Annual Report

Water and Nutrient Research: In-field and Offsite Strategies

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NUTRIENT AND WATER MANAGEMENT PROJECT 2005-2009

Much of Iowa is characterized by relatively flat, poorly-drained soils which, with extensive artificial subsurface drainage, have became some of the most valuable, productive lands in the State. In 2002, the average land value for the 22-county area making up most of the Des Moines Lobe was $2,436 an acre, and 80.5% of that area was in row-crops (42.9% in corn and 37.6% soybeans). However, this drained land has also become a source of significant NO_3 loss because of the changes in land-use and hydrology brought about by tile drainage. While surface runoff is decreased with subsurface drainage (resulting in decreased losses of sediment, ammonium-nitrogen, phosphorus, pesticides and micro-organisms), subsurface flow and leaching losses of NO_3 are increased. This is due mostly to an increase in volume and the "short-circuiting" of subsurface flow, but also in part to the increased aeration of organic-rich soils with potentially increased mineralization and formation of NO_3 (and less denitrification) in the soil profile.

The problem of excess nutrient loads can probably be ameliorated by a combination of in field and off site practices, but the limitations and appropriateness of alternative practices must be understood and outcomes must be measurable. Promising in field practices include nutrient management, drainage management, and alternative cropping systems. Nitrate-removal wetlands are a proven edge-of-field practice for reducing nitrate loads to downstream water bodies and are a particularly promising approach in tile drained landscapes. Strategies are needed that can achieve measurable and predictable reductions in the export of nutrients from tile drained landscapes. The principal objectives of this project are (1) to evaluate the performance of nutrient management, drainage management, and alternative cropping systems with respect to profitability and export of water and nutrients (nitrate-nitrogen and total phosphorus) from tile drained systems and (2) to evaluate the performance of nitrate-removal wetlands in reducing nitrate export from tile drained systems.

This annual report describes activities related to objectives 1 and 2 along with outreach activities that were directly related to this project. For objective 1, crop years 2005, 2006, and 2007 are presented. Also, outreach activities are noted for 2005, 2006, and 2007 to provide an overall project summary.

Gilmore City Project Site

Treatments

The specific treatments investigated at the Gilmore City Research Facility (GCRF) are listed in Table 1. All treatments except the harvestable perennials consist of eight plots with four in soybeans and four in corn each year. The harvestable perennials each have four plots. The harvestable perennials were investigated during the winter of 2004 and planted in spring 2005 after discussion with the investigators and IDALS personnel.

The treatments included allow for varied comparisons as follows:

- Timing of nitrogen application (treatments 1,2 and 3,4 vs. 5,6 and 7,8)
- Rate of nitrogen application (treatments 1,2 vs. 3,4 and 5,6 vs. 7,8 vs. 9,10)
- Method of nitrogen application (treatments 7,8 vs. 15,16)
- Potential impacts of tillage (treatments 7,8 vs. 11,12)
- Cropping practices through the use of a winter cover crop (treatments 7,8 vs. 13,14)

- Impacts of complete conversion to perennial vegetation (treatments 17 and 18 vs. other treatments)

Table 1. Treatments at the Gilmore City Research Facility for Crop Years 2005-2009.

Treatment Number*	Treatment	Nitrogen Application Time	Nitrogen Application Rate (lb/acre)
1,2	Conventional tillage	Fall	75
3,4	Conventional tillage	Fall	125
5,6	Conventional tillage	Spring (early season sidedress)	75
7,8	Conventional tillage	Spring (early season sidedress)	125
9,10	Conventional tillage	Spring (early season sidedress)	150
11,12	Strip tillage	Spring (early season sidedress)	125
13,14	Cover crops after harvest	Spring (early season sidedress)	125
15,16	LCD every other row application	Spring (early season sidedress)	125
17	Kura clover	-	no fertilizer
18	Orchardgrass + Red/Ladino clover	-	no fertilizer

* within the corn and soybean rotation treatments, even numbers are soybean and receive no nitrogen.

These treatments allow for comparison of existing questions related to lower rates of nitrogen application and the potential impacts of fall nitrogen fertilizer application. Additionally, the LCD method of application is being investigated to determine if this application method can reduce nitrate leaching. Inclusion of the strip tillage system will investigate and demonstrate a minimal tillage system and assess its impacts on crop yield and nitrate leaching. Inclusion of cover crops and harvestable perennials allows for evaluating alternative cropping practices and the impact on nutrient movement and drainage. Evaluation of these alternatives is important for considering progressive methods for minimizing nutrient transport from tile-drained landscapes. The concentration and loading of nutrients exiting the various treatments will be monitored and evaluated on an annual basis and for the five year study period, 2005-2009. In addition, crop yield will be documented each year to evaluate treatment effects on yield, specifically whether there are declines in annual yield at the lower nitrogen rate applications. The evaluation of the treatment effects will be for the study period but each year will be analyzed to evaluate treatment effects on a yearly basis and after the completion of this phase of the research study. It is understood that climatic variability plays a significant role in the leaching of nutrients in the tile drained landscape.

From this, it is important to have numerous years of leaching data to evaluate the treatment effects both from a production (crop yield) perspective and a nutrient leaching perspective. The multiple years of data allows for evaluating how the treatments respond under varying climatic conditions and after subsequent years with similar cropping practices. Also, these multiple years of data allow for additional characterization of tile flow under varied precipitation conditions and allow for further understanding of the hydrology of the site.

Agronomic Activities in 2005, 2006 and 2007

Agronomic field activities were completed in a timely manner prior to and during the crop season. Rye for 2005 was seeded on October 15, 2004. Fall chisel plowing was performed on November 2-3, 2004. Fall fertilization was completed on November 15, 2004. Tillage for seedbed preparation was completed in the spring just prior to planting of perennial crops on April 18th and followed by 0.72" of precipitation. Round Up herbicide was applied on April 14, 2005 in the rye/corn system and in rye/soybean plots on May 24. Seedbed preparation for corn and soybean was also completed just prior to May 3 and 4 seeding dates. Fertilizer was applied just after corn crop emergence on May 12-13, 2005. Rye for 2006 was planted on October 11, 2005. Fall chisel plowing of corn residue was performed on November 14, 2005. Fall fertilization for 2006 was completed on November 21, 2005. Field activities in 2006 were completed in a timely manner prior to and during the crop season. Seedbed preparation for corn and soybean was completed just prior to May 4 corn seeding date. Soybean was seeded on May 10. Fertilizer was applied just after corn crop emergence on May 17-18th. Rye cover crop in corn plots was sprayed to eliminate on April 24. Soybean rye cover crop plots were sprayed to eliminate rye on May 16. Rye for 2007 was planted on October 12, 2006. Fall fertilization for 2007 was completed on November 21, 2006. Fall tillage (chisel plow of corn residue) was performed on November 22, 2006. In 2007, seedbed preparation for corn and soybean was completed just prior to May 14 corn seeding date. Soybean was seeded on May 17. Fertilizer was applied just after corn crop emergence on June 5th. Rye cover crop in corn plots was sprayed to eliminate rye on April 30. Soybean rye cover crop plots were sprayed to eliminate rye on May 23.

Weed Control 2005, 2006 and 2007

Round Up ready crops were used at the site in 2005. Dual II was used for pre-plant weed control and was broadcast on May 10, 2005. First application of Round Up was on May 21, 2005. Second application was on June 17, 2005.Weed control was acceptable in most soybean plots; poor control of lambsquarter was noted in 6 of 32 plots, likely due to sprayer malfunction or poor herbicide application timing. Corn weed control was superior; no specific weed control problems were observed. Cultivation for weed control was not incorporated in the weed management system.

Round Up ready crops were again used at the site in 2006. Dual II was used for pre-plant weed control and was broadcast on May 22, 2006. First application of Round-Up for weed control was on May 22 for strip till plots; all other plots had first application on June 2, 2006. Second application was on June 19, 2006 in corn plots only. Soybeans had second application on June 22, 2006. Weed control was acceptable in most soybean plots; poor control of lambsquarter was noted in the strip till plots, for both corn and soybean due to poor herbicide application timing. Corn weed control in all other treatments was superior except as mentioned in strip till plots; no specific weed control problems were observed. Cultivation for weed control was not incorporated in the weed management system.

As in the first two years, Round Up ready crops were used at the site in 2007. Dual II was used for pre-plant weed control and was broadcast on May 31. First application of Round-Up for weed control was on May 31. Second application was on June 13, 2007. Weed control was acceptable in soybean plots; poor control of lambsquarter and dandelion was noted in the strip till plots, for both corn and soybean due to poor herbicide application timing. Corn weed control in all other treatments was superior except as mentioned in strip till plots; no specific weed control problems were observed. Cultivation for weed control was not incorporated in the weed management system.

Precipitation 2005, 2006, and 2007

Precipitation was recorded at the site in 2005 from April through November; freezing weather (Jan-March and December) precipitation was obtained from NOAA weather stations in Pocahontas and Humboldt (Table 2). January through March precipitation in 2005 was slightly below normal at the site. April, May and June were each above normal (0.4" to 1.15" higher). July precipitation was nearly 2", August nearly 3" and September 1.4" below normal. March through November total was 6.47" below normal. Highest individual storm event precipitation was on June 25-26 when 2.65" were recorded.

Table 2. Precipitation in 2005 at the Gilmore City Research Facility (GCRF) and comparisons to norms and amounts at local NOAA weather stations.

Precipitation at the GCRF in 2005				NOAA weather stations in 2005		
			normal*	Pocahontas	Humboldt	average
	mm	inches	inches		inches	
Jan	-	-	0.91	0.62	0.60	0.61
Feb	-	-	0.70	1.77	1.60	1.69
Mar	-	-	2.20	1.33	1.07	1.20
Apr	89	3.49	3.09	3.32	3.61	3.47
May	129	5.09	3.94	5.85	4.15	5.00
Jun	134	5.27	4.37	7.46	8.89	8.18
Jul	63	2.47	4.37	3.82	4.42	4.12
Aug	45	1.76	4.60	1.41	3.20	2.31
Sep	39	1.53	3.16	3.38	4.54	3.96
Oct	20	0.79	2.17	1.00	0.59	0.80
Nov	43	1.69	1.86	1.50	2.18	1.84
Dec	-	-	1.37	1.54	1.23	1.39
total			32.74	33.00	36.08	34.54

* From: Climatological Data for Iowa, National Climate Data Center for Pocahontas Iowa 1971-00.

Precipitation was recorded at the site in 2006 from March through November; freezing weather (Jan-Feb and December) precipitation was obtained from NOAA weather stations in Pocahontas and Humboldt (Table 3). January and February precipitation was slightly below normal. March and April were each above normal (0.51 and 0.57" higher). May, June and July were all well below normal, with August and September slightly above normal. March through November total was 8.59" below normal. Highest individual storm event precipitation was on August 9 when 2.32" was recorded.

Table 3. Precipitation in 2006 at the research site and comparisons to norms and amounts at local NOAA weather stations.

Precipitation at the GCRF in 2006				NOAA weather stations in 2006		
			normal*	Pocahontas	Humboldt	average
	mm	inches	inches		inches	
Jan	-	-	0.91	0.46	0.45	0.46
Feb	-	-	0.70	0.43	0.54	0.49
Mar	69	2.71	2.20	3.74	2.87	3.31
Apr	93	3.66	3.09	4.22	3.54	3.88
May	14	0.87	3.94	0.92	2.08	1.50
Jun	56	2.39	4.37	1.58	1.96	1.77
Jul	26	1.10	4.37	2.64	1.79	2.22
Aug	46	5.30	4.60	5.01	4.39	4.70
Sep	56	3.60	3.16	3.18	4.50	3.84
Oct	19	0.76	2.17	0.70	1.46	1.08
Nov	20	0.78	1.86	1.36	1.36	1.36
Dec	-	-	1.37	1.69	2.04	1.87
total			32.74	25.93	26.98	26.48

* From: Climatological Data for Iowa, National Climate Data Center for Pocahontas Iowa 1971-00

Precipitation was recorded at the site in 2007 from March through November; freezing weather (Jan-Feb and December) precipitation was obtained from NOAA weather stations in Pocahontas and Humboldt (Table 4). January, February, April and May precipitation was above normal. March was slightly below normal. As in 2006, June and July were both well below normal, with August 8.62" above normal and September and October only slightly above normal. March through November total was 3.52" above normal. Highest individual storm event precipitation was on August 21 when 3.70" was recorded.

Drainage 2005, 2006, and 2007

Average soil temperature at a 4" depth rose above freezing in 2005 on March 22 and continued to rise. Treatment plot sampling pumps were installed during the last week of March. Drainage started during this period and the first samples were collected on April 1st. Eighteen of the seventy-two plots had enough drainage to provide a sample on this date. By April 7th, fourteen additional plots were sampled. Samples were collected on at least a weekly basis, and for most plots, drainage was sufficient for sampling through the month of June. Only ten plots had drainage in July; the last samples were gathered on July 26th. Table 5 lists drainage volumes by treatment in 2005 with statistical differences at p=0.05. Five of the eighteen treatments had one of four replications removed due to excessive drainage volume values. Statistical differences among treatments were noted for four of eighteen treatments (LSD=7.22 inches). Average drainage for all treatments was 8.45 inches. When the treatments were grouped by crop (C vs. S) it was noted that there was a significant difference between crops, with soybean having a lower value (C=10.17", S=7.19") possibly related to tillage operations performed prior to the drainage season. With 23.29" of precipitation between March 1 and November 30 and using an overall drainage volume of 8.45", approximately 36% of the precipitation became subsurface drainage. Nearly half of the precipitation amount that occurred between March and the end of July, when drainage ceased, became subsurface drainage (see Table 6). The site was winterized on

December 5. Average soil temperature at 4” depth did not drop below freezing in December 2005 in the region.

Table 4. Precipitation in 2007 at the research site and comparisons to norms and amounts at local NOAA weather stations.

Precipitation at the GCRF in 2007				NOAA weather stations in 2007		
			normal*	Pocahontas	Humboldt	average
	mm	inches	inches		inches	
Jan	-	-	0.91	1.20	1.44	1.32
Feb	-	-	0.70	1.57	1.54	1.55
Mar	46	1.80	2.20	2.31	2.20	2.25
Apr	83	3.27	3.09	4.09	4.70	4.40
May	90	3.54	3.94	4.68	4.38	4.53
Jun	44	1.75	4.37	1.62	2.58	2.10
Jul	41	1.63	4.37	1.19	2.84	2.02
Aug	336	13.22	4.60	13.01	16.68	14.85
Sep	97	3.82	3.16	3.27	2.95	3.11
Oct	107	4.22	2.17	4.23	4.32	4.28
Nov	1	0.03	1.86	0.05	0.05	0.05
Dec	-	-	1.37	NA	NA	NA
total			32.74			

* From: Climatological Data for Iowa, National Climate Data Center for Pocahontas Iowa 1971-00
NA – Not available at time of report preparation

Average soil temperature at a 4”depth rose above freezing in 2006 on March 11 and remained steady and began to rise after the 17th of March. Treatment plot sampling pumps were installed on March 28th. After installation, 0.92” of rainfall was recorded on March 30-31st, 2006 and subsurface drainage began thereafter and the first samples were collected on April 1st. Forty-nine of the seventy-two plots had enough drainage to provide a sample on this date. Samples were collected on at least a weekly basis, and for most plots, drainage was sufficient for sampling through the first week of May. All drainage ceased on May 10, 2006. Table 5 lists drainage volumes by treatment in 2006 with statistical differences at p=0.05. Nine of the eighteen treatments had one of four replications removed due to erroneous (usually excessive because of pump malfunction in an adjacent sump) drainage volume values. No statistical differences among treatments were noted for drainage in 2006 (LSD=2.08 inches). Average drainage for all treatments was 3.60 inches. When the treatments were grouped by crop, no significant difference between crops was noted as was in 2005. With 15.70” of precipitation between March 1 and November 30 and using an overall drainage volume of 3.60”, approximately 23% of the precipitation became subsurface drainage. Nearly half of the precipitation amount that occurred between March and the middle of May, when drainage ceased, became subsurface drainage (see Table 6). The site was winterized on November 28, 2006. Average soil temperature at 4” depth fell below freezing on December 3, 2006.

Table 5. Subsurface drainage volumes with statistical differences at p=0.05, by treatment in 2005, 2006 and 2007. Statistical comparisons are within years only.

Treatment	Description	Drainage (inches)		
		2005	2006	2007
1	Fall 75 Corn	12.03a	3.81a	21.01a
2	Fall 75 soybean	7.14ab	3.33a	20.03a
3	Fall 125 Corn[3]	11.07ab	3.23a	19.98a
4	Fall 125 soybean[1,2]	7.31ab	3.85a	14.94a
5	Spring 75 Corn	11.72ab	3.52a	22.66a
6	Spring 75 soybean	5.27ab	3.63a	17.96a
7	Spring 125 Corn[1,2]	4.70b	3.08a	19.22a
8	Spring 125 soybean[2]	5.95ab	3.67a	15.09a
9	Spring 150 Corn[2]	12.49a	4.21a	22.77a
10	Spring 150 soybean[2]	7.55ab	3.07a	20.63a
11	Strip 125 Corn[1, 2]	9.70ab	4.56a	22.03a
12	Strip 125 soybean[1]	4.80b	3.91a	17.70a
13	Cover Crop 125 Corn[1,2]	6.98ab	3.70a	21.45a
14	Cover Crop 125 soybean[2]	10.53ab	3.30a	22.71a
15	LCD 125 Corn	9.65ab	3.51a	20.58a
16	LCD 125 soybean	6.78ab	4.04a	21.73a
17	Kura clover	10.08ab	3.59a	21.17a
18	Orchardgrass + Red/Ladino clover[2]	8.29ab	2.62a	17.19a
LSD		7.22	2.08	10.51
average drainage		8.45	3.60	19.94
standard deviation		2.53	1.43	2.45
average for corn treatments		10.17	3.67	21.21
average for soybean treatments		7.19**	3.62	18.85

[1] one of four reps not included in 2005 because of erroneous drainage value.
[2] one of four reps not included in 2006 because of erroneous drainage value.
[3] one of four reps not included in 2007 because of erroneous drainage value.
** significantly different from drainage for corn treatments at p=0.05.

Average soil temperature at a 4”depth rose above freezing in 2007on March 13 and remained steady and began to rise after the 17th of March. Treatment plot sampling pumps were installed on March 20th. After installation, 0.60” of rainfall was recorded on March 21-24th, 2007 and subsurface drainage began thereafter and the first samples were collected on March 26th. Forty of the seventy-two plots had enough drainage to provide a sample on this date. Samples were collected on at least a weekly basis, and for most plots, drainage was sufficient for sampling through the first week of June. All drainage ceased after the 1st week of June and commenced the third week of August after 10.5 inches was recorded in the preceding week. At least weekly samples were also available from the 3rd week of September until the end of October, a rather atypical drainage period. Table 5 lists drainage volumes by treatment in 2007 with statistical differences at p=0.05. Only one of the eighteen treatments had one of four replications removed due to erroneous (usually excessive, because of pump malfunction in an adjacent sump) drainage volume values. All other replications were used in statistical analysis. No statistical differences among treatments were noted for drainage in 2007 (LSD=10.51 inches). Average drainage for all treatments was 19.94 inches (5.5x the drainage of 2006 and 2.4x that of 2005). When the treatments were grouped by crop, no significant difference between crops was noted. With 33.28” of precipitation between March 1 and November 30 and using an overall drainage volume of 19.94”, approximately 60% of the precipitation became subsurface drainage. April and October both had more drainage than precipitation, likely caused by drainage delay from the previous month’s precipitation (see Table 6). The site was winterized on November 19, 2007. Average soil temperature at 4” depth fell below freezing on November 28, 2007.

Table 6. Average annual drainage for each month over all treatments with totals and percentage as drainage for April-July 2005, 2006 and 2007.

	2005			2006			2007		
month	precip	drainage	%	precip	drainage	%	precip	drainage	%
	------ inches ------			------ inches ------			------ inches -----		
March	1.20	-	0	2.71	-	0	1.80	0.34	18
April	3.49	2.82	81	3.66	3.05	83	3.27	4.33	132
May	5.09	3.23	63	0.87	0.59	68	3.54	1.37	39
June	5.27	2.46	47	2.39	-	0	1.75	0.27	15
July	2.47	0.12	5	1.10	-	0	1.63	-	0
August	1.76	-	0	5.30	-	0	13.22	8.10	61
September	1.53	-	0	3.60	-	0	3.82	0.16	4
October	0.79	-	0	0.76	-	0	4.22	5.41	128
total	21.60	8.63	53	20.39	3.64	45	33.25	19.98	60

Nitrate Concentrations and Losses 2005, 2006 and 2007

Previous history of current plot treatments quite likely has influenced the nitrate-nitrogen concentrations observed during 2005 and to some extent those in 2006. The majority of plots received 150 or 200 lbs N/acre during the period of 2000-2004 either as manure or aqua ammonia in the spring or fall. Some plots would have received 225 lbs of ammonia, each season. The previous experimental phase also included a split plot methodology with both corn and soybean grown on each plot, as opposed to the current phase utilizing whole plots, which has also contributed to and confounded the 2005 results. No definitive treatment effect trends should be derived from 2005 concentration results. Some treatment effect trends began to emerge in 2006.

In 2005, 535 flow weighted water samples were gathered. Table 7 lists the treatment results. Only the highest and three lowest average concentrations, out of eighteen compared, exhibited significant differences at p=0.05 level. The highest NO_3-N average concentration (18.8 mg/L NO_3-N) was observed in a treatment that was in the soybean year of the rotation and received no nitrogen in 2005. In the previous phase, two of the four replications for this treatment received 225 lbs N/acre and is quite likely a major factor in the elevated levels of NO_3-N observed. Lowest concentration observed was for two treatments: strip tillage 125 and LCD 125 cropped to corn, both averaged 12.9 mg/L NO_3-N.

The highest concentrations in 2006 were recorded for the 150 rate treatment within the soybean year (N applied in 2005 and years prior) and lowest were found in the perennial systems, specifically the Kura clover treatment; all other values were between these treatments values. Annual flow-weighted concentrations ranged from 6.9 to 21.7 mg L^{-1}. Individual, flow weighted averages ranged from 4.5 to 30.1 mg L^{-1} and were recorded within the aforementioned treatments. Average flow weighted values for most treatments only showed minor differences in their NO_3-N concentrations when compared. No significant differences were noted when comparing the fall and spring applications to each other across rates or crops or when rates were compared within the spring application rate treatment only. Use of the LCD applicator compared to a conventional knife also showed no significant differences in resulting concentrations. The use of a cover crop or strip tillage system in either crop also did not exhibit any significant effects on NO_3-N concentrations. The only significance was shown when comparing the N rate treatments within the soybean year of the corn soybean cropping system; nitrate in drainage from the previous season(s) applications at the 150 rate was significantly different than the 75 and 125 rates. Table 7 lists all treatments by year and the statistical differences at the p=0.05 level.

As opposed to 2006, highest concentrations in 2007 were recorded for the 150 rate treatment within the corn year (concentrations were highest in the soybean year in 2006 for the 150 rate) and lowest were found in the perennial systems, specifically the orchardgrass/clover treatment; all other values were between these treatments values. Annual flow-weighted concentrations ranged from 4.4 to 20.3 mg L^{-1}. Individual plot/replication, flow weighted averages ranged from 2.2 to 23.6 mg L^{-1} and were recorded within the aforementioned treatments. Average flow weighted values for most treatments only showed minor differences in their NO_3-N concentrations when compared. No significant differences were noted when comparing the fall and spring applications to each other across rates or crops. Use of the LCD applicator compared to a conventional knife also showed no significant differences in resulting concentrations. The use of a cover crop or strip tillage system in either crop also did not exhibit any significantly different effects on NO_3-N concentrations. However, while not significantly different, on an absolute basis NO_3-N concentrations were between 9% and 23% lower in the treatments with winter cover crops. Significance was noted when comparing the N rate treatments. Nitrate in drainage from the previous season(s) applications at the 150 rate was significantly different than the 75 and 125 rates. Table 7 lists all treatments by year and the statistical differences at the p=0.05 level.

Table 8 lists NO_3-N losses by treatment in 2005, 2006 and 2007. Losses were calculated by multiplying subsurface drainage effluent concentration by drainage volume. Due to the inherent variability between experimental plots and among treatments, loss calculations for one year may not be the best indicator of treatment effect. Losses in 2005 ranged from 17.4 lbs/acre NO_3-N for soybean grown under a strip tillage system, with no fertilizer added in 2005 to 41.1 lbs/acre NO_3-N exiting the subsurface drainage system for an early season sidedress application of 150 lbs N/acre on corn. (Fertilizer was applied on May 12-13.) These two treatments were the only statistically different (p=0.05) treatments for loss in 2005.

Table 7. Average annual flow weighted nitrate concentrations by treatment in 2005, 2006 and 2007 with statistical significance at p=0.05. Statistical comparisons are within years only.

Treatment	Description	nitrate N (mg/L) p=0.05		
		2005	2006	2007
1	Fall 75 corn	14.5ab	17.3abc	10.6cd
2	Fall 75 soybean	17.8ab	10.4efg	11.1bcd
3	Fall 125 corn	14.5ab	16.0bcd	13.8b
4	Fall 125 soybean	13.5ab	14.0bcdef	11.6bcd
5	Spring 75 corn	13.5ab	18.3ab	10.0de
6	Spring 75 soybean	18.8a	12.0def	13.5bc
7	Spring 125 corn	18.1ab	15.4bcd	12.9bcd
8	Spring 125 soybean	17.0ab	13.6bcdef	12.9bcd
9	Spring 150 corn	16.3ab	15.7bcd	20.3a
10	Spring 150 soybean	15.8ab	21.7a	17.6a
11	Strip 125 corn	12.9b	14.1bcdef	11.5bcd
12	Strip 125 soybean	14.2ab	13.4cdef	11.4bcd
13	Cover Crop 125 corn	13.9ab	15.2bcd	11.7bcd
14	Cover Crop 125 soybean	14.4ab	11.4defg	9.9de
15	LCD 125 corn	12.9b	14.8bcde	12.1bcd
16	LCD 125 soybean	16.1ab	12.8cdef	11.3bcd
17	Kura clover	13.1b	6.9g	7.4ef
18	Orchardgrass + Red/Ladino clover	14.7ab	9.7fg	4.4f
	LSD	5.4	4.8	3.2

Losses in 2006 were much below those recorded in 2005 not because of a major drop in concentrations (except for the perennial systems, which did drop substantially) but because drainage volumes were approximately 42% of those recoded in 2005. Losses ranged from 5.2 to 16.5 lbs/acre for the Kura clover treatment and 150 spring applied nitrogen treatment in the soybean year of the rotation, respectively (N applied on May 12-13, 2005 in the corn year). Statistical differences were noted when comparing the spring 150 soybean treatment to both the fall 75 soybean and the perennial systems as listed in Table 8.

Losses in 2007 were the highest recorded since the initiation of this treatment phase in 2005. The increase in loss was due to large drainage volumes in 2007 compared to previous years. Average drainage volume was 2.3 times that recorded in 2005 (5.5 times that of 2006) and the losses increased accordingly. Losses ranged from 18.6 to 101.6 lbs N/acre for the Kura clover treatment and 150 spring applied nitrogen treatment in the corn year of the rotation, respectively (N applied on June 5, 2007 in the corn year). One-third of the 150 rate loss in corn was prior to N application in 2007. Statistical difference was noted when comparing the spring 150 corn treatment compared to all other treatments except for the soybean 150 treatment as listed in Table 8.

Table 8. Average annual flow weighted nitrate losses by treatment in 2005, 2006 and 2007 with statistical significance at p=0.05. Statistical comparisons are within years only.

Treatment	Description	nitrate-N (lbs/acre)		
		2005	2006	2007
1	Fall 75 Corn	38.4ab	15.3ab	51.2c
2	Fall 75 soybean	23.9ab	8.0bc	49.9c
3	Fall 125 Corn	35.4ab	11.4abc	63.6bc
4	Fall 125 soybean	23.7ab	12.4abc	39.4cd
5	Spring 75 Corn	35.3ab	14.3ab	52.3c
6	Spring 75 soybean	23.6ab	10.3abc	53.1c
7	Spring 125 Corn	21.8ab	11.5abc	58.4bc
8	Spring 125 soybean	23.7ab	13.0abc	44.1cd
9	Spring 150 Corn	41.1a	13.4abc	101.6a
10	Spring 150 soybean	27.7ab	16.5a	85.9ab
11	Strip 125 Corn	27.8ab	14.2ab	55.5c
12	Strip 125 soybean	17.4b	12.0abc	43.9d
13	Cover Crop 125 Corn	20.0ab	12.6abc	55.4c
14	Cover Crop 125 soybean	34.9ab	9.4abc	48.4cd
15	LCD 125 Corn	29.7ab	11.5abc	56.1bc
16	LCD 125 soybean	24.5ab	11.4abc	53.1c
17	Kura clover	26.3ab	5.2c	34.6cd
18	Orchardgrass + Red/Ladino clover	26.1ab	5.3c	18.6d
	LSD	22.9	8.4	30.4

Total Reactive Phosphorus 2005, 2006 and 2007

Total reactive phosphorus (TRP) concentrations were measured in tile drainage samples that were also tested for NO_3-N. Table 9 lists TRP concentrations by year for each treatment. Table 10 lists loss by year and treatment in grams per acre. The ascorbic acid method of phosphorus analysis from Standard Methods for the Examination of Water and Wastewater 20th edition was used to determine the concentration of TRP, also known as total orthophosphate. The test measures both dissolved and suspended orthophosphate. This test measures the form most available to plants and is a useful indicator of potential water quality impacts such as algae blooms and weed growth in surface waters. No specific trends were observed over the two year period of observation. Analyses of 2007 water samples for TRP are being completed and will be reported when available.

Table 9. Average annual flow weighted total reactive phosphorus concentrations by treatment in 2005, 2006 and 2007 with statistical significance at p=0.05. Statistical comparisons are within years only.

Treatment	Description	TRP (µg/L) p=0.05		
		2005	2006	2007
1	Fall 75 corn	4.64cd	12.18ab	
2	Fall 75 soybean	6.68cd	6.00b	
3	Fall 125 corn	25.29a	11.19ab	
4	Fall 125 soybean	17.24abc	9.99ab	
5	Spring 75 corn	15.03abcd	6.47b	
6	Spring 75 soybean	8.58cd	7.84b	
7	Spring 125 corn	10.56cd	14.04ab	
8	Spring 125 soybean	22.63ab	11.73ab	
9	Spring 150 corn	13.85bcd	9.31ab	
10	Spring 150 soybean	11.31cd	9.31ab	
11	Strip 125 corn	9.84cd	9.05b	
12	Strip 125 soybean	6.94cd	9.28ab	
13	Cover Crop 125 corn	11.96bcd	17.12a	
14	Cover Crop 125 soybean	13.80bcd	10.69ab	
15	LCD 125 corn	12.63bcd	9.54ab	
16	LCD 125 soybean	12.12bcd	6.71b	
17	Kura clover	9.69cd	12.09ab	
18	Orchardgrass + Red/Ladino clover	7.11cd	11.02ab	
	LSD	11.30	8.10	

Late Spring Nitrate Test 2005, 2006, and 2007

Each corn plot was sampled using the Late Spring Nitrate Test (LSNT) procedures for determination of nitrate-nitrogen concentrations in the top 12" of soil on June 17, 2005 when corn plants were approximately 10" tall. Table 11 lists soil test results and the additional application amount recommended. Test results were for information only and no additional N applications were made. Fall N application plots had lower test values than plots with N applied in the spring. The spring 150 (treatment 9) plots had the highest N concentrations and the fall 125 (treatment 3) the lowest.

Each corn plot was sampled using the Late Spring Nitrate Test (LSNT) procedures for determination of nitrate-nitrogen concentrations in the top 12" of soil on June 6, 2006 when corn plants were approximately 8" tall. Results are listed in Table 11. As in 2005, test results were for information purposes only. No additional N was applied to the treatment plots. Highest values were observed using the LCD applicator at 125 lbs/acre N rate, closely followed by the conventional knife applicator using 150 lbs N/acre. Lowest values were recorded for the Fall 75 treatment.

Each corn plot was sampled using the Late Spring Nitrate Test (LSNT) procedures for determination of nitrate-nitrogen concentrations in the top 12" of soil on June 4, 2007 when corn plants were approximately 6" tall and prior to fertilizer application. Results are listed in Table 11. As in previous years, test results were for information purposes only. No additional N based on LSNT results was applied to the treatment plots. Highest values, 10 mg/L were observed for 3 of the 8 treatments (LCD, Strip, and Fall at 125 lbs/acre N rate), closely followed by all other treatments at 8 mg/L.

Table 10. Average annual flow weighted total reactive phosphorus loss by treatment in 2005 and 2006 with statistical significance at p=0.05. Statistical comparisons are within years only.

Treatment	Description	TRP (grams/acre) p=0.05		
		2005	2006	2007
1	Fall 75 corn	6.4b	4.3abc	
2	Fall 75 soybean	4.3b	2.3c	
3	Fall 125 corn	19.2ab	3.3abc	
4	Fall 125 soybean	14.3ab	4.1abc	
5	Spring 75 corn	13.0ab	2.4c	
6	Spring 75 soybean	5.0b	2.8c	
7	Spring 125 corn	6.2b	6.4ab	
8	Spring 125 soybean	14.8ab	5.6abc	
9	Spring 150 corn	15.4ab	4.4abc	
10	Spring 150 soybean	8.6ab	4.2abc	
11	Strip 125 corn	25.7a	3.1bc	
12	Strip 125 soybean	3.0b	3.4abc	
13	Cover Crop 125 corn	20.6ab	4.1abc	
14	Cover Crop 125 soybean	12.5ab	4.9abc	
15	LCD 125 corn	13.2ab	3.2bc	
16	LCD 125 soybean	8.3ab	6.7a	
17	Kura clover	9.6ab	3.1bc	
18	Orchardgrass + Red/Ladino clover	5.9b	2.7c	
	LSD	19.1	3.4	

Table 11. Late Spring Nitrate Test (LSNT) nitrate-N concentrations and additional N recommended but not applied in 2005, 2006 and 2007.

Treatment	Description	nitrate-N (mg/Kg)	additional N rec. (lb/acre)	nitrate-N (mg/Kg)	additional N rec. (lb/acre)	nitrate-N (mg/Kg)	additional N rec. (lb/acre)
		2005		2006		2007	
1	Fall 75 Corn	8	136	12	106	8	136
3	Fall 125 Corn	6	150	17	62	10	122
5	Spring 75 Corn	10	122	19	52	8	136
7	Spring 125 Corn	9	132	26	0	8	136
9	Spring 150 Corn	18	54	48	0	8	136
11	Strip 125 Corn	10	122	16	72	10	122
13	Cover Crop 125 Corn	10	122	40	0	8	122
15	LCD 125 Corn	16	72	53	0	10	122

Stalk Nitrate Test 2005, 2006, and 2007

Corn stalk nitrate test sampling protocols were followed to determine nitrate-N concentrations in corn stalk tissue from each plot. Results are listed in Table 12. Stalks were sampled on September 29, 2005. Stalk nitrate values can be divided into four categories: low (less than 250 mg/L-N) marginal (250-700) optimal (700 and 2000 mg/Kg). Only the spring 150 treatment was in the optimal range, all other treatments were in the marginal to low range.

As in 2005, corn stalk nitrate test sampling protocols were followed in the fall of 2006 to determine nitrate-N concentrations in corn stalk tissue from each plot. Results are listed in Table 12 by treatment. Stalks were sampled on October 2, 2006. All treatments were in the marginal to low range indicating that additional N should have been supplied to the crop.

As in previous years, corn stalk nitrate test sampling protocols were followed in the fall of 2007 to determine nitrate-N concentrations in corn stalk tissue from each plot. Results are listed in Table 12 by treatment. Stalks were sampled on October 4-5, 2007. One-half of the treatments were in the marginal to low range indicating that additional N should have been supplied to the crop. The other half were in the optimal range: fall 125, spring 125, spring 150, and cover crop 125 treatments.

Table 12. Stalk nitrate test concentrations in 2005 and 2006. Optimal range is between 700 and 2000 mg/L-N.

Treatment	Description	nitrate-N* (mg/Kg)		
		2005	2006	2007
1	Fall 75 Corn	32	238	404
3	Fall 125 Corn	67	484	718
5	Spring 75 Corn	83	171	174
7	Spring 125 Corn	186	310	867
9	Spring 150 Corn	1032	498	1450
11	Strip 125 Corn	260	228	161
13	Cover Crop 125 Corn	178	167	870
15	LCD 125 Corn	178	95	520

* low (less than 250 mg/Kg) marginal (250-700) optimal (700-2000).

Grain Yield 2005, 2006, and 2007

Corn and soybean yields, by treatment, are listed in Tables 13 and 14. Because of the plot configuration in 2004, when corn and soybean were both grown on the same plot, yields for 2005 could be separated into those that followed the same crop or were grown in rotation. Continuous corn yield depression ranged from 12-31%, with an average 18%. Soybean on soybean yield depression was 6-11%, with an average of 9%. Considering only the crops in rotation, yields ranged from 156-179 bu/acre; lowest yield was for Fall 75 treatment and highest for Spring 150. The comparison resulted in a significant difference at p=0.05. All other treatments were not statistically different from these two values. Soybean yield in rotation ranged from 48-53 bu/acre and no significant differences were noted. Pocahontas County corn and soybean yield for 2005 were 183 and 50 bu/acre, respectively.

For 2006, corn yields ranged from 68-157 bu/acre; if the strip crop treatment 11(strip crop with weed pressure) was not included (68 bu/acre), lowest yield was for Fall 75 treatment (138 bu/acre) and highest for Spring 150, as was the case in 2005. In addition, when treatment 11 was removed from the statistical analysis then treatments 1 and 13 both became statistically different from the others. Even in the dry season experienced, the rye cover crop in corn only diminished yields by 4 bu/ac compared to the spring 125 treatment without rye cover. Rye in soybean only lowered yield by 1 bu/ac compared to the spring 125 treatment. Soybean yield ranged from 40-55 bu/acre. The strip crop soybean treatment had the lowest yield due to weed pressure encountered. Highest yield was for the spring 75 treatment. Overall yields at the site were very acceptable considering precipitation in the drainage season (Mar-Nov) was 8.6 inches below normal. Pocahontas County corn and soybean yield were 167 and 52 bu/acre, for 2006.

Below normal precipitation in June and July quite likely diminished corn and soybean yields in 2007. Highest corn yield was for the Fall 125 N treatment. It was closely followed by Fall 75 and Spring 150 treatments. In 2006, Fall 75 had one of the lowest yields and was equal to the yield recorded in 2007, one of the highest. The rye cover crop system showed a decrease in corn yield of 7 bu/acre compared to no cover crop. This could again be the result of below normal precipitation in June and July (~5” below normal from Mar-Jul). Soybean yield ranged from 25-37 bu/acre. Rye in soybean lowered yield by 8 bu/ac compared to the spring 125 treatment. The strip crop soybean treatment had the lowest yield due to weed pressure encountered. Highest yield was for the spring 125 N treatment. Overall yields at the site were below the county average quite likely due to below precipitation in June and July. Pocahontas County corn and soybean yield were 165 and 51 bu/acre, for 2007.

Table 12. Corn yield by treatment in 2005, 2006 and 2007 with statistical significance at p=0.05*.

		yield (bu/acre) p=0.05			
		2005		2006	2007
Treatment	Description	continuous	rotation	rotation	
1	Fall 75 Corn	108d	156b	138a	138ab
3	Fall 125 Corn	137abc	164ab	147a	143a
5	Spring 75 Corn	134bc	162ab	148a	121bcd
7	Spring 125 Corn	153ab	173ab	143a	116cd
9	Spring 150 Corn	156a	179a	157a	136abc
11	Strip 125 Corn	152ab	174ab	68b	106d
13	Cover Crop 125 Corn	134bc	163ab	139a	109d
15	LCD 125 Corn	125cd	163ab	154a	117cd
Pocahontas County average		183		167	165

*significance within a system, i.e. within the rotation and within year. Note: Severe weed pressure (lambsquarter) encountered in 2006 and (dandelion) in 2007 for strip crop treatment.

Table 13. Soybean yield by treatment in 2005, 2006 and 2007 with statistical significance at p=0.05*.

		yield (bu/acre) p=0.05			
		2005		2006	2007
Treatment	Description	continuous	rotation	rotation	
2	Fall 75 Soybean	47a	50a	43bc	36abc
4	Fall 125 Soybean	44a	48a	50ab	37ab
6	Spring 75 Soybean	46a	51a	55a	32bc
8	Spring 125 Soybean	44a	49a	48ab	44a
10	Spring 150 Soybean	47a	53a	51a	42ab
12	Strip 125 Soybean	45a	50a	40c	25c
14	Cover Crop 125	49a	53a	47abc	36abc
16	LCD 125 Soybean	46a	49a	51a	36abc
Pocahontas County average		50		52	51

*significance within a system, i.e. within the rotation.

Rye Biomass Yield 2005, 2006, and 2007

Rye for 2005 was planted on October 15, 2004. The rye in corn plots was burned down with Round Up herbicide on April 14, 2005 and in soybean plots on May 24, 2005 to allow for these crops to flourish. Rye biomass in the soybean plots was allowed to grow 40 additional days resulting in 23.4 times as much dry matter being produced as compared to the rye in corn. Rye in corn produced 105 lbs of dry matter/acre and contained 5.5 lbs N/acre. Rye in soybean plots yielded 2464 lbs of dry matter/acre that contained 46 lbs of N/acre.

Rye for 2006 was planted on October 11, 2005. That in corn plots was burned down with Round Up herbicide on April 26, 2006 and in soybean plots on May 17, 2006 to allow for these crops to flourish. Rye biomass in the soybean plots was allowed to grow 22 additional days resulting in 3.3 times as much dry matter being produced as compared to the rye in corn. Rye in corn produced 812 lbs of dry matter/acre that contained 27 lbs N/acre. Yield in soybean plots was 2672 lbs of dry matter/acre and contained 53 lbs N/acre.

Rye biomass was much lower (~63% less in corn and ~57% less in soy) in 2007 compared to 2006. The decrease was quite likely due to a major growth setback as a result of very cold temperatures on April 12. Rye for 2007 was planted on October 12, 2006. That in corn plots was burned down with Round Up herbicide on May 3, 2007 and in soybean plots on May 25, 2007 to allow for these crops to flourish. Rye biomass in the soybean plots was allowed to grow 22 additional days resulting in 5 times as much dry matter being produced as compared to the rye in corn. Rye in corn produced 295 lbs of dry matter/acre that contained 10 lbs N/acre. Yield in soybean plots was 1504 lbs of dry matter/acre and contained 28 lbs N/acre.

Summary

Crop year 2005 could be considered a ‘calibration’ year for the new treatments imposed at the research site. So, it is difficult to draw broad conclusions from crop year 2005. However, of note is that in the 1st year of conversion from a row-crop system to a perennial system we have seen little if any reduction in nitrate-N concentration. Another important observation is that during

April 2005 approximately 81% of the precipitation was intercepted by and exited via the subsurface drainage system.

The 2006 crop season was marked by typical early-season drainage patterns starting late-March as soils thawed. Drainage and precipitation were slightly above average in late March and April; each month had nearly one-half inch of precipitation greater than normal. Approximately eighty-three percent of April precipitation was intercepted by the drainage system. Excess precipitation basically ceased in early May as did all drainage. The remainder of the season had enough timely precipitation to produce adequate crop yield, but no subsurface drainage. March through November total was 8.59" below normal. Crop yield was very good considering the below normal precipitation experienced at the site. Nitrate-N concentrations the first year after perennial system establishment in 2005 dropped considerably; concentrations in the orchardgrass/clover system decreased by 33% from 14.7 to 9.7 mg/L, those in the kura system dropped from 13.1 to 6.9 mg/L. Of note for the rye cover crop system was that neither corn nor soybean grain yields were not adversely affected, even in a dry year, by the rye cover crop. Nitrate concentrations in subsurface drainage were not greatly reduced through the use of a cover crop.

January, February, April and May precipitation in 2007 was above normal. March was slightly below normal. As in 2006, June and July of 2007 were both well below normal, with August 8.62" above normal and September and October only slightly above normal. March through November total was 3.52" above normal. Average soil temperature at a 4"depth rose above freezing on March 13 and remained steady and began to rise after the 17th of March. All drainage ceased after the 1st week of June and commenced the third week of August after 10.5 inches was recorded in the preceding week. At least weekly samples were also available from the 3rd week of September until the end of October, a rather atypical drainage period. Average drainage for all treatments was 19.94 inches (5.5x the drainage of 2006 and 2.4x that of 2005). With 33.28" of precipitation between March 1 and November 30 and using an overall drainage volume of 19.94", approximately 60% of the precipitation became subsurface drainage.

As opposed to 2006, highest concentrations in 2007 were recorded for the 150 rate treatment within the corn year (concentrations were highest in the soybean year in 2006 for the 150 rate) and as in 2006, lowest concentrations were recorded for the perennial systems, specifically the orchardgrass/clover treatment. No significant differences were noted when comparing the fall and spring applications to each other across rates or crops.

Losses in 2007 were the highest recorded since the initiation of this treatment phase in 2005. The increase in loss was due to large drainage volumes in 2007 compared to previous years. Average drainage volume was 2.3 times that recorded in 2005 (5.5 times that in 2006).

Below normal precipitation in June and July quite likely diminished corn and soybean yields in 2007. Highest corn yield was for the Fall 125 N treatment. The rye cover crop system showed a decrease in corn yield of 7 bu/acre compared to no cover crop. This could again be the result of below normal precipitation in June and July (~5" below normal from Mar-Jul). Soybean yield ranged from 25-37 bu/acre. Rye in soybean lowered yield by 8 bu/ac compared to the spring 125 treatment. Rye biomass was much lower (~63% less in corn and ~57% less in soy) in 2007 compared to 2006. The decrease was quite likely due to a major growth setback as a result of very cold temperatures on April 12.

Pekin Project Site

Drainage management practices are being evaluated at the Pekin school drainage facility. There are a total of nine plots at this facility. Three different management practices are being utilized and evaluated. The treatments include the following:

- 3 – plots with conventional drainage (drain tile at 3.5-4 ft deep).
- 3 – plots with controlled conventional drainage with free flow in the spring (April –May) and fall (September-October). The outlet control was set at 2 ft below the ground surface except during free flow.
- 3 – plots with pseudo-shallow drainage (control structure set at 2 ft below surface). This treatment would be used to represent a system similar to shallow drainage.

These three treatments are being evaluated to investigate the impacts of drainage management practices on drainage volume, nutrient concentrations in the subsurface drainage, and grain yield. Again, these factors will be evaluated over the five year term of this project. Since significant climate variability exists and the response of variable weather conditions on drainage management systems is needed it is important to evaluate the treatment response over the entire duration of the project phase. In addition to drainage management practices, drainage from two plots flows through a passive biofilter. One of the plots is a conventional drainage plot and one is a shallow drainge plot. The concentration of nutrients entering and exiting the biofilters is being monitored to document any reductions as a result of the passive biofilter.

Precipitation and Drainage

Crop years 2005 and 2006 were both unusually dry years at the Pekin site. Precipitation recorded in 2007 was 10” above normal. Precipitation in years 2005 and 2006 was much below the 30-year average for the region (1971-2000). On average, 842mm (33.15”) of precipitation is recorded for the region. In 2005, 633 mm (24.93”) were recorded at the site. Precipitation from mid-March through the end of 2005 was less than 18 inches (Figure 1 and 3) with only about 8 inches from mid-March through the end of June. In 2006, slightly less total precipitation was recorded. Only 580 mm (22.83”) of precipitation was recorded for the year; less than 2/3 of normal amount. In 2007, 1100 mm (43.32”) of precipitation was recorded. Drainage volumes were very similar for both 2005 and 2006. There was on average slightly less than 4 inches of drain flow from the conventional drainage plots and less than 2 inches of flow from the pseudo-shallow drainage plots (Figure 2 and 4). It is likely that there is some lateral seepage from the pseudo-shallow drainage and controlled drainage plots to the conventional drainage plots (See Figures 1-4 below). This is a factor that will be evaluated in great detail in 2008 through additional water table monitoring during periods of high water tables and low evapotranspiration. In 2007 with the above normal precipitation, 42% of precipitation became conventional subsurface drainage. The controlled drainage system drainage volume was reduced by more than one half to 19% of all precipitation. The shallow drainage system yielded only 12% of the annual precipitation. Respectively, drainage volumes were 18.7, 8.6 and 5.2 inches for each of the three systems (Figures 5 and 6). When comparing 2005-06 to 2007 twice as much precipitation occurred in 2007 which resulted in approximately 4.5 times as much drainage.

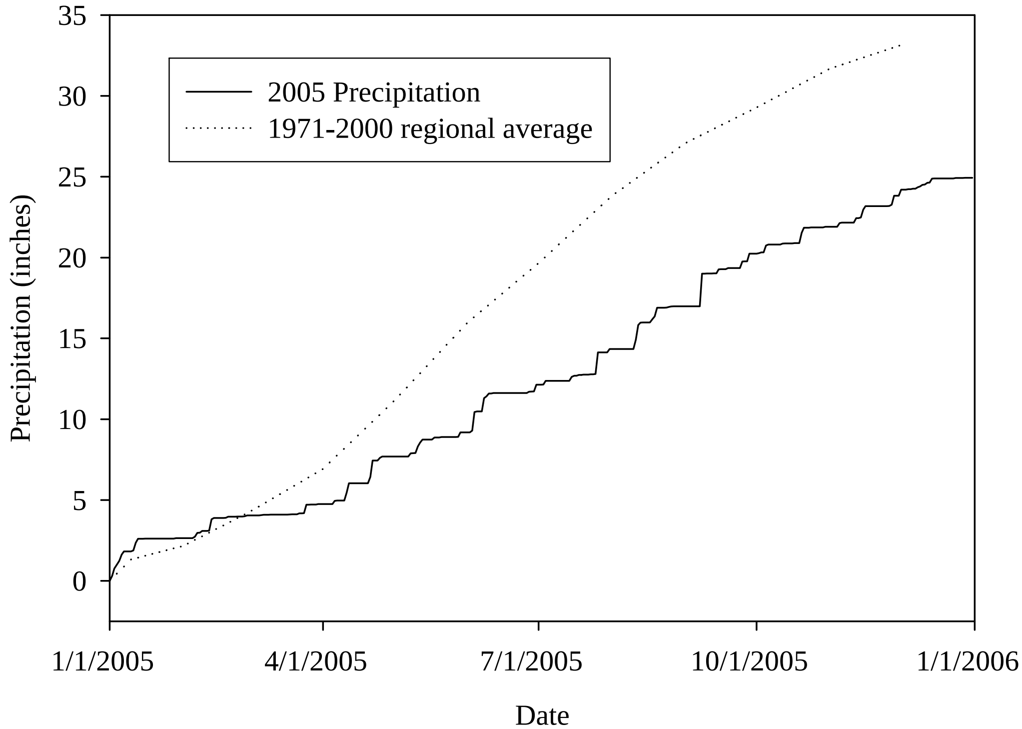

Figure 1. Precipitation in 2005 compared to the 30-year regional average.

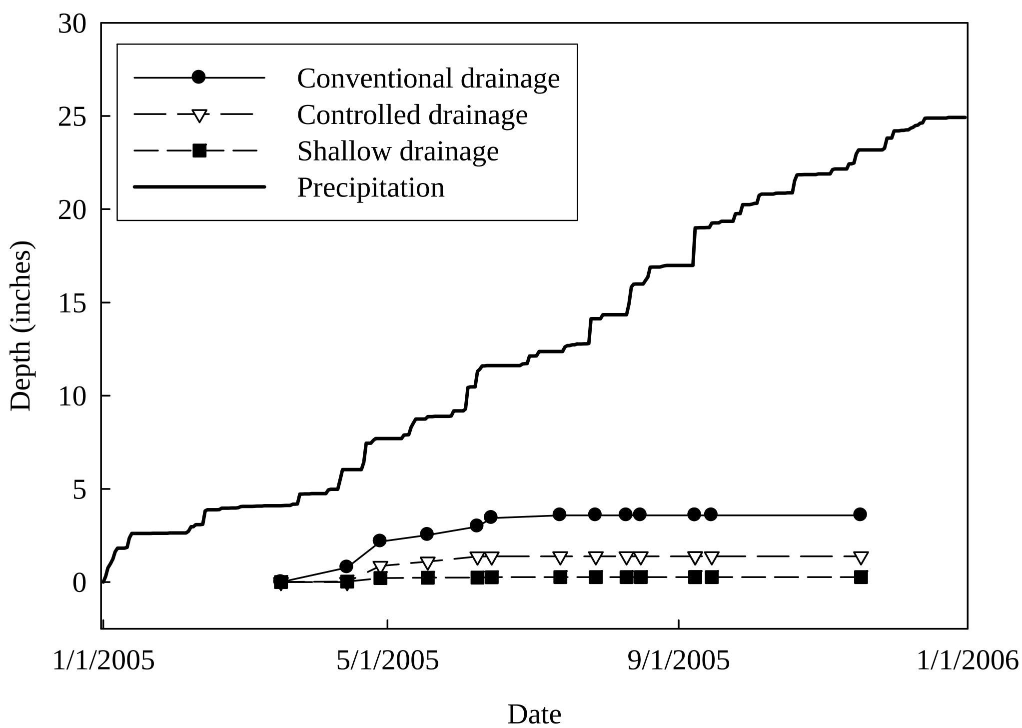

Figure 2. Precipitation and subsurface drainage at the Pekin site in 2005 during monitoring period.

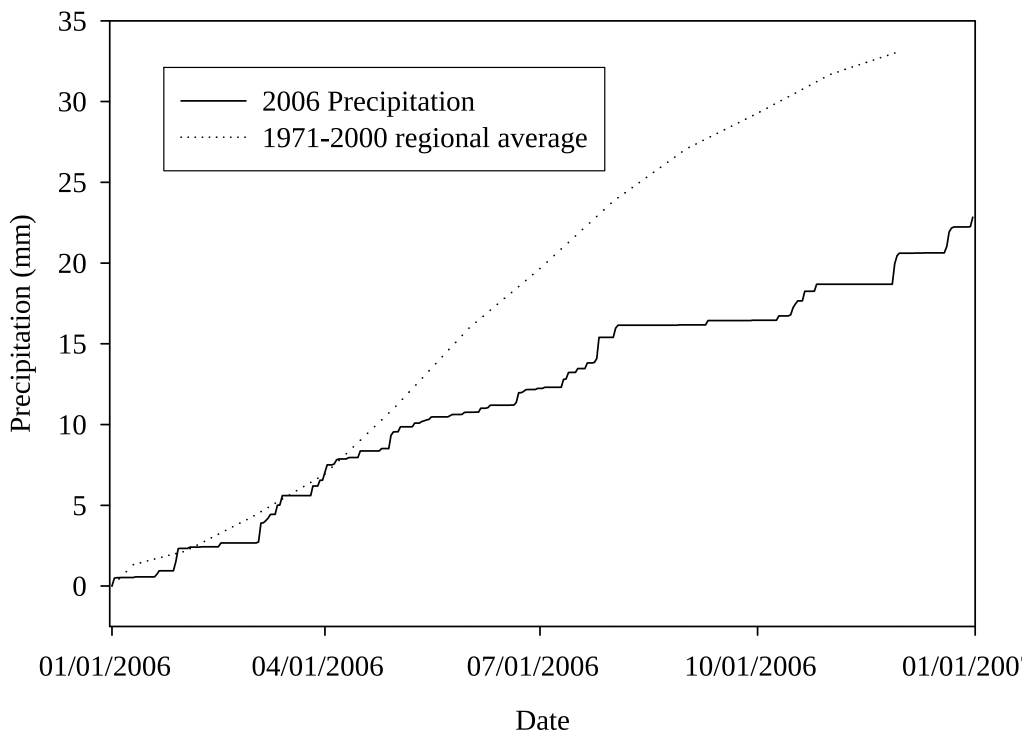

Figure 3. Precipitation in 2006 compared to the 30-year regional average.

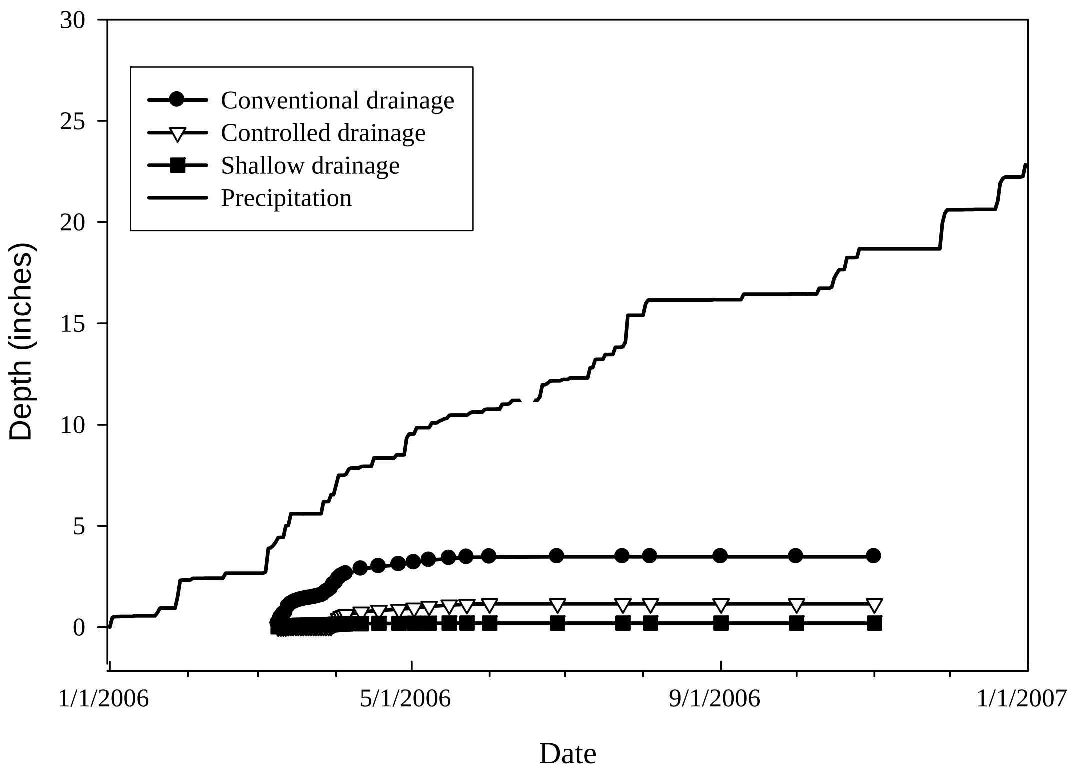

Figure 4. Precipitation and subsurface drainage at the Pekin site in 2006 during the monitoring period.

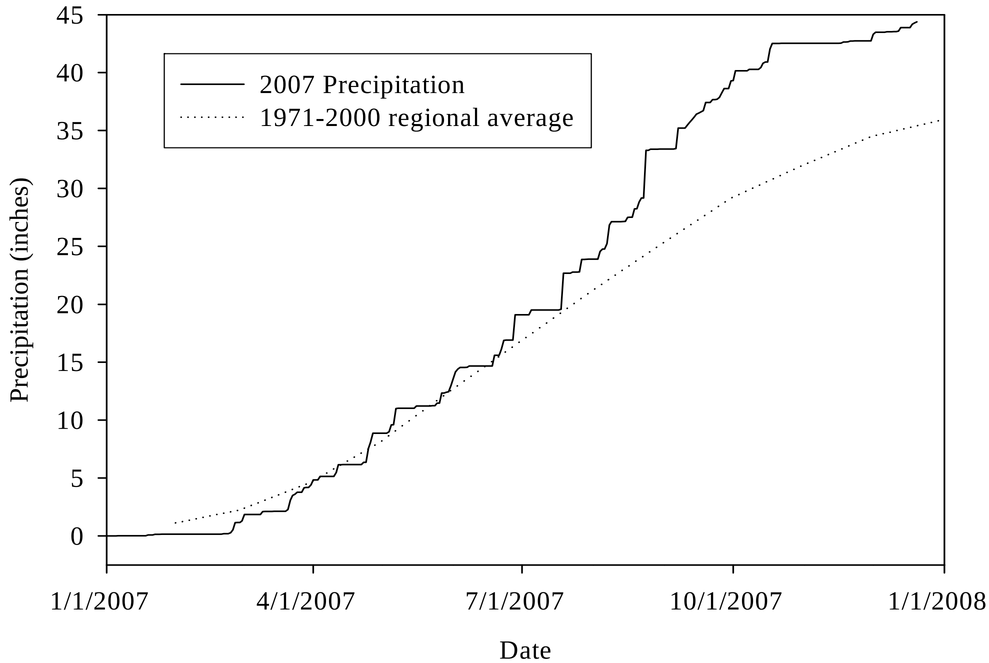

Figure 5. Precipitation in 2007 compared to the 30-year regional average.

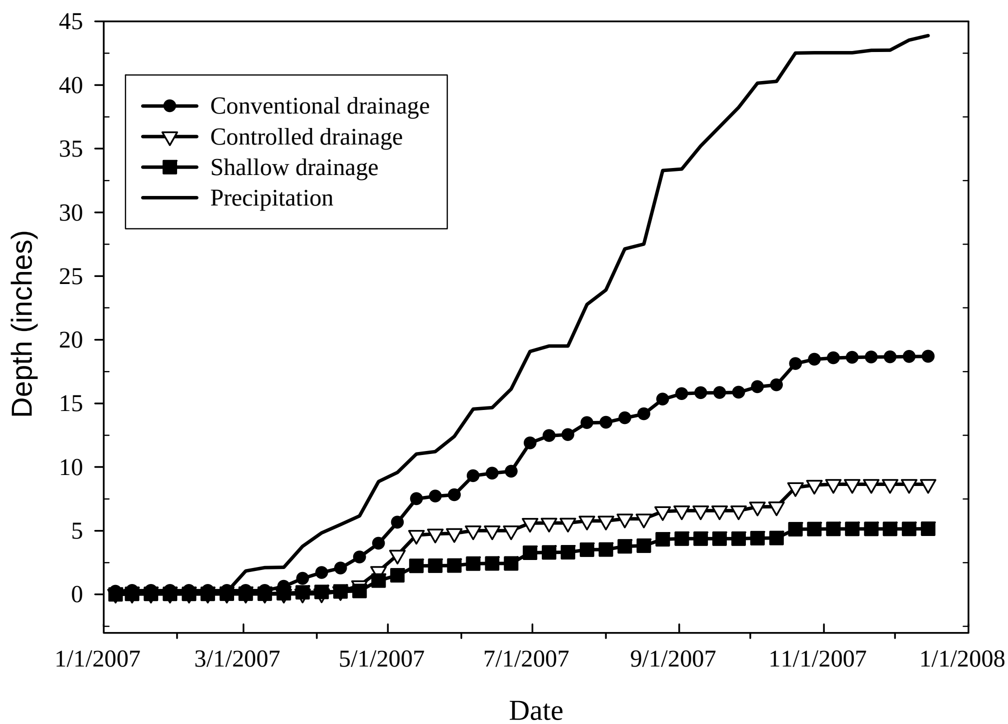

Figure 6. Precipitation and subsurface drainage at the Pekin site in 2007 during the monitoring period.

Nitrate-Nitrogen Concentrations

Water samples to determine nitrate-nitrogen (NO_3-N) concentration were only available in April and May, in 2005-06, due to low flow conditions encountered. In 2007, water samples were available in late March, April, May, June, July, August and early September before drainage ceased. Listed in Table 15 are flow-weighted NO_3-N concentrations for all treatments determined by summing individual loadings through the season and dividing it by the total drainage, thereby weighting the final value to reflect a specific drainage periods influence on the overall value. Values between treatments during individual years were very similar. When comparing years, values were much higher in 2007. The use of a wood-based biofilter constructed at the time of subsurface drain installation and consisting of wood chips surrounding the drain line decreased the concentrations being released from the standard installation, conventional drainage treatment. Results for individual years comparing the use of a biofilter and conventional are illustrated in Figures 5, 6 and 7.

Table 15. Flow-weighted nitrate concentration for all treatments (mg/L).

Treatment	Year	Average	Std. Dev.	Year	Average	Std. Dev.	Year	Average	Std. Dev.
Conventional	2005	6.71	1.16	2006	6.92	0.59	2007	10.69	1.98
Controlled	2005	6.40	2.14	2006	7.20	1.44	2007	12.08	2.75
Shallow	2005	4.57	2.49	2006	6.72	1.86	2007	12.88	1.63

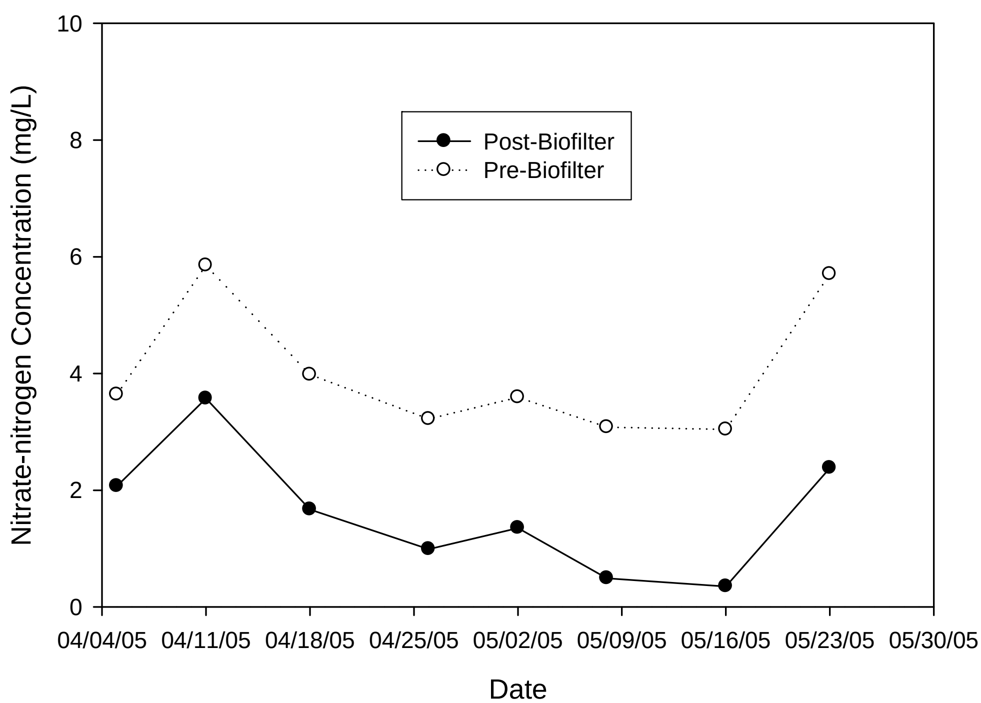

Figure 5. 2005 Conventional drainage bio-filter nitrate data.

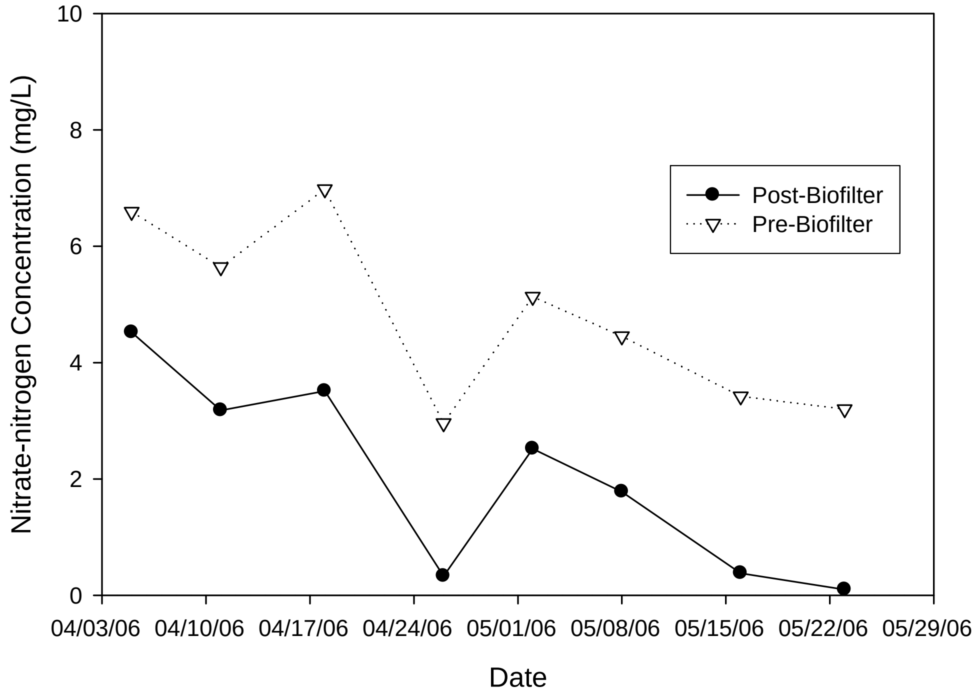

Figure 6. 2006 Conventional drainage bio-filter nitrate data.

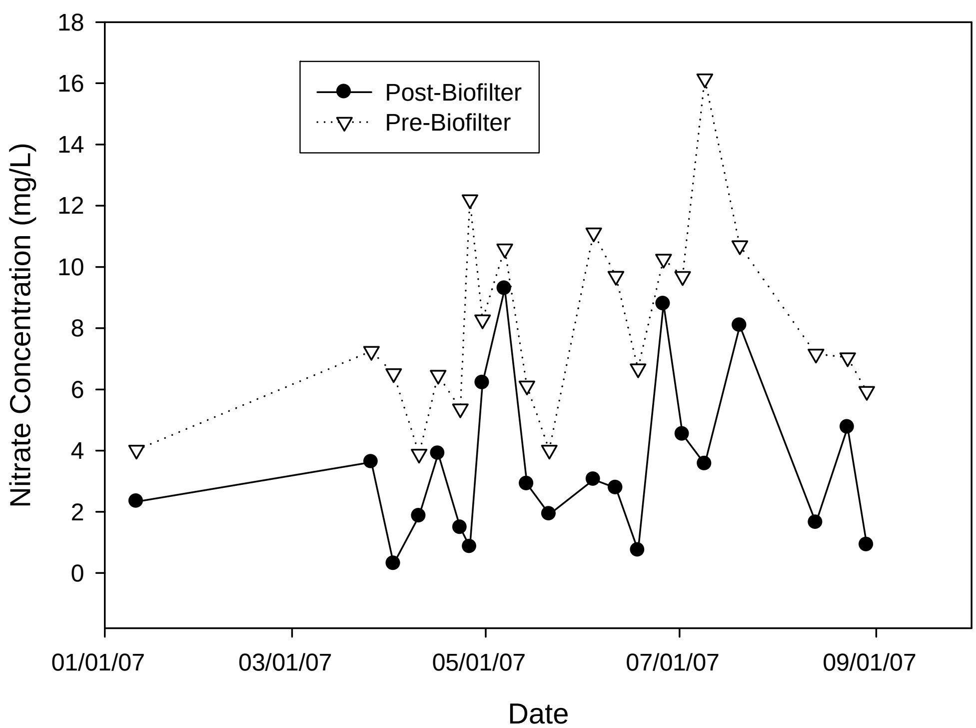

Figure 7. 2007 Conventional drainage bio-filter nitrate data.

Additional Water Quality Testing

While tiles were flowing in 2006, three sets of grab samples were collected over a four- week period from the conventional drainage biofilter plot and analyzed for the presence of additional contaminants that might be present. The results are presented in Table 16. Two useful measures of water quality are biological oxygen demand (BOD) and chemical oxygen demand (COD). They help measure the oxygen-depletion effect of a waste contaminant. The BOD test measures the oxygen demand of biodegradable pollutants whereas the COD test measures the oxygen demand of biodegradable pollutants plus the oxygen demand of non-biodegradable, oxidizable pollutants. COD is expressed as the mass of oxygen consumed per liter of solution. Biological oxygen demand (BOD) or biochemical oxygen is the amount of oxygen required by aerobic microorganisms to decompose the organic matter in a sample of water and used as a measure of the degree of water pollution. Ammonia, sulfate and chloride testing are also good indicators of water quality and were tested for in some of the samples. Ammonia is usually not found in large quantities in tile drainage because in the presence of oxygen rich water it will convert to nitrate. High levels of sulfate or chloride may be indicative of sewage contamination. None of the analytes were found to exceed water quality effluent or MCL standards. Additional testing in the future to detect any trends that may exist is needed.

Table 16. Additional analytical measurements performed on the 2006 conventional drainage biofilter plot.

Sampling Date Location	BOD	COD	Sulfate as SO_4	Ammonia as N	Chloride as Cl
	--- mg/L as O_2 ---		-------- mg/L --------		
4/18/2006					
pre-biofilter	<0.1	24.7	not tested		
post-biofilter	<0.1	45.7			
5/3/2006					
pre-biofilter	0.9	27.5	16.14	0.04	not tested
post-biofilter	1.6	46.2	18.08	0.11	
5/16/2006					
pre-biofilter	0.3	52.5	not tested	0.01	41.18
post-biofilter	0.6	62.7		0.10	34.74

Wetlands Monitoring and Evaluation

A unique aspect of the Iowa CREP is that nitrate reduction is not simply assumed based on wetland acres enrolled, but is calculated based on the measured performance of CREP wetlands. As an integral part of the Iowa CREP, a representative subset of wetlands is monitored and mass balance analyses performed to document nitrate reduction. In addition to documenting wetland performance, this will allow continued refinement of modeling and analytical tools used in site selection, design, and management of CREP wetlands.

During 2007, ten wetlands were monitored for the Iowa CREP (Figure 1). These include Dawes, Gilbert-Dinsdale, Hanlontown Slough, Johnson (Winnebago County), Louscher, Renshaw, Richards, Triple I, Schwartz, and Van Horn wetlands. Flow was measured at all of these wetlands except Richards and autosampler composited daily samples were collected at all except Richards, Schwartz, and Triple I Wetlands. Weekly grab samples were collected at all of the monitored wetlands during 2007.

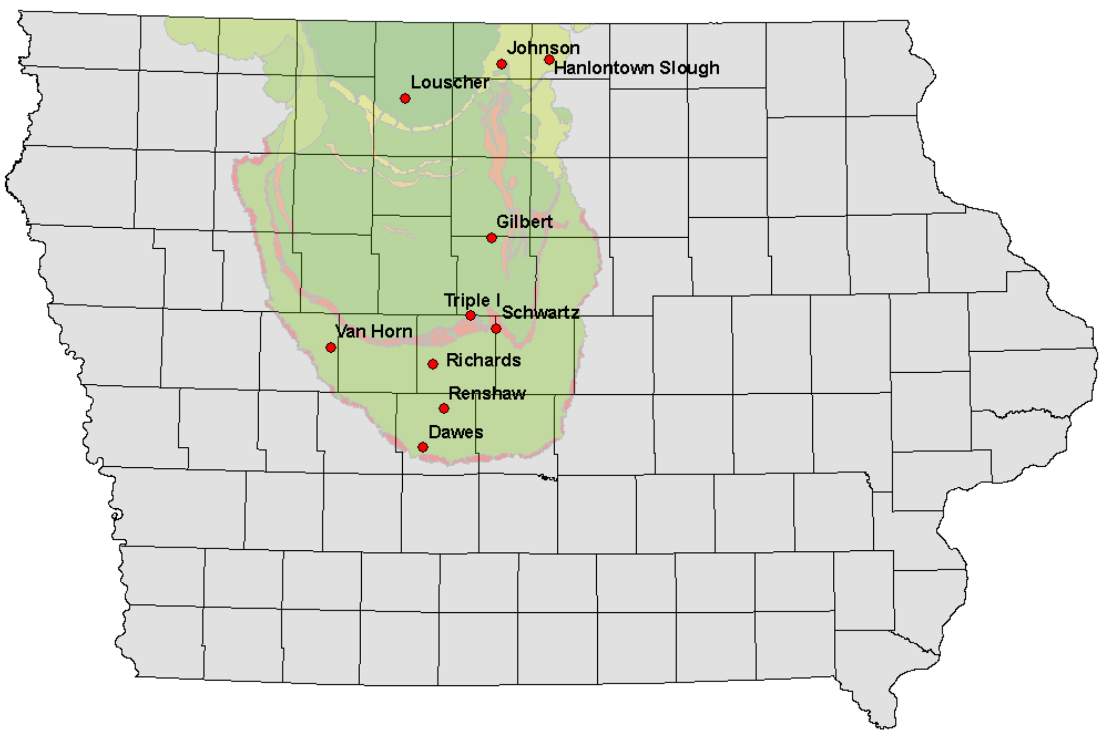

Figure 8. Wetlands monitored during 2007.

For close interval monitoring of nitrate-nitrogen concentrations, wetlands were instrumented with automated samplers that collected daily composite water samples at wetland inflows and outflows. Grab samples were collected at an approximately weekly interval at inflow and outflow locations, and from within the wetland near the outflow location when there was no outflow. Eight wetland inflows and four wetland outflows were instrumented with Doppler flow meters for continuous measurement of water depth and flow velocity. These were combined with channel profiles to calculate discharge. Wetland water levels were monitored continuously using stage recorders in order to calculate pool volume and discharge at outflow structures. Wetland bathymetry was digitized allowing development of mathematical equations to model pool area and volume as functions of wetland depth at six wetlands. Wetland water temperatures were recorded continuously for numerical modeling of nitrate loss rates.

By design, the wetlands selected for monitoring span the 0.5% - 2.0% wetland/watershed area ratio range approved for Iowa CREP wetlands. The wetlands also span a 2-3 fold range in average nitrate concentration. The wetlands thus provide a broad spectrum of those factors most affecting wetland performance: hydraulic loading rate, residence time, nitrate concentration, and nitrate loading rate. Despite significant variation with respect to average nitrate concentrations and loading rates, the wetlands display similar seasonal patterns. Nitrate concentrations and mass loads are typically somewhat depressed during the late winter, increase to their highest levels during high flow periods in spring and early summer, decline with declining flow in mid to late summer, and may increase again if there is increased flow during late summer or fall. These nitrate concentration and flow patterns are representative of the patterns that are expected for future wetlands restored as part of the Iowa CREP.

Nitrate Loss from Wetlands

Mass balance analysis and modeling were used to calculate observed and predicted nitrate removal for wetlands where flow was measured. Inflow and outflow nitrate concentrations measured in 2007 at Johnson, Louscher, and Renshaw Wetlands are illustrated in Figure 2. In addition, Figure 2 shows the range of outflow concentrations predicted for these wetlands by mass balance modeling with 2007 water budget, temperature, and nitrate concentration inputs and forcing functions.

The monitored wetlands performed as expected with respect to nitrate removal efficiency (expressed as percent removal) and mass nitrate removal (expressed as Kg N ha^{-1} $year^{-1}$). Wetland performance is a function of hydraulic loading rate, hydraulic efficiency, nitrate concentration, temperature, and wetland condition. Of these, hydraulic loading rate and nitrate concentration are especially important for CREP wetlands. The range in hydraulic loading rates expected for CREP wetlands is significantly greater than would be expected based on just the four fold range in wetland/watershed area ratio approved for the Iowa CREP. In addition to spatial variation in precipitation (average precipitation declines from southeast to northwest across Iowa), there is tremendous annual variation in precipitation. The combined effect of these factors means that loading rates to CREP wetlands can be expected to vary by more than an order of magnitude, and will to a large extent determine nitrate loss rates for individual wetlands.

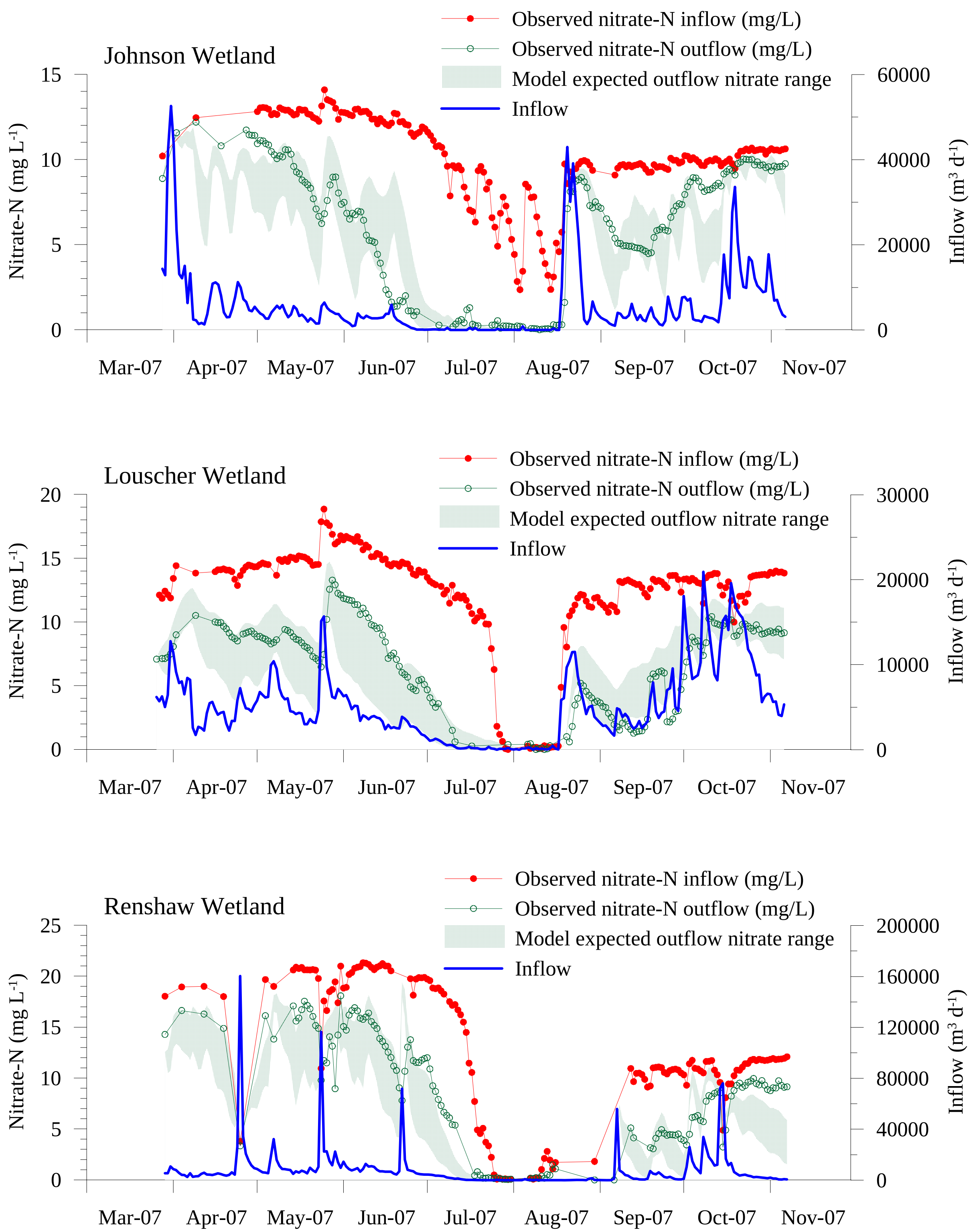

Figure 9. Measured and modeled nitrate concentrations and flows for selected wetlands monitored during 2007.

Mass balance modeling was used to estimate the variability in performance of CREP wetlands that would be expected due to spatial and temporal variability in temperature and precipitation patterns. The percent nitrate removal expected for CREP wetlands was estimated based on hindcast modeling over the 10 year period from 1996 through 2005 (Figure 3). For comparison, percent nitrate removal measured for wetlands monitored during 2007 is also presented and illustrates reasonably good correspondence between observed and modeled performance. Several of the 2007 results show hydraulic loading rates greater than anticipated due to an unusually wet late summer and fall during 2007. Percent nitrate removal is clearly a function of hydraulic loading rate (Figure 3).

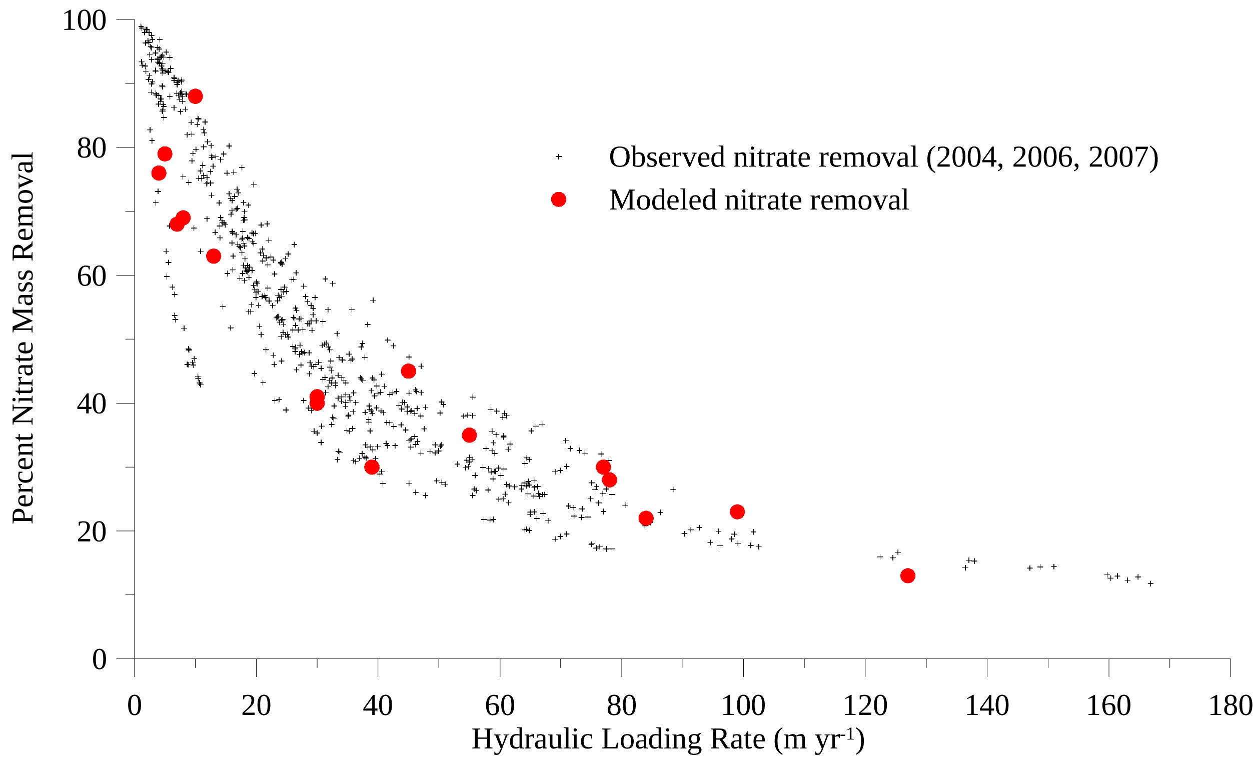

Figure 10. Modeled and observed nitrate removal efficiencies for CREP qualifying wetlands versus Hydraulic Loading Rate based on 1980 to 2005 input conditions.

Mass nitrate removal rates can vary considerably more than percent nitrate removal among wetlands receiving similar hydraulic loading rates. However, mass removal rates are predictable using models that integrate the effects of hydraulic loading rates, nitrate concentration, temperature, and wetland condition. Crumpton et al. (2006) developed and applied a model that explicitly incorporates hydraulic loading rate, nitrate concentration, and temperature to predict performance of US Corn Belt wetlands receiving nonpoint source nitrate loads. This analysis included comparisons for 38 “wetland years” of available data (12 wetlands with 1-9 years of data each) for sites in Ohio, Illinois, and Iowa, including four IA CREP wetlands (2 low load and 2 high load sites). The analysis demonstrated that the performance of wetlands representing a broad range of loading and loss rates can be reconciled by models explicitly incorporating hydraulic loading rates and nitrate concentrations (Crumpton et al. 2006). This model was updated to include the 2007 Iowa CREP sites and exclude wetlands smaller than the 2.5 acre minimum size required by Iowa CREP criteria. The updated model (Figure 4) accounts for 91 percent of the observed variation in mass nitrate removed for all of the wetland sites considered. (The axes in Figure 4 are clipped to HLR <100 m/year and FWA <20 mg/L, which excluded one wetland.)

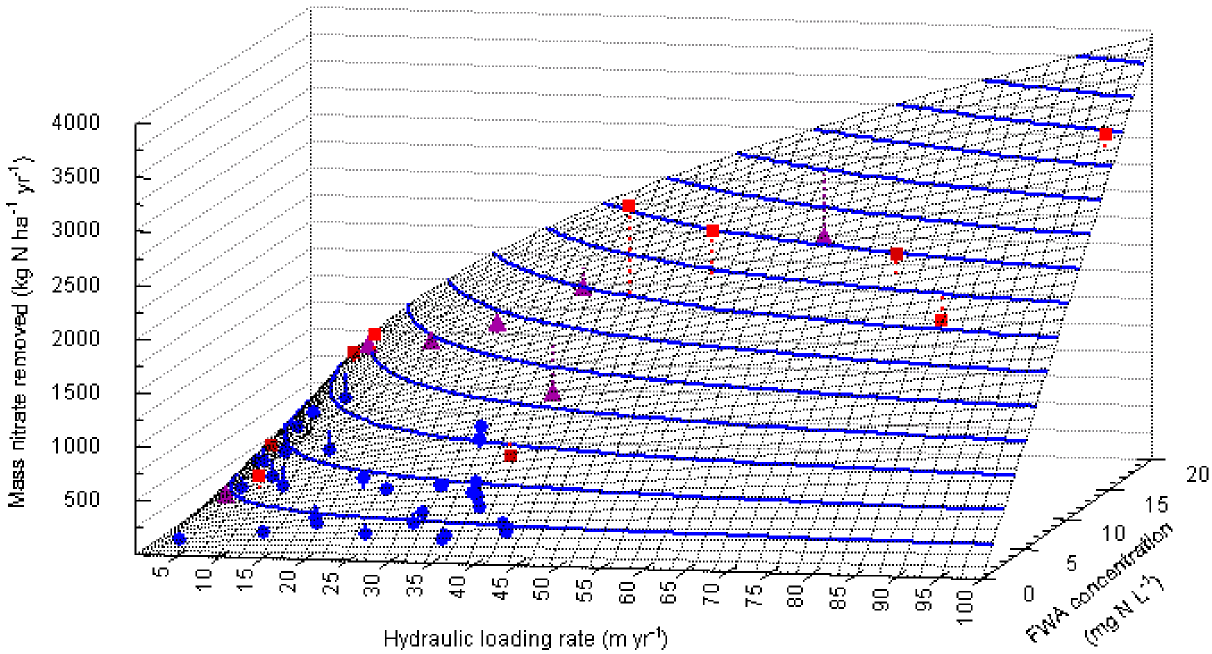

Figure 11. Observed nitrate mass removal includes eight Corn Belt wetlands representing 24 "wetland years" of data shown as blue circles (adapted from Crumpton et al. (2006)). 2007 CREP sites are shown as red squares (Gilbert wetland not shown). Because the fall of 2007 was much wetter than normal resulting in unusually high hydraulic loading, the 2007 CREP wetland growing season (April through August) results are also shown (purple triangles).

References

Crumpton, W.G., G.A Stenback, B.A. Miller, and M.J. Helmers. 2006. Potential benefits of wetland filters for tile drainage systems: Impact on nitrate loads to Mississippi River subbasins. US Department of Agriculture, CSREES project completion report. Washington, D.C. USDA CSREES.

Outreach Activities Year 2005, 2006, and 2007
In addition to the evaluation that is taking place at the project sites in Gilmore City, Pekin, and the Wetlands sites, we have an active outreach program associated with this project. This includes presentations at technical and Extension related meetings, field days, the Drainage Research Forum, and Extension and scientific publications. The activities that are directly associated with the outreach component of this project in 2005, 2006, and 2007 are described below.

Events Organized
November 29, 2007 – Coordinated with Dr. Gary Sands from the University of Minnesota the 8th Annual IA-MN Drainage Research Forum in Ames, IA. There were approximately 75 attendees consisting of producers, contractors, and agency representatives from Iowa and Minnesota.

November 28, 2006 – Coordinated with Dr. Gary Sands from the University of Minnesota the 7th Annual IA-MN Drainage Research Forum in Owatonna, MN. There were approximately 85 attendees consisting of producers, contractors, and agency representatives from Iowa and Minnesota.

November 2, 2005 - Coordinated with Dr. Gary Sands from the University of Minnesota the 6th Annual IA-MN Drainage Research Forum held in Dows, IA. The forum was attended by 80 stakeholders that included individuals from both Iowa and Minnesota.

The Drainage Research Forum program focuses on drainage and water management issues including the implications of nitrogen management, water quality and drainage modeling at the watershed scale, preferential flow on drained lands, nitrate-removal wetlands, cropping strategies for nitrogen management and drainage water management. Presenters commonly include researchers from Iowa State University, University of Minnesota, and the USDA Agricultural Research Service.

Field Days
A field day was organized at the Gilmore City project site. The evening field day on June 30, 2005 was attended by approximately 75 stakeholders. The topics discussed were current crop issues (Paul Kassel), nitrate-removal wetlands (Dr. William Crumpton), the Targeted Watershed Grant (Dean Lemke and County Board of Supervisors), highlights from 15 years at Gilmore City (Dr. Stewart Melvin, Peter Lawlor, and Dr. James Baker), and controlled drainage (Matt Helmers).

Carl Pederson and Matt Helmers presented on drainage water quality and drainage water management at a field day at the Pekin project site on September 15, 2005. The “8 to 80 Water Quality Field Day” was attended by approximately 100 students from surrounding schools.

Oral Presentations at Extension Related Meetings

Extension Presentations (Iowa):

December 19, 2007 – Presentation “Nitrate leaching and subsurface drainage for southern Iowa” at Ag. Chemical Dealer update in Ames, IA (45 attendees).

December 7, 2007 – Presentation “Potential yield impacts of improved drainage” at a meeting of the Iowa Corn Growers Environmental committee in Johnston, IA (15 attendees).

December 7, 2007 – Presentation “Potential yield impacts of improved drainage” at the Iowa Drainage District Association annual meeting in Fort Dodge, IA (55 attendees).

November 28, 2007 – Presentation “Comparison of nitrate-nitrogen in subsurface drainage from continuous corn and corn-soybean rotation” at the Integrated Crop Management Conference in Ames, IA (120 attendees).

August 10, 2007 – Poster presentation “Agricultural drainage research” at the Corn Soybean Initiative Roundtable in Ames, IA.

June 27, 2007 – Presentation “Drainage design for economic and environmental benefits” at Iowa Farm Bureau Conservation and Natural Resource Issues Conference in Des Moines, IA (~30 attendees). [Invited]

March 13, 2007 – Presentation “Controlled drainage – water quality benefits and irrigation potential” at Drainage Workshop in West Bend, IA (20 attendees).

March 13, 2007 – Presentation “Long-term benefits of tiling” at Drainage Workshop in West Bend, IA (20 attendees).

January 24, 2007 – Presentation “Drainage/water quality: Implications of continuous corn” at Crop Advantage Series meeting in Waterloo, IA (~55 attendees).

January 18, 2007 – Presentation “N-application impacts on N-concentration” at Coldwater-Palmer Watershed meeting in Allison, IA (12 attendees).

January 10, 2007 – Presentation “Drainage/water quality: Implications of continuous corn” at Crop Advantage Series meeting in Mason City, IA (~55 attendees).

January 8, 2007 – Presentation “Drainage water management and biofilters in Iowa” at Iowa Land Improvement Contractors Association annual meeting in Des Moines, IA (120 attendees). [Invited by LICA]

December 18, 2006 – Presentation “Pesticide movement in soils” at Agricultural Chemical Update in Denison, IA (40 attendees).

December 8, 2006 – Presentation “Drainage design now and in the future” at Iowa Drainage District Association annual meeting in Fort Dodge, IA (100 attendees).

December 6, 2006 – Presentation “Pesticide movement in soils” at Agricultural Chemical Update in Ames, IA (10 attendees).

November 30, 2006 – Presentation “Economic and environmental considerations for drainage design” at Integrated Crop Management Conference in Ames, IA (225 attendees).

September 7, 2006 – Presentation “Conservation systems and water quality” at Field Day in Hardin County (~45 attendees).

September 6, 2006 – Presentation “Conservation systems and water quality” at Field Day in Plymouth County (~100 attendees).

August 31, 2006 – Presentation “Conservation systems and water quality” at Farm Progress Show.

August 22, 2006 – Presentation “Beef manure and water quality issues” at Manure Management School in Ames, IA (50 attendees).

August 3, 2006 – Presentation "Subsurface drainage bioreactors" at Iowa Land Improvement Contractors Field Day (~65 attendees).

July 12, 2006 – Presentation "Benefits of tiling and drainage water management" at Drainage Field Day at Southeast Iowa Research Farm, CCA Session (50 attendees).

June 19, 2006 – Presentation "Water quality issues in Iowa" to Iowa Pork Industry Center Advisory Group.

March 13-17, 2006 – Presentation "Long-term benefits of tiling" at Iowa Drainage Design Workshops (~200 attendees).

March 13-17, 2006 – Presentation "Controlled drainage: water quality benefits and irrigation potential" at Iowa Drainage Design Workshops (~200 attendees).

March 7, 2006 – Presentation "Conservation systems: manure and drainage water quality" at Agriculture and the Environment Conference in Ames, IA (150 attendees).

March 7, 2006 – Presentation "Subsurface drainage and nitrate-nitrogen leaching from fifteen years in north-central Iowa" at Agriculture and the Environment Conference in Ames, IA (50 attendees).

March 2, 2006 – Presentation "Nitrogen timing effects on drainage water quality" to Iowa Farm Bureau Environmental Advisory Committee [Invited].

February 15, 2006 – Presentation "Drainage design" at Soil and Water Management Clinic in Ames, IA (10 attendees).

February 15, 2006 – Presentation "Drainage water management" at Soil and Water Management Clinic in Ames, IA (10 attendees).

January 24, 2006 – Presentation "Conservation systems: manure and drainage water quality" at Crop Advantage Series meeting in Storm Lake, IA (45 attendees).

January 19, 2006 – Presentation "Conservation systems: manure and drainage water quality" at Crop Advantage Series meeting in Spirit Lake, IA (50 attendees).

January 18, 2006 – Presentation "Agricultural drainage and water research" at Boone, IA weekly ag meeting (26 attendees).

January 13, 2006 – Presentation "Manure and drainage water quality" at North Central Iowa Crop Clinic (25 attendees).

January 12, 2006 – Presentation "Drainage water management" to Boone River Watershed Group (15 attendees).

January 10, 2006 – Presentation "Basic drainage design" at Iowa Land Improvement Contractors Association annual meeting in Des Moines, IA (80 attendees).

January 9, 2006 – Presentation "Drainage water management in Iowa" at Iowa Land Improvement Contractors Association annual meeting in Des Moines, IA (100 attendees).

December 15, 2005 – Presentation "Drainage management and cropping practices" at Iowa Drainage District Association annual meeting in Fort Dodge, IA (75 attendees).

November 30 and December 1, 2005 – Presentation "Conservation systems: effects of manure on drainage water quality" at Integrated Crop Management conference in Ames, IA (220 attendees).

August 24, 2005 – Presentation "Manure effects of water quality" at Manure Management Clinic in Ames, IA (40 attendees).

July 28, 2005 – Presentation "Subsurface drainage design and drainage water management in Iowa" at Ag Insights: Water Management Solutions, meeting sponsored by Hancor in Oelwein, IA (50 attendees).

July 7, 2005 – Presentation “Drainage design for crop production and environmental benefits” at Pro Ag Meeting, Mitchell County Extension, Osage, IA (15 attendees).
January 25, 2005 – Presentation “New tiling research in Iowa” at Crop Advantage Series meeting in Atlantic, Iowa (120 attendees).
January 12, 2005 – Presentation “Modified drainage for improved water quality” at North Central Crop Clinic in Iowa Falls, IA (45 attendees)
January 11, 2005 – Presentation “Tiling research at Iowa State University” at Iowa Land Improvement Contractors of America annual meeting in Des Moines, IA (60 attendees).
January 6, 2005 – Presentation “New tiling research in Iowa” at Crop Advantage Series meeting in Cedar Rapids, Iowa (40 attendees).
January 4, 2005 – Presentation “New tiling research in Iowa and economic considerations” at Crop Advantage Series meeting in Mt. Pleasant, Iowa (25 attendees).
March 1-3, 2005 – Presentation “Wetland design for drainage water treatment” at Minnesota Agricultural Drainage Design Workshop in Mankato, MN (45 attendees).

Extension Presentations (Regional):
October 15-16, 2007 – Project team was involved with presenting information on nitrate removal wetland performance at an IDALS organized meeting with representatives of USDA-FSA, USEPA, state agency, and other NGO personnel from across the cornbelt.
April 4, 2007 – Presentation “Manure application on legumes” at Heartland Animal Manure Management Workshop in Nebraska City, NE (~35 attendees from Iowa, Missouri, Nebraska, Kansas, and EPA) [Invited].
April 4, 2007 – Presentation “ISU long term poultry and swine manure studies on tile drain impacts” at Heartland Animal Manure Management Workshop in Nebraska City, NE (~40 attendees from Iowa, Missouri, Nebraska, Kansas, and EPA) [Invited].
March 8, 2007 –Presentation “Wetland design considerations for drainage water treatment” at Minnesota Agricultural Drainage Design Workshop in Mankato, MN (40 attendees).
March 7, 2007 –Presentation “Intro to conservation drainage design: Shallow and managed drainage systems” at Minnesota Agricultural Drainage Design Workshop in Mankato, MN with Gary Sands(40 attendees).
February 16, 2007 – Webcast presentation “Effects of manure application on drainage water quality” as part of the National Livestock and Poultry Environmental Learning Center webcast series. [Invited – national audience]
November 28, 2006 – Presentation “Drainage Water Management Update from Iowa” at IA-MN Drainage Research Forum in Dows, IA (85 attendees consisting of producers, contractors, and agency representatives from Iowa and Minnesota).
October 16, 2006 – Presentation “Effects of Manure on Drainage Water Quality” to Nebraska Livestock and Environment Issues Committee (~40 participants) [Invited].
March 9, 2006 – Invited presentation “Wetland design for drainage water treatment” at Minnesota Agricultural Drainage Design Workshop in Mankato, MN (50 attendees).
June 7-9, 2005 – Presentation “Subsurface drainage and treatment of drainage water to reduce nitrate-N” at Heartland Water Quality Initiative Nitrogen Workshop in Nebraska City, NE (75 attendees from Iowa, Nebraska, Kansas, Missouri, and USEPA).
June 7-9, 2005 – Presentation “Design of drainage water treatment facilities” at Heartland Water Quality Initiative Nitrogen Workshop in Nebraska City, NE (20 attendees from Iowa, Nebraska, Kansas, Missouri, and USEPA).

January 26-27, 2005 – Presentation “Drainage design and management” at Heartland Water Quality Initiative Nitrogen Roundtable in Nebraska City, NE (30 attendees from Iowa, Nebraska, Kansas, Missouri, and USEPA).

Technical Papers (Peer-reviewed)

Lawlor, P. A., M. J. Helmers, J. L. Baker, S. W. Melvin, and D. W. Lemke. 2008. Nitrogen application rate effects on nitrate-nitrogen concentrations and losses in subsurface drainage. *Trans. ASABE* 51(1): 83-94.

Singh, R., M. J. Helmers, W. G. Crumpton, and D. W. Lemke. 2007. Predicting effects of drainage water management in Iowa’s subsurface drained landscapes. *Agricultural Water Management* 92:162-170.

Singh, R., M. J. Helmers, and Z. Qi. 2006. Calibration and validation of DRAINMOD to design subsurface drainage systems for Iowa’s tile landscapes. *Agricultural Water Management*. 85: 221-232.

Technical Papers, Conference Papers, and Extension Related Publications

Helmers, M. 2007. Drainage/water quality: Implications of continuous corn. p. 28. In *2007 Proceedings Crop Advantage Series*. AEP 0200f. Iowa State Univ., Ames, IA.

Helmers, M. J. and P. Lawlor. 2007. Comparison of nitrate-nitrogen in subsurface drainage from continuous corn and corn-soybean rotation. In *Proceedings of the 19th Annual Integrated Crop Management Conference* (November 29 and 30, 2007, Iowa State University, Ames, IA), pp. 265-277. [Oral Presentation]

Helmers, M. J. and R. Singh. 2006. Economic and environmental considerations for drainage design. In *Proceedings of the 18th Annual Integrated Crop Management Conference* (November 29 and 30, 2006, Iowa State University, Ames, IA), pp. 239-244. [Oral Presentation]

Singh, R. and M. J. Helmers. 2006. Subsurface drainage and its management in the upper Midwest tile landscape. In *Proceedings of the EWRI Congress, ASCE* [Oral Presentation].

Lawlor, P. A., M. J. Helmers, J. L. Baker, S. W. Melvin, and D. W. Lemke. 2005. Nitrogen application rate effects on corn yield and nitrate-nitrogen concentration and loss in subsurface drainage. ASAE Meeting Paper No. 05-2025. St. Joseph, MI: ASAE.

M. J. Helmers, P. A. Lawlor, J. L. Baker, S. W. Melvin, and D. W. Lemke. 2005. Temporal subsurface flow patterns from fifteen years in north-central Iowa. ASAE Meeting Paper No. 05-2234. St. Joseph, MI: ASAE.

Helmers, M. J. and P. A. Lawlor. 2005. Conservation systems: Effects of manure application on drainage water quality. In *Proceedings of the 17th Annual Integrated Crop Management Conference* (November 30 and December 1, 2005, Iowa State University, Ames, IA), pp. 177-188.

Technical Abstracts

Qi, Z. and M. J. Helmers. 2007. Soil moisture and subsurface drainage with winter rye cover crop in Iowa. *In:* ASABE International Meeting. June 17-20, 2007, Minneapolis, MN.

Lemke, D.W., R. L. Cooney, S.L. Richmond, W.G. Crumpton, and M. J. Helmers. 2006. A new vision for federal policy to facilitate restoration and development of wetlands as off-field nitrogen sinks for cropped landscapes. *In:* ASA-CSSA-SSSA Annual Meeting Abstracts. Nov. 12-16, 2006, Indianapolis, IN.

Qi, Z., M. Helmers, and R. Singh. 2006. Evaluating a drainage model using soil hydraulic parameters derived from various methods. ASAE Meeting Paper No. 062318. St. Joseph, Mich.: ASAE.

Singh, R. and M. J. Helmers. 2006. Shallow and controlled drainage systems in Iowa's tile landscapes. *In:* ASA-CSSA-SSSA Annual Meeting Abstracts. Nov. 12-16, 2006, Indianapolis, IN.

Poster Presentations at Extension Related Meetings

June 28, 2006 - Poster Presentation "Water and nutrient management: In-field strategies" Iowa Farm Bureau Ag. And Environment Conference (~65 attendees)

Helmers, M. J., P. A. Lawlor, J. L. Baker, S. W. Melvin, W. Crumpton, D. W. Lemke. 2005. Temporal subsurface flow patterns from fifteen years in north-central Iowa. Agriculture and the Environment Conference (March 8-9, 2005, Iowa State University, Ames, IA).

P. A. Lawlor, M. J. Helmers, J. L. Baker, S. W. Melvin, W. Crumpton, D. W. Lemke. 2005. Nitrogen application rate effects on yield, nitrate-nitrogen concentration and loss in subsurface drainage. Agriculture and the Environment Conference (March 8-9, 2005, Iowa State University, Ames, IA).

Planned Manuscripts to be Submitted in 2008

Lawlor, P. A., M. J. Helmers, J. L. Baker, and S. W. Melvin. Nitrogen Source and Timing Effects on Yields and Nitrate-Nitrogen Concentrations in Subsurface Drainage from a Corn-Soybean Rotation. To be submitted to *Trans ASABE*. [Draft prepared]

Riley, K. D., M. J. Helmers, and P. Lawlor. Water balance investigation of controlled drainage on a small scale. To be submitted to *Applied Engineering in Agriculture.* [Draft prepared]

Helmers, M.J., P. Lawlor, J. L. Baker, and S. W. Melvin. Nitrate-nitrogen in subsurface driange as affected by nitrogen application rate to continuous corn and a corn-soybean rotation. To be submitted to *Agriculture, Ecosystems and Environment*. [Draft prepared]