Arkansas Water Resources Center
Annual Technical Report
FY 2010

Introduction

The Arkansas Water Resources Center located at the University of Arkansas, Fayetteville, Arkansas is part of the network of 54 water institutes established by the Water Resources Research Act of 1964. Since its formation, the Arkansas Water Resources Center (AWRC) program in cooperation with the US Geological Survey and the National Institute for Water Resources has focused on helping local, state and federal agencies understand, manage and protect water resources within Arkansas. AWRC has contributed substantially to the understanding and management of water resources through scientific research and training of students. Center projects have focused on topics concerned with water quality of surface water and ground water, especially non-point source pollution and sensitive ecosystems. AWRC helps organize research to insure good water quality for Arkansas today and in the future.

The AWRC focuses its research on providing local, state and federal agencies with scientific data and information necessary to understand, manage and protect water resources within Arkansas. AWRC cooperates closely with colleges, universities and other organizations in Arkansas to address the state's water and land–related issues, promote the dissemination and application of research results, and provide for the training of scientists in water resources. Each year, several research faculty participate in AWRC projects with the help of students who gain valuable experience doing environmentally related work across the state. AWRC research projects have studied irrigation and runoff, innovative domestic wastewater disposal systems, ground water modeling and landuse mapping, erosion and pollution, water quality and ecosystem functions.

The Center provides support to the State's water research by acting as a liaison between funding groups and the scientists, and then coordinates and administers grants once they are funded. Accounting, reporting and water analyses are major areas of support offered to principal investigators. The AWRC has historically archived reports of water resource studies funded by the 104B program or through the Center on its website.

In addition, the AWRC sponsors an annual water conference held in Fayetteville, Arkansas each spring, drawing over 100 researches, students, agency personnel and interested citizens to hear about results of current research and hot topics in water resources throughout the state. AWRC also co-sponsors short courses and other water-related conferences in the state and region. In addition, AWRC maintains a technical library containing over 900 titles, many of which are online. This valuable resource is utilized by a variety of user groups including researchers, regulators, planners, lawyers and citizens.

The AWRC also maintains a modern water quality laboratory that provides water analyses for researchers, municipal facilities, and watershed stakeholders; farmers and other citizens submit samples through the cooperative extension service. This laboratory is certified through the Arkansas Department of Environmental Quality for the analysis of surface and ground water samples.

The AWRC has a technical advisory committee made up of professionals from educational institutions, environmental organization, water supply districts, and government agencies throughout Arkansas. This committee has the opportunity to evaluate proposals submitted annually to the USGS 104B program, to recommend session topics included in the annual research conference, and to provide general advice to the AWRC Director and staff.

Research Program Introduction

Each year, several researchers participate in 104B projects funded through the Arkansas Water Resources Center (AWRC), and these projects are completed with the help of students in water and environmentally related fields. The research projects funded through the AWRC have studied a broad range of environmental and water issues facing Arkansas, including irrigation and rainfall–runoff, innovated domestic wastewater disposal, groundwater modeling and land use mapping, erosion and nonpoint source pollution, water quality and ecosystem function. The AWRC has given priority to solid scientific research proposals submitted by faculty to the 104B program; the intent has been to provide seed data to researchers such that larger proposals can be developed and submitted to extramural funding sources. The AWRC has funded several projects using 104B funding that have resulted in the award of extramural grants to continue the base research.

To formulate a research program relevant to state water issues, the Center works closely with state and federal agencies, and academic institutions. An advisory committee, composed of representatives from state and federal agencies, industry and academia, provides guidance for the Center. The technical advisory committee plays an important role in insuring that the water institute program (section 104) funds address current and regional issues. The priority research areas of the AWRC base program directly related to the program objectives of the Water Resources Research Act, including research that fosters improvements in water supply, explores new water quality issues, and expands the understanding of water resource and water related phenomena.

Determination of the magnitude of mercury methylation in the water column of a high organic carbon river, lower Ouachita River, Union and Ashley Counties, Arkansas

Basic Information

Title:	Determination of the magnitude of mercury methylation in the water column of a high organic carbon river, lower Ouachita River, Union and Ashley Counties, Arkansas
Project Number:	2010AR248B
Start Date:	3/1/2010
End Date:	2/28/2011
Funding Source:	104B
Congressional District:	3
Research Category:	Water Quality
Focus Category:	Toxic Substances, Surface Water, Hydrogeochemistry
Descriptors:	None
Principal Investigators:	Phil D Hays, Stephen K. Boss, John Van Brahana, Ralph K. K Davis

Publications

1. Schenk, Liam. 2011. Geochemical Controls on Mercury Methlyation in Backwaters of a Gulf Coastal Plain River System, Implications for Water Column Processes. Thesis, Master of Science in Geology, University of Arkansas, Fayetteville, Arkansas.
2. DETERMINATION OF THE MAGNITUDE OF MERCURY METHYLATION IN THE WATER COLUMN OF A RIVER WITH HIGH DISSOLVED ORGANIC CARBON, LOWER OUACHITA RIVER, UNION AND ASHLEY COUNTIES, ARKANSAS: SCHENK, Liam N., Department of Geosciences, University of Arkansas, 113 Ozark Hall, Fayetteville, AR 72701, lschenk@uark.edu and HAYS, Phillip, U.S. Geological Survey, Ozark Hall 113, Fayetteville, AR 72701

Project Title: Determination of the Magnitude of Mercury Methylation in the Water Column of a High Organic Carbon River, Lower Ouachita River, Union and Ashley Counties, Arkansas

Project Team: Dr. Phil D. Hays, Arkansas US Geological Survey

Dr. Stephen K. Boss, Geosciences, University of Arkansas

Dr. John Van Brahana, Geosciences, University of Arkansas

Dr. Ralph K. Davis, Geosciences, University of Arkansas

Interpretative Summary: The abundance and distribution of mercury and methyl mercury were investigated at three sites in the lower Ouachita River in the summer of 2010 in an effort to provide the first characterization of the extent of mercury contamination in this river system, and to investigate the potential for mercury methylation in the water column of backwaters off of the main channel. Results showed that filtered methyl mercury was positively correlated to dissolved organic carbon (r^2=0.76) for water samples taken from the bottom 1 ft of the water column at three sites, suggesting the importance of dissolved organic carbon in mercury methylation. Concentrations of filtered methyl mercury and filtered total mercury in the bottom-water were significantly different (P=0.039 and P=0.022 respectively) at two of the sample sites located approximately 14 river miles apart. Sulfide concentrations of 74.0-142.7 micrograms/liter indicate sulfate reduction was occurring in the bottom water or at the sediment-water interface, yet filtered and particulate methyl mercury concentrations were not significantly correlated to sulfide concentrations. The occurrence of sulfides in the bottom-water is important as sulfate-reducing bacteria are most commonly associated with mercury methylation. Water chemistry results for one site including total iron (39.8 milligrams/liter), high dissolved organic carbon (13.52 milligrams/liter), the highest filtered methyl mercury concentration observed for the study (1.90 nanograms/liter), and no detectable sulfate suggests the predominance of iron reduction at this site. Microbial iron reduction is also a known mercury methylation pathway. Total mercury concentrations for two of seven samples exceeded the Arkansas numeric water quality standard for total recoverable mercury in water (12 nanograms/liter), at concentrations of 13.76 and 13.99 nanograms/liter. These data provide evidence that availability of dissolved organic carbon affects mercury methylation at all three of the sites, and that iron reduction may contribute to mercury methylation at one of the sites. No correlation between sulfide and dissolved methyl mercury was observed, suggesting sulfate reduction may not be the driving process for mercury methylation at all our study sites, and indicating the presence of multiple controls on mercury methylation in this river system.

Introduction: Increased scientific knowledge on mercury (Hg) sources, transport, deposition and cycling, and the toxic effects of Hg species on human populations has led to growing concern over Hg contamination of aquatic systems in recent years. Hg is naturally present in the environment, but human activities such as the combustion of fossil fuels for power generation have increased the amount of Hg cycling through land, atmosphere, and ocean systems (N. E. Selin 2009). As such, atmospheric deposition of Hg is increasing in marine systems (Sunderland, et al. 2009), as well as in riverine systems (Delongchamp, et al. 2009). Riverine systems in some regions such as those draining cinnabar mining districts are at even greater risk of contamination due to exposure and mobilization of Hg during cinnabar mining (Holloway, et al. 2009).

Of primary concern is the formation of the most toxic form of Hg, methylmercury (MeHg). In aquatic systems, Hg can be deposited by either wet or dry deposition in its elemental (Hg_0) and ionic (Hg(II)) forms. Hg_0 and Hg(II) can then be transformed into toxic and highly bioavailable MeHg, the result of processes largely carried out by anaerobic bacteria (Marvin-Dipasquale, et al. 2009). Epidemiological studies have linked exposure to MeHg in pregnant women to neurological and developmental effects in their offspring (Mergler, et al. 2007), (Clarkson 1990). High degrees of human exposure to MeHg most commonly results from the consumption of high trophic-level predaceous fish such as tuna and swordfish in marine systems, and black bass and piranha in freshwater systems.

The objective of this project is two-fold. The first objective is to provide the first detailed characterization of the occurrence and extent of Hg contamination in backwaters of the lower Ouachita River system, and second, to examine the geochemical controls on MeHg in the water column. A detailed multimedia, multi chemical-species sampling scheme was implemented to characterize the relation between organic carbon and Hg methylation. Field parameters along with sulfide, sulfate, and iron concentrations were assessed in the bottom 1-ft of the water column (hereafter referred to as bottom water) to provide insight into oxidation-reduction (redox) conditions that dominate the system and provide evidence for the presence of anaerobic bacteria known to be responsible for Hg methylation. Determination of the controls on MeHg occurrence in the bottom water is achieved by comparing total Hg (THg) and MeHg concentrations to field parameters, DOC, sulfide, iron, sulfate and MeHg sediment concentrations. The characterization of Hg contamination at three backwater sites on the lower Ouachita River provides detailed, state-of-the-science Hg data that give insight into the extent of Hg contamination.

Methods: Three sites (RL-2, OR-2 and OR-11) were chosen as the most likely candidates for MeHG production in the Ouachita River System. Sampling of all three sites was conducted from late July to early August 2010. This time was selected to target the season that would have the highest ambient temperatures and water temperatures of the year, and lowest water flow, and thus the most likely time for stratification to occur in the water column. Surface water samples were collected three times at RL-2 and OR-2 and twice at OR-11 and analyzed for THg, MeHG, DOC, and physico-chemical parameters; sediment samples were collected and analyzed for MeHg. A diurnal sampling event was implemented at Or-2 to determine any potential fluctuations of Hg and sulfides over a 24-hour period.

Non-parametric statistics were used to compare median values of bottom-water concentrations of HG species and other parameters between sites. Sign-rank and rank-sum tests were used to test the equality of median values, and one-way ANOVA's were used to test for equality of means. Statistical significance was set at $\alpha=0.05$.

Results: All three sites exhibited stratification with respect to temperature and DO, with high temperature and high DO in the shallow depths, and lower temperatures and anoxic conditions in the bottom-water. pH values did not vary much between sites or between water surface and bottom water, while specific conductance for all three sites increased with increasing depth in the water column.

Concentrations of Hg compiled from all three sites show increases from the dissolved MeHg (FMeHg) fraction to total Hg (THg), with the lowest FMeHg concentrations occurring at 0.05 ng/L,just above the MDL (0.04 ng/L), and the highest Hg concentrations occurring in the THg fraction at 13.99 ng/L, calculated as the sum of filtered and particulate THg.

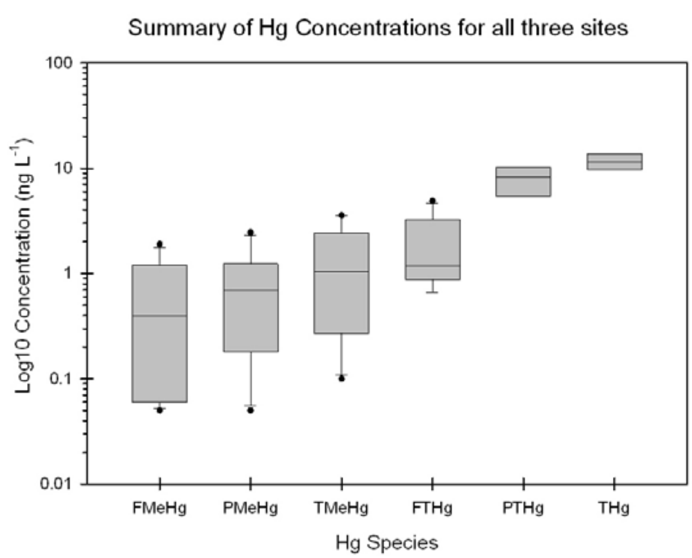

Figure 1: Hg concentrations combined from all three site including mid point water column and bottom-water samples. n=11 for FMeHg, PMeHg, TMeHg, FTHg, n=7 for PTHg, THg

Mercury concentrations in all size fractions and speciation varied between sites (Figure 1). RL-2 had the highest dissolved MeHg and THg as compared to the other sites. OR-11 had the lowest FMeHg, PMeHg, and FTHg, but had the highest PTHg and THg. Hg concentrations at OR-2 were between the other two sites for all size fractions and species. FMeHg and PMeHg at OR-2 showed variability in concentrations between sample days shown by the error bars in Figure 2 representing standard deviation of samples collected on three separate sample days.

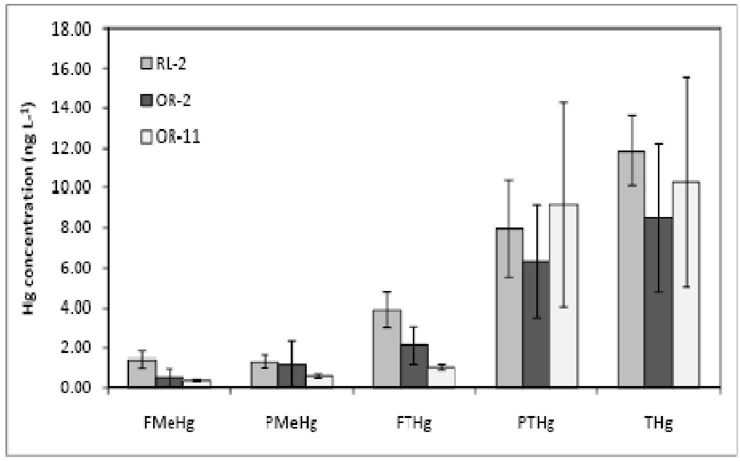

Figure 2: Bottom water concentrations of Hg size fractions and species at all three study sites. N=3 for all sites. Error bars represent standard deviations of samples collected on separate days.

Non-parametric statistics were used to compare bottom-water samples of Hg species and size fractions between sites. There was no statistical difference of median values at the bottom-water for any of the Hg species and size fractions when using rank-sum or sign-rank statistical tests. One-way ANOVA's used to test the difference of means resulted in statistical differences of FMeHg in the bottom-water between RL-2 and OR-11 ($P=0.039$) and FTHg between RL-2 and OR-11 ($P=0.022$) only. All other species and size fractions were not statistically different at the bottom-water between sites. MeHg and THg were positively correlated at the bottom-water for filtered samples, but not significantly correlated for total MeHg (TMeHg) and THg.

Of the three study sites, RL-2 exhibited the highest dissolved MeHg and THg, and particulate MeHg concentrations in the bottom water (Figure 2). Additionally, the highest DOC concentrations were encountered at this site (mean 13.37 mg/L, n=3), and the highest total iron concentration (39.8 mg/L). These data provide evidence for geochemical controls on Hg methylation at this site, as high DOC is often related to high rates of Hg methylation, and high iron concentration gives evidence for redox processes that may have been controlling methylation.

The highest dissolved MeHg concentrations of all three study sites occurred at RL-2 (mean 1.43 ng/L, n=3), which also had the highest DOC concentrations (mean 13.37 mg/L, n=3), highlighting the importance of DOC in Hg methylation processes at this site. The positive linear correlation with DOC and dissolved MeHg (Figure 34) indicates that DOC may not be inhibiting Hg methylation at this site, and is providing an energy source to methylating bacteria, potentially iron reducers, owing to the high iron concentration encountered at this site.

THg and MeHg concentrations at all three study sites on the lower Ouachita River are typically within the range of Hg values reported in the literature for the southeastern United States, and median and mean values exceeded reported concentrations in many areas. The highest dissolved MeHg concentration on the lower Ouachita River system was 1.90 ng/L at RL-2, highlighting the high rates of MeHg production. Although the three study sites on the lower Ouachita are not technically classified as wetlands, they can experience similar fluctuations in water levels as they are hydraulically connected to the main channel of the river, which fluctuates with seasons. These fluctuations do not expose large areas of sediment as compared to most freshwater wetlands. The concentrations of dissolved MeHg at the lower Ouachita sites are much higher than many/most of the regional concentrations, suggesting high rates of methylation, potentially due to similar conditions as explained by Hall, et al. (2008).

Conclusions: Data generated from this study show the spatial variability in geochemistry at the study sites, which has a direct effect on MeHg production. Sites with high DOC had higher concentrations of dissolved MeHg as evidenced by positive correlation between these two constituents. Measureable sulfides in the bottom water at all three sites give evidence for sulfate reduction, yet high absolute values of redox potential indicate that redox potential is not low enough in the bottom-water at the study sites to allow sulfate and iron reduction.

The observed positive linear relation between dissolved MeHg and DOC at the bottom water at all three sites indicates an important influence of DOC on Hg methylation. This relation can be explained by DOC acting as an energy source that stimulates microbial activity, and by low pH in the bottom water providing protons to compete for negatively charged binding sites in DOC that would otherwise be utilized by Hg, thus leaving Hg bioavailable for methylation (Barkay, Gillman and Turner 1997). Channel morphology also plays an important role in the distribution of DOC, and in site specific stratification characteristics.

Measurable sulfide detected at the bottom water at all three sites suggest that sulfate reduction and associated MeHg production may be occurring either in the anoxic water at the base of the water column, at the sediment-water interface, or in sediment pore water with sulfide and MeHg moving out of sediment into the overlying water column. However, ORP values do not show the potential for sulfate reduction in the anoxic bottom waters at the lower Ouachita River sites. Given the conflicting evidence of absolute ORP, further data are needed at corroborate the occurrence of sulfate reduction in the bottom water at these sites including a larger sulfide data set, dissolved iron analysis, and a larger sulfate data set.

Of the three study sites, RL-2 exhibited the highest filtered MeHg, THg, and particulate MeHg concentrations in the bottom water as well as the highest DOC concentrations (mean 13.37 mg/L, n=3). Measureable sulfide at this site indicates that sulfate reduction may be occurring concurrently with iron reduction. It is therefore possible that multiple microbial communities that methylate Hg are responsible for the high concentrations of MeHg at RL-2, potentially even FeRB.

Assessment of seasonal fluctuations of Hg from existing USGS data at sites proximal to the lower Ouachita River sampling sites show peaks in the occurrence of filtered THg and MeHg during late spring, indicating seasonal controls on MeHg production. An increase in the supply of DOC during high precipitation or flood events may increase MeHg production by enhancing microbial activity.

This study provides crucial data describing the extent of Hg contamination in Arkansas, with two of eight bottom-water samples exceeding the numeric water quality standard of 12 ng/L total recoverable Hg in water. As atmospheric Hg deposition increases across the country, the Hg issue in Arkansas only stands to become more prominent, giving impetus for additional research to be conducted on this important environmental issue.

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Thesis or Dissertation: Schenk, Liam. 2011. Geochemical Controls on Mercury Methlyation in Backwaters of a Gulf Coastal Plain River System, Implications for Water Column Processes. Thesis, Master of Science in Geology, University of Arkansas, Fayetteville, Arkansas.

Assessment of water quality and stream bank stability following BMP implementation on the upper Strawberry River watershed

Basic Information

Title:	Assessment of water quality and stream bank stability following BMP implementation on the upper Strawberry River watershed
Project Number:	2010AR249B
Start Date:	3/1/2010
End Date:	2/28/2011
Funding Source:	104B
Congressional District:	AR-001
Research Category:	Not Applicable
Focus Category:	None, None, None
Descriptors:	None
Principal Investigators:	Jennifer L Bouldin

Publication

1. Brueggen, T.R. In progress. Effects of Best Management Practices on the Upper Strawberry River Watershed, Fulton CO, AR. Environmental Sciences, Arkansas State University.

Project Title: Investigation of Land Use and Best Management Practices on the Strawberry River Watershed

Project Team: Dr. Jennifer Bouldin, Environmental Biology, Arkansas State University

Teresa Brueggen, Environmental Sciences, Arkansas State University

Interpretative Summary: Best Management Practices (BMPs) including exclusion of cattle from waterways, providing alternative watering facilities, and use of no-till planting methods have been put into place on three creeks in the upper watershed of the Strawberry River, AR. This study incorporates physical, biological and chemical analyses to determine the effects of the implemented BMPs on water and sediment quality of the three creeks. Protection of upper headwater streams will improve ecosystem integrity downstream in this Ecologically Sensitive Waterbody. This study has the potential to expand the knowledge base of improved water quality from stream-side agricultural BMPs.

Introduction: The Strawberry River Watershed is located in the Ozark Highland Ecoregion of Arkansas and defined as an Extraordinary Resource Water, Ecologically Sensitive Water Body, and Scenic Waterway (ADEQ, 2008). The waters of the Strawberry River support a diversity of species including the endogenous Strawberry River Darter, diverse communities of aquatic macroinvertebrates including several ranked or listed freshwater mussels (Harp and Robinson, 2006). The ADEQ (2008) defines the designated uses for the Strawberry River as Primary and Secondary Contact Recreation, Domestic, Industrial and Agricultural Water Supply. Seven reaches of the Strawberry River Watershed are included in the 303d list as not supporting aquatic life due to excess turbidity (ADEQ, 2008). Land use in the watershed is primarily forested (56.5%) and grassland (35.3%) (ADEQ, 2003), with livestock grazing and hay harvesting for livestock common among the grassland owners. Grazing practices often do not include fencing from the streambed leading to increased bank sloughing. Best management practice implementation is presently underway in the upper watershed and landowner participation is encouraged through an EPA 319 grant issued to the Fulton County Conservation District and Arkansas State University. Upstream and downstream monitoring sites are located on Little Strawberry, Greasy Creek and Sandy Creek.

Methods: Erosion pins were used to assess bank stability and estimate sediment transport from bank erosion. Multiple pins were installed perpendicular into the stream bank. These pins will be installed at the active bank and above the active bank determined at each designated sampling location (Zaimes et al., 2005). A survey of each stream reach quantified the extent of stream with bank instability.

Benthic surveys will be performed with D-frame nets using the traveling kick method. Organisms will be keyed to species according to Merrit et al. (2008) whenever possible and 10% of samples will be referred to a benthic taxonomist for Quality Assurance of identification.

Enumeration of *E. coli* and measures of chlorophyll *a* will be determined monthly. *Escherichia coli* and chlorophyll *a* concentrations will be determined using the filtration technique in accordance with the American Public Health Association (APHA, 2005).

Aqueous and sediment toxicity studies will be performed in the fall and spring. Bioassays will be used to measure the presence of toxicity. *Ceriodaphnia dubia* and *Pimphales promelas* will be used in whole effluent toxicity (WET) 7-d chronic tests, in accordance with the EPA guidelines (2002) to determine aqueous toxicity. Presence of sediment toxicity will be measured using *Chironomus dilutus* with a 10-d acute toxicity test in accordance with EPA guidelines (2000).

Results: Approximately 5480 m of stream bank was assessed within the Little Strawberry Creek. It was determined that there were 24 sites of severe or very severe erosion totaling approximately 746 m of stream bank. Approximately 6340 m of stream bank were assessed of Greasy Creek. In this stretch 16 sites were determined as severely or very severely eroded totaling approximately 500 m. Approximately 13260 m of stream bank was assessed of Sandy Creek. Twenty two sites were classified with severe or very severe erosion totaling approximately 505 m. An assessment of the erosion pins was performed in October 2010.

In spring and fall 2010 benthic macroinvertebrate collections, 2705 and 1328 total organisms were collected, respectively (Fig 1). Sandy Creek upper site was not sampled fall 2010 due to dry conditions. This included the following: Coleoptera, Diptera, Ephemeroptera, Hemiptera, Megaloptera, Odonata, Plecoptera,Trichoptera, Decapoda, and Mollusca. Total family diversity between sites for spring and fall ranged from 2-24 and 6-19, respectively (Fig 2).

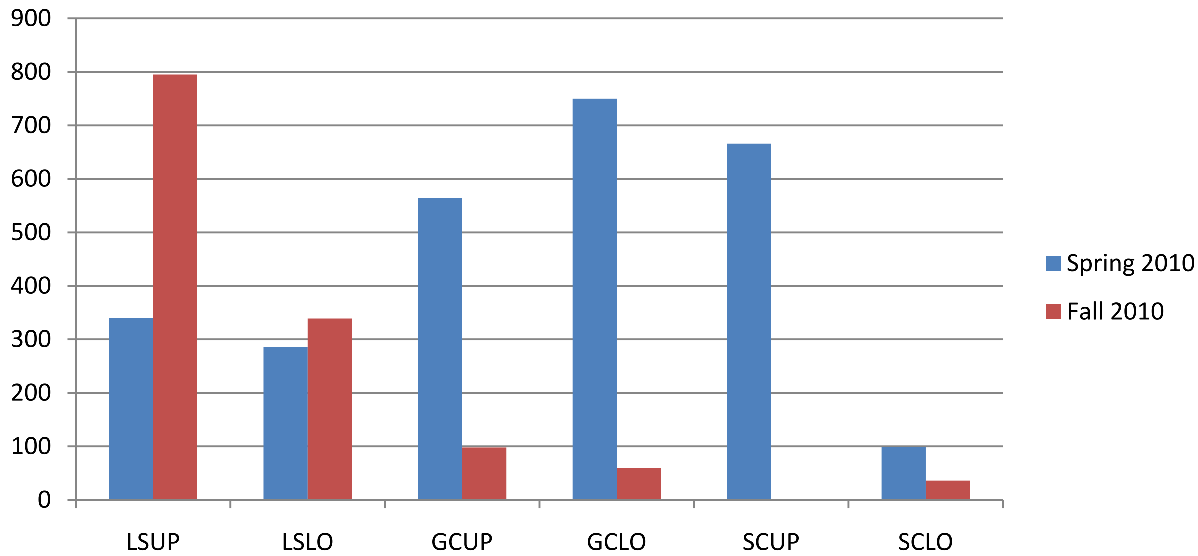

Figure 1. Total number of organisms collected at monitoring sites in the upper watershed of the Strawberry River. Little Strawberry (LS), Greasy Creek (GC), Sandy Creel (SC), upper location (UP) and lower location (LO). SCUP not sampled fall 2010 due to dry sampling location.

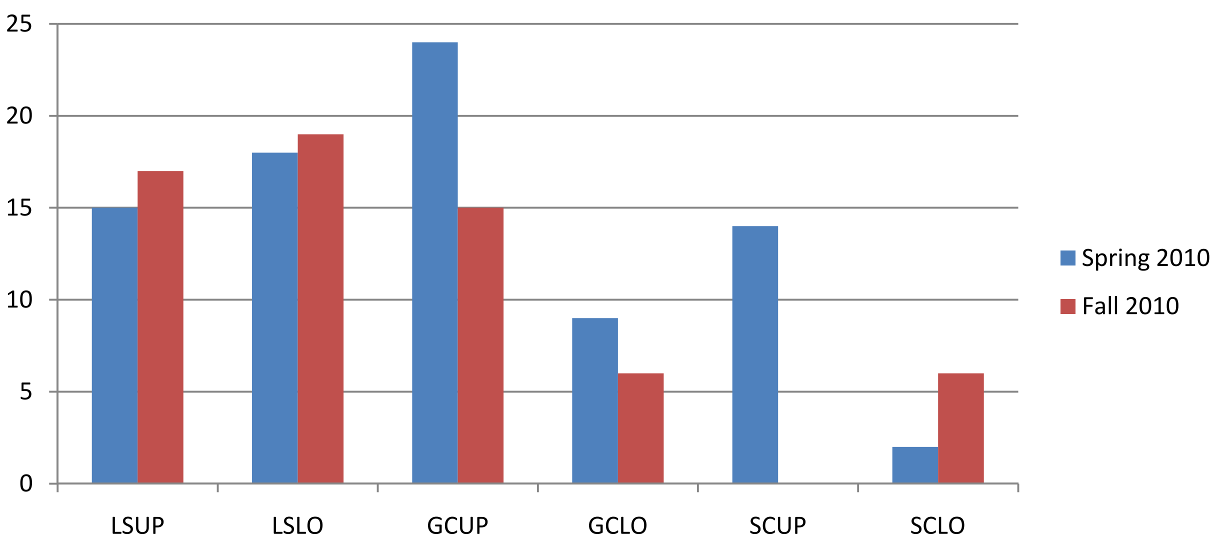

Figure 2. Total number of families identified at monitoring sites in the upper watershed of the Strawberry River. Little Strawberry (LS), Greasy Creek (GC), Sandy Creel (SC), upper location (UP) and lower location (LO). SCUP not sampled fall 2010 due to dry sampling location.

E. coli mean values ranged from 51-215 colony forming units (CFUs). No single sample concentrations exceeded allowable limits (APCEC, 2010). Little Strawberry upper site indicated significant lethal aqueous toxicity using *P. promelas* in Spring 2010 and lethal sediment toxicity in Fall 2010.

Conclusions: This is an ongoing study; therefore, final conclusions are limited. It is evident that multiple years of analysis assessing physical, chemical and biological parameters are vital to evaluate the impact of implemented BMPs. Much variability can occur from year to year as environmental parameters outside of the researcher's control fluctuate (e.g. rainfall, temperature).

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Thesis or Dissertation:

Brueggen, T.R. In progress. Effects of Best Management Practices on the Upper Strawberry River Watershed, Fulton CO, AR. Environmental Sciences, Arkansas State University.

Denitrification, Internal N Cycling, and N Retention in River Impoundment Reservoirs

Basic Information

Title:	Denitrification, Internal N Cycling, and N Retention in River Impoundment Reservoirs
Project Number:	2010AR252B
Start Date:	3/1/2010
End Date:	2/28/2011
Funding Source:	104B
Congressional District:	3
Research Category:	Water Quality
Focus Category:	Geochemical Processes, Nutrients, Sediments
Descriptors:	None
Principal Investigators:	Jefferson Thad Scott

Publication

1. Grantz, E. 2011. Denitrification efficiency in water impoundment reservoirs, Department of Crop, Soil, and Environmental Sciences, University of Arkansas.

Project Title: NITROGEN RETENTION AND DENITRIFICATION EFFECIENCY IN WATER IMPOUNDMENTS

Project Team: J. Thad Scott, Department of Crop, Soil, and Environmental Sciences, Univ. of Arkansas

Interpretative Summary: Reactive nitrogen loss from human-impacted landscapes may be degrading water quality in downstream coastal environments. This project was conducted to determine what role water impoundment reservoirs play in attenuating reactive N from surface waters by transformation to N2 gas via denitrification. Over the last two years we sampled three reservoirs in Northwest Arkansas to determine their capacity to store and transform reactive N. We collected intact sediment cores to quantify denitrification rates, created N mass balances, and developed a new method for estimating whole-ecosystem N2 flux data from thermally stratified reservoirs. Our data suggest that reservoirs are indeed important N sinks and that a substantial portion of stored N is eventually denitrified.

Introduction: Denitrification in water impoundment reservoirs may remove substantial quantities of reactive N from surface waters, but few comprehensive denitrification studies have been conducted on reservoirs (David et al. (2006). More work is needed to quantify denitrification rates in reservoirs and the factors that cause rates to vary across space and time. In particular, these studies should address what percentage of N retention is caused by denitrification. Developing a thorough understanding of the factors that control denitrification in reservoirs will allow us to maximize reservoir N retention through proper reservoir management.

In this study we measured sediment denitrification rates, seasonal ecosystem-scale denitrification, and N storage (mass balance) in three water impoundment reservoirs in Northwest Arkansas. The objective of the study was to quantify denitrification rates in these reservoirs and estimate what portion of stored N in the reservoirs is ultimately denitrified.

Methods: We used intact sediment cores collected from epilimnetic sediments during spring and summer stratification periods, and all sediments during winter mixing, to estimate the rate of denitrification in sediments. Denitrification on intact cores was estimated using a mass balance on N2 concentrations occurring in the inflow and outflow of flow-through core chambers. N2 concentrations were derived from the N2/Ar ratio, measured using membrane inlet mass spectrometry.

Hypolimnetic denitrification was estimated by monitoring the N2/Ar ratio in the hypolimnion of the three study reservoirs through the period of summer stratification in 2010. Briefly, water samples from 4m, 6m, and 8m were collected weekly and preserved immediately with zinc chloride. N2/Ar ratio of these samples was measured using MIMS as described previously. The rate of N2 accumulation was estimated by assuming that Ar concentrations were controlled only by temperature and that the slope of a statistically significant linear regression of N2 concentration versus time represented the N2 accumulation rate.

Nitrogen retention in reservoirs was calculated as the difference between riverine N inputs and outputs. Nitrogen inputs to reservoirs were estimated using the rating curve method (Shivers and Moglen 2008). Briefly, a relationship between stream stage, streamflow, and total N concentrations were derived for inflowing and outflowing streams to estimate N inputs from continuously monitored stream stage. Yields from gauged streams were applied to ungauged streams to estimate whole-system inputs.

Results:

Epilimnetic Sediment Denitrification – Average net sediment N2 flux rates for all three lakes are provided in Figure 1. All three lakes exhibit net denitrification (i.e. positive net N2 flux) during winter. This condition coincides with measurable nitrate-nitrogen (NO3-N) in the lakes during this time. Spring and summer net N2 flux was either negative (i.e. net N2 fixation in May 2010) or zero (i.e. equal amounts of denitrification and N2 fixation). Nitrate concentrations in the epilimnion of these lakes during summer is below detection levels and is probably the limiting factor that inhibits denitrification and cause net zero sediment N2 flux from epilimnetic sediments during spring and summer stratification.

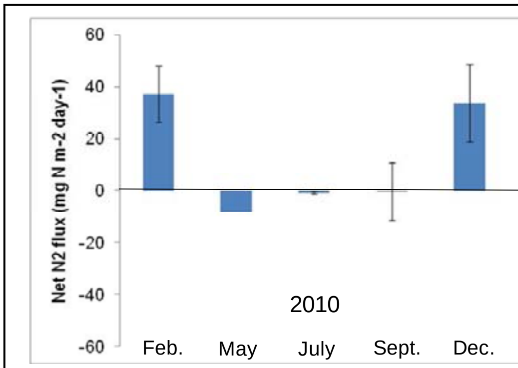

Figure 1. Average Net N2 flux rates derived from intact core experiments on all three study lakes.

Hypolimnetic Denitrification – Hypolimnetic N2 accumulation from one of the study lakes is shown in Figure 2. N2 gas accumulated at a linear rate throughout

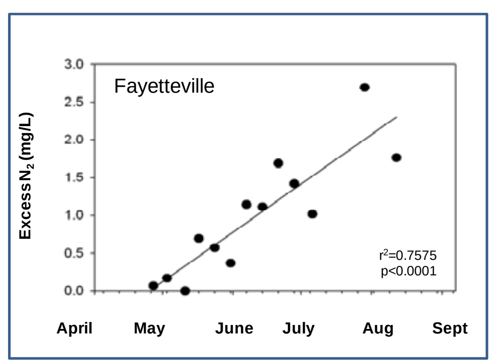

Figure 2. Hypolimnetic N2 accumulation in Lake Fayetteville, one of the three study reservoirs.

the period of spring and summer stratification in Lake Fayetteville. The N2 accumulation in the hypolimnion was equivalent to a denitrification rate of 62 mg N m-2 day-1. When combined with sediment denitrification rates, the whole-ecosystem denitrification flux in Lake Fayetteville was 17 ± 9 (S.D.) g N m-2 year-1.

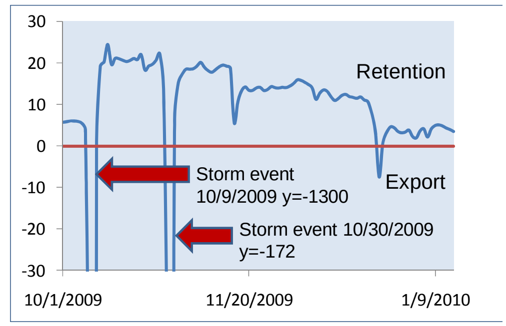

Figure 3. Nitrogen mass balance for Lake Fayetteville. Positive values equal N storage and negative values indicate net N export.

<u>Whole-lake N mass balance</u> – An example of whole-lake N mass balance for Lake Fayetteville is shown in Figure 3. We are currently developing mass balance estimates for the entire study period. Nitrogen storage and export was highly dependent upon hydrology. During baseflow conditions the reservoirs were tremendous N sinks. However, the reservoirs acted as net N sources from brief periods during storm events. When considered together, preliminary estimates indicate that the reservoirs store between 10 – 50 g N m-2 year-1.

Conclusions: Reservoirs can be substantial N sinks and are hotspots for denitrification. As much as 50 g N m-2 year-1 may be trapped by reservoirs, and between 34 – 100% of this stored N is eventually denitrified. These estimates are preliminary and require substantial refinement. However, these preliminary data suggest that reservoirs are very import N sinks and transformers in the landscape that protect downstream water quality by permanently removing reactive N from surface waters.

References:

David, M.B., L.G. Wall, T.V. Royer, and J.L. Tank. 2006. Denitrification and the nitrogen budget of a reservoir in an agricultural landscape, Ecological Applications, 16: 2177 – 2190

Thesis or Dissertation:

Grantz, E. 2011. Denitrification efficiency in water impoundment reservoirs, Department of Crop, Soil, and Environmental Sciences, University of Arkansas.

Information Transfer Program Introduction

Dissemination of information is one of the main objectives of the Arkansas Water Resources Center. To achieve this objective, AWRC sponsors an annual water conference held in Fayetteville, Arkansas, which draws approximately 100 researchers, students, agency personnel, and interested citizens to learn about urgent research and hot topics in water resources throughout the State. AWRC also co-sponsors workshops and other water related conferences in the state and region.

The AWRC maintains a technical library containing over 900 titles, many of which are available online. This valuable resource is utilized by a variety of user groups including researchers students, regulators, planners, lawyers and citizens. Many of the AWRC library holdings have been converted to electronic PDF format which can be accessed via the AWRC website at www.uark.edu/depts/awrc/publications.htm. AWRC is continuing to add archived documents from the library to this electronic data set, and all new titles are added when received.

Arkansas Water Resources Center Information Transfer Program

Basic Information

Title:	Arkansas Water Resources Center Information Transfer Program
Project Number:	2010AR245B
Start Date:	3/1/2010
End Date:	2/28/2011
Funding Source:	104B
Congressional District:	3
Research Category:	Not Applicable
Focus Category:	Surface Water, Groundwater, Water Use
Descriptors:	None
Principal Investigators:	Brian E. Haggard

Publications

1. Massey, L.B., B.E. Haggard, J.M. Galloway, K.A. Loftin, M.T. Meyer, and W.R. Green. 2010. Antibiotic fate and transport in three effluent-dominated Ozark streams. Ecological Engineering36(7): 930-938.
2. Haggard, B.E., A.N. Sharply, L.B. Massey and K.M. Teague. 2010. Final Report to the Illinois River Watershed Partnership: Recommended Watershed Based Strategy for the Upper Illinois River Watershed, Northwest Arkansas. Arkansas Water Resources Center, Fayetteville, Arkansas. Miscellaneous Publication 355: 126 pp. In Press.
3. Haggard, B.E., A. Sharpley, and L. Massey eds. 2010. Handbook of Best Management Practices for the Upper Illinois River Watershed and Other Regional Watersheds. Arkansas Water Resources Center, Fayetteville, Arkansas. Miscellaneous Publication 357:120 pp.
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6. Pennington, J.H., K.A. Teague, and L.B. Massey. 2010. Agricultural Conservation Practices and Programs in Handbook of Best Management Practices for the Upper Illinois River Watershed and Other Regional Watersheds, Haggard, Sharpley and Massey, Eds. Arkansas Water Resources Center, Fayetteville, Arkansas. Miscellaneous Publication 357: 57-82.
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8. Massey, L.B. and B.E. Haggard. 2010. Water Quality Monitoring and Constituent Load Estimation in the Kings River near Berryville, Arkansas, 2009. Arkansas Water Resources Center, Fayetteville, Arkansas. Miscellaneous Publication 361: 16 pp.
9. Massey, L.B., B.E. Haggard, R.S. Avery, and R.A. Morgan. 2010. Water Quality Monitoring and Constituent Load Estimation in the Upper White River Basin, 2009. Arkansas Water Resources

Center, Fayetteville, Arkansas. Miscellaneous Publication 362: 40 pp.

10. Massey, L.B. and B.E. Haggard. 2010. Water Quality Monitoring and Constituent Load Estimation in the Upper Illinois River Watershed, 2009. Arkansas Water Resources Center, Fayetteville, Arkansas. Miscellaneous Publication 363: 52 pp.
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12. Massey, L.B. and B.E. Haggard., 2010. A Volunteer Water Quality Monitoring Program in the Upper Illinois River Watershed, Northwest Arkansas. A Community on Ecosystem Services 2010 Conference, Phoenix, Arizona, December 6-9, 2010.
13. Haggard, B.E., A.N. Sharpley, L.B. Massey and N. Hardiman. 2010. HUC 12 Watershed Prioritization along a Water Quality and Land Use Gradient: Upper Illinois River Watershed Management Plan. USDA-NIFA 2010 Land Grant and Sea Grant National Water Conference. February 21-25, 2010. Hilton Head, South Carolina.
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23. Busch, D. and B. Haggard. 2010. Alternative Surface-Water Sampling Methods. UW Platteville, Pioneer Farms: Producer Driven Agricultural Research, 2 pp.
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ARKANSAS WATER RESOURCES CENTER

AWRC

2010 Annual Research and Watershed Conference

April 13-14, 2010 · Fayetteville, Arkansas
University of Arkansas

A segment of Niokaska Creek at Gulley Park in Fayetteville, Arkansas restored by the Watershed Conservation Resource Center using a natural channel design approach. Photo Credit: Spring Rose Wood/WCRC

UNIVERSITY OF ARKANSAS
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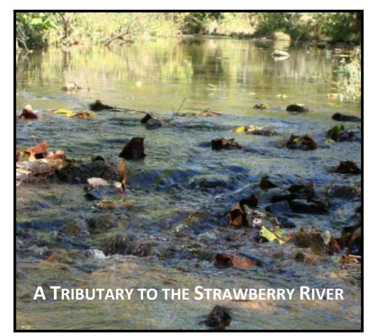
THE WATER RESOURCES RESEARCH ACT

In 1964, Congress passed the Water Resources Research Act, establishing 54 water resources research institutions like Arkansas Water Resources Center at land grant universities throughout the United States. The State Water Resources Research Center Institutes were charged with arranging for competent research that addresses water problems and enhances our understanding, aiding the entry of new research scientists into water resources fields, helping to train future water scientists and engineers, and transferring results of sponsored research to water managers and the public.

Each fall, the AWRC accepts applications for projects funded through the 104b program. This year, the Arkansas Water Resources Center funded three projects including:

- Determination of the magnitude of mercury methylation in the water column of a high organic carbon river, lower Ouachita River, Union and Ashley Counties, Arkansas, Phil Hays, University of Arkansas and US Geological Survey, $19,761.
- Assessment of water quality and stream bank stability following BMP implementation on the upper Strawberry River watershed, Jennifer Bouldin, Arkansas State University, $22,000.
- Denitrification, internal nitrogen cycling and nitrogen retention in river impoundment reservoirs, Thad Scott, UA Division of Agriculture, $20,579.



A TRIBUTARY TO THE STRAWBERRY RIVER

AWRC Annual Conference Program at a Glance

Tuesday April 13, 2010

7:45-8:15	Coffee, Juice, Pastries
8:15- 9:30	Session 1: Groundwater Issues near Eureka Springs, Arkansas
9:30-9:45	Refreshment Break
9:45-11:35	Session 2: Emerging Issues Facing Groundwater in Arkansas
11:35-12:30	Lunch Break
12:30-1:30	Poster Session and Student Poster Competition
1:30-3:00	Session 3: Reservoirs—Understanding and Managing Ecosystem Services
3:00-3:15	Refreshment Break
3:15-5:00	Session 4: Water Supply Reservoirs—Research Needs and Consortium Possibilities
8:00-9:30	Social at Damgoode Pies

Wednesday April 14, 2010

7:45- 8:15	Coffee, Juice, Pastries
8:15- 10:10	Session 5: Improving Aquatic Habitat, Water Quality, and Riparian Areas through Stream Restoration and Bank Stabilization Projects
10:10-10:30	Coffee Break
10:30-11:30	Session 6: Improving Aquatic Habitat, Water Quality, and Riparian Areas through Stream Restoration and Bank Stabilization Projects—Continued
11:55-1:00	Lunch (On Your Own)
1:00-5:00	Field Tour of West Fork White River Stream Restoration at Brentwood (Meet in front of the Cosmopolitan Hotel)

Oral Session Schedule

Tuesday April 13, 2010

Session 1: Groundwater Issues near Eureka Springs, Arkansas
Moderator: Susan Bolyard, U.S. Geological Survey

8:15	Welcome and Introduction, Brian Haggard, Director, AWRC
8:20	The Crumbling Karst of Eureka Springs, Arkansas, Jim Helwig, Consulting Geologist, Eureka Springs (jahelwig@hotmail.com)
8:50	Emerging Contaminants Analysis Results for a Single Sampling Event at Eureka Springs, Arkansas—Implications for the Status of Groundwater Quality, Phillip Hays, U.S. Geological Survey (pdhays@usgs.gov)
9:10	Results of Initial Reconnaissance of Major Ions, Trace Metals and Nutrients in Groundwater in Eureka Springs, Roger Miller, Arkansas Department of Environmental Quality (millerr@adeq.state.ar.us)
9:30	Follow-up Discussion, Questions and Refreshment Break

Session 2: Emerging Issues Facing Groundwater in Arkansas
Moderator: Phil Hays, U.S. Geological Survey

9:45	Industry Perspective on Shale Gas Drilling and Production on Water Resources, Doug Melton, Southwest Energy Company, (Doug_Metlton@swn.com) *Key Note Speaker*
10:10	Regulatory Perspective on Shale Gas Drilling and Production on Water Resources, Chris Davidson, U.S. Fish and Wildlife Service (chris_davidson@fws.gov) *Key Note Speaker*
10:35	Hot Springs Management Strategy for Recharge Protection, Steve Rudd, National Parks Service (stephen_rudd@nps.gov)
11:00	Surface Water and Groundwater Interaction: Using Groundwater Geochemistry to Assess River-Water Infiltration and Natural geochemical Evolution in the Arkansas river Alluvial Aquifer, Tim Kresse, U.S. Geological Survey (tkresse@usgs.gov)

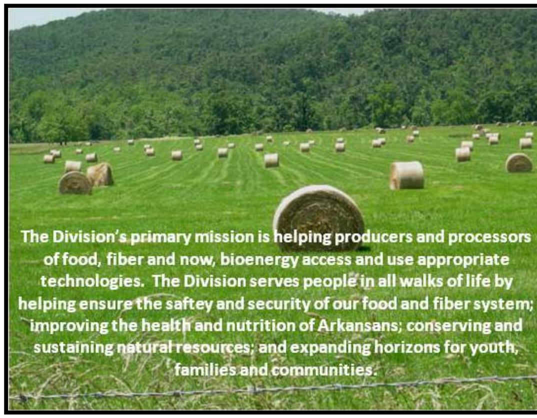
Lunch and Poster Session

11:35- 12:30	Lunch Break – Penguin Ed's Barbeque (Foyer and Room 405)
12:30- 1:30	Poster Session and Student Poster Competition (Presenters should stand at Posters, Room 405)

Notes

Penguin Ed's BBQ

11:35-12:30 in the Foyer
Sponsored by UA Division of Agriculture



UNIVERSITY OF ARKANSAS
DIVISION OF AGRICULTURE
Arkansas Is Our Campus

Poster Session

12:30-1:30 in Rooms 405-407
Sponsored by UA Division of Agriculture

Poster presenters will be at their posters from 12:30-1:30.

Student Poster Competition:

Several students are participating in the student poster competition this year. On the form provided in your folder, please rank the top three student posters based on the poster itself, as well as the student's ability to answer questions. Please return the completed form to the registration desk by 5 PM on Tuesday. The winner of the student poster competition will be announced during the social Tuesday evening.

LIST OF POSTERS:

1. Persistence of Broad-Host-Range Plasmids in Municipal Wastewater Treatment Plants Utilizing Chlorination and UV-Irradiation Disinfection Regimes. K.L. Asfahl*, T. Akiyama and M.C. Savin, Department of Crop, Soil and Environmental Sciences, University of Arkansas, kasfahl@uark.edu.
   Student Poster Presenter.

2. Biologically-Mediated Phosphorus Flux in Illinois River Tributaries. B. Drake* and J.T. Scott, Department of Crop, Soil and Environmental Sciences, University of Arkansas, mdrake@uark.edu.
   Student Poster Presenter.

3. Assessment of OHV Trails in the Lee Creek Watershed. P.R. Easley* and Don Clover, Fort Smith Utility, RandyE@fortsmithar.gov.

4. Tangential Flow, Ultrafiltration and Molecular Detection of Human and Animal Enteric Viruses in Environmental Water Samples. K. Gibson, Johns Hopkins Bloomberg School of Public Health, kgibson@jhsph.edu.

5. Nitrogen Retention and Denitrification Efficiency in Reservoirs. E.M. Grantz* and J.T. Scott, Department of Crop, Soil and Environmental Sciences, University of Arkansas, egrantz@uark.edu.
   Student Poster Presenter.

6. Designing a Demonstration of Nutrient Removal from a Wastewater Treatment Process Utilizing an Algal Growth Bed. J. Hickle and E. Boles. Department of Biological and Agricultural Engineering, University of Arkansas, jphickle@uark.edu, e.boles@uark.edu.
   Student Poster Presenter.

7. Modeling Watershed Scale Sediment Loading in the West Fork of the White River using the Soil and Water Assessment Tool. C. N. Jones*, M.D. Leh, and S.G. Bajwa, Department of Biological and Agricultural Engineering, University of Arkansas, cnj001@uark.edu.
   Student Poster Presenter.

8. Application of the Annualized Agricultural Non-Point Source (AnnAGNPS) Model in the West Fork White River Watershed. M.D. Leh*, S.G. Bajwa and I. Chaubey, Department of Biological and Agricultural Engineering, University of Arkansas, mleh@uark.edu.

9. Cooperative Stakeholder Engagement for Fostering Participation and Gaining Effective Results. J.H. Pennington*, J. Popp, G. Rodriguez, I. Chaubey, and E. Gbur, Washington County Cooperative Extension, jhpennington@uaex.edu

10. Outreach and Education at Its Finest: Working with all Stakeholder Groups to Address Water Quality Issues in an Impaired Watershed. J.H. Pennington* and K. Teague, Washington County Cooperative Extension, jhpennington@uaex.edu

11. Sediment-Water Column Interaction for Streams in the Upper Illinois River Watershed. C.W. Rogers*, A.N. Sharpley, and B.E. Haggard, Department of Crop, Soil and Environmental Sciences, University of Arkansas, cwrogers@uark.edu.
    Student Poster Presenter.

12. Effects of Natural Gas Drilling on Stream Quality and Periphyton in the Fayetteville Shale. A. Jackson, M. Evans-White*, and S. Entrekin, Department of Biological Sciences, University of Arkansas, mevanswh@uark.edu.

13. Cooling Broiler Chickens with Less Water Using Controlled Surface Wetting Method. Y. Liang*, G.T. Tabler, S. Watkins, and I. Berry, Department of Biological and Agricultural Engineering, yliang@uark.edu

14. Connecting Arkansans to their Watershed. S. DeVries* and K. Finefield, Arkansas Watershed Advisory Group, DEVRIES@adeq.state.ar.us.

NOTES

TUESDAY APRIL 13, 2010

SESSION 3: RESERVOIRS—UNDERSTANDING AND MANAGING ECOSYSTEM SERVICES
MODERATOR: THAD SCOTT, UA DIVISION OF AGRICULTURE

1:30 Water Management 101—Corps of Engineers Little Rock District, Janis Jones, US Army Corps of Engineers (jan.r.jones@usace.army.mil)
2:00 Reservoir Eutrophication—déjà vu All Over Again, Kent Thornton, FTN & Associates (kwt@ftn-assoc.com)
2:15 Eutrophication Trends Inferred from Hypolimnetic Dissolved Oxygen Dynamics within Selected White River Reservoirs, Northern Arkansas-Southern Missouri, 1974-2008, Reed Green, Jeanne DeLanois and Drew Westerman, U.S. Geological Survey (wrgreen@usgs.gov)
2:30 General Principles of Sedimentation in Ozark Reservoirs, Steve Boss, University of Arkansas (sboss@uark.edu)
2:45 Reservoir Fisheries Management: The Basics and Conflicts, Darrell Bowman, Bella Vista Property Owners Association (DarrellB@bwpoa.com)
3:00 Refreshment Break

SESSION 4: WATER SUPPLY RESERVOIRS—RESEARCH NEEDS AND CONSORTIUM POSSIBILITIES
MODERATOR: BOB MORGAN, BEAVER WATER DISTRICT

3:15 Regulated Drinking Water Contaminants in Arkansas Reservoirs, Robert Hart, Arkansas Department (Robert.Hart@arkansas.gov)
3:30 Water Quality Concerns and Research Needs—Fort Smith Water Supplies, Randy Easley, Fort Smith Utility (RandyE@fortsmithar.gov)
3:45 Water Quality Concerns and Research Needs—Russellville Water Supplies, Craig Noble, Russellville Water Utilities (cnoble@citycorporation.com)
4:00 Qualitative Risk Assessment for Lake Maumelle, Martin Maner, Central Arkansas Water (Martin.Maner@carkw.com)
4:15 Water Quality Concerns and Research Needs—Lake Wister, OK, Steve Patterson, Bio x Design (spatterson5000@earthlink.net)
4:30 Baylor's Research-Management Partnership Experience: The Center for Reservoir and Aquatic Systems Research, Robert Doyle, Baylor University (Robert_Doyle@baylor.edu)
4:45 Follow-up Discussion, Questions and Next Steps

NOTES

BEAVER WATER DISTRICT

For 50 years, Beaver Water District has supplied Northwest Arkansas with clean, safe drinking water from Beaver Lake. The District's state-of-the-art Administration Center is certified GOLD by the U.S. green Building Council's Leadership in Energy and Environmental Design (LEED®) guidelines.

301 N. Primrose Road | Lowell, AR 72745
479.756.3651 | www.bwdh2o.org

DAMGOODE PIES SOCIAL

Tuesday, April 13 from 8:00-9:30 PM
Sponsored by Hach Environmental

Damgoode Pies is located at 37 East Center Street
(Just East of the Square)
~ 2 minute walk from the Cosmopolitan Hotel

WEDNESDAY APRIL 14, 2010

SESSION 5: IMPROVING AQUATIC HABITAT, WATER QUALITY, AND RIPARIAN AREAS THROUGH STREAM RESTORATION AND BANK STABILIZATION PROJECTS
MODERATOR: MAT VAN EPPS, WATERSHED CONSERVATION RESOURCE CENTER

8:15 Stream Channel Process and Ecological Services, Eric Cummings, UA Division of Agriculture (ecummin@uark.edu)

8:40 Prioritizing Stream Reaches for Restoration on the West Fork White River, Sandi Formica, Watershed Conservation Resource Center (formica@watershedconservation.org)

9:10 Designing and Constructing Stream Restoration to Improve Habitat for Fish and Mussel Species of Concern in the Saline River, Joy DeClerk, The Nature Conservancy (jdeclerk@tnc.org)

9:40 Improving Arkansas Fisheries and Providing Hands-On Environmental Education through Streambank Restoration Projects, Dave Evans and Tim Burnley, Arkansas Game & Fish Commission (daevans@agfc.state.ar.us; tburnley@agfc.state.ar.us)

10:10 Refreshment Break

SESSION 6: IMPROVING AQUATIC HABITAT, WATER QUALITY, AND RIPARIAN AREAS THROUGH STREAM RESTORATION AND BANK STABILIZATION PROJECTS—CONTINUED
MODERATOR: MARTY MATLOCK, CENTER FOR AGRICULTURAL AND RURAL SUSTAINABILITY

10:30 Addressing Headwater Streams as a Sediment Source in the Delta, Matt Lindsey, The Nature Conservancy (mlindsey@tnc.org)

11:00 Design and Construction of a Streambank Stabilization Project to Improve Habitat for the Yellowcheek Darter and Speckled Pocketbook Mussel in the Little Red River Watershed, Josh Duzan and Ethan Inlander, The Nature Conservancy (jduzan@tnc.org; einlander@tnc.org)

11:30 Design and Implementation of Urban and Rural Stream Restoration to Reduce Sediment and Phosphorus Loadings in the Illinois River and Beaver Lake Watersheds, Matt Van Eps, Watershed Conservation Resource Center (vaneps@watershedconservation.org)

11:55 Lunch Break (On Your Own)

NOTES

FIELD TOUR OF WEST FORK WHITE RIVER STREAM RESTORATION AT BRENTWOOD
TOUR LEADERS: SANDI FORMICA AND MATT VAN EPS, WATERSHED CONSERVATION AND RESOURCE CENTER

You are invited to join us for a field tour of the West Fork White River Stream Restoration Project at Brentwood. The project site is about 20 minutes from Fayetteville, just off of Highway 71 South at the community of Brentwood. Wear comfortable clothes and walking shoes. Also bring water and bug spray. Transportation is provided; please meet in front of the Cosmopolitan Hotel by no later than 1:00 PM. It takes approximately one and a half to two hours to walk and discuss the site, so plan to be back at the hotel before 4:00 PM. If you are headed south that day, you may want to bring your own vehicle.

The Watershed Conservation Resource Center (WCRC) worked with local landowners and partners to restore a 1,600 ft section of the West Fork White River (WFWR) near Brentwood, AR. A natural channel stream restoration design was developed and implemented for the unstable section of river, which had streambank erosion rates as high as 13 ft/year and was contributing an average of 1,400 tons of sediment for an average flow year. The new channel design resulted in locating the river away from severely eroding banks and eliminating abrupt and sharp turns in the river channel. Structures made of natural materials were constructed to deflect higher velocity flow toward the center of the channel, further reducing near-bank shear stress and minimizing erosion. The old channel was converted into a series of four settling ponds that act as ephemeral wetlands. Hundreds of native trees, shrubs, and grasses were planted and native grass and wildflower seeds were distributed throughout the site to provide erosion control, improve the riparian areas, and enhance the terrestrial habitat. The project was funded by an EPA Section 319(h) grant administered by the Arkansas Natural Resources Commission with matching funds provided by project partners. Through this project, accelerated streambank erosion has been eliminated; aquatic habitat has been improved; riparian areas have been enhanced; and sediment loadings to the WFWR from this site have been reduced by over 97% improving the WFWR and Beaver Lake's water quality.

Project Partners

Arkansas Natural Resource Commission
U.S. Environmental Protection Agency
Watershed Conservation Resource Center
Arkansas Game & Fish Commission

NOTES

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USGS Summer Intern Program

None.

Student Support					
Category	**Section 104 Base Grant**	**Section 104 NCGP Award**	**NIWR-USGS Internship**	**Supplemental Awards**	**Total**
Undergraduate	4	0	0	3	7
Masters	2	0	0	2	4
Ph.D.	3	0	0	0	3
Post-Doc.	0	0	0	0	0
Total	9	0	0	5	14

Notable Awards and Achievements

Brian Haggard, Director of the Arkansas Water Resources center received the College of Engineering Outstanding Researcher award for the department of Biological and Agricultural Engineering at the University of Arkansas, 2010-2011.