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Arkansas Water Resources Center Annual Technical Report FY 2008

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This publication serves as the annual report the U.S. Geological Survey regarding the projects and activities of the Arkansas Water Resources Center for FY 2008. This document provides summary information for each of the 104 b projects funded 1) Long-term runoff water quality in response to natural rainfall as affected by poultry litter application rate; 2) Source of Geosmin and MIB in drinking water: Identifying the source and mechanisms of taste and odor compounds at Beaver Reservoir, northwest Arkansas; 3) Continuous water-quality monitoring and potential phosphorus source identification with oxygen isotopes; 4) Metal mobilization, especially arsenic in the in the alluvial aquifer in response to water level fluctuations measured by field and laboratory column data; 5) Role of fluvial sediments in Modifying phosphorus export from northwest Arkansas watersheds; 6) Spatial and historical distribution of Geosmin and MIB producers in Beaver Reservoir, northwest Arkansas; 7) Biogeochemical controls and interactions of carbon and nutrient cycling in karst hydrologic systems. This publication also summarizes the Arkansas Water Resources Center information transfer program, student involvement, notable awards and achievements, and publications of previous 104 b projects.

Introduction

The Arkansas Water Resources Center (AWRC), 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. The AWRC in cooperation with the US Geological Survey, and the National Institute for Water Resources has helped local, state and federal agencies learn to manage Arkansas' water resources for more than 30 years.

The AWRC's statewide mission is to 1) arrange for competent research that addresses water problems and enhances our understanding; 2) aid the entry of new research scientists into water resources fields; 3)help to train future water scientists and engineers; and 4)transfer results of sponsored research to water managers and the public.

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 land use mapping, erosion and pollution, water quality, and ecosystems.

AWRC acts 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.

In addition, the AWRC sponsors an annual water conference held in Fayetteville, Arkansas each spring, drawing over 100 researchers, 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, farmers and others.

The AWRC has a technical advisory committee made up of professionals from educational institutions, environmental organizations, 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

None.

Long-term runoff water quality in response to natural rainfall as affected by poultry litter application rate

Basic Information

Title:	Long-term runoff water quality in response to natural rainfall as affected by poultry litter application rate
Project Number:	2007AR162B
Start Date:	3/1/2007
End Date:	12/31/2008
Funding Source:	104B
Congressional District:	3
Research Category:	Water Quality
Focus Category:	Non Point Pollution, Water Quantity, Surface Water
Descriptors:	
Principal Investigators:	Kristofor R. Brye

Publication

Project Title: LONG-TERM RUNOFF WATER QUALITY IN RESPONSE TO NATURAL RAINFALL AS AFFECTED BY POULTRY LITTER APPLICATION RATE

Project Team: Kristofor Brye, Department of Crop, Soil and Environmental Sciences, University of Arkansas

Interpretative Summary: Land-applied poultry litter as fertilizer could contribute nutrients and heavy metals to surface runoff following storm events. Evaluating runoff water quality response to natural precipitation over an extended period may be key to ascertaining long-term impacts of surface-applied broiler litter.

Introduction: Poultry litter contains many water-soluble constituents, such as nitrogen (N) and phosphorus (P) that are beneficial plant nutrients; thus poultry litter is often land applied as fertilizer. Decades of manure land application to pasture soils in the Ozark highlands have resulted in high levels of P in soils throughout northwest Arkansas.

Since poultry litter is land applied without incorporation, it is subject to off-site transport from surface runoff and overland flow. Consequently, animal waste disposal and surface and groundwater quality are major issues in areas with large concentrations of confined animal-feeding operations. Therefore, an accurate quantification of runoff and solutes from land surfaces under natural field conditions is essential to understanding the fate and transport of soluble constituents added to an ecosystem via poultry litter. This objective of this research project is to continuously monitor runoff and solute losses in runoff from pasture amended with varying rates of poultry litter.

Methods: To quantify solute losses in runoff, runoff was collected from six tall fescue plots of Captina silt loam soil with a 5% slope that received a wide variety of poultry litter application rates. Prior to litter application, soil cores were collected to characterize the soil profile distribution of extractable minerals, organic matter and carbon. Poultry litter was applied annually. All soil samples were dried at 70^{O}C for 48 hours, crushed, sieved and Mehlich-3 extractions were used to extract soil for analysis. Samples were analyzed for P, potassium (K), calcium (Ca), magnesium (Mg), sodium (Na) and boron (B) using inductively coupled argon plasma spectrometry (ICAP). A 2:1 soil to water mixture was used to determine soil pH and conductivity. Runoff samples were collected from each plot after storm events

and were analyzed for soluble K Ca, Mg, Na, B, arsenic (As), cadmium (Cd), selenium (Se), nickel (Ni), copper (Cu), manganese (Mn) and iron (Fe) using ICAP spectrometry. Dissolved P, ammonia-nitrogen (NH_4-N), nitrate-nitrogen (NO_3-N) were measured using a Skalar San Plus automated wet chemistry analyzer. A weather station monitored precipitation inputs, wind speed, solar radiation, photosynthetically active radiation, air temperature and relative humidity on an hourly basis.

Results: Runoff from the study plots differed occasionally among litter treatments, but did not differ during an individual annual period. Season and annual flow weighted mean concentrations of nutrients and metals were variable and inconsistent throughout the study. Arsenic concentrations from all treatments exceeded the maximum contaminant level for drinking water. Annual nutrient runoff losses did not differ among treatments during any annual period; however, all nutrient runoff losses, except for K, were numerically greatest from the high-litter treatment.

Conclusions: Results from this study indicate that reducing broiler litter application may potentially reduce runoff losses of some environmentally harmful nutrients and metals (i.e., P, As, and Fe). However, eliminating broiler litter application completely may still lead to years of nutrient and metal-enriched runoff due to the soil's ability to retain and recycle nutrients and metals (i.e., P and As).

Dissertation:

Pirani, Amanda L., 2005. Leaching of plant nutrients and heavy metals from poultry litter-amended tall fescue pasture, Department of Crop, Soil, and Environmental Sciences, University of Arkansas.

Menjoulet, Brie C., 2007. Nutrient and metal runoff from broiler litter-amended tall fescue in response to natural precipitation, Department of Crop, Soil, and Environmental Sciences, University of Arkansas.

Source of Geosmin and MIB in drinking water: Identifying the source and mechanisms of taste and odor compounds at Beaver Reservoir, northwest Arkansas

Basic Information

Title:	Source of Geosmin and MIB in drinking water: Identifying the source and mechanisms of taste and odor compounds at Beaver Reservoir, northwest Arkansas
Project Number:	2007AR164B
Start Date:	3/1/2007
End Date:	12/31/2008
Funding Source:	104B
Congressional District:	3
Research Category:	Water Quality
Focus Category:	Management and Planning, Non Point Pollution, Toxic Substances
Descriptors:	
Principal Investigators:	Sonja Hausmann, Stephen K. Boss, Ralph K. K Davis

Publication

1. Winston, B., 2010. Taste and odor issues of Beaver Reservoir, Environmental Dynamics Program, Department of Geosciences, University of Arkansas.

Project Title: SOURCE OF GEOSMIN AND MIB IN DRINKING WATER: IDENTIFYING THE SOURCE AND MECHANISMS OF TASTE AND ODOR COMPOUNDS AT BEAVER RESERVOIR, NORTHWEST ARKANSAS

Project Team: Sonja Hausmann, Department of Geosciences, University of Arkansas
Stephen K. Boss, Department of Geosciences, University of Arkansas
Ralph K. Davis, Department of Geosciences, University of Arkansas

Interpretative Summary: Taste and odor compounds in lakes and reservoirs are a common problem worldwide. While in some regions the persistence of these compounds has been correlated to cyanobacteria proliferation, actinomycetes, and standing timber, the results of this study suggest correlations among drought conditions, *Cylindrospermopsis raciboborskii, Rhaphidiopsis curvata*, and MIB.

Introduction: Eradicating musty-earthy taste and odor from drinking water is a major challenge for water managers and municipalities. In the Beaver Reservoir, the drinking water supply for northwest Arkansas, theses taste and odors are a result of Geosmin and 2-Methylisoborneol (MIB) in the drinking water. The increasing population in northwest Arkansas will likely increase nutrient concentrations in the reservoir due to urbanization which will exacerbate the MIB and Gesosmin problem driven by algal blooms. Although tastes and odor present no direct risk to human health, indirect consequences and implications include consumer concern, increased treatment costs, and taste and odor compounds may be indicative of potentially toxic cyanobacteria.

The major problem associated with eradicating taste and odor compounds is that he source and production mechanism are poorly understood. Therefore, identification of the source, condition and production mechanisms behind Geosim and MIB production is a necessary first step in establishing effective management strategies. Results from the study will provide information on 1) the source(s) of Geosmin and MIB in Beaver Reservoir, 2) provide information on the conditions conducive to the release of taste and odor compounds, and 3) aid in the development of both lake and watershed management practices. Eradication or reduction of foul taste and odor will increase consumer confidence in the safety of their drinking water.

Methods: Water samples were collected form Beaver Reservoir biweekly from March to October 2007. After identifying the depth of the growing cyanobacteria using an in=situ optical fluorometer, 1 L of water was collected with a Van Dorn type sampler. All samples for microscopic analysis were preserved with glutaraldehyde at collection. Benthic communities were scraped from stones and treated the same way as the water samples. Concentration of organisms were determined by adding an aliquot of a known concentration of beads with a diameter of 6 um and identified with a phase contrast microscope and oil immersion. Geosmin, MIB, total dissolved solids, major ions and inorganic nutrients were analyzed from collected water samples. In addition, pH, temperature, dissolved oxygen and conductance were measured in 1 m intervals.

Results: MIB was detected in 2007 but not in 2008 in the transition zone of the lake while the riverine zone had no measureable MIB in 2007 or 2008. The climate was very different between sampling years. In 2008, the taste and odor free year, the climate was much colder and wetter than 2007, when MIB was detected. During the 2007 drought, the diatoms decreased while the cyanobacteria increased. Diatoms of 2007 were dominated by large *Fragilaria* species such as *F. crotonensis* and *F. ulna*. *Asterionella formosa* was highly correlated to MIB.

Conclusions: The results of this study suggest that climate played an important role in regulating the phytoplankton community. During the hot summer in 2007, deepening of the thermocline increased TP concentrations, the TN:TP ratio became favorable for cyanobacteria, and MIB was released due to their bloom. *Asterionella formosa* was associated with the MIB peak in 2007, and did not occur below 25 cm in the core. Phytoplankton communities during 2008, the cold and wet year, were not comparable and MIB was generally below detection limit. *Aulacoseira granulata* was the dominant diatom in the coldwet MIB-free year in 2008.

Dissertation:

Winston, B., 2010. Taste and odor issues of Beaver Reservoir, Environmental Dynamics Program, Department of Geosciences, University of Arkansas.

Continuous Water-Quality Monitoring and Potential Phosphorus Source Identification with Oxygen Isotopes

Basic Information

Title:	Continuous Water-Quality Monitoring and Potential Phosphorus Source Identification with Oxygen Isotopes
Project Number:	2007AR171B
Start Date:	3/1/2007
End Date:	12/31/2008
Funding Source:	104B
Congressional District:	3
Research Category:	Water Quality
Focus Category:	Water Quality, Surface Water, Non Point Pollution
Descriptors:	
Principal Investigators:	Brian E. Haggard, Phil D Hays

Publication

1. Breaker, B., 2009. Phosphate Oxygen Isotopes as a Tracer for Sources and Cycling of Dissolved Inorganic Phosphates (DIP) in the Illinois River, Department of Geosciences, University of Arkansas.

Project Title: CONTINUOUS WATER-QUALITY MONITORING AND POTENTIAL PHOSPHORUS SOURCE IDENTIFICATION WITH OXYGEN ISOTOPES

Project Team: Brian E. Haggard, Department of Biological and Agricultural Engineering, University of Arkansas

Phil D. Hays, Department of Geosciences, University of Arkansas

Interpretative Summary: Excessive phosphorus in river system can cause eutrophication and impair stream reaches due to point and non-point sources. The $\delta^{18}O_P$ signatures method has shown that it has the potential to help understand PO_4 dynamics in the Illinois River.

Introduction: Excess phosphorus in streams causes eutrophication which can diminish capacity for supporting a healthy and normal ecosystem and diverse species assemblages, diminish water supply quality, and diminish aesthetic and recreational value. Phosphorus concentration and sources have been an environmental and legal issue in the Illinois River in Arkansas and Oklahoma for several decades. The Illinois river and its tributaries are subject to the addition of large amounts of nutrients from point and non-point sources because of land us in the basin and municipal wastewater treatment facilities in the basin.

Isotopic methods that have recently been developed enable comparison of oxygen isotopes in dissolved inorganic phosphates, allowin soures of phosphate in aquatic systems to be identifies. This method has not been applied in the central U.S., but may provide the opportunity to better understand the origins, transport, and cycling of phosphorus in the Illinois River and similarly impacted streams and watersheds in the region. By determining the oxygen isotopic composition of various phosphate sources, specific signatures of the diverse sources may be defined, identification of phosphate sources in streams impacted by various human activities may be enabled, and ultimately the effects of agriculture, wastewater, and natural sources of phosphorus in the Illinois River watershed may be quantified.

Methods: Surface water samples were collected in the Illinois River Basin to establish whether distinctive $\delta^{18}O_P$ signatures could be ascribed to sources such as treated effluent, animal manure, and commercial fertilizer. After samples are taken, MagIC (magnesium-induced co precipitation) was used to determine nanomolar concentrations of SRP and total dissolved phosphorus from marine and freshwater environments. Mg^{2+} concentrations were adjusted and NaOH was added to precipitate $Mg(OH)_2$. Samples were centrifuged downed and decanted to about 50 mL of wet $Mg(OH)_2$. The

precipitate was dissolved in 5 mL of acetic acid and then 10 M nitric acid was added. The pH was buffered to 5.5 with potassium acetate. 400 mg of cerium phosphate precipitation was added to precipitate cerium phosphate. The samples were centrifuged and the solution was rinsed with 0.5M potassium acetate until all Cl^- ions were removed. The solution was then mixed with an ion exchange resin and shaken over night to removed cerium ions. Then, the samples were eluted from the resin and brought to a pH of 7. Phosphate was precipitated at silver phosphate. The silver phosphate was vacuum filtered onto polycarbonate filters, rinse several times with DI water, and filters ere dried in an oven. Oxygen isotope ratios were determined by the pyrolosis of silver phosphate in an elemental analyzer.

Results:

Sample Content or Location	$\delta^{18}O_P$
Poultry Litter Water Extract, 1:100	20.04
Commercial Fertilizer Water Extract, 1:100	18.2
Springdale Waster Water Effluent Discharge	25.18
Illinois River South of Siloam Springs	20.83
Illinois River at Savoy	14.23
Chamber Springs	11.87
Lee Creek at Devil's Den Campsite A	20.92
Osage Creek at HWY 264 Bridge	11.89
Spring Creek Upstream of WWTP	17.24
Spring Creek Downstream of WWTP	17.93
Osage Creek Downstream from Spring Creek	19.63
Little Osage Creek at Osage Mills	11.35
Run-off from Litter Amended Pasture	10.55
Septic Tank Leachate	12.3

Conclusions: The method utitlized for this study may be used as an effective tracer for sources and cycling of phosphates in a inland, freshwater system such as the Illinois river. As an initial study on the effectiveness of this method, this study has shown that it has the potential to help understand PO_4 dynamics in the Illinois River. More time is needed in the lab to gather enough data to sufficiently cover processes occurring in the watershed.

Thesis:

Breaker, B., 2009. Phosphate-Oxygen Isotopes as a Tracer for Sources and Cycling of Dissolved Inorganic Phosphates (DIP) in the Illinois River, Department of Geosciences, University of Arkansas.

Metal Mobilization, Especially Arsenic, in the Alluvial Aquifer in Response to Water Level Fluctuations Measured by Field and Laboratory Column Data

Basic Information

Title:	Metal Mobilization, Especially Arsenic, in the Alluvial Aquifer in Response to Water Level Fluctuations Measured by Field and Laboratory Column Data
Project Number:	2007AR173B
Start Date:	3/1/2007
End Date:	12/31/2008
Funding Source:	104B
Congressional District:	3
Research Category:	Water Quality
Focus Category:	Hydrogeochemistry, Geochemical Processes, Water Quality
Descriptors:	
Principal Investigators:	Kenneth F. Steele

Publication

Project Title: METAL MOBILIZATION, ESPECIALLY ARSENIC, IN THE ALLUVIAL AQUIFER IN RESPONSE TO WATER LEVEL FLUCUATIONS MEASURED BY FIELD AND LABORATORY COLUMN DATA

Project Team: Kenneth F. Steele, Department of Geosciences, University of Arkansas

Interpretative Summary: Arsenic levels present in some groundwater wells can cause severe health problems. Arsenic levels are related to iron levels due to oxyhydroxide reduction and to aquifer depth.

Introduction: Chronic exposure to low levels of arsenic can affect the skin, liver, kidney, circulatory systems, gastrointestinal tract, nervous system, and heart. In the Bayou Bartholomew Watershed in eastern Arkansas several wells had water exceeding the maximum contamination level for arsenic in drinking water. These wells also had high iron concentration.

The reduction-oxidation condition in ground water has a great affect on metal mobilization. Trace metals precipitate under oxic conditions or are sorbed on hydroxyoxides that can be leached or dissolved under reducing conditions. Considering the high concentration I the wells with high arsenic values, the probable process in eastern Arkansas is “oxyhydroxides reduction”. Ground water level fluctuation can change ground-water flow direction and these mobilized metals can ultimately be transported to surface water resources. There is little research on the water quality and or geochemical process associate with intensive ground-water withdrawals causing significant ground-water level fluctuation which can decrease ground-water quality. This project will collect field samples to validates column studies on the influence of ground-water level fluctuation on the water quality in the alluvial aquifer, and to validate the results from physico-chemical models.

Methods: This study evaluated three conceptual models of arsenic mobilization and release mechanisms 1) sulfur model, 2) iron oxyhydroxide reduction model, and 3) competitive ion exchange model by interpreting chemical analyses of sediment and groundwater, and results of model simulations and column tests.

Samples and water levels for the three monitoring wells were collected during a “dry” period and “wet” period. Samples were collected during three periods representing 1) when water levels beginning to rise after irrigation season, 2) when significant recharge to the aquifer occurs, 3) when maximum draw

down occurs because of the lack of recharge and intense irrigation. These three water level condition significantly impacted groundwater chemistry resulting in difference in water chemistry.
Sediments were collected by the split spoon method and analyzed for major and minor cations and anions and other physic-chemical parameters including dissolved oxygen, redox potential, pH, and temperature. Sequential acid extractions for investigating sediment characteristics and potential metal mobilization capacity was conducted.

Results: This study found that arsenic abundance is not significant in carbonate or organic matter, and significant exchangeable As is only present at shallow depths (0-1m). Arsenic was positively correlated to Iron, but the amount of reducible hydrous Fe, as well as its complexed As decreased with depth. As 5+ is the dominant As species in groundwater and is positively correlated to decreasing redox potential. Spatial and temporal variability of As was controlled by spatial distribution and redo status of different redox zones at various depths in the aquifer. The redox state was the primary control on the rate of reduction and the amount of As in groundwater.

Conclusions: The recharge potential, variation of lithology, thickness and permeability of surface aquitard, irrigation pumping and local flow dynamics have positive relations to the horizontal and vertical distribution of redox zones. The amount of reducible Fe decreased noticeable with depth so the amount of complexed As decreases with depth. Although particulate As is very low, significant particulate Fe is present, which may facilitate co-transfer of As through groundwater flow or recharge into deep aquifers.

Dissertation:

Kim, B., 2008, Hydrochemical Evolution of Ground Water in an Intesively Pumpled Alluvial Aquifer. Ph.D. Dissertation, Environmental Dynamics and Department of Geosciences, University of Arkansas, Fayetteville, Arakansas, 238p.

Sharif, M.U., 2007, Hyrogeochemical Evolution of Arsenic in Groundwater: Sources and Sinks in the Mississippi River Alluvial Aquifer Southeastern Arkansas, USA. Ph.D. Dissertation, University of Arkansas, Fayetteville, Arkansas. 367p.

Role of Fluvial Sediments in Modifying Phosphorus Export from Northwest Arkansas Watersheds

Basic Information

Title:	Role of Fluvial Sediments in Modifying Phosphorus Export from Northwest Arkansas Watersheds
Project Number:	2008AR184B
Start Date:	3/1/2008
End Date:	2/28/2009
Funding Source:	104B
Congressional District:	3rd Congressional District of Arkansas
Research Category:	Water Quality
Focus Category:	Nutrients, Sediments, Water Quality
Descriptors:	None
Principal Investigators:	Andrew Sharpley, Brian E. Haggard

Publication

1. Rogers, C.W. 2009 (expected). Role of fluvial sediments in modifying phosphorus export and erosion risk potential of the Illinois River Watershed. Crop, Soils and Environmental Sciences Department, University of Arkansas.

Project Title: ROLE OF FLUVIAL SEDIMENTS IN MODIFYING PHOSPHORUS EXPORT FROM NORTHWEST ARKANSAS WATERSHEDS

Project Team: Andrew Sharpley, Crop, Soils and Environmental Sciences Department, University of Arkansas

Brian Haggard, Biological and Agricultural Engineering Department, University of Arkansas

Interpretative Summary: Interdependent processes in streams influence the amounts and forms of P transported from edge-of-field sources to the point of impact (i.e., river, lake, or reservoir). In better understanding the spatial and temporal extent of these processes via this project, we will be able to more reliably define source management and conservation practice implementation to more accurately determine eutrophic response, the magnitude and extent of change in P transport in river systems, and how long it will be between practice implementation and water quality improvement.

Introduction: The quality of streams and reservoirs in the northwest Arkansas region are influenced by watershed land uses, particularly areas draining agricultural lands (e.g., pastures) and urban-suburban development. Stream concentrations of nutrients, including phosphorus (P), generally increases with an increase in pasture land use and urban development. This project evaluates the role of fluvial sediments in modifying P loss during transfer from edge-of-field to receiving water by establishing a standard protocol for determining P sorption and desorption properties of fluvial sediments, and evaluating when sediments act as sinks or sources of P to stream flow.

Methods: Five stream sites were selected with drainage area reflecting predominately agricultural, forest, and urban land use (Fig. 1). The proportion of each drainage area that was urban, agriculture, and forest was determined from GIS land use maps for each stream site (Table 1). Sediment samples were collected to 10-cm depth at multiple locations within a 50-m reach at each stream site. Sediments were sieved into two size classes (<2mm, >2mm) and relative abundance of each size class was determined.

Table 1. Selected sites and land use designation (bold text represents dominant land use).

Site	Urban	Agric.	Forest
		%	
Chamber Springs	1	28	***71***
Moore's Creek	8	33	***59***
Wildcat Creek	4	***70***	26
L. Wildcat Creek	19	***61***	20
Mud Creek	***68***	7	25

Phosphorus sorption-desorption properties of sediments were determined by equilibrating sediment samples with solutions of graduated P concentrations. The following equilibrating solutions will be used; distilled deionized water, 0.01 and 0.003 *M* $CaCl_2$, 0.01 *M* KCl and filtered stream water.

Chambers Creek

Little Wildcat Creek

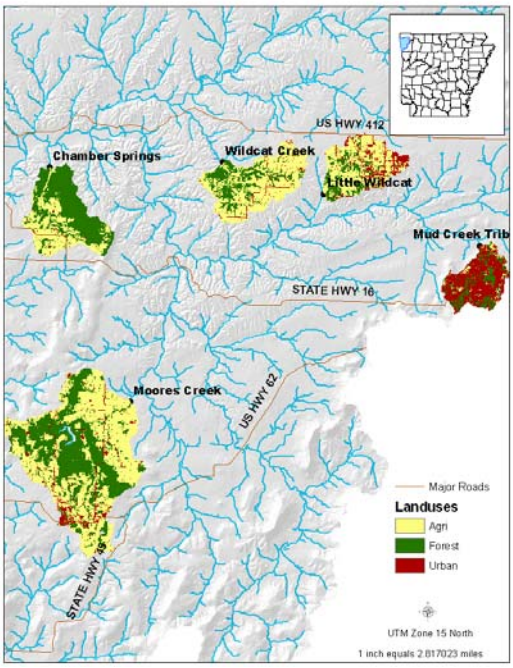

Figure 1. Map of sampling sites and sub-watershed land use.

A purpose built fluvarium housed at U of A, Fayetteville facilities will be used to determine P release and uptake properties of the sediments under simulated stream flow conditions (Fig. 2). Attached to each downslope end of the four 10-m long by 20-cm wide by 20-cm deep troughs (slope angle variable from 0 to 15%) is a reservoir with a total capacity of 300 L from which, water circulates over the sediment. Collected sediment will be placed into two troughs of the fluvarium to a depth of approximately 3 cm and the troughs set at a slope representing the mean of the sampled sites. Each reservoir is filled with

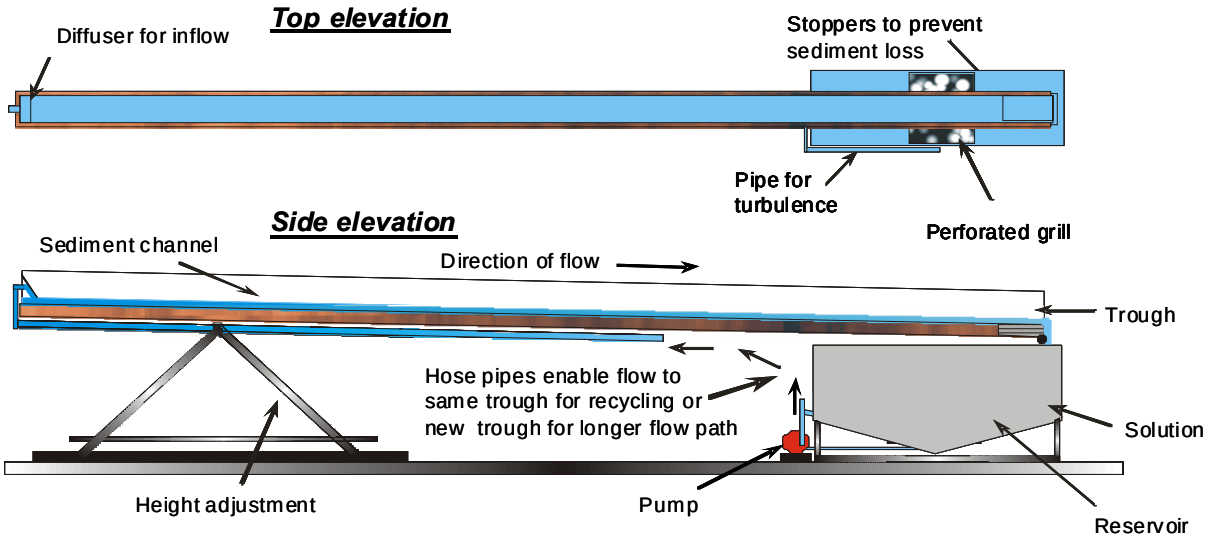

Figure 2. Side-on and top view depicts one trough of the fluvarium. Three other troughs lie alongside. Diagram is not to scale.

180 L of tap water (P less than detection limit of 0.005 mg L^{-1}) and flow pumped over the sediment at a rate of 0.7 L/s (i.e., mean estimated flow velocity for the sites at the time of sampling) for 48 hours. Water samples will then be taken at regular intervals with an automatic sampler. Following this, P-rich runoff collected from manured soils will be introduced into the fluvarium reservoir and water circulated over the sediments for 48 hours and water samples collected.

Results: Using filtered stream water as the equilibration medium, there was an increase in P sorption by Little Wildcat Creek > Moore's Creek > Mud Creek (Figure 3). Based on EPC_o values, sediments from the stream draining an agricultural area (Little Wildcat Creek) could support a greater concentration of P in stream water (0.036 mg/L) than the other land uses (Table 2). As expected, forested stream sediments (Moore's Creek) supported the lowest concentration (0.015 mg/L). The opposite was true for the ability of sediments to store P (P_{max}), with forest stream sediment (268 mg/kg) greater than urban (227 mg/kg) and agricultural (156 mg/kg) stream sediments.

Table 2. P sorption and desorption properties from Langmuir isotherms shown in Figure 3.

Site	Dominant land use	EPC_0 (mg/L)	P_{max} (mg/kg)
L. Wildcat Creek	Agric	0.036	156
Moore's Creek	Forest	0.015	268
Mud Creek	Urban	0.023	227

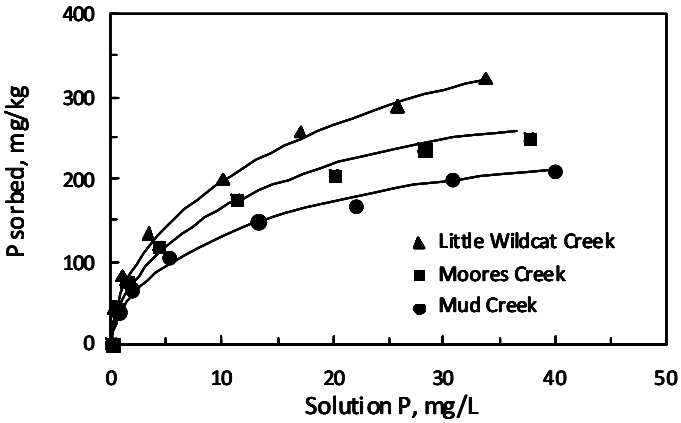

Figure 3. P sorption isotherms for 3 streams draining major land uses.

Conclusions: Differences in the sorptive properties of sediments was observed among land uses. It is expected that this information will explain relative differences in P uptake and release by sediment from flowing waters in the fluvarium study.

Thesis:

Rogers, C.W. 2009 (expected). Role of fluvial sediments in modifying phosphorus export and erosion risk potential of the Illinois River Watershed. Crop, Soils and Environmental Sciences Department, University of Arkansas.

Spatial and historical distribution of Geosmin and MIB producers in Beaver Reservoir, northwest Arkansas

Basic Information

Title:	Spatial and historical distribution of Geosmin and MIB producers in Beaver Reservoir, northwest Arkansas
Project Number:	2008AR191B
Start Date:	3/1/2008
End Date:	2/28/2009
Funding Source:	104B
Congressional District:	3
Research Category:	Water Quality
Focus Category:	Water Quality, Ecology, Toxic Substances
Descriptors:	
Principal Investigators:	Sonja Hausmann, Stephen K. Boss, Ralph K. K Davis

Publication

1. Winton, Byron. 2010 (expected). Taste and odor issues of Beaver Reservoir, Environmental Dynamics Program, Department of Geosciences, University of Arkansas.

Arkansas Water Resources Center 104B Program Project – March 2008 through February 2009

Project Title: SPATIAL AND HISTORICAL DISTRIBUTION OF GEOSMIN AND MIB PRODUCERS IN BEAVER RESERVOIR

Project Team: Sonja Hausmann, Ralph Davis, Steve Boss, Department of Geosciences, University of Arkansas

Interpretative Summary: The presence of taste and odor compounds in lakes and reservoirs is a pervasive problem throughout the world. While in some regions the persistence of these compounds has been correlated to cyanobacteria proliferation, actinomycetes, and standing timber, the source and environmental conditions remained unknown at Beaver Reservoir. Our results suggest strong associations among drought conditions, *Cylindrospermopsis Racioborskii*, *Rhaphidiopsis curvata,* and MIB. A sediment core analysis revealed that the reservoir has oscillated from being dominated by populations of the diatom *Aulacoseira subarctica* (an indicator of oligotrophic-mesotrophic water quality conditions) to domination by *A. granulata* and *Fragilaria crotonensis*, which are both indicators of eutrophic conditions.

Introduction: The Beaver Reservoir located in northwest Arkansas was established in 1964 for flood control, hydropower generation, water supply, and recreation. Beaver Reservoir experiences regular taste and odor episodes for which causes are not yet fully understood. Phytoplankton can produce methylisoborneol (MIB), which is a metabolic byproduct that can cause taste impairment at a concentration of only 5 ng/L. The purpose of this ongoing project is to identify which organisms produce MIB and the environmental conditions conducive to their proliferation. In order to test the hypothesis that the taste and odor problem is related to human population growth in the catchment, we compare historic data with monitored nutrients (TP and TN) and biological indicators such as diatoms archived in the sediments of Beaver Reservoir.

Methods:

In collaboration with the Beaver Water District, water samples were collected from March 2007 to November 2008 from the Transition (TZ) and Riverine (RZ) zones; the RZ included samples from the White River and War Eagle Creek. Water samples were analyzed for phytoplankton, nutrients, and MIB. Concentration of organisms was determined by adding an aliquot of a known concentration of microspheres with a diameter of 6 µm to one liter of water (Batterbee & Keen, 1982). Total dissolved

solids, major ions, and inorganic nutrients were analyzed by the Beaver Water District. In addition, physical parameters such as pH, temperature, dissolved oxygen, and conductance was measured to determine physical profiles for the reservoir at all sites using a HACH Hydrolab DS5 series.

A sediment core that was 85cm long was taken in 2008. For diatom analysis, approximately 0.5 g of freeze dried sediment was treated with 30% H_2O_2 and 10% HCL. After several rinses with deionized water, microspheres were added to the mixture to determine diatom concentration, and then mounted on slides using Naphrax®. Diatom assemblages were partitioned into three zones using the computer program ZONE and the Broken-Stick model. Historic total phosphorus concentrations were inferred by comparison of modern with fossil abundances of diatoms archived in sediments (Hausmann and Kienast, 2006). After we established a chronology, the past nutrient dynamics will be compare with the economic growth in the catchment.

Results:

MIB was detected in 2007 at the TZ, but not in 2008 (Fig. 1). The RZ had no measurable MIB in 2007 or 2008. The two sampling years 2007 and 2008 had a very different climate. The taste and odor free year 2008 was much colder and wetter compared to the MIB-year 2007, which had a very warm and dry July and August (Fig. 1). The epilimnion warmed up to 30°C and the thermocline deepened to 5 m. During the 2007 drought the diatoms decreased, while the cyanobacteria increased (Fig. 1). Diatoms of 2007 were dominated by large *Fragilaria* species such as *F. crotonensis* and *F. ulna*. *Asterionella formosa* was highly correlated to MIB. Diatom growth during spring and early summer2007 seems to have led to depletion of Si and N. Si became limiting for diatoms and their abundance

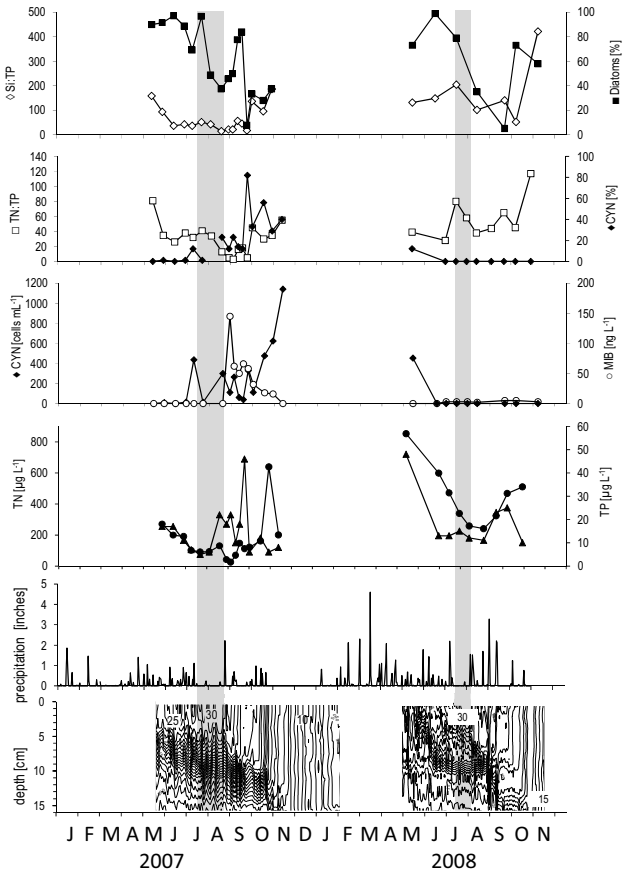

Figure 1: Mean summer values for 2007 and 2008 comparing Si:TP to diatom abundance, TN:TP to % Cyanobacteria, Cyanobacteria abundance to MIB concentration, TN (filled circles) and TP (filled triangles) concentrations precipitation and the depth-temperature profile, respectively at the Transition Zone.

decreased. In addition, the lowering of the thermocline during the drought might have enriched the epilimnion with total phosphorus (TP). When TN:TP fell below the critical ratio of 30:1, cyanobacteria domination by *Cylindrospermopsis racioborskii* and *Rhaphidiopsis curvata* began on August 20th. As a consequence of the rain on August 25th, the surface water temperature cooled and the cyanobacteria concentration decreased. Subsequently MIB peaked at 145 ng L^{-1} on August 30th and the phytoplankton was dominated by *Chrysoccocus* ssp. and *Asterionella formosa*. During the cold and wet year of 2008, the cyanobacteria did not bloom during the summer and the diatoms were dominated by *Aulacoseira granulata*, which is a diatom that likes turbulent water conditions. The TN:TP remained above 30, cyanobacteria was generally undetected, and the MIB concentration was below the detection limit (Fig. 1).

The diatom analysis of the sediment core revealed three diatom assemblage zones (Fig. 2; DAZ 1, DAZ 2 and DAZ 3). Zone 1 and 2 were characterized by *Aulacoseira subarctica* indicator of oligotrophic-mesotrophic water quality conditions. Zone 2 is dominated by *A. granulata* and *Fragilaria crotonensis* both indicators of eutrophic conditions. In DAZ 2, diatom-inferred TP concentrations were up to 200 µg L^{-1}. At low TP optima, the diatom community was dominated by *Navicula cryptocephala* and *Nitzschia amphibia,* while high TP was dominated by *Fragilaria crotonensis, Surirella robusta, Gomphonema Olivaceum* and *Aulacoseira granulata* (Fig2).

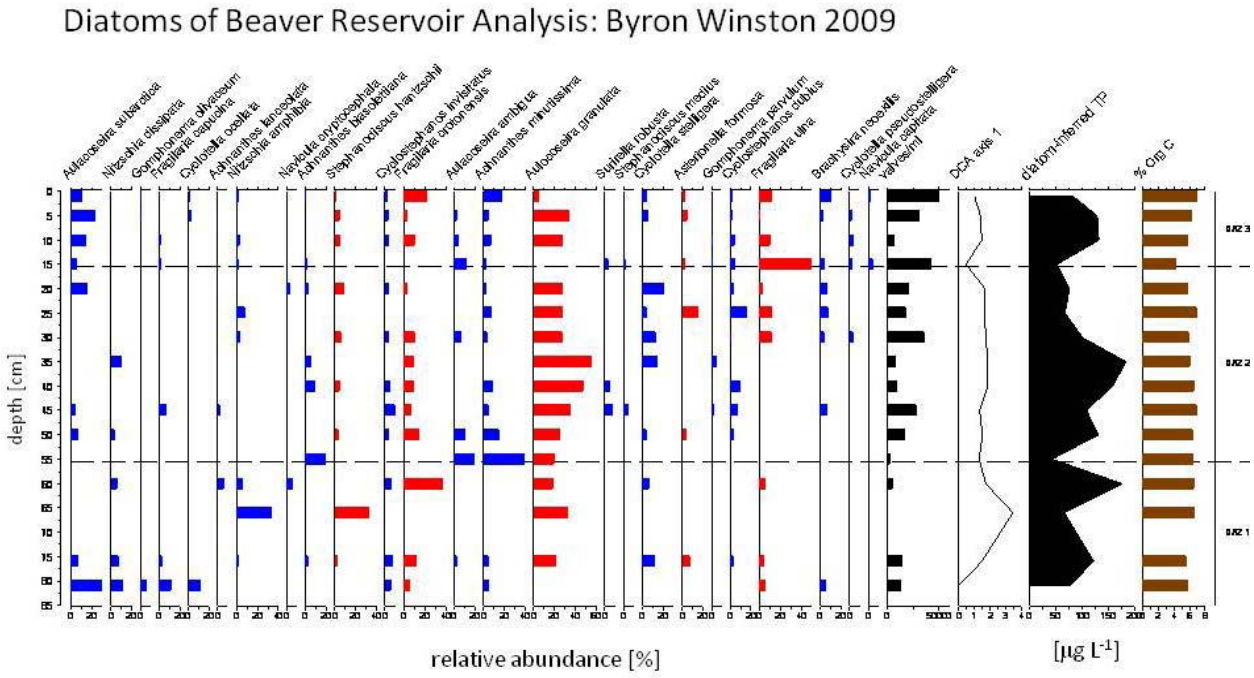

Figure 2: Diatom Assemblage Zones (DAZ) showing the dominant diatoms down the sediment core.

Conclusions: The results of this study suggest that climate played an important role in regulating the phytoplankton community. During the hot summer in 2007, deepening of the thermocline increased TP concentrations, the TN:TP ratio became favorable for cyanobacteria, and MIB was released due to their bloom. *Asterionella formosa* was associated with the MIB peak in 2007, and did not occur below 25 cm in the core. Phytoplankton communities during 2008, the cold and wet year, were not comparable and MIB was generally below detection limit. *Aulacoseira granulata* was the dominant diatom in the cold-wet MIB-free year in 2008 and also in DAZ 2. The diatom assemblage zones in the sediment core of Beaver Reservoir may be a reflection of human activity within the watershed of Beaver Reservoir and will be assessed once the Pb^{210} data is received. In Summer 2009, the hypothesis that lake stratification induces cyanobacteria bloom will be tested using a series of limnocorrals in collaboration with Thad Scott.

References:

Battarbee, R.W., & Kneen, M.J. 1982. The use of electronically counted microspheres in absolute diatom an analysis, Limnology and Oceanography 27: 184–188.

Hausmann S., & Kienast F. 2006. A diatom-inference model for nutrients screened to reduce the influence of background variables: Application to varved sediments of Greifensee and evaluation with measured data, Palaeogeography, Palaeoclimatology, Palaeoecology 233 (2006) 96– 112

Dissertation:

Byron Winston, 2010. Taste and odor issues of Beaver Reservoir, Environmental Dynamics Program, Department of Geosciences, University of Arkansas.

Biogeochemical controls and interactions of carbon and nutrient cycling in karst hydrologic systems.

Basic Information

Title:	Biogeochemical controls and interactions of carbon and nutrient cycling in karst hydrologic systems.
Project Number:	2008AR193B
Start Date:	3/1/2008
End Date:	2/29/2009
Funding Source:	104B
Congressional District:	3
Research Category:	Water Quality
Focus Category:	Hydrogeochemistry, Nitrate Contamination, Water Quality
Descriptors:	None
Principal Investigators:	Erik Pollock, John Van Brahana, Phil D Hays

Publication

1. Knierim, Katherine J., 2009 (expected). Seasonal variation of carbon (DIC/DOC/CO2) and nutrient transfer in a northwestern Arkansas cave, Department of Geosciences, University of Arkansas.

Project Title: BIOGEOCHEMICAL CONTROLS AND INTERACTIONS OF CARBON AND NUTRIENT CYCLING IN KARST HYDROLOGIC SYSTEMS

Project Team: Erik D. Pollock, Department of Biological Sciences, University of Arkansas
Phillip D. Hays, Department of Geosciences, University of Arkansas
John Van Brahana, Department of Geosciences, University of Arkansas

Interpretative Summary: Carbon and nutrient cycling in karst systems show seasonal trends which are overprinted by short-term local changes in weather, temperature, and precipitation. Decreased seasonal variation in organic matter and nutrient concentrations and carbon stable isotopic composition ($\delta^{13}C$) of seep waters indicate cave environments are capable of some nutrient attenuation.

Introduction: Karst aquifers are characterized by high secondary porosity and a component of groundwater flow focused along fractures and conduits (Ford and Williams 2007). This focused flow causes karst aquifers to be especially vulnerable to agricultural pollution because surface waters with increased concentrations of organic matter and nutrients can be rapidly transmitted into the subsurface (Panno et al. 2001, Peterson et al. 2002). Understanding how nutrients and organic matter are processed in karst systems is critical to designing and implementing effective manure management and sustainable agricultural practices.

Inorganic and organic carbon (C) pools are closely linked to biogeochemical processing of nutrients, especially nitrate (NO_3^-). Denitrification is an important mechanism for removal of NO_3^- and has been found to be limited by the availability of dissolved organic carbon (DOC) and produces dissolved inorganic carbon (DIC) (Knowles 1982). Stable isotopes of carbon, nitrogen, and oxygen have proven valuable tools to monitor nutrient processing in karst systems (Panno et al 2001, Winston 2006). The differences in isotopic abundance during biogeochemical transformations are small, so δ notation in units of per mil (‰) are used, as defined:

$$\delta = \left[\frac{(H/L)_{sample}}{(H/L)_{standard}} - 1\right] \times 1000$$

where H is the heavy isotope and L is the light isotope, such as the ratio of $^{13}C/^{12}C$.

Northwestern Arkansas is characterized by karst topography, including abundant caves, sinkholes, and springs, and a large agriculture industry. Nationally, Arkansas is ranked second in broiler production, fourth in turkey production, and seventeenth in cattle production (United States

Department of Agriculture 2007). Studies from northwestern Arkansas have found that DOC and NO_3^- in groundwater vary seasonally and with precipitation events (Winston 2006). Additionally, the soil and epikarst zones are important for NO_3^- storage and biological processing (Peterson et al 2002, Winston 2006). This study aimed to further investigate the seasonal dynamics of carbon and nutrient cycling by monitoring changes in the concentrations and isotopic composition of DIC, DOC, and carbon dioxide (CO_2) along groundwater flow paths in a karst system from the soil, to a cave, to discharge at seeps.

Methods: To quantify changes in the cycling of C and nutrients in the karst system, water and gas samples were collected from soil, cave, and seep locations using a combination of monthly and continuous monitoring. Water samples were collected from two soil lysimeters, one location within the cave, and two seeps on a monthly basis. Physical parameters including temperature, pH, and conductivity were measured during sample collection. Water samples for DIC/DOC were filtered through 0.45 µm filters and collected without headspace. Water samples for basic geochemistry were collected following the procedures of the Arkansas Department of Environmental Quality. All water samples were kept chilled until analyses. Gas samples from the two soil lysimeters and cave atmosphere were collected in serum bottles purged with helium. A Vaisala CARBOCAP ® Hand-Held Carbon Dioxide Meter was used to measure CO_2 concentration (pCO_2) during sample collection. Additionally, a LI-COR© LI-840 CO_2/H_2O Gas Analyzer continuously recorded the pCO_2 of the cave atmosphere.

Results: Concentrations and isotopic compositions of DIC, DOC, and CO_2 were found to vary over the sampling interval between fall (September to November), winter (December to February), and spring (March). In the cave atmosphere, pCO_2 dropped from approximately 4,000 ppm in September to 750 ppm in late October. The $\delta^{13}C$ values of cave-CO_2 also changed; during the winter compositions became heavier, reflecting an input from atmospheric CO_2, whereas in early spring compositions reflected a dominant soil-CO_2 signature. The isotopic compositions of cave-water DIC also supported this conclusion; during the winter compositions became heavier, indicating increased contribution from calcium carbonate bedrock. DOC concentrations generally decreased through the winter and the $\delta^{13}C$ values became lighter, possibly reflecting a source of lighter, labile organic matter that is preferentially processed during the growing season. The variation in data suggest long-term seasonal trends complicated by a high frequency pattern related to recent local weather, temperature, and precipitation.

Conclusions: During the winter, cooler surface temperatures and decreased biogeochemical processing from vegetation and bacteria cause greater C input from atmospheric and bedrock sources. Atmospheric C enters the cave either through ventilation due to a temperature gradient between the cave and surface atmospheres, gas seepage from the soil zone, or gas exchange from infiltrating water. During the fall and spring, a more dominant organic carbon signature reflects the increased contribution from the soil zone. Changes in the C isotopic composition of DIC and DOC reflect the effects of both biological processing and dilution during precipitation events, which illustrates how local climatic changes alter long-term seasonal fluctuations.

References:

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Knowles, R. 1982. Denitrification, Microbiological Reviews, 46: 43 – 70

Panno, S.V., Hackley, K.C., Hwang, H.H., and Kelly, W.R. 2001. Determination of the sources of nitrate contamination in karst springs using isotopic and chemical indicators, Chemical Geology, 179: 113 – 128

Peterson, E.W., Davis, R.K., Brahana, J.V., and Orndorff, H.A. 2002. Movement of nitrate through regolith covered karst terrane, Northwest Arkansas, Journal of Hydrology, 256: 35 – 47

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Winston, B. 2003. The biogeochemical cycling of nitrogen in a mantled karst watershed, unpublished MS Thesis, The University of Arkansas, Fayetteville, AR: 98

Dissertation:

Knierim, Katherine J., Fall 2009. Seasonal variation of carbon (DIC/DOC/CO_2) and nutrient transfer in a northwestern Arkansas cave, Department of Geosciences, University of Arkansas.

Information Transfer Program Introduction

Information transfer is an important part of the Arkansas Water Resources Center. Each year, the AWRC sponsors a water conference held in Fayetteville drawing in around 100 researchers, students, agency personnel and interested citizens to hear about results of current research and hot topics in water resources throughout the state. This year's conference focused on water resources management, water quality studies in transboundary watersheds, nutrient hotspots,and riparian forest buffers. The AWRC also co-sponsors short courses and other water-related conferences in the state and region.

In addition, the 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. Many AWRC publication have been converted to electronic PDF format which can be processed via our website at http://www.uark.edu/depts/awrc/publications.htm. The AWRC will implement new formatting and technical requirements to increase the aesthetic value of our final reports and facts sheets from sponsored research.

Arkansas Water Resources Center Information Transfer Program

Basic Information

Title:	Arkansas Water Resources Center Information Transfer Program
Project Number:	2008AR201B
Start Date:	3/1/2008
End Date:	3/1/2009
Funding Source:	104B
Congressional District:	3
Research Category:	Not Applicable
Focus Category:	Surface Water, Groundwater, Water Use
Descriptors:	None
Principal Investigators:	Ralph K. K Davis, Brian E. Haggard

Publication

ARKANSAS WATER RESOURCES CENTER

AWRC

2009 Annual Research and Watershed Conference

April 14-15, 2009 · Fayetteville, Arkansas
University of Arkansas

Watershed Research and Education Center

UofA UNIVERSITY OF ARKANSAS
DIVISION OF AGRICULTURE

Arkansas Water Resources Center

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THE WATER RESOURCES RESEARCH ACT

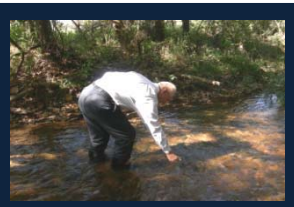
NIWR
The National Institutes for Water Resources

In 1964, Congress passed the Water Resources Research Act, establishing water 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.

This year, the Arkansas Water Resources Center funded three projects including:

- Land-Use Effects on Resistance and Resilience of Stream Metabolism to Flood Events in Ozark Highland Headwater Streams, Michelle Evans-White, University of Arkansas, $20,000.
- Denitrification, Internal Nitrogen Cycling, and Nitrogen Retention in River Impoundment Reservoirs, Thad Scott, UA Division of Agriculture, $21,180.
- Longitudinal Evolution of Nutrients in a Mixed-Use Watershed Under Storm and Non-Storm Flow Regimes, Joshua Romeis, UA Division of Agriculture, $20,380.

This year, the National Institute of Water Resources highlighted several of the AWRC's cooperative projects with the Illinois River Watershed Partnership including the IRWP's volunteer monitoring program and the development of its watershed management plan.



A volunteer collects a water sample from Flint Creek.

AWRC Annual Conference
Program at a Glance

Tuesday April 14, 2009

7:30- 8:15 Coffee, Juice, Pastries

8:15- 9:50 Session 1: Water Resources Management-Special Topics

9:50-10:15 Coffee Break

10:15-11:35 Session 2: Water Quality Studies in Transboundary Watersheds

11:35-12:30 Lunch Break

12:30-13:30 Poster Session and Student Poster Competition

13:30-14:50 Session 3: Nutrient Hotspots and Riparian Forest Buffers

14:50-15:10 Coffee Break

15:10-16:50 Session 4: Arkansas Agency and Scenic River Updates

19:00-19:50 AETN Presents "Troubled Water" in the Arkansas Union Theater on the University of Arkansas Campus.

20:00-22:00 Social at Railhead Saloon

Wednesday April 15, 2009

7:30- 8:25 Coffee, Juice, Pastries

8:25- 9:50 Session 5: Riparian Forest Buffers (RFBs) 101—Everything You Need to Know

9:50-10:15 Coffee Break

10:15-11:30 Session 6: Stakeholder Willingness, Volunteerism and Educational Opportunities

11:30-13:00 Lunch (On Your Own)

13:00-15:00 Riparian Forest Buffer Field Tour and Workshop (Meet at Pauline Whitaker Animal Sciences Arena Parking Lot)

Oral Session Schedule

Tuesday April 14, 2009

Session 1: Water Resources Management-Special Topics
Moderator: Brian Haggard, Arkansas Water Resources Center
UA Division of Agriculture

8:15 Welcome and Introduction

8:20 Bacterial Source Identification—Merging Food Science and Water Resources, Steve Ricke, Institute of Food Science and Engineering, University of Arkansas (sricke@uark.edu)

8:50 Trend Analysis with Water Quality—Basic Principles and Data Needs, Dave Mueller, US Geological Survey, Denver, Colorado (mueller@usgs.gov)

9:20 Soft Sciences and the Hard Reality of Water Resources Management, Kent Thornton, FTN Associates (kwt@ftn-assoc.com)

9:50 Follow-up Discussion, Questions and Refreshment Break

Session 2: Water Quality Studies in Transboundary Watersheds
Moderator: Tommy Daniel, UA Division of Agriculture

10:15 Subsurface Transport of Phosphorus through Preferential Flow Paths in Riparian Floodplains, Garey Fox, Biosystems Engineering Department, Oklahoma State University (garey.gox@okstate.edu)

10:35 Phosphorus Concentrations and Trends in the Lower Illinois River Watershed, Thad Scott, Crop, Soil, and Environmental Sciences Department, UA Division of Agriculture (jts004@uark.edu)

10:55 Regression Models to Estimate Nutrient Concentrations in Beaty and Spavinaw Creeks in Real-Time, Rachel Esralew, US Geological Survey, Oklahoma City, Oklahoma (resralew@usgs.gov)

11:15 Water Quality Changes in the Eucha—Spavinaw Basin after Watershed Management Changes, Brian Haggard, Arkansas Water Resources Center (haggard@uark.edu)

Lunch and Poster Session

11:35- 12:30 Lunch Break – Penguin Ed's Barbeque (Foyer)

12:30- 13:30 Poster Session and Student Poster Competition (Presenters should stand at Posters, Room 405)

PENGUIN ED'S BBQ

11:35-12:30 in the Foyer
Sponsored by Arkansas Farm Bureau

POSTER SESSION

12:30-1:30 in Rooms 405-407
Sponsored by Arkansas Farm Bureau

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. Maximizing Digital Resources: Combining GIS Technology and Field Work for Depicting Low-Order Streams in the Ozark Mountains. A.S. Bartell, M.A. Crump*, and A. Clingenpeel. US DA Forest Service, Russellville, Arkansas, mcrup@fs.fed.us.
2. Persistence of Broad Host Range Plasmids in a Municipal Wastewater Treatment Plant. K.L. Asfahl* and M.C. Savin, Department of Crop, Soil and Environmental Sciences, University of Arkansas, kasfahl@uark.edu. *Student Poster Presenter*.
3. Pharmaceuticals and Organic Wastewater Compounds in Water and Bed Material Downstream of Three Municipal Effluent Discharges. L.D. Bartsch* and B.E. Haggard, Arkansas Water Resources Center, UA Division of Agriculture, lbartsc@uark.edu.
4. Tracking Stream Nitrate Sources and Flow Paths Using Isotopes on a Basin with Mixed Land-Uses and Karst Terrain. A. Buda* and D.R. DeWalle, USDA-ARS, University Park, Pennsylvania, anothony.buda@ars.usda.gov.
5. An Evaluation of Heavy Metal Concentrations in Pond Sediments on the Ozark – St. Francis National Forests. M. Crump* and M. Weeks, USDA Forest Service, Russellville, Arkansas, mcrup@fs.fed.us
6. The Effect of Light and Temperature on Periphyton Phosphorus Uptake over Two Seasons in Several Northwest Arkansas Streams. B.M. Drake*, J.T. Scott, A.N. Sharpley, B.E. Haggard, and C.W. Rogers, Department of Crop, Soil and Environmental Sciences, University of Arkansas, bmdrake@uark.edu. *Student Poster Presenter.*
7. Nutrient Concentrations, Loads, and Yields in the Eucha-Spavinaw Basin. R. Esralew, US Geological Survey, Oklahoma City, resralew@usgs.gov.
8. Development of Regression-Based Models to Predict Fecal Indicator Bacteria at the Illinois River Basin, Arkansas and Oklahoma. B.E. Haggard* and M.M. David, Arkansas Water Resources Center, UA Division of Agriculture, haggard@uark.edu.
9. Benthic Macroinvertebrate Food Web Patterns in a Headwater Stream Prior to a Riparian Zone Restoration. E.N. Jensen*, M. Evans-White, and B.E. Haggard, Department of Biological Sciences, University of Arkansas, exj12@uark.edu. *Student Poster Presenter.*

10. The Use of Stable Carbon Isotopes to Identify Carbon and Nutrient Fluxes in a Northwestern Arkansas Soil-Cave System. K.J. Knierium*, E. Pollock, and P. Hays. Environmental Dynamics Program, University of Arkansas, kknierim@uark.edu.

11. Measuring Stream Bank Erosion Using Images and Digital Photogrammetry. M. Leh*, S. Bajaw, I. Chaubey, J. Cothren, and K. Asante, Department of Biological and Agricultural Engineering, University of Arkansas, mleh@uark.edu.

12. An Initial Assessment of the Invertebrate Assemblage and Aquatic Habitat at the Watershed Research and Education Center. S.D. Longing*, B.E. Haggard, Department of Biological Engineering, University of Arkansas, slonging@uark.edu.

13. Selection and Placement of Best Management Practices Used to Reduce Total Phosphorus Runoff in the Lincoln Lake Watershed in Northwest Arkansas. H.G. Rodríguez* and C. Maringanti, Department of Agricultural Economics and Agribusiness, University of Arkansas, hrodrig@uark.edu. *Student Poster Presenter.*

14. Distribution and Phosphorus-Sorption Characteristics of Select Streams within the Illinois River Watershed. C.W. Rogers*, A.N. Sharpley, B.E. Haggard, J.T. Scott, and B.M. Drake, Department of Crop, Soil and Environmental Sciences, University of Arkansas, cwrogers@uark.edu. *Student Poster Presenter.*

15. Estimation of Phosphorus Loads in Headwater Streams Draining Commercial Poultry-Pasture Operations. J. Romeis*, R. Jackson, D.E. Radcliffe, and M. Risse. Department of Crop Soil and Environmental Sciences University of Arkansas, jromeis@uark.edu.

16. Carbon, Nitrogen and Phosphorus Concentrations in Runoff Water from Urban Streams, Established Green Roofs, and Traditional Roofs. C. Toland*, B.E. Haggard, and M. Boyer. Department of Crop, Soil and Environmental Sciences, cteland@uark.edu. *Student Poster Presenter.*

17. Upward Bound Science Academy: Connecting Surface to Ground Water Processes and Policy through Research. Wendi J.W. Williams* and Brian Raborn, Upward Bound Summer Science Academy, University of Arkansas, wjwillia@uark.edu.

18. Climate, Cynanobacteria and MIB—A Bad Tasting Combination. B. Winston*, S. Hausman, J.T. Scott, R. Davis, R.A. Morgan, W.R. Green, and S. Boss. Environmental Dynamics Program, University of Arkansas, bwinsto@uark.edu.

TUESDAY APRIL 14, 2009

SESSION 3: NUTRIENT HOTSPOTS AND RIPARIAN FOREST BUFFERS
MODERATOR: HAL LIECHTY, ARKANSAS FOREST RESOURCE CENTER
UA MONTICELLO

13:30 Landuse and Water Quality in Alabama Costal Watersheds, Latif Kalin, School of Forestry and Wildlife Sciences, Auburn University (latif@auburn.edu)

13:50 Effects of Hydrology and Field Management on Phosphorus Transfers in Surface Runoff along an Agricultural Hillslope in Pennsylvania, Tony Buda, USDA-ARS, State College, Pennsylvania (anthony.buda@ars.usda.gov)

14:10 Research at the Agroforestry Center, Richard Straight, USDA National Agroforestry Center, Lincoln, NE (rstraight@fs.fed.us)

14:30 Forest BMP Efficiency, Eric Schilling, National Council of Air and Stream Improvement (eschilling@src-ncasi.org)

SESSION 4: ARKANSAS AGENCY AND SCENIC RIVER UPDATES
MODERATOR: JERRY FARRIS, ASSOCIATE DEAN OF THE COLLEGE OF SCIENCE AND MATHEMATICS, ARKANSAS STATE UNIVERSITY

3:10 Arkansas's 319 Program—Update, Current Projects and Future Directions, Tony Ramick, Arkansas Natural Resources Commission (tony.ramick@arkansas.gov)

3:35 Ambient Water Quality Monitoring Program in Arkansas Water Resources, Steve Drown, Arkansas Department of Environmental Quality (drown@adeq.state.ar.us)

4:00 Arkansas's Source Water Protection Program, Wellhead Protection Program, and Pathogens, Dan Smith and Sandra Chandler, Arkansas Department of Health (daniel.smith@arkansas.gov; sandra.chandler@arkansas.gov)

4:25 Discrete Fecal Bacteria Monitoring and Riparian Plans in the Illinois River Watershed, Ed Fite, Oklahoma Scenic Rivers Commission (osrc@fullnet.net)

AETN's "Troubled Water"

Tuesday, April 14 from 7:00-8:00 PM
Arkansas Student Union Theater

The Union Theater is located on the University of Arkansas Campus in the Arkansas Student Union.
435 N Garland Ave
~25 minute walk from the Cosmopolitan hotel

A study of water resources in Arkansas is as varied as the people who live here. Different issues in different parts of the state are raising a common concern—that our status as a water rich state may be in doubt. Growth in industry, agriculture, and population is straining this essential resource and the signs are beginning to show. Water quality is suffering from growth and development in the watersheds, and water levels are dropping in aquifers throughout the State.

"Troubled Water" is an AETN original sixty-minute documentary that travels across the state to learn more about the potential for a water crisis in Arkansas. Farmers, geologists, experts, and concerned citizens share their opinions and stories about how water is managed in Arkansas, and what we need to do to protect this irreplaceable resource.

Railhead Saloon Social

Tuesday, April 14 from 8:00-9:30 PM
Sponsored by Hach Environmental

Railhead Saloon is located at 550 W Dickson Street
(Between Wow Japanese Bistro and On the Rocks)
~15 minute walk from the Cosmopolitan Hotel

Environmental
Be Right. The Environment is Worth it.

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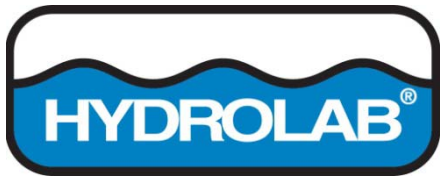

WEDNESDAY APRIL 15, 2009

SESSION 5: RIPARIAN FOREST BUFFERS (RFBS) 101—EVERYTHING YOU NEED TO KNOW
MODERATOR: MIKE FAUPEL, UNIVERSITY OF ARKANSAS

8:25 Introduction, Hal Lietchy, Arkansas Forest Resources Center, UA Monticello (lietchy@uamont.edu)

8:30 Riparian Forest Buffers 101—What, Where and Why? Hal Lietchy, Arkansas Forest Resources Center, UA Monticello (lietchy@uamont.edu)

8:50 Riparian Forest Buffers 101—Site Preparation, Planting and Tree Selection in a Nutshell, Chris Stuhlinger, University of Arkansas System Forest Manager (stuhlinger@uamont.edu)

9:10 Riparian Forest Buffers 101—Planning for Success and Maybe Natural Disasters, Kyle Cunningham, UA Cooperative Extension Service (kcunningham@uaex.edu)

9:30 Wildlife Values of Riparian Buffers in Managed Forests, Phil Tappe, Arkansas Forest Resources Center, UA Monticello (tappe@uamont.edu)

SESSION 6: STAKEHOLDER WILLINGNESS, VOLUNTEERISM AND EDUCATIONAL OPPORTUNITIES
MODERATOR: KYLE CUNNINGHAM, UA COOPERATIVE EXTENSION SERVICE

10:15 Geospatial Technology Approaches for Inventorying Riparian Buffer Cover in L'Anguille River Watershed, Dharmendra Saraswat, UA Cooperative Extension Service (dsaraswat@uaex.edu)

10:35 Stakeholder Willingness to Use BMPs in a Mississippi Watershed, Tim Schauwrecker, Department of Landscape Architecture, Mississippi State University (tschauwecker@lalc.msstate.edu)

10:55 The Riparian Project and Volunteer Monitoring—Updates from the Illinois River Watershed Partnership, Delia Haak, Executive Director, Illinois River Watershed Partnership

11:15 Discovery Farms Concept—Monitoring Farming Practices and BMP Efficiencies in Arkansas, Andrew Sharpley, Crop Soil and Environmental Sciences Department, UA Division of Agriculture (sharpely@uark.edu)

11:25 Watershed Research and Education Center—Introduction, Current Activities and Future Plans, Brian Haggard, Arkansas Water Resources Center, UA Division of Agriculture (haggard@uark.edu)

11:30 Lunch Break (On Your Own)

RIPARIAN FOREST BUFFER FIELD TOUR AND WORKSHOP CONTINUED
WATERSHED RESEARCH AND EDUCATION CENTER
TOUR LEADERS: KYLE CUNNINGHAM, BRIAN HAGGARD, HAL LIECHTY, CHRIS STUHLINGER AND CHUCK WEST, UA DIVISION OF AGRICULTURE

13:00 Tour Starts at the Pauline Whitaker Animal Sciences Arena Parking Lot

Pauline Whitaker Animal Sciences Center is located at 1335 W Knapp Street, Fayetteville Arkansas.

From the Cosmopolitan Hotel, head north on N East Avenue. Turn left onto Dickson Street. Turn right on N West Avenue. Turn left onto W Maple Street. Turn right onto Garland Ave/ AR-112. Follow Garland/AR-112 until you reach Knapp Street on your left. You will notice a large wall sign denoting Pauline Whitaker Animal Science Center.

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In addition, over 20 participants registered on-site during the conference.

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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	3	0	0	4	7
Masters	2	0	0	6	8
Ph.D.	2	0	0	1	3
Post-Doc.	0	0	0	1	1
Total	7	0	0	12	19

Notable Awards and Achievements

Establishing Effective Partnerships

The Arkansas Water Resources Center (AWRC) has teamed with the Illinois River Watershed Partnership (IRWP) to develop the Watershed Management Plan (WMP) for the Upper Illinois river Watershed in northwest Arkansas. This WMP will outline strategies to improve water quality at the HUC 12 (or subwatershed) level within the Upper Illinois River Watershed focused at reducing the concentrations of nitrogen, phosphorus, sediments and bacteria in regional streams. This partnership and WMP are timely efforts given that the Illinois River Watershed in Arkansas and Oklahoma is the focal point of an environmental lawsuit targeting water quality issues and poultry production in this region. The funding for the WMP development was provided by the Walton Family Foundation and the USEPA thro ugh the Arkansas Natural Resources Commission.

The AWRC has also teamed up with the IRWP to conduct various water quality monitoring projects in the Upper Illinois River Watershed, including the water quality monitoring and load estimation at the Illinois River and Ballard creek near the Arkansas and Oklahoma border. The AWRC has been the primary unit monitoring water quality and estimating constituent loads at these sites near the state borders, and this shows that the data provided through the AWRC field service unit and its research teams are considered to be sound,reliable, and unbiased sources of information. It is critical to maintain this level of integrity, when we are dealing with water quality as the focus of legal battles.

The AWRC managed the Volunteer Monitoring Program for the IRWP over this past year, where 37 sites within the Upper Illinois River Watershed was sampled seasonally by volunteers, including IRWP Board Members and AWRC field and research associates. The volunteers were used to collect water samples where various water quality parameters where measured, and these recent measures of water quality will be compared to that measured more than 15 years ago at these same sites. The AWRC field services unit and research associates trained 20 plus volunteers to collect water samples, fill out chain of custody forms, and relinquish the samples to the AWRC certified water quality lab. The IRWP plans to adjust this volunteer monitoring program to target specific subwatersheds within the Upper Illinois River Watershed, developing
long-term databases on various water quality parameters such as nitrogen, phosphorus, and suspended sediment concentrations.

The AWRC was funded by USEPA Region 6 and Headquarters to provide technical assistance to develop nutrient criteria within the multi-jurisdictional Red River Basin through two phases: Phase I organized the database compiling water quality data from the USGS, Arkansas Department of Environmental Quality, Louisiana Department of Environmental Quality, Oklahoma Conservation Commission and Oklahoma Water Resources Board, and the Texas Commission on Environmental Quality, and Phase II provided summaries of the statistical distribution of median nutrient concentrations across the Red River separated into aggregate
watersheds and eco-regions, as well as statistical relations between nutrient concentrations and algal biomass (i.e., chlorophyll a concentrations). These reports will be used in a weight-of-evidence approach to assist the states with catchments draining into the Red River in the development of numerical nutrient criteria.

National Recognition

Dr. Andrew Sharpley, who has received USGS 104B to study fluvial processes that modify phosphorus export from catchments, was recognized nationally for his scientific contributions while with the USDA Agricultural Research Service (USDA–ARS). Dr. Sharpley was selected to be on the Scientific Advisory Board for the Hypoxia in the Northern Gulf of Mexico: Scientific Assessment of Cause and Options for Mitigation for the USEPA; this group of nationally renowned scientists evaluated the state-of-the-science regarding the hypoxic Notable Awards and Achievements 1 zone. Dr. Sharpley was also recently inducted into the USDA–ARS Hall of Fame 'for pioneering nutrient research leading tot eh development of agricultural management practices and strategies that are used nationally and internationally to protect water quality'. Dr. Sharpley received his USGS 104B funding to jump start his research program that he has started here at the University of Arkansas – Division of Agriculture, that will focus on nutrient (especially phosphorus) transport from the edge-of-fields through streams in critically important regional watersheds. Following the change in directors at the Arkansas Water Resources Center (AWRC), Dr. Sharpley was named to the Technical Advisory Committee for the AWRC.

Collaborative Multidisciplinary Research Education Programs

The Arkansas Water Resources Center (AWRC) along with other disciplines (including Animal Sciences, Geosciences, Soils, Environmental Sciences, Ecological Engineering and Biology) have used the USGS 104B funding as a source to initiate research projects at the University of Arkansas Savoy Experimental Watershed (SEW) and to stimulate the inflow of funding from other federal sources to further support this research. The research projects at SEW have addressed a variety of important water issues, and these project were broad across multiple disciplines. Examples of these projects include: 1)Identification of mechanisms (infiltration excess or saturation excess) that produce surface runoff from pasture hill slopes (Ecological Engineering) 2)Water quality of springs and groundwater downslope from ponds holding swine manure (Geosciences & Animal Sciences) 3)Nitrogen transport and utilization along a shallow groundwater flow path (Biology & Geosciences) The focus of research at SEW often revolves around understanding the transport and ate of nutrients in a strongly linked surface-subsurface karst agricultural watershed, which is critical to developing best management practices that will improve water quality and protect human health.

The AWRC has also teamed up with the University of Arkansas Crop, Soil and Environmental Sciences Department and the Landscape Architecture Department to evaluate the quantity and quality of stormwater produced by mock green roofs; the typical industry standard is to mix compost with the growing media used on green roofs at 15% by volume to accelerate plant growth. This project will provide critical information to understanding the water storage capacity of green roofs on a temporal basis, the potential for nutrient and other constituent transport in stormwater, and what plants survive the harsh environmental conditions in these 'green' systems. The AWRC worked closely with the UA Cooperative Extension Service to develop fact sheets, entitled 'Arkansas Watersheds' and 'What is Water Quality'. The fact sheet 'What is Water Quality' provide a less technical resource to help educate our general stakeholders on how water quality, e.g. nutrient concentrations, are influenced by land uses changes, what are designated uses, where water quality standards can be found, and how are impairments determined . The fact sheet 'Arkansas Watersheds' describes what is a watershed, how are watershed indentified, and what is a hydrologic unit code. These fact sheets are unique educational tools that increase the awareness of watershed and water quality within the state of Arkansas.

Cutting Edge Research

The Arkansas Water Resources Center used USGS 104B Funds to initiate a project to determine if different sources of phosphorus had different signatures of oxygen isotopes in dissolved phosphate (PO4), and if so could these different isotopic signatures be used to distinguish between phosphorus sources in regional streams. Recently developed isotopic methods enable determination of oxygen isotope composition of soluble reactive phosphate (SRP), potentially allowing sources of phosphates in aquatic systems to be identified. This project evaluated the oxygen isotope composition of various potential sources of phosphate in aquatic Notable Awards and Achievements 2 systems, including effluent from municipal wastewater treatment plants and water extractable phosphorus from poultry litter and commercial fertilizers. This preliminary work clearly shows that the isotopic oxygen composition in dissolved phosphate varies by source, which potentially enables the partitioning of dissolved phosphorus between sources.

Publications from Prior Years

1. 2006AR122B ("Sediment Characterization in Three Coves - Beaver Reservoir, Arkansas") - Conference Proceedings - Patton, J. and S.K. Boss. 2008. Geochemical characterization of Beaver Reservoir sediments containing drinking water treatment residuals at the 2008 Joint meeting of the Geological Society of America, Soil Science Society of America, American Society of Agronomy, Crop Science Society of America, Gulf Coast Associate of Geological Societies with the Gulf Coast Section of SEPM, Houston, Texas.

2. 2007AR171B ("Continuous Water-Quality Monitoring and Potential Phosphorus Source Identification with Oxygen Isotopes") - Conference Proceedings - Breaker, B., E. Pollock, P. Hays, and B. Haggard. 2008. Use of phosphate-oxygen isotope ratios as a tracer for sources and cycling of phosphorus in the Illinois River in AR and OK at American Geophysical Union, San Francisco, California.

3. 2007AR162B ("Long-term runoff water quality in response to natural rainfall as affected by poultry litter application rate") - Articles in Refereed Scientific Journals - Brie, M., Brye, K.R., Pirani, A.L., Haggard, B.E., and Gbur, E.E. 2009. Runoff water quality from broiler-litter-amended tall fescue in response to natural precipitation in the Ozarks Highlands. Journal of Environmental Quality 38: 343-352.

4. 2007AR164B ("Source of Geosmin and MIB in drinking water: Identifying the source and mechanisms of taste and odor compounds at Beaver Reservoir, northwest Arkansas") – Conference Proceedings - Winston, B., and S Hausman, 2008, Understanding Reservoir Aging through Paleolimnological and Modern Techniques at National Association of Black Geologist and Geophysicist Annual Conference, Atlanta, Georgia.

5. 2007AR171B ("Continuous Water-Quality Monitoring and Potential Phosphorus Source Identification with Oxygen Isotopes") - Articles in Refereed Scientific Journals - Toor, G.S., R.D. Harmel, B.E. Haggard, and G. Schmidt. 2008. Regression methodology with low-frequency water quality sampling to estimate constituent loads for ephemeral watersheds. Journal of Environmental Quality 37:1847-1854.

6. 2007AR173B ("Metal Mobilization, Especially Arsenic, in the Alluvial Aquifer in Response to Water Level Fluctuations Measured by Field and Laboratory Column Data ") - Articles in Refereed Scientific Journals - Sharif, M.U., R. K. Davis, K. F. Steele, B. Kim, T. M. Kresse, P.D. Hays and J.A. Fazio, 2008, Distribution and Variability of Redox Zones as Control of Spatial Variability of Arsenic in the Mississippi River Valley Alluvial Aquifer, Southeastern Arkansas, USA. Journal of Contaminant Hydrology, 99:49-67.

7. 2007AR173B ("Metal Mobilization, Especially Arsenic, in the Alluvial Aquifer in Response to Water Level Fluctuations Measured by Field and Laboratory Column Data ") - Articles in Refereed Scientific Journals - Sharif, M.U., R. K. Davis, K. F. Steele, B. Kim, P. Hays, T. M. Kresse, and J.A. Fazio, 2008, Inverse geochemical modeling of groundwater evolution with emphasis on arsenic in the Mississippi River Valley alluvial aquifer, Arkansas (USA). Journal of Hydrology, 350:41-55.

8. 2007AR173B ("Metal Mobilization, Especially Arsenic, in the Alluvial Aquifer in Response to Water Level Fluctuations Measured by Field and Laboratory Column Data ") - Articles in Refereed Scientific Journals - Sharif, M.U., R. K. Davis, K. F. Steele, B. Kim, T. M. Kresse, P.D. Hays and J.A. Fazio , 2009, Surface Complexation Modeling Using PHREEQC for Predicting Solid-Phase Arsenic Concentrations in the Sediments of the Mississippi River Valley Alluvial Aquifer, Arkansas, USA. Journal of Environmental Science and Health. In Press.

9. Publications from Prior Years 1 2006AR131B ("Occurrence and antibiotic resistance in fecal indicator bacteria upstream and downstream of wastewater treatment plants in northwest Arkansas") - Conference Proceedings - Akiyama, T., and M. C. Savin. 2008. Patterns of multi-drug resistance in Escherichia coli isolated from a stream receiving treated wastewater at Arkansas Water Resources Conference, Fayetteville, Arkansas.

10. 2006AR131B ("Occurrence and antibiotic resistance in fecal indicator bacteria upstream and downstream of wastewater treatment plants in northwest Arkansas") - Conference Proceedings -Akiyama, T., and M. C. Savin. 2008. Antibiotic-resistant Escherichia coli in a Northwest Arkansas stream receiving wastewater treatment plant effluent at American Society for Microbiology Annual Meeting, Boston, Massachusetts.