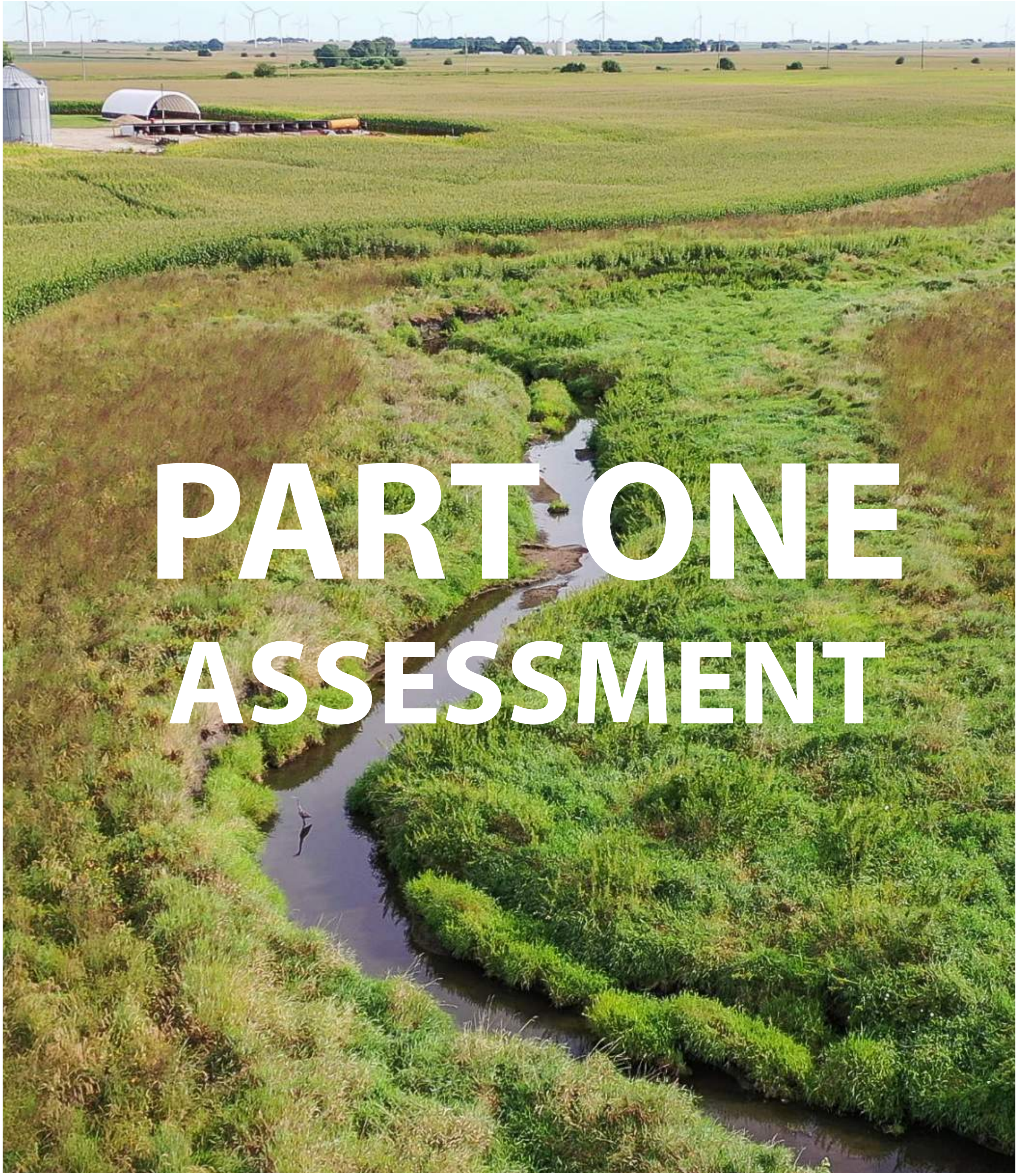
PART ONE
ASSESSMENT



JANUARY 2020

BEAVER CREEK
watershed plan

RDG PLANNING • DESIGN

EOR water ecology community

SNYDER & ASSOCIATES

This watershed plan was commissioned by the members of the

BEAVER CREEK
watershed management authority

With contributions of its Board and Watershed Plan Steering Committee, in partnership with the consultant team led by RDG Planning & Design.

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CONTENTS

WHERE DO I FIND EPA'S NINE MINIMUM ELEMENTS FOR WATERSHED PLANS?

Although many different components may be included in a watershed plan, EPA has identified nine key elements that are critical for achieving improvements in water quality. EPA requires that these nine elements be addressed in watershed plans funded with Clean Water Act section 319 funds and strongly recommends that they be included in all other watershed plans intended to address water quality impairments. In general, state water quality or natural resource agencies and EPA will review watershed plans that provide the basis for section 319-funded projects. Although there is no formal requirement for EPA to approve watershed plans, the plans must address these nine elements if they are developed in support of a section 319-funded project.

- Adapted from "Handbook for Developing Watershed Plans to Restore and Protect Our Waters", USEPA Office of Water – Nonpoint Source Control Branch, March 2008.

#1 - Identification of causes of impairment and pollutant sources or groups of similar sources that need to be controlled to achieve needed load reductions and any goals identified in the watershed plan. Sources that need to be controlled should be identified at the significant subcategory level along with estimates of the extent to which they are present in the watershed.

CHAPTER 2
Factors related to hydrology and potential pollution sources such as terrain, soils, and land use changes.

CHAPTER 3
A review of known impairments of designated uses for water resources within this watershed.

CHAPTER 4
Current and historic climate data is reviewed, along with an analysis of historic streamflow patterns and flood risk.

CHAPTER 5
A review of related studies that were previously completed that influence this plan.

CHAPTER 6
Identification of the key pollutants of concern identified by this plan and the potential impacts of these pollutants. Existing available monitoring data is reviewed. Pollutant load and sources are projected by subwatershed and land use type.

CHAPTER 7
Details regarding stream characteristics, stability and buffering.

CHAPTER 8
Pollutant load and sources are projected by subwatershed and land use type.

#2 - An estimate of the load reductions expected from management measures.

CHAPTER 11
For each of the eleven HUC-12 subwatershed a specific 3-0year implementation plan has been developed which includes projected load reductions.

CHAPTER 14
Rates of implementation and reduction are included in this chapter.

#3 - A description of the non-point source management measures that will need to be implemented to achieve load reductions and a description of the critical areas in which those measures will be needed to implement this plan.

CHAPTER 10

Proposed policy changes are non-structural management measures. The urban and rural policies outlined in this plan are those that are recommended for adoption to achieve the goals of this plan.

CHAPTER 11

For each of HUC-12 subwatersheds the 30-year plan details the type and potential locations of management practices needed to meet the projected load reduction targets.

CHAPTER 12

Measures to address future flood risk are noted.

CHAPTER 14

A list of first steps and adoption rates are included here.

CHAPTER 15

Cost associated with implementation of strategies outlined in this plan are included in this chapter.

#4 - Estimate of the amounts of technical and financial assistance needed, associated costs and/or the sources and authorities that will be relied upon to implement this plan.

CHAPTER 10

Reviews some of the technical assistance needed to implement policy changes.

CHAPTER 11

Evaluates the cost of implementation strategies at the subwatershed scale.

CHAPTER 15

Summarizes costs for watershed scale implementation and monitoring.

#5 - An information and education component used to enhance public understanding of the project and encourage their early and continued participation in selecting, designing and implementing the non-point source management measures that will be implemented.

CHAPTER 13

This is the education and collaboration plan.

#6 - Schedule for implementing the non-point source management measures identified in this plan that is reasonably expeditious.

CHAPTERS 11 AND 12

Include the strategies for addressing water quality and flood risk

CHAPTER 14

The schedule for implementation of the practices listed in Chapters 11 and 12 can be found here.

#7 - A description of interim measurable milestones for determining whether non-point source management measures or other control actions are being implemented.

SEE CHAPTER 14

#8 - A set of criteria that can be used to determine whether loading reductions are being achieved over time and substantial progress is being made toward attaining water quality standards.

SEE CHAPTER 14

#9 - A monitoring component to evaluate the effectiveness of the implementation efforts over time, measured against the criteria established under item #8.

CHAPTER 14

The monitoring program is outlined here.

CHAPTER 15

The costs and schedule for implementing the monitoring program is included in this chapter.

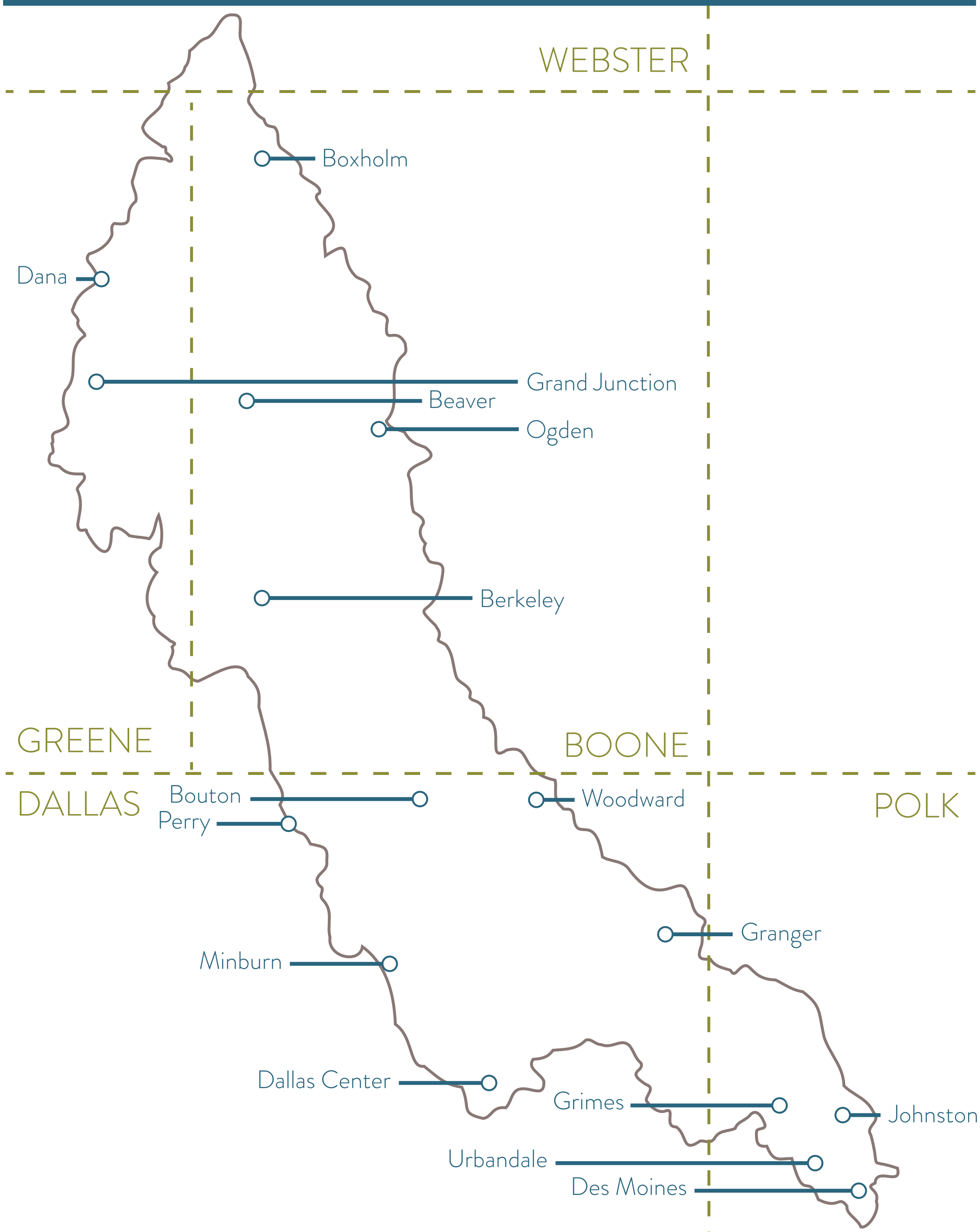
01

THE PROCESS & THIS PLAN

This chapter gives a brief overview of the Beaver Creek Watershed Plan and the process used to interact with key stakeholders throughout to its creation. It also provides guidance on how to use this plan and where to find key pieces of information.

01

Jurisdictions within the watershed.



INTRODUCTION

In 2010, the State of Iowa passed legislation to allow local governments to form Watershed Management Authorities (WMA). The "Authority" in this name is a term the legislature often uses when referencing a convening body. In truth, each WMA has no actual authority. They cannot levy taxes, acquire property or enforce any types of rules on their own. Instead, **each one is an alliance of jurisdictions within a given watershed, coming together to focus on water quality and quantity issues through collaboration and education.** By law, WMAs cannot be formed without inviting all of the Soil and Water Conservation Districts, communities and counties within the designated watershed to the table. It only takes two such jurisdictions, joining together (by mutual adoption of a 28E agreement) to actually form the WMA.

The "authority," however, continues to rest with the local governments within each watershed. **For all practical purposes, a WMA can only recommend that its member-governments take action – it cannot force that action.**

The Beaver Creek WMA in Central Iowa was formed based on this legislation, with the process of building this alliance being spearheaded by the government of Polk County. A grant from the Iowa Department of Natural Resources was secured to pay for consulting services to development of this plan. As of the date of this plan, all but one (Dallas County) of the eligible jurisdictions originally invited to join the WMA have done so.

In 2018, the Beaver Creek WMA selected the consultant team of RDG Planning & Design (Des Moines), Emmons and Olivier Resources (Oakdale, MN / Boone) and Snyder and Associates (Ankeny) to guide the development of the watershed plan. The consultant roles could be generally described as follows:

- **RDG Planning and Design:**

  Project lead and project management, leading stakeholder engagement and public outreach and creating the master plan document, based on technical information provided by their partner firms.
- **Emmons and Olivier Resources:**

  Perform water quality resource assessments and development of related plan elements.
- **Snyder and Associates:**

  Perform water quantity (flood impact) assessments and development of related plan elements.

Stakeholder workshop held in Ogden.

PROCESS

PUBLIC INTERACTIONS

Public involvement and input from key stakeholders were central to plan development. **This approach to stakeholder and public engagement was used to identify issues and build connections among stakeholders.** It allows for the exchange of ideas and builds greater understanding of the watershed. The list of participants involved in developing the plan was enlarged, expanding input and branding ownership.

WMA Meetings and Organization

STEERING COMMITTEE

Monthly meetings with a smaller workgroup dedicated to guiding plan development and providing more detailed review of technical information related to assessments and proposed implementation.

Meeting dates:

October 15, 2018
RDG led discussion about the process and schedule and preliminary assessment data collected.

November 5, 2018
The consultant team led discussion to determine the process for upcoming stakeholder workshops.

February 7, 2019
The consultant team reviewed the plan for Small Group meeting #2.

April 1, 2019
The consultant team led discussion about feedback gathered at Small Group meeting #2 and discussed approaches for developing implementation plan based on that feedback.

May 6, 2019
The consultant team discussed progress and approach for modeling and development of implementation plan.

June 25, 2019
The consultant team reviewed draft version of implementation plan.

August 22, 2019
RDG reviewed draft version of the education and outreach plan.

September 18, 2019
The consultant team reviewed draft plan chapters and comments on previously published report elements.

December 2018, January 2018, March 2019 were not held to accommodate other stakeholder workshops.

QUARTERLY MEETINGS

Scheduled meetings with the full WMA board to review progress and validate decisions made by the steering committee.

Meeting dates:

July 15, 2018:
Consultant team introductions were made to the board.

October 18, 2018
RDG and the consultant team provided update of process, schedule and assessment data collection.

January 17, 2019
RDG and the consultant team provided update of process, output from December and January stakeholder events. Summarized assessment material provided to IDNR.

April 18, 2019
RDG and the consultant team summarized information from prioritization workshops and validated direction on implementation plan that was discussed at the April 1 steering committee meeting.

July 18, 2019
RDG and the consultant team reviewed technical chapters of the HUC-12 water quality plans and approaches to address flooding.

October 18, 2019
Board review of completed watershed plan.

Stakeholder Events

TOPIC-BASED SMALL-GROUP MEETINGS

Description: **Two workshops that engaged small groups with local knowledge of specific watershed issues** (e.g., flooding, producer groups, channel stability) to use watershed data collection to validate assumptions and expand the consultant team's knowledge of local issues the plan should address. One workshop occurred during the assessment phase, the other during development of the implementation plan. When they occurred, they supplanted the steering committee meeting scheduled for that month.

First meeting: December 3, 2018 (assessment) – This meeting was used to review maps to validate assessment information gathered about the watershed related to natural resources, agricultural practices and flooding. Policies were a fourth topic discussed within small groups.

Second meeting: March 14, 2019 (implementation) – This meeting was used to review ACPF output and discuss strategies on how to prioritize work efforts to be described in the implementation plan.

Participants: Pre-identified list of jurisdictional staff, public works, crop service providers, landowners, producers, trade group representatives, women and legacy landowners, early implementors and other local advocates.

Outcome: A better definition of the specific, local issues that the watershed plan needs to address. Validated data collected from assessment reports, consultant analysis and project partners.

VISIONING - GOAL-SETTING WORKSHOP

Description: **A workshop to define the vision, goals and objectives to be addressed** as the plan moves from the assessment phase into implementation.

Meeting date: January 14, 2019 – A facilitated discussion was used to discuss the vision, mission, goals and objectives of the Beaver Creek Watershed plan. Groups offered feedback on "trial balloon mission statements", offering up their own versions of these statements. Refined lists of goals and objectives were also developed related to agricultural practices, flooding, natural resources and policy.

Participants: Pre-identified list of jurisdictional staff, public works, crop service providers, landowners, producers, early implementors and other local advocates.

Outcome: Finalized issues to be addressed by creation of an implementation plan. Described the vision, mission and objectives that the plan will seek to achieve.

NUMERIC DATA COLLECTION AND ANALYSIS

To complete this plan, numeric data was collected and analyzed for several key factors:

- Climate data from the Des Moines Airport Natural Weather Service Station, including temperature, precipitation and length of growing season. This information was used to determine recent and historic trends for these factors.
- Stream gage flow data from a USGS station located along Beaver Creek at NW 70th Avenue in Johnston, including daily average flow rates and gage height (measure of stream depth). This was used to look at seasonal and historic trends and patterns of runoff, stream flow and flood events.
- Water quality monitoring data from available sources. Although available data was limited, it was important in validating the key pollutants of concern, how their levels compare to state water quality standards and their potential sources within the watershed.

Desktop Analysis

Geographic Information System (GIS) data was reviewed to identify important conditions throughout the watershed. Aerial photographs (past and present), topographic information, soils data and other available information was analyzed. Surface information was used to more precisely identify the overall boundary of the Beaver Creek Watershed and subdivide it into smaller subwatershed areas. Output from the Agricultural Conservation Planning Framework tool from Iowa Department of Natural Resources was also integrated into the desktop analysis.

Field Assessments

Conditions noted in desktop assessments were verified by observations in the field. These included:

- Windshield surveys – following along roadways and trails to photograph and note conditions across the watershed.
- Information and photographs from local Soil and Water Conservation Districts, based on their interactions with land owners and producers throughout the watershed.

Drone footage taken from the upper Beaver Creek watershed.

DETAILING THE PLAN

Information gathered through public interaction and data analysis has been developed into this plan. The plan is generally divided into two separate parts:

Part I – Assessment

- **Chapter 1:** The Process and The Plan
- **Chapters 2 - 8:** What did we learn about the watershed?

Part II – Actions and Implementation

ACTIONS

- **Chapters 9 - 12: What strategies, projects and policies are necessary to address the key concerns identified in the assessment?**

IMPLEMENTATION

- **Chapters 13 - 16:**
  - How do we educate key stakeholders on what actions are necessary?
  - What is the timetable to complete improvements, adopt policies and monitor results?
  - What resources are needed to carry out the plan?
  - How should the plan be evaluated and adjusted to stay on track to meet project goals?

HOW TO USE THIS PLAN

This Watershed Plan can be viewed is a comprehensive effort, addressing a wide variety of issues. The discoveries of this plan need to be relayed to a variety of stakeholders with very different levels of awareness. Some findings are larger concepts and more general ideas. Other parts of the plan need to be more technical and detailed, to provide decision-makers with the level of information they need to support the findings of this plan, propose new policies and dedicate or acquire the financial resources to carry them out.

For this reason, each chapter features headers that highlight the most important concepts, both in outline and graphical forms. The content that follows in each chapter features graphs and sidebar discussions which highlight these key ideas. Each chapter also includes a more detailed explanation of these concepts, which is valuable to all, but may be more useful to implementers of the plan.

THE GRAND OVERVIEW

Part 1 – Assessment

Chapter 2 -Watershed Geography

Information about the overall character of the watershed, including soils, terrain, slopes and changes in land use.

Chapter 3 - Designated Uses & Impairments

A closer look at the uses that major streams within the watershed should be expected to support and how which of those uses may not be fully realized based on known pollutants or impairments.

Chapter 4 - Climate, Streamflow & Flood Risk

Analysis of trends in temperature, precipitation, stream flow and flooding. These conditions have a direct impact on the challenges facing this watershed and the measures necessary to address them.

Chapter 5 - Related Studies

This plan isn't the first study related to the Beaver Creek Watershed. A few past studies that influenced the development of this plan are reviewed here. These studies demonstrate what issues have already been identified within this watershed and how this area relates to other areas downstream.

Chapter 6 - Water Quality Assessment

A review and analysis of the available water quality sampling data from the watershed.

Chapter 7 - Streambank Assessment

A desktop review of stream conditions related to stream stability, character and buffer conditions.

Chapter 8 - Pollutant Source Assessment

The key pollutants of concern are identified. The results of computer water quality simulations are listed, including their suspected source (by location and land use).

Part 2 – Actions and Implementation

ACTIONS

Chapter 9 - Strategic Framework

The vision, mission and goals of this plan are outlined here.

Chapter 10 - Policy Recommendations

This chapter outlines policy initiatives and approaches that will be needed to widely adopt recommendations set forth in this plan.

Chapter 11 - Water Quality Improvement Strategies

A key chapter for implementors. Potential conservation practice locations are mapped for each of the 11 HUC-12 subwatersheds of Beaver Creek. For each subwatershed, the most cost effective approach to reaching desired reduction goals is included.

Chapter 12 - Flood Risk Reduction Strategies
This chapter reviews how flood risks could be impacted by increasing precipitation and strategies needed to reduce risk and prevent expansion of areas exposed to impacts from flooding.

IMPLEMENTATION

Chapter 13 - Education and Collaboration Plan
Educating the public, stakeholders and decision makers is essential to the success of this plan. This chapter reviews how to get these groups to understand this plan and how they can work together to carry it out.

Chapter 14 - Measures and Milestones

This chapter addresses these questions:

What is the proposed timeline to implement projects and policy changes? How is progress evaluated?

How do we monitor for improvements in water quality and share data with other groups?

How is progress to be reported back to the board and the public at large?

Chapter 15 - Resource Requirements

Resources are required to execute this plan. This chapter outlines the financial commitments required for coordination, project construction, maintenance and monitoring. It also details some potential methods to fund these needs.

Chapter 16 - Evaluation and Amendments
To be effective, this plan needs to be a "living document," adapted based on lessons learned and changing conditions as the plan is implemented. These conditions need to be regularly evaluated so that regular corrections can be made to the plan to keep it on course.

THE NEXT STEPS

Since watershed management authorities are "authorities without authority," this plan is dependent on a variety of local communities, stakeholders and property owners to carry it out. Upon approval of the plan by the WMA Board, each community will need to take action to adopt the plan. Each jurisdiction will need to review their ordinances and policies to determine what changes are needed to carry out the recommendations of this plan. Projects will need to be incorporated into local budgets or alternative sources of funding (grants, etc.) pursued. Ongoing resources and staff will need to be committed to carrying out water quality monitoring and the education and collaboration plan. Most of all, this plan needs champions – devoted local advocates that are committed to making sure that it is carried to its conclusion.

This plan outlines a long-term process to initiate progress to improving water quality and watershed health. Land uses and other conditions within the certain parts of the watershed are rapidly changing. For this reason, it is difficult to accurately predict conditions that will need to be addressed for a longer period of time. Annual progress toward meeting the objectives of this plan should be monitored by the members of the WMA. At the end of a ten-year period, this planning effort should be re-visited in greater detail by the WMA Board in some fashion, to evaluate results, lessons learned and changed conditions. At that time the path forward for the next ten or twenty years should be set.

The conditions detailed in this plan have developed over a period of more than 150 years. It may take several decades to make enough improvements to meet water quality goals for the entire watershed. The commitment of resources set forth in the plan may be daunting. However, a decision to not commit to these efforts will result in further deterioration in water quality, streambank instability and a potential for greater flood impacts in the future. Not addressing these issues will assuredly lead to greater costs in the future. These aren't just financial costs, but impacts to health, habitat, recreation and our natural resources.

Monarch butterfly caterpillar in a bioretention planter in Johnston.

02

WATERSHED CHARACTERISTICS

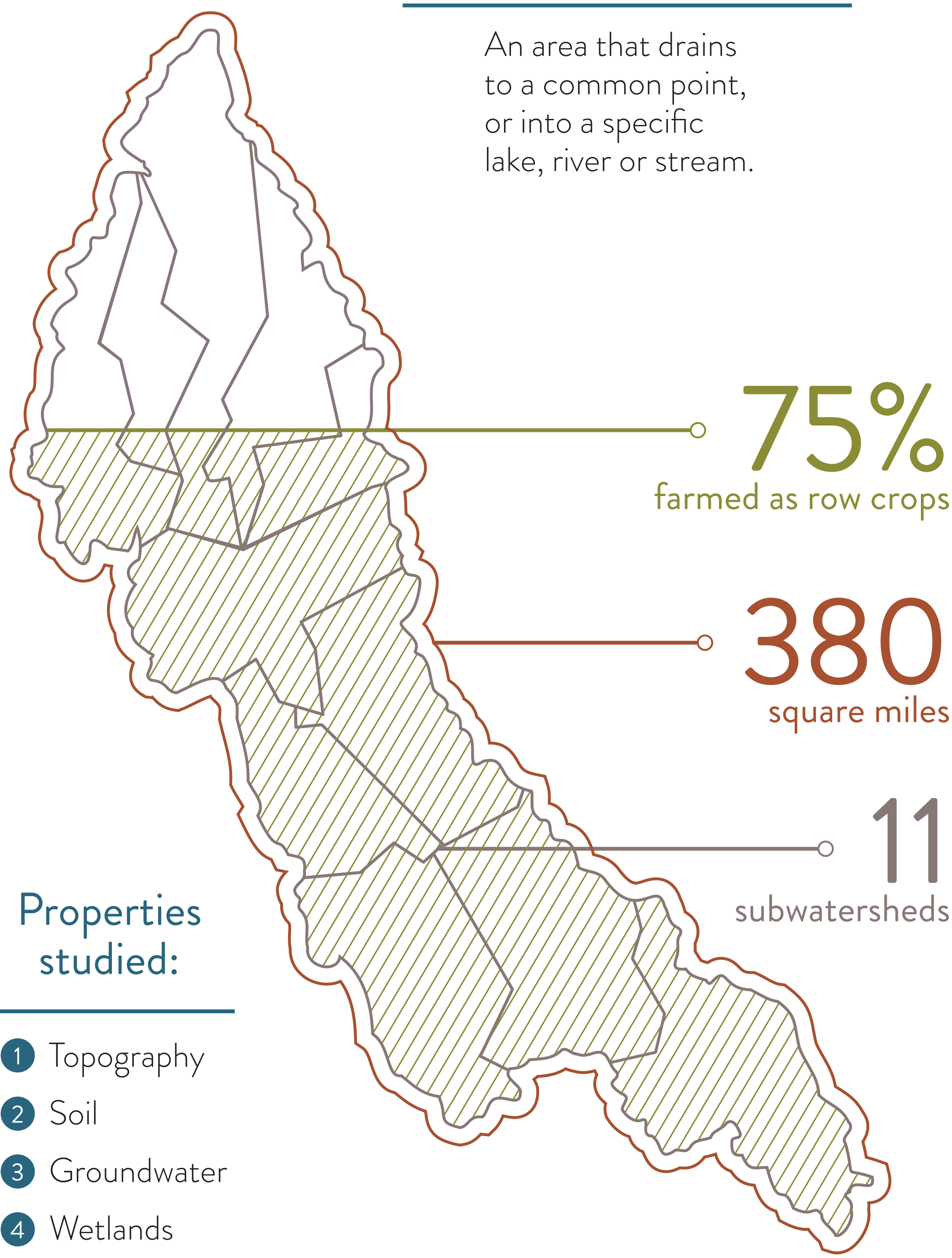
A watershed is an area of land that drains to a common point. The Beaver Creek watershed covers approximately 380 square miles across parts of Boone, Dallas, Greene, Polk and Webster Counties in Central Iowa. The footprint of its watershed includes fifteen communities and unincorporated areas within each county. Beaver Creek generally drains from north to south, to its confluence with the Des Moines River just north of Interstate 80 along the boundary between Des Moines and Johnston.

The Des Moines River flows generally southeast, first through Red Rock Lake in Marion County. Then, into the Mississippi River near Keokuk at the far southeastern corner of the state. The Mississippi River flows south, ultimately reaching the Gulf of Mexico in Louisiana.

02

What is a watershed?

An area that drains to a common point, or into a specific lake, river or stream.



Properties studied:

1. Topography
2. Soil
3. Groundwater
4. Wetlands

WATERSHED NETWORK

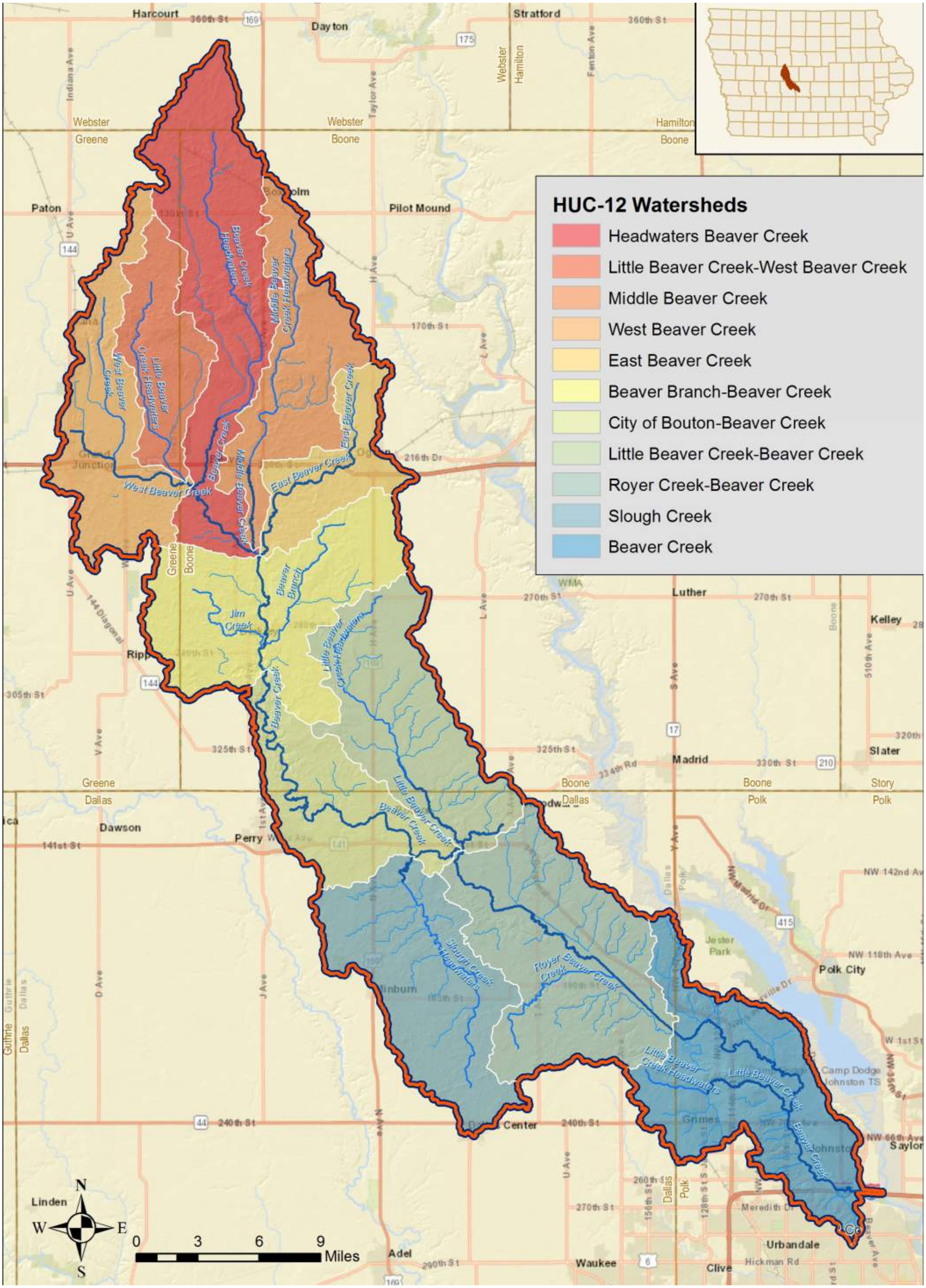
The United States Geological Survey (USGS) created a hierarchical system of watershed areas represented by a unique Hydrologic Unit Code (HUC) number. There are six levels in the hierarchy, represented by hydrologic unit codes from 2 to 12 digits long, called regions, subregions, basins, subbasins, watersheds, and subwatersheds. **Table 2.1 describes the USGS system's hydrologic unit levels and their characteristics.** In this hierarchy, Beaver Creek is a HUC-10 Watershed within the Middle Des Moines Subbasin (HUC-8)

Table 2.1: USGS Watershed Hierarchical System

USGS WATERSHED HIERARCHICAL SYSTEM				
NAME	HUC LEVEL	AVERAGE SIZE	EXAMPLE NAME FROM BEAVER CREEK WATERSHED	EXAMPLE CODE (HUC)
Region	2	177,560 sq-miles	Upper Mississippi River	07
Subregion	4	16,800 sq-miles	Des Moines	0710
Basin	6	10,596 sq-miles	Des Moines	071000
Subbasin	8	700 sq-miles	Middle Des Moines	07100004
Watershed	10	40,000–250,000 acres	Beaver Creek	0710000409
Subwatershed	12	10,000–40,000 acres	Headwaters Beaver Creek	071000040905

Figure 2.1. USGS Hydrologic Hierarchy System: Beaver Creek Illustration

Figure 2.2. HUC-12 Watersheds of the Beaver Creek Watershed



Subwatersheds (HUC-12)

Subwatersheds are the smallest unit within the USGS system although many times these are further subdivided for a variety of purposes, particularly when developing hydrologic and water quality models. **The Beaver Creek Watershed includes eleven Subwatersheds (HUC-12)** as shown in Table 2-2 and Figure 2.2. Subwatersheds are the hydrologic scale that is commonly used for implementation efforts. At this scale landowners are likely to have established personal relationships and a small, dedicated group can have a meaningful role in improving the health of a subwatershed.

Table 2.2: Watersheds and subwatersheds of Beaver Creek Watershed

WATERSHEDS AND SUBWATERSHEDS OF BEAVER CREEK WATERSHED		
SUBWATERSHED NAME	HUC-12 CODE	ACRES
Beaver Branch-Beaver Creek	71000040906	27,747
Beaver Creek	71000040911	28,205
City of Bouton-Beaver Creek	71000040909	16,892
East Beaver Creek	71000040904	10,559
Headwaters Beaver Creek	71000040905	30,156
Little Beaver Creek - Beaver Creek	71000040908	23,627
Little Beaver Creek-West Beaver Creek	71000040901	12,170
Middle Beaver Creek	71000040903	18,537
Royer Creek-Beaver Creek	71000040910	31,767
Slough Creek	71000040907	25,381
West Beaver Creek	71000040902	19,306

LAND COVER

Land cover and use, both natural and human influenced, are the main factors driving the quality and character of water resources in the Beaver Creek Watershed. **Land use within the Beaver Creek Watershed is predominately (>75%) agricultural,** with urban development largely limited to the larger communities surrounding the Des Moines metropolitan area in the southern third of the watershed (Table 2.3 and Figure 2.3). The distribution of land cover in the Beaver Creek Watershed was determined using Iowa's High \Resolution Land Cover Dataset, with a spatial resolution of one square meter. **Figure 2.4 maps the location of the high resolution land cover dataset for all of the Beaver Creek Watershed.** This dataset illustrates that the forested/grassland riparian areas are primarily located along the portion of Beaver Creek that is south of Berkley. Land cover is varied within the developed portions of the watershed.

The impact various land cover has on water quality is further described in the discussion within this report.

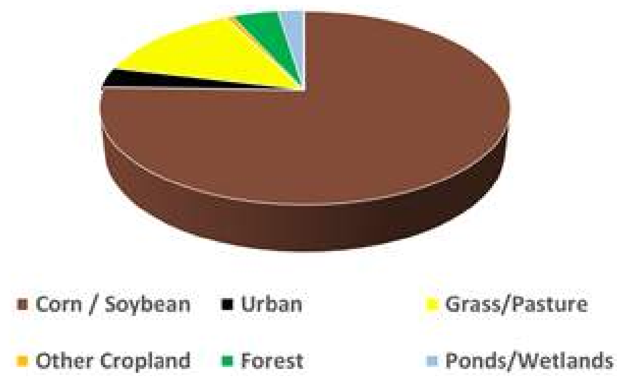
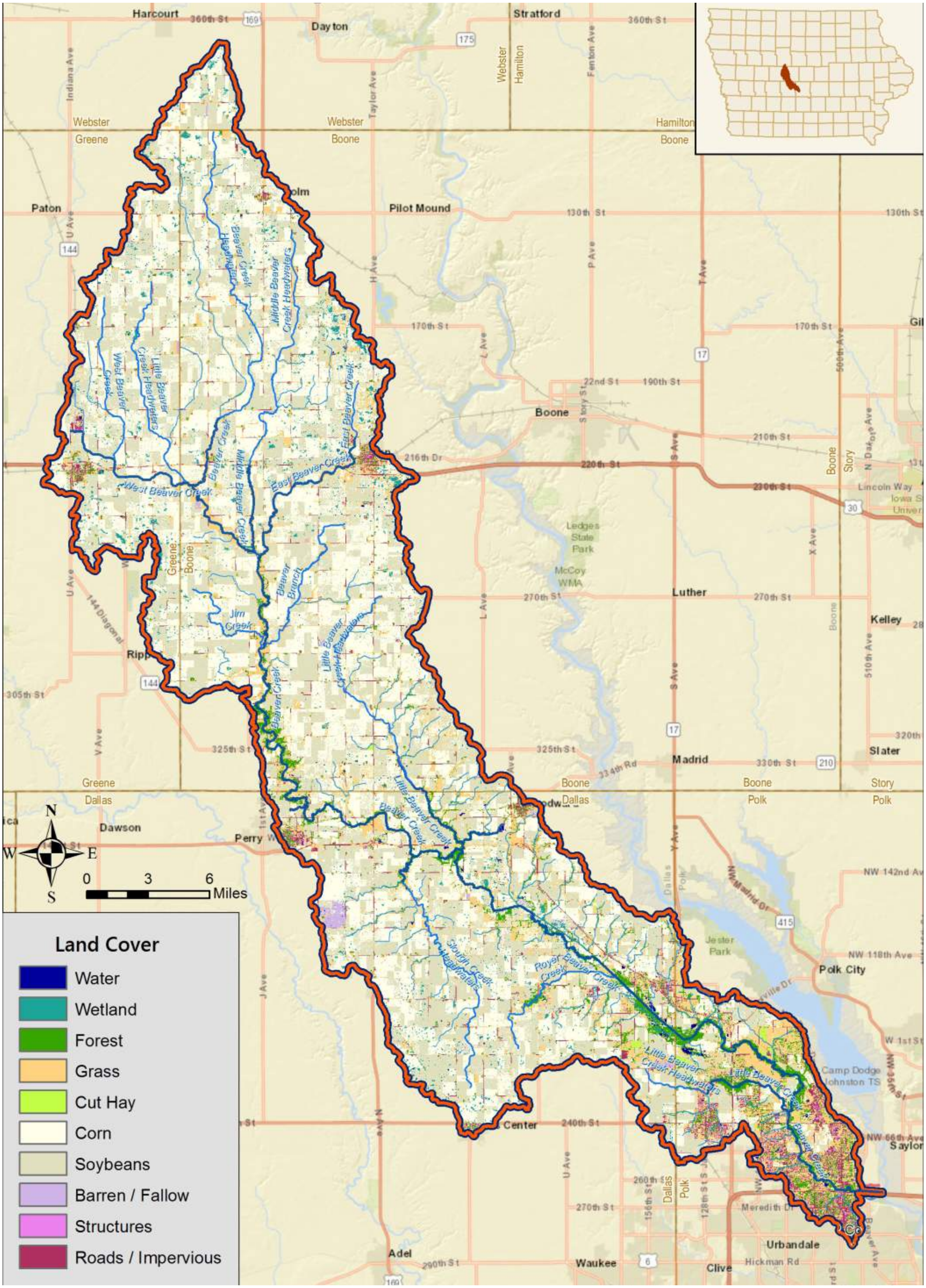


Figure 2.3. HUC-12 Watersheds of the Beaver Creek Watershed

Table 2.3: Creek Watershed - Land Cover

HUC-12 NAMES	% FORESTED	% GRASSLAND	% WATER/ WETLAND	% ROW CROP	% DEVELOPED
City of Bouton	9.4%	9.4%	1.6%	68.5%	3.5%
West Beaver Creek	1.1%	1.1%	3.2%	84.6%	2.8%
Middle Beaver Creek	0.5%	0.5%	4.2%	83.1%	1.4%
Little Beaver Creek	0.5%	0.5%	2.1%	88.2%	1.2%
Beaver Creek	15.0%	15.0%	1.6%	37.8%	12.6%
Slough Creek	1.9%	1.9%	2.4%	84.0%	1.4%
Royer Creek	7.6%	7.6%	2.6%	69.5%	2.5%
Little Beaver Creek	3.0%	3.0%	1.1%	81.2%	1.9%
Beaver Branch	1.3%	1.3%	1.8%	86.4%	1.1%
East Beaver Creek	1.7%	1.7%	3.9%	72.7%	3.8%
Headwaters Beaver Creek	0.7%	0.7%	2.8%	84.7%	1.6%
Watershed Totals	**3.9%**	**3.9%**	**2.5%**	**76.4%**	**3.1%**

Figure 2.4. Beaver Creek Watershed - High Resolution Land Cover



TOPOGRAPHY

Figure 2.5 depicts the topographical relief and varying slopes found within the watershed. It was derived using LIDAR data. LIDAR (Light Detection and Ranging) is a remote sensing method that uses light in the form of a pulsed laser to measure variable distances to the ground. **The vast majority (77.1%) of the watershed has gentle, rolling slopes of less than 5%.** The northern most ten miles of the Beaver Creek are so flat that they have been described as a system of slough and ponds without a defined channel. Steeply sloped areas identified include those areas adjacent to Beaver Creek south of Berkley, areas adjacent to the headwaters of Royer Creek, and areas adjacent to Little Beaver Creek just north of Grimes.

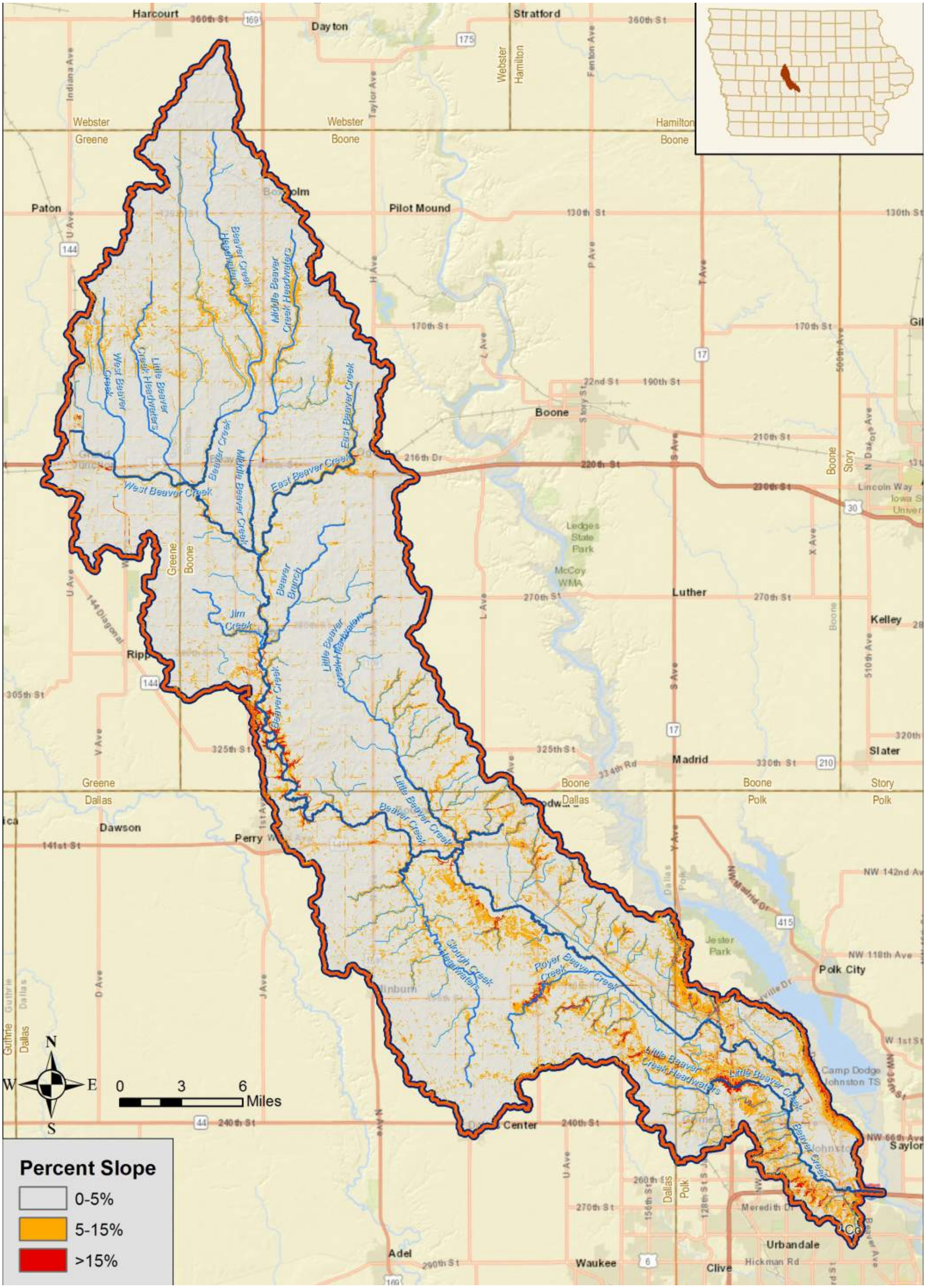
Steeply sloped areas are exceeding 15% which represents less than 3% of the total watershed area.

The topography of the watershed was used as factor in developing recommendations for areas within the watershed to protect. It also provided one of the key indicators in locating streambank erosion areas. Note that the streambank erosion areas identified were not ground-truthed but based on topography and stream stratigraphy and therefore may not reflect reality in the stream. **Further field review is recommended prior to advancing and restoration efforts. Refer to Chapter 7 for more information about stream conditions.**

Did you know?

The highest point in the watershed is located within the Gary moraine, a remnant ridge from the Wisconsin Glaciation located in the northern part of the Webster County with an altitude of 1,184 feet. The lowest elevation is on the flood plain of Beaver Creek where the stream leaves the watershed, at 812 feet.

Figure 2.5: Beaver Creek Watershed – Percent Slope



SOILS

The Soil Survey Geographic (SSURGO) soils GIS layer available from the United States Department of Agriculture (USDA) were clipped to the watershed boundary. This tabular data includes hydrologic soil group classification. Each Map Unit Symbol corresponds to a soil series description, which describes the major characteristics of the soil profile for the given Map Unit.

The Natural Resource Conservation Service (NRCS) has classified soil series into Hydrologic Soils Groups (HGS) based on the soil's runoff potential. There are four major HSGs (A, B, C, and D) and 3 dual HSG groups (A/D, B/D, and C/D). **HSG A soils have the lowest runoff potential whereas HSG D soils have the greatest**. Dual soil series include those soils that have an upper soil profile which is conducive to allowing water to infiltrate similar to a type A, B, or C soil and an underlying confining layer within 60 inches of the soil surface that restricts the downward movement of water. The first letter applies to the drained condition, if undrained, the soil will act more like a D soil with a higher runoff potential and lower infiltration rates. Dual soil series were grouped into one category for mapping purposes.

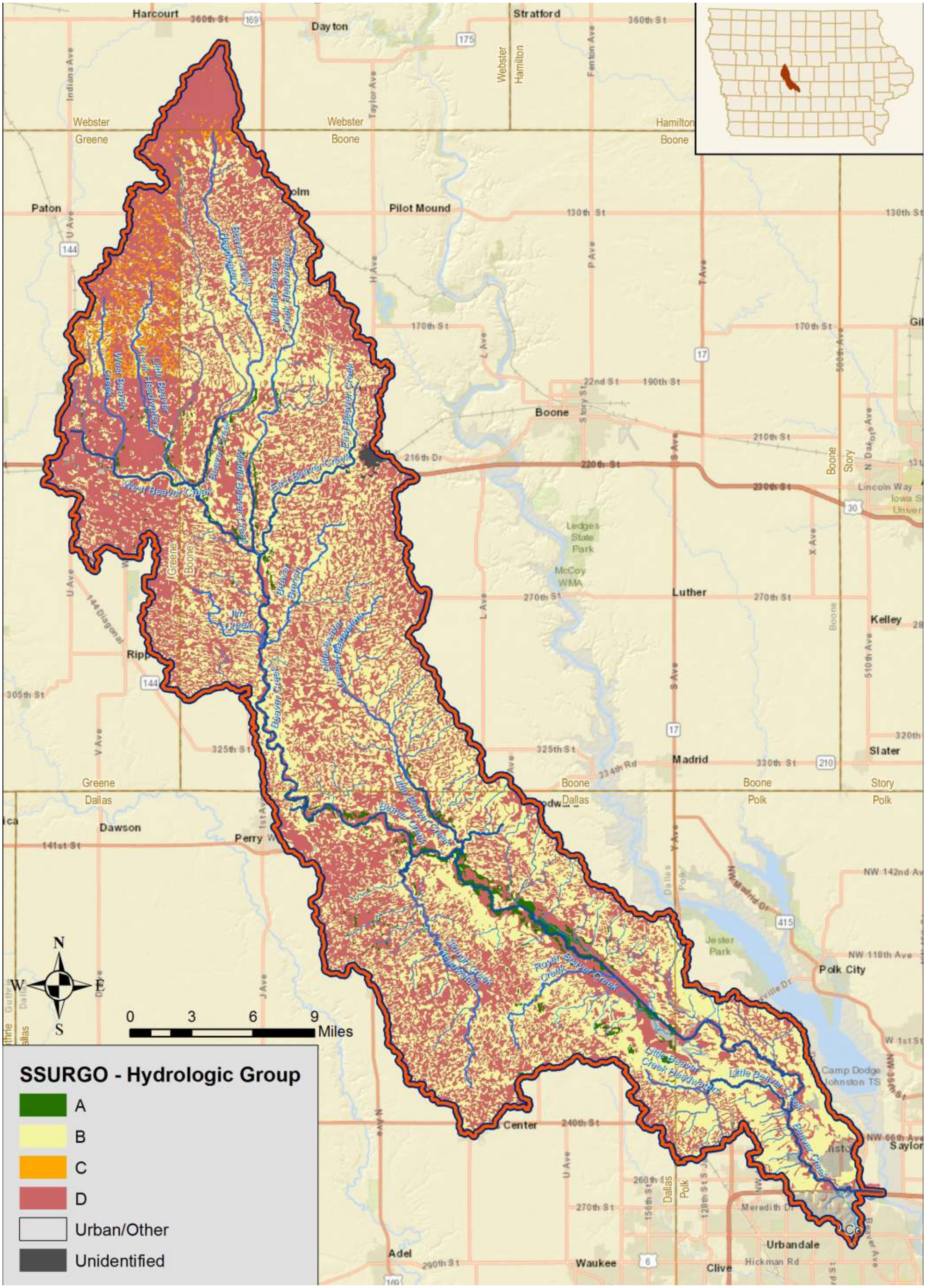
Group A soils consist of sand, loamy sand, or sandy loam soil types. These soils have very low runoff potential and high infiltration rates.

Group B soils consist of silty loams or loams. These soils have moderately high infiltration rates and low runoff potential.
Group C soils consist of sandy clay loam. The have low infiltration rates and consist of soils with a layer that impedes the downward movement of water and soils. These soils have moderately high runoff potential.

Group D soils consist of clay loam, silty clay loam, sandy clay, silty clay, or clay soils with the highest runoff potential. These soils have very low infiltration rates and a high water table.

The hydrologic soil groups in Beaver Creek Watershed are illustrated in Figure 2.6. **The primary soil hydrologic groups are moderately well drained (B) and moderately well drained with a high water table (B/D).** Mapped soil series in the uplands include primarily hydrologic soil group B soils including Clarion, Nicollet, Sparta, and Spillville soil series. These soil series are comprised of deep, moderately drained loams, silty loams and clay loams. Soil series located within the many concave depressions associated with former prairie-pothole wetlands include Knoke, Biscay, Canisteo, Webster, and Zook. These soils series are deep, poorly drained, silty, clay-loams. Areas containing row crop (Corn/Soybean) land cover with B/D or C/D soils represent likely locations for subsurface tile drainage. The installation of subsurface tile drainage in areas with B/D and C/D soils has allowed for row crops to thrive in areas that were historically wetland.

Figure 2.6: Beaver Creek Watershed – Hydraulic Soil Group



GEOLOGY AND GROUNDWATER RESOURCES

The following is a summary of the groundwater resources and underlying geology of the Beaver Creek Watershed, based on available data included in a review of Geology of Boone County, a report compiled by Samuel Walker Beyer; Geology of Dallas County, a report compiled by A.G. Leonard; Geology of Polk County, a report compiled by H.F. Bain; and data collected by the Iowa DNR.

Approximately 80% of Iowa residents in both urban and rural settings rely on groundwater as their primary source of drinking water. Protecting groundwater quality and quantity is extremely important to Beaver Creek Watershed residents as groundwater availability is limited in certain areas of the watershed either due to poor water quality (high mineral content), distribution (distance to areas where it is needed), or yield (adequacy of overall available supply). **In general, the portions of the watershed in Boone County, which includes the northeastern third of the watershed, have limited groundwater availability;** fortunately these areas are outside of large population centers so the amount of water is sufficient for local domestic uses. The westernmost portion of the watershed that falls within **Greene County obtains groundwater from buried sand and gravel aquifers** which vary widely in their capacity to produce high-quality water. The southernmost portions of the watershed that fall in **Dallas County and Polk County contain a greater abundance of groundwater with several artesian wells** located less than 100 feet from the surface that supply a sufficient quantity of water to meet local demand.

Surficial Hydrogeology

The Beaver Creek Watershed is covered by glacial drift commonly associated with two periods of glaciation, the Late Wisconsin Episode (Des Moines Lobe) and the earlier Hudson Episode. Since the glacial period, the surface has been worked and re-worked by rivers and streams, eroding valleys, leaving significant alluvial deposits.

The Cambrian-Ordovician aquifer covers nearly the entire state of Iowa. The Cambro-Ordovician aquifer is the major deep aquifer in the watershed, and includes the St. Peter Sandstone, the Prairie du Chien dolomite, and the Jordan Sandstone, the last being the major water producer (Thompson, 1982). The Cambrian-Ordovician aquifer is confined by a series of geologic units comprised of shale, dolomite and limestone that control downward groundwater transport to the aquifer. **Generalized hydrogeological cross-sections for Iowa including the Des Moines River are shown in (Figure 2.7).** In the Beaver Creek Watershed, the Cambrian-Ordovician aquifer is covered by the Mississippian Aquifer which overlays a series of confining layers consisting of limestone, dolomite, and shale.

These confining layers include the Dakota, Windrow series, the Pella and St. Louis Formation, the Lower and Upper Cherokee Groups, and the Marmaton Group (Figure2.8).

Recharge to the Mississippian aquifer is from: 1) precipitation where the bedrock is at or near the surface, 2) leakage to the aquifer from Beaver Creek and its tributaries, and 3) groundwater inflow from areas outside of the Beaver Creek watershed. The Mississippian Aquifer is heavily used as a drinking and industrial water supply. The Devonian-Silurian Aquifer (Middle Bedrock Aquifer) is also used by several communities and rural residents. The main water-producing units in the Devonian-Silurian are a series of limestones and dolostones. There are also more than 80 shallow, quaternary, and alluvial wells that are heavily used as both a drinking water source and industrial water supply.

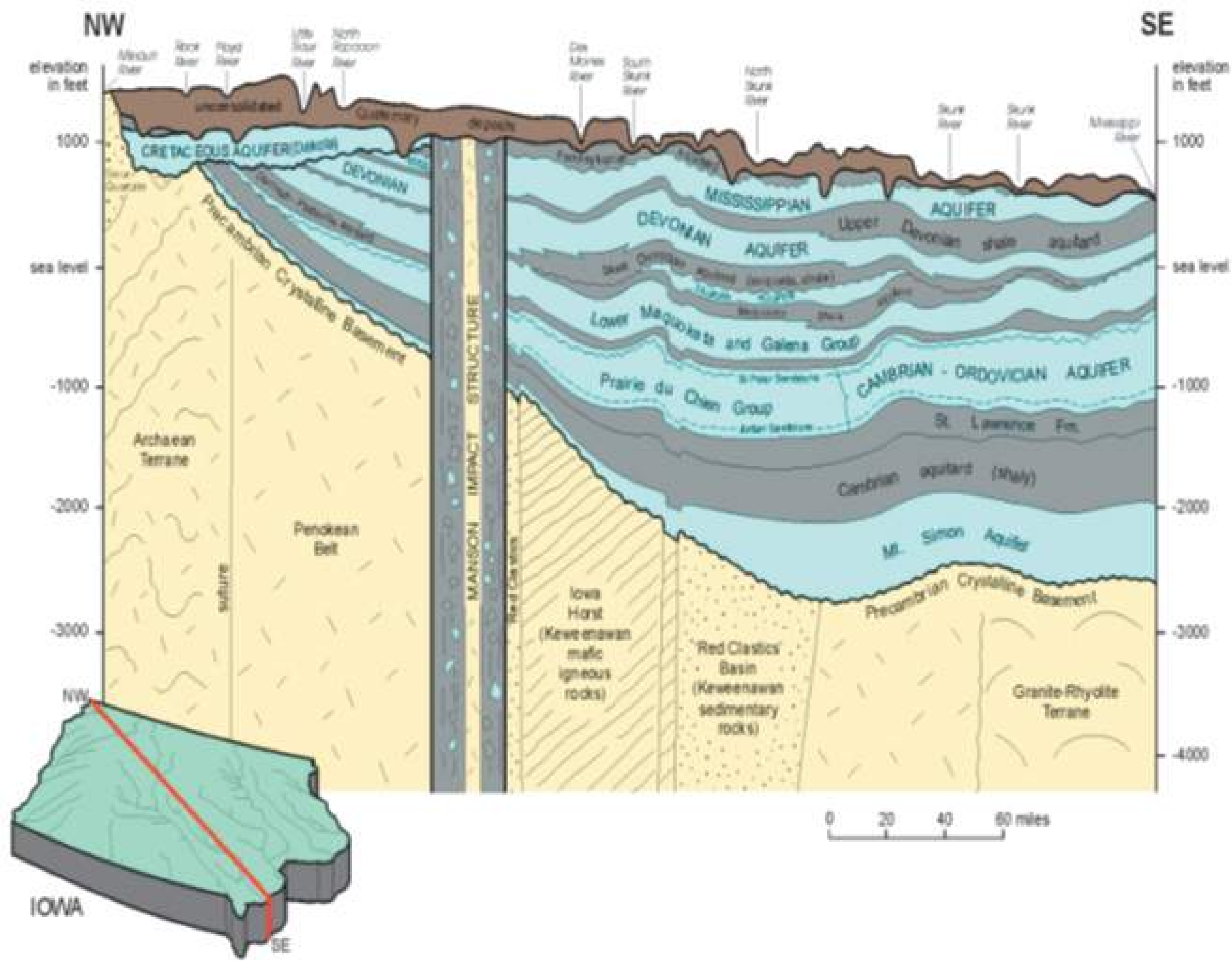
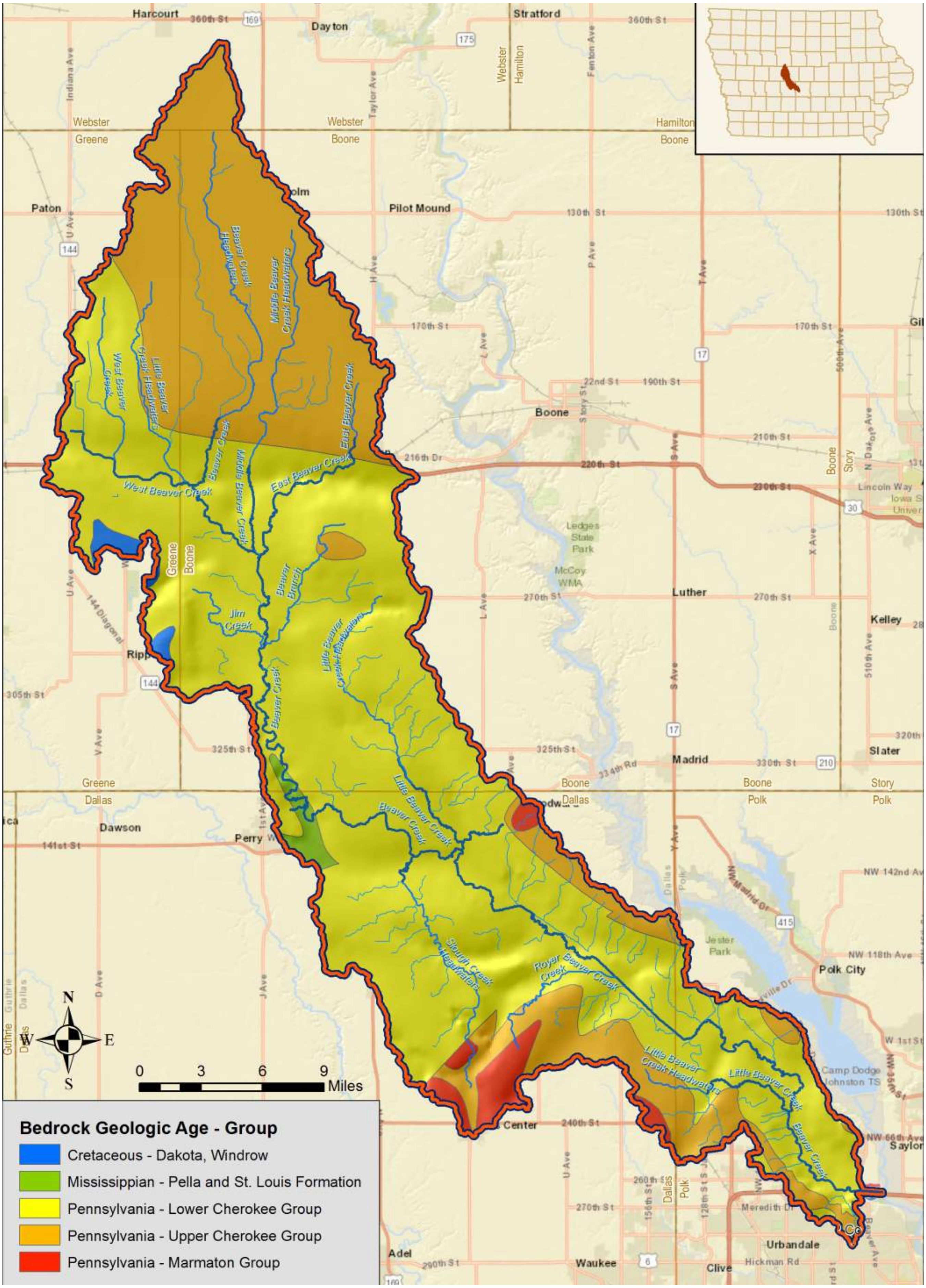


Figure 2.7: Generalized hydrogeological cross-section from northwestern to southeastern Iowa (modified from Prior and others, 2003).

Figure 2.8: Bedrock Geologic Age and Group



Groundwater Vulnerability

In 1991, the Iowa DNR identified regions of Iowa with similar hydrogeological characteristics and classified these characteristics into 10 unique groups (map units) based on their relative vulnerability to groundwater contamination. **Reviewing these classifications for Beaver Creek Watershed makes it possible to see where groundwater protection issues are most relevant.** Within the Beaver Creek Watershed, there are four map unit classifications (Figure 2.9); groundwater quality, yield, and susceptibility to contamination are described below for each map unit:

Alluvial Aquifers: Areas underlain by sand and gravel aquifers situated beneath floodplains along stream valleys, alluvial deposits are associated with stream terraces and benches, and glacial outwash deposits. Natural water quality is generally excellent (less than 500 mg/L total dissolved solids [TDS]) and yields vary with texture and thickness of alluvium (commonly greater than 100 gallons/minute [GPM] in larger valleys, less in smaller valleys). Most wells are very shallow; high potential for aquifer contamination; high potential for well contamination.

Variable Bedrock Aquifers: Area underlain by regional bedrock aquifers, including carbonate and sandstone units; aquifers vary considerably in natural water quality (500-2000 mg/L TDS) and yields (although generally above 20 GPM).

Moderate Drift Confinement: 100 to 300 feet of glacial drift overlie regional aquifers; most wells aredeep and completed in the bedrock aquifer. Low potential for aquifer contamination; low potential for well contamination.

Shale Drift Confinement: Cherokee shales or Upper Cretaceous shales overlie Mississippian carbonate or Dakota Sandstone aquifers respectively. Most wells are shallow and developed in the drift, some wells are deep and completed in the bedrock aquifer. Low potential for aquifer contamination; high potential for contamination of drift wells; moderate potential for contamination of bedrock wells.

Drift Groundwater Source: Bedrock aquifers are absent or overlain by greater than 300 feet of glacial drift; wells are completed in thin, discontinuous deposits of sand and gravel within the till or at the interface between overlying loess and rill: natural water quality is highly variable (250-2500 mg/L TDS) and yields are generally low (less than 10 GPM). Most wells are shallow and completed in the drift; low potential for bedrock aquifer contamination; high potential for well contamination.

Two highly susceptible wells have been identified in 2 communities (Grimes and Woodward) within the Beaver Creek Watershed (Figure 2.9). Communities can coordinate with the IDNR to conduct a site investigation to determine if the contaminant is from a point or non-point source.

Source Water Protection Areas and Highly Vulnerable Groundwater Wells

The Iowa DNR has also developed a GIS layer depicting Groundwater capture zones – the land surface area that has been determined to provide water to a public water supply well based on available geologic and hydrogeologic information. **Groundwater capture zones located in areas with high vulnerability for aquifer and well contamination and/or areas with high-observed pollutant concentrations (i.e., nitrate-nitrite concentrations exceeding 10 mg/L) should be prioritized as source water protection areas** (Figure 2.10). The Iowa DNR operates a Source Water Protection Program, which requires a Phase 1 Assessment that defines the source water area and susceptibility to contamination.

Wetland in the Beaver Creek watershed.

Figure 2.9: Beaver Creek Watershed Highly Susceptible Wells and Groundwater Vulnerability

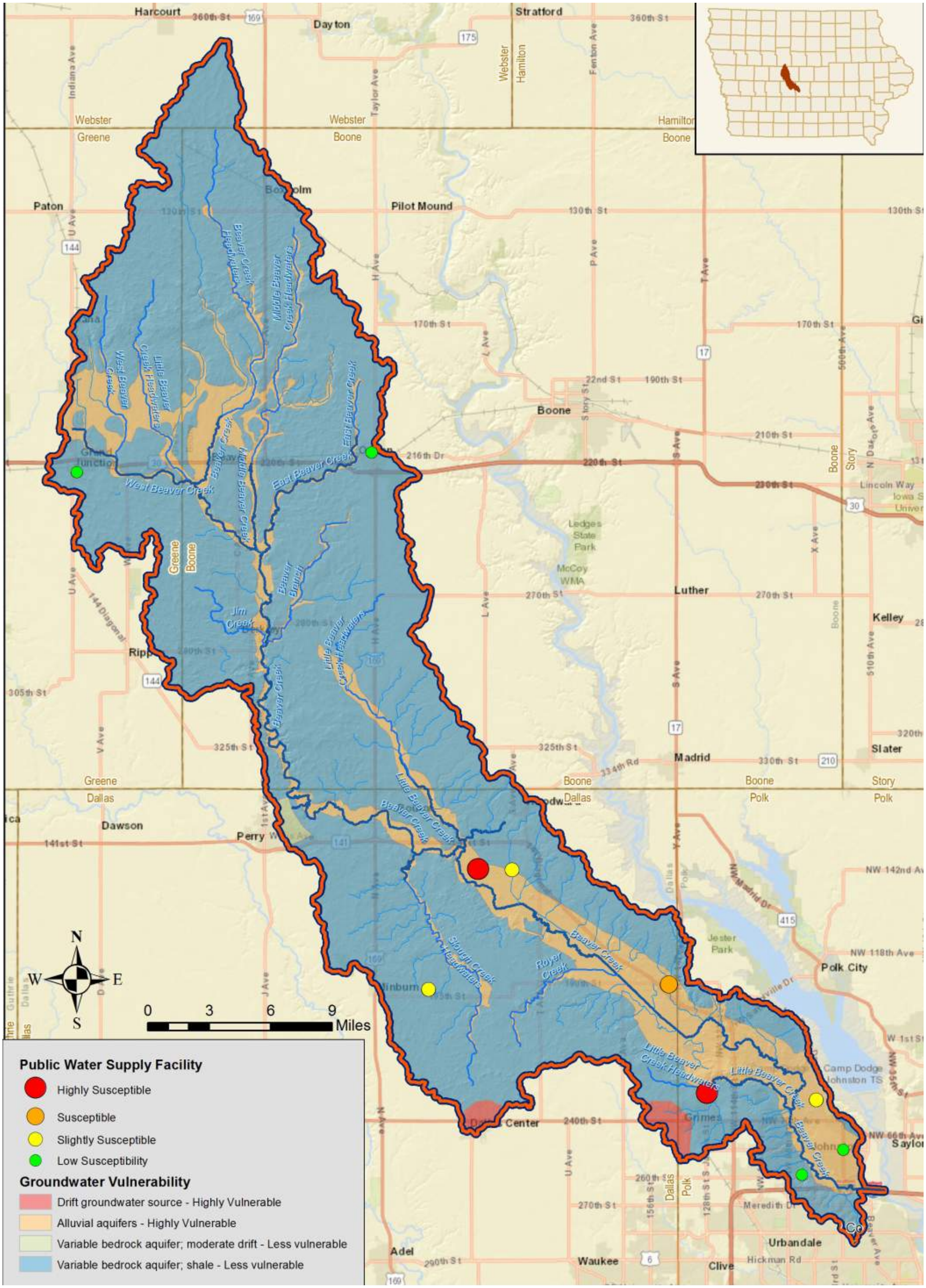
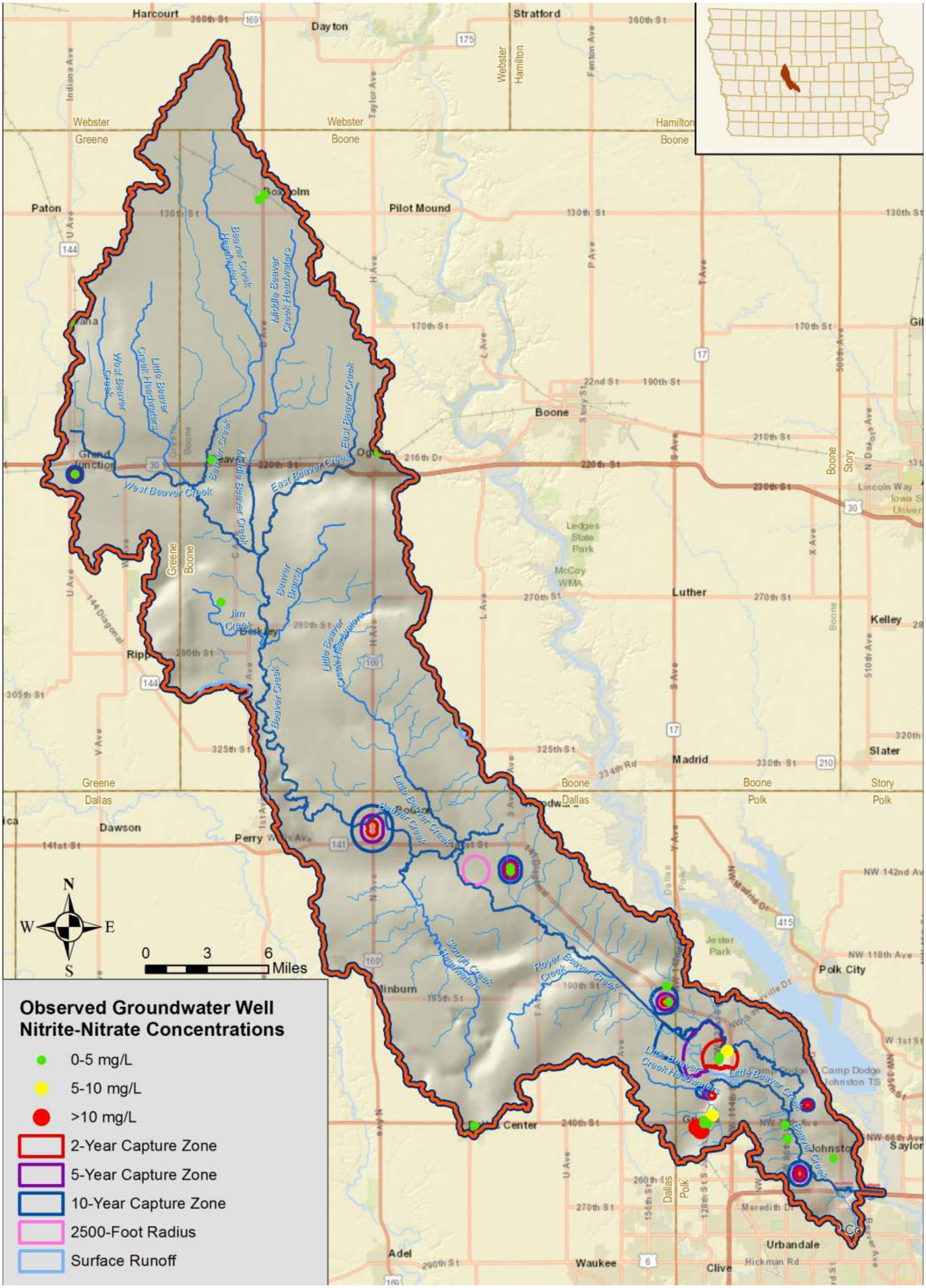


Figure 2.10: Groundwater Capture Zones (SourceWater Protection Areas) and Observed Nitrate-Nitrite Concentrations



STREAM RIPARIAN AREAS

Riparian areas are the areas immediately adjacent to a stream. These areas can provide significant benefits to the stream if they are in a healthy state, adequately vegetated with a natural plant community. **An evaluation of riparian health was conducted by looking at the land cover within the areas immediately adjacent (within 150 feet) to the streams of Beaver Creek Watershed** using the Iowa DNR's High Resolution (1 square meter) Land Cover dataset. Areas where the stream riparian area consisted of natural land (Forests, Grasslands) were mapped as 'natural' areas.

These are riparian areas that should be protected in the future. Table 2.4 provides a breakdown of the riparian landcover distribution for the primary streams in the watershed. **Areas where the exiting landcover within the riparian zone is currently cropland represent restoration opportunities as described later in the report.** There are several examples of where remaining tracts of natural land cover intersect the stream riparian area, such as the largely forested buffers adjacent to Beaver Creek near Berkley (Figure 2.11).

STREAM NAME	% FORESTED	% GRASSLAND	% WETLAND	% ROW CROPS	% DEVELOPED
Beaver Creek (Mouth of Beaver Creek to Boone/Dallas county line)	64%	11%	13%	10%	3%
Beaver Creek (Mouth of Beaver Creek to Boone/Dallas county line)	32%	45%	14%	7%	4%
East Beaver Creek	6%	57%	5%	31%	2%
Little Beaver Creek (Mouth to confluence with an unnamed tributary in Polk County)	55%	21%	3%	16%	5%
Little Beaver Creek (Mouth to confluence with an unnamed trib. in Boone County)	54%	24%	5%	15%	3%
Middle Beaver Creek	1%	68%	11%	18%	1%
Slough Creek	61%	19%	7%	13%	8%
Unnamed Creek (Little Beaver Creek)	53%	21%	1%	24%	2%
Unnamed Creek (City of Bouton)	14%	33%	8%	43%	3%
Unnamed Creek (West Beaver Creek)	0%	21%	3%	51%	27%
Unnamed Creek (West Beaver Creek)	1%	17%	1%	81%	0%
West Beaver Creek	79%	49%	5%	37%	2%

Table 2.4: Riparian Landcover Distribution within 150 feet of Primary Streams in the Beaver Creek Watershed.

** Green shading indicates areas within 150' of a stream where more than 40% of the riparian landcover is mapped as a 'natural' land cover. Red shading indicates areas where more than 40% of the riparian landcover is mapped as cropland or more then 25% mapped as developed (impervious).*

LAKES AND WETLANDS

There are 36 conservation and recreation lands with public accesses located within the Beaver Creek Watershed. Many of these parks contains wetlands, ponds, or lakes that provide valuable fish and wildlife habitat as well as recreational opportunities for area residents and visitors (Figures 2.11a and 2.11b).

Terra Lake

Terra Lake is an 8 acre lake located within a 200 acre park within the City of Johnston. The park provides amenities for large gatherings including a newly-constructed amphitheater for outdoor concerts, hiking/ cross-country skiing trails, a fishing pier, a playground, and numerous native plantings. In 2017, the 8-acre lake was stocked with breeding-size largemouth bass, channel catfish, and bluegills which will provide the start of a healthy fish population.

Figure 2.11a: Terra Lake

Brenton Slough

Brenton Slough is a 53-acre backwater wetland complex located north of Grimes. Brenton Slough is located in Polk County's Northwest Planning Area. Polk County has designated the Brenton Slough Wetland Complex as protected open space. Brenton Slough is a well-known location for bird watchers as it provides critical habitat for rare bird species such as Marsh Wrens. Brenton Slough is also frequently visited by anglers seeking to catch largemouth bass, bluegill, and channel catfish.

Figure 2.11b: Brenton Slough

Figure 2.13: Beaver Creek Watershed Lakes and Wetlands

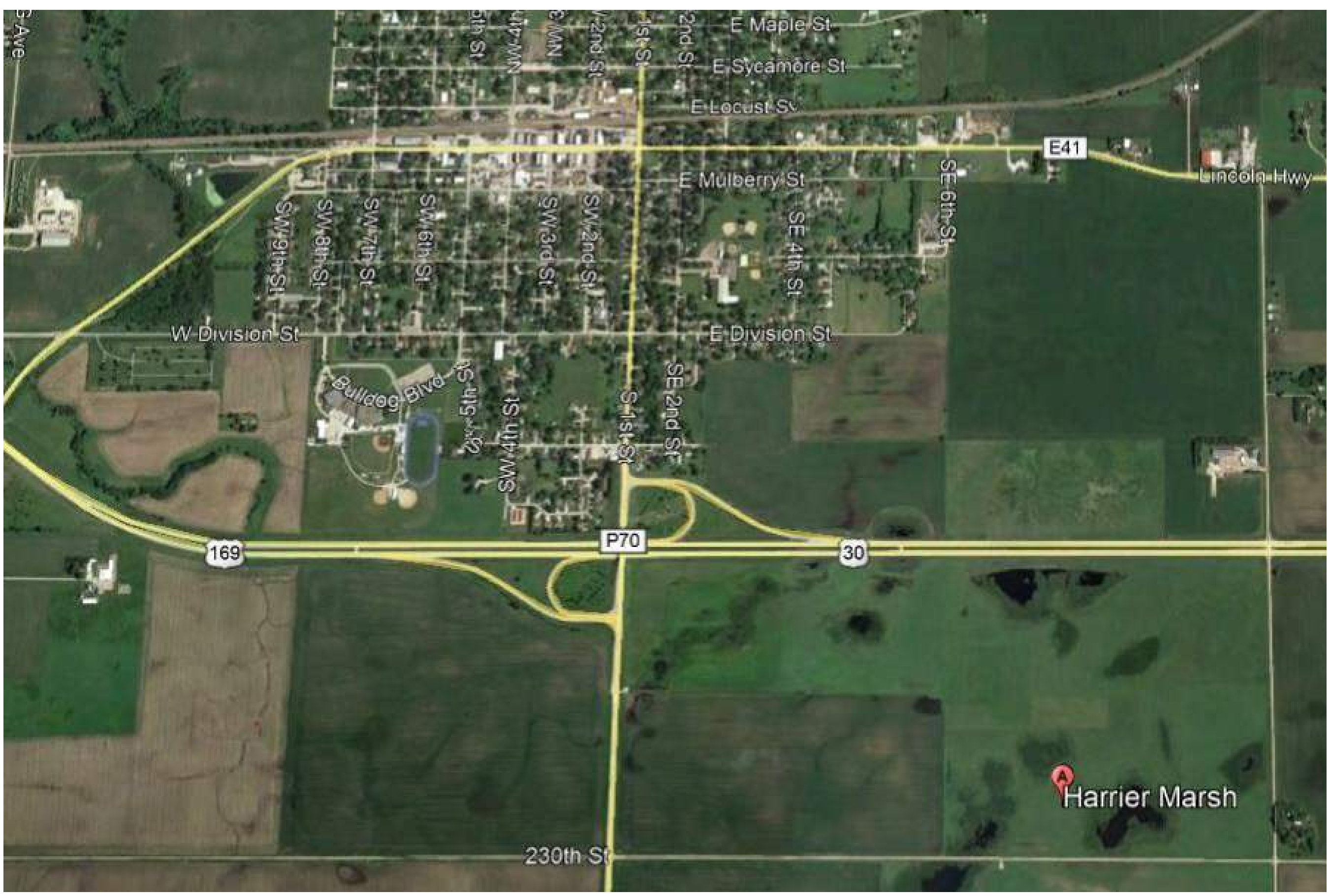
Wetlands

Many of the historic wetlands in the Beaver Creek Watershed were drained for agricultural purposes; however, some wetland areas persist, primarily within floodplains and riparian areas. The remnant wetlands contribute to the watershed through the functions they perform and the value they provide. Wetland functions are the natural processes that occur in the wetlands, and can include hydrologic flux and storage, increased biological productivity, biochemical cycling and storage, increased decomposition, and improved wildlife habitat and diversity. Actual wetland functions vary depending on the type of wetland, position on the landscape, season of the year, and how the surrounding land use impacts the area hydrologically and ecologically.

Wetlands have values that benefit both people and the environment. These values can be based on the functions the wetland carries out, like improving water quality, carbon sequestration, water retention, and habitat; the aesthetic value of the wetland, or the ability of the wetland to provide opportunities for recreation and education.

One wetland in the Beaver Creek Watershed that has been recognized, for not only its wetland functions but its value to the watershed, is Harrier Marsh, located within the 420 acre Harrier Marsh Wildlife Management Area, one mile south of Odgen, near Highway 169.

Aerial photo of Harrier Marsh near Ogden (from Google Earth).



Sign at Harrier Marsh.

Wetland in the Beaver Creek Watershed

03

DESIGNATED USES & IDENTIFIED IMPAIRMENTS

The following sections describe the current state of lakes and streams within the Beaver Creek Watershed. The sections begin with a general summary of the stream network within the watershed followed by a discussion of the water quality conditions of each stream.

03

Support uses

12 segments of Beaver Creek and it's tributaries facilitate recreational uses and wildlife habitat.

Impaired uses

High-levels of nutrients and other biological factors impair recreational uses along Beaver Creek and Little Beaver Creek.

IOWA WATER CLASSIFICATION

Iowa's surface water classifications are described in IAC 61.3(1) as two main categories, **Designated Uses and General Uses.**

Designated use segments are water bodies, which maintain flow throughout the year or contain sufficient pooled areas during intermittent flow periods to maintain a viable aquatic community. **Streams in the Beaver Creek watershed with designated use classifications are described below in Table 3.1.**

General use segments are intermittent watercourses and those watercourses that typically flow only for short periods of time following precipitation and whose channels are normally above the water table. These waters do not support a viable aquatic community during low flow and do not maintain pooled conditions during periods of no flow.

IOWA WATERS DESIGNATED USES

Primary contact recreational use:

Class A1 - Waters in which recreational or other uses may result in prolonged and direct contact with the water, involving considerable risk of ingesting water in quantities sufficient to pose a health hazard. **Such activities would include, but not be limited to, swimming, diving, water skiing, canoeing and kayaking.**

Secondary contact recreational use:

Class A2 - Waters in which recreational or other uses may result in contact with the water that is either incidental or accidental. During the recreational use, the probability of ingesting appreciable quantities of water is minimal. **Class A2 uses include fishing, commercial and recreational boating, any limited contact incidental to shoreline activities,** and activities in which users do not swim or float in the water body while on a boating activity.

Children's recreational use:

Class A3 - Waters in which recreational uses by children are common.

Class A3 waters are water bodies having definite banks and bed with visible evidence of the flow or occurrence of water. **This type of use would primarily occur in urban or residential areas** where children may come in contact with the water resource through such activities as playing/splashing in the stream or attempting to sein for minnows, catch tadpoles, etc.

Warm water Type 1:

Class BWW-1 - Waters in which temperature, flow, and other habitat characteristics are **suitable to maintain warm water game fish populations,** along with a resident aquatic community that includes a variety of native nongame fish and invertebrate species. These waters generally include border rivers, large interior rivers, and the lower segments of medium-size tributary streams.

Warm water Type 2:

Class BWW-2 - Waters in which flow or other physical characteristics are capable of supporting a resident aquatic community that includes a variety of native nongame fish and invertebrate species. The flow and other physical characteristics limit the maintenance of warm water game fish populations. These waters generally consist of small perennially flowing streams.

Human health:

Class HH - Waters in which fish are routinely harvested for human consumption, or waters both designated as a drinking water supply.

Paddlers on Beaver Creek during an event opening a water trails access in Johnston (City of Johnston).

Table 3.1: Surface Water Designated Use Classifications for Beaver Creek Watershed Streams

STREAM	REACH DESCRIPTION	A1	A2	A3	BWW-1	BWW-2	HH
Beaver Creek	Mouth of Beaver Creek (S17, T79N, R24W, Polk Co.) to Boone/Dallas county line (NW 1/4, NW 1/4 S2, T81N, R28W)	✓				✓	
	Boone/Dallas county line (NW 1/4, NW 1/4 S2, T81N, R28W) to the confluence with Unnamed Creek (S29, T84N, R28W, Boone Co.).		✓			✓	
East Beaver Creek	Mouth (NE 1/4 S21, T83N, R28W, Boone Co.) to 210th Street (North Line S31, T84N, R27W, Boone Co.).		✓			✓	
Little Beaver Creek (Beaver Creek)	Mouth (S35, T80N, R25W, Polk Co.) to confluence with an unnamed tributary (SW1/4, SW1/4, S29, T80N, R25W, Polk Co.)		✓			✓	
Little Beaver Creek (Little Beaver Creek)	Mouth (S14, T81N, R27W, Dallas Co.) to confluence with an unnamed tributary (SE1/4, SE1/4, S29, T82N, R27W, Boone Co.)		✓			✓	
Middle Beaver Creek	Mouth (S21, T83N, R28W, Boone Co.) to Hwy. 30 (N. line, S4, T83N, R28W, Boone Co.)		✓			✓	
Slough Creek	Mouth (S16, T81N, R27W, Dallas Co.) to confluence with an unnamed tributary (NW1/4, S21, T81N, R27W, Dallas Co.)		✓			✓	
Unnamed Creek (Little Beaver Creek)	Mouth (S11, T81N, R27W, Dallas Co.) to S. Line SW 1/4, NE 1/4, S12, T81N, R27W, Dallas Co.)		✓			✓	
Unnamed Creek (City of Bouton)	Mouth (S2, T81N, R28W, Dallas Co.) to K Circle (W. Line S2, T81N, R28W, Dallas Co.)		✓			✓	
Unnamed Creek (West Beaver Creek)	Mouth (SE 1/4, SW 1/4, S28, T84N, R29W, Greene Co.) to the road crossing at U Avenue (West line S28, T84N, R29W, Greene Co.).		✓			✓	
Unnamed Creek (West Beaver Creek)	Mouth (SW 1/4, SE 1/4, S34, T84N, R29W, Greene Co.) to the confluence with Unnamed Creek #1 (SE 1/4, SW 1/4, S28, T84N, R29W, Greene Co.).		✓			✓	
West Beaver Creek	Mouth (SE 1/4, SW 1/4, S6, T83N, R28W, Boone Co.) to the confluence with Unnamed Creek #2 (SW 1/4, SE 1/4, S34, T84N, R29W, Greene Co.).		✓			✓	

** Stream designated use classifications are based upon Iowa's Surface Water Classification Document (SWC), which was approved by the EPA on June 17, 2015.*

*** The four Unnamed Creeks were assigned to their respective HUC-12 watersheds shown in parenthesis in an attempt to differentiate the streams and provide additional context as to the location of the stream within the Beaver Creek Watershed.*

Table 3.2: Surface Water Designated Use Summary for Primary Streams in the Beaver Creek Watershed Streams

DESIGNATION CLASS	DESCRIPTION	NUMBER OF DESIGNATED STREAM SEGMENTS
Class A1	Primary contact recreational use	1
Class A2	Secondary contact recreational use	11
Class BWW-2	Warm water Type 2	12

Buffalo Grove Wildlife Area in Boone County.

IMPAIRED WATERS

Stream impairments are described in relation to their surface water classification and designated uses in. The State of Iowa has developed water quality standards for lakes and streams so that these waters support recreational uses and aquatic life (fish and macroinvertebrates). **Two stream reaches within the Beaver Creek Watershed are listed on EPA's 303 D list of impaired waterbodies due to elevated bacteria levels and/or aquatic life impairments (Figure 3.1)**. Beaver Creek is a major tributary to the Des Moines River. The Des Moines River is impaired for excess nutrients (nitrates) and bacteria (E. coli). The Iowa DNR approved the Water Quality Improvement Plan for Des Moines River, Iowa: Total Maximum Daily Load for Nitrate in 2009.

Des Moines River Nitrate TMDL

A TMDL Study is a determination of the maximum load of pollutant a given water body can receive and continue to meet water quality standards for that particular pollutant. TMDLs are conducted on water bodies where pollutant levels have been found to be in excess of water quality standards resulting in the water body failing to meet a designated use. TMDL studies determine a pollutant reduction target and allocate a portion of the needed reductions to each source of pollutant. Pollutant sources are characterized as either point sources or nonpoint sources. **Point sources receive a wasteload allocation (WLA) and include all sources that are subject to regulation under the National Pollutant Discharge Elimination System (NPDES) program,** e.g. wastewater treatment facilities, stormwater discharges in Municipal Separate Storm Sewer System (MS4) Communities, and concentrated animal feeding operations (CAFOs). **Nonpoint sources receive a load allocation (LA) and include all remaining sources of the pollutant as well as natural background sources.**

The Des Moines River TMDL Study for Nitrates was developed by Keith E. Schilling and Calvin F. Wolter. The TMDL was developed to address a reach of the Des Moines River that had been identified as being impaired due to excessive nitrate concentrations. The impaired reach is defined as the Des Moines River from the Center Street dam in the City of Des Moines to the Interstate 80 Bridge (segment 04-UDM-0010_2). **For the impaired segment, the Class C (drinking water) uses were assessed as "not supporting" due to the level of nitrate that exceeds state water quality standards and USEPA maximum contaminant level (MCL).** The applicable water quality standard for nitrate is 10 milligrams per liter (mg/l). The Water Quality Improvement Plan calculated the maximum allowable nitrate load from the 6.245 square mile Des Moines River Watershed that will ensure the impaired segment of the Des Moines River meets water quality standards.

Key Findings of the Des Moines River TMDL

- ✓ During the 1995 to 2006 period, nitrate concentrations in the river ranged from 0.5 to 14.5 mg/l and averaged 6.3 mg/l. Nitrate concentrations exceeded 10 mg/l approximately 16.4 percent of the time from 1995 to 2006 (719 out of 4382 values).
- ✓ Nitrate concentrations exhibit clear seasonality, with higher concentrations occurring during April, May, and June; as well as November and December.
- ✓ Elevated nitrate loading rates were associated with the Beaver Creek watershed located in the southern extent of the Des Moines River basin.
- ✓ Point sources contribute to 6.4 percent of the total nitrate load and nonpoint sources contribute 93.6 percent of the total nitrate load in the watershed.
- ✓ Established a target in-stream Nitrate concentration of 9.5 mg/l
- ✓ Nonpoint source nitrate loads require a reduction of 34.4 percent for all daily nitrate loads to be less than the TMDL target (9.5 mg/l).

For the Des Moines River TMDL several nitrate load reduction scenarios were evaluated using a Soil and Water Assessment Tool (SWAT) Model and finding are presented in following table.

Did you know?

There is limited data on the water quality of streams throughout the state. There is not enough data on most streams to identify if they should be classified as impaired.

Most streams that have been classified as impared were studied in greater detail because of an incident or situation that indicated that an impairment was possible.

More streams might be identified as impaired if additional water quality data was available for review.

GLOBAL SCALE NITRATE LOAD REDUCTION SCENARIOS	
SCENARIO	ESTIMATED NITRATE LOAD REDUCTION AT WATERSHED OUTLET
Ammonia Fertilizer Application 100 Reduce the rate of ammonia fertilizer application in the watershed from 170 kg/ha (152 lb/ac) to 100 kg/ha (89 lb/ac)	25.18%
Ammonia Fertilizer Application 50 Reduce the rate of ammonia fertilizer application in the watershed from 170 kg/ha (152 lb/ac) to 50 kg/ha (45 lbs/ac)	38%
Manure Remove all manure generated from permitted or registered CAFOs and feedlots	7.25%
Human Waste Remove all human waste from the watershed	4.8%
Highest Yielding Subbasins Target major nitrate load reductions in all subbasins with annual average losses greater than 13 lb/ac (Ammonia Fert. 50 Scenario)	14.6%
Downstream-most Subbasins target major nitrate load reductions in subbasins located closest to the DMWW intake (Ammonia Fert. 50 Scenario)	5.4%
Boone River Watershed Target major nitrate load reductions in the Boone River Watershed (Ammonia Fert. 50 Scenario)	5.46%
Upstream-most Subbasins Target major nitrate load reductions in subbasins located furthest away from the DMWW intake / Minnesota subbasins (Ammonia Fert. 50 Scenario)	6.04%

Table 3.3: SWAT Nitrate Load Reduction Scenarios

The target load reductions in Table 3.3 are from the Des Moines River Nitrate TMDL report.

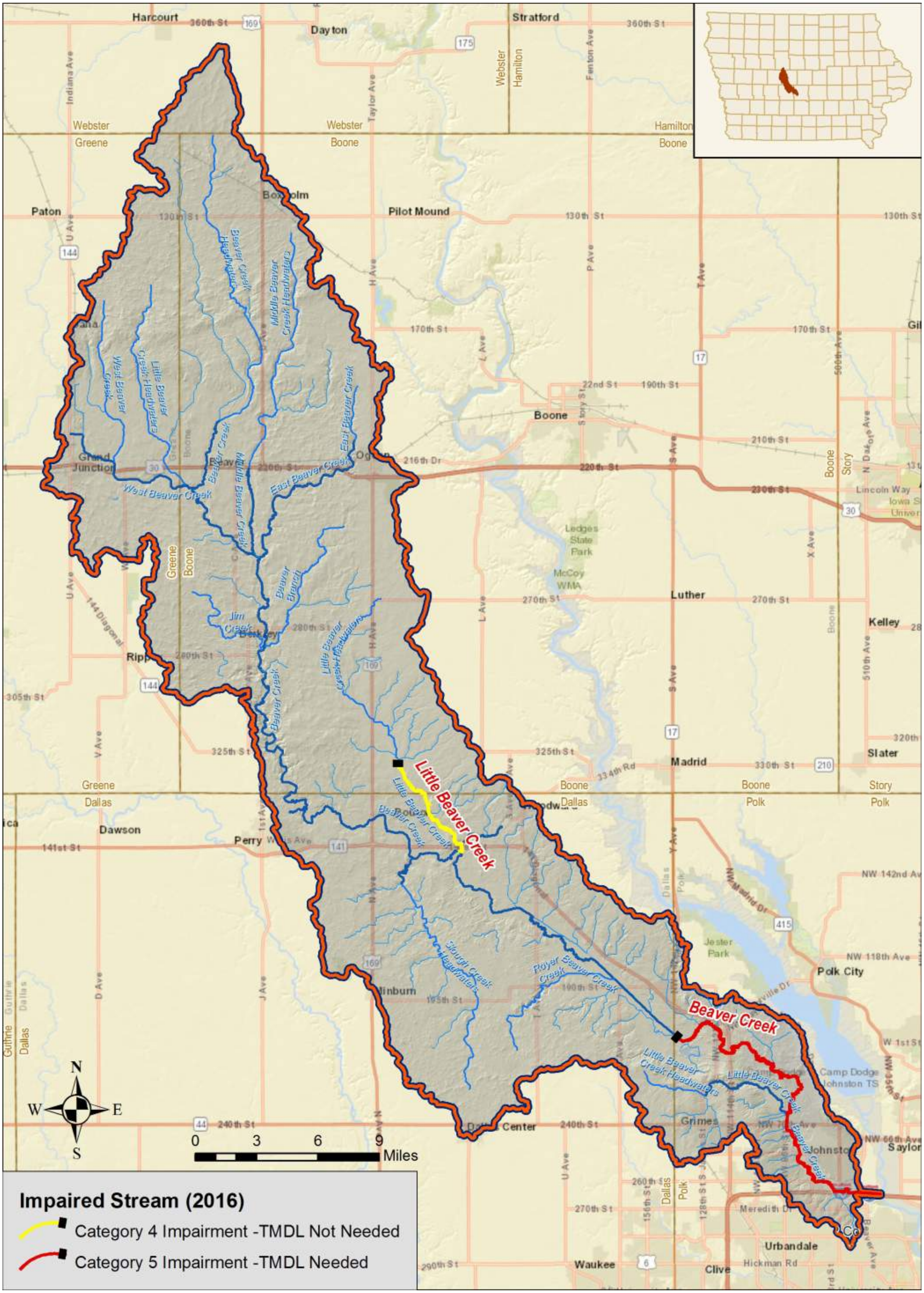


Figure 3.1: Impaired streams within the Beaver Creek Watershed.

Table 3.4: Beaver Creek Watershed Impaired Streams and Lakes

WATERBODY	CATEGORY	IMPAIRED USE	PRIMARY STRESSOR	USE SUPPORT	RATIONALE
Beaver Creek - Mouth (S17, T79N, R24W, Polk Co.) to Boone/ Dallas county line (NW 1/4, NW 1/4 S2, T81N, R28W)	5p 5b-v	Primary Contact Recreation, Aquatic Life	Indicator Bacteria, Biological (Flow, physical characteristics)	Partially* Supporting	Primary Contact: Geometric mean of E. coli is greater than the Class A1 criterion. Biological: Low aquatic macroinvertebrate IBI
Little Beaver Creek - Mouth (S14, T81N, R27W, Dallas Co.) to confluence with an unnamed tributary (SE1/4, SE1/4, S29, T82N, R27W, Boone Co.)	4c	Aquatic Life	Biological (Hydro-modification)	Partially* Supporting	Biological: low fish IBI
Des Moines River - Mouth (S14, T81N, R27W, Dallas Co.) to confluence with an unnamed tributary (SE1/4, SE1/4, S29, T82N, R27W, Boone Co.)	4a	Primary Contact Recreation, Drinking Water	Indicator Bacteria, Nutrients: Nitrates	Partially* Supporting	Primary Contact: Single-sample maximum criterion exceeded in significantly > 10% of bacteria samples Significantly > 10% of Nitrate samples fail to meet criterion

4a- TMDL has been completed but water quality standards have not yet been met

4c - Non-pollutant caused impairment. No TMDL needed

5p- Impairment occurs on a waterbody presumptively designated for Class A1 primary contact recreation use or Class B (WW1) aquatic life use.

5b-v- The aquatic life uses of a stream with a watershed size within the calibration range of IDNR biological assessment protocol (~10 to 500 square miles) are assessed as Section 303(d)-impaired based on results of the required two or more biological sampling events in multiple years within the previous five years needed to confirm the existence of a biological impairment.

*Because state water quality criteria are designed to be fully protective, slight to moderate impairment of a beneficial use do not necessarily preclude that use from being at least partially supported. There may be periods of the year in which these streams meet designated uses.

STREAMS

The streams within the Beaver Creek Watershed have been classified into the following management categories based on their designated uses.

PRIMARY STREAMS

Streams within the Beaver Creek Watershed with a DNR Designated Use are classified as "Primary streams" (Figure 3.2). Primary streams should be protected for their designated use classifications; **these streams represent the highest primary targets for protection and restoration measures.** Unnamed streams with water quality impairments are included within the primary streams. In some cases, the management category for a given stream differs from the upper portion to the lower reaches. A description of the named primary streams follows.

SECONDARY STREAMS

Named streams that maintain flow and/or pooled areas sufficient to maintain a viable aquatic community and support recreational uses that have not been assigned a designated use are classified as "Secondary streams" (Figure 3.2). Secondary streams represent the major tributaries to Beaver Creek Watershed's Primary streams. **Secondary streams represent the second highest primary targets for conservation** (protection and restoration) measures.

OTHER STREAMS

General use, unnamed streams within Beaver Creek Watershed are shown as "Other streams" in Figure 3.2. These **"Other" streams should be protected for livestock and wildlife watering, aquatic life, noncontact recreation, and industrial, agricultural, or domestic withdrawal uses** but do not represent the highest primary targets for implementation of conservation (protection and restoration) measures.

An example of a secondary stream in the Beaver Creek watershed.

Table 3.5: Beaver CreekWatershed Primary and Secondary Streams

STREAM CATEGORY	STREAM NAME
Primary	Beaver Creek
Primary	East Beaver Creek
Primary	Little Beaver Creek
Primary	Middle Beaver Creek
Primary	Slough Creek
Primary	Unnamed Creek (Little Beaver Creek)
Primary	Unnamed Creek (City of Bouton)
Primary	Unnamed Creek (West Beaver Creek)
Primary	Unnamed Creek (West Beaver Creek)
Primary	West Beaver Creek
Secondary	Beaver Branch
Secondary	* Beaver Creek Headwaters
Secondary	* East Beaver Creek Headwaters
Secondary	* Little Beaver Creek Headwaters
Secondary	* Middle Beaver Creek Headwaters
Secondary	Jim Creek
Secondary	Royer Creek
Secondary	* West Beaver Creek Headwaters

** The headwater reaches of these streams are considered a secondary primary because they have not been assigned a designated use and may not be capable of maintaining flow throughout the year or contain sufficient pooled areas during intermittent flow periods to maintain a viable aquatic community.*

Figure 3.2: Beaver Creek Watershed- Stream Classifications

MORE ABOUT THE PRIMARY STREAMS

Beaver Creek

Description

Beaver Creek, a fourth order stream at its mouth, is the most significant stream from a recreational usability perspective within the Beaver Creek Watershed. The Headwaters of Beaver Creek are located near the intersection of U.S. Highway 169 and State Highway 175, near the northern border of Boone County. The Headwaters portion of Beaver Creek has not been assigned a designated use. **The mainstem branch of Beaver Creek begins approximately 36 miles northwest of Des Moines,** northeast of the intersection of U.S. Highway 169 and U.S. Highway 30. The 64 mile long mainstem branch flows generally southeast towards the City of Des Moines, where it joins the Des Moines River, which ultimately drains to the Mississippi River south of Keokuk, Iowa.

Beaver Creek Greenbelt

The lower portion of Beaver Creek is located within the City of Johnston. **Several parks, trails, and greenspaces are located adjacent to the creek, these greenspaces provide natural refuge from the surrounding urbanized, metropolitan area.** Currently, the Creek is used by birders, anglers, and kayakers, however there are additional opportunities being proposed for Beaver Creek by the Iowa DNR, the City of Johnston and the City of Des Moines. These opportunities are largely focused on creating three non-motorized boat/canoe accesses, which would connect to local trail hubs near 70th Avenue, Terra Lake Park, and Merle Hay Road.

Designated Recreational Uses

The portion of Beaver Creek south of the Boone/Dallas County Line is listed as a Class A1 waterbody, indicating it is capable of supporting primary recreational uses such as swimming and kayaking. **The stretch of Beaver Creek north of the Boone/Dallas County Line is listed as a Class A2, BWW-2 waterbody,** indicating this reach is capable of supporting a warm water game fish population. The direct connection with the Des Moines River has allowed for a sustainable population of desirable gamefish species including smallmouth bass to become established within the creek.

Impaired Reaches

The stretch of **Beaver Creek south of the Polk/Dallas County Line** is impaired for biological life based on a low macroinvertebrate biotic index score. This stretch is also impaired for bacteria based on Geometric mean bacteria concentrations exceeding the Class A1 criterion.

For definition of stream order, see discussion on page 66.

East Beaver Creek

Description

East Beaver Creek, a first order stream at its mouth, originates north of the City of Ogden, north of U.S. Highway 30. The 11-mile long creek flows generally southwest around the City of Ogden before joining Beaver Creek. Based on the streambank assessment performed in Chapter 7, **stream banks of East Beaver Creek were identified as having a moderate potential for streambank failure to occur.** The riparian area within 150 feet of the East Beaver Creek channel is more than 50% grassland, these grasslands help to reduce this risk of streambank failure.

Designated Recreational Uses

East Beaver Creek is designated for secondary (canoeing) recreational uses. Gamefish production is limited in East Beaver Creek due to flow constraints and other physical characteristics.

Impaired Reaches

An insufficient amount of data has been collected on this stream to determine whether or not any stream reaches are impaired for their designated use.

Little Beaver Creek (Little Beaver Creek Subwatershed)

Description

Little Beaver Creek, a third order stream at its mouth, originates in central Boone County near U.S. Highway 169. The 15-mile long creek flows generally southeast before joining Beaver Creek west of Woodward. Based on the streambank assessment performed in Chapter 7, **stream banks of Little Beaver Creek were identified as having a moderate potential for streambank failure to occur.**

Designated Recreational Uses

Little Beaver Creek is designated for secondary (canoeing) recreational uses. Gamefish production is limited in Little Beaver Creek due to flow constraints and other physical characteristics.

Impaired Reaches

Results from biological monitoring conducted by the DNR in 2007 suggest the Class B (WW2) aquatic life uses should be considered partially supporting. Habitat alterations and lack of low flow stability associated with channelization and tiling in the watershed are the suspected causes of the impairment.

Little Beaver Creek (Beaver Creek)

Description

Little Beaver Creek, a third order stream at its mouth, originates west of the City of Grimes. The 8-mile long creek flows primarily east through the northern portion of the City of Grimes before joining the mainstem branch of Beaver Creek north of the intersection of NW 86th Street and NW 78th Avenue. Based on the streambank assessment performed in Chapter 7, **stream banks of Little Beaver Creek were identified as having a moderate potential for streambank failure to occur. Three high priority streambank instability sites were identified** in close proximity to the creek channel as described in Chapter 7.

Designated Recreational Uses

Little Beaver Creek is designated for secondary (canoeing) recreational uses. Gamefish production is limited in Little Beaver Creek due to flow constraints and other physical characteristics.

Impaired Reaches

An insufficient amount of data has been collected on this stream to determine whether or not any stream reaches are impaired for their designated use.

Middle Beaver Creek

Description

Middle Beaver Creek, a third order stream at its mouth, bisects the northern third of the Beaver Creek Watershed from North to South. The 15-mile long creek flows primarily south before joining the mainstem branch of Beaver Creek south of the intersection of U.S. Highway 30 and U.S. Highway 169. Based on the streambank assessment performed in Chapter 7, **stream banks of Middle Beaver Creek were generally identified as having a low potential for streambank failure to occur.** Furthermore, the riparian areas within 150 feet of the Middle Beaver Creek channel is more than 68% grassland, these grasslands help to reduce this risk of streambank failure.

Designated Recreational Uses

Middle Beaver Creek is designated for secondary (canoeing) recreational uses. Gamefish production is limited in Middle Beaver Creek due to flow constraints and other physical characteristics.

Impaired Reaches

An insufficient amount of data has been collected on this stream to determine whether or not any stream reaches are impaired for their designated use.

Slough Creek

Description

Slough Creek, a third order stream at its mouth, originates 6.5 southwest of the City of Minburn. The 13-mile long creek flows primarily north before joining the mainstem branch of Beaver Creek approximately 1.5 miles west of the town of Gardiner. Based on the streambank assessment performed in Chapter 7, **stream banks of Slough Creek were generally identified as having a low potential for streambank failure** with the exception of the most downstream reach near the confluence with Beaver Creek which was identified as having a high potential for streambank failure. **High priority streambank instability sites were identified on an unnamed tributary near the Slough Creek headwaters.** Slough Creek itself is well-buffered with 80% of the riparian area within 150 feet of the stream comprised of forest or grasslands.

Designated Recreational Uses

Slough Creek is designated for secondary (canoeing) recreational uses. Gamefish production is limited in Slough Creek due to flow constraints and other physical characteristics.

Impaired Reaches

An insufficient amount of data has been collected on this stream to determine whether or not any stream reaches are impaired for their designated use.

West Beaver Creek

Description

West Beaver Creek, a third order stream, originates in the northwestern third of the Beaver Creek watershed flowing south towards the City of Grand Junction. As the stream passes the City of Grand Junction, it turns to the east where it joins Beaver Creek south of the City of Beaver. **No priority streambank instability sites were identified in the streambank assessment described in Chapter 7.**

Designated Recreational Uses

West Beaver Creek is designated for secondary (canoeing) recreational uses. Gamefish production is limited in West Beaver Creek due to flow constraints and other physical characteristics.

Impaired Reaches

An insufficient amount of data has been collected on this stream to determine whether or not any stream reaches are impaired for their designated use.

Stream Ordering

Stream ordering is a method of assigning a numeric order or rank to each segment of a stream network. This order is a method for identifying and classifying types of streams based on their numbers of tributaries. Some characteristics of streams can be inferred by simply knowing their order. Stream orders provide a way to rank and identify relative sizes of channels in a drainage basin. First-order streams are dominated by overland flow of water; they have no upstream concentrated flow. Because of this, they are most susceptible to non-point source pollution problems and can derive more benefit from wide riparian buffers than other areas of the watershed. The Strahler method is the most commonly used method to describe stream order. In this method, all links without any tributaries are assigned an order of 1 and are referred to as first order. The stream order increases when streams of the same order intersect. Therefore, **the intersection of two first-order links will create a second-order link, the intersection of two second-order links will create a third-order link, and so on.**

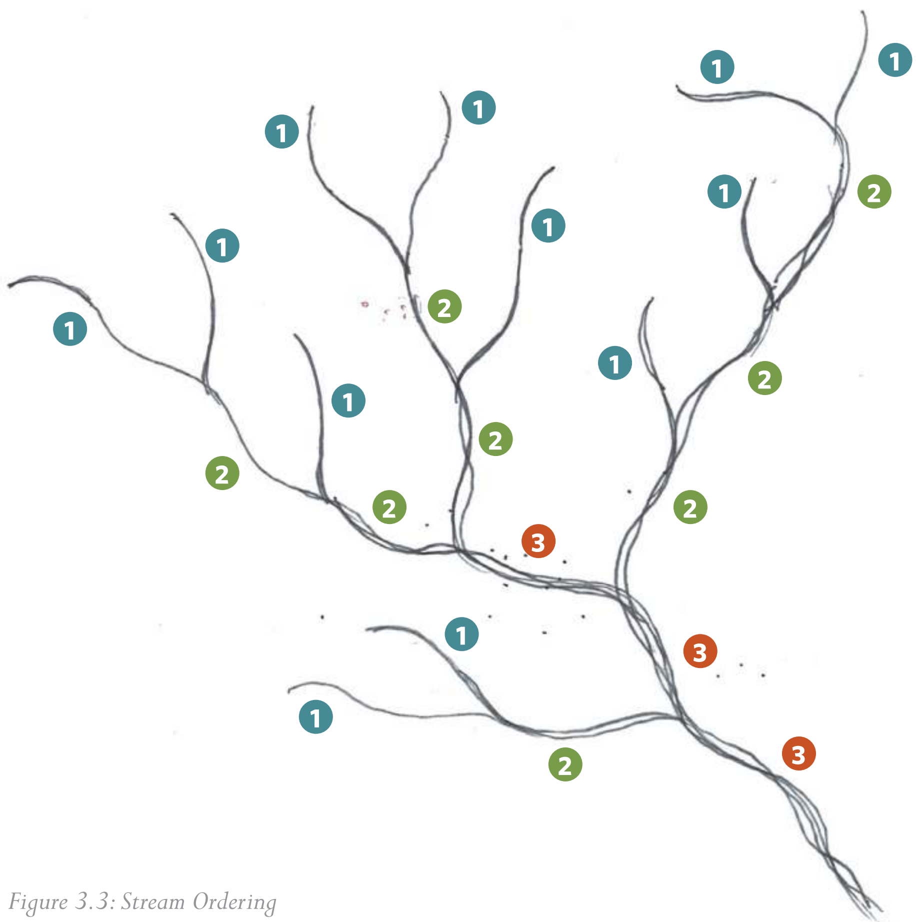


Figure 3.3: Stream Ordering

04

CLIMATE, STREAMFLOW & FLOOD RISK

Climate is the prevailing weather patterns for an area over an extended period of time. This section describes patterns of temperature, rainfall, storm intensities, growing season length, evaporation, and severe weather for Beaver Creek Watershed. Climate conditions are one of the primary factors that influence the volume and quality of runoff from the landscape.

04

Average annual temperature has increased 1.6° F*

1973 — 59.3° F

2019 — 60.9° F

Average annual precipitation has increased 19%*

1978 — 30.5 IN

2019 — 36.2 IN

* In Des Moines

Flow data

Recorded along Beaver Creek, at Johnston, since 1960.

Record flow

The peak annual flow of 21.7 billion cubic feet† would fill Saylorville Lake seven times over.

Streamflow

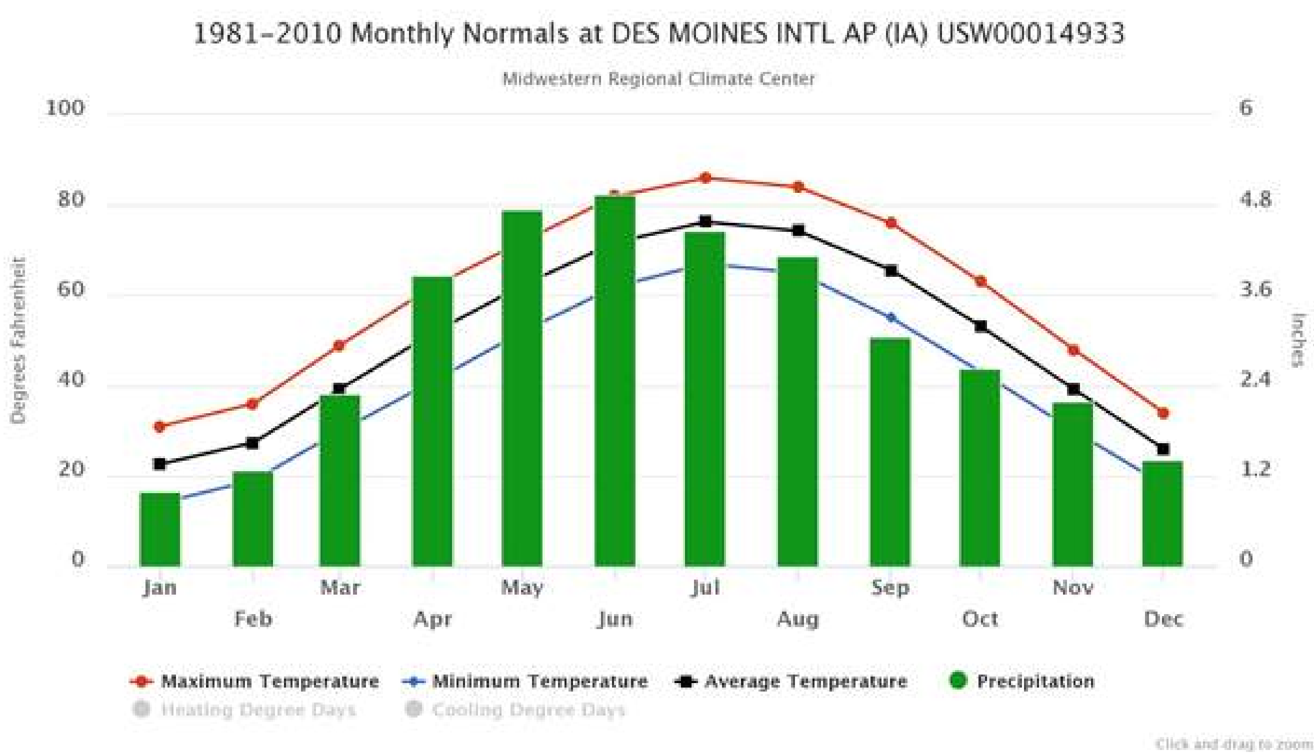
Volume has increased 2.3% on average annually since 1960.

† 2010

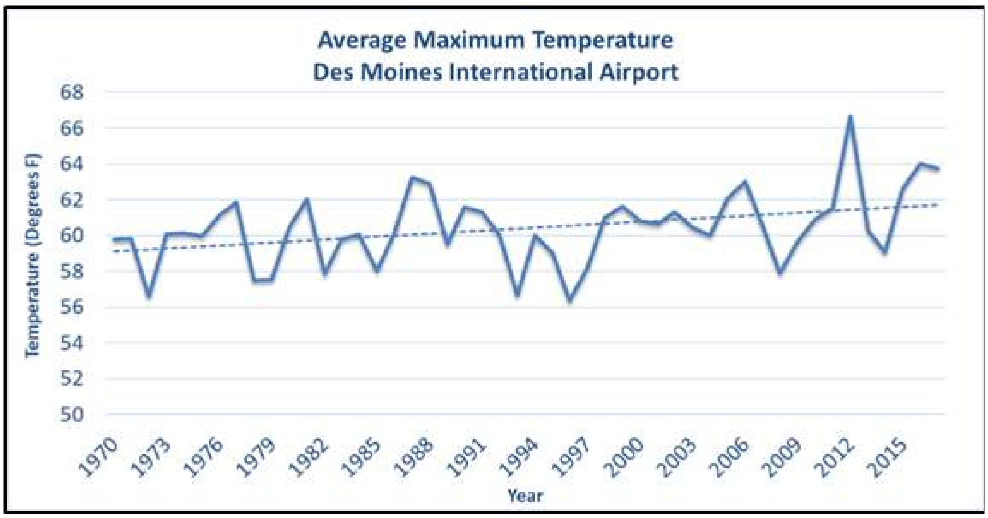
TEMPERATURE

National Oceanic and Atmospheric Administration (NOAA) climate data from Des Moines, IA were summarized with corresponding average, maximum, and minimum monthly temperatures plotted by month (Figure 4.1). There are multiple weather stations either within or in close proximity to the City of Des Moines. The Des Moines International Airport weather station was chosen because the City of Des Moines is located within the watershed and because this station contains climatic data dating back to the 1870's or earlier with 100% data coverage (no missing values). The average annual temperature is about 50° F, with hot and humid summers often near or exceeding 90° F. Peak average daily summer temperatures (about 85° F) are typically observed in July with slightly lower averages noted for June and August. Winters can have temperatures dropping well below freezing in December, January and February. The remaining 'cold' months of November, March and April typically have average daily maximum temperatures above freezing (32°F). Broadly speaking, daily average minimum and maximum temperatures

Figure 3-6. Average monthly climate data for Des Moines, IA. NOAA's Midwestern Regional Climate Center



It has been noted that average regional temperatures have increased over time. To evaluate this pattern, observed average annual minimum and maximum temperatures at the Des Moines International Airport weather station were plotted for the time period 1970 to 2017 in Figure 4.2. While there can be seen a slight increase in average annual maximum temperatures, the increasing pattern is more pronounced for the average annual minimum temperatures. Annual minimum temperature values have increased about 2-3 degrees F from 1970 to 2018. Other studies have noted that since 1970: (1) the nighttime temperatures have increased more than the daytime temperatures; (2) daily minimum temperatures have increased in the summer and winter; (3) daily maximum temperatures have risen in winter but declined substantially in the summer (Report to the Governor and Iowa General Assembly, 2011.)



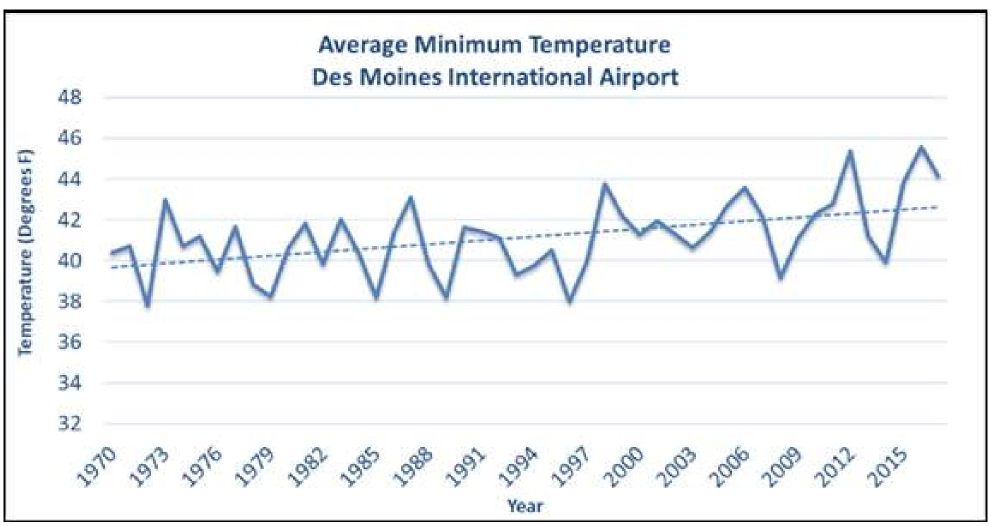


Figure 4.2: Average Annual Maximum and Minimum Temperature for Des Moines, IA. NOAA's Midwestern Regional Climate Center

RAINFALL

Annual average rainfall totals about 35.4 inches with the growing season typically having the highest rainfall totals of about 2 inches to 6 inches per month. Annual rainfall measured at the Des Moines site during the 1970 – 2018 time period has varied from about 22 inches (1988) to 55.8 inches (1993, flood) (Figure 4.3). For the same time period, growing season (May-October) rainfall averaged about 23.6 with values that ranged from about 13.2 inches (2012) to 44.7 inches (1993) (Figure 4.4).

Since the 1970s, Iowa has seen increases in precipitation, changes in timing of precipitation, seasonality, and changes in the frequency of intense rain events (Takle, 2010). Streamflow records in Iowa (including those for the Beaver Creek watershed) suggest that average flows, low flows, and perhaps high flows have all increased and become more variable since the late 1960s or 1970s; however, the relative contributions of land use and climate changes are difficult to sort out. Using land cover information obtained from well documented studies in 1859, 1875, and 2001, Wehmeyer et al. (2011) estimated that the increase in runoff potential in the first 30 years of settlement represents the majority of predicted change in the 1832 to 2001 study period. The study also outlines hydrologic alterations induced by climate change based on evidence provided in the recently released The Climate Science Special Report (USGCRP 2017). This study found that heavy rainfall is increasing in intensity and frequency across the United States and is expected to increase over the next few decades.

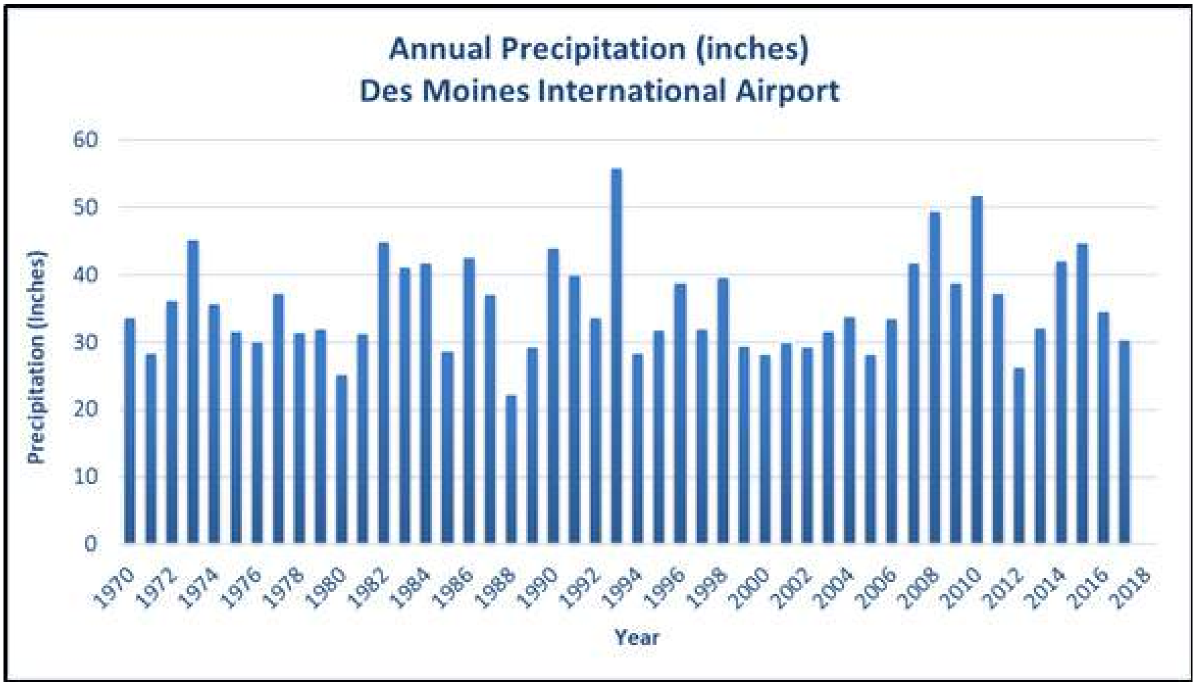


Figure 4.3: Annual Precipitation 1970-2017, Des Moines, IACenter

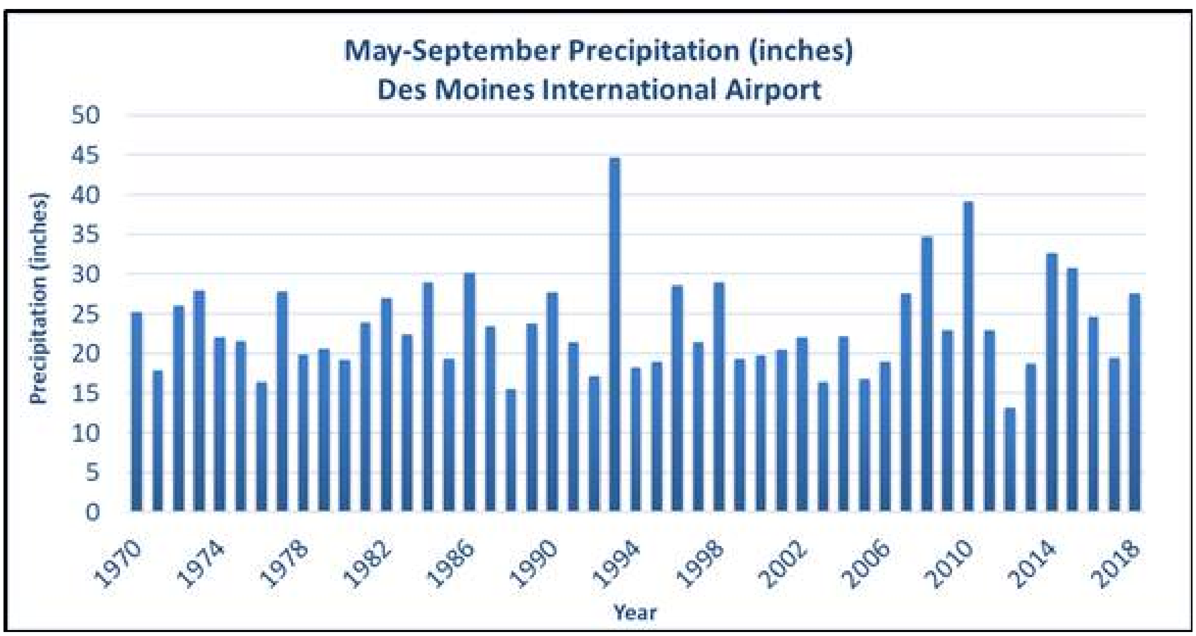


Figure 4.4: Growing Season (May-Sept) Precipitation 1970-2018, Des Moines IA

VARIABLE AND CHANGING CLIMATE

Of the climate data summarized above and from leading Iowa researchers, **there have been several key changes noted over the past 40 years that affect farms, cities, landscapes and waters.** These measured changes include:
Precipitation amounts, the frequency and intensity of large storms, and back-to-back storms have been defined by recent NOAA updates of precipitation data. **In general, the large (and less frequent) storms have increased by 4% to 20+% depending upon location and storm size.** The more frequent storms (occurring less than every ~25 years) have changed small percentages. More precipitation occurs in the first half of the year and less in the second half. Precipitation increases are typically greater on the eastern half of Iowa than the west, with Beaver Creek Watershed being in the middle. **These trends are expected to continue well into the future**.

- **The amount of moisture in the atmosphere has increased as measured by humidity and dew point temperatures by about 13%** (Report to the Governor and Iowa General Assembly, 2011). Atmospheric moisture fuels thunderstorms and severe weather. Beaver Creek Watershed is in the center of America's Heartland, which is a highly active weather area, as evidenced by the number of tornadoes and severe weather events.
- **Growing seasons, or the length of time between spring and fall freezing dates, have increased by about 5 to 10 days**, as defined from the Des Moines, IA weather record (1970-2018).
- **Warmer winter and spring temperatures may translate into earlier and slower snow melts,** reducing springtime flooding incidence at the critical time when vegetation and cover crops are typically at low levels.

- Climatologists have continued to refine changing climate assessment techniques and projections. **In short, there is widespread agreement that many of the above patterns are going to continue, with considerable wet and dry year-to-year variability likely.** In general, factors affecting increased stream flows and flooding are to become more frequent. Hence, **watershed management should incorporate innovations that can address more frequent, high-intensity precipitation events** by retaining water on the land as much as possible.

Source: Report to the Governor and the Iowa General Assembly, 2011. Climate Change Impacts on Iowa. Climate Change Impacts Committee.

http://www.iowadnr.gov/Environment/ClimateChange/ClimateChangeAdvisoryCo.aspx

HISTORIC STREAMFLOW DATA

- **Stream flow data has been collected at a USGS gaging station located north of the NW 70th Avenue Bridge in Johnston, Iowa (USGS 05481950).** Data collection began in April of 1960 and continues through the present day. At this location, Beaver Creek is collecting runoff from an area of 358 square miles (94% of its entire watershed).

ANNUAL FLOWS

- Stream flow varies greatly from year to year. Since 1960, annual flow volumes have ranged from 589 million cubic feet in 1989 to 21.7 billion cubic feet in 2010. To put that in perspective, **the annual volume of flow from 2010 would be enough to completely fill Saylorville Lake 7 times** (Saylorville Lake holds 73,600 acre-ft of water). **An upward trend can be observed in average flow rates**. The value of annual average flow increased by 130 cubic feet per second from 1960 to 2017. This amounts to approximately 2.3% increase every year.

FLOW VARIATION

- Daily average flow rates in Beaver Creek have ranged from very little flow to **11,500 cubic feet per second on July 10, 1993.** Average daily flow rates have exceeded 3,000 cubic feet per second for only 103 days over a period of more than 58 years (less than 0.5% of all days). **The average daily flow rate over the entire period of record is 243 cubic feet per second, or a daily volume of 3.5 million cubic feet.**

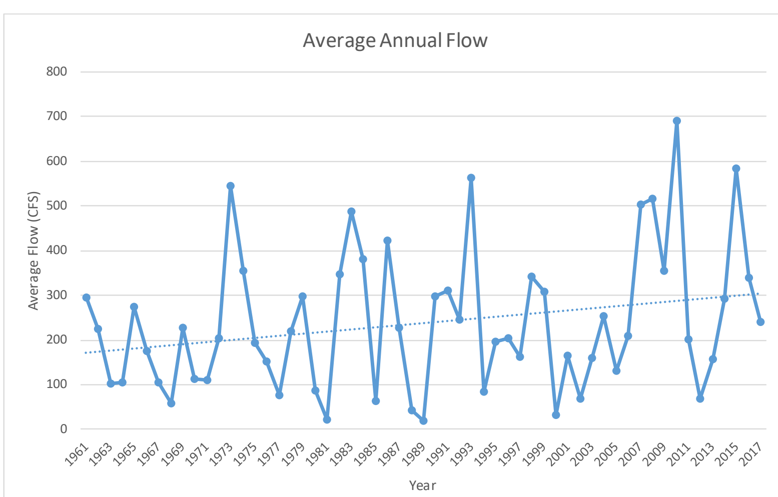
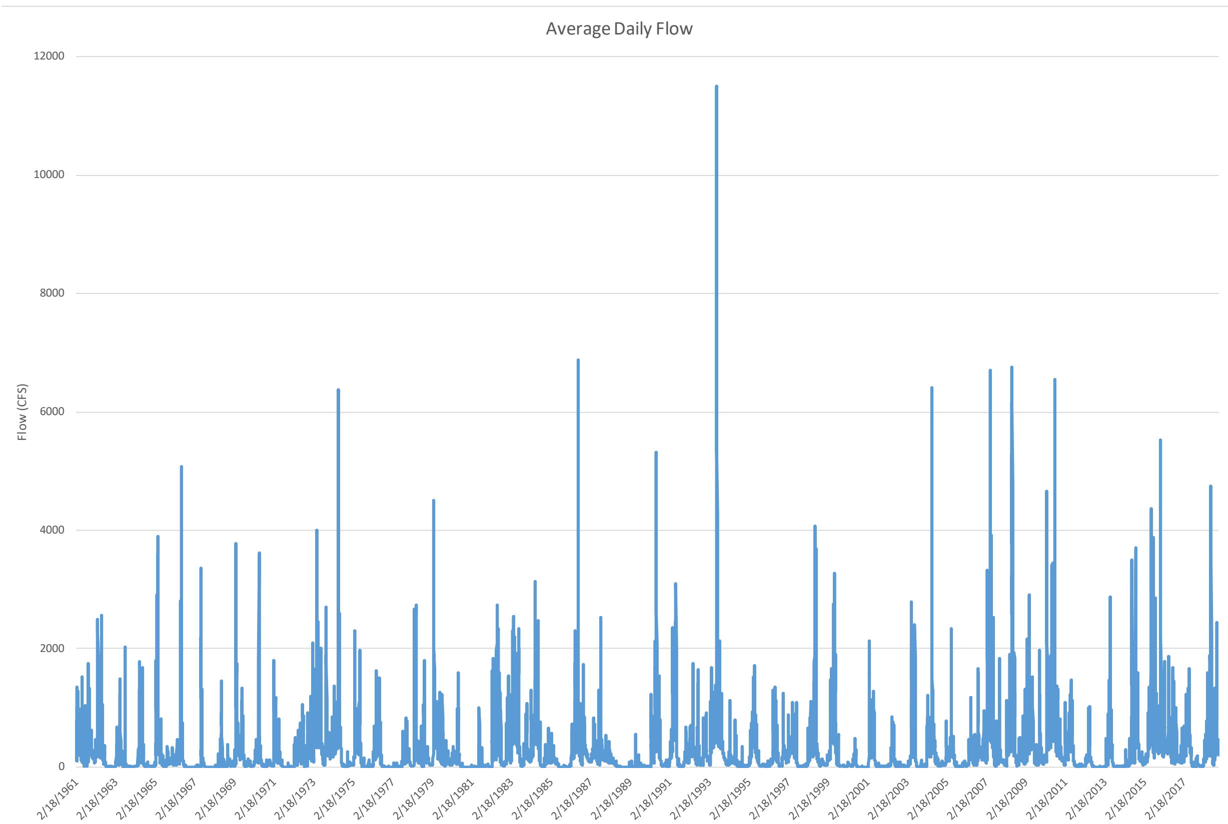


Figure 4.5:Data from USGS Gaging Station #05481950



FLOOD RISK POTENTIAL

Flooding remains a threat within the watershed. As the watershed planning process was getting started, a major event occurred in the downstream portion of the watershed on June 30th, 2018. While the upper portions of the watershed did not experience the rainfall intensity of the lower portion, flash flooding impacts were common in areas of Dallas and Polk County. Beaver Creek remains one of the more undeveloped watersheds that flows through the Des Moines metro area, making flood control and stormwater management planning critically important as development continues. **Flood risk in the watershed have been evaluated multiple times through studies that produce maps indicating different levels of risk associated with the location near a major flow corridor (FEMA Insurance Rate Maps).** These maps are intended to identify the need for flood insurance to be purchased by property owners.

FLOOD HISTORY

At the USGS gauge located north of NW 70th Avenue bridge, major impacts are expected when water levels exceed 16 feet. **Over the 58 years of record, only one year exceeded a gauge height of 16 feet, during the 1993 flood event.**

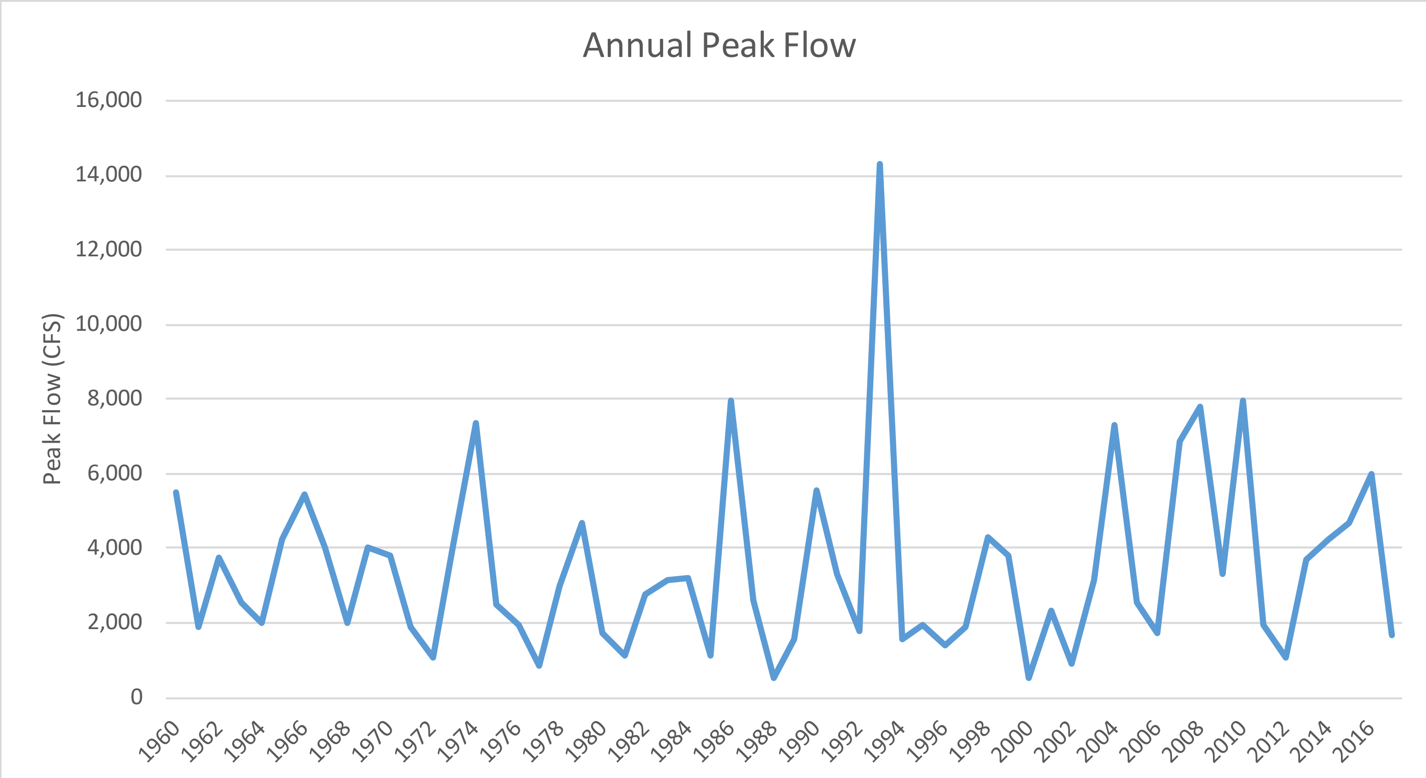


Figure 4.7: Data from USGS Gaging Station #05481950

100 YEAR GAUGE HEIGHT = 16 FT

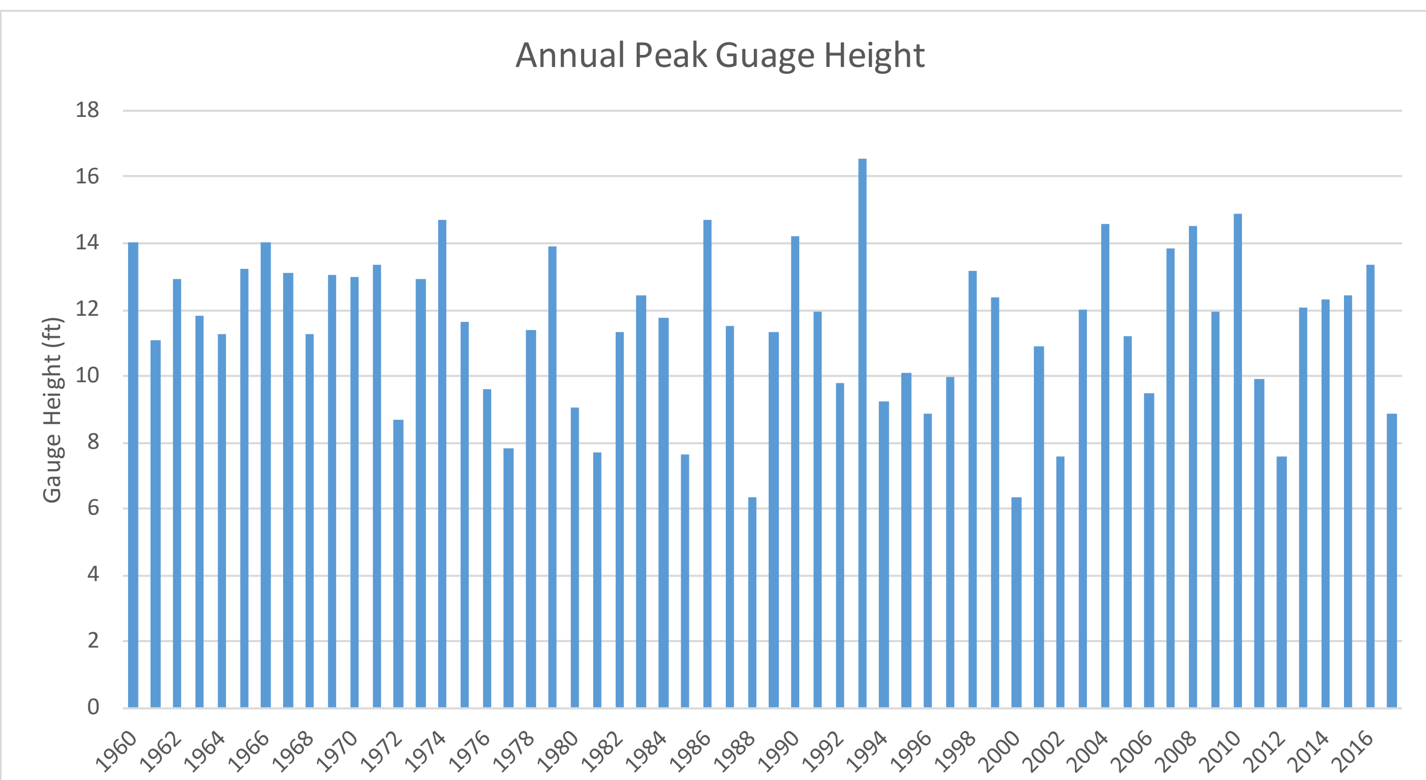


Figure 4.8: Data from USGS Gaging Station #05481950

HYDROLOGIC ASSESSMENT

A hydrologic assessment has been completed to review watershed conditions and estimate the rates and volumes of streamflow that would be expected to be generated by various storm events. This assessment was prepared using information about the land surface and streams throughout the Beaver Creek watershed. Then, **a computer model simulation was created to model the effects created by storm events of various sizes.** The results of this model were compared to available streamgauge data for calibration, to verify that the model is in general agreement with conditions that have been observed at a given point along Beaver Creek.

PREPROCESSING

Hydrologic assessment of the Beaver Creek watershed was performed using Geographic Information System (GIS) tools (ArcMap's GeoHMS v10.2 and HEC-HMS v4.2.1). LiDAR terrain data available through the State of Iowa was used as a basis to create a Digital Elevation Model (DEM), a surface elevation model of the watershed. **This was used to divide the watershed into 85 smaller subwatershed areas, averaging approximately five square miles in area**. For each of these smaller areas, characteristics such as average basin slope, longest flow path, and basin centroid were calculated.

Hydraulic parameters (such as channel shape, size and slope) for Beaver Creek and major tributaries were estimated using the DEM. Identified major tributaries to Beaver Creek include, from upstream to downstream, Middle Beaver Creek, West Beaver Creek, East Beaver Creek, Jim Creek, Beaver Branch, Little Beaver Creek (Boone and Dallas counties), Slough Creek, Royer Creek, and Little Beaver Creek (Polk County).

Reach lengths, channel slopes, and channel dimensions for flow routing were tabulated. Land cover information was used to estimate parameters used to calculate runoff volumes and flow rates for each subwatershed area (NRCS Curve Numbers, time of concentration, etc.). **This collected data was exported into the computer model (HEC-HMS) for analysis.**

RAINFALL EVENTS

The hydrologic model analyzed runoff from events of various return periods. **The return period is an estimate of how frequently a given amount of rain is expected to fall on average over a very long period of time.**

This rainfall was assumed to fall over a 24-hour period, assuming a Type II rainfall distribution pattern. This rainfall pattern is prescribed for use in Iowa, and assumes that most of the rainfall occurs during an intense period in the middle of the storm event.

RETURN PERIOD	RAINFALL DEPTH (INCHES)
2 Year	3.08
10 Year	4.46
25 Year	5.44
100 Year	7.12

Table 4.1: Design Rainfall Depths for the modeled 24-hour storms

MODEL CALIBRATION

Several data sources were used to calibrate the hydrologic model. Principally, flow data from USGS Gage 05481950 along NW 70th Avenue in Grimes was used to compare the hydrologic model to historic flows. In addition, USGS stations 05481690 on West Beaver Creek at Grand Junction and 05481680 on Beaver Creek at Beaver were used to calibrate flows on the upstream reaches. Peak flow estimates from USGS' StreamStats application were obtained to perform an order of magnitude check at non-gaged locations on Beaver Creek and on major tributaries.

Initial runs of the hydrologic model produced a 100-year peak discharge that was nearly 2.5 times larger than the historic largest recorded flow measurement of 14,300 cubic feet per second (cfs) at the Grimes USGS gage during the Flood of 1993. Thus, **several steps were necessary to calibrate the model.** Based on a comparison of the computed hydrograph and the historic gage hydrograph from the Flood of 1993, it was clear that the initial model was not sufficiently attenuating (reducing) flow as it was being routed through the watershed.
The initial model did not include reservoir nodes out of convenience. However, floodplain constrictions such as culverts, bridges, topographic depressions, ponds, agricultural levees, and field berms are prevalent throughout the Beaver Creek watershed and act as flow attenuators, especially during larger rainfall events. Therefore, several reservoir nodes were placed in the model to reduce peak flows. Reservoirs were placed primarily at bridges that appeared to be the largest flow attenuators based on the Zone A floodplain in the watershed. A hydraulic opening and storage curve for each reservoir were estimated based on the DEM.

To further attenuate peak flows in the model to meet calibration data, **channel losses due to percolation were added to the hydrologic model.** Channel losses were estimated in order to avoid overestimating reservoir size and to factor in hydraulic losses in the channel due to the relatively flat slope of Beaver Creek and its tributaries.

Initially, baseflow was factored into the hydrologic model to provide an initial flow value to route through the simulation and improve model stability. However, combining channel losses due to percolation with flat terrain resulted in significant attenuation of baseflow. This resulted in a decrease in flows observed on the computed hydrographs in the downstream portion of the model because baseflow would be attenuated before the runoff generated by each design storm arrived in the stream. **Because of this circumstance, a baseflow method was removed from the hydrologic model.**

MODEL RESULTS

The results of the calibrated hydrologic model are summarized below in Table 4.2 at the outlet of each HUC-12 watershed contained within the Beaver Creek watershed for each design storm. **The calculated discharge at the USGS gage in Johnston was 14,590 cfs. The largest discharge on record at the gage is 14,300 cfs, which was recorded during the Flood of 1993.** Peak flow statistics obtained from USGS at the gage estimate the 100-year peak flood discharge to range between 12,400 and 17,600 depending on the computational method. **Therefore, the hydrologic model has been accurately calibrated to gauge data.**

Source: https://streamstatsags.cr.usgs.gov/gagepages/html/05481950.htm

A comparison of the computed hydrograph at the Johnston USGS gage and the historic hydrograph during the Flood of 1993 is shown in Figures 4.9 and 4.10. This comparison shows that the general appearance of the calculated hydrograph in the hydrologic model is similar to gauge data. While it is important to note that the USGS data does factor in additional rainfall that fell after the peak discharge on July 10, 1993 and the computed hydrograph does not, trends in the hydrograph can be compared.

With both hydrographs, **an early jump in flow is observed due to a first flush of runoff from nearby tributaries** being conveyed to the gage prior to the arrival of the peak discharge. **A large jump occurs in the hydrograph as the peak arrives, which combines local rainfall and runoff with conveyed flow from above the gage**. Due to the size of the overall Beaver Creek watershed, conveyed flow continues to be routed from upstream as the simulation continues. Combined with the gentle slope of Beaver Creek and the watershed as a whole, this phenomenon results in a receding limb of the hydrograph that lingers for several days before finally reaching its baseline value. The similarities with both hydrographs, rainfall non-withstanding, provide another source of calibration and improves confidence in the validity of the hydrologic model.

HUC-12 VALUE	HUC-12 NAME	PEAK DISCHARGES (CFS)			
		2 YEAR	10 YEAR	25 YEAR	100 YEAR
71000040801	Little Beaver Creek - West Beaver Creek	600	1130	1530	2260
71000040802	West Beaver Creek	1260	2350	3010	3900
71000040803	Middle Beaver Creek	780	1680	2320	3230
71000040804	Beaver Creek - West Beaver Creek	2380	4490	5670	7460
71000040805	East Beaver Creek	500	960	1310	1960
71000040806	Beaver Creek - Beaver Branch	2710	5330	6650	8870
71000040807	Slough Creek	880	2050	2650	3360
71000040808	Beaver Creek - Slough Creek	2450	5810	8010	10150
71000040809	Little Beaver Creek - Beaver Creek	1200	2540	3610	5580
71000040810	Beaver Creek - Royer Creek	2200	6460	10010	13730
71000040811	Beaver Creek - Middle Des Moines River	2370	7020	10740	15760

Table 4.2: Hydrologic Model Results

Figure 4.9: Computed HEC-HMS Peak Flow Output near Johnston, IA (called the Grimes gauge by USGS)

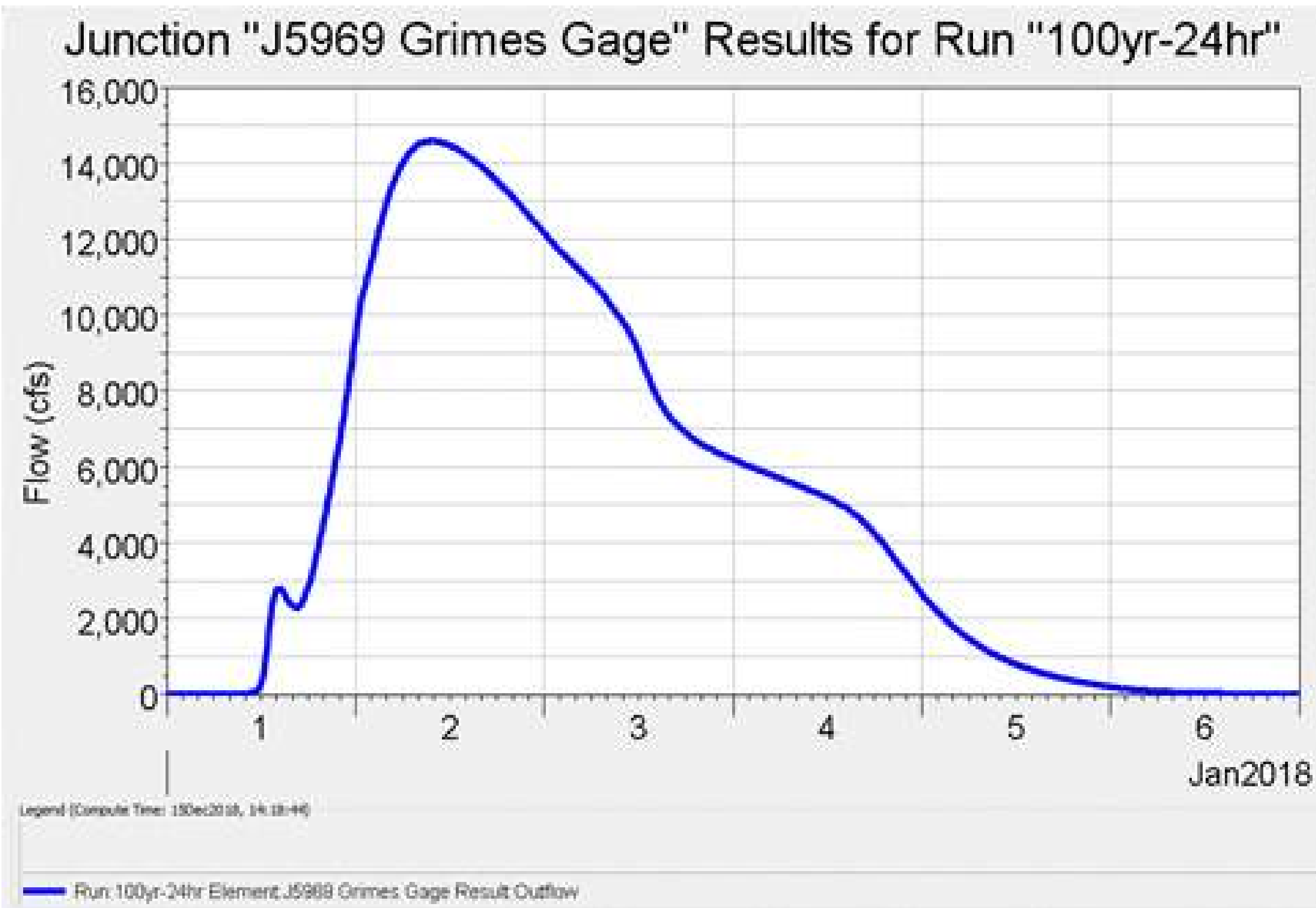
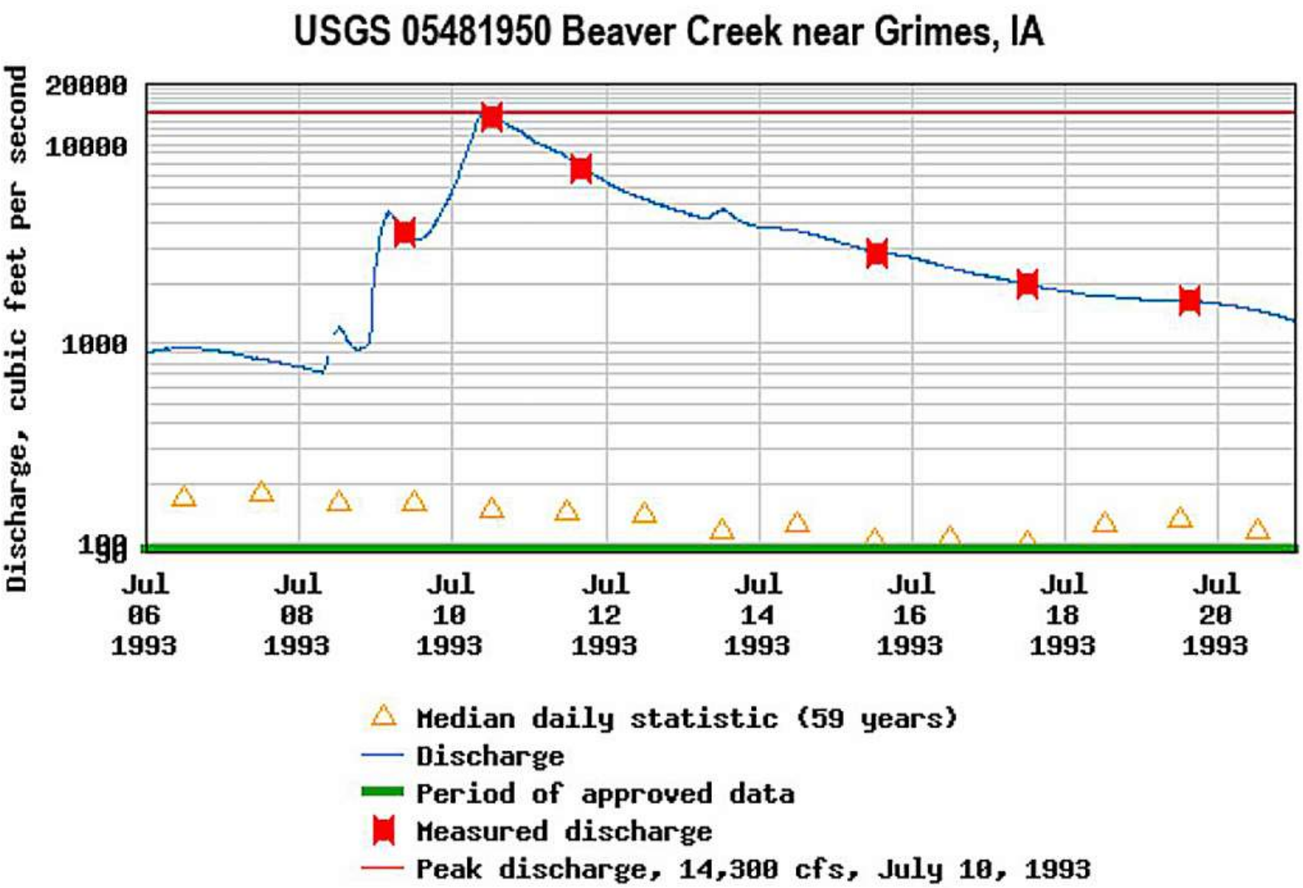


Figure 4.10: Peak Flow Data from USGS Gage near Johnston, IA (called the Grimes gauge by USGS)



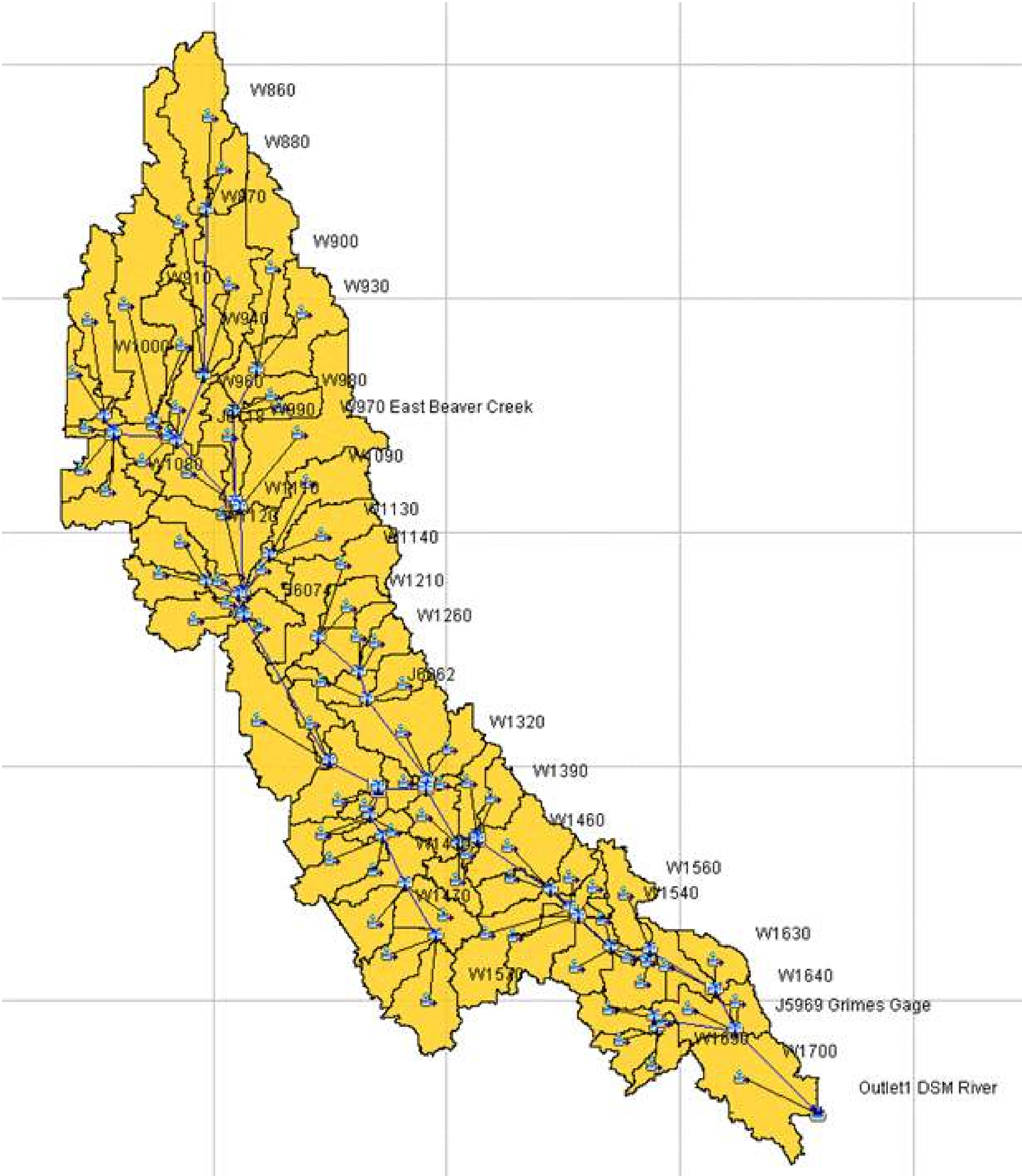


Figure 4.11: HMS Model Schematic

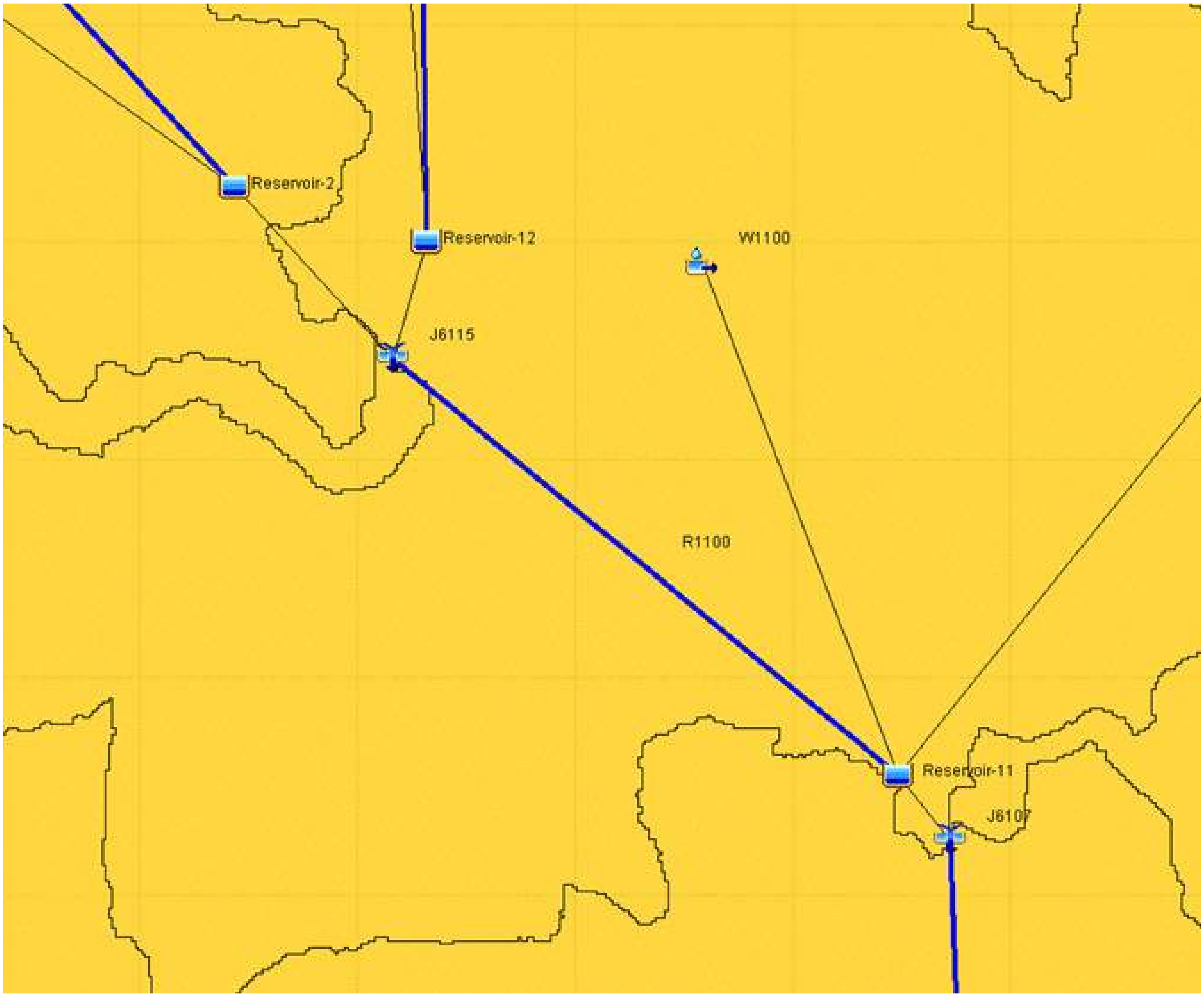


Figure 4.12: Bear Cr HMS Model Close-Up Showing Network of Streams, Reservoirs, Junctions, and Subcatchments

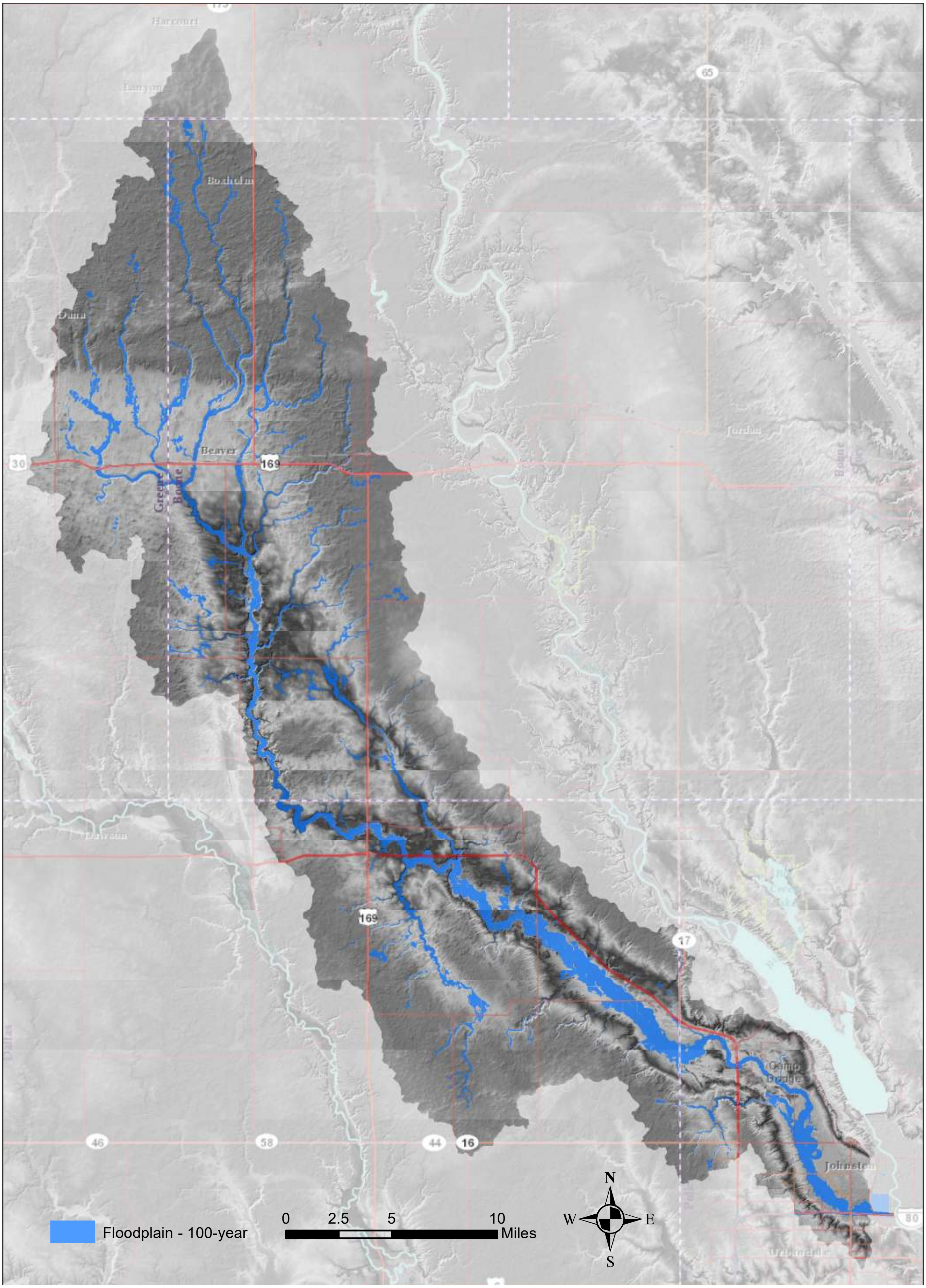
HYDRAULIC MODELING AND FLOOD INUNDATION MAPPING

Following the 2008 flood, the Iowa Statewide Floodplain Mapping project created draft flood hazard maps for the state. In some instances, the data are being used to create or update FEMA Flood Insurance Rate Maps. **On the next page is the preliminary flood hazard map displaying the 100-year event boundary.**

Flooding of farmland in the Beaver Creek watershed.

Drone footage from a flood event in Johnston in 2019 (City of Johnston).

Figure 4.13 - Map of the 100-year floodplain in the Beaver Creek watershed.



05

RELATED STUDIES

A variety of past planning efforts are essential to review and consider in building the foundation of an implementation plan for this watershed. These studies help provide context through data collection, past analyses and projection of future changes that may occur within the watershed.

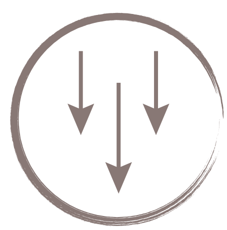
05

Past studies considered during plan development.

Community scale plans

Future land use plans

Smaller
subwatershed plans



Iowa's Nutrient
Reduction Strategy

OVERVIEW OF LOCAL WATERSHED STUDIES

There are a series of previous studies to be considered as part of this assessment and work related to development of a watershed improvement program.

Oxley Creek Watershed Management Plan

The City of Granger created this plan in 2010 to address flood risk, streambank stability, runoff volume reduction and how these issues relate to City policy. The City coordinated with IDALS and local SWCD in the creation of this plan for this 5+ square mile watershed area. The management plan focuses on reduction of sediment delivery, alternative development strategies and informed decision making related to development within the watershed. The plan identified a series of stormwater management projects which could be implemented.

City of Johnston Watershed Assessment and Stormwater Management Action Plan

This document was prepared through an 18-month planning effort, working directly with a steering committee of key stakeholders assembled by the City of Johnston. The project manager for the consultant team leading this current planning effort (Greg Pierce), worked directly with the City and steering committee to complete this plan, during his past employment at Nilles Associates. At the time, **this was a unique effort by the City, to evaluate watershed conditions throughout their community and within its future growth areas.** It included assessments of 25 miles of urban stream corridors and identified over 80 potential improvement projects. Several of these projects were selected for inclusion in a 20-year implementation plan. **This study was a basis for establishment of a new storm water utility to fund projects and updated stormwater requirements for new developments within the City**. Since plan adoption, the City has completed several projects focused on water quality, runoff reduction and stream stabilization.

City of Grimes Watershed Planning

In response to community flooding in 2010, the City completed a community review of stormwater issues. **Through public interaction and assessment of 15 miles of drainage channels, numerous projects were identified to reduce flood risk.** Over $500,000 of projects have been implemented to date.

The City also completed an assessment of their portion of the Little Beaver Creek watershed as part of an application for a Sponsored Project through the SRF program. **This assessment led to identification of a site to create a stormwater wetland to improve water quality.** The City has also moved forward with stream stabilization projects along Little Beaver and Prairie Creeks.

Dallas County Soil and Water Conservation District (SWCD) – 1% Challenge

This program involves networking between farmers to increase implementation of practices which improve soil health. **Such practices include no-till, cover crops and rotation programs, to achieve a goal of improving soil organic matter by 1%.** It is hoped that this effort can be shared with other groups throughout the Beaver Creek watershed. NRCS staff have begun outlining 900 farm parcels that will fall in the area to be covered by this planning effort.

Polk County Conservation Water Quality Monitoring

Polk County Conservation has committed to a routine water quality sampling program across Polk County, including 60 sites in total (7 of which fall within the Beaver Creek watershed). This data will expand the record of available data, allowing for improved calibration of water quality models and evaluation of implemented practices.

Des Moines MPO – Regional Water Trails and Greenways Plan

The Des Moines Metropolitan Planning Organization (MPO) recently completed two separate feasibility studies related to implementation of water trails and greenways improvements throughout the counties and cities that surround the Des Moines metropolitan area. **The location of proposed improvement sites along Beaver Creek identified within the regional feasibility study will be considered as part of development of this plan.**

Nature Conservancy Oxbow Restorations

The Nature Conservancy has been working across Central Iowa since 2016 to locate potential sites for oxbow restoration and implement improvements. This group has allocated funding toward implementing restorations in the Beaver Creek watershed over the next two years.

SUMMARY OF FUTURE LAND USE PLANS

The southern portion of the Beaver Creek watershed is experiencing rapid urban growth. Current and future land uses are a critical consideration in developing a watershed plan that will be able to adjust with anticipated land use changes.

City of Johnston Comprehensive Plan

The City's 2030 Comprehensive Plan was adopted in December 2010, prepared by a consultant team led by Hoisington Koegler Group Inc. Information gathered during the City's watershed assessment (referenced earlier) was considered in the development of this plan. **Chapter 5 of that document details current (at the time) and expected future land uses.** That chapter also details action steps for specific areas, including areas of potential redevelopment. Other important chapters with information related to watershed planning are:

- o Chapter 2 – Johnston in 2030
- o Chapter 4 – Natural Resources
- o Chapter 6 – Transportation
- o Chapter 8 – Parks and Recreation
- o Chapter 9 – Utilities
- o Chapter 10 – Implementation

Current link for additional information: http://www.cityofjohnston.com/109/Comprehensive-Plan

City of Grimes Comprehensive Plan

The Comprehensive Development Plan for Grimes was created in September 2010 and updated in 2018, prepared by RDG Planning & Design. The City is currently working with RDG on an update to this plan, which is expected to be finalized soon. The current version of the plan organizes key information into the following parts:

- o Chapter 2 – A Land Use Profile
- o Chapter 3 – Public Facilities and Infrastructure
- o Section Two – A Community Vision
- o Section Three – A Community Plan

Current link for additional information: http://www.grimesiowa.gov/

The Tomorrow Plan

The Tomorrow Plan was created to convey a vision of sustainable development for the Greater Des Moines region over a 40-year period, starting with its adoption in 2013. Access to the outdoors, environmental health, greenway preservation and regional cooperation were all outlined within this document.

Current link for additional information: https://dmampo.org/the-tomorrow-plan/

IOWA NUTRIENT REDUCTION STRATEGY—UPDATED 2017

The subtitle of this report is "a science and technology based framework to assess and reduce nutrients to Iowa waters and the Gulf of Mexico." It was prepared by the Iowa Department of Agriculture and Land Stewardship (IDALS) along with the IDNR and Iowa State University's College of Agriculture and Life Sciences.

It was developed following the creation of the 2008 Gulf Hypoxia Action Plan that calls for states to create strategies to reduce pollutant loadings to the Gulf of Mexico. The Action Plan set a goal of at least 45% reduction in total nitrogen and total phosphorus loads. The Iowa Nutrient Reduction Strategy outlines steps to prioritize watersheds and resources, improve current state programs and increase voluntary efforts to reduce nutrient loadings (Executive Summary).

The Nutrient Strategy assigns pollutant loadings to both point and non-point sources. **It assumes that a 4% reduction in nitrogen and 16% reduction in phosphorus can be accomplished by point source reductions such as improvements at wastewater treatment plants. The remaining 41% of nitrogen and 29% of phosphorus reductions are identified as being accomplished through non-point source reductions** (page 3).

The Strategy expects that nitrogen losses are a greater concern in tile drained landscapes. The largest losses are expected to occur with sustained flows occurring in the spring and at times with little evapotranspiration and nutrient uptake. **In steeper, hilly areas, phosphorus losses can be greater.** Surface runoff and transported sediment are common carriers of phosphorus. The largest losses can occur after rainfall events (page 9). **Streambank erosion is also identified as potentially significant source of phosphorus loading** (page 10). The Strategy includes the Iowa Nonpoint Source Nutrient Reduction Science Assessment. This is based on peer-reviewed studies of in-field, edge-of-field and watershed scale practices and treatments to determine potential reductions in total nitrogen and phosphorus. The framework for the Nutrient Reduction Strategy includes several major points (pages 18-26).

Prioritization of Watersheds. In 2013, the Water Resources Coordinating Council (WRCC) selected nine priority watersheds to focus targeted conservation and water quality efforts.

Determine Watershed Goals. The WRCC is tasked with coordination of indicators to provide stakeholders with information to establish baselines and report progress.

Ensure Effectiveness of Point Source Permits. The goal is to have major Publicly Owned Treatment Works (POTWs) install improvements to reduce nutrient outflow. Permitted animal feeding operations will continue to be monitored. Iowa point sources, IDNR, IDALS and WRCC will work to develop a nutrient trading credit program, based on 2003 EPA guidance.

Agricultural Areas. Setting priorities includes a focus on conservation, in- and off-field practices, pilot projects and implementation of nutrient trading. Research and Technology will continue to identify new technologies and solutions, develop private and public support for more research and continue to gain a better understanding of the Gulf Hypoxia Zone. An approach to improved outreach, education and collaboration is outlined. Programs for farmer recognition and a statewide education and marketing campaign is identified as a need. Sources of potential funding are briefly described.

Storm Water, Septic Systems, Minor POTWs and Source Water Protection. No specific nutrient reductions are identified for urban stormwater runoff. However, a focus is given to infiltration of the water quality volume (runoff from a 1.25" rainfall event). By managing this volume, reductions of 80-85% of annual runoff volumes could be achieved. Septic systems are proposed to be addressed through time of sale inspections to identify and correct leaky systems. The Iowa Source Water Protection Program educates the public and local officials on the importance of protecting groundwater drinking water resources. A link to potential funding sources is provided. Accountability and Verification Measures. A technical work group will define the process for providing a regular nutrient load estimate. The IDNR will track progress of implementing the reduction strategy for permitted point sources. A system for tracking non-point sources and improvements is outlined.

Public Reporting. WRCC will develop public annual reports. Watershed management plans are expected to include strategies to assess and demonstrate progress in achieving load reductions.

Nutrient Criteria Development. IDNR continues to review and assess water quality, with development of a suitable nutrient criteria as a long-term goal.

- Key practices for nitrogen removal:
  - Nitrogen management practices, **cover crops** and **living mulches**.
  - Land use changes to energy crops, **perennial vegetation** or **extended rotations**.
  - Wetlands, **buffers** and **bioreactors** are edge-of-field practices with greatest potential for nitrogen reduction.
- Key practices for phosphorus removal:
  - Reducing tillage and cover crops can significantly reduce phosphorus loss.
  - Land use changes from corn-soybeans to energy crops, perennial vegetation or extended rotations.
  - Edge of field practices that settle sediment such as ponds and stream buffers.
- The Science Team will publish an updated practice list as an addendum to the Reduction Strategy.

Winter rye cover crops.

06

WATER QUALITY ASSESSMENT

Stream and lake monitoring creates a record of monitored stream and lake conditions that can be compared to standards and criteria, used to detect changes over time, and support future watershed rehabilitation efforts. The ability of a monitoring program to detect such changes and the reliability of the comparisons depend upon the nature and design of the monitoring program.

06

4

Water quality sites

Operated by Iowa Soybean Association and Agriculture's Clean Water Alliance (ACWA) included in data reviewed.

Nitrate concentrations

Commonly exceed the water quality standard of 10mg/L at the sites reviewed.

Water quality data is limited

Sources reviewed as part of this plan:

1. Federal
2. State
3. Volunteer monitoring

WATER QUALITY DATA

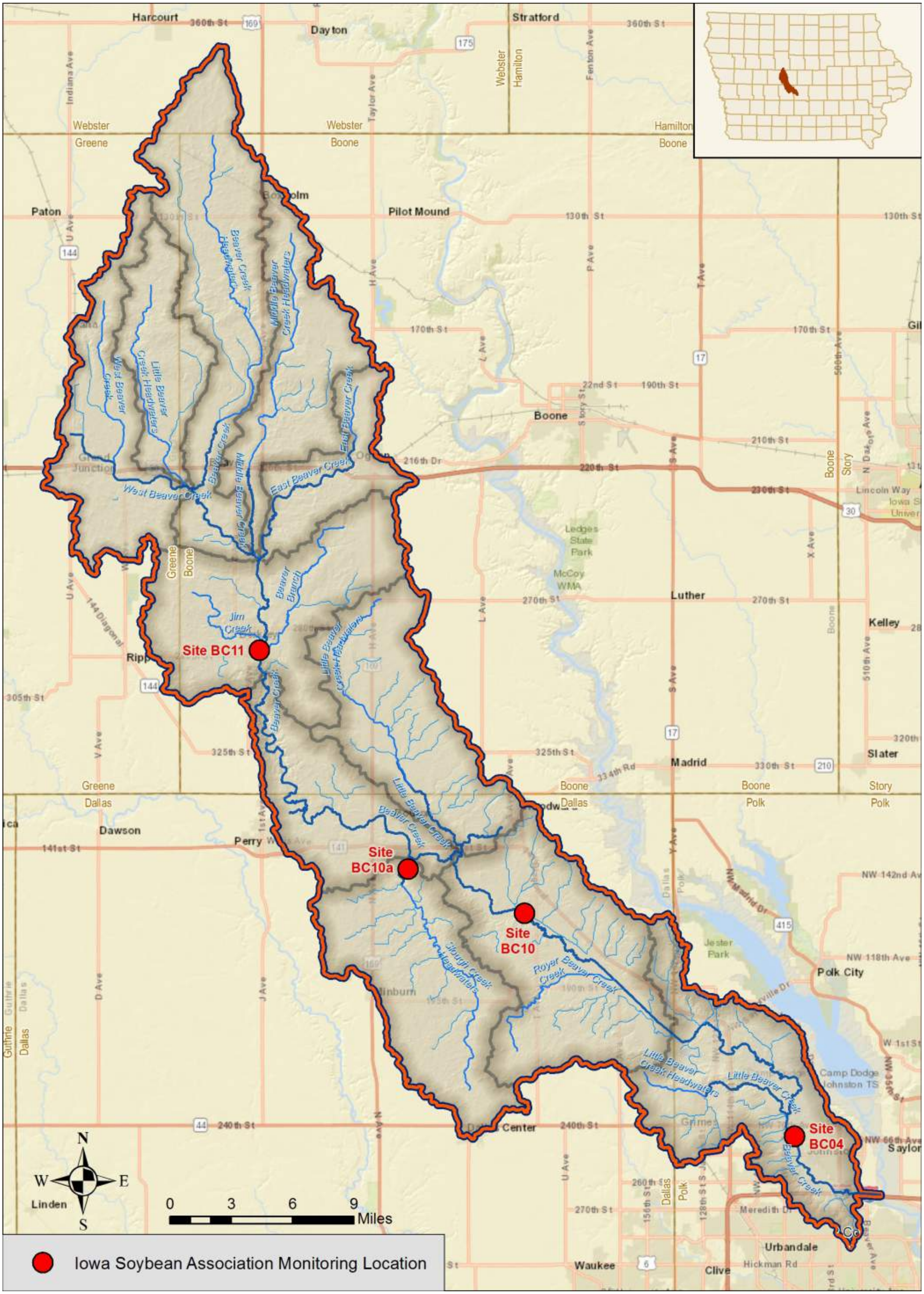
Stream monitoring data has been collected annually during the growing season (April-August) from 2008-2018 by the Iowa Soybean Association (ISA) in coordination with the Agriculture Clean Water Alliance (ACWA) **at four locations within the Beaver Creek Watershed** (Figure 6.1). A review of this information has yielded important information regarding long term average Nitrate-Nitrogen concentration at four locations within the Beaver Creek Watershed.

Additional monitoring efforts of streams in the Beaver Creek Watershed incorporate data collected by the United States Geological Survey (USGS), data collected by the University of Iowa through the Iowa Water Quality Information System and data collected through volunteer-led efforts that engage students and citizens in volunteer monitoring. **The majority of the data found on the EPA's Water Quality Data download portal (formerly STORET) was collected by volunteers through the IOWAWATER program; the IOWAWATER program was discontinued in 2016.** The number of samples per stream reach varied considerably between streams and varied over time. Volunteer monitoring efforts relied upon 'kit' analyses of nitrate and phosphorus concentrations and hence, values were reported in coarse intervals. Given the limited availability and coarse nature of **these sample sets, the foregoing paragraphs were framed in terms of the general nature of observed water quality concentrations** rather than an in-depth statistical analysis of the actual data. In contrast, the nitrate-nitrogen dataset collected by the ISA/ACWA is a consistent long-term dataset from which trends can be evaluated.

Iowa Water Quality Information System:
IWQIS- https://iwqis.iowawis.org/app

Water quality sampling using IOWATER volunteer sampling kit.

Figure 6.1: Iowa Soybean Association / ACWA Monitoring Locations



NITRATE/NITROGEN

Nitrogen is an important nutrient, particularly the dissolved forms, as it increases plant productivity on farm fields, urban lawns and streams/lakes. Nitrate (NO_3) nitrogen is the dominant dissolved fraction with typically very small amounts of nitrite nitrogen present (which can be quite ephemeral). Hence, discussion will focus on nitrate nitrogen. While (NO_3)is one of the primary forms of nitrogen used by plants for growth, **excess amounts in groundwater and streams can cause human health concerns.** At concentrations greater than 10 milligrams per liter (mg/L), nitrate has been linked to methemoglobinemia ("blue baby syndrome"), which primarily impacts infants and susceptible adults. **At high concentrations, nitrates are also toxic to aquatic life and can cause eutrophic conditions.** Sometimes these eutrophic conditions become extreme and can result in areas with little to no oxygen (hypoxic zones). These hypoxic zones cause aquatic life to retreat from the area, or worse, they may suffocate and die resulting in massive fish kills. The applicable water quality standard for nitrate is 10 mg/L.

Table 6.1 displays monthly and overall average (NO_3) concentrations for the four monitored locations in the Beaver Creek Watershed that were annually monitored from April - August by the ACWA. **Observed average (NO3) concentrations (April-August) ranged from a low of 8.4mg/L (Beaver Creek – BC-04) to a high of 12.9 mg/L (Slough Creek – BC-10a).**

Average monthly (NO3) concentrations during the months of May and June consistently exceeded the 10 mg/L standard along every stream reach. In contrast, monthly (NO_3) concentrations during July and August were all below 10 mg/L, with the exception of Slough Creek during the month of July. Observed seasonal changes in (NO_3) concentrations are reflective of a land use change from perennial grasslands to seasonal row crops, which rely on subsurface tile drainage. Given that land use within the Beaver Creek Watershed District is predominately (>75%) agricultural and that tile drainage occurs mostly in the spring, it is not surpising to see elevated (NO_3) concentrations in the spring. Similar seasonal patterns in nitrate concentrations have been observed throughout Iowa, including the Middle Cedar River, and the Raccoon River watershed in west Central Iowa (Schilling, 2004).

Table 6.1: Average Monthly Nitrate Nitrogen Concentrations at 3 monitoring locations on Beaver Creek & 1 monitoring location on Slough Creek from 2008-2018.

STREAM REACH NAME	AVERAGE MONTHLY NITRATE NITROGEN CONCENTRATION (MG/L)					APRIL - AUGUST AVERAGE NITRATE NITROGEN CONCENTRATION (MG/L)
	APRIL	MAY	JUNE	JULY	AUGUST	
Beaver Creek - BC-04	8.8	10.8	11.7	8.0	2.9	8.4
Beaver Creek - BC-10	10.3	12.9	14.3	9.5	3.1	10.0
Slough Creek - BC-10a	13.0	16.3	17.6	12.5	5.1	12.9
Beaver Creek - BC-11	10.9	13.7	14.2	9.3	3.3	10.3

Average annual NO3 concentrations were lowest at BC-04, which is the most downstream reach in the Beaver Creek Watershed (Table 6.2). The highest observed average annual nitrate concentrations across all four monitored streams occurred during the 2013 monitoring season. Precipitation totals during the 2012 and 2013 growing season were lower than average with only 13.2 (2012) and 18.77 (2013) inches of rainfall occuring from May-September. **High nitrate concentrations during periods of time with low rainfall totals indicate point sources may be a potentially significant nitrogen source.**

Table 6.2: Average Yearly Nitrate Nitrogen Concentrations

STREAM REACH NAME	AVERAGE ANNUAL CONCENTRATION											
	'08	'09	'10	'11	'12	'13	'14	'15	'16	'17	'18	11 YEAR AVERAGE
Beaver Creek - BC-4	8.5	7.3	6.3	7.0	7.2	15.5	7.2	10.3	8.3	8.6	8.0	8.7
Beaver Creek - BC-10	10.4	8.3	7.8	7.9	7.7	17.2	9.7	16.4	9.4	9.0	10.3	10.4
Slough Creek - BC-10a	12.3	8.9	11.0	10.0	10.3	24.8	16.8	15.2	12.9	11.3	12.7	13.3
Beaver Creek - BC-11	9.9	8.3	8.2	8.1	7.5	19.6	9.9	15.1	9.3	9.7	11.2	10.6

TOTAL PHOSPHORUS

Phosphorus concentration in water is a primary focus of applied watershed management as this element drives a wide array of river, stream and lake biological responses affecting beneficial uses. **Excess phosphorus concentrations lead to increased algae growth, increased organic matter, and increased bacteria** that lead to boom-bust daily oxygen concentration cycles that limit aquatic life. In severe cases, massive algal mats and scums can be generated by blue-green algae. **Blue-green algae can also produce toxins, such as microcystin, which negatively impact wildlife and drinking water supplies.**

The Environmental Protection Agency (EPA) has developed national nutrient criteria recommendations by ecoregion based on nutrient data from a large number of the nation's lakes and rivers (EPA 2000). Ecoregions are defined as areas of similar ecosystem and geography. The 25th percentile Total Phosphorus (TP) concentration for streams in the Western Corn Belt Plains ecoregion is 0.118 mg/L. **A review of data downloaded from the EPA for the Beaver Creek Watershed revealed the average growing season TP concentration often exceeds this standard for most streams within the watershed**. No distinct seasonal patterns were observed in terms of average monthly TP concentration.

TOTAL SUSPENDED SOLIDS

Total Suspended Solids (TSS) is a measurement of the amount of material suspended instream, which is often referred to as turbidity. As more material is suspended in the stream, less light can pass through, making the water less transparent. **Suspended materials may include soil, algae, plankton, and microbes.**

Excess turbidity can significantly degrade the aesthetic qualities of waterbodies. People are less likely to recreate in waters degraded by excess turbidity. Turbidity can also make the water more expensive to treat for drinking or food processing uses. Excess turbidity can also harm aquatic life, aquatic organisms may have trouble finding food, gill function may be affected, and spawning beds may be buried. **Turbidity can also lead to higher water temperatures which can promote bacteria growth.**

Monthly TSS concentrations were highest from April through June, which correspond to the period of the year where row crops have not yet become established. During this time, bare soil from agricultural fields is more likely to become detached during precipitation events, given the rate and magnitude of water erosion is usually greatest during short-duration, high-intensity thunderstorms; during snowmelt; when soils have high moisture content; and when vegetative cover is minimal.

BACTERIA (E. COLI)

Bacteria are present in the bodies of humans and animals and exist in countless forms in both land and water. Most forms of bacteria are beneficial, but approximately 10% can be harmful when ingested by humans. Symptoms from ingesting harmful bacteria may include gastrointestinal illnesses, fatigue, and a number of other problems. Because there are so many forms of bacteria, testing for E. coli is used as an indicator for possible presence of pathogens in water. Bacteria levels can be affected by many factors, including seasonal weather, stream flow, water temperature, livestock management practices, and sewage over flows. Some types of bacteria are also used as an indicator species for other pathogens (E.coli and fecal coliform). Some viruses, parasites and other organisms are more difficult to test for but may flourish in conditions that also would foster higher levels of these indicator bacteria. So, the risks associated with high levels of E.coli are not limited to illness caused by that specific bacteria, but could also include risks associated with other pathogens.

The Iowa State Standard Maximum Single Sample MPN/100ml E.coli concentration is 235 MPN/100ml. Comparing observed data collected in the Beaver Creek watershed with the 235 MPN/100ml State Standard suggests **all tributaries and mainstem reaches are significantly impaired due to excessive bacteria contributions from the watershed with average E. coli concentrations exceeding 1,200 MPN/100ml.**

Source -- https://www.pca.state.mn.us/sites/default/files/wq-iw3-20.pdf

Cattle in the stream within the Beaver Creek watershed.

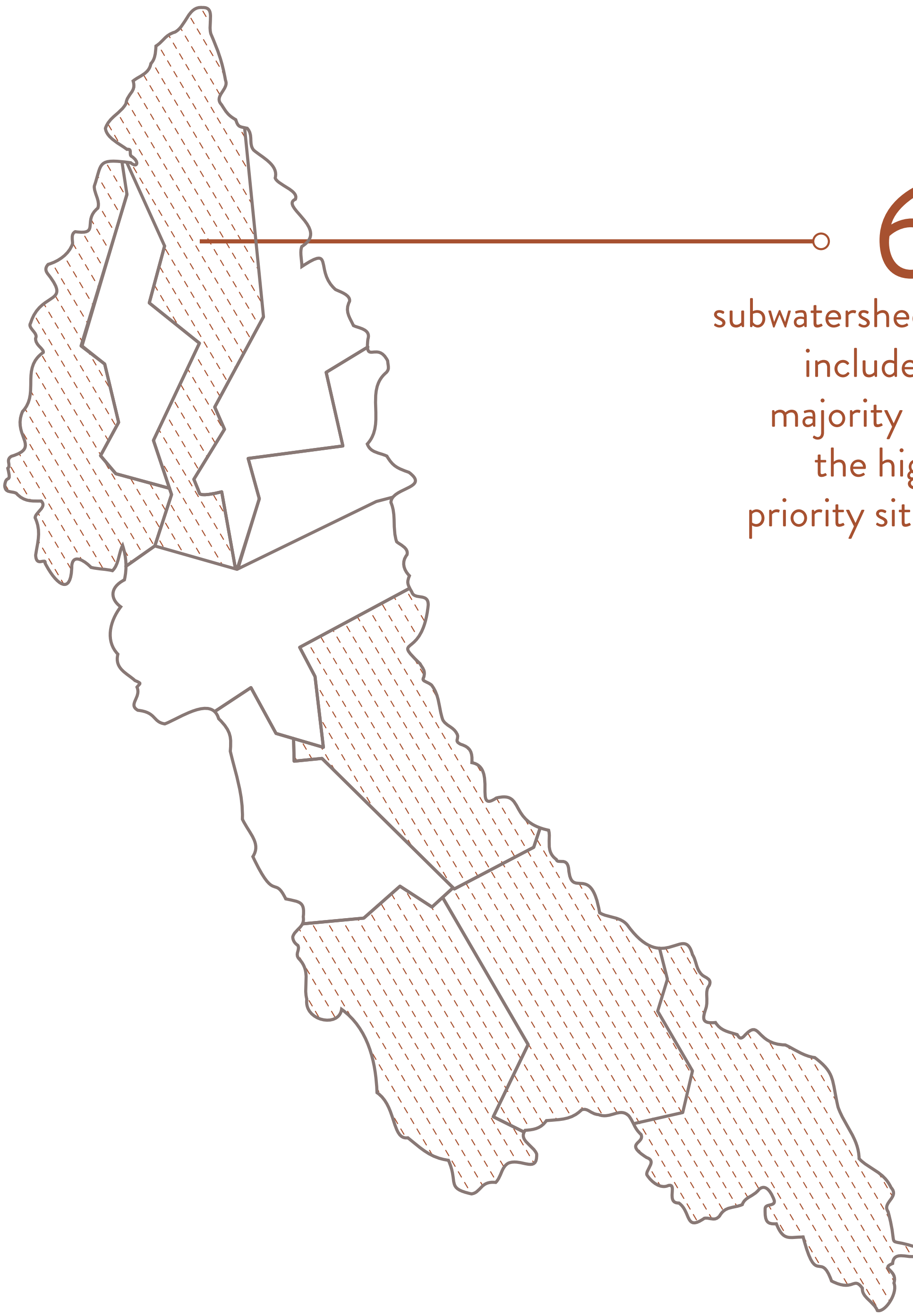
07

STREAMBANK ASSESSMENT

Due to the area of land included as part of this planning effort, a detailed field assessment of conditions along major streams throughout the watershed was not feasible to be completed. GIS data was used to perform a screening level evaluation of conditions along each stream corridor.

07

1,315 high priority sites address channel erosion.



6

subwatersheds include a majority of the high priority sites

STREAMBANK ASSESSMENT

Stream geomorphology and hydrology have a direct influence on stream health and biological integrity. Streams essentially act as conveyance channels for water and sediment flowing through the watershed. Land-use and climate change have a strong influence on stream stability and water quality as described in previous sections. There have been substantial flow increases in most Iowa Rivers over the recent decades, contributing to sediment loading from streambanks. **The sediment that is eroded contributes to water quality degradation and impairs in-stream aquatic life.** The inherent potential for soil to erode is largely determined by the slope and topography of the land; steeply sloped riparian areas maintained in non-natural land uses (row crops, urban settings) represent likely locations for stream bank failures to occur.

LiDAR data was used to evaluate stream bank stability within the Beaver Creek Watershed by combining Stream Power Index (SPI), Topographic Position Index (TPI), and non-natural riparian landcover with steeply sloped near channel areas within 150 feet of a mapped stream channel. For this exercises, steeply sloped, near channel areas were defined as those areas in which critical slopes (> 15%), represented at least 10% of the total area within 150 feet of the mapped stream. As previously mentioned, slopes exceeding 15% represent less than 3% of the total watershed area. Steeply sloped areas in close proximity to the stream channel represent areas more prone to streambank failure. The stream power index (SPI) calculation measures the erosive power of overland flow as a function of local slope and upstream drainage area which is derived from the LIDAR data. High SPI values located in riparian areas with steep slopes are typically correlated with near-channel, active erosion problems (e.g., gullies, ravines) on the landscape. High SPI signatures were intersected with the steeply sloped, near channel areas to further prioritize critical streambank sites within the watershed (Figure 7.1).

The results of the SPI/steeply sloped area intersection were intersected with non-natural stream riparian areas (areas where less than 25% of the land area within 150 feet of the stream was comprised of natural (Forest, Grasslands, Wetlands) land cover.

Next, high stream banks and valued, man-made features (roadways, buildings) were identified using the National Resources Conservation Service (NRCS) Engineering Toolbox Topographic Position Index (TPI) tool, which uses LiDAR data to calculate the difference in height between a given raster cell and the adjacent cells around it. Screening the results from the TPI calculation to include only those raster cells in the top 25% of the TPI score (cells more than 4.25 feet higher in elevation than their surrounding cells) **produced a map which identified both high stream banks, roadways, and buildings.** The intersection of the Top 25% TPI layer with the previous non-natural land use/SPI/steeply sloped area intersection resulted in **1,315 high priority sites that were largely grouped in 6 key areas within the Beaver Creek Watershed** (Figure 7.2).

Figure 7.1: Streambank Assessment - Potential for streambank failure

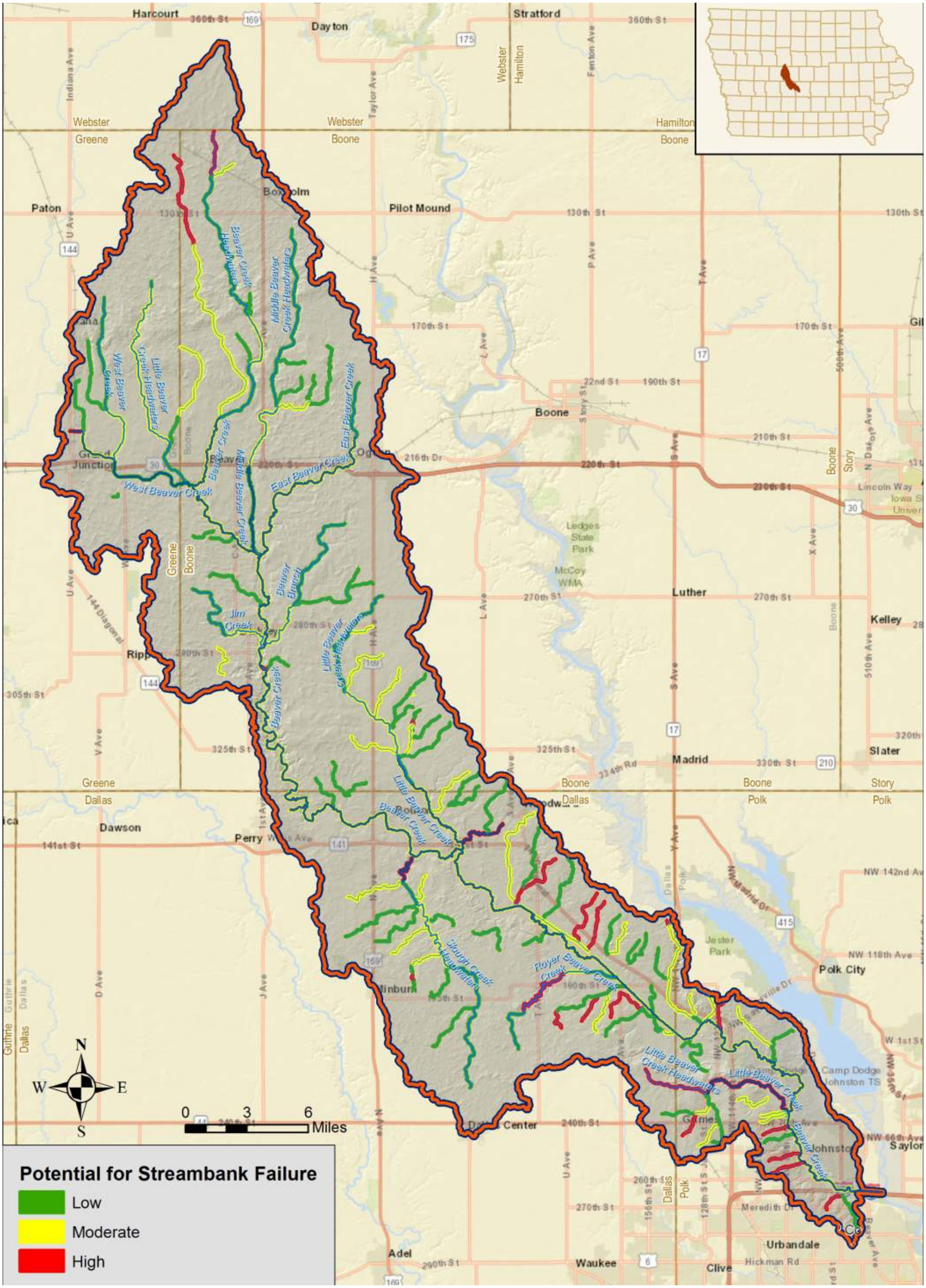
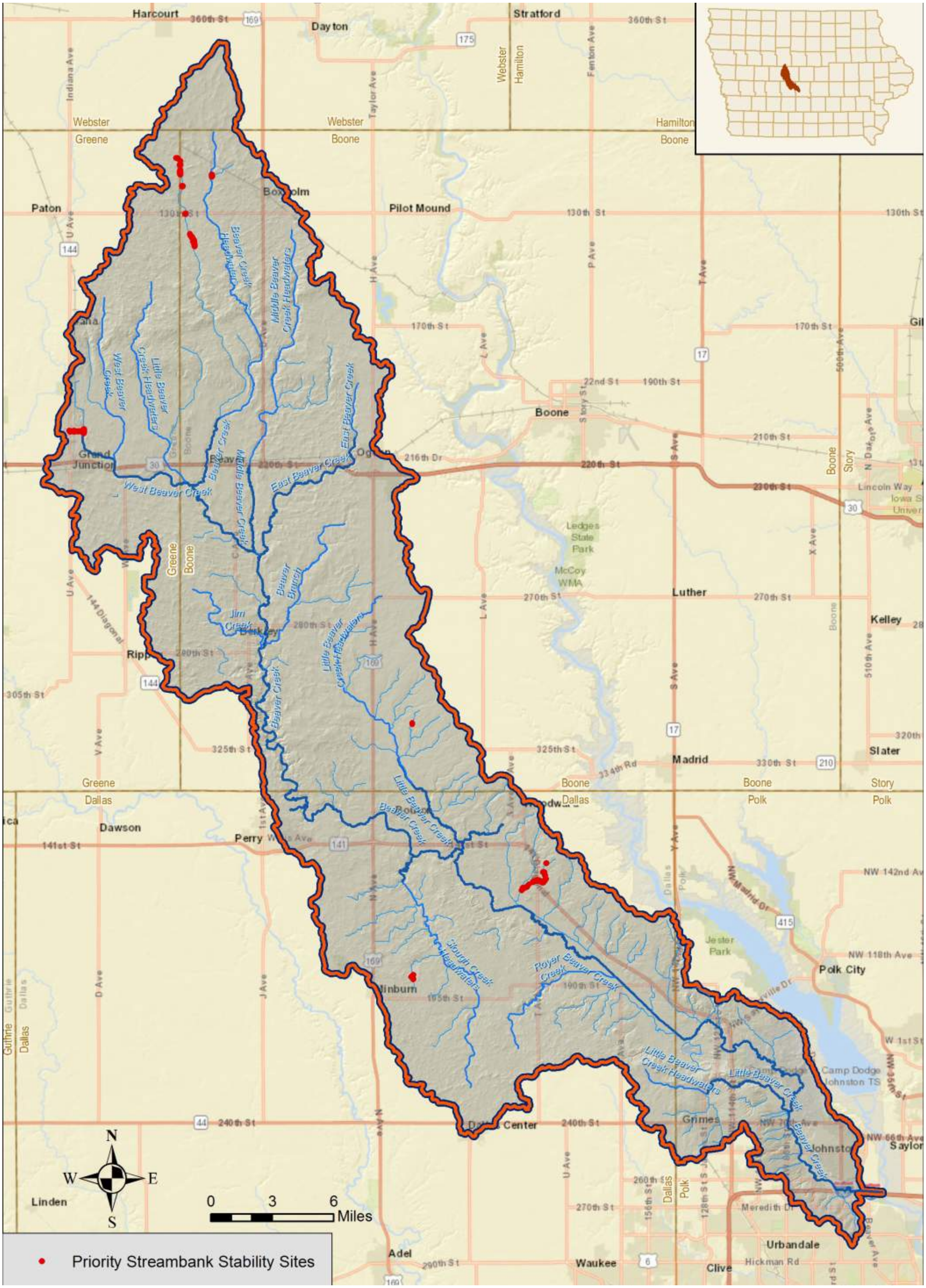


Figure 7.2: Priority streambank sites




Monitoring conducted near an unstable stream bank (City of Johnston).


Bank erosion near a public trail (City of Johnston).


Bank erosion along a tributary to Beaver Creek.


Bank movement has left this tile outlet projecting into the stream in the Beaver Creek watershed.


Aerial image of an unstable streambank (City of Johnston).

EXISTING CONSERVATION PRACTICES

The Iowa DNR - in coordination with Iowa State University - embarked on a project to map agricultural conservation practices that exist in the landscape across Iowa. **The goal of the Iowa BMP (Best Management Practices) Mapping Project was to provide a complete baseline set of BMPs dating from the 2007-2010 timeframe for use in watershed modeling, historic occurrence, and future practice tracking.** The BMPs mapped are: Terraces, Water and Sediment Control Basins (WASCOB), Grassed Waterways, Pond Dams, Contour Strip Cropping and Contour Buffer Strips. The project can't guarantee that mapped practices meet NRCS standards or that they are actually the indicated practice since no ground truthing was performed. Data utilized to digitize the BMPs included LiDAR derived products such as DEM, Hillshade and Slope grids; CIR aerial photography from the 2007-2010 timeframe, NAIP aerial photography and historic aerial photography. This project was funded by the Iowa Department of Natural Resources, Iowa Department of Agriculture and Land Stewardship, Iowa Nutrient Research Center at ISU, National Laboratory for Agriculture and the Environment and Iowa Nutrient Research and Education Council.

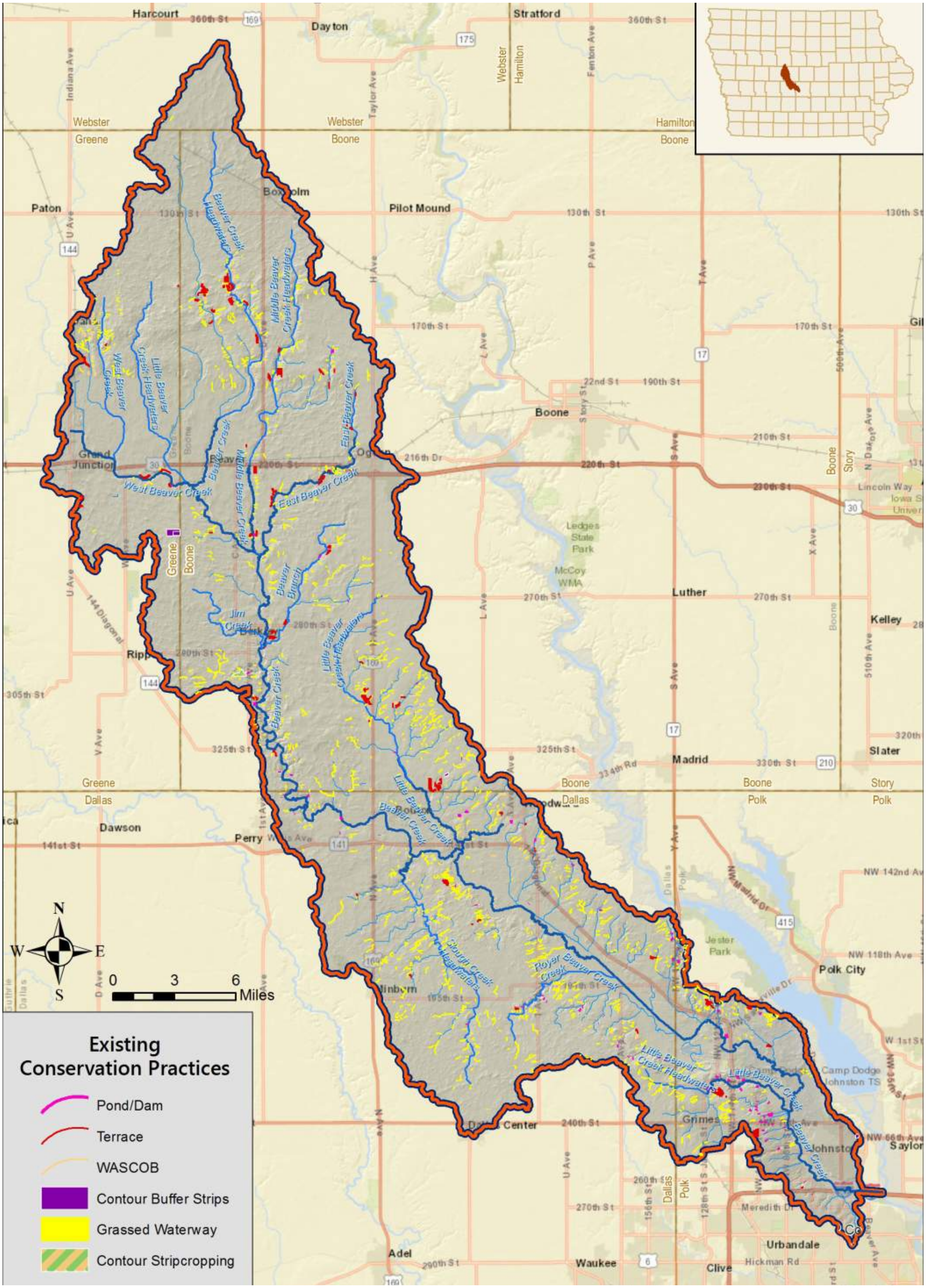
The existing agricultural conservation practices in Beaver Creek Watershed are shown in Figure 7.3.

A summary of the estimated current adoption rate of conservation practices by subwatershed area is included in Chapter 11 (see Table 11.1)

Buffering between cropland and the stream.

Bank stabilization project along Beaver Creek (City of Johnston).

Figure 7.3: .Existing agricultural conservation practices.



08

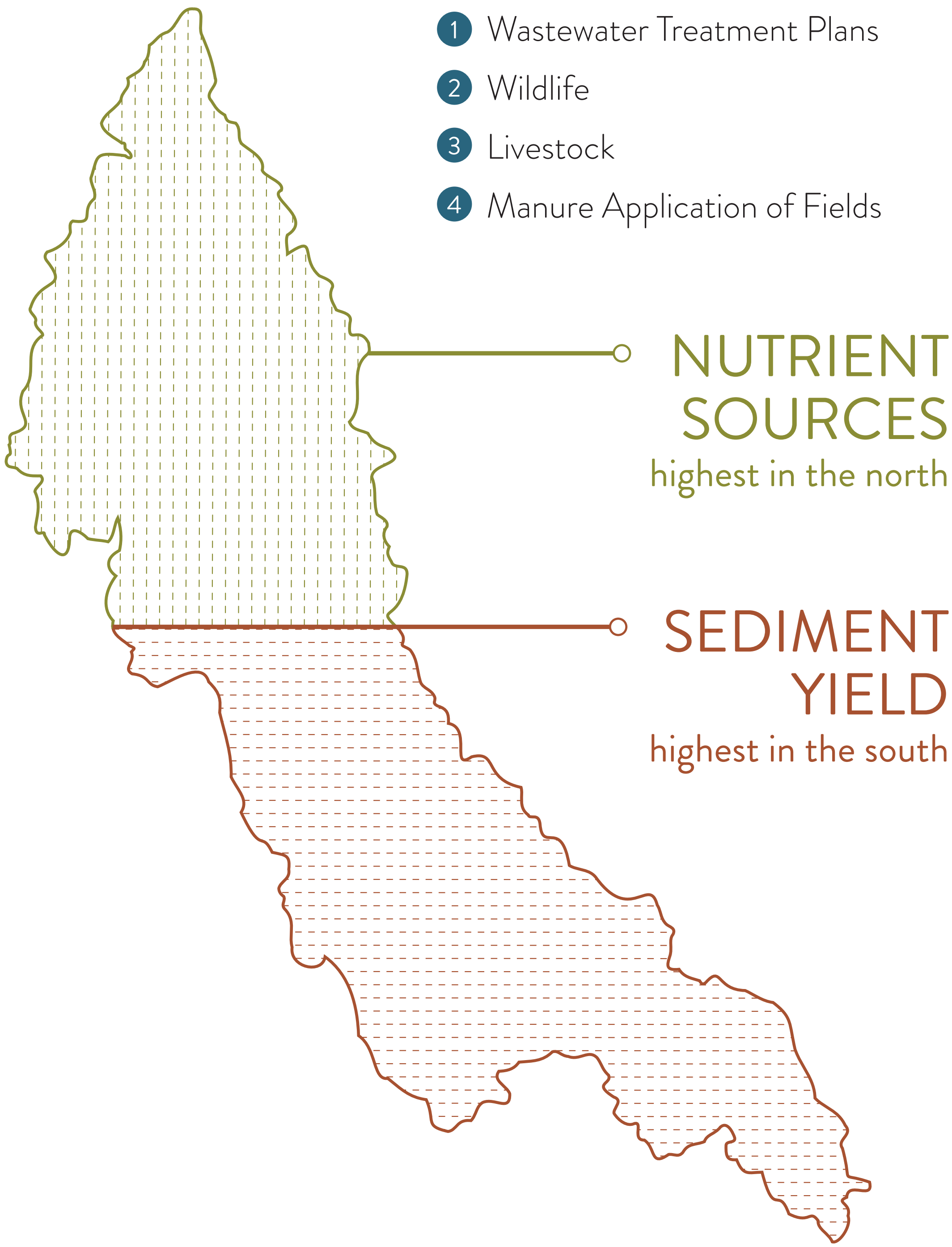
POLLUTANT SOURCE ASSESSMENT

Key pollutants of concern within the Beaver Creek watershed have been defined by considering past studies, collection of stakeholder input and an overview of available water quality monitoring information. This chapter reviews potential sources for these key pollutants, identified as phosphorus, nitrogen, total suspended solids (TSS) and bacteria.

08

Sources of bacteria loadings:

1. Wastewater Treatment Plans
2. Wildlife
3. Livestock
4. Manure Application of Fields



TOTAL PHOSPHORUS

Phosphorus is a primary nutrient for plant growth on the land and in the water. On the land, soil phosphorus concentrations, measured in the part per million range, are closely followed by agricultural and urban land owners. However, in water, phosphorus concentrations in the part per billion range are monitored, with excess phosphorus levels occurring at concentrations much lower than values measured in soils.

Phosphorus loads in water come from a variety of sources, including nonpoint sources (e.g. runoff from pasture and croplands, streambank erosion, urban runoff, non-agricultural runoff, individual sewage treatment systems) and point sources (e.g. municipal and industrial wastewater treatment facilities). The magnitude of phosphorus can vary greatly depending on the landscape characteristics of the watershed.

Source -- https://www.pca.state.mn.us/sites/default/files/wq-iw3-12.pdf

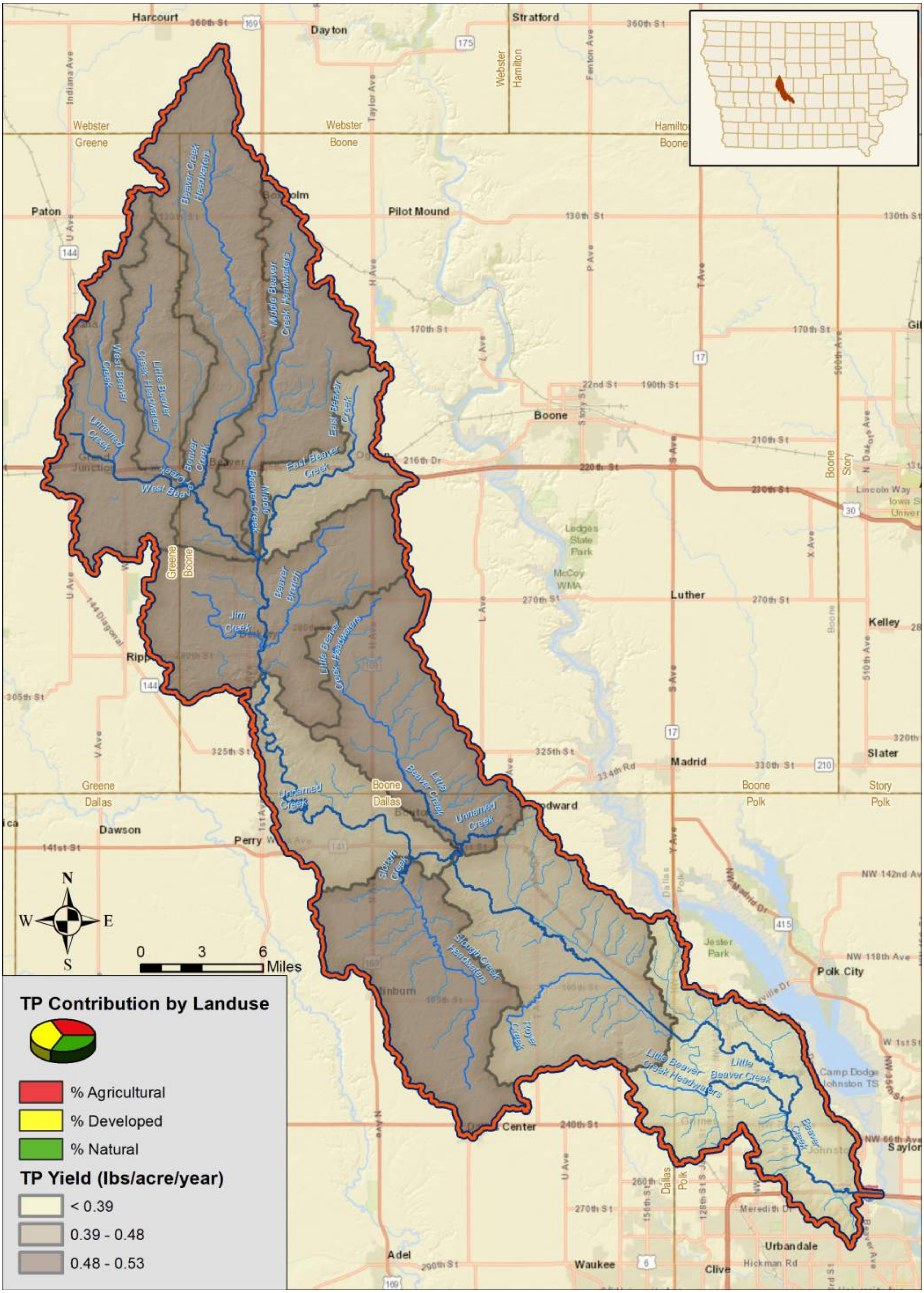
Phosphorus is typically monitored in two forms: dissolved phosphorus (forms most readily used by crops and aquatic plants, resulting in increased productivity); **and total phosphorus** (found in both dissolved and particulate forms).

Total phosphorus (TP) loads were estimated in the watershed by attributing different phosphorus loading rates to the landscape according to land use categories. The three primary high-level land use categories in the watershed are agricultural, developed, and natural areas, and each of these categories contributes phosphorus to receiving waters at a different rate per unit of area (for example, per acre) – often referred to as its unit area load (UAL). In the Beaver Creek watershed, annual TP loads were estimated to range from 0.39 to 0.53 pounds per acre.

A variety of sources were used to verify the UAL values used in the watershed, including values from the Minnesota Pollution Control Agency, the U.S. Army Corps of Engineers, the U.S. Environmental Protection Agency, and from the SWAT model that was constructed and calibrated for the nearby Squaw Creek Watershed. Additionally, the overall predicted TP loading from the watershed was compared to a 2004 report by the Iowa DNR, and the numbers were found to be in general agreement.

Within each subwatershed, the UAL values were multiplied by the total land area in each land use category to estimate the overall contribution of total phosphorus to Beaver Creek. Since agricultural lands account for most of the land area in the watershed, the vast majority of total phosphorus loading originates in those areas.

Figure 8.1: Beaver Creek Watershed Total Phosphorus Yields (Pounds/Acre/Year) by HUC-12 Subwatershed



TOTAL NITROGEN

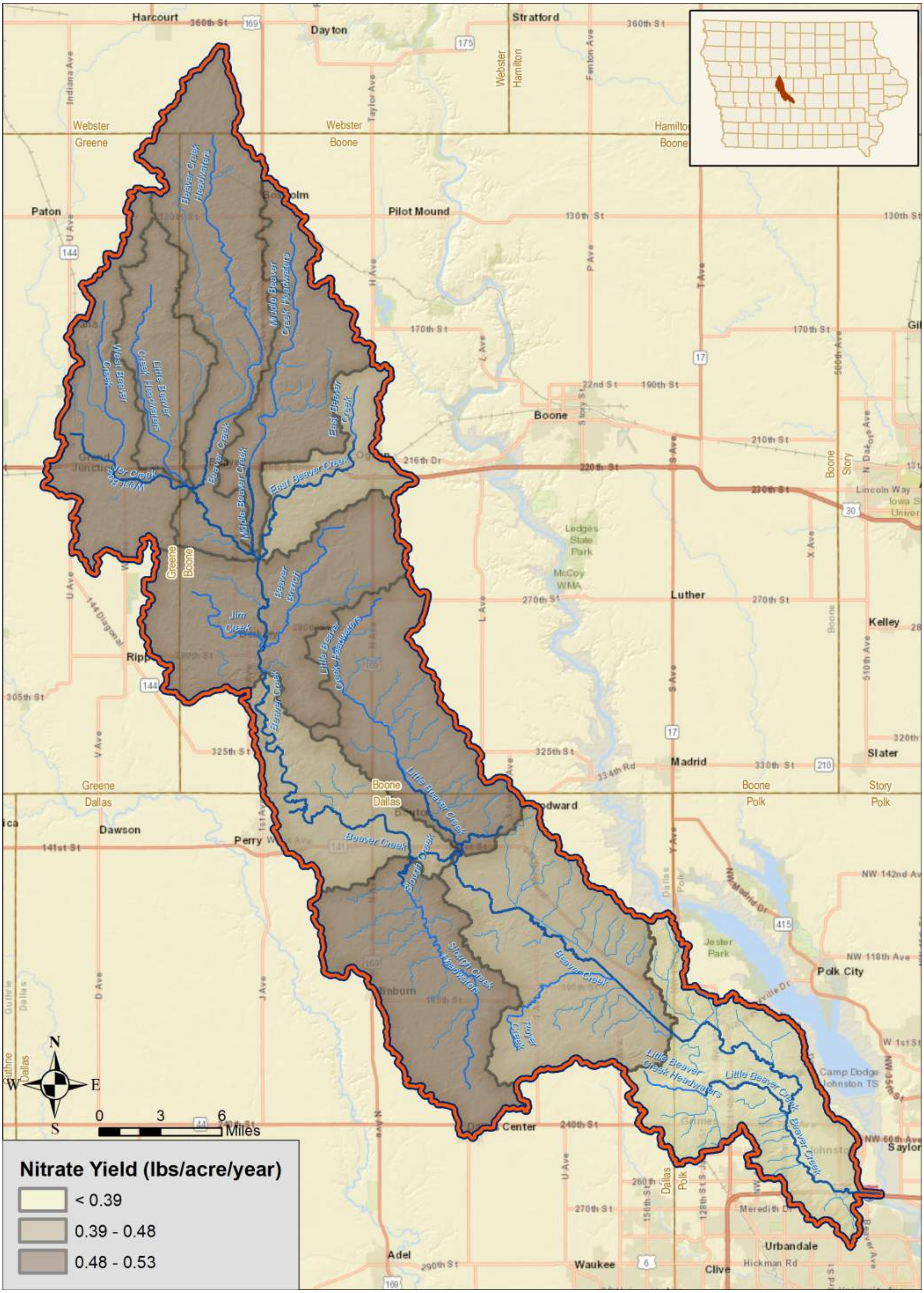
As stated in chapter 6, Nitrate nitrogen is the dominant dissolved form of nitrogen in groundwater and in surface water with high levels of nitrogen. Dissolved nitrite nitrogen is found in much lower levels and is typically measured together with nitrate nitrogen. Therefore, this discussion will focus on the combined nitrate plus nitrite nitrogen, with concentrations that vary seasonally from biological activity and nutrient inputs (fertilizer, wastewater, and urban runoff). Nitrates and other forms of nitrogen can come from natural sources like atmospheric deposition or decaying plant debris, but when the levels of nitrates exceed water quality standards, sources are typically associated with human activities, including fertilizer application, feedlots, or sewage treatment systems.

Source -- https://www.pca.state.mn.us/sites/default/files/wq-s6-26a2.pdf

Total nitrogen consists of dissolved (nitrate plus nitrite) **and organic nitrogen** (total Kjeldahl nitrogen). Nitrate and nitrite are inorganic and dissolved forms of nitrogen used for increasing productivity, with concentrations that vary seasonally from biological activity and nutrient inputs. They are formed through the oxidation of ammonia (NH 3-N) by nitrifying bacteria (nitrification). They are converted to other nitrogen forms by denitrification and plant uptake. Nitrite concentrations are typically quite low in aquatic systems and hence, discussions of nitrogen in streams typically focus on nitrate nitrogen levels.

Nitrate loading rates in the watershed were estimated using values from the SWAT model that was constructed and calibrated for the Des Moines River, to which Beaver Creek is tributary. A unique annual loading rate was assigned to each subwatershed, with values ranging from 12.7 to 20.1 pounds per acre. Since the vast majority of nitrate contributions to the creek come from agricultural lands, the lowest nitrate loading rates were observed in the most highly developed subwatersheds, as well as in subwatersheds with more remnant natural areas – such as those with forested riparian areas near the river.”

Figure 8.2: Beaver Creek Watershed Total Nitrate Yields (Pounds/Acre/Year)by HUC-12 Subwatershed)



TOTAL SUSPENDED SOLIDS

Turbidity or TSS in excess can significantly degrade the aesthetic qualities of waterbodies and can also harm aquatic life. Sources of turbidity in water include natural sources (e.g. erosion from upland, riparian, stream bank and stream channel areas) and human sources (e.g. wastewater treatment facilities, nutrient runoff from cropland, and urban stormwater runoff). The following discussion highlights sources of turbidity in the environment and mechanisms that drive the delivery of sediment to surface waters.

Subwatershed (HUC-12) sediment yield (total sediment loss derived from sheet and rill erosion) and hillside soil loss (the portion of the total sediment yield that is potentially available for delivery to downstream water resources) data were extracted from Iowa's Daily Erosion Project dataset. Sediment yield data provides valuable information on Landscape sediment sources, which are those eroded by sheet or rill flow (i.e., very small channels), the type of erosion often associated with agricultural row-cropped fields but can apply to any landcover type. Sediment delivery data provides an additional weight of evidence that shows the proportion of the total sediment yield derived from the landscape that is delivered, or translocated to a downslope position where ephemeral gulley/ravine erosion processes dominate. Erosional features (ravines, gullies) that occur in close proximity to the watershed's stream channels represent near-channel sources. Collectively, landscape and near-channel sources comprise a watershed's contribution of sediment to downstream water resources.

A 2011 USGS study of select Minnesota Rivers reported an average annual basin TSS yield for the Des Moines River near the border of Minnesota and Iowa at 313 pounds/acre/year; equivalent to 0.15 tons/acre/year (Ellison et. al., 2013). **Modeled sediment delivery rates for subwatersheds in the Beaver Creek Watershed (0.91-2.09 tons/acre/year) were comparatively higher, suggesting TSS loading rates in the Beaver Creek watershed are relatively high**.

Figure 8.3: Beaver Creek Watershed Subwatershed (HUC-12) Total Suspended Solids Yield (Tons/Acre/Year)

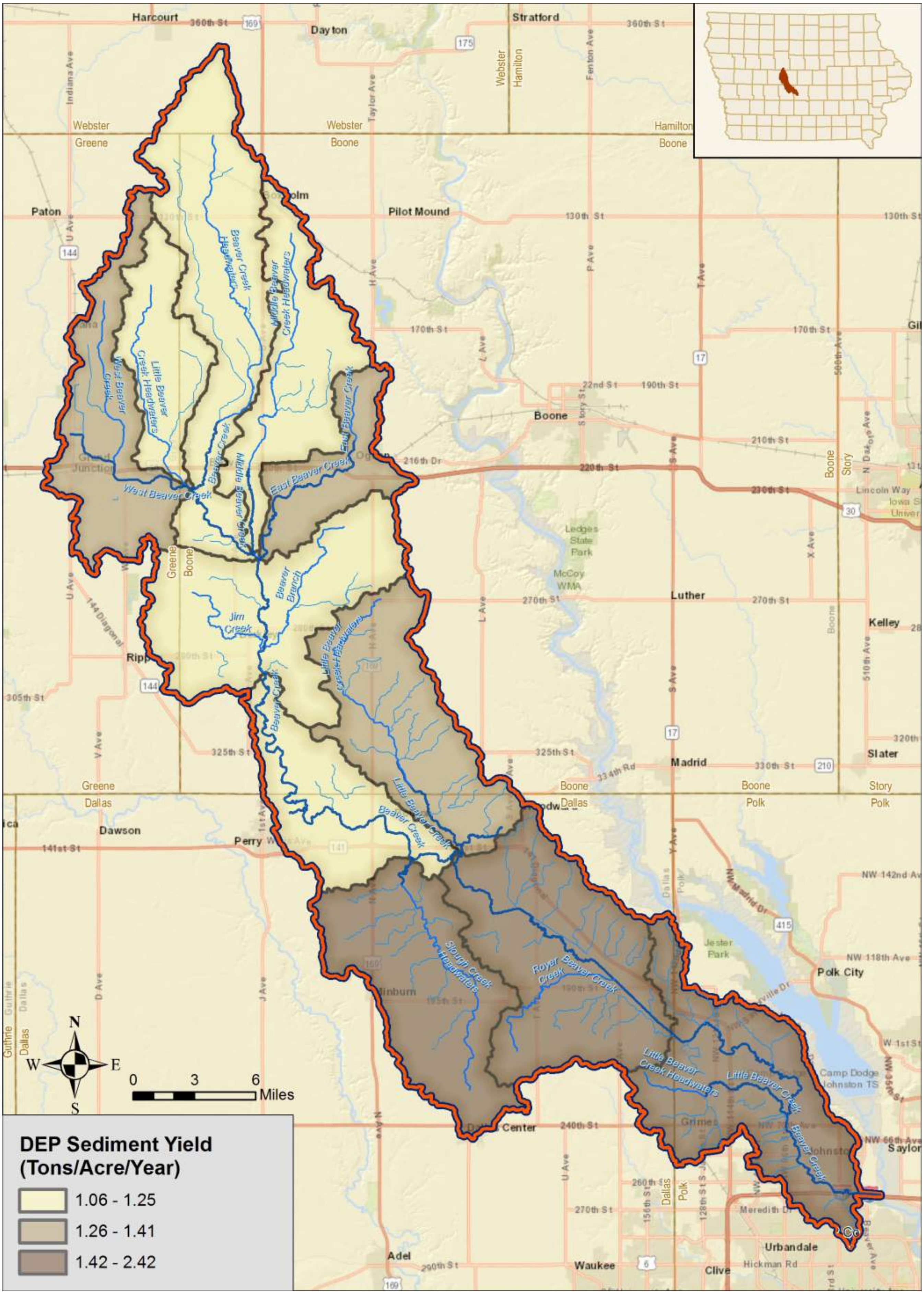
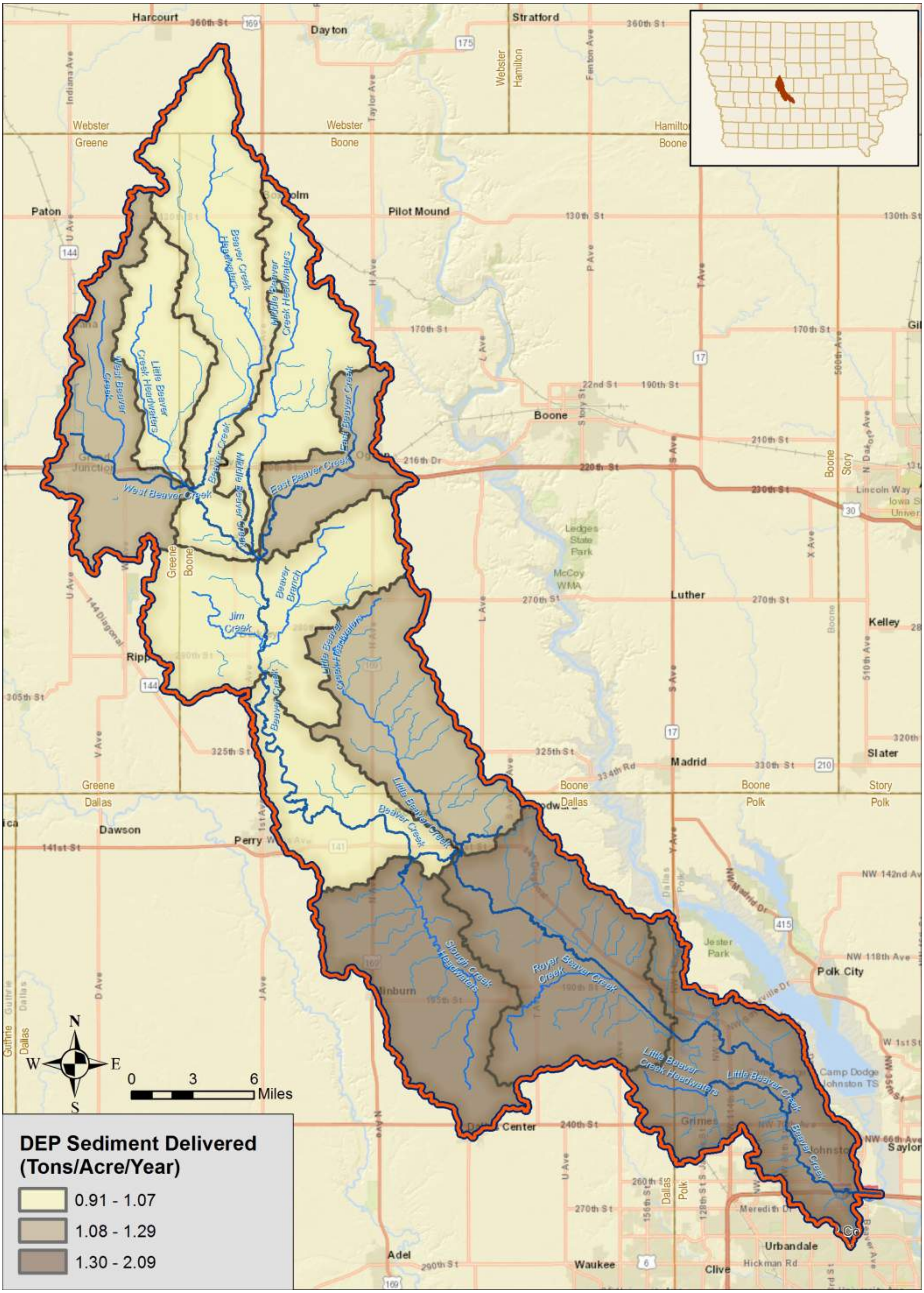


Figure 8.4: Beaver Creek Watershed Hillside Soil Loss (Tons/Acre/Year)by HUC-12 Subwatershed



BACTERIA

Humans, pets, livestock, and wildlife all contribute bacteria to the environment. These bacteria, after being excreted in animal waste, are dispersed throughout the environment by an array of natural and man-made mechanisms. Bacteria fate and transport is affected by disposal and treatment mechanisms, methods of manure reuse, imperviousness of land surfaces, and natural decay and die-off due to environmental factors such as ultraviolet (UV) exposure and detention time in the landscape. The following discussion highlights sources of bacteria in the environment and mechanisms that drive the delivery of bacteria to surface waters.

To evaluate the potential sources of bacteria to surface waters and to assist in targeting future reduction strategies, a desktop analysis was conducted for sources that are potentially contributing E. coli in the Beaver Creek Watershed. These populations may include livestock (cattle, swine or poultry), humans and wildlife (deer, geese). Populations were calculated using published estimates for each source on an individual subwatershed basis in the Beaver Creek Watershed.

Bacteria production estimates are based on the bacteria content in feces and an average excretion rate (with units of colony forming units (cfu)/day-head; where head implies an individual animal). Bacteria content and excretion rates vary by animal type, as shown in Table 8.1. All production rates obtained from the literature are for fecal coliform rather than E. coli due to the lack of E. coli data. The fecal coliform production rates were converted to E. coli production rates using the conversion of 200 fecal coliforms to 126 E. coli per 100 mL, based on relationships determined by the State of Minnesota in establishing their Standards (note EPA has determined a similar relationship).

Table 8.1: Bacteria production by source

SOURCE CATEGORY	PRODUCER	E.COLI PRODUCTION RATE [CFU/DAY-HEAD]	LITERATURE SOURCE
Humans	Humans	1.26×10^{9}	Metcalf and Eddy 1991
Companion Animals	Dogs	3.15×10^{9}	Horsley and Witten 1996
Livestock	Cattle	2.08×10^{10}	Zeckoski et al. 2005
	Hogs	6.93×10^{9}	Zeckoski et al. 2005
	Poultry	6.76×10^{7}	Zeckoski et al. 2005
Wildlife	Deer	2.21×10^{8}	Zeckoski et al. 2005
	Geese	2.5×10^{10}	LIRPB 1978

Wildlife

Deer population estimates in Iowa have remained consistent from 2014-2018 at around 500,000 animals. The Iowa DNR manages deer harvest numbers to be somewhere between 100,000 and 120,000 animals annually or approximately 20% of the total population prior to the hunting season.

The Iowa DNR maintains records of the total number of deer harvested by county annually from which population estimates can be derived. Estimates of deer populations for the Beaver Creek watershed were generated by area-weighting county-wide annual deer harvest totals from the **2017-2018 Trends in Iowa Wildlife** Populations and Harvest report to the total area of each county that is within the Beaver Creek watershed. It was assumed that annual harvest totals represented 20% of the deer herd present in each County.

Geese populations are difficult to estimate. An estimate of 3 geese per square mile was used based on other Iowa TMDLs.

Humans

Human sources are divided by whether the waste is collected and sent to a Waste Water Treatment Facility (WWTF) or if it is treated by an individual system.

WASTE WATER TREATMENT FACILITIES

The WWTFs located in the Beaver Creek Watershed with surface water discharges are summarized in Table 8.2. Bacteria loads from NPDES-permitted WWTFs was estimated based on the design flow and permitted bacteria effluent limit of 126 org/100 mL. According to available information on the DNR website, **there are 16 NPDES permits for wastewater treatment, including six municipalities operating waste water treatment plants and 10 miscellaneous dischargers.** The latter includes two Municipal Separate Storm Sewer Systems (MS4), six industrial dischargers, one Army National Guard Base, and one feedlot.

A deer bounds across a field in the Beaver Creek watershed.

Table 8.2: WWTP design flows and permitted bacteria loads

SUBBASIN	NAME OF WWTF	PERMIT #	DESIGN FLOW [MGD]	EQUIVALENT BACTERIA LOAD AS E.COLI (BILLION ORG/ DAY)
Beaver Creek	Brenton Brothers, Inc-FD-1*	7758687		
	Grimes Water And Wastewater Treatment Facilities	7736001	1.36	6.46
	Grimes, City Of MS4**	7736002	0.01	0.05
	Iowa Army National Guard - Johnston	7700901	0.31	1.46
	Johnston City Of Stp (Green Meadows)	7740001		
	Johnston, City of Ms4**	7740002	0.05	0.22
City of Bouton	McCreary Community Building Mun. Swimmiung Pool***	2561103		
East Beaver Creek	Ogden City of Stp-FD-1	858001	.34	1.62
	Northern Natural Gas Co - Odgen Compressor***	800101		
Headwaters Beaver Creek	Boxholm City of Stp-FD-1	825001	0.03	0.16
Little Beaver Creek-Beaver Creek	Woodward City of Stp-FD-1	2576001	0.34	1.61
Royer Creek-Beaver Creek	Beneventi Chevrolet - Oasis Laser Wash-FD-1	2537001	0.21	0.98
	Granger City of Stp-FD-1	2537102	0.01	0.03

** Brenton Brothers, Inc. Feedlot has a Waste Load Allocation of 0 according to the Des Moines River TMDL, **City of Grimes, Johnston MS4 Wasteload Allocation – Des Moines River TMDL, ***Not found in Des Moines River TMDL – Not a source of bacteria*

CURRENT COMPLIANCE STATUS OF BEAVER CREEK WATERSHED'S WWTPS

Comments regarding the current compliance status for individual facilities in Beaver Creek Watershed are shown below in Table 8.3. Orange highlights indicate a compliance schedule, and **purple highlights indicate an expired permit, with the future permit having the potential for a compliance schedule.** Granger and Woodward currently have adequately functioning treatment systems with NPDES permits valid through 2020. Hyperlinks to the Iowa NPDES Permits databased maintained by the DNR are provided for each facility.

Table 8.3: Compliance Status of Beaver Creek Watershed's WWTPs

MUNICIPAL FACILITY	CURRENT COMPLIANCE STATUS
Boxholm	Permit in compliance
Grand Junction	Lagoons, expired permit awaiting stream designation
Granger	Lagoons, expired permit awaiting stream designation
Grimes	Trickling filter, compliance schedule for ammonia N, total phosphorus and E Coli by June, 2021
Johnston	Closed
Ogden	Trickling filter, compliance schedule for ammonia N, Dissolved Oxygen and E Coli by March, 2019
Woodward	Lagoons, permit in compliance

CURRENT COMPLIANCE STATUS OF BEAVER CREEK WATERSHED'S MISCELLANEOUS DISCHARGERS

The current compliance status for Beaver Creek Watershed's miscellaneous dischargers including stormwater, feedlot, and industrial facilities are shown below in Table 8.3. **Purple highlights indicate an expired permit, with the future permit having the potential for a compliance schedule.**

Table 8.4: Compliance Status of Beaver Creek Watershed's Miscellaneous Dischargers

MUNICIPAL FACILITY	CURRENT COMPLIANCE STATUS
Brenton Brothers, Inc.	Permit in compliance
Louis Dreyfus Commodities	Discharge consists of noncontact cooling water, softener regeneration, reverse osmosis reject and multimedia filter backwash
McCreary Community Building Municipal Swimming Pool	Discharge of swimming pool filter backwash water, permit is expired and application is past due.
Northern Natural Gas Co. Ogden Station	Cooling water from Natural Gas Compression, expired permit awaiting stream designation and review of wasteload allocation.
Iowa Army National Guard - Johnston-FD-1	Lagoons, expired permit awaiting stream designation
Beneventi Chevrolet- Oasis Laser Wash	Discharge from a car wash wastewater reclamation system consisting of reverse osmosis and water softener reject water and overflow of treated wastewater from the wastewater reclamation system. NPDES Permit recently expired and application process has been initiated.

Based on the purple and orange highlighting, it appears that there is potential improvement for NPDES dischargers in the watershed. Most of the compliance schedules are for meeting EPA requirements for ammonia-nitrogen, dissolved oxygen, or E coli. The facilities with permits on hold due to changes in the stream designation will remain on hold until a new permit can be issued. **Before the permit can be issued, the individual streams must be assessed, the recommendations of the assessment must be adopted, and finally, the assessment must meet EPA's approval.** According to DNR, many of the streams that have been through the 2006-2010 assessment have been through the approval process, but **there are still quite a few streams that are still awaiting EPA approval.**

CURRENT STATUS OF BEAVER CREEK WATERSHED'S ONSITE TREATMENT SYSTEMS

In 2009, Iowa passed regulations for an inspection program for time-of-transfer properties for onsite septic systems, requiring systems to be exposed and pumped. If the system fails or does not have a secondary system, they must upgrade to current standards. **While this inspection program has been very effective in bringing noncompliant systems up to code, the state-established list of exemptions** (with no home rule for counties), leaves room for improvement. Exemptions include foreclosures, decedent's estates, consanguinity, or tax sales. **Many of these exemptions are a subset of properties with inadequate systems.**

The DNR is taking measures to bring the municipalities and other dischargers up to EPA standards. Several counties within the Beaver Creek Watershed including **Boone County and Dallas County are being proactive with stringent design and inspection standards for onsite treatment.**

BACTERIA LOADING ESTIMATE: FAILING ONSITE TREATMENT SYSTEMS

Wastewater treatment plants are typically cost-prohibitive for small populations, so residential populations in rural areas can represent an imminent threat to public health and safety (ITPHS) if the alternative methods of handling raw sewage – such as onsite treatment systems (OTS) – fail to adequately protect groundwater from contamination. In general, it is known that a percentage of OTS (also called septic systems) can be considered "failing" at any given time – although even approximating the number of failing systems is difficult at this scale. In populations served by OTS – often referred to as "unsewered" populations – ITPHS can also be associated with so-called "straight pipes", another form of failure where raw sewage is discharged directly to surface waters without any treatment.

The unsewered population in each subwatershed was estimated using data from the 2010 census by excluding areas within the city limits of municipalities with WWTP. The population estimates are shown in Table 8.5 along with the potential ITPHS loads associated with two different OTS failure rates. For reference, according to survey data from 1990 (published by the EPA in the 2002 Onsite Wastewater Treatment Systems Manual), between 50% and 70% of OTS in Minnesota and between 30% and 50% of OTS in Missouri were estimated to be in a state of failure (data for Iowa were not available).

It should be noted that these numbers are merely intend to suggest the potential for ITPHS contributions of excess bacteria to surface waters in the Beaver Creek watershed, and that no watershed-scale data are available to validate these estimates.

SUBWATERSHED - HUC 12	Estimated Rural Population	ITPHS Load 10% Failure Rate (billion org/day)	ITPHS Load 50% Failure Rate (billion org/day)
Beaver Branch-Beaver Creek	181	22.8	114.0
Beaver Creek	2213	278.8	1394.2
City of Bouton-Beaver Creek	618	77.9	389.3
East Beaver Creek	78	9.8	49.1
Headwaters Beaver Creek	151	19.0	95.1
Little Beaver Creek-Beaver Creek	400	50.4	252.0
Little Beaver Creek-West Beaver Creek	97	12.2	61.1
Middle Beaver Creek	226	28.5	142.4
Royer Creek-Beaver Creek	1031	129.9	649.5
Slough Creek	435	54.8	274.1
West Beaver Creek	229	28.9	144.3

Table 8.5: Estimates of rural population based on 2010 Census data and ITPHS population in each subwatershed

Livestock

The total number of livestock in each subwatershed was estimated by the Iowa DNR animal feeding operation (AFO) database (Figure 8.5). The DNR AFO database is current to 2017 and the registered number of animals is known. **AFO's with less than 500 animal units (AU) are not required to register with the Iowa DNR or obtain a manure management plan.** Therefore, in order to estimate the number of unregistered animals in the county, data from the 2012 USDA Agricultural Census was used. **According to the 2012 census, there are approximately 12,035 cattle, 88,389 swine, and 106,888 poultry (chickens and turkeys) within Beaver Creek Watershed.** The total number of cattle, swine, and poultry was subtracted from the number of registered animals and then area-weighted to the subwatersheds in the county that have registered feedlots.

Table 8.6: Livestock summary results by subwatershed in animal units

SUBWATERSHED	REGISTERED			ESTIMATED UNREGISTERED		
	COWS	PIGS	POULTRY	COWS	PIGS	POULTRY
	POPULATION					
Beaver Branch-Beaver Creek	1,633	35,879	106	327	4,117	22
Beaver Creek*	32,795				645	23
City of Bouton-Beaver Creek		5,495	8	198	1,585	14
East Beaver Creek		23,549		67	330	9
Headwaters Beaver Creek		43,028		551	5,417	24
Little Beaver Creek-Beaver Creek	3,606	12,666		2	4,633	19
Little Beaver Creek-West Beaver	5,103	56,221				10
Middle Beaver Creek	2,188	9,980		40	3,397	15
Royer Creek-Beaver Creek		9,263	308	765	2,298	25
Slough Creek	2,467	18,615	11	232	303	20
West Beaver Creek	5,681	71,680				16

** Beaver Creek watershed contains a large feedlot operation (Benton Brothers, Inc.) which houses between 6,500 and 9,000 cattle. This single operation accounts for 33% of all cattle present in Dallas and Polk Counties combined.*

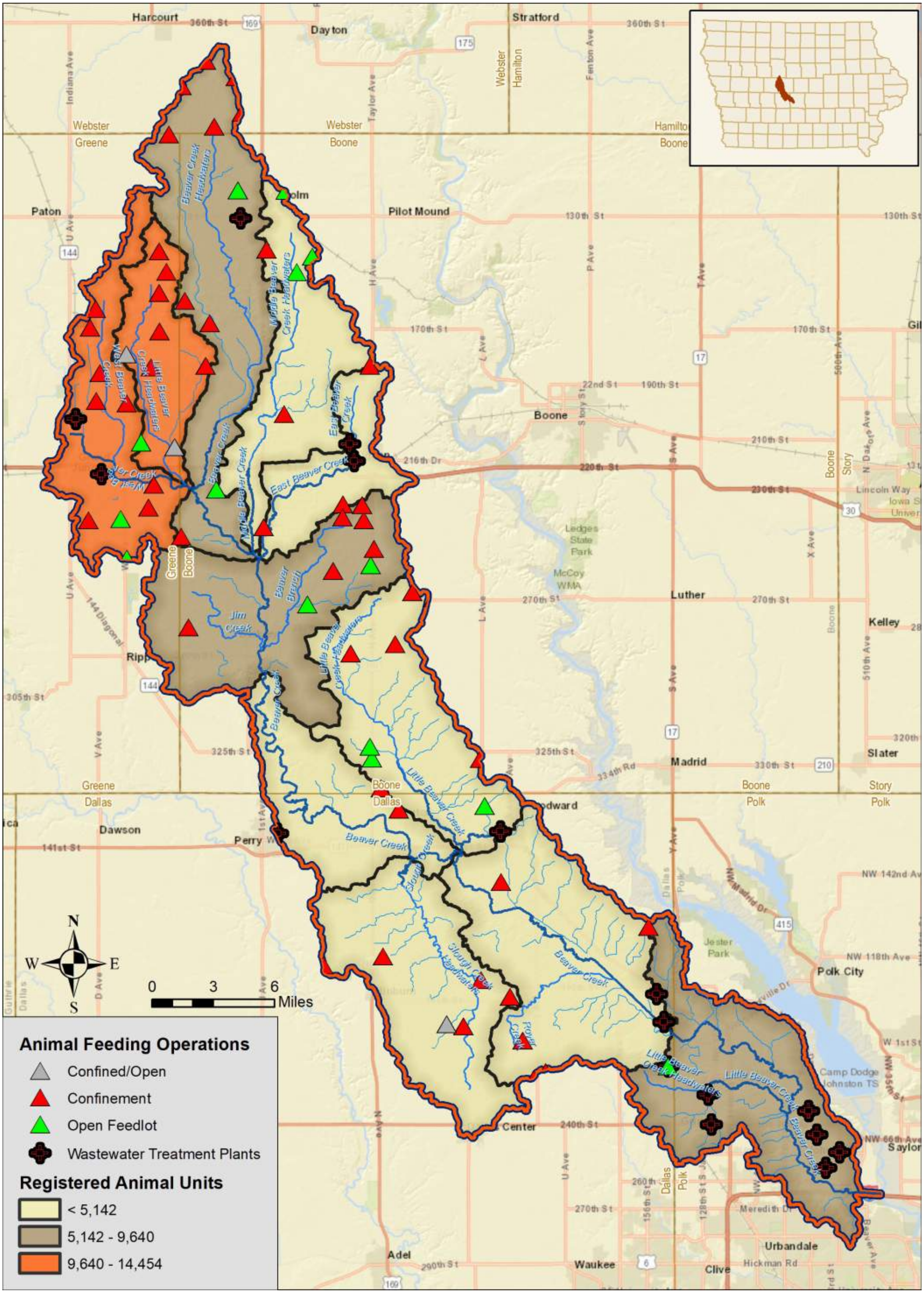
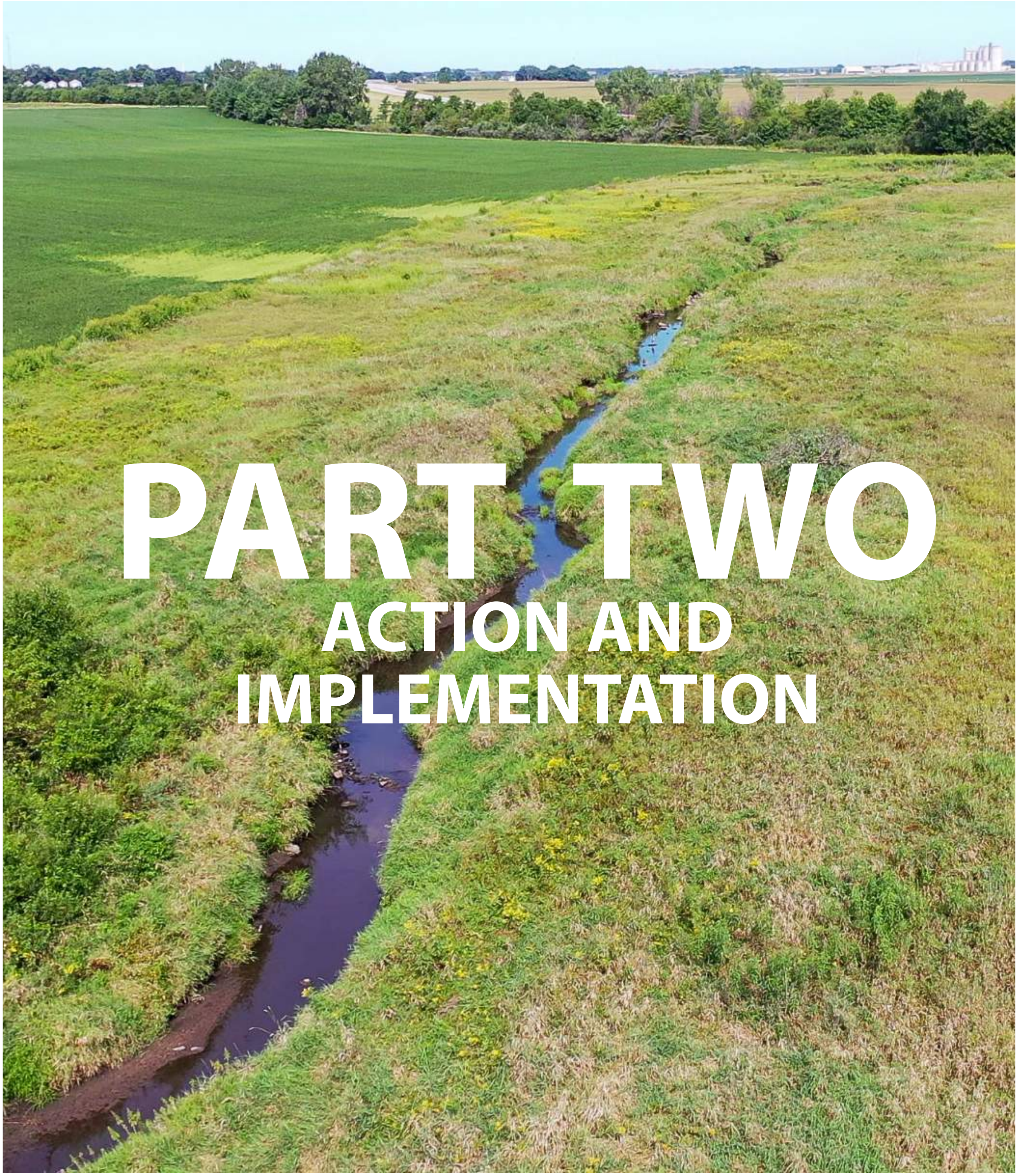


Figure 8.7: Beaver Creek Watershed Subwatershed (HUC-12) Bacteria Sources – Animal Feeding Operations



JANUARY 2020

BEAVER CREEK
watershed plan

RDG PLANNING • DESIGN

EOR water ecology community

SNYDER & ASSOCIATES

This watershed plan was commissioned by the members of the

BEAVER CREEK
watershed management authority

With contributions of its Board and Watershed Plan Steering Committee,
in partnership with the consultant team led by RDG Planning & Design.

RDG PLANNING • DESIGN

EOR water ecology community

SNYDER & ASSOCIATES

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CONTENTS

WHERE DO I FIND EPA'S NINE MINIMUM ELEMENTS FOR WATERSHED PLANS?

Although many different components may be included in a watershed plan, EPA has identified nine key elements that are critical for achieving improvements in water quality. EPA requires that these nine elements be addressed in watershed plans funded with incremental Clean Water Act section 319 funds and strongly recommends that they be included in all other watershed plans intended to address water quality impairments. In general, state water quality or natural resource agencies and EPA will review watershed plans that provide the basis for section 319-funded projects. Although there is no formal requirement for EPA to approve watershed plans, the plans must address these nine elements if they are developed in support of a section 319-funded project.

- Adapted from "Handbook for Developing Watershed Plans to Restore and Protect Our Waters", USEPA Office of Water – Nonpoint Source Control Branch, March 2008.

#1 - Identification of causes of impairment and pollutant sources or groups of similar sources that need to be controlled to achieve needed load reductions and any goals identified in the watershed plan. Sources that need to be controlled should be identified at the significant subcategory level along with estimates of the extent to which they are present in the watershed.

CHAPTER 2
Factors related to hydrology and potential pollution sources such as terrain, soils, and land use changes.

CHAPTER 3
A review of known impairments of designated uses for water resources within this watershed.

CHAPTER 4
Current and historic climate data is reviewed, along with an analysis of historic streamflow patterns and flood risk.

CHAPTER 5
A review of related studies that were previously completed that influence this plan.

CHAPTER 6
Identification of the key pollutants of concern identified by this plan and the potential impacts of these pollutants. Existing available monitoring data is reviewed. Pollutant load and sources are projected by subwatershed and land use type.

CHAPTER 7
Details regarding stream characteristics, stability and buffering.

CHAPTER 8
Pollutant load and sources are projected by subwatershed and land use type.

#2 - An estimate of the load reductions expected from management measures.

CHAPTER 11
For each of the eleven HUC-12 subwatershed a specific 3-0year implementation plan has been developed which includes projected load reductions.

CHAPTER 14
Rates of implementation and reduction are included in this chapter.

#3 - A description of the non-point source management measures that will need to be implemented to achieve load reductions and a description of the critical areas in which those measures will be needed to implement this plan.

CHAPTER 10

Proposed policy changes are non-structural management measures. The urban and rural policies outlined in this plan are those that are recommended for adoption to achieve the goals of this plan.

CHAPTER 11

For each of HUC-12 subwatersheds the 30-year plan details the type and potential locations of management practices needed to meet the projected load reduction targets.

CHAPTER 12

Measures to address future flood risk are noted.

CHAPTER 14

A list of first steps and adoption rates are included here.

CHAPTER 15

Cost associated with implementation of strategies outlined in this plan are included in this chapter.

#4 - Estimate of the amounts of technical and financial assistance needed, associated costs and/or the sources and authorities that will be relied upon to implement this plan.

CHAPTER 10

Reviews some of the technical assistance needed to implement policy changes.

CHAPTER 11

Evaluates the cost of implementation strategies at the subwatershed scale.

CHAPTER 15

Summarizes costs for watershed scale implementation and monitoring.

#5 - An information and education component used to enhance public understanding of the project and encourage their early and continued participation in selecting, designing and implementing the non-point source management measures that will be implemented.

CHAPTER 13

This is the education and collaboration plan.

#6 - Schedule for implementing the non-point source management measures identified in this plan that is reasonably expeditious.

CHAPTERS 11 AND 12

Include the strategies for addressing water quality and flood risk

CHAPTER 14

The schedule for implementation of the practices listed in Chapters 11 and 12 can be found here.

#7 - A description of interim measurable milestones for determining whether non-point source management measures or other control actions are being implemented.

SEE CHAPTER 14

#8 - A set of criteria that can be used to determine whether loading reductions are being achieved over time and substantial progress is being made toward attaining water quality standards.

SEE CHAPTER 14

#9 - A monitoring component to evaluate the effectiveness of the implementation efforts over time, measured against the criteria established under item #8.

CHAPTER 14

The monitoring program is outlined here.

CHAPTER 15

The costs and schedule for implementing the monitoring program is included in this chapter.

09

STRATEGIC FRAMEWORK

Vision:

Stakeholders united in managing and protecting social, economic and natural resources of a healthy, resilient watershed.

Mission:

To mitigate flooding, improve water quality and soil health while enhancing the economic vitality of all watershed partners.

09

VISION

Stakeholders united in managing and protecting social, economic and natural resources of a healthy, resilient watershed.

MISSION

To mitigate flooding, improve water quality and soil health while enhancing the economic vitality of all watershed partners.

Strategic approaches:

1. Flood Mitigation
2. Flood Resilience
3. Agricultural Conservation Practices
4. Natural Resources
5. Standards
6. Outreach

STRATEGIC APPROACHES / GOALS

FLOOD MITIGATION AND RESILIENCE

Measures of Success Include:

Into the future, **no increase in projected high-water levels during a 1% annual chance flood event** (100-year flood). Reduced risk from the 1% event, or a reduction in monetary damages projected to be caused by such an event.

1. Reduce flooding impacts through improved stormwater management and land use practices.

   a. **Implement urban and rural best management practices (BMPs) to:**

      i. Mitigate increases in peak rates of flow and runoff volumes caused by human-made alterations to the landscape to the greatest extent feasible.

      ii. Reconnect Beaver Creek and tributaries with their adjacent flood plains.

      iii. Reduce streambank and channel erosion.

      iv. Reduce flood damage overall and protect infrastructure.

      v. Work to mitigate impacts of tile drainage without sacrificing working lands productivity.

   b. As soil quality has a direct impact on the absorptive capacity of the land and its erodibility, **promote policies and practices which lead to soil quality restoration of both urban and rural landscapes.**

   c. Identify frequently-flooded sites and work with landowners for site-specific improvements that may benefit the larger watershed; employ funding strategies that reflect the broader benefits of the actions. Consider alternatives before repairing or replacing flood damaged structures (e.g., flood proofing, rebuilding elsewhere).

   d. Capitalize on multi-benefit projects

2. Building from current monitoring and planned water trails monitoring, **develop and implement a monitoring program to measure quantity and quality baseline,** progress and results, using this data for continuous improvement of watershed practices. Make collected data accessible to the public.

3. **Build awareness of climate change impacts,** including increased storm frequency and intensity; develop mitigation plans that address structures currently located in areas with elevated flood risk.

AGRICULTURAL PRACTICES/BMPS

Measures of Success include:

Increased conservation practice adoption in high priority areas, growth in use of priority practices (cover crops, strip till/no-till, stream buffers).

1. Increase participation in BMPs, particularly emphasizing cover crops, reduced or no-till management and stream buffers, acknowledging the topography may limit use of certain practices in some areas. **Use practices that best fit the soils and topography of their intended location.**

   a. **Support champions already in place,** e.g., Cover Crop companies within the watershed, Iowa Soybean Association, SWCDs, etc. Develop a list of champion landowners or producers who can help educate and raise awareness.

   b. **Unite agencies and existing commodity groups** for improved information sharing, progress and sustainable funding.

   c. Leverage work of tech companies and those that perform acre-by-acre economic analysis (precision agriculture).

   d. Improve communications on available agency services.

      i. Use IDALS, Farm Service Agency and Natural Resources Conservation Service for outreach to secure watershed grants and low/no-interest loans.

   e. **Grow participation of agricultural partners in the upper reaches of the watershed.**

   f. **Leverage proximity to Iowa State University,** Extension and multi-disciplinary students/interns for improved understanding and adoption of particularly cover crop and no-till BMPs.

   g. Explore casino partnerships as source of multi-county project resources

2. **Work towards 100% implementation of the conservation practices identified for each subwatershed.** Identify areas of focus to maximize cash and intrinsic values of practice installation. Inventory new practices and highlight those located in areas that align with ACPF priorities or high priority subwatersheds.

3. **Develop drainage district-WMA partnership** (see Policy and Education below); look at drainage district discharge as potential source for large-scale regional projects.

4. Encourage farmers to not use more fertilizers than needed. Educate producers regarding optimal application rates.

NATURAL RESOURCES

Measures of Success include:

Increased recreation participation, particularly through growth in introduction to outdoor skills-building activities; improved habitat quality and connections; increased species diversity and wildlife "counts"; reduced erosion and improved soil health.

1. Prioritize natural resources sites for preservation/protection.

    a. **Develop a Beaver Creek Greenbelt Approach** for protection/preservation of vital natural areas.

    b. Update and enhance natural resources inventory to set baselines and aid in developing priorities.

    c. Improve quality of available wildlife habitat, expand/enhance buffers and **create connected habitat corridors.**

    d. Identify new, expanding opportunities for **collaboration with public and private partners** throughout the watershed and within communities.

    e. **Maintain, enhance and protect the undeveloped, riparian corridors that exist** in the watershed's downstream reaches along Beaver Creek.

    i. Employ timber stand improvements, oxbow restoration, partnerships for land acquisition.

    f. **Discourage any additional channelization or shortening of Beaver Creek or its major tributaries.**

    g. **Work to improve habitat conditions for pollinators, migratory birds, wildlife.**

2. **Enhance recreation and public health** through improved water quality, habitat restoration, stream accesses, improved connectivity to parks/trails and cultural opportunities.

    a. **Support goals and projects of the Central Iowa Water Trails Network** that improve stream access and overall awareness of the need for flood mitigation and improved water quality.

    b. Preferentially implement flood control and water quality BMPs that have secondary benefits including:

    i. Restore wetlands/natural areas

    ii. Expand native landscape cover and riparian areas

    iii. Improve wildlife habitat and remove invasive species

    iv. Promote healthy soils

    c. Approaches that improve water quality should support improved habitat and greater diversity in natural resources.

    d. Install conservation practices that can improve wellhead protection.

3. **Pursue means of access beyond hard trails** (gravel, mowed paths, etc.)

STANDARDS AND OUTREACH

Measures of Success include:

Growth in resources available for on-the-ground projects, improved/increased collaborations and projects across jurisdictional boundaries, growth in downstream support of upstream projects.

Numeric outputs, including: Increases in BMP adoption rate (e.g. acres of cover crops), flood storage added, dollars spent in BMPs (mapping of implemented practices).

1. Quantitative goals:

   a. Nutrient reduction:

      i. Monitor rate of BMP adoption annually and compare against the projected target adoption rates for each HUC-12 listed in Chapter 11 of this plan.

      ii. Reduce nitrogen (N), and Phosphorus (TP) loads from the Beaver Creek Watershed.

      – Demonstrate reduction using trend analysis on long-term monitoring data from the mouth of Beaver Creek.

Implementation goals for rates of adoption of BMPs for nutruent and sediment loading for the entirety of the Beaver Creek Watershed can be found in Chapter 14.

   b. Sediment loading reduction:

      i. Monitor rate of BMP, streambank stabilization, streambank restoration and stream buffer installation against the target adoption rates listed in Chapter 11 of this plan.

      ii. Establish a target in-stream sediment load for Beaver Creek by developing a stream sediment budget which partitions watershed, near-stream and in-stream sources of sediment.

      iii.Develop sediment reduction goals for each source of sediment based on in-stream target.

      iv. Develop a relationship between turbidity and total suspended solids and use long term monitoring at Beaver Creek outlet monitoring station to demonstrate reductions over time.

A bioswale at Terra Park (City of Johnston).

c. Improve stream corridor stability and reduce bank erosion potential:

i. Stabilize

– 25% of the High Priority Streambank Stability Sites by 2029

– 50% of the High Priority Streambank Stability Sites by 2039

– 100% of the High Priority Streambank Stability Sites by 2049

ii. Restore:

– 25% of the Streams rated as having High Potential for Streambank Failure by 2029

– 50% of the Streams rated as having High Potential for Streambank Failure by 2039

– 100% of the Streams rated as having High Potential for Streambank Failure by 2049

iii. Establish buffers along streams and waterways throughout the Beaver Creek Watershed as described in the HUC-12 Subwatershed conservation plans.

iv. Monitor rate of BMP adoption annually and compare against the projected target adoption rates for each HUC-12 listed in Chapter 11 of this plan.

d. Flood risk reduction:

i. **No increase in the high-water level of the 1% annual chance flood event through 2049.**

ii. **No additional habitable structures built within areas impacted by the 1% annual chance flood event.**

iii. **Reduce risk exposure** by removing existing habitable structures within the flood plain.

– Reduce the number of structures within areas impacted by the 1% annual chance flood event by 20% by 2049. The number of structures in the floodplain is identified in Chapter 12.

iv. **Identify row-crop areas that are expected to be impacted by the 20% annual chance flood event** (5-year event, impacted at least every 5 years, on average) for conversion to stream buffers with conservation easements. Use FEMA Flood Insurance Rate studies or data from the Iowa Flood Center to evaluate the extent of the area impacted by this type of event.

– Maximize use of a current program available through December 2019 – the NRCS easement emergency watershed protection program. This program is open for the first time in this area since 2008 and was initiated due to disaster declarations issued for multiple counties in Iowa due to severe flooding earlier this year. The program will pay landowners up to 75% of the value of land dedicated to conservation practices within easements. This program should be used to the greatest extent possible while it is open. In the future, flood prone lands should be identified so that the program could be used again in the future when it next becomes available.

– **Reduce row-crop exposure to flood risk,** by converting high risk areas within the 20% annual chance flood event to conservation practices and buffers by:

- No increased exposure by the end of 2024
- 10%, measured at the end of 2029
- 25%, measured at the end of 2039
- 50%, measured at the end of 2049

v. Locate potential sites for and implement practices that provide storage to reduce runoff rates such as ponds, wetlands, water and sediment control basins (WASCOBs).

– Employ multi-stage outlets at these features to maximize control of runoff during both small and larger storm events.

2. **Develop ongoing means for collaboration and implementation of effective standards and practices.** Take a consistent watershed scale approach when practical but distinguishing, as required, standards appropriate for urban areas might not apply in the more rural parts of the watershed and vice-versa.

a. Establish criteria for evaluating standards, policy and practices for adoption by the Watershed Management Authority and its member organizations (criteria policy examples previously mentioned include: consistency, long-term thinking, flexibility for future generations – i.e. "constant but adaptable")

b. Priority guidance for watershed-wide adoption include:

i. **Multi-jurisdictional adoption of a more uniform stormwater management standard** to be applied throughout the Des Moines metro area.

ii. **Flood plain protection standards** designed to reduce structural/property losses, maintain flood storage capacity, identify areas of active stream movement (for preservation) and provide flood "freeboard" (an additional foot of separation between expected flooding levels and protection requirements)

– Given future projections of future increases in annual rainfall volumes and frequency of intense storm events, communities may wish to require higher levels of protection along major streams with known flood risk (e.g. three feet of freeboard above projected high water elevations).

iii. When new developments are proposed, **reserve needed stream buffer widths** in a non-buildable, dedicated parcel prior to any development

c. **Work across jurisdictional boundaries,** pursue resources for plan implementation, noting a project sited in community "A" may benefit community "B".

d. **Explore water funds and needed legal support** that allow downstream partners to support upstream projects.

e. **Support sustainable funding of state programs** such as the Water Quality Initiative (WQI), State Revolving Fund (SRF) and its Sponsored Projects program, Resource Enhancement and Protection (REAP) and Dam Mitigation Program. Promote restoration of annual funding support to the state's Watershed Improvement Review Board (WIRB) grant program. When projects that are supported by these funding sources are constructed, **invite local and state elected officials to ribbon cuttings, field days and tours** to show how important these funding streams are to project implementation.

f. **Support continued funding of the Iowa Flood Center,** operating through the University of Iowa which maintains real-time monitoring programs for both stream flow (flood) and water quality conditions. **Partner with the IFC to setup and maintain a network of real-time streamflow and water quality monitoring stations** within the Beaver Creek Watershed.

g. Similarly, identify **locations and projects to achieve regional-scale benefits.**

h. Identify **mechanisms for fair contributions of funds to support watershed work** while achieving equitable distribution of funds available for projects and education.

i. Establish metrics for projects that identify appropriate scales to measure social, economic, and environmental costs and benefits for projects

j. Structure Watershed Management Authority to ensure proportionate representation of all stakeholders

k. Make sure that **members are given action items to accomplish regularly,** to make sure each community sees value in membership and the group does not become stagnant

l. Routinely **involve drainage districts** in addressing issues and collaborations, provide WMA "seat at table" for drainage district hearings.

3. Advance the public/stakeholder education and outreach plan (framework in Chapter 13) and execute to achieve priority goals including:

- Improved landowner-tenant communications
- Increased understanding of cost-benefit of BMPs
- Improved understanding of value of public lands

Signage along a trail informing the public about oxbow restoration (City of Johnston).

10

POLICY RECOMMENDATIONS

This chapter highlights partnerships, policies and points of emphasis that need to be reviewed and developed to successfully implement this plan. ***New policies do not necessarily mean new regulations.*** In some cases, new educational materials, financial resources or partnerships would assist implementation of this plan. In other cases, policies may be rewritten or differently enforced to help achieve the goals and requirements of this plan.

Assessments completed as part of this planning effort have identified which and how many activities best influence water quality and quantity, change impacts to property and infrastructure, and improve water quality in the Beaver Creek watershed. To address identified concerns, changes are necessary to methods of stormwater management, flood plain and stream buffer protection, construction site pollution prevention and soil quality management / restoration. Within these areas, it is unlikely that all the required changes can be fully implemented on a voluntary basis. ***This chapter outlines policies and ordinances which are recommended to be enforced in order to achieve the desired results.***

10

Policies for urban areas:

1. Application of stormwater management standards
2. Protect floodplains and stream buffers
3. Construction site pollution prevention (generally erosion and sediment control)
4. Preserve and restore healthy topsoil
5. Pursue stormwater retrofits

Policies for rural areas:

1. Sustainable financial support
2. Public / private partnerships
3. Inform and educate about Iowa's Nutrient Reduction Strategy
4. Spread research results
5. Promote practices that improve soil health
6. Protect stream buffers and floodplains

POLICIES FOR URBAN AREAS

STORMWATER MANAGEMENT

In urban areas, traditional stormwater detention practices have been shown to have limited ability to control runoff for the most common small storm events. **Rainfalls of 2.5" or less make up more than 98% of the precipitation volume in Central Iowa.** As the greatest share of annual runoff volume is generated by these types of storms, most of the pollutant load carried from surfaces in the urban landscape are delivered to streams during these events. In addition, most streambank erosion along smaller urban tributaries occurs during the rapid rise and fall of streams during these types of events. To stabilize flowrates in urban areas, adopting policies that address these events is critical. Therefore, this plan recommends **all communities within the watershed adopt the Unified Sizing Criteria, as described within the Iowa Stormwater Management Manual (ISWMM).** This standard would provide for the following:

- **Recharge Volume:** To the greatest extent possible, reduce runoff from a 1.0" storm event through soil quality restoration, rainwater collection and reuse or practices that promote infiltration.
- **Water Quality Volume:** If runoff from the 1.0" event cannot be fully eliminated from a site, then runoff expected to be generated by a 24-hour, 1.25" event should be treated by employing water quality best management practices (BMPs). Over 90% of all precipitation in Central Iowa can be attributed to these types of events.
- **Channel Protection:** To reduce frequently occurring high peak flows, provide extended detention of the 1-year return period storm, with slow release over a period of between 24 and 48 hours. Over 98% of storm events in Central Iowa fall below this level (2.67" in 24-hours).
- **Overbank Flood Protection:** Limit peak runoff rates for the 50%, 20%, 10% annual recurrence (AR) (2-, 5- and 10-year return period) events to pre-settlement levels. Natural levels should be determined by calculating the time of concentration (use the NRCS lag equation based on pre-settlement conditions) and selecting Curve Numbers (based on meadow in good condition) to model such conditions. Refer to the ISWMM manual for additional information.
- **Extreme Flood Protection:** Limit peak runoff rates for the 4%, 2% and 1% AR (25-, 50- and 100-year return period) events to the lesser of natural values for the same storm event OR the values calculated for the 5-year return period event under existing (agricultural) conditions (calculate time of concentration and CN based on current conditions). Provide and maintain a safe path of overflow for the 0.2% AR (500-year) event.

Other facets of implementation:

- **Plan ahead of development, to identify potential opportunities for regional stormwater management.**
- **Use strategies to go beyond just using detention ponds to manage water. Promote a more diverse set of water management practices.**

Application

This plan recommends ordinance and policies be implemented to apply these standards to all new developments. Each community should identify how these standards will be applied to redevelopment sites. A threshold may be set (perhaps 10,000 SF of new impervious area), below which past calculation methods may be amended to reflect redevelopment changes , and above which stormwater management practices would be required to meet the new recommended standards. Opportunities to retrofit existing practices or provide new practices in developed areas should also be pursued, where feasible.

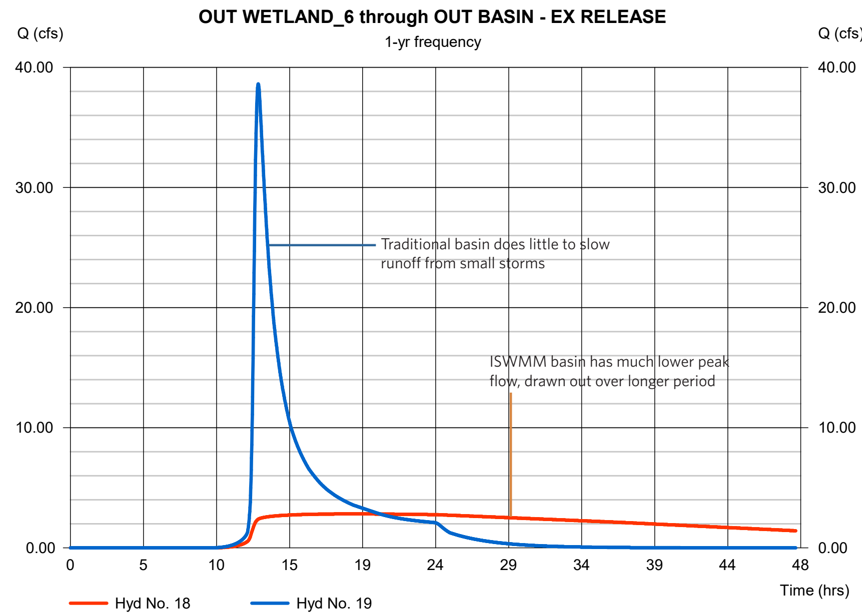
These types of ordinances have already been implemented in varying ways in the communities of Johnston and Grimes. Smaller communities or counties with less frequent urban development may need additional resources for technical assistance and plan review to implement and enforce these ordinances.

The WMA should investigate a mechanism to cooperatively provide technical assistance to smaller communities to answer planning questions and review site development stormwater management proposals. This could be accomplished through voluntary technical support provided by larger communities that deal with growth issues more frequently ("Beaver Creek Community Support Program"). Alternatively, a list of recommended consultants that could be employed on an as-needed basis to aid in plan or design calculation review. Consulting services could be provided on a watershed basis like how IDALS handles review of urban WQI or SRF Sponsored Projects, where there is an annually renewed contract with a consulting firm to help answer engineering questions during the review process at minimal cost.

Expected Impacts to Areas Immediately Downstream

- **Little or no direct surface runoff** during rainfall events that are equal to or less than 1.25" in depth.
- Over **95% reduction in peak flow rates for the 1-year** return period storm event (less flashy streams).
- Approximately **70% reduction in peak flow rates for the 10-year** return period storm event.
- Approximately **20% reduction in peak flow rates for the 100-year** return period storm event.
- **Multi-stage outlets** will often be required to meet small and large storm release rate requirements.
- **Measurable reductions** in nutrient, pathogen and sediment pollution are expected.
- Streambank and gully erosion rates should be reduced due to lower shear stress in streams (caused by lower stream flow rates and velocities).
- Can be implemented either regionally, or within each individual development. However, regional basins may require less total area dedication and provide for more certain execution of long-term maintenance.

Figure 10.1 - Comparing outflow rates during a 1-year storm event between practices designed using ISWMM vs. traditional.



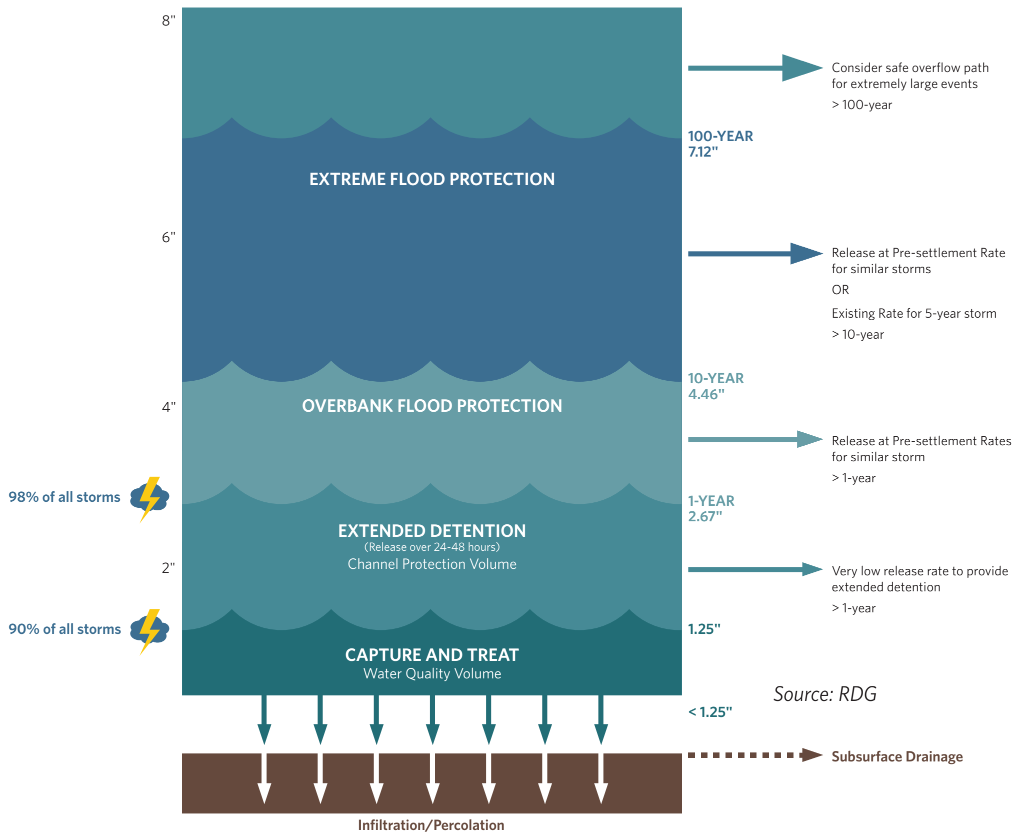
Source: Results from runoff analysis completed as part of Developing Case Study completed by RDG as part of this plan (see appendix resources).

Source: RDG Planning & Design

Figure 10.2 - Flow over a large multi-stage outlet structure in Ankeny, Iowa after a reain event.

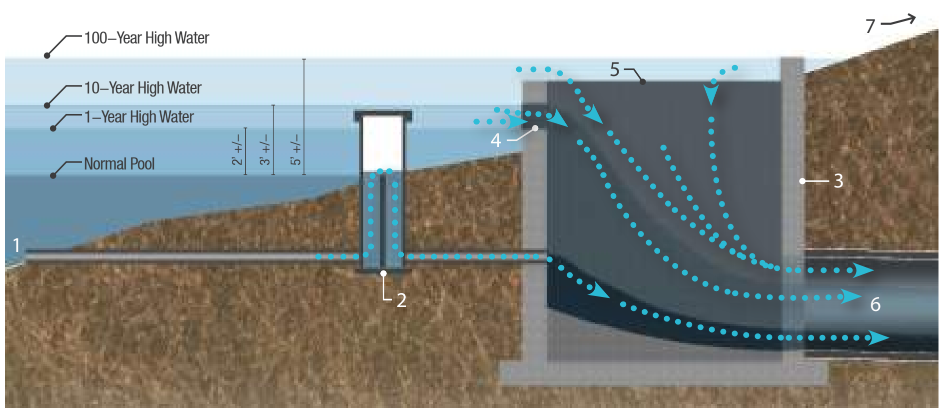
Figure 10.3 - Levels of stromwater management using the ISWMM Unified Sizing Criteria.

Levels of Stormwater Management Using ISWMM's Unified Sizing Criteria



Source: RDG

Example of a multi-stage outlet



1. 1st Stage: Small Diameter Inlet - Low Flow Control (Below Surface)
2. Water Level Control Structure
3. Main Outlet Structure
4. 2nd Stage: Notch Weir or Medium Size Opening (Controls 2-25 Year Storms)
5. 3rd Stage: Longer Overflow Weir (50-100 Year Storms)
6. Pipe Outlet (Likely Controls 50-100 Year Storms)
7. 4th Stage: Emergency Spillway (For Storms Larger Than 100-Year)

Figure 10.4 - A diagram of a smaller scale multi-stage outlet structure and how it is intended to function.

FLOOD PLAIN PROTECTION

Local policies and ordinances should be adopted or amended to protect flood plains in the following ways:

- Reduce structural and property losses during major flood events by **preventing construction of new privately-owned structures within the limits of the 1% annual recurrence (100-year) flood plain.**
- Maintain flood storage capacity by **limiting grading or placement of fill materials within the flood plain.**
- **Identify areas of active stream movement and reserve areas as open space** where future stream movement or flood plain inundation is expected.
- When establishing flood protection elevations, provide at least an additional foot of vertical separation between regulatory 1% AR (100-year) flood elevations and required building protection elevations. **To account for flow increases predicted by use of NOAA Atlas 14 data and make provisions for future increases in rainfall rates, communities may wish to increase this vertical separation to 3 feet.**
    - Collaborate to update local FIRM maps to reflect NOAA Atlas 14 data, at least in the urban areas in Polk and Dallas Counties.

Application

This plan recommends implementing ordinances and policies to apply these standards to all new developments and where land subdivisions are planned to occur adjacent to streams. Existing structures which fall within these protection zones should be identified. **Past known damages to such structures may be reason to pursue opportunities to acquire and remove such structures to avoid recurrent damages and liability.**

Expected Impacts:

- Reduced potential for damages to buildings, property and other infrastructure during flood events .
- Maximized capacity for storage and conveyance of large flood events.
- Reduced risk of higher velocity flows or reduced travel times being created due to narrowing of the flood plain.

Aerial footage of flooding along Beaver Creek in 2019 (City of Johnston).

STREAM BUFFER PROTECTION

In urban areas, stream buffers should be established, either by public land acquisition or through reservation as permanent easements as public or private open space. These buffers should be created along all streams that are first order or larger, as well as any existing or created open drainage course with a drainage area that is larger than 40 acres. Local policies and ordinances should be adopted or amended to establish protected stream buffers, which could become a connected series of greenbelt parks or accessible spaces. Stream buffers should be wide enough to serve the following functions:

- **Include the entirety of the regulatory 1% annual recurrence (100-year) flood plain OR where regulatory flood plains do not exist, include areas expected to be inundated by a 1% AR, 24-hourperiod storm event** (flows calculated using the NRCS TR-55 method for fully developed conditions). Consider inclusion of the regulatory 0.2% annual recurrence (500-year) flood plain within the protected buffer.
- **Allow for expected stream migration,** based on recent movement patterns or historic stream channel locations.
- **Provide enough width for future streambank improvements.** This plan recommends setting a line based on the existing streambank toe locations, or a line that accounts for expected future movement of the streambank toe. From that line, the buffer should include all land which falls between the stream and a projected slope line from the established toe baseline to the surface of the surrounding area. The slope line should not be steeper than a rate of 4 (horizontal) to 1 (vertical).
- **Allow width within the stream buffer for a minimum 15' cleared maintenance path on at least one side of the stream,** with a cross slope not to exceed 5%, to allow for access by trucks, tractors and other maintenance equipment. **Along streams of first order or higher, these maintenance paths should be provided on both sides of the stream.** These paths may be either undeveloped paths, kept clear of trees and brush by annual mowing or paths which are surfaced with pavement or gravel. These paths may fall within the 1% AR flood plain, as the slopes along the route meet the described parameters and the path is not threatened by stream migration or surface erosion.
- **If the maintenance path is outside of the 1% AR flood plain, provide a minimum five foot setback outside of the maintenance path to the edge of the reserved buffer,** on the side opposite the stream from the path.
- For engineered channels in developing areas, construct channels as bioswales where feasible to improved volume reduction and water quality treatment. Refer to the ISWMM for feasibility review and design procedures.
- Program annual maintenance to remove invasive species and improve establishment of erosion resistant surface vegetation within protected buffer zones.
- In all cases, provide a minimum 50 foot building setback from the existing top of bank for a first order stream. Provide a minimum 100-foot building setback from the existing top of bank for higher order streams.

- Identify existing structures located within areas expected to be impacted by the 1% annual recurrence chance flood. **Implement a buyout program, prioritized to target structures that are most frequently flooded or would represent the largest financial or environmental impacts first.** Integrate this approach into the Hazard Mitigation Program for each County (and City as applicable). **Future opportunities for funding for buyouts after disaster declarations could be lost if such approaches are note identified in these Hazard Mitigation Plans.**

Program annual maintenance to remove invasive species and improve establishment of erosion resistant surface vegetation within protected buffer zones.

When possible, **create separate "establishment and maintenance contracts"** on projects that will include creation of new native prairie areas and wetland vegetation. Identify this approach in any grant applications, so that the cost of this maintenance can be included in the total project cost to be covered by the funding request. These would put installation of permanent seeding and plants under the responsibility of a prime contractor (not a sub to a larger contract associated with site grading, utility work, other site improvements) which also would be responsible for a series of quarterly maintenance trips over an extended period after initial installation (3 years recommended).

This is beneficial in several ways:

(1) The selected contractor is more likely to have experience and interest in this type of work, having pursued it as the prime contractor (not just a lowest cost sub selected by another contractor).

(2) It makes the contractor responsible for all activities from seeding / planting to full establishment of the desired vegetation using maintenance work such as weeding, spot spraying, removing invasive species and re-seeding / re-planting as necessary.

(3) This requires the contractor to turn over maintenance responsibilities to an owner in a condition where weed pressure will be much less and ongoing maintenance will be simpler.

It is recommended to use volunteer labor, Conservation Corps or arrange "on call" contracts with maintenance companies as methods to reduce or nearly eliminate the financial cost of many maintenance activities.

Application

This plan recommends applying the urban standards to all new developments and where land subdivisions are planned to occur adjacent to streams subject to these provisions. Existing structures which fall within these protection zones should be identified. Past known damages to such structures may be reason to pursue opportunities to acquire and remove such structures to avoid recurrent damages. Guidelines for rural areas would be applicable to areas outside of the boundaries of incorporated communities or the planning review areas.

Expected Impacts

- **Reduced potential for damages to buildings, property and other infrastructure** during flood events.
- **Maximized capacity for storage and conveyance** of large flood events.
- **Improved access for maintenance** and ability to complete any necessary repairs.
- **Improved filtration of stormwater runoff** through properly designed channels.

STORMWATER UTILITIES

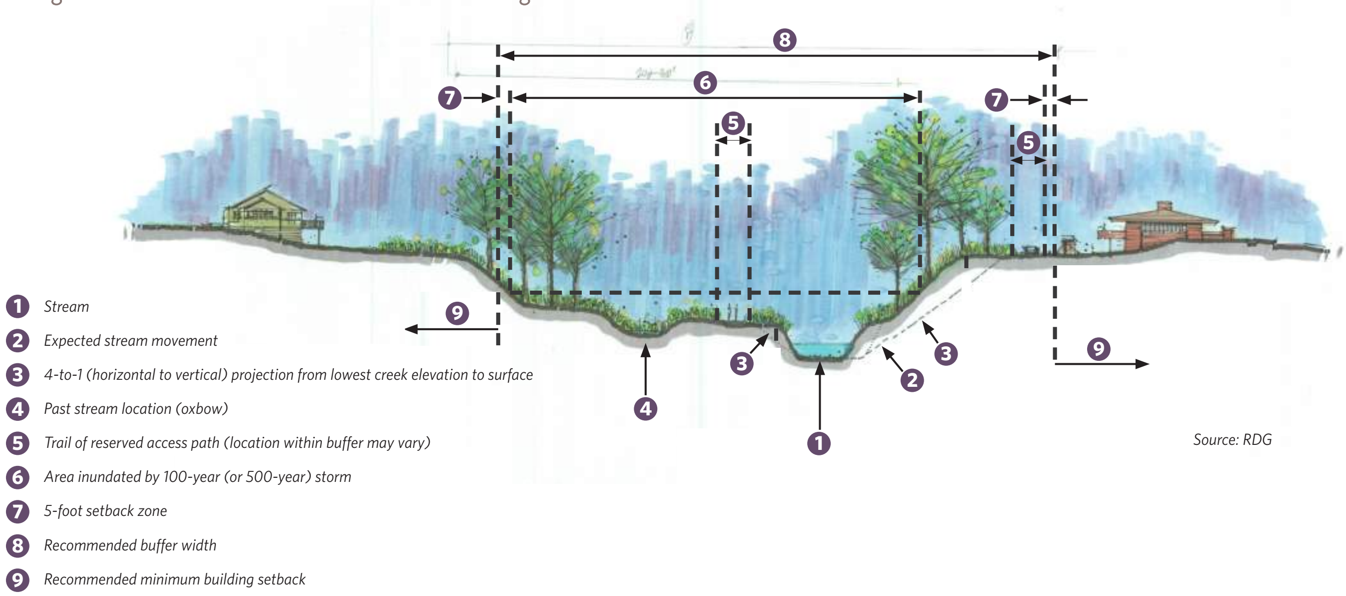
Several communites have adopted citywide utilities that assess fees to property owners to generate revenue that can be used for administration and project costs related to stormwater management. Typically these fees are based on the amount of impervious cover on a given property.

Application

Communities that already have such utilities should **routinely review the revenues being generated and catalog the financial needs** related to stormwater that exist across their jurisdiction. This may require adjustments to the fee collection structure to generate the revenue needed to address identified needs.

Communites without utilities should consider their use. These funds can create a stable source of funding to address stormwater or flooding issues.

Figure 10.5 - Elements to consider when setting stream buffer widths.



CONSTRUCTION SITE POLLUTION PREVENTION

Construction site runoff has been identified as one of the largest sources of sediment loading within urban environments. Many strides have been made over the past two decades in the development and implementation of stormwater pollution prevention plans (SWPPPs). While most sites are applying for required permits and preparing SWPPPs, there appears to be room for improvement in installation and maintenance of adequate erosion and sediment best management practices (BMPs). Erosion control practices protect the surface of the ground from being displaced by the force of falling precipitation or flowing water. Sediment control practices are intended to collect polluted runoff for a period of time, allowing suspended pollutants to settle out of runoff before it is allowed to leave a construction site.

Improvements are recommended in implementation of erosion control practices:

- Designers and developers should **consider stormwater management early in the site design process**. Look for ways to minimize the footprint of disturbed areas, lessen grading volumes and reduce impervious surfaces.
- **Designers should develop a Soil Management Plan (SMP),** to be implemented by contractors on the developer's behalf, with the goal of providing healthy soils across all open space areas on developed landscapes before construction has been completed.
- **Construction should be phased to limit the amount of area that is disturbed** (vegetation removed for construction) **at any one time.**
- Where upstream areas drain through a construction site, **contractors should stage construction to avoid disturbance to the flow path** or provide stabilized methods to divert stormwater around or through site construction.
- **Designers and contractors should increase the use of temporary seeding and mulches.** Use of adequate temporary mulch has been shown to reduce surface erosion by up to 98% compared to sites with no erosion controls. State law currently requires that disturbed areas where grading activities cease for a period of longer than 14 days shall have temporary stabilization (such as mulch with seed) applied immediately after the last grading activity in that area. Many sites are currently not providing adequate temporary stabilization measures to comply with this requirement.
- On steeper slope areas or in areas of concentrated flow, there should be **increased use of rolled erosion control products (RECPs) and turf reinforcement mats (TRMs)** where temporary mulch may be insufficient to prevent erosion.

Recommended improvements for sediment control practices:

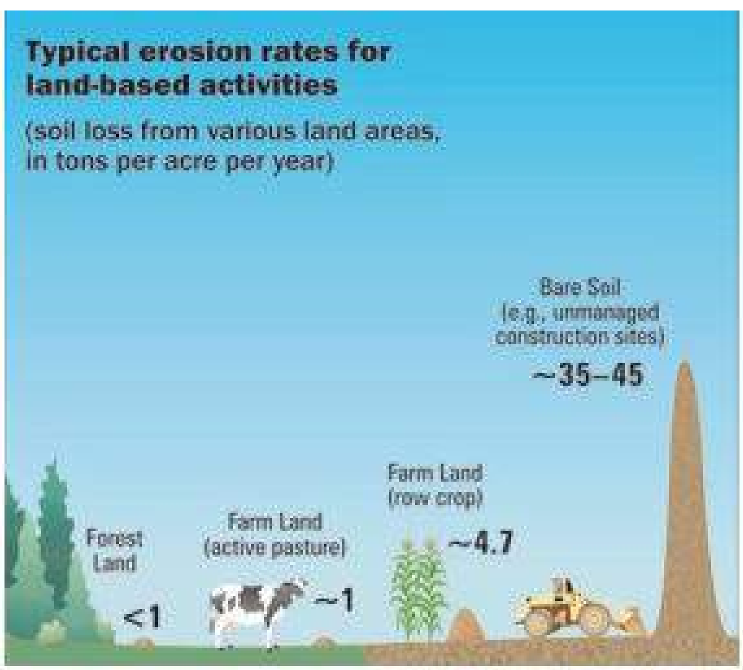
- **Prior to commencing land disturbing activities, contractors should install perimeter site controls** (such as silt fences , filter socks, wattles and sediment basins), stabilized construction entrances, trash collection areas and temporary sanitary facilities for site workers.
- Contractors should **install interior site controls as soon as allowed by grading or utility construction.**
- Contractors should take care not to overload controls. Refer to design guidelines for sizing and design. For example, provide at least 100 feet of silt fence length for each quarter (1/4) acre drained.
- Silt fences should feature "J-hooks" or other methods to increase their storage capacity and prevent concentrated flow from larger areas being directed to a single low point in a long fence. Silt fences often fail when they "blow out" when they have collected too much runoff or sediment, because the area they collect runoff from is too large. Silt fences should have these features placed at intervals of no greater than 200 feet.
- Soil logs or wattles should be used to break up the length of steeper slopes. Reducing the flow length along steep slopes can significantly reduce surface erosion.
- **State law requires sediment basins to be installed where runoff from more than 10 disturbed acres is routed to a common outlet.** These basins are to be designed with floating outlets or devices that collect water from the surface of ponded water. As pollutants settle out by gravity, the surface of the ponded water tends to be
- less polluted than that discharged from the bottom of the basin. Few of these types of outlets have been observed as being utilized currently. Also, as properly sized basins are often most effective at removal of suspended sediment from constructed runoff, it is recommended that new local policies be implemented to require their use in smaller disturbed areas.
- **All site controls should be checked on a weekly basis and before rainfall is expected to make sure they are in good working order.** Controls should be maintained and repaired promptly as needed. Trash and sanitary collection facilities need to be emptied routinely and collected materials disposed of properly. Stabilized entrances may need new surface aggregate provided is they are failing to prevent off-site tracking from occurring.
- When dewatering excavations, divert discharge to a sediment basin or other collection area on-site. **Do not directly discharge such water to the storm sewer system without treatment.** Avoid releasing concentrated flows at the top of steep slopes where gully erosion may be caused.
- **Immediately following full establishment of permanent vegetation, all temporary controls such as silt fences, soil logs, inlet protection devices should be removed.** Accumulated sediment should be properly disposed.

Recommended improvements to SWPPPs:

- **The plan should be a "living document".** The plan should be amended in some fashion so that the site map reflects current site conditions. Inspection records and changes to the sequence of construction events should be made part of the SWPPP document.
- **The SWPPP and all site controls are to be maintained as necessary until full establishment of vegetation across all disturbed areas.** Site inspections and maintenance of controls should continue until all areas are stabilized with permanent vegetation and the Notice of Discontinuation (NOD) has been filed with the Iowa Department of Natural Resources.

Recommended improvements to municipal inspections:

- Routinely check sites to assure that construction sites are in compliance with state and local standards. MS-4 communities should maintain sufficient staffing to provide inspections are happening as frequently as needed.
- Respond promptly when polluted site runoff or off-site tracking is observed, or citizen complaints are received.
- When necessary, use "stop work orders" and other methods to bring sites back into compliance before work on other construction items can proceed.



Source: Dunne, T. and L. Leopold, 1978; NRCS, 2000; NRCS, 2006; ASCE and WEF, 1992

Perimeter controls that have not been maintained that are allowing sediment to be washed into the street gutters and storm sewers.

Tracking from a construction site onto a paved roadway from an unprotected construction entrance.

This area has not been seeded or mulched, leaving it exposed to potential erosion.

Sediment can be seen washing into this inlet.

Application

The plan recommends ordinance and policies be implemented that would apply these standards to all sites requiring either a local grading permit or authorization under the State of Iowa's NPDES General Permit No.2 (construction sites or common plans of development which will disturb at least one acre). **These requirements apply to all sites within the State of Iowa that meet those thresholds, no matter their location.** However, only Johnston and Grimes are communities that are large enough to require their own permit authorization from the state, which also requires them to have ordinances and policies to aid in enforcement of these measures. Smaller communities may not be required to have such permits or ordinances, but they should be aware of the requirements for construction sites that exceed the threshold of requiring a permit through the State.

Expected Impacts

- Successful implementation of these policies could reduce sediment loadings from construction sites by 80%.

Why is Pollution from Construction Sites a Problem?

Construction activities create new development from farmland or other open spaces. These activities strip off any vegetation that is reducing the potential for surface erosion. Once this vegetation is gone, the surface of the soil is easily washed away by rainfall and flowing water. Soil can also be tracked onto roads and highways or dumped into waterways. All of these actions make it likely that soil will be carried off site and washed into downstream storm sewers, creeks and rivers. This eroded soil (sediment) can plug up storm sewers and fill in waterways, affecting their ability to convey runoff. Other impacts of sediment are listed in detail in Chapter 6 of this plan.

Without effective controls, sediment discharge from construction sites often will range between 35–45 tons per acre.[(1)] Compare this with farmland areas which usually have loading rates of less than two tons per acre. Lawns and other stabilized areas have far lower erosion rates.

Construction sites can also be sources of other pollutants such as fuels, oils, paints, concrete washout, construction debris and human waste (collected in temporary toilet facilities from workers).

SOIL QUALITY MANAGEMENT AND RESTORATION

Recently, requirements within the State of Iowa's NPDES General Permit #2 for construction sites were amended. These changes removed a requirement to restore four inches of topsoil across disturbed open spaces. The permit now requires that topsoil be preserved on site where feasible, but does not specify where and how that topsoil is to be placed or preserved. During the discussions leading up to these changes, many concerns were raised by the development and real estate interests about the cost and timing of restoring topsoil, especially on finished lawn spaces within single-family land developments. In some cases in the past, topsoil was preserved within berms or other confined areas and was not always placed uniformly across the landscape. This means that those open spaces often lack the healthy soil material needed to support the growth of lawns and landscaping. Should this continue to occur, soils in such areas would have limited ability to absorb runoff during rainfall events (runoff volumes may be increased by more than 80% during the most commonly occurring storm events). Higher levels of watering and fertilization will be necessary to support desired plant materials. **All of these factors have the potential to increase stormwater runoff volume and pollutant loads.**

For this reason, it is recommended that communities implement local ordinances to protect or restore healthy soils in open space areas. The Iowa Stormwater Management Manual has an entire chapter devoted to the topic of maintaining and restoring healthy soil profiles. Options include limiting the footprint of land disturbance, topsoil stripping / replacing and using soil amendments like compost and sand to rebuild a healthy surface topsoil layer.

To fully realize the benefits of soil quality restoration, the methods within ISWMM manual list various ways to maintain or **create eight inches of a healthy soil profile across the surface.** Requirements to achieve this standard can be incorporated into other ordinances, or implemented as a stand-alone ordinance. Such requirements should include the following elements:

- All construction sites which are subject to local grading permit or State NPDES permit requirements should **develop and maintain a Soil Management Plan (SMP)** which becomes a part of the SWPPP document when one is created for a given site.
- The SMP shall review soils information from county maps, geotechnical studies or other sources to identify where higher quality soils may exist. When possible, the organic content of onsite topsoil material should be determined by testing.
- To the extent possible, **site improvements should be oriented to minimize disturbance of high quality soils.** Site grading should be planned to avoid compacting, filling or tilling under the drip line of trees which are identified as being intended to be preserved through construction.
- Identify where topsoil will be stripped, stockpiled and replaced. The quantity of stockpiled material should be estimated.
- Where grading is necessary, **show the location and type of method of Soil Quality Restoration (SQR) to be applied** (reference ISWMM chapter to see the available methods and how they are achieved).

- In some locations, **it is possible to use SQR techniques to partially or totally address the Unified Sizing Criteria requirements to manage the Water Quality Volume.** If this is proposed, identify locations where SQR techniques are intended to be used to meet such requirements. Include relevant calculations to demonstrate compliance with requirements listed in the ISWMM manual within a stormwater management report submitted to the local jurisdiction for review.
- If SQR techniques are not proposed, or not applied, **appropriate adjustments to runoff coefficients and curve numbers within stormwater design calculations should be made to account for the effects of soil compaction and poor establishment of vegetation.** The ISWMM manual includes recommendations on how to account for these effects.

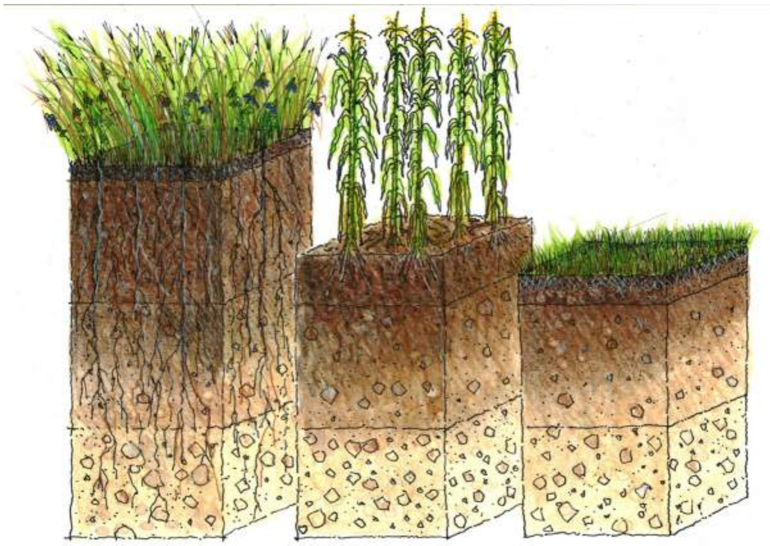
Application

It is recommended that ordinance and policies be implemented that would apply these standards to all sites requiring either a local grading permit or authorization under the State of Iowa's NPDES General Permit No.2 (construction sites or common plans of development which will disturb at least one acre).

Expected Impacts

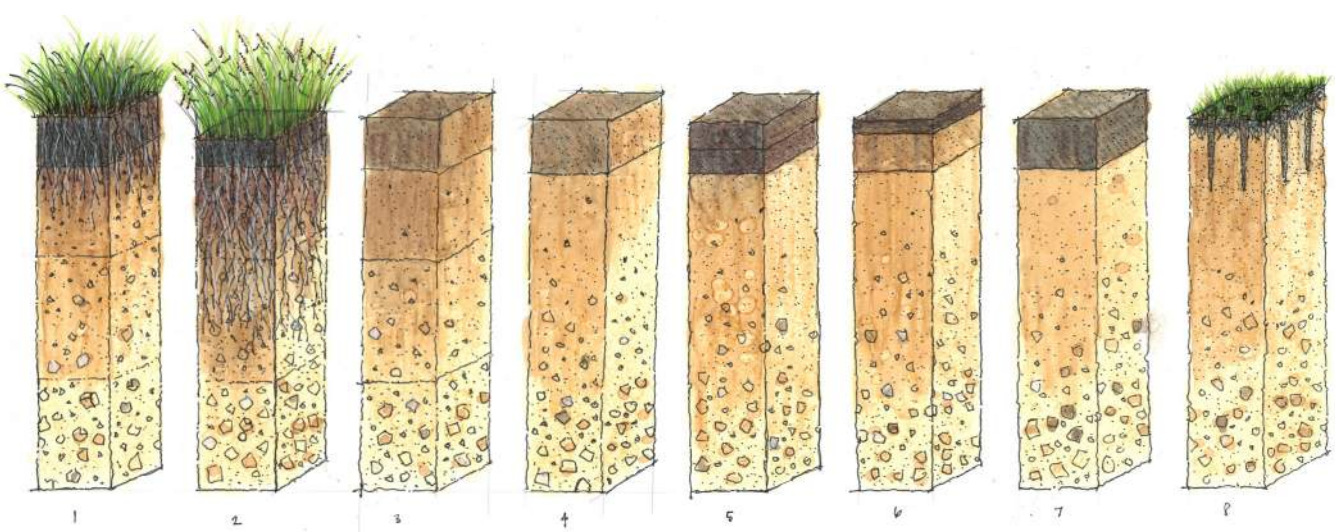
- It is expected that successful implementation of these policies could reduce runoff volumes from suburban development areas by approximately 45% during a 1-year return period storm event (2.67" in 24-hours). This would be a volume reduction of 17,600 gallons per acre drained for that event.
- Runoff reduction from areas developed using these policies during the 1% AR (100-year return period) storm event (7.12" in 24-hours) would be expected to be approximately 20%, compared to sites without soil quality restoration. This would be a volume reduction of 33,400 gallons per acre drained for that event.
- Total pollutant loading would be expected to be reduced by an amount similar to runoff volume reductions.
- Stormwater detention areas and other management practices can be reduced in storage volume and footprint area. Modeling results from the developing case study area indicate that stormwater management areas in areas without soil quality restoration would need to have 48% more volume and be 40% larger in area to limit runoff rates to desired levels.

Figure 10.7 - Patterns of topsoil loss shown in the Iowa Stormwater Management Manual



Historic topsoil depth and organic matter levels have been reduced in agricultural areas. The remaining topsoil is often stripped off or compacted during grading and construction of new land developments.

Figure 10.8 - Various methods of topsoil restoration described in the Iowa Stormwater Management Manual



The Iowa Stormwater Management Manual contains a section on Soil Management and Restoration. It designates eight different methods that can be used to protect or restore a healthy topsoil layer during the construction process. Designers can use this information to develop a Soil Management Plan, which outlines how developers or contractors can use one or more of these eight methods to leave lawn and landscaping areas with adequate topsoil to support vegetation and reduce stormwater runoff.

POLICIES FOR EXISTING DEVELOPED AREAS

While many of the policies in urban areas are focused on new or redeveloping areas, it is important to look for opportunities to make improvements within portions of the watershed that is already developed. Cities can require updated stormwater practices to be installed on properties where site improvements or re-development is proposed to a level where a new site plan must be approved. Other than these situations, cities usually do not have the ability to force private property owners to make improvements to their sites. For this reason, communities may decide to provide incentives (such as cost share programs, grants, utility fee reductions) to promote installation of new stormwater practices. Cities may also look to identify critical areas where stormwater retrofits could lessen the potential for flash flooding or streambank erosion along small urban tributaries. Education and outreach efforts can also broaden use of practices such as rainbarrels and raingardens in residential areas.

POLICIES FOR RURAL AREAS

Rural Policy Recommendations

Over the next decade, it is expected that most water quality improvements will rely on voluntary actions taken by individual farmers and landowners. To support and accelerate the implementation of this plan, a series of policies and action items has been identified.

1. **New sources of financial support are needed to support water quality improvements in rural areas.** Many practices known to be effective at reducing pollutant loads and/or runoff volumes, but several of these have costs associated with their installation or the lost potential for agricultural production. There are many economic factors which may make it more difficult for farmers and land owners to commit to investing in these practices. Low crop prices may leave little room above the "bottom line" to devote to water quality initiatives. With higher prices, there is incentive to maximize productive land, potentially reducing available for buffers and other practices. Federal, state and local resources can be used to bridge this gap and provide water quality and quantity benefits that are important to the entire watershed.
    - Increase funding for progams like CREP to increase the rate of practice implementation.

Some alternatives for funding are listed Chapter 15 (Resource Requirements) of this plan.

2. **Develop private and public partnerships to develop precision business planning for agricultural areas,** targeting those areas which currently farmed on an annual basis, but are routinely not profitable to the producer. These lands could potentially be set aside for water quality practices such as conservation easements, wetlands, buffers, etc.
3. **Additional educational materials are needed that better explain the best management practices that are included in the nutrient reduction strategy:** what they are, where they are best applied, how they work, their benefits and liabilities, and where interested groups can seek out more information for funding or constructing such practices. The need for such materials extends beyond the boundaries of this watershed.
4. **More information on existing research** needs to be accessible to explain to producers and landowners what would be considered "natural" levels of nutrient loadings and how current agricultural practices have been shown to impact these levels.
5. Take collective action to promote, install, establish and maintain conservation approaches and practices that hold water where it falls.
6. **Practices that improve soil health and address water management have benefits beyond water quality and quantity improvements that should be pursued.**
    - Maintaining and improving the structure and organic material within the upper soil profile is key to sustaining agricultural production into the foreseeable future. Practices such as extended crop rotations may cause short term reductions in yield when Felds are used for alfalfa production, but long-term benefits in soil depth and quality are likely to be realized.
    - Methods of subsurface water control may also allow for improved water retention in soil layers during dry period. It has been identified that over the past sixty years, significant crop losses can be attributed to either excess or insufficient moisture. In the past, Feld moisture management has often been focused on drying Felds out during wet years. The importance of having the ability to retain moisture during drought conditions should not be overlooked. **Drought has historically been a larger cause of crop losses than either excess moisture or flooding.**

7. Develop state or federal initiatives to develop new markets for cover crops or other products that could encourage production of crops that would improve soil health or limit nutrient loss.
8. Map Drainage Districts at the subwatershed scale and incorporate information about other subsurface drainage networks, as available.
9. Refine the purpose and function of Drainage Districts to holistically improve water management.

Table 10.1 - Historic Causes of Crop Loss

Portion of All Crop Losses Reported that are Related to Drought, Excess Moisture or Flooding		
Cause of Crop Loss	Iowa Corn (1948-2010)	Iowa Soy (1995-2010)
Drought	40%	28%
Excess Moisture	27%	27%
Flooding	6%	6%
Source: "Managing Risk in Agriculture;" Chad Hart; Presented at Ag Credit School; Ames, Iowa; June 2013.		

Future Considerations

This plan focuses on voluntary efforts to implement measures to improve water quality. A wider establishment of adequate stream buffers and grass waterways is an essential component of this plan. Even if there was a desire to make stream buffer protection a requirement in rural areas, there is not currently a means at the city or county level to execute and enforce such requirements. Therefore, currently it is essential that landowners, farmers, conservation and advocacy organizations work together to more broadly adopt these practices.

Chapter 16 of this plan calls for a more extensive re-evaluation of its achievements after its first ten (10) years of implementation. If at the end of this period there has been little progress adopting stream buffer improvements on a voluntary basis, then there may be a need to advocate for stronger regulatory policies that could be enforced on the state level. Recently, the State of Minnesota implemented a mandatory stream buffer protection and re-establishment policy which will be implemented over the next few years. Should that program be successful, it could serve as a model which could be tailored to address conditions in Iowa.

Regulatory frameworks could "level the playing field" for producers and landowners that are already investing resources in conservation practices.

11

WATER QUALITY IMPROVEMENT STRATEGIES

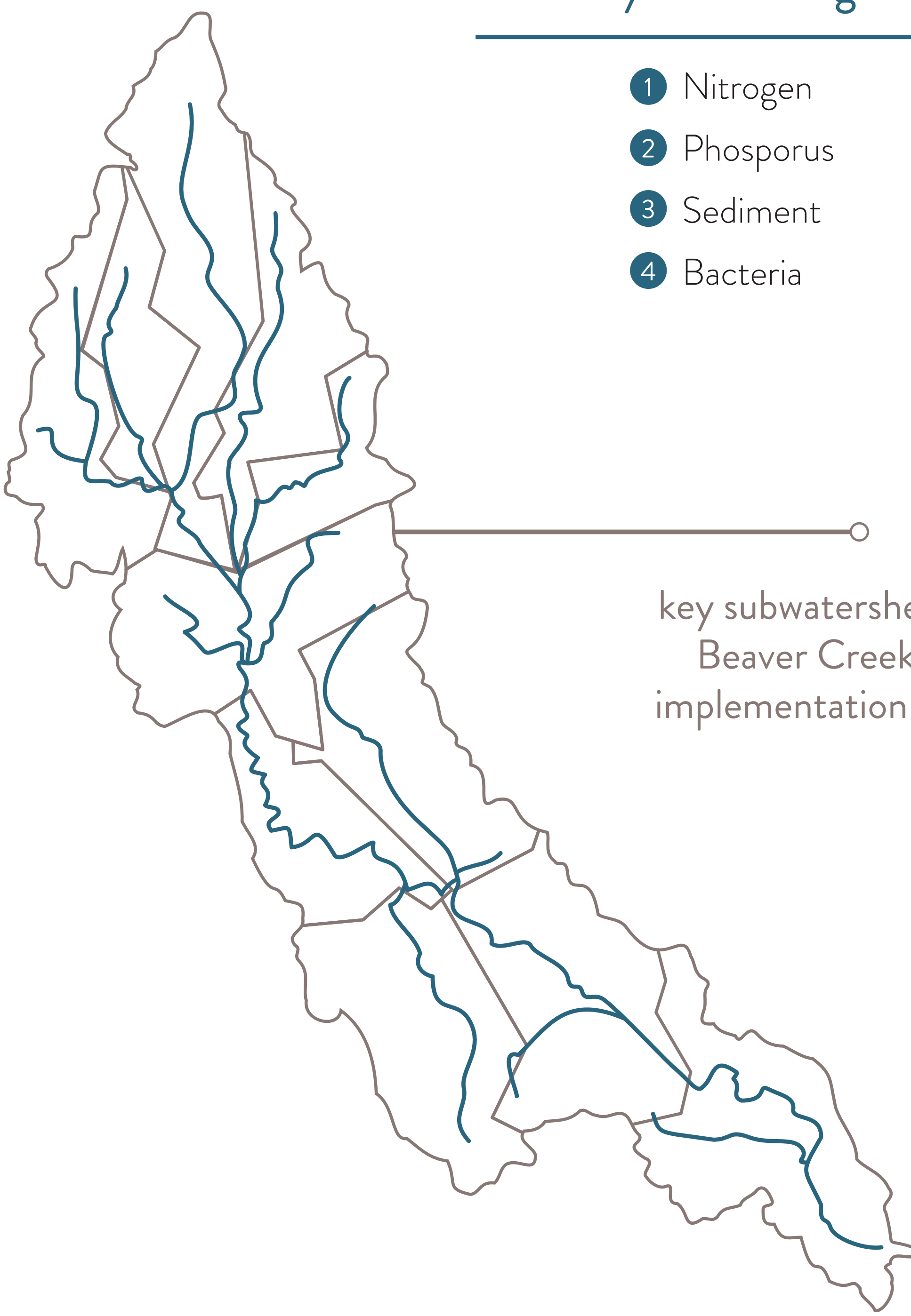
The emphasis in this section is placed on BMP retrofits in both the agricultural and urban landscapes.

This Chapter includes detailed strategies for each of the eleven HUC-12 subwatersheds that drain to Beaver Creek and its tributaries.

11

Improve water quality by addressing:

1. Nitrogen
2. Phosporus
3. Sediment
4. Bacteria



11

key subwatersheds of Beaver Creek have implementation plans

AGRICULTURAL CONSERVATION PRACTICES

The suite of various conservation practices appropriate for addressing the nutrients and sediments contained in agricultural runoff are presented in the context of the agricultural conservation pyramid (Figure 11.1). At the base of the conservation pyramid are practices that build soil health in addition to reducing nutrient and sediment runoff. These practices should be a priority for conservation in the watershed because their primary mechanism for reducing nutrient runoff is through reduced application. Soil health building conservation practices don't take land out of production. They can increase crop productivity and decrease costs associated with fertilizer application and tillage, thus improving farm profitability.

The next level in the conservation pyramid consists of in-field practices. These conservation practices should be considered the next priority in that their mechanism for nutrient and sediment removal is through trapping them within directly on the footprint of farm fields. In-field practices are commonly used to address rill and gully erosion in farm fields. These practices typically involve taking small areas out of production within a given farm field which, in some cases, can complicate routine farming operations by subdividing fields.

The next top level in the conservation pyramid consist of edge-of-field practices. These practices typically involve agricultural land retirement and conversion to conservation. They are typically larger, more costly practices but can involve nutrient and sediment removal for large drainage areas. **At the top of the conservation pyramid are riparian area practices** that can be considered a last defense in keeping nutrients and sediment out of the stream.

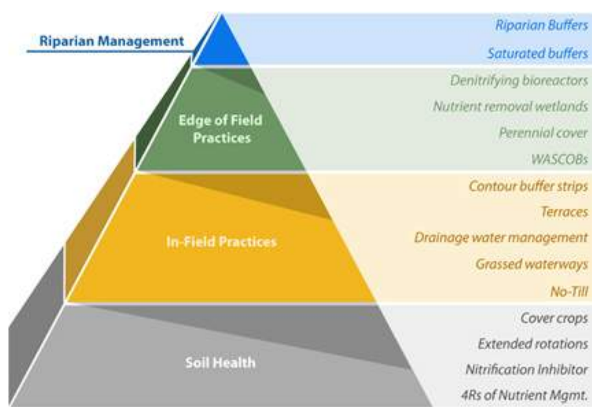


Figure 11.1. Agricultural Conservation Pyramid

Soil Health Practices

Starting at the base of the conservation pyramid, the following practices reduce nutrient and sediment runoff from fields while also building soil health. These conservation practices lead to an increase in soil organic matter, improved soil texture and **greater microbial activity. As a result, healthy soils can provide higher water and nutrient holding capacity and increased infiltration rates**. Healthy can contribute to higher crop productivity and provide increased carbon sequestration. Soil health improvement also has important benefits for flood risk reduction, since according to the Natural Resource Conservation Service (NRCS), **one percent of organic matter in the top six inches of soil holds approximately 27,000 gallons of water per acre.** Soil health practices can be implemented on areas of row crop production throughout the subwatershed regardless of topographic setting.

COVER CROPS:

Cover crops is a term to describe any crop grown primarily for the benefit of the soil rather than the crop yield. These are **grown to provide vegetative cover between harvest and planting**, when soils would typically be most exposed. Cover crops are typically grasses or legumes (planted in the fall between harvest and planting of spring crops) but may be comprised of other green plants. Cover crops prevent erosion, improve the physical and biological properties of soil, supply nutrients, suppress weeds, improve the availability of soil water, and break pest cycles, in addition to a wide range of additional benefits. More information on cover crop use in Iowa can be found at:

https://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs142p2_005818.pdf

EXTENDED CROP ROTATIONS:

An extended crop rotation is a farming practice that includes a **rotation of corn, soybean, and two to three years of alfalfa or legume-grass mixtures** managed for hay harvest. Extended rotations reduce the application and loss of both nitrate-N and P. By growing nitrogen-fixing legumes three years in a row, very little, if any nitrogen needs to be applied in the subsequent corn year. Additional information can be found at:

https://www.cleanwateriowa.org/extended-crop-rotation/

NITRIFICATION INHIBITORS:

When ammonia or ammonium N is added to the soil, it is subject to a process called nitrification. Soil bacteria converts the ammonia (NH3) or ammonium (NH4) to nitrate (NO3). This conversion is strongly temperature dependent and occurs quickly under warm soil temperature conditions. Using a **nitrification inhibitor with applications of ammonia or ammonium nitrogen will slow the conversion to nitrate** until it can be readily used by crops. This will allow the crop to uptake more of the N at critical times in the growing season.

4RS OF NUTRIENT MANAGEMENT:

The 4Rs of nutrient management refer to fertilizer application techniques focused on minimizing the risk of nutrient loss from the field. The principles of the 4R framework include:

Right Source – Ensure a balanced supply of essential nutrients, considering both naturally available sources and the characteristics of specific products, in plant available forms.

Right Rate – Assess and make decisions based on soil nutrient supply and plant demand.

Right Time – Assess and make decisions based on the dynamics of crop uptake, soil supply, nutrient loss risks, and field operation logistics.

Right Place – Address root-soil dynamics and nutrient movement, and manage spatial variability within the field to meet site-specific crop needs and limit potential losses from the field.

Recently a program called 4R Plus was developed by a coalition of organizations dedicated to conservation stewardship for Iowa's farmers.

4R Plus is a nutrient management and conservation program to make farmers aware of practices that bolster production, build soil health and improve water quality in Iowa. The program is guided by a coalition of more than 25 organizations, including agribusinesses, conservation organizations, commodity and trade associations, government agencies and academic institutions.

www.4RPlus.org.

In-field Conservation Practices

The following conservation practices are categorized as in-field management practice because they are **implemented directly within the actively farmed area** of a field. Note that in the case of no-till, this practice can also improve soil health. These practices have benefits for both water quality improvement as well as flood mitigation, since the practices help to slow down runoff rates while also filtering out pollutants.

CONTOUR BUFFER STRIPS:

Contour buffer strips are strips of grass, or a mixture of grasses and legumes, that run along the contour of a farmed field. **Buffer strips are installed in rows down the slope of a field, alternating with wider cropped strips.** Established contour buffer strips can significantly, reduce sheet and rill erosion, slow runoff, and trap sediment. Contaminants such as sediment, nutrients, and pesticides are removed from the runoff as they pass through a buffer strip. Buffer strips may also provide food and nesting cover for wildlife and pollinators. Additional information can be found at:

https://www.nrcs.usda.gov/wps/portal/nrcs/detail/null/?cid=nrcseprd413956

TERRACES:

A terrace is an earth embankment, channel, or a combination ridge and channel constructed across the slope to intercept runoff water. This practice generally applies to cropland but may also be used on other areas where field crops are grown such as wildlife or recreation lands. Terraces serve several purposes, including reducing slope length for erosion control, intercepting and directing runoff, and preventing gully development. Additional information can be found at:

https://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs143_026229.pdf

DRAINAGE WATER MANAGEMENT:

Controlled drainage describes the practice of installing water level control structures within the drain tile system. This practice reduces nitrogen loads by raising the water tables during part of the year, thereby reducing overall tile drainage volume and nitrate load. The water table is controlled through the use of gate structures that are adjusted at different times during the year. When field access is needed for planting, harvest or other operations, the gate can be opened fully to allow unrestricted drainage. When the gate is used to raise local water table levels after spring planting season, this may allow more plant water uptake during dry periods, which can increase crop yields. Controlled drainage may be used on fields with flat topography, typically one percent or less slope.

GRASSED WATERWAYS:

Grassed waterways are constructed channels, seeded with grass, that drain water from areas of concentrated flow. The vegetation slows down the water and the channel conveys the water to a stable outlet at a non-erosive velocity. Grassed waterways should be used where concentrated flows are funneled through a field which could lead to (or is already causing) gully erosion is a problem.. These areas are commonly located between hills and other low-lying areas on hills where water concentrates as it runs off the field (USDA-NRCS 2012). The size and shape of a grassed waterway is based on the amount of runoff that the waterway must carry, the slope, and the underlying soil type. Although a limited function, it is important to note that grassed waterways also have an ability to trap sediment entering them via field surface runoff and in this manner performs similarly to riparian buffer strips.

NO-TILL:

No-till is a way of growing crops or pasture from year to year without disturbing the soil through tillage. No-till increases the amount of water that infiltrates into the soil, the soil's retention of organic matter and its cycling of nutrients. It can also reduce or eliminate soil erosion and increase the amount and variety of life in and on the soil. The most powerful benefit of no-tillage is improvement in soil biological fertility, making soils more resilient to degradation and erosion (NWRM 2015 Jun).

Edge of Field Conservation Practices

The following conservation practices are categorized as edge of field practices due to their **implementation immediately adjacent to the actively farmed field.** Note that conversion to perennial cover is included in this group; the rationale being that since the converted area would no longer be an actively farmed area, it would essentially have been converted to a field edge.

DENITRIFYING BIOREACTORS:

Denitrifying bioreactors are trenches in the ground packed with carbonaceous material, such as wood chips, which allow colonization of soil bacteria that convert nitrate in drainage water to nitrogen gas. **Installed at the outlet of tile drainage systems, each bioreactors are is typically capable of treating 40-60 acres of farmland.** These have limited benefits for flood mitigations, but can be highly beneficial for water quality improvement. According to the Iowa Nutrient Reduction Strategy, bioreactors can achieve an average NO3 reduction of 43% for water going through the bioreactor.

NUTRIENT REMOVAL WETLANDS:

This BMP is a shallow depression created in the landscape where aquatic vegetation is typically established. Nutrient removal wetlands can be a cost-effective approach to reducing nitrogen loadings in watersheds dominated by agriculture and tile drainage. A 0.5% to 2% range in wetland pool-to-watershed ratio permits the wetlands to efficiently remove nitrogen runoff from large areas and data has shown that 40% to 90% of the nitrate flowing into the wetland can be removed. These wetlands and surrounding grassland buffers also provide environmental benefits beyond water quality improvement such as increases in wildlife habitat, carbon sequestration, and minor flood water retention (Crumpton et al. 2006 Dec).

PERENNIAL COVER:

Perennial cover refers to the practice of **converting cropland to a permanent perennial vegetative cover** and/or trees to accomplish any of the following: reduce soil erosion and sedimentation, improve water quality and quantity, improve infiltration, enhance wildlife habitat, improve soil quality, or manage plant pests.

WATER AND SEDIMENT CONTROL BASIN (WASCOB):

Water and sediment control basins are small earthen ridge-and-channel or embankments built across a small watercourse or area of concentrated flow within a field. **They are designed to trap agricultural runoff water, sediment and sediment-borne**

phosphorus as it flows down the watercourse; this keeps the watercourse from becoming a field gully and reduces the amount of runoff and sediment and phosphorus leaving the field. WASCOB's are usually straight slivers that are just long enough to bridge an area of concentrated flow and are generally grassed. The runoff water detained in a WASCOB is released slowly, usually via infiltration or a pipe outlet and tile line. **These practices also have benefits for water storage/flood risk reduction.**

RIPARIAN AREA MANAGEMENT

The final tier of the conservation pyramid is management practices within the areas adjacent to existing waterways. These practices are commonly referred to as riparian area conservation practices. An evaluation of the existing riparian area throughout the subwatershed was conducted. The land cover types within 50 feet on either side of each stream (the riparian area) within the subwatershed were inventoried to determine the current condition. Areas where natural land cover types (forests, wetlands, etc.) were found within the riparian area were determined to have an existing buffer.

Riparian Buffers:

The ACPF tools identify a variety of riparian buffers based on the primary function they serve. The riparian buffer types are as follows:

- **Critical Zone-** sensitive areas: identified as areas with a high level of surface runoff delivery
- **Deep-rooted Vegetation –** for areas with saturated soils
- **Multi-species –** for water uptake, nutrient and sediment trapping
- **Stiff stemmed grasses –** for areas with overland runoff where sediment can be trapped
- **Stream stabilization –** for areas where bank stability is the emphasis

SATURATED BUFFERS:

Saturated buffers are a vegetated area, typically a riparian area along a stream or ditch where drain tile water is dispersed in a manner that maximizes its contact with the soils and vegetation of the area. **Drain tile lines that typically discharge directly to the ditch or stream are intercepted and routed into a new drain tile pipe that runs parallel to the ditch or stream.** This forces tile drain water to percolate through the buffer area before it can reach the stream. The contact with soil and vegetation results in denitrification.

Did you know?

The Agricultural Conservation Planning Framework (ACPF) is a software toolbox that uses Geographic Information System (GIS) data to locate were certain types of conservation practices may best be located. It uses high-resolution land use, soil and topographic data to create maps of possible practice locations.

URBAN STORMWATER MANAGEMENT STRATEGIES

The urban conservation practices described in this section adopt the low impact development (LID) approach to stormwater management. **Use of LID practices should be encouraged in new development projects, retrofit projects and public works improvements such as road reconstruction projects.** LID practices are an effective means to achieve surface water protection, stormwater volume control, and infiltration or groundwater recharge. Various LID practices are described below, including the typical land use settings in which they are applicable and the mechanisms used to treat runoff. LID approaches are preferred over traditional stormwater management techniques because they provide a wider range of benefits for the community and environment. They increase resiliency in the landscape and typically emphasize infiltrating stormwater runoff which reduces volumes.

BIORETENTION CELLS

Bioretention cells are shallow landscaped depressions filled with sandy amended soil, topped with a layer of mulch, and planted with suitable vegetation. Stormwater runoff flows into the depression, with some water stored in the soil profile and the remainder slowly percolates through the soil, or engineered filter media, (which acts as a filter) and into the groundwater at a rate dependent on the underlying soils. Some of the stored water is also taken up by the plants. This important technique uses soil, plants, and microbes to treat stormwater before it is infiltrated or discharged. Bioretention areas are usually designed to allow ponded water 6 to 9 inches deep, with an overflow outlet to prevent flooding during heavy storms. Where soils are compacted, or infiltration is otherwise limited, a perforated underdrain connected to the storm sewer or alternative discharge should be utilized to draw down water levels within an acceptable period of 24 to 48 hours. Practices with an underdrain are sometimes referred to as biofiltration practices since the main treatment mechanism will be filtration, not retention (infiltration). Maintaining the unsaturated soil zone above a perched underdrain system when needed can enhance the performance of bioretention practices, such as higher removal rates for nitrogen.

Bioretention areas provide comprehensive pollutant load reduction through physical, chemical, and biological mechanisms. Infiltration provides the most effective mechanism for pollutant load reduction and should be encouraged where practical.

Multiple types of LID practices are considered bioretention practices but are referred to with more specific names that describe the particular landscape, scale, and vegetation settings where they are applied.

BIOSWALE

Bioswales, also called vegetated swales, are a variation of bioretention basins that utilize slope and earthen dams to temporarily detain flows, which allows infiltration through an engineered soil layer. They are shallow, open vegetated channels designed to provide non-erosive conveyance with longer detention time and slower velocities than traditional curbs and gutter or ditch systems. High sediment load reductions have been observed in well-constructed bioswales. Properly designed bioswales are ideal when used adjacent to roadways or parking lots, where runoff from the impervious surfaces can be directed to the swale via sheet flow. As the vegetative cover is an integral component to the function of grass swales, flow depth should not exceed the height of the vegetation on a regular basis (i.e., small storms). As routing meltwater over a pervious surface will yield some reduction in flow and improved water quality, these practices have been shown to be very effective in cold climate conditions. The effectiveness of the practice is enhanced by using engineered soil mix as the substrate and installing an underdrain. The presence of such designed under layers are the differentiating characteristic of bioswales in comparison to traditional grass swales.

STORMWATER PLANTER BOXES AND TREE TRENCHES

Stormwater planters are another variation of bioretention practices that feature hard side-walls due to their placement in highly urbanized environments, such as along sidewalks in a downtown core. Due to their small size, multiple box planters should be installed at regularly spaced intervals along a project corridor in order to treat the contributing drainage area. Constructed of various materials, box planters can be built close to buildings and are ideal for constrained sites with setback limitations, poorly draining soils, steep slopes, or contaminated areas. Tree trenches are a specific type of box planter that is differentiated by the soil and vegetation components.

GREEN ROOF

Green roofs effectively reduce runoff volume by intercepting rainfall through a layer of growing media and vegetation that are installed and planted on the rooftop. Rainwater captured in the growing media evaporates or is transpired by plants back into the atmosphere. Rainwater not captured by the growing media is detained in a drainage layer below and then flows to roof drains and downspouts. These systems are highly effective at reducing or eliminating rooftop runoff from small to medium storm events. Green roofs can be incorporated into new construction or added to existing buildings during renovation or re-roofing. Green roofs can be designed as extensive, shallow-media systems or intensive, deep-media systems depending on the design goals, roof structural capacity, and available funding.

Residential raingarden (City of Johnston).

In addition to stormwater volume reduction, green roofs offer an array of benefits, including extended roof life span (due to additional sealing, liners, and insulation), improved building insulation and energy use, reduced urban heat island effects, increased opportunities for recreation and rooftop gardening, attenuated noise, and improved aesthetics.

PERMEABLE PAVEMENT

Permeable pavement is a durable, load-bearing paved surface with small voids or aggregate-filled joints that allow water to drain through to an aggregate reservoir. Stormwater stored in the reservoir layer can then infiltrate underlying soils or drain at a controlled rate through underdrains to other downstream stormwater control systems. **Permeable pavement allows streets, parking lots, sidewalks, and other impervious covers to retain the infiltration capacity of underlying soils while maintaining the structural and functional features of the materials they replace.** When designed and installed properly, permeable pavement systems consistently reduce concentrations and loads of several stormwater pollutants, including heavy metals, oil and grease, sediment, and some nutrients (US EPA and Tetra Tech 2014). The aggregate sub-base improves water quality through filtering, but the primary pollutant removal mechanism is typically load reduction by infiltration.

Permeable pavement can be developed using modular paving systems (e.g., permeable interlocking concrete pavers, concrete grid pavers, or plastic grid systems) or poured in place solutions (e.g., pervious concrete or porous asphalt). In many cases, especially where space is limited, permeable pavement is a cost-effective solution relative to other practices because it serves stormwater control and transportation purposes. Permeable pavement can be successful in cold climates when properly installed and maintained. To make sure permeable pavements function properly, it is particularly important to eliminate sand application in the winter.

NATURALIZED DRAINAGE WAYS

Naturalized drainage ways are often used in place of storm sewer trunks to provide a stormwater conveyance function while also creating amenities for surrounding neighborhoods. The drainage ways are larger than grassed swales, more engineered than natural waterways and may look like a small creek due to base flows maintained by contributing drainage systems. The primary treatment mechanisms include (1) slowed velocities through channel roughness and drop structures and (2) evapotranspiration. Infiltration is typically limited by the saturated soils and proximity to groundwater.

RAINWATER/STORMWATER HARVESTING FOR REUSE

Rainwater/stormwater harvesting is the capture and storage of rooftop runoff, and in some cases from other surfaces, for use in irrigating landscaped area and other non-potable uses. **The captured stormwater can be effectively released for irrigation or alternative grey water uses with various control devices in between storm events.** Rainwater/stormwater harvesting is an especially useful method for reducing stormwater runoff volumes in urban areas where site constraints limit the use of other BMPs.

There are different options for how to store the runoff. Cisterns are large storage systems that often require a pump for water removal. Cisterns can be self-contained above or below ground and can collect water from one or more downspouts. Another option is storing the runoff in ponds where there is space available for such features. Rain barrels are smaller storage systems discussed separately.

Because most rainwater/stormwater harvesting systems collect rooftop runoff, which tends to have relatively low levels of physical and chemical pollutants, pollutant reduction mechanisms of tanks are not yet well documented. However, rainwater/stormwater harvesting systems can be equipped with filters to improve water quality and have also been shown to reduce pollutant loads when stored rainwater slowly infiltrates into surrounding soils using a low-flow drawdown configuration. **The use of stored rainwater and stormwater for alternative purposes, such as irrigation, has also been shown to reduce stormwater pollutants.** This practice has been proven to be effective in cold climate conditions, however, barrels need to be drained each fall to avoid ice build-up unless collection occurs below frost line.

RAIN BARRELS

Rain barrels are small scale rainwater/stormwater harvesting systems that typically direct rooftop runoff through a downspout into a barrel that holds less than 100 gallons. The water stored in the barrel can then be used for irrigating gardens or lawns. Drip irrigation outlet systems may also be installed to slowly draw down the water levels in the rain barrel between rainfall events.

RAIN GARDENS

Rain gardens are small versions of the bioretention basins described previously. Due to their scale, rain gardens typically treat runoff from small contributing drainage areas such as rooftops, driveways, sidewalks, and portions of the adjacent road. Bump-out rain gardens include the extension of a road's curb into the street so that the garden can be constructed in the space between the extended curb and the original curb line. Curb cuts are commonly used to direct drainage from the road into the depression. Rain gardens also typically include an overflow pathway designed to safely convey drainage beyond the rain garden's capacity to exit or bypass the facility. Residential rain gardens can look very similar to a conventional planting bed. **The main difference between rain gardens and conventional gardens is that the rain gardens are design with at least a depression and engineered soil layer to capture and treat rain water.**

CONVERSION OF TURF GRASS TO NATIVE PRAIRIE

Restoring native prairie in urban areas is a type of practice that is growing in popularity because of its cost savings and ecosystem benefits. **Converting turf grass to native prairie reduces ongoing maintenance costs from frequent mowing to occasional maintenance of the prairie.** Prairies also provide multiple ecosystem benefits, such as reduced runoff, cleaner runoff, increased bird habitat, increased pollinators, and educational opportunities, in addition to aesthetic benefits.

It should be noted that while use of native vegetation and native prairie is ideal and the preferred alternative in conversions, if the site conditions, social norms, or local ordinances make that difficult to accomplish, other natural plantings can still be employed and be very beneficial in many aspects. For instance, conversion to open space that contains deep rooted and larger canopy plants, such as tall grasses, forbs, shrubs, and trees, whether native or not, can provide many of the benefits desired with converting surface areas.

CONVERSION OF IMPERVIOUS SURFACE TO NATIVE PRAIRIE

Reducing impervious coverage of land is another method to reduce runoff volumes and is combined in this practice with the benefits of restoring native prairies as described in the previous section. This practice may be feasible on properties with excess or un-used paved surfaces, such as abandoned parking lots. The practice could also be implemented where roads, sidewalks, or parking lots could be retrofitted to reduce the total impervious area while providing the same required functionality. This can be achieved by downsizing the required minimum geometry impervious surfaces, such as lane widths, keeping in mind that there are minimum requirements that must be met for fire, snow plow and school bus operation. **Less impervious cover directly translates into less stormwater runoff and pollutant loads generated at the site. While converting impervious surfaces to native prai**rie will provide many benefits, conversion to turf grass or natural plantings may be more appropriate than native prairie in some settings.

ENHANCED TREATMENT USING SAND FILTERS

A sand filter is a flow-through system designed to improve stormwater quality by slowly filtering runoff through sedimentation and filtration chambers. Stormwater is first directed to the sedimentation chamber where larger particles settle with increased detention time. The removal of dissolved phosphorous is significantly enhanced when the sand is amended with iron, calcium, aluminum, or magnesium (Erickson, Weiss, & Gulliver, 2013). Then the filtration chamber below removes pollutants and enhances water quality as the stormwater is strained through a layer of sand. The treated effluent is collected by underdrain piping and discharged to the existing stormwater collection system or downstream LID practice. Sand filters can be used in areas with poor soil infiltration rates, where groundwater concerns restrict the use of infiltration, or for areas with high pollutant loads.

Sand filters are capable of removing a wide variety of pollutant concentrations in stormwater by settling, filtering, and adsorption processes. Sand filters have been a proven technology for drinking water treatment for many years and now have been demonstrated to be effective in removing urban stormwater pollutants including total suspended solids, particulate-bound nutrients, biochemical oxygen demand (BOD), fecal coliform, and metals (Impellitteri et al. 2014). Sand filters are volume-based and intended primarily for treating the water quality design volume. In most cases, sand filters are enclosed concrete or block structures with underdrains; therefore, only minimal volume reduction occurs by evaporation as stormwater percolates through the filter to the underdrain.

STRATEGIES TO ADDRESS BACTERIA

Developing an implementation plan for reducing bacteria concentrations and meeting water quality standards should begin with the most cost effective and efficient methods. This section describes the steps to take to identify sources and reduce loading by source control and the implementation of best management practices (BMPs). For source control, priority should be placed on first reducing human source contributions.

General Strategies

IDENTIFY, MAP, AND MONITOR SOURCES

The most important step is to identify potential and known sources of bacteria. Determining the most likely sources is typically a desktop exercise using mapping to identify where bacteria could be introduced to waterbodies such as pastures/agricultural land where manure is applied, feedlots, and residential onsite wastewater treatment system near waterbodies, at dog parks and areas where wildlife congregate near waterbodies such as fields and golf courses. Mapping bacteria conveyance systems (e.g. stormwater and ditches) is also important. Mapping known and potential sources will ensure that these areas are regularly monitored and inspected. Field monitoring will also identify sources, and should be conducted to regularly inspect known sources.

The Beaver Creek WMA should consider establishing a program to comprehensively map unpermitted and failing on site treatment systems, and illicit discharges associated with unsewered communities and develop a program to prioritize installation and/or replacements of such systems. A livestock assessment should also be performed to identify and map both larger, permitted facilities in addition to smaller, unpermitted feedlots with respect to their proximity to waterways. This will help identify critical areas for livestock management practices described below that would reduce the quantities of manure runoff to local waterways.

FEDERAL, STATE, AND LOCAL REQUIREMENTS

Ensuring state laws and local ordinances are up-to-date and enforced is also a cost effective and efficient way to reduce bacteria loading into waterbodies. Specifically, local ordinances that address manure management and land use regulations should be coordinated with State-level water resource regulations that protect water resources and minimize potential release of bacteria.

OUTREACH/EDUCATION

It is very important that residents are aware of and understand the state and local water and land use regulations, as well as steps they can take to reduce bacteria entering water resources. For example, outreach and education can **ensure that landowners and residents understand the regulations** governing water resources such as collection of pet waste or bans on wildlife feeding in order to comply with them. Residents should also be aware of the best management practices and opportunities available to minimize sources of bacteria on their property.

BEST MANAGEMENT PRACTICES THAT LIMIT INTRODUCTION OF BACTERIA

The most effective method to reduce loads and meet long-term water quality goals is to address the sources that directly contribute bacteria to waterbodies. Source controls are best management practices that focus on limiting the introduction of bacteria into the landscape where it could be transported to waterbodies. Incorporating source controls into local ordinances is a very effective method to reduce release of bacteria into the watershed. Source control activities that reduce bacteria releases from direct sources include excluding livestock from surface waterbodies, effective manure management, regular onsite wastewater treatment system maintenance, pet waste collection, and green infrastructure practices that reduce stormwater runoff rates, volumes, and associated pollutants.

BEST MANAGEMENT PRACTICES THAT REDUCE BACTERIA LOADING TO WATERS

Source control and the methods mentioned above should be the first step of reducing bacterial loading as these methods are the most cost efficient and effective. Source control, however, is not always feasible and **there are a number of Best Management Practices BMPs that can reduce bacteria-laden runoff to waterbodies**. Based on available data, some conventional stormwater BMPs reduce bacterial loads to receiving waters by (a) treating stormwater and removing bacteria from discharged water, or (b) reducing total water discharge along with the associated bacterial load. In some cases, multiple BMPs, including pre-treatment, may be necessary to achieve significant reductions in bacteria concentrations. Additionally, many BMPs are designed to reduce the loading of several pollutants at the same time.

Prior to evaluating BMP performance or selecting BMP strategies to target bacteria, it is important to understand basic fate and transport mechanisms as well as treatment processes anticipated to be effective for removing or **inactivating bacteria. Inactivating bacteria refers to a natural process in which bacteria die-off or fail to reproduce due to existing environmental factors such as pH.** Bacteria can thus be controlled without being removed. However, bacteria population can also increase without further bacteria loading if environmental conditions are conducive to population growth within the conveyance or receiving waters.

Properly designed **BMPs that reduce the total volume** of agricultural or urban runoff (e.g., infiltration BMPs) to receiving waters can effectively reduce the bacteria load by an amount equivalent to that contained in the reduced volume. They may also reduce the frequency of bacterial discharges to receiving waters if volume reductions are sufficient to retain runoff from most events.

BMPs that filter and/or reduce the rate or frequency of runoff (e.g., filtration or other BMPs that do not reduce volumes but do provide treatment) may reduce bacteria concentrations in this runoff and thereby reduce loading to receiving waters. Filtration and similar BMPs should, however, be carefully planned and investigated before implementation as they are sometimes ineffective and may even result in increased bacteria concentrations in discharges.

Overall, data on BMP effectiveness is limited and, with the exception of properly designed infiltration BMPs, broadly applicable conclusions cannot be drawn. Additional studies are needed for all BMP types to increase the confidence of performance estimates with regard to bacteria.

The strategies described above provide a general outline and description for the first steps of reducing bacterial loads through source controls. **However, there are inherent differences in how to reduce bacteria loadings from urban as opposed to rural subwatersheds.** The following section provides more detailed explanations of source controls and BMPs that are applicable more specifically to urban and rural areas. The measures and BMPs described below are not the only available methods for reducing bacteria, but are the actions most recommended and applicable to the Beaver Creek watershed. As mentioned above, efforts to reduce and eliminate bacteria sources should be conducted first, when possible.

Cattle in the stream in the Beaver Creek watershed.

Bacteria Recommendations for Urban Areas

The most common sources of bacteria in urban areas is waste from pets, and to a lesser extent from wildlife. In some areas **humans may be a source** (e.g. failing septic systems or leaks in sanitary sewer collection systems).

SOURCE CONTROLS

Identify and map bacteria sources and conditions

- If the stream's watershed is large, with many stormwater outfalls, consider conducting a **two-year E. coli monitoring program** along the stream to help identify hot spots of higher bacteria concentrations (see the Monitoring & Evaluation Section for recommended sampling frequency). Monitor tributaries flowing into the stream and also consider monitoring stormwater outfalls (or at least the larger ones). Tests can be used to identify the species that is the source of the bacteria.
- Identify subwatersheds for each stormwater outfall or tributary to the stream, **making note of potential high-loading features** within each, including wildlife congregation areas, parks (especially dog parks), septic systems, sanitary systems that are potentially located above stormwater systems, and recreational access points.
- **Walk the stream and visually inspect stormwater outfalls** during dry weather for flows, odor, color, or other conditions (see below for more information on dry weather flows) that would indicate an illicit discharge. Take the appropriate actions to eliminate the illicit discharge relying upon information contained in local Stormwater Pollution Prevention Plan (SWPPP) if available, or readily available SWPPP guidance documents.

Reduce input from pets

- Enact and enforce **pet waste ordinances** and educate pet owners about the ordinances and the impacts of pet waste.
- **Add infiltration BMPs downstream of parks/residential areas** and upstream of stormwater pipes (i.e., somewhere between the park/residential area and the stormwater outfall) to intercept and infiltrate some or all of the flow from these areas.
- Reduce transport from parks, residential, and other areas by the use of **buffers** (e.g., filter strips, un-mowed areas) and other disconnection of flow pathways (e.g., impervious surface disconnection, downspout disconnection).

Reduce input from wildlife

- Consider **wildlife feeding bans and control of nuisance populations**, including ducks and geese and other wildlife.
- **Remove community facilities** such as vending machines for feeding ducks and geese.
- **Add buffers in riparian areas** near waterbodies to deter waterfowl congregation.
- Consider **wildlife barriers** if wildlife (e.g. raccoons) are found to be living in storm sewers.
- When possible, **use infiltration BMPs** instead of detention ponds in residential developments and other areas where wildlife may congregate.

Reduce input from humans

- If a potential human source (e.g. septic systems in area, sewer fungus in stormwater pipes, storm sewer bacteria concentrations above 100,000 total coliform) is detected, consider additional tests (detergents, ammonia, fluoride, video pipe inspection for cracks and leaks, dye testing, fluorometer, or microbial source tracking) to help **determine the location and type of source.**
- Maintain wastewater treatment systems and sanitary sewers through **regular monitoring** and perform immediate repairs when necessary.
- Reduce conditions that promote bacteria growth and survival
- **Reduce dry weather flows**, which provide conditions that promote bacteria growth. Dry weather flows could be from nighttime irrigation of lawns/parks or leaky stormsewer pipes. Dry conditions within stormsewer pipes reduce bacteria survival and growth.
- Investigate ways to **reduce biofilm in stormsewer pipes** to inhibit bacteria survival and growth.

TREATMENT BMPS

Stormwater infiltration practices capture and temporarily store stormwater before allowing it to infiltrate into the soil. Proper design, installation, and maintenance is of paramount importance for any treatment BMP to be effective at protecting water resources.

Infiltration/Bioinfiltration

As the stormwater penetrates the underlying soil, chemical, biological, and physical processes remove pollutants and reduce or delay peak stormwater flows. Bioinfiltration systems are basically infiltration systems, but with an additional biological component such as plants or organic amendments that provide additional pollutant removal from water prior to its infiltration to the subsurface. **Infiltration is considered to be up to 100% effective in removing bacteria loads associated from the infiltrated volume of water.** However, because infiltrated water is channeled to the subsurface, infiltration is not recommended in areas where shallow groundwater is used as a drinking water source or in vulnerable wellhead protection areas (WHP) where surface water directly influences an aquifer or public water supply.

Filtration/Biofiltration

Biofiltration practices filter sediment out of stormwater and watershed runoff through a medium such as sand, compost, soil, or a combination of these materials. **“Biofiltration” indicates that, in addition to the physical “filtration” processes, biological or organic matter processes influence pollutant removal.**

Biofiltration, including rain gardens with underdrains, swales, and sand filters, typically occurs on a smaller scale (2 acres of impervious surfaces or less), such as landscaping islands, cul-de-sacs, parking lot margins, commercial setbacks, open space, rooftop drainage and boulevards where most of the runoff that enters the BMP flows out through an underdrain. The following design considerations can increase the effectiveness of the practice:

- **Employ finer-grained media** (~15 microns) in the filter bed.
- **Remove trapped sediments** from filter pretreatment chambers on a more frequent basis during the growing season.
- Consider employing **pretreatment chambers** that are designed to dry out following storm events.
- Consider **amending the soil matrix within the BMP** with organic matter, iron filings, or other verified amendment after consulting literature on the design and performance of these amendments for bacterial removal.

Filter strips/buffers

A buffer or vegetative strip is an area of vegetation that is planted between potential bacterial sources and waterbodies. Buffers are designed to physically protect and separate the waterbody from future disturbance or encroachment. Vegetative filter strips are strips of vegetation that reduce runoff, and capture sediments and contaminants by settling, infiltration, or filtration. Filter strips located in riparian areas (e.g. lake shore) deter congregation of wildlife by reducing direct access from turf grass areas to open water. Large filter strips (at least half the size of the contributing drainage area) have been reported to remove up to 92% of bacteria in runoff from feedlots. This success is largely the result of the infiltration that occurs in the vegetative strip. Other studies have reported much lower removal rates (~35%) and, depending on the width of the strip and the underlying soils, even zero-to-negative removal rates when the filter strip primarily allows pollutants to settle out of stormwater, rather than infiltrate or filter stormwater. Therefore, if bacterial removal is desired, proper sizing relative to the contributing drainage area should be considered, and estimated removal rates should account for the size of the practice and whether it will infiltrate water or only settle out solids.

- Consider designing **filter strips around ponds, lakes, and streams/rivers** where wildlife, such as geese, congregate or within public areas where dog-walking occurs. This is especially important when impervious sidewalks are located near waterbodies.
- Consider **using native plant species for filter strips** and avoid mowing the strips.

Stormwater ponds and constructed wetlands

Stormwater ponds are open water ponds constructed to promote the settling of particles in stormwater and watershed runoff and the storage of water to limit flooding. Constructed wetlands are man-made systems that are engineered to provide settling, transformation, and filtration functions that are similar to natural wetlands. Constructed wetlands can be used to treat urban/suburban runoff by removing excess nutrients, sediments, and other pollutants, including bacteria. **These BMPs are considered to be between 70-75% effective in removing bacteria if designed, constructed and maintained properly.** However, as with other BMPs that may not provide complete bacterial removal before discharging to receiving waters, some man-made ponds and wetlands may provide little to no treatment. In some cases, these practices may even provide opportunities for bacterial production (e.g., wet ponds with overflows). Therefore, a review of different options and associated studies of bacterial removal is strongly advised.

- **Note:** ponds that dry out between storm events (i.e. dry ponds) may have better bacteria removal rates than wet ponds.
- **Limit overflows.** Design inlet and outlet structures to prevent bacteria-laden sediment from being re-suspended and exported during storm events.
- **Lengthen the flow path** for longer detention times (2-5 days for settling is optimal).
- **Add shallow benches** to wetlands and ponds to enhance the plankton and microbial community for enhanced predation of bacteria.

Bacteria Recommendations for Rural Areas

The most likely sources of bacteria in rural areas include manure that is spread without incorporation, livestock with direct access to streams, and runoff from feedlots and pastures. As in urban areas, bacterial sources in rural areas may include humans (e.g. failing on septic systems), and wildlife and pets.

SOURCE CONTROLS

Reduce direct sources of bacteria from livestock

Livestock exclusion from waterbodies and streambanks eliminates a direct source of bacteria and nutrients from animal wastes.

- **Identify** pastures and grazing lands that have access to streams and waterbodies.
- Work with landowners to **exclude animals** from or limit access to streams and rivers using fences or other exclusion methods.
- Provide livestock with an **alternate water supply** away from the stream, as well as shade to reduce stream access.
- Implement **pasture management techniques** that promote protection of well-maintained and rotated pastures.
- Evaluate and **improve county feedlot inspections** and review to ensure compliance with state law especially with new or expanding feedlot operations.
- Evaluate the need for **increased technical assistance** to feedlot operators located in the impaired watershed.

- **Identify** feedlots within designated shoreland areas and evaluate them for potential run-off and technical assistance.
- **Improve enforcement** of State Concentrated Animal Feeding Operations (CAFO) laws in Iowa Code (2017) Chapters 459, 459A, and 459B.

Reduce manure runoff

- Manure can be **managed and treated** in a number of ways to reduce the risk of bacteria from being transported to waterbodies, such as composting, lime stabilization, and/or anaerobic/aerobic treatments.
- When applying manure to the soil, it should be **incorporated or injected into the ground**, rather than applied directly to the soil surface, to prevent runoff during rain events or snowmelt.
- Manure application should only be conducted on **non-frozen ground**.
- **Cover crops** can also prevent and reduce bacteria-laden runoff from fields.
- **Residue management** should be used in combination with manure management.
- **Reduce runoff from feedlots** by installing structures and implementing best management practices.
- **Filter strips around feedlots** can also prevent bacteria from being released from the site. Proper sizing of filter strips relative to the contributing drainage area is critical, and estimated removal rates should account for the size of the practice and whether it will infiltrate water or only settle out solids.
- **Evaluate the review process** used for manure management plans particularly in areas near tributaries draining to or into the receiving stream.
- **Inspect** the on-site implementation of manure management plans by producers, particularly in areas near tributaries draining to or into the receiving stream.
- Hold **education, field day, or training events** for producers on opportunities to improve manure management and reduce run-off.
- **Identify and monitor** field tile surface inlets, outlets, and drainage ditches for transport of manure from fields.
- Work with growers and **promote improved manure utilization** through application rates, timing, and placement of manure in relation to the crop grown.

Reduce human sources of bacteria

- **Enforce** onsite wastewater treatment system regulations.
- Provide landowners with information about **septic system compliance** and opportunities to replace failed systems.
- Enact and enforce stricter **setback standards** for installing onsite wastewater treatment systems near waterbodies.
- Enact and enforce **sewage land application ordinances.**

TREATMENT BMPS

All of the treatment BMPs described in the urban section are also applicable in rural areas. As noted above, reducing the source of the bacteria should be conducted first when possible.

Feedlot runoff control

Feedlot runoff control uses **a system of structures and best management practices to reduce runoff containing bacteria and nutrients,** thereby protecting waterbodies. The system collects, stores, and treats manure and feed wastes from feedlots, as well as conserves manure to be used for fertilizers. Feedlot runoff control includes clean runoff water diversion structures and feedlot/wastewater filter strips around the perimeter of the feedlots. When implemented properly, these systems will reduce bacteria in runoff by 100%. The use of proper nutrient management techniques in conjunction with feedlot runoff control is critical.

- Install clean runoff water diversion channels across slopes to **prevent rainwater from entering the feedlot area.**
- **Install filter strips around feedlots** to reduce runoff.

Filter strips: Cropland and Pasture Control

Filter strips/ buffers are areas of vegetation that are planted between cropland and pastures to reduce contaminants that runoff the pastures. **Filter strips reduce up to 92% of bacteria in runoff.** Filter strips can be in the form of vegetated buffers or swales. Refer to Appendix B for further information on filter strip effectiveness.

- Install **filter strips around all ditches and waterways** that connect to streams or other waterbodies.
- **Filter strips should be 15-30 feet wide** to be most effective at reducing bacteria levels.

Detention and retention ponds

Sedimentation ponds, also called detention, retention, or stormwater ponds, are open water ponds constructed to allow the particles in stormwater to settle. Detention ponds also store large volumes of stormwater to help limit flooding. Sedimentation ponds are constructed with an engineered outlet and can be used in both agricultural and urban settings on a temporary or permanent basis. When trapping sediment that is contaminated with bacteria, these **ponds can reduce bacteria loading by up to 70%.**

- Maintain ponds periodically to remove sediments.
- Deter wildlife from congregating on ponds.

USE OF NATIVE VEGETATION

Native vegetation should be used in all conservation practices where re-vegetation is required. Visit the Tallgrass Prairie Center website (**www.tallgrassprairiecenter.org**) for complete information about the benefits of native vegetation. The following are examples of conservation practices where native vegetation would be most beneficial.

PERENNIAL COVER

A diverse prairie planting is the most beneficial and resilient permanent cover for erodible or non-productive land and buffers strips.

IN-FIELD PRAIRIE STRIPS

Science-based Trails of Rowcrops Integrated with Prairie Strips (STRIPS) are relatively small (30' minimum width) contour buffer strips strategically placed in crop fields. These strips can yield disproportionate benefits for soil and water: According to data from the Iowa Nutrient Reduction Strategy, **water quality has been shown to improve 66-90%, while streamflow is reduced as much as 37%.** Visit ISU's STRIPS website for detailed information (**www.nrem.iastate.edu/research/STRIPS/**).

PERMANENT COVER FOR CONSERVATION PRACTICES

Ponds, basins and other conservation structures require effective, practical vegetation. In most cases, prairie vegetation may be appropriate. Native vegetation should always be a component of constructed wetlands and considered for oxbow/floodplain restoration.

Diverse, deep-rooted prairie grasses and wildflowers provide durable, perennial cover that protects soil, enhances water quality, and mitigates flooding by slowing runoff, increasing infiltration, reducing soil erosion, and capturing nutrients. This is also a practice that provides an opportunity for pollinator plants, which may be an avenue for expanding potential partners and funding opportunities.

Prairie vegetation reduces and slows runoff and increases infiltration:

- Dense foliage and robust stems reduce runoff rates during heavy rain events and can result in **1.6 times less runoff overall.** (Schulte et al. 2017)
- Standing foliage and residue **intercepts up to 70% of rainfall** (Brye et al. 2000)
- Decaying foliage and **extensive roots** add organic matter to the soil, increasing infiltration and water-holding capacity. Stored water is gradually released.

- Deep perennial roots **lower the water table,** reducing underground drainage to streams.
- Diverse vegetation **spreads water demand across three seasons**. Some prairie plants actively take up water in the spring; others in the summer and fall.

Prairie vegetation reduces soil erosion and captures nutrients:

- Prairie vegetation **reduces soil erosion and surface water sedimentation** by slowing runoff and increasing infiltration.
- Large prairie roots trap and take up excess nitrogen making its way to streams and lakes in water leaching through the soil. **Nitrogen loss is reduced by 84%.** (Zhou et al. 2014)
- By decreasing erosion, native vegetation retains excess phosphorus, which enters water bodies attached to soil particles, on site. **Phosphorus loss is reduced by up to 90%.** (Zhou et al. 2014)

A bioswale and native landscaping along Terra Lake (City of Johnston).

PRIORITIZATION METHODS:

ACPF TARGETING

Siting

Researchers at Iowa State University (ISU) used the Agricultural Conservation Planning Framework (ACPF) locate potential BMPs across each HUC 12 subwatershed in the Beaver Creek watershed. The ACPF tools use GIS data to determine optimal locations for location-dependent BMPs based on factors such as slope, topographic position, land use, drainage area, and proximity to other features (e.g. streams, roads). A detailed description of the ACPF tools, along with links for documentation can be found at https://acpf4watersheds.org/.

Nutrient Removal Benefits

The ACPF outputs were processed by extracting the relevant attributes that could be used to determine (a) the extent/quantity of each BMP type sited within each HUC 12 and (b) the contributing drainage areas to each BMP type within each HUC 12. A summary of the attributes used is shown in Table 11.3.

The nutrient removal effectiveness of each BMP was estimated from literature values, as shown in Table 11.4. With the exception of the nitrogen reduction rate for

terraces, all of these values were retrieved from the Iowa Nutrient Reduction Strategy report.

The potential benefits for each BMP in each HUC 12 were determined by multiplying together the target adoption rate and nutrient removal efficiency. In order to approximate the "treatment train" effect of BMPs in series, the overall (i.e. aggregate) benefits of implementation for a given implementation scenario was determined by first combining the BMPs into groups based on their topological positioning on the landscape. Nutrient removal was estimated based on the assumption that BMPs will be distributed randomly and ideally across the landscape – that is, in appropriate locations subject to significant nutrient loading that have little existing upstream treatment – so the effectiveness of BMPs farther down the treatment train is dependent on the remaining nutrient loading that was not removed by upstream practices. In other words, as more and more upstream nutrient removal is introduced, downstream BMPs become less and less effective. The conceptual model for nutrient removal is shown in Figure 11.2.

Costs

Estimated costs for BMP implementation were obtained from a variety of sources, as summarized in Table 11.5. **As with the nutrient reduction values, most of the cost information came from the Iowa Nutrient Reduction Strategy report.** All values were converted from their equal annualized costs (EAC) to their original total present value (TPV). These costs were then converted back to EAC based on a 20-year planning horizon in order to facilitate comparing the cost-benefit ratios of individual BMP types. More information about EAC and TPV, along with the source data for the original cost estimation exercises, can be found in the references cited in Table 11.5.

BMP Adoption Rate Estimation

The existing adoption rates for each BMP in each subwatershed were determined from multiple sources. First, adoption rates were estimated using data for Greene, Dallas, and Boone counties reported in USDA's 2017 Census of Agriculture. Then, these adoption rates were supplemented in communication with SWCD staff, who used local knowledge to either fill in gaps or scale the broad-brush estimates across subwatersheds according to perceived geographic

trends in implementation. The results of this process are shown in Table 11.1.

Implementation Optimization

Optimization of BMP target adoption rates was performed in order to prioritize implementation of the most cost-effective BMPs to a level that would **achieve the nutrient reduction goals set by the Des Moines River TMDL (34.4% nitrate reduction) and the Iowa Nutrient Reduction Strategy (29% phosphorus reduction).** Implementation scenarios were optimized for each HUC 12 subwatershed by first setting implementation rates to the estimated existing rates (Table 11.1), and then incrementally maximizing implementation of the most cost-effective practice first to a preset threshold value. If the nutrient reduction goals for nitrogen and phosphorus were not achieved, the next most cost-effective practice was maximized. This process was iterated until either the goals were achieved, or all practices had been set to their maximum implementation rates. These maximum implementation rates vary by subwatershed and are summarized in Table 11.2.

BMPs	Little Beaver Creek-West Beaver Creek	West Beaver Creek	Middle Beaver Creek	East Beaver Creek	Headwaters Beaver Creek	Beaver Branch-Beaver Creek	Slough Creek	Little Beaver Creek-Beaver Creek	City of Bouton-Beaver Creek	Royer Creek-Beaver Creek	Beaver Creek
WASCOBs	42%	100%	64%	92%	63%	18%	15%	100%	41%	27%	25%
Riparian buffer: Critical zone buffer	63%	46%	59%	55%	60%	59%	59%	70%	81%	73%	75%
Riparian buffer: Deep-rooted vegetation buffer	63%	46%	59%	55%	60%	59%	59%	70%	81%	73%	75%
Riparian buffer: Multi-species buffer	63%	46%	59%	55%	60%	59%	59%	70%	81%	73%	75%
Riparian buffer: Stiff stem grass buffer	63%	46%	59%	55%	60%	59%	59%	70%	81%	73%	75%
Riparian buffer: Stream stabilization buffer	63%	46%	59%	55%	60%	59%	59%	70%	81%	73%	75%
Nitrogen management: nitrification inhibitor	85%	85%	85%	75%	85%	50%	50%	85%	85%	50%	50%
Nitrogen management: rate control	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%
Nitrogen management: source control	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%
Nitrogen management: timing control	75%	85%	85%	35%	65%	35%	35%	85%	85%	35%	35%
Phosphorus management: placement control	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%
Phosphorus management: rate control	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%
Phosphorus management: source control	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%
Cover crops	1%	3%	1%	1%	1%	2%	4%	2%	3%	4%	2%
Extended rotations	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%
Perennial cover	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%
No-Till	5%	5%	5%	5%	5%	10%	20%	20%	10%	25%	20%
Drainage water management	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Contour buffer strips	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Terraces	100%	100%	88%	100%	95%	100%	45%	100%	90%	33%	100%
Denitrifying bioreactors	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Saturated buffers	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Nutrient removal wetlands	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Grassed waterways	60%	48%	100%	100%	100%	100%	37%	100%	100%	100%	45%

Table 11.1: Existing BMP adoption rate estimates by subwatershed.

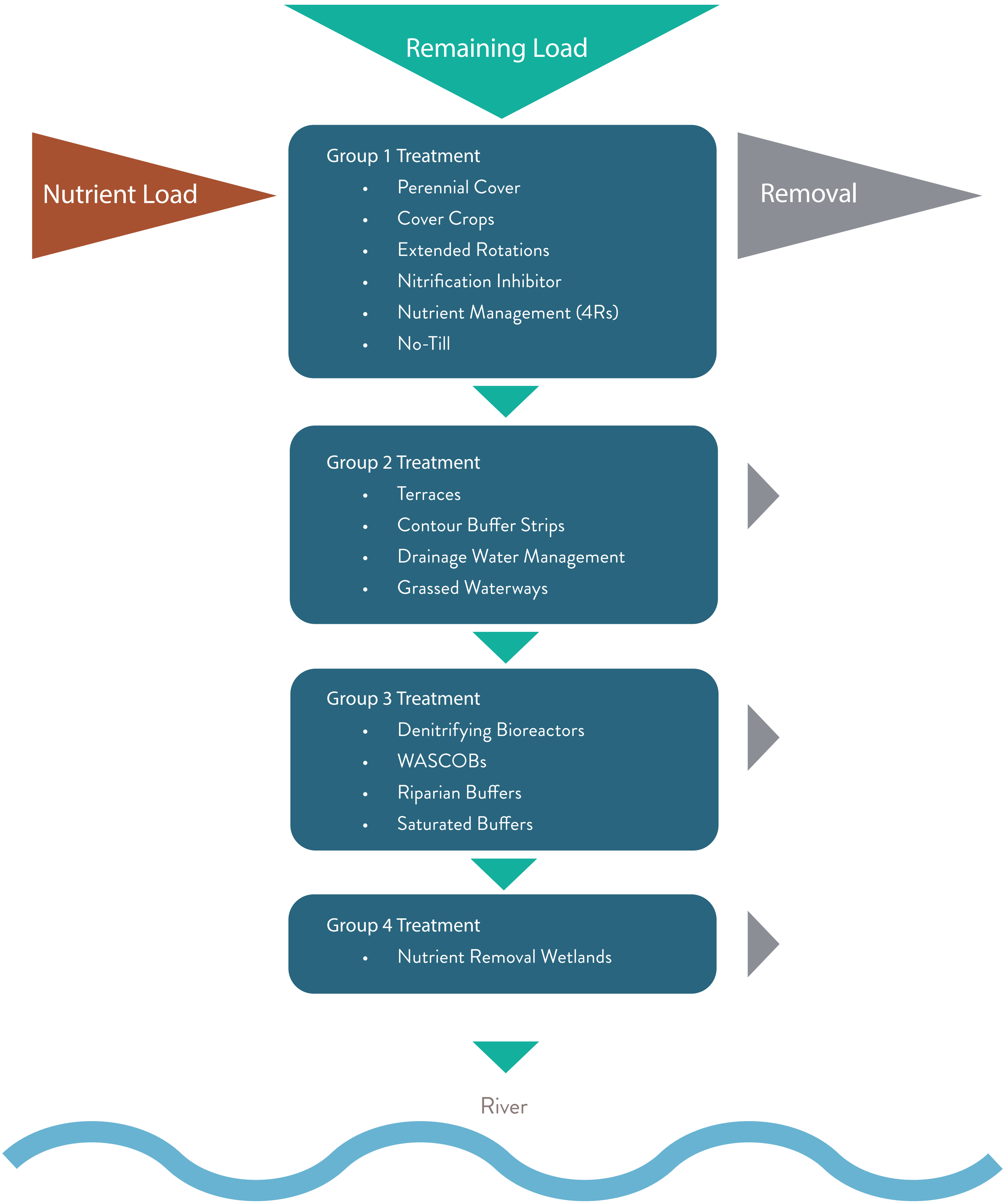
Table 11.2: Target BMP adoption rates.

BMPS	TARGET ADOPTION RATE
WASCOBs	25% increase*
Riparian buffer: Critical zone buffer	100%
Riparian buffer: Deep-rooted vegetation buffer	100%
Riparian buffer: Multi-species buffer	100%
Riparian buffer: Stiff stem grass buffer	100%
Riparian buffer: Stream stabilization buffer	100%
Nitrogen management: nitrification inhibitor	50% increase* (up to 95%)
Nitrogen management: rate control	50% increase* (up to 95%)
Nitrogen management: source control	No increase*
Nitrogen management: timing control	50% increase* (up to 95%)
Phosphorus management: placement control	50% increase* (up to 95%)
Phosphorus management: rate control	50% increase* (up to 95%)
Phosphorus management: source control	No increase*
Cover crops	100% increase*
Extended rotations	2%
Perennial cover	2%
No-Till	100% increase*
Drainage water management	50%
Contour buffer strips	20%
Terraces	75%
Denitrifying bioreactors	25%
Saturated buffers	50%
Nutrient removal wetlands	40%
Grassed waterways	25% increase* (up to 95%)

BMP	Quantity Attribute	Drainage Area Attribute	Notes:
Bioreactors	min_acres	bnd_acc	
Contour Buffer Strips	Shape_Area	*	Contour buffer strips with MeanSlope < 10%
Drainage Water Management	†	cont_acres	
Grassed Waterways	Shape_Length	*	
Nutrient Removal Wetlands	†	ContAreaHA	
Riparian Buffers	Strm_lngth	NTD_Run	Joining RAP with RiparianFunction was required
Saturated Buffers	Strm_lngth	TD_Run	Joining RAP with RiparianPractice was required
Terraces	Shape_Area	*	Contour buffer strips with MeanSlope > 10%
WASCOBs	†	ContAreaAC	
			*relativetoexistingadoptionrateestimate

Table 11.3: ACPF source data summary.

Figure 11.2: Treatment Train Pollutant Removal Evaluation



BMP	N	P	Source	Notes:
Cover crops	31%	29%	Iowa Nutrient Reduction Strategy (revised 2017)	Assumed winter rye
Extended rotations	42%	0%	Iowa Nutrient Reduction Strategy (revised 2017)	At least 2 years of alfalfa in a 4 or 5 year rotation
Nitrogen management: nitrification inhibitor	9%	0%	Iowa Nutrient Reduction Strategy (revised 2017)	Nitrapyrin in fall compared to fall application without
Nitrogen management: rate control	10%	0%	Iowa Nutrient Reduction Strategy (revised 2017)	Reduce to MRTN
Nitrogen management: source control	4%	0%	Iowa Nutrient Reduction Strategy (revised 2017)	Liquid swine manure compared to spring-applied fertilizer
Nitrogen management: timing control	6%	0%	Iowa Nutrient Reduction Strategy (revised 2017)	Move from fall to spring pre-plant application
Phosphorus management: placement control	0%	30%	Iowa Nutrient Reduction Strategy (revised 2017)	Average of (a) broadcast incorporation vs. no incorporation and (b) knifed bands vs. surface application with no incorporation
Phosphorus management: rate control	0%	17%	Iowa Nutrient Reduction Strategy (revised 2017)	Based on soil-test P
Phosphorus management: source control	0%	46%	Iowa Nutrient Reduction Strategy (revised 2017)	Beef, liquid swine, dairy and poultry manure compared to commercial fertilizer
Contour buffer strips	0%	77%	Iowa Nutrient Reduction Strategy (revised 2017)	Assumed equal to terracing
Terraces	38%	77%	Merriman et al. (2009)	Source for N reduction value: Merriman et al. (2009)
Drainage water management	33%	0%	Iowa Nutrient Reduction Strategy (revised 2017)	
Grassed waterways	0%	58%	Iowa Nutrient Reduction Strategy (revised 2017)	
No-Till	0%	90%	Iowa Nutrient Reduction Strategy (revised 2017)	No-till compared to chisel plowing
Denitrifying bioreactors	43%	0%	Iowa Nutrient Reduction Strategy (revised 2017)	
Nutrient removal wetlands	52%	0%	Iowa Nutrient Reduction Strategy (revised 2017)	
Perennial cover	72%	34%	Iowa Nutrient Reduction Strategy (revised 2017)	Energy crops
WASCOBs	0%	85%	Iowa Nutrient Reduction Strategy (revised 2017)	
Riparian buffer: Critical zone buffer	91%	58%	Iowa Nutrient Reduction Strategy (revised 2017)	N removal is only for water that interacts with the active zone below the buffer.
Riparian buffer: Deep-rooted vegetation buffer	91%	58%	Iowa Nutrient Reduction Strategy (revised 2017)	N removal is only for water that interacts with the active zone below the buffer.
Riparian buffer: Multi-species buffer	91%	58%	Iowa Nutrient Reduction Strategy (revised 2017)	N removal is only for water that interacts with the active zone below the buffer.
Riparian buffer: Stiff stem grass buffer	0%	58%	Iowa Nutrient Reduction Strategy (revised 2017)	Assumed no N removal for this buffer type
Riparian buffer: Stream stabilization buffer	0%	58%	Iowa Nutrient Reduction Strategy (revised 2017)	Assumed no N removal for this buffer type
Saturated buffers	50%	0%	Iowa Nutrient Reduction Strategy (revised 2017)	

Table 11.4. Agricultural BMP benefit assumptions.

BMP	EAC[1]	Unit	Source	Notes:
Cover crops	$49.00	treated acre	Iowa Nutrient Reduction Strategy (revised 2017)	
Extended rotations	$30.00	treated acre	Iowa Nutrient Reduction Strategy (revised 2017)	
Nitrogen management: nitrification inhibitor	-$3.00	treated acre	Iowa Nutrient Reduction Strategy (revised 2017)	
Nitrogen management: rate control	-$2.00	treated acre	Iowa Nutrient Reduction Strategy (revised 2017)	
Nitrogen management: source control	-$80.34	treated acre	ISU Extension Swine Manure Calculator	
Nitrogen management: timing control	-$20.00	treated acre	Iowa Nutrient Reduction Strategy (revised 2017)	
Phosphorus management: placement control	$15.00	treated acre	Iowa Nutrient Reduction Strategy (revised 2017)	
Phosphorus management: rate control	-$11.00	treated acre	Iowa Nutrient Reduction Strategy (revised 2017)	
Phosphorus management: source control	-$80.34	treated acre	ISU Extension Swine Manure Calculator	
Contour buffer strips	$1,049.67	linear mile	EQIP FY19 Payment Schedule for Iowa	Assumes 15-foot buffer width
Terraces	$12,914.00	linear mile	EQIP FY19 Payment Schedule for Iowa	
Drainage water management	$400.00	field	Iowa Nutrient Reduction Strategy (revised 2017)	Assumes 40-acre field
Grassed waterways	$8,258.18	linear mile	EQIP FY19 Payment Schedule for Iowa	
No-Till	$12.00	treated acre	Iowa Nutrient Reduction Strategy (revised 2017)	
Denitrifying bioreactors	$500.00	reactor	Iowa Nutrient Reduction Strategy (revised 2017)	Assumes 50 acres of treatment
Nutrient removal wetlands	$6,750.00	wetland	Iowa Nutrient Reduction Strategy (revised 2017)	Assumes 450 acres of treatment
Perennial cover	$390.00	treated acre	Iowa Nutrient Reduction Strategy (revised 2017)	
WASCOBs	$4,444.33	basin	EQIP FY19 Payment Schedule for Iowa	Assumes 300-foot berm
Riparian buffer	$2,992.61	linear mile	Iowa Nutrient Reduction Strategy (revised 2017)	Assumes 50-foot buffer width
Saturated buffers	$24,235.20	linear mile	Iowa Nutrient Reduction Strategy (revised 2017)	

(1) EAC = Equalized Annual Cost

Table 11.5. Agricultural BMP cost assumptions.

Most of this cost analysis is based on values included in the Iowa Nutrient Reduction Strategy. The technical analysis within the strategy collects both benefits and costs into annualized values for each practice. This arrangement makes it difficult to pull out individual aspects of these costs or benefits to compare and contract one-time costs to install infrastructure (pond, wetlands, WASCOBs) and practices requiring annual re-application (cover crops, no-till, etc.). Many infrastructure practices may have life spans beyond the 20-year comparison window. Some practices (such as wetlands, ponds and buffers) have other recreational or habitat benefits that are not fully quantified by the NRS cost analysis.

ACPF TARGETED PRIORITIZATION

The prioritization of conservation practice implementation within the eleven subwatersheds in Beaver Creek Watershed was determined using two primary criteria: 1) **the value of the land's resource production capacity,** and 2) assessment factors that influence where certain BMPs are best suited, or would provide greatest benefit. The first criteria guides practice implementation toward areas that will minimize financial barriers to implementation, while the second criteria guides practice implementation toward areas that will produce the most benefit to the overall subwatershed.

For the first criterion, the Corn Suitability Rating Index (CSR) tool was used. This is a rating applied to different soils based on row-crop productivity. This information indicates the value certain land has to a farmer's productivity. The values are ranked from high to low based on their relation to other land within the Beaver Creek Watershed. **A lower CSR indicates a higher priority for implementation.**

For the second criterion, runoff risk was applied to the landscape to expose regions with the greatest need for practice implementation. Runoff risk is a function of the proximity to a stream and the steepness of a slope. The proximity to a stream establishes the potential conveyance of sediment into the water – ultimately leading to increased pollution. **A higher runoff risk indicates a higher priority for implementation.**

Frequent flood risk to crops is also related to the second criterion. For this reason, maps of the 5-year flood plain (20% annual recurrence chance) have been included. These could be used to identify farmlands that are most frequently flooded which could be opportunities for conversion to edge of field or riparian buffer conservation practices.

Four maps are provided as a guide for implementation within each of the eleven HUC12 subwatersheds in the Beaver Creek Watershed. Each map contains information for the prioritization of different conservation practices. **The implementation process for this subwatershed should utilize these maps and tables as a guide for conservation practice prioritization.**

The maps of "Non-Prioritized Practice Locations" (CSR Map) include practices with a specified location, but no rank. **These include drainage water management practices (in-field), denitrifying bioreactors (edge of field), and saturated buffers (riparian area management). These practices do not have a specific criteria that would provide a helpful guide for implementation.** However, the CSR map may serve as a first step for assessing implementation potential of the practices. The locations suitable for implementing each of these practices, as determined by the ACPF analysis are shown in this map.

The maps of "Wetlands, Grass Waterways and Buffers" (Prioritization of Conservation Practices) include practices with a specified location that have been ranked individually using different parameters. These practices include grassed waterways (in-field), nutrient removal wetlands (edge of field), and riparian buffers (riparian area management).

Grassed waterways are beneficial in locations where gullies are most likely to form in streams. Moore's Stream Power Index (SPI) is applied to these practices to determine ideal locations for implementation. The SPI determines which locations for these practices have the highest stream power, therefore determining areas where gullies are more likely to form. Therefore, the grassed waterways in locations with the highest relative SPI were ranked in highest priority. All grass waterways shown in red should be prioritized for implementation.

Riparian buffers are ranked based on the relative runoff risk associated with the area draining to each practice. **Riparian buffers located in areas of relatively high runoff risk should be prioritized over those in areas with a smaller runoff risk.**

The Nutrient Removal Wetlands are ranked based on the CSR because of the large cost and amount of land associated with wetlands. These wetlands are ranked and labeled based on CSR mean, starting with the lowest CSR mean at #1. Only one wetland per wetland train should be implemented in the initial process. The rankings produced based on these criteria are shown in tables under each subwatershed section. **The area of each wetland pool and drainage area can be used a secondary measure for prioritization.**

Maps of "Contour Buffer Strips and Terraces" (Contour Strips & Terraces) include practices ranked based on the relative slope steepness within the subwatershed. These include contour buffer strips (in-field) and terraces (in-field). Their implementation is prioritized based on slope steepness rather than runoff risk because such practices are found all across the landscape and not just adjacent to streams. Both contour buffer strips and terraces reduce sheet and rill erosion, which is why they are most valuable on steeper slopes. Therefore, **these practices should be prioritized in locations where slopes are steepest** in relation to the subwatershed's landscape.

Maps of "Soil Health Practices, No-Till, Perennial Cover and WASCOBs" (Runoff Risk) prioritize practices based on runoff risk. These practices include all the soil health practices (cover crops, extended rotations, nitrogen management, and phosphorus management), no-till (in-field), perennial cover (edge of field), and WASCOBs (edge of field). All of these practices are recommended across the watershed and are very valuable in reducing the pollutant loads in runoff. Therefore, **land with a relatively higher runoff risk should be prioritized for these practices.**

In summary, for each HUC-12 subwatershed there are seven maps provided.

THREE CRITERIA MAPS:

1. Corn Suitability Rating Map
2. Runoff Risk Map
3. 5-year Flood Plain Map

FOUR PRIORITIZATION MAPS:

4. Non-prioritized Practice Locations
5. Wetlands, Grass Waterways and Buffers
6. Buffer Strips and Terraces
7. Soil Health Practices, No-Till, Perennial Cover and WASCOBs

SUBWATERSHED PRIORITIZATION RESULTS

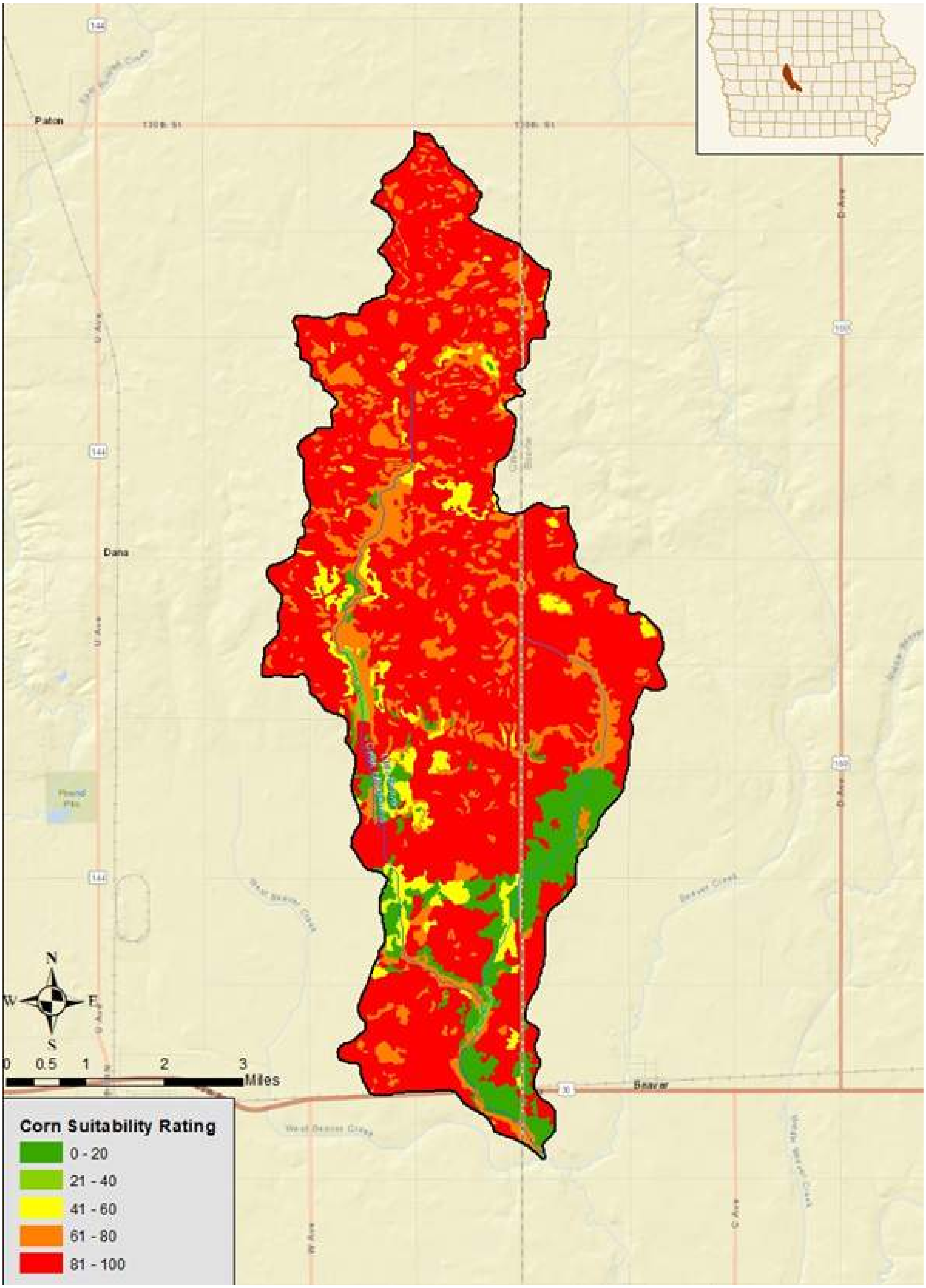
Little Beaver Creek -West Beaver Creek

The specific conservation scenario developed for the Little Beaver Creek-West Beaver Creek Subwatershed is shown in Table 11.6. The table indicates the recommended adoption rate of each practice with the corresponding acreage or quantity and the total implementation over a 20 year period for meeting targets for Nitrogen and Phosphorus for the Beaver Creek Watershed. The conservation practice scenario was developed through an iterative process using a cost-benefit analysis that is described in the Middle Cedar Watershed Management Plan. The equalized annual cost for practice implementation within the subwatershed is $260,000. This total annual cost includes conservation practice expenditures of $321,000 per year and conservation practices that result in a savings of $61,000 per year. Note that the cost provided are for conservation practices only.

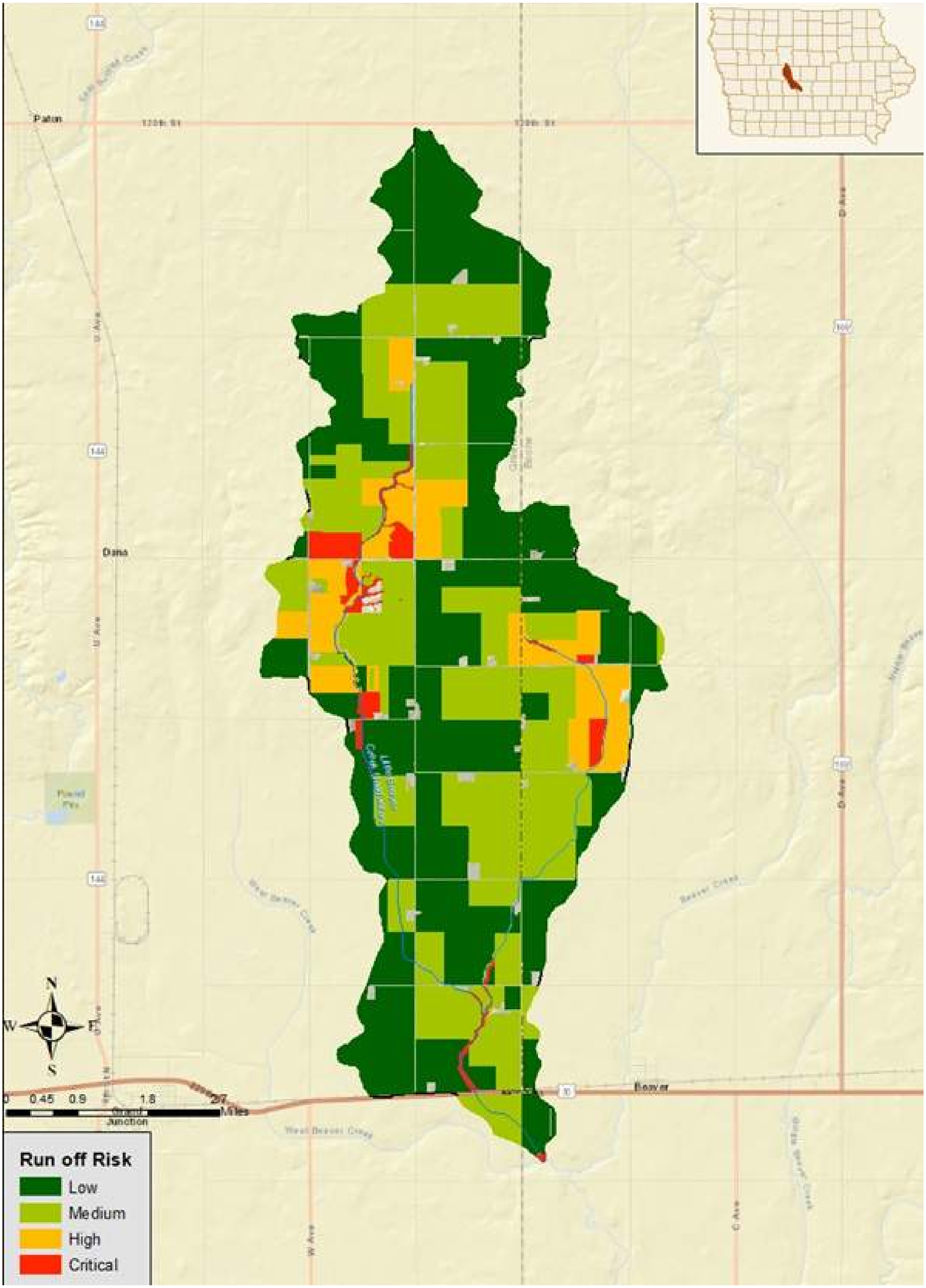
Feasible maximum BMP adoption targets were set using stakeholder input as shown in Table 11.2. However, targeted implementation of BMPs at these rates did not reach the 34.4% total nitrogen reduction goal nor the 29% total phosphorus reduction goal. In order to reach these nutrient reduction goals in this watershed, target adoption rates for some BMPs will need to be increased. Based on our previous experience with watershed planning in Iowa, cover crops and no-till appear to be palatable BMPs to stakeholders, generally, so our recommendation is to pursue increased implementation of these two practices. **For reference, to reach the goals in this watershed we have estimated that an additional 12,778 acres of cover crops ($361,000/yr) would be required above and beyond what is shown in Table 11.6.**

BMP Name	Existing Adoption Rate (%)	Target Adoption Rate (%)	Quantity	Equalized Annual Cost (Savings) [$/yr]
Cover crops	1%	2%	105 acres	$8,404
Extended rotations	1%	2%	105 acres	$2,573
Nitrogen management: nitrification inhibitor	85%	95%	1052 acres	($2,573)
Nitrogen management: rate control	5%	8%	263 acres	($429)
Nitrogen management: source control	10%	10%	0 acres	$0
Nitrogen management: timing control	75%	95%	2104 acres	($17,152)
Phosphorus management: placement control	5%	8%	274 acres	$3,345
Phosphorus management: rate control	25%	38%	1368 acres	($12,263)
Phosphorus management: source control	10%	10%	0 acres	$0
Contour buffer strips	0%	20%	3 miles	$2,073
Terraces	100%	100%	0 miles	$0
Drainage water management	0%	50%	42 fields	$8,306
Grassed waterways	60%	75%	3 miles	$0
No-Till	5%	10%	526 acres	$20,582
Denitrifying bioreactors	0%	25%	9 reactors	$7,188
Nutrient removal wetlands	0%	40%	0 wetlands	$28,342
Perennial cover	1%	2%	107 acres	$34 ,128
WASCOBs	42%	52%	2 basins	$0
Riparian buffer: Critical zone buffer	63%	100%	0 miles	$689
Riparian buffer: Deep-rooted vegetation buffer	63%	100%	5 miles	$8,270
Riparian buffer: Multi-species buffer	63%	100%	2 miles	$2,631
Riparian buffer: Stiff stem grass buffer	63%	100%	1 miles	$4,323
Riparian buffer: Stream stabilization buffer	63%	100%	4 miles	$21,050
Saturated buffers	0%	50%	7 miles	$161,509
				Little Beaver Creek - West Beaver Creek

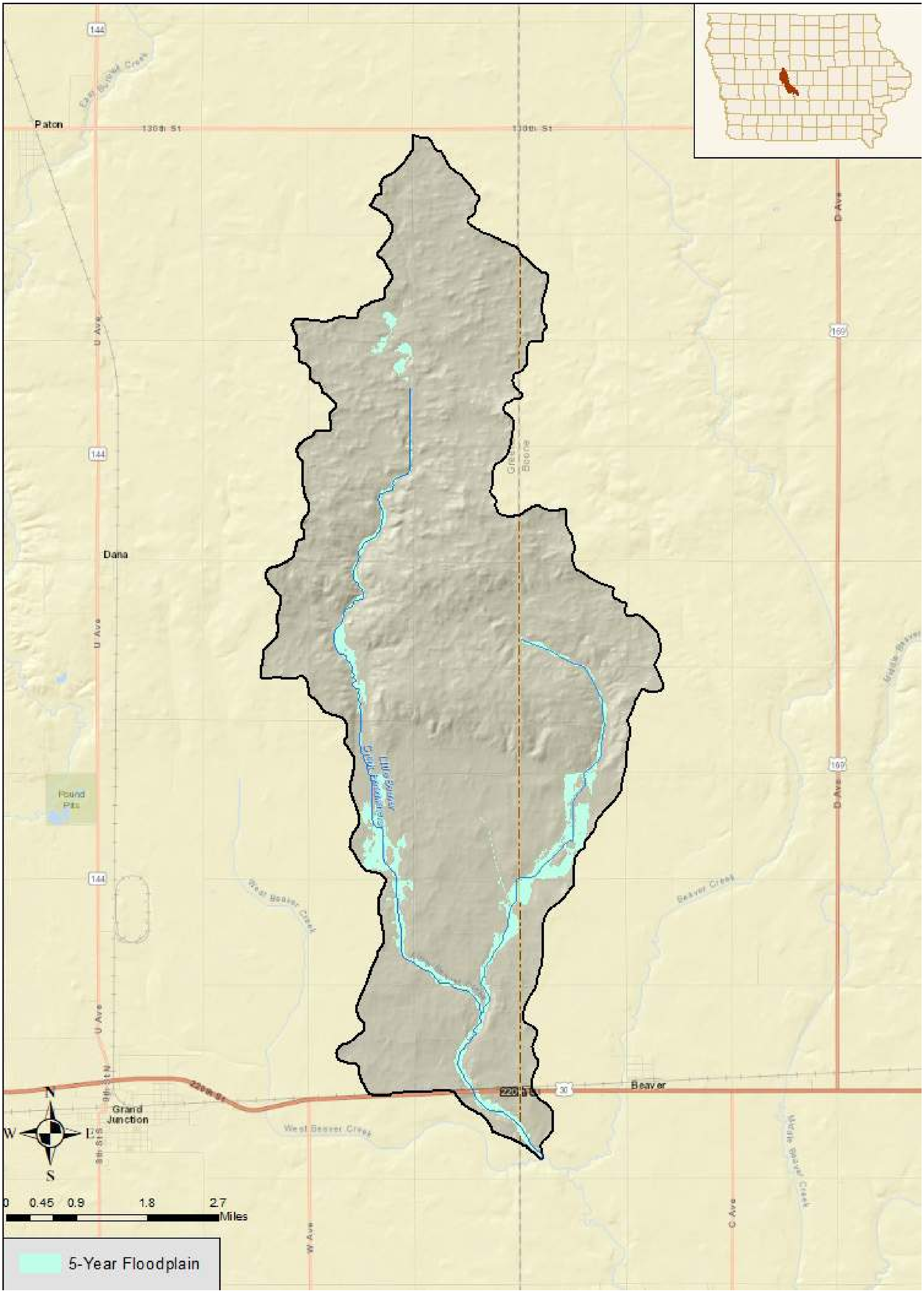
Table 11.6. BMP Adoption for Little Beaver Creek -West Beaver Creek



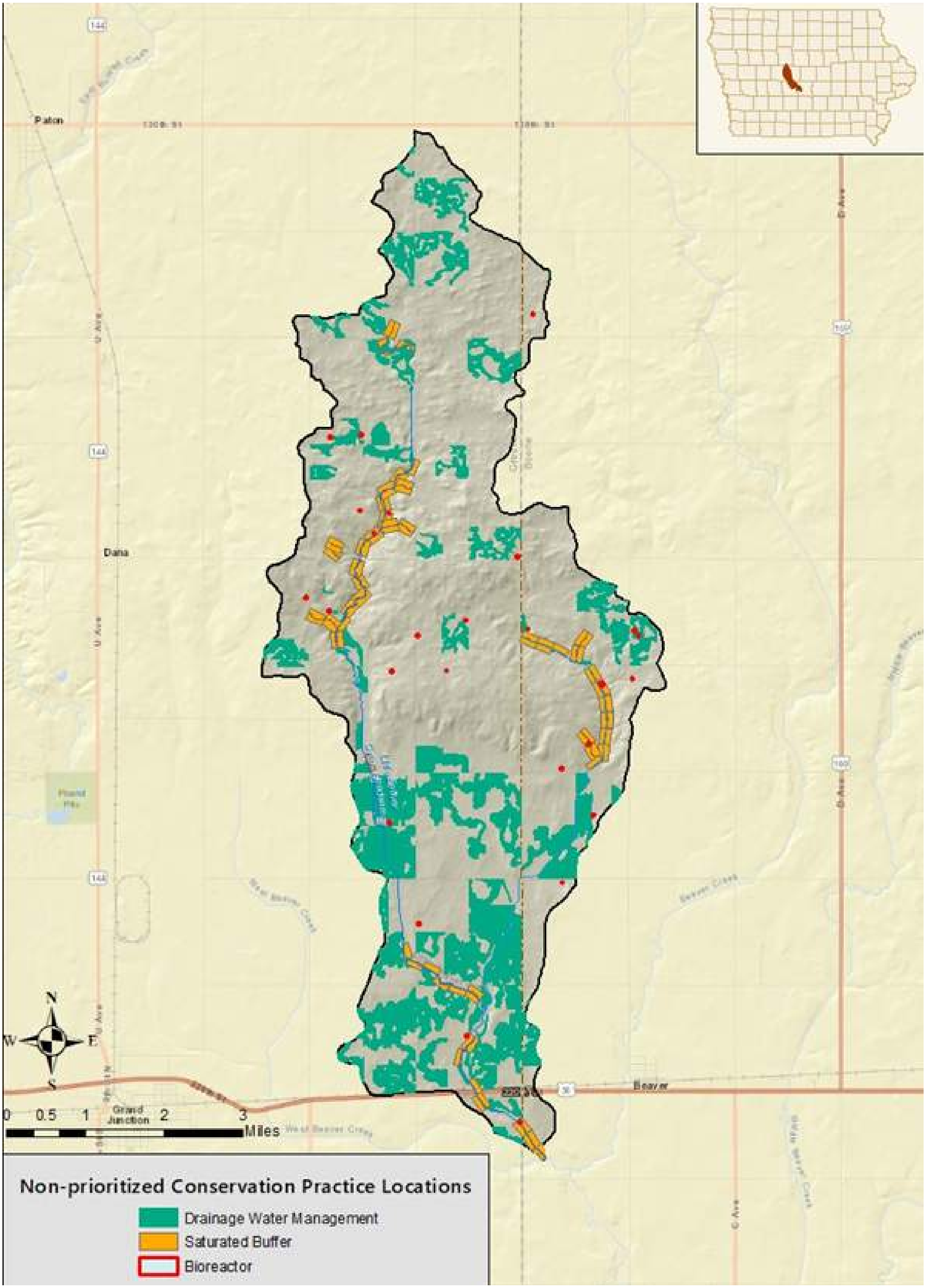
Little Beaver Creek Subwatershed - Map 1



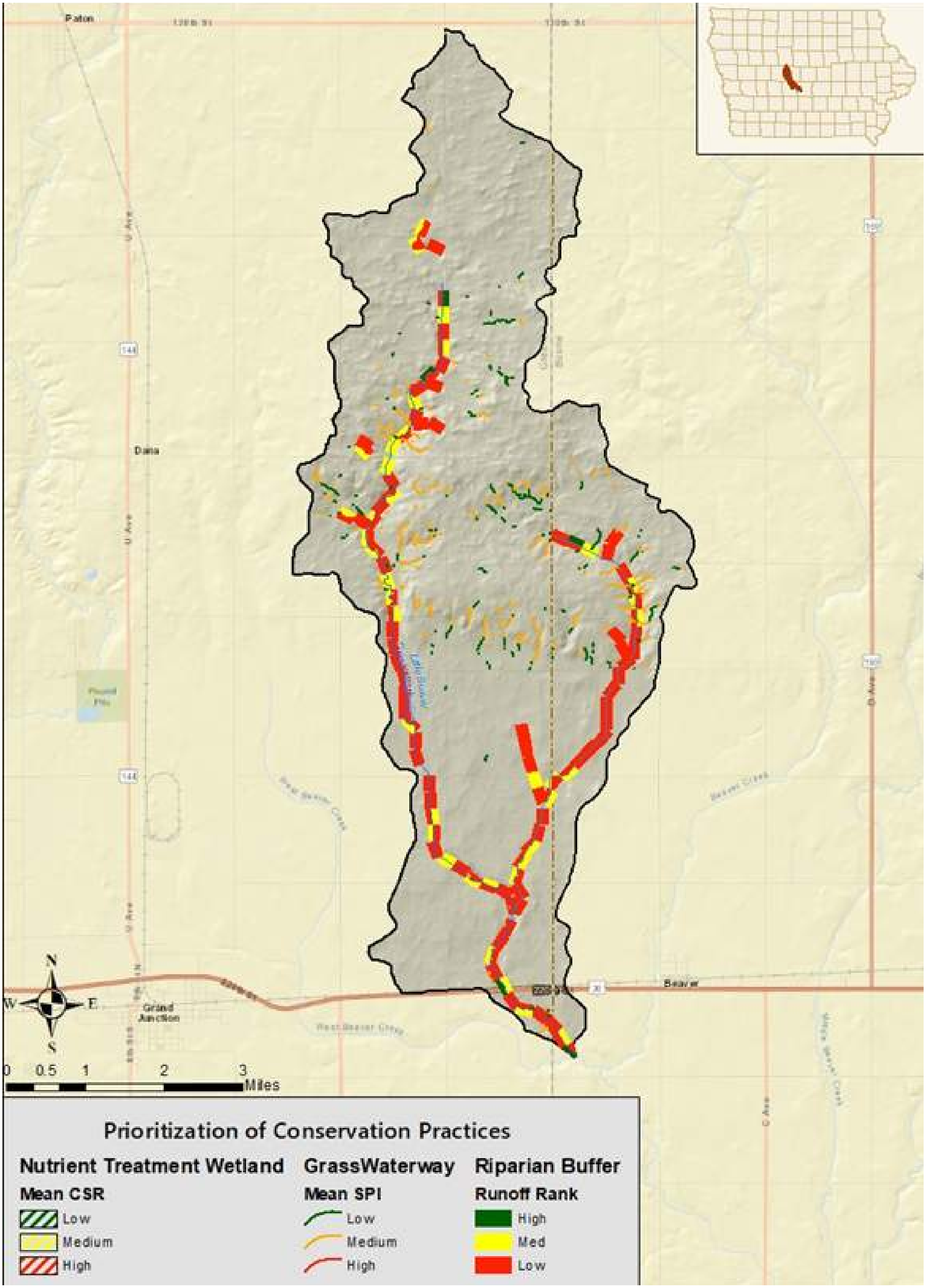
Little Beaver Creek Subwatershed - Map 2



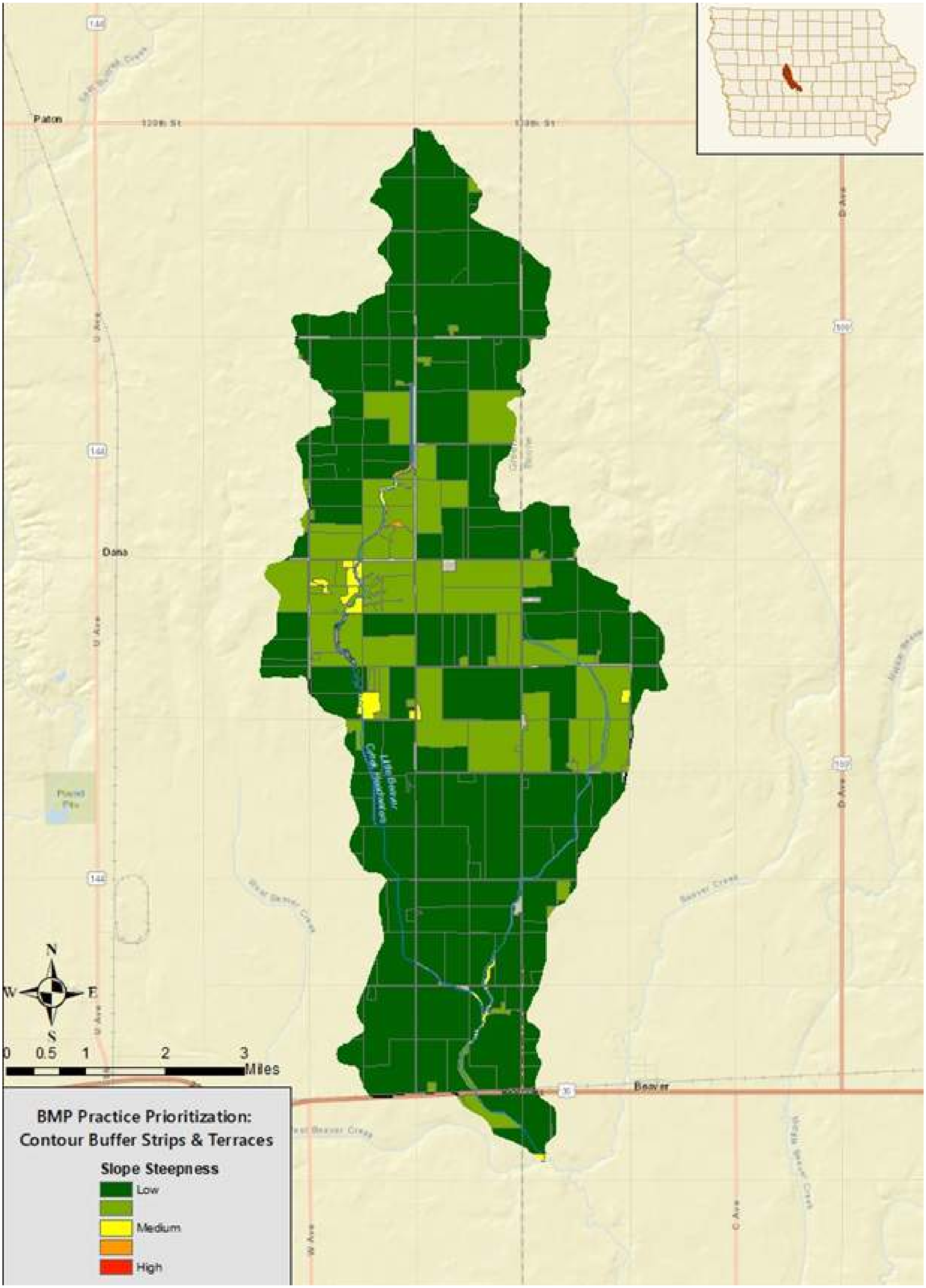
Little Beaver Creek Subwatershed - Map 3



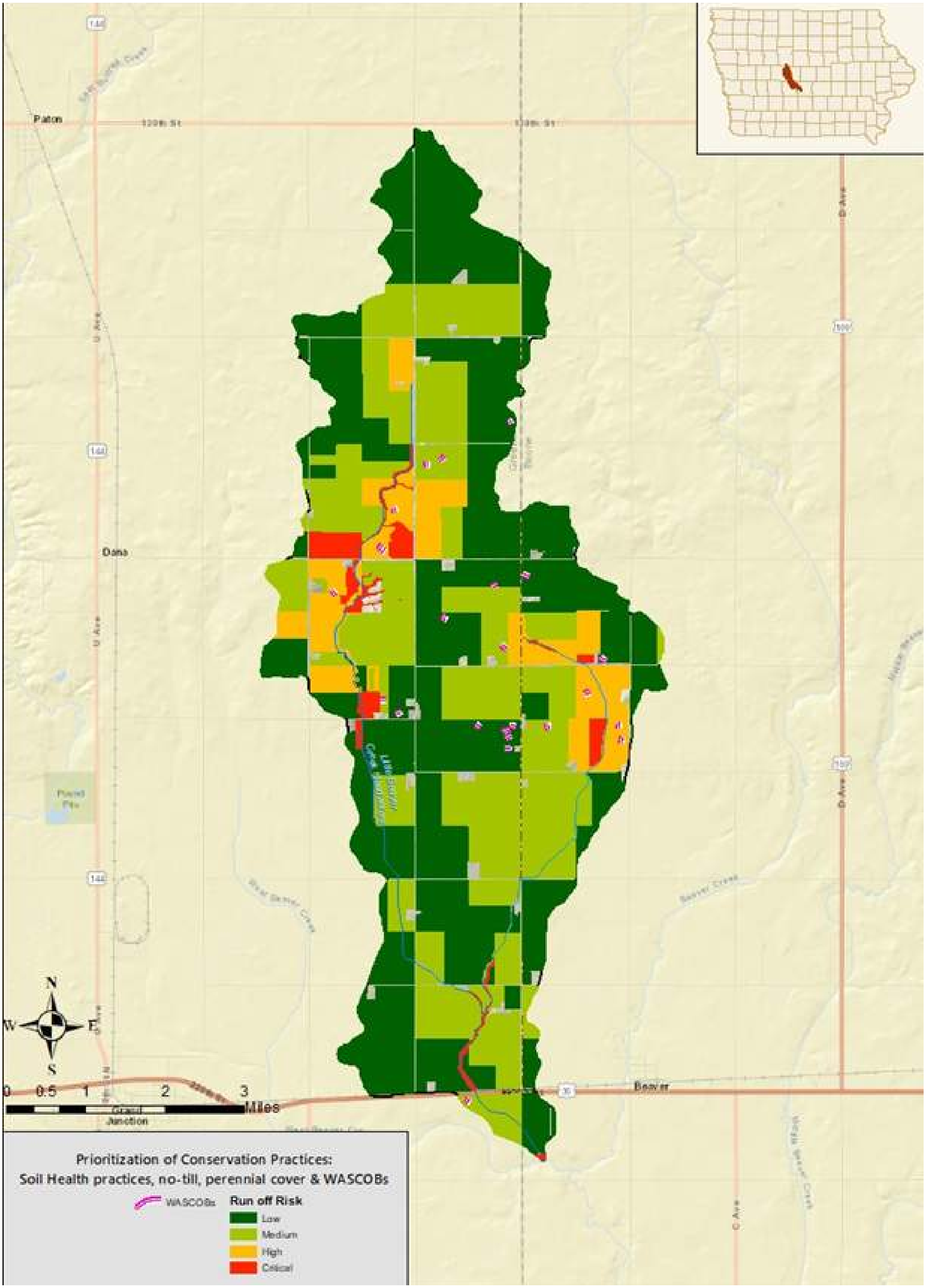
Little Beaver Creek Subwatershed - Map 4



Little Beaver Creek Subwatershed - Map 5



Little Beaver Creek Subwatershed - Map 6



Little Beaver Creek Subwatershed - Map 7

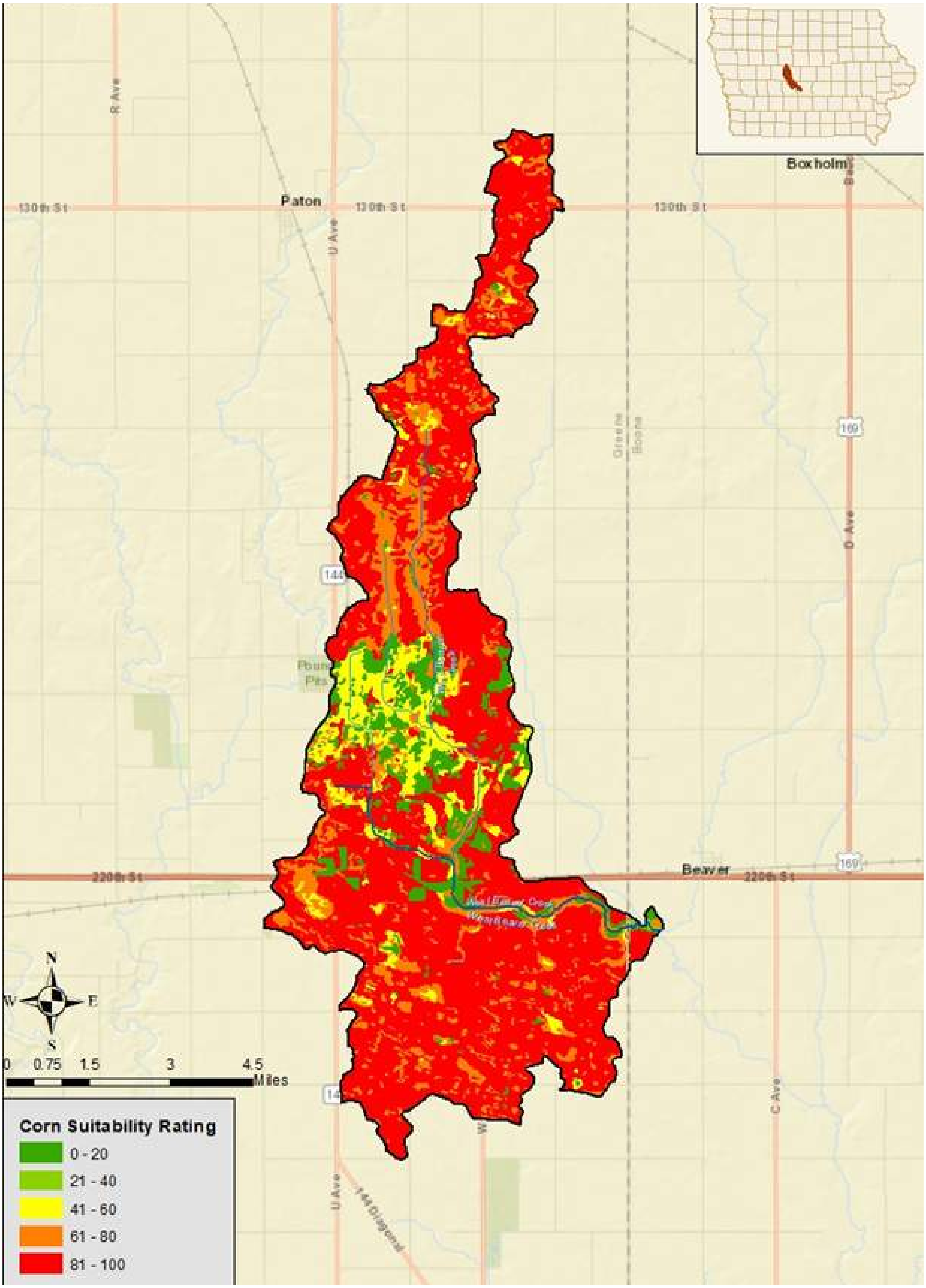
West Beaver Creek

The specific conservation scenario developed for the West Beaver Creek Subwatershed is shown in Table 11.7. The table indicates the recommended adoption rate of each practice with the corresponding acreage or quantity and the total implementation over a 20 year period for meeting targets for Nitrogen and Phosphorus for the Beaver Creek Watershed. The conservation practice scenario was developed through an iterative process using a cost-benefit analysis that is described in the Middle Cedar Watershed Management Plan. The equalized annual cost for practice implementation within the subwatershed is $370,000. This total annual cost includes conservation practice expenditures of $431,000 per year and conservation practices that result in a savings of $61,000 per year. Note that the cost provided are for conservation practices only.

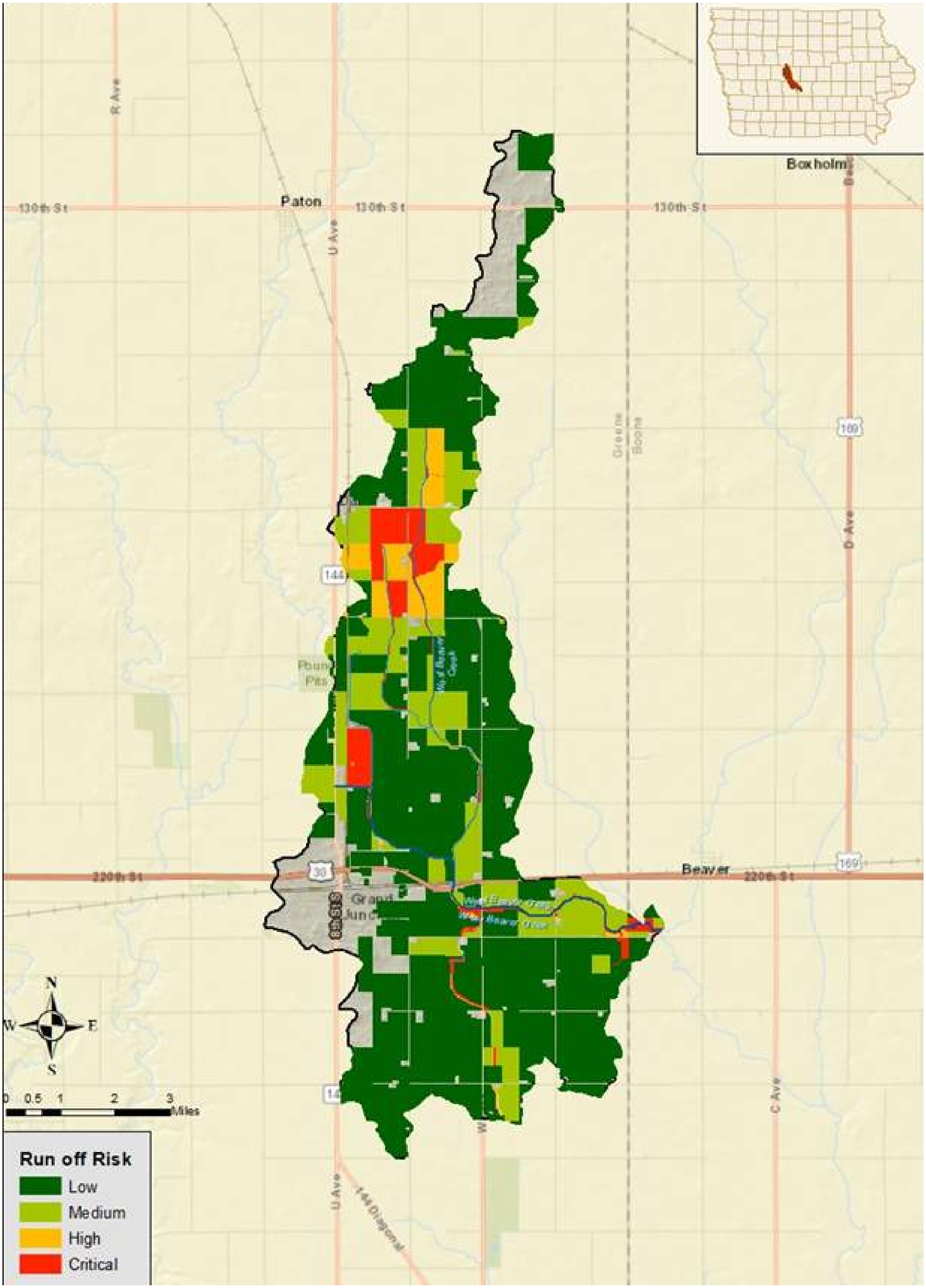
Feasible maximum BMP adoption targets were set using stakeholder input as shown in Table 11.2. However, targeted implementation of BMPs at these rates did not reach the 34.4% total nitrogen reduction goal nor the 29% total phosphorus reduction goal. In order to reach these nutrient reduction goals in this watershed, target adoption rates for some BMPs will need to be increased. Based on our previous experience with watershed planning in Iowa, cover crops and no-till appear to be palatable BMPs to stakeholders, generally, so our recommendation is to pursue increased implementation of these two practices. **For reference, to reach the goals in this watershed we have estimated that an additional 12,164 acres of cover crops ($596,000/yr) would be required above and beyond what is shown in Table 11.7.**

Table 11.7. BMP Adoption for West Beaver Creek Subwatershed

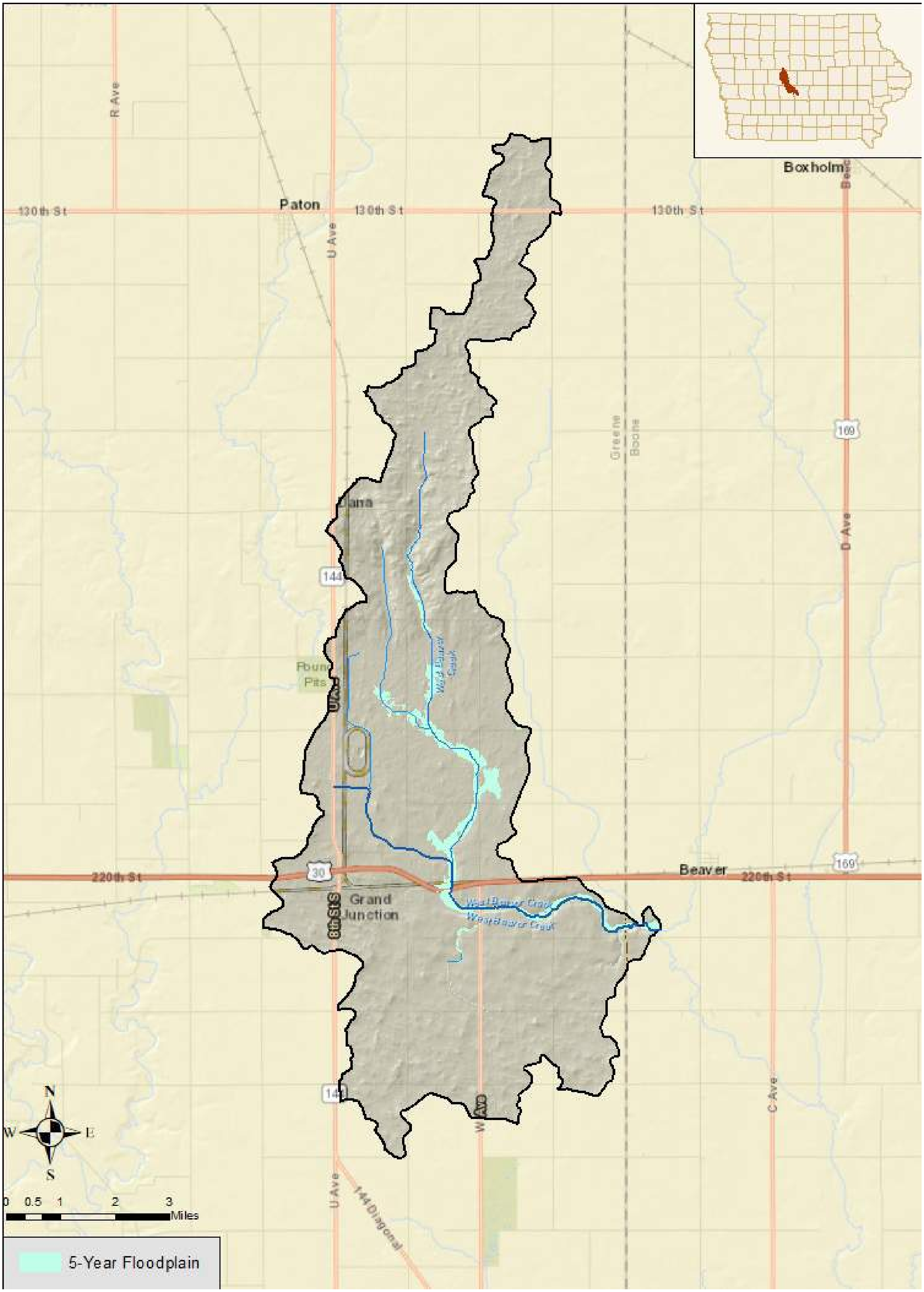
BMP Name	Existing Adoption Rate (%)	Target Adoption Rate (%)	Quantity	Equalized Annual Cost (Savings) [$/yr]
Cover crops	3%	6%	480 acres	$10,738
Extended rotations	1%	2%	160 acres	$2,191
Nitrogen management: nitrification inhibitor	85%	95%	1601 acres	($2,191)
Nitrogen management: rate control	5%	8%	400 acres	($365)
Nitrogen management: source control	10%	10%	0 acres	$0
Nitrogen management: timing control	85%	95%	1601 acres	($14,610)
Phosphorus management: placement control	5%	8%	416 acres	$2,849
Phosphorus management: rate control	25%	38%	2081 acres	($10,446)
Phosphorus management: source control	10%	10%	0 acres	$0
Contour buffer strips	0%	20%	3 miles	$1,487
Terraces	100%	100%	0 miles	$0
Drainage water management	0%	50%	94 fields	$17,069
Grassed waterways	48%	60%	2 miles	$7,208
No-Till	5%	10%	800 acres	$4,383
Denitrifying bioreactors	0%	25%	20 reactors	$4,621
Nutrient removal wetlands	0%	40%	0 wetlands	$0
Perennial cover	1%	2%	163 acres	$29,070
WASCOBs	100%	100%	0 basins	$0
Riparian buffer: Critical zone buffer	46%	100%	0 miles	$228
Riparian buffer: Deep-rooted vegetation buffer	46%	100%	8 miles	$10,841
Riparian buffer: Multi-species buffer	46%	100%	4 miles	$4,907
Riparian buffer: Stiff stem grass buffer	46%	100%	2 miles	$3,195
Riparian buffer: Stream stabilization buffer	46%	100%	10 miles	$13,922
Saturated buffers	0%	50%	8 miles	$84,191
			West Beaver Creek	



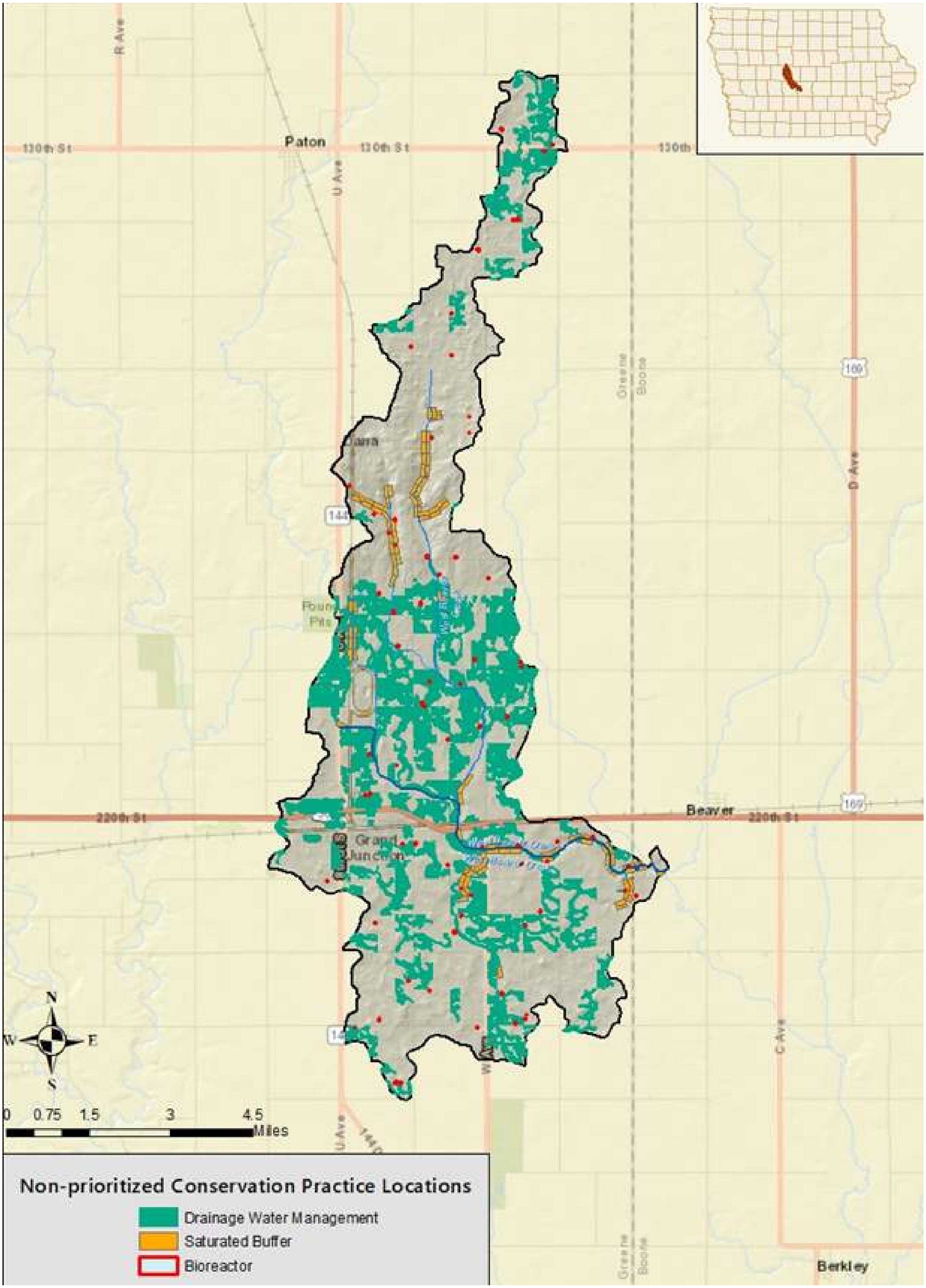
West Beaver Creek Subwatershed - Map 1



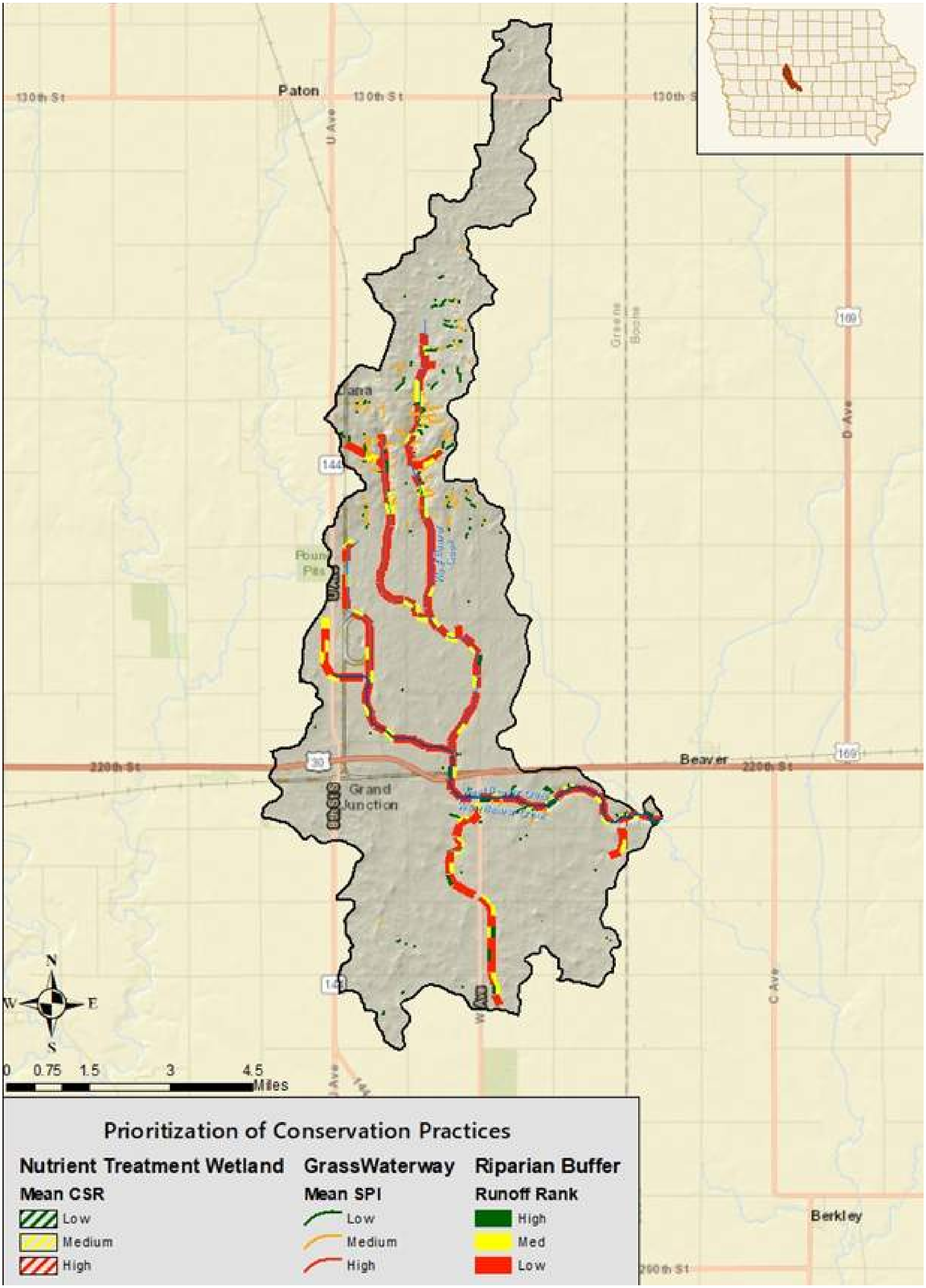
West Beaver Creek Subwatershed - Map 2



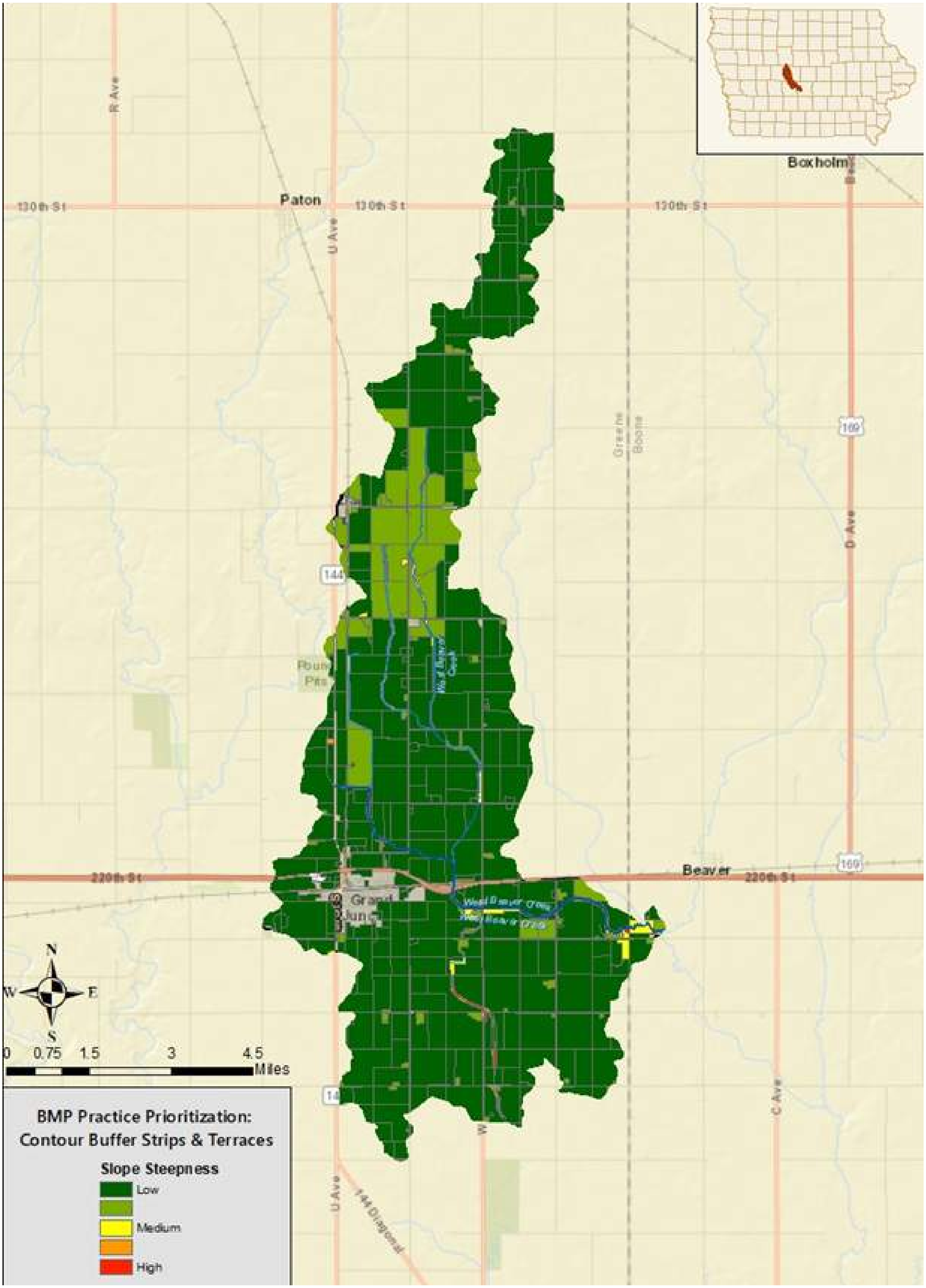
West Beaver Creek Subwatershed - Map 3



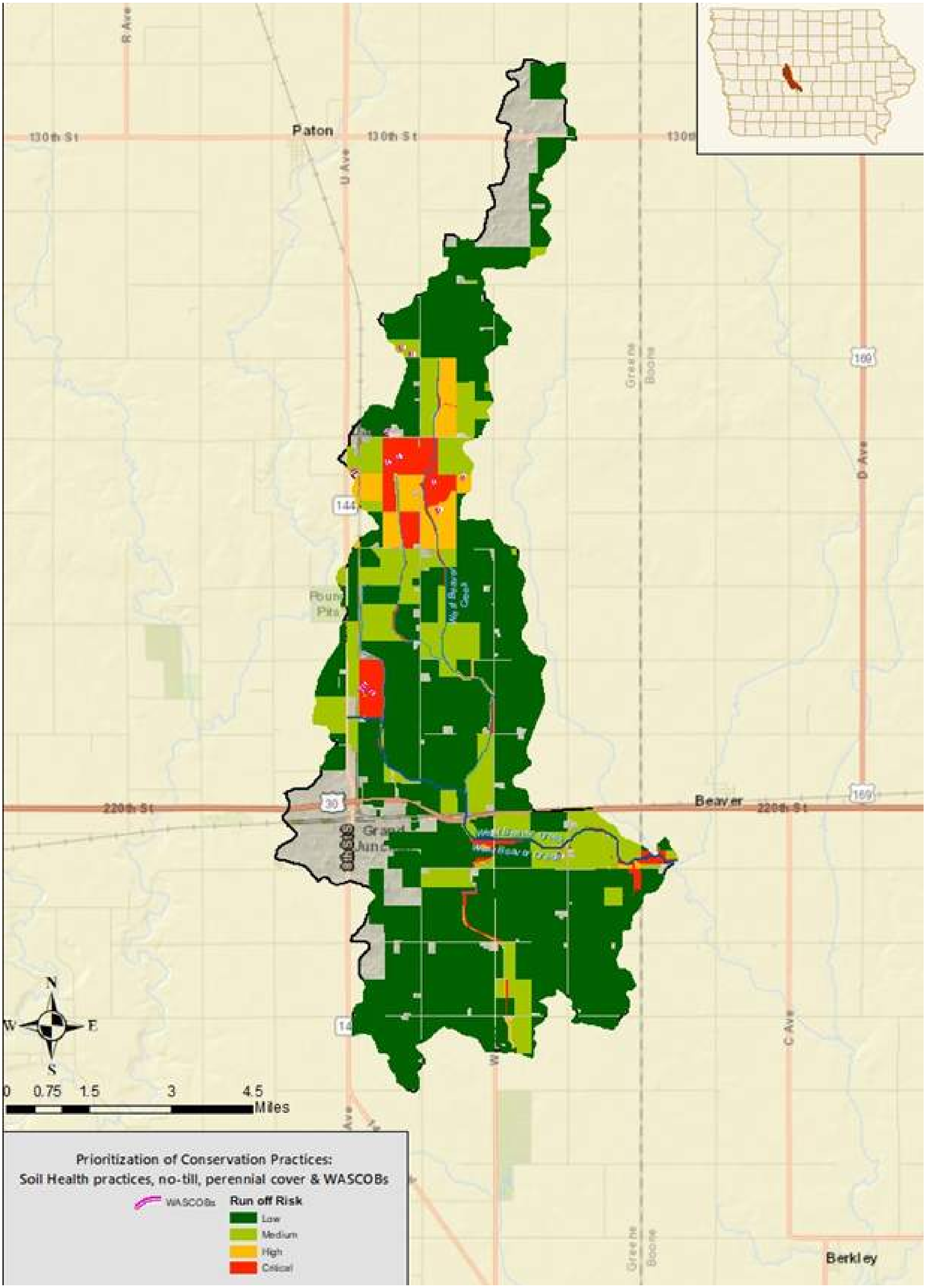
West Beaver Creek Subwatershed - Map 4



West Beaver Creek Subwatershed - Map 5



West Beaver Creek Subwatershed - Map 6



West Beaver Creek Subwatershed - Map 7

Middle Beaver Creek

The specific conservation scenario developed for the Middle Beaver Creek Subwatershed is shown in Table 11.8. The table indicates the recommended adoption rate of each practice with the corresponding acreage or quantity and the total implementation over a 20 year period for meeting targets for Nitrogen and Phosphorus for the Beaver Creek Watershed. The conservation practice scenario was developed through an iterative process using a cost-benefit analysis that is described in the Middle Cedar Watershed Management Plan. The annualized total cost for practice implementation within the subwatershed is $515,000. This equalized annual cost includes conservation practice expenditures of $572,000 per year and conservation practices that result in a savings of $57,000 per year. Note that the cost provided are for conservation practices only.

Feasible maximum BMP adoption targets were set using stakeholder input as shown in Table 11.2. However, targeted implementation of BMPs at these rates did not reach the 34.4% total nitrogen reduction goal nor the 29% total phosphorus reduction goal. In order to reach these nutrient reduction goals in this watershed, target adoption rates for some BMPs will need to be increased. Based on our previous experience with watershed planning in Iowa, cover crops and no-till appear to be palatable BMPs to stakeholders, generally, so our recommendation is to pursue increased implementation of these two practices. For reference, to reach the goals in this watershed we have estimated that an additional 9,665 acres of cover crops ($474,000/yr) and 1,661 acres of no-till ($20,000/yr) would be required above and beyond what is shown in Table 11.8.

Table 11.8. BMP Adoption for Middle Beaver Creek Subwatershed

BMP Name	Existing Adoption Rate (%)	Target Adoption Rate (%)	Quantity	Equalized Annual Cost (Saving) [$/yr]
Cover crops	1%	2%	151 acres	$3,377
Extended rotations	1%	2%	151 acres	$2,068
Nitrogen management: nitrification inhibitor	85%	95%	1510 acres	($2,068)
Nitrogen management: rate control	5%	8%	378 acres	($345)
Nitrogen management: source control	10%	10%	0 acres	$0
Nitrogen management: timing control	85%	95%	1510 acres	($13,784)
Phosphorus management: placement control	5%	8%	393 acres	$2,688
Phosphorus management: rate control	25%	38%	1963 acres	($9,856)
Phosphorus management: source control	10%	10%	0 acres	$0
Contour buffer strips	0%	20%	5 miles	$2,205
Terraces	88%	88%	0 miles	$0
Drainage water management	0%	50%	63 fields	$11,410
Grassed waterways	100%	100%	0 miles	$0
No-Till	5%	10%	755 acres	$4,135
Denitrifying bioreactors	0%	25%	17 reactors	$3,822
Nutrient removal wetlands	0%	40%	3 wetlands	$8,626
Perennial cover	1%	2%	154 acres	$27,428
WASCOBs	64%	80%	7 basins	$13,387
Riparian buffer: Critical zone buffer	59%	100%	1 miles	$788
Riparian buffer: Deep-rooted vegetation buffer	59%	100%	8 miles	$11,126
Riparian buffer: Multi-species buffer	59%	100%	3 miles	$4,643
Riparian buffer: Stiff stem grass buffer	59%	100%	2 miles	$2,716
Riparian buffer: Stream stabilization buffer	59%	100%	6 miles	$8,060
Saturated buffers	0%	50%	14 miles	$154,637

Middle Beaver Creek

RANK	Mean CSR	Basin Size (HA)	Drainage Area (HA)
1	0.39	0.93	122.43
2	61.57	0.69	72.16
3	64.25	0.84	96.96
4	74.92	1.49	117.90
5	88.68	1.70	210.75
6	88.70	1.45	115.76
7	90.65	1.48	75.67

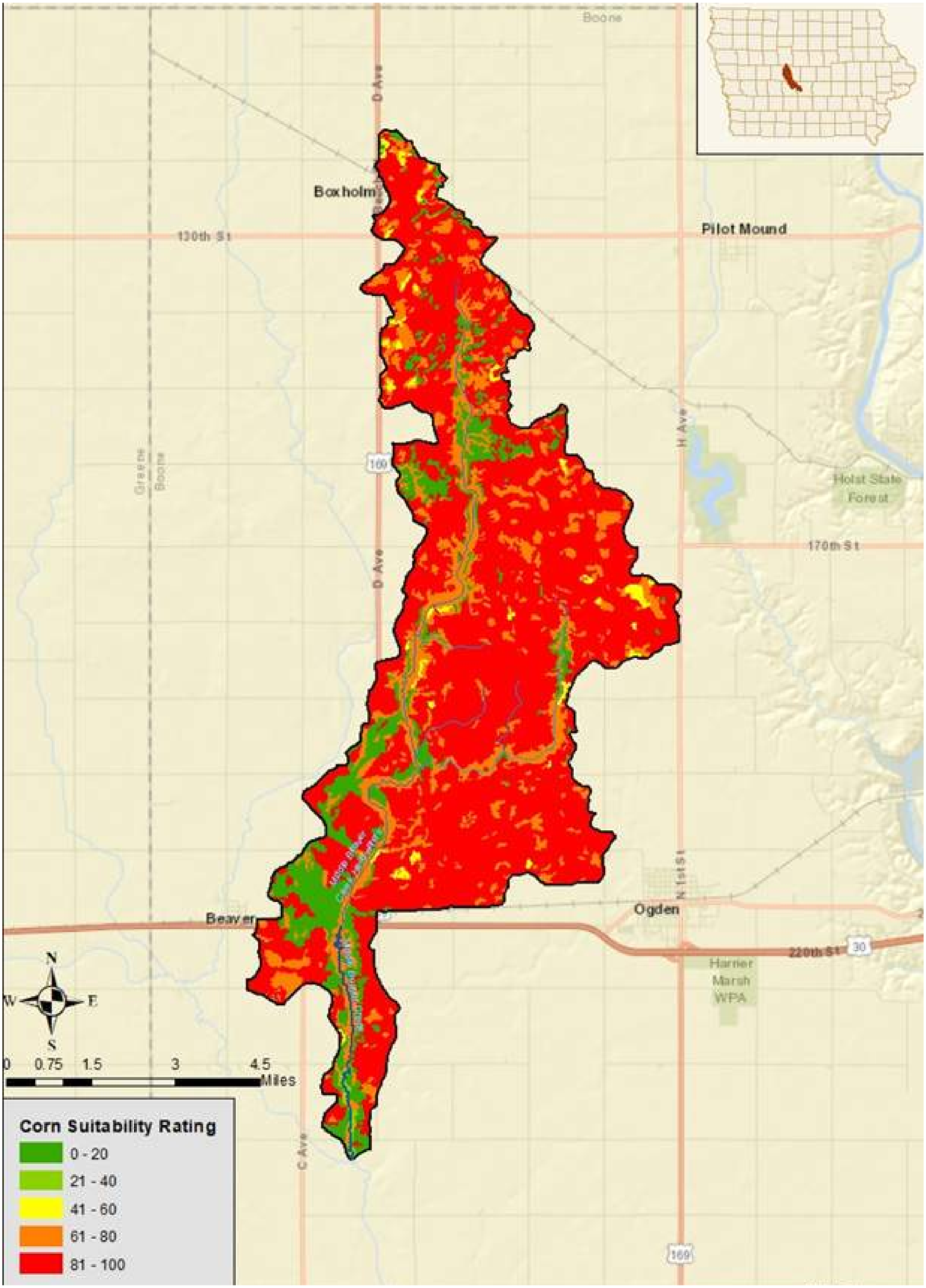
Table 11.8a. Properties of watersheds to each site location

(HA = hectacres = 100 acres)

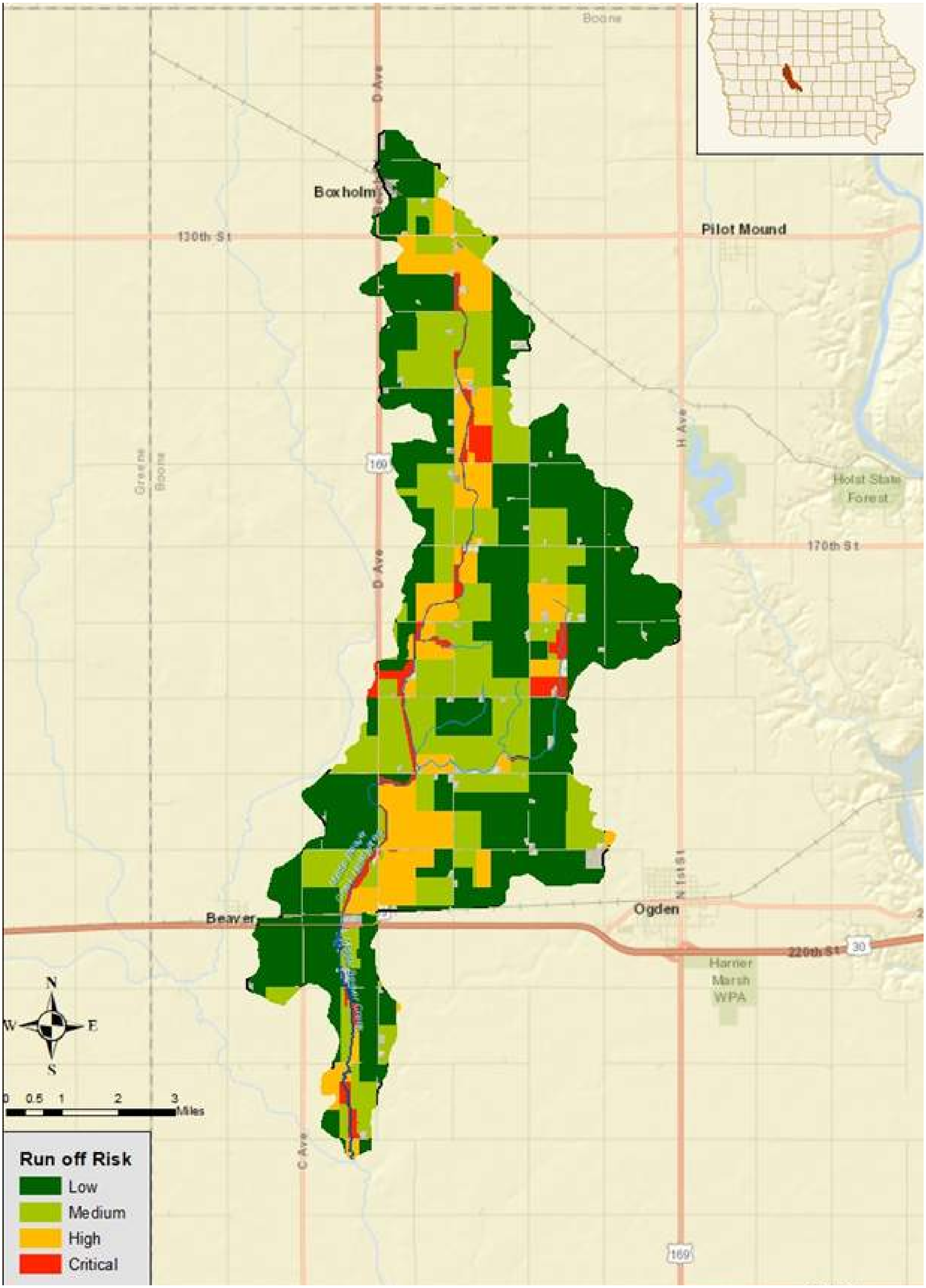
Grouping	Implement first
1	1
2, 4	2
3, 5	3
6	6
7	7

Table 11.8b. - Recommended prioritaztion list

Tables 11.8a and 11.8b refer to Middle Beaver Creek Subwatershed Map 5 on page 235

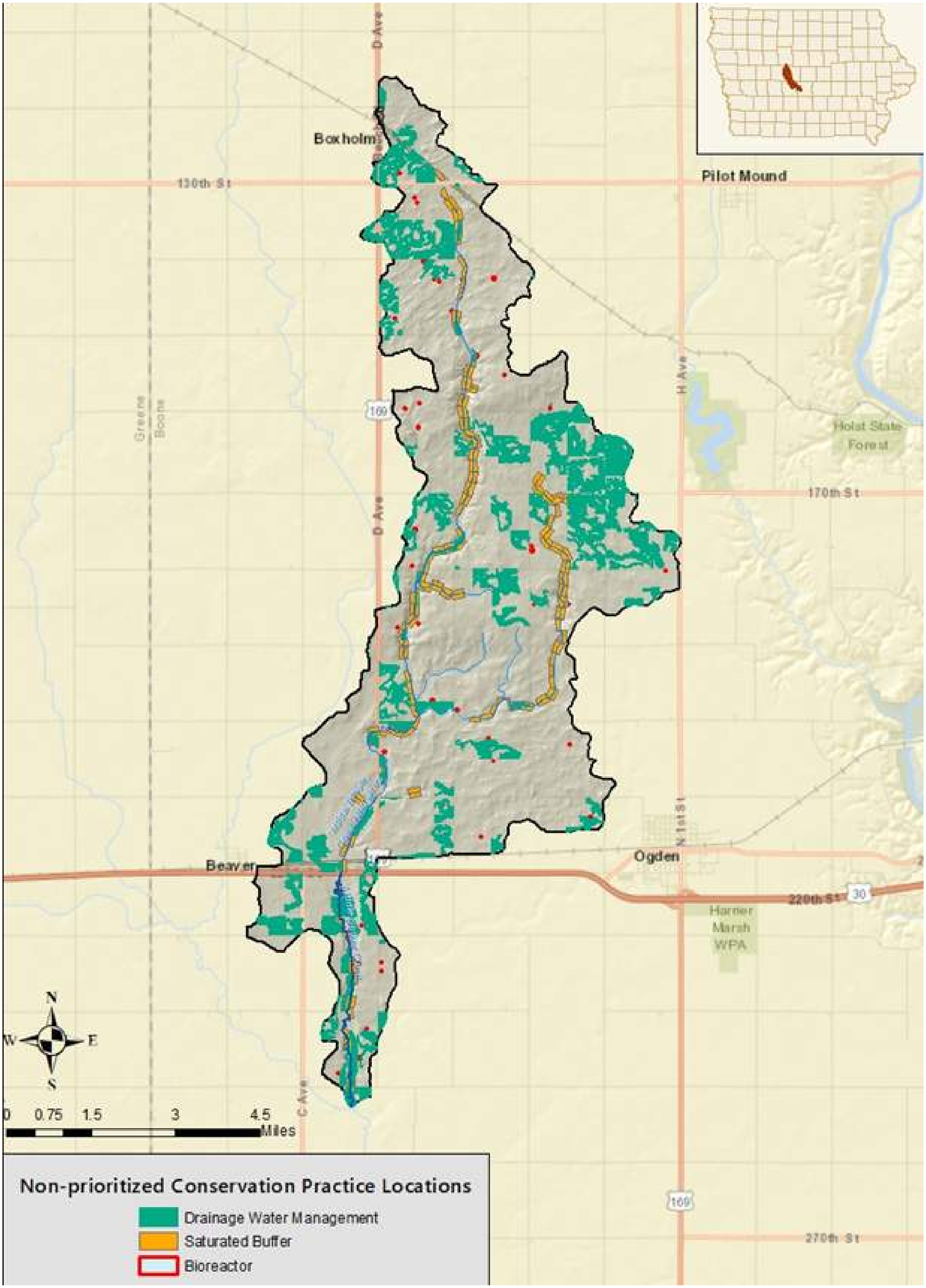


Middle Beaver Creek Subwatershed - Map 1

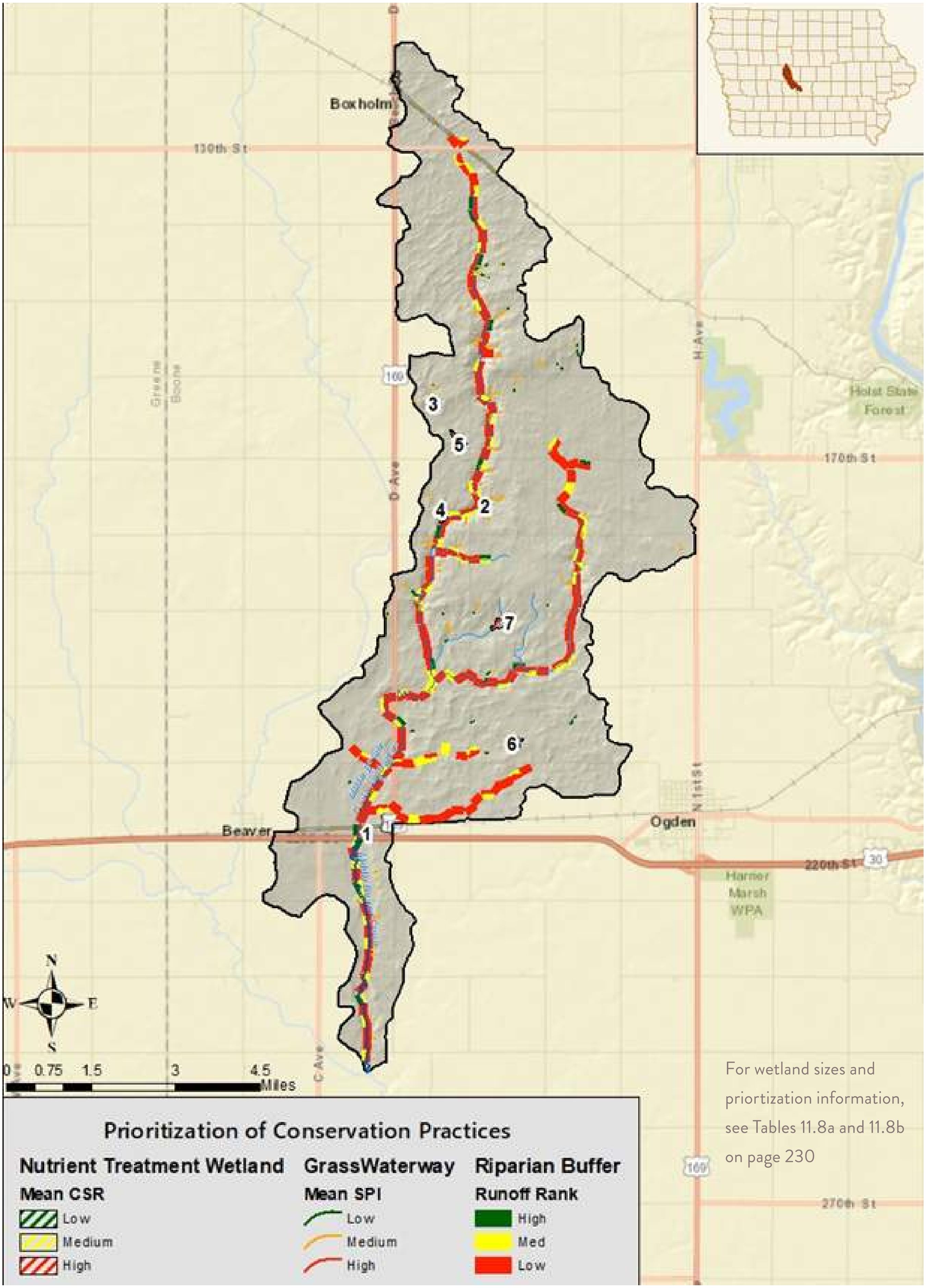


Middle Beaver Creek Subwatershed - Map 2

Middle Beaver Creek Subwatershed - Map 3

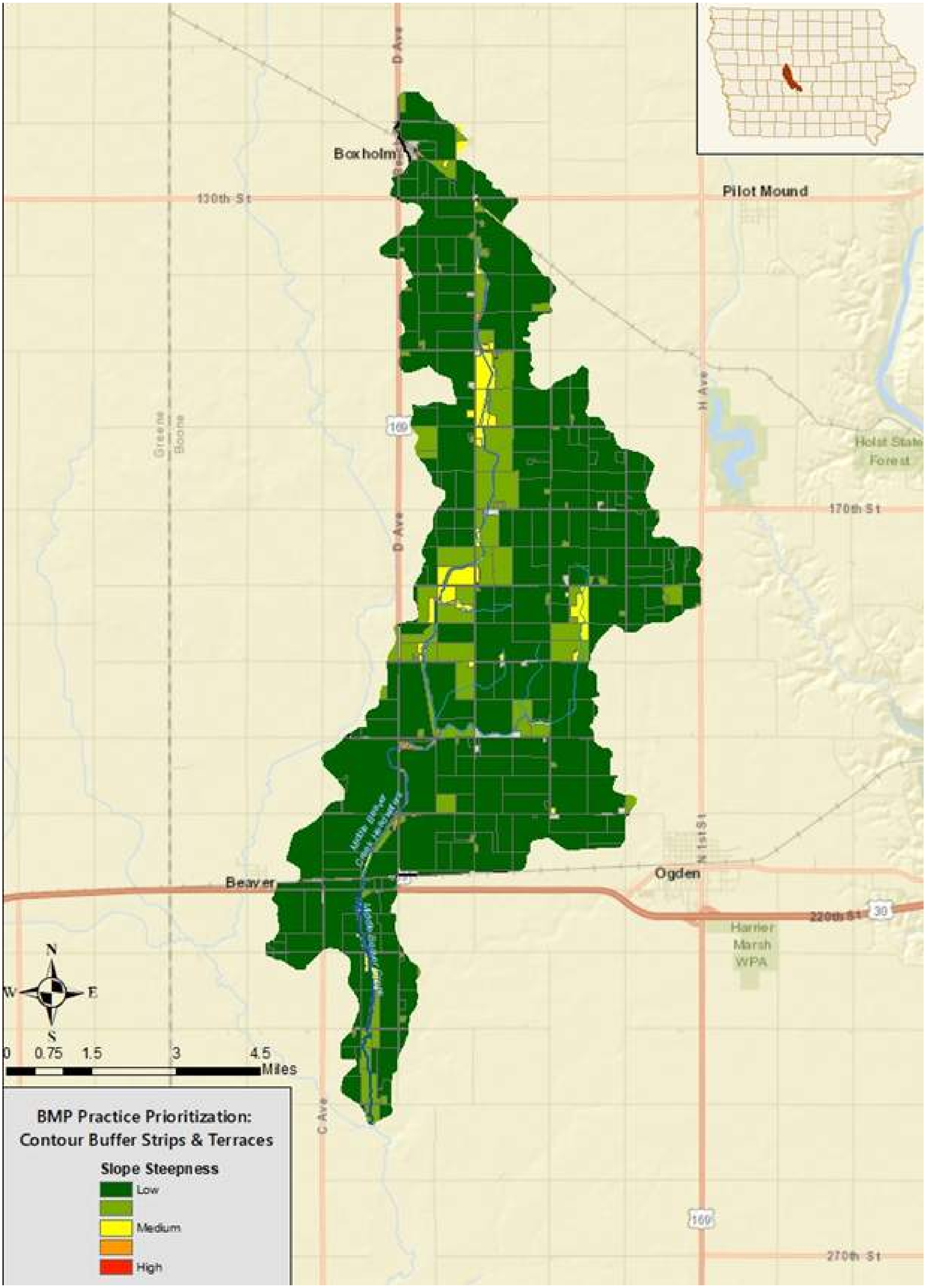


Middle Beaver Creek Subwatershed - Map 4

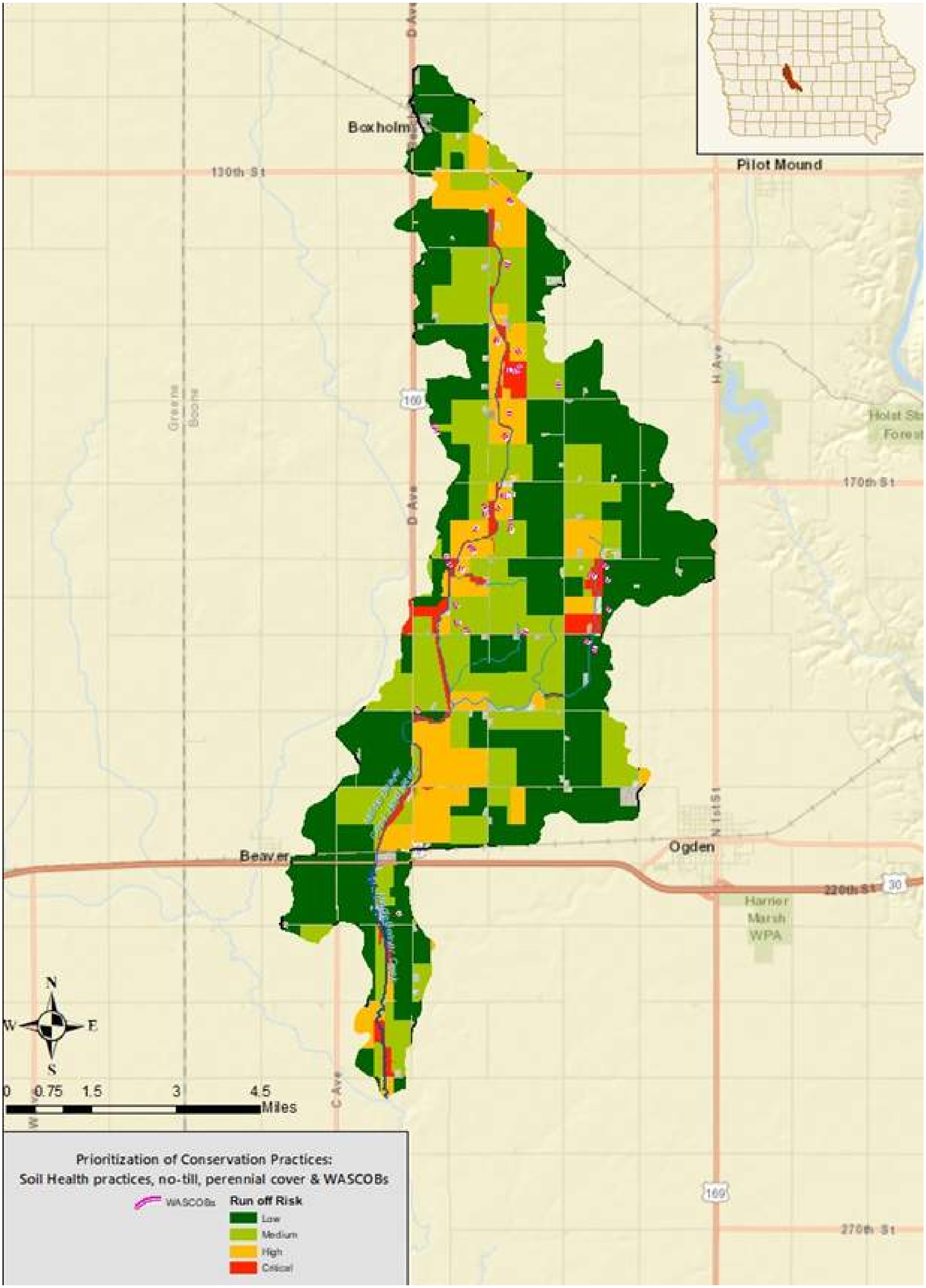


For wetland sizes and priortization information, see Tables 11.8a and 11.8b on page 230

Middle Beaver Creek Subwatershed - Map 5



Middle Beaver Creek Subwatershed - Map 6


Boxholm
Pilot Mound
130th St
D Ave
H Ave
169
Greene
Boone
Holst State Forest
170th St
Ogden
Beaver
220th St
30
Harrier Marsh WPA
C Ave
N 1st St
0 0.75 1.5 3 4.5 Miles
N
S
E
W
Prioritization of Conservation Practices:
Soil Health practices, no-till, perennial cover & WASCOBs
WASCOBs
Run off Risk
Low
Medium
High
Critical
270th St

East Beaver Creek

The specific conservation scenario developed for the East Beaver Creek Subwatershed is shown in Table 11.9. The table indicates the recommended adoption rate of each practice with the corresponding acreage or quantity and the total implementation over a 20 year period for meeting targets for Nitrogen and Phosphorus for the Beaver Creek Watershed. The conservation practice scenario was developed through an iterative process using a cost-benefit analysis that is described in the Middle Cedar Watershed Management Plan. The equalized annual cost for practice implementation within the subwatershed is $266,000. This total annual cost includes conservation practice expenditures of $308,000 per year and conservation practices that result in a savings of $42,000 per year. Note that the cost provided are for conservation practices only.

Feasible maximum BMP adoption targets were set using stakeholder input as shown in Table 11.2. However, targeted implementation of BMPs at these rates did not reach the 34.4% total nitrogen reduction goal nor the 29% total phosphorus reduction goal. In order to reach these nutrient reduction goals in this watershed, target adoption rates for some BMPs will need to be increased. Based on our previous experience with watershed planning in Iowa, cover crops and no-till appear to be palatable BMPs to stakeholders, generally, so our recommendation is to pursue increased implementation of these two practices. **For reference, to reach the goals in this watershed we have estimated that an additional 4,888 acres of cover crops ($240,000/yr) and 1,278 acres of no-till ($15,000/yr) would be required above and beyond what is shown in Table 11.9.**

Table 11.9. BMP Adoption for East Beaver Creek Subwatershed

BMP Name	Existing Adoption Rate (%)	Target Adoption Rate (%)	Quantity	Equalized Annual Cost (Savings) [$/yr]
Cover crops	1%	2%	75 acres	$1,682
Extended rotations	1%	2%	75 acres	$1,030
Nitrogen management: nitrification inhibitor	75%	95%	1504 acres	($2,059)
Nitrogen management: rate control	5%	8%	188 acres	($172)
Nitrogen management: source control	10%	10%	0 acres	$0
Nitrogen management: timing control	35%	53%	1316 acres	($12,011)
Phosphorus management: placement control	5%	8%	196 acres	$1,338
Phosphorus management: rate control	25%	38%	978 acres	($4,907)
Phosphorus management: source control	10%	10%	0 acres	$0
Contour buffer strips	0%	20%	2 miles	$1,065
Terraces	100%	100%	0 miles	$0
Drainage water management	0%	50%	33 fields	$5,933
Grassed waterways	100%	100%	0 miles	$0
No-Till	5%	10%	376 acres	$2,059
Denitrifying bioreactors	0%	25%	10 reactors	$2,282
Nutrient removal wetlands	0%	40%	2 wetlands	$6,161
Perennial cover	1%	2%	77 acres	$13,657
WASCOBs	92%	100%	1 basins	$2,028
Riparian buffer: Critical zone buffer	55%	100%	0 miles	$664
Riparian buffer: Deep-rooted vegetation buffer	55%	100%	6 miles	$7,588
Riparian buffer: Multi-species buffer	55%	100%	2 miles	$2,751
Riparian buffer: Stiff stem grass buffer	55%	100%	1 miles	$1,043
Riparian buffer: Stream stabilization buffer	55%	100%	3 miles	$4,648
Saturated buffers	0%	50%	8 miles	$86,768

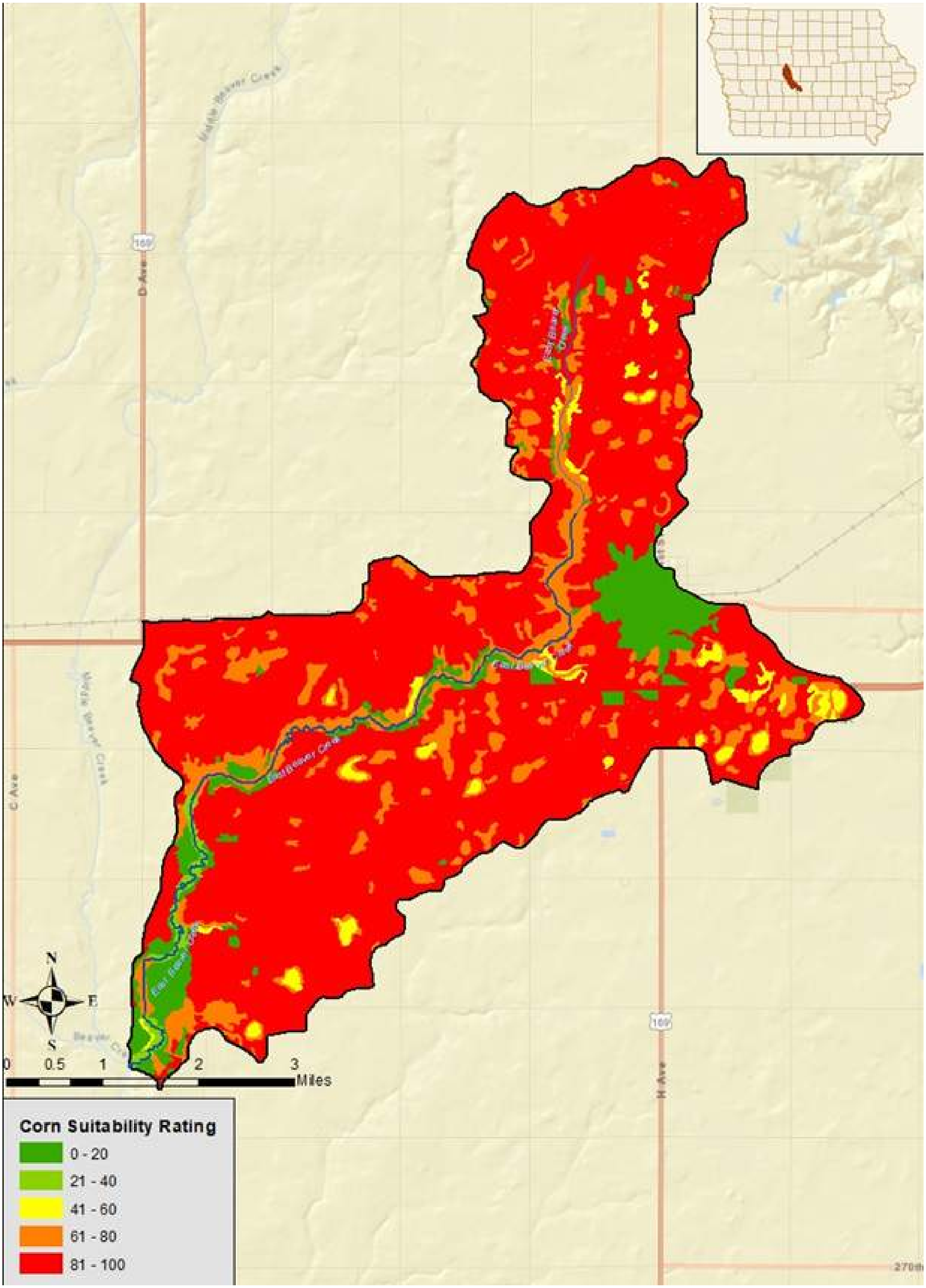
RANK	Mean CSR	Basin Size (HA)	Drainage Area (HA)
1	87.35	0.96	103.29
RANK	Mean CSR	Basin Size (HA)	Drainage Area (HA)
2	88.48	0.94	78.53
3	89.01	0.57	64.58
4	89.77	3.79	248.60

Table 11.9a. Properties of watersheds to each site location
(HA = hectacres = 100 acres)

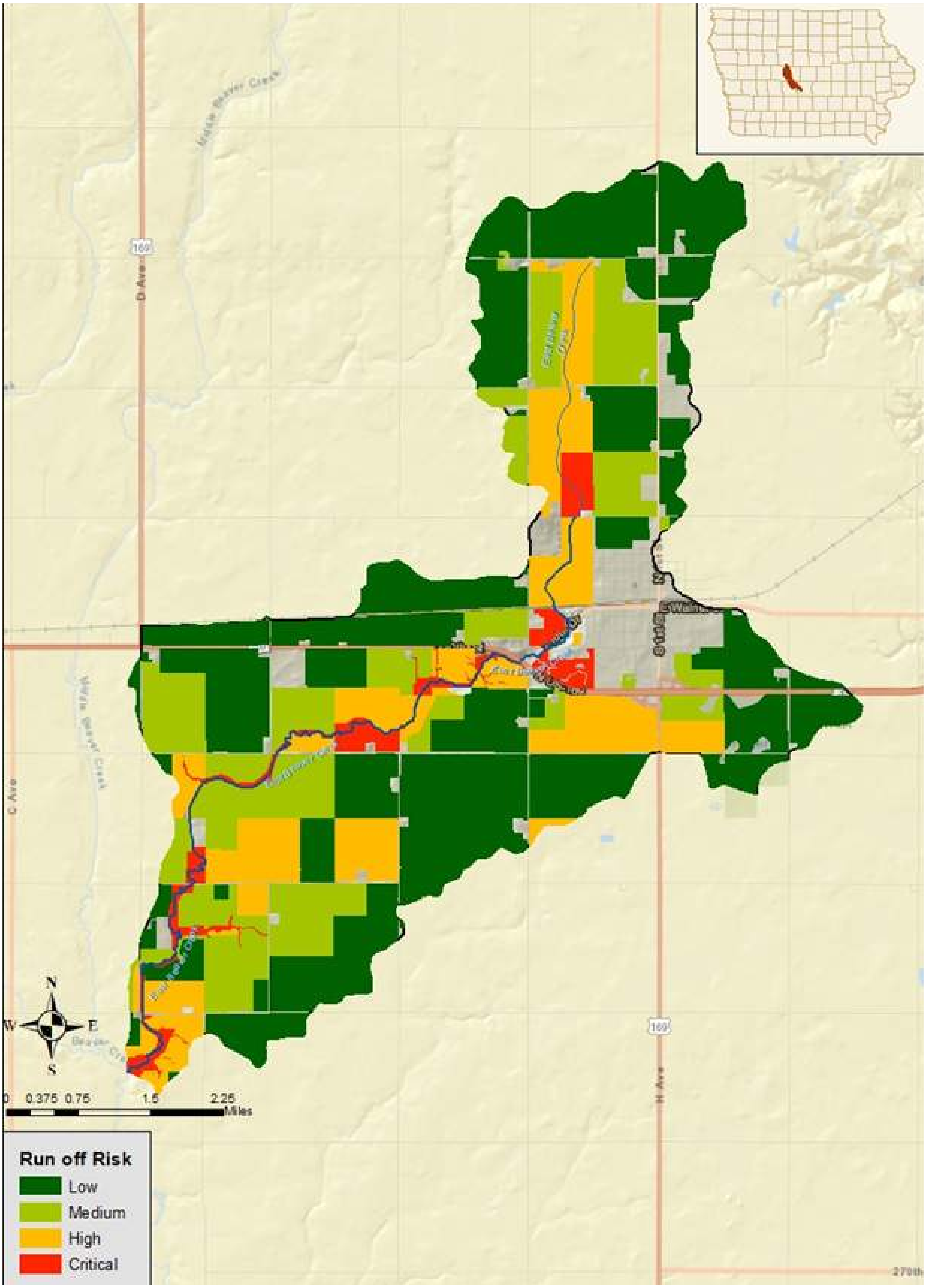
Grouping	Implement first
1	1
Grouping	Implement first
2	2

Table 11.9b. - Recommended prioritaztion list

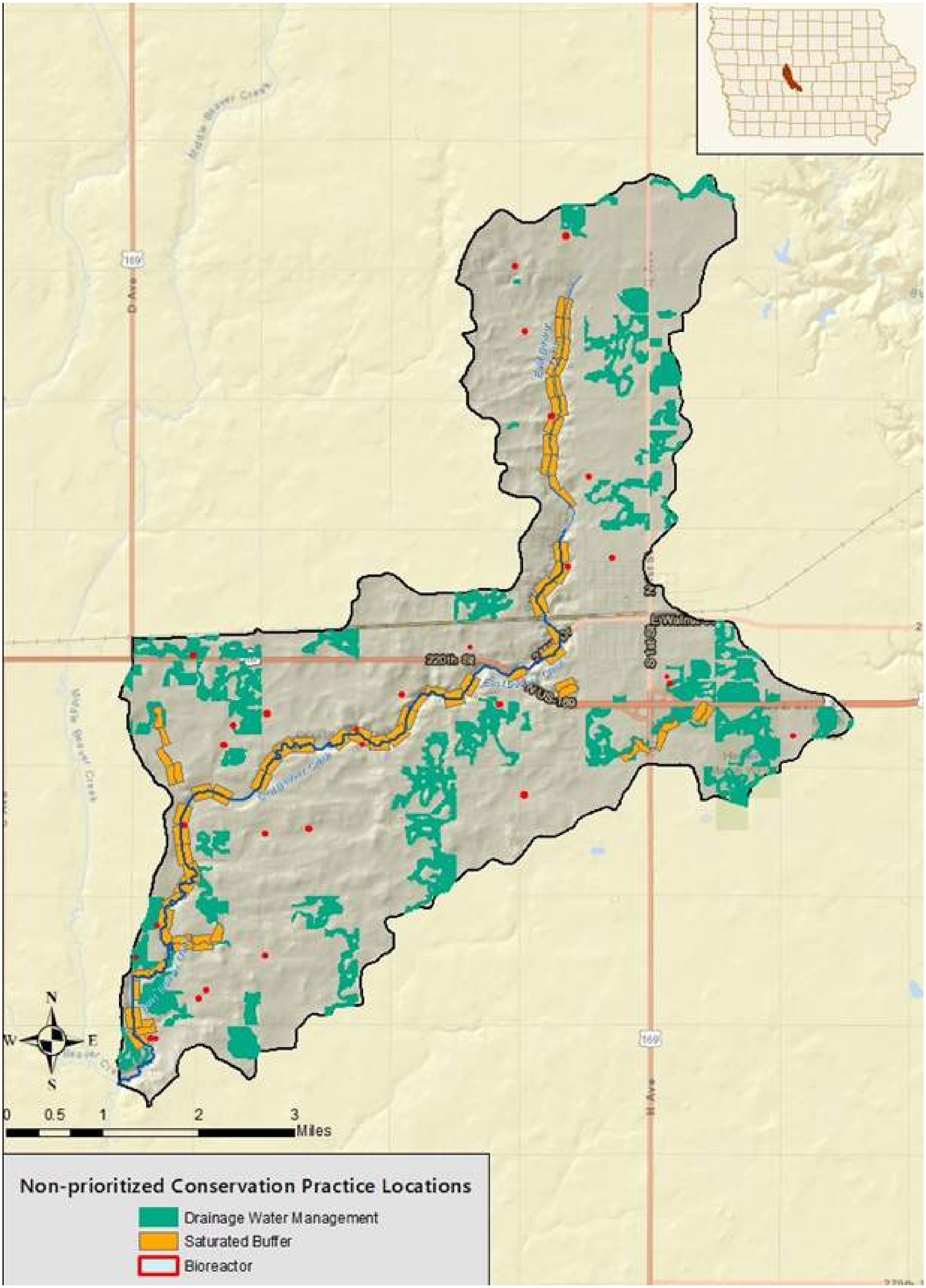
Tables 11.9a and 11.9b refer to East Beaver Creek Subwatershed Map 5 on page 244



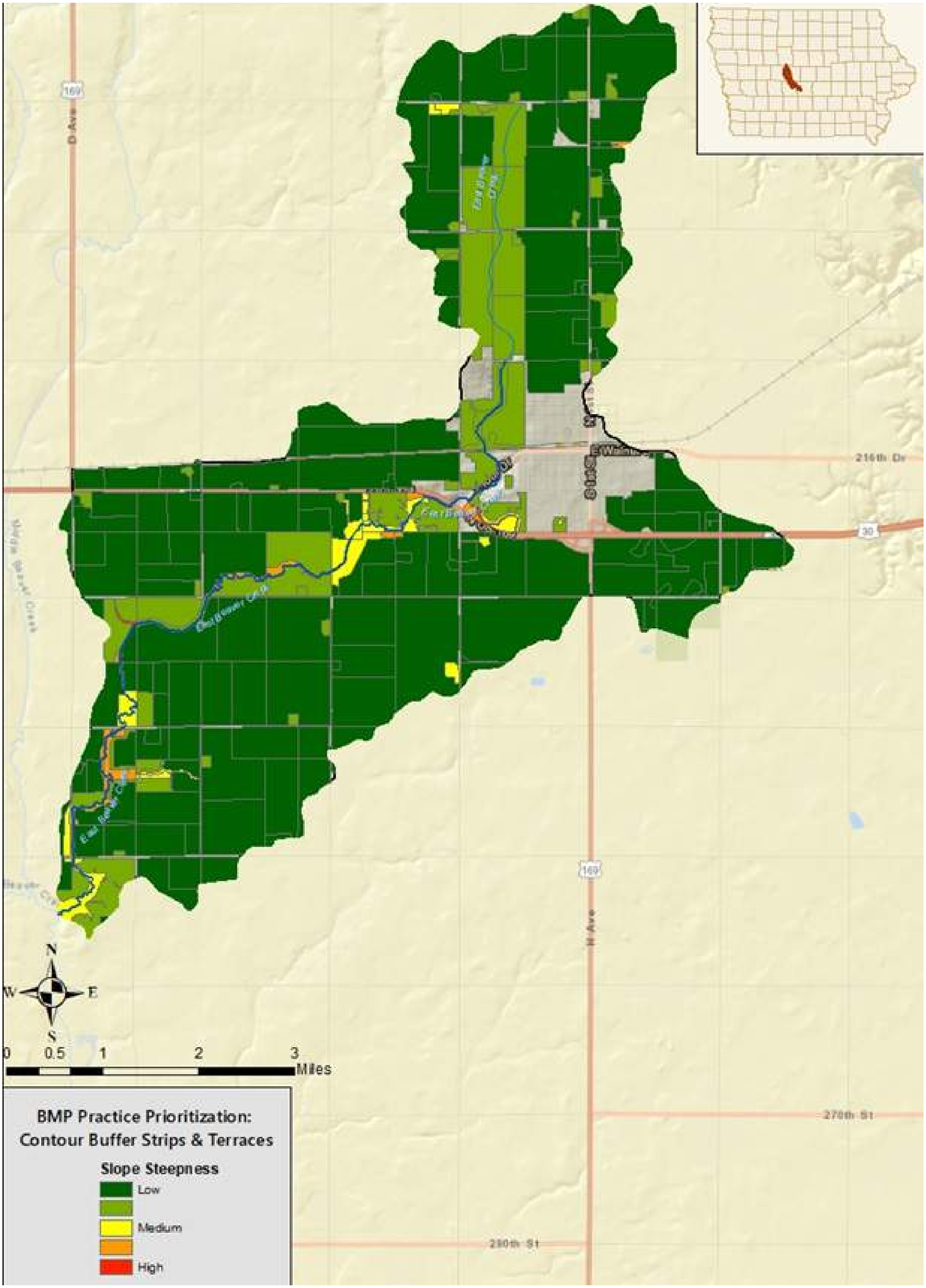
East Beaver Creek Subwatershed - Map 1



East Beaver Creek Subwatershed - Map 2

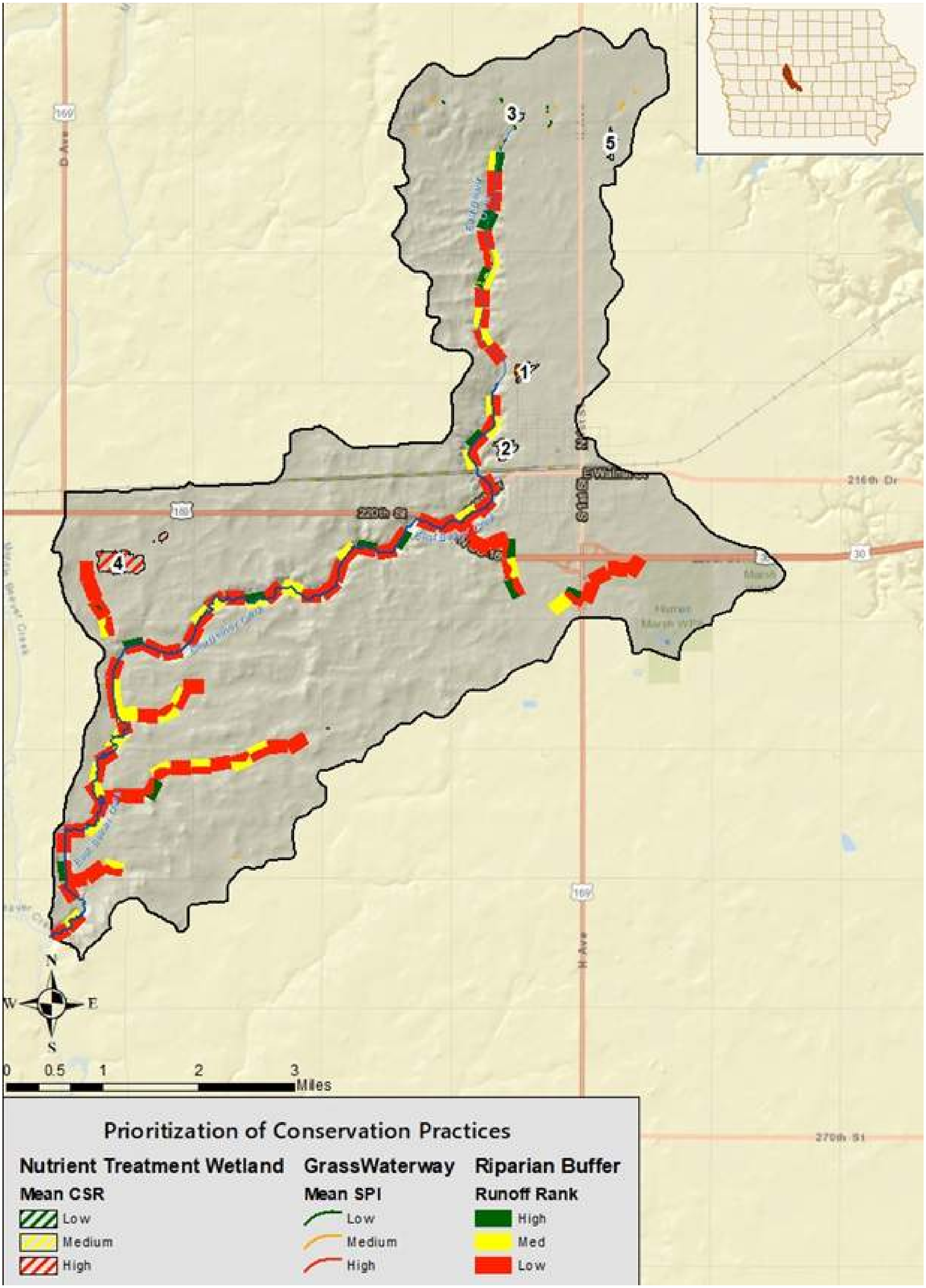


East Beaver Creek Subwatershed - Map 3

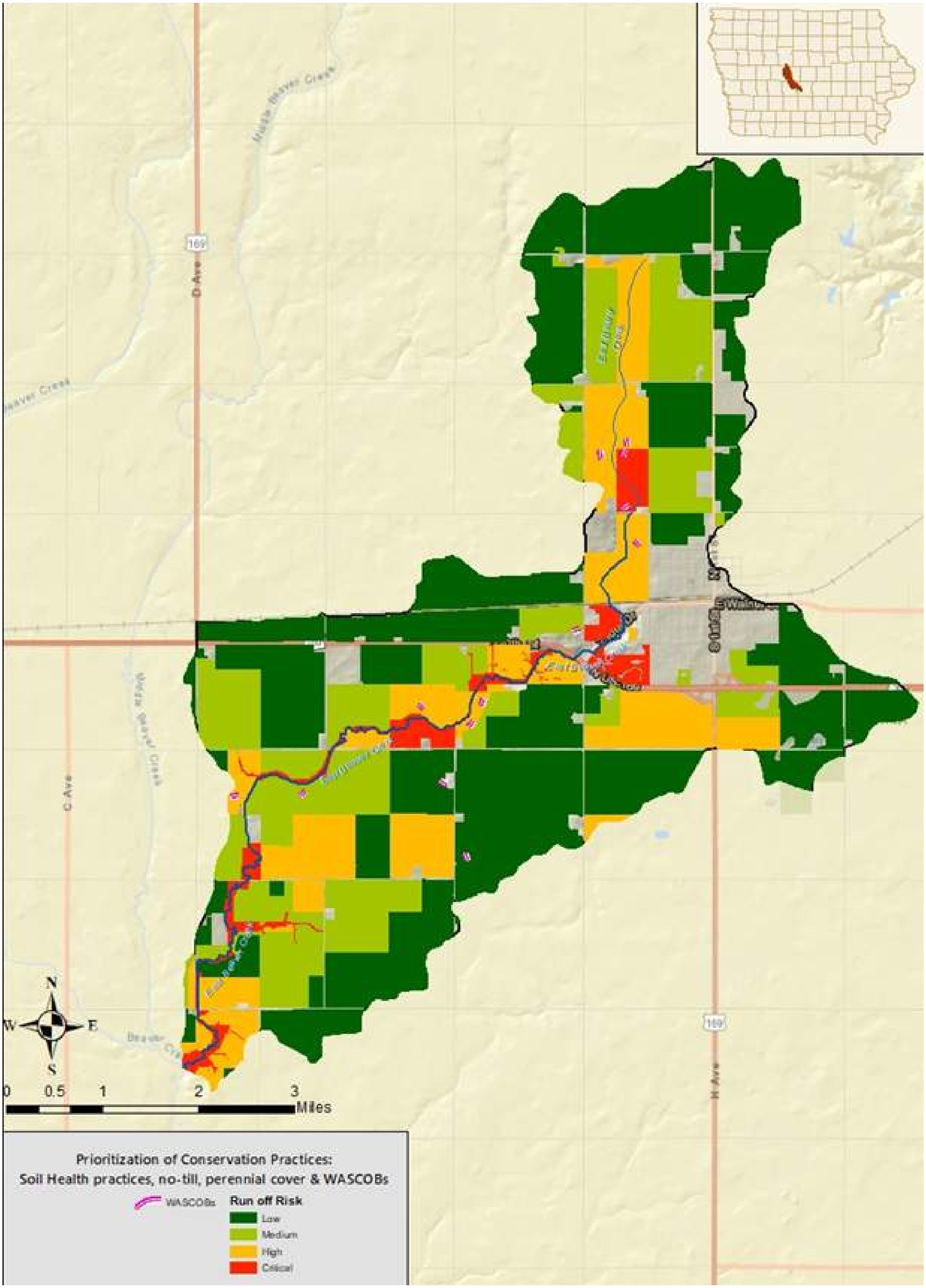


East Beaver Creek Subwatershed - Map 4

Refer to page 239 for wetland size and prioritization



East Beaver Creek Subwatershed - Map 5



East Beaver Creek Subwatershed - Map 6

Headwaters Beaver Creek

The specific conservation scenario developed for the Headwaters Beaver Creek Subwatershed is shown in Table 11.10. The table indicates the recommended adoption rate of each practice with the corresponding acreage or quantity and the total implementation over a 20 year period for meeting targets for Nitrogen and Phosphorus for the Beaver Creek Watershed. The conservation practice scenario was developed through an iterative process using a cost-benefit analysis that is described in the Middle Cedar Watershed Management Plan. The equalized annual cost for practice implementation within the subwatershed is $794,000. This total annual cost includes conservation practice expenditures of $899,000 per year and conservation practices that result in a savings of $105,000 per year. Note that the cost provided are for conservation practices only.

Feasible maximum BMP adoption targets were set using stakeholder input as shown in Table 11.2. However, targeted implementation of BMPs at these rates did not reach the 34.4% total nitrogen reduction goal nor the 29% total phosphorus reduction goal. In order to reach these nutrient reduction goals in this watershed, target adoption rates for some BMPs will need to be increased. Based on our previous experience with watershed planning in Iowa, cover crops and no-till appear to be palatable BMPs to stakeholders, generally, so our recommendation is to pursue increased implementation of these two practices. **For reference, to reach the goals in this watershed we have estimated that an additional 7,434 acres of cover crops ($364,000/yr) and 1,278 acres of no-till ($23,000/yr) would be required above and beyond what is shown in Table 11.10.**

Table 11.10. BMP Adoption for Headwaters Beaver Creek Subwatershed

BMP Name	Existing Adoption Rate (%)	Target Adoption Rate (%)	Quantity	Equalized Annual Cost (Savings) [$/yr]
Cover crops	1%	2%	135 acres	$3,023
Extended rotations	1%	2%	135 acres	$1,851
Nitrogen management: nitrification inhibitor	85%	95%	1352 acres	($1,851)
Nitrogen management: rate control	5%	8%	338 acres	($308)
Nitrogen management: source control	10%	10%	0 acres	$0
Nitrogen management: timing control	65%	95%	4055 acres	($37,011)
Phosphorus management: placement control	5%	8%	351 acres	$2,406
Phosphorus management: rate control	25%	38%	1757 acres	($8,821)
Phosphorus management: source control	10%	10%	0 acres	$0
Contour buffer strips	0%	20%	6 miles	$3,024
Terraces	95%	95%	0 miles	$0
Drainage water management	0%	50%	113 fields	$20,537
Grassed waterways	100%	100%	0 miles	$0
No-Till	5%	10%	676 acres	$3,701
Denitrifying bioreactors	0%	25%	26 reactors	$5,876
Nutrient removal wetlands	0%	40%	2 wetlands	$7,393
Perennial cover	1%	2%	138 acres	$24,548
WASCOBs	63%	79%	9 basins	$18,316
Riparian buffer: Critical zone buffer	60%	100%	0 miles	$420
Riparian buffer: Deep-rooted vegetation buffer	60%	100%	17 miles	$22,747
Riparian buffer: Multi-species buffer	60%	100%	7 miles	$9,401
Riparian buffer: Stiff stem grass buffer	60%	100%	1 miles	$1,931
Riparian buffer: Stream stabilization buffer	60%	100%	5 miles	$6,967
Saturated buffers	0%	50%	25 miles	$278,346
				Headwaters Beaver Creek

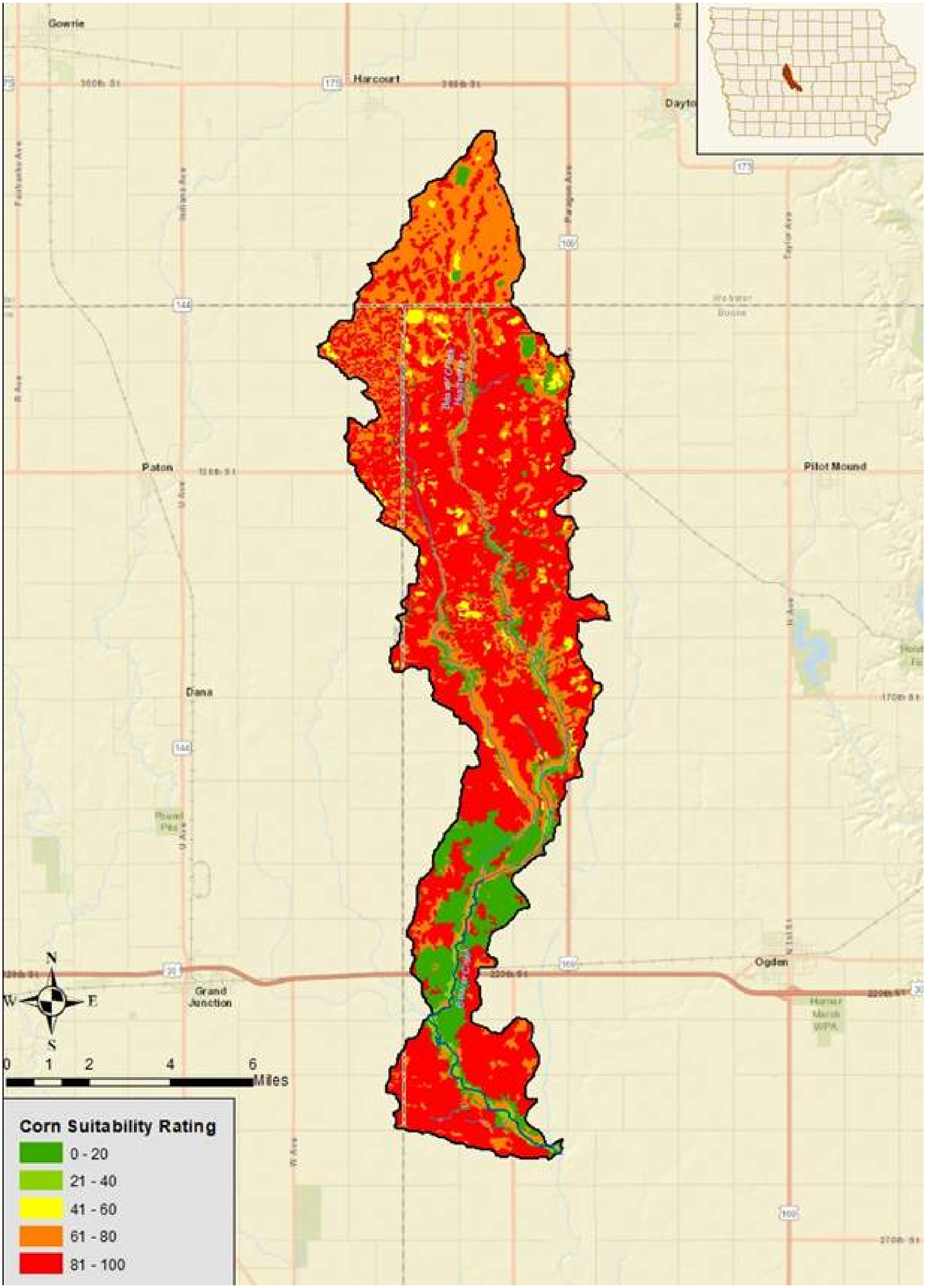
RANK	Mean CSR	Basin Size (HA)	Drainage Area (HA)
1	28.55	1.21	73.44
2	51.98	0.80	139.42
3	71.88	0.57	84.36
4	74.27	1.34	70.70

Table 11.10a. Properties of watersheds to each site location (HA = hectacres = 100 acres)

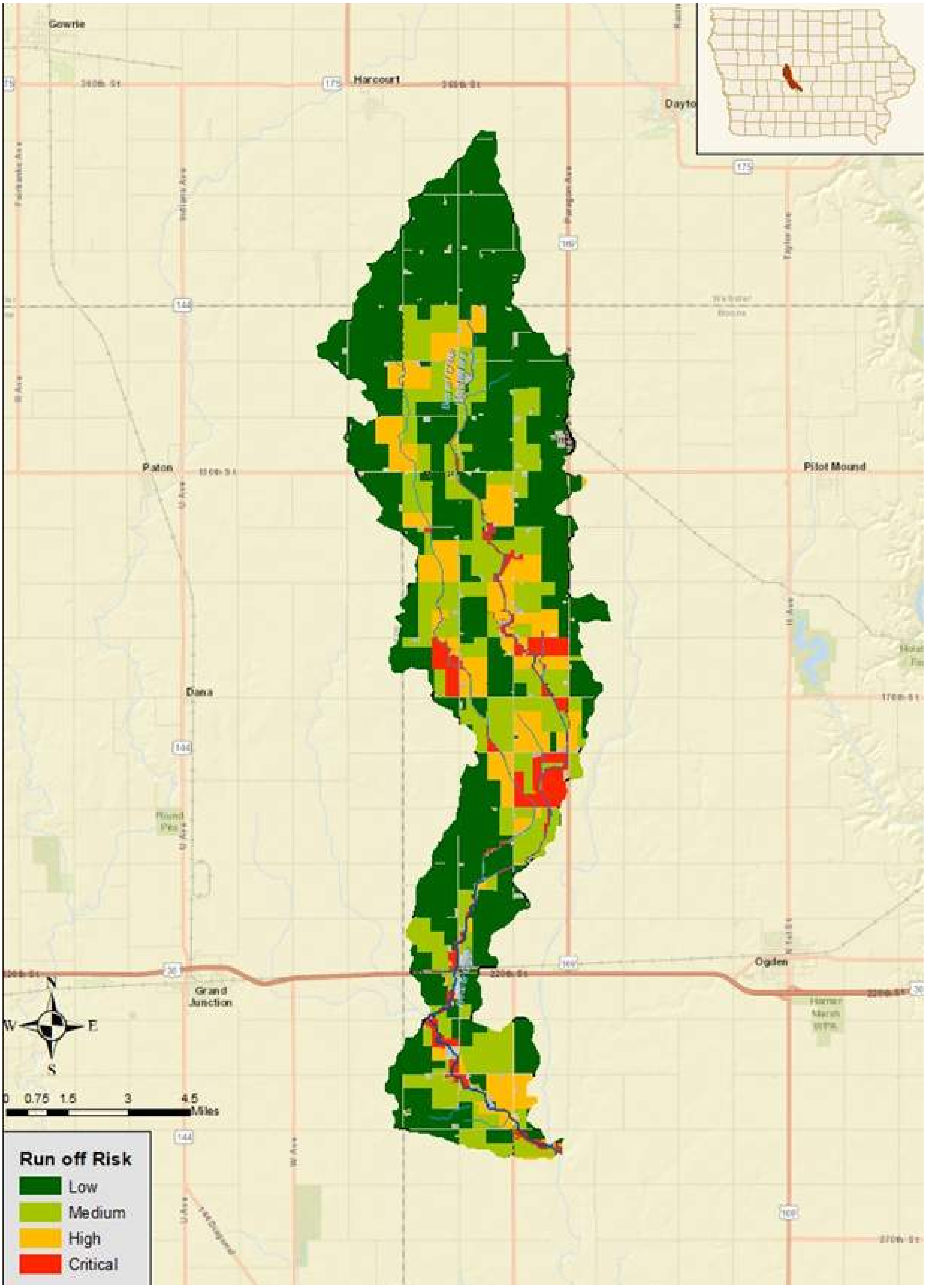
Grouping	Implement first
1	1
2	2
3	3
4	4

Table 11.10b. - Recommended prioritaztion list

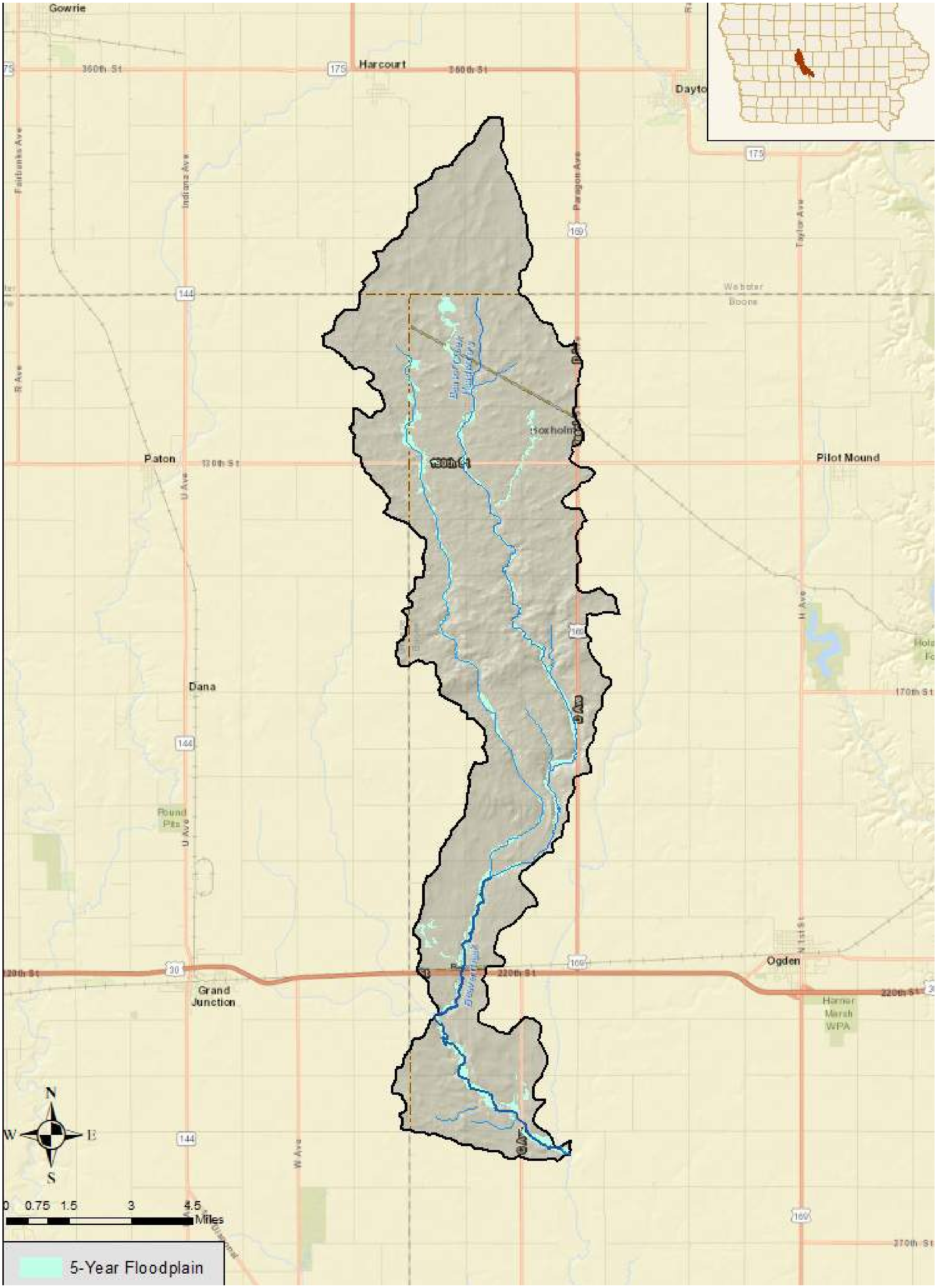
Tables 11.10a and 11.10b refer to Headwaters Beaver Creek Subwatershed Map 5 on page 252



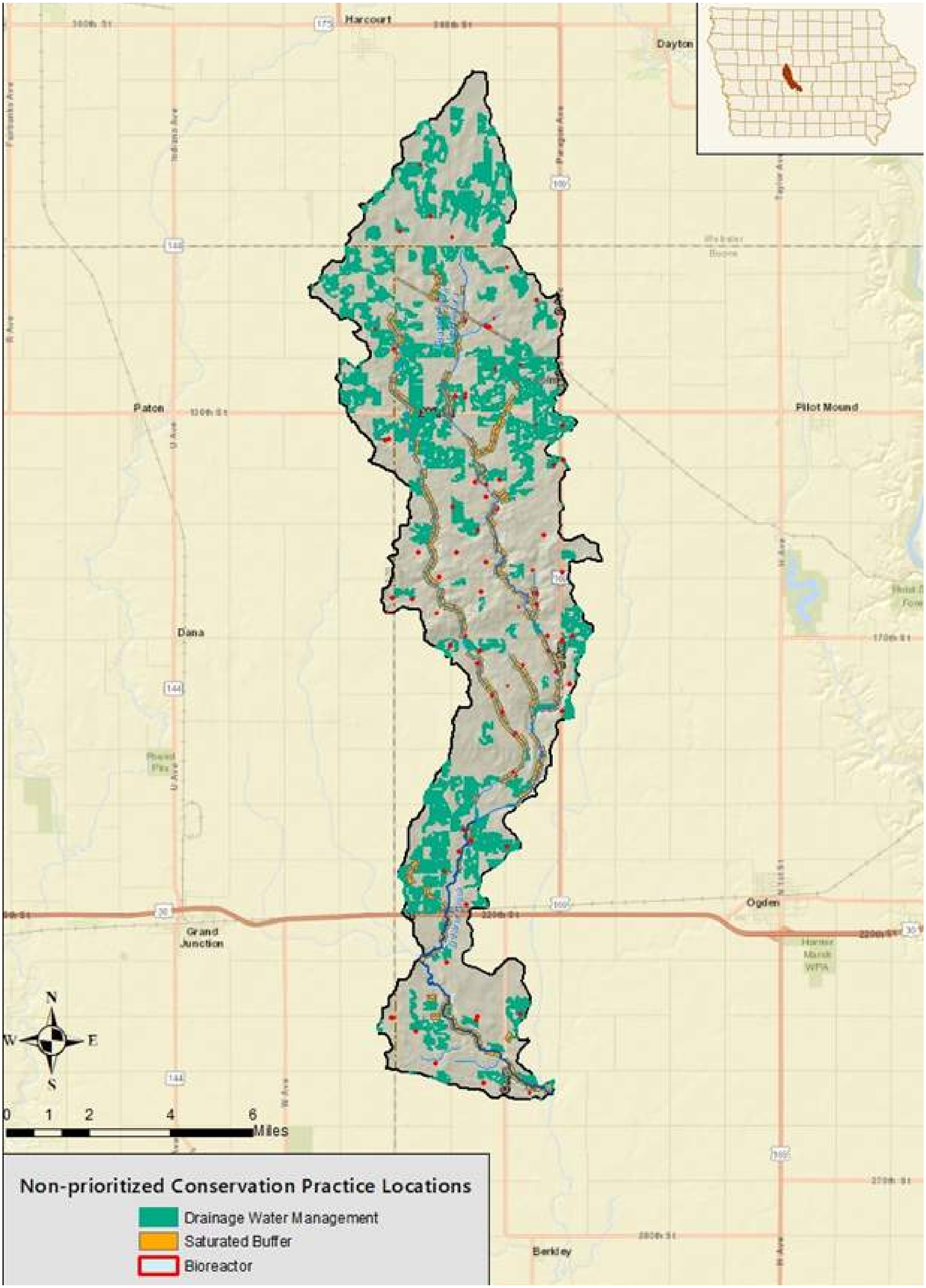
Headwaters Beaver Creek Subwatershed - Map 1



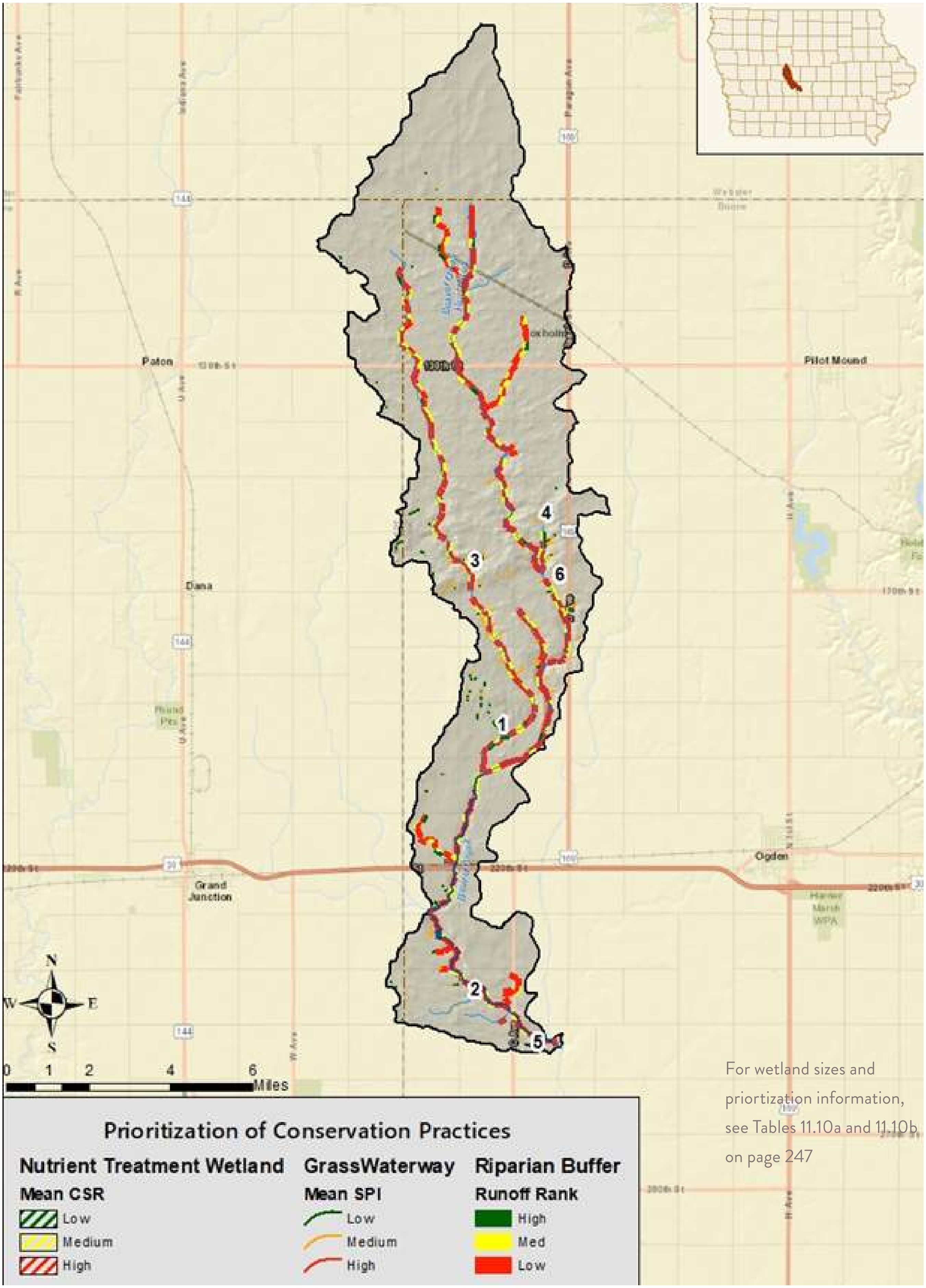
Headwaters Beaver Creek Subwatershed - Map 2



Headwaters Beaver Creek Subwatershed - Map 3

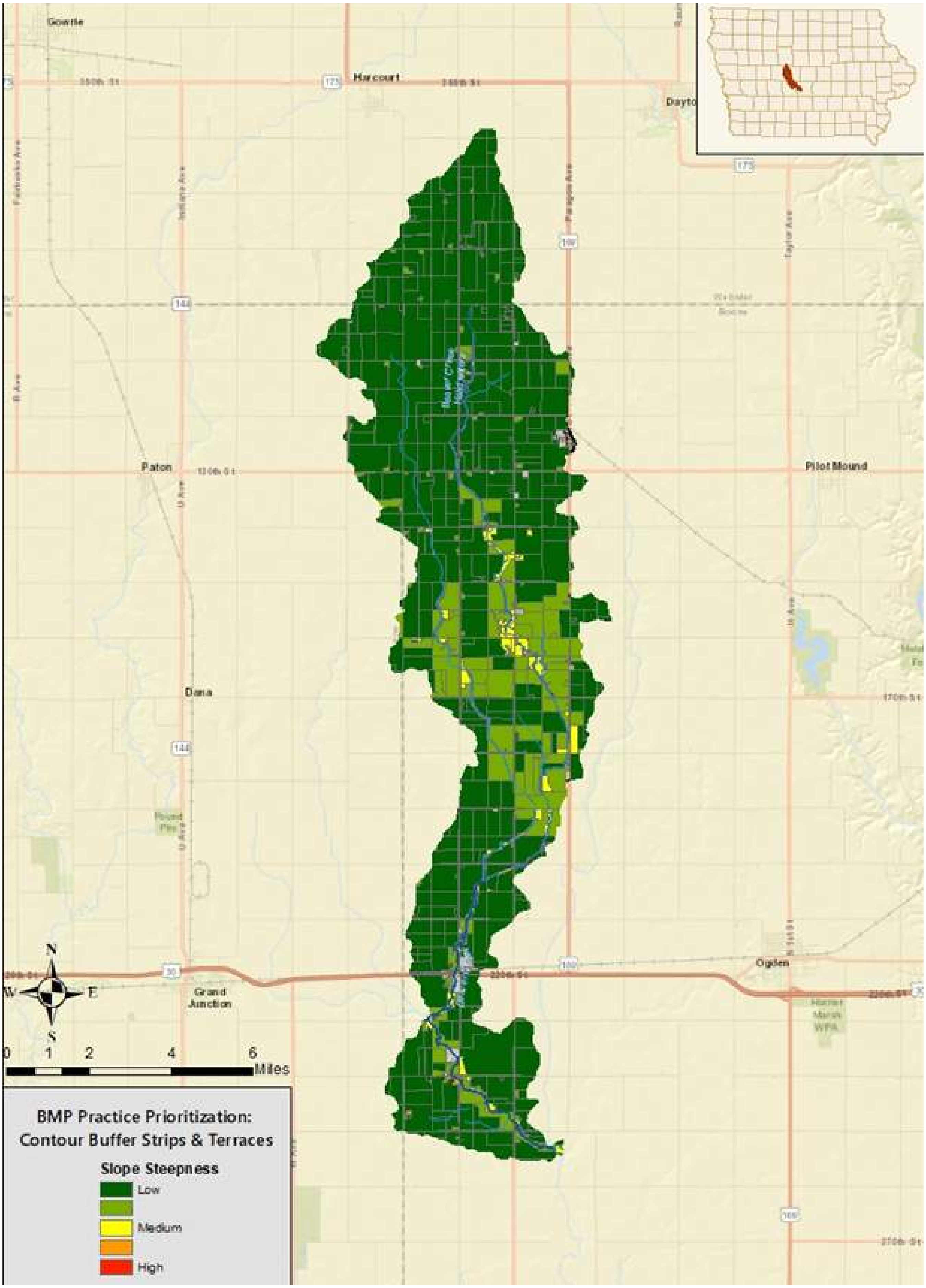


Headwaters Beaver Creek Subwatershed - Map 4

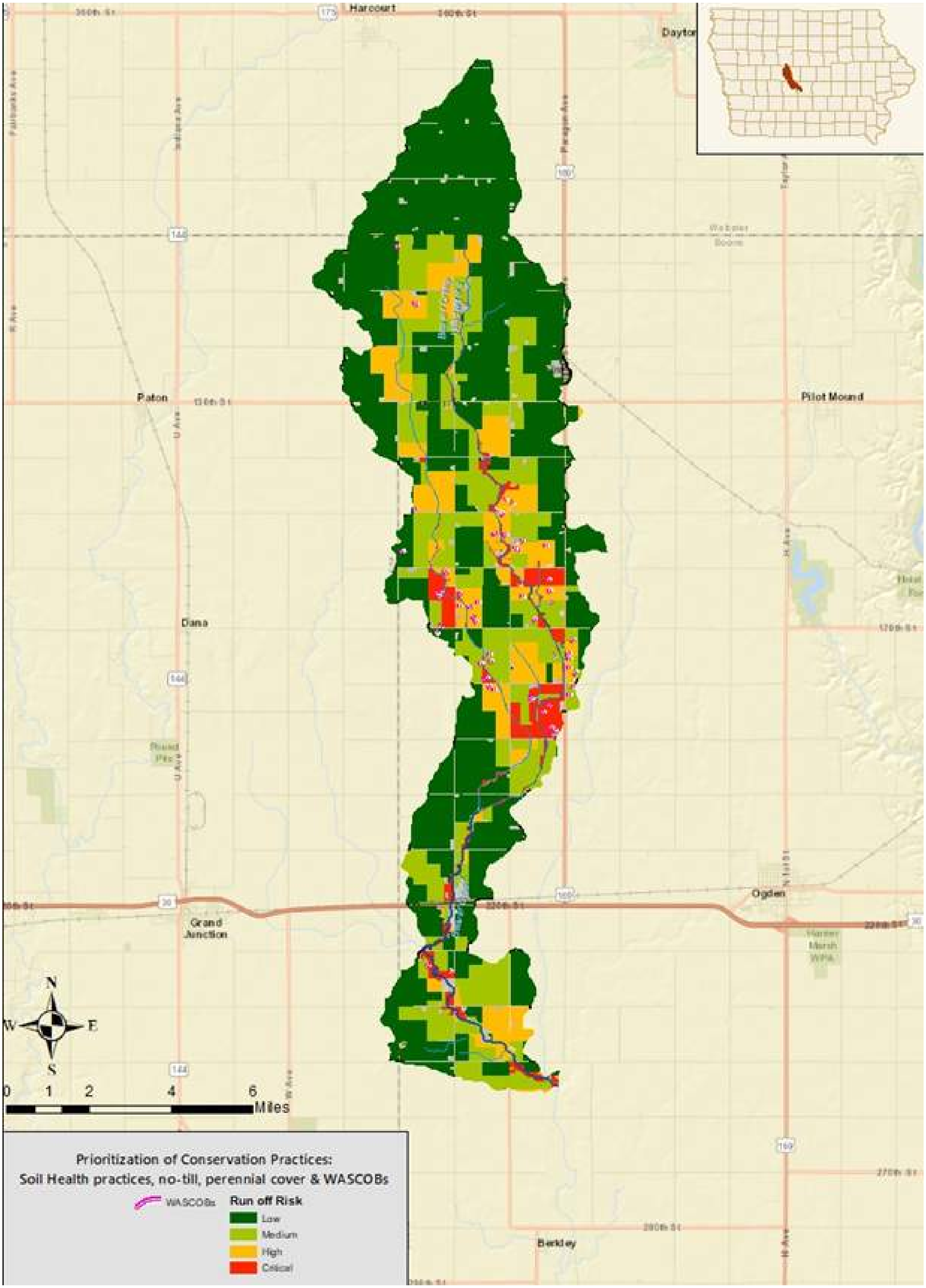


For wetland sizes and priortization information, see Tables 11.10a and 11.10b on page 247

Headwaters Beaver Creek Subwatershed - Map 5



Headwaters Beaver Creek Subwatershed - Map 6



Headwaters Beaver Creek Subwatershed - Map 7

Beaver Branch-Beaver Creek

The specific conservation scenario developed for the Beaver Branch-Beaver Creek Subwatershed is shown in Table 11.11. The table indicates the recommended adoption rate of each practice with the corresponding acreage or quantity and the total implementation over a 20 year period for meeting targets for Nitrogen and Phosphorus for the Beaver Creek Watershed. The conservation practice scenario was developed through an iterative process using a cost-benefit analysis that is described in the Middle Cedar Watershed Management Plan. The equalized annual cost for practice implementation within the subwatershed is $541,000. This total annual cost includes conservation practice expenditures of $676,000 per year and conservation practices that result in a savings of $135,000 per year. Note that the cost provided are for conservation practices only.

Feasible maximum BMP adoption targets were set using stakeholder input as shown in Table 11.2. However, targeted implementation of BMPs at these rates did not reach the 34.4% total nitrogen reduction goal nor the 29% total phosphorus reduction goal. In order to reach these nutrient reduction goals in this watershed, target adoption rates for some BMPs will need to be increased. Based on our previous experience with watershed planning in Iowa, cover crops and no-till appear to be palatable BMPs to stakeholders, generally, so our recommendation is to pursue increased implementation of these two practices. **For reference, to reach the goals in this watershed we have estimated that an additional 15,745 acres of cover crops ($772,000/yr) and 1175 acres of no-till ($14,000/yr) would be required above and beyond what is shown in Table 11.11.**

Table 11.11a. Properties of watersheds to each site location (HA = hectacres = 100 acres)

RANK	Mean CSR	Basin Size (HA)	Drainage Area (HA)
1	33.61	3.68	211.58
2	44.55	1.31	165.89
3	83.46	6.78	339.29
4	84.54	1.76	129.03
5	86.34	0.88	84.84
6	87.46	4.58	231.51
7	89.01	1.03	113.23
8	89.15	1.32	91.73
9	89.42	1.04	65.38
10	89.69	0.86	60.76
11	90.03	0.84	66.48

RANK	Mean CSR	Basin Size (HA)	Drainage Area (HA)
7	90.24	0.55	71.53
8	90.34	0.44	64.65
9	90.36	0.55	67.48
10	90.40	0.94	104.31
11	90.41	1.49	102.39
12	90.77	1.77	89.31
24	90.93	1.05	60.01
25	91.03	1.09	94.85
26	91.08	0.92	147.46
27	91.50	1.47	127.69

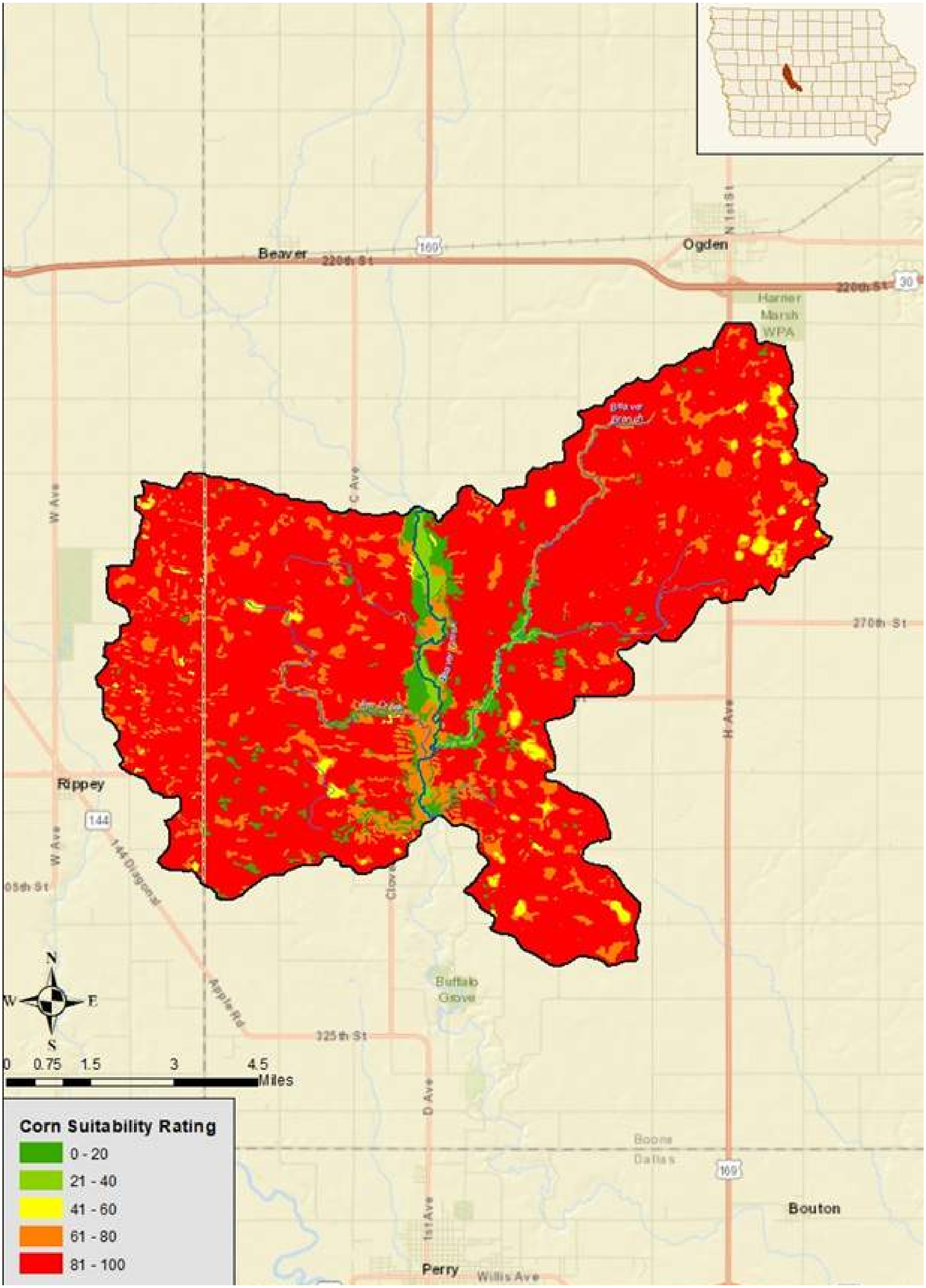
Tables 11.11a and 11.11b refer to Beaver Branch Beaver Creek Subwatershed Map 5 on page 261

BMP Name	Existing Adoption Rate (%)	Target Adoption Rate (%)	Quantity	Equalized Annual Cost (Savings) [$/yr]
Cover crops	2%	4%	470 acres	$10,510
Extended rotations	1%	2%	235 acres	$3,217
Nitrogen management: nitrification inhibitor	50%	75%	5875 acres	($8,044)
Nitrogen management: rate control	5%	8%	587 acres	($536)
Nitrogen management: source control	10%	10%	0 acres	$0
Nitrogen management: timing control	35%	53%	4112 acres	($37,537)
Phosphorus management: placement control	5%	8%	611 acres	$4,183
Phosphorus management: rate control	25%	38%	3055 acres	($15,337)
Phosphorus management: source control	10%	10%	0 acres	$0
Contour buffer strips	0%	20%	2 miles	$1,074
Terraces	100%	100%	0 miles	$0
Drainage water management	0%	50%	74 fields	$13,418
Grassed waterways	100%	100%	0 miles	$0
No-Till	10%	20%	2350 acres	$12,870
Denitrifying bioreactors	0%	25%	19 reactors	$4,279
Nutrient removal wetlands	0%	40%	8 wetlands	$25,877
Perennial cover	1%	2%	240 acres	$42,681
WASCOBs	18%	22%	1 basins	$1,501
Riparian buffer: Critical zone buffer	59%	100%	1 miles	$1,208
Riparian buffer: Deep-rooted vegetation buffer	59%	100%	17 miles	$22,954
Riparian buffer: Multi-species buffer	59%	100%	5 miles	$6,386
Riparian buffer: Stiff stem grass buffer	59%	100%	2 miles	$2,503
Riparian buffer: Stream stabilization buffer	59%	100%	6 miles	$8,198
Saturated buffers	0%	50%	13 miles	$147,764

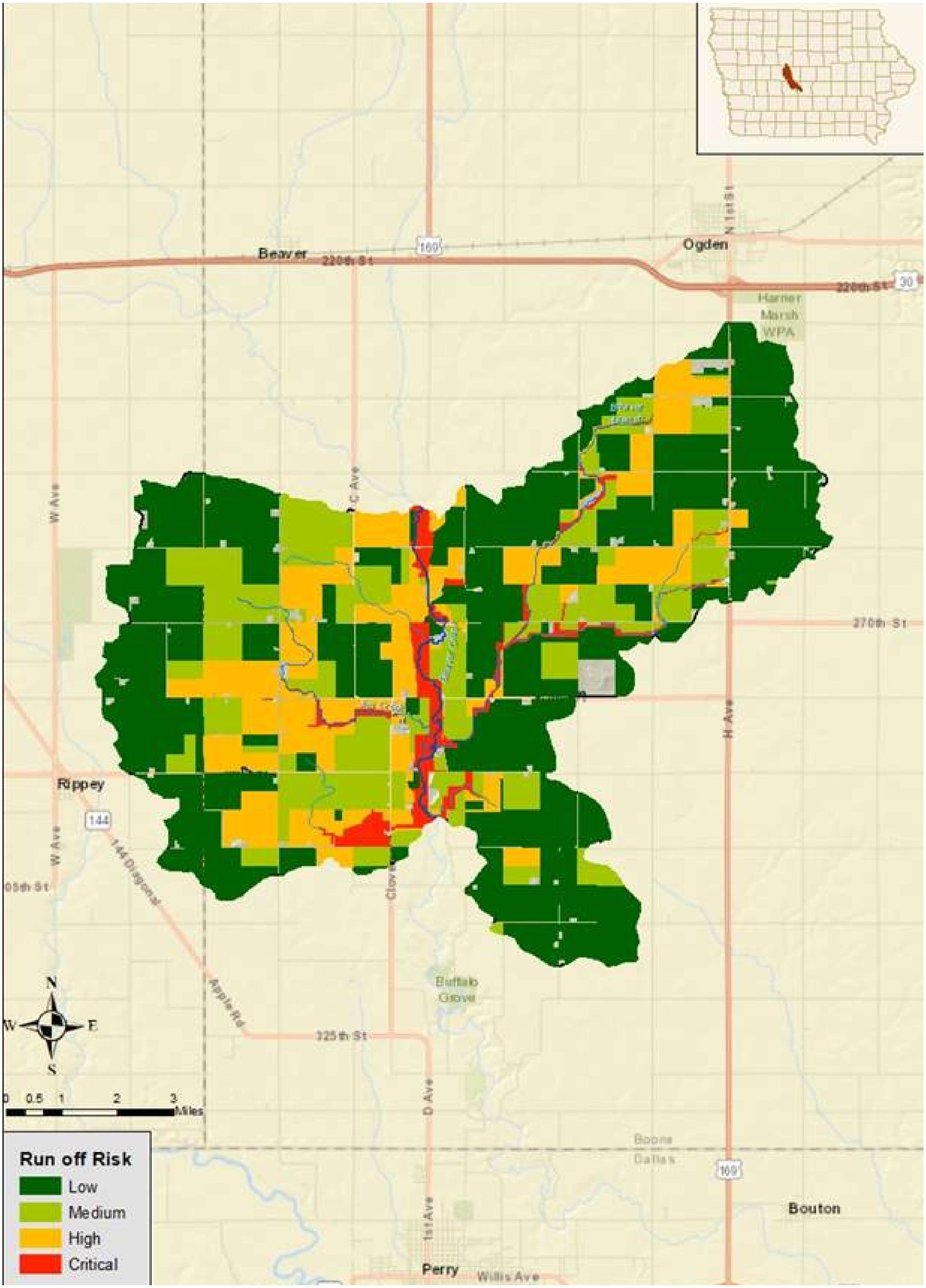
Table 11.11. BMP Adoption for Beaver Branch -Beaver Creek Subwatershed

Grouping	Implement first
1, 2	1
3, 7, 9, 12, 17, 21	3
4, 16	4
5, 6, 14	5
8	8
10	10
11, 20	11
13	13
15	15
18	18
19	19

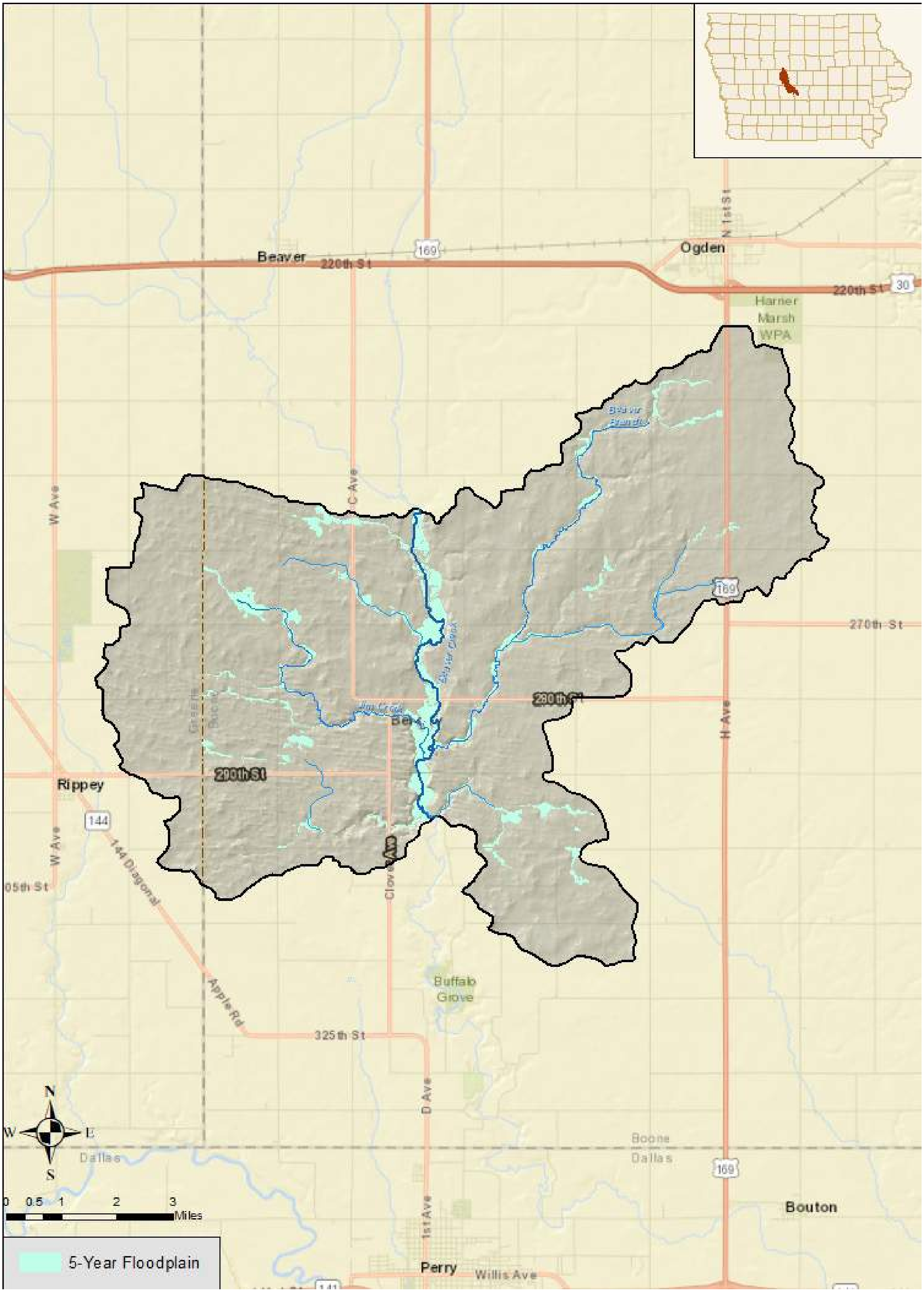
Table 11.11b. - Recommended prioritaztion list

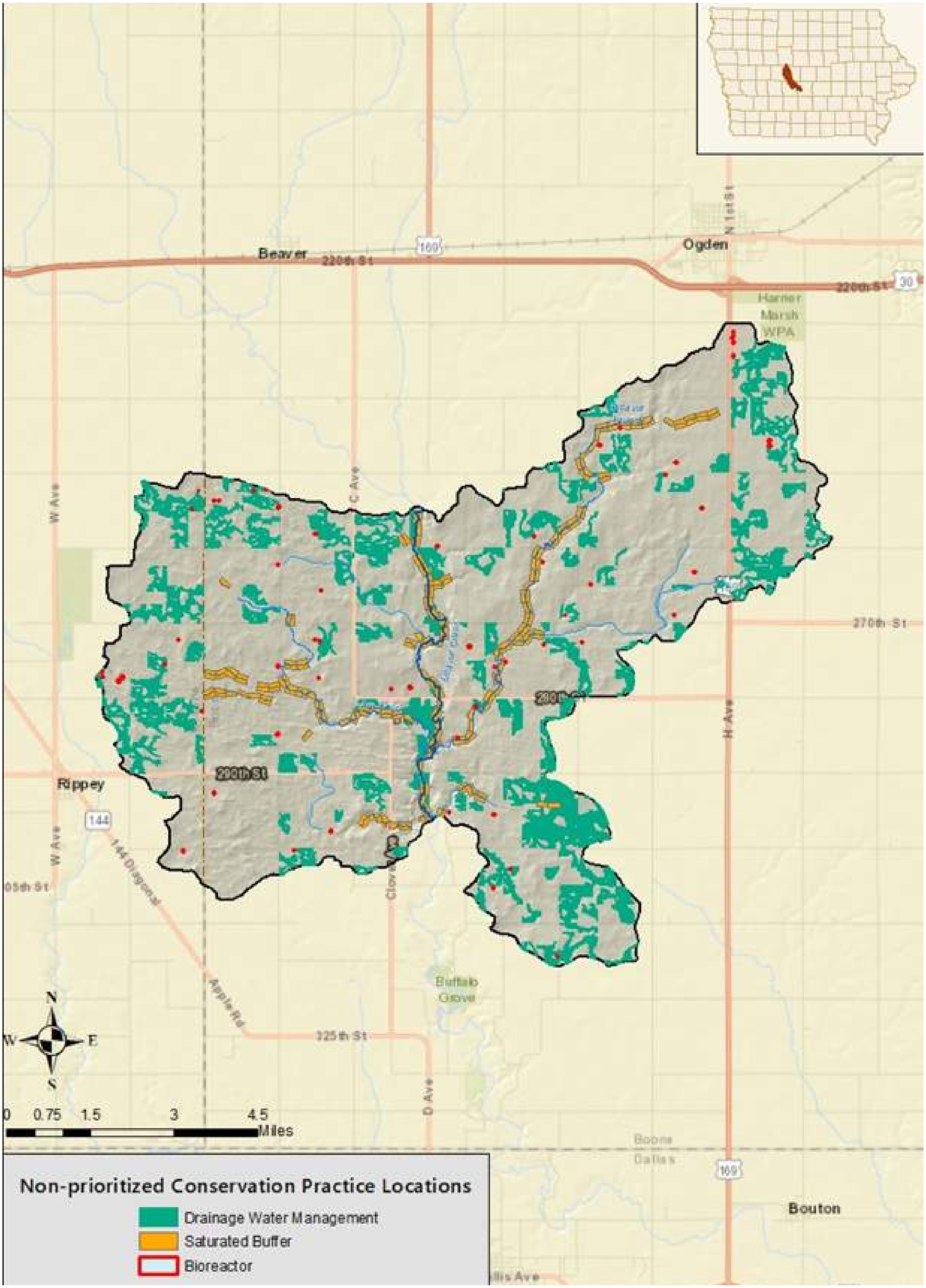


Beaver Branch - Beaver Creek Subwatershed - Map 1

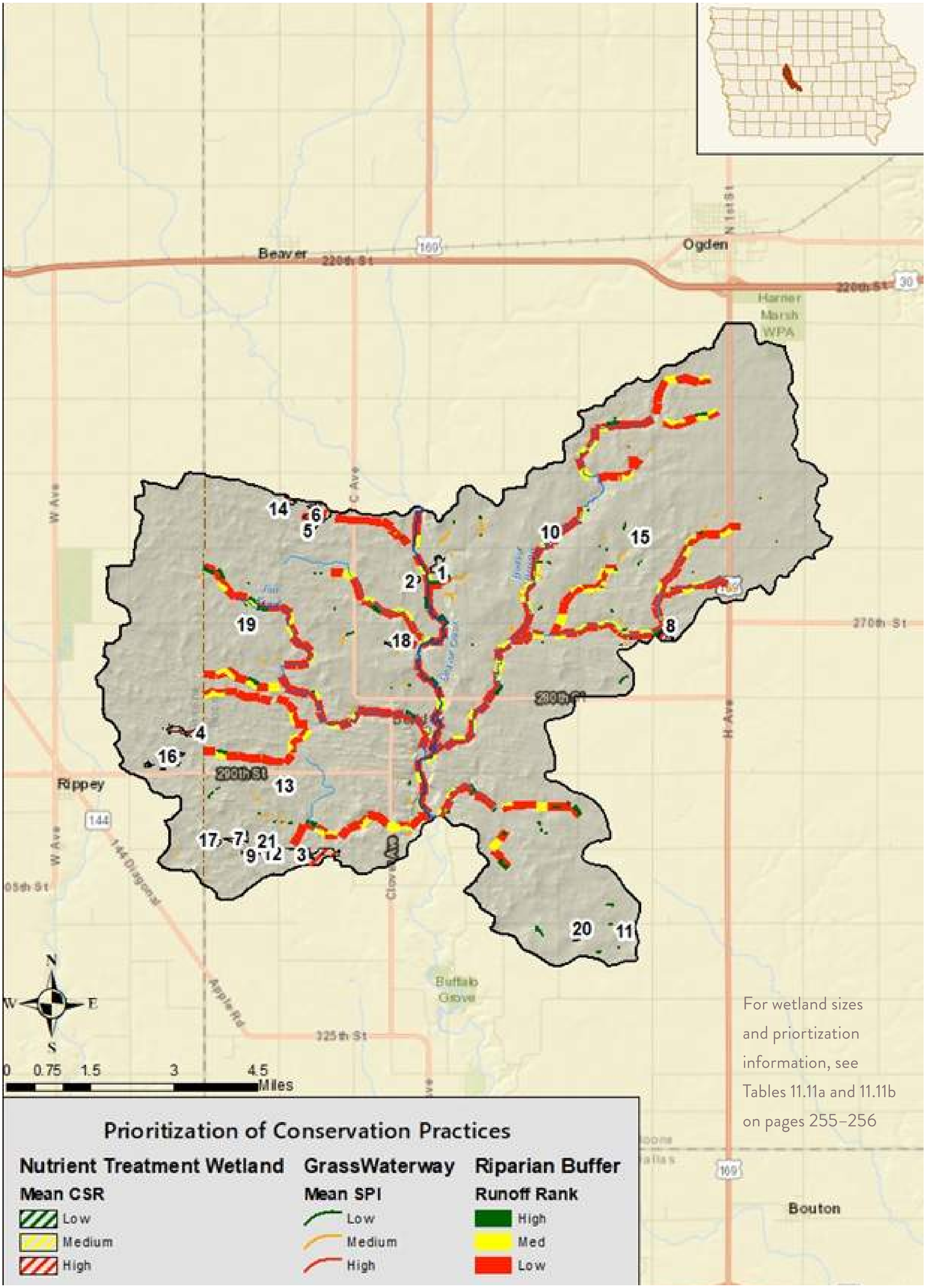


Beaver Branch - Beaver Creek Subwatershed - Map 2

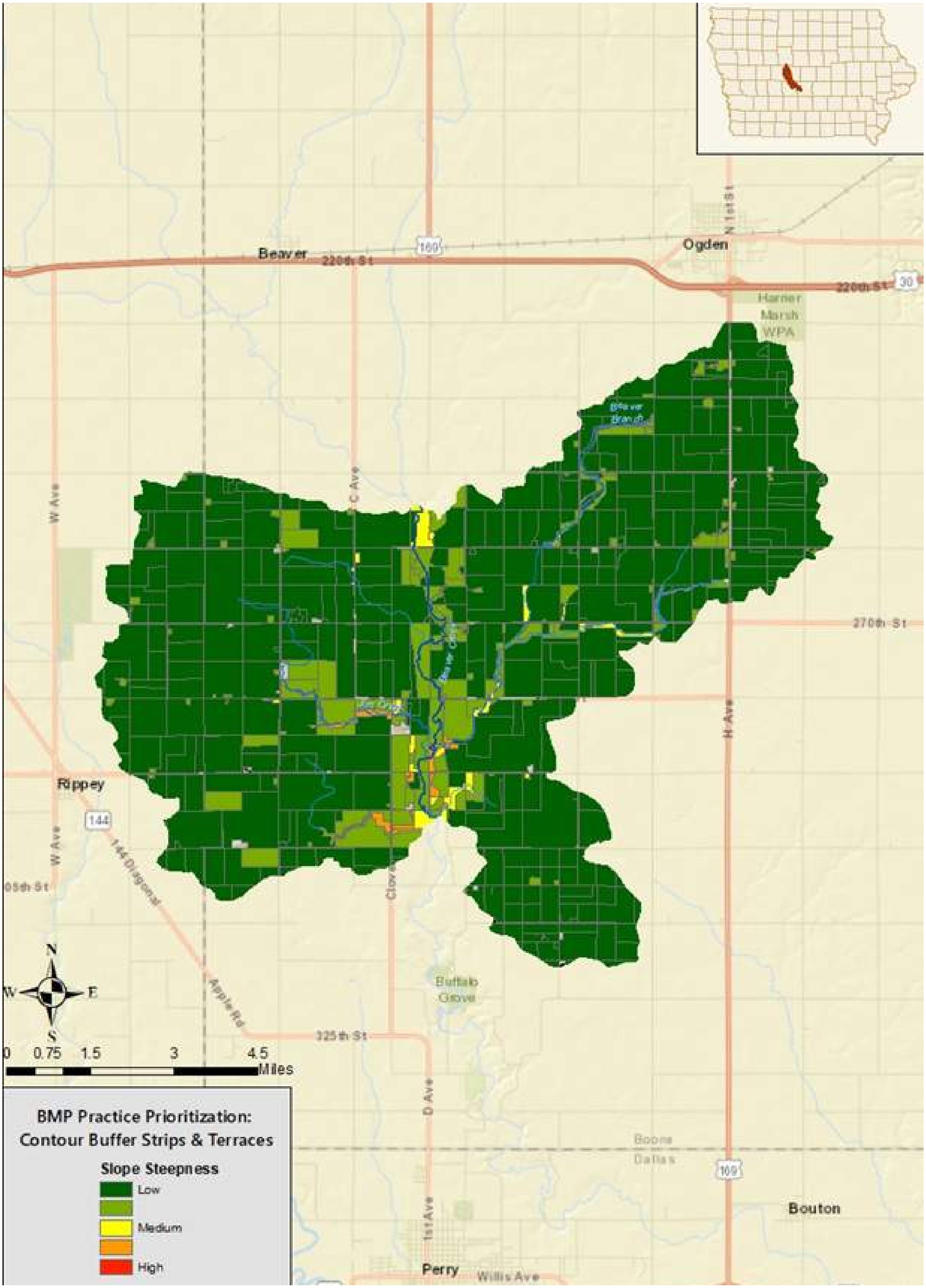

Beaver
220th St
169
Ogden
N 1st St
220th St
30
Harner
Marsh
WPA
Beaver
Branch
C Ave
W Ave
169
270th St
Beaver Creek
280th St
H Ave
290th St
Rippey
144
144 Diagonal
Clover Ave
05th St
Buffalo
Grove
Apple Rd
325th St
D Ave
N
W
E
S
Dallas
Boone
Dallas
169
0 0.5 1 2 3
Miles
Bouton
1st Ave
5-Year Floodplain
Perry
Willis Ave



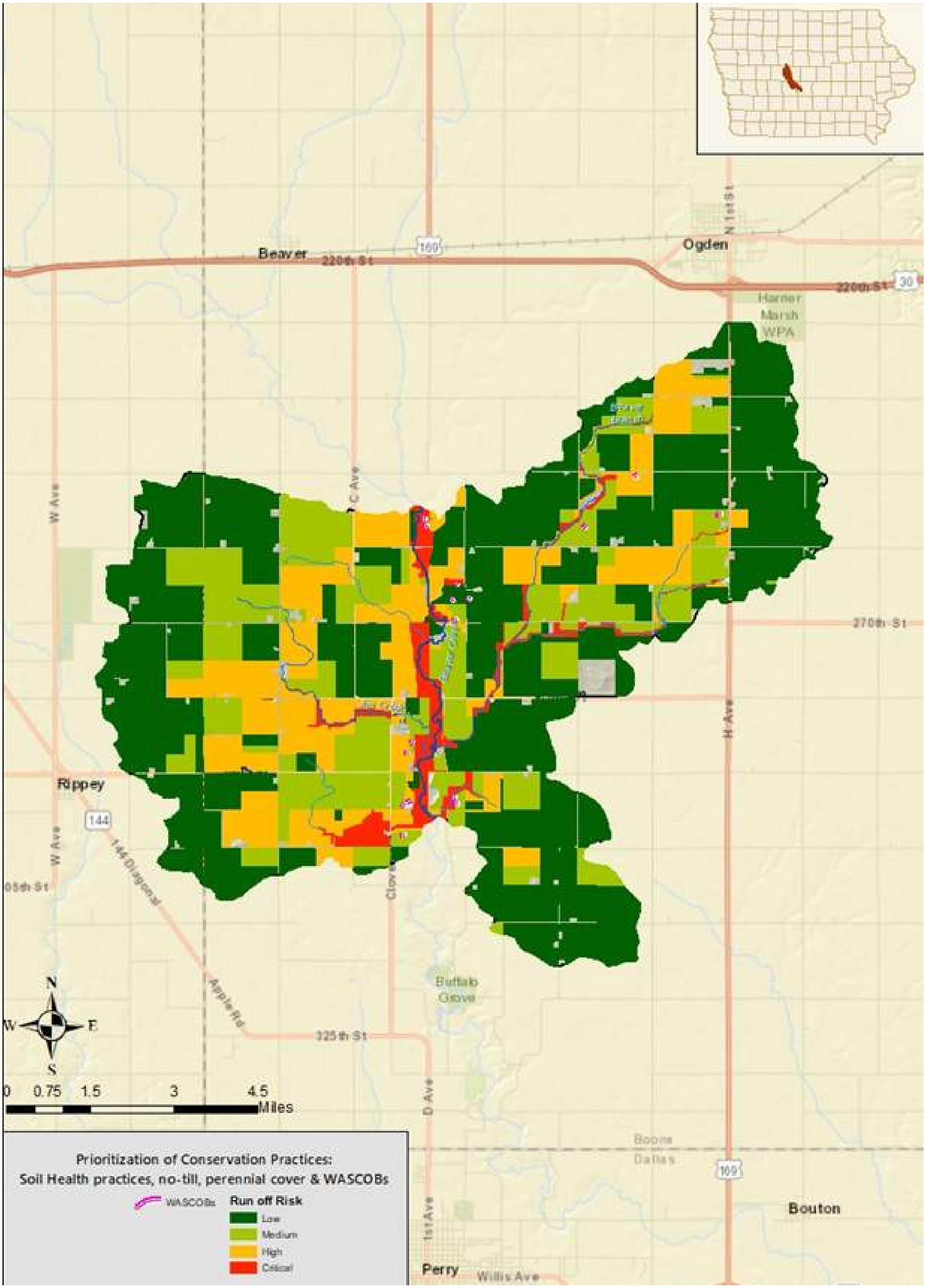
Beaver Branch - Beaver Creek Subwatershed - Map 4



For wetland sizes and priortization information, see Tables 11.11a and 11.11b on pages 255–256



Beaver Branch - Beaver Creek Subwatershed - Map 6



Beaver Branch - Beaver Creek Subwatershed - Map 7

Slough Creek

The specific conservation scenario developed for the Slough Creek Subwatershed is shown in Table 11.12. The table indicates the recommended adoption rate of each practice with the corresponding acreage or quantity and the total implementation over a 20 year period for meeting targets for Nitrogen and Phosphorus for the Beaver Creek Watershed. The conservation practice scenario was developed through an iterative process using a cost-benefit analysis that is described in the Middle Cedar Watershed Management Plan. The equalized annual cost for practice implementation within the subwatershed is $417,000. This total annual cost includes conservation practice expenditures of $537,000 per year and conservation practices that result in a savings of $120,000 per year. Note that the cost provided are for conservation practices only.

Feasible maximum BMP adoption targets were set using stakeholder input as shown in Table 11.2. However, targeted implementation of BMPs at these rates did not reach the 34.4% total nitrogen reduction goal nor the 29% total phosphorus reduction goal. In order to reach these nutrient reduction goals in this watershed, target adoption rates for some BMPs will need to be increased. Based on our previous experience with watershed planning in Iowa, cover crops and no-till appear to be palatable BMPs to stakeholders, generally, so our recommendation is to pursue increased implementation of these two practices. **For reference, to reach the goals in this watershed we have estimated that an additional 15,881 acres of cover crops ($778,000/yr) would be required above and beyond what is shown in Table 11.12.**

RANK	Mean CSR	Basin Size (HA)	Drainage Area (HA)
1	88.45	0.69	102.67
2	88.47	0.91	77.70
3	88.75	0.74	73.15
4	88.87	1.36	91.03
5	89.70	0.97	111.27
6	89.98	1.02	60.42
7	89.98	1.68	148.23

RANK	Mean CSR	Basin Size (HA)	Drainage Area (HA)
8	90.36	0.43	69.23
9	90.46	1.70	92.70
10	90.49	0.92	85.05
11	90.50	2.74	192.00
12	90.67	4.29	455.64
13	90.88	0.65	65.25
14	92.67	1.18	65.23

Table 11.12a. Properties of watersheds to each site location (HA = hectacres = 100 acres)

Tables 11.12a and 11.12b refer to Slough Creek Subwatershed Map 5 on page 270

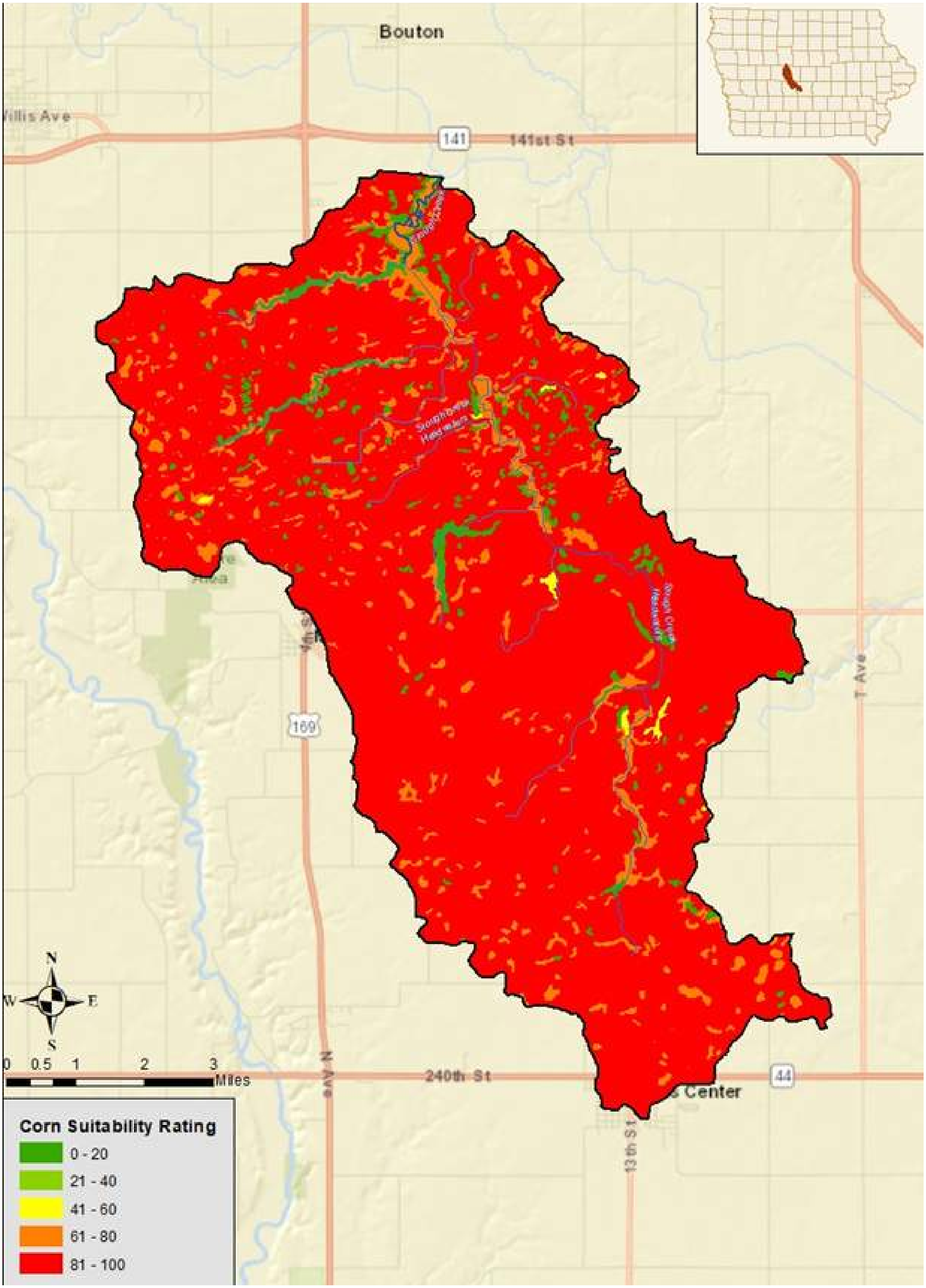
Table 11.12. BMP Adoption for Slough Creek Subwatershed

BMP Name	Existing Adoption Rate (%)	Target Adoption Rate (%)	Quantity	Equalized Annual Cost (Savings) [$/yr]
Cover crops	4%	8%	836 acres	$18,692
Extended rotations	1%	2%	209 acres	$2,861
Nitrogen management: nitrification inhibitor	50%	75%	5224 acres	($7,153)
Nitrogen management: rate control	5%	8%	522 acres	($477)
Nitrogen management: source control	10%	10%	0 acres	$0
Nitrogen management: timing control	35%	53%	3657 acres	($33,379)
Phosphorus management: placement control	5%	8%	543 acres	$3,719
Phosphorus management: rate control	25%	38%	2717 acres	($13,638)
Phosphorus management: source control	10%	10%	0 acres	$0
Contour buffer strips	0%	20%	7 miles	$3,408
Terraces	45%	75%	1 miles	$3,404
Drainage water management	0%	50%	65 fields	$11,865
Grassed waterways	37%	46%	6 miles	$23,645
No-Till	20%	40%	4179 acres	$22,888
Denitrifying bioreactors	0%	25%	31 reactors	$7,074
Nutrient removal wetlands	0%	40%	6 wetlands	$17,251
Perennial cover	1%	2%	213 acres	$37,953
WASCOBs	15%	19%	1 basins	$2,292
Riparian buffer: Critical zone buffer	59%	100%	1 miles	$778
Riparian buffer: Deep-rooted vegetation buffer	59%	100%	10 miles	$13,056
Riparian buffer: Multi-species buffer	59%	100%	3 miles	$4,583
Riparian buffer: Stiff stem grass buffer	59%	100%	2 miles	$2,853
Riparian buffer: Stream stabilization buffer	59%	100%	8 miles	$11,241
Saturated buffers	0%	50%	5 miles	$57,559

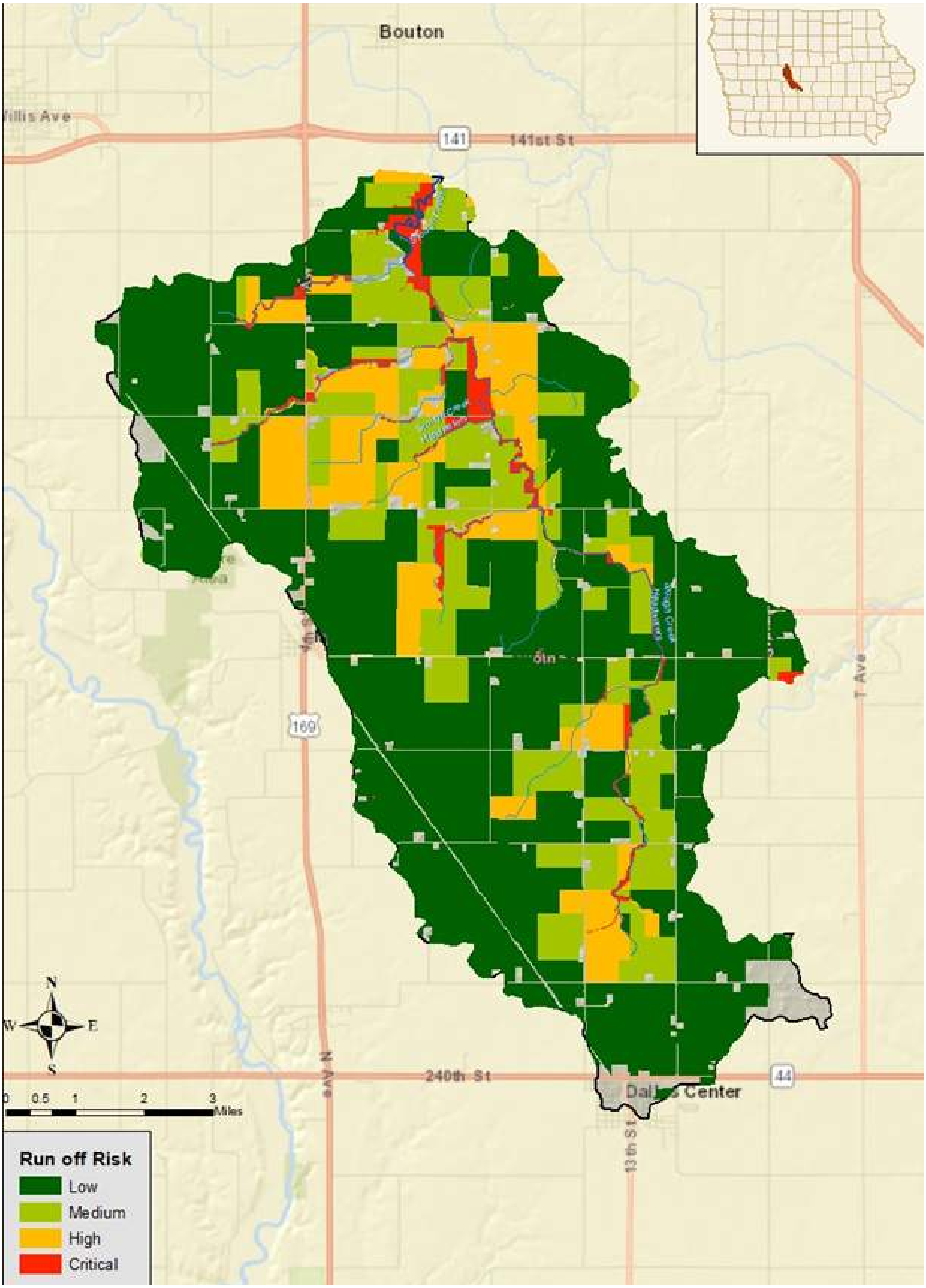
Slough Creek - Beaver Creek

Grouping	Implement first
1	1
2, 13	2
3	3
4	4
5	5
6	6
7	7
8, 11	8
9	9
10	10
12	12
14	14

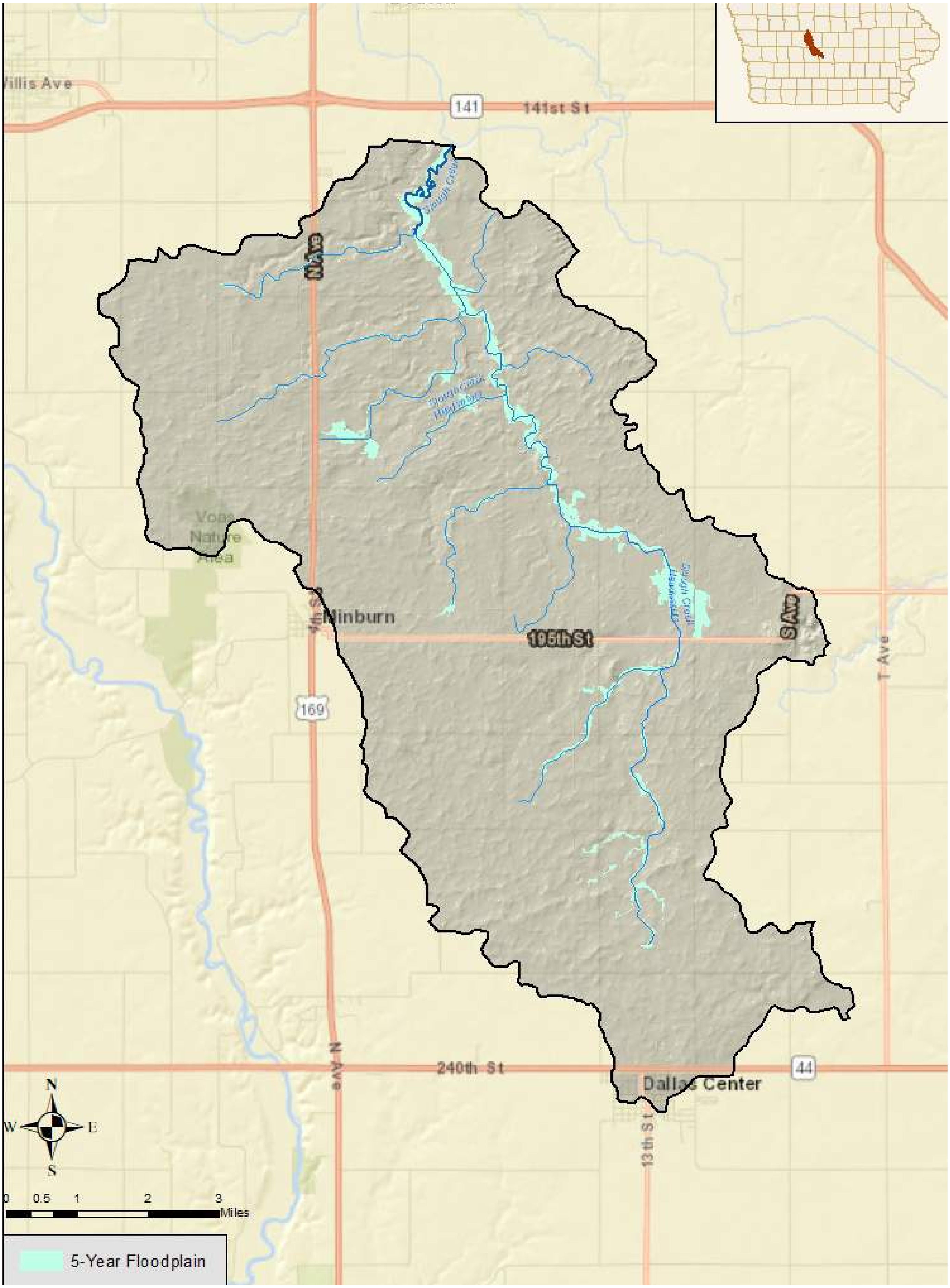
Table 11.12b. - Recommended prioritaztion list



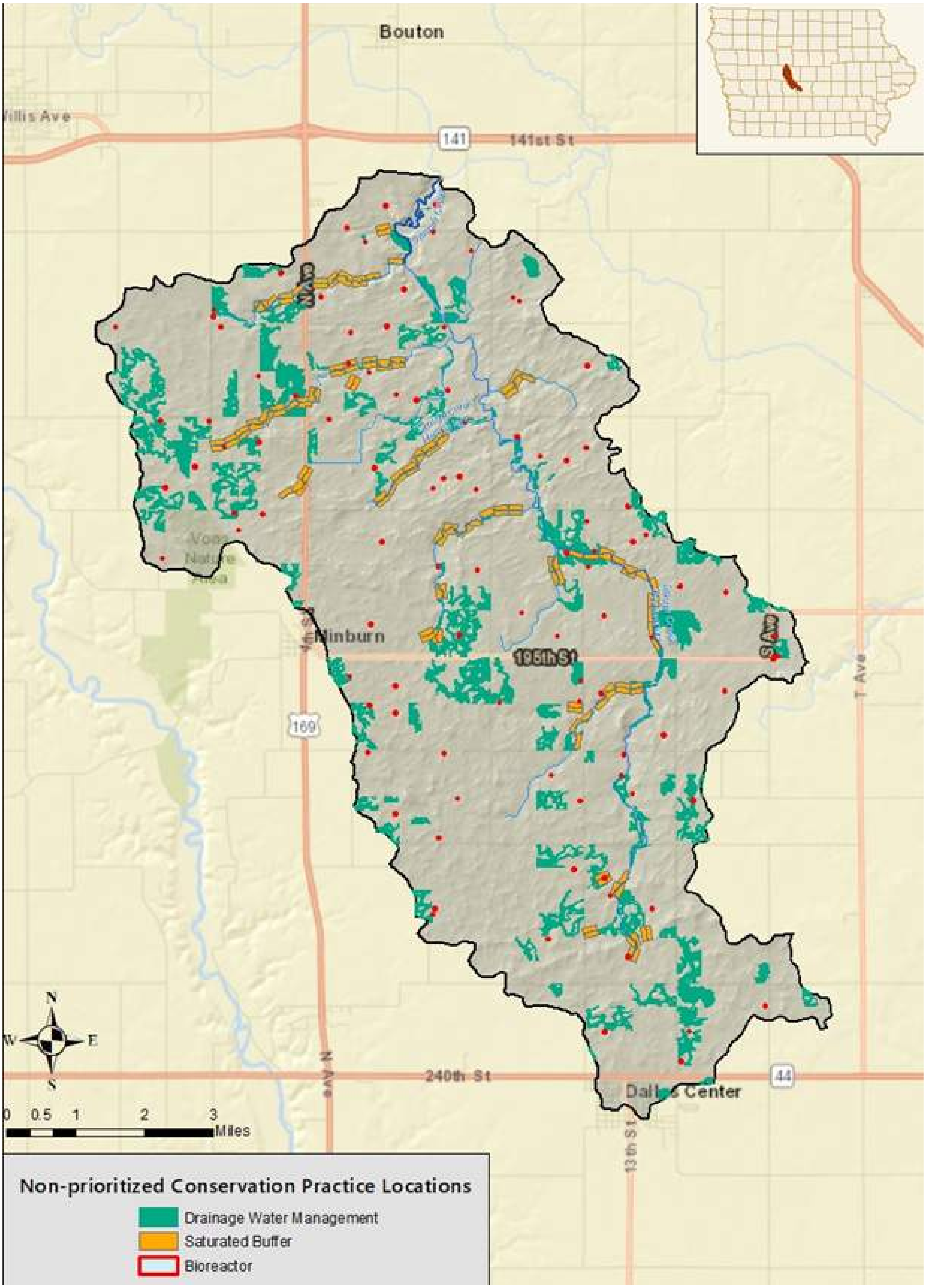
Slough Creek Subwatershed - Map 1



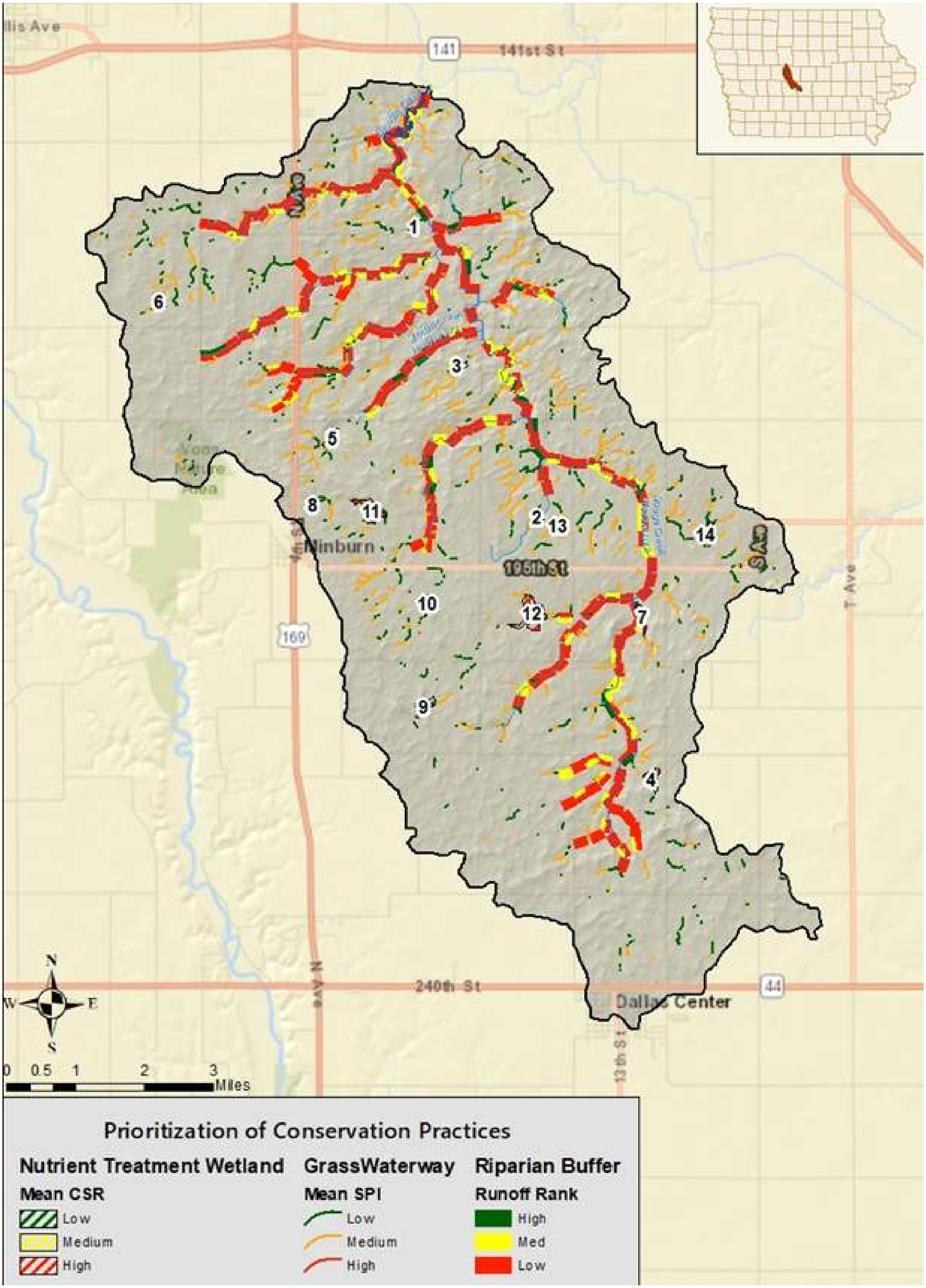
Slough Creek Subwatershed - Map 2



Slough Creek Subwatershed - Map 3

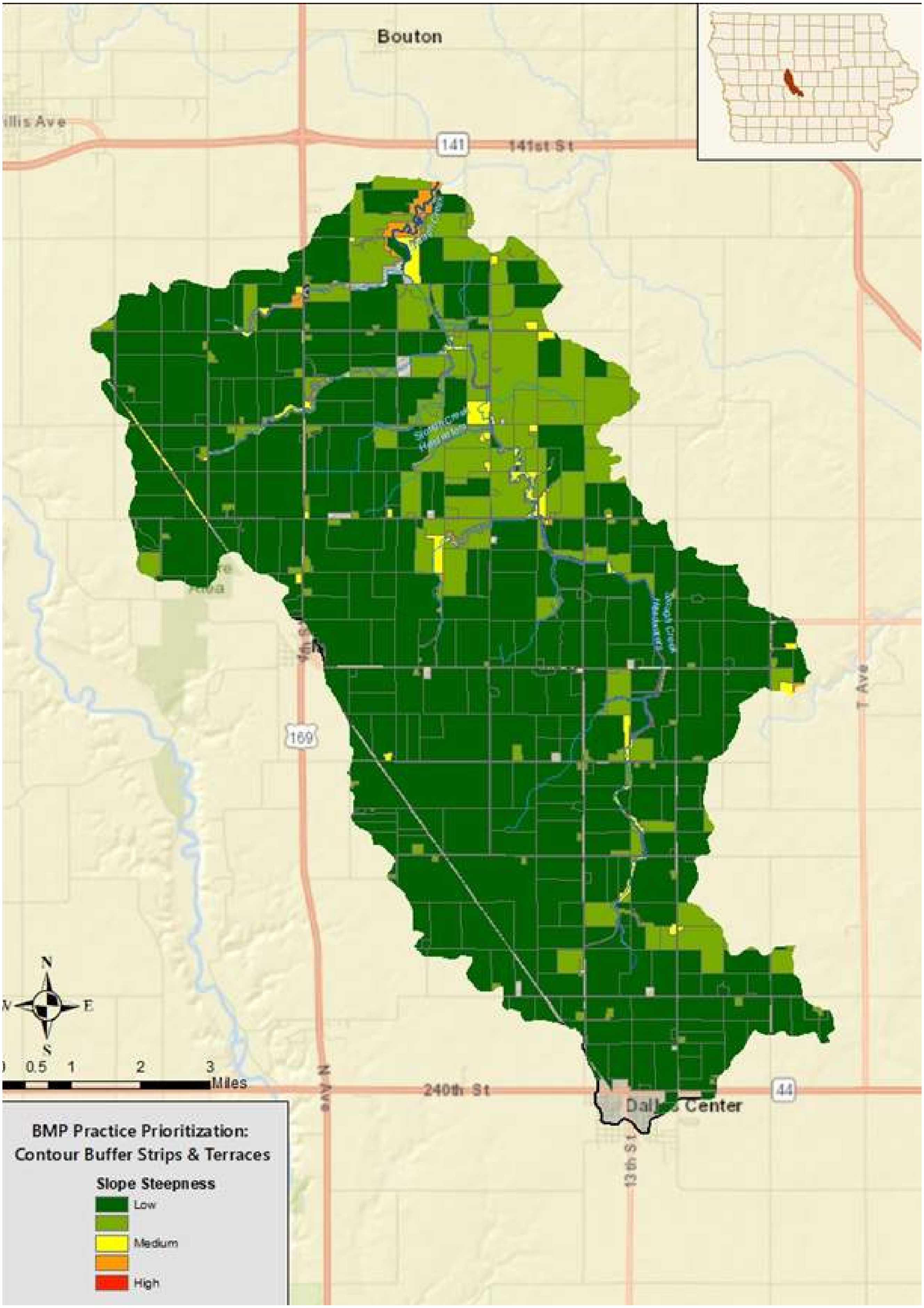


Slough Creek Subwatershed - Map 4

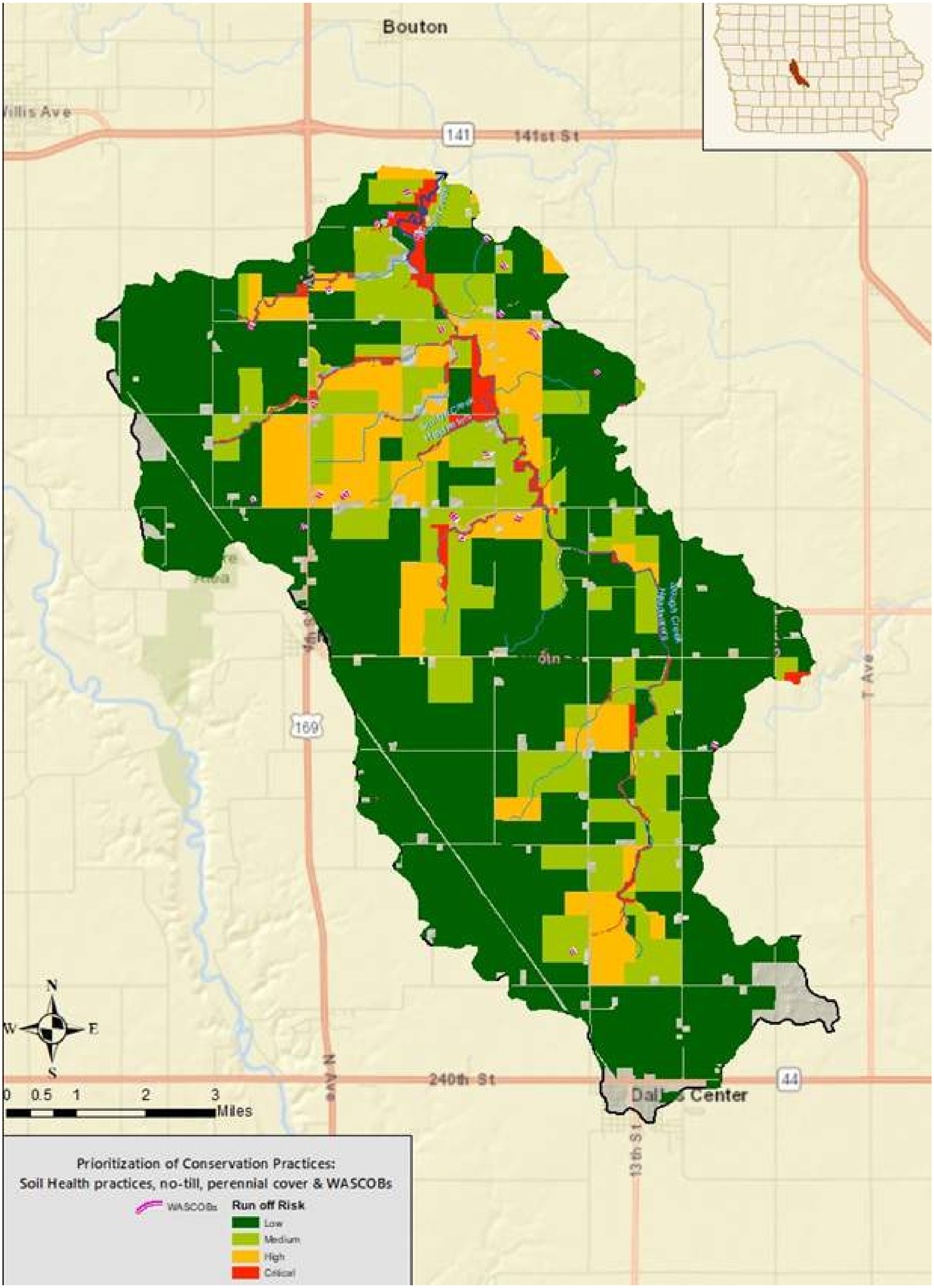


Slough Creek Subwatershed - Map 5

For wetland sizes and prioritization information, see Tables 11.12a and 11.12b on pages 264 and 265



Slough Creek Subwatershed - Map 6



Slough Creek Subwatershed - Map 7

Little Beaver Creek-Beaver Creek

The specific conservation scenario developed for Little Beaver Creek-Beaver Creek Subwatershed is shown in Table 11.13. The table indicates the recommended adoption rate of each practice with the corresponding acreage or quantity and the total implementation over a 20 year period for meeting targets for Nitrogen and Phosphorus for the Beaver Creek Watershed. The conservation practice scenario was developed through an iterative process using a cost-benefit analysis that is described in the Middle Cedar Watershed Management Plan. The equalized annual cost for practice implementation within the subwatershed is $616,000. This total annual cost includes conservation practice expenditures of $687,000 per year and conservation practices that result in a savings of $71,000 per year. Note that the cost provided are for conservation practices only.

Feasible maximum BMP adoption targets were set using stakeholder input as shown in Table 11.2. However, targeted implementation of BMPs at these rates did not reach the 34.4% total nitrogen reduction goal nor the 29% total phosphorus reduction goal. In order to reach these nutrient reduction goals in this watershed, target adoption rates for some BMPs will need to be increased. Based on our previous experience with watershed planning in Iowa, cover crops and no-till appear to be palatable BMPs to stakeholders, generally, so our recommendation is to pursue increased implementation of these two practices. **For reference, to reach the goals in this watershed we have estimated that an additional 12,778 acres of cover crops ($626,000/yr) would be required above and beyond what is shown in Table 11.13.**

RANK	Mean CSR	Basin Size (HA)	Drainage Area (HA)
1	4.42	1.38	81.45
2	45.27	0.66	82.75
3	48.29	0.45	63.37
4	65.91	0.67	91.09
5	70.66	1.52	176.96
6	71.58	1.32	114.30
7	74.55	0.43	69.81
8	76.68	1.09	198.61
9	82.58	0.82	60.01
10	82.97	0.51	70.74
11	85.36	1.17	68.25
12	87.73	1.21	80.86

RANK	Mean CSR	Basin Size (HA)	Drainage Area (HA)
13	88.09	0.85	69.29
14	89.26	0.41	64.73
15	89.54	1.29	64.80
16	89.96	0.99	60.09
17	90.25	1.06	60.87
18	90.39	1.11	91.14
19	90.62	1.61	92.02
20	90.88	1.64	127.58
21	91.79	1.20	83.88
22	91.98	1.27	83.21
23	92.36	1.14	69.38

Table 11.13a. Properties of watersheds to each site location (HA = hectacres = 100 acres)

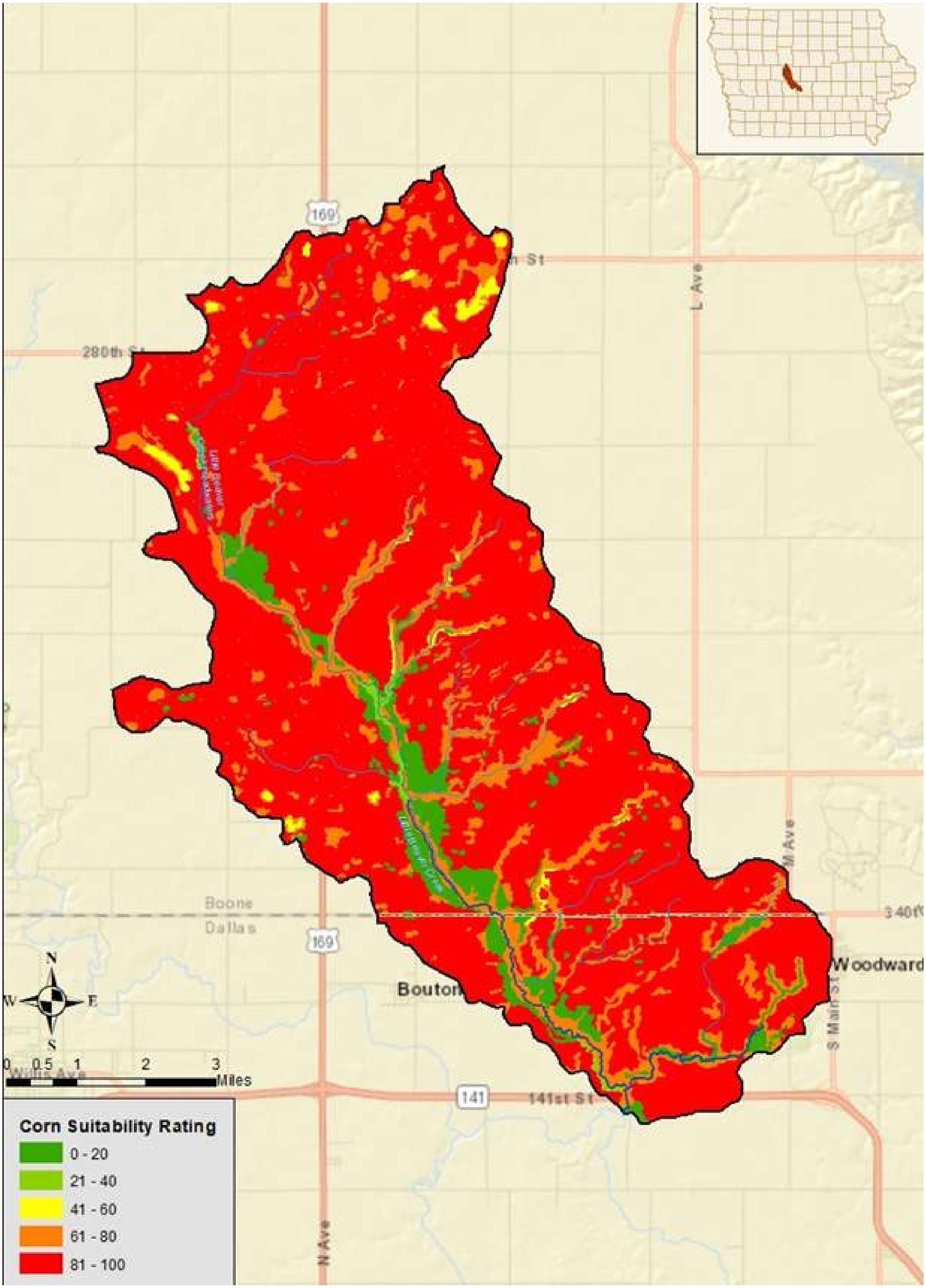
Tables 11.13a and 11.13b refer to Little Beaver Creek - Beaver Creek Subwatershed Map 5 on page 279

BMP Name	Existing Adoption Rate (%)	Target Adoption Rate (%)	Quantity	Equalized Annual Cost (Savings) [$/yr]
Cover crops	2%	4%	376 acres	$8,404
Extended rotations	1%	2%	188 acres	$2,573
Nitrogen management: nitrification inhibitor	85%	95%	1879 acres	($2,573)
Nitrogen management: rate control	5%	8%	470 acres	($429)
Nitrogen management: source control	10%	10%	0 acres	$0
Nitrogen management: timing control	85%	95%	1879 acres	($17,152)
Phosphorus management: placement control	5%	8%	489 acres	$3,345
Phosphorus management: rate control	25%	38%	2443 acres	($12,263)
Phosphorus management: source control	10%	10%	0 acres	$0
Contour buffer strips	0%	20%	4 miles	$2,073
Terraces	100%	100%	0 miles	$0
Drainage water management	0%	50%	46 fields	$8,306
Grassed waterways	100%	100%	0 miles	$0
No-Till	20%	40%	3758 acres	$20,582
Denitrifying bioreactors	0%	25%	32 reactors	$7,188
Nutrient removal wetlands	0%	40%	9 wetlands	$28,342
Perennial cover	1%	2%	192 acres	$34,128
WASCOBs	100%	100%	0 basins	$0
Riparian buffer: Critical zone buffer	70%	100%	1 miles	$689
Riparian buffer: Deep-rooted vegetation buffer	70%	100%	6 miles	$8,270
Riparian buffer: Multi-species buffer	70%	100%	2 miles	$2,631
Riparian buffer: Stiff stem grass buffer	70%	100%	3 miles	$4,323
Riparian buffer: Stream stabilization buffer	70%	100%	15 miles	$21,050
Saturated buffers	0%	50%	15 miles	$161,509
			Little Beaver Creek - Beaver Creek	

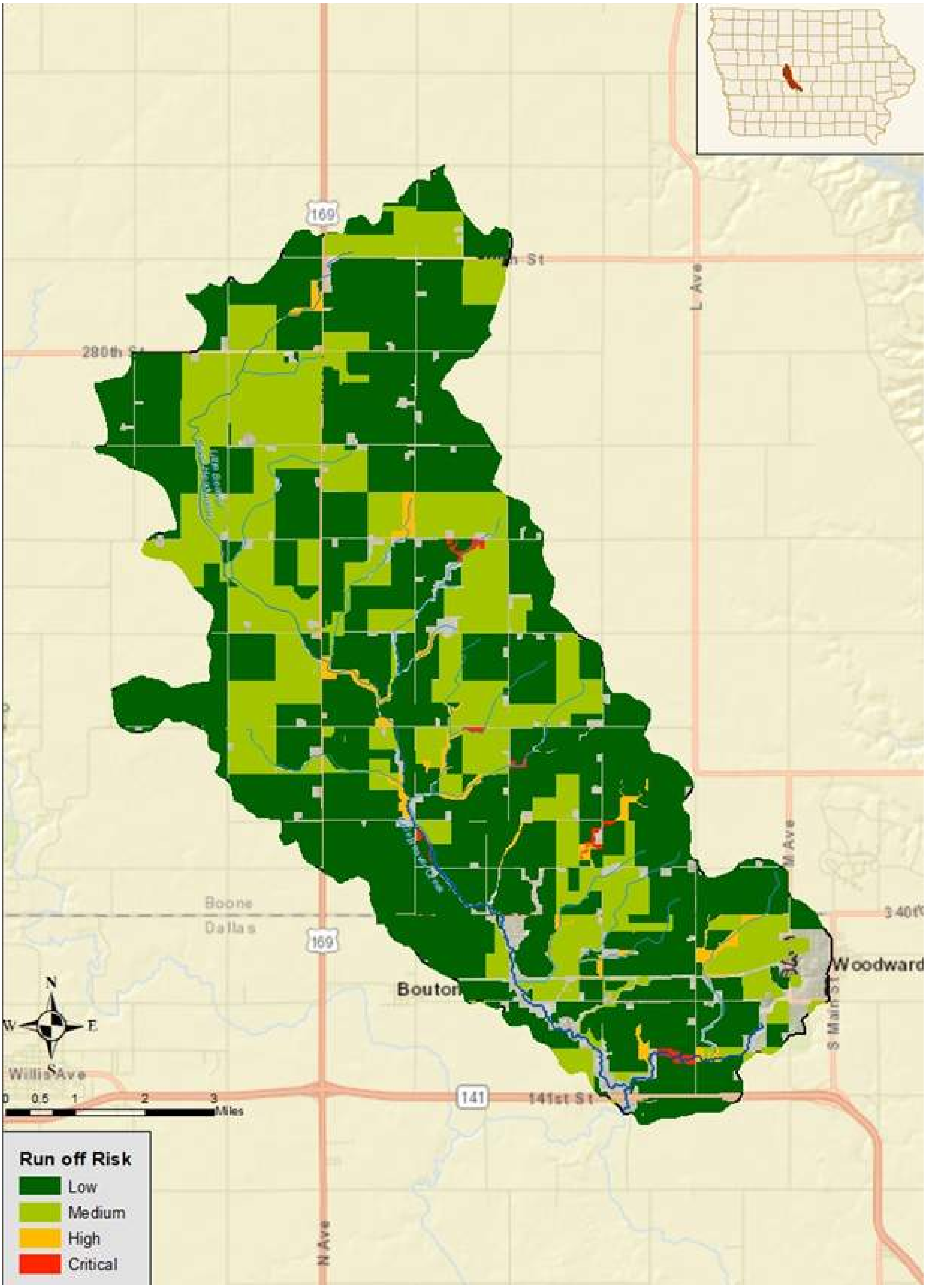
Table 11.13. BMP Adoption for Little Beaver Creek-Beaver Creek Subwatershed

Grouping	Implement first
1	1
2, 3, 4	2
5	5
6	6
7	7
8	8
9, 11, 13	9
10	10
14	14
16	16
17, 21	17
18	18
19	19
20, 22	20
23	23

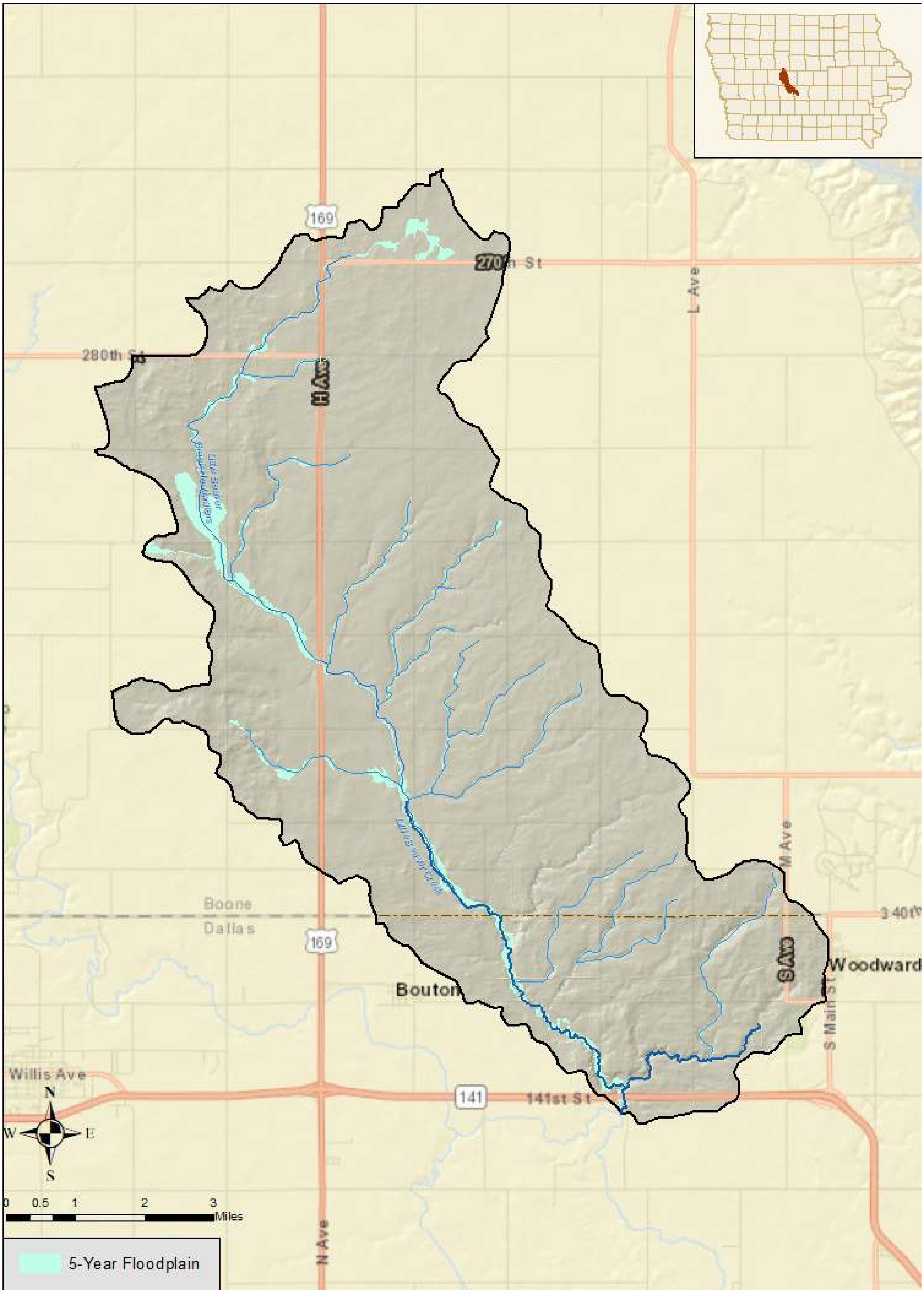
Table 11.13b. - Recommended prioritaztion list



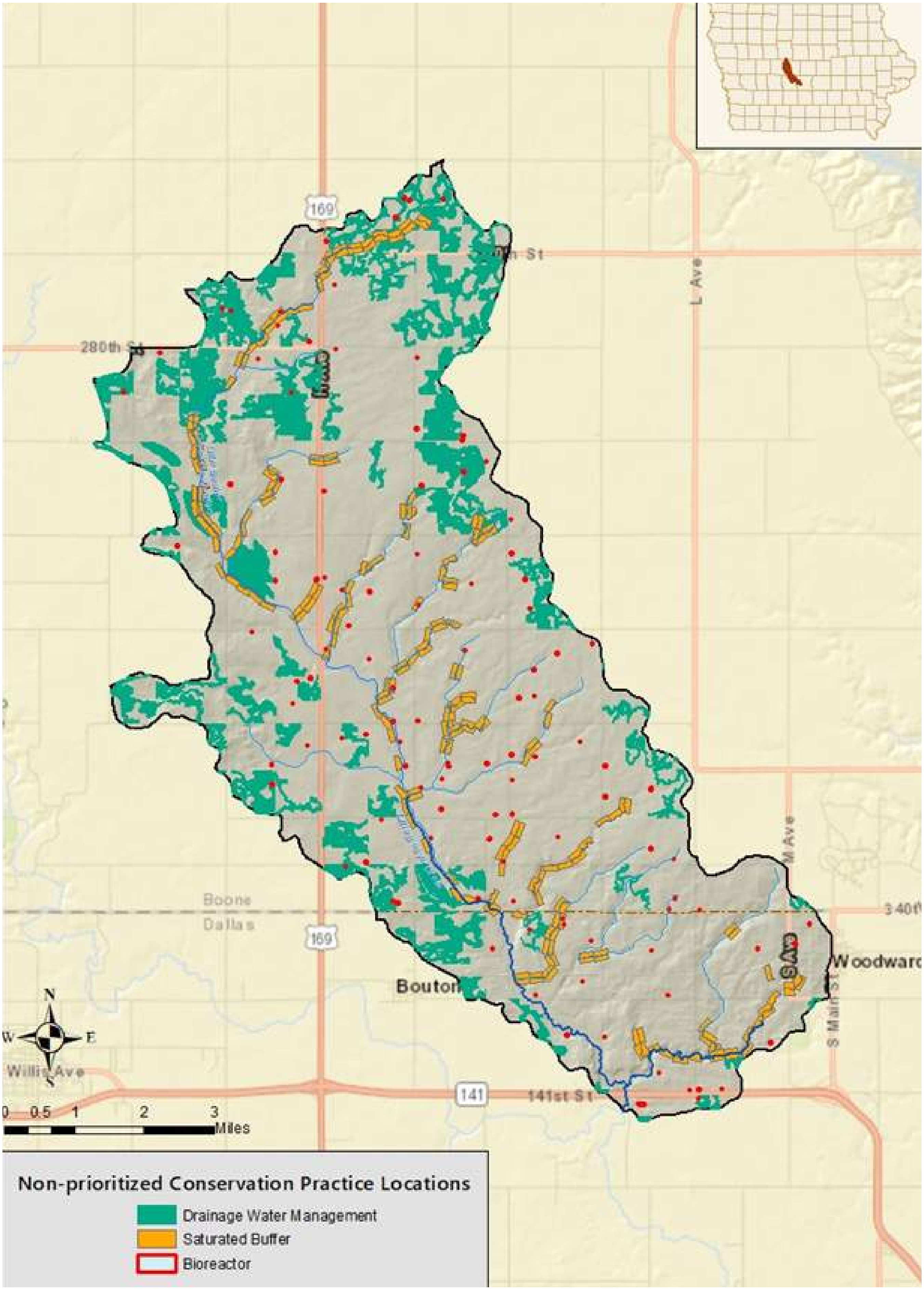
Little Beaver Creek - Beaver Creek Subwatershed - Map 1



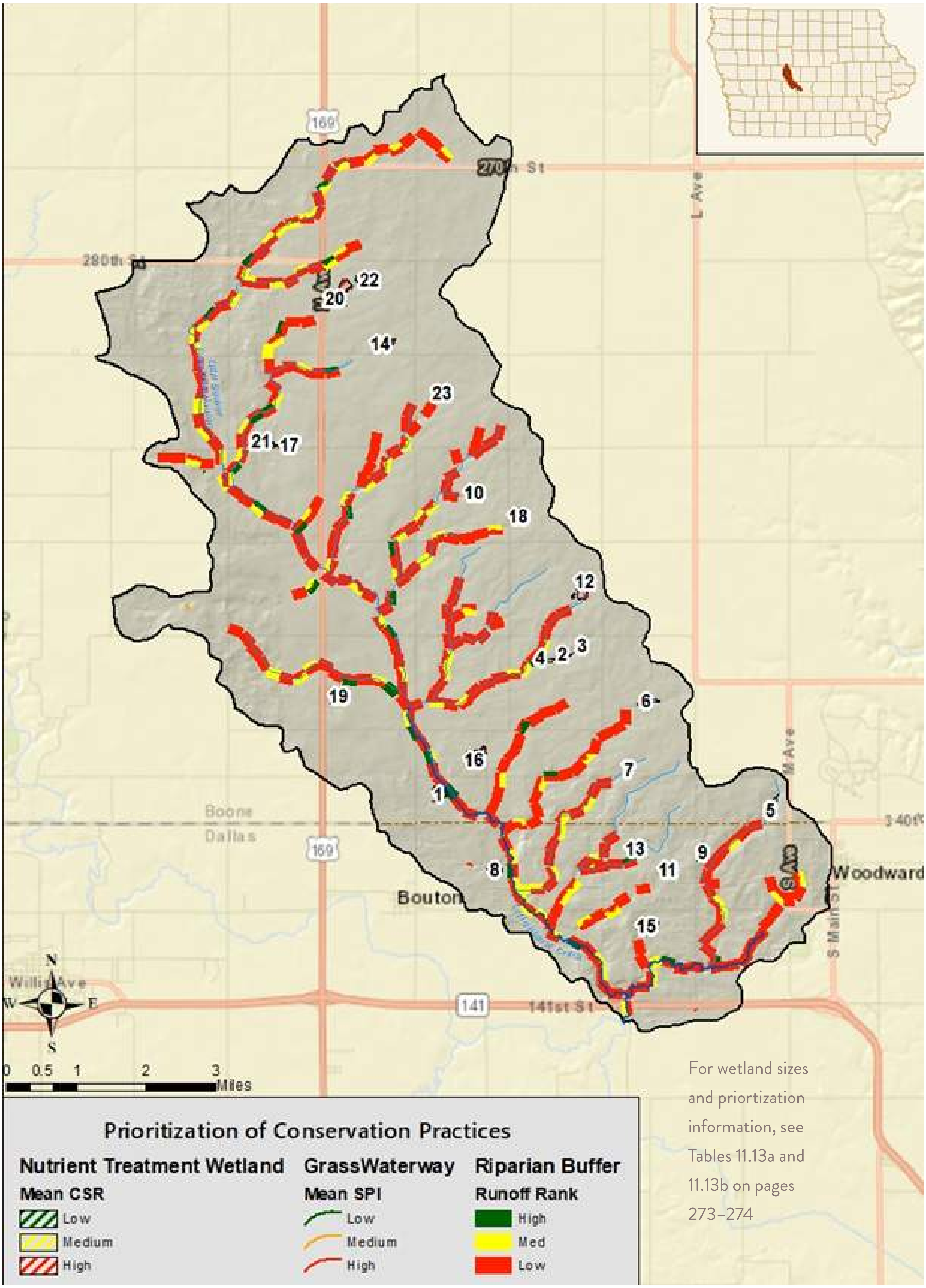
Little Beaver Creek - Beaver Creek Subwatershed - Map 2



Little Beaver Creek - Beaver Creek Subwatershed - Map 3

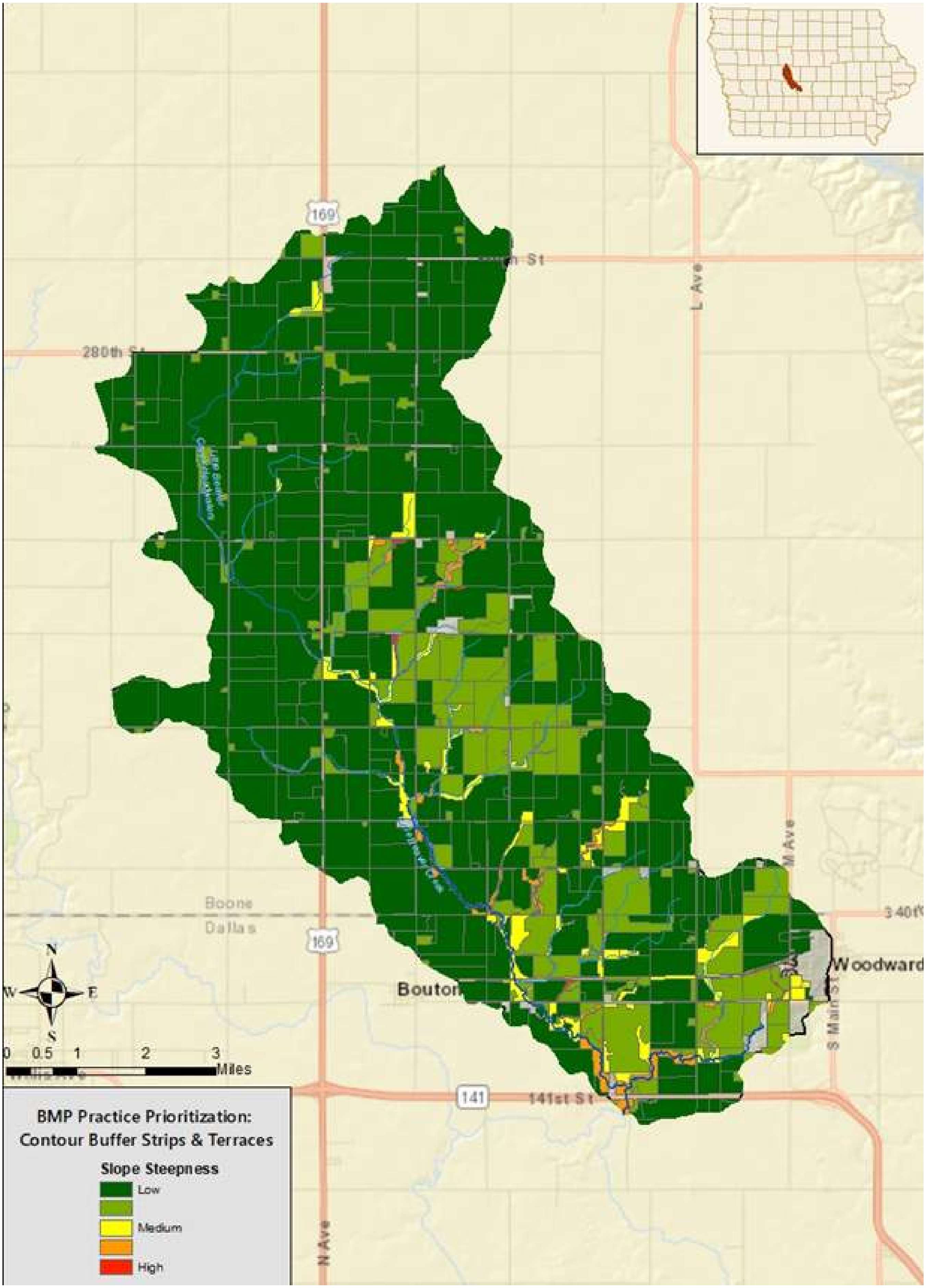


Little Beaver Creek - Beaver Creek Subwatershed - Map 4

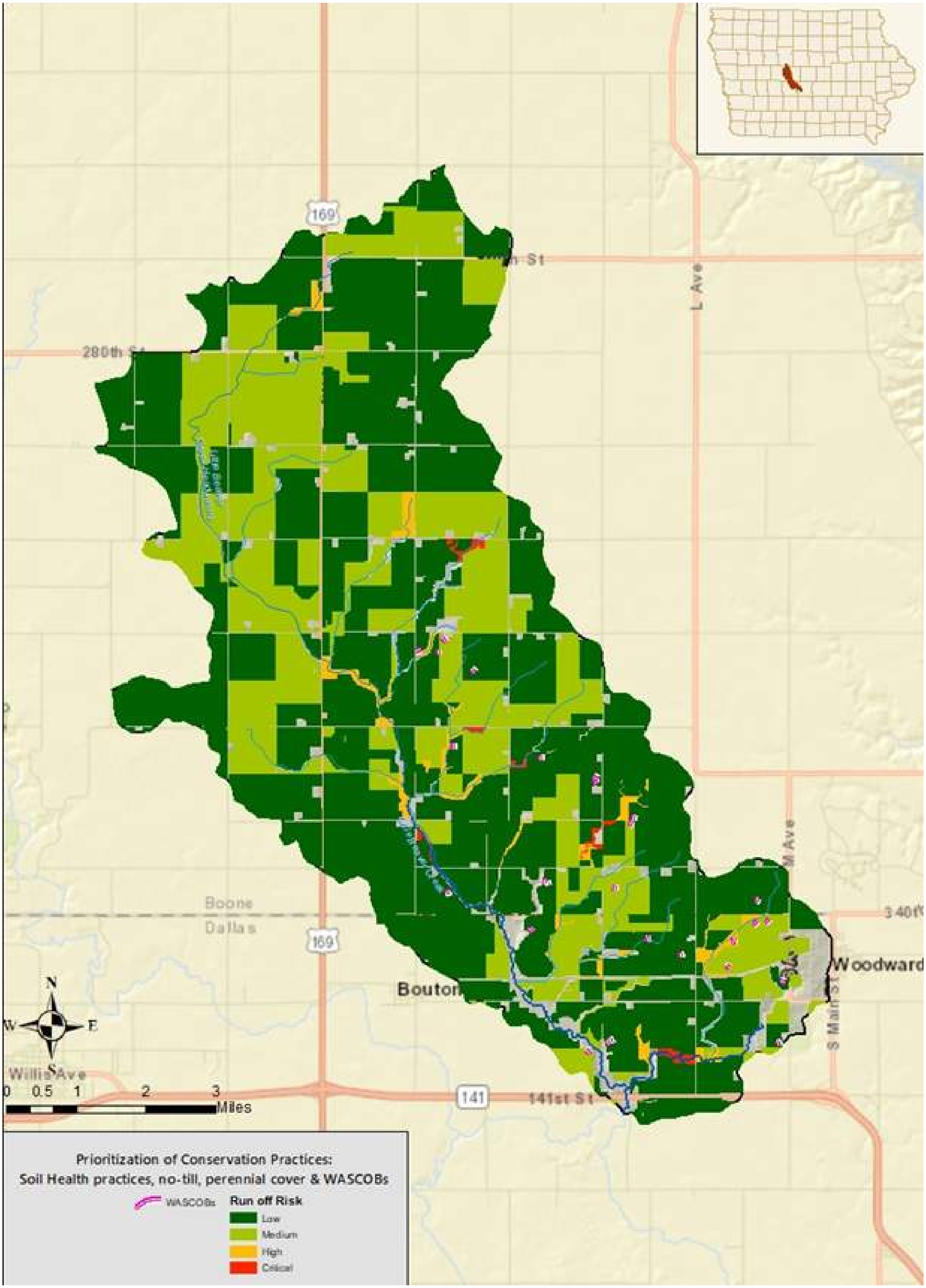


For wetland sizes and priortization information, see Tables 11.13a and 11.13b on pages 273–274

Little Beaver Creek - Beaver Creek Subwatershed - Map 5



Little Beaver Creek - Beaver Creek Subwatershed - Map 6



Little Beaver Creek - Beaver Creek Subwatershed - Map 7

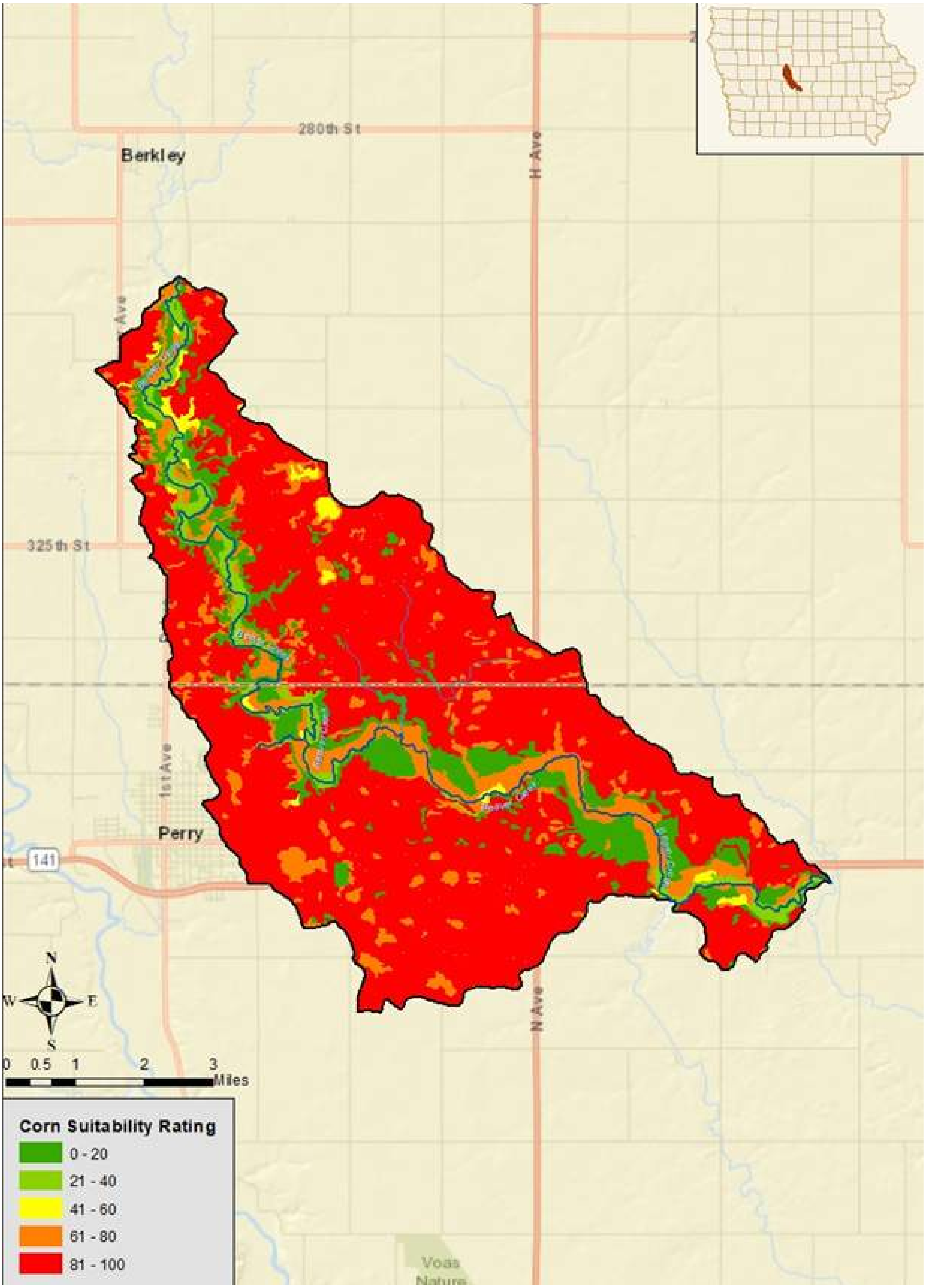
City of Bouton-Beaver Creek

The specific conservation scenario developed for the City of Bouton-Beaver Creek Subwatershed is shown in Table 11.14. The table indicates the recommended adoption rate of each practice with the corresponding acreage or quantity and the total implementation over a 20 year period for meeting targets for Nitrogen and Phosphorus for the Beaver Creek Watershed. The conservation practice scenario was developed through an iterative process using a cost-benefit analysis that is described in the Middle Cedar Watershed Management Plan. The annualized total cost for practice implementation within the subwatershed is $229,000. This equalized annual cost includes conservation practice expenditures of $272,000 per year and conservation practices that result in a savings of $43,000 per year. Note that the cost provided are for conservation practices only.

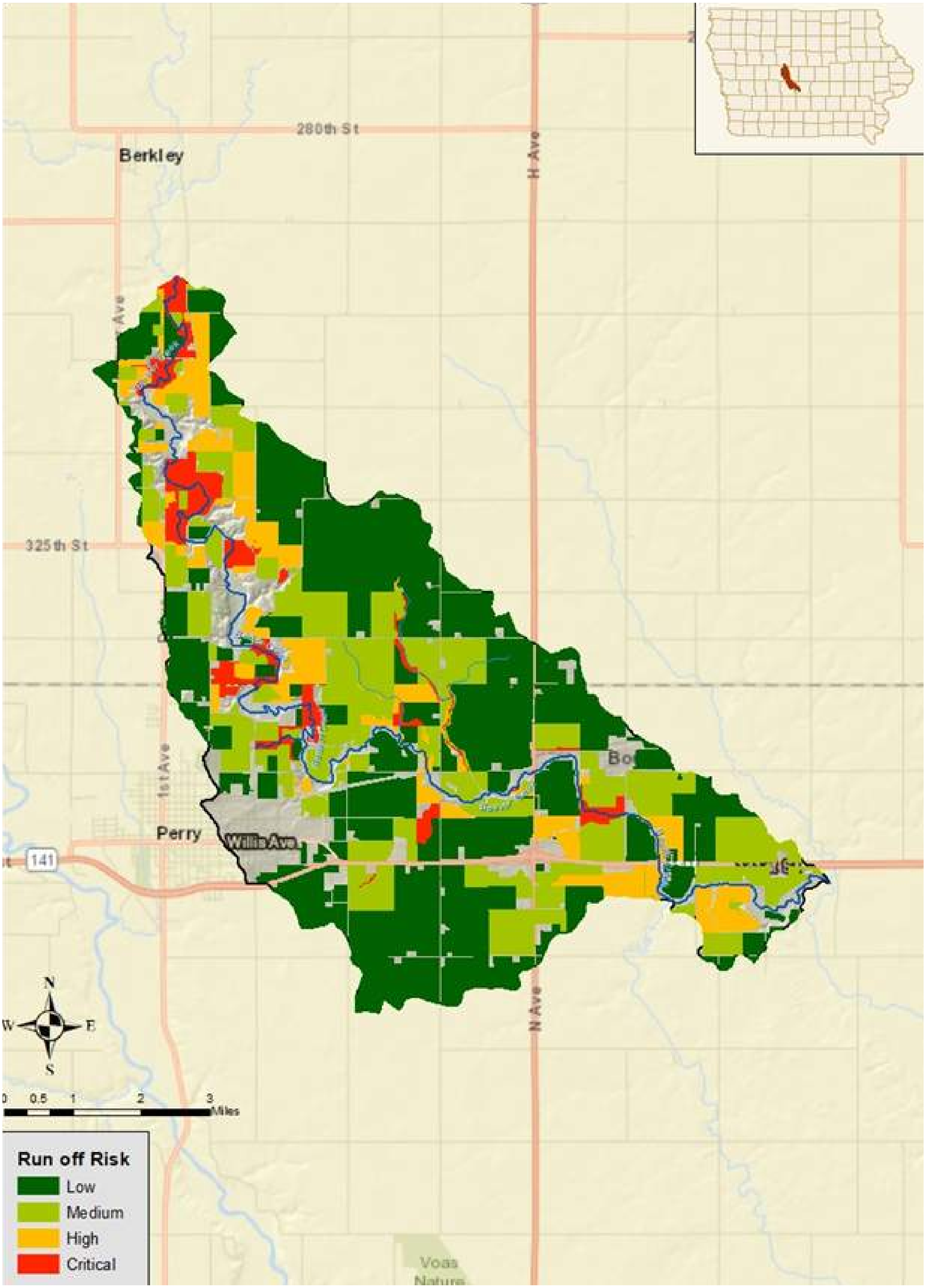
Feasible maximum BMP adoption targets were set using stakeholder input as shown in Table 11.2. However, targeted implementation of BMPs at these rates did not reach the 34.4% total nitrogen reduction goal nor the 29% total phosphorus reduction goal. In order to reach these nutrient reduction goals in this watershed, target adoption rates for some BMPs will need to be increased. Based on our previous experience with watershed planning in Iowa, cover crops and no-till appear to be palatable BMPs to stakeholders, generally, so our recommendation is to pursue increased implementation of these two practices. **For reference, to reach the goals in this watershed we have estimated that an additional 9,531 acres of cover crops ($467,000/yr), 794 acres of no-till ($23,000/yr), 1 bioreactor ($292/yr), and 2 miles of saturated buffers ($38,702/yr) would be required above and beyond what is shown in Table 11.14.**

BMP Name	Existing Adoption Rate (%)	Target Adoption Rate (%)	Quantity	Equalized Annual Cost (Savings) [$/yr]
Cover crops	3%	6%	340 acres	$7,612
Extended rotations	1%	2%	113 acres	$1,553
Nitrogen management: nitrification inhibitor	85%	95%	1135 acres	($1,553)
Nitrogen management: rate control	5%	8%	284 acres	($259)
Nitrogen management: source control	10%	10%	0 acres	$0
Nitrogen management: timing control	85%	95%	1135 acres	($10,356)
Phosphorus management: placement control	5%	8%	295 acres	$2,020
Phosphorus management: rate control	25%	38%	1475 acres	($7,405)
Phosphorus management: source control	10%	10%	0 acres	$0
Contour buffer strips	0%	20%	3 miles	$1,529
Terraces	90%	90%	0 miles	$0
Drainage water management	0%	50%	49 fields	$8,854
Grassed waterways	100%	100%	0 miles	$0
No-Till	10%	20%	1135 acres	$6,214
Denitrifying bioreactors	0%	25%	20 reactors	$4,621
Nutrient removal wetlands	0%	40%	0 wetlands	$0
Perennial cover	1%	2%	116 acres	$20,607
WASCOBs	41%	51%	3 basins	$6,775
Riparian buffer: Critical zone buffer	81%	100%	0 miles	$121
Riparian buffer: Deep-rooted vegetation buffer	81%	100%	4 miles	$5,697
Riparian buffer: Multi-species buffer	81%	100%	1 miles	$1,253
Riparian buffer: Stiff stem grass buffer	81%	100%	1 miles	$1,414
Riparian buffer: Stream stabilization buffer	81%	100%	5 miles	$6,707
Saturated buffers	0%	50%	4 miles	$48,968
				City of Bouton - Beaver Creek

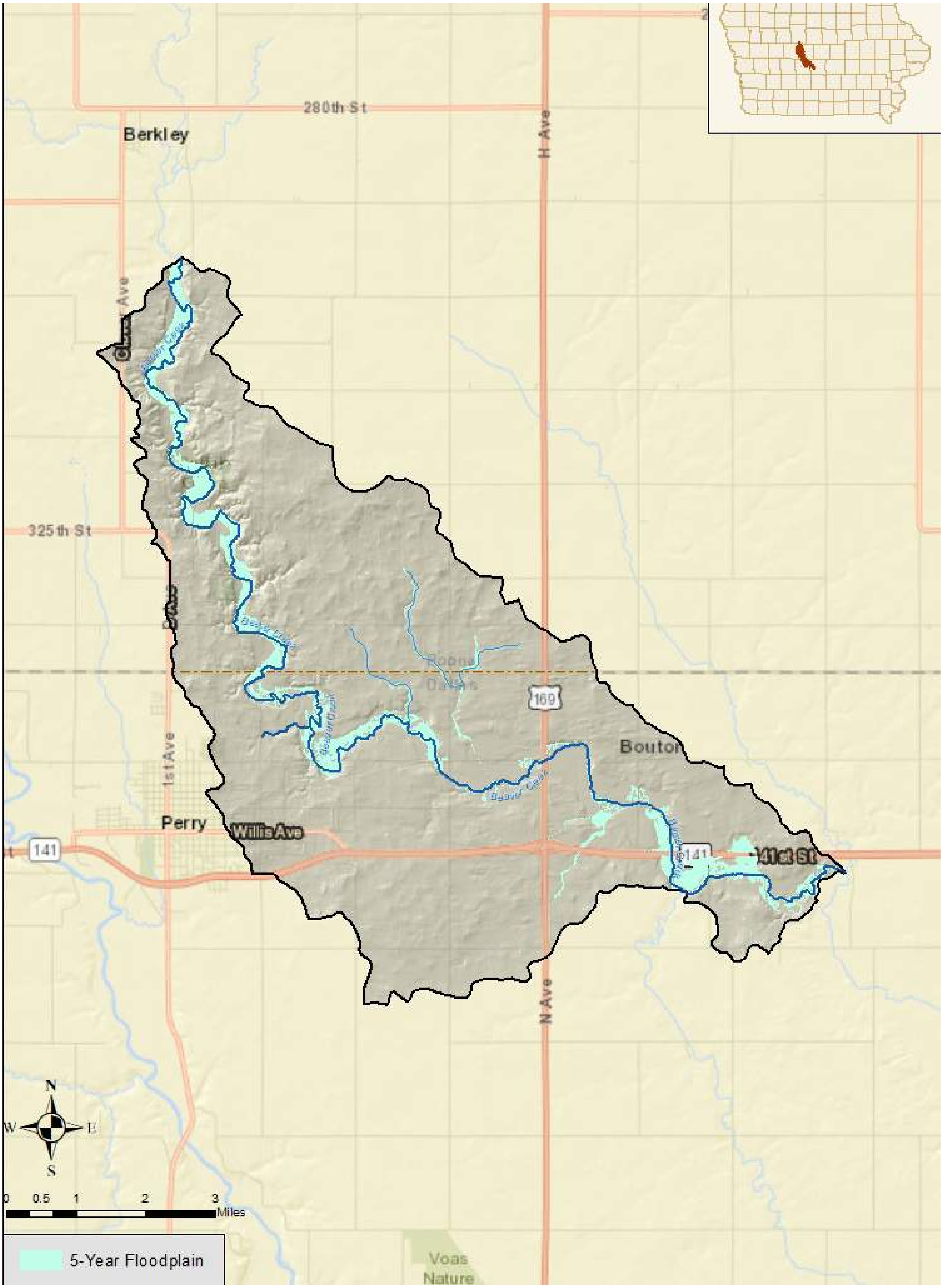
Table 11.14. BMP Adoption for City of Bouton-Beaver Creek Subwatershed



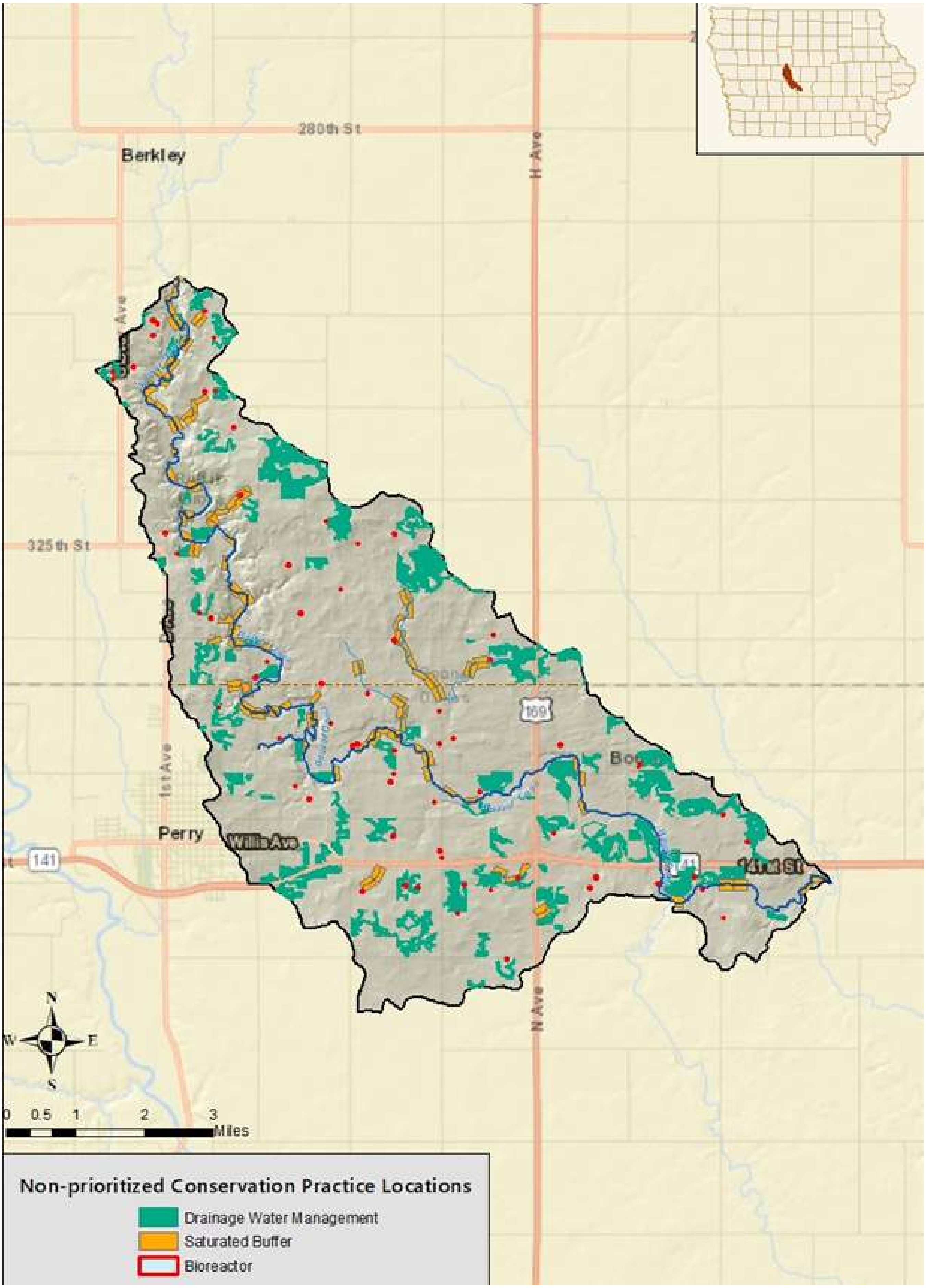
City of Bouton - Beaver Creek Subwatershed - Map 1



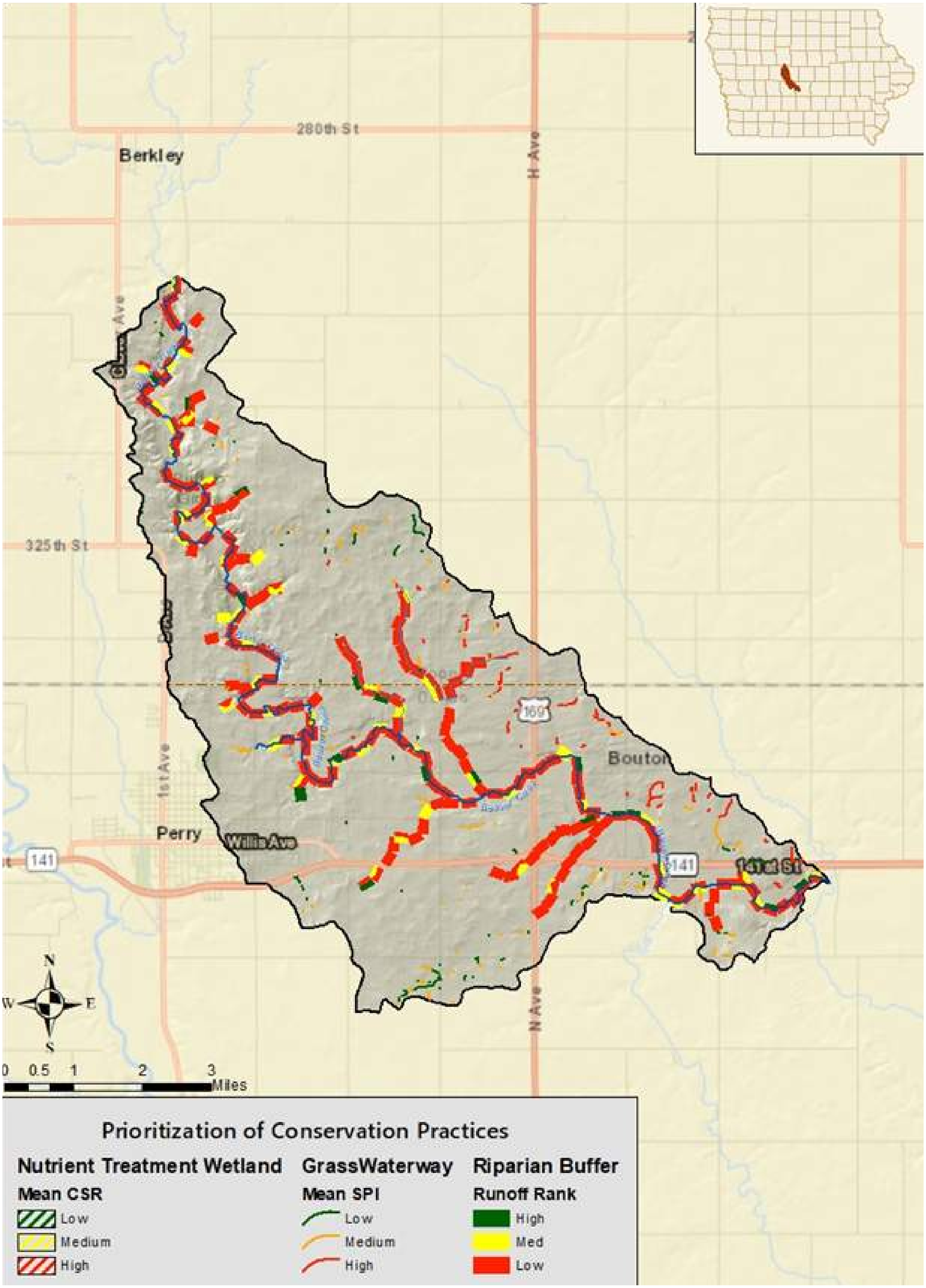
City of Bouton - Beaver Creek Subwatershed - Map 2



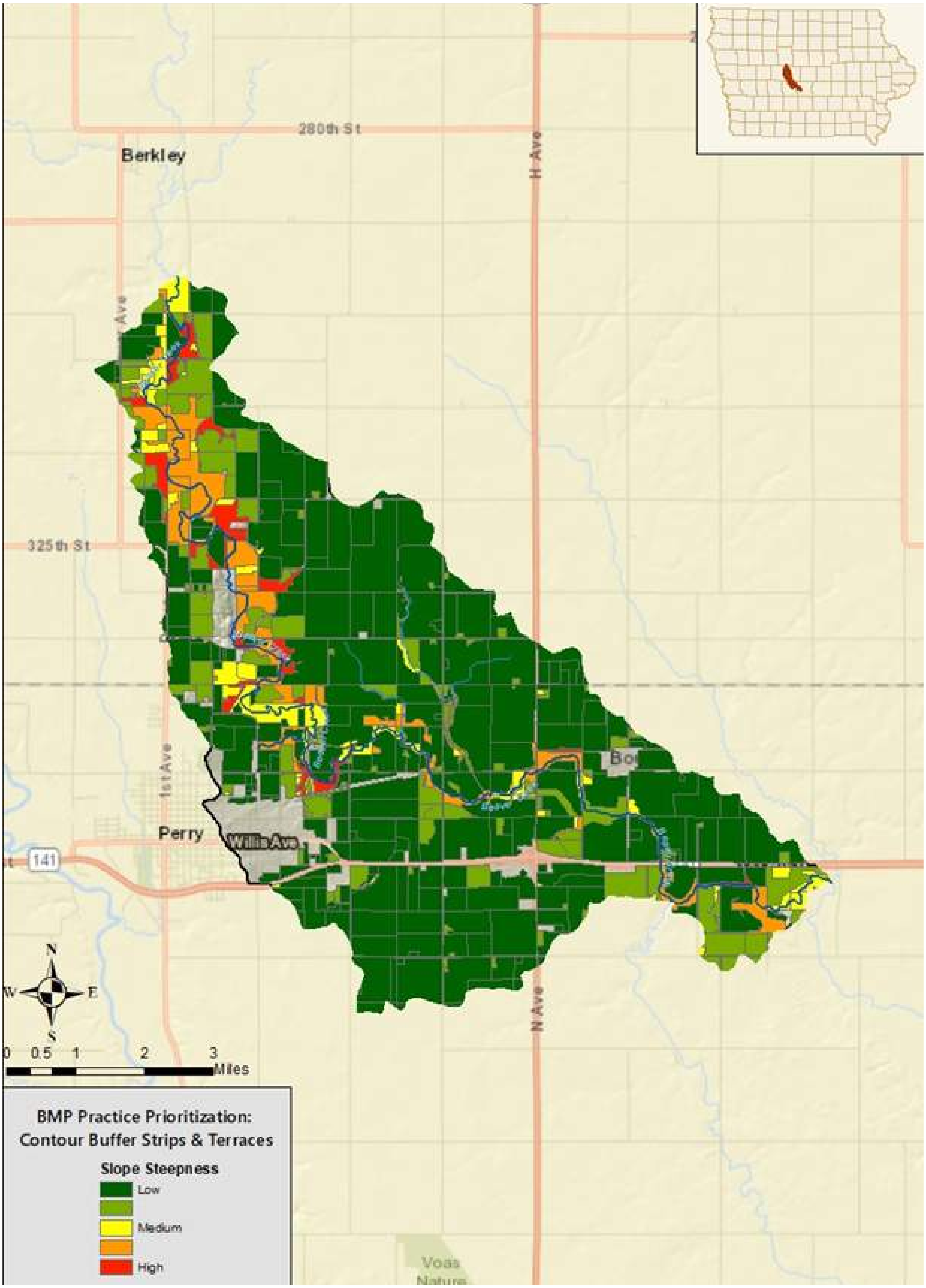
City of Bouton - Beaver Creek Subwatershed - Map 3



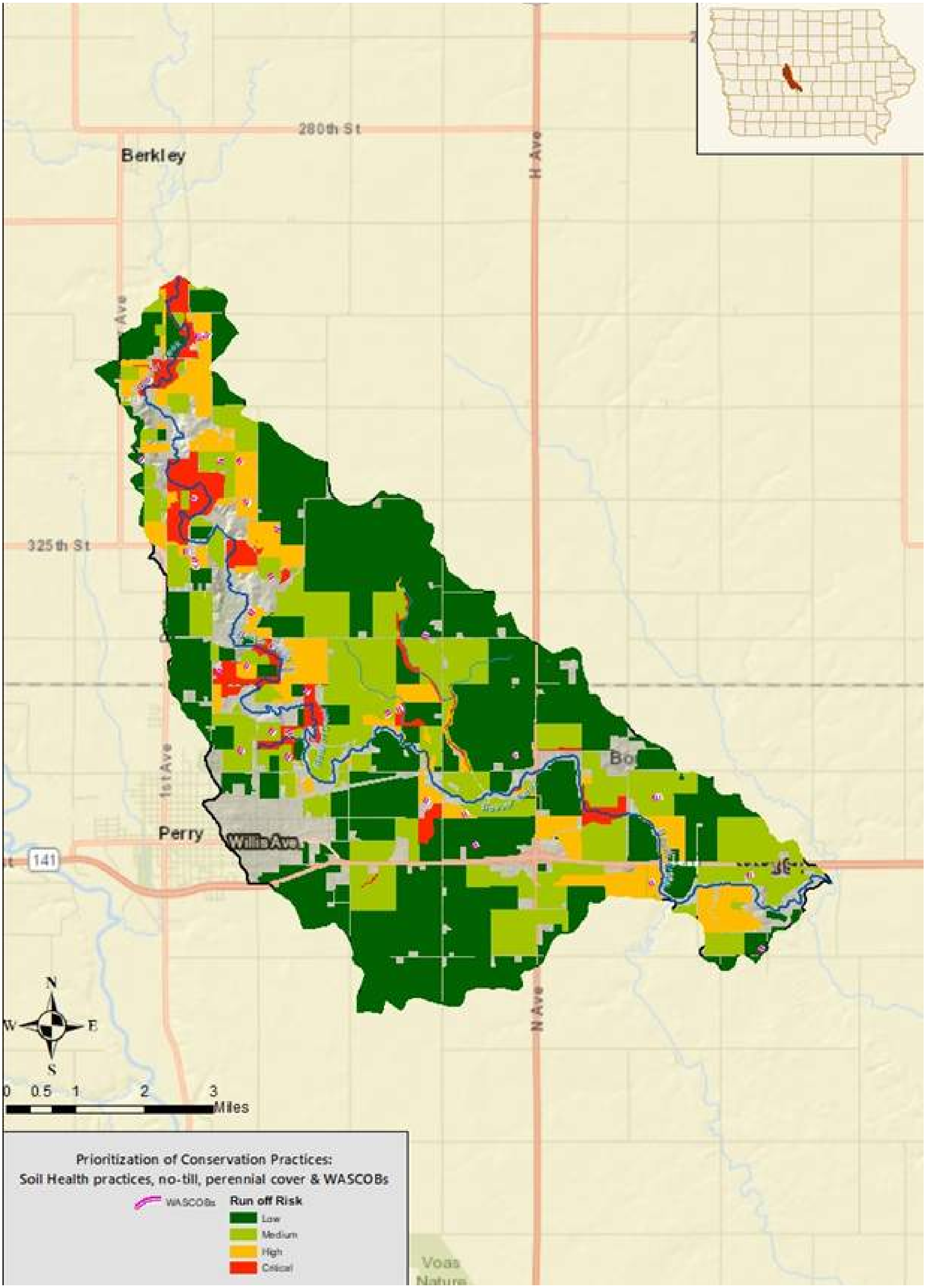
City of Bouton - Beaver Creek Subwatershed - Map 4



City of Bouton - Beaver Creek Subwatershed - Map 5



City of Bouton - Beaver Creek Subwatershed - Map 6



City of Bouton - Beaver Creek Subwatershed - Map 7

Royer Creek-Beaver Creek

The specific conservation scenario developed for the Royer Creek-Beaver Creek Subwatershed is shown in Table 11.15. The table indicates the recommended adoption rate of each practice with the corresponding acreage or quantity and the total implementation over a 20 year period for meeting targets for Nitrogen and Phosphorus for the Beaver Creek Watershed. The conservation practice scenario was developed through an iterative process using a cost-benefit analysis that is described in the Middle Cedar Watershed Management Plan. The equalized annual cost for practice implementation within the subwatershed is $504,000. This total annual cost includes conservation practice expenditures of $628,000 per year and conservation practices that result in a savings of $43,000 per year. Note that the cost provided are for conservation practices only.

Feasible maximum BMP adoption targets were set using stakeholder input as shown in Table 11.2. However, targeted implementation of BMPs at these rates did not reach the 34.4% total nitrogen reduction goal nor the 29% total phosphorus reduction goal. In order to reach these nutrient reduction goals in this watershed, target adoption rates for some BMPs will need to be increased. Based on our previous experience with watershed planning in Iowa, cover crops and no-till appear to be palatable BMPs to stakeholders, generally, so our recommendation is to pursue increased implementation of these two practices. **For reference, to reach the goals in this watershed we have estimated that an additional 16,238 acres of cover crops ($796,000/yr) would be required above and beyond what is shown in Table 11.15.**

RANK	Mean CSR	Basin Size (HA)	Drainage Area (HA)
1	0.00	1.12	60.55
2	15.95	0.89	67.95
3	19.01	0.65	60.77
4	28.95	0.59	88.62
5	31.07	1.12	92.00
6	36.58	1.75	275.31
7	38.86	4.33	253.45
8	52.49	0.80	107.37
9	87.66	0.54	68.45

RANK	Mean CSR	Basin Size (HA)	Drainage Area (HA)
10	88.05	1.36	164.43
11	88.07	0.59	60.02
12	90.07	0.82	64.86
13	90.08	1.75	167.39
14	90.22	1.18	72.75
15	90.43	0.87	96.94
16	90.63	1.15	85.90
17	90.66	0.64	113.69

Table 11.15a. Properties of watersheds to each site location (HA = hectacres = 100 acres)

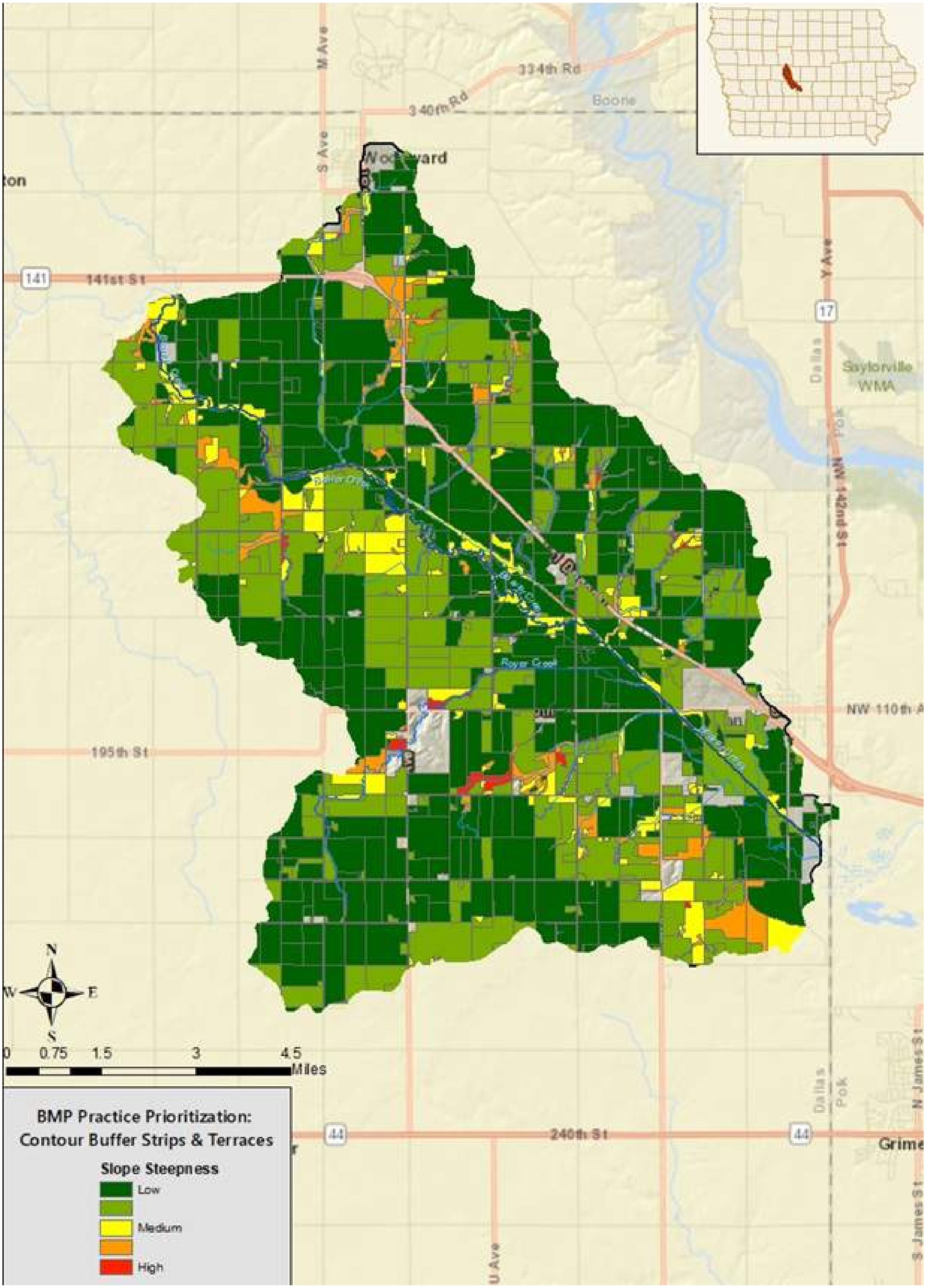
Tables 11.15a and 11.15b refer to Royer Creek - Beaver Creek Subwatershed Map 5 on page 297

BMP Name	Existing Adoption Rate (0%)	Target Adoption Rate (%)	Quantity	Annualized Cost (Saving) [$/yr]
Cover crops	4%	8%	866 acres	$19,367
Extended rotations	1%	2%	217 acres	$2,964
Nitrogen management: nitrification inhibitor	50%	75%	5413 acres	($7,411)
Nitrogen management: rate control	5%	8%	541 acres	($494)
Nitrogen management: source control	10%	10%	0 acres	$0
Nitrogen management: timing control	35%	53%	3789 acres	($34,585)
Phosphorus management: placement control	5%	8%	563 acres	$3,854
Phosphorus management: rate control	25%	38%	2815 acres	($14,130)
Phosphorus management: source control	10%	10%	0 acres	$0
Contour buffer srips	0%	20%	15 miles	$7,193
Terraces	33%	75%	2 miles	$11,714
Drainage water management	0%	50%	78 fields	$14,239
Grassed waterways	100%	100%	0 miles	$0
No-Till	25%	50%	5413 acres	$29,644
Denitrifying bioreactors	0%	25%	38 reactors	$8,557
Nutrient removal wetlands	0%	40%	7 wetlands	$20,948
Perennial cover	1%	2%	221 acres	$39,324
WASCOBs	27%	34%	9 basins	$18,661
Riparian buffer: Critical zone buffer	73%	100%	1 miles	$1,222
Riparian buffer: Deep-rooted vegetation buffer	73%	100%	10 miles	$14,028
Riparian buffer: Multi-species buffer	73%	100%	2 miles	$2,561
Riparian buffer: Stiff stem grass buffer	73%	100%	3 miles	$4,307
Riparian buffer: Stream stabilization buffer	73%	100%	20 miles	$27,125
Saturated buffers	0%	50%	6 miles	$60,996
				Royer Creek - Beaver Creek

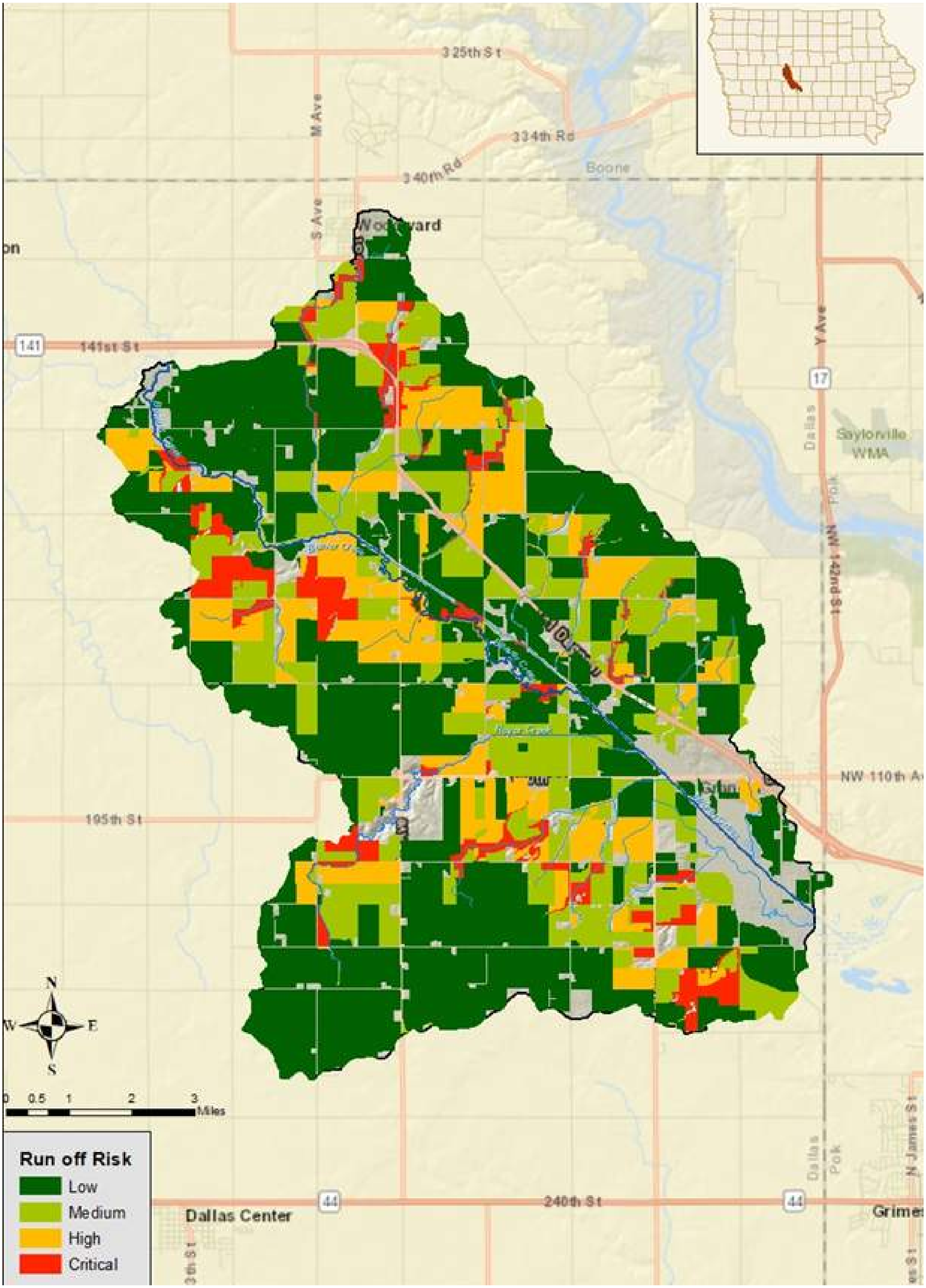
Table 11.15. BMP Adoption for Royer Creek-Beaver Creek Subwatershed

Grouping	Implement first
1, 7	1
2, 4, 10, 12, 15	2
3	3
5	5
6	6
8, 16	8
9, 13, 17	9
11	11
14	14

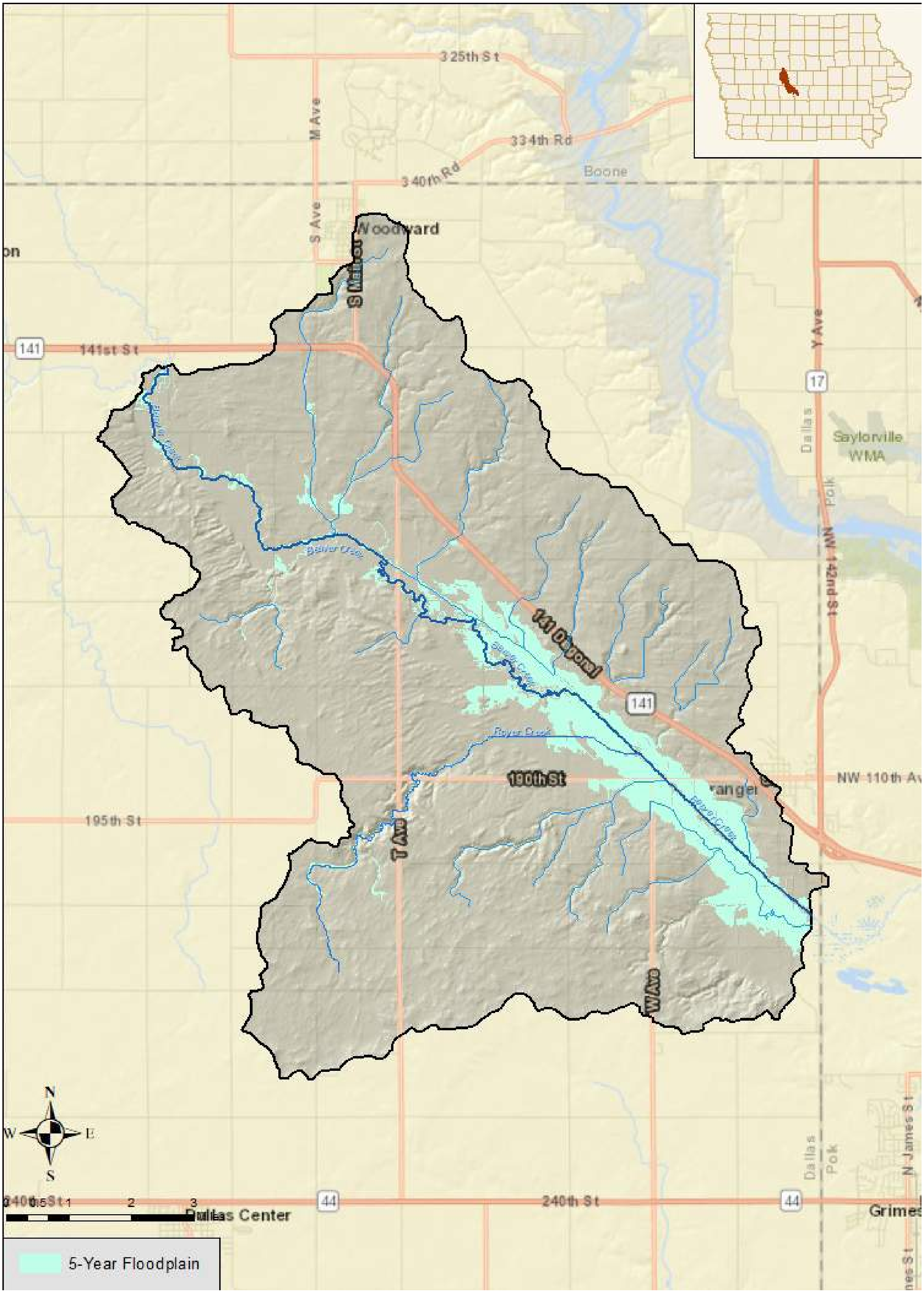
Table 11.15b. - Recommended prioritaztion list



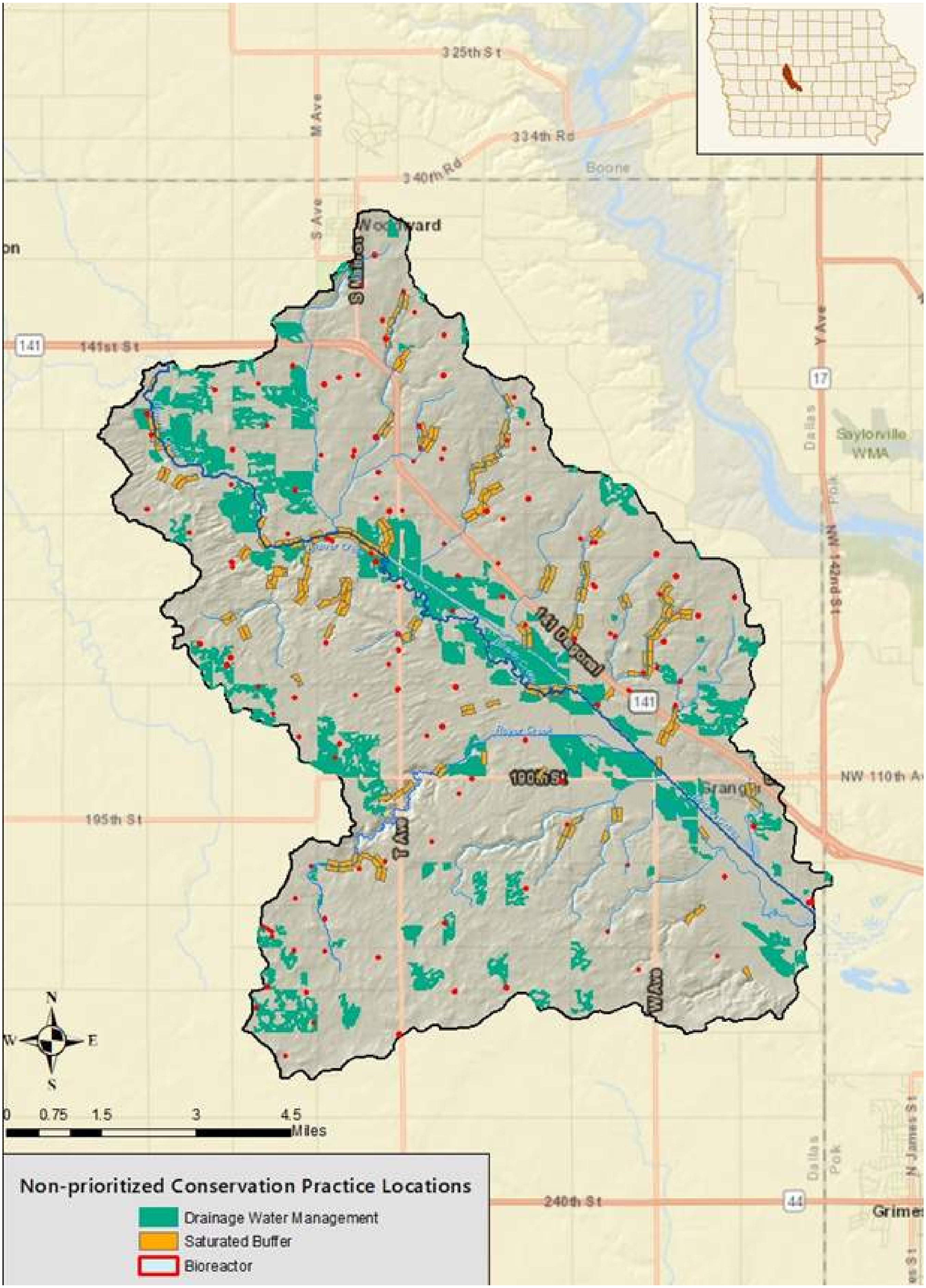
Royer Creek - Beaver Creek Subwatershed - Map 1



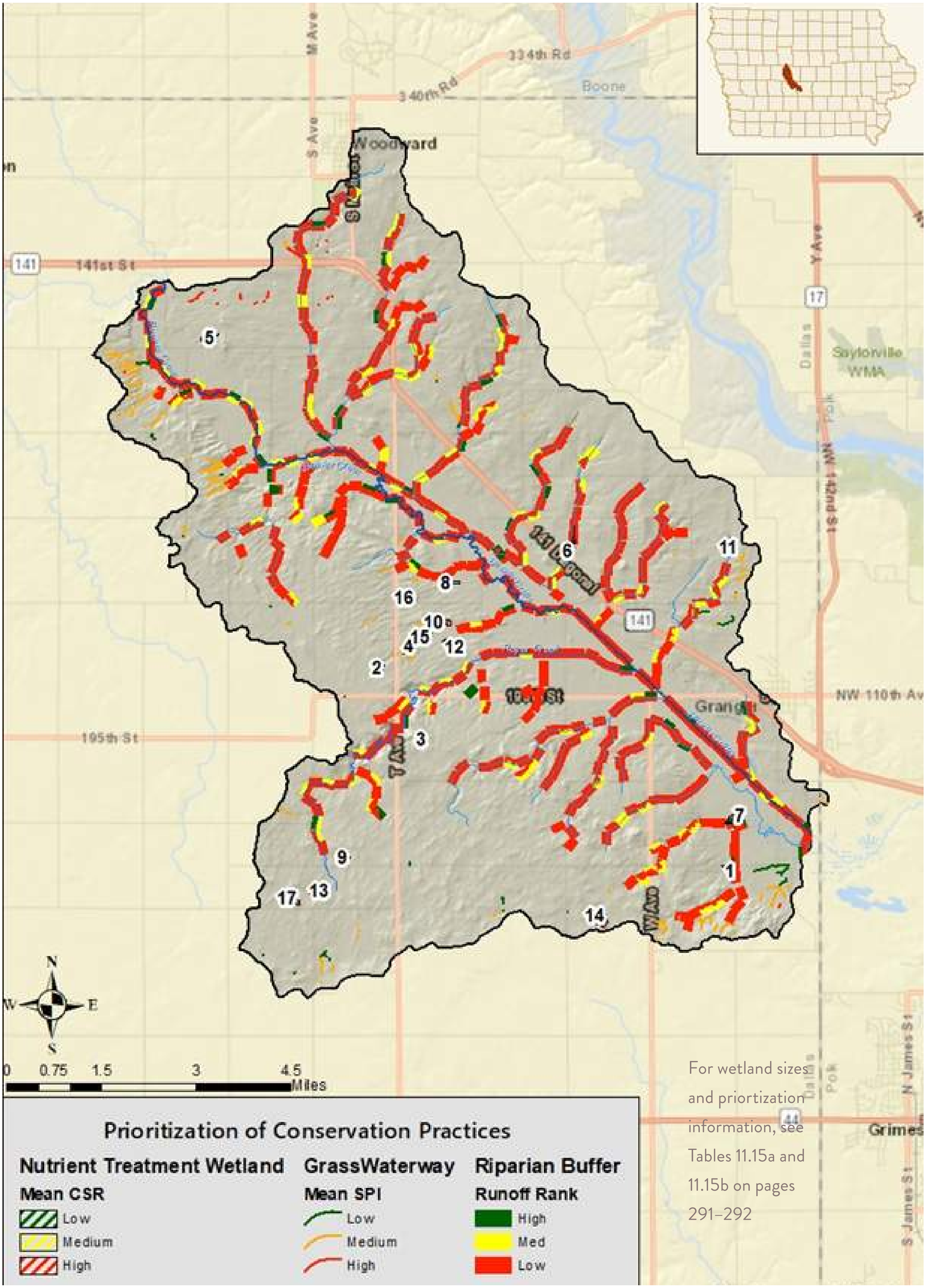
Royer Creek - Beaver Creek Subwatershed - Map 2



Royer Creek - Beaver Creek Subwatershed - Map 3

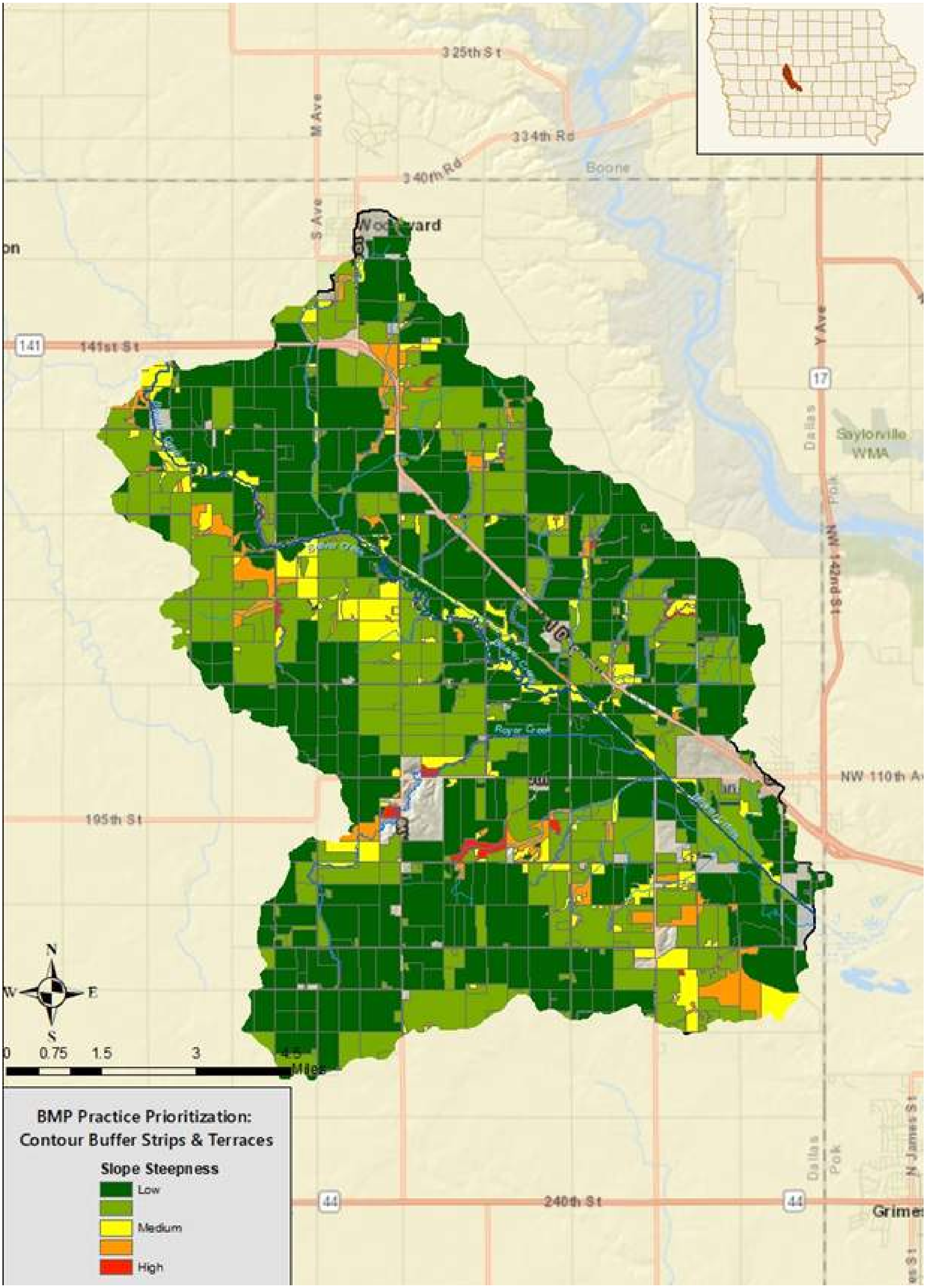


Royer Creek - Beaver Creek Subwatershed - Map 4

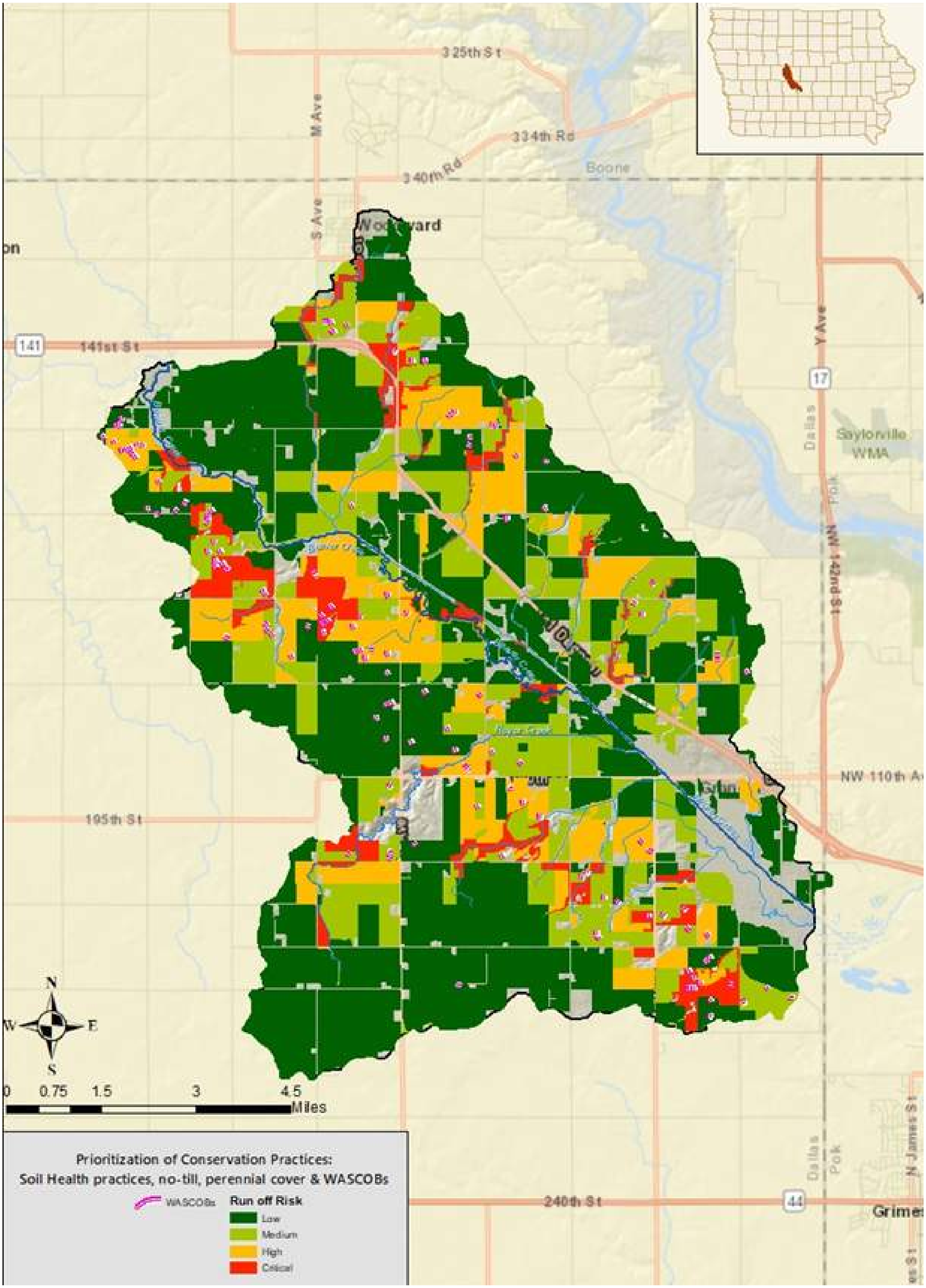


For wetland sizes and priortization information, see Tables 11.15a and 11.15b on pages 291–292

Royer Creek - Beaver Creek Subwatershed - Map 5



Royer Creek - Beaver Creek Subwatershed - Map 6



Royer Creek - Beaver Creek Subwatershed - Map 7

Beaver Creek

The specific conservation scenario developed for the Beaver Creek Subwatershed is shown in Table 11.16. The table indicates the recommended adoption rate of each practice with the corresponding acreage or quantity and the total implementation over a 20 year period for meeting targets for Nitrogen and Phosphorus for the Beaver Creek Watershed. The conservation practice scenario was developed through an iterative process using a cost-benefit analysis that is described in the Middle Cedar Watershed Management Plan. The equalized annual cost for practice implementation within the subwatershed is $450,000. This total annual cost includes conservation practice expenditures of $474,000 per year and conservation practices that result in a savings of $24,000 per year. Note that the cost provided are for conservation practices only.

Feasible maximum BMP adoption targets were set using stakeholder input as shown in Table 11.2. However, targeted implementation of BMPs at these rates did not reach the 34.4% total nitrogen reduction goal nor the 29% total phosphorus reduction goal. In order to reach these nutrient reduction goals in this watershed, target adoption rates for some BMPs will need to be increased. Based on our previous experience with watershed planning in Iowa, cover crops and no-till appear to be palatable BMPs to stakeholders, generally, so our recommendation is to pursue increased implementation of these two practices. **For reference, to reach the goals in this watershed we have estimated that an additional 3,413 acres of cover crops ($167,000/yr) and 987 acres of no-till ($12,000/yr) would be required above and beyond what is shown in Table 11.16.**

RANK	Mean CSR	Basin Size (HA)	Drainage Area (HA)
1	0.00	1.34	74.17
2	2.48	4.51	245.00
3	5.00	1.21	67.36
4	19.80	1.92	133.55
5	85.50	1.32	133.26
6	87.47	1.31	78.71

RANK	Mean CSR	Basin Size (HA)	Drainage Area (HA)
7	88.70	0.54	64.60
8	90.26	2.24	130.73
9	90.26	1.68	108.21
10	90.39	1.77	179.57
11	90.81	1.31	154.11
12	91.45	0.62	82.13

Table 11.16a. Properties of watersheds to each site location
(HA = hectacres = 100 acres)

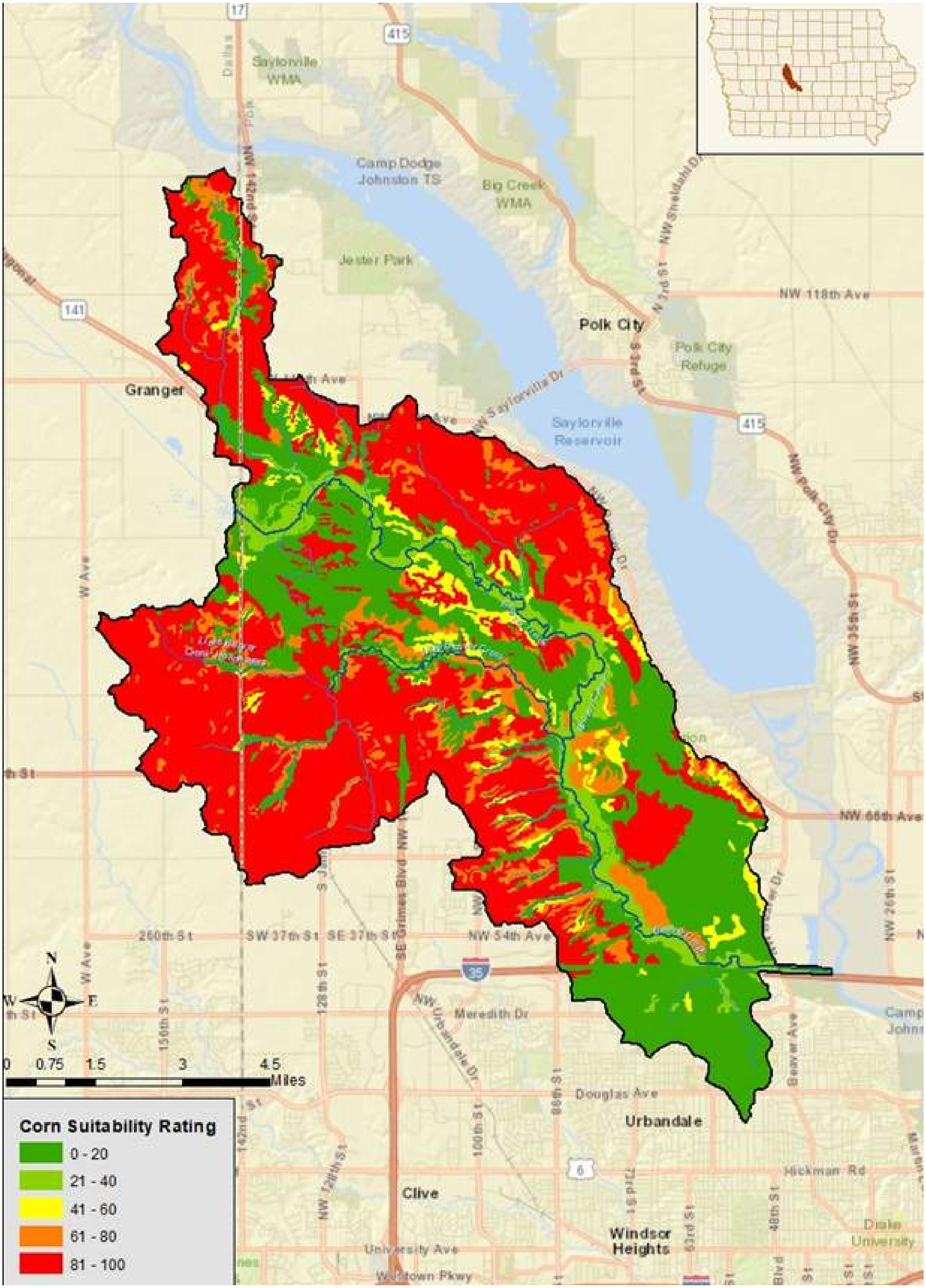
Tables 11.16a and 11.16b refer to Beaver Creek - Beaver Creek Subwatershed Map 5 on page 306

BMP Name	Existing Adoption Rate (%)	Target Adoption Rate (%)	Quantity	Equalized Annual Cost (Savings) [$/yr]
Cover crops	2%	4%	82 acres	$1,839
Extended rotations	1%	2%	41 acres	$563
Nitrogen management: nitrification inhibitor	50%	75%	1028 acres	($1,408)
Nitrogen management: rate control	5%	8%	103 acres	($94)
Nitrogen management: source control	10%	10%	0 acres	$0
Nitrogen management: timing control	35%	53%	720 acres	($6,568)
Phosphorus management: placement control	5%	8%	107 acres	$732
Phosphorus management: rate control	25%	38%	535 acres	($2,684)
Phosphorus management: source control	10%	10%	0 acres	$0
Contour buffer strips	0%	20%	5 miles	$2,556
Terraces	100%	100%	0 miles	$0
Drainage water management	0%	50%	20 fields	$3,560
Grassed waterways	45%	56%	5 miles	$320,021
No-Till	20%	40%	822 acres	$4,504
Denitrifying bioreactors	0%	25%	17 reactors	$3,765
Nutrient removal wetlands	0%	40%	5 wetlands	$14,787
Perennial cover	1%	2%	42 acres	$7,469
WASCOBs	25%	31%	4 basins	$8,276
Riparian buffer: Critical zone buffer	75%	100%	0 miles	$638
Riparian buffer: Deep-rooted vegetation buffer	75%	100%	13 miles	$17,283
Riparian buffer: Multi-species buffer	75%	100%	2 miles	$3,084
Riparian buffer: Stiff stem grass buffer	75%	100%	3 miles	$4,201
Riparian buffer: Stream stabilization buffer	75%	100%	17 miles	$37,323
Saturated buffers	0%	50%	9 miles	$99,655
			Beaver Creek	

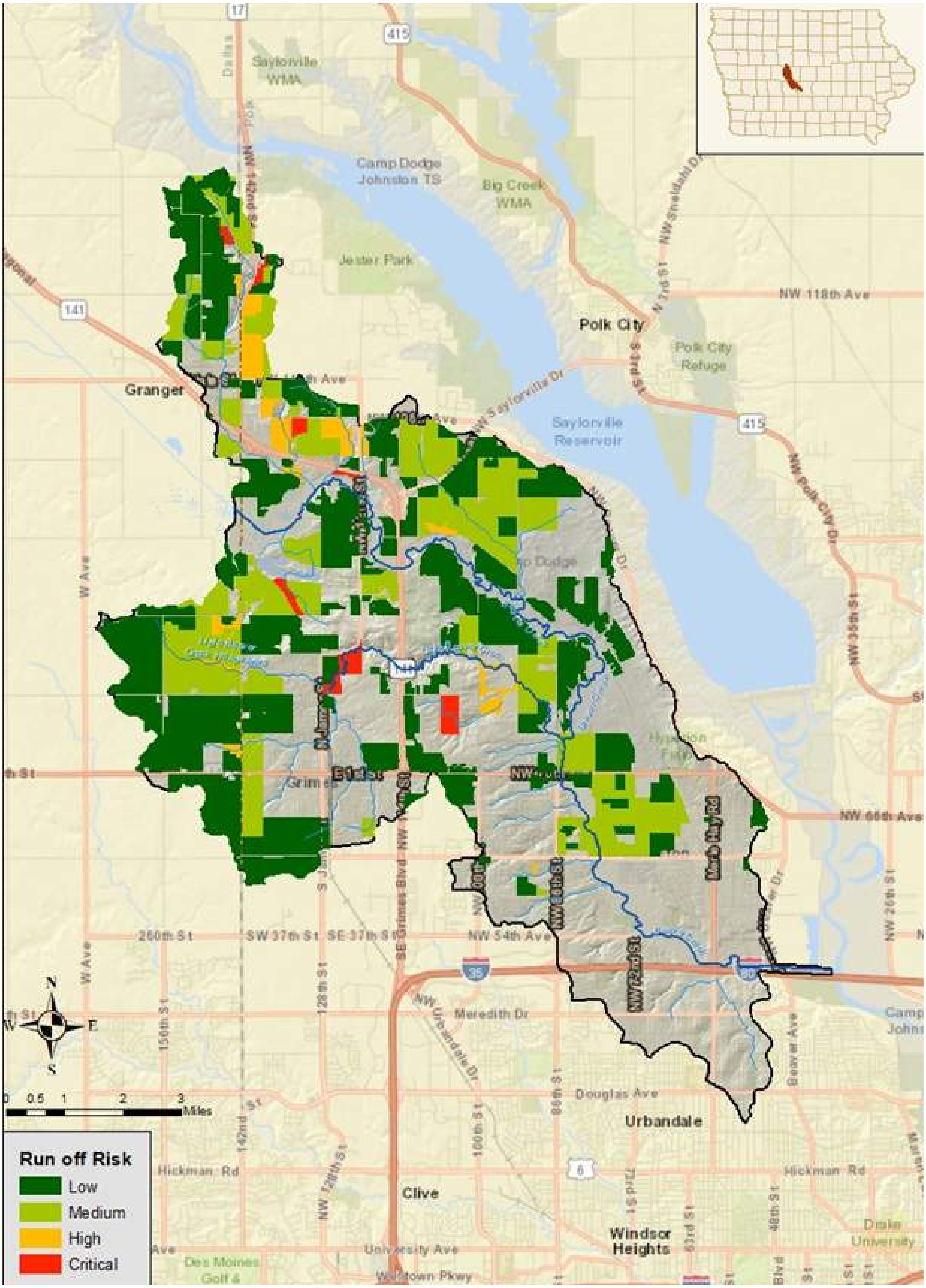
Table 11.16. BMP Adoption for Beaver Creek Subwatershed

Grouping	Implement first
1	1
2	2
3	3
4, 6	4
5, 7, 10	5
8	8
9, 11	9
12	12

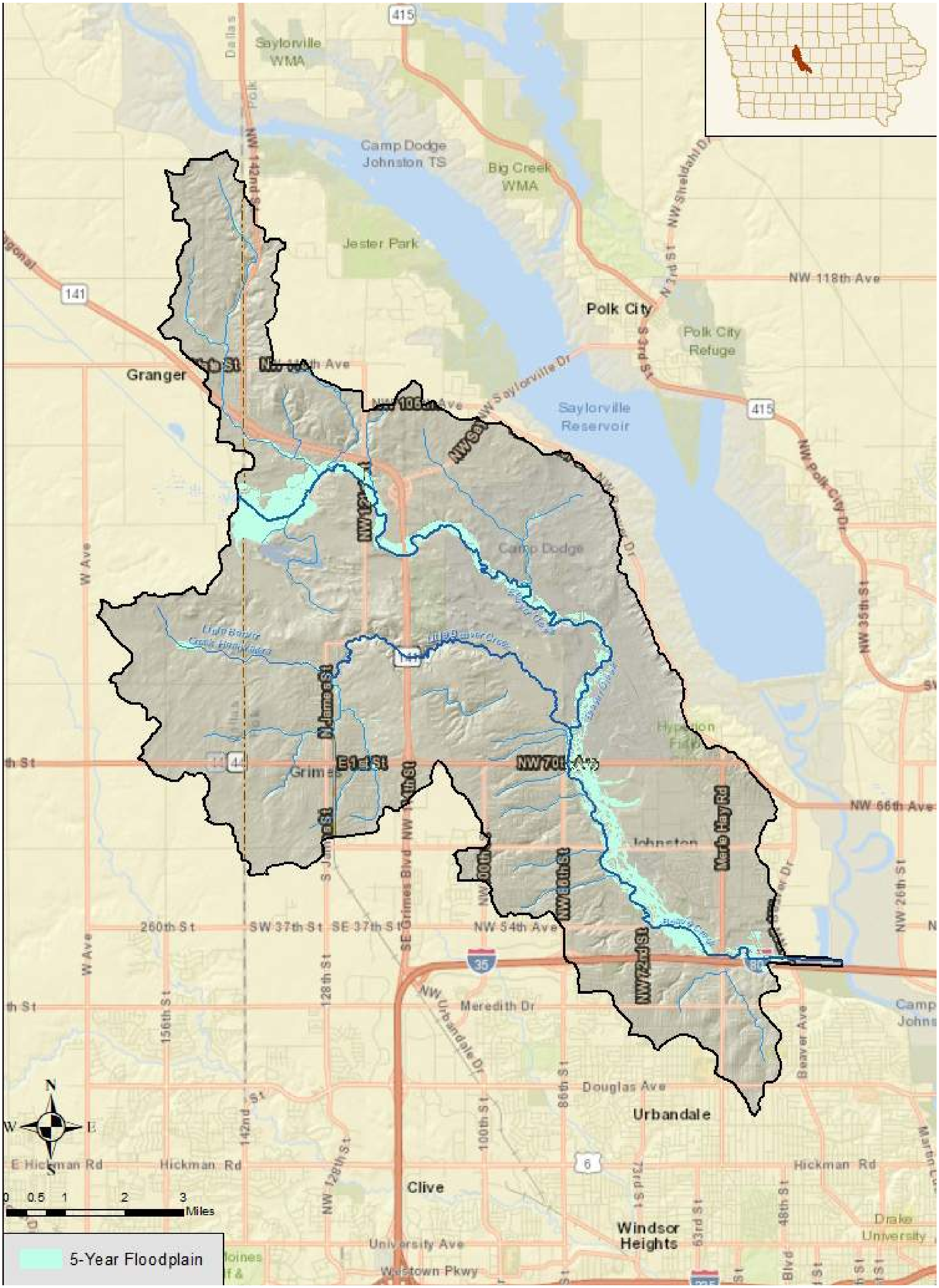
Table 11.16b. - Recommended prioritaztion list



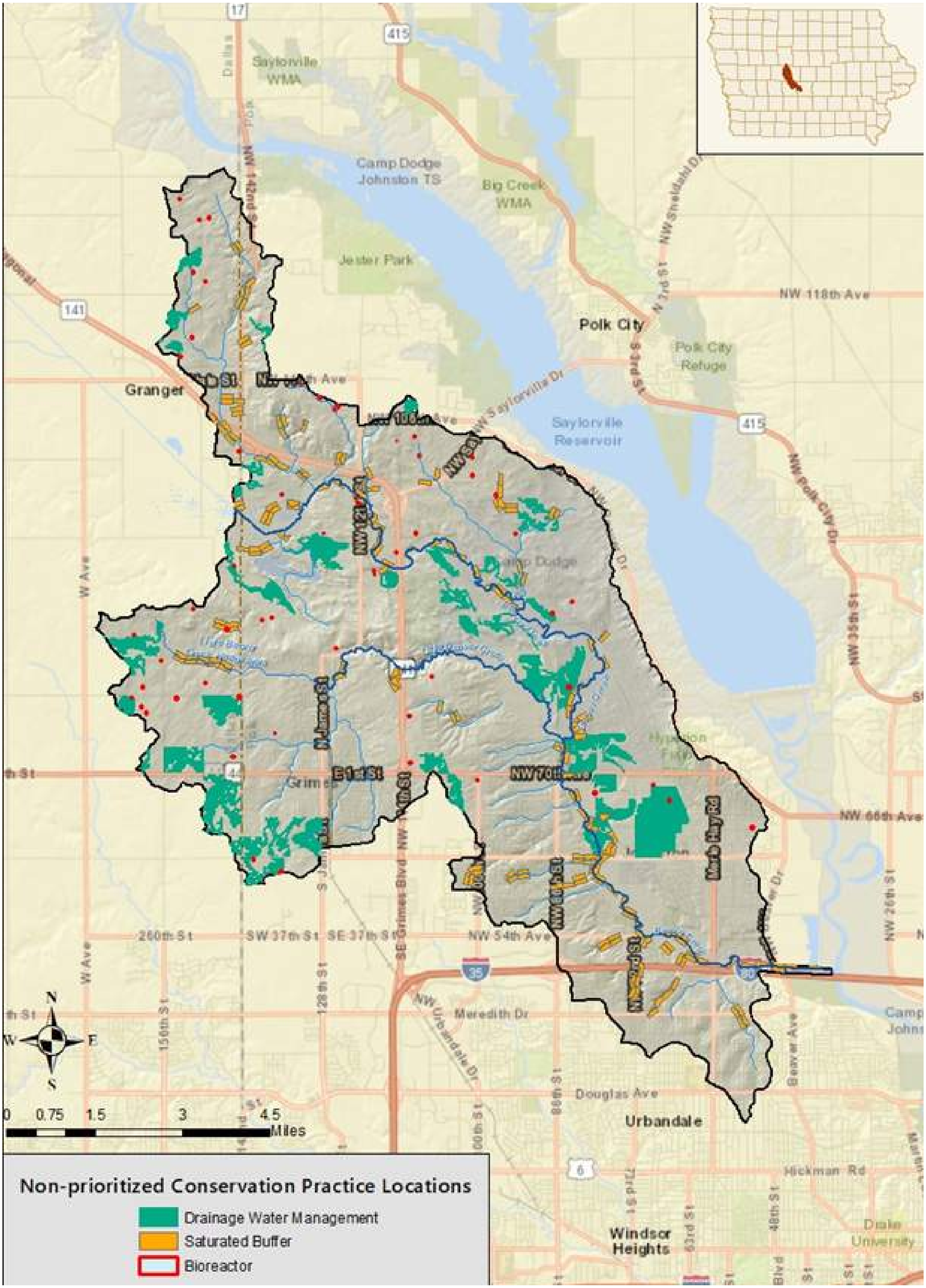
Beaver Creek Subwatershed - Map 1



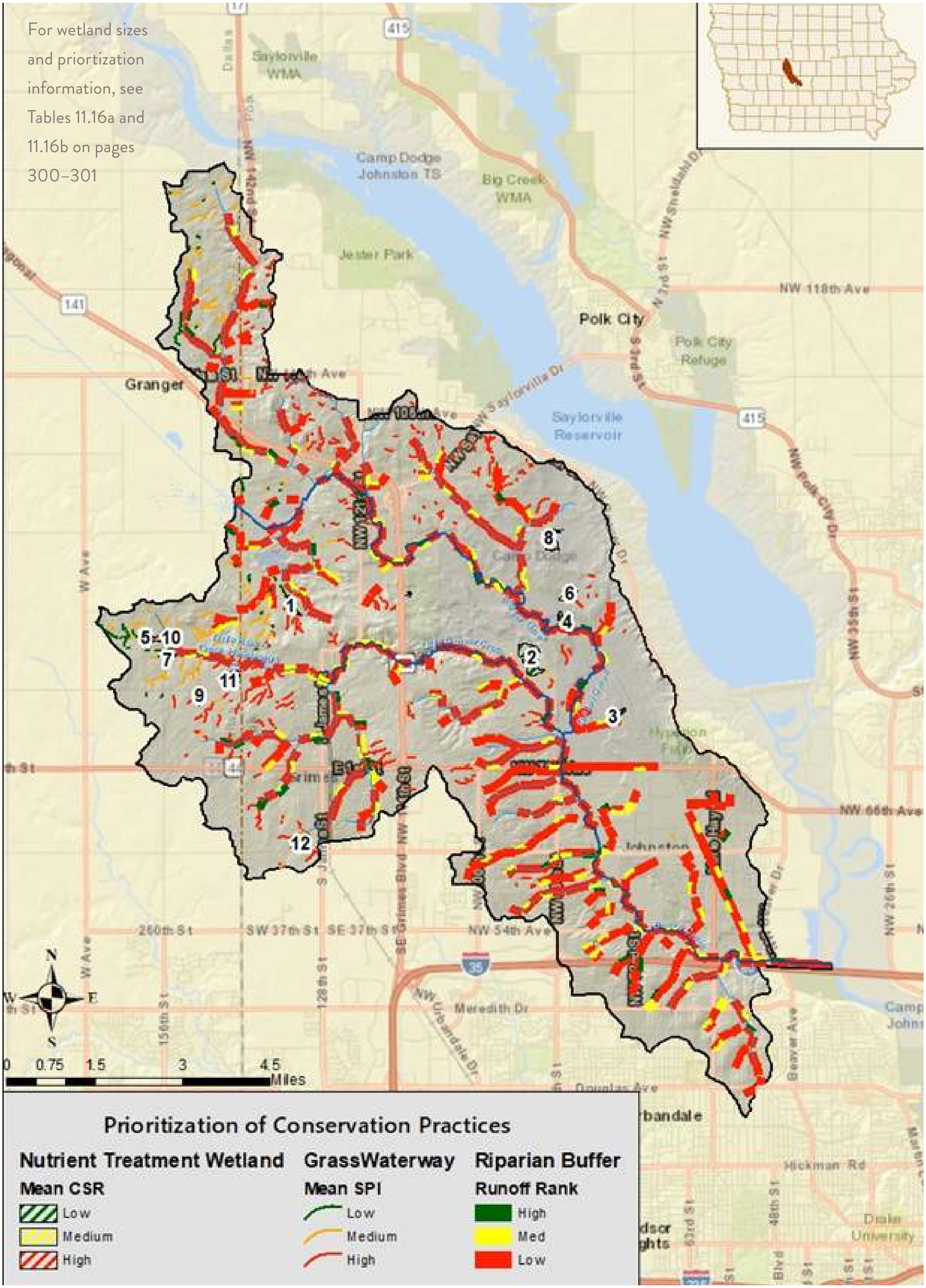
Beaver Creek Subwatershed - Map 2



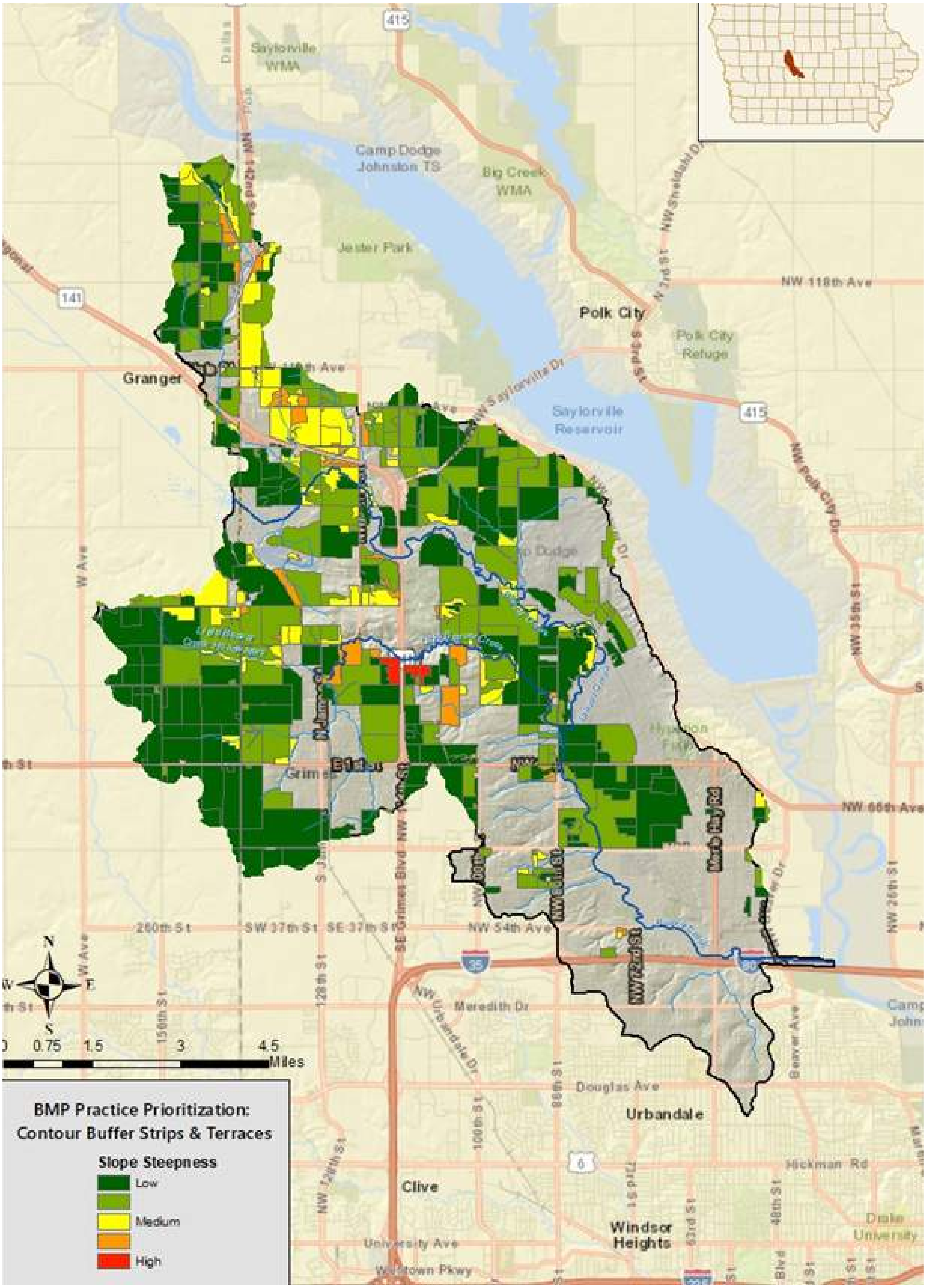
Beaver Creek Subwatershed - Map 3



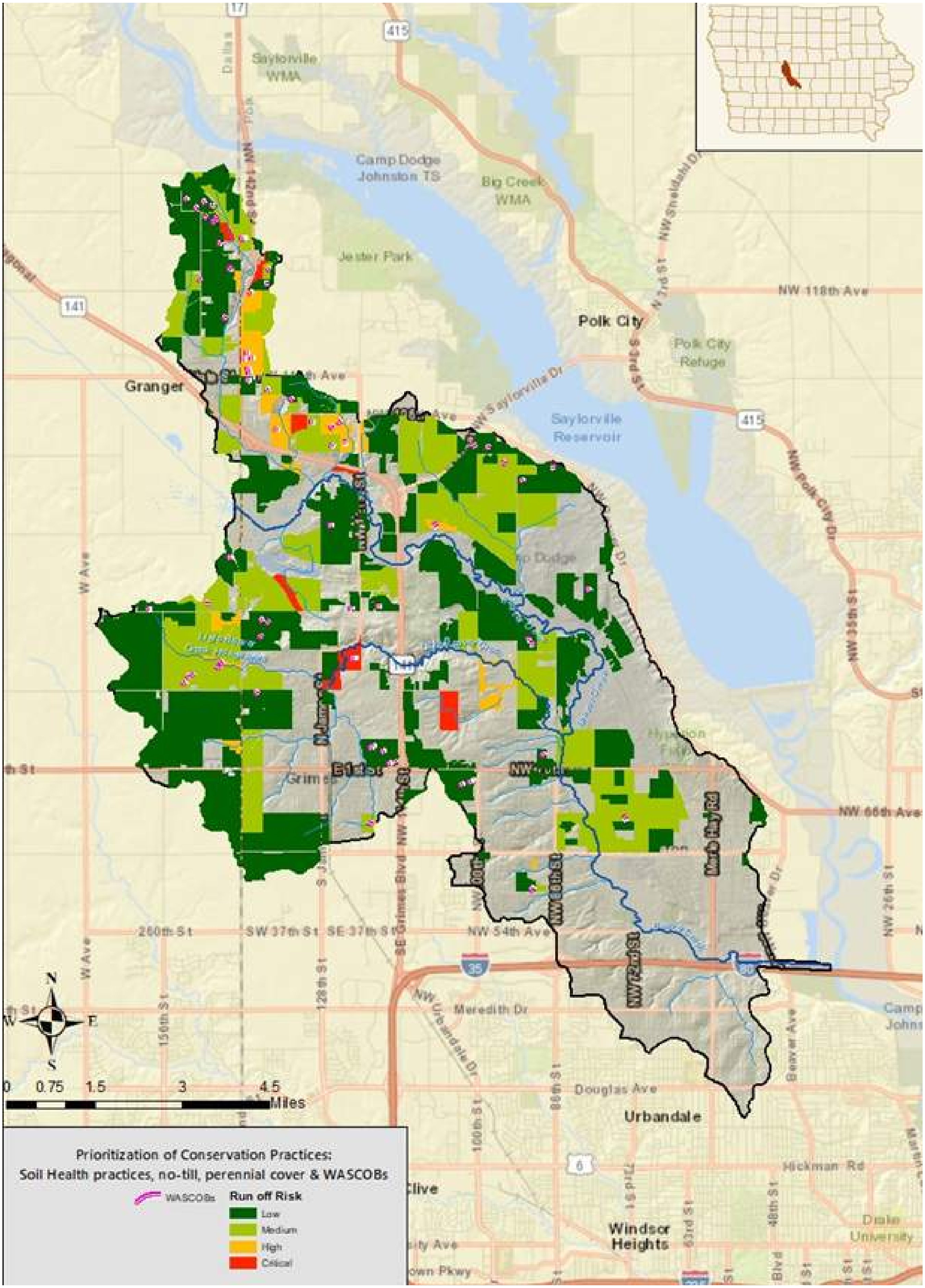
Beaver Creek Subwatershed - Map 4



Beaver Creek Subwatershed - Map 5



Beaver Creek Subwatershed - Map 6



Beaver Creek Subwatershed - Map 7

12

FLOOD RISK REDUCTION STRATEGIES

Chapter 12 reviews the effects of projected rainfall increases and identifies approaches that could be used to maintain existing base flood elevations in the lower, more urban sections of the watershed.

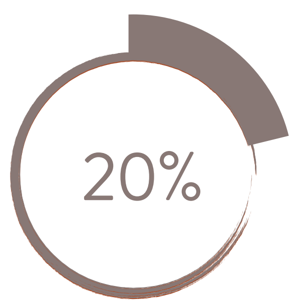
12

High water elevations

With the changes below, during a 100-year event, Beaver Creek could be 2.4 feet higher than what is expected today.

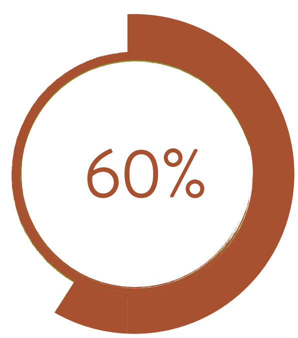
Rainfall volume

are projected to increase by 2050.



Projected flow

could increase, due to added rainfall, during a 100-year flood at the mouth



Flow increase

for a 2-year storm, and may become even larger for more common storms.

EXISTING CONDITIONS HYDROLOGIC MODEL

Hydrologic assessment of the Beaver Creek watershed was initially performed using ArcMap's GeoHMS and HEC-HMS software. The existing conditions hydrologic model used rainfall values established by NOAA Atlas 14. The calculated peak flow values at the outlet of each HUC-12 in the Beaver Creek watershed have been updated and are summarized below in Table 1. These updated discharges at the outlet of each HUC-12 are also shown in Map 12.1

Table 12.1: Existing Atlas 14 Conditions Hydrologic Model Results

HUC-12 VALUE	HUC-12 NAME	PEAK DISCHARGES (cfs)			
		2 YEAR	10 YEAR	25 YEAR	100 YEAR
71000040801	Little Beaver Creek - West Beaver Creek	600	1,130	1,530	2,260
71000040802	West Beaver Creek	1,260	2,350	3,010	3,900
71000040803	Middle Beaver Creek	780	1,680	2,320	3,230
71000040804	Beaver Creek - West Beaver Creek	2,380	4,490	5,670	7,460
71000040805	East Beaver Creek	500	960	1,310	1,960
71000040806	Beaver Creek - Beaver Branch	2,710	5,320	6,640	8,860
71000040807	Slough Creek	880	2,040	2,640	3,350
71000040808	Beaver Creek -Slough Creek	2,440	5,790	7,980	10,130
71000040809	Little Beaver Creek - Beaver Creek	1,200	2,540	3,610	5,580
71000040810	Beaver Creek - Royer Creek	2,160	6,380	9,940	13,670
71000040811	Beaver Creek - Middle Des Moines River	2,330	6,940	10,660	15,690

Map 12.1 - Expected peak discharges at downstream HUC-12 boundaries during a 100-year flood event.

FUTURE CONDITIONS HYDROLOGIC MODEL

The existing condition flood risk modeling and mapping is derived from rainfall data recorded in the past; however, **recent studies suggest that our precipitations patters are changing** (Wuebbles et al., 2017). As part of the watershed plan a future conditions scenario was considered for planning purposes.

Rainfall depths used in the existing Atlas 14 conditions hydrologic model were increased to produce the future conditions hydrologic model. Rainfall increase was based on research developed by the U.S. Global Change Research Program that indicates the **average annual precipitation in the upper Midwest increased by 10-15%** between 1986 and 2015 when compared to rainfall values recorded between 1901 and 1960 (Easterling et. al., 2017). The future conditions model assumes that **present day rainfall increases 15% by 2050** based on the highest increase scenario from this research. All other assumptions between the existing and future conditions models were maintained (i.e. land use, stream hydraulics, etc.). Conversion of landcover from pervious areas to urban is a factor that contributes to increased runoff and peak flows; however, assumptions for the hydrologic change greatly depend on the management strategies implemented locally.

For the purposes of this assessment, only changes in precipitation were considered.

RETURN PERIOD	RAINFALL DEPTH (INCHES OVER 24 HOURS)	
	EXISTING ATLAS 14	FUTURE CONDITIONS
2 Year	3.08	3.54
10 Year	4.46	5.13
25 Year	5.44	6.26
100 Year	7.12	8.19

TABLE 12.2: DESIGN RAINFALL DEPTHS

The increase in rainfall depths is expected to result in an increase in the peak flow values calculated by the future conditions model compared to existing Atlas 14 conditions. This is shown in Table 12.3, displaying future conditions peak flow values at the outlet of each HUC-12. Table 12.4 shows the percent increase in the peak flow values between future and existing Atlas 14 conditions models.

TABLE 12.3: FUTURE CONDITIONS HYDROLOGIC MODEL RESULTS

HUC-12 VALUE	HUC - 12 NAME	PEAK DISCHARGES (cfs)			
		2 YEAR	10 YEAR	25 YEAR	100 YEAR
71000040801	Little Beaver Creek - West Beaver Creek	770	1,400	1,890	2,740
71000040802	West Beaver Creek	1,650	2,840	3,440	4,710
71000040803	Middle Beaver Creek	1,060	2,140	2,800	3,790
71000040804	Beaver Creek - West Beaver Creek	2,980	5,290	6,480	8,650
71000040805	East Beaver Creek	640	1,200	1,620	2,380
71000040806	Beaver Creek - Beaver Branch	3,670	6,210	7,750	10,220
71000040807	Slough Creek	1,230	2,550	2,960	3,890
71000040808	Beaver Creek -Slough Creek	3,750	7,170	9,110	11,340
71000040809	Little Beaver Creek - Beaver Creek	1,620	3,270	4,560	6,880
71000040810	Beaver Creek - Royer Creek	3,390	8,880	11,770	15,820
71000040811	Beaver Creek - Middle Des Moines River	3,670	9,640	13,190	18,660

TABLE 12.4 HYDRAULIC MODEL COMPARISON

HUC-12 VALUE	HUC -12 NAME	% Increase Between Future +Existing Conditions Atlas 14 Models			
		2 YEAR	10 YEAR	25 YEAR	100 YEAR
71000040801	Little Beaver Creek - West Beaver Creek	28.33	23.89	23.53	21.24
71000040802	West Beaver Creek	30.95	20.85	14.29	20.77
71000040803	Middle Beaver Creek	35.90	27.38	20.69	17.34
71000040804	Beaver Creek - West Beaver Creek	25.21	17.82	14.29	15.95
71000040805	East Beaver Creek	28.00	25.00	23.66	21.43
71000040806	Beaver Creek - Beaver Branch	35.42	16.73	16.72	15.35
71000040807	Slough Creek	39.77	25.00	12.12	16.12
71000040808	Beaver Creek -Slough Creek	53.69	23.83	14.16	11.94
71000040809	Little Beaver Creek - Beaver Creek	35.00	28.74	26.32	23.30
71000040810	Beaver Creek - Royer Creek	56.94	39.18	18.41	15.73
71000040811	Beaver Creek - Middle Des Moines River	57.51	38.90	23.73	18.93

HYDRAULIC MODELING

Hydraulic modeling was performed in areas of the Beaver Creek watershed which presently are mapped as FEMA Zone AE floodplains. **A Zone AE floodplain is currently located in Johnston from the mouth of Beaver Creek at the Des Moines River to just upstream of NW 70th Avenue.** This area is henceforth referred to as the "downstream" floodplain. In addition, a Zone AE floodplain is located in unincorporated Polk County just downstream of Iowa Highway 141. This area is henceforth referred to as the "upstream" floodplain.

The purpose of the hydraulic modeling was to update previously completed HEC-RAS models with peak flow discharges obtained from the existing Atlas 14 and future conditions hydrologic models to study the impact of increasing rainfall values on flood elevations in the study reach. For the upstream floodplain hydraulic model, the formerly effective FEMA HEC-2 model was obtained from a previous Snyder & Associates project and duplicated into HEC-RAS as the base model. This model contained the old lettered FEMA cross-sections and was adapted to the newly mapped lettered FEMA cross-sections at comparable locations for this study. For the downstream floodplain hydraulic model, HEC-RAS models used to permit recently re-constructed bridges on NW 62nd Street and NW Beaver Drive were used as a base model.

The effective FEMA 100-year flood discharges published in the Polk County Flood Insurance Study used in the previous hydraulic models were updated with discharges from the existing Atlas 14 and future conditions hydrologic models of the Beaver Creek watershed to perform the hydraulic analysis. All other hydraulic modeling assumptions from previous models (i.e. cross-section location, geometry, downstream boundary conditions, etc.) were maintained. Table 12.5 **shows a comparison between the effective FEMA 100-year flood discharges and the 100-year flood discharges from the Beaver Creek hydrologic models used for hydraulic modeling.**

TABLE 12.5: HYDRAULIC MODEL DISCHARGE COMPARISON

SCENARIO	DISCHARGE (CFS)	
	UPSTREAM FLOODPLAIN	DOWNSTREAM FLOODPLAIN
Effective FEMA Discharge	8,560	12,800
Existing Atlas 14 Conditions	14,160	14,480
Future Scenario	16,590	16,990

Table 12.6 shows a comparison between the existing Atlas 14 and future conditions hydraulic models for the upstream floodplain. Because of the increase in discharges from existing Atlas 14 to future conditions, a steady increase in the 100-year flood elevation of about 1 foot in the future conditions model is observed. The elevation in the downstream-most cross-section remains the same due to this model tying into the boundary condition from the effective FEMA model at this location.

Table 12.7 shows the same comparison for the downstream floodplain, with varying levels of increase throughout the model. The most significant increase occurs just upstream of Merle Hay Road. Unlike the upstream floodplain, the elevation in the downstream-most cross-section differs due to the effective FEMA model assuming normal depth as the downstream boundary condition. Maps 12.2 and 12.3 show the changes in projected floodplain width based on this analysis

TABLE 12.6: UPSTREAM FLOODPLAIN HYDRAULIC MODEL COMPARISON

CROSS SECTION	100 YEAR WATER SURFACE ELEVATION		DIFFERENCE (FUTURE - EXISTING)	REMARK
	EXISTING ATLAS 14 CONDITIONS	FUTURE CONDITIONS		
15.010	832.28	832.28	0.00	FIS XS AH
15.013	834.82	835.44	0.62	
15.016	833.96	834.30	0.34	FIS XS AI
15.018	836.39	837.43	1.04	FIS XS AJ
15.020	836.53	837.57	1.04	FIS XS AK
15.030	836.57	837.60	1.03	
15.035	Herrold Street Bridge (Near NW 88th)			
15.040	836.85	837.91	1.06	
15.050	836.94	838.01	1.07	FIS XS AL
15.060	839.01	840.03	1.02	FIS XS AM
15.070	839.64	840.63	0.99	FIS XS AN
15.080	840.89	841.90	1.01	FIS XS AO
15.090	841.68	842.65	0.97	FIS XS AP
15.100	842.92	843.92	1.00	FIS XS AQ
15.110	843.35	844.36	1.01	FIS XS AR
15.120	844.64	845.69	1.05	FIS XS AS

Aerial footage of flooding along Beaver Creek in 2019 (City of Johnston).

TABLE 12.7: DOWNSTREAM FLOODPLAIN HYDRAULIC MODEL COMPARISON				
CROSS SECTION	100 YEAR WATER SURFACE ELEVATION		DIFFERENCE (FUTURE - EXISTING)	REMARK
	EXISTING ATLAS 14 CONDITIONS	FUTURE CONDITIONS		
0	803.44	804.46	1.02	
3000	806.65	807.71	1.06	FIS XS A
3860	807.33	808.39	1.06	FIS XS B
3980	NW Beaver Drive			
4090	807.44	808.52	1.08	FIS XS C
4900	807.73	808.84	1.11	FIS XS D
5700	808.11	809.19	1.08	FIS XS E
8350	809.47	810.61	1.14	FIS XS F
8800	809.59	810.71	1.12	FIS XS G
9380	809.83	810.91	1.08	FIS XS H
9460	810.50	811.58	1.08	
9550	Merle Hay Road			
9630	810.82	813.16	2.34	
9675	810.61	813.01	2.40	FIS XS I
10350	811.89	814.08	2.19	FIS XS J
11100	812.05	814.19	2.14	FIS XS K
12100	812.32	814.36	2.04	FIS XS L
13300	812.52	814.48	1.96	FIS XS M
14400	812.75	814.63	1.88	FIS XS N
15600	813.00	814.76	1.76	FIS XS O
17150	813.32	814.94	1.62	FIS XS P

TABLE 12.7 - CONT.: DOWNSTREAM FLOODPLAIN HYDRAULIC MODEL COMPARISON				
CROSS SECTION	100 YEAR WATER SURFACE ELEVATION		DIFFERENCE (FUTURE - EXISTING)	REMARK
	EXISTING ATLAS 14 CONDITIONS	FUTURE CONDITIONS		
17900	813.60	815.11	1.51	FIS XS Q
19900	814.32	815.56	1.24	FIS XS R
20800	814.96	815.98	1.02	FIS XS S
22000	815.61	816.48	.87	FIS XST
23100	816.83	817.41	0.58	FIS XS U
23590	817.11	817.67	0.56	FIS XS V
23700	NW 62nd Street			
23868	818.19	819.03	0.84	FIS XS W
24600	818.76	819.68	0.92	FIS XS X
25700	818.99	819.90	0.91	FIS XSY
26800	819.19	820.08	0.89	FIS XS Z
28300	819.74	820.55	.81	FIS XS AA
29700	820.68	821.39	0.71	FIS XS AB
30700	821.20	821.89	0.69	FIS XS AC
32000	822.02	822.73	0.71	FIS XS AD
32900	823.01	823.62	0.61	FIS XS AE
33108	823.20	823.79	0.59	
33150	NW 70th Street			
33192	823.41	823.74	0.33	
33250	823.92	824.40	0.48	FIS XS AF

FLOODPLAIN MAPPING

The 100-year flood water surface elevations for existing Atlas 14 and future conditions shown in Tables 12.6 and 12.7 for the upstream and downstream floodplains were used to perform floodplain mapping in ArcMap. Exhibits comparing the computed flood boundaries for the upstream and downstream floodplains are included in the Appendix. These exhibits show how the 100-year flood boundary will widen as a result of the projected 15% increase in rainfall values when compared to existing conditions, assuming no change in land use or terrain.

WATERSHED RECOMENDATIONS

IMPACTS

Results from the hydraulic modeling indicate that floodplain elevation within the downstream portions of Beaver Creek could increase by as much as 2.4 feet in some areas.

Table 12.8 displays the amount of additional inhabitable structures that are within the future scenario 100-year floodplain. **The future scenario adds 3 inhabitable structures to the floodplain in the upstream portions and 18 inhabitable structures in the downstream portions compared to existing Atlas 14 conditions.**

TABLE 12.8: INHABITABLE STRUCTURES WITHIN THE FLOODPLAIN

SCENARIO	STRUCTURES IN THE FLOODPLAIN	
	UPSTREAM FLOODPLAIN	DOWNSTREAM FLOODPLAIN
Effective FEMA Discharge	0	37
Existing Atlas 14 Conditions	1	24
Future Scenario	4	42

Note: Table 12.8 shows a decrease in structures in the downstream floodplain when comparing existing Atlas 14 conditions to the effective FEMA floodplain. This is due to the floodplain for existing Atlas 14 conditions being mapped on improved topographic data compared to the effective floodplain.

Focusing runoff control projects in areas that produce higher runoff is one method that could be used to prioritize projects. Areas that produce higher runoff are areas that provide the greatest opportunity for reductions.

An exhibit displaying the average HUC-12 runoff coefficient within Beaver Creek is located Map 12.4 (last map in the appendix PDF – full page 7.5x10). Generally, runoff potential increases traveling north in the watershed. Areas on the southern portion contain greater impervious surface; however, this is countered by the amount of hydrologic soil group A in that area, which would be expected to generate less runoff. **On the contrary, areas further north have minor impervious surfaces but hydrologic soil group transitions into C and D soils, which typically convert a larger percentage of rainfall to runoff.**

STRUCTURAL PRACTICES

With a goal of accounting for the additional 15 percent in rainfall during the 100-year event, Beaver Creek would need to add over 20,000 acre-feet of storage within the watershed.

This is about triple the value of initial abstraction in the existing watershed (amount of rainfall the surface can infiltrate before producing runoff). Studies suggest converting row crop to tall-grass prairie can increase the initial abstraction significantly (Basche 2017); however, it is important to note that frozen or fully saturated soil conditions will reduce or eliminate losses through infiltration.

Storage ponds are one strategy to attenuate flows during large rain events. Assuming 20-acre feet of potential storage in an average pond (within range of NRCS guidance documents). **The Beaver Creek watershed would need approximately 1,000 new ponds or 1 pond for every 230 acres of drainage.**

COVER PRACTICES

Another strategy to mitigate changing rainfall patterns and reduce future conditions peak flows in the watershed is to implement widespread agricultural conservation practices. To study this, the future conditions hydrologic model was updated. Research indicates crop lands managed as a part of a no-till corn-wheat-meadow-meadow (CWMM) rotation were observed to have runoff curve numbers averaging 16 points lower than the range of standard curve numbers published by the Natural Resources Conservation Service (Bonta and Shipitalo, 2013). Thus, the curve numbers used in the previous hydrologic modeling for corn and soybeans were reduced accordingly, and a new mean curve number for each subwatershed in the hydrologic model was calculated. **The future conditions model was re-run with adjusted curve numbers and updated hydrologic parameters to establish future conditions peak discharges that reflect a 100 percent conversion to CWMM rotation practices in the Beaver Creek watershed.**

The results of the future conditions CWMM model are shown in Tables 12.9 and 12.10. Table 9 summarizes the peak discharges at the outlet of each HUC-12 watershed. Table 12.10 displays the percent change between the future conditions CWMM model and the existing Atlas 14 rainfall model. **While a CWMM rotation may not be directly applicable in Central Iowa, the comparison in Table 12.10 indicates that widespread agricultural conservation practices could lead to a substantial decrease in the future conditions peak flows when compared to the existing Atlas 14 rainfall model. Extended crop rotations or other BMPs that improve soil health could be expected to achieve some of these benefits.**

One notable exception is observed at the outlet of East Beaver Creek, which still increases compared to existing Atlas 14 rainfall (but decreases when compared to the future conditions model with no change in agricultural practices shown in Table 3). This could be a result of the East Beaver Creek HUC-12 containing a higher portion of urbanized land over a smaller drainage area when compared to adjacent HUC-12's through Beaver Creek, West Beaver Creek, Middle Beaver Creek, and Little Beaver Creek.

TABLE 12.9: FUTURE CONDITIONS CWMM HYDROLOGIC MODEL RESULTS

HUC-12 VALUE	HUC - 12 NAME	PEAK DISCHARGES (cfs)			
		2 YEAR	10 YEAR	25 YEAR	100 YEAR
71000040801	Little Beaver Creek - West Beaver Creek	340	780	1,140	1,820
71000040802	West Beaver Creek	720	1,750	2,430	3,440
71000040803	Middle Beaver Creek	410	1,140	1,780	2,800
71000040804	Beaver Creek - West Beaver Creek	1,010	3,200	4,340	6,570
71000040805	East Beaver Creek	420	950	1,380	2,190
71000040806	Beaver Creek - Beaver Branch	1,240	4,070	5,640	8,060
71000040807	Slough Creek	450	1,410	2,280	3,030
71000040808	Beaver Creek -Slough Creek	1,070	4,380	6,610	9,520
71000040809	Little Beaver Creek - Beaver Creek	670	1,790	2,760	4,640
71000040810	Beaver Creek - Royer Creek	940	4,090	7,540	12,110
71000040811	Beaver Creek - Middle Des Moines River	1,080	4,420	7,880	13,570

TABLE 12.10: CWMM HYDROLOGIC MODEL COMPARISON

HUC-12 VALUE	HUC - 12 NAME	% Change Between Future No-Till + Existing Conditions Models			
		2 YEAR	10 YEAR	25 YEAR	100 YEAR
71000040801	Little Beaver Creek - West Beaver Creek	-43.33	-30.97	-25.49	-19.47
71000040802	West Beaver Creek	-42.86	-25.53	-19.27	-11.79
71000040803	Middle Beaver Creek	-47.44	-32.14	-23.28	-13.31
71000040804	Beaver Creek - West Beaver Creek	-57.56	-28.73	-23.46	-11.93
71000040805	East Beaver Creek	-16.00	-1.04	5.34	11.73
71000040806	Beaver Creek - Beaver Branch	-54.24	-23.50	-15.06	-9.03
71000040807	Slough Creek	-48.86	-30.88	-13.64	-9.55
71000040808	Beaver Creek -Slough Creek	-56.15	-24.35	-17.17	-6.02
71000040809	Little Beaver Creek - Beaver Creek	-44.17	-29.53	-23.55	-16.85
71000040810	Beaver Creek - Royer Creek	-56.48	-35.89	-24.14	-11.41

Another scenario was developed to study the impact of complete conversion of corn and soybeans to native grass. This was performed by changing Curve Numbers for corn and soybeans to Curve Numbers for meadow established by NRCS, calculating a new mean Curve Number for each subwatershed in the hydrologic model, and re-running the hydrologic model. The results of this model are summarized below in Tables 12.11 and 12.12. Table 12.11 summarizes the peak discharges at the outlet of each HUC-12. Table 12.12 shows the percent change between the future conditions native grass model and the existing Atlas 14 rainfall model. **These tables show that the reduction in peak flows in the Beaver Creek watershed, while not as significant as the reduction from the future conditions CWMM model, is large enough to reduce peak flows in most cases to values lower than those observed in the existing Atlas 14 rainfall model.** The lone exception is at the outlet of the East Beaver Creek HUC-12.

TABLE 12.11: FUTURE CONDITIONS NATIVE GRASS HYDROLOGIC MODEL RESULTS

HUC-12 VALUE	HUC - 12 NAME	PEAK DISCHARGES (cfs)			
		2 YEAR	10 YEAR	25 YEAR	100 YEAR
71000040801	Little Beaver Creek - West Beaver Creek	410	890	1,270	1,980
71000040802	West Beaver Creek	840	1,950	2,620	3,610
71000040803	Middle Beaver Creek	490	1,270	1,940	2,930
71000040804	Beaver Creek - West Beaver Creek	1,490	3,600	5,020	6,930
71000040805	East Beaver Creek	460	1,010	1,450	2,280
71000040806	Beaver Creek - Beaver Branch	1,550	4,490	5,920	8,360
71000040807	Slough Creek	510	1,510	2,420	3,100
71000040808	Beaver Creek -Slough Creek	1,350	4,860	6,900	9,720
71000040809	Little Beaver Creek - Beaver Creek	730	1,900	2,890	4,810
71000040810	Beaver Creek - Royer Creek	1,050	4,560	8,030	12,330
71000040811	Beaver Creek - Middle Des Moines River	1,120	4,680	8,320	13,820

TABLE 12.12 : NATIVE GRASS HYDROLOGIC MODEL COMPARISON

HUC-12 VALUE	HUC - 12 NAME	% Change Between Future Native Grass + Existing Conditions Models			
		2 YEAR	10 YEAR	25 YEAR	100 YEAR
71000040801	Little Beaver Creek - West Beaver Creek	-31.67	-21.24	-16.99	-12.39
71000040802	West Beaver Creek	-33.33	-17.02	-12.96	-7.44
71000040803	Middle Beaver Creek	-37.18	-24.40	-16.38	-9.29
71000040804	Beaver Creek - West Beaver Creek	-37.39	-19.82	-11.46	-7.10
71000040805	East Beaver Creek	-8.00	5.21	10.69	16.33
71000040806	Beaver Creek - Beaver Branch	-42.80	-15.60	-10.84	-5.64
71000040807	Slough Creek	-42.05	-25.98	-8.33	-7.46
71000040808	Beaver Creek -Slough Creek	-44.67	-16.06	-13.53	-4.05
71000040809	Little Beaver Creek - Beaver Creek	-39.17	-25.20	-19.94	-13.80
71000040810	Beaver Creek - Royer Creek	-51.39	-28.53	-19.22	-9.80
71000040811	Beaver Creek - Middle Des Moines River	-51.93	-32.56	-21.95	-11.92

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13

EDUCATION PLAN

This education and collaboration plan is intended to inform multiple audiences about this watershed plan and what their roles can be in its implantation. In this approach, the general public refers to anyone that lives, works, recreates or otherwise has interest or involvement in activities that occur in the Beaver Creek watershed.

A collaboration has been formed among the Watershed Management Authorities that have footprints that extend across the Des Moines metropolitan area. This has developed into support via a Watershed Coordinator, which could assist with outreach and plan implantation, more specifically in the lower, more urban parts of the Beaver Creek watershed.

13

How to get the message out.

The education plan describes how to connect:

Participants

PEOPLE

Landowners, Producers (Tenants) and Rural Residents

Include absentee landowners and other affiliated groups

- Agriculture's Clean Water Alliance
- Iowa Agriculture Water Alliance
- Commodity Groups and Co-ops

Developers and members of the Business Community

Stakeholder Groups and Urban/Suburban Residents

ADVOCATES

Non-Governmental Organizations and Non-Profit Organizations

- The Nature Conservancy
- Local groups
  - Pheasants Forever
  - Ducks Unlimited
  - Wild Turkey Federation
  - Izaak Walton League
  - Whitetails Unlimited
  - Central Iowa Paddlers, etc.

AGENCIES

City/County/State Officials and Decision Makers

Government Agencies

- Soil & Water Conservation Districts
- Iowa Department of Natural Resources (IDNR)
- Iowa Department of Agriculture and Lands Stewardship (IDALS)
- Department of Homeland Security
- Federal Emergency Management Agency
- School Districts, Colleges and Universities (Extension)
- NRCS (Natural Resources Conservation Service)
- FSA (Farm Service Agency)

Mayor Paula Dierenfeld of Johnston during the opening of a water trails access in 2019 (City of Johnston).

Partners:

COUNTIES

- Polk
- Dallas*
- Boone
- Greene
- Webster

*Dallas County has not signed the 28E agreement to become an official voting member of the WMA. However, they have been represented and participating in the planning process.

COMMUNITIES

- Beaver
- Berkley
- Boxholm
- Dallas Center
- Dana
- Des Moines
- Grand Junction
- Granger
- Grimes
- Johnston
- Minburn
- Ogden
- Perry
- Urbandale
- Woodward

SOIL AND WATER CONSERVATION DISTRICTS (SWCDS)

- Polk SWCD
- Dallas SWCD
- Boone SWCD
- Greene SWCD
- Webster SWCD

Issues:

- Flooding
- Water Quality
  - High Nutrients (Nitrogen and Phosphorous)
    - Algae blooms
  - Bacteria
  - High levels of sediment
    - Channel erosion
- Buffer, Habitat Protection and Restoration
- Improved Recreational opportunities
- Greenbelt Access/Connectivity
- Resiliency and Risk Reduction
- Urban Issues
- Stormwater runoff volumes and rates and small stream impacts
- Watershed Coordinators
  - Need a dedicated coordinator for upstream, rural areas
  - Partnership with Central Iowa Council of WMAs to provide coordinator for urban areas and practices
- Outreach to counties to determine current level of tech support and needs

Actions:

WATERSHED COORDINATOR(S) AND OTHER LOCAL IMPLEMENTORS:

1. **Local knowledge** - **Implementers and coordinators need to be on the ground in the watershed.** They need to get to know folks in all the participation categories, help them understand what resources are available, and flush out perceptions vs. reality in the watershed.

2. **Workshops/Field Days/Group Outings** - This is an ongoing and collaborative process. Different interest groups will participate in different ways and it's the goal of this plan to provide tools to help meet folks where they are and help them take the next step. It is also a goal to better connect people throughout the watershed by providing networking and idea-sharing opportunities. **No experience is more impactful than getting people out and enjoying the resource.** Build connection through low-stress recreation.

3. **Connection through Social Media** - The more dynamic and exciting the online presence of this plan, the more diverse engagement there will be with the plan. **Utilizing different social media platforms will reach different audiences,** help gather ongoing qualitative and quantitative data and keep individuals and groups engaged in the plan throughout implementation.

4. **Incentives to try practices independently** - What can this plan do to **support and/or incentivize** the use of green stormwater management and best management practices (BMP's) throughout the watershed? What are the cost-share programs available to rural and urban residents? Businesses?

5. **Panel Presentations** - Ongoing education and outreach is most effective when it **increases engagement and connects interested parties to the latest science and research** (or Best Management Practices).

6. **Call directly on farmers** - In order to make sure no one falls through the cracks of an outreach strategy, peer-to-peer contacts remain vital. **It will be the goal of the coordinator to develop and maintain relationships with folks outside of the online reach.**

7. **Coordination with Watershed Groups** - What works? What doesn't? What tools/data/information is out there and being utilized by other watershed groups that could be utilized or replicated in the Beaver Creek Watershed? **How can others get involved as they learn about this effort?**

8. **Traveling Displays** - Opportunities for interpretation are plentiful. **Use "Open House to Go" traveling display materials** to target unique audiences. Examples:

   - Nature centers
   - County and state parks
   - Community events and festivals
   - State and County Fairs
   - Farm Progress shows
   - Ongoing project and repair sites
   - Water trail access points, trailheads

9. **Real-time water quality data sharing** – develop means and applications to **allow the general public to access and monitor current local water quality data.**

LANDOWNERS, PRODUCERS (TENANTS) AND RURAL RESIDENTS

Education, sharing research, experience and ideas, field days, cost-share opportunities

Why care?

What legacy are we leaving behind? This message is best developed and understood as a collective voice from all stakeholders in the watershed. Get folks out and enjoying the legacy resource!

Concerns

Strategies targeted in this plan are intended to **keep soil and nutrients in the upper watershed and to slow down and store water** as it moves through the watershed to address flood concerns. This supports sustainable land use and conservation practices as well as flood mitigation and control tactics.

Share strategies, practices and associated benefits where shifts in practice achieve the greatest overall benefit-to-cost ratio with respect to water management.

Partnerships and Collaboration

Partnerships among landowners and communities **allow cost sharing and efficiency** for the implementation of certain practices. **Provide spaces for information exchange** through field days, panel presentations, workshops and open houses.

Available Resources

Extensive information exists to explain best practices and ensure they are implemented correctly. There are also financial resources that can be used to address cost concerns.

Continue to **improve connections between resources** and on-the-ground actions/practices. Share resources and tools such as the DNR's River Restoration Toolbox and BMP's in the Nutrient Reduction Strategy.

Tactics:

- Work with **Fishers and Farmers** to strategize and organize outreach
- **Schedule outreach** to connect folks to the resource
- **Free Fishing Weekend, family creek walks, citizen science opportunities**
- **Meetings and brainstorming sessions** about roles and responsibilities with area co-ops, RC&D's SWCD's, Iowa Soybean Association (ISA), the local Farm Bureau chapter and county conservation boards. Begin sharing 'emerging themes.' Develop task force with representatives from each group.
- **Highlight most appropriate BMP's** for the area
- **Identify 3-5 conservation farmers/ landowners** with the best practices in place, encourage their participation as watershed educators, highlight via social media and plan field days with them.

- **Share flood modeling and information** per farm/land area/community from the Iowa Flood Center and Iowa State University.
- **Work with the Soil and Water Future Task Force** to keep bringing the Beaver Creek farm community to the table and connect them with cost-share opportunities.
- Identify possible **grants/grant partners** for practice implementation
- **Signs for farmers** to inform others about practices in place for increased visibility
- Share information on local ag-based **radio stations**
- Table at **county fairs and the Farm Progress Show** with WMA's of Iowa using watershed models for kids and families to interact with
- **Outreach to local beef and pork producers**

DEVELOPERS AND MEMBERS OF THE BUSINESS COMMUNITY

Create understanding of the purpose behind local stormwater requirements and work to implement practices that meet those goals in ways that can achieve other benefits such as: publicly accessible open spaces, increased local property values, easier and more consistent maintenance, etc.

Educate local groups and professionals on what they can do to reduce stormwater runoff, improve water quality and enhance local resources.

Share success stories and implementation challenges to find more effective solutions and approaches.

Demonstration and Partnership Opportunities

If practices are implemented within the property, it allows the owner to demonstrate their practice and get recognition throughout the community.

Educate regarding the outcomes of successful projects. Allow partnerships between local businesses for shared costs.

Triple Bottom Line

Profit. People. Planet.

Sharing ideas for effective watershed management practices aims to demonstrate that the financial, social and environmental performance of a corporation can improve over a period.

Resources

Extensive information and teaching resources are available to ensure that practices are implemented correctly.

Once consistency in implementation throughout the watershed is achieved, developers will enjoy an increased efficiency when navigating standards and requirements. **Consistent standards will assist in streamlining the review process.**

Public Health

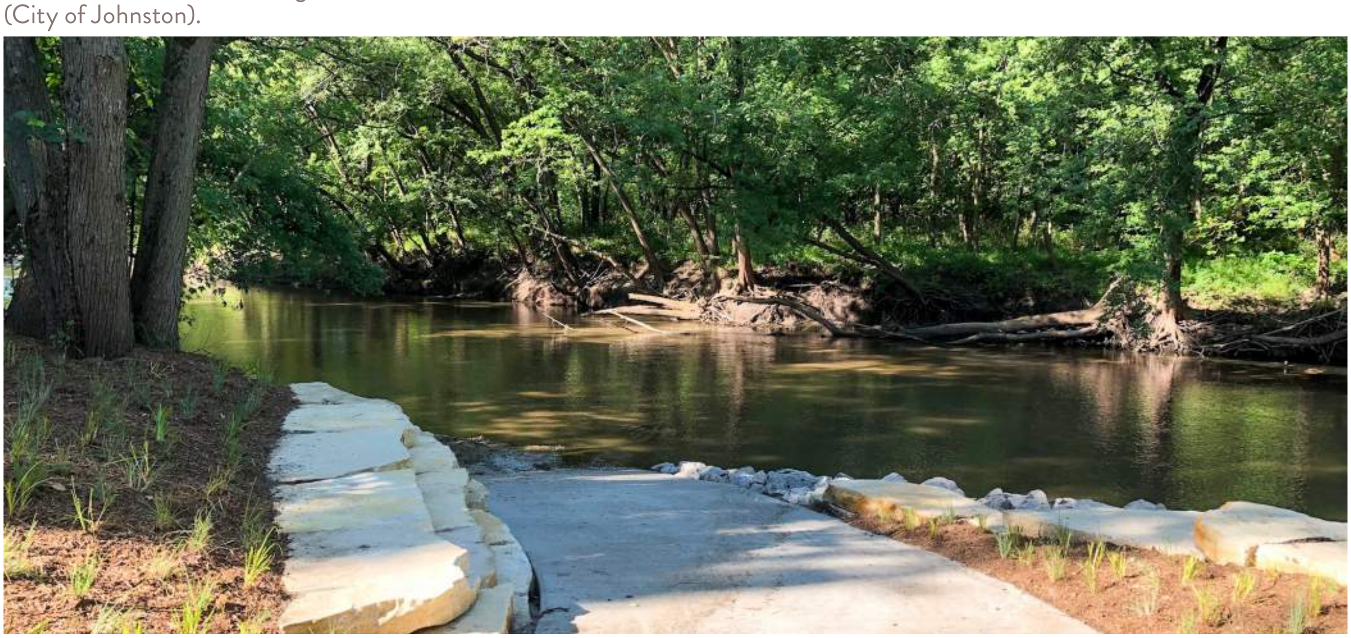
Making a connection between public health of the waterways and overall public health will help make a connection to the public, which builds advocacy. The developer and business community will have this information to take into consideration as they move forward with developments.

Get input from local health officials/professionals on priorities. **Develop communication strategy between health professionals, businesses and the public.**

Tactics:

- **Convene Beaver Creek-area developers** for an interactive presentation on the following existing conditions:
  - Data on development growth and degradation in local watershed / stream conditions over time. **Emphasize the need for new developers to achieve new results** in stormwater management for prevention of additional flood damage and worsening water quality.
  - **Reinforce the connection between topsoil loss and reduction in soil health**
  - Present the vision of a health Beaver Creek watershed resulting in g**rowth in property values and desirability for residents and business interests** (emphasize quality of life, return-on-investments and recreational opportunities)
  - **Establish dialogue** about the necessity of low-impact development principles and associated ordinance/guidance options
  - **Present regional case studies**
- **Encourage developer participation in field days and tours,** as well as information-sharing through design and maintenance and HOA boards
- **Grow the pool of contractors with expertise** (in installation and maintenance of BMP's) by providing training
- **Provide resources for entities that don't want to do it themselves**
  - Ex. Master Gardeners, volunteer groups
- **Engage volunteer groups** to help with fundraising, implementation and education and support garnering
  - Boy/Girl Scouts, Izaak Walton League, Hook and Bullet groups
- **Connect with Hazard Mitigation Planners** to talk about what happens if we DON'T act and formulate how we can communicate that effectively.

New water trails access along Beaver Creek (City of Johnston).



CITY/COUNTY/STATE OFFICIALS AND DECISION MAKERS AND GOVERNMENT AGENCIES

Establish greater consistency in the ordinances/ guidelines throughout the WMA jurisdictions.

Advocacy is the act of education policy makers.

Review of Current Polices

Reviewing the current policies (while getting the business community involved) will connect and inform this groups, as well as give ownership and involvement to the overall process.

Review floodplain ordinances in communities (all floodplains in Polk County should have been updated because the maps were recently update).

Why Regulations Exist

Provide information regarding the **how current or proposed stormwater ordinances address locally observed watershed impairments**, and how such issues could continue to grow without effective controls.

Cost Savings (and sharing) and Return on Investment

If policy changes and investments on practices are made now, **the cost of the future losses, maintenance and repairs can be mitigated.**

Encourage proactive budgeting for projects based on flood damage mitigation and erosion control. Encourage communities in the watershed to apply for grants together yielding stronger applications and more money for bigger, more impactful projects.

Advise communities on how to **budget for ongoing maintenance expenses** to make smaller repairs and to sustain the quality and type of vegetation desired within public open spaces.

Impacts on Other Community Systems

Recognition and mitigation of flood and water quality issues can reduce the resource commitment required to address impacts to utility systems, transportation systems and public health.

- Proactive, holistic approaches

Community Collaboration Opportunities

Some practices provide opportunities for **collaboration among different departments within a jurisdiction** to ensure the most benefits for the community and its residents. There is also the possibility for talent collaboration on joint projects.

Help communities collaborate on project planning and implementation in the watershed.

What is in the Water = Public Health

If the concentrations of contaminants entering Beaver Creek are reduced, the public health of users of the creek and greenway system will be improved. **More citizens outside in the resource means a more active and mentally and physically health community.**

Environmental Education out in the resource with leaders. Passive learning, active engagement and on-site questions and visioning. **More engagement with the resource will lead to more community engagement around the issue and more support for emphasis on public health.**

WMA Education

WMA's are still a new way for agencies to work together.

Provide information for decision makers on the true workings, success stories and potential of WMA's. Ultimately, help leaders recognize the benefits that can result through WMA's.

Tactics:

- The planning team has connected with decision-makers throughout the planning process. This overarching strategy of ongoing communication needs to continue. **This plan is a work-in-progress that they need to be involved in (and champion) every step of the way.**
- After the final changes are incorporated into the plans draft, craft a council/board resolution for plan approval with accompanying presentation talking points. **Urge WMA members to take the summary and resolution to their various jurisdictions for approval.**
- **Publicize and promote** the executive summary, final plan and checklist of early implementation steps (with timelines where available).
- Upon approval, ongoing involvement should include (but is not limited to):
  - **Quarterly updates**/emails/newsletters featuring project highlights, progress and new partners
  - **Annual reports**
  - **Outreach activities** and site visit to view projects and practices

- **Encourage and incentivize designers and consultants to learn about the plan** and motivate them to do something together to move the plan forward for affected communities (they want to do this work- here's why).
- **Maintain an Advisory Council** made up of key implementers within agency staffs to address and plan to execute the priorities of the Beaver Creek Watershed Plan.
  - **Initial meeting:** priority projects, technical understanding and purpose behind recommendations, highlight stormwater management training and principles
  - **Ongoing meetings:** updates, progress reports, ongoing training as needed, site visits, setbacks, etc.
- **Share information comparing urban and rural stormwater requirements** to help folks understand that everyone plays a part.
- Partner with and piggy-back off **The Rain Campaign.**

Bioretention planter along a recent street reconstruction project (City of Johnston).

STAKEHOLDER GROUPS

URBAN / SUBURBAN RESIDENTS

NON-GOVERNMENTAL ORGANIZATIONS AND NON-PROFIT ORGANIZATIONS

Among the general public, some residents have experienced direct effects of flood, silt or erosion damage. Others recognize they are at some risk. A broad percentage of the public has interest in improved water quality and recreational opportunities. Most value environmental education about water and natural resources reaching their school-aged children.

Messaging and Tools:

- Understanding **flood mapping, flood insurance, risks and impacts.**
- What is your **watershed address?**
- Clear understanding of **source water and drinking water standards.**
- Knowing what Iowa **water could/should look like.**
- Understanding the **difference between issues facing recreational water and users vs. drinking water and users.**
- **Effects of urbanization** on erosion, water quality and flooding.
  - Video shorts, podcasts.
- Stormwater management **at home.**
- **Agricultural impacts and potential improvements** through BMP's and stewardship.
- The value of direct involvement through **volunteerism and citizen science.**
- The value of **green space and natural water storage** on overall quality of life.
- Understanding **indicator species and basic biological connections.**
- **Recreation and economic development** potential of natural resources.
- **Home owner/buyer education.**

Tactics:

- **Public meetings** about flood zones, risks and proper precaution.
- **Stormwater workshops** for home owners:
  - Rain barrel/garden workshops
  - Planting for pollinators
- Organize **local creek cleanup** efforts.
- Organize **water quality testing training** for communities.
- Introduce a campaign to **name unnamed creeks** in the watershed.
- Leverage the **MPO's Water Trails Plan.**
- **Support** the work of local county conservation boards, water trails, paddling groups and other education partners.
- Employ and/or promote the **education strategies** of SWCD's Urban Conservation Districts and the Iowa Stormwater Education Partnership
- In partnership with the business community, launch **improved realtor education** and associated materials for distribution to potential home buyers
- Support programs in schools such as **Project WET and Water Rocks!**
- Develop **public information and interpretation and signage** for recreational opportunities and access points to the resource
- **Support STEM programs** in local schools (there are money and programs available)
- **Education and coordination with bankers** who work with farmers, developers and home buyers
  - Speak to folks about their return on investments in the plan
- **Use other groups** such as conservation groups, local watershed groups, churches, paddlers, farm associations, etc. to further education and outreach.

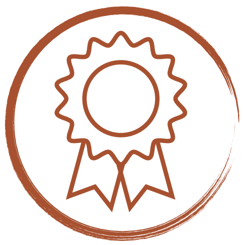
14

MEASURES AND MILESTONES

This chapter outlines the schedule for plan implementation and key milestones to evaluate progress. Included within is a plan for monitoring water quality and a list of criteria to evaluate if the plan is being successful at achieving water quality improvements.

14

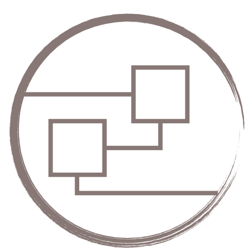
How do we measure success?



Urban policy adoption

Number of practices installed

New water quality



Flow monitoring stations*

*Including real-time data collection

GETTING STARTED

This chapter sets out the initial steps of implementation and the measures and milestones that can be used to evaluate if sufficient progress towards long-term goals is being made. Beyond improved water quality and mitigating flood risk, strategies outlined in this plan can also help improve the health and resilience of agriculture, as well as the quality and diversity of our natural resources.

FIRST STEPS

Where to start? What key actions are needed to build a foundation and gain traction to wider implementation? **Before the end of 2021**, the following actions should be completed:

1. Establish and staff a **rural watershed coordinator** position. Utilize Polk County coordinators to implement urban practices in the lower watershed.

2. With NRCS reorganization, **meet with NRCS and SWCD's to review the WMA plan** and coordinate plan implementation and watershed efforts.

3. Coordinate with USGS and Flood Center and **implement additional sensors** for a more robust flood warning system.

4. **Implement a watershed scale monitoring program.** Collaborate with Polk County Conservation and Save our Streams Program.

5. **Identify frequently flooding farmlands** (those impacted by the 20% AR or 5-year flood event). Prioritize implementation of conservation practices in these areas. Work with NRCS and other agencies to apply existing programs, such as Conservation Reserve Program (CRP).

6. Develop a list of top potential sites for **Conservation Reserve Easement Program** (CREP) **wetlands**, outreach to landowners and Iowa Department of Agriculture Land Stewardship (IDALS) for funding.

7. **Review** oxbow locations **and outreach** to funding partners (TNC, USFWS, IDALS).

8. Communities and counties should **identify stormwater improvement projects** and incorporate them into the Capital Improvement Program for their jurisdiction. Identify funding opportunities and grants to supplement local funding to accomplish watershed plan goals.

9. Facilitate adoption of **more uniform stormwater management standards** across the Des Moines metro area which addresses impacts of small and large storm events. **Support and assist** efforts of other jurisdictions (counties and smaller communities) to adopt similar policies.

10. **Utilize education and outreach** to increase awareness and adoption of practices with initial focus on practices that can be implemented at little or no cost (such as fertilizer rate and source adjustments). Host a field day, complete a practice demonstration.

11. **Develop a report card or dashboard** in greater detail that can be used for annual evaluations and reporting to the WMA board.

12. **Continue to advocate for increased funding** for sustainable sources of funding and grant programs like the Conservation Reserve Enhancement Program (CREP), Resource Enhancement And Protection (REAP), State Revolving Fund (SRF), Water Quality Initiative (WQI), etc.

SCHEDULE

The following is a plan for the implementation of policies, improvements within case study subwatersheds and other key improvements throughout the watershed.

URBAN POLICY ADOPTION

Changes in local ordinances and policies often requires extended interaction with the general public, local stakeholders and elected officials. Ordinance changes often have an impact on costs at various stages of development and how private land can be altered for more intense uses. These factors often result in a resistance to change.

This plan has documented how aspects of urban stormwater management and development within the flood plain can have a negative influence on water quality and stream corridor stability. **It cannot be expected to see improved watershed conditions without alterations to the way policies are enacted and enforced.** The potential impacts and benefits of these policies were outlined in previous chapters.

Wider adoption of such policies will assure more widespread benefits throughout the watershed and reduce the perceptions that one community or municipality has standards which are more adverse towards development than the others. Coordination and collaboration has begun in an attempt to set consistent policies across the Des Moines metropolitan area. The members of the Beaver Creek Watershed Management Authority should participate in and support these efforts.

Several communities in the Des Moines metro area already have stormwater post-construction ordinances that reference the Iowa Stormwater Management Manual. As final guidance is developed on a metro-wide **model stormwater ordinance, these cities should review their current policies and make any adjustments as needed to meet or exceed the minimum levels recommended by any new model ordinances**. Other communities should consider adopting similar measures, however smaller communities may need technical or engineering support to draft, enact and enforce any such ordinances.

TABLE 14.1 - IMPLEMENTATION OF RECOMMENDED POLICIES TABLE		
POLICY	COMMUNITY	ADOPT BY END OF YEAR
Review existing construction site erosion control ordinances. Amend ordinances as required to support enforcement. Coordinate with IDNR storm water coordinator as necessary prior to amending ordinances.	All communities with MS-4 permits	2021
Review existing flood plain protection and stormwater management ordinances. Revise ordinances as needed to include outlined recommendations as described in Chapter 10 of this plan, or as needed to align with county or metro-wide policies.	Des Moines Metro Communities Smaller Communities	2021 2025
Adopt or amend stormwater management ordinances to align policy with metro-wide model ordinances.	Des Moines Metro Communities Smaller Communities	2021 2025
Adopt ordinances related to soil quality management and restoration or amend other ordinances to include requirements as described in Chapter 10 of this plan.	Des Moines Metro Communities	2024

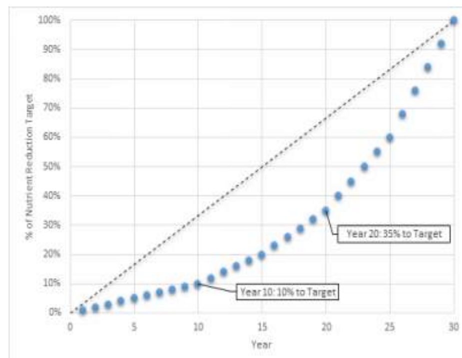
WATERSHED WATER QUALITY IMPROVEMENTS

A task for implementation should be creation and staffing of a rural watershed coordinator position. This should be completed by the end of 2020. **Chapter 11 of this plan includes output from the Agricultural Conservation Planning Framework (ACPF) tool.** This GIS analysis tool was used to identify locations for potential conservation practices throughout each of the eleven HUC-12 watersheds that make up the Beaver Creek watershed. Included with each HUC-12 study, is the optimized approach to implementing these practices to reach the desired nutrient reduction goals.

While long-term trends in downstream water quality will be useful in gaging the efficacy of BMP implementation in reducing nutrient loading over time, there is a great deal of variability in water quality metrics from year-to-year. This makes tracking progress in the short-term more difficult. One way to track progress over shorter periods is to estimate nutrient reductions by tracking BMP implementation over time. **A recommended set of benchmarks is shown in the Table 14.2 and Figure 14.1.** While the estimated costs of BMP implementation were performed assuming a 20-year planning horizon, these benchmarks include a "ramp-up" period during which implementation rates (and annual investment) can gradually increase to the required level, extending the total planning horizon to 30 years. **If this schedule were followed, the total investments in BMPs in all watersheds in years 1 through 10 of the planning period would be approximately $6.2 million, which would achieve about 10% of the nutrient reduction goals.**

A "report card" should be presented at the first quarterly meeting of the WMA each calendar year (currently held in January) to review progress toward this goal. (include a template report card showing target # - # implemented - % of total achieved).

FIGURE 14.1 - IMPLEMENTATION GROWTH



It is worth noting that the progress-to-goals schedule above assumes that all BMPs will be considered equal candidates for implementation throughout the planning period.

TABLE 14.2 - BMP IMPLEMENTATION GOALS

END OF YEAR	% OF TOTAL BMPS IMPLEMENTED
2024	5%
2029	10%
2034	20%
2039	35%
2044	60%
2049	100%

TABLE 14.3 - COST EFFECTIVENESS OF VARIOUS BMPS

COST-EFFECTIVENESS	FOR NITROGEN REDUCTION	FOR PHOSPHORUS REDUCTION
	NUTRIENT MANAGEMENT	NUTRIENT MANAGEMENT
	TERRACES	PERENNIAL COVER
MOST COST EFFECTIVE	PERENNIAL COVER	WASCOBs
	RIPARIAN BUFFER	RIPARIAN BUFFER
	SATURATED BUFFERS	TERRACES
	COVER CROPS	COVER CROPS
	EXTENDED ROTATIONS	GRASSED WATEREWAYS
	NUTRIENT REMOVAL WETLANDS	CONTOUR BUFFER STRIPS
	DRAINAGE WATER MANAGEMENT	NO-TILL
	DENITRIFYING BIOREACTORS	DENTRIFYING BIOREACTORS
	CONTOUR BUFFER STRIPS	DRAINAGE WATER MANAGEMENT
LEAST COST-EFFECTIVE	GREASED WATERWAYS	EXTENDED ROTATIONS
	NO-TILL	NUTRIENT REMOVAL WETLANDS
	WASCOBs	SATURATED BUFFERS

However, if priority is placed on implementing the most cost-effective BMPs first, that same 10-year cumulative investment of $6.2 million could result in significantly faster progress toward reaching the nutrient reduction targets.

WATERSHED WATER QUANTITY IMPROVEMENTS

Chapter 12 of this plan outlines the need to install practices throughout the watershed that will provide temporary water storage, to reduce flowrates. The goal of this storage is simply to provide enough storage to offset projected increases in rainfall that are possible over the next few decades. In so doing, the high-water levels during a 1% annual chance flood event would not be increased over the elevations listed on the FEMA Flood Insurance Rate Maps (FIRMs) that are in effect as of October of 2019.

One measurement of progress toward these target reductions will be the total temporary storage provided by ponds, wetlands and water and sediment control basins (WASCOBs) implemented over a period of years. This benchmark of success will be measured based on the following guidelines:

The "report card" presented annually to the WMA board could include a report of the progress toward this goal.

TABLE 14.4 - GOALS FOR STORAGE BMP IMPLEMENTATION

END OF YEAR	PORTION OF STORAGE IMPLEMENTED
2024	1%
2029	10%
2039	35%
2049	100%

Native landscaping along the edge of a water quality pond with a trail and fishing pier along the Greenwood Hills Greenbelt (City of Johnston).

MONITORING PLAN

One limitation of this watershed plan is the limited quantity of information related to water quality parameters and stream flow rates. **An expanded, ongoing monitoring program is required to better understand existing water quality conditions, better identify pollutant sources and evaluate the impact on installed practices on water quality.** To more accurately define pollutant loadings, data needs to be collected more consistently from a broad number of locations and at dates spread throughout the year.

The WMA should consider creating and staffing a monitoring coordinator position. This person would be responsible to collect and distribute data and to make sure collection follows a process to insure quality. This could be a position that is shared across multiple WMAs or jurisdictions.

Data to be Collected

For each monitoring location that is maintained by the Beaver Creek WMA and its membership, data should be collected on at least these key chemical or environmental parameters:

- Air temperature
- Recent precipitation (from NWS records)
- Transparency, Turbidity or TSS
- pH
- Nitrate
- Nitrite
- Dissolved Oxygen
- Total Phosphorus
- Chloride
- Water Temperature
- Dissolved Phosphorus
- E. coli (lab)
- Conductance (lab)
- Level of Flow
- Identify other pollutants of concern to local stakeholders (e.g. arsenic, commercial pesticides, etc.

At least once annually, at each location collect information on the following physical site characteristics:

- Stream width
- Local stream stability
- Local biological assessment
- Stream depth (from baseflow)

RECOMMENDED IMPLEMENTATION STRATEGIES

Strategy #1 – Coordinate and Build upon Existing Monitoring Efforts

There are several ongoing programs that are collecting water quality information within the Beaver Creek watershed. **The purpose of this plan is to support these efforts, rather than supplanting or competing with them.**

- **Iowa Soybean Association (ISA)/ Agriculture's Clean Water Alliance (ICWA)** - These organizations continue to collect data at three sites on Beaver Creek and one at the outlet of Slough Creek. Their data collection has occurred monthly during the growing season (April-August) since 2008. We would recommend that they expand upon this work, to include year round sampling. In other watersheds, late season spikes in nutrient levels have been reported. Year round testing could determine if such a spike commonly occurs within this watershed and provide a more accurate measurement of annual loadings of the pollutants of concern.

- **Polk County Conservation** - This organization has just initiated a program to monitor select sites within the Fourmile, Beaver and Walnut Creek watershed inside Polk County. They have selected four collection sites within the watershed; near the outlet of the watershed on Beaver Creek at Prairie Point; Beaver Creek at the water trail access on 70th Avenue in Johnston; Beaver Creek at Northwest 121st St.; and Beaver Creek at Xavier Avenue. They plan to collect data during the first and third calendar weeks of each month, on a given day between the hours of 10am and 2pm. During each sample they will assess chemical and physical conditions. IOWATER test kits will be used to evaluate the following parameters:
    - Transparency
    - Nitrate
    - Phosphate
    - pH
    - Nitrite
    - Chloride
    - Dissolved Oxygen

- **Volunteer monitoring** - Volunteer monitoring data used to be collected through the IOWATER program. However, the State of Iowa no longer administers this program or stores the collected data. **It is recommended that either the state restore this effort, or a separate group be organized to collect, record and distribute this data.** As part of that, volunteers should be trained in best practices to ensure consistent collection and recording methods.

-

Strategy #2 – Establish a Network of Real-Time Monitoring Stations within the Watershed

This plan has noted how different pollutants originate from different sources. Some of these sources are less frequently occurring and some are larger sources during storm events. There are some questions that cannot be answered without constant collection of data. **Real time data collection allows more rarely occurring sources of pollution to be identified** (a one-time fertilizer applications prior to a storm event, for example).

Ongoing data collection also makes it possible to understand how pollutant concentrations and loads are changing through the entire duration of a storm event. Higher concentrations are often observed during the "first flush" of storm events. It is challenging to grab samples during this period, as it would require collection of samples on random dates as rainfall occurs, samples would need to be collected within a short window after rainfall begins (often while it is still raining) and high flows could create dangerous conditions for sample collection.

For these reasons, **a network of real-time monitoring stations is recommended as a key part of implementation of water quality improvements.** As such stations come at an expense to install and maintain, this plan must be selective in the recommended initial locations for these stations. Over time, additional stations may be added to the network as dictated by the location of proposed improvements, changes in land use and available funding.

It is recommended that the initial network consist of three stations located throughout the watershed. These locations have been selected to (1) help better define overall watershed pollutant loading rates, (2) differentiate pollutant concentrations and loadings within Beaver Creek and its principal tributaries, and (3) evaluate changes in conditions over time near the outlets of the case-study subwatershed areas.

Initially, these stations would monitor nitrate, turbidity, pH, temperature, dissolved oxygen, specific conductance levels in the stream. However, this program could be expanded in the future as technologies related to detection of phosphorus and bacteria become available. **The approximate cost for each station is expected to be $32,000 for the initial purchase of equipment and installation and average costs of $1,000 per year for ongoing operation and maintenance.**

Water levels and flood conditions should also be monitored in real time. Currently, there two USGS gauges that collect data along Beaver Creek (Woodward and Johnston) and an Iowa Flood Center (IFC) bridge mounted level sensor on the

TABLE 14.5 - RECOMMENDED REAL-TIME BRIDGE SENSORS WITH REAL-TIME WATER QUALITY MONITORING

PRIORITY #	HUC-12 SECTION-TOWNSHIP-RANGE	LOCATION DESCRIPTION
1	710000410 BEAVER CREEK 79N 24W 18 CITY OF BOUTON - POLK COUNTY	**Site 15:** Beaver Creek Mainstem. HUC-10 Watershed Outlet. Note that this an existing Polk County Snapshot Monitoring Site (Beaver Creek at Prairie Point) that we recommend upgrading to a real-time water quality monitoring station along with a real-time stream gauge.
2	71000040909 CITY OF BOUTON - BEAVER CREEK 81N 27W 16 DALLAS COUNTY	**Site 10:** Beaver Creek Mainstem. City of Bouton/Beaver Creek Outlet. Beaver Creek above confluence of Slough Creek and Little Beaver Creek. Above Royer/Beaver HUC-12
3	71000040906 BEAVER BRANCH - BEAVER CREEK 83N 28W21 BOONE COUNTY	**Site 8:** Beaver Creek Mainstem. Below confluence with Beaver Creek Headwaters, Middle Beaver, and East Beaver Creek.

For locations of monitoring sites described in Tables 14.5, refer to Figure 14.1 on page 354

Headwaters Beaver Creek north of Berkley (Site 7). It is recommended to expand this network with five additional stations located throughout the watershed. These locations will help provide earlier warnings for flood hazards and also study which areas of the watershed contribute a greater volume of runoff. This could allow for more strategic positioning of flood control practices across the landscape.

Such a network could be administered through the Iowa Flood Center, to make collected data easily accessible to the public. **The approximate cost for each station is expected to be $5,100 for the initial purchase of equipment and installation and average costs of $200 per year for ongoing operation and maintenance.**

Strategy #3 – Establish Grab Sample Monitoring at Key Locations within the Case Study Subwatersheds

To extend data collection beyond where it is practical (or feasible) to collect data with real-time collection, a more frequent and distributed pattern of monitoring is required. Monitoring sites should be located so that changes in outcomes over time can be evaluated. These sites should be established as soon as possible, so that a time record of water quality conditions prior to any improvements can be established. Over time, this monitoring should determine if measurable changes in water quality parameters can be observed. Trends in data can be reviewed to determine if the proposed

PRIORITY #	HUC-12 SECTION-TOWNSHIP-RANGE JURISDICTION	LOCATION DESCRIPTION
4	71000040909 CITY OF BOUTON-BEAVER CREEK 82N 28W 15 BOONE COUNTY	**Site 9:** Beaver Creek Mainstem. Below outlet of Beaver Branch/Beaver Creek HUC-12
5	71000040905 CITY OF BOUTON - HEADWATERSBEAVER CREEK 83N 28W 16 DALLAS COUNTY	**Site 4:** Headwaters Beaver Creek Mainstem. Below confluence with Little Beaver Creek and West Beaver Creek
6	71000040906 BEAVER BRANCH - BEAVER CREEK 83N 28W21 BOONE COUNTY	**Site 7:** Mainstem Headwaters Beaver Creek
7	71000040910 Royer Creek-Beaver Creek 80N 26W 13	**Site 14:** Mainstem Beaver: Note that this is Polk County Snapshot (Site 18 Beaver Creek).
8	71000040904 East Beaver Creek 83N 28W 15	**Site 6:** East Beaver Creek
9	710000410 Beaver Creek 80N 25W 17 Polk County	Polk County WQ Monitoring Site: Beaver Creek Snapshot (Site 19 - Beaver Creek) NW 121st (recommending installation of a real-time level sensor at this site in addition to the sampling regime used by Polk County)
10	710000410 Beaver Creek 80N 25W 35 Polk County	Polk County WQ Monitoring Site: Beaver Creek Snapshot (Beaver Creek at Water Trail Access) (recommending installation of a real-time level sensor at this site in addition to the sampling regime used by Polk County)
11	71000040903 Middle Beaver Creek 83N 28W 16	**Site 5:** Middle Beaver Creek
12	71000040907 Slough Creek 81N 27W 21	**Site 12:** Slough Creek
13	71000040908 Little Beaver Creek-Beaver Creek 81N 27W 11	**Site 11:** Little Beaver Creek
14	71000040902 West Beaver Creek 83N 29W 1	**Site 1:** West Beaver Creek

TABLE 14.6 - RECOMMENDED REAL-TIME BRIDGE SENSORS WITH REAL TIME WATER QUALITY GRAB SAMPLES

implementation program is working as expected or if the plan needs to be reviewed and amended to improve results.

It is recommended that sampling be conducted using a similar collection schedule as that which has been developed by Polk County Conservation (year round, 1st and 3rd week of each month, collection between 10am and 2pm). This will improve the quality of collected data by collecting it under more uniform conditions. IOWATER test kits could be used for an initial site screening, however it is recommended that samples be collected during each site visit for lab analysis of key pollutants and lab analysis will be necessary to evaluate levels of indicator bacteria present. Certain bacteria samples could also be tested to determine their biological source (species).

Strategy #4 - Collect Data at Conservation Practices and at Subwatershed Lavel

Data should be collected to evaluate the effectiveness of various conservation practices. Additional monitoring should be pursued if work is focused in one or two key subwatersheds. Changes in water quality should be observed more rapidly in smaller watersheds, where a smaller quantity of practices should be necessary to make measurable improvements to water quality.

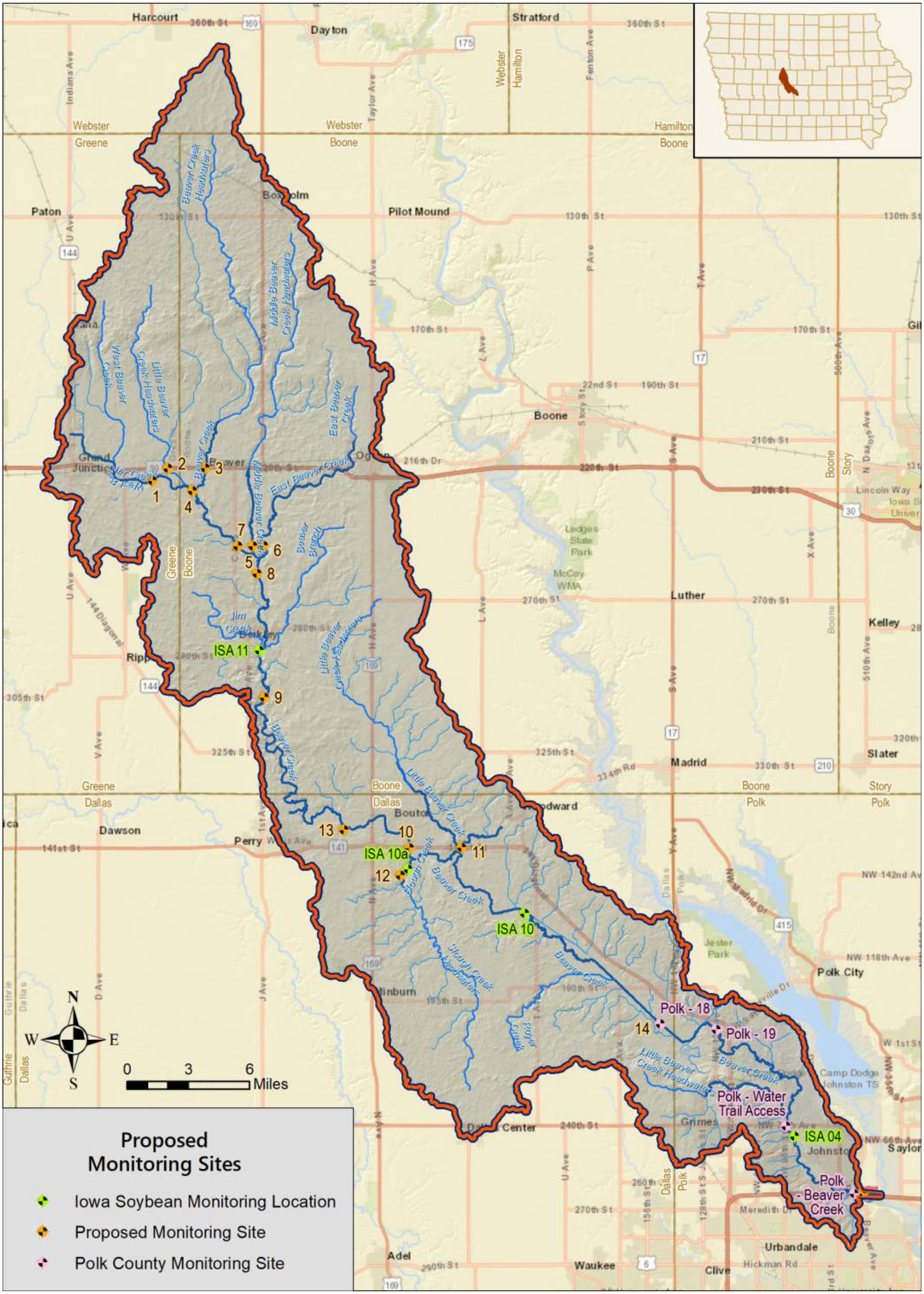
Strategy #5 - Monitor Organic Content in Soils

A program to monitor soil health (by evaluating organic content) should be implemented. This could be done on an voluntary basis to review changes in soil properties in areas that conservation practices have been implemented, which could be contrasted by monitoring properties in locations where such strategies have not been employed.

For locations of monitoring sites described in Tables 14.6 and 7, refer to Figure 14.1 on page 364

PRIORITY #	HUC-12 SECTION-TOWNSHIP-RANGE	LOCATION DESCRIPTION
15	71000040905 HEADWATERS BEAVER CREEK 83N 28W 6	**Site 3:** Mainstream Headwaters Beaver Creek
16	71000040901 LITTLE BEAVER CREEK - WEST BEAVER CREEK 83N 29W 1	**Site 2:** Little Beaver Creek
17	71000040909 CITY OF BOUTON-BEAVER CREEK 81N 28W 12	**Site 13:** City of Perry Tributary

TABLE 14.7 - RECOMMENDED WATER QUALITY GRAB SAMPLES WITH LEVEL MEASUREMENT SITES (NO BRIDGE SENSOR)


Proposed
Monitoring Sites
Iowa Soybean Monitoring Location
Proposed Monitoring Site
Polk County Monitoring Site
0 3 6 Miles
N
E
S
W
ISA 11
ISA 10a
ISA 10
ISA 04
Polk - 18
Polk - 19
Polk - Water Trail Access
Polk - Beaver Creek
Boone
Madrid
Luther
Slater
Kelley
Polk City
Dayton
Stratford
Harcourt
Pilot Mound
Perry
Dawson
Adel
Waukee
Clive
Urbandale
Grimes
Ledges State Park
Jester Park

Quality Control for Data Collection, Recording

The broad number of sites will likely require more than one person or party to complete the recommended sampling. **Data needs to be collected in a consistent manner, to prevent results being influenced by how samples are collected or test kit results are interpreted at each site.** The collected data needs to be collected and frequently uploaded into a database that is accessible to interested parties. For these reasons, the following methods are recommended by this plan:

1. Create a Quality Assurance Project Plan (QAPP) for all water quality monitoring activities. This document should be reviewed and approved by the Iowa Department of Natural Resources.

2. Maintain at least two databases of collected water quality data. Each database should be kept current with recorded results.

3. Collaborate with the ISA/CWA, Polk County Conservation and IOWATER at the end of each quarter year, to share all collected water quality data within the Beaver Creek watershed.

4. Pursue means to use online resources to save data on the cloud and make collected water quality data available for public review.

Reporting Progress toward Water Quality Standards

An annual monitoring report should be prepared and presented to the Beaver Creek WMA board, then made available for public review. The report should include the following information:

1. An overall map of the watershed showing monitoring locations, including those maintained by the Beaver Creek WMA (and its membership), ISA/CWA, Polk County Conservation and IOWATER.

2. The average, maximum and minimum levels of each parameter at each monitoring location for the given year. Note the date when maximum and minimum levels were observed.

3. For each parameter, review changes in levels for each parameter on a month by month basis throughout the given calendar year.

4. Review data related to items #2 and #3 above for prior years, and provide a cumulative analysis for each that includes data collected for all calendar years to date.

5. Provide a brief review data from items #2-#4 above and determine if trends support that appropriate progress is being made toward established water quality goals.

MILESTONES - CRITERIA FOR MEASURING SUCCESS

At the end of each year, progress towards meeting the goals of this plan need to be evaluated. These key milestones represent ways to measure if implementation of this plan is on schedule and that the expected results are being observed.

1. **Document when communities adopt and begin enforcement of the various recommended policies.**
    - Goal: A review of ordinances and adoption of recommended amendments or new ordinances by the dates listed earlier in this chapter.
    - If not achieved by the desired dates, what are the obstacles to adoption?

2. **Document improved compliance with erosion and sediment control requirements through photographs, reductions in enforcement actions or other annual reports.**
    - What are some areas that remain in need of improvement?

3. Document levels of adoption of conservation practices. Document any modifications to the implementation plan or additional practices which are constructed.
    - Review the "report card" for each HUC-12 each year and review if plan implementation is on schedule.
    - If implementation is not on schedule, remark on expected changes to the project list.
    - Are there new challenges that have been identified that impede full completion of this list?

4. **As monitoring and stream data is collected, look for trends or patterns that would indicate water quality improvements or adjustments in stream flow patterns.** With a watershed of this size, it may take many years to see any improvements in data collected in the lower portions of the Beaver Creek watershed. Improvements may be more quickly observed closer to the headwaters of the stream, or where monitoring is conducted on streams flowing from smaller subwatersheds.

15

RESOURCES AND REQUIREMENTS

This chapter outlines the technical and financial resources that are expected to be required to implement this plan.

15

Financial support

Will need to come from:

1. Federal
2. State
3. Local government
4. Private resources

Costs

On average, $10-11 million will be needed to accomplish the goals of this plan, annually.

Paid staff

Implementation will need to be supported by an urban and rural watershed coordinator.

COSTS

Sustainable financial support is key to successful implementation of this plan. Staff support activities, construction of improvements, monitoring water quality and maintenance activities cannot be completed without dedicated funding sources.

STAFFING

Currently, there is a dedicated watershed coordinator that serves several of the watershed management authorities in the Des Moines metro area (Walnut, Fourmile, Mud – Camp – Spring). This position is funded through multiple jurisdictions funding a share of that position, through a formula based on land area and population.

However, the Beaver Creek watershed is too vast to add onto the duties of this coordinator. It is proposed **that the existing coordinator position be used to help promote and implement urban stormwater practices,** with emphasis on those that are located in the lower portion of the watershed (Grimes and Johnston). These are communities that already help to fund the existing coordinator position, and the coordinator is already looking at implementation opportunities within parts of those communities that fall into the Walnut Creek watershed.

There is a need to create a separate watershed coordinator position, which could pursue implementation of rural conservation practices. Their activities would include administration of plan execution, reviewing monitoring data, coordinating or completing grant applications, working with consultants, completing annual "report cards" and reporting results to the Beaver Creek WMA board and public.

A monitoring coordinator position has also been recommended. This position could be funded by shared resources across multiple WMAs or jurisdictions.

PROJECTS AND PRACTICES

Chapters 11 and 12 of this plan identify opportunities for projects and practices that improve water quality and reduce flood risk. These are being organized into two groups:

1. **Annual Investments** – these are the estimated ongoing annual costs associated with implementing all BMPs to a level that will meet the nutrient reduction targets. They are based on the Equivalent Annual Costs (EAC) for each BMP as reported in the Nutrient Reduction Strategy. An EAC is a way of lumping up-front and recurring costs so that BMPs with high capital costs and limited life spans (e.g. constructed wetlands) can be compared directly with BMPs that may only have annually recurring costs (e.g. cover crops), and therefore represent a long-term estimate of average annual costs. These costs will be incurred by whoever funds a particular BMP implementation

effort, whether it is the Watershed Management Coalition, an LGU, a landowner, or some combination of entities in a scenario where grant funding or cost-sharing is involved.

2. **Annual Savings –** these are the estimated ongoing annual savings associated with implementing all BMPs to a level that will meet the nutrient reduction targets. By and large, these savings will be realized by the farmers implementing the BMPs that result in such cost savings.

Communities should evaluate needs for practices or improvements within their jurisdictions. These needs should be integrated into Capital Improvement Programs and methods of funding support should be identified.

SUBWATERSHED	ANNUAL INVESTMENTS ($/YR)	ANNUAL SAVINGS ($/YR)
BEAVER BRANCH – BEAVER CREEK	$1,462,000	($135,000)
BEAVER CREEK	$654,000	($ 24,000)
CITY OF BOUTON – BEAVER CREEK	$802,000	($ 43,000)
EAST BEAVER CREEK	$563,000	($ 42,000)
HEADWATERS BEAVER CREEK	$1,286,000	($105,000)
LITTLE BEAVER CREEK – BEAVER CREEK	$1,246,000	($ 71,000)
LITTLE BEAVER CREEK – WEST BEAVER CREEK	$684,000	($ 61,000)
MIDDLE BEAVER CREEK	$1,066,000	($57,000)
ROYER CREEK – BEAVER CREEK	$1,286,000	($124,000)
SLOUGH CREEK	$1,203,000	($120,000)
WEST BEAVER CREEK	$1,037,000	($ 61,000)
TOTAL FOR IMPROVEMENTS DEFINED BY THIS PLAN	**$11,289,000**	**($843,000)**

TABLE 15.1 - PROJECTED ANNUAL INVESTMENTS FOR CONSERVATION PRACTICES

MONITORING

Water quality and streamflow monitoring will require resources to apply for grants and financial support, install monitoring stations, compensate for staff time and resources to collect samples and record results and pay for laboratory testing.

YEARS	MONITORING BUDGET
2020	$ 52,400
2021	$ 48,000
2022	$ 55,350
2023	$ 40,800
2024	$ 8,800
2025	$ 8,800
2026	$ 8,800
2027	$ 8,800
2028	$ 8,800
2029	$ 8,800
2030	$ 8,800
TOTAL COST (2020-2030)	$258,150
ANNUAL COST BEYOND 2030	$ 8,800

TABLE 15.2 - WATERSHED-SCALE MONITORING COSTS

Year 1 (2020)
Install Water Quality Sensor and Real-time Level/Flow Sensor at Priority Site #1. Install Level/Flow sensor and conduct grab sampling at all sites (Priority Sites 2-8 and 11-17.

Year 2 (2021)
Install Level/Flow Sensors at Priority Sites 4-11 and conduct grab sampling at sites.

The costs listed in Table 15.2 would implement monitoring at the watershed scale. Additional funds would be needed to monitor individual practices or in specific subwatersheds. The costs associated with such monitoring would vary based on the number of locations to be monitored.

MAINTENANCE

Several types of maintenance activities will be required to execute this plan and keep constructed improvements in good working order. Forested areas within stream buffers may need selective clearing of underbrush and invasive species to encourage establishment of more erosion resistant surface vegetation. Where new areas of native vegetation are established, short-term maintenance activities may include minor erosion repair and re-seeding, spot spraying of weeds. Long-term maintenance includes re-seeding, mowing and controlled burns. Streambank stabilization projects may require some repairs after major flood events. Other stormwater best management practices require removal of collected sediments, other debris and repairs to keep them operating as intended. **These needed maintenance activities will likely not occur, if its cost is not identified and included in local budgets.**

SOURCES OF FINANCIAL SUPPORT

There are various avenues for funding conservation practices and stormwater best management practices. However, these sources require constant local support to inform legislators about the needs these programs satisfy. Several of these programs have had their funding levels cut or threatened in recent years.

Iowa Department of Agriculture and Land Stewardship:

- Soil and Water Conservation Districts (SWCDs) through IDALS Division of Soil Conservation
- Iowa Financial Incentives Program through SWCDs
- No-interest loans from the state
- District Buffer Initiatives through SWCDs and USDA programs
- Iowa Watershed Protection Program
- Conservation Reserve Enhancement Program
- REAP Water Quality Improvement Projects
- State Revolving Loan Fund through SWCDs and IDNR and Iowa Finance Authority
- Watershed Improvement Fund

US Department of Agriculture- Farm Services Agency:

- General Signup Conservation Reserve Program (CRP)
- Continuous Conservation Reserve Program (CCRP)
- Farmable Wetland Program (FWP)

US Department of Agriculture- Farm Services Agency and Natural Resources Conservation Service:

- Grassland Reserve Program (GRP)

US Department of Agriculture- Natural Resources Conservation Service:

- Environmental Quality Incentives Program (EQIP)
- Wetland Reserve Program (EQIP)
- Emergency Watershed Protection Program (EWP)
- Wildlife Habitat Incentives Program (WHIP)
- Farm & Ranchlands Protection Program (FRPP)
- Cooperative Conservation Partnership Initiative (CCPI)
- Iowa Conservation and Partnerships: "Supersheds" Program
- Conservation Security Program (CSP)
- Conservation Innovation Grants (CIG)

US Environmental Protection Agency:

- Targeted Watershed Grants
- Water Quality Cooperative Agreements (Section 104(b)(3)]

Iowa Department of Natural Resources:

- Water Monitoring and Assessment Program
- Lake Restoration Fund
- Resource Enhancement and Protection Program (REAP)
- GIS mapping data for watershed managers
- Ambient Water Quality Monitoring Network
- EPA 319 Water Quality Program through IDNR

Source: https://www.iowadnr.gov/portals/idnr/uploads/water/watershed/files/fundinglist.pdf?amp;tabid=762

CREP wetland site in the Beaver Creek watershed.

A potential site for a wetland in a crop field in the Beaver Creek watershed.

Signage along an edge of field buffer site in the Beaver Creek watershed.

Measuring stream width during stream monitoring (City of Johnston).

16

EVALUATION AND AMENDMENTS

This chapter offers recommendations on how the WMA should continue to operate into the future with respect to this master plan. This master plan is intended to be a "living document", which needs to change based on the proceedings of the WMA and the lessons learned through the evaluation framework. The plan should be evaluated at least annually, with more in-depth evaluations after the fifth calendar year (report out at Jan 2025 meeting). After a ten year period, the entire plan should be re-evaluated and the ten-year implementation plan.

16

Address changing watershed conditions.

BEAVER CREEK
watershed plan

Needs to be a living document.

BEAVER CREEK
watershed management authority

1. Annual reports to the WMA board.
2. Robust adjustments on 5- and 10-year cycles.

CONTINUED WMA STRUCTURE

The Beaver Creek WMA currently is coordinated through an executive committee panel and a larger board with representatives from all the jurisdictions located within the Beaver Creek watershed. Other stakeholders and consultants frequently attend the WMA board meetings. **It is recommended that both the executive committee and board continue to meet on at least a quarterly basis, to discuss plan progress and to coordinate implementation of the plan**. Should a project coordinator be designated (refer to Chapter 15), this person would help to schedule meetings, develop agendas and minutes and prepare information for review by the board and committee .

EVALUATION FRAMEWORK

Regular review periods are required to synthesize plan-to-date monitoring results, and to determine whether the watershed is achieving the goals and timeline set forth in the implementation plan.

Annually, complete a report which evaluates progress on the following issues:

- Document which communities have enacted new ordinances related to the recommendations listed in Chapter 10
- Itemize completed improvements projects related to water quality within each community.
- A brief summary of monitoring results, including average, minimum and maximum pollutant concentrations and comparison of those values to those observed during Year 1 (2020) of the monitoring program.
- Refer to Chapter 14 for more details on milestones to be achieved.

After Year 5 of monitoring (2024), the annual report should include a more detailed review of monitoring results and determine if progress towards water quality goals (pollutant concentration reduction) is on pace, based on the level of improvements that has been implemented. At this stage, focus should be given to look at improvements along streams at the HUC-12 scale or smaller. If no improvements are noted, the implementation plan should be reviewed, to see if any adjustments are needed, informed by local observations and updated study related to management practices. **However, it is likely that measurable improvements at the watershed scale should not be expected until Year 10 of monitoring (2029) or beyond.**

PROCESS / TIMELINE TO AMEND THE PLAN

This study has noted rapid urban growth, especially in communities within Polk and Dallas Counties. **During Year 10 of the monitoring program (2029), it is recommended to review and update many of the findings within this plan, and adjust the implementation and monitoring plan from those findings.**

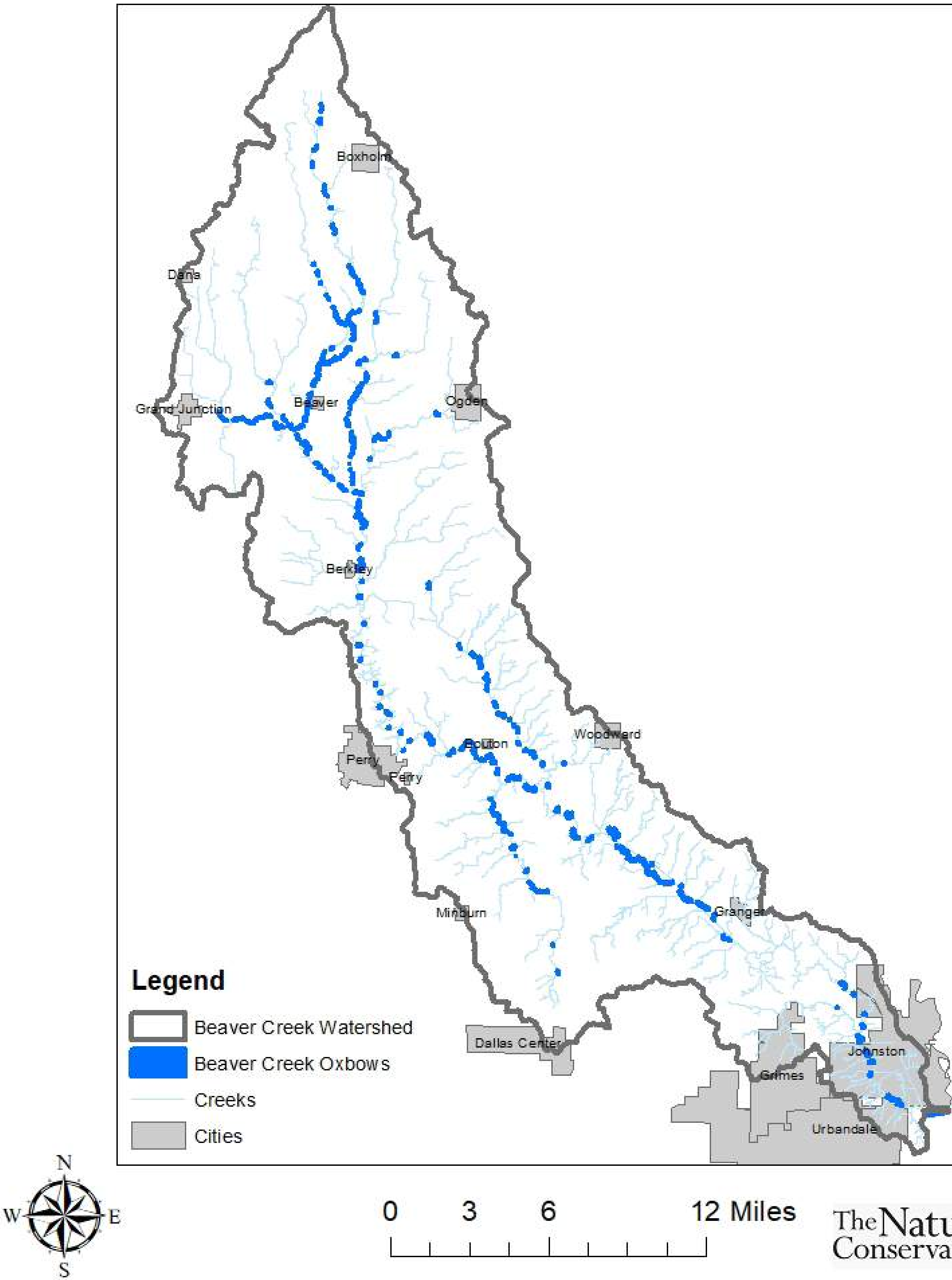
Riparian greenbelt in the Beaver Creek watershed.

A

APPENDIX: OXBOW RESTORATION SITES

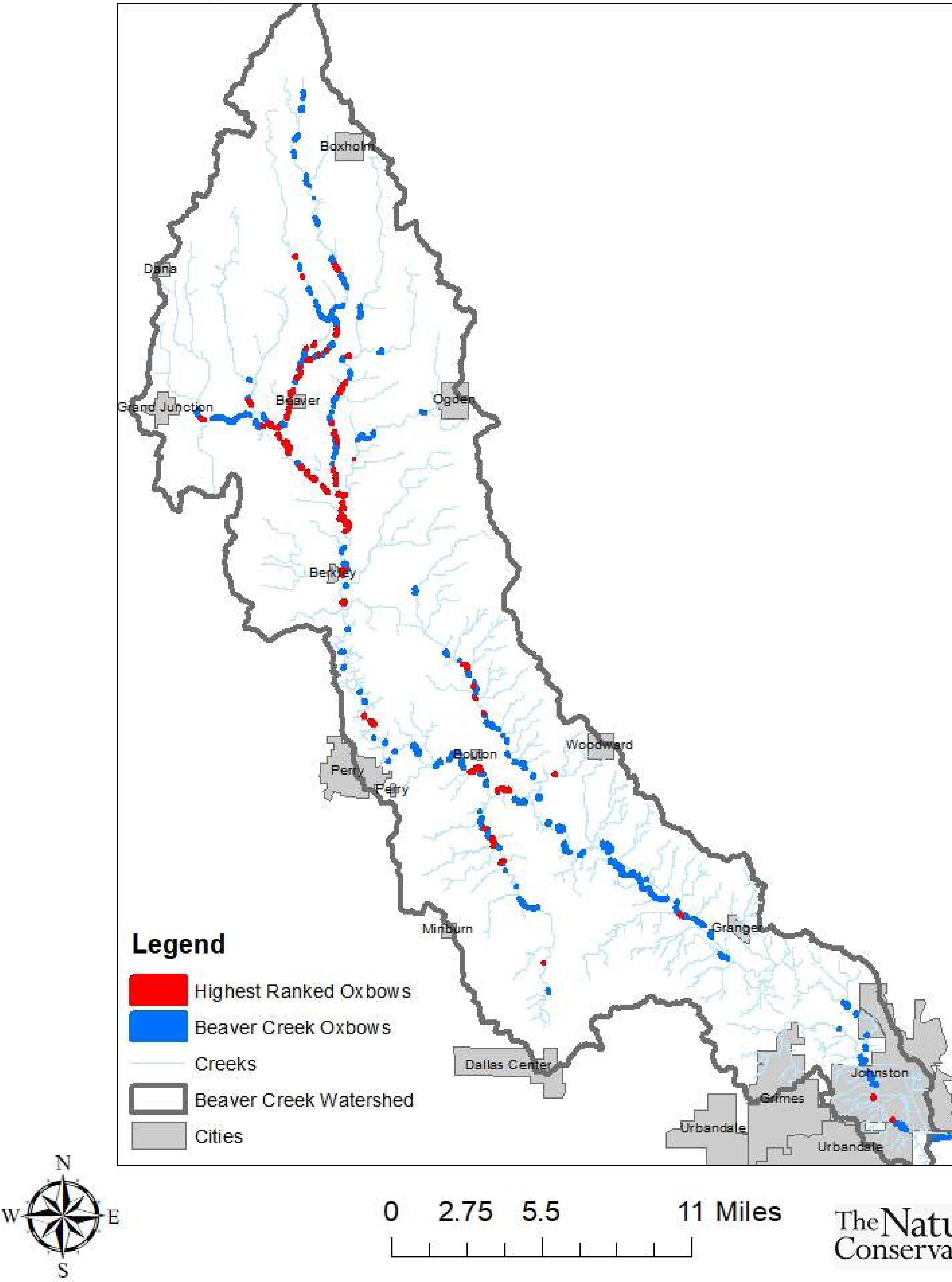
This appendix includes maps provided by the Nature Conservancy, which highlight potential areas along Beaver Creek and a few of its key tributaries that have the greatest potential for oxbow restoration.

Beaver Creek Potential Oxbows



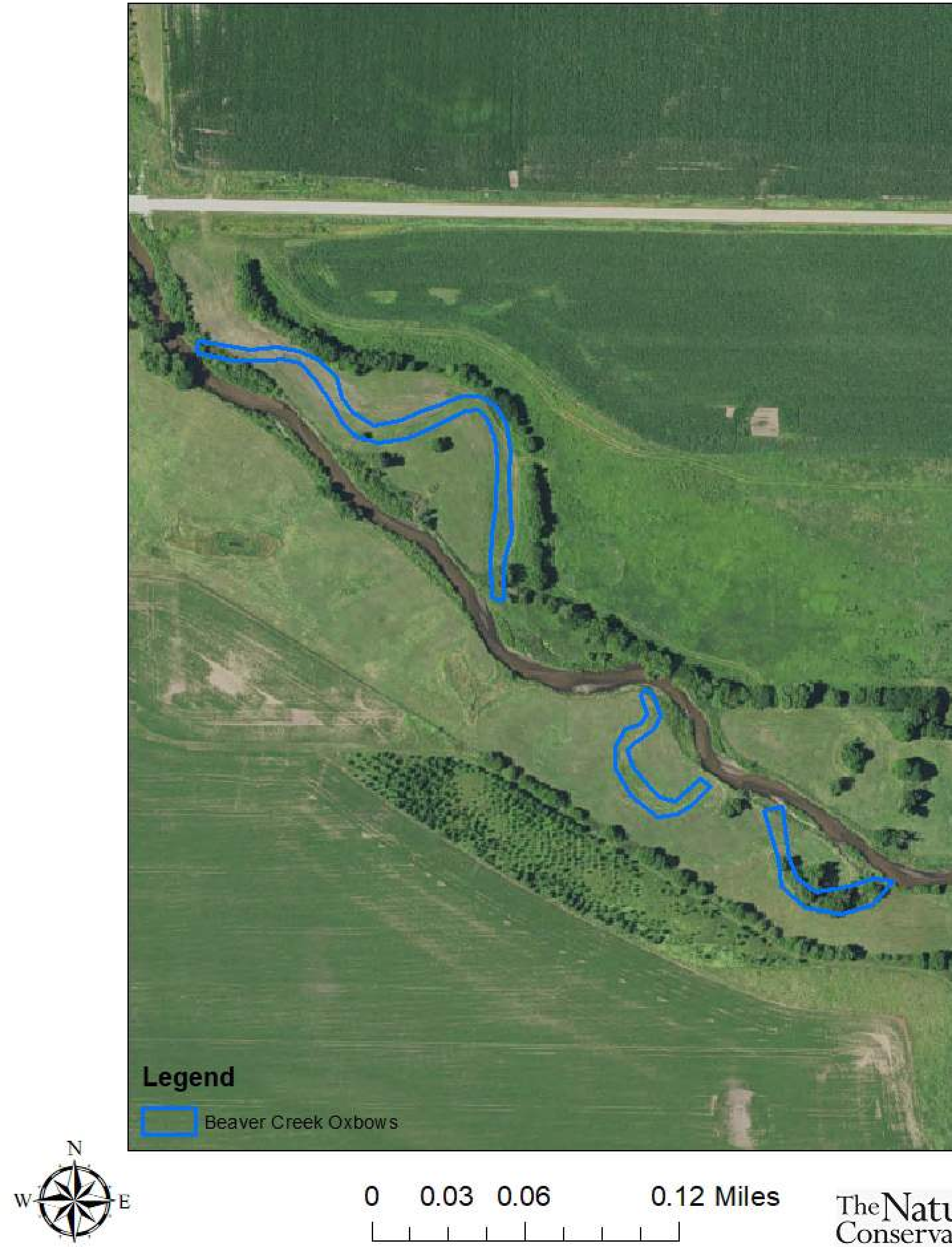
The Nature Conservancy

Beaver Creek Watershed
Highest Ranked Potential Oxbows



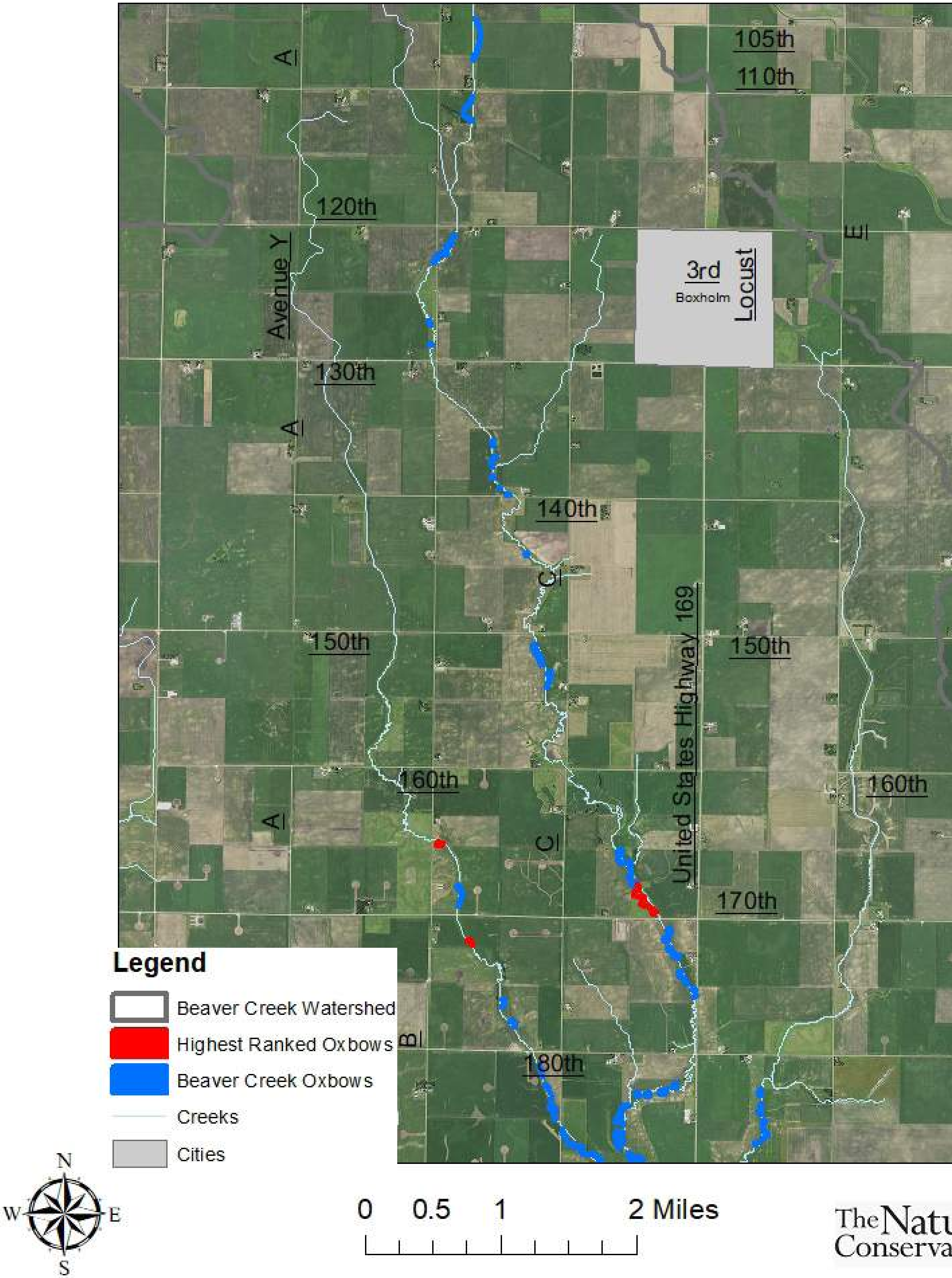
The Nature Conservancy

Beaver Creek Watershed
Highest Ranked Oxbows - Examples



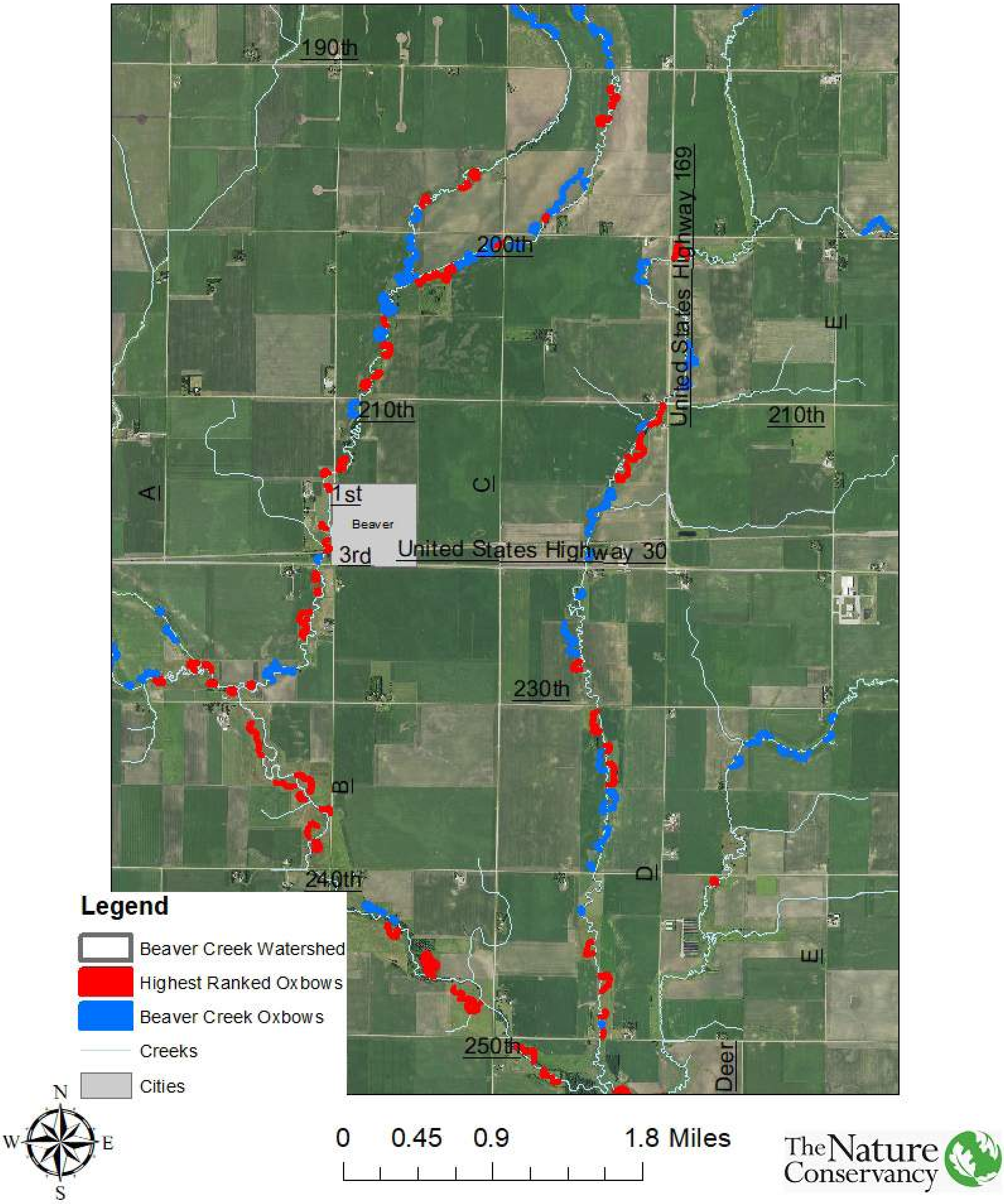
The Nature Conservancy

Beaver Creek Watershed
Northmost Oxbows

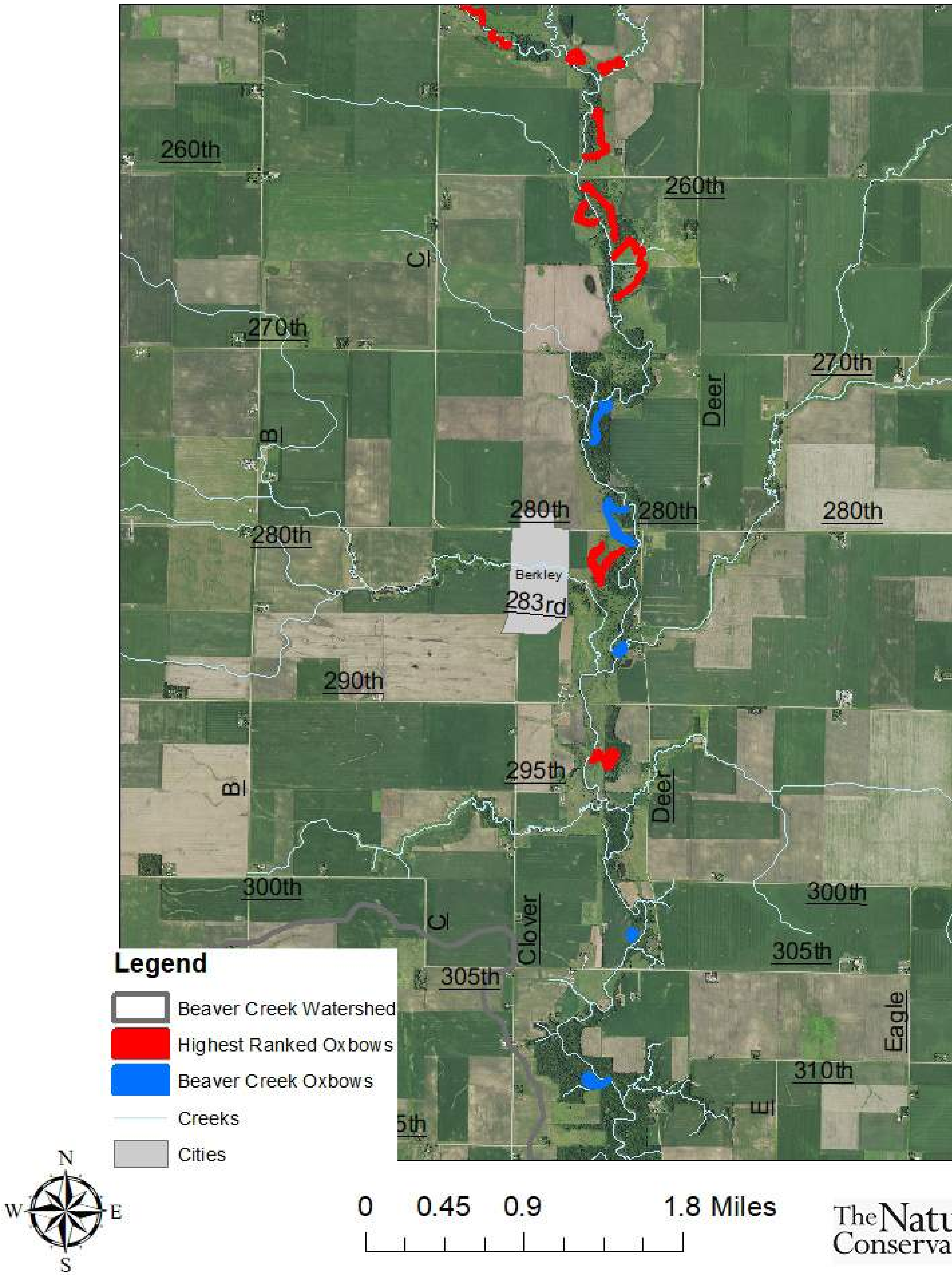


The Nature Conservancy

Beaver Creek Watershed
North Oxbows

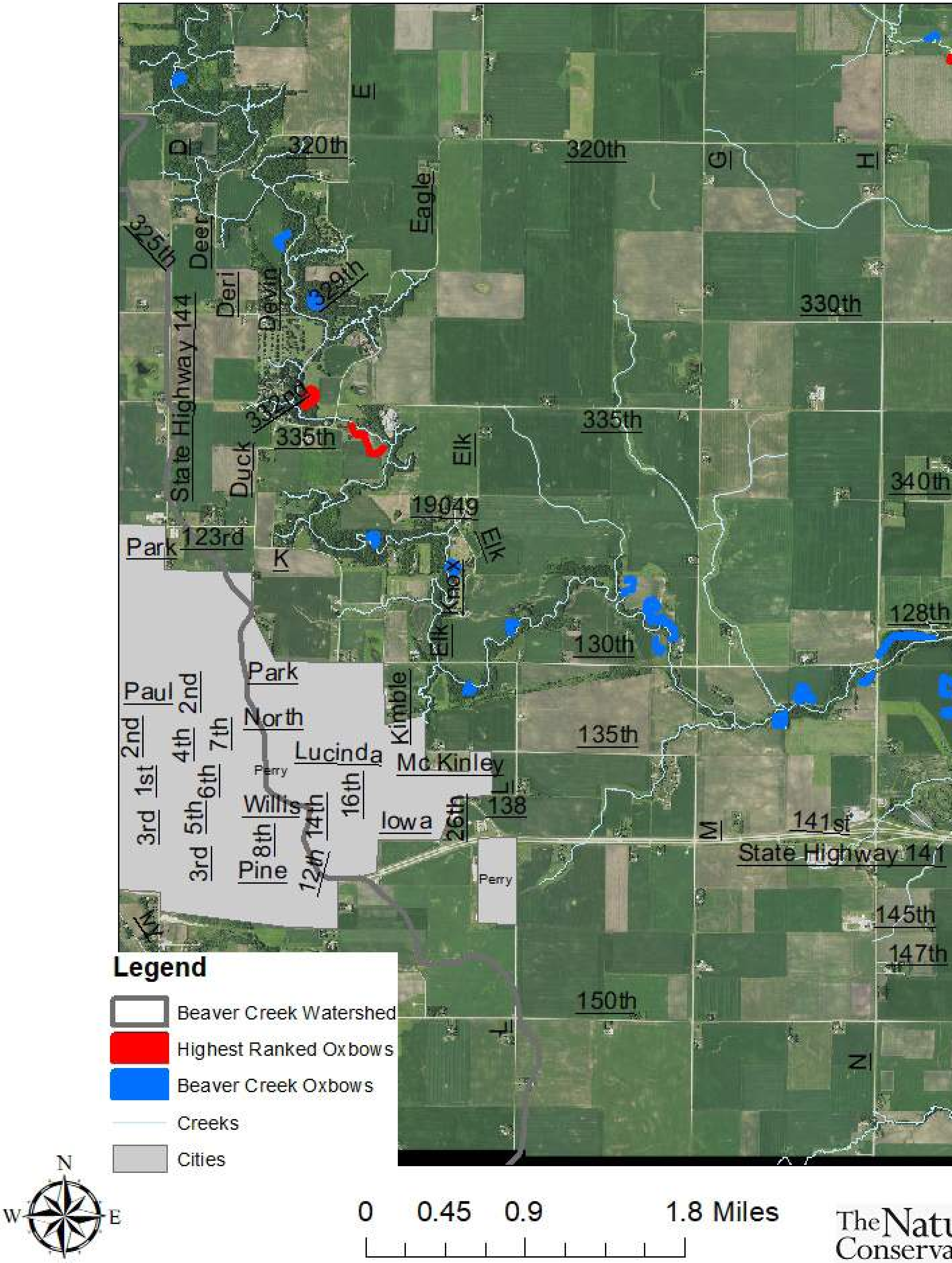


Beaver Creek Watershed
Middle (North) Oxbows



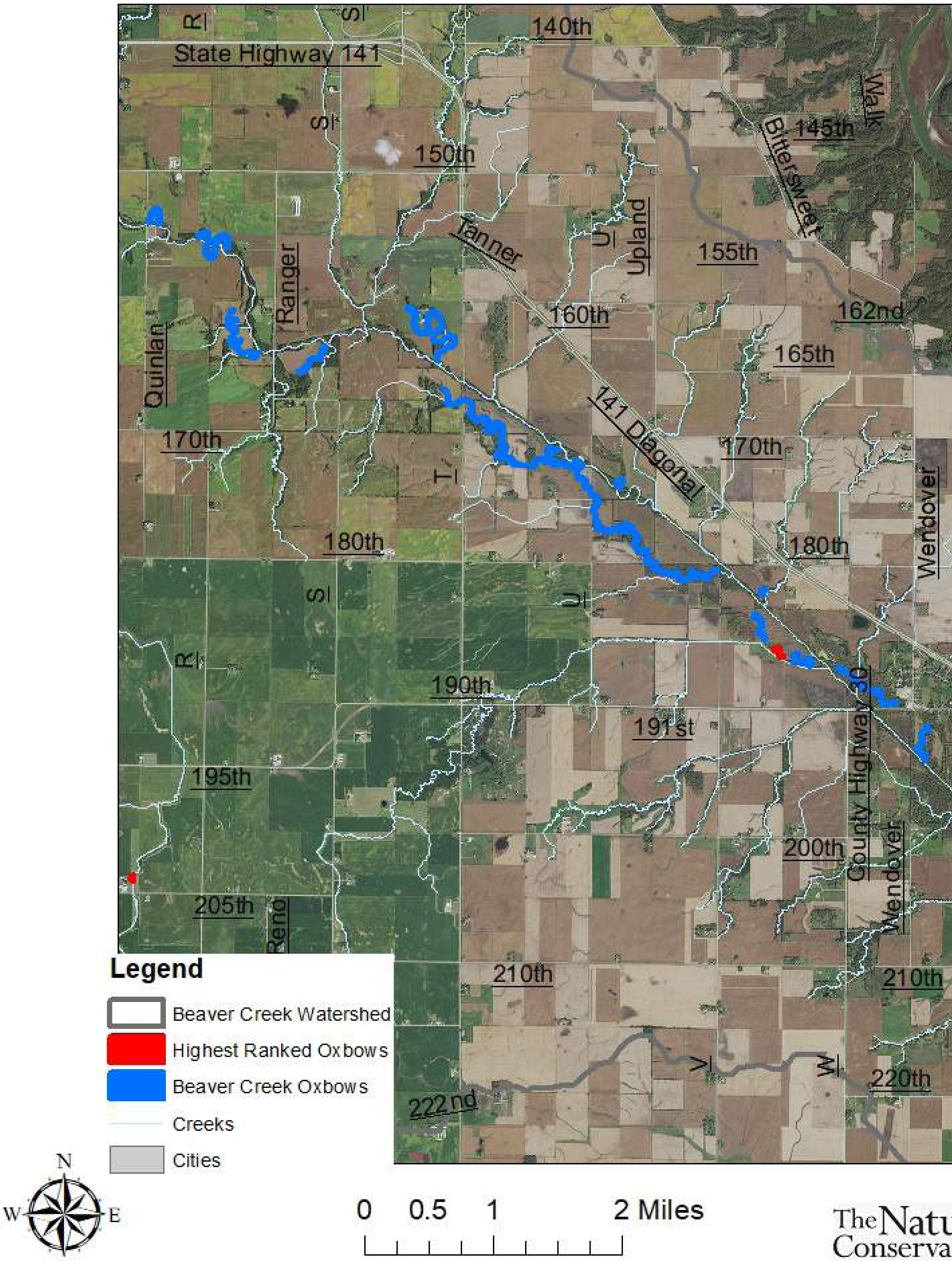
The Nature Conservancy

Beaver Creek Watershed
Middle Oxbows



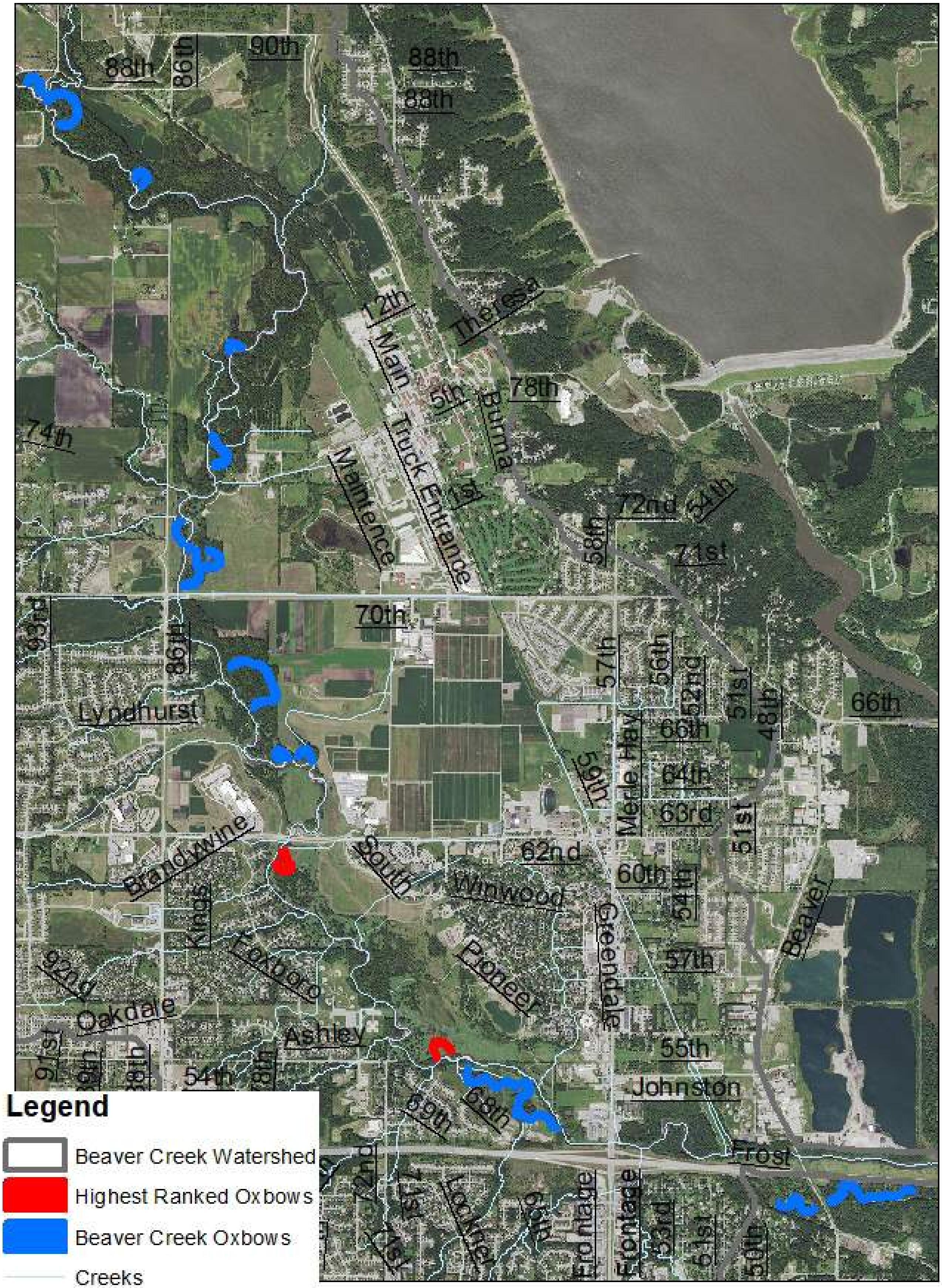
The Nature Conservancy

Beaver Creek Watershed
Middle (South) Oxbows



The Nature Conservancy

Beaver Creek Watershed
South Oxbows

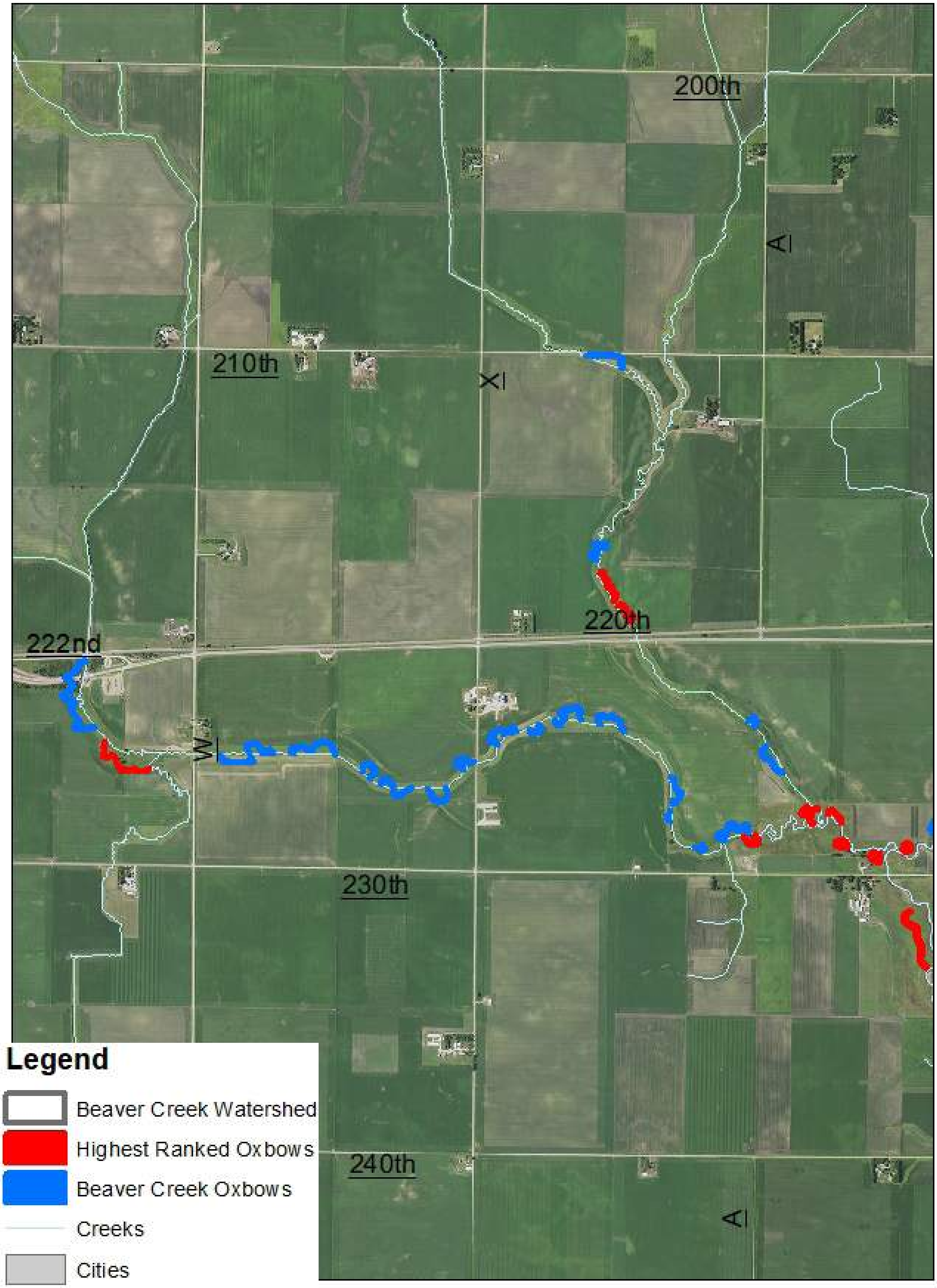


N
W E
S

0 0.375 0.75 1.5 Miles

The Nature Conservancy

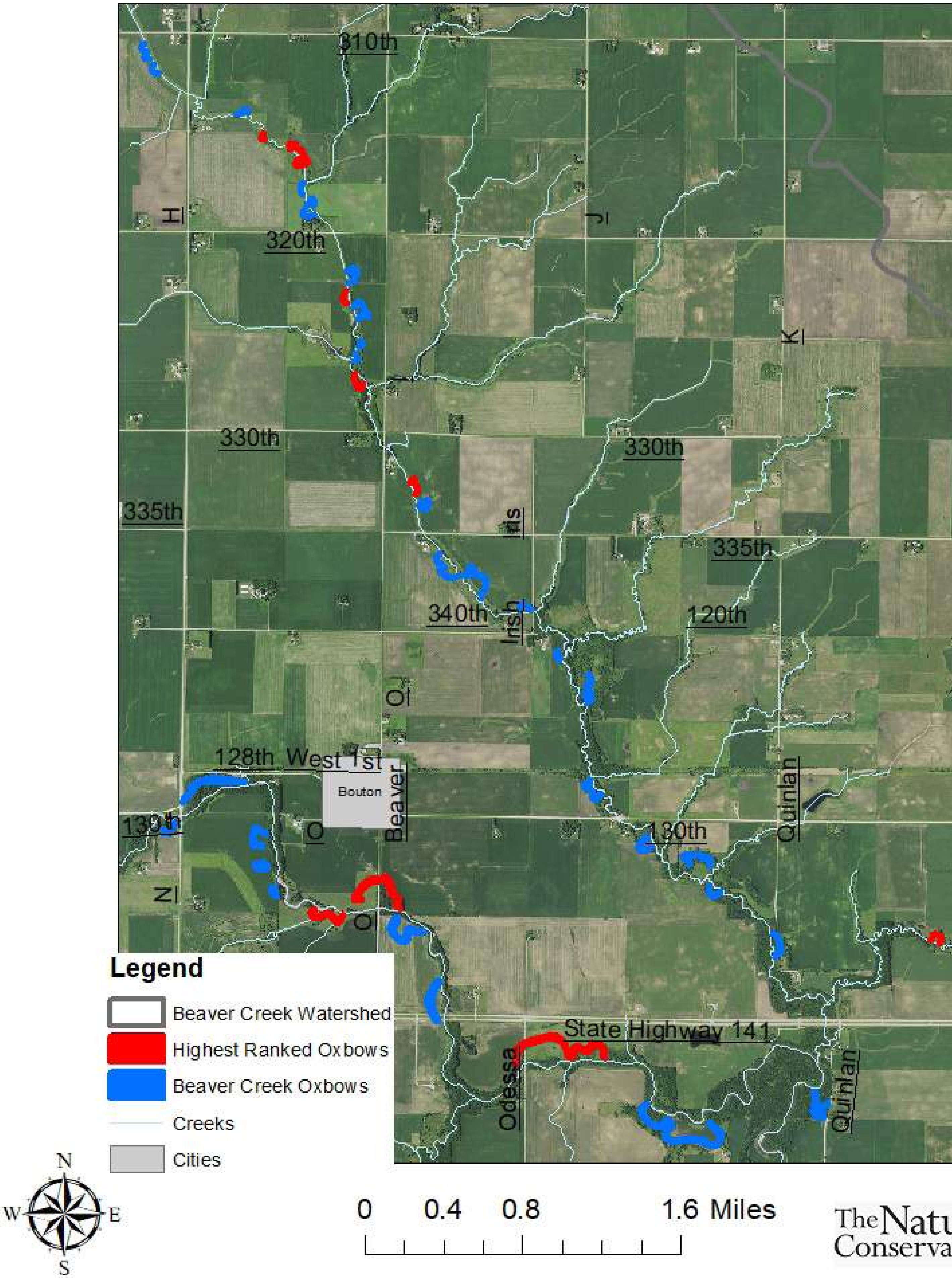
West Beaver Creek & Little Beaver Creek Oxbows



0 0.3 0.6 1.2 Miles

The Nature Conservancy

Little Beaver Creek South Oxbows



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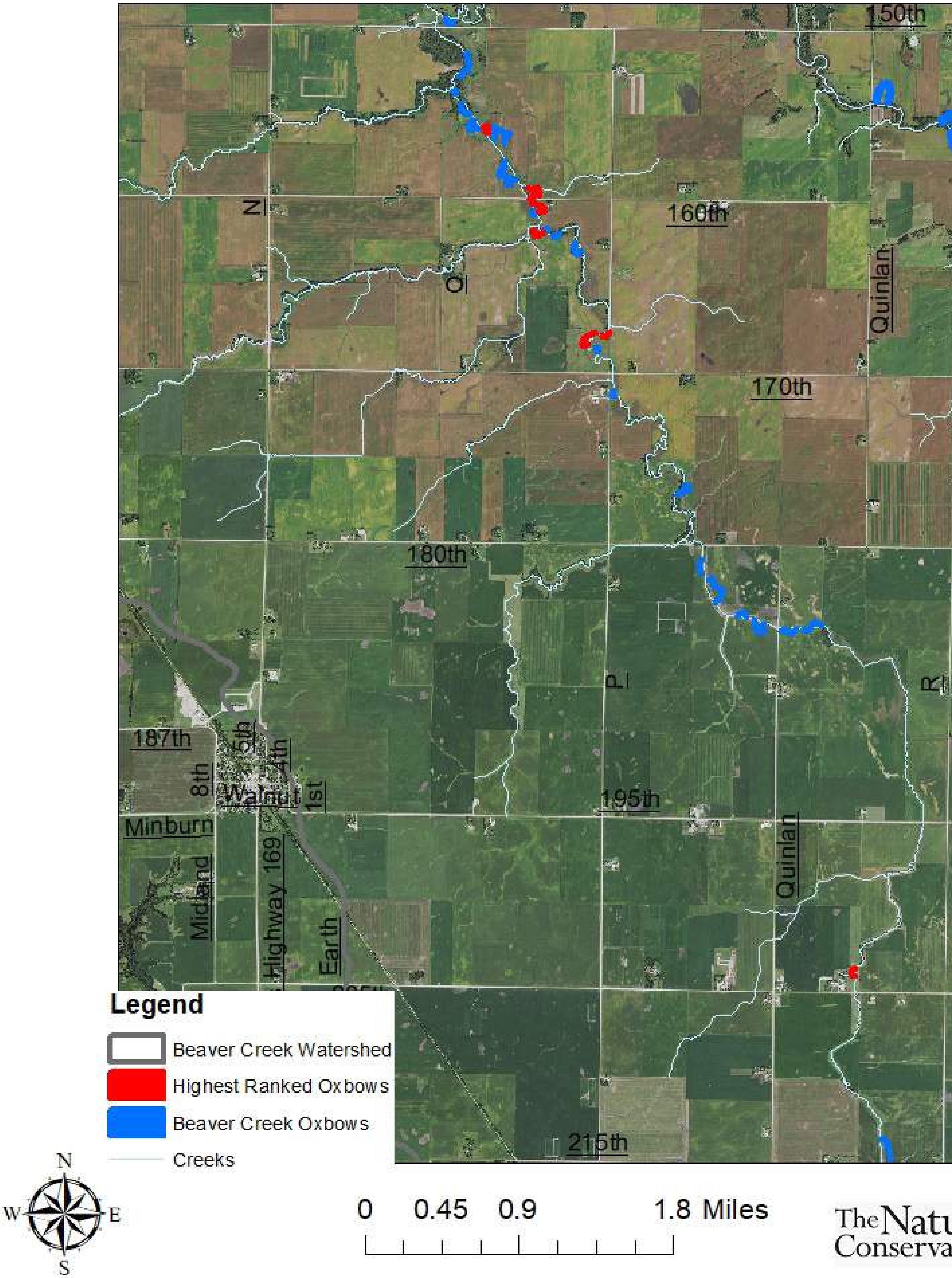
Slough Creek
Oxbows



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