MACROINVERTEBRATE ASSESSMENT OF MAYO CREEK NEAR THE VC SUMMER NUCLEAR STATION OPERATED BY SOUTH CAROLINA ELECTRIC AND GAS COMPANY, FAIRFIELD COUNTY, SOUTH CAROLINA

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Submitted To:

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I. SUMMARY

On October 15, 2008, CARNAGEY BIOLOGICAL SERVICES, LLC (SCDHEC Laboratory Certification Number 32572) conducted a benthic macroinvertebrate community assessment on Mayo Creek, near the VC Summer Nuclear Station, operated by SOUTH CAROLINA ELECTRIC AND GAS COMPANY. The objective of this assessment was to determine the condition of the stream's macroinvertebrate community.

Results of the benthic macroinvertebrate assessment conducted on Mayo Creek, October 15, 2008, indicated the river's macroinvertebrate community was somewhat stressed at all three stations. This may be due to a prolonged drought during the summer preceding the sampling. This drought has persisted for the past year. Stations 1 and 2 had SCDHEC ratings of "good-fair", while Station 3 had a rating of "fair". The NCBI rating for Stations 2 and 3 was "good-fair", while Station 1 had a value of "good". All three stations shared similar taxa richness, number of specimens, EPT indices, and EPT abundance.

The water chemistry data measured in conjunction with the macroinvertebrate assessment reflected similar temperature, pH, and conductivity at all three stations. Dissolved oxygen decreased from 12.25 mg/l at Station 1 to 8.85 mg/l at Station 3. All parameters monitored were within water quality standards for Class FW waters of the State of South Carolina (SCDHEC, 1998).

II. INTRODUCTION

On October 15, 2008, a benthic macroinvertebrate community assessment was conducted on Mayo Creek near the VC Summer Nuclear Station, Fairfield County, South Carolina.

III. DESCRIPTION OF STUDY AREA

Collections of aquatic macroinvertebrates were made from three sampling locations in Mayo Creek near the VC Summer Nuclear Station (Figure 1).

Station 1 was located approximately 1.5 kilometers upstream of Parr Road below the confluence of a small unnamed tributary. The river at this point was approximately 0.5 to 2.0 meters wide, and less than 0.1 to 0.3 meters deep. The substrate consisted mainly of sand with some gravel, cobble, and boulders, and the canopy provided approximately 55% cover.

Station 2 was located approximately 170 meters upstream of Parr Road. The river at this point was 0.1 to 0.2 meters wide and less than 0.1 to 0.1 meters deep. The substrate consisted mainly of sand, with some cobble and exposed cobble and bedrock. This station had approximately 65% canopy cover.

Station 3 was established approximately 50 meters downstream of Parr Road. The river at this point was 0.5 to 2.0 meters wide and less than 0.1 to 0.2 meters deep. The substrate consisted mainly of sand, with some gravel, cobble, and boulders. This station had approximately 75% canopy cover.

Figure 1. Sampling locations for macroinvertebrates collected from Mayo Creek near the effluent discharge of the VC Summer Nuclear Station, operated by SOUTH CAROLINA ELECTRIC AND GAS COMPANY, Fairfield County, South Carolina.

IV. METHODS

A. Field Sampling

Qualitative collections of aquatic macroinvertebrates were made with a D-frame aquatic dip net, a U.S. Standard No. 30 sieve, and hand picking organisms from substrates with forceps. The multiple habitat approach, where specimens from all available habitats (stream margins, leaf packs, aquatic vegetation, water-soaked logs, and sand deposits) are pooled to form one aggregate sample was utilized as the sampling procedure. Samples were preserved in the field with 70% ethanol. Each sample represented 1.5 hours of sampling effort. Sampling procedures and habitat types were kept similar at each station to enable species and numerical population comparisons between stations. Habitat scores were determined using the *Habitat Assessment Field Data Sheet for Low Gradient Streams* (Barbour *et al*., 1999).

B. Water Chemistry

Water chemistry parameters measured at each station in conjunction with the macroinvertebrate sampling included temperature, pH, conductivity, and dissolved oxygen.

C. Sample Processing

Upon return to the laboratory, macroinvertebrates were sorted from debris with the aid of a stereomicroscope. The macroinvertebrates were enumerated and identified to the lowest positive taxonomic level with the aide of appropriate microscopic techniques and taxonomic keys. All specimens will be maintained in CARNAGEY BIOLOGICAL SERVICES, LLC voucher collection for five years or placed into the permanent reference collection.

D. Data Analysis

Comparisons of the macroinvertebrate communities were based on the known tolerance levels and life history strategies of the organisms encountered and on changes in taxonomic composition between sampling stations. Changes in taxonomic composition were determined using metrics outlined in Rapid Bioassessment Protocol III of the US EPA's *Rapid Bioassessment Protocols for Use in Streams and Rivers* (Plafkin *et al.* 1989) and SCDHEC's *Standard Operating and Quality Control Procedures for Macroinvertebrate Sampling* (SCDHEC, 1999). These metrics included the following:

1) Taxa richness - The number of different taxa found at a particular location is an indication of diversity. Reductions in community diversity have been positively associated with various forms of environmental pollution, including nutrient loading, toxic substances, and sedimentation (Barbour *et al*., 1996; Fore *et al*., 1996; Rosenberg and Resh, 1993; Shackleford, 1988).

2) EPT Index - EPT Index is the number of taxa from the insect orders Ephemeroptera, Plecoptera and Trichoptera found at a station. These three insect orders are considered to be intolerant of adverse changes in water quality, especially temperature and dissolved oxygen, and therefore, a reduction in these taxa is indicative of reduced water quality (Barbour *et al*., 1996; Lenat, 1988).

3) Chironomidae taxa and abundance - The Chironomidae are a taxonomically and ecologically diverse group with many taxa which are tolerant of various forms of pollution. The chironomids are often the dominant group encountered at impacted or stressed sites (Rosenberg and Resh, 1993).

4) Ratio of EPT and Chironomidae abundance - The relative abundance of these four indicator groups is a measure of community balance. When compared to a reference site, good biotic conditions are reflected in a fairly even distribution among these four groups (Plafkin *et al*., 1989). The value of this ratio is reduced by impact due to the general reduction of the more sensitive EPT taxa and an increase in the more tolerant chironomid taxa.

5) Ratio of scraper/scraper and filtering collectors - When compared to a reference site, shifts in the dominance of a particular feeding type may indicate a community responding to an over-abundance of a particular food source or toxicants bound to a particular food source (Rosenberg and Resh, 1993).

6) Shredder/total number of specimens collected - When compared to a reference site, reductions in the relative abundance of shredders can indicate changes in the quality or quantity of riparian zone vegetation or the presence of toxic substances bound to organic carbon contained in the leaf and woody material which comprises their food source (Plafkin *et al*., 1989).

7) Percent contribution of dominant taxon - This measures the redundancy and evenness of the community structure. It assumes a highly redundant community reflects an impaired community because as the more sensitive taxa are eliminated, there is often a significant increase in the remaining tolerant forms (Barbour *et al*., 1996; Shackleford, 1988).

8) Dominant taxa in common - When compared to a reference site, major shifts in the composition and abundance of dominant taxa can indicate environmental stress (Barbour *et al*., 1996; Shackleford, 1988).

9) Community loss index (Table 1) - This index measures the loss of taxa between a reference or control station and a study site. It is an index of dissimilarity, with values

increasing as the degree of dissimilarity from the reference station increases (Courtemanch and Davies, 1987; Plafkin *et al*., 1989).

10) Jaccard coefficient of community similarity (Table 1) - This coefficient represents the degree of similarity in taxonomic composition between two stations in terms of taxon presence or absence. Values range from 0 to 1.0, increasing as the degree of similarity increases (Jaccard, 1912; Plafkin *et al*., 1989).

11) Sörensen coefficient (Table 1) - This coefficient represents the degree of similarity in taxonomic composition between two stations in terms of taxon presence or absence. Values range from 0 to 1.0, increasing as the degree of similarity increases (Breitenmoser-Würsten and Satori, 1995).

12) North Carolina biotic index (Table 1) - This index utilizes a pollution tolerance value developed over a wide range of conditions and pollution types to assess the amount of impact (North Carolina Department of Environment, Health and Natural Resources, 1997). The values range from 0-10, increasing as water quality decreases. Taxa are designated as Rare (1-2 specimens), Common (3-9 specimens), or Abundant (≥10 specimens) and assigned a 1, 3, or 10 abundance code, respectively, for calculation of the NCBI.

13) SCDHEC bioclassification – Bioclassification is determined by averaging scores for the NCBI and EPT index at each station, then rating sites as "Excellent, Good, Good-Fair, Fair, or Poor" (SCDHEC, 1999).

Table 1. Procedures used in the calculation of selected metrics used in this report.

Metric	**Procedure**
Community Loss Index	CL = d-a/e Where: a = number of taxa common to both samples. d = total number of taxa present in sample A. e = total number of taxa present in sample B.
Jaccard Coefficient of Similarity	JCS = a/a+b+c Where: a = number of taxa common to both samples. b = number of taxa present in sample B but not A. c = number of taxa present in sample A but not B.
Sörensen Coefficient	C_S= 2a/(d+e) Where: a = number of taxa common to both samples. d = the number of taxa present in sample A. e = the number of taxa present in sample B.
North Carolina Biotic Index	NCBI = TV_iN_i/N Where: TV_i = the tolerance for the *i*th taxon. N_i = the abundance code of the $_i$th taxon. N = sum of abundance codes for all taxa in the sample.

V. RESULTS

A. Physicochemical Analysis

The water chemistry data measured in conjunction with the macroinvertebrate assessment are presented in Table 2. The data reflected similar temperature, pH, and conductivity at all three stations. Dissolved oxygen decreased from 12.25 mg/l at Station 1 to 8.85 mg/l at Station 3.

Table 2. Physicochemical data collected in conjunction with the macroinvertebrate assessment of Mayo Creek near the effluent discharge of the VC Summer Nuclear Station, Fairfield County, South Carolina, 15 October 2008.

	Station		
Parameter	**1**	**2**	**3**
Water Temperature (ºC)	17.11	15.14	14.88
pH (SU)	7.35	7.29	7.31
Conductivity (µmhos/cm)	101	96	106
Dissolved Oxygen (mg/l)	12.25	10.78	8.85

B. Macroinvertebrate Community Analysis

A total of 504 specimens representing 44 taxa were collected from Mayo Creek during this assessment. The taxa list, number of specimens, and relative abundance for each taxon are presented in Table 3. Bioassessment metrics for each sampling station are presented in Table 4. Table 5 lists the dominant taxa for each sampling station. Habitat assessment scores are presented in Table 6 for each station.

The sampling effort at Station 1, the upstream control, yielded 182 specimens representing 30 taxa (Table 3). An EPT index of 9 was calculated for this station (Table 4). The Chironomidae were represented by 1 taxa and contributed 1% of the total specimens collected. The NCBI value of 5.52 resulted in a water quality rating of "good" for this station. The SC Bioclassification score of 2.8 indicated a "good-fair" rating for Station 1. The dominant functional feeding group was the collector-filterers, which contributed 31% of the collection. The dominant taxon was *Caenis* sp., which contributed 24% of the collection (Table 5).

Station 2 yielded 165 specimens representing 23 taxa (Table 3). An EPT index of 9 was calculated for this station (Table 4). The Chironomidae were represented by 3 taxa and contributed 2% of the total specimens collected. The NCBI value of 5.81 results in a water

quality rating of "good-fair" for this station. The SC Bioclassification score of 2.5 indicated a "good-fair" rating for Station 2. The dominant functional feeding group was the collector-gatherers, which contributed 48% of the collection. The community loss index value of 0.57 and the Sörensen coefficient value of 0.64 indicate this station is somewhat similar to Station 1. The dominant taxon was *Caenis* sp., which contributed 45% of the specimens collected (Table 5).

Station 3 yielded 157 specimens representing 25 taxa. An EPT index of 7 was calculated for this station. The Chironomidae were represented by 2 taxa and contributed a total of 2% of the specimens collected. The NCBI value of 6.26 results in a water quality rating of "good-fair" for this station. The SC Bioclassification score of 2.2 indicated a "fair" rating for Station 3. The dominant functional feeding group was the collector-gatherers, which contributed 43% of the collection. The community loss index value of 0.60 and the Sörensen coefficient value of 0.55 indicate this station is somewhat dissimilar to Station 1. The community loss index value of 0.36 and the Sörensen coefficient value of 0.58 indicate this station is slightly similar to Station 2. The dominant taxon was *Caenis* sp., which contributed 41% of the specimens collected (Table 5).

VI. DISCUSSION

Results of the benthic macroinvertebrate assessment conducted on Mayo Creek, October 15, 2008, indicated the river's macroinvertebrate community was somewhat stressed at all three stations. This may be due to a prolonged drought during the summer preceding the sampling. This drought has persisted for the past year. Stations 1 and 2 had SCDHEC ratings of "good-fair", while Station 3 had a rating of "fair". The NCBI rating for Stations 2 and 3 was "good-fair", while Station 1 had a value of "good". All three stations shared similar taxa richness, number of specimens, EPT indices, and EPT abundance.

The water chemistry data measured in conjunction with the macroinvertebrate assessment reflected similar temperature, pH, and conductivity at all three stations. Dissolved oxygen decreased from 12.25 mg/l at Station 1 to 8.85 mg/l at Station 3. All parameters monitored were within water quality standards for Class FW waters of the State of South Carolina (SCDHEC, 1998).

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Table 3. Macroinvertebrates, their North Carolina biotic index tolerance values (TV), functional feeding groups (FG), and abundance collected from Mayo Creek near the effluent discharge of the VC Summer Nuclear Station, Fairfield County, South Carolina, 15 October 2008.

				No. of Individuals			Relative Abundance		
Seq	**Taxon**	**TV**	**FG**	**Sta. 1**	**Sta. 2**	**Sta. 3**	**Sta. 1**	**Sta. 2**	**Sta. 3**
Annelida									
Hirudinea									
Rhynchobdellida									
Glossiphoniidae									
1	Helobdella sp.		P	1			0.01		
Oligochaeta									
Tubificida									
Naididae									
2	Naididae Genus species		SC	2		1	0.01		0.01
Arthropoda									
Arachnoidea									
Acariformes									
Arrenuridae									
3	Arrenurus sp.	5.63	P		3	1		0.02	0.01
Hydrachnidae									
4	Hydrachna sp.	5.63	P	8	5	9	0.04	0.03	0.06
Insecta									
Coleoptera									
Elmidae									
5	Ancyronyx variegatus	6.59	CG		1			0.01	
6	Macronychus glabratus	4.68	CG	1			0.01		
Ptilodactylidae									
7	Anchytarsus bicolor	3.74	SH	3	2		0.02	0.01	
Diptera									
Ceratopogonidae									
8	Culicoides sp.	7.80	P	1			0.01		
Chironomidae									
9	Ablabesmyia mallochi	7.29	P		1	1		0.01	0.01
10	Microtendipes pedellus gr.	5.63	CF		1			0.01	
11	Polypedilum halterale gr.	7.41	SH	2			0.01		
12	Rheocricotopus robacki	7.38	CG		1			0.01	
13	Stenochironomus sp.	6.55	CG			2			0.01

* CG = collector-gatherer, CF = collector-filterer, OM = omnivore, P = predator, SH = shredder, SC = scraper

Table 3. Continued.

				No. of Individuals			Relative Abundance		
Seq	**Taxon**	**TV**	**FG**	**Sta. 1**	**Sta. 2**	**Sta. 3**	**Sta. 1**	**Sta. 2**	**Sta. 3**
Culicidae									
14	Anopheles sp.	8.68	CF	1			0.01		
Dixidae									
15	Dixella indiana		CG			1			0.01
Simuliidae									
16	Prosimulium mixtum	4.10	CF	1			0.01		
Tipulidae									
17	Hexatoma sp.	4.41	P	2			0.01		
18	Tipula sp.	7.43	SH	1	2		0.01	0.01	
Ephemeroptera									
Baetidae									
19	Baetis sp.	4.81	CG	4	2	1	0.02	0.01	0.01
Caenidae									
20	Caenis sp.	7.51	CG	44	74	64	0.24	0.45	0.41
Heptageniidae									
21	Maccaffertium modestum	5.60	SC	13	13	5	0.07	0.08	0.03
22	Stenacron interpunctatum	6.97	SC	7	2		0.04	0.01	
Isonychiidae									
23	Isonychia sp.	3.55	CF	2	11	8	0.01	0.07	0.05
Megaloptera									
Corydalidae									
24	Corydalus cornutus	5.26	P	5	1	1	0.03	0.01	0.01
Odonata									
Calopterygidae									
25	Calopteryx sp.	7.88	P	1	5	2	0.01	0.03	0.01
Coenagrionidae									
26	Argia bipunctulata	8.27	P	6	4	2	0.03	0.02	0.01
27	Enallagma sp.	9.01	P	1	2		0.01	0.01	
Gomphidae									
28	Gomphus sp.	5.90	P	4		3	0.02		0.02
29	Ophiogomphus mainensis	5.64	P	4	1		0.02	0.01	
30	Progomphus sp.		P	1		1	0.01		0.01
Libellulidae									
31	Macromia sp.	6.26	P			1			0.01

* CG = collector-gatherer, CF = collector-filterer, OM = omnivore, P = predator, SH = shredder, SC = scraper

Table 3. Continued.

Seq	Taxon	TV	FG	No. of Individuals			Relative Abundance		
				Sta. 1	Sta. 2	Sta. 3	Sta. 1	Sta. 2	Sta. 3
Plecoptera									
Perlidae									
32	Perlinella drymo	0.01	P	3			0.02		
Trichoptera									
Hydropsychidae									
33	Cheumatopsyche sp.	6.32	CF	31	19	24	0.17	0.12	0.15
Leptoceridae									
34	Ceraclea tarsipunctata	2.11	CG		1			0.01	
35	Triaenodes ignitus	4.68	SH	4	4	3	0.02	0.02	0.02
Philopotamidae									
36	Chimarra sp.	2.86	CF	22	5	3	0.12	0.03	0.02
Malacostraca									
Amphipoda									
Talitridae									
37	Hyalella azteca	7.85	OM			1			0.01
Cyclopoida									
Cyclopidae									
38	Eucyclops agilis		OM			2			0.01
Decapoda									
Cambaridae									
39	Cambaridae Genus species		OM	5	5	8	0.03	0.03	0.05
Isopoda									
Asellidae									
40	Caecidotea sp.	9.21	SC			3			0.02
Mollusca									
Bivalvia									
Unionoida									
Corbiculidae									
41	Corbicula fluminea	6.22	CF			9			0.06
Gastropoda									
Limnophila									
Ancylidae									
42	Ferrissia sp.	6.65	SC	1			0.01		
Physidae									
43	Physa sp.	8.94	SC			1			0.01
Nematomorpha									
44	Nematomorpha Genus sp.		P	1			0.01		

* CG = collector-gatherer, CF = collector-filterer, OM = omnivore, P = predator, SH = shredder, SC = scraper

Table 4. Rapid bioassessment metrics calculated for the three sampling stations on Mayo Creek near the effluent discharge of the VC Summer Nuclear Station, Fairfield County, South Carolina, 15 October 2008.

	Station		
Metric	**1**	**2**	**3**
Taxa Richness	30	23	25
Number of Specimens	182	165	157
EPT Index	9	9	7
EPT Abundance	130	131	108
Chironomidae Taxa	1	3	2
Chironomidae Abundance	2	3	3
EPT/Chironomidae Abundance	65.00	43.67	36.00
North Carolina Biotic Index	5.52	5.81	6.26
SCDHEC Bioclassification	2.8	2.5	2.2
Percent Collector-Filterers	31.32	21.82	28.03
Percent Collector-Gatherers	26.92	47.88	43.31
Percent Omnivores	2.75	3.03	7.01
Percent Predators	20.88	13.33	13.38
Percent Scrapers	12.64	9.09	6.37
Percent Shredders	5.49	4.85	1.91
Scraper/Collector-Filterers	0.40	0.42	0.23
Shredders/Total	0.05	0.05	0.02
Percent Dominant Taxon	24.18	44.85	40.76
Number Of Dominant Taxa	4	4	6
Dominants In Common		3	2
			3
Community Loss Index		0.57	0.60
			0.36
Jaccard Coefficient of Similarity		0.47	0.38
			0.41
Sörensen Coefficient		0.64	0.55
			0.58

Table 5. Dominant taxa (>5% of the collection) for the three sampling stations on Mayo Creek near the effluent discharge of the VC Summer Nuclear Station, Fairfield County, South Carolina, 15 October 2008.

Station 1			**Station 2**			**Station 3**		
Taxon	**No.**	**Rel. Abd.**	**Taxon**	**No.**	**Rel. Abd.**	**Taxon**	**No.**	**Rel. Abd.**
Caenis sp.	44	24.18	Caenis sp.	74	44.85	Caenis sp.	64	40.76
Cheumatopsyche sp.	31	17.03	Cheumatopsyche sp.	19	11.52	Cheumatopsyche sp.	24	15.29
Chimarra sp.	22	12.09	Maccaffertium modestum	13	7.88	Hydrachna sp.	9	5.73
Maccaffertium modestum	13	7.14	Isonychia sp.	11	6.67	Corbicula fluminea	9	5.73
						Cambaridae Genus species	8	5.10
						Isonychia sp.	8	5.10

Table 6. Habitat assessment scores determined in conjunction with the macroinvertebrate assessment for the three sampling stations on Mayo Creek near the effluent discharge of the VC Summer Nuclear Station, Fairfield County, South Carolina, 15 October 2008.

Habitat Parameter	***Sta. 1***	***Sta. 2***	***Sta. 3***
1. Epifaunal Substrate/Available Cover	12	15	11
2. Pool Substrate Characterization	11	16	11
3. Pool Variability	6	10	6
4. Sediment Deposition	17	19	16
5. Channel Flow Status	15	11	11
6. Channel Alteration	20	20	20
7. Channel Sinuosity	16	16	16
8. Bank Stability (Left Bank (LB*))	10	10	10
Bank Stability (Right Bank (RB*))	10	10	10
9. Vegetative Protection (LB*)	10	10	10
Vegetative Protection (RB*)	10	10	10
10. Riparian Vegetative Zone (LB*)	10	10	10
Riparian Vegetative Zone (RB*)	10	10	10
Total Score	157	167	151

* Left or right bank is determined when facing downstream.