Appendix F
Stream Studies

Appendix F1 – Aquatic Biota and Habitat Survey of Two Streams in Rainelle, WV

Appendix F2 – Meander Study Report

Appendix F3 – Mussel Survey Report*

**** A mussel report has been added as Appendix F3 for the Final EIS.***

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Aquatic Biota and Habitat Survey of Two Streams in Rainelle, WV.

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Summary

A general aquatic survey was completed on Wolfpen and Sewell Creeks near Rainelle, WV. The surveys included water chemistry, physical characteristics, habitat assessment, benthic invertebrate sampling with WV SCI calculations, a fish community assessment and a superficial assessment of mussel habitat. Sewell Creek is larger than Wolfpen but both streams have similar physical and chemical water quality. An un-named tributary to Sewell Creek did show evidence of acid mine drainage impact. Both RAPID habitat quality scores (117 and 122) and WV SCI scores (73.68 and 73.64, ranked "good") were better in Wolfpen Creek than in Sewell Creek. Sewell Creek WV SCI scores were ranked "fair" to "grey zone". Fish communities in both streams were dominated by tolerant, pioneering species. No dead shells or living unionid mussels were observed at any of the sites. Small stream size for Wolfpen Creek and poor habitat/flow characteristics in Sewell Creek would make the presence of any federally listed mussel species extremely unlikely. Overall Wolfpen and Sewell Creeks have reasonable water quality but are both habitat and flow limited to support diverse aquatic communities. No rare or endangered aquatic species were located at the five sampling locations.

Introduction

A coal waste fired power plant is proposed for development in Rainelle, West Virginia (Figure 1). A component of the environmental assessment of the location includes detailed sampling of Sewell Creek and its tributary, Wolfpen Creek. This report includes data on habitat, water quality, presence of unionid mussels, assessment of fish populations, and benthic invertebrate populations. Water quality data were collected and analyzed by Acculab Inc., an EPA certified water quality laboratory. The data were collected at four locations (Figure 2, Tables 1- 4). Stream habitat and benthic samples were collected at five locations (Figure 3, Tables 5 – 7, Appendix 1). Fish population assessments were made along 100m transects at three locations (Figure 4, Table 8, and Appendix 2). General habitat assessment for unionid mussels and visual searches for live and or dead shells were made at both invertebrate and fish assessment locations.

Methodology:

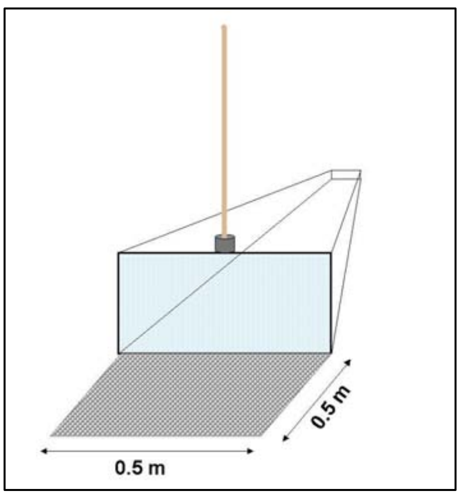
Fishes

State agencies were notified of survey protocols, dates, and times. Area law enforcement agencies were notified to reduce concerns of the public. Three locations were sampled for fishes, two on Sewell Creek and one on Wolfpen Creek (Figure 4). Fish surveys were completed using a Smith Root backpack electro-fishing unit. Special care was taken not to disturb residences. Fishing began upstream and proceeded downstream as a series of zigzag bank encroachments. Blocking nets were not utilized since the stream segments had a series of well defined pools separated by very shallow water riffles. Stunned fishes were netted and placed into five gallon buckets. Shocking time and mean output were recorded at the end of each transect. Large fishes were identified, weighted, and measured for standard length. Small fishes were batch weighed. Images were collected for all species. Most fishes were released and no game fishes were retained. A series of small specimens were retained as vouchers and for identification verification. All vouchers were placed in the Marshall University fish collection.

Benthic Macroinvertebrate Sampling

Five samples were collected, three on Sewell Creek and two on Wolfpen Creek (Figure 3, Table 5). Although the fish and benthic samples were collected in similar locations, specific habitat requirements did cause these sampling sites to differ slightly. Our protocols are directly quoted from the WV DEP's West Virginia Stream Index Protocol. The following are standard protocols (slightly modified) developed by the U.S. Environmental Protection Agency for conducting biological assessments of streams and rivers. A detailed description of the protocol is given in EPA 841-B-99-002 Rapid Bioassessment Protocols for Use in Wadeable Streams and Rivers (RBP).

Benthic macroinvertebrates were collected using a 0.5 meter wide rectangular frame kick net with 600 µm mesh openings. The bottom substrate was examined to ensure that habitat was similar at each collection station. The net was positioned on the stream bottom in a riffle/run area so as to eliminate gaps under the frame. The surfaces of all large substrate particles (large gravel and larger) were cleaned using a dish scrub brush. The substrate particles were held in front of the net while brushing all surfaces so that dislodged organisms flowed into the net. Cleaned substrate particles were then set aside and the substrate was kicked vigorously for 20 seconds in an area approximating 0.25 square meters (one net width wide by one net width upstream of the net). This action dislodges bottom dwelling organisms and washes them into the net. Eight kick samples were collected at each site and composited into one sample that represented approximately 2 square meters of stream bottom substrate. The samples were preserved in 95% ethanol and returned for sorting. Sorting involved placing the entire benthic sample into a rectangular sieve and removing a 200 organism subsample. The organisms were identified to genus or the lowest level possible. A series of biological metrics (core metrics) were then calculated on each sample in order to determine the condition of the site:



Total taxa - measures the total number of macroinvertebrate taxa (diversity or different kinds) collected in the sample. Total taxa generally decreases with increasing stream degradation. In a 200 organism subsample, it is not uncommon for healthy streams to have 17 or more taxa at the family level of identification.

EPT Index - measures the total number of distinct taxa within the generally pollution sensitive groups Ephemeroptera (mayflies), Plecoptera (stoneflies) and Trichoptera (caddisflies). In general, this index increases with improving water quality. This index is widely used because it is very sensitive to changes in water quality. In a 200 organism subsample, healthy streams commonly have 9 to 12 EPT taxa at the family level of identification.

Percent Contribution of 2 Dominant Taxa - measures the relative abundance of the 2 numerically dominant taxa to the total number of organisms in the sample. In healthy streams, there are generally several taxa, with the individuals being relatively evenly distributed among the different taxa. As stream water quality decreases, more individuals are concentrated in fewer, more tolerant taxa, and this metric increases. It is not uncommon for healthy streams to have as few as 40-60% of the total individuals in a sample in the 2 dominant taxa.

Percent EPT – measures the relative abundance of mayfly, stonefly, and caddisfly individuals to the total number of organisms in the sample. In general, this metric increases with improving water quality. It is common in healthy streams that at least 70 to 90% of the total organisms are in these sensitive orders.

Percent Chironomidae – measures the relative abundance of chironomid (midges) individuals to the total number of individuals in the sample. Chironomids are considered to be tolerant to many pollutant sources. This metric generally increases in value with decreasing water quality. In healthy streams, it is not uncommon that less than 10% of the organisms in a sample belong to the family Chironomidae.

HBI (Hilsenhoff's Biotic Index - modified) - summarizes tolerances of the benthic community to organic pollution. Tolerance values are assigned to each taxon on a scale of 0 to 10, with 0 identifying the organisms that are least tolerant (most sensitive), and 10 identifying the most tolerant (least sensitive) organisms. The HBI metric score can be thought of as an average organic pollution tolerance value for a sample, weighted by the abundance of organisms. As water quality of a stream decreases, the HBI increases. This is especially true where organic enrichment is present. Since many of the organic pollution tolerant organisms are also tolerant to other stressors, the HBI is often used as a general indicator of stress. It is not uncommon for healthy streams with good water quality to have HBI scores in the 3 to 4 range.

WVSCI SCORING CRITERIA
VERY GOOD > 78.0 to 100.0
GOOD >68.0 to 78.0
"GRAY ZONE" >60.6 to 68.0
FAIR >45.0 to 60.6
POOR >22.0 to 45.0
VERY POOR 0.0 to 22.0

WVSCI (WV Stream Condition Index) - The six benthic community metrics were combined into a single multimetric index, the West Virginia Stream Condition Index (WVSCI). The WVSCI was developed by Tetra Tech Inc. (2000) using WVDEP data collected from riffle habitats in wadeable streams. In general terms, all metric values were converted to a standard 0 (worst) to 100 (best) point scale. The six standardized metric scores were then averaged for each benthic sample site to come up with a final index score that ranges from 0.0 to 100.0. If a stream site received a WVSCI score greater than 78.0, it was considered in very good condition. A WVSCI score greater than 68.0, but equal to or less than 78.0 indicated good conditions. Initially, a site that received a WVSCI score equal to or less than 68.0 was considered impaired. However, because the final WVSCI score can be affected by a number of factors (collector, micro-habitat variables, subsampling, etc.), agency personnel sampled 26 sites in duplicate to determine the precision of the scoring. Following an analysis of the duplicate data, agency personnel determined the precision estimate to be 7.4 WVSCI points for a single sample. This value (7.4) was then subtracted from the impaired threshold score of 68.0 and generated what is termed the "gray zone" that ranges from 60.6 to 68.0. If a site had a WVSCI score within the gray zone, a single kick sample was considered insufficient for classifying it as impaired. If a site received a WVSCI score equal to or less than 60.6, the agency was highly confident that the site was truly biologically impaired based on a single benthic macroinvertebrate sample. In accordance, scores greater than 45.0 and equal to 60.6 indicated fair conditions. Scores between 22.0 to 45.0 indicated poor conditions, and between 0.0 to 22.0 indicated very poor conditions.

Habitat Evaluation

A habitat evaluation was conducted utilizing a modified version of the Rapid Bioassessment technique. The approach focuses on integrating information from specific parameters on the structure of the physical habitat that are important to the survival and maintenance of benthic macroinvertebrate populations. Ten parameters were evaluated and given a score on a scale of 0 to 20. The scoring is broken down into four categories: 1) 0 to 5 = Poor, 2) 6 to 10 = Marginal, 3) 11 to 15 = Suboptimal, and 4) 16 to 20 = Optimal. The ten scores were summed to provide a total habitat score for each station (maximum score = 200).

Water Quality Sampling

A field technician from Acculab, Inc. completed field testing and laboratory testing of water chemistry. This is an EPA certified laboratory. All standard QA/QC procedures were followed. Water samples were collected from four locations (Figure 2).

Qualitative Mussel Habitat Surveys

While completing the above work qualified graduate students assessed the available suitable habitat for mussels. Specifically habitat for federal listed species was assessed. Students also searched the sampling areas for dead shells or other signs of a viable mussel population. No dead shells or live specimens, if present, were handled.

Results:

Water Quality

Water quality data was independently collected and analyzed by Acculab, LLC. This facility is EPA approved and regularly samples water in southern West Virginia. Table 1 lists the UTM coordinates for zone 16 for each sampling site. Figure 2 shows the approximate locations of the sampling sites on a topographical map layer. Sites one and three were in Sewell Creek, site two was from Wolfpen Creek, and Site 4 was from an unnamed tributary to Sewell Creek. The number of fecal coliform colonies per 100ml sample was calculated for all four sites with a single duplicate at Site 3 (Table 2). Results of the fecal coliform count indicated the numbers of colonies per 100 ml ranged from 56 colonies for site 4 to 243 colonies for Site 3. Fecal coliform numbers were generally low with a small spike at Site 3. This site was a shallow pool with very little flow. Therefore it is not unexpected that it would show elevated fecal coliform levels. The Wolfpen Creek runs through a golf course; surveyors noted footprints, feathers, etc., suggesting ducks, geese, and several mammals living along the creeks. Applied fertilizers and mega fauna are sources of fecal colonies.

Selected water quality criteria was collected from from the four stations is summarized in Table 3. Sites one, three, and duplicate sample three had stream flows that ranged from 13 to 15 cubic feet persecond (cfs), and exhibit strong correlations of flow, conductivity, pH, and temperature measurements. Data collected from the sites show conductivity values ranged from 33.3 to 109.5 umhos, pH values were generally neutral and ranged from 6.9 to 7.3 su, and temperature for the four sites ranhed from 16.4 °C for sites 1 and 3 to 17.9 °C. These sites are all within expected values for a stream of this size and location in West Virginia. The Wolfpen Creek site (Site 2) is much smaller; a flow of 2 cfs compared to a mean of 14 cfs for Sewell Creek, and has a slightly elevated conductivity (109.5 umhos). Site four is on an unnamed tributary of Sewell Creek and has a tenth of the flow of Wolfpen Creek (0.219 cfs).

Additional chemical tests from sites one, two, three, and duplicate three exhibit very similar conditions with little evidence of acid mine drainage impact. The water quality data indicates the concentration of dissolved organic and inorganic minerals range from 0.081miligrams per liter (mg/l) for aluminum, to 19 mg/l for sulfate.The concentration for suspended solids varies from less than 1mg/l to 3 mg/l. The concentration for acidity is typically less than 1 mg/l and alkalinity ranges from 26 mg/l (sites 1 and 3) 44 mg/l (site 2)(see Table 4). However site four does exhibit reduced alkalinity (8 mg/l), increased acidity (6 mg/l), and slightly elevated manganese and total aluminum levels (0.1 mg/l and 0.115 mg/l respectively). All these are chemical signatures of acid mine drainage. Based on size and similarity of physical and chemical measurements the water quality of upstream Sewell Creek would dictate the conditions near the proposed power plant.

Benthic Macroinvertebrates

Five benthic invertebrate samples were collected from Wolfpen and Sewell Creeks near Rainelle, WV (Figure 3, Table 5, and Appendix 2). Stream habitat data were collected from all five sites. Five sites were chosen to assess some measure of in stream variability. The EPA's RAPID protocol habitat score sheets, which were modified by the WVDEP, was used to measure the gradient score. The high gradient score sheet was used since Wolfpen Creek best fits this scoring procedure and therefore direct comparisons could be made between sites. Sewell Creek was judged borderline between high and low gradient. If low gradient scores were utilized, then the mean habitat scores would increase slightly. The high gradient scoring procedure is the most commonly utilized scoring procedure in WV. The RAPID protocol includes ten metrics calculated for each site with a possible maximum of 20 pts per metric (Table 6). Three of the ten metrics, bank stability, vegetative protection, and riparian vegetative zone width are measured along both banks and their cumulative, right and left bank scores can total a maximum 20 pts. Wolfpen Creek sites 1a and 1b scored 117 and 122, respectively. The total possible score is 200. These represent below average stream habitats. The site images found in Appendix 1 shows high gradient rocky bottom locations. These images represent the best benthic habitat in along the stream segment. Benthic samples are collected from a series of riffles within a 100 meter reach. Habitat scores are based on the cumulative habitat across the entire reach. The three sites on Sewell Creek were scored even lower at 94, 88, and 85. All three scores suggest degraded stream habitats.

Table 7 lists the West Virginia Stream Condition Index (WVSCI) scores and metrics for the five locations. The raw sample data is located in appendix 2. The Wolfpen Creek sites scored the highest WVSCI values of 73.68 and 73.64. These sites habitat also scored 20 or more points above the Sewell Creek sites. Habitat scores and WVSCI almost always show a positive correlation. Lack of agreement would suggest anthropomorphic impacts. These site scores would rank in the "Good" criteria zone. Sites 3 and 2b scored 66.3 and 60.92. These values are in the "Grey Zone" criteria zone. This area was defined as an area of overlap between "Good" sites and "Fair" sites. The WV DEP reserves judgment as to the exact classification of this zone. The final benthic site 2a had a score of 56.32 a "Fair" zone classification. All sites show an intermediate level of impairment. The Hilsenhoff Biotic Index (HBI) ranges from 4.32 for site 1A to 5.11 for site 2B, which would characterize water quality as average. No benthic invertebrates of special interest were found within the samples collected.

Fishes

Three electrofishing transects were sampled, site 1a from Wolfpen Creek, sites 2a and 3 from Sewell Creek. (Figure 4, Table 8, Appendix 3). Fish communities at all sites were numerically dominated by creek chubs, stone rollers, blunt nose minnows, and rock bass (Appendix 3). These species are found in small streams that are regularly impacted by low water conditions. They are considered pioneer species. The greatest number of fish species occurred at site 1A (11 species) and site 3 contained the least number of species (1). No fishes of special interest were located during this study. Table 8 lists the commonly used fish metrics for assessment. West Virginia does not have a regionally modified assessment protocol for fishes. Many more individuals were collected from Wolfpen Creek (site 1a) than the other two sites. Wolfpen was much smaller, had more graveled substrates, and had more fish barriers (riffles) than the Sewell Creek. Sewell Creek was larger and consisted of a series of poorly defined pools with sections of water deeper than wadeable. These sites also had significant deposits of fine sediments and very low current velocities. Capture efficiency was near 90% in Wolfpen Creek but was estimated at 35% (site 2a) and 50% (site 3). Both streams have a limited number of fish species (Table 8). In small habitat restricted streams this is not uncommon. No trout were collected at any site. Green sunfish, an invasive species, was collected from all sites in low numbers. No diseased or hybrid individuals were collected from any site. Rock bass and green sunfish were used as the top carnivore since they were collected from all sites. Numerically creek chub dominated the system but they were not collected from site 2a. The northern hog sucker was the only catostomid collected. These values suggest a tolerant community that may be exposed to regularly very low water levels.

Mussel Habitat

Qualified graduate students made observational notes on current mussel populations and potential habitat. General observations were made during an initial walk through of the sites. Wolfpen Creek is small, sand and gravel dominated stream (Appendix 1). During extreme dry years it would mostly consist of a series of isolated pools with little to no current. Invertebrate sampling sites, those imaged, would represent the best benthic habitat available and they should not be considered typical of this stream. Both banks of the stream show extreme evidence of instability and regular sloughing. Sewell Creek is larger but is more base flow in nature (Appendix 1). It is a series of sand dominated shallow pools. Bank height is up to three meters with both sides highly unstable. Figure 3 shows the characteristic meandering of a low gradient stream. The water would be more consistent in this stream. Both streams exhibited signs of enrichment, sheens and bubbles on the water surface and filamentous algae. All sites had very low habitat scores from 85 to 122 out of a possible 200 points (Table 6). Overall, neither site had potential habitat suitable for any federally listed species except the rabbit's foot, *Quadrula cylinderia*. This species is known from sandy, depositional habitats. However, there is no historical record for this species within a 50 mile radius.
While sampling fish, habitat, and benthos additional observations were made noting existing mussel populations and the potential habitat. No evidence of an extant mussel population was found except for the invasive Asiatic clam *Corbicula flumieria*. No live unionids or dead shell material were observed.

Conclusions
A general survey of water quality found the Wolfpen and Sewell Creek sites similar in both physical and chemical characteristics. Sewell Creek is the larger stream. Due to large flow differences upstream Sewell Creek will determine water quality in the area. An unnamed tributary of Sewell Creek exhibits characteristics of limited acid mine drainage input. It is not so heavily contaminated or it's flow large enough to affect Sewell Creek. Wolfpen Creek was found to have higher quality stream habitat and

benthic invertebrate communities. Both sites ranked "good" with the WV SCI. The three Sewell Creek sites had a mean habitat score of 89 out of 200. Their benthic index scores ranked from "fair" to "grey zone". This suggests an intermediate level of impact. Fish communities in both streams were dominated by tolerant, pioneering species. Metric values all suggested either a fish community highly impacted in the recent past and recovering or a system with repeated impacts such as periodic very low flows. No dead shells or living unionid mussels were observed at any of the sites. Small stream size for Wolfpen Creek and poor habitat/flow characteristics in Sewell Creek would make the presence of any federally listed mussel species extremely unlikely. Overall Wolfpen and Sewell Creeks have reasonable water quality but are both habitat and flow limited to support diverse aquatic communities. No rare or endangered aquatic species were located at the five sampling locations.

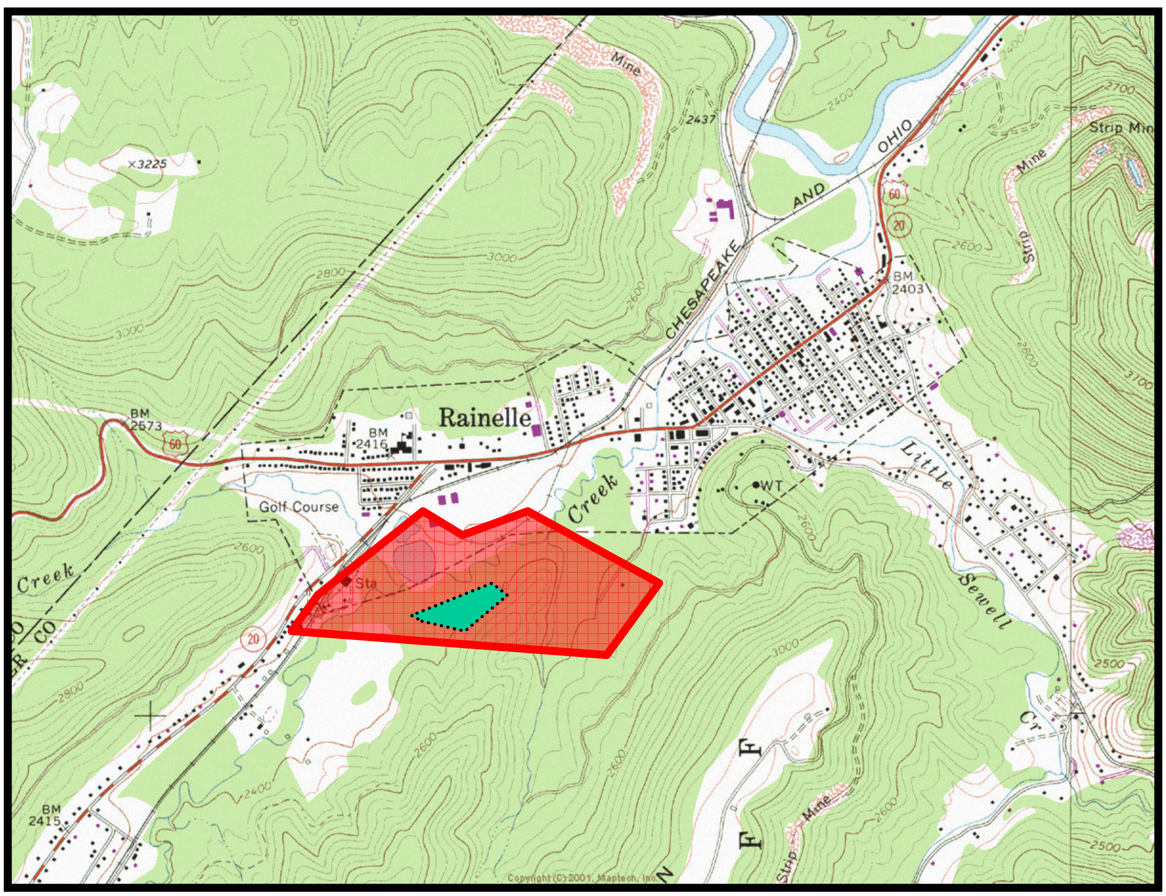


Figure 1. The approximate location of the proposed power plant in Rainelle, WV.

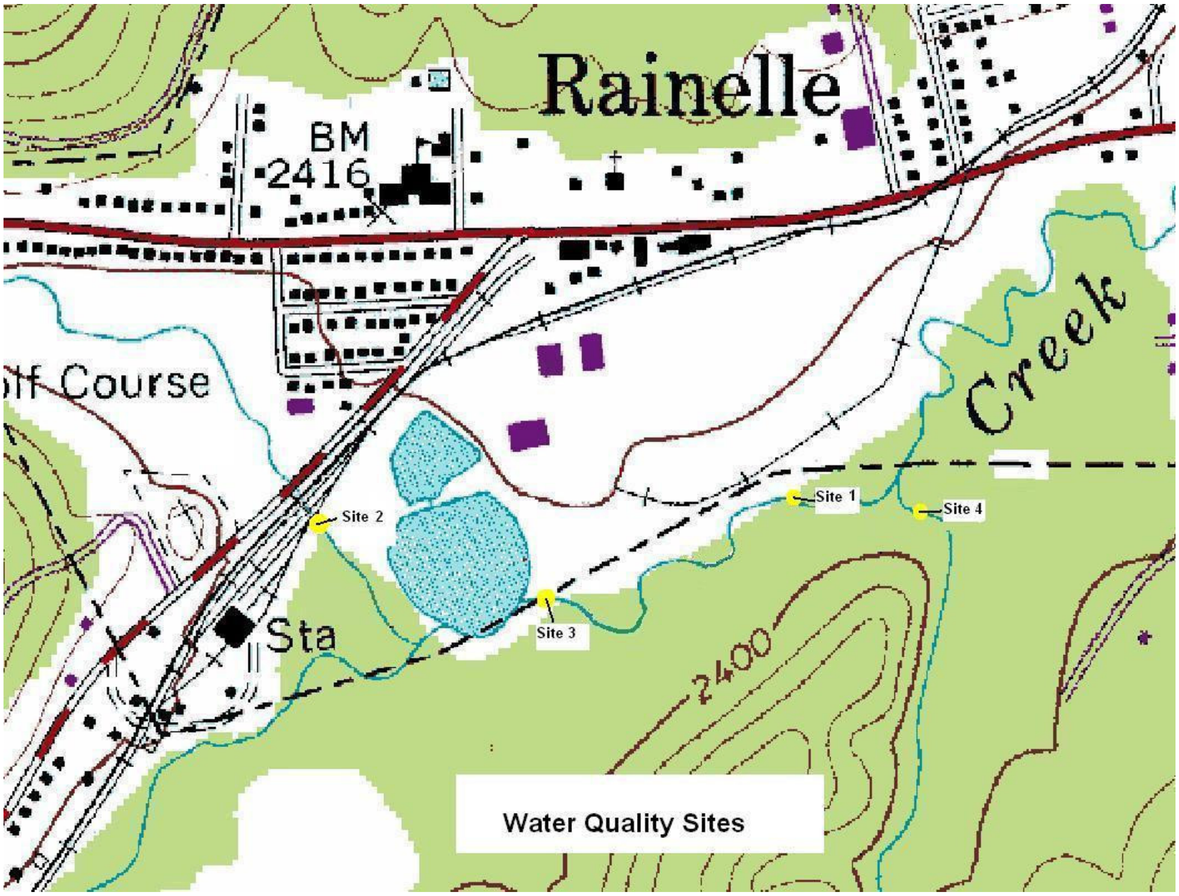


Figure 2. Locations of water quality sampling sites.

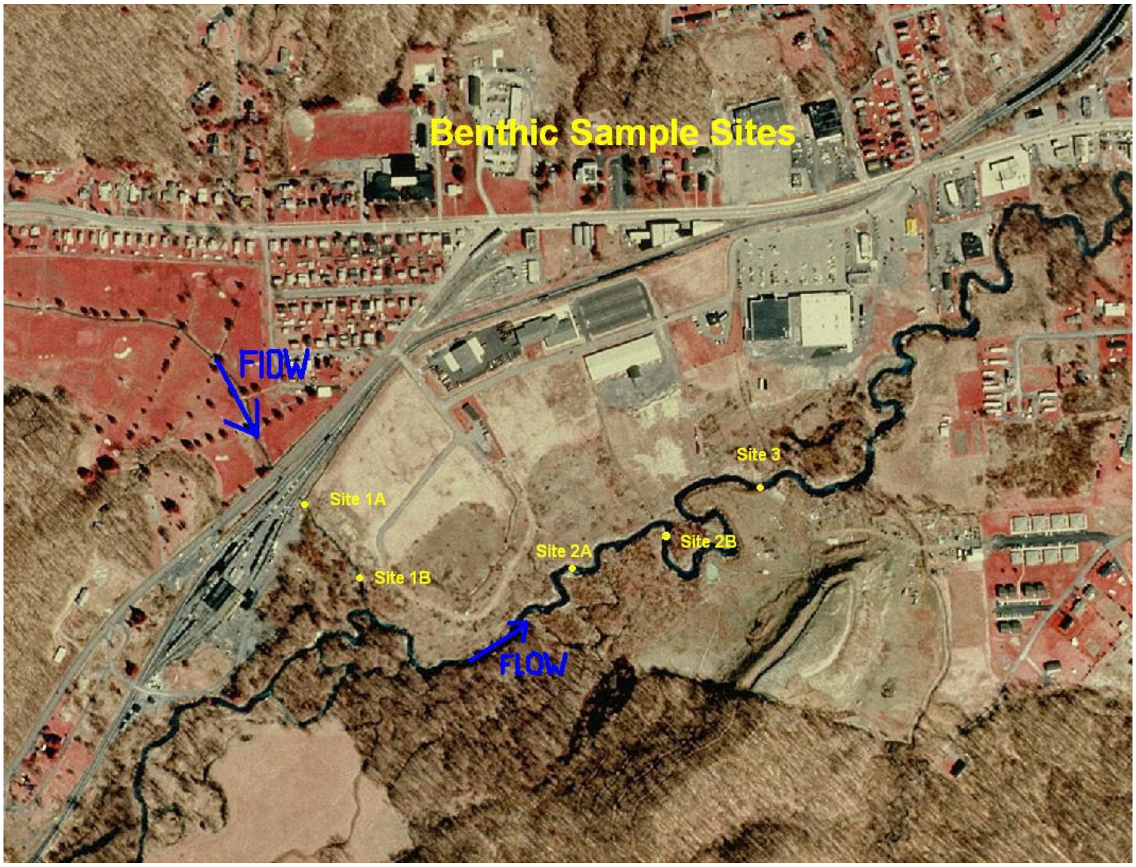


Figure 3. Benthic invertebrate sampling sites on Wolfpen (site 1a & 1b) and Sewell Creeks (sites 2a, 2b, and 3) near Rainelle, WV.

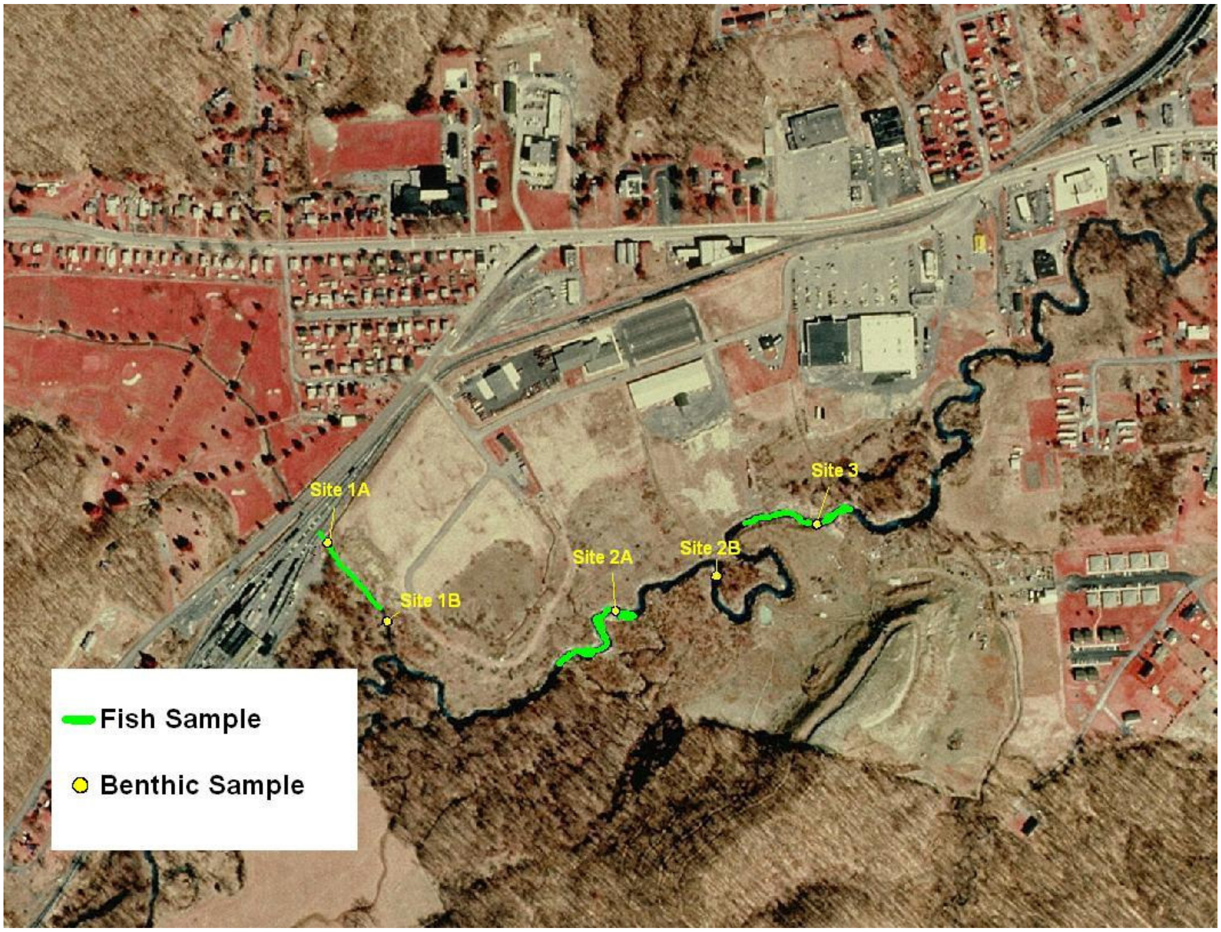


Figure 4. Fish sampling transects on Wolfpen and Sewell Creeks near Rainelle, WV.

Table 1. UTM data on four water quality locations in Rainelle, WV.

Site	Northing	Easting
1	4201919	519763
2	4201894	519190
3	4201798	519473
4	4201902	519926

Table 2. Data on Fecal coliform counts at four locations in Rainelle, WV. (Numbers of colonies per 100ml)

SITE	FECAL COLIFORM
1	124
2	65
3	243
3 DUP	241
4	56

Table 3. Selected water quality data collected from four locations in Rainelle, WV.

PARAMETER	SITE 1	SITE 2	SITE 3	SITE 3 DUP	SITE 4	UNITS
FLOW	13.0	2.0	15.0	15.0	0.219	cfs
CONDUCTIVITY	90.7	109.5	90.7	90.7	33.3	umhos
pH	6.9	7.4	7.3	7.3	7.0	su
TEMPERATURE	16.4	16.8	16.4	16.4	17.9	°C

Table 4. Water quality data collected from four locations in Rainelle, WV.

PARAMETER	SITE 1	SITE 2	SITE 3	SITE3 DUP	SITE 4	UNITS
Total Suspended Solids	<1	2	3	1	4	mg/l
Alkalinity	26	44	26	34	8	mg/l
Acidity	<1	<1	<1	<1	6	mg/l
Hot Acidity	<1	<1	<1	<1	<1	mg/l
Sulfate	17	3	18	19	4	mg/l
Turbidity	4	4	5	4	7	mg/l
Iron	0.43	0.17	0.39	0.48	0.4	mg/l
Manganese	0.08	0.05	0.07	0.08	0.1	mg/l
Aluminum	0.087	0.036	0.156	0.081	0.115	mg/l
Selenium	<2	<2	<2	<2	<2	ug/l
Zinc	<10	<10	<10	<10	<10	ug/l
Dissolved Iron	0.23	0.1	0.17	0.24	0.2	mg/l
Dissolved Aluminum	<0.02	<0.02	<0.02	<0.02	<0.02	mg/l
Dissolved Copper	2	2	2	1	1	ug/l
Dissolved Zinc	<10	<10	<10	<10	<10	ug/l
Nitrite/Nitrate	2.64	1.76	2.2	1.76	1.76	mg/l
Phosphate	<0.05	<0.05	<0.05	<0.05	<0.05	mg/l
Total KJELDAHL Nitrogen	<0.14	<0.14	<0.14	<0.14	<0.14	mg/l

Table 5. Locations of fish and benthic collection sites in Rainelle, WV

Site Name	UTME	UTMN
Lower Sewell Creek Site 3	519772	4201916
Upper Sewell Creek 2A	519532	4201806
Middle Sewell Creek 2B	519643	4201849
Wolfpen Creek Site 1A Upstream Sample	519178	4201877
Wolfpen Creek Site 1B Downstream Sample	519258	4201794

Table 6. Rapid bioassessment habitat data collected from five locations in Rainelle, WV.

Habitat Metrics	**Lower Sewell Creek Site 3**	**Upper Sewell Creek 2A**	**Middle Sewell Creek 2B**	**Wolfpen Creek Site 1A Upstream Sample**	**Wolfpen Creek Site 1B Downstream Sample**
Epifaunal Substrate	5	11	12	12	14
Embeddedness	5	2	3	14	14
Velocity/Depth Regime	4	5	5	13	15
Sediment Deposition	5	2	1	12	14
Channel Flow Status	12	9	8	10	9
Channel Alteration	18	18	17	13	14
Frequency of Riffles	2	2	1	15	16
Bank Stability (LB+RB)	8	5	6	4	3
Vegetative Protection (LB+RB)	15	16	15	8	9
Riparian Vegetative Zone Width (LB+RB)	20	18	17	16	14
Total	**94**	**88**	**85**	**117**	**122**

Table 7. West Virginia stream condition index data from five locations in Rainelle, WV.

Site Name	**TOTAL TAXA**	**EPT TAXA**	**EPT%**	**CHIRO %**	**DOM2 %**	**HBI SCORE**	**WVSCI**
Site 3 Lower Sewell Creek	13	6	44.82759	39.41	64.04	5.03	66.33
Site 1A Wolfpen Creek Upstream	16	8	56.29921	32.68	63.78	4.32	73.68
Site 1B Wolfpen Creek Downstream	15	9	54.31034	26.29	62.93	4.39	73.64
Site 2A Upstream Sewell Creek	15	7	25.70093	66.82	73.64	5.08	56.32
Site 2B Middle Sewell Creek	16	9	33.63636	57.73	77.1	5.11	60.92

Table 8. Fish metrics data collected in Rainelle, WV.

Fish IBI Metrics	Site 1A	Site 2A	Site 3
Total Number of Species	11	8	9
Number of Darter Species	0	1	0
Number of Sunfish Species	2	2	2
Number of Sucker Species (Catostomids)	0	0	1
Number of Intolerant Species (Trout)	0	0	0
% Green Sunfish	0.016	0.034	0.1
% Omnivores (Golden Shiner)	0.008	0	0
% Insectivorous (Cyprinids)	0.94	0.72	0.74
% Top Carnivores (*rupestrus & cyanellus*)	0.044	0.206	0.24
Number of Individuals (or catch per effort)	247	29	50
% Hybrids	0	0	0
% Diseased Individuals (deformities, lesions, and tumors)	0	0	0

Western Greenbrier Co-Generation (WGC) Power Plant
Meander Study Report
Boyd F. Edwards
Department of Physics
West Virginia University
June 20, 2005

1. Conclusion

The meandering study indicates that the construction of the WGC plant might not affect the migration of Sewell Creek for the next 50 years as long as the piers for the permanent bridge over Sewell Creek are located judiciously.

2. Predictions

Figure 1 shows future locations of Sewell Creek (colored traces, by calendar year) predicted by the river meandering model (see Section 4, below). Figure 2 shows the same predictions as Figure 1; however, it is set against the background of a 2004 aerial photograph. In Figure 1, Sewell Creek flows from lower left (southwest) to upper right (northeast). The proposed bridge is planned to be located in quadrant F10. According to the the predictions, Sewell Creek will migrate southeast where it passes under the bridge. This migration is consistent with general features of meander bends, which typically migrate downstream and bulge laterally away from the center of the river valley, until cutoff occurs and an oxbow lake is created.

The locations of the bridge piers is not known at this time. According to correspondence with Potesta & Associates, the bridge will likely consist of three 100' spans, with two intermediate concrete piers, which are 4' wide perpendicular to stream flow and separated by 100'. The bridge design allows for some flexibility in where the bridge piers would be placed; however, placing them at equal distances from the creek center would most likely be the default design.

Two black rectangles superposed on the proposed bridge in quadrant F10 of the image in Figure 1 give one possible location of the bridge piers, separated by 100'. This location would not interfere with the predicted river migration. If instead the bridge were divided into three equal-length spans, then the southeast pier would be standing in the present location of Sewell Creek. Hence, some adjustment in the pier locations must be made from this simple arrangement.

Another place where the migration of Sewell Creek might potentially be affected by the construction is in quadrant F7, where the river is predicted to contact the fill area from the WGC plant, but not until the year 2060.

The large meander loop in quadrant F8 will likely cut off by the year 2060, since the neck is predicted to become smaller and smaller in each successive year. The exact date of the cutoff depends on the extent of flooding each spring, during which most migration occurs. This meander loop will likely cutoff eventually whether or not the plant is constructed.

Barriers to migration turned out to be irrelevant, since the WGC construction is not predicted to present any barriers to migration unless the bridge piers are located injudiciously. It is difficult to include the effects of barriers presented by bridge piers in the analysis because the locations of these piers is not yet known.

3. Past

In order to calibrate the model, the past behavior of Sewell Creek was examined by using the following photography:

Exposure Date	Project Code	Roll	Frame(s)	Type
Nov. 19, 1940	USDA DZC-3R-71	CMS 15	**19**, 20	aerial b/w photograph
April 8, 1970	GS-VCEJ	3	289, **290**	aerial b/w photograph
April 3, 1996	NAPP	9444	**23**, 24	aerial infrared photograph
April 6, 2004				ortho-corrected color image

The first task in examining the past behavior of Sewell Creek was to reorient and rescale the 1940, 1970, 1996 and 2004 aerials and to superimpose these images in order to examine the migration of Sewell Creek.

The file 2004 image includes reference points A, B, C, and D that was used to scale and orient the aerial photos. Only the 2004 photo is ortho-corrected. Accordingly, small orthographic misalignments occur in the 1940, 1970, and 1996 photos. However, since the reference points were chosen to be along Sewell Creek, misalignments in the scaled, reoriented photos should be small (of order 15 feet or less) along the creek.

4. Model

The future positions of Sewell Creek were estimated using a 2400-line FORTRAN code called MEANDER. This code employs the level set numerical method of Sethian (Ref. 1) to implement the mathematical model (Refs. 2 and 3). The 2004 shape of the Sewell Creek centerline is used as the initial condition, and the simulation predicts subsequent river shapes.

One input for the simulation is the scale factor for the images, the pixel width p in meters. This scale factor is easily determined from the digitized form of the WGC topographic map, which has 140 pixels between adjacent longitude lines. According to the scale on the bottom right side of this topographic map, adjacent longitude lines are separated by 250 feet = 76 meters. Thus, p = 76 m / 140 pixels = 0.54 m / pixel.

Three other parameters, though needed for the simulations, are not known directly, and must be tuned using the past behavior of Sewell Creek as a guide, thereby calibrating the model to the specific characteristics of Sewell Creek. The decay length D gives the distance required for cross-stream shear to recover downstream of meander bends. The time scale T gives the basic time scale for lateral migration. A dimensionless parameter P, the Parker number, governs the rate of migration of sharp bends relative to the migration at slower bends. For further details about the mathematical model, see Refs. 2 and 3.

To calibrate the model, the values of D, T, and P were tuned until the 8-year migration of Sewell Creek between 2004 and 2012 approximately matched its 8-year migration between 1996 and 2004. This process involves predicting the migration of several meander bends with different values of D, T, and P, all independent parameters, until an optimal match is obtained. The final values were D = 4.5 m, T = 3.5 years, and P = 1.0.

After imaging Sewell's path based on these values, the MEANDER program rotates the river so that the starting and ending points both lie on the x axis. A 400 x 100 lattice was employed to investigate the meandering. The level set method (Ref. 1) describes the river shape in the x, y plane, defines a function f(x,y,t) whose value is zero on the river, is positive to the right of the river, and is negative to the left. The level set method then relegates the propagation of the river to the time evolution of the function f(x,y,t). Once the values of this function are found in each time step, it is a simple matter to locate the river, by looking for zeros of this function along gridlines. The program uses an adaptive time step which does not allow the river to propagate more than a tenth of a grid spacing per time step.

5. References

1. J. A. Sethian, Level Set Methods and Fast Marching Methods, Cambridge University Press, New York, (1999).

2. B. F. Edwards and D. H. Smith, Critical wavelength for river meandering, Physical Review E **63**, 045304 (2001).

3. B. F. Edwards and D. H. Smith, River meandering dynamics, Physical Review E **65**, 046303 (2002).

6. Disclaimer

This meandering study provides useful information about the past migration of Sewell Creek, and attempts to predict the future migration of this Creek. However, predicting the behavior of rivers far into the future is a notoriously difficult business, involving variability of soil, ground cover, topography, floods, and spring runoff. For rivers, small changes in the initial conditions can grow exponentially and lead to large changes in the future. Accordingly, the predictions described above are not to be used for design purposes.

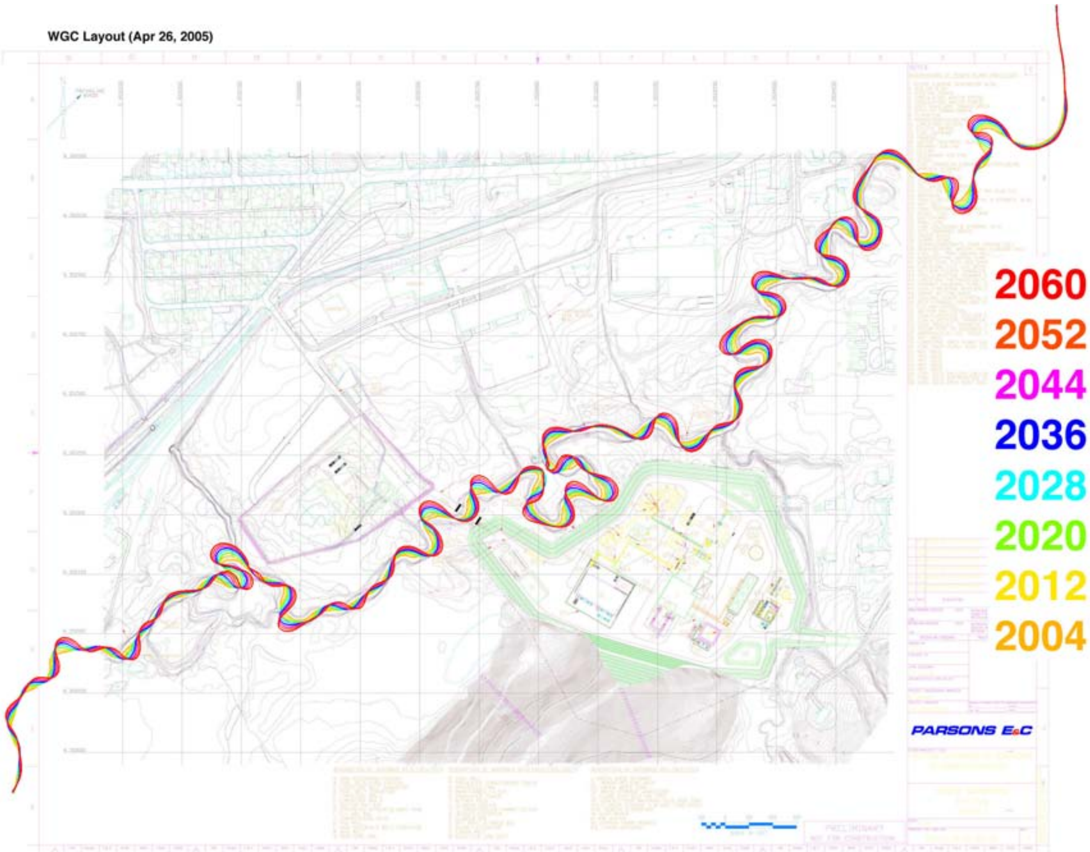


Figure 1. Future Locations of Sewell Creek (topographic survey)

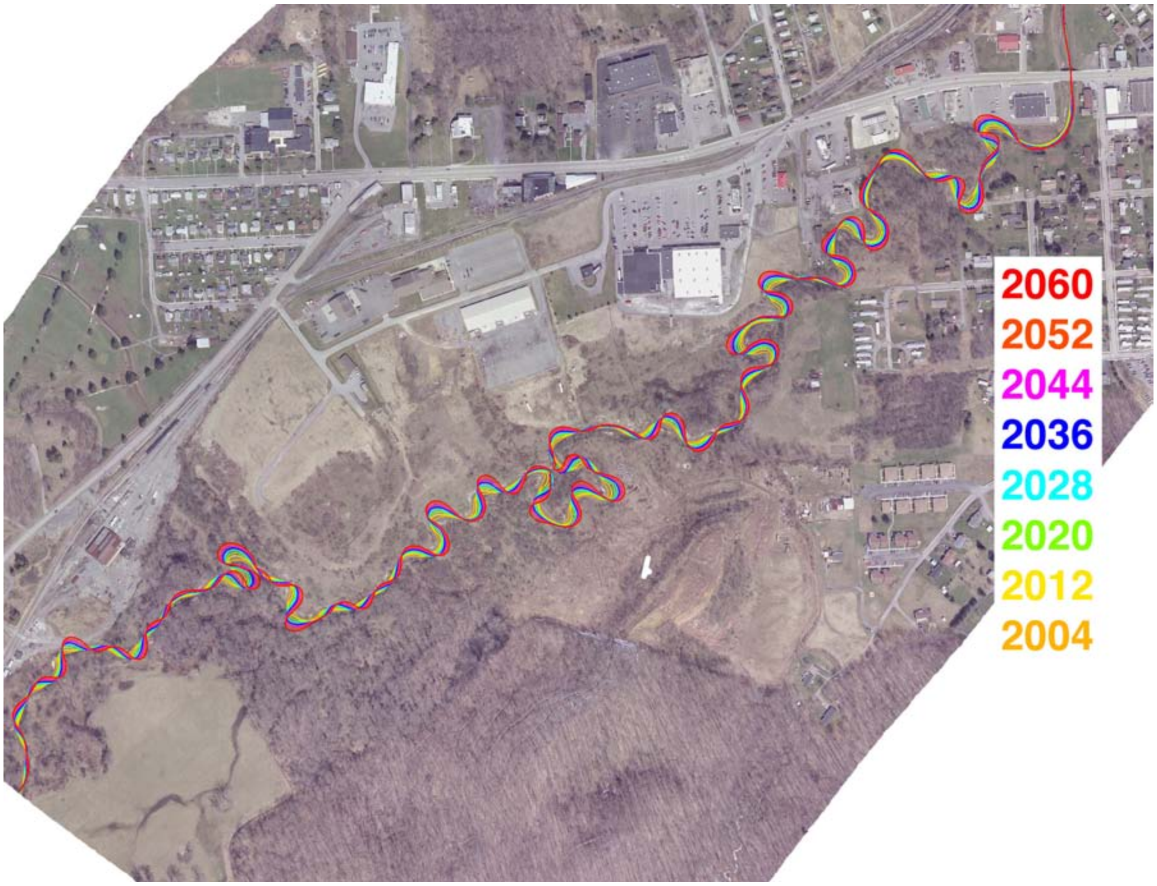


Figure 2. Future Locations of Sewell Creek (2004 aerial)

Mr. Wayne Brown
Western Greenbrier Co-Generation LLC
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P.O. Bax 766
Rainelle WV 25962

August 22, 2006

Mr. Brown,

Here is the final report of our activities at the potential construction site near the confluence of Sewell Creek and Meadow River near Rainelle WV.

On August 1, 2006 I and two divers carried out a stream survey of the portion of the Meadow River that might be impacted by a planned construction of a water intake structure upstream of Sewell Creek. The purpose of the survey was to determine if freshwater mussels inhabited the area.

The River above Sewell Creek was surveyed by putting in bank – to – bank transects (ropes) and having a diver on each side of the rope search for mussels. The divers were attached to the transect by a one meter rope. They then extended to search from finger tip to finger tip thus covering an area of approximately 2 Meters. Ten of these transect ropes were placed at 10 meter intervals. We therefore covered one hundred meters of river above Sewell Creek. The river is approximately 25 meters wide here so we effectively searched 1,000 sq meters. The transect lines are represented on the accompanying map by red lines.

The area covered by green parallel lines represents the area searched without SCUBA gear. This searched area included Sewell Creek up to the current treated outfall and approximately 60 meters below Sewell Creek. The substrate of Meadow River below the creek is almost completely solid rock with a few large rocks (1 foot diameter or less) scattered about. Water was clear on this date and visibility was excellent during all searches. Water on this lower portion of the survey area was less than one foot depth. Approximately 2 man hours were spent searching this area.

Sewell Creek had a similar substrate with more large cobble. One and a half man hours were spent searching the creek.

The results of the survey were negative at all sites. No mollusks of any kind were found in Sewell Creek or below the entrance of the creek in Meadow River. In the area where transects were laid, two specimens of the snail *Helisoma anceps* and one Sphaeriacean Finger-nail clam , *Sphaerium striatinum,* were found. Good numbers of the Asian Clam *Corbicula fluminea* were found on a small sand bar 20 meters below Sewell Creek on the left descending bank.

This work was completed under an addendum to my WV collecting permit NO. 2006-217

A copy of this report has been sent to Ms. Janet Clayton of the WV DNR.

Respectfully submitted,

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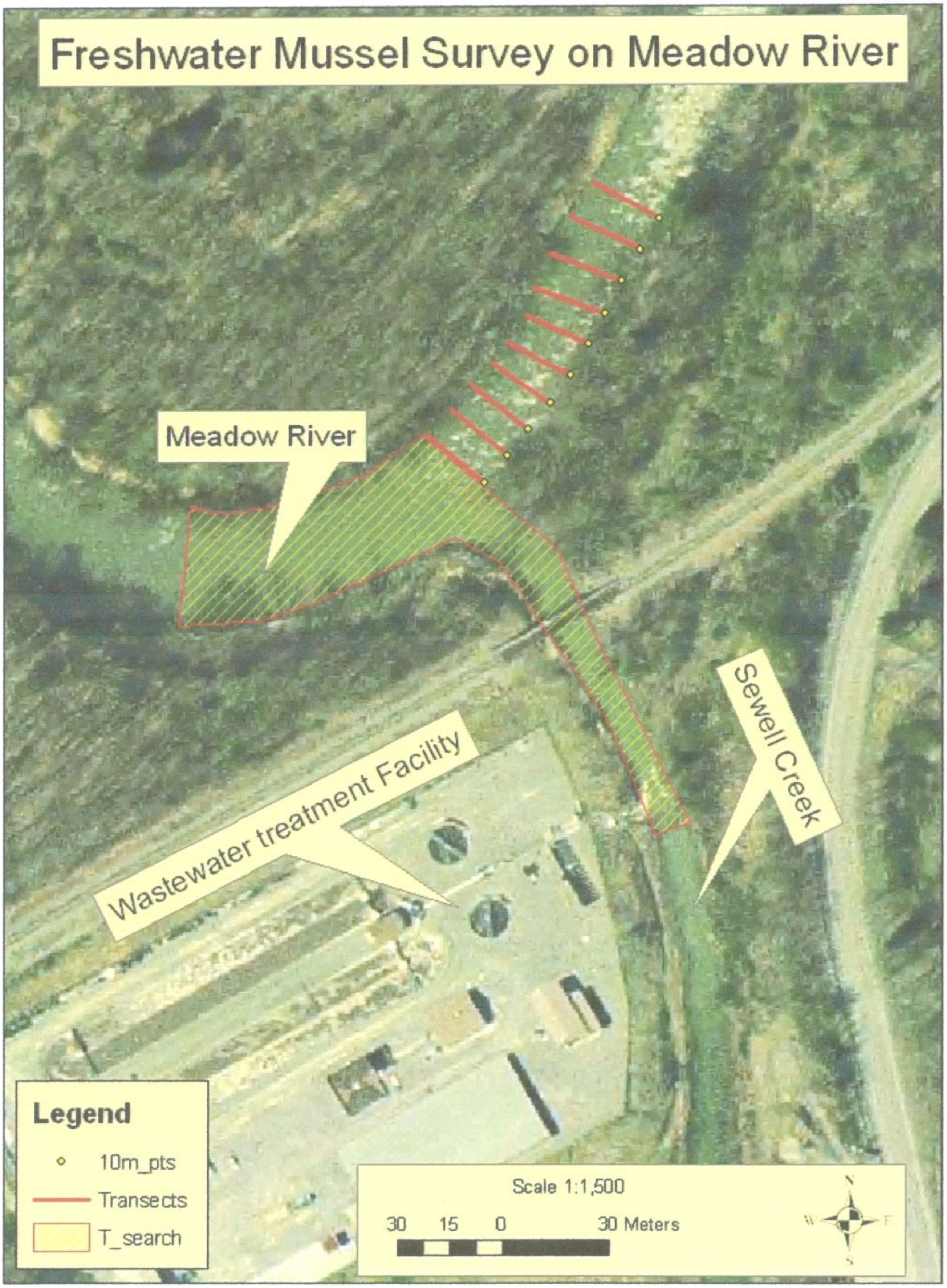
Freshwater Mussel Survey on Meadow River
Meadow River
Wastewater treatment Facility
Sewell Creek
Legend
10m_pts
Transects
T_search
Scale 1:1,500
30 15 0 30 Meters
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W
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