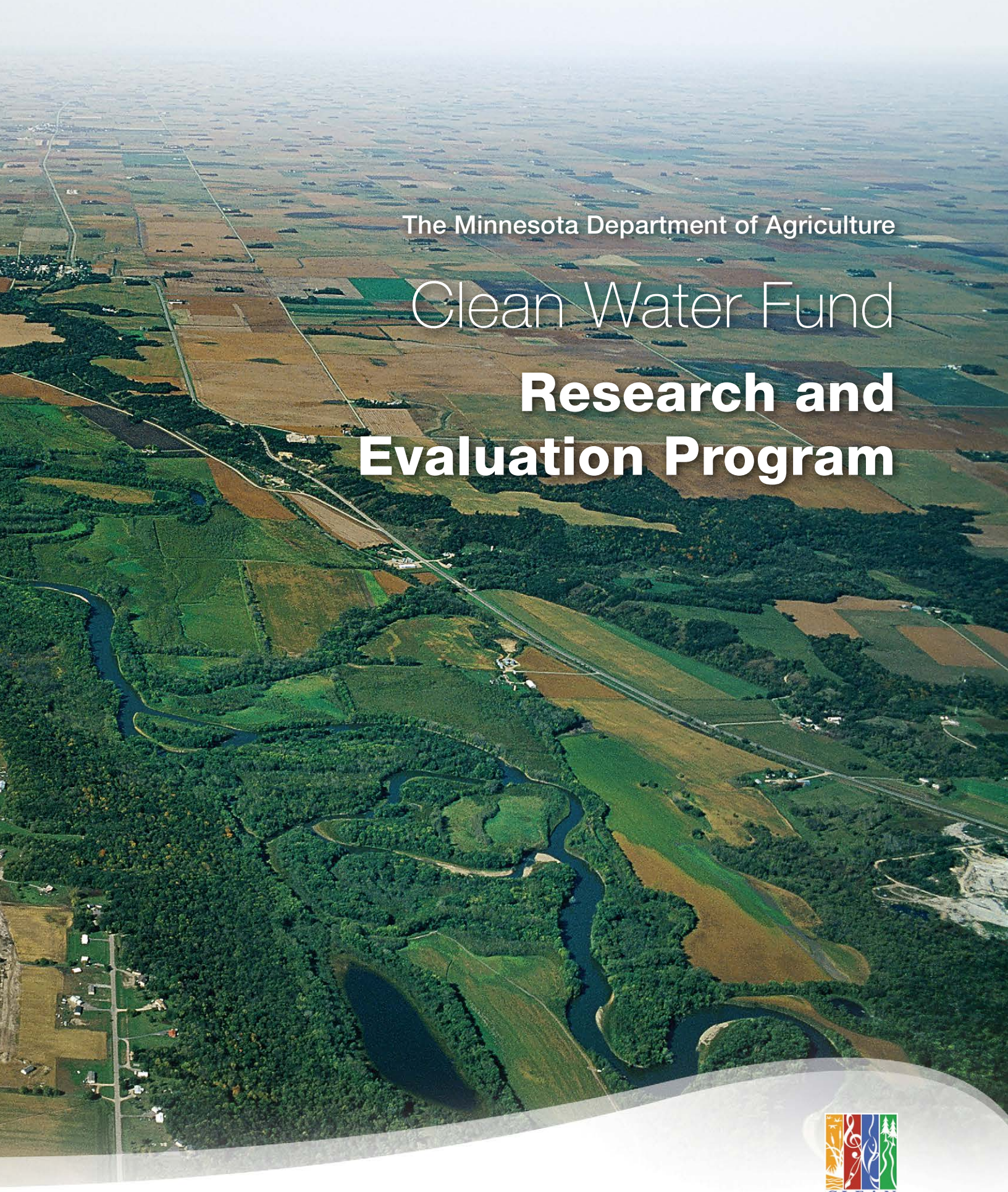

The Minnesota Department of Agriculture

Clean Water Fund

Research and Evaluation Program

Minnesota Department of Agriculture

CLEAN WATER LAND & LEGACY AMENDMENT

Chisago County
Credit: Kent Larson

On November 4, 2008, Minnesota voters approved the Clean Water, Land and Legacy Amendment to the state constitution. The Amendment increased the sales and use tax rate by three-eighths of one percent, starting July 1, 2009 and continuing through 2034. Amendment dollars are dedicated to four separate funds, one of which is the Clean Water Fund.

The Minnesota Department of Agriculture (MDA) is using Clean Water Fund dollars to support agricultural research and evaluation. Funded projects help provide current and accurate scientific data on the environmental impacts of agriculture and help to develop or revise conservation practices. These practices reduce environmental impacts while maintaining farm profitability.

The goals of the program are to promote the development and evaluation of agricultural conservation practices, quantify and reduce agricultural contributions to impaired waters, and identify underlying processes that affect water quality.

Since 2008, the MDA has announced seven requests for research proposals. Any organization, research entity, or individual may apply for these funds. The MDA works cooperatively with the researchers and provides administrative support for the program. This program has sponsored 31 projects, of which 17 have been completed. *Please note that completed projects are indicated by an (*) following the project title.*

www.mda.state.mn.us/cleanwaterfund/research

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Contents

November 2015

Cover Crops, Perennials, and Vegetative Cover

Dual-purpose cover crops and onsite retention of water and nutrients

Principal Investigator: Frank Forcella, University of Minnesota – Agronomy and Plant Genetics
Proposal Year: 2014

Goals:

- Compare agronomic, environmental, and economic characteristics of cash-generating winter oilseed crops *(pennycress and camelina)*, traditional cover crops *(winter rye and tillage radish)*, and conventional winter-fallow systems.
- Determine the limits and feasibility of growing winter oilseed crops across Minnesota.

Improvement of field pennycress germplasm for use as a winter annual cover and oilseed crop

Principal Investigator: James Anderson, University of Minnesota – Agronomy and Plant Genetics
Proposal Year: 2014

Goals:

- Improve the overall agronomic performance of pennycress by selecting and breeding plants that express desirable traits for growth as a cash crop.
- Create a genomic selection model to help accelerate future pennycress breeding efforts.

Optimizing establishment of corn in cover crops and living mulches to maintain yield while reducing nitrate losses

Principal Investigator: Julie Grossman, University of Minnesota - Horticultural Science
Proposal Year: 2014

Goals:

- Test effectiveness of methods (no-till, strip till, rotary zone till, and combined till units) for establishing corn into cover crops and living mulches.
- Reduce negative effects that cover crops and living mulches may have on the early growth of corn seedlings.

Water quality enhancements in corn cropping systems through optimization of cover crop establishment technologies

Principal Investigator: M. Scott Wells, University of Minnesota – Agronomy and Plant Genetics
Proposal Year: 2014

Goals:

- Evaluate cover crop establishment methods and cover crop species/mixture in a corn-based cropping system.
- Assess potential groundwater quality improvements resulting from cover cropping using a calibrated Nitrogen Loss and Environmental Assessment Package (NLEAP) model and estimate soil erosion reductions using Revised Universal Soil Loss Equation (RUSLE).

Late season cover crop photo that shows good red clover establishment in corn. Credit: Reagan Noland. University of Minnesota

- Contribute to an educational program to share research findings and demonstrate cover crop establishment technologies to farmers and agricultural professionals.

Winter rye cover cropping to improve water quality in corn-based cropping systems*

Principal Investigators: Ed Nater and Erik Krueger, University of Minnesota – Soil, Water, and Climate
Proposal Year: 2009

Results Overview:

- Seeding a winter rye cover crop into soybeans can reduce surface runoff, sediment removal, and nutrient transport in fall and spring; the greatest environmental benefit will likely occur in spring.
- Planting a winter rye cover crop after fall corn silage removal will help to prevent surface runoff, soil erosion, and off-site nutrient transport relative to fallow ground.
- Increasing the winter rye cover crop seeding rate beyond 100 pounds per acre (112 kg/ha) into soybeans does not improve the stand or provide increased environmental benefits. Removing corn stover will likely magnify soil erosion risks associated with no-till conventional practices and negatively impact water quality due to increased surface runoff.

Phosphorus, Nitrogen, and Sediment

Assessment of rate and timing of phosphorus application in corn-soybean rotations on the potential for phosphorus loss to surface waters and tile

Principal Investigator: Daniel Kaiser, University of Minnesota – Soil, Water, and Climate
Proposal Year: 2015

Goals:

- Evaluate how rate and timing of phosphorus (P) application in a 2-year corn-soybean rotation affects P loss (soluble and bio-available), including leaching, for different soil types.
- Study the impacts of long-term P management on the amount of P that can be sorbed to surface (0-6 inches) and sub-surface soils (6-12 inches).
- Correlate the Haney H3A soil extract to corn and soybean response to P.
- Determine if chelates could be utilized to increase P availability to crops.

Measuring and modeling watershed phosphorus loss and transport for improved management of agricultural landscapes

Principal Investigator: Jacques Finlay, University of Minnesota – Ecology, Evolution, and Behavior
Proposal Year: 2015

Goals:

- Determine the relative contribution and environmental controls over P losses from agricultural watersheds in Minnesota, including an assessment of dissolved P.
- Measure watershed landscape P sources (wetlands, lakes, and fields), contribution of upstream P sources versus downstream erosional P sources from stream banks and bluffs, and reactivity of dissolved P within channel networks of the Le Sueur River watershed.
- Integrate best available data into the Soil and Water Assessment Tool (SWAT) to link alternative management actions, climate, and landscape features in models of P losses at the watershed scale.

Comparison of real-time N stress sensors and remote sensing from unmanned aerial vehicles for precision management of N fertilizer and improvement of water quality

Principal Investigator: David Mulla, University of Minnesota – Soil, Water, and Climate
Proposal Year: 2013

Goals:

- Assess the ability of various real-time sensors and aerial remote sensing techniques to detect nitrogen (N) stress in corn plots at different times of the growing season.
- Evaluate the field scale effect of variable rate application of N fertilizer on corn yield.
- Measure the benefits of field scale variable rate N fertilizer application on surface water quality.

An integrated sediment budget for the Root River, Southeastern Minnesota

Principal Investigator: Patrick Belmont – Utah State University, Watershed Science
Proposal Year: 2012

Goals:

- Develop a comprehensive sediment budget, which incorporates sediment fingerprinting, Light Detecting and Ranging (LiDAR) terrain analyses, field surveying, water and sediment gaging, and modeling, to identify the most important sediment sources, processes acting on those sources, and potential source mitigation.
- Analyze the spatial and temporal scaling of watershed discharge and related metrics (e.g., runoff ratio).
- Develop a model to estimate downstream sediment routing to inform how sources and sinks influence routing and lag times between implementation of best management practices (BMPs) and observed water quality improvements.
- Develop and distribute computational tools to local technicians, which can be used for source identification and feature extraction from high resolution LiDAR topography data.

Sediment budget for Greater Blue Earth Basin and its response to changes in drainage and river discharge

Principal Investigator: Karen Gran, University of Minnesota – Geological Sciences
Proposal Year: 2012

Goals:

The MDA is supporting one component of a multifaceted project.

- Establish a collaborative of local, state, and industry stakeholders with the goal of developing a consensus plan for reducing sediment loading in the Greater Blue Earth (GBE) watershed.
- Develop a spreadsheet based sediment budget for the GBE Basin including an inventory of sediment sources including ravines, bluffs, and channels.
- Evaluate the cost and efficiency of best management practices for reducing water and sediment delivery to the GBE stream channels.

Tracing sediment sources with meteoric ^{10}Be: Linking erosion and the hydrograph*

Principal Investigator:
Patrick Belmont, University of Minnesota – National Center for Earth-Surface Dynamics
Proposal Year: 2008

Results Overview:
Based on Le Sueur River watershed sediment fingerprinting data.

Patrick Belmont explaining sediment erosion

- Long-lived sediment fingerprinting tracer, ^{10}Be (beryllium), concentrations can be used in combination with measurements of a short-lived, ^{210}Pb (lead), radionuclide to differentiate inputs from stream banks, upland and bluff sources.
- Low ^{10}Be concentrations measured in sediment delivered to Lake Pepin 500 years ago indicate very little upland soil erosion relative to bluff erosion at that time. During the mid-1900s, ^{10}Be concentrations increased indicating a pulse of soil erosion from agricultural fields.
- Both tracers (^{10}Be and ^{210}Pb) indicated shifts back toward near-channel sources over the past three decades, which may be due to a decline in upland soil erosion in response to the emergence of precision-agriculture practices and enhanced conservation efforts.

Conservation Practices

Agricultural BMP Handbook for Minnesota update

Principal Investigator: Christian Lenhart, University of Minnesota – Bioproducts and Biosystems Engineering
Proposal Year: 2015

Goals:

- Incorporate new data and expand the list of BMPs included in the original 2012 handbook.
- Establish a range of estimates that better define the variability of BMP effectiveness by season, geologic setting, soil characteristic, and rainfall regime.
- Discuss management and maintenance requirements and the resulting influence on effectiveness.
- Assess costs and economic considerations in more detail.
- Identify potential barriers to adoption through literature review, agency interviews, and landowner workshops.

Nutrient removal in agricultural drainage ditches

Principal Investigator: Jeff Strock, University of Minnesota – Southwest Research and Outreach Center
Proposal Year: 2013

Goals:

- Evaluate the physical and chemical characteristics of selected P sorbing and N denitrifying media that have potential for use in a bioreactor installed in an agricultural drainage ditch.
- Select three of the P sorbing and N denitrifying media from above results and determine the P and N removal efficiency in laboratory flow columns under a range of temperatures and flows.
- Construct a novel two phase bioreactor in an agricultural drainage ditch and evaluate N and P removal in agricultural runoff under field conditions.

Controlled drainage and bioreactor-research and demonstration site

Principal Investigator: Ashley Brenke – Martin County Soil and Water Conservation District
Proposal Year: 2012

Bioreactor installation in Martin County

Goals:

- Establish a bioreactor demonstration site with and without controlled drainage.
- Monitor water quality and quantity at the inlet (controlled drainage structure or bioreactor inlet), bioreactor outlet, and upstream and down-stream on Elm Creek.
- Host field days and information sessions for local producers and conservation employees demonstrating the treatment technology.

On-farm evaluation of treatment methods for excess nutrients in agricultural subsurface tile drainage

Principal Investigator: Dean Current, University of Minnesota – Forest Resources
Proposal Year: 2012

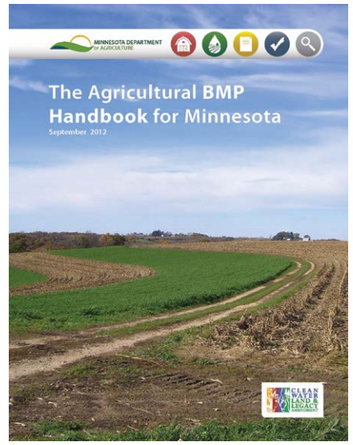
Tile water treatment wetland in Martin County
Credit: Brad Gordon, University of Minnesota

Results Overview:

- Evaluate the effectiveness of constructed wetlands to remove sediment, nitrate, total P, and ortho-P from tile drainage water.
- Assess the contribution of denitrification, plant nutrient uptake, and biomass harvest to the overall nutrient treatment efficiency of the constructed wetland.
- Quantify the hydrologic effects of the treatment wetland to determine if there is any water volume reduction through evapotranspiration in the wetland.

The Agricultural BMP Handbook for Minnesota*

Principal Investigator: Tom Miller- Emmons and Olivier Resources
Proposal Year: 2011



Agricultural BMP Handbook

Results Overview:

- Comprehensive inventory of agricultural BMPs that address water quality impairments in Minnesota including:
  - Definitions
  - Effectiveness estimates
  - Design, installation and maintenance costs
  - Potential barriers to adoption and knowledge gaps
- Recipient of the American Council of Engineering Companies of Minnesota's 2013 Engineering Excellence Honor Award.

Field evaluation of controlled drainage and woodchip bioreactors in reducing contaminant losses from farmed fields with natural background estimate: nitrogen, phosphorus, fecal coliform, herbicides and turbidity*

Principal Investigator: John Moncrief, University of Minnesota – Soil, Water, and Climate
Proposal Year: 2009

Results Overview:

Based on results from a bioreactor installed in summer 2009 and monitored through 2011.

- Overall nitrate reduction was 28%, for water flowing through the bioreactor. This reduction decreased over the growing season, especially as water temperature and air temperature decreased during the month of October.
- Average total phosphorus load reduction was 79%.
- Acetochlor and atrazine concentrations were reduced through the bioreactor.

Evaluation of nutrient retention basins for treating drainage from agricultural landscapes*

Principal Investigator: Jeff Strock, University of Minnesota – Southwest Research and Outreach Center
Proposal Year: 2008

Results Overview:
Based on three design replicates including surface-flow basins, subsurface-flow basins, and vertical-flow basins.

- Basin efficiency to treat total and dissolved reactive P loads generally improved the second sampling season as vegetation was further developed.

Nutrient retention basin at the University of Minnesota's Southwest Research and Outreach Center

- Dissolved reactive and total P inflow loads are reduced by as much as 90% and 75%, respectively.
- Total N and nitrate loads were reduced on average by 55% and 49%, respectively.

Conservation Planning

Assessment and selection of sentinel watersheds for addressing impaired waters*

Principal Investigator: Bruce Wilson, University of Minnesota – Bioproducts and Biosystems Engineering
Proposal Year: 2011

Results Overview:

- Minnesota watersheds were assessed and prioritized into a list of 19 subwatersheds (HUC8 and HUC10) representative of Minnesota's varying landscape, distributed over a range of physical, chemical, biological and social factors, and will provide information about the spatial and temporal scale in the implementation of management practices.
- Sentinel watersheds are the resulting prioritized watersheds, which represent a wide diversity of landscape attributes and conditions in Minnesota important to water resource professionals.

Priority setting for restoration in sentinel watersheds*

Principal Investigator: Chris Lenhart, University of Minnesota – Bioproducts and Biosystems Engineering
Proposal Year: 2011

Results Overview:

- Assessment of water sources in streamflow showed that geochemical methods, specifically isotope tracers (i.e. O^{18}, oxygen, and H^2, hydrogen) and specific conductivity, could be used to clearly distinguish stream source water.
- Practices that increase root depth and density of vegetation may help reduce sediment loading to rivers. In certain scenarios, control of noxious reed canary grass and promotion of native prairie grasses could have bank stability, sediment and nutrient load reduction benefits.
- Lateral migration rates measured from aerial photography can be used for estimating channel erosion in TMDL load calculations. Empirical bank erosion prediction equations (BANCS) are more practical tools for predicting sediment load from stream bank erosion than process-based models with intensive data input requirements such as the Bank Stability and Toe Erosion Model (BSTEM).

Lateral erosion calculation using aerial photography

Identifying priority management zones for best management practice implementation in impaired watersheds*

Principal Investigator: Greg Wilson – Barr Engineering and David Mulla, University of Minnesota
Proposal Year: 2011

Results Overview:

- Development of a web accessible, user-friendly compendium of assessment tools.
- Application of a LiDAR based terrain analysis approach combined with conservation field assessments for identifying Priority Management Zones (PMZs) and critical source areas (CSAs) demonstrated through collaboration with three Minnesota soil and water conservation districts (SWCDs).
- Utilization of the approach by local government units to successfully apply for conservation grants.

Ag BMP assessment and tracking tool*

Principal Investigator: Stephanie Johnson – Houston Engineering
Proposal Year: 2009

Results Overview:

- A web-based, comprehensive database for agricultural BMP tracking was developed.
- The database could be used for record-keeping by local government units to track the implementation of conservation practices that have not received state or federal funding.

Validation of the Minnesota Feedlot Assessment Runoff Model (MinnFARM) for use in assessing TMDLs*

Principal Investigator: Bruce Wilson, University of Minnesota – Bioproducts and Biosystems Engineering
Proposal Year: 2009

Results Overview:

- Model validation indicated that several water quality parameters should be revised. This includes:
  - Curve numbers for feedlot surface (concrete and dirt) should be edited.
  - Initial abstraction depth should be a function of precipitation depth.
- An algorithm was developed and incorporated into the program to include a two chambered biofilter as an alternative runoff treatment system.
- Future improvement in MinnFARM is dependent on obtaining better data sets.
- Feedlot runoff should be integrated into a broader Total Maximum Daily Load (TMDL) modeling framework that considers multiple features of a comprehensive manure management plan.

Evaluation of BMPs in impaired watersheds using the SWAT model*

Principal Investigator: David Mulla, University of Minnesota – Soil, Water, and Climate
Proposal Year: 2007

Results Overview:

- Evaluation of the SWAT model performance for TMDL applications using the Le Sueur River and South Branch of the Root River watersheds.
- Estimates of the load allocations of sediment, P, nitrate-N, acetochlor, metolachlor, and atrazine were calculated.

- Strategies for BMP implementation were modeled to estimate pollutant load reductions.
- Findings from this study can provide immediate input in the development of TMDLs for watersheds located in portions of southern and southeastern Minnesota.
- Limitations of the SWAT model must be considered despite its many strengths.

Targeting BMPs to critical portions of the landscape*

Principal Investigator: David Mulla, University of Minnesota – Soil, Water, and Climate
Proposal Year: 2007

Results Overview:

- A LiDAR data based terrain analysis methodology was developed for identifying CSAs for BMP implementation. CSAs are small areas of the landscape that may contribute to disproportionate nutrient or sediment runoff.
- The methodology effectively identified ravines, upland depressions and high-slope riparian areas as CSAs.

Water Quality Sampling

Evaluation of alternative surface-water monitoring protocols for use in agriculture TMDL load allocation and BMP evaluation*

Principal Investigator: Dennis Busch – University of Wisconsin-Platteville, Pioneer Farm
Proposal Year: 2009

Results Overview:
Based on the comparison of two alternative methodologies for estimating discharge and collecting water quality samples, to the Environmental Protection Agency (EPA) methodology.

- Two-part Flow Weight Composite (FWC) method was able to adequately sample both large and small events. Due to reductions in equipment, technician and sample handling costs, the two-part FWC method would cost about half ($42,320) the EPA method ($75,120), assuming a three-year monitoring program.
- Single-Stage Siphon method did not produce significant differences in measured constituents but did result in different event load suspended sediment. Although this method relies on low cost equipment, there is additional technician time making costs only slightly less ($37,200) than the two-part FWC method.
- Project developed into a three-state (Minnesota, Wisconsin and Iowa) NRCS Conservation Innovation Grant (CIG) project to promote and evaluate simple, inexpensive and reliable edge-of-field surface runoff monitoring.

Evaluation of Acetochlor losses to tile drainage*

Principal Investigator: Gyles Randall, University of Minnesota – Southern Research and Outreach Center
Proposal Year: 2008

Results Overview:

- Acetochlor was detected in 7% of the water samples collected from nine small field plots during a year of abundant tile flow (2010).
- Acetochlor was not recorded in water samples more than six weeks after application.
- Acetochlor application rate reduction resulted in lower concentrations in water and fewer samples at or above the minimum detection level.

Feasibility of an on-farm water quality program in Minnesota*

Principal Investigator: Jim Anderson, University of Minnesota – Water Resources Center
Proposal Year: 2007

Results Overview:

- Minnesota should pursue a program modeled after the Wisconsin Discovery Farms, with outreach as a central focus.
- Monitoring sites should represent major agricultural systems and regions of Minnesota.
- Monitoring design should allow for comparison with other Discovery Farms programs and assess runoff at the field or multi-field scale.
- Feasibility study helped support the development of a Discovery Farms Program in Minnesota; twelve sites have been established and are ongoing.

Microbiology

Analyzing and optimizing denitrification in agricultural surface waters

Principal Investigator: Jessica Kozarek, University of Minnesota – St. Anthony Falls Laboratory
Proposal Year: 2013

Goals:

- Identify what drives denitrification hot spots and moments in Minnesota agricultural landscape, evaluate the interaction of these drivers with engineered surface water features, and provide guidance on how to design, operate and maintain surface water engineering features to optimize denitrification.
- Assess microbial denitrifier populations, optimum soil moisture, and carbon type and content to maximize denitrification.
- Evaluate flooding frequency and duration on denitrification rates in detention basins and within the floodplain of a field-scale channel with various carbon sources.

St. Anthony Falls Outdoor Stream Lab during flood on September 25, 2015 Credit: Jessica Kozarek, University of Minnesota

Growth, survival, and genetic structure of Escherichia coli (E.coli) found in ditch sediments and water at the Seven Mile Creek Watershed*

Principal Investigator: Michael Sadowsky, University of Minnesota – Soil, Water, and Climate
Proposal Year: 2008

Results Overview:

- Polymerase chain reaction (PCR) assays indicated that cattle were likely major contributors to the fecal loading of the Seven Mile Creek, although swine and poultry fecal markers were also detected sporadically.
- DNA analysis indicated that the *E. coli* populations present were very diverse, but consisted of both transient and persistent strains. Persistent strains are likely indigenous to the sites and may grow in the sediment and/or water.
- Water and sediment isolates are closely related in each year, suggesting that there is mixing of *E. coli* strains in the sediment and water column. This may contribute to elevated *E. coli* counts. Flow rate, temperature effects, rainfall and run-off events are likely factors influencing the distribution of *E. coli* populations. *E. coli* counts were highest during the summer.
- DNA analysis has been incorporated into future *E. coli* TMDL studies.

Developing a DNA marker system for bacteria from cattle, swine, and poultry manure*

Principal Investigator: Michael Sadowsky, University of Minnesota – Soil, Water, and Climate
Proposal Year: 2007

Results Overview:

- Researchers utilized subtraction suppressive hybridization (SSH) to identify DNA specific for Escherichia coli (*E. coli*) originating from cows, pigs, and turkeys.
- DNA (polymerase chain reaction) PCR assay indicated that *E. coli* counts in the study area, Little Jordan Creek, exceeded state and federal standards, with detections of a bovine-specific *Bacteroidales*-like marker gene (Bac3).
- Livestock grazing best management practice implementation helped reduce fecal loading.