Annual Report

NCERA217: Drainage design and management practices to improve water quality

Report Information

Annual Meeting Dates: April 9–11, 2013
Reporting Period: July 2012 through May 2013

Participants

Members Present: Jane Frankenberger (IN), Christopher Hay (SD), Matt Helmers (IA), Dan Jaynes (IA), Xinhua Jia (ND), Roxanne Johnson (ND), Rameshwar Kanwar (Admin. Advisor, IA), Gary Sands (MN), and Mohamed Youssef (NC).

Guests Present: Phil Algreen (Agri Drain, IA), Steve Baker (Springfield Plastics, IL), Jeff Barth (Minnehaha County, SD), Leonard Binstock (ADMC, AR), Anna Bramblett (NRCS, AR), Michelle Burke (NRCS, SD), John Downey (Trimble, OH), Bonnie Dybedahl (Farm Bureau, SD), Brian Earl (Ag. and Agri Food Canada, MB), Jeanne Hansen (ADMC, MN), Kyle Horntvedt (NDSU), Govinda Karki (SDSU), Kul Khand (SDSU), Jeppe Kjaersgaard (SDSU), Kelsey Kolars (NDSU), William Kuentsler (NRCS, TX), Cynthuja Partheeban (SDSU), Kent Rodelius (Prinsco, MN), Thomas Scherer (NDSU), Brian Scott (SD Dept. of Ag., SD), Bruce Shewfelt (Ag. and Agri Food Canada, MB), Halis Simsek (NDSU), Brandon Sloan (Univ. of Iowa), Wayne Smith (Farm Bureau, SD), Eric Stearns (SDSU), Paul Sweeney (NRCS, DC), John Torbert (Iowa Drainage District Assoc.), and Nathan Utt (Ecosystem Services Exchange, FL)

Summary of Annual Meeting Minutes

The NCERA217 committee annual meeting was held April 9–11, 2013 in Sioux Falls, South Dakota in conjunction with the Agricultural Drainage Management Systems (ADMS) Task Force. The NCERA217 business meetings were held and station reports were given on April 9–10, a mini-symposium on the hydrologic impacts of drainage was held on April 10, and reports or discussion related to activities of the ADMS Task Force and other partnering organizations were conducted April 10–11. The NCERA217 business meetings were chaired by past chair Xinhua Jia and secretary Chris Hay. Ramesh Kanwar, the adminstrative advisor, reminded the committee that it was up for renewal, and a new proposal would need to be developed and submitted this year. In addition, a termination report for the current project would also need to be submitted. Mary Ann Rozum gave an update from USDA NIFA via telephone. The minutes from last year's meeeting were read and approved. Objectives for the project renewal were discussed, and a committee was formed to draft a renewal proposal. Active and proposed extension drainage and water quality publications were discussed. Mohamed Youssef from North Carolina was elected as the new committee secretary. The committee developed a list of potential meeting locations for next year's meeting, and the business meetings were adjourned.

A detailed agenda and meeting minutes are attached.

Accomplishments and Impacts by Station

Iowa

Iowa State University

Submitted by Matt Helmers

Research and extension efforts at Iowa State University relative to drainage design and management practices to improve water quality continue to center on nutrient export from tile drainage systems and nutrient management practices to minimize this export of nutrients, specifically nitrate-nitrogen. Work is also continuing that is evaluating drainage water management and cropping practice impacts on drainage volume and drainage water quality. New work is specifically examining impacts of various biomass production systems including continuous corn with stover removal and a diverse restored native prairie system. Water quality and water quantity are being monitoring from seven drainage water quality research sites.

Work continued in 2012 examining impacts of perennial based biomass production either restored native prairie or monoculture switchgrass on subsurface drainage water quality. Results indicate dramatic reductions in nitrate concentrations and losses in drainage water with the perennial based systems. This was even the case when nitrogen fertilizer was applied to the perennial based systems. This work is important for assessing environmental impacts/benefits of perennial based biomass production strategies.

Work continued in 2012 examining the impacts of manure (poultry and liquid swine) on drainage water quality. This work is continuing to examine nutrient loss but has been expanded to include bacteria and antibiotic resistant bacteria assessments.

Extension work has focused on disseminating information relative to drainage water quality and economic design of drainage systems. This has included statewide, regional, and local programming events. In collaboration with colleagues at the University of Minnesota and South Dakota State University, the IA-MN-SD Drainage Research Forum was held in November 2012 and was attended by approximately 85 stakeholders. In August 2012, an Iowa Drainage School was held near Ames, IA that focused on hands-on design of drainage systems. Approximately 45 individuals participated in this event.

Impacts. The research work on nitrate concentration as a result of cover crops, living mulch, perennial cover, and timing and rate of nitrogen application was used by the Statewide Nutrient Strategy Technical Team within the State of Iowa. This strategy will be important for developing a course of action for Iowa to meet the Hypoxia reduction goals. This work has been highlighted in presentations to producers throughout the fall and winter of 2012 to increase the understanding of what practices can be used to decrease nutrient loading to downstream water bodies.

An outcome from the IA-MN-SD Drainage Research Forum is that we are providing research-based information on drainage water quality to stakeholders including state agency personnel in Iowa and the Midwest with a goal of improving the knowledge of drainage water quality issues and practices that can be used to minimize drainage water quality impacts. Feedback from the IA-MN-SD Drainage Research Forum continues to indicate attendees valued the research based presentations, the cooperation of Iowa State University, University of Minnesota, and South Dakota State University on drainage issues, and the mix of basic and applied studies that were presented at the meeting.

With Greg Brenneman and Kapil Arora the 6th Iowa Drainage School was organized. Participants rate this program as good to excellent and nearly all participants indicate that the program will help them design more effective drainage systems that will improve their bottom line.

USDA-ARS National Laboratory for Agriculture and the Environment, Ames

Submitted by Dan Jaynes

Accomplishment: *Saturating Riparian Buffers.* In this project we are investigating the efficacy of reconnecting tile drainage to shallow ground water flow through riparian buffers for removing nitrate. By diverting a fraction of the tile discharge through a distributary tile installed along the top of the buffer, we are diverting a fraction of the tile water into shallow ground water flow through the buffer. Within the shallow ground water, both denitrification and sequestration processes known to be active in buffers will remove nitrate before it can enter the adjacent stream. We have connected a diverter box to an existing field tile that exits through a riparian buffer before emptying into Bear Creek. The diverter box is used to divert a fraction of the tile discharge into the distributary tile installed along the field side of the buffer. The diverted water flows as shallow groundwater to the stream and the nitrate contained within the water is subjected to denitrification and plant uptake and sequestration in the buffer.

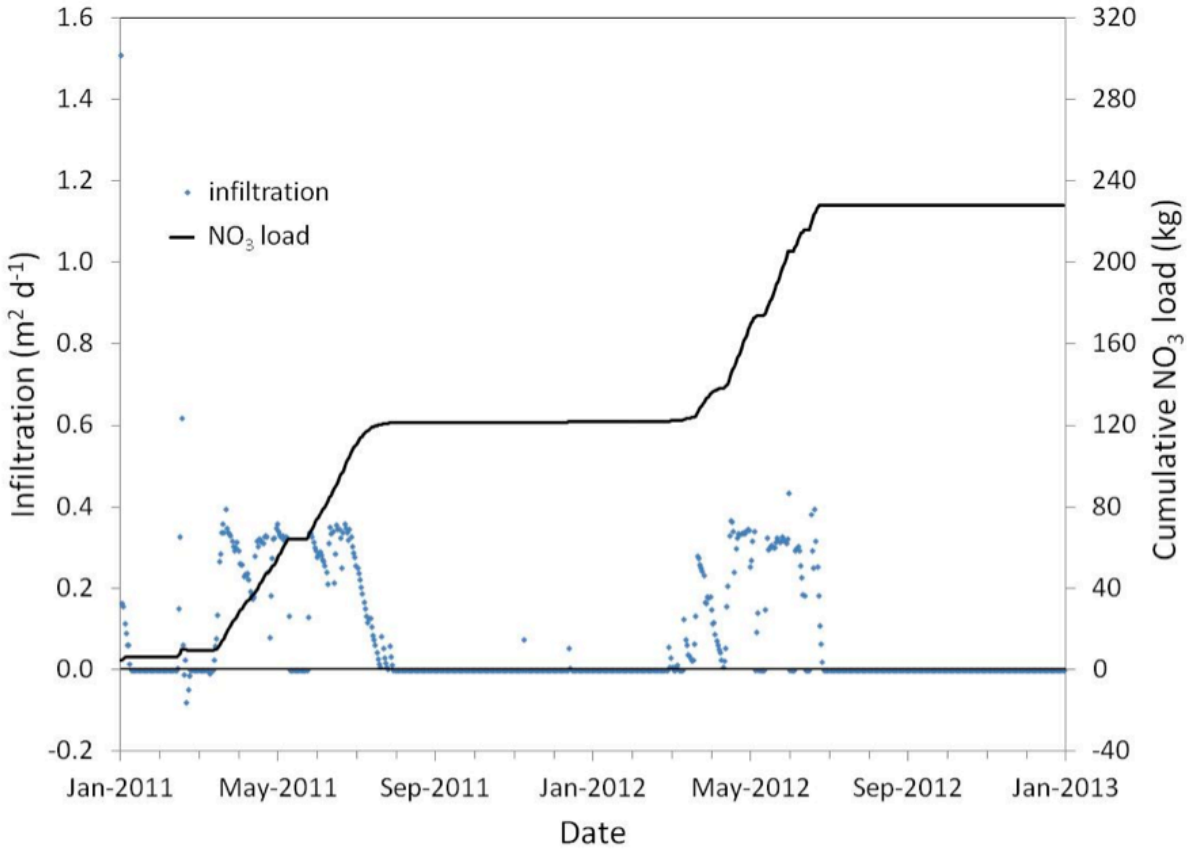

Figure 1. Flow and nitrate diversion into buffer at Bear Creek for 2011 and 2012.

Outcome. We are measuring the water volume and nitrate concentration diverted into the buffer and following the fate of the nitrate through four transects of wells as it moves to the stream. Tile flow diverted into the buffer rather than flowing into the stream has been measured since fall of 2010. The diversion of tile flow into the buffer for 2011 and 2012 is shown in Figure 1. The cumulative nitrate load diverted into the buffer is also shown and amounts to almost 120 kg-N in 2011 and 105 kg-N in 2012. During the two years, the buffer was able to absorb about 50 gallons per minute of the tile drainage leaving the field. Thus, overall the system appears to be functioning as hypothesized. It will be critical to see how much of the tile flow the buffer can absorb during subsequent years. It will also be critical to determine if the nitrate entering the buffer continues to be removed before flowing to the stream in the shallow groundwater. Currently, none of the nitrate

being diverted into the buffer appears to be reaching the stream. Continued monitoring will determine if this continues over time.

Impact. This research has quantified the potential nitrate removal capacity and water quality benefits from reconnecting a portion of field tile flow to riparian buffers. The research has led to a CIG grant from NRCS and an NRCS Interim Conservation Standard # 739 "Vegetated Subsurface Drain Outlet" for the practice.

Michigan

Submitted by Tim Harrigan, Michigan State University

Subsurface Drainage Field Day

A two-day field day highlighting land improvement with an emphasis on subsurface drainage and water quality protection was held at the Lewis Farm in Jonesville, MI. on August 1–2, 2012. The field day was a collaborative effort of the Michigan Land Improvement Contractors Association and Michigan State University Extension with the cooperation and support of local agri-business. Machinery, equipment and installation techniques were demonstrated to attendees in the installation of subsurface drains in the forty-acre field. Daily presentations were made by NCERA217 members Tim Harrigan, Michigan State University (manure slurry seeding of cover crops); Larry Geohring, Cornell University (managing manure on drained cropland); Richard Cooke, University of Illinois (constructed bio-reactor); and Larry Brown, The Ohio State University (drainage system installation and drainage control devices). Approximately 500 landowners, consultants, state and federal agency, agri-business and educators attended the event. Attendees increased their knowledge and awareness of the value of land improvement for farm profitability and protection of soil and water quality, learned new techniques and strategies for managing surface and subsurface drainage, and had the opportunity for face-to-face and peer-to-peer discussions with farmers, landowners, agri-business and university personnel.

Missouri

Submitted by Kelly Nelson, University of Missouri

Field research was initiated on claypan and silty clay soils to evaluate the impacts of managed drainage systems for crop and livestock production from 2009 to 2013 and is ongoing. Corn and soybean research is still evaluated integrated water management systems (2001-present). Current corn (*Zea mays* L.) research evaluated the effects of nitrogen (N) sources [non-treated control, anhydrous ammonia, urea, polymer-coated urea (PCU), and 32% urea ammonium nitrate (UAN) at 168 kg N ha^{-1}] and water management systems [drained, non-irrigated (DNI) at 6.1, 9.2, and 12.2 m spacings; non-drained, non-irrigated (NDNI); non-drained, overhead irrigated (NDOHI); and drained plus subirrigated (DSI) at 6.1, 9.2, and 12.2 m spacings] on yield, plant population, grain protein, and grain N removal. DNI increased grain yield 0.92 to 1.88 Mg ha^{-1} (10% to 22%) compared to NDNI. DSI increased yields up to 4.41 Mg ha^{-1} (24% to 38%) depending on N source and spacing. Nitrogen sources in the NDOHI increased yields 42% to 45% compared to NDNI, and 10% to 20% compared to DSI 6. In irrigated and poorly drained claypan soil (NDOHI), PCU increased yield 0.88 Mg ha^{-1} compared to NCU. PCU had the highest yields among N sources with DSI 6, DSI 9, DSI 12, and DNI 12. In a well drained soil (DNI 6), NCU had the highest yield (8.94 Mg ha^{-1}) among N sources, while anhydrous ammonia had the highest yields in the NDNI control (7.89 Mg ha^{-1}) and DNI 9 (9.07 Mg ha^{-1}). Grain N removal was greatest (201.9 to 202.2 kg ha^{-1}) with anhydrous ammonia and PCU with NDOHI. Nitrogen source selection is an important component of high-yielding corn production systems depending on water management system.

The Missouri Drainage Workshop was held in collaboration with the Missouri Land Improvement Contractors of America and State NRCS engineers in February, 2013 with 50 people registered. Contractors and farmers were trained on drainage

and managed drainage design.

New York

Submitted by Larry Geohring, Cornell University

Accomplishment: *Completion of laboratory study relating phosphorus loss from manure and soil macropore size.* Although there were few statistical differences of note, the laboratory study with soil columns containing macropores produced the majority of soluble reactive phosphorus (SRP) loads to the discharged effluent. The study suggested that the 2 mm diameter macropore threshold may be applicable to P transport since we observed substantially higher amounts and concentrations of SRP for the liquid manure at 3.5% solids and the inorganic P2O5 treatments for the 3 mm macropore columns as compared to those for the 1 mm diameter macropore columns. One explanation for the lack of statistical differences among the treatments is that the soil itself was likely a major source of SRP, and which thus may have masked the differences among treatments and macropore sizes. Indeed, the soil taken from the farm cooperator's field site that was used to fill the columns had a Morgan's P soil test level of 83 mg/Kg in the top soil layer which would be considered a very high soil test level whereby no additional phosphorus fertilizer would be recommended. Although our columns were constructed from a reasonably well-mixed mixture of the top 70 cm of soil, there was potential for large variation and heterogeneities in the soil P content among columns. Furthermore, a large fraction of P retained in this soil is bound to iron (Fe) III (ferric iron) in the presence of oxygen, and was probably released under anaerobic conditions concomitantly with reduced iron II (ferrous iron). The available Al, Fe, and Mn in the field soil used in these columns was likely associated with some readily mobilized P that could have mobilized into the soil solution during the initial column saturation and during the continued wetting with the sprinkler application. The rapid and substantial breakthrough of P from the manure containing 3.5% solids in contrast to the liquid manure containing 7% solids also indicates that the higher liquidity of the manure is more readily transported through the macropores. Manure with a higher solid content that's applied to the soil surface may actually serve to block some soil pores, limiting infiltration and perhaps facilitating more runoff. Although more research would be needed to better quantify the fate of P leaching from liquid manures of varying solids content and to specific macroporosity responses, in summary, this laboratory study indicated that liquid manure at a low solids content of 3.5% applied to the soil surface tended to quickly increase the SRP load and concentration leached from soil with macropores of 3 mm diameter size in response to a wetting event, and which could find its way into tile drains.

Impact. These results indicate P transport to subsurface drains is most likely to occur in soils containing substantial macroporosity greater than 1 mm in diameter, and where liquid manure with a low solid content or inorganic fertilizers are surface applied. Consequently, producers are being encouraged to take management precautions to disturb (i.e., pre-till or incorporate) P nutrient applications on soils vulnerable to macropore or preferential flow, and to avoid making these applications at least a day or two before a forecasted significant rainfall event.

Accomplishment: *Completion of controlled drainage demonstrations and investigations on two cooperator farms.* The implications of the paired-controlled versus uncontrolled drain discharges investigation at one of the cooperator farms had mixed effects. On the one hand the controlled drain appeared to provide some benefit to downstream water quality by reducing the amount of P that was discharged from the controlled drain. The controlled drain provided some reduction in the P concentration in the drained water, likely by slowing down the velocity of water flow through the soil's macroporosity which provided more time for SRP to sorb to the soil matrix. As flow peaked from the uncontrolled drain, The P concentrations rose along with it resulting in somewhat more accumulated total P load loss. The effect, however, seemed to vary depending on the soil's antecedent moisture condition prior to the rain event. When the field was more consistently wetted from repeated rain events, there was less of a difference and reduction in comparative concentrations between the paired treatments, and which was probably an affect whereby the reduced soil profile behind the controlled drain may have resulted in some desorption and mobilization of SRP.

Similar to what other investigators found, nitrate-nitrogen concentrations from the drain outlets were generally similar for controlled versus noncontrolled drain discharges so the primary way nitrate discharges seem to be reduced by controlled drainage is that the control provides a means of reducing the overall drain flow. The farm cooperator suggested that he didn't appreciate the field being wetter for extended periods of time as a result of the drainage control, so achieving nitrogen reduction with controlled drainage will be a management challenge. The higher drain flows during a storm from an uncontrolled drain can actually serve to reduce nitrogen concentrations, but which doesn't necessarily result in any reduction in accumulated total nitrogen load loss. For the drained fields receiving most of the nutrients from applied manure, the nitrogen fate and transport dynamics appear to be somewhat different than in most studies where only inorganic nitrogen fertilizers are applied. We observed that organic nitrogen made up a major proportion of the total dissolved nitrogen, and some loss of particulate nitrogen and ammonium nitrogen also occurred. In one of our earlier studies we found that ammonium-nitrogen can be transported to the drain if rain occurs shortly after a surface manure application, but fortunately the concentrations dissipated quickly. Nevertheless, the fate of the residual organic dissolved nitrogen has not been well investigated under controlled drainage situations. Furthermore, if controlled drainage and the resultant wetter soil profile results in more nitrogen ultimately lost as nitrite, this may be of concern in the immediate downstream environment also.

At the other controlled drainage site on a cooperator farm, over 1100 samples were collected for both total and soluble reactive phosphorus analysis over the three year monitoring period of the study. In summary, the average total phosphorus was 0.08 (range from 0.004 to 2.48) mg/L. The SRP averaged 0.04 (range from 0.001 to 0.8) mg/L, and on average represented about 48 percent of the total phosphorus.

Nitrate-nitrogen was analyzed for 124 samples, with about 75 percent of these collected during the first year of the study. Given the study location in proximity to Lake Champlain where phosphorus is the major concern with respect to eutrophication aspects, the nitrate analysis was of lesser concern. Nevertheless, the average nitrate-nitrogen concentration for these samples was 3.8 (range from 0.4 to 12.1) mg/L.

It was unfortunate that a better paired control analysis could not be done at this site and the results for 2009 prior to controlling the drain outflow are probably not directly comparable to when the drain outlet was managed later as controlled drainage. The higher peak concentrations observed during the controlled drainage in 2010 and 2011 may be partially a result of maintaining the soil at higher soil moisture content, but the peak concentrations typically occurred anyway in response to large precipitation events especially when they closely followed the manure applications. It's interesting to note that the farmer commented that the manure needed to be applied prior to a rain event so that the nutrients could be carried into the soil. His applications typically a day or two prior to rain events were not the result of necessity for emptying the manure storage lagoon. The farmer also pulled the control gates when he felt the field was getting too wet, and so that he could apply manure and carry out tillage operations.

Impact. Outreach efforts in New York consisted of a field day and via extending information on controlled drainage at the annual Northeast Certified Crop Advisors Conference and during training sessions for certified nutrient management planners during the Association of Conservation Districts annually sponsored Water Quality Conference. These outreach activities resulted in greater awareness of the potential water quality impacts of tile drain discharges, so producers and nutrient management planners are now paying more attention to identifying vulnerable tile outlets and adjusting their manure application methods. Drainage contractors, farmers, farm advisors, and soil and water professionals are beginning to learn of the potential water quality benefits of implementing controlled drainage. About 225 people attended the various meetings and training sessions. Information was also presented at the Northeast Agricultural and Biological Engineering Conference held jointly with the Canadian Society of Agricultural Engineers in Ontario Canada.

North Carolina

Submitted by Mohamed Youssef, North Carolina State University

Accomplishments:

1. A new generation of drainage water control structures have been designed to minimize the time and cost of drainage water management. These structures can be adjusted to automatically open and close according to a preset schedule. They will evolve to smart systems that manage the outlets of the drainage systems depending on the soil water conditions in the field. The new structures are being demonstrated in two demonstration sites.

2. Continued to experimentally investigate the effects of drainage water management on crop yield and N export to surface waters. We collect and analyze hydrologic, water quality and yield data for two artificially drained agricultural sites in eastern North Carolina.

3. Experimental research is underway to assess the effectiveness of controlled drainage and bioreactor systems in reducing N export to surface waters from land application of liquid animal waste to subsurface drained fields.

4. Experimental research is ongoing to quantify the impacts of intercropping of switchgrass with managed loblolly pine stands on the hydrology and water quality, soil C and N dynamics, and soil physical and hydraulic properties.

5. The development and field testing of the DRAINMOD-FOREST model have been completed. DRAINMOD-FOREST is a field scale, process based model that simulates the hydrology, soil C and N dynamics, and vegetation growth in drained forests. The model was field tested using a long term data set from an artificially drained loblolly pine plantation in eastern North Carolina.

6. A comprehensive global sensitivity analysis for DRAINMOD-FOREST has been conducted to investigate effects of model parameters on variations of multiple model predictions including evapotranspiration, drainage, soil organic matter content, nitrogen mineralization rate, nitrogen plant uptake, nitrate and dissolved organic nitrogen export, net primary production, and leaf area index.

7. The DRAINMOD-DSSAT model has been developed and field tested. DRAINMOD-DSSAT is a field scale, process based model that simulates the hydrology, soil carbon and nitrogen dynamics, and crop growth for agricultural lands. DRAINMOD-DSSAT was field tested using data sets from two artificially drained agricultural research sites in Iowa and Indiana.

8. The DRAINMOD-NII model has been enhanced to predict the fate and transport of dissolved organic nitrogen. The modified version of DRAINMOD-NII model has been field tested using historic data collected from an artificially drained loblolly pine plantation in eastern North Carolina.

9. Continued to conduct DRAINMOD training and provide technical support to DRAINMOD users in the US and abroad.

Impact:

The conducted research addressed local, national, and global needs, responded to emerging changes in land uses and management practices, and focused on adapting crop production systems on drained lands to a changing environment.

1. The development of the smart agricultural water management system including the automated drainage water control structure will lead to the revitalization of controlled drainage in eastern NC where large areas of agricultural

lands are artificially drained. This will result in a potential increase in crop production, reduction in production cost, conservation of water, and substantial improvement in surface water quality.

2. The results of our research have shown that both controlled drainage and bio-reactor systems have the potential to be used as BMPs for reducing nutrient export from drained spray fields. Our research could lead to the adoption of these two practices by the state of North Carolina to reduce nitrogen losses to surface waters from land application of animal waste to drained fields.

3. The ongoing research on growing bio-energy crops will lead to a better understanding of the impacts of growing these crops on water quantity, quality, and C and N cycling. This is necessary for the evaluation of the sustainability of growing bio-energy crops on lands that are not used for food production.

4. The DRAINMOD suite of models are being used by many researchers in the U.S. and abroad to assess the long term effects of emerging changes in land uses and management practices on the hydrology and biogeochemistry of agricultural and forested lands with improved drainage. Models such as DRAINMOD are particularly essential at this time for predicting the response of agricultural and forest ecosystems to potential changes in the climate and assessing strategies for adapting agricultural and forest production systems on drained land to these changes in the climate.

North Dakota

Submitted by Xinhua Jia, North Dakota State University

Richland County, ND controlled drainage and subirrigation experiment

The demonstration field is located in the Red River Valley at Fairmount, Richland County, North Dakota. It is near the corner of South Dakota, North Dakota and Minnesota. The total acreage of the experimental field is 100 acres, with 30 ft spacing, 3.2–4.0 ft depth, and 1% grade (Figure 1). Two mains in the north-south direction are placed at the center and east side of the field, with the outlets near the north side of the field and drainage outflow being pumped to the surface drainage ditch.

The entire 100 ac field at Miller's Farm was converted to controlled drainage and subirrigation in fall 2011. Sugarbeets were planted in 2012. Due to a high concern for the subirrigation water quality and possible sodic effect to the soil, we monitored the soil quality in the field and water quality at the drainage outlet or subirrigation inlet as well as the up and down streams of the field during the 2012 growing season. The highest soil sodium adsorption ratio (SAR) value was 3.3 at 8 inches distance from the tile, well below the SAR value of 6 in the subirrigation water, indicating that the subirrigation application has not caused any alarming soil sodicity problems. Water quality monitoring at the two sump structures clearly showed the water quality difference between drainage outflow and subirrigation inflow. Subirrigation application decreased or diluted the salt concentrations (from EC = 7000 μmhos/cm in spring to 2000 μmhos/cm in fall) in the drainage water. Controlled drainage process during spring time maintained the higher nitrate-nitrite nitrogen water (70.5 mg/L) in the field, instead of leaching to the surface ditch. Drainage was applied no more than approximately ten days in late October to empty and prepare the field for the next season. Subirrigation was applied from late June to late September for a total amount of 8.8 in. With total rainfall of 16.5 in, the total water application was 25.3 in, which led to a sugarbeet yield of 34.8 tons/ac in the experimental field. The sugarbeet yield was 25% higher than the average sugarbeet yield (27.8 tons/ac) in the region.

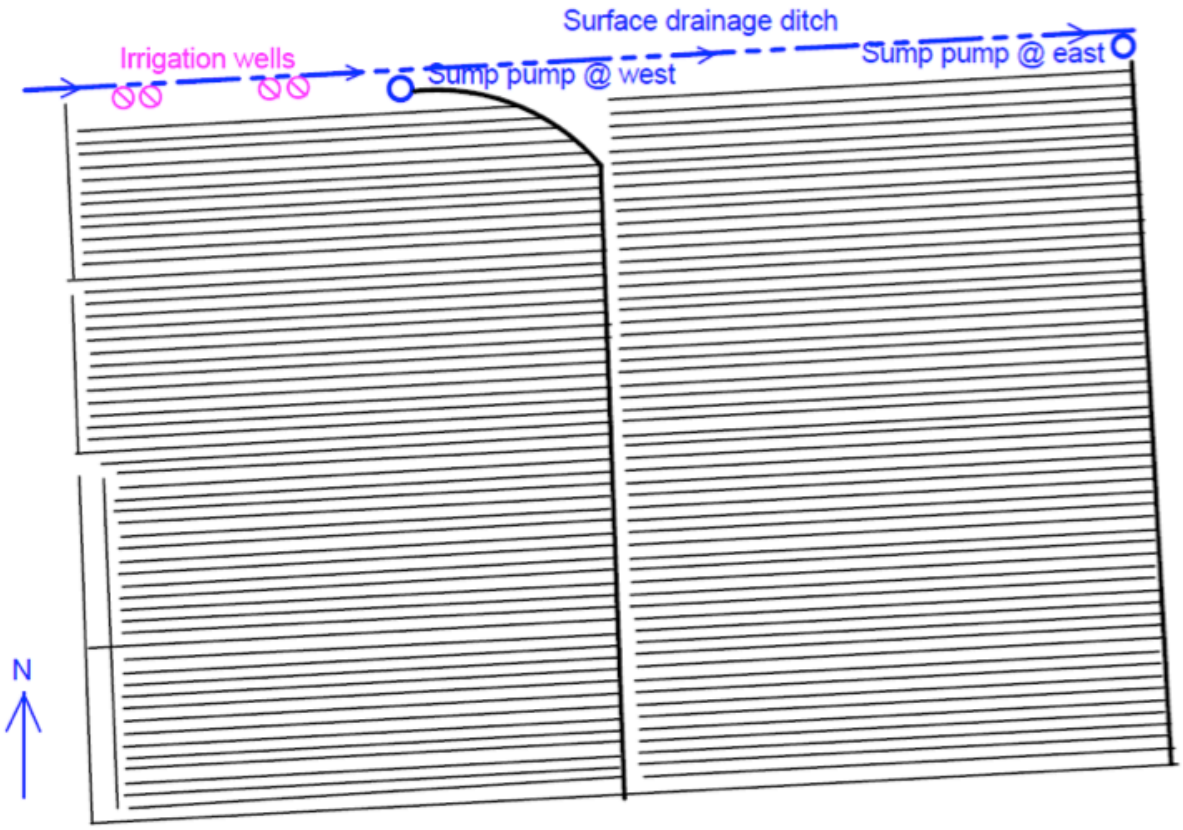

Figure 1. Tile drainage layout at the experimental site.

Clay County, MN optimal water management project

This project is located in Clay County, MN. Four production fields were selected for the experiment. The fields are located next to each other and along the same drainage ditch. Four water treatments, undrained (UD, 40 ac), free tile drainage (FD, 60 ac), controlled drainage (CD, 43 ac), and controlled drainage plus subirrigation (SI, 51 ac) were applied (Figure 2).

Figure 2. Experimental layout.

We focused on optimal water management on production land, with drainage being applied during wet conditions and subirrigation being used during drought condition. In the fall of 2011, we installed 24 observation wells, took 48 soil profile samples, and conducted soil physical and chemical analysis. In the spring of 2012, we installed weather stations and soil moisture sensors in four corn fields; all four fields are located within two miles proximity and have similar soil types. Water quantity and quality monitoring equipment were also installed inside and outside the fields, and along the drainage ditch. As a result of the severe drought conditions in 2012, drainage and controlled drainage practices were not used, instead, subirrigation became the focus. We started testing the subirrigation system on June 15, 2012, a total of 5.4 million gallons of water was applied to one 94 ac corn field. The same subirrigation system was then relocated to a 160 ac sugarbeet field, and 18.6 million gallons of water was applied. This severe drought condition resulted in a water table below 2 m deep, and a moisture condition in the root zone that was far below the 50% available water range. Hence, any water applied to the field was taken up by the crops immediately. The subirrigation practice resulted in a 46% yield increase for corn and 23% yield increase for sugarbeet. Three field tours and several individual tours were given to personnel from federal, state, and county agencies, academia, industry, and landowners in both MN and ND.

South Dakota

Submitted by Chris Hay and Jeppe Kjaersgaard, South Dakota State University

Accomplishment: *Bioreactors.* South Dakota State University initiated a project funded by a SD NRCS Conservation Innovation Grant to evaluate the performance and utility of denitrifying bioreactors in removing nitrate from tile drain

water and assess the production of nitrous oxide, an intermediate product of the denitrification process and a greenhouse gas. Two of a total of four planned reactors were installed; one near Baltic, SD in July 2012 and one near Montrose, SD in December 2012. The Baltic bioreactor was installed on a tile system draining approximately 40 acres in a corn and soybean rotation. Because of the dry condition during the summer and fall of 2012, there was no tile flow in the system, so we did not collect any performance data. The Montrose bioreactor was installed on a tile system draining approximately 35 acres also in corn and soybean rotation.

Impact: The Baltic bioreactor is installed adjacent to the area used for the annual field day organized by the private company Ag PhD. This field day primarily attracts producers. The bioreactor installation was planned around the field day to provide attendees the opportunity to experience what a half completed bioreactor looks like and discuss its utility with the project investigators (Hay, Trooien and Kjaersgaard) and students. The field day attracted approximately 3400 attendees, of which we had direct interactions and discussion with an estimated 250.

Accomplishment: *Cover crop water use.* Work to estimate the consumptive water use by cover crops compared to bare fields in north east South Dakota was continued. Estimates of the consumptive water use by the cover crops are largely unavailable and with the vast number of individualized seed mixtures, variations in planting densities and differences in planting methods, cover crops do not lend themselves well to universal crop coefficients. There is a need, therefore, to estimate and assess the water use by cover crops in order to determine the impact on the soil water balance and soil moisture availability. Suitable models and algorithms applied to high resolution (30 m) satellite imagery provide a cost effective and time efficient method to obtain evapotranspiration estimations from bare soil and vegetation. METRIC (Mapping Evapotranspiration at high Resolution with Internalized Calibration) is a model utilizing satellite imagery that can be used to estimate water use with high resolution (30 m) over a large area, thereby enabling the evaluation of the water consumption on a field-by-field basis. This is advantageous because of the ability to compare fields with different crop rotations side-by-side as well as fields with non-traditional crops, such as cover crops which are both late season and short season crops. The objective of this research is to examine the utility of using METRIC to estimate daily cover crop water use and compare the ET estimates produced by METRIC to ground-based flux point measurements collected using a Bowen Ratio Energy Balance System (BREBS).

Impact: The results showed that the remote sensing-based ET estimates were within 3 % of the BREBS ET estimates for the cover crop season from August 18 – October 18, 2011. From the METRIC estimates, the average consumptive use from three fields with cover crops were 127 mm for the cover crop season, while the soil evaporation was 75 mm for three field without cover crops (stubble) during the same period.

Accomplishment: *Extension drainage programming.* Extension activities were focused on educating producers and the public on drainage and the impacts of drainage on hydrology and water quality. These activities have included a number of local and regional presentations and events. A series of three drainage design workshops were held during the winter in the region in collaboration with University of Minnesota and North Dakota State University Extension. These workshops were targeted at producers, contractors, and others interested in drainage design. The workshops served a total of approximately 200 attendees. The IA-MN-SD Drainage Research Forum was held in November 2012 near Waseca, MN and attracted over 80 attendees. The forum presented basic and applied drainage-related research results to stakeholders. A web-based drain spacing calculator to assist crop producers and drainage contractors with drain spacing decisions, particularly in the Dakotas that don't have existing drainage guides to provide spacing recommendations, was developed. Other presentations included talks to state legislators, county officials, commodity groups, and NRCS personnel and presentations at farm shows and Extension agronomy meetings and workshops.

Impact: Participants in the drainage design workshops rated the programs as very useful or useful. Participants indicated that they gained knowledge on drainage system layout, drainage calculations, and drainage design considerations. They also indicated that this knowledge would give them more confidence in designing drainage systems and help them avoid

mistakes. The drain spacing calculator has seen use from 44 countries, 36 US states, and 6 Canadian provinces.

Other States

Illinois: no written report available.

Indiana: no written report available.

Maryland: no written report available.

Minnesota: no written report available.

Ohio: no written report available.

Publications

1. Ale, S., L.C. Bowling, M.A. Youssef, S.M. Brouder. 2012. Evaluation of simulated strategies for reducing nitrate-nitrogen losses through subsurface drainage systems. *J. Environ. Qual.* 41:217–228.

2. Christianson, L., R. Christianson, M. J. Helmers, C. Pederson, and A. Bhandari. In press. Modeling and calibration of drainage denitrification bioreactor design criteria. Submitted Accepted March 2013 to *Journal of Irrigation and Drainage Engineering*.

3. Christianson, L., M.J. Helmers, and A. Bhandari. In press. Internal hydraulics diagnosis of a poorly performing agricultural drainage bioreactor. Accepted to *Ecological Engineering*.

4. Christianson, L., N. Hoover, A. Bhandari, and M. Helmers. 2012. Technical note: The potential of municipal yard waste to be denitrification bioreactor fill. *Applied Engineering in Agriculture* 26(5): 849–854.

5. Christianson, L., A. Bhandari, and M.J. Helmers. 2012. A practice-oriented review of woodchip bioreactors for agricultural drainage. *Applied Engineering in Agriculture* 28(6): 861–874.

6. Christianson, L., A. Bhandari, M.J. Helmers, K. Kult, T. Sutphin, and R. Wolf. 2012. Performance evaluation of four field-scale agricultural drainage denitrification bioreactors in Iowa. *Trans. ASABE* 55(6): 2163–2174.

7. Geohring, L.D., A.A. Royem, M.T. Walter, and T.S. Steenhuis, 2012, Mitigating Manure Contaminated Drain Discharge with Controlled Drainage, NABEC Paper # 12–068, NABEC/ASABE, St. Joseph, MI.

8. Geohring, L.D., 2012, Subsurface Drainage Water Management to Reduce Manure Contaminated Drain Discharge, Final Project Report submitted to National Fish and Wildlife Foundation, 28 pp.

9. Hankerson, B., J. Kjaersgaard, C. Hay. 2012. Estimation of evapotranspiration from fields with and without cover crops using remote sensing and in situ methods. *Remote Sensing* 4:3796–3812. doi:10.3390/rs4123796.

10. Hay, C. H., J. H. Kjaersgaard, and B. Hankerson. 2012. Measurement of cover crop evapotranspiration and impacts on water management in crop production systems. ASABE Paper No. 121337007. St. Joseph, Mich.: ASABE.

11. Helmers, M.J., R. Christianson, G. Brenneman, D. Lockett, and C. Pederson. 2012. Water table, drainage, and yield response to drainage water management in southeast Iowa. *Journal of Soil and Water Conservation* 67(6): 495–501.

12. Helmers, M.J., X. Xhou, J.L. Baker, S.W. Melvin, and D.W. Lemke. 2012. Nitrogen loss on tile-drained Mollisols as affected by nitrogen application rate under continuous corn and corn-soybean rotation systems. *Canadian Journal of Soil Science* 92: 493–499.

13. IA Dept Agric and Land Stewardship, IA Dept Nat. Resour., and IA State Univ. College of Ag and Life Sci. 2012. Iowa nutrient reduction strategy. A science and technology-based framework to access and reduce nutrients to Iowa water and the Gulf of Mexico. Available on line at http://www.nutrientstrategy.iastate.edu/sites/default/files/documents/NRSfull.pdf.

14. Jaynes, D.B. 2012. Changes in yield and nitrate losses from using drainage water management in Central Iowa, USA. *J. Soil and Water Conservation* 67:485–494. 2012.

15. Jia, X., and T. Scherer. 2013. Reducing cost of water quality monitoring in tile drainage outflow using electrical conductivity as a surrogate. In Using 21st Century Technology to Better Manage Irrigation Water Supplies, Seventh International Conference on Irrigation and Drainage Proceedings. Edited by Wallin, B. T., and S. S. Anderson. U.S. Committee on Irrigation and Drainage, Denver, CO. Pp 213–225.

16. Jia, X., T.M. DeSutter, Z. Lin, W.M. Schuh, and D.D. Steele. 2012. Subsurface drainage and subirrigation effects on water quality in southeast North Dakota. *Transactions of the ASABE* 55(5): 1757–1769.

17. Motavalli, P., K. Nelson, R. Udawatta, B. Zurweller, and C. Dudenhoeffer. 2012. Nitrogen Fertilizer Management of Temporarily Flooded Soils to Improve Corn Production and Reduce Environmental N Loss. Greenley Memorial Research Center Field Day Report. pp. 28–30.

18. Nash, P., K. Nelson, and P. Motavalli. 2012. Effect of Managed Subsurface Drainage and Polymer-Coated urea on Nutrient Loss from a Silty Clay Soil in Corn Production. Abstr. ASA-CSSA-SSSA International Annual Meetings, On-Line.

19. Nash, P., K. Nelson, and P. Motavalli. 2012. Impact of Managed Subsurface Draiange and Polymer-Coated urea on Nutrient Loss from a Claypan Soil in Corn Production. Abstr. ASA-CSSA-SSSA International Annual Meetings, On-Line.

20. Nash, P., K. Nelson, and P. Motavalli. 2012. Utilization of Polymer-Coated Urea Fertilizer and Managed Subsurface Drainage Systems to Improve N Management and Corn Yields. Greenley Memorial Research Center Field Day Report. pp. 9–15.

21. Nash, P., K. Nelson, P. Motavalli, M. Nathan, and R. Udawatta. 2012. Utilization of Enhanced Efficiency Nitrogen Fertilizer and Managed Drainage to Reduce Nitrate-N Loss. CAFNR Agron. Misc. Publ. #12–01. pp. 54–63.

22. Nelson, K., and P. Motavalli. 2012. Nitrogen Source and Drain Tile Spacing Affects Corn Yield Response in a Claypan Soil. Greenley Memorial Research Center Field Day Report. pp. 6–8.

23. Nelson, K.A., C.G. Meinhardt, and R.L. Smoot. 2012. Soybean Cultivar Response to Subsurface Drainage and Subirrigation in Northeast Missouri. Abstr. ASA-CSSA-SSSA International Annual Meetings, On-Line.

24. Nelson, K., and R. Smoot. 2012. Corn Hybrid Response to Drainage, Drainage Plus Subirrigation, and Non-Drained Overhead Irrigation. Greenley Memorial Research Center Field Day Report. pp. 4–5.

25. Qi, Z., L. Ma, M.J. Helmers, L.R. Ahuja, and R.W. Malone. 2012. Simulating nitrate-nitrogen concentration from a subsurface drainage system in response to nitrogen application rates using RZWQM2. *Journal of Environmental Quality* 41: 289–295. [Short Communication]

26. Rijal, S., X. Zhang, and X. Jia. 2012. Estimating surface soil moisture in the Red River Valley of the North Basin using Landsat 5 TM data. *Soil Science Society of America Journal*. In press.

27. Rijal, I., X. Jia, X. Zhang, D. D. Steele, T. F. Scherer, and A. Akyuz. 2012. Effects of subsurface drainage on evapotranspiration for corn and soybean in Southeast North Dakota. *J. of Irrigation and Drainage* 138(12): 1060–1067.

28. Skaggs, R.W., M.A. Youssef, G.M. Chescheir. 2012. DRAINMOD: Model use, calibration and validation. *Trans. ASABE* 55(4):1509–1522.

29. Skaggs, R.W., M.A. Youssef, and G.M. Chescheir. 2012. Methods to estimate effects of drainage water management on annual nitrogen losses to surface waters. *Trans. ASABE* 55(3):799–808.

30. Tian, S., M.A. Youssef, R.W. Skaggs, D.M. Amatya, G.M. Chescheir. 2012. Temporal variations and controlling factors of nitrogen export from an artificially drained coastal forest. *Environmental Science and Technology* 46(18)9956–9963.

31. Tian, S., M.A. Youssef, R.W. Skaggs, D.M. Amatya, and G.M. Chescheir. 2012. DRAINMOD-FOREST: Integrated modeling of hydrology, soil carbon and nitrogen dynamics, and plant growth for drained forests. *J. Environ. Qual.* 41:764–782.

32. Tian, S., M.A. Youssef, R.W. Skaggs, D.M. Amatya, and G.M. Chescheir. 2012. Modeling water, carbon, and nitrogen dynamics for two drained pine plantations under intensive management practices. *Forest Ecology and Management* 264:20–36.

2013 NCERA217 Annual Meeting Minutes

The regular annual meeting of the NCERA217: Drainage design and management practices to improve water quality committee was held April 9–11, 2013 in Sioux Falls, SD. The business meeting was called to order at 3:50 pm on April 9 by Past Chair, Xinhua Jia, in place of the Chair, Tim Harrigan who was absent due to weather.

Ramesh Kanwar, the Administrative Advisor, reported that the annual report would be due within 60 days following the annual meeting. The current project terminates this year, and a proposal for renewal will need to be submitted if the committee desires to continue. Dr. Kanwar suggested that the renewal proposal should discuss how we started, what we accomplished, and what the remaining unanswered questions are. He listed several ideas within the general areas of drainage impacts on the environment and drainage impacts on economics and food security that could be part of a proposal for renewal He suggested setting up a small committee to lead the development of the proposal and discussed the process for approval.

Mary Ann Rozum, the USDA NIFA representative, reported via phone from Washington, DC. She reported on the passing of Richard Hegg in April, which leaves only two ag engineers on their staff. NIFA has taken an approximately 15% total cut this year. Next year's budget could be even worse. This has resulted in 40 frozen positions or about 10% of the staff. Mike O'Neill's position was not replaced in water programs. Some of the AFRI grants expected to be released in August are now on hold because of the budget situation and some may be going to every other year or combined offerings. High numbers of letters of intent and applications are leading to greater workloads and reduced acceptance rates. The 406 integrated water quality program was reinstated for this year. NIFA is collaborating with NSF on a water, sustainability, and climate grant that will be offered every other year. Federal travel has been scaled back, but members are invited to visit when they are in DC. NRCS still has some state-level CIG grants available. EPA is concerned about tile outlets from terraces, particularly in MO and IA, and ideas for remediation or documentation of impacts on nitrates would be appreciated. As part of the Gulf hypoxia task force focus on economic incentives for nitrate reductions, additional documentation of nitrate reductions from agricultural practices are desired.

The minutes of the 2012 meeting were read and approved.

A group discussion on preparing a proposal for renewal followed. It was determined that there was a general consensus to seek a renewal, and ideas for objectives were discussed.

The business meeting went into recess at 5:10 pm. The business resumed at 8:10 am on April 10 with the Secretary presiding.

Mohammed Youssef was nominated to be the incoming secretary for 2013–2014. On motion of Dan Jaynes, nominations were ceased, and Mohammed Youssef was elected as the new secretary.

The location for the 2014 meeting was discussed. North Carolina, Iowa (at the Iowa Soybean Association headquarters if they would be willing again to host), and Ohio were suggested as possible locations. ADMS will also discuss meeting locations and whether to hold it jointly with NCERA217 at their meeting. A follow up poll can be used to help select the location.

Existing and proposed efforts at developing an agricultural drainage BMP manual and potentially other related products were discussed. The proposal from Norm Fausey, Andy Ward, and others from Ohio for a suite of printed and electronic agricultural drainage BMP materials was discussed. There was potential interest expressed by several in the group, but there

were also questions about scope and resources. Jane Frankenberger will craft a response to the group from Ohio to pass along the potential interest and the desire of the group to be informed about developments related to this effort.

Discussion returned to the preparation of new proposal. A writing group, consisting of Matt Helmers, Gary Sands, Chris Hay, Mohamed Youssef, and Xinhua Jia, was established to develop the proposal. Matt Helmers will convene the writing group. Dan Jaynes volunteered to write the termination report for the committee.

The meeting adjourned at 9:20 am.

Christopher H. Hay, Secretary

North Central Extension and Research Activity (NCERA) 217—Drainage Design and Management Practices to Improve Water Quality—and Agricultural Drainage Management Systems Task Force (ADMS TF) Meeting

April 9-11, 2013
Holiday Inn City Centre • Sioux Falls, SD

Meeting Agenda

Tuesday, April 9

Tim Harrigan, Moderator

1:00 PM — Welcome—Overview and Goals of Meeting. Introductions.
Tim Harrigan, Chris Hay

1:25 PM — Drainage Management Research in Indiana
Jane Frankenberger, Purdue University

1:50 PM — Iowa Research and Extension Update: Drainage Activities Associated with the CSCAP
Matt Helmers, Iowa State University

2:15 PM — Subirrigation/Tile Drainage of Potato and Corn
R. Sri Ranjan, University of Manitoba

2:40 PM — Michigan State Report
Tim Harrigan, Michigan State University

3:05 PM — Break

3:35 PM — Minnesota Research and Extension Update
Gary Sands, University of Minnesota

4:00 PM — NCERA 217 Business Meeting 1
Advisor report, Annual report requirements, Proposal to continue.

5:00 PM — Adjourn

Wednesday, April 10

Jeppe Kjaersgaard, Moderator

8:00 AM — NCERA 217 Business Meeting 2
Elect officers, Proposal to continue, Plan next year

9:30 AM — An Update on Drainage Research in North Carolina
Mohamed Youssef, North Carolina State University

9:55 AM — Break

10:30 AM — North Dakota State Report
Xinhua Jia, North Dakota State University

10:55 AM — Water Quality and Flow Measurement from Field Size Tile Systems
Tom Scherer and Roxanne Johnson, North Dakota State University

11:20 AM — South Dakota Research and Extension Activities
Jeppe Kjaersgaard and Chris Hay, South Dakota State University

11:45 AM — Lunch

Mini-Symposium — Hydrologic Impacts of Subsurface Drainage

Chris Hay, Moderator

12:45 PM — Field to Drainage District Scale Hydrologic Impacts of Drainage
Matt Helmers, Iowa State University

1:15 PM — Hydrologic Impacts of Agricultural Tile Drainage in Iowa
Brandon Sloan, University of Iowa

1:45 PM — Modeling Drainage Hydrologic Impacts in the Red River of the North Basin
Gary Sands, University of Minnesota

2:15 PM — Climate and Tile Drainage Impacts on River Discharge and Baseflow
Satish Gupta, University of Minnesota

2:45 PM — Discussion
What does this mean? What are the research/Extension needs? What are the next steps?

3:00 PM — Break

Dan Jaynes, Moderator

3:15 PM — Saturated Buffers—ADMC Project
Nathan Utt, Ecosystem Services Exchange

3:30 PM — Saturated Buffers—Data
Dan Jaynes, USDA ARS

3:45 PM — Saturated Buffer Discussion
All

4:00 PM — Agricultural Drainage Management Coalition Update
Leonard Binstock, ADMC and Charlie Schafer, Agri Drain Corporation

4:30 PM — NRCS Ag Water Management Team
Paul Sweeney, USDA NRCS

4:45 PM — Introductory Discussion: Possibility of an "Agricultural Drainage Management System" for NRCS
Paul Sweeney, USDA NRCS

5:00 PM — Discuss Plans for Tomorrow and Adjourn

Thursday, April 11

Paul Sweeney, Moderator

8:00 AM — Introductions and Goals for the Day

8:15 AM — Performance of Inline Water Control Structures for DWM
Rob Sampson, USDA NRCS

8:30 AM — Edge-Of-Field Water Quality Monitoring NRCS Activity Standards Overview
Anna Bramblett, USDA NRCS

8:50 AM — Bioreactor Results from Minnesota
Andry Ranaivoson, University of Minnesota

9:10 AM — Bioreactor Discussion
How many, where? What do we know about their performance? Remaining questions? Education products and needs
Jeppe Kjaersgaard, South Dakota State University

9:30 AM Break

10:00 AM Canada Manitoba Crop Diversification Center—Update on Drainage Water Management Activities: 2012–2014
Bruce Shewfelt, Agriculture and Agri Food Canada

10:20 AM Conservation Drainage Focus Group and Workshop Results
Mark Dittrich, Minnesota Department of Agriculture

10:40 AM Drainage Water Management Discussion
Overview of the JSWC issue
Education products and needs
- *Updating the DWM FAQ publication*
- *New design guidelines publication*

Jane Frankenberger, Purdue University

11:15 AM Possibility of an "Agricultural Drainage Management System" for NRCS
Paul Sweeney, USDA NRCS

11:30 AM Announcements—What's Next for the ADMS Task Force? —Next Meeting
Jane Frankenberger, Purdue University

12:00 PM Adjourn. Safe Travels!

1:00 PM **Optional Tour to USGS EROS Data Center**