Clay County Drainage Site
Summary of Water Monitoring Data 2011 – 2015

Introduction

The Red River Valley in northwestern Minnesota is experiencing an increase in the amount of agricultural subsurface drainage tile being installed. Drainage tile is common in other areas of the state; however it is relatively new to this region.

Beginning in 2010, the Minnesota Department of Agriculture allocated Clean Water Fund dollars (*from the Clean Water, Land, and Legacy Amendment*) to manage the Clay County Drainage Site. This is an edge-of-field research site designed to monitor the quantity and quality of water leaving an agricultural field via surface and subsurface drainage systems. The purpose of this project is to better understand the volume of drainage and the range of nitrogen, phosphorus, and sediment lost through agricultural drainage and to determine how effective certain agricultural management practices are at reducing nutrient and sediment losses.

The Clay County Drainage Site is located in the Buffalo River watershed, approximately 15 miles north of Moorhead (Figure 1). This area is characterized by flat topography (0-1% slope) and a 137-day average growing season. The site is representative of some of the most productive agricultural fields in the Red River Valley with soils classified as silty clay loam and possible corn yields in the 200 bu/ac range.

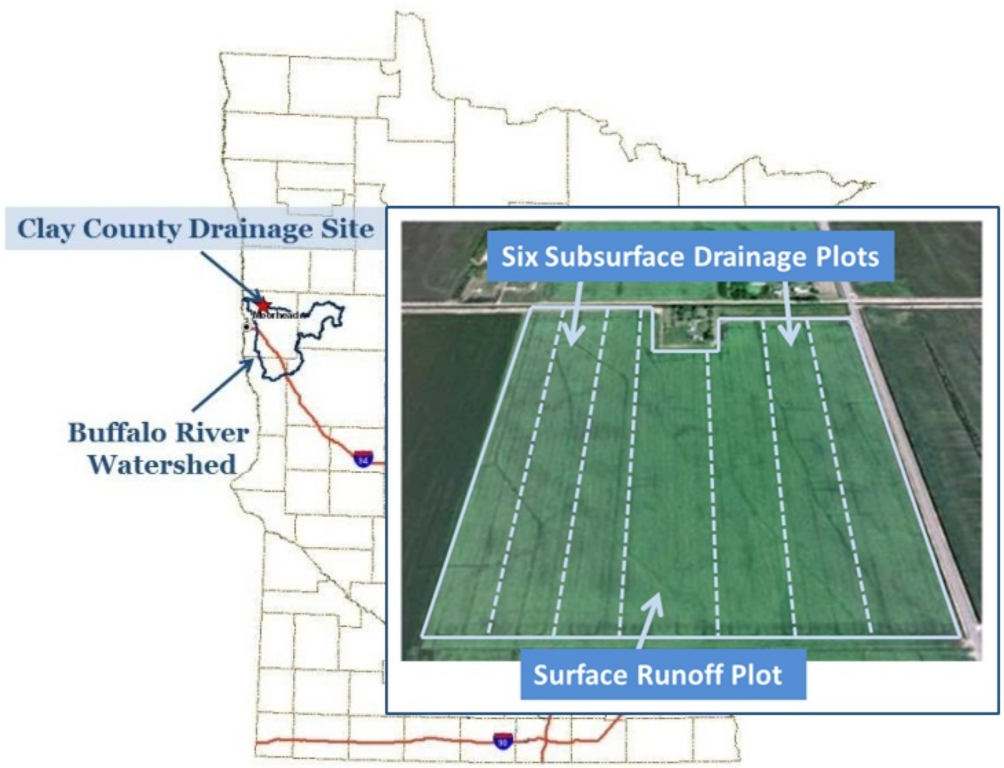

Figure 1: Clay County Drainage Site Location

This report summarizes data collected at the Clay County Drainage Site between January 2011 and December 2015. Subsurface drainage was monitored year-round during those five years. Surface drainage was monitored year-round in 2014 and 2015. Equipment issues while monitoring surface drainage prevented the collection of a year-round dataset prior to 2014.

In 2011 through 2015, plots at the site were uniformly managed in terms of tillage, crops, fertilization, and drainage.[1] Data collected during these years are considered baseline data and provide an understanding of individual plot comparability for future experimental designs which will evaluate drainage associated with different management practices.

Study Design and Methods

The monitored field is approximately 155 acres in size and divided into seven edge-of-field plots (Figure 1). There are six individual plots, ranging from 20-24 acres in size, where subsurface tile drainage monitoring is occurring. The central plot, 24 acres, is surface drained with a shallow drainage way carved into the field to direct surface drainage from this plot to one outlet location.

Each of the seven plots are monitored separately to measure volume of drainage and fully automated to collect water samples when drainage occurs. Figure 2 shows the surface drainage monitoring station and Figure 3 shows three of the six subsurface drainage monitoring stations. Monitoring equipment is operational 365 days per year. All water samples are analyzed for nitrogen, total phosphorus, and dissolved phosphorus[2]. Water samples from the surface drainage plot are also analyzed for total suspended solids.

Figure 1. Surface Drainage Monitoring Stations

Figure 2. Subsurface Drainage Monitoring Station

[1] Years 2011 and 2013 were an exception with the farthest west subsurface drainage plot managed for a different crop than the rest of the field. In these years, five subsurface plots were managed the same instead of all six.

[2] Dissolved phosphorus represents the fraction of total phosphorus which is in solution in the water. Particulate phosphorus represents the remaining fraction of total phosphorus.

Precipitation

Precipitation is measured at the Clay County Drainage Site as rainfall during the full months of April to October. Precipitation is averaged from data collected by two tipping bucket rain gauges; one located at the north-east end of the field and one located at the north-west end of the field. Figure 4 and Table 1 show the precipitation measured at the site from 2011 through 2015 compared to the 30-year normal.

In 2011, snow water equivalent was four to six inches across the Buffalo River Watershed just prior to the snowmelt period[3]. Between April and July 2011, rainfall at the Clay County Drainage Site was near or above normal. Between August and October 2011 rainfall was lower than normal. **Overall, the total rainfall between April and October 2011 was 2.24 inches below the 30-year normal.**

In 2012, snow water equivalent was less than one inch across the watershed just prior to the snowmelt period. Throughout 2012, the rainfall measured was consistently below normal. **Overall, the total rainfall between April and October 2012 was 10.18 inches below the 30-year normal for this time period**.

In 2013, snow water equivalent was four to six inches across the watershed just prior to the snowmelt period. In April 2013, the rainfall measured was comparable to normal. In May and June rainfall exceeded normal conditions. In July and August rainfall was far below normal and in September and October it again exceeded normal conditions. **Overall, 2013 rainfall was characterized by extreme fluctuations from the 30-year normal. The total rainfall between April and October 2013 was 2.21 inches above normal.**

In 2014, snow water equivalent was two to four inches across the watershed just prior to the snowmelt period. Between April and June 2014, rainfall alternated between above normal and below normal and recorded the most precipitation in June. Rainfall from July through October was below normal conditions. **Overall, the total rainfall between April and October 2014 was 2.35 inches below the 30-year normal.**

In 2015, snow water equivalent was less than one inch across the watershed just prior to the snowmelt period. Between April and July 2015, rainfall alternated between below normal and above normal and recorded the most rainfall in May. Rainfall from August through October was below normal conditions. **Overall, the total rainfall between April and October 2015 was 2.48 below the 30-year normal.**

[3] Snow water equivalent information is obtained from the National Weather Service: National Operational Hydrologic Remote Sensing Center, http://www.nohrsc.noaa.gov/interactive/html/map.html.

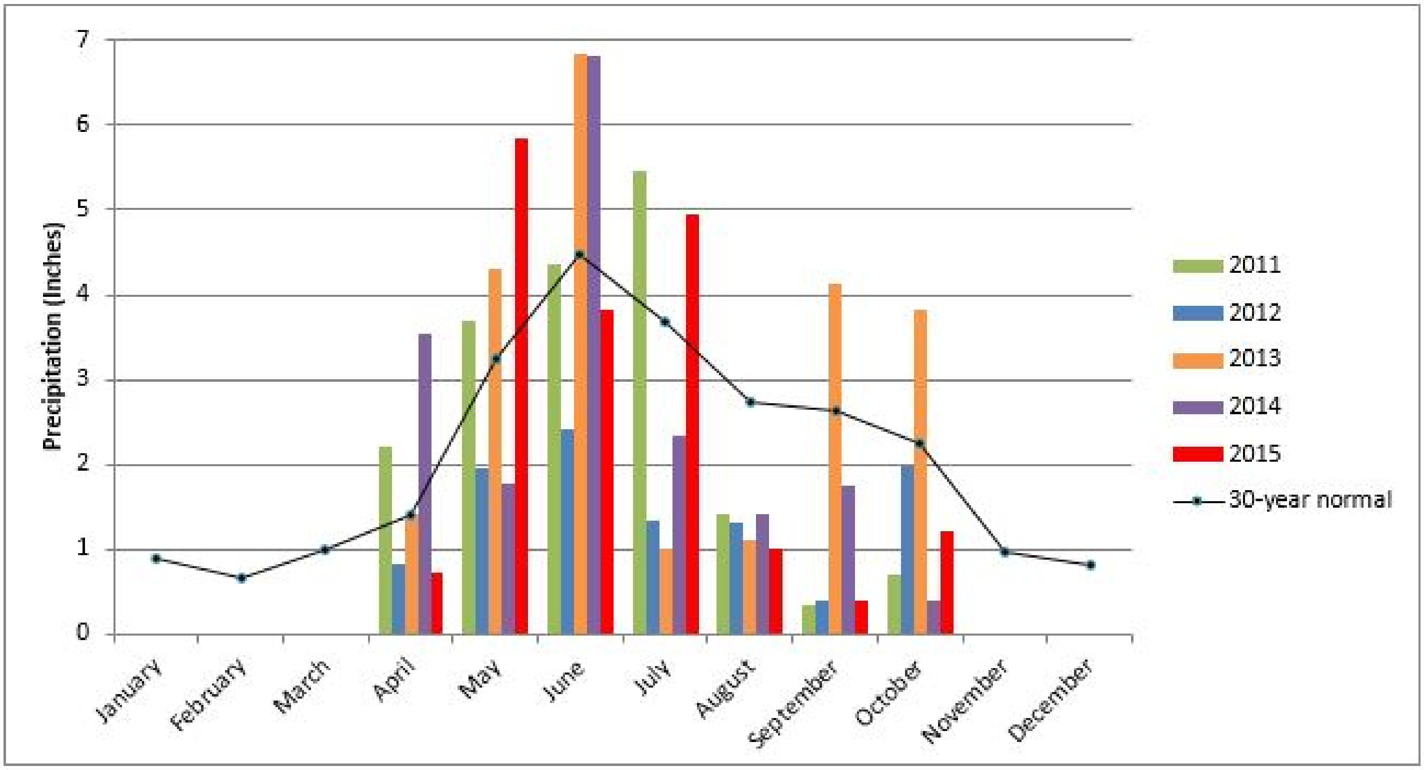

Figure 4. Monthly rainfall at the Clay County Drainage Site compared to the 30-year normal (1981-2010)

Table 1. Observed Rainfall and Subsurface Drainage from April through October

Year	Observed Rainfall (in)	30-Year Normal (in)	Departure from Normal (in)	Observed Subsurface Drainage (in)	Observed Subsurface Drainage as Percent Rainfall
2011	18.18	20.42	-2.24	3.2	17%
2012	10.24	20.42	-10.18	0.0	0%
2013	22.63	20.42	2.21	1.2	5%
2014	18.05	20.42	-2.37	1.0	6%
2015	17.94	20.42	-2.48	1.5	8%

Subsurface Tile Drainage

Drainage is calculated as the total volume of water measured at the outlet of the drainage tile and redistributed equally across the field as water depth in inches. Figure 5 shows the average drainage measured from the subsurface drainage plots across the research site (131 acres). Table 1 displays observed subsurface drainage with comparison to observed rainfall. The maximum and minimum marks on Figure 5 indicate the maximum and minimum drainage measured from the individual plots.

In 2011, subsurface drainage occurred April through August and averaged 3.2 inches. This accounted for 17% of measured rainfall from April through October. Approximately 77% of the subsurface drainage in 2011 occurred in April and May.

In 2012, subsurface drainage did not occur due to dry conditions.

In 2013, subsurface drainage occurred April through July and averaged 1.2 inches. This accounted for 5% of the measured rainfall**.** Approximately 15% of the subsurface drainage in 2013 occurred April through May while 68% occurred in June.

In 2014, subsurface drainage occurred March through July and averaged 1.0 inches. This accounted for 6% of the measured rainfall. Approximately 47% of the subsurface drainage in 2014 occurred in May and June and an additional 47% occurred in July.

In 2015, subsurface drainage occurred May through August and averaged 1.5 inches. This accounted for 8% of the measured rainfall. Approximately 52% of the subsurface drainage in 2015 occurred in June and an additional 32% occurred in July.

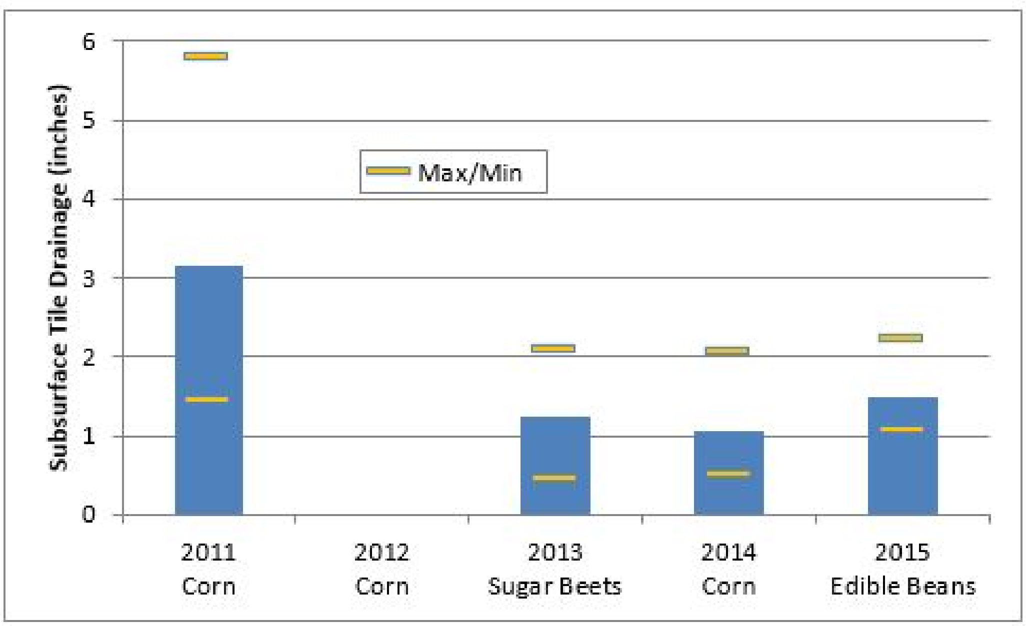

Figure 5. Annual subsurface tile drainage. Columns indicate average drainage across plots. Max/Min marks indicate maximum and minimum drainage of individual plots. No drainage occurred in 2012.

During 2011 and 2013 only five subsurface plots were used to calculate an average because the sixth subsurface plot was planted in a different crop.

Nitrogen Loss in Subsurface Drainage

Nitrogen is an essential nutrient for crop growth. Nitrate and nitrite, highly mobile forms of nitrogen, are susceptible to leaching and can be found in subsurface drainage water. At the Clay County Drainage Site, nitrate-nitrite nitrogen loss is calculated as a flow weighted mean concentration (FWMC). FWMC is often expressed as mg/L (or ppm) and refers to the concentration of a substance in water that is corrected for the volume of water flowing at the time of sampling.

In 2011, the average annual nitrate-nitrite nitrogen loss through subsurface drainage was 3.7 mg/L. The range among plots was 2.2 to 4.6 mg/L.

In 2012 there was no nitrate-nitrite nitrogen loss because subsurface drainage did not occur due to dry conditions.

In 2013, the average annual nitrate-nitrite nitrogen loss through subsurface drainage tile was 23.7 mg/L. The range was 14.2 to 37.4 mg/L.

In 2014, the average annual nitrate-nitrite nitrogen loss through subsurface drainage tile was 14.8 mg/L. The range was 5.0 to 34.4 mg/L

In 2015, the average annual nitrate-nitrite nitrogen loss through subsurface drainage tile was 16.7 mg/L. The range was 9.9 to 36.8 mg/L.

Figure 6 shows annual FWMC of nitrate-nitrite nitrogen loss through subsurface drainage averaged across the plots with maximum and minimum range of individual plot losses. Figure 7 displays nutrient loss in pounds per acre of nitrate-nitrite nitrogen loss through subsurface drainage (lb/acre). Nutrient loss refers to the nutrient load divided by the drainage area.

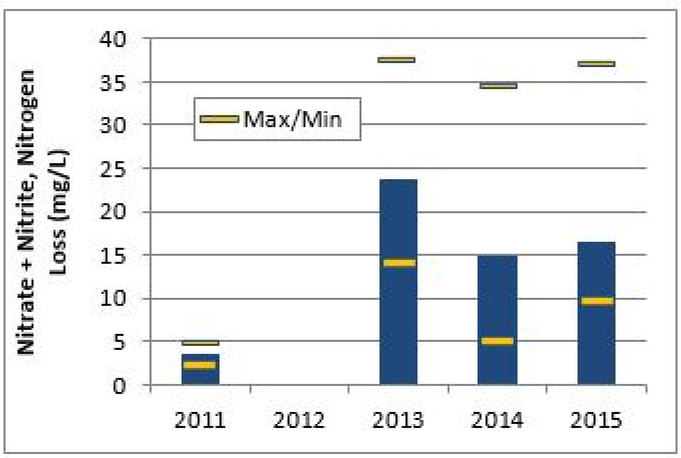

Figure 6. Annual average FWMC nitrate-nitrite nitrogen loss.

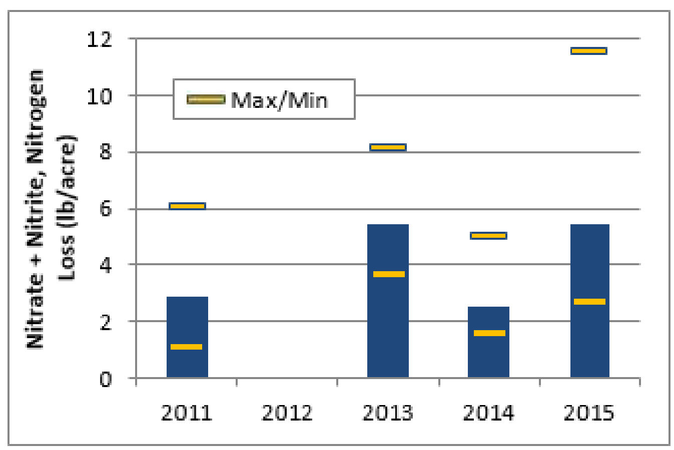

Figure 7. Annual average lb/acre nitrate-nitrite nitrogen loss.

Columns indicate average nitrate-nitrite nitrogen loss across plots. Max/Min marks indicate maximum and minimum loss of individual plots. No drainage occurred in 2012.

Total Phosphorus Loss in Subsurface Drainage

Total phosphorus refers to the combination of phosphorus attached to soil and organic matter and dissolved phosphorus (which moves more easily with water). In crop production systems, supplemental phosphorus is added as fertilizer to optimize crop growth. However, in freshwater water bodies an excessive amount of phosphorus can lead to excessive plant and algae growth. Total phosphorus loss is calculated as a flow weighted mean concentration (FWMC).

In 2011, the average total phosphorus loss was 0.04 mg/L through subsurface drainage. Approximately 95% of the total phosphorus lost was in the dissolved form, which is not attached to sediment. The range of total phosphorus loss measured in 2011 among individual plots was 0.01 to 0.08 mg/L.

In 2012 there was no phosphorus loss because subsurface drainage did not occur at this site.

In 2013, the average total phosphorus loss was 0.07 mg/L. Approximately 97% of the total phosphorus lost was in the dissolved form. The range of total phosphorus loss measured among individual plots in 2013 was 0.02 to 0.11 mg/L.

In 2014, the average total phosphorus loss was 0.08 mg/L. Approximately 90% of the total phosphorus lost was in the dissolved form. The range of total phosphorus loss measured among individual plots in 2014 was 0.008 to 0.18 mg/L.

In 2015, the average total phosphorus loss was 0.03 mg/L. Approximately 44% of the total phosphorus lost was in the dissolved form[4]. The range of total phosphorus loss measured amount individual plots in 2015 was 0.016 to 0.035 mg/L.

Figure 8 shows annual FWMC of total phosphorus loss through subsurface drainage averaged across the plots with maximum and minimum range of individual plot losses. Figure 9 displays nutrient loss in pounds per acre of total phosphorus loss through subsurface drainage (lb/acre)

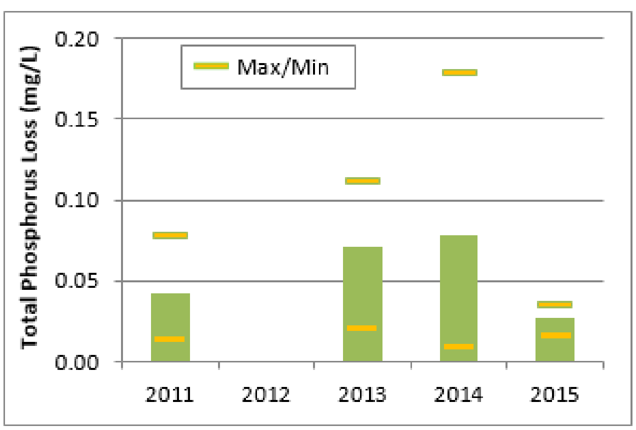

Figure 8. Annual average FWMC total phosphorus loss.

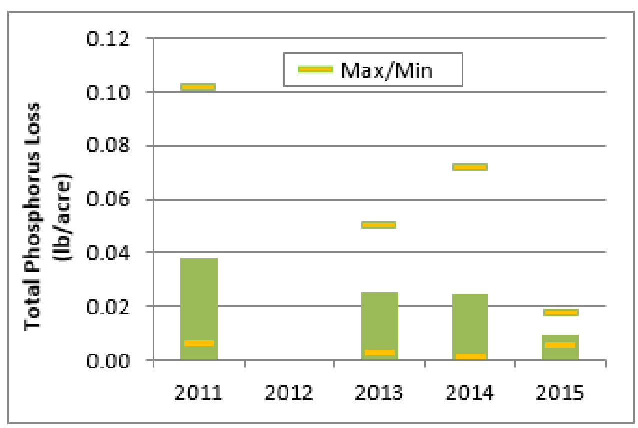

Figure 9. Annual average lb/acre total phosphorus loss.

Columns indicate average total phosphorus loss across plots. Max/Min marks indicate maximum and minimum loss of individual plots. No drainage occurred in 2012.

[4] Phosphorus analysis was transferred to the MN Dept. of Agriculture laboratory beginning in 2015. The transfer of laboratories was for the purpose of using consistent analytical methods with other demonstration and research sites in the area.

Surface Drainage

Year 2014 marks the first complete year of surface drainage monitoring from the outlet of the surface drained plot (24 acres). Surface drainage is calculated as the total volume of water measured at the outlet of the surface drainage way and redistributed equally across the surface drained area as water depth in inches.

In 2014, surface drainage occurred in March, April, and June totaling 0.39 inches. Approximately 11% of the annual surface drainage occurred when the soil was frozen.

In 2015, surface drainage occurred in June and July totaling 0.61 inches. All of the annual surface drainage occurred when the soil was non-frozen.

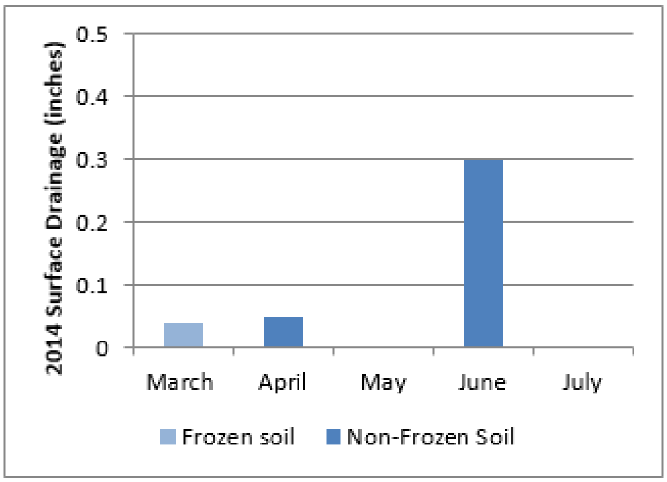

Figure 10. 2014 Drainage from one surface drainage plot

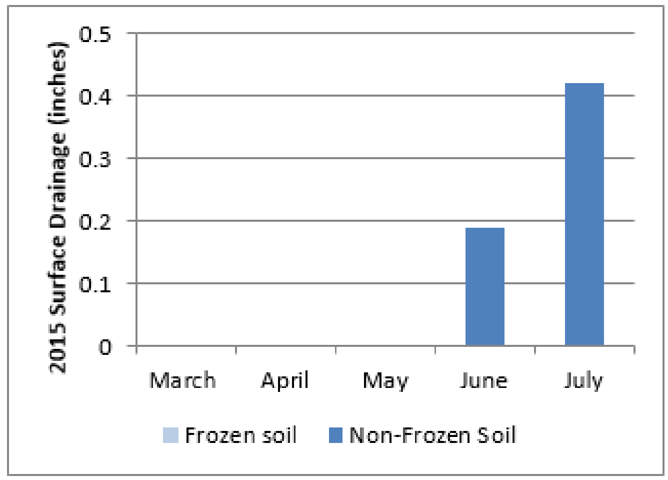

Figure 11. 2015 Drainage from one surface drainage plot

Nutrient and Sediment Loss in Surface Drainage

At the Clay County Drainage Site, nutrient and sediment loss from surface drainage is calculated as flow weighted mean concentration (FWMC). Sediment loss is measured by total suspended solids (TSS). Suspended solids include silt and clay particles, fine organic debris, and other particulate matter that can be trapped by a filter.

In 2014, nitrate-nitrite nitrogen loss was 8.4 mg/L from surface drainage and total phosphorus loss was 2.3 mg/L. Approximately 38% of total phosphorus loss was in the dissolved form. **In 2014, TSS loss from surface drainage was 1,080 mg/L.** Three flow events during June 18th to June 21st totaled 75% of 2014 annual sediment load loss after 2.6 inches of rainfall. On a broader scale, five flow events during June 15th to June 27th totaled 95% of 2014 annual sediment loss after 4.9 inches of rainfall.

In 2015, nitrate-nitrite nitrogen loss was 0.2 mg/L from surface drainage and total phosphorus loss was 0.6 mg/L. Approximately 40% of total phosphorus loss was in the dissolved form. **In 2015, TSS loss from surface drainage was 361 mg/L.** A total of three flow events occurred in 2015. One flow event during July 23rd to July 25th totaled 66% of 2015 annual sediment load loss after 2.1 inches of rainfall.

Figure 11 shows annual FWMC of nutrient and sediment loss from surface drainage. Figure 12 shows annual pounds per acre of nutrient and sediment loss from surface drainage.

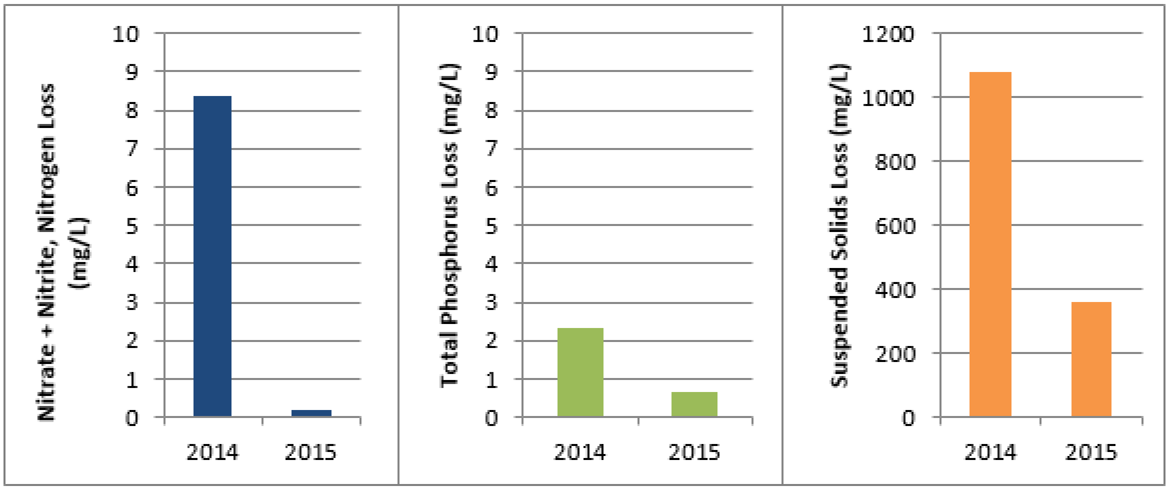

Figure 12. Nutrient and Sediment Loss from Surface Drainage (Flow Weighted Mean Concentration)

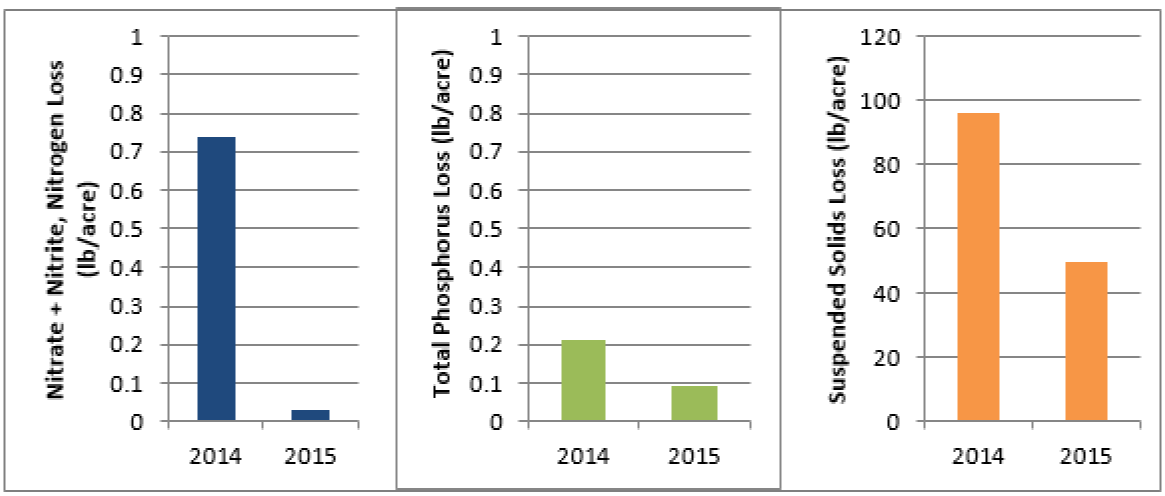

Figure 13. Nutrient and Sediment Loss from Surface Drainage (pounds per acre)

Conclusions

Data presented in this report is intended to provide a summary of precipitation, subsurface drainage and associated nutrient loss, and surface drainage and associated nutrient and sediment loss at the Clay County Drainage Site. At this time, this limited data set should not be used to generalize all subsurface drainage in the Red River Valley. The five-year data set shows variability in precipitation, subsurface drainage and nutrient loss from year to year. Variability also exists amongst plots within the site and will be evaluated during the transition into the treatment phase. Continuing research at the Clay County Drainage Site will build on the existing dataset to further our understanding of agricultural drainage in the Red River Valley.

Acknowledgments

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