South Dakota Water Research Institute

Annual Technical Report

FY 1999

Introduction

The change to a Regional Competitive Grant Program in 1996 reduced the number of research projects conducted at the South Dakota Water Resources Institute (SD WRI). During the tenure of the Regional Competitive Grant Program, only one project was funded in South Dakota, titled "Geochemistry of Dissolved Organic Carbon in the Big Sioux Basin, Eastern South Dakota" by principal investigator Dr. James A. Rice. This project continued through 1999, and a synopsis of that project follows. A return to the pre-1996 format for the 104 Grant Program has resulted in an increase in water resources research designed to address research priorities in the State of South Dakota. These research projects that may be of interest regionally or nationally are expected to produce refereed journal articles. Other projects that focus primarily on problems of interest to South Dakota are expected to produce reports that will assist policymakers in managing South Dakota's water resources, and informational brochures designed to educate the citizens of the state about the status of their water resources. Newly funded research projects included: A project on precision farming was included in the research program for 1999 to improve management of farm fertilizers and chemicals so that are applied only in the amounts needed to reduce the amounts available for runoff and leaching. This is expected to lead to better management to improve environmental quality. A project to evaluate a non-point source pollution project on Pickerel Lake was funded to address the issue of how non-point source projects affect water quality, and to determine whether practices adopted during those projects are maintained after the management incentives end. A wetland project was funded to determine the influence of agricultural management on wetland function and wetland contribution to long term crop production. These issues and how they relate to wetland management options are poorly understood. A summary of each project, methodology, and principal findings and significance are included in the Basic Project Information section. In addition to the 104 program, other research at the SD WRI continued with external funds. A proposal for "A Literature Review of Phosphorus Accumulation in Soils and the Impact on Runoff Water Quality" was funded by the SD DENR and the SD Cattleman's Association. Work on this literature review began in December, 1999 and is scheduled to be completed in August 2000. An ongoing project to document water quality improvements resulting from construction of animal waste management systems on feedlots located in eastern South Dakota continued. The second phase of this project will be completed in the year 2000. Phase three of the project will begin in 2000. This phase will involve support for a graduate student to study the water quality impacts of various management options for the application of manure to cropland. SD WRI also provides technical support and laboratory services to a number of research projects conducted by other organizations/agencies. These include TMDL and other watershed studies conducted by the East Dakota Water Development District, the SDSU Biology Department, and the Lake Kampeska Water Project District.

Research Program

Basic Project Information

Basic Project Information	
Category	**Data**
Title	Geochemistry of Dissolved Organic Carbon in the Big Sioux Basin, Eastern South Dakota
Project Number	C-01
Start Date	10/01/1997
End Date	03/31/2001
Research Category	Biological Sciences
Focus Category #1	Geomorpological and Geochemical Processes
Focus Category #2	Groundwater
Focus Category #3	Surface Water
Lead Institution	South Dakota State University

Principal Investigators

Principal Investigators			
Name	**Title During Project Period**	**Affiliated Organization**	**Order**
James A. Rice	Professor	South Dakota State University	01

Problem and Research Objectives

The Big Sioux Basin is a hydrologic system which covers most of eastern South Dakota. Almost all studies have focused on the inorganic constituents of the basin's surface- and ground-waters. In 1989-1990 we conducted a geochemical baseline survey of the organic constituents of the basin's groundwater that showed that dissolved organic carbon (DOC) levels are low, averaging 7.7 mg DOC/L#. Aquifer recharge is primarily by downward percolation of surface water which makes the aquifers susceptible to contamination by anthropogenic and autochthonous organic substances present in the overlying materials. To begin to explore the relationship between the surface- and ground-water DOC concentrations, we recently established that DOC levels in wetlands, lakes and rivers in the basin that are hydrologically connected to the aquifers can be as much as 30 times higher. An investigation into the chemical nature of the DOC in the basin's aquifers, its relationship to the organic matter in the predominate soil type in the region, and to several potential anthropogenic inputs of organic carbon into the groundwater is also near completion2 However, the flux of organic carbon between hydrologic domains (eg., between surface water and the groundwater, or between the soil and the groundwater), and the effect of sorption of components of the DOC to subsurface and aquifer materials on the chemical characteristics of the groundwater's DOC as it moves from one hydrologic domain to the other are unknown. This study will be provide a broad-based understanding of the movement of DOC through hydrologic systems developed in alluvial and glacially-derived materials. It will provide a detailed description of the organic geochemistry of DOC in the Big Sioux Basin and an understanding of the mechanisms that control and affect the composition of DOC as it is transferred from surface-water to groundwater. The geochemical model of DOC transport from surface waters to the groundwater in the basin should capable of extension to other, similar systems in the North Central Region. The hypothesis which drives this proposal is that selective sorption of surface-water DOC substantially alters the composition of the DOC which is actually introduced into the groundwater during aquifer recharge. The specific objectives of this proposal are to: (1) monitor the fluctuations in the dissolved organic carbon (DOC) concentration of the Big Sioux aquifer and connected wetland and surface water areas in the Big Sioux Basin; 2) use this data to create an estimate of the organic carbon flux into and through the aquifer; 3) perform sorption/desorption experiments using subsurface and aquifer material to quantify the binding of organic carbon to mineral surfaces; (4) assess the importance of sorption to mineral surfaces as a mechanism for controlling DOC composition and concentration in the aquifer, and; 5) identify the controls on organic carbon binding to mineral surfaces in subsurface and aquifer materials.

Methodology

This project involves a combination of field and laboratory studies to assess the flux of DOC between surface and groundwaters within the study site. A detailed hydrologic description of the study site is being prepared. DOC levels are regularly monitored to determine the flux of organic carbon through the site. Periodic bulk water samples are fractionated into hydrophobic and hydrophilic organic acids, bases, and neutral compounds to evaluate seasonal changes in the nature of the DOC. This same fractionation scheme will be used to assess the compositional affect of selective sorption of DOC components to mineral surfaces as surface water DOC percolates down into he groundwater. Finally, a model will be constructed to describe the flux of DOC through the system.

Principal Findings and Significance

HYDROLOGY Weekly water levels were measured in 18 observation wells adjacent to a prairie pothole wetlands. Ground-water levels were observed to rise during the spring and early summer but declined from summer to mid-winter. Hydrographs of the observation wells in the project area show that the water level in the deepest well had an average weekly difference in water level of about 0.05 feet, with a maximum difference of 0.21 feet. In the shallowest well the average weekly difference was about 0.04 feet with a maximum of 0.14 feet and. The observation wells located southeast to the pond had the greatest difference in weekly water levels. Water levels do show a response to significant precipitation events. The May, 2000 water level is an average of 0.28 feet below the May 1999 water levels. Similar water level trends, such as seasonal fluctuation and response to precipitation, where observed in the pothole surface water. Comparison of pothole water stage and ground-water levels indicate a consistent downward gradient since the spring 2000 thaw. Thus, the surface water is recharging the ground water. The seepage rate through the pond bottom to the underlying weathered till was calculated to be 0.005 feet/day. As an aid in better understanding the ground water and surface water interaction at the prairie pothole, a digital ground-water flow model of the weathered till is being developed. The model will be used to test various combinations hydraulic properties, recharge to, and discharge from the weathered till. DOC FLUX A large of enough database of DOC measurements now exists to begin to describe trends in groundwater and surface water DOC levels. Data collected thus far show that groundwater DOC levels peak in the fall and show little effect of spring snowmelt infiltration. SORPTION TO MINERAL SURFACES Using DOC isolated from the surface waters at the intensive study site, and mineral materials (silica, alumina, kaolinite and montmorillonite), study of the sorption of the DOC components to the mineral surfaces has revealed that hydrophobic and hydrophilic acids (as defined by XAD-8/XAD-4 sorption fractionation) selectively sorb to the mineral surfaces. Removal of these components, compared to the original DOC isolate is not quantitative, but in all case more than 75% of these fractions are removed. There is very little, if any, sorption of either hydrophobic or hydrophilic neutral or base fractions to these surfaces. Fluorescent spectra of the original surface water isolate reveal two distinct fluorescent signals, one of these is essentially completely absent after sorption experiments and in the ground water. Chemical characterization, primarily using solution-state 13C NMR, is being completed to further characterize the components being sorbed to the minerals surfaces to better understand the role of mineral surfaces in controling DOC composition as surface water percolates through the unsaturated zone to recharge the aquifer

Descriptors

Dissolved organic carbon, geochemistry, surface-groundwater relationships, soil-water relationships, groundwater recharge

Articles in Refereed Scientific Journals

Williams, M.; Vander Vorste, E.; Rice J. A., 2000, Selective sorption of DOC components to mineral surfaces. IN PREPARATION.

Book Chapters

Dissertations

Sumption, Alison, Hydrology of a Prairie Pothole, MS thesis, South Dakota State University, August 2000

Water Resources Research Institute Reports

Conference Proceedings

Williams, M.*; Rice, J. A., Selective sorption of natural organic matter by mineral surfaces I. Silica and alumina, 34th Midwest Regional Mtg., Am. Chem. Soc., October 1999, Quincy, IL, abstract no. 148
Vander Vorste, E.*; Rice, J. A., Selective sorption of natural organic matter by mineral surfaces II. Clay minerals, 34th Midwest Regional Mtg., Am. Chem. Soc., October 1999, Quincy, IL, abstract no. 150
Williams, M.*; Rice, J. A., Selective sorption of natural organic matter by mineral surfaces. Chemical changes after sorption on sand and alumina, Am. Chem. Soc., 219th San Francisco, CA, March 2000, abstract CHED 755.

Other Publications

Basic Project Information

Basic Project Information	
Category	**Data**
Title	Development of an on-the-go Soil Sensor for Identifying Nutrient Management Zones and Improving Water Quality.
Project Number	B-02
Start Date	03/01/1999
End Date	05/01/2000
Research Category	Water Quality
Focus Category #1	Groundwater
Focus Category #2	Models
Focus Category #3	Non Point Pollution
Lead Institution	South Dakota State University

Principal Investigators

Principal Investigators			
Name	**Title During Project Period**	**Affiliated Organization**	**Order**
David Edward Clay	Associate Professor	South Dakota State University	01
Kevin Dalsted	Professional Staff	South Dakota State University	02
Douglas D. Malo	Professor	South Dakota State University	03
C. Gregg Carlson	Professor	South Dakota State University	04

Problem and Research Objectives

Theoretically, precision farming is the process of using information to develop more profitable and environmentally sound management systems. Key questions in precision nutrient management are: (i) how can costs associated with collecting soil nutrient information be reduced; (ii) how can information be processed into decisions quickly; and (iii) will management practices designed to account for soil spatial variability improve environmental quality? A guiding concept behind this project is that science-based sampling and decision tools can minimize the cost of obtaining information and also facilitate the conversion of information into improved decisions. The objective of this project is to determine the influence of pedogenic processes on soil electrical conductivity and develop and field test an on-the-go soil sensor. The on-the-go soil sensor will be developed by linking pedogenic process models with a survey grade DGPS and an electromagnetic conductivity (EM) sensor. Field testing will include measuring the impact of the sensor on agronomic profitability and estimating the impact of variable rate management, using LEACHEM, on water quality.

Methodology

Three field experiments were initiated at farmers' fields located in South Dakota. In experiment one, the influence of soil temperature, water, pH, and EC on apparent electrical conductivity (ECa) was determined. In this experiment ECa and soil water content were measured at specific locations in three hillslopes ten times during 1999 and 2000. The goal of this experiment was to determine the relationship between ECa, soil temperature, EC, and soil water. In experiment two, the ability of using the EM meter to identify old feedlots was evaluated. In this experiment, soil samples (0-15 cm) from three fields were analyzed for Olsen P. Elevation was measured by a carrier phase single frequency DGPS and ECa was measured multiple times between 1995 and 1999. In experiment three, field studies were initiated in five farmer fields in the spring of 2000. The objective of this experiment was to field test sensor ability to identify nutrient management zones. Elevational, latitude, and longitude information will be collected by a Leica (Leica Inc., Norcross, GA) single frequency DGPS system. Data acquisition mode will be real time/ moving. During the spring of 2000, elevation maps were obtained from five 65 ha fields located in South Dakota. Grid soil nutrient information is available for all of these fields. In the fall of 2000, apparent electrical conductivity maps will be obtained from these fields.

Principal Findings and Significance

Experiment 1 ECa readings were high at low elevation sampling sites and low at high elevation sampling sites. This variation could be explained by considering soil water, temperature, and EC. Using a multiple regression, an equation relating ECa to the soil water contained in the surface 60 cm (AW), soil temperature (AT), and measured EC was: ECa = 27.97 + 1.34(WC) – 1.48(AT) +0.04(EC) $r2=0.64$ When squared and interaction terms were added to the multiple regression, they were not significant. This equation shows that soil water content, soil temperature, and EC interact to influence ECa and that if the goal is to estimate water content, then soil temperature and EC information is needed. The equation also indicates that ECa can be used to estimate EC, which can be used to identify areas with poor drainage. Experiment 2 The three fields which were studied had : (i) skewed P distribution; (ii) strong ECa spatial dependence; (iii) highly significant correlations between ECa values measured at different sampling dates; (iv) water content and salt concentrations which generally were higher in footslope than summit soils; and (v) Olsen P concentrations which were highly correlated to ECa. These findings suggest that by accounting for intrinsic and management induced variations in ECa, it may be possible to identify areas with high P concentrations. In a practical sense, this research indicates by superimposing ECa on a topography map, areas differentially influenced by management can be identified. Once anomalous areas are identified, soil samples should be collected and analyzed to confirm the nutrient management zones. This approach will be tested in Experiment three. Experiment 3 This experiment was started in May 2000, and research results are not yet available. Information Transfer The goal of the Information Transfer component of this project is the development and refinement of educational materials that demonstrate how 21st Century technologies can be used to reduce agriculture impacts on the environment and improve agronomic profitability. The materials developed will provide information that farm managers need to reduce the economic and environmental risk associated with individual decisions. Materials that will be developed include: (i) videos that demonstrate resource management concepts that can be shown at farmer workshops, in the classroom, or on television; (ii) improving and revising the Site-Specific Management Guideline Manual; (iii) presenting findings at field days and scientific conferences.

Descriptors

Chemigation, Nitrogen, Phosphorus

Articles in Refereed Scientific Journals

Clay, D.E., J. Chang, C.G. Carlson, D. Malo S.A. Clay, and M. Ellsbury. 2000. Precision farming protocols: Part 2. A comparison of approaches for precision P management. Com. Plant and Soil Anal. (Submitted 3/23/00). Clay, D.E., J.Chang, D.D. Malo, C.G. Carlson, C.Reese, S.A. Clay, and M. Ellsbury. 2000. Using soil electrical conductivity as a directed sampling tool in fields with varied histories. Agron, Journal (Submitted 5/2/00). Clay, D.E., C.G. Carlson, and S.A. Clay. 2000. A lesson learned in identifying P management zones. Prec. Agriculture (Submitted 3/00)

Book Chapters

Dissertations

Water Resources Research Institute Reports

Conference Proceedings

Other Publications

Clay, D.E., D.D. Malo, C.L. Reese, and C.G. Carlson. 1999. Identifying good candidates for precision phosphorus management. #13. Clay et al. (Ed) Site Specific Management Guidelines. Potash and Phosphate Institute. Norcross, GA

Basic Project Information

Basic Project Information	
Category	**Data**
Title	Wetland Management on Agricultural Landscapes in the Prairie Pothole Region
Project Number	B-04
Start Date	03/01/1999
End Date	02/28/2001
Research Category	Water Quality
Focus Category #1	Water Quality
Focus Category #2	Agriculture
Focus Category #3	Economics
Lead Institution	South Dakota State University

Principal Investigators

Principal Investigators			
Name	**Title During Project Period**	**Affiliated Organization**	**Order**
Diane Rickerl	Professor	South Dakota State University	01
Larry Janssen	Professor	South Dakota State University	02

Problem and Research Objectives

Prairie Pothole Region (PPR) wetlands serve an important role in the hydrology and water quality of the region. Frequently cited wetland functions include floodwater storage, groundwater and soil moisture recharge and nutrient filtering capacity. Although the majority of wetlands in the PPR are located in agricultural environments, the influence of agricultural management on wetland function and wetland contribution to long term crop production is poorly understood. We integrated water quality and agroeconomic data to evaluate wetland management options on cropland in the PPR. Goal: The goal of this project is to determine the impact of wetland management on the viability of agronomic and wetland systems in the Prairie Pothole Region. Objective 1: To determine the influence of wetland landscapes on long term crop productivity. Objective 2. To determine the influence of wetland landscapes on net returns to farmers. Objective 3. To determine wetland management impacts on nutrient concentrations and aquatic invertebrate density in wetlands.

Methodology

Site Selection: Digital GIS data bases (coverages) of National Wetlands Inventory (NWI)-delineated wetlands (1:24,000 scale) for Beadle and Hamlin counties, South Dakota, were reclassified in Arc/INFO to create composite wetland basins (e.g., potholes) (Cowardin 1982). Basins were classified with temporary, seasonal, semipermanent, and permanent water regimes based on the water regime of the most permanent wetland they contained (Johnson and Higgins 1997). Wetland basins are hereafter referred to as wetlands. Digital wetland coverages were integrated in Arc/INFO with Natural Resource Conservation Service digital soils coverages (1:20,000 scale), and a digital Public Land Survey coverage (1:24,000 scale). Five townships were randomly selected in each county. Legal sections within each township were randomly ordered and sequentially reviewed. Land owners and operators were contacted to obtain permission to sample crop yields within and adjacent to selected wetlands. Wetlands were reviewed in the field during May and June 1997. The final selection included 50 wetlands. Agronomic Evaluation: Crop yield samples were collected during September and October 1997, 1998, and 1999. Samples were harvested along three axes at each wetland. Each axis originated at the center of the wetland as determined by water depth and aquatic vegetation. If the wetland was planted through, samples were collected at the center, wetland edge and then 15, 30, and 45 m from the edge. If the wetland was not planted through, distance from the center to the first crop row was determined and samples collected at the crop edge, then 15, 30 and 45 m from the edge. Harvest methodology varied by crop type. For all row crops, row width was recorded at harvest. For alfalfa, three 25 cm2 random samples were cut at ground level at each point. All three samples were put in one bag, dried at 140 F, and the dry weight recorded. For wheat, a 1 m section of row was harvested at ground level at each point. The samples were dried, threshed, weighed, and moisture recorded. For sunflower, heads were collected from 3 m of row at each point. The samples were dried, shelled, weighed, and moisture recorded. For soybean, 2 m of row was harvested at ground level at each point. The samples were dried, threshed, weighed, and moisture recorded. For corn, ears were collected from 3 m of row at each point. The samples were dried, shelled, weighed, and moisture recorded. A differentially corrected (± 5 m) Global Positioning System (GPS) location was collected at each sampling point and integrated with existing GIS coverages. GIS data were collected in UTM coordinates using the North American 1983 datum. Economic Evaluation: Farm-level economic costs and returns per field were estimated using computerized budget generators, which contain standardized unit prices, unit costs, and machinery costs per field operation. The CARE (Cost and Return Estimator) software package developed by USDA - NRCS was the main budget generator. This approach has been used in various agroeconomic studies conducted by SDSU economists and agronomists on the viability of different crop farming systems and can be readily adapted to this project (Cole and Dobbs, 1990; Smolik and Dobbs, 1991; Janssen et al. 1994; Rickerl et al. 1996). Farmer-cooperator interviews were used to obtain information on tillage systems, cultural practices, and fertilizer-pesticide use rates; while yield data was obtained from the agronomic samples. Differences in cropping practices in the wetland basins compared to upland portions of fields were determined. Economic costs and returns were estimated at the field tract level on a per hectare and per unit of output basis. The influence of wetland sites on economic costs and returns was estimated by comparing crop yields and associated production costs per unit of output for each distance interval from the wetland site. Environmental Evaluation: Invertebrate and water quality samples were collected during May and June in1997, 1998, and 1999. Aquatic invertebrates were sampled using a benthic core sampler similar to that used by Swanson (1978; 1983) for assessing waterfowl food resources. Benthic samples were extracted in four random locations within the saturated area from each wetland. The core sampler used in this study was a bulb planter 6 cm in diameter. A plunger was used to remove the benthic sample from the corer. It consisted of a 1 m section of PVC tubing, 4.5 cm in diameter with a cap on the end. The plunger was inserted into the corer, stopping when only the top 10 cm of sediment remained. The excess was scraped off and the 10 cm sample was placed in a ziploc plastic bag. Samples were then preserved in 80% ethanol and stained with rose bengal dye to facilitate sample sorting (Mason and Yevich 1967; Lackey and May 1971). Invertebrates were separated from organic debris by flotation in a magnesium sulfate solution (Ladell 1936). The sample was placed in a saturated salt solution for 3 five minute flotation periods. After each flotation period, the solution was rinsed through a 250 um sieve into a Pyrex plate, and placed over a light table. Invertebrates were then picked and stored in 80% ethanol. The portion of the sample which remained in sediment after three flotations was rinsed through a 500 um sieve to obtain invertebrates which may have been too dense to separate out in the salt solution (i.e., Gastropods). Water samples were collected at 2 random locations within each wetland. Samples were analyzed using Hach procedure 8039 for nitrate and 8048 for orthophosphate (Hach 1992). Data Analysis: GPS locations, crop type, yield (kg/ha), and other ancillary data were entered into a data base. Observation number, and the X- and Y-coordinate locations, for each sampling site were extracted from the data base and used to generate a point coverage in Arc/INFO. Each point was attributed with crop type, yield, and ancillary data by joining the original data base to the point attribute table in Arc/INFO. Point coverages were reprojected using the North American 1927 datum to enable integration with existing digital data. Aerial 35 mm slides of selected sections acquired in July and August, 1997 were obtained from the FSA. Slides were projected at approximately 1:8,000 scale and all wetlands in and within 100 m of fields containing selected wetlands were delineated. Wetlands delineated from FSA slides were digitized and integrated with the point coverage of sampling sites to evaluate potential effects of non-target wetlands on yields. Distance of sample points from any wetland was recorded. Wetland effects on yield by crop type and presence or absence of cultivation were evaluated using analysis of variance (Wilkinson et al. 1996). Economic analyses were applied to acreage estimates. A cumulative distribution of economic costs and returns per crop was used to show this relationship across fields by wetland yield zone. Correlation analysis was used to determine relationships between water quality and wetland invertebrate abundance.

Principal Findings and Significance

YIELD ANALYSES: In 1997 all crops, except wetland-planted (wetland planted through instead of around) sunflower, showed a significant increase in yield between the first and second sample area, as distance from the wetland increased. The only additional yield increase occurred between the near and far zones in the wetland-planted soybean sites. Maximum yields for all crops were achieved in the middle or far zones from the wetland. Yield trends in 1998 were similar to 1997. The most frequent significant yield increases occurred between the first and second sampled area. In the not-planted-wetland sites, yields for corn, soybean, alfalfa and sunflower showed no yield differences due to wetland distance zone. This may have been due to less precipitation in 1998 and less of an edge effect around wetlands that were not planted. Crops planted at monitored wetland sites in 1999 included only corn, soybean, and alfalfa. Yields generally increased between the first and second distance from the wetland sampled. Wetland-not-planted alfalfa sites were an exception. High yields in the edge sample at the alfalfa, wetland-not-planted site were not due to increased alfalfa yields, but due to invasion by weedy species around the margin of the wetland. Two trends seemed consistent in all three years of the study. As the distance away from the wetland increased, most significant yield increases occurred between the zone nearest the wetland (or in it) and the zone adjacent to it. Secondly, in cases with no significant yield differences due to wetland distance zone, the wetland was not planted. Averaged over all three years, all crops had significant yield increases between the first and second zone away from the wetland center. In one case, wetland-planted corn, yields increased again between the edge and near zones. ECONOMIC ANALYSES: Center Zone: Net returns to land and management averaged within the cropped wetland center zones were negative in most fields. The most negative returns usually occurred in corn and/or alfalfa fields. However, net returns to crop production in the cropped wetlands generally exceeded direct costs. This shows the short-term economic incentives to crop wetlands, even though full costs are not recovered. During 1998 and 1999, average yields in the wetland center were 22% and 31% respectively of average yields in the field. Edge Zone: Crop yields and net returns to land and management were generally lower in the edge zone than in the other distance zones and were lower than whole field averages. Corn and soybean yields and net returns in the edge zone were higher if adjacent to wetlands not farmed, compared to farmed through wetlands. Distance Zones. Corn and wheat yields and net returns were usually highest in the middle wetland zone. Soybean yields and net returns were usually highest at the far wetland zone. Crop yields in each distance zone (except wetland center) averaged 15% to 34% higher than whole field averages, while net returns to land & management in each zone (except wetland center) were 26% to 44% higher than whole field average returns. Summary: Economic returns in the wetland center zone, if planted, were almost always negative and reduced whole field net returns an average of $23-$25 per acre. Economic returns in the edge zone, were generally lower than net returns in more distant zones, but were higher than in the wetland center. Economic returns in the middle zone were higher than average whole field net returns. The uniformity of key results, regardless of field, crop raised, or year is very important. It is also important to remember that the study was conducted during a period of average to above long-term average precipitation and soil moisture in spring and early summer. Implications: Many crop production costs cannot be avoided regardless of wetland planted/not planted status. Some direct costs (possibly seed, fertilizer, and pesticide costs) and some machinery operation costs can be avoided by not planting through a wetland. However, farming around wetlands can also incur added machinery/labor time costs that are difficult to estimate. A general management/policy approach to the agricultural wetland use dilemma is to increase the profit (reduce the loss) contribution of the wetland center and edge zone. Wetland management scenarios could include grass/forage strips around wetlands, managing wetlands for hunting, or enrollment in wetland preservation programs. A comparison of wetland management (farm through, buffer, CRP, and WRP) for three types of farming systems (organic, conventional, and no-till) in eastern South Dakota shows that within existing policy frameworks, wetland preservation programs offer economic incentives during wet years. Alternatives (such as stewardship payments or increased drainage) could offer alternatives, but they will also require radically different private sector and societal valuation of wetland benefits and costs. ENVIRONMENTAL ANALYSES: Two wetland invertebrate orders had abundances that were significantly correlated to water nitrate-N concentrations. Ten invertebrate orders had abundances correlated to ortho-phosphate concentrations in wetland water. Since invertebrates do not directly absorb nutrients from the water, these correlations indicate an effect of nutrients on food sources or habitat for the invertebraes. Increases in nutrient concentrations generally increase primary production in wetlands and thus enhance food supplies and habitat for invertebrates. The feeding groups enhanced by increased nutrient concentrations in this study were the detrivore/shredders and the herbivore/shredders. Both groups rely on plant material as a food source.

The higher number of correlations to phosphorus (compared to nitrogen) reflects the ephemeral nature of nitrogen in wetlands. While phosphorus is sorbed to the soil and can continue to cycle, nitrogen is rapidly denitrified and lost from the system. South Dakota State University participates in an international exchange with ENSAT University in Toulouse, France to train students in environmental studies. A student from ENSAT spent two months here working on the environmental aspect of this project, including study of water quality and invertebrates in wetlands. She collected samples, performed analysis and prepared a report on her work here. This report is included in the publication list below. LITERATURE CITED Cole, J.D. and T.L. Dobbs. 1990. Crop enterprise and whole-farm budgets for "conventional" farming systems in five areas of South Dakota. Economics Research Report. 90-3. South Dakota State University, Brookings, SD July. Cowardin, L.M. 1982. Some semantic and conceptual problems in wetland classification and inventory. Wildl. Soc. Bull. 10:57-60. Hach Company. 1992. Water Analysis Handbook. Hach Co., Loveland, CO. Janssen, L.L., D.H. Rickerl, T.A. Machacek, D.Kringen, E. Stebbins, and P.K. Wieland. 1994. Groundwater quality and economic impacts of farm practices in wetland areas. Groundwater Res. and Public Ed. Prog. Final Report. 50 pp. Lackey, R.T. and B.E. May. 1971. Use of sugar flotation and dye to sort benthic samples. Trans. Am. Fish. Soc. 100: 794-797. Ladell, W.R.S. 1936. A new apparatus for separating insects and other arthropods from the soil. Ann. Appl. Biol. 23: 862-879. Mason, W.T. and P.P. Yevich. 1967. The use of phloxine B and rose bengal stains to facilitate sorting benthic samples. Trans. Am. Microsc. Soc. 86: 221-223. Rickerl, D.H., L.L. Janssen, B.H. Bleakley, and D.E. Hubbard. 1996. Impacts of agricultural management systems on economic, environmental, and wildlife values of altered and unaltered wetland areas. North Central Region ACE Program Final Report. 73 pp. Smolik, J. and T. Dobbs. 1991. Crop yields and economic returns accompanying the transition to alternative farming systems. J. of Prod. Ag. 4:153-161. Swanson, G.A. 1978. A simple lightweight core sampler for quantitating waterfowl foods. Journal of Wildlife Management 42: 426-428. Swanson, G.A. 1983. Benthic sampling for waterfowl foods in emergent vegetation. Journal of Wildlife Management 47: 821-823. Wilkinson, L., G. Blank, and Christian Gruber. 1996. Desktop data analysis with SYSTAT. Prentice Hall, Upper Saddle River, NJ.

Descriptors

Wetlands, agroeconomics, and aquatic invertebrates

Articles in Refereed Scientific Journals

Book Chapters

Dissertations

Rogers, Randall. PhD Dissertation. 2000. Farmer's Choice of Conservation Wetland Practices. 178 pp. Jahnke, Brandon. MS Thesis. 2000. Impacts of Land use on Aquatic Invertebrate Abundances and Their Correlations with Nutrients in Prairie Pothole Wetlands. In Progress.

Water Resources Research Institute Reports

Conference Proceedings

Other Publications

Mohr, Eglantine. 1999. N and P in wetland soils and water as influenced by wetland management

system. ENSAT Research Report. Toulouse, France. 27 pp. Rickerl, D., L. Janssen, and R. Johnson. 1999. Agroeconomic impacts of wetlands in the Prairie Pothole Region. Soil and Water Science Research Annual Report. 36. Kirschenmann, T. R., D.E. Hubbard, and D.H. Rickerl. 2000. Avifauna of agricultural wetlands on three farms in eastern South Dakota. SD Academy Science. In Press. Rickerl, D.H., L.L. Janssen, and R. Woodland. 2000. Buffered wetlands on agricultural lands benefit productivity, biodiversity, and nutrient cycling. Assessing the Benefits of Watershed Management Practices. USEPA. April 2000. pp 63-64. Jahnke, B. and D.H. Rickerl. 2000. Impacts of land use on aquatic invertebrate abundances and their correlation to nutrient concentrations in Prairie Pothole wetlands. SD Academy of Sci. In Press. Rickerl, D.H., L.L. Janssen, and R.R. Johnson. 1999. Agroeconomic impacts of wetlands in the Prairie Pothole Region. ASA Abs. p 368.

Basic Project Information

Basic Project Information	
Category	**Data**
Title	Assessment of Non-Point Source Pollution Projects in South Dakota: A Case Study of Pickerel Lake
Project Number	B-03
Start Date	03/01/1999
End Date	02/28/2000
Research Category	Water Quality
Focus Category #1	Non Point Pollution
Focus Category #2	Surface Water
Focus Category #3	Water Quality
Lead Institution	South Dakota State University

Principal Investigators

Principal Investigators			
Name	**Title During Project Period**	**Affiliated Organization**	**Order**
David R. German	Research Associate	South Dakota State University	01

Problem and Research Objectives

Pickerel Lake became the first lake protection project recommended for funding to the US EPA by the Non-Point Source Task Force. A lake protection project sponsored by the Day Conservation District started in 1992. The project was completed in 1996 (Skadsen and German, 1996). Several other lake protection projects have since been funded and are currently in various stages of completion. There have been no efforts made to determine the effectiveness of these projects. Have measurable water quality improvements occurred in the targeted lakes? Have farmers continued to use management practices designed to improve water quality after cost share incentives ended? Did the lake protection project have a lasting affect on land use in the watershed? This proposal is designed to provide quantitative answers to these questions using Pickerel Lake as a case study. This study will provide a means of comparing in-lake water quality before, during and after the Pickerel Lake Protection project to determine if measurable water quality changes have occurred. Evidence of water quality improvement or maintenance of current water quality could be used to support similar efforts underway or planned for other lakes that have been designated for lake protection projects. A more thorough understanding of a lake's response to watershed treatment will improve our ability to manage these lakes. This study will provide better insight into farmer's attitudes and degree of acceptance of lake protection projects. It will also provide a measure of whether watershed treatment measures remain in place after financial incentives have ended. This information will be used by future non-point source projects to improve farmer acceptance and increase the permanence of watershed treatment measures.

Methodology

This project involves use of a Geographic Information System (GIS) which is being used to compare pre-project, post-project, and current watershed conditions. The GIS will be evaluated as a tool for watershed assessment and post-project evaluation. A graduate student in Geography will produce a thesis based on the use of GIS as a watershed evaluation or assessment tool. The graduate student will combine water monitoring and GIS to develop pollutant values for various areas of the watershed, and use a watershed model to predict future water quality and loadings if land use in the watershed changes. In-lake water quality samples were collected from three mid lake stations on Pickerel lake. A composite surface sample for the lake and a composite near bottom sample was formed by mixing water collected near the bottom from each of the three sites in each lake. Composite samples were be collected within six days of mid-month in June, July, August, September and October. Parameters analyzed on lake samples included: 1. Total phosphorus 2. Total dissolved phosphorus 3. Organic nitrogen 4. Ammonia 5. Nitrate + nitrite 6. Suspended solids 7. pH 8. Air and water temperature 9. Dissolved oxygen 10. Secchi depth 11. Chlorophyll a (surface samples only) Runoff samples and flow measurements planned for the project have not been collected due to dry conditions and lack of runoff in the watershed. One site for four land use categories (cropland, CRP, pasture, and hayland) in the watershed was selected. Runoff water quality, if available by the end of the project, will be used to select appropriate runoff coefficients for use in the GIS analysis of the watershed.

Principal Findings and Significance

During the first year of this study, the gruaduate student has: • Evaluated Arc/Info versus ArcView software for best suitability to accomplish the project goals. • Completed course work in the modeling, and spatial applications of ArcView, and basic cartographic and land use land cover philosophies. He also developed a thesis proposal and plan which is under review for application to the South Dakota State University Graduate School. • Conducted a literature search on the use of GIS as a watershed management tool. • Selected representative small watersheds and installed monitoring sites for each land use practice. Four monitoring stations were established in the watershed representing four major land uses. Dry conditions existed following establishment of the sites and no samples were collected. Water quality monitoring at Pickerel Lake indicated no significant change in water quality has occurred. Water quality data was made available to the South Dakota Department of Environment and Natural Resources and a summary of project activities was published in a newsletter published by the Upper Waubay Watershed Improvement Project, sponsored by the Day and Roberts Counties Conservation Districts. Literature Cited Skadsen, Dennis and David German. 1996. Pickerel Lake Protection Project Final Report, Day Conservation District, Webster, South Dakota.

Descriptors

Watershed management, Lakes, Water Quality, Geographic Information System, Non-Point Source Pollution.

Articles in Refereed Scientific Journals

Book Chapters

Dissertations

Water Resources Research Institute Reports

Conference Proceedings

Other Publications

Information Transfer Program

Water is one of the most important resources in South Dakota. Together with the state's largest industry, agriculture, it has and will continue to play an important role in the economic future of the state. Enhancement of the agricultural industry and allied industries, the industrial base and, therefore, the economy of South Dakota all depend on compatible development of our water resources. The South Dakota Water Resources Institute (SD WRI) base grant program, with support from state funds, was used to develop and maintain working relationships with local, state and federal agencies to enhance management of water resources in South Dakota. Information Transfer Program/Publishing The education and information transfer roles are an important part of the SD WRI programs. Information was provided to the public, researchers, resource managers and agencies through SD WRI staff. This included responding to questions received from the general public, other state agencies, livestock producers and County Extension Agents concerning water quality issues related to stream monitoring, surface water ground water interactions, livestock poisoning by algae, lake protection and management, fish kills and other issues related to water quality. The SD WRI Water Quality Laboratory also provided important testing services to livestock producers and other rural water users. The waters in many areas of South Dakota have high sulfates, and other dissolved solids that can be detrimental to livestock health and productivity. Water Resources Institute staff also continued to provide interpretation of analysis and recommendations for use of water samples submitted for analysis for other uses, such as irrigation, lawn and garden, farmstead, and heat pump. SD WRI staff continue to update and improve information available to individuals with water quality problems. The advent of the Internet has dramatically increased the amount of information available for distribution. Educational materials concerning the effects of poor water quality and solutions available are given a high priority. Due to enactment of more stringent controls on agricultural discharges, SD WRI staff have seen a substantial increase in inquiries regarding agricultural practices and their effect on water quality. In response to this, two new package analyses (land application of waste and rural runoff) were added to the Water Quality Lab's list of services. Information transfer to individuals concerned with these issues is becoming an important component of the Institute's Information Transfer Program. SD WRI staff also have created web pages for the Institute as well as the Water Quality Lab to provide up-to-date information to the public about current issues in water quality. EPA is moving toward national regulations for land applications of waste in response to the fact that non-point source discharges of phosphorus, and in some instances nitrogen, are a primary cause of serious eutrophication problems in streams, lakes and wetlands in some agricultural areas where large animal concentrations are present. South Dakota regulations for the application of animal waste are based upon the nitrogen needs of the crop. This results in excessive phosphorus applications (i.e. relative to the phosphorus needs of the crop), and it is likely that eutrophication problems will increase in South Dakota as a result. Information is needed about non-point losses of phosphorus in runoff as affected by land applications of livestock waste. This will provide a basis for the state to develop reasonable regulations that protect the water quality of streams and lakes without placing undue hardships on livestock producers. SD WRI staff have initiated a review of available literature to identify research that is applicable to this problem and to identify research needs. This effort by the SD WRI will likely influence how animal wastes are managed in South Dakota in the future. South Dakota is currently developing Total Maximum Daily Loads (TMDL's) for numerous water bodies. TMDL's are an important tool for the management of water quality. The goal of a TMDL is to ensure that waters of the state attain water quality standards and provide designated beneficial uses. A TMDL is defined as "the sum of the individual waste load allocations for point sources and load allocations for both nonpoint source and natural background sources established at a level necessary to achieve compliance with applicable surface water quality standards". In other words, a TMDL limits the total pollution load of any given water body to the TMDL it can bear and still remain healthy. TMDL's are required on waters that do not attain water quality standards or assigned beneficial uses. The SD WRI Water Quality Laboratory is providing laboratory support for two TMDL projects in eastern South Dakota, including the Central Big Sioux River Watershed Assessment Project, being conducted by East Dakota Water Development District, and the Bachelor Creek project, being conducted by the SDSU Biology Department. Water Festivals were included in the NPS Task Force's Information and Education plan in 1992 with one Water Festival held in Spearfish, South Dakota. Water Festivals have since been held in seven sites including Spearfish, Rapid City, Pierre, Huron, Vermillion, Brookings and Sioux Falls. Since their inception, Water Festivals in South Dakota have impacted approximately 35,000 fourth grade students state wide, 9,500 of which have attended our own local festival, the Big Sioux Water Festival (BSWF). SD WRI staff member David German has served as the Exhibit Hall Chair for the BSWF, held here at South Dakota State University. The Exhibit Hall provides a hands-on learning experience for these students from all over eastern South Dakota. Exhibits ranged from groundwater contamination to live aquatic animals and plants. SD WRI staff members John Bischoff, David German, and Shirley Mittan also hosted exhibits and gave presentations titled "Under the Microscope", "Good Water-Bad Water", "Wonder What's In Your Water?", and a computer quiz on water quality at the BSWF, as well as those in Huron and Sioux Falls, South Dakota. Another SD WRI staff member, Nancy Stuefen, has chaired the BSWF Guide Committee since 1994 and has assisted the Festival Coordinator in developing new presentations each year. The BSWF has also been chosen as a national model of water festivals as a result of our innovative approach to water education, and our festival coordinator has been chosen to serve on the National Water Festival advisory committee, "Tools for Tomorrow". SD WRI continued other activities to support water quality education in local schools. WRI staff presented a water studies activity on water quality to 4th grade classes from Central Elementary, the Brookings Middle School, and classes from the Sioux Valley Schools at Oakwood State Park. In addition, SD WRI Research Associate Dave German gave a talk to Lake Kampeska Water Project District members about River-Pesticide project results and Feedlot Runoff project results, taught a water quality unit to 200 Girl Scouts at a two-day camp at Oak Lake Field Station, and presented a seminar to a SDSU Biology Class regarding careers in water resources. Water education was also used as a training opportunity. Undergraduate students working in summer positions at SD WRI participated as assistant instructors for the Water Festival and gave presentations to local schools. SD WRI staff continue to serve as a resource for SDSU students working on projects and papers related to environmental studies and water quality.

USGS Internship Program

Student Support

Student Support					
Category	**Section 104 Base Grant**	**Section 104 RCGP Award**	**NIWR-USGS Internship**	**Supplemental Awards**	**Total**
Undergraduate	4	2	N/A	N/A	6
Masters	4	1	N/A	N/A	5
Ph.D.	1	N/A	N/A	N/A	1
Post-Doc.	N/A	N/A	N/A	N/A	N/A
Total	9	3	N/A	N/A	12

Awards & Achievements

Project B-02 PI and cooperators have received additional funding for related research as follows: Clay, D.E., C.G. Carlson, K. Dalsted, and S.A. Clay. 2000-2001. Using remote sensing to identify management zones. $50,000, North Central Soybean Board. Clay, D.E., C.G. Carlson, and S.A. Clay. 2000-2003. $55,000. The influence of precision farming on profitability. United Soybean Board through Potash and Phosphate Institute. Clay, D.E. C.G. Carlson, D.D. Malo, and S.A. Clay. 1999-2000. $41,000. Development of educational materials for precision farming. EPA through SD DENR. Clay, D.E., S.A. Clay, and C.G. Carlson. 1999. $5,700. High speed computer and GIS software. Governors technology fund. Clay, D.E., S.A. Clay, C.G. Carlson, and K. Dalsted. 1999-2002. $153,000. Factors limiting soybean yields. North Central Soybean Board. Project B-04 Principal Investigator Dr. Diane Rickerl received an invitation to present research results in a special session at the 1999 American Society of Agronomy Meetings and was also invited by the United States EPA to publish in a Watershed Management publication.

Publications from Prior Projects

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