Environment

Prepared for:
CNA Holdings, Inc.
Spartanburg, SC

Prepared by:
AECOM
Greenville, SC
60280417
January 2013

Auriga Spartanburg
Aquatic Ecosystem Study Data Report
January 2013

Aquatic Ecosystem Study Data Report

Auriga Polymers, Inc. (Former CNA Holdings) Facility Spartanburg, SC

Prepared by:

AECOM, Inc.
10 Patewood Drive
Suite 500, Building VI
Greenville, South Carolina 29615

January 2013

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

LIST OF ACRONYMS

AECOM	AECOM Technical Services, Inc.
CC	Cherokee Creek
CNA	CNA Holdings LLC
COI	chemical of interest
DO	dissolved oxygen
EPA	United States Environmental Protection Agency
EPT	Ephemeroptera, Plecoptera, and Trichoptera
GPS	Global Positioning System
IC	Island Creek
MHSP	multiple-habitat sampling protocol
PCB	polychlorinated biphenyl
PR	Pacolet River
PRE	Preliminary Risk Evaluation
SCDHEC	South Carolina Department of Health and Environmental Control
SOP	standard operating procedure
SVOC	semivolatile organic compound
TCE	trichloroethene
VOC	volatile organic compound

1.0 INTRODUCTION

1.1 BACKGROUND

This Aquatic Ecosystem Study was performed in response to requests from the South Carolina Department of Health and Environmental Control (SCDHEC) in letters dated October 26, 2011 and January 24, 2012. SCDHEC requested that a bioassessment be performed for the Pacolet River and a tributary, Cherokee Creek, adjoining the Auriga Polymers Inc. facility in Spartanburg County, South Carolina (Site ID #00225). This facility historically has been identified with a series of owners, i.e., American Hoechst, Hoechst Celanese, KoSa, and INVISTA.

On July 11, 2011 SCDHEC conducted an aquatic macroinvertebrate bioassessment in the Pacolet River in the vicinity of the Auriga facility (Glover, 2011). In response to a chemical odor detected during this assessment, SCDHEC also conducted sediment sampling along Cherokee Creek on July 15, 2011. The results of these two studies were summarized in a letter dated October 26, 2011 (SCDHEC, 2011). The macroinvertebrate bioassessment calculated bioclassification scores for the benthic communities at three sample locations in the reach of the Pacolet River adjacent to the Site, and all three locations were rated good/fair with no obvious impacts from the facility. The near absence of one taxon was noted by SCDHEC at the middle location on the Pacolet nearest the facility. The taxon, caddisflies of the family Hydropsychidae, is considered sensitive and its absence may be caused by a variety of natural factors. However the relative paucity of this taxon at this location resulted in a SCDHEC request that further benthic invertebrate bioassessments be performed in this reach of the river.

The collection of sediment chemistry samples in Cherokee Creek by SCDHEC included analyses for volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), polychlorinated biphenyls (PCBs), and organochlorine pesticides, as well as tentatively identified compounds that were not target compounds. The target compounds detected were 1,1-biphenyl, methylphenol, Aroclor 1254, and seven pesticides. Diphenyl ether also was detected in the August 2011 surface water sample collected from location SW-05. Diphenyl ether was previously not detected at SW-05 in surface water samples collected from 1999 through 2010.

SCDHEC proposed additional assessment of sources and possible impacts in Cherokee Creek and the Pacolet River. On December 1, 2011, AECOM Technical Services (AECOM) submitted to SCDHEC a proposal on behalf of CNA Holdings LLC (CNA) for conducting a bioassessment of the Pacolet River as well as Cherokee Creek. SCDHEC responded with comments in a letter dated January 24, 2012. On February 23, 2012, a meeting was held between personnel from SCDHEC, CNA, and AECOM to obtain general agreement with the approach to respond to

SCHDEC's requests for additional assessment. A Work Plan presenting the approach for the Ecological Study was reviewed by SCDHEC, which provided approval with minor comments on June 6, 2012.

1.2 STUDY OBJECTIVES

The objectives of this Aquatic Ecosystem Study were to (1) measure concentrations of the chemicals of interest (COIs) in sediment and fish tissue to which human and ecological receptors may be exposed within the aquatic ecosystems of the Pacolet River and Cherokee Creek adjacent to the Auriga Polymers facility; (2) measure COI concentrations in sediment at background locations in the Pacolet River, Cherokee Creek, and Island Creek; and (3) assess the benthic macroinvertebrate communities of these streams as an indication of whether these ecological receptors have been impacted by contaminants.

Sediment sampling was conducted in the Pacolet River upstream and downstream of Cherokee Creek to (1) determine whether the compounds detected in the creek are present in sediment of the Pacolet River; (2) identify the portion of the river affected, if any; and (3) provide concentrations for screening and evaluation of risk. Sediment sampling was conducted in Cherokee Creek to (1) confirm the results of the previous SCDHEC sediment samples, (2) investigate patterns of contamination and contaminant transport within the creek, if any, and (3) provide concentrations for screening and evaluation of risk. Tissue samples from fish collected in the Pacolet River and Cherokee Creek, as well as clams collected in the river, were analyzed to evaluate potential food chain transfer of the COIs and to provide exposure concentrations for evaluating risk to humans that consume fish and wildlife that consume fish and clams.

Bioassessment of the benthic invertebrate community was conducted at multiple locations in the Pacolet River and Cherokee Creek to address questions raised by the previous SCDHEC macroinvertebrate bioassessment (August 2011) and provide an additional line of evidence for assessing ecological risk. Clam tissue residues also provide a possible line of evidence for use in assessing potential effects on mollusks or other macroinvertebrates in the river.

The data generated by these investigations, along with results from other data collection activities planned at the Site, will be utilized to develop an updated human health and ecological preliminary risk evaluation (PRE). The intent of the PRE will be to provide CNA and SCDHEC with a conservative evaluation of the potential risks to human and ecological receptors in these streams and adjoining areas surrounding the Auriga Polymers facility. An additional, related study will investigate potential on-site sources for the 2011 detections of diphenyl ether and PCBs as well as the possibility of site-related sources for the other COIs detected. The results of this potential source investigation will be submitted in a separate report.

2.0 FIELD SAMPLING ACTIVITIES AND ANALYSES

2.1 SAMPLING ACTIVITIES

Sampling for the Aquatic Ecosystem Study was conducted in three streams, the Pacolet River, Cherokee Creek, and Island Creek, between July 23 and August 9, 2012. The following activities were performed:

- Pacolet River – sediment chemistry analysis, fish tissue analysis, clam tissue analysis, and benthic macroinvertebrate community assessment;
- Cherokee Creek - sediment chemistry analysis, fish tissue analysis, and benthic macroinvertebrate community assessment;
- Island Creek - sediment chemistry analysis and benthic macroinvertebrate community assessment.

The Pacolet River and Cherokee Creek were the focus of this investigation because these two water bodies could be impacted by groundwater migrating from the Site, NPDES permitted discharges, and/or stormwater and overland flow from the Site. The purpose of sampling Island Creek was to provide background data for sediment chemistry and benthic macroinvertebrate assessment.

The sampling locations and the activities performed at each location are shown on Figure 2-1. Sample locations were mapped based on Global Positioning System (GPS) coordinates and established sampling points and landmarks. The types and numbers of samples collected in each stream is summarized in Table 2-1. Descriptions of each sample collected and the analyses performed for each are provided in Table 2-2. The analyses were performed by analytical laboratories certified by SCDHEC: sediment was analyzed by Davis and Floyd in Greenwood, SC; fish tissue and clam tissue were extracted by GEL Laboratories in Charleston, SC and analyzed by Davis and Floyd as well as GEL Laboratories. Benthic macroinvertebrate community assessments were performed by ETT Environmental in Greer, SC. Sampling activities are described below by medium.

2.1.1 Sediment Sampling and Analysis

Sediment samples for chemistry analysis were collected from a depth interval of approximately 0 to 6 inches below the sediment surface using a hand auger. Samples were collected in accordance with USEPA Region 4 Standard Operating Procedure (SOP) SESDPROC-200-R2 (USEPA, 2010). Quality control samples collected in conjunction with the river/creek sediment samples were one field duplicate and one matrix spike/matrix spike duplicate.

In the Pacolet River, sediment samples were collected at four locations, including three locations downstream of the mouth of Cherokee Creek and one upstream reference location; in Cherokee Creek, sediment samples were collected at eight locations, including two upstream reference locations; and in Island Creek, sediment samples were collected at one reference location slightly upstream of the mouth of Island Creek at the Pacolet River (Figure 2-1). The samples from each location were analyzed for the following:

- PCBs (Aroclor 1016, Aroclor 1221, Aroclor 1232, Aroclor 1242, Aroclor 1248, Aroclor 1254, and Aroclor 1260) by U.S. Environmental Protection Agency (EPA) SW-846 (USEPA, 2008) Method 8082
- Pesticides by EPA SW-846 Method 8081
- VOCs plus 1,4-dioxane by EPA SW-846 Method 8260B
- SVOCs by EPA SW-846 Method 8270C
- 1,1-biphenyl and diphenyl ether by EPA SW-846 Method 8270C.

Water quality parameters (dissolved oxygen [DO], pH, temperature, oxidation-reduction potential, and specific conductivity) were measured in the field at each sediment sample location.

2.1.2 Tissue Sampling and Analysis

In accordance with a request from SCDHEC (SCDHEC, 2011), fish and clams from the Pacolet River and fish from Cherokee Creek were collected to obtain information regarding potential accumulation of contaminant residues in their tissues. Fish were collected using a backpack electrofishing device while wading. Samples were collected in accordance with USEPA Region 4 SOP SESDPROC-512-R3 (USEPA, 2011) and the bioassessment protocols presented in EPA 841-B-99-002 (Barbour et al., 1999), adjusted as dictated by field conditions. Fish that were temporarily stunned by the electrical field were collected in nets. Individual fish considered large enough for human consumption were targeted. However, no such large, edible fish were found in either the Pacolet River or Cherokee Creek in the sampled locations adjacent to the site. Therefore, smaller fish that were potentially large enough to be filleted were kept.

Secondary consumer fish, such as bass, sunfish, and catfish, were targeted for collection because they are higher on the food chain, more likely to contain higher concentrations of bioaccumulative chemicals, and more likely to be large enough to be consumed by people. Immediately upon collection, fish were placed in a mesh bag in contact with the water. When samples were returned to the vehicle access point on land, the collected fish were placed in a plastic zip-lock bag, labeled, and placed on ice. At the end of each day, fish samples were brought to a processing facility where samples were weighed, filleted, prepared for chemical analysis, and frozen. Fish tissue samples were prepared as follows:

- Fish were photographed, identified by species, weighed, and measured to determine length. (Photos showing examples of the fish and clams collected are provided in Appendix A.)
- Fish were rinsed with tap water and patted dry.
- A pre-cleaned stainless steel fillet knife on a cutting board covered with clean sheets of aluminum foil was used in sample processing.
- Fish were scaled (except catfish, which lack scales) and viscera were removed prior to collecting a filet from each side of the fish (with skin on). Filets from both sides of the fish constituted one sample from a given fish. Each sample was weighed prior to being placed in aluminum foil and frozen.
- Decontamination procedures utilized for all equipment included changing of all foil between each fish tissue sample and decontaminating filet knives and cutting boards using detergent wash, isopropyl alcohol rinse, and deionized water rinse.
- Approximately 50 grams of tissue was needed for each sample. Depending on the species and number of samples collected, multiple fish samples were combined to obtain sufficient sample mass for chemical analysis.

Clam samples were collected in the Pacolet River by hand, dipnet, and kicknet. Collected clams were placed in a plastic zip-lock bag, labeled, and placed on ice. At the end of each day, clam samples were brought to a processing facility where samples were prepared for chemical analysis by removing each organism from its shell, weighing, and freezing. Clam tissue samples were prepared as follows:

- Clam samples were rinsed with tap water and patted dry.
- A pre-cleaned, stainless steel shucking knife was used for sample processing.
- Each clam was opened and the soft tissue removed. Collected clams were processed until sufficient biomass was obtained for chemical analysis (approximately 50 grams). Upon obtaining one sample, a final weight was determined and the sample placed in aluminum foil and frozen.
- Decontamination procedures utilized for all equipment included decontaminating shucking knives and cutting boards using detergent wash, isopropyl alcohol rinse, and deionized water rinse.
- Approximately 50 grams of tissue was needed for each sample.

Fish and clam tissue samples were analyzed for the following:

- PCBs (Aroclor 1016 , Aroclor 1221, Aroclor 1232, Aroclor 1242, Aroclor 1248, Aroclor 1254, and Aroclor 1260) by EPA SW-846 Method 8082
- Pesticides by EPA SW-846 Method 8081
- 1,1-biphenyl and diphenyl ether by EPA SW-846 Method 8270C.

Table 2-3 provides documentation of each fish collected, including the species, length and weight of each specimen. It also documents the aggregation of tissue from multiple specimens that was required to obtain the necessary mass for the suite of analyses to be performed for the targeted number of samples from each stream. The masses of clam tissue collected from the Pacolet River also are included.

In the Pacolet River, five secondary consumer fish tissue samples and three clam samples initially were targeted for collection. The specimen data (Table 2-3) demonstrate that the collectable fish in the sampled reach of the Pacolet River consisted overwhelmingly of brown bullhead catfish (*Ameiurus nebulosus*). Sufficient tissue mass for five fish samples was collected in the 2-day sampling effort in the river, but the fish were small – 23 cm (9 inches) or less in length and 120 grams (0.26 pound) or less in total weight. Such small fish are considered very unlikely to be of sufficient size to be caught, kept, and consumed by a fisherman. Of the 17 brown bullhead specimens collected, fillets from 16 were combined to compose five samples for chemistry analysis. The single sunfish collected was too small to provide the tissue mass needed for analysis of that species. Sufficient clams (*Corbicula fluminea*) could be collected in the 2-day sampling effort in the river to provide enough tissue mass for only one *Corbicula* sample.

In Cherokee Creek, three secondary consumer fish tissue samples and no clam samples initially were targeted for collection. The specimen data (Table 2-3) demonstrate that the collectable fish in the sampled reach of Cherokee Creek consisted predominantly of three species: brown bullhead, redbreast sunfish (*Lepomis auritus*), and white sucker (*Catostomus commersoni*). All of the fish collected in Cherokee Creek were small and considered very unlikely to be of sufficient size to be caught, kept, and consumed by a fisherman. In order to obtain sufficient tissue mass to compose a sample of each of these species, fillets from multiple fish were combined. In addition to the redbreast sunfish, a single bluegill sunfish (*Lepomis macrochirus*) also was collected. Because the bluegill was the largest sunfish specimen collected and this species is in the same genus and very similar to the redbreast sunfish, the bluegill fillets were combined with fillets from three redbreast sunfish to obtain a sunfish tissue sample.

2.1.3 Benthic Macroinvertebrate Community Sampling and Assessment

At each sediment sample location, invertebrates were sampled and benthic macroinvertebrate community assessments were performed by ETT Environmental and AECOM personnel using a methodology based on the SCDHEC SOP for macroinvertebrate sampling (SCDHEC, 1998), which is a timed, qualitative, multiple-habitat sampling protocol (MHSP). Sorting and taxonomic identification were performed by ETT Environmental, which is a biological laboratory certified by SCDHEC for taxonomic identification of invertebrates. Two upstream locations on the Pacolet River initially were proposed as macroinvertebrate reference locations. However, the upstream habitat was low in diversity and limited in its comparability to the downstream habitats. Consequently, it was determined in the field that the collection of macroinvertebrate data at more than one upstream river location within the same habitat was not warranted.

Details of the sampling and analytical methodology are described in the Macroinvertebrate Stream Assessment report provided in Appendix B. Generally, samples were collected by using a D-frame dipnet, kicknet, and hand-sieve in all available habitats within a given reach of stream. Habitats sampled included (1) snag habitats, such as sticks and leaves caught in fast current, and material scraped from the surfaces of submerged rocks and logs; and (2) coarse particulate organic matter samples, consisting of mud, sand, leaf packs, roots, and black organic matter collected by dip net from depositional areas and dipnet sweeps along banks. In addition to direct collection of specimens in the field, samples of benthic substrate also were preserved and returned to the laboratory for sorting of specimens.

At each sampling site, a team of two biologists sampled for aquatic macroinvertebrates for approximately 2 man-hours (with an additional 1 hour of laboratory sorting). The goal of the sampling team was to collect as many different macroinvertebrate taxa as possible during the allotted time. Although the MHSP is a qualitative method, the actual collection of samples is a disciplined procedure designed to ensure that all habitats present at a site are thoroughly sampled and a good representation of the macroinvertebrate community is obtained. With the aid of a D-frame dip net, kick net, hand sieve, white plastic pan, and fine mesh sampler, all the available natural habitats at each location were sampled. Macroinvertebrates also were collected directly from the habitat with forceps. Collected macroinvertebrates were placed in containers filled with 85% ethanol and labeled with the site, collector, and collection date. In the laboratory, sorted macroinvertebrates were transferred to a glass petri dish, examined under a dissecting microscope, and identified to the lowest possible taxonomic level using appropriate taxonomic references.

Invertebrates were identified to the lowest practical taxonomic level, and the resulting data were analyzed based on the calculation of multiple biological indices (Appendix B Tables III and IV). Index values were used in conjunction with the SCDHEC protocols to calculate a bioclassification score for the invertebrate community at each sample site (Appendix B Table III). The scores were used to determine whether water quality or other aspects of habitat quality differ from reference locations, to determine a bioclassification score for each sample area, to assign each sample area to a bioclassification category (e.g., good, fair, poor), and to categorize the aquatic life use support provided by each area (e.g., fully supporting, partially supporting).

2.2 ANALYTICAL RESULTS

This section summarizes the results from the analyses of sediment and tissue chemistry as well as the macroinvertebrate community assessment. The full data reports for sediment and tissue submitted by the analytical chemistry laboratories will be provided in a separate report.

2.2.1 Sediment

Analytical results for the sediment samples collected in the Pacolet River and the background location on Island Creek are summarized in Table 2-4; results for the samples collected in Cherokee Creek are summarized in Table 2-5. The surface water quality data measured in the field at the time of sediment sample collection are also included in these tables. The analytes detected in sediment samples from the Pacolet River were: 1,4-dioxane, 2-butanone, acetone, and toluene. Each was detected in only one sample except for acetone, which was detected in two samples. The analytes detected in sediment samples from Cherokee Creek were: Aroclor 1260, 1,1-biphenyl, diphenyl ether, trichloroethene (TCE), and acetone. Each was detected in only one sample except for acetone, which was detected in two samples. No analytes were detected at the two background sediment locations, one on Island Creek and one on Cherokee Creek.

2.2.2 Fish and Clam Tissue

Analytical results for the fish tissue samples collected in the Pacolet River and Cherokee Creek, as well as the clam tissue sample from the Pacolet River, are provided in Table 2-6. The analytes detected in fish tissue samples from the Pacolet River were: 4,4'-DDE and Aroclor 1260 in all five brown bullhead samples, and 4,4'-DDT in one sample. All of the concentrations of DDE and DDT were estimated values below the reporting limit (J-flagged results). In clam tissue samples from the Pacolet River, the only analyte detected was DDE, and this concentration also was estimated. In fish tissue samples from Cherokee Creek, the analytes detected were: diphenyl ether in one sample (white sucker), DDE in one sample (brown bullhead), and Aroclor 1260 in two samples (brown bullhead and sunfish). The concentrations of three of these four detections in fish from Cherokee Creek were estimated values below the reporting limit.

2.2.3 Macroinvertebrate Community Assessment

Results of the assessment of benthic macroinvertebrate communities in the Pacolet River (four locations), Cherokee Creek (eight locations), and Island Creek (one location) are presented in the Macroinvertebrate Stream Assessment report provided in Appendix B. At each location, collected invertebrates were identified to the lowest practical taxonomic level and enumerated. These data were employed in calculating biological indices useful in characterizing and comparing benthic macroinvertebrate communities. In accordance with procedures of the SCDHEC MHSP (SCDHEC, 1998) and the SCDHEC study of the Pacolet River that elicited this investigation (Glover, 2011), this assessment focused on the Ephemeroptera, Plecoptera, Trichoptera (EPT) Index and the Biotic Index. A higher EPT Index indicates a greater proportion in the benthic invertebrate community of these organisms (mayflies, stoneflies, and caddisflies) that typically are intolerant of pollution, whereas a higher Biotic Index typically is interpreted to indicate a greater proportion of invertebrates that are pollution tolerant.

Values for the EPT Index and the Biotic Index were converted to scores, and a combined (mean) bioclassification score was calculated from the two index scores (Table 2-7). The bioclassification scores were used to determine whether water quality or other aspects of habitat quality at a sample location differ from background locations, to assign each location to a bioclassification category, and to categorize the aquatic life use support provided by each location. Thus, the combined bioclassification score was used to determine a bioclassification for the invertebrate community at each location based on SCDHEC protocol (SCDHEC, 1998). The bioclassifications (and associated combined index scores) are: excellent (>4.5), good (3.5 - 4.5), good-fair (2.5 - 3.5), fair (1.5 - 2.5), and poor (<1.5). These bioclassifications are associated with categories of aquatic life use support as follows: excellent or good → fully supporting, good-fair or fair → partially supporting, and poor → not supporting (SCDHEC, 1998). In addition, bioclassification scores for each location were subtracted from the score for a background location, and the decrease in score relative to background was used to categorize the level of impairment. Levels of impairment (and associated bioclassification scores) are: not impaired (≤0.4), slightly impaired (0.6 - 1.4), moderately impaired (1.6 - 2.4), and severely impaired (≥2.6) (SCDHEC, 1998).

The bioassessment of three locations (PR-1, PR-2, and PR-3) on the Pacolet River adjacent to the Auriga Polymers Inc. facility determined that the benthic macroinvertebrate communities at these locations were not impaired relative to the upstream background location on the river (PR-4). When compared to the background location on Island Creek (IC-1), downstream locations PR-2 and PR-3 were slightly impaired, and PR-1 was moderately impaired (Table 2-7). These results appear to be correlated with the differences in habitat between the downstream river locations and the two background locations. The habitat at PR-4 is different than the three downstream locations because the upstream reach where PR-4 is located is a deep, lentic (lake-like) habitat with very slow flow due to a natural bedrock dam immediately upstream of the mouth of Cherokee Creek. Such conditions are naturally less supportive of a diverse community with an abundance of sensitive macroinvertebrate species. In contrast, the reference location on Island Creek (IC-1) is characterized by optimal lotic (flowing) conditions with diverse habitats that include shallow riffles, runs, snags (woody debris that tends to support a variety of macroinvertebrates), and herbaceous vegetation. Compared to IC-1, the habitats at the three downstream river locations are somewhat less optimal, with greater depths and flow and minimal woody snags or herbaceous vegetation. Thus, the slight (PR-2, PR-3, and PR-4) to moderate (PR-1) levels of impairment indicated by comparisons of the bioclassification scores for the river locations to the Island Creek location are not unexpected and can be attributed to differences in the natural habitats available at each location.

The bioclassification process, based on independent evaluation of the scores calculated for each Pacolet River location and Island Creek, indicated that conditions of the benthic macroinvertebrate community were good (IC-1), good-fair (PR-2), or fair (PR-1, PR-3, and PR-4). Based on these bioclassifications and the SCDHEC protocol (SCDHEC, 1998), the habitat at all river locations was determined to be partially supporting of aquatic life use.

The bioassessment of six locations (CC-1 through CC-6) on Cherokee Creek adjacent to the Auriga Polymers Inc. facility determined that the benthic macroinvertebrate communities at locations CC-6, CC-5, and CC-4, were not impaired relative to the upstream background locations CC-7 and CC-8, while the more downstream locations CC-3 and CC-2 were slightly impaired and CC-1 was moderately impaired (Table 2-7). The habitat at CC-1 is substantially different than the other non-background locations because the downstream area where CC-1 is located is a deep, pool habitat with very slow flow immediately upstream of the mouth of Cherokee Creek. In contrast, the background locations are characterized by lotic conditions with diverse habitats that include shallow riffles, runs, and woody snags. Compared to CC-7 and CC-8, the habitats at the three most downstream creek locations are characterized by greater depths, slower flows, and a substrate composition consisting of much more sand and almost no gravel or cobble, conditions that are naturally less optimal for supporting a diverse community of sensitive macroinvertebrate species.

The bioclassification process, based on independent evaluation of the scores calculated for each Cherokee Creek location, indicated that conditions of the benthic macroinvertebrate community were good (CC-6 and CC-5), good-fair (CC-8, CC-7, and CC-4), fair (CC-3 and CC-2), or poor (CC-1). Based on these bioclassifications and the SCDHEC protocol (SCDHEC, 1998), the habitat at the creek locations was determined to be fully supporting of aquatic life use at CC-6 and CC-5; partially supporting at CC-8, CC-7, CC-4, CC-3, and CC-2; and not supporting at CC-1.

2.3 CONCLUSIONS AND USE OF STUDY RESULTS

The primary use of the results from the Aquatic Ecosystem Study reported herein will be their inclusion as a portion of the update of the PRE for these streams and adjoining areas surrounding the Auriga Polymers facility. The PRE will comprise a conservative, screening-level evaluation of risk to both human health and ecological receptors. The analytical data gathered during this study will be used to develop the quantitative human and ecological risk screenings for the aquatic ecosystems of the Pacolet River and Cherokee Creek adjacent to the facility and to provide additional lines of evidence for use in interpreting the screening results.

The benthic invertebrate community analysis completed during this study provides an initial assessment of the ecological health of the stream segments evaluated. The results of the benthic analysis indicated that the stream locations evaluated were either comparable to background areas or would be expected to be rated as of lower quality due to natural stream conditions (deeper, relatively stagnant locations) that provide poorer habitat for the more sensitive organisms that are the focus of the metrics used. The condition of the benthic communities in these areas was not measurably different than would be expected in the absence of the activities at the facility. Given the standard accepted use of benthic invertebrate communities as sensitive indicators of ecological health, the results of this benthic community analysis suggest that aquatic life in these streams is not impaired by site conditions.

The analysis of tissue samples detected Aroclor-1260, 4,4'-DDT, and 4,4'-DDE. These compounds are not historically associated with the site, and their detection suggests that other sources of these compounds may exist in the watershed.

While the benthic community assessment provides evidence of current ecological health, the overall evaluation of risk for both human and ecological receptors is an important additional phase of the evaluation of these aquatic ecosystems. As previously described, the results of this study are being included as a portion of the site data in the PRE currently in development. The PRE will be submitted in the near future.

3.0 REFERENCES

Barbour, Michael T., J. Gerrisen, 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, Office of Water.

Glover, James G. 2011. An Aquatic Macroinvertebrate Bioassessment of the Pacolet River between Lake Blalock and Interstate I-85 (Spartanburg Bounty, SC), Bureau of Water, Aquatic Biology Section, South Carolina Department of Health and Environmental Control, August 2011, Technical Report Number 8A19-11.

South Carolina Department of Health and Environmental Control (SCDHEC). 1998. Standard Operating and Quality Control Procedures for Macroinvertebrate Sampling, Technical Report No. 004-98, Bureau of Water, Columbia, SC.

South Carolina Department of Health and Environmental Control (SCDHEC). 2011. Letter regarding: Invista/Kosa/Auriga (Hoechst Celanese Textile) Site ID #00225, Aquatic Macroinvertebrate Bioassessment of the Pacolet River performed by SCDHEC on 7-11-2011, Cherokee Creek sampling performed by SCDHEC 7-15-2011, Spartanburg County. To Mr. Steve Simpson, Celanese Corp., from Ms. Addie Walker, Hydrologist, and Mr. Tom Knight, Manager, Contamination Mitigation Section, Division of Site Assessment, Remediation and Revitalization, Bureau of Land and Waste Management. October 26.

U.S. Environmental Protection Agency (USEPA), December 1989. *Risk Assessment Guidance for Superfund (RAGS): Volume 1, Human Health Evaluation Manual, Part A.* USEPA/5401-89/002, Office of Emergency and Remedial Response, Washington, District of Columbia.

U.S. Environmental Protection Agency (USEPA), 2008. Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, SW-846.

U.S. Environmental Protection Agency (USEPA), 2010. Sediment Sampling, EPA Region 4 Operating Procedure Number SESDPROC-200-R2, Science and Ecosystem Support Division, Athens, Georgia, September 8, 2010.

U.S. Environmental Protection Agency (USEPA), April 2011. Fish Tissue Sampling, EPA Region 4 Operating Procedure Number SESDPROC-512-R3, Science and Ecosystem Support Division, Athens, Georgia, April 14, 2011.

FIGURE

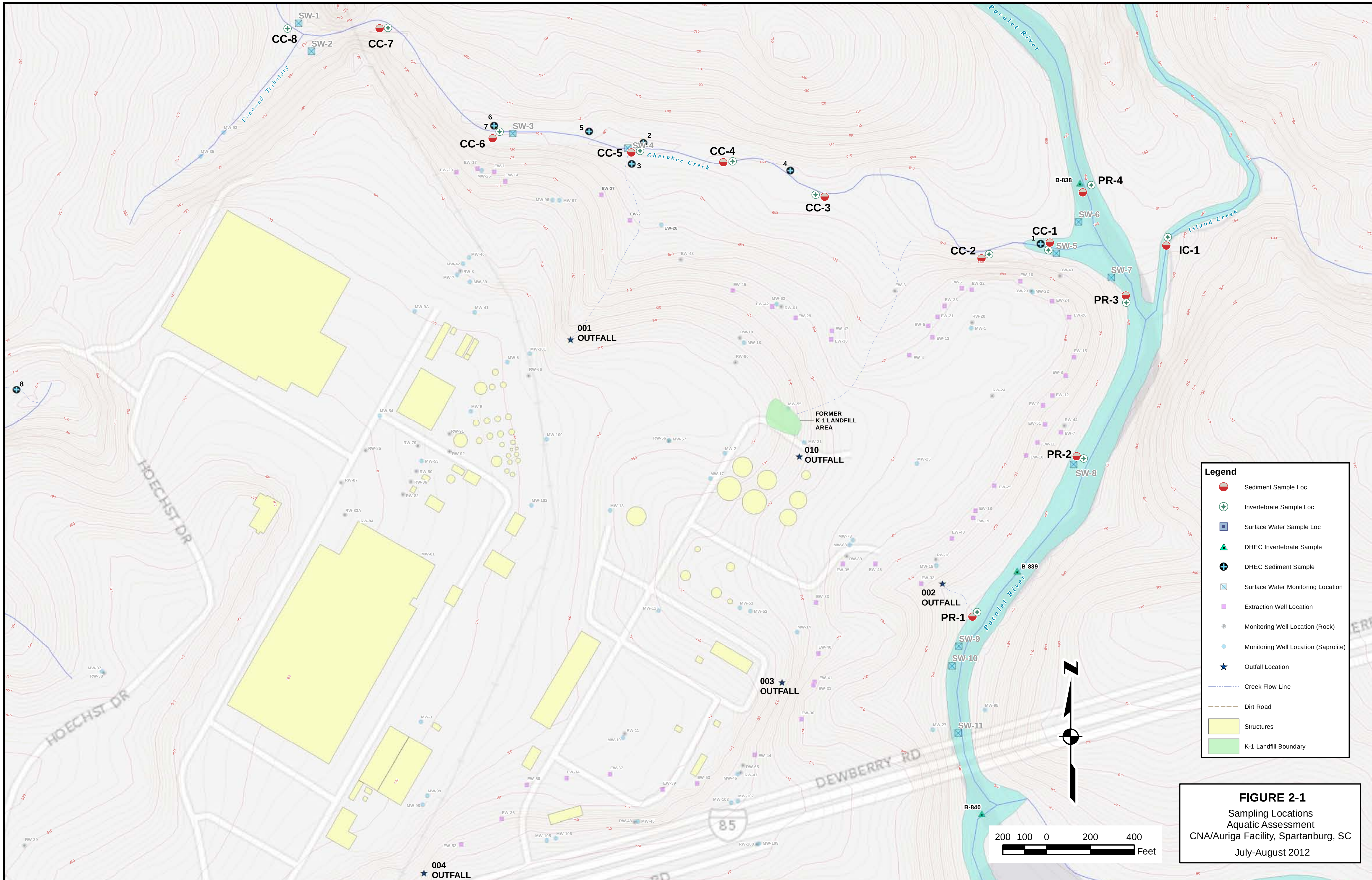


FIGURE 2-1

Sampling Locations
Aquatic Assessment
CNA/Auriga Facility, Spartanburg, SC

July-August 2012

Path: L:\Group\earth\ATLANTA Cadd Files\79748 Spartanburg\GIS\Projects\Proposed SurfSed Sample Location Map CC and PR ONLY.mxd

TABLES

Table 2-1
Numbers of Samples by Stream
Aquatic Ecosystem Study
Auriga/Former CNA Facility, Spartanburg, South Carolina

Stream	Sediment (0-6 inches)	Fish Tissue	Clam Tissue	Benthic Macroinvertebrate Community Assessment
Pacolet River	3	5	1	3
Pacolet River -- background	1			1
Island Creek -- background	1			1
Cherokee Creek	6	3		6
Cherokee Creek -- background	1			2

Table 2-2
Summary of Samples Collected and Chemical Analyses
Aquatic Ecosystem Study
Auriga/Former CNA Facility, Spartanburg, South Carolina

Sample ID	Date Collected	Sample Type	VOCs [(1)]	SVOCs [(2)]	Pesticides [(3)]	PCBs [(4)]	Surface Water Quality Parameters [(5)]
Sediment Samples							
Cherokee Creek							
CC-1-SED(0-6)	7/23/2012	Primary	X	X	X	X	X
CC-2-SED(0-6)	7/23/2012	Primary	X	X	X	X	X
CC-3-SED(0-6)	7/23/2012	Primary	X	X	X	X	X
CC-4-SED(0-6)	7/23/2012	Primary	X	X	X	X	X
CC-4-SED(0-6)	7/23/2012	Duplicate	X	X	X	X	X
CC-5-SED(0-6)	7/24/2012	Primary	X	X	X	X	X
CC-6-SED(0-4)	7/24/2012	Primary	X	X	X	X	X
CC-7-SED(0-6)	7/24/2012	Primary	X	X	X	X	X
Pacolet River							
PR-1-SED(0-6)	7/23/2012	Primary	X	X	X	X	X
PR-2-SED(0-4)	7/23/2012	Primary	X	X	X	X	X
PR-3-SED(0-6)	7/23/2012	Primary	X	X	X	X	X
PR-4-SED(0-6)	7/25/2012	Primary	X	X	X	X	X
Island Creek							
IC-1-SED(0-6)	7/25/2012	Primary	X	X	X	X	X
Tissue Samples							
Cherokee Creek							
CC-BB-1	8/9/2012	Primary		X [(6)]	X	X	
CC-SF-1	8/9/2012	Primary		X [(6)]	X	X	
CC-WS-1	8/9/2012	Primary		X [(6)]	X	X	
Pacolet River							
PR-BB-1	8/8/2012	Primary		X [(6)]	X	X	
PR-BB-2	8/8/2012	Primary		X [(6)]	X	X	
PR-BB-3	8/8/2012	Primary		X [(6)]	X	X	
PR-BB-4	8/8/2012	Primary		X [(6)]	X	X	
PR-BB-5	8/8/2012	Primary		X [(6)]	X	X	
PR-CO-1	8/8/2012	Primary		X [(6)]	X	X	

Notes:

(1) Volatile organic compounds (VOCs) analyzed by EPA SW-846 Method 8260B

(2) Semivolatile organic compounds (SVOCs) analyzed by EPA SW-846 Method 8270D

(3) Pesticides analyzed by EPA SW-846 Method 8081B

(4) Polychlorinated biphenyls (PCBs) analyzed by EPA SW-846 Method 8082A

(5) Includes pH, redox potential, specific conductivity, water temperature, dissolved oxygen, and turbidity.

(6) Analyzed for 1,1'-biphenyl and diphenyl ether only.

Table 2-3
Fish and Clam Samples Collected and Analyzed (August 2012)
Aquatic Ecosystem Study
Auriga/Former CNA Facility, Spartanburg, South Carolina

Stream/	Specimen Data							Tissue Samples for Chemical Analysis		
	Date	Specimen		Fish Length		Weight (grams)		Analytical	Specimens Combined	Total sample
Species	Collected	Designation		(cm)	(in)	Whole Body	Fillet	Sample ID	in Analytical Sample[1]	wt (grams)
Pacolet River										
Brown bullhead catfish	8/8/2012	A		23.0	9.1	120.2	41.4	PR-BB-1	A, I	77.3
Brown bullhead catfish	8/8/2012	B		19.0	7.5	76.0	25.3	PR-BB-2	B, J	54.0
Brown bullhead catfish	8/8/2012	C	*	14.0	5.5	31.9	8.0	PR-BB-3	H, K, L	50.5
Brown bullhead catfish	8/8/2012	E		15.0	5.9	31.9	10.4	PR-BB-4	M, N, O, P	62.8
Brown bullhead catfish	8/8/2012	F		16.5	6.5	42.2	11.7	PR-BB-5	E, F, G, Q, R	56.4
Brown bullhead catfish	8/8/2012	G		15.5	6.1	33.0	10.6			
Brown bullhead catfish	8/8/2012	H		16.5	6.5	46.2	20.0			
Brown bullhead catfish	8/9/2012	I		22.5	8.9	116.9	35.9			
Brown bullhead catfish	8/9/2012	J		21.0	8.3	88.7	28.7			
Brown bullhead catfish	8/9/2012	K		19.5	7.7	55.8	15.4			
Brown bullhead catfish	8/9/2012	L		17.5	6.9	56.1	15.1			
Brown bullhead catfish	8/9/2012	M		17.5	6.9	56.3	16.6			
Brown bullhead catfish	8/9/2012	N		16.0	6.3	47.2	17.1			
Brown bullhead catfish	8/9/2012	O		16.0	6.3	42.2	14.6			
Brown bullhead catfish	8/9/2012	P		16.3	6.4	45.4	14.5			
Brown bullhead catfish	8/9/2012	Q		15.5	6.1	38.1	11.7			
Brown bullhead catfish	8/9/2012	R		16.0	6.3	39.3	12.0			
Redbreast sunfish	8/8/2012	D	*	15.5	6.1	69.2	26.3			
Clam (*Corbicula)*	8/8/2012	--		--	--	26.5 [2]	--	PR-CO-1	Collected 8/8 and 8/9	54.5
Clam (*Corbicula)*	8/9/2012	--		--	--	28.0 [2]	--			
Cherokee Creek										
Brown bullhead catfish	8/9/2012	CF1		17.1	6.8	52.3	19.8	CC-BB-1	CF1, CF2, CF3, CF4	53.5
Brown bullhead catfish	8/9/2012	CF2		17.8	7.0	53.5	14.5			
Brown bullhead catfish	8/9/2012	CF3		15.2	6.0	42.8	10.2			
Brown bullhead catfish	8/9/2012	CF4		14.0	5.5	31.9	9.0			
Brown bullhead catfish	8/9/2012	CF5	*	13.3	5.3	23.2	--			
Brown bullhead catfish	8/9/2012	CF6	*	11.4	4.5	14.7	--			
Brown bullhead catfish	8/9/2012	CF7	*	11.4	4.5	16.4	--			
Brown bullhead catfish	8/9/2012	CF8	*	10.2	4.0	10.4	--			
Brown bullhead catfish	8/9/2012	CF9	*	8.9	3.5	7.6	--			
Bluegill sunfish	8/9/2012	SF1		15.9	6.3	74.1	27.7	CC-SF-1	SF1, SF2, SF3, SF4	78.1
Redbreast sunfish	8/9/2012	SF2		14.0	5.5	47.1	15.2			
Redbreast sunfish	8/9/2012	SF3		13.3	5.3	46.0	15.0			
Redbreast sunfish	8/9/2012	SF4		14.0	5.5	53.2	20.2			
Redbreast sunfish	8/9/2012	SF5	*	10.2	4.0	20.8	--			
Redbreast sunfish	8/9/2012	SF6	*	10.8	4.3	26.5	--			
Redbreast sunfish	8/9/2012	SF7	*	10.2	4.0	19.9	--			
Redbreast sunfish	8/9/2012	SF8	*	10.2	4.0	19.1	--			
Redbreast sunfish	8/9/2012	SF9	*	8.3	3.3	11.7	--			
White sucker	8/9/2012	SR1		22.2	8.8	106.7	49.8	CC-WS-1	SR1, SR2, SR3	142.3
White sucker	8/9/2012	SR2		21.6	8.5	105.0	45.9			
White sucker	8/9/2012	SR3		21.6	8.5	99.2	46.6			
White sucker	8/9/2012	SR4	*	16.5	6.5	47.0	--			
White sucker	8/9/2012	SR5	*	15.9	6.3	45.4	--			
White sucker	8/9/2012	SR6	*	13.3	5.3	33.6	--			

Notes:
(1) Analytical samples consisted of: for fish -- fillets; for clams -- composite of soft tissues removed from shells of many individuals
(2) Clam tissue weight shown is the total collected from multiple individuals (approximately 1 gram per individual clam)
* = tissue from this specimen not sent to laboratory for analysis
-- = not applicable or not measured

Table 2-4
Summary of Sample Results -- Pacolet River and Island Creek Sediment
Aquatic Ecosystem Study
Auriga/Former CNA Facility, Spartanburg, South Carolina

Sample ID / Date Collected	PR-1-SED(0-6) 07/23/12	PR-2-SED(0-4) 07/23/12	PR-3-SED(0-6) 07/23/12	PR-4-SED(0-6) 07/25/12	IC-1-SED(0-6) 07/25/12
Volatile Organic Compounds (mg/kg)					
1,1,1-trichloroethane	< 0.00462	< 0.00493	< 0.00549	< 0.00533	< 0.00531
1,1,2,2-tetrachloroethane	< 0.00462	< 0.00493	< 0.00549	< 0.00533	< 0.00531
1,1,2-trichloro-1,2,2-trifluoroethane	< 0.00923	< 0.00985	< 0.011	< 0.0107	< 0.0106
1,1,2-trichloroethane	< 0.00462	< 0.00493	< 0.00549	< 0.00533	< 0.00531
1,1-dichloroethane	< 0.00462	< 0.00493	< 0.00549	< 0.00533	< 0.00531
1,1-dichloroethene	< 0.00462	< 0.00493	< 0.00549	< 0.00533	< 0.00531
1,2,3-trichlorobenzene	< 0.00462	< 0.00493	< 0.00549	< 0.00533	< 0.00531
1,2,4-trichlorobenzene	< 0.00462	< 0.00493	< 0.00549	< 0.00533	< 0.00531
1,2-dibromo-3-chloropropane	< 0.00462	< 0.00493	< 0.00549	< 0.00533	< 0.00531
1,2-dibromoethane	< 0.00462	< 0.00493	< 0.00549	< 0.00533	< 0.00531
1,2-dichlorobenzene	< 0.00462	< 0.00493	< 0.00549	< 0.00533	< 0.00531
1,2-dichloroethane	< 0.00462	< 0.00493	< 0.00549	< 0.00533	< 0.00531
1,2-dichloropropane	< 0.00462	< 0.00493	< 0.00549	< 0.00533	< 0.00531
1,3-dichlorobenzene	< 0.00462	< 0.00493	< 0.00549	< 0.00533	< 0.00531
1,4-dichlorobenzene	< 0.00462	< 0.00493	< 0.00549	< 0.00533	< 0.00531
2-butanone	< 0.00923	< 0.00985	< 0.011	0.013	< 0.0106
2-hexanone	< 0.00923	< 0.00985	< 0.011	< 0.0107	< 0.0106
4-methyl-2-pentanone	< 0.00462	< 0.00493	< 0.00549	< 0.00533	< 0.00531
acetone	< 0.00923	< 0.00985	0.0263	0.0558	< 0.0106
benzene	< 0.00462	< 0.00493	< 0.00549	< 0.00533	< 0.00531
bromodichloromethane	< 0.00462	< 0.00493	< 0.00549	< 0.00533	< 0.00531
bromoform	< 0.00462	< 0.00493	< 0.00549	< 0.00533	< 0.00531
bromomethane	< 0.00923	< 0.00985	< 0.011	< 0.0107	< 0.0106
carbon disulfide	< 0.00462	< 0.00493	< 0.00549	< 0.00533	< 0.00531
carbon tetrachloride	< 0.00462	< 0.00493	< 0.00549	< 0.00533	< 0.00531
chlorobenzene	< 0.00462	< 0.00493	< 0.00549	< 0.00533	< 0.00531
chloroethane	< 0.00923	< 0.00985	< 0.011	< 0.0107	< 0.0106
chloroform	< 0.00462	< 0.00493	< 0.00549	< 0.00533	< 0.00531
chloromethane	< 0.00923	< 0.00985	< 0.011	< 0.0107	< 0.0106
cis-1,2-dichloroethene	< 0.00462	< 0.00493	< 0.00549	< 0.00533	< 0.00531
cis-1,3-dichloropropene	< 0.00462	< 0.00493	< 0.00549	< 0.00533	< 0.00531
cyclohexane	< 0.00462	< 0.00493	< 0.00549	< 0.00533	< 0.00531
dibromochloromethane	< 0.00462	< 0.00493	< 0.00549	< 0.00533	< 0.00531
ethylbenzene	< 0.00462	< 0.00493	< 0.00549	< 0.00533	< 0.00531
isopropylbenzene	< 0.00462	< 0.00493	< 0.00549	< 0.00533	< 0.00531
methyl acetate	< 0.00462	< 0.00493	< 0.00549	< 0.00533	< 0.00531
methylcyclohexane	< 0.00462	< 0.00493	< 0.00549	< 0.00533	< 0.00531
methylene chloride	< 0.00462	< 0.00493	< 0.00549	< 0.00533	< 0.00531
styrene	< 0.00462	< 0.00493	< 0.00549	< 0.00533	< 0.00531
tetrachloroethene	< 0.00462	< 0.00493	< 0.00549	< 0.00533	< 0.00531
toluene	< 0.00462	< 0.00493	0.0362	< 0.00533	< 0.00531
trans-1,2-dichloroethene	< 0.00462	< 0.00493	< 0.00549	< 0.00533	< 0.00531
trans-1,3-dichloropropene	< 0.00462	< 0.00493	< 0.00549	< 0.00533	< 0.00531
trichloroethene	< 0.00462	< 0.00493	< 0.00549	< 0.00533	< 0.00531
vinyl acetate	< 0.00923	< 0.00985	< 0.011	< 0.0107	< 0.0106
vinyl chloride	< 0.00923	< 0.00985	< 0.011	< 0.0107	< 0.0106
xylenes	< 0.00462	< 0.00493	< 0.00549	< 0.00533	< 0.00531

Table 2-4
Summary of Sample Results -- Pacolet River and Island Creek Sediment
Aquatic Ecosystem Study
Auriga/Former CNA Facility, Spartanburg, South Carolina

Sample ID	PR-1-SED(0-6)			PR-2-SED(0-4)			PR-3-SED(0-6)			PR-4-SED(0-6)			IC-1-SED(0-6)		
Date Collected	07/23/12			07/23/12			07/23/12			07/25/12			07/25/12		
Semivolatile Organic Compounds (mg/kg)															
1,1-biphenyl	<	0.416	UJ	<	0.423		<	0.466	UJ	<	0.467		<	0.413	
1,2,4,5-tetrachlorobenzene	<	0.416	R	<	0.423	R	<	0.466	R	<	0.467		<	0.413	
1,4-dioxane		0.208		<	0.0127		<	0.014		<	0.014		<	0.0124	
1-methylnapthalene	<	0.416	R	<	0.423	R	<	0.466	R	<	0.467		<	0.413	
2,2'-oxybis(2-chloropropane)	<	0.416	R	<	0.423	R	<	0.466	R	<	0.467		<	0.413	
2,4,5-trichlorophenol	<	0.416		<	0.423		<	0.466		<	0.467		<	0.413	
2,4,6-trichlorophenol	<	0.416		<	0.423		<	0.466		<	0.467		<	0.413	
2,4-dichlorophenol	<	0.416		<	0.423		<	0.466		<	0.467		<	0.413	
2,4-dimethylphenol	<	0.416		<	0.423		<	0.466		<	0.467		<	0.413	
2,4-dinitrophenol	<	1.04	R	<	1.06	R	<	1.17	R	<	1.17		<	1.03	
2,4-dinitrotoluene	<	0.416	UJ	<	0.423		<	0.466	UJ	<	0.467		<	0.413	
2,6-dinitrotoluene	<	0.416	UJ	<	0.423		<	0.466	UJ	<	0.467		<	0.413	
2-chloronaphthalene	<	0.416	UJ	<	0.423		<	0.466	UJ	<	0.467		<	0.413	
2-chlorophenol	<	0.416		<	0.423		<	0.466		<	0.467		<	0.413	
2-methylnaphthalene	<	0.416	R	<	0.423	R	<	0.466	R	<	0.467		<	0.413	
2-methylphenol	<	0.416	R	<	0.423	R	<	0.466	R	<	0.467		<	0.413	
2-nitroaniline	<	0.416	UJ	<	0.423		<	0.466	UJ	<	0.467		<	0.413	
2-nitrophenol	<	0.416	R	<	0.423	R	<	0.466	R	<	0.467		<	0.413	
3,3'-dichlorobenzidine	<	0.416	UJ	<	0.423		<	0.466	UJ	<	0.467		<	0.413	
3-nitroaniline	<	0.416	R	<	0.423	R	<	0.466	R	<	0.467		<	0.413	
4,6-dinitro-2-methylphenol	<	1.04	R	<	1.06	R	<	1.17	R	<	1.17		<	1.03	
4-bromophenyl phenyl ether	<	0.416	UJ	<	0.423		<	0.466	UJ	<	0.467		<	0.413	
4-chloro-3-methylphenol	<	0.416		<	0.423		<	0.466		<	0.467		<	0.413	
4-chloroaniline	<	0.416	UJ	<	0.423		<	0.466	UJ	<	0.467		<	0.413	
4-chlorophenyl phenyl ether	<	0.416	UJ	<	0.423		<	0.466	UJ	<	0.467		<	0.413	
4-nitroaniline	<	0.416	UJ	<	0.423		<	0.466	UJ	<	0.467		<	0.413	
4-nitrophenol	<	1.04		<	1.06		<	1.17		<	1.17		<	1.03	
acenaphthene	<	0.416	UJ	<	0.423		<	0.466	UJ	<	0.467		<	0.413	
acenaphthylene	<	0.416	UJ	<	0.423		<	0.466	UJ	<	0.467		<	0.413	
anthracene	<	0.416	UJ	<	0.423		<	0.466	UJ	<	0.467		<	0.413	
atrazine	<	0.416	UJ	<	0.423		<	0.466	UJ	<	0.467		<	0.413	
benzaldehyde	<	0.416	R	<	0.423	R	<	0.466	R	<	0.467	R	<	0.413	R
benzo(a)anthracene	<	0.416	UJ	<	0.423		<	0.466	UJ	<	0.467		<	0.413	
benzo(a)pyrene	<	0.416	UJ	<	0.423		<	0.466	UJ	<	0.467		<	0.413	
benzo(b)fluoranthene	<	0.416	UJ	<	0.423		<	0.466	UJ	<	0.467		<	0.413	
benzo(g,h,i)perylene	<	0.416	UJ	<	0.423		<	0.466	UJ	<	0.467		<	0.413	
benzo(k)fluoranthene	<	0.416	UJ	<	0.423		<	0.466	UJ	<	0.467		<	0.413	
benzyl alcohol	<	0.416		<	0.423		<	0.466		<	0.467		<	0.413	
bis(2-chloroethoxy)methane	<	0.416	R	<	0.423	R	<	0.466	R	<	0.467		<	0.413	
bis(2-chloroethyl)ether	<	0.416	R	<	0.423	R	<	0.466	R	<	0.467		<	0.413	
bis(2-ethylhexyl)phthalate	<	0.416	UJ	<	0.423		<	0.466	UJ	<	0.467		<	0.413	
butyl benzyl phthalate	<	0.416	UJ	<	0.423		<	0.466	UJ	<	0.467		<	0.413	
caprolactam	<	0.416	UJ	<	0.423		<	0.466	UJ	<	0.467		<	0.413	
carbazole chrysene	<	0.416	UJ	<	0.423		<	0.466	UJ	<	0.467		<	0.413	
dibenz(a,h)anthracene	<	0.416	UJ	<	0.423		<	0.466	UJ	<	0.467		<	0.413	
	<	0.416	UJ	<	0.423		<	0.466	UJ	<	0.467		<	0.413	

Table 2-4
Summary of Sample Results -- Pacolet River and Island Creek Sediment
Aquatic Ecosystem Study
Auriga/Former CNA Facility, Spartanburg, South Carolina

Sample ID Date Collected	PR-1-SED(0-6) 07/23/12	PR-2-SED(0-4) 07/23/12	PR-3-SED(0-6) 07/23/12	PR-4-SED(0-6) 07/25/12	IC-1-SED(0-6) 07/25/12
Semivolatile Organic Compounds (mg/kg) Continued					
dibenzofuran	< 0.416 UJ	< 0.423	< 0.466 UJ	< 0.467	< 0.413
diethyl phthalate	< 0.416 UJ	< 0.423	< 0.466 UJ	< 0.467	< 0.413
dimethyl phthalate	< 0.416 UJ	< 0.423	< 0.466 UJ	< 0.467	< 0.413
di-n-butyl phthalate	< 0.416 UJ	< 0.423	< 0.466 UJ	< 0.467	< 0.413
di-n-octyl phthalate	< 0.416 UJ	< 0.423	< 0.466 UJ	< 0.467	< 0.413
diphenyl ether	< 0.416 UJ	< 0.423	< 0.466 UJ	< 0.467	< 0.413
fluoranthene	< 0.416 UJ	< 0.423	< 0.466 UJ	< 0.467	< 0.413
fluorene	< 0.416 R	< 0.423 R	< 0.466 R	< 0.467	< 0.413
hexachlorobenzene	< 0.416 UJ	< 0.423	< 0.466 UJ	< 0.467	< 0.413
hexachlorobutadiene	< 0.416 R	< 0.423 R	< 0.466 R	< 0.467	< 0.413
hexachlorocyclopentadiene	< 0.416 UJ	< 0.423	< 0.466 UJ	< 0.467	< 0.413
hexachloroethane	< 0.416 R	< 0.423 R	< 0.466 R	< 0.467	< 0.413
indeno(1,2,3-cd)pyrene	< 0.416 R	< 0.423 R	< 0.466 R	< 0.467	< 0.413
isophorone	< 0.416 R	< 0.423 R	< 0.466 R	< 0.467	< 0.413
naphthalene	< 0.416 R	< 0.423 R	< 0.466 R	< 0.467	< 0.413
nitrobenzene	< 0.416 R	< 0.423 R	< 0.466 R	< 0.467	< 0.413
n-nitrosodiphenylamine	< 0.416 UJ	< 0.423	< 0.466 UJ	< 0.467	< 0.413
n-nitrosodipropylamine	< 0.416 R	< 0.423 R	< 0.466 R	< 0.467	< 0.413
pentachlorophenol	< 1.04	< 1.06	< 1.17	< 1.17	< 1.03
phenanthrene	< 0.416 UJ	< 0.423	< 0.466 UJ	< 0.467	< 0.413
phenol	< 0.416	< 0.423	< 0.466	< 0.467	< 0.413
pyrene	< 0.416 UJ	< 0.423	< 0.466 UJ	< 0.467	< 0.413
Pesticides (mg/kg)					
4,4'-DDD	< 0.00208	< 0.00212	< 0.00233	< 0.00234	< 0.00207
4,4'-DDE	< 0.00208	< 0.00212	< 0.00233	< 0.00234	< 0.00207
4,4'-DDT	< 0.00208	< 0.00212	< 0.00233	< 0.00234	< 0.00207
aldrin	< 0.00208	< 0.00212	< 0.00233	< 0.00234	< 0.00207
alpha-BHC	< 0.00208	< 0.00212	< 0.00233	< 0.00234	< 0.00207
beta-BHC	< 0.00208	< 0.00212	< 0.00233	< 0.00234	< 0.00207
chlordane (technical)	< 0.0208	< 0.0212	< 0.0233	< 0.0234	< 0.0207
delta-BHC	< 0.00208	< 0.00212	< 0.00233	< 0.00234	< 0.00207
dieldrin	< 0.00208	< 0.00212	< 0.00233	< 0.00234	< 0.00207
endosulfan I	< 0.00208	< 0.00212	< 0.00233	< 0.00234	< 0.00207
endosulfan II	< 0.00208	< 0.00212	< 0.00233	< 0.00234	< 0.00207
endosulfan sulfate	< 0.00208	< 0.00212	< 0.00233	< 0.00234	< 0.00207
endrin	< 0.00208	< 0.00212	< 0.00233	< 0.00234	< 0.00207
endrin aldehyde	< 0.00208	< 0.00212	< 0.00233	< 0.00234	< 0.00207
gamma-BHC	< 0.00208	< 0.00212	< 0.00233	< 0.00234	< 0.00207
heptachlor	< 0.00208	< 0.00212	< 0.00233	< 0.00234	< 0.00207
heptachlor epoxide	< 0.00208	< 0.00212	< 0.00233	< 0.00234	< 0.00207
methoxychlor	< 0.0208	< 0.0212	< 0.0233	< 0.0234	< 0.0207
toxaphene	< 0.0208	< 0.0212	< 0.0233	< 0.0234	< 0.0207

Table 2-4
Summary of Sample Results -- Pacolet River and Island Creek Sediment
Aquatic Ecosystem Study
Auriga/Former CNA Facility, Spartanburg, South Carolina

Sample ID / Date Collected	PR-1-SED(0-6) 07/23/12		PR-2-SED(0-4) 07/23/12		PR-3-SED(0-6) 07/23/12		PR-4-SED(0-6) 07/25/12			IC-1-SED(0-6) 07/25/12		
Polychlorinated Biphenyls (mg/kg)												
Aroclor 1016	<	0.0208	<	0.0212	<	0.0233	<	0.0234	R	<	0.0207	R
Aroclor 1221	<	0.0208	<	0.0212	<	0.0233	<	0.0234		<	0.0207	
Aroclor 1232	<	0.0208	<	0.0212	<	0.0233	<	0.0234		<	0.0207	
Aroclor 1242	<	0.0208	<	0.0212	<	0.0233	<	0.0234		<	0.0207	
Aroclor 1248	<	0.0208	<	0.0212	<	0.0233	<	0.0234		<	0.0207	
Aroclor 1254	<	0.0208	<	0.0212	<	0.0233	<	0.0234		<	0.0207	
Aroclor 1260	<	0.0208	<	0.0212	<	0.0233	<	0.0234	R	<	0.0207	R
Surface Water Quality Parameters												
pH (standard units)		6.91		6.27		6.23		6.79			6.03	
Redox potential, Eh (millivolts)		14.4		57.8		74.0		48.5			82.4	
Specific conductivity (millisiemens per cm)		0.165		0.054		0.055		0.058			0.044	
Water temperature (degrees Celsius)		27.17		27.02		27.09		26.70			23.28	
Dissolved oxygen (mg/L)		6.15		7.49		7.56		5.34			NM	
Turbidity (nephelometric turbidity units)		9.10		4.98		5.41		3.58			19.88	

Notes:
Shading indicates a detected concentration.
< indicates the chemical was not detected -- the value shown is the reporting limit.
cm = centimeter
mg/L = milligrams per liter
NM = no measurement
Data Flag Definitions:
R - The sample result is rejected due to serious deficiencies in the ability to analyze the chemical and meet quality control criteria. The presence or absence of the chemical cannot be verified.
UJ - The analyte was not detected above the reported sample quantitation limit. However, the reported quantitation limit is approximate and may or may not represent the actual limit of quantitation necessary to accurately and precisely measure the analyte in the sample.

Table 2-5
Summary of Sample Results -- Cherokee Creek Sediment
Aquatic Ecosystem Study
Auriga/Former CNA Facility, Spartanburg, South Carolina

Sample ID Date Collected	CC-1-SED(0-6) 07/23/12	CC-2-SED(0-6) 07/23/12	CC-3-SED(0-6) 07/23/12	CC-4-SED(0-6) 07/23/12	CC-4-SED(0-6) * 07/23/12	CC-5-SED(0-6) 07/24/12	CC-6-SED(0-4) 07/24/12	CC-7-SED(0-6) 07/24/12
Volatile Organic Compounds (mg/kg)								
1,1,1-trichloroethane	< 0.00559	< 0.00473	< 0.00524	< 0.00593	< 0.00512	< 0.00491	< 0.00605	< 0.00525
1,1,2,2-tetrachloroethane	< 0.00559	< 0.00473	< 0.00524	< 0.00593	< 0.00512	< 0.00491	< 0.00605	< 0.00525
1,1,2-trichloro-1,2,2-trifluoroethane	< 0.0112	< 0.00946	< 0.0105	< 0.0119	< 0.0102	< 0.00982	< 0.0121	< 0.0105
1,1,2-trichloroethane	< 0.00559	< 0.00473	< 0.00524	< 0.00593	< 0.00512	< 0.00491	< 0.00605	< 0.00525
1,1-dichloroethane	< 0.00559	< 0.00473	< 0.00524	< 0.00593	< 0.00512	< 0.00491	< 0.00605	< 0.00525
1,1-dichloroethene	< 0.00559	< 0.00473	< 0.00524	< 0.00593	< 0.00512	< 0.00491	< 0.00605	< 0.00525
1,2,3-trichlorobenzene	< 0.00559	< 0.00473	< 0.00524	< 0.00593	< 0.00512	< 0.00491	< 0.00605	< 0.00525
1,2,4-trichlorobenzene	< 0.00559	< 0.00473	< 0.00524	< 0.00593	< 0.00512	< 0.00491	< 0.00605	< 0.00525
1,2-dibromo-3-chloropropane	< 0.00559	< 0.00473	< 0.00524	< 0.00593	< 0.00512	< 0.00491	< 0.00605	< 0.00525
1,2-dibromoethane	< 0.00559	< 0.00473	< 0.00524	< 0.00593	< 0.00512	< 0.00491	< 0.00605	< 0.00525
1,2-dichlorobenzene	< 0.00559	< 0.00473	< 0.00524	< 0.00593	< 0.00512	< 0.00491	< 0.00605	< 0.00525
1,2-dichloroethane	< 0.00559	< 0.00473	< 0.00524	< 0.00593	< 0.00512	< 0.00491	< 0.00605	< 0.00525
1,2-dichloropropane	< 0.00559	< 0.00473	< 0.00524	< 0.00593	< 0.00512	< 0.00491	< 0.00605	< 0.00525
1,3-dichlorobenzene	< 0.00559	< 0.00473	< 0.00524	< 0.00593	< 0.00512	< 0.00491	< 0.00605	< 0.00525
1,4-dichlorobenzene	< 0.00559	< 0.00473	< 0.00524	< 0.00593	< 0.00512	< 0.00491	< 0.00605	< 0.00525
2-butanone	< 0.0112	< 0.00946	< 0.0105	< 0.0119	< 0.0102	< 0.00982	< 0.0121	< 0.0105
2-hexanone	< 0.0112	< 0.00946	< 0.0105	< 0.0119	< 0.0102	< 0.00982	< 0.0121	< 0.0105
4-methyl-2-pentanone	< 0.00559	< 0.00473	< 0.00524	< 0.00593	< 0.00512	< 0.00491	< 0.00605	< 0.00525
acetone	< 0.0112	< 0.00946	< 0.0105	0.027	< 0.0102	< 0.00982	0.0229	< 0.0105
benzene	< 0.00559	< 0.00473	< 0.00524	< 0.00593	< 0.00512	< 0.00491	< 0.00605	< 0.00525
bromodichloromethane	< 0.00559	< 0.00473	< 0.00524	< 0.00593	< 0.00512	< 0.00491	< 0.00605	< 0.00525
bromoform	< 0.00559	< 0.00473	< 0.00524	< 0.00593	< 0.00512	< 0.00491	< 0.00605	< 0.00525
bromomethane	< 0.0112	< 0.00946	< 0.0105	< 0.0119	< 0.0102	< 0.00982	< 0.0121	< 0.0105
carbon disulfide	< 0.00559	< 0.00473	< 0.00524	< 0.00593	< 0.00512	< 0.00491	< 0.00605	< 0.00525
carbon tetrachloride	< 0.00559	< 0.00473	< 0.00524	< 0.00593	< 0.00512	< 0.00491	< 0.00605	< 0.00525
chlorobenzene	< 0.00559	< 0.00473	< 0.00524	< 0.00593	< 0.00512	< 0.00491	< 0.00605	< 0.00525
chloroethane	< 0.0112	< 0.00946	< 0.0105	< 0.0119	< 0.0102	< 0.00982	< 0.0121	< 0.0105
chloroform	< 0.00559	< 0.00473	< 0.00524	< 0.00593	< 0.00512	< 0.00491	< 0.00605	< 0.00525
chloromethane	< 0.0112	< 0.00946	< 0.0105	< 0.0119	< 0.0102	< 0.00982	< 0.0121	< 0.0105
cis-1,2-dichloroethene	< 0.00559	< 0.00473	< 0.00524	< 0.00593	< 0.00512	< 0.00491	< 0.00605	< 0.00525
cis-1,3-dichloropropene	< 0.00559	< 0.00473	< 0.00524	< 0.00593	< 0.00512	< 0.00491	< 0.00605	< 0.00525
cyclohexane	< 0.00559	< 0.00473	< 0.00524	< 0.00593	< 0.00512	< 0.00491	< 0.00605	< 0.00525
dibromochloromethane	< 0.00559	< 0.00473	< 0.00524	< 0.00593	< 0.00512	< 0.00491	< 0.00605	< 0.00525
ethylbenzene	< 0.00559	< 0.00473	< 0.00524	< 0.00593	< 0.00512	< 0.00491	< 0.00605	< 0.00525
isopropylbenzene	< 0.00559	< 0.00473	< 0.00524	< 0.00593	< 0.00512	< 0.00491	< 0.00605	< 0.00525
methyl acetate	< 0.00559	< 0.00473	< 0.00524	< 0.00593	< 0.00512	< 0.00491	< 0.00605	< 0.00525
methylcyclohexane	< 0.00559	< 0.00473	< 0.00524	< 0.00593	< 0.00512	< 0.00491	< 0.00605	< 0.00525
methylene chloride	< 0.00559	< 0.00473	< 0.00524	< 0.00593	< 0.00512	< 0.00491	< 0.00605	< 0.00525
styrene	< 0.00559	< 0.00473	< 0.00524	< 0.00593	< 0.00512	< 0.00491	< 0.00605	< 0.00525
tetrachloroethene	< 0.00559	< 0.00473	< 0.00524	< 0.00593	< 0.00512	< 0.00491	< 0.00605	< 0.00525
toluene	< 0.00559	< 0.00473	< 0.00524	< 0.00593	< 0.00512	< 0.00491	< 0.00605	< 0.00525
trans-1,2-dichloroethene	< 0.00559	< 0.00473	< 0.00524	< 0.00593	< 0.00512	< 0.00491	< 0.00605	< 0.00525
trans-1,3-dichloropropene	< 0.00559	< 0.00473	< 0.00524	< 0.00593	< 0.00512	< 0.00491	< 0.00605	< 0.00525
trichloroethene	< 0.00559	< 0.00473	< 0.00524	< 0.00593	< 0.00512	< 0.00491	0.00614	< 0.00525
vinyl acetate	< 0.0112	< 0.00946	< 0.0105	< 0.0119	< 0.0102	< 0.00982	< 0.0121	< 0.0105
vinyl chloride	< 0.0112	< 0.00946	< 0.0105	< 0.0119	< 0.0102	< 0.00982	< 0.0121	< 0.0105
xylenes	< 0.00559	< 0.00473	< 0.00524	< 0.00593	< 0.00512	< 0.00491	< 0.00605	< 0.00525

Table 2-5
Summary of Sample Results -- Cherokee Creek Sediment
Aquatic Ecosystem Study
Auriga/Former CNA Facility, Spartanburg, South Carolina

Sample ID Date Collected	CC-1-SED(0-6) 07/23/12	CC-2-SED(0-6) 07/23/12	CC-3-SED(0-6) 07/23/12	CC-4-SED(0-6) 07/23/12	CC-4-SED(0-6) * 07/23/12	CC-5-SED(0-6) 07/24/12	CC-6-SED(0-4) 07/24/12	CC-7-SED(0-6) 07/24/12
Semivolatile Organic Compounds (mg/kg)								
1,1-biphenyl	< 0.436	< 0.432	< 0.432	< 0.43	< 0.431 UJ	1.84 J	< 0.526	< 0.445
1,2,4,5-tetrachlorobenzene	< 0.436 R	< 0.432 R	< 0.432 R	< 0.43 R	< 0.431 R	< 0.417 R	< 0.526 R	< 0.445 R
1,4-dioxane	< 0.0131	< 0.0129	< 0.013	< 0.0129	< 0.0129	< 0.0125	< 0.0158	< 0.0133
1-methylnapthalene	< 0.436 R	< 0.432 R	< 0.432 R	< 0.43 R	< 0.431 R	< 0.417 R	< 0.526 R	< 0.445 R
2,2'-oxybis(2-chloropropane)	< 0.436 R	< 0.432 R	< 0.432 R	< 0.43 R	< 0.431 R	< 0.417 R	< 0.526 R	< 0.445 R
2,4,5-trichlorophenol	< 0.436	< 0.432	< 0.432	< 0.43	< 0.431	< 0.417	< 0.526	< 0.445
2,4,6-trichlorophenol	< 0.436	< 0.432	< 0.432	< 0.43	< 0.431	< 0.417	< 0.526	< 0.445
2,4-dichlorophenol	< 0.436	< 0.432	< 0.432	< 0.43	< 0.431	< 0.417	< 0.526	< 0.445
2,4-dimethylphenol	< 0.436	< 0.432	< 0.432	< 0.43	< 0.431	< 0.417	< 0.526	< 0.445
2,4-dinitrophenol	< 1.09 R	< 1.08 R	< 1.08 R	< 1.08 R	< 1.08 R	< 1.04 R	< 1.32 R	< 1.11 R
2,4-dinitrotoluene	< 0.436	< 0.432	< 0.432	< 0.43	< 0.431 UJ	< 0.417 UJ	< 0.526	< 0.445
2,6-dinitrotoluene	< 0.436	< 0.432	< 0.432	< 0.43	< 0.431 UJ	< 0.417 UJ	< 0.526	< 0.445
2-chloronaphthalene	< 0.436	< 0.432	< 0.432	< 0.43	< 0.431 UJ	< 0.417 UJ	< 0.526	< 0.445
2-chlorophenol	< 0.436	< 0.432	< 0.432	< 0.43	< 0.431	< 0.417	< 0.526	< 0.445
2-methylnaphthalene	< 0.436 R	< 0.432 R	< 0.432 R	< 0.43 R	< 0.431 R	< 0.417 R	< 0.526 R	< 0.445 R
2-methylphenol	< 0.436 R	< 0.432 R	< 0.432 R	< 0.43 R	< 0.431 R	< 0.417 R	< 0.526 R	< 0.445 R
2-nitroaniline	< 0.436	< 0.432	< 0.432	< 0.43	< 0.431 UJ	< 0.417 UJ	< 0.526	< 0.445
2-nitrophenol	< 0.436 R	< 0.432 R	< 0.432 R	< 0.43 R	< 0.431 R	< 0.417 R	< 0.526 R	< 0.445 R
3,3'-dichlorobenzidine	< 0.436	< 0.432	< 0.432	< 0.43	< 0.431 UJ	< 0.417 UJ	< 0.526	< 0.445
3-nitroaniline	< 0.436 R	< 0.432 R	< 0.432 R	< 0.43 R	< 0.431 R	< 0.417 R	< 0.526 R	< 0.445 R
4,6-dinitro-2-methylphenol	< 1.09 R	< 1.08 R	< 1.08 R	< 1.08 R	< 1.08 R	< 1.04 R	< 1.32 R	< 1.11 R
4-bromophenyl phenyl ether	< 0.436	< 0.432	< 0.432	< 0.43	< 0.431 UJ	< 0.417 UJ	< 0.526	< 0.445
4-chloro-3-methylphenol	< 0.436	< 0.432	< 0.432	< 0.43	< 0.431	< 0.417	< 0.526	< 0.445
4-chloroaniline	< 0.436	< 0.432	< 0.432	< 0.43	< 0.431 UJ	< 0.417 UJ	< 0.526	< 0.445
4-chlorophenyl phenyl ether	< 0.436	< 0.432	< 0.432	< 0.43	< 0.431 UJ	< 0.417 UJ	< 0.526	< 0.445
4-nitroaniline	< 0.436	< 0.432	< 0.432	< 0.43	< 0.431 UJ	< 0.417 UJ	< 0.526	< 0.445
4-nitrophenol	< 1.09	< 1.08	< 1.08	< 1.08	< 1.08	< 1.04	< 1.32	< 1.11
acenaphthene	< 0.436	< 0.432	< 0.432	< 0.43	< 0.431 UJ	< 0.417 UJ	< 0.526	< 0.445
acenaphthylene	< 0.436	< 0.432	< 0.432	< 0.43	< 0.431 UJ	< 0.417 UJ	< 0.526	< 0.445
anthracene	< 0.436	< 0.432	< 0.432	< 0.43	< 0.431 UJ	< 0.417 UJ	< 0.526	< 0.445
atrazine	< 0.436	< 0.432	< 0.432	< 0.43	< 0.431 UJ	< 0.417 UJ	< 0.526	< 0.445
benzaldehyde	< 0.436 R	< 0.432 R	< 0.432 R	< 0.43 R	< 0.431 R	< 0.417 R	< 0.526 R	< 0.445 R
benzo(a)anthracene	< 0.436	< 0.432	< 0.432	< 0.43	< 0.431 UJ	< 0.417 UJ	< 0.526	< 0.445
benzo(a)pyrene	< 0.436	< 0.432	< 0.432	< 0.43	< 0.431 UJ	< 0.417 UJ	< 0.526	< 0.445
benzo(b)fluoranthene	< 0.436	< 0.432	< 0.432	< 0.43	< 0.431 UJ	< 0.417 UJ	< 0.526	< 0.445
benzo(g,h,i)perylene	< 0.436	< 0.432	< 0.432	< 0.43	< 0.431 UJ	< 0.417 UJ	< 0.526	< 0.445
benzo(k)fluoranthene	< 0.436	< 0.432	< 0.432	< 0.43	< 0.431 UJ	< 0.417 UJ	< 0.526	< 0.445
benzyl alcohol	< 0.436	< 0.432	< 0.432	< 0.43	< 0.431	< 0.417	< 0.526	< 0.445
bis(2-chloroethoxy)methane	< 0.436 R	< 0.432 R	< 0.432 R	< 0.43 R	< 0.431 R	< 0.417 R	< 0.526 R	< 0.445 R
bis(2-chloroethyl)ether	< 0.436 R	< 0.432 R	< 0.432 R	< 0.43 R	< 0.431 R	< 0.417 R	< 0.526 R	< 0.445 R
bis(2-ethylhexyl)phthalate	< 0.436	< 0.432	< 0.432	< 0.43	< 0.431 UJ	< 0.417 UJ	< 0.526	< 0.445
butyl benzyl phthalate	< 0.436	< 0.432	< 0.432	< 0.43	< 0.431 UJ	< 0.417 UJ	< 0.526	< 0.445
caprolactam	< 0.436	< 0.432	< 0.432	< 0.43	< 0.431 UJ	< 0.417 UJ	< 0.526	< 0.445
carbazole chrysene	< 0.436	< 0.432	< 0.432	< 0.43	< 0.431 UJ	< 0.417 UJ	< 0.526	< 0.445
dibenz(a,h)anthracene	< 0.436	< 0.432	< 0.432	< 0.43	< 0.431 UJ	< 0.417 UJ	< 0.526	< 0.445
	< 0.436	< 0.432	< 0.432	< 0.43	< 0.431 UJ	< 0.417 UJ	< 0.526	< 0.445

Table 2-5
Summary of Sample Results -- Cherokee Creek Sediment
Aquatic Ecosystem Study
Auriga/Former CNA Facility, Spartanburg, South Carolina

Sample ID Date Collected	CC-1-SED(0-6) 07/23/12	CC-2-SED(0-6) 07/23/12	CC-3-SED(0-6) 07/23/12	CC-4-SED(0-6) 07/23/12	CC-4-SED(0-6) * 07/23/12	CC-5-SED(0-6) 07/24/12	CC-6-SED(0-4) 07/24/12	CC-7-SED(0-6) 07/24/12
Semivolatile Organic Compounds (mg/kg) Continued								
dibenzofuran	< 0.436	< 0.432	< 0.432	< 0.43	< 0.431 UJ	< 0.417 UJ	< 0.526	< 0.445
diethyl phthalate	< 0.436	< 0.432	< 0.432	< 0.43	< 0.431 UJ	< 0.417 UJ	< 0.526	< 0.445
dimethyl phthalate	< 0.436	< 0.432	< 0.432	< 0.43	< 0.431 UJ	< 0.417 UJ	< 0.526	< 0.445
di-n-butyl phthalate	< 0.436	< 0.432	< 0.432	< 0.43	< 0.431 UJ	< 0.417 UJ	< 0.526	< 0.445
di-n-octyl phthalate	< 0.436	< 0.432	< 0.432	< 0.43	< 0.431 UJ	< 0.417 UJ	< 0.526	< 0.445
diphenyl ether	< 0.436	< 0.432	< 0.432	< 0.43	< 0.431 UJ	5.09	< 0.526	< 0.445
fluoranthene	< 0.436	< 0.432	< 0.432	< 0.43	< 0.431 UJ	< 0.417 UJ	< 0.526 R	< 0.445
fluorene	< 0.436 R	< 0.432 R	< 0.432 R	< 0.43 R	< 0.431 R	< 0.417 R	< 0.526 R	< 0.445 R
hexachlorobenzene	< 0.436	< 0.432	< 0.432	< 0.43	< 0.431 UJ	< 0.417 UJ	< 0.526	< 0.445
hexachlorobutadiene	< 0.436 R	< 0.432 R	< 0.432 R	< 0.43 R	< 0.431 R	< 0.417 R	< 0.526 R	< 0.445 R
hexachlorocyclopentadiene	< 0.436	< 0.432	< 0.432	< 0.43	< 0.431 UJ	< 0.417 UJ	< 0.526	< 0.445
hexachloroethane	< 0.436 R	< 0.432 R	< 0.432 R	< 0.43 R	< 0.431 R	< 0.417 R	< 0.526 R	< 0.445 R
indeno(1,2,3-cd)pyrene	< 0.436 R	< 0.432 R	< 0.432 R	< 0.43 R	< 0.431 R	< 0.417 R	< 0.526 R	< 0.445 R
isophorone	< 0.436 R	< 0.432 R	< 0.432 R	< 0.43 R	< 0.431 R	< 0.417 R	< 0.526 R	< 0.445 R
naphthalene	< 0.436 R	< 0.432 R	< 0.432 R	< 0.43 R	< 0.431 R	< 0.417 R	< 0.526 R	< 0.445 R
nitrobenzene	< 0.436 R	< 0.432 R	< 0.432 R	< 0.43 R	< 0.431 R	< 0.417 R	< 0.526 R	< 0.445 R
n-nitrosodiphenylamine	< 0.436	< 0.432	< 0.432	< 0.43	< 0.431 UJ	< 0.417 UJ	< 0.526	< 0.445
n-nitrosodipropylamine	< 0.436 R	< 0.432 R	< 0.432 R	< 0.43 R	< 0.431 R	< 0.417 R	< 0.526 R	< 0.445 R
pentachlorophenol	< 1.09	< 1.08	< 1.08	< 1.08	< 1.08	< 1.04	< 1.32	< 1.11
phenanthrene	< 0.436	< 0.432	< 0.432	< 0.43	< 0.431 UJ	< 0.417 UJ	< 0.526	< 0.445
phenol	< 0.436	< 0.432	< 0.432	< 0.43	< 0.431	< 0.417	< 0.526	< 0.445
pyrene	< 0.436	< 0.432	< 0.432	< 0.43	< 0.431 UJ	< 0.417 UJ	< 0.526	< 0.445
Pesticides (mg/kg)								
4,4'-DDD	< 0.00218	< 0.00216	< 0.00216	< 0.00215 UJ	< 0.00216	< 0.00208 UJ	< 0.00263	< 0.00222
4,4'-DDE	< 0.00218	< 0.00216	< 0.00216	< 0.00215 UJ	< 0.00216	< 0.00208 UJ	< 0.00263	< 0.00222
4,4'-DDT	< 0.00218	< 0.00216	< 0.00216	< 0.00215 UJ	< 0.00216	< 0.00208 UJ	< 0.00263	< 0.00222
aldrin	< 0.00218	< 0.00216	< 0.00216	< 0.00215 UJ	< 0.00216	< 0.00208 UJ	< 0.00263	< 0.00222
alpha-BHC	< 0.00218	< 0.00216	< 0.00216	< 0.00215 UJ	< 0.00216	< 0.00208 UJ	< 0.00263	< 0.00222
beta-BHC	< 0.00218	< 0.00216	< 0.00216	< 0.00215 UJ	< 0.00216	< 0.00208 UJ	< 0.00263	< 0.00222
chlordane (technical)	< 0.0218	< 0.0216	< 0.0216	< 0.0215 UJ	< 0.0216	< 0.0208 UJ	< 0.0263	< 0.0222
delta-BHC	< 0.00218	< 0.00216	< 0.00216	< 0.00215 UJ	< 0.00216	< 0.00208 UJ	< 0.00263	< 0.00222
dieldrin	< 0.00218	< 0.00216	< 0.00216	< 0.00215 UJ	< 0.00216	< 0.00208 UJ	< 0.00263	< 0.00222
endosulfan I	< 0.00218	< 0.00216	< 0.00216	< 0.00215 UJ	< 0.00216	< 0.00208 UJ	< 0.00263	< 0.00222
endosulfan II	< 0.00218	< 0.00216	< 0.00216	< 0.00215 UJ	< 0.00216	< 0.00208 UJ	< 0.00263	< 0.00222
endosulfan sulfate	< 0.00218	< 0.00216	< 0.00216	< 0.00215 UJ	< 0.00216	< 0.00208 UJ	< 0.00263	< 0.00222
endrin	< 0.00218	< 0.00216	< 0.00216	< 0.00215 UJ	< 0.00216	< 0.00208 UJ	< 0.00263	< 0.00222
endrin aldehyde	< 0.00218	< 0.00216	< 0.00216	< 0.00215 UJ	< 0.00216	< 0.00208 UJ	< 0.00263	< 0.00222
gamma-BHC	< 0.00218	< 0.00216	< 0.00216	< 0.00215 UJ	< 0.00216	< 0.00208 UJ	< 0.00263	< 0.00222
heptachlor	< 0.00218	< 0.00216	< 0.00216	< 0.00215 UJ	< 0.00216	< 0.00208 UJ	< 0.00263	< 0.00222
heptachlor epoxide	< 0.00218	< 0.00216	< 0.00216	< 0.00215 UJ	< 0.00216	< 0.00208 UJ	< 0.00263	< 0.00222
methoxychlor	< 0.0218	< 0.0216	< 0.0216	< 0.0215 UJ	< 0.0216	< 0.0208 UJ	< 0.0263	< 0.0222
toxaphene	< 0.0218	< 0.0216	< 0.0216	< 0.0215 UJ	< 0.0216	< 0.0208 UJ	< 0.0263	< 0.0222

Table 2-5
Summary of Sample Results -- Cherokee Creek Sediment
Aquatic Ecosystem Study
Auriga/Former CNA Facility, Spartanburg, South Carolina

Sample ID Date Collected	CC-1-SED(0-6) 07/23/12	CC-2-SED(0-6) 07/23/12	CC-3-SED(0-6) 07/23/12	CC-4-SED(0-6) 07/23/12	CC-4-SED(0-6) * 07/23/12	CC-5-SED(0-6) 07/24/12	CC-6-SED(0-4) 07/24/12	CC-7-SED(0-6) 07/24/12
Polychlorinated Biphenyls (mg/kg)								
Aroclor 1016	< 0.0218 R	< 0.0216 R	< 0.0216 R	< 0.0215	< 0.0216	< 0.0208	< 0.0263	< 0.0222
Aroclor 1221	< 0.0218 R	< 0.0216	< 0.0216	< 0.0215	< 0.0216	< 0.0208	< 0.0263	< 0.0222
Aroclor 1232	< 0.0218 R	< 0.0216	< 0.0216	< 0.0215	< 0.0216	< 0.0208	< 0.0263	< 0.0222
Aroclor 1242	< 0.0218 R	< 0.0216	< 0.0216	< 0.0215	< 0.0216	< 0.0208	< 0.0263	< 0.0222
Aroclor 1248	< 0.0218 R	< 0.0216	< 0.0216	< 0.0215	< 0.0216	< 0.0208	< 0.0263	< 0.0222
Aroclor 1254	< 0.0218 R	< 0.0216	< 0.0216	< 0.0215	< 0.0216	< 0.0208	< 0.0263	< 0.0222
Aroclor 1260	< 0.0218 R	< 0.0216 R	< 0.0216 R	< 0.0215	< 0.0216	0.144	< 0.0263	< 0.0222
Surface Water Quality Parameters								
pH (standard units)	6.08	5.55	6.28	6.58	NA	6.46	6.19	6.9
Redox Potential, Eh (millivolts)	63.3	56.8	66.1	66.2	NA	-2	-13.5	-31.6
Specific Conductivity (millisiemens per cm)	0.063	0.062	0.058	0.060	NA	0.061	0.064	0.061
Water Temperature (degrees Celsius)	25.34	25.75	25.99	25.90	NA	24.15	25.39	26.57
Dissolved Oxygen (mg/L)	6.88	7.75	7.71	6.73	NA	7.66	5.8	5.71
Turbidity (nephelometric turbidity units)	6.38	5.68	4.99	7.60	NA	4.89	3.66	4.04

Notes:

Shading indicates a detected concentration.

* - Indicates a field duplicate sample.

cm - centimeter

mg/L - milligrams per liter

NA - not applicable

Data Flag Definitions:

J - The reported result is an estimated value (e.g., matrix interference observed or concentration outside the quantitation range).

R - The sample result is rejected due to serious deficiencies in the ability to analyze the chemical and meet quality control criteria. The presence or absence of the chemical cannot be verified.

UJ - The analyte was not detected above the reported sample quantitation limit. However, the reported quantitation limit is approximate and may or may not represent the actual limit of quantitation necessary to accurately and precisely measure the analyte in the sample.

Table 2-6
Summary of Sample Results -- Fish and Clam Tissue
Aquatic Ecosystem Study
Auriga/Former CNA Facility, Spartanburg, South Carolina

Sample ID	CC-BB-1	CC-SF-1	CC-WS-1	PR-BB-1	PR-BB-2	PR-BB-3	PR-BB-4	PR-BB-5	PR-CO-1
Date Collected	08/09/12	08/09/12	08/09/12	08/08/12	08/08/12	08/08/12	08/08/12	08/08/12	08/08/12
Semivolatile Organic Compounds (mg/kg)									
1,1'-biphenyl	< 1.02	< 0.975	< 0.978	< 0.98	< 1.02	< 0.995	< 1.01	< 0.998	< 1.08
diphenyl ether	< 1.02	< 0.975	0.306 J	< 0.98	< 1.02	< 0.995	< 1.01	< 0.998	< 1.08
Pesticides (mg/kg)									
4,4'-DDD	< 0.0077	< 0.00734 UJ	< 0.00811	< 0.00777	< 0.00794	< 0.00791	< 0.00805	< 0.00797	< 0.00816
4,4'-DDE	0.00487 J	< 0.00734 UJ	< 0.00811	0.00348 J	0.00374 J	0.00726 J	0.00457 J	0.00472 J	0.00304 J
4,4'-DDT	< 0.0077	< 0.00734 UJ	< 0.00811	< 0.00777	< 0.00794	0.00734 J	< 0.00805	< 0.00797	< 0.00816
aldrin	< 0.00385	< 0.00367 UJ	< 0.00405	< 0.00389	< 0.00397	< 0.00396	< 0.00402	< 0.00398	< 0.00408
alpha-BHC	< 0.00385	< 0.00367 UJ	< 0.00405	< 0.00389	< 0.00397	< 0.00396	< 0.00402	< 0.00398	< 0.00408
beta-BHC	< 0.00385	< 0.00367 UJ	< 0.00405	< 0.00389	< 0.00397	< 0.00396	< 0.00402	< 0.00398	< 0.00408
chlordane	< 0.0481	< 0.0459	< 0.0507	< 0.0486	< 0.0496	< 0.0495	< 0.0503	< 0.0498	< 0.051
delta-BHC	< 0.00385	< 0.00367 UJ	< 0.00405	< 0.00389	< 0.00397	< 0.00396	< 0.00402	< 0.00398	< 0.00408
dieldrin	< 0.0077	< 0.00734 UJ	< 0.00811	< 0.00777	< 0.00794	< 0.00791	< 0.00805	< 0.00797	< 0.00816
endosulfan I	< 0.00385	< 0.00367 UJ	< 0.00405	< 0.00389	< 0.00397	< 0.00396	< 0.00402	< 0.00398	< 0.00408
endosulfan II	< 0.0077	< 0.00734 UJ	< 0.00811	< 0.00777	< 0.00794	< 0.00791	< 0.00805	< 0.00797	< 0.00816
endosulfan sulfate	< 0.0077	< 0.00734 UJ	< 0.00811	< 0.00777	< 0.00794	< 0.00791	< 0.00805	< 0.00797	< 0.00816
endrin	< 0.0077	< 0.00734 UJ	< 0.00811	< 0.00777	< 0.00794	< 0.00791	< 0.00805	< 0.00797	< 0.00816
endrin aldehyde	< 0.0077	< 0.00734 UJ	< 0.00811	< 0.00777	< 0.00794	< 0.00791	< 0.00805	< 0.00797	< 0.00816
endrin ketone	< 0.0077	< 0.00734 UJ	< 0.00811	< 0.00777	< 0.00794	< 0.00791	< 0.00805	< 0.00797	< 0.00816
gamma-BHC	< 0.00385	< 0.00367 UJ	< 0.00405	< 0.00389	< 0.00397	< 0.00396	< 0.00402	< 0.00398	< 0.00408
heptachlor	< 0.00385	< 0.00367 UJ	< 0.00405	< 0.00389	< 0.00397	< 0.00396	< 0.00402	< 0.00398	< 0.00408
heptachlor epoxide	< 0.00385	< 0.00367 UJ	< 0.00405	< 0.00389	< 0.00397	< 0.00396	< 0.00402	< 0.00398	< 0.00408
methoxychlor	< 2.04	< 1.95 UJ	< 1.96	< 1.96	< 2.05	< 1.99	< 2.02	< 2	< 2.15
toxaphene	< 0.0962	< 0.0917	< 0.101	< 0.0972	< 0.0992	< 0.0989	< 0.101	< 0.0996	< 0.102
Polychlorinated Biphenyls (mg/kg)									
Aroclor 1016	< 0.0198	< 0.0195	< 0.0202	< 0.0197	< 0.02	< 0.0195	< 0.02	< 0.0202	< 0.0214
Aroclor 1221	< 0.0198	< 0.0195	< 0.0202	< 0.0197	< 0.02	< 0.0195	< 0.02	< 0.0202	< 0.0214
Aroclor 1232	< 0.0198	< 0.0195	< 0.0202	< 0.0197	< 0.02	< 0.0195	< 0.02	< 0.0202	< 0.0214
Aroclor 1242	< 0.0198	< 0.0195	< 0.0202	< 0.0197	< 0.02	< 0.0195	< 0.02	< 0.0202	< 0.0214
Aroclor 1248	< 0.0198	< 0.0195	< 0.0202	< 0.0197	< 0.02	< 0.0195	< 0.02	< 0.0202	< 0.0214
Aroclor 1254	< 0.0198	< 0.0195	< 0.0202	< 0.0197	< 0.02	< 0.0195	< 0.02	< 0.0202	< 0.0214
Aroclor 1260	0.0128 J	0.02	< 0.0202	0.0269	0.0417	0.0716	0.0338	0.0291	< 0.0214

Notes:

Key to Sample IDs: first two letters indicate the stream from which the sample was collected, second two letters indicate the species:

CC = Cherokee Creek   BB = brown bullhead catfish   WS = white sucker

PR = Pacolet River   SF = sunfish   CO = *Corbicula* (clam)

Shading indicates a detected concentration.

< indicates the chemical was not detected -- the value shown is the reporting limit.

Data Flag Definitions:

J - the reported result is an estimated value (e.g., matrix interference observed or concentration outside the quantitation range).

UJ - The analyte was not detected above the reported sample quantitation limit. However, the reported quantitation limit is approximate and may or may not represent the actual limit of quantitation necessary to accurately and precisely measure the analyte in the sample.

Table 2-7
Summary of Benthic Macroinvertebrate Community Bioassessment*
Aquatic Ecosystem Study
Auriga/Former CNA Facility, Spartanburg, South Carolina

Metrics	Cherokee Creek								Pacolet River				
	Background		Downstream Locations						Background		Downstream Locations		
	CC-8	CC-7	CC-6	CC-5	CC-4	CC-3	CC-2	CC-1	IC-1	PR-4	PR-3	PR-2	PR-1
EPT Index	11	14	12	15	8	9	4	2	21	2	7	8	9
Biotic Index	5.41	5.34	5.02	5.17	4.68	6.07	5.96	7.11	5.6	6.37	6.47	5.67	6.86
EPT Index score	2	2.4	2	2.4	1.6	1.6	1	1	3	1	1.4	1.6	1.6
Biotic Index score	4	4	5	4.6	4	3	3	2	4	3	2.6	4	2
Combined (mean) bioclassification score	3	3.2	3.5	3.5	2.8	2.3	2	1.5	3.5	2	2	2.8	1.8
	Comparison to background location CC-7								**Comparison to background location IC-1**				
Background score minus combined score	0.2	--	-0.3	-0.3	0.4	0.9	1.2	1.7	--	1.5	1.5	0.7	1.7
Level of impairment vs. background	none	--	none	none	none	slight	slight	moderate	--	slight	slight	slight	moderate
	Comparison to background location CC-8								**Comparison to background location PR-4**				
Background score minus combined score	--	-0.2	-0.5	-0.5	0.2	0.7	1	1.5	-1.5	--	0	-0.8	0.2
Level of impairment vs. background	--	none	none	none	none	slight	slight	moderate	none	--	none	none	none
Bioclassification													
Bioclassification category	good-fair	good-fair	good	good	good-fair	fair	fair	poor	good	fair	fair	good-fair	fair
Aquatic life use support category	partially	partially	fully	fully	partially	partially	partially	not	fully	partially	partially	partially	partially

Note:
* Appendix A provides: supporting data; methods used in calculating indices and scores; and the basis for assigning levels of impairment, bioclassification categories, and aquatic life use support categories.

APPENDIX A

PHOTOGRAPHS OF FISH AND CLAMS COLLECTED

Photo 1: Asiatic clam

Photo 2: Brown bullhead catfish

Photo 3: Sunfish

Photo 4: White suckers

APPENDIX B

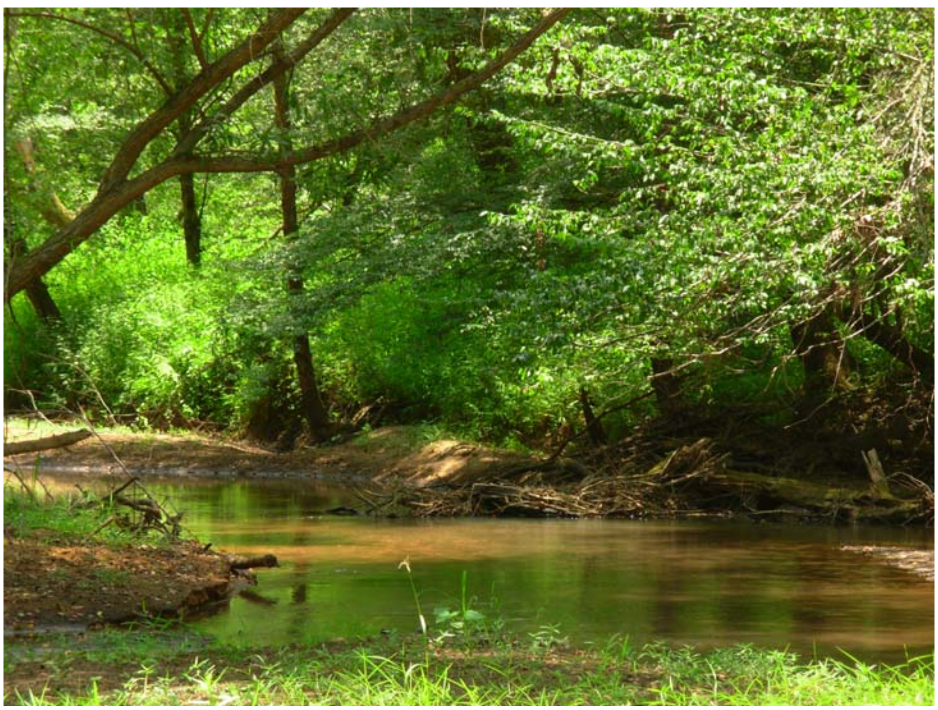
MACROINVERTEBRATE STREAM ASSESSMENT: CHEROKEE CREEK, ISLAND CREEK, AND THE PACOLET RIVER

ETT environmental, Inc.
(864) 877-6942 . FAX (864) 877-6938
P.O. Box 16414, Greenville, SC 29606
Craftsman Court, Greer, SC 29650

MACROINVERTEBRATE STREAM ASSESSMENT:
CHEROKEE CREEK, ISLAND CREEK,
AND THE PACOLET RIVER

Conducted for AECOM

At AURIGA Site in Spartanburg County, SC



DRAFT

CONFIDENTIAL

October 2012

ETT State Certification # 23104

TABLE OF CONTENTS

Page #

1.0 EXECUTIVE SUMMARY

An in-stream aquatic macroinvertebrate assessment of Cherokee Creek, Island Creek, and the Pacolet River was conducted by ETT Environmental, Inc. and AECOM on July 23-25, 2012. A timed, qualitative, multiple habitat sampling protocol was used. A benthic biologist supervised the sampling by two HAZWOPER trained, AECOM field personnel. Aquatic macroinvertebrates were identified to the lowest practical taxonomic level and data were analyzed using the EPT index, the Biotic Index, and other biological metrics.

Cherokee Creek was sampled at several sites, from immediately upstream from the railroad bridge (north-northwest of the Auriga site) to the confluence with the Pacolet River. The EPT index ranged from two species at Site CC-1 to 15 species at Site CC-5. The Biotic Index ranged from 4.68 at Site CC-4 to 7.11 at Site CC-1. (Better water/habitat quality generally is indicated by a higher EPT Index or a lower Biotic Index.) In the most downstream section of the creek the habitat was an important factor. Unlike the rocky, lotic (flowing) habitat upstream, downstream sites CC-1 and CC-2 were characterized by lentic (stagnant flow) conditions. Such conditions have a profound effect on the biological metrics.

Island Creek was sampled near the point of confluence with the Pacolet River. At this site the EPT Index was 21 species and the Biotic Index was 5.60.

The Pacolet River flows from the Lake Blalock dam upstream. At the upstream control site for this study (PR-4), immediately upstream from the confluence with Cherokee Creek, the flow is slowed by a natural bedrock feature which partially dams the river. The result is a river section with lentic conditions and very slow flow. In addition the water is deep, with very little snag habitat or near surface rock outcrops. The EPT index ranged from two species at Site PR-4 to nine species at Site PR-1. The Biotic Index ranged from 5.67 at Site PR-2 to 6.86 at Site PR-1.

2.0 INTRODUCTION

An in-stream aquatic macroinvertebrate assessment of Cherokee Creek, Island, Creek, and the Pacolet River was conducted by ETT Environmental, Inc. and AECOM on July 23-25, 2012. A timed, qualitative, multiple habitat sampling protocol was used. A benthic biologist supervised the sampling by two AECOM field personnel. Aquatic macroinvertebrates were identified to the lowest practical taxonomic level and data were analyzed using the EPT index, the Biotic Index, and other biological metrics.

3.0 SAMPLING SITES

Maps of the sampling sites are included as Figures 1 and 2. A description of the site locations is provided below:

Cherokee Creek

Site CC-8:	300 ft upstream from Railroad Bridge
Site CC-7:	100 ft downstream from Railroad Bridge
Site CC-6:	immediately upstream from Outfall 001 drainage
Site CC-5:	midpoint between Railroad Bridge and Outfall 001 drainage
Site CC-4:	300 ft downstream from Outfall 001 drainage
Site CC-3:	midpoint between Outfall 010 drainage and Outfall 001 drainage
Site CC-2:	300 ft downstream from Outfall 010 drainage
Site CC-1:	immediately upstream from confluence with Pacolet River

Island Creek

Site IC-1:	immediately upstream from confluence with Pacolet River

Pacolet River

Site PR-4:	immediately upstream from confluence with Cherokee Creek
Site PR-3:	200 ft downstream from confluence with Cherokee Creek
Site PR-2:	midpoint between PR-1 and PR-3
Site PR-1:	immediately downstream from Outfall 002 drainage

Figure 1. Cherokee Creek Sites
Auriga Site, Spartanburg County, SC

Sites on Cherokee Creek

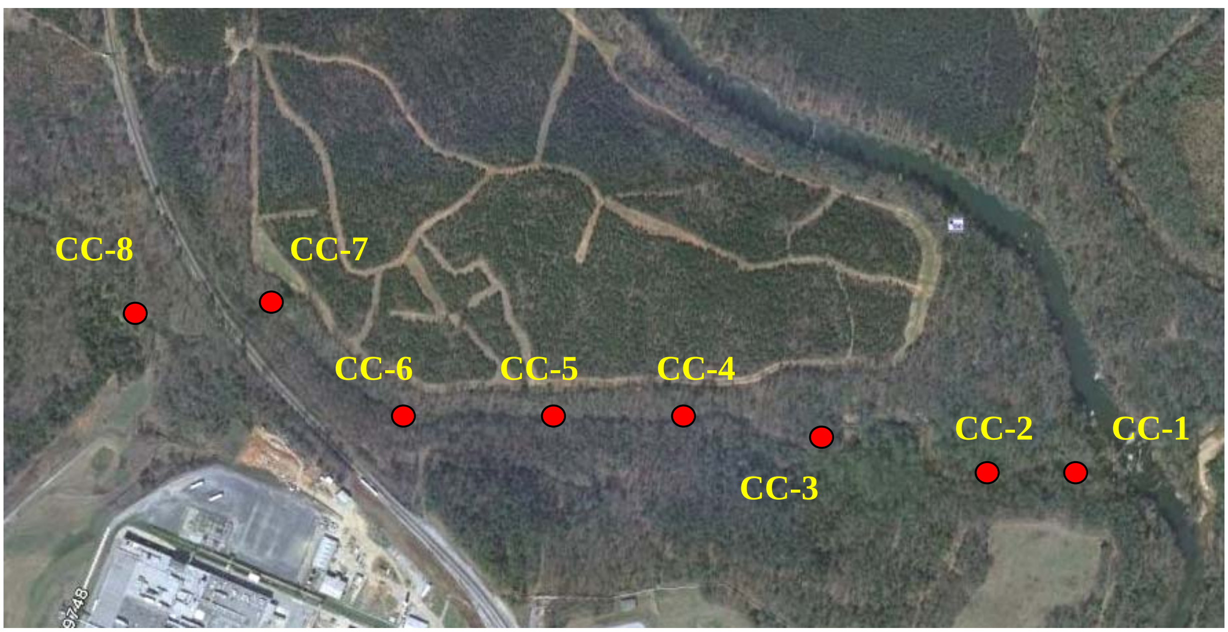
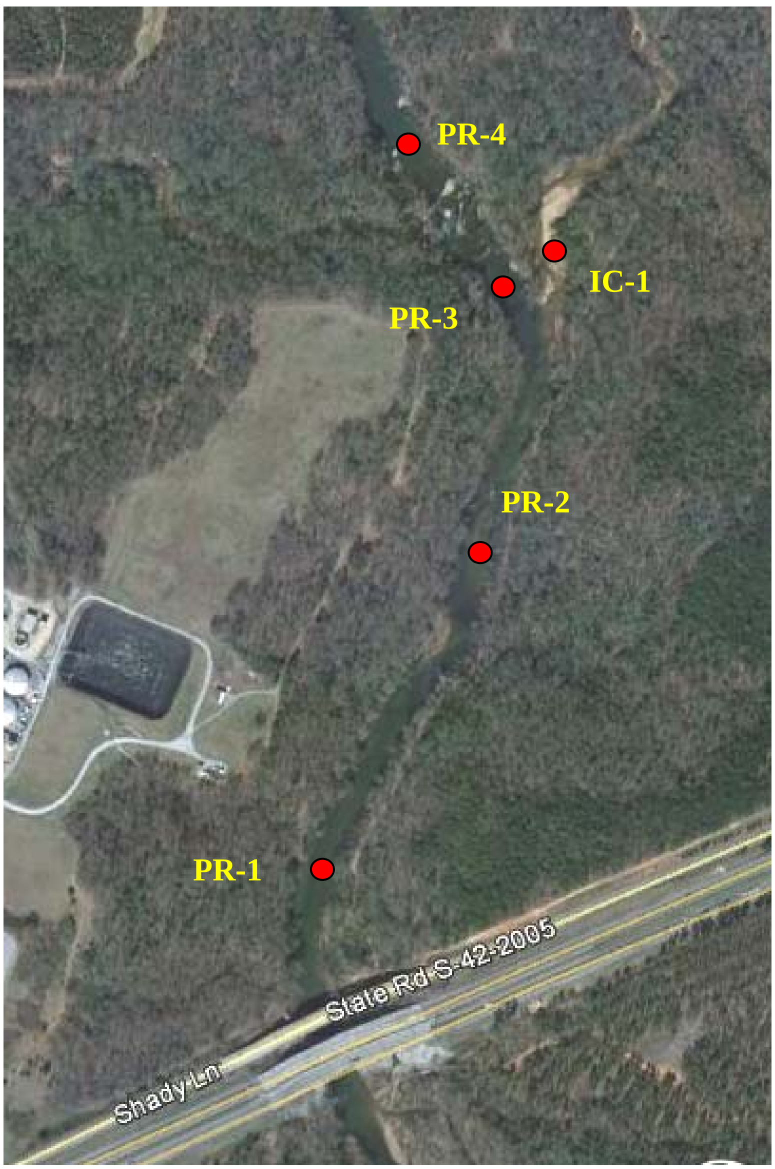


Figure 2. Island Creek and Pacolet River Sites
Auriga Site, Spartanburg County, SC

Sites on Pacolet River and Island Creek



4.0 METHODS

4.1 Sample Collection

4.1.1 *Qualitative Methods* (*Timed Qualitative Multiple-Habitat Sampling Protocol*)

Sampling was conducted using the SCDHEC timed qualitative multiple-habitat sampling protocol (MHSP) (SCDHEC 1998). At each sampling site, a team of two biologists sampled for approximately 2 man-hours (with an additional 1 hour of laboratory sorting). The goal of the sampling team was to collect as many different macroinvertebrate taxa as possible during the allotted time.

Samples were collected by using a D-frame dipnet, kicknet, and hand-sieve in all available habitats. Macroinvertebrates were collected directly from the habitat with forceps. Habitats included 1) snag habitats, such as sticks and leaves caught in fast current, and material scraped from the surfaces of submerged rocks and logs, and 2) coarse particulate organic matter samples, comprised of mud, sand, leaf packs, roots, and black organic ooze collected by dip net from depositional areas of the stream and dipnet sweeps from undercut banks. Samples were sieved in the field to remove mud and silt. All macroinvertebrates were placed in containers filled with 85% ethanol (EtOH) and labeled with the site, collector, and collection date. ETT methodology strives to obtain greater diversity and numbers of midges by returning stream samples to the laboratory for sorting. For samples sorted at the laboratory a 500 mL and a 250 mL container of benthic substrate were preserved with ethanol. For taxa which could be identified in the field, only 10-15 specimens needed to be collected.

Multiple habitat sampling of some type is widely used by many regulatory agencies and commercial laboratories in the United States. The greatest benefit from using the MHSP is that it enables benthic biologists to collect representative macroinvertebrate taxa from the wide variety of natural habitats in a stream. Since macroinvertebrates occupy all habitat types, many taxa may not be collected when selected habitats are sampled by specific sampling devices (e.g. Surber net, Ponar dredge, etc.). This can lead to exclusion of a variety of taxa and inaccurate water quality assessments.

Midge and Small Macroinvertebrate Collection Procedure

An important component of the macroinvertebrate community is the midge family, Chironomidae. Midges generally account for at least 50% of the total species diversity in most systems. Since midges are relatively small, they are collected with fine mesh samplers. The fine mesh samplers are made with micro-screen cloth material that has a mesh size of 300 micron. Although the objective of the fine mesh net is to collect midges, it can also collect other small macroinvertebrates.

Collection Steps:

1. A 12.0 liter bucket with fine mesh screen bottom filled to approximate one half full with water.
2. Two or three samples of all the habitat types present at a stream site collected by hand (rocks, sticks, leaf packs, root banks, etc.) and rinse in the bucket to remove midges and other macroinvertebrates. Attached root banks (wads) and vegetation rinsed directly in the bucket without detachment.
3. Since some midge taxa are sand dwellers, a sandy bottom site in the stream is selected and midges collected by placing the small mesh bag on the bottom with the open end facing upstream. Approximately a 1.0 m^2 area of the sand upstream of the bag disturbed and the sand and midges allowed to drift into the bag. Three sand samples from three different areas of the stream collected. The bag is only used when there are sandy bottom areas available. **No sandy bottom areas were present in this study (although silt substrate was sampled).**
4. The contents of the bag were to be emptied into the same bucket of water that contained the other habitat washes and the bag was moved up and down in the bucket to remove the attached midges.
5. As much of the larger debris as possible was rinsed and removed by hand from the bucket and discarded. Water in the bucket was stirred and strained through the micro-screen cloth covered pipe.
6. Small portions of the detritus left in the bottom of the micro-screen container were removed and placed in a white pan 1/4 filled with water. The detritus was spread evenly in the pan by hand so that the macroinvertebrates could be seen against the white background. With the aid of forceps, the midges were collected, as well as other small macroinvertebrates and preserved them in a container with 85% EtOH.
7. Step 6 repeated until all the detritus in the micro-screen cloth pipe was examined.

No more than 100 midges were collected in the field, but they were collected in relative proportion to the size classes present. Other macroinvertebrates were sampled proportional to the relative abundance in each pan picked. Although the emphasis of the fine mesh sampler is to collect small macroinvertebrates, larger macroinvertebrates were collected as they were encountered.

D-frame Dip Net Collection Procedure

The habitat type most often sampled with the dip net is root bank habitat. Root banks are usually present at all stream sites and they support a variety of small caddisflies and other taxa. Aquatic vegetation, when present, also was sampled with the dip net.

Collection Steps:

1. Root banks were sampled by repeatedly jabbing a D-frame dip net (500 micron mesh size) into the root wads along a stretch of bank until the net was about 1/4 full of detritus and root debris. Several root wads were washed down by hand into the dip net to remove firmly attached macroinvertebrates. Aquatic vegetation was sampled by sweeping the dip net through the vegetation two or three times.
2. The bottom of the dip net was rinsed in the stream to remove excess mud and silt. Small portions of the detritus were removed from the net and spread them evenly in a white pan 1/4 filled with water.
3. Using forceps, macroinvertebrates were removed from the pan and place in jar of 85% EtOH.

Based on the quality of the root banks and/or aquatic vegetation, one or two dip net samples were collected in the root banks and two or three samples in the aquatic vegetation.

Kick Net Collection Procedure

The kick net is a 1.0 m^2 sheet of micro-screen cloth (500 micron mesh size) attached on two sides to 1.5 m long poles. The kick net is used to sample rock/gravel riffles and snags/leaf packs.

Collection Steps:

1. The kick net is placed slightly downstream of the area to be sampled (snags/leaf packs and/or rock/gravel riffle). About 1.0 m^2 of the habitat is disturbed and the debris and macroinvertebrates that drift are caught into the net.
2. The kick net is spread out on a sand bar or a flat area on the bank and macroinvertebrates are collected from the net with forceps and preserved in a jar of 85% EtOH.

If the habitat is mostly snags/leaf packs, a minimum of two kick net samples were taken. If the habitat is a mix of both rock/gravel riffle and snags/leaf packs, a minimum of one kick net sample was taken from each habitat. In streams that are mostly rock/gravel riffle, a minimum of two kick net samples were taken in the riffle areas. One kick net sample was taken from a high velocity riffle area and the other was taken from a low velocity riffle area.

Hand Sieve Collection Procedure

Hand sieves are used to sample all habitat types and are also used during visual collections. Hand sieve sizes used are the U.S. #30 (0.6 mm openings) and the U.S. #10 (2.0 mm openings). The #10 sieve is used primarily in the sand while the #30 is used on all habitat types. The hand sieve enables the biologist to sample large amounts of habitat quickly and is invaluable for collecting sediment-dwelling taxa such as: Odonata (dragonflies), Gastropoda (snails), Pelecypoda (clams, mussels), Polycentropodidae (burrowing caddisflies), sand case building and burrowing caddisflies (Molannidae, Sericostomadidae, Dipseudopsidae, Odontoceridae), and Ephemeridae (burrowing mayflies). The hand sieve can be used effectively in the same habitat types that are sampled with the dip net and kick net.

Collection Steps:

1. The sand and mud for was visually inspected for signs of macroinvertebrate activity. For example, the movement of burrowing odonates and mussels leaves trails in the sand. Small holes can be seen in the mud, clay, or sand in areas where burrowing mayflies are found. The tubes of *Phylocentropus* sp. larvae can be seen extending above the substrate when they are present.
2. With either the #30 sieve, the mud or sand were sampled where there were signs of macroinvertebrate activity. The excess sand, mud, silt, and detritus were sieved in the stream to trap macroinvertebrates in the sieve.
3. Macroinvertebrates were collected from the sieve and placed in jar of 85% EtOH.
4. With the #30 sieve, root bank and snag sites were sampled and processed as above.

Visual Collection Procedure

The collection procedure described above is the minimum sampling effort conducted at each stream site. For an additional 1.5 man-hours, stream habitats were visually searched for macroinvertebrates, and collected directly from the habitat with forceps and placed in jars filled with 85% EtOH. For example, rocks and logs were searched for taxa such as the retreat building *Psychomyia* sp. (caddisfly) and for retreat building Hydropsychidae. The undersides of rocks were examined for macroinvertebrates such as Ephemeroptera (mayflies), Plecoptera (stoneflies), Gastropoda (snails), Psephenidae (water pennies) and Megaloptera (hellgrammites). The crevices in rocks and logs were searched for caddisflies such as *Nyctiophylax* sp., *Pycnopsyche* sp., and *Ceraclea* sp. Decaying logs are picked apart to reveal midges and other taxa. Aquatic vegetation, sticks, and limbs were visually searched for small caddisflies (Hydroptilidae and Brachycentridae) and other macroinvertebrates. Mature leaf packs, snags, and root banks were sampled with a #30 sieve to collect a variety of other macroinvertebrates.

Qualitative Collection Procedures Summary

No attempt was made to collect all specimens encountered. If a taxon could be reliably identified in the field, only 10-15 specimens were collected, other taxa were collected in approximate proportion to their abundance in each sampling method (net, pan, sieve, etc.). Since the emphasis of the MHSP method is to collect different taxa, abundance is considered only in a relative sense (see Data Analysis). Some taxa were not collected including: Nematoda, Collembola, semiaquatic Coleoptera, and most Hemiptera except Naucoridae, Belostomatidae, Corixidae, and Nepidae. These are not collected because they are most often found on the water surface or on the banks, and are not truly benthic.

There was no established distance of stream reach sampled at any particular site, but approximately 100 m of stream (both sides) was sampled.

Qualitative sampling methods were conformed to SCDHEC methodology except that some of the collected substrate and macroinvertebrates were returned to the laboratory for processing and sorting (rather than being done in the field).

Each detritus sample returned to the laboratory was sieved through a 600 µm mesh in the field and fixed with 70% ethanol. Fixed samples were placed in 500 ml plastic containers, labeled by site, date, collector and sample type and returned to the laboratory. Sampling information was recorded in a bound field book, including the date, sampling team, time of collection, descriptions of the site and habitat, and water quality measurements ([D.O.], pH, temperature, and conductivity). Dissolved oxygen and pH meters were calibrated in the field. A Chain of Custody Sheet was completed by the field team and returned to the laboratory with the samples.

4.2 Sample Receipt

Upon return to the laboratory, all samples were assigned a unique sample identification number and logged into the sample receipt log. A chain of custody was prepared and the log-in technician signed the Chain of Custody Sheet to receive the samples and recorded the sample numbers on the sample containers and the Chain of Custody Sheet.

4.3 Sample Processing

Each sample was divided into approximately 100-ml portions and backwashed with tap water in a U.S. Standard #30 mesh (600 µm) sieve to remove small particles/turbidity. Rinsed portions were placed in white trays and covered with 2 cm of water. Macroinvertebrates were removed with forceps and were placed with the macroinvertebrates collected in the field in ethanol in labeled vials. Sample debris was retained for a second (quality control) sorting of 10% of the samples by a second biologist.

4.4 Taxonomic Identification

Sorted macroinvertebrates were transferred to a glass petri dish containing 70% ethanol and examined under a Meiji dissecting microscope (15X-67.5X magnification) illuminated with a fiber optic light source. Macroinvertebrates were identified to the lowest possible taxonomic level using appropriate taxonomic references. Midges which could not be identified under the dissecting microscope were mounted on slides and were then identified with the use of an Meiji MX4300L Compound Microscope at 400X power. CMC-10 was used as a mounting medium.

General references used for taxonomic identification included the following:

Brigham et al. (1982): Used for species identifications for some families of Ephemeroptera, Odonata, Plecoptera, Megaloptera, Heteroptera, Trichoptera, Coleoptera.

Merritt & Cummins (4th Ed.): Used for generic identifications of Odonata, Coleoptera, Diptera (excluding midges).

Needham, Westfall, May (2000): Used for species identifications of dragonflies.

Epler - NCDENR (2001): Used for generic identifications of midges.

Pennak/Smith (2001). 4th ed.: Used for generic identifications of mollusks, annelids and crustacea.

Numerous other specific references were used for appropriate species identifications. All identifications were recorded on Aquatic Fauna bench sheets by site, collection date, and sample identification number.

4.5 Data Analysis

4.5.1 Calculation of Biological Metrics

A list of species, with the number of organisms of each species collected at each site, was compiled from the bench sheets. These data were used to calculate a series of biological metrics (parameters). Metrics included taxa richness, numbers of organisms collected, the EPT Index, and the Biotic Index as per SCDHEC protocols (SCDHEC 1998. The metrics used to give an assessment of the stream condition at each site are outlined below and their values are provided in Table III:

Metric 1. TAXA RICHNESS

The total number of species collected at a site. Unimpacted sites are typically characterized by large numbers of species (>50), with 30-40 species characteristic of slightly impacted sites, 20-30 species at moderately impacted sites and less than 20 species at severely degraded sites.

Metric 2. TOTAL NUMBER OF ORGANISMS PER SITE

The total number of individual organisms of all taxa combined that are collected at a site. The MHSP is a qualitative sampling procedure, so the number of organisms collected is not intended to provide a quantitative evaluation of abundance. However, this number provides a general indication of the relative numbers of organisms collected as a result of a similar level of sampling effort at each site.

Metric 3. EPT INDEX

The EPT index is the total number of species in the aquatic insect orders Ephemeroptera (E), Plecoptera (P) and Trichoptera (T), which are generally more intolerant to pollution than other groups of aquatic insects. A high EPT index indicative of excellent water quality can exceed 20 species. A degraded site may support fewer than 5 species of these orders of insects. Lentic (lake, pond, swamp) habitats do not support many EPT species due to the slow water velocity. SCDHEC ratings for EPT values in the piedmont ecoregion, in which the study area streams are located, were used to determine the scoring of each site for this metric. An EPT score was assigned based on the EPT index value using a table provided by SCDHEC that assigns a score (from 1 through 5) to EPT index values depending on which of 13 numerical brackets they fall into (ranging from 0 to >33 for the Piedmont ecoregion).

Metric 4. BIOTIC INDEX

Aquatic macroinvertebrates differ in their tolerance to degraded water quality conditions. Hilsenhoff (1987) assigned an organic pollution tolerance rating to many species of aquatic insects using a 0 - 10 scale. Low tolerance values correspond to pollution intolerance and high tolerance ratings are assigned to very tolerant species. The tolerance ratings used by Hilsenhoff were assigned based upon data from tolerance to organic pollution in northern streams. A parallel list of tolerance ratings has been developed for the southeastern United States by the North Carolina Department of Environmental Management (NCDEM). In this study the NCDEM tolerance ratings were used.

The biotic index is calculated by multiplying the abundance (number of organisms) of each species by the tolerance value for that species, summing the products of the tolerance values and abundance values for each species, and dividing by the total number of organisms.

$$\text{Biotic Index} = (\sum TV_i N_i) / \text{Total N}$$

TV_i = i^{th} taxon tolerance value

N_i = i^{th} taxon abundance

Total N = total number of organisms

SCDHEC ratings for Biotic Index values in the piedmont ecoregion, were used to determine the scoring of each site for this metric. To determine the abundance values per SCDHEC protocols, each species was designated as rare (1-2 individuals), common (3-9 individuals), or abundant (10 or more individuals), and assigned a corresponding abundance value of 1, 3, or 10, respectively. Thus, the Biotic Index calculation does not include all specimens collected but rather a maximum of 10 specimens per species (to reduce the potential for the index to be biased because some species are more successfully collected than others) (SCDHEC 1998).

4.5.2 Calculation of Bioclassification Score and Aquatic Life Use Status

Each site was independently assessed using the SCDHEC bioclassification system (lower portion of Table III). In accordance with SCDHEC protocols, the EPT Index and Biotic Index for each site were assigned scores as described above based on their calculated value for the Piedmont region. An average was then taken of the two scores to give a combined score for use in determining the final bioclassification for the site. The SCDHEC system used in this study classifies sites based on their combined score into bioclassification categories according to the protocol below. The bioclassification is then used to determine the site's level of support of aquatic life as represented in this study by the benthic macroinvertebrate community (SCDHEC 1998).

Score	Bioclassification	Aquatic Life Use Support
>4.5	excellent	fully supporting
3.5-4.5	good	fully supporting
2.5-3.5	good-fair	partially supporting
1.5-2.5	fair	partially supporting
<1.5	poor	not supporting

SCDHEC (1998) describes the three categories of aquatic life use support as follows:

Fully supporting: Reliable data indicate functioning, sustainable biological assemblages (e.g., macroinvertebrates) none of which has been modified significantly beyond the natural range of the reference condition.

Partially supporting: At least one assemblage indicates moderate modification of the biological community as compared to the reference condition.

Not supporting: At least one assemblage indicates a severely impacted macroinvertebrate community. Data clearly indicate severe modification of the biological community compared to the reference condition.

In addition to using the bioclassification score (mean of the EPT score and Biotic Index score) to determine a bioclassification and corresponding ability of the habitat to support aquatic life, the bioclassification score also can be used to categorize the level of impairment at a site by comparing its benthic macroinvertebrate community to an upstream control/reference site. In this study, Pacolet River Sites PR-3, PR-2, and PR-1 were compared to upstream site PR-4, and Cherokee River Sites CC-1 through CC-6 were compared to upstream site CC-7. In accordance with the SCDHEC protocol (SCDHEC 1998), this comparison was performed by subtracting the mean bioclassification score at the upstream reference site from the score at each downstream site on the same stream. The decrease in bioclassification score (calculated in the lower portion of Table III) was converted to a level of impairment based on the following protocol:

Decrease in Bioclassification Score	Level of Impairment
≤ 0.4	None (unimpaired)
0.6-1.4	Slightly impaired
1.6-2.4	Moderately impaired
≥ 2.6	Severely impaired

The results of this evaluation of the level of impairment of the benthic macroinvertebrate community at each site based on comparison to a reference site are provided in the lower portion of Table III.

4.5.3 Additional Metrics

In addition to the metrics discussed above, other metrics from among those listed in the USEPA Rapid Bioassessment Protocol (Plafkin et al., 1989; Barbour et al., 1999) also were calculated from the macroinvertebrate data collected at each site. These metrics include the EPT/chironomid ratio, scraper/filterer ratio, % dominant taxon, proportion of shredders, and community loss index (Table IV). Also, the percentage of each major taxonomic group in the macroinvertebrate community was calculated, and a functional feeding group analysis calculated the percentage of the five major trophic groups in the macroinvertebrate community at each site (Table IV). These metrics provide information that may be useful in characterizing the benthic invertebrate community at each site and comparing sites.

Metric 5. RATIO OF EPT AND CHIRONOMIDAE ABUNDANCES

Chironomidae (midges) generally comprise up to 50% of the organisms present in southeastern streams. In unpolluted streams, the intolerant insect orders Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies) are also well represented in the community. A stressed waterway will typically support few species of mayflies, stoneflies and caddisflies, with a dominance by midges. Ratios are shown for each site in Table IV.

Metric 6. RATIOS OF SCRAPERS TO COLLECTOR-FILTERERS

Aquatic insects have been categorized according to feeding strategy by Merritt & Cummins (1984) into six primary groups: collector-gatherers, collector-filterers, predators, scrapers, shredder-detritivores, and shredder-herbivores. Collector-filterers strain fine particulate organic matter (FPOM; e.g., diatoms) from the water column. Scrapers graze on periphyton on the surfaces of submerged plants, detritus, rocks, and logs. Nutrient enrichment tends to increase FPOM and filamentous algae, which in turn supports a higher proportion of filterers. Streams without nutrient enrichment tend to have a higher proportion of scrapers. Ratios are shown for each site in Table IV.

Metric 7. PERCENT CONTRIBUTION BY DOMINANT TAXON

An unimpacted stream is characterized by many species of aquatic macroinvertebrates with only a few representatives of each species. When water quality has been degraded by organic loading, intolerant species die or drift downstream to areas of superior water quality. The consequent reduction in competition for habitat along with an abundant organic food supply allows more tolerant species to multiply in population and dominate the system. Often a single dominant genus, such as *Chironomus*, will become particularly abundant. Percentages are shown for each site in Table IV.

Metric 8. RATIO OF SHREDDERS TO TOTAL NUMBER OF ORGANISMS COLLECTED

Shredders (herbivores and detritivores) consume coarse particulate organic matter (CPOM) in the form of aquatic vegetation (e.g., filamentous algae, grasses) as well as leaves and woody materials that naturally enter the stream from the riparian (terrestrial) zone. If toxicants are associated with this CPOM, they may have a disproportionate impact on shredders and can reduce this portion of the community. In contrast, nutrient loading of the stream water typically stimulates growth of vegetation and, therefore, provides a greater availability of this food source. Ratios are shown for each site in Table IV.

Metric 9. COMMUNITY LOSS INDEX

Calculation of the community loss index can provide an indication of the degree of similarity of the benthic invertebrate communities at different sites. Similarity is calculated by subtracting the number of species common to two sites (upstream reference and downstream) from the number of species at the reference site and dividing by the number of species at the downstream site. A value close to zero indicates similar communities at both sites, whereas higher index values indicate greater dissimilarity between communities at the two sites. Index values are shown for each site in Table IV.

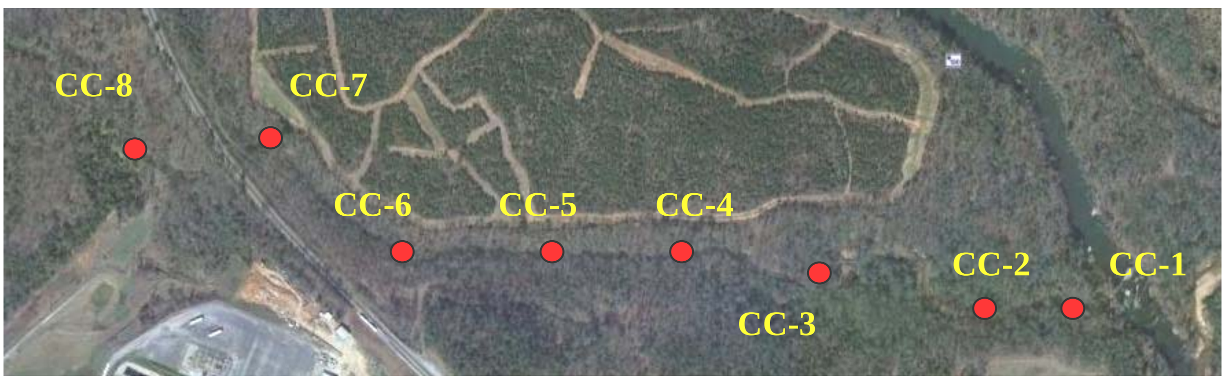
Metric 10. FUNCTIONAL FEEDING GROUP ANALYSIS

Analysis of the functional feeding groups within the benthic invertebrate community provides information on the balance of feeding strategies and adaptations represented. Stressed conditions may result in relatively unstable food dynamics and an imbalance in functional feeding groups, though the usefulness of these measures has not been well demonstrated (Barbour et al., 1999). Generally, specialized feeders such as scrapers and shredders are thought to be more sensitive and better represented in healthy streams, while generalists such as gatherers have a broader range of acceptable food materials and thus are more tolerant of stressors that might alter the availability of certain foods (Barbour et al., 1999).

5.0 RESULTS

A list of the species collected at each site, along with the number of organisms of each species collected at each site, is provided in Table I. Percentages of organisms by major taxonomic group are presented in Table II. The numbers of taxa and organisms collected at each site, the EPT index and score, and the Biotic Index and score are provided in Table III. In addition, Table III provides for each site the results of the bioclassification of the sites and the assessment of their support of aquatic life use, and it provides for the downstream sites an assessment of their level of impairment relative to a reference site. Analysis of the functional feeding groups at each site are provided for each stream in Table IV.

5.1 Cherokee Creek



The results of the aquatic macroinvertebrate assessment of Cherokee Creek may be referenced to the maps above and are summarized as follows:

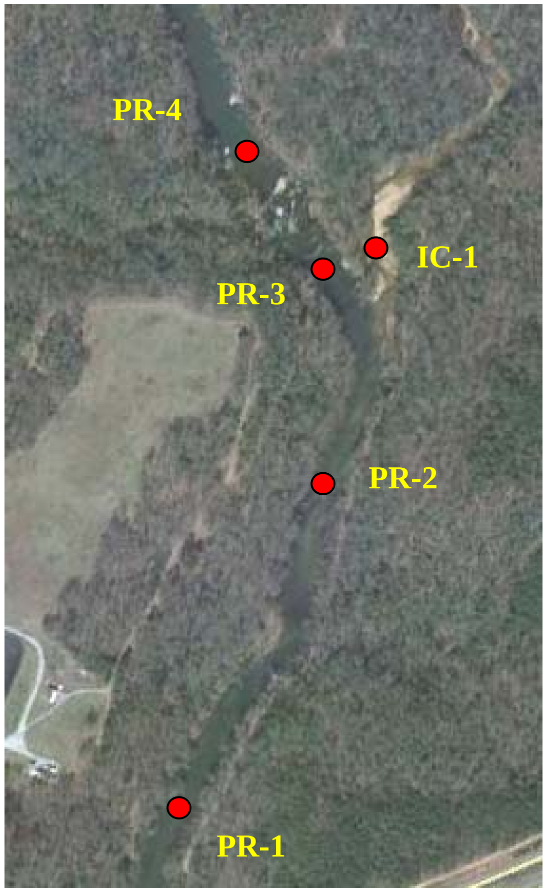
Site	EPT Index	Biotic Index	Bioclassification Score
CC-8	11	5.41	3.0
CC-7	14	5.34	3.2
CC-6	12	5.02	3.5
CC-5	15	5.17	3.5
CC-4	8	4.68	2.8
CC-3	9	6.07	2.3
CC-2	4	5.96	2.0
CC-1	2	7.11	1.5

In the upstream reaches of Cherokee Creek (CC-8, CC-7, CC-6, CC-5), the EPT index ranged from 11-15 species. The biotic index ranged from 5.02 to 5.41. The trend toward higher biotic index values at CC-7 and CC-8 is a function of larger populations of the hydropsychid caddisflies *Cheumatopsyche sp.* and *Hydropsyche betteni.* Both of these taxa have relatively high tolerance ratings, which skews the biotic index higher. It should be noted that hydropsychid caddisflies are filterers and require a relatively high water velocity. Therefore, the prevalence of these species at sites CC-7 and CC-8 may reflect the habitat. Stoneflies were largely absent from this stretch of the creek, with only a single specimen of a perlid stonefly found at CC-7. Among the mayflies, the baetid mayfly *Baetis pluto,* the isonychiid mayfly *Isonychia sp.*, the heptageniid mayflies *Heptagenia nr. flavescens* and *Maccaffertium modestum ,* and the leptohyphid mayfly *Tricorythodes sp.* were found at all these sites in the upstream reaches. *Baetis flavigastra* was found at sites CC-5, CC-6, and CC-7 but not at Site CC-8. The mayfly *Maccaffertium modestum* is widespread in upstate South Carolina and quite tolerant of degraded water quality. However, *Heptagenia nr. flavescens* tends to be found only in streams of very good water quality. The only abundant caddisflies in these upstream reaches of the creek were hydropsychids (*Cheumatopsyche sp., Hydropsyche betteni),* and *Chimarra aterrima,* all of which inhabit rocky substrate. These two species of hydropsychids are quite tolerant of degraded water quality, although *Chimarra aterrima* is not as tolerant. Elmid beetles and hellgrammites also were abundant in this section of the stream.

A lower EPT index and higher biotic index was noted at CC-4. The EPT index was 8 species. The biotic index was 4.68. At Site CC-3 the bioclassification rating was 2.3, the lower value being due largely to an increase in the biotic index.

Sites CC-2 and CC-1 were characterized by poor habitat, which would be expected to be reflected in the aquatic macroinvertebrate community. At site CC-2 hard clay benthic substrate with a lack of snag habitat was noted, along with slow water velocity. At site CC-1 there was little gradient to the stream and the water column was largely stagnant. The bioclassification score was 2.0 at Site CC-2 and 1.5 at Site CC-1. Much of the poor bioclassification may be attributable to habitat. Hydropsychid caddisflies (which require strong water velocity) were absent. Baetid, heptageniid, and isonychiid mayflies were all sparse, as were elmid beetles.

5.2 Island Creek and Pacolet River



The results of the aquatic macroinvertebrate assessment of Island Creek and the Pacolet River may be referenced to the maps above and are summarized as follows:

Site	EPT Index	Biotic Index	Bioclassification Score / Rating
IC-1	21	5.60	3.5
PR-4	2	6.37	2.0
PR-3	7	6.47	2.0
PR-2	8	5.67	2.8
PR-1	9	6.86	1.8

Island Creek showed a bioclassification score of 3.5. A total of 21 EPT species were collected at this site. This included 12 species of mayflies, three species of stoneflies, and six species of caddisflies. Mayfly species included six baetid species, isonychiids, ephemerellids, heptageniids, and leptohyphids. Stoneflies included two species of perlids and *Tallaperla sp.* In addition to the common hydropsychid caddisflies, other caddisfly species included leptocerids, limnephilids, and philopotamids. Several of the EPT species are indicative of excellent water quality. The biotic index was a little higher than might be expected based on the EPT index. This appears to be a function of large populations of the hydropsychid caddisflies *Cheumatopsyche sp.* and *Hydropsyche betteni,* which have high tolerance ratings.

Although rocky substrate was abundant in the Pacolet River, snag habitat (which tends to support a variety of aquatic macroinvertebrates) was sparse.

The upstream site on the Pacolet River (PR-4) is upstream from a natural bedrock dam, which results in the site being a lentic habitat with very slow flow. In addition to the slow flow factor, the river is deep at this site, with very little accessible benthic habitat. As a result, the habitat at the site strongly impacts the bioclassification. The bioclassification rating of the site is 2.0. Two EPT species were present; the mayflies *Caenis diminuta* and *Hexagenia limbata.* Both mayfly species are characteristic of lentic habitats. The biotic index was relatively high (6.37), reflecting the dominance of dragonflies, damselflies, and midges. Due to the interference of habitat, it cannot be determined what the condition of the aquatic macroinvertebrate community would be with lotic (optimal) habitat conditions.

At sites PR-3, PR-2, and PR-1 the EPT index ranged from 7-9 species. No stoneflies were present. Mayflies found throughout this stretch of the river included *Isonychia sp., Maccaffertium modestum,* and *Tricorythodes sp.* A few baetids were found at site PR-3. Hydropsychid caddisflies were present at Site PR-3, PR-2, and PR-1. There were no significant differences in the EPT taxa among these sites. The biotic index was lowest at Site PR-2 (5.67) and highest at Site PR-1 (6.86). The lower biotic index at site PR-2 appeared to be a function of larger mayfly populations and fewer dragonflies, damselflies and midges. This may be related to slight habitat differences and flow from Island Creek.

TABLES

TABLE I. Species List. Qualitative Macroinvertebrate Assessment

Client: AECOM / AURIGA
Stream: Cherokee Creek
County: Spartanburg, SC
Collection Date: 23-24 July 2012

		Site / # of Organisms							
ORDER EPHEMEROPTERA (mayflies)	stage	CC8	CC7	CC6	CC5	CC4	CC3	CC2	CC1
Acentrella turbida complex	N	0	1	0	0	0	0	0	0
Baetis flavigastra	N	0	3	1	5	0	4	0	0
Baetis intercalaris	N	0	0	0	0	0	2	0	0
Baetis pluto	N	2	18	4	6	7	0	0	0
Caenis diminuta	N	1	0	0	2	0	0	0	0
Centroptilum sp.	N	0	2	0	0	0	0	1	0
Eurylophella doris/temporalis	N	2	0	0	0	0	0	0	0
Labiobaetis propinquus	N	0	0	0	7	0	2	0	0
Heptagenia nr. flavescens	N	2	4	10	12	5	0	0	0
Isonychia	N	19	18	17	12	32	3	2	0
Telagonopsis deficiens	N	0	0	0	1	1	2	0	0
Stenacron interpunctatum	N	0	1	1	1	0	0	0	0
Maccaffertium terminatum	N	2	0	0	0	0	0	0	0
Maccaffertium modestum	N	14	16	4	5	25	19	2	0
Tricorythodes	N	1	5	2	5	0	3	1	1

ORDER PLECOPTERA (stoneflies)	stage	CC8	CC7	CC6	CC5	CC4	CC3	CC2	CC1
Acroneuria sp.	N	0	1	0	0	0	0	0	0

ORDER TRICHOPTERA (caddisflies)	stage	CC8	CC7	CC6	CC5	CC4	CC3	CC2	CC1
Cheumatopsyche	L	84	57	26	17	0	0	0	0
Chimarra aterrima	L	33	35	22	15	0	0	0	0
Hydropsyche betteni	L	10	33	9	6	0	0	0	0
Lepidostoma sp.	L	0	0	0	1	0	0	0	0
Lype diversa	L	0	0	0	0	0	0	0	1
Triaenodes ignitus	L	0	1	0	1	0	0	0	0
Pycnopsyche luculenta/sonso	L	0	0	1	0	0	0	0	0
Ptilostomis sp.	L	0	0	1	0	0	0	0	0

TABLE I. Species List. Qualitative Macroinvertebrate Assessment

Client: AECOM / AURIGA
Stream: Cherokee Creek
County: Spartanburg, SC
Collection Date: 23-24 July 2012

ORDER ODONATA (dragonflies)	stage	CC8	CC7	CC6	CC5	CC4	CC3	CC2	CC1
Boyeria vinosa	N	0	1	3	8	3	1	0	1
Calopteryx dimidiata	N	0	0	0	11	3	4	1	0
Corduliidae	N	0	0	0	0	0	0	1	0
Gomphus lividus	N	0	0	0	1	0	0	0	0
Hagenius brevistylus	N	1	0	0	3	0	0	0	0
Macromia sp.	N	0	0	0	0	0	0	0	1

O. MEGALOPTERA (hellgrammites)	stage	CC8	CC7	CC6	CC5	CC4	CC3	CC2	CC1
Coyrdalus cornutus	L	5	7	7	3	7	4	0	0
Nigronia fasciatus	L	0	2	0	0	0	0	0	0
Nigronia serricornis	L	2	2	0	0	0	0	0	0

ORDER COLEOPTERA (beetles)	stage	CC8	CC7	CC6	CC5	CC4	CC3	CC2	CC1
Anchyiarsus bicolor	L	1	0	0	0	0	0	1	0
Ancyronyx variegatus	L	0	1	2	1	0	16	0	2
Dineutus sp.	L	0	1	0	0	0	0	0	0
Dubiraphia vittata	A	0	3	11	10	0	1	1	0
Helichus fastigiatus	A	1	7	0	6	8	7	1	0
Macronychus glabratus	L, A	3	6	17	2	6	6	0	0
Stenelmis sp.	A	0	0	2	0	0	0	0	1

ORDER DIPTERA - other than midges	stage	CC8	CC7	CC6	CC5	CC4	CC3	CC2	CC1
Anopheles sp.	L	0	0	0	0	0	0	0	1
Antocha sp.	L	0	0	0	1	0	0	0	0
Dixa sp.	L	0	0	0	0	0	1	0	0
Simulium tuberosum gp.	L	9	7	5	1	5	0	0	0
Tipula (N.) abdominalis	L	0	1	0	0	0	0	0	0
Tipula sp.	L	0	0	0	0	0	0	0	2

TABLE I. Species List. Qualitative Macroinvertebrate Assessment

Client: AECOM / AURIGA
Stream: Cherokee Creek
County: Spartanburg, SC
Collection Date: 23-24 July 2012

Site / # of Organisms

ORDER DIPTERA - (Tanypodinae)	stage	CC8	CC7	CC6	CC5	CC4	CC3	CC2	CC1
Ablabesmyia mallochi	L	0	1	4	0	0	0	1	8
Conchapelopia gp.	L	1	3	2	2	2	2	0	1
Labrundinia pilosella	L	0	0	0	0	0	0	2	4
Natarsia	L	0	0	1	1	0	0	0	1
Paramerina	L	0	0	0	0	0	0	0	1
Zavrelimyia sp.	L	0	0	0	0	0	0	0	1

ORDER DIPTERA - (Orthocladiinae)	stage	CC8	CC7	CC6	CC5	CC4	CC3	CC2	CC1
Brillia flavifrons	L	0	4	0	0	0	0	0	0
Nanocladius	L	0	0	0	0	0	1	1	0
Parametriocnemus sp.	L	1	5	1	0	1	0	0	0
Rheocricotopus robacki	L	0	0	0	1	1	0	0	0

ORDER DIPTERA - (Chironomini)	stage	CC8	CC7	CC6	CC5	CC4	CC3	CC2	CC1
Chironomus	L	0	0	0	0	0	0	0	1
Cryptochironomus fulvus gp.	L	0	0	0	0	0	0	1	0
Dicrotendipes neomodestus	L	0	0	0	0	0	0	0	1
Paratendipes albimanus	L	0	1	1	0	0	0	0	1
Polypedilum nr. flavum	L	3	2	1	2	2	0	0	0
Polypedilum illinoense gp.	L	0	0	0	0	0	3	1	1
Tribelos jucundum	L	2	0	3	0	0	1	0	1
Stictochironomus devinctus	L	0	0	0	0	0	1	0	0
Stenochironomus	L	0	0	0	0	1	0	0	0

ORDER DIPTERA - (Tanytarsini)	stage	CC8	CC7	CC6	CC5	CC4	CC3	CC2	CC1
Rheotanytarsus exiguus	L	0	0	0	0	0	0	1	0
Tanytarsus sp. S	L	0	0	0	0	0	0	2	0
Tanytarsus sp.	L	0	0	0	0	0	0	0	2

TABLE I. Species List. Qualitative Macroinvertebrate Assessment

Client: AECOM / AURIGA
Stream: Cherokee Creek
County: Spartanburg, SC
Collection Date: 23-24 July 2012

PHYLUM ANNELIDA (worms,leeches)		CC8	CC7	CC6	CC5	CC4	CC3	CC2	CC1
Tubificidae (w/o cap. setae)		1	0	0	1	1	1	1	2

CLASS CRUSTACEA/MISCELLANEOUS	stage	CC8	CC7	CC6	CC5	CC4	CC3	CC2	CC1
Cambarinae	J	0	3	1	3	3	2	0	0
Cambarus sp.	J	1	0	0	0	0	0	0	0

PHYLUM MOLLUSCA (clams, snails)		CC8	CC7	CC6	CC5	CC4	CC3	CC2	CC1
Corbicula fluminea	clam	0	7	1	1	0	2	0	1

TABLE I. Species List. Qualitative Macroinvertebrate Assessment

Client: AECOM / AURIGA
Stream: Island Creek (IC) / Pacolet River (PR)
County: Spartanburg, SC
Collection Date: 25 July 2012

Site / # of Organisms

ORDER EPHEMEROPTERA (mayflies)	stage	IC1	PR4	PR3	PR2	PR1
Baetis flavigastra	N	2	0	0	0	0
Baetis pluto	N	4	0	3	0	0
Plauditus dubius	N	9	0	0	0	0
Plaiditus nr. gloveri	N	2	0	0	0	0
Caenis diminuta	N	1	1	0	0	0
Centroptilum sp.	N	1	0	0	0	0
Labiobaetis propinquus	N	1	0	1	0	0
Hepiagenia nr. flavescens	N	1	0	0	0	0
Hexagenia limbata	N	0	2	0	0	0
Isonychia	N	42	0	2	19	2
Telagonopsis deficiens	N	2	0	0	0	0
Leucrocuta nr. maculipennis	N	0	0	0	0	1
Maccaffertium terminatum	N	0	0	0	2	1
Maccaffertium modestum	N	12	0	0	3	2
Tricorythodes	N	26	0	0	5	2

ORDER PLECOPTERA (stoneflies)	stage	IC1	PR4	PR3	PR2	PR1
Acroneuria sp.	N	1	0	0	0	0
Perlesta sp.	N	1	0	0	0	0
Tallaperla sp.	N	1	0	0	0	0

ORDER TRICHOPTERA (caddisflies)	stage	IC1	PR4	PR3	PR2	PR1
Cernotina	L	0	0	0	2	1
Cheumatopsyche	L	9	0	27	17	10
Chimarra aterrima	L	1	0	0	0	0
Hydropsyche betteni	L	45	0	15	8	1
Hydropsyche rossi	L	0	0	5	0	2
Hydropsyche nr. venularis	L	1	0	0	0	0
Triaenodes ignitus	L	4	0	1	0	0
Pycnopsyche luculenta/sonso	L	0	0	0	1	0
Pycnopsyche scabripennis	L	2	0	0	0	0

TABLE I. Species List. Qualitative Macroinvertebrate Assessment

Client: AECOM / AURIGA
Stream: Island Creek (IC) / Pacolet River (PR)
County: Spartanburg, SC
Collection Date: 25 July 2012

Site / # of Organisms

ORDER ODONATA (dragonflies)	stage	IC1	PR4	PR3	PR2	PR1
Argia tibialis	N	0	1	0	0	0
Argia sedula	N	0	4	0	0	0
Boyeria vinosa	N	8	0	1	1	1
Calopteryx dimidiata	N	2	0	1	0	0
Basiaeshna janata	N	0	5	0	0	0
Dromogomphus spinosus	N	0	2	0	0	0
Gomphus (Gomphurus) rogersi	N	0	0	1	0	0
Gomphus lividus	N	0	4	0	0	0
Gomphus sp.	N	1	0	0	0	0
Hagenius brevistylus	N	1	0	0	4	0
Ischnura sp.	N	0	1	0	0	0
Macromia taeniolata	N	0	2	0	1	3
Neurocordulia obsoleta	N	0	0	0	1	0
Ophiogomphus mainensis	N	2	0	2	0	0

ORDER HETEROPTERA (true bugs)	stage	IC1	PR4	PR3	PR2	PR1
Rhagovelia obesa	A	3	0	1	1	1

O. MEGALOPTERA (hellgrammites)	stage	IC1	PR4	PR3	PR2	PR1
Coyrdalus cornutus	L	3	0	0	5	1
Sialis sp.	L	2	0	0	0	0
Nigronia serricornis	L	0	0	1	1	0

ORDER COLEOPTERA (beetles)	stage	IC1	PR4	PR3	PR2	PR1
Ancyronyx variegatus	L	0	0	0	0	1
Dineutus sp.	L	1	0	0	0	0
Dubiraphia vittata	A	2	10	0	0	0
Dubiraphia sp.	L	1	2	0	0	0
Helichus fastigiatus	A	2	0	0	0	0
Neoporus clypealis	A	0	1	0	0	0

TABLE I. Species List. Qualitative Macroinvertebrate Assessment

Client: AECOM / AURIGA
Stream: Island Creek (IC) / Pacolet River (PR)
County: Spartanburg, SC
Collection Date: 25 July 2012

ORDER DIPTERA - other than midges	stage	IC1	PR4	PR3	PR2	PR1
Antocha sp.	L	0	0	0	0	1
Anopheles sp.	L	0	1	0	0	0
Crysops	L	0	0	0	0	1
Dixa sp.	L	0	1	0	0	0
Hemerodromia sp.	L	0	0	0	0	1
Simulium tuberosum gp.	L	1	0	7	0	0

ORDER DIPTERA - (Tanypodinae)	stage	IC1	PR4	PR3	PR2	PR1
Ablabesmyia mallochi	L	4	2	2	2	1
Clinotanypus pinguis	L	0	0	0	2	0
Conchapelopia gp.	L	1	0	0	0	0
Procladius sp.	L	1	0	0	0	0
Zavrelimyia sp.	L	1	0	0	0	0

ORDER DIPTERA - (Orthocladiinae)	stage	IC1	PR4	PR3	PR2	PR1
Cricotopus bicinctus	L	0	0	1	0	2
Nanocladius rectinervis	L	0	0	1	0	0
Nanocladius balticus sp.	L	0	0	0	0	1
Orthocladius nr annectens	L	1	0	0	0	0

ORDER DIPTERA - (Chironomini)	stage	IC1	PR4	PR3	PR2	PR1
Chironomus	L	0	0	0	0	2
Cryptochironomus fulvus gp.	L	1	0	4	0	0
Dicrotendipes neomodestus	L	2	0	0	0	0
Paracladopelma sp.	L	0	0	1	0	1
Paralauterborniella nigrohalteralis	L	0	0	1	0	0
Tribelos jucundum	L	1	0	1	0	0

TABLE I. Species List. Qualitative Macroinvertebrate Assessment

Client: AECOM / AURIGA
Stream: Island Creek (IC) / Pacolet River (PR)
County: Spartanburg, SC
Collection Date: 25 July 2012

Site / # of Organisms

ORDER DIPTERA - (Tanytarsini)	stage	IC1	PR4	PR3	PR2	PR1
Paratanytarsus sp.	L	0	0	0	0	1
Rheotanytarsus exiguus	L	0	5	63	0	3
Tanytarsus sp. C	L	0	0	2	0	0
Tanytarsus sp. L	L	0	0	2	0	0

PHYLUM ANNELIDA (worms,leeches)		IC1	PR4	PR3	PR2	PR1
Tubificidae (w/o cap. setae)		4	2	3	0	10

CLASS CRUSTACEA/MISCELLANEOUS	stage	IC1	PR4	PR3	PR2	PR1
Cambarinae	J	0	0	1	0	1
Cambarus sp.	J	3	0	0	0	0
Carambincola	A	1	0	0	0	0
ACARI- Lebertia	A	1	0	0	0	1

PHYLUM MOLLUSCA (clams, snails)		IC1	PR4	PR3	PR2	PR1
Corbicula fluminea	clam	13	2	11	18	13
Helisoma anceps	snail	0	0	0	1	0
Physa acuta	snail	0	0	1	0	2

TABLE II. Percent Composition by Major Taxonomic Group

Client: AECOM / AURIGA
Stream: Cherokee Creek
County: Spartanburg, SC
Collection Date: 25 July 2012

Taxon	CC8	CC7	CC6	CC5	CC4	CC3	CC2	CC1
Annelida (worms)	0.5%	0.0%	0.0%	0.6%	0.9%	1.1%	4.8%	5.6%
Mollusca (clams, snails)	0.0%	2.7%	0.6%	0.6%	0.0%	2.3%	0.0%	2.8%
Crustacea (crayfish, shrimp)	0.5%	1.2%	0.6%	1.9%	2.7%	2.3%	0.0%	0.0%
Ephemeroptera	21.4%	26.3%	24.4%	36.4%	61.9%	39.8%	28.6%	2.8%
Plecoptera	0.0%	0.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Trichoptera	63.2%	48.6%	36.9%	26.0%	0.0%	0.0%	0.0%	2.8%
Megaloptera	3.5%	4.2%	4.4%	1.9%	6.2%	4.5%	0.0%	0.0%
Odonata	0.5%	0.4%	1.9%	14.9%	5.3%	5.7%	9.5%	5.6%
Heteroptera	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Coleoptera	2.5%	6.9%	20.0%	12.3%	12.4%	34.1%	14.3%	8.3%
Diptera (excl. midges)	4.5%	3.1%	3.1%	1.3%	4.4%	1.1%	0.0%	8.3%
Diptera (midges)	3.5%	6.2%	8.1%	3.9%	6.2%	9.1%	42.9%	63.9%

TABLE II. Percent Composition by Major Taxonomic Group

Client: AECOM / AURIGA
Stream: Island Creek (IC) / Pacolet River (PR)
County: Spartanburg, SC
Collection Date: 25 July 2012

Taxon	IC1	PR4	PR3	PR2	PR1
Annelida (worms)	1.6%	4.2%	1.9%	0.0%	14.7%
Mollusca (clams, snails)	5.3%	4.2%	7.4%	20.2%	22.1%
Crustacea (crayfish, shrimp)	2.1%	0.0%	0.6%	0.0%	2.9%
Ephemeroptera	42.4%	6.3%	3.7%	30.9%	11.8%
Plecoptera	1.2%	0.0%	0.0%	0.0%	0.0%
Trichoptera	25.5%	0.0%	29.6%	29.8%	20.6%
Megaloptera	2.1%	0.0%	0.6%	6.4%	1.5%
Odonata	5.8%	39.6%	3.1%	7.4%	5.9%
Heteroptera	1.2%	0.0%	0.6%	1.1%	1.5%
Coleoptera	7.4%	27.1%	0.6%	0.0%	1.5%
Diptera (excl. midges)	0.4%	4.2%	4.3%	0.0%	4.4%
Diptera (midges)	4.9%	14.6%	47.9%	4.3%	15.7%

TABLE III. Biological Parameter Results and Water Quality Ratings

Client: AECOM / AURIGA
Stream: Cherokee Creek
County: Spartanburg, SC
Collection Date: 23-24 July 2012

BIOLOGICAL PARAMETER RESULTS Parameters	Site CC8	Site CC7	Site CC6	Site CC5	Site CC4	Site CC3	Site CC2	Site CC1
1. Taxa Richness	24	33	28	33	21	25	17	22
2. Total Number of Organisms / Site	201	259	160	154	244	119	21	36
3. EPT Index	11.0	14.0	12.0	15.0	8.0	9.0	4.0	2.0
4. Biotic Index	5.41	5.34	5.02	5.17	4.68	6.07	5.96	7.11

WATER QUALITY RATING SCORE Parameters	Site CC8	Site CC7	Site CC6	Site CC5	Site CC4	Site CC3	Site CC2	Site CC1
EPT Score	2.0	2.4	2.0	2.4	1.6	1.6	1.0	1.0
Biotic Index Score	4.0	4.0	5.0	4.6	4.0	3.0	3.0	2.0
MEAN SCORE	**3.0**	**3.2**	**3.5**	**3.5**	**2.8**	**2.3**	**2.0**	**1.5**
Decrease in Bioclassification Score vs. Control)			**-0.3**	**-0.3**	**0.4**	**0.9**	**1.2**	**1.7**
Level of Impairment vs. Reference Site			**none**	**none**	**none**	**slight**	* **slight**	* **moderate**
Bioclassification of Site (Independent)	**good-fair**	**good-fair**	**good**	**good**	**good-fair**	**fair**	**fair**	**poor**
Aquatic Life Use Support	**partially**	**partially**	**fully**	**fully**	**partially**	**partially**	**partially**	**not**

* Note: Indicated impairment maybe attributable to lentic habitat.

TABLE III. Biological Parameter Results and Water Quality Ratings

Client: AECOM / AURIGA
Stream: Island Creek (IC) / Pacolet River (PR)
County: Spartanburg, SC
Collection Date: 25 July 2012

BIOLOGICAL PARAMETER RESULTS Parameters	Site IC1	Site PR4	Site PR3	Site PR2	Site PR1
1. Taxa Richness	48	18	29	19	29
2. Total Number of Organisms / Site	243	48	163	94	70
3. EPT Index	21.0	2.0	7.0	8.0	9.0
4. Biotic Index	5.60	6.37	6.47	5.67	6.86

WATER QUALITY RATING SCORE Parameters	Site IC1	Site PR4	Site PR3	Site PR2	Site PR1
EPT Score	3.0	1.0	1.4	1.6	1.6
Biotic Index Score	4.0	3.0	2.6	4.0	2.0
MEAN SCORE	**3.5**	**2.0**	**2.0**	**2.8**	**1.8**
Decrease in Bioclassification Score vs. Site PR4	**NA**	**NA**	**0.0**	**-0.8**	**0.2**
Level of Impairment vs. Reference Site			**none**	**none**	**none**
Bioclassification of Site (Independent)	**good**	**fair**	**fair**	**good-fair**	**fair**
Aquatic Life Use Support	**fully**	**partially**	**partially**	**partially**	**partially**

TABLE IV. Additional Metrics

Client: AECOM / AURIGA
Stream: Cherokee Creek
County: Spartanburg, SC
Collection Date: 23-24 July 2012

BIOLOGICAL PARAMETER RESULTS Parameters	Site CC8	Site CC7	Site CC6	Site CC5	Site CC4	Site CC3	Site CC2	Site CC1
5. EPT / Chironomid Ratio	24.3	12.20	7.54	16.00	28.70	8.30	0.67	0.09
6. Scraper / Filterer Ratio	1.00	0.20	0.33	0.56	0.15	0.84	0.81	0.04
7. % Dominant Taxon	42%	22%	16%	11%	38%	25%	10%	22%
8. Shredder / Total # of Organisms Ratio	0.02	0.03	0.02	0.03	0.01	0.03	0.00	0.14
9. Community Loss Index	N/A	N/A	0.61	0.58	0.86	0.72	1.06	0.82
10. Functional Feeding Group Analysis								
Collector - Gatherers	9.5%	17.6%	20.3%	25.3%	13.4%	28.1%	23.8%	13.9%
Collector - Filterers	77.1%	60.6%	50.0%	33.8%	63.9%	26.1%	23.8%	8.3%
Scrapers	6.7%	12.0%	16.3%	18.8%	9.7%	21.1%	11.9%	6.9%
Predators	4.5%	7.1%	11.3%	19.2%	10.5%	18.4%	28.6%	52.8%
Shredders	2.2%	2.7%	2.2%	2.9%	2.5%	6.3%	11.9%	18.1%

TABLE IV. Additional Metrics

Client: AECOM / AURIGA
Stream: Island Creek (IC) / Pacolet River (PR)
County: Spartanburg, SC
Collection Date: 25 July 2012

BIOLOGICAL PARAMETER RESULTS Parameters	Site IC1	Site PR4	Site PR3	Site PR2	Site PR1
5. EPT / Chironomid Ratio	14.0	0.43	0.69	14.25	2.00
6. Scraper / Filterer Ratio	1.00	0.93	0.03	0.04	0.14
7. % Dominant Taxon	19%	21%	39%	20%	19%
8. Shredder / Total # of Organisms Ratio	0.04	0.04	0.03	0.01	0.17
9. Community Loss Index	N/A	N/A	0.07	0.21	1.45
10. Functional Feeding Group Analysis					
Collector - Gatherers	24.1%	17.7%	4.6%	8.0%	15.0%
Collector - Filterers	46.1%	14.6%	82.2%	69.1%	47.1%
Scrapers	10.7%	13.5%	2.1%	2.7%	6.4%
Predators	14.8%	50.0%	8.3%	19.1%	14.3%
Shredders	4.3%	4.2%	2.8%	1.1%	17.1%

6.0 REFERENCES

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, DC.

Brigham, A.R., W.U. Brigham and A. Gnilka (eds.). 1982. The aquatic insects and oligochaetes of North and South Carolina. Midwest Enterprises, Mahomet, Ill. 837 pp.

Epler, John H. 2001. Identification Manual for Larval Chironomidae (Diptera) of North and South Carolina. NCDENR.

Fitzpatrick, Joseph F. 1983 How to know the freshwater Crustacea. Wm. C. Brown Company Publishers. 227 pp.

Hilsenhoff, W.L. 1987. An improved biotic index of organic stream pollution. Great Lakes Entomol. 20:31-39.

Merritt, R.W., K.W. Cummins, and M.B. Berg. 2008. An introduction to the aquatic insects of North America. 4th Ed. Kendall/Hunt Publishing Co., Dubuque, Iowa. 1158 pp.

Needham, James G., Minter J. Westfall and Michael L. May. 2000. Dragonflies of North America. Scientific Publishers. 939 pp.

Pennak, R.W. 1978. Freshwater invertebrates of the United States. (2nd Ed.). J. Wiley and Sons, N.Y. 803 pp.

Plafkin, J.L., M.T. Barbour, K.D. Porter, S.K. Gross and R.M. Hughes. 1989. Rapid bioassessment protocols for use in streams and rivers. Benthic macroinvertebrates and fish. EPA 444/4-89-001.

South Carolina Department of Health and Environmental Control (SCDHEC). 1998. Standard Operating Procedures for Macroinvertebrate Sampling. Technical Report No. 004-98. Bureau of Water. Columbia, SC.

Smith, Douglas Grant. 2001. Pennak's Freshwater Invertebrates of the United States: Porifera to Crustacea. 4th Ed. John Wiley and Sons.638 pp.

Stewart, K.W., and B.P. Stark. 1988. Nymphs of North American Stonefly Genera (Plecoptera).University of North Texas Press, TX. 460 pp.

Weiderholm, T. 1983. Keys and Diagnoses to the Holarctic Chironomidae. Part 1. Larvae. Ent. Scand. Supp. 19.

Westfall, Minter J. and Michael L. May. 1996. Damselflies of North America. Scientific Publishers. 649 pp.