Arkansas Water Resources Center

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

Arkansas Water Resources Center

Annual Technical Report

FY 1999

Introduction

Research Program

Basic Project Information

Basic Project Information	
Category	**Data**
Title	Continuation of Investigation of Optimum Sample Number and Timing for Determining Pollution Loads
Project Number	C-02
Start Date	09/01/1998
End Date	08/31/1999
Research Category	Water Quality
Focus Category #1	Hydrology
Focus Category #2	Non Point Pollution
Focus Category #3	Nutrients
Lead Institution	University of Arkansas

Principal Investigators

Principal Investigators			
Name	**Title During Project Period**	**Affiliated Organization**	**Order**
Thomas S. Soerens	Assistant Professor	University of Arkansas	01
Marc A. Nelson	Research Associate	University of Arkansas	02
Jean Spooner	Associate Professor	North Carolina State University	03

Problem and Research Objectives

Accurate measurements of pollution loads in streams are critical for determining the impacts of non point source (NPS) pollution and for developing TMDLs. A common sampling method for determining pollution loads is to continuously monitor flow and intermittently collect water samples. The purpose of this study was to determine the optimum number and timing of storm and baseflow water quality sampling to determine pollutant loads in streams with high precision and accuracy. The objectives of this study were to: Accurately determine pollutant loads at two sites by sampling storm runoff events at thirty-minute intervals, develop sub-sampling and other data analysis techniques to determine the effect of sample interval on load calculation accuracy, and find the minimum sample interval required to determine storm loads at a required accuracy.

Methodology

Two stream sites in the Illinois River basin were sampled: 1) Moores Creek, a small 1st order stream with a drainage area of about 1000 hectares in the headwaters of the Illinois River. Moores Creek is impacted primarily by non-point source pollution from agriculture, forest, and low-density housing. 2) Illinois River near Siloam Springs, Arkansas, a larger 3rd to 5th order stream with a drainage area of about 150,000 hectares. The Illinois River is impacted by urban point source and rural non-point source pollution. Gauges at the sites continuously measured and recorded stage and calculated discharge. Automatic samplers installed at the sites were triggered by the state gauges to take storm samples at 30 minute intervals during the rising limb and 60 minute intervals during the falling limb of the storm hydrographs. All samples were collected from the sites within 24 hours and analyzed at the Arkansas Water Quality Lab using EPA approved analysis and QA/QC procedures. The samples were analyzed for NO3-N, NH4-N, TKN, Ortho-P, Total-P, and TSS. This study (i.e., the continuation) was designed to sample four storms at both the Illinois River and the Moores Creek sites (the same storms). Storm loads were calculated by multiplying discharged volume by concentration for each sampling interval and summing over the storm. The loads calculated using the 30 minute interval data were termed the "best estimate" load. Loads were also calculated for 60, 120, and 240 minute sampling intervals using subsets of the data. The load estimates for the longer sampling intervals were expressed as a percentage of the best estimate load.

Principal Findings and Significance

In the first year of the project, nine storms were sampled at the Illinois Hwy 59 site and three storms at the Moores Creek site. In the second year, five storms were sampled at each site. Storm load results show that as a sampling interval increased, the error of the load estimate increased. Optimum sampling intervals for the sites were calculated. For example, if we desire that the calculated load is within 5% of the best estimate load with a 95% confidence level, the optimum sampling interval for TSS at the Moores Creek site is 50 minutes. This optimum sampling interval varies with the parameter measured and with the stream order. The pollutants that show the most peaking effect during a storm require the smallest sampling interval. Also, Moores Creek, which is flashier than the main branch of the Illinois River, requires a shorter sampling interval for accurate storm load calculations. The results lead to the following conclusions: 1) The sample interval affects load calculation precision and accuracy. 2) An optimum sample interval can be calculated using sub-sampling techniques. 3) The optimum sample interval varies by parameter measured and by drainage basin size. The information gathered and the methods developed in this research will be useful in all parts of the country for optimizing sampling strategies used in the determination of TMDLs. The information gained will allow water quality investigators to design sampling schemes for their particular sites and conditions that use only enough samples to adequately characterize pollutant loads and concentrations, saving time and money. It will

also increase the precision and accuracy of the load calculations, making assessments of improvements from Best Management Practices more reliable and assisting in setting more accurate TMDL limits.

Descriptors

Streams, Suspended Sediments, Nutrient Transport, Water Quality Monitoring

Articles in Refereed Scientific Journals

Book Chapters

Dissertations

Lo, Yian-Mei, 2000, Optimum Storm Sampling for the Calculation of Nutrient Loads in the Illinois River, "M.S. Report," Department of Civil Engineering, University of Arkansas, Fayetteville, Arkansas.

Water Resources Research Institute Reports

Conference Proceedings

Soerens, Thomas, M. Nelson, and J. Spooner, 1999, Optimum Sampling Intervals for Calculating Pollutant Loads in Streams, "in" Proceedings of WEFTEC '99, Water Environment Federation Annual Conference, October 9-13, 1999, New Orleans, Louisiana. Soerens, Thomas, M. Nelson, and J. Spooner, 1999, Optimum Sampling for Determining Pollution Loads in Streams, "in" Proceedings of 1999 International Water Resources Engineering Conference, ASCE Specialty Conference, August 8-11, 1999, Seattle, Washington.

Other Publications

PRESENTATIONS: Lo, Yian-Mei, T. Soerens, and M. Nelson, "Optimum Sampling for Calculation of Nutrient Loads in Moores Creek and the Illinois River," 1999, Arkansas Academy of Science 83rd Annual Meeting, April 2-3, 1999, Russellville, Arkansas. Nelson, M., T. Soerens, and J. Spooner, "Investigation of Optimum Sample Intervals for Storm Sampling," Arkansas Water Resources Center Annual Conference, April 2-5, 2000, Fayetteville, Arkansas. Nelson, M.A., T.S. Soerens, and K. Steele, "Illinois River Arkansas-Oklahoma Transboundary Load Determination Issues," American Geophysical Union 2000 Spring Meeting, May 30 - June 3, 2000, Washington, D.C. Soerens, Thomas, M. Nelson, J. Spooner, and Y. Lo, "Optimum Sampling for Storm Load Determination," American Geophysical Union 1999 Spring Meeting, June 1-4, 1999, Boston, Massachusetts. Soerens, Thomas, M. Nelson, and J. Spooner, "Optimum Sampling for Determining Pollution Loads in Streams," 1999 International Water Resources Engineering Conference, ASCE Specialty Conference, August 8-11, 1999, Seattle, Washington. Soerens, Thomas, M. Nelson, and J. Spooner, "Optimum Sampling Intervals for Calculating Pollutant Loads in Streams," WEFTEC '99, Water Environment Federation Annual Conference, October 9-13, 1999, New Orleans, Louisiana. Soerens, Thomas, "Lessons Learned from Water Quality Studies," 4-State Heartland Community Development Conference, November 4-5, 1999, Muskogee, Oklahoma. Soerens, Thomas, M. Nelson, J. Spooner, and Y. Lo, "Investigation of Optimum Sampling for Calculation of Nutrient Loads in Moores Creek and the Illinois River," Arkansas Water Resources Center 1999 Annual Conference, April 13-15, 1999, Fayetteville, Arkansas. Soerens, T.S., and Nelson, M.A., "Pollutant-Specific Stream Sampling

Protocol," American Geophysical Union 2000 Spring Meeting, May 30 - June 3, 2000, Washington, D.C. INFORMATION TRANSFER: M. Nelson presented the findings of this project to the technical committee of the Arkansas-Oklahoma Arkansas River Compact Commission and to the Compact Commission's annual meeting.

Basic Project Information

Basic Project Information	
Category	**Data**
Title	Assessment of Public Drinking Water Supplies in Arkansas, Phases I-IV
Project Number	S-03
Start Date	09/01/1998
End Date	08/31/2001
Research Category	Water Quality
Focus Category #1	Water Quality
Focus Category #2	Water Supply
Focus Category #3	Management and Planning
Lead Institution	University of Arkansas

Principal Investigators

Principal Investigators			
Name	**Title During Project Period**	**Affiliated Organization**	**Order**
W. F. LIMP	Professor	University of Arkansas	01
R. K. Davis	Assistant Professor	University of Arkansas	02

Problem and Research Objectives

GIS Portion of the Project: The purpose for the proposed work was to obtain information on the location of all public water intakes in the state of Arkansas and the location and characteristics of Potential Sources of Contamination (PSOC) that are within their immediate vicinity (either one-quearter or one-half mile – for wells). The purpose of this work was to develop base data to be used by the U.S. Geological Survey to assess the potential for contamination for the state's public water intakes. PSOC data needed for assessment of public surface water sources (impoundment's, rivers, etc.) will be provided to the USGS. The individual assessment's performed by USGS will be provided to the Arkansas Department of Health as part of the EPA required program on source water assessment (EPA 816-R-97-009 "State source water assessment and protection program guidance"). Hydrology Portion of the Project: Develop a management tool for public water utilities to enhance the protection of their source of drinking water via identification of source water assessment areas of drinking water supplies and identification of potential sources of contamination within distinct delineated areas.

Methodology

GIS Portion of the Project: Due to the large number of public water intakes and potential PSOCs it would be enormously expensive and almost impossible to field map all these data using traditional methods, therefore the use of Geographic Information Systems (GIS) technologies enables such a large project to be completed in a timely manner. The goal of this data collection task is to develop a GIS data set that can serve as a useful basis for assessing the potential for contamination for every public water system within Arkansas. The final mapping script continued to be tested, evaluated and reviewed by the entire project team during this quarter and it was estimated that approximately 90% of this task had been completed at the conclusion of this quarter. The PSOC test report format and output script also matured during this quarter and approximately 90% of this task was completed by the end of the quarter. Additionally, another 15% of the GIS data layers that had been developed for this project had been documented with official FGDC metadata at the conclusion of this quarter. Completed Tasks as of 2/28/00: TASK 1 - Convert key base map GIS data into common digital format/projection TASK 2 - Convert key PSOC data to digital format TASK 3 - Geo-code PSOC databases TASK 4 - Seamless Data Base Assembly TASK 5 - Macro Development TASK 6 - Draft Map production TASK 7 - Edit PSOC locations/attributes from field maps TASK 8 - Calculate the elevation of each PSOC collected. TASK 9 - Construct and Deliver Access Database to project team. TASK 10 - Determine PSOC Distance Weighting TASK 11 - Prepare Final Map Prototypes and GIS Scripts (90% Complete) TASK 12 - Prepare Final PSOC location text reports (90% Complete) TASK 13 - Convert Oil & Gas Well Data into GIS Coverage TASK 14 - Develop FGDC Compliant metadata (40% Complete) Hydrology Portion of the Project: Delineate and assess the area of approximately 140 public drinking water sources in four counties in northwest Arkansas. The delineation and assessment are conducted in accordance with procedures described in " Source Water Assessment Program" Arkansas Department of Health. Phase II involves compilation of existing data primarily for surface water systems and selected springs and wells that are considered to be directly influenced by surface sources (Groundwater Under the Direct Influence of Surface Water).

Principal Findings and Significance

GIS Portion of the Project: For the estimated 1500 public water intakes at the time of this project, approximately 3 to 5 individual map layout formats and reports were customized by CAST. These changes came about via extensive testing and evaluation by the entire project team, as well as, the SWAP projects Technical and Citizens Advisory Committees, which met in Little Rock at a public meeting. Another 15% of the GIS data layers that had been developed for this project had been documented with official FGDC metadata at the conclusion of this quarter. Compiled GIS Data Layers: 1. Geology (1:500k) vector 2. Soils (STATSGO 1:250k) vector 3. Poultry/Swine houses 4. Land Cover reclass of GAP (30m raster) 5. Canals and Ditches (1:100k TIGER/DLG) 6. Irrigation Wells (ASWCC) 7. NPDES and TRI (EPA) 8. Highways by classification, railroads, airports, bridges (AHTD) 9. Pipelines (TIGER 1:100k) 10. RCRA 11. ERNS 12. Cemeteries (AHTD/GNIS) 13. Schools (AHTD/GNIS) 14. Septic Systems (AHTD) 15. Mines (GNIS) 16. Elevation (30m where available; else 80m) 17. Streams/Rivers (DLG 1:100k) 18. Dairies (Ark. Dept. of Health) Potential Sources of Contamination (PSOC): As identified the USGS and Arkansas Department of Health 1. Above ground storage tanks 2. Under ground storage tanks 3. Leaking storage tanks 4. Agri Industry 5. Pesticides applied per acre 6. Airports 7. Repair Shops 8. Cemeteries 9. Chemical Storage 10. Dry cleaners 11. Electric substations 12. Golf Courses 13. Gravel Pits (& PC&E Streaming Mining) 14. Highways 15. Manufacturing facilities (non-specific) 16. Pipelines 17. Oil and gas wells 18. Salvage yards 19. Sewage treatment plants (NPDES facilities) 20. Septic tanks 21. Landfills 22. Water wells 23. Confined animal operations 24. Aqua-culture 25. Land application of Solid Waste (PC&E) 26. Waste water lagoon (Discharge data) 27. In-steam gravel removal (PC&E Permits) 28. RCRA 29.

CERCLA (Superfund) 30. Marinas 31. Mining Hydrology Portion of the Project: All public water supplies were visited in the four county study area. GPS locations for each well were collected as well as a wellhead inspection during site visits. A summary report detailing the condition of the wellhead and noting any wellhead deficiencies was prepared and is being incorporated into the source water assessment for each public water supply. The University of Arkansas Center for Advanced Spatial Technologies has prepared an extensive data set as their component of this project. These data sets are now being incorporated into the overall assessment process.

Descriptors

Water pollution potential, geographical information systems, drinking water, source water assessment, wellhead protection

Articles in Refereed Scientific Journals

Book Chapters

Dissertations

Water Resources Research Institute Reports

Conference Proceedings

Hydrology Portion of the Project: White, P. and R.K. Davis, 1999, Subtantiating the Need to Base Delineation of Source Water Assessment and Protection Areas on Hydrogeology in Mantled Karst Aquifers, "in" Association of Groundwater Scientists and Engineers, Technical Program, National Groundwater Association Annual Meeting, December 3-6, 1999, Nashville, TN. Davis, R.K. and P. E. Anderson, 2000, Arkansas' Source Water Assessment Program Delineations for Groundwater and Implications in Mantled Karst Aquifers, "in" Abstracts with Programs, Geological Society of America, v. 32, n. 3, p A7.

Other Publications

GIS Portion of the Project: PRESENTATION: Source Water Protection Methodologies in Arkansas, Research Seminar of King Faisal University Dept. of Soil and Water, Hofuf, Saudi Arabia, February 2000.

Basic Project Information

Basic Project Information	
Category	**Data**
Title	Fiscal year 1999 Arkansas State Water Resources Research Program
Project Number	B-01
Start Date	03/01/1999
End Date	02/28/2000
Research Category	Water Quality
Focus Category #1	Non Point Pollution

Focus Category #2	Education
Focus Category #3	Water Quality
Lead Institution	University of Arkansas

Principal Investigators

Principal Investigators			
Name	**Title During Project Period**	**Affiliated Organization**	**Order**
Kenneth F. Steele	Professor	University of Arkansas	01

Problem and Research Objectives

The following water problems/issues are currently important in Arkansas: 1. non-point source contamination (nutrients and pesticides) 2. development of methods for determination of total maximum daily loads (TMDLs) 3. declining ground water levels, especially in eastern Arkansas and associated salt water contamination. 4. development of efficient septic systems 5. wetlands and flooding All of these issues/problems were addressed by 47 Center projects this year and are briefly discussed below. The Center's training and information dissemination programs were also focused on these areas. Non-point Source Contamination and TMDL Development Non-point source contamination by nutrients and pesticides, is an area of concern for the nation and Arkansas. This year three of the Center's projects, partially funded under section 104, were related to non-point source pollution. One project was related to animal production activities that produce significant amounts of manure which are applied to pastureland as fertilizer. Runoff from the pastures can result in excess nutrients being delivered to streams and lakes. The focus of this 104 project was determination of optimum sampling protocol for determination of total maximum daily loads. Five other U.S. Geological Survey projects were related to both non-point and point source pollution. This project in conjunction with the U.S. Geological Survey Little Rock District, the Arkansas Health Department and the University of Arkansas Center for Advanced Spatial Technology is assessing the pollution potential for public systems source water. This project covers the entire state that has over 1400 public supply systems. Geographical Information Systems and hydrologic information are being used to assess each system. There were a total of 35 non-104 and U.S. Geological Survey projects administered by the Center this year involving non-point source pollution. Five of these projects were focused on development of optimum sampling for determination of TMDLs that directly complimented the 104 project on this topic. Thirteen projects were concerned with water quality (nutrients and pesticides)and an additional 11 dealt with development and evaluation of best management practices (BMPs). In addition five GIS projects and one constructed wetland were also related to non-point source pollution. 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 ground 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. Wetlands and Floods Two 104 projects focused on water issues in the Mississippi River Delta region of Arkansas. One project investigated the decline of water levels using soil wetness features. The other project assessed the economic factors of using on-farm reservoirs to distribute surface to areas with depleted ground water. Wetlands are an important issue nationally and the Center has recognized the importance of these areas. The Center currently is involved in one constructed wetland study. This project is administered is investigating the remediation of wastewater at a swine rearing facility. Another project is developing a method of

determining the amount of inundation of stream floodplains and specific stream gage data. Declining Water Levels and Salt Water Contamination Declining water levels, especially in eastern Arkansas, are the result of agricultural, industrial and municipal over pumpage of aquifers. This has led to the legal designation of areas in eastern Arkansas as "critical ground water areas." Both the Alluvial and Sparta aquifers now have such designation. Models for management of these aquifers are available but could be refined. The Center became involved in saline water issues this year through two projects, one of which was a 104 project.

Methodology

AWRC has a Technical Advisory Committee composed of representatives of all of the state/federal water resources agencies, academia, industry and private groups that selects proposals for Regional Competition and that provides general advice for the Center's operation. The Center also assists agencies and other groups in forming research teams to address water resource issues. In addition, the Center helps academic researchers in presenting their ideas for research to the correct agency and agency representative. The Center acts as the liaison between funding groups and the scientists, and then coordinates and administers grants once they are funded. Accounting, reporting, and water analyses (through the AWRC Water Quality Laboratory), are major areas of support offered to principal investigators. The Center's training and information dissemination programs are intricately involved with the research projects. Many students are trained through participation in research projects and also at the Water Quality Laboratory. The information dissemination program consists of the publication of journal articles and other reports, presentation at professional meetings, and organization of conferences and short courses related to the research program.

Principal Findings and Significance

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 Housing and Urban Development Agency cooperate with the Arkansas Water Resources Center Water Quality Laboratory in a water quality program for farmers and rural residents. The Laboratory is certified for drinking water by the Louisiana Health Department and for waste water by the Arkansas Department of Environmental Quality. This facility provides services to researchers and through its cooperators to citizens and state and federal agencies. The Center's program includes significant effort in information dissemination. In addition to the 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 "Environmental Hydrology" that was held jointly with the South-central Section Meeting of the Geological Society of America. AWRC also sponsored a short course titled "Hydrogeology and Geochemistry of Salt Water Contamination by Charles Kreitler." 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 can be strengthened. The research priorities of the Center were reviewed and re-authorized at the January 7, 1999 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 In addition to the state priorities the Southeastern and Islands Region of the National Institutes of Water Resources has the following 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 surface 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, wetlands, and ground water quantity. This focus should allow the Center and the state/federal agencies to continue to cooperate 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.

Descriptors

Ecosystems, Groundwater Quality, Streams, Water Quality, Water Quality Monitoring

Articles in Refereed Scientific Journals

Lin, H.S., H.D. Scott, K.F. Steele and H.I. Inyang, 1999, Agricultural chemicals in the alluvial aquifer of a typical county of the Arkansas Delta, "in" Environmental Monitoring and Assessment, Vol. 58, p. 151-172.

Book Chapters

Dissertations

Water Resources Research Institute Reports

Conference Proceedings

Other Publications

PRESENTATIONS: Steele, K.F. and David Mott, "Water Quality and Management Challenges for the Buffalo National River," University Council on Water Resources and International Water Resource Economics Consortium, June 29-July 2, 1999, Kamuela, Hawaii. Steele, Kenneth, "Success with USGS," National Institutes of Water Resources Annual Meeting, Washington DC, March 7-9, 1999. Dixon, B., H.D. Scott, H. Lin, and K.F. Steele, 1999, "Comparison of Modified DRASTIC and Fuzzy-Logic Predictive Models in Ground Water Contamination," Joint Meeting of the Nonpoint Source Watershed Conference (Innovative Strategies for the New Millennium) and the Arkansas Water Resources Conference (Water Resources Issues in the Arkansas Delta), April 11-15, 1999, Fayetteville, Arkansas.

Basic Project Information

Basic Project Information	
Category	**Data**
Title	Survival of Esherichia Coli in the Sediments of a Northwest Arkansas Spring and Stream
Project Number	B-02
Start Date	03/01/1999
End Date	02/29/2000
Research Category	Water Quality
Focus Category #1	Non Point Pollution
Focus Category #2	Groundwater
Focus Category #3	Water Quality
Lead Institution	University of Arkansas

Principal Investigators

Principal Investigators			
Name	**Title During Project Period**	**Affiliated Organization**	**Order**
R. K. Davis	Assistant Professor	University of Arkansas	01

Problem and Research Objectives

Esherichia Coli have been observed in springs and streams of northwest Arkansas at increased concentrations with storm pulses. Samples collected from streams and springs show that concentrations of fecal coliform bacteria rise significantly during the early portion of a storm pulse

which may indicate that the bacteria are in-residence in the sediments in the streams and springs. This study places innoculated bacterial survival chambers into these hydrologic environments to assess the survival of bacteria.

Methodology

Survival chambers loaded with sediment and innoculated with E. Coli were placed in a stream and spring during the fall of 1999. Replicate survival chambers were then collected over time and analyzed for E. Coli. Sample collection and analysis was conducted from mid-November to late-January. Time series of bacterial concentrations were plotted and compared for the spring and the stream.

Principal Findings and Significance

The results indicate that E. Coli is able to survive in these environments for extended periods of time. One-log die off occurred within the first 2 days, while it took about 40 more days for two-log die off to occurr. Three-log die off took approximately 70 days in both environments. This is significant because it indicates that bacterial populations can survive in the sediments for the interim period between storm pulse events. They become mobilized with the first turbulent flow associated with the storm pulse and a new population is introduced with each succeeding storm pulse.

Descriptors

Springs, Karst, Bacteria, E. Coli

Articles in Refereed Scientific Journals

Book Chapters

Dissertations

Water Resources Research Institute Reports

Conference Proceedings

Hamilton, Sherri, R.K. Davis and P.F. Vendrell, 2000, Survival of Escherichia Coli in a Mantled Karst Terrane, "in" Abstracts with Programs, v. 32, n. 3, Geological Society of America, Boulder, Colorado, p. A13.

Other Publications

Basic Project Information

Basic Project Information	
Category	**Data**
Title	Land Use, Ground Water Decline, and Soil Wetness Features of the Southern Mississippi Valley
Project Number	B-03
	03/01/1999

Start Date	03/01/1999
End Date	02/28/2000
Research Category	Water Quality
Focus Category #1	Management and Planning
Focus Category #2	Groundwater
Focus Category #3	Waste Water
Lead Institution	University of Arkansas

Principal Investigators

Principal Investigators			
Name	**Title During Project Period**	**Affiliated Organization**	**Order**
E. Moye Rutledge	Professor	University of Arkansas	01
Sophia Morrison	Student	University of Arkansas	02
Michele Steele	Student	University of Arkansas	03
J. Van Brahana	Professor	University of Arkansas	04

Problem and Research Objectives

The Lower Mississippi River Floodplains and younger terraces have undergone extensive alteration within the last 100 years with respect to water movement and content. Perhaps most important to this study, groundwater withdrawal, primarily for agricultural use, has resulted in groundwater decline. The changes in water control, use, and management strongly suggest that the relationship between redoximorphic features (RMF) and the occurrence of free-water should be expected to be different today than in the recent past. Free-water occurs in the soil because there is something that limits its downward movement. The limitation may be (1) a low hydraulic conductivity horizon within the soil having > 35% clay or (2) the presence of the regional groundwater within the soil. The objective of this research is to test the hypothesis that drainage in the floodplain area of the Lower Mississippi River has resulted in relic wetness features, possibly changing the classification of these soils.

Methodology

Monitoring wells and piezometers were installed at 4 locations in the protected portion of the floodplain of the Mississippi River and within a few miles of Blytheville, Arkansas. Shallow wells or piezometers (a depth of 4-5 ft) were used to measure free-water in the soil, and deep piezometers (depth > 12 ft) were installed to measure the regional groundwater. Weekly (approximately) measurements of the depth to free-water were taken in each piezometer or well. Both wells and piezometers are constructed by boring a 4" diameter hole and back-filling 4-6" with pea grave (<½ in diameter). A section of 1½", SCH 40, PVC pipe is then inserted on top of the pea gravel and centered. If a well is to be constructed, pea gravel is added to encase the outside of the pipe to within about 7" from the surface. Then a mixture of approximately 85% ready-mix and 15% cement is prepared with

water and poured on top of the gravel to about 4" from the surface. After the cement dries, soil is added around the PVC pipe. A 2" PVC cap with a short section of 2" PVC pipe lining the cap is placed on top of the pipe. If a piezometer is to be constructed, after the 1½" PVC pipe is placed on top of the pea gravel, additional pea gravel is added until it encases the lower 6" of the pipe. The cement mixture is prepared as above and poured to within 3" of the surface. Soil is then added, as before, and the pipe is capped.

Principal Findings and Significance

All the soils in this study had RMF in all horizons below the plow layer. Several sites in the area contained surfical liquifaction features, "sand blows". Some had sufficient "sand blow" thickness that some of the undisturbed "sand blow" remained below the plow layer. In all cases, the sand blow materials below the plow layer contained RMF. Most, although not all, "sand blows" occurred during the New Madrid Earthquakes of 1811 and 1812. Our present interpretation of these observations is that the regional groundwater once came to the soil surface in this floodplain, evidently as recently as 1811 and 1812, or more recently. An alternative interpretation is that the redoximorphic features were caused by flooding before levees were constructed. However, both may have occurred. Our data, although not as extensive as desirable, suggests that the soils of the Lower Mississippi River Floodplain are not as wet as they once were. The human impact on the water status, especially lowering of groundwater, has evidently reduced the wetness of many soils. These data suggest that soils that do not perch water themselves are not as wet as they once were. Also, soils that perch water are not necessarily as wet as the RMF indicate. Soil morphology indicates that the groundwater once came to, or very near, the soil surface; however, groundwater in the study area is presently at 6 feet or below. Our observations suggest that redoximorphic features are not a reliable indicator of contemporary soil behavior, especially wetness, in this area. Suggested future activities are (1) continue monitoring our present sites; (2) add two more sets of sites, one of which should be in Chicot or an adjacent county; (3) intensify the efforts in hydrogeology. The identification of soils that are not as wet as they once were allows for the possibility of reclassification. These soils would then have the potential for more uses in society, as they would be better suited for wastewater renovation, housing, construction, and other uses.

Descriptors

Groundwater Hydrology, Groundwater Movement, Land Use, Perched Water Table, Septic Tanks, Soil-Water Relationships, Urban Planning, Wastewater, Water Levels.

Articles in Refereed Scientific Journals

Book Chapters

Dissertations

Water Resources Research Institute Reports

Conference Proceedings

Other Publications

PRESENTATIONS: Rutledge, E. Moye, S. Morrison, J. V. Brahana, M. Steele, and P. R. Owens,

"Ecosystem Changes in Response to Lowering of Groundwater in the Lower Mississippi Valley," United States Geologic Survey Planning Session, December 7-10, 1999, St. Louis, Missouri.
INFORMATION TRANSFER: An interim report was distributed to the Individual Sewage Disposal Advisory Committee, Little Rock, Arkansas, the Natural Resource Conservation Service, and Robert Goff, State Soil Scientist for Arkansas Department of Health. Also, this information is being presented to Arkansas Department of Health Environmental Specialists and other employees currently enrolled in Soil Classification and Genesis being taught by Moye Rutledge June - August 2000.

Basic Project Information

Basic Project Information	
Category	**Data**
Title	Economics of Using On-Farm Reservoirs to Distribute Diverted Surface Water to Depleted Ground Water Areas of the Southern Mississippi Valley Region
Project Number	B-04
Start Date	03/01/1999
End Date	02/28/2000
Research Category	Water Quality
Focus Category #1	Surface Water
Focus Category #2	Economics
Focus Category #3	Models
Lead Institution	University of Arkansas

Principal Investigators

Principal Investigators			
Name	**Title During Project Period**	**Affiliated Organization**	**Order**
E. Wailes	Professor	University of Arkansas	01
Kenneth Young	Research Associate	University of Arkansas	02
Gail L Cramer	Professor	University of Arkansas	03
Jennie S Popp	Assistant Professor	University of Arkansas	04

Problem and Research Objectives

Rapid ground water depletion has become a significant problem for parts of the Southern Mississippi River Valley. In 1997, the Arkansas Soil and Water Conservation Commission (ASWCC) declared six counties in the Grand Prairie of Arkansas critical ground water areas. A proposed solution to the ground water depletion problem in this region is to divert surplus flows from the White River by a

canal system to the farmer stakeholders. To make the system work, on-farm reservoirs will be needed to store and manage the diverted surface water for crop irrigation use during the growing season. The objective of this study was to estimate the optimal use of water sources utilizing on-farm reservoirs and tail water recovery under different ground water resource situations for a 30-year period, with and without access to supplemental diverted surface water.

Methodology

Previous and on-going research about the White River Diversion Project was reviewed to identify the gaps in understanding the economic costs and benefits of the diversion scheme at the farm level. Information was collected about the proposed project service area, diverted surface water flow and delivery cost for individual farms. A sample of 10 farms inside and outside of the proposed diversion project service area that are representative of the various resource conditions (soils, water availability, farm size, etc.) was selected for the farm level case studies. The case studies required on-farm visits to assess the resources, management and investment implications of accessing the diverted surface water. Information was collected on crop rotations, ground water supply conditions, rainfall runoff area, irrigation methods, field efficiencies and other farm conditions. These representative farms were then analyzed using the Modified Arkansas Off-stream Reservoir Analysis (MARORA) model. Refinements of the MARORA computer model were required to reflect the investment and management implications of the additional availability of the diverted water supply. Modifications to the MARORA model included purchasing and storing the diverted surface water. Modifications were based on diverted water flow, annual allocation and cost parameters set by the White River Irrigation District plan. The simulation model was applied to estimate the optimal use of on-farm reservoirs and determine the value of accessing diverted surface water as stated in the objectives. The cost of the water was set at $27.71 per acre-foot. Farmers are guaranteed a supply allocation of 1.5 acre-feet per irrigated acre, at a guaranteed flow rate of 2.5 gallons per acre per minute.

Principal Findings and Significance

Results of the project were generated for alternative representative farms. The results differed by initial ground water saturated thickness, rate of decline, crop rotation and crop prices. The result for the most representative farm in the critical ground water area of the Grand Prairie was that the farmland value was higher by $569/acre as a result of access to the diverted water. This result is difference in the total 30-year net present value of a farm with access to the diverted water compared to one without access. This result was generated for an 160-acre farm area planted 1/3 rice and 2/3 soybeans. The initial saturated depth on this farm was 25 feet with a decline in the water table of 1 foot per year. The optimal size reservoir with access to the diverted water was 200-acre feet, which required 22.5 acres of cropland. Without access to the diverted water, the optimal reservoir size was zero acre-feet. The farm could only produce rice using the depleting ground water for the first two years of the 30-year analysis. By year 10 the farm was restricted to only dry-land soybean production. The significance of the findings of this study is that the agricultural economy, land value, and value-added activities would be sharply curtailed without the development of alternative surface water for the critical ground water area in the Grand Prairie, Arkansas. Based on the results of this study, for the 350 thousand irrigated acres in the Grand Prairie, total loss of land value would be $199 million, loss of value-added economic activities would reach approximately $500 million.

Descriptors

Diverted surface water, reservoir distribution, irrigation value, management

Articles in Refereed Scientific Journals

Book Chapters

Dissertations

Water Resources Research Institute Reports

Conference Proceedings

Wailes, E.J., K. Young, and J. Smartt, 2000, Economic Analysis of On-farm Reservoirs to Sustain Irrigated Agriculture in Eastern Arkansas, "in" Proceedings of the Arkansas Water Resources Center Annual Conference, K.F. Steele (Editor), Arkansas Water Resources Center Publication No. MSC 0, University of Arkansas, Fayetteville, Arkansas, p. 34-41.

Other Publications

Smartt, J., E. Wailes, K. Young, 1999, Economics of Developing Alternative Water Resources for a Representative Rice/Soybean Farm with Saline Water Problems in the Bayou de View Watershed of Eastern Arkansas. Technical report prepared for Project 810, J. Gilmour (Editor), Department of Crop, Soil, and Environmnetal Sciences, University of Arkansas, Fayetteville, Arkansas. Smartt, J., E. Wailes, K. Young, 1999, Efffect of Quantitative and Temporal Refill Scheduling on Determining Optimal Reservoir Size. Technical report prepared for USGS Groundwater Depletion Project. Department of Agricultural Economics and Agri Business, University of Arkansas, Fayetteville, Arkansas. Wailes, E., K. Young, J. Smartt, 1999, Analyzing Conjunctive Use of On-farm Resrvoirs and Irrigation Wells in the Arkansas Delta. Poster presented at Southern Agricultural Economics Association annual meeting, Memphis, Tennessee, Abstract in Journal of Agriculture and Application Economics, Vol 31, No. 2, p. 410. PRESENTATIONS: Wailes, E.J., 1999, "Economic Analysis of On-farm Reservoirs to Sustain Irrigated Agriculture in Eastern Arkansas," Arkansas Water Resources Center Annual Conference, April 12-13, University of Arkansas, Fayetteville, Arkansas. Wailes, E.J., 1999, "Impact of On-farm Reservoirs on Rice Production in the Grand Prairie," Arkansas Rice Research and Promotion Board. Little Rock, Arkansas. INFORMATION TRANSFER: Wailes, E., Young, K., Smartt, J., 1999, "Analyzing Conjunctive Use of On-farm Reservoirs and Irrigation Wells in the Arkansas Delta." Poster presented at Southern Agricultural Economics Association annual meeting, Memphis, Tennessee. Wailes, E., Young K., Smartt, J., 1999, "Economic Impact on Arkansas Rice from Ground Water Depletion." Poster presented at AES Rice Field Day, University of Arkansas, Division of Agriculture, Stuttgart, Arkansas. Wailes E., Young, K., Smartt, J., 1999, "On-farm Reservoir Investment in the Arkansas Delta." Poster presented at Arkansas Water Resource Center Annual Conference, April 12-13, University of Arkansas, Fayetteville, Arkansas.

Information Transfer Program

Basic Project Information

Basic Project Information	
Category	**Data**
Title	Arkansas Water Resources Center Annual Conference
Description	Water Resources Issues in the Arkansas Delta
Start Date	04/12/1999
End Date	04/13/1999
Type	Conferences
Lead Institution	University of Arkansas

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Articles in Refereed Scientific Journals

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Water Resources Research Institute Reports

Conference Proceedings

Steele, Kenneth F. (Editor), 2000, Proceedings of the Arkansas Water Resources Center Annual Conference: Water Resources Issues in the Arkansas Delta, April 12-13, 1999, AWRC Publication No. MSC 0, University of Arkansas, Fayetteville, Arkansas, 67 p.

Other Publications

Basic Project Information

Basic Project Information	
Category	**Data**
Title	Vadose Zone Hydrology Short Course
Description	Short Course presented by Dr. Glenn Wilson for the Arkansas Water Resources Center Annual Conference
Start Date	04/13/1999

End Date	04/13/1999
Type	Conferences
Lead Institution	University of Arkansas

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Basic Project Information	
Category	**Data**
Title	AWRC Newsletter
Description	Annual newsletter of the Arkansas Water Resources Center
Start Date	08/01/1999
End Date	08/01/1999
Type	Newsletter
Lead Institution	University of Arkansas

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USGS Internship Program

Student Support

Student Support					
Category	**Section 104 Base Grant**	**Section 104 RCGP Award**	**NIWR-USGS Internship**	**Supplemental Awards**	**Total**
Undergraduate	1	0	0	1	2
Masters	2	2	0	5	9
Ph.D.	0	0	0	0	0
Post-Doc.	0	0	0	0	0
Total	3	2	0	6	11

Awards & Achievements

B-02 Title: Survival of Esherichia Coli in the Sediments of a Northwest Arkansas Spring and Stream Investigators: R.K. Davis, P.F. Vendrell, and M.A. Nelson, University of Arkansas Fayetteville This project has enhanced our understanding of bacterial survival and movement in mantled karst terrane. The results of this project will help us to carry out a tagged bacterial tracer test in the mantled karst aquifer. These data are extremely important in terms of proper management of land applied animal waste in these types of hydrogeologic settings. B-03 Title: Land Use, Ground Water Decline, and Soil Wetness Features of the Southern Mississippi Valley Investigators: E. Moye Rutledge, Sophia Morrison, Michele Steele, and John Van Brahana, University of Arkansas, Fayetteville These data have strong implications for improvements of life for people who live in one of the most depressed areas of the country. Society will benefit from the identification of more soils that have the potential to change from "unsuited" to "suited" for wastewater renovation. These soils will also be more beneficial to society than previously indicated for playgrounds, local roads, housing, and many other uses. Perhaps as much as 1.1 million acres, 15% of MLRA-131 in Arkansas, and 5 million acres in the entire Lower Mississippi Valley have the potential to be reclassified. Reclassification of soils presents the opportunity for improvement in the quality of life and economic standing. B-04 Title: Economics of Using On-Farm Reservoirs to Distribute Diverted Surface Water to Depleted Ground Water Areas of the Southern Mississippi Valley Region Investigators: Eric J. Wailes, Kenneth Young, Gail L. Cramer and Jennie Popp The project provided information through presentations and posters to producer stakeholders who finally in February, 2000 voted to move the Grand Prairie Area Demonstration Project forward for congressional funding. This project will be responsible for

the diversion of the White River for irrigation in the Grand Prairie. C-02 Title: Continuation of Investigation of Optimum Sample Number and Timing for Determining Pollution Loads Investigators: Thomas S. Soerens and Marc A. Nelson, University of Arkansas, Fayetteville, Arkansas, and Jean Spooner, North Carolina State University, Raleigh, North Carolina A news release on the project was published up by Yahoo Science, Lakenet newsletter, UniSci, the Arkansas Democrat-Gazette, and other publications. There have been a number of inquiries about the project from engineers, scientists, and government agencies. S-03 Title: Assessment of Public Drinking Water Supplies in Arkansas Investigators: W.F. Limp, Center for Advanced Spatial Technologies, and R.K. Davis, Department of Geosciences, University of Arkansas, Fayetteville, Arkansas GIS Portion of the Project: Environmental and landuse data important for evaluating potential contamination of source water are now available for public water intakes (about 1450) in Arkansas. Hydrology Portion of the Project: Presentations related to site specific delineation techniques in the mantled karst area of northwest Arkansas have been well received both at the state level and at the national level. The standard approach has been a "cookie cutter" method for delineation of the assessment areas and our work shows that this is not an adequate representation of these very complex hydrogeologic systems.

Publications from Prior Projects

Articles in Refereed Scientific Journals

Nichols, Terry, Kenneth Steele, Paul Vendrell, and H. Don Scott, 1998, Ground Water Monitoring in the Arkansas Delta: 1992-1998, "in" Water Resources Engineering 98, Vol. II, American Society of Civil Engineering, Reston, VA, p 1242-1247.

Book Chapters

Dissertations

Water Resources Research Institute Reports

Conference Proceedings

Other Publications

PRESENTATIONS: Nelson, Marc A., Thomas S. Soerens, Jean Spooner, Kenneth F. Steele, and Paul F. Vendrell, 1998, "Investigation Of Optimum Sample Number and Timing for Determining Pollution Loads and TMDLs," U.S. Environmental Protection Agency Meeting on Water Quality Standards, Water Quality Criteria, and Implementation, including Water Quality-Based Permitting, August 24-27, Philadelphia, Pennsylvania (presented by Soerens). Nichols, Terry, Kenneth Steele, Paul Vendrell, and H. Don Scott, 1998, "Ground Water Monitoring in the Arkansas Delta:1992-1998," International Water Resources Engineering Conference, August 3-7, Memphis (presented by Nichols).