Biological Assessment Report

Cave Springs Branch
McDonald County, Missouri
Delaware County, Oklahoma

2013 – 2014

Prepared for:

Missouri Department of Natural Resources
Division of Environmental Quality
Water Protection Program
Water Pollution Control Branch

Prepared by:

Missouri Department of Natural Resources
Division of Environmental Quality
Environmental Services Program
Water Quality Monitoring Section

Table of Contents

Section Page

1.0 Introduction ... 1
1.1 Study Area/Justification ... 2
1.2 Objectives ... 3
1.3 Tasks ... 3
1.4 Null Hypotheses ... 3
2.0 Methods ... 5
2.1 Study Timing ... 5
2.2 Station Descriptions ... 5
2.2.1 Cave Springs Branch Bioassessment Sampling Stations ... 5
2.2.2 Candidate Reference Bioassessment Sampling Stations ... 5
2.3 MoRAP Aquatic Ecological Classification ... 7
2.3.1 Ecological Drainage Unit ... 7
2.3.2 Aquatic Ecological Systems ... 7
2.3.3 Valley Segment Types ... 11
2.4 Stream Habitat Assessment ... 13
2.5 Biological Assessment ... 13
2.5.1 Macroinvertebrate Collection and Analysis ... 13
2.6 Physicochemical Data Collection and Analysis ... 14
2.6.1 *In situ* Water Quality Measurements ... 14
2.6.2 Water Chemistry ... 14
2.7 Data Analysis and Quality Control ... 14
3.0 Results ... 14
3.1 Stream Habitat Assessment ... 14
3.2 Macroinvertebrate Biological Assessment ... 15
3.2.1 Semi-quantitative Macroinvertebrate Stream Bioassessment Project Procedure (SMSBPP) ... 15
3.2.1.1 Fall 2013 Sampling Season ... 15
3.2.1.2 Spring 2014 Sampling Season ... 18
3.2.2 Macroinvertebrate Percent and Community Composition ... 20
3.2.2.1 Fall 2013 Sampling Season ... 20
3.2.2.2 Spring 2014 Sampling Season ... 29
3.3 Physicochemical Data ... 37
3.3.1 Stream Discharge ... 37
3.3.2 Conductivity ... 37
3.3.3 Chloride ... 37
3.3.4 Sulfate ... 38
3.3.5 Nitrate + Nitrite-N ... 38
3.3.6 Total Nitrogen ... 38
3.3.7 Total Phosphorus ... 39
3.3.8 Turbidity ... 39
3.4 Quality Control ... 39
4.0 Discussion ... 42
4.1 Effect of Stream Size on MSCI Scores ... 42
4.2 Possible Water Quality Effects on the Biological Metrics ... 42
4.3 Functional Feeding and Habit Groups ... 44

4.4 Hydrology and Land Use 47
5.0 Conclusions 48
6.0 References Cited 50

Tables

Table 1 Percent Land Cover from MoRAP Thematic Mapper Satellite Data From 2000 to 2004 9
Table 2 Percent Land Cover from USGS GAP Analysis 10
Table 3 Physical Characteristics of the Sample Reaches for Cave Springs Branch and the Candidate Reference Streams Based on Values from the MoRAP Valley Segment Types (VST) Geographic Information Systems (GIS) Layer and Other GIS Sources 12
Table 4 Predominant Category Habitat Values, Category Habitat Scores, and Total Habitat Scores from Stream Habitat Assessments for the Ozark/Neosho Candidate Reference Sampling Stations and Cave Springs Branch Test Stations 16
Table 5 Fall 2013 Riffle/Pool Ozark/Neosho EDU Perennial/Wadeable Stream Biological Criteria, Biological Support Categories, Biological Metric Values and Scores Shown in Parentheses, and Macroinvertebrate Stream Condition Index (MSCI) Scores for the Candidate Reference and Cave Springs Branch Sampling Stations .. 17
Table 6 Fall 2013 Riffle/Pool Ozark/Neosho EDU Candidate Reference Stream Biological Criteria, Biological Support Categories, Biological Metric Values and Scores Shown in Parentheses, and Macroinvertebrate Stream Condition Index (MSCI) Scores for the Cave Springs Branch Sampling Stations 18
Table 7 Spring 2014 Riffle/Pool Ozark/Neosho EDU Stream Biological Criteria, Biological Support Categories, Biological Metric Values and Scores Shown in Parentheses, and Macroinvertebrate Stream Condition Index (MSCI) Scores for the Candidate Reference and Cave Springs Branch Sampling Stations .. 19
Table 8 Spring 2014 Riffle/Pool Ozark/Neosho EDU Candidate Reference Stream Biological Criteria, Biological Support Categories, Biological Metric Values and Scores Shown in Parentheses, and Macroinvertebrate Stream Condition Index (MSCI) Scores for the Cave Springs Branch Sampling Stations 20
Table 9 Biological Metric Values for Sensitive Taxa, Functional Feeding Groups (FFG), and Functional Habitat Groups (FHG) Metrics for the Biological Criteria Reference Samples, Candidate Reference Samples, and the Cave Springs Branch Test Stations, Fall 2013 22
Table 10 Percent EPTT and Dominant EPTT at the Cave Springs Branch Test Stations, Candidate Reference Stations, and the Ozark/Neosho EDU Biological Criteria Reference Samples, Fall 2013 26
Table 11 Percent Dominant Macroinvertebrate Families at the Cave Springs Branch Test Stations, Candidate Reference Stations, and the Ozark/Neosho EDU Biological Criteria Reference Samples, Fall 2013 27

Table 12 Percent Dominant Macroinvertebrate Taxa at the Cave Springs Branch Test Stations, Candidate Reference Stations, and the Ozark/Neosho EDU Biological Criteria Reference Samples, Fall 2013 28
Table 13 Biological Metric Values for Sensitive Taxa, Functional Feeding Groups (FFG), and Functional Habitat Groups (FHG) for the Biological Criteria Reference Samples, Candidate Reference Samples, and the Cave Springs Branch Test Stations, Spring 2014 .. 30
Table 14 Percent EPTT and Dominant EPTT at the Cave Springs Branch Test Stations, Candidate Reference Stations, and the Ozark/Neosho EDU Biological Criteria Reference Samples, Spring 2014 33
Table 15 Percent Dominant Macroinvertebrate Families at the Cave Springs Branch Test Stations, Candidate Reference Stations, and the Ozark/Neosho EDU Biological Criteria Reference Samples, Spring 2014 35
Table 16 Percent Dominant Macroinvertebrate Taxa at the Cave Springs Branch Test Stations, Candidate Reference Stations, and the Ozark/Neosho EDU Biological Criteria Reference Samples, Spring 2014 36
Table 17 Physicochemical Variables at the Cave Springs Branch Bioassessment Study Sampling Stations, Fall 2013 40
Table 18 Physicochemical Variables at the Cave Springs Branch Bioassessment Study Sampling Stations, Spring 2014 41

Figures

Figure 1 Map of Cave Springs Branch and Sampling Stations. 4
Figure 2 Location of Cave Springs Branch and the Candidate Reference Streams 6
Figure 3 Land Use of the Cave Springs Branch Watershed 8
Figure 4 Percent of Taxa by Biotic Index Range, Fall 2013 21
Figure 5 Percent of Taxa by Functional Feeding Group, Fall 2013 23
Figure 6 Percent of Taxa by Functional Habitat Group, Fall 2013 24
Figure 7 Percent of Taxa by Biotic Index Range, Spring 2014 29
Figure 8 Percent of Taxa by Functional Feeding Group, Spring 2014 31
Figure 9 Percent of Taxa by Functional Habitat Group, Spring 2014 32

Attachments

Appendix A Macroinvertebrate Bench Sheets for Cave Springs Branch and Candidate Reference Streams

1.0 Introduction

At the request of the Missouri Department of Natural Resources (**MDNR**) Water Protection Program (**WPP**), the Environmental Services Program (**ESP**) Water Quality Monitoring Section (**WQMS**) conducted a biological assessment of Cave Springs Branch. Cave Springs Branch is a tributary of Honey Creek, located in the Ozark/Neosho Ecological Drainage Unit (**EDU)** and originates near the town of Southwest City, Missouri, near the Missouri and Oklahoma state line. Cave Springs Branch flows west for 4 miles in Missouri and 3 miles in Delaware County, Oklahoma before it discharges into Honey Creek.

Although the stream reach in Missouri was previously not listed in the Missouri Water Quality Standards (MDNR 2012), it was assigned the water body identification number (**WBID**) 3245U-01 for the 2004-2006 303(d) List of Impaired Waters (MDNR 2010a). The stream reach is now included in the Missouri Water Quality Standards (MDNR 2014) and falls within the "Missouri Use Designation Dataset (**MUDD)** Version 1.0" as of August 20, 2013. Streams like Cave Spring Branch that were previously not included in the water quality standards did not have designated uses with numeric criteria assigned to them, but had to meet the narrative general criteria and acute toxicity criteria of Tables A and B in the Missouri Water Quality Standards (MDNR 2014). The downstream 0.2 miles of Cave Springs Branch in Missouri was added to the 1998 Missouri 303(d) list for nutrients and the Oklahoma 2008 303(d) list for sulfates, total dissolved solids, fecal coliform, *E. coli*, and chloride for the entire stream reach. Impaired designated uses in Oklahoma are Primary Body Recreation and Agriculture (OWRB 2013).

Cave Springs Branch is classified in Appendix A of Oklahoma's Water Quality Standards as a Cool Water Aquatic Community water body and a High Quality Water. The Cool Water Aquatic Community classification is defined as a water body with water quality, water temperature, and habitat that are adequate to support cool water climax fish communities and includes an environment suitable for the full range of cool water benthos (OWRB 2013). Typical species found in this classification may include smallmouth bass, certain darters, and stoneflies. The High Quality Water designation is given to water bodies whose historic water quality and physical habitat provide conditions suitable for the support of sensitive and intolerant climax communities of aquatic organisms whether or not that water body currently contains such a community, and support high levels of recreational opportunity. These water bodies will generally have higher quality habitat, a more diverse and more intolerant biotic community and, as a result, may provide more ecological refuges and recreational opportunities than other waters in the same ecoregion with similar chemistry and physical conditions.

The Simmons Foods, Inc. poultry processing plant wastewater treatment facility (NPDES permit number MO-0036773) discharges into a tributary of Cave Springs Branch near the Missouri and Oklahoma state line. According to the permit, the discharge from this point source has a design flow of 2.0 MGD (3.1 cfs) or the human population equivalent of 189,312.

1.1 Study Area/Justification

Cave Springs Branch suffered water quality problems in the 1990s due to malfunctions of the Simmons Foods, Inc. wastewater treatment facility (**WWTF**) (MDNR 2010a). Water quality problems that occurred at the facility included acutely toxic levels of ammonia and chronically high concentrations of nutrients (nitrogen and phosphorus) that led to excessive algal growth in Cave Springs Branch. The excessive algal growth in Cave Springs Branch led to water quality violations of the narrative general criteria. A dye trace study conducted in 1998 found that there was a hydrological connection between some storm water collection basins on Simmons Foods, Inc. property and two springs (Miller and O'Brien springs) that discharge into Cave Springs Branch (MDNR 2010a). By 1999, improvements at the WWTF had improved the water quality in Cave Springs Branch, including reductions of nutrient concentrations in the effluent. Although effluent quality has improved, the effluent, land application of poultry litter, and other agricultural practices in the watershed continue to contribute to elevated nutrient levels in Cave Springs Branch (MDNR 2010a).

A macroinvertebrate bioassessment study was conducted by GBMc & Associates in July and August of 2000 using the Rapid Bioassessment Protocol (**RBP**) III (Barbour et al. 1999) at three sampling stations on Cave Springs Branch (GBMc & Associates 2000). Sufficient differences between the RBP method and MDNR's Semi-quantitative Macroinvertebrate Stream Bioassessment Project Procedure (MDNR 2012) prevent direct comparison of RBP samples to Ozark/Neosho EDU biological criteria. Differences included the time of year that samples were collected, the macroinvertebrate target number (100 organisms for the RBP compared to 1200 for MDNR), and field (RBP) versus laboratory (MDNR) sample processing.

Results of the GBMc & Associates (2000) study found that the upstream station, located about 0.2 miles downstream of the Simmons Foods, Inc. outfall, was affected by organic enrichment or habitat degradation. The macroinvertebrate community was dominated by planarians, leeches, and chironomids, and no EPTT were found at the upstream sampling station. The other two sampling stations, located from about 1.5 to 2.5 miles downstream, showed a much more diverse and intolerant macroinvertebrate community, which indicated that the water quality was relatively improved at these sampling stations. The macroinvertebrate community at these downstream sampling stations included some EPTT taxa, and taxa tolerant of organic enrichment were much lower in abundance. This study will assess the current status of the macroinvertebrate community using MDNR protocols at three sampling stations at or near the sampling stations of the GBMc & Associates study (Figure 1).

Because Cave Springs Branch is much smaller than the reference stream segments used to calculate riffle/pool biological criteria for the Ozark/Neosho EDU, macroinvertebrate samples were assessed using two sets of criteria. Macroinvertebrate samples were first compared to the Ozark/Neosho EDU biological criteria for wadeable/perennial streams. The samples were then compared to candidate reference stream criteria that were

calculated from five streams that were similar in size to Cave Springs Branch. The Valley Segment Type (VST) five digit codes developed by the Missouri Resource Assessment Program (MORAP) were used in the selection of candidate reference stream segments for this study (Sowa et al. 2004). Candidate reference streams were chosen from a list of streams that had the same or a very similar five digit VST code as the Cave Springs Branch test stations and had little or no observable water quality problems in their watersheds. Candidate reference streams were chosen only after meeting the same requirements as biological criteria reference streams as described in *Biological Criteria for Wadeable/Perennial Streams of Missouri* (MDNR 2002).

1.2 Objectives

1) Assess the biological (macroinvertebrate) integrity of Cave Springs Branch downstream of the Simmons Foods, Inc. WWTF discharge.

2) Assess the water quality of Cave Springs Branch downstream of the Simmons Foods, Inc. WWTF discharge.

1.3 Tasks

1) Conduct a biological assessment at the sampling stations on Cave Springs Branch and the five candidate reference streams.

2) Conduct a stream habitat assessment at the sampling stations on Cave Springs Branch and the five candidate reference streams to ensure comparability of aquatic habitats.

3) Collect water samples and water quality field measurements at the sampling stations on Cave Springs Branch and the five candidate reference streams.

1.4 Null Hypotheses

1) The macroinvertebrate community will not differ among longitudinally separate reaches of Cave Springs Branch.

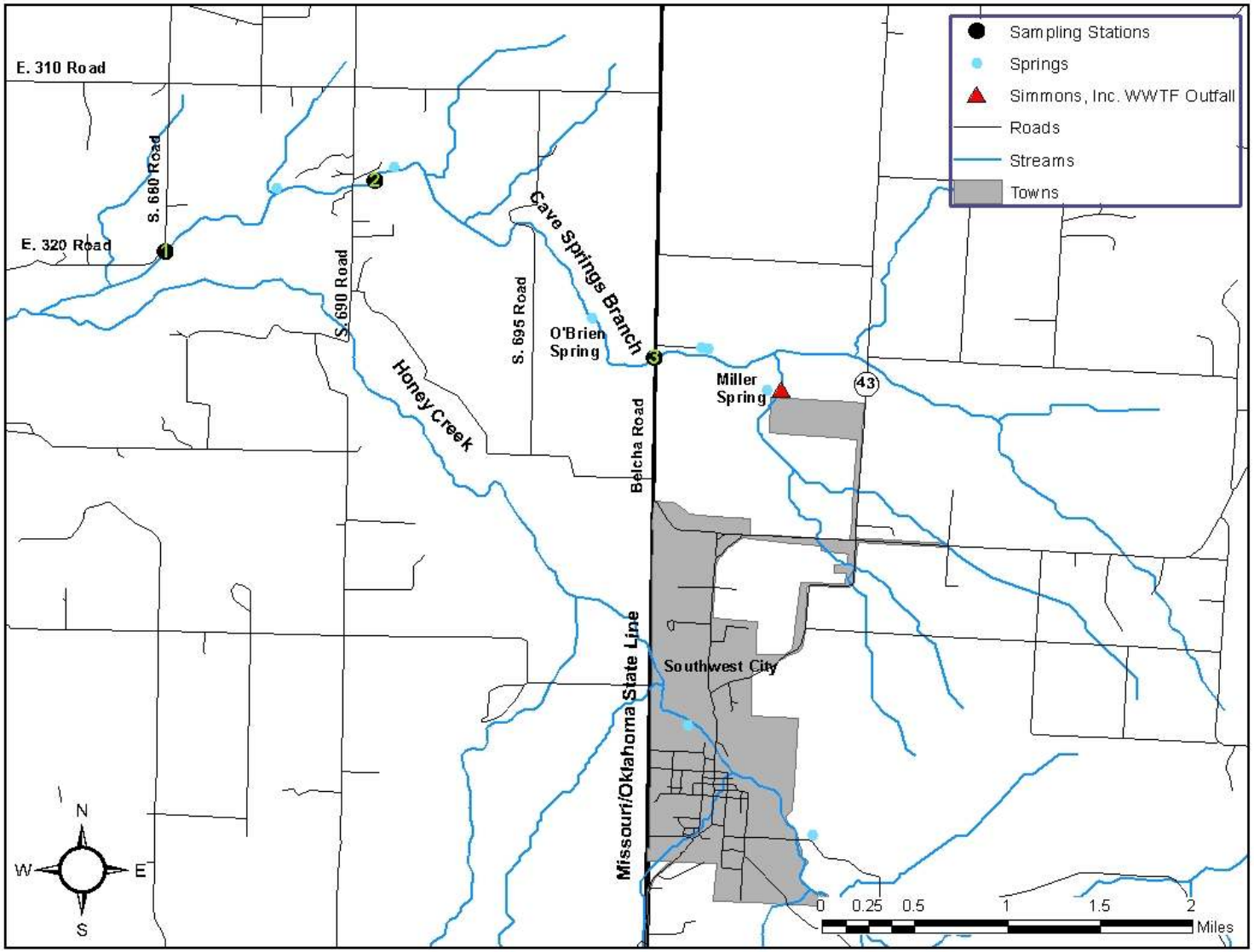
2) The macroinvertebrate assemblages in the Cave Springs Branch samples will be similar to the Ozark/Neosho EDU wadeable/perennial stream biological criteria.

3) The macroinvertebrate assemblages in the Cave Springs Branch samples will be similar to the Ozark/Neosho EDU candidate reference stream criteria.

4) Physicochemical water quality in Cave Springs Branch will meet the Water Quality Standards (**WQS**) of Missouri (MDNR 2014).

5) Physicochemical water quality will not differ among longitudinally separate reaches of Cave Springs Branch.

Figure 1
Map of Cave Springs Branch and Sampling Stations



2.0 Methods

Carl Wakefield, Brandy Bergthold, Mike Irwin, and Dave Michaelson of the MDNR, Division of Environmental Quality, ESP, WQMS, Aquatic Biological Assessment Unit conducted this study.

2.1 Study Timing

Macroinvertebrate and discrete water quality samples were collected during the fall 2013 and spring 2014 sampling seasons. Fall 2013 sampling was conducted on September 23-25, 2013, and spring 2014 sampling was conducted March 25-26, 2014.

2.2 Station Descriptions

The study area and sampling locations for the Cave Springs Branch bioassessment study are shown in Figures 1 and 2. A total of three Cave Springs Branch test stations and five candidate reference stations were surveyed for this study.

2.2.1 Cave Springs Branch Bioassessment Sampling Stations

Cave Springs Branch #1 – Delaware County, Oklahoma. Legal description was SW ¼, Sec. 17, T. 24 N., R. 25 E. Geographic coordinates were UTM zone 15, 0350940 Easting, 4046840 Northing. The station was located upstream of East 320 Road.

Cave Springs Branch #2 – Delaware County, Oklahoma. Legal description was SW ¼, Sec. 16, T. 24 N., R. 25 E. Geographic coordinates were UTM zone 15, 0352769 Easting, 4047468 Northing. The station was located upstream of South 690 Road.

Cave Springs Branch #3 – McDonald County, Missouri. Legal description was NW ¼, Sec. 21, T. 21 N., R. 34 W. Geographic coordinates were UTM zone 15, 0355203 Easting, 4045898 Northing. The station was located upstream of Belcha Road.

2.2.2 Candidate Reference Bioassessment Sampling Stations

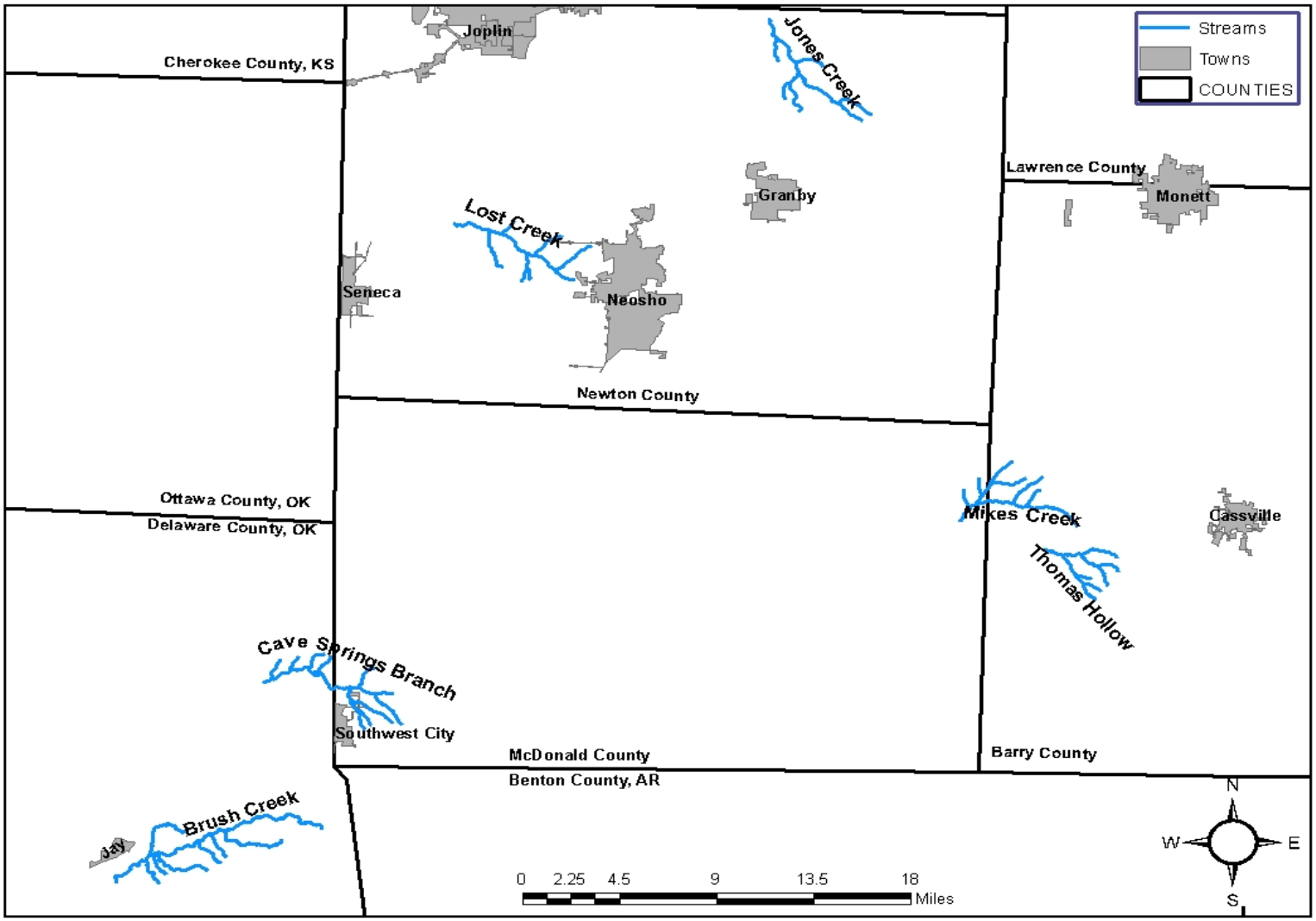
Thomas Hollow #1 – Barry County, Missouri. Legal description was NE ¼, Sec. 2, T. 22 N., R. 29 W. Geographic coordinates were UTM zone 15, 0408255 Easting, 4057209 Northing. The station was located downstream of County Road 1025.

Mikes Creek #3 – McDonald County, Missouri. Legal description was NW ¼, Sec. 29, T. 23 N., R. 29 W. Geographic coordinates were UTM zone 15, 0402214, Easting, 4060351 Northing. The station was located downstream of Highway U.

Lost Creek #1 – Newton County, Missouri. Legal description was NE ¼, Sec. 15, T. 25 N., R. 33 W. Geographic coordinates were UTM zone 15, 0364041, Easting, 4084135 Northing. The station was located upstream of Highway CC.

Jones Creek #3 – Newton County, Missouri. Legal description was NE ¼, Sec. 25, T. 27 N., R. 31 W. Geographic coordinates were UTM zone 15, 0387913, Easting, 4099852 Northing. The station was located upstream of Aspen Road.

Figure 2
Location of Cave Springs Branch and the Candidate Reference Streams



Brush Creek #1 – Delaware County, Oklahoma. Legal description was NE ¼, Sec. 12, T. 22 N., R. 23 W. Geographic coordinates were UTM zone 15, 0339086 Easting, 4030429 Northing. The station was located upstream of 5th Street.

2.3 MoRAP Aquatic Ecological Classification

The aquatic ecological classification developed by the MoRAP is a classification system that divides the aquatic resources of Missouri into distinct regions. It has seven levels of classification starting at large regions and then dividing them into smaller sub-regions (Sowa et al. 2004). The following are the seven levels of classification in hierarchical order: zone, subzone, region, aquatic subregions, EDU, Aquatic Ecological Systems (**AES**), and Valley Segment Types (**VST**). The levels of classification are based on biology, zoogeography, taxonomic composition, geology, soils, and groundwater connection. Some levels of the hierarchical system use geology and soils to classify whereas other levels use biology and taxonomic composition of aquatic communities. EDU, AES, and VST are the three levels of classification that will be assessed in detail for this study.

2.3.1 Ecological Drainage Unit

The EDU is level five of the classification hierarchy and is based on geographical variation of the taxonomic composition of the level four subregions. An EDU is a region in which aquatic biological communities and habitat conditions can be expected to be similar. Land cover percentages for the Missouri portion of the Ozark/Neosho EDU, the Cave Springs Branch test stations, and the candidate reference stations are shown in Figure 3 and Tables 1 and 2. Land cover data for Figure 3 and Table 1 were derived from the MoRAP Thematic Mapper (**TM**) satellite data from 2000 to 2004 and USGS GAP analysis from Landsat TM satellite imagery 1999 to 2001 for Table 2. The USGS GAP data were used so that land cover for the Brush Creek candidate reference station could be compared to the other stations since no MoRAP data were available for the Brush Creek watershed. Land use among Cave Springs Branch test stations was higher for percent grassland and lower for deciduous forest than the candidate reference stations and the Missouri portion of the Ozark/Neosho EDU.

2.3.2 Aquatic Ecological Systems

Aquatic Ecological Systems are level six of the classification hierarchy. They classify aquatic systems based on geology, soils, landform, and groundwater influence. Cave Springs Branch is located in the Finley Creek AES type (Sowa and Diamond 2006). Local relief for the Finley Creek AES type is variable and ranges from nearly zero to 200 feet. Bedrock geology is dominated by Mississippian period cherty limestones with significant karst features like sinkholes, caves, and springs. Sinkholes and losing streams are very abundant, with some of the highest densities occurring in this AES type. Surface soil textures consist of cherty and silt loams with moderate to slow infiltration rates. Streams carry bed loads consisting of sand and chert gravel with very little suspended sediment. Springs are common and can be quite large, contributing significantly to stream base flows. Groundwater and cold water are abundant and an important

Figure 3
Land Use of the Cave Springs Branch Watershed

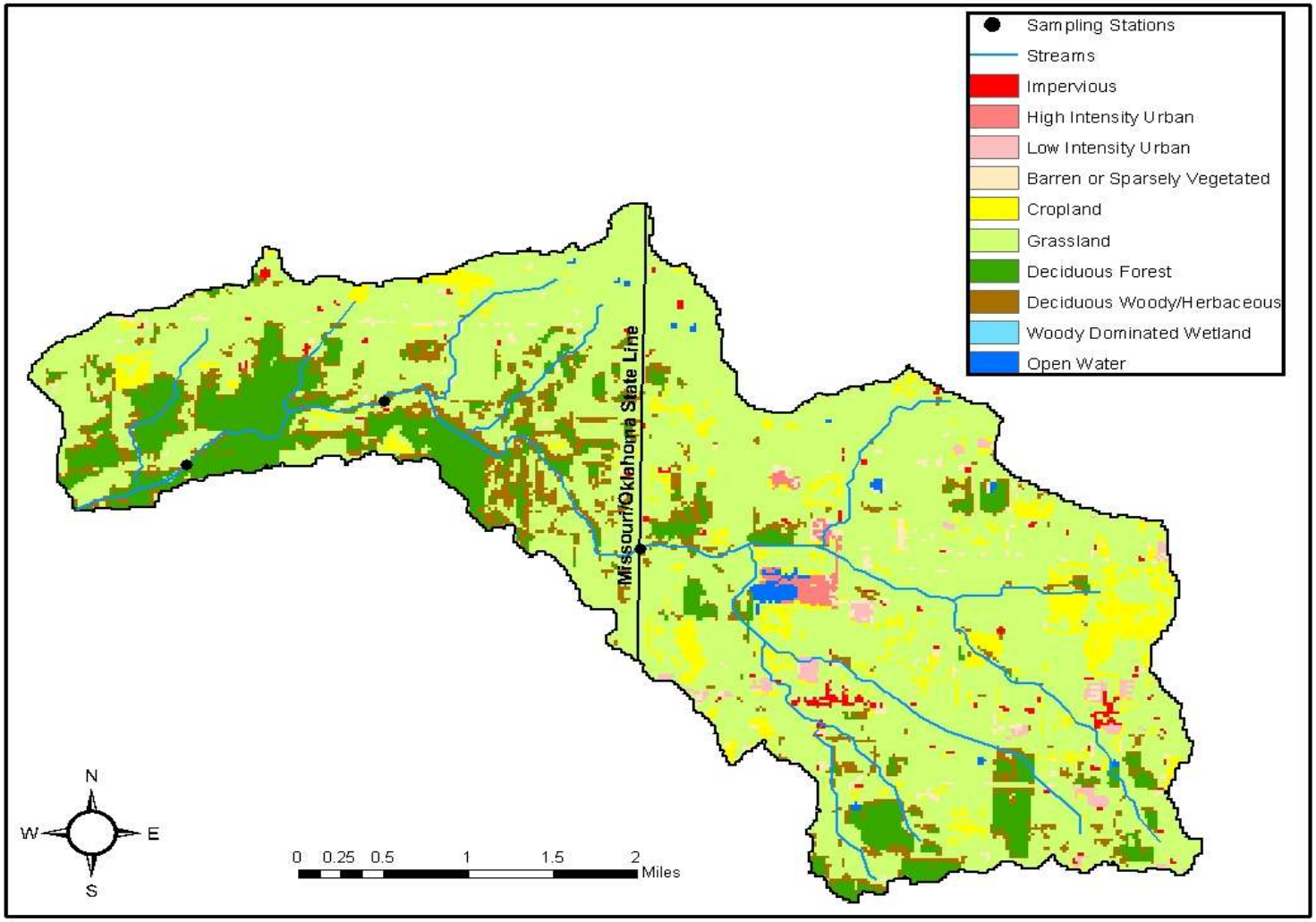


Table 1
Percent Land Cover from MoRAP Thematic Mapper satellite data from 2000 to 2004

Land Cover	Ozark/Neosho EDU*	Thomas Hollow #1	Mikes Creek #3	Lost Creek #1	Jones Creek #3	Cave Springs Branch #3	Cave Springs Branch #2	Cave Springs Branch #1
Impervious	2.6	0.49	0.34	5.13	0.72	1.04	0.89	0.89
High Intensity Urban	0.2	--	--	0.18	--	0.92	0.70	0.65
Low Intensity Urban	1.9	0.07	0.30	1.54	0.13	1.34	1.02	0.94
Barren/Sparsely Vegetated	0.6	0.52	0.39	0.30	< 0.01	1.76	1.62	1.56
Cropland	15.2	4.48	0.62	5.30	5.15	8.24	7.22	6.80
Grassland	52.8	36.67	30.24	63.76	69.54	71.88	73.03	70.92
Deciduous Forest	20.3	43.63	58.44	20.45	19.24	7.40	7.60	10.34
Evergreen Forest	0.1	0.01	0.02	0.01	0.04	--	--	--
Deciduous Woody/Herbaceous	4.8	14.11	9.64	3.23	4.78	6.78	7.36	7.37
Evergreen Woody/Herbaceous	--	--	--	--	--	--	--	--
Woody Dominated Wetland	0.9	--	--	0.04	0.16	--	--	0.02
Herbaceous-Dominated Wetland	0.2	--	--	--	0.05	--	--	--
Open Water	0.5	0.03	0.01	0.05	0.18	0.64	0.55	0.50

*These statistics were available only for the portion of this EDU located in Missouri.

Table 2
Percent Land Cover from USGS GAP Analysis

Land Cover	Thomas Hollow #1	Mikes Creek #3	Lost Creek #1	Jones Creek #3	Brush Creek #1	Cave Springs Branch #3	Cave Springs Branch #2	Cave Springs Branch #1
Developed Open Space	4.02	3.81	4.26	3.92	3.46	5.01	4.45	4.81
Developed, High Intensity	--	--	0.21	--	0.06	0.33	0.25	0.22
Developed, Medium Intensity	0.03	--	0.61	--	0.09	0.15	0.11	0.10
Developed, Low Intensity	--	0.07	0.87	0.12	0.47	0.57	0.43	0.38
Cropland	--	0.13	0.10	1.85	--	0.24	0.18	0.16
Pasture/Hay	40.93	31.12	64.59	61.32	52.87	84.03	83.34	79.77
Forest	53.43	63.74	25.25	28.32	42.76	8.51	10.38	13.79
Open Water	--	--	--	--	0.01	0.26	0.19	0.17

ecological feature of this AES type. Historic vegetation consisted primarily of prairie, but timber was located along stream valleys.

Candidate reference streams Mikes Creek and Thomas Hollow are located in the Middle Upper Little Sac AES type. This AES type has local relief that is variable, but typically it ranges from 50 to 200 feet. Bedrock geology is Mississippian cherty limestone with some karst features. Surface soil texture consists of cherty soils and silt loams with moderate to slow infiltration rates. Streams have narrow floodplains and carry bed loads of gravel and sand that form bars. Springs are common and can be quite large, contributing greatly to stream base flows. Groundwater is relatively abundant and of good quality. Historic vegetation consisted of prairie on the flat portions with oak savanna and woodlands in more rugged regions.

Candidate reference streams Lost Creek and Jones Creek are located in the Moniteau Creek AES type. This AES type has local relief that ranges from nearly zero to 200 feet. Bedrock geology is made primarily of Mississippian cherty limestone. Karst features are scattered in the AES type and sinkholes are common. Surface soil textures are primarily loams or silt loams with slow to moderate infiltration rates. Stream bed loads are made of gravel and sand. Groundwater is abundant in the AES type.

The candidate reference stream Brush Creek has no assigned AES type since it is located outside of the boundary of the MoRAP AES type GIS layer. The AES types that are the closest to the Brush Creek watershed are Finley Creek and Drowning Creek. Both of these AES types are located just north of the Brush Creek watershed. Brush Creek does have the same geology as Cave Springs Branch based on the Oklahoma DEQ ArcGIS viewer (http://gis.deq.ok.gov/flexviewer/). According to the ArcGIS viewer, both Brush Creek and Cave Springs Branch have geology of the Keokuk, Reeds Spring, and St. Joe group formations from the Mississippian period. The Keokuk and Reeds Spring formations are made up of chert and limestone and the St. Joe group formation is made of limestone and shale.

2.3.3 Valley Segment Types

Valley Segment Types are level seven of the classification hierarchy. Stream segments in the GIS stream network layer are classified using a 5-digit code. The 5-digit VST code is based on temperature regime, stream size, flow regime, geology, and relative gradient. The 5-digit VST codes and the values for the five parameters making up the codes can be found in Table 3.

Table 3
Physical Characteristics of the Sample Reaches for Cave Springs Branch and the Candidate Reference Streams Based on Values from the MoRAP Valley Segment Types (VST) Geographic Information Systems (GIS) Layer and Other GIS Sources

	Cave Springs Branch #1	Cave Springs Branch #2	Cave Springs Branch #3	Thomas Hollow #1	Mikes Creek #3	Lost Creek #1	Jones Creek #3	Brush Creek #1
County	Delaware	Delaware	McDonald	Barry	McDonald	Newton	Newton	Delaware
State	Oklahoma	Oklahoma	Missouri	Missouri	Missouri	Missouri	Missouri	Oklahoma
Watershed Area (mi^2)	12.7	11.6	8.0	7.4	12.1	13.8	11.4	27.1
Strahler Order	3	3	3	3	3	3	3	2
Link Magnitude	9	8	6	6	7	7	6	8
VST 5 Digit Code	22123	22123	22123	22123	22123	22123	22122	22121
Temperature Regime	Warm	Warm	Warm	Warm	Warm	Warm	Warm	Warm
Stream Size	Creek	Creek	Creek	Creek	Creek	Creek	Creek	Creek
Flow Regime	Permanent	Permanent	Permanent	Permanent	Permanent	Permanent	Permanent	Permanent
Geology	Limestone	Limestone	Limestone	Limestone	Limestone	Limestone	Limestone	Limestone
Relative Gradient	High	High	High	High	High	High	Medium	Low

2.4 Stream Habitat Assessment

A standardized assessment procedure was followed as described for Riffle/Pool Habitat in the Stream Habitat Assessment Project Procedure (**SHAPP**) (MDNR 2010d). The habitat assessments were conducted at the three Cave Springs Branch test stations and the five candidate reference stations during September of 2013.

2.5 Biological Assessment

Biological assessments consist of macroinvertebrate collection and physicochemical sampling for two sample periods.

2.5.1 Macroinvertebrate Collection and Analysis

A standardized macroinvertebrate sample collection and analysis procedure was followed as described in the Semi-quantitative Macroinvertebrate Stream Bioassessment Project Procedure (**SMSBPP**) (MDNR 2012) for riffle/pool (**RP**) streams. Three standard habitats— flowing water over coarse substrate (**CS**), depositional substrate in non-flowing water (**NF**), and rootmat (**RM**)—were collected at the sampling stations.

Macroinvertebrate data were analyzed using three methods. The first analysis was to calculate the Macroinvertebrate Stream Condition Index (**MSCI**) using the four general biological metrics found in the SMSBPP (MDNR 2002; MDNR 2012). These four biological metrics included: 1) Taxa Richness (**TR**);
2) Ephemeroptera/Plecoptera/Trichoptera Taxa (**EPTT**); 3) Biotic Index (**BI**); and 4) Shannon Diversity Index (**SDI**). These individual metrics were scored by comparing them to the biological criteria for perennial/wadeable streams from the Ozark/Neosho EDU and combined to form the Macroinvertebrate Stream Condition Index (**MSCI**). MSCI scores of 16-20 qualify as fully supporting, 10-14 are partially supporting, and 4-8 are considered non-supporting of the protection of warm water aquatic life beneficial use designation as specified in the Missouri Water Quality Standards (MDNR 2014).

The second analysis was to calculate MSCI scores using the same four metrics listed above, but with criteria based on macroinvertebrate data collected from Ozark/Neosho EDU candidate reference streams. Because the Cave Springs Branch test stations were much smaller than the reference streams used to calculate Ozark/Neosho EDU biological criteria, candidate reference criteria were developed. This analysis was conducted to determine the extent to which stream size affected the Cave Springs Branch macroinvertebrate community.

The third analysis was an evaluation of macroinvertebrate community composition using percent composition of EPT, sensitive taxa, functional feeding groups (FFG), functional habit groups (FHG), and dominant macroinvertebrate families and taxa. Comparisons of the macroinvertebrate community of Cave Springs Branch, the candidate reference streams, and the biological criteria reference streams were made.

2.6 Physicochemical Data Collection and Analysis

2.6.1 *In situ* Water Quality Measurements

During each sampling period, *in situ* water quality measurements were collected at each of the bioassessment sampling stations. Field measurements included water temperature (°C), dissolved oxygen (mg/L), conductivity (µS/cm), and pH.

2.6.2 Water Chemistry

Grab samples of stream water were collected and returned for analyses to ESP's Chemical Analysis Section. Samples were analyzed for total suspended solids, turbidity, chloride, sulfate, total calcium, total magnesium, total hardness, total phosphorus, ammonia-N, nitrate+nitrite-N, and total nitrogen. Procedures outlined in *Required/Recommended Containers, Volumes, Preservatives, Holding Times, and Special Sampling Considerations* [Standard Operating Procedure (**SOP**) MDNR-ESP-001 (MDNR 2011)] and *Field Sheet and Chain-of-Custody Record* [SOP MDNR-ESP-002 (MDNR 2010b)] were followed when collecting water quality samples. Stream velocity was measured at each station using a SonTek/YSI FlowTracker Handheld-ADV (Acoustic Doppler Velocimeter). Discharge was calculated per the methods in SOP MDNR-ESP-113, *Flow Measurement in Open Channels* (MDNR 2013).

2.7 Data Analysis and Quality Control

Physicochemical data were examined by analyte to determine whether stations had violations of the Missouri WQS (MDNR 2014). Sampling stations that had values not in compliance with the WQS or recommend U.S. Environmental Protection Agency (U.S. EPA) recommended reference values will be discussed with possible influences being identified.

Quality control was maintained by following applicable MDNR Project Procedures and Standard Operating Procedures. Duplicate samples were collected and analyzed for macroinvertebrate and physicochemical parameters at Jones Creek #3 during the fall 2013 sampling season and Cave Springs Branch #2 during the spring 2014 sampling season. A random number of processed macroinvertebrate samples were rechecked for missed specimens in the lab.

3.0 Results

3.1 Stream Habitat Assessment

Table 4 provides habitat assessment scores for the Cave Springs Branch test stations and the candidate reference sampling stations. Stream habitat data were collected in September of 2013 with Carl Wakefield and Mike Irwin performing the assessment. SHAPP guidance states that test stations scoring at least 75 percent of the total score of reference station should support a similar biological community. Because Cave Springs Branch habitat assessment scores were ≥75 percent of the candidate reference scores, test stations should be capable of supporting a similar macroinvertebrate community. Most Cave Springs Branch habitat metrics scores either were in the optimal or suboptimal

range. The metrics that did not perform as well at Cave Springs Branch #3 were riffle quality, bank vegetative protection, and riparian zone width for the left bank. At Cave Springs Branch #2, sediment deposition, channel flow status, riffle quality, and vegetative protection had values in the marginal or poor category. Metrics that did not perform as well at Cave Springs Branch #1 were epifaunal substrate, riffle quality, and vegetative protection.

3.2 Macroinvertebrate Biological Assessment

3.2.1 Semi-quantitative Macroinvertebrate Stream Bioassessment Project Procedure (SMSBPP)

3.2.1.1 Fall 2013 Sampling Season

Ozark/Neosho Biological Criteria Reference Stream Scoring

MSCI scores were calculated for Cave Springs Branch test stations using riffle/pool perennial/wadeable biological criteria for the Ozark/Neosho EDU (Table 5). Cave Springs Branch test station #1 had a fully supporting score of 16, test station #2 had a partially supporting score of 14, and test station #3 had a partially supporting score of 12 during the fall 2013 sampling season (Table 5). All of the candidate reference streams had fully supporting MSCI scores except Mikes Creek, with scores ranging from 14 to 18.

Each of the Cave Springs Branch test stations had at least two biological metrics that were lower than the optimal biological criteria reference range calculated for the Ozark/Neosho EDU during the fall 2013 sampling season (Table 5). Biotic Index and EPT values were suboptimal (metric score of 3) at all three test stations. All four biological metrics were suboptimal at test station #3, three of four metrics were suboptimal at test station #2, and two of four metrics were suboptimal at test station #1.

Candidate Reference Stream Criteria Scoring

Fall 2013 MSCI scores calculated using candidate reference samples are shown in Table 6. All of the Cave Springs Branch test stations had MSCI scores in the partially supporting range during the fall 2013 sampling season. Test stations #2 and #3 had MSCI scores of 12 and test station #1 had an MSCI score of 14. The test station #1 SDI value was at the scoring threshold (Table 6), and a slightly higher value for this metric would have resulted in a change from a partially to a fully supporting MSCI score.

All of the biological metric values except TR at test station #1 were in the partially supporting range (metric score of 3) during the fall 2013 sampling season. Biotic index values were higher and EPTT and SDI values were lower than optimum at all of the test stations.

Table 4
Predominant Category Habitat Values, Category Habitat Scores, and Total Habitat Scores from Stream Habitat Assessments for the Ozark/Neosho Candidate Reference Sampling Stations and Cave Springs Branch Test Stations

Stream Habitat Parameters	Thomas Hollow #1	Mikes Creek #3	Lost Creek #1	Jones Creek #3	Brush Creek #1	Cave Springs Branch #3	Cave Springs Branch #2	Cave Springs Branch #1
Macroinvertebrate Sample Number	132051	132052	132053	132054 and 132055	132056	132057	132058	132059
Stream Habitat Assessment Date	09/23/2013	09/24/2013	09/24/2013	09/24/2013	09/25/2013	09/25/2013	09/25/2013	09/25/2013
Epifaunal Substrate/Available Cover	III (10)	III (9)	III (10)	II (11)	III (9)	I (17)	II (11)	III (10)
Embeddedness	I (17)	II (15)	II (14)	I (16)	I (18)	I (18)	II (14)	II (15)
Velocity/Depth Regime	I (17)	II (14)	II (15)	I (17)	II (14)	II (14)	II (15)	II (15)
Sediment Deposition	II (15)	II (13)	III (6)	III (10)	II (13)	II (12)	III (10)	II (12)
Channel Flow Status	II (11)	III (8)	II (14)	II (12)	III (8)	II (11)	III (8)	II (11)
Channel Alteration	I (20)	I (20)	I (20)	I (19)	I (20)	I (20)	I (20)	I (20)
Riffle Quality	II (12)	III (9)	III (10)	III (10)	III (7)	III (9)	III (10)	III (8)
Bank Stability – Left Bank	II (7)	I (9)	I (9)	I (9)	I (9)	I (10)	I (10)	III (5)
Bank Stability – Right Bank	I (9)	I (10)	I (9)	I (10)	IV (2)	I (9)	I (9)	I (9)
Vegetative Protection – Left Bank	IV (0)	IV (1)	IV (2)	IV (1)	IV (0)	III (3)	IV (1)	IV (0)
Vegetative Protection – Right Bank	IV (2)	IV (0)	IV (1)	IV (2)	IV (1)	IV (0)	IV (2)	IV (0)
Riparian Zone Width – Left Bank	II (8)	I (10)	II(6)	III (5)	I (9)	IV (2)	II (6)	I (10)
Riparian Zone Width – Right Bank	I (10)	I (9)	IV (2)	II (8)	I (10)	I (9)	I (9)	I (10)
Total Habitat Score	**138**	**127**	**118**	**130**	**120**	**134**	**125**	**125**

Habitat parameter categories range from I to IV with category I = optimal, category II = suboptimal, category III = marginal, and category IV = poor. Habitat parameter scores are listed in parentheses and range from 0 to 20 except for vegetative protection and riparian zone categories, which range from 0 to 10.

Table 5
Fall 2013 Riffle/Pool Ozark/Neosho EDU Perennial/Wadeable Stream Biological Criteria, Biological Support Categories, Biological Metric Values and Scores Shown in Parentheses, and Macroinvertebrate Stream Condition Index (MSCI) Scores for the Candidate Reference and Cave Springs Branch Sampling Stations

Station	Sample No.	TR	EPTT	BI	SDI	MSCI	Support
Candidate Reference Sampling Stations							
Thomas Hollow #1	132051	74 (3)	22 (3)	4.9 (5)	3.23 (5)	16	F
Mikes Creek #3	132052	71 (3)	17 (3)	5.0 (5)	2.89 (3)	14	P
Lost Creek #1	132053	90 (5)	25 (5)	5.5 (3)	3.17 (5)	18	F
Jones Creek #3a	132054	90 (5)	22 (3)	5.6 (3)	3.37 (5)	16	F
Jones Creek #3b	132055	90 (5)	24 (3)	5.6 (3)	3.44 (5)	16	F
Brush Creek #1	132056	75 (3)	24 (3)	5.1 (5)	3.32 (5)	16	F
Cave Springs Branch Sampling Stations							
Cave Springs Br. #3	132057	63 (3)	13 (3)	6.5 (3)	2.62 (3)	12	P
Cave Springs Br. #2	132058	72 (3)	20 (3)	6.2 (3)	3.06 (5)	14	P
Cave Springs Br. #1	132059	78 (5)	19 (3)	6.1 (3)	3.19 (5)	16	F
Ozark/Neosho EDU Biological Criteria							
Metric Score=5	If	>77	>24	<5.5	>2.97	20-16	**F**ull
Metric Score=3	If	77-39	24-12	5.5-7.7	2.97-1.49	14-10	**P**artial
Metric Score=1	If	<39	<12	>7.7	<1.49	8-4	**N**on

MSCI Scoring Table (in light gray) developed from Ozark/Neosho EDU BIOREF samples (n=10); TR=taxa richness; EPTT=Ephemeroptera, Plecoptera, Trichoptera Taxa; BI=Biotic Index; SDI=Shannon Diversity Index

Table 6
Fall 2013 Riffle/Pool Ozark/Neosho EDU Candidate Reference Stream Biological Criteria, Biological Support Categories, Biological Metric Values and Scores Shown in Parentheses, and Macroinvertebrate Stream Condition Index (MSCI) Scores for the Cave Springs Branch Sampling Stations

Station	Sample No.	TR	EPTT	BI	SDI	MSCI	Support
Fall 2013 Sampling Season							
Cave Springs Br. #3	132057	63 (3)	13 (3)	6.5 (3)	2.62 (3)	12	P
Cave Springs Br. #2	132058	72 (3)	20 (3)	6.2 (3)	3.06 (3)	12	P
Cave Springs Br. #1	132059	78 (5)	19 (3)	6.1 (3)	3.19 (3)	14	P
Ozark/Neosho EDU Candidate Reference Biological Criteria							
Metric Score=5	If	>74	>22	<5.6	>3.19	20-16	**F**ull
Metric Score=3	If	74-37	22-11	5.6-7.8	3.19-1.59	14-10	**P**artial
Metric Score=1	If	<37	<11	>7.8	<1.59	8-4	**N**on

MSCI Scoring Table (in light gray) developed from Ozark/Neosho EDU Candidate Reference samples for fall 2013 (n=6); TR=taxa richness; EPTT=Ephemeroptera, Plecoptera, Trichoptera Taxa; BI=Biotic Index; SDI=Shannon Diversity Index

3.2.1.2 Spring 2014 Sampling Season

Ozark/Neosho Biological Criteria Reference Stream Scoring

MSCI scores were calculated for Cave Springs Branch test stations using the riffle/pool perennial/wadeable biological criteria for the Ozark/Neosho EDU (Table 7). Cave Springs Branch test station #1 and both duplicate samples at test station #2 had fully supporting scores of 16 and test station #3 had a partially supporting score of 12 during the spring 2014 sampling season. All of the candidate reference streams had fully supporting MSCI scores except Mikes Creek, with scores ranging from 14 to 18.

Each of the Cave Springs Branch test stations had at least two biological metrics that were lower than the optimal biological criteria reference range during the spring 2014 sampling season (Table 7). Biotic Index and EPT values were suboptimal (metric score of 3) at all three test stations. All four biological metrics were suboptimal at test station #3.

Candidate Reference Stream Criteria Scoring

Spring 2014 MSCI scores calculated using candidate reference samples are shown in Table 8. Cave Springs Branch test station #1 had a fully supporting score of 16, duplicate samples at test station #2 had fully supporting scores of 18, and test station #3 had a partially supporting score of 14 during the spring 2014 sampling season.

Three of the biological metric values at test station #3, two of the metric values at test station #1, and one of the metric values at test station #2 were suboptimal during the spring 2014 sampling season. Biotic index was higher and EPTT was lower at test station #1 and EPTT was lower at test station #2 than optimal candidate reference criteria. Only biotic index was in the optimal range at test station #3 using candidate reference criteria.

Table 7
Spring 2014 Riffle/Pool Ozark/Neosho EDU Stream Biological Criteria, Biological Support Categories, Biological Metric Values and Scores shown in Parentheses, and Macroinvertebrate Stream Condition Index (MSCI) Scores for the Candidate Reference and Cave Springs Branch Sampling Stations

Station	Sample No.	TR	EPTT	BI	SDI	MSCI	Support
Candidate Reference Sampling Stations							
Thomas Hollow #1	149832	73 (5)	27 (3)	3.9 (5)	2.93 (3)	16	F
Mikes Creek #3	149833	67 (3)	21 (3)	4.5 (5)	2.97 (3)	14	P
Jones Creek #3	149834	86 (5)	25 (3)	6.1 (3)	3.55 (5)	16	F
Lost Creek #1	149835	95 (5)	26 (5)	6.0 (3)	3.51 (5)	16	F
Brush Creek #1	149836	73 (5)	27 (3)	4.9 (5)	3.40 (5)	18	F
Cave Springs Branch Sampling Stations							
Cave Springs Br. #3	149837	62 (3)	14 (3)	5.9 (3)	2.65 (3)	12	P
Cave Springs Br. #2a	149838	84 (5)	21 (3)	5.9 (3)	3.44 (5)	16	F
Cave Springs Br. #2b	149839	91 (5)	23 (3)	5.8 (3)	3.35 (5)	16	F
Cave Springs Br. #1	149840	87 (5)	23 (3)	6.2 (3)	3.36 (5)	16	F
Ozark/Neosho EDU Biological Criteria							
Metric Score=5	If	>72	>27	<5.3	>3.01	20-16	**F**ull
Metric Score=3	If	72-36	27-13	5.3-7.7	3.01-1.51	14-10	**P**artial
Metric Score=1	If	<36	<13	>7.7	<1.51	8-4	**N**on

MSCI Scoring Table (in light gray) developed from Ozark/Neosho EDU BIOREF samples (n=12); TR=taxa richness; EPTT=Ephemeroptera, Plecoptera, Trichoptera Taxa; BI=Biotic Index; SDI=Shannon Diversity Index

Table 8
Spring 2014 Riffle/Pool Ozark/Neosho EDU Candidate Reference Stream Biological Criteria, Biological Support Categories, Biological Metric Values and Scores Shown in Parentheses, and Macroinvertebrate Stream Condition Index (MSCI) Scores for the Cave Springs Branch Sampling Stations

Station	Sample No.	TR	EPTT	BI	SDI	MSCI	Support
Spring 2014 Sampling Season							
Cave Springs Br. #3	149837	62 (3)	14 (3)	5.9 (5)	2.65 (3)	14	P
Cave Springs Br. #2a	149838	84 (5)	21 (3)	5.9 (5)	3.44 (5)	18	F
Cave Springs Br. #2b	149839	91 (5)	23 (3)	5.8 (5)	3.35 (5)	18	F
Cave Springs Br. #1	132059	87 (5)	23 (3)	6.2 (3)	3.36 (5)	16	F
Ozark/Neosho EDU Candidate Reference Biological Criteria							
Metric Score=5	If	>73	>25	<6.0	>2.97	20-16	**F**ull
Metric Score=3	If	73-37	25-13	6.0-8.0	2.97-1.49	14-10	**P**artial
Metric Score=1	If	<37	<13	>8.0	<1.49	8-4	**N**on

MSCI Scoring Table (in light gray) developed from Ozark/Neosho EDU Candidate Reference samples for fall 2013 (n=5); TR=taxa richness; EPTT=Ephemeroptera, Plecoptera, Trichoptera Taxa; BI=Biotic Index; SDI=Shannon Diversity Index

3.2.2 Macroinvertebrate Percent and Community Composition

The percent composition of sensitive taxa, FFG, FHG, EPTT, and the five dominant macroinvertebrate families and taxa at each station are presented in Figures 4 through 9 and Tables 9 through 16. Values in bold type represent the five dominant macroinvertebrate families and taxa for each station.

3.2.2.1 Fall 2013 Sampling Season

Percent Composition of Sensitive Taxa

Taxa found in the Cave Springs Branch samples were generally more tolerant of organic pollution than the biological criteria reference streams and the candidate reference streams (Figure 4 and Table 9). The percentage of Cave Springs Branch taxa in the tolerant biotic index range (7.5-8.9) was much higher and percent of taxa in the intolerant biotic index range (2.5-4.9) was much lower than the biological criteria reference streams and candidate reference streams during the fall 2013 sampling season. The percentage of Cave Spring Branch taxa in the moderately tolerant biotic index range (5.0-7.4) was also higher than biological criteria streams and most of the candidate reference streams. Taxa in the very intolerant biotic index range (<2.5) among Cave Spring Branch stations were much less abundant than the biological criteria reference streams. However, the percentage of very intolerant taxa at test stations #1 and #2 was higher than some of the

candidate reference streams. Taxa in the very intolerant range at Cave Springs Branch #3 was much lower than most of the biological criteria and candidate reference streams.

Figure 4
Percent of Taxa by Biotic Index Range, Fall 2013

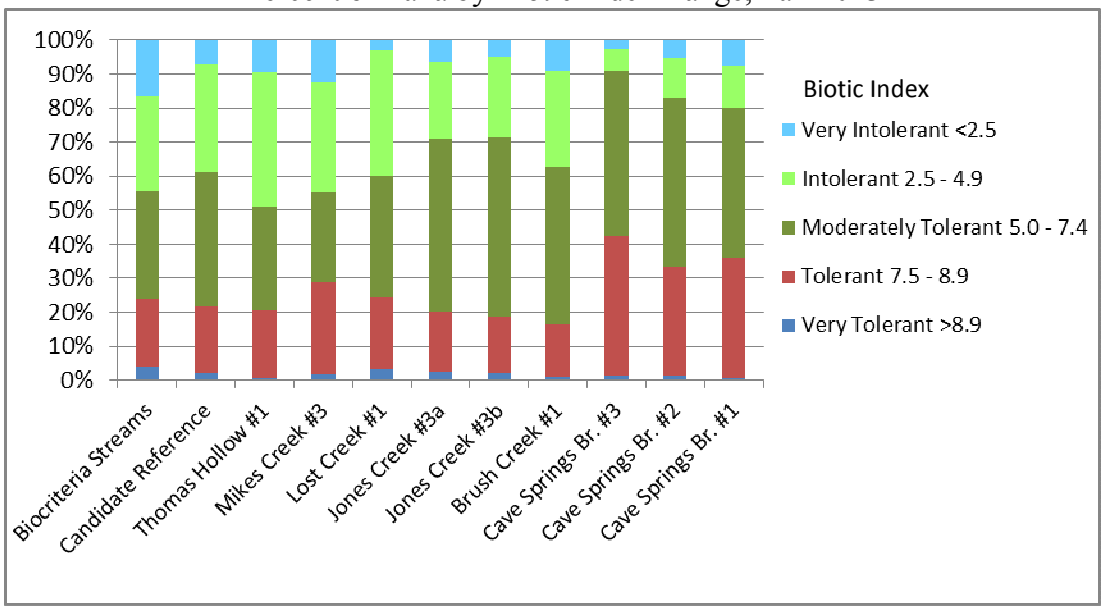


Table 9
Biological Metric Values for Sensitive Taxa, Functional Feeding Groups (FFG), and Functional Habit Groups (FHG) Metrics for the Biological Criteria Reference Samples, Candidate Reference Samples, and the Cave Springs Branch Test Stations, Fall 2013

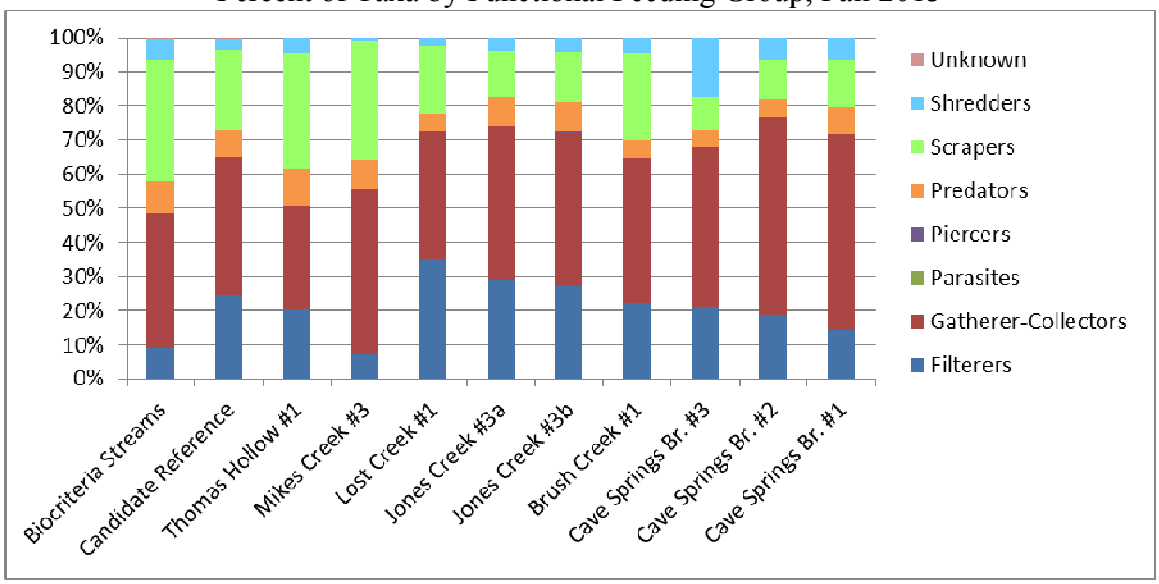
Variable-Station	**Biocriteria Reference Data**	**Candidate Reference Streams**	**Thomas Hollow #1**	**Mikes Creek #3**	**Lost Creek #1**	**Jones Creek #3a**	**Jones Creek #3b**	**Brush Creek #1**	**Cave Springs Br. #3**	**Cave Springs Br. #2**	**Cave Springs Br. #1**
Sample Number			132051	132052	132053	132054	132055	132056	132057	132058	132059
Sensitive Taxa											
% Biotic Index >8.9	3.9	2.0	0.6	1.6	3.42	2.6	2.2	0.9	1.5	1.3	0.8
% Biotic Index 7.5-8.9	20.2	19.8	20.0	27.3	20.8	17.7	16.4	15.6	40.8	32.0	35.1
% Biotic Index 5.0-7.4	31.4	39.5	30.5	26.2	36.0	50.5	52.7	46.0	48.5	49.6	44.2
% Biotic Index 2.5-4.9	28.2	31.6	39.4	32.4	36.9	22.5	23.4	28.6	6.6	11.8	12.2
% Biotic Index <2.5	16.4	7.2	9.5	12.5	3.0	6.6	5.0	8.9	2.6	5.3	7.7
Functional Feeding Groups											
% Filterers	9.2	24.5	20.2	7.2	34.9	28.7	27.2	22.1	21.2	18.9	14.4
% Gatherer-Collectors	39.3	40.7	30.5	48.7	37.5	45.5	44.9	42.5	46.7	57.7	57.2
% Parasites	0.02	0.01	--	--	--	--	0.1	--	--	--	0.1
% Piercers	0.02	0.01	--	--	--	--	0.1	--	--	--	0.1
% Predators	9.3	7.8	11.1	8.7	5.5	8.6	8.7	5.3	5.3	5.6	7.8
% Scrapers	35.9	23.7	33.9	34.9	19.8	13.6	14.9	25.5	9.5	11.3	13.8
% Shredders	6.2	3.2	4.3	0.6	2.2	3.7	4.2	4.6	17.3	6.5	6.6
% Unknown	0.2	0.2	--	--	0.1	--	--	--	--	--	--
Functional Habit Groups											
% Burrowers	3.3	1.5	1.7	1.0	0.9	2.4	2.1	1.1	6.0	2.4	2.2
% Clingers	45.8	49.0	57.2	39.1	54.5	41.6	41.8	53.5	29.7	27.2	30.9
% Climbers	6.0	7.1	9.5	8.2	2.7	10.4	8.1	6.4	20.9	10.6	10.4
% Divers	--	--	--	--	--	--	--	--	--	--	--
% Skaters	0.1	0.03	0.1	--	--	--	0.1	--	0.04	--	--
% Sprawlers	11.5	6.6	4.5	3.9	4.6	13.5	11.4	4.2	35.3	13.4	14.4
% Swimmers	11.0	12.3	7.0	19.2	7.5	10.8	14.5	19.9	2.2	18.8	17.5
% Unknown	22.3	23.4	20.1	28.6	29.7	21.3	21.9	15.0	5.8	27.6	24.6

Biocriteria and candidate reference stream data values are average percent.

Functional Feeding Groups (FFGs)

Gatherer-collectors and filterers were the two most abundant FFGs at the Cave Springs Branch test stations during the fall 2013 sampling season (Figure 5 and Table 9). Generally, a higher percentage of gatherer-collectors were present among Cave Springs Branch stations than biological criteria and candidate reference streams. Cave Springs Branch also had a much higher percentage of filterers than the biological criteria streams but a lower percentage than most of the candidate reference streams. The percentage of scrapers was much lower at Cave Springs Branch than the biological criteria reference streams and most of the candidate reference streams. Shredders represented a much higher percentage of the test station #3 samples compared to the biological criteria reference streams. Compared to the candidate reference streams, the percentage of shredders at Cave Springs Branch ranged from slightly higher at stations #1-#2 to much higher at station #3. The percentage of predators was lower at Cave Springs Branch than the biological criteria reference streams and lower than three of five candidate reference streams.

Figure 5
Percent of Taxa by Functional Feeding Group, Fall 2013

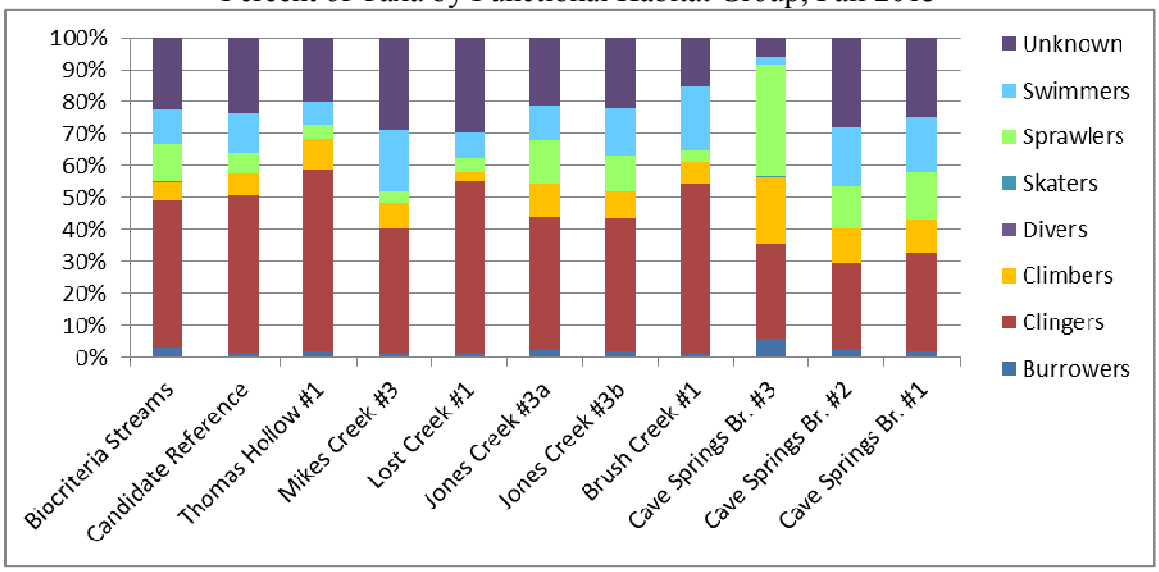


Functional Habit Groups (FHGs)

During the fall 2013 sampling season, clingers were the most abundant FHG at Cave Springs Branch #1 and #2, and sprawlers were the dominant FHG at station #3 (Figure 6 and Table 9). Taxa designated as unknown also accounted for a large percentage of the station #1 and #2 samples. Clingers made up about 27 to 31 percent of taxa at Cave Springs Branch, which was much lower than the biological criteria reference and candidate reference streams. Sprawlers made up about 35 percent of the Cave Spring Branch #3 sample and were much more abundant than the biological criteria and candidate reference streams. Sprawlers were present in similar percentages at stations #1 and #2 compared to biological criteria reference streams and higher than most candidate

reference streams. Climbers were much more abundant at test station #3 than both reference datasets. Swimmers made up a much lower percentage of the Cave Springs Branch #3 sample than both reference datasets, but they were higher at stations #1 and #2 than the biological criteria reference streams and three of five of the candidate reference streams. Cave Springs Branch #3 had a higher percentage of burrowers than both reference datasets, but the remaining two test stations had similar burrower percentages compared to the biological criteria reference streams and most candidate reference streams.

Figure 6
Percent of Taxa by Functional Habitat Group, Fall 2013



Macroinvertebrate Community Composition

During the fall 2013 sampling season, percent EPTT and percent Ephemeroptera were higher among Cave Springs Branch test stations than the biological criteria reference streams and most of the candidate reference streams (Table 10). Brush Creek #1 was the only candidate reference stream that had higher values for EPTT than the test stations. This site also had a higher percentage of Ephemeroptera than the two downstream Cave Springs Branch stations. Most Ephemeroptera abundance among test stations was made up of three taxa (*Baetis*, *Caenis latipennis*, and *Stenonema femoratum*) that had BI values in the moderately tolerant or tolerant range. *C. latipennis* was the dominant taxon at test station #3, whereas *Baetis* was the most abundant mayfly at the other two test stations. Plecoptera were present at the two downstream test stations in similar percentages compared to the biological criteria streams and most of the candidate reference streams. At test station #3, however, stoneflies were found only in the large/rare part of the sample. The percentage of Trichoptera at Cave Springs Branch was similar to the biological criteria reference streams but lower than most of the candidate reference streams. Only Mikes Creek #3 had a lower percentage of Trichoptera than the Cave Springs Branch test stations. *Chematopsyche* was the most abundant Trichoptera taxon

found in most of the samples, but this genus generally was more abundant in the candidate reference streams than the Cave Springs Branch test stations. Other EPT taxa such as leptophlebiid mayflies, *Maccaffertium* sp., *Acroneuria*, and *Polycentropus* occurred in some or all of the candidate reference streams in varying abundance, but they either were absent or occurred in very low abundance in Cave Springs Branch samples. Most of these taxa had BI values that were lower (more sensitive) than the most common EPTT found in the test stations. The tolerant mayfly *C. latipennis* made up most of the mayfly abundance at test station #3, and it was more abundant at this site than the biological criteria and candidate reference streams. Although *C. latipennis* was also abundant at the two downstream Cave Springs Branch test stations, it was present in much lower numbers than test station #3. The caddisfly *Cheumatopsyche* was numerous among Cave Springs Branch stations, but its abundance was much lower than candidate reference streams except Mikes Creek #3. The mayfly *Baetis* and the amphipod *Hyalella azteca* were much more abundant at the two downstream test stations than reference conditions and test station #3.

Chironomidae were much more abundant at Cave Springs Branch #3 than the biological criteria reference streams, the candidate reference streams, and the other two Cave Springs Branch stations (Table 11). The percentage of Chironomidae at the two downstream test stations was higher than all of the candidate reference streams except the two Jones Creek #3 samples. Three chironomids, *Polypedilum flavum, Rhetotanytarsus,* and *Paratendipes*, were more abundant at test station #3 than the other sampling stations (Table 12). *P. flavum* also was more abundant at test stations #1 and #2 than reference streams, but this species was especially abundant at test station #3. Three taxa, the elmid beetle *Optioservus sandersoni*, the isopod *Lirceus*, and leptophlebiid mayflies, were more common among most biological criteria reference and candidate reference streams compared to Cave Springs Branch stations. The water penny *Psephenus herricki* was also more abundant in the biological criteria streams than the Cave Springs Branch test stations.

Table 10
Percent EPTT and Dominant EPTT at the Cave Springs Branch Test Stations, Candidate Reference Stations, and the Ozark/Neosho EDU Biological Criteria Reference Samples, Fall 2013

Variable-Station	**Biotic Index**	**Biocriteria Reference Data**	**Candidate Reference Data**	**Thomas Hollow #1**	**Mikes Creek #3**	**Lost Creek #1**	**Jones Creek #3a**	**Jones Creek #3b**	**Brush Creek #1**	**Cave Springs Br. #3**	**Cave Springs Br. #2**	**Cave Springs Br. #1**
Sample Number				132051	132052	132053	132054	132055	132056	132057	132058	132059
Percent EPTT												
EPT		35.1	39.8	36.5	29.6	43.1	37.2	39.9	50.9	48.5	40.1	40.6
Ephemeroptera		21.5	20.1	14.3	24.8	14.7	16.8	22.1	33.9	37.7	29.2	30.9
Plecoptera		2.0	1.2	1.6	1.8	0.7	0.1	0.2	2.9	L/R	1.0	1.5
Trichoptera		11.5	15.1	20.6	2.9	27.6	20.3	17.5	14.1	10.7	10.0	8.2
Percent Ephemeroptera Taxa												
Paraleptophlebia	1.2	**4.6**	--	--	--	--	--	--	--	--	--	--
Baetis	6.0	**3.2**	**6.6**	2.3	**10.4**	**4.7**	**5.8**	**7.9**	**11.2**	0.3	**16.5**	**15.5**
Caenis latipennis	7.6	**3.1**	0.2	--	--	0.1	0.5	0.4	--	**30.3**	**8.3**	**8.9**
Stenacron	7.1	1.7	**2.3**	**4.2**	1.1	**2.1**	1.4	1.5	**2.9**	0.04	0.1	--
Leptophlebiidae	2.0	1.4	**2.7**	**3.4**	**7.1**	0.5	**2.4**	**1.9**	2.4	--	0.1	0.1
Stenonema femoratum	7.5	1.6	1.5	1.5	**3.1**	0.2	1.4	1.4	2.2	**5.1**	**1.9**	**4.1**
Maccaffertium pulchellum	3.0	0.2	1.6	1.1	--	**4.0**	--	--	2.6	--	--	--
Acentrella	4.0	0.1	1.0	0.3	1.0	1.5	**1.9**	0.9	0.3	--	**1.3**	0.9
Maccaffertium modestum	5.8	0.6	0.6	0.1	--	--	**1.9**	**2.2**	--	--	--	--
Fallceon	6.0	--	--	--	--	--	--	--	--	**2.0**	0.2	--
Percent Plecoptera Taxa												
Acroneuria	1.4	0.3	0.6	0.5	**1.6**	0.1	L/R	0.2	1.6	L/R	L/R	0.1
Neoperla	1.6	0.4	<0.1	--	--	--	--	--	0.1	L/R	1.0	**1.4**
Percent Trichoptera Taxa												
Cheumatopsyche	6.6	**4.8**	**12.1**	**12.1**	0.3	**15.7**	**16.0**	**13.5**	**12.3**	**7.3**	**8.5**	**5.7**
Marilia	*	**3.1**	<0.1	--	--	--	--	--	0.1	--	0.1	0.1
Polycentropus	3.5	0.4	1.3	**4.0**	**2.1**	0.4	0.3	0.7	0.5	0.04	--	0.1
Chimarra	2.8	0.5	**4.1**	**2.5**	0.2	**11.0**	**3.1**	**2.1**	0.8	**2.8**	0.2	0.7

Biocriteria and candidate reference stream data are average percent.
L/R = large/rare taxa. Values in bold type represent the five dominant EPT taxa for each station.
*A biotic index value for this taxon was not available.

Table 11

Percent Dominant Macroinvertebrate Families at the Cave Springs Branch Test Stations, Candidate Reference Stations, and the Ozark/Neosho EDU Biological Criteria Reference Samples, Fall 2013

Variable-Station	**Biocriteria Reference Data**	**Candidate Reference Streams**	**Thomas Hollow #1**	**Mikes Creek #3**	**Lost Creek #1**	**Jones Creek #3a**	**Jones Creek #3b**	**Brush Creek #1**	**Cave Springs Br. #3**	**Cave Springs Br. #2**	**Cave Springs Br. #1**
Sample Number			132051	132052	132053	132054	132055	132056	132057	132058	132059
Percent Dominant Families											
Psephenidae	**16.7**	3.6	**9.9**	3.1	1.5	--	--	6.9	0.5	3.3	5.0
Chironomidae	**12.9**	**15.8**	**13.5**	**13.2**	**9.3**	**25.4**	**22.6**	**16.1**	**36.5**	**19.3**	**18.5**
Heptageniidae	**8.8**	6.7	7.2	5.0	6.4	5.1	6.2	**10.2**	**5.1**	2.0	4.5
Hyalellidae	**8.2**	2.0	4.2	3.5	0.9	0.3	0.7	2.6	0.5	**17.2**	**15.4**
Elmidae	**7.5**	**11.9**	**15.6**	**24.8**	**10.1**	**7.5**	**7.0**	**7.4**	**4.0**	5.2	**6.7**
Hydropsychidae	5.3	**12.4**	**12.4**	0.3	**16.1**	**16.2**	**14.0**	**12.3**	**7.7**	**9.1**	5.9
Asellidae	3.8	**12.3**	**8.8**	**15.7**	**17.7**	**11.5**	**10.2**	6.4	2.5	3.4	5.0
Baetidae	4.7	**9.5**	3.5	**12.1**	**6.8**	**8.4**	**12.6**	**17.3**	2.2	**18.2**	**17.3**
Leptophlebiidae	6.2	2.7	3.4	**7.1**	0.5	2.4	1.9	2.4	--	0.1	0.1
Philopotamidae	0.5	4.1	2.5	0.2	11.0	3.1	2.1	0.8	2.8	0.2	0.7
Caenidae	3.4	0.2	--	--	0.1	0.5	0.4	--	**30.3**	**8.3**	**8.9**

Biocriteria and candidate reference stream data are average percent.
Values in bold type represent the five dominant macroinvertebrate families for each station.

Table 12
Percent Dominant Macroinvertebrate Taxa at the Cave Springs Branch Test Stations, Candidate Reference Stations, and the Ozark/Neosho EDU Biological Criteria Reference Samples, Fall 2013

Variable-Station	**Biotic Index**	**Biocriteria Reference Data**	**Candidate Reference Streams**	**Thomas Hollow #1**	**Mikes Creek #3**	**Lost Creek #1**	**Jones Creek #3a**	**Jones Creek #3b**	**Brush Creek #1**	**Cave Springs Br. #3**	**Cave Springs Br. #2**	**Cave Springs Br. #1**
Sample Number				132051	132052	132053	132054	132055	132056	132057	132058	132059
Percent Dominant Taxa												
Family Elmidae												
Optioservus sandersoni	2.7	2.9	**10.6**	**14.8**	**23.7**	**9.0**	**5.5**	**5.7**	**5.4**	0.2	0.1	0.1
Family Psephenidae												
Psephenus herricki	2.5	**15.9**	3.4	**9.9**	3.1	0.8	--	--	**6.9**	0.4	3.0	**4.5**
Family Chironomidae												
Paratendipes	5.3	0.5	0.5	0.1	0.6	--	1.3	1.2	0.1	**5.2**	2.1	1.5
Polypedilum flavum	5.3	1.3	0.7	0.5	0.1	0.1	0.1	0.1	3.6	**16.0**	**5.0**	**4.9**
Rheotanytarsus	6.4	0.4	1.5	0.8	0.1	0.8	1.3	2.1	4.8	**6.7**	2.1	1.5
Stempellinella	5.3	1.3	3.0	1.3	0.7	1.2	**7.4**	**6.5**	2.6	1.5	2.4	1.7
Tanytarsus	6.7	1.6	1.5	1.3	**6.0**	0.1	1.3	0.8	0.8	1.9	3.3	2.0
Family Simuliidae												
Simulium	4.4	0.1	3.4	2.1	--	4.2	5.3	**5.7**	3.0	2.0	3.3	1.7
Family Asellidae												
Caecidotea	8.0	0.1	3.7	--	--	**14.7**	--	--	--	--	--	--
Lirceus	7.7	3.1	**8.4**	**8.6**	**14.5**	3.1	**11.5**	**10.2**	**6.4**	--	0.4	0.4
Family Hyalellidae												
Hyalella azteca	7.9	**8.2**	2.0	**4.2**	3.5	0.9	0.3	0.7	2.6	0.5	**17.2**	**15.4**
Order Ephemeroptera												
Baetis	6.0	**3.2**	**6.6**	2.3	**10.4**	**4.7**	**5.8**	**7.9**	**11.3**	0.3	**16.5**	**15.5**
Caenis latipennis	7.6	3.1	0.2	--		0.1	0.5	0.4	--	**30.3**	**8.3**	**8.9**
Leptophlebiidae	2	**6.0**	2.7	3.4	**7.1**	0.5	2.4	1.9	2.4		0.1	0.1
Order Trichoptera												
Cheumatopsyche	6.6	**4.8**	**12.1**	**12.1**	0.3	**15.7**	**16.0**	**13.5**	**12.3**	**7.3**	**8.5**	5.7
Chimarra	2.8	0.5	**4.1**	2.5	0.2	**11.0**	3.1	2.1	0.8	2.8	0.2	0.7

Biocriteria and candidate reference stream data values are average percent
Values in bold type represent the five dominant macroinvertebrate taxa for each station.

3.2.2.2 Spring 2014 Sampling Season

Percent Composition of Sensitive Taxa

Similar to the fall data, the taxa found in the Cave Springs Branch spring 2014 samples were generally more tolerant of organic pollution than the biological criteria reference streams and most of the candidate reference streams (Figure 5 and Table 13). The only exceptions occurred at Lost Creek #1 and Jones Creek #3. At Lost Creek #1, the percentage for tolerant (7.5-8.9) and very tolerant taxa (>8.9) was higher, and the percentage for very intolerant taxa (<2.5) was lower compared to the test stations. Jones Creek #3 had a higher percentage of very tolerant taxa and a similar value for very intolerant taxa compared to most of the Cave Springs Branch test stations. The majority of taxa found in the Cave Springs Branch test stations, especially at test station #3, had biotic index values in the moderately tolerant range (5.0-7.4). Taxa in this range made up a much higher percentage of Cave Springs Branch samples than the biological criteria and candidate reference streams. The percentage of taxa in the intolerant biotic index range (2.5-4.9) and the very intolerant range (<2.5) was also lower in the Cave Springs Branch test stations than the biological criteria reference streams and most of the candidate reference streams. The percentage of Cave Springs Branch samples in the tolerant range was similar to biological criteria reference streams and was also similar to the middle range of candidate reference stream values. The percentage of Cave Spring Branch samples in the very tolerant range was variable compared to the reference datasets.

Figure 7
Percent of Taxa by Biotic Index Range, Spring 2014

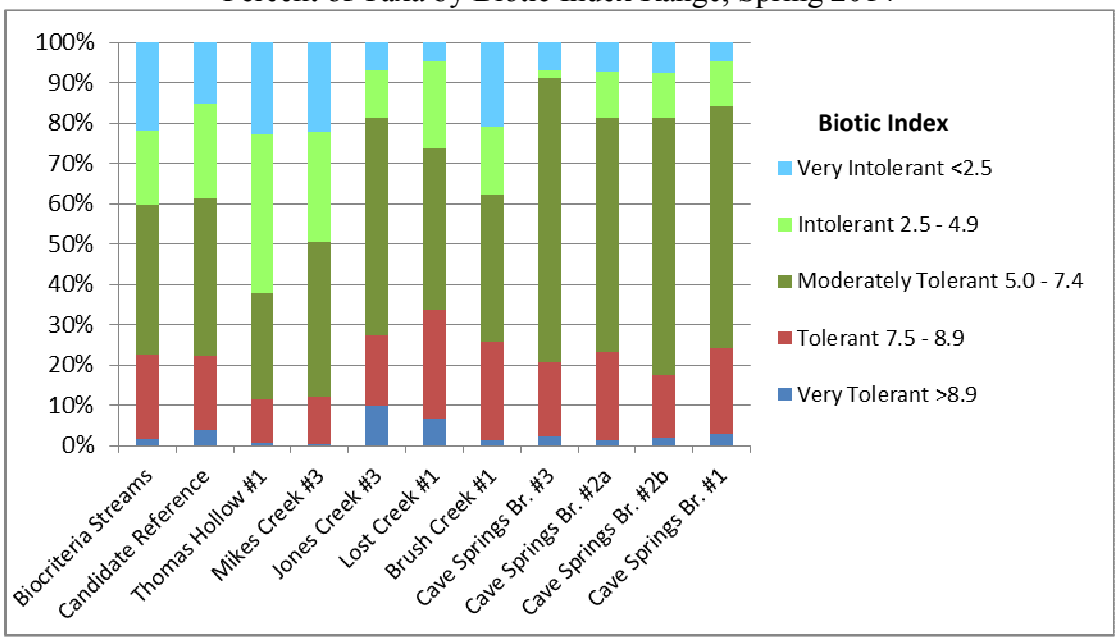


Table 13
Biological Metric Values for Sensitive Taxa, Functional Feeding Groups (FFG), and Functional Habit Groups (FHG) for the Biological Criteria Reference Samples, Candidate Reference Samples, and the Cave Springs Branch Test Stations, Spring 2014

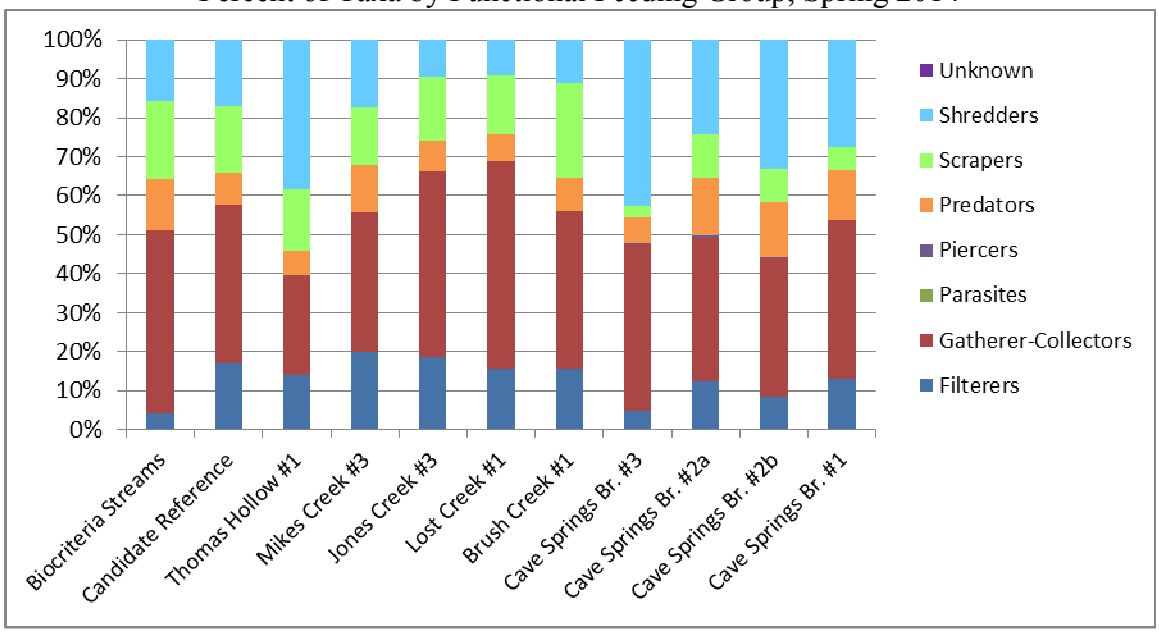
Variable-Station	**Biocriteria Reference Data**	**Candidate Reference Streams**	**Thomas Hollow #1**	**Mikes Creek #3**	**Jones Creek #3**	**Lost Creek #1**	**Brush Creek #1**	**Cave Springs Br. #3**	**Cave Springs Br. #2a**	**Cave Springs Br. #2b**	**Cave Springs Br. #1**
Sample Number			149832	149833	149834	149835	149836	149837	149838	149839	149840
Sensitive Taxa											
% Biotic Index >8.9	1.7	3.8	0.8	0.2	9.9	6.6	1.2	2.3	1.3	1.8	2.9
% Biotic Index 7.5-8.9	21.0	18.5	10.7	12.0	17.3	27.1	24.6	18.3	22.0	15.7	21.2
% Biotic Index 5.0-7.4	37.1	39.0	26.3	38.2	54.0	40.0	36.5	70.6	58.1	63.9	60.0
% Biotic Index 2.5-4.9	18.4	23.4	39.3	27.3	11.8	21.8	16.7	1.8	11.5	10.9	11.2
% Biotic Index <2.5	21.8	15.3	22.9	22.3	7.0	4.6	21.0	7.0	7.2	7.7	4.7
Functional Feeding Groups											
% Filterers	4.2	16.9	14.2	20.1	18.5	15.6	15.8	4.8	12.5	8.5	13.1
% Gatherer-Collectors	47.0	40.7	25.4	35.5	47.8	53.2	40.2	42.8	36.5	35.3	40.5
% Parasites	<0.1	--	--	--	--	--	--	--	--	--	--
% Piercers	<0.1	--	--	--	--	--	--	0.4	0.7	0.3	--
% Predators	13.0	8.5	6.3	12.3	7.9	6.9	8.7	6.4	14.9	14.1	12.8
% Scrapers	20.0	17.1	15.6	14.9	16.3	15.1	24.3	3.1	11.3	8.8	6.1
% Shredders	15.7	16.9	38.5	17.2	9.5	9.2	11.0	42.5	24.1	33.0	27.4
% Unknown	<0.1	--	--	--	--	--	--	0.1	--	--	--
Functional Habit Groups											
% Burrowers	2.4	2.5	0.7	0.7	5.7	4.4	0.5	18.1	4.0	4.6	6.1
% Clingers	39.2	35.8	33.0	28.4	33.6	37.9	46.8	26.5	31.2	33.9	36.9
% Climbers	5.4	11.5	7.5	29.8	8.1	4.1	7.4	29.7	18.1	19.7	10.9
% Divers	--	<0.1	--	--	--	--	0.2	--	0.1	--	0.4
% Skaters	0.1	--	--	--	--	--	--	--	--	0.1	0.1
% Sprawlers	15.9	17.3	40.7	20.3	9.0	7.2	10.4	17.3	23.8	25.6	23.1
% Swimmers	11.9	8.0	6.0	5.6	10.5	8.9	8.8	2.8	1.4	1.6	3.9
% Unknown	25.1	25.0	12.1	15.2	33.0	37.6	25.9	5.5	21.5	14.5	18.6

Biocriteria and candidate reference stream data values are average percent.

Functional Feeding Groups (FFGs)

Gatherer-collectors and shredders were the two most abundant FFGs at the Cave Springs Branch test stations during the spring 2014 sampling season (Figure 8 and Table 13). Gatherer-collectors were the most abundant FFG at the Cave Springs Branch stations, but generally they were not higher in abundance than the biological criteria and the candidate reference streams. The percentage of shredders was much higher among Cave Springs Branch samples than the biological criteria reference streams and most candidate reference streams. Scrapers were not as abundant at the Cave Springs Branch test stations (3 to 11 percent) compared to the biological criteria (20 percent) and candidate reference streams (15 to 24 percent). Although the percentage of filterers at station #3 was similar to the biological criteria reference streams, filterers were more abundant at the remaining test stations. Compared to the candidate reference streams, however, the percentage of filterers was lower at all test stations. Predators were less abundant at test station #3 compared to stations #1 and #2, which were similar to the biological criteria reference streams. Compared to candidate reference streams, predators made up a higher percentage of station #1 and #2 samples; however, predators were slightly lower in abundance at station #3 than most candidate references.

Figure 8
Percent of Taxa by Functional Feeding Group, Spring 2014

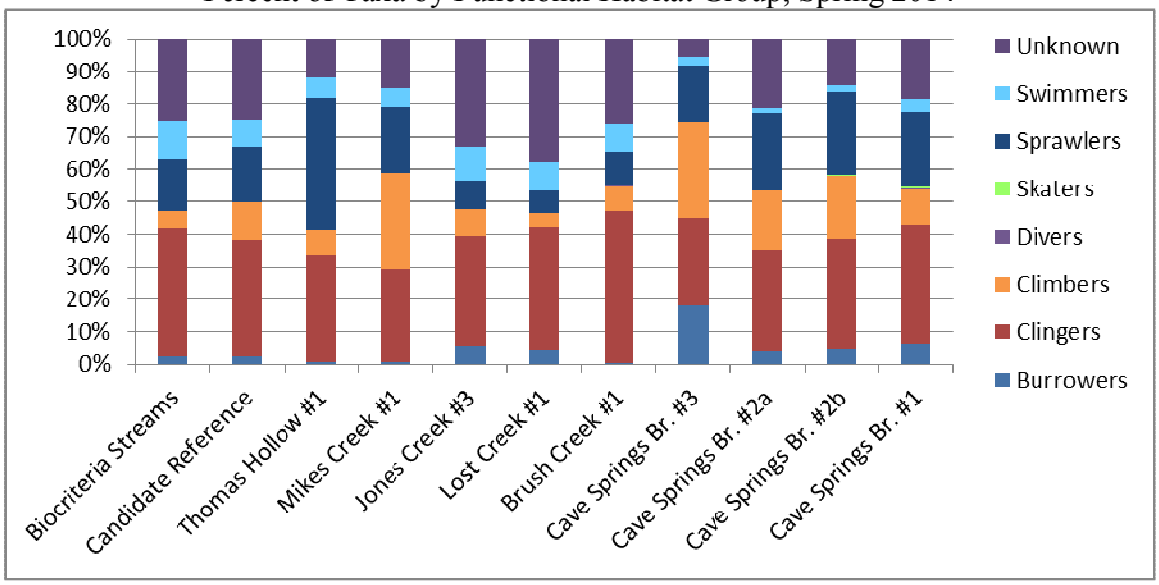


Functional Habit Groups (FHGs)

During the spring 2014 sampling season, clingers were the most abundant FHG at Cave Springs Branch stations #1 and #2 and second in abundance at station #3 (Figure 9 and Table 13). Clingers were generally similar in abundance at stations #1 and #2 compared to both reference datasets, but station #3 had a lower percentage. Climbers were much more abundant among test stations, especially at test station #3, than the biological

criteria reference streams and most candidate reference streams. The percentage of sprawlers was lower at Cave Springs Branch #3 compared to stations #1 and #2; however, station #3 sprawler abundance was similar to the average of both reference datasets. The percentage of sprawlers was variable among candidate reference streams, ranging from 7.2 to 40.7 percent of samples. Burrowers made up a much higher percentage of the station #3 sample compared to the other test stations and both reference datasets. Swimmers were lower in abundance at the Cave Springs Branch test stations than the biological criteria and candidate reference streams.

Figure 9
Percent of Taxa by Functional Habitat Group, Spring 2014



Macroinvertebrate Community Composition

During the spring 2014 sampling season, the percent EPTT among Cave Springs Branch test stations was much lower than the biological criteria reference and the candidate reference streams (Table 14). Percent Ephemeroptera was much lower at the test stations than the biological criteria reference streams, but the results were more variable when compared to the candidate reference streams. Percent Ephemeroptera at test stations #1 and #3 were similar to or slightly lower than most of the candidate reference streams, but the results from the duplicate samples at test station #2 were lower than all of the candidate reference streams. *Caenis latipennis* and *Stenonema femoratum*, which have BI values in the tolerant range, were generally the two most common mayflies found in Cave Springs Branch. *C. latipennis* made up most of the Ephemeroptera abundance at test station #3. *C. latipennis* was not only more abundant at station #3 than the remaining Cave Springs Branch stations, it was also more abundant than the biological criteria reference streams and candidate reference streams. The moderately tolerant mayfly *Fallceon* was relatively abundant at station #3, and intolerant mayflies *Acentrella* and *Acerpenna* were fairly abundant at station #1. Plecoptera made up a much lower percentage of test station samples compared to biological criteria reference streams and

Table 14
Percent EPTT and Dominant EPTT at the Cave Springs Branch Test Stations, Candidate Reference Stations, and the Ozark/Neosho EDU Biological Criteria Reference Samples, Spring 2014

Variable-Station	**Biotic Index**	**Biocriteria Reference Data**	**Candidate Reference Data**	**Thomas Hollow #1**	**Mikes Creek #3**	**Jones Creek #3**	**Lost Creek #1**	**Brush Creek #1**	**Cave Springs Br. #3**	**Cave Springs Br. #2a**	**Cave Springs Br. #2b**	**Cave Springs Br. #1**
Sample Number				149832	149833	149834	149835	149836	149837	149838	149839	149840
Percent EPTT												
EPT		39.7	41.4	63.7	36.5	33.7	30.7	46.0	18.8	18.2	14.7	19.7
Ephemeroptera		27.5	15.3	10.8	11.1	15.7	16.2	23.5	14.1	7.9	6.4	12.1
Plecoptera		7.4	13.1	35.7	18.4	0.6	1.8	10.3	1.7	2.4	2.8	2.7
Trichoptera		4.8	13.0	17.1	7.0	17.4	12.0	12.2	3.0	7.8	5.5	8.7
Percent Ephemeroptera Taxa												
Leucrocuta	0	**3.9**	1.3	2.0	1.1	--	--	**3.6**	--	0.1	0.5	0.5
Paraleptophlebia	1.2	**3.6**	0.6	--	0.5	--	--	2.9	--	--	--	--
Eurylophella bicolor	5.1	**2.8**	**2.3**	1.3	**3.5**	0.5	1.6	**4.7**	--	--	--	--
Acentrella	4.0	**2.7**	1.8	**3.1**	1.3	0.4	**3.2**	0.6	--	--	0.2	**1.3**
Diphetor	5.0	**2.6**	**2.2**	1.8	0.5	**4.7**	2.0	1.9	--	0.1	--	--
Leptophlebia	6.4	2.0	0.7	0.3	**2.9**	0.2		0.2	--	--	--	--
Baetis	6.0	0.2	1.4	--	--	**3.4**	**2.6**	1.0	--	--	0.1	0.1
Stenacron	7.1	1.6	1.2	0.8	0.1	**2.1**	1.4	1.9	--	--	--	--
Maccaffertium pulchellum	3.0	0.2	0.9	--	--	--	**3.8**	0.4	--	--	--	--
Stenonema femoratum	7.5	1.5	1.1	0.2	0.8	0.7	0.1	**3.8**	**1.3**	**2.6**	**1.8**	**1.7**
Caenis latipennis	7.6	1.4	<0.1	--	--	0.1	--	0.1	**10.3**	**4.0**	**2.9**	**2.4**
Fallceon	6.0	--	<0.1	--	0.2	--	--	--	**2.6**	0.7	**0.7**	--
Acerpenna	3.7	0.6	0.8	0.3	0.1	1.7	--	2.2	--	--	--	**2.0**
Percent Plecoptera Taxa												
Amphinemura	3.4	0.9	**8.0**	**27.2**	**13.0**	--	0.2	**0.2**	--	--	0.1	0.6
Leuctridae	0	1.4	**3.2**	**7.9**	1.5	0.3	1.5	**5.3**	0.1	0.1	0.1	0.1
Isoperla	2.0	1.4	1.5	0.5	**3.8**	--	--	**3.3**	--	0.4	0.3	0.7
Perlesta	0	0.4	--	--	--	--	--	--	**1.6**	**1.5**	**2.2**	0.2
Percent Trichoptera Taxa												
Cheumatopsyche	6.6	1.0	**7.4**	**7.5**	1.9	**11.8**	**8.0**	**8.2**	**1.5**	**5.2**	**4.0**	**6.4**
Agapetus	0	1.3	2.1	**6.5**	**2.0**	0.3	0.4	1.4	--	--	--	--
Chimarra	2.8	0.2	1.3	0.7	0.4	**2.1**	**2.2**	1.0	0.5	**1.0**	0.5	**1.3**

Biocriteria and candidate reference stream data values are average percent.
Values in bold type represent the five dominant EPT taxa for each station.

three of five candidate reference streams (Table 14). *Perlesta* was the most abundant stonefly at the Cave Springs Branch test stations. Trichoptera was present in a slightly lower percentage at test station #3 compared to the biological criteria reference streams, but caddisflies were slightly more abundant than references at test stations #1 and #2. Compared to candidate reference streams, Trichoptera made up a lower percentage of test station samples. *Cheumatopsyche* was the dominant caddisfly taxon among test stations, but it was generally less abundant than the candidate reference streams. Compared to biocriteria reference streams, however, *Cheumatopsyche* was present in greater numbers in Cave Springs Branch samples. The EPT taxa *Leucrocuta*, *Eurylophella bicolor*, *Acentrella*, *Diphetor*, *Leptophlebia*, *Baetis*, *Stenacron*, *Maccaffertium pulchellum*, *Amphinemura,* leuctrid stoneflies, *Isoperla*, and *Agapetus* occurred in some or all of the candidate reference streams, but either were not present or occurred in very low abundance in Cave Springs Branch samples. Most of these taxa had BI values that were lower than the most common EPTT found in the test stations.

Chironomidae were much more abundant among Cave Springs Branch test stations than the biological criteria and candidate reference streams (Table 15). Three chironomids, *Cricotopus/Orthocladius* group, *Polypedilum flavum,* and *Paratendipes*, were more abundant at test station #3 than the other sampling stations (Table 16). *Cricotopus/Orthocladius* group and *Polypedilum flavum* also were among the most abundant taxa at test stations #2 and #3. The elmid beetle *Optioservus sandersoni* was more abundant in the biological criteria (2.1 percent) and the candidate reference streams (2 to 10 percent) than the Cave Springs Branch test stations (≤0.5 percent).

The most abundant taxa found in biological criteria reference spring samples were the isopod *Lirceus*, the chironomids *Cricotopus/Orthocladius* group and *Thienemannimyia* group, and the mayflies *Leucrocuta* and *Paraleptophlebia* (Table 16). The two chironomid groups were common in the Cave Springs Branch test stations, but the three other taxa listed above were not common in most of the test stations. *Lirceus* was only abundant at test station #1, *Leucrocuta* was found in very low abundance at all test stations, and *Paraleptophlebia* was absent from test station samples.

Table 15

Percent Dominant Macroinvertebrate Families at the Cave Springs Branch Test Stations, Candidate Reference Stations, and the Ozark/Neosho EDU Biological Criteria Reference Samples, Spring 2014

Variable-Station	**Biocriteria Reference Data**	**Candidate Reference Streams**	**Thomas Hollow #1**	**Mikes Creek #3**	**Jones Creek #3**	**Lost Creek #1**	**Brush Creek #1**	**Cave Springs Br. #3**	**Cave Springs Br. #2a**	**Cave Springs Br. #2b**	**Cave Springs Br. #1**
Sample Number			149832	149833	149834	149835	149836	149837	149838	149839	149840
Percent Dominant Families											
Chironomidae	**28.6**	**24.9**	**18.6**	**37.4**	**29.1**	**19.9**	**18.9**	**73.0**	**55.4**	**67.1**	**58.5**
Asellidae	**14.3**	**12.9**	**7.7**	**6.3**	**11.2**	**22.7**	**15.5**	**1.9**	2.3	0.8	**8.2**
Heptageniidae	**9.9**	5.0	3.5	2.0	4.5	5.3	**10.0**	1.3	2.8	2.3	2.2
Baetidae	**6.1**	6.3	5.1	2.1	**10.2**	**8.1**	5.7	**2.6**	1.1	1.3	**3.5**
Leptophlebiidae	**5.6**	1.5	0.9	3.5	0.3	0.1	3.0	--	--	--	--
Nemouridae	0.9	**8.0**	**27.2**	**13.0**	--	0.2	0.2	--	--	0.1	0.6
Leuctridae	1.4	3.2	**7.9**	1.5	0.3	1.5	5.3	0.1	0.1	0.1	0.1
Hydropsychidae	1.0	**7.5**	**7.8**	1.9	**12.3**	**8.0**	**8.2**	1.6	**5.3**	**4.1**	**6.5**
Elmidae	3.7	**7.1**	4.3	**10.0**	3.0	**9.3**	**8.3**	**1.9**	2.7	1.9	1.2
Perlodidae	1.4	1.5	0.6	**3.8**	--	--	3.3	--	0.4	0.3	0.7
Physidae	0.1	1.3	0.5	--	**5.2**	0.2	1.0	0.1	0.1	0.1	2.0
Caenidae	1.5	<0.1	--	--	0.2	--	0.1	**10.3**	**4.0**	2.9	2.4
Planariidae	0.8	1.1	0.6	1.9	0.7	0.6	1.6	1.3	**8.2**	**4.7**	1.3
Pleuroceridae	3.2	0.6	--	--	0.6	0.4	1.9	--	**4.3**	**3.6**	0.1
Hyalellidae	0.8	1.7	1.6	2.5	0.3	1.9	2.1	0.5	3.6	**3.1**	**3.7**

Biocriteria and candidate reference stream data values are average percent.
Values in bold type represent the five dominant macroinvertebrate families for each station.

Table 16
Percent Dominant Macroinvertebrate Taxa at the Cave Springs Branch Test Stations, Candidate Reference Stations, and the Ozark/Neosho EDU Biological Criteria Reference Samples, Spring 2014

Variable-Station	**Biotic Index**	**Biocriteria Reference Streams**	**Candidate Reference Streams**	**Thomas Hollow #1**	**Mikes Creek #3**	**Jones Creek #3**	**Lost Creek #1**	**Brush Creek #1**	**Cave Springs Br. #3**	**Cave Springs Br. #2a**	**Cave Springs Br. #2b**	**Cave Springs Br. #1**
Sample Number				149832	149833	149834	149835	149836	149837	149838	149839	149840
Percent Dominant Taxa												
Family Chironomidae												
Cricotopus/Orthocladius grp.	6.5	**10.6**	3.8	1.9	1.7	**6.1**	5.2	3.8	**17.9**	**11.3**	**18.9**	**19.1**
Micropsectra	1.4	1.6	4.5	4.3	**11.9**	4.0	0.3	1.9	**3.2**	2.1	3.5	0.6
Paratendipes	5.3	0.1	0.9	0.1	--	3.1	1.1	--	**15.8**	3.2	3.2	2.6
Polypedilum flavum	5.3	0.9	0.3	3.0	0.1	--	0.4	0.8	**23.1**	**10.7**	**10.9**	**5.9**
Rheocricotopus	7.3	0.1	0.2	0.3	0.1	0.3	0.4	--	--	3.7	3.7	**6.8**
Tanytarsus	6.7	2.1	**5.1**	1.7	**17.5**	1.1	0.8	3.8	1.8	2.3	2.0	2.7
Thienemannimyia grp.	6.0	**3.9**	1.5	1.7	1.7	1.1	1.4	1.4	2.4	**5.7**	**5.8**	3.4
Order Isopoda												
Caecidotea	8.0	0.2	2.7	--	--	--	**12.0**	--	--	--	--	--
Lirceus	7.7	**13.9**	**10.0**	**7.7**	**5.7**	**11.1**	**10.5**	**15.5**	--	0.3	0.3	**7.5**
Order Ephemeroptera												
Leucrocuta	0	**3.9**	1.3	2.0	1.1	--	--	3.6	--	0.1	0.5	0.5
Diphetor	5.0	2.5	2.2	1.8	0.5	**4.7**	2.0	1.9	--	0.1	--	--
Paraleptophlebia	1.2	**3.6**	0.6	--	0.5	--	--	2.9	--	--	--	--
Eurylophella bicolor	5.1	2.8	2.3	1.3	3.5	0.5	1.6	**4.7**	--	--	--	--
Caenis latipennis	7.6	1.4	<0.1	--	--	0.1	--	0.1	**10.3**	4.0	2.9	2.4
Order Plecoptera												
Amphinemura	3.4	0.9	**8.0**	**27.2**	**13.0**	--	0.2	0.2	--	--	0.1	0.6
Leuctridae	0	1.4	3.2	**7.9**	1.5	0.3	1.5	**5.3**	0.1	0.1	0.1	0.1
Order Trichoptera												
Cheumatopsyche	6.6	1.0	**7.4**	**7.5**	1.9	**11.8**	**8.0**	**8.2**	1.5	**5.2**	**4.0**	**6.4**
Agapetus	0	1.3	2.1	**6.5**	2.0	0.3	0.4	1.4	--	--	--	--
Family Elmidae												
Optioservus sandersoni	2.7	2.1	**6.3**	4.3	**9.8**	2.2	**7.4**	**7.5**	0.1	0.5	0.1	0.2
Family Physidae												
Physella	9.1	0.1	1.3	0.5	--	**5.2**	0.2	1.0	0.1	0.1	0.1	2.0
Order Tricladida												
Planariidae	7.5	0.8	1.1	0.6	1.9	0.7	0.6	1.6	1.3	**8.2**	**4.7**	1.3
Order Tubificida												
Tubificidae	9.2	0.6	1.9	--	--	3.4	**5.6**	0.1	1.0	--	--	--

Biocriteria and candidate reference stream data values are average percent.
Values in bold type represent the five dominant macroinvertebrate taxa for each station.

3.3 Physicochemical Data

Water samples and field measurements were collected during the fall 2013 and spring 2014 macroinvertebrate sampling periods (Tables 17 and 18). The results showed that the chronic water quality standard for chloride during the fall 2013 sampling season was violated (MDNR 2010c) and other parameters were elevated compared to reference conditions or U.S. EPA Nutrient Criteria recommended reference values for the Level III Ozark Highlands ecoregion (U.S. EPA 2000). Physicochemical results are arranged to demonstrate trends of certain variables that may suggest a source of effects at the Cave Springs Branch test stations. Results shown here are for stream discharge, conductivity, chloride, sulfate, nitrate + nitrite-N, total nitrogen, total phosphorus, and turbidity by season.

3.3.1 Stream Discharge

Discharge at the Cave Springs Branch test stations was similar to discharge values at the candidate reference streams during the fall 2013 sampling season, ranging from 2.6 cfs at test station #3 to 4.9 cfs at test station #1 (Table 17). At the candidate reference streams, discharge ranged from 3.0 cfs at Mikes Creek #3 to 7.2 cfs at Jones Creek #3.

Discharge was higher during the spring 2014 sampling season, ranging from 5.6 cfs at test station #3 to 12.2 cfs at test station #1 (Table 18). Candidate reference stream discharge ranged from 4.9 cfs at Thomas Hollow #1 to 19.4 cfs at Brush Creek #1.

3.3.2 Conductivity

Cave Springs Branch conductivity was higher than the candidate reference streams during both sampling seasons (Tables 17 and 18). During the fall 2013 sampling season, conductivity at Cave Springs Branch ranged from 943 µmhos/cm at test station #1 to 1504 µmhos/cm at test station #3. Among candidate reference streams, conductivity ranged from 282 µmhos/cm at Jones Creek #3 to 309 µmhos/cm at Thomas Hollow #1.

During the spring 2014 sampling season, conductivity at Cave Springs Branch ranged from 756 µmhos/cm at test station #1 to 1235 µmhos/cm test station #3 (Table 18). At the candidate reference streams, conductivity ranged from 241 µmhos/cm at Brush Creek #1 to 272 µmhos/cm at Thomas Hollow #1.

3.3.3 Chloride

Chloride concentrations were higher among Cave Springs Branch test stations compared to the candidate reference streams during both sampling seasons; however, except for test station #3 during the fall 2013 sampling season, the values were below chronic Missouri Water Quality Standards that have been approved by the U.S. Environmental Protection Agency (MDNR 2010c). The hardness-dependent chloride water quality standards that were listed in the 2012 and 2014 water quality standards have been disapproved by the U.S. EPA (John Hoke, MDNR WPP Watershed Protection Section Chief, pers. comm.) As a result, the 2010 chloride standards are used. The chronic chloride water quality standard is 230 mg/L, and the acute standard is 860 mg/L (MDNR 2010c). Chloride

ranged from 156 mg/L at test station #1 to 290 mg/L at test station #3 during the fall 2013 sampling season (Table 17). Among candidate reference streams, chloride ranged from 6.22 mg/L at Jones Creek #3a to 12.3 mg/L at Brush Creek #1.

During the spring 2014 sampling season, chloride ranged from 115 mg/L at test station #1 to 225 mg/L test station #3 (Table 18). At the candidate reference streams, chloride ranged from 4.78 mg/L at Mikes Creek #3 to 7.63 mg/L at Lost Creek #1.

3.3.4 Sulfate

Although sulfate concentrations were higher among Cave Springs Branch test stations than the candidate reference streams during both sampling seasons, they were below water quality standards (Tables 17 and 18). Sulfate and chloride (sulfate + chloride) are linked together in U.S. EPA-approved Missouri's Water Quality Standards, with a compliance threshold of 1000 mg/L (MDNR 2010c). The hardness-dependent sulfate water quality standards listed in the 2012 and 2014 water quality standards have been disapproved by the U.S. EPA (John Hoke, MDNR WPP Watershed Protection Section Chief, pers. comm.) In fall 2013, Cave Springs Branch sulfate concentrations ranged from 125 mg/L at test station #1 to 204 mg/L at test station #3. Among candidate reference streams, sulfate ranged from <3.50 mg/L at Thomas Hollow #1 to 8.43 mg/L at Brush Creek #1.

During the spring 2014 sampling season, Cave Springs Branch sulfate concentrations ranged from 68.4 mg/L at test station #1 to 125 mg/L at test station #3 (Table 18). Among candidate reference streams, sulfate ranged from 6.43mg/L at Thomas Hollow #1 to 7.22 mg/L at Lost Creek #1.

3.3.5 Nitrate + Nitrite-N

During the fall 2013 sampling season, Cave Springs Branch and candidate reference stream samples had nitrate + nitrite-N concentrations above the U.S. EPA recommended reference value (0.24 mg/L) for the Level III Ozark Highlands ecoregion (U.S. EPA 2000). Nitrate + nitrite-N at Cave Springs Branch ranged from 3.20 mg/L at test station 3 to 4.71 mg/L at test station 2 (Table 17). Among candidate reference streams, nitrate + nitrite-N ranged from 1.59 mg/L at Brush Creek #1 to 3.45 mg/L at Jones Creek #3.

Nitrate + nitrite-N values also were much higher than the U.S. EPA recommended reference value during the spring 2014 sampling season (Table 18). Nitrate + nitrite-N at Cave Springs Branch ranged from 6.92 mg/L at station #1 to 9.76 mg/L at station #3. At the candidate reference streams, nitrate + nitrite-N ranged from 1.94 mg/L at Mikes Creek #1 to 3.50 mg/L at Jones Creek #3.

3.3.6 Total Nitrogen

Total nitrogen was elevated at Cave Springs Branch and the candidate reference streams during the fall 2013 sampling season compared to the U.S. EPA recommended reference value (0.29 mg/L) for the Level III Ozark Highlands ecoregion (U.S. EPA 2000). Total

nitrogen at Cave Springs Branch ranged from 4.11 mg/L at station #3 to 5.27 mg/L at station #2 (Table 17). At the candidate reference streams, nitrate + nitrite-N ranged from 1.79 mg/L at Brush Creek #1 to 3.96 mg/L at Jones Creek #3a.

Total nitrogen values also were much higher than the U.S. EPA recommended reference value during the spring 2014 sampling season (Table 18). Total nitrogen at Cave Springs Branch ranged from 6.59 mg/L at station #1 to 9.70 mg/L at station #3. At the candidate reference streams, total nitrogen ranged from 1.76 mg/L at Mikes Creek #1 to 3.27 mg/L at Jones Creek #3.

3.3.7 Total Phosphorus

Total phosphorous was elevated at Cave Springs Branch and the candidate reference stream Lost Creek during the fall 2013 sampling season compared to the U.S. EPA recommended reference value (0.007 mg/L) for the Level III Ozark Highlands ecoregion (U.S. EPA 2000). Total phosphorus at Cave Springs Branch ranged from 0.04 mg/L at test station #3 to 0.06 mg/L at stations #1 and #2 (Table 17). Total phosphorus was below the CAS detection limit of 0.01 mg/L at all candidate reference sampling stations except Lost Creek #1. Total phosphorus at Lost Creek #1 was 0.02 mg/L.

Cave Springs Branch and Lost Creek also had higher total phosphorus concentrations than U.S. EPA recommended reference values during the spring 2014 sampling season (Table 18). Total phosphorus at Cave Springs Branch ranged from 0.015 mg/L at station #3 to 0.02 mg/L at station #1. At the candidate reference streams, total phosphorus was below the detection limit of 0.01 mg/L at all of the sampling stations except Lost Creek #1, which had a concentration of 0.016 mg/L.

3.3.8 Turbidity

Candidate reference streams Lost Creek and Jones Creek had turbidity values that were higher than the U.S. EPA recommended reference value of 1.43 NTU for turbidity (U.S. EPA 2000) during the fall 2013 sampling season. Turbidity at Lost Creek #1 was 1.74 NTU, 2.36 NTU at Jones Creek #3a, and1.83 NTU at Jones Creek #3b (Table 17). Turbidity at the remaining candidate reference and Cave Springs Branch stations were <1 NTU.

Turbidity was elevated compared to the U.S. EPA recommended reference value at Jones Creek, Lost Creek, Brush Creek, and Cave Springs Branch #3 (Table 18) during the spring 2014 sampling season. Turbidity at Cave Springs Branch ranged from 1.01 NTU at station #1 to 1.83 NTU at station #3. Among candidate reference streams, turbidity ranged from 0.78 NTU at Thomas Hollow #1 to 2.57 NTU at Lost Creek #1.

3.4 Quality Control

Quantitative Similarity Index for Taxa (QSIT) is a sampling protocol quality control measure that expresses taxa similarity between two samples as a percentage. QSIT was calculated for the duplicate samples collected at Jones Creek #3 during the fall 2013

Table 17
Physicochemical Variables at the Cave Springs Branch Bioassessment Study Sampling Stations, Fall 2013

	Thomas Hollow #1	Mikes Creek #3	Lost Creek #1	Jones Creek #3a	Jones Creek #3b	Brush Creek #1	Caves Springs Branch #3	Cave Springs Branch #2	Cave Springs Branch #1
Invertebrate Sample Number	132051	132052	132053	132054	132055	132056	132057	132058	132059
Physicochemical Sample Number	133978	133979	133980	133981	133982	133983	133984	133985	133986
Sample Date	09/23/2013	09/24/2013	09/24/2013	09/24/2013	09/24/2013	09/25/2013	09/25/2013	09/25/2013	09/25/2013
Sample Time	1620	0855	1110	1355	1356	0915	1130	1310	1435
Ammonia	<0.03[a]	<0.03[a]	<0.03[a]	<0.03[a]	0.07	0.07	0.10	<0.03[a]	0.10
Chloride	8.98	8.48	10.7	6.22	6.50	12.3	**290**	176	156
Sulfate	<3.50[a]	5.44	6.66	5.39[e]	4.73[d]	8.43	204[c]	126[c]	125[c]
Total Recoverable Calcium	63.6	67.6	65.3	58.0[e]	58.4	64.5	60.7	69.7	68.0
Total Recoverable Magnesium	3.45	2.33	1.99	4.57	4.58	1.97	21.3	12.1	10.9
Total Recoverable Hardness as $CaCO_3$	173	178	171	164	165	169	239	224	215
Dissolved Oxygen	8.53	6.94	9.22	9.14	9.16	7.52	9.13	9.57	10.19
Discharge (cfs)	3.0	3.0	7.1	7.2	7.2	3.1	2.6	4.3	4.9
pH (Units)	8.3	7.6	7.8	8.0	8.0	7.8	7.6	7.7	8.0
Conductivity (µmhos/cm)	309	301	296	282	283	308	1504	1008	943
Temperature (°C)	19.5	18.4	16.3	17.0	16.9	17.6	19.9	19.2	20.3
Turbidity (NTU)	< 1	< 1	**1.74**	**2.36**	**1.83**	< 1	< 1	< 1	< 1
Total Suspended Solids	<5[ab]	<5[a]	<5[a]	<5[a]	<5[a]	<5[a]	<5[a]	<5[a]	<5[a]
Nitrate + Nitrite	**2.67[c]**	**2.00**	**3.06[c]**	**3.45[c]**	**3.45[c]**	**1.59**	**3.20[c]**	**4.71**	**4.22[c]**
Total Nitrogen	**2.83**	**2.12**	**3.37**	**3.96**	**3.72**	**1.79**	**4.11**	**5.27**	**4.60**
Total Phosphorus	<0.01[a]	<0.01[a]	**0.02[d]**	<0.01[a]	<0.01[a]	<0.01[a]	**0.04**	**0.06**	**0.06**

[a] Below detectable limits
[b] Exceeded holding times
[c] Sample was diluted during analysis
[d] Estimated value, detected below Practical Quantitation Limit
[e] Estimated value, QC data outside limits
Units mg/L unless otherwise noted. Values in bold exceed Missouri Water Quality Standards or are elevated compared to U.S. EPA recommended reference condition values.

Table 18
Physicochemical Variables at the Cave Springs Branch Bioassessment Study Sampling Stations, Spring 2014

	Thomas Hollow #1	Mikes Creek #3	Jones Creek #3	Lost Creek #1	Brush Creek #1	Caves Springs Branch #3	Caves Springs Branch #2a	Cave Springs Branch #2b	Cave Springs Branch #1
Invertebrate Sample Number	149832	149833	149834	149835	149836	149837	149838	149839	149840
Physicochemical Sample Number	149664	149665	149666	149667	149668	149669	149670	149671	149672
Sample Date	03/25/2014	03/25/2014	03/25/2014	03/25/2014	03/26/2014	03/26/2014	03/26/2014	03/26/2014	03/26/2014
Sample Time	1230	1324	1520	1650	0945	1140	1255	1255	1500
Ammonia	<0.03[a]	<0.03[a]	<0.03[a]	<0.03[a]	<0.03[a]	0.30	0.05	0.04[c]	0.03[c]
Chloride	6.00	4.78	5.23	7.63	7.28	225	140	139	115
Sulfate	6.43	6.78	6.76	7.22	7.20	125	80.4	80.5	68.4
Total Recoverable Calcium	49.4	47.4	47.0	48.6	44.9	56.8	61.5	59.5	59.3
Total Recoverable Magnesium	2.66	1.64	4.25	1.68	1.38	22.4	12.8	12.4	10.1
Total Recoverable Hardness as $CaCO_3$	134	125	135	128	118	234	206	200	190
Dissolved Oxygen	12.19	11.72	12.02	11.92	11.03	11.53	15.27	15.29	14.21
Discharge (cfs)	4.9	7.9	9.5	8.6	19.4	5.6	8.7	8.5	12.2
pH (Units)	8.4	8.3	8.0	8.3	8.1	7.5	8.8	8.8	8.8
Conductivity (µmhos/cm)	272	252	261	248	241	1235	854	862	756
Temperature (°C)	10.7	9.8	14.3	14.6	10.4	12.4	10.9	10.9	10.1
Turbidity (NTU)	<1	<1	**1.74**	**2.57**	**1.61**	**1.83**	1.09	1.29	1.01
Total Suspended Solids	<5[a]	<5[a]	<5[a]	<5[a]	<5[a]	<5[a]	<5[a]	<5[a]	<5[a]
Nitrate + Nitrite	**3.14[b]**	**1.94**	**3.50[b]**	**3.06[b]**	**2.66[b]**	**9.76[b]**	**7.75[b]**	**7.71[b]**	**6.92[b]**
Total Nitrogen	**2.89**	**1.76**	**3.27**	**2.80**	**2.22**	**9.70**	**7.40**	**7.25**	**6.59**
Total Phosphorus	<0.01[a]	<0.01[a]	<0.01[a]	**0.016[c,d]**	<0.01[a]	**0.015[c,d]**	**0.017[c,d]**	**0.016[c,d]**	**0.02[c]**

[a] Below detectable limits
[b] Sample was diluted during analysis
[c] Estimated value, detected below Practical Quantitation Limit
[d] Analyte present in blank at > ½ reported value
Units mg/L unless otherwise noted. Values in bold are elevated compared to U.S. EPA recommended reference condition values

sampling season and Cave Springs Branch #2 during the spring 2014 sampling season. Duplicate samples are expected to have a score of 70 percent or greater (Rabeni et al. 1999). The fall 2013 QSIT for duplicate samples at Jones Creek #3 was 83.7 percent, and the spring 2014 QSIT for duplicate samples at Cave Springs Branch #2 was 80.8 percent.

Duplicate water samples also were collected at Jones Creek #3 during the fall 2013 sampling season and Cave Springs Branch #2 during the spring 2014 sampling season as part of quality control procedures. Field measurements and water sample physicochemical analysis results were similar for the duplicate samples.

4.0 Discussion

4.1 Effect of Stream Size on MSCI Scores

Differences between the biological criteria and candidate reference criteria for the individual biological metrics were generally small during both sampling seasons (Tables 5-8). During the fall 2013 sampling season, only the SDI metric exhibited a notable difference between the two datasets, with candidate reference streams having higher criteria threshold values. For the other metrics, the TR and EPTT scoring thresholds were slightly lower and BI was slightly higher for the candidate reference streams. The difference in SDI threshold values resulted in MSCI scoring differences between biological criteria and candidate reference criteria at two Cave Springs Branch stations. Using biological criteria scoring thresholds, stations #1 and #2 both had fall 2013 MSCI scores that were two points higher than when candidate reference thresholds are used. Only Cave Springs Branch station #1 exhibited a difference in support category between the two datasets. Station #1 attained a fully supporting MSCI score using biological reference criteria but a partially supporting score using candidate reference criteria.

During the spring 2014 sampling season, only BI had a large difference between the two datasets, with a higher threshold value for the candidate reference streams. For the remaining metric threshold values, candidate reference TR was slightly higher and EPTT and SDI were slightly lower than biological criteria references. During the spring 2014 sampling season, the higher candidate reference BI threshold value resulted in station #2 and #3 MSCI scores being two points higher than MSCI scores calculated using the biological criteria. The station #1 MSCI score did not change between datasets. Despite the scoring differences at stations #1 and #2, both stations were fully supporting, regardless of the criteria set used.

Differences between the criteria datasets primarily affected one metric for each sampling season. Although these differences did affect MSCI scores, a difference in support category occurred only with the fall 2013 Cave Springs Branch station #1 sample.

4.2 Possible Water Quality Effects on the Biological Metrics

Results from the surface water samples showed that nitrate + nitrite-N and total nitrogen were elevated at the Cave Springs Branch test stations and the candidate reference

streams compared to U.S. EPA recommended reference values (U.S. EPA 2000) during both sampling seasons (Tables 17 and 18). Nitrogen values were higher at the Cave Springs Branch test stations than the candidate reference streams during both sampling seasons, with much higher values occurring during the spring 2014 sampling season. Nitrogen values were generally higher at Jones Creek #3 and Lost Creek #1 than the other candidate reference streams during both sampling seasons. Total phosphorus was also slightly elevated at the Cave Springs Branch test stations and the Lost Creek candidate reference station compared to the U.S. EPA recommended reference value during both samplings seasons. Some of the other total phosphorus values for this study may have been higher than the recommended reference value, but the CAS detection limit for total phosphorus is actually higher than the recommended reference value.

There was evidence that elevated nutrients affected some of the biological metrics used in MSCI calculation at the Cave Springs Branch test stations. Biotic index, an indicator of organic pollution, was elevated at the Cave Springs Branch test stations during both sampling seasons compared to the biological criteria. When assessing biotic index using candidate reference criteria, however, BI scores were consistently suboptimal only for fall 2013. Total nitrogen concentration at two candidate reference streams, Jones and Lost creeks, generally were higher than the remaining candidate reference streams, and BI values were similar to those found in the test stations during spring 2014. These higher BI values at Jones and Lost creeks caused the BI criteria for the candidate reference streams to be similar to the BI values of the Cave Springs Branch test stations. Biotic index also was higher at Jones and Lost creeks than the other candidate reference streams in fall 2013. Elevated nitrogen levels and BI values appeared to be related during both sampling seasons at Cave Springs Branch, Jones Creek, and Lost Creek.

Compared to most of the biological criteria and candidate reference stream samples, the EPTT metric ranged from much lower at Cave Springs Branch station #3 to slightly lower at the other two test stations during both sampling seasons (Tables 5-8). The reduced number of EPTT was probably caused by elevated nutrients or a combination of nutrients and other water quality constituents. Other possible pollutants that might have affected EPTT and the other biological metrics were chloride and sulfate. The test station #3 chloride concentration violated the chronic water quality standard in the fall 2013 sampling season and was very close to the chronic standard in spring 2014 (MDNR 2010c). Chloride concentrations at test stations #1 and #2 and sulfate at all three sampling stations were below water quality standards during both sampling seasons; however, they were higher among Cave Springs Branch stations compared to the candidate reference streams (See section 3.3.2). The Simmons WWTF effluent was the likely source of the elevated chloride and sulfate values in the Cave Springs Branch water samples. A United States Geological Survey (USGS) study found that water samples collected from Cave Springs Branch in August 1999 and the Simmons WWTF effluent in March 2000 had elevated values of sodium, potassium, chloride, and sulfate (USGS 2000). Macroinvertebrate community analysis in this study showed that most of the common EPTT that occurred in the Cave Springs Branch test stations such as *Caenis*

latipennis, *Stenonema femoratum*, and *Cheumatopsyche* had BI values either in the moderately tolerant or tolerant range (Tables 12 and 16). The community analysis also showed that there were other EPTT that generally had BI values in the intolerant range that occurred in some or all of the candidate reference streams, but these taxa either were not present or were found in low numbers in the Cave Springs Branch samples.

Other taxonomic groups also indicate that the community had likely been affected by nutrient enrichment or other water quality parameters. The percent of taxa made up of chironomids at the Cave Springs Branch samples generally was higher than most candidate reference streams during both sampling seasons (Tables 12 and 16). This observation was the most pronounced at test station #3 during both sampling seasons. Chironomids were also elevated at the other two test stations during the spring 2014 sampling season. Most of the common chironomid taxa in the Cave Springs Branch samples, including *Paratendipes*, *Polypedilum flavum*, *Rheotanytarsus*, and *Cricotopus/Orthocladius* group, had BI values that were primarily in the moderately tolerant range and were generally more abundant than the candidate reference streams. Another difference in the macroinvertebrate community compositon was the higher abundance of the the intolerant riffle beetle *Optioservus sandersoni* in the candidate reference streams. This beetle was one of the most common taxa found in the candidate reference streams during both sampling seasons, but it made up less than 1 percent of any of the Cave Springs Branch samples. During the fall 2013 sampling season, the intolerant water penny *Psephenus herricki* was very low in abundance at Cave Springs Branch #3, but it increased in abundance at downstream stations to a level that was comparable to some of the candidate reference streams. This pattern of increased abundance at the downstream stations suggests that water quality was improving farther downstream.

4.3 Functional Feeding and Habit Groups

Differences were observed in some of the FFGs and FHGs between the Cave Springs Branch test stations and the biological criteria and candidate reference streams (Tables 9 and 13). The scraper FFG was consistently less abundant at the test stations than the biological criteria and candidate reference streams during both sampling seasons, with the lowest values occurring at test station #3. Scrapers include macroinvertebrates such as heptageniid mayflies, water pennies, elmid beetles, and snails that generally feed on periphyton made up primarily of diatoms that grow on the bottom substrates of streams. As mentioned in the previous section, some of the heptageniid mayfly taxa and the elmid riffle beetle *Optioservus sandersoni* were lower in abundance at all test stations than both reference datasets during both sampling seasons. The water penny *Psephenus herricki* also was less abundant at test station #3 compared to both reference datasets during the fall sampling season. Heptageniid mayflies from the genus *Maccaffertium* were not present in the Cave Springs Branch samples during either sampling season. Scrapers are usually lower in abundance in stream reaches that have lower amounts of hard substrate and higher amounts of fine sediment (Rabeni et al. 2005). Cave Springs Branch, however, generally did not have high amounts of fine sediment, but rather had a high

abundance of hard substrates on the stream bottom. Some factor other than bottom substrate composition was the likely cause of the lower of abundance of scrapers in Cave Spring Branch. One possible cause could be the type of algae present in the stream. Scrapers cannot efficiently harvest filamentous algae and mosses (Andrade 2006). Although there was little or no filamentous algae observed during the fall sampling season at Cave Springs Branch, it was abundant at test stations #1 and #2 during the spring sampling season (personal observation). An algal survey was not conducted as part of this study, but during the fall sampling season the bottom substrate was covered by what looked like dark, slick algae that may have been diatomaceous. This condition was especially evident at test station #3. Some of the slick, darker-colored algae also were present at the other two test stations, but to a lesser degree than test station #3. These algae were also present in spring 2014 at test station #3, although the color and texture were somewhat different than what was observed in the fall 2013 sampling season.

The percentage of shredders was generally higher in Cave Springs Branch than both reference datasets during both sampling seasons. Shredders were especially abundant at test station #3. The only exception was at Thomas Hollow #1 during the spring 2014 sampling season, which had a percent shredder value similar to test station #3. The higher shredder abundance at the Cave Springs Branch test stations during the fall 2013 sampling season was caused by the higher abundance of the chironomid *Polypedilum flavum*. During the spring 2014 sampling season, most of the shredder abundance at Cave Springs Branch was made up of the chironomid taxa *Cricotopus/Orthocladius* group and *Polypedilum flavum*, whereas the dominant shredder taxa at Thomas Hollow #1 were leuctrid stoneflies and the stonefly *Amphinemura*. Shredders are generally more abundant in headwater streams than larger creeks and rivers because headwater streams are strongly influenced by riparian vegetation that reduces autotrophic production by shading and produces large amounts of coarse organic matter (Vannote et al. 1980). At test station #3 Cave Springs Branch is a small creek, but it does not have the high quality riparian zone common of many headwater streams that can provide large amounts of coarse organic matter for shredders. The higher abundance of moderately tolerant chironomid shredder taxa at test station #3 instead of more intolerant shredder taxa that occurred at the candidate reference streams indicate that shredder taxa were more likely influenced by water quality than by riparian vegetation.

The burrower FHG was more abundant at Cave Springs Branch #3 than all other stations sampled in this study during both sampling seasons (Tables 8 and 10). An increase in burrowers often indicates that fine sediment is elevated within the sampling reach, but this was not evident at test station #3. Most of the burrower abundance at test station #3 was caused by the chironomid *Paratendipes*, which was much more abundant at this station than the other sites. *Paratendipes* was especially abundant during the spring 2014 sampling season at test station #3, making up almost 16 percent of the sample. *Paratendipes* is a moderately tolerant taxon (BI = 5.3) that occurs in a variety of habitats including standing waters, flowing waters, in soft sediments, and sandy bottoms (Epler et

al. 2013). It is unknown what was driving the high abundance of *Paratendipes*, which led to the higher burrower value at test station #3, but there is no evidence from other studies that it is tolerant of elevated nutrient levels.

The clinger FHG was lower in abundance at the Cave Springs Branch test stations than the candidate reference streams during the fall 2013 sampling season. During spring 2014, however, this FHG was similar in abundance among candidate reference and test streams. Clingers are primarily made of taxa that are members of the scraper FFG such as heptageniid mayflies that feed on the periphyton and the filterer FFG such as hydropsychid caddisflies that attach to harder substrates and filter particles out of the water column. Clinger taxa made up primarily of EPTT and Coleoptera taxa were more abundant in the candidate reference streams than the Cave Springs Branch test stations during the fall 2013 sampling season. Moderately tolerant and tolerant EPTT and Coleoptera taxa such as *Cheumatopsyche*, *Stenonema femoratum*, and *Stenelmis* were found in the test stations. Although more tolerant EPTT (*Cheumatopsyche*, *Stenonema femoratum*, and *Stenacron*) were common among candidate reference stations, other more intolerant taxa such as *Eurylophella*, *Maccaffertium*, perlid stoneflies, *Optioservus sandersoni* were also found in some or all of these samples. During the spring 2014 sampling season, clinger values were similar at most of the sampling stations. The similarity in the clinger values between the test and candidate reference stations was primarily caused by a higher abundance of the chironomid *Cricotopus/Orthocladius* group at the test stations and a higher abundance of clinger EPTT and Coleoptera taxa at the candidate reference streams. *Cricotopus/Orthocladius* group made up from about 11 to 19 percent of the Cave Springs Branch samples and about 2 to 6 percent of the samples from the candidate reference streams. Coleoptera and EPTT clingers made up about 6 to 16 percent of Cave Springs Branch samples and about 21 to 40 percent of candidate reference samples. Lower values for all clinger taxa at Cave Springs Branch during the fall 2013 sample season were countered by the higher abundance of a more tolerant clinger taxon (*Cricotopus/Orthocladius*) during the spring 2014 sampling season. This increased abundance led to similar clinger values among all sampling stations in spring 2014. These results suggest that water quality conditions influenced the clinger abundance and composition at Cave Springs Branch.

There were some differences in sprawler abundance that resulted from a few taxa that either had higher abundances in the Cave Springs Branch test stations or the candidate reference streams (Tables 9 and 13). During the fall 2013 sampling season, the percentage of sprawlers was much higher at Cave Springs Branch #3 than all of candidate reference streams. The remaining two test stations were higher in sprawlers than the candidate reference streams except Jones Creek #3. Most Cave Springs Branch sprawler abundance in fall 2013 was from the high abundance of *Caenis latipennis*, whereas most of the sprawler abundance at Jones Creek #3 was from the chironomid *Stempellinella*. During the spring 2014 sampling season, the percentage of sprawlers at the Cave Springs Branch test stations was higher than or similar to four of the five candidate reference streams. The only candidate reference stream that had a higher percent sprawler value

was Thomas Hollow #1, which was primarily caused by the high abundance the stonefly *Amphinemura* and stoneflies from the family Leuctridae. Mikes Creek #3, which had a percent sprawler value similar to the test stations, also had higher abundances of *Amphinemura* and leuctrid stoneflies compared to the test stations. Like the fall 2013 sampling season, most of the sprawler abundance at test station #3 was made up of *Caenis latipennis* in spring 2014. At the other two test stations, sprawler abundance was made up primarily by a combination of *C. latipennis* and chironomids such as *Thienemannimyia* group and *Rheocrictopus*. It is likely that water quality conditions influenced sprawler abundance since the tolerant *Caenis latipennis* was primarily responsible for the higher sprawler values, especially during the fall 2013 sampling season, at test station #3.

Most of the differences in FFG and FHG between the Cave Springs Branch test stations and reference conditions showed some of the same trends that were observed from the macroinvertebrate community composition analysis. Cave Springs Branch, especially station #3, generally had a higher abundance of *C. latipennis* and chironomids than the candidate reference streams. Macroinvertebrate taxa that were found at some of the candidate reference streams during one or both sampling seasons such as *Optioservus sandersoni*, *Amphinemura*, and the heptageniid mayflies *Maccaffertium* spp. and *Leucrocuta* were not present or were found in lower abundances in the Cave Spring Branch test stations.

4.4 Hydrology and Land Use

The geology of Cave Springs Branch is made up of karst topography, and it is hydraulically connected to the groundwater, which generally flows from east to west within the watershed (USGS 2000). The 2000 USGS study found that on average about a third of the stream discharge in Cave Springs Branch at the state line is from Simmons WWTF effluent, and there are three separate losing stream segments on Cave Springs Branch. The three sampling reaches for this study were located just upstream (test station #3) or within (test stations #1 and #2) the losing stream segments that were defined in the 2000 USGS study. A fluorescein dye tracer study conducted in 1998 by the Missouri Department of Natural Resources (as referenced in MDNR 2010a) found that there was a hydrological connection between the Simmons storm water basin; Miller Spring, located near the processing plant; and O'Brien Spring, located downstream in Oklahoma (Figure 1). The dye study did not determine if a hydrological connection existed between the two springs and the poultry plant WWTF lagoons, but water sample results from the 2000 USGS study indicated that there might be a connection to O'Brien Spring. Results from the USGS study found that chloride, nitrogen, and phosphorus were elevated in O'Brien Spring samples.

Compared to the candidate reference watersheds, the Cave Springs Branch watershed had more agricultural land use types, such as grassland and cropland, and less forest cover (Table 2 and 3). Grassland, including pasture, made up 70 percent of land use in the Cave Springs Branch watershed. Cropland values in the Cave Springs Branch watershed

were slightly higher than the candidate reference streams, making up about 7 to 8 percent of the watershed. Forest made up about 10 percent or less of the Cave Spring Branch watershed, which was much lower than the candidate reference watersheds.

Poultry and other livestock operations are common in the Cave Springs Branch watershed. Studies on Cave Springs Branch have documented the presence of cattle at test station #3 in 2000 (GBMc & Associates 2000; USGS 2000), and cattle were observed just upstream of test station #2 during the fall 2013 sampling season of this study (personal observation). There are also seven poultry broiler houses near the Simmons WWTF. These broiler houses have Missouri general permits that allow for the use of dry litter manure systems, in which waste is stored until a flock cycles and weather conditions allow for the removal and land application of the material (MDNR 2010a). The permits allow 1,804,333 birds to be produced from the seven facilities and allow for the poultry litter to be sold. It is not known if the poultry litter that is sold is land applied in the Cave Spring Branch watershed or other surrounding watersheds. Because of these agricultural activities, it is difficult to distinguish the effects of these operations compared to the Simmons WWTF effluent on nutrient enrichment and other water quality attributes in Cave Springs Branch. The USGS study (2000) found some evidence that non-point source pollution was occurring in Cave Springs Branch downstream of O'Brien Spring. The study also found that values of chloride, total phosphorus, orthophosphate, *Escherichia coli*, and fecal streptococcal bacteria were higher at a sampling station near test station #2 compared to those in samples collected at O'Brien spring in August 1999. These results indicated that the increased values were caused by animal or human waste or fertilizer somewhere between O'Brien Spring and test station #2.

5.0 Conclusions

A comparison of the candidate reference stream and the wadeable/perennial biological criteria showed that most of the biological metrics had similar criteria values during both sampling seasons. Differences between the two datasets included a higher SDI threshold value during the fall 2013 and a higher BI threshold value during the spring 2014 for candidate reference stream criteria.

During fall 2013 Cave Springs Branch test stations generally had higher MSCI scores when results were scored using wadeable/perennial biological criteria than when using candidate reference criteria. Using the wadeable/perennial biological criteria, test station #1 had a fully supporting MSCI score of 16, test station #2 had a partially supporting MSCI score of 14 and test station #3 had a partially MSCI score of 12. When the test stations were compared to the candidate reference criteria, both test stations #1 and #2 had lower MSCI scores, and test station #1 changed from a fully supporting score of 16 to a partially supporting score of 14. The station #3 score was unchanged.

During the spring 2014 sampling season, Cave Springs Branch test stations generally had higher MSCI scores using the candidate reference stream criteria, but there were no differences in support categories between the two criteria datasets. Using

wadeable/perennial biological criteria to calculate MSCI scores, test station #1 and the duplicate samples at test station #2 had fully supporting scores of 16, and test station #3 had a partially supporting score of 12. Using candidate reference criteria, Cave Springs Branch attained a fully supporting score of 16 at test station #1, fully supporting scores of 18 for the test station #2 duplicate samples, and a partially supporting score of 14 at test station #3.

Based on MSCI scores calculated using wadeable/perennial biological criteria, this study has shown that test station #1 was not impaired. Results for test station #2 were inconclusive, and test station #3 was impaired. The results at test station #2 were inconclusive because the MSCI score for fall 2013 was in the partially supporting range, and the spring 2014 scores for the duplicate samples were in the fully supporting range.

Nutrient enrichment from the Simmons WWTF effluent is the likely cause of the partially supporting and borderline fully supporting MSCI scores at the Cave Spring Branch test stations. Elevated levels of chloride and sulfate, likely due to the Simmons WWTF effluent as well as nutrient enrichment from non-point sources of pollution, also may be affecting the macroinvertebrate community in Cave Springs Branch.

Tests of the null hypotheses resulted in the following conclusions.

1) The macroinvertebrate community will not differ among longitudinally separate reaches of Cave Springs Branch. This hypothesis was rejected because of partially supporting MSCI scores at Cave Springs Branch #3 during both sampling seasons and Cave Springs Branch #2 during the fall 2013 sampling season. At Cave Springs Branch #1, MSCI scores during both sampling seasons were in the fully supporting range.

2) The macroinvertebrate assemblages in the Cave Springs Branch samples will be similar to the Ozark/Neosho EDU wadeable/perennial stream biological criteria. This hypothesis was rejected because of partially supporting MSCI scores at Cave Springs Branch #3 during both sampling seasons and Cave Springs Branch #2 during the fall 2013 sampling season.

3) The macroinvertebrate assemblage in the Cave Springs Branch samples will be similar to the Ozark/Neosho EDU candidate reference stream criteria. This hypothesis was rejected because all Cave Springs Branch test stations had partially supporting MSCI scores during the fall 2013 sampling season, and Cave Springs Branch #3 had a partially supporting MSCI score during the spring 2014 sampling season.

4) Physicochemical water quality in Cave Springs Branch will meet the Water Quality Standards of Missouri. The fourth null hypothesis was rejected since the chronic water quality standard for chloride at test station #3 during the fall 2013 sampling season was violated. All of the chloride values and all sulfate values at the test stations during the study were elevated compared to the candidate reference streams, but the values were

below the water quality standards. Nutrients like nitrogen and phosphorus were elevated in Cave Springs Branch compared to recommended reference conditions, but there are currently no criteria for nutrients in the Missouri Water Quality Standards.

5) Physicochemical water quality will not differ among longitudinally separate reaches of Cave Springs Branch. The fifth hypothesis was rejected. Chloride, sulfate, and nutrient concentrations were elevated at all Cave Springs Branch sampling stations. There was a decreasing trend for chloride and sulfate moving downstream during both sampling seasons. There was a decreasing trend for nutrient concentrations moving downstream during the spring 2014 sampling season, but not for the fall 2013 sampling season. During the fall 2013 sampling season, higher nutrient values occurred at test stations #1 and #2 than test station #3. The spring 2014 nutrient values showed a decreasing trend moving downstream with the highest values occurring at test station #3.

6.0 References Cited

Andrade, P.C.N. 2006. The Use of Benthic Macroinvertebrate Functional Feeding Groups to Assess Stream Ecosystem Attributes. M.S. Thesis. Loyola University of Chicago, Chicago, IL.

Barbour, M.T., J. Gerritsen, B.D. Snyder, and J.B. Stribling. 1999. Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers: Periphyton, Benthic Macroinvertebrates and Fish, Second Edition. EPA 841-B-99-002. U.S. Environmental Protection Agency; Office of Water; Washington, D.C.

Epler, J.H., T. Ekrem, and P.S. Cranston. The Larvae of Holarctic Chironominae (Diptera: Chironomidae) – Keys and Diagnoses. *In*: Anderson T., P.S. Cranston, and J.H. Epler (Sci. eds): The Larvae of Chironomidae (Diptera) of the Holarctic Region. Keys and Diagnoses. Insect Systematics & Evolution, Supplement. 66:387-556. Lund, Sweden 17 June 2013. ISSN 2001-4945.

GBMc & Associates. 2000. Stream Assessment of Cave Springs Branch and Honey Creek, Delaware County, Oklahoma. GBMc & Associates, 219 Brown Lane, Bryant, AR 72022. 43 pp.

Missouri Department of Natural Resources. 2002. Biological Criteria for Wadeable/Perennial Streams of Missouri. Missouri Department of Natural Resources, Environmental Services Program, P.O. Box 176, Jefferson City, Missouri 65102. 32 pp.

Missouri Department of Natural Resources. 2010a. Cave Springs Branch Total Maximum Daily Load (TMDL). Missouri Department of Natural Resources, Water Protection Program, Water Pollution Control Branch, P.O. Box 176, Jefferson City, Missouri. 43 pp.

Missouri Department of Natural Resources. 2010b. Field Sheet and Chain-of-Custody Record. Missouri Department of Natural Resources, Environmental Services Program, P.O. Box 176, Jefferson City, Missouri 65102. 14 pp.

Missouri Department of Natural Resources. 2010c. Rules of Department of Natural Resources Division-Clean Water Commission, Chapter 7-Water Quality. 10 CSR 20-7.031 Water Quality Standards. pp. 12-150.

Missouri Department of Natural Resources. 2010d. Stream Habitat Assessment Project Procedure. Missouri Department of Natural Resources, Environmental Services Program, P.O. Box 176, Jefferson City, Missouri. 40 pp.

Missouri Department of Natural Resources. 2011. Required/Recommended Containers, Volumes, Preservatives, Holding Times, and Special Sampling Considerations. Missouri Department of Natural Resources, Environmental Services Program, P.O. Box 176, Jefferson City, Missouri 65102. 27 pp.

Missouri Department of Natural Resources. 2012. Rules of Department of Natural Resources Division-Clean Water Commission, Chapter 7-Water Quality. 10 CSR 20-7.031 Water Quality Standards. pp. 12-148.

Missouri Department of Natural Resources. 2012. Semi-quantitative Macroinvertebrate Stream Bioassessment Project Procedure. Missouri Department of Natural Resources, Environmental Services Program, P.O. Box 176, Jefferson City, Missouri 65102. 26 pp.

Missouri Department of Natural Resources. 2013. Flow Measurements in Open Channels. Missouri Department of Natural Resources, Environmental Services Program, P.O. Box 176, Jefferson City, Missouri 65102. 13 pp.

Missouri Department of Natural Resources. 2014. Rules of Department of Natural Resources Division-Clean Water Commission, Chapter 7-Water Quality. 10 CSR 20-7.031 Water Quality Standards. pp. 12-149.

Oklahoma Department of Environmental Quality. Oklahoma DEQ ArcGIS Viewer. Available URL: http://gis.deq.ok.gov/flexviewer/

Oklahoma Water Resources Board. 2013. Chapter 45 – Oklahoma's Water Quality Standards. 130 pp.

Rabeni, C.F., K.E. Doisy, and L.D. Zweig. 2005. Stream Invertebrate Community Functional Responses to Deposited Sediment. Aquatic Sciences 67:395-402.

Rabeni, C.F., N. Wang, and R.J. Sarver. 1999. Evaluating Adequacy of the Representative Stream Reach used in Invertebrate Monitoring Programs. Journal of the North American Benthological Society 18:284-291.

Shackleford, B. 1988. Rapid Bioassessment of Lotic Macroinvertebrate Communities. Arkansas Dept. of Pollution Control and Ecology, Little Rock, Arkansas. 44 pp.

Sowa, S.P., D.D. Diamond, R.A. Abbitt, G.M. Annis, T. Gordon, M.E. Morey, G.R. Sorensen, and D. True. 2004. Final Report of the Aquatic Component of GAP Analysis: A Missouri Prototype. Missouri Resource Assessment Partnership (MoRAP), University of Missouri. 111 pp.

Sowa, S., and D. Diamond. 2006. Using GIS and an Aquatic Ecological Classification System to Classify and Map Distinct Riverine Ecosystems Throughout EPA Region 7. Missouri Resource Assessment Partnership (MoRAP), University of Missouri. 242 pp.

United States Environmental Protection Agency. 2000. Ambient Water Quality Criteria Recommendations. Information Supporting the Development of State and Tribal Nutrient Criteria for River and Streams in Nutrient Ecoregion XI. United States Environmental Protection Agency, Office of Water, Washington, D.C., EPA-822-B-00-020. 28 pp.

United States Geological Survey. 2000. Reconnaissance of the Hydrology, Water Quality and Sources of Bacterial and Nutrient Contamination in the Ozark Plateau Aquifer System and Cave Springs Branch of Honey Creek, Delaware County, Oklahoma, March 1999-March 2000. USGS WRI 00-4210. 67 pp.

Vannote, R. L., G.W. Minshall, K.W. Cummins, J.R. Sedell, and C.E. Cushing. 1980. The River Continuum Concept. Canadian Journal of Fisheries and Aquatic Sciences 37:130-137.

Submitted by: _____

Carl Wakefield
Environmental Specialist
Water Quality Monitoring Section
Environmental Services Program

Date: _____

Approved by: _____

Lynn Milberg
Chief, Water Quality Monitoring Section
Environmental Services Program

LM:cwc

c: Trish Rielly, QAPP Project Manager, WPP
Cindy Davies, Southwest Regional Office

Appendix A

Macroinvertebrate Bench Sheets for Cave Springs Branch and Candidate Reference Streams

Aquid Invertebrate Database Bench Sheet Report
Thomas Hollow [132051], Station #1, Sample Date: 9/23/2013 4:10:00 PM
CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
"HYDRACARINA"			
Acarina	9	11	1
AMPHIPODA			
Hyalella azteca		6	69
BASOMMATOPHORA			
Ancylidae		2	4
BRANCHIOBDELLIDA			
Branchiobdellida			1
COLEOPTERA			
Dubiraphia			3
Optioservus sandersoni	136	114	14
Psephenus herricki	79	92	5
Stenelmis	4	1	6
DECAPODA			
Orconectes macrus	-99		
Orconectes neglectus	-99	-99	2
DIPTERA			
Ablabesmyia		3	1
Brillia			1
Ceratopogoninae	2	3	
Chironomidae			2
Cricotopus bicinctus			1
Cricotopus/Orthocladius			1
Dicrotendipes			1
Dixella			1
Labrundinia		1	
Micropsectra		31	24
Microtendipes		17	2
Orthocladius (Symposiocladius)			1
Parametriocnemus	8		3
Paratendipes			1
Polypedilum aviceps	28		2
Polypedilum flavum	7	2	
Polypedilum tritum			1

Aquid Invertebrate Database Bench Sheet Report
Thomas Hollow [132051], Station #1, Sample Date: 9/23/2013 4:10:00 PM
CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
Rheocricotopus	3		1
Rheotanytarsus	4	1	9
Simulium	34		3
Stempellinella	2	17	4
Stenochironomus		1	1
Tanytarsus	7	11	5
Thienemanniella	3		5
Thienemannimyia grp.	6	10	9
Tipula	2		
Zavrelimyia		2	1
EPHEMEROPTERA			
Acentrella	6		
Baetis	39		2
Diphetor	11		4
Eurylophella		2	1
Leptophlebiidae		60	
Leucrocuta	1	6	
Maccaffertium modestum			1
Maccaffertium pulchellum	4	14	2
Procloeon		1	
Stenacron	4	68	2
Stenonema femoratum	1	25	1
HEMIPTERA			
Rhagovelia			1
ISOPODA			
Caecidotea (Blind & Unpigmented)		4	
Lirceus	65	36	52
LUMBRICINA			
Lumbricina	2	1	
LUMBRICULIDA			
Lumbriculidae		3	1
MEGALOPTERA			
Nigronia serricornis			2
NEOTAENIOGLOSSA			

Aquid Invertebrate Database Bench Sheet Report
Thomas Hollow [132051], Station #1, Sample Date: 9/23/2013 4:10:00 PM
CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
Elimia		1	-99
ODONATA			
Argia	7	2	2
Calopteryx			19
Enallagma			3
Hetaerina		1	5
Stylogomphus albistylus	6	3	7
PLECOPTERA			
Acroneuria	7	2	
Zealeuctra	7	10	2
TRICHOPTERA			
Ceratopsyche morosa grp	2		
Cheumatopsyche	214		2
Chimarra	45		
Helicopsyche	3	10	
Hydropsyche	3		
Lype diversa	2		2
Polycentropus	13	40	18
Pycnopsyche			-99
Triaenodes			13
TRICLADIDA			
Planariidae	57	4	1
TUBIFICIDA			
Tubificidae			2
VENEROIDA			
Pisidiidae			1

Aquid Invertebrate Database Bench Sheet Report
Mikes Cr [132052], Station #3, Sample Date: 9/24/2013 8:45:00 AM
CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
"HYDRACARINA"			
Acarina	10	8	3
AMPHIPODA			
Hyalella azteca		1	47
Stygobromus		2	
BASOMMATOPHORA			
Ancylidae			1
Menetus			6
Physella			5
BRANCHIOBDELLIDA			
Branchiobdellida			2
COLEOPTERA			
Optioservus sandersoni	241	68	16
Psephenus herricki	19	21	3
Stenelmis	6	2	7
DECAPODA			
Orconectes macrus	3		
Orconectes neglectus	-99	-99	-99
DIPTERA			
Ablabesmyia		3	
Anopheles			1
Ceratopogoninae		1	
Corynoneura		1	2
Cricotopus bicinctus	2		
Cricotopus/Orthocladius			1
Cryptochironomus		3	
Dicrotendipes	1		1
Limnophyes	1		
Micropsectra	4	5	6
Microtendipes		6	1
Paramerina		1	
Parametriocnemus	1		2
Paratendipes		5	3
Polypedilum aviceps	1		

Aquid Invertebrate Database Bench Sheet Report
Mikes Cr [132052], Station #3, Sample Date: 9/24/2013 8:45:00 AM
CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
Polypedilum flavum	1		
Polypedilum illinoense grp	1	1	1
Rheotanytarsus	1		
Stempellinella	1	5	3
Stenochironomus			1
Synorthocladius	3		1
Tabanus		1	
Tanytarsus	21	49	13
Thienemanniella	5		
Thienemannimyia grp.	7	5	4
Zavrelimyia		3	5
EPHEMEROPTERA			
Acentrella	14		
Baetis	138		5
Diphetor	9		
Eurylophella	3	3	3
Leptophlebiidae		60	37
Leucrocuta	8		
Maccaffertium vicarium	2	1	
Stenacron		13	2
Stenonema femoratum		41	1
Tricorythodes		1	
ISOPODA			
Caecidotea (Blind & Unpigmented)	6	11	
Lirceus	98	37	64
LUMBRICINA			
Lumbricina		2	
LUMBRICULIDA			
Lumbriculidae		2	5
MEGALOPTERA			
Corydalus	-99		
Nigronia fasciatus	-99		
Nigronia serricornis	-99		
NEOTAENIOGLOSSA			

Aquid Invertebrate Database Bench Sheet Report
Mikes Cr [132052], Station #3, Sample Date: 9/24/2013 8:45:00 AM
CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
Elimia	8	1	3
ODONATA			
Aeshnidae			1
Argia	1		
Calopteryx			3
Gomphidae	1	1	
Hetaerina			4
Stylogomphus albistylus			-99
PLECOPTERA			
Acroneuria	19	3	
Agnetina capitata	3		
TRICHOPTERA			
Cheumatopsyche	4		
Chimarra	3		
Helicopsyche	3	1	
Limnephilidae		-99	-99
Polycentropus	3	12	14
TRICLADIDA			
Planariidae	39	9	14
TUBIFICIDA			
Tubificidae		1	1

Aquid Invertebrate Database Bench Sheet Report
Lost Cr [132053], Station #1, Sample Date: 9/24/2013 11:10:00 AM
CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
"HYDRACARINA"			
Acarina	13	27	10
AMPHIPODA			
Gammarus	-99	3	9
Hyalella azteca			23
Stygobromus		8	1
BASOMMATOPHORA			
Ancylidae	4	10	4
Menetus			5
Physella			1
BRANCHIOBDELLIDA			
Branchiobdellida	7	5	1
COLEOPTERA			
Dubiraphia		9	13
Ectopria nervosa		15	2
Optioservus sandersoni	218	4	1
Psephenus herricki	11	8	
Stenelmis			2
DECAPODA			
Orconectes macrus	-99	-99	
Orconectes neglectus	1	1	-99
DIPTERA			
Ceratopogoninae		11	
Chelifera	1		
Chrysops		1	
Corynoneura		1	1
Cricotopus/Orthocladius		1	
Cryptochironomus		2	
Cryptotendipes		4	
Hemerodromia	2		1
Hexatoma		2	
Labrundinia			1
Micropsectra	1		11
Microtendipes		24	17

Aquid Invertebrate Database Bench Sheet Report
Lost Cr [132053], Station #1, Sample Date: 9/24/2013 11:10:00 AM
CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
Nanocladius	3		
Natarsia		1	
Paralauterborniella		1	
Parametriocnemus	16		4
Paratanytarsus			5
Polypedilum aviceps	32		
Polypedilum flavum	1		1
Polypedilum scalaenum grp		4	
Procladius		1	
Rheocricotopus	6		
Rheotanytarsus	13		6
Simulium	101	2	
Stempellina		12	
Stempellinella	4	24	1
Tabanus	1		
Tanytarsus		2	
Thienemanniella	1		
Thienemannimyia grp.	4	1	1
Tribelos		2	1
Tvetenia bavarica grp	15		
Zavrelimyia		4	
EPHEMEROPTERA			
Acentrella	35		1
Baetis	111	4	
Caenis anceps	2	1	
Caenis latipennis		3	
Diphetor	7		1
Ephemera simulans		1	
Eurylophella	4	4	
Hexagenia limbata		3	
Isonychia bicolor	6		
Leptophlebiidae	1	11	1
Maccaffertium pulchellum	99		
Procloeon		6	1
Stenacron	3	48	1

Aquid Invertebrate Database Bench Sheet Report
Lost Cr [132053], Station #1, Sample Date: 9/24/2013 11:10:00 AM
CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
Stenonema femoratum		5	
Tricorythodes		2	
ISOPODA			
Caecidotea		6	354
Lirceus	37	3	35
LEPIDOPTERA			
Petrophila	7	2	
LUMBRICINA			
Lumbricina	-99	4	1
LUMBRICULIDA			
Lumbriculidae		2	2
MEGALOPTERA			
Corydalus	-99		
Nigronia serricornis	35	-99	-99
Sialis		-99	-99
NEOTAENIOGLOSSA			
Elimia	28	3	2
ODONATA			
Gomphidae	1		
Hetaerina			2
Stylogomphus albistylus		1	1
PLECOPTERA			
Acroneuria	2		
Agnetina capitata	1		
Zealeuctra	15		
TRICHOPTERA			
Ceratopsyche morosa grp	10		
Cheumatopsyche	367		18
Chimarra	270		
Helicopsyche	2		
Lype diversa	1		
Polycentropus	1	1	7
Triaenodes			1
TRICLADIDA			
Planariidae	3		1

Aquid Invertebrate Database Bench Sheet Report
Lost Cr [132053], Station #1, Sample Date: 9/24/2013 11:10:00 AM
CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
TUBIFICIDA			
Aulodrilus		7	
Limnodrilus hoffmeisteri		1	
Tubificidae		71	
VENEROIDA			
Pisidiidae	2	15	3

Aquid Invertebrate Database Bench Sheet Report
Jones Cr [132054], Station #3a, Sample Date: 9/24/2013 2:00:00 PM
CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
"HYDRACARINA"			
Acarina	11	10	17
AMPHIPODA			
Gammarus		8	26
Hyalella azteca			5
Stygobromus		1	
BASOMMATOPHORA			
Ancylidae	1	2	1
Menetus			5
Physella			10
BRANCHIOBDELLIDA			
Branchiobdellida			1
COLEOPTERA			
Dubiraphia		5	21
Helichus basalis			1
Optioservus sandersoni	65	10	4
Psephenus herricki	-99	-99	
Scirtidae	1		
Stenelmis			3
Tropisternus			-99
DECAPODA			
Orconectes macrus	-99		
Orconectes neglectus	-99	-99	-99
Orconectes virilis			-99
DIPTERA			
Ablabesmyia		6	
Brillia	2		2
Ceratopogoninae		1	
Chironomidae	1		
Chironomus		2	
Corynoneura	3		
Cricotopus/Orthocladius	1	1	
Cryptochironomus		7	
Eukiefferiella	1		

Aquid Invertebrate Database Bench Sheet Report
Jones Cr [132054], Station #3a, Sample Date: 9/24/2013 2:00:00 PM
CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
Eukiefferiella brehmi grp			1
Hemerodromia	2		
Hexatoma	-99	1	
Labrundinia			1
Micropsectra	9	3	39
Microtendipes		13	3
Natarsia		1	
Paramerina		1	3
Parametriocnemus	6		10
Paratendipes		18	1
Polypedilum aviceps	20	1	12
Polypedilum fallax grp	1		
Polypedilum flavum	1		
Polypedilum illinoense grp	1		
Polypedilum scalaenum grp		7	
Rheocricotopus	1		1
Rheotanytarsus	5		14
Simulium	53	1	22
Stempellinella	17	84	6
Stictochironomus		6	
Tabanus		1	
Tanytarsus	5	12	1
Thienemanniella	4	2	2
Thienemannimyia grp.	4		4
Tipula	-99		
Tvetenia bavarica grp	8		3
Zavrelimyia	1	5	2
EPHEMEROPTERA			
Acentrella	26		2
Baetis	66		17
Caenis latipennis		6	1
Diphetor	1		9
Eurylophella	2		1
Heptageniidae			6
Leptophlebiidae		29	5

Aquid Invertebrate Database Bench Sheet Report
Jones Cr [132054], Station #3a, Sample Date: 9/24/2013 2:00:00 PM
CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
Maccaffertium modestum	21	1	5
Stenacron		18	2
Stenonema femoratum		20	
Tricorythodes		3	
HEMIPTERA			
Microvelia			-99
ISOPODA			
Lirceus	44	21	101
LUMBRICINA			
Lumbricina	-99	3	
LUMBRICULIDA			
Lumbriculidae	3	1	1
MEGALOPTERA			
Nigronia serricornis	6		1
NEOTAENIOGLOSSA			
Elimia	2	2	7
ODONATA			
Calopteryx			32
Enallagma			1
Gomphidae			1
Macromia			-99
PLECOPTERA			
Acroneuria	-99		
Agnetina capitata	1		
Zealeuctra	1		
TRICHOPTERA			
Agapetus	3		
Ceratopsyche morosa grp	1		
Cheumatopsyche	191	3	36
Chimarra	38		6
Helicopsyche	2	1	2
Hydropsyche	2		
Polycentropus	-99	3	1
Triaenodes			3
TRICLADIDA			

Aquid Invertebrate Database Bench Sheet Report
Jones Cr [132054], Station #3a, Sample Date: 9/24/2013 2:00:00 PM
CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
Planariidae	3		2
TUBIFICIDA			
Quistradrilus multisetosus		1	
Tubificidae		11	
VENEROIDA			
Pisidiidae	1	2	3

Aquid Invertebrate Database Bench Sheet Report
Jones Cr [132055], Station #3b, Sample Date: 9/24/2013 2:00:00 PM
CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
"HYDRACARINA"			
Acarina	17	14	13
AMPHIPODA			
Gammarus	-99	13	14
Hyalella azteca			9
BASOMMATOPHORA			
Ancylidae	1	2	
Menetus			12
Physella			6
BRANCHIOBDELLIDA			
Branchiobdellida		1	
COLEOPTERA			
Dubiraphia		1	17
Ectopria nervosa		-99	
Helichus basalis			1
Optioservus sandersoni	66	8	2
DECAPODA			
Orconectes macrus	-99	-99	
Orconectes neglectus	-99	-99	
DIPTERA			
Ablabesmyia		2	
Brillia	1		
Ceratopogoninae	1	2	
Chironomidae		1	1
Clinocera			1
Corynoneura	1	2	1
Cricotopus bicinctus			1
Cricotopus/Orthocladius		1	
Cryptochironomus		2	
Hemerodromia	1		
Hexatoma	2	-99	
Micropsectra	10	2	14
Microtendipes		17	
Natarsia		2	

Aquid Invertebrate Database Bench Sheet Report
Jones Cr [132055], Station #3b, Sample Date: 9/24/2013 2:00:00 PM
CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
Paramerina			1
Parametriocnemus	7		1
Paraphaenocladius			2
Paratendipes		16	
Polypedilum aviceps	28	1	16
Polypedilum fallax grp	1		
Polypedilum flavum	1		
Polypedilum scalaenum grp		4	
Rheotanytarsus	10		18
Simulium	41		36
Stempellina		3	
Stempellinella	10	76	2
Tanytarsus	2	9	
Thienemanniella			3
Thienemannimyia grp.	5	1	3
Tipula			1
Tvetenia bavarica grp	14		6
Zavrelimyia		6	
EPHEMEROPTERA			
Acentrella	12		
Acerpenna			1
Baetis	105	1	
Caenis latipennis		6	
Diphetor	40		10
Eurylophella	7		
Heptageniidae	11		
Leptophlebiidae	1	23	2
Maccaffertium mediopunctatum	1		
Maccaffertium modestum	23		6
Maccaffertium pulchellum	3		
Stenacron	5	14	1
Stenonema femoratum		19	
Tricorythodes		4	2
HEMIPTERA			
Microvelia			2

Aquid Invertebrate Database Bench Sheet Report
Jones Cr [132055], Station #3b, Sample Date: 9/24/2013 2:00:00 PM
CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
ISOPODA			
Lirceus	68	26	43
LUMBRICINA			
Lumbricina	4	1	
LUMBRICULIDA			
Lumbriculidae	1	1	1
MEGALOPTERA			
Nigronia serricornis	9	1	-99
Sialis		1	
NEOTAENIOGLOSSA			
Elimia	1		8
Hydrobiidae	2		
ODONATA			
Calopteryx			15
Gomphidae	1	1	
Hetaerina	1		
Somatochlora			-99
PLECOPTERA			
Acroneuria	2	1	
RHYNCHOBDELLIDA			
Glossiphoniidae	1		
TRICHOPTERA			
Ceratopsyche morosa grp	4	1	
Ceratopsyche slossonae	1		
Cheumatopsyche	157		25
Chimarra	27		1
Helicopsyche	5	1	1
Lype diversa	1		
Oxyethira			1
Polycentropus	4	2	4
Triaenodes			1
TRICLADIDA			
Planariidae	6		
TUBIFICIDA			
Enchytraeidae			1

Aquid Invertebrate Database Bench Sheet Report
Jones Cr [132055], Station #3b, Sample Date: 9/24/2013 2:00:00 PM
CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
Tubificidae		11	
VENEROIDA			
Pisidiidae	5	9	3

Aquid Invertebrate Database Bench Sheet Report
Brush Cr [132056], Station #1, Sample Date: 9/25/2013 9:15:00 AM
CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
"HYDRACARINA"			
Acarina	1		6
AMPHIPODA			
Gammarus	3	4	
Hyalella azteca			37
Stygobromus		1	
BASOMMATOPHORA			
Ancylidae	1		1
Menetus			1
COLEOPTERA			
Dubiraphia			3
Optioservus sandersoni	64	9	4
Psephenus herricki	72	23	3
Scirtidae			2
Stenelmis	8	14	2
DECAPODA			
Orconectes macrus	-99	-99	
Orconectes neglectus	2	-99	1
DIPTERA			
Ablabesmyia		3	2
Anopheles			2
Ceratopogoninae		1	
Chironomidae	1	1	1
Chironomus		4	
Cricotopus bicinctus	1		
Cryptochironomus		2	
Dicrotendipes		1	1
Forcipomyiinae		1	
Hexatoma		1	
Micropsectra		1	15
Microtendipes		4	
Natarsia		1	
Nilotanypus			1
Paraphaenocladius		1	2

Aquid Invertebrate Database Bench Sheet Report
Brush Cr [132056], Station #1, Sample Date: 9/25/2013 9:15:00 AM
CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
Paratendipes		2	
Pentaneura	1		
Polypedilum aviceps	4		1
Polypedilum fallax grp			1
Polypedilum flavum	43		8
Polypedilum illinoense grp			1
Polypedilum scalaenum grp		1	
Rheotanytarsus	9		59
Simulium	33		10
Stempellinella	7	25	5
Tanytarsus	2	6	3
Thienemannimyia grp.	1	1	5
Tipula			2
EPHEMEROPTERA			
Acentrella	4		
Acerpenna	12		31
Baetis	157		1
Diphetor	29		10
Eurylophella		35	21
Heptageniidae		10	1
Leptophlebiidae	1	33	
Leucrocuta	11	11	1
Maccaffertium pulchellum	32	2	3
Maccaffertium vicarium		1	
Procloeon			1
Stenacron		39	2
Stenonema femoratum		31	
ISOPODA			
Caecidotea (Blind & Unpigmented)		1	
Lirceus	23	15	52
LUMBRICINA			
Lumbricina		3	
LUMBRICULIDA			
Lumbriculidae	1	1	

Aquid Invertebrate Database Bench Sheet Report
Brush Cr [132056], Station #1, Sample Date: 9/25/2013 9:15:00 AM
CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
NEOTAENIOGLOSSA			
Elimia	5		1
ODONATA			
Calopteryx			1
Gomphidae			1
Stylogomphus albistylus		-99	
PLECOPTERA			
Acroneuria	19	3	
Agnetina capitata	17		
Neoperla	1		
Perlinella ephyre		-99	
Zealeuctra	1		
TRICHOPTERA			
Cheumatopsyche	138	1	35
Chimarra	10		1
Helicopsyche	5	1	
Marilia	1		
Polycentropus			7
Triaenodes			1
TRICLADIDA			
Planariidae	34	2	12
TUBIFICIDA			
Tubificidae		3	

Aquid Invertebrate Database Bench Sheet Report
Cave Springs Br [132057], Station #3, Sample Date: 9/25/2013 11:30:00 AM
CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
"HYDRACARINA"			
Acarina	1		
AMPHIPODA			
Hyalella azteca			12
ARHYNCHOBDELLIDA			
Erpobdellidae	-99	-99	
BASOMMATOPHORA			
Menetus			1
COLEOPTERA			
Dubiraphia		4	6
Ectopria nervosa		3	
Optioservus sandersoni	1	2	2
Psephenus herricki	6	3	
Scirtidae			3
Stenelmis	31	6	42
DECAPODA			
Orconectes neglectus	-99	-99	-99
Orconectes virilis			-99
DIPTERA			
Ablabesmyia		42	
Chironomidae		3	
Chironomus		13	
Cricotopus bicinctus	4		
Cricotopus/Orthocladius	9	1	1
Cryptochironomus		2	
Dicrotendipes		1	
Labrundinia			2
Nilotanypus	1		
Parametriocnemus	2		4
Paratanytarsus			5
Paratendipes		121	2
Pentaneura	1		1
Phaenopsectra		1	
Polypedilum flavum	295	2	80

Aquid Invertebrate Database Bench Sheet Report
Cave Springs Br [132057], Station #3, Sample Date: 9/25/2013 11:30:00 AM
CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
Polypedilum illinoense grp	3		4
Polypedilum scalaenum grp		4	
Procladius		2	
Pseudosmittia			1
Rheotanytarsus	97		61
Simulium	37		11
Stempellinella	4	30	1
Tabanus	2		
Tanytarsus	7	34	3
Thienemanniella	4		1
Thienemannimyia grp.	11		1
Tipula			1
EPHEMEROPTERA			
Baetis	7		
Caenis latipennis	13	683	19
Fallceon	34		12
Stenacron		1	
Stenonema femoratum	1	117	2
HEMIPTERA			
Microvelia			1
ISOPODA			
Caecidotea (Blind & Unpigmented)		60	
MEGALOPTERA			
Corydalus	2		-99
ODONATA			
Argia	5	14	6
Calopteryx			14
Enallagma			8
Hagenius brevistylus			2
Hetaerina			7
PLECOPTERA			
Acroneuria	-99		
Neoperla	-99		
TRICHOPTERA			

Aquid Invertebrate Database Bench Sheet Report
Cave Springs Br [132057], Station #3, Sample Date: 9/25/2013 11:30:00 AM
CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
Cheumatopsyche	118		54
Chimarra	44		22
Helicopsyche		1	
Hydropsyche	5		4
Polycentropus		1	
Triaenodes			4
TRICLADIDA			
Planariidae	36	5	15
TUBIFICIDA			
Tubificidae	1	2	
VENEROIDA			
Pisidiidae		1	1

Aquid Invertebrate Database Bench Sheet Report
Cave Springs Br [132058], Station #2, Sample Date: 9/25/2013 1:10:00 PM
CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
"HYDRACARINA"			
Acarina	4	8	
AMPHIPODA			
Hyalella azteca		5	212
Stygobromus		4	
ARHYNCHOBDELLIDA			
Erpobdellidae		1	
BASOMMATOPHORA			
Ancylidae		1	1
Menetus			3
COLEOPTERA			
Dubiraphia			11
Ectopria nervosa	2	1	
Microcylloepus pusillus	11		
Optioservus sandersoni			2
Psephenus herricki	24	14	
Stenelmis	10	19	12
DECAPODA			
Orconectes neglectus		-99	1
DIPTERA			
Ablabesmyia		8	4
Chironomidae	2		
Corynoneura			1
Cricotopus/Orthocladius			1
Cryptochironomus		2	
Dixella			1
Hemerodromia	1		
Labrundinia		1	1
Micropsectra			1
Microtendipes		5	1
Nilotanypus	3		1
Paratanytarsus		1	2
Paratendipes		15	11
Polypedilum flavum	61		2

Aquid Invertebrate Database Bench Sheet Report
Cave Springs Br [132058], Station #2, Sample Date: 9/25/2013 1:10:00 PM
CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
Polypedilum illinoense grp	2	1	2
Polypedilum scalaenum grp		6	
Rheotanytarsus	11		16
Simulium	40		1
Stempellinella	10	19	1
Tabanus		-99	
Tanytarsus	11	24	6
Thienemannimyia grp.	5	4	
Tribelos		2	
EPHEMEROPTERA			
Acentrella	16		
Acerpenna	5		
Baetis	203		5
Caenis latipennis		88	16
Diphetor	3		
Fallceon	2		
Isonychia bicolor	1		
Leptophlebiidae		1	
Stenacron	1		
Stenonema femoratum	1	22	1
Tricorythodes		1	1
ISOPODA			
Caecidotea (Blind & Unpigmented)		38	
Lirceus			5
LUMBRICINA			
Lumbricina		1	
MEGALOPTERA			
Corydalus	3		
Nigronia serricornis		-99	
NEOTAENIOGLOSSA			
Elimia	18	2	7
ODONATA			
Argia	2	1	4
Calopteryx			2

Aquid Invertebrate Database Bench Sheet Report
Cave Springs Br [132058], Station #2, Sample Date: 9/25/2013 1:10:00 PM
CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
Enallagma			3
Hagenius brevistylus		-99	
Stylogomphus albistylus		-99	
PLECOPTERA			
Acroneuria	-99	-99	
Neoperla	12	-99	
Perlinella ephyre		-99	
RHYNCHOBDELLIDA			
Glossiphoniidae			-99
TRICHOPTERA			
Cheumatopsyche	107		
Chimarra	3		
Helicopsyche		1	
Hydropsyche	7		1
Marilia			1
Triaenodes			6
TRICLADIDA			
Planariidae	17	7	1
TUBIFICIDA			
Limnodrilus hoffmeisteri			2
Tubificidae		1	4
VENEROIDA			
Pisidiidae		1	3

Aquid Invertebrate Database Bench Sheet Report
Cave Springs Br [132059], Station #1, Sample Date: 9/25/2013 2:35:00 PM
CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
"HYDRACARINA"			
Acarina	16		
AMPHIPODA			
Hyalella azteca	1	6	224
Stygobromus	2	1	
BASOMMATOPHORA			
Physella			4
COLEOPTERA			
Dubiraphia		1	18
Ectopria nervosa		6	2
Microcylloepus pusillus	33		
Neoporus			1
Optioservus sandersoni	4	7	
Psephenus herricki	36	31	
Scirtidae			1
Stenelmis	9	11	18
DECAPODA			
Orconectes neglectus	3	1	
DIPTERA			
Ablabesmyia		20	3
Ceratopogoninae			1
Chironomidae		1	
Corynoneura			2
Cricotopus bicinctus			2
Dicrotendipes		3	1
Diptera		1	
Dixella			1
Labrundinia			1
Microtendipes		5	
Nilotanypus	1		
Paramerina			1
Parametriocnemus	1		
Paratanytarsus			9
Paratendipes		14	8

Aquid Invertebrate Database Bench Sheet Report
Cave Springs Br [132059], Station #1, Sample Date: 9/25/2013 2:35:00 PM
CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
Pentaneura	1		
Phaenopsectra			4
Polypedilum aviceps	1		
Polypedilum fallax grp			1
Polypedilum flavum	68	1	4
Polypedilum illinoense grp			2
Rheocricotopus	3		1
Rheotanytarsus	25		32
Simulium	25		
Stempellinella	4	19	2
Tabanus	1	1	
Tanytarsus	11	14	5
Thienemannimyia grp.	5	2	
Tvetenia bavarica grp	1		
EPHEMEROPTERA			
Acentrella	13		
Acerpenna	12		2
Baetis	232		1
Caenis latipennis	3	111	20
Isonychia bicolor	1		
Leptophlebiidae		1	
Leucrocuta	7		
Stenonema femoratum	1	59	1
HEMIPTERA			
Belostoma			-99
ISOPODA			
Caecidotea (Blind & Unpigmented)	1	38	
Lirceus	13	4	19
LUMBRICINA			
Lumbricina		1	
MEGALOPTERA			
Corydalus	2		
NEOTAENIOGLOSSA			
Elimia			2

Aquid Invertebrate Database Bench Sheet Report
Cave Springs Br [132059], Station #1, Sample Date: 9/25/2013 2:35:00 PM
CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
ODONATA			
Argia	1	11	1
Basiaeschna janata		-99	
Boyeria			-99
Calopteryx			4
Enallagma			3
Hagenius brevistylus		2	1
Hetaerina			10
Stylogomphus albistylus		5	
PLECOPTERA			
Acroneuria	-99	1	
Neoperla	20	1	
Zealeuctra	1		
RHYNCHOBDELLIDA			
Glossiphoniidae			1
TRICHOPTERA			
Cheumatopsyche	85		1
Chimarra	10		
Helicopsyche	2	2	
Hydropsyche	2		
Hydroptila	1		
Marilia	2		
Polycentropus		1	
Triaenodes			18
TRICLADIDA			
Planariidae	16	11	2
VENEROIDA			
Pisidiidae			1

Aquid Invertebrate Database Bench Sheet Report
Thomas Hollow [149832], Station #1, Sample Date: 3/25/2014 12:30:00 PM
CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
"HYDRACARINA"			
Acarina	9		7
AMPHIPODA			
Hyalella azteca		2	20
Stygobromus		1	
BASOMMATOPHORA			
Ancylidae	1		
Lymnaeidae			-99
Physella	1	2	4
COLEOPTERA			
Optioservus sandersoni	43	7	7
Psephenus herricki	1	5	
DECAPODA			
Orconectes neglectus		-99	-99
Orconectes williamsi	1		
DIPTERA			
Ceratopogoninae		1	1
Chironomidae		1	
Clinocera	2	1	
Cricotopus/Orthocladius	4	5	17
Diamesa	1		
Eukiefferiella			1
Hemerodromia	1		1
Hexatoma		-99	
Labrundinia			2
Micropsectra	4	41	13
Microtendipes		4	
Orthocladius (Symposiocladius)		1	
Parametriocnemus		2	
Paratendipes		1	
Polypedilum aviceps	10	1	
Polypedilum flavum	1	1	1
Polypedilum scalaenum grp		1	
Polypedilum tritum			1

Aquid Invertebrate Database Bench Sheet Report
Thomas Hollow [149832], Station #1, Sample Date: 3/25/2014 12:30:00 PM
CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
Rheocricotopus	1		3
Rheotanytarsus	6	1	42
Stempellinella	3	22	7
Stenochironomus			1
Sympotthastia		2	
Tabanus	1		
Tanytarsus	2	16	5
Thienemannimyia grp.	1	12	10
Tipula	-99		
Zavrelimyia		2	
EPHEMEROPTERA			
Acentrella	37		4
Acerpenna		2	2
Diphetor	13	2	9
Eurylophella bicolor		11	6
Leptophlebia		2	2
Leptophlebiidae	2	5	1
Leucrocuta	20	7	
Maccaffertium vicarium	3	2	1
Stenacron	3	8	
Stenonema femoratum		3	
ISOPODA			
Lirceus	36	42	25
LUMBRICINA			
Lumbricina	-99	1	-99
LUMBRICULIDA			
Lumbriculidae		1	
MEGALOPTERA			
Sialis		1	
ODONATA			
Argia			1
Calopteryx			-99
Stylogomphus albistylus	1	1	2
PLECOPTERA			
Acroneuria	-99	-99	

Aquid Invertebrate Database Bench Sheet Report
Thomas Hollow [149832], Station #1, Sample Date: 3/25/2014 12:30:00 PM
CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
Amphinemura	254	21	89
Chloroperlidae	1		
Clioperla clio			1
Isoperla	6		1
Leuctridae	28	52	26
TRICHOPTERA			
Agapetus	85		2
Ceratopsyche slossonae			-99
Cheumatopsyche	96	-99	5
Chimarra	9		
Helicopsyche	3	1	
Hydropsyche	4		
Ironoquia			-99
Polycentropus	3	12	4
Psychomyia	1		
Pycnopsyche	-99	1	1
Triaenodes			2
TRICLADIDA			
Planariidae	7		1

Aquid Invertebrate Database Bench Sheet Report
Mikes Cr [149833], Station #3, Sample Date: 3/25/2014 1:24:00 PM
CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
"HYDRACARINA"			
Acarina	13	32	7
AMPHIPODA			
Hyalella azteca			36
BASOMMATOPHORA			
Ancylidae			4
Menetus			3
Physella			-99
COLEOPTERA			
Enochrus			1
Optioservus sandersoni	67	68	8
Paracymus			1
Psephenus herricki	2	2	1
Stenelmis			3
DECAPODA			
Orconectes macrus	-99		
Orconectes neglectus		-99	-99
DIPTERA			
Ceratopogoninae	1		
Chelifera	1		1
Chironomidae		1	1
Clinocera	2	1	2
Cricotopus/Orthocladius	4	6	15
Dicrotendipes		2	1
Labrundinia		1	
Micropsectra	53	97	25
Microtendipes		2	
Paratanytarsus			5
Polypedilum aviceps			3
Polypedilum flavum	2		
Rheocricotopus			2
Rheotanytarsus			2
Stempellinella	2	29	2
Sympotthastia		1	3

Aquid Invertebrate Database Bench Sheet Report
Mikes Cr [149833], Station #3, Sample Date: 3/25/2014 1:24:00 PM
CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
Synorthocladius		3	1
Tanytarsus	62	136	59
Thienemannimyia grp.	5	11	9
Tipula	-99	-99	-99
Zavrelimyia		2	1
EPHEMEROPTERA			
Acentrella	18		1
Acerpenna		1	
Diphetor	7		1
Eurylophella bicolor		39	12
Fallceon			3
Leptophlebia		15	28
Leucrocuta	16		
Paraleptophlebia	7	1	
Stenacron		1	
Stenonema femoratum	-99	12	-99
HEMIPTERA			
Belostoma			-99
ISOPODA			
Caecidotea (Blind & Unpigmented)		8	
Lirceus	27	12	45
LEPIDOPTERA			
Petrophila	1		
LUMBRICINA			
Lumbricina		-99	
LUMBRICULIDA			
Lumbriculidae	1	1	
MEGALOPTERA			
Nigronia serricornis	1	-99	-99
NEOTAENIOGLOSSA			
Elimia		-99	
ODONATA			
Boyeria			-99
Calopteryx			-99

Aquid Invertebrate Database Bench Sheet Report
Mikes Cr [149833], Station #3, Sample Date: 3/25/2014 1:24:00 PM
CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
Gomphidae	2	1	
Stylogomphus albistylus		-99	-99
PLECOPTERA			
Acroneuria	3	-99	-99
Amphinemura	119		71
Isoperla	49	1	5
Leuctridae	4	15	3
TRICHOPTERA			
Agapetus	25	2	2
Cheumatopsyche	28		
Chimarra	6		
Ironoquia		-99	1
Lype diversa			1
Polycentropus	5	4	19
Pycnopsyche		-99	9
TRICLADIDA			
Planariidae	17	5	6

Aquid Invertebrate Database Bench Sheet Report
Jones Cr [149834], Station #3, Sample Date: 3/25/2014 3:20:00 PM
CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
"HYDRACARINA"			
Acarina	15	27	3
AMPHIPODA			
Gammarus	3	19	16
Hyalella azteca			4
Stygobromus		2	
BASOMMATOPHORA			
Ancylidae		3	
Menetus		2	25
Physella	1	9	59
BRANCHIOBDELLIDA			
Branchiobdellida			1
COLEOPTERA			
Dubiraphia		6	3
Optioservus sandersoni	26	3	1
Psephenus herricki		1	
Stenelmis			1
DECAPODA			
Orconectes macrus	1		
Orconectes neglectus	2	1	1
DIPTERA			
Ablabesmyia		2	
Ceratopogoninae	3		1
Chironomidae		3	
Cricotopus/Orthocladius	55	5	22
Cryptochironomus		4	
Diamesa	1		
Dicrotendipes			1
Eukiefferiella	8		2
Hemerodromia	3	1	2
Hexatoma	1		
Micropsectra	24	1	29
Microtendipes		8	2
Neoplasta		1	

Aquid Invertebrate Database Bench Sheet Report
Jones Cr [149834], Station #3, Sample Date: 3/25/2014 3:20:00 PM
CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
Neozavrelia	2		
Orthocladius (Symposiocladius)			1
Parakiefferiella		3	1
Paramerina			2
Parametriocnemus			1
Paratanytarsus			1
Paratendipes		41	1
Polypedilum aviceps	7		11
Polypedilum scalaenum grp		20	
Rheocricotopus	1		3
Rheotanytarsus	6		6
Stempellina		1	
Stempellinella	2	42	3
Stenochironomus			1
Stictochironomus		20	
Tanytarsus	4	7	4
Thienemanniella			2
Thienemannimyia grp.	7	1	7
Tipula	1		
Tribelos		3	
Tvetenia bavarica grp	1		4
Zavrelimyia		7	
EPHEMEROPTERA			
Acentrella	5		
Acerpenna	19		4
Baetis	38		8
Caenis latipennis		2	
Diphetor	54		9
Eurylophella bicolor	1	1	5
Leptophlebia		3	
Leptophlebiidae	1		
Maccaffertium modestum	22		1
Stenacron	2	26	
Stenonema femoratum		9	
ISOPODA			

Aquid Invertebrate Database Bench Sheet Report
Jones Cr [149834], Station #3, Sample Date: 3/25/2014 3:20:00 PM
CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
Caecidotea (Blind & Unpigmented)		1	
Lirceus	90	5	54
LUMBRICINA			
Lumbricina	1	2	
LUMBRICULIDA			
Lumbriculidae	1		
MEGALOPTERA			
Nigronia serricornis	2	1	1
NEOTAENIOGLOSSA			
Elimia	4		4
ODONATA			
Calopteryx			1
PLECOPTERA			
Acroneuria	1	1	
Agnetina capitata	2		
Leuctridae	4		
TRICHOPTERA			
Agapetus	4		
Ceratopsyche morosa grp	3		
Ceratopsyche slossonae	3		
Cheumatopsyche	147		11
Chimarra	27		1
Helicopsyche	12		1
Lype diversa	1		
Neophylax	1		
Polycentropus		2	8
Psychomyia	8	2	
Pycnopsyche		1	1
TRICLADIDA			
Planariidae	4		6
TUBIFICIDA			
Limnodrilus hoffmeisteri		6	
Quistradrilus multisetosus		2	
Tubificidae		46	

Aquid Invertebrate Database Bench Sheet Report
Jones Cr [149834], Station #3, Sample Date: 3/25/2014 3:20:00 PM
CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
VENEROIDA			
Corbicula		17	1

Aquid Invertebrate Database Bench Sheet Report
Lost Cr [149835], Station #1, Sample Date: 3/25/2014 4:50:00 PM
CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
"HYDRACARINA"			
Acarina	3		6
AMPHIPODA			
Gammarus	1	6	22
Hyalella azteca			30
Stygobromus	1	9	
BASOMMATOPHORA			
Ancylidae		4	
Menetus			1
Physella		3	
BRANCHIOBDELLIDA			
Branchiobdellida	1		2
COLEOPTERA			
Dubiraphia	5		24
Ectopria nervosa		4	5
Optioservus sandersoni	101	9	6
Psephenus herricki		2	
Stenelmis			1
DECAPODA			
Orconectes neglectus	-99	-99	2
Orconectes virilis		1	
DIPTERA			
Ablabesmyia		1	
Cardiocladius	1		
Ceratopogoninae		21	2
Chironomidae	2		1
Cricotopus bicinctus			1
Cricotopus/Orthocladius	62	6	13
Cryptochironomus	1	12	
Cryptotendipes		8	2
Dicrotendipes		1	
Dixella			1
Eukiefferiella	8		1
Hemerodromia	2		2

Aquid Invertebrate Database Bench Sheet Report
Lost Cr [149835], Station #1, Sample Date: 3/25/2014 4:50:00 PM
CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
Labrundinia		1	2
Micropsectra	3		1
Microtendipes	1	1	4
Nanocladius	1		
Neozavrelia		1	
Parakiefferiella			1
Paralauterborniella		1	
Paratendipes		17	
Polypedilum aviceps	16		4
Polypedilum flavum	6		
Polypedilum illinoense grp			1
Polypedilum scalaenum grp		7	
Rheocricotopus	4	1	2
Rheotanytarsus	23	1	14
Simulium	2		
Stempellina		11	
Stempellinella	2	8	2
Stenochironomus		4	
Synorthocladius		3	
Tanytarsus	2	6	4
Thienemannimyia grp.	7	2	13
Tipula	-99		
Tribelos		12	
Tvetenia bavarica grp	2		
Zavrelimyia		1	
EPHEMEROPTERA			
Acentrella	50		1
Baetis	39		2
Centroptilum		1	3
Diphetor	29		3
Ephemera simulans		-99	
Eurylophella bicolor	1	16	8
Hexagenia limbata		7	
Isonychia bicolor	8		1
Leptophlebiidae		2	

Aquid Invertebrate Database Bench Sheet Report
Lost Cr [149835], Station #1, Sample Date: 3/25/2014 4:50:00 PM
CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
Maccaffertium pulchellum	55		4
Maccaffertium vicarium	2		
Stenacron	1	20	1
Stenonema femoratum		-99	1
ISOPODA			
Caecidotea		10	178
Caecidotea (Blind & Unpigmented)		3	
Lirceus	77	3	85
LEPIDOPTERA			
Petrophila		1	
LUMBRICINA			
Lumbricina		-99	
LUMBRICULIDA			
Lumbriculidae			4
MEGALOPTERA			
Corydalus	3		
Nigronia serricornis	8	-99	
Sialis	1		
NEOTAENIOGLOSSA			
Elimia	5	1	
ODONATA			
Argia			1
Calopteryx			1
PLECOPTERA			
Acroneuria	1		
Agnetina capitata	2		
Amphinemura	2		1
Leuctridae	19		4
TRICHOPTERA			
Agapetus	7		
Ceratopsyche morosa grp	-99		
Cheumatopsyche	117	1	7
Chimarra	35		
Helicopsyche	2		1

Aquid Invertebrate Database Bench Sheet Report
Lost Cr [149835], Station #1, Sample Date: 3/25/2014 4:50:00 PM
CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
Lype diversa			1
Polycentropus	1	1	13
Pycnopsyche		1	-99
Triaenodes			1
TRICLADIDA			
Planariidae	3		7
TUBIFICIDA			
Aulodrilus		1	
Limnodrilus hoffmeisteri		10	
Tubificidae		86	2
VENEROIDA			
Pisidiidae		15	3

Aquid Invertebrate Database Bench Sheet Report
Brush Cr [149836], Station #1, Sample Date: 3/26/2014 9:45:00 AM
CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
"HYDRACARINA"			
Acarina	5	7	
AMPHIPODA			
Gammarus	9	9	3
Hyalella azteca			27
Stygobromus	2		
BASOMMATOPHORA			
Ancylidae	1		1
Menetus			2
Physella		6	7
BRANCHIOBDELLIDA			
Branchiobdellida	1		
COLEOPTERA			
Dubiraphia			1
Dytiscidae	1	1	
Optioservus sandersoni	72	20	5
Psephenus herricki	2	3	1
Scirtidae			1
Stenelmis	2	5	2
DECAPODA			
Orconectes neglectus	1	2	-99
DIPTERA			
Ablabesmyia		3	
Ceratopogoninae		1	
Corynoneura		1	
Cricotopus/Orthocladius	26	18	5
Cryptochironomus		1	
Dicrotendipes		2	
Hemerodromia	1		1
Hexatoma	1	1	
Micropsectra	15	6	3
Microtendipes		2	
Nilotanypus		1	
Parametriocnemus	1	8	

Aquid Invertebrate Database Bench Sheet Report
Brush Cr [149836], Station #1, Sample Date: 3/26/2014 9:45:00 AM
CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
Paratanytarsus		5	1
Polypedilum aviceps	4		
Polypedilum flavum	10		
Polypedilum scalaenum grp		6	
Rheotanytarsus		1	33
Stempellinella	6	15	
Stenochironomus			1
Synorthocladius		3	
Tabanus	-99		
Tanytarsus	4	45	
Thienemannimyia grp.	5	11	2
Tipula	-99		
EPHEMEROPTERA			
Acentrella	7		1
Acerpenna	9		19
Baetis	7		6
Caenis latipennis		1	
Diphetor	11		14
Eurylophella bicolor	2	43	15
Heptageniidae			3
Leptophlebia		1	1
Leucrocuta	24	22	
Maccaffertium pulchellum	4		1
Maccaffertium vicarium	2	-99	-99
Paraleptophlebia	25	10	2
Stenacron		24	
Stenonema femoratum	2	47	-99
ISOPODA			
Lirceus	122	24	54
LUMBRICULIDA			
Lumbriculidae		1	
NEOTAENIOGLOSSA			
Elimia		-99	25
ODONATA			
Gomphidae			1

Aquid Invertebrate Database Bench Sheet Report
Brush Cr [149836], Station #1, Sample Date: 3/26/2014 9:45:00 AM
CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
Stylogomphus albistylus		-99	-99
PLECOPTERA			
Acroneuria	-99	1	
Agnetina capitata	6		
Amphinemura			3
Chloroperlidae	9	4	
Isoperla	27	-99	15
Leuctridae	31	32	5
TRICHOPTERA			
Agapetus	18		
Cheumatopsyche	89	1	16
Chimarra	12		1
Helicopsyche	8	3	
Polycentropus	2	5	
Pycnopsyche		-99	-99
Triaenodes			2
TRICLADIDA			
Planariidae	21		
TUBIFICIDA			
Tubificidae		1	

Aquid Invertebrate Database Bench Sheet Report
Cave Springs Br [149837], Station #3, Sample Date: 3/26/2014 11:40:00 AM
CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
"HYDRACARINA"			
Acarina	1	1	1
AMPHIPODA			
Hyalella azteca		1	9
ARHYNCHOBDELLIDA			
Erpobdellidae	-99		
BASOMMATOPHORA			
Menetus			6
Physella			1
COLEOPTERA			
Agabus		1	1
Dubiraphia		1	12
Optioservus sandersoni			1
Peltodytes			2
Psephenus herricki	3	-99	
Stenelmis	11	1	8
DECAPODA			
Orconectes neglectus	-99	-99	-99
DIPTERA			
Ablabesmyia	1	9	2
Chironomidae	4	1	1
Chironomus		6	
Cricotopus bicinctus	1		2
Cricotopus/Orthocladius	221	15	92
Dicrotendipes	5	17	8
Diptera			1
Eukiefferiella brehmi grp	3		
Larsia			9
Micropsectra	14	8	36
Microtendipes	1	1	
Nanocladius		1	2
Paramerina			1
Parametriocnemus	5		1
Paratanytarsus		4	17

Aquid Invertebrate Database Bench Sheet Report
Cave Springs Br [149837], Station #3, Sample Date: 3/26/2014 11:40:00 AM
CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
Paratendipes	14	264	10
Polypedilum flavum	340		82
Polypedilum illinoense grp	1	2	6
Polypedilum scalaenum grp		7	
Potthastia			1
Procladius		1	1
Rheotanytarsus	3		11
Tabanus	1		
Tanytarsus	8	11	13
Thienemanniella	14		8
Thienemannimyia grp.	35	2	7
Zavrelimyia	1		2
EPHEMEROPTERA			
Caenis latipennis	31	133	23
Fallceon	23		24
Stenonema femoratum	18	5	
ISOPODA			
Caecidotea (Blind & Unpigmented)		35	
MEGALOPTERA			
Corydalus	1		
ODONATA			
Argia	1	-99	3
Calopteryx			2
PLECOPTERA			
Acroneuria	-99		
Leuctridae	1		
Perlesta	27		3
TRICHOPTERA			
Cheumatopsyche	18	1	8
Chimarra	7		3
Helicopsyche	2		
Hydropsyche	2		
Hydroptila	5		
Oecetis			2

Aquid Invertebrate Database Bench Sheet Report
Cave Springs Br [149837], Station #3, Sample Date: 3/26/2014 11:40:00 AM
CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
Polycentropus		-99	
Triaenodes			6
TRICLADIDA			
Planariidae	16	1	7
TUBIFICIDA			
Enchytraeidae		1	
Limnodrilus hoffmeisteri		1	
Tubificidae	4	14	
VENEROIDA			
Pisidiidae		1	

Aquid Invertebrate Database Bench Sheet Report
Cave Springs Br [149838], Station #2a, Sample Date: 3/26/2014 12:55:00 PM
CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
"HYDRACARINA"			
Acarina	17	7	
AMPHIPODA			
Hyalella azteca			49
Stygobromus		2	
BASOMMATOPHORA			
Ancylidae			4
Menetus		1	6
Physella			2
BRANCHIOBDELLIDA			
Branchiobdellida			1
COLEOPTERA			
Agabus		1	3
Dubiraphia		4	1
Dytiscidae			1
Ectopria nervosa		1	1
Microcylloepus pusillus	4		
Optioservus sandersoni	7		
Psephenus herricki	5	2	
Scirtidae			1
Stenelmis		17	4
DECAPODA			
Orconectes neglectus	-99	-99	-99
DIPTERA			
Ablabesmyia	2	16	10
Corynoneura	3	1	2
Cricotopus/Orthocladius	104	24	25
Dicrotendipes	3	3	4
Eukiefferiella	17		
Hemerodromia		1	
Hydrobaenus			1
Labrundinia			8
Micropsectra	21	1	7
Microtendipes	1	1	10

Aquid Invertebrate Database Bench Sheet Report
Cave Springs Br [149838], Station #2a, Sample Date: 3/26/2014 12:55:00 PM
CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
Nanocladius	1		
Nilotanypus	6	1	2
Paramerina			3
Parametriocnemus	26		
Paratanytarsus		1	
Paratendipes	5	26	12
Phaenopsectra			1
Polypedilum aviceps	1		
Polypedilum flavum	146		
Polypedilum illinoense grp		2	8
Polypedilum scalaenum grp		4	9
Potthastia	3		
Procladius		1	
Rheocricotopus	49		1
Rheotanytarsus	25		14
Stempellinella	2	2	
Stenochironomus			1
Tabanus	-99	-99	
Tanytarsus	21	2	8
Thienemanniella	16	1	7
Thienemannimyia grp.	54	18	5
Tvetenia bavarica grp	6		
EPHEMEROPTERA			
Acerpenna	2		1
Caenis latipennis	5	43	7
Diphetor	2		
Fallceon	10		
Leucrocuta	2		
Stenonema femoratum	9	22	5
HEMIPTERA			
Belostoma			-99
ISOPODA			
Caecidotea (Blind & Unpigmented)		27	
Lirceus			4

Aquid Invertebrate Database Bench Sheet Report
Cave Springs Br [149838], Station #2a, Sample Date: 3/26/2014 12:55:00 PM
CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
MEGALOPTERA			
Corydalus	1	-99	
NEOTAENIOGLOSSA			
Elimia	15	2	42
ODONATA			
Argia	5		2
Basiaeschna janata			-99
Boyeria			-99
Calopteryx			3
Enallagma			1
Ischnura			1
Stylogomphus albistylus		-99	-99
PLECOPTERA			
Acroneuria	-99		
Clioperla clio			-99
Isoperla	6		
Leuctridae		2	
Neoperla	4	-99	
Perlesta	21		
TRICHOPTERA			
Cheumatopsyche	71	-99	
Chimarra	14		
Helicopsyche	2		1
Hydropsyche	1		
Hydroptila	9		1
Polycentropus	2	1	-99
Psychomyia			1
Pycnopsyche			-99
Triaenodes			3
TRICLADIDA			
Planariidae	81	5	26
VENEROIDA			
Pisidiidae			2

Aquid Invertebrate Database Bench Sheet Report
Cave Springs Br [149839], Station #2b, Sample Date: 3/26/2014 12:55:00 PM
CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
"HYDRACARINA"			
Acarina	14		1
AMPHIPODA			
Hyalella azteca			47
Stygobromus		3	
ARHYNCHOBDELLIDA			
Erpobdellidae			-99
BASOMMATOPHORA			
Ancylidae			1
Menetus		1	
Physella		1	
BRANCHIOBDELLIDA			
Branchiobdellida			2
COLEOPTERA			
Agabus	1	2	2
Dubiraphia			4
Ectopria nervosa		1	
Lutrochus	1		
Microcylloepus pusillus	1		
Optioservus sandersoni	2		
Psephenus herricki	9	2	
Stenelmis	7	10	5
DECAPODA			
Orconectes neglectus	-99	1	4
DIPTERA			
Ablabesmyia		24	7
Chironomidae	2	2	2
Corynoneura	15	8	16
Cricotopus bicinctus			1
Cricotopus/Orthocladius	174	48	65
Dicrotendipes	2	8	5
Eukiefferiella	20		3
Eukiefferiella brehmi grp	4		
Eukiefferiella devonica grp	10		

Aquid Invertebrate Database Bench Sheet Report
Cave Springs Br [149839], Station #2b, Sample Date: 3/26/2014 12:55:00 PM
CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
Hemerodromia	1		
Labrundinia		1	4
Micropsectra	23	10	20
Microtendipes			3
Nilotanypus	12		5
Paralauterborniella		1	
Paramerina			1
Parametriocnemus	13		
Paraphaenocladius	1		
Paratanytarsus			1
Paratendipes		40	9
Phaenopsectra		3	
Polypedilum aviceps	3		
Polypedilum fallax grp	1		2
Polypedilum flavum	164		1
Polypedilum illinoense grp	6	2	17
Polypedilum scalaenum grp		7	
Potthastia	2		
Rheocricotopus	53	2	1
Rheotanytarsus	10	3	10
Simulium	3		
Stempellinella	4	8	
Synorthocladius	5		
Tabanus	-99	-99	
Tanytarsus	21	7	2
Thienemanniella	23	1	7
Thienemannimyia grp.	57	16	15
Tipula		-99	
Tvetenia bavarica grp	6		
Zavrelimyia		1	
EPHEMEROPTERA			
Acentrella	3		
Acerpenna	4		1
Baetis	1		
Caenis latipennis	1	36	7

Aquid Invertebrate Database Bench Sheet Report
Cave Springs Br [149839], Station #2b, Sample Date: 3/26/2014 12:55:00 PM
CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
Fallceon	9		1
Leucrocuta	6	1	
Stenonema femoratum	14	12	2
HEMIPTERA			
Microvelia			1
ISOPODA			
Caecidotea (Blind & Unpigmented)		8	
Lirceus			4
MEGALOPTERA			
Corydalus	-99		
NEOTAENIOGLOSSA			
Elimia	2		53
ODONATA			
Argia	-99	2	5
Basiaeschna janata			-99
Calopteryx			1
Stylogomphus albistylus	-99	-99	
PLECOPTERA			
Acroneuria	1	-99	
Agnetina flavescens	1		
Amphinemura	1		
Clioperla clio	-99		
Isoperla	3		1
Leuctridae		1	1
Neoperla	1		
Perlesta	33		
TRICHOPTERA			
Cheumatopsyche	59	1	1
Chimarra	7		
Helicopsyche		1	-99
Hydropsyche	1		
Hydroptila	4	1	
Polycentropus		1	1
Pycnopsyche			-99

Aquid Invertebrate Database Bench Sheet Report
Cave Springs Br [149839], Station #2b, Sample Date: 3/26/2014 12:55:00 PM
CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
Triaenodes			6
TRICLADIDA			
Planariidae	63	6	3
TUBIFICIDA			
Enchytraeidae			1
VENEROIDA			
Pisidiidae			1

Aquid Invertebrate Database Bench Sheet Report
Cave Springs Br [149840], Station #1, Sample Date: 3/26/2014 3:00:00 PM
CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
"HYDRACARINA"			
Acarina	27	4	1
AMPHIPODA			
Hyalella azteca			53
BASOMMATOPHORA			
Physella	14		15
BRANCHIOBDELLIDA			
Branchiobdellida		1	
COLEOPTERA			
Agabus		2	3
Dineutus			-99
Dubiraphia		1	
Dytiscidae			6
Ectopria nervosa	1		
Microcylloepus pusillus	7		
Optioservus sandersoni	3		
Psephenus herricki	4	5	1
Scirtidae			2
Stenelmis	1	4	1
Tropisternus			-99
DECAPODA			
Orconectes neglectus	-99	-99	
DIPTERA			
Ablabesmyia		20	8
Brillia		1	
Ceratopogoninae	1	1	
Chironomidae	5	2	4
Corynoneura	5	9	14
Cricotopus bicinctus	2	1	7
Cricotopus/Orthocladius	115	76	80
Cryptochironomus			1
Dicrotendipes		13	19
Eukiefferiella	24	3	3
Hemerodromia	2		

Aquid Invertebrate Database Bench Sheet Report
Cave Springs Br [149840], Station #1, Sample Date: 3/26/2014 3:00:00 PM
CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
Labrundinia			14
Micropsectra	2	1	6
Nilotanypus	2		
Parametriocnemus	7	2	
Paratanytarsus		1	3
Paratendipes		31	6
Phaenopsectra	1		
Polypedilum aviceps	1		
Polypedilum flavum	83		1
Polypedilum illinoense grp			5
Polypedilum scalaenum grp		1	
Rheocricotopus	94		3
Rheotanytarsus	20	1	11
Sciomyzidae			1
Simulium	3		
Stempellinella	2	4	1
Stenochironomus			2
Synorthocladius	4	3	6
Tabanus	-99	-99	
Tanytarsus	9	19	11
Thienemanniella	5		7
Thienemannimyia grp.	22	21	6
Tipula	-99		-99
Tvetenia bavarica grp	1		
EPHEMEROPTERA			
Acentrella	19		
Acerpenna	26	2	1
Baetis	2		
Caenis latipennis		33	1
Eurylophella bicolor		2	
Isonychia bicolor	-99		
Leptophlebiidae			-99
Leucrocuta	7		
Stenonema femoratum		22	2
HEMIPTERA			

Aquid Invertebrate Database Bench Sheet Report
Cave Springs Br [149840], Station #1, Sample Date: 3/26/2014 3:00:00 PM
CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
Microvelia			1
ISOPODA			
Caecidotea (Blind & Unpigmented)	5	5	
Lirceus	46	26	34
LUMBRICINA			
Lumbricina		-99	
MEGALOPTERA			
Corydalus	-99		
Nigronia serricornis			-99
NEOTAENIOGLOSSA			
Elimia	1		
ODONATA			
Argia	4	1	
Basiaeschna janata			-99
Calopteryx			2
Stylogomphus albistylus		1	-99
PLECOPTERA			
Acroneuria	4	-99	
Agnetina flavescens	2		
Amphinemura	8		
Isoperla	10		-99
Leuctridae		1	1
Neoperla	10		
Perlesta	3		
TRICHOPTERA			
Cheumatopsyche	91		
Chimarra	19		
Helicopsyche	3		
Hydropsyche	2		
Polycentropus	-99	1	1
Pycnopsyche	-99	-99	
Triaenodes			7
TRICLADIDA			
Planariidae	18		1

Aquid Invertebrate Database Bench Sheet Report
Cave Springs Br [149840], Station #1, Sample Date: 3/26/2014 3:00:00 PM
CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
TUBIFICIDA			
Enchytraeidae			1