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Assessment of a sinkhole-water reservoir in Fort Springs, WV within the Greenbrier River Watershed

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Abstract:

An assessment was completed on a sinkhole reservoir located in Fort Springs, West Virginia. The water reservoir is found within the Greenbrier River Watershed of southeastern West Virginia. The watershed spans the width of four counties within West Virginia, including Pocahontas County, Greenbrier County, Monroe County, and Summer County. This assessment took place in Greenbrier County. The assessment included a habitat assessment, a physical characteristics assessment, water chemistry analysis, and a fecal coliform analysis. The only viable species found within the reservoir was the *Lepomis cyanellus*, commonly known as the green sunfish. *Lepomis cyanellus* is a versatile organism tolerant of a wide range of environmental extremes. The water chemistry of the reservoir displayed values within the standards set by the West Virginia Department of Environmental Protection (WVDEP). The two exceptions were the hardness and the dissolved oxygen levels of the water. The reservoir exhibited hardness levels ranging from 205-274mg/L. Hardness levels this high are associated with limestone formations. The reservoir also displayed low levels of dissolved oxygen. The dissolved oxygen levels fluctuated between 2.9-5.8ppm. Levels this low do not support a wide variety of aquatic life. The fecal coliform analysis of the reservoir presented large amounts of *Escherichia coli* forming coliforms. Fecal coliform contamination is the direct result of fecal contamination from either a human or animal. Overall the water reservoir in Fort Springs, WV is not suitable for a wide range of aquatic life to thrive nor is the water suitable for human consumption.

Introduction:

An assessment was completed on a sinkhole reservoir located in Fort Springs, WV in order to gain detailed knowledge about the surrounding habitat, the water chemistry and the bacterial content of the water. The water reservoir is found within the Greenbrier River

watershed of southeastern West Virginia (Figure 1). The watershed spans the width of four counties within West Virginia, including Pocahontas County, Greenbrier County, Monroe County, and Summers County. The assessment took place in Greenbrier County, approximately ten miles south of Lewisburg, West Virginia.

The reservoir is positioned in a forested area inhabited by numerous livestock. The reservoir itself is located at 37ºN, 80ºW. The reservoir assessment began in September (9/21/08) and ran through to early in November (11/5/08). The reservoir contained a small pebble streambed in combination with a short slope composed of deposits similar to the streambed. Climatic conditions changed significantly as the overall assessment proceeded. During the months of September and October weather conditions were very dry causing water levels to remain low. As the assessment continued through October and into November weather conditions were wetter altering some of the water chemistry.

As the reservoir assessment proceeded through the months of September, October and November weather conditions surrounding the reservoir altered the water temperatures. The reservoir contains standing water surrounded by forested woodlands where direct sunlight is unable to reach the water. The highest water temperature was 14.3ºC recorded on September 24, 2008. The lowest water temperature was 9.2ºC recorded on October 29, 2008. Varying water levels presented clear water clarity with a brown streambed.

The overall significance of this research will be to obtain information about the habitat in and surrounding the sinkhole reservoir. By analyzing the habitat, including water chemistry with fecal coliform analyses, numerous parameters of the study can be completed. Not only will the research be used for my personal research project, but once the research is completed the information will be given to the Greenbrier River Watershed Association for background use within future research projects.

Methods:

Habitat Assessment

The habitat assessment included identification of the surrounding vegetation. The habitat assessment also included becoming educated on the history surrounding the local cemetery and the storm water tunnel leading into the Greenbrier River.

Physical Assessment

A physical assessment was completed for the water reservoir. The physical assessment included identifying the latitude and longitude of the reservoir and the elevation of the reservoir. In order to acquire this information a global positioning system was used on a regular basis. The physical assessment also included researching the water color and studying the streambed deposits.

Biotic Identification

The final portion of the physical assessment included identification of the fish species that were present within the water reservoir. This aspect of the assessment was completed by dropping nets into the water, dragging the entire reservoir with the nets and finally, identifying the fish specimens.

Water Chemistry

Numerous water samples were collected over the entire course of the reservoir assessment. The water chemistry of the reservoir was measured using a variety of different kits and meters. Measurements of the pH, phosphate, iron, alkalinity, hardness and turbidity were all completed with Hach drop count and color disk kits. Dissolved oxygen and temperature levels were measured using a YSI Dissolved Oxygen 200 meter. Water chemistry results are shown in Tables 1-9.

Fecal Coliform Analysis

Fecal coliform analyses were made on the water reservoir. Water samples were collected and enclosed within sterilewhirl- pak bags. Each sample was kept in a cool area until the proper tests could be completed. During each analysis three to four petri dishes were labeled with their corresponding dilutions. The proper dilutions, ranging from a negative control of 1mL tap water to 5mL volume of the sample water, were then sterilely transferred to various bottles of Coliscan Easygel bottles. The bottles were swirled to evenly distribute the samples then transferred to their respective petri dishes for an incubation period lasting approximately 48-96 hours. After the incubation period, the petri dishes were inspected for the appearance of both *Escherichia coli* and fecal coliforms then reported in terms of coliforms per 100mL of water. *E. coli* was recognized as dark blue/purple spots while the fecal coliforms were identified as pink spots within the petri dishes. The calculation for reporting coliforms per 100mL of water is as follows: (100mL/ Sample Volume) multiplied by the total number of coliforms counted within each sample petri dish. The results of the fecal coliform analyses are shown in Tables 10-12.

Results:

Habitat Assessment

The habitat assessment of the reservoir revealed a diverse array of plant life. An abundance of sycamores were viewed. Sycamores are a member of the Platanaceae family. Sycamores are one of the largest eastern hardwoods, containing white bark and inhabiting wet soils of stream banks and floodplains. The second most abundant tree found was the black walnut. The black walnut is a member of the Juglandaceae Family. The walnut inhabits moist, well drained soils along streams.

Numerous other trees were identified surrounding the sinkhole. Trees such as the boxelder and sugar maple were observed, both being members of the Aceraceae Family. Both

the boxelder and sugar maple are found in moist soils along valleys and streams. The tulip poplar, black locust, and black ash were also represented along the creek leading from the reservoir to the Greenbrier River. All of the previously mentioned trees are found in wet soils of valleys, streams, and slopes.

Two rare trees were also identified during the habitat assessment. The osage-orange was identified due to its fruit. This tree is a member of the Moraceae family and is found in wet soils of river valleys. The second rarity was the pawpaw tree. The pawpaw tree is a member of the Annonaceae Family and inhabits moist soils of flood plains.

The final portion of the habitat assessment included viewing and researching the history surrounding the local cemetery and the storm water tunnel leading into the Greenbrier River in Fort Springs, West Virginia. The cemetery dates back to the 1800's and is believed to have begun due to the acquirement of typhoid fever within the community due to drinking water from the sinkhole. Typhoid fever is a serious bacterial disease that results in fever, weakness, and in severe cases, death. Typhoid fever is caused by the bacterium *Salmonella typhi* and is passed through contaminated water. The storm water tunnel was originally built in 1872 and is the direct inlet of the sinkhole reservoir into the Greenbrier River. The cemetery and storm water tunnel can be viewed in Figures 2-3.

Physical Assessment

The physical assessment revealed the exact location and elevation of the reservoir. The reservoir is located at 37ºN, 80ºW and 488m above sea level. The water had a clear to brown color. The turbidity levels were low throughout the three months of the study (Tables 1-9). The stream bed consisted of brown pebbles varying in sizes all considered fine to course gravel, revealing that the pebbles have been constantly washed over by the water. The depth of the

water also increased from 86cm to 112cm over the course of the study. The final depth was measured at 1.1 meter (Table 8).

Biota Identification

The second part of the physical assessment included identifying the fish that were thriving within the reservoir. The only species found within the sinkhole was the *Lepomis cyanellus*. The green sunfish, *Lepomis cyanellus* is a member of the Centrarchidae family. The green sunfish is a versatile species, tolerant of a wide range of environmental conditions and common in unstable conditions. After dragging of the water reservoir was completed only six green sunfish were captured, identified and then subsequently released.

Water Chemistry

The reservoir had a pH of 7.5 over the entire course of the study. Both the phosphate and iron levels were found to be 0mg/L. Phosphate levels of 0mg/L are normally deemed unpolluted, while 0mg/L of iron support good water quality. Alkalinity levels were between 180-220mg/L, typically being associated with limestone bedrock. High hardness levels of 273.6mg/L may be associated with limestone bedrock in the area. Turbidity levels were very low (0-3 FAU).

Dissolved oxygen levels were found to be between 2.9 and 5.8ppm, which is low according to the West Virginia Department of Environmental Protection standards. Dissolved oxygen levels were directly related to the water temperature. As the water temperature dropped from 14ºC to 10ºC so did the dissolved oxygen levels (Figure 4).

Fecal Coliform Analysis

The first fecal coliform analysis completed on September 21, 2008 yielded in no *E. coli* present within the control (Table 10). Two thousand coliform forming units per 100mL (CFU/100mL) non-*E.coli* coliforms were found in the 2mL sample volume, while 1825

CFU/100mL non *E. coli* coliforms were found within the 4mL sample volume. The second fecal coliform analysis, completed on September 29, 2008 also resulted in no *E. coli* being found within the control (Table 11). The 1mL sample volume showed 10,000 CFU/100mL non-*E. coli* coliforms. Both the 3mL and 5mL sample volumes resulted in *E.coli,* with 367 CFU/100mL in the 3mL sample volume and 500 CFU/100mL in the 5mL sample volume. The final fecal coliform analysis was completed on October 29, 2008 (Table 12). The 1mL sample volume resulted in 100 CFU/100mL *E. coli* coliforms. Both the 3mL and 5mL sample volumes also resulted in *E. coli*, with 133 CFU/100mL in the 3mL sample volume and 250 CFU/100mL in the 5mL sample volume. *Escherichia coli* totals were fairly high, inconsistent with good water quality.

Conclusions;

Most of the assessments completed during the process of the research presented results well within the standards set by the West Virginia Department of Environmental Protection (WVDEP). The water chemistry of the reservoir displayed optimal pH levels ideal for most organisms to strive. With no phosphate or iron being present the water would be considered unpolluted. Alkalinity levels are greatly determined by the type of underlying bedrock and soil which the water flows. Alkalinity levels, within the study, were fairly high according to the WVDEP. Levels as high as 200mg/L are associated with a limestone topography. The high hardness levels could be associated with the limestone bedrock found within the sinkhole and surrounding area.

Dissolved oxygen levels of the reservoir were low according to West Virginia Department of Environmental Protection standards. Dissolved oxygen levels of at least 4-5ppm are needed to support a wide range of aquatic life. There was only one species of fish found

within the reservoir supporting the fact that the low dissolved oxygen levels could not support a wide variety of aquatic life.

Since the reservoir is surrounded by trees, the foliage is constantly being compounded in the water of the reservoir supporting the high levels of bacteria found during the fecal coliform analysis. Another explanation for the high levels of bacteria found within the reservoir is directly related to the livestock found within the area. During the course of the study the livestock were permitted to roam the area surrounding the sinkhole. Livestock waste that had drained into the reservoir would certainly account for the high levels of *E. coli* found within the water.

My conclusion is that although the majority of the water chemistry levels were well within the WVDEP standards the dissolved oxygen levels do not support enough aquatic life in order to use the reservoir for any recreational purposes such as fishing. High hardness levels along with high bacteria levels found during the fecal coliform analyses do not make the water suitable for human consumption. Although the water would not cause death an upset stomach may ensue after consuming a small amount of the reservoir's water.

Figures and Tables:

Figure 1: Greenbrier River Watershed

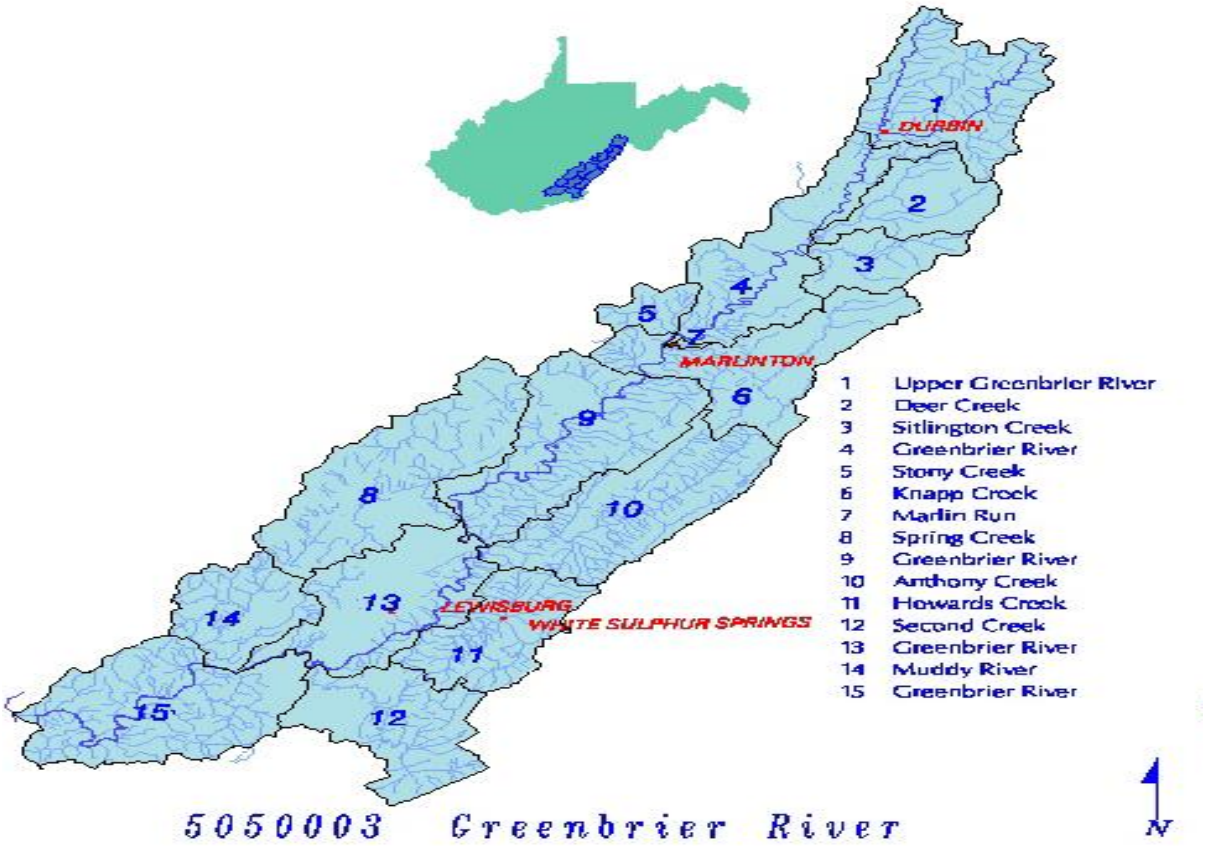

Figure 2: Local Cemetery

Figure 3: Storm water tunnel

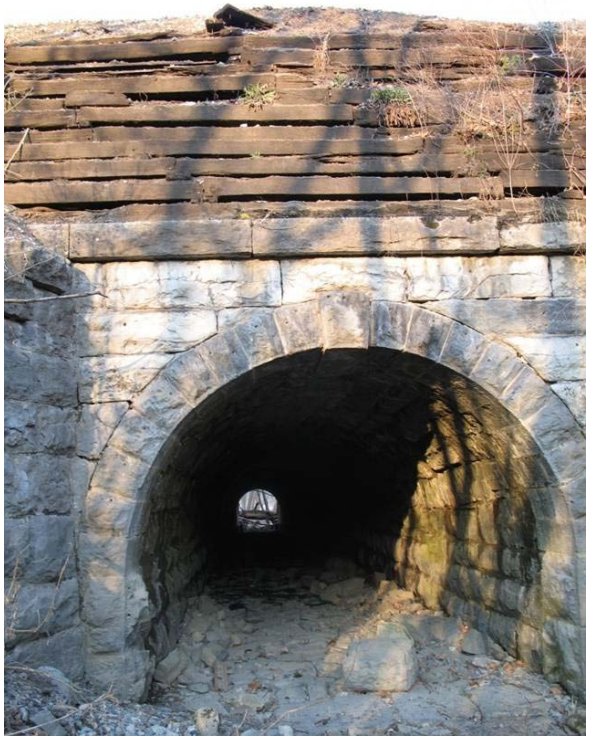

Figure 4: Temperature verses Dissolved Oxygen

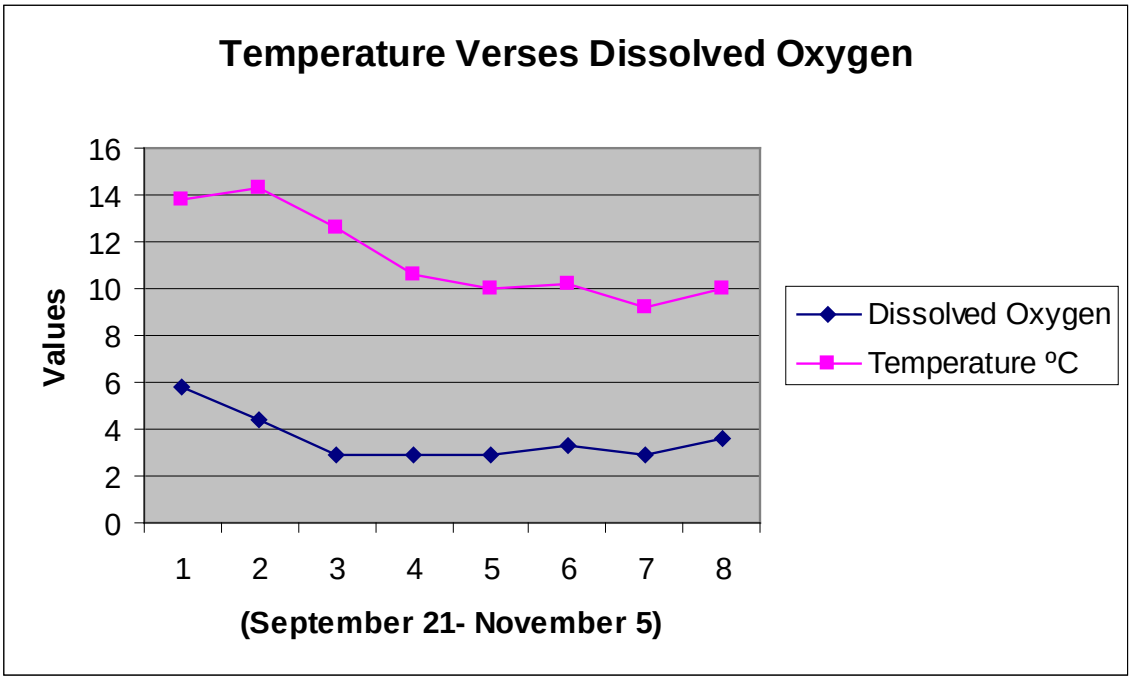

Table 1: September 21, 2008

Water Chemistry			
Parameter	**Kit/Meter**	**Value**	**Units**
Turbidity	Hach DR820	2	FAU (Formazin Attenuation Units)
pH	Hach color disk kit	7.5	
Alkalinity	Hach drop count	180	mg/L
Phosphate	Hach drop count	0	mg/L
Hardness	Hach drop count	239.4	mg/L
Iron	Hach color disk test	0	mg/L
Depth	-----	0.95	meters

Table 2: September 24, 2008

Water Chemistry				
Parameter	**Kit/Meter**	**Depth**	**Value**	**Units**
Dissolved Oxygen	YSI	.5m	5.8	ppm
			56.2	% saturation
Temperature	YSI	13.8		ºC
		57		ºF
Turbidity	Hach DR820	2		FAU (Formazin Attenuation Units)
pH	Hach color disk kit	7.5		
Alkalinity	Hach drop count	180		mg/L
Phosphate	Hach drop count	0		mg/L
Hardness	Hach drop count	205.2		mg/L
Iron	Hach color disk test	0		mg/L
Depth	-----	0.94		meters

Table 3: September 29, 2008

Water Chemistry				
Parameter	**Kit/Meter**	**Depth**	**Value**	**Units**
Dissolved Oxygen	YSI	.5m	4.4	ppm
			43.2	% saturation
Temperature	YSI	14.3		ºC
		58		ºF
Turbidity	Hach DR820	0		FAU (Formazin Attenuation Units)
pH	Hach color disk test	7.5		
Alkalinity	Hach drop count	200		mg/L
Phosphate	Hach drop count	0		mg/L
Hardness	Hach drop count	205.2		mg/L
Iron	Hach color disk test	0		mg/L
Depth	------	0.99		meters

Table 4: October 17, 2008

Water Chemistry				
Parameter	**Kit/Meter**	**Depth**	**Value**	**Units**
Dissolved Oxygen	YSI	.5m	2.9	Ppm
			27	% saturation
Temperature	YSI	12.6		ºC
		55		ºF
Turbidity	Hach DR820	3		FAU (Formazin Attenuation Units)
pH	Hach color disk test	7.5		
Alkalinity	Hach drop count	200		mg/L
Phosphate	Hach drop count	0		mg/L
Hardness	Hach drop count	256.5		mg/L
Iron	Hach color disk test	0		mg/L
Depth	------	0.86		meters

Table 5: October 20, 2008

Water Chemistry				
Parameter	**Kit/Meter**	**Depth**	**Value**	**Units**
Dissolved Oxygen	YSI	.5m	2.94	ppm
			26.7	% saturation
		1m	2.94	ppm
			26.6	% saturation
Temperature	YSI	10.6		ºC
		51		ºF
Turbidity	Hach DR820	0		FAU (Formazin Attenuation Units)
pH	Hach color disk test	7.5		
Alkalinity	Hach drop count	220		mg/L
Phosphate	Hach drop count	0		mg/L
Hardness	Hach drop count	273.6		mg/L
Iron	Hach color disk test	0		mg/L
Depth	------	0.94		meters

Table 6: October 24, 2008

Water Chemistry				
Parameter	**Kit/Meter**	**Depth**	**Value**	**Units**
Dissolved Oxygen	YSI	.5m	3.1	Ppm
			27.1	% saturation
		1m	2.93	Ppm
			26.9	% saturation
Temperature	YSI	10		ºC
		50		ºF
Turbidity	Hach DR820	2		FAU (Formazin Attenuation Units)
pH	Hach color disk test	7.5		
Alkalinity	Hach drop count	220		mg/L
Phosphate	Hach drop count	0		mg/L
Hardness	Hach drop count	273.6		mg/L
Iron	Hach color disk test	0		mg/L
Depth	------	0.96		meters

Table 7: October 26, 2008

Water Chemistry				
Parameter	**Kit/Meter**	**Depth**	**Value**	**Units**
Dissolved Oxygen	YSI	.5m	3.12	Ppm
			28.2	% saturation
		1m	3.31	Ppm
			29.9	% saturation
Temperature	YSI	10.2		ºC
		50		ºF
Turbidity	Hach DR820	0		FAU (Formazin Attenuation Units)
pH	Hach color disk test	7.5		
Alkalinity	Hach drop count	200		mg/L
Phosphate	Hach drop count	0		mg/L
Hardness	Hach drop count	239.4		mg/L
Iron	Hach color disk test	0		mg/L
Depth	------	1.1		meters

Table 8: October 29, 2008

Water Chemistry				
Parameter	**Kit/Meter**	**Depth**	**Value**	**Units**
Dissolved Oxygen	YSI	.5m	3.16	Ppm
			27.7	% saturation
		1m	2.94	Ppm
			25.8	5 saturation
Temperature	YSI	9.2		ºC
		49		ºF
Turbidity	Hach DR820	3		FAU (Formazin Attenuation Units)
pH	Hach color disk test	7.5		
Alkalinity	Hach drop count	200		mg/L
Phosphate	Hach drop count	0		mg/L
Hardness	Hach drop count	273.6		mg/L
Iron	Hach color disk test	0		mg/L
Depth	------	1.1		meters

Table 9: November 5, 2008

Water Chemistry				
Parameter	**Kit/Meter**	**Depth**	**Value**	**Units**
Dissolved Oxygen	YSI	.5m	3.7	Ppm
			33	% saturation
		1m	3.63	Ppm
			32	% saturation
Temperature	YSI	10		ºC
		50		ºF
Turbidity	Hach DR820	0		FAU (Formazin Attenuation Units)
pH	Hach color disk test	7.5		
Alkalinity	Hach drop count	200		mg/L
Phosphate	Hach drop count	0		mg/L
Hardness	Hach drop count	256.5		mg/L
Iron	Hach color disk test	0		mg/L
Depth	------	1.1		meters

Table 10: September 21, 2008

Fecal Coliform Analysis		
Negative Control: (1mL dH20)		**CFU/100mL**
Coliforms (not E. coli; pink)	0 CFUs	
E. coli (dark blue/purple)	0 CFUs	0 CFU/100mL
Total coliforms	0 CFUs	0 CFU/100mL
Sample Volume: 2mL		
Coliforms (not E. coli; pink)	40 CFUs	
E. coli (dark blue/purple)	0 CFUs	0 CFU/100mL
Total coliforms	40 CFUs	2000 CFU/100mL
Sample Volume: 4mL		
Coliforms (not E. coli; pink)	73 CFUs	
E. coli (dark blue/purple)	0 CFUs	0 CFU/100mL
Total coliforms	73 CFUs	1825 CFU/100mL

Table 11: September 29, 2008

Fecal Coliform Analysis		
Negative Control: (1mL dH20)		**CFU/100mL**
Coliforms (not E. coli; pink)	0 CFUs	
E. coli (dark blue/purple)	0 CFUs	0 CFU/100mL
Total coliforms	0 CFUs	0 CFU/100mL
Sample Volume: 1mL		
Coliforms (not E. coli; pink)	100 CFUs	
E. coli (dark blue/purple)	0 CFUs	0 CFU/100mL
Total coliforms	100 CFUs	10000 CFU/100mL
Sample Volume: 3mL		
Coliforms (not E. coli; pink)	200 CFUs	
E. coli (dark blue/purple)	11 CFUs	367 CFU/100mL
Total coliforms	211 CFUs	7033 CFU/100mL
Sample Volume: 5mL		
Coliforms (not E.coli; pink)	375 CFU's	
E. coli (dark blue/purple)	25 CFU's	500 CFU/100mL
Total Coliforms	400 CFU's	8000 CFU/100mL

Table 12: October 29, 2008

Fecal Coliform Analysis		
Negative Control: (1mL dH20)		**CFU/100mL**
Coliforms (not E. coli; pink)	0 CFUs	
E. coli (dark blue/purple)	0 CFUs	0 CFU/100mL
Total coliforms	0 CFUs	0 CFU/100mL
Sample Volume: 1mL		
Coliforms (not E. coli; pink)	70 CFUs	
E. coli (dark blue/purple)	1 CFUs	100 CFU/100mL
Total coliforms	71 CFUs	7100 CFU/100mL
Sample Volume: 3mL		
Coliforms (not E. coli; pink)	180 CFUs	
E. coli (dark blue/purple)	4 CFUs	133 CFU/100mL
Total coliforms	184 CFUs	6133 CFU/100mL
Sample Volume: 5mL		
Coliforms (not E.coli; pink)	250 CFU's	
E. coli (dark blue/purple)	10 CFU's	250 CFU/100mL
Total Coliforms	260 CFU's	6500 CFU/100mL

References:

1. Harrelson, Cheryl C, Rawlins, C.L., Potyondy, John P. 1994. Stream channel reference sites; an illustrated guide to field technique. Gen. Tech. Rep. RM-245. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 61 p. Available at: http://www.fs.fed.us/rm/pubs_rm/rm_gtr245.pdf
2. Little, Elbert L. "The Audubon Society- Field Guide to North American Trees, Eastern Region". Alfred A. Knopf, Inc. 1980.
3. McNeel, William P. "Greenbrier River." *The West Virginia Encyclopedia*. Ken Sullivan, editor. Charleston, WV: West Virginia Humanities Council. 2006.
4. Micrology Laboratories LLC. www.micrologylabs.com
5. Rosenburg, Matt. Karst Topography. About.com:Geography. http://64.233.169.132/search?q=cache:f39cBc8rZ4oJ:geography.about.com/od/physicalgeography/a/karst.htm+Sinkholes+formed+from+underground+caves&hl=en&ct=clnk&cd=5&gl=us
6. The Lehigh Earth Observatory. www.leo.lehigh.edu/projects/hydroprobe/wqdef.html