Coldwater Conservation Plan 2015

Bells Gap Headwaters: Conserving newly found *Salvelinus fontinalis* (brook trout) populations

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Bear Loop Run

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TABLE OF CONTENTS

Introduction

Purpose

In 2014, Juniata College, headed by the Grant Lab, received a grant from the Coldwater Heritage Partnership to assess the headwater stream system of Bells Gap Run, including Green Springs Run, Tubb Run, and Bear Loop Run which are located near Bellwood in Blair County, Pennsylvania. The purpose of this assessment was to further assess the headwater ecosystem of Bells Gap Run after a small wild brook trout population had been found in this region during sampling in the summer of 2013 as part of the PA Fish and Boat Commission's Unassessed Waters Initiative. The Unassessed Water Initiative is a program that assesses many miles of unassesed streams in order to help and protect wild trout populations. This conservation plan is the result of a detailed assessment, including basic water quality measurements, macroinvertebrate and fish biodiversity, trout population structure, and mercury (Hg) concentrations in sediment, macroinvertebrates and fish. We worked to identify potentially harmful threats to the ecosystem and human health and suggest potential remedies towards ensuring long-term sustainability of wild brook trout in the Bells Gap headwaters.

Description of the Watershed

The Bells Gap watershed is located in the northern part of Blair County along the Centre and Cambria County borders. It encompasses approximately 11,273 acres, 93.2% of which is forested, 3.9% of which is urbanized, 1.6% of which is in agriculture, and 1.3% is in roads (Figures 1 and 2). The watershed contains large portions of State Game Lands 156 and 108, as well as the Bellwood Reservoir, which serves as one of the sources of public drinking water to the City of Altoona with a population of over 45,000 (Blair County Tributary Strategy and Implementation Plan 2005) and the Borough of Bellwood's only public water supply with a population of 1,800.

Pennsylvania has an extensive coal mining history, which has led to the issue of Abandoned Mine Drainage (AMD). Bells Gap watershed has been mined for coal as far back as the late 17th century and impacts from AMD have still been noted in recent years (Wiley and Garner, eds. 1892, Capacasa 2003). Concerned citizens submitted a complete "Areas Unsuitable for Mining (UFM)" petition in 1986 for the watershed, claiming that AMD would cause long-term degradation of the public water supply and negatively impact the wild and stocked populations of trout. The three main tributaries to Bells Gap that we set out to assess are Tubb, Run, Bear Loop Run, and Green Springs Run. Both Bells Gap Run and Bear Loop Run are currently both on the PA Department of Environmental Protection's 303(d) list of impaired waters in Pennsylvania, as a result of AMD(EPA 2004). Mining impacts are notable in the headwaters of Tubb Run and Bear Loop Run, with Bear Loop Run experiencing AMD remediation efforts (Figure 1). The current design of this study allows for comparison between Green Springs Run-no AMD impacts, Bear Loop -impacted by AMD with some remediation, and Tubb Run -impacted by AMD with no remediation efforts.

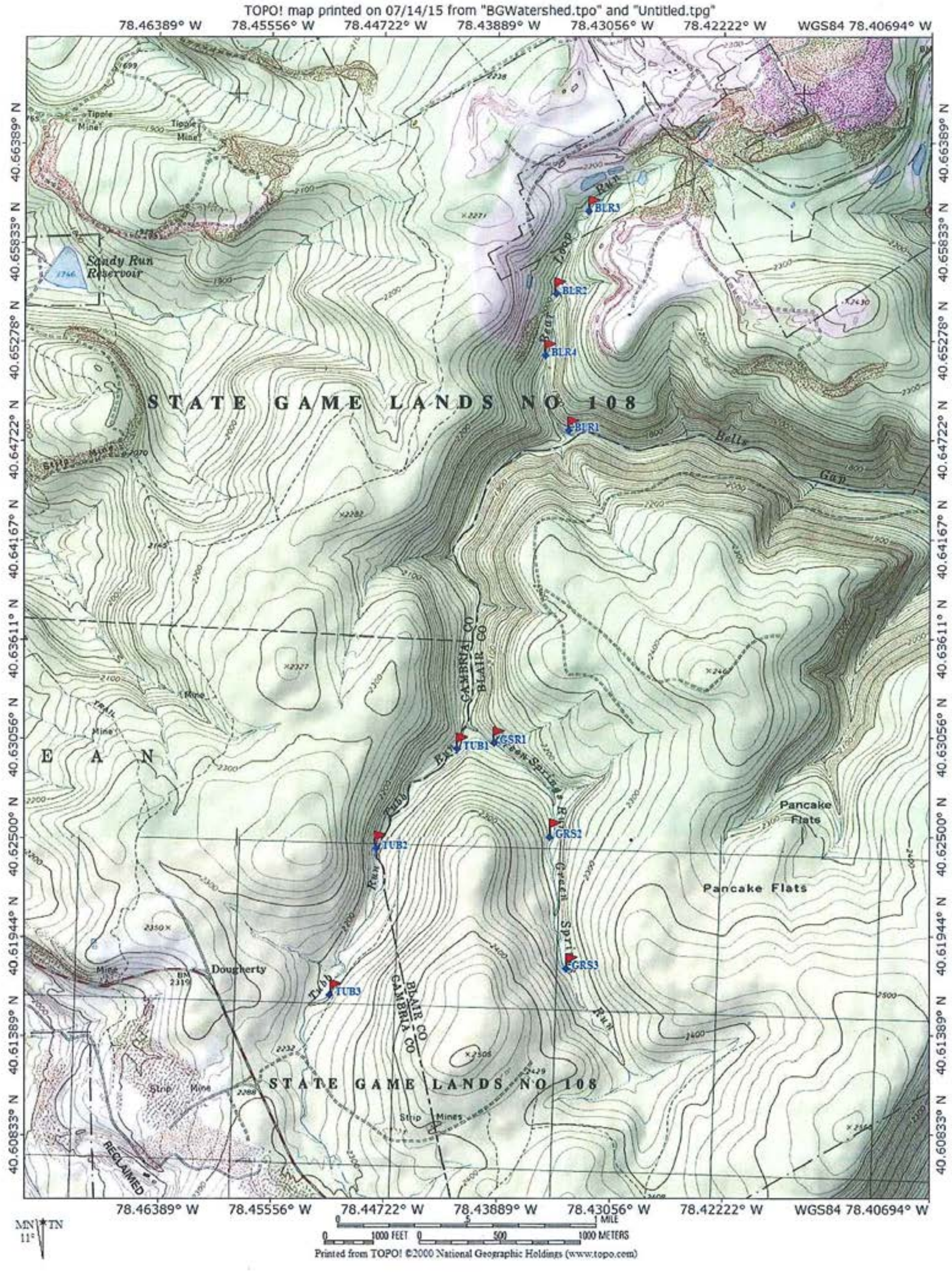

Figure 1: Map depicting part of the watershed containing areas of Tubb Run, Green Springs Run, and Bear Loop Run. There are three sampling sites marked on Tubb Run and Green Springs. There are four marked on Bear Loop because an extra one was done in search of Brook Trout.

Sampling Procedures

This study consisted of an in depth analysis of three streams, Bear Loop Run, Green Springs Run, and Tubb Run, all of which are tributaries to Bells Gap Run. Our sampling strategy allows for a paired watershed design to be employed between Bear Loop Run, Tubb Run and Green Springs Run. The close geographic proximity and relatively similar watersheds will allow for comparison of sites with and without the effects of acid mining drainage (Figure 1). Comparing these sites would allow for observation regarding the impacts of acid mine drainage on water quality, fish and macroinvertebrate biodiversity, trout populations, and aquatic mercury concentrations. Additionally, since at least three sites were sampled per stream, this allows for statistical comparisons to be made between each stream.

Water Quality

Water quality measurements collected at each site included temperature (^{o}C), pH, conductivity (µS), total dissolved solids (TDS) (ppm), salinity (ppm), alkalinity (mg/L), and total hardness (mg/L). All measurements excluding alkalinity and hardness were taken using a PCSTestr 35 Multi-parameter test probe. Alkalinity and hardness were both measured using colormetric processes. Alkilinity used a colorimetric kit that uses a mixed Bromcresol Green-Methyl Red indicator and a titrate of 0.2N sulfuric acid provided by the fish and game commission that is also used for the unassessed waters project. The hardness was measured using a colorimetric Hach Total Hardness Test Kit model HA-71A. All statistics for water quality were run using Minitab. One-way ANOVA tests were used to compare Green Springs Run to the AMD impacted streams, Tubb Run and Bear Loop Run through temperature, pH, conductivity, and total dissolved solids (TDS). A T-test was run to compare alkalinity.

Fish Collection

Fish biodiversity assessments were accomplished through two-pass depletion methods of electro-fishing with a Smith and Root LR 24 backpack electrofisher with pulsed direct currents ranging from 400-800 volts, depending on stream conductivity. All stunned fish were held in buckets from each pass, were measured for length (to the nearest mm) and weight (to the nearest 0.1g), and returned to the stream. Three to five fish from each site were kept for later Hg analysis. These fish were placed in a cooler in the field before being stored at -20^{o}C back at the lab. Filet samples were taken from the left dorsal section posterior to the depressed dorsal fin and analyzed for mercury content using a Milestone DMA-80. Total mercury was corrected for sample weight and length normalized (LN) for each fish. Population estimates were calculated following using Seber and Le Cren's (1967) two pass depletion estimates.

Macroinvertebrates

Macroinvertebrate biodiversity assessments were completed through composite kicknet sampling at each site. Macroinvertebrates from kicknet samples from 4 riffles within each site were combined to create one macroinvertebrate sample for each site. All macroinvertebrates were stored in water and frozen at -20 ^{o}C also. Macroinvertebrates were then identified in the lab to the lowest possible classification level and divided into feeding groups (shredders, collectors, predators, and scrapers) (Chalfant 2012). All individuals from each feeding group per site were compiled to create a sample for Hg analysis. Feeding group samples were homogenized. Samples were then analyzed for total mercury using a Milestone DMA-80. Approximately 0.1g was used for each analysis. Mercury readings were then adjusted for sample weight. Additionally, for each stream, an Index of Biotic Integrity (IBI) was calculated. This involves calculating the total taxa richness, pollution tolerance values (PTV), Shannon Wiener Index, Ephemeroptera + Plecoptera + Trichoptera (EPT) taxa richness, Beck's Index, Hilsenhoff Biotic Index (HBI) and percent sensitive individuals for each site. After standardization procedures, all indices are averaged together to create an IBI for that site. This process is explained in detail in Chalfant (2012).

Sediment

Composite sediment samples were collected at each site using clean trace techniques; samples were collected with Teflon scoops and placed into pre-cleaned glass vials (US EPA 2007, US EPA 2001). Samples were stored at -20^{o}C until preparation for Hg analysis. Sediment samples were removed from the freezer and allowed to thaw. Uncapped vials were placed into a Precision oven at 50°C for 24-48 hours (US EPA 2007). Samples were removed when completely dry and allowed to cool at room temperature. When samples were cool, Teflon stir rods were used to homogenize the samples (US EPA 2007; US EPA 2001; Cesa et al. 2008).

Following homogenization, sub-samples were analyzed on a Milestone DMA-80. Approximately 0.1g of sediment was used for analysis. Priority was given to fine particulate sediment with organic matter as opposed to large pebbles. Samples were run following standard operating procedure (US EPA 2007).

Results/Discussion

Water Quality

Water quality measurements are often very good indicators of potential harmful effects to an aquatic ecosystem. Stream temperatures indicated a significant difference between streams (p=0.019; Figure 2). However, all temperatures were within the optimal range for growth and survival of brook trout of 11-16 degrees Celsius (Alabaster 1982). Stream temperature plays an important role in ecosystem health and is a major determining factor in what organisms can live in an environment. Water temperature out of an organism's desired range will increase metabolic demands, decrease growth, and affect respiration rate (Alabaster 1982). Further, brook trout have specific temperature requirements in order to survive and reproduce and cannot survive for extended periods of time in water with a temperature exceeding 25 degrees Celsius (Raleigh 1982). Macroinvertebrates, also have temperature requirements, they are taxa and species dependent. More sensitive macros like mayflies are more volatile in reaction to a temperature change than brook trout are (Fengqing Li et al. 2013), and their loss could inhibit brook trout feeding and survival. Since all of our stream temperatures were all within the optimal range for brook trout, we do not feel this is an issue that needs to be addressed.

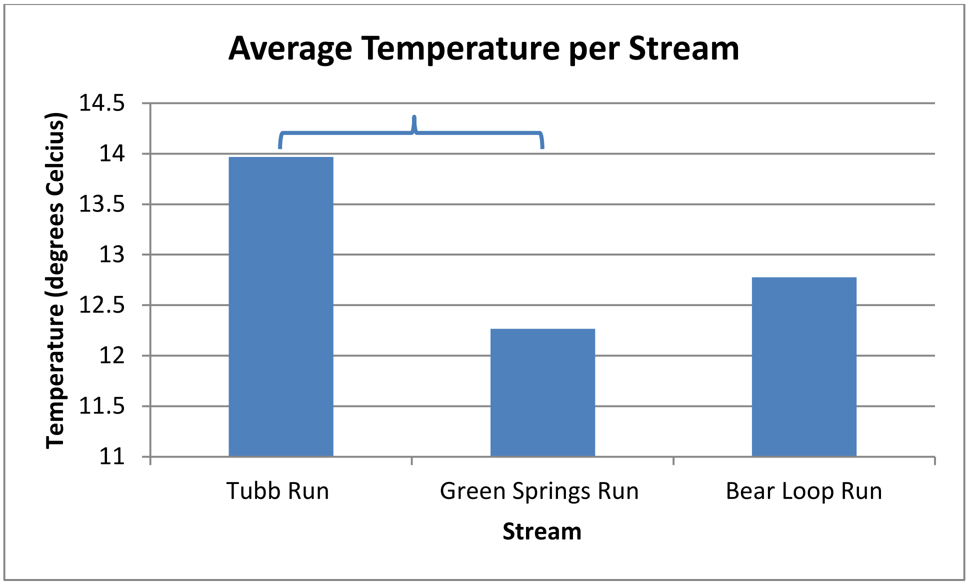

Figure 2: Graph depicting the average temperature (^{o}C) per stream. The bracket indicates that Tubb Run and Green Springs Run were significantly different than one another.

Stream pH was observed to be significantly different between the streams (p=0.0069; Figure 3). Tubb Run, which has no remediation, had a significantly lower pH than Bear Loop Run, which has some historical remediation and has a significantly lower pH ($p<0.05$) than pristine Green Springs Run ($p<0.01$; Figure 3). This follows our expectations because AMD causes a more acidic pH in the effected streams. This low pH in Tubb Run could affect the aquatic organisms living in the stream. All aquatic organisms have a pH range that must be met if that organism is to occupy and perpetuate in stream ecosystems. If the pH were too high or too low, an organism's proteins and enzymes would denature, inhibiting functions necessary for life (Alabaster 1982). Brook trout can tolerate a pH range of 3.5-9.8, with optimal conditions around 6.5-8.0 (Gunderson, et. al. 1994). Average pH of a healthy stream is anywhere from 6.5-8.5 (Alabaster 1982). All of the streams could be considered acidic because they are all below a pH of 7. But, both Bear Loop Run and Tubb Run are under this average healthy pH and so remediation or further remediation would be appropriate for both streams. The acidity of both streams could negatively affect the aquatic organisms in the stream.

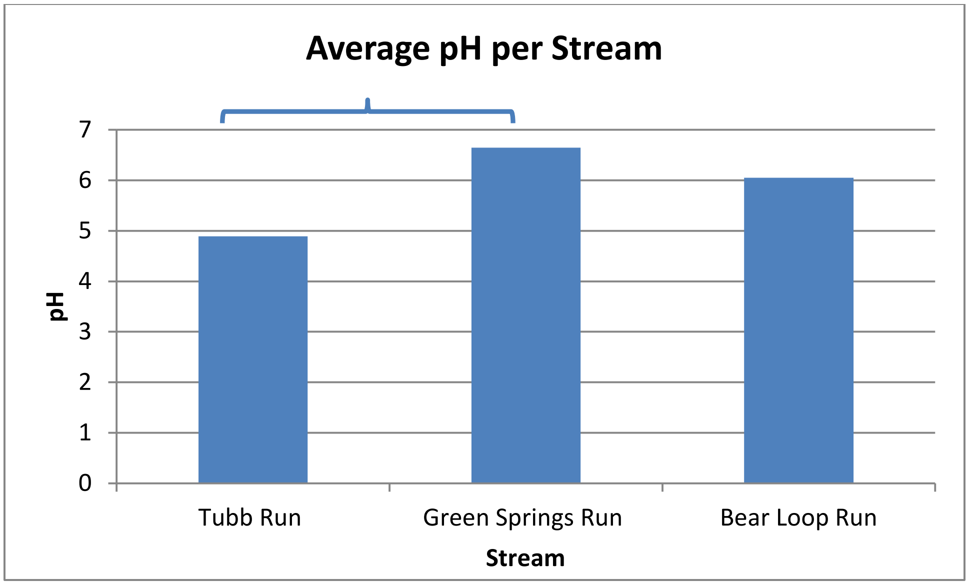

Figure 3: Graph depicting the average pH per stream. The brackets indicates the streams that are significantly different from one another

There was a significant difference observed between alkalinity measured at Green Springs Run and Bear Loop Run. Green Springs Run had a significantly higher mean alkalinity than Bear Loop Run (p=0.0123) (Figure 4). This aligns with the fact that AMD generally reduces a streams buffering capacity. Since Tubb Run had no measured alkalinities, we are unable to compare the stream to the others. Higher alkalinity measures are normally associated with healthier streams, whereas streams with low alkalinities are generally unhealthy due to the inability to resist changes in pH. However it is possible to have healthy streams with alkalinities that are too low to measure and unhealthy streams that have alkalinity that is too high (i.e. agricultural land use). AMD decreases the alkalinity in a stream because the increased number of hydrogen ions effectively neutralizes the bicarbonate and carbonate ions in the water. These two ions are generally what provide the stream with buffering capabilities. Due to the decreased buffering capacities, AMD affected streams are generally more acidic. The lower alkalinity in Bear Loop Run follows the results in pH. The lower alkalinity and pH in Bear Loop Run indicates that it is an unhealthy stream especially since the pH is lower than what is considered normal or healthy. This should be considered in the remediation efforts for Bear Loop Run.

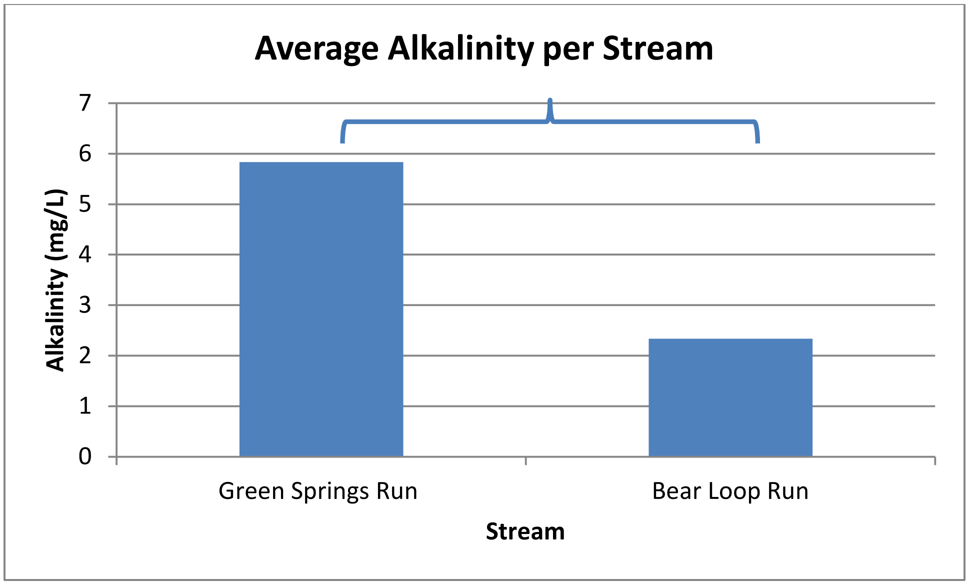

Figure 4: Graph depicting the average alkalinity (mg/L) per stream. Green Springs Run was significantly higher than Bear Loop Run, as indicated by the bracket.

There was a significant difference between measured TDS in each stream ($p=0.015$). More specifically, Bear Loop Run had a significantly higher mean TDS than Green Springs Run ($p<0.05$) (Figure 5). This difference might stem from the fact that Bear Loop Run had two observed seeps, which are likely contributing large amounts of dissolved solids. We can also account for the unusually high TDS in Bear Loop Run because on the day we were sampling we received significant rainfall in the days leading up to sampling which elevated streamflow and dissolved solids. AMD is known to increase concentrations of iron (Fe), aluminum (Al), and manganese (Mn), as well as other metals. High amounts of TDS in streams have been shown to have very toxic and negative effects on streams. They can cause shifts in biotic communities and have chronic and acute effects on different life stages (Scannell and Duffy 2007). However the levels at which TDS effects aquatic organisms in this way are much higher than what we found. And so the levels of TDS are not necessarily a concern at this current time.

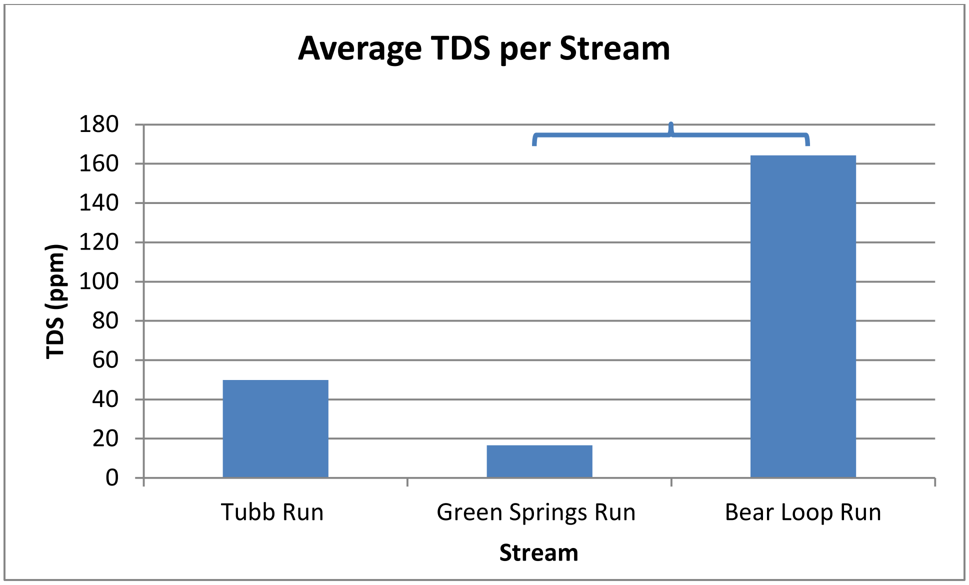

Figure 5: Graph depicting the average TDS (ppm) per stream. The brackets indicates the streams that are significantly different from one another

A significant difference between stream mean conductivity (p=0.015) was found. Bear Loop Run was seen to have a significantly higher measured conductivity than Green Springs Run ($p<0.05$) (Figure 6). This similar result to TDS is expected, and the two seeps in Bear Loop Run and amount of rain are likely contributing to these results. Both TDS and conductivity are good measures of AMD impaction since they either directly or indirectly measure by-products of AMD, specifically in the form of dissolved Fe, Al, Mn, salts, and other metals. TDS is closely related to the water quality measure of conductivity. Conductivity increases with increasing amount of dissolved ions and salts in the stream water, a measure which is represented by TDS. Therefore, streams with increased TDS values should have corresponding increased conductivity measures. This is shown in the streams we sampled. Bear Loop run has a much higher conductivity than the other two streams, most likely because of the higher TDS levels which we found.

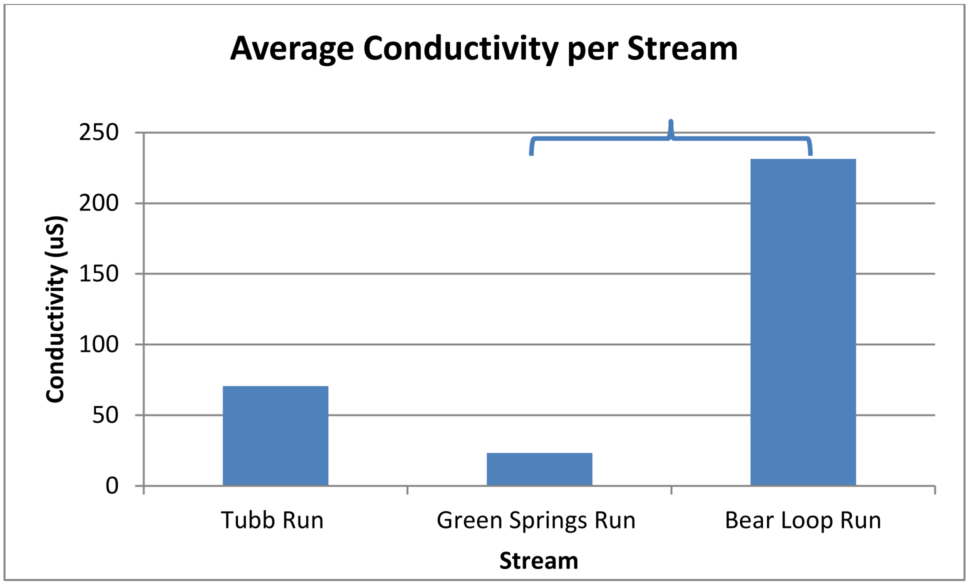

Figure 6: Graph depicting the average conductivity (µS) per stream. The brackets indicates the streams that are significantly different from one another

Table 1: Summary of water quality data from each site at each stream. Averages and standard deviations (SD) were calculated per stream. NM= Not Measured

Stream	Site	Temp (°C)	pH	Cond	TDS	Alkalinity
Tubb Run	1	14	4.93	62.4	44.3	NM
Tubb Run	2	14.1	4.73	67	46.7	NM
Tubb Run	3	13.8	5.02	82.7	58.5	NM
Green Springs Run	1	12.6	6.51	25.2	17.9	8
Green Springs Run	2	11.5	6.66	25.6	18.2	6
Green Springs Run	3	12.7	6.77	19.5	13.8	3.5
Bear Loop Run	1	12.2	6.63	230	164	2
Bear Loop Run	2	12.5	6.3	320	228	3
Bear Loop Run	3	13.7	5.04	75	53.1	NM
Bear Loop Run	4	12.7	6.23	300	212	2
Tubb Run Average		13.96	4.89	70.7	49.83	NM
Green Springs Run Average		12.26	6.64	23.43	16.63	5.83
Bear Loop Run Average		12.77	6.05	231.25	164.27	2.33
Tubb Run SD		0.15	0.14	10.64	7.60	NM
Green Springs Run SD		0.66	0.13	3.41	2.45	2.25
Bear Loop Run SD		0.65	0.69	111.08	78.94	0.57

Macroinvertebrate Biodiversity

We anticipated that the IBI scores of Tubb and Bear Loop Runs would be lower than Green Springs Run. Results confirmed this, showing a significant difference between the mean IBI score for each stream ($p=0.0505$, $\alpha=0.1$; Figure 7). Across all three streams, shredders were the most common feeding group among macroinvertebrates, while scrapers were the least common feeding group. Collectors were more common in Tubb Run and Bear Loop Run than predators, and the reverse was true for Green Springs Run (Figures 8, 9, and 10).

Shredders feed on leaf detritus and typically have lower levels of mercury compared to predators (which feed on other macroinvertebrates), collectors (which eat anything they can collect) and scrapers (which feed on periphyton). Each feeding group can have a variety of macroinvertebrates in it with multiple pollution tolerances. However, stoneflies, mayflies and caddisflies are typically the more sensitive taxa that can appear in all feeding groups. All feeding groups are important to be present in a stream ecosystem and the inclusion of all groups typically indicates a healthier ecosystem than streams missing a feeding group. A missing feeding group could indicate lower water quality and can also affect organisms that consume them (such as brook trout) by limiting the number of macroinvertebrates available to feed on.An ecosystem is said to have biotic integrity if it supports and maintains varied processes and elements expected in an ecosystem with little to no human impacts (Karr and Dudley 1981; Davis and Simon 1995; Davies and Jackson 2006). Therefore IBIs are very good indicators of an ecosystems' health, as higher IBI scores correlate to less human impact.

A macroinvertebrate IBI score reveals a lot about a stream water ecosystem. As a major dietary source for brook trout and other fish species, macroinvertebrates are essential to preserve these newly found populations of brook trout in these streams. The fact that Green Springs had a better IBI score means that that stream is healthier than the other two. It is actually significantly healthier indicating that remediation of the streams should be done at Tubb and Bear Loop Run. Bear Loop has gone through some remediation and so the macroinvertebrate population may come back, it may just take some more time. There could be a number of factors, like lack of habitat; metal content and acidic agents from the seeps are into Bear Loop that affects macroinvertebrates communities (species list in Appendix B).

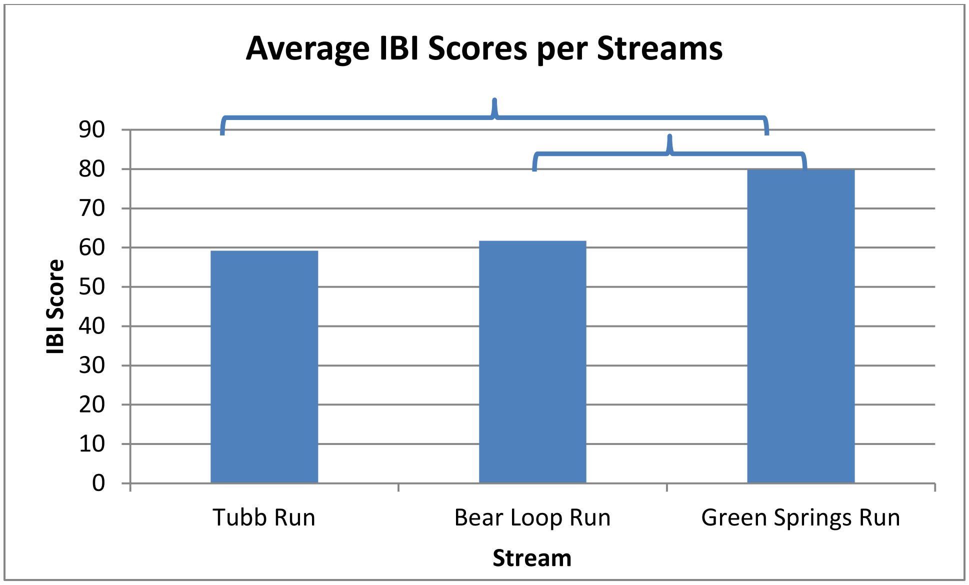

Figure 7: Graph depicting the average IBI score per stream. The brackets indicate the streams that are significantly different from one another. Tubb Run and Bear Loop Run are significantly lower than Green Springs Run ($p=0.059$, $p=0.092$, $\alpha=0.1$, respectively)

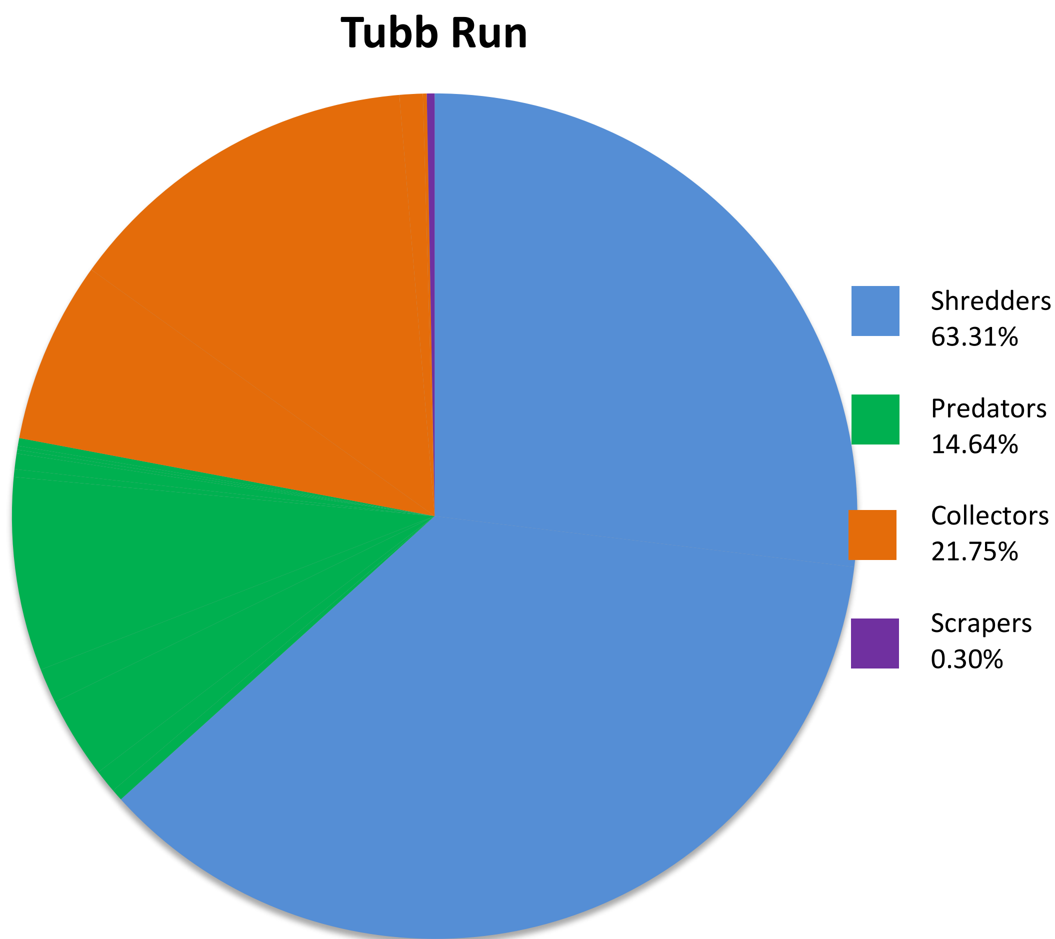

Figure 8: Pie chart depicting the taxa of macroinvertebrates and their respective abundance in Tubb Run as well as the breakdown of feeding group percentages

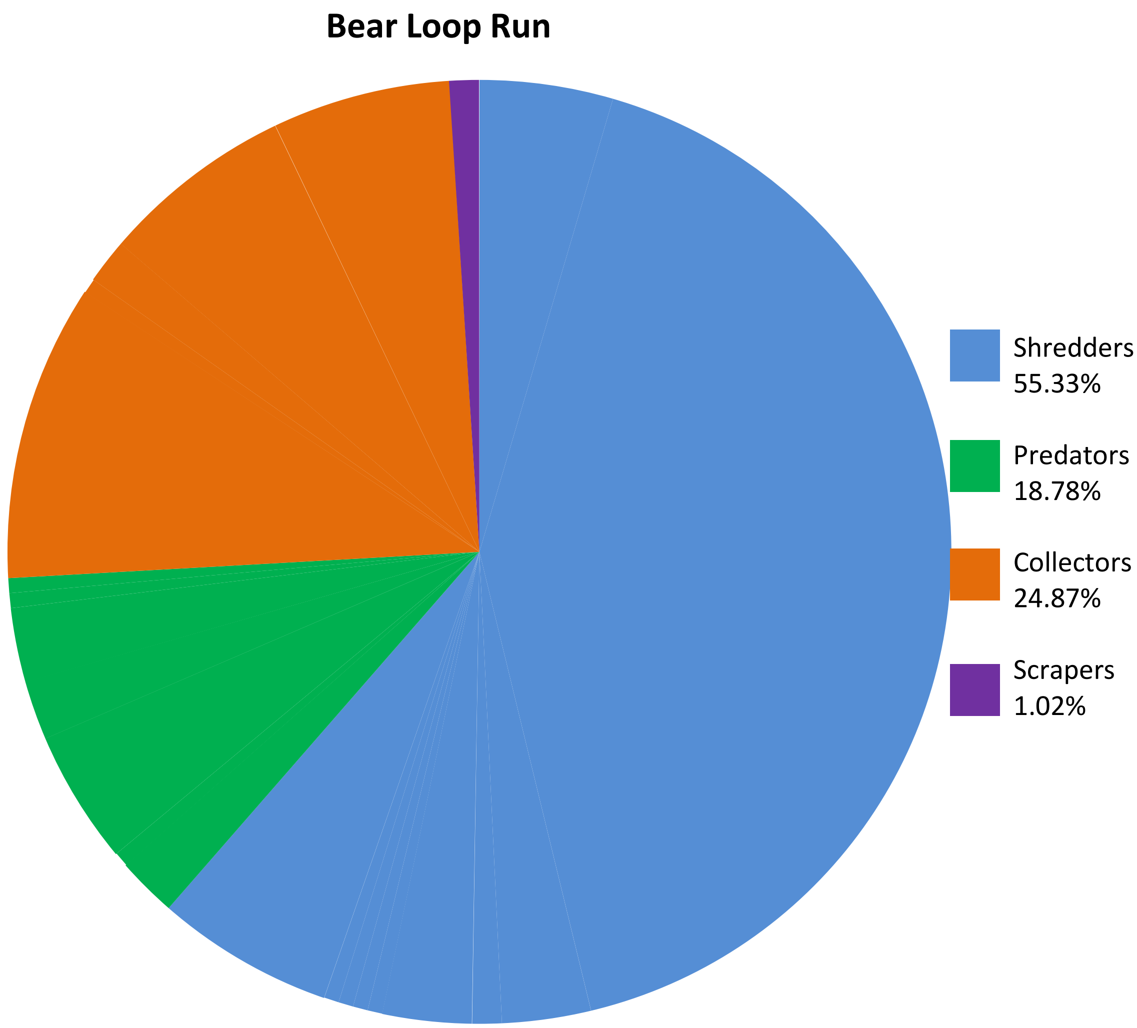

Figure 9: Pie chart depicting the taxa of macroinvertebrates and their respective abundance in Bear Loop Run as well as the breakdown of feeding group percentages

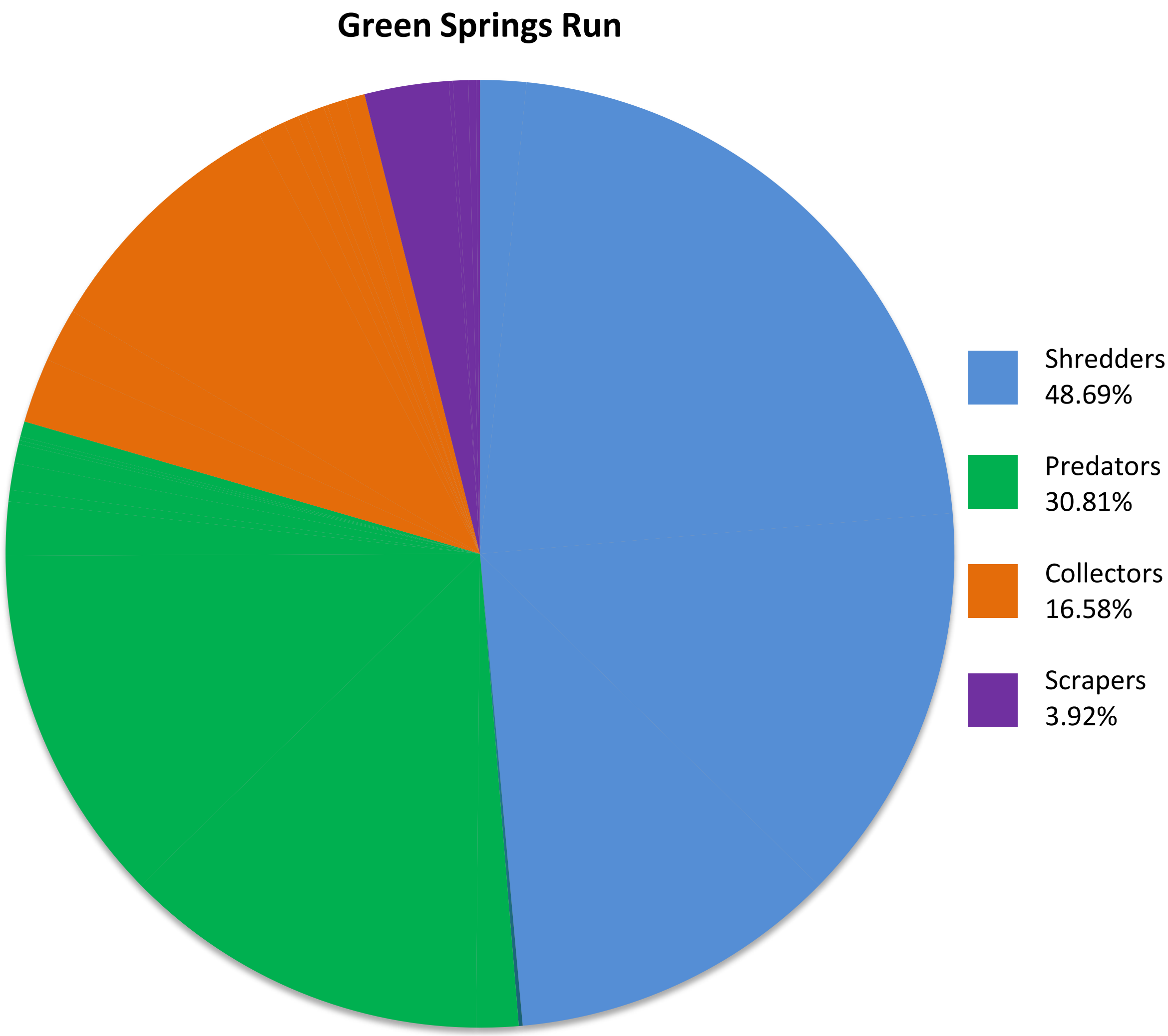

Figure 10: Pie chart depicting the taxa of macroinvertebrates and their respective abundance in Green Springs Run as well as the breakdown of feeding group percentages

Fish Biodiversity

Two species of fish were encountered across our study sites; brook trout (*Salvelinus fontinalis*) and slimy sculpins (*Cottus cognatus*). While the main focus was on the newly discovered wild brook trout (*Salvelinus fontinalis*) populations, slimy sculpins (*Cottus cognatus*) were captured at a few sites as well. Since each brook trout caught was measured, it was possible to allocate each fish to a certain size class. Results of the fish biodiversity aspect of this study are summarized in Table 2. The results are what we would have expected with Green Springs having no known AMD impacts. Green Springs has a larger population of brook trout, an average of 40.2 trout, than the AMD affected sites. This also matches the IBI scores, which are better in Green Springs than the other two streams. Green Springs is exhibiting signs of stability, while Tubb Run and Bear Loop indicate the need for additional AMD remediation.

Table 2: Summary of the fish captured during the electrofishing surveys at each stream. These results suggest that Green Springs Run supports the healthiest populations of brook trout due to the higher population estimates and number of age classes represented, however a one-way ANOVA reveals no significant difference between the number of brook trout captured in each stream (p=0.12)

		Size Classes (mm)										
Stream Name	Site #	24-59	50-74	75-99	100-124	125-149	150-174	175-199	200-224	Trout Total	Trout Pop. Estimate	Other Species
Tubb Run	1	*	*	*	5	1	*	*	*	6	6.2	*
	2	*	*	*	*	*	*	*	*	*	*	*
	3	*	*	*	*	*	*	*	*	*	*	*
Bear Loop Run	1	6	2	3	4	*	*	*	*	15	15.4	*
	2	*	*	*	*	*	*	*	*	*	*	*
	3	*	*	*	*	*	*	*	*	*	*	*
	4	*	*	*	*	*	*	*	*	*	*	*
Green Springs Run	1	*	12	*	16	1	1	1	*	31	37.2	Slimy Sculpin-17
	2	*	23	4	7	3	1	3	1	42	43.2	*
	3	*	*	*	*	*	*	*	*	*	*	*

Mercury Analysis

Recent research has suggested that mercury (Hg) can leach from abandoned coalmines (Fields 2003) with the potential to threaten stream ecosystems. Mercury is a potent neurotoxin with the ability to bioaccumulate and biomagnify up food chains with potentially harmful effects on ecosystems and human health. Elevated Hg levels in fish not only pose a threat for human consumption, but also have been shown to decrease a fish's ability to forage, avoid predation, and reproduce. The daily exposure to mercury for humans is 0.1 µg/kg/bw/day (US EPA 2001). This is the level of exposure that will not affect the brain or growth of a body. There are usually fish advisories on how much fish you should consume from a certain area put out by the Fish and Boat commission. It is also possible to view this information online from the fish and boat website. We measured sub-samples of brook trout Hg from each site, and both macroinvertebrates and sediment samples were analyzed for Hg.

Stream Sediment

Sediment Hg values from all collected sites are shown in Table 3. A significant difference was found between stream sediment Hg concentrations at an ɑ level of 0.1. ($p=0.054$). Green Springs Run had a significantly higher average sediment Hg concentration than Bear Loop Run ($p<0.05$). This could be possible because one of the samples tested at Green Spring was over 90 ng/g possibly skewing the data. Stream sediments have been implicated as good long-term indicators of Hg load to aquatic ecosystems (Scudder at al. 2009) and as a source of Hg to aquatic environments (Evers et al. 2007; Munthe et al. 1995). Increased Hg concentrations found in the sediment from the AMD impacted streams may implicate Hg leaching from the abandoned mines in the watershed.

Table 3: Hg concentrations from the sediment samples collected at each site. Averages for the each stream are given in the right-hand column

Stream	[Hg] (ng/g)	Average [Hg] (ng/g)
Green Spring, Site 1	63.18	
Green Spring, Site 2	91.12	
Green Spring, Site 3	69.64	74.65
Bear Loop, Site 1	61.13	
Bear Loop, Site 2	52.30	
Bear Loop, Site 3	55.65	
Bear Loop, Site 4	50.50	54.90
Tubb Run, Site 1	64.21	
Tubb Run, Site 2	55.61	
Tubb Run, Site 3	60.67	60.16

Macroinvertebrates

Macroinvertebrate Hg analysis shows no significant difference between streams (p=0.13). However, the mean Hg concentration from each stream does follow the expected pattern. Pristine Green Springs Run had the lowest mean Hg concentration in macroinvertebrates of 3.40 ng/g. Next, Bear Loop Run, which has had some remediation efforts, had a mean Hg concentration in macroinvertebrates of 7.25 ng/g. Lastly, Tubb Run, which has no remediation efforts, had a mean Hg concentration in macroinvertebrates of 10.38 ng/g.

Additionally, the bioaccumulation and biomagnification of Hg was examined in macroinvertebrates. Since the macroinvertebrates were separated into their respective feeding groups, we could examine how Hg was accumulating up the macroinvertebrate food web. Since predatory macroinvertebrates feed on other inverts, it was expected that the predator feeding group would have the highest mercury concentration. This was true in all but two sites (Bear Loop Run Site 1 and Green Springs Run Site 1). However, one-way ANOVAs comparing feeding groups within each stream reveal no significant differences. Additionally, when feeding groups were combined among all streams, no significant difference was found (Figure 11)

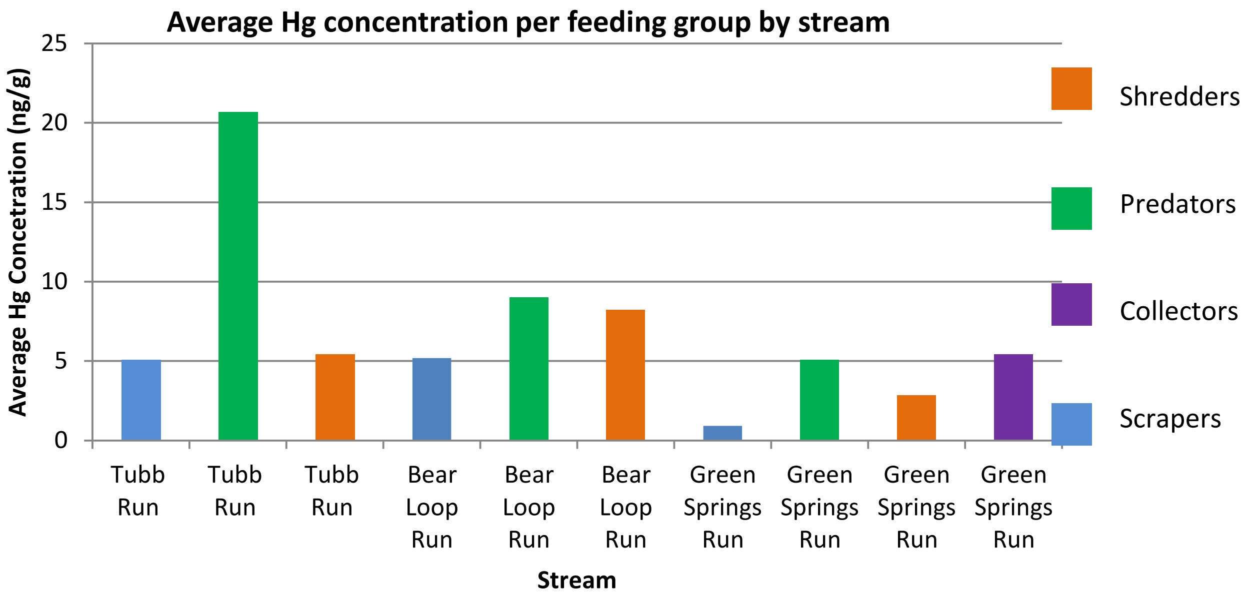

Figure 11: Graph depicting the average Hg concentrations of each feeding group in each stream

Brook Trout

Total Hg measured in each brook trout sample was length normalized (LN) to account for the fact that larger fish generally have a higher concentration of Hg. After the Hg concentrations were LN, we found a significant difference among the mean LN Hg concentration per stream ($p=0.004$). Both Tubb Run and Green Springs Run showed significantly higher average LN trout Hg concentrations compared to Bear Loop Run ($p<0.05$ in both cases) (Figure 12.1). The fact that Bear Loop run has the lowest mercury content is contrary to our expectations. We expected Green Springs Run, the unaffected stream to have the lowest mercury levels. Figure 12.0 shows the individual levels of mercury. The graph shows that none of the Hg levels in fish are above US EPA human consumption criteria (300PPB) or US Fish and Wildlife Service fish eating wildlife criteria of 100 ng/g (100 PPB). Results suggest that while Hg levels varied significantly between sites, absolute Hg levels are low.

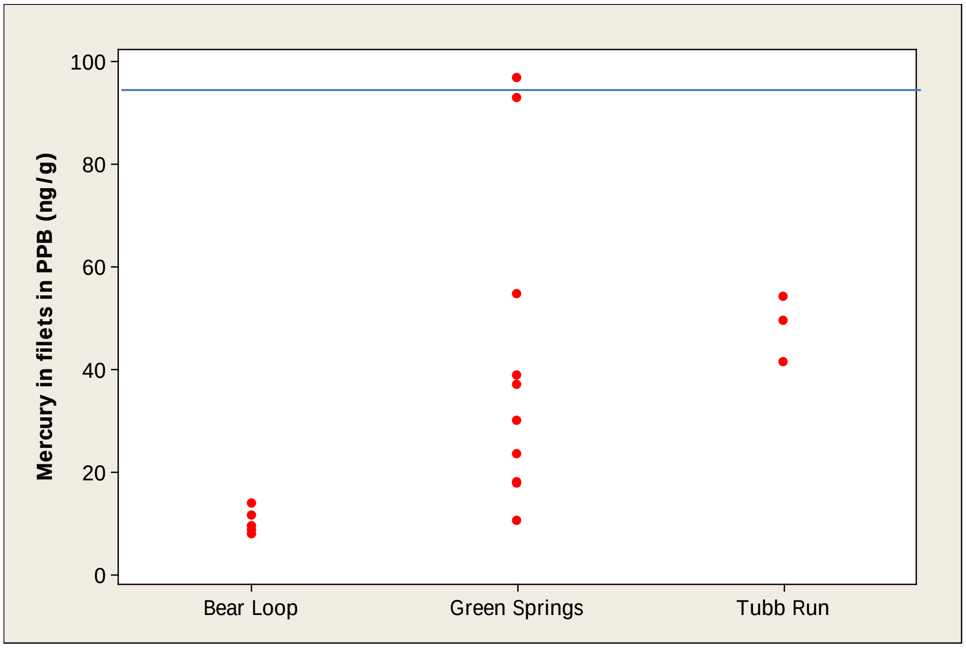

Figure 12.0: Individual value plot levels of Hg in fish filets in ng/g. The blue line at the top indicates the U.S. Fish and Wildlife Service fish eating wildlife consumption criteria of 100 ng/g.

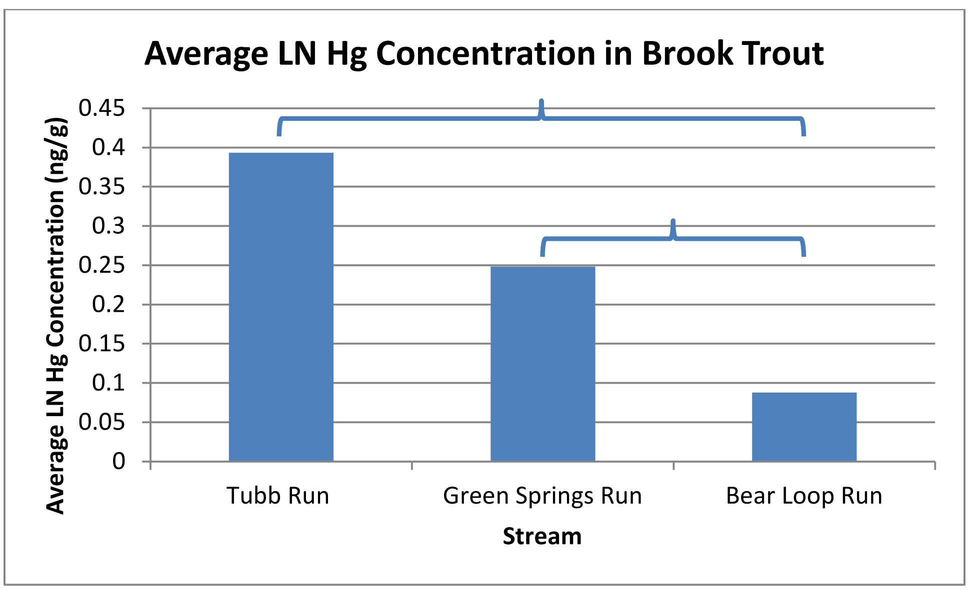

Figure 12.1: Graph depicting the average LN Hg concentrations in brook trout captured at each stream. The brackets indicates the streams that are significantly different from one another

Ecological Concerns

The major cause for concern within the Bells Gap watershed is abandoned or acid mine drainage (AMD). These effects are witnessed mainly in the water quality parameters measured at each site, which in turn, is affecting fish and macroinvertebrate biodiversity. AMD occurs when water comes into contact with iron pyrite, which is common in Pennsylvania, and has been exposed due to mining practices, including surface and deep mines. Water and iron pyrite react with air forming dissolved iron and sulfuric acid. As a result, water leaving abandoned mines is highly acidic. The high acidity of the water is able to dissolve out other metals in rock, such as aluminum and manganese. The acidic water drainage that enters into a stream delivers high concentrations of dissolved metals as well as drastically reduces the pH of the stream water.

Therefore, the fact that these streams feed into the Bellwood Reservoir, which provides public drinking water for the City of Altoona, and Bellwood is a major concern. Impacted streams have the potential to supply impacted water to the reservoir, which raises many public health concerns. We sampled one point in Bells Gap Run just below the confluence with Bear Loop Run, which is also downstream of the confluences with Green Springs Run and Tubb Run, in order to see if any AMD impacts from the tributaries are apparent in the main reach. A pH of 7.45 was recorded at this site. Showing that downstream pH is relatively unaffected.

The mercury levels in the brook trout and the macroinvertebrates should also be a concern for the ecological integrity of the streams. For stocked brook trout mercury levels are allowed to be 0.3 micrograms/g and in wild brook trout consumption levels are set at 0.1 micrograms/g. The levels of mercury that we found were still in ng. All of the streams are under the suggested amount of mercury eaten and so this does not need to be worried about. Research would need to be done to look at the mercury levels between treated Bear Loop Run and unaffected Green Springs Run because those levels were unexpected.

Although they were not significant differences between the mercury levels in macroinvertebrate feeding groups it was observed that predators have higher mercury levels than the other feeding groups in the AMD affected streams. It has been shown in many papers that mercury levels increase as trophic level increases making these a possible cause for concern in the future.

Figure 13: Photo taken along Bear Loop Run showing a "dead zone" where AMD has killed off most of the vegetation on its way down into the stream. Notice the red tint indicative of iron

Current and Continuing AMD Remediation Efforts

As the historical range of the brook trout is continuously being depleted, the brook trout is in need of conservation. As the state fish of Pennsylvania, protecting wild populations of this species will enhance the state's natural beauty. AMD is a large and ongoing problem for Pennsylvanian streams that is threatening brook trout habitat. Remediation efforts are needed in order to protect the diminishing number of wild brook trout populations in the state, like the ones in the present study.

While Bear Loop Run has experienced some remediation efforts, our research still shows significant impacts from AMD to this stream. Bear Loop Run currently has a passive treatment system in place, but according to the EPA in a document from 2003, it is not functioning properly (Capacasa 2003). Additionally, Bear Loop Run still has multiple deep mine and acidic-manganese discharges that enter directly into the stream (Capacasa 2003) (Figure 13).

Both Bells Gap Run and Bear Loop Run were listed in the 2004 Pennsylvania Integrated Water Quality Monitoring and Assessment Report (Blair County Tributary Strategy and Implementation Plan 2005). Bells Gap Run was on List 5: Pollutants Impaired Streams

Requiring a TMDL (Total Maximum Daily Load). Bells Gap Run was listed because of siltation and sedimentation from dirt roads that are unstabilized and effects on pH and metal content from AMD. Bear Loop Run was on List 4: Impaired for One or More Designated Uses, TMDL has been completed. Because of more concerns of inorganics and metals the Pennsylvania Department of Environmental Protection prepared the TMDL report for the Bear Loop Run Watershed in 2002 (Bear Loop Run Watershed TMDL 2002).

Short Term Recommendations

Since both Bells Gap Run and Bear Loop Run have already been listed, a good short-term goal for this watershed would include getting Tubb Run listed on Pennsylvania's Imparied Water 303 (d) list. The data collected supports the hypothesis that Tubb Run is impacted by AMD and is therefore, impaired, and should require a TMDL report. After this step, TMDLs should be completed for both Tubb Run and Bells Gap Run. These reports would be very helpful in determining how large a remediation effort is needed and could also indicate the best method of remediation. Additionally, water quality measurements should be compared to the TMDL completed for Bear Loop Run to ensure how well remediation efforts are working, if at all. Juniata College has applied for assistance through the Trout Unlimited AMD Technical Assistance Program in conducting a rapid AMD characterization of Tubb Run, including a TMDL study, as well as a follow up study on the existing AMD treatment system on Bear Loop Run (see Appendix).

Additional short term recommendations include raising awareness of this watershed and its importance as both a public water supply and a wild brook trout habitat. If remediation efforts are to be put in place, an agency or agencies are needed to lead and fund the project

Before any sort of AMD remediation effort is put into place, the issue of the unstabalized dirt roads should be addressed first. According to the Pennsylvania Integrated Water Quality Monitoring and Assessment Report, there are 1343 miles of unstabalized dirt roads in the Bells Gap Run Watershed. According to the $6.35 per mile average from 1997-2004, stabilizing these dirt roads would cost $8528 (Blair County Tributary Strategy and Implementation Plan 2005). However, this should be reevaluated owing to the fact that there could likely be a price change from 2004-2015.

Lastly, as originally stated in this planning grant, the section of Bells Gap Run between the confluence with Bear Loop Run and the confluences of Green Springs Run and Tubb Run should be evaluated in the same manner. By adding this site, we would be able to determine the detrimental AMD effects on Bells Gap Run from just Tubb Run. As Green Springs Run is unimpacted by AMD, any findings that suggest AMD impaction at this site would have to come from Tubb Run. Adding this site would be extremely helpful in determining a remediation plan for Tubb Run specifically.

Long Term Recommendations

Recommendations for the long term health of this watershed would largely depend on findings under the short term recommendations. Without TMDL calculated for Tubb Run and Bells Gap Run, specifics of AMD remediation efforts are still unclear. In general, a remediation plan would need to be developed to reduce the dissolved metals in the stream water and increase the pH so that it is more neutral. By remediating the water quality issues caused by AMD, the biological factors (macroinvertebrates and fish) affected by poor water quality can begin to recover.

Decisions about what type of remediation plan would include using abiotic or biological methods, or a combination of the two. Then, within those categories comes decisions on active vs. passive treatment systems. The best remediation plan for the Bells Gap Watershed would depend on further data collection to design a specific treatment system to the exacts water quality problems experienced in the watershed.

Abiotic treatment systems involve the addition of a neutralizing agent to increase stream water pH. Active abiotic systems require continuous additions of the chosen neutralizing agent, whereas in passive abiotic treatment systems, a drain is created that hold the neutralizing agent and water is forced through the drain (Johnson and Hallberg 2004). Biotic treatment systems take advantage of some microorganisms natural function to immobilize dissolved metals and increase the alkalinity in stream water. Active biotic systems involve a system known as off-line sulfidogenic bioreactors (Johnson 2000, Boonstra et al. 1999). Passive biotic systems generally involve the creation of wetlands that house the microorganisms that naturally remediate the AMD affected water (Johnson and Hallberg 2004). These different treatment options are summarized in Figure 14 (Johnson and Hallberg 2004).

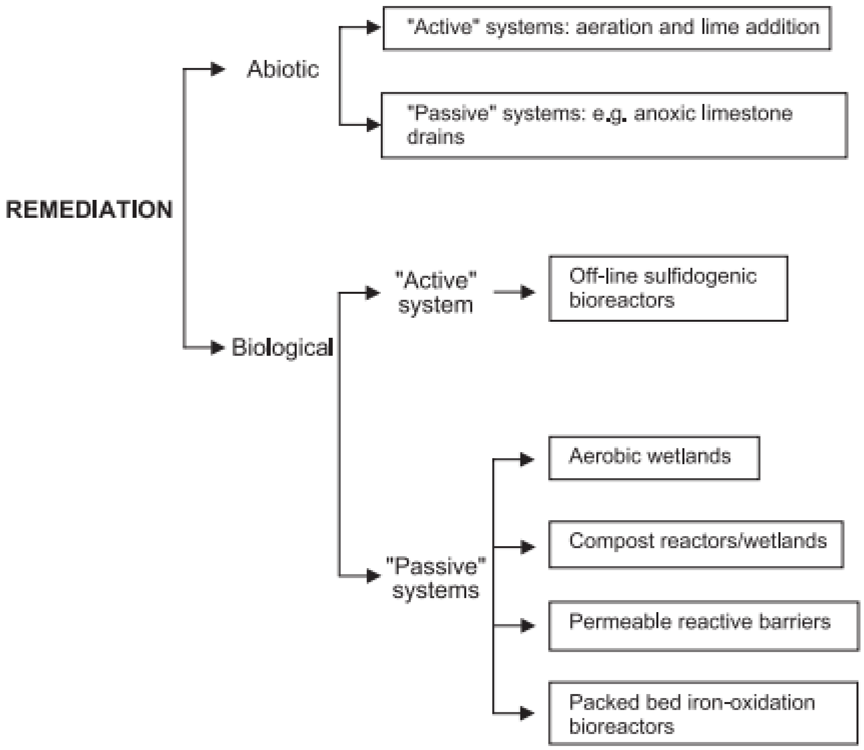

Figure 14: The different types of AMD remediation, showing the active and passive options within abiotic and biological systems

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Appendix A

Application for Assistance through Trout Unlimited's AMD Technical Assistance Program

Date Received: ______ *For Office Use Only* Group Eligible: ______
TAG Number: ______ Project Priority: H M L

Trout Unlimited's AMD Technical Assistance Program

TROUT UNLIMITED

Request Form

Please fill in the following form as completely as possible. Feel free to use the back of this page to describe the type of assistance you require. Provide as much detail as possible as it will assist us in helping you quickly.

Name of Your Organization or Municipality: Juniata College

When was your group formed? 1876 **Approx. Membership:** 1600 students

Name/Title of Contact Person: Jennifer Graves-Research Technician

Address: 69 Highland Drive

Phone: (860) 268-9789 **Fax:** ( )

Email: gravejm10@gmail.com

Do you have 501(c)(3) (incorporated non-profit) status? **Yes** **No** **Don't know**

What stream or watershed area requires the technical assistance (watershed, county or counties, townships, or other geographical description of your area): Bear Loop Run and Tubb Run Blair County, PA

1. What kind(s) of technical assistance do you require (check all that apply and describe on back)?

- [x] Rapid AMD Characterization (characterization of a single discharge or a combination of discharges in a watershed and will evaluate the type and severity of the AMD, as well as the treatment restoration potential)
- [x] Rapid AMD Watershed Snapshot (one-time snapshot of water quality and flow to assess metals and acidity loadings on a stream or in a specific problem area)
- [x] Conceptual Design for AMD Treatment System
- [ ] Full Design and Permitting for AMD Treatment System (please call us first as only a limited number of projects will be considered)
- [ ] Construction Oversight of AMD Remediation Project Construction
- [x] Existing Treatment System Evaluation and Recommendations
- [ ] Watershed Restoration Plan Development (for Qualified Hydrologic Unit approval)
- [ ] Monitoring Plan Development
- [ ] Biological Survey (Fish, Macroinvertebrates) and/or Stream Habitat Survey
- [ ] Documentation of Improving Waters
- [ ] Technical Capacity Building
- [ ] Other AMD-Related Assistance (Please describe on next page or attach separate page)

2. What information on your watershed or area of concern already exists (check all that apply)?

- ■ Stream Restoration/Management Plan
- ☐ Rivers Conservation Plan
- ☐ Project Scarlift Report
- ■ TMDL Study
- ☐ EPA Section 319 Watershed Implementation Plan
- ■ Water Quality Data (please describe type and condition of data on back)
- ☐ GIS mapping
- ☐ Other (please fully describe on back)

3. Are you requesting technical assistance that is necessary to implement recommendations in your watershed restoration plan or other similar plan?

☐ No ☑ Yes (Please provide the name of the plan Bells Gap Conservation Plan)

4. Are you requesting technical assistance that must be completed in order for your group to apply for grant funds?

☑ No ☐ Yes Funding Source:________________
Funding Application Deadline Date:________________
(Please describe the project you will be applying for below or on back.)

Please provide additional comments below (indicate question number from above if applicable) :

1. - We have a unique watershed set-up of three streams. Green Springs Run is pristine, Bear Loop Run is AMD impacted with some remediation efforts, and Tubb Run is AMD impacted with no remediation efforts. We have completed a biological and water quality survery on all three streams, plus at one site in Bells Gap Run downstream of all three streams. We are requesting a rapid AMD characterization/snapshot of Tubb Run, including a TMDL study, as nothing is really known about the extent of AMD impacts on Tubb Run. This information would be essential for designing an AMD treatment system for Tubb Run. Additionally we are requesting a follow-up assessment on the existing AMD treatment system on Bear Loop Run.

2. - The stream restoration/management plan that we have on this watershed is in the process of being completed. A TMDL study has been completed on Bear Loop Run, but not Tubb Run. The water qualiy data collected from these streams include temperature, pH, conductivity, TDS, salinity, hardness, and alkalinity. Water quality data is attached in the conservation plan and excel sheet.

I am drafting the conservation plan and participated in all data collection, however Dr. Chris Grant at Juniata College is the true leader of the project and is an additional contact. His email is grant@juniata.edu. Lastly, Juniata College does have 501(c)(3) status.

Please mail the completed form to:
Trout Unlimited AMD Technical Assistance
18 E. Main St, Suite 3, Lock Haven, PA 17745
Or scan and email it to awolfe@tu.org
If you have any questions or concerns, please contact Amy Wolfe at (570) 786-9562.

Appendix B

Macroinvertebrates Found in Streams and their common names:

Predators	**Common Name**
Sialidae Sialis	Alderflies
Chloroperlidae Suwallia	York Sallfly
Chironomidae Tanypodinae	Nonbiting Midge
Tipulidae Dicranota	Large Crane Fly
Rhyacophiladae Rhyacophila	Green Sedge
Dytiscidae Hydrocolus	Predacious Diving Beetle, or water tiger
Corydalidae Nigronia	Hellgramite or Fishfly
Tipulidae Hexatoma	Large Crane Fly
Tipulidae Pedicia	Large Crane Fly
Chironomidae Tanypodinae	Midge
Cordulegastridae Cordulegaster	Say's Spiketail
Tipulidae Rhabdomastix	Cranefly
Perlodidae Isoperla	Yellow Stonefly or Springfly
Gomphidae Lanthus	Clubtail Dragonfly
Chloroperlidae Haploperla	Least Sallfly
Perlodidae Oconoperla	Stonefly
Chloroperlidae Sweltsa	Green Stonefly
Shredders	Common Names
Leuctridae Leuctra	Rolled Wing stonefly
Nemouridae Amphinemura	Forestfly
Peltoperlidae Peltoperla	Roachfly
Tipulidae Leptotarsus	Green Cranefly
Tipulidae Tipula	Cranefly
Scirtidae Cyphon	Marsh Beetle
Limnephilidae Pycnopsyche	Northern Caddisfly
Lepidoptera Crambidae	Leafcutter Moth
Lepidostomatidae Lepidostoma	Little plain brown sedge
Pteronarcyidae Pteronarcys	Salmonfly
Lepidostomatidae	Tube case-maker Caddisfly
Collectors	Common Names
Simulidae Simulium	Black Fly
Hydropsychidae Diplectrona	Caddisfly
Brachycentridae Brachycentrus	Apple Cadis
Elmidae Dubiraphia	Riffle Beetle
Tipulidae Ormosia	Cranefly
Chironomidae Podonominae	Midge

Philopotamidae Wormaldia	Little Autum Sedge
Hydropsychidae Parapsyche	Net-spinning Caddisfly
Philopotamidae Dolophilodes	Medium Evening Sedge
Leptohyphidae Leptohypes	Mayfly
Baetidae Baetis	Blue Winged Olive
Tipulidae Cryptolabis	Cranefly
Dixidae Dixa	Meniscus Midge
Scrapers	Common Names
Psychomyidae Lype	Dark Eastern Woodland Sedge
Heptageniidae Stenonema	Mayfly
Glossosomatidae Protoptila	Tiny Spotted Short-horned Caddis
Glossosomatidae Glossosoma	Little Brown Short-horned Sedge
Heptageniidae Epeorus	Sulphur Mayfly