Nebraska Water Resources Center

Annual Technical Report

FY 1998

Introduction

Research Program

Basic Project Information

Basic Project Information	
Category	**Data**
Title	Field Verification of the Dipole Flow Test:colon; A New Approach for the In-situ Determination of Trtansport Parameters
Project Number	C-44
Start Date	08/01/1996
End Date	08/01/1999
Research Category	Ground-water Flow and Transport
Focus Category #1	Methods
Focus Category #2	Groundwater
Focus Category #3	Solute Transport
Lead Institution	Nebraska Water Resources Center

Principal Investigators

Principal Investigators			
Name	**Title During Project Period**	**Affiliated Organization**	**Order**
Vitaly Zlotnik	Professor	Univ. of Nebraska City Campus	01
James Butler, Jr.	Unknown	University of Kansas	02
Thomas G. Franti	Assistant Professor	University of Nebraska, East Campus	03

Problem and Research Objectives

Many important aquifers consist of unconsolidated alluvium lying in major river valleys. The purpose of this project is to explore a promising approach, the dipole flow test (DFT), for characterization small-scale heterogeneities of aquifer hydraulic conductivity (K), which control the contaminant transport.The primary research objectives include a thorough field assessment of the dipole probe developed at the University of Nebraska-Lincoln at two thoroughly studied sites in Nebraska and Kansas, a detailed comparison of this new methodology with currently available approaches for aquifer characterization (the multi-level slug test and the borehole flowmeter test), and the development of practical guidelines for the performance and interpretation of the DFT. INFORMATION TRANSFER. Results were presented at two national meetings (American Geophysical Union, Spring 1998, Boston, Natinal Groundwater Association, 1998, Las Vegas) and several seminars (U. of Arizona, 1997; Swiss Federal Institute of Technology, Zurich, Switzerland, 1997; U. of Tuebingen, Germany, 1997; CSIRO, Australia, 1999). The techniques were included into the class "Field Techniques in Hydrogeology", Spring 1998, University of Nebraska-Lincoln. STUDENT SUPPORT. One M.S. student and one Ph.D. student were partially supported from the grant in Geosciences Department, UNL. In addition, summer support is provided for the undergratuate student at the University of Kansas (KU). The results of this research were incorporated into courses in hydrogeology that are offered at the UNL and KU

Methodology

A new UNL dipole probe has been tested at two sites in Nebraska and Kansas where hydraulic parameters have previously been determined using core analyzes, and various types of well tests (slug, pumping, and tracer tests). The procedures for the field component of the research were as follows: (a) two 4" diameter wells were installed at the MSEA site (Nebraska) using the hydraulic reverse rotary drilling method, and two wells were installed at the GEMS site (Kansas) using the hollow stem auger; (b) profiles of K versus depth were obtained from the steady-state DFT using the dipole probe using several different recirculation rates and the dipole probe configurations; (c) multi-level slug tests and the borehole flowmeter test were used to establish profiles of K from the Springer-Gelhar method and compare with results of the DFT; (d) the theory for interpretation of the steady-state was applied for interpretation of the DFT; and (e) analysis of the effects of well construction, development, and deterioration on the DFT and other hydraulic testing methods was performed.

Principal Findings and Significance

At both sites (MSEA, Nebraska, and GEMS, Kansas), the DFTs were performed, and K values were collected at each well at approximately 20 elevations. These measurements were repeated with several dipole probe configurations and/or recirculation regimes at both sites. Total number of the DFT experiments was on the order of 500. It has been demonstrated that the dipole probe and a steady-state DFT yield valuable data on variations of K in highly conductive unconsolidated sediments, where K is as high as 300 m/day. The profiles of K obtained from the multi-level slug tests and the electromagnetic borehole flowmeter tests exhibit a very strong correlation with the profiles from the DFT. The DFT has potential for more detailed interpretation of K. Interpretation of the steady-state DFT indicates that this technique provides reliable, fast, and simple estimates of the vertical variations of hydraulic conductivity. Other methods of the DFT use based on the transient response or chamber-by-chamber interpretation can enhance the potential use of the DFT. Experiments with well development at the both sites and repetitive measurements for monitoring of well deterioration due to extensive well flushing testing indicate that the well development and well drilling technique play the paramount role in quality

of data collected by the DFT, and special care must be taken in designing wells for the DFT. The significance of this work is three-fold. Firstly, the experimental framework of this study is quite unique: three various hydraulic testing techniques were tested and successfully compared in field conditions. Secondly, the DFT proved to be practical, accurate, and reliable technique, and a set of guidelines for its wide use was proposed. And lastly, a significant potential exists for further development and applications of this technique, including data collection and interpretation.

Descriptors

Aquifer Parameters, Groundwater Movement, Hydrogeology

Articles in Refereed Scientific Journals

Zlotnik, V.A., and Zurbuchen, B.R., 1998, Dipole probe: design and field applications of a single-borehole device for measurements of vertical variations of hydraulic conductivity, Ground Water, 36(6), 894-893.

Book Chapters

Dissertations

B. Zurbuchen, 1996, The dipole probe development and dipole flow test applications in sand and gravel aquifer (MSEA site, Shelton, Nebraska), M.S. Thesis, University of Nebraska-Lincoln, Lincoln, Nebraska, v. 1 (100 p.), v.2 (280 p.) B. Zurbuchen, in progress, Evaluation of hydraulic techniques to characterize hydraulic conductivity and its vertical variability in sand and gravel aquifers: double-packer slug test,, dipole flow test, and borehole flowmeter test. Ph. D. Dissertation.

Water Resources Research Institute Reports

Conference Proceedings

Other Publications

Zurbuchen, B.R., Zlotnik, V.A., Butler, J.J., Jr., Healy, J., and Ptak, T., 1998, Steady-state dipole flow tests in sand and gravel aquifers: summary of field results. GSA Abstracts with Programs, Toronto, Ontario, October 26-29, p. A226. Butler, J. J., Jr., Zlotnik, V.A., Zurbuchen, B.R., and Healy, J. M., 1998, Single-borehole hydraulic tests for characterization of vertical variations in hydraulic conductivity: A field and theoretical assessment, Proc. of Technical Program for the NGWA 50th National Convention and Exposition, Dec. 13-16, 1998, Las-Vegas, 94-95. V. Zlotnik, B. Zurbuchen, J.J. Butler, Jr., and J. Healy, 1998, Field comparison of single-borehole hydraulic testing methods for estimating vertical K-profiles in highly permeable aquifers: Preliminary results, EOS Transactions, American Geophysical Union, AGU Spring Meeting, Boston, Abstracts, 79(17), S153. Butler, J.J., Jr., Healy, J.H., Zlotnik, V.A., and B.R. Zurbuchen, 1998, The dipole flow test for site characterization: Some practical considerations, EOS Transactions, American Geophysical Union, AGU Spring Meeting, Boston, Abstracts, 79(17), S153.

Basic Project Information

Basic Project Information	
Category	**Data**
Title	Advanced Assessment for Spot Spraying Plants to Reduce Chemical Input and Improve Water Quality
Project Number	C-77
Start Date	09/01/1996
End Date	09/30/1999
Research Category	Water Quality
Focus Category #1	Water Quality
Focus Category #2	Non Point Pollution
Focus Category #3	Management and Planning
Lead Institution	Nebraska Water Resources Center

Principal Investigators

Principal Investigators			
Name	**Title During Project Period**	**Affiliated Organization**	**Order**
David A. Mortensen	Associate Professor	University of Nebraska, East Campus	01
George E. Meyer	Professor	University of Nebraska, East Campus	01
Thomas G. Franti	Assistant Professor	University of Nebraska, East Campus	01

Problem and Research Objectives

The premise of these studies is that reduction in the use of chemicals can be achieved by selectively and intermittently applying chemicals to the plants themselves and not the soil, thus reducing chemicals in runoff water and infiltration into the groundwater. Initial estimates are that 15-65% of current applications could be eliminated while maintaining crop yields. This premise will be tested by the following objectives: (1) Develop and test an advanced machine vision-based assessment and plant mapping system to evaluate optical sensor controlled spot sprayers under field conditions. (2) Analyze both plant spatial distributions and spot sprayer performance to evaluate the efficacy, efficiency, and economics of intermittent chemical applications. (3) Use the performance data from Objectives 1-2 to simulate and study the impact of spot spraying on surface water quality. Personnel Support Two graduate students currently support the project: Mr. Tim Hindman is an USDA National Needs Ph.D. Fellow, and Miss. Yan Li, is a Masters student supported by the project. Mr. Hindman is working on the weed identification technology. Miss. Li joined the project in January 1999 and is working on the surface water quality problem. Dr. Franti is conducting work on the environmental impact of spot spraying technology. Paul Woodward is a Sophomore Biological Systems Engineering also working on the project. Project Impact Widespread use of chemicals exemplifies both the success of the American

agricultural system, but also presents potential tragedy to the environment. 8.2 metric tons (18,000 lbs.) per day of herbicide flow have been reported down the Mississippi River during peak spring runoff. 68,182 metric tons (150 million pounds) of five herbicides - atrazine, cyanazine, simazine, alachor, and metolachor are applied every spring across the corn belt. In Nebraska, approximately 15,000 metric tons (33 million pounds) of pesticides are applied annually (Baker, Peterson and Kamble, 1990), with a large percentage applied in the spring. Most herbicides are broadcast preemergence to the crop. While herbicides have been effective for weed control, water quality problems have also resulted. Spot sprayer operations in agricultural systems and road side or highway control of weeds can potentially reduce chemical usage, adverse environmental and health consequences, and improve surface water quality. The objective of this technology is to apply chemicals only in correct doses to individual or specific groups of plants and not to the soil or environment. However, simple optical plant sensor accuracy is currently only 60-70 percent. Better detection systems are needed to accurately detect and classify plants and chemical impact (hit, miss, and kill rate) during spot spraying. The use of machine vision-spot spraying will reduce the amount of herbicides used under most conditions, and the water quality impacts are expected to be great. Post-applied products will be used for spot spraying, and preliminary research results indicate the use of post-emerge only applications of atrazine can reduce long-term atrazine runoff to surface waters greater than 50% compared to pre-emergent applications. One reason is that for a post application atrazine is applied at a lower rate and is applied after many runoff events have already occurred. Long-term herbicide runoff modeling for spot-spraying will be conducted over the next 18 months by Miss Li who started in January, 1999.

Methodology

Objective 1. Machine Vision Assessment using electronic images of crop and weeds in the field will provide location of plants, plant type, and chemical coverage of leaves. By using and testing various segmentation methods, plant regions will be separated from backgrounds in these images. Once located, further image analysis will result in plant size, shape and type (monocot or dicot), numbers of clusters, wetting of leaves by the chemical and plant distribution. Genetic and inductive textural algorithms will assist in plant species identification. Objectives 2. UNL has been a pioneer by building a field scale prototype optical sensor controlled spot sprayer as a research tool. Weed threshold information for economic and environmental considerations will assist in describing the performance characteristics of spot spraying. These data will be used to calculate (a) how much chemical application is reduced through spot spraying, (b) how effective was the chemical application control using spot spraying. Follow-up video assessment will show which plants died. Plant type and distribution data will be further analyzed using geographic information system and geostatistics software. Using these software, the spatial variability of plants (crop and weeds) will be analyzed. We will also determine spatial criteria for improved sampling procedures. These data will essentially tell us if selected plants were sprayed or missed and why. Objective 3. The plant distribution and chemical use reduction data collected will be used in two water quality models, the Agricultural Nonpoint Source (AGNPS) surface water quality model and the Groundwater Loading Effects of Agricultural Management Systems (GLEAMS) pesticide runoff model. These will be used to model field-scale runoff (GLEAMS) and watershed-scale runoff (AGNPS) to determine the long-term impacts of improving chemical management on reducing pesticide runoff losses. Simulations of runoff events will be performed using synthetic rainfall data and with atrazine and alachlor as the subject pesticides. Typical corn production at a central Nebraska location will be modeled on a field scale with GLEAMS and a typical 800-acre watershed in central Nebraska will be used for the AGNPS modeling. Pesticide management alternatives evaluated will include spray application using conventional spray (broadcast and banded), with and without incorporation versus intermittent sprayer technology, and timing of application, e.g. preemergent herbicide application (standard) versus postemergent with spot spraying.

Principal Findings and Significance

Summary of Results (March 1, 1997 – February 26, 1999) This period of the project focused on developing and refining machine vision software techniques for identifying, counting, and identifying weed types. Weed identification for potential spot spraying is based on weed seedlings of three weeks of age or less using post-emergence application of chemicals. During this period, it is assumed that the highest probability of identifying the species of weed based on basic botanical keying and imaging methods. The principal software packages used were Image-Pro for NT and Visual Basic. Image-Pro contains an auto macro language that is implemented with Visual Basic. The combined use of these two software packages provides the analysis tools needed for weed identification, based on canopy structure and individual leaf venation and shapes. The principle problem is to find the plant and distinguish it from the background. This is called image segmentation. Color images are used to find weed plants. A Kodak DC 120 digital camera is the primary tool for obtaining electronic images of various plant species. Plants are grown in the plant growth chamber, the greenhouse, and in the field. The camera is adjusted to include the entire plant within the camera's field of view. Canopy lighting affects the degree of light and dark transitions, edginess, and feature detail. Different lighting conditions are being tested, forward lighting with soil background and back lighting without soil background. The DC 120 camera is very versatile for various lighting conditions and automatically adjusts for light quality within limits. We are also testing it with manual settings with plants under different lighting sources, described by light intensity and color temperature. For example, full sun on clear day manifests around 10,000 K color temperature, cloudy days 8000 K, all the way to incandescent lights at 2800 K. This is the major source of segmentation error. Using the software provided with the digitized camera, digitized images are transferred to a 400 MHz, Pentium computer with 128 megabytes memory running Windows NT for image analysis. Digital resolution is 25 dots/inch, with a width of 1280 pixels and height of 960. All electronic images are compressed and saved in a 24-bit color format (JPEG) on CD-ROM. Digitally scanned pictures were then resized during pre-processing to a width of 384 pixels and a height of 288 pixels for television-like analysis. As mentioned, a very critical processing step is the segmentation of plant regions from background regions. If this is not done correctly, a random number generating system may result. There are several approaches to segmenting the plant from the soil background to obtain a binary template image. The simplest method is to use a threshold value such that all pixels with greater value were selected as leaf (white) and all pixels with less value were taken as soil background (black). This is usually done after analyzing a histogram. However, this method always brings in background errors that make identification of the plant difficult. The pixel intensity at some places in the soil background may be at the same level as or higher than that of leaf, thus causing errors in the computation of co-occurrence matrices since the program will use those tonal areas as well. These errors can show up on a grayscale as well as any color rasters of an red-green-blue (RGB) or hue-saturation intensity (HSI) image. A solution to segment leaf from soil background is to use a variance-based object detection method. With this approach, the outlines of all candidate areas are identified. Generally, edge detection techniques will create a number of boundaries of objects found within an image. These boundaries are next investigated to determine which ones have the highest probability of being the plant and then are further confirmed by feature analyses. The selected plant outlines are then painted or filled using application programming interface (API) functions from Visual Basic. The comparation of these two methods are shown in Figure 2. Once the binary template is developed, excellent algorithms for feature analysis, counting or enumeration is available. Feature parameters such maximum ferret, minimum ferret, perimeter, area of the leaf, maximum length, maximum width, aspect ratio and roundness are used to calculate other complex shape factors were obtained from the template image. Dimensionless shape features independent of size and orientation, identified by Yonekawa et al, (1996) are currently being investigated. Texture features of angular second moment, local homogeneity,

inertia and entropy are computed, based on the co-occurrence matrices of the original gray scale images at all four directional orientations: . Feature data is currently put into a large Access database for further analysis. The binary template has been shown to reduce the errors brought about by background segmentation noise, (Mehta, et. al, 1998). Statistical analyses and hypothesis testing are performed using SAS Canonical Discriminate Analysis. Preliminary results support the methodology for identification of individual plant species as shown in figure 3. This summer's activity is development of a ground-based field assessment prototype that can identify and count weeds over large crop production areas for assessment of intermittent spraying and its subsequent impact on water quality. To date, much of this work has been done by transects and manual counting directly in the field. Aerial and satellite imaging tends to be very expensive. Several ground-imaging methods have been tested, including 35-mm color slides, digital still imaging, and video. Analog video is easily automated, has sufficient resolution (Hi-band 8 or Super VHS), but tends to provide a lot or redundant information at 30 frames per second. Redundant frames can be reduced by digitizing the video at lower frame rates according to the ground speed of the surveying process. Individual sets of sequential still frames of TIF or BMP formats representing the field area covered are extracted from uncompressed AVI digital video formats, using Adobe Premier and Digital Video Recording. Extracted still frame images are then analyzed with Image-Pro. Plans are to conduct field studies of weed populations this summer using this methodology.

Descriptors

Pesticides, Spot Spraying, Machine Vision, Spatial Variability, Water Quality Assessment

Articles in Refereed Scientific Journals

Meyer G.E., T.G. Franti, and D.A. Mortensen. 1997. Seek and Destroy - Machine vision identifies weeds for spot spraying. Resource Magazine, Engineering and Technology for a Sustainable World. ASAE 4(12):13-14. Meyer G.E., T. Mehta, M. F. Kocher,, D. A. Mortensen, and A. Samal.1998. Textural Imaging and Discriminate Analysis for Distinguishing Weeds for Spot Spraying. TRANSACTIONS of ASAE, 41(4): 1189-1197.

Book Chapters

Dissertations

Water Resources Research Institute Reports

Conference Proceedings

Meyer G.E and, J.A. DeShazer. 1997. (Chairs/Editors). Optics in Agriculture, Forestry, and Biological Processing II. SPIE--The International Society for Optical Engineering, Bellingham, WA.. (ISBN: 0-8194-2309-2) 2907: 284 pp. Meyer G.E, T.W. Hindman, and M.Schultz. 1997. Simulation Tools for Evaluating Optical Plant Sensors for Variable-Rate Application Technologies. In Meyer G.E and, J.A. DeShazer. Optics in Agriculture, Forestry, and Biological Processing II. SPIE--The International Society for Optical Engineering, Bellingham, WA.. 2907:139-150. Meyer, G.E. and J.A. DeShazer (Chairs/Editors) 1998. Precision Agriculture and Biological Quality. Proceedings of SPIE -- The International Society for Optical Engineering, Bellingham, WA. (ISBN: 0-8194-3155-9) 3543: 390 pages Meyer, G.E, .T.W. Hindman, and K. Laksmi 1998. Machine vision parameters for plant species identification. In Meyer, G.E. and J.A. DeShazer, Precision Agriculture and Biological Quality. Proceedings of SPIE -- The International Society for Optical Engineering, Bellingham, WA. 3543: 327-

335.

Other Publications

Basic Project Information

Basic Project Information	
Category	**Data**
Title	Reducing Atrazine Contamination of Interstate Surface Water
Project Number	C-55
Start Date	09/01/1996
End Date	11/01/1998
Research Category	Biological Sciences
Focus Category #1	Water Quality
Focus Category #2	Economics
Focus Category #3	Agriculture
Lead Institution	Nebraska Water Resources Center

Principal Investigators

Principal Investigators			
Name	**Title During Project Period**	**Affiliated Organization**	**Order**
Thomas G. Franti	Assistant Professor	University of Nebraska, East Campus	01
Philip Barnes	Assistant Professor	Kansas State University	02

Problem and Research Objectives

Collaborators: University of Nebraska Kansas State University Brian Benham, Biological Dan Devlin, Agronomy Systems Engineering Dean Eisenhauer, Biological Systems Engineering Bill Miller, Agricultural Economics Roger Selley, Agricultural Economics Statement of Critical Regional and State Water Problem Throughout the U.S., herbicides are appearing in surface water at concentrations greater than established standards, or maximum contaminant levels (US EPA, 1992; Snow and Spalding, 1993; Goolsby and Battaglin, 1993). Concentrations of herbicides in surface water in the Midwest are highest after heavy spring and summer runoff events that carry large quantities of runoff into rivers and lakes (Stamer, 1993). The U.S. Geological Survey's National Water Quality Assessment (NAQWA) program has documented that atrazine concentrations in surface water in northeast Kansas and southeast Nebraska often exceed the maximum contaminant level (mcl) of 3.0 ug/L (micrograms per liter) established by the U.S. Environmental Protection Agency under the Safe Drinking Water Act of 1986 (Fallon and McChesney, 1993). The Blue River Basins comprise a 7,200 square mile agricultural watershed in Kansas and Nebraska, and includes the Big Blue River and Little Blue River in Nebraska and Tuttle Creek Reservoir in Kansas. Currently, elevated atrazine concentrations in surface water in the Blue River Basins are of concern to some Kansas municipalities, and are a common problem throughout the Midwest wherever surface water is used for drinking water. Atrazine was the herbicide

most frequently detected in samples of surface water collected and analyzed by the U.S. Geological Survey from March 1989 to February 1990 in the lower Kansas River Basin, which includes the Blue River Basins. Atrazine concentrations in Tuttle Creek Reservoir have on occasion exceeded the maximum contaminant level for drinking water (3 ppb). Water from Tuttle Creek Reservoir is used for drinking water by Topeka and Kansas City, Kansas (combined population greater than 275,000). Atrazine is a special problem for public drinking water supplies because it is not removed by conventional water treatment. Objectives of Research This project is part of a larger three Phase project that is being implemented in the Blue River Basins by the University of Nebraska-Lincoln (UNL) and Kansas State University (KSU). The project phases are: I) determine atrazine concentrations in surface water runoff from targeted Blue River Basin watersheds in Nebraska and Kansas; II) evaluate the economic and water quality impact of proposed management practices for atrazine; and, III) transfer knowledge gained into atrazine practice changes in targeted subwatersheds. Objectives The objectives of this project are: 1. Obtain atrazine runoff data from replicated field plots to evaluate several atrazine management practices for dryland and irrigated agriculture. 2. Use modeling to evaluate the economic and surface water quality impact of atrazine management alternatives. One Masters degree candidate graduated with thesis completed. Two years of field data collected (year 2 not evaluated yet) Project is continued and expanded through a USDA Fund For Rural America grant Project sites used for annual field demonstrations and for 1998 Blued River Basins Water Quality Tour. Results of research shared at Extension meetings and presentations. Continuation of Project Tasks yet to be completed include: Evaluation of second year of runoff data Economic evaluation of herbicide management practices

Methodology

This project will build on current field research in both Kansas and Nebraska. Kansas has conducted research for several years on the runoff of atrazine and alachlor at the Foster Research/Demonstration site near Rossville, Kansas. Herbicides have been applied to three fields under established ridge-till and no-till conditions. In Nebraska, atrazine runoff from three fields, each under different tillage/herbicide management practices has been monitored for the past two years. Evaluating the impact of management practices on atrazine losses has been the primary focus of these field studies. Through modeling, this proposed project will provide additional insight into the economic dimension and the long-term water quality impact of atrazine management practices, and provide the information needed to recommend effective best management practices that are technically sound and economically viable for dryland and irrigated producers. Project Locations: The 10-acre KSU Foster Research/Demonstration site is located in northeast Kansas, near Rossville and consists of three fields in row crop. The soil is a Wabash silty-clay loam with a slope ranging from 5% to less than 1%, which is representative of northeast Kansas. In 1990, the site was designed and developed; terraces and berms were built; and sampling equipment was installed. Sampling equipment includes a gage house, automated samplers, data loggers, and a weather station. The south part of the field is terraced with underground outlets. Each terrace is drained by a separate pipe, allowing measurement and sampling of the individual terraces if desired. The north field is separated from the terraced side by a grassed berm, preventing runoff from mixing. A berm across the top of the slope prevents any runoff from entering from outside the fields. A second grassed berm on the north side of the grass filter strips field guides runoff to the sampling point. After the 1991 harvest the site was modified to implement planting the fields on the contour. In the fall of 1991, a third field was established just north and adjacent to the nonterraced field. This third field was designed to have similar slope and size as the existing fields and was set up to examine the effect of ridge-till cultivation on herbicide transport. The KSU site will be used to evaluate the runoff of atrazine from non-irrigated no-till and ridge-till treatments, planted to continuous corn. The UNL study site is located at the South Central Research and Extension Center (SCREC) research farm near Clay Center, Nebraska. This field is 392 m long and 392 m wide, and is furrow irrigated with a gated pipe source. Soils at the study site

are Hastings silt loam (Udic Argiustoll). The soils are moderately well drained on uplands, fine, montmorillonitic, and mesic. This site will be used to evaluate atrazine runoff from three replicates of the following tillage treatments, which have been in place since 1976: disk and surface plant (conventional), ridge till, and slot plant (no-till with cultivation). The treatments are arranged in a randomized complete block design. Continuous corn is grown on the plots and the field slope is 0.5%. The plot width is 10 m and length is 392 m. Facilities and Equipment: The KSU field site is completely instrumented and has been in full operation for two years. Farming and sampling equipment and hydrologic instrumentation used to implement and evaluate agricultural practices are available onsite or at the Kansas River Valley Experiment Field; no new equipment expenditures are anticipated during the duration of the study. At the UNL field site, each plot will be instrumented with a 2-inch Parshall flume. Two replications will be equipped with water stage recorders while the other replication will be equipped with pressure transducers for head measurement. Each flume will be equipped with two single stage samplers (Brakensiek et al., 1979) to sample the first flows at each selected stage. The UNL field location is equipped with a weather station to collect on-site weather data for use in data evaluation and model calibration. In Kansas, atrazine is broadcast sprayed on the no-till treatments prior to planting, and is banded at planting on the ridge-till treatments. In Nebraska, atrazine is broadcast sprayed immediately after planting on each treatment, and planting, chemical application, and irrigation will occur on the same dates for each treatment. Data on soils, including organic matter content and residue cover, field operations, atrazine application rate, land slope and drainage area will be gathered for each plot. Also, runoff rate and amount, and atrazine concentration will be determined from each plot for the first four rainfall runoff events after atrazine application, up to the first irrigation event of each year in Nebraska (usually about July 1). Two water samples collected from each plot will be evaluated for atrazine concentration using gas chromatography and the results will be used to determine atrazine runoff from each treatment. Water Quality Modeling: The objective of the water quality modeling will be to determine the long-term impacts of tillage and atrazine management practices on atrazine losses using computer simulation modeling. The GLEAMS model (Leonard et al., 1987), or other appropriate models will be used for the simulation study. The model will be calibrated for the Kansas dryland scenario and the Nebraska irrigated scenario using the field data discussed above. The parameters that may be adjusted during calibration include the runoff curve number, the C-value in the USLE, and the soil parameters. Following the modeling calibration, the model will be used to determine the long-term effects of tillage and atrazine management on atrazine loading from agricultural fields to first order streams. Long-term weather data will be generated for the two sites of interest. Frequency distributions of annual peak concentrations and annual atrazine loading will be determined from simulation. The scenarios for simulation will include the following: Dryland: Silty clay loam soil, moderate land slope. Tillage will include no-till and ridge till. Irrigated: Silt loam soil, low land slope, furrow irrigation. Tillage will include slot plant, ridge till and disk till. The herbicide treatments to be evaluated for each scenario include broadcast spray at label rates, broadcast spray at reduced rates, banding, incorporation with tillage and split application (early pre-plant/ post-plant). Economic Modeling The objective of the economic modeling study will be to determine the impact of alternative tillage/atrazine management practices on net revenue. To model the economic impact of the alternative atrazine management practices it is necessary to include the impact on the timeliness of the operations performed by the producer. A whole farm model will be used because many complex economic interrelationships are altered by a change in atrazine management practices. The economic model inputs will be the same as for the water quality model so the many similar external driving factors (e.g. soil type, weather, machinery options) are taken into consideration in evaluating the economic performance of the farm operation. The economic model will include the working field days available each week based upon historical weather patterns. Weather influences the date of tillage, planting, cultivation and herbicide application. The economic model will include the machinery complement and labor available for several operations typical of those found in the watershed. Crop yields will be influenced by the alternative dates of tillage, planting, cultivation, and herbicide application. Model results for alternative cases will

permit comparisons of net revenue among the different atrazine management practices.

Principal Findings and Significance

Field experiments were performed by measuring edge-of-field atrazine and water loss from disk-till, ridge-till, and slot plant (no-till) management systems. Runoff measurements in south central Nebraska were conducted with 0.12 ha plots on a silt loam soil with 0.5% slope. Results indicated less water runoff from no-till (34% less) and ridge-till (36%) than disk-till. Similarly, atrazine loss was also less; 24% less for no-till and 17% less for ridge-till than disk-till. GLEAMS simulations were calibrated using field-measured inputs and verified against observed data form two independent sites in south central Nebraska. Simulations were performed using 50 yr of rainfall data and 15 different combinations of herbicide application and tillage practices. Compared to pre-emergent broadcast + post application on corn with disk-till, annual reductions in atrazine loss for the alternative practices ranged from 17 to 77% in south central Nebraska and from 4 to 66 % in northeast Kansas. The percent of total atrazine lost ranged from 0.57 to 1.2 % in south central Nebraska and 3.7 to 7.1% in northeast Kansas. By evaluating the annual losses occurring during the 50 yr simulation, we found that for broadcast and banded applications, annual losses from 7 to 10 years constituted >50% of the total 50-year loss. Based on recurrence interval evaluation, pre-emergent incorporation and pre-emergent banding were most effective at reducing long-term atrazine losses at both locations.

Descriptors

Atrazine, economics, modeling, runoff, water quality

Articles in Refereed Scientific Journals

Book Chapters

Dissertations

Water Resources Research Institute Reports

Conference Proceedings

Other Publications

Two papers presented based on research: Gorneau, W.S., T.G. Franti, and B.L. Benham. 1998. Evaluation of Tillage and Herbicide Application Practices Using a Calibrated GLEAMS Model. Presented at Mid-Central ASAE Meeting, St. Joseph, MO, April 24-25, 1998. Paper No. MC98-184. Gorneau, W.S., T.G. Franti, and B.L. Benham. 1998. Evaluation of Best Management Practices for Reducing Herbicide Loading to Interstate Waters NE-KS. Presented at ASAE International Meeting, Orlando, FL, July 11-16, Paper No. 98-2223.

Basic Project Information

Basic Project Information	
Category	**Data**
Title	Herbicide Effects on Water Quality in the Great Plains:colon; Mechanisms of Selective Toxicity in Freshwater Algae
Project Number	C-33
Start Date	09/01/1997
End Date	08/01/1999
Research Category	Water Quality
Focus Category #1	Water Quality
Focus Category #2	Toxic Substances
Focus Category #3	None
Lead Institution	Nebraska Water Resources Center

Principal Investigators

Principal Investigators			
Name	**Title During Project Period**	**Affiliated Organization**	**Order**
Kyle D. Hoagland	Professor	University of Nebraska, East Campus	01
Blair D. Siegfried	Associate Professor	University of Nebraska, East Campus	02

Problem and Research Objectives

It has recently been shown that different divisions of freshwater algae and even clones of the same algal species may exhibit differential responses to atrazine exposure. In the agricultural Midwest where even higher order streams such as the Platte River have detectable levels of atrazine virtually year-round, it is clearly important to understand how these toxicants currently affect community structure and biomass production. Because many aquatic systems in North America receive inputs of atrazine and other soluble herbicides, this study addresses a potential problem of significant proportion. The overall goal of this research is to determine the ecotoxicological effects of atrazine on attached algal communities in freshwater ecosystems in the Midwest. The specific objectives are to: (1) determine the relative tolerance to atrazine exposure in representative species of five major algal Divisions from several streams and rivers throughout the Region, and (2) ascertain the mechanisms of differential toxicity in these representative species by comparing the relative rates of atrazine uptake, atrazine metabolism, and photosynthetic inhibition. Thus, the principal aim of the study is to provide a much more environmentally realistic assessment of the effects of atrazine, and by implication other commonly occurring herbicides, on surface water quality in the agricultural Midwest. Student Support One Master's student (Christine King)

Methodology

The proposed project consists of four major tasks, namely the isolation and culturing of representative algal taxa from five algal Divisions, acute bioassays to determine relative toxicities, measurement of atrazine uptake and metabolism (using 14C-labeled atrazine), and determination of photosynthetic inhibition at the population level.

Principal Findings and Significance

During the first 18 months of this project the following tasks have been accomplished: (1) a very promising graduate research assistant (M.S. level) was recruited to conduct the research (she was awarded a Grant-in-Aid of Research from the Phycological Society of America), (2) clonal cultures of six algal divisions are now in defined medium (diatoms, green algae, blue-green algae, xanthophytes, cryptophytes, and euglenoids), and (3) standard growth curves for each taxon have been determined under control conditions, prior to atrazine exposure, and (4) acute bioassays have been completed for a majority of the algae. Preliminary results exhibit a broad range of sensitivities to atrazine among the algae, indicating that atrazine in streams and lakes will likely reduce algal diversity and shift species composition. Algae form the base of aquatic food webs, thus inputs of to this herbicide to surface waters may impact higher trophic levels as well.

Descriptors

Pesticides, atrazine, water quality, algae, streams

Articles in Refereed Scientific Journals

Book Chapters

Dissertations

Water Resources Research Institute Reports

Conference Proceedings

Other Publications

Tang, J.-X., B.D. Siegfried and K.D. Hoagland. 1998. Glutathione-s-transferase and in vivo metabolism of atrazine in freshwater algae. Pesticide Biochemistry and Physiology 59:155-161. Tang, J.-X., K.D. Hoagland and B.D. Siegfried. 1998. Uptake and biocentration of atrazine by selected freshwater algae. Environmental Toxicology and Chemistry 17:1085-1090.

Basic Project Information

Basic Project Information	
Category	**Data**
Title	Site-Specific Management Strategies for Improving Nitrogen use Efficiency Under Furrow Irrigation
Project Number	C-22
Start Date	09/01/1997
End Date	08/31/2000
Research Category	Water Quality
Focus Category #1	Nitrate Contamination
Focus Category #2	Irrigation
Focus Category #3	Methods
Lead Institution	Nebraska Water Resources Center

Principal Investigators

Principal Investigators			
Name	**Title During Project Period**	**Affiliated Organization**	**Order**
Gary W. Hergert	Unknown	Nebraska Water Resources Center	01

Problem and Research Objectives

Richard B. Ferguson, Associate Professor, UNL-SCREC and Brian L. Benham, Assistant Professor, UNL-SCREC, Clay Center, NE 68933 Charles A. Shapiro, Associate Professor, UNL-NEREC and William L. Kranz, Assistant Professor, UNL-NEREC, Concord, NE 68728 C. Dean Yonts, Associate Professor, UNL-PREC and Jurg Blumenthal, Assistant Professor of Agronomy, UNL-PREC, Scottsbluff, NE 69361 Current best management practices (BMPs) for nitrogen and irrigation used by most producers and Natural Resource Districts in Nebraska have been developed primarily from University of Nebraska research. Additional research is required to provide next generation BMPs which will continue to reduce nitrate-N loss. Although there has been a transition to sprinkler irrigation during the past 25 years in the central Great Plains, large areas of cropland are still furrow irrigated (50% in Nebraska). Changing to sprinkler irrigation is expensive and offers no immediate economic returns other than labor savings for irrigated land in river valleys. Furrow irrigation will continue to be a major factor influencing N management and leaching although the impact of alternate row irrigation and N application has not been thoroughly investigated. Increasing levels of nitrate in groundwater have been observed in some river valleys in Nebraska since the mid-1950's. In the most recent statewide evaluation of groundwater nitrate and pesticide levels, over half of the wells in the state testing higher that 10 ppm NO3-N were in irrigated river valleys. A significant number of wells exceed 10 ppm NO3-N in southern Phelps and southwestern Kearney counties, an irrigated corn producing area of fine-textured soils with depths to ground water between 15 and 30 m. Other research has shown that nitrate

has moved down at least 18 m in 15 years under furrow-irrigated research plots on a silt loam soil. This situation may also be representative of most furrow irrigated areas from the arid west to the corn belt. A more recent concern about agriculture's impact is the hypoxia question in the Gulf of Mexico. Many sources of N contribute to increased stream flow nitrate, but crop land N management can have an influence. Improvements in N use efficiency in all parts of the Mississippi watershed will be required if agriculture is part of the hypoxia cause. The objectives of the project are to: 1. Compare spatial nitrogen use efficiency and N balances for alternate row irrigation and alternate row N application versus every row N application and irrigation for variable rate and fixed rate side-dressed anhydrous ammonia. 2. Compare spatial nitrate-N movement of the four methods using a conservative (KBr) tracer. 3. Correlate spatial N leaching to crop and soil parameters including grain yield, N applied, field position and conservative tracer leaching. 4. Compare systematic soil sampling strategies for the 4 management schemes that will provide the best estimate of residual nitrate N that will be used in N recommendation algorithms for the next corn crop. INFORMATION TRANSFER PROGRAM: Information on improving nitrogen and irrigation management has been presented at the Tri-state irrigation conference during 1999 and at different field days held at the UN-SCREC and UNL-WCREC during the past year. The primary audience was producers. STUDENT SUPPORT: Four undergraduate students have been hired to provide assistance for the project during summers of 1998 and 1999.

Methodology

This project was conducted at 3 locations across Nebraska in 1998 representing the major corn production areas--Western NE near Scottsbluff, West Central NE near North Platte, and South Central NE near Clay Center. Treatments within the 4 management schemes were combine-width (6 to 8 rows) by full field length (usually 300-400 m). This required large experiment areas (15-20 acres or 6-8 ha) to sufficiently measure treatment effects and to compare soil sampling schemes. The four management schemes being compared were: 1. Every furrow application of anhydrous ammonia (fixed rate based on average soil nitrate, average organic matter and average expected yield) and every furrow surge irrigation. 2. Every furrow application of anhydrous ammonia (variable rate based on spatial soil nitrate, spatial organic matter and average expected yield) and every furrow surge irrigation. 3. Every other furrow application of anhydrous ammonia (fixed rate based on average soil nitrate, average organic matter and average expected yield) and every other furrow surge irrigation in the non-N application furrows. 4. Every other furrow application of anhydrous ammonia (variable rate based on spatial soil nitrate, spatial organic matter and average expected yield) and every other furrow surge irrigation in the non-N application furrows. Anhydrous ammonia was applied at the 4 to 8 leaf stage corresponding to current BMP suggestions. Treatments were replicated 4 to 5 times and were arranged as indicated in Figs 1 and 2. A treatment map is not included for the Scottsbluff location, but the experimental design there is similar to the other two locations. Anhydrous ammonia application was made with a variable rate applicator (VRA) owned by the investigators. Grain yields were determined with a conventional 6 or 8 row combine equipped with a GPS and a yield monitoring system or a 3-row plot combine. Preplant soil nitrate samples were taken and logged with a GPS. During harvest, samples of grain were taken at the previously logged soil sampling locations and analyzed for N content. Post-harvest soil samples for nitrate were taken from the previous soil and grain sampling sites. The information on preseason nitrate, grain N removal, post season nitrate and N applied will be used to calculate a spatial N balance and apparent nitrogen use efficiency calculation for the management schemes. Mini-plots of KBr (30 cm x 120 cm) were spaced along the length of furrows from the upper to lower end of the field (5 to 6/furrow depending on furrow length) in irrigated and non-irrigated furrows. KBr was applied within several days after N application (200 kg/ha Br watered in with 1 ha-cm of water) but before irrigation began. Two in-season and one post season sampling was sed to determine Br and NO3-N movement and distribution in the root zone. Nitrogen unaccounted for calculated from the N balance

under Objective 1 will be correlated with other parameters listed. A paired sample grid with individual 5 cm cores taken on the furrow shoulder was used on adjacent rows of the alternate furrow N application and irrigation treatments. An unaligned grid was used on the every furrow N/irrigation schemes to estimate residual nitrate. The unaligned grid was used to avoid 'systematic' error from application. Samples were taken at short lag distances to determine small scale variation and to allow simulation of nitrate predictability if multiple lag lengths (2X or 3X, i.e. one half to one third the samples) were used. Sites were sampled during the fall of 1997 or the spring of 1998 for residual nitrate and soil organic matter. Maps for these soil properties for the Clay Center and North Platte sites are shown in Figs 3-8. (Maps for the Scottsbluff location were not available at the time this report was written.) The spatial data for organic matter and nitrate were used to develop spatial N rate recommendations using the University of Nebraska N recommendation algorithm for corn. This data was kriged to develop N rate application maps. N was sidedressed in early to mid-June 1998

Principal Findings and Significance

Objective 1: Spatial N use efficiency and N balances. There was significant spatial variability in soil parameters that influence N availability as indicated by the organic matter maps generated from grid soil sample data (Figs 4 and 7). At Clay Center, soil organic matter levels varied from about 1% in an area where topsoil had previously been removed to 3% in the better areas of the field. Soil organic matter content at North Platte also varied from 1 to 3%. At both Clay Center and North Platte, yields from plots that received no N fertilizer (check plots) were significantly lower than those that did receive N, but grain yield was not significantly affected by N application rate (recommended versus 75% of recommended; at North Platte only), application method (variable versus uniform rate) or applicator knife spacing (every furrow versus every other furrow) (Fig 9). These results suggest that variable rate N application provided no field-wide yield advantage compared to uniform (fixed-rate) N application. The lack of treatment effect at these two locations may be partially due to greater than expected mineralization of soil organic N. This resulted in a nonlimiting supply of N even when the application rate was reduced to 75% of the recommended rate at North Platte. Had the N supply been more limiting, variable rate application may have produced greater yields than fixed rate application. As was the case at Clay Center and North Platte, application of N fertilizer at the Scottsbluff location increased corn yield compared to the unfertilized check while variable rate N application did not result in a significant yield advantage over uniform rate application (Fig 10). In contrast to the other two locations, grain yield at Scottsbluff was significantly lower when nitrogen and irrigation water were separated in the alternate furrow application scheme than when these inputs were applied in every furrow. The sandy textured, low organic matter soil at this location resulted in limited lateral movement of irrigation water, which in turn prevented wetting of the entire root zone when irrigation water was applied in every other furrow. Due to the semi-arid climate of western Nebraska, precipitation amounts were not sufficient to wet the non-irrigated furrow resulting in reduced soil moisture and limited root access to the N fertilizer band. Despite failing to produce a yield benefit at any of the three locations, variable rate N application did appear to reduce the spatial variability residual nitrate. A more uniform spatial distribution of residual nitrate results in fewer localized areas with excessively high soil nitrate levels which are more likely to contribute to N loss and groundwater pollution. One way to measure the variability of soil nitrate levels within the different application methods is to look at the coefficient of variability (CV) of the treatment means. The CVs of the treatment means at North Platte show that in both every-row and alternate-row N placement schemes, variable rate application resulted in more uniform distribution of residual nitrate (Table 1). Table 1. Variability of residual soil nitrate as affected by N application method at North Platte. N application method CVs for Residual Soil Nitrate Means Alternate Row Every Row 1997 Variable Rate 37% 30% Uniform Rate 47% 35% 1998 Variable Rate 27% 26% Uniform Rate 56% 33% This advantage was particularly evident when N was placed in every other furrow as

indicated by CVs that were 10 to 29% lower than in the every row placement system. Similar results were observed at Clay Center when N was applied in every furrow (Table 2), but a combination of application and sampling errors prevented a valid analysis for the alternate-furrow treatment. (A measure of variability was not available for the Scottsbluff location at the time this report was written.) Table 2. Variability of residual soil nitrate as affected by N application method at Clay Center. N application method CVs for Residual Soil Nitrate Means Alternate Row† Every Row 1997 Variable Rate -- 40% Uniform Rate -- 46% †Data not available due to a combination of application and sampling problems. The variability in residual soil nitrate levels also provides an indirect measure of the spatial N use efficiency for each of the application systems. A direct measure of this parameter was difficult to obtain in this study due to the difficulty of determining point-specific N application rates for the variable rate application system due to software limitations. The concept of N use efficiency as it relates to residual soil nitrate levels and yield response to N application rate is illustrated in Fig 11, which shows data from the North Platte location in 1997 and 1998. Grain yield increased between 0 and 75% of the recommended application rate, but did not increase significantly as the application rate was increased to the full recommended rate. There was a moderate increase in residual nitrate as N application rate increase to 0 to 75%, but the increase was more dramatic between 75% and 100% of the recommended rate. This increase in residual nitrate is a typical result of the reduced N use efficiency at N application rates in excess of the optimum. Beyond that point, additional N fertilizer does not contribute to increased yield. These data are from field-scale averages, but the same principle applies to the spatial data. Points within the field where residual nitrate is very high indicate low N use efficiency, while areas with low residual nitrate levels indicate greater N use efficiency and, in cases where levels are very low, yield may be reduced because of N deficiency. Objectives 2 and 3: Spatial nitrate-N movement and correlation of spatial N leaching to crop and soil parameters. These objectives, which include the use of a bromide tracer to model nitrate movement, are part of the PhD project of a graduate student working under the direction of Dr. Charles Shapiro and Dr. Gary Hergert at the WCREC in North Platte. The summary of these data are unavailable at the present time pending the completion of the graduate student's dissertation. Objective 4: Comparison of systematic soil sampling strategies. One difficulty with alternate-furrow N application is the subsequent collection of a representative soil sample to estimate residual nitrate. With every-furrow N application, individual soil cores may be collected from any row as long as the position within the furrow is consistent for all cores; however, with alternate-furrow application, since N is injected into half as many furrows, the amount of N fertilizer in a single fertilized furrow is twice that injected into each furrow in the every-furrow application scheme and no N is injected into the alternate furrow. The expected result of this every-other-furrow application would be a larger amount of residual nitrate in the furrow that received N (hard furrow) and a smaller amount in the furrow that did not receive N (soft furrow) as compared to the every-furrow application scheme. This is indeed the result observed at North Platte, particularly when the full recommended rate (100%) was applied (Fig 12). The effect was less obvious when the N fertilizer was applied at 75% of the recommended rate, probably as a result of more complete utilization of the fertilizer N. The difference in residual nitrate level between the hard and soft furrows at Scottsbluff was even greater than at North Platte (Fig 13, top). Because of these spatial differences with the alternate-furrow application, any sample favoring either the hard or soft furrows will not accurately estimate the average residual nitrate level. On the other hand, a systematic sampling pattern with equal numbers of soil cores collected from both hard and soft furrows yielded average residual nitrate values that were very similar to the values generated in the every-furrow application scheme at North Platte (Fig 14). This was not the case at Scottsbluff where the average residual nitrate value with alternate furrow N application was significantly greater than that with every row N application (Fig 13, bottom). This result is not surprising, however, because the lower grain yield produced with the alternate furrow application scheme should result in a greater amount of residual soil nitrate than with the every furrow application scheme where higher grain yield required greater N uptake. Despite these trends, there is still insufficient data to determine whether the residual nitrate value representing the average of the hard and soft furrows is the best predictor of

the contribution this residual nitrate will make to the subsequent corn crop. If alternate-furrow placement of N and irrigation water leads to greater N use efficiency as suggested previously, the average value may not be the best using the current N recommendation algorithum. Further field research conducted at multiple locations during multiple years will be required to identify crop response to residual nitrate following alternate-furrow N application. SUMMARY: Theoretically, reduced leaching of fertilizer N with alternate-furrow N application should result in greater N use efficiency making it possible to produce similar grain yields using less fertilizer N than with the traditional every-furrow application method. Moreover, alternate-furrow application of irrigation water should result in more efficient use of irrigation water since less of the soil volume is wetted during irrigation and more precipitation can be captured and utilized by the crop as compared to every-furrow irrigation. However, results from this experiment were insufficient to draw reliable conclusions regarding these hypotheses. Results of this study did indicate that alternate-furrow application of N fertilizer and irrigation water is a viable management practice in central and west central Nebraska. This conclusion is based on the finding that during the two years of the study, corn yield was not significantly decreased with this practice as compared to applying both N fertilizer and irrigation water to every furrow. Alternate-furrow application of N and irrigation water may not be as effective in dryer climates, such as in the Nebraska panhandle, where insufficient moisture in the furrow where N fertilizer is applied may reduce availability of that N to the plant. This effect was evident at our Scottsbluff location where not only was precipitation limited, but the sandy soil texture resulted in poor lateral movement of irrigation water from the irrigated furrow into the non-irrigated furrow. It was concluded that if every-other-furrow N application is practiced, an accurate estimate of average residual nitrate cannot be accomplished without a systematic soil sampling pattern that ensures equal representation of furrows that receive N and furrows that do not. Further research is needed to estimate the effect of the uneven distribution of this residual nitrate on subsequent crop response and N fertilizer recommendations. Finally, variable rate N application did not produce higher average corn yields than did uniform, or fixed rate application. As was indicated previously, N was not limiting in any of the treatments with the exception of the check treatment. It is possible that with more limited N levels, variable rate N application may produce higher average yields with the same amount of N fertilizer than would fixed rate application due to greater N use efficiency with variable rate application. Results from this study provide evidence that this may be the case as the variability of residual nitrate levels within the variable rate treatments was less than in the fixed rate plots, but no conclusive evidence was obtained to support this theory.

Descriptors

Irrigation manangement, nitrogen, fertilizers, leaching, water quality management, water use efficiency

Articles in Refereed Scientific Journals

Book Chapters

Dissertations

Water Resources Research Institute Reports

Conference Proceedings

Other Publications

Echavaria, F., C.A. Shapiro and G.W. Hergert. 1999. Bromide Movement under Alternate Irrigation

and Fertilization. To be presented as a poster at the 1999 American Society of Agronomy Meetings. Summary will be printed in Agronomy Absracts, 91st Annual Meeting, ASA-CSSA-SSSA, Madison, WI. Shapiro, C.A., J.M. Blumenthal, B.L. Benham, R.B. Ferguson, G.W. Hergert, W.L. Kranz, W.B. Stevens and C.D. Yonts. 1999. Site-Specific Nitrogen and Irrigation Managment across Nebraska Agro-Ecological Zones. To be presented as a poster at the 1999 American Society of Agronomy Meetings. Summary will be printed in Agronomy Absracts, 91st Annual Meeting, ASA-CSSA-SSSA, Madison, WI.

Basic Project Information

Basic Project Information	
Category	**Data**
Title	Determination of Aquifer and Aquitard Hydraulic Properties and Their Role in Streamflow Depletion
Project Number	C-88
Start Date	09/01/1998
End Date	02/28/2001
Research Category	Ground-water Flow and Transport
Focus Category #1	Groundwater
Focus Category #2	None
Focus Category #3	None
Lead Institution	Nebraska Water Resources Center

Principal Investigators

Principal Investigators			
Name	**Title During Project Period**	**Affiliated Organization**	**Order**
Robert F. Diffendal, Jr.	Professor	Univ. of Nebraska City Campus	01
Xun-Hong Chen	Professor	Univ. of Nebraska City Campus	01

Problem and Research Objectives

Problem: Streamflow depletion caused by groundwater withdrawal. Objectives: 1) to apply new methodologies for collecting high quality pumping and recovery test data and for determination of reliable hydraulic properties of aquifers; and 2) to analyze the role of aquifer and aquitard hydraulic conductivity in streamflow depletion due to groundwater pumpage. INFORMATION TRANSFER PROGRAM During site selection, we visited with several Natural Resource Districts along the Platte River valley, Nebraska, which have strong interests in the study of streamflow depletion. We have informed them the locations and hydrogeological conditions of the two selected sites. Researchers at the Management System Evaluation Area, Nebraska were also contacted and invited to visit the study sites. STUDENT SUPPORT A graduate student was hired to develop computer programs for the analysis of

well hydraulics and the design of monitoring wells.

Methodology

Design and construction of monitoring wells in alluvial aquifers, which connects to streams; Long-term groundwater level monitoring for determination of recharge and the responses of aquifer to groundwater pumping; Conducting pumping tests; Determination of aquifer and aquitard hydraulic properties; Analysis of the role of aquifer and aquitard hydraulic properties in streamflow depletion using numerical modeling analysis.

Principal Findings and Significance

The research was in its first year and will continue to 2001. Between Sept. 1, 1998 to June 30, 1999, we examined the log records of test holes and irrigation wells in the Platte River valley, Nebraska and analyzed regional hydrostratigraphic features. We identified two study sites in the Platte River valley, one near Shelton and the other near Woodriver, Nebraska. The Shelton site contains aquifer and aquitard units and the Woodriver site contains an alluvial aquifer. After the selection of the two study sites, we used sensitivity analysis method and designed 12 monitoring wells for each study site. Construction of monitoring wells has been scheduled in July 1999. We designed conceptual models of three-dimension and analyzed the role of aquifer and aquitard hydraulic properties in streamflow depletion.

Descriptors

Aquifer parameters, Conjunctive use, Groundwater modeling, Surface-groundwater Relationships, Well hydraulics

Articles in Refereed Scientific Journals

Chen, X.-H. and Y. Yin, 1999. Evaluation of streamflow depletion for vertical anisotropic aquifers. Journal of Environmental Systems, v. 27, no. 1, pp. 55-70.

Book Chapters

Dissertations

Water Resources Research Institute Reports

Conference Proceedings

Chen, X.-H. and Y. Yin, 1999. Modeling of Stream-aquifer interactions in the Republican River valley, Nebraska. Abstract for the 19th Annual Hydrology Days, August 16-20, 1999. Colorado State University, Fort Collins, Colorado.

Other Publications

Basic Project Information

Basic Project Information	
Category	**Data**
Title	Hydraulic Characterization of the Stream-Aquifer Interface:colon;colon;colon; Theory, Field Implementation, and Practical Ramifications - a Multi-state Proposal
Project Number	C-66
Start Date	09/01/1998
End Date	08/01/2001
Research Category	Climate and Hydrologic Processes
Focus Category #1	Groundwater
Focus Category #2	Methods
Focus Category #3	Water Quantity
Lead Institution	Nebraska Water Resources Center

Principal Investigators

Principal Investigators			
Name	**Title During Project Period**	**Affiliated Organization**	**Order**
James Butler, Jr.	Unknown	Other	01
Vitaly Zlotnik	Professor	Univ. of Nebraska City Campus	01

Problem and Research Objectives

Surface-ground water interactions are often a key component of the hydrologic budgets of aquifers and streams. In Nebraska and Kansas, as well as many other areas in the Great Plains and elsewhere in the United States, these interactions have very significant socio-economic and political ramifications. As illustrated by the numerous interstate conflicts that have arisen from disagreements concerning the impact of groundwater pumping on stream flow, there is a critical need to quantify the volumes involved in water exchanges between streams and aquifers. Given the potential magnitude of the fianancial stakes, it is imperative that this quantification be founded on methodology with a sound scientific basis. A key element of efforts to quantify stream-aquifer interactions is the estimation of the impact of pumping from alluvial aquifers on stream flows. Although several methods for estimation of pumping-induced water transfers have been developed over the last 50 years, these methods are based on mathematical models of hypothetical flow systems that often bear little resemblance to stream-aquifer systems in the Great Plains. Recent work has shown that these simplistic models can introduce significant errors into estimates of the impact of groundwater pumping on stream flows as a result of their neglect of critical aspects of the stream-aquifer interface, specifically the near-stream channel.

Clearly, there is a pressing need to develop field and modeling methods that can result in estimates of pumping-induced water transfers that are based on more realistic representations of the stream-aquifer interface. The development of such methods is the primary purpose of this research. INFORMATION TRANSFER. Results were presented at two international meetings (Congress of International Association of Hydro geologists: Gambling with Groundwater: Physical, Chemical, and Biological Aspects of Aquifer-Stream Relations", Las Vegas, Nevada, Sept. 27-Oct.2, 1998; Joint Congress, Water 99, Brisbane, Australia, July 6-8, 1999), and one national meeting (American Geophysical Union, Spring 1999, Boston). In addition, the results were presented to the Central Platte Natural Resources District, Nebraska. The materials were also included into the seminar "Modern Problems of Hydrogeology", Spring 1999, University of Nebraska-Lincoln. Computer software for prediction of pumping-induced drawdown and stream depletion is currently being distributed by the Kansas Geological Survey. STUDENT SUPPORT. One M.S. student and one Ph.D. student were partially supported from the grant in Geosciences Department, UNL.Total number - 2 students.

Methodology

Methodology includes field and modeling studies at two sites in Nebraska and Kansas. Field studies involve development of networks of observation wells at the selected sites and stream gauging stations. These wells will be used for measurements of head changes invoked by pumping from irrigation wells and varying in time stream stages. In addition, small-scale hydraulic methods for aquifer characterization (borehole flowmeter, multi-level slug test, dipole-flow test) will be used for independent estimation of hydraulic conductivity of the aquifer and stream-aquifer interface zone. Transient head changes will be interpreted in terms of aquifer properties and characteristics of the stream-aquifer interface. New and improved mathematical models of head changes invoked by pumping and stream stage fluctuations will be developed. Based on these solutions, new procedures will be developed for analysis of the head data. The obtained results will be compared with other hydraulic methods used for assessment of aquifer and stream-aqquifer interface properties. This study will result in analytical and numerical methods for assessment of stream depletion.

Principal Findings and Significance

Currently, screening of more than twenty potential sites on Silver Creek watershed (Platte River tributary, Nebraska) yielded two potential sites with saturated thicknesses of 8 ft and more than 60 ft, respectively. These sites are located on privately owned land and have existing pumping wells (capacities 200 gpm and 1200 gpm). At each site a two-well transect were installed and tested by pumping. It has been established by pumping tests that the drawdown on the opposite side of the stream from the irrigation wells is detectable by the pressure transducers after one-day pumping, and the drawdown is larger at the site with 1200 gpm. Both sites have 4" wells designed for hydraulic testing of the aquifer. In the future, research efforts in Nebraska will be concentrated at one site. In Kansas, research efforts are concentrated on the search for appropriate sites and exploring the potential of "direct push" methodology to replace conventional drilling for installation of near-stream piezometers. Current experience indicates that a combination of drilling and direct push techniques may be the most efficient strategy for site instrumentation and exploration. Significant progress has been made in the development of analytical models of stream-aquifer interaction. These models explicitly consider conditions of shallow penetration and low-permeable streambed sediments common to the Great Plains and many other areas of the United States. Three major results include: (1) aquifer response to stream stage fluctuations, (2) stream depletion, and (3) head drawdown under pumping conditions near partially penetrating streams. This work has a significant element of novelty and resulted in peer-reviewed publications and conference presentations.

Descriptors

Surface-Groundwater Relationships, Groundwater Movement, Streams, Groundwater Hydrology

Articles in Refereed Scientific Journals

Zlotnik, V.A., and Huang, H., 1999, Effect of partial penetration and streambed sediments on aquifer response to stream stage fluctuations, Ground Water, 37(4), 599-605.

Book Chapters

Dissertations

Huang, Huihua, in preparation, "Evaluation of stream-aquifer interactions considering streambed sediments and partial penetration effects", M.S. Thesis, Department of Geosciences, University of Nebraska-Lincoln, Lincoln, Nebraska.

Water Resources Research Institute Reports

Conference Proceedings

Zlotnik, V., Huang, H., and Butler, J.J., Jr., 1999, Evaluation of stream depletion considering finite stream width, shallow penetration, and properties of streambed sediments, in "Proceedings of Joint Congress, Water 99, Brisbane, Australia, July 6-8, 1999", 221-226. Zlotnik, V.A., and Huang, H., 1998, An analytical model of aquifer response to stream stage fluctuations: Effect of partial penetration and streambed sediments, in "Proceedings of XXVIII Congress of International Association of Hydro geologists: Gambling with Groundwater: Physical, Chemical, and Biological Aspects of Aquifer-Stream Relations", Las Vegas, Nevada, Sept. 27-Oct.2, 1998, ed.: V.Brahana, Y.Eckstein et al., 297-304.

Other Publications

Butler, J.J., Jr., Tsou, M.-S., Zlotnik, V.A., and H. Huang, Drawdown and stream depletion produced by pumping in the vicinity of a finite-width stream of shallow penetration (abstract), EOS, Transactions, American Geophysical Union 1999 Spring Meeting, v. 80, no. 17S, p. S137, 1999. Butler, J.J., Jr., Tsou, M.-S., Zlotnik, V.A., and H. Huang, Drawdown and stream depletion produced by pumping in the vicinity of a finite-width stream of shallow penetration, Kansas Geological Survey Open-File Report 99-16, 22 pp., 1999. Butler, J.J., Jr., and M.-S. Tsou, The StrpStrm model for calculation of pumping-induced drawdown and stream depletion (version 1.0), Kansas Geological Survey Computer Series Report 99-1, 1999.

Information Transfer Program

Basic Project Information

Basic Project Information	
Category	**Data**
Title	Information Transfer Plan
Description	Communications
Start Date	03/01/1998
End Date	02/28/1999
Type	Newsletter
Lead Institution	Nebraska Water Resources Center

Principal Investigators

Principal Investigators			
Name	**Title During Project Period**	**Affiliated Organization**	**Order**
Steven W. Ress	Professional Staff	University of Nebraska, East Campus	01

Problem and Research Objectives

Not applicable.

Methodology

Not applicable.

Principal Findings and Significance

Not applicable.

Articles in Refereed Scientific Journals

Not applicable

Book Chapters

Not applicable

Dissertations

Not applicable

Water Resources Research Institute Reports

Not applicable

Conference Proceedings

"Overview of Vision Statements Created at the 28th Annual Nebraska Water Conference," a summation of conference vision statements on the future uses, challenges and opportunities facing Nebraska's water supplies in the 21st century. Distributed free. CONFERENCES, SEMINARS AND TOURS: Annual Nebraska Water Conference conducted each March and co-sponsored by the University of Nebraska Water Center/Environmental Programs, School of Natural Resource Sciences, Nebraska Department of Water Resources, Nebraska Water Conference Council and others. In 1998, the 27th annual conference began a three-year series to explore the past, present and future of Nebraska water and Nebraska water issues under the collective title of "Nebraska Water 2000." The conference annually attracts 200-300 speakers and participants. News releases, brochures and a program are produced in conjunction with this event. Annual Water Resources Seminar Series is a series of 12 to 14 public lectures held from January to April each year and co-sponsored by the University of Nebraska Water Center/Environmental Programs, School of Natural Resource Sciences, and other NU departments and centers. The series may be taken for graduate or undergraduate student credit and is available on video tape for students opting for a distance learning option. Weekly attendance at the lectures is approximately 30 students and another 40 from the public at-large. News releases, mailings and brochures are produced in conjunction with this event. Fall Festival of Color is an annual summer horticulture and lawn and garden open house co-sponsored by the University of Nebraska-Lincoln Department of Horticulture, Water Center/Environmental Programs, School of Natural Resource Sciences, Cooperative Extension and Institute of Agriculture and Natural Resources. The one-day event, held at UNLs Agricultural Research and Development Center (ARDC) located between Lincoln and Omaha, attracts great media interest and is attended by more than 10,000. News releases and newspaper advertisements are produced in conjunction with this event. Platte Watershed Program Symposium is co-sponsored by University of Nebraska Platte Watershed Program, Water Center/Environmental Programs, School of Natural Resource Sciences, U.S. Environmental Protection Agency, Region VII and the U.S. Fish and Wildlife Service. The symposium explores research and educational programming related to the ecology of the Platte River Basin area of Nebraska. Attended by approximately 150 speakers and members of the public. News releases and brochures are produced in conjunction with this event. Annual Summer Water Tour co-sponsored by the Nebraska Water Conference Council, Nebraska Department of Water Resources, NU Water Center/Environmental Programs and School of Natural Resource Sciences, and other public, private and commercial entities. The annual tours, normally conducted in July or August, explore current water projects, legislation, research and water-related issues in Nebraska and neighboring states. They attract educators, water users, legislators and members of the public at-large and are typically attending by approximately 200. Tours last from two to four days, depending on location. Recent tours have visited Nebraska, Colorado, Kansas and Wyoming. News releases, mailings and a brochure are produced in conjunction with this event. CONFERENCES AND EDUCATIONAL DISPLAYS: The Water Center/Environmental Programs makes frequent public displays in association with conferences, symposiums, water-related trade shows and water and environmental festivals. These average eight to 10 per year. A new Downing Display highlighting the latest Water Center-sponsored research and/or programming is created approximately every 18 months. A wide variety of informational and educational materials are distributed at no charge at these events. Water Center faculty and staff also use a Groundwater Flow model to help introduce elementary and middle school science students to the concepts of groundwater and groundwater contamination issues. Presentations are scheduled on an as-requested basis.

Other Publications

NEWSLETTER: The "Water Current" newsletter is in it’s 32nd year of continuos publication. Published six times per year in February, April, June, August, October and December. An annual reader survey is published in the April edition of the newsletter. Survey results help drive editorial content of the publication and overall design evolution. Each issue is eight pages in length. Research briefs and RFPs are frequently published as inserts to the newsletter. The publication covers all types of research, extension and outreach programming and educational efforts sponsored all or in part by the UNL Water Center/Environmental Programs unit. Distribution reaches international proportions. Subscriptions are provided at no charge to the public and there are approximately 3,800 subscribers. WETLANDS TABLOID: "Wetlands - Understanding a Resource" a 16-page newspaper tabloid on wetlands-related issues was published in May, 1998. 200,000 copies were printed and distributed to the public at-large, public and private schools; other educational programs; non-profit environmental organizations and to co-sponsoring local, state and federal agencies. This was the third in a series of water and wetlands-related tabloids that have been published by the Water Center/Environmental Programs unit since 1994. A fourth tabloid on drinking water issues is currently in the works and will be published and distributed through the Omaha World-Herald newspaper in late 1999. OTHER PRINTED PUBLICATIONS: "How To Access Water Resources Information," a public guide to local and internet resources on a variety of water and water-related issues. Distributed free to the public at seminars, conferences and displays and available free through the Water Center/Environmental Programs internet web site. "Nebraska Water Resources Directory," a public guide to federal, state and local water resources agencies, organizations and educational institutions. Distributed free to the public at seminars, conferences and displays and available free through the Water Center/Environmental Programs internet web site. Water Center/Environmental Programs and School of Natural Resource Sciences informational brochures. Updated and produced annually to provide overawes of the mission and programming of these two University of Nebraska programs. Distributed free. NEWS RELEASES: The Water Center/Environmental Programs produces about 40 press releases annually based on research, cooperative extension, teaching and public outreach programming sponsored by the unit. These press releases receive wide publication in state newspapers, as well as in organization, trade and research journals. ELECTRONIC RESOURCES: Electronic versions of newsletters, other printed materials, RFPs, up-to-date information about the unit and its research faculty and information about the associated Water Sciences Laboratory and Pesticide Education Resources programs are available on the internet at http://www.ianr.unl.edu/ianr/waterctr/wchome.html The Water Center/Environmental Programs also co-sponsors three additional educational internet sites. These sites are associated with the Water Center, the Water Sciences Laboratory, the Platte Watershed Program and the UNL Horticulture Department’s Festival of Color. Each of the sites is program specific, but all are linked. Many free water-related print and electronic publications are available through these five sites. Addresses for the other four sites are: Water Sciences Laboratory: http://www.ianr.unl.edu/waterscience/wsl.html Platte Watershed Program: http://ianrwww.unl.edu/ianr/pwp/pwp.html Fall Festival of Color: http://hort.unl.edu/fallfest/

USGS Internship Program

Student Support

Awards & Achievements

Publications from Prior Projects

Articles in Refereed Scientific Journals

Book Chapters

Dissertations

Water Resources Research Institute Reports

Conference Proceedings

Other Publications