LIME CREEK

• Watershed Improvement Plan •

A roadmap for improved water quality, sustained agricultural productivity & reduced flood risk

Prepared by:

Iowa Soybean Association
Environmental Programs & Services

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Watershed residents, farmers and landowners

Lime Creek Watershed Improvement Association

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Buchanan County Conservation Board

Buchanan Soil and Water Conservation District

Natural Resources Conservation Service

Coe College

A ROADMAP FOR IMPROVED WATER QUALITY, SUSTAINED AGRICULTURAL PRODUCTIVITY AND REDUCED FLOOD RISK

What is the purpose of the Lime Creek Watershed Improvement Plan?

This document is intended to provide a roadmap for water and soil improvements in the Lime Creek Watershed while at the same time maintaining or improving agronomic performance and quality of life. Environmental improvements are a big task, and trying to tackle everything at once can be daunting. This plan lays out a phased approach to implementation to ensure continuous improvements are made towards achieving long-term goals for the watershed.

Who owns this watershed plan?

This plan is for all stakeholders interested in the Lime Creek Watershed including landowners, famers, residents, nongovernmental organizations as well as local, state and federal units of government and others. Ultimately, successful implementation of this plan will rest with these stakeholders.

Who developed this watershed plan?

This plan was developed by the Iowa Soybean Association with guidance and input from representatives of landowners, famers, residents, nongovernmental organizations, local and federal units of government and others. The watershed planning process and document preparation was led by the Iowa Soybean Association with assistance from the Lime Creek Watershed Improvement Association, Iowa State University Extension and Outreach, Buchanan County Conservation Board, Coe College, Buchanan Soil and Water Conservation District and the Natural Resources Conservation Service (NRCS).

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1. EXECUTIVE SUMMARY

A watershed is an area of land that drains to a single point. The Lime Creek Watershed drains 26,774 acres of southwest Buchanan County and north central Benton County into the Cedar River southwest of Brandon, Iowa. This watershed plan defines and addresses existing land and water quality conditions, identifies challenges and opportunities and provides a path for improvement. The development of this document followed the watershed planning process and incorporated input from a variety of public and private stakeholders. The Iowa Soybean Association led development of this watershed plan with input from watershed farmers and landowners, conservation professionals and others. The Lime Creek Watershed Improvement Plan serves as the culmination of existing studies, citizen and stakeholder input and recommendations for conservation practices aimed at meeting the goals established through the watershed planning process.

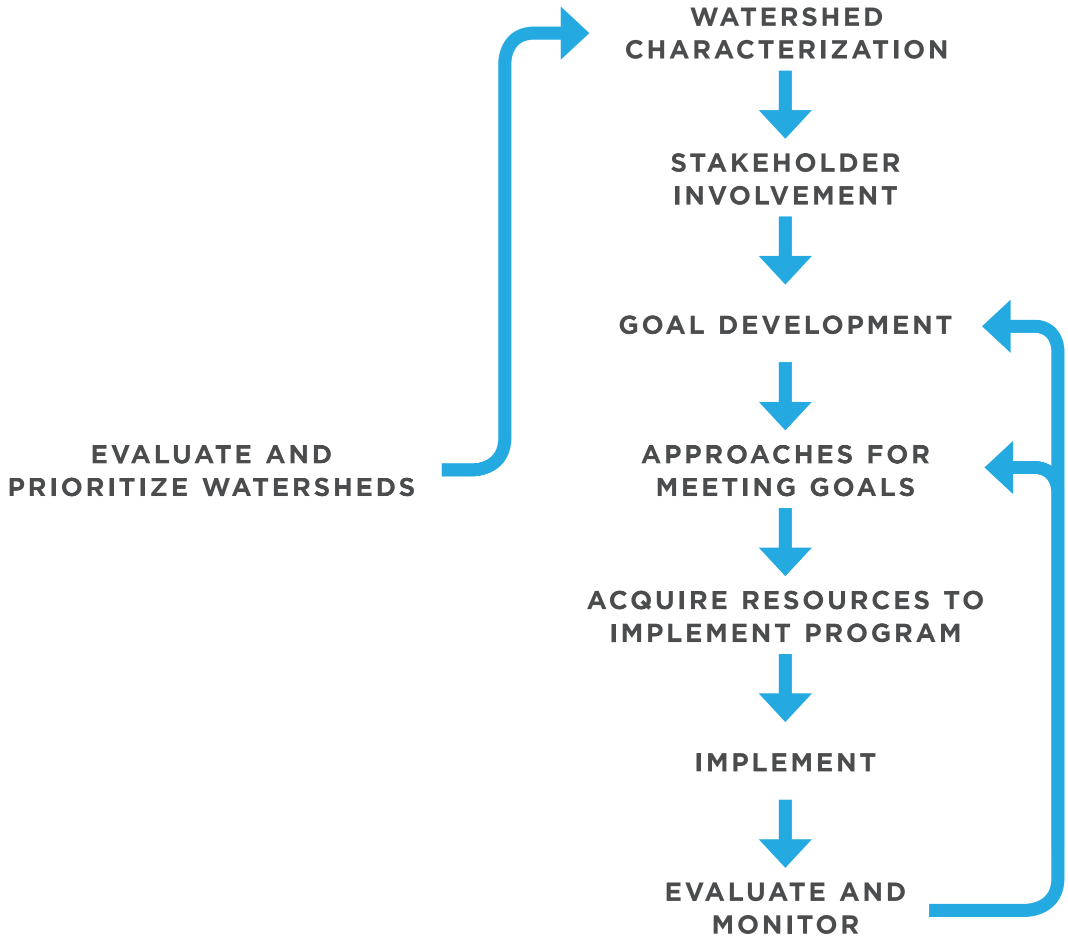


Figure 1.1. The watershed planning process.

The Lime Creek Watershed was selected for watershed planning to build on previous efforts of the Lime Creek Watershed Improvement Association, a farmer-led group organized in 2006 with the goals of reducing nitrate and phosphorus in Lime Creek by 35 percent. A 2007 to 2009 project led by the Lime Creek Watershed group resulted in improved in-stream nitrate concentrations relative to six other tributaries of the Cedar River monitored by Coe College. Along with growing interest and awareness of the topic of water quality in Iowa, as indicated by the recently developed Iowa Nutrient Reduction Strategy, highly engaged local stakeholders in the Lime Creek Watershed and existing water quality impairments in both Lime Creek and the Cedar River made the Lime Creek Watershed a high priority for watershed planning.

Goals have been established in order to achieve the vision of all stakeholders. This document guides stakeholders through a continuous improvement approach to watershed management, understanding that big changes result from stacked small successes. The long-term goals of the Lime Creek Watershed Improvement Plan are to:

1. Reduce in-stream nonpoint source nitrogen loads by 41 percent.
2. Reduce in-stream nonpoint source phosphorus loads by 29 percent.
3. Reduce flood risk in Lime Creek and downstream.
4. Maintain and improve aquatic habitat.
5. Maintain and increase agricultural productivity and profitability.

Public involvement was an essential component of the watershed planning process. Watershed planners initiated public participation during the planning process and incorporated multiple levels of involvement. Members of the Lime Creek Watershed Improvement Association served as a watershed advisory committee to provide input as the farmers, landowners and residents of the watershed. Input from the advisory committee, other local stakeholders and conservation experts was used to guide development of this document.

Improving land and water resources in the Lime Creek Watershed is a complex and challenging task and will require significant collaboration and partnerships. The implementation schedule in this watershed plan was developed to balance current resources with the desire to make land and water improvements. A 15-year phased implementation schedule has been created to allow for continuous improvements that can be evaluated to determine if progress is being made towards achieving desired goals. The total investment needed to achieve the goals identified in this plan is estimated to be approximately $2,277,663.20 for structural practices and $955,320.70 for management practices.

2. WATERSHED CHARACTERISTICS

2.1. General Information

The Lime Creek Watershed encompasses 26,774 acres and is dominated by 79 percent row crop agriculture. Terrain in the watershed varies from relatively low slopes to gently rolling. Smaller streams and tributaries flow into Lime Creek, which flows predominately from north to south towards its confluence with the Cedar River southwest of Brandon. Incorporated communities within the watershed include a portion of Independence and all of Brandon. Public land in the watershed includes Crumbacher Wildlife Area and Lime Creek County Park. Table 2.1.1 lists general information for the Lime Creek stream segments and 12-digit Hydrologic Unit Code (HUC) watershed.

Table 2.1.1. General watershed data for Lime Creek. (Designated use classes are A: primary contact recreation, B: Aquatic Life and HH: fish consumption. See Appendix B for full definitions of designated uses. OIW denotes Outstanding Iowa Water.)

	LIME CREEK WATERSHED	
LOCATION	Buchanan County and Benton County	
WATERBODY ID	IA 02-CED-0270_01	IA 02-CED-0270_02
DESIGNATED USES	A1, B(WW-1), HH, OIW	A1, B(WW-2)
STREAM SEGMENT LENGTH	8.8 miles	7.3 miles
WATERSHED AREA	26,774 acres	
DOMINANT LAND USE	Row crop agriculture	
INCORPORATED COMMUNITIES	Brandon, Independence	
HUC8 WATERSHED	Middle Cedar	
HUC8 ID	07080205	
HUC10 WATERSHED	Spring Creek-Cedar River	
HUC10 ID	0708020510	
HUC12 WATERSHED	Lime Creek	
HUC12 ID	070802051003	

2.2. Water & Wetlands

A well-connected stream network flows through the Lime Creek Watershed. Figure 2.2.1 shows the identified incised and non-incised streams within the watershed. Figure 2.2.2 is a map of the wetlands in the Lime Creek Watershed as identified by the National Wetlands Inventory (NWI), which are summarized in Table 2.2.1. The NWI dataset was developed by the U.S. Fish and Wildlife Service, but may not capture all wetlands because the original maps were derived from aerial photo interpretation and therefore may be limited by image quality and scale.

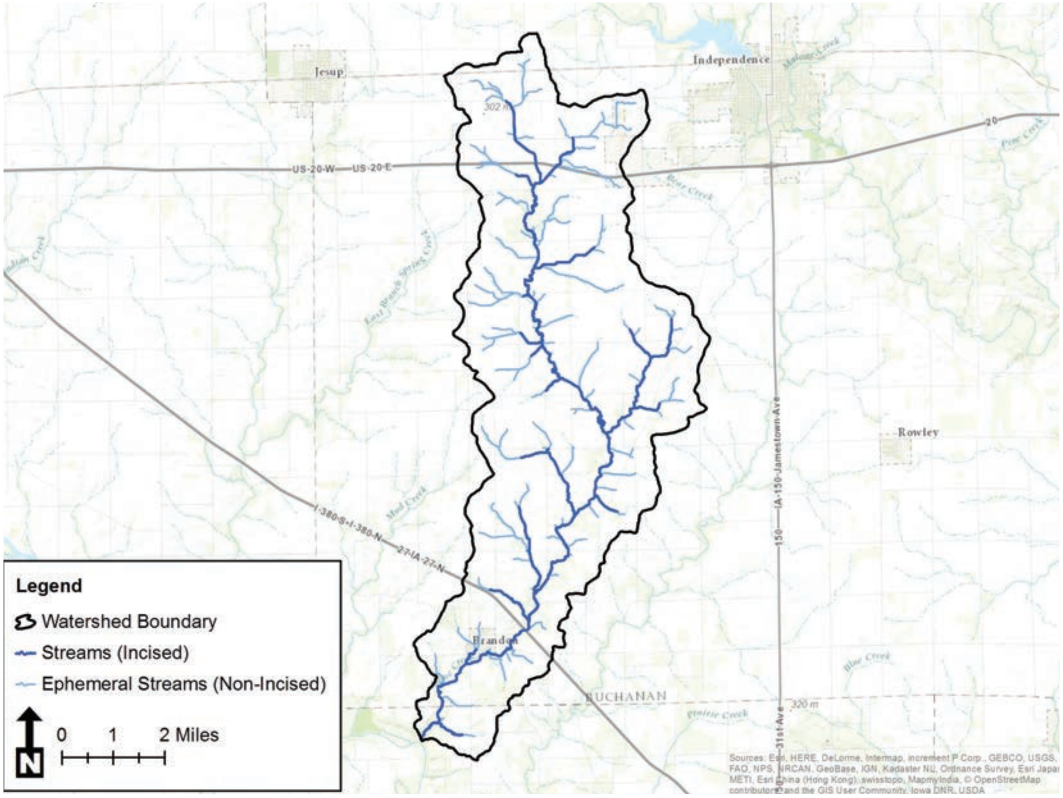


Figure 2.2.1. Streams identified in the Lime Creek Watershed.

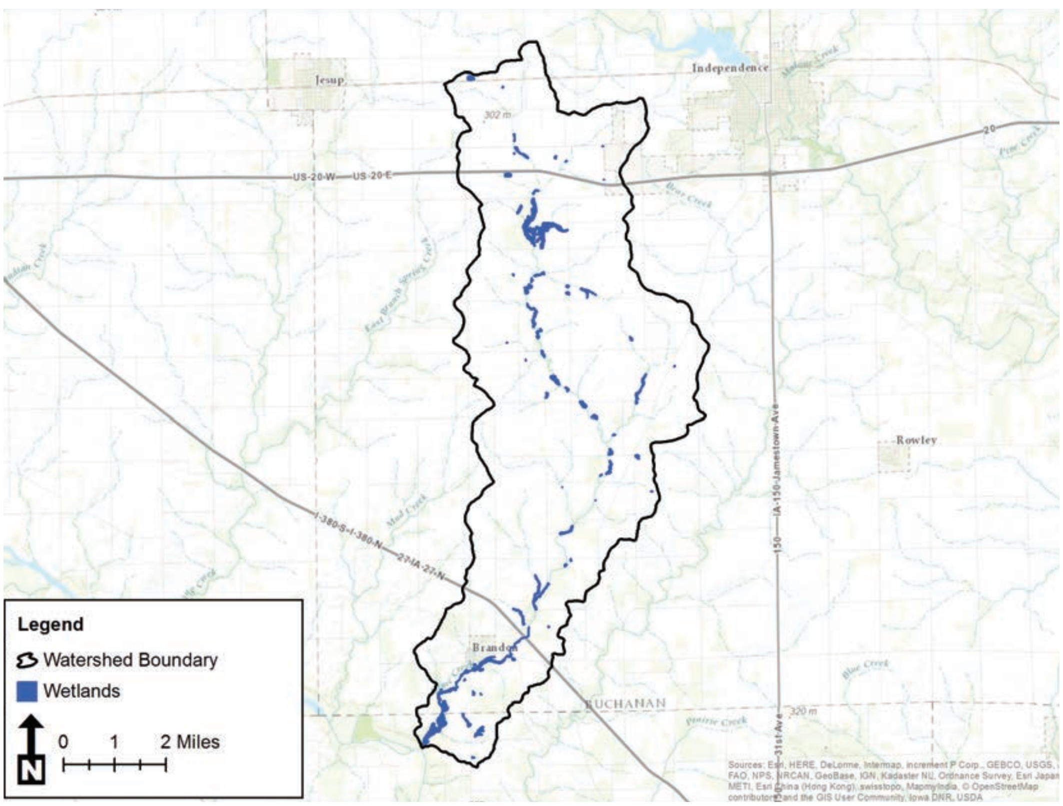


Figure 2.2.2. Wetlands of the Lime Creek Watershed according to the National Wetlands Inventory.

Table 2.2.1. Classification of wetlands within the Lime Creek Watershed.

TYPE	ACRES	PERCENT
Artificially Flooded	1	0.3
Intermittently Exposed	33	9.1
Intermittently Flooded	7	1.8
Saturated	2	0.7
Seasonally Flooded	78	21.6
Semipermanently Flooded	13	3.6
Temporarily Flooded	214	59.5
Other	12	3.4
Total	360	100

2.3. Climate

Climate data from Daymet for the Lime Creek Watershed show annual total precipitation averaged 35.7 inches per year between 2001 and 2015, but the range of 22.3 inches to 56.7 inches for yearly totals during the same time period suggests large variability. Annual total precipitation trends are shown in Figure 2.3.1. Precipitation also is seasonal in the Lime Creek Watershed, with May, June and July having the highest average monthly rainfall. Monthly precipitation averages are displayed in Figure 2.3.2.

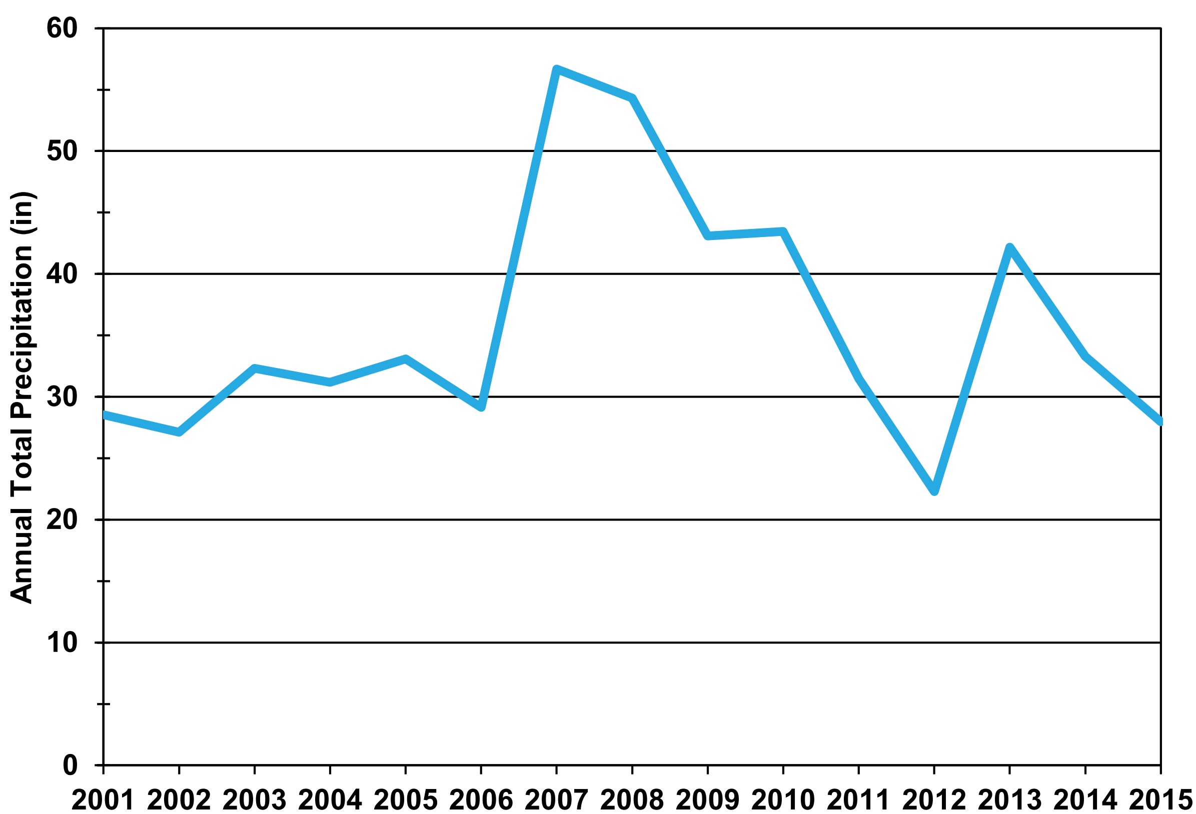


Figure 2.3.1. Annual total precipitation for the Lime Creek Watershed 2001 to 2015.

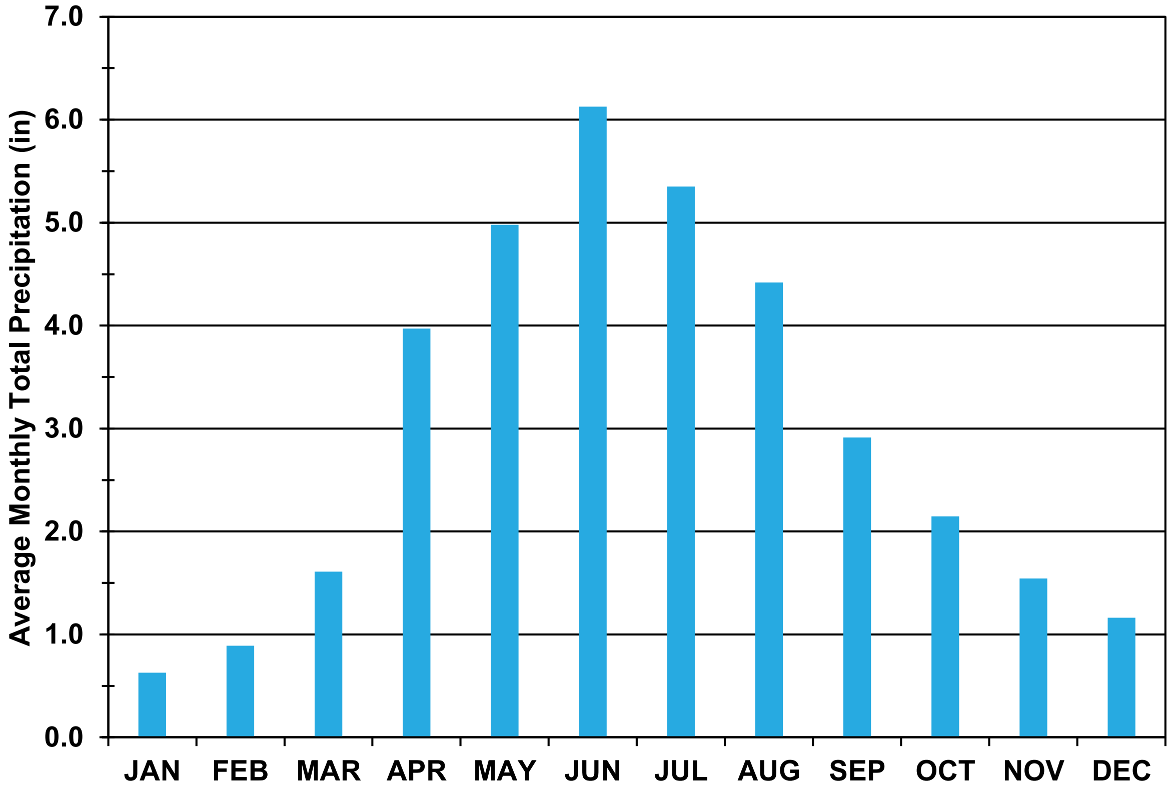


Figure 2.3.2. 2001 to 2015 average monthly total precipitation for the Lime Creek Watershed.

2.4. Geology & Topography

The entire Lime Creek Watershed is located within the Iowan Surface landform region. The Iowan Surface was last glaciated approximately 300,000 years ago. The present day landscape is dominated by gently rolling terrain created by glacial processes and ensuing episodes of intense erosion, which most recently occurred between 21,000 and 16,500 years ago. The watershed also is located within the Eastern Iowa and Minnesota Till Prairies Major Land Resource Area (MLRA 104).

Land surface elevation in the watershed ranges from 239 to 310 meters above sea level. Figure 2.4.1 shows elevation as derived from Light Detection and Ranging (LiDAR) data. Figure 2.4.2 displays the slope classification of the watershed, which also is listed in Table 2.4.1.

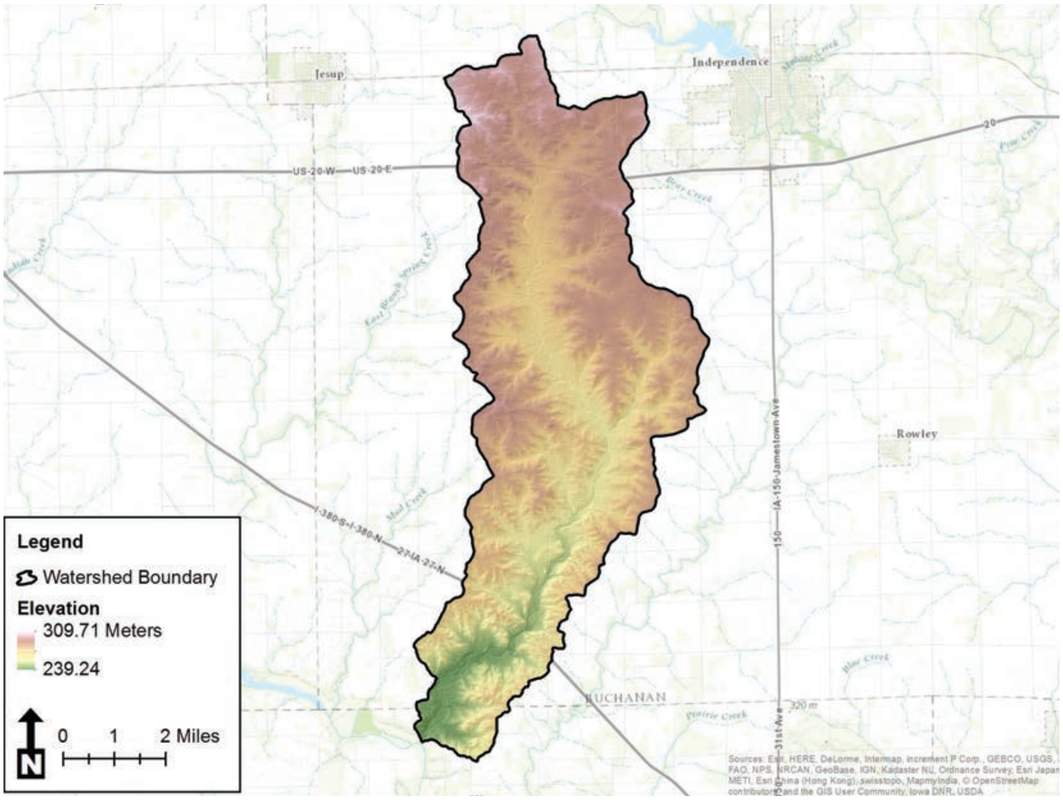


Figure 2.4.1. LiDAR-derived elevations within the Lime Creek Watershed.

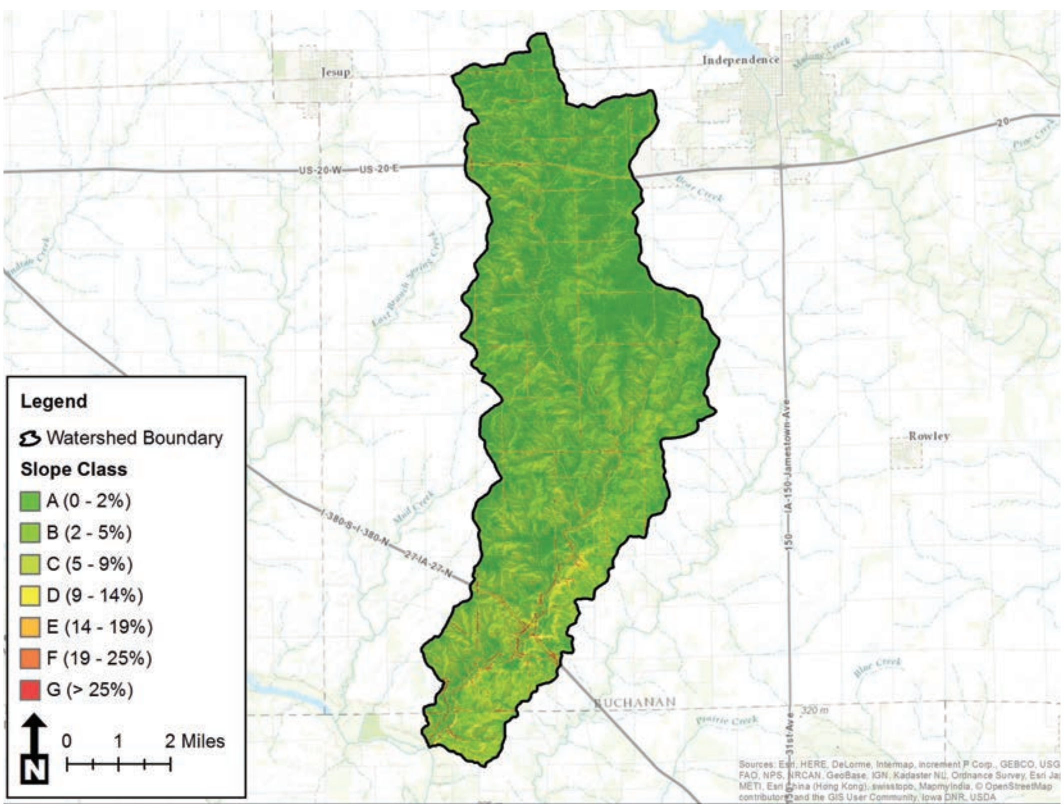


Figure 2.4.2. Lime Creek Watershed slope classifications derived from LiDAR elevation data.

Table 2.4.1. Extent of each slope class within the Lime Creek Watershed.

SLOPE CLASS	RANGE	ACRES	PERCENT OF TOTAL AREA
A	0-2%	10,188	38.0
B	2-5%	12,002	44.8
C	5-9%	3,553	13.3
D	9-14%	645	2.4
E	14-19%	188	0.7
F	19-25%	124	0.5
G	>25%	75	0.3

2.5. Soils

The predominant soil associations mapped in the Lime Creek Watershed are the Clyde-Floyd complex and the Kenyon, Readlyn and Olin series. These four soil types comprise nearly two-thirds of the watershed. Figure 2.5.1 shows a map of the most common soils within the watershed according to the Soil Survey Geographic Database (SSURGO) coverage developed by the National Cooperative Soil Survey and the USDA-NRCS. Descriptions of the Clyde, Floyd, Kenyon, Readlyn and Olin soil series are given in Table 2.5.1.

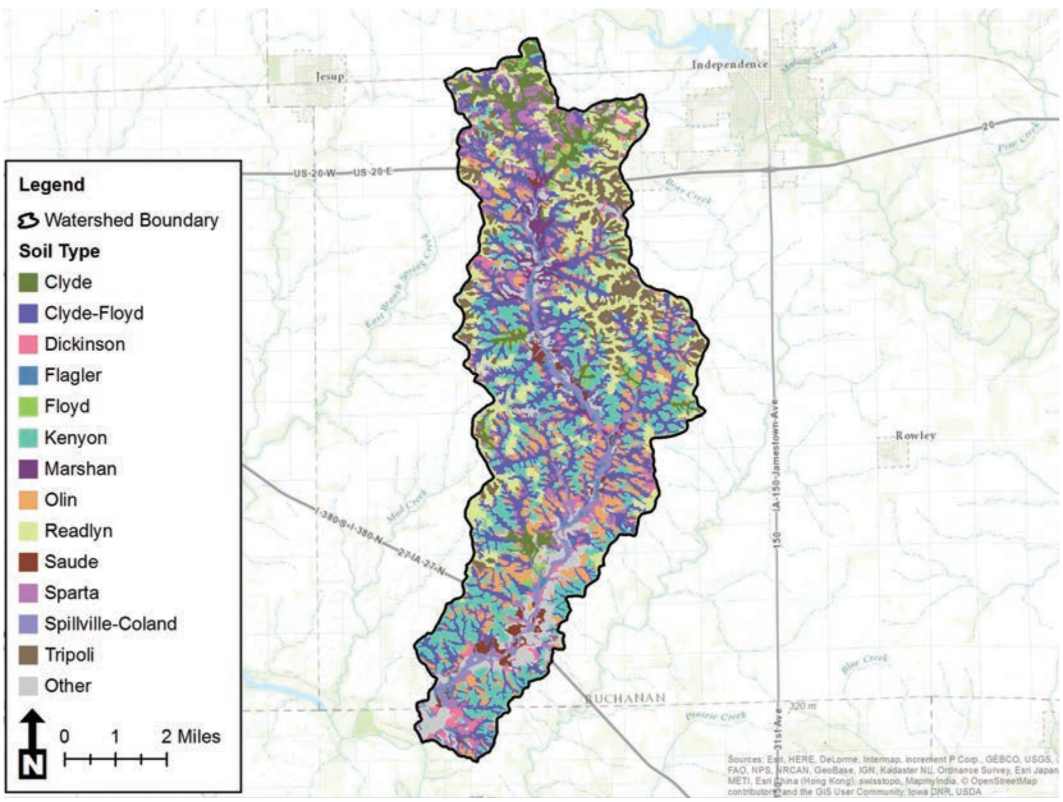


Figure 2.5.1. Lime Creek Watershed soil map derived from SSURGO data.

Table 2.5.1. Descriptions of the most common soil series of the Lime Creek Watershed (USDA-NRCS).

SOIL SERIES	DESCRIPTION
Clyde	The Clyde series consists of very deep, poorly and very poorly drained soils formed in 75 to 150 centimeters of loamy glacial outwash or erosional sediments and the underlying loamy till. These soils are on nearly level positions, swales and concave drainageways on interfluves on dissected till plains. Slope ranges from 0 to 4 percent.
Floyd	The Floyd series consists of very deep, somewhat poorly drained soils formed in 75 to 150 centimeters of loamy sediments and in the underlying till. These soils are on concave foot slopes adjacent to upland drainageways on dissected till plains. Slope ranges from 0 to 5 percent.
Kenyon	The Kenyon series consists of very deep, moderately well drained soils formed in 30 to 75 centimeters of silty or loamy sediments and the underlying till. These soils are on interfluves and side slopes on dissected till plains on the Iowan Erosion Surface. Slope ranges from 2 to 35 percent.
Readlyn	The Readlyn series consists of very deep, somewhat poorly drained soils that formed in 30 to 75 centimeters of loamy sediments and the underlying till. Readlyn soils are on slightly convex side slopes on dissected till plains of low relief on the Iowan Erosion Surface. Slope ranges from 0 to 5 percent.
Olin	The Olin series consists of very deep, well drained soils formed in 60 to 91 centimeters of loamy sediments and in the underlying glacial till. These soils are on interfluves and side slopes on dissected till plains. Slopes range from 2 to 14 percent.

Table 2.5.2 summarizes the soil characteristics that affect water movement within the watershed. Approximately 58.2 percent of the soils are classified as hydric, which means they are saturated, flooded or ponded long enough during the growing season to develop anaerobic conditions in the upper portion of the soil profile. A soil is classified as hydric regardless of its drainage status, so tiled soils may be hydric. Hydric soils within the Lime Creek Watershed are mapped in Figure 2.5.2. As in many other watersheds in the relatively flat landscapes of Iowa, land within the Lime Creek Watershed is artificially drained in order to make agriculture possible and productive. Figure 2.5.3 shows where tile drainage may be needed to achieve full agricultural productivity. The map may not capture all areas that currently have subsurface tile drainage infrastructure.

Table 2.5.2. Drainage characteristics of predominant soils in the Lime Creek Watershed.

SOIL	ACRES	PERCENT OF TOTAL AREA	DRAINAGE CLASS	HYDROLOGIC SOIL GROUP	HYDRIC CLASS
Clyde-Floyd	6,159	23.0%	Poorly drained	B/D	Partially hydric
Kenyon	4,381	16.4%	Moderately well drained	B	Not hydric
Readlyn	3,903	14.6%	Somewhat poorly drained	B	Partially hydric
Olin	2,879	10.8%	Well drained	B	Not hydric

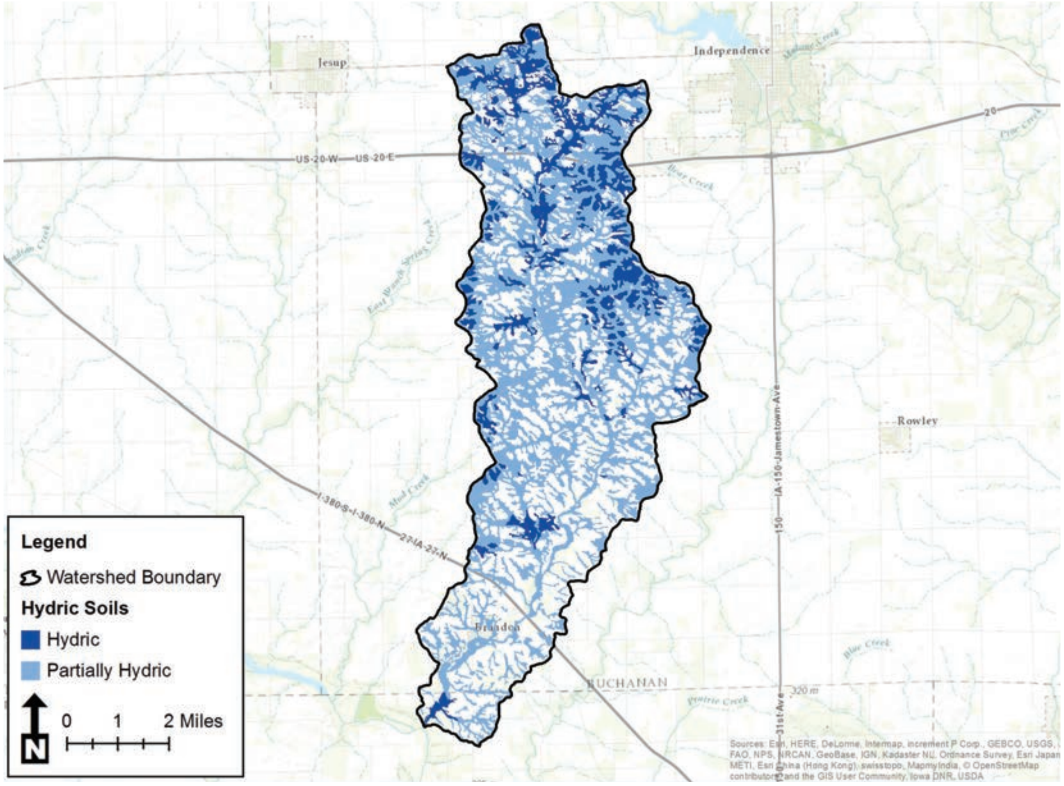


Figure 2.5.2. Soil map units in the Lime Creek Watershed that are classified as hydric.

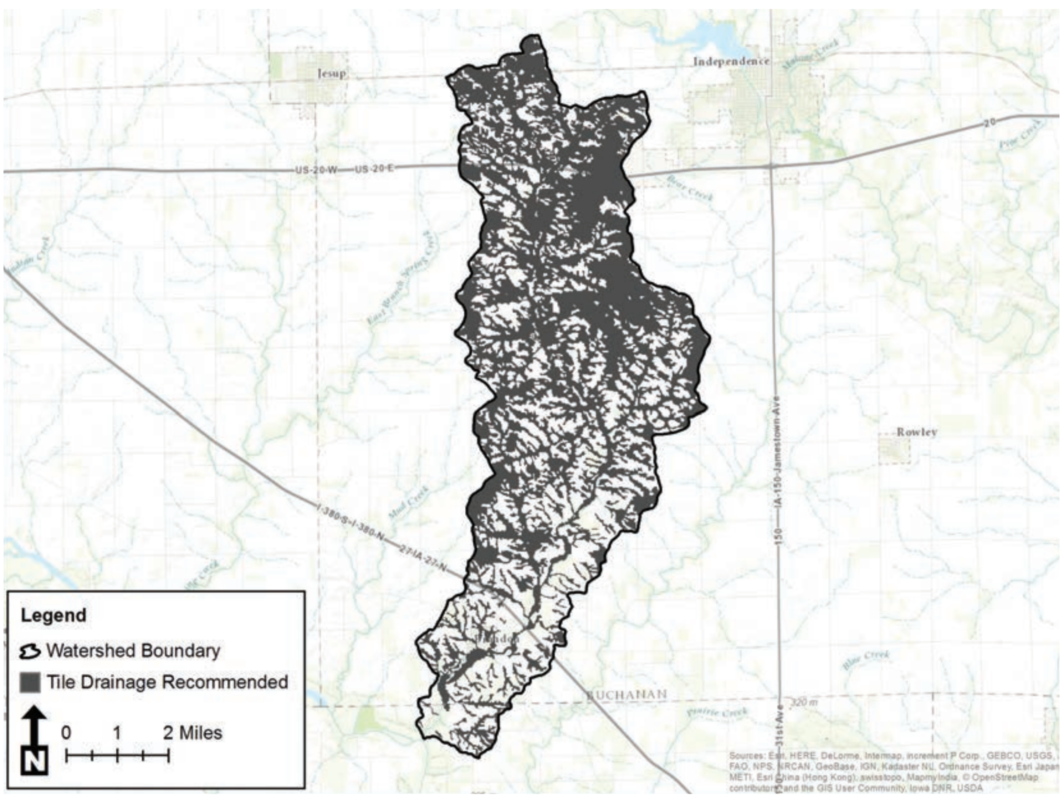


Figure 2.5.3. Areas requiring tile drainage to achieve full agricultural productivity.

Figure 2.5.4 shows a map of highly erodible land (HEL) within the watershed. Approximately 20.4 percent of the watershed is considered HEL or potentially HEL.

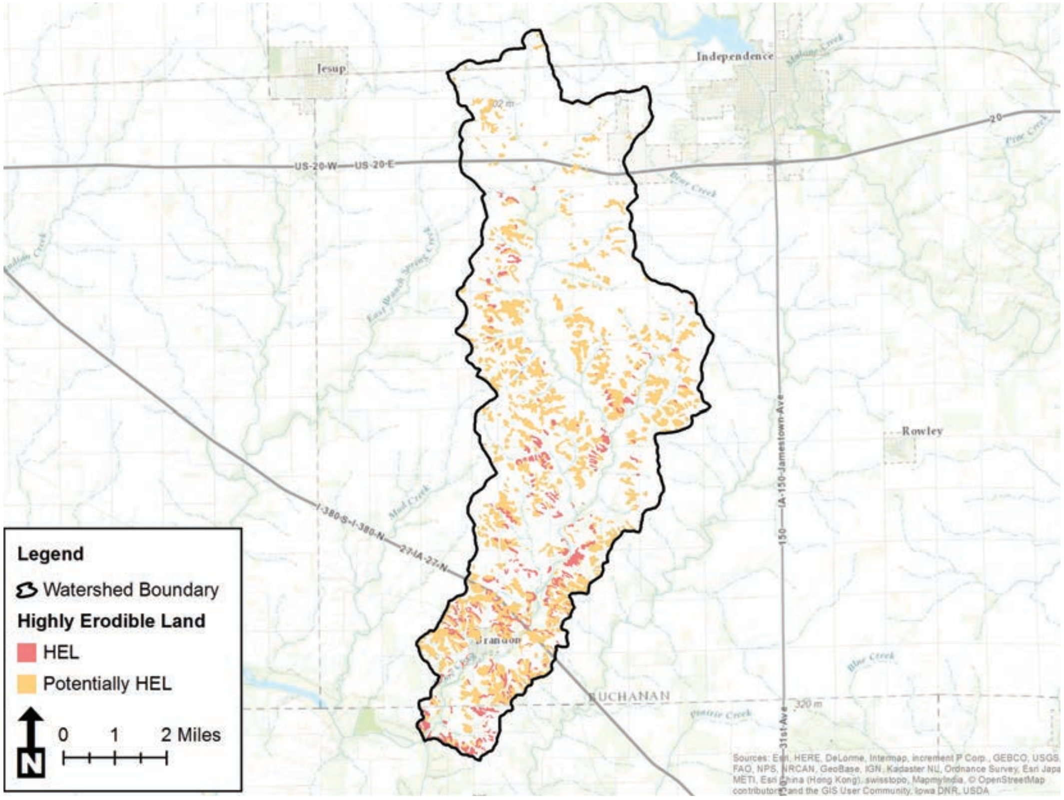


Figure 2.5.4. Highly erodible land (HEL) classification based on SSURGO data.

Soil map units in Iowa are assigned Corn Suitability Rating 2 (CSR2) values. Figure 2.5.5 displays the CSR2 values for land within the Lime Creek Watershed. This map was generated by matching spatial SSURGO data to the Iowa Soil Properties and Interpretations Database 8.1 (ISPAID 8.1). The CSR2 is an index that provides a relative ranking of soils mapped in Iowa based on their potential to be utilized for intensive row crop production and thus can be used to compare soils' yield potential. CSR2 ratings range from 5 (severely limited soils) to 100 (soils with no physical limitations, no or low slope and can be continuously farmed). The rating system assumes adequate management, natural precipitation, artificial drainage where necessary, no negative effects from flooding and no land leveling or terracing.

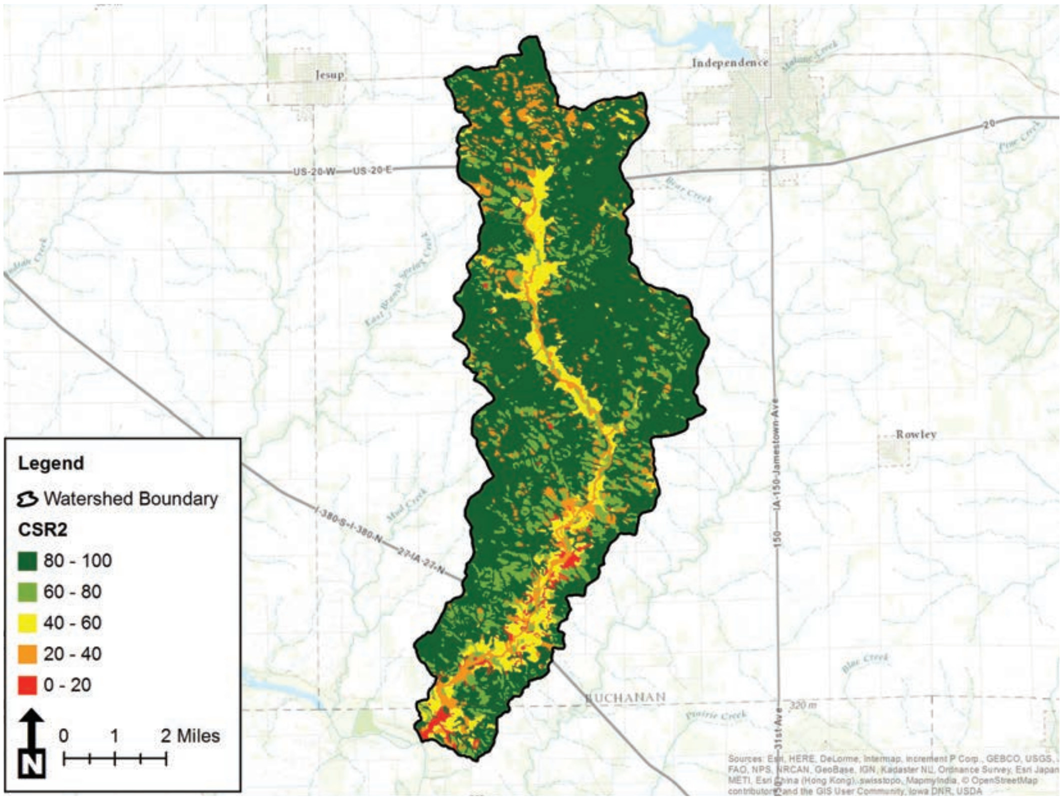


Figure 2.5.5. Corn Suitability Rating 2 (CSR2).

2.6. Land Use & Management

Land in the Lime Creek Watershed is used primarily for row crop agriculture, which is a drastic change from its natural state. The General Land Office (GLO) first surveyed the land in Iowa between 1832 and 1859. Surveyors recorded descriptive notes and maps of the landscape and natural resources such as vegetation, water, soil and landform. The collection of historic GLO maps and survey notes is one of few sources of information about native vegetation before much of Iowa's landscape was converted to intensive agriculture. The GLO surveyors classified land within the Lime Creek Watershed as 92 percent prairie and 8 percent forest. Figure 2.6.1 shows most of the native forest grew along the lower reaches of Lime Creek, with prairie species inhabiting the remainder of the watershed.

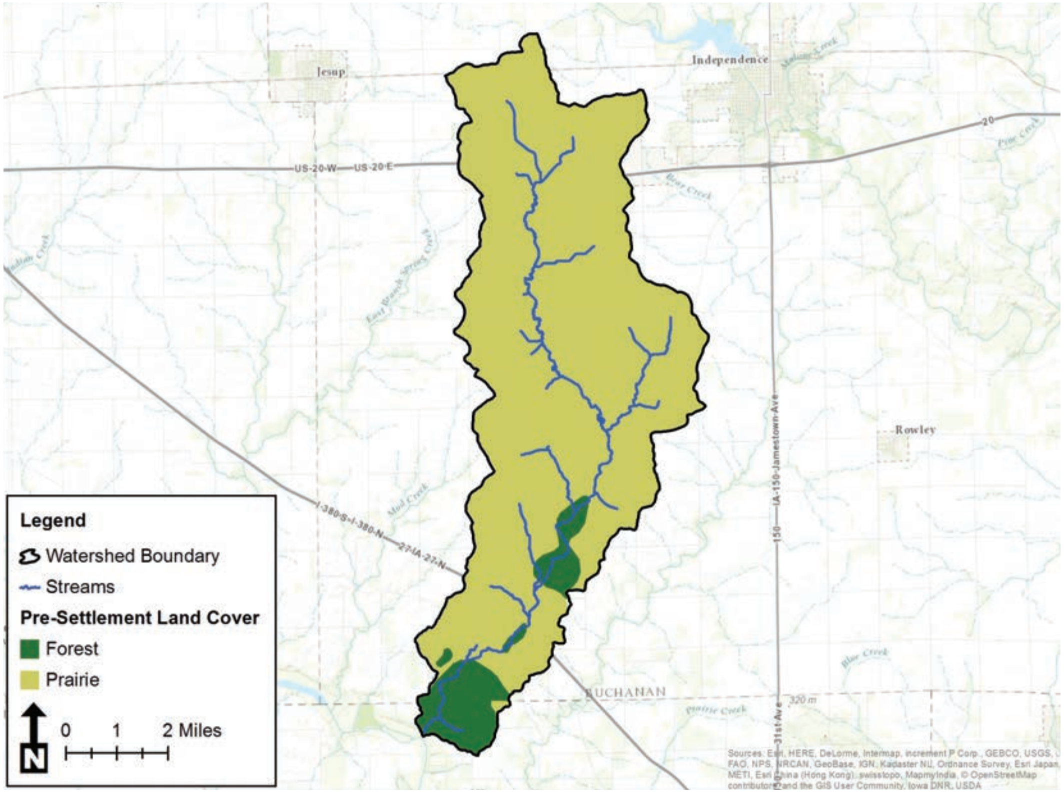


Figure 2.6.1. Pre-settlement land cover according to GLO surveys in the mid-1800s.

Recent and current land use practices were assessed using USDA-National Agricultural Statistics Service (NASS) Cropland Data Layer 2000 through 2015 information and high-resolution Iowa Department of Natural Resources (DNR) data from 2009. Land use trends based on NASS data are shown in Figure 2.6.2. The DNR land use data was developed from aerial imagery and LiDAR elevation data. A summary of the high-resolution DNR land use data is presented in Table 2.6.1 and Figure 2.6.3. Notably, 79 percent of the watershed is used for corn and soybean production.

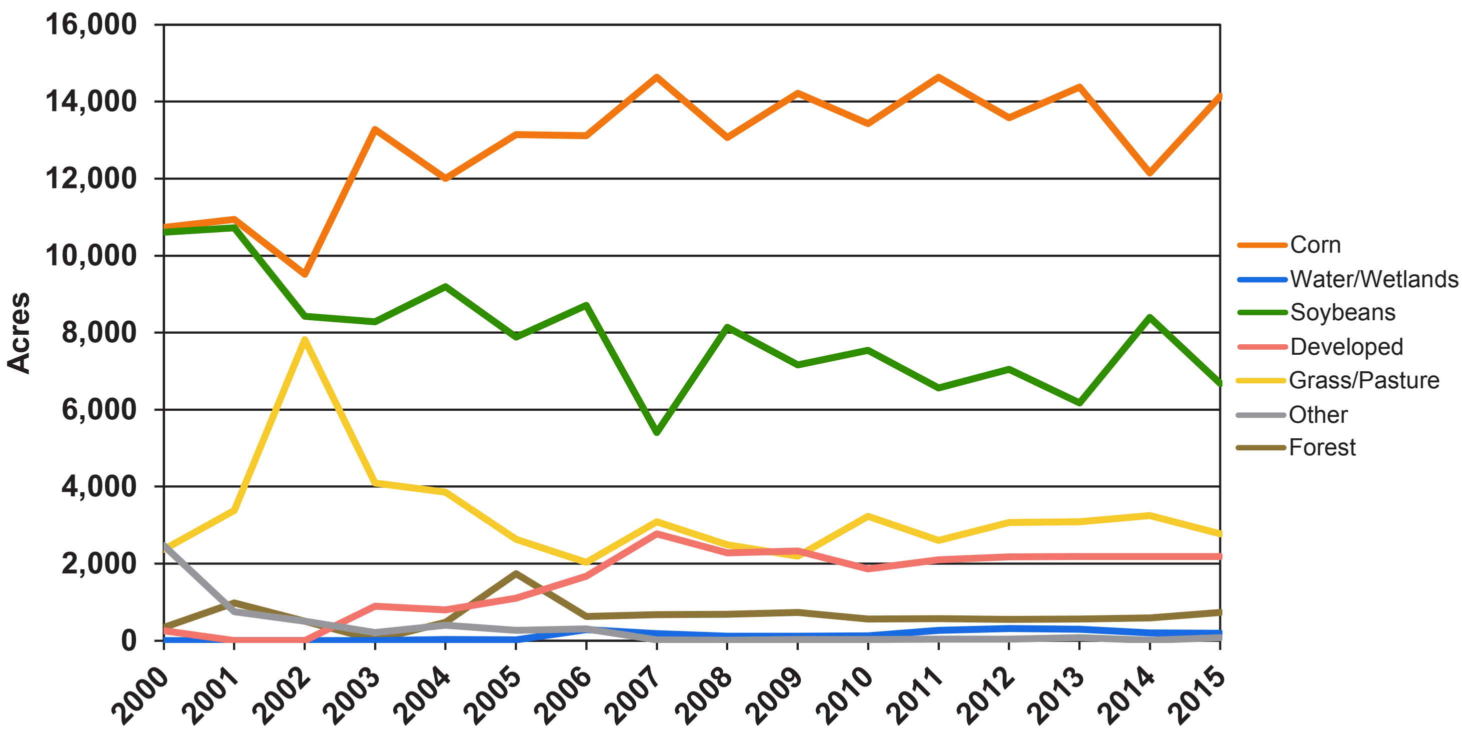


Figure 2.6.2. Lime Creek 2000 through 2015 land use.

Table 2.6.2. Lime Creek Watershed land use.

LAND USE	ACRES	PERCENT
Water	36	0.1
Wetland	97	0.4
Coniferous Forest	9	<0.1
Deciduous Short	536	2.0
Deciduous Medium	410	1.5
Deciduous Tall	432	1.6
Grass 1	1,705	6.4
Grass 2	1,530	5.7
Cut Hay	101	0.4
Corn	13,251	49.5
Soybeans	7,891	29.5
Barrent/Fallow	152	0.6
Structures	52	0.2
Roads/Impervious	534	2.0
Shadow/No Data	37	0.1
Total	26,774	100

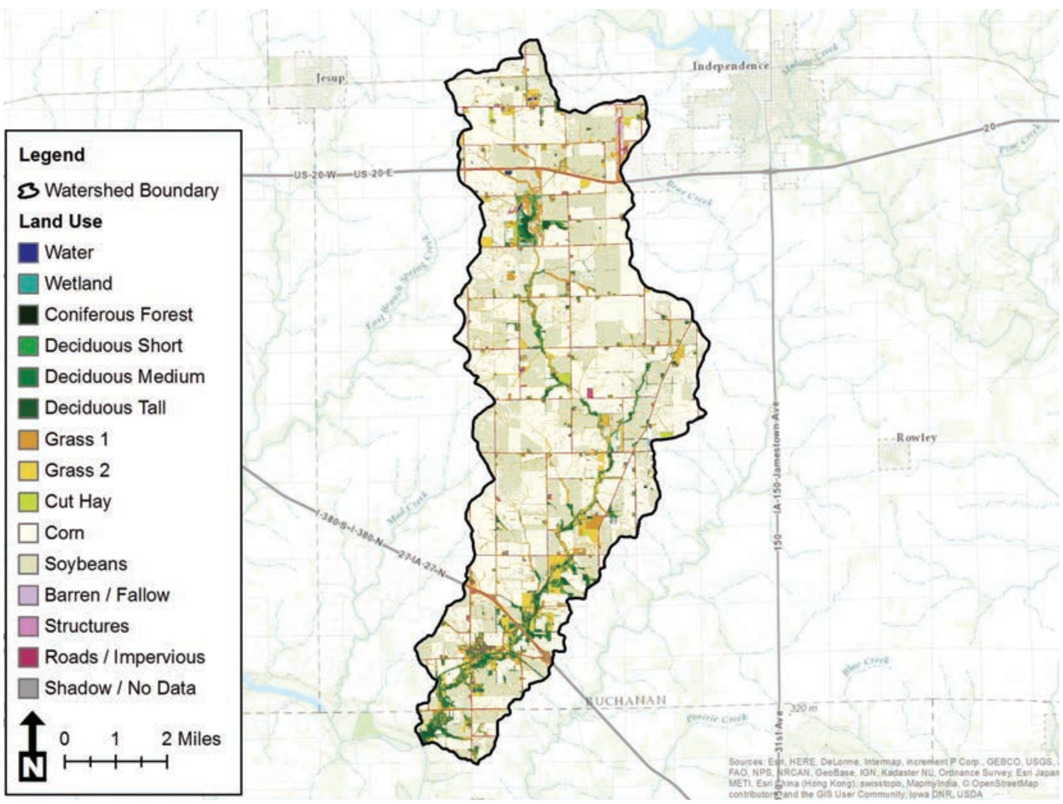


Figure 2.6.3. High-resolution land use map of the Lime Creek Watershed.

2.7. Population

According to United States Census Bureau 2010 census data, 779 people live in census tracts in the Lime Creek Watershed, which equates to a population density of 18.6 people per square mile. There are an estimated 342 housing units within the watershed.

2.8. Existing Conservation Practices

Cataloging existing conservation infrastructure is an important assessment of current conditions as well as a useful exercise for determining the need for future conservation practice placement. Aerial photography and watershed surveys revealed many conservation practices currently in place within the watershed, but determining levels of in-field management practices (e.g. nutrient management, tillage and cover crops) can be difficult. Perennial vegetation is present throughout the watershed, but Crumbacher Wildlife Area provides 360 acres of permanent perennial cover including a small constructed wetland. Table 2.8.1 lists all practices and known existing implementation levels within the watershed. Figure 2.8.1 provides a map of existing conservation practices as of 2016. See Appendix I for a larger map of conservation practices.

Table 2.8.1. Inventory of Lime Creek existing conservation practices.

PRACTICE	QUANTITY
Grassed Waterways	345,708 feet
Terraces	40,114 feet
No-Till/Strip-Till	Unknown
Nutrient Management	Unknown
Cover Crops	Unknown
Perennial Cover (CRP)	290 acres
100' Stream Buffers	74% grass or trees
Bioreactors	1
Wetlands/Ponds	97 acres

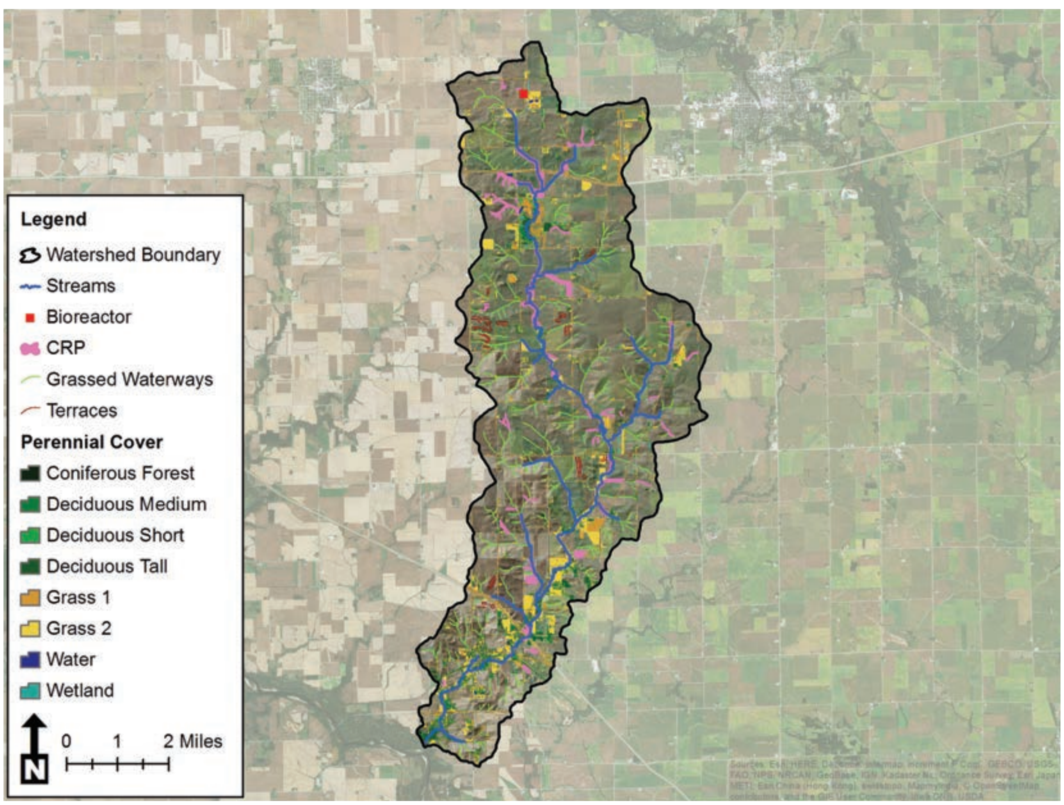


Figure 2.8.1. Conservation practices with known locations in the Lime Creek Watershed as of 2016.

3. STREAM PHYSICAL, CHEMICAL & BIOLOGICAL CONDITIONS

3.1. Cedar River Nitrate Impairment

The Lime Creek Watershed is a subwatershed of the larger Cedar River Watershed (Figure 3.1.1). The Cedar River, near Cedar Rapids, is impaired for elevated levels of nitrate that impact the drinking water source of the city of Cedar Rapids. Because of this impairment, a Water Quality Improvement Plan (or total maximum daily load, TMDL) for nitrate was developed by the Iowa DNR and approved by the Environmental Protection Agency (EPA) in 2006.

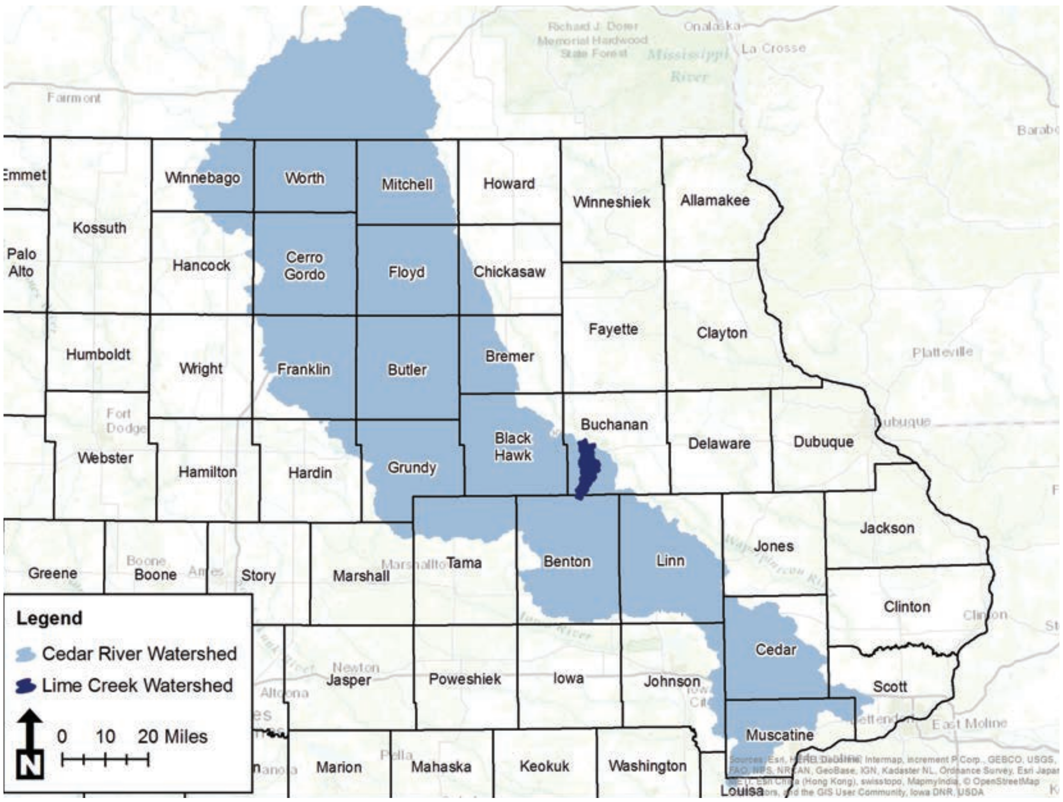


Figure 3.1.1. Location of the Lime Creek Watershed within the Cedar River Watershed.

The 2004 305(b) Iowa Integrated Report showed the designated drinking water use of the Cedar River in Cedar Rapids (segment IA 02-CED-0030_2) was impaired due to nitrate-nitrogen (nitrate) concentrations exceeding state water quality standards. For the impaired segment, the Class C (drinking water) uses were assessed as “not supporting” due to the level of nitrate exceeding state water quality standards and the EPA maximum contaminant level (MCL). The applicable water quality standard for nitrate is 10 milligrams per liter (mg/L). A TMDL was developed to calculate the maximum allowable nitrate load for the impaired segments of the Cedar River to ensure compliance with water quality standards.

The Cedar River in Cedar Rapids drains a watershed of 6,530 square miles flowing from its headwaters in Minnesota through north-central and northeast Iowa. The watershed is located primarily within the Iowan Surface landform region characterized by gently rolling landscapes and mature drainage patterns. Land cover in the Cedar River Watershed is predominantly agricultural, consisting of 73 percent row crops, 18 percent grass, 4 percent forest, 4 percent urban and 1.2 percent water and wetlands.

Surface water from the Cedar River is used by the city of Cedar Rapids to provide drinking water to approximately 130,000 residents. The TMDL reported nitrate concentrations in the river from 2001 to 2004 ranged from 0.36 to 14.7 mg/L and averaged 6.75 mg/L. Nitrate concentrations exhibit clear seasonality, with higher concentrations occurring during April, May and June as well as November and December. The sources of nitrate can be divided into two major categories: point sources and nonpoint sources. The Cedar River TMDL reports 91 percent of the nitrate in the Cedar River can be attributed to nonpoint sources, while the remaining 9 percent is from point sources.

The TMDL incorporated two water quality models to evaluate stream flow and pollutant loading patterns in the Cedar River Watershed. The Diffusion Analogy Surface Water Flow (DAFLOW) model was used to route and estimate stream flows. A second model, Water Quality Simulation Program (WASP), was used to interpret and predict water quality parameters in aquatic systems, such as the Cedar River. The model inputs included climate, topography, land use, soils, feedlots and confinements, manure application areas, waste water treatment plants and census data. The Cedar River Watershed was divided into seven subbasins for the modeling effort. These included the drainage areas for Upper Cedar, Shell Rock, West Fork, Beaver, Black Hawk and Wolf tributaries, along with the Middle Cedar subbasin. Nitrate loss rates in the subbasins varied from about 10 pounds per acre per year in the Beaver subbasin to more than 25 pounds per acre per year in the Upper Cedar subbasin. When combined with stream flow information, it was found the Upper Cedar subbasin contributes 42 percent of the nitrate load, Shell Rock 29 percent, West Fork 16 percent, Black Hawk 5 percent, Beaver 4 percent and Wolf 4 percent of the total nitrate load flowing into the Middle Cedar subbasin.

Nitrate sources are separated into point and nonpoint sources. The TMDL further divides the nonpoint sources into wildlife, septic, atmospheric deposition, manure application, legume fixation and fertilizer application. The nitrate contributions of these sources within each subbasin are shown in Table 3.1.1.

Table 3.1.1. Nitrate contributions in the Cedar River Watershed.

SUBBASIN	POINT SOURCES (T/YR)	WILDLIFE (T/YR)	SEPTIC SYSTEMS (T/YR)	ATMOSPHERIC DEPOSITION (T/YR)	MANURE (T/YR)	LEGUME (T/YR)	FERTILIZER (T/YR)
Upper Cedar	794	105	114	4,117	13,070	22,201	33,061
Shell Rock	464	64	90	4,312	9,629	23,183	38,822
West Fork	45	31	36	2,097	9,298	11,364	18,702
Beaver	29	12	22	976	4,169	5,567	8,684
Black Hawk	28	9	15	828	2,264	4,835	8,574
Wolf	30	12	15	814	1,260	4,692	7,694
Middle Cedar	1,132	149	131	2,989	5,957	15,034	27,136
Total	2,522	382	423	16,133	45,647	86,876	142,673

The TMDL reports a 35 percent reduction in the Cedar River nitrate concentration is necessary to attain a maximum daily nitrate concentration of 9.5 mg/L in order to meet water quality standards. The Lime Creek Watershed is located within the Middle Cedar subbasin.

3.2. Lime Creek Water Quality

The Lime Creek Watershed has a thorough database of water quality information from 2002 to the present. Iowa DNR 2014 assessments for both segments of Lime Creek (waterbody ID codes IA 02-CED-0270_1 and IA 02-CED-0270_2) have been completed and are listed in Iowa's 305(b) Assessed Waters Report. In 2004, the downstream segment

(IA 02-CED-0270_1) was listed in Iowa's 303(d) Impaired Waters Report for impaired aquatic life due to biological stress, which was determined by a greater than 50 percent decline in species richness of mussel species in Lime Creek. However, DNR surveys in 2007, 2009 and 2010 revealed the mussel community had recovered sufficiently, which led to the removal of the segment of Lime Creek from the 303(d) list in 2012. A portion of the downstream segment of Lime Creek shown in Figure 3.2.1 is classified as an Outstanding Iowa Water.

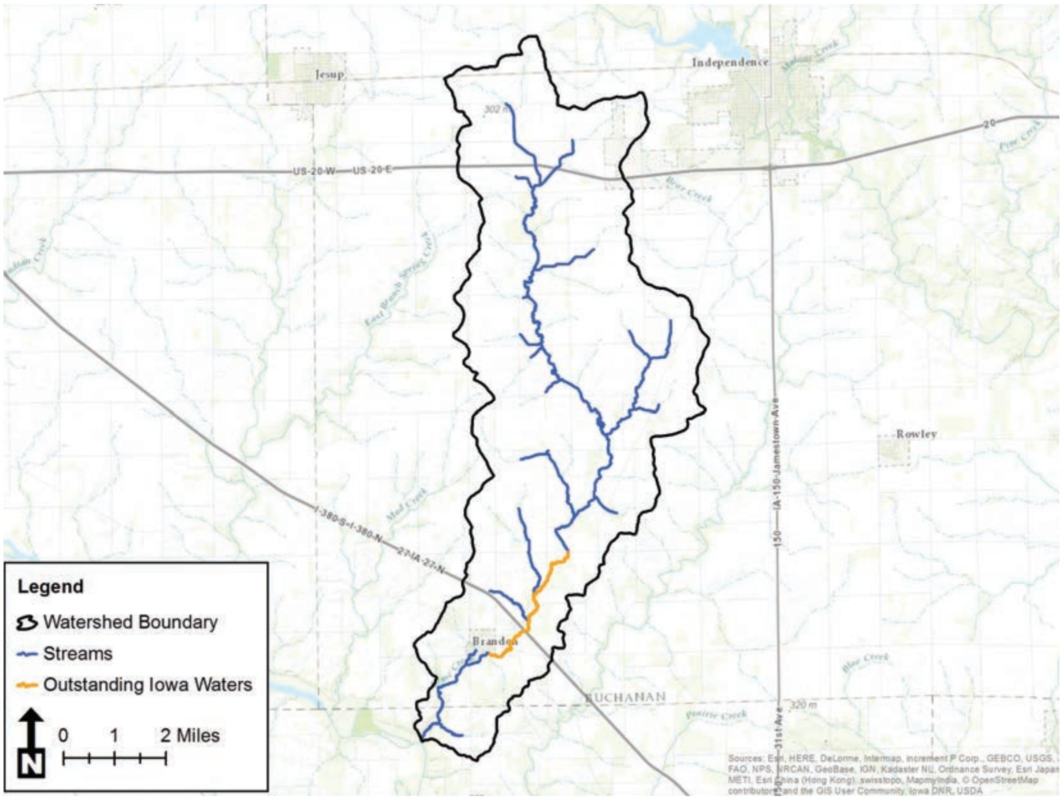


Figure 3.2.1. A 3-mile segment of Lime Creek northeast of Brandon is designated as an Outstanding Iowa Water.

Both segments of Lime Creek are currently on Iowa's 303(d) list due to a bacteria impairment, which impairs the Class A1 designated use of primary contact recreation. Figure 3.2.2 displays both impaired segments. The impairment in both stream segments was established on the basis of high observed levels of indicator bacteria. A TMDL has not been completed for either Lime Creek stream segment.

The 2014 DNR water quality assessment indicates that the downstream segment of Lime Creek (IA 02-CED-0270_1) was assessed as "not supported." The Class A1 designated use based on 2010 and 2011 monitoring data from three sites showed the geometric mean *E. coli* concentrations exceeded the 126 organisms/100 mL standard (Table 3.2.1). The Class B(WW-1) designated use (aquatic life) was assessed as "fully supported" because no samples violated the Class B criteria for dissolved oxygen, pH or temperature during the monitoring period. DNR and State Hygienic Laboratory (SHL) biological surveys resulted in a 2008 fish index of biological integrity (FIBI) score of 69 (good) and benthic macroinvertebrate index of biological integrity (BMIBI) score of 83 (excellent) — similar 2013 surveys resulted in a FIBI score of 78 (excellent) and a BMIBI score of 61 (good). The Class HH designated use (fish consumption) was "not assessed" during the monitoring period prior to the 2014 report. The DNR water quality assessment database records a fish kill in Lime Creek that occurred on July 9, 2008 in a 4.2 mile stream section northeast of Brandon. A DNR investigation did not find a cause and both chemical and biological monitoring indicated suitable aquatic habitat within the stream. See Appendix C for the complete DNR notes on this fish kill.

Table 3.2.1. Annual geometric mean indicator bacteria (*E. coli*) concentrations for three sites along Lime Creek segment IA 02-CED-0270_1 from May 2010 through July 2011. The Class A1 criterion is 126 organisms/100 mL. Iowa's STORET water quality database contains water quality information for sites where water quality samples are collected.

	GEOMETRIC MEAN *E. COLI* CONCENTRATION (ORGANISMS/100 ML)	
STORET STATION	**2010**	**2011**
11100001	1,426	1,874
15100010	1,615	1,322
15100011	1,963	1,819

The 2014 DNR water quality assessment for the upstream Lime Creek segment (IA 02-CED-0270_2) lists the stream Class A1 designated use as "not supported" due to excessive concentrations of *E. coli* bacteria. This stream segment had not been previously assessed, so the bacteria impairment was new in the 2014 reporting cycle. Table 3.2.2 shows 2010 and 2011 monitoring data that reflect indicator bacteria concentrations in excess of the Class A1 threshold. The Class B(WW-2) aquatic life designated use was assessed as "fully supported" on the basis that no 2010 and 2011 samples violated temperature criteria, but 4 percent of samples during the same period failed to meet dissolved oxygen and pH requirements.

Table 3.2.2. Annual geometric mean indicator bacteria (*E. coli*) concentrations for two sites along Lime Creek segment IA 02-CED-0270_2 from May 2010 through July 2011. The Class A1 criterion is 126 organisms/100 mL.

	GEOMETRIC MEAN *E. COLI* CONCENTRATION (ORGANISMS/100 ML)	
STORET STATION	**2010**	**2011**
15100007	637	946
15100008	677	957

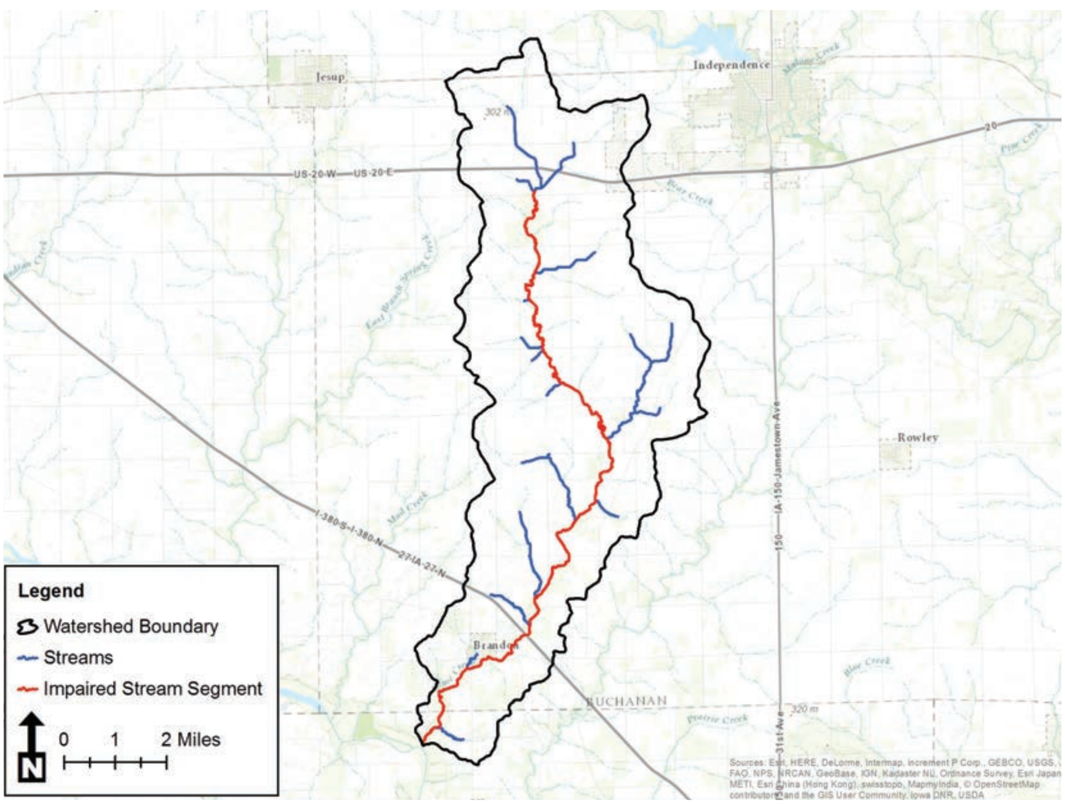


Figure 3.2.2. Both segments of Lime Creek assessed by the Iowa DNR have a bacteria impairment.

Lime Creek has been sampled near the watershed outlet at the Cedar River since 2002, and upstream water sampling sites have been added more recently. Stream site sampling has been led by Coe College. Average stream nitrate concentration at the Lime sampling site near the mouth of Lime Creek from 2002 to 2015 was 11.3 mg/L. Annual variability is high, as reflected by the large range in average stream nitrate concentrations of 5.7 mg/L (2012) to 15.6 mg/L (2015). Numerous sites have been monitored by Coe College, but six sites have highly detailed and consistent data beginning in 2007. These sites (Lime, Lime240, Lime250, Lime290, LimeFin and LimeHam) have exhibited similar average nitrate concentrations with the exception of LimeHam, which had an average 2007 to 2015 nitrate concentration 31 percent higher than the other five sites. Figures 3.2.3 and 3.2.4 show these differences. Coe College also has partnered with farmers in the Lime Creek Watershed to monitor drainage tile outlets. The 2015 average nitrate concentration in tile water from row crop fields was 22.0 mg/L.

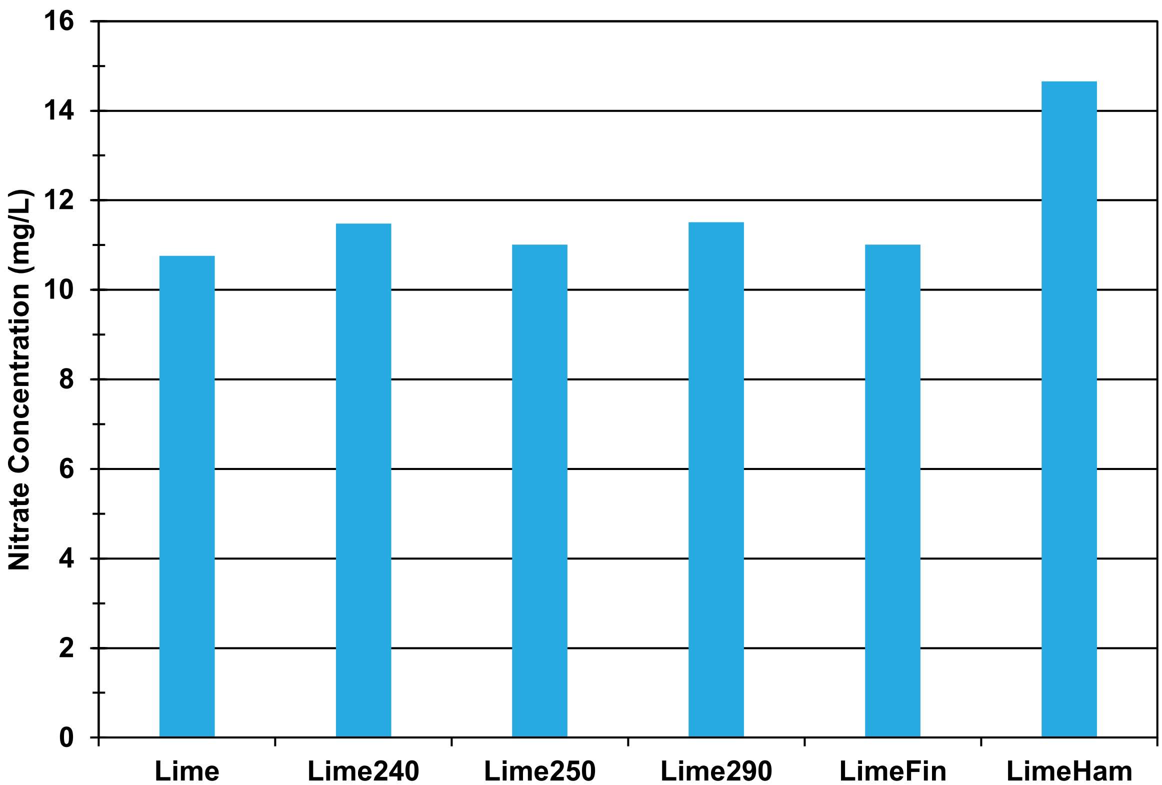


Figure 3.2.3. Average 2007 to 2015 stream nitrate concentration for six Lime Creek monitoring locations.

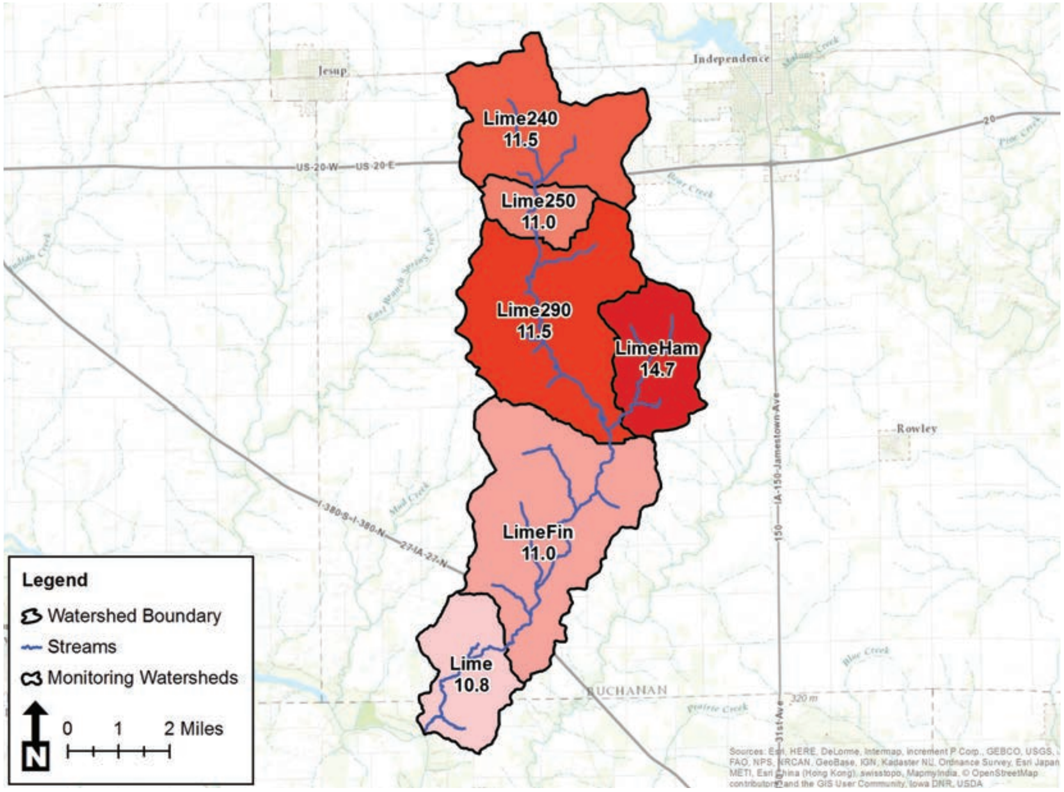


Figure 3.2.4. Spatial distribution of six Lime Creek monitoring sites and average 2007 to 2015 nitrate concentration by site-specific drainage area.

4. GOALS & OBJECTIVES

This watershed management plan will be of little value to real water and soil quality improvement unless watershed improvement activities and best management practices (BMPs) are implemented. This will require active engagement of local stakeholders and collaboration of local, state and federal agricultural and conservation agencies. In addition to the implementation of BMPs, continued water quality monitoring is necessary. Monitoring is a crucial element to assess the status of water quality goals, standards and designated uses; to determine if water quality is improving, degrading or remaining unchanged; and to assess the effectiveness of implementation activities and the possible need for additional BMPs.

This plan is intended to be used by local agencies, watershed managers and citizens for decision-making support and planning purposes. The BMPs listed below represent a suite of tools that will help achieve water quality, soil health, agronomic and quality of life goals if appropriately utilized. It is up to all stakeholders to determine exactly how to best implement them. Locally driven efforts have proven to be the most successful in obtaining real and significant water quality improvements.

The final element of the planning process, which is implementation of the plan, begins after the goals, objectives and action statements have been identified. Plan implementation continues through adherence to the goals, objectives and action statements set forth in this plan. However, it should be emphasized that these items are not "set in stone." While these goals, objectives and action statements have been developed with input from local stakeholders based on the best information available and based on the current needs and opportunities of the watershed, changing needs and desires within the watershed, economy or Farm Bill may mean these items will need to be re-evaluated. This plan must allow for sufficient flexibility to respond to changing needs and conditions, while still providing a strong guiding mechanism for future work.

Through the watershed planning process the following goals addressing water, soil and flood reduction have been identified:

1. **REDUCE IN-STREAM NONPOINT SOURCE NITROGEN LOADS BY 41 PERCENT.** This goal will reach reduction targets for both the nonpoint source goal within the Iowa Nutrient Reduction Strategy (41 percent) and the Cedar River Nitrate TMDL (35 percent).
2. **REDUCE IN-STREAM NONPOINT SOURCE PHOSPHORUS LOADS BY 29 PERCENT.** This goal will reach the nonpoint source goal included in the Iowa Nutrient Reduction Strategy for phosphorus.
3. **REDUCE FLOOD RISK IN LIME CREEK AND DOWNSTREAM.** Practices that simultaneously reduce nutrient loading and improve water retention on the landscape should be emphasized.
4. **MAINTAIN AND IMPROVE AQUATIC HABITAT.** Reducing in-stream sedimentation from upland and streambank erosion will allow for sustained stream habitat integrity.
5. **MAINTAIN AND INCREASE AGRICULTURAL PRODUCTIVITY AND PROFITABILITY.** The Lime Creek Watershed is agricultural, and that economic and social identity should be sustained.

This watershed plan uses the year 2010 as the baseline for conservation practice implementation and determining progress towards reaching set goals by 2030. Watershed models were developed to determine the baseline and future nitrogen, phosphorus and sediment loads plus associated reductions in the Lime Creek Watershed. Table 4.1 provides estimates of watershed loading rates for the 2010 baseline and conditions after the implementation of practices identified in this watershed plan and also provides percent reduction estimates from the 2010 baseline. A practice-based model was used to determine the nitrogen load reductions based on practice efficiencies from the Iowa Nutrient Reduction Strategy Science Assessment. Soil erosion projections were based on Daily Erosion Project data and, together with a Sediment Delivery Model, were used to estimate sediment delivery levels and reductions. A phosphorus enrichment ratio of 1.3 pounds of phosphorus per ton of sediment delivery was used to estimate phosphorus loading.

Table 4.1. Baseline and estimated future total contaminant loading within Lime Creek and expected reductions after watershed plan implementation.

	UNITS	2010 BASELINE	2030 TARGET	MODELED REDUCTION
SHEET & RILL EROSION	tons/year	36,736	22,955	38%
STREAMBANK EROSION	tons/year	671	461	31%
SEDIMENT DELIVERY	tons/year	4,729	2,993	37%
PHOSPHORUS LOAD	pounds/year	6,148	3,891	37%
NITROGEN LOAD	pounds/year	241,010	142,738	41%

5. CONCEPTUAL PLAN

Best management practices are part of the foundation for achieving water quality, soil health and flood reduction goals. BMPs include practices and programs designed to improve water quality and other identified resource concerns, such as changes in land use or management, physical pollutant mitigation structures and changes in social norms and human behavior pertaining to watershed resources along with their perception and valuation. Efforts are made to encourage long-term BMPs, but this is often dependent upon landscape characteristics, land tenure, commodity prices and other market trends that potentially compete with conservation efforts. With this in mind, it is important to identify all possible BMPs needed to achieve the goals of a watershed project. From an initial list of potential practices, priority practices were narrowed down to those most acceptable to watershed stakeholders. Watershed planning facilitators used an effort versus impact exercise to prioritize BMPs which provide the greatest benefit and are the most acceptable to local stakeholders.

When selecting and implementing BMPs, it is important to identify if a particular practice is feasible in a given location. Site feature suitability and practice alignment with stakeholder values should be considered. It also is important to determine how effective the practice will be at achieving goals, objectives and targets. Table 5.1 provides a list of BMPs identified by watershed stakeholders. BMPs in bold font show those practices included in the conceptual plan. Included in Table 5.1 is a rating of each practice's efficacy to address identified water and soil goals. While only the practices in bold are included in the conceptual plan and nutrient reduction calculations, the other practices will be important to consider when making decisions about water and soil improvement. Figure 5.1 provides a map of a conceptual BMP implementation scenario that sites BMPs in locations intended to achieve maximum benefit (e.g. nitrate removal wetlands placed at strategic locations or bioreactors placed at drainage tile outlets). See Appendix I for a larger map of the conceptual plan.

Table 5.1. Best management practices (3 = high impact, 2 = moderate impact, 1 = low impact, 0 = no impact).

	PRACTICE	WATER QUALITY: NITROGEN	WATER QUALITY: PHOSPHORUS	SOIL HEALTH	WATER QUANTITY (FLOOD REDUCTION)
IN-FIELD	**Perennial Cover (including CRP)**	**3**	**3**	**3**	**3**
	Cover Crops	**3**	**3**	**3**	**1**
	No-Till/Strip-Till	**0**	**3**	**3**	**1**
	Grassed Waterways	0	2	1	1
	4R Nutrient Management	**1**	**1**	**1**	**0**
	Drainage Water Management	3	0	0	2
	Nitrification Inhibitor	**1**	**0**	**0**	**0**
EDGE-OF-FIELD	Stream Buffers	1	3	0	1
	Bioreactors	**3**	**1**	**0**	**0**
	Saturated Buffers	**3**	**0**	**0**	**0**
IN-STREAM	Ponds	1	3	0	3
	Nitrate Removal Wetlands (CREP)	**3**	**1**	**0**	**2**
	Streambank Stabilization	**0**	**2**	**0**	**0**

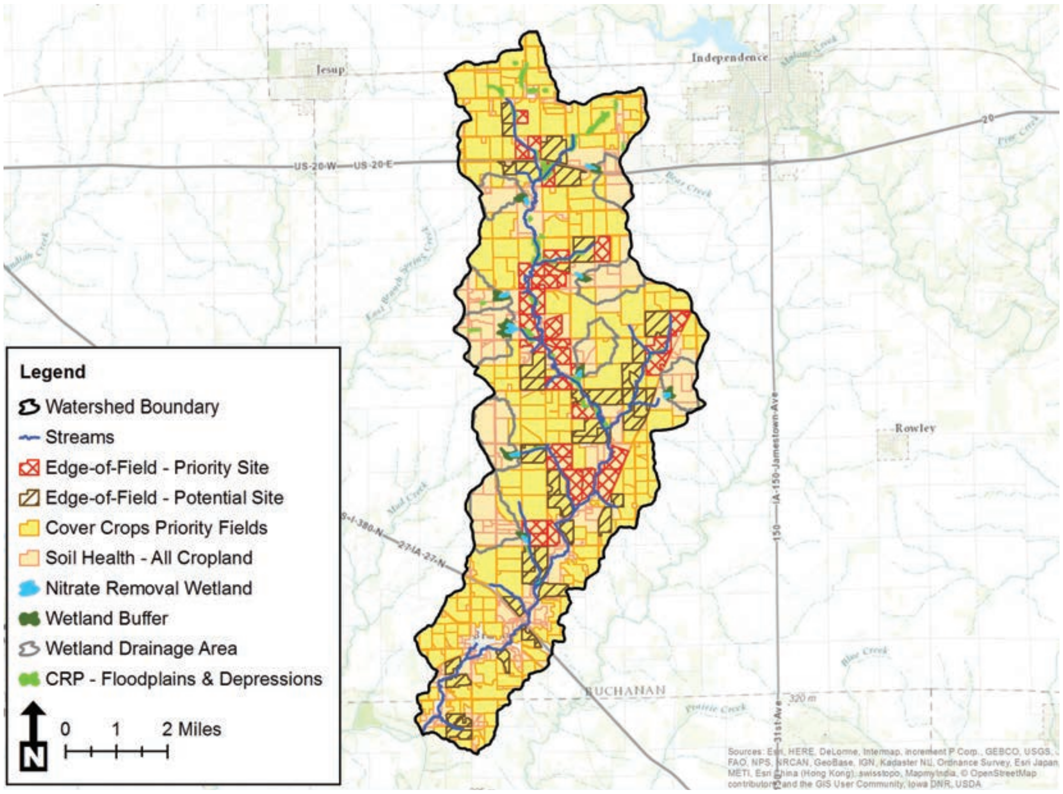


Figure 5.1. Conceptual plan for BMP implementation in the Lime Creek Watershed.

The BMP conceptual plan presented in Figure 5.1 is ambitious, but this level of implementation is needed to achieve the goals identified in this watershed management plan. This scenario is one of many potential combinations of BMPs that would allow for this plan's goals to be reached. Deviations from the proposed implementation plan should be made with the knowledge that additional practices may then be needed in other locations within the watershed to ensure that goals are met. For example, cover crops grown within a wetland drainage area may not result in the same downstream water quality benefit as cover crops grown downstream of a wetland.

A team of USDA-Agricultural Research Service scientists have developed the Agricultural Conservation Planning Framework (ACPF) to facilitate the selection and implementation of conservation practices in watersheds with predominately agricultural land use (Tomer et al., 2013). The ACPF outlines an approach for conservation-oriented watershed management. The framework can conceptually be considered as a pyramid. This "conservation pyramid" is built on a foundation of soil health. The cover crop area delineated in Figure 5.1 has been identified for maximum water quality improvement potential at the outlet of the Lime Creek Watershed, but such practices that build soil health will result in additional benefits including erosion control, water retention and flood reduction, increased soil organic matter and improved nutrient cycling. Therefore management practices that improve soil health like cover cropping and reducing tillage should be promoted and implemented on all cropland within the Lime Creek Watershed. According to the "conservation pyramid" concept, structural practices to control and treat water should then be targeted to specific in-field, edge-of-field and in-stream locations where maximum water quality benefits can be realized. The ACPF includes a mapping toolbox to identify potential locations for conservation practice adoption. Appendix J contains detailed results of applying these siting tools to the Lime Creek Watershed.

The practices proposed in this conceptual plan were selected primarily for their water quality, water quantity and soil health impacts (Table 5.1). The recommended practices will mitigate some risk of bacteria transport to Lime Creek and its tributaries, but additional practices should be adopted where applicable in order to address the bacteria impairment in Lime Creek. Such practices include adhering to manure management plans, maintaining manure applicator certifications, using setback distances for manure application, updating septic systems, constructing monoslope buildings for livestock, maintaining or planting stream buffers, constructing stream crossings for cattle and taking precautions to avoid over-application of manure or equipment failure. Together with the practices listed in Table 6.1, these practices will reduce both nutrient and bacteria loads in Lime Creek.

6. IMPLEMENTATION SCHEDULE

Implementation schedules are intended to serve as a reference tool to recognize tasks scheduled for the upcoming year and to focus the necessary resources for the current phase of the project. The implementation schedule should be adaptable and updated on a regular basis due to shifting priorities, new opportunities and unexpected delays.

The following 15-year phased implementation schedule was approved by watershed stakeholders and should be used to set yearly goals and gauge progress. It should be noted, practices included in the implementation table only include those identified to reach the watershed plan goals. Other practices such as drainage water management, structural runoff control (e.g. grassed waterways, terraces, contour filter strips), oxbow restoration and stream buffers should be promoted whenever appropriate.

Perennial cover, such as CRP, should be targeted to locations on the landscape with maximum potential to improve water quality. For example, the Science-based Trials of Rowcrops Integrated with Prairie Strips (STRIPS) project has demonstrated the effectiveness of such targeted conservation. In addition to nutrient removal, fields with strategic portions in perennial cover may provide other ecosystem services such as wildlife and pollinator habitat.

	PRACTICE	UNIT	EXISTING	2016-2020 GOAL	2021-2025 GOAL	2026-2030 GOAL	TOTAL 2030 GOAL
SOIL HEALTH	No-Till/Strip-Till	acres	Unknown	Maximum acres possible			
	Nutrient Management (MRTN)	acres	Unknown	3,000	4,000	3,000	10,000
	Nitrification Inhibitor	acres	Unknown	2,000	2,000	1,000	5,000
	Cover Crops	acres	Unknown	4,000	6,000	5,000	15,000
	Perennial Cover (CRP)	acres	290	380	200	-	870
IN-FIELD	Grassed Waterways	feet	345,708	Where necessary			
	Terraces	feet	40,114	Where necessary			
EDGE-OF-FIELD	Stream Buffers	percent	74%	Remaining 26% of streams			
	Bioreactors	structures	1	2	3	4	10
	Saturated Buffers	structures	0	4	6	5	15
IN-STREAM	Nitrate Removal Wetlands	sites	0	2	3	4	9
	Streambank Stabilization	feet	Unknown	260	400	-	660

Table 6.1. Targeted implementation schedule.

7. MONITORING PLAN

Monitoring is an essential component of watershed plan implementation and provides an opportunity to assess progress. Monitoring can come in many different forms including water monitoring, biological surveys, soil and plant tissue sampling as well as social assessments. This section describes recommendations for future monitoring actions to document improvements resulting from watershed plan implementation.

7.1. Stream Monitoring

Perhaps the most important monitoring activity is stream sampling due to the charge laid out in the Iowa Nutrient Reduciton Strategy to reduce nutrient loading in Iowa's rivers. Figure 7.1.1 displays sites where water samples have been collected for various stream monitoring efforts.

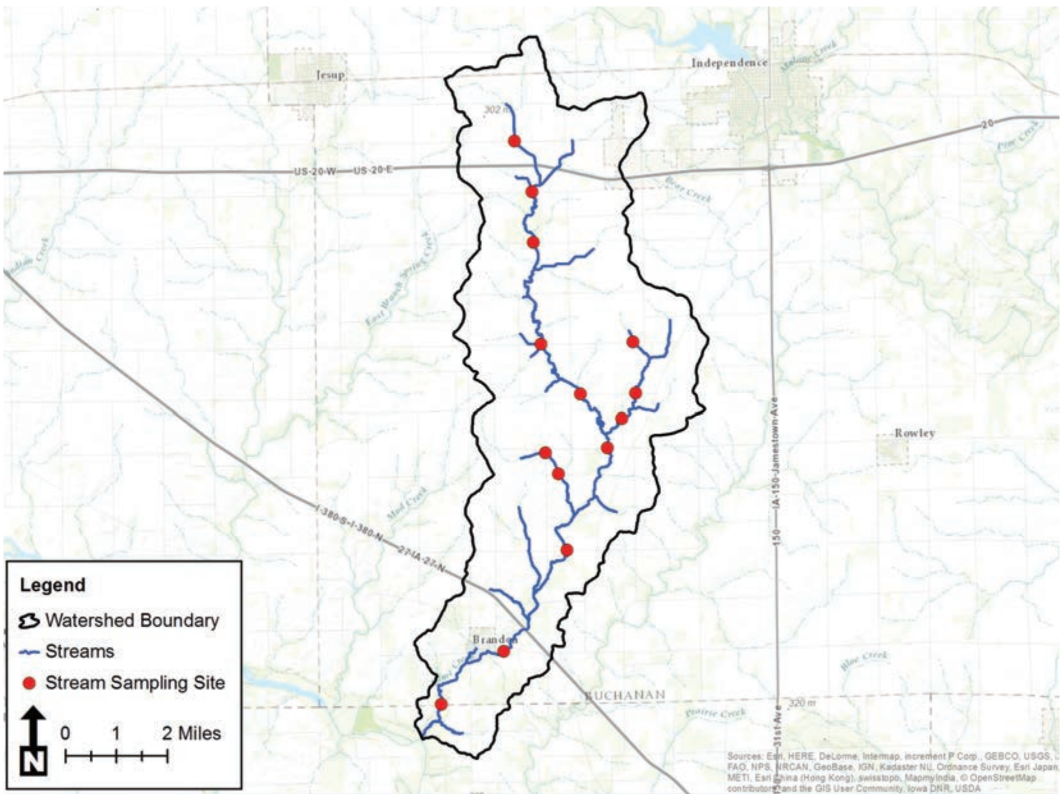


Figure 7.1.1. Previously and currently sampled stream monitoring locations in the Lime Creek Watershed.

Many stream sites have been visited for water sampling in Lime Creek, but the six locations listed in Table 7.1.1 have detailed and consistent data for 2007 through 2015. While sampling additional sites would provide more information, water sampling should continue long-term at these six locations to document changes in water quality throughout the different phases of watershed plan implementation. This site network will allow for consistent water quality information to be gathered throughout the entire watershed. Ideally, bi-weekly samples should be collected beginning in April and extending through October. The samples should be analyzed for nitrate, phosphorus and sediment.

Table 7.1.1. Location of six Lime Creek stream monitoring sites with detailed recent records (Figure 7.1.1).

SITE	LATITUDE °N	LONGITUDE °W
Lime	42.297575	-92.018089
LimeFin	42.312444	-91.994000
Lime290	42.369878	-91.953492
LimeHam	42.378103	-91.947756
Lime250	42.428294	-91.980839
Lime240	42.442697	-91.981206

In addition to water grab sampling, stream discharge also should be recorded in order to determine nitrogen, phosphorus and sediment loading. One method to capture stream discharge is to measure the stream stage and use a hydrograph to calculate discharge. The U.S. Geological Survey Water Science School provides an overview of this process. At a minimum, streamflow should be captured at site Lime near the watershed outlet into the Cedar River.

Other existing water sampling programs offer additional data sources or opportunities to document water quality in the Lime Creek Watershed. The Iowa STORET database maintained by the DNR contains water physical, chemical, biological and habitat data. The DNR's ADBNet database documents Iowa's water quality assessments for Clean Water Act section 305(b) reporting. Volunteer water quality monitoring such as IOWATER also can be important sources of information, especially to yield a detailed, one-time "snapshot" of water quality. The Iowa Water Quality Information System (IWQIS) provides real-time water quality data. IWQIS sensor WQS0027 is located at site Lime from Table 7.1.1.

7.2. Biological Monitoring

The biological community of a stream reflects its overall health along with chemical and physical water quality. Surveys of benthic macroinvertebrate species in streams are excellent biological indicators of water quality, where more diverse communities and presence of sensitive species reflect good quality streams. The IOWATER program provides protocols and recommendations for assessing the stream biological community in its Biological Monitoring Manual. Fish surveys also could be conducted to provide further indication of water quality, particularly if habitat improvement projects, such as oxbow restoration or streambank stabilzation and shading, are implemented. Existing biological monitoring data are stored in the DNR BioNet database.

7.3. Field Scale Water Monitoring

In addition to monitoring streams and tributaries in the Lime Creek Watershed, water quality monitoring at finer scales should be conducted to assess the effectiveness of individual conservation practice installations. Water samples at this scale should be collected from either tile water exiting subsurface drainage systems or surface runoff from a targeted area. Monitoring surface runoff is extremely difficult because runoff events are episodic and often missed via regularly scheduled monitoring programs. Tile water monitoring is easier because tiles tend to flow more consistently. However, monitoring tile water may only provide data on nitrate loss as the majority of phosphorus and sediment loss occurs via surface runoff.

Tile monitoring should be targeted to drainage systems that drain a single field to allow for changes in management practices to be isolated and detectable. Tile outlets that are easily accessible and provide the opportunity to capture sufficient tile flow should be selected for monitoring. Flow volume from tiles can be calculated by measuring the time needed to fill a container of known volume or by using flow sensors such as pressure transducers. Tile flow along with nutrient concentrations can be used to calculate loading at a tile outlet.

7.4. Soil Sampling

Agricultural soils contain many nutrients, especially where fertilizer or manure have been applied. Soil samples should be analyzed for phosphorus, potassium, nitrogen and organic matter (which affects nutrient cycling) at a minimum. Improved soil fertility data will better inform nutrient management, which can result in the multiple benefit scenario of increased profitability and decreased nutrient export due to precise nutrient application. Additionally, collection of soil samples in coordination with field scale water monitoring could improve understanding of the relationship between nutrient management practices, soil fertility and health and water quality. Soil samples should be collected for multiple years, particularly if agronomic management practices are altered or conservation practices, such as cover crops, are implemented. In-season soil nitrate testing can be used to inform adaptive nutrient management practices with the goals of improving agronomic production and reducing nutrient losses. Tests to measure soil health and biological activity also should be utilized to quantify additional benefits of management practices that build soil health like no-till and cover crops.

7.5. Plant Tissue Sampling

The end-of-season corn stalk nitrate test is a tool used to evaluate the availability of nitrogen to the corn crop. Nitrate concentrations measured from stalk sections for the lower portion of a corn plant taken after the plant reaches maturity are indicative of nitrogen availability to the plant. The corn plant will move available nitrogen to the grain first. By measuring the amount of nitrogen left after grain fill, a determination can be made as to how much nitrogen was left in the plant relative to what was needed for optimal grain yield. This is a very basic and easy management evaluation tool. It should be noted the test is a point in time and producers should collect samples over multiple years to account for weather and seasonal variations before adopting wide scale change.

7.6. Social Surveys

Biophysical assessments are useful benchmarks of natural resource quality, but conservation practices only will be adopted and implemented in the Lime Creek Watershed if local stakeholders recognize and value how such BMPs align within the contexts of both individual farming operations and broader watershed goals. Surveys are one tool that should be used to periodically assess awareness and attitudes regarding the general issue of water quality and the goals of this watershed plan. For example, a detailed survey could be conducted during each 5-year phase of the implementation schedule (Table 6.1). Surveys also could be paired with specific educational events like field days to assess the effectiveness of different outreach formats, which could improve information and education strategies as the project proceeds.

8. INFORMATION & EDUCATION PLAN

Producers' behavior patterns must be considered in both BMP design and implementation strategies for water quality projects. To affect changes in behavior, there must be strategies in place to direct education and outreach to the target audience. Many obstacles to the adoption of conservation practices may be overcome by providing adequate education and outreach of how land management practices influence nonpoint source pollutant losses to surface water resources. Knowledge increases awareness, which may then motivate changes in behavior.

As with any watershed project, an education, communication and outreach program will need to be designed to teach producers and other stakeholders about the resource issues within the Lime Creek Watershed. The anticipated outcome of this education and outreach is to bring stakeholders' attention to the impact their land use and management decisions might make, how they can effectively address those impacts and what opportunities and innovative solutions exist. Table 8.1 summarizes an information and education strategy, and the following tables list potential partners and outreach tools.

Table 8.1. Components of the information and education plan.

GOAL	Increase awareness and adoption of practices to achieve watershed land and water goals.
TARGET AUDIENCE	Watershed community, including farmers, local and absentee landowners, residents, educators, students and others.
MESSAGE	Surveys have indicated most farmers and landowners have a sense of shared responsibility, simultaneously value individualism and personal responsibility plus have concern for future generations. Outreach should attempt to capture these beliefs and promote watershed goals. For example, "Be a part of the cover crop and soil health movement, do your share to protect land and water for the future."

Table 8.2. Key partners, contacts and local media.

PROJECT PARTNERS	Soil and Water Conservation District Commissioners Buchanan County Conservation Board Natural Resources Conservation Service Iowa Department of Agriculture and Land Stewardship Iowa Department of Natural Resources Agribusinesses and farm cooperatives
LOCAL AGRICULTURE AND OUTDOOR GROUPS	4-H FFA Farm Bureau Pheasants Forever Ducks Unlimited
NEWSPAPERS	Waterloo Courier Independence Bulletin-Journal Independence The News/Buchanan County Review Jesup Citizen-Herald La Porte City Progress-Review
RADIO STATIONS	KQMG 95.3 FM Independence

Table 8.3. Outreach strategies and tools.

Branding development (e.g. logo)	Stream signs
Website and social media	Conservation practice signs
Fact sheets	IOWATER volunteer workshops
Direct mailings	Youth outdoor learning opportunities
Conservation demonstration field days	Urban-Ag learning exchanges
Watershed boundary signs	Stream clean-up events

9. EVALUATION

Evaluating project success or failure is a critically important step in implementing any watershed plan. This section lays out a self-evaluation process for project partners to gauge project progress in four categories: 1) project administration, 2) attitudes and awareness, 3) performance and 4) results. These four indicator categories are described in the following sections. A project evaluation worksheet can be found in Appendix D.

9.1. Project Administration

- **YEARLY PARTNER REVIEW MEETING.** Watershed project partners should host an annual review meeting. This will provide an opportunity to evaluate project progress using the evaluation matrix.

- **QUARTERLY PROJECT PARTNER UPDATE.** Each quarter, project leadership should ensure project goals and objectives are being accomplished, plan logistics and coordinate field days, events and monitoring.

9.2 Attitudes & Awareness

- **FARMER AND LANDOWNER SURVEYS.** Periodically a survey should be conducted with a statistically valid sample of farmers and landowners in the watershed. Results of the surveys should be used to determine changes in attitudes and behaviors.

- **FIELD DAY ATTENDANCE.** Field days are an important outreach component of watershed projects. To gauge the impact of the field days, a short survey should be administered at the conclusion of each field day. The goal of the surveys will be to determine if understanding or attitudes were changed as a result of the field day events.

- **REGIONAL AND STATEWIDE MEDIA AWARENESS.** Media awareness and promotion of the project should be tracked by collecting and cataloging all articles and stories related to the watershed project.

9.3. Performance

- **PRACTICE ADOPTION LEVELS.** Locations of implemented practices should be tracked over the life of the project. Practice adoption rates will be aggregated to the watershed scale and reported to partners.

- **PRACTICE RETENTION.** Retention of management practices, such as cover crops, should be emphasized. Yearly follow-up with farmers implementing practices will help gauge practice retention trends.

9.4. Results

- **PRACTICE SCALE MONITORING.** Tile water or edge-of-field monitoring results should be used to gauge water quality improvements at the field scale. Individual results should be provided to farmer participants. All monitoring data should be aggregated to the watershed scale and shared with other famers, landowners and partners. This aggregated data also may be used in a publication to bring broader recognition to these and other Iowa water quality efforts.

- **STREAM SCALE MONITORING.** In-stream water monitoring sites should be used to determine if long-term water quality improvements are being realized. Year to year improvements will likely be undetectable but long-term progress — 10 years or more — may be evident if significant practice adoption takes place in the watershed.
- **SOIL AND AGRONOMIC ANALYSIS.** Scientifically valid methods should be used to determine soil and agronomic impacts of practice adoption. These results will be shared with farmer participants. All soil and agronomic results should be aggregated to the watershed scale and shared with other farmers, landowners and partners.
- **MODELED IMPROVEMENTS.** The project should work with appropriate groups or individuals to estimate soil and water improvements resulting from practice implementation. Appendix E can be used to estimate nitrate reduction based on BMP implementation.

10. ESTIMATED RESOURCE NEEDS

An estimate of resource needs is crucial to gain support from potential funding sources. Table 10.1 provides an estimate of the total cost to implement conservation practices identified in this plan. Some practices, such as nutrient management and cover crops, may result in cost savings to farmers and landowners. Therefore cost-share and/or incentive payment rates may need to be evaluated during the implementation phase of this plan.

Table 10.1. Estimated resource needs to reach the Lime Creek Watershed Plan targets.

	PRACTICE	TOTAL 2030 GOAL	UNIT	COST PER UNIT	TOTAL COST
SOIL HEALTH	No-Till/Strip-Till	All cropland	acres	-	As needed
	Nutrient Management (MRTN)	10,000	acres	-$8.75	-$87,500.00
	Nitrification Inhibitor	5,000	acres	$12.00	$60,000.00
	Cover Crops	15,000	acres	$50.00	$750,000.00
	Perennial Cover (CRP)	870	acres	$267.61	$232,820.70
IN-FIELD	Grassed Waterways	Where necessary	feet	-	As needed
	Terraces	Where necessary	feet	-	As needed
EDGE-OF-FIELD	Stream Buffers	Remaining 26%	percent	-	As needed
	Bioreactors	10	structures	$16,550.00	$165,500.00
	Saturated Buffers	15	structures	$2,392.00	$35,880.00
IN-STREAM	Nitrate Removal Wetlands	9	sites	$230,000.00	$2,070,000.00
	Streambank Stabilization	660	feet	$9.52	$6,283.20

Cost estimates are based on Environmental Quality Incentives Program (EQIP) 2016 cost-share rates and practice standards for bioreactors, saturated buffers and streambank stabilization. Nitrate removal wetland costs were estimated from Iowa Conservation Reserve Enhancement Program (CREP) program data. Nitrification inhibitor costs reflect commercial prices for nitrapyrin. Maximum return to nitrogen (MRTN), a nitrogen management approach based on the economic optimum rate, can result in decreased fertilizer application and therefore a net economic benefit (negative cost). Cover crop costs include seed, labor and termination cost estimates from Iowa State University Extension and Outreach Ag Decision Maker tools. The estimated Conservation Reserve Program (CRP) cost is the average soil rental rate for Buchanan County.

The investment needed to construct all proposed structural practices (bioreactors, saturated buffers, streambank stabilization and wetlands) is estimated at **$2,277,663.20**. Annual investments are necessary to continue adoption and implementation of management practices (cover crops, nutrient management, nitrification inhibitors and potentially reduced tillage). The estimated yearly total for management practices is **$955,320.70**. Cost-share payments may not be permanently available, so alternative funding sources for management practices may need to be pursued or developed. The dollars necessary to fund structural and management practices could come from many different sources, including farmers and landowners, downstream municipalities, other local or regional stakeholders as well as conservation organizations.

Additional costs associated with watershed improvement such as salary and benefits for a watershed coordinator, information and education activities, monitoring, office space, computer, phone and vehicle are estimated at **$85,000.00** per year.

11. FUNDING OPPORTUNITIES & APPROACHES

To achieve the goals of this watershed plan, significant resources will be needed. Current funding mechanisms provided by local, state and federal units of government may not be adequate to address all goals outlined in this plan, so other creative and/or sustainable approaches will be needed. Appendix F provides a listing of current local, state and federal programs and grants that may be able to provide resources for plan implementation. The list below provides some ideas to leverage additional "nontraditional" resources. Further research is needed to determine feasibility.

- **LOCALLY ORGANIZED COVER CROP SEEDING PROGRAMS.** Farmers and landowners are often busy with harvest during the prime cover crop seeding time period. To simplify cover crop adoption, cover crop seeding programs could be developed at the Soil and Water Conservation District (SWCD), County Conservation Board or local farm cooperatives. Seeding programs have been established in Allamakee and Sac SWCDs, and these programs have resulted in a simplified process for farmers and expanded cover crop adoption.

- **LOCAL COVER CROP SEED PRODUCTION.** Access to and cost of cover crop seed will likely become problematic as adoption of cover crops increases in Iowa and the Upper Mississippi Basin. A solution to this problem is to promote local production of cover crop seed, such as cereal rye. Typical yield of rye is 30 to 50 bushels per acre, so a seeding rate of 1.5 bushels per acre means that every acre of rye grown for seed would allow a rye cover crop to be planted on 20 to 33 acres of row crop land. To avoid taking productive land out of corn and soybean production, rye plantings could be targeted to marginal soils or lands.

- **PROPERTY OR INCOME TAX DEDUCTIONS.** Currently, some income tax deductions are available to landowners implementing soil and water conservation programs. More details can be found in the publication Implications of Soil and Water Conservation Programs. Additional local property tax deductions could be developed that promote the adoption of cover crops and other conservation practices.

- **CONSERVATION ADDENDUM TO AGRICULTURAL LEASES.** More than half of Iowa's farmland is cash rented or crop shared, and an increase in this trend presents issues for ensuring proper conservation measures are in place on Iowa farms. Conservation addendums may be a way to ensure both the landowner and the tenant agree on conservation. Addendums could include any conservation measure, but the practices included in this plan would be of most benefit. A standard conservation addendum could be developed and shared with all absentee landowners in the Lime Creek Watershed.

- **CONSERVATION EASEMENT PROGRAMS.** Land easements have proven successful in preservation of conservation and recreation land in Iowa (e.g. Iowa Natural Heritage Foundation, Wetland Reserve Enhancement Program, etc.). Some landowners may be interested in protecting sensitive land for extended periods of time or into perpetuity. For these landowners, long-term conservation easements may be a good fit.

- **NONTRADITIONAL WATERSHED PARTNERS.** Traditional watershed partners (e.g. IDALS, DNR, SWCD and NRCS) likely will not have the financial resources to fully implement this plan, so local project partners should seek nontraditional partners to assist with project promotion and funding. Involvement could be in the form of cash or in-kind donations.
- **NUTRIENT OR FLOOD REDUCTION TRADING.** Water quality trading programs are market-based programs involving the exchange of pollutant allocations between sources within a watershed. The most common form of trading occurs when trading nutrient credits between point and nonpoint sources. Trading programs could be established to trade nutrient or flood impact credits.
- **RECREATIONAL LEASES.** Recreational leases, such as hunting leases, may be promoted as a tool to increase landowner revenue generated from conservation lands, such as wetlands or grasslands.
- **EQUIPMENT RENTAL PROGRAMS.** Farmers are often hesitant to invest in new conservation technologies that require new equipment or implements. Project partners could invest in conservation equipment, such as a strip-till bar or cover crop drill, and then rent the equipment to interested farmers.
- **REVERSE AUCTIONS.** Reverse auctions, or pay for performance programs, can be a cost-effective way to allocate conservation funding. In some watersheds where reverse auctions have been used, the environmental benefits per dollar spent have been significantly more efficient than traditional programs such as EQIP. In a reverse auction, landowners or farmers compete to provide a service (or conservation practice) to a single buyer (e.g. SWCD). All bids are analyzed for their environmental benefits and the organizer (e.g. SWCD) begins providing funds to the most efficient bids (environmental benefit per dollar).
- **WATERSHED ORGANIZATION.** Often the most successful watershed projects are led by formal watershed organizations. Groups can be formed via a nonprofit organization, 28E intergovernmental agreement, Watershed Management Authority or other agreement or organization. Most watershed projects have significant partner involvement, each with an existing mission or goal. A watershed organization with a mission to improve land and water quality in the Lime Creek Watershed may prove to be more successful than existing groups working together without formal organization. The Lime Creek Watershed Improvement Association has led successful projects in the past. The Lime Creek Watershed Improvement Association should schedule regular meetings to evaluate progress, strategize and set specific work plans to ensure progress is made towards the 2030 watershed plan goals.
- **SUBFIELD PROFIT ANALYSIS.** Farmers understand some locations within a field produce higher yields and profits, so understanding the distribution of long-term profitability within fields may be an important selling point for conservation. Private companies in Iowa are developing tools to analyze profitability within crop fields. Incorporating profitability analysis into conservation planning could result in higher profit margins and increased conservation opportunities on land that consistently yields zero or lost revenue.

12. ROLES & RESPONSIBILITIES

ROLE	RESPONSIBILITY
Farmers	Engage with watershed plan implementation, farm, field and subfield evaluation, conservation practice implementation and knowledge sharing.
Landowners	Engage with tenants on conservation practices, incorporation of conservation addendums to lease agreements and conservation practice implementation.
Lime Creek Watershed Improvement Association	Provide project leadership, engage farmers and landowners, build watershed community and evaluate progress.
Natural Resources Conservation Service	Provide conservation practice design and engineering services, project partnership, house project staff as well as provide computer and office space.
Soil and Water Conservation District Commissioners	Provide project leadership, participate in project meetings and events, hire staff, advocate for project goals plus promote project locally and regionally.
County Conservation Board	Provide project partnership, easement management and public education.
Iowa Department of Natural Resources	Provide in-stream monitoring of biological community (fish, macroinvertebrates), project partnership and technical advice.
Iowa Department of Agriculture and Land Stewardship	Provide technical support to project, provide the opportunity to receive state funding for soil and water conservation plus provide a contact for the Iowa CREP program.
County Supervisors	Engage with project to determine mutual benefits.
Agribusiness	Engage project partners and promote project goals to members and/or customers.
Commodity Groups	Engage project partners, promote project goals to members and/or customers and provide agronomic and environmental services when appropriate.
Conservation Groups	Engage project partners, provide habitat-planning services as well as promote practices that have habitat and water quality benefits.
Media	Develop and distribute news stories related to project activities and/or goals plus attend project events.

APPENDIX A

Glossary of Terms & Acronyms

303(D) LIST	Refers to section 303(d) of the Federal Clean Water Act, which requires a listing of all public surface water bodies (creeks, rivers, wetlands and lakes) that do not support their general and/or designated uses. Also called the state's "Impaired Waters List."
305(B) ASSESSMENT	Refers to section 305(b) of the Federal Clean Water Act. A comprehensive assessment of the state's public water bodies' ability to support their general and designated uses. Those bodies of water which are found to be not supporting or just partially supporting their uses are placed on the 303(d) list.
319	Refers to Section 319 of the Federal Clean Water Act, the Nonpoint Source Management Program. Under this amendment, states receive grant money from EPA to provide technical and financial assistance, education and monitoring to implement local nonpoint source water quality projects.
ACPF	Agricultural Conservation Planning Framework. Software toolbox that allows watershed planners and stakeholders to identify on-farm conservation options using soils, land use and topographic data.
AFO	Animal Feeding Operation. A livestock operation, either open or confined, where animals are kept in small areas (unlike pastures) allowing manure and feed to become concentrated.
BASE FLOW	The fraction of discharge (flow) in a river that comes from ground water.
BENTHIC	Of or relating to or happening on the bottom under a body of water.
BMIBI	Benthic Macroinvertebrate Index of Biotic Integrity. An index-based scoring method for assessing the biological health of streams and rivers (scale of 0-100) based on characteristics of bottom-dwelling invertebrates.
BMP	Best Management Practice. A general term for any structural or upland soil or water conservation practice. For example, terraces, grass waterways, sediment retention ponds, reduced tillage systems, etc.
CAFO	Confinement Animal Feeding Operation. An animal feeding operation in which livestock are confined and totally covered by a roof, and not allowed to discharge manure to a water of the state.
CREP	Conservation Reserve Enhancement Program. Farm Service Agency (FSA) program that targets high-priority conservation issues by paying annual rent to producers to remove agricultural land from production. Iowa CREP focuses on wetland restorations in heavily tile-drained portions of the state.

CRP — Conservation Reserve Program. Farm Service Agency (FSA) program in which farmers receive annual rental payments to remove environmentally sensitive land from production by planting perennial species.

CSR — Corn Suitability Rating. Index developed by Iowa State University to rate the productivity of a given soil based primarily on its profile properties.

DESIGNATED USE(S) — Refer to the type of economic, social or ecologic activities a specific water body is intended to support. See Appendix B for a description of all general and designated uses.

DNR (OR IDNR) — Iowa Department of Natural Resources.

ECOREGION — A system used to classify geographic areas based on similar physical characteristics such as soils and geologic material, terrain and drainage features.

EPA (OR USEPA) — United States Environmental Protection Agency.

EQIP — Environmental Quality Incentives Program. Natural Resources Conservation Service (NRCS) program that provides financial and technical assistance to farmers to address natural resource concerns.

FIBI — Fish Index of Biotic Integrity. An index-based scoring method for assessing the biological health of streams and rivers (scale of 0-100) based on characteristics of fish species.

FSA — Farm Service Agency (United States Department of Agriculture). Federal agency responsible for implementing farm policy, commodity and conservation programs.

GENERAL USE(S) — Refer to narrative water quality criteria that all public water bodies must meet to satisfy public needs and expectations. See Appendix B for a description of all general and designated uses.

GIS — Geographic Information System(s). A collection of map-based data and tools for creating, managing and analyzing spatial information.

GLO — General Land Office. Federal agency that conducted first survey of public lands in Iowa. Later dissolved into the United States Department of the Interior Bureau of Land Management.

GULLY EROSION — Soil movement (loss) that occurs in defined upland channels and ravines that are typically too wide and deep to fill in with traditional tillage methods.

HEL — Highly Erodible Land. Defined by the USDA Natural Resources Conservation Service (NRCS) as land that has the potential for long term annual soil losses to exceed the tolerable amount by eight times or more for a given agricultural field.

HUC — Hydrologic Unit Code. A unique watershed identification number with two to twelve digits, where more digits correspond to a more precise (smaller) watershed.

IDALS Iowa Department of Agriculture and Land Stewardship. IDALS includes the Division of Soil Conservation & Water Quality (DSCWQ).

INTEGRATED REPORT Refers to a comprehensive document that combines the 305(b) assessment with the 303(d) list, as well as narratives and discussion of overall water quality trends in the state's public water bodies. The Iowa Department of Natural Resources submits an integrated report to the EPA biennially in even numbered years.

LA Load Allocation. The fraction of the total pollutant load of a water body which is assigned to all combined nonpoint sources in a watershed. (The total pollutant load is the sum of load allocation and waste load allocation.)

LIDAR Light Detection and Ranging. Remote sensing technology commonly used to measure topography or elevation.

LOAD The total amount (mass) of a particular pollutant in a waterbody.

MLRA Major Land Resource Area. Geographic area identified by the Natural Resources Conservation Service (NRCS) to have similar soils, climate, water resources and land use.

MOS Margin of Safety. In a total maximum daily load (TMDL) report, it is a set-aside amount of a pollutant load to allow for any uncertainties in the data or modeling.

NONPOINT SOURCE POLLUTION A collective term for contaminants that originate from a diffuse source.

NPDES National Pollution Discharge Elimination System. Allows a facility (e.g. an industry or a wastewater treatment plant) to discharge to a water of the United States under regulated conditions.

NRCS Natural Resources Conservation Service (United States Department of Agriculture). Federal agency that provides technical assistance for the conservation and enhancement of natural resources.

NUTRIENT REDUCTION STRATEGY Science-based approach developed by Iowa Department of Natural Resources, Iowa Department of Agriculture and Land Stewardship and Iowa State University College of Agriculture and Life Sciences to establish baseline conditions, needed goals and potential practices to reduce nutrient export to surface waters from point and nonpoint source pollution.

NWI National Wetlands Inventory. Mapping and classification of wetlands by the United States Fish and Wildlife Service based on aerial imagery. May exclude some farmed wetlands.

PHYTOPLANKTON A collective term for all self-feeding (photosynthetic) organisms that provide the basis for the aquatic food chain. Includes many types of algae and cyanobacteria.

POINT SOURCE POLLUTION A collective term for contaminants that originate from a specific point, such as an outfall pipe. Point sources are generally regulated by an NPDES permit.

PPB Parts per Billion. A measure of concentration approximately equal to micrograms per liter (µg/L).

PPM Parts per Million. A measure of concentration approximately equal to milligrams per liter (mg/L).

RCPP Regional Conservation Partnership Program. Natural Resources Conservation Service (NRCS) program that promotes formation of partnerships to facilitate conservation practice implementation. Each partner within a project must make a significant cash or in-kind contribution.

RIPARIAN Refers to site conditions that occur near water, including specific physical, chemical and biological characteristics that differ from upland (dry) sites.

RUSLE Revised Universal Soil Loss Equation. An empirical model for estimating long term, average annual soil losses due to sheet and rill erosion.

SECCHI DISK A device used to measure transparency in water bodies. The greater the secchi depth (measured in meters), the more transparent the water.

SEDIMENT DELIVERY RATIO A value, expressed as a percent, which is used to describe the fraction of gross soil erosion that is ultimately delivered to a water body of concern.

SESTON All particulate matter (organic and inorganic) in the water column.

SHEET & RILL EROSION Soil loss that occurs diffusely on hillslopes ranging from generally flat areas of land to steep hillsides.

SHL State Hygienic Laboratory (University of Iowa). Provides physical, biological and chemical sampling for water quality purposes in support of beach monitoring and impaired water assessments.

SI Stressor Identification. A process by which the specific cause(s) of a biological impairment to a water body can be determined from cause-and-effect relationships.

SSURGO Soil Survey Geographic Database. Database of soils information including tables, maps and metadata compiled by the National Cooperative Soil Survey for nearly all United States lands.

STORM FLOW (OR STORM WATER) The fraction of discharge (flow) in a river which arrives as surface runoff directly caused by a precipitation event. Storm water generally refers to runoff which is routed through some artificial channel or structure, often in urban areas.

STP Sewage Treatment Plant. General term for a facility that processes municipal sewage into effluent suitable for release to public waters.

STRIPS — Science-based Trials of Rowcrops Integrated With Prairie Strips. Collaborative project that researches and promotes installation of small prairie restorations in targeted locations in farm fields to improve ecosystem services in agricultural landscapes.

SWCD — Soil and Water Conservation District. Agency that provides local assistance for soil conservation and water quality project implementation, with support from the Iowa Department of Agriculture and Land Stewardship.

TMDL — Total Maximum Daily Load. As required by the Federal Clean Water Act, a comprehensive analysis and quantification of the maximum amount of a particular pollutant that a water body can tolerate while still meeting its general and designated uses.

TSI (OR CARLSON'S TSI) — Trophic State Index. A standardized scoring system (scale of 0-100) used to characterize the amount of algal biomass in a lake or wetland.

TSS — Total Suspended Solids. The quantitative measure of seston, all organic and inorganic materials held in the water column.

TURBIDITY — The degree of cloudiness or murkiness of water caused by suspended particles.

UAA — Use Attainability Analysis. A protocol used to determine which (if any) designated uses apply to a particular water body. See Appendix B for a description of all general and designated uses.

USDA — United States Department of Agriculture.

USGS — United States Geologic Survey (United States Department of the Interior). Federal agency responsible for implementation and maintenance of discharge (flow) gauging stations on the nation's water bodies.

WATERSHED — The land (measured in units of surface area) which drains water to a particular body of water or outlet.

WLA — Waste Load Allocation. The fraction of waterbody loading capacity assigned to point sources in a watershed. Alternatively, the allowable pollutant load that an NPDES permitted facility may discharge without exceeding water quality standards.

WMA — Watershed Management Authority. Interagency partnership between cities, counties and Soil and Water Conservation Districts (SWCDs) established under a Chapter 28E Agreement to assess and address water resource concerns, educate watershed residents and identify and allocate funds.

WQI — Water Quality Initiative. Program established by Iowa legislature in 2013 to implement the Nutrient Reduction Strategy. Funds include support for conservation practice cost-share, water monitoring and watershed project administration.

WQS

Water Quality Standards. Defined in Chapter 61 of Environmental Protection Commission [567] of the Iowa Administrative Code, they are the specific criteria by which water quality is gauged in Iowa.

WWTP

Waste Water Treatment Plant. General term for a facility that processes municipal, industrial or agricultural waste into effluent suitable for release to public waters or for land application.

ZOOPLANKTON

Collective term for all animal plankton that serve as secondary producers in the aquatic food chain and the primary food source for larger aquatic organisms.

APPENDIX B

List of Designated Uses

Descriptions of designated uses for Iowa's public water bodies are provided below. General uses refer to narrative water quality criteria all public water bodies must meet to satisfy public needs and expectations. Designated uses refer to the type of economic, social or ecologic activities a specific water body is intended to support.

The Iowa Department of Natural Resources (DNR) defines a general use for intermittent waters that "flow only for short periods, are above the water table and do not maintain viable aquatic community or pooled conditions during periods of no flow." The DNR establishes designated uses for waters that "maintain flow throughout year or sufficient pools during intermittent flow to maintain viable aquatic community." Rulemaking is only required for assessed streams with designated uses, i.e. those with perennial flow or sufficient intermittent flow. Designated uses can be classified as recreational, aquatic life, human health and drinking water. The following text is from DNR publicly available resources.

DESIGNATED USES

Waterbody segments designated for recreational use are protected for uses that involve human contact with the water. Three types of recreational uses are:

- **CLASS A1 - PRIMARY CONTACT RECREATIONAL USE:** The water's recreation uses involve full body immersion with prolonged and direct contact with the water, such as swimming and water skiing.
- **CLASS A2 - SECONDARY CONTACT RECREATIONAL USE:** Water recreation uses involve incidental or accidental contact with the water, where the probability of ingesting water is minimal, such as fishing and shoreline activities.
- **CLASS A3 - CHILDREN'S RECREATIONAL USE:** Water recreation uses where children's activities are common, like wading or playing in the water. These waters are commonly located in urban or residential areas where the banks are defined and there is visible evidence of flow.

Warm water waterbodies also can be designated to protect aquatic life, such as fish, plants and insects that live in and around the water. Streams that maintain flow throughout the year, or contain sufficient pooled areas during intermittent flow periods to maintain a viable aquatic community, can be designated for aquatic life uses for warm water species. The three warm water uses include:

- **CLASS B(WW-1):** Typically large interior and border rivers and the lower segments of medium-size tributary streams capable of supporting and maintaining a wide variety of aquatic life, including game fish.
- **CLASS B(WW-2):** Typically smaller, perennially flowing streams capable of supporting and maintaining a resident aquatic community, but lack the flow and habitat necessary to fully support and sustain game fish populations.
- **CLASS B(WW-3):** Intermittent stream with nonflowing perennial pools capable of supporting and maintaining a resident aquatic community in harsher conditions. These waters lack the flow and habitat necessary to fully support and sustain a game fish population.

Iowa also has a small group of cold water waterbodies, many of which are located in the northeast portions of the state. These also can be designated to protect aquatic life, such as fish, plants and insects that live in and around these streams. Waters in which the temperature and flow are suitable can be designated for aquatic life uses for cold water species. The two cold water uses include:

- **CLASS B(CW-1):** Waters in which temperature and flow are suitable for the maintenance of a variety of coldwater species, including populations of trout (Salmonidae) and associated aquatic communities.
- **CLASS B(CW-2):** Waters including small, channeled streams, headwaters and spring runs that possess natural coldwater attributes of temperature and flow. They do not support populations of trout (Salmonidae), but may support vertebrate and invertebrate organisms.

Other designated uses are related to fish and water consumption:

- **CLASS HH - HUMAN HEALTH:** Waters in which fish are routinely harvested for human consumption or waters both designated as public water supply and routinely harvested for human consumption.
- **CLASS C - DRINKING WATER SUPPLY:** Waters which are used as a raw water source of potable water supply.

APPENDIX C

Lime Creek 2008 Fish Kill

The following text from the Lime Creek segment IA 02-CED-0270_1 2014 Water Quality Assessment in the Iowa Department of Natural Resources ADBNet 305(b) Water Quality Assessment Database describes the fish kill that occurred in July 2008 in the Lime Creek Watershed:

A fish kill occurred on Lime Creek on July 9, 2008. The kill occurred along 4.2 miles of Lime Creek northeast of Brandon and affected approximately 2,720 fish. High water occurred during, or after, the kill event because some fish were observed 2-3 feet above the water level present during the day of investigation. Fish carcasses were easily identifiable to family group, but identification to species was not possible for most Cyprinidae species due to poor physical condition of specimens. The following species were positively identified: Common Shiner, Creek Chub, Northern Hog sucker, Northern Logperch, Rock Bass, Smallmouth Bass and Stonecat. It is likely high water flows flushed a significant number of dead fish from the investigated area, and decay and predation further reduced counts of small-bodied fishes. The estimated value of the fish was $3,004.36. No definite source for the fish kill was found; however, two feedlots and an herbicide over-application were investigated. According to IDNR's assessment/listing methodology, the occurrence of a single pollutant-caused fish kill, or a fish kill of unknown origin, on a waterbody or waterbody reach during the most recent assessment period indicates a severe stress to the aquatic community and suggests that the aquatic life uses should be assessed as "impaired." If a cause of the kill was not identified during the IDNR investigation, or if the kill was attributed to nonpollutant causes (e.g., winterkill), the assessment type will be considered "evaluated." Such assessments, although suitable for Section 305(b) reporting, lack the degree of confidence to support addition to the state Section 303(d) list of impaired waters (IR Category 5). However, results of chemical monitoring and biological (fish, macroinvertebrate, and freshwater mussel) monitoring conducted since the July 2008 fish kill suggest full recovery of Lime Creek's aquatic communities. Thus, this fish kill is not considered as a cause of impairment of the aquatic life uses of this stream.

APPENDIX D

Watershed Self-Evaluation Worksheet

PURPOSE

This self-evaluation worksheet is a means to assess annual watershed project progress and to identify areas of strength and weakness. The evaluation worksheet should be completed annually by project leaders and partners. Results should be compiled and shared with all project partners.

Evaluation Watershed Project: ______________________________

Evaluator Name: _________________

Evaluation Date: _________________

Evaluation Time Period: _________________ to _________________

PROJECT ADMINISTRATION

	EXCEEDS	MEETS	PARTIALLY MEETS	DOES NOT MEET	NA
Project annual review meeting held.					
Watershed partners represent a broad and diverse membership which represents most interests in the watershed.					
Watershed partners understand their responsibilities and roles.					
Watershed partners share a common vision and purpose.					
Watershed partners are aware of and involved in project activities.					
Watershed partners understand decision making processes.					
Watershed meetings are well-organized and productive.					
Watershed partners advocate for the mission.					

ATTITUDES AND AWARENESS

	EXCEEDS	MEETS	PARTIALLY MEETS	DOES NOT MEET	NA
Positive changes in attitudes, beliefs and practices have occurred in the watershed.					
Field days and other events have been held in the watershed.					
Watershed project has received publicity via local and regional media outlets.					

PERFORMANCE

	EXCEEDS	MEETS	PARTIALLY MEETS	DOES NOT MEET	NA
Yearly ______________ (insert conservation practice) implementation goals have been met.					
Yearly ______________ (insert conservation practice) implementation goals have been met.					
Yearly ______________ (insert conservation practice) implementation goals have been met.					
Yearly ______________ (insert conservation practice) implementation goals have been met.					
Yearly ______________ (insert conservation practice) implementation goals have been met.					
Yearly ______________ (insert conservation practice) implementation goals have been met.					
Yearly ______________ (insert conservation practice) implementation goals have been met.					
Yearly ______________ (insert conservation practice) implementation goals have been met.					
The majority of implemented conservation practices have been retained after cost-share payments ended.					

RESULTS

	EXCEEDS	MEETS	PARTIALLY MEETS	DOES NOT MEET	NA
Monitoring of __________ (insert variable) has shown progress towards reaching plan goals.					
Monitoring of __________ (insert variable) has shown progress towards reaching plan goals.					
Monitoring of __________ (insert variable) has shown progress towards reaching plan goals.					
Impact (financial or other) to farmers and landowners has been positive or minimal.					
Modeled impacts on _____________ (insert variable) have shown progress towards reaching plan goals.					
Modeled impacts on _____________ (insert variable) have shown progress towards reaching plan goals.					
Modeled impacts on _____________ (insert variable) have shown progress towards reaching plan goals.					

STRENGTHS, WEAKNESSES, OPPORTUNITIES AND THREATS ANALYSIS

Thinking about the goals of the watershed plan, brainstorm the Strengths, Weaknesses, Opportunities and Threats (SWOTs) relevant to the project. Identification of SWOTs is important as they help shape successful watershed plan implementation.

STRENGTHS	OPPORTUNITIES
WEAKNESSES	**THREATS**

APPENDIX E

Nitrogen Reduction Calculation Worksheet

This worksheet can be used to estimate nitrate-nitrogen reduction at the watershed outlet based on the number of acres treated with best management practices (BMPs).

INSTRUCTIONS

1. Enter acres covered by, treated with or drained into BMPs into "Acres Treated" column for each BMP.
2. Multiply "Acres Treated" by "Multiplier" for each BMP and enter result into "N Load Reduction" column.
3. "Total N Load Reduction" equals the sum of the top seven rows in the "N Load Reduction" column.
4. Obtain "Baseline N Load" value from watershed plan document.
5. Calculate "Percent N Reduction" as "Total N Load Reduction" divided by "Baseline N Load" multiplied by a factor of 100.

BEST MANAGEMENT PRACTICE	ACRES TREATED	MULTIPLIER	N LOAD REDUCTION
Cover Crops, below EOF*		4.0	
Cover Crops, above EOF*		2.0	
Nutrient Management**		1.2	
Perennial Cover		10.2	
Bioreactors		5.6	
Saturated Buffers		6.5	
Wetlands		6.8	
Total N Load Reduction			
Baseline N Load			
Percent N Reduction			

*The location of cover crops relative to edge-of-field (EOF) practices is important. Cover crops "below", or downstream of, EOF practices result in greater nitrate-nitrogen reduction than cover crops located "above", or upstream of, EOF practices.

**Include only acres treated with nutrient management (MRTN application rate, nitrification inhibitor, etc.) that do not also have cover crops.

APPENDIX F

Potential Funding Sources

PROGRAM	DESCRIPTION	AGENCY/ ORGANIZATION
Iowa Financial Incentives Program	50 percent cost-share available to landowners through 100 SWCDs for permanent soil conservation practices.	IDALS-DSCWQ
No-Interest Loans	State administered loans to landowners for permanent soil conservation practices.	IDALS-DSCWQ
District Buffer Initiatives	Funds for SWCDs to initiate, stimulate, and incentivize signup of USDA programs, specifically buffers.	IDALS-DSCWQ
Iowa Watershed Protection Program	Funds for SWCDs to provide water quality protection, flood control, and soil erosion protection in priority watersheds; 50-75 percent cost-share.	IDALS-DSCWQ
Conservation Reserve Enhancement Program	Leveraging USDA funds to establish nitrate removal wetlands in north central Iowa with no cost to landowner.	IDALS-DSCWQ
Soil and Water Enhancement Account - REAP Water Quality Improvement Projects	REAP funds for water quality improvement projects (sediment, nutrient and livestock waste) and wildlife habitat and forestry practices; 50-75 percent cost-share. Used as state match for EPA 319 funding. Tree planting, native grasses, forestry, buffers, streambank stabilization, traditional erosion control practices, livestock waste management, ag drainage well closure and urban storm water.	IDALS-DSCWQ
State Revolving Loans	Low interest loans provided by SWCDs to landowners for permanent water quality improvement practices; subset of DNR program.	IDALS-DSCWQ
Watershed Improvement Fund	Local watershed improvement grants to enhance water quality for beneficial uses, including economic development.	IDALS-DSCWQ
General Conservation Reserve Program	Encourages farmers to convert highly erodible land or other environmentally sensitive land to vegetative cover; farmers receive annual rental payments.	USDA-FSA
Continuous Conservation Reserve Program	Encourages farmers to convert highly erodible land or other environmentally sensitive land to vegetative cover, filter strips or riparian buffers; farmers receive annual rental payments.	USDA-FSA
Farmable Wetland Program	Voluntary program to restore farmable wetlands and associated buffers by improving hydrology and vegetation.	USDA-FSA
Grassland Reserve Program	Provides funds to grassland owners to maintain, improve and establish grass. Contracts of easements up to 30 years.	USDA-FSA
Environmental Quality Incentives Program	Provides technical and financial assistance for natural resource conservation in environmentally beneficial and cost-effective manner; program is generally 50 percent cost-share.	USDA-NRCS
Wetland Reserve Program	Provides restoration of wetlands through permanent and 30 year easements and 10 year restoration agreements.	USDA-NRCS
Emergency Watershed Protection Program	Flood plain easements acquired via USDA designated disasters due to flooding.	USDA-NRCS
Wildlife Habitat Incentives Program	Cost-share contracts to develop wildlife habitat.	USDA-NRCS
Farm and Ranchland Protection Program	Purchase of easements to limit conversion of ag land to non-ag uses. Requires 50 percent match.	USDA-NRCS
Cooperative Conservation Partnership Programs	Conservation partnerships that focus technical and financial resources on conservation priorities in watersheds and airsheds of special significance.	USDA-NRCS
Conservation Security Program	Green payment approach for maintaining and increasing conservation practices.	USDA-NRCS
Conservation Innovation Grants	National and state grants for innovative solutions to a variety of environmental challenges.	USDA-NRCS
Regional Conservation Partnership Program	Grants from national, state or Critical Conservation Area funding pools to promote formation of partnerships to facilitate conservation practice implementation. Each partner within a project must make a significant cash or in-kind contribution.	USDA-NRCS

Potential Funding Sources (cont.)

PROGRAM	DESCRIPTION	AGENCY/ ORGANIZATION
Conservation Stewardship Program	Encourages farmers to begin or continue conservation through five-year contracts to install and maintain conservation practices and adopt conservation crop rotations.	USDA-NRCS
Aquatic Ecosystem Restoration — Section 206	Restoration projects in aquatic ecosystems such as rivers, lakes and wetlands.	US Army Corps
Habitat Restoration of Fish and Wildlife Resources	Must involve modification of the structures or operations of a project constructed by the Corps of Engineers.	US Army Corps
Section 319 Clean Water Act	Grants to implement NPS pollution control programs and projects in watersheds with EPA approved watershed management plans.	EPA/DNR
Iowa Water Quality Loan Fund	Source of low-cost financing for farmers and landowners, livestock producers, community groups, developers, watershed organizations and others.	DNR
Sponsored Projects	Wastewater utilities can finance and pay for projects, within or outside the corporate limits, that cover best management practices to keep sediment, nutrients, chemicals and other pollutants out of streams and lakes.	DNR/Iowa Finance Authority
Resource Enhancement and Protection Program	Provides funding for enhancement and protection of State's natural and cultural resources.	DNR
Streambank Stabilization and Habitat Improvement	Penalties from fish kills used for environmental improvement on streams impacted by the kill.	DNR/IDALS-DSCWQ
State Revolving Fund	Provides low interest loans to municipalities for waste water and water supply; expanding to private septics, livestock, storm water and NPS pollutants.	DNR
Watershed Improvement Review Board	Comprised of representatives from agriculture, water utilities, environmental organizations, agribusiness, the conservation community and state legislators and provides grants to watershed and water quality projects.	WIRB
Iowa Water Quality Initiative	Initiated by IDALS-DSCWQ as a demonstration and implementation program for the Nutrient Reduction Strategy. Funds are targeted to 9 priority HUC-8 watersheds.	IDALS-DSCWQ
Fishers and Farmers Partnership	Fishers & Farmers Partnership for the Upper Mississippi River Basin is a self-directed group of nongovernmental agricultural and conservation organizations, tribal organizations and state and federal agencies working to achieve the partnership's mission "… to support locally-led projects that add value to farms while restoring aquatic habitat and native fish populations."	U.S Fish and Wildlife Service and others

Private Funding Sources (not inclusive)

PROGRAM	DESCRIPTION	WEBSITE
Field to Market® Alliance	Field To Market® is a diverse alliance working to create opportunities across the agricultural supply chain for continuous improvements in productivity, environmental quality and human well-being. The group provides collaborative leadership that is engaged in industry-wide dialogue, grounded in science and open to the full range of technology choices.	https://www.fieldtomarket.org/members/
International Plant Nutrition Institute (IPNI)	The IPNI is a not-for-profit, science-based organization dedicated to the responsible management of plant nutrition for the benefit of the human family.	http://www.ipni.net
Iowa Community Foundations	Iowa Community Foundations are nonprofit organizations established to meet the current and future needs of our local communities.	http://www.iowacommunityfoundations.org/
Iowa Natural Heritage Foundation	Private nonprofit conservation organization working to ensure Iowans will always have beautiful natural areas — to bike, hike and paddle; to recharge, relax and refresh; and to keep Iowa healthy and vibrant.	http://www.inhf.org
McKnight Foundation — Mississippi River Program	Program goal is to restore the water quality and resiliency of the Mississippi River.	www.mcknight.org/grant-programs/mississippi-river
National Fish and Wildlife Foundation (NFWF)	NFWF provides funding on a competitive basis to projects that sustain, restore and enhance our nation's fish, wildlife and plants and their habitats.	www.nfwf.org
National Wildlife Foundation	Works to protect and restore resources and the beneficial functions they offer.	www.nwf.org
The Fertilizer Institute (TFI)	TFI is the leading voice in the fertilizer industry, representing the public policy, communication and statistical needs of producers, manufacturers, retailers and transporters of fertilizer. Issues of interest to TFI members include security, international trade, energy, transportation, the environment, worker health and safety, farm bill and conservation programs to promote the use of enhanced efficiency fertilizer.	http://www.tfi.org
The Nature Conservancy (TNC)	TNC is the largest freshwater conservation organization in the world — operating in 35 countries with more than 300 freshwater scientists and 500 freshwater conservation sites globally. TNC works with businesses, governments, partners and communities to change how water is managed around the world.	http://www.nature.org
Trees Forever — Working Watersheds Program	Annually work with 10-15 projects in Iowa that emphasize water quality through our Working Watersheds: Buffers and Beyond program.	www.treesforever.org/
Walton Family Foundation — Environmental Program	Work to achieve lasting change by creating new and unexpected partnerships among conservation, business and community interests to build durable solutions to big problems.	www.waltonfamilyfoundation.org/environment

APPENDIX G

Reducing Nutrient Loss: Science Shows What Works

Iowa Strategy to Reduce Nutrient Loss: Nitrogen Practices[1]

	PRACTICE	COMMENTS	% NITRATE-N REDUCTION + AVERAGE (SD*)
EDGE-OF-FIELD	Drainage Water Mgmt.	No impact on concentration	33 (32)
	Shallow Drainage	No impact on concentration	32 (15)
	Wetlands	Targeted water quality	52
	Bioreactors		43 (21)
	Buffers	Only for water that interacts with the active zone below the buffer. This would only be a fraction of all water that makes it to a stream.	91 (20)
	Saturated Buffers	Divert fraction of tile drainage into riparian buffer to remove Nitrate-N by denitrification.	50 (13)
LAND USE	Perennial	Energy Crops — Compared to spring-applied fertilizer	72 (23)
		Land Retirement (CRP) — Compared to spring-applied fertilizer	85 (9)
	Extended Rotations	At least 2 years of alfalfa in a 4 or 5 year rotation	42 (12)
	Grazed Pastures	No pertinent information from Iowa — assume similar to CRP	85
NITROGEN MANAGEMENT	Timing	Moving from fall to spring pre-plant application	6 (25)
		Spring pre-plant/sidedress 40-60 split compared to fall-applied	5 (28)
		Sidedress — Compared to pre-plant application	7 (37)
		Sidedress — Soil test based compared to pre-plant	4 (20)
	Source	Liquid swine manure compared to spring-applied fertilizer	4 (11)
		Poultry manure compared to spring-applied fertilizer	-3 (20)
	Nitrogen Application Rate	Nitrogen rate at the MRTN (0.10 N:corn price ratio) compared to current estimated application rate. (ISU Corn Nitrogen Rate Calculator—http://extension.agron.iastate.edu/soilfertility/nrate.aspx can be used to estimate MRTN but this would change Nitrate-N concentration reduction)	10
	Nitrification Inhibitor	Nitrapyrin in fall — Compared to fall-applied without Nitrapyrin	9 (19)
	Cover Crops	Rye	31 (29)
		Oat	28 (2)
	Living Mulches	e.g. Kura clover — Nitrate-N reduction from one site	41 (16)

+A positive number is nitrate concentration or load reduction and a negative number is an increase.
*SD = standard deviation. Large SD relative to the average indicates highly variable results.
[1]Source: Iowa Nutrient Reduction Strategy Nitrogen Practices Assessment https://store.extension.iastate.edu/Product/Reducing-Nutrient-Loss-Science-Shows-What-Works

Iowa Strategy to Reduce Nutrient Loss: Phosphorus Practices[1]

	PRACTICE	COMMENTS	% P LOAD REDUCTION+ AVERAGE (SD*)
EROSION CONTROL PRACTICES	Terraces		77 (19)
	Buffers		58 (32)
	Control	Sedimentation basins or ponds	85
LAND USE CHANGE	Perennial Vegetation	Energy Crops	34 (34)
		Land Retirement (CRP)	75
		Grazed pastures	59 (42)
PHOSPHORUS MANAGEMENT PRACTICES	Phosphorus Application	Applying P based on crop removal — Assuming optimal STP level and P incorporation	0.6[a]
		Soil-Test P — No P applied until STP drops to optimum or, when manure is applied, to levels indicated by the P Index[b]	17[c]
	Source of Phosphorus	Liquid swine, dairy, and poultry manure compared to commercial fertilizer — Runoff shortly after application	46 (45)
		Beef manure compared to commercial fertilizer — Runoff shortly after application	46 (96)
	Placement of Phosphorus	Broadcast incorporated within 1 week compared to no incorporation, same tillage	36 (27)
		With seed or knifed bands compared to surface application, no incorporation	24 (46)
	Cover Crops	Winter rye	90 (17)
	Tillage	Conservation till — Chisel plowing compared to moldboard plowing	33 (49)
		No till compared to chisel plowing	90 (17)

+A positive number is P load reduction and a negative number is increased P load.
*SD = standard deviation. Large SD relative to the average indicates highly variable results.
aMaximum and average estimated by comparing application of 200 and 125 kg P2O5/ha, respectively, to 58 kg P2O5 /ha (corn-soybean rotation requirements) (Mallarino et al., 2002).
bISU Extension and Outreach Publication (PM 1688)
cMaximum and average estimates based on reducing the average STP (Bray-1) of the two highest counties in Iowa and the statewide average STP (Mallarino et al., 2011a), respectively, to an optimum level of 20 ppm (Mallarino et al., 2002). Minimum value assumes soil is at the optimum level.
1Source: Iowa Nutrient Reduction Strategy Phosphorus Practices Assessment https://store.extension.iastate.edu/Product/Reducing-Nutrient-Loss-Science-Shows-What-Works

APPENDIX H

Iowa Nutrient Reduction Strategy Practice Costs & Benefits

The following text is from the Iowa Science Assessment of Nonpoint Source Practices to Reduce Nitrogen and Phosphorus Transport in the Mississippi River Basin (Iowa State University Science Team, 2013). The text outlines the costs and benefits of conservation practices, many of which are identified in this watershed plan. None of the costs or benefits include cost-share, incentive or rental payments offered to farmers and landowners within the watershed. The cost estimates below are based on local conditions for MLRA 104, Eastern Iowa and Minnesota Till Prairies. The costs included are farm level costs associated with each practice, so some practices may have additional costs or benefits.

MOVING FROM FALL TO SPRING NITROGEN APPLICATION

This practice is dynamic between Major Land Resource Areas (MLRAs) because the yield impact by moving from fall to spring varies by the different baseline corn yield in each MLRA. Although there may be a risk of not having enough suitable days to apply all nitrogen in the spring, this was not factored into the cost as the "value" of risk was not a component of this practice evaluation. This value could be included in future practice evaluations, such as the following example by Hanna and Edwards (2007).

Cost in a corn/soybean rotation is -$18.00/acre (negative cost results in a benefit)

Cost in a continuous corn system is -$35.00/acre

REDUCING NITROGEN RATE

This practice involves reducing the MLRA average nitrogen rate applied to corn to the Maximum Return to Nitrogen (MRTN) recommendation, the rate currently recommended in Iowa for continuous corn and corn following soybean. This practice utilizes the online Corn Nitrogen Rate Calculator (MTRN based recommendation system) (Sawyer et al., 2011b) to determine nitrogen rate impacts on fertilizer cost and yield return. Application rate is highly dynamic as any nitrogen application rate may be selected and each MLRA has different baseline application rates.

SIDEDRESS ALL SPRING APPLIED NITROGEN

Since the number of field trips due to various field activities in the spring and early summer can vary depending on the year, producer and crop, simply adding the cost of an additional operation for side dressing was not possible. As a result, there was no cost associated with switching to a sidedress application and there was no corn yield benefit.

USING A NITRIFICATION INHIBITOR

Use of nitrapyrin with all fall applied anhydrous ammonia could have an impact on demand for the product, which could increase cost, but for this analysis it is assumed the cost of nitrapyrin would not change with increased use. Currently it is estimated that 2 million acres are receiving nitrapyrin in Iowa (Dow Agro Sciences, 2012).

Research shows a corn yield increase and nitrate-N loss decrease when using nitrapyrin with fall applied anhydrous ammonia when compared to anhydrous ammonia applied at the same nitrogen rate without nitrapyrin. Because yield is impacted, the Equal Annualized Cost (EAC) for nitrapyrin application is different for each MLRA. Additionally, there is a product cost of approximately $11.50/acre (Sawyer, 2011).

Cost in a corn/soybean rotation is -$22.00/acre

Cost in a continuous corn system is -$43.00/acre

COVER CROPS

The cover crop in this practice/scenario is late summer or early fall seeded winter cereal rye. Winter rye offers benefits of easy establishment, seeding aerially or drilling, growth in cool conditions and initial growth when planted in the fall as well as continued growth in the spring.

The winter rye cover crop practice is an annual cost with little to no capital investment. Items included in the annual cost are seed, seeding and cover crop termination. Seeding at a rate of 60 lb/acre and at a cost of $0.125/lb seed the total seed cost would be $7.50/acre per year (Singer, 2011). There were several cost sources for seeding using a no-till drill, which range from $8.40/acre (Duffy, 2011) to $15/acre (Singer, 2011), with Edwards et al. (2011) estimating $13.55/acre. In order to grow the primary crop, the cover crop must be terminated – chemically killed and/or plowed down. Glyphosate is the primary herbicide used for this procedure, and Singer (2011) suggested use at 24 oz product/acre with a cost of $0.083/oz, or $2.00/acre. Additionally, there is a cost associated with hiring spray equipment between $6 to $8/acre (Edwards et al., 2011).

The base cost of this practice, before any corn yield impact, ranges from $29/acre to $32.50/acre per year – value of $32.50/acre used for cost analysis. Any cost associated with a corn yield reduction due to the preceding rye cover crop depends on the baseline corn yields in each MLRA. From the review of literature, the estimated yield impact for corn following rye is -6 percent. No yield impact occurs with soybean following a preceding rye cover crop, therefore, no soybean yield impact is included in the implementation cost.

Cost in a corn/soybean rotation is $42.50/acre

Cost in a continuous corn system is $87.50/acre

This cost is for operations, materials and corn yield decrease of 6 percent.

Other ecosystem or environmental services include wildlife habitat, decreased erosion and loss of surface runoff contaminants (e.g. reduced phosphorus loss) and benefits to soil health and soil organic matter.

WETLANDS (TARGETED FOR WATER QUALITY)

Wetland installation and maintenance cost estimates (from Christianson et al., In Preparation) include design cost, construction, seeding (buffer area around wetland), outflow structure, land acquisition, management (mowing) and control structure replacement. The example used (Christianson et al., In Preparation) was based on a 10-acre wetland, with a 35-acre buffer, treating 1,000 acres. The resulting EAC was $14.94/treated acre per year with a net present value cost of $321/treated acre. They used a 4 percent discount rate and 50-year design life. With wetlands, it may be possible to target the highest nitrate yielding areas of the landscapes and areas of the state in order to maximize overall nitrate-N reduction.

Other ecosystem or environmental services include increased aesthetic landscape, increased habitat for Iowa game and waterfowl, and depending on design, could provide hydrologic services through water flow attenuation.

BIOREACTORS

Bioreactor installation and maintenance cost estimates (from Christianson et al., In Preparation) include control structures, woodchips, design, construction, seeding, additional tile, management and maintenance. The example used in (Christianson et al., In Preparation) was based on a 0.25 acre bioreactor with a 50 acre treatment area. The resulting EAC was $10.23/treated acre per year with a net present value cost of $220/treated acre.

BUFFERS

Buffers have the potential to be implemented adjacent to streams to intercept shallow groundwater and reduce nitrate-N concentrations. While there could be broad implementation of this practice, the nitrate-N load reduction will be limited by the amount of shallow groundwater intercepted by the buffer.

Costs of buffers can vary greatly depending on width, type of vegetation and if substantial earthwork is required. For the analysis, a cost of establishment and implementation was assumed to be $300/acre with an EAC of $13.96/acre/year. In addition, there would be a cost of land out of production which was assumed to be equal to the average cash rent for corn and soybean land for each MLRA (Edwards and Johanns, 2011a; Edwards and Johanns, 2011b).

Cost to implement buffers is $241.00/acre

In terms of other ecosystem or environmental services, buffers would be expected to reduce nitrate-N load from shallow groundwater, provide wildlife habitat benefits, reduce greenhouse gas emissions, vegetation would sequester carbon, stabilize stream banks and potentially reduce flood impacts and improve aquatic ecosystem integrity.

CONTROLLED DRAINAGE

Controlled drainage, also known as drainage water management (DWM), has limited applicability in Iowa due to the requirement of low slopes. This scenario considers controlled drainage, but drainage water management could also be achieved through shallower drain placement. However, shallower drain placement would have significant costs due to replacement of existing tile systems.

Controlled drainage and drainage water management installation and maintenance cost estimates (from Christianson et al., In Preparation) include structure cost (assumption of 20 acres per structure), system design, contractor installation, farmer management time (raise and lower control gate devices), structure replacement and control device replacement. Resulting EAC was $9.86/acre per year.

Other ecosystem or environmental services include managing the water table at a shallower depth could result in increased surface runoff, which would have implications for soil erosion and transport of other surface runoff contaminants (e.g. phosphorus).

LAND RETIREMENT — REPLACING ROW CROPS WITH PERENNIAL VEGETATION

Cost estimates for land retirement were based on income lost by taking land out of corn and soybean production — cash rent for corn and soybean — plus an annual maintenance cost. The maintenance was assumed to be mowing twice per year at a cost of $13.85/acre/mowing event ($27.70/acre/year) (Edwards et al., 2011).

Cost to implement is $254.00/acre (not including a CRP payment)

Other ecosystem or environmental services include increased wildlife habitat; decreased soil erosion, surface runoff and surface runoff transported pollutant export (e.g. P); hydrologic services, that is, reduction of water runoff amount and rate; increased carbon sequestration; and reduced greenhouse gas emissions.

LAND CONVERSION — PERENNIAL ENERGY CROPS REPLACING ROW CROPS

Although there is not a current large market for perennial biomass crops as a source for energy or transportation fuel production, there are local and regional markets for those crops with current prices (example $50/ton). A publication from 2008 in the Ag Decision Maker series (Duffy, 2008) had estimates on the cost of production, transportation and storage of switchgrass. At an assumed 4 ton/acre production level, the resulting revenue is $200/acre. The $50/ton does not cover the cost to harvest, store and transport, thus, land retirement is more profitable. The Ag Decision Maker costs factor in a land charge, and land rent for corn and soybean was used to represent the cost of switching from row crops to perennials.

Cost to implement is $405.00/acre

This cost includes production, transportation, land rent and estimated sales return.

NOT APPLYING P ON ACRES WITH HIGH OR VERY HIGH SOIL-TEST P

This practice involves not applying phosphorus (P) on fields where soil-test P (STP) values exceed the upper boundary of the optimum level for corn and soybean in Iowa (20 ppm, Bray-1 or Mehlich-3 tests, 6-inch sampling depth). This practice would be employed until the STP level reaches the optimum levels.

The average estimated STP values from Mallarino et al.(2011) were used, along with the estimate of 1 ppm STP per year reduction in high or very high testing soils when growing a corn-soybean rotation without P application (Mallarino and Prater, 2007) for each MLRA to estimate the number of years required for not applying P. Cost savings were based on $0.59/lb of phosphate ($P_2O_5$) and an application rate of 56 lb P_2O_5/acre — average annual need for a corn-soybean rotation with 180 bu/acre corn and 55 bu/acre soybean. This equates to $36/acre/year savings in continuous corn and $33/acre/year savings in a corn-soybean rotation.

Cost to implement is -$9.00/acre

CONVERT ALL TILLED AREA TO NO-TILL

Tillage reduction will reduce P transport associated with soil erosion and surface runoff. This practice involves the conversion of all tillage to no-till, whereby the soil is left undisturbed from harvest to planting except for strips up to one-third of the row width made with the planter — strips may involve only residue disturbance or may include soil disturbance. This practice assumes approximately 70 percent or more of the soil surface is covered with crop residue, after planting, to reduce soil erosion by water.

Practice limitations, concerns or considerations include no-till results in lower corn yield than with moldboard or chisel-plow tillage. However, the yield reduction is less or none for other minimum tillage options that, on the other hand, are less efficient at controlling soil erosion and surface runoff. No-till or conservation tillage does not affect soybean yield significantly.

The EAC of converting to no-till (70 percent residue) from either "conventional" (< 20 percent residue) or "conservation" (30 percent residue) tillage systems were based on data from the publication Estimated Costs of Crop Production in Iowa (Duffy, 2012). Costs varied with average land rent in each MLRA. Also, since there is a 6 percent corn yield reduction when using no-till, there was a different cost for each MLRA associated with variable MLRA yields.

Cost of converting from conventional tillage to conservation tillage = -$1.18/acre

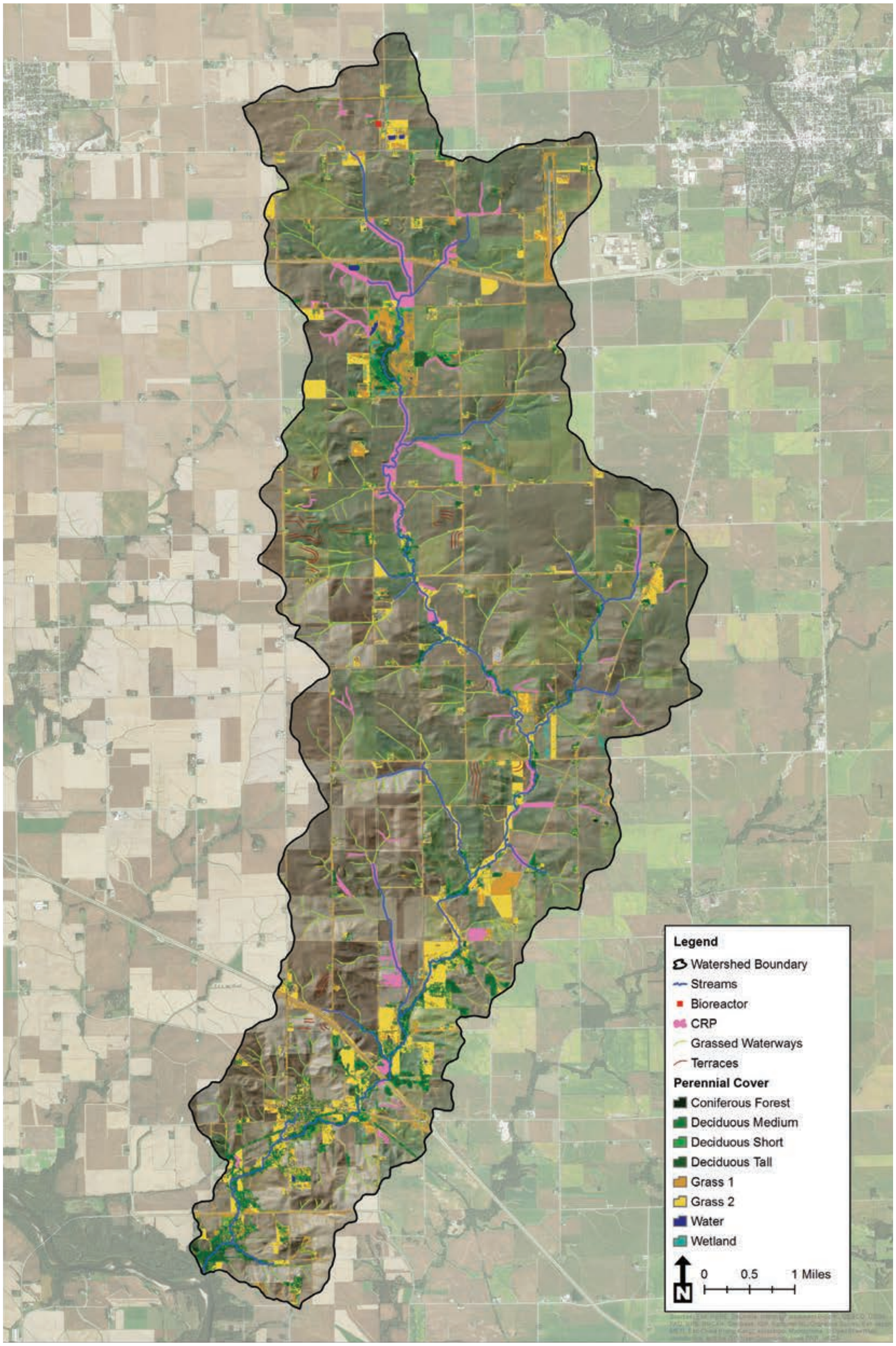
Cost of converting from conservation tillage to no-till = $13.41/acre

Cost of converting from conventional tillage to no-till = $10.64/acre

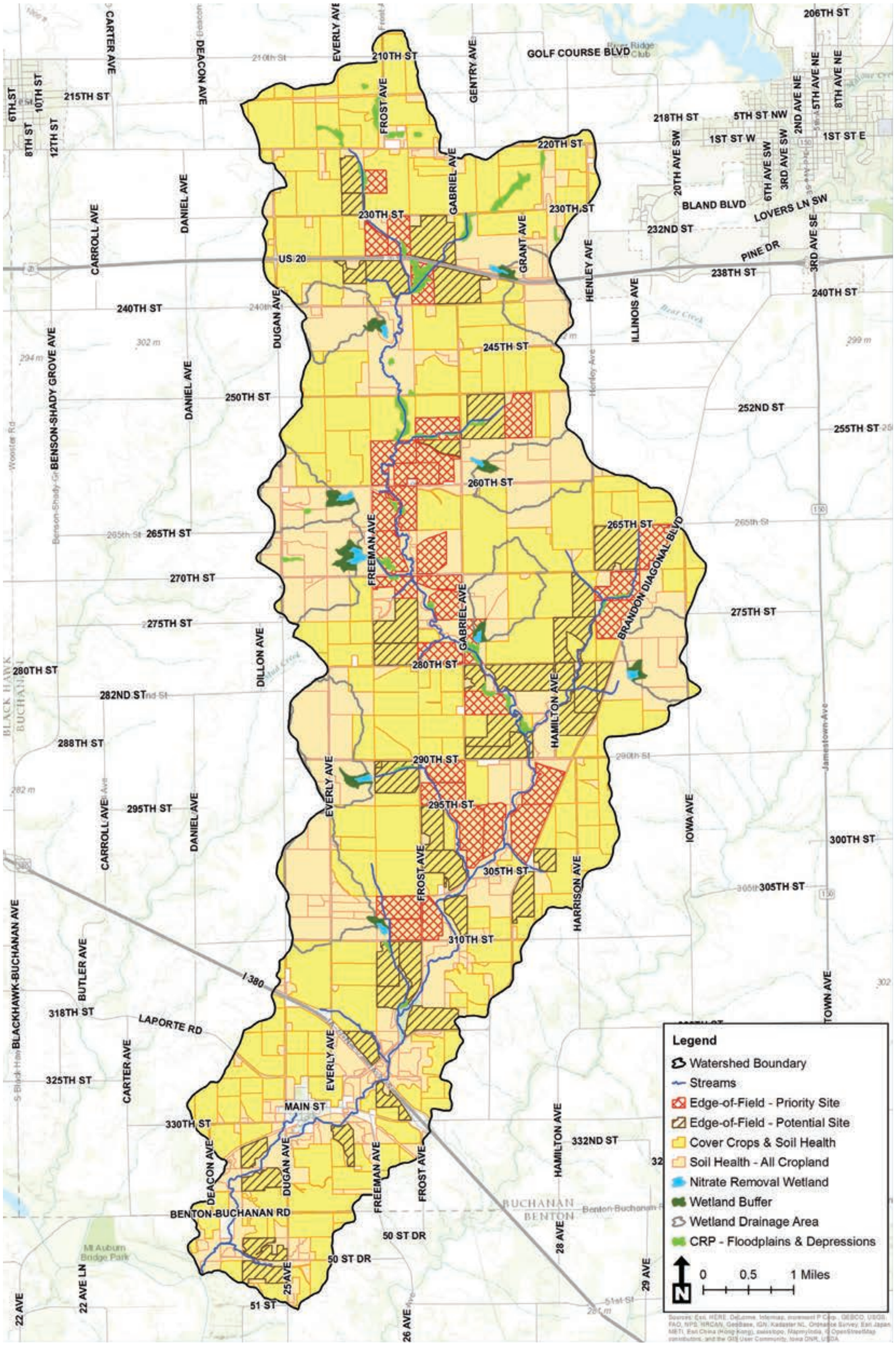
Other ecosystem or environmental services include increased long-term soil productivity and crop yield, reduced sediment loss, which extends the longevity of reservoirs, and reduced suspended and bedded sediments, thereby improving aquatic ecosystem integrity.

APPENDIX I

Lime Creek Watershed Existing Conservation Practices



Lime Creek Watershed Conceptual Plan



APPENDIX J

Lime Creek Watershed Agricultural Conservation Planning Framework Atlas

Contents

The Agricultural Conservation Planning Framework (ACPF) provides software tools that allow for best management practice (BMP) siting to assist watershed planning in agricultural watersheds. The tools use elevation, land use and soils data to identify potential locations for BMPs that improve water quality. The following abstract and sources are from the Agricultural Conservation Planning Framework ArcGIS® Toolbox User's Manual:

Abstract

Agricultural Conservation Planning Framework (ACPF) comprises an approach for applying concepts of precision conservation to watershed planning in agricultural landscapes. To enable application of this approach, USDA/ARS has developed a set of Geographic Information System (GIS) based software tools to identify candidate locations for different types of conservation practices that can be placed within and below fields in order to reduce, trap and treat hydrologic flows, and thereby improve water quality in agricultural watersheds. This manual describes how to apply the ACPF planning tools, with instructions on input data, data maintenance and file management, digital-terrain-model processing, stream delineations, runoff risk assessment and execution of Python programming scripts that are used to propose conservation-practice placements. Possible locations for surface-intake filters, drainage water management, grassed waterways, contour buffer strips, nutrient removal wetlands and water/sediment control basins are identified and mapped by the ACPF tools. Routines that help the user assess a watershed's riparian corridors and identify appropriate riparian buffer placements also are included as part of the ACPF toolbox. Results from applying these tools provide an inventory of opportunities for conservation practice placement at the Hydrologic Unit Code (HUC)12 watershed scale, which is meant to help facilitate the watershed planning process. USDA/ARS has developed ACPF input data bases for land use and soils for Iowa, Illinois, southern Minnesota and parts of northern Indiana. High resolution terrain data, typically obtained through LiDAR surveys, are required but becoming widely available. This manual accompanies these ACPF software tools as a training and referencing resource for use with the initial release version of these tools, written for use in the ArcGIS version 10.2 or 10.3 environment. The authors strongly recommend these tools be used as part of a collaborative planning effort that includes local landowners, and be applied by planning staff with knowledge of, and access to, the subject watershed.

Sources

Porter, S.A., M.D. Tomer, D.E. James, and K.M.B. Boomer. 2015. Agricultural Conservation Planning Framework: ArcGIS®Toolbox User's Manual. USDA Agricultural Research Service, National Laboratory for Agriculture and the Environment, Ames Iowa. Available: http://northcentralwater.org/acpf/

GENERAL CONCEPTS BEHIND THE ACPF:

Tomer, M.D., S.A. Porter, D.E. James, K.M.B. Boomer, J.A. Kostel, and E. McLellan. 2013. Combining precision conservation technologies into a flexible framework to facilitate agricultural watershed planning. Journal of Soil and Water Conservation 68:113A-120A. http://www.jswconline.org/content/68/5/113A.full.pdf + html

DEVELOPMENT OF SPECIFIC PRACTICE SITING TOOLS:

Tomer, M.D., S.A. Porter, K.M.B. Boomer, D.E. James, J.A. Kostel, M.J. Helmers, T.M. Isenhart, and E. McLellan. 2015. Agricultural Conservation Planning Framework: 1. Developing multi-practice watershed planning scenarios and assessing nutrient reduction potential. J. Environ. Qual. 44(3):754-767. https://dl.sciencesocieties.org/publications/jeq/articles/44/3/754

DEVELOPMENT OF THE RIPARIAN CLASSIFICATION SCHEME:

Tomer, M.D., K.M.B. Boomer, S.A. Porter, B.K. Gelder, D.E. James, and E. McLellan. 2015. Agricultural Conservation Planning Framework: 2. Classification of riparian buffer design-types with application to assess and map stream corridors. J. Environ. Qual. 44(3):768-779. https://dl.sciencesocieties.org/publications/jeq/articles/44/3/768

Best Management Practice Descriptions

The following are brief descriptions of the best management practices (BMPs) identified by the ACPF tools. Drainage BMPs (drainage water management, tile intake buffer, nitrate removal wetland) primarily reduce nitrogen in water leaving farm fields whereas runoff BMPs (grassed waterway, contour buffer strip, water and sediment control basin) typically reduce phosphorus delivery to streams, but it is important to note that many practices have multiple nutrient reduction benefits and may contribute additional ecosystem services such as flood reduction and improved wildlife habitat.

DRAINAGE WATER MANAGEMENT

Drainage water management involves using control structures to periodically limit drainage. Nitrate loss is reduced by limiting drainage volume, and crop yields can be improved due to increased water availability. This practice is suitable for fields with less than one percent slope.

TILE INTAKE BUFFER

Local depressions with poorly drained soil types may experience decreased or inhibited agricultural production due to excess moisture. Surface tile intakes can mitigate these production challenges, and installation of small buffers in depressions allows for water filtration prior to entering drainage tile.

NITRATE REMOVAL WETLAND

Nitrate removal wetlands, also called nutrient removal or nutrient reduction wetlands, are restored or constructed wetlands that remove nitrate from drainage tile water through denitrification and reduce phosphorus export by trapping sediment. Wetland footprint includes a wetland and a grass buffer to prevent sedimentation. Potential wetland sites are prioritized based on drainage area and wetland area to drainage area ratio.

GRASSED WATERWAY

Grassed waterways are used to control concentrated runoff and associated erosion such as ephemeral and classical gully erosion. Grassed waterways limit soil erosion and nutrient loss by protecting the soil surface and improving soil cohesion.

CONTOUR BUFFER STRIP

Contour buffer strips are filter strips of perennial vegetation sited along contours. Stiff stemmed grasses in the strips slow runoff and limit soil erosion and loss of sediment-adsorbed nutrients such as phosphorus.

WATER & SEDIMENT CONTROL BASIN

Water and sediment control basins (WASCOBs) are small impoundments sited within concentrated flowpaths. WASCOBs reduce runoff, downslope erosion and sediment and phosphorus losses.

Riparian Function

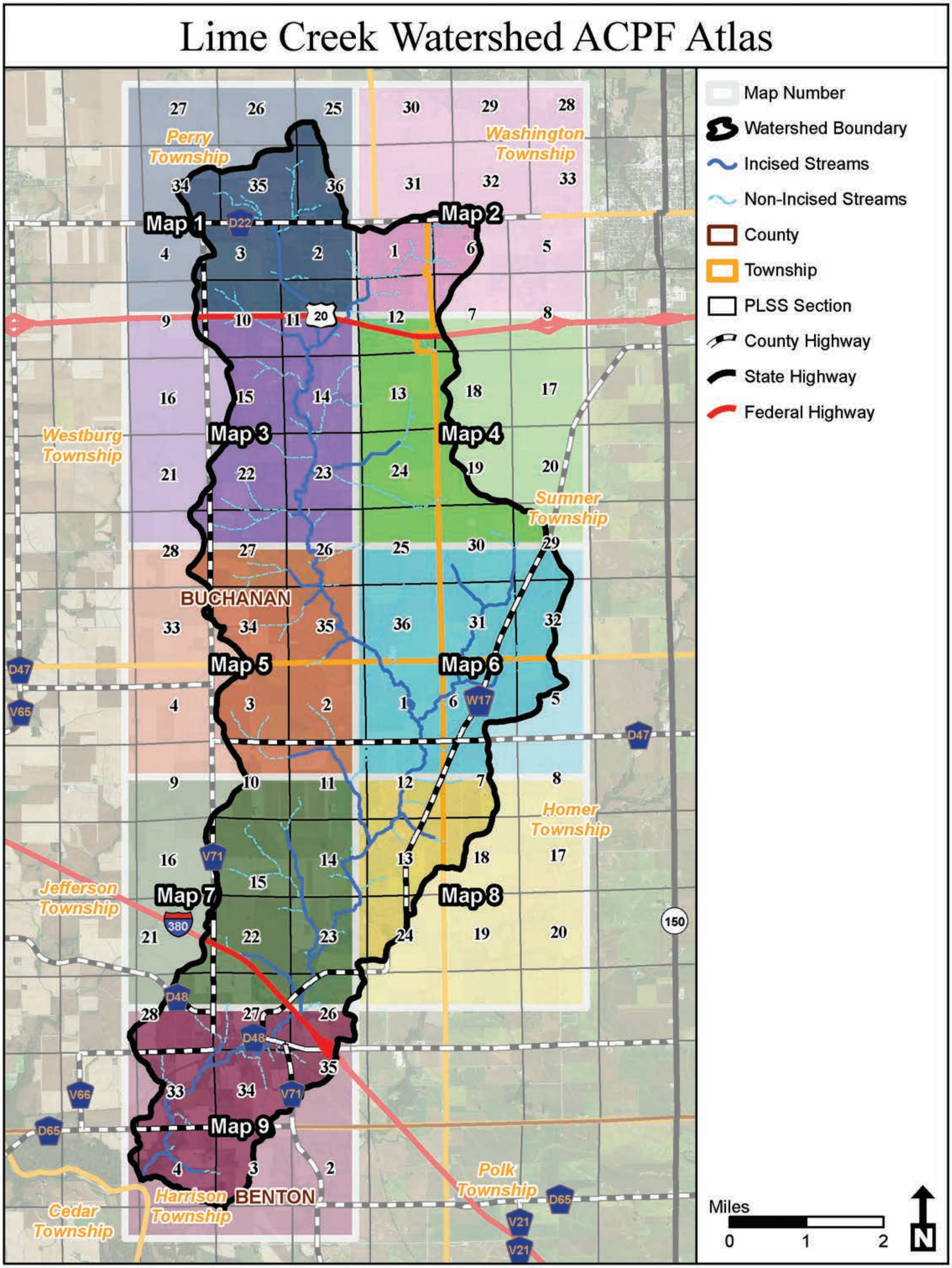
The ACPF includes a riparian assessment tool that identifies riparian management alternatives based on runoff and water table conditions. The five buffer types are determined with the following matrix (Tomer et al., 2015b):

RUNOFF DELIVERY	SHALLOW WATER TABLE WIDTH: HIGH	MEDIUM	LOW
HIGH	CZ	MSB	SSG
MEDIUM	MSB	MSB	SSG
LOW	DRV	DRV	SBS

Riparian buffer alternatives are identified based on potential for runoff interception (stiff stemmed grasses, SSG), shallow groundwater treatment (deep rooted vegetation, DRV), both (critical zone, CZ, and multi species buffer, MSB), or other stream protection (stream bank stabilization, SBS).

Acknowledgments

David James, USDA-Agricultural Research Service, provided the digital elevation model used to run the ACPF tools.


Lime Creek Watershed ACPF Atlas
Map Number
Watershed Boundary
Incised Streams
Non-Incised Streams
County
Township
PLSS Section
County Highway
State Highway
Federal Highway
Perry Township
Washington Township
Westburg Township
Sumner Township
Homer Township
Jefferson Township
Cedar Township
Harrison Township
Polk Township
BUCHANAN
BENTON
Map 1
Map 2
Map 3
Map 4
Map 5
Map 6
Map 7
Map 8
Map 9
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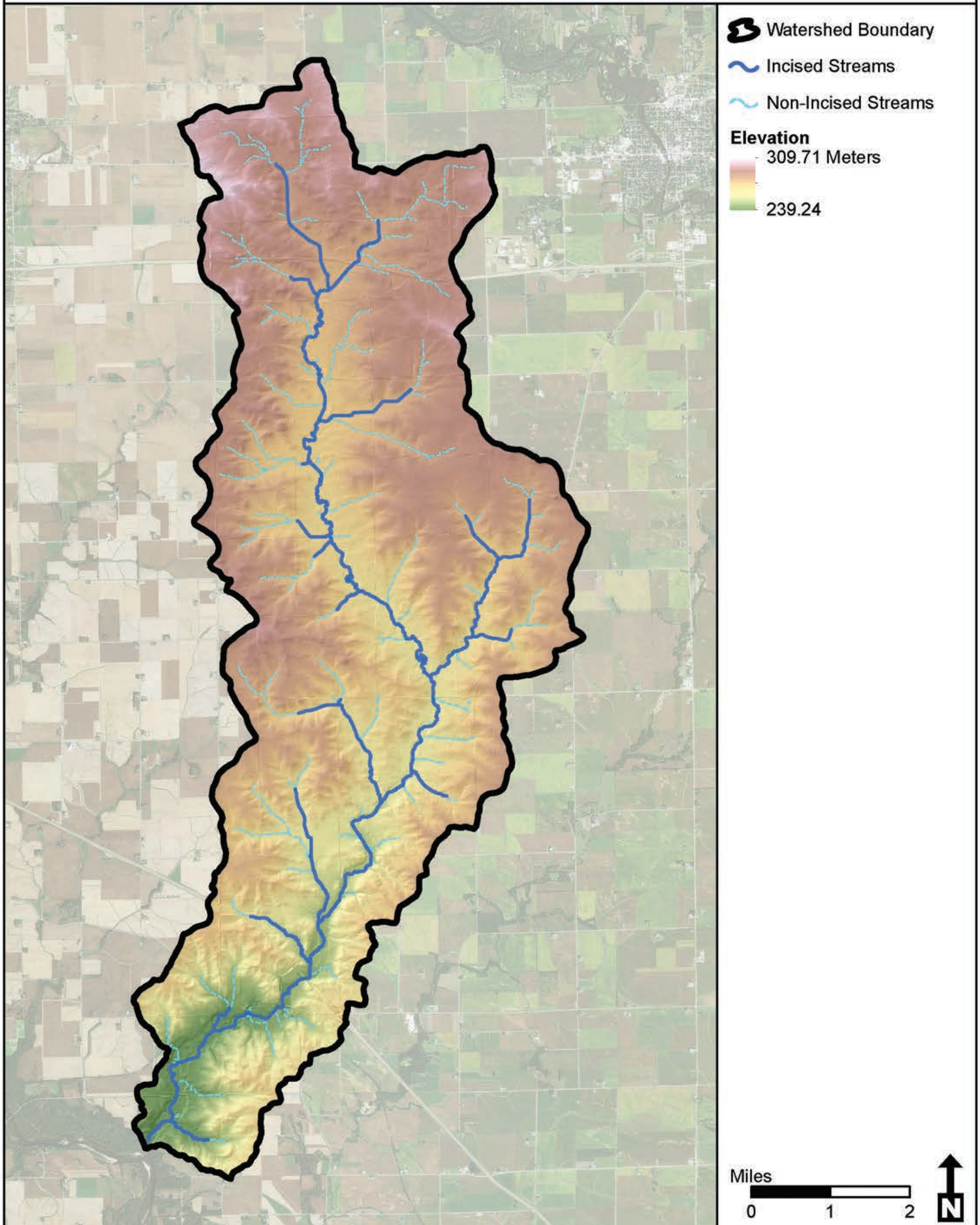
2
N

Elevation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Non-Incised Streams
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239.24
Miles
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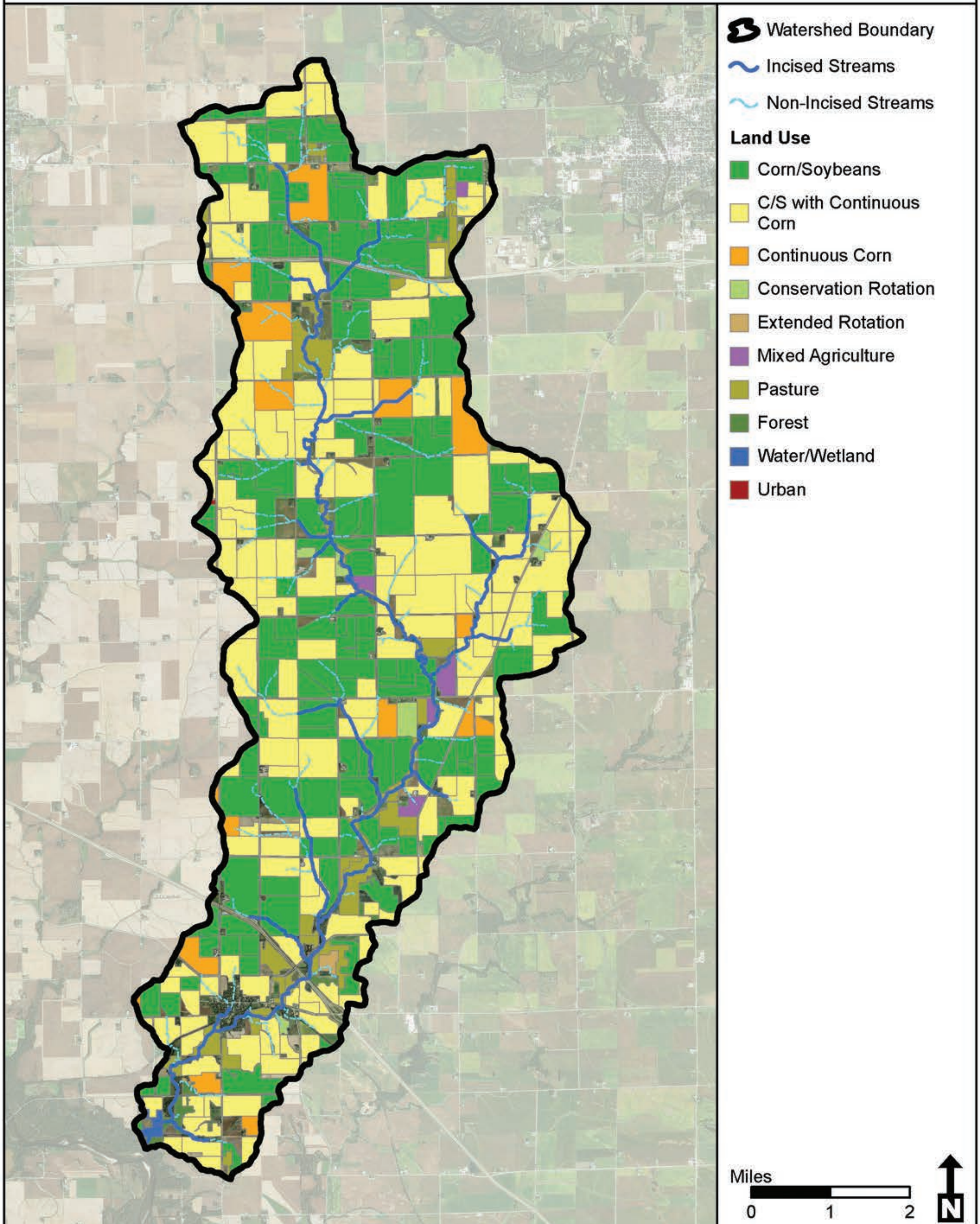
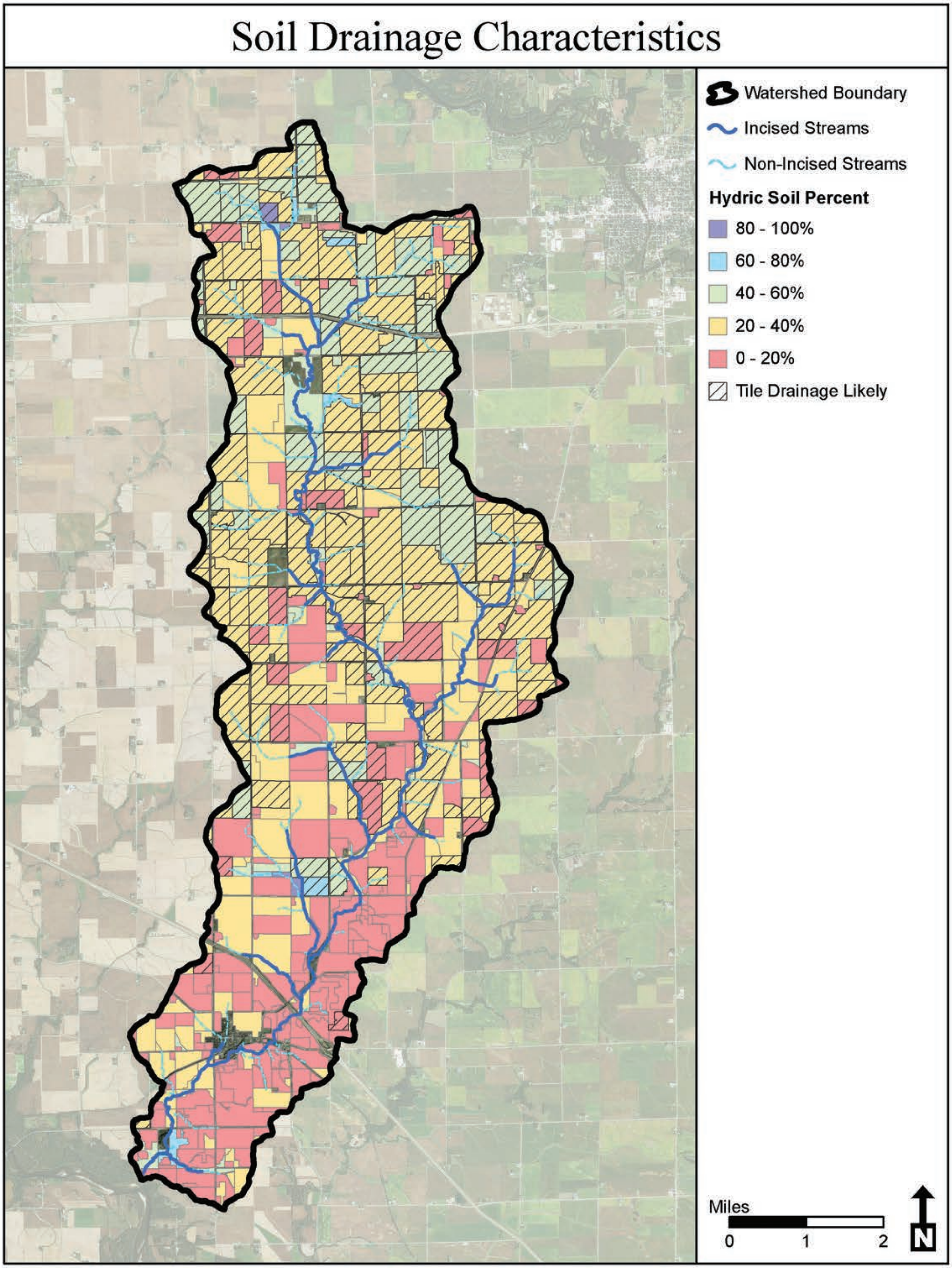
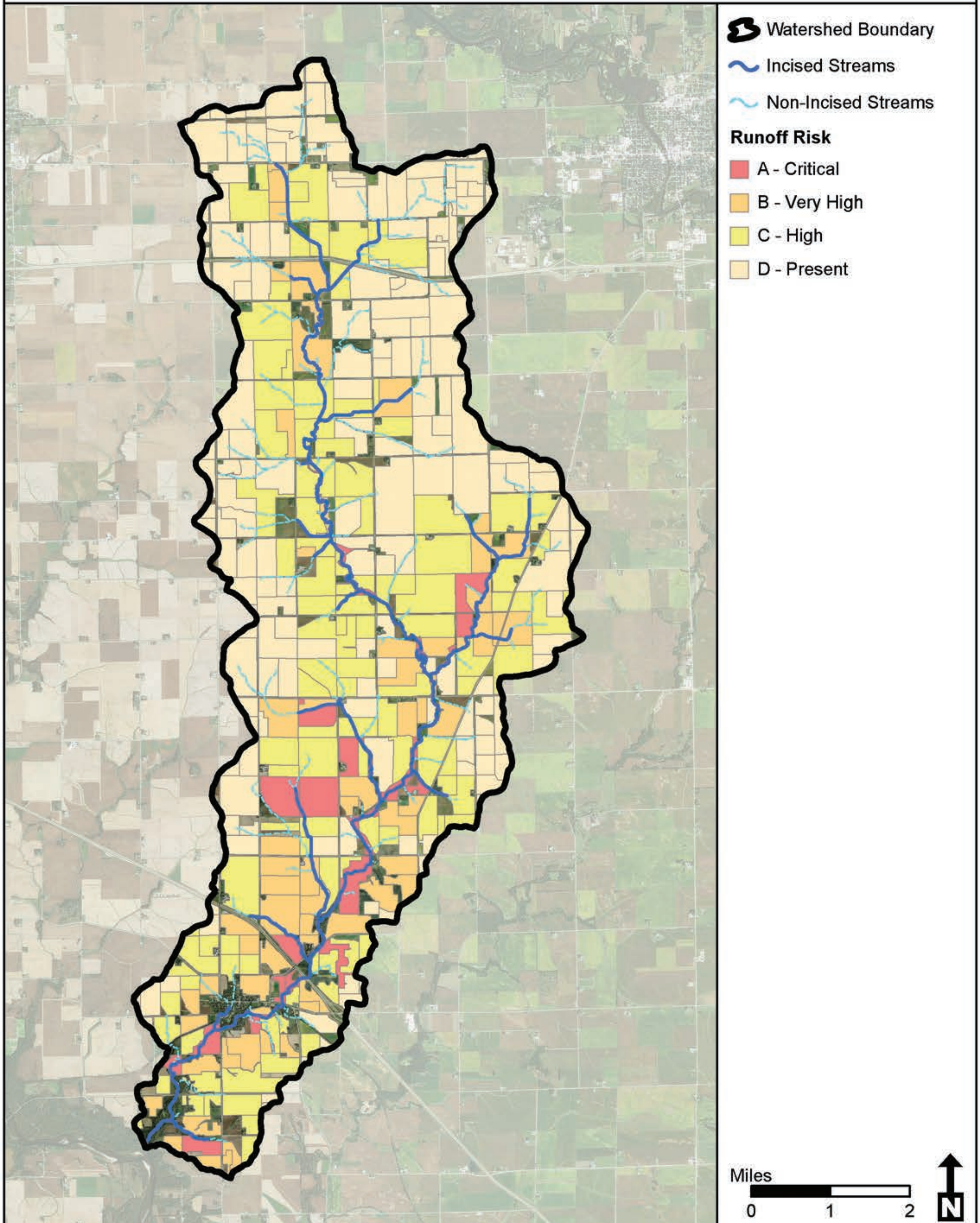
1
2
N

Land Use

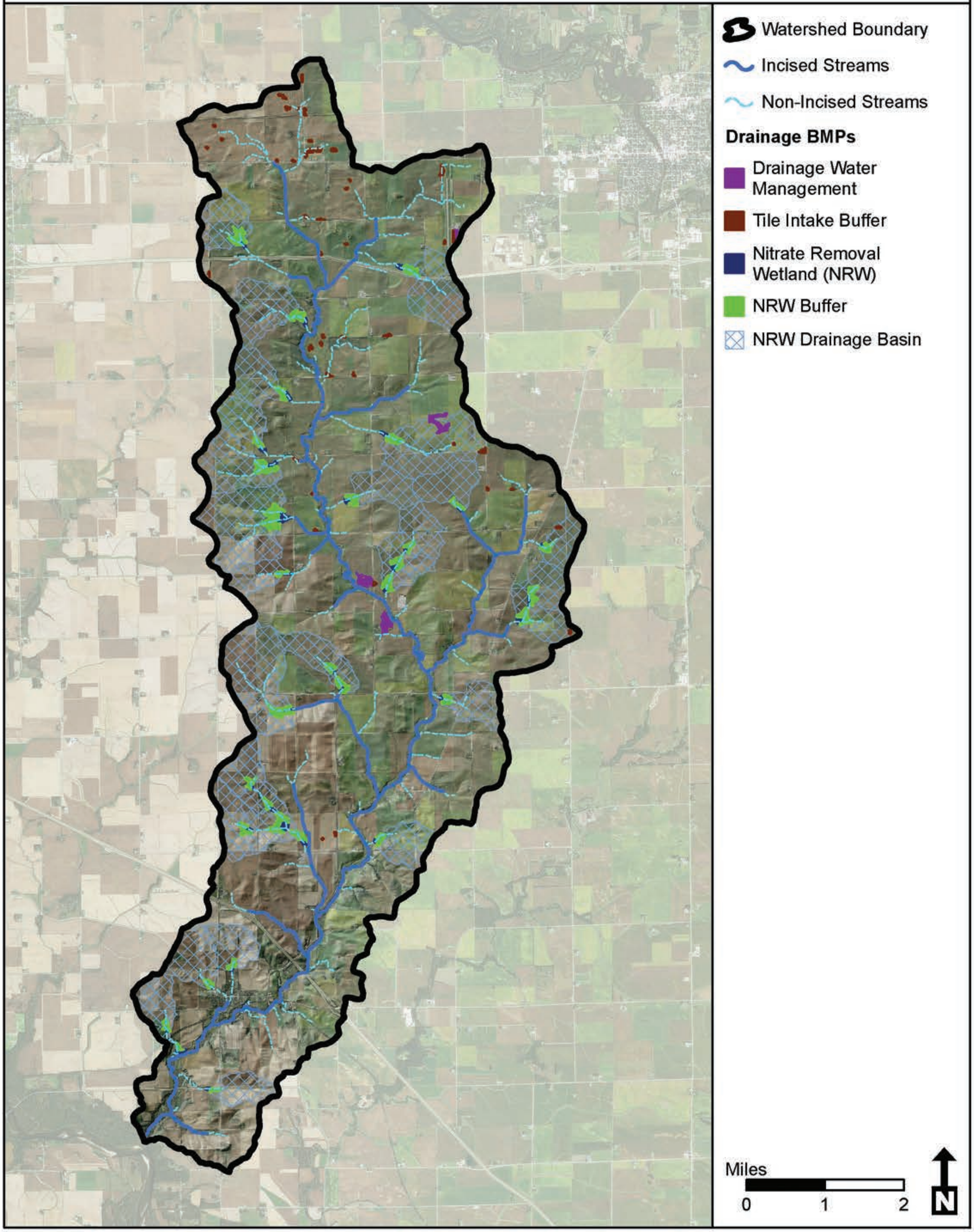

Watershed Boundary
Incised Streams
Non-Incised Streams
Land Use
Corn/Soybeans
C/S with Continuous Corn
Continuous Corn
Conservation Rotation
Extended Rotation
Mixed Agriculture
Pasture
Forest
Water/Wetland
Urban
Miles
0
1
2
N

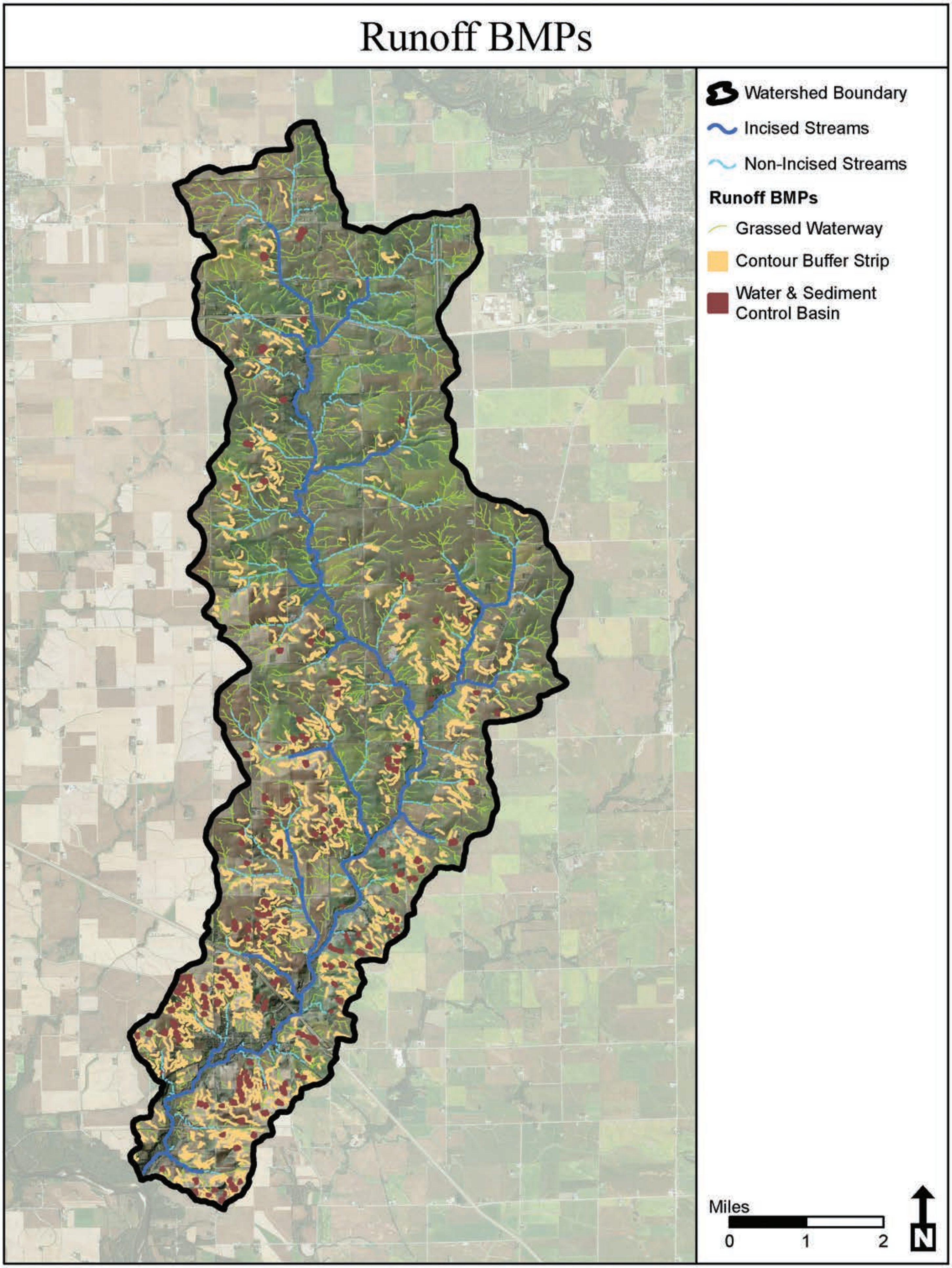

Soil Drainage Characteristics
Watershed Boundary
Incised Streams
Non-Incised Streams
Hydric Soil Percent
80 - 100%
60 - 80%
40 - 60%
20 - 40%
0 - 20%
Tile Drainage Likely
Miles
0
1
2
N

Runoff Risk

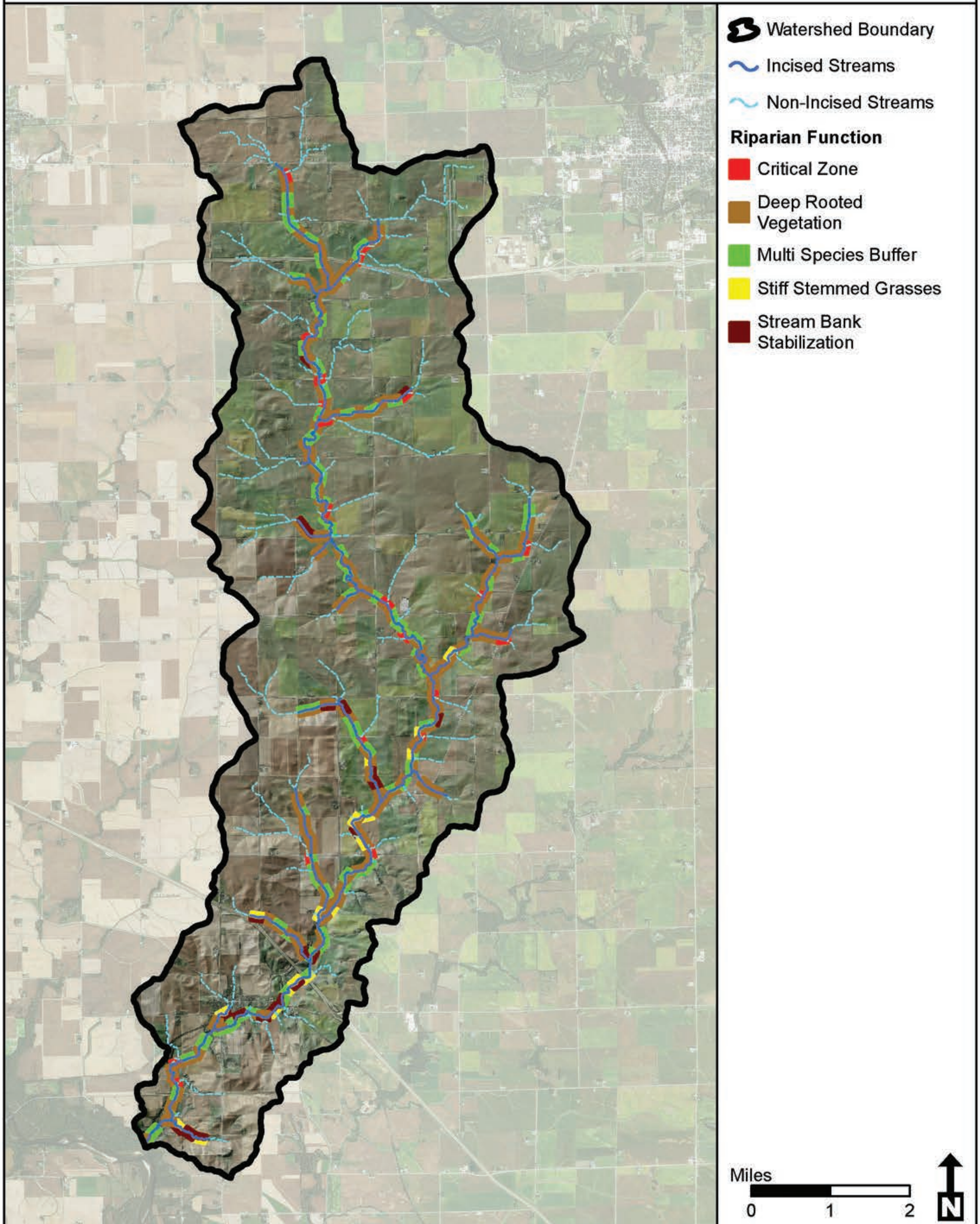

Watershed Boundary
Incised Streams
Non-Incised Streams
Runoff Risk
A - Critical
B - Very High
C - High
D - Present
Miles
0
1
2
N

Drainage BMPs

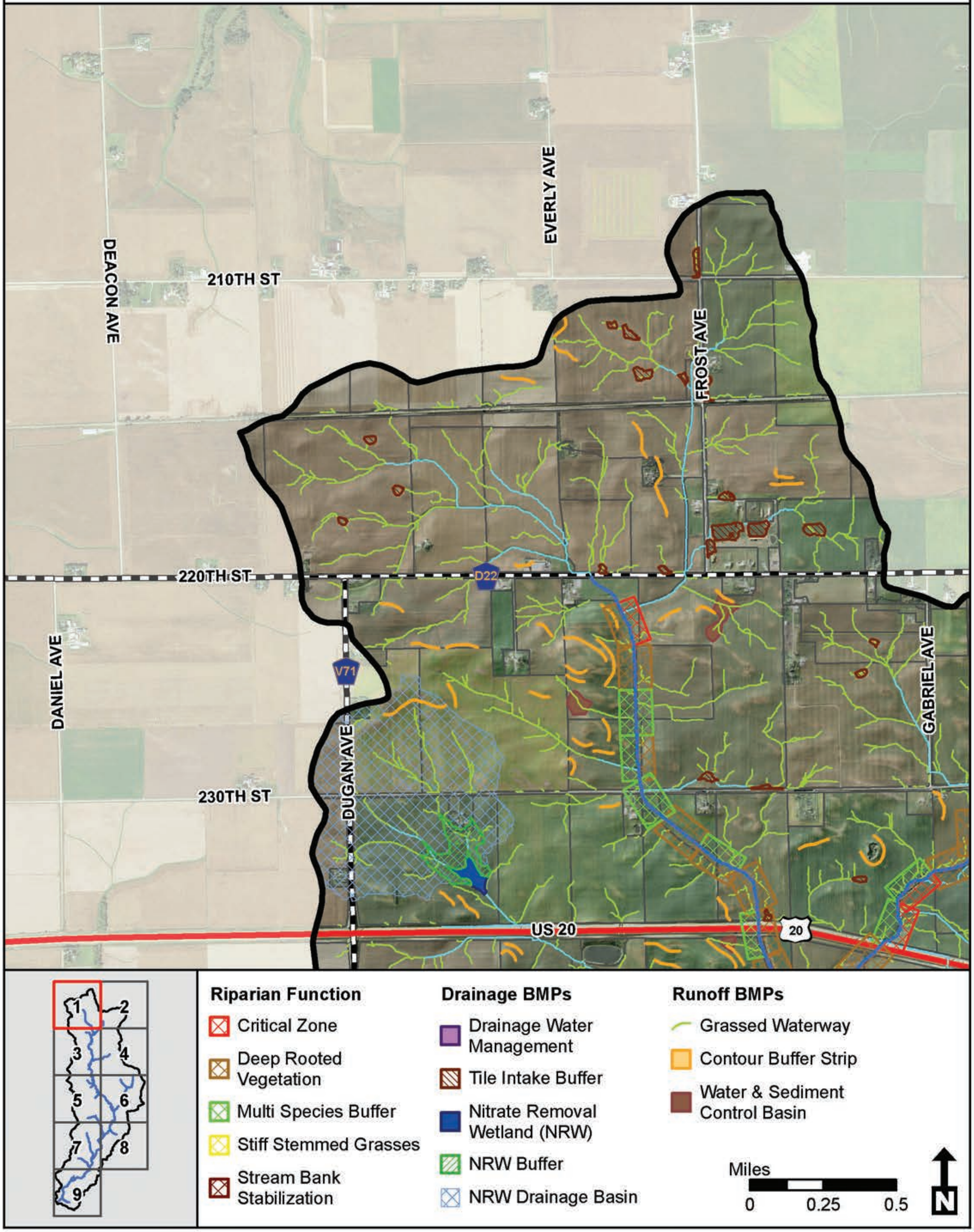



Runoff BMPs
Watershed Boundary
Incised Streams
Non-Incised Streams
Runoff BMPs
Grassed Waterway
Contour Buffer Strip
Water & Sediment Control Basin
Miles
0
1
2
N

Riparian Function

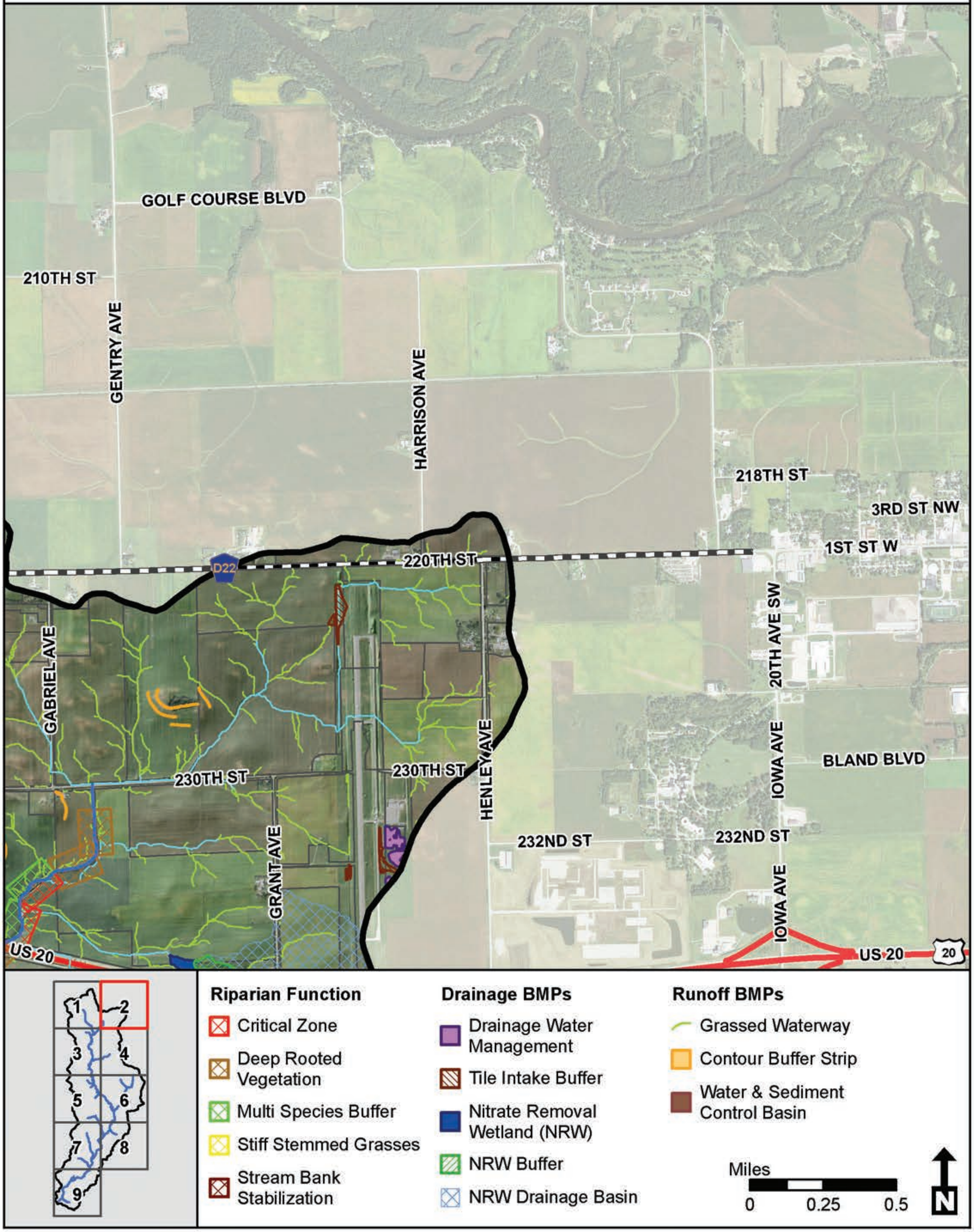


Map 1

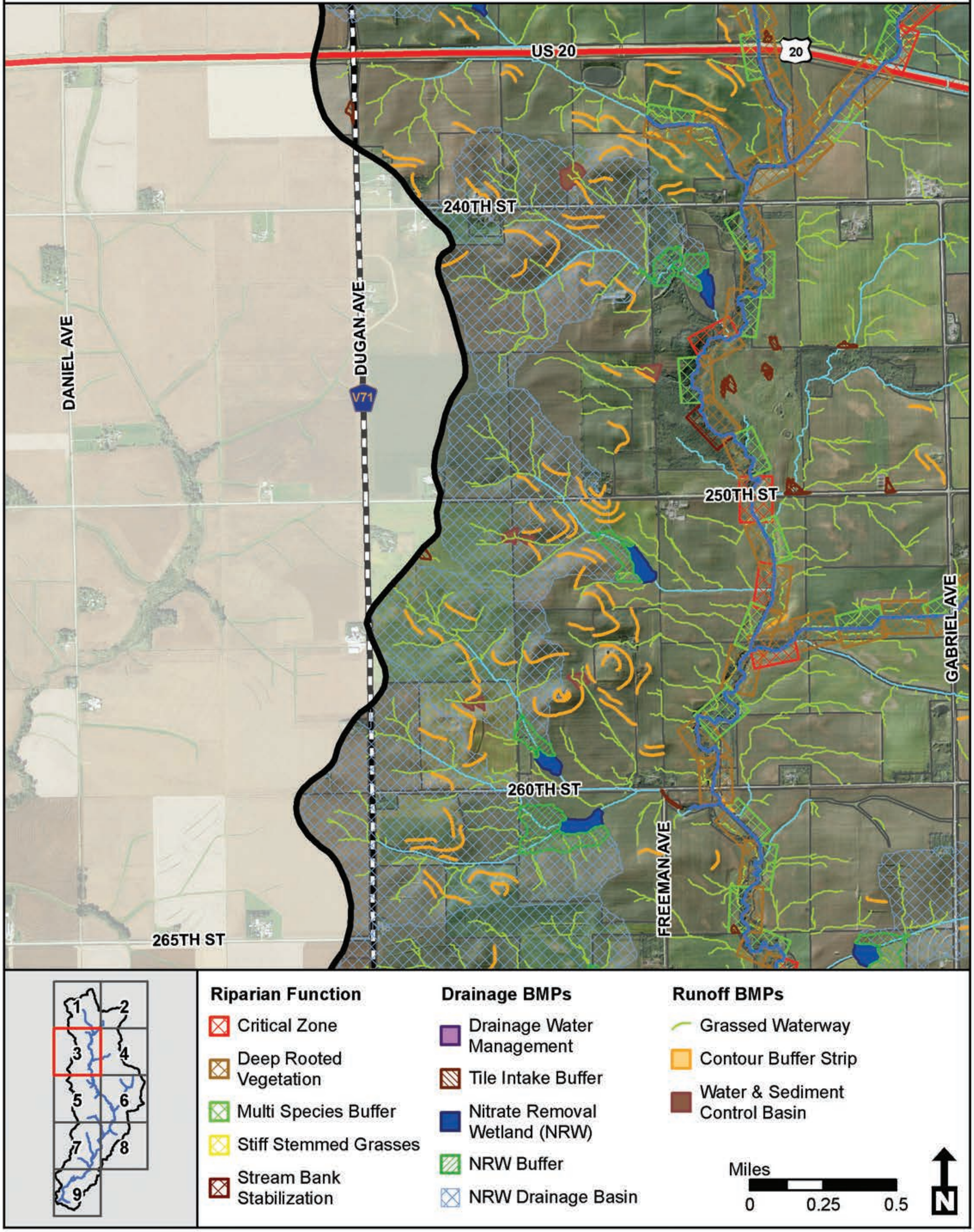


EVERLY AVE
DEACON AVE
210TH ST
FROST AVE
220TH ST
D22
V71
DANIEL AVE
GABRIEL AVE
DUGAN AVE
230TH ST
US 20
20
1
2
3
4
5
6
7
8
9
Riparian Function
Critical Zone
Deep Rooted Vegetation
Multi Species Buffer
Stiff Stemmed Grasses
Stream Bank Stabilization
Drainage BMPs
Drainage Water Management
Tile Intake Buffer
Nitrate Removal Wetland (NRW)
NRW Buffer
NRW Drainage Basin
Runoff BMPs
Grassed Waterway
Contour Buffer Strip
Water & Sediment Control Basin
Miles
0
0.25
0.5
N

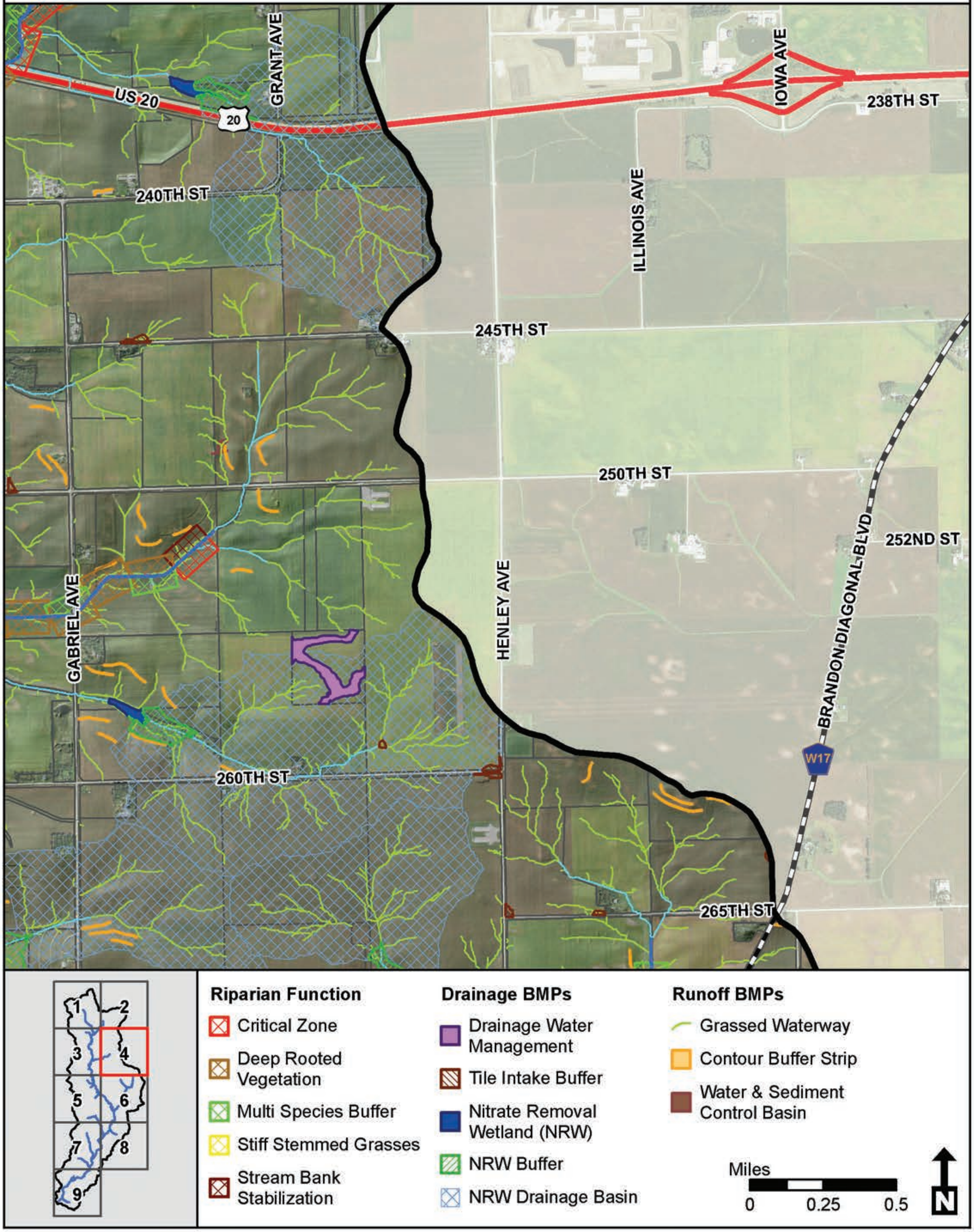
Map 2


GOLF COURSE BLVD
210TH ST
GENTRY AVE
HARRISON AVE
218TH ST
3RD ST NW
1ST ST W
D22
220TH ST
20TH AVE SW
GABRIEL AVE
230TH ST
230TH ST
HENLEY AVE
BLAND BLVD
IOWA AVE
232ND ST
232ND ST
GRANT AVE
IOWA AVE
US 20
US 20
20
1
2
3
4
5
6
7
8
9
Riparian Function
Critical Zone
Deep Rooted Vegetation
Multi Species Buffer
Stiff Stemmed Grasses
Stream Bank Stabilization
Drainage BMPs
Drainage Water Management
Tile Intake Buffer
Nitrate Removal Wetland (NRW)
NRW Buffer
NRW Drainage Basin
Runoff BMPs
Grassed Waterway
Contour Buffer Strip
Water & Sediment Control Basin
Miles
0
0.25
0.5
N

Map 3

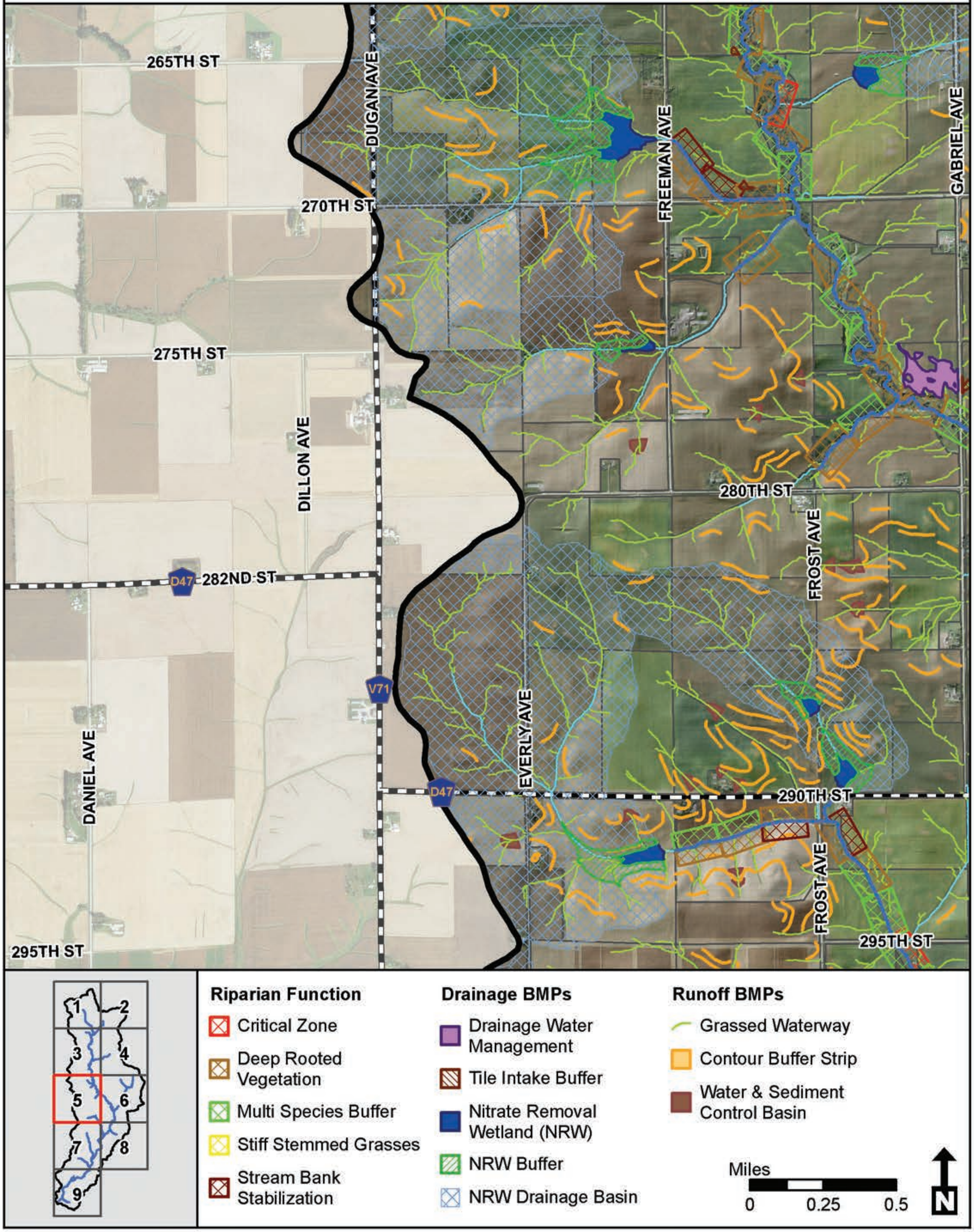

US 20
20
240TH ST
250TH ST
260TH ST
265TH ST
DANIEL AVE
DUGAN AVE
V71
FREEMAN AVE
GABRIEL AVE
1
2
3
4
5
6
7
8
9
Riparian Function
Critical Zone
Deep Rooted Vegetation
Multi Species Buffer
Stiff Stemmed Grasses
Stream Bank Stabilization
Drainage BMPs
Drainage Water Management
Tile Intake Buffer
Nitrate Removal Wetland (NRW)
NRW Buffer
NRW Drainage Basin
Runoff BMPs
Grassed Waterway
Contour Buffer Strip
Water & Sediment Control Basin
Miles
0
0.25
0.5
N

Map 4



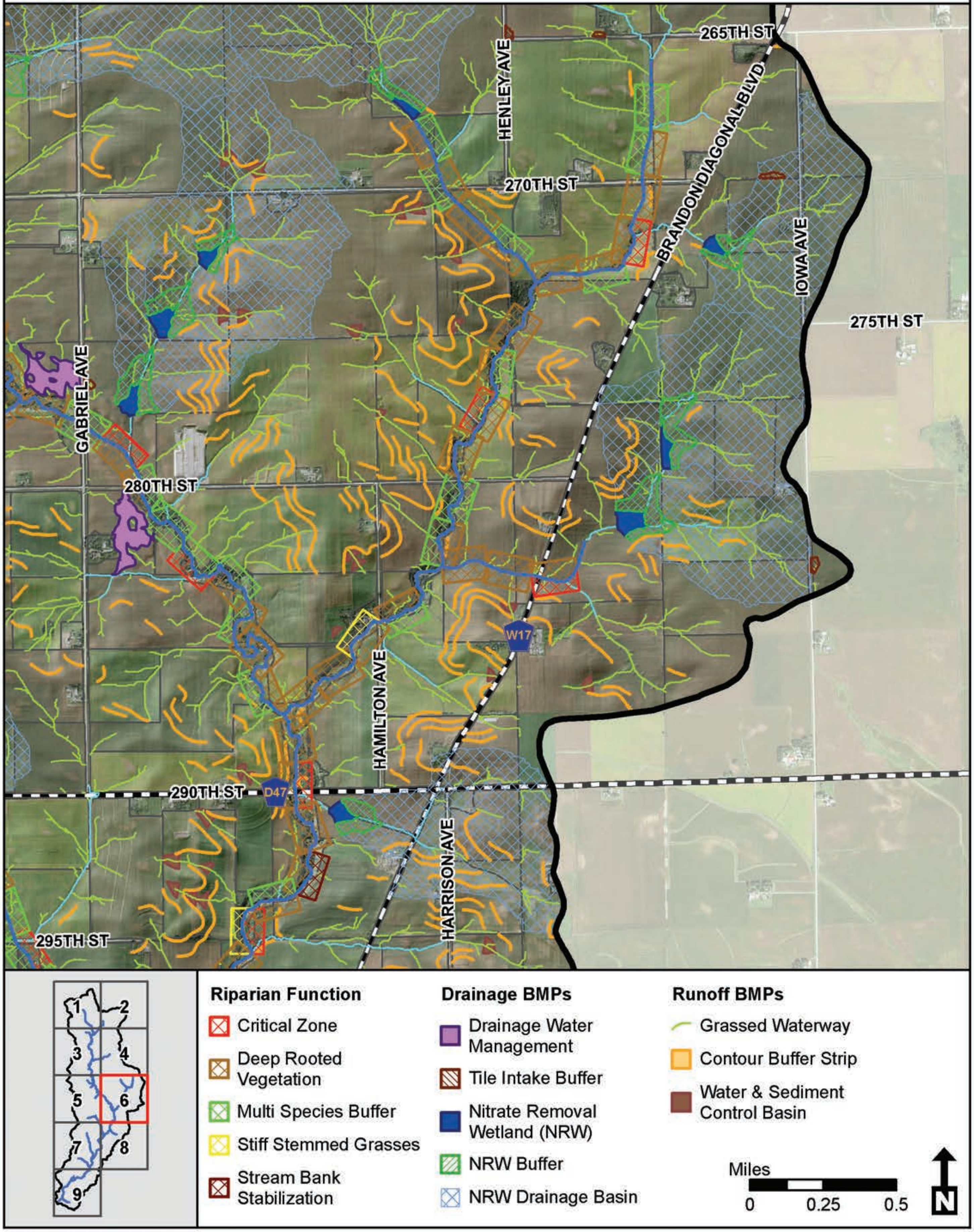
US 20
20
GRANT AVE
IOWA AVE
238TH ST
240TH ST
ILLINOIS AVE
245TH ST
250TH ST
252ND ST
BRANDON DIAGONAL BLVD
HENLEY AVE
GABRIEL AVE
W17
260TH ST
265TH ST
1
2
3
4
5
6
7
8
9
Riparian Function
Critical Zone
Deep Rooted Vegetation
Multi Species Buffer
Stiff Stemmed Grasses
Stream Bank Stabilization
Drainage BMPs
Drainage Water Management
Tile Intake Buffer
Nitrate Removal Wetland (NRW)
NRW Buffer
NRW Drainage Basin
Runoff BMPs
Grassed Waterway
Contour Buffer Strip
Water & Sediment Control Basin
Miles
0
0.25
0.5
N

Map 5

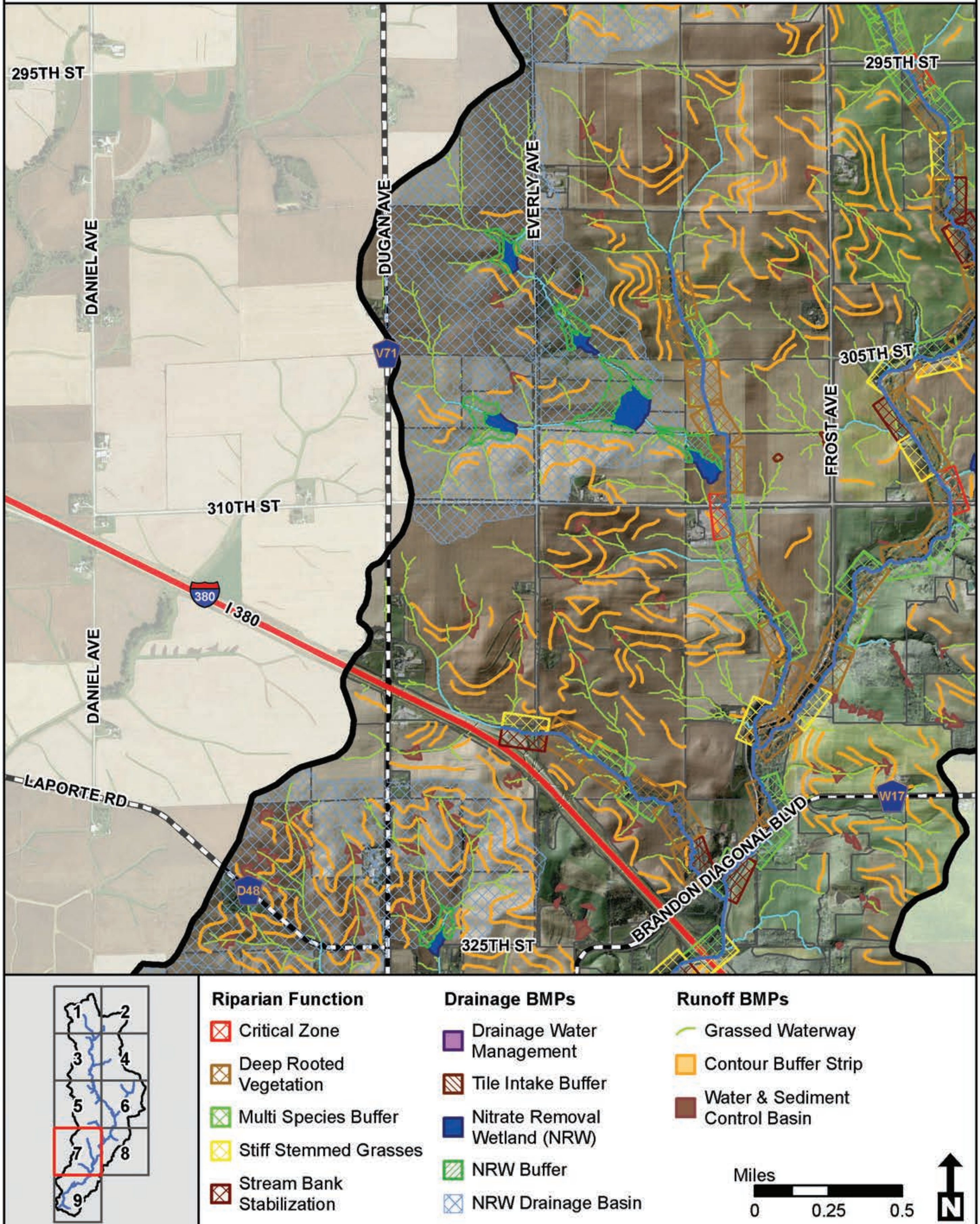


265TH ST
DUGAN AVE
FREEMAN AVE
GABRIEL AVE
270TH ST
275TH ST
DILLON AVE
280TH ST
FROST AVE
D47
282ND ST
V71
DANIEL AVE
EVERLY AVE
290TH ST
295TH ST
1
2
3
4
5
6
7
8
9
Riparian Function
Critical Zone
Deep Rooted Vegetation
Multi Species Buffer
Stiff Stemmed Grasses
Stream Bank Stabilization
Drainage BMPs
Drainage Water Management
Tile Intake Buffer
Nitrate Removal Wetland (NRW)
NRW Buffer
NRW Drainage Basin
Runoff BMPs
Grassed Waterway
Contour Buffer Strip
Water & Sediment Control Basin
Miles
0
0.25
0.5
N

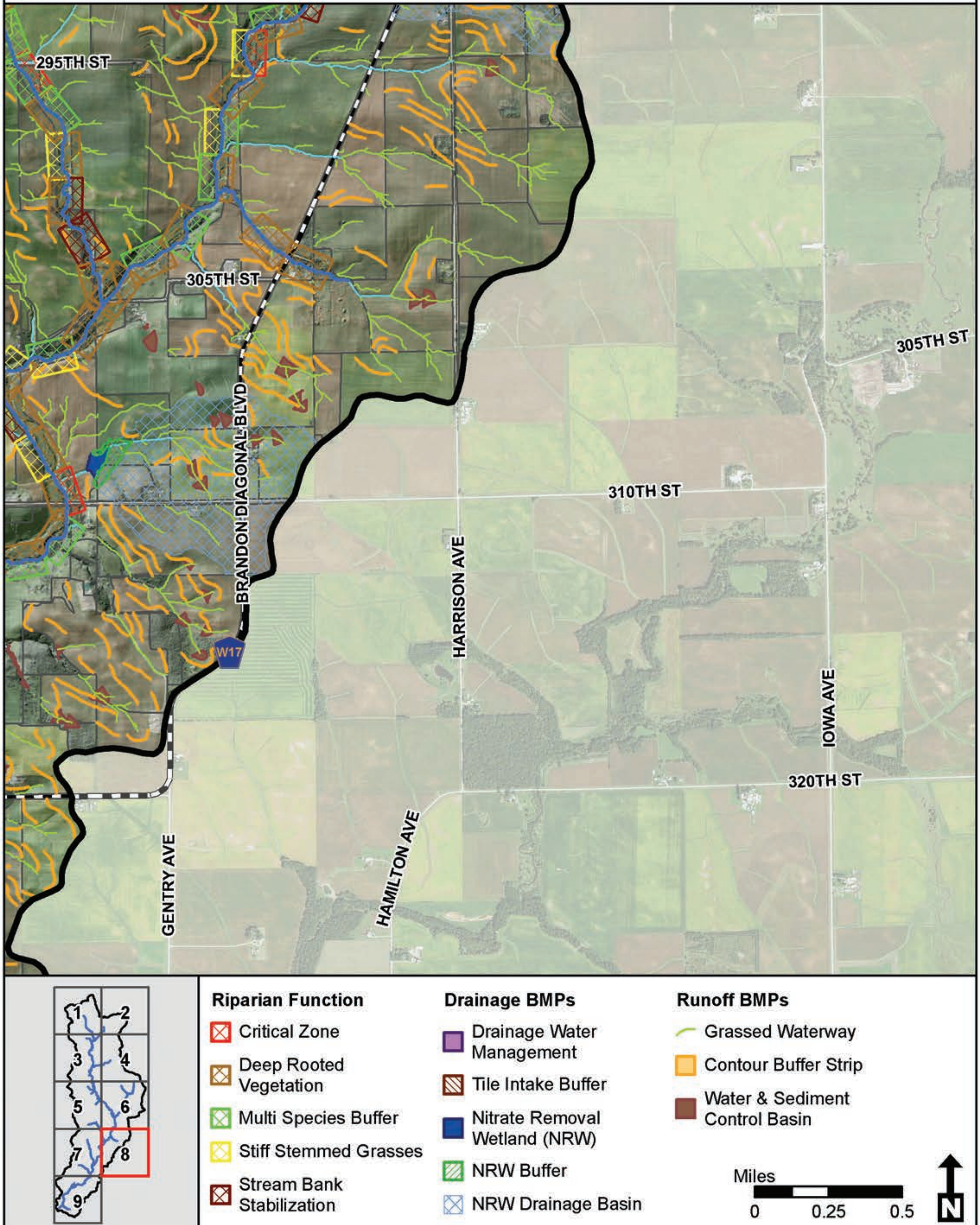
Map 6


265TH ST
HENLEY AVE
BRANDON DIAGONAL BLVD
270TH ST
IOWA AVE
275TH ST
GABRIEL AVE
280TH ST
W17
HAMILTON AVE
290TH ST
D47
HARRISON AVE
295TH ST
1
2
3
4
5
6
7
8
9
Riparian Function
Critical Zone
Deep Rooted Vegetation
Multi Species Buffer
Stiff Stemmed Grasses
Stream Bank Stabilization
Drainage BMPs
Drainage Water Management
Tile Intake Buffer
Nitrate Removal Wetland (NRW)
NRW Buffer
NRW Drainage Basin
Runoff BMPs
Grassed Waterway
Contour Buffer Strip
Water & Sediment Control Basin
Miles
0
0.25
0.5
N

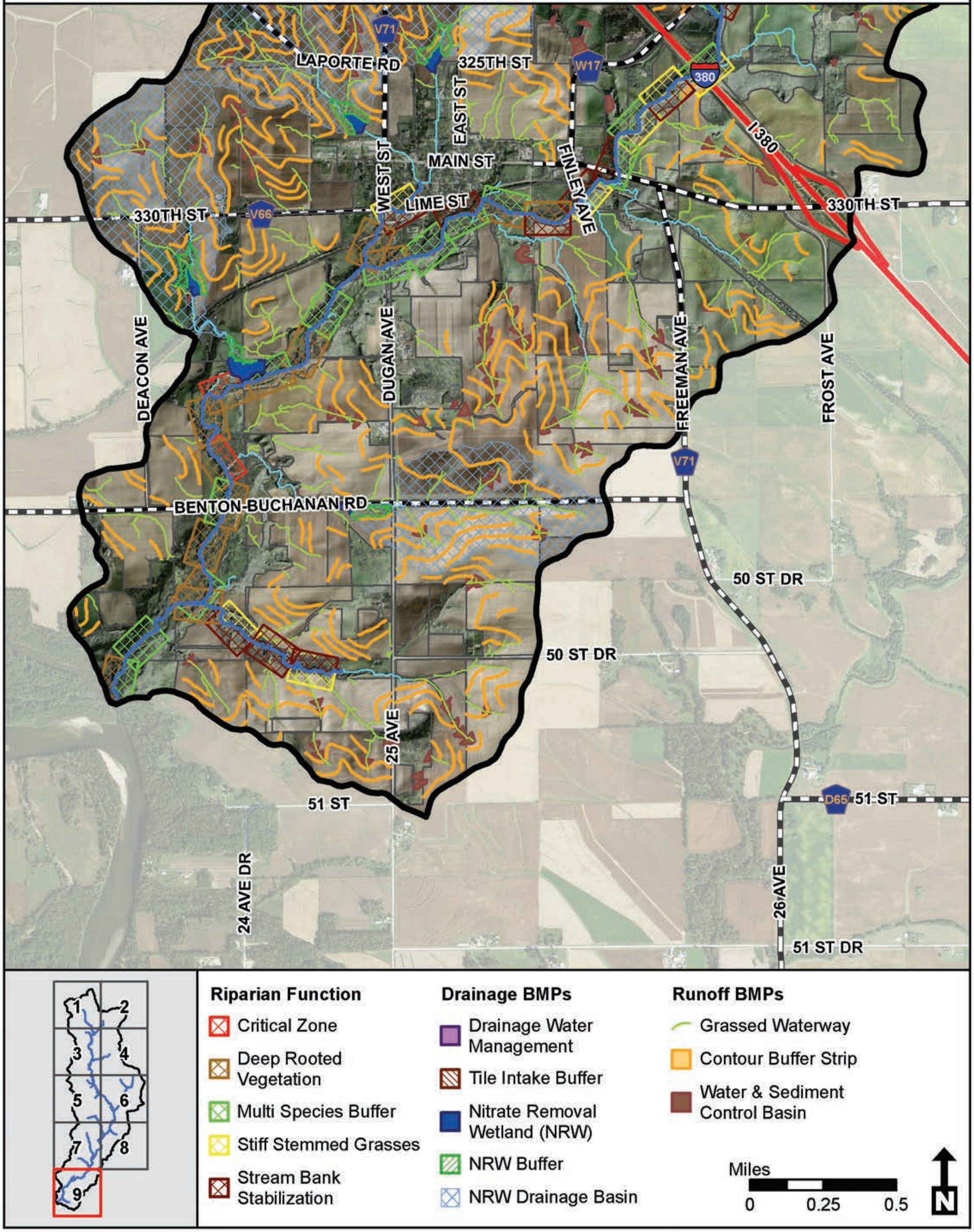
Map 7


295TH ST
295TH ST
DANIEL AVE
DUGAN AVE
EVERLY AVE
V71
305TH ST
FROST AVE
310TH ST
380
I 380
DANIEL AVE
LAPORTE RD
W17
BRANDON DIAGONAL BLVD
D48
325TH ST
1
2
3
4
5
6
7
8
9
Riparian Function
Critical Zone
Deep Rooted Vegetation
Multi Species Buffer
Stiff Stemmed Grasses
Stream Bank Stabilization
Drainage BMPs
Drainage Water Management
Tile Intake Buffer
Nitrate Removal Wetland (NRW)
NRW Buffer
NRW Drainage Basin
Runoff BMPs
Grassed Waterway
Contour Buffer Strip
Water & Sediment Control Basin
Miles
0
0.25
0.5
N

Map 8


295TH ST
305TH ST
BRANDON DIAGONAL BLVD
W17
305TH ST
310TH ST
HARRISON AVE
IOWA AVE
320TH ST
GENTRY AVE
HAMILTON AVE
1
2
3
4
5
6
7
8
9
Riparian Function
Critical Zone
Deep Rooted Vegetation
Multi Species Buffer
Stiff Stemmed Grasses
Stream Bank Stabilization
Drainage BMPs
Drainage Water Management
Tile Intake Buffer
Nitrate Removal Wetland (NRW)
NRW Buffer
NRW Drainage Basin
Runoff BMPs
Grassed Waterway
Contour Buffer Strip
Water & Sediment Control Basin
Miles
0
0.25
0.5
N

Map 9


LAPORTE RD
325TH ST
EAST ST
WEST ST
MAIN ST
FINLEY AVE
LIME ST
330TH ST
I-380
DEACON AVE
DUGAN AVE
FREEMAN AVE
FROST AVE
BENTON-BUCHANAN RD
50 ST DR
25 AVE
51 ST
24 AVE DR
26 AVE
51 ST DR
V71
W17
V66
380
D65
1
2
3
4
5
6
7
8
9
Riparian Function
Critical Zone
Deep Rooted Vegetation
Multi Species Buffer
Stiff Stemmed Grasses
Stream Bank Stabilization
Drainage BMPs
Drainage Water Management
Tile Intake Buffer
Nitrate Removal Wetland (NRW)
NRW Buffer
NRW Drainage Basin
Runoff BMPs
Grassed Waterway
Contour Buffer Strip
Water & Sediment Control Basin
Miles
0
0.25
0.5
N

Not funded by the soybean checkoff.

Iowa Soybean Association
Environmental
Programs & Services

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Association
Expanding Opportunities. Delivering Results.