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The Effect of Restored and Native Oxbows on Hydraulic Loads of Nutrients and Stream Water Quality

Office of Research and Development
National Risk Management Research Laboratory

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Notice/Disclaimer Statement

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Abstract

The use of oxbow wetlands has been identified as a potential strategy to reduce nutrient transport from agricultural drainage tiles to streams in Iowa. In 2013 and 2014, a study was conducted in north-central Iowa in a native oxbow in the Lyons Creek watershed and two restored oxbow wetlands in the Prairie Creek watershed (Smeltzer west and Smeltzer east) to assess their effectiveness at reducing nitrogen and phosphorus loads. The tile line inlets carrying agricultural runoff to the oxbows, the outfall from the oxbows, and the surface waters in the streams receiving the outfall water were monitored for discharge and nutrients from February 2013 to September 2015. Smeltzer west and east also had four monitoring wells each, two in the upland and two between the oxbow and Prairie Creek to monitor surface water-groundwater interaction. The Smeltzer west and east oxbow sites also were instrumented to continuously measure the nitrate concentration. Rainfall was measured at one Lyons Creek and one Smeltzer site. Daily mean nitrate-N concentrations in Lyons Creek in 2013 ranged from 11.8 mg/L to 40.9 mg/L, the median daily mean nitrate-N concentration was 33.0 mg/L. Daily mean nitrate-N concentrations in Prairie Creek in 2013 ranged from 0.07 mg/L in August to 32.2 mg/L in June. In 2014, daily mean nitrate-N concentrations in Prairie Creek ranged from 0.17 mg/L in April to 26.7 mg/L in July; the daily mean nitrate-N concentration for the sampled period was 9.78 mg/L. Nutrient load reduction occurred in oxbow wetlands in Lyons and Prairie Creek watersheds in north-central Iowa but efficiency of reduction was variable. Little nutrient reduction occurred in the native Lyons Creek oxbow during 2013. Concentrations of all nutrient constituents were not significantly ($P>0.05$, Wilcoxon rank sum) different in water discharging from the tile line than in water leaving the Lyons Creek oxbow. A combination of physical features and flow conditions suggest that the residence time of water in the oxbow may not have been sufficient to allow for removal of substantial amounts of nutrients. Approximately 54 percent less nitrate-N was measured leaving the Smeltzer west oxbow than was measured entering from a small 6-inch field tile. The efficiency of nitrate-N removal in the oxbow was not able to be definitively quantified as other hydrologic factors such as overland and groundwater flow into and through the oxbow were not addressed and may provide alternative routes for nutrient transport. Damage to the Smeltzer east oxbow outfall weir prevented analysis of its nutrient load reduction capability. The study provides important information to managers and land owners looking for strategies to reduce nutrient transport from fields. Additional research is needed to understand how increased discharge from larger field tiles and drainage district mains may influence the efficiency of nutrient reduction in relation to the size, type, and landscape setting of a wetland.

Foreword

The U.S. Environmental Protection Agency (USEPA) is charged by Congress with protecting the Nation's land, air, and water resources. Under a mandate of national environmental laws, the Agency strives to formulate and implement actions leading to a compatible balance between human activities and the ability of natural systems to support and nurture life. To meet this mandate, USEPA's research program is providing data and technical support for solving environmental problems today and building a science knowledge base necessary to manage our ecological resources wisely, understand how pollutants affect our health, and prevent or reduce environmental risks in the future.

The National Risk Management Research Laboratory (NRMRL) within the Office of Research and Development (ORD) is the Agency's center for investigation of technological and management approaches for preventing and reducing risks from pollution that threaten human health and the environment. The focus of the Laboratory's research program is on methods and their cost-effectiveness for prevention and control of pollution to air, land, water, and subsurface resources; protection of water quality in public water systems; remediation of contaminated sites, sediments, and groundwater; prevention and control of indoor air pollution; and restoration of ecosystems. NRMRL collaborates with both public and private sector partners to foster technologies that reduce the cost of compliance and to anticipate emerging problems. NRMRL's research provides solutions to environmental problems by: developing and promoting technologies that protect and improve the environment; advancing scientific and engineering information to support regulatory and policy decisions; and providing the technical support and information transfer to ensure implementation of environmental regulations and strategies at the national, state, and community levels.

This report documents the results of hydraulic and water quality monitoring that was conducted from 2013 through 2014 in two restored and one native oxbow wetlands receiving agricultural runoff via drain tiles from row crop agriculture in north-central Iowa. Flow and selected nitrogen and phosphorus species were monitored in these oxbows and the nearby streams receiving their discharges to assess the effectiveness of oxbow wetlands at reducing nutrients. The primary objectives of this report are to (1) document the methods used to collect data that estimate and characterize the nutrient loads from the oxbow inlets and compare these loads with the nutrient loads at the oxbow outlets and the receiving streams and (2) to summarize flow, concentrations, and loads in oxbow wetland inflow and outflow; summarize water levels and water quality in groundwater in the vicinity of the oxbow wetlands; and summarize flow, concentrations, and loads in the streams receiving discharge from the wetlands.

Cynthia Sonich-Mullen, Director
National Risk Management Research Laboratory

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Conversion Factors

Inch/Pound to International System of Units

Multiply	By	To obtain
	Length	
inch (in.)	2.54	centimeter (cm)
inch (in.)	25.4	millimeter (mm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
mile, nautical (nmi)	1.852	kilometer (km)
yard (yd)	0.9144	meter (m)
	Area	
acre	4,047	square meter (m^2)
acre	0.4047	hectare (ha)
acre	0.004047	square kilometer (km^2)
square mile (mi^2)	259.0	hectare (ha)
square mile (mi^2)	2.590	square kilometer (km^2)
	Volume	
gallon (gal)	3.785	liter (L)
gallon (gal)	0.003785	cubic meter (m^3)
cubic foot (ft^3)	0.02832	cubic meter (m^3)
acre-foot (acre-ft)	1,233	cubic meter (m^3)
acre-foot (acre-ft)	0.001233	cubic hectometer (hm^3)
	Flow rate	
acre-foot per year (acre-ft/yr)	1,233	cubic meter per year (m^3/yr)
acre-foot per year (acre-ft/yr)	0.001233	cubic hectometer per year (hm^3/yr)
cubic foot per second (ft^3/s)	0.02832	cubic meter per second (m^3/s)
cubic foot per second per square mile [(ft^3/s)/mi^2]	0.01093	cubic meter per second per square kilometer [(m^3/s)/km^2]
mile per hour (mi/h)	1.609	kilometer per hour (km/h)
	Mass	
pound, avoirdupois (lb)	0.4536	kilogram (kg)
ton, short (2,000 lb)	0.9072	megagram (Mg)
ton per day (ton/d)	0.9072	metric ton per day
ton per day (ton/d)	0.9072	megagram per day (Mg/d)
ton per day per square mile [(ton/d)/mi^2]	0.3503	megagram per day per square kilometer [(Mg/d)/km^2]
ton per year (ton/yr)	0.9072	megagram per year (Mg/yr)
ton per year (ton/yr)	0.9072	metric ton per year

Temperature in degrees Fahrenheit (°F) may be converted to degrees Celsius (°C) as °C = (°F – 32) / 1.8.

Acronyms and Abbreviations

USEPA	U.S. Environmental Protection Agency
GIS	Geographic Information System
GPS	Global Positioning System
IDNR	Iowa Department of Natural Resources
MRBI	Mississippi River Basin Initiative
NRCS	Natural Resources Conservation Service
NWIS	U.S. Geological Survey National Water Information System
PVC	Polyvinyl Chloride
RPD	Relative Percent Difference
UMESC	U.S. Geological Survey, Upper Midwest Environmental Sciences Center
USGS	U.S. Geological Survey

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1.0 Introduction

Excess nutrients (primarily nitrogen and phosphorus) are ranked as one of the top 10 leading causes for a majority of the impairments to U.S. waters (USEPA 2000, 2009). A NOAA Estuarine Eutrophication Survey (Bricker and others, 1999) found that 89% of the U.S. coastal estuaries show signs of impairment due to eutrophication. In addition, excess nitrogen transport from the Upper Midwest, primarily associated with agricultural activities, has been cited as a major contributor to the annual formation of a large hypoxic zone in the Gulf of Mexico (Scavia and others, 2000). Management and reduction of excess nitrogen and phosphorus loading is a major goal for reducing coastal hypoxia and the risk of harmful and toxic algal blooms. The goal of this study was to assess the ability of restored and native oxbows to reduce nutrient loads from agricultural runoff. The practice of restoring or reconstructing oxbow wetlands has been identified as one potential strategy among others to reduce the amount of nutrients transported by agricultural drainage tiles from reaching stream surface waters. Off-channel habitats such as oxbow wetlands are also thought to serve as important habitat for the federally endangered Topeka Shiner (Bakevich and others, 2013) and act as refugia for life stages of other fish and amphibians.

This report documents the hydraulic and water quality monitoring conducted from 2013 through 2014 in two restored and one native oxbow wetlands receiving agricultural row crop runoff via drain tiles in north-central Iowa. Flow and selected nitrogen and phosphorus species were monitored in these oxbows and the nearby streams receiving the oxbow discharge to assess the effectiveness of oxbow wetlands at reducing nutrients. The primary objectives of this report are to (1) document the methods used to collect data that estimate and characterize the nutrient loads from the oxbow inlets and compare these loads with the nutrient loads at the oxbow outlets and the receiving streams and (2) to summarize flow, concentrations, and loads in oxbow wetland inflow and outflow; to summarize water levels and water quality in groundwater in the vicinity of the oxbow wetlands; and to summarize flow, concentrations, and loads in the streams receiving discharge from the wetlands. The streamflow information will be used to understand the watershed setting of the oxbows.

2.0 Description of the Study Area

2.1 Location

The study was conducted at two sites in north-central Iowa (Fig. 1) in the Des Moines Lobe landform area which is the southernmost extent of the Prairie Pothole Region in central North America. Its characteristic knob-and-kettle terrain was formed by the Wisconsinan Glaciation, the last glacial episode in the state (Prior, 1991). This region of the state contains most of Iowa's natural lakes and contained abundant prairie pothole wetlands and oxbow lakes prior to agricultural drainage (Prior, 1991). The soils are mostly composed of poorly-drained clay loams, with smaller percentages of moderately well-drained loams. Most of the pothole wetlands were drained in the early 1900's to grow crops (Dahl and Allord, 1996). Additional extensive subsurface tile drainage has been installed during the last decade to lower the water table to increase crop production.

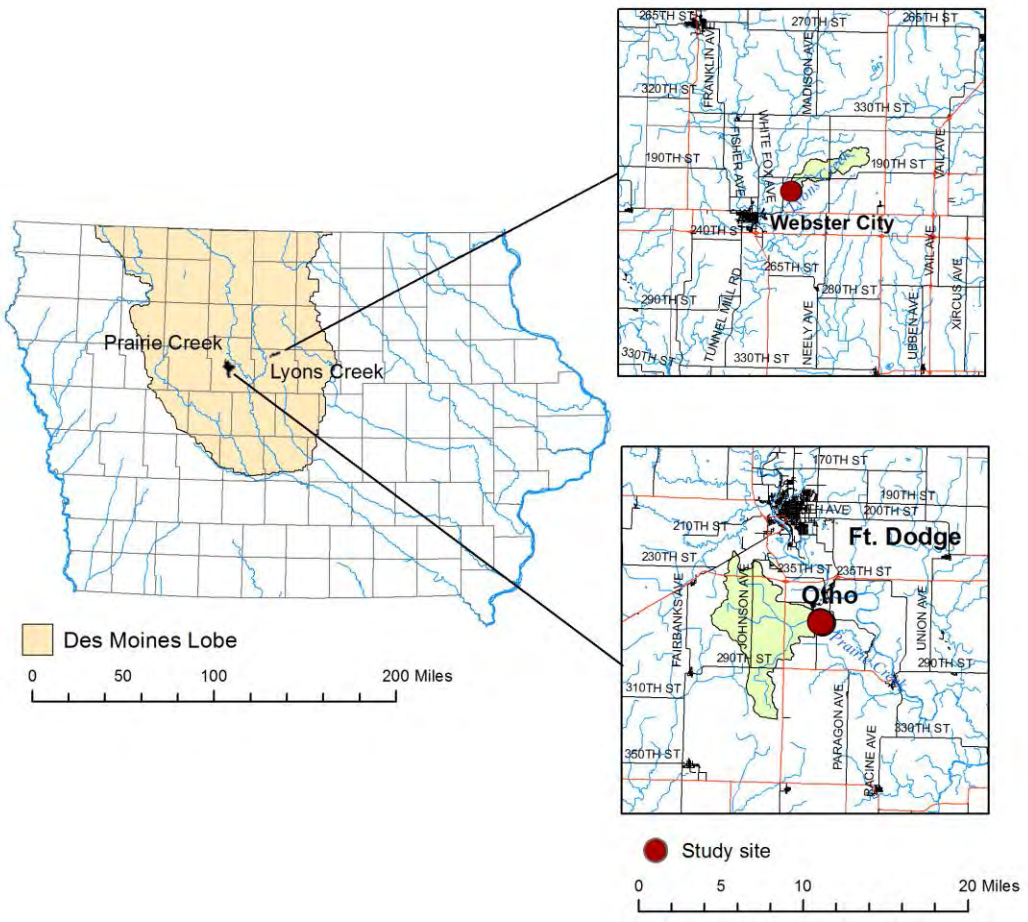


Figure 1. Location of the oxbow wetland study sites in the Prairie and Lyons Creek watersheds in Iowa

2.2 Physical Features

A native oxbow wetland located in the Lyons Creek watershed near Webster City, Iowa (Fig. 1) was selected for study. Lyons Creek drains an 18-mi^2 (Larimer, 1974) watershed and joins the Boone River near Webster City. The Lyons Creek oxbow wetland is located 0.25 mi south of 203rd Street. The study site is 4.0 miles upstream of the confluence of Lyons Creek and the Boone River. Lyons Creek drains 7.0 mi^2 upstream of the study site. The native oxbow wetland is adjacent to Lyons Creek and is located in a narrow valley that has relatively steep sides and is generally less than 1,000 ft wide. The land adjacent to the wetland along the stream valley north to 203rd St is not farmed, being covered mainly with prairie. The surrounding land to the east and west is used for row crops and the land to the south of the oxbow wetland is in pasture. Lyons Creek oxbow appears to have been formed naturally and has been present since at least 1950 (Fig. 2). Over time, the Lyons Creek oxbow has filled with sediment. The wetland had open water in 1950, but now (2013) is shallow and covered with emergent vegetation (Fig. 2). The Lyons Creek oxbow is not directly connected to the creek but may become inundated during flooding. Water discharged from a field tile enters the wetland from the southwest. A narrow channel is present in the vegetation between the point where the tile discharges and the outlet of the oxbow.

1950

2013

Aerial photos from Iowa State University Geographic Map Server

Figure 2. Lyons Creek study site showing location of sampling sites and changes in the Lyons Creek channel from 1950 to 2013.

The two restored oxbow wetlands are located on the Smeltzer Learning Farms in the Prairie Creek watershed near Ft. Dodge, IA (Fig. 3). Prairie Creek drains a 34-mi^2 (Larimer, 1974) watershed and joins the Des Moines River near Otho, IA. The Smeltzer Farms oxbow wetlands are located

approximately 1,500 ft downstream of county highway P59. The study site is located 7.5 miles upstream of the confluence of Prairie Creek and the Des Moines River. Prairie Creek drains 28 mi^2 of land upstream of the study site. The Smeltzer west oxbow wetland was created sometime between 1970 and 1980 when natural stream meanders were cut off from the stream by channelization of Prairie Creek. Based on changes observed in historical aerial photos, the Smeltzer east oxbow wetland may have formed naturally when the channel cut off a meander sometime between 1950 and 1960 (Fig. 3). Both Smeltzer east and west oxbow wetlands were restored in 2012 by removal of deposited sediment. These wetlands are situated in the valley of Prairie Creek that is generally less than 1,500 ft wide with a floodplain that is generally less than 400 ft wide. A grass buffer extends from the creek to the top of the valley. Farmland is adjacent to both the north and south sides of the valley. The restored wetlands are not connected directly to Prairie Creek but may become inundated during flooding. Water discharged from field tile draining farmland to the south enters both wetlands on the east. Excess water is discharged from the wetland through drainage control structures on the west. A denitrification bed or bioreactor (Schipper and others, 2010) using wood chips as the carbon substrate was installed on the tile line discharging to the Smeltzer east oxbow. Its purpose was to reduce nitrate concentrations of the water before it entered the oxbow wetland.

1950

2013

Aerial photos from Iowa State University Geographic Map Server

Figure 3. Prairie Creek study site showing location of sampling sites at the Smeltzer farms east and west oxbow wetlands and changes in the Prairie Creek channel from 1950 to 2013. [Aerial photos from Iowa State University Geographic Map Server]

2.3 Climatic Conditions

The climatic conditions during the 2013 to 2014 study period can be characterized as colder winters and wetter springs than the 30-year average. Generally the winter and early months in north-central Iowa

from November through April during the study were colder (fig. 4) than normal (1981-2010 average). Air temperatures in late spring and summer through the growing season were similar to the 30-year average (fig. 4). Average monthly air temperatures increased from 44.8°F in April 2013 to 71.6 ° F in July 2013 before decreasing to 51.3°F in October at the end of the growing season (Fig. 4). Average monthly air temperatures were similar in 2014, but the greatest monthly average (70.9° F) was one month later than in 2013 (fig. 4). Monthly precipitation in north-central Iowa during the study period (Fig. 4) was variable but was greater in April through June in relation to the 30-year average. Average monthly rainfall was more than 2.0 inches greater than normal in April 2013 and June 2014. With the exception of August 2014, rainfall the remainder of the growing season was near or below the 30-year average. Rainfall normally decreases from 4.25 inches in June to 3.01 inches October (Fig. 4).

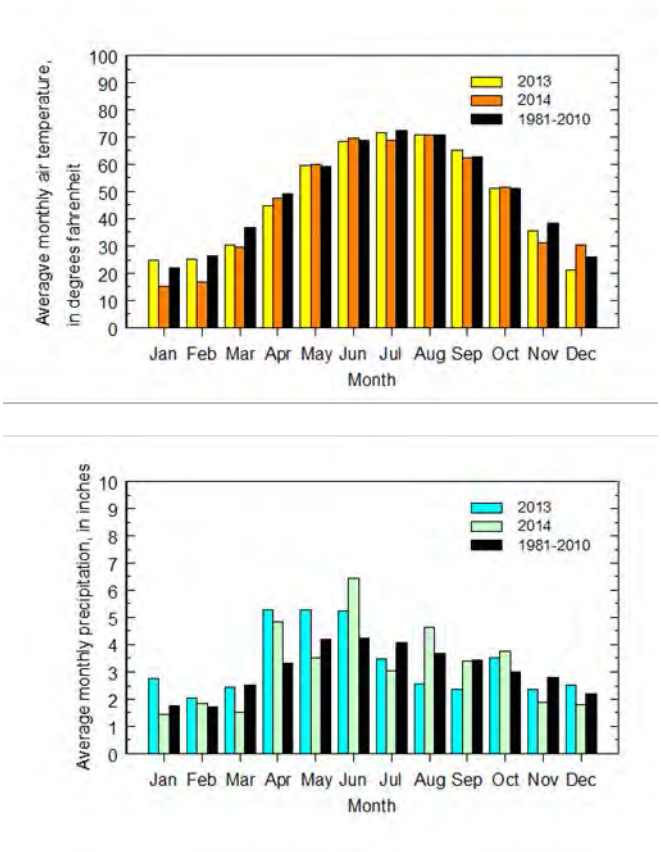


Figure 4. Average monthly air temperature and precipitation in north-central Iowa in 2013 and 2014 in relation to the 30-year average. (monthly summary of the entire Iowa climatic region 5; data from NOAA, 2015)

3.0 Methods

This project focused on monitoring the restored oxbow wetlands identified as Smeltzer west oxbow and Smeltzer east oxbow and a native Lyons Creek oxbow (Figs. 2 and 3). A field-scale watershed approach was used to estimate nutrient loads entering and leaving the oxbows and groundwater interaction with the oxbows.

The monitoring sites were established at the inlets and outlets of the oxbow (Table 1). Discharge and water-quality data were collected at these oxbows to quantify the nitrogen and phosphorus loads entering and leaving the restored and native oxbows. Smeltzer west and east had four monitoring wells

each, two in the upland and two between the oxbow and Prairie Creek to monitor surface water-groundwater interaction. One stream monitoring station was located on Prairie Creek at a footbridge near the Smeltzer oxbows. Another stream monitoring station was located on Lyons Creek, near the native oxbow to evaluate its performance in reducing the nutrient export.

Each stream and oxbow wetland site was instrumented to measure water levels and collect water samples. The Smeltzer west and east oxbow sites also were instrumented to continuously measure the nitrate concentration. Rainfall was measured at one Lyons Creek and one Smeltzer site. Control of the instrumentation and recording and transmittal of data was with a Campbell® data logging and control system (data logger). Data collected at each site was radioed to a central location at each of the Lyons Creek and Smeltzer study areas for transmittal via cell phone to the U.S. Geological Survey National Water Information System (NWIS) database (http://dx.doi.org/10.5066/F7P55KJN).

Table 1. Oxbow wetland and stream sites in the Lyons and Prairie Creek watersheds, IA 2013-2014

Map number	Site identification number	Site name	Site type	Decimal latitude	Decimal longitude	County
L1	422935093460401	Lyons Oxbow Inlet near Webster City, IA (L1)	Tile inlet	42.4932	-93.7678	Hamilton
L2	422935093460001	Lyons Oxbow Outlet near Webster City, IA (L2)	Oxbow outlet	42.4933	-93.7669	Hamilton
L3	05480986	Lyons Creek near Webster City, IA (L3)	Stream	42.4933	-93.7668	Hamilton
S1	422436094082501	Smeltzer west Oxbow Inlet near Otho, IA (S1)	Tile inlet	42.4102	-94.1403	Webster
S2	422438094082701	Smeltzer west Oxbow Outlet near Otho, IA (S2)	Oxbow outlet	42.4106	-94.1410	Webster
S3	05480603	Prairie Creek at Otho, IA (S3)	Stream	42.4109	-94.1413	Webster
S4	422432094081701	Smeltzer east Oxbow Inlet near Otho, IA (S4)	Tile inlet	42.4091	-94.1383	Webster
S5	422433094081801	Smeltzer east Oxbow Outlet near Otho, IA (S5)	Oxbow outlet	42.4094	-94.1385	Webster

3.1 Hydrologic Data Collection

3.1.1 Precipitation

Rainfall was recorded using 6-inch (15.24 cm) tipping bucket rain gages at the Lyons Creek native oxbow site and at the Prairie Creek restored wetland sites. The rain gages were mounted above one of the instrument structures 10 ft above land surface. Each tip of the rain gage bucket generated a pulse signal that was converted to the rainfall amount and recorded by the data logger. A tip of the bucket measured 0.01 inches. The amount of rainfall was summed for each 15-minute period. The rain gage at the Prairie Creek oxbow site malfunctioned during June 22 to July 3, 2014 when the area received substantial rains. Daily rainfall on these days was supplemented with data from NOAA's rain gage 1.6 miles east northeast of Fort Dodge, IA (NOAA, 2015).

Routine maintenance and annual calibration were performed to ensure that the rain gages accurately measured precipitation. Routine maintenance included inspection and if necessary cleaning of the collector, funnel, and screen. A manual tip test was conducted to check the integrity and operation of the gage sensor and wiring. Each rain gage was calibrated using a simulated precipitation intensity of 2 inches per hour.

3.1.2 Tile line and oxbow

Flow into and discharge from the restored and native oxbow wetlands was measured on a 5- to 15-minute time period using rated weirs and discharge control boxes.

At the Lyons Creek site, a weir was constructed at both the tile line (L1) and oxbow wetland (L2) discharge points to route the water through a 2-ft. "H" flume. The level of water (stage) in the flume was measured using a gas purge pressure transducer and recorded by the data-logger. The stage data were used with the "H" flume rating (Appendix 1.1) to calculate flow at 15-minute intervals.

Water discharged from tile lines to Smeltzer east (S4) and west (S1) oxbow wetlands was routed through a 60^{o} V shaped trapezoidal flume so that flow could be accurately measured. As in the Lyons Creek flumes, the water level in the trapezoidal flume was measured using a gas purge pressure system and recorded by the onsite data logger. The stage data were used with the flume manufacturer's theoretical rating curve (Appendix 1.2) to calculate flow at 15-minute intervals.

Water discharged from Smeltzer east and west oxbows was routed through a commercial flow control box.

3.1.3 Groundwater level

Water levels were monitored in 10 wells to measure water table fluctuations along a groundwater flow path through each oxbow wetland. Wells were from 7.6 to 13.8 ft deep. Well screens were installed in the lower 5.0 ft. of each well. The monitoring wells were constructed with a drill rig using a 6-inch hollow stem auger. When the auger reached the completed depth it was removed and a 2-inch polyvinyl chloride (PVC) well casing along with the 5-ft screen were inserted down the bore hole. The hole was then backfilled with sand to 1.0 ft above the screen (sand pack), followed by bentonite to within 3 ft of the surface, and finally cement from the top of the bentonite to the surface. The bentonite and concrete ensured that water would not seep down the bore hole. A 6-inch PVC protective casing was set in the concrete to secure the well. The well was then developed to remove fine sediment from the sand pack by pumping until the water cleared.

Table 2. Groundwater monitoring well information

Map number	USGS Station identification number	Station name	Longitude	Latitude	Land-surface altitude	Well Depth (feet)
LW1	422936093460401	Lyons oxbow (W1)	-93.767917	42.493389	1099.14	11.8
LW4	422935093460002	Lyons oxbow (W4)	-93.766917	42.493222	1090.94	7.6
SW1	422436094082901	Smeltzer west oxbow (W1)	-94.141389	42.410000	1101.34	12.6
SW2	422436094082801	Smeltzer west oxbow (W2)	-94.141222	42.410111	1088.97	12.5
SW3	422437094082701	Smeltzer west oxbow (W3)	-94.140917	42.410278	1092.22	13.8
SW4	422437094082501	Smeltzer west oxbow (W4)	-94.140500	42.410528	1089.43	12.7
SW5	422432094082001	Smeltzer east oxbow (W5)	-94.138889	42.409139	1098.32	10.6
SW6	422433094081901	Smeltzer east oxbow (W6)	-94.138667	42.409167	1089.30	12.6
SW7	422433094081802	Smeltzer east oxbow (W7)	-94.138444	42.409194	1093.80	13.0
SW8	422433094081601	Smeltzer east oxbow (W8)	-94.138028	42.409361	1090.12	11.9

The water level and temperature in the water table was recorded in 6 of the 10 monitoring wells (SW1, SW2, SW3, SW4, SW6, and SW8; Table 2) at 15-minute intervals using a self-contained level-logger system (Aqua TROLL, In-Situ Inc., Fort Collins, CO). Water levels were measured using a pressure transducer and water temperature was measured using a thermistor that was set near the bottom of the screened interval. The pressure transducer was vented to the surface to allow compensation for changes

in atmospheric pressure. The sensors were set near the bottom of the screened interval to ensure that they were measuring water that was moving through the water table; not stagnant water trapped in the well casing. Initial water levels were set in the level logger based on manual measurements using an electrical tape. Recorded water levels were checked periodically against manual measurements to allow compensation for drift over time (Cunningham and Schalk, 2011).

Water level and temperature data recorded by the level loggers were uploaded to a laptop computer when personnel visited the site for cleaning and maintenance. Upon return to the office, data were uploaded to the USGS NWIS database.

3.1.4 Streamflow

Periodic streamflow measurements (Appendix 1.3) were made at Lyons Creek near Webster City, IA and Prairie Creek at Otho, IA to develop a stage-discharge relation (Rantz and others, 1982a) that was used to calculate flow at 15-minute intervals. Discharge measurements were made over a range of stream stages using the midsection method (Sauer and Turnipseed, 2010) with an Acoustic Doppler Velocity meter (ADVM) for wading measurements and a cable mounted Acoustic Doppler Current Profiler (ADCP) for high flow measurements.

Stage-discharge ratings were developed for the sites on Prairie and Lyons Creek from streamflow measurements made at a range of stream height (stage) using methods outlined in Rantz and others (1982b). These stage-discharge relations or rating curves (Appendix 1.4 and Appendix 1.5) were then used along with the measured stage to calculate stream discharge at 15-minute intervals. All resulting discharge records were then reviewed to identify and edit erroneous data and make shift adjustments if needed (Sauer, 2002). The reviewed records were then checked by another technician before being approved for use or publication.

Stage, as measured in relation to a set datum, was recorded at 15-minute intervals with a gas purge pressure sensor system and was stored in the onsite data logger. Stored stage data were periodically transmitted throughout the day to the USGS NWIS database via cell modem. Stream discharge corresponding to each 15- minute stage measurement was calculated using the established stage-discharge relations for Lyons Creek near Webster City, IA (Appendix 1.4) and for Prairie Creek at Otho, IA (Appendix 1.5). Mean daily discharge was then calculated from the 15-minute data.

Recorded stage values were checked during each site visit against an outside staff gage that was surveyed to a known datum to ensure that the water level in the streams was measured accurately.

3.2 Water Quality Data Collection

Water quality data were initially collected manually and with automatic samplers which were then analyzed using methods described below in section 3.2.4. Manual samples were collected periodically as needed and automatic samplers were used to collect samples during storm events when personnel were not available. Nitrate plus nitrite as nitrogen (N) sensors that allowed for high frequency measurement of concentrations were installed in June 2013. Data from the nitrate sensors replaced data obtained from the manual and automatic sample collection. Both laboratory analysis and measurement using in situ sensors measure both the nitrate-N and nitrite-N species. However, in well oxygenated environments similar to sites in this study, nitrate-N is the predominant species in solution. Therefore the nitrate plus nitrite as nitrogen concentration and load will be referred to as nitrate-N concentration and load in the remainder of the report.

3.2.1 Periodic samples

Periodic water quality samples for the analysis of selected nitrogen and phosphorus species were collected from the tile inflow and oxbow discharge at all three oxbow wetland sites. Periodic samples were also collected from the two streams receiving oxbow discharge. A single sample was collected from the monitoring wells to quantify nitrogen and phosphorus concentrations in shallow groundwater. Samples were collected using methods that resulted in a representative sample (U.S. Geological Survey, 2006).

Sampling equipment that included samplers, sample churns, and tubing were cleaned before each sample to ensure that cross contamination did not occur. Detailed cleaning instructions are provided in Wilde (2004) and are summarized here. The sampling equipment were soaked in a non-phosphate detergent solution and scrubbed, if needed, to remove any adhering material. The equipment was then rinsed first with tap water and then with deionized water to remove any remaining detergent. If not immediately needed, the sampling equipment was allowed to air dry and then stored in sealed plastic bags.

Water samples were collected into a clean sample churn by pumping with a peristaltic pump (oxbow outlets), with a hand or line sampler for the streams, and by water flowing directly into the churn (tile-lines). Two bottles were filled for each sample. Stream samples were a composite of depth integrated samples from a minimum of 10 equal width verticals across the stream (U.S. Geological Survey, 2006). One pre-rinsed clear polyethylene bottle for analysis of total (unfiltered) constituents (Table 3) was filled directly from the churn without filtering. Water to be analyzed for dissolved nutrients was filtered through a 0.45-µm capsule filter into a brown polyethylene bottle (Wilde and others, 2004).

Because of the small production capacity of the shallow monitoring wells, samples were collected during a two-day period. On the first day, old or stagnant water was pumped from the well casing until the well was dry. Water was allowed to flow back into the well overnight before samples were collected the following day. Water was pumped from the monitoring wells with a peristaltic pump directly into a clear polyethylene bottle for analysis of total constituents and through a 0.45-µm capsule filter into a brown polyethylene bottle for analysis of dissolved constituents (Wilde and others, 2004).

3.2.2 Automatic storm samples

The large number of sampling sites and the general timing of rainfall precluded field personnel from manually collecting water quality samples during all storm events. A set of automatic samplers was installed to collect water quality samples from Lyons and Prairie Creeks and from the three oxbow inlet and discharge sites to supplement manual sampling in 2013. Automatic samples were collected from April to October in 2013. Automatic samplers were superseded by the use of nitrate-N sensors in June 2013.

ISCO® portable automatic samplers controlled by a Campbell® data logging and control system were used to collect water samples during periods of rainfall when flow at the sampling sites substantially increased. Stage in the streams, tile-line weir, and oxbow control boxes were measured using the gas purge pressure system. Stage measurements recorded by the data loggers were used to trigger sampling by the automatic samplers.

The data logger signaled sampling to start when a pre-set stage was reached or exceeded. Once triggered, the automatic samplers were programed to sample at pre-set intervals. Before the sampler began collection, the tubing was back flushed to remove water that remained in the tube after the

previous sample. The sample bottle was then filled to a programmed volume. Samples were removed from the automatic sampler within a day of collection, put on ice, and transported back to the field office for processing. A subset of the autosamples were selected for processing and shipment to the laboratory for analysis. Water for analysis of dissolved nitrogen and phosphorus species was filtered through a 0.45-µm cartridge filter into a separate polyethylene bottle. Water for analysis of total nitrogen and phosphorus was transferred to a polyethylene bottle unfiltered. Both the filtered and unfiltered sample bottles were shipped chilled at or less than 4° C to the laboratory for analysis (Wilde and others, 2004).

3.2.3 Continuous nitrate monitoring

New instrumentation (NITRATAX probe manufactured by Hach Corporation Germany) that allows for high-frequency measurements of nitrate-N was installed at a number of sites midway through the summer of 2013. The NITRATAX probes used were factory serviced and certified annually, across a concentration range of 0.1-50 mg/L nitrate-N (Table 3). USGS Standard Operating Procedures described in detail by Pellerin and others (2013) were followed to calibrate and maintain the probes used to ensure accurate nitrate-N measurements. The procedures followed are briefly summarized here. Upon arrival at the site, an initial sensor measurement was recorded for comparison to a field measurement after the sensor was cleaned. The sensor was removed and inspected for fouling and potential damage to the instrument. The optical window of the sensor was cleaned using distilled water. If staining was visible, the optical window was rinsed with a mild hydrochloric acid solution. If needed, the remainder of the sensor was also cleaned. The sensor was then returned to the monitoring location and a new measurement was made to compare to the pre-cleaning measurement.

Field calibration checks were made after cleaning with commercially available nitrate-N standards (obtained from Hach Corporation). The sensor readings were checked using three known concentration standards. Zero concentration was checked with deionized water. Additional nitrate-N concentration standards of 11.3 and 22.6 mg/L were measured to verify accuracy over the expected range to be measured. When ambient nitrate-N concentrations exceeded 22.6 mg/L, a 45.2 mg/L standard was used to check the calibration at the high end of nitrate-N range of the instrument.

Ambient water quality samples collected soon after cleaning were used to check the sensor measurement with concentrations determined using approved wet chemistry analytical methods (see description of analytical methods in next section).

3.2.4 Water quality analysis

All water quality samples were chilled on ice after collection and were transported to the U.S. Geological Survey Upper Midwest Environmental Sciences Center (UMESC) water quality laboratory in La Crosse, WI for analysis. Samples were analyzed for three nitrogen and two phosphorus species by standard methods (Table 3).

Table 3. Analytical methods for nitrogen and phosphorus species, 2013-2014. [Pcode, U.S. Geological Survey parameter code; mg/L, milligrams per liter; N, nitrogen; P, phosphorus: methods from Rice and others, 2012]

Analyte (Pcode)	Matrix	Range Low	Range High	Units	Method
USGS Upper Mississippi Environmental Science Center laboratory					
Nitrate+Nitrite-N (00631)	Water, filtered	0.01	250	mg/L	4500 NO3- I
Ammonium-N (00608)	Water, filtered	0.008	250	mg/L	4500-NH3 G
Total Nitrogen-N Unfiltered (62855)	Water, unfiltered	0.01	250	mg/L	4500-N C
Ortho-phosphate-P (00671)	Water, filtered	0.001	100	mg/L	4500-P E
Total Phosphorus-P Unfiltered (00665)	Water, unfiltered	0.001	100	mg/L	4500-P E
Hach NITRATAX sensor					
Nitrate+Nitrite-N (99133)	Water, unfiltered	0.1	50	mg/L	Ultraviolet adsorption measurement

Analytical data were transferred from the UMESC laboratory via emailed Excel spreadsheets to the USGS Iowa Water Science Center where it was batch uploaded into the USGS NWIS database. Data uploaded included station identification number, station name, date, time, analyzing agency, method code, laboratory results, and laboratory comments.

Additional data (Appendix 1.6) were collected throughout the study to assure that analyzed and measured concentrations of the nutrient constituents of interest were accurate and reproducible. Data were also collected to document that equipment and sampling supplies did not "carry over" nutrient residues from previous samples. Accuracy in the laboratory analysis was documented by annual analysis of standard reference samples (U.S. Geological Survey, undated; https://bqs.usgs.gov/) and analytical reproducibility was documented through the analysis of replicate or "split" ambient samples. The effectiveness of equipment cleaning and handling to eliminate carry over of nutrient residues from sample to sample was evaluated by analysis of blank samples. A separate set of quality assurance and quality control data were collected to ensure that the NITRATAX nitrate sensors installed at the study sites were measuring accurate nitrate plus nitrite as nitrogen concentrations and that these results were not substantially different than laboratory analytical determinations. The quality assurance and quality control data show that both laboratory analysis and field sensor measurement were able to produce accurate and precise concentration data that can be used to compute the transport load of selected nutrient species at the monitoring stations (Appendix 1.6).

4.0 Results

4.1. Hydrology

4.1.1 Rainfall

Monthly rainfall in the Lyons and Prairie Creek study areas initially was less than normal for central

Iowa (Table 4, Appendix 2.1 and Appendix 2.2) in February and March 2013, but increased to much greater than normal in April and May, 2013. Rainfall through the remainder of the summer was generally less than normal. Monthly rainfall in the Prairie Creek study area was near normal in spring 2014 and was greater than normal in 2 of 4 months during the summer (Table 4).

The total rainfall during the February through September 2013 period was 21.79 inches in Lyons Creek and 20.49 inches at the Prairie Creek site. More than half the total occurred in April and May. Although rainfall in 2013 was almost twice the normal amount during the April and May, the total was from 5.4 to 6.7 inches below normal for the entire 2013 study period.

In contrast, rainfall in 2014 at the Prairie Creek site was 2.0 inches greater than normal during the April through September period. Total recorded rainfall was 24.86 inches at the Prairie Creek site (Table 4).

Table 4. Monthly rainfall and inflow and outflow from oxbow wetlands in the Lyons and Prairie Creek study sites. [Regional normal rainfall from NOAA, 2015: NA, not available]

		Rainfall, inches			Discharge, acre feet				
Year	Month	Lyons Creek study site	Prairie Creek study site	Regional Normal (1981-2010)	Lyons oxbow inlet (L1)	Lyons oxbow outlet (L2)	Smeltzer west oxbow inlet (S1)	Smeltzer west oxbow outlet (S2)	Smeltzer east oxbow inlet (S4)
2013	Feb	0.4	0.34	1.72	0.00	0.00	0.00	0.00	0.50
2013	Mar	1.3	1.18	2.52	1.80	5.70	0.05	2.40	1.30
2013	Apr	6.67	6.53	3.33	8.90	9.90	1.50	3.00	1.10
2013	May	7.88	7.28	4.21	32.00	70.00	7.40	18.00	4.60
2013	Jun	4.07	3.97	4.25	22.00	40.00	4.30	9.60	1.40
2013	Jul	1.19	0.11	4.06	3.20	3.20	0.50	1.00	0.20
2013	Aug	0.28	0.87	3.66	0.00	0.00	0.00	0.00	0.00
2013	Sep	NA	0.21	3.44	0.00	0.00	0.00	0.00	0.00
2013	Total	21.79	20.49	27.19	67.90	128.80	13.75	34.00	9.10
2014	Feb	NA	NA	1.72	NA	NA	NA	NA	NA
2014	Mar	NA	NA	2.52	NA	NA	NA	NA	NA
2014	Apr	NA	3.91	3.33	NA	NA	0.00	0.00	0.50
2014	May	NA	3.51	4.21	NA	NA	0.60	0.00	0.70
2014	Jun	NA	5.71	4.25	NA	NA	4.40	8.30	3.40
2014	Jul	NA	1.83	4.06	NA	NA	3.70	5.70	1.20
2014	Aug	NA	6.16	3.66	NA	NA	0.30	0.00	0.20
2014	Sep	NA	3.74	3.44	NA	NA	2.10	2.00	1.50
2014	Total	NA	24.86	27.19	NA	NA	11.1	16	7.5

4.1.2 Tile line and oxbow

4.1.2.1 Lyons Creek site

Daily mean discharge from the field tile draining into the Lyons Creek oxbow wetland ranged from 0.0 to 2.2 ft^3/s in 2013 (Appendix 2.3). Water did not flow from the tile during the winter in January and February, 2013. Water began to flow from the tile line on March 9, 2013 (Fig. 5) after a period of above

freezing air temperature. Flow continued the remainder of the spring and into the summer and again ceased on July 23, 2013 when rainfall was less than normal (Fig. 5). The greatest daily mean discharge occurred on June 25 (2.2 ft^3/s) and May 27, 2013 (2.0 ft^3/s). Almost 40 percent of the water discharged (27.2 acre-ft) by the tile line during the study was during the 10 days of these two storm events that occurred from May 25-30 and from June 24-28, 2013.

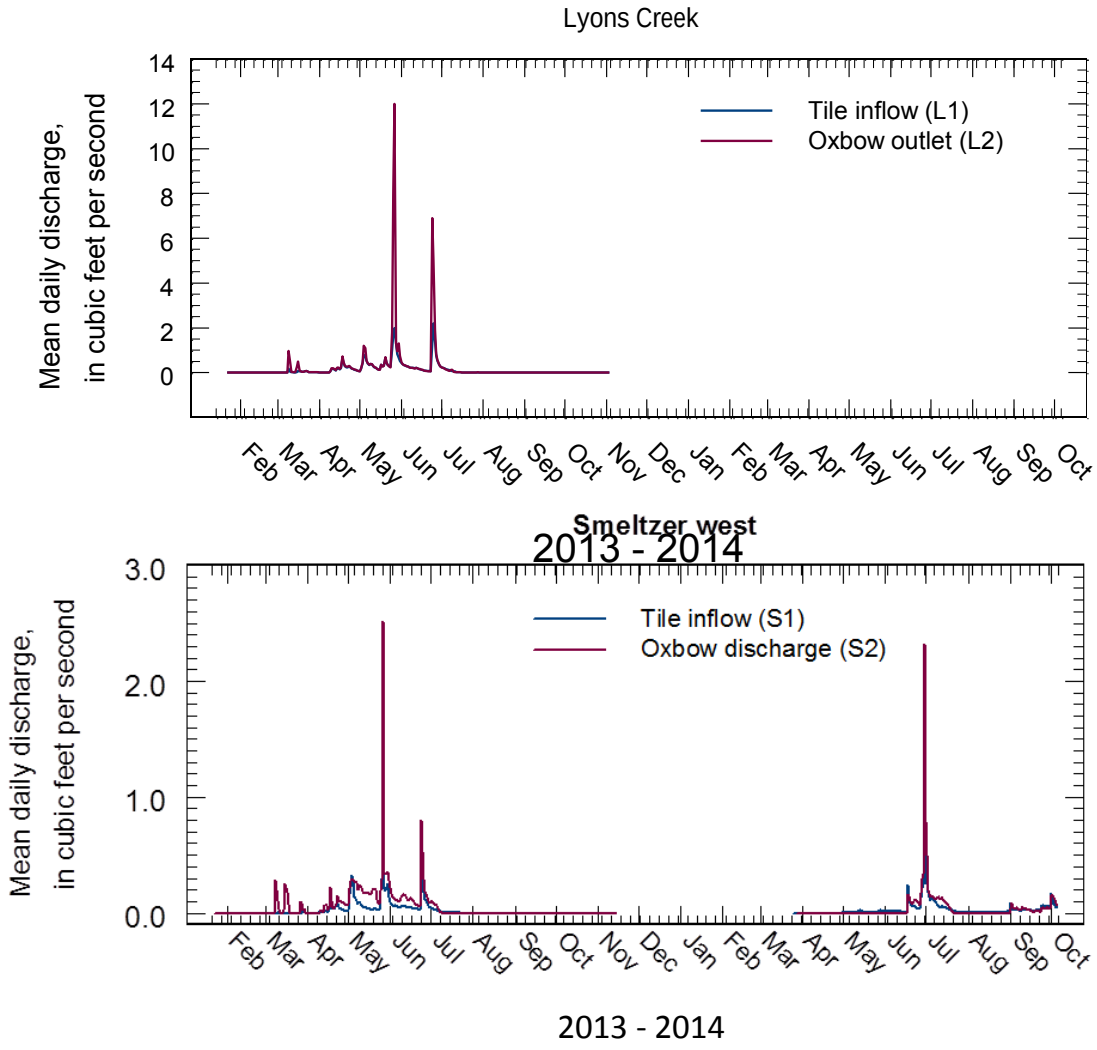


Figure 5. Tile inflow and discharge out of the Lyons and Prairie Creek oxbow wetlands

Flow of water leaving the Lyons Creek oxbow wetland paralleled that from the field tile. Flow from the wetland did not begin until water was entering from the field tile on March 9, 2013 (Appendix 2.4). Flow continued through the spring and early summer until July 29, 2013. The maximum daily discharge from the wetland at site L2 was 12 ft^3/s on May 27, 2013 and 6.9 ft^3/s on June 24, 2013. The maximum daily discharge from the wetland was 3-6 times greater than the maximum daily discharge from the field tile (Fig. 5). As with the field tile, a large amount of the water leaving the wetland during the study occurred during the 10 days of the two major storm events. Sixty-two percent of the total discharge from the wetland at site L3 occurred during these events.

Tile line discharge into the Lyons Creek native oxbow wetland from January 22, 2013 to November 3, 2013 was approximately 69.0 acre-ft of water. Water flowing out of the oxbow during this same period was 129 acre-ft of water; almost twice the amount that entered from the tile line. Although not

measured, the additional water most likely originated from overland flow, groundwater inflow, and Lyons Creek overflow. Water from the oxbow wetland contributed 2.8 percent of the flow recorded in Lyons Creek during the study.

4.1.2.2 Prairie Creek site

Smeltzer west oxbow-Daily mean discharge from the field tile (site S1) draining into the Smeltzer west restored oxbow wetland ranged from 0.0 ft^3/s to 0.40 ft^3/s in 2013 and from 0.0 ft^3/s to 0.62 ft^3/s in 2014 (Appendix 2.6). Water did not flow from the tile in January and February and most days in March 2013. Flow began on a consistent basis beginning on April 10 and continued the remainder of the spring and early summer until July 23. No discharge was recorded for the remainder of the summer. Instrumentation was reinstalled again on March 25 in 2014 but there was no flow until April 30. Flow then continued through the spring and summer until data collection ended on October 5. The greatest daily mean discharge (0.40 ft^3/s) was recorded on May 27 during a three-day rain event beginning on May 25th when 3.42 in was recorded at the Prairie Creek site. Thirty-seven percent of the water discharged by field tile S1 during 2013 occurred during two storm events: May 2 to May 11 and June 24 to June 30, 2013. However, in 2014, only 23 percent of the water discharged occurred during the largest rain event from June 27 to July 10, 2014.

Flow leaving the Smeltzer west restored oxbow wetland (S2) in 2013 generally paralleled that from the field tile (S1). Water began to flow periodically from the wetland to Prairie Creek in March, 2013 (Appendix 2.7). Discharge from the Smeltzer west oxbow wetland was then continuous from April 10 to July 9, 2013. Discharge from the oxbow wetland stopped even though small amounts of water (less than 0.10 ft^3/s) continued to enter the wetland from the field tile for almost two additional weeks. Discharge from the wetland did not occur until the following summer. Flow from the Smeltzer west wetland began on June 17, 2014 during a two-day storm event where more than 2.50 inches fell. Flow from the wetland began 48 days after water began flowing into the wetland from the field tile. Discharge continued until July 21 when flow again ceased for 40 days and then resumed on September 1 and continued through the end of the study. The maximum daily mean discharge from the Smeltzer west wetland in 2014 was 2.32 ft^3/s on June 30, 2014.

The measured tile line discharge flowing into the Smeltzer west restored oxbow wetland in 2013 and 2014 was 24.9 acre-ft of water. Of the total amount, 13.8 acre-ft was discharged in 2013, and 11.1 acre-ft was discharged in 2014. Water flowing out of the oxbow during the two-year study period was 50 acre-ft of water; twice the amount that entered from the tile line. The additional water probably entered the oxbow wetland from overland flow and from groundwater inflow. Water from the Smeltzer west oxbow wetland contributed a very small proportion (0.2 percent in both 2013 and 2014) of the flow recorded in Prairie Creek during the study.

Smeltzer east oxbow-Due to damage to the weir and control structure, outflow from the Smeltzer east oxbow (S5) was not quantified. The control box at this site was damaged on installation which did not allow the weir plates to be installed correctly. This also prevented outflow loads for nutrients to be calculated at this site. However, the tile inflows can be described and nutrient loads input into Smeltzer east oxbow can be calculated. Despite the damage, the water nutrient concentrations entering and leaving Smeltzer east oxbow can be evaluated.

Daily mean discharge from the field tile (site S4) draining into the Smeltzer east restored oxbow wetland ranged from 0.0 ft^3/s to 0.42 ft^3/s in 2013 and from 0.0 ft^3/s to 0.54 ft^3/s in 2014 (Appendix 2.9). Water did not flow from the tile in January and flow was intermittent in February 2013. Flow began on a consistent basis beginning on March 8 and continued through the remainder of the spring and early

summer, with one interruption from April 3 through April 9. Flow at site S4 ceased on July 23 and no discharge was recorded for the remainder of the summer. Flow was again measured in 2014 beginning on March 15. Substantial flow began on April 28 and continued with several short interruptions through the spring and summer until data collection ended on October 5. The greatest daily mean discharge (0.417 ft^3/s) was recorded on May 27, 2013 during a three-day rain event beginning on May 25th when 3.42 inches was recorded at the Prairie Creek site.

Fifty percent of the water discharged by field tile S4 in 2013 occurred in May. However, in 2014, only 9 percent of the total water discharged occurred in May. The greatest monthly discharge from S4 in 2014 was in June when 42 percent of the total occurred.

4.1.3 Groundwater

The altitude of the water levels in the monitoring wells, Smeltzer west oxbow wetland, and in Prairie Creek indicated that for much of 2013 there was a gradient from the upland areas across the flood plain including the Smeltzer west oxbow wetland to Prairie Creek. During the late summer and early fall dry conditions, the oxbow wetland may have stored water since there was little or no tile inflow (Fig. 5) and its altitude was higher than in the groundwater (Fig. 6). Water levels were relatively constant during the winter of 2013-2014 (Appendix 2.10 – 2.15) and began to rise with the onset of snowmelt in March 2014. The water level in both SW2 (Appendix 2.11) and SW3 (Appendix 2.12) increased 1.0 ft. Water levels in these wells continued to increase into June, 2014. A more dramatic water level increase occurred in SW1 than in wells SW2 and SW3 in 2014. Through the winter and early spring the water level was below the bottom of the SW1 monitoring well. The water level was first recorded above the bottom of the well on April 14. The water level continued to increase through the end of the study. The water level in SW4, the well closest to Prairie Creek, was higher but mirrored the level in the creek (Fig. 6). The difference in water level suggests that Prairie Creek was consistently receiving groundwater inflow from the adjacent alluvial material in the study area.

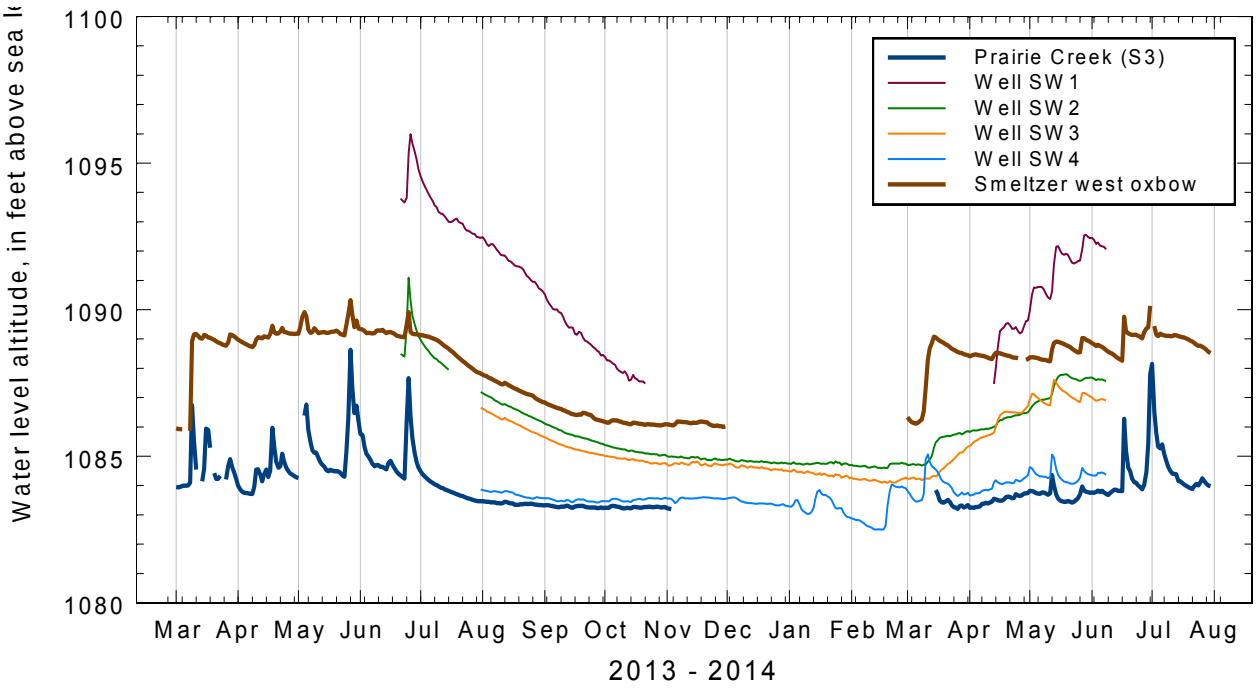


Figure 6. Altitude of water level in groundwater and the Smeltzer west oxbow wetland.

4.1.4 Streamflow

Lyons Creek

The daily mean discharge in Lyons Creek at site L3 averaged 8.7 ft^3/s during 2013. Daily mean discharge ranged from no flow at the end of the summer to a maximum of 173 ft^3/s on May 27, 2013 (Appendix 2.16). A number of rain events resulted in at least five separate stream runoff events in 2013 (Fig. 7). Dry conditions during late summer and fall resulted in no streamflow in Lyons Creek after August 20, 2013. The total amount of water discharged from the Lyons Creek watershed upstream of site L3 was 4,570 acre-ft in 2013.

Prairie Creek

Discharge in Prairie Creek at site S3 averaged 24.7 ft^3/s in 2013 and 15.9 ft^3/s in 2014 (Appendix 2.17). As in Lyons Creek, five separate runoff events occurred during spring and early summer in 2013. In contrast only two large runoff events were recorded in 2014. Less rainfall than normal in July through August, 2013 (Fig. 4) resulted in no flow conditions beginning on August 28, 2013 and continued through the end of the 2013 study period in early November (Fig. 7). Normal to below normal precipitation in January through May 2014 resulted in mean daily flow that was generally less than 5.0 ft^3/s and averaged 2.4 ft^3/s. The total amount of water discharged from the Prairie Creek watershed upstream of site S3 was 13,200 acre-ft in 2013 and 6,390 acre-ft in 2014.

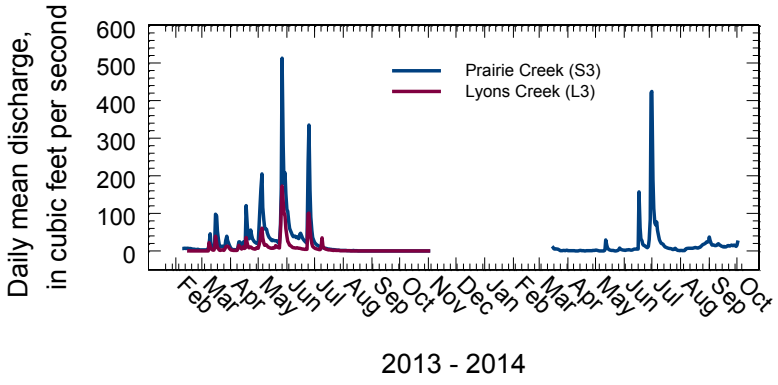


Figure 7. Daily mean discharge in the streams receiving water from oxbow wetlands in the Prairie and Lyons Creeks study sites.

4.2 Water quality

4.2.1 Periodic samples

4.2.1.1 Lyons Creek study area

The median concentrations of the nitrogen and phosphorus species sampled (Fig. 8) were not significantly ($P>0.05$, Wilcoxon rank sum) different in tile discharge entering the Lyons Creek oxbow wetland than water leaving the wetland in 2013. The median ammonia-N concentration was 0.03 mg/L in the tile inlet and 0.02 mg/L in the oxbow outlet. Median nitrate-N concentrations were 23 and 21 mg/L in the inlet and outlet, respectively. Although not significant, the median ortho-phosphate concentration was slightly smaller in water entering (0.13 mg/L) than in the water leaving (0.19 mg/L) the oxbow wetland. There was no difference in the median total phosphorus concentrations between site L1 and L2 (Table 5).

*Table 5. Statistical summary of water quality of discrete samples from streams, tile inflow, and oxbow discharge in the Lyons and Prairie Creek, IA study areas, 2013-2014.[*, water flowed through a bioreactor before discharging to the oxbow wetland]*

Map number	Station name	Number of samples	Minimum	Percentile 25	Percentile 50 (median)	Percentile 75	Maximum	Mean
Ammonia, water, filtered, milligrams per liter as nitrogen								
L1	Lyons Oxbow Inlet near Webster City, IA	27	<0. 008	0.02	0.03	0.06	0.85	0.10
L2	Lyons Oxbow Outlet near Webster City, IA	33	<0. 008	0.02	0.02	0.05	0.41	0.05
L3	Lyons Creek near Webster City, IA	28	<0. 008	0.03	0.05	0.17	4.7	0.60
S1	Smeltzer West Oxbow Inlet near Otho, IA	33	<0. 008	0.01	0.01	0.02	0.05	0.02
S2	Smeltzer West Oxbow Outlet near Otho, IA	29	0.02	0.03	0.03	0.05	0.38	0.06
S3	Prairie Creek at Otho, IA	46	<0. 008	0.04	0.06	0.09	1.5	0.20
S4*	Smeltzer East Oxbow Inlet near Otho, IA	37	<0. 008	0.02	0.04	0.32	1.6	0.16
S5	Smeltzer East Oxbow Outlet near Otho, IA	32	0.02	0.04	0.19	0.32	0.53	0.21
Nitrate plus nitrite, water, filtered, milligrams per liter as nitrogen								
L1	Lyons Oxbow Inlet near Webster City, IA	27	5.9	12	23	46	52	27
L2	Lyons Oxbow Outlet near Webster City, IA	33	6.4	14	21	42	52	26
L3	Lyons Creek near Webster City, IA	28	2.8	7.8	22	31	39	20
S1	Smeltzer West Oxbow Inlet near Otho, IA	33	<0.01	15	18	20	27	17
S2	Smeltzer West Oxbow Outlet near Otho, IA	29	1.4	4	9.4	11	14	8.2
S3	Prairie Creek at Otho, IA	46	<0.01	7	16	27	33	17
S4*	Smeltzer East Oxbow Inlet near Otho, IA	37	<0.01	1.5	2.7	6.8	19	4.6
S5	Smeltzer East Oxbow Outlet near Otho, IA	32	0.33	1.2	1.7	2.8	4.6	2.1
Total nitrogen (nitrate + nitrite + ammonia + organic-N), water, unfiltered, analytically determined, milligrams per liter								
L1	Lyons Oxbow Inlet near Webster City, IA	27	7.7	13	24	47	57	29
L2	Lyons Oxbow Outlet near Webster City, IA	33	7.9	15	21	42	52	27
L3	Lyons Creek near Webster City, IA	28	6.0	14	23	32	40	22
S1	Smeltzer West Oxbow Inlet near Otho, IA	33	0.03	16	18	21	27	17
S2	Smeltzer West Oxbow Outlet near Otho, IA	29	2.5	5.4	10	12	15	9.1
S3	Prairie Creek at Otho, IA	46	0.98	11	18	27	34	19
S4*	Smeltzer East Oxbow Inlet near Otho, IA	37	1.5	3.9	5.0	8.2	18	6.2
S5	Smeltzer East Oxbow Outlet near Otho, IA	32	1.8	2.8	3.4	4.5	5.7	3.6
Ortho-phosphate, water, filtered, milligrams per liter as phosphorus								
L1	Lyons Oxbow Inlet near Webster City, IA	27	0.03	0.07	0.13	0.22	0.67	0.19
L2	Lyons Oxbow Outlet near Webster City, IA	33	0.05	0.08	0.19	0.22	0.48	0.18
L3	Lyons Creek near Webster City, IA	28	0.01	0.09	0.21	0.40	4.4	0.76
S1	Smeltzer West Oxbow Inlet near Otho, IA	33	0.01	0.01	0.02	0.06	0.79	0.07
S2	Smeltzer West Oxbow Outlet near Otho, IA	29	0.003	0.01	0.1	0.30	3.6	0.39
S3	Prairie Creek at Otho, IA	46	0.004	0.02	0.11	0.23	2.2	0.29
S4*	Smeltzer East Oxbow Inlet near Otho, IA	37	0.01	0.26	0.88	1.5	3.9	1.1
S5	Smeltzer East Oxbow Outlet near Otho, IA	32	0.02	0.21	0.59	1.1	1.9	0.68
Phosphorus, water, unfiltered, milligrams per liter as phosphorus								
L1	Lyons Oxbow Inlet near Webster City, IA	27	0.07	0.11	0.23	0.45	1.2	0.36
L2	Lyons Oxbow Outlet near Webster City, IA	33	0.09	0.15	0.23	0.43	3.0	0.38
L3	Lyons Creek near Webster City, IA	28	0.05	0.19	0.43	1.7	5.2	1.4
S1	Smeltzer West Oxbow Inlet near Otho, IA	33	0.01	0.02	0.03	0.13	0.81	0.11
S2	Smeltzer West Oxbow Outlet near Otho, IA	29	0.02	0.11	0.22	0.83	3.7	0.57
S3	Prairie Creek at Otho, IA	46	0.02	0.14	0.26	0.72	2.7	0.60
S4*	Smeltzer East Oxbow Inlet near Otho, IA	37	0.05	0.37	1.2	2.0	4.7	1.5
S5	Smeltzer East Oxbow Outlet near Otho, IA	32	0.14	0.43	0.85	1.2	3.0	0.95

The range in nitrate-N concentrations during 2013 was similar between the tile line input and output from the oxbow wetland. Concentrations ranged from less than 10 mg/L in March during snowmelt to more than 50 mg/L in early May (appendix 3.1).

The water quality in Lyons Creek was similar to that of the water entering from the Lyons Creek oxbow wetland (Appendix 3.1). Significant differences in concentrations of all constituents were found in March during snowmelt and early spring rains and in concentrations of total phosphorus throughout the year. Nitrate-N concentrations in samples collected from Lyons Creek (L3) throughout 2013 were not significantly different than those collected from discharge from the Lyons Creek oxbow (Fig. 8). The median concentration in the Lyons Creek oxbow wetland outlet (L2) was 21 mg/L and the median concentration in Lyons Creek at site L3 was 22 mg/L. Median ortho-phosphate and ammonia concentrations were not significantly different during the year in the oxbow discharge and Lyons Creek. Concentrations of ammonia-N, ortho-phosphate-P, and total phosphorus in samples collected from Lyons Creek (L3) in March were substantially greater than in samples collected from the tile (L1) and oxbow (L2) (Appendix 3.1). The late winter trend in nutrient concentrations suggest that water in Lyons Creek originates mainly from overland flow from snowmelt and or rain on frozen ground. During late winter, groundwater through tile line discharge contributed water with small concentrations of nutrients (Appendix 3.1). Total phosphorus, a constituent usually associated with fine-grained sediment, was present in significantly greater concentrations in Lyons Creek (site L3) than in the water discharging from the oxbow wetland (site L2). The median total phosphorus concentration in water outflowing from the oxbow in 2013 was 0.23 mg/L which compares to a median concentration of 0.43 mg/L in Lyons Creek.

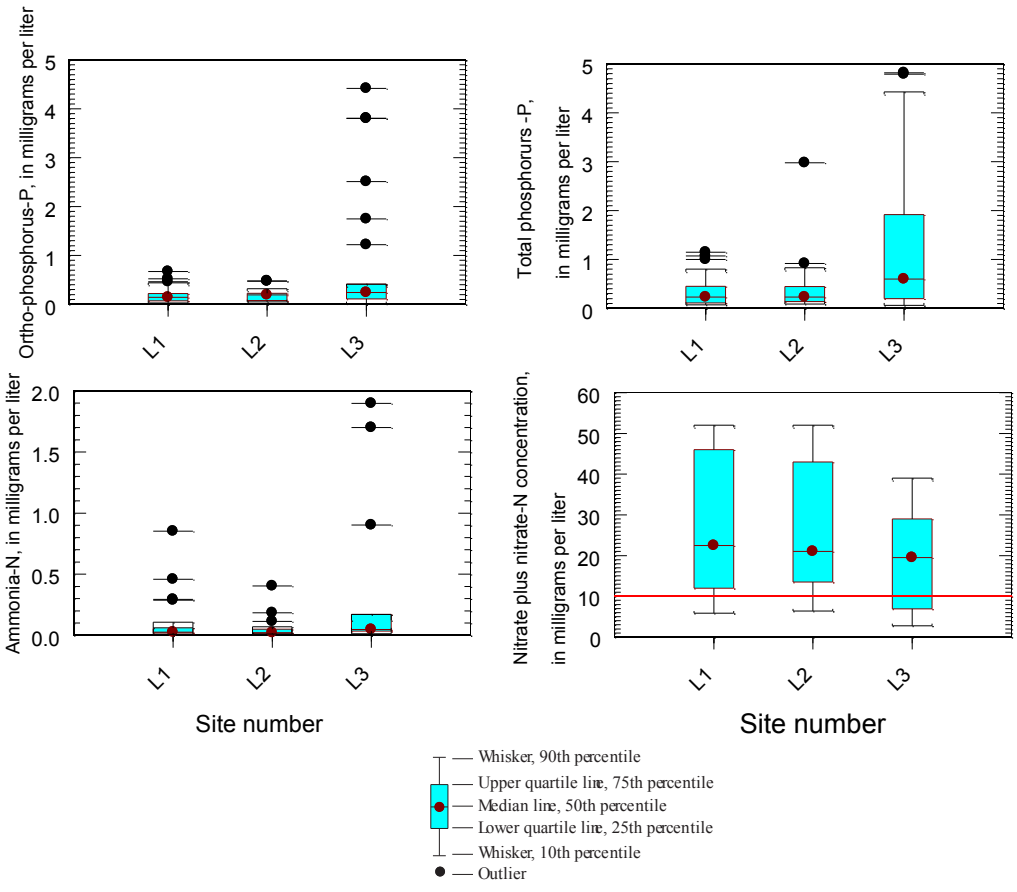


Figure 8. Summary of concentrations of selected phosphorus and nitrogen species at the Lyons Creek study site, 2013
[The horizontal red line is the drinking water standard. It is supplied for a perspective as to how much the nutrient concentrations in the water would need to be reduced by water treatment to be consumed as drinking water. Iowa does not currently have numeric criteria for surface water nutrients.]

4.2.1.2 Prairie Creek study area

Quality of water in the Prairie Creek study area-Nitrogen and phosphorus concentrations in periodic samples from the tile lines discharging into the Smeltzer east and Smeltzer west oxbow wetlands were significantly different ($P<0.05$, Wilcoxon rank sum) during the study. Tile line discharge into Smeltzer west oxbow contained significantly ($P<0.05$, Wilcoxon rank sum) greater concentrations of nitrate-N than in Smeltzer east tile line discharge. Conversely, concentrations of both ortho and total phosphorus and ammonia-N were significantly greater ($P<0.05$, Wilcoxon rank sum) in the Smeltzer east tile line discharge. The nitrate-N concentration at site S1 (Table 5) ranged from less than the detection limit of 0.01 mg/L to 27 mg/L with a median concentration of 18 mg/L. The nitrate-N concentration at site S4 (Table 5) ranged from less than the detection limit of 0.01 mg/L to 19 mg/L but only had a median concentration of 2.7 mg/L. The median concentration of ammonia (0.04 mg/l), ortho-phosphate (0.88 mg/L), and total phosphorus (1.2 mg/L) in Smeltzer east tile line discharge at site S4 was significantly ($P<0.05$, Wilcoxon rank sum) greater than the median ammonia (0.01 mg/L), ortho-phosphate (0.02 mg/L), and total phosphorus (0.03 mg/L) in Smeltzer west tile line discharge at site S1 (Fig. 8, Table 5)

Several major differences were noted in the water quality of oxbow inflow in relation to outflow. First, there was large variability but generally greater ammonia concentrations in outflow than inflow; second, there were smaller nitrate-N concentrations in outflow than in inflow; and third, greater total phosphorus concentration in outflow than inflow occurred at only one oxbow.

Water flowing into both Smeltzer east and west oxbow wetlands from the tiles had significantly ($P<0.05$, Wilcoxon rank sum) greater ammonia concentrations and significantly ($P<0.05$, Wilcoxon rank sum) smaller nitrate-N concentrations than in the water discharging from the oxbow wetlands. The median ammonia-N concentrations in samples from tile inflow to Smeltzer east oxbow was 0.04 mg/L in relation to the median concentration of 0.19 mg/L from oxbow discharge (Table 5). At the Smeltzer west oxbow wetland, the median ammonia concentration was 0.01 mg/L in tile inflow increasing to 0.03 mg/L in oxbow wetland outflow. The median nitrate-N concentration in samples from water leaving Smeltzer west oxbow (site S2) was about half of the median nitrate-N concentration in samples from water entering the oxbow from tile discharge (site S1). The median nitrate-N concentration in samples from S2 was 9.4 mg/L and was 18 mg/l in samples from S1. Because of the much smaller concentrations in tile discharge into the Smeltzer east oxbow, the difference between median nitrate-N concentrations in samples from inflow and outflow was only 1.0 mg/L (Table 5). The median nitrate-N concentration in samples from S4 was 2.7 mg/L and was 1.7 mg/l in samples from S5.

Water flowing into both Smeltzer east and west oxbow wetlands from the tiles did not have significantly ($P>0.05$, Wilcoxon rank sum) different ortho-phosphate concentrations than in the water discharging from the oxbow wetlands (Fig. 9). However, the difference between inflow and outflow concentrations of total phosphorus varied between oxbow wetlands. No significant ($P>0.05$, Wilcoxon rank sum) differences were found between median total phosphorus concentrations of samples from tile inflow (S4) and wetland discharge (S5). A significantly ($P<0.05$, Wilcoxon rank sum) greater median total phosphorus concentration occurred in samples from oxbow discharge than in tile line inflow to Smeltzer west oxbow wetland. The median total phosphorus concentration increased from 0.03 mg/L at site S1 to 0.22 mg/L at site S2.

The concentrations of nitrogen and phosphorus from the Smeltzer east and west oxbow wetlands were not the same as in Prairie Creek. The median concentrations of nitrate-N in discharge from both the east and west oxbow wetlands, and the median concentrations of ammonia-N in Smeltzer west oxbow discharge (S2), were less than the median concentrations in Prairie Creek. Although the median concentration in samples from Smeltzer east oxbow discharge (S5) was greater than the median

concentration of samples from Prairie Creek (S3), the difference was not statistically significant ($P>0.05$, Wilcoxon rank sum test). Concentrations of all species other than nitrate-N and total N were greater in water discharging from Smeltzer east (S5) than in Prairie Creek (S3). Nitrate-N concentrations were greater in Prairie Creek than in oxbow discharge.

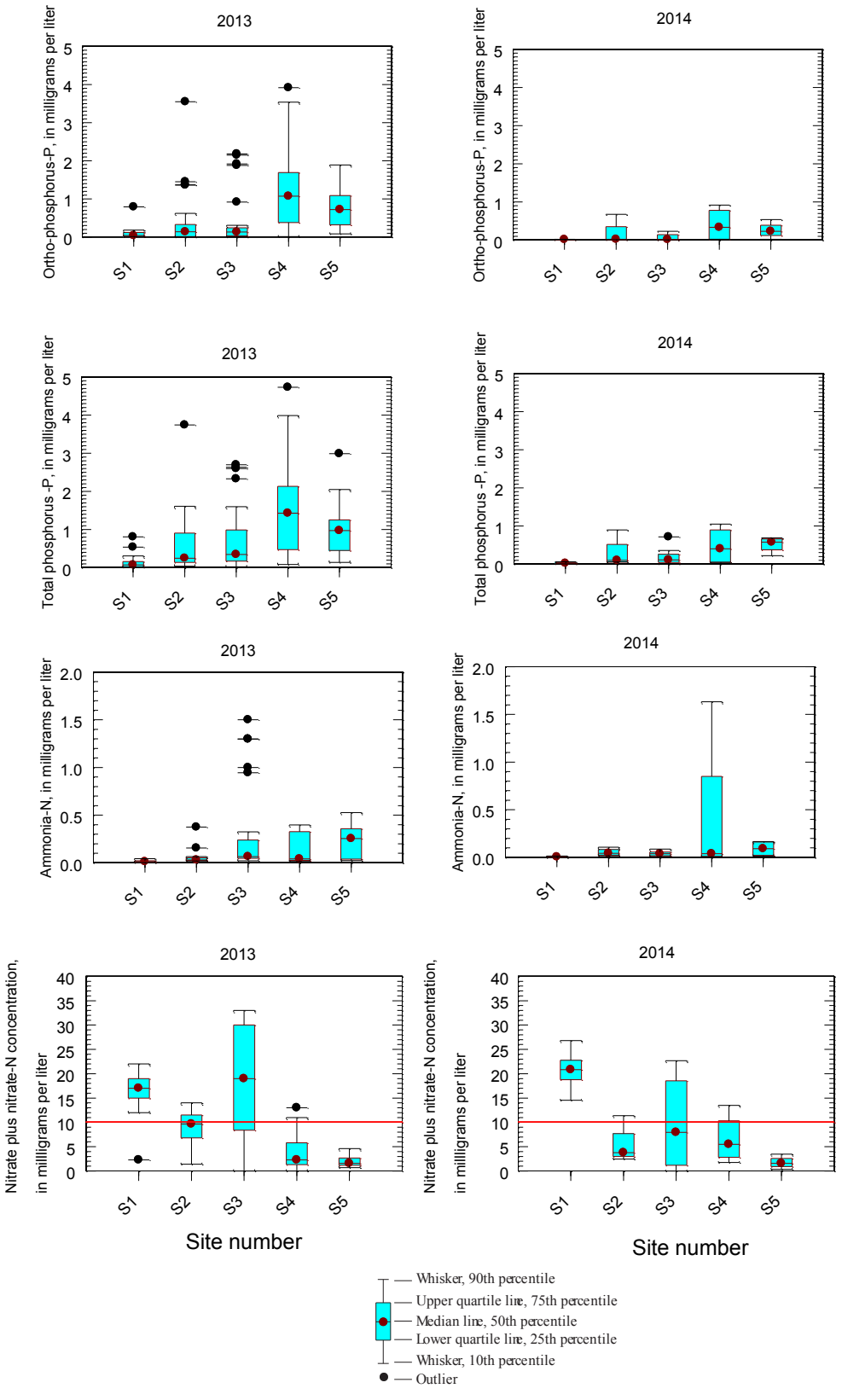


Figure 9. Summary of concentrations of selected phosphorus and nitrogen species at the Prairie Creek study site, 2013-2014.
[The horizontal red line is the drinking water standard. It is supplied for a perspective as to how much the nutrient concentrations in the water would need to be reduced by water treatment to be consumed as drinking water. Iowa does not currently have numeric criteria for surface water nutrients.]

4.2.1.3 Groundwater

The water quality in shallow groundwater from the edge of the field downgradient through the oxbow wetland and the creek varied in the Prairie Creek study area (Table 6). Nitrate-N concentrations upgradient from the oxbow wetlands were less than 1.0 mg/L (Fig. 10). Water adjacent and upgradient (SW2 and SW6) to the oxbow wetland had little or no detectable nitrate-N (Table 6). In contrast, water adjacent to and downgradient from (SW3 and SW7) the oxbow wetlands had a substantial (more than 3.0 mg/L) amount of nitrate-N. Water from the most downgradient wells (SW4 and SW8) nearest Prairie Creek had very different nitrate-N concentrations. The nitrate-N concentration in SW4 was 10.6 mg/L and in SW8 was 0.04 mg/L). Water in both SW2 and SW6 had low dissolved oxygen concentrations (less than 1.5 mg/L) and elevated ammonia-N concentrations (0.406 mg/L and 1.38 mg/L); evidence that denitrification was occurring in the shallow aquifer upgradient from the oxbow wetlands.

Table 6. Water quality of samples from the Prairie Creek study area monitoring wells

[mg/L, milligrams per liter: uS/cm, microSiemens per centimeter at 25 degrees Celsius: ^{0}C, degrees Celsius: N, nitrogen: P, phosphorus]

Well number (table)	Station identification number	Sample date	Sample time	Depth to water, feet below land surface	Dissolved oxygen (mg/L)	pH, standard units	Specific conductance (uS/cm)	Water temperature (°C)	Dissolved ammonia as N (mg/L)	Dissolved nitrate plus nitrite as N (mg/L)	Dissolved ortho-phosphate as P (mg/L)	Total phosphorus as P (mg/L)	Total nitrogen as N (mg/L)
Upgradient from Smelzer west oxbow													
SW1	422436094082901	6/10/2014	835	7.75	8.1	7.1	724	9.5	<0.024	0.147	0.022	0.248	0.56
SW1	422436094082901	10/8/2014	825	5.39	7.7	7.1	750	14.0					
SW2	422436094082801	6/10/2014	900	4.56	0.8	7.0	768	9.2	0.406	0.033	0.028	0.063	0.68
SW2	422436094082801	10/8/2014	840	3.28	1.1	7.0	756	13.6					
Downgradient from Smeltzer west oxbow													
SW3	422437094082701	6/10/2014	915	5.33	8.0	7.1	1090	10.2	0.034	3.15	0.030	0.054	3.29
SW3	422437094082701	10/8/2014	900	4.13	7.9	7.0	1090	14.3					
SW4	422437094082501	6/10/2014	945	4.53	1.5	7.1	804	9.7	<0.02	10.6	0.086	0.113	10.8
SW4	422437094082501	10/8/2014	910	3.02	1.2	7.0	952	14.1					
Upgradient from Smeltzer east oxbow													
SW5	422432094082001	10/8/2014	925	7.83	8.1	7.5	629	13.7					
SW6	422433094081901	6/10/2014	1015	5.62	1.4	7.1	856	9.3	1.38	0.017	0.082	0.118	1.74
SW6	422433094081901	10/8/2014	935	3.97	1.0	7.1	841	13.7					
Downgradient from Smeltzer east oxbow													
SW7	422433094081802	6/10/2014	1030	8.05	4.9	7.0	960	9.7	0.003	8.76	0.028	0.036	8.81
SW7	422433094081802	10/8/2014	945	7.37	0.6	6.9	941	14.2					
SW8	422433094081601	6/10/2014	1045	4.18	8.9	8.5	375	20.4	0.027	0.039	0.056	0.07	0.29
SW8	422433094081601	10/8/2014	1000	3.63	3.6	7.0	774	15.0					

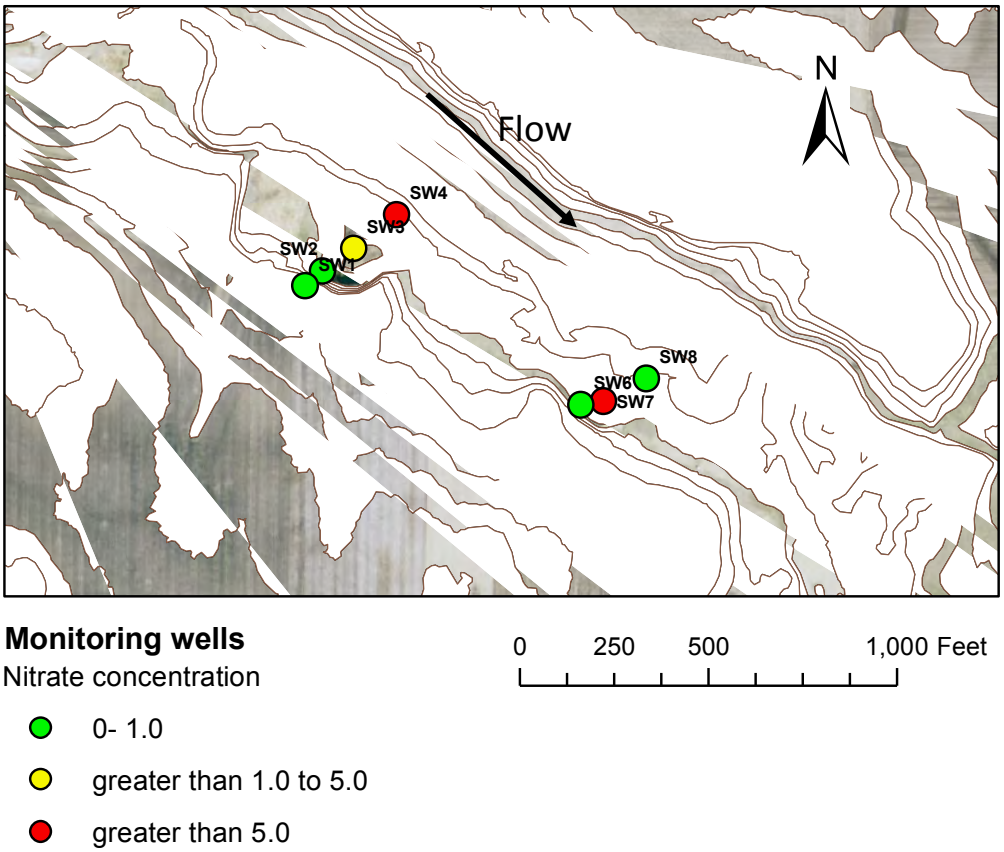


Figure 10. Nitrate plus nitrite as nitrogen concentrations (mg/L) in monitoring wells in the Prairie Creek study area, June 10, 2014

Phosphorus concentrations in the shallow groundwater in the Prairie Creek study area on June 10, 2014 varied to a lesser degree than did nitrate-N concentrations. Ortho-phosphate concentrations ranged from 0.022 mg/L to 0.086 mg/L and total phosphorus concentrations ranged from 0.036 mg/L to 0.248 mg/L (Table 6). Total phosphorus concentrations generally were greater in samples from monitoring wells upgradient from the oxbow wetlands (Table 6). The greatest total phosphorus concentration was in a sample from the most upgradient monitoring well (SW1) at the edge of the field (Table 6).

4.2.2 Automatic storm samples

A subset of the periodic samples were collected using automatic samplers during a number of storm events early in 2013. Samples were collected at sites in the Lyons Creek study area during storm events on April 13-16 and June 24-27. One inch of rain was recorded on April 14 and 15 (Appendix 2.1) and 2.65 inches of rain was recorded on June 24-26. Most of the rain (2.55 inches) recorded during the second event fell on June 24 (Appendix 2.1).

The first event samples were collected in early May in the Prairie Creek study area when a total of 1.8 inches of rain fell from April 30 through May 2 (Appendix 2.2). Samples were collected during a more intense rainfall event when 1.30 inches and 0.74 inches fell on June 24 and 25, 2013.

4.2.2.1 Lyons Creek storm flow

Samples were collected automatically from the April and June storm events from tile inflow (L1) and

discharge (L2) from the Lyons Creek oxbow wetland. Flow into the wetland (L1) increased on April 14 from 0.09 ft^3/s at 0600 hours to 0.31 ft^3/s at 1900 hours (Fig. 11). Inflow gradually decreased the following two days to 0.12 ft^3/s. Outflow from the wetland at site L2 was only slightly greater than the amount entering from the tile line at site L1. Wetland discharge increased during the storm event from 0.13 ft/s early on April 14 to a maximum of 0.32 ft^3/s at 1900 hours on April 14. Flow leaving the Lyons Creek oxbow wetland during the April 13-16 event averaged only 13 percent greater than water entering the wetland from the tile line.

Inflow from the tile line increased rapidly from 0.06 ft^3/s to the maximum of 2.5 ft^3/s on June 24. Discharge from the tile line remained greater than 2.0 ft^3/s until early on June 26 before beginning a steady decline. Flow exceeded the capacity (more than 8.0 ft^3/s) of the flume at the oxbow wetland (L2) during the large storm event on June 24 to 27, 2013.

4.2.2.2 Lyons Creek storm water quality

Although there were small differences, concentration of ammonia-N, nitrate-N, ortho-phosphate, and total phosphorus were similar in the Lyons Creek tile-line discharge (L1) and the oxbow wetland outlet (L2) during a storm in April 2013 (Fig. 11). Ammonia-N concentrations in tile discharge ranged from less than detection to 0.09 mg/L while ammonia-N concentrations in oxbow wetland discharge ranged from less than detection to 0.02 mg/L. Nitrate-N concentrations in the tile discharge decreased from 12 mg/L to 6.5 mg/L with the initial increase in discharge on April 14. Concentrations then were from 14 mg/L to 22 mg/l through April 16. Nitrate-N concentrations in wetland discharge also ranged from 14 mg/L to 21 mg/L through the event. Concentrations of ortho-phosphate and total phosphorus were essentially the same in wetland inflow (L1) and outflow (L2) during this storm event (Fig. 11).

Sufficient samples from the wetland inflow (L1) were not available to document changes in nutrient concentrations between the inflow (L1) and outflow from Lyons Creek oxbow wetland during the initial part of the large rain event on June 24-27, 2013. Samples were not collected from the tile-line discharge during the initial increase in flow that corresponds to samples collected from wetland discharge on June 24. Data suggest that much of the water leaving the wetland on June 24 may have been from overbank flow from Lyons Creek. The level of Lyons Creek rose 5.0 ft from 1000 to 1600 hours on June 24, most likely overflowing the stream bank into the upper part of the oxbow wetland. With the exception of ortho-phosphate, the level and pattern of ammonia-N, nitrate-N, and total phosphorus concentrations in the wetland discharge (L2) was similar to that in Lyons Creek (L3).

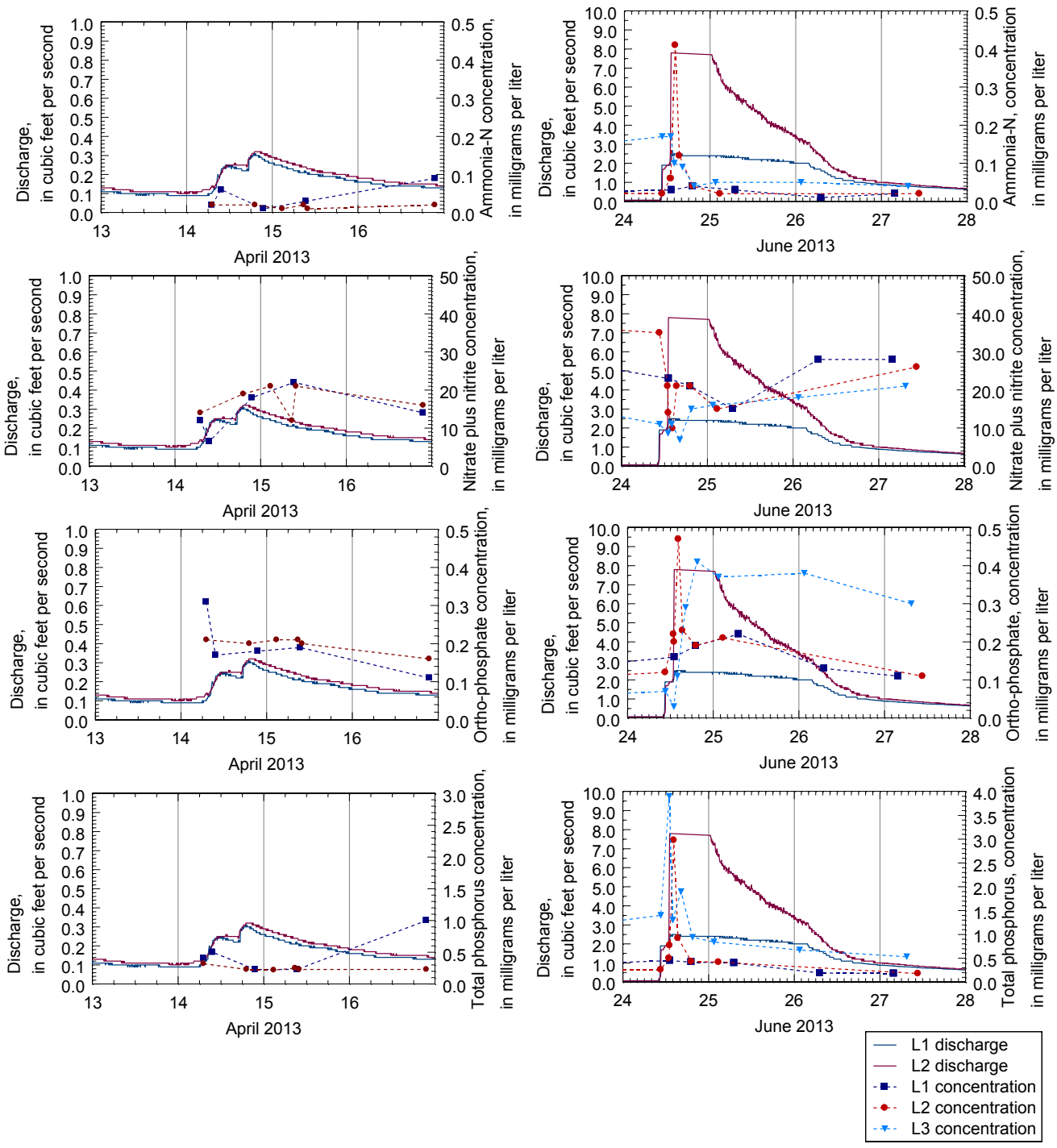


Figure 11. Flow and concentrations of selected nitrogen and phosphorus species in tile line inflow (L1) and discharge from (L2) the Lyons Creek oxbow wetland during two storm events in 2013. [Note; flow exceeded capacity of weir (flat hydrograph) at site L2 on June 24, 2013]

4.2.2.3 Prairie Creek study area storm flow

A subset of the periodic samples were collected using automatic samplers during two storm events early in 2013. The first event samples were collected in early May in the Prairie Creek study area when a total of 1.8 inches of rain fell from April 30 through May 2 (Appendix 2.2). Samples were collected during a

more intense rainfall event when 1.30 in and 0.74 inches fell on June 24 and 25, 2013, respectively (Appendix 2.2).

Rainfall in the Prairie Creek study area during the first storm event corresponded with a gradual increase in flow into the Smeltzer west oxbow wetland from the field tile (S1). Inflow increased from 0.02 ft^3/s on May 1, 2013 to 0.24 ft^3/s on May 2. Flow peaked two days later on May 4 at 0.43 ft^3/s before steadily decreasing to 0.10 on May 7 (Fig. 12). The amount of water leaving Smeltzer west oxbow wetland initially increased in a similar pattern as that of the tile-line inflow. The amount of water leaving the oxbow wetland (S2) averaged 40 percent more than the amount entering from the tile line (S1) on May 1 to 3. Oxbow discharge was relatively constant in the 0.20 to 0.30 ft^3/s range the remainder of the event (Fig. 12) even as tile inflow peaked on May 4 and declined through May 7.

An intensive storm event beginning on June 23 and ending on June 25 produced 2.29 inches (Appendix 2.2) of rain in the Prairie Creek study area. Tile flow into the wetland increased rapidly on June 24 from 0.026 ft^3/s at 1000 hours to a peak flow of 0.50 ft^3/s at 1420 hours. Flow then steadily decreased until additional rain fell the following day when tile-line discharge again rapidly increased to 0.50 ft^3/s at 0600 hours. Similar to tile inflow, outflow from the Smeltzer west oxbow increased rapidly with the onset of rain on June 24. However, the peak outflow (3.05 ft^3/s) on June 24 was substantially greater than the tile-line inflow and occurred three hours later than the peak tile inflow. Rainfall on June 25 produced an additional smaller peak (1.29 ft^3/s) in the oxbow wetland discharge (S2).

4.2.2.4 Prairie Creek study area storm water quality

The water quality of tile-line and oxbow wetland discharge began to change soon after the onset of a significant rain event. As the rate of discharge increased, concentrations of ammonia-N, nitrate-N, ortho-phosphate, and total phosphorus also changed. However, the direction and magnitude of change was not always the same in the water entering the oxbow wetland as in the water leaving the wetland. Also the pattern of change in concentration was similar between inflow and outflow water during a small May event but was very different during a substantial event in June.

At the Smeltzer west oxbow wetland, concentrations of ammonia-N, ortho-phosphate, and total phosphorus initially increased with increased discharge on May 2 (Fig. 12). In water entering the oxbow wetland, ammonia concentrations increased slightly from 0.02 mg/L to 0.03 mg/L and then were variable during the remainder of the event (Fig. 12). The increase in phosphorus concentrations (both ortho and total phosphorus) were delayed several hours from that of ammonia. Orthophosphorus increased from 0.01 mg/L before the rain event to a maximum of 0.18 mg/L on May 2. Similarily, total phosphorus concentrations increased from 0.02 mg/L on May 1 to a maximum concentration of 0.29 mg/L on May 2. In contrast, nitrate-N concentrations in the tile-line discharge (S1) decreased from 22 mg/L before the rain on May 1 to 15 mg/L four days later on May 5. Generally the pattern of phosphorus concentrations in water leaving the oxbow wetland (S2) was the same as water entering the wetland at site S1 with ortho-phosphate concentrations increasing from less than detection to 0.10 mg/L and total phosphorus concentrations increasing from 0.10 mg/L to 0.21 mg/L. During the May 1 to 6 event, ammonia-N and nitrate-N concentrations in oxbow wetland discharge (S2) either remained relatively constant or decreased.

During a large rain event on June 24 to 27, 2013, concentrations of ammonia-N, ortho-phosphate, and total phosphorus in both tile-line inflow and wetland discharge decreased with the onset of the rain event. After the initial decrease, concentrations in tile-line discharge (S1) remained relativly constant but concentrations in the wetland discharge varied with discharge during the remainder of the event. The average concentration of ammonia-N, ortho-phosphate, and total phosphorus in samples from wetland

discharge (S2) were several times greater than the average concentrations of water entering the wetland from the tile line (S1).

The pattern of nitrate-N concentrations in tile line inflow and wetland discharge was opposite of the other nutrients sampled. Rather than intially decreasing with the onset of the event, nitrate-N concentrations in tile line discharge (S1) increased from 12 mg/L to 14 mg/L on June 24. Nitrate-N concentrations in the wetland discharge (S2) decreased from 10.0 mg/L to 8.3 mg/L with the onset of the rain event before increasing to a peak concentration of 12 mg/L that corresponded to the peak discharge (Fig. 12). After peaking on June 24, nitrate-N concentrations decreased as flow from the oxbow decreased.

The concentrations of all nitrogen and phosphorus species in water leaving the Smeltzer west oxbow (S2) initially decreased with the increase in discharge and then increased substantially peaking with the peak outflow on June 24. A similar concentration pattern occurred during a secondary discharge peak on June 25.

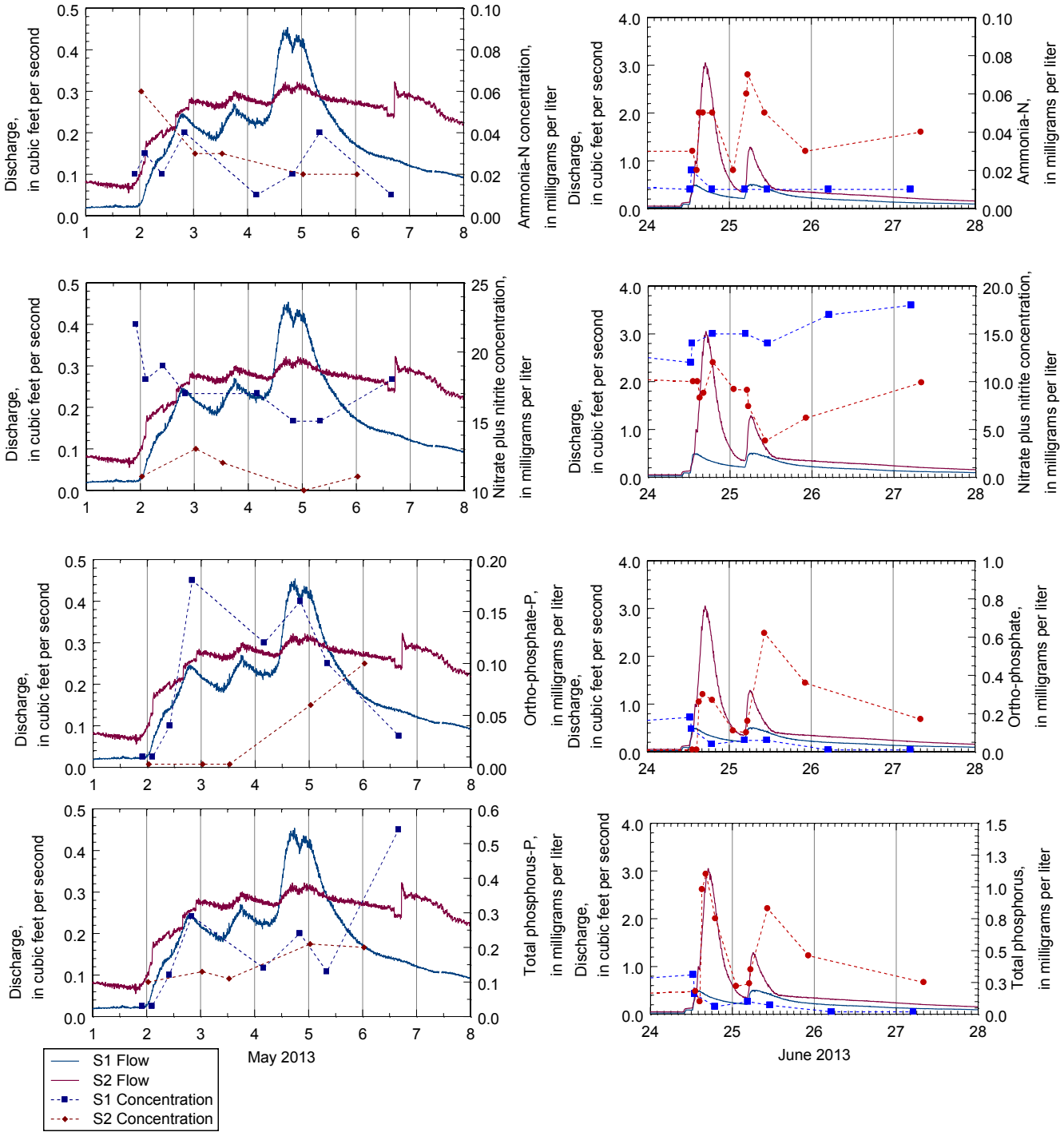


Figure 12. Flow and concentrations of selected nitrogen and phosphorus species in tile line inflow (S1) and discharge from (S2) the Smeltzer west oxbow wetland during two storm events in May 2013

4.2.3 Continuous nitrate-N monitoring

Nitrate-N concentrations were monitored continuously for 102 days beginning on February 8 and ending on August 27, 2013 when flow ceased in Lyons Creek near Webster City, IA. Nitrate-N concentrations

were not measured in the Lyons Creek study area in 2014 due to funding limitations. Nitrate-N concentrations were measured continuously during both 2013 and 2014 at the inflow (S1) and outflow (S2) to Smeltzer west oxbow and in Prairie Creek (S3). Water discharged from the tile drain (S1) into the Smeltzer west oxbow almost twice as many days as water drained (S2) from the oxbow to Prairie Creek during the study period (Table 7). As in Lyons Creek, measurement of nitrate-N concentrations ended when flow in Prairie Creek ceased on August 28, 2013. Continuous nitrate-N measurements resumed the following spring on March 20, 2014 after the ice was gone from the stream. Nitrate-N concentrations were measured in the inflow (S4) and outflow (S5) from the Smeltzer East oxbow only during 2014 (Table 7).

Table 7. Statistical summary of daily mean nitrate plus nitrite as nitrogen from streams, tile inflow, and oxbow discharge continuously measured in the Lyons and Prairie Creek, IA study areas, 2013-2014

Site number	Station name	Number of days	Minimum	Percentile 25	Percentile 50 (median)	Percentile 75	Maximum	Mean
Nitrate plus nitrite, water, in situ, milligrams per liter as nitrogen								
L3	Lyons Creek near Webster City, IA	#102	11.8	28.0	33.0	36.0	41.0	32.0
S1	Smeltzer West Oxbow Inlet near Otho, IA	169	14.0	18.0	19.7	21.2	27.5	19.9
S2	Smeltzer West Oxbow Outlet near Otho, IA	85	1.79	4.32	5.68	9.39	13.3	6.61
S3	Prairie Creek at Otho, IA	272	0.07	1.11	9.78	21.5	32.2	11.5
S4	Smeltzer East Oxbow Inlet near Otho, IA	*95	0.07	4.00	10.9	14.4	23.6	9.62
S5	Smeltzer East Oxbow Outlet near Otho, IA	*50	0.40	0.72	0.81	1.76	4.35	1.34

2013 only

* 2014 only

4.2.3.1 Lyons Creek study site

Daily mean nitrate-N concentrations in Lyons Creek varied with streamflow during the spring and early summer growing season and then decreased as flow decreased during late summer. Daily mean nitrate-N concentrations ranged from 41 mg/L on May 15 in spring to 11.8 mg/L when flow in Lyons Creek ceased at the end of August (Appendix 3.2). The median daily mean nitrate-N concentration for the sampled period was 33 mg/L. Nitrate-N concentrations decreased substantially during four high-flow periods in 2013. During a five-day period from May 1 to 5, when daily mean discharge increased from 6.8 to 61 ft^3/s, the mean daily nitrate-N concentration decreased slightly from 38 to 30 mg/L. A more substantial decrease in mean daily nitrate-N concentration occurred during the largest flow of the year. The mean daily nitrate-N concentration decreased from 41 mg/L when mean daily discharge was 8.1 ft^3/s on May 24 to 23 mg/L on May 27 when flow peaked at 173 ft^3/s. Daily mean nitrate-N concentration temporarily decreased by 22 mg/L during a high-flow event on June 23 to 28 and temporarily decreased by 14 mg/L during the last high flow event on July 7 to 12. Nitrate-N concentrations returned to pre-storm event levels several days after the peak discharge occurred. During the remainder of July and August as flow decreased, nitrate-N concentrations also decreased from more than 30 to 12 mg/L (Fig. 13).

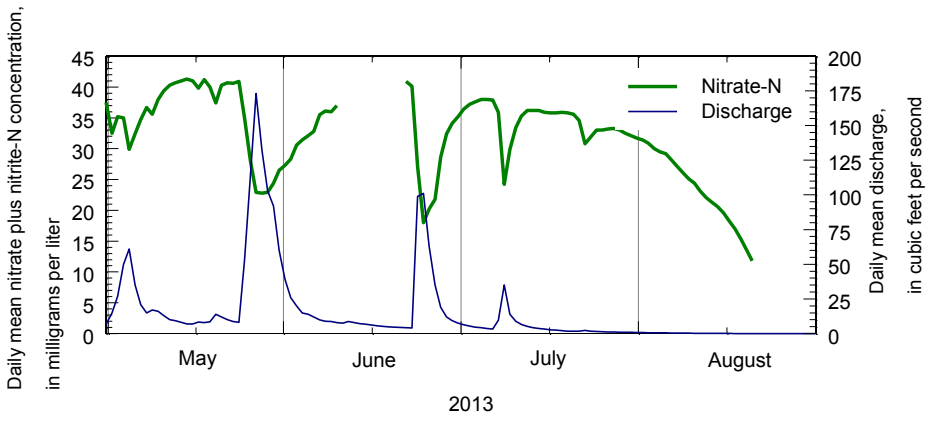


Figure 13. Daily mean nitrate plus nitrite-N concentration and daily mean discharge in Lyons Creek (L3)

During the period when there was flow in Lyons Creek, the daily nitrate-N load (Appendix 3.2) ranged from less than 0.01 tons per day at the end of August to 11 tons per day on May 27, 2013 when stream discharge was the greatest (Fig. 13). A total of 137 tons were transported past site L3 during the May through August period in 2013. Sixty-four percent of this total was transported in Lyons Creek during May; 90 percent of the total measured nitrate-N load was transported in May and June.

4.2.3.2 Prairie Creek study site

4.2.3.2.1 Smeltzer west oxbow wetland

Daily mean nitrate-N concentrations in water from the tile line discharging to the Smeltzer west oxbow wetland (S1) ranged from 14.0 mg/L to 27.5 mg/L during the study (Fig. 14; Appendix 3.3). Water leaving the Smeltzer west oxbow had variable daily mean nitrate-N concentrations (Appendix 3.4). Daily mean nitrate-N concentrations at site S2 ranged from 1.8 mg/L to 13.3 mg/L. Overall, daily mean nitrate-N concentrations at site S2 were substantially less in 2014 (median of 4.9 mg/L) than in 2013 (median of 10.7 mg/L). Nitrate-N concentrations in tile inflow to the Smeltzer west oxbow wetland were substantially greater than the nitrate-N concentrations in water discharged from the wetland. The average daily mean nitrate-N concentration for the sampled period was 19.7 mg/L in the tile-line discharge at site S1 and was 5.65 mg/L in the oxbow wetland discharge at site S2. The difference in nitrate-N concentration between inflow and outflow in Smeltzer west oxbow wetland was greater in 2014. The difference in average concentration between inflow and outflow in 2014 (15.3 mg/L) was twice that in 2013 (7.2 mg/L).

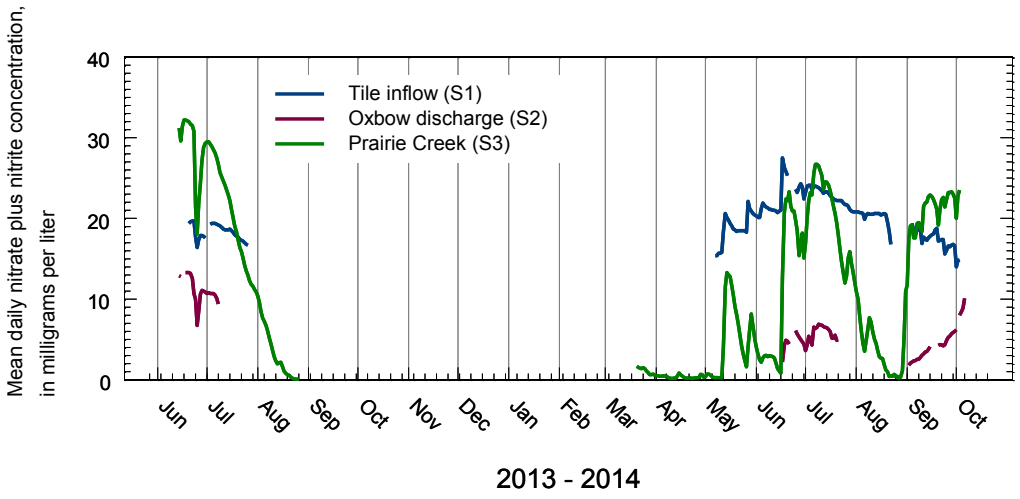


Figure 14. Daily mean nitrate plus nitrite concentration in Smeltzer west oxbow wetland inflow (S1), outflow (S2), and in the receiving stream, Prairie Creek (S3)

The average daily nitrate-N load discharging from the tile line (S1) into the Smeltzer west oxbow ranged from 0.0 lb/day on days of no flow to more than 74 lb/day (Appendix 3.3) on June 30, 2014. The average daily nitrate-N load leaving the oxbow ranged from 0.0 lb/day (Appendix 3.4) on days of no flow to 55 lb/day on June 30, 2014. The maximum daily loads in both the inflow and outflow of Smeltzer west oxbow occurred after a substantial rain event.

The total measured nitrate-N load discharged from the Smeltzer west oxbow (S2) during the study was 381 lb, while the total measured load flowing into the oxbow from the tile line (S1) was 825 lb. Most (79 percent) of the nitrate-N load entered the oxbow during early summer in June and July. A similar pattern was observed in nitrate-N transport out of the oxbow. The measured nitrate-N load discharged from the oxbow in June and July was 88 percent of the total measured for the study. There was a 70 percent reduction in the measured mass of nitrate-N that entered and the mass that left the oxbow in June and July. Throughout the entire study period the reduction was 54 percent.

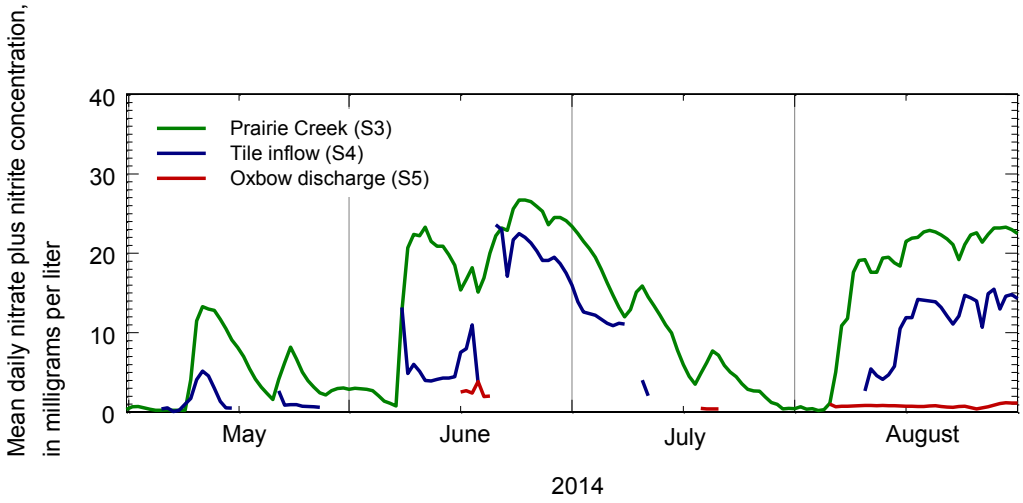
4.2.3.2.2 Smeltzer east oxbow wetland

Although continuous nitrate-N data were only collected in 2014, daily mean nitrate-N concentrations in water entering the Smeltzer east oxbow from tile-line were much more variable and had smaller concentrations than tile-line discharge into Smeltzer west oxbow. This pattern of concentrations was similar to that in Prairie Creek.

Daily mean nitrate-N concentrations in water entering the Smeltzer east oxbow wetland in 2014 ranged from 0.07 mg/L to 23.6 mg/L with a median daily concentration of 10.9 mg/L (Appendix 3.5). In comparison, daily mean nitrate-N concentrations in water leaving the Smeltzer east oxbow wetland were substantially less than in the tile discharge and ranged from 0.04 mg/L to 4.35 mg/L with a median concentration of 0.81 mg/L (Appendix 3.6). The greatest nitrate-N concentrations in tile inflow and wetland outflow were in June. Nitrate-N concentration in tile discharge decreased in late June and July as rainfall decreased below normal but then increased again in August when rainfall was greater than normal.

The range of nitrate-N concentrations of water discharging from the Smeltzer east tile-line were similar to that of Prairie Creek in 2014. Daily mean nitrate-N concentrations in tile discharge at site S4 ranged from 0.07 to 23.6 mg/L and in Prairie Creek at site S3 ranged from 0.07 mg/L to 32.2 mg/L. The median

nitrate-N concentration at site S4 (10.9 mg/L) was slightly greater than at S3 (9.78 mg/L).



4.2.3.2.3 Prairie Creek

The nitrate-N concentration in Prairie Creek was highly variable during the study. The daily mean nitrate-N concentration varied from 0.07 in August to 32.2 mg/L in June 2013 (Appendix 3.7). In 2014, the daily mean nitrate-N concentration ranged from 0.17 mg/L in April to 26.7 mg/L in July (Appendix 3.7). The median daily nitrate-N concentration during the two-year study was 9.78 mg/L (Table 7).

The nitrate-N concentration in Prairie Creek varied both seasonally and with stream discharge (Fig. 16). Concentrations increased during the spring and generally were the greatest during June and July. The maximum daily mean nitrate-N concentration was 32.2 mg/L in June 2013 as compared to a smaller maximum concentration of 26.7 mg/L in July, 2014. Concentrations then generally decreased through late summer as streamflow decreased. Flow in Prairie Creek ceased at the end of August 2013 and did not resume before monitoring was discontinued for the winter. During August 2014, a number of rains occurred (Appendix 2.2) which caused flow in Prairie Creek to again increase. A rise in concentrations occurred along with the flow increases until nitrate-N concentrations stabilized around 20 mg/L (Fig. 16) during the remainder of 2014 until monitoring was discontinued in October. The daily mean nitrate-N concentration responded to increased streamflow in two distinct patterns. Generally in the late winter and spring, an increase in streamflow was accompanied by an increase in nitrate-N concentrations. In summer, substantial increases in streamflow were initially accompanied by a decrease in nitrate-N concentrations. As streamflow peaked, nitrate-N concentrations again began to increase (Fig. 16).

Nitrate-N concentrations in Prairie Creek were substantially less than in Lyons Creek in 2013. The average daily mean nitrate-N concentration in Prairie Creek (15.0 mg/L) was 47 percent of that in Lyons Creek (32.0 mg/L). The maximum daily nitrate-N concentration in Prairie Creek was 32.0 mg/L and the maximum daily-N concentration in Lyons Creek was 41.0 mg/L.

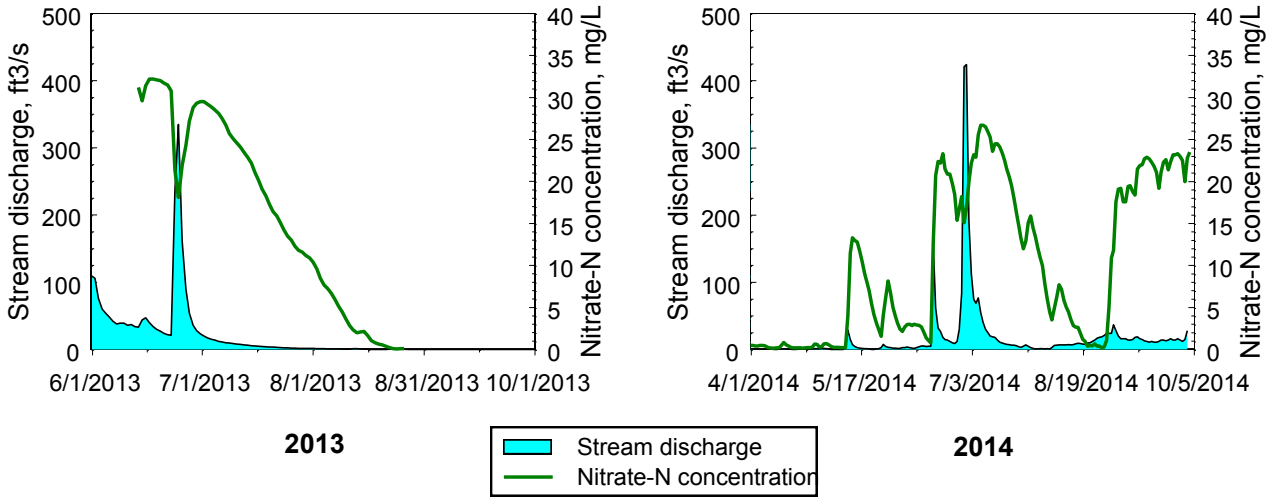


Figure 16. Daily mean discharge and nitrate nitrogen concentration in Prairie Creek, 2013-14 [ft3/s, cubic feet per second: mg/L, milligrams per liter: N, nitrogen]

The nitrate-N load in Prairie Creek was measured for only part of 2013. The total measured load (June through September) in 2013 was 77.5 tons. In 2014 when the nitrate-N concentration was measured from March through September, the nitrate-N load was 144 tons. These yearly loads resulted in measured yield in the Prairie Creek watershed of 8.7 lb/acre/yr in 2013 and 16.0 lb/acre/yr in 2014. Much of the measured nitrate-N was transported during early summer. Seventy-seven percent (111 tons) of the total nitrogen (144 tons) measured in Prairie Creek from March through September, 2014 was transported in June and July (Appendix 3.7).

5.0 Discussion

Results of this study show that nutrient load reduction occurred in oxbow wetlands in Lyons and Prairie Creek watersheds in north-central Iowa but efficiency of reduction was variable. In addition to biological processing, the study results suggest that overland and groundwater flow may factor into the nutrient reduction in the restored oxbow wetland.

The study data suggest that little nutrient reduction occurred in the native Lyons Creek oxbow during 2013. Concentrations of all nutrient constituents (Table 5) were not significantly ($P>0.05$, Wilcoxon rank sum) different in water discharging from the tile line than in water leaving the Lyon Creek oxbow. A combination of physical features and flow conditions suggest that the residence time of water in the oxbow may not have been sufficient to allow for removal of substantial amounts of nutrients. Tile line discharge entered the wetland midpoint in the wetland and flowed the remainder of the distance to the oxbow outlet in a channel formed in the wetland vegetation. This channel allowed the tile line water to move rapidly to the oxbow outlet. In 2013, almost twice as much water flowed out of Lyons Creek oxbow (129 acre-ft) than entered it (69 acre-ft) from the tile discharge. Flow and nutrient concentrations of the tile line discharge (L1) outflow from the Lyons Creek oxbow were essentially the same during a relatively small rain event on April 14, 2013 (Fig. 11). This response suggests that water and nutrients moved rapidly unchanged through the Lyons Creek oxbow.

Because of its proximity to Lyons Creek, the oxbow was susceptible to inundation during periods of streambank overflow. Water from both Lyons Creek and the tile line discharge may be flushed from the oxbow during inundation allowing little time for nutrient processing. This was illustrated by conditions

during a large runoff event in June 2013 (Fig. 11) when a large part of the flow from the oxbow originated from flood flow and nutrient concentrations were similar to those in Lyons Creek.

A measureable reduction in nitrate-N loads occurred through a restored oxbow in the Prairie Creek watershed in 2013 and 2014. However, the results of this study raised additional questions on the impact of groundwater and overland flow on the nutrient reduction efficiency of the wetland.

The tile-line water flowing into the oxbow wetland transported about 770 lb of nitrate-N during the two-year monitoring effort (Table 8). During this same period, only about 380 lb of nitrate-N were transported in water discharging directly into Prairie Creek. The nitrate-N reduction of slightly more than 50 percent was at least partially due to uptake by algae and plants in the oxbow wetland and possibly denitrification in bottom sediments.

Because nitrate-N was continuously monitored for only part of 2013, the amount of nitrate-N measured flowing into and out of the Smeltzer west oxbow was much less in 2013 than in 2014. In 2013, flow was measured from June 1 until the tile line went dry on July 23. The amount of water flowing into the oxbow wetland from the tile line (S1) averaged 0.01 ft^3/s during the monitoring period in 2013 and averaged 0.03 ft^3/s during the monitoring period in 2014 (Table 8). A total of 2.75 acre-ft in 2013 and 11.9 acre-ft in 2014 entered the oxbow wetland from the tile line. The water flowing from the tile line transported an average of 0.91 lb/day in 2013 and 3.3 lb/day in 2014.

Table 8. Inflow and outflow of water and nitrate nitrogen in the Smeltzer west oxbow wetland in relation to flow in Prairie Creek, 2013 and 2014

Monitoring period	Tile inflow (site S1)				Oxbow wetland outflow (site S2)				Prairie Creek (site S3)			
	Water		Nitrate-N		Water		Nitrate-N		Water		Nitrate-N	
	Average daily flow (ft^3/s)	Total flow (acre ft)	Average daily (lb/day)	Total transported (lb)	Average daily flow (ft^3/s)	Total flow (acre ft)	Average daily (lb/day)	Total transported (lb)	Average daily flow (ft^3/s)	Total flow (acre ft)	Average daily (lb/day)	Total transported (lb)
6/20-2013 - 11/3/2013	0.01	2.75	0.91	125	0.02	5.73	1.11	152	9.28	2,522	1,130	155,300
3/25/2014 - 10/05/2014	0.03	11.94	3.3	642	0.04	17.22	1.19	229	16.5	6,280	1,500	287,200
Both monitoring periods	0.02	14.69	2.31	767	0.04	22.95	1.15	381	13.5	8,802	1,340	442,500

The amount of water and nitrate-N flowing into the Smeltzer west restored oxbow wetland was not the same as that discharging from the oxbow wetland directly into Prairie Creek. Flow leaving the oxbow was greater than the tile-line discharge during the study. About14.7 acre-ft of water was measured entering the oxbow wetland from the tile line and almost 23 acre-ft of water was measured leaving the oxbow wetland (Table 8). The additional water likely entered the wetland from other sources that may include groundwater and overland flow during storms.

Differences between inflow and outflow of water and nitrate-N in the Smeltzer west oxbow during large storm events suggest other nutrient transport pathways also may play a role in the oxbow reduction of

nutrient loads. During large storm events, more water was measured flowing from the oxbow wetland than entering from the tile line. The additional water entering the oxbow did not carry a proportional amount of nitrate-N; the amount of nitrate-N leaving during the events was similar or less than what entered from the tile line. Two examples, a rain event from June 20 to June 30 in 2013 and a second event from June 25 to July 5, 2014, illustrate the impact of rainfall on the transport of nitrate-N through the oxbow wetland (Fig. 17). During both storm events, more than twice as much water flowed out of the oxbow wetland directly into Prairie Creek than entered the oxbow from the tile line. At the same time, similar or smaller amounts of nitrate-N were transported out of the wetland than entered from the tile line (Fig. 17). During the 2013 storm event, 2.24 acre-ft of water with 106 lb of nitrate-N was discharged by the tile line (S1) and 4.75 acre-ft of water with 123 lb of nitrate-N flowed from the oxbow wetland (S2) to Prairie Creek. The pattern of nitrate-N transport was repeated during the June 25 to July 5 storm in 2014 when 4.24 acre ft of water with 270 lb of nitrate-N was discharged by the tile line (S1) and 9.34 acre-ft of water and 113 lb of nitrate-N discharged (S2) from the Smeltzer west oxbow wetland into Prairie Creek. These results suggest that during large rain events, substantial amounts of additional dilute (in relation to nitrate-N) water entered the oxbow wetland. The source of this additional water was most likely from rainfall runoff that flows directly into the oxbow wetland. Because of the grassy buffer adjacent to the wetland, rainfall runoff would likely transport little nitrate-N from the land surface to the oxbow wetland.

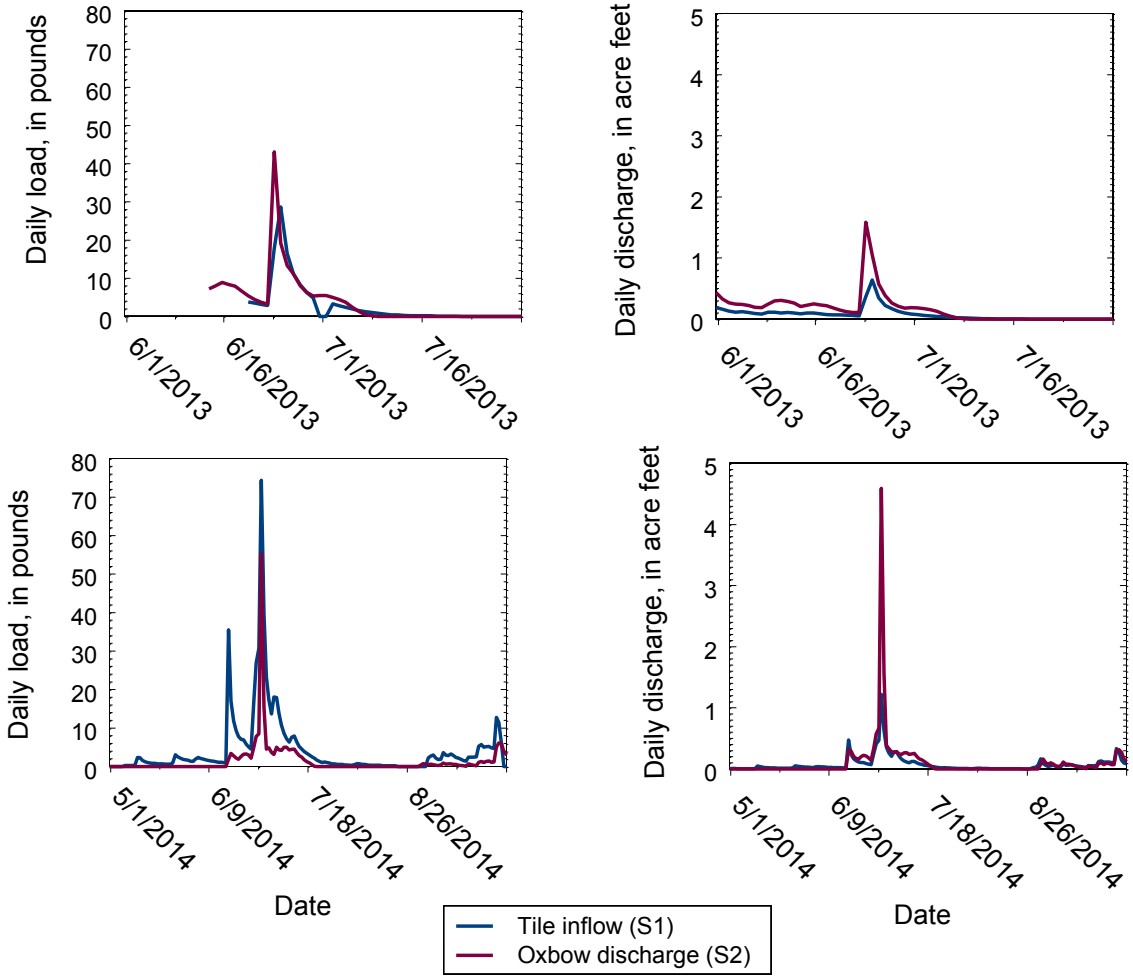


Figure 17.—Daily Inflow from a tile line (S1) and outflow (S2) of water and nitrate from the Smeltzer west restored oxbow wetland, 2013 and 2014.

During dry conditions during the summer, discharge from the Smeltzer west oxbow wetland ended while inflow from the tile line continued. This occurred during a 13-day period from July 10 through July 22 in 2013 and during two periods in 2014; May 7 through June 16 and July 22 through August 31(Appendix 2.6 and Appendix 2.7). A small amount of water (90 ft^3) with an average nitrate-N concentration of 18.2 mg/L discharged from the tile line (S1) during the July 10 through July 22 2013 period resulted in only 3.7 lb entering the oxbow wetland. During the May 7 through June 16 period in 2014, 43,800 ft^3 of water with an average nitrate-N concentration of 19.3 mg/L discharged from the tile line. Fifty- three lb of nitrate-N entered the oxbow wetland without any nitrogen being discharged directly into Prairie Creek. During the second period, 19,400 ft^3 of water with an average nitrate-N concentration of 20.6 mg/L discharged from the tile line. Eighteen lb of nitrate-N entered the oxbow wetland during this period. The water entering from the tile line was stored in the oxbow wetland during these periods but some may have evaporated or seeped into a hydrologically connected shallow water-table aquifer.

Seepage of water and nitrate-N into the underlying aquifer may be another possible transport process involved in nutrient reduction in the wetland. A groundwater gradient (Fig. 6) across the Smeltzer west oxbow suggests water was seeping from the wetland into the shallow groundwater. The lack of nitrate-N in an upgradient well (SW2) and the presence of substantial nitrate-N concentrations in the downgradient well (SW3) (Table 6) show that additional nitrate-N may be transported to the shallow groundwater which flows into Prairie Creek. Analysis of the groundwater component was beyond the scope of this project, but a one-dimensional numerical groundwater flow model may provide additional information to help quantify the oxbow seepage and nitrate-N transport to Prairie Creek.

Discharge from the Smeltzer west oxbow wetland contributes a small amount of water and nitrate-N in relation to that measured in Prairie Creek at the study site. The total flow entering Prairie Creek from the Smeltzer west oxbow wetland during the two monitoring periods was 22.95 acre feet; approximately 0.3 percent of the flow (8,800 acre ft) measured in Prairie Creek. Similarly, the amount of nitrate-N in Prairie Creek originating from the Smeltzer west oxbow wetland (381 lb.) was 0.09 percent of the total transported in Prairie Creek. The tile line discharge, if flowing directly into the creek, would have contributed 0.2 percent of the total measured in Prairie Creek.

6.0 Conclusion

The results of the study provide important information to managers and land owners that are looking for strategies to reduce nutrient transport from agricultural fields. This study showed that 54 percent less nitrate-N was measured leaving the Smeltzer west oxbow than was measured entering from a 6-inch field tile. Little apparent nutrient reduction was seen in the Lyons Creek oxbow due to the short residence time of the tile line discharge and flushing due to stream flooding. This study provided answers on the efficiency of nutrient removal while generating additional questions on the importance of overland and groundwater flow on the ability of oxbow wetlands to mitigate nutrient discharge to streams. These questions identified the need for additional study of the overland and groundwater components of nutrient transport into and through an oxbow wetland. The Smeltzer west restored oxbow was able to partially remove nitrate-N in water from a small field tile. Additional research is necessary to understand how increased discharge from larger field tiles and drainage district mains may influence the efficiency of nutrient reduction in relation to the size, type, and landscape setting of an oxbow wetland.

7.0 References cited

Bakevich, B.D., Pierce, C.L., and Quist, M.C., 2013, Habitat, fish species, and fish assemblage associations of the Topeka Shiner in West-Central Iowa. North American Journal of Fisheries Management. Vol. 33. p 1258-1268.

Bricker S.B., et al. 1999. National eutrophication assessment: Effects of nutrient enrichment in the nations' estuaries. NOAA National Ocean Service, Silver Spring, MD.

Cunningham, W.L., and Schalk, C.W., comps., 2011, Groundwater technical procedures of the U.S. Geological Survey: U.S. Geological Survey Techniques and Methods 1–A1, 151 p. accessed online on October 17, 2016 at http://pubs.usgs.gov/tm/1a1/

Dahl, T.E., and Allord, G.J., 1996, History of wetlands in the conterminous United States, *in* Fretwell, J.D. (compiler), Williams, J.S. and Redman, P.J., National water summary on wetland resources: U.S. Geological Survey Water Supply Paper 2425, 431 p. accessed online on October 24, 2016 at https://pubs.er.usgs.gov/publication/wsp2425

Larimer, O.J., 1974, Drainage areas of Iowa Streams, Iowa Highway Research Board Bulletin No. 7, 440 p.

NOAA, 2015, NOAA National Centers for Environmental Information (NCEI), NOAA data obtained from the Midwestern Regional Climate Center, cli-MATE (MRCC Application Tools Environment, accessed online on October 17, 2016 at http://mrcc.isws.illinois.edu/CLIMATE/

Pellerin, B.A., Bergamaschi, B.A., Downing, B.D., Saraceno, J.F., Garrett, J.A., and Olsen, L.D., 2013, Optical techniques for the determination of nitrate in environmental waters: Guidelines for instrument selection, operation, deployment, maintenance, quality assurance, and data reporting: U.S. Geological Survey Techniques and Methods 1–D5, 37 p. accessed online on October 17, 2016 at https://pubs.er.usgs.gov/publication/tm1D5/

Prior, J.C, 1991, Landforms of Iowa, University of Iowa Press, Iowa City, IA, 153 p.

Rantz, S.E., and others, 1982a, Measurements and computation of streamflow, volumes 1 and 2: U.S. Geological Survey Water-Supply Paper 2175, 631 p. accessed online on October 17, 2016 at http://pubs.usgs.gov/wsp/wsp2175/

Rantz, S.E., and others, 1982b, Measurements and computation of streamflow: Volume 2. Computation of discharge: U.S. Geological Survey Water-Supply Paper 2175, 631 p. accessed online on October 17, 2016 at http://pubs.usgs.gov/wsp/wsp2175/

Rice, E.W., Baird, R.B., Eaton, A.D., and Clesceri, L.S. eds., 2012, Standard methods for the examination of water and wastewater, 22nd edition, American Public Health Association, American Water Works Association, 1496 p.

Sauer, V.B., 2002, Standards for the analysis and processing of surface-water data and information using electronic methods: U.S. Geological Survey Water-Resources Investigations Report 01–4044, 91 p. accessed online on October 17, 2016 at https://pubs.er.usgs.gov/publication/wri20014044/

Sauer, V.B., and Turnipseed, D.P., 2010, Stage measurement at gaging stations: U.S. Geological Survey Techniques and Methods book 3, chap. A7, 45 p. available online at http://pubs.usgs.gov/tm/tm3-a7/

Scavia, D. et al. (18 co-authors) 2000. Integrated assessment of hypoxia in the northern Gulf of Mexico. National Science and Technology Council Committee on Environment and Natural Resources (CENR), Washington, DC.

Schipper, L.A., Robertson, W. D., Gold, A.J., Jaynes, D.B. and Cameron, S.C., 2010, Denitrifying bioreactors—An approach for reducing nitrate loads to receiving waters, Ecological Engineering, vol. 36, pp. 1532-1543.

Turnipseed, D.P., and Sauer, V.B., 2010, Discharge measurements at gaging stations: U.S. Geological Survey Techniques and Methods book 3, chap. A8, 87 p., accessed online on October 17, 2016 at http://pubs.usgs.gov/tm/tm3-a8/

U.S. EPA. 2000. The Quality of Our Nations Waters. A summary of the National Water Quality Inventory: 1998 Report to Congress. United States Environmental Protection Agency Office of Water Washington, DC 20460 EPA EPA841-S-00-001.

U.S. EPA, 2009, National Water Quality Inventory: Report to Congress 2004 Reporting Cycle. United States Environmental Protection Agency Office of Water Washington, DC 20460 EPA 841-R-08-001.

U.S. Geological Survey, undated, U.S. Geological Survey Standard Reference Sample Project—performance evaluation of analytical laboratories: U.S. Geological Survey Fact Sheet, accessed online on October 19, 2016 at https://bqs.usgs.gov/srs/FactSheet.htm

U.S. Geological Survey, 2006, Collection of water samples (ver. 2.0): U.S. Geological Survey Techniques of Water-Resources Investigations, book 9, chap. A4, September 2006, accessed online on October 17, 2016 at http://pubs.water.usgs.gov/twri9A4/

Wilde, F.D., eds, 2004, Cleaning of equipment for water sampling (ver. 2.0)): U.S. Geological Survey Techniques of Water-Resources Investigations, book 9, chap. A3, April 2004 accessed online on October 17, 2016 at http://pubs.water.usgs.gov/twri9A3/

Wilde, F.D., Radtke, D.B., Gibs, Jacob, and Iwatsubo, R.T., eds., 2004 with updates through 2009, Processing of water samples (ver. 2.2): U.S. Geological Survey Techniques of Water-Resources Investigations, book 9, chap. A5, April 2004, accessed online on October 17, 2016 at http://pubs.water.usgs.gov/twri9A5/

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Appendices

Appendix 1.—Flow ratings and analytical quality assurance

Appendix 1.1-- Theoretical ratings for 2/0' "H" Flume

[CFS, cubic feet per second: GPM, gallons per minute; MGD, million gallons per day; from Field Manual for Research in Agricultural Hydrology, 1979; provided by TRACOM® Document: H20-D-T Rev.: 0 Date: April 6, 2000 By: Jon Wachter]

LEVEL		FLOW			LEVEL		FLOW		
FEET	INCHES	CFS	GPM	MGD	FEET	INCHES	CFS	GPM	MGD
0.01	0.12				1.01	12.12	2.30	1032.2	1.486
0.02	0.24	0.0014	0.63	0.001	1.02	12.24	2.35	1054.7	1.519
0.03	0.36	0.0031	1.39	0.002	1.03	12.36	2.40	1077.1	1.551
0.04	0.48	0.0050	2.24	0.003	1.04	12.48	2.45	1099.6	1.583
]0.05	0.60	0.0073	3.28	0.005	1.05	12.60	2.51	1126.5	1.622
0.06	0.72	0.0100	4.49	0.006	1.06	12.72	2.56	1148.9	1.655
0.07	0.84	0.0130	5.83	0.008	1.07	12.84	2.62	1175.9	1.693
0.08	0.96	0.0166	7.45	0.011	1.08	12.96	2.67	1198.3	1.726
0.09	1.08	0.0205	9.20	0.013	1.09	13.08	2.73	1225.2	1.764
0.10	1.20	0.0248	11.13	0.016	1.10	13.20	2.78	1247.7	1.797
0.11	1.32	0.0293	13.1	0.019	1.11	13.32	2.84	1274.6	1.835
0.12	1.44	0.0341	15.3	0.022	1.12	13.44	2.90	1301.5	1.874
0.13	1.56	0.0392	17.6	0.025	1.13	13.56	2.96	1328.4	1.913
0.14	1.68	0.0447	20.1	0.029	1.14	13.68	3.02	1355.4	1.952
0.15	1.80	0.0505	22.7	0.033	1.15	13.80	3.08	1382.3	1.991
0.16	1.92	0.0567	25.4	0.037	1.16	13.92	3.14	1409.2	2.029
0.17	2.04	0.0632	28.4	0.041	1.17	14.04	3.20	1436.2	2.068
0.18	2.16	0.0701	31.5	0.045	1.18	14.16	3.26	1463.1	2.107
0.19	2.28	0.0774	34.7	0.050	1.19	14.28	3.32	1490.0	2.146
0.20	2.40	0.0850	38.1	0.055	1.20	14.40	3.38	1516.9	2.184
0.21	2.52	0.0930	41.7	0.060	1.21	14.52	3.45	1548.4	2.230

LEVEL		FLOW			LEVEL		FLOW		
FEET	INCHES	CFS	GPM	MGD	FEET	INCHES	CFS	GPM	MGD
0.22	2.64	0.1015	45.6	0.066	1.22	14.64	3.51	1575.3	2.269
0.23	2.76	0.1103	49.5	0.071	1.23	14.76	3.58	1606.7	2.314
0.24	2.88	0.1195	53.6	0.077	1.24	14.88	3.65	1638.1	2.359
0.25	3.00	0.1290	57.9	0.083	1.25	15.00	3.71	1665.0	2.398
0.26	3.12	0.1390	62.4	0.090	1.26	15.12	3.78	1696.5	2.443
0.27	3.24	0.1494	67.1	0.097	1.27	15.24	3.85	1727.9	2.488
0.28	3.36	0.1602	71.9	0.104	1.28	15.36	3.92	1759.3	2.533
0.29	3.48	0.171	76.9	0.111	1.29	15.48	3.99	1790.7	2.579
0.30	3.60	0.183	82.1	0.118	1.30	15.60	4.06	1822.1	2.624
0.31	3.72	0.195	87.5	0.126	1.31	15.72	4.13	1853.5	2.669
0.32	3.84	0.207	92.9	0.134	1.32	15.84	4.20	1885.0	2.714
0.33	3.96	0.220	98.7	0.142	1.33	15.96	4.28	1920.9	2.766
0.34	4.08	0.234	105.0	0.151	1.34	16.08	4.35	1952.3	2.811
0.35	4.20	0.248	111.3	0.160	1.35	16.20	4.43	1988.2	2.863
0.36	4.32	0.262	117.6	0.169	1.36	16.32	4.50	2019.6	2.908
0.37	4.44	0.276	123.9	0.178	1.37	16.44	4.58	2055.5	2.960
0.38	4.56	0.291	130.6	0.188	1.38	16.56	4.66	2091.4	3.012
0.39	4.68	0.307	137.8	0.198	1.39	16.68	4.74	2127.3	3.063
0.40	4.80	0.323	145.0	0.209	1.40	16.80	4.82	2163.2	3.115
0.41	4.92	0.339	152.1	0.219	1.41	16.92	4.90	2199.1	3.167
0.42	5.04	0.356	159.8	0.230	1.42	17.04	4.98	2235.0	3.219
0.43	5.16	0.374	167.9	0.242	1.43	17.16	5.06	2270.9	3.270
0.44	5.28	0.392	175.9	0.253	1.44	17.28	5.14	2306.8	3.322
0.45	5.40	0.410	184.0	0.265	1.45	17.40	5.23	2347.2	3.380
0.46	5.52	0.429	192.5	0.277	1.46	17.52	5.31	2383.1	3.432
0.47	5.64	0.448	201.1	0.290	1.47	17.64	5.40	2423.5	3.490
0.48	5.76	0.468	210.0	0.302	1.48	17.76	5.48	2459.4	3.542

LEVEL		FLOW			LEVEL		FLOW		
FEET	INCHES	CFS	GPM	MGD	FEET	INCHES	CFS	GPM	MGD
0.49	5.88	0.488	219.0	0.315	1.49	17.88	5.57	2499.8	3.600
0.50	6.00	0.509	228.4	0.329	1.50	18.00	5.65	2535.7	3.652
0.51	6.12	0.530	237.9	0.343	1.51	18.12	5.74	2576.1	3.710
0.52	6.24	0.552	247.7	0.357	1.52	18.24	5.83	2616.5	3.768
0.53	6.36	0.574	257.6	0.371	1.53	18.36	5.92	2656.9	3.826
0.54	6.48	0.597	267.9	0.386	1.54	18.48	6.01	2697.3	3.884
0.55	6.60	0.620	278.3	0.401	1.55	18.60	6.11	2742.2	3.949
0.56	6.72	0.644	289.0	0.416	1.56	18.72	6.20	2782.6	4.007
0.57	6.84	0.668	299.8	0.432	1.57	18.84	6.29	2823.0	4.065
0.58	6.96	0.693	311.0	0.448	1.58	18.96	6.38	2863.3	4.123
0.59	7.08	0.719	322.7	0.465	1.59	19.08	6.48	2908.2	4.188
0.60	7.20	0.745	334.4	0.481	1.60	19.20	6.58	2953.1	4.253
0.61	7.32	0.771	346.0	0.498	1.61	19.32	6.67	2993.5	4.311
0.62	7.44	0.798	358.1	0.516	1.62	19.44	6.77	3038.4	4.375
0.63	7.56	0.826	370.7	0.534	1.63	19.56	6.87	3083.3	4.440
0.64	7.68	0.854	383.3	0.552	1.64	19.68	6.97	3128.1	4.505
0.65	7.80	0.882	395.8	0.570	1.65	19.80	7.07	3173.0	4.569
0.66	7.92	0.911	408.9	0.589	1.66	19.92	7.17	3217.9	4.634
0.67	8.04	0.941	422.3	0.608	1.67	20.04	7.27	3262.8	4.699
0.68	8.16	0.971	435.8	0.628	1.68	20.16	7.37	3307.7	4.763
0.69	8.28	1.002	449.7	0.648	1.69	20.28	7.47	3352.5	4.828
0.70	8.40	1.03	462.3	0.666	1.70	20.40	7.58	3401.9	4.899
0.71	8.52	1.07	480.2	0.692	1.71	20.52	7.68	3446.8	4.964
0.72	8.64	1.10	493.7	0.711	1.72	20.64	7.79	3496.2	5.035
0.73	8.76	1.13	507.1	0.730	1.73	20.76	7.90	3545.5	5.106
0.74	8.88	1.16	520.6	0.750	1.74	20.88	8.00	3590.4	5.170
0.75	9.00	1.20	538.6	0.776	1.75	21.00	8.11	3639.8	5.241

LEVEL		FLOW			LEVEL		FLOW		
FEET	INCHES	CFS	GPM	MGD	FEET	INCHES	CFS	GPM	MGD
0.76	9.12	1.23	552.0	0.795	1.76	21.12	8.22	3689.1	5.313
0.77	9.24	1.27	570.0	0.821	1.77	21.24	8.33	3738.5	5.384
0.78	9.36	1.30	583.4	0.840	1.78	21.36	8.44	3787.9	5.455
0.79	9.48	1.34	601.4	0.866	1.79	21.48	8.56	3841.7	5.532
0.80	9.60	1.38	619.3	0.892	1.80	21.60	8.67	3891.1	5.603
0.81	9.72	1.42	637.3	0.918	1.81	21.72	8.78	3940.5	5.675
0.82	9.84	1.46	655.2	0.944	1.82	21.84	8.90	3994.3	5.752
0.83	9.96	1.49	668.7	0.963	1.83	21.96	9.01	4043.7	5.823
0.84	10.08	1.53	686.7	0.989	1.84	22.08	9.13	4097.5	5.901
0.85	10.20	1.57	704.6	1.015	1.85	22.20	9.24	4146.9	5.972
0.86	10.32	1.62	727.1	1.047	1.86	22.32	9.36	4200.8	6.049
0.87	10.44	1.66	745.0	1.073	1.87	22.44	9.48	4254.6	6.127
0.88	10.56	1.70	763.0	1.099	1.88	22.56	9.60	4308.5	6.204
0.89	10.68	1.74	780.9	1.125	1.89	22.68	9.72	4362.3	6.282
0.90	10.80	1.78	798.9	1.150	1.90	22.80	9.85	4420.7	6.366
0.91	10.92	1.83	821.3	1.183	1.91	22.92	9.97	4474.5	6.444
0.92	11.04	1.87	839.3	1.209	1.92	23.04	10.09	4528.4	6.521
0.93	11.16	1.92	861.7	1.241	1.93	23.16	10.21	4582.2	6.599
0.94	11.28	1.96	879.6	1.267	1.94	23.28	10.34	4640.6	6.683
0.95	11.40	2.01	902.1	1.299	1.95	23.40	10.47	4698.9	6.767
0.96	11.52	2.06	924.5	1.331	1.96	23.52	10.60	4757.3	6.851
0.97	11.64	2.10	942.5	1.357	1.97	23.64	10.72	4811.1	6.928
0.98	11.76	2.15	964.9	1.390	1.98	23.76	10.85	4869.5	7.012
0.99	11.88	2.20	987.4	1.422	1.99	23.88	10.98	4927.8	7.096
1.00	12.00	2.25	1009.8	1.454					

Appendix 1.2—Discharge rating for extra-large 60º trapezoidal flume

[CFS, cubic feet per second: GPM, gallons per minute; MGD, million gallons per day; from "Development of Theoretical Rating Curves for Standardized Extra Large 60° V Trapezoidal Flumes,"; TRACOM®, Inc Document: TRAP-XL60-D-T Rev.: 0 Date: May 1, 2001 By: Jon Wachter

Water level		Flow			Water level		Flow		
Feet	Inches	CFS	GPM	MGD	Feet	Inches	CFS	GPM	MGD
0.01	0.12				0.51	6.12	0.2645	118.71	0.17095
0.02	0.24				0.52	6.24	0.2780	124.75	0.17964
0.03	0.36	0.0002	0.09	0.00012	0.53	6.36	0.2918	130.97	0.18860
0.04	0.48	0.0004	0.18	0.00026	0.54	6.48	0.3061	137.38	0.19783
0.05	0.60	0.0007	0.31	0.00045	0.55	6.60	0.3208	143.97	0.20733
0.06	0.72	0.0011	0.50	0.0007	0.56	6.72	0.3359	150.76	0.21710
0.07	0.84	0.0017	0.74	0.0011	0.57	6.84	0.3514	157.73	0.22714
0.08	0.96	0.0023	1.04	0.0015	0.58	6.96	0.3674	164.90	0.23746
0.09	1.08	0.0031	1.41	0.0020	0.59	7.08	0.3838	172.26	0.24807
0.10	1.20	0.0041	1.85	0.0027	0.60	7.20	0.4007	179.82	0.25895
0.11	1.32	0.0052	2.36	0.0034	0.61	7.32	0.4180	187.58	0.27013
0.12	1.44	0.0066	2.94	0.0042	0.62	7.44	0.4357	195.54	0.28159
0.13	1.56	0.0080	3.61	0.0052	0.63	7.56	0.4539	203.70	0.29334
0.14	1.68	0.0097	4.36	0.0063	0.64	7.68	0.4725	212.06	0.30539
0.15	1.80	0.0116	5.20	0.0075	0.65	7.80	0.4916	220.64	0.31773
0.16	1.92	0.0137	6.14	0.0088	0.66	7.92	0.5112	229.41	0.33037
0.17	2.04	0.0160	7.17	0.010	0.67	8.04	0.5312	238.40	0.34331
0.18	2.16	0.0185	8.29	0.012	0.68	8.16	0.5517	247.60	0.35656
0.19	2.28	0.0212	9.52	0.014	0.69	8.28	0.5727	257.01	0.37011
0.20	2.40	0.0242	10.9	0.016	0.70	8.40	0.5941	266.64	0.38397
0.21	2.52	0.0274	12.3	0.018	0.71	8.52	0.6160	276.48	0.39815
0.22	2.64	0.0309	13.8	0.020	0.72	8.64	0.6385	286.54	0.41263
0.23	2.76	0.0346	15.5	0.022	0.73	8.76	0.6614	296.82	0.42744
0.24	2.88	0.0385	17.3	0.025	0.74	8.88	0.6848	307.32	0.44256
0.25	3.00	0.0428	19.2	0.028	0.75	9.00	0.7087	318.05	0.45800
0.26	3.12	0.0473	21.2	0.031	0.76	9.12	0.7331	328.99	0.47377

Water level		Flow			Water level		Flow		
Feet	Inches	CFS	GPM	MGD	Feet	Inches	CFS	GPM	MGD
0.27	3.24	0.0521	23.4	0.034	0.77	9.24	0.7580	340.17	0.48987
0.28	3.36	0.0571	25.6	0.037	0.78	9.36	0.7834	351.57	0.50629
0.29	3.48	0.0625	28.1	0.040	0.79	9.48	0.8093	363.21	0.52304
0.30	3.60	0.0682	30.6	0.044	0.80	9.60	0.8357	375.07	0.54013
0.31	3.72	0.0741	33.3	0.048	0.81	9.72	0.8627	387.17	0.55755
0.32	3.84	0.0804	36.1	0.052	0.82	9.84	0.8902	399.50	0.57531
0.33	3.96	0.0870	39.0	0.056	0.83	9.96	0.9182	412.07	0.59341
0.34	4.08	0.0939	42.1	0.061	0.84	10.08	0.9467	424.88	0.61185
0.35	4.20	0.1011	45.4	0.065	0.85	10.20	0.9758	437.92	0.63063
0.36	4.32	0.1086	48.7	0.070	0.86	10.32	1.0054	451.21	0.64977
0.37	4.44	0.1165	52.3	0.075	0.87	10.44	1.0355	464.74	0.66925
0.38	4.56	0.1247	56.0	0.081	0.88	10.56	1.0662	478.51	0.68908
0.39	4.68	0.1333	59.8	0.086	0.89	10.68	1.0974	492.53	0.70927
0.40	4.80	0.1422	63.8	0.092	0.90	10.80	1.1292	506.79	0.72981
0.41	4.92	0.1514	68.0	0.098	0.91	10.92	1.1616	521.31	0.75071
0.42	5.04	0.1610	72.3	0.104	0.92	11.04	1.1945	536.07	0.77198
0.43	5.16	0.1710	76.8	0.111	0.93	11.16	1.2279	551.09	0.79360
0.44	5.28	0.1814	81.4	0.117	0.94	11.28	1.2619	566.36	0.81559
0.45	5.40	0.1921	86.2	0.124	0.95	11.40	1.2965	581.88	0.83795
0.46	5.52	0.2032	91.2	0.131	0.96	11.52	1.3317	597.66	0.86067
0.47	5.64	0.2147	96.3	0.139	0.97	11.64	1.3674	613.70	0.88377
0.48	5.76	0.2265	101.7	0.146	0.98	11.76	1.4037	630.00	0.90724
0.49	5.88	0.2388	107.2	0.154	0.99	11.88	1.4406	646.56	0.93108
0.50	6.00	0.2514	112.8	0.163	1.00	12.00	1.4781	663.38	0.95531

Appendix 1.3—Stream discharge measurements in Lyons Creek near Webster City, IA (L3) and Prairie Creek at Otho, IA (S3)

Measurement number	Measurement date/time	Gage height (ft.)	Stream discharge (ft3/s)	Shift adjustment (ft)	Measurement rating
USGS 05480986 Lyons Creek near Webster City, IA (L3)					
1	3/12/2013 10:38	5.99	2.86		POOR
2	3/27/2013 9:16	5.38	5.23	0.020	GOOD
3	4/10/2013 8:47	5.92	19.3	0.000	GOOD
4	5/6/2013 10:10	6.33	33.8	0.000	GOOD
5	6/24/2013 15:37	10.19	321	0.000	POOR
6	6/24/2013 15:50	10.19	324	0.000	UNSP
7	7/29/2013 9:54	5.05	1.04	0.000	GOOD
8	8/27/2013 9:13	4.66	0.00	0.000	GOOD
9	11/4/2013 8:30	3.76	0.00		GOOD
USGS 05480603 Prairie Creek at Otho, IA (S3)					
1	3/12/2013 13:44	3.84	7.04	-0.270	POOR
2	3/27/2013 13:25	3.74	14.1	-0.270	POOR
3	4/10/2013 12:25	4.05	28.9	-0.140	GOOD
4	4/18/2013 7:52	5.48	134	0.000	FAIR
5	6/3/2013 13:06	4.69	74.6	0.080	GOOD
6	6/24/2013 17:37	8.36	561	0.023	POOR
7	6/24/2013 17:53	8.36	589	0.022	POOR
8	7/16/2013 14:53	3.17	5.18	-0.100	GOOD
9	7/29/2013 13:27	2.85	1.65	0.000	GOOD
10	8/27/2013 11:12	2.74	0.19	0.000	FAIR
11	11/4/2013 12:30	2.55	0.00	0.000	GOOD
12	4/2/2014 11:09	2.63	0.94	0.170	GOOD
13	5/7/2014 11:13	3.17	0.58	-0.400	GOOD
14	6/4/2014 8:57	3.16	2.87	-0.230	GOOD
15	6/17/2014 9:14	6.46	244	0.000	GOOD
16	7/1/2014 9:31	7.59	443	0.130	FAIR
17	8/4/2014 13:46	3.48	1.17	-0.660	GOOD
18	9/15/2014 14:09	4.65	11.7	-1.270	GOOD

Commented [KJL1]: What does UNSP mean?

Appendix 1.4 – Stage-discharge relation at Lyons Creek near Webster City, IA (L3)

1 U.S. DEPARTMENT OF THE INTERIOR - U.S. GEOLOGICAL SURVEY - WATER RESOURCES

STATION:05480986 Lyons Creek near Webster City, IA (L3) TYPE:STREAM AGENCY:USGS STATE:19 COUNTY:079
LATITUDE: 422935.7 LONGITUDE: 0934600.5 NAD83 DRAINAGE AREA:7.82 CONTRIBUTING DRAINAGE AREA: DATUM:
Rating for Discharge (ft3/s)
RATING ID: 1.0 TYPE: stage-discharge EXPANSION: logarithmic STATUS: approved

RATING REMARKS: First rating at site. Based on measurements 2-7 and GZF on 7/29/2013.

OFFSET: 4.50

EXPANDED RATING TABLE

Gage height, feet	Discharge (ft3/s) (STANDARD PRECISION) .00	.01	.02	.03	.04	.05	.06	.07	.08	.09	DIFF IN Q PER .1 UNITS
4.70							0.00*	0.01	0.01	0.02*	0.07
4.80	0.03	0.04	0.06*	0.08	0.10	0.13*	0.15	0.18	0.21	0.25	0.26
4.90	0.29	0.34*	0.38	0.43*	0.47	0.51	0.56*	0.61	0.66	0.71*	0.47
5.00	0.76	0.81	0.87*	0.93	0.99	1.0	1.1	1.2	1.3	1.3	0.64
5.10	1.4	1.5	1.6	1.6	1.7	1.8	1.9	2.0	2.1	2.2	0.90
5.20	2.3	2.4	2.6	2.7	2.8	2.9	3.1	3.2	3.3	3.5	1.3
5.30	3.6	3.8	3.9	4.1*	4.3	4.4	4.6	4.7	4.9	5.1	1.7
5.40	5.3	5.4	5.6	5.8	6.0	6.2	6.4	6.6	6.8	7.0	1.9
5.50	7.2	7.4	7.7	7.9	8.1	8.4	8.6	8.9	9.1	9.4	2.4
5.60	9.6	9.9	10.2*	10.4	10.6	10.9	11.1	11.4	11.6	11.9	2.5
5.70	12.1	12.4	12.6	12.9	13.1	13.4	13.7	14.0	14.2	14.5	2.7
5.80	14.8	15.1	15.4	15.7	16.0	16.3	16.6	16.9	17.2	17.5	3.0
5.90	17.8	18.1	18.5	18.8	19.1	19.5	19.8	20.1	20.5	20.8	3.4
6.00	21.2	21.6	21.9	22.3	22.6	23.0	23.4	23.8	24.1	24.5	3.7
6.10	24.9	25.3	25.7*	26.1	26.5	26.9	27.3	27.6	28.0	28.4	3.9
6.20	28.8	29.3	29.7	30.1	30.5	30.9	31.3	31.8	32.2	32.6	4.3
6.30	33.1	33.5	34.0	34.4	34.9	35.3	35.8	36.2	36.7	37.2	4.5
6.40	37.6	38.1	38.6	39.1	39.6	40.0*	40.5	41.0	41.4	41.9	4.8
6.50	42.4	42.9	43.4	43.9	44.3	44.8	45.3	45.8	46.3	46.9	5.0
6.60	47.4	47.9	48.4	48.9	49.4	50.0	50.5*	51.0	51.5	52.0	5.1
6.70	52.5	53.0	53.5	54.0	54.5	55.0	55.5	56.0	56.6	57.1	5.1
6.80	57.6	58.1	58.7	59.2	59.7	60.3	60.8	61.4	61.9	62.5	5.4
6.90	63.0	63.6	64.1	64.7	65.3	65.8	66.4	67.0	67.5	68.1*	5.7
7.00	68.7	69.2	69.8	70.3	70.9	71.4	72.0	72.6	73.1	73.7	5.6
7.10	74.3	74.9	75.4	76.0	76.6	77.2	77.8	78.3	78.9	79.5	5.8
7.20	80.1	80.7	81.3	81.9	82.5	83.1	83.7	84.3	85.0	85.6	6.1
7.30	86.2	86.8	87.4	88.1	88.7	89.3	89.9	90.6	91.2	91.8	6.3
7.40	92.5	93.1	93.8*	94.4	95.0	95.6	96.2	96.8	97.5	98.1	6.2

1 U.S. DEPARTMENT OF THE INTERIOR - U.S. GEOLOGICAL SURVEY - WATER RESOURCES

STATION:05480986 Lyons Creek near Webster City, IA (L3) TYPE:STREAM AGENCY:USGS STATE:19 COUNTY:079
LATITUDE: 422935.7 LONGITUDE: 0934600.5 NAD83 DRAINAGE AREA:7.82 CONTRIBUTING DRAINAGE AREA: DATUM:
Rating for Discharge (ft3/s)
RATING ID: 1.0 TYPE: stage-discharge EXPANSION: logarithmic STATUS: approved

RATING REMARKS: First rating at site. Based on measurements 2-7 and GZF on 7/29/2013.

OFFSET: 4.50

EXPANDED RATING TABLE

Gage height, feet	Discharge (ft3/s) (STANDARD PRECISION) .00	.01	.02	.03	.04	.05	.06	.07	.08	.09	DIFF IN Q PER .1 UNITS
7.50	98.7	99.3	100	101	101	102	102	103	104	104	6.3
7.60	105	106	106	107	108	108	109	110	110	111	7.0
7.70	112	112	113	114	114	115	116	116	117	118	6.0
7.80	118	119	120	120	121	122	122	123	124	125	7.0
7.90	125*	126	127	127	128	129	129	130	131	131	7.0
8.00	132	133	133	134	135	136	136	137	138	138	7.0
8.10	139	140	141	141	142	143	143	144	145	146	7.0
8.20	146	147	148	148	149	150	151	151	152	153	8.0
8.30	154	154	155	156	157	157	158	159	160	160	7.0
8.40	161	162	163	163	164	165	166	167	167	168	8.0
8.50	169	170	170	171	172	173*	174	174	175	176	8.0
8.60	177	177	178	179	180	181	181	182	183	184	8.0
8.70	185	185	186	187	188	189	189	190	191	192	8.0
8.80	193	193	194	195	196	197	198	198	199	200	8.0
8.90	201	202	203	203	204	205	206	207	208	208	8.0
9.00	209	210	211	212	213	214	214	215	216	217	9.0
9.10	218	219	220	220	221	222	223	224	225	226	8.0
9.20	226	227	228	229	230	231	232	233	234	234	9.0
9.30	235	236	237	238	239	240	241	242	243	243	9.0
9.40	244	245	246	247	248	249	250	251	252	253	9.0
9.50	253	254	255	256	257	258	259	260	261	262	10.0
9.60	263	264	265	266	267	267	268	269	270	271	9.0
9.70	272	273	274	275	276	277	278	279	280	281	10.0
9.80	282	283	284	285	286	287	288	289	290	291	10.0
9.90	292	293	293	294	295	296	297	298	299	300	9.0
10.00	301	302	303	304	305	306	307	308	309	310	10.0
10.10	311	312	313	315	316	317	318	319	320	321	11.0
10.20	322	323	324	325	326	327	328	329	330	331	10.0
10.30	332	333	334	335	336	337	338	339	340	341	10.0
10.40	342	344	345	346	347	348	349	350	351	352	11.0

Appendix 1.5—Stage-discharge relation at Prairie Creek at Otho, IA (S3)

1 U.S. DEPARTMENT OF THE INTERIOR - U.S. GEOLOGICAL SURVEY - WATER RESOURCES

STATION:05480603 Prairie Creek at Otho, IA (S3) TYPE:STREAM AGENCY:USGS STATE:19 COUNTY:187
LATITUDE: 422439.2 LONGITUDE: 0940828.7 NAD83 DRAINAGE AREA:28.0 CONTRIBUTING DRAINAGE AREA: DATUM:
Rating for Discharge (ft3/s)
RATING ID: 1.0 TYPE: stage-discharge EXPANSION: logarithmic STATUS: approved

RATING REMARKS: First rating at site. Based on measurements 3-7.

OFFSET: 2.30

EXPANDED RATING TABLE

Gage height, feet	Discharge (ft3/s) (STANDARD PRECISION) .00	.01	.02	.03	.04	.05	.06	.07	.08	.09	DIFF IN Q PER .1 UNITS
2.70			0.00*	0.10	0.19*	0.27	0.38	0.53*	0.64	0.76	1.1
2.80	0.91	1.1*	1.2	1.3	1.4	1.6	1.7*	1.9	2.0	2.2	1.5
2.90	2.4*	2.5	2.7	2.8	3.0	3.2*	3.3	3.5	3.7*	3.9	1.6
3.00	4.0	4.2*	4.4	4.6	4.7	4.9*	5.1	5.3	5.5	5.7	1.9
3.10	5.9*	6.1	6.2	6.4	6.6	6.8*	7.0	7.2	7.4	7.6	1.9
3.20	7.8	8.0	8.2	8.4	8.6	8.8	9.0	9.2	9.4	9.6	2.0
3.30	9.8	10.1	10.3	10.5	10.7	11.0	11.2	11.5	11.7	11.9	2.4
3.40	12.2	12.4	12.7	13.0	13.2	13.5	13.7	14.0	14.3	14.6	2.6
3.50	14.8	15.1	15.4	15.7	16.0	16.3	16.6	16.9	17.2	17.5	3.0
3.60	17.8	18.1	18.4	18.7	19.0	19.3	19.7	20.0	20.3	20.7	3.2
3.70	21.0	21.3	21.7	22.0	22.4	22.7	23.1	23.4	23.8	24.2	3.5
3.80	24.5	24.9	25.3	25.6	26.0	26.4	26.8	27.2	27.6	28.0	3.9
3.90	28.4	28.8	29.2	29.6	30.0	30.4	30.8	31.2	31.7	32.1	4.1
4.00	32.5	32.9	33.4	33.8	34.3	34.7	35.2	35.6	36.1	36.5	4.5
4.10	37.0	37.4	37.9	38.4	38.9	39.3	39.8	40.3	40.8	41.3	4.8
4.20	41.8	42.3	42.8	43.3	43.8	44.3	44.8	45.3	45.8	46.4	5.1
4.30	46.9	47.4	48.0	48.5	49.0	49.6	50.1	50.7	51.2	51.8	5.4
4.40	52.3	52.9	53.5	54.0	54.6	55.2	55.8	56.4	56.9	57.5	5.8
4.50	58.1	58.7	59.3	59.9	60.5	61.1	61.8	62.4	63.0	63.6	6.1
4.60	64.2	64.9	65.5	66.1	66.8	67.4	68.1	68.7	69.4	70.0	6.5
4.70	70.7	71.4	72.0	72.7	73.4	74.1	74.8	75.4	76.1	76.8	6.8
4.80	77.5	78.2	78.9	79.6	80.3	81.1	81.8	82.5	83.2	84.0	7.2
4.90	84.7	85.4	86.2	86.9	87.6	88.4	89.2	89.9	90.7	91.4	7.5
5.00	92.2	93.0	93.7	94.5	95.3	96.1	96.9	97.7	98.5	99.3	7.8
5.10	100	101	102	103	103	104	105	106	107	107	8.0
5.20	108	109	110	111	112	113	113	114	115	116	9.0
5.30	117	118	119	120	120	121	122	123	124	125	9.0
5.40	126	127	128	129	130	130	131	132	133	134	9.0

1 U.S. DEPARTMENT OF THE INTERIOR - U.S. GEOLOGICAL SURVEY - WATER RESOURCES

STATION:05480603 Prairie Creek at Otho, IA (S3) TYPE:STREAM AGENCY:USGS STATE:19 COUNTY:187
LATITUDE: 422439.2 LONGITUDE: 0940828.7 NAD83 DRAINAGE AREA:28.0 CONTRIBUTING DRAINAGE AREA: DATUM:
Rating for Discharge (ft3/s)
RATING ID: 1.0 TYPE: stage-discharge EXPANSION: logarithmic STATUS: approved

RATING REMARKS: First rating at site. Based on measurements 3-7.

OFFSET: 2.30

EXPANDED RATING TABLE

Gage height, feet	Discharge (ft3/s) (STANDARD PRECISION) .00	.01	.02	.03	.04	.05	.06	.07	.08	.09	DIFF IN Q PER .1 UNITS
5.50	135	136	137	138	139	140	141	142	143	144	10.0
5.60	145	146	147	148	149	150	151	152	153	154	10.0
5.70	155	156	157	158	159	160	161	162	163	164	10.0
5.80	165	167	168	169	170	171	172	173	174	175	11.0
5.90	176	177	179	180	181	182	183	184	185	186	12.0
6.00	188	189	190	191	192	193	194	196	197	198	11.0
6.10	199	200	201	203	204	205	206	207	209	210	12.0
6.20	211	212	214	215	216	217	219	220	221	222	13.0
6.30	224	225	226	227	229	230	231	232	234	235	12.0
6.40	236	238	239	240	242	243	244	246	247	248	13.0
6.50	249	251	252	254	255	256	258	259	260	262	14.0
6.60	263	264	266	267	269	270	271	273	274	276	14.0
6.70	277	278	280	281	283	284	286	287	289	290	14.0
6.80	291	293	294	296	297	299	300	302	303	305	15.0
6.90	306	308	309	311	312	314	315	317	318	320	15.0
7.00	321	323	325	326	328	329	331	332	334	335	16.0
7.10	337	339	340	342	343	345	347	348	350	351	16.0
7.20	353	355	356	358	360	361	363	365	366	368	17.0
7.30	370	371	373	375	376	378	380	381	383	385	16.0
7.40	386	388	390	392	393	395	397	398	400	402	18.0
7.50	404	405	407	409	411	412	414	416	418	420	17.0
7.60	421	423	425	427	429	430	432	434	436	438	19.0
7.70	440	441	443	445	447	449	451	452	454	456	18.0
7.80	458	460	462	464	466	468	469	471	473	475	19.0
7.90	477	479	481	483	485	487	489	491	493	495	19.0
8.00	496	498	500	502	504	506	508	510	512	514	20.0
8.10	516	518	520	522	524	526	528	530	532	535	21.0
8.20	537	539	541	543	545	547	549	551	553	555	20.0
8.30	557	559	561	564	566	568	570	572	574	576	21.0

1 U.S. DEPARTMENT OF THE INTERIOR - U.S. GEOLOGICAL SURVEY - WATER RESOURCES

STATION:05480603 Prairie Creek at Otho, IA (S3) TYPE:STREAM AGENCY:USGS STATE:19 COUNTY:187
LATITUDE: 422439.2 LONGITUDE: 0940828.7 NAD83 DRAINAGE AREA:28.0 CONTRIBUTING DRAINAGE AREA: DATUM:
Rating for Discharge (ft3/s)
RATING ID: 1.0 TYPE: stage-discharge EXPANSION: logarithmic STATUS: approved

RATING REMARKS: First rating at site. Based on measurements 3-7.

OFFSET: 2.30

EXPANDED RATING TABLE

Gage height, feet	Discharge (ft3/s) (STANDARD PRECISION) .00	.01	.02	.03	.04	.05	.06	.07	.08	.09	DIFF IN Q PER .1 UNITS
8.40	578	581	583	585	587	589	591	594	596	598	22.0
8.50	600	602	604	607	609	611	613	615	618	620	22.0
8.60	622	624	627	629	631	633	635	638	640	642	23.0
8.70	645	647	649	651	654	656	658	661	663	665	22.0
8.80	667	670	672	674	677	679	681	684	686	688	24.0
8.90	691	693	696	698	700	703	705	707	710	712	24.0
9.00	715	717	719	722	724	727	729	732	734	736	24.0
9.10	739	741	744	746	749	751	754	756	759	761	25.0
9.20	764	766	769	771	774	776	779	781	784	786	25.0
9.30	789	791	794	796	799	801	804	807	809	812	25.0
9.40	814	817	820	822	825	827	830	833	835	838	26.0
9.50	840*										

Appendix 1.6— Analytical quality assurance and quality control

Additional data were collected throughout the study to assure that analyzed and measured concentrations of the nutrient constituents of interest were accurate and reproducible. All water samples were analyzed by the USGS Upper Midwest Environmental Sciences Center (UMESC) laboratory in LaCrosse, WI. Data were also collected to document that equipment and sampling supplies did not “carry over” nutrient residues from previous samples. Accuracy in the laboratory analysis was documented by annual analysis of standard reference samples and analytical reproducibility was documented through the analysis of replicate or “split” ambient samples. The effectiveness of equipment cleaning and handling to eliminate carry over of nutrient residues from sample to sample was evaluated by analysis of blank samples. A separate set of quality assurance and quality control data were collected to ensure that the NATRATAX nitrate sensors installed at the study sites were measuring accurate nitrate plus nitrite as nitrogen concentrations and that these results were not substantially different than laboratory analytical determinations.

The relative percent difference method was used to compare differences between quality assurance and quality control samples. The relative percent difference is calculated by the following equation:

$$RPD(\%) = \frac{(abs|c1 - c2|) * 100}{\frac{(c1 + c2)}{2}}$$

where abs = absolute value
c1 = observed values, and
c2 = known values

The "known" values include the most probable value for standard reference samples, the ambient sample for replicate samples, the nitrate standard concentration for the calibration check, and the laboratory determined concentration for the nitrate sensor laboratory comparison. (see description below).

Standard Reference Samples

The UMESC laboratory participates in the USGS standard reference sample quality assurance project to document the ability of the laboratory to accurately measure nutrient concentrations in water samples. Though this is not a laboratory certification program, participation in this continuing quality assurance program is used to alert participating laboratories of possible deficiencies in their analytical operations. Laboratories are evaluated by using performance evaluation samples, called Standard Reference Samples (SRSs). SRSs prepared by the USGS Branch of Quality Systems (BQS; https://bqs.usgs.gov/) are submitted to laboratories annually for round-robin laboratory performance comparison purposes. Currently (2013), approximately 100 USGS, other Federal agencies, and State laboratories are evaluated for their analytical performance on six SRSs for inorganic and nutrient constituents. Laboratories submit their results the USGS BQS which are then compiled and evaluated by using non-parametric statistics. Data for each SRS constituent are tabulated in descending order and the median (midpoint of all values) is considered the most probable value (MPV).

Results of the annual standard reference sample analysis for 2013 and 2014 (Appendix 1.6 Table 1) indicated that the average relative percent difference between the UMESC reported concentration and the most probable value for all constituents, based on two samples for each constituent, was generally less than 5.0 percent. The one exception was for ammonia-N where the average relative percent difference was 5.33 percent. The average relative percent difference between the UMESC laboratory reported concentration and the most probable value was 0.35

percent for nitrate-N; 5.33 percent for ammonia-N; 2.81 percent for total nitrogen-N; 2.52 percent for orthophosphate-P; and 0.77 percent for total phosphorus-P.

Appendix 1.6 Table 1 -- Analytical results from U.S. Geological Survey Upper Midwest Science Center (UMESC) laboratory annual standard reference sample analysis, 2013-2014.

Analyte	Parameter code	Analytical method	Date Analyzed	UMESC reported Value (mg/L)	Most probable value (mg/L)	Difference (mg/L)	Relative percent difference	Relative standard deviation
Nitrate + Nitrite as N	00631	4500 NO3- I	4/1/2014	0.417	0.418	-0.001	0.24	0.002
			4/1/2013	0.221	0.220	0.001	0.45	0.003
Ammonia as N	00608	4500-NH3 G	4/1/2014	0.090	0.098	-0.008	8.86	0.060
			4/1/2013	0.384	0.391	-0.007	1.81	0.013
Total Nitrogen as N	62855	4500-N C	4/1/2014	0.527	0.555	-0.028	5.18	0.036
			4/1/2013	0.644	0.641	0.003	0.45	0.003
Orthophosphate as P	00671	4500-P E	4/1/2014	0.091	0.089	0.002	2.22	0.016
			4/1/2013	0.366	0.356	0.010	2.85	0.020
Total Phosphorus as P	00665	4500-P E	4/1/2014	0.163	0.162	0.001	0.81	0.006
			4/1/2013	0.400	0.397	0.003	0.73	0.005

Variability in analytical results

Additional samples were collected to assess overall precision, including the reproducibility of (combined) sampling and analytical procedures. The additional samples were replicates of 11 ambient samples collected at most study sites (Appendix 1.6 – Table 2). Selected ambient samples were split in the field to produce an additional replicate sample. Both samples were processed using standard protocols for filtered and whole water samples and then shipped chilled to the laboratory. The replicate sample time was offset from the ambient sample for identification (Appendix 1.6 – Table 2). Samples were used to assess overall precision, including the reproducibility of (combined) sampling and analytical procedures (as distinguished from the precision of analysis of laboratory replicates).

Appendix 1.6 – Table 2.-- Analytical results from U.S. Geological Survey Upper Midwest Science Center (UMESC) laboratory replicate and blank sample analysis, 2013-2014. [Concentrations in milligrams per liter, parameter code in parentheses, N, nitrogen; P, phosphorus: <, less than; M, trace concentration]

Station identification number	Station name	Sample date	Sample time	Sample type	Ammonia-N, water, filtered (P00608)	Nitrate plus nitrite-N, water, filtered (P00631)	Total nitrogen-N, unfiltered (P62855)	Orthophosphate-P, water, filtered (P00671)	Total phosphorus-P, water, unfiltered (P00665)
05480603	Prairie Creek at Otho, IA (S3)	3/9/2013	1326	Ambient	1.5	4	7.98	1.88	2.7
05480603	Prairie Creek at Otho, IA (S3)	3/9/2013	1330	Replicate	1.5	3.9	7.82	1.71	2.61
05480603	Prairie Creek at Otho, IA (S3)	6/27/2013	805	Ambient	0.07	22	25.4	0.13	0.36
05480603	Prairie Creek at Otho, IA (S3)	6/27/2013	810	Replicate	0.06	23	23.6	0.14	0.28
05480986	Lyons Creek near Webster City, IA (L3)	5/3/2013	800	Ambient	0.06	35	35.8	0.11	0.20
05480986	Lyons Creek near Webster City, IA (L3)	5/3/2013	805	Replicate	0.02	45	47.8	0.04	0.07
05480986	Lyons Creek near Webster City, IA (L3)	5/21/2013	827	Ambient	< 0.01	39	40.4	0.03	0.06
05480986	Lyons Creek near Webster City, IA (L3)	5/21/2013	830	Replicate	< 0.02	39	40.1	0.03	0.05
422432094081701	Smeltzer East Oxbow Inlet near Otho, IA (S4)	3/9/2013	1527	Ambient	0.34	1.3	4.49	2.81	3.17
422432094081701	Smeltzer East Oxbow Inlet near Otho, IA (S4)	3/9/2013	1530	Replicate	0.34	1.7	4.48	2.93	3.13
422433094081801	Smeltzer East Oxbow Outlet near Otho, IA (S5)	3/10/2013	530	Ambient	0.31	1.7	4.53	1.56	1.9
422433094081801	Smeltzer East Oxbow Outlet near Otho, IA (S5)	3/10/2013	535	Replicate	0.31	1.6	4.27	1.58	1.98
422438094082701	Smeltzer West Oxbow Outlet near Otho, IA (S2)	6/27/2013	805	Ambient	0.04	9.9	10.5	0.17	0.25
422438094082701	Smeltzer West Oxbow Outlet near Otho, IA (S2)	6/27/2013	810	Replicate	0.04	10	10.8	0.15	0.26
422935093460001	Lyons Oxbow Outlet near Webster City, IA (L2)	5/21/2013	843	Ambient	0.016	44	45	0.08	0.10
422935093460001	Lyons Oxbow Outlet near Webster City, IA (L2)	5/21/2013	844	Replicate	0.017	45	46.2	0.07	0.10
422935093460001	Lyons Oxbow Outlet near Webster City, IA (L2)	6/27/2013	1039	Ambient	0.02	26	27.1	0.11	0.18
422935093460001	Lyons Oxbow Outlet near Webster City, IA (L2)	6/27/2013	1044	Replicate	0.02	27	28.9	0.13	0.18
422935093460401	Lyons Oxbow Inlet near Webster City, IA (L1)	5/3/2013	800	Ambient	0.02	46	47	0.03	0.07
422935093460401	Lyons Oxbow Inlet near Webster City, IA (L1)	5/3/2013	805	Replicate	0.03	45	47.2	0.03	0.08
422935093460401	Lyons Oxbow Inlet near Webster City, IA (L1)	5/21/2013	751	Ambient	0.02	46	47.2	0.07	0.10
422935093460401	Lyons Oxbow Inlet near Webster City, IA (L1)	5/21/2013	752	Replicate	0.02	44	45.5	0.05	0.09

422436094082501	Smeltzer West Oxbow Inlet near Otho, IA (S1)	2/13/2013	1300	Blank	<	0.008	<	0.01		0.03	0.005	0.005
422935093460401	Lyons Oxbow Inlet near Webster City, IA (L1)	4/16/2013	1600	Blank	<	0.008	<	0.01		0.01	0.002	0.001
422935093460401	Lyons Oxbow Inlet near Webster City, IA (L1)	4/16/2013	1620	Blank		0.002	<	0.01		0.02	0.001	0.001
05480603	Prairie Creek at Otho, IA (S3)	4/2/2014	1210	Blank		0.009	<	0.01	<	0.01	0.003	0.003

Analytical results of replicates (Appendix 1.6 – Table 2) show that the average relative percent difference between the ambient and replicate samples for nitrate-N and total nitrogen-N for all sample pairs was less than 10 percent. The average relative percent difference for ammonia-N, orthophosphate-P, and total phosphorus-P was between 10 and 20 percent. The average relative percent difference for ammonia-N was 14.13 percent, for nitrate plus nitrite was 7.12 percent and for total nitrogen-N was 5.54 percent. The average relative percent difference for orthophosphate-P was 17.41 percent and for total phosphorus-P was 16.00 percent. However, the difference in both phosphorus species between the ambient and replicate samples was much smaller when the sample collected from Lyons Creek near Webster City, IA (L3) on May 3, 2013 is removed from the dataset. The relative percent difference for both species was greater than 90 percent in this sample. The reason for the large difference is unknown. When this sample result was removed from the QA dataset, the average for orthophosphate would be 9.82 percent and for total phosphorus would be 7.97 percent.

Field Blanks

Field blanks were collected using the same methods by which regular field samples are collected. Commercially available (Ricci) ACS reagent grade water is pumped through the automatic sampler's intake tube and pumping mechanism into the sample bottles. Samples are shipped chilled to the UMESC laboratory. This process is used to monitor overall sample integrity and to check for any contamination that may be introduced into samples by the sampling equipment.

Analytical results (Appendix 1.6 – Table 2) indicated that if present, only very small amounts of the nutrient species were present in the field blank samples. Ammonia-N was detected at concentrations near the method detection level in 2 of 4 samples. Total nitrogen-N was detected in three of four samples at a concentration of 0.01 mg/L. Nitrate-N was not detected in any blank sample. Ortho-phosphorus-P and total phosphorus were detected in all blank samples at concentrations near the method detection level.

Quality assurance of the NITRATAX sensor

Collection of quality assurance information for the Hach NITRATAX field nitrate sensor was designed to (1) document changes over time due to physical and biological fouling, (2) ensure that measured values were accurate and did not change over time, and (3) evaluate the ability of the sensor to replicate laboratory analytical concentrations.

Appendix 1.6 – Table 3.-- Quality assurance data, fouling, calibration, and laboratory checks for the Hach NITRATAX nitrate sensors at sites in the Lyons and Prairie Creek study areas [All concentrations are in milligrams per liter]

		Fouling check		Calibration check						Laboratory check	
Date (MM DD YYYY)	Time (HHMM)	Sensor reading before cleaning	Sensor reading after cleaning	Nitrate standard 1	Sensor reading, standard 1	Nitrate standard 2	Sensor reading, standard 2	Nitrate standard 3	Sensor reading, standard 3	Laboratory sample time (HHMM)	Laboratory nitrate-N
(05480986) Lyons Creek near Webster City, IA (L3)											
04 26 2013	1150	38.4		0	0	11.3	11.4	22.6	22.7		
06 03 2013	0830	30.3	30.3	0	0.2	11.3	11.5	22.6	22.6	954	29.3
06 13 2013	0820			11.3	11.2	22.6	22.4	45.2	43.6		
07 16 2013	0845	36.5	36.2	0	0.2	11.3	11.5	22.6	22.8	1105	31.8
07 23 2013	1318	29.9	29.8								
07 29 2013	0955	32.6	32.5	11.3	11.6	22.6	22.8	45.2	43.7	1047	31.8
08 27 2013	0854	2.5	2.6	11.3	11.4	22.6	22.6	45.2	43.4		
(422436094082501) Smeltzer West Oxbow Inlet near Otho, IA (S1)											
06 19 2013	1430	19.3		0	0.1	11.3	11.4	22.6	22.7		
07 16 2013	1717	18.5	18.4	0	0.2	11.3	11.6	22.6	22.6		
07 29 2013	1429	16.3	0.3	0	0.1	11.3	11.7	22.6	22.4		
08 27 2013	1439	0.4		0	0.3	11.3	11.7	22.6	22.5		
03 20 2014	0932			0	0	11.3	11.2	22.6	22.4		
05 07 2014	1030			0	0	11.3	11.4	22.6	22.4	1030	14.6
06 04 2014	1015	21.3	21.4	0	0.2	11.3	11.5	22.6	22.6	1015	20.2
07 01 2014	1055	23.1	23.2	0	0.2	11.3	11.5	22.6	22.6	1110	22.2
07 24 2014	1100	22.3	22.3	0	0.2	11.3	11.7	22.6	22.9		
08 04 2014	1152	20.7	20.7	0	0.1	11.3	11.6	22.6	22.8	1217	20.9
08 19 2014	1027	0.2	20.7	0	0.2	11.3	11.3	22.6	22.8		
09 15 2014	1202	17.7	17.7	0	0.2	11.3	11.4	22.6	22.6	1202	17.4
10 06 2014	1200	15.4	15.5	0	0.2	11.3	11.5	22.6	22.6	1145	15.0

(422438094082701) Smeltzer West Oxbow Outlet near Otho, IA (S2)											
06 13 13	1443		13	0	0.1	11.3	11.5	22.6	22.6		
07 16 2013	1431			0	0.3	11.3	11.6	22.6	22.9		
05 07 2014	1135			0	0	11.3	11.3	22.6	22.4		
06 04 2014	0950	0.4	0.6	0	0.2	11.3	11.5	22.6	22.8		
07 01 2014	1018	3.65	4.2	0	0	11.3	11.2	22.6	22.5	1038	3.5
07 24 2014	1009	0.2	0.1	0	0.1	11.3	11.4	22.6	22.6		
08 04 2014	1433	0.1	0.1	0	0.1	11.3	11.4	22.6	22.5		
08 19 2014	0955	0.1	0.1	0	0.1	11.3	11.3	22.6	22.4		
09 15 2014	1241	4.1	4.15	0	0	11.3	11.3	22.6	22.4	1241	4.0
10 06 2014	1045	10.1	10	0	0.1	11.3	11.3	22.6	22.5	1045	10.0
(05480603) Prairie Creek at Otho, IA (S3)											
06 13 2013	1343		30.5	11.3	11.4	22.6	22.6	45.2	43.7		
07 16 2013	1547	20.9	20.9	0	0.2	11.3	11.5	22.6	22.5	1630	19.1
07 29 2013	1313	11.5	11.6	0	0.2	11.3	11.4	22.6	22.2	1350	11.0
08 27 2013	1242	0.1	0.2	0	0	11.3	11.3	22.6	22.1	1330	
03 20 2014	1015		1.8	0	0	11.3	11.3	22.6	22.4		
04 02 2014	1045	0.5	0.5	0	0	11.3	11.3	22.6	22.4	1230	0.3
05 07 2014	1130	0.2	0.3	0	0	11.3	11.3	22.6	22.5	1200	
06 04 2014	0840	2.1	2.2	0	0.1	11.3	11.4	22.6	22.5	925	2.0
07 01 2014	0846	16.8	17	0	0.1	11.3	11.3	22.6	22.5	1016	16.1
(422432094081701) Smeltzer East Oxbow Inlet near Otho, IA (S4)											
04 02 2014	0910			0	0	11.3	11.3	22.6	22.4		
05 07 2014	0845			0	0	11.3	11.4	22.6	22.6		
06 04 2014	1121	0.3	0.5	0	0.2	11.3	11.4	22.6	22.7		
07 01 2014	1125	2.4	2.3	0	0.3	11.6	11.6	22.6	22.7	1136	1.7
07 24 2014	1204	10.4	11.4	0	0.4	11.3	11.8	22.6	23		
08 04 2014	0855	0.3	0.2	0	0.3	11.3	11.8	22.6	23		
08 19 2014	1105	0.03	0.3	0	0.3	11.3	11.8				
09 15 2014	0843	14.1	14.3	0	0.3	11.3	11.2	22.6	22.8	843	13.5
10 06 2014	1350	18.3	18	0	0.3	11.3	11.7	22.6	22.7	1345	19.0

(422433094081801) Smeltzer East Oxbow Outlet near Otho, IA (S5)											
03 24 2014	1245			11.3	11.3						
04 02 2014	1008			0	0	11.3	11.3	22.6	22.4		
05 07 2014	1300			0	0	11.3	11.3	22.6	22.5		
06 04 2014	1055			0	0	11.3	11.4	22.6	22.5		
07 01 2014	1152	2.1	2.1	0	0	11.3	11.1	22.6	22.5	1215	1.7
07 24 2014	1246			0	0	11.3	11.3	22.6	22.4		
08 04 2014	0935	0	0.15	0	0.1	11.3	11.4	22.6	22.4		
08 19 2014	1128	1.8	1.8	0	0	11.3	11.3	22.6	22.4		
09 15 2014	1015	1.2	0.7	0	0.1	11.3	11.5	22.6	22.5	1015	0.3
10 06 2014	1256	4.25	4.5	0	0	11.3	11.2	22.6	22.3	1245	4.1

Calibration

The Hach NITRATAX nitrate sensors were calibrated during each maintenance visit to the study site (Appendix 1.6 – Table 3). Calibration was made after the sensor's optical window was cleaned using three known concentration standards that bracketed the expected range of nitrate-N. Most frequently, the nitrate sensors were calibrated to the 0.0 mg/L, 11.3 mg/L, and 22.6 mg/L standards. Because ambient nitrate-N concentrations exceeded 25 mg/L at times at some sites, the nitrate sensor was calibrated to the upper end of its range. The upper calibration was made using the 11.3 mg/L, 22.6 mg/L, and 45.2 mg/L standards. Deionized water was used as the zero mg/L standard , whereas the 11.3 mg/L, 22.6 mg/L, and 45.2 mg/L nitrate-N standards were obtained commercially from the Hach Corporation.

Sensor measurements of the zero nitrate-N standard were frequently (63 percent) in the 0.1 to 0.4 mg/L range (Appendix 1.6 – Table 3). Although these concentrations were substantially greater than zero, the sensor readings were within the manufacturers specifications for accuracy (plus or minus 3 percent of measured value plus 0.5 mg/L). Sensor measurements of the two standards in the middle part of the instruments range on average calibrated to less than 1.5 percent of the 11.3 mg/L and 22.6 mg/L standards (Appendix 1.6 – Table 3). The relative percent difference between the nitrate sensors and the 11.3 mg/L standard was 1.23 percent and between the sensor and 22.6 mg/L standard was 0.84 percent. At the high end of the sensors range, the relative percent difference between the sensor and 45.2 mg/L standard was 3.54 percent. However, the nitrate sensors were only calibrated four times with the 45.2 mg/L standard.

Comparison of NITRTAX sensor concentrations to laboratory analytical results

NITRATAX nitrate field sensors replaced laboratory analysis of discrete samples part way through the study as the primary method to measure nitrate-N concentrations at the Lyons and Prairie Creek study sites. Evaluation of the comparability of nitrate-N concentrations measured by each method was made to ensure that data could be used interchangeably. Nitrate-N concentrations from laboratory analysis of 20 ambient samples were compared to NITRATAX nitrate-N measurements after the sensor was cleaned during maintenance visits. The relative percent difference between nitrate-N concentrations determined analytically in the UMESC laboratory and those measured by the NITRATAX sensor in the field was 8.49 percent (Appendix 1.6 – Table 3).

Data limitations

The quality assurance and quality control data show that both laboratory analysis and field sensor measurement were able to produce accurate and precise concentration data that can be used to compute the transport load of selected nutrient species at the monitoring stations data. The analytical accuracy and the precision for nitrate-N, total nitrogen-N, orthophosphate-P, and total phosphorus-P were within the targeted range (relative percent difference of less than 10 percent). The overall precision for the phosphorus species was greater than 10 percent, but when one replicate sample with large differences was removed, the average relative percent difference was less than 10 percent. Because reproducibility in all but one replicate sample were within the targeted range, orthophosphate-P and total phosphorus-P data are acceptable for documenting the occurrence and transport through the study wetlands. The precision of ammonia concentrations may be suspect as RPD greater than 10 percent and these data should be used with caution.

Nitrate-N concentrations determined analytically and those measured in the field with the nitrate sensor are directly comparable. Although there was a general trend in that the NITRATAX sensor measured smaller nitrate-N concentrations than was determined by laboratory analysis, differences were within the targeted range. Nitrate-N data collected with the nitrate sensors are suitable for comparison between sites and for calculating nitrate-N loads transported through the study wetlands and streams.

Appendix 2.—Hydrologic data

Appendix 2.1—Precipitation in the Lyons Creek study area

1 U.S. DEPARTMENT OF THE INTERIOR - U.S. GEOLOGICAL SURVEY - WATER RESOURCES

STATION:422935093460401 Lyons Oxbow Inlet near Webster City, IA (L1) TYPE:WETLAND AGENCY:USGS STATE:19 COUNTY:079
LATITUDE: 422935.6 LONGITUDE: 0934604.0 NAD83 DATUM:
Lowest aging status in period is APPROVED
Precipitation, total, inches
WATER YEAR OCTOBER 2012 TO SEPTEMBER 2013
DAILY SUM VALUES

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	---	---	---	---	0.00	0.00	0.00	0.34	0.12	0.00	0.00	---
2	---	---	---	---	0.00	0.00	0.00	1.15	0.01	0.00	0.07	---
3	---	---	---	---	0.00	0.00	0.00	0.12	0.01	0.00	0.01	---
4	---	---	---	---	0.00	0.01	0.00	0.10	0.05	0.00	0.00	---
5	---	---	---	---	0.00	0.00	0.00	0.00	0.04	0.00	0.00	---
6	---	---	---	---	0.00	0.00	0.05	0.01	0.01	0.00	0.07	---
7	---	---	---	---	0.00	0.00	0.00	0.00	0.00	0.00	0.01	---
8	---	---	---	---	0.00	0.04	0.00	0.06	0.04	0.07	0.00	---
9	---	---	---	---	0.01	0.81	2.15	0.45	0.01	0.04	0.00	---
10	---	---	---	---	0.23	0.34	0.42	0.00	0.19	0.02	0.00	---
11	---	---	---	---	0.00	0.01	0.49	0.00	0.01	0.02	0.02	---
12	---	---	---	---	0.00	0.00	0.00	0.00	0.32	0.00	0.01	---
13	---	---	---	---	0.00	0.00	0.02	0.00	0.00	0.00	0.00	---
14	---	---	---	---	0.00	0.07	0.99	0.00	0.07	0.00	0.00	---
15	---	---	---	0.00	0.00	0.00	0.00	0.00	0.20	0.00	0.00	---
16	---	---	---	---	0.00	0.00	0.00	1.08	0.00	0.06	0.00	---
17	---	---	---	---	0.00	0.00	0.99	0.00	0.00	0.00	0.00	---
18	---	---	---	---	0.00	0.00	0.70	0.00	0.00	0.00	0.00	---
19	---	---	---	---	0.00	0.00	0.00	1.02	0.00	0.06	0.00	---
20	---	---	---	---	0.00	0.00	0.00	0.01	0.00	0.00	0.00	---
21	---	---	---	---	0.00	0.00	0.30	0.00	0.00	0.00	0.00	---
22	---	---	---	---	0.01	0.00	0.33	0.04	0.00	0.76	0.08	---
23	---	---	---	0.00	0.06	0.00	0.00	0.01	0.34	0.00	0.00	---
24	---	---	---	0.00	0.06	0.00	0.00	0.03	2.55	0.00	0.01	---
25	---	---	---	0.00	0.01	0.02	0.00	1.50	0.06	0.13	0.00	---
26	---	---	---	0.00	0.02	0.00	0.00	1.10	0.04	0.01	0.00	---
27	---	---	---	0.01	0.00	0.00	0.00	0.57	0.00	0.00	0.00	---
28	---	---	---	0.06	0.00	0.00	0.00	0.08	0.00	0.00	---	---
29	---	---	---	0.01	---	0.00	0.02	0.19	0.00	0.00	---	---
30	---	---	---	0.00	---	0.00	0.21	0.02	0.00	0.02	---	---
31	---	---	---	0.00	---	0.00	---	0.00	---	0.00	---	---

Appendix 2.2—Precipitation in the Prairie Creek study area

1 U.S. DEPARTMENT OF THE INTERIOR - U.S. GEOLOGICAL SURVEY - WATER RESOURCES

STATION:422433094081801 Smeltzer Oxbows TYPE:WETLAND AGENCY:USGS STATE:19 COUNTY:187
LATITUDE: 422433.9 LONGITUDE: 0940818.7 NAD83 DATUM:
Lowest aging status in period is APPROVED
DD #8
Precipitation, total, inches
WATER YEAR OCTOBER 2012 TO SEPTEMBER 2013
DAILY SUM VALUES

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	---	---	---	---	0.00	0.00	0.00	0.54	0.22	0.00	0.00	0.03
2	---	---	---	---	0.00	0.00	0.00	0.96	0.00	0.00	0.06	0.00
3	---	---	---	---	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	---	---	---	---	0.00	0.03	0.00	0.19	0.31	0.00	0.00	0.00
5	---	---	---	---	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.02
6	---	---	---	---	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00
7	---	---	---	---	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05
8	---	---	---	---	0.00	0.08	0.00	0.07	0.06	0.00	0.00	0.00
9	---	---	---	---	0.03	0.67	1.75	0.38	0.05	0.07	0.00	0.00
10	---	---	---	---	0.22	0.31	0.27	0.00	0.03	0.00	0.00	0.01
11	---	---	---	---	0.00	0.01	0.34	0.00	0.18	0.00	0.80	0.00
12	---	---	---	---	0.00	0.00	0.00	0.00	0.32	0.00	0.00	0.00
13	---	---	---	---	0.00	0.00	0.02	0.00	0.00	0.00	0.01	0.00
14	---	---	---	---	0.00	0.01	1.14	0.00	0.03	0.00	0.00	0.00
15	---	---	---	---	0.00	0.00	0.00	0.00	0.34	0.00	0.00	0.00
16	---	---	---	---	0.00	0.00	0.00	0.26	0.00	0.00	0.00	0.00
17	---	---	---	---	0.00	0.00	1.10	0.00	0.00	0.00	0.00	0.01
18	---	---	---	---	0.00	0.00	0.64	0.00	0.00	0.00	0.00	0.00
19	---	---	---	---	0.00	0.00	0.00	0.41	0.00	0.00	0.00	0.00
20	---	---	---	---	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.01
21	---	---	---	---	0.00	0.00	0.30	0.00	0.00	0.00	0.00	0.00
22	---	---	---	---	0.07	0.00	0.57	0.04	0.00	0.00	0.00	0.00
23	---	---	---	0.00	0.01	0.00	0.00	0.02	0.25	0.00	0.00	0.00
24	---	---	---	0.00	0.00	0.00	0.01	0.08	1.30	0.00	0.00	0.00
25	---	---	---	0.00	0.00	0.00	0.00	1.39	0.74	0.01	0.00	0.00
26	---	---	---	0.00	0.01	0.00	0.00	0.81	0.00	0.00	0.00	0.00
27	---	---	---	0.01	0.00	0.00	0.00	1.22	0.00	0.00	0.00	0.00
28	---	---	---	0.23	0.00	0.00	0.00	0.15	0.00	0.00	0.00	0.08
29	---	---	---	0.01	---	0.00	0.07	0.40	0.10	0.00	0.00	0.00
30	---	---	---	0.00	---	0.07	0.30	0.25	0.00	0.03	0.00	0.00
31	---	---	---	0.00	---	0.00	---	0.01	---	0.00	0.00	---

1 U.S. DEPARTMENT OF THE INTERIOR - U.S. GEOLOGICAL SURVEY - WATER RESOURCES

STATION:422433094081801 Smeltzer Oxbows TYPE:WETLAND AGENCY:USGS STATE:19 COUNTY:187
LATITUDE: 422433.9 LONGITUDE: 0940818.7 NAD83 DATUM:
Lowest aging status in period is APPROVED
DD #8
Precipitation, total, inches
WATER YEAR OCTOBER 2013 TO SEPTEMBER 2014
DAILY SUM VALUES

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	0.00	0.00	---	---	---	---	0.00	0.06	0.06	*1.30	0.00	0.01
2	0.00	0.00	---	---	---	---	0.00	0.00	0.01	*0.00	0.00	0.17
3	0.08	0.00	---	---	---	---	0.20	0.00	0.68	0.00	0.00	0.00
4	0.76	---	---	---	---	---	0.03	0.06	0.03	0.00	0.00	0.00
5	0.00	---	---	---	---	---	0.00	0.00	0.00	0.76	0.00	0.58
6	0.14	---	---	---	---	---	0.02	0.00	0.00	0.00	1.27	0.00
7	0.00	---	---	---	---	---	0.11	0.00	0.00	0.00	0.02	0.00
8	0.00	---	---	---	---	---	0.00	0.37	0.00	0.00	0.00	0.13
9	0.00	---	---	---	---	---	0.00	0.00	0.00	0.15	0.00	0.45
10	0.00	---	---	---	---	---	0.00	0.04	0.00	0.00	0.00	0.04
11	0.03	---	---	---	---	---	0.00	0.69	0.00	0.09	0.00	0.00
12	0.00	---	---	---	---	---	0.81	1.03	0.00	0.26	0.00	0.29
13	0.00	---	---	---	---	---	0.86	0.00	0.00	0.05	0.00	0.00
14	0.42	---	---	---	---	---	0.00	0.00	0.01	0.03	0.00	0.00
15	0.08	---	---	---	---	---	0.00	0.08	0.01	0.00	0.27	0.02
16	0.00	---	---	---	---	---	0.00	0.00	1.07	0.00	0.00	0.00
17	0.00	---	---	---	---	---	0.00	0.00	1.58	0.00	0.00	0.00
18	0.00	---	---	---	---	---	0.00	0.00	0.05	0.00	0.00	0.00
19	0.01	---	---	---	---	---	0.00	0.02	0.09	0.00	0.00	0.00
20	0.00	---	---	---	---	---	0.01	0.00	0.00	0.00	0.35	0.60
21	0.00	---	---	---	---	---	0.13	0.00	0.00	0.00	0.01	0.00
22	0.17	---	---	---	---	---	0.00	0.00	*0.01	0.01	0.00	0.00
23	0.04	---	---	---	---	---	0.12	0.00	*0.85	0.00	0.67	0.00
24	0.00	---	---	---	---	---	0.09	0.00	*0.00	0.19	0.02	0.66
25	0.00	---	---	---	---	---	0.00	0.00	*0.00	0.38	0.15	0.00
26	0.00	---	---	---	---	---	0.00	1.13	*0.00	0.00	0.23	0.00
27	0.00	---	---	---	---	---	0.75	0.03	*0.28	0.00	0.00	0.23
28	0.00	---	---	---	---	---	0.14	0.00	*0.49	0.00	0.76	0.00
29	0.00	---	---	---	---	0.00	0.15	0.00	*1.31	0.00	1.15	0.00
30	0.22	---	---	---	---	0.00	0.49	0.00	*1.05	0.00	0.06	0.56
31	0.00	---	---	---	---	0.03	---	0.00	---	0.00	1.20	---

* Data from NOAA(2015) 1.6 mile east northeast Fort Dodge, IA

Appendix 2.3—Discharge, Lyons oxbow inlet near Webster City, IA (L1)

1 U.S. DEPARTMENT OF THE INTERIOR - U.S. GEOLOGICAL SURVEY - WATER RESOURCES

STATION:422935093460401 Lyons Oxbow Inlet near Webster City, IA (L1) TYPE:WETLAND AGENCY:USGS STATE:19 COUNTY:079
LATITUDE: 422935.6 LONGITUDE: 0934604.0 NAD83 DATUM:
Lowest aging status in period is APPROVED
DD #2
Discharge, cubic feet per second
WATER YEAR OCTOBER 2012 TO SEPTEMBER 2013
DAILY MEAN VALUES

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	---	---	---	---	0.00	0.00	0.01	0.06	0.43	0.24	e0.00	0.00
2	---	---	---	---	0.00	0.00	0.00	0.17	0.37	0.21	e0.00	0.00
3	---	---	---	---	0.00	0.00	0.00	0.41	0.33	0.19	e0.00	0.00
4	---	---	---	---	0.00	0.00	0.00	0.79	0.30	0.17	e0.00	0.00
5	---	---	---	---	0.00	0.00	0.00	0.75	0.29	0.15	e0.00	0.00
6	---	---	---	---	0.00	0.00	0.00	0.53	0.26	0.13	e0.00	0.00
7	---	---	---	---	0.00	0.00	0.00	0.41	0.23	0.11	0.00	0.00
8	---	---	---	---	0.00	0.00	0.00	0.34	0.22	0.08	0.00	0.00
9	---	---	---	---	0.00	0.18	0.06	0.39	0.22	0.07	0.00	0.00
10	---	---	---	---	0.00	0.04	0.17	0.38	0.21	0.06	0.00	0.00
11	---	---	---	---	0.00	0.02	0.17	0.29	0.20	0.05	0.00	0.00
12	---	---	---	---	e0.00	0.02	0.14	0.24	0.22	0.03	0.00	0.00
13	---	---	---	---	e0.00	0.01	0.10	0.21	0.19	0.03	0.00	0.00
14	---	---	---	---	0.00	0.01	0.20	0.17	e0.16	0.02	0.00	0.00
15	---	---	---	---	0.00	0.03	0.20	0.13	0.14	0.02	0.00	0.00
16	---	---	---	---	0.00	0.08	0.14	0.14	0.13	0.01	0.00	0.00
17	---	---	---	---	0.00	0.06	0.20	0.36	0.11	0.01	0.00	0.00
18	---	---	---	---	0.00	0.05	0.65	0.28	0.10	0.01	0.00	0.00
19	---	---	---	---	0.00	0.04	0.43	0.30	0.09	0.01	0.00	0.00
20	---	---	---	---	0.00	0.04	0.28	0.67	0.08	0.01	0.00	0.00
21	---	---	---	---	0.00	0.05	0.23	0.43	0.08	0.01	0.00	0.00
22	---	---	---	0.00	0.00	0.07	0.24	0.33	0.07	0.01	0.00	0.00
23	---	---	---	0.00	0.00	0.05	0.28	0.28	0.06	0.00	0.00	0.00
24	---	---	---	0.00	0.00	0.03	0.23	0.26	1.3	0.00	0.00	0.00
25	---	---	---	0.00	0.00	0.02	0.18	1.0	2.2	0.00	0.00	0.00
26	---	---	---	0.00	0.00	0.02	0.16	1.7	1.4	e0.00	0.00	0.00
27	---	---	---	0.00	0.00	0.02	0.13	2.0	0.76	e0.00	0.00	0.00
28	---	---	---	0.00	0.00	0.02	0.11	1.3	0.54	e0.00	0.00	0.00
29	---	---	---	0.00	---	0.02	0.09	0.83	0.37	e0.00	0.00	0.00
30	---	---	---	0.00	---	0.02	0.07	0.66	0.28	e0.00	0.00	0.00
31	---	---	---	0.00	---	0.01	---	0.52	---	e0.00	0.00	---

1 U.S. DEPARTMENT OF THE INTERIOR - U.S. GEOLOGICAL SURVEY - WATER RESOURCES

STATION:422935093460401 Lyons Oxbow Inlet near Webster City, IA (L1) TYPE:WETLAND AGENCY:USGS STATE:19 COUNTY:079
LATITUDE: 422935.6 LONGITUDE: 0934604.0 NAD83 DATUM:
Lowest aging status in period is APPROVED
DD #2
Discharge, cubic feet per second
WATER YEAR OCTOBER 2013 TO SEPTEMBER 2014
DAILY MEAN VALUES

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	0.00	0.00	---	---	---	---	---	---	---	---	---	---
2	0.00	0.00	---	---	---	---	---	---	---	---	---	---
3	0.00	0.00	---	---	---	---	---	---	---	---	---	---
4	0.00	---	---	---	---	---	---	---	---	---	---	---
5	0.00	---	---	---	---	---	---	---	---	---	---	---
6	0.00	---	---	---	---	---	---	---	---	---	---	---
7	0.00	---	---	---	---	---	---	---	---	---	---	---
8	0.00	---	---	---	---	---	---	---	---	---	---	---
9	0.00	---	---	---	---	---	---	---	---	---	---	---
10	0.00	---	---	---	---	---	---	---	---	---	---	---
11	0.00	---	---	---	---	---	---	---	---	---	---	---
12	0.00	---	---	---	---	---	---	---	---	---	---	---
13	0.00	---	---	---	---	---	---	---	---	---	---	---
14	0.00	---	---	---	---	---	---	---	---	---	---	---
15	0.00	---	---	---	---	---	---	---	---	---	---	---
16	0.00	---	---	---	---	---	---	---	---	---	---	---
17	0.00	---	---	---	---	---	---	---	---	---	---	---
18	0.00	---	---	---	---	---	---	---	---	---	---	---
19	0.00	---	---	---	---	---	---	---	---	---	---	---
20	0.00	---	---	---	---	---	---	---	---	---	---	---
21	0.00	---	---	---	---	---	---	---	---	---	---	---
22	0.00	---	---	---	---	---	---	---	---	---	---	---
23	0.00	---	---	---	---	---	---	---	---	---	---	---
24	0.00	---	---	---	---	---	---	---	---	---	---	---
25	0.00	---	---	---	---	---	---	---	---	---	---	---
26	0.00	---	---	---	---	---	---	---	---	---	---	---
27	0.00	---	---	---	---	---	---	---	---	---	---	---
28	0.00	---	---	---	---	---	---	---	---	---	---	---
29	0.00	---	---	---	---	---	---	---	---	---	---	---
30	0.00	---	---	---	---	---	---	---	---	---	---	---
31	0.00	---	---	---	---	---	---	---	---	---	---	---

Appendix 2.4 – Discharge, Lyons oxbow outlet near Webster City, IA (L2)

U.S. DEPARTMENT OF THE INTERIOR - U.S. GEOLOGICAL SURVEY - WATER RESOURCES

STATION:422935093460001 Lyons Oxbow Outlet near Webster City, IA (L2) TYPE:WETLAND AGENCY:USGS STATE:19 COUNTY:079
LATITUDE: 422935.7 LONGITUDE: 0934600.8 NAD83 DATUM:
Lowest aging status in period is APPROVED
Discharge, cubic feet per second
WATER YEAR OCTOBER 2012 TO SEPTEMBER 2013
DAILY MEAN VALUES

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	---	---	---	---	0.00	0.00	0.01	0.06	0.47	0.24	0.00	0.00
2	---	---	---	---	0.00	0.00	0.01	0.18	0.38	0.21	0.00	0.00
3	---	---	---	---	0.00	0.00	0.01	0.44	0.34	0.18	0.00	0.00
4	---	---	---	---	0.00	0.00	0.01	1.2	0.32	0.15	0.00	0.00
5	---	---	---	---	0.00	0.00	0.01	1.1	0.29	0.12	0.00	0.00
6	---	---	---	---	0.00	0.00	0.01	0.54	0.27	0.10	0.00	0.00
7	---	---	---	---	0.00	0.00	0.01	0.43	0.23	0.08	0.00	0.00
8	---	---	---	---	e0.00	0.00	0.00	0.35	0.21	0.12	0.00	0.00
9	---	---	---	---	e0.00	e0.97	0.06	0.39	0.21	0.13	0.00	0.00
10	---	---	---	---	e0.00	e0.47	0.20	0.38	0.20	0.04	0.00	0.00
11	---	---	---	---	0.00	0.04	0.20	0.30	0.18	0.03	0.00	0.00
12	---	---	---	---	e0.00	e0.02	0.16	0.25	0.22	0.03	0.00	0.00
13	---	---	---	---	e0.00	e0.02	0.11	0.21	0.20	0.02	0.00	0.00
14	---	---	---	---	e0.00	e0.02	0.21	0.17	0.17	0.02	0.00	0.00
15	---	---	---	---	e0.00	e0.25	0.23	0.13	0.16	0.02	0.00	0.00
16	---	---	---	---	e0.00	e0.50	0.16	0.13	0.13	0.01	0.00	0.00
17	---	---	---	---	e0.00	0.09	0.23	0.36	0.12	0.01	0.00	0.00
18	---	---	---	---	e0.00	0.05	0.72	0.27	0.10	0.01	0.00	0.00
19	---	---	---	---	e0.00	0.04	0.47	0.30	0.08	0.01	0.00	0.00
20	---	---	---	---	e0.00	0.04	0.31	0.69	0.07	0.01	0.00	0.00
21	---	---	---	---	0.00	0.06	0.26	0.44	0.06	0.00	0.00	0.00
22	---	---	---	0.00	0.00	0.07	0.26	0.33	0.06	0.01	0.00	0.00
23	---	---	---	0.00	0.00	0.06	0.30	0.26	0.06	0.01	0.00	0.00
24	---	---	---	0.00	0.00	0.03	0.25	0.23	e6.9	0.00	0.00	0.00
25	---	---	---	0.00	0.00	0.02	0.20	1.8	5.0	0.00	0.00	0.00
26	---	---	---	0.00	0.00	0.02	0.17	e8.0	1.9	0.01	0.00	0.00
27	---	---	---	0.00	0.00	0.02	0.14	e12	0.83	0.01	0.00	0.00
28	---	---	---	0.00	0.00	0.03	0.12	1.3	0.57	e0.02	0.00	0.00
29	---	---	---	0.00	---	0.02	0.10	0.95	0.39	e0.01	0.00	0.00
30	---	---	---	0.00	---	0.02	0.08	1.3	0.29	e0.00	0.00	0.00
31	---	---	---	0.00	---	0.02	---	0.74	---	e0.00	0.00	---

1 U.S. DEPARTMENT OF THE INTERIOR - U.S. GEOLOGICAL SURVEY - WATER RESOURCES

STATION:422935093460001 Lyons Oxbow Outlet near Webster City, IA (L2) TYPE:WETLAND AGENCY:USGS STATE:19 COUNTY:079
LATITUDE: 422935.7 LONGITUDE: 0934600.8 NAD83 DATUM:
Lowest aging status in period is APPROVED
Discharge, cubic feet per second
WATER YEAR OCTOBER 2013 TO SEPTEMBER 2014
DAILY MEAN VALUES

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	0.00	0.00	---	---	---	---	---	---	---	---	---	---
2	0.00	0.00	---	---	---	---	---	---	---	---	---	---
3	0.00	0.00	---	---	---	---	---	---	---	---	---	---
4	0.00	---	---	---	---	---	---	---	---	---	---	---
5	0.00	---	---	---	---	---	---	---	---	---	---	---
6	0.00	---	---	---	---	---	---	---	---	---	---	---
7	0.00	---	---	---	---	---	---	---	---	---	---	---
8	0.00	---	---	---	---	---	---	---	---	---	---	---
9	0.00	---	---	---	---	---	---	---	---	---	---	---
10	0.00	---	---	---	---	---	---	---	---	---	---	---
11	0.00	---	---	---	---	---	---	---	---	---	---	---
12	0.00	---	---	---	---	---	---	---	---	---	---	---
13	0.00	---	---	---	---	---	---	---	---	---	---	---
14	0.00	---	---	---	---	---	---	---	---	---	---	---
15	0.00	---	---	---	---	---	---	---	---	---	---	---
16	0.00	---	---	---	---	---	---	---	---	---	---	---
17	0.00	---	---	---	---	---	---	---	---	---	---	---
18	0.00	---	---	---	---	---	---	---	---	---	---	---
19	0.00	---	---	---	---	---	---	---	---	---	---	---
20	0.00	---	---	---	---	---	---	---	---	---	---	---
21	0.00	---	---	---	---	---	---	---	---	---	---	---
22	0.00	---	---	---	---	---	---	---	---	---	---	---
23	0.00	---	---	---	---	---	---	---	---	---	---	---
24	0.00	---	---	---	---	---	---	---	---	---	---	---
25	0.00	---	---	---	---	---	---	---	---	---	---	---
26	0.00	---	---	---	---	---	---	---	---	---	---	---
27	0.00	---	---	---	---	---	---	---	---	---	---	---
28	0.00	---	---	---	---	---	---	---	---	---	---	---
29	0.00	---	---	---	---	---	---	---	---	---	---	---
30	0.00	---	---	---	---	---	---	---	---	---	---	---
31	0.00	---	---	---	---	---	---	---	---	---	---	---

e Estimated

Appendix 2.5—Altitude of water in Smeltzer West oxbow

1 U.S. DEPARTMENT OF THE INTERIOR - U.S. GEOLOGICAL SURVEY - WATER RESOURCES

STATION:422432094081701 Smeltzer East Oxbow TYPE:WETLAND AGENCY:USGS STATE:19 COUNTY:187
LATITUDE: 422432.6 LONGITUDE: 0940817.9 NAD83 DATUM:
Lowest aging status in period is WORKING
DD #2, oxbow
Gage height, feet
WATER YEAR OCTOBER 2012 TO SEPTEMBER 2013
DAILY MEAN VALUES

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	---	---	---	---	3.786	5.321	8.349	8.558	8.715	8.511	7.159	6.204
2	---	---	---	---	3.787	5.306	8.305	8.783	8.692	8.496	7.125	6.166
3	---	---	---	---	3.788	5.300	8.265	9.124	8.651	8.479	7.098	6.133
4	---	---	---	---	---	5.296	8.228	9.288	8.572	8.464	7.059	6.107
5	---	---	---	---	---	---	8.189	9.148	8.586	8.449	7.024	6.081
6	---	---	---	---	---	---	8.157	8.698	8.571	8.424	6.992	6.054
7	---	---	---	---	---	---	8.123	8.585	8.560	8.394	6.957	6.022
8	---	---	---	---	---	5.244	8.094	8.614	8.574	8.364	6.918	6.003
9	---	---	---	---	---	8.297	8.166	8.737	8.660	8.337	6.883	5.981
10	---	---	---	---	4.224	8.524	8.348	8.669	8.669	8.299	6.844	5.947
11	---	---	---	---	4.537	8.543	8.432	8.574	8.656	8.244	6.823	5.927
12	---	---	---	---	4.572	8.481	8.417	8.596	8.685	8.189	6.879	5.896
13	---	---	---	---	4.841	8.408	8.393	8.601	8.617	8.131	6.838	5.860
14	---	---	---	---	5.266	8.388	8.458	8.610	8.577	8.086	6.796	5.831
15	---	---	---	---	5.315	8.510	8.446	8.586	8.606	8.038	6.761	5.807
16	---	---	---	---	5.301	8.486	8.420	8.581	8.607	7.981	6.723	5.787
17	---	---	---	---	5.298	8.428	8.535	8.611	8.584	7.928	6.687	5.782
18	---	---	---	---	5.305	8.412	8.822	8.618	8.549	7.865	6.651	5.800
19	---	---	---	---	5.267	8.379	8.601	8.632	8.493	7.799	6.618	5.792
20	---	---	---	---	5.225	8.339	8.550	8.657	8.472	7.738	6.586	5.852
21	---	---	---	---	5.226	8.294	8.563	8.606	8.456	7.684	6.554	5.841
22	---	---	---	---	5.262	8.259	8.631	8.544	8.441	7.627	6.527	5.813
23	---	---	---	0.993	5.281	8.230	8.751	8.521	8.435	7.565	6.499	5.793
24	---	---	---	0.992	5.269	8.195	8.614	8.498	8.878	7.510	6.477	5.776
25	---	---	---	0.994	5.280	8.165	8.599	8.857	9.292	7.459	6.460	5.697
26	---	---	---	0.993	5.294	8.144	8.575	9.206	8.607	7.407	6.439	5.641
27	---	---	---	0.995	5.311	8.254	8.559	9.704	8.553	7.349	6.376	5.619
28	---	---	---	0.997	5.310	8.529	8.554	9.188	8.536	7.300	6.319	5.604
29	---	---	---	0.997	---	8.509	8.549	8.776	8.534	7.254	6.285	5.587
30	---	---	---	0.995	---	8.460	8.550	8.997	8.516	7.223	6.254	5.566
31	---	---	---	2.115	---	8.407	---	8.727	---	7.197	6.222	---

1 U.S. DEPARTMENT OF THE INTERIOR - U.S. GEOLOGICAL SURVEY - WATER RESOURCES

STATION:422432094081701 Smeltzer East Oxbow TYPE:WETLAND AGENCY:USGS STATE:19 COUNTY:187
LATITUDE: 422432.6 LONGITUDE: 0940817.9 NAD83 DATUM:
Lowest aging status in period is WORKING
DD #2, oxbow
Gage height, feet
WATER YEAR OCTOBER 2013 TO SEPTEMBER 2014
DAILY MEAN VALUES

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	5.545	5.460	5.390	5.000	4.193	5.710	7.870	7.745	8.230	---	7.789	8.678
2	5.523	5.454	5.393	4.982	4.283	5.605	7.849	7.755	8.188	8.817	7.738	8.505
3	5.518	5.440	5.401	4.892	4.234	5.538	7.837	7.746	8.140	8.530	7.690	8.457
4	5.574	5.430	5.416	5.009	4.293	5.511	7.851	7.735	8.172	8.475	7.640	8.443
5	5.602	5.468	5.375	4.927	4.350	5.482	7.829	7.718	8.135	8.552	7.601	8.500
6	5.592	5.556	5.296	4.698	4.193	5.510	7.811	7.692	8.096	8.519	7.654	8.489
7	5.594	5.553	5.204	4.688	4.021	5.565	7.802	7.670	8.049	8.497	7.714	8.479
8	5.569	5.547	5.197	4.739	3.944	5.629	7.788	7.674	7.992	8.482	7.693	8.485
9	5.544	5.542	5.300	4.682	3.928	5.897	7.760	7.670	7.944	8.477	7.658	8.516
10	5.522	5.537	5.315	4.769	3.928	6.655	7.733	7.649	7.907	8.475	7.622	8.587
11	5.512	5.531	5.307	5.061	3.890	7.625	7.703	7.652	7.872	8.472	7.586	8.555
12	5.495	5.514	5.294	5.059	3.858	7.986	7.692	8.068	7.823	8.510	7.538	8.583
13	5.473	5.503	5.305	5.269	4.003	8.121	7.822	8.263	7.767	8.496	7.490	8.582
14	5.460	5.515	5.325	5.406	4.269	8.392	7.903	8.285	7.717	8.474	7.452	8.575
15	5.515	5.512	5.301	5.255	4.228	8.424	7.893	8.275	7.672	8.452	7.440	8.571
16	5.508	5.520	5.283	5.205	4.236	8.366	7.884	8.258	7.632	8.438	7.429	8.556
17	5.498	5.547	5.307	5.067	4.362	8.308	7.862	8.233	9.132	8.420	7.403	8.537
18	5.483	5.557	5.311	4.953	5.057	8.272	7.840	8.198	8.636	8.391	7.369	8.518
19	5.474	5.550	5.340	5.069	5.757	8.237	7.819	8.164	8.562	8.358	7.341	8.503
20	5.464	5.540	5.317	5.405	5.964	8.192	7.798	8.131	8.538	8.320	7.340	8.587
21	5.449	5.531	5.255	5.111	6.050	8.154	7.787	8.096	8.508	8.280	7.289	8.555
22	5.459	5.464	5.233	4.775	6.034	8.099	7.756	8.041	8.515	8.238	7.239	8.539
23	5.461	5.440	5.193	4.394	6.022	8.044	7.734	7.996	8.514	8.182	7.270	8.537
24	5.457	5.406	5.098	4.345	5.985	8.003	7.736	7.953	8.480	8.134	7.272	8.662
25	5.451	5.404	5.148	4.793	5.962	7.976	7.719	7.912	8.441	8.148	7.254	8.629
26	5.445	5.430	5.234	4.918	5.944	7.956	---	7.920	8.398	8.110	7.236	8.614
27	5.433	5.395	5.254	4.707	5.912	7.932	---	8.405	8.601	8.060	7.206	8.651
28	5.427	5.394	5.355	4.232	5.896	7.934	---	8.392	8.729	8.001	7.226	8.631
29	5.427	5.372	5.372	4.182	---	7.916	7.664	8.353	8.767	7.943	7.643	8.623
30	5.446	5.394	5.043	4.375	---	7.904	7.690	8.314	9.500	7.891	7.784	8.636
31	5.463	---	5.002	4.414	---	7.901	---	8.274	---	7.839	7.859	---

Appendix 2.6—Discharge, Smeltzer West oxbow inlet near Otho, IA (S1)

1 U.S. DEPARTMENT OF THE INTERIOR - U.S. GEOLOGICAL SURVEY - WATER RESOURCES

STATION:422436094082501 Smeltzer West Oxbow Inlet near Otho, IA (S1) TYPE:WETLAND AGENCY:USGS STATE:19 COUNTY:187
LATITUDE: 422436.7 LONGITUDE: 0940825.1 NAD83 DATUM:
Lowest aging status in period is APPROVED
DD #4
Discharge, cubic feet per second
WATER YEAR OCTOBER 2012 TO SEPTEMBER 2013
DAILY MEAN VALUES

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	---	---	---	---	0.000	0.000	0.00	0.022	0.095	0.043	0.000	0.000
2	---	---	---	---	0.000	0.000	0.00	0.158	0.081	0.037	0.000	0.000
3	---	---	---	---	0.000	0.000	0.000	0.219	0.066	0.032	0.000	0.000
4	---	---	---	---	0.000	0.000	0.000	0.324	0.058	0.027	0.000	0.000
5	---	---	---	---	0.000	0.000	0.000	0.267	0.062	0.023	0.000	0.000
6	---	---	---	---	0.000	0.000	0.000	0.143	0.055	0.019	0.000	0.000
7	---	---	---	---	0.000	0.000	0.000	0.106	0.047	0.015	0.000	0.000
8	---	---	---	---	0.000	0.000	0.000	0.082	0.043	0.012	0.000	0.000
9	---	---	---	---	0.000	0.000	0.000	0.096	0.057	0.010	0.000	0.000
10	---	---	---	---	0.000	0.003	0.012	0.089	0.057	0.008	0.000	0.000
11	---	---	---	---	0.000	0.000	0.013	0.067	0.052	0.006	0.000	0.000
12	---	---	---	---	0.000	0.000	0.008	0.052	0.056	0.004	0.000	0.000
13	---	---	---	---	0.000	e0.00	0.005	0.046	0.050	0.004	0.000	0.000
14	---	---	---	---	0.000	0.000	0.019	0.042	0.044	0.003	0.000	0.000
15	---	---	---	---	0.000	e0.00	0.016	0.036	0.050	0.002	0.000	0.000
16	---	---	---	---	0.000	e0.00	0.010	0.033	0.051	0.002	0.000	0.000
17	---	---	---	---	0.000	e0.00	0.028	0.032	0.045	0.002	0.000	0.000
18	---	---	---	---	0.000	0.00	0.131	0.031	0.038	0.002	0.000	0.000
19	---	---	---	---	0.000	e0.00	0.068	0.031	0.036	0.001	0.000	0.000
20	---	---	---	---	0.000	e0.00	0.040	0.037	0.036	0.001	0.000	0.000
21	---	---	---	---	0.000	e0.00	0.033	0.037	0.033	0.001	0.000	0.00
22	---	---	---	---	0.000	e0.00	0.062	0.031	0.030	0.001	0.000	0.000
23	---	---	---	0.000	0.000	e0.00	0.090	0.027	0.027	0.000	0.000	0.000
24	---	---	---	0.000	0.00	e0.00	0.053	0.026	0.187	0.000	0.000	0.000
25	---	---	---	0.000	0.000	e0.00	0.039	0.192	0.324	0.000	0.000	0.000
26	---	---	---	0.000	0.000	e0.00	0.032	0.295	0.176	0.000	0.000	0.000
27	---	---	---	0.000	0.000	e0.00	0.027	0.40	0.114	0.000	0.000	0.000
28	---	---	---	0.000	0.000	0.005	0.024	0.213	0.086	0.000	0.000	0.000
29	---	---	---	0.000	---	0.008	0.020	0.188	0.065	0.000	0.000	0.000
30	---	---	---	0.000	---	0.009	0.019	0.250	0.051	0.000	0.000	0.000
31	---	---	---	0.000	---	0.002	---	0.141	---	0.000	0.000	---

1 U.S. DEPARTMENT OF THE INTERIOR - U.S. GEOLOGICAL SURVEY - WATER RESOURCES

STATION:422436094082501 Smeltzer West Oxbow Inlet near Otho, IA (S1) TYPE:WETLAND AGENCY:USGS STATE:19 COUNTY:187
LATITUDE: 422436.7 LONGITUDE: 0940825.1 NAD83 DATUM:
Lowest aging status in period is APPROVED
DD #4
Discharge, cubic feet per second
WATER YEAR OCTOBER 2013 TO SEPTEMBER 2014
DAILY MEAN VALUES

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	0.000	0.000	---	---	---	---	0.000	e0.003	0.015	0.318	0.005	0.085
2	0.000	0.000	---	---	---	---	0.000	e0.004	0.013	0.180	0.004	0.044
3	0.000	0.000	---	---	---	---	0.000	e0.004	0.012	0.134	0.004	0.031
4	0.000	---	---	---	---	---	0.000	e0.003	0.017	0.105	0.003	0.021
5	0.000	---	---	---	---	---	0.000	e0.003	0.020	0.142	0.003	0.027
6	0.000	---	---	---	---	---	0.000	e0.003	0.018	0.139	0.005	0.031
7	0.000	---	---	---	---	---	0.000	e0.003	0.017	0.106	0.007	0.022
8	0.000	---	---	---	---	---	0.000	0.003	0.015	0.083	0.006	0.018
9	0.000	---	---	---	---	---	0.000	0.003	0.014	0.067	0.005	0.019
10	0.000	---	---	---	---	---	0.000	0.003	0.013	0.057	0.005	0.040
11	0.000	---	---	---	---	---	0.000	0.003	0.012	0.050	0.004	0.031
12	0.000	---	---	---	---	---	0.000	0.024	0.011	0.061	0.003	0.030
13	0.000	---	---	---	---	---	0.000	0.021	0.010	0.063	0.003	0.035
14	0.000	---	---	---	---	---	0.000	0.015	0.010	0.051	0.003	0.030
15	0.000	---	---	---	---	---	0.000	e0.012	0.009	0.042	0.003	0.025
16	0.000	---	---	---	---	---	0.000	e0.010	0.008	0.037	0.003	0.022
17	0.000	---	---	---	---	---	0.000	0.009	0.239	0.032	0.002	0.019
18	0.000	---	---	---	---	---	0.000	0.008	0.120	0.028	e0.002	0.015
19	0.000	---	---	---	---	---	0.000	0.008	0.085	0.025	e0.002	0.014
20	0.000	---	---	---	---	---	0.000	0.007	0.069	0.021	e0.002	0.026
21	0.000	---	---	---	---	---	0.000	0.007	0.058	0.018	e0.002	0.026
22	0.000	---	---	---	---	---	0.000	0.007	0.053	0.014	e0.002	0.026
23	0.000	---	---	---	---	---	0.000	0.006	0.053	0.011	e0.002	0.027
24	0.000	---	---	---	---	---	0.000	0.006	0.045	0.009	e0.002	0.063
25	0.000	---	---	---	---	0.000	0.000	0.006	0.040	0.010	0.001	0.066
26	0.000	---	---	---	---	0.000	0.000	0.009	0.036	0.009	0.001	0.056
27	0.000	---	---	---	---	0.000	0.000	0.026	0.129	0.008	0.001	0.058
28	0.000	---	---	---	---	0.000	0.000	0.022	0.205	0.006	0.002	0.058
29	0.000	---	---	---	---	0.000	0.000	0.019	0.238	0.006	0.012	0.054
30	0.000	---	---	---	---	0.000	0.001	0.017	0.615	0.005	0.013	0.052
31	0.000	---	---	---	---	0.000	---	0.016	---	0.005	0.030	---

e Estimated

Appendix 2.7—Discharge, Smeltzer west oxbow outlet near Otho, IA

1 U.S. DEPARTMENT OF THE INTERIOR - U.S. GEOLOGICAL SURVEY - WATER RESOURCES

STATION:422438094082701 Smeltzer West Oxbow Outlet near Otho, IA (S2) TYPE:WETLAND AGENCY:USGS STATE:19 COUNTY:187
LATITUDE: 422438.3 LONGITUDE: 0940827.5 NAD83 DATUM:
Lowest aging status in period is APPROVED
DD #4, from script
Discharge, cubic feet per second
WATER YEAR OCTOBER 2012 TO SEPTEMBER 2013
DAILY MEAN VALUES

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	---	---	---	---	0.000	0.000	0.000	0.076	0.220	0.095	0.000	0.000
2	---	---	---	---	0.000	0.000	0.000	0.207	0.167	0.094	0.000	0.000
3	---	---	---	---	0.000	0.000	0.000	0.276	0.136	0.086	0.000	0.000
4	---	---	---	---	0.000	0.000	0.000	0.289	0.124	0.077	0.000	0.000
5	---	---	---	---	0.000	0.000	0.000	0.286	0.122	0.064	0.000	0.000
6	---	---	---	---	0.000	0.000	0.000	0.270	0.112	0.043	0.000	0.000
7	---	---	---	---	0.000	0.000	0.000	0.256	0.097	0.024	0.000	0.000
8	---	---	---	---	0.000	0.000	0.000	0.201	0.096	0.010	0.000	0.000
9	---	---	---	---	0.000	0.286	0.000	0.211	0.124	0.004	0.000	0.000
10	---	---	---	---	0.000	0.111	0.004	0.244	0.150	0.000	0.000	0.000
11	---	---	---	---	0.000	0.040	0.021	0.217	0.156	0.000	0.000	0.000
12	---	---	---	---	0.000	0.002	0.012	0.189	0.146	0.000	0.000	0.000
13	---	---	---	---	e0.000	0.000	0.009	0.174	0.133	0.000	0.000	0.000
14	---	---	---	---	e0.000	0.000	0.070	0.165	0.104	0.000	0.000	0.000
15	---	---	---	---	e0.000	0.024	0.062	0.167	0.116	0.000	0.000	0.000
16	---	---	---	---	e0.000	0.253	0.023	0.166	0.127	0.000	0.000	0.000
17	---	---	---	---	e0.000	0.182	0.046	0.161	0.118	0.000	0.000	0.000
18	---	---	---	---	e0.000	0.077	0.218	0.158	0.111	0.000	0.000	0.000
19	---	---	---	---	e0.000	0.005	0.110	0.189	0.093	0.000	0.000	0.000
20	---	---	---	---	e0.000	0.000	0.046	0.210	0.075	0.000	0.000	0.000
21	---	---	---	---	0.000	0.000	0.041	0.204	0.062	0.000	0.000	0.000
22	---	---	---	---	0.000	0.000	0.077	0.119	0.055	0.000	0.000	0.000
23	---	---	---	0.000	0.000	0.000	0.148	0.086	0.056	0.000	0.000	0.000
24	---	---	---	0.000	0.000	0.000	0.102	0.075	0.801	0.000	0.000	0.000
25	---	---	---	0.000	0.000	0.000	0.099	0.187	0.530	0.000	0.000	0.000
26	---	---	---	0.000	0.000	0.000	0.097	0.279	0.290	0.000	0.000	0.000
27	---	---	---	0.000	0.000	0.094	0.083	2.514	0.194	0.000	0.000	0.000
28	---	---	---	0.000	0.000	0.085	0.085	0.353	0.134	0.000	0.000	0.000
29	---	---	---	0.000	---	0.029	0.076	0.339	0.106	0.000	0.000	0.000
30	---	---	---	0.000	---	0.027	0.072	0.359	0.091	0.000	0.000	0.000
31	---	---	---	0.000	---	0.010	---	0.285	---	0.000	0.000	---

1 U.S. DEPARTMENT OF THE INTERIOR - U.S. GEOLOGICAL SURVEY - WATER RESOURCES

STATION:422438094082701 Smeltzer West Oxbow Outlet near Otho, IA (S2) TYPE:WETLAND AGENCY:USGS STATE:19 COUNTY:187
LATITUDE: 422438.3 LONGITUDE: 0940827.5 NAD83 DATUM:
Lowest aging status in period is APPROVED
DD #4, from script
Discharge, cubic feet per second
WATER YEAR OCTOBER 2013 TO SEPTEMBER 2014
DAILY MEAN VALUES

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	0.000	0.000	---	---	---	---	0.000	0.000	0.000	0.792	0.000	0.039
2	0.000	0.000	---	---	---	---	0.000	0.000	0.000	0.196	0.000	0.083
3	0.000	0.000	---	---	---	---	0.000	0.000	0.000	0.169	0.000	0.054
4	0.000	0.000	---	---	---	---	0.000	0.000	0.000	0.141	0.000	0.036
5	0.000	0.000	---	---	---	---	0.000	0.000	0.000	0.135	0.000	0.051
6	0.000	0.000	---	---	---	---	0.000	0.000	0.000	0.143	0.000	0.040
7	0.000	0.000	---	---	---	---	0.000	0.000	0.000	0.125	0.000	0.027
8	0.000	0.000	---	---	---	---	0.000	0.000	0.000	0.120	0.000	0.021
9	0.000	0.000	---	---	---	---	0.000	0.000	0.000	0.134	0.000	0.027
10	0.000	0.000	---	---	---	---	0.000	0.000	0.000	0.136	0.000	0.057
11	0.000	0.000	---	---	---	---	0.000	0.000	0.000	0.119	0.000	0.038
12	0.000	0.000	---	---	---	---	0.000	0.000	0.000	0.125	0.000	0.039
13	0.000	0.000	---	---	---	---	0.000	0.000	0.000	0.129	0.000	0.036
14	0.000	0.000	---	---	---	---	0.000	0.000	0.000	0.105	0.000	0.029
15	0.000	---	---	---	---	---	0.000	0.000	0.000	0.085	0.000	0.025
16	0.000	---	---	---	---	---	0.000	0.000	0.000	0.076	0.000	0.016
17	0.000	---	---	---	---	---	0.000	0.000	0.161	0.063	0.000	0.014
18	0.000	---	---	---	---	---	0.000	0.000	0.149	0.046	0.000	0.008
19	0.000	---	---	---	---	---	0.000	0.000	0.105	0.032	0.000	0.003
20	0.000	---	---	---	---	---	0.000	0.000	0.087	0.019	0.000	0.029
21	0.000	---	---	---	---	---	0.000	0.000	0.079	0.002	0.000	0.020
22	0.000	---	---	---	---	---	0.000	0.000	0.102	0.000	0.000	0.015
23	0.000	---	---	---	---	---	0.000	0.000	0.113	0.000	0.000	0.010
24	0.000	---	---	---	---	---	0.000	0.000	0.107	0.000	0.000	0.047
25	0.000	---	---	---	---	---	0.000	0.000	0.091	0.000	0.000	0.050
26	0.000	---	---	---	---	---	0.000	0.000	0.071	0.000	0.000	0.036
27	0.000	---	---	---	---	0.000	0.000	0.000	0.173	0.000	0.000	0.046
28	0.000	---	---	---	---	0.000	0.000	0.000	0.290	0.000	0.000	0.047
29	0.000	---	---	---	---	0.000	0.000	0.000	0.336	0.000	0.000	0.035
30	0.000	---	---	---	---	0.000	0.000	0.000	2.316	0.000	0.000	0.036
31	0.000	---	---	---	---	0.000	---	0.000	---	0.000	0.000	---

e Estimated

Appendix 2.8—Altitude of water in Smeltzer East oxbow near Otho, IA

1 U.S. DEPARTMENT OF THE INTERIOR - U.S. GEOLOGICAL SURVEY - WATER RESOURCES

STATION:422432094081701 Smeltzer East Oxbow near Otho, IA (S4) TYPE:WETLAND AGENCY:USGS STATE:19 COUNTY:187
LATITUDE: 422432.6 LONGITUDE: 0940817.9 NAD83 DATUM:
Lowest aging status in period is WORKING
DD #2, oxbow
Gage height, feet
WATER YEAR OCTOBER 2012 TO SEPTEMBER 2013
DAILY MEAN VALUES

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	---	---	---	---	3.786	5.321	8.349	8.558	8.715	8.511	7.159	6.204
2	---	---	---	---	3.787	5.306	8.305	8.783	8.692	8.496	7.125	6.166
3	---	---	---	---	3.788	5.300	8.265	9.124	8.651	8.479	7.098	6.133
4	---	---	---	---	---	5.296	8.228	9.288	8.572	8.464	7.059	6.107
5	---	---	---	---	---	---	8.189	9.148	8.586	8.449	7.024	6.081
6	---	---	---	---	---	---	8.157	8.698	8.571	8.424	6.992	6.054
7	---	---	---	---	---	---	8.123	8.585	8.560	8.394	6.957	6.022
8	---	---	---	---	---	5.244	8.094	8.614	8.574	8.364	6.918	6.003
9	---	---	---	---	---	8.297	8.166	8.737	8.660	8.337	6.883	5.981
10	---	---	---	---	4.224	8.524	8.348	8.669	8.669	8.299	6.844	5.947
11	---	---	---	---	4.537	8.543	8.432	8.574	8.656	8.244	6.823	5.927
12	---	---	---	---	4.572	8.481	8.417	8.596	8.685	8.189	6.879	5.896
13	---	---	---	---	4.841	8.408	8.393	8.601	8.617	8.131	6.838	5.860
14	---	---	---	---	5.266	8.388	8.458	8.610	8.577	8.086	6.796	5.831
15	---	---	---	---	5.315	8.510	8.446	8.586	8.606	8.038	6.761	5.807
16	---	---	---	---	5.301	8.486	8.420	8.581	8.607	7.981	6.723	5.787
17	---	---	---	---	5.298	8.428	8.535	8.611	8.584	7.928	6.687	5.782
18	---	---	---	---	5.305	8.412	8.822	8.618	8.549	7.865	6.651	5.800
19	---	---	---	---	5.267	8.379	8.601	8.632	8.493	7.799	6.618	5.792
20	---	---	---	---	5.225	8.339	8.550	8.657	8.472	7.738	6.586	5.852
21	---	---	---	---	5.226	8.294	8.563	8.606	8.456	7.684	6.554	5.841
22	---	---	---	---	5.262	8.259	8.631	8.544	8.441	7.627	6.527	5.813
23	---	---	---	0.993	5.281	8.230	8.751	8.521	8.435	7.565	6.499	5.793
24	---	---	---	0.992	5.269	8.195	8.614	8.498	8.878	7.510	6.477	5.776
25	---	---	---	0.994	5.280	8.165	8.599	8.857	9.292	7.459	6.460	5.697
26	---	---	---	0.993	5.294	8.144	8.575	9.206	8.607	7.407	6.439	5.641
27	---	---	---	0.995	5.311	8.254	8.559	9.704	8.553	7.349	6.376	5.619
28	---	---	---	0.997	5.310	8.529	8.554	9.188	8.536	7.300	6.319	5.604
29	---	---	---	0.997	---	8.509	8.549	8.776	8.534	7.254	6.285	5.587
30	---	---	---	0.995	---	8.460	8.550	8.997	8.516	7.223	6.254	5.566
31	---	---	---	2.115	---	8.407	---	8.727	---	7.197	6.222	---

1 U.S. DEPARTMENT OF THE INTERIOR - U.S. GEOLOGICAL SURVEY - WATER RESOURCES

STATION:422432094081701 Smeltzer East Oxbow near Otho, IA (S4) TYPE:WETLAND AGENCY:USGS STATE:19 COUNTY:187
LATITUDE: 422432.6 LONGITUDE: 0940817.9 NAD83 DATUM:
Lowest aging status in period is WORKING
DD #2, oxbow
Gage height, feet
WATER YEAR OCTOBER 2013 TO SEPTEMBER 2014
DAILY MEAN VALUES

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	5.545	5.460	5.390	5.000	4.193	5.710	7.870	7.745	8.230	---	7.789	8.678
2	5.523	5.454	5.393	4.982	4.283	5.605	7.849	7.755	8.188	8.817	7.738	8.505
3	5.518	5.440	5.401	4.892	4.234	5.538	7.837	7.746	8.140	8.530	7.690	8.457
4	5.574	5.430	5.416	5.009	4.293	5.511	7.851	7.735	8.172	8.475	7.640	8.443
5	5.602	5.468	5.375	4.927	4.350	5.482	7.829	7.718	8.135	8.552	7.601	8.500
6	5.592	5.556	5.296	4.698	4.193	5.510	7.811	7.692	8.096	8.519	7.654	8.489
7	5.594	5.553	5.204	4.688	4.021	5.565	7.802	7.670	8.049	8.497	7.714	8.479
8	5.569	5.547	5.197	4.739	3.944	5.629	7.788	7.674	7.992	8.482	7.693	8.485
9	5.544	5.542	5.300	4.682	3.928	5.897	7.760	7.670	7.944	8.477	7.658	8.516
10	5.522	5.537	5.315	4.769	3.928	6.655	7.733	7.649	7.907	8.475	7.622	8.587
11	5.512	5.531	5.307	5.061	3.890	7.625	7.703	7.652	7.872	8.472	7.586	8.555
12	5.495	5.514	5.294	5.059	3.858	7.986	7.692	8.068	7.823	8.510	7.538	8.583
13	5.473	5.503	5.305	5.269	4.003	8.121	7.822	8.263	7.767	8.496	7.490	8.582
14	5.460	5.515	5.325	5.406	4.269	8.392	7.903	8.285	7.717	8.474	7.452	8.575
15	5.515	5.512	5.301	5.255	4.228	8.424	7.893	8.275	7.672	8.452	7.440	8.571
16	5.508	5.520	5.283	5.205	4.236	8.366	7.884	8.258	7.632	8.438	7.429	8.556
17	5.498	5.547	5.307	5.067	4.362	8.308	7.862	8.233	9.132	8.420	7.403	8.537
18	5.483	5.557	5.311	4.953	5.057	8.272	7.840	8.198	8.636	8.391	7.369	8.518
19	5.474	5.550	5.340	5.069	5.757	8.237	7.819	8.164	8.562	8.358	7.341	8.503
20	5.464	5.540	5.317	5.405	5.964	8.192	7.798	8.131	8.538	8.320	7.340	8.587
21	5.449	5.531	5.255	5.111	6.050	8.154	7.787	8.096	8.508	8.280	7.289	8.555
22	5.459	5.464	5.233	4.775	6.034	8.099	7.756	8.041	8.515	8.238	7.239	8.539
23	5.461	5.440	5.193	4.394	6.022	8.044	7.734	7.996	8.514	8.182	7.270	8.537
24	5.457	5.406	5.098	4.345	5.985	8.003	7.736	7.953	8.480	8.134	7.272	8.662
25	5.451	5.404	5.148	4.793	5.962	7.976	7.719	7.912	8.441	8.148	7.254	8.629
26	5.445	5.430	5.234	4.918	5.944	7.956	---	7.920	8.398	8.110	7.236	8.614
27	5.433	5.395	5.254	4.707	5.912	7.932	---	8.405	8.601	8.060	7.206	8.651
28	5.427	5.394	5.355	4.232	5.896	7.934	---	8.392	8.729	8.001	7.226	8.631
29	5.427	5.372	5.372	4.182	---	7.916	7.664	8.353	8.767	7.943	7.643	8.623
30	5.446	5.394	5.043	4.375	---	7.904	7.690	8.314	9.500	7.891	7.784	8.636
31	5.463	---	5.002	4.414	---	7.901	---	8.274	---	7.839	7.859	---

Appendix 2.9.—Discharge, Smeltzer East oxbow inlet near Otho, IA

1 U.S. DEPARTMENT OF THE INTERIOR - U.S. GEOLOGICAL SURVEY - WATER RESOURCES

STATION:422432094081701 Smeltzer East Oxbow Inlet near Otho, IA (S4) TYPE:WETLAND AGENCY:USGS STATE:19 COUNTY:187
LATITUDE: 422432.6 LONGITUDE: 0940817.9 NAD83 DATUM:
Lowest aging status in period is APPROVED
Discharge, cubic feet per second
WATER YEAR OCTOBER 2012 TO SEPTEMBER 2013
DAILY MEAN VALUES

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	---	---	---	---	0.000	0.001	e0.01	0.003	0.034	0.008	0.000	0.000
2	---	---	---	---	0.000	0.000	0.01	0.121	0.023	0.008	0.000	0.000
3	---	---	---	---	0.00	0.000	0.000	0.264	0.017	0.007	0.000	0.000
4	---	---	---	---	0.000	0.000	0.000	0.234	0.016	0.007	0.000	0.000
5	---	---	---	---	e0.00	0.000	0.000	0.135	0.018	0.006	0.000	0.000
6	---	---	---	---	e0.00	0.000	0.000	0.032	0.017	0.006	0.000	0.000
7	---	---	---	---	e0.00	0.000	0.000	0.019	0.016	0.005	0.000	0.000
8	---	---	---	---	e0.01	0.009	0.000	0.017	0.016	0.005	0.000	0.000
9	---	---	---	---	0.012	0.251	0.000	0.039	0.014	0.005	0.000	0.000
10	---	---	---	---	0.007	0.063	0.005	0.026	0.012	0.004	0.000	0.000
11	---	---	---	---	e0.01	0.004	0.009	0.019	0.011	0.004	0.000	0.000
12	---	---	---	---	e0.02	e0.00	0.006	0.016	0.010	0.003	0.000	0.000
13	---	---	---	---	0.029	e0.00	0.003	0.012	0.009	0.003	0.000	0.000
14	---	---	---	---	0.006	e0.03	0.024	0.008	0.008	0.003	0.000	0.000
15	---	---	---	---	0.00	0.055	0.013	0.007	0.008	0.002	0.000	0.000
16	---	---	---	---	e0.00	0.058	0.007	0.006	0.007	0.002	0.000	0.000
17	---	---	---	---	e0.00	0.022	0.052	0.005	0.007	0.002	0.000	0.000
18	---	---	---	---	0.03	0.010	0.191	0.004	0.007	0.002	0.000	0.000
19	---	---	---	---	0.048	0.003	0.030	0.004	0.007	0.002	0.000	0.000
20	---	---	---	---	0.021	e0.01	0.014	0.004	0.006	0.001	0.000	0.000
21	---	---	---	---	0.011	e0.01	0.011	0.005	0.006	0.001	0.000	0.000
22	---	---	---	0.00	0.008	e0.01	0.054	0.006	0.006	0.001	0.000	0.000
23	---	---	---	0.000	0.01	e0.00	0.060	0.006	0.006	0.000	0.000	0.000
24	---	---	---	0.000	0.00	e0.00	0.016	0.006	0.130	0.000	0.000	0.000
25	---	---	---	0.000	0.04	e0.01	0.011	0.116	0.220	0.000	0.000	0.000
26	---	---	---	0.000	0.005	e0.01	0.008	0.217	0.029	0.000	0.000	0.000
27	---	---	---	0.000	0.001	0.030	0.006	0.417	0.017	0.000	0.000	0.000
28	---	---	---	0.000	0.001	0.044	0.005	0.236	0.013	0.000	0.000	0.000
29	---	---	---	0.000	---	0.028	0.004	0.114	0.011	0.000	0.000	0.000
30	---	---	---	0.000	---	0.005	0.003	0.168	0.009	0.000	0.000	0.000
31	---	---	---	0.000	---	0.001	---	0.051	---	0.000	0.000	---

1 U.S. DEPARTMENT OF THE INTERIOR - U.S. GEOLOGICAL SURVEY - WATER RESOURCES

STATION:422432094081701 Smeltzer East Oxbow Inlet near Otho, IA (S4) TYPE:WETLAND AGENCY:USGS STATE:19 COUNTY:187
LATITUDE: 422432.6 LONGITUDE: 0940817.9 NAD83 DATUM:
Lowest aging status in period is APPROVED
DD #3
Discharge, cubic feet per second
WATER YEAR OCTOBER 2013 TO SEPTEMBER 2014
DAILY MEAN VALUES

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	0.000	0.000	---	---	---	---	0.000	e0.135	0.006	e0.243	0.000	0.104
2	0.000	0.000	---	---	---	---	0.000	e0.034	0.005	0.106	0.000	0.023
3	0.000	0.000	---	---	---	---	0.000	e0.010	0.002	0.015	0.000	0.018
4	0.000	0.000	---	---	---	---	0.000	e0.003	0.001	0.012	0.000	0.016
5	0.000	0.000	---	---	---	---	0.000	e0.001	0.005	0.043	0.000	0.028
6	0.000	0.000	---	---	---	---	0.000	0.000	0.005	0.019	e0.000	0.019
7	0.000	0.000	---	---	---	---	0.000	0.000	0.005	0.014	0.000	0.016
8	0.000	0.000	---	---	---	---	0.000	e0.000	0.005	0.012	0.000	0.014
9	0.000	0.000	---	---	---	---	0.000	0.000	0.004	0.010	0.000	0.025
10	0.000	0.000	---	---	---	---	0.000	0.000	0.004	0.009	0.000	0.025
11	0.000	0.000	---	---	---	---	0.000	0.000	0.004	0.009	0.000	0.017
12	0.000	0.000	---	---	---	---	0.001	0.047	0.002	0.010	0.000	0.022
13	0.000	0.000	---	---	---	---	0.001	0.013	0.000	0.010	0.000	0.018
14	0.000	0.000	---	---	---	---	0.000	0.008	0.000	0.009	0.000	0.016
15	0.000	0.000	---	---	---	e0.001	0.000	0.006	0.000	0.009	e0.000	e0.014
16	0.000	---	---	---	---	e0.001	0.000	0.004	0.000	0.008	0.000	0.014
17	0.000	---	---	---	---	e0.001	0.000	0.003	0.344	0.009	0.000	0.013
18	0.000	---	---	---	---	0.001	0.000	0.001	0.036	0.009	0.000	0.013
19	0.000	---	---	---	---	0.000	0.000	0.001	0.025	0.009	0.000	0.014
20	0.000	---	---	---	---	0.000	0.000	0.000	0.023	0.008	e0.000	0.036
21	0.000	---	---	---	---	e0.000	0.000	0.000	0.022	0.007	0.000	0.021
22	0.000	---	---	---	---	e0.000	0.000	e0.000	0.023	0.007	0.000	0.020
23	0.000	---	---	---	---	e0.000	0.000	0.000	0.025	0.006	e0.000	0.020
24	0.000	---	---	---	---	0.000	e0.000	0.000	0.025	e0.005	0.000	0.064
25	0.000	---	---	---	---	0.000	0.000	0.000	0.025	0.004	e0.000	0.027
26	0.000	---	---	---	---	0.000	e0.000	0.037	0.027	0.003	e0.000	0.025
27	0.000	---	---	---	---	0.000	e0.000	0.026	0.147	0.003	0.000	0.037
28	0.000	---	---	---	---	0.000	e0.053	0.010	0.220	0.001	e0.000	0.026
29	0.000	---	---	---	---	0.000	e0.080	0.007	0.203	0.000	0.035	0.024
30	0.000	---	---	---	---	0.000	e0.106	0.006	0.541	0.000	0.006	0.046
31	0.000	---	---	---	---	0.000	---	0.006	---	e0.000	0.055	---

e Estimated

Appendix 2.10—Water level in monitoring well SW1

1 U.S. DEPARTMENT OF THE INTERIOR - U.S. GEOLOGICAL SURVEY - WATER RESOURCES

STATION:422436094082901 088N28W29BBDA 2013Smeltzer West Oxbow (W1) TYPE:WELL AGENCY:USGS STATE:19 COUNTY:187
LATITUDE: 422436.0 LONGITUDE: 0940829.0 NAD83 WELL DEPTH: 12.6 GEOLOGIC UNIT:110QRNR DATUM: 1101.34 NAVD88
DD #1
Depth to water level, feet below land surface
WATER YEAR OCTOBER 2012 TO SEPTEMBER 2013
DAILY MEAN VALUES

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	---	---	---	---	---	---	---	---	---	4.93	7.00	8.96
2	---	---	---	---	---	---	---	---	---	5.10	7.10	9.13
3	---	---	---	---	---	---	---	---	---	5.25	7.23	9.26
4	---	---	---	---	---	---	---	---	---	5.40	7.31	9.35
5	---	---	---	---	---	---	---	---	---	5.53	7.24	9.45
6	---	---	---	---	---	---	---	---	---	5.65	7.24	9.48
7	---	---	---	---	---	---	---	---	---	5.77	7.33	9.47
8	---	---	---	---	---	---	---	---	---	5.92	7.44	9.56
9	---	---	---	---	---	---	---	---	---	5.98	7.51	9.59
10	---	---	---	---	---	---	---	---	---	6.13	7.61	9.71
11	---	---	---	---	---	---	---	---	---	6.20	7.62	9.88
12	---	---	---	---	---	---	---	---	---	6.21	7.63	10.0
13	---	---	---	---	---	---	---	---	---	6.28	7.72	10.09
14	---	---	---	---	---	---	---	---	---	6.39	7.81	10.08
15	---	---	---	---	---	---	---	---	---	6.48	7.84	10.09
16	---	---	---	---	---	---	---	---	---	6.49	7.90	10.31
17	---	---	---	---	---	---	---	---	---	6.46	7.97	10.33
18	---	---	---	---	---	---	---	---	---	6.40	8.00	10.23
19	---	---	---	---	---	---	---	---	---	6.37	8.01	10.27
20	---	---	---	---	---	---	---	---	---	6.49	8.03	10.43
21	---	---	---	---	---	---	---	---	5.69	6.52	8.09	10.53
22	---	---	---	---	---	---	---	---	5.76	6.54	8.21	10.57
23	---	---	---	---	---	---	---	---	5.82	6.70	8.32	10.62
24	---	---	---	---	---	---	---	---	5.66	6.78	8.39	10.67
25	---	---	---	---	---	---	---	---	4.14	6.79	8.47	10.75
26	---	---	---	---	---	---	---	---	3.49	6.83	8.53	10.80
27	---	---	---	---	---	---	---	---	3.82	6.89	8.53	10.87
28	---	---	---	---	---	---	---	---	4.08	6.90	8.63	10.91
29	---	---	---	---	---	---	---	---	4.35	6.99	8.75	11.04
30	---	---	---	---	---	---	---	---	4.69	7.01	8.79	11.02
31	---	---	---	---	---	---	---	---	---	7.03	8.86	---

1 U.S. DEPARTMENT OF THE INTERIOR - U.S. GEOLOGICAL SURVEY - WATER RESOURCES

STATION:422436094082901 088N28W29BBDA 2013Smeltzer West Oxbow (W1) TYPE:WELL AGENCY:USGS STATE:19 COUNTY:187
LATITUDE: 422436.0 LONGITUDE: 0940829.0 NAD83 WELL DEPTH: 12.6 GEOLOGIC UNIT:110QRNR DATUM: 1101.34 NAVD88
DD #1
Depth to water level, feet below land surface
WATER YEAR OCTOBER 2013 TO SEPTEMBER 2014
DAILY MEAN VALUES

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	11.09	11.99	12.04	12.04	12.03	12.03	12.05	9.51	7.03	---	---	---
2	11.21	11.99	12.04	12.04	12.03	12.03	12.05	8.96	7.09	---	---	---
3	11.21	11.99	12.04	12.04	12.03	12.03	12.05	8.72	7.23	---	---	---
4	11.26	12.01	12.04	12.03	12.03	12.03	12.05	8.73	7.19	---	---	---
5	11.32	12.04	12.04	12.03	12.03	12.03	12.05	8.70	7.29	---	---	---
6	11.36	12.04	12.04	12.03	12.03	12.03	12.05	8.70	7.32	---	---	---
7	11.49	12.04	12.04	12.03	12.03	12.03	12.05	8.70	7.34	---	---	---
8	11.56	12.04	12.04	12.03	12.03	12.03	12.05	8.81	7.42	---	---	---
9	11.61	12.04	12.04	12.03	12.03	12.03	12.05	8.95	---	---	---	---
10	11.64	12.04	12.04	12.03	12.03	12.03	12.05	9.06	---	---	---	---
11	11.58	12.04	12.04	12.03	12.03	12.03	12.05	9.11	---	---	---	---
12	11.70	12.04	12.04	12.03	12.03	12.03	12.05	8.85	---	---	---	---
13	11.90	12.04	12.04	12.03	12.03	12.03	12.01	7.92	---	---	---	---
14	11.87	12.04	12.04	12.03	12.03	12.04	11.47	7.34	---	---	---	---
15	11.70	12.04	12.04	12.03	12.03	12.05	10.78	7.31	---	---	---	---
16	11.81	12.04	12.04	12.03	12.03	12.05	10.21	7.45	---	---	---	---
17	11.85	12.04	12.04	12.03	12.03	12.05	10.14	7.57	---	---	---	---
18	11.93	12.04	12.04	12.03	12.03	12.05	10.08	7.61	---	---	---	---
19	11.93	12.04	12.04	12.03	12.03	12.05	9.96	7.57	---	---	---	---
20	11.93	12.04	12.04	12.03	12.03	12.05	9.93	7.61	---	---	---	---
21	12.00	12.04	12.04	12.03	12.03	12.05	10.0	7.75	---	---	---	---
22	11.99	12.04	12.04	12.03	12.03	12.05	10.13	7.88	---	---	---	---
23	11.99	12.04	12.04	12.03	12.03	12.05	10.13	7.90	---	---	---	---
24	11.99	12.04	12.04	12.03	12.03	12.05	10.07	7.87	---	---	---	---
25	11.99	12.04	12.04	12.03	12.03	12.05	10.21	7.82	---	---	---	---
26	11.99	12.04	12.04	12.03	12.03	12.05	10.29	7.80	---	---	---	---
27	11.99	12.04	12.04	12.03	12.03	12.05	10.24	7.42	---	---	---	---
28	11.99	12.04	12.04	12.03	12.03	12.05	10.04	6.94	---	---	---	---
29	11.99	12.04	12.04	12.03	---	12.05	9.87	6.93	---	---	---	---
30	11.99	12.04	12.04	12.03	---	12.05	9.85	7.00	---	---	---	---
31	11.99	---	12.04	12.03	---	12.05	---	7.04	---	---	---	---

Appendix 2.11—Water level in monitoring well SW2

1 U.S. DEPARTMENT OF THE INTERIOR - U.S. GEOLOGICAL SURVEY - WATER RESOURCES

STATION:422436094082801 088N28W29BBDA 2013Smeltzer West Oxbow (W2) TYPE:WELL AGENCY:USGS STATE:19 COUNTY:187
LATITUDE: 422436.4 LONGITUDE: 0940828.4 NAD83 WELL DEPTH: 12.5 GEOLOGIC UNIT:110QRNR DATUM: 1088.97 NAVD88
Lowest aging status in period is WORKING
DD #1
Depth to water level, feet below land surface
WATER YEAR OCTOBER 2012 TO SEPTEMBER 2013
DAILY MEAN VALUES

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	---	---	---	---	---	---	---	---	---	2.81	4.62	5.66
2	---	---	---	---	---	---	---	---	---	2.92	4.67	5.69
3	---	---	---	---	---	---	---	---	---	3.01	4.70	5.71
4	---	---	---	---	---	---	---	---	---	3.11	4.73	5.75
5	---	---	---	---	---	---	---	---	---	3.19	4.76	5.78
6	---	---	---	---	---	---	---	---	---	3.28	4.81	5.80
7	---	---	---	---	---	---	---	---	---	3.36	4.86	5.83
8	---	---	---	---	---	---	---	---	---	3.43	4.90	5.88
9	---	---	---	---	---	---	---	---	---	3.46	4.94	5.89
10	---	---	---	---	---	---	---	---	---	3.53	4.98	5.93
11	---	---	---	---	---	---	---	---	---	3.58	5.01	5.97
12	---	---	---	---	---	---	---	---	---	3.63	4.99	6.00
13	---	---	---	---	---	---	---	---	---	3.70	5.03	6.02
14	---	---	---	---	---	---	---	---	---	3.76	5.07	6.04
15	---	---	---	---	---	---	---	---	---	3.82	5.09	6.05
16	---	---	---	---	---	---	---	---	---	---	5.13	6.09
17	---	---	---	---	---	---	---	---	---	---	5.16	6.09
18	---	---	---	---	---	---	---	---	---	---	5.19	6.10
19	---	---	---	---	---	---	---	---	---	---	5.22	6.13
20	---	---	---	---	---	---	---	---	---	---	5.26	6.15
21	---	---	---	---	---	---	---	---	3.28	---	5.30	6.17
22	---	---	---	---	---	---	---	---	3.33	---	5.34	6.18
23	---	---	---	---	---	---	---	---	3.37	---	5.36	6.20
24	---	---	---	---	---	---	---	---	2.33	---	5.40	6.23
25	---	---	---	---	---	---	---	---	---	---	5.42	6.25
26	---	---	---	---	---	---	---	---	1.45	---	5.46	6.27
27	---	---	---	---	---	---	---	---	1.99	---	5.49	6.29
28	---	---	---	---	---	---	---	---	2.27	---	5.52	6.32
29	---	---	---	---	---	---	---	---	2.49	---	5.55	6.34
30	---	---	---	---	---	---	---	---	2.67	---	5.58	6.35
31	---	---	---	---	---	---	---	---	---	4.58	5.62	---

1 U.S. DEPARTMENT OF THE INTERIOR - U.S. GEOLOGICAL SURVEY - WATER RESOURCES

STATION:422436094082801 088N28W29BBDA 2013Smeltzer West Oxbow (W2) TYPE:WELL AGENCY:USGS STATE:19 COUNTY:187
LATITUDE: 422436.4 LONGITUDE: 0940828.4 NAD83 WELL DEPTH: 12.5 GEOLOGIC UNIT:110QRNR DATUM: 1088.97 NAVD88
Lowest aging status in period is WORKING
DD #1
Depth to water level, feet below land surface
WATER YEAR OCTOBER 2013 TO SEPTEMBER 2014
DAILY MEAN VALUES

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	6.39	6.77	6.89	7.02	7.07	7.07	5.94	5.19	4.09	0.31	---	---
2	6.41	6.79	6.86	7.03	7.10	7.07	5.91	5.07	4.13	1.20	---	---
3	6.43	6.78	6.88	6.98	7.10	7.05	5.89	5.00	4.17	1.69	---	---
4	6.45	6.79	6.90	7.02	7.11	7.04	5.90	4.94	4.15	2.05	---	---
5	6.47	6.79	6.94	7.03	7.13	7.07	5.89	4.90	4.16	1.91	---	---
6	6.48	6.81	6.95	7.02	7.12	7.05	5.87	4.86	4.16	1.99	---	---
7	6.50	6.81	6.95	7.04	7.11	7.06	5.85	4.84	4.18	2.27	---	---
8	6.51	6.78	6.90	7.06	7.11	7.09	5.86	4.84	4.21	2.46	---	---
9	6.53	6.82	6.92	7.03	7.15	7.06	5.83	4.83	---	2.63	---	---
10	6.54	6.83	6.93	7.02	7.16	7.06	5.84	4.81	---	2.75	---	---
11	6.54	6.84	6.96	7.05	7.14	6.96	5.82	4.79	4.19	2.86	---	---
12	6.58	6.85	6.94	7.04	7.13	6.88	5.79	4.66	4.15	2.86	---	---
13	6.60	6.80	6.94	7.02	7.13	6.78	5.78	4.38	4.18	2.87	---	---
14	6.58	6.80	6.96	7.01	7.17	6.48	5.73	4.18	4.19	2.98	---	---
15	6.59	6.82	6.96	7.00	7.16	6.30	5.62	4.07	4.24	3.07	---	---
16	6.62	6.80	6.96	7.01	7.18	6.23	5.54	4.01	4.28	3.14	---	---
17	6.62	6.84	6.97	7.03	7.16	6.15	5.54	4.00	1.44	3.19	---	---
18	6.64	6.88	6.94	7.02	7.17	6.12	5.49	3.99	1.93	3.24	---	---
19	6.64	6.86	6.97	7.03	7.17	6.11	5.46	3.97	2.37	3.28	---	---
20	6.65	6.86	6.97	7.02	7.04	6.09	5.44	4.01	2.63	3.32	---	---
21	6.68	6.90	6.98	6.99	7.02	6.07	5.44	4.07	2.84	3.36	---	---
22	6.68	6.90	6.99	6.98	7.02	6.09	5.42	4.11	2.98	---	---	---
23	6.69	6.91	7.01	7.02	7.02	6.06	5.39	4.13	3.04	---	---	---
24	6.71	6.87	6.99	6.95	7.02	6.04	5.38	4.15	3.16	---	---	---
25	6.70	6.85	7.00	7.00	7.02	6.03	5.38	4.18	3.25	---	---	---
26	6.71	6.89	7.01	6.99	7.00	6.00	5.36	4.20	3.31	---	---	---
27	6.71	6.88	7.01	7.07	7.02	5.98	5.32	4.17	2.82	---	---	---
28	6.75	6.90	6.99	7.03	7.02	6.03	5.30	4.13	1.71	---	---	---
29	6.74	6.90	7.01	7.01	---	5.99	5.30	4.10	1.05	---	---	---
30	6.73	6.88	7.00	7.04	---	5.94	5.27	4.10	0.24	---	---	---
31	6.73	---	7.02	7.08	---	5.92	---	4.09	---	---	---	---

Appendix 2.12—Water level in monitoring well SW3

1 U.S. DEPARTMENT OF THE INTERIOR - U.S. GEOLOGICAL SURVEY - WATER RESOURCES

STATION:422437094082701 088N28W29BBDA 2013Smeltzer West Oxbow (W3) TYPE:WELL AGENCY:USGS STATE:19 COUNTY:187
LATITUDE: 422437.0 LONGITUDE: 0940827.3 NAD83 WELL DEPTH: 13.8 GEOLOGIC UNIT:110QRCU DATUM: 1092.22 NAVD88
DD #1
Depth to water level, feet below land surface
WATER YEAR OCTOBER 2012 TO SEPTEMBER 2013
DAILY MEAN VALUES

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	---	---	---	---	---	---	---	---	---	---	5.58	6.56
2	---	---	---	---	---	---	---	---	---	---	5.62	6.59
3	---	---	---	---	---	---	---	---	---	---	5.67	6.63
4	---	---	---	---	---	---	---	---	---	---	5.70	6.66
5	---	---	---	---	---	---	---	---	---	---	5.73	6.69
6	---	---	---	---	---	---	---	---	---	---	5.77	6.72
7	---	---	---	---	---	---	---	---	---	---	5.81	6.75
8	---	---	---	---	---	---	---	---	---	---	5.85	6.78
9	---	---	---	---	---	---	---	---	---	---	5.89	6.80
10	---	---	---	---	---	---	---	---	---	---	5.93	6.83
11	---	---	---	---	---	---	---	---	---	---	5.95	6.86
12	---	---	---	---	---	---	---	---	---	---	5.89	6.88
13	---	---	---	---	---	---	---	---	---	---	5.94	6.90
14	---	---	---	---	---	---	---	---	---	---	5.98	6.91
15	---	---	---	---	---	---	---	---	---	---	6.01	6.94
16	---	---	---	---	---	---	---	---	---	---	6.04	6.97
17	---	---	---	---	---	---	---	---	---	---	6.07	6.98
18	---	---	---	---	---	---	---	---	---	---	6.11	6.99
19	---	---	---	---	---	---	---	---	---	---	6.14	7.01
20	---	---	---	---	---	---	---	---	---	---	6.17	7.03
21	---	---	---	---	---	---	---	---	---	---	6.21	7.04
22	---	---	---	---	---	---	---	---	---	---	6.25	7.06
23	---	---	---	---	---	---	---	---	---	---	6.28	7.08
24	---	---	---	---	---	---	---	---	---	---	6.32	7.09
25	---	---	---	---	---	---	---	---	---	---	6.35	7.10
26	---	---	---	---	---	---	---	---	---	---	6.38	7.12
27	---	---	---	---	---	---	---	---	---	---	6.40	7.13
28	---	---	---	---	---	---	---	---	---	---	6.43	7.14
29	---	---	---	---	---	---	---	---	---	---	6.46	7.16
30	---	---	---	---	---	---	---	---	---	---	6.50	7.16
31	---	---	---	---	---	---	---	---	---	5.55	6.53	---

1 U.S. DEPARTMENT OF THE INTERIOR - U.S. GEOLOGICAL SURVEY - WATER RESOURCES

STATION:422437094082701 088N28W29BBDA 2013Smeltzer West Oxbow (W3) TYPE:WELL AGENCY:USGS STATE:19 COUNTY:187
LATITUDE: 422437.0 LONGITUDE: 0940827.3 NAD83 WELL DEPTH: 13.8 GEOLOGIC UNIT:110QRCU DATUM: 1092.22 NAVD88
DD #1
Depth to water level, feet below land surface
WATER YEAR OCTOBER 2013 TO SEPTEMBER 2014
DAILY MEAN VALUES

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	7.19	7.48	7.49	7.71	7.94	7.97	6.85	5.27	5.20	---	---	---
2	7.20	7.53	7.45	7.72	7.97	7.97	6.80	5.07	5.26	---	---	---
3	7.21	7.51	7.47	7.66	7.97	7.94	6.71	5.09	5.31	---	---	---
4	7.22	7.47	7.50	7.69	7.99	7.93	6.68	5.16	5.29	---	---	---
5	7.23	7.43	7.57	7.75	8.00	7.98	6.64	5.22	5.26	---	---	---
6	7.24	7.45	7.59	7.74	8.00	7.97	6.59	5.27	5.25	---	---	---
7	7.27	7.47	7.58	7.73	7.98	7.96	6.56	5.33	5.27	---	---	---
8	7.27	7.41	7.51	7.78	7.98	8.02	6.54	5.38	5.30	---	---	---
9	7.28	7.44	7.53	7.75	8.02	7.98	6.51	5.42	---	---	---	---
10	7.28	7.47	7.54	7.71	8.04	7.96	6.49	5.45	---	---	---	---
11	7.27	7.48	7.60	7.75	8.03	7.96	6.47	5.47	---	---	---	---
12	7.31	7.50	7.56	7.76	8.01	7.96	6.44	4.95	---	---	---	---
13	7.34	7.42	7.54	7.79	8.01	7.90	6.40	4.59	---	---	---	---
14	7.31	7.40	7.58	7.82	8.06	7.87	6.20	4.69	---	---	---	---
15	7.29	7.41	7.58	7.82	8.07	7.89	5.98	4.80	---	---	---	---
16	7.34	7.38	7.59	7.78	8.10	7.84	5.81	4.88	---	---	---	---
17	7.34	7.44	7.61	7.84	8.07	7.73	5.75	4.95	---	---	---	---
18	7.36	7.52	7.57	7.80	8.08	7.65	5.70	4.99	---	---	---	---
19	7.35	7.49	7.60	7.81	8.11	7.61	5.68	5.03	---	---	---	---
20	7.36	7.45	7.62	7.86	8.05	7.54	5.68	5.09	---	---	---	---
21	7.40	7.51	7.62	7.88	8.08	7.46	5.69	5.15	---	---	---	---
22	7.40	7.53	7.65	7.85	8.10	7.43	5.70	5.20	---	---	---	---
23	7.42	7.54	7.68	7.90	8.09	7.37	5.70	5.24	---	---	---	---
24	7.45	7.48	7.65	7.81	8.05	7.29	5.71	5.28	---	---	---	---
25	7.44	7.44	7.64	7.84	8.02	7.23	5.73	5.33	---	---	---	---
26	7.43	7.48	7.66	7.84	7.97	7.15	5.73	5.36	---	---	---	---
27	7.43	7.49	7.67	7.94	7.96	7.07	5.72	5.05	---	---	---	---
28	7.48	7.50	7.65	7.91	7.93	7.08	5.64	5.04	---	---	---	---
29	7.46	7.51	7.70	7.87	---	7.03	5.56	5.07	---	---	---	---
30	7.44	7.48	7.68	7.88	---	6.94	5.49	5.12	---	---	---	---
31	7.43	---	7.70	7.95	---	6.87	---	5.16	---	---	---	---

Appendix 2.13—Water level in monitoring well SW4

1 U.S. DEPARTMENT OF THE INTERIOR - U.S. GEOLOGICAL SURVEY - WATER RESOURCES

STATION:422437094082501 088N28W29BADB 2013Smeltzer West Oxbow (W4) TYPE:WELL AGENCY:USGS STATE:19 COUNTY:187
LATITUDE: 422437.9 LONGITUDE: 0940825.8 NAD83 WELL DEPTH: 12.7 GEOLOGIC UNIT:110QRNR DATUM: 1089.43 NAVD88
DD #1
Depth to water level, feet below land surface
WATER YEAR OCTOBER 2012 TO SEPTEMBER 2013
DAILY MEAN VALUES

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	---	---	---	---	---	---	---	---	---	---	5.07	5.35
2	---	---	---	---	---	---	---	---	---	---	5.09	5.35
3	---	---	---	---	---	---	---	---	---	---	5.10	5.35
4	---	---	---	---	---	---	---	---	---	---	5.12	5.38
5	---	---	---	---	---	---	---	---	---	---	5.14	5.40
6	---	---	---	---	---	---	---	---	---	---	5.12	5.43
7	---	---	---	---	---	---	---	---	---	---	5.11	5.45
8	---	---	---	---	---	---	---	---	---	---	5.13	5.45
9	---	---	---	---	---	---	---	---	---	---	5.14	5.44
10	---	---	---	---	---	---	---	---	---	---	5.16	5.45
11	---	---	---	---	---	---	---	---	---	---	5.15	5.45
12	---	---	---	---	---	---	---	---	---	---	5.11	5.41
13	---	---	---	---	---	---	---	---	---	---	5.11	5.43
14	---	---	---	---	---	---	---	---	---	---	5.13	5.47
15	---	---	---	---	---	---	---	---	---	---	5.15	5.49
16	---	---	---	---	---	---	---	---	---	---	5.16	5.43
17	---	---	---	---	---	---	---	---	---	---	5.21	5.40
18	---	---	---	---	---	---	---	---	---	---	5.24	5.39
19	---	---	---	---	---	---	---	---	---	---	5.25	5.40
20	---	---	---	---	---	---	---	---	---	---	5.27	5.39
21	---	---	---	---	---	---	---	---	---	---	5.30	5.42
22	---	---	---	---	---	---	---	---	---	---	5.31	5.45
23	---	---	---	---	---	---	---	---	---	---	5.33	5.46
24	---	---	---	---	---	---	---	---	---	---	5.33	5.46
25	---	---	---	---	---	---	---	---	---	---	5.35	5.46
26	---	---	---	---	---	---	---	---	---	---	5.37	5.48
27	---	---	---	---	---	---	---	---	---	---	5.34	5.50
28	---	---	---	---	---	---	---	---	---	---	5.31	5.49
29	---	---	---	---	---	---	---	---	---	---	5.33	5.45
30	---	---	---	---	---	---	---	---	---	---	5.34	5.45
31	---	---	---	---	---	---	---	---	---	5.05	5.35	---

1 U.S. DEPARTMENT OF THE INTERIOR - U.S. GEOLOGICAL SURVEY - WATER RESOURCES

STATION:422437094082501 088N28W29BADB 2013Smeltzer West Oxbow (W4) TYPE:WELL AGENCY:USGS STATE:19 COUNTY:187
LATITUDE: 422437.9 LONGITUDE: 0940825.8 NAD83 WELL DEPTH: 12.7 GEOLOGIC UNIT:110QRNR DATUM: 1089.43 NAVD88
DD #1
Depth to water level, feet below land surface
WATER YEAR OCTOBER 2013 TO SEPTEMBER 2014
DAILY MEAN VALUES

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	5.45	5.36	5.36	5.63	6.04	5.10	5.26	4.29	4.57	0.88	---	---
2	5.45	5.36	5.34	5.64	6.06	5.20	5.25	4.34	4.58	2.11	---	---
3	5.46	5.37	5.33	5.57	6.09	5.31	5.22	4.44	4.58	2.76	---	---
4	5.40	5.44	5.32	5.43	6.10	5.40	5.18	4.52	4.49	3.18	---	---
5	5.37	5.52	5.33	5.41	6.11	5.46	5.18	4.57	4.49	3.18	---	---
6	5.37	5.46	5.37	5.57	6.15	5.46	5.17	4.61	4.48	3.15	---	---
7	5.38	5.37	5.42	5.72	6.20	5.44	5.10	4.61	4.50	3.41	---	---
8	5.41	5.33	5.46	5.80	6.26	5.42	5.08	4.62	4.55	3.61	---	---
9	5.44	5.33	5.47	5.85	6.30	5.21	5.06	4.63	---	3.77	---	---
10	5.46	5.36	5.50	5.89	6.33	4.03	5.08	4.66	---	3.88	---	---
11	5.46	5.35	5.51	5.88	6.36	3.85	5.05	4.64	4.52	3.97	---	---
12	5.45	5.36	5.52	5.83	6.40	4.10	5.03	3.86	4.48	3.95	---	---
13	5.46	5.36	5.52	5.69	6.42	4.25	4.81	3.96	4.47	3.96	---	---
14	5.48	5.36	5.53	5.36	6.41	4.31	4.74	4.36	4.50	4.05	---	---
15	5.42	5.35	5.54	5.13	6.41	4.37	4.81	4.55	4.53	4.14	---	---
16	5.41	5.35	5.54	5.07	6.42	4.46	4.85	4.65	4.52	4.21	---	---
17	5.39	5.33	5.53	5.20	6.41	4.60	4.87	4.72	2.66	4.28	---	---
18	5.37	5.33	5.53	5.24	6.28	4.74	4.85	4.78	3.24	4.33	---	---
19	5.39	5.31	5.53	5.24	5.60	4.80	4.81	4.80	3.68	4.38	---	---
20	5.40	5.32	5.54	5.29	5.11	4.83	4.81	4.81	3.79	4.44	---	---
21	5.39	5.32	5.55	5.32	4.89	4.86	4.81	4.85	3.95	4.50	---	---
22	5.36	5.33	5.54	5.42	4.91	4.91	4.84	4.86	4.01	---	---	---
23	5.34	5.34	5.54	5.56	4.96	5.00	4.83	4.85	4.02	---	---	---
24	5.35	5.35	5.57	5.69	4.97	5.16	4.72	4.81	4.09	---	---	---
25	5.35	5.36	5.59	5.71	4.98	5.22	4.76	4.75	4.16	---	---	---
26	5.36	5.35	5.59	5.69	4.95	5.28	4.78	4.65	4.22	---	---	---
27	5.35	5.36	5.59	5.70	4.99	5.22	4.74	4.32	3.97	---	---	---
28	5.36	5.37	5.57	5.84	5.01	5.16	4.67	4.42	3.55	---	---	---
29	5.38	5.38	5.56	5.95	---	5.22	4.63	4.49	2.90	---	---	---
30	5.36	5.37	5.60	5.99	---	5.21	4.57	4.53	1.01	---	---	---
31	5.33	---	5.62	6.00	---	5.17	---	4.55	---	---	---	---

Appendix 2.14—Water level in monitoring well SW6

1 U.S. DEPARTMENT OF THE INTERIOR - U.S. GEOLOGICAL SURVEY - WATER RESOURCES

STATION:422433094081901 088N28W29BACD 2013Smeltzer East Oxbow (W6) TYPE:WELL AGENCY:USGS STATE:19 COUNTY:187
LATITUDE: 422433.0 LONGITUDE: 0940819.2 NAD83 WELL DEPTH: 12.6 GEOLOGIC UNIT:110QRNR DATUM: 1089.30 NAVD88
DD #1
Depth to water level, feet below land surface
WATER YEAR OCTOBER 2012 TO SEPTEMBER 2013
DAILY MEAN VALUES

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	---	---	---	---	---	---	---	---	---	---	---	5.85
2	---	---	---	---	---	---	---	---	---	---	---	6.00
3	---	---	---	---	---	---	---	---	---	---	---	6.07
4	---	---	---	---	---	---	---	---	---	---	---	6.14
5	---	---	---	---	---	---	---	---	---	---	---	6.24
6	---	---	---	---	---	---	---	---	---	---	---	6.28
7	---	---	---	---	---	---	---	---	---	---	---	6.34
8	---	---	---	---	---	---	---	---	---	---	---	6.48
9	---	---	---	---	---	---	---	---	---	---	---	6.51
10	---	---	---	---	---	---	---	---	---	---	---	6.69
11	---	---	---	---	---	---	---	---	---	---	---	6.85
12	---	---	---	---	---	---	---	---	---	---	---	6.96
13	---	---	---	---	---	---	---	---	---	---	---	7.03
14	---	---	---	---	---	---	---	---	---	---	---	7.02
15	---	---	---	---	---	---	---	---	---	---	4.68	7.12
16	---	---	---	---	---	---	---	---	---	---	4.76	7.30
17	---	---	---	---	---	---	---	---	---	---	4.80	7.21
18	---	---	---	---	---	---	---	---	---	---	4.82	7.03
19	---	---	---	---	---	---	---	---	---	---	4.85	7.08
20	---	---	---	---	---	---	---	---	---	---	4.90	7.26
21	---	---	---	---	---	---	---	---	---	---	4.99	7.26
22	---	---	---	---	---	---	---	---	---	---	5.09	7.25
23	---	---	---	---	---	---	---	---	---	---	5.15	7.31
24	---	---	---	---	---	---	---	---	---	---	5.20	7.34
25	---	---	---	---	---	---	---	---	---	---	5.26	7.34
26	---	---	---	---	---	---	---	---	---	---	5.31	7.40
27	---	---	---	---	---	---	---	---	---	---	5.34	7.48
28	---	---	---	---	---	---	---	---	---	---	5.47	7.56
29	---	---	---	---	---	---	---	---	---	---	5.57	7.63
30	---	---	---	---	---	---	---	---	---	---	5.63	7.64
31	---	---	---	---	---	---	---	---	---	---	5.73	---

1 U.S. DEPARTMENT OF THE INTERIOR - U.S. GEOLOGICAL SURVEY - WATER RESOURCES

STATION:422433094081901 088N28W29BACD 2013Smeltzer East Oxbow (W6) TYPE:WELL AGENCY:USGS STATE:19 COUNTY:187
LATITUDE: 422433.0 LONGITUDE: 0940819.2 NAD83 WELL DEPTH: 12.6 GEOLOGIC UNIT:110QRNR DATUM: 1089.30 NAVD88
DD #1
Depth to water level, feet below land surface
WATER YEAR OCTOBER 2013 TO SEPTEMBER 2014
DAILY MEAN VALUES

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	7.71	6.94	6.70	6.85	7.23	6.71	4.10	3.39	3.06	---	---	---
2	7.81	7.12	6.56	6.92	7.34	6.74	4.10	3.27	3.14	---	---	---
3	7.86	7.04	6.59	6.75	7.31	6.64	3.99	3.32	3.23	---	---	---
4	7.91	7.01	6.66	6.79	7.39	6.51	4.05	3.39	3.17	---	---	---
5	7.87	7.06	6.90	7.01	7.41	6.62	4.07	3.38	3.19	---	---	---
6	7.78	7.04	6.98	6.98	7.39	6.58	3.98	3.40	3.23	---	---	---
7	7.74	7.05	6.97	6.90	7.32	6.51	3.96	3.42	3.28	---	---	---
8	7.69	6.86	6.73	7.04	7.30	6.69	4.02	3.51	3.34	---	---	---
9	7.67	6.89	6.74	6.99	7.41	6.55	3.97	3.57	---	---	---	---
10	7.66	7.00	6.76	6.83	7.41	6.40	3.99	3.58	---	---	---	---
11	7.62	6.99	6.93	6.90	7.42	6.35	4.04	3.58	---	---	---	---
12	7.67	7.08	6.81	6.89	7.41	6.25	3.95	3.31	---	---	---	---
13	7.74	6.80	6.70	6.96	7.37	5.83	3.83	2.93	---	---	---	---
14	7.65	6.67	6.78	7.01	7.46	5.43	3.55	2.81	---	---	---	---
15	7.53	6.70	6.76	6.96	7.49	5.13	3.47	2.79	---	---	---	---
16	7.50	6.59	6.75	6.76	7.54	4.81	3.41	2.84	---	---	---	---
17	7.44	6.71	6.81	6.88	7.50	4.36	3.62	2.91	---	---	---	---
18	7.42	6.99	6.69	6.78	7.47	4.26	3.63	2.96	---	---	---	---
19	7.36	6.90	6.71	6.83	7.49	4.36	3.59	2.95	---	---	---	---
20	7.32	6.76	6.75	6.80	7.38	4.29	3.61	3.04	---	---	---	---
21	7.35	6.89	6.74	6.78	7.29	4.19	3.66	3.16	---	---	---	---
22	7.31	6.99	6.84	6.67	7.21	4.32	3.72	3.23	---	---	---	---
23	7.29	6.98	7.00	6.91	7.13	4.27	3.68	3.26	---	---	---	---
24	7.28	6.79	6.89	6.68	6.97	4.15	3.65	3.29	---	---	---	---
25	7.21	6.62	6.81	6.82	6.85	4.16	3.73	3.32	---	---	---	---
26	7.09	6.74	6.82	6.85	6.65	4.06	3.74	3.35	---	---	---	---
27	7.04	6.76	6.82	7.19	6.62	3.98	3.69	3.17	---	---	---	---
28	7.15	6.77	6.72	7.10	6.53	4.19	3.57	3.03	---	---	---	---
29	7.10	6.82	6.85	6.96	---	4.17	3.58	3.01	---	---	---	---
30	6.96	6.68	6.79	6.96	---	4.00	3.59	3.05	---	---	---	---
31	6.86	---	6.80	7.24	---	3.91	---	3.07	---	---	---	---

Appendix 2.15—Water level in monitoring well SW8

1 U.S. DEPARTMENT OF THE INTERIOR - U.S. GEOLOGICAL SURVEY - WATER RESOURCES

STATION:422433094081601 088N28W29BADC 2013Smeltzer East Oxbow (W8) TYPE:WELL AGENCY:USGS STATE:19 COUNTY:187
LATITUDE: 422433.7 LONGITUDE: 0940816.9 NAD83 WELL DEPTH: 11.9 GEOLOGIC UNIT:110QRNR DATUM: 1090.12 NAVD88
DD #1
Depth to water level, feet below land surface
WATER YEAR OCTOBER 2012 TO SEPTEMBER 2013
DAILY MEAN VALUES

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	---	---	---	---	---	---	---	---	---	---	---	5.80
2	---	---	---	---	---	---	---	---	---	---	---	5.82
3	---	---	---	---	---	---	---	---	---	---	---	5.84
4	---	---	---	---	---	---	---	---	---	---	---	5.87
5	---	---	---	---	---	---	---	---	---	---	---	5.89
6	---	---	---	---	---	---	---	---	---	---	---	5.91
7	---	---	---	---	---	---	---	---	---	---	---	5.93
8	---	---	---	---	---	---	---	---	---	---	---	5.95
9	---	---	---	---	---	---	---	---	---	---	---	5.97
10	---	---	---	---	---	---	---	---	---	---	---	5.99
11	---	---	---	---	---	---	---	---	---	---	---	6.02
12	---	---	---	---	---	---	---	---	---	---	---	6.04
13	---	---	---	---	---	---	---	---	---	---	---	6.06
14	---	---	---	---	---	---	---	---	---	---	---	6.09
15	---	---	---	---	---	---	---	---	---	---	5.52	6.11
16	---	---	---	---	---	---	---	---	---	---	5.54	6.14
17	---	---	---	---	---	---	---	---	---	---	5.56	6.15
18	---	---	---	---	---	---	---	---	---	---	5.58	6.17
19	---	---	---	---	---	---	---	---	---	---	5.60	6.20
20	---	---	---	---	---	---	---	---	---	---	5.62	6.22
21	---	---	---	---	---	---	---	---	---	---	5.64	6.25
22	---	---	---	---	---	---	---	---	---	---	5.66	6.27
23	---	---	---	---	---	---	---	---	---	---	5.68	6.29
24	---	---	---	---	---	---	---	---	---	---	5.70	6.32
25	---	---	---	---	---	---	---	---	---	---	5.72	6.34
26	---	---	---	---	---	---	---	---	---	---	5.73	6.36
27	---	---	---	---	---	---	---	---	---	---	5.71	6.38
28	---	---	---	---	---	---	---	---	---	---	5.72	6.40
29	---	---	---	---	---	---	---	---	---	---	5.75	6.43
30	---	---	---	---	---	---	---	---	---	---	5.77	6.45
31	---	---	---	---	---	---	---	---	---	---	5.78	---

1 U.S. DEPARTMENT OF THE INTERIOR - U.S. GEOLOGICAL SURVEY - WATER RESOURCES

STATION:422433094081601 088N28W29BADC 2013Smeltzer East Oxbow (W8) TYPE:WELL AGENCY:USGS STATE:19 COUNTY:187
LATITUDE: 422433.7 LONGITUDE: 0940816.9 NAD83 WELL DEPTH: 11.9 GEOLOGIC UNIT:110QRNR DATUM: 1090.12 NAVD88
DD #1
Depth to water level, feet below land surface
WATER YEAR OCTOBER 2013 TO SEPTEMBER 2014
DAILY MEAN VALUES

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	6.48	7.54	12.20	12.57	12.83	13.10	4.94	4.13	3.94	---	---	---
2	6.51	7.58	12.21	12.58	12.84	13.10	4.91	4.05	4.00	---	---	---
3	6.54	7.61	12.22	12.58	12.85	13.10	4.89	4.09	4.05	---	---	---
4	6.57	9.15	12.23	12.59	12.86	13.10	4.87	4.14	4.02	---	---	---
5	6.60	11.67	12.25	12.60	12.87	13.11	4.86	4.17	4.02	---	---	---
6	6.63	11.71	12.27	12.61	12.88	13.11	4.84	4.21	4.06	---	---	---
7	6.67	11.74	12.29	12.62	12.89	13.11	4.82	4.24	4.09	---	---	---
8	6.70	11.76	12.30	12.63	12.90	13.12	4.81	4.28	4.13	---	---	---
9	6.73	11.78	12.31	12.64	12.91	13.11	4.79	4.30	---	---	---	---
10	6.77	11.81	12.32	12.64	12.93	13.11	4.79	4.32	---	---	---	---
11	6.80	11.84	12.34	12.65	12.93	13.11	4.78	4.33	---	---	---	---
12	6.83	11.87	12.35	12.65	12.94	13.12	4.77	3.88	---	---	---	---
13	6.87	11.88	12.36	12.67	12.95	13.11	4.75	3.50	---	---	---	---
14	6.91	11.90	12.37	12.68	12.96	11.39	4.64	3.58	---	---	---	---
15	6.94	11.91	12.38	12.69	12.97	9.15	4.50	3.65	---	---	---	---
16	6.98	11.92	12.39	12.69	12.99	9.14	4.42	3.71	---	---	---	---
17	7.02	11.94	12.41	12.71	12.99	9.13	4.42	3.77	---	---	---	---
18	7.06	11.97	12.41	12.71	13.00	9.11	4.41	3.82	---	---	---	---
19	7.09	11.99	12.42	12.72	13.02	9.09	4.41	3.86	---	---	---	---
20	7.12	12.01	12.44	12.73	13.02	8.92	4.42	3.91	---	---	---	---
21	7.16	12.03	12.45	12.74	13.04	6.12	4.43	3.96	---	---	---	---
22	7.20	12.06	12.46	12.75	13.05	5.27	4.45	4.02	---	---	---	---
23	7.24	12.08	12.48	12.77	13.06	5.23	4.45	4.06	---	---	---	---
24	7.28	12.10	12.48	12.76	13.07	5.19	4.46	4.11	---	---	---	---
25	7.32	12.11	12.49	12.77	13.08	5.16	4.47	4.15	---	---	---	---
26	7.36	12.12	12.50	12.77	13.08	5.12	4.48	4.18	---	---	---	---
27	7.39	12.14	12.52	12.79	13.09	5.09	4.48	3.88	---	---	---	---
28	7.43	12.16	12.52	12.80	13.09	5.06	4.40	3.78	---	---	---	---
29	7.46	12.18	12.54	12.80	---	5.03	4.34	3.80	---	---	---	---
30	7.49	12.19	12.54	12.80	---	4.99	4.29	3.85	---	---	---	---
31	7.51	---	12.55	12.82	---	4.96	---	3.89	---	---	---	---

Appendix 2.16—Stream discharge, Lyons Creek near Webster City, IA (L3)

1 U.S. DEPARTMENT OF THE INTERIOR - U.S. GEOLOGICAL SURVEY - WATER RESOURCES

STATION:05480986 Lyons Creek near Webster City, IA (L3) TYPE:STREAM AGENCY:USGS STATE:19 COUNTY:079
LATITUDE: 422935.7 LONGITUDE: 0934600.5 NAD83 DRAINAGE AREA: CONTRIBUTING DRAINAGE AREA: DATUM:
Lowest aging status in period is APPROVED
DD #3
Discharge, cubic feet per second
WATER YEAR OCTOBER 2012 TO SEPTEMBER 2013
DAILY MEAN VALUES

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	---	---	---	---	---	0.00	3.7	6.8	e39	7.5	0.80	0.00
2	---	---	---	---	---	0.00	2.4	15	e26	6.3	0.74	0.00
3	---	---	---	---	---	0.00	1.9	27	e20	5.5	0.67	0.00
4	---	---	---	---	---	0.00	1.5	50	15	4.7	0.57	0.00
5	---	---	---	---	---	0.00	1.5	61	14	4.2	0.56	0.00
6	---	---	---	---	---	0.00	1.4	35	12	3.7	0.53	0.00
7	---	---	---	---	---	0.00	1.2	21	9.9	3.3	0.47	0.00
8	---	---	---	---	---	e0.18	1.1	15	8.9	9.6	0.37	0.00
9	---	---	---	---	---	e22	5.8	17	8.7	35	0.35	0.00
10	---	---	---	---	---	e13	15	16	8.0	14	0.30	0.00
11	---	---	---	---	---	e5.9	12	13	7.5	8.9	0.28	0.00
12	---	---	---	---	---	e3.7	8.9	10	8.7	6.5	0.25	0.00
13	---	---	---	---	0.00	e2.4	4.9	9.2	7.9	5.2	0.19	0.00
14	---	---	---	---	0.00	e2.4	9.8	8.2	7.1	4.3	0.15	0.00
15	---	---	---	---	e0.46	e9.7	11	7.0	6.8	3.7	0.14	0.00
16	---	---	---	---	e0.15	39	6.2	6.9	6.2	3.2	0.13	0.00
17	---	---	---	---	e0.21	21	7.8	8.3	5.7	2.8	0.10	0.00
18	---	---	---	---	e0.14	8.8	36	7.9	5.2	2.5	0.08	0.00
19	---	---	---	---	e0.08	5.9	21	8.6	4.9	2.2	0.04	0.00
20	---	---	---	---	e0.02	2.2	12	14	4.6	1.8	0.02	0.00
21	---	---	---	---	0.00	1.3	8.9	12	4.5	1.7	0.00	0.00
22	---	---	---	---	0.00	1.8	8.6	10	4.2	1.7	0.00	0.00
23	---	---	---	---	0.00	2.8	11	8.7	4.1	2.3	0.00	0.00
24	---	---	---	---	0.00	2.9	8.6	8.1	99	1.7	0.00	0.00
25	---	---	---	---	e0.03	1.6	6.6	53	101	1.5	0.00	0.00
26	---	---	---	---	e0.01	5.9	5.8	114	63	1.4	0.00	0.00
27	---	---	---	---	0.00	11	5.0	173	35	1.2	0.00	0.00
28	---	---	---	---	0.00	13	4.7	132	19	1.1	0.00	0.00
29	---	---	---	---	---	13	7.7	103	12	1.0	0.00	0.00
30	---	---	---	---	---	10	9.3	92	9.3	0.98	0.00	0.00
31	---	---	---	---	---	6.4	---	e60	---	0.91	0.00	---

1 U.S. DEPARTMENT OF THE INTERIOR - U.S. GEOLOGICAL SURVEY - WATER RESOURCES

STATION:05480986 Lyons Creek near Webster City, IA (L3) TYPE:STREAM AGENCY:USGS STATE:19 COUNTY:079
LATITUDE: 422935.7 LONGITUDE: 0934600.5 NAD83 DRAINAGE AREA: CONTRIBUTING DRAINAGE AREA: DATUM:
Lowest aging status in period is APPROVED
DD #3
Discharge, cubic feet per second
WATER YEAR OCTOBER 2013 TO SEPTEMBER 2014
DAILY MEAN VALUES

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	0.00	0.00	---	---	---	---	---	---	---	---	---	---
2	0.00	0.00	---	---	---	---	---	---	---	---	---	---
3	0.00	0.00	---	---	---	---	---	---	---	---	---	---
4	0.00	---	---	---	---	---	---	---	---	---	---	---
5	0.00	---	---	---	---	---	---	---	---	---	---	---
6	0.00	---	---	---	---	---	---	---	---	---	---	---
7	0.00	---	---	---	---	---	---	---	---	---	---	---
8	0.00	---	---	---	---	---	---	---	---	---	---	---
9	0.00	---	---	---	---	---	---	---	---	---	---	---
10	0.00	---	---	---	---	---	---	---	---	---	---	---
11	0.00	---	---	---	---	---	---	---	---	---	---	---
12	0.00	---	---	---	---	---	---	---	---	---	---	---
13	0.00	---	---	---	---	---	---	---	---	---	---	---
14	0.00	---	---	---	---	---	---	---	---	---	---	---
15	0.00	---	---	---	---	---	---	---	---	---	---	---
16	0.00	---	---	---	---	---	---	---	---	---	---	---
17	0.00	---	---	---	---	---	---	---	---	---	---	---
18	0.00	---	---	---	---	---	---	---	---	---	---	---
19	0.00	---	---	---	---	---	---	---	---	---	---	---
20	0.00	---	---	---	---	---	---	---	---	---	---	---
21	0.00	---	---	---	---	---	---	---	---	---	---	---
22	0.00	---	---	---	---	---	---	---	---	---	---	---
23	0.00	---	---	---	---	---	---	---	---	---	---	---
24	0.00	---	---	---	---	---	---	---	---	---	---	---
25	0.00	---	---	---	---	---	---	---	---	---	---	---
26	0.00	---	---	---	---	---	---	---	---	---	---	---
27	0.00	---	---	---	---	---	---	---	---	---	---	---
28	0.00	---	---	---	---	---	---	---	---	---	---	---
29	0.00	---	---	---	---	---	---	---	---	---	---	---
30	0.00	---	---	---	---	---	---	---	---	---	---	---
31	0.00	---	---	---	---	---	---	---	---	---	---	---

e Estimated

Appendix 2.17—Stream discharge, Prairie Creek at Otho, IA (S3)

1 U.S. DEPARTMENT OF THE INTERIOR - U.S. GEOLOGICAL SURVEY - WATER RESOURCES

STATION:05480603 Prairie Creek at Otho, IA (S3) TYPE:STREAM AGENCY:USGS STATE:19 COUNTY:187
LATITUDE: 422439.2 LONGITUDE: 0940828.7 NAD83 DRAINAGE AREA: CONTRIBUTING DRAINAGE AREA: DATUM:
Lowest aging status in period is APPROVED
DD #3
Discharge, cubic feet per second
WATER YEAR OCTOBER 2012 TO SEPTEMBER 2013
DAILY MEAN VALUES

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	---	---	---	---	---	e2.6	8.4	19	110	23	1.4	0.00
2	---	---	---	---	---	e2.5	5.9	62	106	20	1.3	0.00
3	---	---	---	---	---	e2.8	4.5	123	76	17	1.2	0.00
4	---	---	---	---	---	e2.9	3.7	164	60	15	1.1	0.00
5	---	---	---	---	---	e2.8	3.6	205	54	14	0.95	0.00
6	---	---	---	---	---	e2.5	3.5	116	48	12	0.86	0.00
7	---	---	---	---	---	e3.1	3.2	82	42	11	0.85	0.00
8	---	---	---	---	e6.7	e6.6	3.2	63	38	10	0.60	0.00
9	---	---	---	---	e6.5	e18	7.7	58	39	9.6	0.55	0.00
10	---	---	---	---	e6.8	e46	24	58	39	8.7	0.42	0.00
11	---	---	---	---	e7.0	e15	24	48	36	7.9	0.59	0.00
12	---	---	---	---	e6.5	e6.9	18	40	37	7.4	1.1	0.00
13	---	---	---	---	e6.9	e5.6	12	36	34	6.8	1.0	0.00
14	---	---	---	---	e7.1	e5.6	19	33	33	6.2	0.65	0.00
15	---	---	---	---	e6.5	24	24	29	44	5.7	0.39	0.00
16	---	---	---	---	e6.2	98	16	27	47	5.3	0.43	0.00
17	---	---	---	---	e6.2	93	25	29	40	4.8	0.00	0.00
18	---	---	---	---	e5.5	53	121	28	34	4.5	0.04	0.00
19	---	---	---	---	e4.8	e29	71	27	30	4.1	0.04	0.00
20	---	---	---	---	e4.4	16	41	27	27	3.7	0.15	0.00
21	---	---	---	---	e4.9	11	32	27	24	3.4	0.14	0.00
22	---	---	---	---	e3.9	11	34	25	22	3.3	0.29	0.00
23	---	---	---	---	e3.4	13	56	21	21	2.8	0.27	0.00
24	---	---	---	---	e4.1	e12	41	20	236	2.5	0.23	0.00
25	---	---	---	---	e4.0	e9.8	32	69	335	2.4	0.34	0.00
26	---	---	---	---	e3.4	10	27	168	162	2.1	0.24	0.00
27	---	---	---	---	e3.0	28	24	513	90	1.9	0.09	0.00
28	---	---	---	---	e2.9	39	22	282	54	1.7	0.00	0.00
29	---	---	---	---	---	28	21	179	36	1.6	0.00	0.00
30	---	---	---	---	---	20	20	208	28	1.5	0.00	0.00
31	---	---	---	---	---	14	---	152	---	1.5	0.00	---

1 U.S. DEPARTMENT OF THE INTERIOR - U.S. GEOLOGICAL SURVEY - WATER RESOURCES

STATION:05480603 Prairie Creek at Otho, IA (S3) TYPE:STREAM AGENCY:USGS STATE:19 COUNTY:187
LATITUDE: 422439.2 LONGITUDE: 0940828.7 NAD83 DRAINAGE AREA: CONTRIBUTING DRAINAGE AREA: DATUM:
Lowest aging status in period is APPROVED
DD #3
Discharge, cubic feet per second
WATER YEAR OCTOBER 2013 TO SEPTEMBER 2014
DAILY MEAN VALUES

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	0.00	0.00	---	---	---	---	0.77	2.3	2.1	424	1.3	37
2	0.00	0.00	---	---	---	---	0.73	1.9	1.7	191	1.2	28
3	0.00	0.00	---	---	---	---	0.54	1.2	1.8	113	1.0	20
4	0.00	---	---	---	---	---	0.64	e0.70	3.0	75	1.2	16
5	0.00	---	---	---	---	---	0.45	e0.31	2.8	69	0.99	e16
6	0.00	---	---	---	---	---	e0.42	e0.20	3.7	77	2.9	e16
7	0.00	---	---	---	---	---	e0.37	e0.27	2.8	55	6.3	e14
8	0.00	---	---	---	---	---	e0.38	e0.15	2.3	40	6.4	e14
9	0.00	---	---	---	---	---	e0.35	e0.26	1.8	30	e6.8	e15
10	0.00	---	---	---	---	---	e0.35	e0.21	2.9	25	e6.8	e18
11	0.00	---	---	---	---	---	e0.30	2.2	4.0	20	e6.9	e19
12	0.00	---	---	---	---	---	e0.25	29	5.2	19	e7.0	e16
13	0.00	---	---	---	---	---	e0.51	15	5.2	18	e7.2	e15
14	0.00	---	---	---	---	---	e1.1	7.5	4.7	14	e7.1	e13
15	0.00	---	---	---	---	12	e1.1	4.5	4.8	11	e7.5	e12
16	0.00	---	---	---	---	9.5	e0.81	3.1	4.9	9.8	e8.6	e11
17	0.00	---	---	---	---	5.7	e0.60	2.3	157	8.7	e9.3	e12
18	0.00	---	---	---	---	5.0	e0.48	1.6	62	7.9	e8.8	e11
19	0.00	---	---	---	---	5.4	e0.28	1.3	32	7.3	e8.1	e11
20	0.00	---	---	---	---	5.0	e0.25	1.5	27	6.7	e7.8	e12
21	0.00	---	---	---	---	4.8	e0.38	0.76	18	6.4	e9.6	e14
22	0.00	---	---	---	---	3.7	e0.52	0.22	15	5.7	e10	e14
23	0.00	---	---	---	---	2.0	e0.46	0.31	14	4.2	e12	e13
24	0.00	---	---	---	---	0.78	e0.50	0.83	12	3.3	e14	e14
25	0.00	---	---	---	---	0.74	e0.57	1.5	10	5.0	17	e16
26	0.00	---	---	---	---	0.36	e0.62	3.1	8.8	7.1	18	e14
27	0.00	---	---	---	---	1.5	e0.86	7.7	12	4.8	19	e14
28	0.00	---	---	---	---	1.6	1.5	4.6	30	3.0	21	e16
29	0.00	---	---	---	---	0.77	1.4	3.5	84	1.7	24	e14
30	0.00	---	---	---	---	1.2	1.4	2.9	421	1.1	24	e12
31	0.00	---	---	---	---	2.0	---	2.3	---	0.85	24	---

e Estimated

Appendix 3.—Water quality data

Appendix 3.1—Water quality in discrete samples collected from streams, tile inflow, and oxbow discharge in the Lyons and Prairie Creek study areas

[<, less than; >, greater than]

Sample date	Sample time	Discharge, instantaneous, cubic feet per second	Ammonia, water, filtered, milligrams per liter as nitrogen	Nitrate plus nitrite, water, filtered, milligrams per liter as nitrogen	Ortho-phosphate, water, filtered, milligrams per liter as phosphorus	Phosphorus, water, unfiltered, milligrams per liter as phosphorus	Total nitrogen (nitrate + nitrite + ammonia + organic-N), water, unfiltered, analytically determined, milligrams per liter
Lyons Oxbow Inlet near Webster City, IA (L1)							
3/9/2013	1015	0.21	0.85	5.9	0.52	1.2	9.2
3/9/2013	1645	0.07	0.29	7.3	0.67	1.1	11
3/10/2013	0450	0.02	0.29	12	0.44	0.80	13
3/10/2013	1650	0.05	0.46	9.2	0.46	0.62	23
3/11/2013	1650	0.02	0.11	9.8	0.37	0.45	11
3/27/2013	1010	0.01	0.04	8.8	0.19	0.31	9.3
4/14/2013	0705	0.1	0.02	12	0.31	0.41	12
4/14/2013	0940	0.22	0.06	6.5	0.17	0.50	7.7
4/14/2013	2135	0.28	< 0.008	18	0.18	0.23	19
4/15/2013	0925	0.21	0.03	22	0.19	0.23	22
4/16/2013	2135	0.13	0.09	14	0.11	1.0	19
4/24/2013	0837	0.23	0.02	39	0.12	0.15	40
5/2/2013	0225	0.07	0.02	42	0.10	0.14	42
5/3/2013	0800	0.38	0.02	46	0.03	0.07	47
5/4/2013	0805	0.54	< 0.008	46	0.04	0.07	50
5/4/2013	1520	1.1	0.04	48	0.03	0.11	48
5/5/2013	0320	0.90	< 0.008	52	0.05	0.08	57
5/6/2013	0320	0.58	0.03	47	0.08	0.11	48
5/21/2013	0751	0.45	0.02	46	0.07	0.10	47
6/3/2013	1025	0.33	< 0.008	35	0.07	0.11	35
6/18/2013	0916	0.1	< 0.008	46	0.03	0.07	47

Sample date	Sample time	Discharge, instantaneous, cubic feet per second		Ammonia, water, filtered, milligrams per liter as nitrogen	Nitrate plus nitrite, water, filtered, milligrams per liter as nitrogen	Ortho-phosphate, water, filtered, milligrams per liter as phosphorus	Phosphorus, water, unfiltered, milligrams per liter as phosphorus	Total nitrogen (nitrate + nitrite + ammonia + organic-N), water, unfiltered, analytically determined, milligrams per liter
6/24/2013	1310	2.5		0.03	23	0.16	0.45	24
6/24/2013	1910	2.4		0.04	21	0.19	0.42	21
6/25/2013	0710	2.3		0.03	15	0.22	0.40	15
6/26/2013	0710	1.6	<	0.008	28	0.13	0.19	30
6/27/2013	0355	0.83	<	0.008	28	0.11	0.18	29
7/16/2013	1117	0.01		0.02	38	0.07		39
Lyons Oxbow Outlet near Webster City, IA (L2)								
3/9/2013	1037	6.8		0.18	6.4	0.48	0.83	9.4
3/10/2013	0310	1.0		0.07	10	0.32	0.49	11
3/10/2013	0830	2.3		0.06	10	0.32	0.48	11
3/10/2013	1420	0.74		0.05	12	0.30	0.46	12
3/11/2013	2050	0.02		0.05	13	0.27	0.40	15
3/12/2013	2050	0.02		0.04	14	0.24	0.34	15
3/27/2013	1120	0.02		0.03	7.5	0.15	0.20	7.9
4/14/2013	0710	0.14		0.02	14	0.21	0.32	14
4/14/2013	1910	0.32		0.02	19	0.2	0.23	19
4/15/2013	0250	0.27	<	0.008	21	0.21	0.22	21
4/15/2013	0850	0.24		0.02	12	0.21	0.25	13
4/15/2013	0956	0.23	<	0.008	21	0.20	0.23	22
4/16/2013	2135	0.15		0.02	16	0.16	0.23	16
4/24/2013	0905	0.26	<	0.008	37	0.11	0.16	38
5/2/2013	0010	0.07		0.04	46	0.09	0.15	48
5/3/2013	0645	0.41		0.02	42	0.05	0.11	42
5/4/2013	1305	0.77	<	0.008	44	0.06	0.09	47
5/4/2013	1610	1.5	<	0.008	47	0.05	0.09	47
5/4/2013	1810	2.2	<	0.008	49	0.06	0.09	50
5/5/2013	0540	1.3	<	0.008	52	0.06	0.09	52
5/6/2013	0330	0.55		0.02	47	0.06	0.10	49
5/21/2013	0843	0.45	<	0.02	44	0.08	0.10	45
6/3/2013	1002	0.34	<	0.008	34	0.07	0.16	36

Sample date	Sample time		Discharge, instantaneous, cubic feet per second		Ammonia, water, filtered, milligrams per liter as nitrogen	Nitrate plus nitrite, water, filtered, milligrams per liter as nitrogen	Ortho-phosphate, water, filtered, milligrams per liter as phosphorus	Phosphorus, water, unfiltered, milligrams per liter as phosphorus	Total nitrogen (nitrate + nitrite + ammonia + organic-N), water, unfiltered, analytically determined, milligrams per liter
6/18/2013	0856		0.10		0.03	44	0.05	0.13	45
6/24/2013	1035		0.46		0.02	35	0.12	0.26	36
6/24/2013	1255		3.1		0.06	21	0.22	0.50	21
6/24/2013	1305		7.8		0.06	14	0.20	0.77	16
6/24/2013	1415	>	7.8		0.41	9.9	0.47	2.98	16
6/24/2013	1525	>	7.8		0.12	21	0.23	0.92	23
6/24/2013	1910	>	7.8		0.04	21	0.19	0.43	21
6/25/2013	0245		6.7		0.02	15	0.21	0.42	16
6/27/2013	1039		0.85		0.02	26	0.11	0.18	27
7/16/2013	1110		0.01		0.04	31	0.16	0.17	32
Lyons Creek near Webster City, IA (L3)									
3/9/2013	1054		98		2.7	3.0	3.8	4.4	7.7
3/9/2013	1335		85		4.7	2.8	4.4	5.1	8.8
3/10/2013	1425		45		1.9	6.6	2.5	5.2	13
3/10/2013	2035		22		3.8	4.1	3.8	4.8	8.2
3/11/2013	0000		15		1.7	5.7	1.8	4.8	14
3/27/2013	1100		4.9		0.90	4.2	1.2	1.4	6.0
4/14/2013	0710		4.6		0.03	23	0.17	0.20	25
4/14/2013	1415		14		0.05	25	0.25	0.31	25
4/15/2013	0215		15		0.04	22	0.18	0.24	22
4/15/2013	1005		12		0.04	27	0.23	0.29	28
4/16/2013	2140		5.3	<	0.008	29	0.14	0.18	29
4/24/2013	0919		8.9	<	0.008	37	0.08	0.13	38
5/2/2013	1140		16		0.02	30	0.05	0.13	31
5/3/2013	0800		26		0.06	35	0.11	0.20	36
5/6/2013	1040		34		0.04	32	0.25	0.31	33
5/21/2013	0827		13	<	0.01	39	0.03	0.06	40
6/3/2013	0954		18		0.04	29	0.19	0.32	30
6/18/2013	0835		5.4	<	0.008	38	0.01	0.06	39
6/24/2013	1035		14		0.17	11	0.07	1.4	14

Sample date	Sample time	Discharge, instantaneous, cubic feet per second	Ammonia, water, filtered, milligrams per liter as nitrogen	Nitrate plus nitrite, water, filtered, milligrams per liter as nitrogen		Ortho-phosphate, water, filtered, milligrams per liter as phosphorus	Phosphorus, water, unfiltered, milligrams per liter as phosphorus	Total nitrogen (nitrate + nitrite + ammonia + organic-N), water, unfiltered, analytically determined, milligrams per liter
6/24/2013	1300	96	0.17	8.6		0.03	3.9	17
6/24/2013	1400	222	0.10	11		0.11	1.3	14
6/24/2013	1616	316	0.09	6.9		0.29	1.9	11
6/24/2013	1930	182	0.04	15		0.41	0.94	17
6/25/2013	0130	118	0.05	16		0.37	0.84	17
6/26/2013	0130	83	0.05	18		0.38	0.67	20
6/27/2013	0730	39	0.04	21		0.30	0.53	23
7/16/2013	1105	3.3	0.03	32		0.09	0.12	33
7/29/2013	1047	1.0	0.01	32		0.03	0.05	33
Prairie Creek at Otho, IA (S3)								
3/9/2013	1326		1.5	4.0		1.9	2.7	8.0
3/10/2013	0515	75	1.3	4.3		2.2	2.6	7.6
3/10/2013	1415	87	1.0	6.2		2.2	2.6	9.3
3/11/2013	0505	11	0.94	6.2		1.9	2.3	9.8
3/27/2013	1410	15	0.28	3.7		0.92	0.99	5.4
4/14/2013	0705	12	1.3	14		0.01	0.17	17
4/14/2013	1905	28	0.30	12		0.12	0.26	12
4/15/2013	0105	31	0.24	13		0.13	0.26	14
4/15/2013	1146	23	0.33	16		0.18	0.33	18
4/16/2013	2140	13	0.08	19		0.05	0.16	19
4/24/2013	1147	43	0.09	31		0.04	0.25	32
5/1/2013	1635	18	0.05	27	<	0.001	0.17	28
5/2/2013	1130	63	0.04	23		0.01	0.09	25
5/3/2013	0330	121	0.04	30		0.03	0.17	30
5/3/2013	2130	130	0.07	32		0.11	0.25	33
5/4/2013	1530	155	0.05	31		0.14	0.26	33
5/4/2013	2355	261	0.10	31		0.19	0.56	32
5/5/2013	1155	198	0.05	32		0.15	0.49	33
5/6/2013	0555	127	0.04	33		0.08	0.26	34
5/21/2013	1225	27	0.02	30		0.01	0.09	32

Sample date	Sample time	Discharge, instantaneous, cubic feet per second	Ammonia, water, filtered, milligrams per liter as nitrogen	Nitrate plus nitrite, water, filtered, milligrams per liter as nitrogen	Ortho-phosphate, water, filtered, milligrams per liter as phosphorus	Phosphorus, water, unfiltered, milligrams per liter as phosphorus	Total nitrogen (nitrate + nitrite + ammonia + organic-N), water, unfiltered, analytically determined, milligrams per liter
6/3/2013	1242	75	0.16	27	0.03	1.0	27
6/18/2013	1141	35	0.09	30	< 0.004	0.23	30
6/24/2013	1235	64	0.07	19	0.10	0.45	21
6/24/2013	1300	133	0.06	15	0.16	0.87	17
6/24/2013	1325	221	0.06	6.6	0.23	1.6	12
6/24/2013	1410	390	0.06	7.0	0.24	1.6	14
6/24/2013	1645	581	0.05	8.4	0.25	1.5	11
6/24/2013	2245	437	0.06	14	0.30	0.72	15
6/25/2013	0545	431	0.08	14	0.31	0.86	16
6/25/2013	2345	227	0.04	20	0.23	0.43	20
6/27/2013	0805	95	0.07	22	0.13	0.36	25
7/2/2013	0822	20	0.03	28	0.04	0.08	29
7/16/2013	1630	5.1	0.03	19	0.01	0.02	19
7/29/2013	1350	1.6	0.04	11	0.01	0.03	11
8/27/2013	1330	0.02	0.05	< 0.01			
4/2/2014	1230	0.85	0.05	0.31	0.02	0.08	1.0
5/7/2014	1200	0.56	0.01	< 0.01	< 0.004	0.06	0.98
5/13/2014	0911	7.1	0.06	10	0.21	0.33	11
6/4/2014	0925	4.4	0.09	2.0	0.01	0.05	2.9
6/17/2014	0935	243	0.07	14	0.23	0.71	16
6/19/2014	1545	28	0.05	23	0.10	0.14	23
6/23/2014	1600	14	0.03	21	0.05	0.18	23
7/1/2014	1016	414	0.03	16	0.18	0.36	17
8/4/2014	1345	1.3	0.05	5.6	0.01	0.04	5.7
9/15/2014	1316	12	0.02	23	0.01	0.03	24
10/6/2014	0915		0.01	24	0.02	0.03	24
Smeltzer West Oxbow Inlet near Otho, IA (S1)							
2/13/2013	1300		0.02	< 0.01	0.01	0.05	0.03
3/27/2013	1500	0.01	0.05	2.3	0.79	0.81	2.7
4/14/2013	1905	0.03	< 0.01	19	0.04	0.15	21

Sample date	Sample time	Discharge, instantaneous, cubic feet per second		Ammonia, water, filtered, milligrams per liter as nitrogen	Nitrate plus nitrite, water, filtered, milligrams per liter as nitrogen	Ortho-phosphate, water, filtered, milligrams per liter as phosphorus	Phosphorus, water, unfiltered, milligrams per liter as phosphorus	Total nitrogen (nitrate + nitrite + ammonia + organic-N), water, unfiltered, analytically determined, milligrams per liter
4/15/2013	1209	0.01	<	0.008	19	0.02	0.03	20
4/24/2013	1104	0.05	<	0.008	22	0.01	0.02	23
5/1/2013	2200	0.02		0.02	22	0.01	0.03	22
5/2/2013	0225	0.06		0.03	18	0.01	0.03	19
5/2/2013	1005	0.14	<	0.008	19	0.04	0.12	20
5/2/2013	2005	0.24		0.04	17	0.18	0.29	17
5/4/2013	0400	0.23	<	0.008	17	0.12	0.14	18
5/4/2013	2005	0.41		0.02	15	0.16	0.24	16
5/5/2013	0805	0.29		0.04	15	0.10	0.13	16
5/6/2013	1600	0.14	<	0.008	18	0.03	0.54	19
5/21/2013	1151	0.04		0.03	20	0.01	0.01	20
6/3/2013	1328	0.06	<	0.008	18	0.01	0.01	18
6/18/2013	1044	0.04	<	0.008	18	0.01	0.03	19
6/24/2013	1235	0.19	<	0.008	12	0.18	0.31	13
6/24/2013	1255	0.38		0.02	14	0.12	0.16	14
6/24/2013	1855	0.33	<	0.008	15	0.04	0.06	16
6/25/2013	0435	0.26	<	0.008	15	0.06	0.10	15
6/25/2013	1105	0.41	<	0.008	14	0.06	0.07	14
6/26/2013	0505	0.20	<	0.008	17	0.01	0.02	18
6/27/2013	0505	0.12	<	0.008	18	0.01	0.02	18
7/16/2013	1731	0.002	<	0.008	16	0.02	0.02	17
5/7/2014	1030	0.002		0.01	15	0.01	0.01	15
5/13/2014	0955	0.02		0.01	20	0.02	0.03	21
6/4/2014	1015	0.02	<	0.008	21	0.01	0.01	21
6/17/2014	1100	0.23		0.01	27	0.01	0.03	27
6/23/2014	1613	0.05		0.01	23	0.02	0.01	24
7/1/2014	1110	0.30		0.01	22	0.02	0.03	22
8/4/2014	1217	0.003		0.01	21	0.01	0.05	22
9/15/2014	1202	0.03		0.02	17	0.02	0.01	18
10/6/2014	1145	0.07		0.01	15	0.01	0.01	14

Sample date	Sample time	Discharge, instantaneous, cubic feet per second	Ammonia, water, filtered, milligrams per liter as nitrogen	Nitrate plus nitrite, water, filtered, milligrams per liter as nitrogen	Ortho-phosphate, water, filtered, milligrams per liter as phosphorus	Phosphorus, water, unfiltered, milligrams per liter as phosphorus	Total nitrogen (nitrate + nitrite + ammonia + organic-N), water, unfiltered, analytically determined, milligrams per liter
Smeltzer West Oxbow Outlet near Otho, IA (S2)							
3/9/2013	1406	0.35	0.38	2.2	3.6	3.7	5.4
4/14/2013	1215	0.07	0.04	1.4	1.5	1.6	2.5
4/15/2013	0015	0.09	0.03	1.6	1.4	1.6	2.8
4/15/2013	1129	0.06	0.02	1.6	1.4	1.6	2.9
4/24/2013	1130	0.11	0.02	9.4	0.3	0.55	10
5/2/2013	0040	0.11	0.06	11	< 0.003	0.10	13
5/3/2013	0040	0.28	0.03	13	< 0.003	0.13	13
5/3/2013	1240	0.26	0.03	12	< 0.003	0.11	13
5/5/2013	0040	0.31	0.02	10	0.06	0.21	11
5/6/2013	0040	0.27	0.02	11	0.10	0.20	12
5/21/2013	1258	0.22	0.03	14	0.01	0.04	15
6/3/2013	1250	0.13	0.16	12	0.10	0.15	12
6/18/2013	1110	0.11	0.03	12	< 0.003	0.04	12
6/24/2013	1315	0.43	0.03	10	0.01	0.18	11
6/24/2013	1430	1.1	< 0.008	10	0.01	0.10	11
6/24/2013	1510	1.8	0.05	8.3	0.26	0.98	9.4
6/24/2013	1620	2.9	0.05	8.8	0.30	1.1	11
6/24/2013	1905	2.2	0.05	12	0.27	0.75	13
6/25/2013	0110	0.47	0.02	9.2	0.11	0.22	9.5
6/25/2013	0505	0.83	0.06	9.1	0.10	0.24	9.6
6/25/2013	0525	1.1	0.07	7.4	0.16	0.35	8.3
6/25/2013	1020	0.61	0.05	3.8	0.62	0.83	5.2
6/25/2013	2220	0.35	0.03	6.2	0.36	0.46	7.3
6/27/2013	0805	0.20	0.04	9.9	0.17	0.25	11
6/17/2014	1030	0.21	0.06	2.5	0.03	0.14	3.7
6/23/2014	1608	0.12	0.02	11	0.01	0.06	12
7/1/2014	1038	0.24	0.11	3.5	0.67	0.90	4.8
9/15/2014	1241	0.03	0.03	4.0	0.01	0.05	4.8
10/6/2014	1045	0.02	0.05	10	0.01	0.02	10

Sample date	Sample time		Discharge, instantaneous, cubic feet per second		Ammonia, water, filtered, milligrams per liter as nitrogen		Nitrate plus nitrite, water, filtered, milligrams per liter as nitrogen	Ortho-phosphate, water, filtered, milligrams per liter as phosphorus	Phosphorus, water, unfiltered, milligrams per liter as phosphorus	Total nitrogen (nitrate + nitrite + ammonia + organic-N), water, unfiltered, analytically determined, milligrams per liter
Smeltzer East Oxbow Inlet near Otho, IA (S4)										
3/8/2013	2240		0.04		0.33		1.3	1.9	2.1	3.7
3/9/2013	0015		0.1		0.36		1.6	1.9	2.3	4.2
3/9/2013	0105		0.19		0.40		1.7	1.7	2.0	4.5
3/9/2013	0155		0.32		0.35		1.5	1.7	2.0	5.0
3/9/2013	0755		0.36		0.27		1.6	1.9	2.1	3.6
3/9/2013	1527		0.25		0.34		1.3	2.8	3.2	4.5
3/10/2013	0350		0.07		0.35		1.8	3.5	4.0	4.1
3/10/2013	0850		0.1		0.33		2.7	3.9	4.7	5.4
3/10/2013	2025		0.01		0.32		1.4	3.5	3.9	4.6
3/27/2013	1330	<	0.01		0.03	<	0.03	0.38	0.47	1.5
4/14/2013	1645		0.09		0.04		13	1.1	1.2	14
4/15/2013	1257		0.01	<	0.008		0.59	0.26	0.37	1.5
4/24/2013	1228		0.02		0.02		3.9	0.37	0.46	5.0
5/2/2013	0305		0.01		0.03		5.3	0.04	0.16	5.9
5/2/2013	1120		0.08		0.04		5.4	0.93	1.1	6.1
5/2/2013	1900		0.25		0.04		3.1	1.4	1.6	3.9
5/3/2013	1300		0.31		0.03		2.3	1.5	1.6	2.9
5/4/2013	0700		0.18		0.02		5.1	1.3	1.4	5.1
5/4/2013	1900		0.27		0.03		4.9	1.2	1.3	4.9
5/5/2013	0700		0.18		0.02		5.8	1.1	1.2	5.8
5/6/2013	0100		0.04	<	0.008		8.9	0.57	0.77	9.1
5/21/2013	1055		0.01		0.04		9.2	0.02	0.08	9.5
6/3/2013	1421		0.02		0.06		7.7	0.09	0.18	8.2
6/18/2013	1312		0.01		0.03		9.1	0.01	0.08	9.4
6/24/2013	1230		0.3		0.38		0.73	0.73	3.8	8.4
6/24/2013	1830		0.34		0.05		1.9	1.5	2.0	4.4
6/24/2013	2145		0.09	<	0.008		6.8	0.59	0.75	7.1
6/25/2013	0435		0.31		0.06		1.0	0.88	1.4	3.1
6/25/2013	1035		0.33		0.16		1.1	0.70	4.0	7.8

Sample date	Sample time	Discharge, instantaneous, cubic feet per second	Ammonia, water, filtered, milligrams per liter as nitrogen	Nitrate plus nitrite, water, filtered, milligrams per liter as nitrogen	Ortho-phosphate, water, filtered, milligrams per liter as phosphorus	Phosphorus, water, unfiltered, milligrams per liter as phosphorus	Total nitrogen (nitrate + nitrite + ammonia + organic-N), water, unfiltered, analytically determined, milligrams per liter
6/25/2013	1635	0.35	0.08	1.1	0.88	1.3	2.7
6/27/2013	0650	0.02	< 0.008	11	0.08	0.14	12
5/13/2014	1100	0.01	0.02	2.3	0.02	0.19	3.9
6/17/2014	1110	0.45	1.6	7.2	0.92	1.1	10
6/23/2014	1620	0.02	0.01	3.9	0.02	0.05	4.6
7/1/2014	1136	0.58	0.07	1.7	0.65	0.74	2.7
9/15/2014	0843	0.01	0.01	14	0.02	0.06	14
10/6/2014	1345	0.03	0.06	19	0.01	0.06	18
Smeltzer East Oxbow Outlet near Otho, IA (S5)							
3/9/2013	1440	7.2	0.30	1.6	1.6	1.9	4.5
3/10/2013	0530	6.6	0.31	1.7	1.6	1.9	4.5
3/10/2013	1030	7.2	0.32	1.6	1.6	1.9	4.3
3/12/2013	2230	6.4	0.31	1.6	1.9	2.1	4.1
4/24/2013	1306	0.83	0.03	2.5	0.78	1.3	3.7
5/2/2013	0525	1.5	0.13	1.3	0.48	0.73	2.8
5/3/2013	0420	2	0.03	1.8	0.65	3.0	3.3
5/3/2013	1535	2.7	0.03	2.2	0.83	1.2	3.5
5/4/2013	0200	4.3	0.09	2.4	1.1	1.2	3.1
5/4/2013	1625	4.9	0.08	3.1	1.1	1.2	4.0
5/5/2013	0045	6.8	0.03	3.4	1.1	1.3	4.6
5/5/2013	1055	5.4	0.06	4.0	1.1	1.2	4.8
5/5/2013	1400	3.1	0.03	4.0	1.0	1.2	4.9
5/6/2013	0440	1.2	0.04	4.6	1.1	1.2	5.0
5/21/2013	1132	1	0.21	1.6	0.10	0.21	2.9
6/3/2013	1443	0.87	0.25	2.9	0.61	0.82	4.5
6/18/2013	1224	1.2	0.03	2.7	0.19	0.41	3.9
6/24/2013	1110	1.3	0.53	0.95	0.08	0.14	2.5
6/24/2013	1335	3.8	0.52	0.72	0.14	0.25	2.4
6/24/2013	1415	7.8	0.50	0.94	0.14	0.22	2.4
6/24/2013	1645	13	0.47	0.97	0.17	0.27	2.5

Sample date	Sample time	Discharge, instantaneous, cubic feet per second	Ammonia, water, filtered, milligrams per liter as nitrogen	Nitrate plus nitrite, water, filtered, milligrams per liter as nitrogen	Ortho-phosphate, water, filtered, milligrams per liter as phosphorus	Phosphorus, water, unfiltered, milligrams per liter as phosphorus	Total nitrogen (nitrate + nitrite + ammonia + organic-N), water, unfiltered, analytically determined, milligrams per liter
6/24/2013	2245	11	0.47	1.1	0.32	0.45	2.5
6/25/2013	0345	6.7	0.44	1.3	0.55	0.75	3.1
6/25/2013	0515	11	0.36	1.2	0.54	0.88	3.2
6/25/2013	1115	11	0.30	1.2	0.57	0.87	3.1
6/25/2013	2130	4.8	0.25	1.2	0.77	0.97	2.7
6/27/2013	0050	1	0.29	2.2	0.72	0.74	3.3
6/17/2014	1200	3.3	0.17	1.5	0.22	0.63	4.3
6/23/2014	1625	0.62	0.03	3.5	0.24	0.52	5.7
7/1/2014	1215	9.4	0.16	1.7	0.54	0.69	2.8
9/15/2014	1015	0.91	0.02	0.33	0.02	0.22	1.8
10/6/2014	1245	0.93	0.06	4.1	0.05	0.24	5.4

Appendix 3.2 –Nitrate plus nitrite nitrogen concentration and load in Lyons Creek near Webster City, IA

1 U.S. DEPARTMENT OF THE INTERIOR - U.S. GEOLOGICAL SURVEY - WATER RESOURCES

STATION:05480986 Lyons Creek near Webster City, IA (L3) TYPE:STREAM AGENCY:USGS STATE:19 COUNTY:079
LATITUDE: 422935.7 LONGITUDE: 0934600.5 NAD83 DRAINAGE AREA: CONTRIBUTING DRAINAGE AREA: DATUM:
Lowest aging status in period is APPROVED
DD #2
Nitrate plus nitrite, water, in situ, milligrams per liter as nitrogen
WATER YEAR OCTOBER 2012 TO SEPTEMBER 2013
DAILY MEAN VALUES

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	---	---	---	---	---	---	---	37.5	27.3	35.2	31.7	---
2	---	---	---	---	---	---	---	32.5	28.3	36.4	31.4	---
3	---	---	---	---	---	---	---	35.2	30.6	37.2	30.9	---
4	---	---	---	---	---	---	---	35.0	31.4	37.6	30.0	---
5	---	---	---	---	---	---	---	29.9	32.1	38.0	29.5	---
6	---	---	---	---	---	---	---	32.4	32.8	38.0	29.2	---
7	---	---	---	---	---	---	---	34.7	35.5	37.9	28.2	---
8	---	---	---	---	---	---	---	36.7	36.1	35.9	27.1	---
9	---	---	---	---	---	---	---	35.6	36.0	24.2	26.1	---
10	---	---	---	---	---	---	---	38.0	37.0	29.9	25.1	---
11	---	---	---	---	---	---	---	39.4	---	33.4	24.4	---
12	---	---	---	---	---	---	---	40.3	---	35.3	23.1	---
13	---	---	---	---	---	---	---	40.7	---	36.2	22.1	---
14	---	---	---	---	---	---	---	41.0	---	36.2	21.3	---
15	---	---	---	---	---	---	---	41.3	---	36.2	20.6	---
16	---	---	---	---	---	---	---	41.0	---	35.9	19.6	---
17	---	---	---	---	---	---	---	39.8	---	35.8	18.3	---
18	---	---	---	---	---	---	---	41.2	---	35.8	17.0	---
19	---	---	---	---	---	---	---	40.0	---	35.9	15.4	---
20	---	---	---	---	---	---	---	37.4	---	35.8	13.6	---
21	---	---	---	---	---	---	---	40.3	---	35.6	11.8	---
22	---	---	---	---	---	---	---	40.7	40.9	34.6	---	---
23	---	---	---	---	---	---	---	40.6	40.1	30.8	---	---
24	---	---	---	---	---	---	---	40.9	27.1	31.9	---	---
25	---	---	---	---	---	---	---	35.0	18.0	33.0	---	---
26	---	---	---	---	---	---	---	28.0	20.2	33.0	---	---
27	---	---	---	---	---	---	38.3	22.9	21.8	33.2	---	---
28	---	---	---	---	---	---	38.4	22.8	28.6	33.3	---	---
29	---	---	---	---	---	---	36.6	22.9	32.4	33.0	---	---
30	---	---	---	---	---	---	35.2	24.4	34.1	32.5	---	---
31	---	---	---	---	---	---	---	26.5	---	32.1	---	---

1 U.S. DEPARTMENT OF THE INTERIOR - U.S. GEOLOGICAL SURVEY - WATER RESOURCES

STATION:05480986 Lyons Creek near Webster City, IA (L3) TYPE:STREAM AGENCY:USGS STATE:19 COUNTY:079
LATITUDE: 422935.7 LONGITUDE: 0934600.5 NAD83 DRAINAGE AREA: CONTRIBUTING DRAINAGE AREA: DATUM:
Lowest aging status in period is APPROVED
DD #7
Nitrate plus nitrite, water, total, tons per day as nitrogen
WATER YEAR OCTOBER 2012 TO SEPTEMBER 2013
DAILY MEAN VALUES

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	---	---	---	---	---	---	---	0.69	2.9	0.71	0.07	---
2	---	---	---	---	---	---	---	1.3	2.0	0.62	0.06	---
3	---	---	---	---	---	---	---	2.6	1.6	0.55	0.06	---
4	---	---	---	---	---	---	---	4.7	1.3	0.48	0.05	---
5	---	---	---	---	---	---	---	5.1	1.2	0.43	0.04	---
6	---	---	---	---	---	---	---	3.1	1.1	0.38	0.04	---
7	---	---	---	---	---	---	---	2.0	0.95	0.34	0.04	---
8	---	---	---	---	---	---	---	1.5	0.87	0.93	0.03	---
9	---	---	---	---	---	---	---	1.6	0.85	2.3	0.03	---
10	---	---	---	---	---	---	---	1.6	0.80	1.2	0.02	---
11	---	---	---	---	---	---	---	1.3	0.76	0.80	0.02	---
12	---	---	---	---	---	---	---	1.1	---	0.62	0.01	---
13	---	---	---	---	---	---	---	---	---	0.50	0.01	---
14	---	---	---	---	---	---	---	0.91	0.76	0.42	0.01	---
15	---	---	---	---	---	---	---	0.78	0.72	0.36	0.01	---
16	---	---	---	---	---	---	---	0.77	0.66	0.31	0.01	---
17	---	---	---	---	---	---	---	0.90	0.61	0.27	0.01	---
18	---	---	---	---	---	---	---	0.88	0.57	0.24	0.00	---
19	---	---	---	---	---	---	---	0.92	0.54	0.21	0.00	---
20	---	---	---	---	---	---	---	1.4	0.51	0.18	0.00	---
21	---	---	---	---	---	---	---	1.3	0.49	0.16	0.00	---
22	---	---	---	---	---	---	---	1.2	0.46	0.16	---	---
23	---	---	---	---	---	---	---	0.95	0.45	0.19	---	---
24	---	---	---	---	---	---	---	0.89	7.2	0.15	---	---
25	---	---	---	---	---	---	---	5.0	4.9	0.14	---	---
26	---	---	---	---	---	---	---	8.7	3.4	0.13	---	---
27	---	---	---	---	---	---	0.52	11	2.1	0.11	---	---
28	---	---	---	---	---	---	0.49	8.2	1.5	0.10	---	---
29	---	---	---	---	---	---	0.77	6.4	1.1	0.09	---	---
30	---	---	---	---	---	---	0.88	6.1	0.85	0.09	---	---
31	---	---	---	---	---	---	---	4.3	---	0.08	---	---

Appendix 3.3 – Nitrate plus nitrite nitrogen concentration and load in the Smeltzer West Oxbow Inlet near Otho, IA (S1)

1 U.S. DEPARTMENT OF THE INTERIOR - U.S. GEOLOGICAL SURVEY - WATER RESOURCES

STATION:422436094082501 Smeltzer West Oxbow Inlet near Otho, IA (S1) TYPE:WETLAND AGENCY:USGS STATE:19 COUNTY:187
LATITUDE: 422436.7 LONGITUDE: 0940825.1 NAD83 DATUM:
Lowest aging status in period is APPROVED
DD #3
Nitrate plus nitrite, water, in situ, milligrams per liter as nitrogen
WATER YEAR OCTOBER 2012 TO SEPTEMBER 2013
DAILY MEAN VALUES

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	---	---	---	---	---	---	---	---	---	---	---	---
2	---	---	---	---	---	---	---	---	---	---	---	---
3	---	---	---	---	---	---	---	---	---	19.3	---	---
4	---	---	---	---	---	---	---	---	---	19.4	---	---
5	---	---	---	---	---	---	---	---	---	19.4	---	---
6	---	---	---	---	---	---	---	---	---	19.4	---	---
7	---	---	---	---	---	---	---	---	---	19.3	---	---
8	---	---	---	---	---	---	---	---	---	19.2	---	---
9	---	---	---	---	---	---	---	---	---	19.1	---	---
10	---	---	---	---	---	---	---	---	---	18.9	---	---
11	---	---	---	---	---	---	---	---	---	18.7	---	---
12	---	---	---	---	---	---	---	---	---	18.6	---	---
13	---	---	---	---	---	---	---	---	---	18.6	---	---
14	---	---	---	---	---	---	---	---	---	18.6	---	---
15	---	---	---	---	---	---	---	---	---	18.7	---	---
16	---	---	---	---	---	---	---	---	---	18.5	---	---
17	---	---	---	---	---	---	---	---	---	18.3	---	---
18	---	---	---	---	---	---	---	---	---	18.0	---	---
19	---	---	---	---	---	---	---	---	---	17.8	---	---
20	---	---	---	---	---	---	---	---	19.4	17.7	---	---
21	---	---	---	---	---	---	---	---	19.6	17.4	---	---
22	---	---	---	---	---	---	---	---	19.7	17.3	---	---
23	---	---	---	---	---	---	---	---	19.7	17.2	---	---
24	---	---	---	---	---	---	---	---	17.7	17.0	---	---
25	---	---	---	---	---	---	---	---	16.4	16.8	---	---
26	---	---	---	---	---	---	---	---	17.4	16.7	---	---
27	---	---	---	---	---	---	---	---	17.9	---	---	---
28	---	---	---	---	---	---	---	---	17.9	---	---	---
29	---	---	---	---	---	---	---	---	17.8	---	---	---
30	---	---	---	---	---	---	---	---	17.6	---	---	---
31	---	---	---	---	---	---	---	---	---	---	---	---

1 U.S. DEPARTMENT OF THE INTERIOR - U.S. GEOLOGICAL SURVEY - WATER RESOURCES

STATION:422436094082501 Smeltzer West Oxbow Inlet near Otho, IA (S1) TYPE:WETLAND AGENCY:USGS STATE:19 COUNTY:187
LATITUDE: 422436.7 LONGITUDE: 0940825.1 NAD83 DATUM:
Lowest aging status in period is APPROVED
DD #3
Nitrate plus nitrite, water, in situ, milligrams per liter as nitrogen
WATER YEAR OCTOBER 2013 TO SEPTEMBER 2014
DAILY MEAN VALUES

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	---	---	---	---	---	---	---	---	20.3	23.2	20.8	---
2	---	---	---	---	---	---	---	---	20.1	24.0	20.8	---
3	---	---	---	---	---	---	---	---	20.1	24.1	20.7	---
4	---	---	---	---	---	---	---	---	21.2	24.1	20.7	19.4
5	---	---	---	---	---	---	---	---	21.9	23.6	20.6	18.5
6	---	---	---	---	---	---	---	---	21.6	23.9	19.9	18.0
7	---	---	---	---	---	---	---	15.4	21.4	24.0	20.4	18.6
8	---	---	---	---	---	---	---	15.4	21.3	23.9	20.6	18.7
9	---	---	---	---	---	---	---	15.7	21.1	23.8	20.5	18.6
10	---	---	---	---	---	---	---	15.7	21.1	23.6	20.5	16.9
11	---	---	---	---	---	---	---	15.8	21.0	23.4	20.5	17.7
12	---	---	---	---	---	---	---	18.4	21.0	23.1	20.6	17.5
13	---	---	---	---	---	---	---	20.6	20.9	23.3	20.6	17.3
14	---	---	---	---	---	---	---	20.1	20.7	23.3	20.6	17.6
15	---	---	---	---	---	---	---	19.8	20.9	23.1	20.6	17.8
16	---	---	---	---	---	---	---	19.4	21.0	22.8	20.4	18.0
17	---	---	---	---	---	---	---	19.1	27.5	22.6	20.5	18.1
18	---	---	---	---	---	---	---	18.7	26.3	22.4	20.6	18.6
19	---	---	---	---	---	---	---	18.6	25.8	22.3	20.5	18.8
20	---	---	---	---	---	---	---	18.4	25.3	22.2	19.5	17.2
21	---	---	---	---	---	---	---	18.5	---	22.2	18.4	17.3
22	---	---	---	---	---	---	---	18.5	---	22.2	16.8	17.4
23	---	---	---	---	---	---	---	18.5	---	22.2	---	17.4
24	---	---	---	---	---	---	---	18.5	---	21.9	---	15.6
25	---	---	---	---	---	---	---	18.5	23.6	21.7	---	16.1
26	---	---	---	---	---	---	---	18.3	23.2	21.7	---	16.6
27	---	---	---	---	---	---	---	22.1	23.9	21.5	---	16.5
28	---	---	---	---	---	---	---	21.2	24.3	21.1	---	16.7
29	---	---	---	---	---	---	---	20.9	23.9	20.9	---	16.8
30	---	---	---	---	---	---	---	20.6	22.4	20.8	---	16.6
31	---	---	---	---	---	---	---	20.4	---	20.8	---	---

1 U.S. DEPARTMENT OF THE INTERIOR - U.S. GEOLOGICAL SURVEY - WATER RESOURCES

STATION:422436094082501 Smeltzer West Oxbow Inlet near Otho, IA (S1) TYPE:WETLAND AGENCY:USGS STATE:19 COUNTY:187
LATITUDE: 422436.7 LONGITUDE: 0940825.1 NAD83 DATUM:
Lowest aging status in period is APPROVED
DD #6
Nitrate plus nitrite, water, unfiltered, pounds of nitrogen per day
WATER YEAR OCTOBER 2012 TO SEPTEMBER 2013
DAILY MEAN VALUES

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	---	---	---	---	---	---	---	---	---	---	0.00	0.00
2	---	---	---	---	---	---	---	---	---	---	0.00	0.00
3	---	---	---	---	---	---	---	---	---	3.3	0.00	0.00
4	---	---	---	---	---	---	---	---	---	2.8	0.00	0.00
5	---	---	---	---	---	---	---	---	---	2.4	0.00	0.00
6	---	---	---	---	---	---	---	---	---	2.0	0.00	0.00
7	---	---	---	---	---	---	---	---	---	1.6	0.00	0.00
8	---	---	---	---	---	---	---	---	---	1.3	0.00	0.00
9	---	---	---	---	---	---	---	---	---	1.1	0.00	0.00
10	---	---	---	---	---	---	---	---	---	0.77	0.00	0.00
11	---	---	---	---	---	---	---	---	---	0.57	0.00	0.00
12	---	---	---	---	---	---	---	---	---	0.45	0.00	0.00
13	---	---	---	---	---	---	---	---	---	0.35	0.00	0.00
14	---	---	---	---	---	---	---	---	---	0.28	0.00	0.00
15	---	---	---	---	---	---	---	---	---	0.23	0.00	0.00
16	---	---	---	---	---	---	---	---	---	0.22	0.00	0.00
17	---	---	---	---	---	---	---	---	---	0.19	0.00	0.00
18	---	---	---	---	---	---	---	---	---	0.16	0.00	0.00
19	---	---	---	---	---	---	---	---	---	0.13	0.00	0.00
20	---	---	---	---	---	---	---	---	3.7	0.10	0.00	0.00
21	---	---	---	---	---	---	---	---	3.4	0.08	0.00	0.00
22	---	---	---	---	---	---	---	---	3.1	0.06	0.00	0.00
23	---	---	---	---	---	---	---	---	2.9	0.00	0.00	0.00
24	---	---	---	---	---	---	---	---	17.9	0.00	0.00	0.00
25	---	---	---	---	---	---	---	---	28.6	0.00	0.00	0.00
26	---	---	---	---	---	---	---	---	16.5	0.00	0.00	0.00
27	---	---	---	---	---	---	---	---	11.0	0.00	0.00	0.00
28	---	---	---	---	---	---	---	---	8.3	0.00	0.00	0.00
29	---	---	---	---	---	---	---	---	6.2	0.00	0.00	0.00
30	---	---	---	---	---	---	---	---	4.9	0.00	0.00	0.00
31	---	---	---	---	---	---	---	---	---	0.00	0.00	---

1 U.S. DEPARTMENT OF THE INTERIOR - U.S. GEOLOGICAL SURVEY - WATER RESOURCES

STATION:422436094082501 Smeltzer West Oxbow Inlet near Otho, IA (S1) TYPE:WETLAND AGENCY:USGS STATE:19 COUNTY:187
LATITUDE: 422436.7 LONGITUDE: 0940825.1 NAD83 DATUM:
Lowest aging status in period is APPROVED
DD #6
Nitrate plus nitrite, water, unfiltered, pounds of nitrogen per day
WATER YEAR OCTOBER 2013 TO SEPTEMBER 2014
DAILY MEAN VALUES

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	0.00	0.00	---	---	---	---	0.00	---	1.6	39.8	0.51	---
2	0.00	0.00	---	---	---	---	0.00	---	1.4	23.3	0.46	---
3	0.00	0.00	---	---	---	---	0.00	---	1.3	17.4	0.42	---
4	0.00	0.00	---	---	---	---	0.00	---	2.0	13.6	0.39	2.2
5	0.00	---	---	---	---	---	0.00	---	2.3	18.1	0.35	2.7
6	0.00	---	---	---	---	---	0.00	---	2.1	17.9	0.51	3.0
7	0.00	---	---	---	---	---	0.00	0.26	2.0	13.7	0.79	2.2
8	0.00	---	---	---	---	---	0.00	0.26	1.7	10.7	0.68	1.8
9	0.00	---	---	---	---	---	0.00	0.24	1.6	8.6	0.57	1.9
10	0.00	---	---	---	---	---	0.00	0.25	1.5	7.3	0.51	3.6
11	0.00	---	---	---	---	---	0.00	0.25	1.4	6.4	0.44	3.0
12	0.00	---	---	---	---	---	0.00	2.4	1.3	7.6	0.35	2.9
13	0.00	---	---	---	---	---	0.00	2.4	1.1	8.0	0.30	3.2
14	0.00	---	---	---	---	---	0.00	1.7	1.1	6.5	0.30	2.8
15	0.00	---	---	---	---	---	0.00	e1.3	1.0	5.3	0.28	2.4
16	0.00	---	---	---	---	---	0.00	e1.0	0.95	4.6	0.28	2.1
17	0.00	---	---	---	---	---	0.00	0.91	35.5	3.9	0.24	1.9
18	0.00	---	---	---	---	---	0.00	0.81	17.0	3.4	e0.24	1.5
19	0.00	---	---	---	---	---	0.00	0.78	11.8	3.0	e0.24	1.4
20	0.00	---	---	---	---	---	0.00	0.73	9.4	2.6	e0.23	2.4
21	0.00	---	---	---	---	---	0.00	0.71	---	2.1	e0.21	2.4
22	0.00	---	---	---	---	---	0.00	0.65	---	1.7	e0.18	2.4
23	0.00	---	---	---	---	---	0.00	0.64	---	1.3	---	2.6
24	0.00	---	---	---	---	---	0.00	0.63	---	1.1	---	5.3
25	0.00	---	---	---	---	0.00	0.00	0.60	5.1	1.2	---	5.8
26	0.00	---	---	---	---	0.00	0.00	0.88	4.5	1.1	---	5.0
27	0.00	---	---	---	---	0.00	0.00	3.1	16.6	0.87	---	5.1
28	0.00	---	---	---	---	0.00	0.00	2.5	26.9	0.71	---	5.2
29	0.00	---	---	---	---	0.00	0.00	2.2	30.7	0.64	---	4.9
30	0.00	---	---	---	---	0.00	---	1.9	74.3	0.59	---	4.7
31	0.00	---	---	---	---	0.00	---	1.7	---	0.55	---	---

e Estimated

Appendix 3.4 – Nitrate plus nitrite nitrogen concentration and load in the Smeltzer West Oxbow Outlet near Otho, IA (S2)

1 U.S. DEPARTMENT OF THE INTERIOR - U.S. GEOLOGICAL SURVEY - WATER RESOURCES

STATION:422438094082701 Smeltzer West Oxbow Outlet near Otho, IA (S2) TYPE:WETLAND AGENCY:USGS STATE:19 COUNTY:187
LATITUDE: 422438.3 LONGITUDE: 0940827.5 NAD83 DATUM:
Lowest aging status in period is APPROVED
DD #3
Nitrate plus nitrite, water, in situ, milligrams per liter as nitrogen
WATER YEAR OCTOBER 2012 TO SEPTEMBER 2013
DAILY MEAN VALUES

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	---	---	---	---	---	---	---	---	---	10.7	---	---
2	---	---	---	---	---	---	---	---	---	10.8	---	---
3	---	---	---	---	---	---	---	---	---	10.7	---	---
4	---	---	---	---	---	---	---	---	---	10.7	---	---
5	---	---	---	---	---	---	---	---	---	10.7	---	---
6	---	---	---	---	---	---	---	---	---	10.5	---	---
7	---	---	---	---	---	---	---	---	---	10.1	---	---
8	---	---	---	---	---	---	---	---	---	9.39	---	---
9	---	---	---	---	---	---	---	---	---	---	---	---
10	---	---	---	---	---	---	---	---	---	---	---	---
11	---	---	---	---	---	---	---	---	---	---	---	---
12	---	---	---	---	---	---	---	---	---	---	---	---
13	---	---	---	---	---	---	---	---	---	---	---	---
14	---	---	---	---	---	---	---	---	12.9	---	---	---
15	---	---	---	---	---	---	---	---	12.8	---	---	---
16	---	---	---	---	---	---	---	---	---	---	---	---
17	---	---	---	---	---	---	---	---	---	---	---	---
18	---	---	---	---	---	---	---	---	13.3	---	---	---
19	---	---	---	---	---	---	---	---	13.3	---	---	---
20	---	---	---	---	---	---	---	---	13.3	---	---	---
21	---	---	---	---	---	---	---	---	13.2	---	---	---
22	---	---	---	---	---	---	---	---	12.6	---	---	---
23	---	---	---	---	---	---	---	---	10.7	---	---	---
24	---	---	---	---	---	---	---	---	9.96	---	---	---
25	---	---	---	---	---	---	---	---	6.72	---	---	---
26	---	---	---	---	---	---	---	---	8.53	---	---	---
27	---	---	---	---	---	---	---	---	10.6	---	---	---
28	---	---	---	---	---	---	---	---	11.1	---	---	---
29	---	---	---	---	---	---	---	---	11.0	---	---	---
30	---	---	---	---	---	---	---	---	10.9	---	---	---
31	---	---	---	---	---	---	---	---	---	---	---	---

1 U.S. DEPARTMENT OF THE INTERIOR - U.S. GEOLOGICAL SURVEY - WATER RESOURCES

STATION:422438094082701 Smeltzer West Oxbow Outlet near Otho, IA (S2) TYPE:WETLAND AGENCY:USGS STATE:19 COUNTY:187
LATITUDE: 422438.3 LONGITUDE: 0940827.5 NAD83 DATUM:
Lowest aging status in period is APPROVED
DD #3
Nitrate plus nitrite, water, in situ, milligrams per liter as nitrogen
WATER YEAR OCTOBER 2013 TO SEPTEMBER 2014
DAILY MEAN VALUES

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	---	---	---	---	---	---	---	---	---	3.60	---	---
2	---	---	---	---	---	---	---	---	---	4.31	---	1.79
3	---	---	---	---	---	---	---	---	---	5.38	---	2.08
4	---	---	---	---	---	---	---	---	---	4.90	---	2.21
5	---	---	---	---	---	---	---	---	---	4.28	---	2.34
6	---	---	---	---	---	---	---	---	---	6.54	---	2.38
7	---	---	---	---	---	---	---	---	---	6.36	---	2.54
8	---	---	---	---	---	---	---	---	---	6.50	---	2.54
9	---	---	---	---	---	---	---	---	---	6.90	---	2.77
10	---	---	---	---	---	---	---	---	---	6.80	---	3.03
11	---	---	---	---	---	---	---	---	---	6.75	---	3.20
12	---	---	---	---	---	---	---	---	---	6.61	---	3.43
13	---	---	---	---	---	---	---	---	---	6.51	---	3.51
14	---	---	---	---	---	---	---	---	---	6.46	---	3.77
15	---	---	---	---	---	---	---	---	---	6.24	---	4.08
16	---	---	---	---	---	---	---	---	---	5.97	---	---
17	---	---	---	---	---	---	---	---	2.20	5.16	---	---
18	---	---	---	---	---	---	---	---	4.25	5.12	---	---
19	---	---	---	---	---	---	---	---	4.89	5.52	---	---
20	---	---	---	---	---	---	---	---	4.77	4.91	---	4.26
21	---	---	---	---	---	---	---	---	4.42	4.93	---	4.35
22	---	---	---	---	---	---	---	---	---	---	---	4.33
23	---	---	---	---	---	---	---	---	---	---	---	4.21
24	---	---	---	---	---	---	---	---	---	---	---	4.32
25	---	---	---	---	---	---	---	---	6.10	---	---	4.89
26	---	---	---	---	---	---	---	---	5.65	---	---	5.27
27	---	---	---	---	---	---	---	---	5.30	---	---	5.42
28	---	---	---	---	---	---	---	---	5.00	---	---	5.68
29	---	---	---	---	---	---	---	---	4.71	---	---	5.87
30	---	---	---	---	---	---	---	---	4.42	---	---	5.98
31	---	---	---	---	---	---	---	---	---	---	---	---

1 U.S. DEPARTMENT OF THE INTERIOR - U.S. GEOLOGICAL SURVEY - WATER RESOURCES

STATION:422438094082701 Smeltzer West Oxbow Outlet near Otho, IA (S2) TYPE:WETLAND AGENCY:USGS STATE:19 COUNTY:187
LATITUDE: 422438.3 LONGITUDE: 0940827.5 NAD83 DATUM:
Lowest aging status in period is APPROVED
DD #7
Nitrate plus nitrite, water, unfiltered, pounds of nitrogen per day
WATER YEAR OCTOBER 2012 TO SEPTEMBER 2013
DAILY MEAN VALUES

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	---	---	---	---	---	---	---	---	---	5.4	0.00	0.00
2	---	---	---	---	---	---	---	---	---	5.5	0.00	0.00
3	---	---	---	---	---	---	---	---	---	4.9	0.00	0.00
4	---	---	---	---	---	---	---	---	---	4.4	0.00	0.00
5	---	---	---	---	---	---	---	---	---	3.7	0.00	0.00
6	---	---	---	---	---	---	---	---	---	2.4	0.00	0.00
7	---	---	---	---	---	---	---	---	---	1.3	0.00	0.00
8	---	---	---	---	---	---	---	---	---	0.50	0.00	0.00
9	---	---	---	---	---	---	---	---	---	---	0.00	0.00
10	---	---	---	---	---	---	---	---	---	0.00	0.00	0.00
11	---	---	---	---	---	---	---	---	---	0.00	0.00	0.00
12	---	---	---	---	---	---	---	---	---	0.00	0.00	0.00
13	---	---	---	---	---	---	---	---	---	0.00	0.00	0.00
14	---	---	---	---	---	---	---	---	7.3	0.00	0.00	0.00
15	---	---	---	---	---	---	---	---	8.1	0.00	0.00	0.00
16	---	---	---	---	---	---	---	---	---	0.00	0.00	0.00
17	---	---	---	---	---	---	---	---	---	0.00	0.00	0.00
18	---	---	---	---	---	---	---	---	7.9	0.00	0.00	0.00
19	---	---	---	---	---	---	---	---	6.6	0.00	0.00	0.00
20	---	---	---	---	---	---	---	---	5.3	0.00	0.00	0.00
21	---	---	---	---	---	---	---	---	4.5	0.00	0.00	0.00
22	---	---	---	---	---	---	---	---	3.7	0.00	0.00	0.00
23	---	---	---	---	---	---	---	---	3.3	0.00	0.00	0.00
24	---	---	---	---	---	---	---	---	43.0	0.00	0.00	0.00
25	---	---	---	---	---	---	---	---	19.2	0.00	0.00	0.00
26	---	---	---	---	---	---	---	---	13.3	0.00	0.00	0.00
27	---	---	---	---	---	---	---	---	11.1	0.00	0.00	0.00
28	---	---	---	---	---	---	---	---	8.0	0.00	0.00	0.00
29	---	---	---	---	---	---	---	---	6.3	0.00	0.00	0.00
30	---	---	---	---	---	---	---	---	5.3	0.00	0.00	0.00
31	---	---	---	---	---	---	---	---	---	0.00	0.00	---

1 U.S. DEPARTMENT OF THE INTERIOR - U.S. GEOLOGICAL SURVEY - WATER RESOURCES

STATION:422438094082701 Smeltzer West Oxbow Outlet near Otho, IA (S2) TYPE:WETLAND AGENCY:USGS STATE:19 COUNTY:187
LATITUDE: 422438.3 LONGITUDE: 0940827.5 NAD83 DATUM:
Lowest aging status in period is APPROVED
DD #7
Nitrate plus nitrite, water, unfiltered, pounds of nitrogen per day
WATER YEAR OCTOBER 2013 TO SEPTEMBER 2014
DAILY MEAN VALUES

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	0.00	0.00	---	---	---	---	0.00	0.00	0.00	15.4	0.00	---
2	0.00	0.00	---	---	---	---	0.00	0.00	0.00	4.6	0.00	0.80
3	0.00	0.00	---	---	---	---	0.00	0.00	0.00	4.9	0.00	0.61
4	0.00	0.00	---	---	---	---	0.00	0.00	0.00	3.7	0.00	0.43
5	0.00	0.00	---	---	---	---	0.00	0.00	0.00	3.1	0.00	0.64
6	0.00	0.00	---	---	---	---	0.00	0.00	0.00	5.0	0.00	0.52
7	0.00	0.00	---	---	---	---	0.00	0.00	0.00	4.3	0.00	0.37
8	0.00	0.00	---	---	---	---	0.00	0.00	0.00	4.2	0.00	0.29
9	0.00	0.00	---	---	---	---	0.00	0.00	0.00	5.0	0.00	0.40
10	0.00	0.00	---	---	---	---	0.00	0.00	0.00	5.0	0.00	0.94
11	0.00	0.00	---	---	---	---	0.00	0.00	0.00	4.3	0.00	0.65
12	0.00	0.00	---	---	---	---	0.00	0.00	0.00	4.4	0.00	0.72
13	0.00	0.00	---	---	---	---	0.00	0.00	0.00	4.5	0.00	0.68
14	0.00	0.00	---	---	---	---	0.00	0.00	0.00	3.7	0.00	0.59
15	0.00	---	---	---	---	---	0.00	0.00	0.00	2.9	0.00	0.56
16	0.00	---	---	---	---	---	0.00	0.00	0.00	2.4	0.00	---
17	0.00	---	---	---	---	---	0.00	0.00	1.9	1.8	0.00	---
18	0.00	---	---	---	---	---	0.00	0.00	3.4	1.3	0.00	---
19	0.00	---	---	---	---	---	0.00	0.00	2.8	0.94	0.00	---
20	0.00	---	---	---	---	---	0.00	0.00	2.2	0.49	0.00	0.68
21	0.00	---	---	---	---	---	0.00	0.00	1.9	0.06	0.00	0.46
22	0.00	---	---	---	---	---	0.00	0.00	---	0.00	0.00	0.35
23	0.00	---	---	---	---	---	0.00	0.00	---	0.00	0.00	0.22
24	0.00	---	---	---	---	---	0.00	0.00	---	0.00	0.00	1.1
25	0.00	---	---	---	---	---	0.00	0.00	3.0	0.00	0.00	1.3
26	0.00	---	---	---	---	---	0.00	0.00	2.1	0.00	0.00	1.0
27	0.00	---	---	---	---	0.00	0.00	0.00	5.0	0.00	0.00	1.3
28	0.00	---	---	---	---	0.00	0.00	0.00	7.8	0.00	0.00	1.4
29	0.00	---	---	---	---	0.00	0.00	0.00	8.5	0.00	0.00	1.1
30	0.00	---	---	---	---	0.00	0.00	0.00	55.2	0.00	0.00	1.1
31	0.00	---	---	---	---	0.00	---	0.00	---	0.00	0.00	---

Commented [KJL2]: Load values are missing from appendix 3.4

Appendix 3.5-- Nitrate plus nitrite nitrogen concentration and load in the Smeltzer East Oxbow Inlet near Otho, IA (S4)

1 U.S. DEPARTMENT OF THE INTERIOR - U.S. GEOLOGICAL SURVEY - WATER RESOURCES
STATION:422432094081701 Smeltzer East Oxbow Inlet near Otho, IA (S4) TYPE:WETLAND AGENCY:USGS STATE:19 COUNTY:187
LATITUDE: 422432.6 LONGITUDE: 0940817.9 NAD83 DATUM:
Lowest aging status in period is APPROVED
DD #5
Nitrate plus nitrite, water, in situ, milligrams per liter as nitrogen
WATER YEAR OCTOBER 2013 TO SEPTEMBER 2014
DAILY MEAN VALUES

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	---	---	---	---	---	---	---	---	0.70	---	---	---
2	---	---	---	---	---	---	---	---	0.67	---	---	2.29
3	---	---	---	---	---	---	4.89	---	0.60	23.6	---	---
4	---	---	---	---	---	---	---	---	---	23.0	---	2.67
5	---	---	---	---	---	---	---	---	---	17.1	---	5.45
6	---	---	---	---	---	---	---	---	---	21.7	---	4.60
7	---	---	---	---	---	---	---	0.40	---	22.5	---	4.14
8	---	---	---	---	---	---	---	0.55	---	22.0	---	4.71
9	---	---	---	---	---	---	---	0.07	---	21.3	---	5.78
10	---	---	---	---	---	---	---	0.24	---	20.3	---	10.5
11	---	---	---	---	---	---	---	1.00	---	19.1	---	11.9
12	---	---	---	---	---	---	---	1.74	---	19.1	---	11.9
13	---	---	---	---	---	---	---	4.09	---	19.5	---	14.2
14	---	---	---	---	---	---	---	5.18	---	18.7	---	14.1
15	---	---	---	---	---	---	---	4.57	---	17.5	---	14.0
16	---	---	---	---	---	---	---	3.02	---	16.0	---	13.9
17	---	---	---	---	---	---	---	1.35	13.2	13.9	---	13.2
18	---	---	---	---	---	---	---	0.53	4.86	12.6	---	12.1
19	---	---	---	---	---	---	---	0.52	6.03	12.4	---	11.1
20	---	---	---	---	---	---	---	---	5.14	12.2	---	12.1
21	---	---	---	---	---	---	---	---	4.00	11.7	---	14.7
22	---	---	---	---	---	---	---	---	3.91	11.2	---	14.4
23	---	---	---	---	---	---	---	---	4.11	10.9	---	14.0
24	---	---	---	---	---	---	---	---	4.30	11.2	---	10.7
25	---	---	---	---	---	---	---	---	4.30	11.1	---	14.9
26	---	---	---	---	---	---	---	---	4.48	---	---	15.5
27	---	---	---	---	---	---	---	2.66	7.55	---	---	13.0
28	---	---	---	---	---	---	---	0.89	7.97	4.03	---	14.6
29	---	---	---	---	---	---	---	0.95	11.0	2.06	---	14.8
30	---	---	---	---	---	---	---	0.96	3.68	---	---	14.3
31	---	---	---	---	---	---	---	0.73	---	---	---	---

1 U.S. DEPARTMENT OF THE INTERIOR - U.S. GEOLOGICAL SURVEY - WATER RESOURCES

STATION:422432094081701 Smeltzer East Oxbow Inlet near Otho, IA (S4) TYPE:WETLAND AGENCY:USGS STATE:19 COUNTY:187
LATITUDE: 422432.6 LONGITUDE: 0940817.9 NAD83 DATUM:
Lowest aging status in period is APPROVED
DD #6
Nitrate plus nitrite, water, unfiltered, pounds of nitrogen per day
WATER YEAR OCTOBER 2013 TO SEPTEMBER 2014
DAILY MEAN VALUES

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	---	---	---	---	---	---	---	---	0.02	---	0.00	---
2	---	---	---	---	---	---	---	---	0.02	---	0.00	0.28
3	---	---	---	---	---	---	0.00	---	0.01	2.0	0.00	---
4	---	---	---	---	---	---	0.00	---	---	1.5	0.00	0.23
5	---	---	---	---	---	---	0.00	---	---	4.0	0.00	0.82
6	---	---	---	---	---	---	0.00	0.00	---	2.2	e0.00	0.48
7	---	---	---	---	---	---	0.00	0.00	---	1.7	0.00	0.36
8	---	---	---	---	---	---	0.00	0.00	---	1.4	0.00	0.36
9	---	---	---	---	---	---	0.00	0.00	---	1.2	0.00	0.77
10	---	---	---	---	---	---	0.00	e0.00	---	1.0	0.00	1.4
11	---	---	---	---	---	---	0.00	0.00	---	0.91	0.00	1.1
12	---	---	---	---	---	---	---	0.44	---	1.1	0.00	1.4
13	---	---	---	---	---	---	---	0.29	0.00	1.1	0.00	1.4
14	---	---	---	---	---	---	0.00	0.23	0.00	0.89	0.00	1.2
15	---	---	---	---	---	---	0.00	0.15	0.00	0.81	e0.00	e1.1
16	---	---	---	---	---	---	0.00	0.07	0.00	0.73	0.00	1.0
17	---	---	---	---	---	---	0.00	0.02	24.5	0.68	0.00	0.94
18	---	---	---	---	---	---	0.00	0.00	0.93	0.59	0.00	0.88
19	---	---	---	---	---	---	0.00	0.00	0.81	0.57	0.00	0.87
20	---	---	---	---	---	---	0.00	0.00	0.63	0.54	e0.00	2.3
21	---	---	---	---	---	---	0.00	0.00	0.47	0.47	0.00	1.6
22	---	---	---	---	---	---	0.00	e0.00	0.48	0.41	0.00	1.6
23	---	---	---	---	---	---	0.00	0.00	0.55	0.34	e0.00	1.5
24	---	---	---	---	---	---	e0.00	0.00	0.58	e0.28	0.00	3.7
25	---	---	---	---	---	---	0.00	0.00	0.59	0.22	e0.00	2.2
26	---	---	---	---	---	---	e0.00	---	0.65	---	e0.00	2.1
27	---	---	---	---	---	---	e0.00	0.37	6.0	---	0.00	2.6
28	---	---	---	---	---	---	---	0.05	9.4	0.03	e0.00	2.1
29	---	---	---	---	---	---	---	0.04	12.0	0.00	---	1.9
30	---	---	---	---	---	---	---	0.03	10.7	0.00	---	3.6
31	---	---	---	---	---	---	---	0.02	---	0.00	---	---

e Estimated

Appendix 3.6— Nitrate plus nitrite nitrogen concentration in the Smeltzer East Oxbow Outlet near Otho, IA (S5)

1 U.S. DEPARTMENT OF THE INTERIOR - U.S. GEOLOGICAL SURVEY - WATER RESOURCES

STATION:422433094081801 Smeltzer East Oxbow Outlet near Otho, IA (S5) TYPE:WETLAND AGENCY:USGS STATE:19 COUNTY:187
LATITUDE: 422433.9 LONGITUDE: 0940818.7 NAD83 DATUM:
Lowest aging status in period is APPROVED
DD #11
Nitrate plus nitrite, water, in situ, milligrams per liter as nitrogen
WATER YEAR OCTOBER 2013 TO SEPTEMBER 2014
DAILY MEAN VALUES

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	---	---	---	---	---	---	---	---	---	1.95	---	0.76
2	---	---	---	---	---	---	---	---	---	2.04	---	0.78
3	---	---	---	---	---	---	---	---	---	---	---	0.80
4	---	---	---	---	---	---	---	---	---	---	---	0.85
5	---	---	---	---	---	---	---	---	---	---	---	0.84
6	---	---	---	---	---	---	---	---	---	---	---	0.82
7	---	---	---	---	---	---	---	---	---	---	0.48	0.83
8	---	---	---	---	---	---	---	---	---	---	0.41	0.81
9	---	---	---	---	---	---	---	---	---	---	0.40	0.81
10	---	---	---	---	---	---	---	---	---	---	0.41	0.79
11	---	---	---	---	---	---	---	---	---	---	---	0.76
12	---	---	---	---	---	---	---	---	---	---	---	0.73
13	---	---	---	---	---	---	---	---	---	---	---	0.72
14	---	---	---	---	---	---	---	---	---	---	---	0.72
15	---	---	---	---	---	---	---	---	---	---	---	0.79
16	---	---	---	---	---	---	---	---	---	---	---	0.80
17	---	---	---	---	---	---	---	---	4.07	---	---	0.72
18	---	---	---	---	---	---	---	---	---	---	---	0.63
19	---	---	---	---	---	---	---	---	---	---	---	0.61
20	---	---	---	---	---	---	---	---	---	---	---	0.70
21	---	---	---	---	---	---	---	---	---	---	---	0.76
22	---	---	---	---	---	---	---	---	---	---	---	0.56
23	---	---	---	---	---	---	---	---	---	---	---	0.42
24	---	---	---	---	---	---	---	---	---	---	---	0.54
25	---	---	---	---	---	---	---	---	---	---	---	0.68
26	---	---	---	---	---	---	---	---	---	---	---	0.88
27	---	---	---	---	---	---	---	---	2.53	---	---	1.07
28	---	---	---	---	---	---	---	---	2.70	---	---	1.19
29	---	---	---	---	---	---	---	---	2.39	---	1.03	1.16
30	---	---	---	---	---	---	---	---	3.86	---	0.69	1.16
31	---	---	---	---	---	---	---	---	---	---	0.74	---

Appendix 3.7 –Nitrate plus nitrite nitrogen concentration and load in Prairie Creek at Otho, IA

1 U.S. DEPARTMENT OF THE INTERIOR - U.S. GEOLOGICAL SURVEY - WATER RESOURCES

STATION:05480603 Prairie Creek at Otho, IA (S3) TYPE:STREAM AGENCY:USGS STATE:19 COUNTY:187
LATITUDE: 422439.2 LONGITUDE: 0940828.7 NAD83 DRAINAGE AREA:28.0* CONTRIBUTING DRAINAGE AREA: DATUM:
Lowest aging status in period is APPROVED
DD #2
Nitrate plus nitrite, water, in situ, milligrams per liter as nitrogen
WATER YEAR OCTOBER 2012 TO SEPTEMBER 2013
DAILY MEAN VALUES

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	---	---	---	---	---	---	---	---	---	29.5	10.4	---
2	---	---	---	---	---	---	---	---	---	29.5	9.58	---
3	---	---	---	---	---	---	---	---	---	29.2	8.46	---
4	---	---	---	---	---	---	---	---	---	28.9	7.66	---
5	---	---	---	---	---	---	---	---	---	28.5	7.25	---
6	---	---	---	---	---	---	---	---	---	28.1	6.69	---
7	---	---	---	---	---	---	---	---	---	27.5	5.98	---
8	---	---	---	---	---	---	---	---	---	26.7	5.16	---
9	---	---	---	---	---	---	---	---	---	25.7	4.45	---
10	---	---	---	---	---	---	---	---	---	25.1	3.63	---
11	---	---	---	---	---	---	---	---	---	24.6	2.86	---
12	---	---	---	---	---	---	---	---	---	24.1	2.34	---
13	---	---	---	---	---	---	---	---	---	23.5	1.97	---
14	---	---	---	---	---	---	---	---	31.2	22.9	2.09	---
15	---	---	---	---	---	---	---	---	29.6	22.2	2.15	---
16	---	---	---	---	---	---	---	---	31.4	21.1	1.63	---
17	---	---	---	---	---	---	---	---	32.2	20.1	1.06	---
18	---	---	---	---	---	---	---	---	32.2	19.1	0.80	---
19	---	---	---	---	---	---	---	---	32.1	18.3	0.63	---
20	---	---	---	---	---	---	---	---	32.0	17.3	0.55	---
21	---	---	---	---	---	---	---	---	31.7	16.4	0.37	---
22	---	---	---	---	---	---	---	---	31.5	15.9	0.21	---
23	---	---	---	---	---	---	---	---	30.8	15.1	0.09	---
24	---	---	---	---	---	---	---	---	21.4	14.2	0.07	---
25	---	---	---	---	---	---	---	---	18.1	13.5	0.08	---
26	---	---	---	---	---	---	---	---	21.9	13.0	0.09	---
27	---	---	---	---	---	---	---	---	24.3	12.3	---	---
28	---	---	---	---	---	---	---	---	27.2	11.8	---	---
29	---	---	---	---	---	---	---	---	28.8	11.6	---	---
30	---	---	---	---	---	---	---	---	29.3	11.2	---	---
31	---	---	---	---	---	---	---	---	---	10.9	---	---

1 U.S. DEPARTMENT OF THE INTERIOR - U.S. GEOLOGICAL SURVEY - WATER RESOURCES

STATION:05480603 Prairie Creek at Otho, IA (S3) TYPE:STREAM AGENCY:USGS STATE:19 COUNTY:187
LATITUDE: 422439.2 LONGITUDE: 0940828.7 NAD83 DRAINAGE AREA:28.0* CONTRIBUTING DRAINAGE AREA: DATUM:
Lowest aging status in period is APPROVED
DD #2
Nitrate plus nitrite, water, in situ, milligrams per liter as nitrogen
WATER YEAR OCTOBER 2013 TO SEPTEMBER 2014
DAILY MEAN VALUES

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	---	---	---	---	---	---	0.50	0.33	3.97	16.9	11.0	11.8
2	---	---	---	---	---	---	0.49	0.69	3.14	20.0	9.97	17.6
3	---	---	---	---	---	---	0.43	0.70	2.45	22.2	7.82	19.1
4	---	---	---	---	---	---	0.44	0.55	2.15	23.2	5.98	19.2
5	---	---	---	---	---	---	0.48	0.36	2.70	22.9	4.49	17.6
6	---	---	---	---	---	---	0.48	0.25	2.98	25.6	3.52	17.6
7	---	---	---	---	---	---	0.46	0.25	3.03	26.7	4.86	19.4
8	---	---	---	---	---	---	0.31	0.26	2.87	26.7	6.22	19.5
9	---	---	---	---	---	---	0.20	0.23	3.01	26.5	7.70	18.8
10	---	---	---	---	---	---	0.18	0.22	2.93	25.9	7.16	18.4
11	---	---	---	---	---	---	0.18	0.23	2.88	25.3	5.87	21.5
12	---	---	---	---	---	---	0.20	4.08	2.69	23.6	5.03	21.9
13	---	---	---	---	---	---	0.19	11.5	2.05	24.5	4.48	22.0
14	---	---	---	---	---	---	0.50	13.3	1.38	24.5	3.60	22.7
15	---	---	---	---	---	---	0.83	13.0	1.11	24.1	2.86	22.9
16	---	---	---	---	---	---	0.55	12.8	0.79	23.4	2.66	22.7
17	---	---	---	---	---	---	0.42	11.7	12.7	22.5	2.63	22.3
18	---	---	---	---	---	---	0.27	10.5	20.7	21.5	1.90	21.8
19	---	---	---	---	---	---	0.19	9.09	22.4	20.6	1.23	21.1
20	---	---	---	---	---	1.66	0.19	8.14	22.2	19.5	0.97	19.2
21	---	---	---	---	---	1.54	0.21	7.01	23.3	18.0	0.40	21.1
22	---	---	---	---	---	1.42	0.19	5.47	21.5	16.3	0.48	22.3
23	---	---	---	---	---	1.36	0.17	4.16	20.9	14.7	0.44	22.6
24	---	---	---	---	---	1.50	0.19	3.16	20.9	13.2	0.68	21.4
25	---	---	---	---	---	1.37	0.23	2.37	19.8	12.0	0.38	22.4
26	---	---	---	---	---	1.10	0.22	1.59	18.5	12.9	0.43	23.2
27	---	---	---	---	---	0.91	0.25	4.11	15.4	15.1	0.19	23.2
28	---	---	---	---	---	0.63	0.65	6.22	16.7	15.9	0.29	23.3
29	---	---	---	---	---	0.64	0.63	8.17	18.2	14.5	1.10	23.0
30	---	---	---	---	---	0.71	0.29	6.71	15.1	13.4	5.05	22.5
31	---	---	---	---	---	0.57	---	5.04	---	12.2	10.9	---

1 U.S. DEPARTMENT OF THE INTERIOR - U.S. GEOLOGICAL SURVEY - WATER RESOURCES

STATION:05480603 Prairie Creek at Otho, IA (S3) TYPE:STREAM AGENCY:USGS STATE:19 COUNTY:187
LATITUDE: 422439.2 LONGITUDE: 0940828.7 NAD83 DRAINAGE AREA:28.0* CONTRIBUTING DRAINAGE AREA: DATUM:
DD #5,
Nitrate plus nitrite, water, total, tons per day as nitrogen
WATER YEAR OCTOBER 2012 TO SEPTEMBER 2013
DAILY MEAN VALUES

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	---	---	---	---	---	---	---	---	---	1.8	0.04	---
2	---	---	---	---	---	---	---	---	---	1.6	0.03	---
3	---	---	---	---	---	---	---	---	---	1.4	0.03	---
4	---	---	---	---	---	---	---	---	---	1.2	0.02	---
5	---	---	---	---	---	---	---	---	---	1.1	0.02	---
6	---	---	---	---	---	---	---	---	---	0.94	0.02	---
7	---	---	---	---	---	---	---	---	---	0.83	0.01	---
8	---	---	---	---	---	---	---	---	---	0.74	0.01	---
9	---	---	---	---	---	---	---	---	---	0.67	0.01	---
10	---	---	---	---	---	---	---	---	---	0.59	0.00	---
11	---	---	---	---	---	---	---	---	---	0.52	0.01	---
12	---	---	---	---	---	---	---	---	---	0.48	0.01	---
13	---	---	---	---	---	---	---	---	---	0.43	0.01	---
14	---	---	---	---	---	---	---	---	2.8	0.39	0.00	---
15	---	---	---	---	---	---	---	---	3.5	0.34	0.00	---
16	---	---	---	---	---	---	---	---	4.0	0.30	0.00	---
17	---	---	---	---	---	---	---	---	3.5	0.26	8.2	---
18	---	---	---	---	---	---	---	---	3.0	0.23	8.3	---
19	---	---	---	---	---	---	---	---	2.6	0.20	6.3	---
20	---	---	---	---	---	---	---	---	2.3	0.17	0.00	---
21	---	---	---	---	---	---	---	---	2.1	0.15	0.00	---
22	---	---	---	---	---	---	---	---	1.9	0.14	0.00	---
23	---	---	---	---	---	---	---	---	1.7	0.11	6.8	---
24	---	---	---	---	---	---	---	---	14	0.10	4.1	---
25	---	---	---	---	---	---	---	---	16	0.09	7.7	---
26	---	---	---	---	---	---	---	---	9.5	0.07	---	---
27	---	---	---	---	---	---	---	---	5.9	0.06	---	---
28	---	---	---	---	---	---	---	---	4.0	0.06	---	---
29	---	---	---	---	---	---	---	---	2.8	0.05	---	---
30	---	---	---	---	---	---	---	---	2.2	0.04	---	---
31	---	---	---	---	---	---	---	---	---	0.04	---	---

1 U.S. DEPARTMENT OF THE INTERIOR - U.S. GEOLOGICAL SURVEY - WATER RESOURCES

STATION:05480603 Prairie Creek at Otho, IA (S3) TYPE:STREAM AGENCY:USGS STATE:19 COUNTY:187
LATITUDE: 422439.2 LONGITUDE: 0940828.7 NAD83 DRAINAGE AREA:28.0* CONTRIBUTING DRAINAGE AREA: DATUM:
DD #5,
Nitrate plus nitrite, water, total, tons per day as nitrogen
WATER YEAR OCTOBER 2013 TO SEPTEMBER 2014
DAILY MEAN VALUES

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	---	---	---	---	---	---	0.001	0.002	0.014	21.6	0.039	1.16
2	---	---	---	---	---	---	0.001	0.003	0.011	12.4	0.033	1.33
3	---	---	---	---	---	---	0.001	0.002	0.010	8.54	0.021	1.04
4	---	---	---	---	---	---	0.001	0.001	0.017	6.14	0.019	0.852
5	---	---	---	---	---	---	0.001	0.000	0.021	5.66	0.012	0.737
6	---	---	---	---	---	---	0.001	---	0.030	6.87	0.028	0.764
7	---	---	---	---	---	---	0.002	0.000	0.023	5.33	0.083	0.835
8	---	---	---	---	---	---	0.001	0.000	0.018	4.05	0.107	0.776
9	---	---	---	---	---	---	0.001	---	0.014	3.14	0.157	0.757
10	---	---	---	---	---	---	0.000	---	0.023	2.55	0.158	0.877
11	---	---	---	---	---	---	0.001	0.000	0.031	2.10	0.147	1.09
12	---	---	---	---	---	---	0.001	0.178	0.038	1.85	0.138	0.946
13	---	---	---	---	---	---	0.001	0.202	0.029	1.83	0.123	0.902
14	---	---	---	---	---	---	0.003	0.043	0.017	1.47	0.096	0.821
15	---	---	---	---	---	---	0.003	---	0.014	1.13	0.087	0.724
16	---	---	---	---	---	---	0.001	---	0.010	0.934	0.095	0.695
17	---	---	---	---	---	---	0.001	---	5.39	0.763	0.098	0.699
18	---	---	---	---	---	---	0.001	---	3.48	0.623	0.073	0.844
19	---	---	---	---	---	---	0.001	---	1.92	0.516	0.048	0.919
20	---	---	---	---	---	---	0.001	---	1.62	0.419	0.040	1.24
21	---	---	---	---	---	0.020	0.001	---	1.14	0.336	0.017	1.66
22	---	---	---	---	---	0.014	0.000	---	0.841	0.252	0.019	1.72
23	---	---	---	---	---	0.007	0.000	---	0.773	0.168	0.018	1.74
24	---	---	---	---	---	0.003	0.001	---	0.661	0.116	0.031	1.82
25	---	---	---	---	---	---	0.001	---	0.538	0.161	0.018	2.20
26	---	---	---	---	---	---	0.000	0.004	0.436	0.248	0.021	2.25
27	---	---	---	---	---	0.004	0.001	0.056	0.515	0.198	0.010	2.08
28	---	---	---	---	---	0.003	0.003	0.043	1.33	0.129	0.016	1.96
29	---	---	---	---	---	0.001	0.002	0.041	4.13	0.068	0.070	1.87
30	---	---	---	---	---	0.002	0.001	0.028	---	0.038	0.330	1.85
31	---	---	---	---	---	0.003	---	0.018	---	0.028	0.696	---