Biological Assessment of
Carbon Run and Treatment System #42

Report prepared by Trout Unlimited

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Introduction:

Trout Unlimited (TU) provided technical assistance to the Northumberland County Conservation District (NCCD) to document current biological communities and water quality in Carbon Run, a tributary to Shamokin Creek in the Susquehanna River basin, with respect to the rehabilitation of the Site 42 abandoned mine drainage (AMD) passive treatment system. Carbon Run is currently listed as impaired by the Pennsylvania Department of Environmental Protection (DEP). Funding for this project was provided through a grant from Williams Transcontinental Pipeline.

TU field staff, assisted by NCCD staff, visited Carbon Run on two occasions in 2017 to assess biological communities and collect water quality samples. The sample locations were located on land owned and managed by the Anthracite Outdoor Adventure Area (AOAA). AOAA staff assisted TU and NCCD staff in obtaining safe access to the sample locations that are within the off-road park on old coal mine refuse land. The stream channel and surrounding landscape have been altered from generations of coal mining practices. Sparse vegetation, erosion, and sedimentation are evident throughout the upper reaches of the watershed as Carbon Run passes through large expanses of abandoned coal mine land currently being used by 4WD vehicles as an off-road park.

Four sites were surveyed for water quality and two sites were surveyed for biological communities (Table 1; Figure 1). Water quality samples were collected on the main stem of Carbon Run upstream of the passive treatment system (CR01), the outflow of vertical flow pond

1 (CR02), the final effluent of the treatment system (CR03), and on the main stem of Carbon Run approximately 300 meters downstream of where the final effluent rejoins the main stem (CR04) (Figure 2). Fishery and benthic macroinvertebrate samples were collected from Carbon Run at sites CR01 and CR04.

Table 1: Site locations within the Carbon Run watershed and treatment site #42

Site ID	Latitude	Longitude	Location Description
CR01	40.771301	-76.61728	Carbon Run upstream of site 42
CR02	40.772161	-76.614807	Effluent of vertical flow pond 1 in site 42
CR03	40.77206	-76.611384	Final effluent channel at site 42
CR04	40.771845	-76.608221	Carbon Run ~300m downstream of final effluent

Figure 1: Sampling locations within the Carbon Run watershed and treatment system #42.

Methods:

DEP Instream Comprehensive Evaluation (ICE) protocols were followed for water quality monitoring. A Swoffer 3000 flow meter was used to measure flow in stream and a graduated bucket and stop watch were used to collect point flows from the treatment system during each sampling event. Samples were preserved and kept on ice and delivered to DEP approved laboratory, Mahaffey Lab, for analysis. Loadings were calculated based on metal concentrations and using the following formula:

Pounds/Year *= Flow (GPM) x metal concentration (mg/L) x 3.784 L/gal x 0.001g/mg x 0.002lb/g x 1,440 min/day x 365 days/year*

Benthic macroinvertebrate collections were made according to DEP's ICE protocol (specifically section C.1.b. *Antidegradation Surveys*). In short, benthic macroinvertebrate samples consisted of a combination of six D-frame efforts in a 100-meter stream section. These efforts were spread out so as to select the best riffle habitat areas with varying depths. Each effort consisted of an area of 1 m^2 to a depth of at least 4 inches as substrate allowed and was conducted with a 500 micron mesh 12-inch diameter D-frame kick net. The six individual efforts were composited and preserved with ethanol for processing in the laboratory. Individuals were identified by taxonomists certified by the North American Benthological Society to genus or to the next highest possible taxonomic level. Samples containing 160 to 240 individuals were evaluated according to the six metrics comprising the DEP's Index of Biological Integrity (IBI) (Total Taxa Richness, EPT Taxa Richness, Beck's Index V.3, Shannon Diversity, Hilsenhoff Biotic Index, and Percent Sensitive Individuals). Appendix A contains a description of each of these six metrics. These metrics were standardized and used to determine if the stream met the Aquatic Life Use (ALU) threshold for coldwater fishes, warmwater fishes, and trout stocked fishes.

Fisheries data were collected using battery powered backpack electrofishing gear using pulsed direct current. A Smith-Root model LR-24 backpack electrofisher was used for the surveys. Electrofishing proceeded straight upstream from the beginning of each sample site. All fish observed by the field crew were identified in the field and a subjective abundance rating was assigned to each species based on Pennsylvania Fish and Boat Commission (PFBC) protocol.

Results:

Water Quality

Altered stream channel and habitat was observed throughout the watershed. Large refuse piles and tailings make up the stream banks and, although sparsely revegetated, are notably altered and unnatural. Water samples were collected during both high and low flow events to better characterize pollutants (Table 2). Due to the subsurface collection of raw, untreated water entering treatment system #42, a raw sample was not collected. Annual potential loadings and percent reductions in parameters for sites CR01 and CR04 are shown in Table 3. Alkalinity increased by as much as 500% from site CR01 to CR04 during the high flow sampling event and acidity was neutralized during both events. Overall, metals were reduced between sites CR01 and CR04 during both sampling events. Aluminum was reduced below the level of detection during the high flow event.

Table 2: Water quality results from the four sampling locations. Data in red text show concentrations that exceeded the threshold for aquatic life according to DEP Ch. 93 water quality standards.

Site ID	**CR01**		**CR02**		**CR03**		**CR04**	
Date	**2/8/17**	**6/5/17**	**2/8/17**	**6/5/17**	**2/8/17**	**6/5/17**	**2/8/17**	**6/5/17**
Field Temp. (C)	5.7	13.2	4.1	17.8	8.1	11	5.8	14.9
Lab pH	4.9	6	7.6	6.4	6.7	6.6	7.4	6.4
Specific Conductance (µs)	94	121	285	306	290	462	182	210
Alkalinity (Mg/L)	5	13	42	57	38	148	25	40
Acidity (Mg/L)	10	15	-27	-31	-25	-117	-11	-13
Iron (Mg/L)	0.42	1.49	0.25	0.33	6.22	13.04	0.35	0.23
Manganese (Mg/L)	0.36	0.23	0.18	0.59	1.48	1.97	0.2	0.25
Aluminum (Mg/L)	0.37	**0.55**	<0.05	<0.05	<0.05	<0.05	0.1	<0.05
Sulfate (Mg/L)	31	39	91	92	88	84	56	59
Suspended Solids (Mg/L)	<5	7	<5	4	6	28	<5	6
Total Dissolved Solids (Mg/L)	58	86	171	209	175	297	113	139
Flow (GPM)	80	52	111	195	12	9	231	528

Table 3: Total maximum annual loadings (lb/year) and % change between sites CR01 and CR04

Site	**CR01**		**CR04**		**% Change**	
Date	2/8/17	6/5/17	2/8/17	6/5/17	2/8/17	6/5/17
Alkalinity (lb/yr)	1,750	4,550	8,751	14,001	+500	+307
Acidity (lb/yr)	3,500	5,251	-3,850	-4,550	-110	-186
Iron (lb/yr)	147	522	123	81	-16	-85
Manganese (lb/yr)	126	81	70	88	-45	+8
Aluminum (lb/yr)	130	193	35	Na	-73	Na
Sulfate (lb/yr)	10,851	13,651	19,602	20,652	+47	+34

Figure 2: NCCD staff collecting a water sample at site CR02 in February, 2017

Benthic Macroinvertebrate Communities

Benthic macroinvertebrate samples were collected in February, 2017 at two locations: upstream and downstream of treatment system #42 (sites CR01 and CR04). Calculated biological metrics for sites CR01 and CR04 showed neither site to be attaining the aquatic life use assigned by DEP (Table 4). In order for a site to be considered attaining its aquatic life use, the IBI score from macroinvertebrate samples collected in the October-May timeframe must be ≥50 (Figure 3). Complete descriptions of the biological metrics discussed below can be found in Appendix A.

Chironomidae was the dominant taxa at both sites. This member of family Diptera can be found in many ecosystems, but when it is found to be the most dominant taxa, and the sample lacks more sensitive taxa such as Ephemeroptera, it is considered to be an indicator of pollution. At site CR01 the second most dominant taxa was the stonefly Leuctra. Leuctra is a known acid tolerant member of the Plecoptera family and can be a fairly reliable indicator of acidification in a stream, especially when observed with low diversity and abundance of mayfly taxa, as was the case at CR01. A complete list of benthic macroinvertebrate taxa and abundancies collected at both sites can be found in table 5. Sedimentation issues may also contribute to the low diversity and abundance of macroinvertebrates in Carbon Run and should be further evaluated (Figures 4a and 4b).

Table 4: Biological metrics and calculated IBI score for sample sites CR01 and CR04. *IBI score not valid due to low number of total individuals in this sample.

Metric	CR01	CR04
	Observed Value	Observed Value
Total Taxa Richness	12	15
EPT Taxa Richness (PTV 0 – 4)	2	5
Beck’s Index, version 3	8	5
Hilsenhoff Biotic Index	4.15	5.72
Shannon Diversity	1.62	0.78
Percent Sensitive Individuals (PTV 0 – 3)	34.7	2.9
IBI SCORE	39.6*	28.1

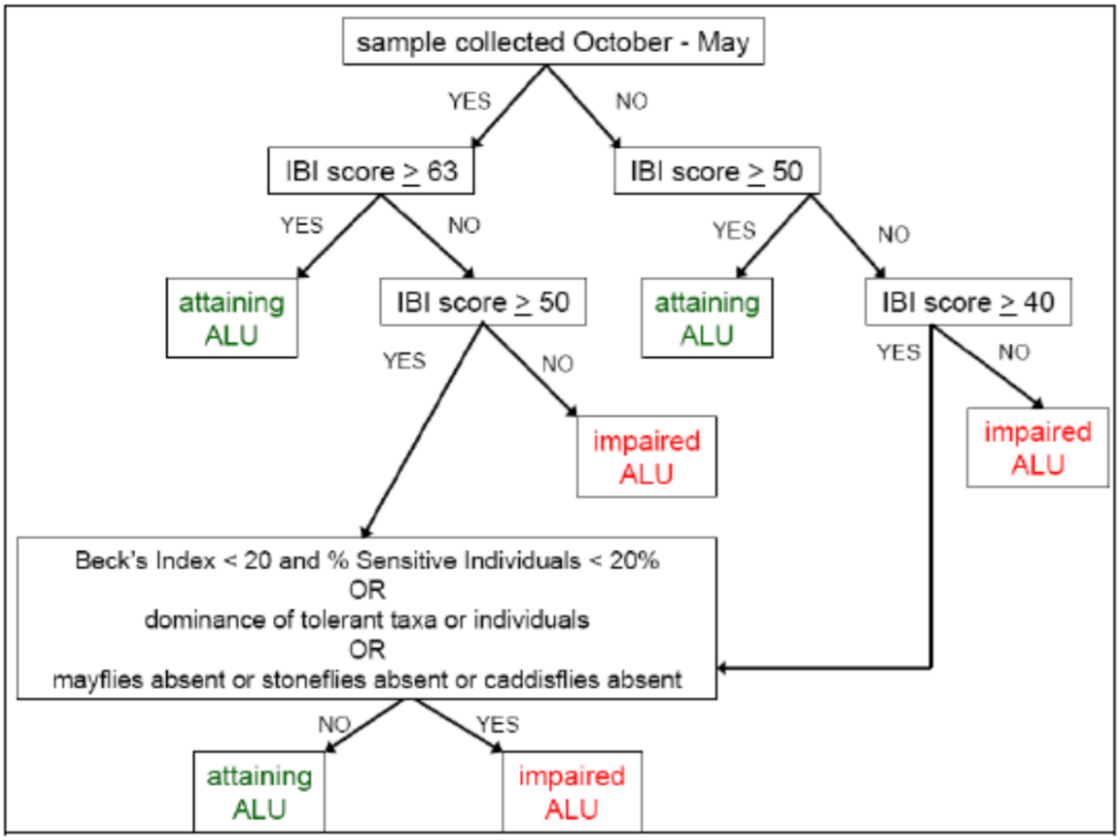

Figure 3: Aquatic life use determination chart for macroinvertebrate sampling.

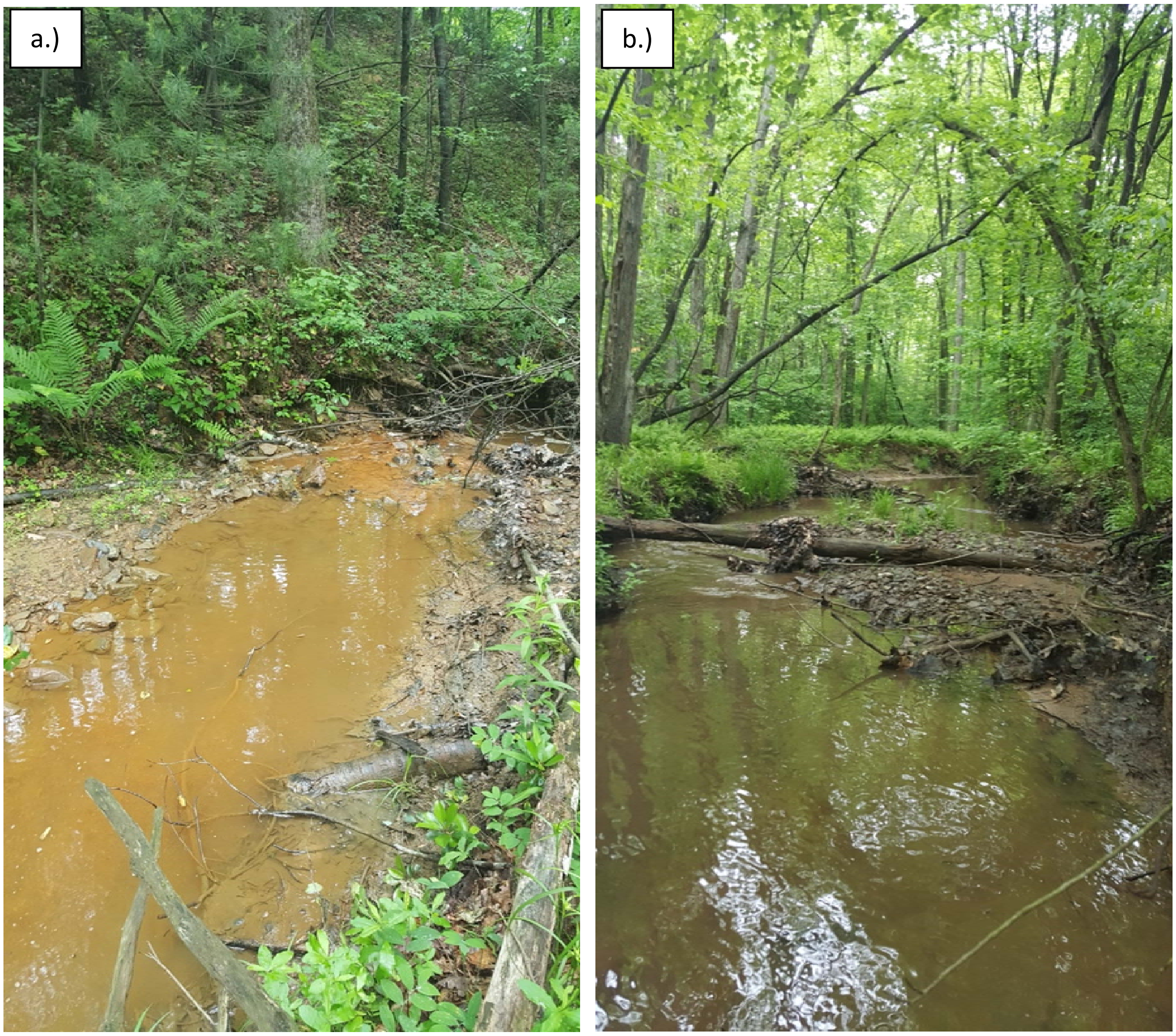

Figure 4: Instream habitat and sediment rich substrate at sites CR01 (a) and CR04 (b).

Table 5: Complete list of taxa and abundancies found at sites CR01 and CR04.

Order	Family	PA Taxon	CR01 # of Individuals	CR04 # of Individuals
		Oligochaeta	4	2
Coleoptera	Elmidae	Stenelmis		1
Diptera	Ceratopogonidae	Bezzia	1	2
		Dasyhelea	1	
	Chironomidae	Chironomidae	53	174
	Empididae	Hemerodromia		3
		Neoplasta		3
	Simuliidae	Prosimulium	3	
		Stegopterna	14	
	Tipulidae	Pseudolimnophila		2
		Tipula	2	
Ephemeroptera	Baetidae	Acerpenna		1
Megaloptera	Corydalidae	Nigronia	3	
	Sialidae	Sialis	4	
Plecoptera	Perlidae	Eccoptura		1
	Capniidae	Allocapnia		1
	Chloroperlidae	Chloroperlidae		1
	Leuctridae	Leuctra	36	
Trichoptera	Hydropsychidae	Cheumatopsyche		1
		Diplectrona	1	
	Philopotamidae	Chimarra		8
	Uenoidae	Neophylax		1
Veneroida	Sphaeriidae	Sphaeriidae	2	
Nemata		Nematoda		4

Fishery Communities

Fishery surveys were completed on Carbon Run at sites consistent with benthic macroinvertebrate sampling: CR01 and CR04. Habitat at both sites did not appear optimal for brook trout (*Salvelinus fontinalis*) (Figures 4a, 4b). In addition to adequate water quality, brook trout require cold, well oxygenated water with stable instream habitat and riparian habitat that provides thermal refuge during warmer times of the year. Eastern Brook Trout Joint Venture

(EBJV) identifies poor land management, increased thermal conditions, and sedimentation as leading threats to brook trout populations throughout their native northeast range. Large areas of sediment and erosion were evident at both sites resulting in the substrate being blanketed by sediment. Creek chub, *Semotilus atromaculatus*, were found to be abundant (>33 individuals) at both sites and blacknose dace, *Rhinichthys atratulus*, were found to be common (9-33 individuals) at site CR04. No salmonid species were found at either location in Carbon Run.

At site CR01 surveys began downstream of a road culvert in the AOAA property that is posing a potential barrier to aquatic organism passage (AOP) (Figure 5a, 5b). No fish species were found upstream of the culvert. The culvert was also in poor condition and deformed from the weight of the road above and erosion of fill material. TU and NCCD staff alerted AOAA staff to the condition of the culvert. AOP status of the culvert should be further evaluated according to North Atlantic Aquatic Connectivity (NAACC) protocols and plans should be made to address the culvert to improve aquatic organism passage and reduce downstream sediment erosion.

Figure 5 a & b: Deformation, outlet drop, and erosion around culvert at site CR01 downstream (a) and deformation and erosion around pipe upstream (b).

APPENDIX A

Description of Instream Comprehensive Evaluation biological metrics that were used in this project.

Total Abundance

The total abundance is the total number of organisms collected in a sample or sub-sample.

Dominant Taxa Abundance

This metric is the total number of individual organisms collected in a sample or sub-subsample that belong to the taxa containing the greatest numbers of individuals.

Taxa Richness

This is a count of the total number of taxa in a sample or sub-sample. This metric is expected to decrease with increasing anthropogenic stress to a stream ecosystem, reflecting loss of taxa and increasing dominance of a few pollution-tolerant taxa.

% EPT Taxa

This metric is the percentage of the sample that is comprised of the number of taxa belonging to the orders Ephemeroptera, Plecoptera, and Trichoptera (EPT). Common names for these orders are mayflies, stoneflies, and caddisflies, respectively. The aquatic life stages of these three insect orders are generally considered sensitive to, or intolerant of, pollution (Lenat and Penrose 1996). This metric is expected to decrease in value with increasing anthropogenic stress to a stream ecosystem, reflecting the loss of taxa from these largely pollution-sensitive orders.

Shannon Diversity Index

The Shannon Diversity Index is a community composition metric that takes into account both taxonomic richness and evenness of individuals across taxa of a sample or sub-sample. In general, this metric is expected to decrease in value with increasing anthropogenic stress to a stream ecosystem, reflecting loss of pollution-sensitive taxa and increasing dominance of a few pollution-tolerant taxa.

Hilsenhoff Biotic Index

This community composition and tolerance metric is calculated as an average of the number of individuals in a sample or sub-sample, weighted by pollution tolerance values. The Hilsenhoff Biotic Index was developed by William Hilsenhoff (Hilsenhoff 1977, 1987; Klemm et al. 1990) and generally increases with increasing ecosystem stress, reflecting dominance of pollution-tolerant organisms. Pollution tolerance values used to calculate this metric are largely based on organic nutrient pollution. Therefore, care should be given when interpreting this metric for stream ecosystems that are largely impacted by acidic pollution from abandoned mine drainage or acid deposition.

Beck's Biotic Index

This metric combines taxonomic richness and pollution tolerance. It is a weighted count of taxa with PTVs of 0, 1, or 2. It is based on the work of William H. Beck in 1955. The metric is expected to decrease in value with increasing anthropogenic stress to a stream ecosystem, reflecting the loss of pollution-sensitive taxa.

Percent (%) Sensitive Individuals

This community composition and tolerance metric is the percentage of individuals with PTVs of 0 to 3 in a sample or sub-sample and is expected to decrease in value with increasing anthropogenic stress to a stream ecosystem, reflecting the loss of pollution-sensitive organisms