Arkansas Water Resources Center

1995 Institute Program Report

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By:

Kenneth F. Steele, Director

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Arkansas Water Resources Center
112 Ozark Hall
University of Arkansas
Fayetteville, Arkansas 72701

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G-1549-07

FISCAL YEAR 1995 PROGRAM REPORT
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FOR

U.S. DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

BY

ARKANSAS WATER RESOURCES CENTER
UNIVERSITY OF ARKANSAS
FAYETTEVILLE, ARKANSAS 72701

KENNETH F. STEELE, DIRECTOR

JUNE 1996

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ABSTRACT

Institute Program Report G-1549-06, June 1996

Two of the Institute Program (Section 104) projects relate to non-point source pollution from nutrients and pesticides. One project investigated the movement and persistence of rice pesticides into ponded water sources used for recycling irrigation water and determining the dissipation mechanisms involved. The second project investigated an alluvial aquifer in northeastern Arkansas for nitrate, lead, and total coliform bacteria concentrations. A third project investigated the bioaccumulation of mercury in a food chain, and verified mercury accumulation in a south Arkansas oxbow lake by *in situ* exposure. The fourth section 104 project has determined that the zebra mussel population in Lake Dardanelle has increase exponentially since their appearance in 1992. The population has recently reached a size that appears to be significantly impacting the ecology of the reservoir.

Over 18 projects administered by the Center were directly or indirectly related to non-point source pollution. Those projects related to non-point source pollution included several pesticide contamination studies on ground water, impact of silviculture practices on stream water quality, demonstrations of grass buffer strips and use of alum as best management practices (BMPs) for poultry litter, use of poultry litter to reduce sediment and nutrient losses from cotton cropland, demonstration of cotton production BMPs on soil and water in the Delta, prioritization of subwatersheds within the Illinois River in terms of pollution, and demonstration of BMPs on water quality in the upper White River watershed.

Several geographical information systems (GIS) projects are indirectly related to non-point source pollution in the Buffalo National River, and the Millwood Lake watershed. Other GIS projects included mapping and analyses of soils, land use, spatial analysis of causes of mercury contamination of fish in Arkansas, and wetlands in eastern Arkansas. There was one project investigating constructed wetlands as a means of remediation of wastewater at swine rearing facilities.

Six riparian zone projects inventoried and characterized riparian zone vegetation along streams and springs in the Ozark region, surveyed birds in this habitant, and surveyed threatened species. A project on climate and streamflow reconstructions for the Ozark Highlands using long-term tree-ring data was completed.

The Center also continued to administer the project for the development of innovative septic tank designs for areas that do not accommodate standard designs. These areas occur throughout the state and are primarily the result of thin soils, impermeable layers near the surface, and high water tables.

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WATER PROBLEMS AND ISSUES OF ARKANSAS

The following water problems/issues are currently important in Arkansas:

1. non-point source contamination (nutrients and pesticides)
2. development of efficient septic systems
3. wetlands
4. zebra mussel infestation of Arkansas lakes and streams may be a serious problem in the near future
5. mercury content of fish flesh, especially in southeastern Arkansas, continues to be an important problem
6. Sources of bacteria in water and interpretation of the results
7. lowering of ground water levels in eastern and southern Arkansas and the associated potential salt water contamination of fresh ground water
8. dissolved oxygen content for reservoir release waters.

The first six problems/issues were the focus of Center projects this year and are briefly discussed below.

Non-point Source Contamination

Non-point source contamination by nutrients, bacteria, and pesticides, is an area of concern for the nation and Arkansas. This year two of the Center's projects, partially funded under section 104, were related to non-point source pollution by agricultural activities. These projects considered non-point source pollution in terms of ground water and rice production.

Efficient Septic Tank Design

Work has continued on the development of efficient septic tank design for problem areas of Arkansas, e.g., those areas with shallow soils, or high water tables. The project is funded by the state through the University of Arkansas. The principal investigators work closely with the Arkansas Department of Health in development of projects and technical information transfer.

Constructed Wetlands

Wetlands are an important issue nationally and the Center has recognized the importance of the areas. The Center currently is involved in two constructed wetland studies. During the next year a major mapping program for wetlands in Arkansas is anticipated.

Zebra Mussel Infestation

The northern areas of the United States have experienced problems with zebra mussels for several years. Zebra mussels have been present in Arkansas for several years, and it is important that baseline data be collected now concerning the possible infestation of these mussels in Lake Dardanelle. This project was supported in part with section 104 funds.

Mercury Content of Fish

The state recognized the mercury contamination of fish, especially in southeastern Arkansas several years ago. The Center partially supported a project on bioaccumulation of methyl mercury through the food chain with section 104 funds this year.

Bacteria Studies

One of the section 104 projects studying non-point source pollution includes bacteria as one of the parameters studied.

PROGRAM GOALS AND PRIORITIES

Expansion of the Center's research support and capabilities continues to be one of the major goals of the Center. The Cooperative Extension Service and the Department of Agronomy continue to cooperate with the Arkansas Water Resources Center Water Quality Laboratory in a water quality program for farmers and rural residents of the state. The Center's program includes significant effort in information dissemination. In addition to publication of reports, journal articles, and books, the Center sponsors and co-sponsors conferences for dissemination of information. This past year the Center sponsored a conference on "Arkansas Diversity of Water Resources Research," a short course titled "Water Quality Monitoring Design and Statistical Analysis for Nonpoint Source Pollution Studies," and co-sponsored the national conference on "Animal Waste and the Land-Water Interface." The major information dissemination efforts by the Center were for the conference on "Animal Waste and the Land-Water Interface," and the associated publications, including a hardbound book by the same title published by Lewis/CRC Publishers.

Although the Center has a strong cooperative research programs with state and federal agencies, these can be expanded and strengthened. Cooperative efforts with environmental and industrial organizations need to be established.

The research priorities of the Center were reviewed and re-authorized at the November 16, 1995 Technical Advisory Committee meeting and are as follows:

Arkansas Water Research Priorities by Rank

1. Investigate the physical, chemical, and biological characteristics of streams, reservoirs, etc. (storm events, substrate/water interactions, identification of new resources, reference systems, etc.).

2. Quantify and qualify the trophic levels and associated parameters in lentil and lotic ecosystems (modeling, energy transfer, production, etc.).

3. Determine the impact of natural and synthetic chemicals on surface water quality (point and non-point sources, toxic material, pesticides, industrial and mining wastes, etc.).

4. Develop analytical techniques and protocols for assessing water quality (quality control, quality assurance, microbiological, indicator species, etc.).

5. Develop mechanisms for improving quality and quantity of water supplies for surface applications and the impact of the applications (water treatments, Irrigation, return flow, leaching, etc.).

Regional Research Priorities

Water Quality: Needs in the water quality area involve information, information management, and the protection of surface and ground water from degradation. It includes industrial and municipal wastewater treatment and municipal wastewater treatment and subsurface disposal of hazardous/toxic wastes. In addition, problems

from non-point sources of both municipal and agricultural sources, including soil erosion, agricultural runoff, and pesticides, pertain to this area. The development and improvement of monitoring techniques and analysis are also important, as well as water quality problems associated with eutrophication and weed control.

Water Management: Research needs in the area of water management include legal, institutional, and financial arrangements. Specific items such as basin planning, water use control, transfers and/or diversions of water, flood control, and drought planning are all priority issues.

It also includes construction of facilities, financing and pricing, and water conservation and reuse. Management includes quality protection studies, upgrading of supplies, and state and/or federal and interstate interactions or compacts.

Water Quantity: Research needs in the water quantity area include studies of the basin water cycle for an understanding of prediction. It also includes items of surface water flow, basin planning, low flow predictions (7Q10), flood control, water use, and water allocation. Included also are studies of ground water availability and the locations, movement, and volume of ground water. Also of importance are use and user impacts and suface and ground water interaction.

Aquatic and Environmental Protection: Research needs in this area include studies of wetlands, swamps and marshes, fish and other biota, and the quality of life. It also includes studies of ecological balance, protection of endangered species, and studies of dredging and filling.

Emerging Problems: Studies not included in other priority areas, but which are dedicated to solving emerging water problems which are identified as critical issues by key state water management officials in the region, are included in this category.

During the next year, these research priorities will be reviewed with the Technical Advisory Committee. Although no major changes in the priorities are anticipated, more focus will probably be placed on current specific problems, e.g., non-point source contamination and wetlands. This focus should allow the Center and the state/federal agencies to cooperate more effectively in solving water resource problems in Arkansas.

The Arkansas Water Resources Center, in conjunction with state and federal agencies, is addressing many of the issues described under Water Problems and Issues of Arkansas. A list of the accounts active at the Arkansas Water Resources Center for 1995 is given in the following table.

AWRC ACTIVE ACCOUNTS
FOR FISCAL YEAR 1995

COMPANY COST CENTER NUMBER	ACCOUNT NAME	DEPARTMENT UNIVERSITY	PRINCIPAL INVESTIGATOR	BEGINNING DATE TERMINATION DATE	AGENCY	FUNDING MATCH	TOTAL
0102-04121-00-0000 STATE OF ARKANSAS	SEPTIC TANK II	AGRONOMY UAF ENGINEERING UALR	MOYE RUTLEDGE, DUANE WOLF, MARK GROSS	7/01/94 TO 6/30/9	71,000	0	71,000
0102-13560-21-0000 STATE OF ARKANSAS	WRRC MAINTENANCE	AWRC UAF	KENNETH STEELE	7/01/95 TO 6/30/96	21,940	0	21,940
0402-05027-21-0000 NATIONAL PARK SERVICE	LABORATORY ANALYSIS ON WATER SAMPLES FROM OZARK AND OUACHITA NATIONAL FOREST	AWRC UAF	PAUL VENDRELL & KENNETH STEELE	10/01/95 TO 11/01/96	6,000	6,717	12,717
0402-14098-21-0000 NATIONAL PARK SERVICE	MONITOR RAIN EVENTS	AWRC UAF	KENNETH STEELE	06/01/94 TO 09/30/96	23,500	11,998	35,498
0402-14099-21-0000 NATIONAL PARK SERVICE	INVENTORY AND CHARACTERIZATION OF THE RIPARIAN ZONE AT THE CURRENT AND JACKS FORK RIVERS	BIOLOGICAL SCIENCES UAF	CYNTHIA SAGERS	09/14/94 TO 07/31/96	55,000	9,121	64,121
0402-14102-21-0000 U.S. GEOLOGICAL SURVEY	PROGRAM MANAGEMENT	AWRC UAF	KENNETH STEELE	07/01/95 TO 06/30/96	23,213	67,848	91,061
0402-14103-21-0000 U.S. GEOLOGICAL SURVEY	WATER QUALITY OF RURAL DOMESTIC SUPPLY WELLS IN SELECT AQUIFERS IN ARKANSAS	GEOLOGY UAF	RALPH DAVIS	07/01/95 TO 06/30/96	19,852	14,062	33,914
0402-14104-21-0000 U.S. GEOLOGICAL SURVEY	BIOACCUMULATION OF METHYL MERCURY THROUGH A FOOD CHAIN	BIOLOGY OUACHITA BAPTIST UNIV.	TIM KNIGHT	7/01/95 TO 06/30/96	9,368	18,782	28,150
0402-14105-21-0000 U.S. GEOLOGICAL SURVEY	INFLUENCE OF RICE PRODUCTION ON THE QUALITY OF WATER IN TAILWATER COLLECTION RESERVOIRS	AGRONOMY UAF	TERRY LAVY	07/01/95 TO 06/30/96	10,000	20,270	30,270
0402-14106-21-0000 U.S. GEOLOGICAL SURVEY	EFFECTS OF ZEBRA MUSSEL, DREISSENA POLYMORPHA, INFESTATION ON LAKE DARDNAELLE WATER QUALITY	BIOLOGY ARKANSAS TECH UNIVERSITY	CHARLES GAGEN & JOSEPH STOECKEL	07/01/95 TO 06/30/96	16,112	33,205	49,317
0402-14107-21-0000 U.S. GEOLOGICAL SURVEY	PROGRAM MANAGEMENT	AWRC UAF	KENNETH STEELE	03/01/96 TO 02/28/97	20,000	42,247	62,247
0402-14535-21-0000 NATIONAL PARK SERVICE	INVENTORY AND MAPPING OF THE RIPARIAN ZONE (WETLANDS) AT BUFFALO NATIONAL RIVER	BIOLOGICAL SCIENCES UAF	CYNTHIA SAGERS	5/24/94 TO 9/30/96	38,000	6,649	44,649

COMPANY COST CENTER NUMBER	ACCOUNT NAME	DEPARTMENT UNIVERSITY	PRINCIPAL INVESTIGATOR	BEGINNING DATE TERMINATION DATE	AGENCY	FUNDING MATCH	TOTAL
0402-14545-21-0000 NATIONAL PARK SERVICE	PLANT INVENTORY OF SELECTED SPRINGS AND SEEPS AT BUFFALO NATIONAL RIVER	BIOLOGICAL SCIENCES UAF	CYNTHIA SAGERS	07/19/95 TO 09/30/96	12,000	10,631	22,631
0402-14546-21-0000 NATIONAL PARK SERVICE	INVENTORY AND CHARACTERIZATION OF THE RIPARIAN ZONE OF THE CURRENT AND JACKS FORK RIVERS	BIOLOGICAL SCIENCES UAF	CYNTHIA SAGERS	08/28/95 TO 07/31/97	27,500	4,813	32,313
0402-25012-21-0000 ARKANSAS DEPARTMENT OF POLLUTION CONTROL & ECOLOGY	SPATIAL ANALYSIS OF CAUSE OF MERCURY CONTAMINATION IN FISH IN ARKANSAS	AGRONOMY UAF	HANGSHENG LIN H. DON SCOTT	05/20/96 TO 06/30/97	4,990	887	5,877
0402-32011-21-0000 ARKANSAS SOIL AND WATER CONSERVATION COMMISSION	WATERSHED PRIORITIZATION, FIRST AND SECOND YEAR STUDY	CIVIL ENGINEERING & AGRONOMY UAF	DAVID G. PARKER, H. DON SCOTT	01/01/93 TO 12/31/96	273,326	51,631	324,957
0402-32013-21-0000 ARKANSAS SOIL AND WATER CONSERVATION COMMISSION	ILLINOIS RIVER WATER QUALITY AUTOMATIC SAMPLER MONITORING STATION INSTALLATION	CIVIL ENGINEERING UAF	DAVID PARKER	10/05/93 TO 09/30/96	24,952	NONE	24,952
0402-32014-21-0000 ARKANSAS SOIL AND WATER CONSERVATION COMMISSION	DEVELOPMENT OF A GEOGRAPHICAL INFORMATION SYSTEM FOR MILLWOOD LAKE WATERSHED IN ARKANSAS	AGRONOMY UAF	DON SCOTT	10/05/93 TO 06/30/96	51,918	NONE	51,918
0402-32015-21-0000 ARKANSAS SOIL AND WATER CONSERVATION COMMISSION	DEMONSTRATION OF NUTRIENT MANAGEMENT FOR POULTRY LITTER USING ALUM PRECIPITATION OF SOLUBLE PHOSPHORUS	AGRONOMY UAF	PHILIP MOORE, JR. TOMMY DANIEL	07/01/94 TO 12/31/97	146,819	95,775	242,594
0402-32017-21-0000 ARKANSAS SOIL AND WATER CONSERVATION COMMISSION	DEMONSTRATION OF GRASS BUFFER STRIPS AS A BEST MANAGEMENT PRACTICE FOR POULTRY LITTER APPLICATION	AGRONOMY UAF	TOMMY DANIEL	07/01/94 TO 08/30/95	19,390	NONE	19,390
0402-32018-21-0000 ARKANSAS SOIL AND WATER CONSERVATION COMMISSION	POTEAU RIVER AND UPPER MILLWOOD LAKE WATERSHEDS, WATER QUALITY ANALYSIS	AWRC UAF	PAUL VENDRELL	07/01/94 TO 01/31/97	16,634	2,911	19,545
0402-32019-21-0000 ARKANSAS SOIL AND WATER CONSERVATION COMMISSION	YELL COUNTY, WATER QUALITY ANALYSIS	AWRC UAF	PAUL VENDRELL	08/01/94 TO 01/031/99	9,202	NONE	9,202

COMPANY COST CENTER NUMBER	ACCOUNT NAME	DEPARTMENT UNIVERSITY	PRINCIPAL INVESTIGATOR	BEGINNING DATE TERMINATION DATE	AGENCY	FUNDING MATCH	TOTAL
0402-32020-21-0000 ARKANSAS SOIL AND WATER CONSERVATION COMMISSION	CONTINUATION OF ILLINOIS RIVER WATER QUALITY MONITORING OF MOORES CREEK	AWRC UAF	PAUL VENDRELL MARC NELSON KENNETH STEELE	10/1/94 TO 9/30/97	151,252	19,360	170,612
0402-32021-21-0000 ARKANSAS SOIL AND WATER CONSERVATION COMMISSION	MONITORING BEST MANAGEMENT PRACTICES ON GROUND WATER QUALITY IN N.W. ARKANSAS	GEOLOGY AWRC UAF	R.ALPH DAVIS KENNETH STEELE	01/01/95 TO 09/30/98	110,099	22,020	132,119
0402-32025-21-0000 ARKANSAS SOIL AND WATER CONSERVATION COMMISSION	INTRA-COUNTY LAND USE DATA FOR THE BOEUF-TENSAS AREA	AGRONOMY UAF	DON SCOTT	02/03/95 TO 12/31/95	5,500	962	6,462
0402-32026-21-0000 ARKANSAS SOIL AND WATER CONSERVATION COMMISSION	UPPER WHITE RIVER BMP IMPLEMENTATION PROJECT	AWRC AGRONOMY WA. CO. CONS.	PAUL VENDRELL DON SCOTT PAUL SMITH	05/02/95 TO 04/30/98	254,841	178,510	433,351
0402-32027-21-0000 ARKANSAS SOIL AND WATER CONSERVATION COMMISSION	REDUCING SEDIMENT AND NUTRIENT LOSSES FROM COTTON CROPLAND BY USE OF POULTRY LITTER AS A FERTILIZER	BIO./AGRI ENG UAF	TOM COSTELLO	05/08/95 TO 07/01/98	150,407	111,281	261,688
0402-32028-21-0000 ARKANSAS SOIL AND WATER CONSERVATION COMMISSION	DEMONSTRATION OF COTTON PRODUCTION BMP IMPACT ON THE SOIL & WATER RESOURCES OF THE DELTA	AGRONOMY UAF	WILLIAM BAKER	05/08/95 TO 05/31/98	297,966	106,680	404,646
0402-32029-21-0000 ARKANSAS SOIL AND WATER CONSERVATION COMMISSION	CONSTRUCTED WETLANDS FOR WASTEWATER REMEDIATION AT SWINE REARING FACILITIES	AGRONOMY UAF	PHILIP MOORE, JR. DUANE WOLF TOMMY DANIEL	05/03/95 TO 04/30/98	297,574	234,498	532,072
0402-32030-21-0000 ARKANSAS SOIL AND WATER CONSERVATION COMMISSION	SPRING RIVER SAMPLING	AWRC UAF	PAUL VENDRELL	08/01/95 TO 12/31/99	13,224	2,314	15,538
0402-32031-21-0000 ARKANSAS SOIL AND WATER CONSERVATION COMMISSION	PESTICIDE MONITORING IN EASTERN ARKANSAS	AWRC UAF	PAUL VENDRELL	01/01/95 TO 09/15/95	4,756	832	5,588

COMPANY COST CENTER NUMBER	ACCOUNT NAME	DEPARTMENT UNIVERSITY	PRINCIPAL INVESTIGATOR	BEGINNING DATE TERMINATION DATE	AGENCY	FUNDING MATCH	TOTAL
0402-32032-21-0000 ARKANSAS SOIL AND WATER CONSERVATION COMMISSION	DIGITIZATION OF THE SOILS IN THE BEOUF-TENSAS REGION OF ARKANSAS	AGRONOMY UAF	DON SCOTT	10/01/95 TO 09/01/96	57,000	10,125	67,125
0402-32033-21-0000 ARKANSAS SOIL AND WATER CONSERVATION COMMISSION	GIS BASED WETLANDS ANALYSIS FOR BAYO METO AND GRAND PRAIRIE, ARKANSAS	CAST UAF	FRED LIMP	11/20/95 TO 07/15/96	29,140	5,272	34,412
0402-32034-21-0000 ARKANSAS SOIL AND WATER CONSERVATION COMMISSION	MINIMIZING IMPACTS OF ANIMAL WASTE ON SHALLOW KARST AQUIFERS	GEOLOGY UAF	RALPH DAVIS	01/01/96 TO 09/01/97	50,000	7,134	57,134
0402-32035-21-0000 ARKANSAS SOIL AND WATER CONSERVATION COMMISSION	ARKANSAS GROUND WATER QUALITY	AWRC UAF	PAUL VENDRELL KENNETH STEELE	01/01/96 TO 01/31/97	12,588	2,360	14,948
0402-36147-21-0000 AR/OK AR RIVER COMPACT COMMISSION	AUTOMATIC SAMPLER INSTALLATION ON MAIN STEM OF THE ILLINOIS RIVER NEAR WATTS, OKLAHOMA	CIVIL ENGINEERING UAF	DAVID PARKER	07/31/95 TO 07/30/96	51,400	7,682	59,082
0402-36149-21-0000 ARKANSAS TECH UNIVERSITY	WATER ANALYSES - ATU	AWRC UAF	PAUL VENDRELL	11/01/95 TO 08/30/96	5,500	0	5,500
0402-36155-21-0000 ARKANSAS STATE PLANT BOARD	PESTICIDE GROUND WATER MONITORING PROJECT FOR MOST VULNERABLE AREAS OF ARKANSAS	AWRC UAF	TERRY NICHOLS PAUL VENDRELL KENNETH STEELE	02/01/96 TO 06/30/96	61,950	11,616	73,566
TOTAL:					2,753,913	1,118,193	3,572,106

RESEARCH PROJECT SYNOPSES

SYNOPSIS

Project Number: 02

Start: 7/1/95
End: 6/30/96

Title: Water Quality of Rural Domestic Supply Wells in Select Aquifers in Arkansas

Investigators: Ralph K. Davis, University of Arkansas, Fayetteville, Arkansas

COWRR: GW, WQL, WS

Congressional District: Third

Descriptors: ground-water quality, water quality, rural domestic water supply

Problem and Research Objectives: Rural domestic water quality is an important issue nationally and in Arkansas. In Arkansas, ground water supplies over 90% of rural domestic needs (Augustine, 1985). Rural domestic use accounts for about 22% of the population of the state. It is therefore essential to have a basic knowledge of ground-water quality for this large user group. However, ground-water quality monitoring has focused primarily on public water supplies. Ground-water quality data from some areas of Arkansas indicate that about 5% of wells and springs are impacted by concentrations of nitrate-N in excess of 10 mg/L state wide (Teaque, et al., 1993; Thornton and Steele, 1992; Smith and Steele, 1990). Three areas of Arkansas appear to be most impacted by nitrate-N: the Springfield Plateau, Boston Mountains and West Gulf Coastal Plain.

The goal of the project is augmentation of water quality data for rural domestic wells in Arkansas. Specific objectives are:

1. Identify an aquifer in Arkansas based on background ground-water quality data that shows elevated concentrations of nitrate-N and lead.

2. Collect and analyze ground-water samples for the following parameters from this aquifer.

nitrate-N	sulfate	chloride	alkalinity
calcium	sodium	magnesium	potassium
lead	copper	zinc	iron
total coliform bacteria			

3. Determine statistical significance of selected parameters, such as nitrate-N.

4. Provide graphical representations of these data.

Methodology: Identification of an aquifer for sampling and analysis involved assessment of background ground-water quality data from across the state. The Springfield Plateau, Boston Mountains and West Gulf Coastal Plain had been identified in previous studies as areas having elevated concentrations of nitrate-N in ground

water. A decision was made to concentrate on alluvial aquifers since several other investigations were being conducted in the Springfield Plateau. Available ground-water quality data were reviewed for all alluvial aquifers in Arkansas. A study area in northeastern Arkansas was selected based on concentrations of nitrate-N and lead in the ground-water, and the low number of ground-water quality analyses available for the area.

Ground water samples were collected from rural domestic wells and a few irrigation wells in the spring and summer of 1996. These samples were delivered to the Arkansas Water Resources Center Water Quality Laboratory for analysis, which is ongoing. Once all analyses have been competed these data will be compiled and statistical and graphical analyses will be done prior to interpretation and presentation of the findings.

Principle Findings and Significance: The data are just now becoming available for about fifty-five ground water samples that have been collected and analyzed. It is not possible at this time to report on results and their significance. Several components have delayed progress of this project. First, the project was initially designed to coordinate with ground-water sampling for lead contamination conducted by the Arkansas Water Well Commission. Funding for the Water Well Commission project was not appropriated resulting in a change in the design and overall objectives for this project. Second, what was anticipated as about a 15 day sampling process was actually about a 60 day process. The significant lack of background data from the selected study area was due to a lack of functional rural domestic wells within the area. Ground-water quality problems related to high concentrations of iron caused many people to abandon their rural domestic wells in favor of tapping into the extensive rural water system developed in the region over the last decade. When the pumps in the wells became inoperable the wells were abandoned and are not available for sample collection. The net result has been much greater time required in the field to identify acceptable sampling sites.

Ground-water quality data will be reduced as soon as possible. These data will fill a significant ground-water quality data void in the northeastern corner of Arkansas and will provide invaluable background data for any future investigations in this region. In addition, the study area borders areas of recent investigations of pesticides and nitrate-N in ground water to the south and southeast.

References

Augustine, H.L., 1985, Arkansas Ground-Water Resources, National Water Summary-Arkansas. U.S. Geological Survey Water-Supply Paper 2275, p. 141-148.

Smith, C.R., and K.F. Steele, 1990, Nitrate Concentrations of Ground Water Benton County, Arkansas. AWRRC Misc. Publication No. 73, 48 p.

Teaque, W., P. Tacker and S. Chapman, 1993, Status Report: Nitrate Testing and Source Evaluation for Private Rural Water Supplies in Arkansas. Cooperative Extension Service, University of Arkansas.

Thornton, T., and K.F. Steele, 1992, Reconnaissance Survey of Nitrate Concentrations in Ground Water in Howard and Pike Counties, Arkansas. AWRRC Misc. Publications No. 85, 33p

SYNOPSIS

Project Number: 03

Start: 7/1/95
End: 6/30/96

Title: Bioaccumulation of Methyl Mercury Through a Food Chain

Investigators: John T. Knight, Department of Biology, Ouachita Baptist University, Arkadelphia, Arkansas

COWRR: ECL, WQL

Congressional District: Third

Descriptors: Bioaccumulation, Trophic Levels, Mercury

Problem and Research Objectives: The problem addressed in this study is the bioaccumulation of mercury in a food chain and the verification of mercury accumulation in a south Arkansas oxbow lake by *in situ* exposure. The objectives were threefold. The first objective was to trace the accumulation of methyl mercury through a specific food chain under controlled conditions. The second objective was to derive a Bioaccumulation Factor (BAF) for each trophic level. Three organisms, an alga, an aquatic invertebrate and a fish, were utilized to represent the three trophic levels of the simulated food chain.

The third objective was to test the results of the simulated food chain and the derived BAF's in a field situation. The field site chosen was Woodard Lake, an oxbow lake of the Ouachita River, located in Ouachita County. This site has been chosen based on known contamination with mercury.

Methodology: Briefly, the simulated laboratory food chain consisted of the alga (Selenastrum capricornutum), a water flea, (Daphnia magna) and the Fathead Minnow (Pimephales promelas). The alga were grown in prepared media containing methyl mercury. Prepared algal suspensions of both "clean" and "hot" (methyl mercury contaminated) algae were then fed to the Daphnia. Daphnia were then fed to the Fathead Minnows. In this way, Bioaccumulation Factors can be determined utilizing the three trophic levels of the food chain. A BAF is calculated by dividing the concentration found in the organism by the concentration found in the available food. Methyl mercury (as total mercury) has been determined using cold vapor atomic absorption spectroscopy.

The field portion of this study was designed to verify the bioaccumulation potential of the (methyl) mercury using caged organisms. Daphnia and Fathead Minnows were caged and left in Woodard lake for 5-7 days. Upon collection of the organisms in the field, the samples were preserved and analyzed for methyl mercury.

The cages were designed to provide maximum exposure to possible water contaminants (mercury) while providing maximum protection to predators.

Principle findings and significance: The primary problems encountered in this study have been in the area of analysis. When using small organisms, i.e. algae or water fleas, the amount of tissue required to perform the analysis is difficult to accomplish. This

has not been difficult with the fish. Additionally, the high sensitivity of the mercury analyzer has added to our problems since we do not have a "clean lab". However, these problems have been overcome and the results of the study will provide relatively good data for Bioaccumulation Factors involving these particular organisms. Since we have artificially constructed the food chain, actual BAF for the native biota of Woodard Lake will still be unknown. The results of this study will however provide a beginning model to verify the movement of methyl mercury through the trophic levels in south Arkansas waters.

SYNOPSIS

Project Number: 04

Start: 7/1/95
End: 6/30/96

Title: Influence of Rice Production on the Quality of Water in Tailwater Collection Reservoirs

Investigators: Terry L. Lavy and Reece A. Dewell, Department of Agronomy, University of Arkansas, Fayetteville, Arkansas

COWRR: NPP, SW, WQ

Congressional District: Third

Descriptors: pesticides, irrigation management, water quality management

Problem and Research Objectives: Water quality is a nationwide concern and many variables are involved. As public awareness and concern over the quality of our water supply continue to increase, we affiliated with the agricultural production area need to show our responsibility. Arkansas rice producers, like many others, rely on man-made pesticides and fertilizers to achieve optimum yields. Since rice is produced under flooded soil conditions, and pesticides and fertilizers are often applied directly to the water, their residual time in tailwaters should be researched. Since these materials have the potential for impacting water quality both at nearby outlets and much further downstream, it is important that Arkansas conduct research to help maintain our high quality water supplies while continuing to be the leading rice producing state in the nation.

Specific Objective:

1. To investigate the movement and persistence of rice pesticides into ponded water sources used for recycling irrigation water and determine the dissipation mechanisms involved.

Methodology: Based on state recommendations for rice production, a list of potential pesticides was made. This list included the following pesticides: benomyl, carbofuran, carbaryl, propanil, molinate, methyl parathion, malathion, propiconazole, thiobencarb, iprodione, pendimethalin, fenoxaprop-ethyl, quinclorac, 2,4-D, MCPA, triclopyr, and bensulfuron methyl.

Working in cooperation with county extension agents in the major rice producing counties of the state, we identified five rice production systems in 1995 and 1996 where irrigation water is pumped from confined ponds and tailwaters drain back to the same pond. However, due to excessive rainfall in 1996, two of the locations have had delayed planting of their rice and may not be planted to rice at all. Tailwaters, pond water, and water from irrigation pumps will be sampled multiple times during the growing season. Two new sites were added in 1996 that incorporated precision levelled fields and water seeding. Water samples will be collected from the selected locations and transported to our laboratory for extraction and analysis. The extract will be analyzed by appropriate chromatographic methods (GC, HPLC, and GC-MS for confirmation of positive samples).

Principal Findings and Significance: Five independent locations in Arkansas, Conway, and Faulkner counties were monitored during this time period. During the 1995 growing season, 2,4-D, benomyl, molinate, propanil, quinclorac, thiobencarb, and pendimethalin were the pesticides applied. Presently, the 1996 program also includes 5 independent locations, some of which were not included during 1995. Similar pesticides will be applied during 1996, however, bensulfuron methyl has been applied at 2 new locations.

Regardless of season, shortly after flood establishment, trace levels of propanil, quinclorac, pendimethalin, and thiobencarb were detected in tailwaters. Similarly, post flood applications of 2,4-D, benomyl, and molinate resulted in trace level detections shortly following application. To date, these residues have not lead to any pesticide buildup in adjacent reservoirs used for water collection. Quinclorac residues in the tailwaters have been more persistent (detectable for up to 8 weeks following flood establishment) than the other detected compounds, which generally persist less than 2 weeks in water. Low level pendimethalin residues were detected frequently in 1995; their source could be from rice tailwaters or runoff from neighboring soybean fields.

SYNOPSIS

Project Number: 05

Start: 7/1/95
End: 6/30/96

Title: Effects of Zebra Mussel, Dreissena Polymorpha, Infestation on Lake Dardanelle Water Quality

Investigators: Charles J. Gagen and Joseph N. Stoeckel, Department of Biological Sciences, Arkansas Tech University, Russellville, Arkansas

COWRR: WQL, ECL

Congressional District: Third

Descriptors: zebra mussel, lakes, water quality, plankton dynamics, macrophytes, aquatic community

Problem and Research Objectives: Strayer (1991) predicted that Arkansas was near the southern limit of habitable waters for a recently introduced European species, the zebra mussel, Dreissena polymorpha. However, in September 1992 zebra mussels were discovered in Lake Dardanelle, a 13,800 hectare impoundment on the Arkansas River. It subsequently has been found in all reaches of the Arkansas River that are open to commercial barge traffic and in other southern waters as far south as southern Louisiana. Rapid disbursement of zebra mussels is facilitated by their characteristic attachment to hard surfaces, including boat hulls. This characteristic has also lead to its notoriety as a biofouler of water supply intakes and other human structures. Furthermore, the high filtration capacity of dense populations has greatly altered water quality and the ecology of recently invaded northern lakes (Kryger and Riisgard, 1988; Leach 1993).

Zebra mussel proliferation in Lake Dardanelle has paralleled proliferation in the Great Lakes where the high filtration rate of dense populations has increased clarity and altered nutrient dynamics. Effects of zebra mussels on water quality and the ecology of Lake Dardanelle are difficult to predict, because it is a different system (i.e., has different water chemistry, thermal regimes, aquatic community structure, etc.) from those that have been previously studied. Arkansans that can be affected by the changes brought about by the zebra mussel are boaters, swimmers and skiers, anglers, commercial fisherman, lakeshore owners, public water suppliers, agricultural water users, electrical power produces, and other groups that use water from the reservoir.

This field-oriented study was designed to sample key aquatic variables at three fixed stations. The goal was to establish rigorous baseline data prior to establishment of a high density population of zebra mussels in Lake Dardanelle and to subsequently evaluate the impact of a high density population in a southern reservoir. The ongoing study is focused on spatial and temporal variability in water quality, zooplankton, phytoplankton (as a function of chlorophyll), and macrophytes. We will be testing several working hypotheses: 1) Water filtration by feeding zebra mussels will lead to decreases in phytoplankton and zooplankton densities (and probably changes in species composition toward larger forms), 2) Water filtration by feeding zebra mussels will lead to decreased suspended solids and turbidity, and subsequently, to increased water clarity, 3) Total phosphorous will decrease, because it is largely associated with

suspended material that is susceptible to filtration by zebra mussels; however, phosphate and other inorganic nutrients will increase during the exponential growth phase of the zebra mussel population, because uptake by phytoplankton will decrease, 4) Increased water clarity and availability of inorganic nutrients is expected to lead to proliferation of rooted macrophytes; and if a proliferation of rooted macrophytes does occur, the dominant substrate for zebra mussel attachment will shift from rocks to macrophytes because Lake Dardanelle is shallow (» 2 m), 5) The effects listed above will be most dominant at times and places least influenced by Arkansas River flow (e.g., summer, and in the Illinois Bayou arm of Lake Dardanelle).

Methodology: We collected water biweekly from a depth of 1 m in a polycarbonate sampler to analyze selected water chemistry parameters and chlorophyll levels at three sites in Lake Dardanelle. Lake Dardanelle does not stratify for an extended period in summer, therefore, stratified sampling was unnecessary. Secchi disk depth and dissolved oxygen and temperature profiles were also recorded when water samples were collected. Refrigerated water samples were transported to the Arkansas Water Resources Center Water Quality Laboratory for analysis by EPA accepted methods. Analyses included: total phosphorous, chlorophylls a, b, c, ammonia, nitrate, chloride, calcium, magnesium, phosphate, pH, nitrite, sulfate, turbidity, conductivity, and suspended solids. The first six parameters were measured for all samples (45 completed and 3 in process), and the remainder were also measured for every other sample (23 competed and 2 in process).

Zooplankton was collected in a 64 micron mesh Nitex net, preserved in Lugol's solution, and analyzed at ATU laboratories following the methodology of Wetzel and Likens (1991). For each zooplankton sample, the density of individuals in each major group, Copepoda, Cladocera, Ostracoda, nauplii, Rotifera, and other, was determined. Zebra mussel veligers were identified and counted in these samples under polarized light (this aspect was funded cooperatively). We also monitored PVC plates for settling juveniles biweekly and searched rocks for adults at fixed stations less frequently under the cooperative contract with Entergy Corporation.

The percentage of bottom area covered by submerged and emergent macrophytes in 100 m by 25 m areas near each of the three sample sites was estimated visually with the aid of a rake and SCUBA. These seasonal samples were in water up to 2 m deep and within 25 m of shore.

Principle Findings and Significance: Since zebra mussels first appeared in Lake Dardanelle (in 1992), their population has been increasing at an exponential rate. Densities of zebra mussel larvae (veligers) in our samples increased one-hundred-fold from 1993 to 1994. The high production of veligers was repeated during the reproductive seasons of 1995 and 1996. Peak density of settling juveniles exploded from 0/m^2 in 1993 to 35,000/m^2 in 1994, and 80,000/m^2 in 1995. Peak density of settling juveniles is another order of magnitude higher in 1996. The mean count of adult zebra mussels captured in each hour of effort increased from 45 to 58, then to 140 in 1993, 1994, and 1995, respectively. During this past year, 1996, densities have reached high enough levels to begin a more quantitative analysis. We have just sampled 15 sites, distributed throughout the lake, and estimate the mean density to be 7,012/m^2 (range = 0 to 23,146/m^2). The highest density recorded this summer was at the intake canal for Arkansas Nuclear One. Local marinas have reported several incidents of biofouling leading to engine overheating and major water users, e.g. Arkansas Nuclear One and

Dardanelle Lock and Dam, are beginning to spend more time and money on maintenance to compensate for the proliferation of this nuisance species.

In the 1994-1995 sample year, turbidity averaged 22.7 NTU and Secchi disk depths were averaged 54.1 cm. Through May of the 1995-1996 sample year, the mean turbidity has dropped to an average of 18.5 NTU and the mean Secchi disk visibility has increased 5.3 cm. In June, we measured the greatest Secchi disk depths ever reported on Lake Dardanelle, 2.05 m. Thus, it appears that we may be documenting the beginning of a zebra mussel effect on the lake. It is still too early to be confident that this trend will persist. However, the ecology of the lake will be totally different if the increased clarity persists. Most of the chlorophyll was chlorophyll a (two-year mean of 16.1 ug/L) which was lowest in winter (< 8 ug/L) when water temperatures and solar infiltration were the lowest. Chlorophyll concentration has not decreased significantly between the two sample years.

The zooplankton community in Lake Dardanelle is numerically dominated by rotifers. Copepods and cladocerans are still well represented. However, if zebra mussels selectively remove larger zooplankton, copepods and cladocerans should comprise smaller proportions of future samples. In that case it seems likely that productivity of larval fish would be negatively impacted. Larval fish densities were measured for many years prior to zebra mussel invasion in Lake Dardanelle (e.g. Tatum, 1991). A new study of larval fish density could be compared to the historic data to provide an adequate test of this hypothesis.

We found no significant increase in coverage of emergent vegetation or submergent vegetation from the 1994-1995 to the 1995-1996 sample year. High nutrient availability and suitable substrate could support macrophyte proliferation; however, light penetration is limiting in Lake Dardanelle (and most other reservoirs on the Arkansas River). Thus, if the recent increase in light penetration that we have documented on Lake Dardanelle persists, dense beds of macrophytes that can drastically influence fish population dynamics and negatively impact boating may soon begin to develop.

Conclusion: As anticipated, the zebra mussel population in Lake Dardanelle is increasing rapidly. The population has recently reached a size where it appears to be significantly impacting the ecology of the reservoir. We have made substantial progress toward characterizing key water quality and biotic parameters of Lake Dardanelle, and upon completion of this study we plan to test critical hypotheses relative to zebra mussel invasion of shallow southern reservoirs.

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ADDENDUM TO SYNOPSIS

Table 1. Summary of Lake Dardanelle water chemistry from September 1994 through May 1996. Data are presented as mean (standard error) in mg/L (unless noted) for the farthest upstream site to the farthest downstream site.

Variable	Piney Bay Area	Main Lake	Ill. Bayou Area
Ca	24.0(2.0)	32.5(1.2)	26.7(1.9)
Cl	57.2(6.1)	76.4(5.3)	71.2(5.5)
Mg	5.8(0.7)	8.0(0.6)	6.7(0.8)
NH4-N	0.04(0.004)	0.04(0.003)	0.05(0.01)
NO3-N	0.21(0.03)	0.25(0.03)	0.22(0.03)
NO2-N	0.006(0.001)	0.007(0.0008)	0.008(0.001)
pH	7.43(0.35)	7.63(0.35)	7.61(0.36)
PO4-P	0.04(0.007)	0.07(0.014)	0.06(0.023)
SO4	30.4(3.7)	37.8(2.9)	37.3(3.3)
Total P	0.08(0.006)	0.09(0.007)	0.09(0.019)
TSS	14.3(3.1)	20.9(4.0)	9.3(1.0)
Turbidity (NTU)	16.7(3.3)	23.6(4.2)	14.2(1.9)
Conductivity (uS/cm)	368(48)	483(39)	413(46)
Chlorophyll A (ug/L)	14.9(1.7)	15.5(1.6)	17.8(1.7)
Chlorophyll B (ug/L)	0.6(0.1)	0.7(0.2)	0.5(0.1)
Chlorophyll C (ug/L)	1.9(0.2)	2.1(0.2)	2.1(0.3)

OTHER PROJECT SUMMARIES

Project Title: *Demonstration of Cotton Production BMP Impact on the Soil and Water Resources of the Arkansas Delta*

Funding Agency: Arkansas Soil and Water Conservation Commission, Little Rock, Arkansas

Project Period: 5/8/95 to 5/31/98

Principal Investigator(s): William H. Baker, Agronomy Department, Soil Testing and Research Lab, University of Arkansas, Fayetteville, Arkansas

Project Summary: The Arkansas Delta, with its deep alluvial sediments laid down by the Mississippi, is a rich resource of soil, timber, wildlife and water. Although the sediments are deep, in many areas, the top foot is the productive component containing the nutrients and organic matter needed to yield healthy crops. Because of the slow processes that produce soil, there is no real replacement for this topsoil as it is lost through erosion.

Row crop agriculture is the dominant feature across the Delta landscape. One of the major crops in terms of production and income is cotton. This project was initiated to evaluate and demonstrate a combination of production systems in cotton. These systems, or best management practices (BMPs) are designed to protect the soil and water. In addition to protecting resources, cotton production as a whole should be improved and made more profitable from the employment of these BMPs.

The objective was to keep the BMPs simple such that a cotton producer could place any of these systems into effect with the equipment and resources at hand. The first BMP is to produce a series of maps from a soil sampling campaign that effectively characterizes the nutritional status of the field. From this information, fertilizer recommendations are more accurate and the rate and placement of fertilizer (mainly nitrogen, phosphorus, and potassium) is made much more precise. Additional BMPs are directed at containing the soil and nutrient runoff. These BMPs included following a reduced tillage program, placing grassed water ways at the field outlets and in field drainage areas, and planting a winter cover crop of wheat. The reduced tillage avoids several trips across the field that would normally leave freshly plowed soil exposed to the weather. Fewer trips across the field with the tillage equipment also translates into less oil compaction, which improves the soil quality, and less equipment operating expenses. The wheat cover crop is established at a seeding rate that is not intended to produce a wheat crop. This helps to reduce the cost. The benefit is from having plant material tracking down the soil during the winter months. Under conventional practices, fields are left fallow with a great deal of soil left exposed to the elements.

The demonstration site has been selected and established. An adjacent conventional cotton production system is being used to compare the results observed from the BMP field. Both fields are large scale cotton production systems. The demonstration area has been mapped using GPS receivers. These base maps have then been used to select sampling sites for soil and water samples. In addition, several sites within the

drainage basin have been selected to provide baseline water quality information of the area. The soil nutritional status will be charactized this fall. All of this data has, and will continue to be, placed into a GIS. This summer, satellite imagery will be used to determine the acreage of cotton in this drainage basin. Results from this work will then be used to assess the effectiveness of these BMPs on the soil and water quality if they were employed as a whole across the drainage basin.

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Project Title: *Minimizing Impacts of Animal Waste on Shallow Karst Aquifers in Northwest Arkansas*

Funding Agency: Arkansas Soil and Water Conservation Commission, Little Rock, Arkansas

Project Period: 1/1/96 to 9/1/97

Principal Investigator(s): Ralph Davis, Department of Geology, University of Arkansas, Fayetteville, Arkansas

Project Summary: The primary objective of this project is to add a fifth spring site to the project to demonstrate ground-water protection by implementation of Best Management Practices (BMP's) related to animal wastes in karst and/or fractured hydrogeologic settings.

Grab samples were collected from five springs in the Yokum Creek area in Carrol County, AR. At the time of sample collection a general reconnaissance of the watershed was made to assess the percentage of poultry production and pasture land which provides an indication of the level of animal waste applied as fertilizer within the assumed recharge area for each spring. Based on this reconnaissance a spring was selected that was previously the water supply for Green Forest, AR. as the monitoring site.

Equipment to instrument this site has been ordered. The site will be instrumented with automated sampling and data logging equipment including continuous recording of temperature, spring stage, specific conductance and precipitation. These data will be beneficial when deciding which samples to retain for analysis from those collected over a storm hydrograph. The continuously recorded parameters will also provide basic information about the hydrogeology of the springs which will help better define the boundaries of the recharge area.

Sampling over the hydrograph of a storm event for this spring will occur in late-fall 1996. BMP's will be implemented at this site in early to late-fall 1996. Samples over the hydrograph of a second storm event will be collected in the spring of 1997.

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Project Title: *Monitoring Best Management Practices on Ground Water Quality in Northwest Arkansas*

Funding Agency: Arkansas Soil and Water Conservation Commission, Little Rock, Arkansas

Project Period: 1/1/95 to 9/30/98

Principal Investigator(s): Ralph Davis, Department of Geology, University of Arkansas, Fayetteville, Arkansas

Project Summary: The primary objective of this project is to prevent further contamination of vulnerable ground water in Northwest Arkansas. This will be accomplished by demostrating ground-water protection through detection of areas of intense karstification and/or fracturing, and the implementation of Best Management Practices (BMP's) related to animal wastes.

Grab samples from twenty springs where collected in Carrol, Benton and Washington counties in the early summer 1995. Water quality data from these sites were used to select four springs for monitoring over the duration of the project. The initial four sites are all in areas subjected to historic and current applications of animal waste as fertilizer to pasture land. Site 1 (Benton County near Decatur, AR) is in a system of fractured limestone exposed at the surface or covered by a very thin veneer of regolith. Sites 2 (southern Washington County near Lincoln, AR) and 3 (eastern Carrol County near Alpena, AR) are in areas of significant karstification including sinkholes. Site 4 (northern Washington County near Springdale, AR) is in an area of fractured limestone with significant regolith cover. This diversity of hydrogeologic settings is typical of the region. Understanding impacts to ground-water quality in these various hydrogeologic settings will enable more site specific BMP's to be implemented.

Landowners in the contributing watershed for each spring have been contacted and cooperative agreements reached for access and the implementation of BMP's. Each of the four springs has been instrumented with automated water sampling and data logging equipment including continuous recording of temperature, spring stage and precipitation.

Analysis of the initial grab samples from 20 springs indicated that approximately 85% of the springs exceeded the primary drinking water standard maximum contaminant level (MCL) for both Fecal Coliform and E. Coli bacteria. In addition, 5% of the springs exceeded the MCL for nitrate-N.

Samples were collected over the hydrograph of 2 separate storm events. Eight samples were collected over the storm hydrograph for each spring in mid-December, 1995 and again in mid-April 1996. These data clearly show that concentrations of Fecal Coliform, E. Coli and nitrate-N directly correlate with spring stage, increasing with increasing spring stage.

Findings from the grab samples and the two storm events have been presented at four conferences. Initial findings were presented by Ms. Naomi Sinor (graduate student) at the Annual Meeting of the Geological Society of America, in early November in New Orleans, LA, and at the 6th Biennial State Water Conference and 8th Annual

AWRA-AR/AGWA Symposium on December 7 in Little Rock, AR. Mr. Rick Monk (graduate student) presented storm event data for Decatur Spring in Benton County to the South-Central Section of the Geological Society of America in Austin, TX in early March, 1996. Ralph Davis presented an overview of the project at the Arkansas Water Resources Center Annual Conference in late-April in Fayetteville, AR.

It is anticipated that BMP's will be in place by late-summer or early-fall. Additional base-flow and storm event samples will be collected and analyzed following BMP implementation to assess the impact on ground-water quality.

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Project Title: *Constructed Wetlands for Wastewater Remediation at Swine Rearing Facilities*

Funding Agency: Arkansas Soil and Water Conservation Commission, Little Rock, Arkansas

Project Period: 5/3/95 to 4/30/98

Principal Investigator(s): Philip Moore, Jr., USDA Agricultural Research Service and Department of Agronomy, and Duane Wolf and Tommy Daniel, Department of Agronomy, University of Arkansas, Fayetteville, Arkansas

Project Summary: Swine producers in southwestern Arkansas were contacted beginning in April, 1995 at the Liquid Waste Training Meetings in DeQueen and Hope, AR. Other growers in northwestern Arkansas were contacted via mail. Growers expressing interest in the project were then contacted by phone, and on-site visits were made.

Based on these visits, the southwestern Arkansas farms selected were Hickory Hill Farm and the Delbert Baker Farm. The NRCS evaluated both farms, and thought them suitable for the project. The NRCS then surveyed each farm and designed wetland systems for both sites. Approval was granted by the ADPC&E on 19 March 1996 to construct and operate the two systems. The cooperators at Hickory Hill Farm expressed some reservations about the layout of the system at their farm, so the system was redesigned to address their concerns.

Bids were requested for the two systems, and an on-site inspection visit was conducted for potential contractors on 13 July 1996. During these site tours, a flaw in the design at the Delbert Baker Farm became evident; the system, as designed, would extend across his property line. Apparently, the location of the property line was not indicated on the survey, thus the design engineer was not aware of its location. As a result, attempts were made to redesign the system to fit on Mr. Baker's farm. Unfortunately, these attempts were to no avail; the physical limitations precluded use of this farm for the project. Several growers have been contacted as potential replacements, and a site-suitability inspection has been arranged for 20 August 1996 at two farms.

Bids were opened for the Hickory Hill Farm on 30 July 1996. The low bidder was Evergreen Lawns of Springdale, AR ($19,995.00). Construction is scheduled to begin on this system the week of 19 August, once a contract has been executed for the work.

In northwestern Arkansas, the Hampton-Taylor farm initially expressed strong interest in cooperating on this project. This farm in the Buffalo River watershed offered a great opportunity for this project in that it was actually two separate production units. This would

have allowed placement of both systems on the same farm, thus minimizing variation due to management, weather, soil type, and similar factors. Unfortunately, the producers later decided that their wastewater held too much value as a fertilizer to warrant their cooperation on the project.

The NRCS office in Russellville was then contacted to locate other potential cooperators. With their assistance, we were able to visit several farms, three of which appeared suitable for the project. Of the three, two were selected as cooperators: the Metz Brothers Farm and the Lucky Lady Farm. Surveys and designs were completed for these farms by the NRCS. These designs were submitted to ADPC&E on 18 July 1996 and approval was granted on 9 August 1996 for construction and operation of the two systems.

The Quality Assurance Project Plan (QAPP) has been submitted to ASWCC for approval. Mr. Andrei Novikov was initially assigned as the ASWCC QA Officer for this project, but has since resigned. Mr. Fred Morgan has assumed his duties as QA Officer. The QAPP has been revised to address comments from EPA and ASWCC. We are expecting approval of the QAPP in the near future.

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Project Title: ***Demonstration of Nutrient Management for Poultry Litter Using Alum Precipitation of Soluble Phosphorus***

Funding Agency: Arkansas Soil and Water Conservation Commission, Little Rock, Arkansas

Project Period: 7/1/94 to 12/31/97

Principal Investigator(s): Philip Moore, Jr., USDA Agricultural Research Services and Department of Agronomy, and Tommy Daniel, Department of Agronomy, University of Arkansas, Fayetteville, Arkansas

Project Summary: Beginning in June of 1994, two tons of aluminum sulfate (alum) were placed in half of the houses at two commercial broiler farms. Litter characteristics such as TKN, TP, total metals, soluble metals, ammonium and nitrate were monitored at the beginning and ending of each growout. Litter pH and atmospheric ammonia in the houses was monitored weekly. Fecal coliform, E. coli, aerobic plate count and yeasts and molds were also determined in the litter on a weekly basis. Bird weight gains were determined by the integrators.

Alum reduced litter pH for the first four weeks of the growout. This resulted in a significant decrease in atmospheric ammonia in the houses. E. coli numbers were lower in the litter of the alum-treated houses for the first two weeks of the growout. Birds weights were significantly heavier in the alum-treated houses (3.80 lbs) compared to the controls (3.65 lbs). We do not know if these weight gains are due to pathogen reduction or a reduction in atmospheric ammonia. Feed conversion was only measured once, but was much better for birds grown in alum-treated houses (1.83 for alum-treated birds vs. 1.89 for controls). Energy use was also less for the alum-treated houses, since ventilation needs were lowered by a decrease in ammonia volatilization. The average alum-treated house used 11% less propane and 13% less electricity.

Two one-acre watersheds were formed side by side at each farm by bringing in topsoil and creating berms. The watersheds were outfitted with approaches and flumes which were instrumented with automatic water samplers. Runoff water samples were taken beginning in March of 1995. On April 26, 1995, 5000 lbs of litter was applied to each watershed, with one receiving alum-treated litter and the other normal litter. Runoff water samples were collected from each rainfall event thereafter that resulted in runoff.

Unfortunately, there has not been any runoff from the watersheds at one of the farms since the litter was applied. However, at the other farm there has been several runoff events prior to and following litter application. Prior to litter application the soluble P concentrations in the runoff from the watersheds receiving alum-treated and control litter were 0.12 and 0.11 mg P L^{-1}, respectively. After the litter application, the average concentration of P in the runoff water in 1995 was 0.79 and 2.93 mg P L^{-1} for the alum-treated and control, respectively, indicating that alum treatment of poultry litter results in a significant reduction in P runoff. In 1996, phosphorus concentrations in runoff were still much lower for alum-treated litter (2.04 mg P/L) than normal litter (4.24 mg P/L). The average soluble aluminum concentrations in the runoff water were 0.13 mg Al L^{-1} for both the alum-treated and the control litter, indicating that alum does not increase alum runoff.

Sampling of Beaver Lake watershed was conducted from August 1, 1993 to August 1, 1995, although the official starting and ending dates for this project were August 1, 1994 to August 1, 1995. Ten lake sites and ten tributary sites were sampled at dates corresponding to a study conducted in 1973-1974. These samples have all been analyzed and the data are currently being entered.

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Project Title: *Septic Tank II*

Funding Agency: State of Arkansas

Project Period: 7/1/94 to 6/30/96

Principal Investigator(s): E. Moye Rutledge and Duane C. Wolf, Department of Agronomy, and Mark A. Gross, Department of Civil Engineering, University of Arkansas, Fayetteville, Arkansas

Project Summary: The ArkansasOn-site Domestic Wastewater Renovation Project has been most active in conducting full-scale field studies to evaluate the design and performance of conventional and alternative systems. Cooperation of personnel at the Arkansas Department of Health has been critical to the success of the numerous research projects. Communication and education have also been important components of the project.

There is no doubt that soil will continue to be used as a medium for wastewater disposal and renovation. Reducting ground and surface water pollution will continue to receive local and national attention. Past, present, and future studies are fundamental in the search for innovative, economical, and environmentally sound on-site wastewater renovation systems.

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Project Title: *Plant Species Associations in Two Ozark Riparian Systems*

Funding Agency: National Park Service, Harrison, Arkansas

Project Period: 1994 to 1997

Principal Investigator(s): Cynthia Sagers, J. Lyon, and E.E. Dale, Jr., Department of Biological Sciences, University of Arkansas, Fayetteville, Arkansas

Project Summary: Riparian plant communities are credited with a number of ecosystem functions that include maintaining and restoring water quality (Barton et al. 1985, Vought et al. 1994, Darveau et al. 1995), promoting vertebrate species diversity (Doyle 1990, Stauffer and Best 1990), mediating stream channel morphogenesis (McKenney et al. 1995), and providing breeding grounds for migrant birds (Hunter et al. 1993). Despite their ecological significance, most bottomland forests of North America have been substantially altered during the last century (Sharitz and Mitsch 1993). Because of the impending threat to essential ecosystem functions, effective management strategies must be devised to preserve and restore riparian corridors (Brinson et al. 1981, Abernathy and Turner 1987, Gooselink and Lee 1989, Taylor et al. 1990). Nonetheless, management strategies have been slow to develop because of a limited understanding of the composition and character of riparian forests. Our work has focused on identifying plant species assemblages and determining the primary environmental gradients that influence species associations in two riparian forests of the Ozarks: the Buffalo National River, Arkansas, and the Ozark Scenic Riverways, Missouri.

The Ozark Plateau has been a continuous land area since the end of the Paleozoic (Branson 1944, Steyermark 1959). Because the Ozark region has never been glaciated, it has been open for plant migration since the Tertiary. However, much of the riparian landscape has been slightly disturbed since European settlement (around 1800). Clearning for cattle pasture was the predominant land-use until around 1880, when large-scale timber exploitation was initiated (Jacobson and Primm 1994). The forests of the Ozarks experienced dramatic anthropogenic disturbances from 1890 to `920 in the form of large-scale and indiscriminate clearcutting, agricultural clearings, burning, and grazing (Stevens 1991). During this period, esentially all the forest cover was cut over. The existing secondary forests have been broadly classified as oak-pine and oak-hickory (Braun 1950, Eyre 1980), but specific forest assemblages range from wet bottomland to mesic mid-slope to more xeric upland.

Our primary objective has been to develop recommendations for ecosystem-level management of the riparian zone. Of the existing vegetation studies in the Ozarks, most have sampled only large, woody canopy dominants (Read 1952, Redfearn et al. 1970, Zimmerman and Wagner 1979, Nigh et al. 1985, Pallardy et al. 1988, Ware et al. 1992, Cutter and Guyette 1994), and have failed to include the most diverse vegetation layers. An unusual approach in our sampling strategy was to incorporate the shrub and herb layers to assess vegetation patterns of the forest as a whole. To date we have found that species composition shifts along coincident pH and elevational gradients, and that the transitions among forest types are gradual and not well-defined. The relative importance of secondary factors, such as soil particle size or organic matter content, in determining species associations differed among vegetation layers, so that species associations shift at different rates along secondary gradients. Differential

response to environmental gradients effectively uncouples plant associations between the canopy and understory, so that communities described by dominant woody species are not necessarily consistent with shrub and herb associations. This is an important finding for ecological sampling generally, and may explain in part the complex community patterns common to riparian systems. In addition to recognizing the complex patterns of species groups, we also have found an intriguing absence of pattern in species numbers. Species diversity appears not to be correlated with any environmental factor, and many species, approximately 40% of all trees, herbs and shrubs, are uncommon and occur in fewer than 1% of the study plots. The commonness of rarity has not been reported for riparian systems. These factors make management of the riparian zone especially difficult, since an ecosystem-level management strategy would recommend that all parts of the zone are essential for the maintenance of species diversity and protection of landscape function.

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Project Title: *Intra-County Land Use for the Boeuf-Tensas Area*

Funding Agency: Arkansas Soil and Water Conservation Commission, Little Rock, Arkansas

Project Period: 2/3/95 to 12/31/95

Principal Investigator(s): H.D. Scott, Department of Agronomy, University of Arkansas, Fayetteville, Arkansas

Project Summary: The objectives of this work were to determine the spatial variability of land use in four counties in eastern Arkansas and to quantify the areal extent of several land use categories in the counties. The counties included Union, Cleveland, Bradley, and Independence. The work was partially funded by the Arkansas Soil and Water Conservation Commission.

The land use classification was adapted from the GAP project based on 1992 LandSat V Thematic Mapper satellite imagery at the 30-meter resolution. Three land use categories were developed: forest vegetation, water and agriculture (primarily pasture). The forest category was subdivided into 16+ categories representing differeing species of trees. Color maps were developed that displayed land use characteristics, incorporated areas and major roads within each county. Consistent color schemes were chosen to display as much contrast between the categories as possible.

Areal summaries indicated that the dominant land use in each county is forest. The areas classified in agriculture for the three southeast counties were similar and represented about 10% of the area in each county. In contrast, in Independence County agriculture represented over 42% of the areas.

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Project Title: *Development of a Geographical Information System for Millwood Land Watershed in Arkansas*

Funding Agency: Arkansas Soil and Water Conservation Commission, Little Rock, Arkansas

Project Period: 10/5/93 to 9/30/96

Principal Investigator(s): H.D. Scott and J.M. McKimmey, Department of Agronomy, University of Arkansas, Fayetteville, Arkansas

Project Summary: The objective of this project was to compile a complete digital GIS database of the Millwood Lake Watershed in Southwest Arkansas. The work was conducted in the Soil Physics/GIS Laboratory in the Department of Agronomy on the Fayetteville campus of the University of Arkansas in cooperation with the state offfice of the Natural Resources Conservation Service (NRCS) in Little Rock. This project was funded by the Arkansas Soil and Water Conservation Commission.

The Millwood Lake Watershed covers 1.3 million acres in Arkansas and encompasses all or parts of Hempstead, Howard, Little River, Polk, and Sevier counties. Data development and storage is being done in the GIS software Geographic Resources Analysis Support System (GRASS). GRASS is primarily a raster based GIS; however, much of the data is stored in a vector format. Both data formats can be converted to other formats at a later time. Some of the data development is being done with LT4X, a raster and a vector based data input software. This allows hard copy maps to be scanned in as a raster data, edited, converted to vector, and exported to any number of spatial data formats.

The watershed consists of 54 7.5-minute quadrangles with each quadrangle named from its published USGS 1:24,000 Topographic Series Maps. Much of the data obtained and developed are based upon this scale and these quadrangle boundaries. These data include Digital Elevation Models (DEM), surface geology, 11 digit hydrologic units, and soils. Other data were based on a county format and compiled at a scale of 1:100,000. The source for these data was the TIGER Census data and include county boundaries, roads, and streams. Another format in the database is based upon the USGS 1° x 0.5° quadrangle format. These data are duplicate themes of roads and streams. There are some differences between the data of these two sources. All digital data in the database are both patched together for a total watershed coverage and in their original formats. All these data themes with the exception of roads and streams have been converted to raster data.

Additional data have been derived from the existing DEMs in both a quadrangle format and a watershed format. These data are slope in degrees from horizontal and directional aspect of the scopes.

Data to be completed include two Digital Elevation Models, Nashvillel, and Baker Springs quadrangles, and soils for all counties with the exception of Polk County. The hypsography for the two DEMs have been ordered while the soil masters are currently going through a quality assurance check in the state NRCS office in Little Rock. Digitizing will begin once these source materials are received in the Soil Physics Laboratory.

Project Title: *Upper White River Best Management Practices Implementation Project: Sub-Project I*

Funding Agency: Arkansas Soil and Water Conservation Commission, Little Rock, Arkansas

Project Period: 5/2/95 to 4/30/98

Principal Investigator(s): H.D. Scott and J.M. McKimmey, Department of Agronomy, University of Arkansas, Fayetteville, Arkansas

Project Summary: This sub-project incorporates the use of Geographic Information Systems (GIS) in conjunction with Best Management Practices (BMP) for sediment and nutrient transport from pastures in the Upper White River Wateshed in Northwest Arkansas. Sub-Project I is conducted in the Soil Physics/GIS Laboratory in the Department of Agronomy on the Fayetteville campus of the University of Arkansas. It is in conjunction with the NRCS and the Arkansas Water Resources Laboratory. This project is funded by the Arkansas Soil and Water Conservation Commission.

The project area includes the Middle Fork and the Main Ford sub-basins of the upper White River. The BMP project area is located in the Main Fork sub-basins on Cannon and Shumate Creek sub-basins. Shumate Creek and Cannon Creeks sub-basins cover 1,445 and 1,543 acres, respectively, for a total of 2,988 acres. These sub-basin areas were based upon the upstream areas that drain into the sample locations on each creek. Sample locations were obtained with Global Positioning Systems (GPS) and differential corrections. The sub-basins were interpolated by hand using a 1:24,000 7.5-minute quadrangle map. The sub-basins were then scanned, edited and exported to the GIS using LT4X.

Much of the GIS data in the project area is already in the database. These data were dreived from several sources on other projects completed in the Soil Physics Laboratory. Land use and land cover were derived from 1988 aerial photography at a scale of 1:24,000 by the Tennessee Valley Authority and incorporated into GRASS by Soil Physics/GIS Laboratory personnel. Digital Elevation Models were obtained from the USGS in a raster 7.5-minute format; however, some quadrangles in the Middle and Main Forks of the White River will need to be developed. Roads and streams were obtained from U.S. Census Bureaus TIGER data. Soils were digitized by Soil Physics/GIS Laboratory personnel from Order II Soil Surveys. Hydrologic units (8, 11, and 14 digit), are currently being developed by the Soil Physics/GIS Laboratory. There are other data themes that are available within the GIS databases.

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Project Title: *Digitization of Soils in the Beouf-Tensas Region of Arkansas*

Funding Agency: Arkansas Soil and Water Conservation Commission, Little Rock, Arkansas

Project Period: 10/1/95 to 9/1/96

Principal Investigator(s): H.D. Scott, Barnali Mitra, and J.M. McKimmey, Department of Agronomy, University of Arkansas, Fayetteville, Arkansas

Project Summary: The objectives of this project are to digitize the soils in the Beouf-Tensas region of eastern Arkansas. This work, which is partially funded by the Arkansas Soil and Water Conservation Commission, is conducted in the Soil Physics/GIS laboratory in the Department of Agronomy on the campus of the University of Arkansas, Fayetteville, and in cooperation with the state office of Natural Resources Conservation Service (NCRS) in Little Rock.

The Beous-Tensas region is located in the southern part of Arkansas and, in this work, the region consists of 65 7.5-minute USGS quadrangles. Personnel in the NRCS develop and ink the Order II soil Survey of the 65 7.5-minute quadrangles onto mylar and send these to the UA Soil Physics/GIS laboratory for further processing. The UA personnel digitize, scan and patch the recompiled soils data using scanning software LT4X and the geographical information system software known as Geographical Resources Analysis Support System (GRASS), as well as other computer equipment in the laboratory. Current SSURGO standards are followed as closely as possible by both the NRCS in recompiling the maps and the Soil Physics/GIS laboratory in digitizing and patching the woil maps. The data are stored by 7.5-minute quadrangles on tape and in a module in a memory tower.

In order to minimize the time of scanning, edge-matching and attributing the soils, the65 quadrangles were divided into two groups: Group A consists of 35 quads, Group B consists of 30 quads. All soil maps in Group A have been digitized and are ready for edge-matching. Maps in Group B have all been vectorized and edge-matched while 10 of the 30 are awaiting attributing. Once all 65 quandragles are completed, they will be send to the state NRCS office for inspection.

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Project Title: *Monitoring Rain Events*

Funding Agency: National Park Service, Harrison, Arkansas

Project Period: 6/1/94 to 9/30/96

Principal Investigator(s): Kenneth F. Steele, Arkansas Water Resources Center and Department of Geology, University of Arkansas, Fayetteville, Arkansas

Project Summary: The water quality of three Buffalo River tributaries were monitored during three rain storms in 1994-1995 in order to evaluate the effect of animal production (pastureland) on storm water quality. The three tributaries are Tomahawk, Bear, and Calf Creeks located near Arkansas Highway 65 bridge on the Buffalo River. Calf and Tomahawk creeks are about the same area (31,613 and 23, 613 acres, respectively), but Bear Creek is almost twice as large (58,933 acres). Approximately 40% of each basin is in pastureland.

Nutrients (TKN [total Kjeldahl nitrogen], NO_3 NH_3, PO_4, and total P) and fecal coliform were the focus of the project because of the concentration of these parameters in animal manure. Total suspended sediments (TSS) also is of interest because excessive

TSS may be from erosion of poorly managed pastureland. TKN, total P, fecal coliform and TSS increase in concentration with increasing stream discharge. Peak storm concentrations are one to two order of magnitudes greater than base flow; whereas, peak mass loads for these parameters are about one to five orders of magnitude greater than base flow loads. The change in nitrate concentrations is erratic during storms. The concentrations of PO_4 and NH_3 are very small (often below detection) throughout the storms.

Comparison of storm data for these tributaries with storm data for a pristine site on the upper Buffalo River Wilderness indicates that pastureland causes increases in concentrations of fecal coliform (90x), TKN (2x), NO_3 (45x), total P (10x). Although NH_3 concentrations show a decrease (0.67x) in concentration in these tributary basins relative to the pristine area, it should be noted that the NH_3 concentrations are very small for all sites and for all storms (<0.12 mg/L).

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Project Title: *Laboratory Analysis on Water Samples from Ozark and Ouachita National Forest*

Funding Agency: U.S. Forest Service, Russellville, Arkansas

Project Period: 10/1/95 to 11/1/96

Principal Investigator(s): Paul Vendrell and Kenneth Steele, Department of Geology and Arkansas Water Resources Center, University of Arkansas, Fayetteville, Arkansas, Connie Neff, Ozark National Forest, USDA Forest Service, Russellville, Arkansas, Allen Clingenpell, Ouachita National Forest, USDA Forest Service, Hot Springs, Arkansas

Project Summary: This project is the third year of an ongoing agreement between the Ozark and Ouachita National Forest, U. S. Department of Agriculture Forest Service (USFS), and the Arkansas Water Resources Center (AWRC). In agreement the AWRC-Water Quality Laboratory (WQL) will provide laboratory analysis on water samples from the Ozark and Ouachita National Forest. Water samples taken by USFS staff and delivered to the WQL are analyzed for parameters that evaluate the effect of forest management on the quality of surface waters.

In this third year, monitoring continues to address three goals. The three goals are to 1) evaluate site-specific management impact, 2) continue accumulation of data for long-term trend analysis, and 3) develop a wilderness station data base to be used as a reference for least-impacted water quality.

The site-specific management impact uses streams water quality to evaluate the impact from timber sales. The monitoring plan is designed to address the effects from roads, traffic, and harvest activities. Water samples will be collected from streams before, during, and after timber sales. Impact from harvesting activity will be evaluated by comparing data collected before roads were construction to data after instillation. Harvesting activity will be evaluated in the same manor by comparing data collected before timber harvest begins to water quality during and following the harvest. Storm water samples will also be collected in these watersheds upstream from the timber harvest sites to be used for comparison to downstream water quality.

The long-term trend analysis is a project that continues the collection of water quality information to characterize forest ecoregions in Arkansas. The regions included in this project are the Boston Mountains, Arkansas River Valley, Delta Region, and Ouachita Mountains. Subtle changes in water quality that could go unnoticed during short-term projects, could be recognized by this long-term approach.

Three sites on the Buffalo River have been designated as wilderness stations. Water quality from these wilderness stations will be used as references for least-impacted water quality. References are useful when evaluating either short or long-term forest management.

This agreement is benefitting both organizations by providing needed services and consultation to the USFS, while the AWRC gets access to water quality data from extensive areas of Arkansas. Continuation of cooperative efforts between the USFS and AWRC will not only benefit the cooperators but will enhance the understanding of water quality issues on a statewide basis.

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Project Title: *Continuation of Illinois River Water Quality Monitoring of Moores Creek*

Funding Agency: Arkansas Soil and Water Conservation Commission, Little Rock, Arkansas

Project Period: 10/1/94 to 9/30/97

Principal Investigator(s): Paul Vendrell and Kenneth Steele, Department of Geology and Arkansas Water Resources Center, and Marc Nelson, Arkansas Water Resources Center, University of Arkansas, Fayetteville, Arkansas

Project Summary: The objective of the Moores Creek project is to demonstrate the integrated impact of the UDSA-Natural Resources Conservation Service best management practice implementation on the quality of Moores Creek and Beatty Branch. These streams are the main source of water to Lincoln Lake that is the drinking water supply for Lincoln, Arkansas. The first three years of the project (1991 to 1994) showed decreasing trends in stream levels of ammonia, total Kjeldahl nitrogen, chemical oxygen demand, nitrate, total phosphorus, and total suspended solids. To show that the downward trends continue or remained at the decreased levels, this project will continue until September 1997.

An obstacle has arisen in the Moores Creek basin that if not addressed could interfere with this objective. The High Ocean Ranch that comprises approximately 800 acres of the Moores Creek bottom was sold. The new owners decided to sell the timber and logging began in late in 1995. Beatty Branch basin is unaffected. The areas logged are both above and below our sampling station. It is apparent from general observations that the effect of this silvicultural operation will be significant. We are concerned that this activity will mask our ability to discern any integrated impact of the BMPs. Therefore, we carried out a modification to the existing sampling plan. An additional sampling station higher in the Moors Creek basin above the logging activity was installed to give us background data that could be used to determine the effect of the

logging. With this information we can partition the effect of the BMPs and increase the likelihood for successfully demonstrating the objective.

Although, not part of this project, the information gained regarding the silvicultural practices on this watershed will be useful for future agricultural BMP implementation projects. In the Ozarks, seldom does a watershed have only agricultural activity. Most often watersheds are mixtures of agriculture, silviculture, urban, and rural development. Our ability to partition and understand the weight of each activity is limited. The scope of additional work needed to deal with the logging is: 1) instillation of an automatic sampling station upstream of the logged acres, 2) development of the stage discharge curve, 3) collection of 37 additional grab samples and 25 composite storm samples (over the life of the project from March 1996 until September 1997), 4) and laboratory analysis of the water samples for parameters currently measured. We installed this additional site on June 28, 1996. Grab samples have been collected, however, on storm events have occurred since installation.

Two graduate students from Geology are now involved with the project. One student will do a Masters thesis on the Moores Creek project and may preform a companion study of the nitrate distribution in the groundwater of this watershed. The students are trained to operate all the sampling and data logging equipment, collect and preserve samples, and preform some analytical procedures.

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Project Title: *Pesticides in Ground Water Monitoring Project for Arkansas, Phase IV*

Funding Agency: Arkansas State Plant Board, Little Rock, Arkansas

Project Period: 11/1/94 to 2/1/96

Principal Investigators: Paul Vendrell and Kenneth F. Steele, Department of Geology and Arkansas Water Resources Center, Terry Nichols, Arkansas Water Resources Center, and H. Don Scott, Department of Agronomy, University of Arkansas, Fayetteville, Arkansas

Project Summary: Ground water monitoring for pesticides is an ongoing cooperative effort between the Arkansas State Plant Board (ASPB) and AWRC with supplementary funding from the Arkansas Soil and Water Conservation Commission (ASWCC). This monitoring is called for in the Arkansas Agricultural Chemical Ground-Water Management Plan and is expected to continue into the indefinite future.

As previously reported, monitoring was conducted in seven Arkansas counties during the first three phases. In Phase IV of the project, AWRC produced detailed vulnerability maps for all the farming counties of Eastern Arkansas. Estimates of vulnerability were refined by including clay cap data available from USGS. Also other soil and topographic variables included in the model were upgraded on the basis of more detailed information now available. The maps were produced using Geographic Information Systems (GIS) techniques.

Monitoring during this phase was focused on vulnerable areas in Pulaski, Lee and Jackson counties. One well in Crittenden county and two wells in Lonoke County were

also sampled. In all, 56 samples were drawn from 55 wells. The wells were tested for thirteen pesticides used in large quantities in the Arkansas Delta. Samples were also tested for nitrate.

As a result of this monitoring, one additional contaminated well was discovered. Pulaski well #14 was found to contain aciflurofen, 27 ug/L (ppb), bentazon, 135 ug/L, fluometuron, 24 ug/L, and metribuzin, 4 ug/L. The bentazon concentration was the highest concentration of any pesticide detected in ground water in Arkansas. When this well was resampled 3 months later all the concentrations were lower. The bentazon concentration was down to 57 ug/L. Sixteen of the wells tested had nitrate levels of 1 mg/L or more. Ten of these were over 3 mg/L and one (17.7 mg/L) was over the MCL for drinking water. These results support the contention that nitrate contamination is wide spread and that pesticide contamination is much less common.

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Project Title: *Pesticides in Ground Water Monitoring Project for Arkansas, Phase V*

Funding Agency: Arkansas State Plant Board, Little Rock, Arkansas

Project Period: 2/1/96 to 6/30/96

Principal Investigators: Paul Vendrell and Kenneth F. Steele, Department of Geology and Arkansas Water Resources Center, Terry Nichols, Arkansas Water Resources Center, and H. Don Scott, Department of Agronomy, University of Arkansas, Fayetteville, Arkansas

Project Summary: Ground water monitoring for pesticides is an ongoing cooperative effort between the Arkansas State Plant Board (ASPB) and the Arkansas Water Resources Center with supplementary funding from the Arkansas Soil and Water Conservation Commission (ASWCC). This monitoring is called for in the Arkansas Agricultural Chemical Ground-Water Management Plan and is expected to continue into the indefinite future.

During the first 4 phases of this project 195 samples were drawn from 175 wells in 12 counties in eastern Arkansas. Thirteen of the 175 wells had detectable concentrations of pesticides with bentazon (Basagran) being found most frequently (9 hits). The highest concentration found was also bentazon, 135 ug/L. Nitrate concentrations over 1 mg/L were found in 54 wells with 32 wells having nitrate concentrations of 3 mg/L or more.

Phase V of the monitoring focused on vulnerable areas in Monroe and Lawrence counties. Additionally, three more samples were drawn from Jackson county. As of July 1, 1996, forty-five samples have been collected from 43 wells. Only one additional well with pesticide contamination was discovered. Monroe #1 was found to have 87 ug/L bentazon and 148 ug/L Aciflurofen, making it the most contaminated well yet detected. The well was resampled after several weeks resulting in even higher concentrations, 103 ug/L bentazon and 180 ug/L aciflurofen. The State Plant Board and the Department of Pollution Control and Ecology have begun an investigation of this site.

Once again several wells were found to contain high nitrate. Of the 43 wells 14 had 1 mg/L or more of nitrate and 12 wells had concentrations of 3 mg/L or more. One cluster

of 4 wells in Monroe county all had nitrate over 5 mg/L. This may be the most extensive area of nitrate contamination yet encountered.

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Project Title: *Analytical Services for the Arkansas Soil and Water Conservation Commission*

Funding Agency: Arkansas Soil and Water Conservation Commission, Little Rock, Arkansas

Principal Investigator(s): Paul Vendrell and Kenneth Steele, Department of Geology and Arkansas Water Resources Center, University of Arkansas, Fayetteville, Arkansas, Ron Redman, Arkansas Soil and Water Conservation Commission, Little Rock, Arkansas

Project Summary: The Arkansas Soil and Water Conservation Commission (ASWCC) has several projects throughout Arkansas that require water chemical, physical, and microbiological analysis. The water bodies being studied by the ASWCC are: Arkansas River, Petit Jean River, Fourche Lafave River, Poteau River, Upper Millwood Lake, Spring River, and Cadron Creek. The Arkansas Water Resources Center, Water Quality Laboratory is cooperating with the ASWCC by providing this analysis.

In Arkansas, Yell County contains all or parts of four major drainage basins. The four major drainage basins are the Arkansas River, Petit Jean River, and part of the Fourche Lafave River These rivers are all in the Arkansas River Valley ecoregion. Twenty miles of the Arkansas River in this area is not suitable for aquatic life and drinking water uses due to municipal wastewater discharge. About 70 miles of the Petit Jean River has impaired water quality, attributed to non-point sources. The Fourche Lafave River was reported as "partially supporting aquatic life and primary contact usages." Reasons for this impairment have been attributed to agricultural and silvicultural practices. The Petit Jean River was selected for the first area for monitoring.

The ASWCC will conduct rapid bioassessment at 18 sites in the Petit Jean River basin. Bioassesments will be used to ranked sub-basins from least impaired to most impaired and to evaluate the best management practices implemented in the affected areas. Once ranked, the sub-basins will be sampled monthly for water quality parameters.

The Upper Millwood and Poteau River Watersheds are parts of the interstate monitoring network between Arkansas and Oklahoma. The Millwood Lake drainage basin has been reported as having eleven streams threatened from the wastes of confined animal operations. The Poteau River was reported as having three streams threatened and one stream impacted.

Streams are being sampled to assess impacts or possible toxicity to the aquatic environment from point and non-point sources of contamination. The Arkansas Soil and Water Conservation Commission (ASWCC) is sampling these watersheds for chemical, physical, and biological attributes.

A program conducted by the Arkansas Soil and Water Conservation Commission (ASWCC) is designed to help dairy farmers with the implementation of waste management systems. The Cadron Creek drainage basin has 182 diaries in operation.

This basin has been targeted for evaluating the effectiveness of best management practices (BMP) for dairy waste management (DWM). The study's objective is to evaluate BMPs designed to limit stream pollution by fecal bacteria and nutrient runoff from dairy waste.

One means of BMP evaluation is the chemical, physical, and microbiological quality of the stream water. Water samples are taken monthly and analyzed for nutrient and fecal bacteria.

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Project Title: *Upper White River BMP Implemention Project, Water Quality Monitoring*

Funding Agency: Arkansas Soil and Water Conservation Commission, Little Rock, Arkansas

Project Period: 5/2/95 to 4/30/98

Principal Investigator(s): Paul Vendrell and Kenneth Steele, Department of Geology and Arkansas Water Resources Center, Don Scott, Department of Agronomy, and Marc Nelson, Arkansas Water Resources Center, University of Arkansas, Fayetteville, Arkansas

Project Summary: The Upper White River project has three parts. The parts of this cooperative project are Geographic Information System (GIS) modeling, best management practice (BMP) implementation, and water quality monitoring. This summary covers the water quality monitoring aspect of the project.

Monitoring of the Upper White River watershed is underway. The objective of the water quality monitoring is to demonstrate the effectiveness of BMPs in reducing nutrient, sediment, and bacteria transport into the river. To demonstrate reduced transport, vulnerable areas have been selected for monitoring. The approach to select the vulnerable areas used a set of objective criteria. Criteria for selecting the vulnerable sub-basins were: 1) a high percentage of BMP acreage in relation to total sub-basin acreage, 2) large potential input of nutrients, bacteria, or sediments to the sub-basin waterways, 3) a sub-basin small enough to limit interference from non-agricultural sources (mines, mills, road construction, bridge construction, logging, and home developments), however, large enough to represent the watershed, 4) and access to the stream along with permission from the landowner.

Two vulnerable sites selected for monitoring are Cannon Creek and Shumate Creek, tributaries of the White River main fork. Shumate and Cannon Creeks are adjacent tributaries, with Shumate being the most vulnerable due to the amount of animal manure used for pasture fertilization. Whereas, Cannon Creek is less impacted from nutrients and bacteria and will be useful as a reference stream.

Other monitoring efforts focus on the terminal pools of the White River prior to Lake Sequoyah. Lake Sequoyah is fed by two branches of the White River, the Main and Middle Forks. Terminal pools are to be used to evaluate if the nutrient status of the Upper White River changes. The algae that grow in these terminal pools may do a good job of integrating the nutrient loads from these two forks of the White River. The U.S. Army Corps of Engineers will sharing data they have collected over the past three

years at the terminal pool of the Main Fork of the White River. Combining data will extend the period used for trend analysis and increase our ability to detect decreasing nutrient, sediment, and bacteria loads.

Automatic samplers with pressure transducers are installed and operating on the Middle Fork (Hwy. 16 bridge), Main Fork (Hwy. 74 bridge), Cannon Creek, and Shumate Creek. We are proceeding with the development of stage-discharge curves for these locations. From all sites, eight base-flow and 91 storm flow samples have collected and analyzed so far. Water samples will be collected and analyzed form these sites until May 1998.

BMPs are implemented and we are collecting data to determine the effectiveness of the BMPs. We have reviewed the water quality data from Shumate and Cannon Creeks with the Washington County Conservation District (WCCD). The WCCD has met with the landowners to compare the water quality data to the landowner's records of animal waste applications. The goal of this meeting was to provide the opportunity for the landowners to modify and improve their BMPs. Fine tuning the BMPs and increasing their effectiveness in reducing nutrient, bacteria, and sediment loss will increase our ability to demonstrate the effect of implemented BMPs on water quality.

INFORMATION TRANSFER ACTIVITIES

The professional presentations and publications by the principal investigators of Section 104 grants are listed in the Publications section on page 40 of this report. The Center sponsored a conference attended by over 100 persons titled "Diversity of Arkansas Water Resources Research," a short course titled "Water Quality Monitoring Design and Statistical Analysis for Nonpoint Source Pollution Studies," co-sponsored the national conference on "Animal Waste and the Land-Water Interface," and was a co-sponsor of the American Society of Civil Engineers' conference on "North American Water and Environment Congress '96." In addition to these efforts, the Director and many of the investigators have communicated information to various groups and individuals in less formal discussions. These activities include discussions of research topics with state and federal agencies and private groups, and interviews with media reporters, including appearances on television news and information programs. Most of these activities have served the dual purpose of informing professional groups and the public of:

1) water resources problems and solutions, and;
2) the Center's activities in water resources.

During the grant period, the principal investigators and Director produced the following:

1) Presentations: 30
2) Professional Publications: 22

In addition, the Center staff publishes the Arkansas Water Resources Center Newsletter quarterly.

6 technology transfers were conducted during the last year involving 2 separate 104 funded projects.

Technology transfer for the Septic Tank II project funded by the State of Arkansas included short courses ranking from 0.5 to 7 days. The courses were mainly conducted for the Sanitarians from the Arkansas Department of Health, although personnel from other agencies and the private sector participated. An on-site wastewater system educational slide set has been developed. In addition to the technology transfer courses, two college credit courses have been developed and taught at the University of Arkansas at Fayetteville as an outgrowth of the research project. A senior-level course entitled "Septic Systems" is offered in the Departments of Agronomy and Civil Engineering. The second course is a senior-level Civil Engineering course called "Small Community Wastewater Systems."

The Center continues to have formal relationships with three state agencies this year. The Center has a long-standing Cooperative Agreement with the Arkansas Soil and Water Conservation Commission and is presently cooperating with this agency on over 15 projects, mostly related to non-point source pollution. The Center is also cooperating with the Department of Pollution Control & Ecology and the State's Mercury Task Force on a geographical information system study of the spatial distribution of contaminated fish. The State Plant Board continues to collaborate with the Center on its projects concerned with monitoring and modeling pesticide contamination of ground water.

There were four federal agencies with formal relationships with the Center this year. The Center cooperated with the U.S. National Biological Survey (NBS) on the recently completed project on Global Climate Change in the Ozark Highlands and is providing chemical analyses of water to the NBS Cooperative Unit on several projects. Studies on stream water quality, and riparian vegetation characterization and inventory are included in the cooperative agreement with the National Park Service, Buffalo National River. Another federal agency cooperative agreement is in place with the U.S. Forest Service for water quality work in the Ouachita, Ozark and St. Francis National Forests. The section 104 funds are administered by the U.S. Geological Survey.

The Center also works closely with other agencies informally. The Center works closely with the Arkansas Department of Health, Arkansas Geological Commission, U.S. Geological Survey, U.S. Natural Resources Conservation Commission and Cooperative Extension Service in sharing data, information and expertise. For example, the Arkansas Department of Health provides technical input and advice for the Arkansas Onsite Domestic Renovation Project.. The U.S. Geological Survey hydrogeologist at Fayetteville also provides an avenue for interaction with the Survey.

Many of the state's water resource committees have a representative from the Center which allows interaction with many other agencies and groups represented on the committee. AWRC is represented on the State Mercury Task Force, Arkansas Ground Water Protection and Management Committee (Arkansas Soil and Water Conservation Commission), White River Coordinating Committee (U.S. Corps of Engineers), State Management Plan Liaison Committee (State Plant Board), National Assessment of Water Quality Liaison Committees for the Ozark Region and also for the Lower Mississippi River Region (U.S. Geological Survey), and the Nitrate Committee (Arkansas Health Department).

The AWRC Technical Advisory Committee is composed of representatives from state and federal agencies, academia, industry, and private groups. This Committee has played an important role in cooperative efforts with various agencies and groups. Membership of the Technical Advisory Committee follows the specific project cooperators list below.

Specific Project Cooperators

Project 02, Water Quality of Rural Domestic Supply Wells in Select Aquifers in Arkansas - The Department of Geology is coordinating with the Arkansas Water Resources Center Water Quality Laboratory for analysis of samples. The field technician (graduate student) has met with and/or obtained data from the U.S. Geological Survey office in Little Rock and Fayetteville, Arkansas Extension Service, local Natural Resources Conservation Service personnel, and county health personnel. All organizations and

agencies have been very cooperative and have provided valuable data and/or contacts.

Project 03, Bioaccumulation of Methyl Mercury Through a Food Chain - This project was done in cooperation with personnel from the Arkansas Game and Fish Commission, Little Rock, Arkansas, and the Department of Biology, Ouachita Baptist University, Arkadelphia, Arkansas. The results of this project will be of great interest to the State Mercury Task force.

Project 04, Influence of Rice Production on the Quality of Water in Tailwater Collection Reservoirs - Cooperators on this project included county extension agents in the Cooperative Extension Service, and Drs. John Mattice, Briggs Skulman, Ron Talbert, Charles Guy and Ronnie Helms, of the Department of Agronomy at the University of Arkansas, Fayetteville, Arkansas.

Project 05, Effects of Zebra Mussel, Dreissena Polymorpha, Infestation on Lake Dardanelle Water Quality - This project currently monitors zebra mussel populations (biweekly between March and November) in Lake Dardandelle under contract with Entergy Corporation. This private corporation has allowed use of their equipment as needed, and to collect water quality, zooplankton, and vegetation samples concurrent with zebra mussel samples. It is this agreement, in conjunction with the grant from the Arkansas Water Resources Center, that will permit us to establish baseline data and evaluate the impact of zebra mussel infestation on the water quality, zooplankton, and vegetation of Lake Dardanelle, Arkansas.

ARKANSAS WATER RESOURCES CENTER
TECHNICAL ADVISORY COMMITTEE
1995-96

Mr. Don Alexander
Director
Arkansas State Plant Board
Division of Feeds, Fertilizers, and Pesticides
No. 1 Natural Resources Drive
Little Rock, AR 72205

Mr. Charles Bennett
Arkansas Department of Pollution Control & Ecology
8001 National Drive
Little Rock, AR 72209

Dr. Jim Brag
Department of Biology
Henderson State University
1100 Henderson Street
Arkadelphia, AR 71999-0001

Mr. William Bush
Arkansas Geological Commission
3815 West Roosevelt Road
Little Rock, AR 72704

Mr. Kenneth Carter
Department of the Army
Little Rock District Cops of Engineers
Planning Division
P.O. Box 867
Little Rock, AR 72203-0867

Mr. Stanley L. Chapman
Cooperative Extension Service
University of Arkansas
2201 Brookwood Drive
P.O. Box 391
Little Rock, AR 72203

Dr. David Chittenden
Arkansas State University
Department of Chemistry
State University, AR 72467

Dr. Bernie Daniels
Associate Director
Agricultural Experiment Station
University of Arkansas
AGRI 205
Fayetteville, AR 72701

Mr. Danny Goodwin
Water Quality Specialist
USDA Natural Resources Conservation Service
5404 Federal Office Building
700 West Capitol Avenue
Little Rock, AR 72201

Mr. John Harbison (Alternate)
School of Law
University of Arkansas
Fayetteville, AR 72701

Mr. Tim Kresse (Alternate)
Arkansas Department of Pollution Control & Ecology
8001 National Drive
Little Rock, AR 72209

Dr. Ed Lawson
University of Arkansas, Monticello
Department of Forestry
Box 3468
Monticello, AR 71655

Mr. Bob Lidwin
Arkansas District Chief
U.S. Department of Interior
Geological Survey
401 Hardin
Little Rock, AR 72211

Mr. Darryl Little (Alternate)
Assistant Director
Arkansas State Plant Board
Division of Feeds, Fertilizers and Pesticides
No. 1 Natural Resources Drive
Little Rock, AR 72205

Dr. Richard Meyer
Department of Biology
University of Arkansas
Fayetteville, Arkansas 72701

Dr. Gaylord Northrop
Director
Graduate Institute of Technology
University of Arkansas, Little Rock
2801 South University
Little Rock, AR 72204-1099

Dr. Phillip E. Norvell
School of Law
University of Arkansas
WATR 318A
Fayetteville, Arkansas 72701

Dr. David Parker
Civil Engineering
University of Arkansas
Fayetteville, Arkansas 72701

Ms. April Ralston
Arkansas Game & Fish Commission
2 Natural Resources Drive
Little Rock, AR 72205

Dr. John Rickett
University of Arkansas, Little Rock
Department of Biology
2801 South University
Little Rock, AR 72204

Dr. Don Scott
Department of Agronomy
University of Arkansas
Fayetteville, Arkansas 72701

Mr. Harold R. Seifert
Division of Engineering
Arkansas Department of Health
4815 West Markham
Little Rock, AR 72205

Dr. Kenneth F. Steele
Arkansas Water Resources Center
113 Ozark Hall
University of Arkansas
Fayetteville, Arkansas 72701

Mr. John Sweeney
Arkansas Soil & Water Conservation
Commission
101 East Capitol, Suite 350
Little Rock, AR 72201

Mr. Bill Thompson
International Paper Company
P.O. Box 7069
Pine Bluff, AR 71611

Mr. Randy Thurman
Arkansas Environmental Federation
Union Train Station, Suite 250
1400 West Markham Street
Little Rock, AR 72201

Dr. Paul Vendrell
Arkansas Water Resources Center
University of Arkansas
Fayetteville, Arkansas 72701

Dr. Joseph A. Ziegler
Department of Economics
University of Arkansas
BADM 402
Fayetteville, AR 72701

PUBLICATIONS

1. Dissertations

Citation	Field of Study	Supporting Project No.
None.		

2. Conference Presentations

Citation	Supporting Project No.
Dewell, R.A., T.L. Lavy, and C.R. Beard, 1995, The Impact of Rice Production on Water Quality, Presentation at the 6th Biennial State Water Conference and 8th Annual AWRC-AR and AGWA Joint Symposium, "The Stewardship of our Water Supplies: Arkansas' Wealth." Little Rock, AR.	04
Dewell, R.A., T.L. Lavy, and C.R. Beard, 1996, Aquatic degradation of pesticides in Arkansas rice production, Picogram, ACS, New Orleans, LA, March 1996, In Press.	04
Dewell, R.A., T.L. Lavy, and C.R. Beard, 1996, Degradation or Dillution? Evaluating Selected Rice Pesticides in Aquatic Systems, Proceedings Southern Weed Science Society, 49:(In Press).	04
Gagen, C.J. and J.N. Stoeckel, April 1996, Effects of Zebra Mussel, Dreissena Polymorpha, Infestation on Lake Dardanelle Water Quality, Arkansas Water Resources Center Conference on Diversity of Arkansas Water Resources Research, Fayetteville, AR.	05
Howell, C.S., III, C.J. Gagen, and J.N. Stoeckel, 1996, Zebra Mussel Proliferation in Lake Dardanelle on the Arkansas River, Joint meeting of the Arkansas River Conservation Committee Meeting and Eightieth annual meeting of the Arkansas Academy of Science, Fort Smith, AR.	05
Shook, S.D., C.S. Gagen, and J.N. Stoeckel, February 1995, Changes in Denisty of Larval Zebra Mussel (Dreissena polymorpha) in Lake Dardanelle, Arkansas, Annual meeting of the Arkansas Chapter of American Fisheries Society, Pine Bluff, AR.	05

3. Articles in Refereed Scientific Journals

Citation	Supporting Project No.
None.	

4. Other Publications

Citation	Supporting Project No.
Davis, Ralph K., 1996, Water Quality of Rural Domestic Supply Wells in Select Aquifers in Arkansas, Arkansas Water Resources Center Technical Completion Report, In Press.	02
Knight, John T., 1996, Bioaccumulation of Methyl Mercury Through a Food Chain, Arkansas Water Resources Center Technical Completion Report, In Press.	03
Lavy, T.erry L. and Reece A . Dewell, Influence of Rice Production on the Quality of Water in Tailwater Collection Reservoirs, 1996, Arkansas Water Resources Center Technical Completion Report, In Press.	04
Lavy, T.L., R.A. Dewell, C.R. Beard, J.D. Mattice, and B.W. Skulman, 1996, Environmental Implications of Pesticides in Rice Production, Arkansas Rice Research Studies 1995, In Press.	04
Gagen, Charles J. And Joseph N. Stoeckel, 1996, Effects of Zebra Mussel, Dreissena Polymorpha, Infestation on Lake Dardanelle Water Quality, Arkansas Water Resources Center Technical Completion Report, In Press.	05

OTHER PUBLICATIONS
(Non USGS Funded Projects)

1. Dissertations

   Citation

   None.

2. Conference Presentations

   Citation

   Baker, William H., 1996, Effectiveness of GIS and GPS Technologies in Agronomic Production Systems, Grower Production Short Course, Phillips County Community College and the Arkansas Cooperative Extension Service.

   Baker, Wiliam H., 1996, The Emerging Role of GIS and GPS Technologies in Production Agriculture in the South, Alexandria, Louisiana, Pest Management Consultants Workshop, Louisiana State University and the Louisiana Agricultural Consultants Association.

   Baker, William H., 1996, Identification of Soil pH Variables Using GPS and GIS Technologies, Helena, Arkansas, Arkansas Cotton Meetings, University of Arkansas.

   Baker, William H., 1996, Precision Agriculture Technologies, Russellville, Arkansas, Arkansas Cooperative Extension Service.

   Baker, William H., 1996, Precision Agriculture Technologies, Jonesboro, Arkansas, Arkansas Cooperative Extension Service.

   Baker, William H., 1996, Precision Agriculture Technologies, Pine Bluff, Arkansas, Arkansas Cooperative Extension Service.

   Baker, William H., 1996, Definitive Spatial Technologies, Advanced Spacial Technologies Workshop, Mississippi State University and Mississippi Cooperative Extension Service.

   Baker, William H., 1996, Assessment of Soil pH using GIS and GPS Technologies, 1996, Stuttgart, Arkansas, Arkansas Cooperative Extension Service.

   Baker, William H., 1996, Implications of Precision Farming, 1996, Starkville, Mississippi, Agricultural Economics Association and Mississippi State Cooperative Extension Service.

   Edwards, D.R., J.F. Murdoch, T.C. Daniel and P.A. Moore, Jr., 1995, Runoff Quality Response to Inorganic Fertilizer Applications to Pastures Previously Treated with Animal Manure, In: Transactions of the American Society of Agricultural Engineers (In Press).

Haggard, B.E., P.A. Moore, Jr., R.L. Meyer, T.C. Daniel and D.R. Edwards, 1995, Trophic State of Beaver Lake, Arkansas, Agronomy Abstracts.

Haggard, B.E., P.A. Moore, Jr., R.L. Meyer, T.C. Daniel and D.R. Edwards, 1995, State of Beaver Lake, Arkansas, Proceedings of Animal Waste and the Land-Water Interface.

Jaster, A.G., D.N. Mott and K.F. Steele, 1996, Storm Event Water Quality of Three Middle Buffalo River Tributaries, In: Arkansas Academy of Science Abstracts.

Moore, P.A., Jr., T.C. Daniel, J.T. Gilmour and D.R. Edwards, 1995, Evaluation of Alum-Treated Poultry Litter on Metal Runoff and Uptake by Fescue.

Moore, P.A., Jr., T.C. Daniel, D.R. Edwards and A. Waldroup, 1995, Evaluation of Alum Application to Poultry Litter in Commercial Broiler Houses, Proceedings of Animal Waste and the Land-Water Interface.

Moore, P.A., Jr., T.C. Daniel, D.M. Miller, D.R. Edwards and B.R. Shreve, 1995, Reducing Phosphorus Runoff and Inhibiting Ammonia Volatilization from Poultry Litter with Aluminum Sulfate. Supplement to Proceedings of Animal Waste and the Land-Water Interface.

Moore, P.A., Jr., A.L. Waldroup and T.C. Daniel, 1995, Effect of Aluminum Sulfate on Broiler Litter Characteristics and Broiler Production in Commercial Houses, Poultry Science Abstracts.

Moore, P.A., Jr., T.C. Daniel, D.M. Miller, B.R. Shreve, and D.R. Edwards, 1995, Reducing Atmospheric Ammonia Contamination and Non-Point Source Phosphorus Runoff from Poultry Manure with Aluminum Sulfate, In: Proceedings of XII International Symposium on Environmental Biogeochemistry, Rio de Janerio, Brazil.

Moore, P.A., Jr., W.E. Huff, T.C. Sauer, T.C. Daniel and D.R. Edwards, 1996, A Simple Method for Measuring Ammonia Volatilization From Poultry Litter, Poultry Science (In Press).

Moore, P.A., Jr., 1995, Reducing Ammonia Volatilization and Phosphorus Solubility in Poultry Litter with Alunimum Sulfate. In: (H.H. Van Horn, ed.) Nuisance Concerns in Animal Manure Management: Odors and Flies. Proc. Of Conference Held March 21-22, 1995, Gainesville, Florida.

Moore, P.A., Jr., 1995, Reducing Phosphorus Runoff and Inhibiting Ammonia Volatilization from Poultry Litter with Aluminum Sulfate. In: Proceedings of 1995 Poultry Environmental Management Seminar held August 3-4 in Atlanta, Georgi.

Moore, P.A., Jr., 1995, Reducing Ammonia Volatilization from Poultry Litter with Aluminum Sulfate. Proceedings fo the 1995 Arkansas Poultry Federation Nutrition Conference.

Nichols, D.J., T.C. Daniel, P.A. Moore, Jr. and D.R. Edwards, 1995, Evaluation of Two Methods for Reducing Estradiol in Runoff from Fescue Applied Poultry Litter, Agronomy Abstracts.

Scantling, Mary, Amy Waldroup, John Marcy and Phillip Moore, Jr., 1995, Microbiological Effects of Treating Poultry Litter with Aluminum Sulfate, Poultry Science Abstracts.

3. Articles in Refereed Scientific Journals

Citation

Edwards, D.R., J.F. Murdoch, H.D. Scott, T. C. Daniel, M.J. Habiger and H.M. Burks, 1995, Water Quality Impacts of Best Management Practice Implementation in a Northwest Arkansas Basin, Water Resources Bulletin (In Press).

Edwards, D.R., T.C. Daniel, J.F. Murdoch and P.A. Moore, Jr., 1995, Microbiological Quality of Runoff from Four Grazed Northwest Arkansas Fields, Water Resources Bulletin (In Press).

Edwards, D.R., M.S. Coyne, T.C. Daniel, P.F. Vendrell, J.F. Murdoch and P.A. Moore, Jr., 1996, Indicator Bacteria Concentrations of Two Northwest Arkansas Streams in Relation to Flow and Season, Water Resources Bulletin (In Press).

Moore, P.A., Jr., 1996, Best Management Practices for Poultry Manure Utilization that Enhance Agricultural Productivity and Reduce Pollution. In: Advances in Soil Science.

4. Other Publications

Citation

Haggard, B.E., P.A. Moore, Jr., R.L. Meyer, T.C. Daniel and D.R. Edwards, 1995, Trophic State of Beaver Lake, Arkansas, Agronomy Abstracts.

Haggard, B.E., P.A. Moore, Jr., R.L. Meyer, T.C. Daniel and D.R. Edwards, 1995, State of Beaver Lake, Arkansas, Proceedings of Animal Waste and the Land-Water Interface.

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Moore, P.A., Jr., T.C. Daniel, D.R. Edwards and A. Waldroup, 1995, Evaluation of Alum Application to Poultry Litter in Commercial Broiler Houses, Proceedings of Animal Waste and the Land-Water Interface.

Moore, P.A., Jr., T.C. Daniel, D.M. Miller, D.R. Edwards and B.R. Shreve, 1995, Reducing Phosphorus Runoff and Inhibiting Ammonia Volatilization from Poultry Litter with Aluminum Sulfate. Supplement to Proceedings of Animal Waste and the Land-Water Interface.

Moore, P.A., Jr., A.L. Waldroup and T.C. Daniel, 1995, Effect of Aluminum Sulfate on Broiler Litter Characteristics and Broiler Production in Commercial Houses, Poultry Science Abstracts.

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Moore, P.A., Jr., 1995, Reducing Ammonia Volatilization and Phosphorus Solubility in Poultry Litter with Aluminum Sulfate. In: (H.H. Van Horn, ed.) Nuisance Concerns in Animal Manure Management: Odors and Flies. Proc. Of Conference Held March 21-22, 1995, Gainesville, Florida.

Moore, P.A., Jr., 1995, Reducing Phosphorus Runoff and Inhibiting Ammonia Volatilization from Poultry Litter with Aluminum Sulfate. In: Proceedings of 1995 Poultry Environmental Management Seminar held August 3-4 in Atlanta, Georgia.

Moore, P.A., Jr., 1995, Reducing Ammonia Volatilization from Poultry Litter with Aluminum Sulfate. Proceedings of the 1995 Arkansas Poultry Federation Nutrition Conference.

Nichols, D.J., T.C. Daniel, P.A. Moore, Jr. and D.R. Edwards, 1995, Evaluation of Two Methods for Reducing Estradiol in Runoff from Fescue Applied Poultry Litter, Agronomy Abstracts.

Scantling, Mary, Amy Waldroup, John Marcy and Phillip Moore, Jr., 1995, Microbiological Effects of Treating Poultry Litter with Aluminum Sulfate, Poultry Science Abstracts.

SPECIAL RECOGNITION AWARDS RECEIVED BY THE APPLICANT

Award	Supporting Project No.
Best Undergraduate Paper Award, received by student presenter, Shannon Shook, at Annual meeting of the Arkansas Chapter of the American Fisheries Society, February 1995, Pine Bluff, Arkansas.	05
2nd Place, Best Undergraduate Paper Award, received by student presenter, Coburn Howell, at the Arkansas Academy of Sciences Annual Meeting, Life Sciences Division, 1996.	05

NOTABLE ACHIEVEMENTS

Project No. 05, Effects of Zebra Mussel, Dreissena Polymorpha, Infestation on Lake Dardanelle Water Quality - The primary achievement of the first two years of this project is the establishment of the initial year of baseline data that can be used to test hypotheses relative to the impact of zebra mussel introduction on the water resources of Lake Dardanelle. Thus far, the data collected on zebra mussels has been used several times to compare the population dynamics of zebra mussels in Lake Dardanelle with other areas that have been infested with zebra mussels. Similarly, after the remainder of the data from this study have been compiled and analyzed, we will be able to compare zebra mussel impacts on key water resource parameters of Lake Dardanelle with those of other lakes and reservoirs. Personnel from Louisiana State University have contacted us, and are very interested in comparing our data with those they collected in more southern rivers and reservoirs. Information from this project has also been used extensively by the Arkansas Zebra Mussel Task Force and other groups to help alert industry and the public to potential impacts of the zebra mussel infestation and to the dangers of moving zebra mussels to inland lakes.

TRAINING ACCOMPLISHMENTS

Field of Study	Academic Level: Undergraduate	Master's Degree	Ph.D. Degree	Post Ph.D.	Total
Chemistry					
Engineering:					
- Agricultural					
- Civil					
- Environmental					
- Soils					
- Systems					
- Other*					
Geology		5			5
Hydrology					
Agronomy	7	2	2		11
Biology	6	3	1		10
Ecology	3				3
Fisheries, Wildlife and Forestry	5				5
Computer Science					
Economics					
Geography					
Law					
Resource Planning					
Other: Environmental Soil & Water	4				4
TOTAL:	25	10	3		38

*Less than 5 students in any one field of study.

POSTGRADUATE EMPLOYMENT

	Degree			Employer				
				Government				
Student	BS	MS	Ph.D.	Federal	State	Local	Private Sector	College or University
1.	1							1
2.	1						1	
3.	1						1	
4.	1						1	
5.	1						1	
6.	1						1	
7.		1			1			
8.								
9.								
10.								