. While Simpson's diversity is good in 2011, the taxa density indicates poor distribution among the taxa. VWIN monitoring finds high sediment concentrations in this watershed.

Site #20 – Sandymush Creek
Sandymush Creek originates in northwestern Buncombe County, and then runs along the Madison County border until its confluence with the French Broad River. This site is located approximately 50 meters downstream of the Willow Creek Road bridge and corresponds to VWIN site B3B. Trees and shrubs dominate the stream at this site, with much of the surrounding land dedicated to agriculture. The substrate is mostly gravel and cobblestones. Volunteers reported muddy or tea-colored water for 57% of all sample occasions.
Sandymush Creek was first sampled in the fall of 2005, but not sampled in the spring of 2011. The fall IWL rating was *Fair*, and had a barely *Acceptable* VASOS rating. Net-spinning caddisflies comprised 67% of the fall sample, with no pollution-sensitive stoneflies observed. The low leaf input value illustrates the disruption of riparian buffer upstream of the monitoring site. The top-down metric indicates a balanced community with herbivores present. The diversity and taxa density both show poor distribution of the observed taxa. VWIN data show that sedimentation rates are higher here in the upper reaches of the watershed, due to steeper slopes and higher rates of erosion. Livestock waste and clay runoff also appear to contribute to high nitrate and conductivity levels. DWQ has documented declining benthic macroinvertebrate scores in lower Sandymush Creek, particularly EPT taxa richness.

Site #21 – California Creek at Radford Rd
California Creek is a tributary to the Little Ivy River in southeastern Madison County. This site is located off Old California Creek Road, approximately 50 meters upstream of the bridge at Radford Road, which is just downstream of US 19. It corresponds with VWIN site B13, and DWQ site EB188 at SR1541. Riparian vegetation is mostly trees and shrubs, but roads, pastures, and residential areas have disturbed the riparian buffer. The stream bottom is mostly gravel and cobblestones.

California Creek was first sampled here in the spring of 2005. This site has had an *Excellent* IWL rating since the spring of 2008, except the spring 2011 sample, which had a rating of *Fair* and the lowest IWL score that season. The IWL rating came back up to *Excellent* in the fall of 2011. In the spring, the taxa richness score was one of the lowest three scores, and the EPT taxa richness was one of the lowest four scores of all sites in the spring sampling. Both metrics came back up to normal levels in the fall sample. Spiny crawler mayflies (76%) dominated the spring sample. Net-spinning caddisflies (27%), round headed swimmer mayflies (22%), and small head caddisflies (19%) were abundant in the fall. Water pennies and coiled right face snails were present at this site, which are indicative of good water quality. The leaf input metric for the spring was one of the lowest two values, but that improved in the fall. However, the spring top-down metric indicated herbivores present, while the fall value showed a predator-controlled community. The diversity and taxa density measures showed poor distribution of taxa, except the fall diversity value. VWIN data show most chemical parameters to be nearly average, with the exception of high conductivity levels. This may be due to chemical contaminants that the VWIN program does not monitor.

Site #22 – California Creek at Beech Glen
This California Creek site is located approximately 1.3 miles downstream of SMIE site #21, downstream of the confluence with Middle Fork but upstream of the confluence with Paint Fork. The riparian zone is mostly trees and shrubs. The substrate is a combination of gravel, cobblestones, sand, bedrock, and boulders, with rocks moderately embedded in fine sediment.

The fall of 2011 was the first sampling occasion, so it will take more sampling to round out the ecological picture at this location. The IWL rating was *Good*, although the site had a barely *Acceptable* VASOS score. The taxa richness median (consisting of only the one value) is one of the highest fall medians. Net-spinning caddisflies (59%) and flattened scraper mayflies (11%) are the dominant taxa. The leaf input metric indicates an impaired riparian buffer. The top-down ratio suggests a stable community, with a variety of trophic groups. A poor distribution of taxa may be the reason for low diversity and taxa density values. VWIN does not have chemical data for this site, but Middle Fork generally has lower levels of conductivity than upstream on California Creek, which may effectively dilute the water in California Creek below the confluence.

Site #25 – Big Ivy River at Forks of Ivy
The Big Ivy River is a tributary of the French Broad River, mostly situated in southeastern Madison County. This site is located in the Forks of Ivy area off Ellisboro Road, upstream of the confluence with the Little Ivy River. It corresponds to VWIN site B1A and DWQ site EB200 at SR2150. The riparian zone is mainly trees and shrubs, with a road and several houses along this part of the stream. Loosely embedded gravel and cobblestones comprise the stream substrate. Volunteers have described the water as clear during past samplings, but noted a tea-color in the spring of 2011.

The Big Ivy was first sampled in the spring of 2005, and is frequently used as the SMIE field training location. The spring IWL rating was *Good*, while the fall rating was *Fair* in 2011. EPT taxa richness values for both seasons were low, with one of the lowest values in the spring. Spiny crawler mayflies (68%), net-spinning caddisflies (14%), and quick crawling predator stoneflies (11%) were abundant in the spring. Net-spinning caddisflies (48%) and hellgrammites (12%) were prevalent in the fall. Leaf input measures show riparian impairment. The top-down metric indicates a predator-controlled community, particularly in the fall. Diversity and taxa density indices show poorly distributed taxa. Even though the upper reaches of the watershed are mainly forested, VWIN monitoring shows erosion upstream of this site causing increased turbidity and total suspended solids. DWQ gives this site a *Good* bioclassification.

Site #24 – Little Ivy River at Forks of Ivy
The Little Ivy River is a tributary to the Big Ivy River. This monitoring site is located in the Forks of Ivy area at the border of Madison and Buncombe Counties. It is approximately 100 meters upstream of the confluence with Big Ivy River and corresponds to VWIN site B1B and DWQ site EB205 at SR1610. Grasses and vines dominate the riparian zone, with a road in close proximity to the left side of the stream and a few trees present. The substrate consists of gravel, cobblestone, boulders, and bedrock, with algae growing on the rocks. Volunteers have observed tea-colored water in both the fall of 2009 and the spring of 2011.

The Little Ivy was first sampled in the spring of 2005. The spring and fall of 2011 both yielded *Good* IWL ratings. The EPT taxa richness was one of the lowest values in the spring of 2011. Spiny crawler mayflies comprised 77% of the spring sample. Net-spinning caddisflies (42%) and round headed swimmer mayflies (25%) were abundant in the fall, with pollution-sensitive giant shredder stoneflies observed. The leaf input metrics indicate riparian disruption, and the top-down metrics show a borderline-good balance of trophic groups. Diversity and taxa density values show a borderline-poor distribution of taxa. The Little Ivy River has a *Poor* VWIN rating due to elevated median and maximum values for many parameters. DWQ gives this site a *Good-Fair* bioclassification, attributing declining water quality to increased non-point source pollution from agricultural, residential, and forest use.

Site #23 – East Fork of Bull Creek
Bull Creek is another tributary of the Big Ivy River. This site is located on the East Fork of Bull Creek, approximately ¼ mile upstream from the East Fork Road bridge, east of Beetree Road. It corresponds to the VWIN site M4. The riparian zone is composed of trees and shrubs, with some grass and vines present. The substrate consists of gravel, cobblestones, bedrock, and boulders. The volunteers noted muddy water in the spring of 2010.

The East Fork was first sampled in the spring of 2009, but not sampled in the spring of 2011. The fall IWL score was *Good*. Fragile detritivore stoneflies (28%), net-spinning caddisflies (26%), and quick crawling predator stoneflies (12%) were the most abundant taxa. A pollution-sensitive giant shredder stonefly was also observed in this sample. The leaf input score was one of the highest values in 2011, and indicates a sufficient riparian buffer. The top-down metric shows a predator-controlled community, with diversity and taxa density values giving mixed results. VWIN has identified nutrients and sedimentation as problems in this watershed, but they have been declining in recent years. DWQ has determined that development and agricultural land use impact water quality in the watershed.

Site #27 – Puncheon Fork Creek
Puncheon Fork Creek is a tributary located in the headwaters of Big Laurel Creek in northeastern Madison County. This site is located near Ebbs Chapel at the junction of Laurel Valley Road and Puncheon Fork Road, just upstream of the culvert under Laurel Valley Road. It corresponds to a discontinued VWIN site (M20) and DWQ site EB217 at SR1503. The riparian zone is mainly trees and shrubs, with some grass and vines. The substrate is composed of loosely embedded gravel and cobblestones.

Puncheon Fork Creek was first sampled in the fall of 2007. This site had a *Good* IWL rating in both the spring and fall of 2011. Spiny crawler mayflies (48%) and quick crawling predator stoneflies (30%) dominated the spring sample. Round headed swimmer mayflies (20%), small head caddisflies (16%), spiny crawler mayflies (15%), and net-spinning caddisflies (13%) were abundant in the fall. The sensitive giant shredder stoneflies were observed in both seasons. The leaf input metric indicates riparian disruption, and the top-down metric shows a predator-controlled community. Diversity and taxa density indices demonstrate an uneven taxa distribution, except for the diversity in the fall of 2011, which was the highest of all sites that season. Past VWIN monitoring detected elevated sediment levels, and DWQ gives this site an *Excellent* bioclassification.

Site #26 – Shelton Laurel Creek
Shelton Laurel Creek is another tributary to Big Laurel Creek, draining the far north reaches of Madison County. This site is located adjacent to the Belva Baptist Church parking lot on Guntertown Road, near the intersection with NC208 and NC212. It corresponds to a discontinued VWIN site (M9) and DWQ site EB219 at NC208. Trees and shrubs border the stream upstream of this site, but at this location, the trees and shrubs are mostly on the left bank. Shrubs, grasses, and herbs consistent with roadside habitat characterize the riparian zone on the right bank. The substrate is mostly gravel and cobblestones.

Shelton Laurel Creek was first sampled in the spring of 2006. IWL ratings for both the spring and fall of 2011 were *Excellent*. This site has one of the two highest fall taxa richness values, and one of the four highest fall medians. The spring EPT taxa richness was the highest of any site in 2011, with this site having one of the four highest spring medians. However, taxa richness, and to some extent EPT taxa richness, appear to have been declining in the past two years. Spiny crawler mayflies (26%) and flattened scraper mayflies (17%) were the most abundant taxa in the spring, with many sensitive water pennies observed. Net-spinning caddisflies (27%), round headed swimmer mayflies (21%), and quick crawling predator stoneflies (20%) were the dominant taxa in the fall. Leaf input metrics show some disruption of the riparian zone. The top-down metrics show a predator-controlled habitat. The diversity measures indicate a good distribution of taxa in the sample, with the taxa density showing less positive results. DWQ gives this site an *Excellent* bioclassification.

Site #28 – Big Laurel Creek
Big Laurel Creek is a tributary of the French Broad River in rural northeastern Madison County. This monitoring site is located about 3.5 miles upstream of the confluence with the French Broad River. It is approximately 200 meters downstream of the bridge at the Hwy 25/70 and NC 208 junction, near the confluence with the French Broad River. It corresponds to a discontinued VWIN site (M10). There is a small campground and parking lot on the left side of the creek upstream of the monitoring site. Trees and shrubs comprise the riparian zone, and gravel and cobblestones make up the stream bottom.

Big Laurel Creek was first sampled in the fall of 2005. The IWL rating for the spring of 2011 was *Fair*, while the fall rating rose to *Good*. The spring taxa richness value was one of the three lowest in the spring of 2011. Spiny crawler mayflies (40%) and flattened scraper mayflies (30%) were dominant in the spring. Round headed swimmer mayflies (27%), hellgrammites (16%), and water pennies (14%) were abundant in the fall, with one sensitive roach shredder stonefly observed. The P/R ratio was the third highest of all sites in 2011, and indicates an autotrophic habitat with an over-abundance of nutrients. The leaf input metric shows impairment of the riparian buffer. The top-down metric was better in the spring than the fall, with a higher ratio of herbivores observed in the spring. Diversity measures showed a relatively even distribution of taxa in the samples, while the taxa density values were not as positive. DWQ gives this stream an *Excellent* bioclassification, and streams throughout the entire watershed are considered HQW (high quality waters).

<u>Nolichucky Subbasin (Mitchell and Yancey Counties)</u>
The North Toe and Cane Rivers in Mitchell and Yancey Counties combine to form the Nolichucky River, which then flows into Tennessee to the north.

Site #29 – Cane Creek at Bakersville
Cane Creek is a tributary of the North Toe River in Mitchell County. This sample is collected just upstream of the South Mitchell Avenue bridge, near the intersection of Highway 226 (Crimson Laurel Way) and Mitchell Avenue. This corresponds to VWIN site T1. The riparian zone is mostly trees, shrubs, and grasses, with some vines present. The stream habitat consists of gravel, cobblestones, and sand.

Cane Creek was first sampled in the spring of 2008. The IWL ratings for both seasons in 2011 were *Good*. Spiny crawler mayflies (74%) dominated the spring sample. Filter mayflies (47%), round headed swimmer mayflies (16%), and flattened scraper mayflies (12%) were most abundant in the fall. The leaf input metric shows impairment of the riparian zone. The spring top-down metric showed a balance of trophic groups in the community, while the fall results indicated more predator-control. Diversity and taxa density indicate an uneven distribution of taxa. VWIN analysis shows high maximum sediment values, likely due to upstream runoff and agricultural activities.

Site #30 – North Toe River
The North Toe River originates in Avery County, and travels through Mitchell County and along the Yancey County border. This site is located downstream of Spruce Pine, on Penland Road off US 19E. It corresponds to DWQ site EB286 at SR1162. The riparian zone consists of trees and shrubs, and the stream's substrate is made up of gravel and cobblestones.

The North Toe River was first sampled in the spring of 2009. Both seasons in 2011 resulted in *Excellent* IWL ratings, with IWL scores increasing since the first sampling in 2009. This site has one of the four lowest fall EPT taxa richness medians. Only 63 individuals were captured in the spring, but 194 individuals were found in the fall. Round headed swimmer mayflies (20%) and quick crawling predator stoneflies (17%) were abundant in the spring. Net-spinning caddisflies (71%) dominated the fall sample. Coiled right face snails were present in the fall, indicating good water quality. The leaf input scores show riparian disruption, with the spring value being one of the two lowest in that season. The top-down metric indicates a predator-controlled community. Diversity and taxa density measures in the spring were among the highest in 2011, while the fall exhibited lower values, showing an uneven distribution of taxa. VWIN data from a site downstream of this display high sediment and conductivity in the North Toe River. DWQ gives this site a *Good* rating, and attributes variation in the benthic community to NPDES dischargers upstream and a petroleum spill that took place in 2002.

Site #31 – Cane River

The Cane River forms in the Pisgah National Forest on the west site of the Black Mountain Range, then flows through Yancey County before merging with the North Toe River. This monitoring site is located near the Mountain Heritage High School practice football field, about a mile west of Burnsville. It corresponds to VWIN site T5 and is near the DWQ site EB303 at US 19E. The river runs alongside US 19 for much of its length, which disrupts the riparian buffer. The riparian zone is mostly trees at the monitoring site, with some clearing close to the left bank where river rocks are intermittently mined. The substrate is mainly gravel and cobblestones.

Sampling the Cane River began in the fall of 2008. The IWL ratings for both seasons in 2011 were *Excellent*. Taxa richness and IWL scores have been rising since the spring of 2010, indicating that the benthic invertebrate communities are recovering after the failure of the Burnsville WWTP in July 2008. Spiny crawler mayflies (26%), flattened scraper mayflies (15%), net-spinning caddisflies (10%), and filter mayflies (10%) were abundant in the spring. Net-spinning caddisflies (48%), giant shredder stoneflies (12%), flattened scraper mayflies (10%), and filter mayflies (10%) were abundant in the fall. Leaf input metrics indicate an impaired buffer zone. Top-down metrics showed a predator-controlled community in the fall, but more balance among trophic groups in the fall. Diversity and taxa density scores give mixed results. While most chemical parameters are below average for VWIN, the site does exhibit some of the highest maximum values for nutrients in the area, likely due to the influence of the Burnsville WWTP upstream. The highest orthophosphate and ammonia values in the past three years occurred in July 2008 following the failure at the Burnsville WWTP, which was detrimental to the biological community in the Cane River. DWQ gives this site an *Excellent* biological rating, attributing high water quality from contributions from undisturbed tributaries.

4.0 SUMMARY

The spring 2011 sampling season marked the beginning of the SMIE program's seventh year. There are now 31 active sites. Volunteers are collecting samples from streams that have some of the best water quality in western North Carolina. However, they are also collecting from some of the worst streams. The sampling protocols are consistent with DWQ protocols but data analysis issues are still being resolved with help from the NC DWQ staff.

There is a need to improve the collection skills of the volunteer base as evidenced by low sample numbers. Low sample numbers significantly affect data interpretation and samples with low numbers must be interpreted conservatively. The low numbers collected in many of the samples can explain much of the discrepancies between metrics, particularly VASOS and IWL, P/R and Leaf Input ratios, and historical trends. Future efforts need to target collecting 200 organisms per sample. Based on the analyses of preserved specimens, more emphasis needs to be put on the importance of group leaders submitting preserved specimens for analysis, recording accurate notes on data sheets, and in some cases attending refresher trainings.

Based on SMIE biomonitoring results, the five highest quality sites in 2011 were (in no particular order) the East Fork of the Pigeon River, Cane Creek at Miller Road, Ashworth Creek, Bent Creek, and Reems Creek. The five lowest quality sites were the Pigeon River downstream of Canton, Smith Mill Creek, Reed Creek at the Botanical Gardens, Lower Newfound Creek, and the Swannanoa River downstream of Beetree Creek.

Discounting inadequate numbers, the efforts of SMIE Program volunteers appear to show that streams in Buncombe, Haywood, Madison, Mitchell, and Yancey Counties are impacted by multiple factors, particularly those related to land use. One consistent trend is that most riparian zones are less than adequate, even in the relatively pristine watersheds. Human encroachment leads to increased impervious surfaces and reduces naturally vegetated landscapes, which leads to increased stream flows and subsequent erosion and flooding downstream, as well as reduced inputs of leaves and woody debris that serve as the base of the food chain. Exotic and invasive plant species are present in almost every watershed and are an indicator of how disturbed the ecological processes are in these systems. Another consistent trend is the presence of excess sediment. Few sites had substrates that were loose and easily moved. Embedded substrates reduce the quantity and quality of benthic habitats, and lead to leaf pack and woody debris removal by high flow events.

Another variable influencing streams is rainfall. It was a very wet year in 2009, which found frequent high flow events in the sample streams. High flows lead to increased habitat availability, but also substrate scouring if levels are too high. The low top-down metric scores are evidence that many of the streams were recently scoured. Higher rainfalls also means more non-point source pollutants (i.e., dirt, fertilizers, pesticides, oil, trash) washing off the landscape and a higher potential for flooding and stream bank erosion, which can partially explain water quality impacts.

The quality of the resources available to benthic macroinvertebrate communities is a function of many ecological processes (pollutant loads, flow, seasonality), which affect the distribution and abundance of aquatic invertebrates. Since the SMIE approach uses benthic macroinvertebrate data to evaluate ‘water quality’, it must include those factors in our evaluation. The next steps in development of the SMIE program are to continue building the skills of volunteers, building a database that strengthens data analysis, working to develop a user-friendly index that accurately reflects water quality condition, and analyze the data using land use and water chemistry parameters.

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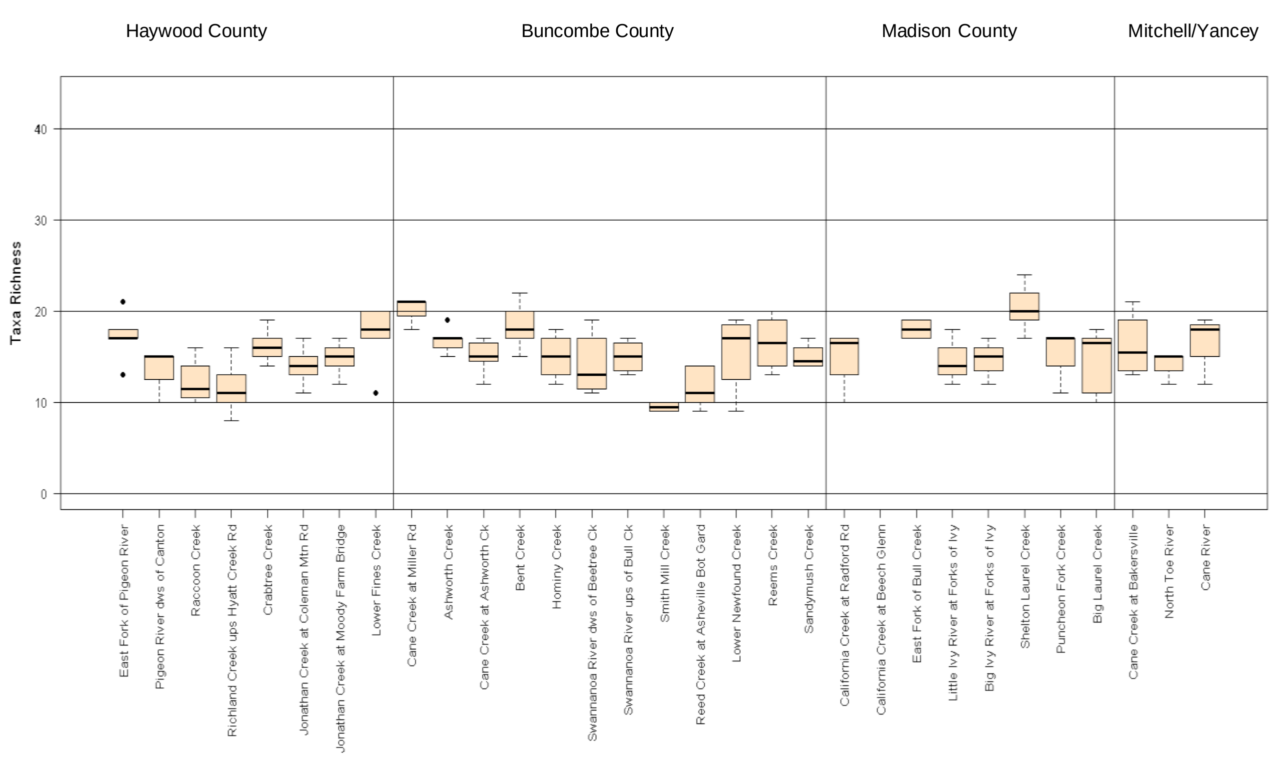

Figure 2a. Cumulative taxa richness values for all spring seasons (43 taxa possible).

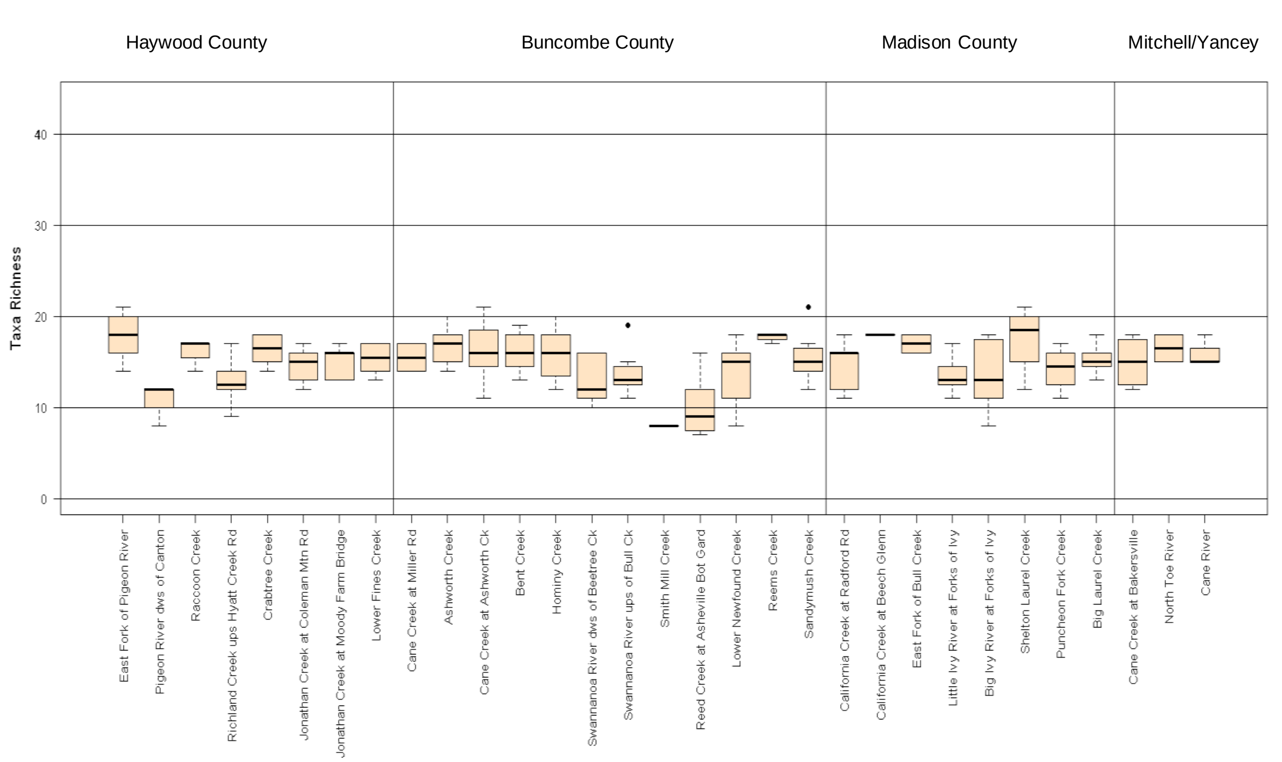

Figure 2b. Cumulative taxa richness values for all fall seasons (43 taxa possible).

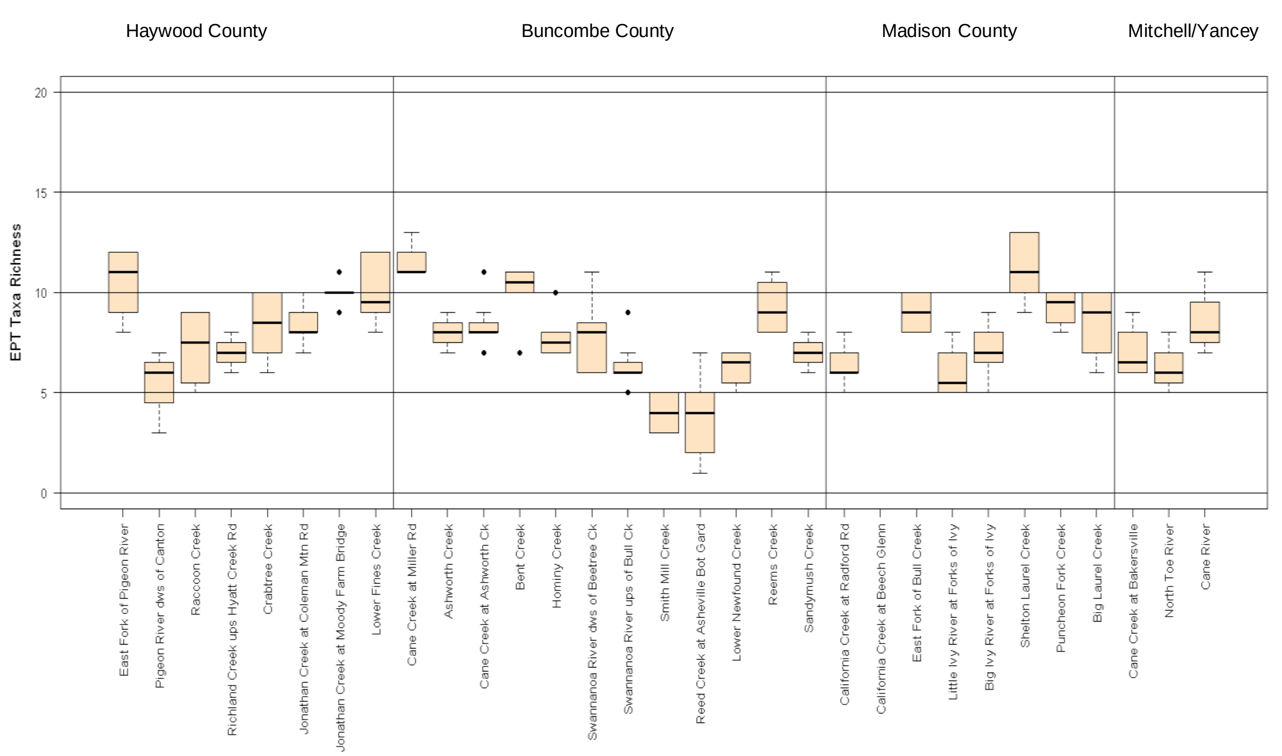

Figure 3a. Cumulative EPT taxa richness values for all spring seasons (19 taxa possible).

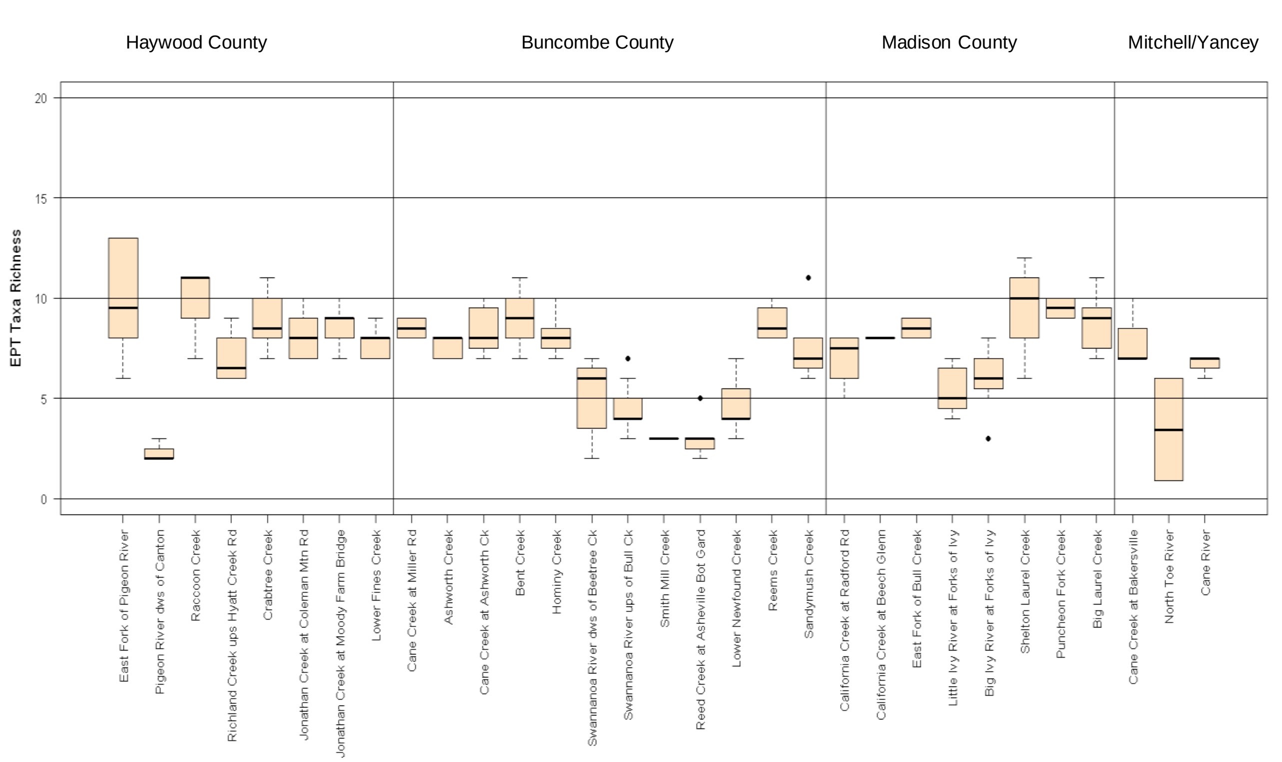

Figure 3b. Cumulative EPT taxa richness values for all fall seasons (19 taxa possible).

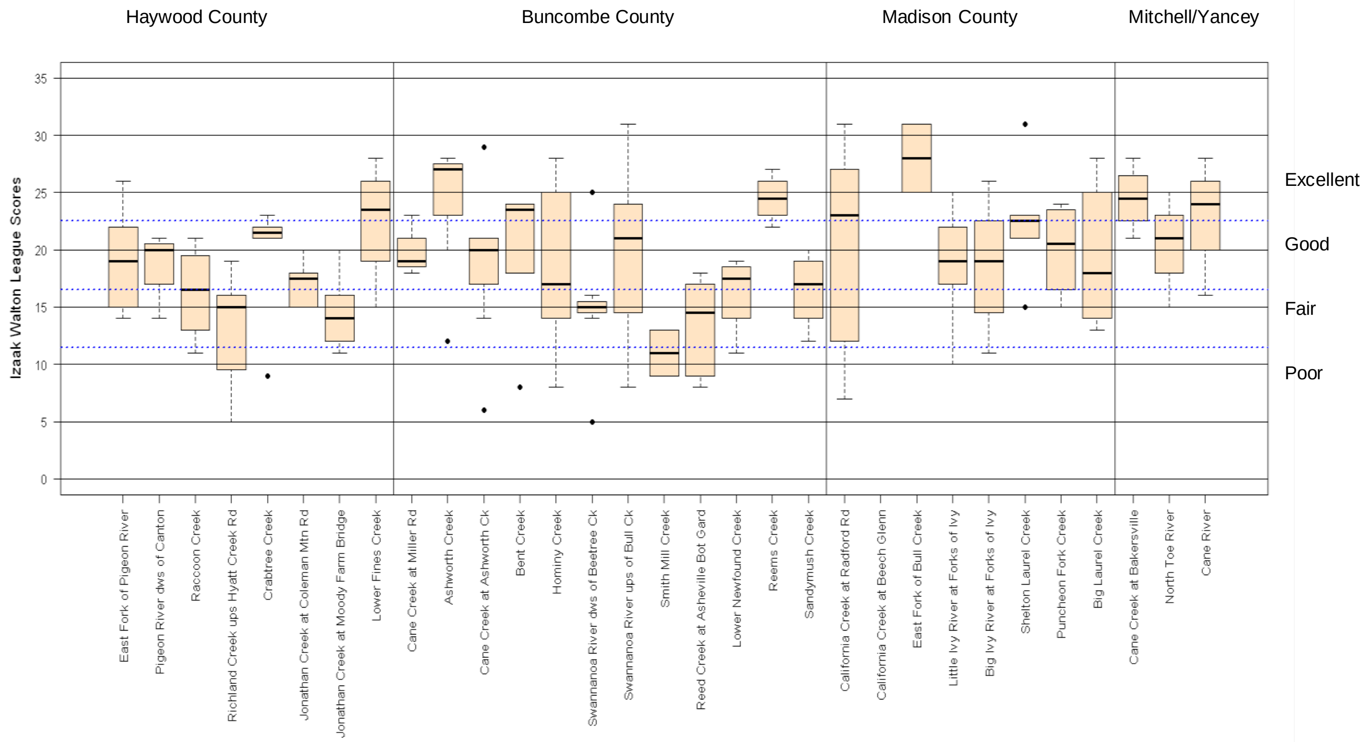

Figure 4a. Cumulative Izaak Walton League scores for all spring seasons.

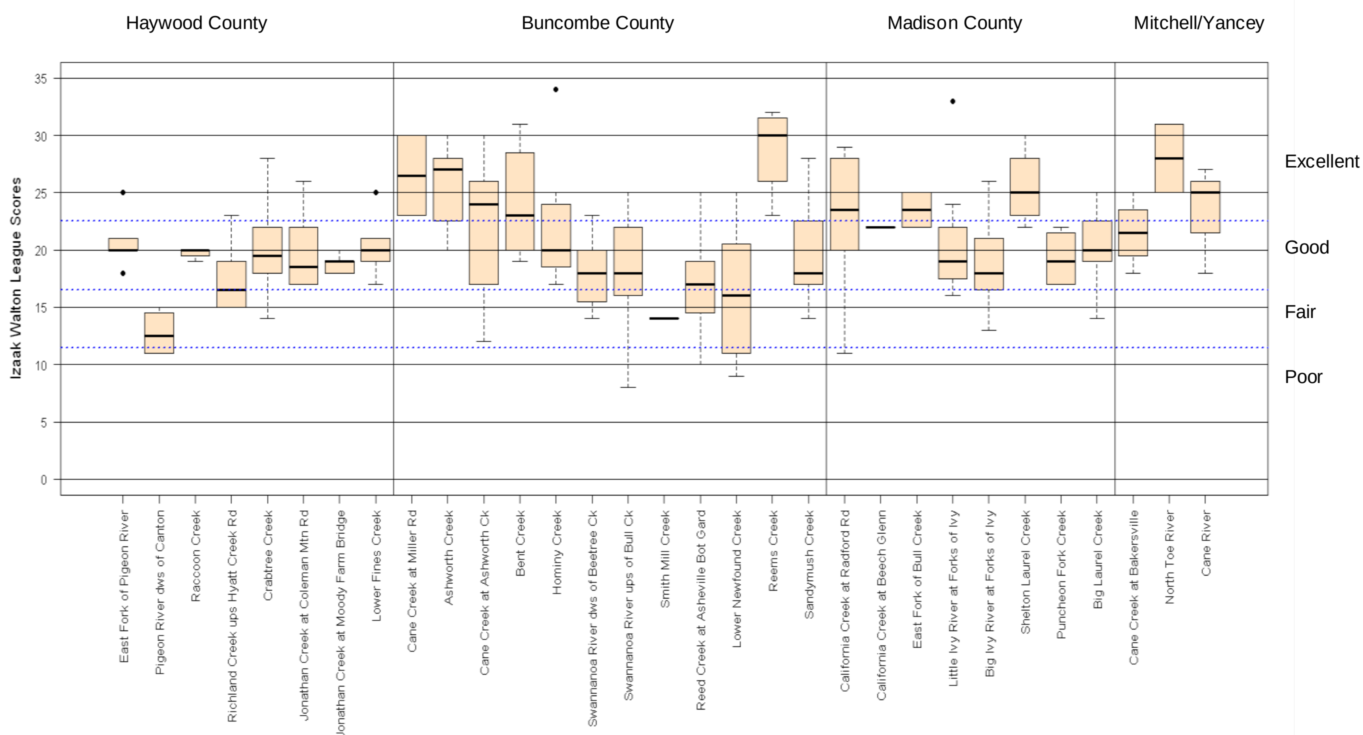

Figure 4b. Cumulative Izaak Walton League scores for all fall seasons.

Table 3. SMIE summary data (spring and fall 2011; richness, abundance, VASOS, and IWL data).

Site #	Site	Season	Taxa Richness	Total Number Collected	Number of EPT Taxa	VASOS	VASOS Rating	Izaak Walton League	Izaak Walton League Rating
1	East Fork of Pigeon River	Spring	*Not sampled*						
		Fall	20	198	10	7	Acceptable	25	Excellent
2	Pigeon River dws of Canton	Spring	*Not sampled*						
		Fall	12	370	3	2	Unacceptable	15	Fair
3	Raccoon Creek	Spring	16	177	9	11	Acceptable	18	Good
		Fall	17	161	11	10	Acceptable	20	Good
4	Richland Creek ups Hyatt Creek Rd	Spring	10	117	7	10	Acceptable	17	Good
		Fall	13	183	9	10	Acceptable	16	Fair
5	Crabtree Creek	Spring	*Not sampled*						
		Fall	14	213	8	8	Acceptable	18	Good
6	Jonathan Creek at Coleman Mtn Rd	Spring	*Not sampled*						
		Fall	16	116	8	11	Acceptable	26	Excellent
7	Jonathan Creek at Moody Farm Bridge	Spring	*Not sampled*						
		Fall	17	108	10	10	Acceptable	19	Good
8	Lower Fines Creek	Spring	*Not sampled*						
		Fall	13	185	7	8	Acceptable	17	Good
9	Cane Creek at Miller Rd	Spring	*Not sampled*						
		Fall	17	269	9	8	Acceptable	30	Excellent
10	Ashworth Creek	Spring	16	400	7	11	Acceptable	28	Excellent
		Fall	20	143	7	8	Acceptable	25	Excellent
11	Cane Creek at Ashworth Ck	Spring	17	808	8	10	Acceptable	29	Excellent
		Fall	20	309	9	9	Acceptable	30	Excellent
12	Bent Creek	Spring	20	354	10	10	Acceptable	24	Excellent
		Fall	19	263	11	10	Acceptable	31	Excellent
13	Hominy Creek	Spring	17	244	7	9	Acceptable	25	Excellent
		Fall	20	148	9	8	Acceptable	34	Excellent
14	Swannanoa River dws of Beetree Ck	Spring	11	99	6	9	Acceptable	16	Fair
		Fall	10	186	3	5	Unacceptable	16	Fair
15	Swannanoa River ups of Bull Ck	Spring	15	169	6	10	Acceptable	23	Excellent
		Fall	13	264	6	6	Unacceptable	18	Good
16	Smith Mill Creek	Spring	*Not sampled*						
		Fall	8	51	3	10	Acceptable	14	Fair
17	Reed Creek at Asheville Bot Gard	Spring	14	178	5	6	Unacceptable	17	Good
		Fall	14	199	3	9	Acceptable	25	Excellent
18	Lower Newfound Creek	Spring	*Not sampled*						
		Fall	8	418	3	6	Unacceptable	9	Poor

Table 3 (continued). SMIE summary data (spring and fall 2011; richness, abundance, VASOS, and IWL data).

Site #	Site	Season	Taxa Richness	Total Number Collected	Number of EPT Taxa	VASOS	VASOS Rating	Izaak Walton League	Izaak Walton League Rating
19	Reems Creek	Spring	15	273	8	12	Acceptable	27	Excellent
		Fall	18	218	8	11	Acceptable	29	Excellent
20	Sandymush Creek	Spring	*Not sampled*						
		Fall	17	227	7	7	Acceptable	14	Fair
21	California Creek at Radford Rd	Spring	10	277	5	11	Acceptable	12	Fair
		Fall	18	171	8	10	Acceptable	29	Excellent
22	California Creek at Beech Glenn	Fall	18	217	8	7	Acceptable	22	Good
23	East Fork of Bull Creek	Spring	*Not sampled*						
		Fall	16	237	9	9	Acceptable	22	Good
24	Little Ivy River at Forks of Ivy	Spring	15	242	5	11	Acceptable	22	Good
		Fall	13	174	7	8	Acceptable	19	Good
25	Big Ivy River at Forks of Ivy	Spring	12	232	5	10	Acceptable	18	Good
		Fall	12	205	5	7	Acceptable	13	Fair
26	Shelton Laurel Creek	Spring	19	199	13	12	Acceptable	23	Excellent
		Fall	12	88	6	9	Acceptable	25	Excellent
27	Puncheon Fork Creek	Spring	11	214	8	10	Acceptable	15	Fair
		Fall	14	167	9	12	Acceptable	17	Good
28	Big Laurel Creek	Spring	10	179	7	11	Acceptable	14	Fair
		Fall	15	152	8	12	Acceptable	19	Good
29	Cane Creek at Bakersville	Spring	13	304	6	10	Acceptable	21	Good
		Fall	13	180	7	10	Acceptable	22	Good
30	North Toe River	Spring	15	63	8	12	Acceptable	25	Excellent
		Fall	15	194	6	8	Acceptable	31	Excellent
31	Cane River	Spring	18	235	8	10	Acceptable	28	Excellent
		Fall	18	253	7	9	Acceptable	27	Excellent

EPT = Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies); VASOS = Virginia Save Our Streams Index
See Section 2.3 of this report for descriptions of scoring techniques.

Table 4. SMIE summary data (spring and fall 2011; ecological ratios, diversity, and density data).

Site #	Site	Season	P/R	Leaf Input	Top-Down	Simpsons Diversity	Taxa Density
1	East Fork of Pigeon River	Spring	*Not sampled*				
		Fall	0.17	0.05	0.25	0.70	0.10
2	Pigeon River dws of Canton	Spring	*Not sampled*				
		Fall	0.11	0.00	0.06	0.55	0.03
3	Raccoon Creek	Spring	0.10	0.08	0.05	0.67	0.09
		Fall	0.40	0.11	0.27	0.84	0.11
4	Richland Creek ups Hyatt Creek Rd	Spring	3.61	1.33	0.37	0.72	0.09
		Fall	0.71	0.07	0.21	0.67	0.07
5	Crabtree Creek	Spring	*Not sampled*				
		Fall	0.19	0.05	0.23	0.78	0.07
6	Jonathan Creek at Coleman Mtn Rd	Spring	*Not sampled*				
		Fall	0.73	0.06	0.36	0.85	0.14
7	Jonathan Creek at Moody Farm Bridge	Spring	*Not sampled*				
		Fall	0.61	0.17	0.73	0.86	0.16
8	Lower Fines Creek	Spring	*Not sampled*				
		Fall	0.06	0.11	0.19	0.72	0.07
9	Cane Creek at Miller Rd	Spring	*Not sampled*				
		Fall	0.28	0.29	0.10	0.73	0.06
10	Ashworth Creek	Spring	0.05	0.01	0.08	0.40	0.04
		Fall	0.24	0.40	0.10	0.75	0.14
11	Cane Creek at Ashworth Ck	Spring	0.12	0.21	0.18	0.61	0.02
		Fall	0.44	0.84	0.18	0.83	0.06
12	Bent Creek	Spring	0.12	0.07	0.57	0.83	0.06
		Fall	0.22	0.17	0.56	0.77	0.07
13	Hominy Creek	Spring	0.06	0.02	0.12	0.61	0.07
		Fall	0.20	0.32	0.15	0.82	0.14
14	Swannanoa River dws of Beetree Ck	Spring	0.03	0.24	0.07	0.81	0.11
		Fall	0.09	0.00	0.04	0.44	0.05
15	Swannanoa River ups of Bull Ck	Spring	0.11	0.01	0.05	0.62	0.09
		Fall	0.58	0.05	0.06	0.74	0.05
16	Smith Mill Creek	Spring	*Not sampled*				
		Fall	1.76	0.06	0.06	0.64	0.16
17	Reed Creek at Asheville Bot Gard	Spring	0.02	0.03	0.02	0.45	0.08
		Fall	0.02	0.03	0.13	0.74	0.07

Table 4 (continued). SMIE summary data (spring and fall 2011; ecological ratios, diversity, and density data).

Site #	Site	Season	P/R	Leaf Input	Top-Down	Simpsons Diversity	Taxa Density
18	Lower Newfound Creek	Spring	*Not sampled*				
		Fall	0.03	0.00	0.00	0.14	0.02
19	Reems Creek	Spring	0.49	0.08	0.55	0.74	0.05
		Fall	0.20	0.16	0.78	0.80	0.08
20	Sandymush Creek	Spring	*Not sampled*				
		Fall	0.06	0.10	0.05	0.52	0.07
21	California Creek at Radford Rd	Spring	0.07	0.00	0.07	0.41	0.04
		Fall	0.10	0.15	0.34	0.83	0.11
22	California Creek at Beech Glenn	Fall	0.24	0.03	0.04	0.57	0.08
23	East Fork of Bull Creek	Spring	*Not sampled*				
		Fall	0.42	0.90	0.17	0.80	0.07
24	Little Ivy River at Forks of Ivy	Spring	0.12	0.02	0.09	0.55	0.06
		Fall	0.13	0.04	0.15	0.70	0.07
25	Big Ivy River at Forks of Ivy	Spring	0.03	0.01	0.14	0.50	0.05
		Fall	0.11	0.01	0.33	0.71	0.06
26	Shelton Laurel Creek	Spring	0.55	0.20	0.18	0.87	0.10
		Fall	0.15	0.06	0.51	0.84	0.14
27	Puncheon Fork Creek	Spring	0.12	0.07	0.47	0.67	0.05
		Fall	0.12	0.04	0.37	0.87	0.08
28	Big Laurel Creek	Spring	0.91	0.10	0.03	0.73	0.06
		Fall	0.48	0.07	0.42	0.85	0.10
29	Cane Creek at Bakersville	Spring	0.06	0.01	0.13	0.44	0.04
		Fall	0.17	0.01	0.18	0.73	0.07
30	North Toe River	Spring	0.18	0.00	0.38	0.87	0.24
		Fall	0.04	0.01	0.15	0.50	0.08
31	Cane River	Spring	0.33	0.15	0.36	0.86	0.08
		Fall	0.20	0.19	0.08	0.73	0.07

See Section 2.3 of this report for descriptions of scoring techniques.

Table 5. Cumulative SMIE data (spring 2005 – fall 2011).

Site #	Site	County	Date	Taxa Richness	Number of EPT Taxa	VASOS	Izaak Walton League
1	East Fork of Pigeon River	Haywood	Fall 2005	21	13	9	20
			Spring 2006	13	8	9	15
			Fall 2006	16	8	12	20
			Spring 2007	21	12	10	22
			Fall 2007	14	6	11	20
			Spring 2008	17	12	10	19
			Fall 2008	20	13	10	21
			Spring 2009	18	11	10	14
			Fall 2009	16	9	8	18
			Spring 2010	17	9	11	26
			Fall 2010	*Not sampled*			
			Spring 2011	*Not sampled*			
			Fall 2011	20	10	7	25
2	Pigeon River dws of Canton	Haywood	Fall 2006	12	2	2	14
			Spring 2007	15	7	4	20
			Fall 2007	12	2	2	11
			Spring 2008	10	3	4	14
			Fall 2008	8	2	3	11
			Spring 2009	15	6	6	20
			Fall 2009	*Not sampled*			
			Spring 2010	15	6	4	21
			Fall 2010	*Not sampled*			
			Spring 2011	*Not sampled*			
			Fall 2011	12	3	2	15
3	Raccoon Creek	Haywood	Spring 2008	11	5	9	15
			Fall 2008	14	7	8	19
			Spring 2009	12	6	11	21
			Fall 2009	*Not sampled*			
			Spring 2010	10	9	10	11
			Fall 2010	17	11	10	20
			Spring 2011	16	9	11	18
			Fall 2011	17	11	10	20
4	Richland Creek ups Hyatt Creek Rd	Haywood	Spring 2005	14	8	9	5
			Fall 2005	12	6	8	17
			Spring 2006	10	7	10	12
			Fall 2006	9	6	8	15
			Spring 2007	16	8	10	19
			Fall 2007	14	7	9	19
			Spring 2008	11	7	10	15
			Fall 2008	17	8	10	23
			Spring 2009	8	6	10	7
			Fall 2009	*Not sampled*			
			Spring 2010	12	6	10	15
			Fall 2010	13	9	10	16
			Spring 2011	10	7	10	17
			Fall 2011	13	9	10	16
5	Crabtree Creek	Haywood	Spring 2005	14	8	9	9
			Fall 2005	18	11	7	14
			Spring 2006	16	10	10	21
			Fall 2006	17	7	7	22
			Spring 2007	15	6	9	22
			Fall 2007	18	8	7	28
			Spring 2008	17	9	9	21
			Fall 2008	15	10	10	19
			Spring 2009	16	7	10	23
			Fall 2009	16	9	10	20
			Spring 2010	19	10	8	22
			Fall 2010	*Not sampled*			
			Spring 2011	*Not sampled*			
			Fall 2011	14	8	8	18

Table 5 (continued). Cumulative SMIE data (spring 2005 – fall 2011).

Site #	Site	County	Date	Taxa Richness	Number of EPT Taxa	VASOS	Izaak Walton League
6	Jonathan Creek at Coleman Mtn Rd	Haywood	Spring 2005	11	7	10	15
			Fall 2005	14	8	8	17
			Spring 2006	17	9	10	20
			Fall 2006	13	7	10	17
			Spring 2007	13	8	10	18
			Fall 2007	16	9	8	17
			Spring 2008	14	8	10	17
			Fall 2008	17	10	10	22
			Spring 2009	14	10	11	18
			Fall 2009	12	7	11	20
			Spring 2010	15	8	10	15
			Fall 2010	*Not sampled*			
			Spring 2011	*Not sampled*			
			Fall 2011	16	8	11	26
7	Jonathan Creek at Moody Farm Bridge	Haywood	Spring 2005	12	9	9	11
			Fall 2005	13	7	7	19
			Spring 2006	17	10	10	16
			Fall 2006	16	9	11	18
			Spring 2007	16	10	10	15
			Fall 2007	16	9	9	20
			Spring 2008	15	10	10	12
			Fall 2008	13	8	9	18
			Spring 2009	15	11	10	20
			Fall 2009	*Not sampled*			
			Spring 2010	14	10	10	13
			Fall 2010	*Not sampled*			
			Spring 2011	*Not sampled*			
			Fall 2011	17	10	10	19
8	Lower Fines Creek	Haywood	Spring 2005	20	12	10	19
			Fall 2005	14	9	7	19
			Spring 2006	11	9	10	15
			Fall 2006	14	7	9	21
			Spring 2007	20	12	10	22
			Fall 2007	17	8	8	21
			Spring 2008	17	9	10	26
			Fall 2008	17	8	8	25
			Spring 2009	19	8	10	28
			Fall 2009	17	8	10	19
			Spring 2010	17	10	9	25
			Fall 2010	*Not sampled*			
			Spring 2011	*Not sampled*			
			Fall 2011	13	7	8	17
9	Cane Creek at Miller Rd	Buncombe	Spring 2008	18	11	11	19
			Fall 2008	14	8	7	23
			Spring 2009	21	11	11	23
			Fall 2009	*Not sampled*			
			Spring 2010	21	13	12	18
			Fall 2010	*Not sampled*			
			Spring 2011	*Not sampled*			
			Fall 2011	17	9	8	30
10	Ashworth Creek	Buncombe	Spring 2005	15	8	7	12
			Fall 2005	15	8	7	20
			Spring 2006	16	7	10	20
			Fall 2006	14	8	6	20
			Spring 2007	17	8	10	26
			Fall 2007	19	8	10	30
			Spring 2008	17	8	12	28
			Fall 2008	17	7	6	27
			Spring 2009	19	9	12	27
			Fall 2009	15	7	7	28
			Spring 2010	17	9	11	27
			Fall 2010	17	8	7	28
			Spring 2011	16	7	11	28
			Fall 2011	20	7	8	25

Table 5 (continued). Cumulative SMIE data (spring 2005 – fall 2011).

Site #	Site	County	Date	Taxa Richness	Number of EPT Taxa	VASOS	Izaak Walton League
11	Cane Creek at Ashworth Ck	Buncombe	Spring 2005	12	8	9	6
			Fall 2005	11	7	9	12
			Spring 2006	17	11	8	14
			Fall 2006	16	10	8	12
			Spring 2007	16	9	9	20
			Fall 2007	17	8	7	25
			Spring 2008	15	8	11	21
			Fall 2008	13	7	9	22
			Spring 2009	15	8	11	21
			Fall 2009	21	10	11	27
			Spring 2010	14	7	10	20
			Fall 2010	16	8	8	24
			Spring 2011	17	8	10	29
			Fall 2011	20	9	9	30
12	Bent Creek	Buncombe	Spring 2005	15	7	9	8
			Fall 2005	16	9	8	20
			Spring 2006	17	11	8	18
			Fall 2006	17	8	9	28
			Spring 2007	22	11	11	24
			Fall 2007	13	7	7	23
			Spring 2008	17	10	10	24
			Fall 2008	14	8	10	19
			Spring 2009	*Not sampled*			
			Fall 2009	15	11	9	20
			Spring 2010	19	11	12	23
			Fall 2010	19	9	10	29
			Spring 2011	20	10	10	24
			Fall 2011	19	11	10	31
13	Hominy Creek	Buncombe	Spring 2005	12	7	9	8
			Fall 2005	12	8	7	18
			Spring 2006	13	8	9	14
			Fall 2006	15	7	7	20
			Spring 2007	*Not sampled*			
			Fall 2007	12	8	6	17
			Spring 2008	15	7	10	28
			Fall 2008	18	10	7	23
			Spring 2009	18	10	9	19
			Fall 2009	16	7	9	19
			Spring 2010	15	8	11	15
			Fall 2010	18	8	7	25
			Spring 2011	17	7	9	25
			Fall 2011	20	9	8	34
14	Swannanoa River dws of Beetree Ck	Buncombe	Spring 2005	11	6	9	5
			Fall 2005	10	6	8	15
			Spring 2006	17	9	8	15
			Fall 2006	12	4	5	18
			Spring 2007	13	8	10	14
			Fall 2007	12	2	6	14
			Spring 2008	17	8	9	25
			Fall 2008	16	6	7	22
			Spring 2009	12	6	9	15
			Fall 2009	16	7	7	18
			Spring 2010	19	11	9	15
			Fall 2010	16	7	7	23
			Spring 2011	11	6	9	16
			Fall 2011	10	3	5	16

Table 5 (continued). Cumulative SMIE data (spring 2005 – fall 2011).

Site #	Site	County	Date	Taxa Richness	Number of EPT Taxa	VASOS	Izaak Walton League
15	Swannanoa River ups of Bull Ck	Buncombe	Spring 2005	13	9	9	13
			Fall 2005	11	4	7	14
			Spring 2006	17	6	6	21
			Fall 2006	13	4	5	8
			Spring 2007	16	6	9	8
			Fall 2007	14	4	5	23
			Spring 2008	17	5	11	31
			Fall 2008	15	3	5	21
			Spring 2009	13	6	10	16
			Fall 2009	19	7	7	25
			Spring 2010	14	7	10	25
			Fall 2010	12	4	3	18
			Spring 2011	15	6	10	23
			Fall 2011	13	6	6	18
16	Smith Mill Creek	Buncombe	Spring 2009	10	3	5	13
			Fall 2009	*Not sampled*			
			Spring 2010	9	5	7	9
			Fall 2010	*Not sampled*			
			Spring 2011	*Not sampled*			
			Fall 2011	8	3	10	14
17	Reed Creek at Asheville Bot Gard	Buncombe	Spring 2005	10	7	9	9
			Fall 2005	7	2	5	16
			Spring 2006	14	3	5	18
			Fall 2006	7	3	6	10
			Spring 2007	*Not sampled*			
			Fall 2007	9	3	9	17
			Spring 2008	10	2	6	13
			Fall 2008	8	2	6	13
			Spring 2009	9	1	8	8
			Fall 2009	10	3	4	19
			Spring 2010	12	5	10	16
			Fall 2010	16	5	5	19
			Spring 2011	14	5	6	17
			Fall 2011	14	3	9	25
18	Lower Newfound Creek	Buncombe	Fall 2005	17	7	6	20
			Spring 2006	18	7	7	19
			Fall 2006	18	6	8	25
			Spring 2007	*Not sampled*			
			Fall 2007	11	4	7	13
			Spring 2008	19	7	9	17
			Fall 2008	15	4	5	21
			Spring 2009	16	6	6	18
			Fall 2009	15	5	5	16
			Spring 2010	9	5	6	11
			Fall 2010	11	4	3	9
			Spring 2011	*Not sampled*			
			Fall 2011	8	3	6	9
19	Reems Creek	Buncombe	Fall 2007	17	8	11	32
			Spring 2008	18	11	12	24
			Fall 2008	18	10	11	23
			Spring 2009	13	8	11	25
			Fall 2009	18	9	10	31
			Spring 2010	20	10	12	22
			Fall 2010	*Not sampled*			
			Spring 2011	15	8	12	27
			Fall 2011	18	8	11	29

Table 5 (continued). Cumulative SMIE data (spring 2005 – fall 2011).

Site #	Site	County	Date	Taxa Richness	Number of EPT Taxa	VASOS	Izaak Walton League
20	Sandymush Creek	Buncombe	Fall 2005	12	6	6	19
			Spring 2006	14	6	7	12
			Fall 2006	13	7	8	16
			Spring 2007	*Not sampled*			
			Fall 2007	15	8	6	18
			Spring 2008	15	7	10	16
			Fall 2008	15	8	8	18
			Spring 2009	14	7	10	18
			Fall 2009	21	11	8	26
			Spring 2010	17	8	10	20
			Fall 2010	16	6	6	28
			Spring 2011	*Not sampled*			
			Fall 2011	17	7	7	14
21	California Creek at Radford Rd	Madison	Spring 2005	13	6	8	7
			Fall 2005	16	8	7	22
			Spring 2006	16	6	10	22
			Fall 2006	12	5	9	20
			Spring 2007	*Not sampled*			
			Fall 2007	11	6	8	11
			Spring 2008	17	8	11	24
			Fall 2008	16	7	7	25
			Spring 2009	17	6	11	31
			Fall 2009	16	8	9	28
			Spring 2010	17	7	12	27
			Fall 2010	*Not sampled*			
			Spring 2011	10	5	11	12
			Fall 2011	18	8	10	29
22	California Creek at Beech Glenn	Madison	Fall 2011	18	8	7	22
23	East Fork of Bull Creek	Madison	Spring 2009	17	8	12	25
			Fall 2009	18	8	9	25
			Spring 2010	19	10	12	31
			Fall 2010	*Not sampled*			
			Spring 2011	*Not sampled*			
			Fall 2011	16	9	9	22
24	Little Ivy River at Forks of Ivy	Buncombe	Spring 2005	13	5	9	10
			Fall 2005	11	5	7	18
			Spring 2006	16	8	12	21
			Fall 2006	13	4	10	17
			Spring 2007	12	5	11	17
			Fall 2007	15	6	7	24
			Spring 2008	13	6	9	17
			Fall 2008	14	5	10	16
			Spring 2009	18	7	10	25
			Fall 2009	12	4	10	20
			Spring 2010	*Not sampled*			
			Fall 2010	17	7	8	33
			Spring 2011	15	5	11	22
			Fall 2011	13	7	8	19
25	Big Ivy River at Forks of Ivy	Madison	Spring 2005	17	7	9	11
			Fall 2005	17	7	7	26
			Spring 2006	14	8	9	22
			Fall 2006	8	3	12	16
			Spring 2007	13	6	12	11
			Fall 2007	18	8	6	17
			Spring 2008	15	7	9	23
			Fall 2008	18	7	7	22
			Spring 2009	15	8	10	19
			Fall 2009	10	6	11	18
			Spring 2010	17	9	10	26
			Fall 2010	13	6	7	20
			Spring 2011	12	5	10	18
			Fall 2011	12	5	7	13

Table 5 (continued). Cumulative SMIE data (spring 2005 – fall 2011).

Site #	Site	County	Date	Taxa Richness	Number of EPT Taxa	VASOS	Izaak Walton League
26	Shelton Laurel Creek	Madison	Spring 2006	24	13	11	15
			Fall 2006	19	11	9	30
			Spring 2007	19	9	12	23
			Fall 2007	20	10	11	23
			Spring 2008	22	12	10	31
			Fall 2008	18	10	12	22
			Spring 2009	21	10	12	21
			Fall 2009	21	12	11	25
			Spring 2010	17	10	9	22
			Fall 2010	15	8	12	28
			Spring 2011	19	13	12	23
			Fall 2011	12	6	9	25
27	Puncheon Fork Creek	Madison	Fall 2007	11	9	11	17
			Spring 2008	17	10	9	18
			Fall 2008	17	10	11	21
			Spring 2009	17	9	10	23
			Fall 2009	15	10	8	22
			Spring 2010	17	10	10	24
			Fall 2010	*Not sampled*			
			Spring 2011	11	8	10	15
			Fall 2011	14	9	12	17
28	Big Laurel Creek	Madison	Fall 2005	18	11	8	25
			Spring 2006	18	10	12	25
			Fall 2006	16	9	11	19
			Spring 2007	17	9	12	16
			Fall 2007	15	10	11	20
			Spring 2008	17	10	11	28
			Fall 2008	14	7	9	14
			Spring 2009	11	6	12	13
			Fall 2009	16	9	12	24
			Spring 2010	16	9	11	20
			Fall 2010	13	7	12	21
			Spring 2011	10	7	11	14
			Fall 2011	15	8	12	19
29	Cane Creek at Bakersville	Mitchell	Spring 2008	21	9	12	24
			Fall 2008	12	7	11	18
			Spring 2009	14	7	10	25
			Fall 2009	17	7	12	25
			Spring 2010	17	6	10	28
			Fall 2010	18	10	9	21
			Spring 2011	13	6	10	21
			Fall 2011	13	7	10	22
30	North Toe River	Mitchell	Spring 2009	12	6	9	15
			Fall 2009	*Not sampled*			
			Spring 2010	15	5	8	21
			Fall 2010	18	9	7	25
			Spring 2011	15	8	12	25
			Fall 2011	15	6	8	31
31	Cane River	Yancey	Fall 2008	15	6	8	18
			Spring 2009	12	7	9	16
			Fall 2009	*Not sampled*			
			Spring 2010	19	11	10	24
			Fall 2010	15	7	11	25
			Spring 2011	18	8	10	28
			Fall 2011	18	7	9	27

What do the scores mean?

Total Taxa Richness = the higher the better

EPT Taxa Richness = the higher the better

Izaak Walton Score: *Excellent* > 22, *Good* 17-22, *Fair* 11-16, *Poor* < 11

Note: IWL modified their index calculation; the SMIE Program used the revised methods in spring 2008, all previous years data were calculated using the old methods.

VA SOS Rating: *Acceptable* 7-12, *Unacceptable* 0-6

Appendix A. Biological monitoring data sheet (invertebrate identification)

Stream Monitoring Information Exchange - Data Sheet

Environmental Quality Institute (EQI)

County:
Date:
Location:

GPS Coordinates:
Weather and Stream Conditions (past 24 hours):

Sampling crew:

Benthic Macroinvertebrates

ID#		KICK NET	LEAF PACK	VISUAL
	STONEFLIES			
1	Giant Shredder			
2	Roach Shredder			
3	Quick Crawling Predator			
4	Fragile Detritivore			
	MAYFLIES			
5	Flattened Scrapers			
6	Spiny Crawler			
7	Round Headed Swimmer			
8	Burrowing Mayflies			
9	Spiny Turtle Mayfly			
10	Filter Mayfly			
	CADDISFLIES			
	Free Living			
11	Net Spinner			
12	Small Head Caddis			
	Organic Cases			
13	Stick Bait Caddis			
14	Square Log Cabin Caddis			
15	Sand and Stick Case Caddis			
16	Vegetative Case Caddis			
	Mineral Cases			
17	Gravel Coffin Case Caddis			
18	Sand Snail Case			
19	Sand or Mineral Case Caddis			
	BEETLES			
20	Water Penny			
21	Predator Beetle			
22	Adult Riffle Beetle			
23	Larval Riffle Beetle			

Appendix A (continued). Biological monitoring data sheet (invertebrate identification)

Stream Monitoring Information Exchange - Data Sheet

Environmental Quality Institute (EQI)

County:

Date:

Location:

Benthic Macroinvertebrates

ID#		KICK NET	LEAF PACK	VISUAL
	MEGALOPTERANS			
24	Hellgrammite			
25	Two Toed Fishfly			
26	One Toed Alderfly			
	OLIGOCHAETES/LEECHES			
27	Oligochaete			
28	Leech			
	DIPTERANS			
29	Watersnipe			
30	Water-worm			
31	Fat-head Cranefly			
32	Chironomid Midge			
33	Red Midge			
34	Blackfly			
	CRUSTACEANS			
35	Crayfish			
36	Sowbug			
37	Scud			
	SNAILS/CLAMS/MUSSELS			
38	Coiled Left Face Snail			
39	Coiled Right Face Snail			
40	Rounded Right Face Snail			
41	Clams and Mussels			
	ODONATES			
42	Damselfly			
43	Dragonfly			

Notes: