Introduction

The Kansas Water Resources Institute is part of a national network of water resources institutes in every state and territory of the U.S. established by law in the Water Resources Research Act of 1964. The network is funded by a combination of federal funds through the U.S. Department of the Interior/Geological Survey (USGS) and non-federal funds from state and other sources. KWRI is administered by the Kansas Center for Agricultural Resources and the Environment (KCARE) at Kansas State University. An Administrative Council comprised of representatives from participating higher education or research institutions, state agencies, and federal agencies assists in policy making. The mission of KWRI is to: 1) develop and support research on high priority water resource problems and objectives, as identified through the state water planning process; 2) facilitate effective communications among water resource professionals; and 3) foster the dissemination and application of research results. We work towards this mission by: 1) providing and facilitating a communications network among professionals working on water resources research and education, through electronic means, newsletters, and conferences; and 2) supporting research and dissemination of results on high priority topics, as identified by the Kansas State Water Plan, through a competitive grants program.
Research Program Introduction

Our mission is partially accomplished through our competitive research program. We encourage the following through the research that we support: interdisciplinary approaches; interagency collaboration; scientific innovation; support of students and new young scientists; cost-effectiveness; relevance to present and future water resource issues/problems as identified by the State Water Plan; and dissemination and interpretation of results to appropriate audiences. In implementing our research program, KWRI desires to: 1) be proactive rather than reactive in addressing water resource problems of the state; 2) involve the many water resources stakeholders in identifying and prioritizing the water resource research needs of the state; 3) foster collaboration among state agencies, federal agencies, and institutions of higher education in the state on water resource issues; 3) leverage additional financial support from state, private, and other federal sources; and 4) be recognized in Kansas as a major institution to go to for water resources research.
An Analysis of Sedimentation Reduction Strategies for Tuttle Creek Lake

Basic Information

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Publication

An Analysis of Sedimentation Reduction Strategies for Tuttle Creek Lake

Kansas Water Resources Competitive Grants Program
FY 2008

Principal Investigators and Institutional Affiliations:
Dr. Amirpouyan Nejadhashemi, Biosystems Engineering, Michigan State University
Mr. Craig Smith, Agricultural Economics, Kansas State University
Dr. Jeff Williams, Agricultural Economics, Kansas State University
Dr. Kyle Douglas-Mankin, Biological and Agricultural Engineering, Kansas State University
Dr. Bill Golden, Agricultural Economics, Kansas State University

Project duration: March 1, 2008 to February 28, 2011 (3 Years)

Keywords: Decision support system, Economic analysis, Sediment load, Watershed modeling.
An Analysis of Sedimentation Reduction Strategies for Tuttle Creek Lake

Problem Statement and Objectives
Sediment is a leading cause of stream and lake impairment in the U.S. (US EPA, 2000). Sediment is related to several important issues including water quality and reservoir water-storage capacity. Many citizens, municipalities, and industries in Kansas rely on federal reservoirs as a source of drinking water, recreation, and water supply. Because of their significance to the State of Kansas, management of the reservoirs and their associated watersheds is important to protect the reservoirs from further degradation. Cost-effective reservoir management requires information about water quality, sedimentation, sediment quality, and the costs of alternative management strategies. In Kansas, 33% of assessed lake acres were impaired for suspended solids and 78% were impaired for nutrients/eutrophication (KDHE, 2004). Channelization of streams and accelerated sedimentation in streams have led to flooding, loss of fish habitat, and loss of stream function. Like many states, Kansas is seeking to develop watershed restoration and protection strategies that address these impairments with sound land-management decisions. The major emphasis of these efforts is to address water quantity and quality problems by reducing contributions of sediment from croplands, grazing-lands, streambanks, and urbanized areas.

Tuttle Creek Lake exhibits, perhaps, one of the most critical cases of reservoir sedimentation in Kansas. As of 2005, USGS estimated that the lake’s sediment pool had reached about 70% of design capacity and would fill by 2023 (Zeigler and Juracek, 2006). Even more startling, they reported that Tuttle Creek Lake’s conservation pool was almost 40% full with sediment, a unique result of the sediment pool volume being over half of the conservation pool volume. Urgent action is needed to reverse sediment accumulation trends in Tuttle Creek Lake and other Kansas reservoirs, and this action must be based on a better understanding of watershed and stream sediment loading characteristics as well as the economic implications of alternative reservoir/watershed management alternatives.

The following project objectives are proposed toward addressing these problems:

1) estimate total sediment volume and mass;
2) estimate annual sediment deposition and yield from the basin;
3) determine the occurrence and trends of constituents;
4) quantify sediment delivery ratios above the reservoirs;
5) quantify linkages among nutrient management, land use, best management practice (BMP) implementation, and water quality at watershed scale;
6) estimate costs of alternative BMP scenarios to reduce reservoir sedimentation;
7) estimate the amount of additional conservation funding that would be needed to achieve various levels of annual sedimentation reduction;
8) develop a dredging cost analysis;
9) compare the costs of watershed management scenarios to dredging (and various combinations of each) to a “do-nothing” scenario;
10) apply Decision Support System (DSS) technology to develop a BMP allocation plan for sediment control; and
11) provide a baseline for future assessments.
Methods

Data collection is the first step in this study. This is important because it helps to provide essential information for the watershed modeling and economic analysis. In this regard, the following information was collected for the Lower Little Blue and Lower Big Blue watersheds:

1.0 Watershed Assessment

1.1 Watershed Summary: This section provides a general overview about the watershed.

1.2 Overview of Water Quality Issues and Potential Pollution Sources: This section summarizes the previous studies concerning the source and severity of the water quality problems in the watershed.

2.0 Climate Data

2.1 30-Year Average Annual Precipitation Map: This data set contains spatially gridded average monthly and annual precipitation for the climatological period 1971-2000. Distribution of the point measurements to a spatial grid was accomplished using the parameter-elevation regressions on independent slopes (PRISM) model, developed by of Oregon State University PRISM Group.

2.2 30-Year Average Daily Maximum Temperature Map: This data set contains spatially gridded monthly and annual maximum temperature for the climatological period 1971-2000. Distribution of the point measurements to a spatial grid was accomplished using the parameter-elevation regressions on independent slopes (PRISM) model, developed by of Oregon State University PRISM Group.

2.3 30-Year Average Daily Minimum Temperature Map: This data set contains spatially gridded monthly and annual minimum temperature for the climatological period 1971-2000. Distribution of the point measurements to a spatial grid was accomplished using the parameter-elevation regressions on independent slopes (PRISM) model, developed by of Oregon State University PRISM Group.

2.4 Weather Station Locations: Weather stations within the area of interest were identified. The climatological data was downloaded from the National Climatic Data Center (NCDC) for all of the stations. However, we do not have a plan to use all stations for the modeling. The selected stations should contain long-term climatological data and located within and around the study area to represent variable meteorological conditions in the watershed.

2.5 Meteorological Products (such as precipitation and temperature): Long-term meteorological data were downloaded and compiled for all weather stations within the study area. These set of databases will be incorporated in the model in the next step of this study.
3.0 Land Use/ Land Cover Maps

3.1 Land Use (GIRAS 1980s): This is land use/land cover digital data collected by USGS and converted to ARC/INFO by the EPA. This data, which resides in EPA's Spatial Data Library (ESDLS), is useful for environmental assessment of land use patterns with respect to water quality analysis, growth management, and other types of environmental impact assessment.

3.2 Land Use (NLCD 1992): Derived from the early to mid-1990s Landsat Thematic Mapper satellite data, the National Land Cover Data (NLCD) is a 21-class land cover classification scheme applied consistently over the United States. The spatial resolution of the data is 30 meters and mapped in the Albers Conic Equal Area projection, NAD 83. The NLCD are provided on a state-by-state basis.

3.3 Land Use (NLCD 2001): NLCD 2001 products include 21 classes of Land Cover, Percent Tree Canopy and Percent Urban Imperviousness at 30 m cell resolution.

Note: Three sets of land use maps were obtained for the study area. In addition, the overall landuse changes were observed and summarized in a table, which was presented in the comprehensive assessment reports.

4.0 River Network

4.1 Reach File Version 1 (RF1): Provides stream network for major rivers and supports development of stream routing for modeling purposes.

4.2 National Hydrography Dataset: Spatial dataset based upon the USGS DLG and the USEPA Reach File Version 3 that is more refined and expanded. Contains information about surface water features which are combined to form reaches (surface water drainage network), facilitating in routing for modeling purposes (1:100K).

5.0 Hydrologic Soil Groups

5.1 Hydrologic Soil Groups: The hydrological soil groups’ map was provided for the study area based on the Soil Survey Geographic (SSURGO) Database.

6.0 Water Quality Conditions

6.1 The 303d List of Impaired Waterbodies: The map of impaired streams that are not meeting their designated uses as defined in Section 303(d) of the Clean Water Act was developed. This can be used to identify specific stream segments and lakes for which, in accordance with their priority ranking, TMDLs may need to be developed. Also for each impaired stream, the causes of impairment were identified and presented in a table in the comprehensive assessment reports.
6.2 Water Quality Observation Stations: Water quality monitoring stations were identified within the watersheds. The observed water quality data of some of these sites will be used to calibrate and validate the modeling results.

6.3 USGS Gage Stations: The USGS gage stations were identified and mapped. In addition, the period of record for each station were reported. The data from these stations will be used to calibrate the model performance regarding surface water flow.

6.4 Permitted Point Source Facilities: The data and map regarding the national pollutant discharge elimination system (NPDES) permit-holding facility within the study area were collected and summarized. These information contains parameter-specific loadings to surface waters computed using the EPA Effluent Decision Support System (EDSS) for 1990-1999. The summary of discharge concentrations and loads allows the user to perform a planning-level assessment of the magnitude and severity of point source contributions. Analyzing the data for different years can provide information to evaluate changes in contributions from various point sources over time and support trend analysis.

6.5 Confined Animal Feeding Operations (CAFOs): Animal feeding operations classified as large or presenting a high risk to discharge can be classified as CAFOs and are likely required to have an NPDES permit. Even though the data from this section might not directly applicable to this study; however, this information can be used by other people while performing overall water quality assessment for the watershed.

6.6 1990 Population and Sewerage by Census Tract: The information provided in this section can be used to examine specific areas for population density and the prevalence of septic systems, which can be significant sources of pathogens, household chemicals, and nutrients (especially nitrate) escaping into groundwater and nearby receiving water bodies. Similar to section 6.5, this information might not directly applicable to this study; however, it can be used by other people while performing overall water quality assessment for the watershed.

7.0 Agricultural Economy

7.1 Corn Cost-Return Budget: The information provided in a corn cost-return budget can be used for characterizing the current agricultural economy when combined with data from the 2002 Census of Agriculture. This will be useful in analyzing the economic and environmental impacts of different BMPs.

7.2 Soybean Cost-Return Budget: The information provided in a soybean cost-return budget can be used for characterizing the current agricultural economy when combined with data from the 2002 Census of Agriculture. This will be useful in analyzing the economic and environmental impacts of different BMPs.

7.3 Wheat Cost-Return Budget: The information provided in a wheat cost-return budget can be used for characterizing the current agricultural economy when combined with data
from the 2002 Census of Agriculture. This will be useful in analyzing the economic and environmental impacts of different BMPs.

7.4 Grain Sorghum Cost-Return Budget: The information provided in a grain sorghum cost-return budget can be used for characterizing the current agricultural economy when combined with data from the 2002 Census of Agriculture. This will be useful in analyzing the economic and environmental impacts of different BMPs.

7.5 Alfalfa Cost-Return Budget: The information provided in an alfalfa cost-return budget can be used for characterizing the current agricultural economy when combined with data from the 2002 Census of Agriculture. This will be useful in analyzing the economic and environmental impacts of different BMPs.

7.6 Common Cropland BMPs in the Watershed: This list contains common cropland BMPs that are most effective at reducing erosion and sedimentation in the Tuttle Creek watershed. Typical BMP budgets and economic analyses are presented for vegetative buffers and streambank stabilization projects in the Tuttle Creek watershed. Similar types of analyses will be performed on other BMPs in the list.

7.7 Economic Contributions of Recreation at the Lake: This study estimated the regional economic effects arising from recreation at Tuttle Creek Lake. This analysis can help local and state decision-makers and others appreciate the value of preserving recreational amenities at Tuttle Creek Lake.

7.8 Census Data: The 2002 Census of Agriculture data was compiled to show the size and sales distribution of farms, harvested crop acreage, and livestock numbers in the Tuttle Creek watershed. When combined with the crop and BMP budget data, this will be useful in analyzing the economic and environmental impacts of various sedimentation reducing strategies.

8.0 Modeling

Thorough assessment of a watershed often requires the use of watershed models to evaluate the effects of land uses and practices on pollutant loading to waterbodies. Like any project, time and money are two major limitations in water quality projects. Therefore, it is important to select the simplest model that will answer watershed stakeholder questions. In this stage of study, Spreadsheet Tool for Estimating Pollutant Load (STEPL) model was used as a basic screening tool, which is capable of providing a rapid, initial assessment of water quality conditions. The results of the STEPL modeling support an assessment of the relative significance of different pollutant sources and provide direction for continuing monitoring efforts. STEPL model generates gross estimates of pollutant loadings and have limited predictive capability. This model is typically applied on a sub-watershed basis, where loading can be aggregated over longer periods. This model also can be used to examine the impact of BMPs on pollutant loading over annual period. The major advantage of employing the STEPL model is that it provides a rapid means of identifying different pollutant sources and determining the impact of
BMPs with minimal effort and data requirements. This model can appropriately apply to conduct preliminary planning level investigations.

8.1 Subbasin Map: All subbasins in HUC 14 digit were identified and their areas were estimated.

8.2 Input Data: National databases were compiled and used to estimate the landuse and animal distribution, number of septic system and failure rate, and hydrologic group for the area of interest. This information is required input for the STEPL model.

8.3 Model Output: The model outputs are provided by HUCO (overlay of county and 8-digit hydrologic unit boundary). In addition, the contribution of each land use to the total pollution load was presented in a separate table.

Results and their Significance

Two comprehensive reports were published and posted online; one for the Lower Big Blue watershed, and a second one for the Lower Little Blue watershed.

Initial modeling study showed that the biggest source of the sedimentation in the watershed originates from the cropland fields.

Decision-Making Tool Development

With sedimentation threatening the current and future utility of many of our nation’s drinking water reservoirs, it is particularly critical, especially in tight budgetary times, that conservation investments be targeted to projects that yield the most environmental improvements per dollar spent. This can be a challenging task considering the multitude of political, economic, and environmental variables involved in the (typically) local decision-making process. To aid in the development of cost-effective watershed scale management plans, agricultural economists at Kansas State University developed a user-friendly tool, K-State Watershed Manager.

K-State Watershed Manager is a spreadsheet program that can support local technical-assistance outreach to enhance the development of cost-effective watershed-scale management plans. Using this program, watershed stakeholder groups and technical assistance providers can estimate, optimize, and compare the economic and environmental effects of alternative watershed management plans.

Users begin by providing a quantitative description of their watershed along with their pollutant reduction goals. Next, users identify a preferred set of cropland BMPs. K-State Watershed Manager provides estimates of both the investment and annualized costs of the BMPs along with estimates of potential cost-share funding and pollutant load reductions. Users then have the option of either optimizing their plan (subject to a budget constraint or pollutant reduction goal) or continuing with their initial set of selected BMPs. Finally, users can compare cost estimates of pollutant load reductions for multiple watershed management plans.
**K-State Watershed Manager** is a flexible program that accommodates watershed-specific data. This includes, but is not limited to: user-identified BMPs, costs, pollutant reduction efficiencies, pollutant reduction goals, combinations of BMPs, and various levels and scales of watershed modeling.

**K-State Watershed Manager** has been and is currently being used to analyze the cost-effectiveness of various watershed management plans in the Tuttle Creek watershed. Utilizing **K-State Watershed Manager**, each plan is evaluated in terms of the amount of sediment, phosphorus, and nitrogen load reduction from cropland fields in the watershed. The results have been presented to the local stakeholders for their input. This iterative process has occurred over multiple months and will ultimately conclude with the approval of a preferred BMP implementation plan.

A User’s Guide with complete documentation is currently being developed to accompany this tool. The development and refinement of this decision-making tool has been financially supported by various WRAPS projects along with this KWRI grant.

### List of Publications and Presentations


Smith, C.M. "Developing a BMP Implementation Plan Using K-State Watershed Manager.” Presented at:


**K-State Watershed Manager** was used by Watershed Economist, Josh Roe, at the following Tuttle Creek Lake WRAPS Stakeholder Leadership Team Meetings on the following dates:
- August 29, 2008
- September 30, 2008
- October 30, 2008
- November 19, 2008
- December 15, 2008
- January 15, 2009
- February 17, 2009
- April 1, 2009
May 5, 2009

**Information Transfer**

This project is a fully integrated Research/Extension education initiative. Extension programming includes developing and delivering educational programs. To this extent, we have published two comprehensive reports that are posted online. These reports were presented to the stakeholder leadership team and their feedback was used to update and refine the information within those reports.

**Student Support**

This project will provide partial funding for one Agricultural Economics PhD graduate student, Craig Smith. Craig’s plans are to complete, along with Jeff Williams and Bill Golden, all economic analyses tasks as presented in the original project proposal. In addition, Craig hopes to extend this project further using more complex analytical and optimization techniques in an effort to produce dissertation-quality research which will be at the frontier of sedimentation and watershed management research. Craig continues to work with the current Watershed Economist, Josh Roe, and Jeff Williams in the development and application of *K-State Watershed Manager* in watersheds throughout the state.
Information Transfer Program Introduction

The primary information transfer program of the KWRI is an annual statewide water conference held in March each year. The conference in 2008 was the 25th annual conference. The theme was "Past Accomplishments/Future Challenges". Approximately 220 people attended. twenty-four scientific papers were presented in plenary and concurrent sessions.
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### Publication
2008 Kansas Water Resources Competitive Grants Program

Title of project: Water and the Future of Kansas Conference

Principal Investigators and institutional affiliations: Dr. William Hargrove, Director of the Kansas Center for Agricultural Resources and the Environment

Project category: Information Transfer

Project duration: March 1, 2008 to February 28, 2009

Federal funds requested: $2,902

Non-federal funds pledged (matching): $21,749

Key words: Water, information transfer, sedimentation, conference
Annual Conference and Other Meetings
The annual Water and the Future of Kansas Conference is an event sponsored by KWRI. The conference: 1) is an important venue for disseminating results of research sponsored by KWRI; 2) serves as a “Water Resources Town Meeting” to discuss general research needs, specific agency needs, and technology transfer needs in the area of water resources; and 3) provides a forum for stakeholders to make input that would serve as a basis for the competitive grants program “Call for Proposals”.

The 2008 conference will be held March 25, 2008 at the Maner Conference Center at the Capitol Plaza Hotel in Topeka, KS.

Plenary Sessions

- 25 Years of Progress in Kansas Water Policy: Kansas Governors Panel
  Governor Kathleen Sebelius (invited)
  Former Governor John Carlin (1979-1987)
  Former Governor Mike Hayden (1987-1991)
- Well, Well, Well: The High Plains Aquifer
  David Pope
  Former Chief Engineer, Division of Water Resources
  Kansas Department of Agriculture
- Bioenergy and Water: Does It Make Cents/Sense?
  Dennis Kenney
  Former Director, Leopold Center, Iowa State University
  Senior Fellow, Institute for Agriculture and Trade Policy, Ames, Iowa
- Smart Growth: Can We Do It in Kansas?
  Stacy Hutchinson
  Department of Biological and Agricultural Engineering
  Kansas State University
- Sedimentation of Our Reservoirs: Are They Half Full or Half Empty?
  Mark Jakubauskas
  Kansas Biological Survey
  University of Kansas
- New Water Quality Challenges: Emerging Contaminants
- Emerging Contaminants of Surface and Groundwater
  Mark Meyer
  U. S. Geological Survey
  University of Kansas
• Occurrence of Antibiotics in Treated Wastewater Discharged to Surface Water in Kansas
  Alok Bhandari
  Department of Civil Engineering
  Kansas State University

• Occurrence and Fate of Steroidal Hormones in Surface Waters Impacted by Cattle Grazing and Animal Agriculture
  Ed Kolodziej
  Department of Civil and Environmental Engineering
  University of Nevada

Concurrent Sessions

• Sedimentation of Our Federal Reservoirs

• Adaptive Watershed Modeling: An Approach to Integrate Local Stakeholder Knowledge with Best Science
  Pouoyan Nejadeshemi and Kyle Mankin
  Department of Biological and Agricultural Engineering
  Kansas State University

• BMP Auctions as a Tool for Targeting Implementation of Conservation Practices
  Craig Smith and John Leatherman
  Department of Agricultural Economics
  Kansas State University

• Smart Growth

• The Art and Science of Bioretention Cells: Lessons Learned from Lenexa, KS
  Mike Beezhold
  City of Lenexa
  Lenexa, Kansas

• Alternative Urban Stormwater Management Research and Education Programs in Landscape Architecture at Kansas State University
  Lee Skabelund
  Department of Landscape Architecture
  Kansas State University

• Bioenergy and Water

• Bioenergy and Water Panel: Lessons Learned in Iowa, Applications in Kansas
  Rick Cruse
Director, Water Center
Iowa State University

- Dennis Keeney
  Senior Fellow, IATP
  Ames, Iowa

- Bill Hargrove
  Director, Kansas Center for Agricultural Resources and the Environment
  K-State Research and Extension

- The Future of Cellulosic Ethanol in Kansas
  Tom Robb
  Abengoa, Inc.
  Garden City, Kansas

- Closed Cycle Processing of Natural Products: Possible Lessons from Pulp Production
  Peter Pfromm
  Department of Chemical Engineering
  Kansas State University

- High Plains Aquifer
- Deficit Irrigation Management
  Freddie Lamm
  Northwest Kansas Research and Extension Center
  Colby, Kansas

Lunch Presentation

- Climate Change Impacts on Kansas and the Great Plains
  Dr. Roger Pulwarty, Director
  Climate Diagnostics Center/Western Water Assessment
  National Oceanic and Atmospheric Administration and the University of Colorado

Poster Sessions

- Poster papers on a wide variety of water resource-related issues
USGS Summer Intern Program

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Notable Awards and Achievements