

**HERCULES RADFORD ARMY  
AMMUNITION PLANT**

**BENTHIC STUDY**

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## EXECUTIVE SUMMARY

According to the discharge permit issued to the Hercules Radford Army Ammunition Plant (RAAP) by the Department of Environmental Quality, an annual benthic study must be performed to determine if any environmental impact has occurred within the New River as a result of the RAAP's activities. By comparing this year's findings with those from 1988 through 1993, potential long term impact can be determined.

In general, our findings this year indicate that no impairment to the New River is occurring as a result of the RAAP. In comparing the data from the last six years, the overall condition of the New River seems to be good.

## INTRODUCTION

The Hercules Radford Army Ammunition Plant is located near Radford, Virginia; all of its outfalls discharging into the New River. The plant manufactures many types of explosives, ammunitions and rocket fuel. During the sampling event, there was no obvious activity which seemed to have any impact on the New River.

Due to the various river conditions at each station, some of the left bank samples were actually taken at midstream (this is further detailed in the Station Description section). The river bed of the New River is a mixture of sand and cobble with sheets of bedrock, as well as plentiful growths of elodea and other macrophytes. Several deep holes and large boulders periodically complicated sampling. The section of the New River which was sampled had large amounts of vegetation covering both right and left banks showing very little evidence of any severe erosion. Periodic changes in the water level of the New River due to the opening of Claytor Lake dam were possible, however, water level changes were not noted during our sampling period.

## METHODS AND PROCEDURES

Central Virginia Laboratories and Consultants (CVLC) was contracted to perform a qualitative benthic survey during the delegated time frame and in accordance with requirements discussed in the Hercules RAAP NPDES Permit. The methods used in this study were approved by the Department of Environmental Quality before any analysis was performed. This study consisted mainly of benthic macroinvertebrate identification and general observations of each site in terms of bank erosion or other possible signs of impact.

Samples were collected by, M. Yates, E. Carico, R. Foust and J. Stewart all of CVLC, on September 19, 1994 through September 21, 1994. Samples were collected between 0800 and 1630 on each of these days. Eleven stations were studied, ten on the New River and one on Stroubles Creek, each with six subsites. The subsites have been broken down to reflect left and right bank samples. Each subsite has been sampled and analyzed in a separate manner, however, after analysis, data for each station was compiled in order to generate taxa richness, total number of organisms found and a Shannon Weaver Index for that station as requested by the client.

At each station, water was tested for depth, temperature, specific conductance, pH and Dissolved Oxygen.

## Methods and Procedures (Cont'd)

As requested, the presence or absence of Sphaerotilus at each site has been noted.

All comparisons and conclusions drawn from this study have been performed only against historical data which has been generated from the same sites.

Benthic sampling was performed using the Canton modification of the Hess Stream Bottom Sampler. The sampler is a stainless steel cylinder 33 cm in diameter and 51 cm high. Organisms were obtained by scrubbing and dislodging any and all organisms from rocks and debris contained within the sampler. Next, the substrate within the sampler was disturbed to 15 cm below packed surface or until bedrock was reached, allowing benthic organisms to be collected. All samples, once collected, were preserved in a 70% ethanol solution for transport to the laboratory. At the laboratory, all organisms were classified to the lowest practical taxonomic level. Stations 1 and 2, and the upstream site at Station 10 represent reference controls since they are areas outside of RAAP's discharge zone. All other stations are located adjacent to or below RAAP and municipal point discharges.

## Station descriptions

As mentioned earlier, samples were taken from both left and right banks of the New River. The right bank samples were taken to assess areas of direct impact from the RAAP discharges, the left bank samples serve as a comparison for that section of the river. The river is wide enough that the left bank is not directly affected by the RAAP discharges. In some cases, the river current was too swift to safely cross to obtain left bank samples, so in the instances pointed out below, left bank samples were taken from mid-stream.

Station 1 is located just downstream from the State Route 114 bridge, crossing the New River. This site serves as one of the reference sites to which other sites downstream can be compared. The site itself is used as a public boat launch and appeared very polluted as it did in last year's survey. The number of organisms is about the same as last year, however, the number of taxa has increased, and diversity indexes were much higher. The river bed at this site was very sandy and silty. On the right bank a brown detergent-like foam was observed. This is unchanged from last years study. The banks were also muddy and sandy indicating an area of possible erosion. Overall stream conditions at this site have improved since last year. Due to stream depth, right bank samples were taken directly off the right bank and left bank samples were taken directly off the left bank (this is the only site where there is access to both sides of the river). There was no evidence of any Sphaerotilus growth.

### Station descriptions (continued)

Station 2 is also upstream from RAAP activities and is used as a reference site to which downstream sites can be compared. At this station the river appeared normal with no signs of impact or impairment. The river bed is composed of large boulders, bedrock and sand, with a healthy population of elodea and other aquatic macrophytes. Aquatic vegetation was found hanging from trees which suggests that flooding may have occurred. Foam was present along the shore of the river. Samples from this site were taken near the rapids, and left bank samples were taken from mid-stream. There was no evidence of Sphaerotilus growth.

Station 3 is located below the Oleum plant discharge and also has a stormwater outfall which discharges nearby. The river at this station appeared normal with no obvious signs of impact or impairment. There were signs of flooding (fallen trees and exposed tree roots). The left bank samples were taken midstream at the island due to extreme current flow on the other side of the centrally located island. There was no evidence of Sphaerotilus growth.

Station 4 is located directly upstream from the RAAP bridge which crosses the New River. Elodea and other vegetation were found near the shore. No signs of environmental impact or impairment were noted. There was a thick silt layer near the shore, with exposed bedrock and pebbles in center of stream. Blue gills and sculpin were seen throughout this site. Left bank samples were taken from mid-stream. There was no evidence of Sphaerotilus growth.

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**Station descriptions (continued)**

Station 5 is located at the Power Plant effluent discharge point. Near shore the river bed consisted of bedrock with a thin layer of silt and mud. There was filamentous algae near shore, with more vegetation towards the center of the river. The left bank samples were taken mid-stream. There was no evidence of Sphaerotilus growth.

Station 6 is located below the combined effluent discharge. The river bed consisted of pebbles, and is shallow to the center island. On the left bank side of the island the water is much deeper. The island has plentiful vegetation, showing that the middle of the stream has suitable living conditions for vast amounts of vegetation. Stream conditions appear normal; elodea minnows and clam shells were present. There was no evidence of Sphaerotilus growth, consistent with observations since 1990. Ephemeroptera and Trichoptera populations have decreased from last year. However, overall taxa remain the same with the greatest number of taxa being found on the RAAP side of the river. The Shannon-Weaver Index does indicate a drop in diversity at the right bank of this site in comparison with previous years. At this site, sampling transected two thirds of the entire stream width.

Station 7 is located downstream of the Blacksburg-Virginia Polytechnic Institute sewage treatment plant. Floating foam was being discharged from the outfall. Both the right and left banks were densely overgrown with brush and saplings. The river bed was largely composed of small rocks, with little to no silt. Minnows were spotted throughout the stream, as were a flock of geese. There was evidence of Sphaerotilus growth where the Blacksburg/VPI outfall contacted the shore (this observation was confirmed by RAAP

### Station Descriptions (continued)

personnel). Perhaps this would explain why there were much fewer Ephemeroptera and Trichoptera found at this site than in years previous, however, clams and snails were abundant. Again, most of the taxa found were located on the RAAP side of the river, however, the Shannon-Weaver Index showed a drop in diversity at the right bank site in comparison to previous years. This drop has probably been caused by the growth which is present, as was previously discussed. At this site, sampling transected the entire stream width.

Station 8 is located downstream from the Stroubles Creek-New River confluence. This site is also across from the waste-fuel burning area. The stream itself was very shallow with two islands in the center. The right bank was muddy with run-off from Stroubles Creek. The left bank area was normal. Four species of aquatic plants were present including Elodea. There was no evidence of Sphaerotilus growth, consistent with observations since 1989. This station was transected three quarters of the way across when sampled.

Station 9 is located near the lower magazine area. The river bed consisted of small rocks covering bedrock. There was evidence of flooding at the site with exposed tree roots and some erosion noted on the mid-stream island. Several small springs line the right bank of this site and discharge directly into the river. The water current at this site was very steady but calm, schools of small fish were noted in pools. There was no evidence of Sphaerotilus growth.

### **Station descriptions (continued)**

Station 10 is divided into two sections, the upstream and the downstream of the TNT plant on Stroubles Creek. This station was very narrow and was very easy to transect completely. The stream bed was rocky both near shore and in the center. At the "down" position of this site there was floating foam noted, however, there was also a large fish population noted. This would suggest that the presence of foam was only temporary. There was evidence of previous flooding with bank erosion. There was no evidence of Sphaerotilus growth.

Station 11 is the farthest away from the RAAP and is downstream from all of the above stations. This station is fairly new and had not been sampled before 1991. The shore line showed evidence of flooding with fallen trees and disturbed soil. The river bed had elodea and two other species of vegetation. The samples for this site were collected upstream from the riffle zone. Several small fish were spotted at this station, as well as a blue gill. There was no evidence of Sphaerotilus growth at this station.

### **Chemical and Physical Measurements**

Measurements performed in the field included pH, Dissolved Oxygen, temperature and conductivity. The pH and temperature readings were taken using an Orion 250A meter, the Dissolved Oxygen readings were performed using a YSI field meter and the conductivity readings were taken using an Orion meter. All meters were calibrated before measurement at each site.

## **Biological Sampling**

As requested by the contract proposal, biological samples were collected using the Canton Modification of the Hess Stream Bottom Sampler. This sampling method has only been used for the last four sampling events. All sampling events prior to 1991 were performed using a "D" frame kick net. It is important to note, however, when comparing data from 1990 through 1994 to all other historical data, due to different techniques, discrepancies in organism numbers could be noted. For example when sampling with a Hess Bottom sampler, a defined area is all that is sampled, when sampling with a "D" frame kick net an undetermined area is sampled due to the size of the individuals foot, stride or the angle of the foot when kicking. As mentioned earlier, this may not affect the total number of taxa found, however it can affect the actual numbers of each of those taxa found.

At each station, six samples were taken, three representing the right bank transection and three representing the left bank transection. Each of the subsites were kept separate and were preserved in 70% ethanol for transport to the laboratory. Once at the laboratory, the organisms were sorted by station and subsite into order classifications. From the order classifications, the organisms were further sorted into the lowest practical taxonomic classification (Family, Genus and species). Using the findings of the laboratory enumeration, data was compiled to determine taxa richness and the Shannon-Weaver index for diversity.

## RESULTS

### **Chemical Data**

On the days of sample collection, all of the analyses were normal in comparison with historical data. As in the past, the New River had normal pH readings and Dissolved Oxygen readings were suitable for aquatic life, ranging from 7.5 to 11.0 mg/l (see Table I). Temperatures were also constant throughout the river. Stroubles Creek exhibited chemical parameters expected of a mountain stream. The temperatures at Stroubles Creek were much lower than that of the New River (14.7 and 14.6°C as opposed to 19.9 to 21.2°C of the New River). Overall chemical conditions at all of the sites were very good.

### **Biological Data**

The number of organisms collected at each station ranged from 121 found at Station 1 to 319 organisms found at Station 9. Total numbers of taxa ranged from 9 at Station 3 to 18 found at Station 9. Station 1 has shown definite improvement in comparison with the previous year. Overall, the number of taxa found at the stations directly affected by RAAP were higher than what was found in 1992. This would suggest that there has been no impact

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### Biological Data (continued)

to the New River at least within the previous calendar year and in comparing with the last six years of data, the stream bed is continuing to thrive after the stress and severe impairment caused by the Sphaerotilus growth which occurred in the late 1980's.

The Shannon-Weaver Index is a diversity index which calculates the taxa diversity of the organisms found during the survey. The Shannon-Weaver Index was calculated using a Log Base 2 conversion. In comparing with historical data, it appears that Log Base 2 was used in the studies previous to 1993. There is no notation of which Log Base has been used, however, the numbers in the historical data are within the same ranges so the assumption is being made, while making comparisons, that the previous data is in Log Base 2.

In comparison with the historical data, the taxa diversity has changed somewhat this year. Station 1 is a reference site and has significantly improved within the last year. Overall, taxa diversity showed no signs of impairment as a result of Hercules RAAP discharges. Stations 6 and 7 did show a slight decrease in diversity in comparison with last year, this could be attributed to the flooding which appeared evident at the time of sampling, or by the Sphaerotilus growth which was found to be present at Station 7.

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**Biological Data (continued)**

In the 1991, 1992 and 1993 surveys, the river was dominated by Mayflies and clams. This appears to be true for the 1994 survey as well. The fact that the Mayflies (Ephemeroptera) are present shows that the river is in good condition. Mayflies are a pollutant sensitive insect and can therefore be very indicative of the quality of the water conditions in a river system. The fact that they have been thriving for the last several years shows that river conditions are favorable for aquatic life. In 1990 there was a noticeable drop in the number of clams found; in 1991 they were again dominant and the 1992 report does not have any reference to them. They were another dominant species found during the 1993 and 1994 survey; however, they are a very pollution tolerant species and their presence may or may not give any indication as to the water quality. CVLC feels that the presence of the mayflies, and to a much lesser extent the presence of the clams, indicates that water conditions continue to remain favorable for all types aquatic life (both tolerant and intolerant species).

## CONCLUSIONS

This study was performed to determine if any impact has occurred to the New River as a result of activities performed by Hercules Radford Army Ammunition Plant. In comparison with historical data, in particular last years' data, insect population (in terms of numbers not taxa) have decreased. This could be due to the flooding of which we found much evidence. The 1994 study suggests that river conditions are favorable at all stations (except for Stations 6 and 7 which was previously explained) for aquatic life and that there are no negative impacts on the New River as a result of the activities of Hercules RAAP.

**TABLE I**  
**Organism density per Site and Station**

Station # 1

<u>Insecta</u>	Right Bank				Left Bank			
	1	2	3	Total	1	2	3	Total
Ephemeroptera								
Heptageniidae <u>Stenonema</u>								
<u>Arthroplea</u>								
Siphonuridae <u>Isonychia</u>	11			11	3	2	7	12
Baetidae <u>Beatis</u>							2	2
<u>Pseudocloeon</u>								
Ephemeridae <u>Ephemera</u>								
Odonata								
(Zygoptera) Coenagrionidae <u>Argia</u>								
(Anisoptera) Gomphidae <u>Gomphus</u>	1			1			1	1
Trichoptera								
Hydroptilidae spp.								
Hydropsychidae <u>Hydropsyche</u>							1	1
Brachycentridae <u>Brachycentrus</u>								
Helicopsychidae <u>Helicopsyche</u>								
Megaloptera								
Sialidae <u>Sialis</u>								
Corydalidae <u>Corydalus</u>								
Diptera								
Chironimidae	4			4	2	1	5	8
Simulidae								
Plecoptera								
Perlidae <u>Perlinella</u>								
Neuroptera <u>Sisrydae</u>								

2

Organism density per Site and Station

Station # 1

<u>Insecta</u> , Continued	Right Bank				Left Bank			
	1	2	3	Total	1	2	3	Total
Diptera								
Tipulidae							1	1
Coleoptera			1	1			3	3
Elmidae <u>Stenelmis</u>							2	2
Psephenidae <u>Psephenus</u>								
<u>Non-Insecta</u>								
Annelida								
(Oligochaeta) Tubificidae	8	3	9	20	12	8		20
Naididae								
(Hirudinea) Hirudinidae								
Amphipoda								
Gammaridae <u>Gammarus</u>	3	4		7	4	1	6	11
Turbellaria								
(Tricladida) Planariidae <u>Dugesia</u>								
Decapoda								
Astacidae <u>Cambarus</u>								
Pelecypoda								
Corbiculidae <u>Corbicula</u>	4	3	3	10		5	1	6
Gastropoda								

2

Organism density per Site and Station

Station # 2

<u>Insecta</u>	Right Bank				Left Bank			
	1	2	3	Total	1	2	3	Total
Ephemeroptera								
Heptageniidae <u>Stenonema</u>								
<u>Arthoplea</u>								
Siphonuridae <u>Isonychia</u>	12	5	7	24	6	2	3	11
Baetidae <u>Beatis</u>	1		4	5	3			3
<u>Pseudocloeon</u>								
Ephemeridae <u>Ephemera</u>							1	1
Odonata								
(Zygoptera) Coenagrionidae <u>Argia</u>								
(Anisoptera) Gomphidae <u>Gomphus</u>								
Trichoptera								
Hydroptilidae spp.								
Hydropsychidae <u>Hydropsyche</u>	61	21	3	85	41	15	14	70
Brachycentridae <u>Brachycentrus</u>								
Helicopsychidae <u>Helicopsyche</u>	5		1	6		2	1	3
Megaloptera								
Sialidae <u>Sialis</u>								
Corydalidae <u>Corydalus</u>								
Diptera								
Chironimidae	2	6	12	20	12	2	5	19
Simuliidae								
Plecoptera								
Perlidae <u>Perlinella</u>			1	1				
Neuroptera <u>Sisyridae</u>								

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Organism density per Site and Station

Station # 2

Insecta, Continued	Right Bank				Left Bank			
	1	2	3	Total	1	2	3	Total
Diptera								
Tipulidae								
Coleoptera								
Elmidae <u>Stenelmis</u>	3	1		4	2	2	1	5
Psephenidae <u>Psephenus</u>								
Non-Insecta								
Annelida								
(Oligochaeta) Tubificidae		1		1				
Naididae								
(Hirudinea) Hirudinidae								
Amphipoda								
Gammaridae <u>Gammarus</u>	4	2	19	25	5	5	7	17
Turbellaria								
(Tricladida) Planariidae <u>Dugesia</u>								
Decapoda								
Astacidae <u>Cambarus</u>								
Pelecypoda								
Corbiculidae <u>Corbicula</u>	2	1	1	4				
Gastropoda								

Organism density per Site and Station

Station # 3

Insecta	Right Bank				Left Bank			
	1	2	3	Total	1	2	3	Total
Ephemeroptera								
Heptageniidae <u>Stenonema</u>								
<u>Arthoplea</u>								
Siphonuridae <u>Isonychia</u>					2			2
Baetidae <u>Beatis</u>								
<u>Pseudocloeon</u>								
Ephemeridae <u>Ephemera</u>								
Odonata								
(Zygoptera) Coenagrionidae <u>Argia</u>								
(Anisoptera) Gomphidae <u>Gomphus</u>	1			1				
Trichoptera								
Hydroptilidae spp.								
Hydropsychidae <u>Hydropsyche</u>	1	1	3	5	2			2
Brachycentridae <u>Brachycentrus</u>								
Helicopsychidae <u>Helicopsyche</u>								
Megaloptera								
Sialidae <u>Sialis</u>								
Corydalidae <u>Corydalus</u>								
Diptera								
Chironimidae	1			1	1	6	7	14
Simulidae								
Plecoptera								
Perlidae <u>Perlinella</u>								
Neuroptera <u>Sisyridae</u>								

Organism density per Site and Station

Station # 3

<u>Insecta</u> , Continued	Right Bank				Left Bank			
	1	2	3	Total	1	2	3	Total
Diptera								
Tipulidae								
Coleoptera								
Elmidae <u>Stenelmis</u>	5	6	3	14	5	8		13
Psephenidae <u>Psephenus</u>								
<u>Non-Insecta</u>								
Annelida								
(Oligochaeta) Tubificidae					3			3
Naididae								
(Hirudinea) Hirudinidae								
Amphipoda								
Gammaridae <u>Gammarus</u>						1		1
Turbellaria								
(Tricladida) Planariidae <u>Dugesia</u>								
Decapoda								
Astacidae <u>Cambarus</u>								
Pelecypoda								
Corbiculidae <u>Corbicula</u>	3	5	9	17	10		1	11
Gastropoda	3	4	45	52	7	1		8

Organism density per Site and Station

Station # 4

<u>Insecta</u>	Right Bank				Left Bank			
	1	2	3	Total	1	2	3	Total
Ephemeroptera								
Heptageniidae <u>Stenonema</u>					4		1	5
<u>Arthroplea</u>								
Siphonuridae <u>Isonychia</u>	4	2	2	8	4	2	4	10
Baetidae <u>Beatis</u>	1			1	7	2	1	10
<u>Pseudocloeon</u>		1		1				
Ephemeridae <u>Ephemera</u>								
Odonata								
(Zygoptera) Coenagrionidae <u>Argia</u>								
(Anisoptera) Gomphidae <u>Gomphus</u>	1	2		3				
Trichoptera								
Hydroptilidae spp.								
Hydropsychidae <u>Hydropsyche</u>					1	2	2	5
Brachycentridae <u>Brachycentrus</u>	1			1				
Helicopsychidae <u>Helicopsyche</u>								
Megaloptera								
Sialidae <u>Sialis</u>								
Corydalidae <u>Corydalus</u>								
Diptera								
Chironimidae	1			1				
Simulidae								
Plecoptera								
Perlidae <u>Perlinella</u>								
Neuroptera <u>Sisyridae</u>								

Organism density per Site and Station

Station # 4

<u>Insecta</u> , Continued	Right Bank				Left Bank			
	1	2	3	Total	1	2	3	Total
Diptera								
Tipulidae								
Coleoptera								
Elmidae <u>Stenelmis</u>	3		2	5	7	1	10	18
Psephenidae <u>Psephenus</u>								
<u>Non-Insecta</u>								
Annelida								
(Oligochaeta) Tubificidae	4			4	3		3	6
Naididae								
(Hirudinea) Hirudinidae								
Amphipoda								
Gammaridae <u>Gammarus</u>	1			1	4	6	15	25
Turbellaria								
(Tricladida) Planariidae <u>Dugesia</u>								
Decapoda								
Astacidae <u>Cambarus</u>								
Pelecypoda								
Corbiculidae <u>Corbicula</u>	1	1	1	3	2	23	88	114
Gastropoda		3	26	29	17	3	14	34

Organism density per Site and Station

Station # 5

Insecta	Right Bank				Left Bank			
	1	2	3	Total	1	2	3	Total
Ephemeroptera								
Heptageniidae <u>Stenonema</u>						1	1	2
<u>Arthroplea</u>								
Siphonuridae <u>Isonychia</u>	14	17		31		3	4	7
Baetidae <u>Beatis</u>	1	1		2	1	1	1	3
<u>Pseudocloeon</u>								
Ephemeridae <u>Ephemera</u>								
Odonata								
(Zygoptera) Coenagrionidae <u>Argia</u>								
(Anisoptera) Gomphidae <u>Gomphus</u>			1	1				
Trichoptera								
Hydroptilidae spp.			1	1				
Hydropsychidae <u>Hydropsyche</u>	2		14	16				
Brachycentridae <u>Brachycentrus</u>	1			1				
Helicopsychidae <u>Helicopsyche</u>								
Megaloptera								
Sialidae <u>Sialis</u>								
Corydalidae <u>Corydalus</u>			1	1				
Diptera								
Chironimidae	1	1		2		7	2	9
Simuliidae								
Plecoptera								
Perlidae <u>Perlinella</u>								
Neuroptera <u>Sisyridae</u>								

Organism density per Site and Station

Station # 5

Insecta, Continued	Right Bank				Left Bank			
	1	2	3	Total	1	2	3	Total
Diptera								
Tipulidae								
Coleoptera								
Elmidae <u>Stenelmis</u>							1	1
Psephenidae <u>Psephenus</u>		1		1			1	1
<u>Non-Insecta</u>								
Annelida								
(Oligochaeta) Tubificidae	2	1	4	7	1	1	1	3
Naididae								
(Hirudinea) Hirudinidae			1	1	1			1
Amphipoda								
Gammaridae <u>Gammarus</u>	1	2		3		3	1	4
Turbellaria								
(Tricladida) Planariidae <u>Dugesia</u>								
Decapoda								
Astacidae <u>Cambarus</u>								
Pelecypoda								
Corbiculidae <u>Corbicula</u>		6	21	27				
Gastropoda					2	1		3

Organism density per Site and Station

Station # 6

Insecta	Right Bank				Left Bank			
	1	2	3	Total	1	2	3	Total
Ephemeroptera								
Heptageniidae <u>Stenonema</u>								
<u>Arthoplea</u>								
Siphonuridae <u>Isonychia</u>			1	1				
Baetidae <u>Beatis</u>								
<u>Pseudocloeon</u>								
Ephemeridae <u>Ephemera</u>						1		1
Odonata								
(Zygoptera) Coenagrionidae <u>Argia</u>								
(Anisoptera) Gomphidae <u>Gomphus</u>								
Trichoptera								
Hydroptilidae spp.								
Hydropsychidae <u>Hydropsyche</u>	1			1				
Brachycentridae <u>Brachycentrus</u>								
Helicopsychidae <u>Helicopsyche</u>								
Megaloptera								
Sialidae <u>Sialis</u>								
Corydalidae <u>Corydalus</u>								
Diptera								
Chironimidae		3		3				
Simuliidae								
Plecoptera								
Perlidae <u>Perlinella</u>								
Neuroptera <u>Sisrydae</u>								

Organism density per Site and Station

Station # 6

Insecta, Continued	Right Bank				Left Bank			
	1	2	3	Total	1	2	3	Total
Diptera								
Tipulidae								
Coleoptera								
Elmidae <u>Stenelmis</u>	3	2	1	6				
Psephenidae <u>Psephenus</u>			1	1				
<u>Non-Insecta</u>								
Annelida								
(Oligochaeta) Tubificidae			3	3	2	2	1	5
Naididae			2	2				
(Hirudinea) Hirudinidae								
Amphipoda								
Gammaridae <u>Gammarus</u>	4		1	5	4	2	3	9
Turbellaria								
(Tricladida) Planariidae <u>Dugesia</u>								
Decapoda								
Astacidae <u>Cambarus</u>								
Pelecypoda								
Corbiculidae <u>Corbicula</u>	1	92	20	117			2	2
Gastropoda		3	6	9	2	2	2	6

Organism density per Site and Station

Station # 7

Insecta	Right Bank				Left Bank			
	1	2	3	Total	1	2	3	Total
Ephemeroptera								
Heptageniidae <u>Stenonema</u>								
<u>Arthroplea</u>								
Siphonuridae <u>Isonychia</u>						1		1
Baetidae <u>Beatis</u>		1		1				
<u>Pseudocloeon</u>								
Ephemeridae <u>Ephemera</u>			1	1				
Odonata								
(Zygoptera) Coenagrionidae <u>Argia</u>								
(Anisoptera) Gomphidae <u>Gomphus</u>			1	1		1	1	2
Trichoptera								
Hydroptilidae spp.		1		1				
Hydropsychidae <u>Hydropsyche</u>	2			2				
Brachycentridae <u>Brachycentrus</u>			1	1				
Helicopsychidae <u>Helicopsyche</u>		1	1	2	1			1
Megaloptera								
Sialidae <u>Sialis</u>								
Corydalidae <u>Corydalus</u>								
Diptera								
Chironimidae							2	2
Simulidae								
Plecoptera								
Perlidae <u>Perlinella</u>								
Neuroptera <u>Sisyridae</u>								

Organism density per Site and Station

Station # 7

Insecta, Continued	Right Bank				Left Bank			
	1	2	3	Total	1	2	3	Total
Diptera								
Tipulidae								
Coleoptera								
Elmidae <u>Stenelmis</u>					1	1		2
Psephenidae <u>Psephenus</u>								
<u>Non-Insecta</u>								
Annelida								
(Oligochaeta) Tubificidae		1	2	3	2	2	4	8
Naididae								
(Hirudinea) Hirudinidae								
Amphipoda								
Gammaridae <u>Gammarus</u>			3	3		1		1
Turbellaria								
(Tricladida) Planariidae <u>Dugesia</u>		3		3				
Decapoda								
Astacidae <u>Cambarus</u>								
Pelecypoda								
Corbiculidae <u>Corbicula</u>	16	50	42	108	11	21	2	34
Gastropoda	2	2	2	6	8	7	14	29

Organism density per Site and Station

Station # 8

Insecta	Right Bank				Left Bank			
	1	2	3	Total	1	2	3	Total
Ephemeroptera								
Heptageniidae <u>Stenonema</u>	1			1	1	1	4	6
<u>Arthoplea</u>								
Siphonuridae <u>Isonychia</u>					5	1		6
Baetidae <u>Beatis</u>	1			1	6	1		7
<u>Pseudocloeon</u>					2			2
Ephemeridae <u>Ephemera</u>								
Odonata								
(Zygoptera) Coenagrionidae <u>Argia</u>								
(Anisoptera) Gomphidae <u>Gomphus</u>						2		2
Trichoptera								
Hydroptilidae spp.								
Hydropsychidae <u>Hydropsyche</u>	1		1	2	3	1		4
Brachycentridae <u>Brachycentrus</u>						2		2
Helicopsychidae <u>Helicopsyche</u>								
Megaloptera								
Sialidae <u>Sialis</u>								
Corydalidae <u>Corydalus</u>								
Diptera								
Chironimidae								
Simulidae								
Plecoptera								
Perlidae <u>Perlinella</u>								
Neuroptera <u>Sisyridae</u>								

Organism density per Site and Station

Station # 8

<u>Insecta</u> , Continued	Right Bank				Left Bank			
	1	2	3	Total	1	2	3	Total
Diptera								
Tipulidae								
Coleoptera								
Elmidae <u>Stenelmis</u>	6	1	3	10	6	1		7
Psephenidae <u>Psephenus</u>							2	2
<u>Non-Insecta</u>								
Annelida								
(Oligochaeta) Tubificidae	2			2				
Naididae								
(Hirudinea) Hirudinidae								
Amphipoda								
Gammaridae <u>Gammarus</u>					13			13
Turbellaria								
(Tricladida) Planariidae <u>Dugesia</u>								
Decapoda								
Astacidae <u>Cambarus</u>					1			1
Pelecypoda								
Corbiculidae <u>Corbicula</u>	27		22	49	12	33	27	72
Gastropoda	6	6	3	15	1	25	4	30

Organism density per Site and Station

Station # 9

<u>Insecta</u>	Right Bank				Left Bank			
	1	2	3	Total	1	2	3	Total
Ephemeroptera								
Heptageniidae <u>Stenonema</u>					1			1
<u>Arthroplea</u>								
Siphonuridae <u>Isonychia</u>			1	1	6			6
Baetidae <u>Beatis</u>					1	3		4
<u>Pseudocloeon</u>					1			1
Ephemeridae <u>Ephemera</u>								
Odonata								
(Zygoptera) Coenagrionidae <u>Argia</u>								
(Anisoptera) Gomphidae <u>Gomphus</u>			1	1	3			3
Trichoptera								
Hydroptilidae spp.							3	3
Hydropsychidae <u>Hydropsyche</u>	1	14	2	17	8	3	4	15
Brachycentridae <u>Brachycentrus</u>								
Helicopsychidae <u>Helicopsyche</u>								
Megaloptera								
Sialidae <u>Sialis</u>								
Corydalidae <u>Corydalus</u>					3			3
Diptera								
Chironimidae	5	2		7				
Simuliidae								
Plecoptera								
Perlidae <u>Perlinella</u>								
Neuroptera <u>Sisyridae</u>								

Organism density per Site and Station

Station # 9

Insecta, Continued	Right Bank				Left Bank			
	1	2	3	Total	1	2	3	Total
Diptera								
Tipulidae			1	1	2			2
Coleoptera					1			1
Elmidae <u>Stenelmis</u>	10	6	2	18	7		4	11
Psephenidae <u>Psephenus</u>	1			1				
<u>Non-Insecta</u>								
Annelida								
(Oligochaeta) Tubificidae	1		2	3	2			2
Naididae								
(Hirudinea) Hirudinidae								
Amphipoda								
Gammaridae <u>Gammarus</u>	1		2	3	28			28
Turbellaria								
(Tricladida) Planariidae <u>Dugesia</u>	1			1				
Decapoda								
Astacidae <u>Cambarus</u>								
Pelecypoda								
Corbiculidae <u>Corbicula</u>	22	10	4	36	24	18	81	123
Gastropoda	4			4	3	2	18	23

Organism density per Site and Station

Station # 10

Insecta	Right Bank (Up)				Left Bank (Down)			
	1	2	3	Total	1	2	3	Total
Ephemeroptera								
Heptageniidae <u>Stenonema</u>					2			2
<u>Arthoplea</u>								
Siphonuridae <u>Isonychia</u>	1			1	5			5
Baetidae <u>Beatis</u>	1	1	5	7	5			5
<u>Pseudocloeon</u>								
Ephemeridae <u>Ephemera</u>								
Odonata								
(Zygoptera) Coenagrionidae <u>Argia</u>								
(Anisoptera) Gomphidae <u>Gomphus</u>								
Trichoptera								
Hydroptilidae spp.								
Hydropsychidae <u>Hydropsyche</u>	8	2	18	28	34			34
Brachycentridae <u>Brachycentrus</u>								
Helicopsychidae <u>Helicopsyche</u>	1		1	2	5			5
Megaloptera								
Sialidae <u>Sialis</u>								
Corydalidae <u>Corydalus</u>	1			1				
Diptera								
Chironimidae		2	3	5	5		2	7
Simulidae								
Plecoptera								
Perlidae <u>Perlinella</u>								
Neuroptera <u>Sisyridae</u>								

Organism density per Site and Station

Station # 10

<u>Insecta</u> , Continued	Right Bank (Up)				Left Bank (Down)			
	1	2	3	Total	1	2	3	Total
Diptera								
Tipulidae	1		41	42				
Coleoptera								
Elmidae <u>Stenelmis</u>	4	6	4	14	36	2	5	43
Psephenidae <u>Psephenus</u>	13	2	8	23	7	7	1	15
<u>Acneus</u>								
<u>Non-Insecta</u>								
Annelida								
(Oligochaeta) Tubificidae					3	1		4
Naididae								
(Hirudinea) Hirudinidae					3			3
Amphipoda								
Gammaridae <u>Gammarus</u>								
Turbellaria								
(Tricladida) Planariidae <u>Dugesia</u>								
Decapoda								
Astacidae <u>Cambarus</u>								
Pelecypoda								
Corbiculidae <u>Corbicula</u>								
Gastropoda								

Organism density per Site and Station

Station # 11

Insecta	Right Bank				Left Bank			
	1	2	3	Total	1	2	3	Total
Ephemeroptera								
Heptageniidae <u>Stenonema</u>	1			1		1	1	2
<u>Arthoplea</u>								
Siphonuridae <u>Isonychia</u>	1		2	3			3	3
Baetidae <u>Beatis</u>		1		1	1	3		4
<u>Pseudocloeon</u>								
Ephemeridae <u>Ephemera</u>						1		1
Odonata								
(Zygoptera) Coenagrionidae <u>Argia</u>								
(Anisoptera) Gomphidae <u>Gomphus</u>								
Trichoptera								
Hydroptilidae spp.								
Hydropsychidae <u>Hydropsyche</u>	3		13	16	1	2	11	14
Brachycentridae <u>Brachycentrus</u>							1	1
Helicopsychidae <u>Helicopsyche</u>								
Megaloptera								
Sialidae <u>Sialis</u>								
Corydalidae <u>Corydalus</u>								
Diptera								
Chironimidae	6	7	1	14	1	1	11	13
Simulidae								
Plecoptera								
Perlidae <u>Perlinella</u>								
Neuroptera <u>Sisyridae</u>								

Organism density per Site and Station

Station # 11

Insecta, Continued	Right Bank				Left Bank			
	1	2	3	Total	1	2	3	Total
Diptera								
Tipulidae								
Coleoptera								
Elmidae <u>Stenelmis</u>	5		16	21	3	1	2	6
Psephenidae <u>Psephenus</u>						1		1
Non-Insecta								
Annelida								
(Oligochaeta) Tubificidae			1	1			1	1
Naididae								
(Hirudinea) Hirudinidae								
Amphipoda								
Gammaridae <u>Gammarus</u>		1		1			3	3
Turbellaria								
(Tricladida) Planariidae <u>Dugesia</u>								
Decapoda								
Astacidae <u>Cambarus</u>								
Pelecypoda								
Corbiculidae <u>Corbicula</u>	10	4	27	41	3	30	27	60
Gastropoda	2		3	5	2	4		6

**TABLE II****DIVERSITY INDEX FOR SAMPLING STATIONS**

September 1994 Study

Station #	1	2	3	4	5	6	7	8	9	10	11
Total Organisms	121	304	144	284	128	171	212	234	319	246	219
Total Taxa	11	11	9	13	16	11	15	14	18	12	13
Right Bank (d)Up	2.88	2.31	1.70	2.43	2.63	1.32	1.26	2.10	3.01	2.44	5.15
Left Bank (d)Down	3.44	2.06	2.57	2.59	2.96	2.02	2.02	2.55	2.37	2.60	4.88

(d)=Shannon Weaver Index for Diversity (In Base 2)

**TABLE III**

**TOTAL TAXA, RIGHT BANK VS. LEFT BANK**

September 1994 Study

Station #	1	2	3	4	5	6	7	8	9	10	11
Right Bank (Up)	7	10	6	11	13	10	12	7	12	9	10
Left Bank (Down)	11	8	8	9	10	5	9	13	15	10	13

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TABLE IV

## PERCENT COMPOSITION PER STATION

September 1994 Study

Station #	1	2	3	4	5	6	7	8	9	10	11
Total # of Org.	121	304	144	284	128	171	212	234	319	246	219
<u>TAXA</u>	*	*	*	*	*	*	*	*	*	*	*
Ephemeroptera	21	14	1.4	12	35	1	1	10	4	8	7
Odonata	2	0	0.7	1	0.7	0	1	1	1.3	0	0
Trichoptera	1	54	5	2	14	0.5	3	3.4	11	28	14
Megaloptera	0	0	0	0	0.7	0	0	0	1	0.4	0
Diptera	8	13	10	1	9	2	0.9	0	3	22	12
Plecoptera	0	0.3	0	0	0	0	0	0	0	0	0
Neuroptera	0	0	0	0	0	0	0	0	0	0	0
Coleoptera	5	3	19	8	2	4	0.9	8	10	39	13
Annelida	33	0.3	2	3.5	9	6	7	1	2	0	1
Amphipoda	15	14	0.7	9	5	8	2	6	10	3	2
Decapoda	0	0	0	0	0	0	0	0.4	0	0	0
Pelecypoda	13	1.3	19	41	21	70	67	52	50	0	46
Gastropoda	0	0	42	22	2	9	17	19	8	0	5

Number of Organisms (% Taxa)

TABLE V

WATER CHEMISTRY FOR RAAP BENTHIC STUDY

September 1994 Study

Station #	Water Depth (cm)	Temp. °C	Specific conductance (umhos)	pH (S.U.)	Dissolved Oxygen (mg/l)
1	0-122	21.2	104	8.34	9.3
2	0-107	19.9	103	7.57	8.9
3	0-132	20.7	102	8.32	9.1
4	0-112	21.0	110	7.53	8.8
5	0-128	21.0	105	7.86	9.0
6	0-162	20.7	101	8.08	8.7
7	0-147	20.7	101	7.89	7.5
8	0-137	20.5	101	7.10	8.2
9	0-96	21.4	110	8.16	8.5
10 Up	0-125	14.7	479	8.36	11.0
10 Down	0-53	14.6	469	8.35	9.3
11	0-76	20.1	118	8.20	9.1

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**REFERENCES**

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Radford Army Ammunition Plant  
Route 114, P.O. Box 1  
Radford, VA 24141  
USA

January 28, 2002

US Army Corps of Engineers  
ATTN: CENAB-EN-HM  
10 South Howard Street  
Baltimore, MD 21201

Attention: Mr. John Tesner

Subject: Benthic Surveys, Radford Army Ammunition Plant

Dear Sir:

Enclosed please find copies of our Benthic Studies conducted in the years 1994 thru 1998, in accordance with the requirements of our Virginia Pollution Discharge Elimination System Permit.

If additional information is needed, please contact Mr. J. J. Redder (540) 639-7536.

Very truly yours,

A handwritten signature in black ink that reads "C. A. Jake".

C. A. Jake, Environmental Manager  
Alliant Ammunition and Powder Company LLC

Enclosures

Coordination:

A handwritten signature in black ink that reads "J. McKenna".  
J. McKenna

bc: Administrative File  
J. J. Redder  
J. McKenna  
Env File – Enclosures located in the Water Cabinet (Env. Library)