Impact Assessment of the Barre Coal Tar Site on the Aquatic Biota of the Stevens Branch, Barre, VT

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Executive Summary

To evaluate the impact of the Barre Coal Tar (BCT) site on the aquatic biota of the Stevens Branch, the pollution source (BCT) was spatially bracketed and both macroinvertebratre and fish populations were sampled above and below the groundwater influence of the BCT site. The biological integrity of the stream reaches above and below the BCT site were found to be highly similar in the biological attributes (biometrics) which describe the community integrity. The biological integrity of the Stevens Branch, both above, adjacent to and below the BCT site, was rated as being in fair to good condition compared to the VT DEC statewide reference quality stream database. The aquatic communities both above and below the BCT site are, only marginally meeting the State's W.Q. biological standard for a class "B" stream. The difference between the two sites was not significant and well within the variability of the indices used to describe the communities. **The conclusion of this study is that the BCT site is not having "an undue adverse" impact on the aquatic communities of the Stevens Branch.**

Introduction

The Barre Coal Tar (BCT) site is a former manufactured gas plant with contaminated ground water and soils from volatile organic and semi-volatile organic compounds associated with the gasification process on the site. The BCT site has been listed as a hazardous waste site by the State of Vermont since 1983, at which time it was determined to be a risk to human health and the environment. The groundwater flow direction is in a SW direction towards the Stevens Branch river. Remedial recovery actions at the site have included a groundwater recovery system, with bioremediation and recirculation. Despite these efforts low levels of PAH compounds have been detected in the stream sediments. This study will evaluate the effect of the BCT site as it is currently being managed on the aquatic communities of the Stevens Branch river.

Methods

The Stevens Branch river was sampled for both macroinvertebrates and fish in mid September 1996. The macroinvertebrate community was sampled at three sites located above (4.9), adjacent to (4.8) and below (4.7) the BCT site, (**Figure 1**). A 2-min Kick Net sample was collected in replicate at all three sites (VT DEC 1987). The samples were preserved in 75 percent ETOH in the field and returned to the R.A.LaRosa Laboratory for processing. Samples were processed at the laboratory using VT DEC standardized subsampling methods (VT DEC 1987), and all animals were identified to their lowest practical taxonomic level, usually genus or species. The raw count data by site and replicate is in **Appendix C.**

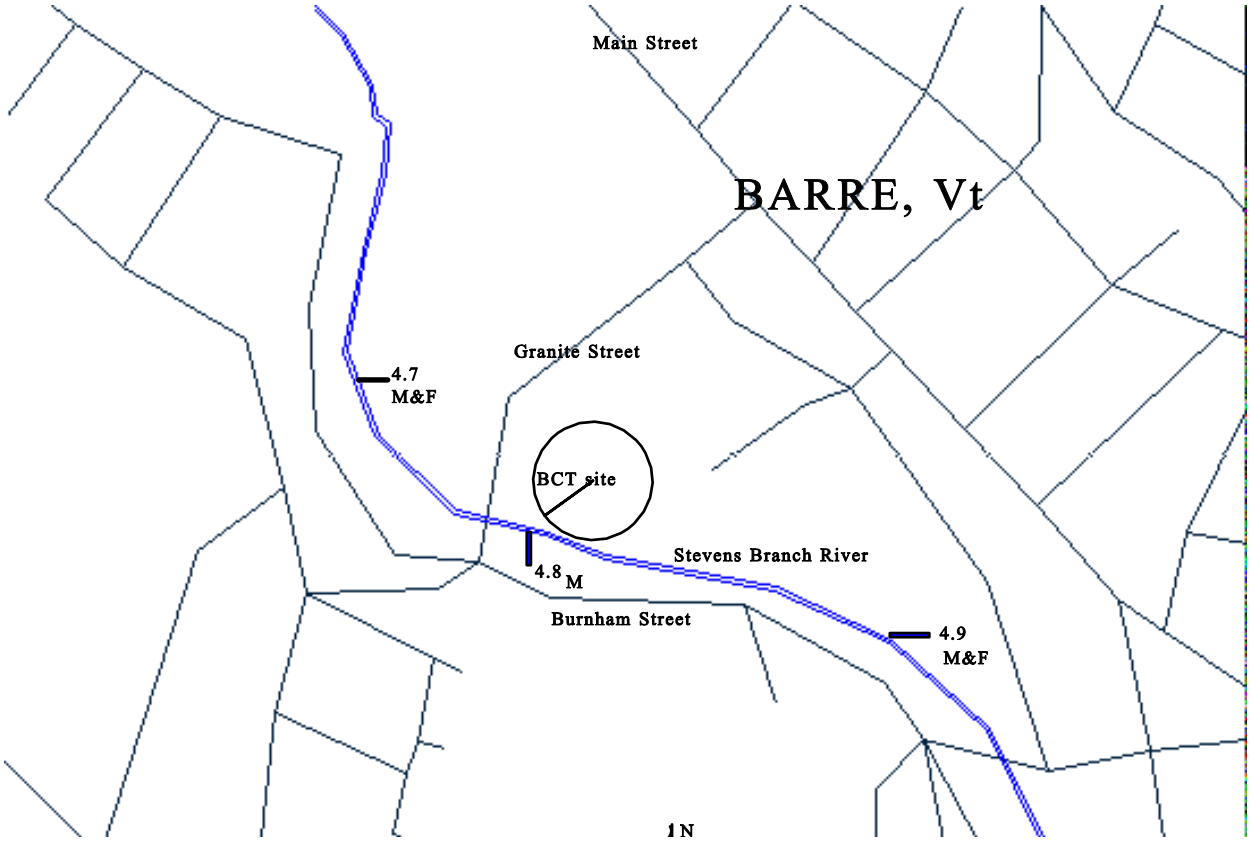
The fish community was sampled at two sites, one above (4.9) and one below (4.7) the BCT site,(**Figure 1**). A reach-representative section which included both riffles and pools was sampled from each site. The section lengths were 83m at site 4.9 and 70m at site 4.7. Two electroshocking passes were carried out at each sampling site. Fish were collected by electroshocker, identified in the field, and returned to the stream. The raw counts for each site and pass are presented in **Appendix D.**

A habitat assessment was conducted at each sampling site which included an estimate of substrate composition and embeddedness, periphyton cover, canopy cover, and stream width and depth of the fished reaches. The physical and chemical measures of pH, Alkalinity, Conductivity, and Temperature were also recorded at the time of sampling.

Results and Discussion

The macroinvertebrate community biometrics are presented in **Table 1**. None of the biometrics significantly changed from above to below the BCT site. The density between all the sites was very similar and ranged from 1834/KN at site 4.9 to 1240/KN at site 4.8. The three insect Orders: Ephemeroptera, Plecoptera, Trichoptera (EPT) that are considered sensitive to water quality impacts were represented at all three sites by similar numbers of species and densities. The mean taxa Richness, and EPT (sensitve taxa) richness did not change significantly

Figure 1 Locations of biological assessments on Stevens Branch in Barre in relationship tp BCT site



from above to below the BCT site. Compared to the VTDEC preliminary macroinvertebrate biocriteria (**Appendix A**) both of the taxa richness measures categorize the Stevens Branch river as having good biological integrity. No categorical differences in either density or richness between the sites indicates that the BCT site is not having a toxic effect on the macroinvertebrate community in the Stevens Branch.

The Bio Index value is a measure of community tolerance toward organic enrichment. The index ranges from 0-5 with >4 being very tolerant and <2 being intolerant. All three sites had values of about 2.5, indicating a moderate amount of organic enrichment both above and below the BCT site. The ratio of EPT density to the combined densities of EPT and Chironimidae (midge) (EPT/EPT&Chiros), is also a good measure of the communities tolerance of enrichment. All three sites rated as having a good to excellent density ratio between the sensitve EPT animals and the more tolerant Chironomid animals. The site above the BCT site in fact had a slightly lower ratio then site 4.8 and 4.7 adjacent to and below the BCT site. The percent of the community made up by the Hydropsyche taxa is a good measure of functional balance in the community. A high percent composition of Hydropsyche taxa can indicate that nonpoint particulate runoff is negatively impacting the community. The percent Hydropsyche taxa mimics the percent dominant taxa at all three sites and increased at the lower two sites. This is an indication that storm water runoff is having an influence on the biological integrity of the lower site. The rating of these metrics (**Appendix A**) decreased from excellent at the upper site 4.9 to good at the lower site 4.7

Table 1: The macroinvertebrate biometrics from three sites on the Stevens Branch, Barre ,VT. Bracketing the Barre Coal Tar site.

Site # (location)	4.9 (above)	4.8 (adjacent)	4.7 (below)
Density/KN	1834	1240	1373
m-Richness	40	39	35
EPT	19.5	19.5	18.5
EPT/Richness	.49	.50	.53
Diversity (INDEX!)	4.93	4.35	4.49
BioIndex (0-5)	2.55	2.47	2.37
EPT/ EPT&Chiros	.73	.88	.82
% Hydropsyche	25	30	36
% Dominant Taxa (Taxa)	19 (*Symphitopsyche)*	25 (*Symphitopsyche*)	29 (*Symphitopsyche)*
E/P/T	9/5/10	9/4/10	7/3/9

Tables 2 & 3 show the percent composition of the major groups and the functional feeding groups at all the sites. No biologically significant differences are evident in the percent composition of the major groups or the functional composition between the sites. The **Ephemeroptera** and **Trichoptera** orders dominated the communities at all three sites. The abundance of Plecoptera was low at all three sites perhaps due to a combination of warm summer temperatures and a lack of leaf litter contributing to the stream's functions, as indicated by the shredder functional group not being represented at sites 4.9 and 4.7, and making up less then 1 percent at site 4.8. The collector gatherer and filterer functional groups dominated all three sites ranging from 70 to 77 percent between the sites, a difference of only 7 percent. The scraper functional group was also well represented at all three sites ranging from 14 to 19 percent. This shows the stream supports a periphyton community which is dominated by diatom algae species. Observations of the physical habitat presented in **Table 7** show that Diatoms appeared to be the dominate algae at all three sites. The lower percentage of herbivore shredders (1-6 percent) indicates that filamentous algae often associated with nutrient enrichment is not the prevalent periphyton in the Stevens Branch at these sites. The overall lower percentage of scrappers and shredders and the presence of leaf shredders at the adjacent site compared to both the above and below site, may be in part do to the greater canopy cover at site 4.8 (**Table 7**). Canopy from the riparian vegetation can shade a stream, holding down algae growth and stream temperatures as well as contributing directly as a food source for detritivore shredders.

Table 2: The Percent Composition of the Major Macroinvertebrate Groups, from three sites on the Stevens Branch, bracketing the Barre Coal Tar site. Percents rounded to whole number.

Site # (location)	4.9 (above)	4.8 (adjacent)	4.7 (below)
% Coleoptera	8	1	3
% Diptera	26	13	19
% Ephemeroptera	35	50	35
% Plecoptera	1	2	1
% Trichoptera	31	34	42
% other	<1	<1	<1

Table 3 :The Percent Composition of the Macroinvertebrate Functional Feeding Groups, from three sites in the Stevens Branch, bracketing the Barre Coal Tar site. Percents are rounded off to whole numbers.

Site # (location)	4.9 (above)	4.8 (adjacent)	4.7 (below)
% Coll. Gath.	47	46	33
% Coll. Filt	26	31	37
% Predator	4	4	4
% Shredder Det.	0	<1	0
% Shredder Herb.	6	1	4
% Scrapper	16	14	19

Table 4 presents the percent composition and density of the dominant taxa (percent composition >3%) from all three sites on the Stevens Branch river. Eleven taxa were found to be dominate from all three sites. They included three **Diptera** (midges), three **Ephemeroptera** (Mayflies), three **Trichoptera** (Caddisflies) and one **Coleoptera** (Beetle). The mayfly *Baetis spp* and the caddisfly *Symphitopsyche spp* were the overall co-dominants, each representing from between 16 to 25 percent of the community at all three sites. The midges *Cricotopus spp*, and *Orthocladious sp,* and the caddisfly *Glossosoma sp,* were more dominant at the two sites above and below the BCT then the adjacent site 4.8. This may be a reflection of decreased periphyton growth at the adjacent site compared to the others due to the greater percentage of canopy cover (**table 7**).

Table 5 presents the results of the Pinkham Pearson Coefficeint of Similarity (PPCS) between both of the above between all the sites. The PPCS is a measure of the similarity between the communities. The PPCS ranges from 100 percent to 0 percent. A similarity of less then 25 percent between any two sites indicates their are extreme differences in the community composition. A similarity of greater then 60 percent indicates the sites are fairly similar, this level of similarity is often found between replicate samples from the same site. The similarity analysis of the dominant taxa shows all the sites to be relatively similar, with site 4.9 above the BCT being slightly more similar to site 4.7 below the BCT, then to site 4.8 located adjacent to the BCT. The communities were slightly more similar in percent composition of the dominant taxa then they were in density of these taxa. The slightly lower similarity of the adjacent site probably is in part a
reflection of the above mentioned habitat differences created by the greater canopy cover at the adjacent site, and not due to water quality differences caused by the BCT site..

Table 4: The Percent composition and density of the dominant macroinvertebrate species from three sites on the Stevens Branch, Barre, VT bracketing the Barre Coal Tar site.

Site # (location)			4.9 (above)		4.8 (adjacent)		4.7 (below)	
Cricotopus spp	***#***	***%***	102	5.6	15	1.2	53	3.9
Orthocladious sp	***#***	***%***	106	5.8	23	1.9	79	5.7
Tvetenia spp	***#***	***%***	142	7.8	54	4.4	55	4.0
Baetis spp	***#***	***%***	290	15.8	310	25.1	189	13.7
Pseudocloen spp	***#***	***%***	60	3.1	126	10.2	170	12.4
Ephemerella spp	***#***	***%***	60	3.3	42	3.4	51	3.7
Glossosoma sp	***#***	***%***	92	5.0	31	2.5	55	4.0
Symphitopsyche spp	***#***	***%***	346	19.0	301	24.4	397	29.0
Cheumatopsyche spp	***#***	***%***	58	3.2	3	0.2	24	1.8
Optiosevus sp	***#***	***%***	114	6.2	7	0.6	27	2.0

Table 5 :The PPCoefficient of Similarity (PPCS) Between the dominant taxa from three sites in the Stevens Branch Barre, VT bracketing the Barre Coal Tar site. The similarity in density and percent composition of the dominant taxa are presented between all sites.

Site # (location) # / %	4.9 (above)	4.8 (adjacent) %	4.7 (below)
4.9 (above)	100	44	65
4.8 (adjacent) #	42	100	57
4.7 (below)	56	54	100

In **conclusion** the macroinvertebrate community shows no undue adverse effect on the aquatic biota of the Stevens Branch from above to below the BCT. All sites presently meet the rivers Class "B" W.Q. designation. The density, taxa richness, EPT index, Bio Index, EPT/EPT&Chiro ratio, and %Dominance biometrics all indicate the macroinvertebrate community is in good overall condition (compared to the VTDEC regional reference data base). The negligible presence of the detritivore shredding functional feeding group does indicate the overall lack of a riparian zone leaf litter contribution to community energetics.

The fish assemblages at the two Stevens Branch sites above and below the BCT were similar in species composition and density, **(Table 6)** . Total densities were measured by numbers collected in two electrofishing passes converted to numbers /100 m^2 . Both sites supported the same 12 species. The similarity between the two sites was measured by a modified PPCS. The value of 63 percent indicates that the two fish species assemblages above and below the BCT are very similar.

Despite the similarities in assemblage structure, the final VT IBI scores differed by four points between the two sites. The VT IBI (**Appendix B**) is comprised of nine biometrics or population parameters which are scored individually and then totaled for a final score that ranges from 9 (very poor) to 45 (excellent). Site 4.7 below the BCT scored 29 and site 4.9 above, scored a 33. These values are indicative of degraded conditions which are probably due to the cumulative effects stemming from the urban setting of this stream reach. Although a difference of four points with the VT IBI is not considered significant, the gap between the two scores was located on the threshold of pass/fail for the Class B biological standard. Site 4.7 barely failed Class B standards while site 4.9 barely passed.

The differences in the final VT IBI were seen in the biometrics that evaluate fish community functional structure; the relative proportions of generalist feeders, insectivores and top carnivores in the community. At site 4.7 all three of these biometrics scored lower than at site 4.9. These differences are probably not due to changes in water quality between the two sites but discrepancies in the physical habitats between the two sites (**see table 7**). Though an effort was made to select sampling sections of equal habitat, the lower section had a greater proportion of pool area (40%) than the upper section (20%), and conversely the upper section had a greater proportion of riffle area. Since fish assemblage composition is determined in part by the nature of the habitat sampled (regardless of the water quality or impact being measured) this difference in pool/riffle area probably explained the minor differences in the fish communities as measured by the VT IBI. More individuals of species characteristic of pools and fewer characteristic of riffles were collected in the lower section than from the upper section. Since most pool species are generalist feeders (more tolerant to pertabation) and all riffle species are insectivores (less tolerant), the shifts in the relative proportion of each group, primarily caused by differences in the pool/riffle ratio, were largely responsible for the four point difference in VT IBI scores.

In **conclusion**, anticipated significant effects from the BCT on the fish population of the Stevens Branch would have included loss of species, occurrence of lesions and other deformities and a decrease in overall assemablge density. None of these phenomena were observed in the present study. It is concluded then, that the insigificant change in VT IBI scores between the two sites is due to differences in habitat sampled and not from any influences from the BCT site.

Table 6: Fish assemblage information from two sites on the Stevens Branch, Barre, VT. bracketing the Barre Coal Tar site.

Parameter	4.9 (above)	4.7 (below)
VT IBI[1]	31 (fair)	27 (poor)
Species Richness	12	12
% Generalist Feeders and metric score	39.5 (3)	65.5 (1)
% Insectivores and metric score	56.0 (5)	32.3 (3)
% top carnivores and metric score	4.5 (3)	2.1 (1)
Total Density	80.8 /100m ^{2}	82.6/100m ^{2}
PPCS	63%	

1. Vermont Index of Biotic Integrity; possible scores range from 9 (very poor) to 45 (excellent), appendix B.

Table 7: Some physical, chemical habitat characteristics from three sites on the Stevens Branch, Barre, VT. bracketing the Barre Coal Tar site.

Parameter	4.9 (above)	4.8 (adjacent)	4.7 (below)
pH	7.24	7.79	7.79
Alkalinity	150	150	150
Conductivity	443	443	444
% Riffle	25	-	10
% Run	55	-	50
% Pool	20	-	40
% Canopy	20	40	30
% Embeddedness	35	35	35
% Diatoms	100	100	100
% Filamentous Green	5	0	0
% Moss	40	35	40

References

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3. Tate, M.W. and R.C. Clelland. 1957. Non-parametric and shortcut statistics. The Interstate, Danville, Illinois.

4. Vermont Department of Environmental Conservation. 1989. Field Methods Manual. Waterbury, VT.

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Appendix A:

MACROINVERTEBRATE BIOCRITERIA

Biocriteria used for determining the biological integrity of the aquatic biota for wadeable streams and rivers in Vermont. Method used 2 min. kick net sample subsampled in laboratory by picking one quarter of sample; if subsample is less than 300 animals then additional subsample is picked until a minimum of 300 animals are in the subsample. The proportion of sample picked is then recorded. Identifications are done in the laboratory to the genus - species level. The overall biological integrity of a stream is determined by evaluating the rating and degree of each metric and the number of metrics which are found to be in an acceptable or unacceptable range.

Metric Mean Rating	Mean Richness	Bio EPT	Index	Diversity
Very Poor	<15	<8	≥3.50	<1.50
Poor	15-19	8-12	3.01-3.49	1.51 - 2.24
Fair	20-29	13-17	2.75-3.00	2.25 - 2.99
		Unacceptable		
		Acceptable		
Good	30-39	18-22	2.01-2.74	3.00-3.99
Very Good	40-49	23-25	1.51-2.00	4.00-4.49
Excellent	≥50	>25	≤1.50	>4.50

Metric Rating	% Dominant Genera	#EPT/#EPT&CHIRO	# EPT/# Chiro	EPT/R
Poor	≥55	<.25	≤.50	≤.30
Fair	≥40 <55	>.25<.45	>.5 <1.00	>.30 ≤.45
		Unacceptable		
Good	≥25 <40	>.45<.75	>1 <2	>.45 ≤.60
Excellent	<25	>.75	>2	>.60

Appendix B:

THE VERMONT IBI

			Scoring Criteria		
			5	**3**	**1**
Species Richness and Composition					
1.	Total number of fish species		(Follows maximum species richness lines)		
2.	Number and identity of intolerant species	[Site Elevation >125m]	>1	1	0
		[Site Elevation <125m]	1	0	-
3.	Number and identity of benthic insectivore species		>1	1	0
4.	Proportion of individuals as white suckers and creek chubs		<20%	20-40%	>40%
Trophic Composition					
5.	Proportion of individuals as generalist feeders	[Site Elevation >210m]	<20%	20-45%	>45%
		[Site Elevation <210m]	<30%	30-60%	>60%
6.	Proportion of individuals as water column and benthic insectivores	[Site Elevation >210m]	>65%	30-65%	<30%
		[Site Elevation <210m]	>55%	20-55%	<20%
7.	Proportion of individuals as top carnivores:	Cold Water	>20%	3-20%	<3%
		Warm Water	>10%	3-10%	<3%
Fish Abundance and Condition					
8.	Proportion of individuals with disease, tumors, fin damage and other anomalies		<2%	2-5%	>5%
			5	3	1 *
9.	Abundance in Sample (one pass - #100m^2)	[Site Elevation <210m]	>20	10-20	<10
		[Site Elevation >210m]			
		[Alk. >9mg/l]	>10	7-10	<7
		[Alk. <9mg/l]	>6	3-6	<3

*Site fails to meet Class B Standards

Metric Scores

Excellent	41-45
Good	33-37
Fair*	27-29
Poor*	<27

Conditions for Use

1. For wadeable streams only.
2. At least four species including one generalist feeder.
3. Only individuals more than 25mm TL.
4. Only native resident stream species.
5. Only species with more than one individual captured are entered in metrics 2 & 3.

Appendix C: Raw counts of macroinvertebrate taxa by site and replicate from three sites on the Stevens Branch, bracketing the Barre Coal Tar site, in Barre, Vt.

Site 4.7

Order	Genera	Species	Count 1	Count 2	Mean	% Comp
COLEOPTERA	OPTIOSERVUS	sp	21	24	22.2	1.6
COLEOPTERA	OPTIOSERVUS	fastiditus	0	10	5.1	0.3
COLEOPTERA	STENELMIS	sp	0	3	1.7	0.1
COLEOPTERA	PSEPHENUS	herricki	3	10	6.8	0.4
DIPTERA	ORTHOCLADIINAE	unid	0	7	3.4	0.2
DIPTERA	CARDIOCLADIUS	sp	17	24	20.5	1.4
DIPTERA	CRICOTOPUS	bisinctus	7	14	10.2	0.7
DIPTERA	CRICOTOPUS	tremulus	3	7	5.1	0.3
DIPTERA	CRICOTOPUS	trifascia	41	34	37.7	2.7
DIPTERA	DIAMESA	sp	0	3	1.7	0.1
DIPTERA	EUKIEFFERIELLA	devonica	10	0	5.1	0.3
DIPTERA	EUKIEFFERIELLA	pseudomontana	7	0	3.4	0.2
DIPTERA	EUKIEFFERIELLA	brevicalar	7	7	6.8	0.4
DIPTERA	EUORTHOCLADIUS	sp	0	7	3.4	0.2
DIPTERA	ORTHOCLADIUS	sp	79	79	78.8	5.7
DIPTERA	THIENEMANNIELLA	sp	7	7	6.8	0.4
DIPTERA	TVETENIA	discoloripes	72	27	49.7	3.6
DIPTERA	TVETENIA	bavarica	10	0	5.1	0.3
DIPTERA	EMPIDIDAE	unid	3	14	8.5	0.6
DIPTERA	ANTOCHA	sp	0	14	6.8	0.4
DIPTERA	DICRANOTA	sp	3	0	1.7	0.1
DIPTERA	HEXATOMA	sp	7	7	6.8	0.4
EPHEMEROPTERA	BAETIDAE	unid	10	5	30.8	2.2
EPHEMEROPTERA	BAETIS	flavistriga	17	14	15.4	1.1
EPHEMEROPTERA	BAETIS	intercalaris	141	168	154.2	11.6
EPHEMEROPTERA	BAETIS	tricaudatus	17	21	18.8	1.3
EPHEMEROPTERA	PSEUDOCLOEON	sp	69	72	70.28	5.1
EPHEMEROPTERA	PSEUDOCLOEON	carolina	127	72	99.4	7.2
EPHEMEROPTERA	EPHEMERELLIDAE	unid	7	17	12	0.8
EPHEMEROPTERA	EPHEMERELLA	subvaria	41	62	51.4	3.7
EPHEMEROPTERA	HEPTAGENIIDAE	unid	14	17	15.4	1.1
EPHEMEROPTERA	STENONEMA	sp	0	7	3.4	0.2
EPHEMEROPTERA	STENONEMA	luteum	0	0	0	0
EPHEMEROPTERA	LEPTOPHLEBIIDAE	unid	14	10	12.0	0.8
TRICHOPTERA	GLOSSOSOMA	sp	62	48	54.8	3.9
TRICHOPTERA	HYDROPSYCHIDAE	imm	106	34	70.2	5.1
TRICHOPTERA	CHEUMATOPSYCHE	sp	34	14	24.0	1.7
TRICHOPTERA	SYMPHITOPSYCHE	bronta	137	117	126.8	9.2

Order	Genera	Species	Count 1	Count 2	Mean	% Comp
TRICHOPTERA	SYMPHITOPSYCHE	morosa	82	79	80.5	5.8
TRICHOPTERA	SYMPHITOPSYCHE	slossonae	175	147	161.1	11.7
TRICHOPTERA	SYMPHITOPSYCHE	sparna	41	17	29.1	2.1
TRICHOPTERA	PSILOTRETA	sp	0	3	1.7	0.1
TRICHOPTERA	DOLOPHILODES	sp	21	14	17.1	1.2
TRICHOPTERA	PSYCHOMYIA	sp	7	7	6.8	0.4
PLECOPTERA	PARAGNETINA	media	10	3	6.8	0.4
PLECOPTERA	PARAGNETINA	immarginata	3	7	5.1	0.3
PLECOPTERA	AGNETINA	capitata	7	0	3.4	0.2
MEGALOPTERA	NIGRONIA	sp	3	0	1.7	0.1
DECAPODA	ORONECTES	virilis	0	0	0	0
OLIGOCHAETA	TUBIFICIDAE	unid	3	0	1.7	0.1

Site 4.8

Order	Genera	Species	Count 1	Count 2	Mean	% Comp
COLEOPTERA	OPTIOSERVUS	sp	4	6	5	0.4
COLEOPTERA	OPTIOSERVUS	fastiditus	4	0	2	0.2
COLEOPTERA	PSEPHENUS	herricki	4	0	2	0.2
DIPTERA	BRILLIA	sp	4	0	2	0.2
DIPTERA	CARDIOCLADIUS	sp	4	9	6.5	0.5
DIPTERA	CRICOTOPUS	sp	4	3	3.5	0.3
DIPTERA	CRICOTOPUS	bisinctus	4	3	3.5	0.3
DIPTERA	CRICOTOPUS	trifascia	4	12	8	0.6
DIPTERA	EUKIEFFERIELLA	devonica	4	3	3.5	0.3
DIPTERA	EUKIEFFERIELLA	pseudomontana	4	6	5	0.4
DIPTERA	EUKIEFFERIELLA	claripennis	12	21	16.5	1.3
DIPTERA	EUORTHOCLADIUS	sp	0	6	3	0.2
DIPTERA	ORTHOCLADIUS	sp	16	30	23	1.8
DIPTERA	PARAMETRIOCNEMUS	sp	8	9	8.5	0.7
DIPTERA	POLYPEDILUM	fallax	0	3	1.5	0.1
DIPTERA	POLYPEDILUM	aviceps	4	0	2	0.2
DIPTERA	THIENEMANNEMYIA	sp	8	6	7	0.6
DIPTERA	TVETENIA	discoloripes	64	15	39.5	3.2
DIPTERA	TVETENIA	bavarica	24	6	15	1.2
DIPTERA	ANTOCHA	sp	4	3	3.5	0.3
DIPTERA	DICRANOTA	sp	0	3	1.5	0.1
DIPTERA	HEXATOMA	sp	20	3	11.5	0.9
EPHEMEROPTERA	BAETIDAE	unid	120	36	78	6.3
EPHEMEROPTERA	BAETIS	sp	24	0	12	1.0
EPHEMEROPTERA	BAETIS	flavistriga	32	18	25	2.0
EPHEMEROPTERA	BAETIS	intercalaris	296	216	256	20.6
EPHEMEROPTERA	BAETIS	tricaudatus	20	15	17.5	1.4
EPHEMEROPTERA	PSEUDOCLOEON	sp	104	21	62.5	5.0
EPHEMEROPTERA	PSEUDOCLOEON	carolina	64	63	63.5	5.1
EPHEMEROPTERA	EPHEMERELLIDAE	unid	12	6	9	0.7
EPHEMEROPTERA	EPHEMERELLA	subvaria	56	27	41.5	3.3
EPHEMEROPTERA	HEPTAGENIIDAE	unid	24	18	21	1.7
EPHEMEROPTERA	RHITHROGENA	sp	12	3	7.5	0.6
EPHEMEROPTERA	STENONEMA	sp	8	0	4	0.3
EPHEMEROPTERA	STENONEMA	luteum	8	0	4	0.3
EPHEMEROPTERA	LEPTOPHLEBIIDAE	unid	20	12	16	1.3
EPHEMEROPTERA	ISONYCHIA	sp	0	0	0	0
TRICHOPTERA	BRACHYCENTRUS	numerosus	0	0	0	0
TRICHOPTERA	GLOSSOSOMA	sp	32	30	31	2.5
TRICHOPTERA	HYDROPSYCHIDAE	imm	60	66	63	5.1

Order	Genera	Species	Count 1	Count 2	Mean	% Comp
TRICHOPTERA	CHEUMATOPSYCHE	sp	0	6	3	0.2
TRICHOPTERA	SYMPHITOPSYCHE	bronta	92	138	115	9.3
TRICHOPTERA	SYMPHITOPSYCHE	morosa	116	63	89.5	7.2
TRICHOPTERA	SYMPHITOPSYCHE	slossonae	84	81	82.5	6.6
TRICHOPTERA	SYMPHITOPSYCHE	sparna	24	6	15	1.2
TRICHOPTERA	DOLOPHILODES	sp	24	6	15	1.2
TRICHOPTERA	PSYCHOMYIA	sp	0	3	1.5	0.1
TRICHOPTERA	RHYACOPHILA	melita	4	3	3.5	0.3
PLECOPTERA	CHLOROPERLIDAE	unid	8	3	5.5	0.4
PLECOPTERA	PARAGNETINA	media	8	12	10	0.8
PLECOPTERA	PARAGNETINA	immarginata	0	3	1.5	0.1
PLECOPTERA	AGNETINA	capitata	8	0	4	0.3
PLECOPTERA	ISOPERLA	sp	4	3	3.5	0.3
OLIGOCHAETA	NAIDIDAE	unid	4	3	3.5	0.3
OLIGOCHAETA	TUBIFICIDAE	unid	0	3	1.5	0.1

Site 4.9

Order	Genera	Species	Count 1	Count 2	Mean	% Comp
COLEOPTERA	OPTIOSERVUS	sp	120	92	106	5.78
COLEOPTERA	OPTIOSERVUS	trivittatus	12	4	8	0.44
COLEOPTERA	PROMORESIA	tardella	0	4	2	0.11
COLEOPTERA	STENELMIS	sp	16	24	20	1.09
COLEOPTERA	PSEPHENUS	herricki	4	4	4	0.22
COLEOPTERA	CURCULIONIDAE	unid	0	4	2	0.11
DIPTERA	ATHERIX	sp	12	0	6	0.33
DIPTERA	CARDIOCLADIUS	sp	20	36	28	1.53
DIPTERA	CLADOTANYTARSUS	sp	4	0	2	0.11
DIPTERA	CRICOTOPUS	bisinctus	8	4	6	0.33
DIPTERA	CRICOTOPUS	trifascia	88	104	96	5.23
DIPTERA	EUKIEFFERIELLA	devonica	16	24	20	1.09
DIPTERA	EUKIEFFERIELLA	claripennis	4	12	8	0.44
DIPTERA	ORTHOCLADIUS	sp	112	100	106	5.78
DIPTERA	PARACHAETOCLADIUS	sp	4	0	2	0.11
DIPTERA	PARAMETRIOCNEMUS	sp	20	20	20	1.09
DIPTERA	POLYPEDILUM	aviceps	8	4	6	0.33
DIPTERA	RHEOTANYTARSUS	sp	0	8	4	0.22
DIPTERA	STEMPELLINA	sp	4	0	2	0.11
DIPTERA	THIENEMANNEMYIA	sp	4	4	4	0.22
DIPTERA	TVETENIA	discoloripes	64	160	112	6.11
DIPTERA	TVETENIA	bavarica	20	40	30	1.64
DIPTERA	EMPIDIDAE	unid	4	0	2	0.11
DIPTERA	ANTOCHA	sp	8	0	4	0.22
DIPTERA	HEXATOMA	sp	12	12	12	0.65
EPHEMEROPTERA	BAETIDAE	imm	136	192	164	8.94
EPHEMEROPTERA	BAETIS	sp	12	4	8	0.44
EPHEMEROPTERA	BAETIS	flavistriga	40	8	24	1.31
EPHEMEROPTERA	BAETIS	intercalaris	200	152	176	9.60
EPHEMEROPTERA	BAETIS	tricaudatus	100	64	82	4.47
EPHEMEROPTERA	PSEUDOCLOEON	sp	44	68	56	3.05
EPHEMEROPTERA	PSEUDOCLOEON	carolina	8	0	4	0.22
EPHEMEROPTERA	EPHEMERELLIDAE	imm	8	24	16	0.87
EPHEMEROPTERA	EPHEMERELLA	subvaria	64	56	60	3.27
EPHEMEROPTERA	HEPTAGENIIDAE	unid	24	8	16	0.87
EPHEMEROPTERA	EPEORUS	sp	8	0	4	0.22
EPHEMEROPTERA	RHITHROGENA	sp	4	0	2	0.11
EPHEMEROPTERA	PARALEPTOPHLEBIA	sp	16	28	22	1.20
TRICHOPTERA	GLOSSOSOMA	sp	116	68	92	5.02
TRICHOPTERA	HYDROPSYCHIDAE	imm	48	60	54	2.94

Order	Genera	Species	Count 1	Count 2	Mean	% Comp
TRICHOPTERA	CHEUMATOPSYCHE	sp	72	44	58	3.16
TRICHOPTERA	SYMPHITOPSYCHE	bronta	120	136	128	6.98
TRICHOPTERA	SYMPHITOPSYCHE	morosa	88	124	106	5.78
TRICHOPTERA	SYMPHITOPSYCHE	slossonae	56	100	78	4.25
TRICHOPTERA	SYMPHITOPSYCHE	sparna	36	32	34	1.85
TRICHOPTERA	DOLOPHILODES	sp	8	8	8	0.44
TRICHOPTERA	RHYACOPHILA	fuscula	4	0	2	0.11
TRICHOPTERA	RHYACOPHILA	melita	4	8	6	0.33
TRICHOPTERA	RHYACOPHILA	carpenteri	4	0	2	0.11
PLECOPTERA	CHLOROPERLIDAE	unid	12	0	6	0.33
PLECOPTERA	PARAGNETINA	media	4	8	6	0.33
PLECOPTERA	PARAGNETINA	immarginata	0	0	0	0.00
PLECOPTERA	AGNETINA	capitata	4	0	2	0.11
PLECOPTERA	ISOPERLA	sp	4	0	2	0.11
MEGALOPTERA	NIGRONIA	sp	4	0	2	0.11
MEGALOPTERA	SIALIS	sp	4	0	2	0.11

Appendix D: Raw counts of fish species by site and run from two sites on the Stevens Branch river, bracketing the Barre Coal Tar site, in Barre, Vt

Site 4.7

Species	Run 1	Run 2	Total/100m2	% Composition
Blacknose Dace	103	45	17.48	21.17
Brook Trout	1	1	0.24	0.29
Brown Trout	5	1	0.71	0.86
Common Shiner	17	12	3.43	4.15
Creek Chub	12	6	2.13	2.58
Lake Chub	174	42	25.51	30.90
Longnose Dace	38	28	7.80	9.44
Longnose Sucker	83	67	17.72	21.46
Pumpkinseed	8	2	1.18	1.43
Rainbow Trout	6	1	0.83	1.00
White Sucker	36	9	5.32	6.44
Yellow Perch	1	1	0.24	0.29

Site 4.9

Species	Run 1	Run 2	Total/100m2	% Composition
Blacknose Dace	114	52	26.35	32.61
Brook Trout	1	1	0.32	0.39
Brown Trout	13	1	2.22	2.75
Common Shiner	8	6	2.22	2.75
Creek Chub	1	0	0.16	0.20
Lake Chub	55	14	10.95	13.56
Longnose Dace	60	58	18.73	23.18
Longnose Sucker	63	35	15.56	19.25
Pumpkinseed	1	0	0.16	0.20
Rainbow Trout	6	1	1.11	1.38
Redbelly Dace	2	0	0.32	0.39
White Sucker	16	1	2.70	3.34