The Effects of Pollution Reduction on a Wild Trout Stream

Baseline Studies Report: 2006

Spring Run

Dumpling Run

April 2007

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Introduction

Spring Run is a unique aquatic resource in the Potomac Highlands region of West Virginia. Unlike many small headwater streams that tend to go dry, it is fed by the largest spring in the region, with discharge typically ranging from 3000-3500 gallons per minute. With a temperature of ~53 °F at the spring and a pH of ~8, aquatic conditions are ideal for trout and the aquatic insects they eat. Spring Run flows about two miles from the spring source to its confluence with South Mill Creek, which is about four miles from the South Branch of the Potomac River. Spring Run has no tributaries. Much of the stream is shallow, and does not provide the complex habitat that trout need - but that is not the case in one three-fourths mile section in the middle of the Run.

Since the early 1960's, landowner's have issued permits for fly fishing, catch-and-release on about one mile of Spring Run. Landowners and other interested parties have installed and maintained various structures to form pools and overhead cover that provide hiding and feeding habitat for trout. Spring Run is recognized as one of the best "wild" rainbow trout fisheries in West Virginia. Friends of Springs Run's Wild Trout, was formed in 1996 to restore structure to Spring Run following flooding in 1996.

In the last few years, however, fishermen have noted a decline in the fishery. Emergence of the mayfly, Ephemerellidae (sulfurs) largely disappeared in the late 1990s. The number of large trout (14" and above) has decreased and trout in the 11-13" range have also declined in abundance. The population of trout is considerably lower in the lower reach of the three-fourths mile section. Algae formation is heavy in the upper reach of the catch-and-release section, much heavier than in the past, and algae reforms soon after washout by high water.

Spring Run is rich in nutrients, delivered largely in effluent from the Spring Run Trout Hatchery (SRH) which is located about one-third mile upstream from the upper end of the fly fishing section and about one-forth mile below the spring. (SRH is a rearing facility; trout are not spawned there). In recent years, however, SRH has been producing more rainbow and "golden trout" for stocking West Virginia streams, and it seems that the effluent stream now may be a problem for the health of Spring Run. WVDEP issued a citation for violation of the Spring Run Trout Hatchery NPDES permit in January 2004, specifically for discharging excess biochemical oxygen demand (BOD) and total suspended solids (TSS). WVDNR, which operates SRH, has now installed an effluent treatment process at the facility to meet their permit requirements.

Installation of effluent treatment at SRH provides a unique opportunity to address a number of issues of both regional and national significance:

1. Will the hatchery effluent treatment process significantly reduce nutrient discharge? Fish hatcheries throughout the country produce nutrient-rich effluents of concern to receiving waters. This study will evaluate the downstream result of effluent reduction of BOD and TSS, as well as nutrients, from a small but high throughput point source. The results of renovation at SRH and this study will provide important information to the WV Potomac Tributary Strategy point source innovation process.
2. What are the biological impacts of Spring Run's high nutrient levels, and how is the biota affected by reductions in nutrients, TSS and BOD following hatchery upgrades? This issue is of importance to the nutrient criteria development process that WV and the other 49 states are currently struggling through, as one of the key questions is: "what does nutrient impairment look like?"
3. Is the wild trout population in Spring Run being harmed by hatchery effluent, and does improvement in that effluent improve the trout fishery?

4. Is the benthic invertebrate population in Spring Run being harmed by hatchery effluent, and does improvement in that effluent improve diversity? Spring Run fishermen have noted the loss in recent years of a certain family of mayflies, the Ephemerellidae (Spiny crawler mayfly) that used to emerge regularly in the springtime. Also, WV DEP's Tim Craddock completed a benthic assessment of Spring Run in 2002, and found the lower part of the fly fishing section to be dominated by Chironomidae (midge) larvae, a group often indicative of pollution by organic waste.
5. Why do trout, especially larger fish, favor the upper part of the fly-fishing section? Why has the density-center of the trout population moved upstream in recent years? Is there a relationship between distribution of benthic invertebrates in the stream and trout distribution? If the Ephemerellidae mayflies and other pollution sensitive macroinvertebrates rebound after the hatchery effluent is treated, will the trout population improve also? In particular, are trout avoiding areas they used to frequent that are now dominated by midge larvae? If upgrades to the hatchery reduce organics in the stream and also the midge populations, will trout return to those areas? If that turns out to be true, and we could demonstrate that it is true, that would buttress public acceptance of benthic invertebrate stream assessments.

Overall, this project will have the potential to be used to address many questions beyond the five questions identified above.

Partners

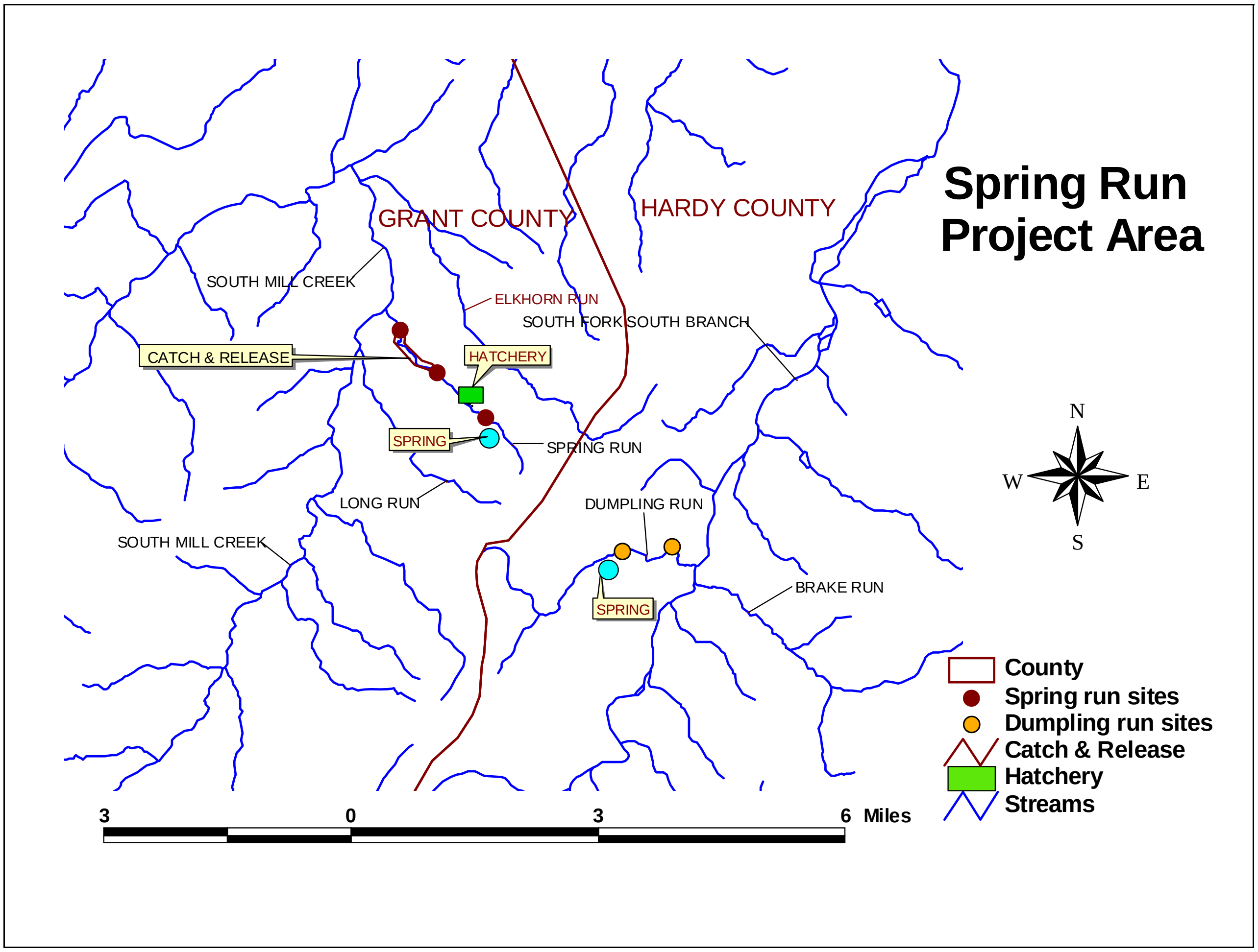
Friends of Spring Run's Wild Trout, Cacapon Institute (CI), the WV Conservation Agency (WVCA), WV Department of Agriculture (WVDA), WV Division of Natural Resources (WVDNR), WV Department of Environmental Protection (WVDEP), and the Freshwater Institute are partnering in this study. This project is funded primarily by West Virginia Conservation Agency's participation through the Chesapeake Bay Program. An associated sediment reduction project is funded through a Friends of Spring Run's Wild Trout 2005 Stream Partners Grant. Additionally, a home school group is monitoring the lower portion of Spring Run on a regular basis.

WVDA, WVDEP and WVDNR are all contributing in-kind services to the project. WVDA is collecting water samples, taking flow measurements, and performing field and laboratory water quality analyses. WVDEP is participating in collections of benthic invertebrate and periphyton and helping to cover the costs of analysis. WVDNR is performing fish surveys and Friends of Spring Run's Wild Trout is providing information on size and location of trout caught and released by permitted fly fisherman.

The Freshwater Institute provided guidance to WVDNR on treatment methods for their effluent and is providing technical guidance for the project. WVCA is acting as project coordinator. Cacapon Institute has overall technical oversight for the project, will participate in field work, and will, in cooperation with partnering organizations, be responsible for data analysis and production of annual reports.

Methods

The project has two experimental components, an upstream/downstream design in Spring Run, and a control/experimental design that includes Dumpling Run, another spring fed stream nearby. Both streams have their origins in the same geology: limestone (Helderberg and Tonoloway/Wills Creek) and sandstone (Oriskany, McKenzie) formations. Spring Run flows off the ridge to the northwest into South Mill Creek, a tributary of the South Branch of the Potomac River. Dumpling Run flows east into the South Fork of the South Branch of the Potomac River.



The upstream/downstream part includes three sites in Spring Run: the first site is near the spring upstream of the hatchery; the second site is near the upper end of the fly fishing stream section; and the third is near the lower end of the fly fishing section. There are two sites on Dumpling Run, one just below the spring, the other some distance downstream. Overall, this design allows within stream and between stream comparisons. Under most conditions of flow the springs constitute the main source of water in both streams, but both streams also have periodic surface flow entering the main channel upstream of the spring. Due to unanticipated delays in construction of the effluent treatment system, the baseline period of data collection lasted for two years (2005-2006).

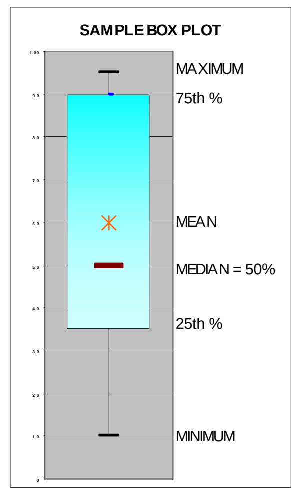
Water chemistries are collected monthly from April through September, typically on Wednesday. We chose to avoid collections on Mondays at the time of the hatchery cleanout because the "biosolids from the aquaculture effluent are notoriously patchy and difficult to characterize in sampling. . . . my thoughts on the nutrients is to focus on the residual chronic impacts, not the pulse of the cleaning plume" (Joe Hankins, Freshwater Institute, personal communication). However, due to scheduling requirements, samples in September 2006 were collected on a Monday during the cleanout.

Water quality parameters include nitrogen in the forms of ammonia-nitrogen, nitrate/nitrite, total Kjeldahl nitrogen, total nitrogen (the sum of nitrate/nitrite and TKN), soluble reactive phosphorus, total phosphorus, total suspended solids (TSS), biochemical oxygen demand (BOD_5), and basic field parameters (pH, temperature, conductivity) (see Appendix 2 for laboratory methods). Flow measurements are collected at the same time as water samples at one site in each stream. This work is done primarily by the WVDA.

Benthic invertebrate and periphyton samples are collected twice each year at all sites, in May and August, according to the standard protocols in use by the WVDEP. WVDEP format Rapid Bioassessment Protocol habitat analyses will be conducted once each year. WVDEP and Cacapon Institute are primarily responsible for this fieldwork.

WVDNR will conduct electro shocking fishery assessments, and the permitted fly fishermen of Spring Run have been enlisted to record information on size and location of trout caught and released.

Since changes to the system may not occur rapidly, an assessment will be made at the end of the third year to determine if "out year" monitoring might be needed?



The methods used to analyze water quality data were graphical and statistical. Data distributions were displayed using box plots (figure at right), which are useful for side-by-side visual comparisons of data distributions. One way analysis of variance (ANOVA) was run on rank transformed data for comparison of median concentration distributions. An alpha value of 0.05 was used as the threshold for statistical significance. If a significant difference among group medians was detected, Tukey's multiple comparison test was used on the rank transformed data to determine where differences were located (Helsel and Hirsh, 1992). Statistics were calculated using JMP Statistical Discovery Software (version 4.0.2). Summary statistics and raw data are provided in Appendix XX.

Baseline Water Chemistry & Flow Data Results

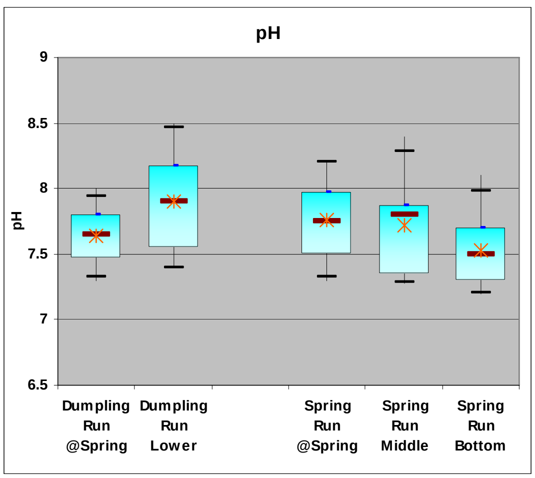
Pre-treatment results and analysis the water quality data will focus on five questions:

1. How does the spring source water of the two streams compare? It is assumed that the springs constitute the main source of water in both streams, certainly true at most conditions of flow. Note: both streams periodically have surface flow entering the main channel upstream of the spring.
2. How does the water in the control stream change as it flows downstream?
3. How does the water in the experimental stream change as it flows downstream?
4. Are there significant differences in water chemistry at any of the sites?
5. How did water quality vary over time?

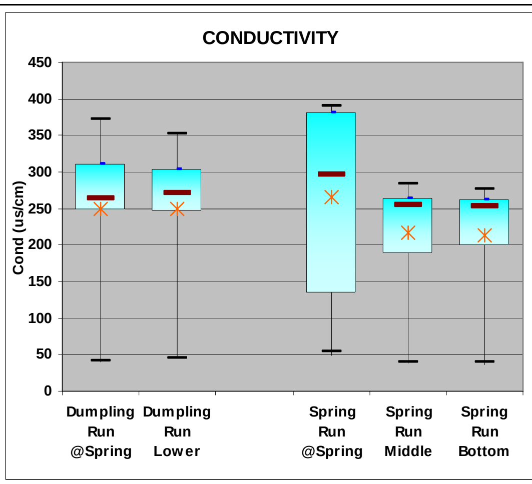
While viewing the baseline results, it is important to recognize that the data set is still fairly small at twelve samples per site (six monthly samples per year over two years for each site), which reduces the power of statistical tests to detect differences. No attempt was made to separate or compare data from the two baseline years in this section.

Results

Field Parameters: pH, Dissolved Oxygen and Conductivity (see Appendix 1 for summary statistics).

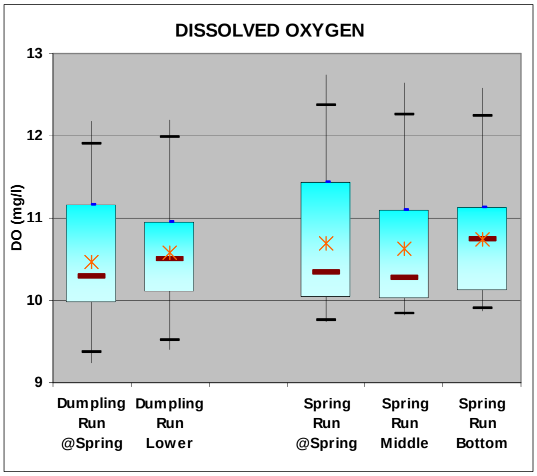


Source Water: pH in the main source water for the two streams was similar, with data ranging narrowly from 7.3 to 8.0 and 7.3 to 8.2 in Dumpling Run and Spring Run, respectively.
Control Stream Trends: median pH tended to increase in a downstream direction.
Experimental Stream Trends: median pH tended to decrease in a downstream direction in Spring Run, with Spring Run at the bottom station distinctly, although not significantly, lower than the other two sites.
Significant differences: pH in SR Bottom was significantly lower than DR Lower.



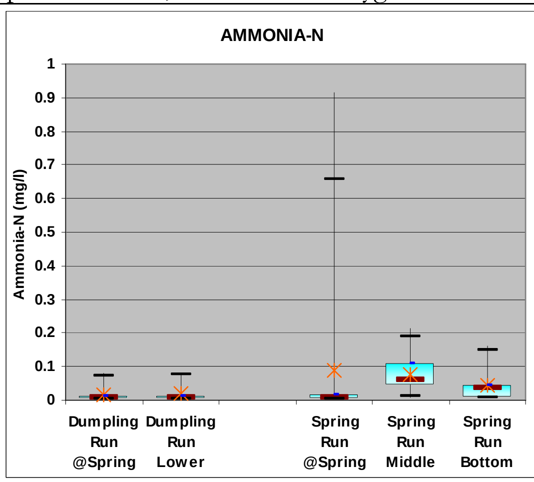
Source Water: Median conductivity in the two streams was very similar, with data ranging broadly from 39 to 372 and 49 to 391.1 (µs/cm) in Dumpling Run and Spring Run, respectively.
Control Stream Trends: median conductivity did not change in a downstream direction.
Experimental Stream Trends: Median conductivity was lower (not significantly) at the two downstream sites than the source water in Spring Run.
Significant differences: No sites were significantly different.

Field Parameters: pH, Dissolved Oxygen and Conductivity (see Appendix 1 for summary statistics).



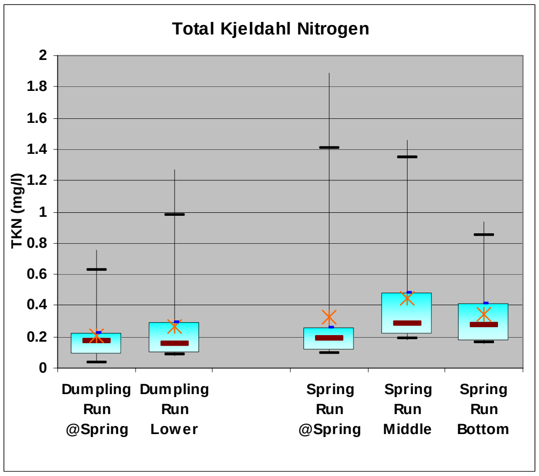
Source Water: Median dissolved oxygen in the two streams was similar and high, with data ranging from 9.2 to 12.2 and 9.75 to 12.8 (mg/l) in Dumpling Run and Spring Run, respectively.
Control Stream Trends: DO trended slightly higher in a downstream direction.
Experimental Stream Trends: DO was slightly higher at SR Bottom.
Significant differences: there were no significant differences.

Laboratory Parameters: Ammonia, TKN, Nitrate, Nitrite, Total Nitrogen, Total Phosphorus, Total Suspended Solids, Biochemical Oxygen demand. (See Appendix 1 for summary statistics).

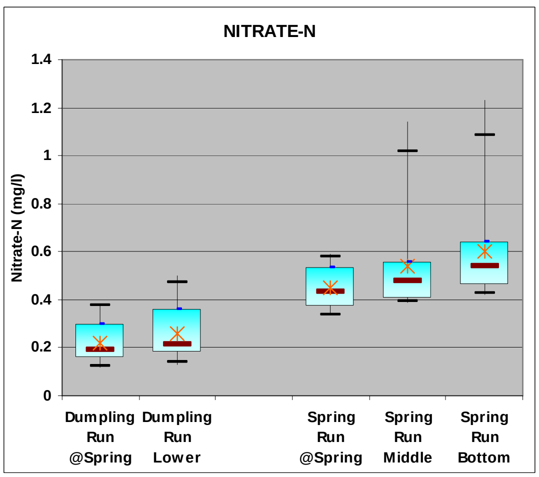


Source Water: Median ammonia in the main source water for the two streams was below the MDL (minimum detection limit) for the parameter. However, while the data in Dumpling Run ranged narrowly to 0.082 mg/l, the highest level detected in Spring Run was high (0.915 mg/l). This one high value was an outlier over the baseline period, with the next highest reading being 0.055 mg/L and all values in 2006 below the detection limit.
Control Stream Trends: no trends are apparent.
Experimental Stream Trends: Ammonia was distinctly higher at the middle site, and then decreased in the downstream direction. The reduction in ammonia between SPR Middle and SPR Bottom is likely due to normal in-stream processes that convert ammonia to nitrate.
Significant differences: SR Middle was significantly higher than all sites except SR Bottom.

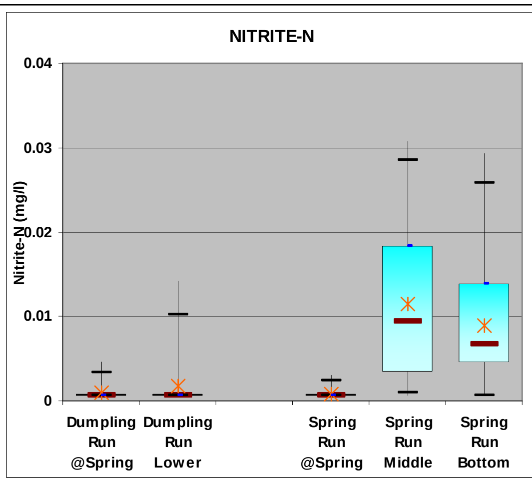
Laboratory Parameters: Ammonia, TKN, Nitrate, Nitrite, Total Nitrogen, Total Phosphorus, Total Suspended Solids, Biochemical Oxygen demand. (See Appendix 1 for summary statistics).



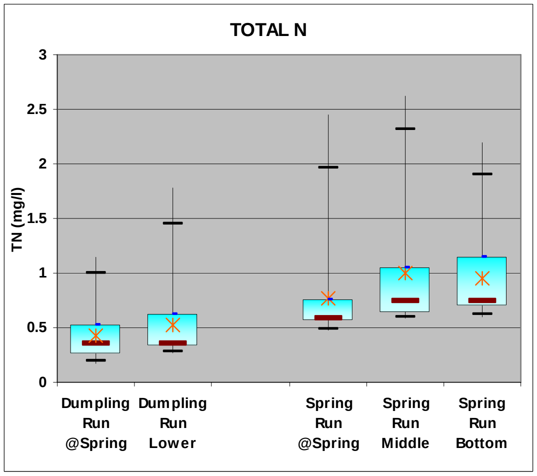
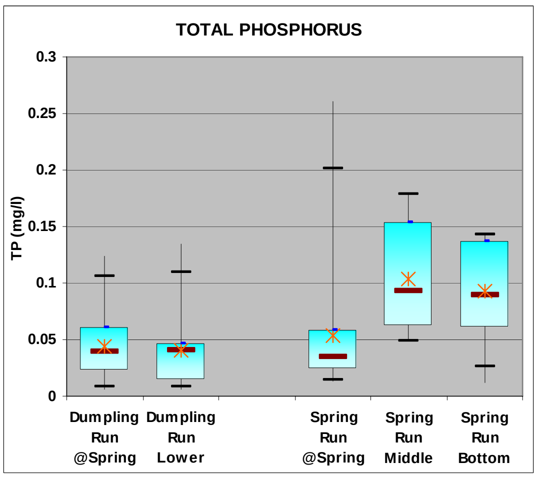
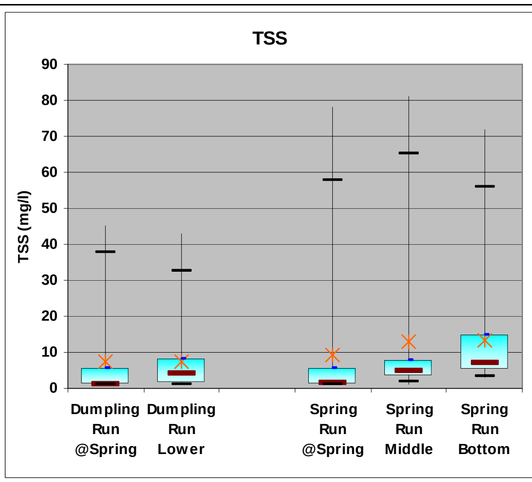
Source Water: Median TKN in the two streams was very similar, with data ranging broadly from 0.035 to 0.758 and 0.091 to 1.89 (mg/l) in Dumpling Run and Spring Run, respectively.
Control Stream Trends: median TKN did not change in a downstream direction.
Experimental Stream Trends: Median TKN was higher (not significantly) at the two downstream sites than the source water in Spring Run.
Significant differences: Spring Run Middle was significantly higher than Dumpling Run at the spring..



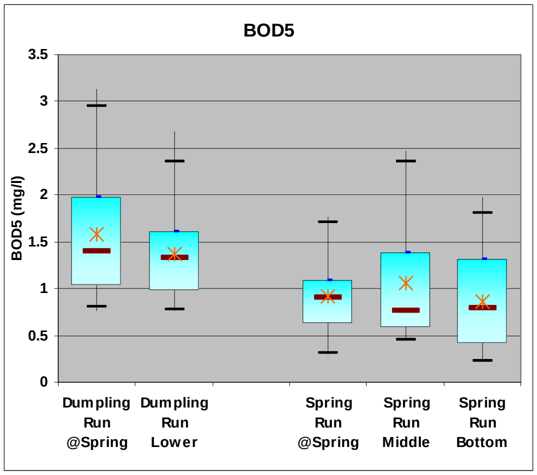
Source Water: Median nitrate (NO_3-N) in the two streams was significantly higher in SR than DR. Data in both streams ranged narrowly from 0.12 to 0.38 and 0.34 to 0.59 (mg/l) in DR and SR, respectively.
Control Stream Trends: median nitrate did not change in a downstream direction.
Experimental Stream Trends: Median nitrate and the range of values increased in the downstream direction (not significantly).
Significant differences: All SR sites had significantly higher nitrate than both DR sites.



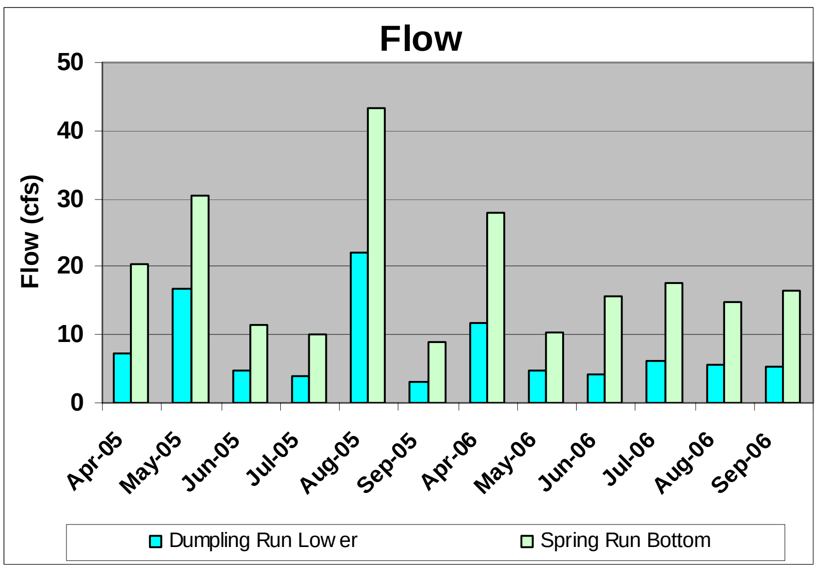
Source Water: Median nitrite (NO_2-N) concentrations in the two streams were below the laboratory's minimum detection limits. Each site had a single measurable concentration during a high water event in August 2005.
Control Stream Trends: nitrite was detected in DR sites only in the August 2005 samples.
Experimental Stream Trends: Nitrite was typically detectable at low concentrations at the two downstream sites.
Significant differences: SR Middle and Lower had higher nitrite than SR at Spring and both DR sites.

Laboratory Parameters: Ammonia, TKN, Nitrate, Nitrite, Total Nitrogen, Total Phosphorus, Total Suspended Solids, Biochemical Oxygen demand. (See Appendix 1 for summary statistics).	
	**Source Water:** Median Total N was distinctly (not significantly) higher in SR than DR. Data in both streams ranged broadly from 0.18 to 1.14 and 0.48 to 2.45 (mg/l) in DR and SR, respectively. **Control Stream Trends:** median TN did not change in a downstream direction. **Experimental Stream Trends:** Median TN was higher (not significantly) at the two downstream sites than in the source water in SR. **Significant differences:** SR Middle and Lower had higher TN than both DR sites. SR at Spring was higher than DR at Spring.
	**Source Water:** Median Total Phosphorus in the two streams was very similar, with data ranging from 0.007 to 0.124 and 0.013 to 0.261 (mg/l) in DR and SR, respectively. **Control Stream Trends:** median TP did not change in a downstream direction. **Experimental Stream Trends:** TP was distinctly (and significantly) higher at the two downstream sites than in the source water in Spring Run. **Significant differences:** TP in SR Middle and SR Bottom was significantly higher than all other locations.
	**Source Water:** Median Total Suspended Solids was similar, with data ranging broadly from 1.15 to 45 and 1.0 to 78.0 (mg/l) in Dumpling Run and Spring Run, respectively. **Control Stream Trends:** median TSS increased slightly in a downstream direction. **Experimental Stream Trends:** Median TSS increased in a downstream direction (not significantly. **Significant differences:** SR Bottom was significantly higher than the DR and SR spring sites.

Laboratory Parameters: Ammonia, TKN, Nitrate, Nitrite, Total Nitrogen, Total Phosphorus, Total Suspended Solids, Biochemical Oxygen demand. (See Appendix 1 for summary statistics).



Source Water: Median Biochemical Oxygen Demand was distinctly (but not significantly) higher in DR than SR. Data ranged broadly in DR from 0.76 to 3.13 and narrowly in SR from 0.3 to 1.76 (mg/l).
Control Stream Trends: median BOD did not change in a downstream direction, although the range of values was lower downstream.
Experimental Stream Trends: Median BOD did not change in a downstream direction, but the range of values was greater downstream than at the source.
Significant differences: SR Bottom was significantly lower than DR at Spring.



Flow measurements were taken at the Dumpling Run Lower and Spring Run Bottom sites. Flow in Dumpling Run ranged from about one third to one half of the flow in Spring Run (figure at left). During 2005, water samples were collected on three days with fairly low water (June, July, and September), two moderate flow (April and May), and one high water (August). Flows on sampling days were much less variable in 2006, with an active runoff event reported during the April sampling period.

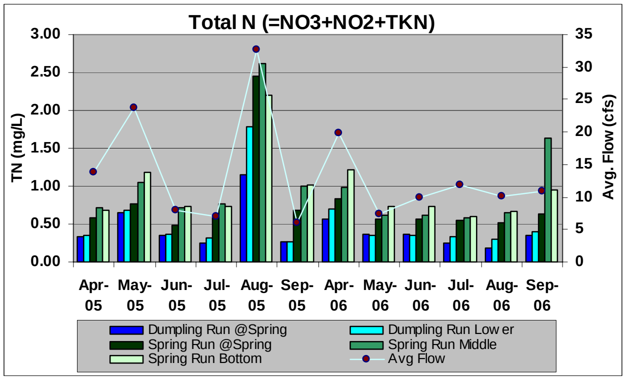
Since we are most concerned with local effects in this study, concentration is the most relevant way to look at the data. However, flow is necessary for interpretation of the time series data presented below.

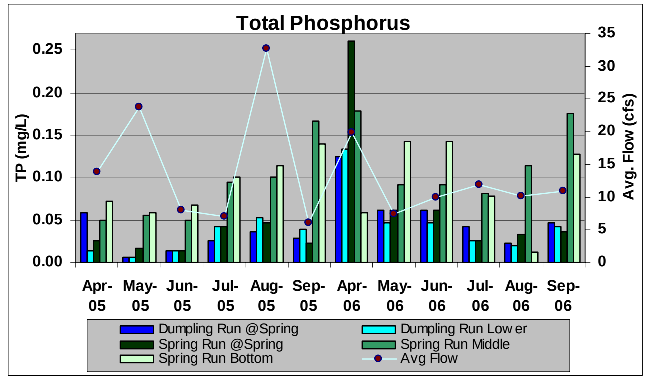
The flow stations are not suitable surrogates for flows at all of the stations. This is particularly an issue in Spring Run, where a significant portion of the total stream flow is diverted at the springhouse to the trout hatchery and does not flow through the upper channel where samples are collected. This means that we cannot reasonably estimate parameter loadings at any sites but those with flow measurements.

How did water quality vary over time?

The following four time-series bar graphs and associated text show how total N, total P, TSS and BOD5 concentrations varied during the two-year baseline sampling period. Also shown on each graph is the average of the flows at the two flow stations for each sampling period; this was done for the sake of graphic simplification, justified because these values were very strongly correlated ($r^2 = 0.94$).

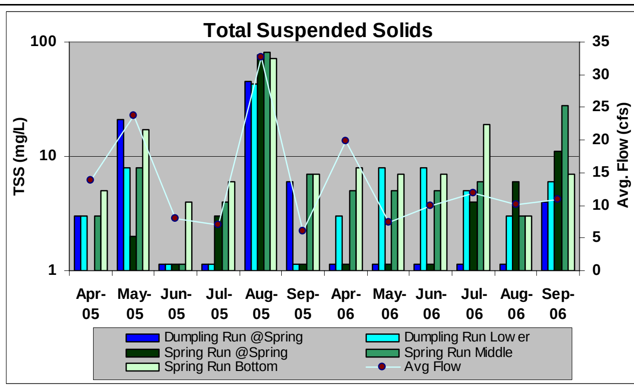
Time series bar graphs of total nitrogen, total phosphorus, total suspended solids, and biochemical oxygen demand concentrations at all permanent study sites.

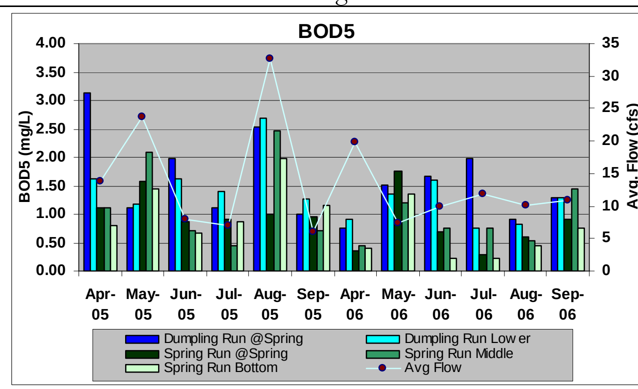




Total nitrogen (TN) varied widely and generally tracked with flows at all sites (see correlation tables below). The highest levels at all sites were observed in August '05 during a high water event. TN was always higher in all SR sites than DR. Elevated TN at SR Middle and SR Bottom in September 2006 was probably due to sampling that occurred on hatchery cleanout day.

Total phosphorus (TP) varied widely over time at all sites and did not apparently vary with flow levels (see correlation tables below). However, the highest TP concentrations at all sites except SR Bottom were recorded during an active runoff event in April 2006. Elevated TP in the hatchery effluent was evident at all flows at SR Middle and Bottom. However, unlike 2005, TP concentrations at the two point source sites were often distinctly different in 2006. Elevated TP at SR Middle and SR Bottom in September 2006 may have been due to sampling that occurred on hatchery cleanout day; however, TP was similarly high at these two sites in September 2005 when cleanout was not occurring.





TSS varied widely and very roughly tracked with flows at all sites (see correlation tables below). The highest levels were observed in August '05 during a high water event. TSS concentrations were more consistently elevated at DR Lower, SR Middle and SR Bottom in 2006 than 2005. Elevated TSS at SR Middle and SR Bottom in September 2006 may have been due to sampling on hatchery cleanout day; however, TSS was high at both spring sampling sites on that day as well.

BOD5 varied substantially between sites. BOD5 at Spring Run point source impacted sites tended to vary with flows, while patterns of BOD5 concentrations in non point sites had no apparent relationship to flow (see correlation tables below). BOD5 concentrations were noteably low during the active runoff event in April 2006, and noteably high at all sites except DR Spring during a high water event in August 2005..

Correlation Analysis

The following three tables present simple correlation analysis on the un-transformed sample data for key parameters: total N, total P, TSS, BOD5, and flow. The purpose of the tables is to examine effects that might be due to different factors, such as point and non point sources of pollution. The first table offers correlations on all sites, the second excludes point source impacted sites in Spring Run, and the third includes only the point source impacted sites in Spring Run. More sophisticated approaches will be used in future reports during the post-upgrade period.

Total nitrogen and TSS were strongly and positively correlated with flow and with each other, in all three tables. These were the only significant correlations for the non-point impacted sites group (Table 2). TSS, total N and flow were all positively correlated with BOD5 in the point source impacted sites in Spring Run (Table 3). Total P was not significantly correlated with any other parameters.

Table 1. Correlations for key parameters and flow at all stations.

	Total N	TP	TSS	BOD5	FLOW
Total N (mg/L)	1	**	***	n.s.	***
TP (mg/L)	0.3438	1	n.s.	n.s.	*
TSS (mg/L)	0.8843	0.0983	1	**	***
BOD5 (mg/L)	0.2223	-0.2269	0.3761	1	n.s.
FLOW (cfs)	0.8371	0.2563	0.7082	0.0681	1

Table 2. Correlations for key parameters and flow for all non point source stations (i.e.: not SR Middle and SR Bottom).

	Total N	TP	TSS	BOD5	FLOW
Total N (mg/L)	1	n.s.	***	n.s.	***
TP (mg/L)	0.1505	1	n.s.	n.s.	n.s.
TSS (mg/L)	0.8956	-0.0622	1	n.s.	***
BOD5 (mg/L)	0.1064	-0.1972	0.2292	1	n.s.
FLOW (cfs)	0.8423	0.2331	0.666	-0.1113	1

Table 3. Correlations for key parameters and flow for point source stations SR Middle and SR Bottom.

	Total N	TP	TSS	BOD5	FLOW
Total N (mg/L)	1	n.s.	***	***	***
TP (mg/L)	0.2277	1	n.s.	n.s.	n.s.
TSS (mg/L)	0.9272	0.1426	1	***	***
BOD5 (mg/L)	0.7325	0.0282	0.6965	1	**
FLOW (cfs)	0.7741	-0.1073	0.7621	0.6029	1

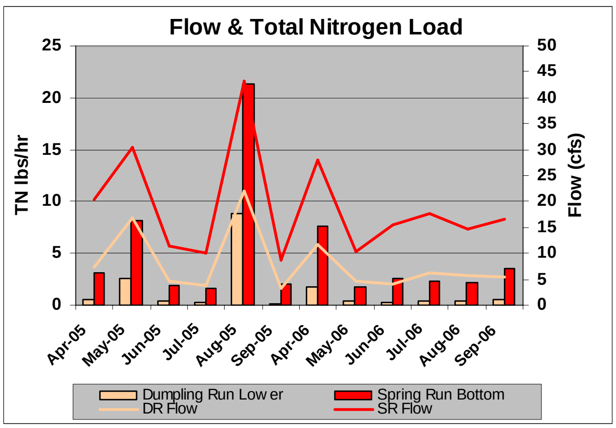
Correlation Tables Note: n.s. means not significant; * = significant at p=0.05; ** = significant at 0.01; *** = significant at 0.001

Table 4 provides correlations between flow and each of the key parameters total N, total P, TSS, and BOD5 at each sampling station. The results generally confirm the results above for station groupings (point source, etc.). However, BOD5 was positively correlated with flow at non point source site Dumpling Run Bottom.

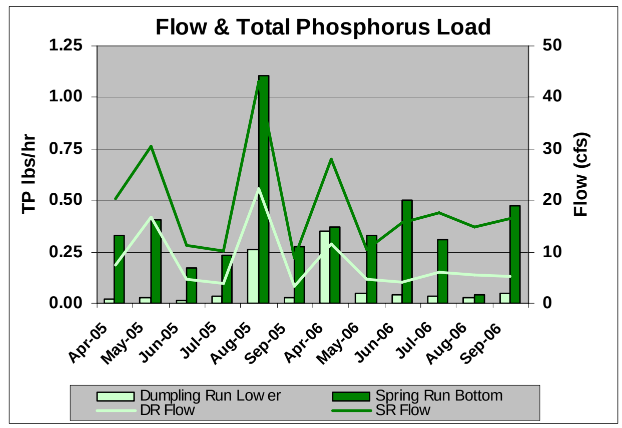
Table 4. Correlations between key water quality parameters and flow at each sampling station.	Non Point Stations			Point Source Sta.	
	Dumpling Run @Spring	Dumpling Run Bottom	Spring Run @Spring	Spring Run Middle	Spring Run Bottom
Total N (mg/L)	0.851	0.903	0.794	0.915	0.819
TP (mg/L)	0.099	0.219	0.233	-0.061	-0.193
TSS (mg/L)	0.863	0.786	0.741	0.731	0.817
BOD5 (mg/L)	0.261	0.489	0.075	0.758	0.531

How did loads of key parameters vary over time? The following four time-series bar graphs and associated text show how total N, total P, TSS and BOD5 loads (in pounds per hour) varied at the two flow station sites during the two-year baseline sampling period.

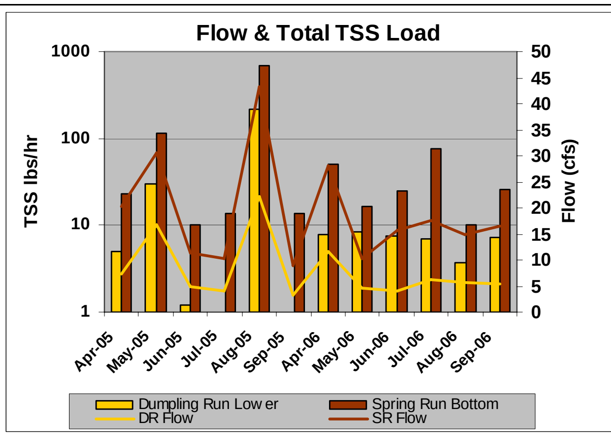
Time series bar graphs of total nitrogen, total phosphorus, total suspended solids, and biochemical oxygen demand loads (in pounds per hour) at the two flow sites.



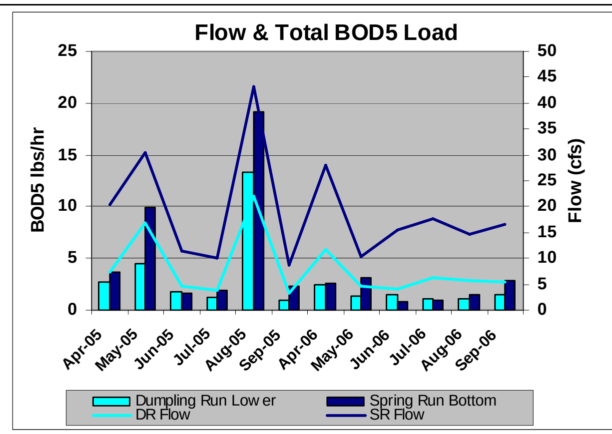
Total nitrogen loads varied widely and generally tracked with flows at all sites. As with TN concentrations, SR consistently had the higher TN loads. The highest loads at both sites were delivered during the three highest water events.



Total phosphorus loads varied much more widely over time at DR than SR. As with TP concentrations, SR consistently had the higher TP loads. The phosphorus from the hatchery was evident at all flows.



TSS loads varied widely and roughly tracked with flows at both sites. The highest loads were observed in August 2005 during a high water event.



BOD5 loads varied substantially between the two sites and roughly varied with flows. The highest loads at both sites were observed in August 2005 during a high water event

Discussion of water quality results

The two study streams are impacted by a variety of potential sources of pollution, some readily apparent and some not. The Spring Run watershed contains the trout rearing facility point source, which is a known source of BOD, TSS and nutrients, as well as a number of non point sources including poultry houses, residences, roads, and occasional cattle. The Dumpling Run watershed has no point sources, and apparently no poultry houses, but includes residences and small farms with livestock, as well as a dirt and gravel road. In addition, the source springs in both watersheds both originate in limestone and sandstone strata and show rapid changes (turbidity, increase in flow) following heavy precipitation; this is indicative of solution channel connections through limestone at the surface of the ground.

Despite the wealth of confounding variables, some patterns are reasonably clear from the baseline data. The spring source water for the two streams has similar pH, conductivity, dissolved oxygen, TSS, and phosphorus. Source water in Dumpling Run tends to have less nitrate, and total N than Spring Run, and higher BOD5. Conductivity and pH tend to increase or not change in a downstream direction in Dumpling Run, and tend to decrease in a downstream direction in Spring Run. Nutrients and TSS are generally similar in the two Dumpling Run sites, and tend to increase in a downstream direction in Spring Run, often dramatically.

The decision to collect water samples two days after the scheduled Monday cleanouts at the hatchery probably contributed to the apparently anomalous result of Dumpling Run having somewhat more BOD5 and TSS than Spring Run. It is quite clear that we are not observing a significant residual impact in the water column from those cleanouts two days after the fact. However, sampling that occurred in September 2006 on '"cleanout day" provided a surprising result – somewhat elevated TSS and BOD5 in both streams. This result may well have been an anomaly, because suspended material is readily observed in Spring Run on cleanout days.

The purpose of this report was to establish baseline conditions in Spring Run and Dumpling Run based on two years of sampling. Future reports will include more comprehensive analyses of these data in the context of changing conditions in Spring Run due to the effluent upgrade.

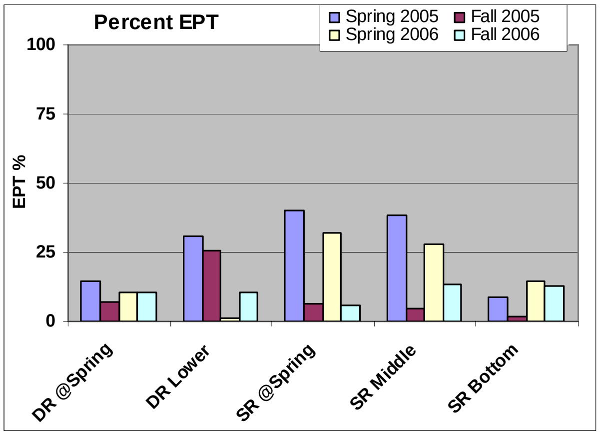
Benthic Macroinvertebrate & Periphyton Analysis

An assessment of Spring Run in 2003 by WVDEP (Tim Craddock, 2003) collected benthic invertebrate samples at sites near those chosen for the current study. The study found low diversity at the lower station, where the most abundant family was the Chironomidae, an indicator of organic pollution. It also found abundant Gammaridae amphipods at all sites. (See Appendix 3 for results, as well as a commentary of the challenge of assessing Spring Run macroinvertebrates by WV DEP's Tim Craddock..)

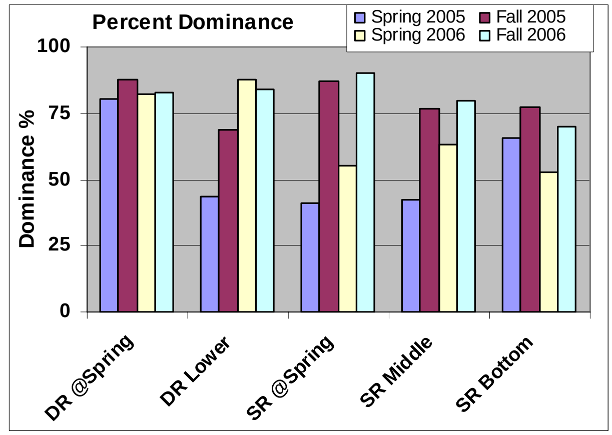
An earlier qualitative assessment of Spring Run's catch and release area benthic macroinvertebrate community was conducted in September 1995 by aquatic ecologist Steve Hiner (Burke, personal communication). At that time, Mr. Hiner found a fairly diverse community, dominated by amphipods, with good representation of mayflies (3 species), stoneflies (3), and caddisflies (2). His field notes for Burke of Friends of Spring Run Wild Trout indicated that the "scuds (amphipods), this little critter plus the worms below make your rainbows fat and sassy."

Benthic samples for this project were collected twice each baseline year, in the spring and in the autumn, at all water quality sampling sites. The benthic data for 2005 and 2006 is provided in Appendix 4. Observations during benthic field collections indicated abundance, often overwhelming abundance, of amphipods in both streams (Craddock and Gillies, personal observations). Amphipods are often abundant in limestone spring fed streams, and their abundance renders many standard benthic invertebrate indices unsuitable for assessing this type of stream. Assessment of benthic communities in this setting will depend on comparisons between control and experimental sites, not standard metrics.

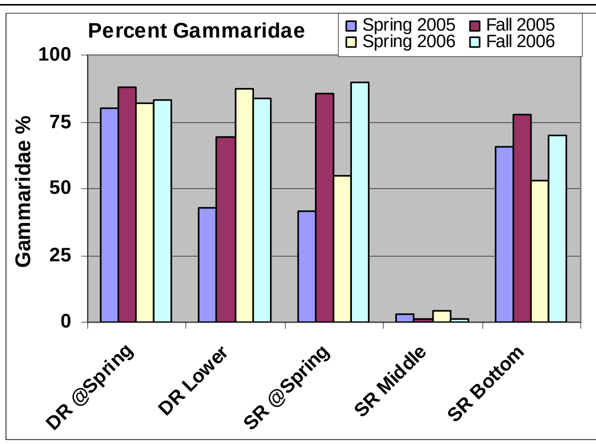
Results indicate that all study sites are dominated by one of two benthic invertebrate families, Gammaridae (amphipods) and Chironomidae (midges) (see figures below). The Gammaridae were the dominant organism at four of the five sites, accounting for 41% to 88% of all the organisms collected. Chironomidae were abundant in both of the Spring Run sampling sites located below the hatchery, and overwhelmingly dominate in the more upstream site. The results in the latter site were not surprising, as it was notable for the large amount of organic matter and matted algae entrained in the stream sediment. Chironomidae were present in relatively low numbers at the non point source sites (Dumpling Run and Spring Run above the hatchery).



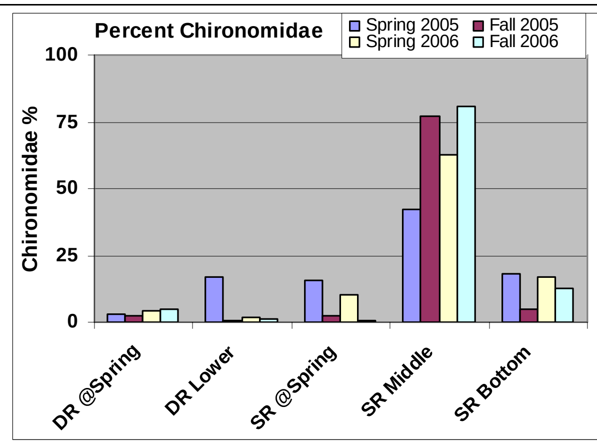
Percent EPT (Ephemeroptera - mayfly, Plecoptera - stonefly, Trichoptera - caddisfly) is a standard benthic invertebrate index where higher values are considered indicative of good water quality. %EPT was never particularly high. It was always low at DR Spring, and SR Bottom. It was quite variable at DR Lower, SR Spring and SR Lower. It tended to be lower in the fall at the latter two sites.



Percent dominance is common metric where high numbers typically indicate poor water quality. As noted above, however, such metrics are problematic in limestone spring fed streams where dominance by amphipods is common. All sites had relatively high dominance. Dominance was consistently very high at DR Spring. At other sites, %dominance was always high but much more variable.



Percent Gammaridae is not a standard metric. It is used here in recognition that amphipods are commonly abundant in limestone spring fed streams, and their abundance in the two study streams makes many standard metrics unreliable. Amphipods were consistently dominant at DR Spring and SR Bottom, more so at the former site. They were more variably dominant at DR Lower and SR Spring. They were never dominant at SR Middle.



Percent Chironomidae is a common metric where high numbers typically indicate poor water quality and organic pollution. Chironomids were the dominant group at SR Middle, more so in the Fall than the Spring, replacing the amphipods that were dominant at all other sites. As mentioned above, this site was distinctive for the large amount of organic matter and matted algae entrained in the stream sediment

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Table 5. Relative Density of Benthic Macroinvertebrates.	2005		2006	
	Spring	Fall	Spring	Fall
DR @Spring	5600	5975	4600	2929
DR Lower	3500	2975	2986	7533
SR @Spring	3833	3800	4180	5625
SR Middle	3042	19500	523	3071
SR Bottom	7800	4800	3767	2300

Abundance, or density, of benthic macroinvertebrates is not a reliable parameter because of the difficulty in collecting truly quantitative samples on hard bottomed streams. However, as the collection method and number of replicates for each site is the same, extrapolating from the numbers collected in the sorted subsample to the entire sample allows a rough estimate of relative density. Table 5 provides these estimates. With the understanding that such data are not terribly reliable, it is notable that relative density varied by a factor of three at the non point source impacted sites and SR Bottom. Relative density was much more variable at SR Middle, ranging from a low of 523 in Spring 2006 and 19,500 in the Fall 2005. This great variability, along with abundant Chironomids and a very heavy mass of entrained algae and organic matter at this site, were probably causally related.

Periphyton data is not yet available.

Fisherman Survey

Table 6. Spring Run angler catch reports.

Spring Run Angler Catch Reports, Rainbow Trout: April thru Dec 2005												
65 Anglers Reporting 230 Fishing Sessions												
	Stream Section											
Length	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**Total**	%
0-7	70	108	77	130	220	335	201	142	58	47	**1388**	37.5
8--10	22	35	26	72	146	221	191	217	203	162	**1295**	35
11--13	7	5	17	27	39	75	75	89	170	175	**679**	18.3
14--16		1		16	25	23	33	27	29	86	**240**	6.5
17--19				1	5	4	9	7	10	24	**60**	1.6
20--up			1		1	4	7	10	6	13	**42**	1.1
Total	**99**	**149**	**121**	**246**	**436**	**662**	**516**	**492**	**476**	**507**	**3704**	
%	2.7	4	3.3	6.6	11.8	17.9	13.9	13.3	12.9	13.7		
16.1 rainbow trout/angler session												

Spring Run Angler Catch Reports, Rainbow Trout: Jan thru Dec 2006												
76 Anglers Reporting 232 Fishing Sessions												
	Stream Section											
Length	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**Total**	**%**
0-7	25	46	42	89	134	153	112	46	30	33	718	31.6
8--10	18	14	20	49	103	109	121	134	64	66	698	30.7
11--13	4	10	18	18	34	46	77	104	109	136	536	23.6
14--16		4	4	8	9	18	31	42	43	92	251	11
17--19		1	1	1	3	2	2	9	4	19	42	1.8
20--up				1	3	1		1	1	8	15	O.7
Total	**47**	**75**	**85**	**160**	**286**	**329**	**343**	**336**	**251**	**354**	**2272**	
%	2.1	3.3	3.7	7	12.6	14.5	15.1	14.8	11	15.6		
9.8 rainbow trout/angler session												

Anglers with permits to fly fish, catch-and-release were invited, by a notice posted at the Spring Run parking area, to report the date fished, species, length, and stream location of their catch. The fly-fishing, catch-and-release section of Spring Run extends for about ¾ mile. This section was arbitrarily divided into10 sections, marked at streamside; Numbered 0 thru 9, beginning with 0 at the downstream boundary and increasing upstream. Sections were not of equal length. Anglers fished wherever they chose. Fishing sessions ranged from less than an hour to several hours. Anglers reported on a card designed with stream sections vs. 6 length categories, in inches; 0-7, 8-10, 11-13, 14-16, 17-19, 20-up. This card was available from a box located convenient to the parking area and next to a locked box for depositing completed reports. The parking area was adjacent to stream section Number 4. A member of the monitoring team collected reports frequently and summarized data monthly. The purpose of the study was to acquire data on number, size, and location of Spring Run trout, not to evaluate angler success.

Anglers cooperated willingly in collecting data with a participation rate estimated above 80% for sessions fished.

Summary data presented above are for April through December in 2005, and January through December in 2006. The most heavily fished period is April through September. In 2005, 65 anglers reported 230 fishing sessions and in 2006, 76 anglers reported 232 fishing sessions.

Data presented are for rainbow trout. A small number of brown, brook and golden trout were reported. A more detailed presentation of data will be done after another year or more of data collection.

Evaluation of Fisheries Resources in Spring Run, Grant County, West Virginia

The West Virginia Division of Natural Resources, in cooperation with the West Virginia Conservation Agency, conducted two fishery surveys in Spring Run in 2005. The first was in Section 4 of the fly-fishing managed section of Spring Run (see Fisherman Survey section above) on May 23, 2005. The second was conducted on September 1, 2005 approximately 450 feet upstream from the confluence of Spring Run with South Mill Creek, well below the managed section. The methods used in each survey were comparable, with triple pass backpack electro fishing sampling beginning at the downstream end of each stream section and extending upstream to the end of the selected reach. Fish population estimates were based on a 100-meter stream for comparisons. Collected specimens were measured, weighed and released downstream from the survey area. A total biomass was also calculated based on species-specific population estimates. Reports were issued by the WVDNR for each sampling event.

In addition, a previous fish survey was conducted on Spring Run in October of 1978 (Gerald Lewis, unpublished data, 1978), in a 150-foot stream reach located approximately 250 feet from the mouth of Spring Run. The 1978 samples were collected using the parallel wire electro fishing method. In 1978, the surveyed section of Spring Run was a stocked, put-and-take fishery; trout stocking was discontinued in 1987. A brief summary of the data provided in these reports follows.

Table 7 provides estimated numbers of each fish species captured per hundred meters of stream, as well as estimated biomass of fish by species per acre. A total of nine fish species were observed in the October 1978 samples. The fish community was dominated by two species of dace (blacknose and longnose, at 2,012 and 466 individuals per 100 m, respectively), followed in abundance by the central stoneroller (304) and the mottled sculpins (190). Rainbow trout were uncommon (6). Rare species observed in 1978, but not seen in 2005, were the fantail darter, greenside darter, rock bass, central stoneroller, and white sucker. Brook trout and brown trout, captured in the 2005 samples, were not observed. The total estimated number of fish was 3,010/100 meters and estimated biomass was 311 lbs./acre.

Four fish species were captured in the Spring 2005 samples. Rainbow trout were the most common species (112/100 m), representing 91.8% of the relative abundance. Three additional species were also captured in low abundance: brook trout, brown trout and mottled sculpins. The total estimated number of fish was 122/100 meters and estimated biomass was 133 lbs./acre.

The Fall 2005 sampling was done in the same general area as the 1978 study to allow a more direct comparison. Six species were captured. Mottled sculpin were most abundant (607/100 m), followed by longnose dace (223/100 m) and rainbow trout (112/100 m). Brown trout, brook trout and blacknose dace were captured in low abundance (6, 4, and 3 per 100 m, respectively). The total estimated number of fish was 955/100 meters and estimated biomass was 149 lbs./acre.

Table 7. Modified from: Table 3. Comparisons of population and biomass of estimates from electro fishing surveys conducted on Spring Run in 1978 and 2005, Grant County, West Virginia. *In*: Evaluation of Fisheries Resources in Spring Run, Grant County, West Virginia, September 2005.

	Number per 100 meters			**Biomass lbs./acre**		
Common Name ***Scientific Name***	**1978**	**Spring 2005**	**Fall 2005**	**1978**	**Spring 2005**	**Fall 2005**
Blacknose Dace *Rhinichthys atratulus*	2,012	-	3	107.40	-	0.31
Brook Trout *Salvelinus fontinalis*	-	1	4	-	2.54	0.77
Brown Trout *Salmo trutta*	-	5	6	-	18.98	5.07
Fantail Darter *Etheostoma flabellare*	10	-	-	0.49	-	-
Greenside Darter *Etheostoma blennioides*	6	-	-	0.76	-	-
Longnose Dace *Rhinichthys cataractae*	466	-	223	47.22	-	10.30
Mottled Sculpin *Cottus bairdi*	190	4	607	24.70	0.82	61.36
Rainbow Trout *Oncorhynchus mykiss*	6	112	112	6.72	110.84	70.90
Rock Bass *Ambloplites rupestris*	14	-	-	23.84	-	-
Central Stoneroller *Campostoma anomalum*	304	-	-	97.03	-	-
White Sucker *Catostomus commersoni*	2	-	-	3.21	-	-
Totals	**3,010**	**122**	**955**	**311**	**133**	**148.7**

Table Note: Both location and timing of electro shocking samples may well have contributed to the above results. The 1978 and Fall 2005 samples were collected in the same general region of the stream, well below the catch and release managed section near the confluence of Spring Run with South Mill Creek. The Spring 2005 samples were conducted in Section 4 of the fly-fishing managed section .

There was a striking difference in number of species, evenness (relative abundance of species), distribution of abundance and biomass among species, and of total abundance and biomass between sampling events in 1978 and 2005. The reductions in all of these parameters were large. The main contributors to fish biomass in 1978, the central stoneroller and the blacknose dace, were either absent or rare in 2005. These differences could, in part, have been due to changes in Spring Run's receiving stream - South Mill Creek, rather than changes in Spring Run. For example, South Mill Creek is wider and warmer than Spring Run, and the stoneroller is generally found in somewhat wider and warmer streams than the blacknose dace (Bilger & Brightbill., 1998). If conditions in South Mill Creek had become somehow inhospitable for stonerollers, the pool of individuals available for excursions into Spring Run at favorable times may have disappeared.

However, blacknose dace are a very widespread and abundant species in the Northeast. A study in Pennsylvania found them to be a dominant species in moderate gradient, cold-water, limestone spring-fed streams with a good canopy cover – streams much like Spring Run (Bilger & Brightbill., 1998). Their dominance in 1978 would have been expected. In 2005, the absence of blacknose dace in the catch and release section, and their extreme rarity in the lower section, might be a cause for concern.

The WVDNR reports note that, in 2005, "Spring Run has a high rainbow trout density and 112 trout per 100 meters were estimated during both 2005 surveys. The average relative weight for rainbow trout over 120 mm was Wr = 104, during the spring 2005 survey which indicated trout were feeding well (Anderson and Neumann 1996). Due to natural reductions in aquatic insect populations in the fall, the relative weight observed during the fall 2005 survey was reduced to Wr = 87 as predicted in the spring survey report." Rainbow trout were rare in 1978, despite the fact that Spring Run was a stocked, put-and-take stream at the time.

Length frequencies of rainbow trout in the 2005 sampling indicated strong year classes of rainbow trout in the 110 mm and 200 mm size range and few fish in the larger size groups (see figure below). WVDNR found a high rainbow trout density, with a biomass of rainbow trout fewer than 6 inches greater than 12 kg/ha. A "Class A" wild rainbow trout stream in Pennsylvania has a total biomass greater than 2.0 kg/ha of rainbow trout fewer than 6 inches (Graff 1997). Despite the high biomass of up to 6-inch rainbow trout, the report noted a dramatic difference in overall fish biomass per acre when compared to a 1978 Spring Run survey (311 lbs./acre in 1978 vs. 133 lbs./acre in Spring 2005 and 149 lbs./acre in Fall 2005, based on an average stream width of 19 feet. The Fisherman Survey results (page 17) indicate that a fish survey conducted further upstream would likely have produced significantly different length frequency results.

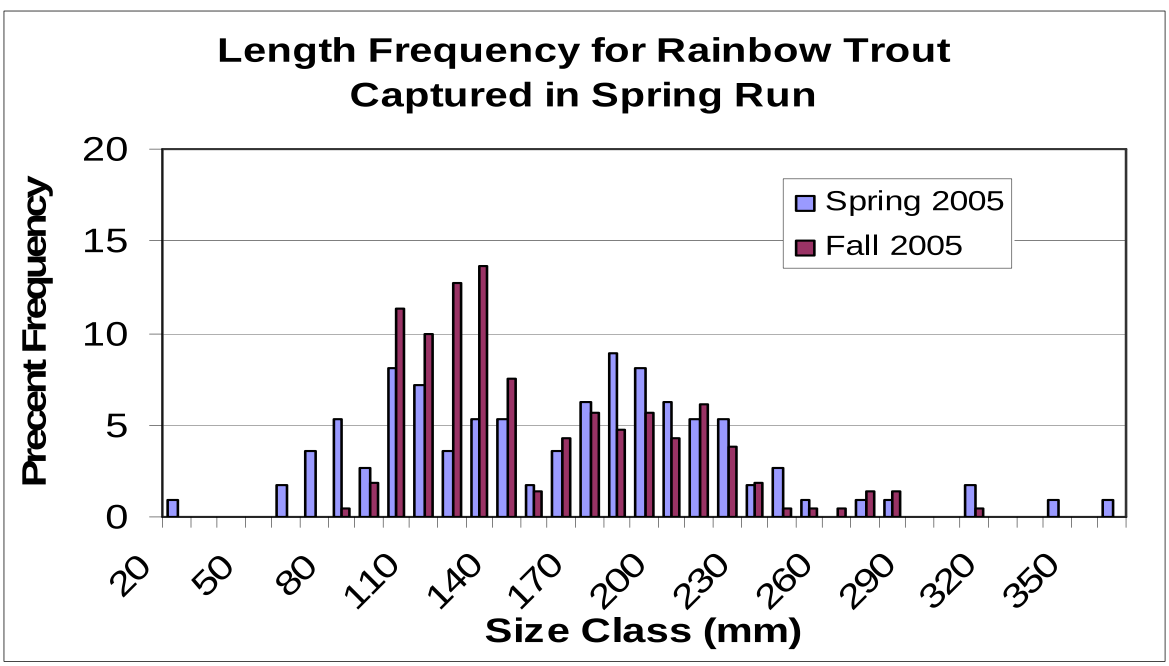

Figure from: Evaluation of Fisheries Resources in Spring Run, Grant County, West Virginia, September 2005.

Update On Upgrade Of Rearing Facility

Completion of the treatment upgrade is anticipated in March 2007. The treatment system is designed to capture approximately 95% of the total TSS and BOD load that is currently "swept" into the stream during raceway cleaning operations that typically occur on Mondays. This material will be transferred to a clarifier, with solids later relocated to a storage tank for later removal from the site. There is no treatment of the "once-through" spring water that is returned directly to Spring Run after it passes through the raceway system. (Rick Backus, WVDNR, December 2006; information updated by Shingleton in March 2007; both personal communication with Gillies)

Benthic Monitoring/Water Quality Workshops

"An educational day couldn't get any better than this," was the statement made by Arthur Halterman, middle and high school teacher at East Hardy Early Middle School. Mr. Halterman was referring to the benthic-monitoring workshops held on Spring Run.

Friends of Spring Run's Wild Trout, along with project partners, hosts the annual one-day benthic workshops on Spring Run that are an important public outreach component of the Spring Run project. Over forty individuals took part in the hands-on program in 2005. The benthic workshop brought together a diverse group of individuals ranging from students; fly-fisherman, environmental professional and community leaders to better understand freshwater ecology.

Another **Spring Run Workshop was** held on May 23, 2006. In 2006 the project team made the decision to expand the agenda to cover not only macroinvertebrate monitoring but also to include simple water chemistry testing techniques and flow monitoring. Twelve students from Petersburg High School and six students from East Hardy High School participated in the event along with several interested anglers. Representatives from DEP's Save Our Stream's Program, West Virginia Department of Agriculture's Water Quality Program, Trout Unlimited, Friends of Spring Run's Wild Trout, West Virginia Conservation Agency and Cacapon Institute all provided informational programs for the students. Students were broken down into monitoring teams and were responsible for assessing a stream section and then delivering a report on the project team's data back to the entire group at the end of the afternoon.

Volunteer Involvement

The Potomac Christian Educators, a home school group with members located in the North Mill Creek watershed, Petersburg, Cabins and the surrounding area will also be contributing to the project. This group has been trained and certified by WV Save Our Streams and will use the level one methods to monitor Spring Run at the lower portions of the catch and release area. The results of their first monitoring from August of 2005 can be viewed on the Internet through WV Save Our Streams Volunteer Access Database (VAD) http://www.wvdep.org/dwwm/wvsos/vad/index.htm.

At the sign-in screen, select "**View stream assessment reports**"; you do not have to register to view reports. You will see a complete list of streams currently in the database. To locate the Spring Run report, select the South Branch Potomac basin and click-on [**GO**]. The stream names and report codes are listed in alphabetical order.

Outreach- Watershed Celebration Day and Volunteer Monitoring in the Mid-Atlantic- Displays & awards

Education and outreach are a key component to this study. A table top display has been designed and displayed at several conferences including 2005 Watershed Celebration Day and the recent Volunteer Monitoring in the Mid-Atlantic Conference held in Canaan Valley. The display gives a comprehensive overview of the study and encourages public interest and participation. The first year's results were presented at the 2006 WV Water Quality Conference (sponsored by WVDEP), and are scheduled to be updated at the 2007 version of the same event.

Channel Stabilization Project

Directly above the spring feeding Spring Run is a deeply eroding channel, which lends significant amounts of sediment to the system. The original bed of this channel was relocated by road construction and is now constrained on one side by the road and on the other side by a steep hillside. Through a Stream Partner Grant, Friends of Spring Run's Wild Trout were able to partner with the West Virginia Conservation Agency and use natural streambank restoration techniques to stabilize the channel and slow down the sediment loading. The WVCA provided in-kind services to design and oversee the installation of a series of approximately 15 log cross vanes to stabilize the banks and direct the flow of runoff to the middle of the channel thereby relieving the stress on the banks of the channel. In certain areas, the banks were laid back to a 2:1 slope and re-vegetated. Native seedlings and shrubs were planted in March 2007 to stabilize the banks.

Site during construction.

Completed structure.

Year Three expectations

Post trout rearing facility effluent treatment system upgrade sampling will begin in April 2007, and continue through the September of 2007.

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Appendix 1. Water quality summary data.

Site	Yr	Minimum	Median	Maximum	Mean	Std.Dev.
Ammonia-N (mg/L)						
Dumpling Run @Spring	2005	0.003	0.007	0.082	0.025	0.033
Dumpling Run Bottom		0.003	0.007	0.079	0.028	0.037
Spring Run Bottom		0.017	0.043	0.161	0.07	0.059
Spring Run Middle		0.051	0.093	0.214	0.107	0.063
Spring Run @Spring		0.003	0.012	0.915	0.167	0.367
Dumpling Run @Spring	2006	0.008	0.008	0.008	0.008	0.000
Dumpling Run Bottom		0.008	0.008	0.008	0.008	0.000
Spring Run Bottom		0.008	0.008	0.041	0.019	0.017
Spring Run Middle		0.008	0.046	0.102	0.048	0.034
Spring Run @Spring		0.008	0.008	0.008	0.008	0.000
Nitrate-N (mg/L)						
Dumpling Run @Spring	2005	0.17	0.225	0.38	0.26	0.079
Dumpling Run Bottom		0.19	0.255	0.5	0.31	0.117
Spring Run Bottom		0.5	0.605	1.23	0.7	0.275
Spring Run Middle		0.43	0.49	1.14	0.63	0.273
Spring Run @Spring		0.37	0.475	0.59	0.48	0.083
Dumpling Run @Spring	2006	0.120	0.160	0.360	0.185	0.088
Dumpling Run Bottom		0.130	0.180	0.400	0.207	0.097
Spring Run Bottom		0.420	0.480	0.620	0.503	0.078
Spring Run Middle		0.390	0.410	0.570	0.448	0.074
Spring Run @Spring		0.340	0.405	0.550	0.413	0.079
Nitrite-N (mg/L)						
Dumpling Run @Spring	2005	0.001	0.001	0.005	0.001	0.002
Dumpling Run Bottom		0.001	0.001	0.014	0.003	0.006
Spring Run Bottom		0.001	0.006	0.029	0.01	0.011
Spring Run Middle		0.001	0.007	0.023	0.009	0.009
Spring Run @Spring		0.001	0.001	0.003	0.001	0.001
Dumpling Run @Spring	2006	0.001	0.001	0.001	0.001	0.000
Dumpling Run Bottom		0.001	0.001	0.001	0.001	0.000
Spring Run Bottom		0.004	0.007	0.016	0.008	0.004
Spring Run Middle		0.004	0.009	0.031	0.014	0.010
Spring Run @Spring		0.001	0.001	0.001	0.001	0.000
TKN (mg/L)						
Dumpling Run @Spring	2005	0.041	0.115	0.758	0.24	0.273
Dumpling Run Bottom		0.081	0.108	1.27	0.33	0.471
Spring Run Bottom		0.167	0.291	0.938	0.38	0.291
Spring Run Middle		0.214	0.305	1.46	0.51	0.475
Spring Run @Spring		0.099	0.15	1.89	0.44	0.711
Dumpling Run @Spring	2006	0.035	0.203	0.233	0.163	0.079
Dumpling Run Bottom		0.135	0.175	0.294	0.200	0.068
Spring Run Bottom		0.156	0.277	0.642	0.307	0.176
Spring Run Middle		0.181	0.214	1.090	0.387	0.355
Spring Run @Spring		0.091	0.214	0.287	0.201	0.066

Appendix 1. Water quality summary data.

Site	Yr	Minimum	Median	Maximum	Mean	Std.Dev.
Total N (mg/L)						
Dumpling Run @Spring	2005	0.252	0.341	1.143	0.5	0.348
Dumpling Run Bottom		0.274	0.364	1.784	0.63	0.583
Spring Run Bottom		0.688	0.877	2.197	1.09	0.574
Spring Run Middle		0.71	0.887	2.616	1.14	0.736
Spring Run @Spring		0.476	0.641	2.453	0.93	0.755
Dumpling Run @Spring	2006	0.176	0.364	0.569	0.348	0.134
Dumpling Run Bottom		0.296	0.356	0.695	0.407	0.146
Spring Run Bottom		0.601	0.734	1.216	0.818	0.227
Spring Run Middle		0.580	0.634	1.631	0.849	0.412
Spring Run @Spring		0.522	0.570	0.838	0.615	0.116
TP (mg/L)						
Dumpling Run @Spring	2005	0.007	0.028	0.059	0.028	0.019
Dumpling Run Bottom		0.007	0.026	0.052	0.028	0.019
Spring Run Bottom		0.059	0.087	0.14	0.092	0.031
Spring Run Middle		0.049	0.075	0.166	0.086	0.046
Spring Run @Spring		0.013	0.025	0.046	0.028	0.014
Dumpling Run @Spring	2006	0.022	0.054	0.124	0.060	0.035
Dumpling Run Bottom		0.020	0.044	0.134	0.052	0.041
Spring Run Bottom		0.012	0.103	0.143	0.094	0.053
Spring Run Middle		0.081	0.103	0.179	0.122	0.044
Spring Run @Spring		0.026	0.049	0.261	0.080	0.090
TSS (mg/L)						
Dumpling Run @Spring	2005	1.15	4.5	45	12.88	17.423
Dumpling Run Bottom		1.15	2.075	43	9.58	16.588
Spring Run Bottom		4	6.5	72	18.5	26.629
Spring Run Middle		1.15	5.5	81	17.36	31.281
Spring Run @Spring		1	1.575	78	14.38	31.175
Dumpling Run @Spring	2006	1.150	1.150	4.000	1.625	1.164
Dumpling Run Bottom		3.000	5.500	8.000	5.500	2.258
Spring Run Bottom		3.000	7.000	19.000	8.500	5.431
Spring Run Middle		3.000	5.000	28.000	8.667	9.522
Spring Run @Spring		1.150	2.575	11.000	4.075	3.933
Turbidity (NTU)						
Dumpling Run @Spring	2005	0.451	0.903	22.95	7.52	10.603
Dumpling Run Bottom		1.24	2.115	43.8	10.29	16.826
Spring Run Bottom		1.96	3.145	51.3	13.4	19.656
Spring Run Middle		1.31	3.4	36	9.58	13.519
Spring Run @Spring		1.03	1.945	18.42	5.22	6.842
Dumpling Run @Spring	2006	0.67	0.97	2.15	1.14	0.59
Dumpling Run Bottom		2.71	3.54	4.31	3.61	0.58
Spring Run Bottom		4.82	5.82	7.88	6.02	1.27
Spring Run Middle		2.43	3.65	12.80	5.27	4.00
Spring Run @Spring		3.14	4.78	7.47	4.86	1.66

Appendix 1. Water quality summary data.

Site	Yr	Minimum	Median	Maximum	Mean	Std.Dev.
BOD5 (mg/L)						
Dumpling Run @Spring	2005	1.01	1.54	3.13	1.81	0.884
Dumpling Run Bottom		1.18	1.515	2.68	1.63	0.546
Spring Run Bottom		0.66	1.01	1.97	1.15	0.489
Spring Run Middle		0.45	0.91	2.47	1.255	0.827
Spring Run @Spring		0.86	0.985	1.58	1.07	0.263
Dumpling Run @Spring	2006	0.760	1.400	1.970	1.352	0.460
Dumpling Run Bottom		0.760	1.100	1.590	1.123	0.336
Spring Run Bottom		0.230	0.425	1.360	0.572	0.432
Spring Run Middle		0.450	0.760	1.440	0.858	0.389
Spring Run @Spring		0.300	0.645	1.760	0.768	0.535
DO (mg/L)						
Dumpling Run @Spring	2005	9.24	10.29	11.14	10.23	0.624
Dumpling Run Bottom		9.4	10.42	11.48	10.45	0.688
Spring Run Bottom		9.98	10.575	11.18	10.59	0.476
Spring Run Middle		10.15	10.275	11.35	10.55	0.53
Spring Run @Spring		10.02	10.34	11.5	10.59	0.632
Dumpling Run @Spring	2006	9.650	10.595	12.180	10.708	0.982
Dumpling Run Bottom		9.770	10.600	12.200	10.707	0.860
Spring Run Bottom		9.870	10.740	12.580	10.902	0.997
Spring Run Middle		9.830	10.410	12.640	10.707	1.092
Spring Run @Spring		9.750	10.450	12.750	10.782	1.174
pH						
Dumpling Run @Spring	2005	7.4	7.75	8	7.69	0.236
Dumpling Run Bottom		7.5	8.05	8.5	7.99	0.361
Spring Run Bottom		7.2	7.5	7.7	7.47	0.229
Spring Run Middle		7.28	7.8	8	7.75	0.25
Spring Run @Spring		7.38	7.85	8.2	7.8	0.309
Dumpling Run @Spring	2006	7.30	7.60	7.80	7.60	0.17
Dumpling Run Bottom		7.40	7.80	8.40	7.80	0.38
Spring Run Bottom		7.30	7.55	8.10	7.58	0.31
Spring Run Middle		7.30	7.65	8.40	7.68	0.42
Spring Run @Spring		7.30	7.70	8.20	7.72	0.31
Conductivity (µs/cm)						
Dumpling Run @Spring	2005	45.8	286.9	372	260	112.414
Dumpling Run Bottom		48.1	283.5	352	257	106.735
Spring Run Bottom		45.1	247.5	276	213	85.869
Spring Run Middle		44.9	255	284	223	88.651
Spring Run @Spring		64.6	296.1	390	269	109.377
Dumpling Run @Spring	2006	39.0	254.2	372.0	239.6	108.9
Dumpling Run Bottom		44.9	263.9	352.0	241.3	103.5
Spring Run Bottom		36.3	253.2	276.0	213.0	90.6
Spring Run Middle		37.7	255.2	284.0	211.2	93.7
Spring Run @Spring		49.0	330.3	391.1	263.0	154.0

Appendix 2. Laboratory Methods for Water Quality Parameters.

Parameter	**Method**
Ammonia Nitrogen	EPA 350.2
Nitrate	EPA 353.2
Nitrite	EPA 353.2
* Ortho Phosphate	HACH 8048
Total Phosphate	EPA 365.2
Total Kjeldahl Nitrogen	EPA 351.2
Total Suspended Solids	SM 2540D
* Turbidity	HACH 2100N
Biochemical Oxygen Demand 5	SM5210B

Appendix 3. WV Save Our Streams Macroinvertebrate Assessment July 2003

Station 1 (catch-and-release)

Ephemeroptera (mayflies)	
Baetidae	73
Heptageniidae	2
Trichoptera (caddisflies)	
Rhyacophilidae	2
Hydropsychidae	13
Diptera (true flies)	
Simuliidae	8
Chironomidae	67
Amphipoda (scuds)	
Gammaridae	31
Total	196

Station 2 (catch-and-release)

Ephemeroptera (mayflies)	
Ephemerellidae	1
Heptageniidae	4
Baetidae	45
Plecoptera (stoneflies)	
Capniidae	1
Chloroperlidae	1
Perlodidae	4
Trichoptera (caddisflies)	
Glossosomatidae	2
Rhyacophilidae	1
Hydropsychidae	18
Coleoptera (beetles)	
Elmidae	4
Diptera (true flies)	
Simuliidae	16
Chironomidae	37
Amphipoda (scuds)	
Gammaridae	125
Total	259

Station 3 (above hatchery)

Ephemeroptera (mayflies)	
Isonychiidae	2
Ephemerellidae	3
Baetidae	30
Plecoptera (stoneflies)	
Capniidae	17
Perlodidae	6
Trichoptera (caddisflies)	
Rhyacophilidae	3
Hydropsychidae	17
Coleoptera (beetles)	
Elmidae	12
Psephenidae	1
Diptera (true flies)	
Dixidae	1
Simuliidae	12
Chironomidae	6
Amphipoda (scuds)	
Gammaridae	60
Total	170

Appendix 4. Assessing the Condition of the Macroinvertebrate Communities of Spring Run (Tim Craddock, Citizen's Monitoring Coordinator). Tables provide 2005 data only.

Typically bioassessment procedures follow a monitoring and assessment strategy. The procedures from this strategy are developed to better assess regional conditions. In other words, what are the best methods suited for a given region (Eco-Region). The procedures are also in place to reduce bias and introduce randomness.

In some cases this type of regionally based approach may not provide the correct type of information. WV DEP uses a suite of metrics, which together are known as the WV Stream Condition Index (WVSCI). Point values are determined for each metrics in the suite based upon theoretical or in some cases actual reference conditions, and these are integrated into a final score. This WVSCI score is given an integrity rating (e.g. Optimal, Sub-optimal, Marginal or Poor). These metrics were developed from many years of study. Percent dominance is one of the metrics in the suite, which in most cases is a good indicator of impairment, but in highly alkaline waters may not be as important. These types of streams often have high dominance of Gammaridae. A second hindrance is the sub-sampling methods, which again are meant to be random and not biased but may not capture true diversity in a community with an abundant and very dominant group.

In these situations it may be best to compare how the community changes over time, or how the community compares to a control or reference site, instead of using a standard suite of metrics or a standard sub-sampling procedure. I believe this is the case at Spring Run. To appropriately assess the benthic community changes we must look at the stability of the community itself, how it changes over time and how it compares to a reference stream of the same type. There is variability in the natural world, but in most cases unless there is a dramatic influence the community composition does not change quickly. Mostly the community remains relatively stable in terms of composition, diversity and abundance.

Here, we may use the same suite of metrics, however the overall score may become less important. Instead we need to evaluate the variability of these scores (metrics). Spring Run thus far has shown a great deal of variability, whereas Dumpling Run has not. We do expect variability in natural populations, but to what extent? As we begin to assess the meaning of these changes we need to look at how the human influences and natural influences are changing the biological communities and how the communities respond to the changes.

The families, counts and metrics for Spring Run and Dumpling Run can be viewed in the tables on the next several pages. Additional comparisons include calculations regarding density and relative percent difference (RPD). RPD was used to compare the changes from spring to fall. Results greater than 0.4 (> 40%) are considered to be significant and these are indicated. A negative value indicates a decrease, which is good for certain metrics (e.g. %Tolerant, %Chironomidae, %Dominant, %Hydropsychidae) but for other metrics increasing values is an indication of improving conditions. Regardless of an increase or decrease the benthic communities should remain relatively unchanged (stable) based upon reference conditions.

Spring Run (0.4)	May-05	
Class/Order	**Family**	Count
Oligochaeta	Lumbriculidae	1
Gastropoda	Physidae	1
Amphipoda	Gammaridae	154
Ephemeroptera	Ephemerellidae	15
Ephemeroptera	Baetidae	3
Ephemeroptera	Leptophlebiidae	1
Trichoptera	Hydropsychidae	11
Trichoptera	Brachycentridae	1
Coleoptera	Elmidae	3
Megaloptera	Corydalidae	1
Diptera	Chironomidae	43
	Total	234

Spring Run (0.4)	October-05	
Class/Order	**Family**	Count
Amphipoda	Gammaridae	149
Ephemeroptera	Ephemerellidae	2
Ephemeroptera	Baetidae	1
Trichoptera	Hydropsychidae	10
Coleoptera	Elmidae	21
Diptera	Chironomidae	9
	Total	192

Spring Run (1.6)	May-05	
Class/Order	**Family**	Count
Oligochaeta	Lumbriculidae	10
Turbellaria	Planariidae	14
Gastropoda	Lymnaeidae	1
Bivalvia	Sphaeriidae	1
Amphipoda	Gammaridae	6
Ephemeroptera	Ephemerellidae	23
Ephemeroptera	Baetidae	39
Ephemeroptera	Heptageniidae	6
Plecoptera	Leuctridae	1
Plecoptera	Perlodidae	10
Trichoptera	Hydropsychidae	2
Trichoptera	Rhyacophilidae	3
Coleoptera	Elmidae	3
Diptera	Chironomidae	90
Diptera	Simuliidae	2
Diptera	Tipulidae	2
	Total	213

Spring Run (1.6)	October-05	
Class/Order	**Family**	Count
Oligochaeta	Lumbriculidae	2
Turbellaria	Planariidae	1
Amphipoda	Gammaridae	2
Ephemeroptera	Baetidae	1
Ephemeroptera	Ephemerellidae	1
Plecoptera	Perlodidae	1
Trichoptera	Rhyacophilidae	6
Trichoptera	Hydropsychidae	27
Coleoptera	Elmidae	3
Diptera	Chironomidae	150
Diptera	Simuliidae	1
	Total	195

Spring Run (2.3)	May-05	
Class/Order	**Family**	Count
Turbellaria	Planariidae	1
Amphipoda	Gammaridae	95
Ephemeroptera	Ephemerellidae	12
Ephemeroptera	Heptageniidae	17
Ephemeroptera	Baetidae	50
Ephemeroptera	Leptophlebiidae	1
Plecoptera	Perlodidae	9
Plecoptera	Leuctridae	1
Plecoptera	Nemouridae	1
Trichoptera	Hydropsychidae	4
Trichoptera	Rhyacophilidae	1
Trichoptera	Glossosomatidae	1
Diptera	Chironomidae	36
Diptera	Empididae	1
	Total	230

Spring Run (2.3)	October-05	
Class/Order	**Family**	Count
Amphipoda	Gammaridae	163
Ephemeroptera	Heptageniidae	6
Odonata	Gomphidae	1
Plecoptera	Chloroperlidae	3
Plecoptera	Perlodidae	3
Trichoptera	Hydropsychidae	4
Trichoptera	Rhyacophilidae	3
Diptera	Chironomidae	5
Diptera	Tipulidae	2
	Total	190

Spring Run (0.4)	May-05	
Metrics	Value	Points
Total Taxa	11	52.4
EPT Taxa	5	38.5
Biotic Index	5.39	65.8
% EPT	8.9	9.9
% Dominant	65.5	43.1
% Tolerant	19.1	82.5
% Chironomidae	18.3	82.5
% Hydropsychidae	4.7	97.2
Stream Index		**48.7**
Number of Grids	3	78.0

Spring Run (0.4)	October-05	
Metrics	Value	Points
Total Taxa	6	28.6
EPT Taxa	3	23.1
Biotic Index	5.01	71.4
% EPT	1.6	1.7
% Dominant	77.6	28.0
% Tolerant	4.7	97.3
% Chironomidae	4.7	96.3
% Hydropsychidae	5.2	96.7
Stream Index		**41.7**
Number of Grids	4	48.0

RPD	
-0.59	**-58.8**
-0.50	**-50.0**
0.08	8.2
-1.41	**-141.4**
-0.42	**-42.5**
0.16	16.5
0.15	15.4
-0.01	-0.5
-0.15	-15.5
-0.48	**-47.6**

Spring Run (1.6)	May-05	
Metrics	Value	Points
Total Taxa	16	76.2
EPT Taxa	7	53.8
Biotic Index	5.76	60.6
% EPT	38.5	42.8
% Dominant	42.3	72.2
% Tolerant	54.0	46.9
% Chironomidae	42.3	58.3
% Hydropsychidae	0.9	100.0
Stream Index		**58.8**
Number of Grids	7	30.4

Spring Run (1.6)	October-05	
Metrics	Value	Points
Total Taxa	11	52.4
EPT Taxa	5	38.5
Biotic Index	7.20	40.0
% EPT	4.6	5.1
% Dominant	76.9	28.8
% Tolerant	78.5	22.0
% Chironomidae	76.9	23.3
% Hydropsychidae	13.8	88.0
Stream Index		**31.1**
Number of Grids	1	195.0

RPD	
-0.37	-37.0
-0.33	-33.2
-0.41	**-41.0**
-1.57	**-157.4**
-0.86	**-85.9**
-0.72	**-72.3**
-0.86	**-85.8**
-0.13	-12.8
-0.62	**-61.6**
1.46	**146.1**

Spring Run (2.3)	May-05	
Metrics	Value	Points
Total Taxa	14	66.7
EPT Taxa	10	76.9
Biotic Index	4.78	74.5
% EPT	40.4	44.9
% Dominant	41.3	73.4
% Tolerant	16.1	85.6
% Chironomidae	15.7	85.2
% Hydropsychidae	1.7	100.0
Stream Index		**70.3**
Number of Grids	6	38.3

Spring Run (2.3)	October-05	
Metrics	Value	Points
Total Taxa	8	38.1
EPT Taxa	4	30.8
Biotic Index	4.89	73.0
% EPT	6.4	7.1
% Dominant	87.2	16.0
% Tolerant	2.7	99.3
% Chironomidae	2.7	98.3
% Hydropsychidae	2.1	99.9
Stream Index		**44.1**
Number of Grids	5	38.0

RPD	
-0.55	**-54.6**
-0.86	**-85.6**
-0.02	-2.0
-1.45	**-145.4**
-1.28	**-128.4**
0.15	14.8
0.14	14.3
0.00	-0.1
-0.46	**-45.8**
-0.01	-0.8

Dumpling Run (1.4)	May-05	
Class/Order	**Family**	Count
Amphipoda	Gammaridae	92
Ephemeroptera	Heptageniidae	50
Ephemeroptera	Ephemerellidae	7
Ephemeroptera	Baetidae	1
Plecoptera	Perlidae	1
Plecoptera	Leuctridae	1
Trichoptera	Philopotamidae	3
Trichoptera	Hydropsychidae	1
Trichoptera	Rhyacophilidae	1
Trichoptera	Glossosomatidae	1
Odonata	Gomphidae	2
Coleoptera	Elmidae	8
Diptera	Chironomidae	35
Diptera	Empididae	4
Diptera	Blephariceridae	1
Diptera	Tipulidae	2
	Total	210

Dumpling Run (1.4)	October-05	
Class/Order	**Family**	Count
Oligochaeta	Lumbriculidae	1
Amphipoda	Gammaridae	163
Ephemeroptera	Baetidae	32
Ephemeroptera	Heptageniidae	13
Ephemeroptera	Leptophlebiidae	1
Plecoptera	Perlodidae	3
Plecoptera	Chloroperlidae	3
Plecoptera	Capniidae	5
Trichoptera	Hydropsychidae	2
Trichoptera	Philopotamidae	2
Trichoptera	Rhyacophilidae	1
Coleoptera	Elmidae	8
Diptera	Chironomidae	2
Diptera	Empididae	1
Diptera	Simuliidae	1
	Total	238

Dumpling Run (2.2)	May-05	
Class/Order	**Family**	Count
Amphipoda	Gammaridae	180
Ephemeroptera	Ephemerellidae	11
Ephemeroptera	Heptageniidae	8
Ephemeroptera	Baetidae	9
Plecoptera	Chloroperlidae	3
Trichoptera	Glossosomatidae	2
Coleoptera	Elmidae	2
Diptera	Chironomidae	7
Diptera	Blephariceridae	1
Diptera	Tipulidae	1
	Total	224

Dumpling Run (2.2)	October-05	
Class/Order	**Family**	Count
Amphipoda	Gammaridae	210
Ephemeroptera	Baetidae	2
Ephemeroptera	Heptageniidae	5
Plecoptera	Chloroperlidae	3
Plecoptera	Perlodidae	1
Plecoptera	Capniidae	1
Trichoptera	Glossosomatidae	4
Trichoptera	Rhyacophilidae	1
Coleoptera	Elmidae	5
Diptera	Chironomidae	6
Diptera	Tipulidae	1
	Total	239

Dumpling Run (1.4)	May-05	
Metrics	Value	Points
Total Taxa	16	76.2
EPT Taxa	9	69.2
Biotic Index	4.80	74.4
% EPT	31.0	34.4
% Dominant	43.8	70.2
% Tolerant	16.7	85.0
% Chironomidae	16.7	84.1
% Hydropsychidae	0.5	100.0
	Stream Index	**68.2**
Number of Grids	6	35.0

Dumpling Run (1.4)	October-05	
Metrics	Value	Points
Total Taxa	14	66.7
EPT Taxa	9	69.2
Biotic Index	4.54	78.0
% EPT	25.3	28.1
% Dominant	68.8	39.0
% Tolerant	0.8	100.0
% Chironomidae	0.8	100.0
% Hydropsychidae	0.8	100.0
	Stream Index	**63.5**
Number of Grids	8	29.8

RPD	
-0.133	-13.3
0.000	0.0
0.047	4.7
-0.202	-20.2
-0.571	**-57.1**
0.162	16.2
0.173	17.3
0.000	0.0
-0.071	-7.1
-0.160	-16.0

Dumpling Run (2.2)	May-05	
Metrics	Value	Points
Total Taxa	10	47.6
EPT Taxa	5	38.5
Biotic Index	4.78	74.6
% EPT	14.7	16.4
% Dominant	80.4	24.6
% Tolerant	3.1	98.9
% Chironomidae	3.1	97.9
% Hydropsychidae	0.0	100.0
	Stream Index	**50.1**
Number of Grids	4	56.0

Dumpling Run (2.2)	October-05	
Metrics	Value	Points
Total Taxa	11	52.4
EPT Taxa	7	53.8
Biotic Index	4.85	73.6
% EPT	7.1	7.9
% Dominant	87.9	15.2
% Tolerant	2.5	99.5
% Chironomidae	2.5	98.5
% Hydropsychidae	0.0	100.0
	Stream Index	**50.4**
Number of Grids	4	59.8

RPD	
0.096	9.6
0.332	33.2
-0.013	-1.3
-0.700	**-70.0**
-0.472	**-47.2**
0.006	0.6
0.006	0.6
0.000	0.0
0.006	0.6
0.066	6.6