Introduction

West Virginia Water Research Institute

The West Virginia Water Research Institute is dedicated to the preservation and restoration of the natural environment through research and outreach with industry, government agencies, academic and the public.

Introduction

Water is one of West Virginia's most precious resources. It is essential for life and our economic prosperity, yet so many of the activities that keep our economy alive, and growing, also threaten our water resources. Energy generation, mineral extraction, agricultural production and other industrial activities all impact our water, making it increasingly necessary to find new ways to protect and restore this vital commodity as our economic activity accelerates. For over 40 years, the West Virginia Water Research Institute (WVWRI) has been leading the important work of addressing these issues and is the go-to organization for solving West Virginia's water-related problems.

While much of the work we do is focused on exploring and implementing technologies to improve and protect the quality of our State's water resources, we are also dedicated to expanding the understanding of threats and opportunities related to this critically important resource. We strive to bring together a diverse cross section of stakeholders to participate in water-related research throughout West Virginia. We encourage a constructive and respectful dialog about the future of our lakes, rivers and streams as well as our groundwater supplies.

Today, the WVWRI continues to grow its established programs and develop new initiatives to address emerging problems affecting the State's environmental and economic health. With continued financial support from our State and Federal partners and with the expertise of our staff and collaborating researchers, the WVWRI will continue to work for real improvements to West Virginia's water resources.

Water Research for West Virginia: A Team Approach

In 1967, under Federal legislation, the United States Geological Survey established the West Virginia Water Research Institute (WVWRI) to conduct research related to water issues in the State. Today, the WVWRI develops state water research priorities with oversight and guidance from the West Virginia Advisory Committee for Water Research, a committee represented by members of Federal and State agencies, academia and industry. Our programs and projects develop strong, multi-disciplinary research teams through collaboration with West Virginia University colleges and divisions, higher education institutions across the country and industry professionals. This team approach offers the best expertise available to address West Virginia water issues and allows the WVWRI to perform research in a number of areas at any given time. More information on WVWRI programs, research, projects, initiatives and publications can be found at www.wvwri.org.

West Virginia Advisory Committee for Water Research

Our research program is guided by the West Virginia Advisory Committee for Water Research. It includes representatives from the following:

West Virginia Department of Natural Resources
West Virginia Department of Health & Human Resources
West Virginia Chamber of Commerce
West Virginia Coal Association
West Virginia Department of Environmental Protection
West Virginia Farm Bureau
U.S. Federal Bureau of Investigation
U.S. Geological Survey
U.S. Environmental Protection Agency
U.S. Department of Energy - National Energy Technology

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Laboratory U.S. Army Corps of Engineers - Huntington, WV District West Virginia University

The Advisory Committee develops the Institute's research priority list, reviews its progress and selects startup projects at its annual meeting. With this direction, the Institute recruits new researchers to study emerging water research issues. Because the Advisory Committee understands future regulatory and economic driving factors, these issues tend to grow in importance and have often led to follow-on funding from their agencies.

Funding Strategy

The Institute received a grant of $92,335 through the U.S. Geological Survey Clean Water Act section 104b program. We use this funding to develop research capabilities in priority areas and to provide service to State agencies, industry and citizen groups. Our strategy relies on using the USGS section 104b funding to develop competitive capabilities that, in turn, translate into successful proposals funded by a broad spectrum of Federal and State agencies. As of the beginning of 2011, the WVWRI has 35 active projects with a total project value of $6,267,721.

Our strategy also relies on maintaining a broad cadre of researchers within WVU and other institutions within the state. We also work with faculty from institutions across the country to form competitive research partnerships. As West Virginia University is the State's flagship research institution, its researchers have played the dominant role. Our funding strategy relies on successful competition for Federal dollars while teaming with State agency and industry partners. The later provide test sites, in-kind support and invaluable background data. The institute has 12 full time staff, added a new project manager, and is in the process of hiring 3 new full time staff this year. The institute also supports numerous students (4 within the WVWRI) and more through other departmental projects. All but two positions are supported entirely on grant funds. Roughly two-thirds of the Institute staff is directly engaged in research projects; the remaining handle administration and outreach.

Research Priorities

The following is a list of state research priorities identified by the WV Advisory Committee for Water Research for 2010.

Energy production impacts on water resources (oil and gas drilling; hydroelectric; biofuels; etc.); Nutrient reduction/nutrient control/sources of air deposition Mercury (informational fact sheets) Valley fills (viability of fill areas for community uses; protect as a water source; how to handle sewage); Flooding Aquatic ecosystem integrity (anti-degradation, water quality criteria, nutrient/pathogen impacts, headwater stream valuation/mitigation) Water metrics (methods for measuring physical, chemical, biological components, in situ monitoring, PPCP's, pathogens in drinking water) Uses for mine water discharge (drinking water potential for underground mine pools, irrigation, industrial heating/cooling) Industrial processes and urban sprawl (water budgets, contaminants, flooding, ground-water recharge, storm water applications) Evaluation of water resources (uses)

Outreach

The WVWRI performs outreach through meetings, workshops, conferences, site visits, web site, newsletters, and publications. Specific accomplishments include a new Institute brochure that was developed and published this year. Also, the WVWRI led the best attended state water conference to date. The 2010 state water conference is detailed in the Information Technology Transfer section of this report.

The Institute's web site contains information on all the WVWRI programs and projects. This site is updated on an on-going basis as new information becomes available. This year, the WVWRI purchased the following url
addresses for the Institute web site:

www.wvwri.org www.wvwri.net www.wvwri.com
Research Program Introduction

The USGS 104b research program for this reporting period consists of two projects:

Controlling Phosphate in Agricultural Field Leachate Using Mine Drainage Treatment Ferrihydrite

and

Development and Presentation of Current Monongahela River Water Quality Data for the Public

Reports on these projects follow.
(WRI-117) Controlling Phosphate in Agricultural Field Leachate Using Mine Drainage Treatment Ferrihydrite

Basic Information

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Publications


Controlling Phosphate in Agricultural Field Leachate Using Mine Drainage Treatment Ferrihydrite

WRI-117
USGS award number: 2009WV122B

FINAL REPORT

REPORTING PERIOD: MARCH 1, 2010 - FEBRUARY 28, 2011

PRINCIPAL INVESTIGATORS:
Paul Ziemkiewicz, Ph.D.
Louis McDonald, PhD.
Richard Herd, M.S.
Melissa O’Neal, B.S.

MAY 31, 2011

West Virginia Water Research Institute
National Research Center for Coal and Energy
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Abstract

Agriculture, including confined poultry production, is a major source of phosphorus (P) contamination to the Chesapeake Bay. Confined poultry production results in large quantities of P-containing manure. The repeated application of manure to soils based on the nitrogen content of this material results in soil P buildup; a process that has been linked to eutrophication of surface waters. Active treatment of acid mine drainage produces an iron-based waste product, acid mine drainage treatment residuals (AMD-TR) that are known to bind inorganic and organic P. Our overall goal was to evaluate the feasibility of using AMD-TRs to reduce P contamination in waters draining to the Bay using field (Phase 1) and laboratory (Phase 2) experiments. The objective of Phase 1 was to determine the extent to which AMD-TRs could reduce water soluble P in the leachate from a tile-drained field. Six AMD-TRs collected from northern West Virginia were characterized for their ability to bind water soluble P using P-sorption isotherms. To collect baseline data, soil samples were collected from five depths and poultry litter was applied to a tile-drained field at the Reymann Memorial Farm in Wardensville, WV. Water samples were collected at the tile drain outlet six times during the corn growing season. P-sorption capacities ranged from 16.9 to 69.5 mg P (kg AMD-TR)^{-1}. Dissolved P concentrations from the tile-drain were never greater than 0.05 mg P L^{-1}. The objective of Phase 2 was to quantify the reduction and variability of reduction in plant available P in poultry litter when AMD-TRs were incorporated. Two of the AMD-TRs were used in a wetting and drying incubation experiment with five poultry litters. Litter extractable P decreased by 190 to 680 mg P for every % (w/w) increase in AMD-TR, but was dependent on AMD-TR source and litter type. In a separate experiment, application of 20% AMD-TR to litter reduced extractable P by a factor of three, with a first order decay constant of 0.056 (% AMD-TR)^{-1}. The potential for AMD-TRs to adsorb P from animal manures could convert what is now a liability (AMD-TR disposal) into an opportunity (P-management technology).

Introduction

Phosphorus from non-point source discharges is a major contributor to water quality degradation (Haustein et al., 2000). Phosphorus pollution has been linked to a wide array of problems including eutrophication, fish kills, loss of sea grass, and “dead zones” (Carpenter et al., 1998). In 1987, EPA set a maximum contamination level of 0.05 mg L^{-1} phosphorus in
streams where it enters a lake or reservoir and 0.1 mg L\(^{-1}\) in streams that do not directly discharge into a lake or reservoir (USEPA, 1987).

Animal manure is an important soil amendment for agricultural soils because it has lime value, contains organic matter, and plant essential macro- and micro-nutrients (Haering and Evanylo, 2005). However, relative to plant needs, animal manures are enriched in phosphorus (P) such that repeated manure applications to meet fertilizer nitrogen (N) needs leads to excess soil test phosphorus (STP), especially in watersheds with extensive confined animal feeding operations (CAFOs) and limited arable land. There is a positive correlation between STP and dissolved P in runoff (Pote et al., 1996).

Iron and aluminum oxyhydroxides have the ability to adsorb P from soil solutions (Barrow et al., 1980). Stable inner sphere complexes are formed because of the high affinity that phosphate has for exchanging surface ligands (Geelhoed, et al. 1998). Metal oxides have been used in the past to reduce phosphorus loss from non-point sources (Haustein et al., 2000; Rhoton and Bigham, 2005). Drinking water treatment residuals (TR) have been used to reduce P bioavailability and P-runoff from fields (Codling et al. 2000; Ippolito et al., 1999), but availability and cost have limited their use.

AMD treatment technologies also produce iron and aluminum oxides that have the ability to adsorb P (Sekhon, 2002, Sibrell et al., 2009). The potential for AMD –TR to adsorb P from animal manure, could convert what is now a liability (AMD-TR disposal costs) into an opportunity (P-management technology). However, AMD-TRs are known to be variable in composition, structure and reactivity due to a variety of factors including influent water quality, treatment type and age (Skousen and Ziemkiewicz, 1996; Lenter et al., 2002). Thus, not all AMD-TRs may be suitable for manure treatment. Animal manures are also variable due to species, diet, storage type and age (Haering and Evanylo, 2005).

To address this problem, there are four potential solutions. First, AMD-TRs could be applied to agricultural fields to reduce soluble P concentrations. Second, excess manure could be removed from the watershed to P-deficient fields in another watershed. Third, manures could be applied to fields to meet P needs and supplemental inorganic N applied to meet N needs. Fourth, plant available P in the manure could be reduced so that land application more closely matches
target plant N and P needs. Options 2 and 3 have not, to date, been economically feasible. Therefore, our objectives were to quantify the effects of added AMD-TR on the reduction of dissolved P in a tile drained field where poultry litter had been applied (Phase 1) and to model the reduction in plant available P in poultry litter when AMD-TRs were incorporated (Phase 2).

**Phase 1 Project Goals**

1) Identify sources of AMD treatment sludge.
2) Characterize the sludge for its ability to adsorb water soluble phosphorus.
3) Identify field sites for study.
4) Characterize field site soils and phosphorus loading to local waters.

1. **Identify sources of AMD treatment sludge**

   Six AMD-TR slurries were provided by the West Virginia Department of Environmental Protection that had been precipitated with calcium hydroxide (Ca(OH)₂).

2. **Characterize the sludge for its ability to adsorb water soluble phosphorus**

   Samples were air-dried, ground to pass a 2mm sieve and stored in plastic pails at room temperature until use. Total carbon (C) and sulfur (S) were determined by dry combustion (LECO TruSpec CHNS Analyzer, LECO Corp., St. Joseph, MI) before (C\text{init}) and after (C\text{final}) treatment with 1 M nitric acid (HNO₃) to remove carbonates. pH was determined 1:1 (w/w) in distilled, deionized water. Total elemental analyses (Fe, Al, Mn, Ca, Mg, and P) were determined by ICP-OES (Optima DV2100, Perkin Elmer Corp, Norwalk, CT) following microwave-assisted (MARS 5, CEM Corp. Matthews, NC) HNO₃ digestion (EPA 3051).

   A P sorption isotherm was constructed using 0.5 g of each AMD-TR and increasing concentrations of inorganic P as KH₂PO₄ such that equilibrium P concentrations ranged from zero to approximately 500 mg P L⁻¹ in triplicate. Sorption maxima from the mean of triplicate isotherms were determined and compared using Analysis of Variance (ANOVA) with AMD-TR type as a categorical variable and means separated by Least Significant Difference (PROC GLM, SAS ver 9.2, SAS Inst. Cary, NC). The AMD-TRs with the largest and smallest P sorption maxima were used in the first incubation experiment.
AMD-TR colors ranged from the typical orange-red (487 and 032) to light brown (081) to dark brown, almost black (685, 776, and 481) (Figure 1).

Figure 1. Photographs of the six AMD-TR samples a) 487, b) 685, c) 776, d) 481, e) 032, and f) 081.

All AMD-TRs were alkaline in pH and contained between 1.1 and 12% Fe and between 2.2 and 6.2% Al (Table 1). The high pH and difference between $C_{\text{initial}}$ and $C_{\text{final}}$ suggests the presence of unreacted lime. The AMD-TRs contained only trace quantities of native P.

Table 1. Mean pH, and total C, S, Fe, Al, Mn, Ca, Mg, and P for six acid mine drainage treatment residuals (AMD-TRs). $C_{\text{initial}}$ and $C_{\text{final}}$ refers to before and after acid treatment to remove unreacted lime.

<table>
<thead>
<tr>
<th>AMD-TR</th>
<th>pH</th>
<th>$C_{\text{initial}}$</th>
<th>$C_{\text{final}}$</th>
<th>S</th>
<th>Fe</th>
<th>Al</th>
<th>Mn</th>
<th>Ca</th>
<th>Mg</th>
<th>P (mg kg$^{-1}$)</th>
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<tr>
<td>487</td>
<td>9.3</td>
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<td>0.41</td>
<td>3.2</td>
<td>10</td>
<td>3.4</td>
<td>0.3</td>
<td>19</td>
<td>1.0</td>
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<td>685</td>
<td>9.2</td>
<td>3.7</td>
<td>0.43</td>
<td>2.3</td>
<td>1.8</td>
<td>2.2</td>
<td>3.2</td>
<td>12</td>
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<td>776</td>
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<td>1.1</td>
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<td>1.1</td>
<td>6.2</td>
<td>2.5</td>
<td>2.0</td>
<td>2.6</td>
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<td>481</td>
<td>8.0</td>
<td>1.4</td>
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<td>1.3</td>
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<td>4.4</td>
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<tr>
<td>032</td>
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<td>0.85</td>
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<td>0.9</td>
<td>14</td>
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</table>
Sample 487 had the largest P sorption maxima of approximately 70 g P kg⁻¹ sludge (Table 2), followed by sample 685 at 27 g P kg⁻¹ sludge and sample 081 at 17 g P kg⁻¹ sludge. All other samples had P sorption maxima of less than 22 g kg⁻¹. Sample 487 had the highest Ca content (Table 1) which could indicate that unreacted lime or gypsum (CaSO₄) was the sorbent (Callahan et al., 2002) or that Ca-phosphates had precipitated. There was no correlation between Fe, Al, or (Fe + Al) concentrations and P sorption capacity. There was no correlation between Fe, Al, or (Fe + Al) concentrations and P sorption capacity. This may indicate the influence of oxide morphology on P sorption (Torrent et al., 1990) which was not determined.

Table 2. Mean P sorption capacity for six acid mine drainage treatment residuals (AMD-TRs). Different superscripted letters indicate significant differences (α=0.05).

<table>
<thead>
<tr>
<th>AMD-TR</th>
<th>P Sorption Capacity mg kg⁻¹</th>
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<tr>
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</tr>
<tr>
<td>081</td>
<td>16.9c</td>
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3. Identify Field Sites for Study

The Reymann Memorial Farm in Hardy County, WV was selected as the field study location based on ability to conduct research within a controlled environment (Figures 2 and 3). Farm managers readily shared information regarding the site, tile drain locations, discharge locations, and were willing and able to provide detailed information regarding poultry litter applications to the field.
This site was chosen mainly due to the tile drains that were present in the field, providing a reliable way to collect water that was draining directly off of the fields. It was determined that two sets of drains had been installed in 1962 and 1984. Both sets of drains are believed to be below a two foot depth (Figures 4 and 5).
Figure 4. Underground tile drains installed in 1984.

Figure 5. Underground tile drains that were installed in 1962.
4. Characterize field site soils and phosphorus loading to local waters

Soil Sampling

At twenty foot intervals, a total of forty-two core samples were collected at a depth of six inches. Every one hundred feet, increment samples were taken up to a two foot depth during a sampling in 2009 (Figure 6).

Figure 6. Locations of soil sample collection.

Soil pH, and Mehlich 1 extractable P, K, Ca and Mg were determined by the West Virginia University Soil Testing Laboratory (WVU-STL). According to WVU-STL interpretations, the surface 0 – 6 cm contains excessive P (> 40 mg kg⁻¹), excessive K (> 120 mg kg⁻¹) and excessive Ca (>2000 mg kg⁻¹).
Table 3. Summary statistics for soil test parameters pH, P, K, Ca, and Mg at five sampling depths.

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Water Quality

Grab water samples were collected from May to September 2009. All samples were collected and analyzed as per EPA methods. Laboratory analysis performed by the National Research Center for Coal and Energy at West Virginia University, and the June 30th sample was analyzed by the WV State Agriculture Laboratory. Resultant data showed that dissolved P concentrations were very low or below detection limits (Table 4).

Table 4. Water quality analytical results.

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<th>Sampling Date</th>
<th>Date Analyzed</th>
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<th>TSS</th>
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<th>Acidity [mg/L]</th>
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<th>Dissolved P [mg/L]</th>
<th>Ortho P [mg/L]</th>
<th>Total Fe [mg/L]</th>
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na = not analyzed
* = samples collected and analyzed by State Ag Lab

Conclusions

The lack of P in the tile-drain effluent meant that the effects of adding AMD-TR could not be determined.
Phase 2 Project Goals

1) Collect and characterize poultry litter samples.
2) Conduct litter – AMD-TR incubation studies and model effects of AMD-TR on reductions in plant available P in poultry litter.

1. Collect and characterize poultry litter samples

Five raw poultry litter samples, three chicken (A, B, C) and two turkey (D, E) were used. Samples were air-dried, ground to pass a 2mm sieve and stored in plastic pails at room temperature until use. Mehlich I extractable Ca, Mg, K, and P, and pH were determined as described above. A sixth chicken litter sample (F) was obtained later and used in a separate experiment. Samples A, B, and F were provided by Mr. Tom Green.

The pH of all litter samples was between 6.5 and 8.4 (Table 5). Turkey litters had larger P concentrations than did the chicken litters (p<0.01). All litters samples contained large K concentrations.

Table 5. Mean (n=2) pH and Mehlich I extractable Ca, Mg, K, and P for six poultry litter samples.

<table>
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<tr>
<th>Incubation</th>
<th>Litter</th>
<th>Type</th>
<th>pH</th>
<th>Ca</th>
<th>Mg</th>
<th>K</th>
<th>P</th>
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<td>--------</td>
</tr>
<tr>
<td>1</td>
<td>A</td>
<td>Chicken</td>
<td>7.0</td>
<td>7300</td>
<td>3490</td>
<td>16900</td>
<td>8980</td>
</tr>
<tr>
<td>1</td>
<td>B</td>
<td>Chicken</td>
<td>8.4</td>
<td>6550</td>
<td>3270</td>
<td>14800</td>
<td>7900</td>
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<tr>
<td>1</td>
<td>C</td>
<td>Chicken</td>
<td>7.3</td>
<td>3820</td>
<td>3530</td>
<td>17000</td>
<td>6240</td>
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<tr>
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<td>D</td>
<td>Turkey</td>
<td>6.5</td>
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<td>3170</td>
<td>16500</td>
<td>11000</td>
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<tr>
<td>1</td>
<td>E</td>
<td>Turkey</td>
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<td>5300</td>
<td>3110</td>
<td>17600</td>
<td>10900</td>
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<tr>
<td>2</td>
<td>F</td>
<td>Chicken</td>
<td>6.9</td>
<td>5760</td>
<td>2870</td>
<td>27300</td>
<td>6900</td>
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</table>

2. Incubation Experiments and Statistical Modeling

The first AMD-TR - Litter incubation study was conducted by mixing 50.0 g of each of the first five litter samples (A – E) with 0, 0.25, 0.5, 1.25 or 2.5 g of the two AMD-TRs with the largest (487) and smallest (081) P sorption capacity as determined above (Table 2). Samples were wet with just enough distilled deionized water to mix thoroughly and allowed to air dry in a dark incubator (~30°C). Samples were typically dry in two to three days. Each week a subsample was removed for pH and Mehlich I extractable Ca, Mg, K, and P determination, as described above. The remaining sample was rewet and the cycle repeated for a total of four weeks. Data
were analyzed using PROC GLM (SAS ver 9.2, SAS Inst. Cary, NC) with AMD-TR type (n=2) and Litter type (n=5) as categorical variables and week (n=4) and added AMD-TR (%) (n=5) as regression variables. The initial statistical model was

\[ \text{Mehlich I P} = \text{AMD-TR} + \text{Litter} + \text{AMD-TR type} \times \text{Litter type} + \text{AMD-TR} (\%) + \text{week} \]  

(1)

The same procedure was repeated with one of the AMD-TR samples and a new litter sample (F) except that the mass of AMD-TR added was increased to 0, 0.5, 1, 2, 4, 5 and 10 g and subsamples were collected each week for three weeks. Data were fit using the SAS NLIN procedure (ver. 9.2 SAS Inst., Cary, NC). All experiments were conducted in duplicate with duplicate subsamples. Although several elements were determined, only P is discussed here. For all statistical analyses the significance level (\( \alpha \)) was 0.05

In the first incubation experiment, the statistical model (Eq. 1) was significant (p < 0.0001) and \( R^2 = 0.913 \). The effect of week was not significant (p = 0.1298) and so data were pooled and a simpler statistical model was analyzed individually by AMD-TR and Litter.

\[ \text{Mehlich I P} = \text{AMD-TR} (\%) \]  

(2)

Over the range of added AMD-TR phosphorus removal was linear, as determined by inspection of residuals. Removal capacities were between 190 and 680 mg P (\% AMD-TR)\(^{-1}\) depending on the litter sample (Table 6). Phosphorus removal with AMD-TR-C was greater than or equal to that of AMD-TR-081, except for Litter E, although this difference was not statistically different. AMD-TR-487 contained more Fe than did AMD-TR-081 (Table 1) and so would be expected to adsorb more P.
Table 6. Mehlich I extractable P reductions for five poultry litters by two AMD-TRs as determined by Eq. 2. Standard errors in parentheses (n=8).

<table>
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<tr>
<th>Litter</th>
<th>AMD-TR 081</th>
<th>AMD-TR 487</th>
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<tr>
<td>A</td>
<td>430 (50)</td>
<td>440 (30)</td>
</tr>
<tr>
<td>B</td>
<td>190 (20)</td>
<td>240 (40)</td>
</tr>
<tr>
<td>C</td>
<td>280 (20)</td>
<td>400 (20)</td>
</tr>
<tr>
<td>D</td>
<td>260 (40)</td>
<td>680 (50)</td>
</tr>
<tr>
<td>E</td>
<td>440 (70)</td>
<td>340 (50)</td>
</tr>
</tbody>
</table>

Phosphorus removal as a function of added AMD-TR-487 in the second incubation with Litter F was not linear (Fig. 7) and so was fit with a first order decay function. Although curvilinear, there was no evidence of P saturation. The first-order decay constant was 0.0562 (AMD-TR%)^{-1}.

\[ P = 7385e^{(-0.0562*\%AMD-TR)} \]

Figure 7. Mehlich I extractable P in poultry litter F as a function of added AMD-TR 487. Dashed lines above and below data points indicate 95% confidence intervals (n=6).
Based on the result in Fig. 7, the data from the first incubation were also fit to a first-order function (Table 7). Decay constants were variable by litter although AMD-TR 487 had consistently better than or equal P removal than did AMD-TR 081, except for litter sample E (Table 7). Results from the first-order analyses (Table 6) were consistent with the simple linear regression results (Table 6) with a Pearson correlation coefficient of 0.73 and a rank correlation coefficient of 0.98. There was no correlation (<0.43) between either the linear or first-order P reductions and initial P concentration in the litter. Litter sample F had a P concentration similar to sample C, but the decay constant was larger in incubation 1 (0.082 %\(^{-1}\)) than in incubation 2 (0.057 %\(^{-1}\)); further evidence that P removal is not simply related to litter P concentration. Although there was no \textit{a priori} reason to fit a first order model to the data, some type of curvilinear function is appropriate because the P sorption capacity of AMD-TR is finite. It simply could not be justified given the data from the first incubation. Note that the range of AMD-TR added in the second incubation was four times larger than in the first incubation.

Table 7. First-order decay constants for Mehlich 1 P reduction for five poultry litters by two AMD-TR samples. Standard errors in parentheses (n = 6).

<table>
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<tr>
<th>Litter</th>
<th>AMD-TR 081 (%)</th>
<th>AMD-TR 487 (%)</th>
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<tbody>
<tr>
<td>A</td>
<td>0.052 (0.002)</td>
<td>0.052 (0.005)</td>
</tr>
<tr>
<td>B</td>
<td>0.024 (0.004)</td>
<td>0.032 (0.006)</td>
</tr>
<tr>
<td>C</td>
<td>0.051 (0.002)</td>
<td>0.082 (0.002)</td>
</tr>
<tr>
<td>D</td>
<td>0.028 (0.006)</td>
<td>0.071 (0.004)</td>
</tr>
<tr>
<td>E</td>
<td>0.049 (0.007)</td>
<td>0.038 (0.005)</td>
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**Conclusion**

Calcium-hydroxide neutralized AMD-TRs reduced plant available P concentrations in poultry litter, but the effect was dependent on the AMD-TR and poultry litter. Differences in P removal varied by a factor of three whether determined by linear reductions (Table 6) or first-order decay (Table 7). There was considerable variability (> 3X) in removal effectiveness depending on the AMD-TR and Litter combination. P removal was not related to Fe and Al content of the AMD-TR or the initial P content of the litter. The reason for this variability
deserves more attention. However, because Mehlich 1 extractable P concentrations did not change after the first week, a specific AMD-TR – litter combination could be quickly evaluated for P-removal effectiveness with a relatively simple experiment.

Mehlich I P concentrations could be reduced by a factor of three with the application of 20% (w/w) AMD-TR. Potentially, this could bring plant available N and P in poultry litter closer to actual crop needs, reduce soil P build up and the associated water quality problems. However, the results from this study should be considered a best-case scenario because complete mixing of the AMD-TR and litter could be obtained, a result unlikely to occur under field conditions.

Literature Citations


Lenter, C. M., L. M. McDonald, J. G. Skousen, and P. F. Ziemkiewicz. The effects of sulfate on the physical and chemical properties of actively treated acid mine drainage floc. Mine Water Environ. 21:114-120.


Project Publications


Information Transfer

none
Attachment 1

Project No.: WRI - 117
Project Title: Controlling Phosphate in Agricultural Field Leachate Using Mine Drainage Treatment Fennihydrite
Recipient: West Virginia University
Principle Investigator: Paul Ziemkiewicz
paul.ziemkiewicz@mail.wvu.edu
(304) 293-2867 x 5441
Co-Investigators: Richard Herd
rherd@mail.wvu.edu
(304) 293-2867 x 5442
Melissa J. O’Neal
melissa.o’Neal@mail.wvu.edu
(304) 293-2867 x 5439
Funding: USGS $30,350.65
WVU Cost Share $60,704.91
Total Value $91,055.56
Project Description:

In an effort to reduce phosphorous contamination in the Chesapeake Bay watershed, the West Virginia Water Research Institute is studying the possibility of using a byproduct from the treatment of acid mine drainage (AMD) to absorb excess phosphorus in waters leaving agricultural lands.

Excess phosphorus in the Chesapeake Bay is a nutrient of concern associated with the eutrophication of the Bay. This results in an increase in the ecosystem’s primary productivity leading to excessive plant growth and decay, and further effects including lack of oxygen and reductions in water quality, fish, and other animal populations. Runoff and ground water draining from agricultural lands have been identified as sources of some of this phosphorus contamination. Land applied litter from the many large poultry farms as well as excess fertilization of crops contribute to the pollution which results in these detrimental impacts on the ecological functions of the Bay.

The treatment of AMD in settling ponds produces a byproduct with sufficient fennihydrite to effectively absorb water soluble phosphorus in laboratory testing. Project researchers will identify suitable sources of AMD precipitate byproducts and perform lab analysis to determine phosphorus absorption potential. Suitable agricultural field sites will be identified as study areas and appropriate treatment prescriptions will be determined. Field studies will take place and monitoring will be undertaken to determine the effectiveness of the treatment in reducing phosphorus in water samples collected from field drainage.

If this process proves successful in field studies, the resultant benefits would be to utilize a would-be waste product to reduce phosphorus concentrations leaving agricultural fields, improving the ecological integrity of the Chesapeake Bay.
(WRI-119) Development and Presentation of Current Water Quality Data for the Public

Basic Information

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<td>Principal Investigators:</td>
<td>Paul Ziemkiewicz, Ben Mack, Melissa J. O'Neal, Dave Saville, Tamara Vandivort</td>
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Publications

There are no publications.
Development and Presentation of Current Monongahela River Water Quality Data for the Public

WRI-119
USGS award number: 2009WV127B

Annual Report

Reporting Period: March 1, 2010 - February 28, 2011

Principal Investigators:
Paul Ziemkiewicz, Ph.D.
Tamara Vandivort, M.S.
Dave Saville, M.S.
Ben Mack, M.S.
Melissa O’Neal

May 31, 2011

West Virginia Water Research Institute
National Research Center for Coal and Energy
West Virginia University
PO Box 6064
Morgantown, WV 26506
The Monongahela River has been impacted by acid mine drainage and episodes of high total dissolved solids (TDS) from flooded underground coal mines and other sources. In year one of this two-year project, the West Virginia Water Research Institute developed a comprehensive water quality monitoring program and reporting mechanism for the Monongahela River. Twelve locations were originally selected for sampling including 4 sites on the main stem of the Monongahela River and at the mouths of 8 of its largest tributaries. Year two of the project added sampling locations at the mouths of four additional significant tributaries. Field parameters have been recorded and samples have been collected every other week and analyzed in the laboratory for a total of 19 water quality parameters monitored.

The analytical chemistry program includes a suite of acid mine drainage parameters (acidity, alkalinity, pH, specific conductivity, sulfate, iron, manganese, aluminum, calcium, magnesium) and dissolved metals (aluminum, iron, manganese, calcium, sodium, chloride, bromide, and total suspended and dissolved solids). The resultant data is regularly placed in a useful and user-friendly manner on a website (www.MonWQ.net) using a Geographic Information System database. Besides the water quality data presented, the website also includes a description of water quality parameters that are being analyzed, basic information on the Monongahela River Watershed, a map of sampling locations, links to relevant websites, and a list of project participants.

The interactive database which has been developed allows users to select date ranges and parameters to create “on the fly” graphs that graphically display the data for the unique queries. Statistical analysis has been incorporated into an easy to visualize color-coded ranking of TDS loading at the various sampling locations in the watershed.

This project has the support of the West Virginia Advisory Committee for Water Research and stakeholders including the U.S. Geological Survey, U.S. Army Corps of Engineers, WV Department of Environmental Protection, WV Department of Natural Resources, WV Division of Health & Human Resources, West Virginia University Extension Service, industry, citizen organizations and others.
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Figure 25. Youghiogheny River (YO) TDS loadings (tpy) and concentrations (mg/L).

Figure 26. Specific conductance (EC) at the West Fork site, measured in the field, laboratory and as reported by USGS gage.

Figure 27. Specific conductance (EC) at Point Marion, PA on the Monongahela River, measured in the field, laboratory and as reported by USGS gage.

Figure 28. Specific conductance (EC) at Elizabeth, PA on the Monongahela River, measured in the field, laboratory and as reported by USGS gage.

Figure 29. Location of USGS gage and WRI sampling location on the Youghiogheny River.

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Figure 36. Flow rating curve for Indian Creek.

Figure 37. Flow rating curve for Whiteday Creek.

Figure 38. Flow rating curve for Whiteley Creek.

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EXECUTIVE SUMMARY

This project systematically collects water quality information for the Monongahela River watershed and makes it readily accessible to the public in a user-friendly manner via the internet.

Current water quality information can be useful to many users of the Monongahela River. Water conditions are also important to industries while upsets in the quality of the water is important information for regulatory agencies. Policy makers need accurate information to develop sound policies to protect our water resources. Nearly one million people get their drinking water from the Monongahela River. This program fulfills a vital need to gather and present current water quality information in a form that is accessible to the public. This information can be used to:

- Assess the quality of the fishery and other recreational opportunities
- Identify upsets in water quality
- Evaluate historic trends
- Provide a framework for other data sources
- Aid in the development of policy and regulations

INTRODUCTION

The need for chemical data on the Monongahela River became apparent following episodes of high TDS in the River during the summer and fall of 2008. After initial meetings and discussions with regulatory agencies and stakeholders, including the WV Department of Environmental Protection, U.S. Geological Survey, US Environmental Protection Agency Region 3, US Army Corps of Engineers, and others, this need became even clearer.

A great deal of stream data is, and has been, collected by watershed associations, agencies, municipalities, industry and research organizations but it is not readily available, organized or presented in a systematic way. At the beginning of year 1 of this project, an advisory committee was established consisting of WVWRI personnel as well as representatives from other various research interests. The Committee met several times and a questionnaire was developed to determine what water chemistry data was available and/or being collected on the Monongahela River and its tributaries. The questionnaire also asked what parameters needed to be measured. This initial outreach determined that much data was being collected, but it was not measured using compatible techniques or organized into parameters and locations easily included in a monitoring program. To create a database with useful, accurate and current information, it was decided that a standardized, systematic program was necessary.

PROJECT IMPLEMENTATION

A strategic monitoring program for the Monongahela River watershed was developed which was implemented in July, 2009. The program included water quality monitoring and sampling on a bi-weekly basis. Monitoring locations were determined partially based on the availability of stream flow data at 12 locations in the watershed. These locations included 4 sites on the Monongahela River and at 8 locations at the mouths of its major tributaries. During year one,
flow calculations for locations without regularly collected flow information were determined based on nearest USGS gage, or calculated from basin area.

The monitoring program collects field parameters including electrical conductivity, oxidation reduction potential, pH, and temperature. Grab samples are collected and analyzed in the laboratory at the REIC Laboratories Inc. for acidity, alkalinity, conductivity, sulfates, bromide, chloride, and dissolved: calcium, iron, magnesium, manganese, sodium, as well as total suspended solids.

Year two of the program added four additional monitoring locations at additional significant tributaries of the Monongahela River. Continuous monitors for flow were also installed where gage data were not available.

**PUBLIC OUTREACH**

An important part of this program is the dissemination of the results of the monitoring program to the public. The principle venue for sharing this information is the project website, www.MonWQ.net. This website uses a GIS database and map. The map makes it easy to view the project area and the “zoom-in” feature allows visitors to identify the monitoring locations as well as other details about the watershed. Map view options include highways, topographic features or aerial imagery.

Website visitors are able to view the resultant data from the monitoring program by entering a query by monitoring location. Graphs are then generated for each of the monitored parameters. Lab analyzed data for the various components of TDS are compiled and depicted in “stacked bar graphs.” These stacked bar graphs are constructed for each monitoring date and depict TDS loading for all monitored locations. The TDS loading graphs are organized on the website by month. There is also a color-coded map feature to display the TDS concentrations at the various monitoring locations. These are depicted by different color and size “dots” at the sample sites.

The project website also includes basic information about the Monongahela River and project details including participants, news items and links to related websites. Detailed descriptions of the measured parameters and a printable fact sheet about the project are included. A slide show on the home page shows images of the sampling locations.

**PROJECT IMPORTANCE**

Soon after the monitoring program was implemented, a fish kill in September 2009 on Dunkard Creek, a tributary of the Monongahela River monitored in this program, gained much media attention. The WV DEP and PA DEP determined that the fish kill was caused by a toxic bloom of golden algae, *P. parvum*, which flourishes in salty water. Not typically found in the freshwater streams of the Appalachians, it has not been determined how the algae were introduced into Dunkard Creek. Testing done by the WV and PA DEPs has since determined that the algae have also been introduced into other streams in the watershed and states. The water quality data collected by this study has been very helpful in determining sources and concentrations of the pollutants that allowed these exotic algae to flourish.
As coal mining continues in the Monongahela River watershed, and gas well drilling is on the upswing, the water quality of the River is a topic of much concern. Increases in the demand for water, including nearly one million people who get their drinking water from the Monongahela River have further intensified the debate. The fishery in the River has improved over the years and there is a considerable increase in the amount of sport fishing taking place there. Several large fishing tournaments are now taking place on the River increasing the economic impacts from this recreational use. Fishing access to the river has been made easier by a new boat launch and docking facility built on the Morgantown Pool by the WV Division of Natural Resources.

Increases in water usage, recreational usage, and industrial impacts to the river have caused considerable debate about the adequacy of existing water quality regulations. The data generated from this study has provided crucial information to inform many of these concerns. It has provided the accurate and current water quality information necessary to inform the public and to aid regulatory personnel and legislators in making sound policy decisions. For example, information provided by this watershed monitoring program was important in drafting the newly proposed water quality regulations by the WV Department of Environmental Protection (WVDEP). Competitors in fishing tournaments on the Mon River in both Pennsylvania and West Virginia use current information about the water quality to gain a competitive edge. These tournaments are important economic contributors and examples of the importance of a clean river for our state’s natural resource based tourism economy.

**PROJECT CONTINUANCE**

Year two of the project has included the addition of four monitoring locations on other significant tributaries including Indian Creek, Robinson Run, Flaggy Meadows Run and White Day Creek. Continuous data loggers have been installed at several locations to better calculate stream flow. The project website continues to be updated regularly and improvements in data depiction and usefulness have been incorporated. Because of the considerable interest in this project there has been additional emphasis on it among local residents, recreationists, industry and the media. Increasing visitation to the project website has been a result.
Experimental Methods

Baseline sampling of the Monongahela River and its tributaries began on July 29, 2009 and is currently ongoing. Samples are now being collected by WVWRI staff at 16 different locations every other week from four locations on the Monongahela River and twelve locations on major tributaries that enter the Monongahela River (Table 1, Figure 1).

Table 1. Sample location descriptions (sites with asterisks were added to the sampling plan during the summer of 2010).

<table>
<thead>
<tr>
<th>Site ID</th>
<th>Waterbody</th>
<th>lat</th>
<th>long</th>
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</thead>
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<td>Tygart Valley River</td>
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<tr>
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<tr>
<td>WD*</td>
<td>Whiteday Creek</td>
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</tr>
<tr>
<td>FM*</td>
<td>Flaggy Meadow Run</td>
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<td>M102</td>
<td>Monongahela R. mile 102</td>
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<td>-79.9685</td>
</tr>
<tr>
<td>DE</td>
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<td>39.6288</td>
<td>-79.9685</td>
</tr>
<tr>
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</tr>
<tr>
<td>M89</td>
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<tr>
<td>CH</td>
<td>Cheat River</td>
<td>39.7204</td>
<td>-79.8603</td>
</tr>
<tr>
<td>DU</td>
<td>Dunkard Creek</td>
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<td>Whiteley Creek</td>
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<td>YO</td>
<td>Youghiogheny River</td>
<td>40.2367</td>
<td>-79.8067</td>
</tr>
</tbody>
</table>
Figure 1. Topographic map of sample locations and sub-watersheds within the study area.
FIELD PARAMETERS

A suite of parameters to incorporate into the monitoring program was determined during early meetings with the project Advisory Committee. Parameters analyzed in the field include: electrical conductivity, pH, and temperature. Flow is determined for some of the sampling points using the nearest USGS gages. Transducers were installed at five sites and flow rating curves were developed and utilized to determine discharge. For those sites that are located on ungaged streams in West Virginia, flow is estimated based on Watershed Characterization Modeling System (WCMS).

Electrical Conductivity
Electrical conductivity is an indicator of dissolved metals. Some common metals that may be found in surface water include: iron, aluminum, calcium, magnesium, and others. High conductivity levels may be due to several different factors, including: untreated wastewater infiltration, mining, and agricultural runoff. High conductivity concentrations can be damaging to aquatic life because of increased salinity in the stream and possible smothering of the stream bottom (Kentucky Water Watch, 2010a). A notable example of increased conductivity causing water quality problems is the Dunkard Creek fish kill that occurred in September 2009 (Jernejcic and Wellman, 2009).

For the purposes of this study, the graphical range for conductivity is 0-10,000 µs/cm. Detection limits for conductivity are as low as 0 µs/cm, with an upper value of 9,999 µs/cm. Conductivity is measured in the lab using SM 2510 B (American Public Health Association et al., 1998) and in the field with an YSI model 556 multiprobe or a YSI Professional Series multiprobe.

Oxidation-Reduction Potential (ORP)
ORP is the potential of a chemical species to acquire (reduction) or lose (oxidation) electrons. An oxidizing substance, such as chloride, will have a positive ORP value, while a reducing agent, such as hydrogen sulfide, will have a negative ORP value. High or low ORP values could indicate the presence of large amounts of certain chemical species, such as chlorine or hydrogen sulfide, which may affect aquatic life (Andrews et al., 2004).

For the purposes of this study, the graphical range for conductivity is -50-250 millivolts. There are no upper or lower detection limits for ORP. ORP is measured in the field with an YSI multiprobe instrument.

pH
Values of pH in surface water outside acceptable ranges can indicate human impacts such as agricultural runoff, mining, or infiltration of untreated wastewater. Low pH is acidic and can cause corrosion of pipes, as well as increased dissolved metals concentrations in surface water. High pH is alkaline and can cause scale buildup in fixtures, bad taste, and reduce the effectiveness of chlorine disinfection, as well as increased metal concentrations in stream sediments (Kentucky Water Watch, 2010b).
For the purposes of this study, the graphical range for pH is 4-10 standard units. Detection limits for pH are between 0 and 14 standard units. pH is measured in the field using a portable YSI multiprobe instrument.

**Temperature**
Temperature has a large impact on the biological activity of aquatic organisms. All aquatic organisms have a preferred temperature range. If the water temperature gets too far above or below this range, then the biological community becomes stressed and may have difficulty maintaining a stable population (USEPA, 1986).

Temperature is also important because of its influence on water chemistry. The rate of chemical reactions generally increases at higher temperature, which in turn affects biological activity. Another important example of the effects of temperature on water chemistry is its impact on oxygen. Warm water holds less oxygen than cool water, so it may be saturated with oxygen but still not contain enough for survival of aquatic invertebrates or certain fish (USEPA, 1986).

For the purposes of this study, the graphical range for temperature is -30 to 100 degrees Centigrade. There are no upper or lower detection limits for water temperature. Water temperature was measured in the field with YSI multiprobe instrumentation.

**Laboratory Parameters**
Parameters analyzed in the laboratory include: aluminum (Al), acidity (acid), alkalinity (alk), bromide (Br), calcium (Ca), chloride (Cl), electrical conductivity, iron (Fe), magnesium (Mg), manganese (Mn), pH, sodium (Na), sulfate (SO4-2), and Total Dissolved Solids (TDS).

**Aluminum (Al)**
Aluminum is the third most common element on Earth. In most forms, aluminum is not very soluble in water. However, low pH waters, such as those associated with mine drainage, may contain large amounts of dissolved aluminum due to dissolution of aluminum-containing minerals within the local geology. When aluminum precipitates within the water column, it is in the form of an aluminum hydroxide. Aluminum hydroxide may be very harmful to aquatic life due to smothering of the stream bed of the water body. Aluminum may also clog the gills of aquatic organisms if the concentration is high enough (Kentucky Water Watch, 2010c).

For the purposes of this study, the graphical range for both dissolved and total aluminum is 0-20 mg/L. The lower detection limit for aluminum is 0.021 mg/L and there is no upper detection limit. Both total and dissolved aluminum is measured in the lab using EPA method 200.7. (American Public Health Association et al., 1998)

**Acidity**
Low pH values indicate that surface water is acidic. High acidity values in surface water may come from several sources including mining and acid precipitation. Acid precipitation may cause the dissolution of aluminum in soils with poor buffering capacity, which in turn causes acidity to increase in surface water when the soil enters the stream as runoff. As acidity
increases, dissolved metal concentrations increase, which in turn may cause problems for aquatic life in streams and rivers (Kentucky Water Watch, 2010b).

For the purposes of this study, the graphical range for acidity is 0-1,000 mg/L as CaCO3. Detection limits for acidity are as low as 2 mg/L, with no upper value. Acidity was measured in the lab using SM 2310 B (American Public Health Association et al., 1998).

**Alkalinity**
High pH values indicate that surface water is alkaline in nature and that the water has a greater neutralization capacity. Alkalinity is made up of the constituents of the water that elevate pH above 4.5 (USEPA, 1986). Typically, a small to moderate amount of alkalinity in water is also important to have for the well-being of the organisms that live in the water body. However, too much alkalinity can be toxic to wildlife. High alkalinity can also have other impacts including scale buildup in fixtures, bad taste in drinking water, and a reduction in the effectiveness of chlorine disinfection. Alkaline water may also impact irrigation if the alkalinity of the water is greater than the alkalinity of the surrounding soil.

For the purposes of this study, the graphical range for alkalinity is 0-1,000 mg/L as CaCO3. Detection limits for alkalinity are as low as 2 mg/L, with no upper value. Alkalinity was measured in the lab using SM 2320 B (American Public Health Association et al., 1998).

**Bromide (Br)**
Bromide is an ion of bromine, which is a chemical element found in the halogen group. At room temperature, it is a reddish-brown liquid that is slightly soluble in water. Dissolved bromide comes from several sources, including surrounding geology, fluids used in gas well drilling, seawater infiltration, and industrial waste (Sollars et al., 1982). Elevated levels of dissolved bromide may interfere with water treatment, as well as pose a possible increased cancer risk to humans and wildlife.

For the purposes of this study, the graphical range for dissolved bromide is 0-5 mg/L. The lower detection limit for bromide is 0.13 mg/L and there is no upper detection limit. Bromide is measured in the lab using EPA method 300.0 (American Public Health Association et al., 1998).

**Calcium (Ca)**
Calcium is an element that is found naturally in water due to its abundance in the Earth's crust. Large bodies of surface water, such as rivers, typically contain 1-2 mg/L of calcium. High levels of calcium in surface water mean that the water is “hard,” which helps aquatic life by buffering the pH of the water and protecting those organisms with gills from direct metal uptake. However, if calcium and hardness are too high, hardening of pipes and staining may occur (Kentucky Water Watch, 2010d).

For the purposes of this study, the graphical range for dissolved calcium is 0-20 mg/L. The lower detection limit for calcium is 0.007 mg/L and there is no upper detection limit. Dissolved calcium is measured in the lab using EPA method 200.7 (American Public Health Association et al., 1998).
Chloride (Cl)
Chloride is an ion of chlorine. It occurs naturally as a green gas. It appears in many different compounds. The most important chloride compound for many forms of life is NaCl, or salt. Chloride (as the Cl- ion) is the most abundant dissolved ion in salt water, and is also found in freshwater in much smaller concentrations. Freshwater chloride is usually derived from chlorine mineral dissolution. Other sources of chloride in freshwater may include wastewater runoff and breakdown of chlorinated compounds. High amounts of dissolved chloride can be very harmful to wildlife due to the oxidative properties of chloride (USEPA, 1986). When chloride concentrations reach a certain level within the organism, it combines with the water and oxygen to create hydrochloric acid, which destroys animal tissues.

For the purposes of this study, the graphical range for dissolved chloride is 0-20 mg/L. The lower detection limit for chloride is 0.10 mg/L and there is no upper detection limit. Dissolved chloride is measured in the lab using EPA method 300.0 (American Public Health Association et al., 1998).

Iron (Fe)
Iron is the most abundant metal in the Earth's core. It is found in a large range of compounds in either a +2 or +3 oxidation state. It is also very important to humans and other organisms, as it is partially responsible for transporting oxygen through the bloodstream (USEPA, 1986). Iron is easily dissolved in water and can be found naturally occurring in water bodies. High levels of precipitated iron oxides may cause smothering of stream bottoms and plugging of organism's gills.

For the purposes of this study, the graphical range for both dissolved and total iron is 0-20 mg/L. The lower detection limit for iron is 0.013 mg/L and there is no upper detection limit. Both total and dissolved iron is measured in the lab using EPA method 200.7 (American Public Health Association et al., 1998).

Magnesium (Mg)
Magnesium is found in large concentrations in both the Earth's crust and the human body. It is highly soluble in water, and is the third most abundant element in sea water. Concentrations of magnesium in freshwater vary according to surrounding geology. Along with calcium, magnesium concentrations are used to determine water hardness. High concentrations of magnesium cause similar problems to high concentrations of calcium, including staining and hardening of pipes and fixtures (Wilkes University Center for Environmental Quality, Environmental Engineering and Earth Sciences, 2010a).

For the purposes of this study, the graphical range for both dissolved and total magnesium is 0-20 mg/L. The lower detection limit for magnesium is 0.003 mg/L and there is no upper detection limit. Both total and dissolved magnesium is measured in the lab using EPA method 200.7 (American Public Health Association et al., 1998).

Manganese (Mn)
Manganese is commonly found in soil in its oxide form (pyrolusite) (USEPA, 1986). It is used in the steel making process, and is also an essential nutrient for most living organisms. High
concentrations of manganese in humans can cause many different health problems, including Parkinson's disease and bronchitis. Manganese is also soluble in water, with large concentrations causing health problems in aquatic life. Manganese can also bioaccumulate through the food chain, causing top predators to have unhealthy levels of manganese in their bodies.

For the purposes of this study, the graphical range for both dissolved and total manganese is 0-20 mg/L. The lower detection limit for manganese is 0.017 mg/L and there is no upper detection limit. Both total and dissolved manganese is measured in the lab using EPA method 200.7 (American Public Health Association et al., 1998).

**Sodium (Na)**
Sodium is a very common element found in rocks and soils. It is needed for all life forms to aid in the transmission of nerve impulses. It is also highly soluble in water and will react violently with water to form lye and hydrogen gas. Sodium is found naturally in freshwater bodies. Concentrations of sodium vary greatly, and are dependent on the surrounding soil and geology (Kentucky Water Watch, 2010e). Too much sodium can raise the pH level of a water body to the point where it is too high for certain species of aquatic life to survive.

For the purposes of this study, the graphical range for both dissolved and total sodium is 0-5 mg/L. The lower detection limit for sodium is 0.012 mg/L and there is no upper detection limit. Both total and dissolved sodium is measured in the lab using EPA method 200.7 (American Public Health Association et al., 1998).

**Sulfate (SO\textsubscript{4} -2)**
Sulfate is a salt consisting of one sulfur atom and four oxygen atoms with an oxidation number of -2. Sulfate is naturally occurring in almost all water bodies. It usually comes from oxidation of sulfite ores, dissolution of sulfate minerals, shale, and industrial wastes. High concentrations of dissolved sulfate may give water an unpleasant taste and may be corrosive to plumbing. It may also have health effects including nausea and diarrhea (Kentucky Water Watch, 2010f).

For the purposes of this study, the graphical range for both dissolved and total sulfate is 0-200 mg/L. The lower detection limit for sulfate is 0.15 mg/L, and there is no upper detection limit. Both total and dissolved sulfate is measured in the lab using EPA method 300.0 (American Public Health Association et al., 1998).

**Sulfur (S)**
Sulfur is a non-metal that is a yellow solid at room temperature. Sulfur is found in many different minerals and is extracted by melting the surrounding rock and collecting the molten sulfur. It may also be produced from hydrogen sulfide. It is a required nutrient for life on Earth and it is an essential building block of cells. It is insoluble in water. However, high concentrations of sulfur-containing compounds, such as sulfate, may be found in water due to human activities, such as mining. High concentrations of sulfur may cause corrosion of pipes and fixtures, as well as reducing the effectiveness of water used for laundry (Wilkes University Center for Environmental Quality, Environmental Engineering and Earth Sciences, 2010b).
For the purposes of this study, the graphical range for both dissolved and total sulfur is 0-20 mg/L. The lower detection limit for sulfur is 0.05 mg/L, and there is no upper detection limit. Both total and dissolved sulfur is measured in the lab using EPA method 200.7 (American Public Health Association et al., 1998).

**Total Suspended Solids (TSS)**

TSS, or turbidity, is the measure of the suspended particles in the water column. High levels of turbidity can come from many sources, such as urban runoff, soil erosion, wastewater discharges, agriculture, and removal of riparian zones. Increased levels of turbidity may cause water to darken, which in turn leaves less light for aquatic plants to perform photosynthesis. This in turn decreases the amount of dissolved oxygen being added to the water, which can affect aquatic organisms that are higher on the food chain (USEPA, 1986). Extreme levels of TSS can also clog fish gills.

For the purposes of this study, the graphical range for TSS is 0-250 mg/L. The lower detection limit for TSS is 2.4 mg/L and there is no upper detection limit. TSS was measured in the lab using Standard Method SM2540D (American Public Health Association et al., 1998).

**Total Dissolved Solids (TDS)**

TDS is measured in the lab as part of this research using gravimetric methods. The gravimetric method is considered more accurate, particularly for solutions where most of the TDS is composed of inorganic salts (American Public Health Association et al., 1998). The lower detection limit for TDS is 3.36 mg/L and there is no upper detection limit. Standard Method SM2540 C was used by the laboratory to determine TDS concentrations (American Public Health Association et al., 1998).

**Sampling Methodology**

Two water samples are collected at each sample point: (I) a 1 L unfiltered sample was taken for general water chemistry (pH, conductivity, TDS, TSS, total acidity and alkalinity by titration, bromide, chloride, and sulfate), and (II) a 125 mL sample filtered with a 0.45 micrometer Nalgene syringe filter was acidified to pH of <2 with 0.5 ml concentrated nitric acid and used to determine all metal concentrations.

**Analysis**

Water quality samples have been collected from each of the sixteen sites bi-weekly throughout the reporting period. Samples were picked up by REIC Laboratories every Thursday and were kept in a refrigerator until pickup. All samples were analyzed according to EPA procedures and methods (Table 2).

Table 2. Mean water quality parameters for the March 2010 to February 2011 reporting period.
RESULTS AND DISCUSSION

WATER QUALITY
Healthy, clean, cold tributaries are vital not only in headwaters, but for the overall health and substance of entire watersheds. While this study focuses on the water quality of the Monongahela River, it also provides valuable monitoring of smaller tributaries that ultimately contribute to the health of the Monongahela River Watershed. A sub-watershed within the Upper Monongahela River Basin that has received much attention since the fall of 2009 is Dunkard Creek.

DUNKARD CREEK
Shortly after this monitoring program was implemented in 2009, a devastating fish kill occurred on Dunkard Creek, a major tributary of the Monongahela River flowing along the Pennsylvania/West Virginia border. Sampling for this study had occurred the week prior and week following the initial fish kill. In looking at the Total Dissolved loadings in tons per year (tpy), which is calculated based off of flow discharge (cubic feet per second) and concentration of TDS (mg/L), it is evident that a low flow situation and an increase in high concentrations of TDS existed which helped to create the extremely poor water quality conditions that ultimately led to the fish kill (Figure 2). Between the 25 August 09 and 8 September 10 sampling dates, the TDS concentrations jumped from 3813.21 (mg/L) to 8103.22 (mg/L) while discharge remained around 20 cubic feet per second.
TDS Loadings

TDS loadings are quite useful in realizing the contribution of tributaries to the mainstem of the Monongahela (Mon) River in tons per year. During our study period, Dunkard Creek (DE) which has a drainage area of 229 square miles, was the highest contributor of TDS among the watersheds in our study with a basin area between 200 - 1500 square miles. In watersheds less than 200 square miles, Flaggy Meadows had the highest TDS loading (Table 3, Figure 3).
Table 3. Mean TDS loadings during the March 2010 - February 2011 at project sampling locations.

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<tr>
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<th>Q cfs</th>
<th>Na</th>
<th>Ca</th>
<th>Mg</th>
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Figure 3. TDS loading (tpy) averages at sampling locations between March 2010 - February 2011.
TDS loadings were determined for each sampling period and provide a snapshot of water quality conditions during that day. Some sampling periods noted quite high TDS loadings throughout the Mon River basin, while other sampling periods were relatively low in TDS loadings. High rainfall events and the resultant increase in stream flows prior to the December 3rd, February 4th, and March 3rd sampling events were largely responsible for the extreme high TDS loadings (Figures 4-10).
Figure 4. TDS loadings (tpy) at sampling locations during the March and early April sampling events.
Figure 5. TDS loadings (tpy) at sampling locations during the late April and early May sampling events.
Figure 6. TDS loadings (tpy) at sampling locations during the late May and June sampling events.
Figure 7. TDS loadings (tpy) at sampling locations during the July and August sampling events.
Figure 8. TDS loadings (tpy) at sampling locations during the September and early October, 2010 sampling events.
Figure 9. TDS loadings (tpy) at sampling locations during the October through December, 2010 sampling events.
Figure 10. TDS loadings (tpy) at sampling locations during the January and February, 2011 sampling events.
Looking at the TDS loadings (tpy) and TDS concentrations (mg/L) of individual streams provides an in-depth look at the conditions on each tributary over time. The concentrations (mg/L) of TDS and loadings of TDS (tpy) vary dependent on flow conditions (as loading is calculated by Q x mg/L). In the larger tributaries, such as West Fork River, Tygart Valley, the concentration of TDS (mg/L) remains relatively constant, even through periods of low flow conditions (Figures 11 and 12). Subsequently, as discharges increase, the TDS concentrations (mg/L) correlate with loadings (tpy).

**Figure 11.** West Fork River (WF) TDS loadings (tpy) and concentrations (mg/L).

**Figure 12.** Tygart Valley River (TV) TDS loadings (tpy) and concentrations (mg/L).
Tributaries with lower flows, such as Indian Creek showed a high correlation between TDS concentration (mg/L) and loading (tpy) (Figure 13). Whiteday Creek, is our most un-impacted waterway in the study and TDS concentrations were below 250 mg/L and loadings under 4,000 tpy throughout the study year (Figure 14).

Figure 13. Indian Creek (IN) TDS loadings (tpy) and concentrations (mg/L).

Figure 14. Whiteday Creek (WD) TDS loadings (tpy) and concentrations (mg/L).
The sample site at Flaggy Meadows Run is downstream of an Acid Mine Drainage Treatment system, and impacts from AMD can be noted in the high TDS (mg/L) values (Figure 15) and chemical signatures (page 52).

![Figure 15. Flaggy Meadows Run (FM) TDS loadings (tpy) and concentrations (mg/L).](image)

The sample site on the Monongahela at Morgantown shows the dilution effect of a larger waterbody, as more discharge is input from tributaries during higher flow periods, higher loadings are transported downstream. During low flow situations, TDS concentrations remain somewhat steady and remain below 464 mg/L (Figure 16).

![Figure 16. Monongahela River at Morgantown (M102) loadings (tpy) and concentrations (mg/L).](image)
Concentrations of TDS (mg/L) ranged from 73 mg/L to 689 mg/L and loadings from 1,643 tpy to 31,896 tpy (Figure 17).

Figure 17. Deckers Creek (DE) TDS loading (tpy) and concentrations (mg/L).

Robinson Run is another tributary in the study that is impacted by AMD (page 52), the TDS concentrations (mg/L) ranged from 740 mg/L to 2,970 mg/L and loadings (tpy) correlated with concentrations, ranging from 6,229 tpy to 25,102 tpy (Figure 18).

Figure 18. Robinson Run (RO) TDS loading (tpy) and concentrations (mg/L).
The Monongahela at Point Marion showed similar trends as the upstream site in Morgantown with slightly lower loadings, with the maximum loading at 2,009,341 tpy. Concentrations ranged from 101 mg/L to 429 mg/L (Figure 19).

![Figure 19. Monongahela River at Point Marion (M89) TDS loadings (tpy) and concentrations (mg/L).](image1)

The Cheat River TDS concentrations remained somewhat constant throughout the study year, ranging from 42 to 98 mg/L and loadings ranged from 2,118 to 110,424 tpy (Figure 20).

![Figure 20. Cheat River (CH) TDS loadings (tpy) and concentrations (mg/L).](image2)
Concentrations of TDS on Dunkard Creek ranged from 371 to 4,657 mg/L and loadings ranged from 42,918 to 356,298 tpy (Figure 21).

The Monongahela River site in Masontown, PA showed concentrations of TDS ranging from 78 to 360 mg/L and loadings ranged from 177,246 to 3,512,026 tpy (Figure 22).

Figure 21. Dunkard Creek (DU) TDS loadings (tpy) and concentrations (mg/L).

Figure 22. Monongahela River at Masontown, PA (M82) TDS loadings (tpy) and concentrations (mg/L).
Tenmile Creek TDS concentrations ranged from 209 to 1,728 mg/L and loading ranged from 2,697 to 103,200 tpy (Figure 23.)

Monongahela River at Elizabeth TDS concentrations ranged from 115 to 491 mg/L and loadings ranged from 291,788 to 6,673,163 tpy (Figure 24.)
The Youghiogheny River site TDS ranged from 113 to 491 mg/L and loadings from 198,991 to 1,863,586 tpy (Figure 25).

Figure 25. Youghiogheny River (YO) TDS loadings (tpy) and concentrations (mg/L).

TDS versus Electrical Conductivity

As described in the Sample Parameter section of this report, the term TDS describes all solids (usually mineral salts) that are dissolved in water. The TDS and the electrical (interchangeably referred to as “specific”) conductivity (EC) are in a close connection. The more salts dissolved in the water, the higher is the value of the electric conductivity. EC is relatively easy to determine in the field using instruments such as a YSI multi-probe meter. From this field measurement, TDS can be determined by a simply multiplying that EC (ms/cm) by 0.7 to result in an estimate of TDS (mg/L). For this study, we are closely following this relationship to validate our measurements. Not only are we recording EC in the field, but also in the REIC laboratory and many USGS Gages are equipped to report EC. This provides us with the reassurance that our field equipment is in fact, working properly. Furthermore, after running our calculations in converting EC to TDS, the REIC laboratory runs an analytic test to measure TDS (following EPA procedures). In comparing the calculated TDS versus the actual TDS, we are able to report our results with the utmost confidence.

Specific Conductance (EC) comparison of Field, Laboratory, and USGS Gage

The comparison of EC values among the field, lab, and gage measurements were fairly similar throughout the study. Differences among the field versus lab and/or gage readings indicated when instrumentation was not working properly. Occasional high readings for the field measurement are likely due to interferences at the sampling location. (Figures 26-28).
Figure 26. Specific conductance (EC) at the West Fork site, measured in the field, laboratory and as reported by USGS gage.

Figure 27. Specific conductance (EC) at Point Marion, PA on the Monongahela River, measured in the field, laboratory and as reported by USGS gage.
Figure 28. Specific conductance (EC) at Elizabeth, PA on the Monongahela River, measured in the field, laboratory and as reported by USGS gage.

Youghiogheny River Gage

The gage on the Youghiogheny River in Suttersville, PA is located on the opposite side of the river from the water collection site for this study. A disparity in conductivity measurements has been observed at this location (Figure 29). A tributary influenced by acid mine drainage, Sewickley Run, is the suspected cause for the variation among gage versus field and laboratory EC measurements (Figure 30). (Note that discoloration of the Monongahela River in the Figure is due to spring versus summer aerial imagery.)
Because there are no flow gages located on these streams, pressure transducers were installed on Robinson Run, Flaggy Meadows Run, Indian Creek, Whiteday Creek, and Whiteley Creek to obtain water pressure data which can then be used to calculate stream flow. Each transducer was installed in a PVC pipe to create a stilling well. The stilling well allows the pressure transducers to be uninfluenced by water turbulence and to properly measure water height. The water pressure values are then mathematically converted to water stage readings (Figures 31-33).
Figure 31. Pressure transducer at Indian Creek site.

Figure 32. Pressure transducer at Robinson Run site.
Multiple discharge values were also collected at each of these streams using a Marsh-McBirney Flo-Mate flow meter. Total discharge was determined by running a tape measure across the width of the stream and measuring water depth at multiple points along the transect. At each transect point, the flow meter also provided a velocity measurement. Velocity was multiplied by the water depth and the distance from one point to the next on the transect (width) to determine the discharge at each transect point. Finally, these data were added together to determine the total discharge in the stream. The discharge values were graphed against the water stages that were established by the pressure transducers to create a rating curve. Figures 34-36 show the flow rating curves for each of the five ungauged streams. Discharge values will continue to be collected periodically with the Marsh-McBirney flow meter in order to refine the accuracy of the rating curves.
Figure 35. Flow rating curve for Flaggy Meadow Run

Figure 36. Flow rating curve for Indian Creek.
The Watershed Characterization Modeling System (WCMS) is an extension tool developed for ArcGIS. The WCMS extension tool was utilized to determine the 30 year average flows at all West Virginia sampling sites (WCMS is limited to the state of WV). Flow rating graphs were created for the sites. Discharge on sites that did not have gages, were determined by reviewing the graph for sites with known discharge and relating those current conditions to ungaged sites. For example, when the known discharge of the West Fork is 2000 cfs, the assumed discharge on the Monongahela River at Morgantown (M102) is 7000 cfs (Figure 39).
Figure 39. WCMS 30 year average flow ratings for sites with discharges above 1000 cfs.
Figure 40. WCMS 30 year average flow ratings for sites with discharges below 1000cfs.

**Tributary Sites**

Good water quality of headwater streams and major tributaries is vital to maintain a healthy watershed ecosystems and fisheries. Equally as important is the ability of these tributaries to supply the Mononaghela with quality drinking water.

In addition to tributary sampling on the West Fork River, Tygart Valley River, Deckers Creek, Cheat River, Whiteley Creek, Dunkard Creek, Tenmile Creek, and the Youghiogheny River, sample locations were selected and collection initiated in May 2010 for Robinson Run, Flaggy Meadows Run, and Indian Creek. Whiteday Creek was added to the sampling regime in July 2010. Tributary loading data (tpy) were calculated to view the sampling regime prior and post addition of the new sites. Data reveals that the Youghiogheny River is the highest contributor of flow as well as TDS (Figures 41 to 48).

Figure 41. Q (cfs) for tributary sites pre (A) and post (B) addition of Robinson Run, Flaggy Meadows Run, Indian Creek, and Whiteday Creek.
Figure 42. Calcium (tpy) for tributary sites pre (A) and post (B) addition of Robinson Run, Flaggy Meadows Run, Indian Creek, and Whiteday Creek.

Figure 43. Alkalinity (tpy) for tributary sites pre (A) and post (B) addition of Robinson Run, Flaggy Meadows Run, Indian Creek, and Whiteday Creek.
Figure 44. Chloride (tpy) for tributary sites pre (A) and post (B) addition of Robinson Run, Flaggy Meadows Run, Indian Creek, and White day Creek.

Figure 45. Magnesium (tpy) for tributary sites pre (A) and post (B) addition of Robinson Run, Flaggy Meadows Run, Indian Creek, and White Day Creek.

Figure 46. Sodium (tpy) for tributary sites pre (A) and post (B) addition of Robinson Run, Flaggy Meadows Run, Indian Creek, and Whiteday Creek.
Figure 47. Sulfate (tpy) for tributary sites pre (A) and post (B) addition of Robinson Run, Flaggy Meadows Run, Indian Creek, and Whiteday Creek.

Figure 48. Total Dissolved Solids (tpy) for tributary sites pre (A) and post (B) addition of Robinson Run, Flaggy Meadows Run, Indian Creek, and Whiteday Creek.

LOADINGS AT ELIZABETH PA

The final downstream site in our study is at river mile 23 on the Monongahela, our site #M23, near Elizabeth PA. For the validity of the study, we determined loadings (tpy) on the Monongahela and the Youghiogheny and combined other tributaries for each of our parameters. The output pie charts show they we capturing the majority of high loading tributary contributions to the Monongahela (Figures 49-56). The “???” are for unaccountable loadings that are contributed by tributaries not included in our study.
Figure 49. Alkalinity average loading (tpy) at sample locations.

Figure 50. Calcium average loading (tpy) at sample locations.
Figure 51. Chloride average loading (tpy) at sample locations.

- YO: 89,237 tpy
- M23: 79,180 tpy
- ?? M82 to M23: 26,522 tpy
- M82: 52,658 tpy
- ?? US M82: 25,267 tpy
- tribs US M82: 27,391 tpy

Figure 52. Magnesium average loading (tpy) at sample locations.

- YO: 15,988 tpy
- M23: 43,543 tpy
- ?? M82 to M23: 11,272 tpy
- M82: 32,271 tpy
- ?? US M82: 15,384 tpy
- tribs US M82: 16,887 tpy
Figure 53. Sodium average loading (tpy) at sample locations.

Figure 54. Sulfate average loading (tpy) at sample locations.

Figure 55. Q (cfs) average at sample locations.
Figure 56. Total Dissolved Solids average loading (tpy) on mainstem Monongahela and Youghiogheny River Sites.

**CHEMICAL SIGNATURES**

Calculating the mmol/L for each site revealed unique chemical signatures for the tributaries and mainstem Monongahela. Tributaries that are influenced by acid mine drainage, such as Flaggy Meadows Run, has a high ratio of sodium and sulfates. Whereas waters influenced by brine inputs such as the Youghiogheny River have a chemical signature of sodium chloride (Figure 57).
A shift in the sodium chloride ratio is evident in the Youghiogheny River (Figure 59).

Figure 57. Chemical signatures (mmol/L) of tributary sites.

Figure 58. Chemical signatures (mmol/L) of Tygart Valley, West Fork, and Mononaghela Rivers.

Figure 59. Seasonal shift in TDS constituents in the Youghiogheny River.
**CONCLUSIONS**

Much progress has been made during the reporting period to reach the goals of this project. Stakeholders were brought together and important decisions were made to craft a water quality monitoring program for the Monongahela River. Additional sampling sites were added, flow data collection refined for ungaged tributaries by installing pressure transducers and utilizing WCMS data to estimate realistic discharges.

Data processing revealed clear chemical signatures of typical mine influenced water versus brine waters (Figure 57). TDS concentrations in the mainstem of the Monongahela remain below 500 mg/L during the study period (Figures 16, 22, and 24). The majority of tributary contributions upstream of the Monongahela River at Elizabeth, PA are captured during this study, with only 208,579 tpy of TDS and 203 cfs of discharge unaccounted for (Figures 55 and 56). The Youghiogheny River is a major contributor of flow to the Monongahela and has shown a shift in sodium chloride ratios during higher flow periods (Figure 59).

Outreach efforts were undertaken including the establishment of a very useful and user friendly website with a GIS database and map to display the data. A project fact sheet was developed and refined, and numerous presentations were made to diverse audiences to share the data generated by this program and to raise awareness of the project and the public’s access to the results.

Because flow data is necessary to determine loading, we have had to develop and refine instrumentation and methodology to determine flow rates at our various sampling locations. Year two of the project has also seen the addition of four more sampling locations. Monitoring of these additional tributaries, some with industrial activities, have been added to the program. Because of the interest level in this project now, and the completely operational nature of the project website, we have been working closely with the media, local watershed organizations, industries and regulatory agencies to help raise awareness of the program and the public’s ability to access the information via the internet.
References


**Publications**

We have not yet published any formal articles, but have received quite a bit of media attention. Attached are news articles in reference to our project (Attachments 2-3).

**Information Transfer Program**

Raising the awareness of the general public to Monongahela River water quality issues and making the project results readily accessible to the public are principal components of this project. A project website, www.MonWQ.net, was created to disseminate as much pertinent information generated by this project in the timeliest fashion possible. Presentations of the data generated have been presented at numerous public forums. A project fact sheet was produced and disseminated at various meetings and also available in a printable format on the project website (Attachment 1). Project findings were presented at the 2010 state water conference, an information transfer project funded through the USGS 104b program.

**Project Website**

**Home Page**

Because the internet is an extremely effective way to disseminate the project results to the most people in the timeliest fashion, a website has been developed as the primary tool for information transfer. A domain name, www.MonWQ.net, was selected. Short and descriptive, it was decided upon for its simplicity and is easy to remember. The site’s home page briefly describes the Monongahela River and the project (Figure 60). It includes hot button links to the other pages on the site including a page detailing the study, a project map, graphically depicted resultant data, measured parameter descriptions, project participants, printable fact sheet, links and contact information. A rolling slide show of pictures representing the sampling locations is also a component of the website’s home page. Usage has steadily increased since the site went online (Figure 66).
Figure 60. Project website home page.
Utilizing the ArcGIS program, this interactive and user-friendly map serves as the foundation to share the sample locations with website visitors (Figure 61). A “zoom” feature allows site visitors to see the sampling locations as well as anyplace in the watershed at a detailed level. Maps can be displayed showing streets and highways, topographic features, or high resolution aerial imagery (Figure 62). Watershed boundaries for the Monongahela River and the monitored tributaries are outlined. Monitoring site data is graphically displayed on the map by sampling date. A color coded “dot” display indicated levels of TDS by color and size of the dot located at the monitoring site.

Figure 61. Website screen image of interactive ArcGIS map.
Figure 62. Project website map provides users with street view, imagery, or topographic background images.

**DATA PAGE**

The webpage depicting the project data allows the site visitor to query the data by monitoring location. Graphs are then generated for each monitored parameter (Figure 63). Lab analyzed data for the various components of TDS are compiled and depicted in “stacked bar graphs.” These stacked bar graphs are constructed for each monitoring date and depict TDS loading for all monitored locations. The TDS loading graphs are organized by month (Figure 64).
Figure 63. Screen image of website data graphs page.
Figure 64. Screen image of TDS loading stacked bar graphs page on MonWQ website.

**Website Traffic**

The website has received more than 4,000 unique visitors and approximately 137,000 visits between March 2010 and March 2011 (Figure 65).
Figure 65. Monthly user statistics from the project website.

PRESENTATIONS
Because the data generated by this project is extremely pertinent to the public dialog currently being undertaken regarding the water quality of the Monongahela River, its presentation has been of interest. The Upper Monongahela River Association has been holding a series of monthly “Monongahela River Watersheds Compact” meetings where the project and resultant data updates are regularly presented to citizens and local Watershed Associations who meet to discuss ongoing projects and activities in the Watershed. The results of this project were presented by Dr. Paul Ziemkiewicz, Principal Investigator and Director of the WV Water Research Institute, at the 5th Annual Mon River Summit April 19, 2010, held at the Waterfront Place Hotel. This event was attended by approximately 200 people interested in the Monongahela River. Dr. Ziemkiewicz also gave presentations about the project at the 2010 WV Water Conference, Acid Mine Drainage Taskforce Symposium, the Technical Committee of the WV Coal Association, the Water Resources Section of the WV Department of Environmental Protection as well as presentations to Committees of the West Virginia State Legislature and to various committees and delegations in the US Congress.
Monongahela River Water Quality Study

The West Virginia Water Research Institute is undertaking a comprehensive water quality monitoring and reporting project for the Monongahela River. Bi-weekly samples are being collected and lab-analyzed with the resultant water quality data organized and presented via a website utilizing a Geographic Information System map and database.

Water Quality Study
The West Virginia Water Research Institute began monitoring the water quality in the Monongahela River Basin in July of 2009. Initially, 8 tributary and 4 mainstem stations were sampled bi-weekly. Three additional tributary stations were added to the sampling regime on March 1, 2010.

As a means of displaying the water quality data to the public, a website was developed to provide easy to understand visualizations of the water quality in the Mon River basin. Geographic Information System (GIS) mapping also provides users of the site with the ability to see the Mon River watershed and specific sampling locations.

Water quality analysis consisting of 19 different field and lab determined parameters are available on the website, along with easy to understand descriptions of each measured parameter.

Many users of the Monongahela River such as recreationists, anglers, industry, policy makers and regulators will benefit from having accurate and current information about water quality conditions.

For more information, or to view the map and sampling results, visit: www.MonWQ.net

The Monongahela River Water Quality Study is being funded by the WV Water Research Institute and the U.S. Geological Survey.

The West Virginia Water Research Institute is a program of the National Research Center for Coal & Energy at West Virginia University.

Monongahela River
Known locally as “The Mon,” the Monongahela River originates in north-central West Virginia and flows through south-western Pennsylvania to Pittsburgh where it meets the Allegheny River to form the Ohio River. It is 128 miles long and has a drainage basin of 7,340 square miles. The Native American word “Monongahela,” means “falling banks,” in reference to the geologic instability of the river’s banks.

Formed by the confluence of the West Fork River and the Tygart Valley River at Fairmont, WV, the Mon is navigable for its entire length. A series of locks and dams maintain a minimum depth of 9 feet to accommodate barge and tow boat traffic. In Pennsylvania the Mon is met by two major tributaries: the Cheat River which joins in Pt. Marion, and the Youghiogheny River which joins in McKeesport.

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Dedicated to the preservation and restoration of the natural environment through research and outreach with industry, government agencies, academia, and the public.
Monongahela River Water Quality Study
Monongahela River Water Quality Study

Sampling Parameters and Descriptions

To determine the baseline quality of a water body, water sampling must be performed. The sampled parameters vary depending on the goals of the project team. In the case of the Monongahela River Water Quality Study, Total Dissolved Solids and its constituents were the parameters of interest. Because of this, the following parameters are sampled for this study:

pH
Values of pH in surface water outside acceptable ranges can indicate human impacts such as agricultural runoff, mining, or infiltration of untreated wastewater. Low pH is acidic and can cause corrosion of pipes, as well as increased dissolved metals concentrations in surface water. High pH is alkaline and can cause scale buildup in fixtures, bad taste, and reduce the effectiveness of chlorine disinfection, as well as increased metal concentrations in stream sediments.

Acidity
Low pH values indicate that surface water is acidic. High acidity values in surface water may come from several sources, such as mining and acid precipitation. Acid precipitation may cause the dissolution of aluminum in soils with poor buffering capacity, which in turn causes acidity to increase in surface water when the soil enters the stream as runoff. As acidity increases, dissolved metal concentrations increase, which in turn may cause problems for aquatic life in streams and rivers.

Alkalinity
High pH values indicate that surface water is alkaline in nature and that the water has a greater neutralization capacity. Typically, a small to moderate amount of alkalinity in water is also important to have for the well-being of the organisms that live in the water body. However, too much alkalinity can be toxic to wildlife. High alkalinity can also cause impacts to humans, including scale buildup in fixtures, bad taste, and reduce the effectiveness of chlorine disinfection. Alkaline water may also impact irrigation if the alkalinity of the water is greater than the alkalinity of the surrounding soil.

Electrical Conductivity
Electrical conductivity is an indicator of dissolved metals. Some common metals that may be found in surface water include: iron, aluminum, calcium, magnesium, and others. High conductivity levels may be due to several different factors, including: untreated wastewater infiltration, mining, and agricultural runoff. High conductivity concentrations can be damaging to aquatic life because of increased salinity in the stream and possible smothering of the stream bottom.

Oxidation-Reduction Potential (ORP)
ORP is the potential of a chemical species to acquire (reduction) or lose (oxidation) electrons. An oxidizing substance, such as chlorine, will have a positive ORP value, while a reducing agent, such as hydrogen sulfide, will have a negative ORP value. High or low ORP values could indicate the presence of large amounts of certain chemical species, such as chlorine or hydrogen sulfide, which may affect aquatic life.

Temperature
Temperature has a large impact on the biological activity of aquatic organisms. All aquatic organisms have a preferred temperature range. If the water temperature gets too far above or below this range, then the biological community becomes stressed and may have difficulty maintaining a stable population.

Temperature is also important because of its influence on water chemistry. The rate of chemical reactions generally increases at higher temperature, which in turn affects biological activity. Another important example of the effects of temperature on water chemistry is its impact on oxygen. Warm water holds less oxygen than cool water, so it may be saturated with oxygen but still not contain enough for survival of aquatic invertebrates or certain fish.

Total Dissolved Solids (TDS)
TDS is a general indicator of overall water quality. It is a measure of inorganic and organic materials dissolved in water. High levels of TDS in surface water may be due to factors such as sedimentation, mining, or storm water runoff. Increased TDS may impart a bad odor or taste to drinking water and cause scaling of pipes and corrosion.

Total Suspended Solids (TSS)
TSS, or turbidity, is the measure of the suspended particles in the water column. High levels of turbidity can come from many sources, such as urban runoff, soil erosion, wastewater discharges, agriculture, and removal of riparian zones. Increased levels of turbidity may cause water to darken, which in turn leaves less light for aquatic plants to perform photosynthesis. This in turn decreases the amount of dissolved oxygen being added to the water, which can affect aquatic organisms that are higher on the food chain. Extreme levels of TSS can also clog fish gills.

Cations/Anions
Specific cations and anions will also be sampled as part of this project. Both dissolved and total concentrations will be determined for all species. Dissolved concentrations allow the researcher to infer more detailed water chemistry information, while total concentrations are used to promulgate and enforce water quality regulations.
Monongahela River Water Quality Study

Sampling Parameters and Descriptions (Continued)

Aluminum (Al)
Aluminum is the third most common element on Earth. In most forms, aluminum is not very soluble in water. However, low pH waters, such as those associated with mine drainage, may contain large amounts of dissolved aluminum due to dissolution of aluminum-containing minerals within the local geology. When aluminum precipitates within the water column, it is in the form of an aluminum hydroxide. Aluminum hydroxide may be very harmful to aquatic life due to smothering of the stream bed of the water body. Aluminum may also clog the gills of aquatic organisms if the concentration is high enough.

Bromine (Br)
Bromine is a chemical element found in the halogen group. At room temperature, it is a reddish-brown liquid that is slightly soluble in water. Dissolved bromine comes from several sources, including surrounding geology, fluids used in gas well drilling, seawater infiltration, and industrial waste. Elevated levels of dissolved bromine may interfere with water treatment, as well as pose a possible increased cancer risk to humans and wildlife.

Calcium (Ca)
Calcium is an element that is found naturally in water due to its abundance in the Earth's crust. Large bodies of surface water, such as rivers, typically contain 1-2 mg/L of calcium. High levels of calcium in surface water mean that the water is hard, which helps aquatic life by buffering the pH of the water and protecting those organisms with gills from direct metal uptake. However, if calcium and hardness are too high, hardening of pipes and staining may occur.

Chlorine (Cl)
Chlorine occurs naturally as a green gas. It appears in many different compounds. The most important chlorine compound for many forms of life is NaCl, or salt. Chlorine (as the Cl- ion) is the most abundant dissolved ion in salt water, and is also found in freshwater in much smaller concentrations. Freshwater chlorine is usually derived from chlorine mineral dissolution. Other sources of chlorine in freshwater may include wastewater runoff and breakdown of chlorinated compounds. High amounts of dissolved chlorine can be very harmful to wildlife due to the oxidative properties of chlorine. When chlorine concentrations reach a certain level within the organism, it combines with the water and oxygen to create hydrochloric acid, which destroys animal tissues.

Iron (Fe)
Iron is the most abundant metal in the Earth's core and is found in a large range of compounds. It is also very important to humans and other organisms, as it is partially responsible for transporting oxygen through the bloodstream. Iron is easily dissolved in water and can be found naturally occurring in water bodies. High levels of precipitated iron oxides may cause smothering of stream bottoms and plugging of organism’s gills.

Magnesium (Mg)
Magnesium is found in large concentrations in both the Earth’s crust and the human body. It is highly soluble in water, and is the third most abundant element in sea water. Concentrations of magnesium in freshwater vary according to surrounding geology. Along with calcium, magnesium concentrations are used to determine water hardness. High concentrations of magnesium cause similar problems to high concentrations of calcium, including staining and hardening of pipes and fixtures.

Manganese (Mn)
Manganese is commonly found in soil in its oxide form (pyrolusite). It is used in the steel making process, and is also an essential nutrient for most organisms. High concentrations of manganese in humans can cause many different health problems, including Parkinson’s disease and bronchiitis. Manganese is also soluble in water, with large concentrations causing health problems in aquatic life. Manganese can also bioaccumulate through the food chain, causing top predators to have unhealthy levels of manganese in their bodies.

Sodium (Na)
Sodium is a very common element found in rocks and soils. It is needed for all life forms to aid in the transmission of nerve impulses. It is also highly soluble in water and will react violently with water to form lye and hydrogen gas. Sodium is found naturally in freshwater bodies. Concentrations of sodium vary greatly, and are dependent on the surrounding soil and geology. Too much sodium can raise the pH level of a water body to the point where it is too high for certain species of aquatic life to survive.

Sulfate (SO4 -2)
Sulfate is a salt consisting of one sulfur atom and four oxygen atoms with an oxidation number of -2. Sulfate is naturally occurring in almost all water bodies. It usually comes from oxidation of sulfite ores, dissolution of sulfate minerals, shale, and industrial wastes. High concentrations of dissolved sulfate may give water an unpleasant taste and may be corrosive to plumbing. It may also have health effects including nausea and diarrhea.

Sulfur (S)
Sulfur is a non-metal that is a yellow solid at room temperature. Sulfur is found in many different minerals and is extracted by melting the surrounding rock and collecting the molten sulfur. It may also be produced from hydrogen sulfide. It is a required nutrient for life on Earth and it is an essential building block of cells. It is insoluble in water. However, high concentrations of sulfur-containing compounds, such as sulfate, may be found in water due to human activities, such as mining.

For more information about the sampled parameters (including measurement units, ranges, and analysis techniques), visit our project website at www.MonWQ.net
Information Transfer Program Introduction

The WVWRI has led or co-sponsored a state or regional water conference almost every year since 2003. In 2010, the WVWRI led a state event in Morgantown, WV which was very successful and had the highest attendance of any of the yearly events since 2003. A more detailed report follows.
Basic Information

<table>
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<th>(WRI-135) West Virginia Water Conference 2010</th>
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<tr>
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<td>3/1/2010</td>
</tr>
<tr>
<td>End Date:</td>
<td>2/28/2011</td>
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</tr>
<tr>
<td>Principal Investigators:</td>
<td>Tamara Vandivort, Dave Saville</td>
</tr>
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Publications

There are no publications.
2010 West Virginia Water Conference

West Virginia’s Water Resources: Threats and Opportunities

Description

The West Virginia Water Research Institute at West Virginia University and the US Geological Survey organized and hosted a statewide Water Conference entitled, West Virginia’s Water Resources: Threats and Opportunities. A record attendance of over 225 people attended the Conference which took place in Morgantown, WV at the Waterfront Place Hotel on October 6 & 7, 2010. The event was co-sponsored by the WV Department of Health & Human Resources, WV Department of Environmental Protection, WV Department of Natural Resources, Hatch Mott MacDonald, Triad Engineering, WV Highlands Conservancy, Earth Vector Systems, Timmermeyer PLLC., WV Rivers Coalition and the Upper Monongahela River Association.

The conference was highlighted by several special guest speakers sharing their expertise and perspectives on various topics. Attendees were welcomed to the conference by Morgantown Mayor, Bill Byrne, while West Virginia University President, Dr. James P. Clements, introduced Keynote Speaker Congressman Alan Mollohan. The Congressman reflected on many of the important water related issues he has been involved with during his 28 years representing the First Congressional District in West Virginia. He commented on the importance of the water resources to the State’s economy and its future. He also stressed the importance of WVU and its role in increasing our understanding of our water resources and the work being done to find solutions to the many challenges we face in protecting them while allowing our economy to flourish.

The Chief Scientist for Hydrology at the US Geological Survey, Jarred Bales, presented on Water Information for West Virginia and the Nation. Author and Ecologist George Constantz presented Hollows, Peepers and Highlanders: An Appalachian Ecology during a special lunchtime slide show. Over 50 researchers also shared their work and what they are doing to learn more about our water resources and how to protect and restore them.

For the first time, a student debate took place at the conference pitting debate teams from Alderson Broaddus College against Shepherd University. “Should West Virginia have regulations regarding water withdrawals for gas well drilling” was the resolution debated. The students, who were given one month to compose both affirmative and negative arguments, conducted a lively and entertaining debate. The Parliamentary style of debate encouraged the audience to cheer and jeer as they were moved by the arguments made by the competitors.
Methods, Procedures, Facilities

Planning

The West Virginia Water Research Institute served as lead for the conference and established a conference advisory committee to participate in meetings and conference calls to develop the theme, agenda, identify and contact speakers, select a facility, and develop materials for the event. Members represented on the Advisory Committee included:

David W. Saville, WVWRI
Tamara Vandivort, WVWRI
Brady Gutta, WVWRI
Jen Fulton, WVWRI
Gary Wick, FBI
Danny Bennett, WV Department of Natural Resources
Frank Borsuk, US Environmental Protection Agency
Ron Evaldi, US Geological Survey
David Meadows, US Army Corps of Engineers
Todd Petty, WVU Wildlife & Fisheries
Bill Toomey, WV Department of Health & Human Resources
Stephanie Timmermeyer, Timmermeyer PLLC.

Call for Abstracts

A call for abstracts was issued. Approximately 60 abstracts were received. These were evaluated for applicability and categorized by topic to help develop the agenda. Authors were asked to prepare and submit presentations which have all been posted on the event website.
The West Virginia Water Conference is the annual statewide event that combines exceptional educational programs with outstanding opportunities for researchers, policy makers, regulators, agencies and the public to share in the latest information, technologies and research relating to our state’s water resources. It provides excellent networking opportunities as well as a productive forum to discuss pertinent water-based issues. The West Virginia Water Conference is hosted by the West Virginia Water Research Institute with support from the US Geological Survey.

Abstracts

Submit an abstract of 150-250 words and include the presentation title, speaker(s), affiliation(s) of speaker(s), phone number(s), and email address(s). Also include whether you would like to present orally or as a poster. Abstracts must include sufficient content and information to be evaluated by the Conference Planning Committee. The Planning Committee reserves the right to accept, place in oral or poster session, or reject any submission. Abstracts are to be submitted via email to:

wvwaterconference@mail.wvu.edu

ABSTRACTS DUE JUNE 30, 2010

Notification of Acceptance

By August 2, 2010 the Conference Planning Committee will inform the submitting authors of their abstract’s status. A Speaker’s Guide will be provided to presenters whose abstracts have been accepted. This guide will provide information necessary for presenting orally or by poster at the Conference.

Often called The Birthplace of Rivers, West Virginia has abundant water resources which are facing numerous threats while providing equally numerous opportunities. Exploring the threats and opportunities to West Virginia’s water resources is what this year’s conference is all about. Suggested topics include, but are not limited to the following:

Supply - Whether its for energy production, agriculture, domestic or industrial needs, the demand for water is increasing within our state and region.

Energy - Water is required to produce energy and its production can impact water quality and supply.

Policy - Increasing demands, opportunities and threats to our water resources are creating the need for new water management policy and regulation.

Technology - New technologies offer opportunities to protect and restore our water resources.

Monitoring - Sound water management and policy decisions require accurate data.

Water quality - Contaminants to our water supply are a constant threat.

Questions and Assistance

For more information visit our conference website at:
www.wvwaterconference.org

West Virginia Water Conference
Glenn Waldron,
Conference Coordinator
304-293-2867 x 5468
wvwaterconference@mail.wvu.edu
Call for Sponsors

A call for sponsors was issued. Sponsorships were received by the WV Department of Health & Human Resources, WV Department of Environmental Protection, WV Department of Natural Resources, Hatch Mott MacDonald, Triad Engineering, WV Highlands Conservancy, Earth Vector Systems, Timmermeyer PLLC., WV Rivers Coalition and the Upper Monongahela River Association.

2010 West Virginia Water Conference
West Virginia's Water Resources: Threats and Opportunities
Waterfront Place Hotel, Morgantown, WV - October 6-7, 2010

CALL FOR SPONSORS
The West Virginia Water Research Institute invites you to join us in co-sponsoring the 2010 West Virginia Water Conference:
West Virginia's Water Resources - Threats and Opportunities

West Virginia Water Conference

The West Virginia Water Conference is the annual statewide event that combines exceptional educational programs with outstanding opportunities for researchers, policy makers, regulators, agencies and the public to share in the latest information, technologies and research relating to our state’s water resources. It provides excellent networking opportunities as well as a productive forum to discuss pertinent water-based issues.

Threats and Opportunities
This year’s conference is focusing on the many opportunities our rich water resources provide us as well as the many threats. Currently presenters are being solicited on a host of issues including Water Supply, Energy, Policy, Technology, monitoring and water quality issues.

Event Sponsorship
The conference is hosted by the West Virginia Water Research Institute with support from the US Geological Survey. The event would not be possible however without the help from sponsors. Attendees will range from researchers from colleges and universities (faculty, graduate and undergraduate students), policy-makers and regulatory representatives from federal and state agencies, private organizations and industry, to consulting firms, and others.

Reach Important Stakeholders
As a sponsor, you will help support an increase in knowledge among primary stakeholders and decision-makers in the region as we move forward to address issues related to our water resources. Your support creates many avenues for recognition and demonstrates the dedication of your organization, agency or company to studying, protecting, and restoring the vital water resources of our state.

Free registration, free exhibit space, and prominent logo placement on conference printed materials and are all available to sponsors among the various sponsorship packages.

Become a Sponsor!
We have established several ways for you to provide meaningful support to the Conference. The choice is yours. Any and all contributions will be used solely to support this event. If you would like to support the event but do not see an attractive option for your organization, please contact us with your ideas or suggestions.

To co-sponsor this event, please log onto the conference web site at www.wvwaterconference.org and click on “Sponsorship.”

For more information, contact us.

West Virginia Water Conference
Glenn Waldron, Conference Coordinator
304-293-2867 x 5468
wvwaterconference@mail.wvu.edu

www.wvwaterconference.org
Sponsorship Opportunities

Platinum Level Sponsorship Opportunity ($2,500 level)

**Collegiate Debate** (1 sponsorship available)
This sponsorship is for a Collegiate Debate to be performed by two local College Debate Teams. This event will generate interest from conference attendees and from the general public who will be invited to attend.

Platinum Level Sponsorships Include:
- Two (2) free full registrations to the conference sessions, meals and reception
- One free exhibit space
- A full page ad in conference program
- Premium location of Logo on event web site and all conference printed and promotional materials
- Description of services your organization provides included on conference web site and program
- Included on sponsorship posters with organization name and logo at the event
- Announcement of sponsorship during the debate

Gold Level Sponsorship Opportunities ($1,000 level)

**Lunch** (2 sponsorships available)
These sponsorships would be sole sponsor of one of the lunches on each day of the event.

**Reception** (2 sponsorships available)
These are Co-sponsorships for the evening reception on October 6.

Gold Level Sponsorships Include:
- Two (2) free full registrations to the conference sessions, meals and reception
- One free exhibit space
- A 1/2 page ad in conference program
- Premium location of Logo on event web site and all conference printed and promotional materials
- Description of services your organization provides included on conference web site and program
- Included on sponsorship posters with organization name and logo at the event
- Poster and verbal Announcement of sponsorship during that part of the program

Silver Level Sponsorship Opportunities ($500 level)

**Session Breaks** (6 available)
These are Co-sponsorships for each of the mid-morning and afternoon coffee/networking breaks.

Silver Level Sponsorships Include:
- One (1) free full registration to the conference sessions, meals and reception
- One free exhibit space
- Logo added to conference web site, and conference printed and promotional materials
- Description of services your organization provides included on web site and in conference program
- Included on sponsorship posters with organization name and logo at the event
- Logos included on Break refreshment tables

Bronze Level Sponsorship Opportunities ($250 level)

**Scholarship Fund** (unlimited)
The Conference will provide the opportunity for students and representatives of non-profit organizations to apply for need-based scholarships to cover the cost of registration to the conference.

Bronze Level Sponsorships Include:
- One free exhibit space
- Logo added to conference web site, and all conference printed and promotional materials
- Description of services your organization provides included on conference web site and program
- Included on sponsorship posters with organization name and logo at the event
# Agenda

**West Virginia Water Conference 2010**  
**Draft Agenda (8/20/2010)**  
**Wednesday October 6, 2010**

<table>
<thead>
<tr>
<th>Time</th>
<th>Session</th>
</tr>
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</table>
| 9:00 am - 9:10 am | Welcome & Introductions  
Morgantown Mayor Bill Bernie (invited) |
| 9:10 am - 9:30 am | Keynote Speaker  
Congressman Alan Mollohan (invited) |
| 9:30 am - 10:45 am | Plenary Session:  
Legislation |
| 10:45 am - 11:15 am | Networking Break |
| 11:15 am - 12:30 pm | Plenary Session:  
Surface Mining |
| 12:30 pm - 1:30 pm | Lunch  
"Special Guest Speaker George Constantine  
"Hollows, Peaks, and Highlanders: An Appalachian Mountain Ecology" |

**Concurrent Sessions**

- **1:30 pm - 2:45 pm**  
  Stream Restoration  
  Ground Water  
  Monitoring Programs  
  PTTC
- **2:45 pm - 4:00 pm**  
  Acid Mine Drainage  
  Nutrients  
  Monitoring Methodology  
  PTTC
- **4:00 pm - 4:30 pm**  
  Networking Break
- **4:30 pm - 6:00 pm**  
  Parliamentary Style Collegiate Debate  
  Fairmont State College vs. Alderson Broaddus  
  Topic: Marcellus Gas Well Drilling Water Withdrawals
- **6:00 pm - 7:30 pm**  
  Reception/Poster Session
- **7:30 PM**  
  Adjourn

**Thursday October 7, 2010**

<table>
<thead>
<tr>
<th>Time</th>
<th>Session</th>
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<tr>
<td>8:30 am - 9:15 am</td>
<td>Housekeeping &amp; Keynote</td>
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</tbody>
</table>
| 9:15 am - 10:30 am | Plenary Session:  
Policy (Northern West Virginia) |
| 10:30 am - 11:00 am | Networking Break |
| 11:00 am - 12:30 pm | Plenary Session:  
Marcellus Shale |
| 12:30 pm - 1:30 pm | Lunch |

**Concurrent Sessions**

- **1:30 pm - 2:45 pm**  
  Dunkard Creek Fish Kill  
  Water Use/Quantity  
  EDGs
- **2:45 pm - 4:00 pm**  
  Energy Issues  
  Water Planning Lessons  
  Economics
- **4:00 pm**  
  Adjourn
2010 West Virginia Water Conference

West Virginia’s Water Resources: Threats and Opportunities

Session Summaries

PLENARY SESSIONS

Legislative Approaches to Addressing West Virginia’s Water Quality Issues

When: Wednesday, October 6th (9:30 AM – 10:30 AM)
Moderator: Joyce McConnell – Dean, College of Law at West Virginia University
Speakers: Don Garvin – Legislative Coordinator, WV Environmental Council

Joe Altizer – Counsel, WV House of Delegates Judiciary Committee
Abstract Title: Recent WV Legislative Activities Relating to the State’s Water Resources, Quality and Quantity.

Corky DeMarco – Executive Director, WV Oil & Natural Gas Association
Tim Manchin – Delegate Marion County & Chair, Water Resources Committee

Surface Mining and Water Resources in West Virginia Coal Fields

When: Wednesday, October 6th (11:00 AM – 12:00 PM)
Moderator: Dr. Scott Simonton – Professor, Marshall University
Speakers: Mindy Armstead – Potesta and Associates Inc.

Todd Petty – Assoc. Professor, Division of Forestry, West Virginia University
Abstract Title: Towards Managing Impacts in Actively Mined Watersheds

Pat Marik – Unit Leader and Adjunct Assoc. Professor, Division of Forestry, West Virginia University
PLENARY SESSIONS (continued)

_The Monongahela River TDS Policy Concerns_

**When:** Thursday, October 7\(^\text{th}\) (9:00 AM – 10:15 AM)  
**Moderator:** Stephanie Timmermeyer – Environmental Consulting and Legal Services  
**Speakers:**  
- Paul Ziemkiewicz – Director, West Virginia Water Research Institute  
- Evan Hansen – Down Stream Strategies  
- David Yaussey - Robinson & McElwee PLC  
**Abstract Title:** Water Quality Criteria and the TDS Conundrum

_New Gas Well Extraction Methods: Does Marcellus Opportunity Mean Water Threats?_

**When:** Thursday, October 7\(^\text{th}\) (10:45 AM – 12:00 PM)  
**Moderator:** Michael Holm – Director, West Virginia Geological Survey  
**Speakers:**  
- Lee Avary - (Retired) West Virginia Geological Survey  
**Abstract Title:** The Marcellus Shale Play in West Virginia  
**Abstract Title:** Mitigating Environmental Impacts of Oil and Gas E&P Operations  
- Dave McMahon – West Virginia Surface Owners’ Rights Organization  
**Abstract Title:** The Real and Timely Issues caused by the Marcellus Shale Play
Concurrent Sessions

Stream Restoration

When:  Wednesday, October 6th (1:30 PM – 2:45 PM)
Moderator:  Todd Petty - Associate Professor, Division of Forestry at WVU
Speakers:

Eric Miller – WVU Grad Student
Abstract Title:  Fish Habitat Restoration on the Little Coal River, WV as Compensation for Mining Impacts to Headwater Streams: Benefits and Constraints.

Neil Gillies – Executive Director, Cacapon Institute
Abstract Title:  Failure is not an Option: A Low Cost Deer Exclusion Approach for Forested Riparian Buffer Plantings.

Scott Copen – Senior Engineer, Morgantown Utility Board

Abby McQueen – Aquatic Restoration Specialist, Cacapon Valley Institute
Abstract Title:  Stream Restoration Success Monitoring: Is it Successful?

Ground Water

When:  Wednesday, October 6th (1:30 PM – 2:45 PM)
Moderator:  Bill Toomey – West Virginia Bureau for Public Health
Speakers:

Mark Kozar – US Geological Survey
Abstract Title:  Use of Equivalent Porous Media Methods for Simulating Groundwater Flow in Karst Aquifers, Shenandoah Valley of Virginia and West Virginia

Dr. Benjamin M. Stout III – Wheeling Jesuit University
Abstract Title:  Coal Slurry and Rural Well water Quantity in Southern West Virginia

Jeremy White – US Geological Survey
Abstract Title:  Ambient Groundwater Quality in West Virginia, 1993-2008

Paul Ziemskiewicz – Director, West Virginia Water Research Institute
Abstract Title:  Slurry Study

Andrew (Nick) Schaer – WV DEP
Abstract Title:  Findings of the WVDEP and OSMRE SCR-15 “Phase I” Study on the Underground injection of Coal Slurry
Concurrent Sessions (continued)

**Monitoring Programs**

**When:** Wednesday, October 6th (1:30 PM – 2:45 PM)

**Moderator:** Gary Wick - Federal Bureau of Investigation

**Speakers:**
- Duane Nichols – Cheat Lake Environmental & Recreation Association
  **Abstract Title:** Significant Results of Monitoring Local Streams in North Central West Virginia Over the Past Decade

- Ron Evoli – US Geological Survey
  **Abstract Title:** USGS West Virginia Hydrologic Data Programs

- Sarah Veselka, Martin Christ & Brian Carlson - Friends of Deckers Creek
  **Abstract Title:** Eight Years of the Clean Creek Program

**PTTC Workshop**

**When:** Wednesday, October 6th (1:30 PM – 4:00 PM)

**Instructors:**
- Kristin Carter - Chief, Carbon Sequestration Section, Pennsylvania Geological Survey
- Paul Ziemkiewicz - Director, West Virginia Water Research Institute
- Ronald E. McIlwain - President, FilterSure, Inc
- C. David Loeke - Principle Petroleum Engineer, Marcellus Shale Fracwater Cleanup Project

**Description:**
West Virginia University, FilterSure, Inc and Powell Water Systems, Inc have combined their expertise to develop a treatment for water returned to the surface from massive hydraulic fracture treatments applied to horizontal Marcellus Shale gas wells. The main goal of this project is to develop and demonstrate a process for treating Frac Water Returns (FWR) that will allow an increased recycle rate while decreasing makeup water volumes and disposal requirements.

Successful results were achieved from laboratory Phase I, in Phase II, a mobile unit with a rated capacity of 30 gallons per minute (GPM) will be constructed and tested at an active field well site(s). The results for Phase I, and the 2011 field plan for Phase II, will be presented during this workshop.

During Phase I, the West Virginia Water Research Institute received free water return samples from producers active in Marcellus Shale development. Various options for cleaning the FWR were evaluated. Electrocoagulation (EC) followed by FilterSure multi-media filtration produced a crystal clear effluent with the desired water chemistry needed for the next hydraulic fracture treatment.

The highly successful laboratory results can only be confirmed by field tests at active Marcellus Shale development sites. Therefore, in Phase II, a 30 GPM mobile unit will be constructed for field trials in the spring of 2011. Plans for these field trials, and opportunities for companies to participate and actually lease this unit, will be presented.
Concurrent Sessions (continued)

Mine Drainage

When: Wednesday, October 6th (2:45 PM – 4:00 PM)
Moderator: Brady Gotta – Research Associate, WV Water Research Institute
Speakers:
Brittney Holmes – Graduate Student, Marshall University
Abstract Title: Environmental Site Characterization and Assessment of As, Cd, Zn, Pb, and Se

Fionna Stewart – Graduate Student, West Virginia University
Abstract Title: Effects of Acid Precipitation and Acid Mine Drainage on Leaf Litter Decomposition Rates in Central Appalachian Streams

Ben Mack – Research Associate, West Virginia Water Research Institute
Abstract Title: An Analysis of Steel Slag and Its Use in Acid Mine Drainage (AMD) Treatment

Katlyn Amos: Biology Department, Concord University (West Virginia)
Abstract Title: Detrital Processes in Streams Across a Conductivity Gradient in an Intensively Mined Watershed

Eric Merriam – Graduate Student, West Virginia University
Abstract Title: Additive Effects of Mining and Residential Development on Stream Conditions in a Central Appalachian Watershed

Nutrients

When: Wednesday, October 6th (2:45 PM – 4:00 PM)
Moderator: Neil Gillies – Executive Director, Corepon Institute
Speakers:
Alan Collins – Professor, Agricultural and Resource Economics Program, West Virginia University
Abstract Title: Engaging Farmers on a Watershed Basis to Solve Agricultural Pollution

Mike Arcuri – Environmental Resources Analyst, WV DEP
Nei Gillies – Corepon Institute
Abstract Title: Failure is not an Option: A Low Cost Deer Exclusion Approach for Forested Riparian Buffer Plantings

Joe Hankins – Director, Freshwater Institute
Concurrent Sessions (continued)

Monitoring Methods/Methodology

When: Wednesday, October 6th (2:45 PM – 4:00 PM)
Title: Concurrent Session - Monitoring Methods/Methodology
Moderator: Melissa O’Neal – Environmental Technician, West Virginia Water Research Institute
Speakers: David Gruber - Biological Monitoring, Inc.

Abstract Title: A Biological Water Quality Monitor

Jenna Fehr - OSM/VISTA Volunteerism Coordinator.
Appalachian Coal Country Watershed Team
Abstract Title: Approaches to Volunteer Monitoring in Rural Mining Communities

Sharma Shikaku - Assistant Professor in Department of Geology and Geography, West Virginia University
Abstract Title: Management of coal bed natural gas co-produced water: potential role of stable isotopes

Dunkard Creek

When: Thursday, October 7th (1:00 PM – 2:15 PM)
Moderator: Amy Bergdale – Aquatic Biologist, US EPA
Speakers: Frank Jernejcic – Fisheries Biologist, West Virginia DNR

Dan Cincotta – WV DNR
Pat Campbell – WV DEP
Concurrent Sessions (continued)

**Water Use / Water Planning Lessons**

When: Thursday, October 7th (1:00 PM – 3:30 PM)

Moderator: Ron Evaldi – US Geological Survey

Speakers:
- Heidi Moltz - Senior Water Resources Scientist, ICPRB
  **Abstract Title**: WV Statewide Water Planning from the Ground Up: Lessons from Local Trainings in Water Resource Management

- Karin Beneals - Water Resources Planner, ICPRB
  **Abstract Title**: WV Statewide Water Planning from the Ground Up: Lessons from Local Trainings in Water Resource Management

- Lawrence Johnson - Chester Engineers
  **Abstract Title**: Water Reuse – Is It in West Virginia’s Future

- Joseph Hankins – Director, Fresh Water Institute
  **Abstract Title**: Water Reuse – Is It in West Virginia’s Future

- Dewey Sanderson – Department of Geology, Marshall University
  **Abstract Title**: Water Budget of the Coal River Basin 2009

- Timothy Ball - Interim General Manager, Morgantown Utility Board
  **Abstract Title**: Morgantown Utility Board - Perspectives and Efforts of a Leading Local Agency

**EDC’s**

When: Thursday, October 7th (1:00 PM – 2:15 PM)

Moderator: Frank Borsuk - Aquatic/Fisheries Biologist, US EPA

Speakers:
- Shanda Minney – West Virginia Rivers Coalition
- Doug Chambers - US Geological Survey
- Sam Dinkins – ORSANCO
Concurrent Sessions (continued)

Energy Issues

When: Thursday, October 7th (2:15 PM – 3:30PM)

Moderator: Rob Reash – American Electric Power

Speakers: Jeff Brown - Energy Economics & Project Development
Abstract Title: Geothermal Power Plant Cooling

Emily Grubert – Master’s Student, University of Texas at Austin
Abstract Title: Air Impacting Water: How Carbon Emissions Standards Could Impact West Virginia Water

Rob Reash – American Electric Power

POSTER PRESENTATIONS

1.) Title: Water Use Estimates for West Virginia, 2004
   Author(s): John Atkins, Jr.
   Affiliation(s): USGS

2.) Title: Designing In Stream Flow Programs for West Virginia
   Author(s): Terry Messinger
   Affiliation(s): USGS

3.) Title: Diversity of Ohio River Bacterial Communities Using
   Next-Generation Sequencing Techniques
   Author(s): Emily Annen, Rutmann Desauguste, Gary Schultz
   Affiliation(s): Marshall University

4.) Title: Fish Cell Lines as Versatile Tools to Screen and Monitor Water Quality
   Author(s): Selvaraj Vellaisamy, Elizabeth Murray
   Affiliation(s): Marshall University

5.) Title: Determining Field Methods to Measure Boundary Shear Stress Along Vegetated Streambanks
   Author(s): Leslie Hopkinson, T.M. Wynn
   Affiliation(s): West Virginia University, Virginia Tech University

6.) Title: Generalized Skew Coefficients of Annual Peak Flows for Rural, Unregulated Streams in West Virginia
   Author(s): John Atkins
   Affiliation(s): USGS

7.) Title: DNA Phylogeography of Rhiynchobdys Species in West Virginia
   Author(s): Samantha Taylor, Geoffrey Smith, Thomas Jones, Elizabeth Murray
   Affiliation(s): Pennsylvania Fish and Boat Commission

8.) Title: Green Technologies in Spotsylvania County
   Author(s): Richard Street
   Affiliation(s): Spotsylvania County St. Environmental Engineer
**Petroleum Technology Transfer Council (PTTC)**

The Petroleum Technology Transfer Council (PTTC) is a national not-for-profit organization led by an independent Board of Directors and managed by the American Association of Petroleum Geologists. PTTC was established to provide a forum for transfer of technology and best-practices within the producer community. Local Producer Advisory Groups work to ensure that PTTC activities in a particular region address the technology needs of producers in that area.

PTTC is a partnership to connect independents with the technology and knowledge to safely and responsibly develop the nation’s oil and gas resources. The Council provided a workshop to its members in conjunction with the WV Water Conference. This provided members the opportunity to attend the conference in addition to participating in the PTTC workshop.

**Facility**

The Waterfront Place Hotel and Conference Center in Morgantown, WV was selected as the venue for this conference due to its location, appropriateness of the facilities and availability.

**Registration and Materials**

On-line registration was developed and handled by the WV Water Research Institute. Lunches and materials were provided to approximately 225 attendees. A registration fee was charged to cover the costs associated with renting the facility and providing lunches and refreshments.

In addition to the agenda, a program was handed out that included abstracts associated with the presentations, speaker biographies, session summaries and an attendee list. Additional materials in the form of brochures, newsletters, and fact sheets providing information about the WV Water Research Institute and other event hosts and sponsors were also distributed.

**Scholarships**

To encourage participation by students and volunteers and staff with non-profit organizations, scholarships were made available to cover the cost of registration. Twenty five scholarships were authorized for approved individuals.
2010 West Virginia Water Conference
West Virginia’s Water Resources: Threats and Opportunities
Waterfront Place Hotel  Morgantown, WV  -  October 6-7, 2010

Scholarship Application Form

Complete this form and mail to:
West Virginia Water Conference
PO Box 6064
Morgantown, WV 26506

*Applications Due August 31, 2010*

The West Virginia Water Research Institute extends an invitation to any interested individuals to apply for a limited number of scholarships to attend the 2010 West Virginia Water Conference. While we must cover the costs associated with hosting this important event, and therefore must charge a registration fee, we also don’t want anyone sincerely interested in attending to not do so for lack of financial resources. We thank our event hosts and sponsors for making these scholarships available.

Questions or inquiries:
Glenn Waldron
(304) 293-2867 ext. 5468
wwwaterconference@mail.wvu.edu

Name_____________________________Title_____________________________

Company/Organization/College

Address

City____________________________State__________Zip Code__________________

Phone______________FAX____________________________

E-Mail____________________________

Brief Statement of need

________________________________________

Signature____________________________________
Exhibits

Nineteen (19) exhibitors participated in the conference. These included research posters presented by participating researchers from around the state who submitted abstracts as well as displays from non-profit watershed associations, interested businesses and event sponsors.

Publicity/Technology Transfer

The conference was publicized in a number of ways as follows:

- Website Development, A Domain, [www.wvwaterconference.org](http://www.wvwaterconference.org) was procured and a website was set up to promote the conference, provide for registration and facilitate communications with registrants and other interested individuals. The site included sponsorship information, scholarship opportunities, displayed the event schedule and agenda, session summaries and has provided an outlet to distribute speaker presentations and follow-up materials.

- Press releases were released periodically and picked-up by news outlets around the state, samples below;

**WV Water Research Institute Solicits Abstracts Abstracts for Annual Water Conference**

**Morgantown, W. Va. – June 14, 2010** – The West Virginia Water Research Institute, located at the National Research Center for Coal and Energy at West Virginia University, is accepting abstracts through June 30, 2010 for the 7th annual West Virginia Water Conference. The Conference combines educational programs with opportunities for researchers, policy makers, regulators, agencies and the public to share in the latest information, technologies and research relating West Virginia’s water resources.

Abstracts for basic and applied research papers are currently being solicited in all areas related to water and the environment including water supply, energy, policy, technology, water quality, mining, nutrients, water use, economics, urbanization, oil and gas. Researchers from colleges and universities, federal and state agencies, private organizations, consulting firms, and others are invited to submit abstracts for consideration to present orally or as posters. The theme for this year’s Conference is, “West Virginia’s Water Resources: Threats and Opportunities,” and is scheduled for October 6-7 at the Waterfront Place Hotel in Morgantown.

“The WV Water Research Institute is proud to host this annual event which provides a critical forum for discussions about important issues relating to our water resources,” commented Dr. Paul Ziemkiewicz, Director of WVWRI. “This year’s conference is sure to resonate with participants, especially at a time when water related issues are making local and national headlines.”

For more information on the 2010 West Virginia Water Conference and complete submission details visit, [www.wvwaterconference.org](http://www.wvwaterconference.org).
The West Virginia Water Research Institute has been in existence since 1967 and serves as a statewide vehicle for performing research related to water issues. It is the premier water research center in West Virginia and, within selected fields, an international leader.

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**West Virginia Water Conference to Include Marcellus Shale Discussion**

*Morgantown, W. Va. – September 17, 2010* – – The West Virginia Water Research Institute (WVWRI) at West Virginia University, with support from the United States Geological Survey, will hold its seventh annual West Virginia Water Conference on Oct. 6 and 7. The conference will combine educational programs with opportunities for researchers, policy makers, regulators, agencies and the public to share in the latest information, technologies and research relating West Virginia’s water resources.

The conference program, which includes over 50 water quality experts from West Virginia University, the state and nation, will feature four plenary sessions, numerous concurrent sessions and special guest speakers throughout the two day event. This year’s theme is, “West Virginia’s Water Resources: Threats and Opportunities” and will take place at the Waterfront Place Hotel in Morgantown, W.Va.

“New Gas Well Extraction Methods: Does Marcellus Opportunity Mean Water Threats?” is one of four plenary sessions scheduled for the event. Paul Ziemkiewicz, director of the WVWRI, a program of WVU’s National Research Center for Coal and Energy, is one of the panelists for “The Mon River TDS Policy Concerns” and Joyce McConnell, dean of the WVU College of Law, is the moderator for “Legislative Approaches to Addressing West Virginia’s Water Quality Issues.” Another WVU researcher, Todd Petty, will be a panelist in the “Surface Mining and Water Resources in the WV Coalfields” session.

“In previous years, this conference was more research-focused,” said David Saville, outreach coordinator for the WVWRI. “This year, there is an increased emphasis on policy because of Marcellus Shale drilling and the regulatory challenges it presents along with TDS and other water related issues that have continued to gain regional and national prominence.”

According to the West Virginia Department of Environmental Protection, about 500 gas wells have been drilled within state borders in the last three years with no signs of letting up. Since early 2008, the Pennsylvania DEP has issued 3,800 Marcellus shale well permits.

The Shale, a geological formation stretching under West Virginia and much of the Appalachian Basin, is one of the nation’s largest reservoirs of natural gas, with at least one estimate saying it could provide cheap gas for the U.S. for 14 years. A recent report from the American Petroleum Institute estimated it contained gas reserves worth $2 trillion.

Tapping the Shale’s gas using hydraulic fracturing – which requires millions of gallons of fresh water plus small amounts of sand and chemical additives – has created environmental concerns.
New York State has not allowed gas well drilling into the shale for two years but drilling continues in Pennsylvania and West Virginia.

Paul Ziemkiewicz, commented that, “we’re assisting industries develop technologies to treat frac water. This will allow for continued economic development while protecting our state’s valuable water resources.” To help address issues relating to the hydraulic fracturing process, Ziemkiewicz has received $600,000 in federal grant money for a research and demonstration project that aims to facilitate recycling of the returned water. The grant was awarded from the U.S. Department of Energy National Energy Technology Laboratory under its Oil and Natural Gas Program and links WVU with Filtersure Inc., a company that already developed a self-cleaning filter that removes solid particles suspended in frac water. Removing solids is the first step in almost any water treatment process but Ziemkiewicz is also looking for ways to remove enough of the salt and minerals so that water can be reused on the next natural gas well. Ziemkiewicz is also exploring ways to reuse treated mine water in the drilling and fracturing process.

For additional program details see: [www.wvwaterconference.org](http://www.wvwaterconference.org).

Check [http://wvutoday.wvu.edu/](http://wvutoday.wvu.edu/) daily for the latest news from the University. Follow @WVUToday on Twitter.

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- Advertisement in the West Virginia State Journal

- E-mail notices to WRRI list serves. Regular announcements were sent out to constituents for information transfer and networking purposes.
- Announcements provided to all on planning committee to distribute via their own agency web sites and mailing lists.

- A flyer was developed and distributed.

- A Tote Bag was also designed and distributed to Conference Participants. Printed theme;
USGS Summer Intern Program

None.
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<th>NIWR-USGS Internship</th>
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Notable Awards and Achievements

As a result of TDS monitoring of the Monongahela River Water Quality study, coal industries are coordinating their discharges to maintain optimal TDS levels in the river.
Publications from Prior Years


