Nine Years of Volunteer Biomonitoring in Western North Carolina Streams

Stream Monitoring Information Exchange Year 2013

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Ann Marie Traylor

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Acknowledgments

The Stream Monitoring Information Exchange (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 continue to support the work and use the data to improve water quality in western North Carolina. The Environmental Quality Institute (EQI) wishes to thank the Pigeon River Fund of the Community Foundation of Western North Carolina for their financial support of this work in Haywood, Buncombe, and Madison Counties. The SMIE and DWR protocol comparison study was funded by New Belgium Brewing. EQI would like to give special thanks to the group leaders who undergo extra training and take on additional sampling responsibilities. The advice of Dave Penrose, Jason Robinson, Eric Romaniszyn, David Gillette, Steven Patch, and the staff of NC DENR's Division of Water Resources' Biological Assessment Branch have been crucial to establishment of data analysis and reporting methods. Thank you to Chloe Gagin for developing the SMIE map, and many other EQI interns for their data management work. The Environmental and Conservation Organization (ECO) would like to thank Diane Silver with the Mud Creek Watershed Restoration Project, Doreen Blue and Lucy Butler, ECO's SMIE Coordinators, Lee McCall, ECO's Water Quality Committee Chair and Team Captains for making the 2013 SMIE sampling possible. Now, more than ever, there is an urgent need for well-educated, engaged community volunteers. SMIE volunteers continue to provide very high levels of in-kind support and have kept the program sustainable.

2013 EQI Volunteers (GL=Group Leader):

Carla Billips (GL)	Kira Despins (GL)	Sarah Bivens	Jennifer Cooper
Jim Carroll (GL)	Kendall Walton (GL)	Amber Williams	Joe Coleman
Mark Ethridge (GL)	Robert Windsor	Ansley Ricker	John Lombardi
Tim Forest (GL)	Wyatt Windsor	Barbara Sloss	Kelsey Meyers
Katie Hicks (GL)	Julia Kelly	Ben Yoke	Lou Lieb
Kevin Keen (GL)	Randy Burroughs	Bob Broadhead	Morgan Lambert
Roger Makepeace (GL)	David Johnston	Carole Larivee	Samantha Johnson
Matt Milnes (GL)	Ed Lohrer	Chris Gilbert	Sarah Carothers
Gracia O'Neill (GL)	Caroline Ketcham	Deb Swanson	Skip Wynn
Dave Penrose (GL)	Noelle Kearney	Eileen Hallman	Tom Anspach
Eric Romaniszyn (GL)	Corinne Fretwell	Erin Damtoft	Tom Southard
Ann Marie Traylor (GL)	Greg Yost	Grace Lancaster	Will Hamilton
James Wood (GL)	Shawn Swartz	Hannah Billian	Zach Gregg
Cat Dillard (GL)	Diane Kent	Hannah Jeske	
	Leif Olson	Jasper Yoke	

2013 ECO Volunteers (TC=Team Captain):

Doreen Blue (TC)	Bailey Newell	Elizabeth Curtis	Marian Soss
Lucy Butler (TC)	Barbara Rothrock	Helen Struve	Mary Beth Hayes
Anthony Brancato (TC)	Barbara Sloss	Jamie Davidson	Mel Meibers
Bob Brown (TC)	Brenda Cross	Jan Allen	Mike Vogt
Ruth Cumberland (TC)	Chris Berg	Jerry Brill	Patrick Garrison
Harry Fozzard (TC)	Dan Waugh	Jim Czarnezki	Patty Davis
Bill Garrison (TC)	David Davis	Jim Lee	Reba Brinkman
Lee McCall (TC)	Don Huneycutt	Joe Boeckz	Rich DeSimone
JR Mason (TC)	Donna Byce	Kate Bond	Robert Black
Don & Linda Miller (TC)	Dorothee Kellinghusen	Katherine Freeman	Tamara Heinemann
Rick Burt (TC)	Duke Guenther	Kay Shurtleff	Tom Clyde
Alex Rodriguez	Edith Dziorney	Lucy Prim	
	Eileen Blackwell	Lynn Boeckz	

1.0 INTRODUCTION

This report details the results of the Stream Monitoring Information Exchange from the spring and fall of 2013. SMIE, a project of EQI, has assumed responsibility for designing and implementing a program to train volunteers to use standardized protocols for benthic macroinvertebrate monitoring in western North Carolina. Protocols were developed by Jason Robinson (Kanugalihi Biological Consulting), the NC Division of Water Resources (DWR), and the SMIE program itself, which is a collaboration between regional organizations, educational institutions, and government agencies with an interest in water quality issues. EQI coordinates the training and sampling in Haywood, Buncombe, Madison, Mitchell, and Yancey Counties. ECO coordinates the training and sampling in Henderson County using the same protocols.

Biological stream monitoring is one 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 have limited mobility and have specific habitat requirements and tolerance levels to pollution. If a stream has good chemical ratings but poor biological scores, it could mean that unmeasured toxic substances are getting into the water periodically or that the habitat has been degraded. These biomonitoring data are valuable to researchers as well as watershed managers.

Volunteer stream monitoring data are also used increasingly by government agencies for planning and review purposes. The NC DWR is operating on an increasingly restrictive budget, and looking to collaborate with environmental organizations that share their mission to protect and enhance water quality. SMIE provides more frequent sampling at a greater variety of sites in the region and helps DWR identify streams that may be degrading or in threat of degradation. The data can be used to raise red flags so that DWR can provide an in-depth survey of pollution sources and stressors. This protocol is specifically designed to mimic DWR collection techniques in order to facilitate comparisons between those data. The advanced level of identification (often to species) used by DWR precludes anything but general comparisons with SMIE data, as the volunteer monitoring protocol identifies only to the family or group of families.

In 2013, EQI's core SMIE program conducted biannual sampling at 36 sites, while ECO sampled 20 additional sites in Henderson County following the SMIE protocol. Figure 1 depicts the locations of sites Haywood, Buncombe, Madison, Mitchell, Yancey and Henderson Counties. Table 1 lists of all SMIE monitoring sites in the region. Results are available through technical reports that can be accessed at EQI's website (www.eqilab.org), ECO's website (www.eco-wnc.org), or by request. These websites also have online SMIE training videos, which cover basic stream ecology, macroinvertebrate identification, sampling protocols, and habitat assessment.

Figure 1. Map of 2013 SMIE Monitoring Sites

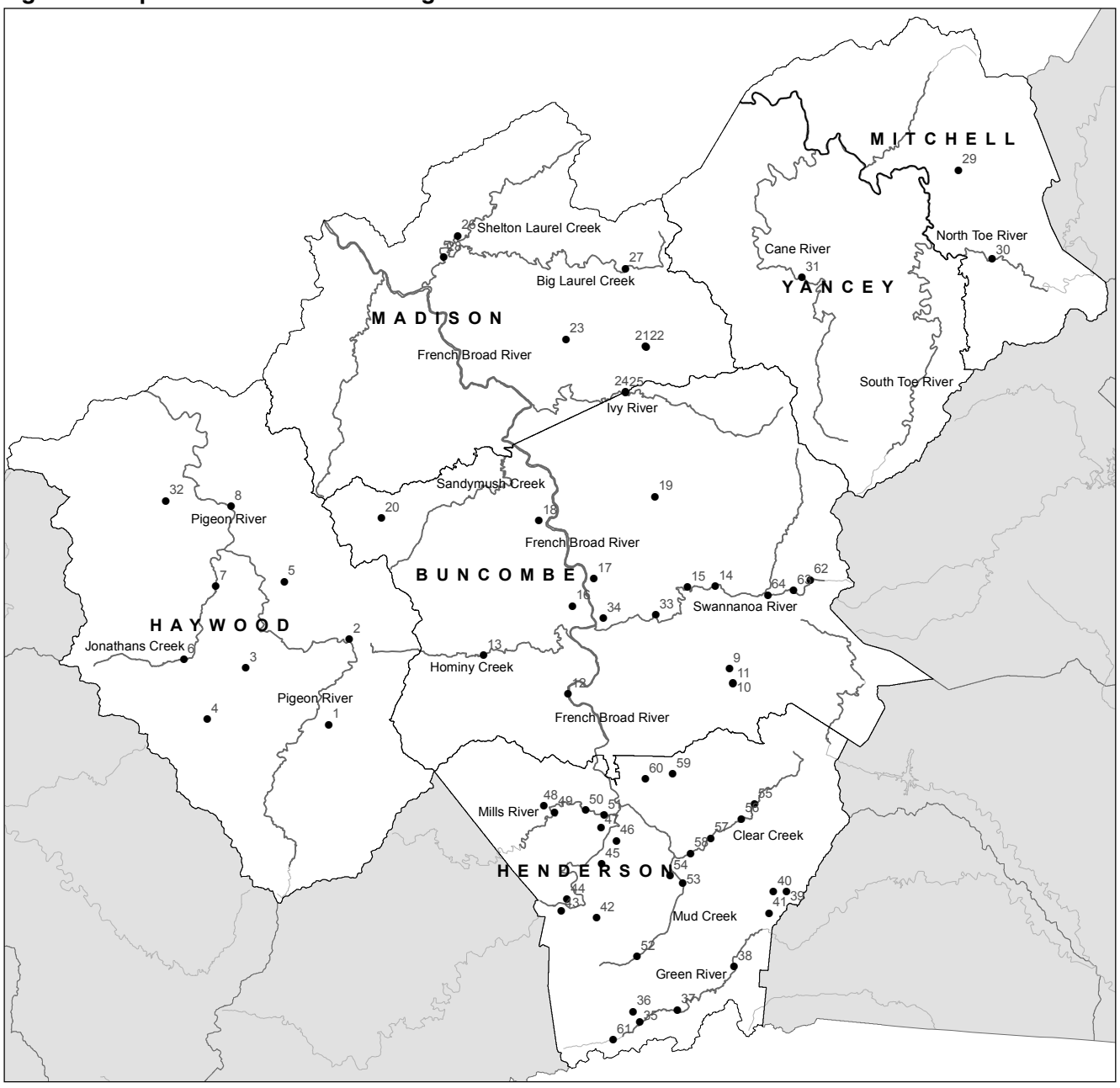

Table 1. List of 2013 SMIE Monitoring Sites

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 at Moody Farm Bridge
8	Lower Fines Creek
32	Cataloochee Creek

Buncombe County

9	Cane Creek at Miller Rd
10	Ashworth Creek
11	Cane Creek at Ashworth Creek
12	Bent Creek
13	Hominy Creek
62	Swannanoa River at Flat Creek
63	Swannanoa River at Blk Mtn Rec Park
64	Swannanoa River at Kearfott
14	Swannanoa River dnstrm of Beetree Ck
15	Swannanoa River upstream of Bull Creek
33	Swannanoa River at Nature Center
34	Nasty Branch
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

Henderson County

61	Uncle's Creek (UNCLGR)
35	Green River @ Bobs Creek Road (GR42)
36	Rock Creek on Rock Creek Road (GR46)
37	Green River @ Terry's Creek Road (GR12)
38	Green River below Lake Summit (GR11)
39	Big Hungry River upstream (HR43)
40	Little Hungry River (HR44)
41	Big Hungry River downstream (HR13)
42	Big Willow Creek @ Patterson Road (MR23)
43	Little Willow at Pleasant Grove Rd (MR24)
44	Gash Creek @ Etowah Park (MR25)
45	Shaw Creek @ Hunter's Glen (MR28)
46	Mill Pond Creek (MR27)
47	Boylston Creek @ Ladson Road (MR14)
48	North Fork Mills River (MR7)
49	South Fork Mills River (MR8)
50	Mills River @ Davenport Bridge (MR9)
51	Mills River @ Hooper's Lane (MR10)
52	Mud Creek @ Berea Church Road (MC21)
53	Mud Creek @ 7th Avenue (MC18)
54	Brittain Creek at Patton Park (MC26)
55	Clear Creek @ Bearwallow Road (MC20)
56	Clear Creek @ Gilliam Road (MC40)
57	Clear Creek @ Lancaster Road (MC41)
58	Clear Creek at Nix Road (MC5)
59	Hooper's Creek @ Jackson Rd (CC22)
60	Cane Creek @ Howard Gap (CC16)

Mitchell County

29	Cane Creek at Bakersville
30	North Toe River

Yancey County

31	Cane River

2.0 METHODS

2.1 Instruction and Training

EQI volunteers are solicited through participating SMIE organizations as well as through public outreach. Ten people attended the March 2013 training and 12 new recruits attended in September, which were both led by Dave Penrose of Watershed Science Consulting and Gracia O'Neill of EQI. Haywood Community College and Tim Forrest from the University of North Carolina-Asheville were instrumental in providing classroom resources to host the spring and fall training sessions. Afternoon field sessions were conducted in Richland Creek at the Waynesville Recreation Park in the spring, and the Big Ivy River monitoring site in the fall. The 2013 Henderson County training session was held at Blue Ridge Community College in March and was led by Seirisse Baker of ECO and Gracia O'Neill of EQI. A total of 21 participants attended with 8 new volunteers registering in the program. ECO's biomonitoring Coordinators and Water Quality Committee members greatly assisted in facilitating the training. Special thanks are deserved by Dean David Davis and Blue Ridge Community College for providing lab space and equipment and Dr. Calvin Koonce for use of the Big Hungry River monitoring site where afternoon field lessons took place.

At these trainings, 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. 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 EQI monitoring sites, assisting with logistics, and having the final say on identification of specimens. EQI 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, Dave Penrose. 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 follows the SMIE stream monitoring protocols (Robinson 2004). At least one group leader or the SMIE biologist is in charge of leading each EQI group. Sites are selected, when possible, as Volunteer Water Information Network (VWIN) sites (a chemical water monitoring program, also coordinated by EQI) or DWR sampling sites as identified from the French Broad Basinwide Water Quality Plans and Assessment Reports (NCDENR-DWR-BPU 2011, NCDENR-DWR-ESS 2008). Samples are collected using kicknet, 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 kicknet (mesh size 500 μm). Sampling consists of overturning

stones (by feet or hands) for one minute within a $15ft^2$ area upstream of the net. Organisms are picked from the net for 20 minutes, 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 kicknet several times to isolate insects and reduce the volume of material to be searched. Organisms are picked from the net and leaf material for ten minutes, identified, and recorded separately from the kicknet and visual collections.

The visual survey is performed for five minutes by someone with a working knowledge of different types of habitats and insects; in most instances the group leader. Searchable habitats include pools, riffles, runs, aquatic macrophytes, submerged mosses, undercut banks, large logs, boulders, and sand bars. This method often yields taxa not collected in the other two samples and provides a more accurate estimate of taxa richness at a site. These organisms are identified and recorded separately from the kicknet 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 problems such 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. Samples that require extra effort may indicate 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 kicknet and leaf pack samples. With good species diversity, high total numbers can indicate 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 uneven macroinvertebrate distribution in the stream. 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 number of organisms collected 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 using the kicknet data, 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 common net-spinning caddisflies (Hydropsychidae), 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 in the kicknet data, 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.

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 kicknet collect >200 organisms).

2.4 SMIE Biotic Index Development

Since SMIE monitoring began in 2005, overall water quality ratings have been assigned using the IWL and VASOS analysis methods described in the Section 2.3. Sometimes these IWL ratings did not seem to accurately describe the actual conditions in the streams when compared to DWR data. The VASOS ratings did not have much separation between sites and only classifies them as *Acceptable* or *Unacceptable*. Additional questions lingered, such as how do the IWL and VASOS ratings compare to DWR sampling results at the same locations, and can we fine-tune the bioclassifications to better fit our data.

A few things stood out when examining the calculations used for the IWL and VASOS rating systems. Both used only kicknet counts in the analysis, while SMIE also collects data from leaf pack and visual surveys. IWL and VASOS only separate the taxa into 20 or 24 groups respectively, while SMIE volunteers identify 43 taxa groups. Also, both methods only use three sensitivity categories for their macroinvertebrate taxa. These methods of analysis did not seem to be using SMIE data to its fullest potential.

In the fall of 2013, Dave and Ann Marie conducted sampling side-by-side at four SMIE sites using both DWR and SMIE protocols in order to compare the ratings. Table 2 lists the results of that sampling. The VASOS ratings do not give enough detail to evaluate the sites. The IWL ratings do not compare well to the DWR ratings. For example, Reed and Reems Creeks do not have the same water quality, and Raccoon Creek does not have the highest water quality of these four sites, as the IWL ratings suggest.

Table 2. Comparison of DWR, VASOS, and IWL ratings

	Score (Rating)		
Creek	**DWR**	**VASOS**	**IWL**
Reems	(Good)	9 (Acceptable)	16 (Fair)
Richland	(Good/Fair)	8 (Acceptable)	19 (Good)
Raccoon	(Good/Fair)	7 (Acceptable)	21 (Good)
Reed	(Poor)	7 (Acceptable)	14 (Fair)

The solution was to develop a new SMIE Biotic Index (BI), similar to the scoring system that DWR uses. To maximize our data usage, the BI calculation includes all 43 of the taxa, as well as kicknet, leaf pack, and visual macroinvertebrate counts. Sensitivity scores were assigned to each taxa that ranged from 0-10 based on the EPA's Rapid Bioassessment Protocol criteria (Dates and Byrne 1997). These sensitivity scores were further refined for families found in WNC by Dave Penrose. The BI is calculated as the sum of each taxa abundance times the sensitivity scores for the taxa, divided by the total abundance of all individuals captured. The formula is:

$$SMIE\ BI = \sum Abundance \times Tolerance\ Values / Total\ Abundance$$

With the new scores in place, a bioclassification system was developed. Expert advice was gathered from Dave Penrose, Jason Robinson, Eric Romaniszyn, Dr. David Gillette, Dr. Steven Patch, and the staff of NC DENR's Division of Water Resources' Biological Assessment Branch. Based on their feedback, BI scores were calculated for all previous sampling occasions, resulting in 558 data points. These samples were divided into bins based on percentiles to approximate a normal distribution: the top 10% were classified as *Excellent*, the next 20% were classified as *Good*, the middle 40% were classified as *Good-Fair*, the next 20% were classified as *Fair*, and the bottom 10% were classified as *Poor*. The rating limits were further refined by comparing SMIE samples that occurred in the same years and locations as DWR samples (where available). There were 72 comparable samples, mostly collected in 2007 and 2012. Once the fixed rating category endpoints were established, they were applied to all SMIE samples.

3.0 RESULTS and DISCUSSION

3.1 SMIE Biotic Index Results

The new SMIE BI bioclassifications were compared to the DWR/SMIE protocol comparison samples collected in the fall of 2013. Table 3 shows that the new BI score ranked the four sites in the appropriate order of quality (low BI = high water quality, high BI = low water quality). Three of the four sites earned the same rating using either DWR or SMIE protocols, which is much more comparable than the IWL and VASOS ratings.

Table 3. Comparison of DWR and SMIE BI ratings

	Score (Rating)	
Creek	**DWR**	**SMIE BI**
Reems	(Good)	3.56 (Good)
Richland	(Good/Fair)	3.79 (Good/Fair)
Raccoon	(Good/Fair)	4.05 (Good/Fair)
Reed	(Poor)	4.65 (Fair)

Biological ratings from SMIE samples that occurred in the same years (mostly 2007 and 2012) and locations as DWR samples were compared. Of all the available samples, 39% had the same bioclassification, 43% were only one rating unit apart, and 18% were greater than one rating unit apart. There are many reasons that SMIE BI ratings could be different than the state's. For example, SMIE uses volunteers instead of professional benthologists and only identifies macroinvertebrates to families or groups of families instead of species like DWR. SMIE and DWR also have a slightly different sampling procedures, and sample in different seasons (spring and fall for SMIE and summer for DWR). Considering these differences, the fact that 82% of SMIE samples rated within one unit of DWR samples validates this new rating method. Besides better accuracy, another benefit to this method is that there is no change to the field protocol, so the analysis can be applied to all previous samples collected since 2005. Table 4 shows the final SMIE bioclassification categories.

Table 4. Final SMIE BI rating categories

Rating	SMIE BI Scores
Excellent	<3.09
Good	3.10-3.56
Good-Fair	3.57-4.10
Fair	4.11-5.21
Poor	>5.22

3.2 Training Sessions

All EQI training participants complete an evaluation of the instructor, methods and materials, overall efficacy of the training, and individual performance. Previous stream monitoring experience ranged from none to some college level courses – for the first time, some participants had prior SMIE experience acquired through work with SMIE partner organizations. Ten of the 22 participants had no prior macroinvertebrate experience. Evaluations from 2013 showed that all participants felt the SMIE training improved their monitoring skills and knowledge. Most participants felt they had improved their knowledge of threats to water quality, and all showed they were more empowered to address threats to water quality. The pre- and post-training surveys of the SMIE trainings found all participants maintained or improved their basic invertebrate identification skills, and all but one participant either maintained or improved their comprehension of basic stream ecology and water quality assessment concepts after completing the training sessions. The average taxonomy score on the 15-question identification quiz was 75% in the spring training. In the fall, the average score for the identification quiz was 69%.

ECO's 2013 training session integrated several new components including a pre-survey and post-survey on a variety of general water quality topics and a macroinvertebrate identification quiz of preserved specimens using microscopes. Lessons included introductory elements of stream ecology and identifying key components of habitat as well as the various causes and effects of poor water quality. ECO training

attendees completed an evaluation survey on the dynamics of the program format, suggestions for improvement, and increased knowledge of water quality issues and macroinvertebrate identification. Prior experience in stream monitoring and ecology ranged from none to professional levels. All participants felt that the training increased their understanding of stream ecology and monitoring methods. All surveys indicated an improvement in macroinvertebrate identification skills of at least 2 points on a scale of 1-10 except three attendees who had extensive previous knowledge of benthic taxa.

3.3 Quality Control

As a continuing check on the volunteer skills, the SMIE biologist checks the identifications and counts of preserved specimens for one site from each of EQI's group leaders each season. Specimens from the kicknet, leaf pack, and visual sampling are preserved in separate vials. SMIE uses a proportional similarity calculation to compare the volunteer field identifications and biologist re-identifications of the samples quantitatively (Garey and Smock 2007). Table 5A and 5B summarize the results for EQI's 2013 quality control checks. The spring 2013 median similarity for kicknets was 84% (range: 47-98%) and for leaf packs was 89% (range: 50-97%). The fall 2013 median similarity for kicknets was 91% (range: 83-98%) and for leaf packs was 75% (range: 42-91%). Additionally, SMIE BI scores were calculated to see if the bioclassifications changed between the biologist and volunteer identifications. In the spring, three samples earned different ratings, but two of the three were tightly straddling the range limits. All sample ratings matched in the fall, showing no changes in stream ratings due to volunteer mis-identifications. Group leaders receiving similarity values less than 85% are encouraged to attend a refresher training session. In addition to misidentifications, small differences in similarity may be due to individuals that were discarded prior to preservation (due to large size or predatory habits), degradation of the preserved specimens, or transcription errors on data sheets.

Table 5A. EQI volunteer and biologist proportional similarity for kicknet (KN) and leaf pack (LP) data, with comparisons of SMIE BI scores and ratings (Spring 2013).

	% similarity		SMIE BI (score/rating)			
Stream	**KN**	**LP**	**Volunteer**		**Biologist**	
Jonathan Creek at Coleman Mtn Rd	86	94	*3.11*	*Good*	*3.05*	*Excellent*
Jonathan Creek at Moody Farm Rd	74	94	*2.66*	*Excellent*	*3.15*	*Good*
Sandymush Creek	98	92	3.64	Good-Fair	3.67	Good-Fair
Puncheon Fork	89	97	3.05	Excellent	3.09	Excellent
Cane Creek at Miller Rd	47	50	*3.04*	*Excellent*	*3.11*	*Good*
Ashworth Creek	86	92	3.82	Good-Fair	3.86	Good-Fair
Swannanoa River at Beetree Cr	74	96	4.81	Fair	4.66	Fair
East Fork of Pigeon River	93	96	3.23	Good	3.24	Good
East Fork of Bull Creek	92	83	3.20	Good	3.32	Good
Big Ivy River	96	94	3.18	Good	3.25	Good
Mean:	84	89				

Table 5B. EQI volunteer and biologist proportional similarity for kicknet (KN) and leaf pack (LP) data, with comparisons of SMIE BI scores and ratings (Fall 2013).

	% similarity		SMIE BI (score/rating)			
Stream	KN	LP	Volunteer		Biologist	
Reems Creek	96	89	3.69	Good-Fair	3.71	Good-Fair
Ashworth Creek	95	76	3.85	Good-Fair	3.85	Good-Fair
East Fork of Bull Creek	91	76	3.22	Good	3.24	Good
Big Laurel River	90	50	3.77	Good-Fair	3.72	Good-Fair
Big Ivy River	91	87	3.36	Good	3.46	Good
Hominy Creek	87	86	3.64	Good-Fair	3.78	Good-Fair
Swannanoa River at North Fork	98	76	4.00	Good-Fair	3.98	Good-Fair
Swannanoa River at Bull Creek	83	42	3.88	Good-Fair	3.74	Good-Fair
Jonathan Creek at Moody Farm Rd	89	91	2.61	Excellent	2.74	Excellent
Mean:	91	75				

To assess their volunteers' skills, ECO performed identification checks on each sample during the spring of 2013. All specimens were preserved in one vial per site. It is important to note that the quality control portion of ECO's SMIE program is limited to one staff person who is not a trained invertebrate biologist, along with the Water Quality Committee Chair, the Biomonitoring Program Chair, and team leaders that have exceptional ID skills. Table 5C summarizes the results for the 2013 quality control checks. The spring 2013 median similarity was 76% (range: 46-94%). Seven of 19 samples resulted in different ratings for the volunteer and biologist identifications. The quality control portion of ECO's SMIE protocol is being re-evaluated to include supervised biologist input over the next several years.

Table 5C. ECO volunteer and biologist proportional similarity with comparisons of SMIE BI scores and ratings (Spring 2013).

	% similarity	SMIE BI (score/rating)			
Stream	combined	Volunteer		Biologist	
Green River at Terry's Creek	64	*3.64*	*Good-Fair*	*3.02*	*Excellent*
Green River at Bob's Creek	86	2.72	Excellent	3.05	Excellent
Rock Creek	80	2.92	Excellent	2.97	Excellent
Lower Big Hungry River	76	3.07	Excellent	3.01	Excellent
Upper Big Hungry River	77	3.45	Good	3.46	Good
Clear Creek at Nix Road	92	*4.03*	*Good-Fair*	*4.11*	*Fair*
Mud Creek at 7th Ave	84	*3.94*	*Good-Fair*	*4.28*	*Fair*
Clear Creek at Bearwallow Rd	94	3.69	Good-Fair	3.64	Good-Fair
Mud Creek at Berea Church Rd	62	*4.26*	*Fair*	*3.81*	*Good-Fair*
Brittain Creek	77	*5.40*	*Poor*	*4.83*	*Fair*
North Mills River	75	2.58	Excellent	2.80	Excellent
Mills River at Hooper's Lane	77	*3.49*	*Good*	*3.97*	*Good-Fair*
Boylston Creek	83	5.96	Poor	5.54	Poor
Little Willow Creek	90	3.30	Good	3.35	Good
Mill Pond Creek	82	5.13	Fair	5.10	Fair
Shaw Creek	47	3.95	Good-Fair	3.70	Good-Fair
South Mills River	88	2.00	Excellent	2.05	Excellent
Cane & Hooper's Creek combined	46	n/a	n/a	n/a	n/a
Uncle's Creek	71	*3.00*	*Excellent*	*3.22*	*Good*
Mean:	76				

3.4 Site Descriptions and Stream Monitoring Results

Most of the monitored streams addressed in this report are tributaries in the French Broad River Basin, and are located in the Pigeon River, Upper French Broad River, and Nolichucky River subbasins. The following section describes the location, habitat, and monitoring results of each SMIE site. The sites are grouped by subbasin and watershed and are generally described from upstream to downstream, not necessarily by numerical order. Unique SMIE site identification numbers have been assigned to each site, but corresponding DWR and VWIN site identifications and water quality ratings are specified if available. The SMIE bioclassifications or ratings refer only to the new SMIE Biotic Index, not IWL or VASOS ratings as in previous reports. Overall water quality patterns for many of the streams or their parent watersheds are described in the NC Department of Environment and Natural Resources DWR basinwide reports for the French Broad River basin (NCDENR-DWR-BPU 2011, NCDENR- DWR-ESS 2008). VWIN chemical monitoring is described in technical reports (Traylor 2013a; Traylor 2013b; Westphal, Patch, & Traylor 2009a; Westphal, Patch, & Traylor 2009b; Westphal et al 2008), and water quality ratings used in this report are updated with data through 2013. Volunteer observations are also critical in documenting habitat and water characteristics at specific sites.

Table 6 summarizes the collected data from 2013. Table 7 lists cumulative results from all sampling occasions. 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).

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, and is about six miles downstream of DWR site EB230. Trees and shrubs dominate the banks, and the substrate is gravel and cobblestones.

This site was first sampled in the fall of 2005. The East Fork of the Pigeon River earned a *Good* SMIE bioclassification in the spring, and *Excellent* in the fall of 2013. Spiny crawler mayflies represented 64% of the spring sample, followed by flattened scraper mayflies. In the fall, 20% of the individuals were net spinner caddisflies and 22% small head caddisflies, along with spiny crawler mayflies. Most samples at this site since 2005 have earned an *Excellent* or *Good* SMIE rating. The DWR also gave this site *Excellent* biological ratings in both 2006 and 2012. The VWIN project has assigned an *Excellent* chemical rating to the East Fork, showing the water quality is comparable with relatively undisturbed streams.

Site #2 – Pigeon River downstream of Canton

This site is located on the Pigeon River just downstream of the Evergreen Packaging mill in Canton. It is located near Fiberville Street off NC215 in Canton, and is very close to VWIN site Y4. DWR site EB257 is located about four miles downstream from this location. 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 most sampling events.

The Pigeon River was first sampled here in the fall of 2006. It received a *Good-Fair* SMIE rating in the spring of 2013, and *Fair* in the fall. Both seasons rate worse than the upstream, East Fork monitoring site. In the spring, 47% of the individuals were spiny crawler mayflies, with fewer net spinner caddisflies. This sample had one of the highest taxa richness values in 2013 with 20 taxa, and there were representatives of both pollution-sensitive and tolerant taxa. In the fall, 83% of the macroinvertebrates were net spinner caddisflies, with only one quick crawling predator stonefly as the only pollution-sensitive individual. In the earlier years of monitoring (2006-2008) this site rated *Fair* each spring and *Poor* each fall. In the past three years, each spring rating has improved to *Good-Fair* and each fall has improved to *Fair*. The spring SMIE scores have been better than the fall scores of each year. DWR assigned a *Good-Fair* biological rating to this site in 2012, up from *Fair* in 2006. They found benthic macroinvertebrate communities largely comprised of pollution-tolerant taxa just downstream of the mill and the City of Waynesville's Wastewater Treatment Plant (WWTP). VWIN rates this site as *Average*, and shows high conductivity and orthophosphate concentrations.

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 and DWR site EB262 is about three miles downstream. The stream resembles a long straight channel with little riffle formation or bank heterogeneity. The riparian zone includes trees and shrubs, but it is highly modified by both a large parking lot and residential homes. The substrate is mostly gravel and cobblestone.

Richland Creek was first sampled in the spring of 2005. It received a *Good* SMIE rating in the spring and *Good-Fair* in the fall of 2013. In the spring, 68% of the individuals were spiny crawler mayflies, followed by flattened scraper mayflies. In the fall, 42% were net spinner caddisflies, in addition to flattened scraper and round headed swimmer mayflies. Leaf packs were difficult to find in both seasons, and only 95 individuals were collected in the fall. Also in the fall, there was a fisherman nearby who had caught 11 trout in the creek. While Fair and Poor SMIE ratings were common in 2005-2006, this site has mainly earned *Good* bioclassifications since then. DWR has found improved benthic macroinvertebrate communities at various sites along this creek (with *Good-Fair* ratings in both 2007 and 2012), attributed mainly to the repair of leaking sewer lines in the watershed. VWIN chemical analysis shows overall *Good* water quality, with sediment an ongoing issue in Richland Creek.

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. The riparian zone consists of trees and shrubs, and the substrate is mainly gravel, cobblestones, and sand. The riffles are located adjacent to oil tanks at Peak Energy. Volunteers noted muddy water in the spring and tea-colored water with an oily smell in the fall of 2013.

Raccoon Creek was first sampled in the spring of 2008. It earned an SMIE rating of *Good* in the spring of 2013, and *Good-Fair* in the fall. Spiny crawler mayflies comprised 53% of the sample in the spring, along with some small head caddisflies. In the fall, 60% of the sample was comprised of net spinner caddisflies, in addition to round headed swimmer mayflies. The SMIE ratings have stayed mostly at *Good-Fair* since monitoring began in 2008. This VWIN monitoring site exhibits a *Below Average* chemical rating, with high turbidity, total suspended solids, and nitrate concentrations.

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, sand, bedrock, and boulders, with a riparian zone of trees and shrubs. Volunteers noticed a strong manure smell in the leaf packs in both 2012 and 2013.

Crabtree Creek was first sampled in the spring of 2005. This monitoring site received a *Good* SMIE bioclassification in the spring of 2013, and *Good-Fair* in the fall. Almost half of the individuals in the spring sample were spiny crawler mayflies, followed by quick crawling predator stoneflies and net spinner caddisflies. Two kicknet samples were collected in the spring to achieve adequate numbers. In the fall, 65% of the individuals were net spinner caddisflies. Over the monitoring years, most samples have had a *Good* to *Good-Fair* SMIE rating. DWR cites cattle as likely sources of sediment and nutrients to this rural stream. The VWIN chemical rating for Crabtree Creek is *Below Average*, with data showing above average levels of turbidity, total suspended solids, conductivity, and orthophosphate.

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 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 and is about three miles downstream of DWR site EB238. The riparian zone is mostly trees and shrubs, with a roadway and houses paralleling the stream. The dominant substrates are gravel and cobblestones, which the volunteers describe as very slippery.

This site on Jonathan Creek was first sampled in the spring of 2005. It received an *Excellent* SMIE rating in the spring and fall of 2013, and both seasons had some of the best SMIE BI scores. In the spring sample, 47% of the individuals were spiny crawler mayflies, and 34% were quick crawling predator stoneflies. Taxa were a bit more evenly represented in the fall, with 25% small head caddisflies, 20% quick crawling predator stoneflies, 17% flattened scraper mayflies, and 13% net spinner caddisflies. The fall sample had some of the highest EPT taxa richness and pollution-sensitive taxa values in 2013. This site tends to jump from *Good-Fair* to *Excellent* SMIE bioclassifications, with no obvious pattern. The nearest DWR site had an *Excellent* biological rating in 2007. VWIN gives this site an *Excellent* rating, and shows median levels of most chemical parameters are less than the regional medians. However, this site shows slightly higher maximum nutrient 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 Jonathan Creek monitoring site is located approximately 50 meters downstream of the Coleman Mountain Road Bridge (SR 1364) near the junction with SR 276. It corresponds with VWIN site Y12, is between DWR 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 and cobblestone. Volunteers reported a heavy manure smell in the spring of 2013.

This downstream site on Jonathan Creek was first sampled in the spring of 2005. It had an SMIE rating of *Good* in the spring of 2013, and *Excellent* in the fall. Spiny crawler mayflies made up half of the spring sample, in addition to quick crawling predator stoneflies, flattened scraper mayflies, and net spinner

caddisflies. Net spinner caddisflies represented half of the fall sample, as well as small head caddisflies and quick crawling predator stoneflies. Leaf packs were difficult to find in the spring. Both seasons had worse SMIE scores than the upstream Jonathan Creek site. Over the years, this site has displayed a pattern of lower scores in the spring and higher scores in the fall. The SMIE biological rating at this site has mostly been *Good* over the years. DWR has also given nearby sites *Good* bioclassifications in 2007 and 2013, with declines in EPT taxa attributed to effluent from the Maggie Valley WWTP discharge during drought conditions. This site on Jonathan Creek has a *Good* VWIN chemical rating.

Site #8 – Lower Fines Creek

Fines Creek is a tributary to the Pigeon River in northeastern Haywood County. This site is located near the bridge on SR 1355 near the junction with SR 1338, approaching the confluence with the Pigeon River. It corresponds to VWIN site Y7 and DWR site EB231 at SR1355. The right side of the stream is mainly trees and shrubs, but the left side is grassy with a road in close proximity to the stream. The substrate is mostly boulders and bedrock, with some gravel, cobblestone, and a substantial amount of sand present. A nearby waterfall provides a barrier to fish movement. Volunteers report that sediment has been accumulating at this site over the years.

Fines Creek was first sampled in the spring of 2005. This site had a SMIE rating of *Excellent* in both seasons of 2013, and has demonstrated high water quality in previous years. It received one of the best SMIE scores in the fall. In the spring, 59% of the individuals were spiny crawler mayflies, followed by quick crawling predator stoneflies. The stream flow was swift during the spring sample, making kicknetting difficult. In the fall, 29% of the sample was represented by net spinner caddisflies, in addition to small head caddisflies, fragile detritivore stoneflies, and quick crawling predator stoneflies. SMIE ratings have ranged from *Good-Fair* to *Excellent* over the years. DWR gave this site a *Good* bioclassification in both 2007 and 2012, with steep slopes in the upper reaches and dairy farms in the valleys causing the most impact to water quality. Fines Creek received a *Below Average* VWIN chemical rating, with *Poor* sediment scores.

Site #32 – Cataloochee Creek

Cataloochee Creek is located in the Great Smoky Mountains National Park in northwestern Haywood County. It empties into the Pigeon River at the northern end of Waterville Lake. EQI holds a National Park Service permit to conduct scientific research related to the SMIE project, but is not allowed to disclose the specific sampling site publicly. DWR monitors this stream at site EB320. The riparian zone is mostly trees and shrubs with some grass. The stream substrate is composed of gravel, cobblestones, bedrock, and boulders.

Cataloochee Creek was first sampled in the spring of 2012. It was not sampled in the spring of 2013, but it received an *Excellent* rating with one of the best SMIE scores when sampled in the fall. Taxa with the most individuals were net spinner caddisflies, round headed swimmer mayflies, flattened scraper mayflies, fragile detritivore stoneflies, quick crawling predator stoneflies, and dragonflies. This creek has a reputation for very high water quality and intact habitats due to the large amount of protected land in the watershed. DWR assigned this stream an *Excellent* bioclassification in both 2007 and 2012.

Green River Subbasin (Henderson County)

The Green River and its tributaries originate in Henderson County and flow into the Broad River. The upper Green River above the confluence with Rock Creek is classified as High Quality Water by DWR. Much of the catchment is forested, but agriculture and residential development along the escarpment, and sediment pollution from silviculture activities are evident in some areas and beginning to threaten the high water quality.

Site #61 - Uncle's Creek *(UNCLGR)*
Uncle's Creek is a tributary to the Green River located in the rural area near Bear Paw Ridge Road. There is a sparse residential area nearby, along with a private camp. The streambed is gravel, cobblestone, bedrock, and boulders. The riparian zone is mostly trees and shrubs. Volunteers reported tea-colored water in the spring of 2013, but clear in the fall.

The Uncle's Creek monitoring site was established in the fall of 2012 to serve as a reference site. It had an *Excellent* rating in both the spring and fall of 2013, with some of the best SMIE scores. Prevalent taxa included flattened scraper mayflies, roach shredder stoneflies, small head caddisflies, and fragile detritivore stoneflies in the spring. In the fall, the sensitive roach shredder stoneflies comprised 42% of the sample, followed by net spinner caddisflies. Uncle's Creek is mostly untouched by any form of development as it flows off the protected property of the Green River Preserve summer camp. As concerns grew that logging in the Green River basin were adding large amounts of sediment to sections of the Green River and its tributaries, ECO decided to establish a reference site on the basin to represent normal, undisturbed conditions.

Site #35 - Green River at Bobs Creek Road *(GR42)*
This sampling location is situated on the property of a local church where the riparian zone is very narrow if existent at all along the waterway. On the opposite side of the church property, a large field that possibly supports agriculture is present. The riparian zone is mostly made up of trees, shrubs, grass, and construction fill. The stream bottom consists of gravel and cobblestone.

The Green River was first sampled at this site using the SMIE protocol in the spring of 2009. It received an *Excellent* rating in both the spring and fall of 2013, with some of the best SMIE scores. Both seasons had some of the highest EPT taxa richness and pollution-sensitive values. In the fall, nine of ten possible sensitive taxa were observed. In the spring quick crawling predator stoneflies made up 45% of the sample, followed by flattened scraper mayflies and blackflies. Quick crawling predator stoneflies represented 23% of the fall sample, in addition to giant shredder stoneflies. Evidence of recent high water levels was observed during the fall sampling. This site has earned SMIE ratings from *Good-Fair* to *Excellent* since 2010.

Site #36 - Rock Creek on Rock Creek Road *(GR46)*
The Rock Creek sampling site is within a private RV campground and receives some input from agricultural land uses across the creek. The creek is wide and shallow, but receives high amounts of organic input from dense upstream streambank vegetation. Though the banks are steep, they are mostly intact; however, the riparian zone on the campground side has little to no buffer and the opposite buffer is quite narrow. The riparian zone is mostly trees, shrubs, grasses, and vines. The stream bottom consists of gravel and cobblestone.

Rock Creek was first sampled using the SMIE protocol in the spring of 2009. It received an *Excellent* rating in the spring of 2013, with one of the best SMIE scores, but only *Good-Fair* in the fall. The spring sample had some of the highest EPT taxa richness and pollution-sensitive taxa values in 2013. Flattened scraper mayflies and quick crawling predator stoneflies each comprised more than a third of the spring sample. These two taxa were prevalent in the fall also, but by a lesser percent. Only 92 specimens were collected in the fall, a camper mentioned that the rocks in the creek had been rearranged by high water compared to previous years. Leaf packs deposited two to three feet above the water line were indicative of recent high creek levels. This site has earned SMIE bioclassifications from *Fair* to *Excellent* since 2010.

Site #37 - Green River at Terry's Creek Road *(GR12)*
This Green River site is downstream of SMIE site #35 and Rock Creek. Habitat data from years past suggest sedimentation issues have lowered water quality in this stretch of the Green River. Trees and shrubs comprise the buffer zone of the river, with construction fill present. The substrate is gravel, cobblestones, and sand. There is a tree farm nearby. This site corresponds to VWIN site H12. Volunteers noted tea-colored water in both seasons of 2013, with a musky odor in the fall. In the fall of 2012 volunteers reported an irrigation pipe present.

The Green River was first sampled at this site using the SMIE protocol in the spring of 2009. It received a *Good-Fair* biological rating in the spring of 2013, and *Fair* in the fall. These bioclassifications are worse than those at the upstream Green River SMIE site. Round headed swimmer mayflies and quick crawling predator stoneflies each represented about 20% of the spring sample, followed by flattened scraper mayflies. Net spinner caddisflies comprised 37% of the fall sample, with flattened scraper mayflies fewer in number. The SMIE rating at this site has mostly been *Fair* since 2010. This site has a *Good* VWIN chemical rating and while nutrients are not a problem, excessive sediment is notable in the results.

Hungry River Watershed
The Big Hungry River flows into the Green River just above "The Narrows", before the Green River flows into Polk County. The Hungry River is an escarpment system with very high gradient and good water quality in the upper reaches. This subbasin is located within the larger Broad River Basin, which covers the southeastern portion of Henderson County and reaches across the border into Polk County. The catchment contains sections of the Green River Gamelands, which protects just over 10,000 acres of land. Sedimentation is problematic in some areas, which leads to habitat loss and water quality degradation.

Site #39 - Big Hungry River at Schoolhouse Road *(HR43)*
This Big Hungry River site is located upstream of the dam. The riparian zone is mostly trees, shrubs, and grasses. There are eroding streambanks at the monitoring site, and the stream bottom is gravel, cobblestone, bedrock, and boulders. There is a nearby waterfall.

The Big Hungry River was first sampled at this site using the SMIE protocol in the spring of 2009. It received a *Good* rating in the spring of 2013, and *Excellent* in the fall. The fall sample had the second best SMIE score of all site sampled in 2013. Flattened scraper mayflies and spiny crawler mayflies each made up almost a third of the spring sample. Net spinner caddisflies represented 26% of the fall sample, followed by small head caddisflies. This site has typically rated from *Good-Fair* to *Excellent* since 2010.

Site #41 - Big Hungry River below dam *(HR13)*
Located downstream of the dam, the riparian zone at this Big Hungry River location is made up of trees, shrubs, grasses, vines. There are eroding streambanks, a small waterfall upstream, and the substrate is mostly sand. The volunteers note that it is getting harder to sample in this location due to silt and debris, and access to the stream is degrading. The volunteers noted muddy water in the fall and tea-colored water in the spring. Seasonal differences in results are likely due to the overriding effects of the dam. This site corresponds to VWIN site H13.

The Big Hungry River was first sampled below the dam using the SMIE protocol in the spring of 2009. This site rated *Excellent* in the both seasons of 2013. The SMIE scores were better at this downstream site than upstream, and the fall score was the third best of all sites sampled in 2013. The spring sample had one of the highest taxa richness scores, with 20 taxa. There were heavy rains prior to the sampling, so it was difficult to use the kicknet. Spiny crawler mayflies made up 33% of the spring sample, along with quick crawling predator stoneflies and flattened scraper mayflies. In the fall, quick crawling predator

stoneflies were one quarter of the sample, in addition to small head caddisflies, giant shredder stoneflies, and fat-head craneflies. The volunteers reported a rotten-egg smell in the fall leaf pack, and only 70 specimens were observed in the entire sample. This site has most frequently earned *Excellent* SMIE ratings since 2010. It received an *Average* VWIN chemical rating in 2013. Sediment has a bigger negative influence than nutrients, despite being downstream of the dam that should act as a sediment sink.

Upper French Broad River Subbasin (Henderson, Buncombe and Madison Counties)

The French Broad River originates in Transylvania County and flows through Henderson, Buncombe, and Madison Counties in North Carolina before entering into Tennessee. Though the headwaters are located within mostly protected forested land, the river encounters high agricultural land uses in Transylvania and Henderson Counties.

Henderson County French Broad Tributaries

Site #43 - Little Willow Creek at Pleasant Grove Road *(MR24)*

Little Willow Creek runs along the property of a multi-acre abandoned development. The riparian zone at this creek is overgrown with invasive plant species, but less than five feet wide on both sides. The creek is very narrow and shallow, making it difficult to take an accurate sample with few riffles. Riparian zone vegetation includes shrubs and grasses, and the stream substrate is sand. The streambank is also eroding. In the fall, the volunteers noted that the stream was almost totally covered with vegetation so the sampling was conducted under the bridge at the only riffle present. This site corresponds to VWIN site H24.

Little Willow Creek was first sampled using the SMIE protocol in the spring of 2009. This site rated *Good* in the spring of 2013, but only *Fair* in the fall. The spring sample resulted in only five taxa (including two pollution-sensitive taxa), and was dominated by spiny crawler mayflies (80%). In the fall, tolerant water worms were prevalent (23%) followed by flattened scraper mayflies and quick crawling predator stoneflies. Only 55 insects were captured in the spring, and 84 in the fall. Sedimentation and erosion issues from this property may seriously affect the biological integrity of this location, leaving little habitat for the benthic macroinvertebrates. Riffle habitat directly under a bridge may inaccurately represent the overall macroinvertebrate community in that stretch of the stream. This site has earned *Good-Fair* to *Poor* SMIE ratings since 2010. The VWIN chemical rating is *Average*, with excessive sedimentation evident.

Site #45 - Shaw Creek at Hunter's Glen *(MR28)*

The Shaw Creek catchment is forested but residential development has impacted the quality of the stream, along with one permitted discharger. Trees, shrubs, and vines make up the riparian zone, and the streambank is steep and eroded. The stream bottom is about 90% sand with some gravel or cobblestones present. Volunteers frequently report that the water is tea-colored. In the fall, volunteers reported that the bank on the north side had been disturbed due to clearing out of culverts. This site corresponds to VWIN site H28.

Shaw Creek was first sampled using the SMIE protocol in the spring of 2009. It rated *Good-Fair* in the spring and *Fair* in the fall of 2013. Half of the individuals were round headed swimmer mayflies in the spring, along with some net spinner caddisflies. Chironomid midges made up 31% of the fall sample, in addition to water worms and net spinner caddisflies. In the spring, 82 individuals were observed, with only 74 in the fall. This site has earned *Good-Fair* to *Poor* SMIE ratings since 2010. Shaw Creek has a VWIN chemical rating of *Average*, with a low sediment score that indicates runoff and erosion in the watershed.

Site #46 - Mill Pond Creek at Haywood Knolls Road *(MR27)*
Much of the Mill Pond Creek watershed is suburban, has narrow to non-existent riparian buffers, and directly catches stormwater runoff from commercial and residential development. Stormwater scour has resulted in eroded and undercut streambanks. There are two permitted wastewater dischargers along this creek, and its headwaters originate in the landfill. Due to the general shallowness of this stream, riffles and runs are very rare, making biomonitoring difficult. The riparian zone is primarily trees and shrubs with some construction fill present. In the spring of 2013, brush had been cleared on one bank and young crab apple trees had been planted. The stream bottom is mostly sand, along with some gravel and cobblestones. There is also a culvert or pipe present creating a barrier to fish movement. This site is located near VWIN site H27. DWR samples this stream at site EB115.

Mill Pond Creek was first sampled using the SMIE protocol in the spring of 2009. It received a bioclassification of *Fair* in the spring of 2013, and *Good* in the fall. Chironomid midges were prevalent in the spring sample (61%), along with net spinner caddisflies and vegetative case caddisflies. Caddisflies dominated in the fall, with 47% net spinner caddisflies and 38% small head caddisflies. From the spring of 2010 to the spring of 2012, this site earned only *Poor* SMIE ratings. Since then it has been *Fair,* with recorded small head caddisflies improving the score to Good in the fall of 2013. This site was listed as "Not Rated" by DWR in 2007. Mill Pond Creek has a *Poor* VWIN chemical rating, and has major issues with sediment and nutrients. This site exhibits the highest median alkalinity, ammonia, and conductivity, with the median conductivity continuing to be more than twice the value of any other monitored site in Henderson County.

Site #47 - Boylston Creek at Ladson Road *(MR14)*
Boylston Creek is a tributary of the French Broad River that has extensive agriculture, with cattle pasture and row crops dominating the land use. Riparian buffers are minimal on both sides of the sampling location, which is also located underneath a frequently used bridge. The riparian zone consists of trees, shrubs, grasses, and vines. The substrate is mostly sand with some gravel and cobblestone, and the streambank is eroding in places. Volunteers frequently describe the water as tea-colored. This site corresponds to VWIN site H14 and DWR site EB159.

Boylston Creek was first sampled using the SMIE protocol in the spring of 2009. It received a *Poor* SMIE rating in both seasons of 2013. While the spring and fall samples both earned some of the worst SMIE scores in 2013, the spring sample was the third worst of all samples. Chironomid midges made up half of the spring sample, and oligochaetes made up 25%. The only pollution-sensitive taxa observed was one gravel coffin case caddisfly. In the fall, water worms and round headed swimmer mayflies each represented 25% of the sample, followed by chironomid midges and net spinner caddisflies. Only 28 and 32 individuals were collected in the spring and fall respectively. Habitat loss in the form of sedimentation, erosion, and lack of riparian buffers may be causing the extremely low macroinvertebrate counts at this site. Prior to the *Poor* SMIE bioclassifications in 2013, all prior ratings since 2010 have been *Fair*. DWR biological ratings declined from *Good-Fair* in 2007 to *Fair* in 2012. VWIN gives Boylston Creek an overall *Average* chemical rating, and a *Poor* sediment rating.

Mills River Watershed
Mills River serves as the drinking water source for Henderson County, with intakes on the North Fork and Bradley Branch in Pisgah National Forest. Much of the headwaters are within the National Forest. Agricultural influences come from pasture and cropland, specifically cattle, peppers, corn, and tomatoes. Agriculture is denser closest to the confluence of the forks. The Mills River Partnership has been created to address the water quality issues in the catchment and to implement best management practices.

Site #48 - North Fork Mills River *(MR7)*
Much of the land upstream from the North Fork monitoring site is within the Pisgah National Forest but there are isolated tomato, corn, and cattle farms within the watershed. The stream bottom is gravel and cobblestone, and the riparian zone consists of trees and shrubs. This site corresponds to DWR site EB396, with VWIN site H7 just upstream of this location.

The North Fork of Mills River was first sampled using the SMIE protocol in the spring of 2009. It rated *Excellent* in the spring of 2013, with one of the best SMIE scores, but only *Fair* in the fall. Quick crawling predator stoneflies made up 37% of the spring sample, followed by small head caddisflies. The spring sample had some of the highest EPT taxa and pollution-sensitive taxa values in 2013. There were heavy rains preceding the sampling, and the river was high and fast. In the fall, 41% of the macroinvertebrates were round headed swimmer mayflies and 34% were water worms. (If the water worms in the fall sample were actually mistakenly identified watersnipes, the biological rating could have actually been higher.) Only 105 individuals were observed in the spring, while 241 were caught in the fall. Most samples since 2010 have earned *Excellent* SMIE ratings, except for three fall samples which were rated *Fair*. In 2011 the DWR assigned this site an *Excellent* bioclassification. In 2012 it rated *Excellent* during "pre-pesticide" sampling in April but declined to *Good* during "post-pesticide" sampling in August. The North Fork of Mills River has a *Good* VWIN chemical rating, with nutrient pollution being minimal at this site.

Site #49 - South Fork Mills River *(MR8)*
The catchment above the South Fork monitoring location is also mostly forested but some isolated tomato and cattle farms possibly influence the water quality. This site is located directly next to row crop fields with narrow riparian zones. The stream substrate is sand, gravel, and cobblestone. The volunteers noted algae on the streambed in both seasons. The riparian zone consists of trees and shrubs. This site corresponds to DWR site EB395, and is located downstream of VWIN site H8.

The South Fork of Mills River was first sampled using the SMIE protocol in the spring of 2009. It had a SMIE rating of *Excellent* in the spring of 2013, and *Good* in the fall. The spring sample had the best SMIE score in 2013. Quick crawling predator stoneflies comprised 68% of the spring sample. Small head caddisflies represented 25% of the fall sample, along with square log cabin caddisflies and coiled right face snails. As at the North Fork of Mills River, the river was high in the spring due to recent heavy rains. Ninety-eight macroinvertebrates were collected in the spring, and with only 32 in the fall. A larger sample size in the fall may have resulted in a more representative SMIE rating. SMIE ratings at this site have ranged from *Good-Fair* to *Excellent*, although spring ratings have been better than the fall ratings each year. This site received an *Excellent* biological rating from DWR in 2010 and 2012 (both pre- and post-pesticide sampling). The South Fork of Mills River received a *Good* VWIN chemical rating in 2013, with sediment more of a problem than nutrients.

Site #51 - Mills River at Hooper's Lane *(MR10)*
This is the furthest downstream monitoring location on Mills River, not far from the confluence with the French Broad River. The land use near this site is primarily agriculture (soybeans, sod, peppers, corn) and erosion of streambanks at this site is problematic. Heavy traffic on Hooper's Lane possibly contributes to the amount of trash in the river at this site. Riparian buffers with trees, shrubs, and grasses are largely overgrown during the spring season but tend to be narrow on both sides of the river. The stream bottom includes gravel, cobblestone, and woody debris, with extensive algae. This site corresponds to VWIN site H10 and DWR site EB168.

Mills River was first sampled at this site using the SMIE protocol in the spring of 2009. It received a *Fair* SMIE rating in both seasons of 2013. This rating is typical for this site based on previous monitoring. Spiny crawler mayflies and blackflies each made up a quarter of the spring sample, followed by net

spinner caddisflies. It rained heavily five days prior to the spring sampling. Net spinner caddisflies comprised 29% of the fall sample, along with round headed swimmer mayflies, water worms, and chironomid midges. This site has regularly earned either *Fair* or *Good* SMIE ratings since 2010. DWR gave this stretch of Mills River an *Excellent* rating in 2011, although it has varied over the years. In 2012 it rated *Excellent* during "pre-pesticide" sampling in April but *Good* during "post-pesticide" sampling in August. This location received a *Good* VWIN chemical rating in 2013.

Mud Creek Watershed

Mud Creek is a very large urban tributary of the French Broad River that receives stormwater runoff from the city of Hendersonville. Local land uses include cropland, pasture, orchards, forestland, and urban development. The Mud Creek Watershed Restoration Project, an EPA 319 Clean Water Act grant, and Ecological Enhancement Program restoration projects are actively working in the catchment to improve water quality conditions. Projects have focused on curbing stormwater and treating it before it rushes into Mud Creek and tributaries, as well as restoring and stabilizing streambanks.

Site #52 - Mud Creek at Berea Church Road *(MC21)*

This upstream Mud Creek site lies between two major agricultural fields. The riparian zone is narrow on both sides and limited bumper crop planting between seasons contributes major sediment to the stream during heavy rains. The stream bottom has lots of silt and sand, and the riparian zone consists of grasses and vines with eroding streambanks. There is little to no shade along the stream. This site corresponds to VWIN site H21 and DWR site EB119.

Mud Creek was first sampled at Berea Church Road using the SMIE protocol in the spring of 2009. This site received a *Fair* bioclassification in the spring of 2013, and *Poor* in the fall. Both seasons had worse scores at this site than the downstream site at 7th Ave. Spiny crawler mayflies, round headed swimmer mayflies, and NS each made up more than 20% of the spring sample, followed by chironomid midges. Net spinner caddisflies made up 34% of the fall sample, along with tolerant water worms, red midges, and chironomid midges. The fall SMIE score was the second worst of all 2013 samples. This site has earned SMIE ratings from *Good* to *Poor* since 2010, but the spring samples have displayed higher water quality than the fall samples each year. DWR gave this site a *Fair* biological rating in 2007. Their basinwide report indicated that pollutants included excessive nutrients and sediment, as well as the concern of agricultural runoff in the headwater reaches of the catchment. This site had an *Average* VWIN chemical rating in 2013, with sediment pollution evident.

Site #53 - Mud Creek at 7th Avenue *(MC18)*

This Mud Creek location is situated in an urbanized area of the City of Hendersonville. It runs along the Oklawaha Greenway for approximately 1.5 miles but still suffers from urban inputs that increase sediment and turbidity. The creek travels under major roads, which contribute high amounts of stormwater runoff filled with pollutants. Volunteers frequently note tea-colored water at this site. The stream bottom is mostly gravel, cobble, and sand, and the riparian zone consists of trees and shrubs. This site corresponds to VWIN site H18 and DWR site EB122.

Mud Creek was first sampled at 7th Avenue using the SMIE protocol in the spring of 2009. It earned a *Good-Fair* SMIE rating in the spring of 2013, and *Fair* in the fall. Thirty percent of the spring sample consisted of net spinner caddisflies, followed by spiny crawler mayflies and quick crawling predator stoneflies, and only 114 individuals were collected. Net spinner caddisflies were also about one third of the sample in the fall (84 individuals), along with water worms, flattened scraper mayflies, and round headed swimmer mayflies. No pollution-sensitive taxa were observed in the fall, and volunteers noticed about 50 open clams in mouth of outgoing pipe about ten feet downstream of the bridge. This site has also ranged from *Good* to *Poor* since 2010. DWR assigned this site a *Poor* biological rating in 2001. It

received an *Average* VWIN chemical rating in 2013, and sampling shows that sediment runoff and erosion are detrimental to the water quality.

Site #54 - Brittain Creek at Patton Park *(MC26)*
Brittain Creek is a major tributary of Mud Creek. The watershed is nearly 75% developed and the stream parallels the heavily used SR 191. The creek runs through several subdivisions upstream before entering Patton Park where the ECO team monitors the waterway. Brittain Creek at this point receives stormwater runoff from impervious surfaces in the catchment. Both residential and commercial development in the area heavily influences the taxa groups in Brittain Creek. In the past, there have been local issues at this site concerning a constant removal via mowing of the already narrow riparian zone. Though the buffer has been allowed to grow up since 2010, it is not nearly wide enough to provide adequate filtration of runoff from the nearby parking lots before stormwater enters the creek. The stream bottom consists of gravel, cobblestone, and sand. The riparian zone includes trees, shrubs, grass, and vines. This site corresponds to VWIN site H26.

Brittain Creek was first sampled using the SMIE protocol in the spring of 2009. It received a *Poor* rating in the spring of 2013, with one of the worst SMIE scores, and *Fair* in the fall. On April 2, 2013, a fish kill was observed which was attributed to approximately 8-10 gallons of diluted chlorinated water used during maintenance on a public pool being drained onto the parking lot approximately 200 feet from the creek. The SMIE sample on April 26th yielded only 65 individuals, with chironomid midges and net spinner caddisflies each comprising about one quarter of the spring sample, followed by oligochaetes and blackflies. Net spinner caddisflies made up 46% of the fall sample, with chironomid midges representing 31%. No pollution-sensitive taxa were captured in either season. Since 2010, this site has usually received either a *Fair* or *Poor* SMIE rating. The VWIN chemical rating at this site is *Good*.

Clear Creek Watershed
Clear Creek is a large tributary of Mud Creek in Henderson County. Land use within the catchment is primarily agriculture (row crops and orchards) and urban or suburban. This watershed has a very high concentration of apple orchards and water quality problems may be associated with pesticide use (NCDENR 2008). It also has four permitted dischargers along its length.

Site #55 - Clear Creek at Bearwallow Road *(MC20)*
This site is located in a primarily rural area with several large residences, orchards, and cleared fields nearby. Bearwallow Road at this site seems to be relatively new and well maintained, though runoff from stormwater is able to filter directly into Clear Creek. The streambanks are eroded. Volunteers have noted tea-colored water at this site. The stream substrate is mostly gravel and cobblestone but some sand is present. Trees make up the riparian zone. This site corresponds to VWIN site H20 and DWR site EB71.

Clear Creek was first sampled at Bearwallow Road using the SMIE protocol in the spring of 2009. It received a *Good-Fair* bioclassification in the spring of 2013, and *Poor* in the fall. Spiny crawler mayflies dominated the spring sample with 70%. Water worms made up half of the fall sample, along with net spinner caddisflies and round headed swimmer mayflies. The fall sample had one of the worst SMIE scores in 2013. The seasonal impacts of land use practices may be evident on the macroinvertebrate community. There was a huge difference in the total number of individuals collected, with 414 in the spring, but only 74 in the fall. SMIE ratings have varied from *Good* to *Poor* since 2010. DWR rated this site *Good-Fair* in 2006. VWIN gives this site an *Average* chemical rating, with sediment issues present in the watershed.

Site #58 - Clear Creek at Nix Road *(MC5)*
Clear Creek at this point in the catchment is mostly forested but agriculture comprises just under half of the local land use. The wastewater treatment plant is located at Nix Road. The riparian zone is all grasses and vines. Steep and eroding streambanks are making it difficult to access the stream at this location. The stream bottom is mostly gravel, cobblestone, and sand. Volunteers reported that the water appeared milky in the spring of 2013, with extensive algae growth. This site corresponds to VWIN site H5 and DWR site EB73.

Clear Creek was first sampled at Nix Road using the SMIE protocol in the spring of 2009. It received a *Good-Fair* rating in the spring of 2013, and *Poor* in the fall. This site also displayed one of the worst SMIE scores in the fall. Sixty-five percent of the spring invertebrates were spiny crawler mayflies, along with some coiled right face snails (which are pollution-sensitive and may have helped the spring rating). Net spinner caddisflies made up one-third of the fall sample, followed by water worms, flattened scraper mayflies, and round headed swimmer mayflies. SMIE ratings have usually earned *Fair* to *Poor* ratings since 2010. The DWR biological rating declined from *Good-Fair* in 2007 to *Fair* in 2012. VWIN rates this site as *Below Average*, with much higher sediment and nutrient concentrations than the upstream site.

Cane Creek Watershed
Cane Creek is a large tributary of the French Broad River that drains much of southeastern Buncombe County and northeastern Henderson County before its confluence with the French Broad River. Agriculture and pasture are the principal land uses in the catchment. DWR has documented declining water quality in this watershed. The Cane Creek valley is becoming more developed and increased erosion may be responsible for high values for both turbidity and total suspended solids. DWR also reports excessive sedimentation at many locations, suggesting the effects of non-point source pollution.

Site #9 - Cane Creek at Miller Rd
The upstream Cane Creek site is near the Cane Creek cemetery and Fairview School in Buncombe County. The sample is collected off US-74 near the bridge where Miller Road crosses Cane Creek (below Ballard Creek). The riparian zone is mainly trees and shrubs, while the stream substrate is composed of gravel and cobblestones. The site corresponds to DWR monitoring site EB67 at SR2800.

This site on Cane Creek was first sampled in the spring of 2008. It earned a *Good* SMIE rating in the spring of 2013, and *Good-Fair* in the fall. Round headed swimmer mayflies comprised 34% of the spring sample, along with quick crawling predator stoneflies. Net spinner caddisflies made up half of the fall sample, which had one of the three highest taxa richness scores in 2013 (21 taxa). In the fall, volunteers noted that there was evidence of stream flooding up to two feet above the surface. The SMIE rating for this site has usually been *Good* since monitoring began in 2008. DWR assigned this site a *Good* biological rating in 1999, but has not sampled since.

Site #11 – Cane Creek at Ashworth Creek
This site on Cane Creek is approximately 50 meters upstream of the US 74 bridge in Fairview, near the confluence with Ashworth Creek and less than a mile downstream of the SMIE site #9 at Miller Rd. 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, but volunteers have noted that the amount of sediment seems greater. It corresponds with VWIN site B15A.

Cane Creek was first sampled near Ashworth Creek in the spring of 2005. This site rated *Good-Fair* in both seasons of 2013. Spiny crawler mayflies made up 48% of the spring sample, followed by quick crawling predator stoneflies. Net spinner caddisflies comprised 54% of the fall sample, in addition to quick crawling predator stoneflies. The stream was swift and turbid in the spring, perhaps resulting in

lower numbers of individuals collected. While this site ranged from *Good-Fair* to *Excellent* in the early years of monitoring, it has not received an *Excellent* SMIE rating since 2008. This site had a VWIN chemical rating of *Average* in 2013.

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. The riparian zone is primarily composed of trees and shrubs with a road running parallel to the stream. The substrate is gravel and cobblestone. It is just downstream of VWIN site B15B.

Ashworth Creek was first sampled in the spring of 2005. It had a *Good-Fair* rating in both seasons of 2013. Spiny crawler mayflies dominated the spring sample (74%), followed by chironomid midges. Taxa were more evenly distributed in the fall, with net spinner caddisflies and round headed swimmer mayflies each making up a quarter of the sample, followed by small head caddisflies and water worms. This site has a *Below Average* VWIN chemical rating, with sediment and nutrient pollution affecting the stream.

Site #59 - Hooper's Creek at Jackson Road *(CC22)*
Much of the Hooper's Creek watershed in Henderson County is forested, with agriculture comprising substantial areas of land. This site is located in a residential area with an open field. The stream bottom is dominated by gravel, cobblestone, and sand, while the riparian zone is mostly trees and shrubs. This site corresponds to VWIN site H22.

Hooper's Creek was first sampled using the SMIE protocol in the spring of 2009. It rated *Fair* in both seasons of 2013. Round headed swimmer mayflies comprised 39% of the spring sample, along with flattened scraper mayflies and chironomid midges. In the fall, 38% of individuals were net spinner caddisflies, followed by water worms and blackflies. Volunteers described the stream as muddy in the spring. A *Fair* SMIE bioclassification has most frequently been applied to this site since 2010. Hooper's Creek has a *Below Average* VWIN chemical rating, with sediment being the biggest issue in the creek.

Site #60 - Cane Creek at Howard Gap *(CC16)*
The local land uses at this downstream Cane Creek site include a large town park in the Fletcher Community, a private golf course, and private agricultural lands that border the golf course. The stream bottom substrate is gravel, cobblestone, and sand. The riparian zone is mostly comprised of trees and shrubs. Volunteers noted tea-colored water in the spring. This site corresponds to VWIN site H16 and DWR site EB66.

Cane Creek was first sampled at Howard Gap using the SMIE protocol in the spring of 2009. It had *Fair* ratings for both seasons of 2013, which indicate worse water quality than the upstream Cane Creek sites. Fat-head craneflies made up one-third of the spring sample, followed by red midges, spiny crawler mayflies, and net spinner caddisflies. Net spinner caddisflies made up one-third of the fall sample, along with round headed swimmer mayflies, chironomid midges, flattened scraper mayflies, and red midges. There were only seven taxa observed in the fall, with only one pollution-sensitive giant shredder. Only 42 individuals were collected in the spring and 41 were collected in the fall. Volunteers described the stream as deep, muddy, and swift due to recent rainfall in the spring. This site has earned only *Fair* SMIE ratings since 2011. The DWR bioclassification has improved from *Poor* in 2007 to *Good-Fair* in 2012. This location has a *Below Average* VWIN chemical rating, with high turbidity, total suspended solids, and conductivity values.

Buncombe County French Broad Tributaries

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 is approximately 10 meters upstream of the trail bridge. 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. The site is just upstream of VWIN site B12A, and about one mile downstream of DWR site EB359 on FSR479.

Bent Creek was first sampled in the spring of 2005. It received an *Excellent* rating in the spring of 2013, and *Good* in the fall. Only 105 specimens were collected in the spring, despite taking three kicknet samples, but the collection had some of the highest EPT taxa richness and pollution-sensitive taxa values. Quick crawling predator stoneflies made up one-quarter of the spring sample, followed by flattened scraper mayflies and round headed swimmer mayflies. Quick crawling predator stoneflies comprised one-third of the fall sample, along with net spinner caddisflies. In the fall, 114 individuals were collected. Most SMIE samples since monitoring began in 2005 have rated *Excellent*. DWR gave this site a *Good* bioclassification in 2007. This stream has an *Excellent* VWIN chemical rating, with very little sediment pollution.

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. The riparian zone consists of trees, shrubs, impervious surfaces, and some grass. The substrate is composed of gravel, cobblestones, and sand. Volunteers regularly report trash and eroding streambanks, which are making it difficult to access the stream. This site corresponds to a discontinued VWIN site (B11A) and DWR site EB103 at NC151.

Hominy Creek was first sampled in the spring of 2005. It rated *Fair* in the spring of 2013, and *Good-Fair* in the fall. The water was high and fast during the spring sample. After taking three kicknet samples, volunteers still only collected 32 individuals. Round headed swimmer mayflies made up 22% of the sample, followed by hellgrammites. Net spinner caddisflies comprised 61% of the fall sample, along with some fragile detritivore stoneflies. This site has fluctuated from *Good* to *Poor* over the years of monitoring. DWR gave this site a *Good* bioclassification in 2002, with the stream showing elevated conductivity and silt on the substrate.

Site #14 – Swannanoa River at Flat 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 on the east side of Black Mountain in the headwaters of the Swannanoa River. The streambed is comprised of gravel and cobblestones. The riparian zone is mostly trees and shrubs, along with a grassy lawn. Heavy spring rains deposited rocks, changed the riverbed downstream, and destroyed a beaver dam upstream on the Swannanoa tributary.

This upstream site was first sampled in the spring of 2013. It received a *Good-Fair* rating in the spring of 2013, but *Excellent* in the fall with one of the best SMIE scores. Spiny crawler mayflies comprised 31% of the spring sample, along with round headed swimmer mayflies, flattened scraper mayflies, and blackflies. In the fall, 35% of the individuals were small head caddisflies, along with quick crawling predator stoneflies, flattened scraper mayflies, and net spinner caddisflies. A nearby fisherman caught a trout in the spring.

Site #14 – Swannanoa River the Black Mountain Recreation Park
This site is located in Black Mountain at the Recreation Park, just upstream of Tomahawk Branch. The substrate is mostly cobblestone and gravel. The riparian zone is mostly trees and shrubs, along with grass from a disc golf course. It corresponds to the DWR site EB144.

This site was first sampled in the spring of 2013. It rated *Good* in the spring of 2013, and *Good-Fair* in the fall. Two kicknet samples were collected in the spring. Two-thirds of the spring individuals were spiny crawler mayflies, followed by flattened scraper mayflies. In the fall, net spinner caddisflies dominated with 70% of the sample. The presence of algae is common at this site, which clogged the kicknet during the fall sample. DWR assigned this site a *Fair* rating in 2003

Site #14 – Swannanoa River at Kearfott
This site is located on the west side of Black Mountain, downstream of the Ingles Distribution Warehouse, and across US-70 from Kearfott. It is just upstream of the North Fork tributary. The substrate is mostly gravel, cobblestone, and sand. The riparian zone is comprised of tress, shrubs, and grasses. It corresponds to VWIN site B24.

This site was first sampled in the spring of 2013. It rated *Good-Fair* in both seasons of 2013. As at the Black Mountain Recreation Park, two-thirds of the spring sample was comprised of spiny crawler mayflies, and net spinner caddisflies dominated in the fall with 74% of the sample. VWIN gave this site a *Good* chemical rating in 2013.

Site #14 – Swannanoa River downstream of Beetree Creek
This site is located off Warren Wilson Road at Charles D. Owen Park, below the confluence with Beetree Creek. Prior to 2013, this was the furthest upstream SMIE site on the Swannanoa River. 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. It corresponds to VWIN site B9B, and is located downstream of DWR site EB143.

This monitoring site was first sampled in the spring of 2005. It had a SMIE bioclassification of *Fair* in the spring of 2013, and *Good-Fair* in the fall. This site exhibits a pattern of lower water quality scores in the spring than the fall. Pollution-tolerant oligochaetes made up 37% of the spring sample, along with spiny crawler mayflies and round headed swimmer mayflies. As at the previous two upstream sites, net spinner caddisflies comprised 71% of the fall sample. This site has regularly earned *Fair* SMIE ratings over the years. DWR assigned a site approximately five miles upstream a *Good-Fair* bioclassification in 2002. It also had a *Good* VWIN chemical rating in 2013.

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. The riparian zone consists of trees and shrubs, and the substrate is gravel, cobblestones, and sand. The streambed is covered with silt and algae. It corresponds to VWIN site B38, and is located downstream of DWR site EB142 on SR2416.

This SMIE site was first sampled in the spring of 2005. It received a *Fair* rating in the spring of 2013, and *Good-Fair* in the fall. Two kicknets were collected in the spring, and the beach used to set up the table in previous years was gone following recent flooding. While only 83 individuals were collected in the spring, 443 were collected in the fall. Half of the individuals in the spring were round headed swimmer mayflies,

along with oligochaetes. Similar to the three previous upstream sites, net spinner caddisflies comprised three-quarters of the fall sample. This site has usually earned *Fair* SMIE ratings since 2005, with *Good-Fair* ratings becoming more frequent since 2010. The DWR bioclassification improved from *Good-Fair* in 2007 to *Good* in 2012. This site has an *Average* VWIN chemical rating, with sediment more of a problem than nutrients.

Site #34 – Nasty Branch (Town Branch)
Nasty (Town) Branch is a small urban tributary on the east side of the French Broad River in Asheville. There is a substantial amount of impervious surfaces throughout the watershed, resulting in large volumes of stormwater runoff. Volunteers regularly describe the water as tea-colored. Culverts impact the habitat in this stream. The substrate is mostly gravel or cobblestones, with algae and woody debris present. The riparian zone consists of trees and shrubs, grass, along with rip-rap that was added during MSD sewer line work in the winter of 2011.

Nasty Branch was first sampled in the fall of 2012. It received a *Poor* SMIE rating in both seasons, earning some of the worst SMIE scores of 2013. The spring sample had the worst score of all sites sampled in 2013. There were heavy rains prior to sampling in the spring and the fall. Two kicknet samples were collected in the spring, and still only resulted in 32 individuals, including only five taxa and no pollution-sensitive taxa. Oligochaetes made up 72% of the sample, followed by net spinner caddisflies. Clean Water for North Carolina noted that two weeks after the spring SMIE sampling, an unspecified chemical spill was observed in this creek. The fall sample yielded 223 individuals, including mostly round headed swimmer mayflies, coiled left face snails, and net spinner caddisflies, and chironomid midges. Only one sensitive taxa was collected in the fall (one small head caddisfly individual). These results are indicative of a very poor habitat for the benthic macroinvertebrate community, with a lack of microhabitats available due to sedimentation.

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. 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. There is a lot of garbage present due to the site's proximity to the KFC restaurant and heavily travelled roads. It corresponds to VWIN site B35.

Smith Mill Creek was first sampled in the spring of 2009. It rated *Fair* for both season in 2013, with two kicknet samples collected in both the spring and fall. Just 48 individuals were collected in the spring, 58% of which were round headed swimmer mayflies. The only pollution-sensitive individual in the spring was one water penny. In the fall, almost 200 individuals were collected including net spinner caddisflies (41%), flattened scraper mayflies, and round headed swimmer mayflies. This site has displayed either *Fair* or *Poor* SMIE ratings since monitoring began in 2009. Smith Mill Creek has a *Poor* VWIN rating, due to excessive sediment and nutrients.

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. 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, cobblestones, and sand. It is downstream of VWIN sites B7A and B7B, which are both above the confluence of Glenn and Reed Creeks.

Reed Creek was first sampled in the spring of 2005. This site had a *Fair* rating in both seasons of 2013. Two kicknet samples were collected in the spring. Round headed swimmer mayflies comprised 36% of the sample, followed by net spinner caddisflies and chironomid midges. In the fall, 64% of the individuals were net spinner caddisflies, along with round headed swimmer mayflies. The fall sample had no pollution-sensitive taxa. This site has received *Good-Fair* to *Poor* SMIE ratings since 2005, with *Fair* bioclassifications most common. The Glenn Creek and Reed Creek VWIN sites above the confluence have *Below Average* chemical ratings. While sediment is of concern in these streams, very high nutrient and conductivity values characterize the stream water.

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. 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. Volunteers almost always describe this stream as muddy, which can make leaf packs very hard to find. It corresponds to VWIN site B4 and is near DWR site EB129, which is upstream on SR1622 (Rhymer Rd).

Newfound Creek was first sampled in the fall of 2005. It had a *Fair* rating in both seasons of 2013. Net spinner caddisflies comprised 68% of the sample in the spring, followed by spiny crawler mayflies, and 67% in the fall, followed by round headed swimmer mayflies. In the fall, the only representative of a pollution-sensitive taxa was one small head caddisfly. The SMIE rating at this site has almost always been *Fair* since 2005. DWR gave the nearby site a *Fair* bioclassification in both 2007 and 2012. This site, as well as two other sites upstream on Newfound Creek, had a *Poor* VWIN chemical rating with severe sediment and nutrient pollution.

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 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. DWR sampled this stream at site EB131.

SMIE sampling started in the fall of 2007 on Reems Creek. This site rated *Good-Fair* in the spring of 2013, and *Good* in the fall. Flattened scraper mayflies made up 37% and spiny crawler mayflies made up 32 of the spring sample. There was also evidence of stream levels two to three feet higher than normal on that occasion. Round headed swimmer mayflies comprised 32% of the fall sample, followed by net spinner caddisflies and quick crawling predator stoneflies. This site has earned SMIE ratings ranging from *Good-Fair* to *Excellent* since monitoring began in 2007. DWR gave this stream an *Excellent* rating in both 2002 and 2012. The VWIN site on Reems Creek upstream of the confluence with Ox Creek has an *Average* chemical rating and Ox Creek has a *Good* VWIN rating.

Site #20 – Sandymush Creek
Sandymush Creek originates in northwestern Buncombe County, 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 bridge on Willow Creek Road and corresponds to VWIN site B3B. The substrate is mostly gravel and cobblestones. Trees and shrubs dominate the stream at this site, with much of the surrounding land dedicated to agriculture (mostly corn, tomatoes, and cattle). The volunteers noted a manure smell during the fall of 2012 sampling. VWIN volunteers have also noted this smell in the creek, although livestock are not within sight of the sampling area.

Sandymush Creek was first sampled in the fall of 2005. It rated *Good-Fair* in the spring of 2013, and *Fair* in the fall. Round headed swimmer mayflies comprised 37% of the spring sample, followed by spiny crawler mayflies (32%) and quick crawling predator stoneflies. The spring leaf pack was mainly limited to sticks and roots, and the water was muddy. Net spinner caddisflies comprised 45% of the fall sample, in addition to water worms and flattened scraper mayflies. This site has only earned *Good-Fair* or *Fair* SMIE ratings since 2005. DWR has documented declining benthic macroinvertebrate scores in lower Sandymush Creek, particularly EPT taxa richness. The VWIN chemical rating is *Poor* at this site on Sandymush Creek, and it exhibits the lowest overall score of all Buncombe County VWIN sites. This has worse water quality than a downstream VWIN site largely due to cattle pollution from upstream.

Madison County French Broad Tributaries

Ivy River Watershed

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. 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. This site corresponds with VWIN site M13 and is just upstream of DWR site EB188.

California Creek was first sampled at Radford Road in the spring of 2005. It received a *Good* rating in both seasons of 2013. Spiny crawler mayflies made up 37% of the spring sample, followed by flattened scraper mayflies and quick crawling predator stoneflies. Net spinner caddisflies made up 60% of the fall sample, along with small head caddisflies. From 2005 to around 2010, SMIE bioclassifications at this site were usually *Good-Fair*. Since then, most samples have earned a *Good* rating. All VWIN sites in Madison County have *Poor* water quality ratings, with very high nutrient and sediment loads, and this site is no exception.

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, and an eroding streambank was noted by the volunteers. The substrate is a combination of gravel, cobblestones, sand, bedrock, and boulders, with rocks moderately embedded in fine sediment. In the fall of 2013, there was a newly constructed rock wall along about 100 feet of streambank to control erosion. DWR samples this stream at site EB188.

This site was first sampled in the fall of 2011. It received a *Fair* rating in the spring of 2013, and *Good-Fair* in the fall. These bioclassifications were worse than the upstream SMIE site. As at the upstream site on California Creek, spiny crawler mayflies made up 37% of the spring sample and net spinner caddisflies dominated the fall sample with 71%. In the spring, oligochaetes also made up 28% of the sample, and only 43 individuals were collected. Since sampling began in 2011, all samples except the spring of 2013 have earned a *Good-Fair* SMIE rating. DWR rated this site *Good-Fair* in 1997, but have not sampled since then.

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 DWR 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 silt and algae on the rocks.

The Little Ivy was first sampled in the spring of 2005. This site had a *Good* SMIE rating in the spring of 2013, and *Good-Fair* in the fall. In the spring sample was dominated by spiny crawler mayflies (70%). Two kicknets were collected in the spring, and the stream flow was swift. Net spinner caddisflies represented 57% of the fall collection, along with quick crawling predator stoneflies. This site regularly exhibits a *Good* to *Fair* SMIE rating. DWR gave this site a *Good-Fair* bioclassification in 2007 and 2012, attributing declining water quality (since the 1990's) to increased non-point source pollution from agricultural, residential, and forest use. The VWIN chemical rating for the Little Ivy River is *Poor*, with sediment and nutrient pollution evident.

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 at the border of Madison and Buncombe Counties, upstream of the confluence with the Little Ivy River. 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. It corresponds to VWIN site B1A and DWR site EB200 at SR2150.

The Big Ivy was first sampled in the spring of 2005, and is frequently used as the SMIE field training location due to the diversity of taxa observed. It had a *Good* rating in the both seasons of 2013, with higher SMIE scores than the Little Ivy River site. Sixty-three percent of the spring sample was made up of spiny crawler mayflies, followed by quick crawling predator stoneflies. Two kicknets were collected in the spring, and the water was high and fast. In the fall, 41% of the individuals were net spinner caddisflies, followed by flattened scraper mayflies, quick crawling predator stoneflies, and small head caddisflies. This site has usually earned *Good* to *Good-Fair* SMIE ratings since 2005. DWR gave this site an *Excellent* bioclassification in 2007 and 2012. The Big Ivy River has an *Average* VWIN rating, with high turbidity and total suspended solids values.

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. The riparian zone is composed of trees and shrubs, with some grass and vines present. The substrate consists of gravel, cobblestones, bedrock, and boulders. This site corresponds to the VWIN site M4.

The East Fork was first sampled in the spring of 2009. The rating was *Good* in both seasons of 2013. Forty percent of the spring specimens were net spinner caddisflies, but the fall sample was dominated by spiny crawler mayflies (64%) and flattened scraper stoneflies. The fall sample had one of the three highest taxa richness scores in 2013, with 21 taxa. It also had the second-highest number of pollution-sensitive taxa (8 out of 10 possible) and EPT taxa. DWR has determined that development and agricultural land use impact water quality in the watershed. The East Fork of Bull Creek has a *Poor* VWIN chemical rating with heavy sediment and nutrient pollution.

<u>Laurel Creek Watershed</u>

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. The riparian zone is mainly trees and shrubs, with some grass and vines. The substrate is composed of loosely embedded gravel and cobblestones. It corresponds to a discontinued VWIN site (M20) and DWR site EB217 at SR1503.

Puncheon Fork was first sampled in the fall of 2007. It received an *Excellent* rating in both seasons of 2013. In the spring, 64% of the specimens were spiny crawler mayflies, followed by flattened scraper mayflies. In the fall, 40% of the individuals were net spinner caddisflies. Most samples since 2007 have had either *Excellent* or *Good* SMIE ratings. DWR gave this site an *Excellent* bioclassification in both 2007 and 2012. Past VWIN monitoring detected elevated sediment levels.

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. Trees and shrubs border the stream upstream of this site, but 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. It corresponds to a discontinued VWIN site (M9) and DWR site EB219 at NC208.

Shelton Laurel Creek was first sampled in the spring of 2006. It received a *Good-Fair* in the spring of 2013, and *Good* in the fall. Flattened scraper mayflies comprised 42% of the spring sample, followed by spiny crawler mayflies. No leaf packs were found in the spring, which may have contributed to its lower rating. One-third of the individuals in the fall were net spinner caddisflies, along with flattened scraper mayflies and quick crawling predator stoneflies. Two kicknet samples were collected in the fall. This site usually had a *Good* SMIE rating until 2010, and since then it has mostly rated *Good-Fair*. DWR gave this site an *Excellent* bioclassification in 2006 and 2012.

Site #28 – Big Laurel Creek
Big Laurel Creek is a tributary of the French Broad River in rural northeastern Madison County. It is approximately 200 meters downstream of the bridge at the Hwy 25/70 and NC 208 junction, near the confluence with the river. 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. Gravel, cobblestones, and boulders make up the stream bottom, with sandy deposits along the bank. It corresponds to a discontinued VWIN site (M10) and DWR site EB181.

Big Laurel Creek was first sampled in the fall of 2005. It had a *Good* rating in the spring of 2013, and *Good-Fair* in the fall. In the spring, 38% of the individuals were flattened scraper mayflies and 32% were spiny crawler mayflies, along with quick crawling predator stoneflies. No leaf pack was found in the spring. In the fall, 36% were net spinner caddisflies, 31% round headed swimmer mayflies, followed by quick crawling predator stoneflies. This site has fluctuated between *Good-Fair* to *Excellent* SMIE ratings over the years. DWR gave this stream an *Excellent* bioclassification in both 2006 and 2012, and streams throughout the entire watershed are considered HQW (high quality waters).

Nolichucky Subbasin (Mitchell and Yancey Counties)

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. The riparian zone is mostly trees, shrubs, and construction fill on the right

bank and grasses, with some vines present, on the left bank. The stream habitat consists of gravel and cobblestones. This location corresponds to VWIN site T1.

Cane Creek in Mitchell County was first sampled in the spring of 2008. It had a *Good* rating in the spring of 2013, but was not sampled in the fall. Spiny crawler mayflies comprised almost two-thirds of the sample. Volunteers noted urban stormwater runoff during the spring sample. This site has regularly earned from *Good-Fair* to *Excellent* SMIE ratings since 2008. The VWIN chemical rating for this site is *Good*.

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. The riparian zone consists of trees and shrubs. The stream's substrate is composed of gravel and cobblestones, with more sand than the other SMIE sites in the Nolichucky subbasin. It corresponds to DWR site EB286 at SR1162.

The North Toe River was first sampled in the spring of 2009. This site had a *Fair* SMIE rating in the spring of 2013, but was not sampled in the fall. The spring sampling required two kicknets and still only 100 individuals were collected. One-third of the individuals were net spinner caddisflies, followed by spiny crawler mayflies and chironomid midges. Since monitoring began in 2009, this site has always had a *Good-Fair* or *Fair* SMIE rating. DWR gives this site an *Excellent* biological rating in 2009 and a *Good* rating in 2012. They attribute variation in the benthic community to NPDES dischargers upstream and a petroleum spill that took place in 2002. A VWIN site downstream of this area has a *Good* chemical rating, but displays fairly high sediment and conductivity.

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 Mountain Heritage High School's practice football field, about a mile west of Burnsville. The river runs alongside Highway NC 197 for much of its length, which disrupts the riparian buffer. The riparian zone is about half trees and half grass 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. This site corresponds to VWIN site T5 and is near the DWR site EB303 at US 19E.

Sampling the Cane River began in the fall of 2008. The rating for the spring of 2013 was *Excellent*, with one of the best SMIE scores of 2013. This site was not sampled in the fall. Quick crawling predator stoneflies comprised 35% of the spring sample, followed by flattened scraper mayflies, net spinner caddisflies, and spiny crawler mayflies. The sample had one of the three highest taxa richness scores in 2013, with 21 taxa. It also yielded one of the highest numbers of EPT taxa and pollution-sensitive taxa. Volunteers noticed that there appeared to have been extremely high stream flows prior to the spring sampling. This site has earned SMIE ratings ranging from Excellent to Poor since 2008, with no apparent pattern. DWR gave this site a *Fair* rating in 2007, which improved to an *Excellent* biological rating in 2012. The high water quality is attributed to contributions from undisturbed tributaries. The Cane River has a *Good* VWIN rating, with moderate nutrient values likely due to the WWTP upstream.

3.5 Summary

WNC experienced an extreme drought that lasted approximately two years from 2007 to 2009. There were abnormally dry conditions during parts of 2010 and 2011, but 2012 had mostly normal amounts of rainfall (Drought Management Advisory Council 2014). Heavy rainfall throughout the region in 2013 likely

elevated sediment contributions to the streams through stormwater runoff and flooding. Many volunteers in the spring and fall seasons mentioned swift or high streams resulting from recent rains, which could have diminished the efficacy of their sampling (i.e. not finding leaf packs, being able to conduct visual surveys, or kicknet complications). Particularly in the spring, volunteers needed to collect multiple kicknet samples at many sites. Drought conditions can have long lasting and severe impacts on streams by reducing aquatic habitats, providing less water to dilute point source pollution, and reducing nonpoint source pollution between rainfall events. Heavy rains can also have consequences for the invertebrate communities due to streambed scour, deposition of sediment, increased pollutant loads, or temperature increases from runoff.

Other factors affecting WNC streams 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. 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. In more urban areas, stormwater infrastructure diverts pollutant-laden runoff directly to streams. Excess sediment particularly contributes to the degradation of WNC streams.

In 2013, EQI and ECO conducted biomonitoring at 56 sites in the spring and fall seasons. DWR's protocols are more rigorous and detailed than the SMIE protocol, but they sample substantially fewer sites in WNC. Additionally, they sample their sites once every five years, in which time environmental conditions can change dramatically. The work performed by the SMIE program puts additional feet into regional streams to help document local water quality and educate the public about natural resources. The new SMIE Biotic Index analysis has helped relate the volunteer monitoring results to the state data. SMIE also aims to continue improving the skills of volunteers and building a database of biomonitoring results in WNC. Additional goals include further development of information available on the website (www.eqilab.org), targeted training based on QAQC results, the addition of new monitoring sites, and analysis of biological data with land use and water chemistry.

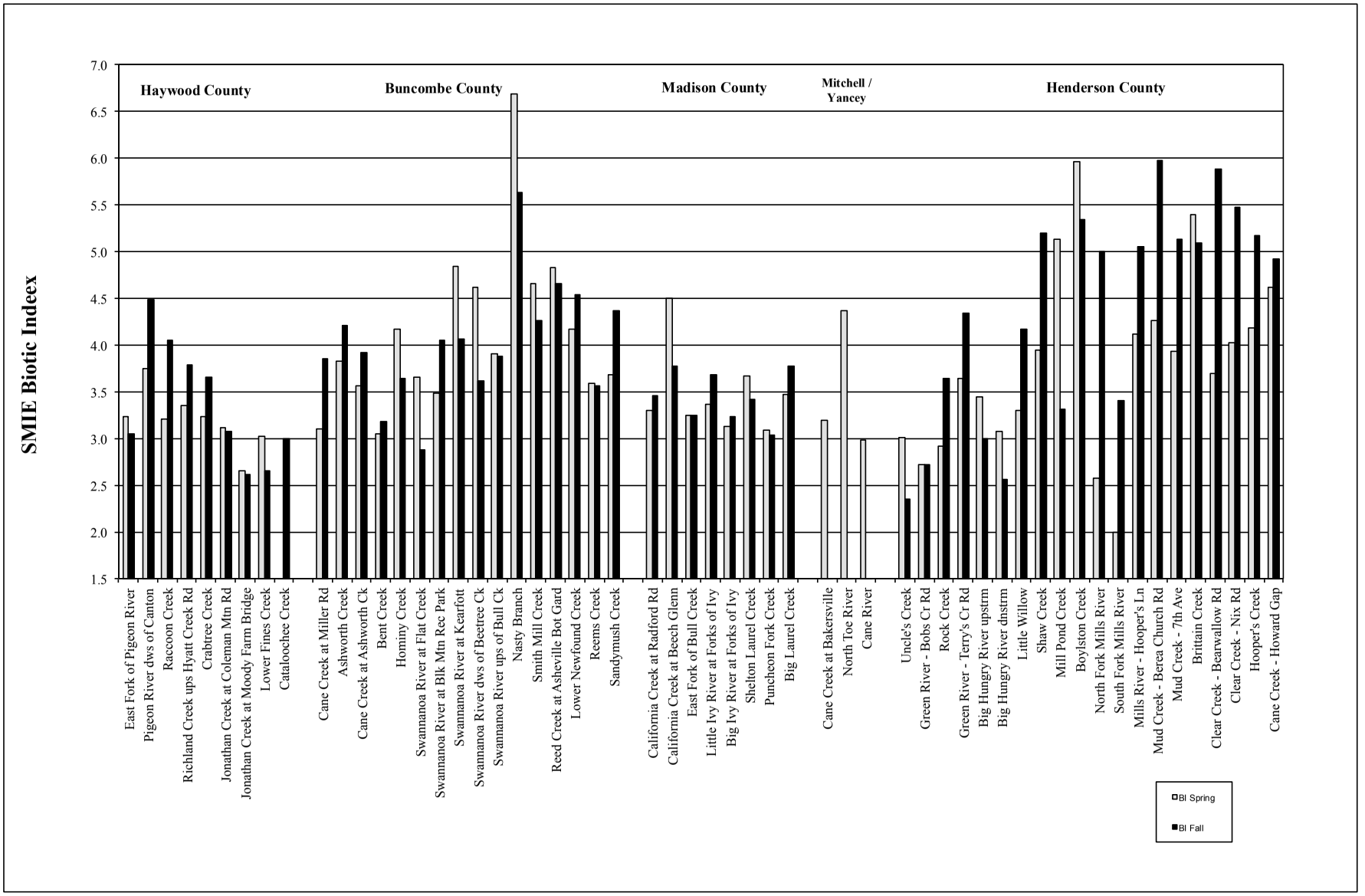

Figure 2. SMIE Biotic Index values for spring and fall 2013 (low scores = good quality, high scores = poor quality).

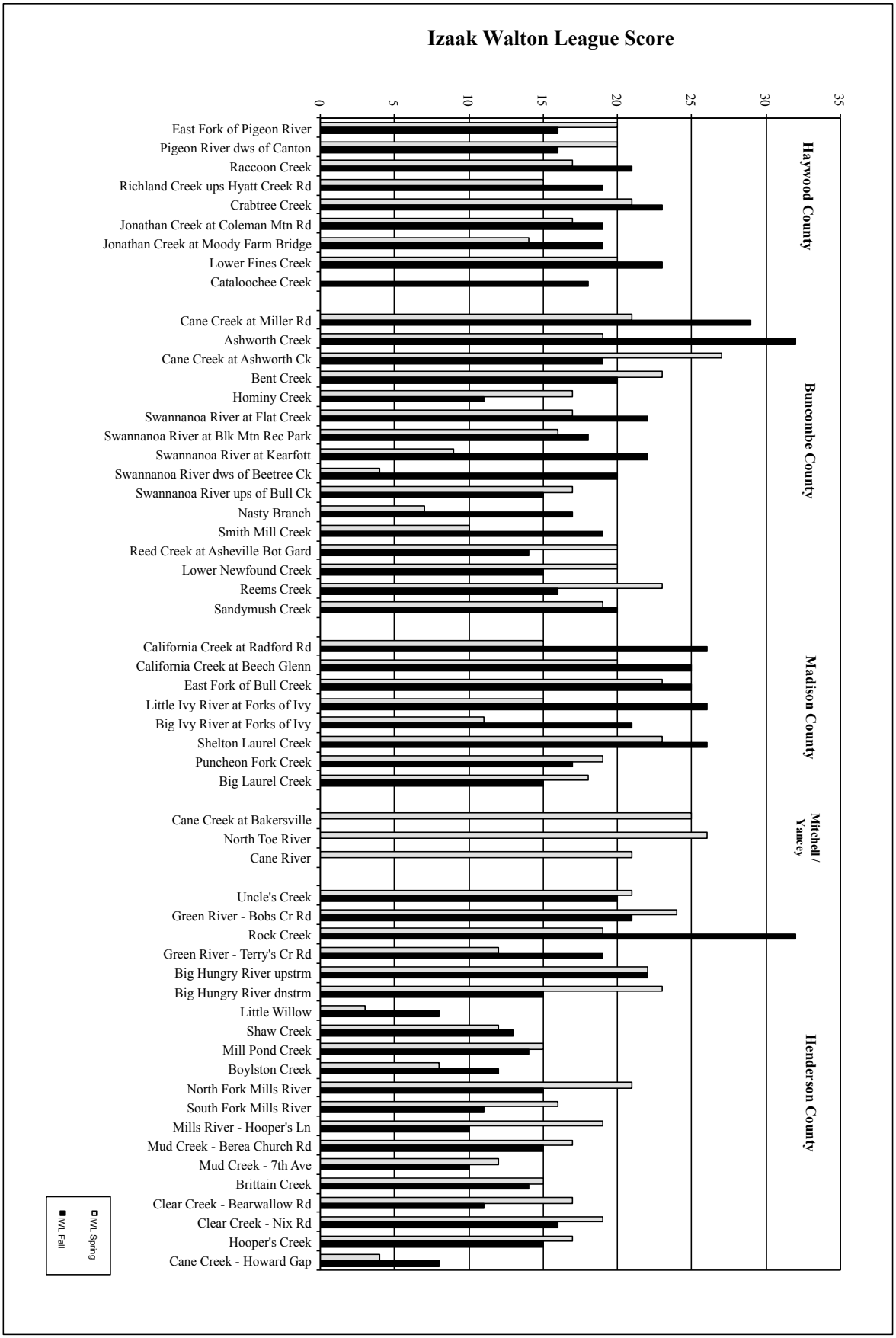

Figure 3. Izaak Walton League scores for spring and fall 2013.

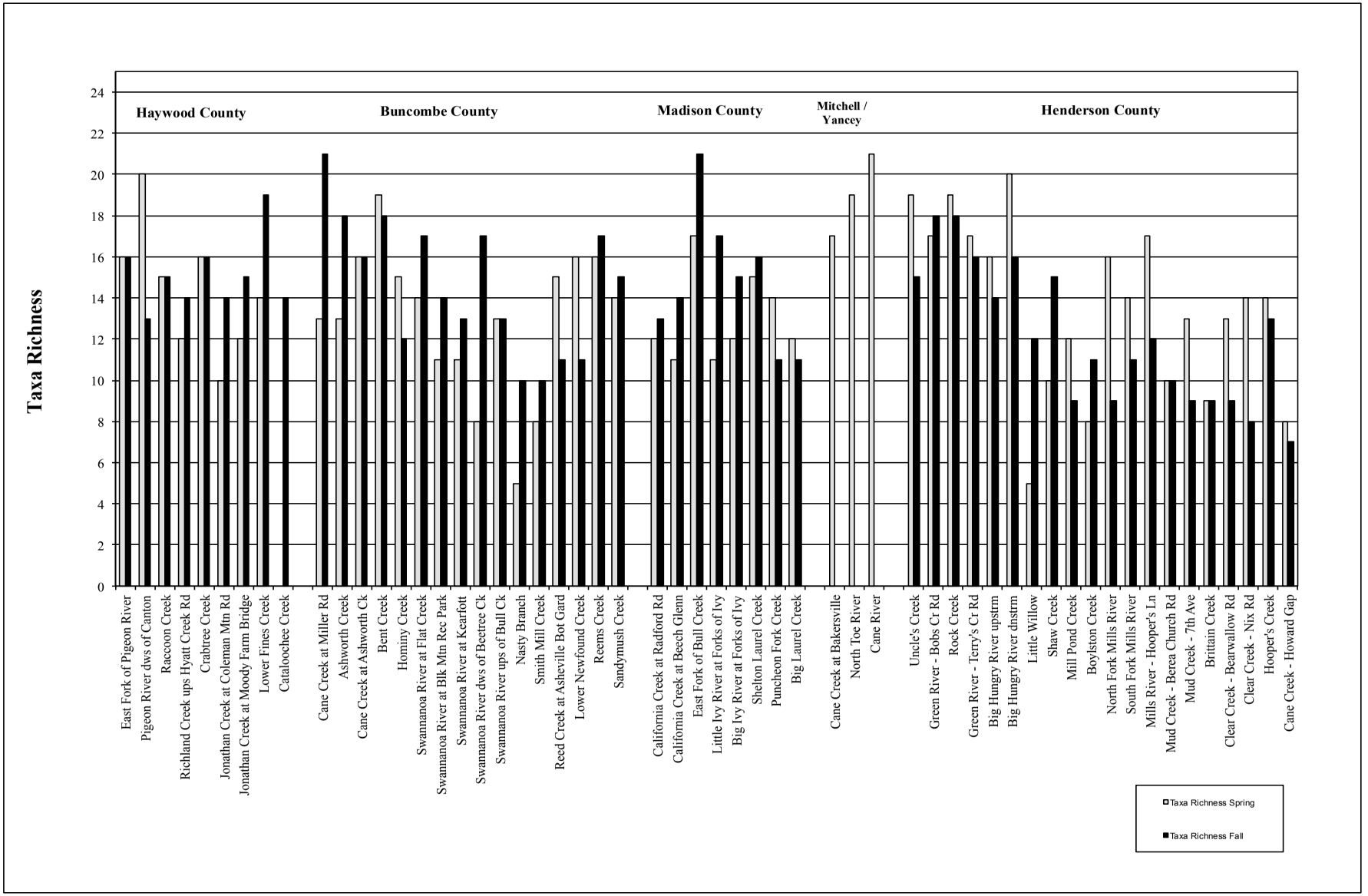

Figure 4. Taxa richness values for spring and fall 2013 (43 taxa possible).

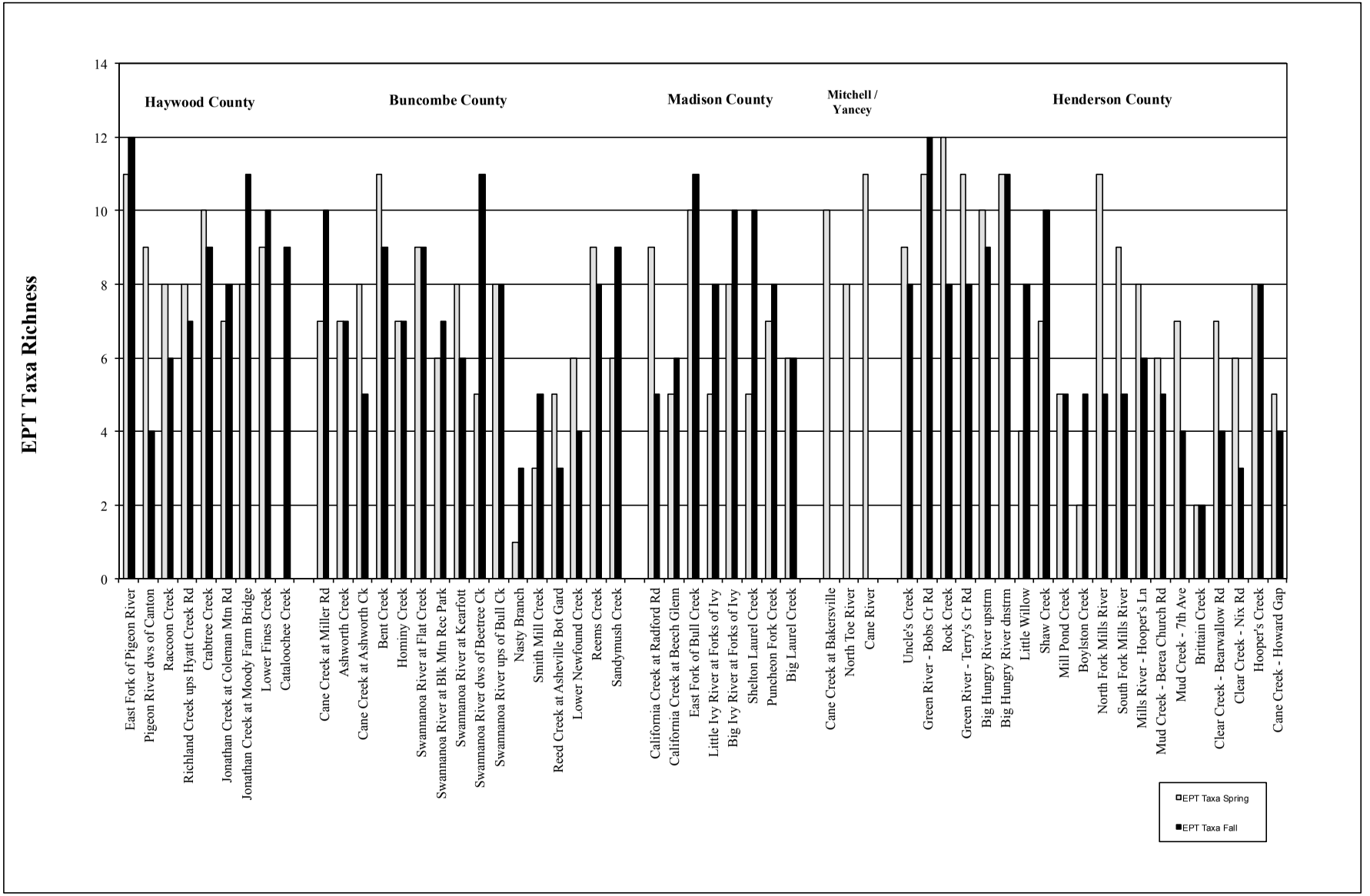

Figure 5. EPT taxa richness values for spring and fall 2013 (19 taxa possible).

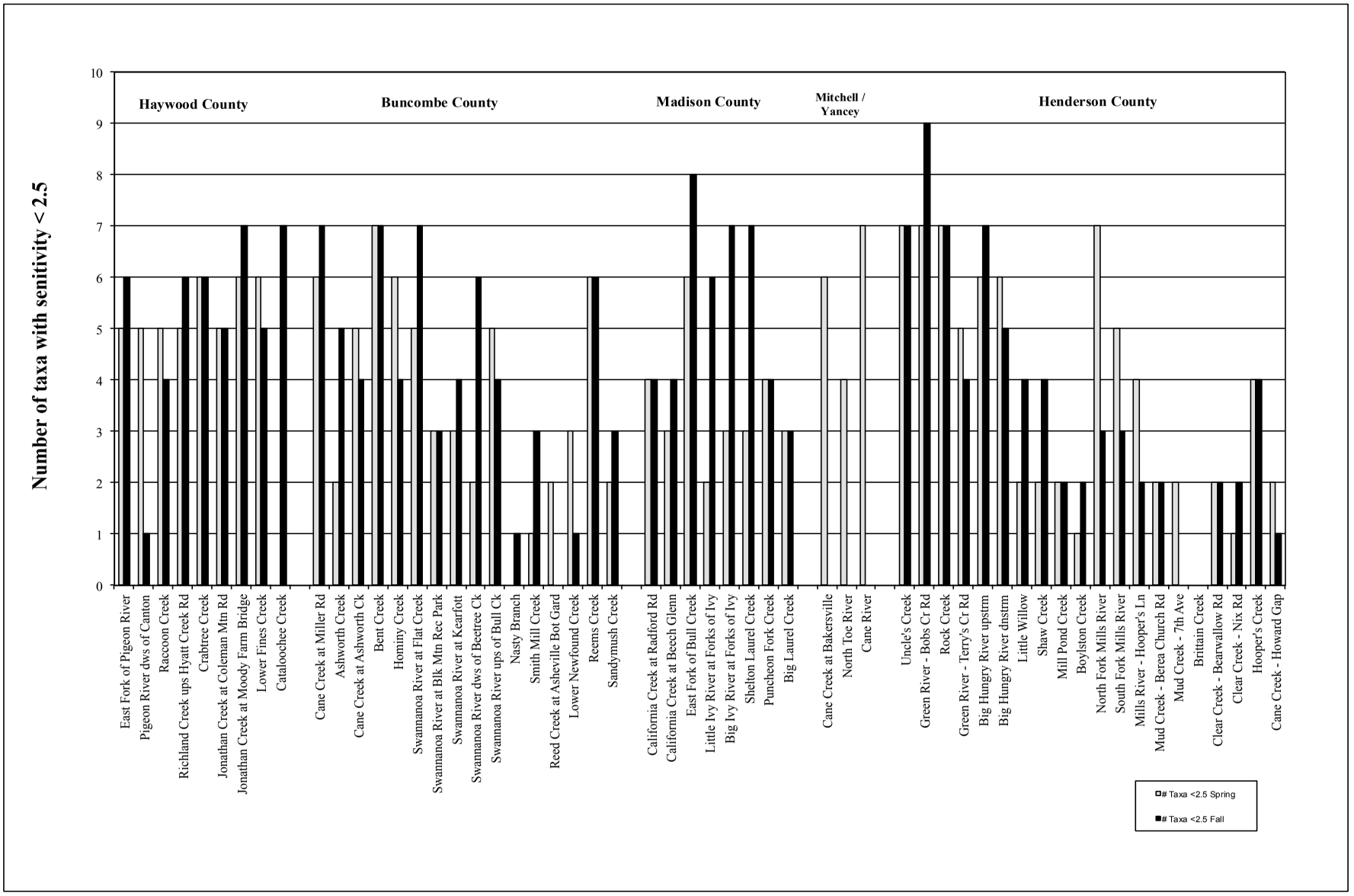

Figure 6. Number of taxa with sensitivity <2.5 for spring and fall 2013 (10 taxa possible).

Table 6. SMIE summary data (spring and fall 2013; richness, abundance, VASOS, IWL, and BI data).

Site #	Site Name	Season	Taxa Richness	Total # Individuals	EPT Richness	VASOS Score	VASOS Rating	IWL Score	IWL Rating	SMIE BI Score	SMIE BI Rating	EPT BI	#Taxa <2.5 Sens
1	East Fork of the Pigeon River	Spring	16	147	11	11	Acceptable	20	Good	3.24	Good	3.17	5
1	East Fork of the Pigeon River	Fall	16	124	12	9	Acceptable	16	Fair	3.04	Excellent	2.68	6
2	Pigeon River downstream of Canton	Spring	20	159	9	10	Acceptable	20	Good	3.74	Good-Fair	3.26	5
2	Pigeon River downstream of Canton	Fall	13	228	4	4	Unacceptable	16	Fair	4.48	Fair	3.97	1
3	Raccoon Creek	Spring	15	224	8	10	Acceptable	17	Good	3.21	Good	3.03	5
3	Raccoon Creek	Fall	15	200	6	7	Acceptable	21	Good	4.05	Good-Fair	3.81	4
4	Richland Creek	Spring	12	280	8	10	Acceptable	15	Fair	3.35	Good	3.32	5
4	Richland Creek	Fall	14	95	7	8	Acceptable	19	Good	3.79	Good-Fair	3.83	6
5	Crabtree Creek	Spring	16	225	10	10	Acceptable	21	Good	3.23	Good	3.14	6
5	Crabtree Creek	Fall	16	355	9	7	Acceptable	23	Excellent	3.65	Good-Fair	3.51	6
6	Jonathan Creek at Coleman Mountain Rd	Spring	10	335	7	10	Acceptable	17	Good	3.11	Good	3.07	5
6	Jonathan Creek at Coleman Mountain Rd	Fall	14	154	8	8	Acceptable	19	Good	3.07	Excellent	3.03	5
7	Jonathan Creek at Moody Farm Rd	Spring	12	220	8	10	Acceptable	14	Fair	2.66	Excellent	2.61	6
7	Jonathan Creek at Moody Farm Rd	Fall	15	134	11	10	Acceptable	19	Good	2.61	Excellent	2.55	7
8	Fines Creek	Spring	14	228	9	10	Acceptable	20	Good	3.03	Excellent	3.00	6
8	Fines Creek	Fall	19	245	10	9	Acceptable	23	Excellent	2.65	Excellent	2.58	5
9	Cane Creek at Miller Rd	Spring	13	179	7	10	Acceptable	21	Good	3.10	Good	2.94	6
9	Cane Creek at Miller Rd	Fall	21	219	10	8	Acceptable	29	Excellent	3.85	Good-Fair	3.46	7
10	Ashworth Creek	Spring	13	200	7	10	Acceptable	19	Good	3.82	Good-Fair	3.36	2
10	Ashworth Creek	Fall	18	240	7	10	Acceptable	32	Excellent	4.21	Fair	3.52	5
11	Cane Creek at Ashworth Creek	Spring	16	201	8	12	Acceptable	27	Excellent	3.56	Good-Fair	3.17	5
11	Cane Creek at Ashworth Creek	Fall	16	166	5	7	Acceptable	19	Good	3.92	Good-Fair	3.52	4
12	Bent Creek	Spring	19	105	11	10	Acceptable	23	Excellent	3.04	Excellent	2.52	7
12	Bent Creek	Fall	18	114	9	11	Acceptable	20	Good	3.18	Good	2.46	7
13	Hominy Creek	Spring	15	32	7	11	Acceptable	17	Good	4.17	Fair	3.12	6
13	Hominy Creek	Fall	12	161	7	6	Unacceptable	11	Fair	3.64	Good-Fair	3.40	4
14	Swannanoa River downstream of Beetree Cr	Spring	11	83	8	9	Acceptable	9	Poor	4.83	Fair	3.40	3
14	Swannanoa River downstream of Beetree Cr	Fall	17	443	11	7	Acceptable	20	Good	3.61	Good-Fair	3.46	6
15	Swannanoa River upstream of Bull Creek	Spring	15	76	8	11	Acceptable	20	Good	4.41	Fair	3.82	5
15	Swannanoa River upstream of Bull Creek	Fall	13	218	8	6	Unacceptable	15	Fair	3.88	Good-Fair	3.64	4
16	Smith Mill Creek	Spring	8	48	3	10	Acceptable	10	Poor	4.65	Fair	4.23	1
16	Smith Mill Creek	Fall	10	193	5	8	Acceptable	19	Good	4.26	Fair	3.98	3
17	Reed Creek at the Botanical Gardens	Spring	15	150	5	9	Acceptable	20	Good	4.83	Fair	3.95	2
17	Reed Creek at the Botanical Gardens	Fall	11	168	3	7	Acceptable	14	Fair	4.65	Fair	4.06	0
18	Newfound Creek	Spring	16	200	6	6	Unacceptable	20	Good	4.17	Fair	3.85	3
18	Newfound Creek	Fall	11	244	4	5	Unacceptable	15	Fair	4.54	Fair	4.03	1
19	Reems Creek	Spring	16	223	9	10	Acceptable	23	Excellent	3.59	Good-Fair	3.32	6
19	Reems Creek	Fall	17	257	8	9	Acceptable	16	Fair	3.56	Good	3.32	6

Table 6 (continued). SMIE summary data (spring and fall 2013; richness, abundance, VASOS, IWL, and BI data).

Site #	Site Name	Season	Taxa Richness	Total # Individuals	EPT Richness	VASOS Score	VASOS Rating	IWL Score	IWL Rating	SMIE BI Score	SMIE BI Rating	EPT BI	#Taxa <2.5 Sens
20	Sandymush Creek	Spring	14	475	6	10	Acceptable	19	Good	3.68	Good-Fair	3.46	2
20	Sandymush Creek	Fall	15	134	9	7	Acceptable	20	Good	4.37	Fair	3.49	3
21	California Creek at Radford Rd	Spring	12	192	9	10	Acceptable	15	Fair	3.30	Good	3.18	4
21	California Creek at Radford Rd	Fall	13	247	5	8	Acceptable	26	Excellent	3.45	Good	3.32	4
22	California Creek at Beech Glen	Spring	11	43	5	10	Acceptable	20	Good	4.50	Fair	3.41	3
22	California Creek at Beech Glen	Fall	14	287	6	7	Acceptable	25	Excellent	3.77	Good-Fair	3.60	4
23	East Fork of Bull Creek	Spring	17	313	10	10	Acceptable	23	Excellent	3.25	Good	3.13	6
23	East Fork of Bull Creek	Fall	21	248	11	9	Acceptable	25	Excellent	3.25	Good	3.12	8
24	Little Ivy River	Spring	11	212	5	11	Acceptable	15	Fair	3.36	Good	3.24	2
24	Little Ivy River	Fall	17	197	8	7	Acceptable	26	Excellent	3.68	Good-Fair	3.50	6
25	Big Ivy River	Spring	12	181	8	11	Acceptable	11	Fair	3.13	Good	3.10	3
25	Big Ivy River	Fall	15	257	10	8	Acceptable	21	Good	3.24	Good	3.13	7
26	Shelton Laurel	Spring	15	194	5	11	Acceptable	23	Excellent	3.66	Good-Fair	3.49	3
26	Shelton Laurel	Fall	16	213	10	10	Acceptable	26	Excellent	3.42	Good	3.48	7
27	Puncheon Fork	Spring	14	187	7	10	Acceptable	19	Good	3.09	Excellent	2.96	4
27	Puncheon Fork	Fall	11	157	8	8	Acceptable	17	Good	3.03	Excellent	2.94	4
28	Big Laurel River	Spring	12	139	6	10	Acceptable	18	Good	3.46	Good	3.36	3
28	Big Laurel River	Fall	11	163	6	8	Acceptable	15	Fair	3.77	Good-Fair	3.61	3
29	Cane Creek at Bakersville	Spring	17	332	10	10	Acceptable	25	Excellent	3.19	Good	3.10	6
29	Cane Creek at Bakersville	Fall	not sampled										
30	North Toe River @ Penland	Spring	19	100	8	9	Acceptable	26	Excellent	4.36	Fair	3.58	4
30	North Toe River @ Penland	Fall	not sampled										
31	Cane River in Yancey Co	Spring	21	205	11	10	Acceptable	21	Good	2.98	Excellent	2.73	7
31	Cane River in Yancey Co	Fall	not sampled										
32	Cataloochee Creek	Spring	not sampled										
32	Cataloochee Creek	Fall	14	335	9	9	Acceptable	18	Good	2.99	Excellent	2.89	7
34	Nasty Branch (Town Branch)	Spring	5	32	1	4	Unacceptable	7	Poor	6.68	Poor	4.00	0
34	Nasty Branch (Town Branch)	Fall	10	223	3	5	Unacceptable	17	Good	5.63	Poor	4.16	1
35	Green River below Bob's Creek Rd	Spring	17	295	11	10	Acceptable	24	Excellent	2.72	Excellent	2.32	7
35	Green River below Bob's Creek Rd	Fall	18	184	12	10	Acceptable	21	Good	2.71	Excellent	2.22	9
36	Rock Creek	Spring	19	321	12	10	Acceptable	19	Good	2.92	Excellent	2.73	7
36	Rock Creek	Fall	18	92	8	10	Acceptable	32	Excellent	3.64	Good-Fair	2.69	7
37	Green River at Terry's Creek Rd	Spring	17	127	11	10	Acceptable	12	Fair	3.64	Good-Fair	3.15	5
37	Green River at Terry's Creek Rd	Fall	16	126	8	8	Acceptable	19	Good	4.34	Fair	3.70	4
39	Upper Big Hungry @ Old Schoolhouse Rd	Spring	16	146	10	10	Acceptable	22	Good	3.45	Good	3.08	6
39	Upper Big Hungry @ Old Schoolhouse Rd	Fall	14	118	9	10	Acceptable	22	Good	3.00	Excellent	2.73	7
41	Lower Big Hungry River	Spring	20	229	11	10	Acceptable	23	Excellent	3.07	Excellent	2.82	6
41	Lower Big Hungry River	Fall	16	70	11	10	Acceptable	15	Fair	2.56	Excellent	2.05	5

Table 6 (continued). SMIE summary data (spring and fall 2013; richness, abundance, VASOS, IWL, and BI data).

Site #	Site Name	Season	Taxa Richness	Total # Individuals	EPT Richness	VASOS Score	VASOS Rating	IWL Score	IWL Rating	SMIE BI Score	SMIE BI Rating	EPT BI	#Taxa <2.5 Sens
43	Little Willow Creek	Spring	5	55	4	10	Acceptable	3	Poor	3.30	Good	3.27	2
43	Little Willow Creek	Fall	12	84	8	8	Acceptable	8	Poor	4.17	Fair	2.89	4
45	Shaw Creek at Hunter's Glen	Spring	10	82	7	10	Acceptable	12	Fair	3.95	Good-Fair	3.78	2
45	Shaw Creek at Hunter's Glen	Fall	15	74	10	9	Acceptable	13	Fair	5.20	Fair	3.22	4
46	Mill Pond Creek	Spring	12	139	5	7	Acceptable	15	Fair	5.13	Fair	3.24	2
46	Mill Pond Creek	Fall	9	149	5	8	Acceptable	14	Fair	3.31	Good	2.92	2
47	Boylston Creek	Spring	8	28	2	6	Unacceptable	8	Poor	5.96	Poor	2.40	1
47	Boylston Creek	Fall	11	32	5	9	Acceptable	12	Fair	5.34	Poor	3.83	2
48	North Fork Mills River	Spring	16	105	11	9	Acceptable	21	Good	2.58	Excellent	2.10	7
48	North Fork Mills River	Fall	9	241	5	10	Acceptable	15	Fair	5.00	Fair	3.46	3
49	South Fork Mills River	Spring	14	98	9	10	Acceptable	16	Fair	2.00	Excellent	1.69	5
49	South Fork Mills River	Fall	11	32	5	8	Acceptable	11	Fair	3.41	Good	2.46	3
51	Mills River at Hooper Lane	Spring	17	141	8	10	Acceptable	19	Good	4.12	Fair	3.14	4
51	Mills River at Hooper Lane	Fall	12	138	6	10	Acceptable	10	Poor	5.05	Fair	3.77	2
52	Mud Creek at Berea Church Rd	Spring	10	123	6	10	Acceptable	17	Good	4.26	Fair	3.63	2
52	Mud Creek at Berea Church Rd	Fall	10	165	5	6	Unacceptable	15	Fair	5.98	Poor	3.91	2
53	Mud Creek at 7th Ave	Spring	13	114	7	9	Acceptable	12	Fair	3.94	Good-Fair	3.35	2
53	Mud Creek at 7th Ave	Fall	9	84	4	8	Acceptable	10	Poor	5.13	Fair	4.04	0
54	Brittain Creek	Spring	9	65	2	8	Acceptable	15	Fair	5.40	Poor	4.08	0
54	Brittain Creek	Fall	9	167	2	6	Unacceptable	14	Fair	5.09	Fair	4.03	0
55	Clear Creek at Bearwallow	Spring	13	414	7	10	Acceptable	17	Good	3.69	Good-Fair	3.53	2
55	Clear Creek at Bearwallow	Fall	9	74	4	9	Acceptable	11	Fair	5.88	Poor	3.78	2
58	Clear Creek at Nix Rd	Spring	14	136	6	9	Acceptable	19	Good	4.03	Good-Fair	3.45	1
58	Clear Creek at Nix Rd	Fall	8	201	3	5	Unacceptable	16	Fair	5.47	Poor	3.89	2
59	Hooper's Creek at Jackson Rd	Spring	14	170	8	10	Acceptable	17	Good	4.18	Fair	3.67	4
59	Hooper's Creek at Jackson Rd	Fall	13	163	8	7	Acceptable	15	Fair	5.17	Fair	3.81	4
60	Cane Creek at Howard Gap	Spring	8	42	5	7	Acceptable	4	Poor	4.62	Fair	3.32	2
60	Cane Creek at Howard Gap	Fall	7	41	4	9	Acceptable	8	Poor	4.92	Fair	4.02	1
61	Uncle's Creek at Green River	Spring	19	120	9	10	Acceptable	21	Good	3.00	Excellent	2.35	7
61	Uncle's Creek at Green River	Fall	15	115	8	9	Acceptable	20	Good	2.35	Excellent	2.03	7
62	Swannanoa River at Flat Creek	Spring	13	146	8	10	Acceptable	17	Good	3.90	Good-Fair	3.33	5
62	Swannanoa River at Flat Creek	Fall	17	165	9	10	Acceptable	22	Good	2.88	Excellent	2.16	7
63	Swannanoa River at Blk Mtn Rec Park	Spring	11	151	6	11	Acceptable	16	Fair	3.49	Good	3.38	3
63	Swannanoa River at Blk Mtn Rec Park	Fall	14	243	7	6	Unacceptable	18	Good	4.05	Good-Fair	3.76	3
64	Swannanoa River at Kearfott	Spring	14	194	9	11	Acceptable	17	Good	3.66	Good-Fair	3.39	5
64	Swannanoa River at Kearfott	Fall	13	221	6	6	Unacceptable	22	Good	4.06	Good-Fair	3.81	4

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

Table 7. Cumulative SMIE data (spring 2005 – fall 2013)

Site #	Site Description	County	Date	Taxa Richness	EPT Taxa Richness	VASOS Score	IWL Score	SMIE BI Score
1	East Fork of Pigeon River	Haywood	Fall 2005	21	13	9	20	3.09
			Spring 2006	13	8	9	15	3.60
			Fall 2006	16	8	12	20	4.20
			Spring 2007	21	12	10	22	2.91
			Fall 2007	14	6	11	20	3.05
			Spring 2008	17	12	10	19	2.87
			Fall 2008	20	13	10	21	3.15
			Spring 2009	18	11	10	14	3.24
			Fall 2009	16	9	8	18	3.45
			Spring 2010	17	9	11	26	2.94
			Fall 2010	*Not sampled*				
			Spring 2011	*Not sampled*				
			Fall 2011	20	10	7	25	3.99
			Spring 2012	26	14	11	29	3.50
			Fall 2012	18	10	10	24	3.33
			Spring 2013	16	11	11	20	3.24
			Fall 2013	16	12	9	16	3.04
2	Pigeon River dws of Canton	Haywood	Fall 2006	12	2	2	14	5.90
			Spring 2007	15	7	4	20	4.47
			Fall 2007	12	2	2	11	8.23
			Spring 2008	10	3	4	14	4.76
			Fall 2008	8	2	3	11	5.94
			Spring 2009	15	6	6	20	4.56
			Fall 2009	*Not sampled*				
			Spring 2010	15	6	4	21	4.89
			Fall 2010	*Not sampled*				
			Spring 2011	*Not sampled*				
			Fall 2011	12	3	2	15	4.74
			Spring 2012	20	8	7	27	3.68
			Fall 2012	17	7	1	19	5.16
			Spring 2013	20	9	10	20	3.74
			Fall 2013	13	4	4	16	4.48
3	Raccoon Creek	Haywood	Spring 2008	11	5	9	15	3.59
			Fall 2008	14	7	8	19	4.13
			Spring 2009	12	6	11	21	3.89
			Fall 2009	*Not sampled*				
			Spring 2010	10	9	10	11	3.42
			Fall 2010	17	11	10	20	3.77
			Spring 2011	16	9	11	18	3.88
			Fall 2011	17	11	10	20	3.77
			Spring 2012	13	8	10	8	3.82
			Fall 2012	14	7	8	22	4.01
			Spring 2013	15	8	10	17	3.21
			Fall 2013	15	6	7	21	4.05
4	Richland Creek ups Hyatt Creek Rd	Haywood	Spring 2005	14	8	9	5	n/a
			Fall 2005	12	6	8	17	4.12
			Spring 2006	10	7	10	12	3.29
			Fall 2006	9	6	8	15	4.70
			Spring 2007	16	8	10	19	3.44
			Fall 2007	14	7	9	19	3.16
			Spring 2008	11	7	10	15	3.61
			Fall 2008	17	8	10	23	3.40
			Spring 2009	8	6	10	7	3.69
			Fall 2009	*Not sampled*				
			Spring 2010	12	6	10	15	3.41
			Fall 2010	13	9	10	16	3.30
			Spring 2011	10	7	10	17	3.17
			Fall 2011	13	9	10	16	3.30
			Spring 2012	15	9	10	20	3.42
			Fall 2012	18	9	12	22	3.11
			Spring 2013	12	8	10	15	3.35
			Fall 2013	14	7	8	19	3.79
5	Crabtree Creek	Haywood	Spring 2005	14	8	9	9	n/a
			Fall 2005	18	11	7	14	2.76
			Spring 2006	16	10	10	21	3.29
			Fall 2006	17	7	7	22	3.72
			Spring 2007	15	6	9	22	3.30

Table 7 (continued). Cumulative SMIE data (spring 2005 – fall 2013).

Site #	Site Description	County	Date	Taxa Richness	EPT Taxa Richness	VASOS Score	IWL Score	SMIE BI Score
5	Crabtree Creek (continued)	Haywood	Fall 2007	18	8	7	28	4.20
			Spring 2008	17	9	9	21	3.60
			Fall 2008	15	10	10	19	3.79
			Spring 2009	16	7	10	23	3.55
			Fall 2009	16	9	10	20	3.52
			Spring 2010	19	10	8	22	3.55
			Fall 2010	*Not sampled*				
			Spring 2011	*Not sampled*				
			Fall 2011	14	8	8	18	3.92
			Spring 2012	11	7	11	16	3.36
			Fall 2012	15	8	8	19	3.54
			Spring 2013	16	10	10	21	3.23
			Fall 2013	16	9	7	23	3.65
6	Jonathan Creek at Coleman Mtn Rd	Haywood	Spring 2005	11	7	10	15	3.21
			Fall 2005	14	8	8	17	3.18
			Spring 2006	17	9	10	20	3.24
			Fall 2006	13	7	10	17	3.32
			Spring 2007	13	8	10	18	3.41
			Fall 2007	16	9	8	17	3.52
			Spring 2008	14	8	10	17	3.38
			Fall 2008	17	10	10	22	3.66
			Spring 2009	14	10	11	18	3.48
			Fall 2009	12	7	11	20	3.58
			Spring 2010	15	8	10	15	3.83
			Fall 2010	*Not sampled*				
			Spring 2011	*Not sampled*				
			Fall 2011	16	8	11	26	3.40
			Spring 2012	12	10	12	15	3.29
			Fall 2012	18	10	10	27	3.36
			Spring 2013	10	7	10	17	3.11
			Fall 2013	14	8	8	19	3.07
7	Jonathan Creek at Moody Farm Bridge	Haywood	Spring 2005	12	9	9	11	n/a
			Fall 2005	13	7	7	19	3.72
			Spring 2006	17	10	10	16	3.84
			Fall 2006	16	9	11	18	3.68
			Spring 2007	16	10	10	15	2.78
			Fall 2007	16	9	9	20	2.82
			Spring 2008	15	10	10	12	2.98
			Fall 2008	13	8	9	18	2.75
			Spring 2009	15	11	10	20	3.46
			Fall 2009	*Not sampled*				
			Spring 2010	14	10	10	13	3.61
			Fall 2010	*Not sampled*				
			Spring 2011	*Not sampled*				
			Fall 2011	17	10	10	19	2.95
			Spring 2012	15	8	10	28	3.88
			Fall 2012	19	11	12	21	2.73
			Spring 2013	12	8	10	14	2.66
			Fall 2013	15	11	10	19	2.61
8	Lower Fines Creek	Haywood	Spring 2005	20	12	10	19	3.21
			Fall 2005	14	9	7	19	3.55
			Spring 2006	11	9	10	15	3.11
			Fall 2006	14	7	9	21	3.01
			Spring 2007	20	12	10	22	3.51
			Fall 2007	17	8	8	21	3.79
			Spring 2008	17	9	10	26	3.39
			Fall 2008	17	8	8	25	3.51
			Spring 2009	19	8	10	28	3.39
			Fall 2009	17	8	10	19	3.57
			Spring 2010	17	10	9	25	3.03
			Fall 2010	*Not sampled*				
			Spring 2011	*Not sampled*				
			Fall 2011	13	7	8	17	3.70
			Spring 2012	20	12	11	26	3.41
			Fall 2012	17	10	10	24	3.44
			Spring 2013	14	9	10	20	3.03
			Fall 2013	19	10	9	23	2.65

Table 7 (continued). Cumulative SMIE data (spring 2005 – fall 2013).

Site #	Site Description	County	Date	Taxa Richness	EPT Taxa Richness	VASOS Score	IWL Score	SMIE BI Score
9	Cane Creek at Miller Rd	Buncombe	Spring 2008	18	11	11	19	3.13
			Fall 2008	14	8	7	23	3.58
			Spring 2009	21	11	11	23	3.25
			Fall 2009	*Not sampled*				
			Spring 2010	21	13	12	18	3.11
			Fall 2010	*Not sampled*				
			Spring 2011	*Not sampled*				
			Fall 2011	17	9	8	30	3.41
			Spring 2012	20	11	11	24	3.24
			Fall 2012	17	7	8	24	3.23
			Spring 2013	13	7	10	21	3.10
			Fall 2013	21	10	8	29	3.85
10	Ashworth Creek	Buncombe	Spring 2005	15	8	7	12	n/a
			Fall 2005	15	8	7	20	3.60
			Spring 2006	16	7	10	20	3.47
			Fall 2006	14	8	6	20	4.26
			Spring 2007	17	8	10	26	2.83
			Fall 2007	19	8	10	30	3.87
			Spring 2008	17	8	12	28	3.73
			Fall 2008	17	7	6	27	4.54
			Spring 2009	19	9	12	27	3.28
			Fall 2009	15	7	7	28	3.50
			Spring 2010	17	9	11	27	3.37
			Fall 2010	17	8	7	28	4.02
			Spring 2011	16	7	11	28	3.55
			Fall 2011	20	7	8	25	3.56
			Spring 2012	19	8	12	33	3.19
			Fall 2012	16	6	8	29	4.04
			Spring 2013	13	7	10	19	3.82
			Fall 2013	18	7	10	32	4.21
11	Cane Creek at Ashworth Ck	Buncombe	Spring 2005	12	8	9	6	n/a
			Fall 2005	11	7	9	12	2.14
			Spring 2006	17	11	8	14	3.51
			Fall 2006	16	10	8	12	3.60
			Spring 2007	16	9	9	20	2.97
			Fall 2007	17	8	7	25	3.98
			Spring 2008	15	8	11	21	3.61
			Fall 2008	13	7	9	22	2.47
			Spring 2009	15	8	11	21	3.33
			Fall 2009	21	10	11	27	3.41
			Spring 2010	14	7	10	20	3.21
			Fall 2010	16	8	8	24	3.47
			Spring 2011	17	8	10	29	3.66
			Fall 2011	20	9	9	30	3.28
			Spring 2012	17	8	11	28	3.38
			Fall 2012	17	7	9	27	3.15
			Spring 2013	16	8	12	27	3.56
			Fall 2013	16	5	7	19	3.92
12	Bent Creek	Buncombe	Spring 2005	15	7	9	8	n/a
			Fall 2005	16	9	8	20	2.86
			Spring 2006	17	11	8	18	2.95
			Fall 2006	17	8	9	28	2.87
			Spring 2007	22	11	11	24	2.69
			Fall 2007	13	7	7	23	3.27
			Spring 2008	17	10	10	24	3.45
			Fall 2008	14	8	10	19	2.39
			Spring 2009	*Not sampled*				
			Fall 2009	15	11	9	20	2.56
			Spring 2010	19	11	12	23	2.55
			Fall 2010	19	9	10	29	2.42
			Spring 2011	20	10	10	24	3.13
			Fall 2011	19	11	10	31	3.29
			Spring 2012	18	9	11	28	3.05
			Fall 2012	19	10	11	27	2.90
			Spring 2013	19	11	10	23	3.04
			Fall 2013	18	9	11	20	3.18

Table 7 (continued). Cumulative SMIE data (spring 2005 – fall 2013).

Site #	Site Description	County	Date	Taxa Richness	EPT Taxa Richness	VASOS Score	IWL Score	SMIE BI Score
13	Hominy Creek	Buncombe	Spring 2005	12	7	9	8	n/a
			Fall 2005	12	8	7	18	3.49
			Spring 2006	13	8	9	14	4.11
			Fall 2006	15	7	7	20	4.40
			Spring 2007	*Not sampled*				
			Fall 2007	12	8	6	17	3.98
			Spring 2008	15	7	10	28	3.57
			Fall 2008	18	10	7	23	4.00
			Spring 2009	18	10	9	19	4.22
			Fall 2009	16	7	9	19	3.19
			Spring 2010	15	8	11	15	4.32
			Fall 2010	18	8	7	25	3.53
			Spring 2011	17	7	9	25	3.57
			Fall 2011	20	9	8	34	4.66
			Spring 2012	15	7	10	23	3.46
			Fall 2012	13	6	7	23	4.56
			Spring 2013	15	7	11	17	4.17
			Fall 2013	12	7	6	11	3.64
14	Swannanoa River dws of Beetree Ck	Buncombe	Spring 2005	11	6	9	5	n/a
			Fall 2005	10	6	8	15	3.55
			Spring 2006	17	9	8	15	4.04
			Fall 2006	12	4	5	18	4.32
			Spring 2007	13	8	10	14	4.01
			Fall 2007	12	2	6	14	4.52
			Spring 2008	17	8	9	25	4.04
			Fall 2008	16	6	7	22	4.30
			Spring 2009	12	6	9	15	5.11
			Fall 2009	16	7	7	18	4.40
			Spring 2010	19	11	9	15	3.97
			Fall 2010	16	7	7	23	4.28
			Spring 2011	11	6	9	16	4.57
			Fall 2011	10	3	5	16	4.31
			Spring 2012	9	5	9	14	4.38
			Fall 2012	15	6	7	22	4.60
			Spring 2013	11	8	9	9	4.83
			Fall 2013	17	11	7	20	3.61
15	Swannanoa River ups of Bull Ck	Buncombe	Spring 2005	13	9	9	13	n/a
			Fall 2005	11	4	7	14	4.27
			Spring 2006	17	6	6	21	4.71
			Fall 2006	13	4	5	8	4.81
			Spring 2007	16	6	9	8	4.46
			Fall 2007	14	4	5	23	4.35
			Spring 2008	17	5	11	31	4.81
			Fall 2008	15	3	5	21	5.39
			Spring 2009	13	6	10	16	4.59
			Fall 2009	19	7	7	25	4.40
			Spring 2010	14	7	10	25	3.79
			Fall 2010	12	4	3	18	4.73
			Spring 2011	15	6	10	23	3.71
			Fall 2011	13	6	6	18	5.21
			Spring 2012	17	6	9	25	4.01
			Fall 2012	16	6	3	22	4.42
			Spring 2013	15	8	11	20	4.41
			Fall 2013	13	8	6	15	3.88
16	Smith Mill Creek	Buncombe	Spring 2009	10	3	5	13	6.50
			Fall 2009	*Not sampled*				
			Spring 2010	9	5	7	9	5.77
			Fall 2010	*Not sampled*				
			Spring 2011	*Not sampled*				
			Fall 2011	8	3	10	14	4.69
			Spring 2012	9	2	9	14	6.08
			Fall 2012	9	4	10	13	4.41
			Spring 2013	8	3	10	10	4.65
			Fall 2013	10	5	8	19	4.26
17	Reed Creek at Asheville Bot Gardens	Buncombe	Spring 2005	10	7	9	9	n/a
			Fall 2005	7	2	5	16	5.14
			Spring 2006	14	3	5	18	5.30

Table 7 (continued). Cumulative SMIE data (spring 2005 – fall 2013).

Site #	Site Description	County	Date	Taxa Richness	EPT Taxa Richness	VASOS Score	IWL Score	SMIE BI Score
17	Reed Creek at Bot Gardens (continued)	Buncombe	Fall 2006	7	3	6	10	3.94
			Spring 2007	*Not sampled*				
			Fall 2007	9	3	9	17	4.67
			Spring 2008	10	2	6	13	4.82
			Fall 2008	8	2	6	13	5.35
			Spring 2009	9	1	8	8	4.96
			Fall 2009	10	3	4	19	6.14
			Spring 2010	12	5	10	16	4.88
			Fall 2010	16	5	5	19	5.08
			Spring 2011	14	5	6	17	4.49
			Fall 2011	14	3	9	25	4.64
			Spring 2012	11	5	9	17	3.77
			Fall 2012	10	3	8	20	4.54
			Spring 2013	15	5	9	20	4.83
			Fall 2013	11	3	7	14	4.65
18	Lower Newfound Creek	Buncombe	Fall 2005	17	7	6	20	4.13
			Spring 2006	18	7	7	19	4.27
			Fall 2006	18	6	8	25	4.32
			Spring 2007	*Not sampled*				
			Fall 2007	11	4	7	13	4.33
			Spring 2008	19	7	9	17	4.29
			Fall 2008	15	4	5	21	4.49
			Spring 2009	16	6	6	18	4.03
			Fall 2009	15	5	5	16	4.76
			Spring 2010	9	5	6	11	4.84
			Fall 2010	11	4	3	9	4.63
			Spring 2011	*Not sampled*				
			Fall 2011	8	3	6	9	4.15
			Spring 2012	11	6	8	15	3.86
			Fall 2012	13	4	7	21	4.25
			Spring 2013	16	6	6	20	4.17
			Fall 2013	11	4	5	15	4.54
19	Reems Creek	Buncombe	Fall 2007	17	8	11	32	3.23
			Spring 2008	18	11	12	24	3.28
			Fall 2008	18	10	11	23	2.97
			Spring 2009	13	8	11	25	2.63
			Fall 2009	18	9	10	31	3.64
			Spring 2010	20	10	12	22	3.06
			Fall 2010	*Not sampled*				
			Spring 2011	15	8	12	27	2.77
			Fall 2011	18	8	11	29	3.11
			Spring 2012	22	12	12	28	3.09
			Fall 2012	17	9	11	27	3.31
			Spring 2013	16	9	10	23	3.59
			Fall 2013	17	8	9	16	3.56
20	Sandymush Creek	Buncombe	Fall 2005	12	6	6	19	3.87
			Spring 2006	14	6	7	12	4.40
			Fall 2006	13	7	8	16	4.25
			Spring 2007	*Not sampled*				
			Fall 2007	15	8	6	18	5.08
			Spring 2008	15	7	10	16	3.62
			Fall 2008	15	8	8	18	4.12
			Spring 2009	14	7	10	18	3.56
			Fall 2009	21	11	8	26	3.56
			Spring 2010	17	8	10	20	3.47
			Fall 2010	16	6	6	28	4.26
			Spring 2011	*Not sampled*				
			Fall 2011	17	7	7	14	4.48
			Spring 2012	15	8	9	16	3.70
			Fall 2012	15	7	10	25	4.45
			Spring 2013	14	6	10	19	3.68
			Fall 2013	15	9	7	20	4.37
21	California Creek at Radford Rd	Madison	Spring 2005	13	6	8	7	n/a
			Fall 2005	16	8	7	22	4.00
			Spring 2006	16	6	10	22	3.92
			Fall 2006	12	5	9	20	4.11
			Spring 2007	*Not sampled*				

Table 7 (continued). Cumulative SMIE data (spring 2005 – fall 2013).

Site #	Site Description	County	Date	Taxa Richness	EPT Taxa Richness	VASOS Score	IWL Score	SMIE BI Score
21	California Creek at Radford Rd (continued)	Madison	Fall 2007	11	6	8	11	3.91
			Spring 2008	17	8	11	24	3.69
			Fall 2008	16	7	7	25	3.77
			Spring 2009	17	6	11	31	3.62
			Fall 2009	16	8	9	28	3.14
			Spring 2010	17	7	12	27	3.77
			Fall 2010	*Not sampled*				
			Spring 2011	10	5	11	12	3.37
			Fall 2011	18	8	10	29	3.87
			Spring 2012	12	9	12	19	3.39
			Fall 2012	15	9	10	21	3.11
			Spring 2013	12	9	10	15	3.30
			Fall 2013	13	5	8	26	3.45
22	California Creek at Beech Glenn	Madison	Fall 2011	18	8	7	22	4.01
			Spring 2012	16	6	11	24	4.09
			Fall 2012	17	7	10	28	4.00
			Spring 2013	11	5	10	20	4.50
			Fall 2013	14	6	7	25	3.77
23	East Fork of Bull Creek	Madison	Spring 2009	17	8	12	25	3.40
			Fall 2009	18	8	9	25	3.11
			Spring 2010	19	10	12	31	3.63
			Fall 2010	*Not sampled*				
			Spring 2011	*Not sampled*				
			Fall 2011	16	9	9	22	2.88
			Spring 2012	16	10	12	22	3.27
			Fall 2012	17	9	10	28	3.17
			Spring 2013	17	10	10	23	3.25
			Fall 2013	21	11	9	25	3.25
24	Little Ivy River at Forks of Ivy	Buncombe	Spring 2005	13	5	9	10	n/a
			Fall 2005	11	5	7	18	4.11
			Spring 2006	16	8	12	21	3.52
			Fall 2006	13	4	10	17	4.00
			Spring 2007	12	5	11	17	3.52
			Fall 2007	15	6	7	24	4.08
			Spring 2008	13	6	9	17	4.05
			Fall 2008	14	5	10	16	3.95
			Spring 2009	18	7	10	25	4.10
			Fall 2009	12	4	10	20	5.10
			Spring 2010	*Not sampled*				
			Fall 2010	17	7	8	33	4.22
			Spring 2011	15	5	11	22	3.45
			Fall 2011	13	7	8	19	4.19
			Spring 2012	15	6	12	20	3.49
			Fall 2012	15	7	10	23	3.63
			Spring 2013	11	5	11	15	3.36
			Fall 2013	17	8	7	26	3.68
25	Big Ivy River at Forks of Ivy	Madison	Spring 2005	17	7	9	11	n/a
			Fall 2005	17	7	7	26	4.00
			Spring 2006	14	8	9	22	3.22
			Fall 2006	8	3	12	16	3.88
			Spring 2007	13	6	12	11	3.55
			Fall 2007	18	8	6	17	3.98
			Spring 2008	15	7	9	23	3.86
			Fall 2008	18	7	7	22	3.91
			Spring 2009	15	8	10	19	3.55
			Fall 2009	10	6	11	18	2.84
			Spring 2010	17	9	10	26	3.74
			Fall 2010	13	6	7	20	4.14
			Spring 2011	12	5	10	18	3.38
			Fall 2011	12	5	7	13	4.08
			Spring 2012	12	6	11	19	3.31
			Fall 2012	17	9	9	27	3.74
			Spring 2013	12	8	11	11	3.13
			Fall 2013	15	10	8	21	3.24
26	Shelton Laurel Creek	Madison	Spring 2006	24	13	11	15	3.55
			Fall 2006	19	11	9	30	2.47
			Spring 2007	19	9	12	23	3.26

Table 7 (continued). Cumulative SMIE data (spring 2005 – fall 2013).

Site #	Site Description	County	Date	Taxa Richness	EPT Taxa Richness	VASOS Score	IWL Score	SMIE BI Score
26	Shelton Laurel Creek (continued)	Madison	Fall 2007	20	10	11	23	3.72
			Spring 2008	22	12	10	31	3.53
			Fall 2008	18	10	12	22	3.19
			Spring 2009	21	10	12	21	3.42
			Fall 2009	21	12	11	25	3.24
			Spring 2010	17	10	9	22	3.35
			Fall 2010	15	8	12	28	3.78
			Spring 2011	19	13	12	23	3.66
			Fall 2011	12	6	9	25	3.78
			Spring 2012	23	14	11	25	3.73
			Fall 2012	18	8	10	28	3.78
			Spring 2013	15	5	11	23	3.66
			Fall 2013	16	10	10	26	3.42
27	Puncheon Fork Creek	Madison	Fall 2007	11	9	11	17	2.47
			Spring 2008	17	10	9	18	3.56
			Fall 2008	17	10	11	21	3.09
			Spring 2009	17	9	10	23	3.40
			Fall 2009	15	10	8	22	3.34
			Spring 2010	17	10	10	24	3.27
			Fall 2010	*Not sampled*				
			Spring 2011	11	8	10	15	2.87
			Fall 2011	14	9	12	17	3.23
			Spring 2012	19	12	8	20	3.46
			Fall 2012	15	8	12	22	3.38
			Spring 2013	14	7	10	19	3.09
			Fall 2013	11	8	8	17	3.03
28	Big Laurel Creek	Madison	Fall 2005	18	11	8	25	3.47
			Spring 2006	18	10	12	25	3.38
			Fall 2006	16	9	11	19	2.53
			Spring 2007	17	9	12	16	3.19
			Fall 2007	15	10	11	20	3.04
			Spring 2008	17	10	11	28	3.43
			Fall 2008	14	7	9	14	3.78
			Spring 2009	11	6	12	13	3.34
			Fall 2009	16	9	12	24	3.44
			Spring 2010	16	9	11	20	3.04
			Fall 2010	13	7	12	21	3.61
			Spring 2011	10	7	11	14	3.53
			Fall 2011	15	8	12	19	3.96
			Spring 2012	17	9	10	23	3.42
			Fall 2012	14	7	12	18	3.76
			Spring 2013	12	6	10	18	3.46
			Fall 2013	11	6	8	15	3.77
29	Cane Creek at Bakersville	Mitchell	Spring 2008	21	9	12	24	2.83
			Fall 2008	12	7	11	18	3.85
			Spring 2009	14	7	10	25	3.36
			Fall 2009	17	7	12	25	3.38
			Spring 2010	17	6	10	28	3.42
			Fall 2010	18	10	9	21	3.95
			Spring 2011	13	6	10	21	3.38
			Fall 2011	13	7	10	22	3.83
			Spring 2012	19	7	12	28	3.46
			Fall 2012	15	9	10	21	2.93
			Spring 2013	17	10	10	25	3.19
			Fall 2013	*Not sampled*				
30	North Toe River	Mitchell	Spring 2009	12	6	9	15	4.90
			Fall 2009	*Not sampled*				
			Spring 2010	15	5	8	21	4.06
			Fall 2010	18	0.9	7	25	4.11
			Spring 2011	15	8	12	25	3.64
			Fall 2011	15	6	8	31	4.07
			Spring 2012	15	6	7	21	4.99
			Fall 2012	17	7	5	29	4.28
			Spring 2013	19	8	9	26	4.36
			Fall 2013	*Not sampled*				

Table 7 (continued). Cumulative SMIE data (spring 2005 – fall 2013).

Site #	Site Description	County	Date	Taxa Richness	EPT Taxa Richness	VASOS Score	IWL Score	SMIE BI Score
31	Cane River	Yancey	Fall 2008	15	6	8	18	4.12
			Spring 2009	12	7	9	16	4.21
			Fall 2009	*Not sampled*				
			Spring 2010	19	11	10	24	3.09
			Fall 2010	15	7	11	25	5.29
			Spring 2011	18	8	10	28	3.69
			Fall 2011	18	7	9	27	
			Spring 2012	22	11	9	30	3.20
			Fall 2012	21	10	9	24	3.19
			Spring 2013	21	11	10	21	2.98
			Fall 2013	*Not sampled*				
32	Cataloochee Creek	Haywood	Spring 2012	12	8	10	16	3.22
			Fall 2012	18	12	10	19	2.25
			Spring 2013	*Not sampled*				
			Fall 2013	14	9	9	18	2.99
33	Swannanoa River at Nature Center	Buncombe	Fall 2012	17	10	7	22	3.88
			Discontinued					
34	Nasty Branch	Buncombe	Fall 2012	3	1	2	5	6.35
			Spring 2013	5	1	4	7	6.68
			Fall 2013	10	3	5	17	5.63
62	Swannanoa River at Flat Creek	Buncombe	Spring 2013	13	8	10	17	3.90
			Fall 2013	17	9	10	22	2.88
63	Swannanoa River at Blk Mtn Rec Park	Buncombe	Spring 2011					4.05
			Spring 2013	11	6	11	16	3.49
			Fall 2013	14	7	6	18	4.05
64	Swannanoa River at Kearfott	Buncombe	Spring 2013	14	9	11	17	3.66
			Fall 2013	13	6	6	22	4.06
35	Green River at Bobs Creek Road	Henderson	Spring 2009	11	8	9	12	n/a
			Fall 2009	13	8	10	19	n/a
			Spring 2010	12	7	9	16	3.27
			Fall 2010	16	11	10	19	4.05
			Spring 2011	17	10	10	24	3.49
			Fall 2011	15	8	10	24	3.05
			Spring 2012	21	11	10	24	3.30
			Fall 2012	19	11	9	27	4.09
			Spring 2013	17	11	10	24	2.72
			Fall 2013	18	12	10	21	2.71
36	Rock Creek	Henderson	Spring 2009	15	11	8	17	n/a
			Fall 2009	13	6	10	19	n/a
			Spring 2010	22	14	10	26	3.16
			Fall 2010	18	9	6	27	3.81
			Spring 2011	15	9	10	15	3.44
			Fall 2011	17	10	10	22	3.00
			Spring 2012	20	11	10	26	3.20
			Fall 2012	18	10	9	26	4.15
			Spring 2013	19	12	10	19	2.92
			Fall 2013	18	8	10	32	3.64
37	Green River at Terry's Creek Road	Henderson	Spring 2009	9	6	10	18	n/a
			Fall 2009	8	4	9	10	n/a
			Spring 2010	21	12	9	28	3.16
			Fall 2010	15	9	9	24	4.35
			Spring 2011	23	13	7	23	3.37
			Fall 2011	9	4	9	9	5.20
			Spring 2012	14	6	9	14	4.20
			Fall 2012	13	5	9	12	4.54
			Spring 2013	17	11	10	12	3.64
			Fall 2013	16	8	8	19	4.34
38	Green River below Lake Summit	Henderson	Spring 2009	7	2	5	14	n/a
			Fall 2009	13	7	9	23	n/a
			Spring 2010	11	8	6	13	n/a
			Fall 2010	11	5	8	18	n/a
			Discontinued					
39	Big Hungry River upstream	Henderson	Spring 2009	12	7	10	18	n/a
			Fall 2009	12	7	9	10	n/a
			Spring 2010	20	12	8	21	3.43
			Fall 2010	14	8	12	17	3.81
			Spring 2011	11	5	11	18	n/a

Table 7 (continued). Cumulative SMIE data (spring 2005 – fall 2013).

Site #	Site Description	County	Date	Taxa Richness	EPT Taxa Richness	VASOS Score	IWL Score	SMIE BI Score
39	Big Hungry River upstream (continued)	Henderson	Fall 2011	13	7	12	19	2.87
			Spring 2012	20	13	11	26	3.01
			Fall 2012	16	8	9	31	3.91
			Spring 2013	16	10	10	22	3.45
			Fall 2013	14	9	10	22	3.00
40	Little Hungry River	Henderson	Spring 2009	15	8	12	21	n/a
			Fall 2009	12	9	8	16	n/a
			Spring 2010	16	8	8	24	n/a
			Fall 2010	12	5	11	23	n/a
			Spring 2011	15	8	11	18	n/a
			Discontinued					
41	Big Hungry River downstream	Henderson	Spring 2009	15	11	9	17	n/a
			Fall 2009	9	5	10	9	n/a
			Spring 2010	17	8	9	25	3.51
			Fall 2010	13	7	10	16	2.62
			Spring 2011	20	11	10	29	n/a
			Fall 2011	15	8	10	24	2.90
			Spring 2012	15	10	12	20	2.61
			Fall 2012	17	10	11	28	3.12
			Spring 2013	20	11	10	23	3.07
			Fall 2013	16	11	10	15	2.56
42	Big Willow Creek	Henderson	Spring 2009	12	6	9	20	n/a
			Fall 2009	10	5	7	7	n/a
			Spring 2010	13	8	10	18	n/a
			Fall 2010	12	5	7	19	n/a
			Discontinued					
43	Little Willow	Henderson	Spring 2009	6	4	8	8	n/a
			Fall 2009	7	4	8	5	n/a
			Spring 2010	17	9	10	23	3.58
			Fall 2010	4	2	10	9	6.02
			Spring 2011	12	7	10	17	3.96
			Fall 2011	8	4	9	12	4.11
			Spring 2012	6	4	10	6	4.18
			Fall 2012	*Not sampled*				
			Spring 2013	5	4	10	3	3.30
			Fall 2013	12	8	8	8	4.17
44	Gash Creek	Henderson	Spring 2009	8	3	6	9	n/a
			Fall 2009	6	3	7	8	n/a
			Spring 2010	9	4	7	11	n/a
			Fall 2010	4	2	6	6	n/a
			Spring 2011	8	2	6	15	n/a
			Fall 2011	6	2	5	6	n/a
			Discontinued					
45	Shaw Creek	Henderson	Spring 2009	9	4	10	11	n/a
			Fall 2009	9	1	7	12	n/a
			Spring 2010	12	6	9	13	4.73
			Fall 2010	7	3	8	11	4.32
			Spring 2011	10	3	10	15	3.81
			Fall 2011	8	3	7	12	4.82
			Spring 2012	5	3	10	6	5.25
			Fall 2012	11	6	9	13	4.47
			Spring 2013	10	7	10	12	3.95
			Fall 2013	15	10	9	13	5.20
46	Mill Pond Creek	Henderson	Spring 2009	5	2	6	6	n/a
			Fall 2009	12	3	10	18	n/a
			Spring 2010	8	4	6	6	6.00
			Fall 2010	11	3	5	10	5.34
			Spring 2011	5	1	6	4	n/a
			Fall 2011	4	0	2	2	8.56
			Spring 2012	13	5	6	11	5.79
			Fall 2012	10	3	9	15	4.74
			Spring 2013	12	5	7	15	5.13
			Fall 2013	9	5	8	14	3.31
47	Boylston Creek	Henderson	Spring 2009	12	5	7	22	n/a
			Fall 2009	9	2	6	10	n/a
			Spring 2010	12	7	10	16	4.82
			Fall 2010	11	4	7	10	5.20

Table 7 (continued). Cumulative SMIE data (spring 2005 – fall 2013).

Site #	Site Description	County	Date	Taxa Richness	EPT Taxa Richness	VASOS Score	IWL Score	SMIE BI Score
47	Boylston Creek (continued)	Henderson	Spring 2011	6	4	10	9	n/a
			Fall 2011	9	3	6	14	4.69
			Spring 2012	8	5	10	12	4.27
			Fall 2012	7	3	9	8	5.19
			Spring 2013	8	2	6	8	5.96
			Fall 2013	11	5	9	12	5.34
48	North Fork Mills River	Henderson	Spring 2009	11	7	10	16	n/a
			Fall 2009	11	7	10	15	n/a
			Spring 2010	14	11	10	16	2.79
			Fall 2010	10	5	7	17	4.55
			Spring 2011	15	11	10	18	2.36
			Fall 2011	18	10	10	24	2.89
			Spring 2012	21	15	10	17	2.77
			Fall 2012	19	10	8	25	4.19
			Spring 2013	16	11	9	21	2.58
			Fall 2013	9	5	10	15	5.00
49	South Fork Mills River	Henderson	Spring 2009	10	6	11	12	n/a
			Fall 2009	14	8	12	16	n/a
			Spring 2010	13	10	10	12	2.04
			Fall 2010	12	7	11	15	3.39
			Spring 2011	11	9	10	9	2.12
			Fall 2011	14	7	12	18	3.70
			Spring 2012	15	9	10	10	3.23
			Fall 2012	21	10	12	30	3.96
			Spring 2013	14	9	10	16	2.00
			Fall 2013	11	5	8	11	3.41
50	Mills River at Davenport Bridge	Henderson	Spring 2009	10	5	10	10	n/a
			Fall 2009	8	5	9	9	n/a
			Spring 2010	12	6	10	15	n/a
			Fall 2010	12	6	7	18	n/a
			Discontinued					
51	Mills River at Hooper's Lane	Henderson	Spring 2009	12	6	10	12	n/a
			Fall 2009	7	5	8	5	n/a
			Spring 2010	12	6	10	16	3.50
			Fall 2010	11	5	6	17	4.40
			Spring 2011	15	9	10	17	n/a
			Fall 2011	13	9	6	13	4.56
			Spring 2012	13	9	10	13	3.49
			Fall 2012	13	9	10	14	3.51
			Spring 2013	17	8	10	19	4.12
			Fall 2013	12	6	10	10	5.05
52	Mud Creek at Berea Church Road	Henderson	Spring 2009	11	6	10	15	n/a
			Fall 2009	9	4	9	13	n/a
			Spring 2010	15	9	12	21	3.47
			Fall 2010	8	3	8	5	6.04
			Spring 2011	13	7	12	21	3.79
			Fall 2011	4	1	6	7	5.93
			Spring 2012	9	5	11	14	3.43
			Fall 2012	9	2	6	9	4.96
			Spring 2013	10	6	10	17	4.26
			Fall 2013	10	5	6	15	5.98
53	Mud Creek at 7th Avenue	Henderson	Spring 2009	6	3	6	6	n/a
			Fall 2009	6	2	10	13	n/a
			Spring 2010	10	4	10	13	3.35
			Fall 2010	10	3	6	10	4.89
			Spring 2011	8	3	5	16	n/a
			Fall 2011	9	3	6	14	4.56
			Spring 2012	9	3	10	6	5.29
			Fall 2012	11	5	8	8	4.20
			Spring 2013	13	7	9	12	3.94
			Fall 2013	9	4	8	10	5.13
54	Brittain Creek	Henderson	Spring 2009	5	2	10	9	n/a
			Fall 2009	6	2	7	13	n/a
			Spring 2010	10	4	10	18	5.12
			Fall 2010	10	3	8	15	4.08
			Spring 2011	7	2	9	14	5.30
			Fall 2011	8	2	9	18	4.69

Table 7 (continued). Cumulative SMIE data (spring 2005 – fall 2013).

Site #	Site Description	County	Date	Taxa Richness	EPT Taxa Richness	VASOS Score	IWL Score	SMIE BI Score
54	Brittain Creek (continued)	Henderson	Spring 2012	6	2	9	10	5.11
			Fall 2012	7	3	8	11	4.39
			Spring 2013	9	2	8	15	5.40
			Fall 2013	9	2	6	14	5.09
55	Clear Creek at Bearwallow Road	Henderson	Fall 2009	15	8	9	22	n/a
			Spring 2010	12	6	10	14	3.47
			Fall 2010	16	8	6	24	5.50
			Spring 2011	18	7	10	19	3.78
			Fall 2011	12	4	11	23	3.97
			Spring 2012	15	7	10	16	4.20
			Fall 2012	22	11	6	24	4.14
			Spring 2013	13	7	10	17	3.69
			Fall 2013	9	4	9	11	5.88
56	Clear Creek at Gilliam Road	Henderson	Spring 2011	7	4	10	9	n/a
			Fall 2011	13	5	6	16	n/a
			Discontinued					
57	Clear Creek at Lancaster Road	Henderson	Spring 2009	11	6	9	11	n/a
			Fall 2009	13	5	7	27	n/a
			Spring 2010	16	7	9	23	n/a
			Fall 2010	13	6	7	15	n/a
			Discontinued					
58	Clear Creek at Nix Road	Henderson	Spring 2009	16	7	6	16	n/a
			Fall 2009	9	3	4	15	n/a
			Spring 2010	9	4	8	12	4.24
			Fall 2010	13	6	8	23	4.83
			Spring 2011	10	3	7	12	5.18
			Fall 2011	10	3	7	15	5.89
			Spring 2012	16	8	6	18	5.00
			Fall 2012	12	5	9	21	5.45
			Spring 2013	14	6	9	19	4.03
			Fall 2013	8	3	5	16	5.47
59	Hooper's Creek	Henderson	Spring 2009	11	4	n/a	n/a	n/a
			Fall 2009	7	4	n/a	n/a	n/a
			Spring 2010	16	10	9	20	4.27
			Fall 2010	17	6	8	24	5.22
			Spring 2011	9	5	8	8	4.47
			Fall 2011	16	5	x	x	3.92
			Spring 2012	13	6	10	21	3.35
			Fall 2012	10	4	7	9	4.94
			Spring 2013	14	8	10	17	4.18
			Fall 2013	13	8	7	15	5.17
60	Cane Creek at Howard Gap	Henderson	Spring 2009	10	5	10	7	n/a
			Fall 2009	8	3	7	9	n/a
			Spring 2010	13	7	10	14	3.84
			Fall 2010	9	2	6	9	5.53
			Spring 2011	7	4	9	11	4.19
			Fall 2011	14	5	10	16	4.69
			Spring 2012	11	6	9	11	5.12
			Fall 2012	8	4	10	13	4.70
			Spring 2013	8	5	7	4	4.62
			Fall 2013	7	4	9	8	4.92
61	Uncle's Creek	Henderson	Fall 2012	13	8	12	19	3.57
			Spring 2013	19	9	10	21	3.00
			Fall 2013	15	8	9	20	2.35

What do the scores mean?

Taxa Richness: the higher the better (total of 43 possible)

EPT Taxa Richness: the higher the better (total of 19 possible)

VASOS Score: *Acceptable* 7-12; *Unacceptable* 0-6

IWL 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.

SMIE Biotic Index: *Excellent* <2.00-3.09; *Good* 3.10-3.56; *Good-Fair* 3.57-4.10; *Fair* 4.11-5.21; *Poor* 5.22-7.00+

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Appendix A. SMIE biological monitoring data sheet (invertebrate identification)

SMIE Biomonitoring Field ID Sheet

Stream: _____ **Nearby Road:** _____ **County:** _____ **Date:** _____

Group Leader: _____ **Volunteers:** _____ **Weather:** _____

			KICK NET	*Total*	LEAF PACK	*Total*	VISUAL	*Total*
		Tolerance Value*	**STONEFLY**					
1. Giant Shredder		*1.8*						
2. Roach Shredder		*1.3*						
3. Quick Crawling Predator		*1.3*						
4. Fragile Detritivore		*1.3*						
			MAYFLY					
5. Flattened Scraper		*4.0*						
6. Spiny Crawler		*3.4*						
7. Round Headed Swimmer		*4.3*						
8. Burrowing Mayfly		*4.0*						
9. Spiny Turtle Mayfly		*3.2*						
10. Filter Mayfly		*3.6*						
			CADDISFLY					
FREE LIVING	**11.** Net Spinner Caddis	*4.0*						
	12. Small Head Caddis	*1.5*						
ORGANIC CASES	**13.** Stick Bait Caddis	*2.5*						
	14. Square Log Cabin	*2.2*						
	15. Sand and Stick	*4.0*						
	16. Vegetative Case	*2.9*						
MINERAL CASES	**17.** Gravel Coffin Case	*0.8*						
	18. Sand Snail Case	*0.0*						
	19. Sand/ Mineral Case	*2.6*						
			BEETLES					
20. Water Penny		*2.3*						
21. Predator Beetle		*6.4*						
22. Adult Riffle Beetle		*4.5*						
23. Larval Riffle Beetle		*3.2*						
			MEGALOPTERAN					
24. Hellgrammite		*5.2*						
25. Fishfly		*5.3*						
26. Alderfly		*7.0*						
27. Oligochaete		*7.0*						
			DIPTERAN					
28. Leech		*7.1*						
29. Watersnipe		*1.8*						
30. Water-worm		*7.5*						
31. Fat-headed Cranefly		*3.5*						
32. Chironomid Midge		*6.0*						
33. Red Midge		*9.3*						
34. Blackfly		*4.9*						
			CRUSTACEANS					
35. Crayfish		*6.0*						
36. Sowbug (Isopod)		*7.4*						
37. Scud (Amphipod)		*7.2*						
			SNAILS					
38. Coiled Left Face Snail		*8.7*						
39. Coiled Right Face Snail		*5.6*						
40. Rounded Right Face Snail		*6.6*						
			BIVAVLES					
41. Mussels and Clams		*5.3*						
			ODONATES					
42. Damselfly		*7.0*						
43. Dragonfly		*4.0*						

Total Kicknet #:		**Total Leafpack #:**	

Please write NOTES on the back, (e.g. if you collected more than one sample, if you preserved the samples, if you threw out some specimens in the preserved sample, etc)

Tolerance values range from 0 to 10, with 0 representing the most sensitive taxa and 10 representing the most tolerant taxa.

Appendix B. EQI's habitat data sheet

SMIE Habitat Sheet

Stream: _____ Nearby Road: _____ County: _____ Date: _____

Group Leader: _____ Volunteers: _____ Weather: _____

Habitat Characteristics *(Circle or place a check next to all that applies, unless otherwise instructed)*

1. Fish Presence

- □ None Observed
- Fishes Observed (1-10 11-50 51-100)
- □ Minnows/small fishes
- □ Sunfish, catfish and/or bass
- □ Trout or sculpin

2. Barriers to Fish Movement

- □ No barriers
- □ Waterfall
- □ Beaver pond or lake
- □ Culvert or pipe

3. Stream Characteristics

- □ Clear
- □ Oily
- □ Tea-colored
- □ Muddy
- □ Green
- □ Smelly - describe: _____

4. Leaf Packs

- □ No leaf packs found
- □ Leaf packs found within 10 feet
- □ Leaf packs found within 50 feet
- □ Leaf packs found more than 50 feet away

5. Stream Bottom (*and approximate percentages*)

- □ Gravel or cobblestones ____%
- □ Sand ____%
- □ Bedrock or boulders ____%
- □ Clay ____%
- □ Algae ____%
- □ Woody debris ____%

6. Riparian Zone Characteristics (and approximate percentage

- □ Mostly trees and shrubs ____%
- □ Grasses ____%
- □ Vines (e.g. kudzu) ____%
- □ Eroding stream bank ____%
- □ Rip-rap or construction fill ____%
- □ Exotic plant and tree species ____%
- □ Roads/parking lots ____%

7. Litter and Trash

- □ No trash or litter in water or along bank
- □ Trash or litter in water but not on bank
- □ Trash and litter in trees 1 foot above water surface
- □ Trash and litter in trees more than 1 foot above water surface

Types of trash: _____

8. Riffle Sampling Effort

- □ Rocks extremely embedded into riffle (very difficult or impossible to kick or disturb, sand filling spaces between rocks
- □ Rocks moderately embedded into riffle (removed with effort, less sand inspaces)
- □ Rocks loose in riffle, easy to manipulate

Notes (may include changes or descriptions of site):

We love pictures! Pics of the sampling sites, with or without volunteers, may be emailed to: amt@environmentalqualityinstitute.org.

Appendix C. ECO's habitat data sheet

WATER QUALITY SURVEY SHEET

County_____ **Date**_____ **GPS Coordinates**_____
Weather (last 24 hours) _____
Sampling Location (Road Name, River/Stream Name) _____
Water Quality Volunteers _____
Time Started: _____ **Time Finished:** _____ **Total Hours:** _____

VWIN and SMIE surveys are to be marked for the site only with the most common choice for each category.
Adopt-A-Stream surveys are to consider the full length of the waterway observed and may mark more than one choice.

STREAM CHARACTERISTICS

1. WATER APPEARANCE
___ Clear
___ Oily (colored sheen)
___ Tea-colored but clear
___ Muddy ____Green
___ Foamy ____ Milky
___ Black ____ Grey
Other _____

2. STREAM BOTTOM
(Check most common)
___ Gravel or cobblestone
___ Bedrock or boulders
___ Sand
___ Clay
___ Algae
___ Woody debris

3. RIFFLE PRESENCE
___ None ___ 1 to 5
___ 5 to 10 ___ Many

4. ALGAE PRESENCE
___ None ___ Spotty
___ Extensive

5. ALGAE COLOR/APPEARANCE
___ Light green
___ Dark green
___ Brown coated
___ Matted on stream bed
___ Hairy

6. ODOR
___ None ___ Rotten eggs
___ Musky ___ Oil
___ Sewage
Other _____

7. LEAF PACKS *(for SMIE only)*
___ None found
___ Found within 10 feet or less
___ Found within 50 feet
___ Found > than 50 feet

RIPARIAN ZONE

8. STREAMBANK VEGETATION
___ Mostly trees and shrubs
___ Grasses and vines
___ Eroding stream bank
___ Rip-rap or construction fills
___ Exotic plant and tree species
___ Natural rocks or boulders
Other _____

9. LITTER AND TRASH
___ None
___ Only in water
___ Only on banks
___ In water and on banks
___ In trees/brush ≤ 1 ft. above water surface
___ In trees/brush ≥ 1 ft above water surface

10. RIFFLE SAMPLING EFFORT
___ Rocks *extremely* embedded into riffles*
___ Rocks *moderately* embedded into riffles^
___ Rocks loose, easy to move

11. STREAM BANK SHADE
___ None
___ Some, but very little
___ Less than half
___ Half or more
___ Almost Total
___ Full shade

* Very difficult or impossible to disturb because sand is filling the spaces between rocks
^ Removed with effort because there is less sand in spaces

OTHER OBSERVATIONS

12. FISH PRESENCE
___ None observed
___ 1-10 scattered individuals
___ 11-50 scattered schools
___ 51-100
___ Minnows/small fishes
___ Sunfish, catfish, or sculpin
___ Trout or bass

13. BARRIERS TO FISH MOVEMENT
___ None
___ Waterfall(s) ≥ 1 ft.
___ Beaver pond or lake
___ Culvert or pipe
___ Man-made dam
Other _____

14. NEARBY LAND USE
(On both sides of streambanks)
___ Residential
___ Industrial
___ Agricultural
**Type of Ag.* _____
___ Commercial
___ Open/green space
___ Undeveloped
___ Parking lot(s) present
Other _____

15. NOTES & COMMENTS:
Indicate current and/or potential threats to stream health, possible pollution sources, and other comments. Also note any other wildlife observed.

_____
_____
_____
_____
_____
_____
_____
_____
_____
_____

TURN OVER TO TAKE MORE NOTES

Appendix D. SMIE Biotic Index tolerance values*

Taxa #	Group	SMIE Taxa Name	Tolerance Value
1	Plecoptera	Giant Shredder	1.8
2	Plecoptera	Roach Shredder	1.3
3	Plecoptera	Quick Crawling Predator	1.3
4	Plecoptera	Fragil Detritivores	1.3
5	Ephemeroptera	Flattened Scraper	4.0
6	Ephemeroptera	Spiney Crawler	3.4
7	Ephemeroptera	Round Headed Swimmer	4.3
8	Ephemeroptera	Burrowing mayflies	4.0
9	Ephemeroptera	Spiny Turtle	3.2
10	Ephemeroptera	Filter Mayfly	3.6
11	Trichoptera	Net Spinning Caddis	4.0
12	Trichoptera	Small Head Caddis	1.5
13	Trichoptera	Stick Bait Caddis	2.5
14	Trichoptera	Square Log Cabin Caddis	2.2
15	Trichoptera	Sand and Stick Case Caddis	4.0
16	Trichoptera	Vegetated Case Caddis	2.9
17	Trichoptera	Gravel Coffin Case Caddis	0.8
18	Trichoptera	Sand Snail Shell Caddis	0.0
19	Trichoptera	Sand and Mineral Case Caddis	2.6
20	Coleoptera	Water Penny	2.3
21	Coleoptera	Predator Beetle larvae	6.4
22	Coleoptera	Adult Riffle Beetles	4.5
23	Coleoptera	Larval Riffle Beetles	3.2
24	Megaloptera	Hellgrammite	5.2
25	Megaloptera	Fishfly	5.3
26	Megaloptera	Alderfly	7.0
27	Oligochaete	aquatic worms	7.0
28	Oligochaete	Leech	7.1
29	Diptera	Water Snipe	1.8
30	Diptera	Water Worm	7.5
31	Diptera	Fat Headed Cranefly	3.5
32	Diptera	Chironomid Midge	6.0
33	Diptera	Red Midge	9.3
34	Diptera	Blackfly	4.9
35	Crustacea	Crayfish	6.0
36	Crustacea	Sowbug (Isopod)	7.4
37	Crustacea	Scud (Amphipod)	7.2
38	Gastopoda	Coiled Left Face Snail	8.7
39	Gastopoda	Coiled Right Face Snail	5.6
40	Gastopoda	Rounded Right Face Snail	6.6
41	Pelecypoda	Mussels and Clams	5.3
42	Odonata	Damselflies	7.0
43	Odonata	Dragonflies	4.0

*Tolerance values: low scores = pollution sensitive, high scores = pollution tolerant