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Countywide Watershed Assessment

This appendix includes the Countywide Watershed Assessment Report completed in June 2018 which summarizes the current state of the subwatersheds within Story County, Iowa.

It was developed to serve as a starting point in guiding future watershed management decisions.

Prepared by: EOR

For Story County, Iowa

Countywide Watershed Assessment

06.19.2018

Cover Image

South Skunk River at 170th Avenue

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City of Kelley

Executive Summary

The following report summarizes the current state of the subwatersheds within Story County, Iowa. It was developed to serve as a starting point in guiding future watershed management decisions.

Story County Water Resources

The report begins with a summary of applicable water quality standards and a description of the water resources found in the County. Specifically, the stream network is described and a proposed classification scheme is presented in Table 1-4. A brief description is provided for each of the named, priority streams within the County. The area immediately adjacent to a stream, typically referred to as a stream riparian area or buffer, plays a critical role in determining stream health. The current condition of stream riparian areas within Story County was evaluated and a summary of the methodology is presented in Section 1.5. An interactive map has been created to depict the findings of the riparian area evaluation and many other aspects of the watershed assessment that will be described below. The interactive map can be found on the watershed management page of the Story County website (www.storycountyiowa.gov). A snapshot to illustrate the findings of the riparian area evaluation is provided in Figure 19 but the complete map for the county is far too detailed to adequately map. The lakes within Story County are also described in this opening section.

Watershed Assessment

The watershed assessment section of the report begins with a description of the USGS hydrological hierarachy (HUC-8 subbasin, HUC10 watershed, HUC-12 subwatershed) which provides the context for the report. Most of Story County is within the South Skunk River Subbasin but portions of the county are within five other subbasins. Traditional aspects of a watershed assessment are then explored including, soils, climate, topography, land use, and geology. A data set presented in the watershed assessment section unique to Story County is the Environmentally Sensitive Areas Inventory, which is currently being developed by Wildlands Ecological Services. The Iowa DNR (IDNR) recently conducted an inventory of agricultural conservation practices statewide. This inventory is displayed in the watershed assessment section and is also used in developing the specific agricultural conservation practice scenario for each HUC-12 subwatershed. A pollutant source assessment was conducted for phosphorus, nitrogen, total suspended solids (TSS) and bacteria. The approach used for the phosphorus, nitrogen and TSS assessment was based on EPAs unit area loading methodology. The approach for bacteria was to examine each source of bacteria and determine its potential for contamination within the county. The bacteria source assessment was based largely upon information provided by Story County staff for human sources of bacteria and IDNR information on animal numbers in the county.

Subwatershed Prioritization

Using the findings of the watershed assessment summarized by HUC-12 subwatershed in the matrix shown in Table 3-1. A subjective prioritization of the HUC-12 Subwatersheds was developed and is included in the matrix and is also mapped in this section. The primary prioritization factor used was the presence of a priority stream with South Skunk River given the highest priority followed by East and West Indian Creeks.

Recommendations

The recommendation section of the report begins with a summary of the countywide GIS analysis that was performed. The analysis identified areas that Story County should consider protecting. These **protection areas** include; streams and lakes, stream riparian buffer areas, wetlands and source water protection areas. The analysis also identified **restoration opportunities** that Story County should consider. The restoration opportunities include; impaired lakes and streams, restorable wetlands, degraded stream riparian buffers, potential environmentally sensitive areas, and eroded streambanks. Mapping of the protection and restoration areas is available on the interactive map found on the watershed management page of the Story County website (www.storycountyiowa.gov).

Recommendations are included to address nutrient, sediment and bacteria pollutant loading from agricultural and urban areas in the county. The approach for addressing nutrient loading from **agricultural areas** is based on the Agricultural Conservation Practice Framework (ACPF) tools that were run for the county as part of the project. The ACPF tools primarily site terrain-dependent conservation practices. The results of the ACPF analysis can be viewed on an interactive map on the watershed management page of the Story County Website (www.storycountyiowa.gov). Recommendations are included for additional practices such as cover crops, the 4Rs of nutrient management and conversion to perennial cover. A specific suite of agricultural conservation practices designed to meet the Iowa Nutrient Reduction Strategy goals for N (41%) and P (29%) reduction countywide is provided for each of the HUC-12 subwatersheds in the county.

While the county is predominantly agricultural, recommendations are also included for addressing urban stormwater runoff. A key element in managing **urban stormwater runoff** is to limit the impacts associated with newly developed urban areas. To this end, a set of recommendations was developed to improve the County's ordinances related to stormwater management, and erosion and sedimentation control. These recommendations are found in Appendix A. A Model Stormwater Ordinance is provided in Appendix D that can be used by municipalities within the county. Recommendations for various low impact development techniques for addressing stormwater runoff are also provided in this section.

Recommendations are provided for addressing sources of **bacteria pollution** in the county. The most important step is to identify potential and known sources of bacteria. Mapping known and potential sources will ensure that these areas are regularly monitored and inspected. Story County 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.

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. Refer to Appendix A for recommendations related to improving existing county feedlot and manure application strategies, including the importance of enforcing current standards.

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. Recommended source control practices include excluding livestock from surface waterbodies, effective manure management, regular onsite wastewater treatment system maintenance, pet waste collection, and low impact development practices that reduce stormwater runoff rates, volumes, and associated pollutants.

The recommendation section concludes with recommendations tailored to each of the HUC-12 subwatersheds in the county. Included in this section are monitoring recommendations, resource specific improvements as presented in previous plans, recommendations for bacteria source controls, and the specific scenario for agricultural conservation practices designed to meet the Iowa Nutrient Reduction Strategy targets for nitrogen and phosphorus.

Monitoring

A description of existing monitoring efforts in the county and a set of recommendations for future monitoring is provided in this section. Three main objectives are recommended for future Story County monitoring efforts: (1) pair water quality data with existing IFIS sites to evaluate compliance to water quality standards and criteria; (2) conduct more intense monitoring to assess county-wide trends and changes from restoration actions and variable climate at strategically designated full diagnostic monitoring locations and (3) engage citizens to conduct sampling efforts on secondary and "other" streams.

Appendix A Review of County Ordinances

Appendix A is a summary of an initial review of Story County's ordinances and feedlot management strategy. The review attempted to achieve three distinct goals. First, the County's land development regulations were analyzed to gauge the status and potential effectiveness of existing construction erosion and sediment control and stormwater management provisions. Second, the floodplain management ordinance was examined to understand its potential impact on implementing water quality and conservation practices within the floodplain and adjacent areas. Third, potential strategies for increasing County influence on animal feeding operations (feedlots) and manure application were researched.

Appendix B: County Role as Drainage District Trustees

Appendix B contains recommendations for improving the practices used by the county is performing ditch improvements. Many of the recommendation center on improving planning and procedural items as well as refining the roles and responsibilities of the county, landowners and contractors. Moreover, recommendations are provided for integrating conservation practices into ditch improvement projects.

Appendix C: County Road Authority Role: Stream Crossings

Appendix C includes recommendations to minimize the impact of county road projects on streams. There are three primary types of stream crossing problems: (1) undersized crossings, (2) shallow crossings, and (3) crossings that are perched. All three can be barriers to fish and wildlife and lead to negative consequences for water quality and stream habitat.

Appendix D: Model Stormwater Ordinance

The model stormwater ordinance is provided to serve as a starting point for municipalities. It can be modified and adapted to suite the specific needs of the community.

Introduction

While the vast majority of Story County drains to the Skunk River (via the South Skunk River and North Skunk River), portions of the county also drain to the Des Moines River and the Iowa River. All areas flow southeast to the Mississippi River, ultimately draining into the Gulf of Mexico. Streams within Story County include the South Skunk River, Squaw Creek, the West and East Branches of Indian Creek, Minerva Creek, Worle Creek, Walnut Creek, and Ballard Creek. Story County also has a handful of lakes including Ada Hayden Heritage Park Lake (City of Ames), Dakins Lake, and Hickory Grove Lake.

Figure 1. Hydrology of Story County

Recent watershed planning efforts in Story County began with the formation of the Squaw Creek Watershed Management Authority (WMA) in 2012. The primary objectives of the Squaw Creek WMA are to assess and reduce flood risk, assess and improve water quality, educate residents of the watershed about flood risks and water quality concerns, and allocate funds for projects that improved water quality or reduced flood risk. Work towards these objectives began with the development of a 20 year watershed management plan, initiated by Story County and led by Prairie Rivers of Iowa Resource Conservation and Development (PRIRCD) with Emmons & Olivier Resources (EOR). Data collected during the development of the 20-year plan were used to describe the health of Squaw Creek's major tributaries, perform pollutant source assessments, and prioritize implementation efforts. Story County is also a member of the Fourmile Creek Watershed Management Authority which adopted its Watershed Management Plan in 2015. A similar watershed planning effort is currently underway on the Keigley Branch of the South Skunk River Watershed. Findings from the development of both plans suggest that significant improvements in water quality will be required to meet the goals outlined in Iowa's Nutrient Reduction Strategy.

Story County recognizes the importance of working with together with other entities committed to watershed management and is building upon these efforts to further prioritize implementation efforts on a Countywide scale. Development of a Countywide watershed assessment position the County to obtain state funding for implementation of water quality projects, including competing for the $282 million recently made available through water quality bill SF 512 which was signed by Governor Reynolds on January 31, 2018.

This report includes a physical environmental inventory of Story County's waterbodies, designated recreational uses, known water quality impairments, watershed characteristics (land cover, climate, soils, topography, etc.) and modeled pollutant sources.

A subwatershed (HUC12) prioritization was conducted which summarizes the resources within each subwatershed along with recommendations for restoration and protection strategies.

There are two companion pieces to this report in the form of on-line mapping applications. The first displays the resources within the County that should be protected or restored in order to improve water quality, reduce flood impacts and provide recreation and habitat benefits. The interactive map can be found on the watershed management page of the Story County website (www.storycountyiowa.gov).

The second on-line mapping application displays the results of the Agricultural Conservation Practices Framework (ACPF) which consists of specific sites throughout Story County where agricultural conservation practices can be constructed. This interactive map can also be found on the watershed management page of the Story County website (www.storycountyiowa.gov).

In addition to the watershed assessment, EOR conducted a review of applicable County Ordinances and made recommendations for potential improvements. This review can be found in Appendix A.

EOR also developed a set of recommendations for the County to consider related to its role as Drainage District Trustees. The recommendations are found in Appendix B. Finally, EOR developed a set of recommendation for the County to consider regarding County road improvements which can be found in Appendix C.

Calamus Creek at 640th Street

1. Story County Water Resources

The following section describes the current state of lakes and streams within Story County. The section begins with a general summary of the stream network within the County followed by a discussion of water quality conditions in the various streams within the County.

1.1. 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. Designated use classifications pertinent to Story County are described below in Table 1-1.

General use segments are intermittent watercourses and those watercourses which 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.

1.2. 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.

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 and in which fish are routinely harvested for human consumption.*

Table 1-1. Surface Water Designated Use Classifications for Story County's Priority Streams

Stream	Reach Description	Designated Use Classification					
		A1	A2	A3	BWW-1	BWW-2	HH
Ballard Creek	From the mouth to 580th Street (West Line S16, T82N, R23W)			✓		✓	
	From 580th Street to the confluence with Unnamed Creek (S15, T82N, R24W)		✓			✓	
	From the confluence with Unnamed Creek to the confluence with Unnamed Creek (S15, T82N, R24W)	✓				✓	
Bear Creek*	Mouth (Story Co.) to the city of Roland WWTP outfall	✓			✓	✓	
College Creek	Mouth to the confluence with Unnamed Creek (#1) (SW1/4, S3, T83N, R24W,).			✓		✓	
Dye Creek	Mouth to 248th St. bridge crossing (S13, T83N, R22W,)	✓				✓	
	From the 248th St. bridge crossing to confluence with unnamed tributary (NW1/4, S7, T83N, R21W,)	✓				✓	
East Indian Creek	Confluence with Dye Creek to confluence with an unnamed tributary (S34, T85N, R22W,)	✓				✓	
	Mouth to confluence with Dye Creek (SE¼, S14, T83N, R22W)	✓				✓	
Fourmile Creek	City of Slater WWTP outfall to the Hwy 210 bridge crossing (N. line S31, T82N, R24W)	✓				✓	
	From the 142nd Ave bridge crossing to the City of Slater WWTP outfall (NE 1/4, SE 1/4, S31, T82N, R24W)	✓				✓	
Indian Creek	Mouth to confluence with E. and W. Br. Indian Creeks. (S16, T82N, R22W)	✓				✓	
Keigley Branch	Mouth to N. line of S35, T85N, R24W	✓				✓	
Long Dick Creek	Mouth (Story Co.) to bridge crossing (N. line, S34, T86N, R23W)	✓				✓	
Minerva Creek	Mouth to confluence with an unnamed tributary (S33, T86N, R21W, Hardin Co.)	✓				✓	
Rock Creek	From its mouth to the Highway 210 bridge (North line, S27, T82N, R22W, Story Co.)		✓			✓	
South Skunk River	Confluence with Indian Cr. (Jasper Co.) to Ames Waterworks Dam	✓				✓	
	Ames Waterworks Dam to N. line S6, T85N, R23W, Story Co.	✓			✓		✓
	N. line S6, T85N, R23W, Story Co. to confluence with D.D. No. 71	✓				✓	
Squaw Creek	Mouth to confluence with an unnamed tributary (NW1/4, S9, T85N, R25W,)	✓				✓	

Stream	Reach Description	Designated Use Classification					
		A1	A2	A3	BWW-1	BWW-2	HH
Unnamed Creek Ballard	From the mouth of Unnamed Creek to the Huxley WWTP outfall (SE1/4, NW1/4, S24, T82N, R24W, Story Co.)		✓			✓	
Unnamed Creek Worle	From its mouth to the Iowa State University Heating Plant's outfall (SW1/4, S3, T83N, R24W)			✓			
	From its mouth to the confluence with Unnamed Creek (#2) (SW1/4, S3, T83N, R24W)			✓		✓	
Unnamed Creek Dye	Mouth (S13, T83N, R22W, Story County) to Country Living Court WWTP outfall (S13, T83N, R22W)		✓			✓	
Walnut Creek	Mouth (S5, T82N, R23W, Story Co.) to confluence with an unnamed tributary (SE1/4, S34, T83N, R24W)	✓				✓	
West (Branch) Indian Creek	Mouth (S16, T82N, R22W, Story Co.) to the City of Nevada's wastewater treatment facility outfall channel (S18, T83N, R22W)		✓			✓	
	From the City of Nevada's wastewater treatment facility outfall channel (S18, T83N, R22W, Story Co.) to confluence with an unnamed tributary (S1, T83N, R23W)	✓				✓	

** Headwaters of Bear Creek is listed as BWW-1 stream while the main stem reach is listed as a BWW-2 stream*

***The unnamed creek located near Iowa State University's Heating Plant has been classified as a general use waterbody.*

Table 1-2. Surface Water Designated Use Summary for Story County's Priority Streams

Designation Class	Description	Number of Designated Stream Segments
Class A1	Primary contact recreational use	17
Class A2	Secondary contact recreational use	6
Class A3	Children's recreational use	4
Class BWW-1	Warm water Type 1	1
Class BWW-2	Warm water Type 2	25
Class HH	Human Health	1

1.3. Impaired Waters

Stream and lake impairments are described in relation to their surface water classification and designated uses (Table 1-3). 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). Seven stream reaches and one lake within Story County are listed on EPA's 303 D list of impaired waterbodies due to elevated pollutant and bacteria levels and/or aquatic life impairments (Figure 2).

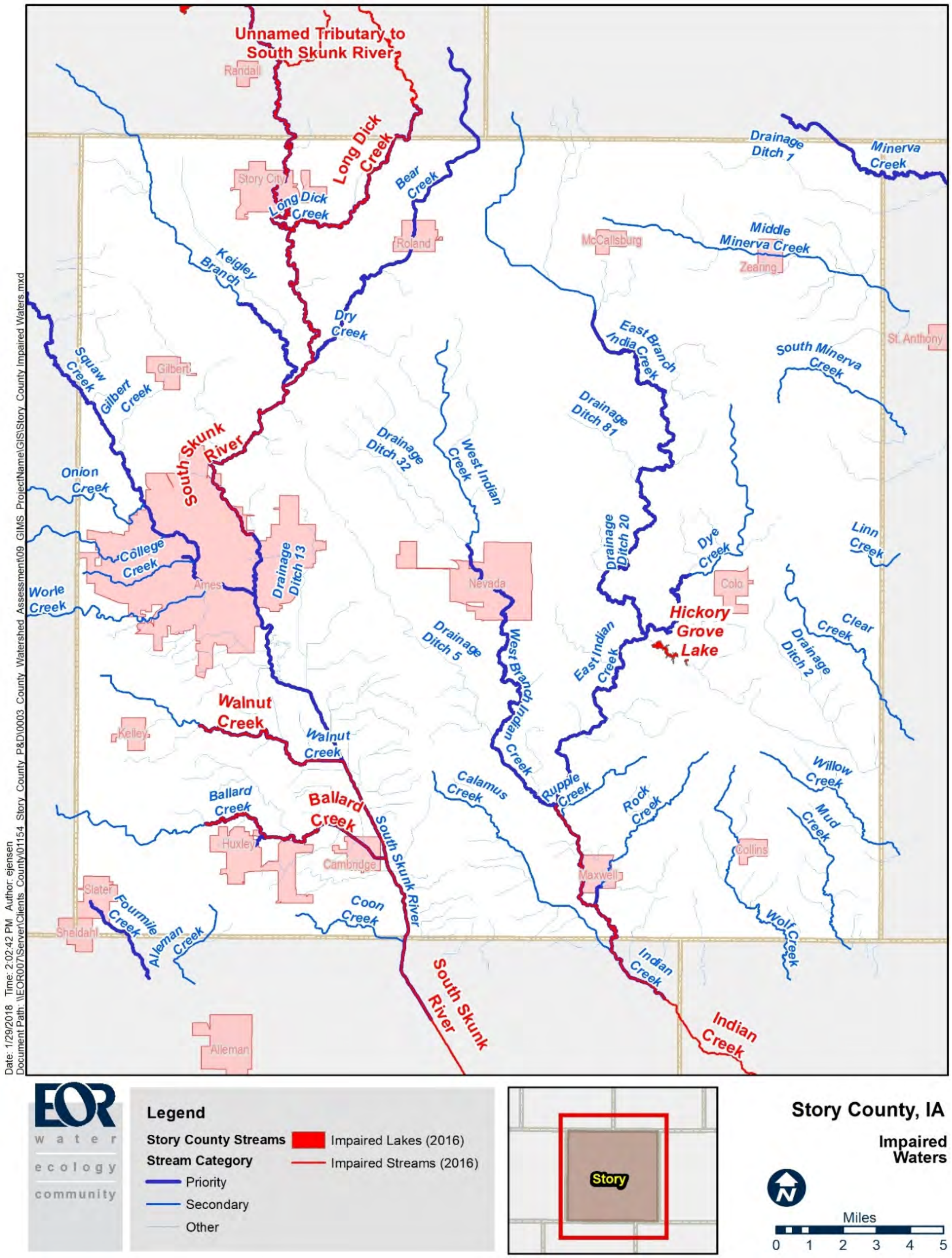


Figure 2. Impaired streams and lakes within Story County.

Table 1-3. Story County Impaired Streams and Lakes

Waterbody	Category	Impaired Use	Primary Stressor	Use Support	Rationale
Ballard Creek - Mouth to unnamed tributary in Story Co.	5b	Aquatic Life	Ammonia	Partially Supporting	fish kill in 2002
Long Dick Creek -Mouth to N. line of Hamilton Co.	5b	Aquatic Life	Biological (Low DO; Organic Enrichment)	Partially Supporting	Low biotic index
Indian Creek - Mouth to confluence of East Indian and West Indian creeks	5p	Primary Contact	Indicator Bacteria	Not supporting	Geometric mean of *E. coli* is greater than the Class A1 criterion.
South Skunk River - Ames Water Works dam to the Co. Rd. (approximately 1 mile NNE of Story City)	5a	Primary Contact	Indicator Bacteria	Partially Supporting	> 10% of samples > 400 orgs/100 mL
South Skunk River - North line of Story Co. to confluence with Drainage Ditch 71 in Hamilton Co.	5b	Aquatic Life	Biological	Partially Supporting	Low biotic index
South Skunk River- Confluence with Indian Creek to outfall of Ames wastewater treatment plant	5a	Primary Contact	Indicator Bacteria	Not supporting	Geometric mean of *E. coli* is greater than the Class A1 criterion.
Walnut Creek - Mouth to confluence with unnamed tributary in SE Story Co.	5b	Aquatic Life	Biological	Partially Supporting	Low biotic index
Hickory Grove Lake	5a	Primary Contact		Partially Supporting	Geometric mean of *E. coli* is greater than the Class A1 criterion.

- Water is impaired or threatened by a pollutant stressor and a TMDL is needed

5b- Impairment is based on results of biological monitoring or a fish kill investigation where specific causes and/or sources of the impairment have not yet been identified

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

1.4. Priority Streams

The streams within Story County have been classified into the following management categories based on their designated uses and priority within the County.

Priority Streams

Streams within Story County with a DNR Designated Use are classified as "Priority streams" (Figure 3). Priority streams should be protected for their designated use classifications; these streams represent the highest priority targets for protection and restoration measures. Unnamed streams with water quality impairments are included within the priority streams. In some cases, the management category for a given stream differs in the upper portion to the lower reaches. A description of the named priority 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). Secondary streams represent the major tributaries to Story County's Priority streams. Secondary streams represent the second highest priority targets for conservation (protection and restoration) measures.

Others Streams

General use streams within Story County are shown as "Other streams" in Figure 3. 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 priority targets for implementation of conservation (protection and restoration) measures.

Table 1-4. Story County Streams by Stream Management Classification

Stream Category	Stream Name		Stream Category	Stream Name
Priority	South Skunk River		Secondary	Dye Creek
Priority	Ballard Creek Lower Reach		Secondary	Willow Creek
Priority	Bear Creek		Secondary	Mud Creek
Priority	College Creek		Secondary	Rock Creek Upper Reach
Priority	Dye Creek Lower Reach		Secondary	Calamus Creek
Priority	East Indian Creek Lower Reach		Secondary	Rupple Creek
Priority	Fourmile Creek		Secondary	Wolf Creek
Priority	Indian Creek		Secondary	Walnut Creek Upper Reach
Priority	Keigley Branch Lower Reach		Secondary	Ballard Creek Upper Reach
Priority	Long Dick Creek		Secondary	Coon Creek
Priority	Minvera Creek		Secondary	South Minerva Creek
Priority	Rock Creek Lower Reach		Secondary	Middle Minerva Creek
Priority	Squaw Creek		Secondary	Linn Creek
Priority	Walnut Creek Lower Reach		Secondary	Alleman Creek
Priority	West Indian Creek Lower Reach		Other	Gilbert Creek
Priority	Unnamed Creek Worle		Other	Dry Creek
Priority	Unnamed Creek Ballard		Other	Drainage Ditch 1
Priority	Unnamed Creek Dye		Other	Drainage Ditch 1
Secondary	Onion Creek		Other	Drainage Ditch 5
Secondary	Clear Creek		Other	Drainage Ditch 13
Secondary	Worle Creek		Other	Drainage Ditch 20
Secondary	Keigley Branch Upper Reach		Other	Drainage Ditch 32
Secondary	West Indian Creek Upper Reach		Other	Drainage Ditch 36
Secondary	East Indian Creek Upper Reach		Other	Drainage Ditch 81

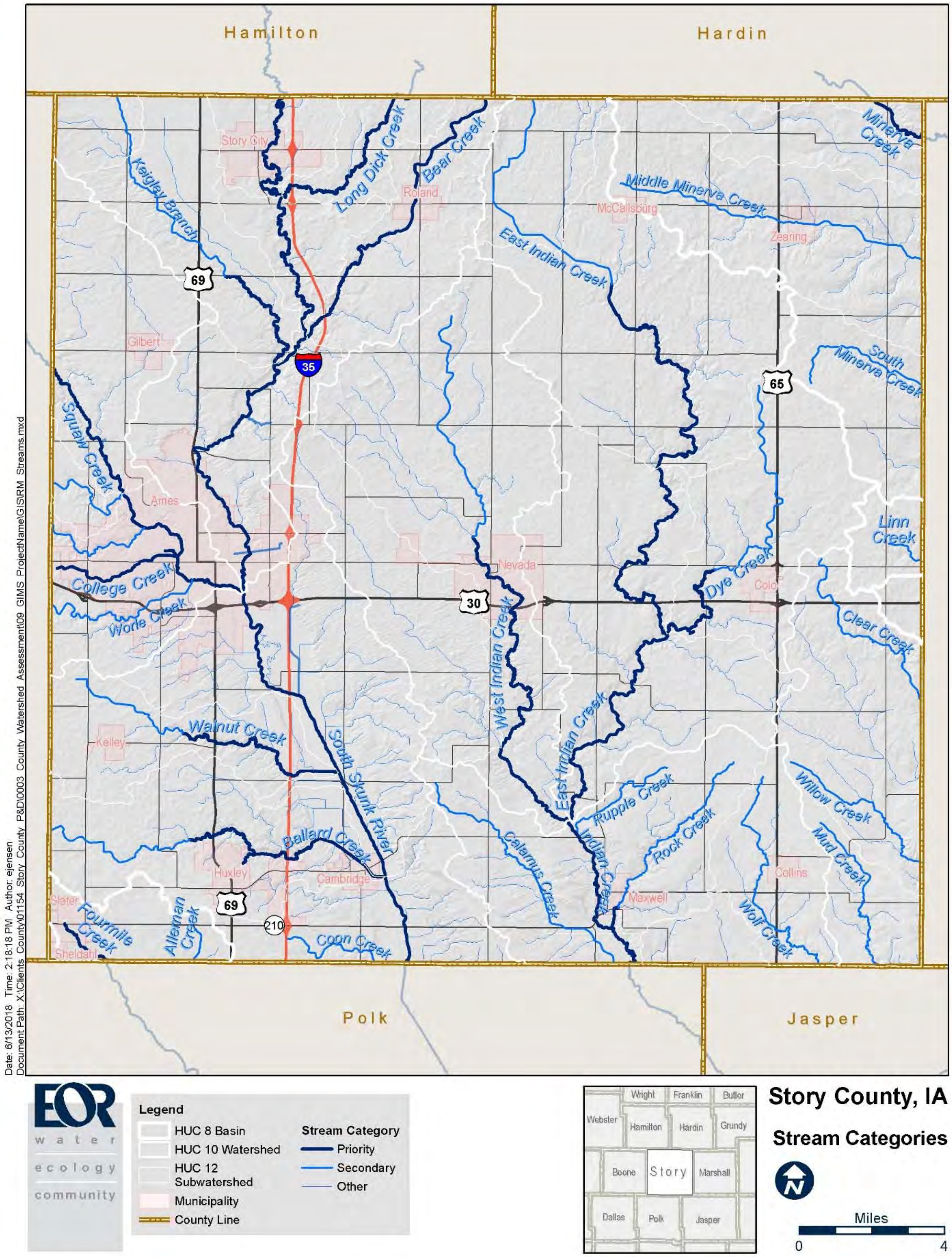


Figure 3. Story County- Stream Classifications

1.4.1. South Skunk River

Description

The South Skunk River is the most significant stream within Story County. The origin of the South Skunk River is in Hamilton County approximately 19 miles upstream of Story City. The 185 mile long river flows generally southward west of Interstate 35 through the City of Ames. It joins the North Skunk River in Keokuk County to form the Skunk River which ultimately drains to the Mississippi River 5 miles south of Burlington, Iowa. The South Skunk River's stream banks are in poor condition, 15 high priority streambank instability sites were identified in close proximity to the river channel.

Skunk River Greenbelt / Water Trail

Story County has developed the Skunk River Greenbelt/ Water Trail which encompasses most of the river within the county, from mile 246 in Story City to mile 212 at the Schreck Access (Hwy 210). Portions of the trail provide amenities for bicycling, canoeing, cross country skiing, fishing, kayaking, and hiking. There are eleven public river accesses on the South Skunk River within Story County.

Designated Recreational Uses

The South Skunk River is listed as a Class A1 waterbody, indicating it is capable of supporting primary recreational uses such as swimming and kayaking. The stretch of the South Skunk River below Ames Waterworks Dam is listed as a Class BWW-1 waterbody, indicating this reach is capable of supporting a warm water game fish population. Anglers can expect to catch channel catfish, bullhead, smallmouth bass, and buffalo.

Impaired Reaches

The stretch of the South Skunk River below Ames Waterworks Dam is impaired for biological life based on low fish and macroinvertebrate biotic index scores The stretch of the South Skunk River from the confluence with Indian Creek to the outfall of Ames wastewater treatment plant is also impaired for biological life as well as bacteria.

Figure 4. South Skunk River

1.4.2. Ballard Creek

Description

Ballard Creek originates within Boone County just 1 mile west of the Story County boundary. The 14 mile long creek flows generally east through the City of Huxley before joining the South Skunk River in Cambridge. Ballard Creek's stream banks are in poor condition, 14 high priority streambank instability sites were identified in close proximity to the creek channel.

Designated Recreational Uses

Ballard Creek contains reaches capable of supporting primary recreation but also contains reaches designated for secondary (canoeing) or Children's recreational uses (urban/residential settings). Gamefish production is limited in Ballard Creek due to flow constraints and other physical characteristics.

Impaired Reaches

Ballard Creek is currently listed on Iowa's 303d list of impaired waterbodies due to a localized (40 meter segment) fish kill which occurred in 2002; approximately 100 fish were killed. The kill was believed to be caused by manure. Results from biological monitoring conducted by the DNR in 2007 and 2013 suggest the Class B (WW2) aquatic life uses should be considered partially supporting (PS). Additional biological monitoring is needed to fully evaluate the extent of the biological impairment. The presumptive Class A1 (primary contact recreation) uses remain not assessed (N/A).

Figure 5. Ballard Creek

1.4.3. Bear Creek

Description

Bear Creek originates within Hamilton County just a few miles north of the Story County boundary. The 16 mile long creek flows generally southwest through the City of Roland before joining the South Skunk River northeast of Ames. Bear Creek's stream banks appear to be in good condition, only 3 high priority streambank instability sites were identified in close proximity to the creek channel.

Designated Recreational Uses

Bear Creek is listed as a Class A1 waterbody, indicating it is capable of supporting primary recreational uses such as swimming and kayaking. Bear Creek is listed as a Class BWW-1 waterbody, indicating this reach is capable of supporting a warm water game fish population. Prior to the changes in Iowa's surface water classification, Bear Creek's headwaters reach was classified only for general uses due to the inability of the stream to support a viable aquatic community at low-flow conditions.

Figure 6. Bear Creek

Impaired Reaches

Results from biological monitoring conducted by the DNR in 2003 and 2007 suggest the Class B (WW1) aquatic life uses should be considered partially supporting (PS) in the headwaters and fully supporting (FS) in the downstream reach. A fish kill occurred in the headwaters reach on August 27, 2001. Approximately 2,500 fish, mostly minnows, shiners, and creek chubs were killed. The source of the kill was traced to a hog confinement facility.

1.4.4. College Creek

Description

College Creek is located almost entirely within the City of Ames. The nearly 4 mile long creek flows west through Ames before joining Squaw Creek. High priority streambank instability sites were not identified.

Designated Recreational Uses

College Creek contains reaches capable of supporting Children's recreational uses. Gamefish production is limited in College Creek due to flow constraints and other physical characteristics.

Impaired Reaches

An insufficient amount of data has been collected to determine if designated uses are met in College Creek. Preliminary data suggests potential biological (fish) impairment.

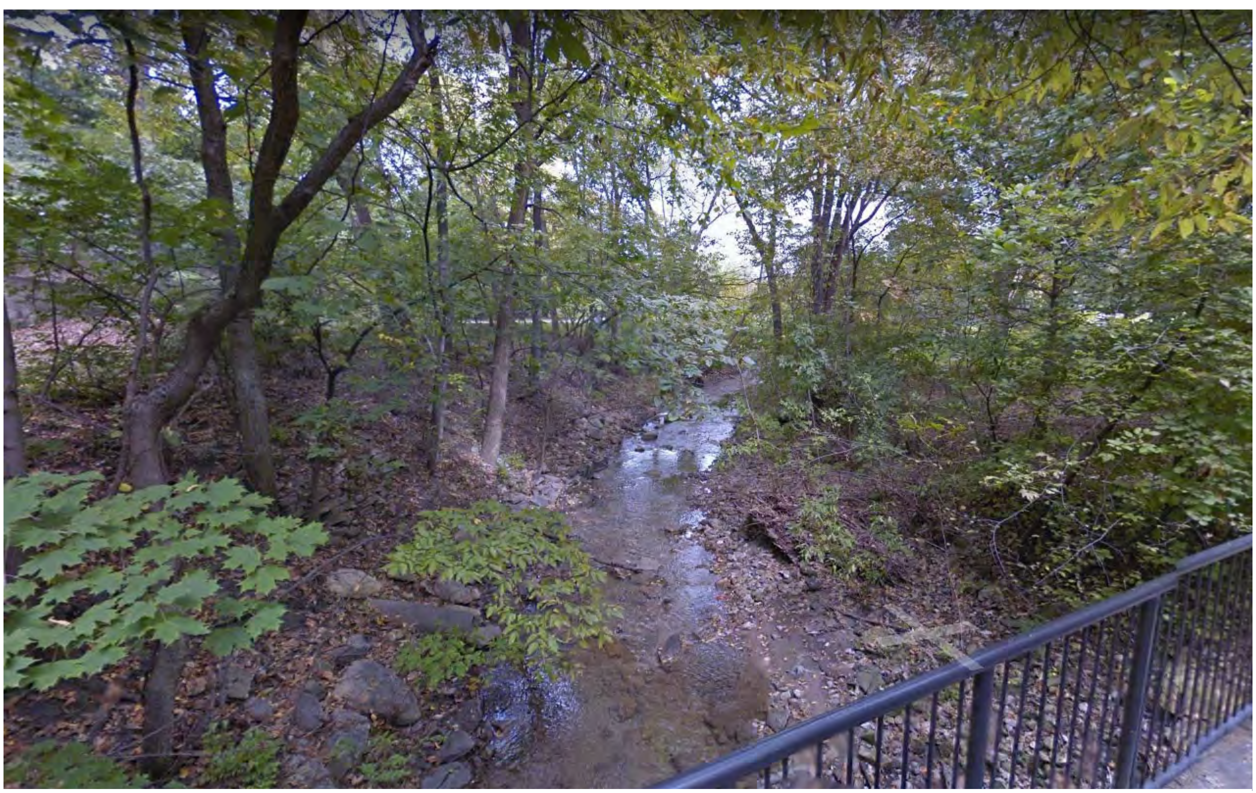


Figure 7. College Creek

1.4.5. Dye Creek

Description

Dye Creek, a second order stream at its mouth, is located 5 miles north of the City of Colo. The 12 mile long creek flows southwest around Colo before joining the East Branch Indian Creek near Hickory Grove lake. High priority streambank instability sites were not identified.

Designated Recreational Uses

Dye Creek supports primary recreational uses. Gamefish production is limited 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.

Figure 8. Dye Creek

1.4.6. East Indian Creek

Description

East Indian Creek bisects Story County from North to South. The 37 mile long creek flows primarily south before joining the West Branch Indian Creek just north of Maxwell. East Indian Creek's stream banks are highly unstable, 43 high priority sites were identified.

Designated Recreational Uses

East Indian Creek supports primary recreational uses. Gamefish production is limited in East Indian Creek due to flow constraints and other physical characteristics.

Impaired Reaches

An insufficient amount of data has been collected to determine if designated uses are met. Preliminary data suggests potential biological (fish) impairment.

Figure 9. East Indian Creek

1.4.7. Fourmile Creek

Description

Fourmile Creek starts in the extreme southwestern corner of Story County. Fourmile Creek's stream banks appear to be in good condition, high priority streambank sites were not identified. A watershed plan was developed for Fourmile Creek in 2015.

Designated Recreational Uses

Fourmile Creek supports primary recreational uses. Gamefish production is limited 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.

Figure 10. Fourmile Creek

1.4.8. Indian Creek

Description

Indian Creek starts at the confluence of the East and West Branch of Indian Creek in Maxwell. The 20 mile creek flows southeast before joining the South Skunk River in Jasper County near Colfax. Indian Creek's stream banks appear to be in good condition, only one high priority streambank sites was identified.

Designated Recreational Uses

Indian Creek supports primary recreational uses. Gamefish production is limited.

Impaired Reaches

Geometric means for *E. coli* exceeded the Class A1 criterion of 126 orgs/100 ml during all three years data was collected (2012-2014). Results from biological monitoring conducted by the DNR in 2003, 2012, and 2013 suggest the Class B (WW2) aquatic life uses should be considered partially supporting (PS).

Figure 11. Indian Creek

1.4.9. Keigley Branch

Description

The Keigley Branch starts in Hamilton County and travels 15 miles southwest before joining the South Skunk River. Four high priority streambank sites were identified; overall stream bank health is good.

Designated Recreational Uses

The Keigley Branch supports primary recreational uses. Gamefish production is limited.

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.

Figure 12. Keigley Branch

1.4.10. Long Dick Creek

Description

Long Dick Creek starts approximately 1 mile north of the Story County border and flows 9 miles southwest before joining the South Skunk River just south of Story City. Long Dick Creek's stream banks appear to be in good condition, priority streambank sites were not identified.

Designated Recreational Uses

Long Dick Creek supports primary recreational uses. Gamefish production is limited.

Impaired Reaches

Biological monitoring conducted on the Story County portion of Long Dick Creek in 2003 and 2008 suggest the Class B (WW2) aquatic life uses should be considered partially supporting (PS). No bacteria sampling has been conducted on the Story County portion of Long Dick Creek. Bacteria sampling conducted on Long Dick Creek in Hamilton County exceeded Class A1 criterion (126 orgs/100 ml) in 2008 and 2009.

Figure 13. Long Dick Creek

1.4.11. Minerva Creek

Description

Minerva Creek starts in Hardin County, intersecting the northeastern corner of Story County as it flows southwest before joining the Iowa River near Albion, Iowa. Minerva Creek's stream banks appear to be in good condition, priority streambank sites were not identified.

Designated Recreational Uses

Minerva Creek supports primary recreational uses. Gamefish production is limited.

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.

Figure 14. Minerva Creek

1.4.12. Rock Creek

Description

Rock Creek located in southern Story County, flows through the City of Maxwell before joining Indian Creek. Rock Creek's stream banks appear to be in good condition, high priority streambank sites were not identified.

Designated Recreational Uses

Rock Creek supports primary recreational uses. Gamefish production is limited.

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.

Figure 15. Rock Creek

1.4.13. **Squaw Creek**

Description

At its mouth, Squaw Creek is a meandering stream that drains 229 sq. miles of Boone, Hamilton, Story and Webster Counties. Squaw Creek's stream banks appear to be in good condition; only 8 high priority streambank sites were identified.

Designated Recreational Uses

Squaw Creek supports primary recreational uses. Gamefish production is limited.

Impaired Reaches

The Class A1 uses remain not assessed (N/A) due to the lack of information upon which to base an assessment. The Class B (WW2) aquatic life uses remain assessed as fully supported (FS) based on biological sampling in 2000 and 2002. The macroinvertebrate community sampled in Squaw Creek in 2002 scored excellent on the DNR's benthic macroinvertebrate index indicating good stream habitat integrity.

Figure 16. Squaw Creek

1.4.14. Walnut Creek

Description

Walnut Creek winds 10.5 miles from its headwaters near Story County's western border to its confluence with the South Skunk River. Walnut Creek's stream banks appear to be in good condition, 5 high priority streambank sites were identified.

Designated Recreational Uses

Walnut Creek supports primary recreational uses. Gamefish production is limited.

Impaired Reaches

The presumptive Class A1 uses remain not assessed (N/A) due to the lack of information upon which to base an assessment. The Class B (WW2) aquatic life uses are assessed as partially supported (PS) based on results of biological sampling in 2007 and 2011.

Figure 17. Walnut Creek

1.4.15. West Indian Creek

Description

West Indian Creek flows primarily south through the City of Nevada before joining East Indian Creek just north of Maxwell. West Indian Creek's stream banks appear to be in poor condition, 15 high priority streambank sites were identified.

Designated Recreational Uses

North of the City of Nevada, West Indian Creek supports primary recreational uses. West Indian Creek south of the City of Nevada supports secondary recreational uses. Gamefish production is limited

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.

Figure 18. West Indian Creek

1.5. 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 to the streams of Story County 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. Areas where the exiting landcover within the riparian zone was 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 near the confluence of Bear Creek and the South Skunk River (Figure 19). Since it is difficult to adequately map these areas due to their size, the information is available only on the ***Story County Watershed Assessment Web Map***.

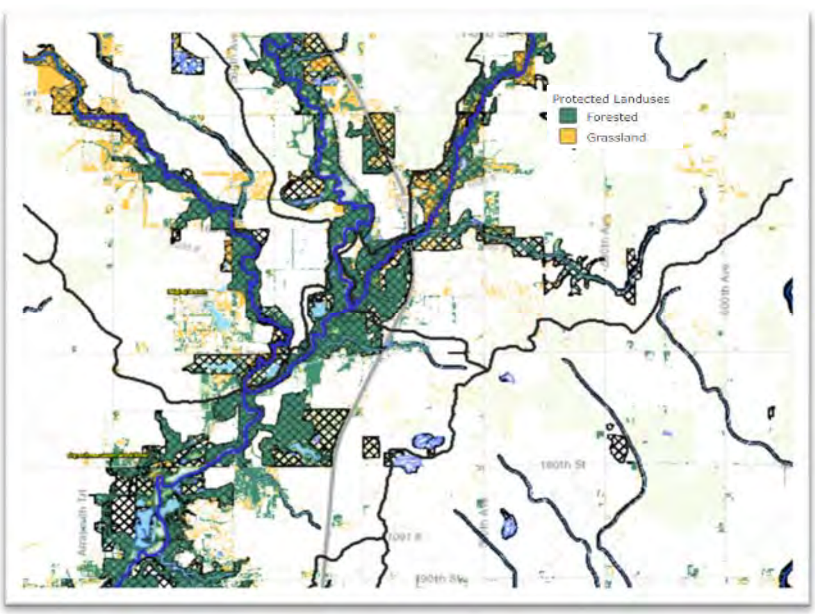


Figure 19. Example of Natural Riparian Buffers near Confluence of Bear Creek with the South Skunk River

1.6. Lakes and Wetlands

There are 36 parks located within Story County. Five of these parks contain lakes larger than five acres in size, that are either managed by Story County Conservation, the City of Ames, or Iowa DNR as public fisheries (Figure 20). Lakes in Story County provide recreational opportunities for County residents and visitors. Common recreational activities observed in Story County's lakes including boating (electric trolling motors only), fishing, swimming, canoeing and kayaking. They also provide fish and wildlife habitat that is scarce within the County.

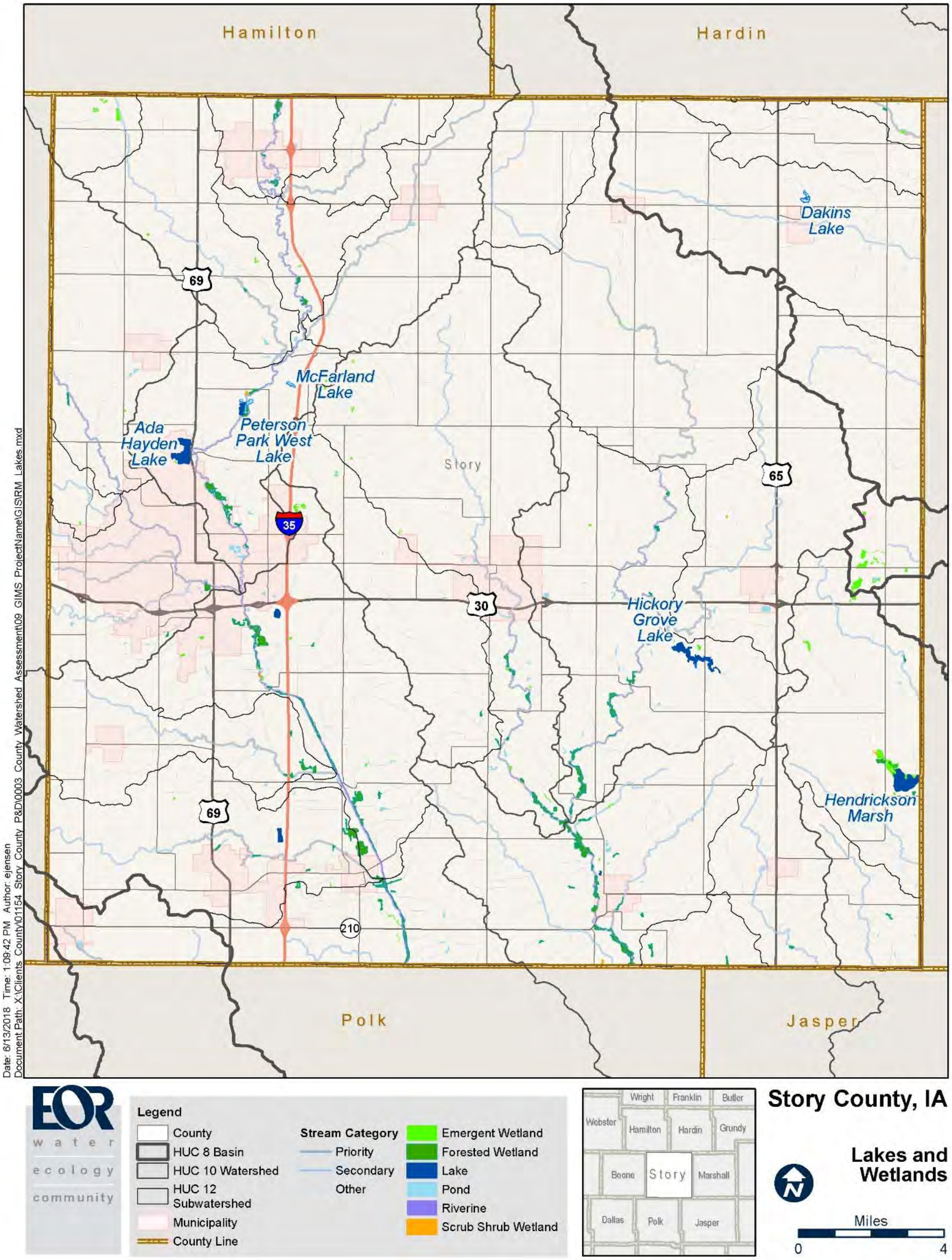


Figure 20. Story County Lakes and Wetlands

1.6.1. Ada Hayden Heritage Park Lake

Ada Hayden Heritage Park Lake is the largest lake within Story County at 137 acres. This popular recreational lake is divided into two separate lake basins (North and South) within Ada Hayden Heritage Park located in the City of Ames.

The park provides amenities for boating (electric motor only), biking, nature viewing, and fishing. Crappie, bluegill, Wiper (Hybrid White Bass/Striper), and largemouth bass can all be caught within the lake. Rainbow trout, brook trout, and channel catfish are also stocked annually and provide additional angling opportunities. In the early 2000's the lakes were converted into an emergency water source for the City of Ames, Iowa.

The City of Ames is working with the State Hygienic Laboratory to conduct water quality monitoring. Historical water quality data suggests good water quality near the surface but poor water quality near the bottom of the lake. Monitoring results from the major tributaries to Ada Hayden Lake have identified high nutrient loads from the watershed. Furthermore, constructed wetlands adjacent to the lake have been identified as potential sources of phosphorus and sediment, the likely result of sediment resuspension caused by carp feeding activities.

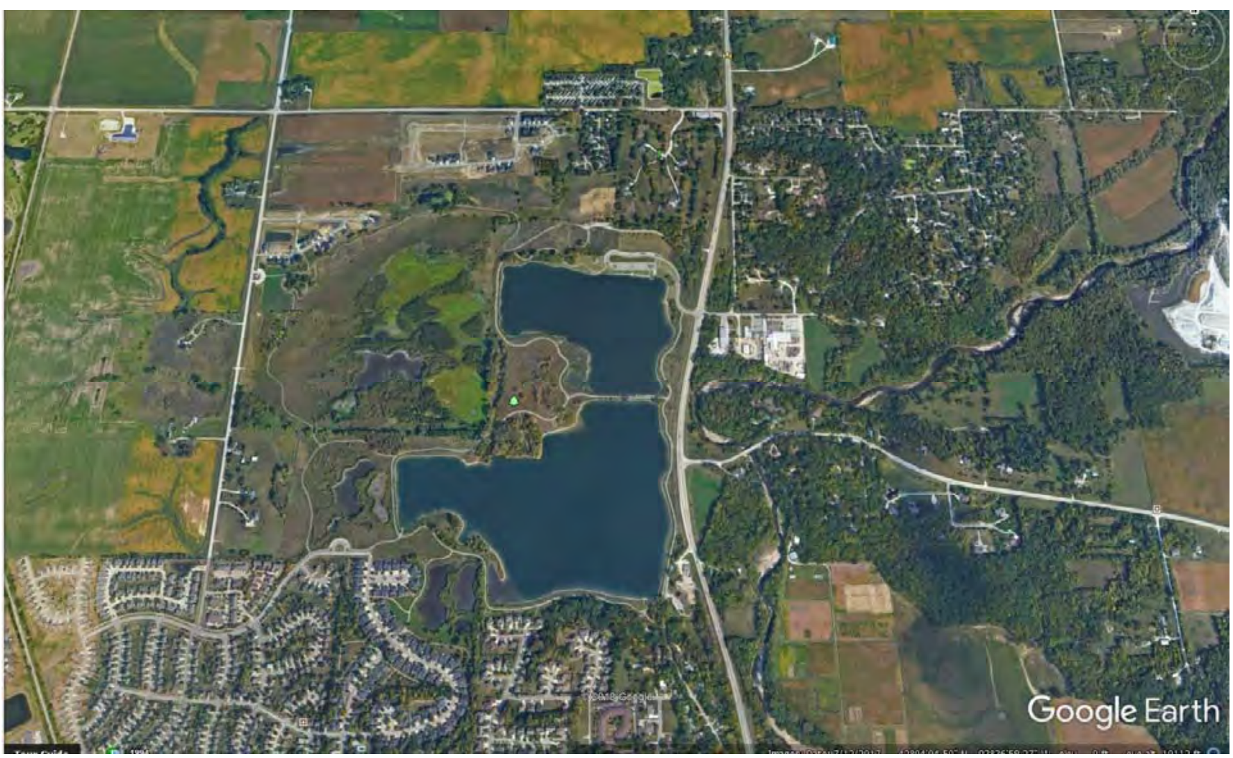


Figure 21. Ada Hayden Lake

1.6.2. Hickory Grove Lake

Hickory Grove Lake is the second largest lake within Story County at 98 acres. This popular recreational lake is located within Hickory Grove Park, Story County's largest and most popular park at 445 acres. Further information on the lake can be found on the Story County Website: Hickory Grove Lake Web Page (https://www.storycountyiowa.gov/1375/Hickory-Grove-Lake-Restoration).

The park provides amenities for camping, canoeing, fishing, kayaking, swimming, and hunting. Crappie and largemouth bass reproduce naturally in the lake, channel catfish are also stocked by the Iowa DNR.

Hickory Grove Lake was listed as an Impaired Water in 2008 due to high levels of indicator bacteria (E.coli) and algae. The Class A1 (primary contact recreation) uses are assessed (monitored) as "partially supported" due to levels of indicator bacteria that exceed Iowa's water quality standard and aesthetically objectionable conditions caused by algae blooms.

Since 2008, Story County has worked with private and public stakeholders to complete several conservation projects including; livestock exclusion and stream stabilization, shoreline stabilization, septic system upgrades, and gully stabilization practices within the park.

Future in-lake restoration work is slated for 2018-2021 including a full lake drawdown and fishery renovation focusing on common carp removal. Removal of carp in combination with other watershed and in-lake improvements should help promote clear water and aquatic plant growth which in turn will help to maintain a healthy gamefish community. (See the Hickory Grove Lake Management Plan https://www.storycountyiowa.gov/DocumentCenter/View/3246/Hickory-Grove-Lake_WMP)

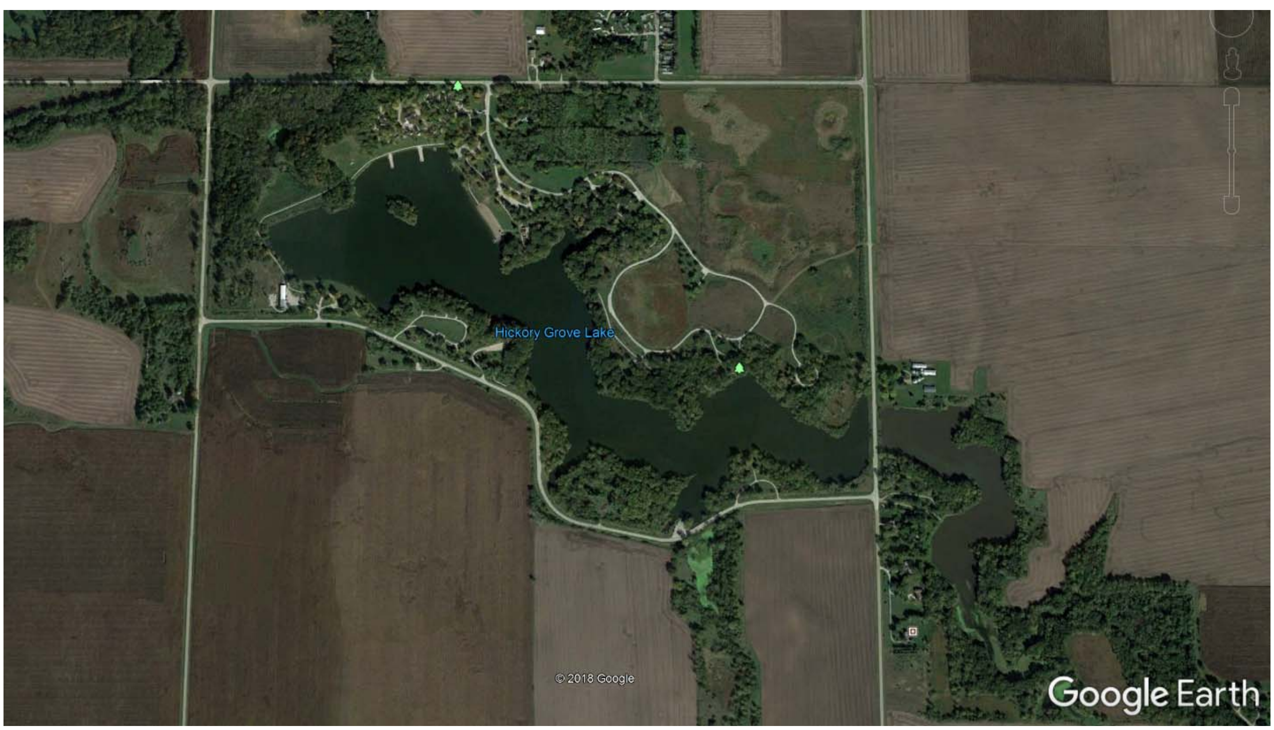


Figure 22. Hickory Grove Lake

1.6.3. Peterson Park West Lakes

Peterson Park West contains four gravel pit lakes with a combined area of 31 acres located along the Skunk River Greenbelt. Collectively these lakes are referred to as Peterson Park Lake West Lakes or Lake.

The park provides amenities for swimming, canoeing, kayaking, fishing, and public hunting. Fisheries surveys conducted by the DNR found abundant bluegill, crappie, largemouth bass and channel catfish within the lake. Peterson Park West Lake also contains a swimming beach.

Figure 23. Peterson Park West Lakes

1.6.4. McFarland Lake

McFarland Lake is a 6.5 acre lake stocked with bluegill, bass, and catfish located in the 200 acre McFarland Park. McFarland Park offers over 5.5 miles of natural surface trails that weave through tall grass prairie and woodlands as well as around the McFarland Lake and along the South Skunk River.

The park provides amenities for canoeing, kayaking, fishing, and picnicking. The park also features the Touch-a-Life Trail, a hard surfaced trail which winds through a variety of native plant communities including prairies, savanna, and the lake.

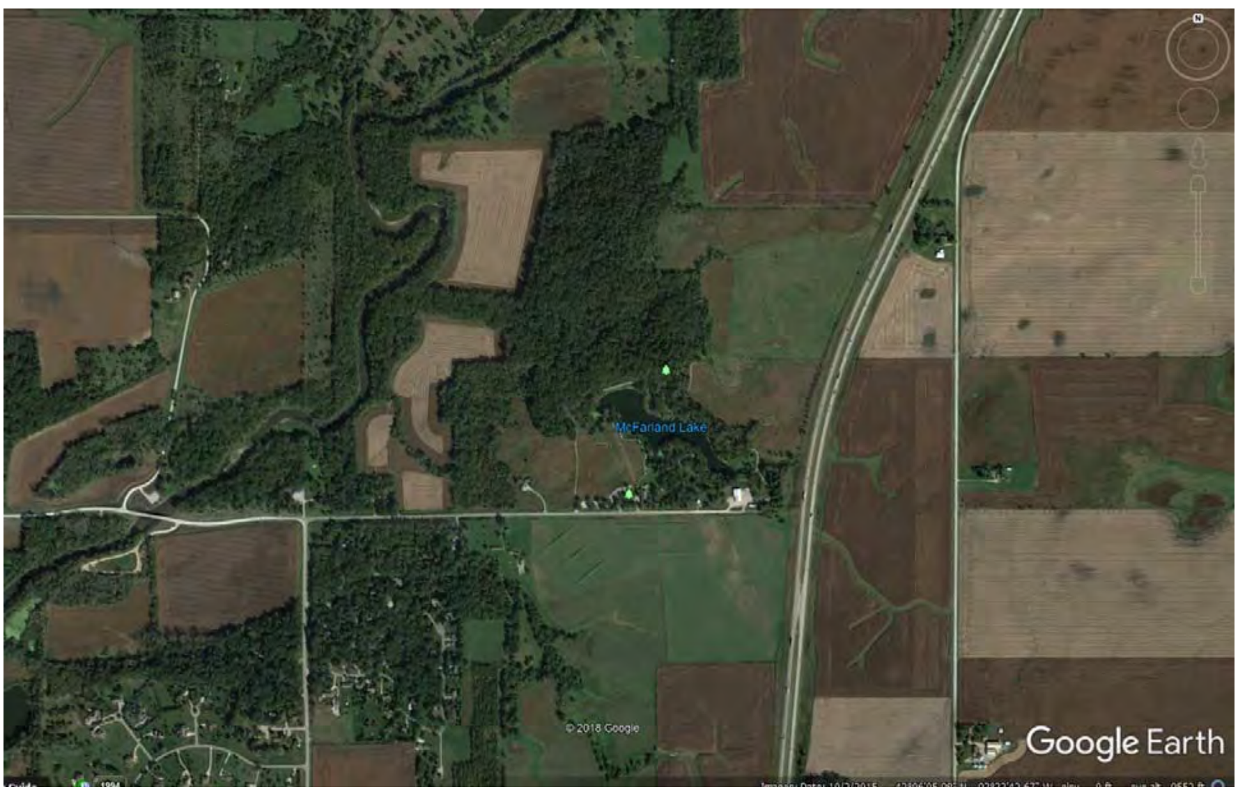


Figure 24. McFarland Lake

1.6.5. Dakins Lake

Dakins Lake is a 20 acre lake located within a 103 acre park in northeast Story County. The park provides amenities for camping, fishing, bird watching, and geocaching.

The 20 acre lake is stocked with bass, bluegill, channel catfish, and yellow perch. Dakins Lake underwent a major restoration in 2015 which expanded the lake from 5 acres to 20 acres. The new lake now includes additional fishing jetties, a boat ramp, and a fish cleaning station. Hiking and off-road biking on the park's two miles of trail represent additional amenities.

Water quality in Dakins Lake is protected by a series of three constructed wetlands which were designed to filter out sediments and nutrients as part of the lake expansion.

Figure 25. Dakins Lake

1.6.6. Wetlands

While many of Story County's wetlands have been previously drained for agricultural production, some wetland areas persist, primarily within the floodplain/riparian. These wetland provide many functions and values in the watershed. Wetland functions are science based natural processes that occur in wetlands. Wetland functions vary depending on the type of wetland, the season in the year, the position on the landscape and land uses that affect the hydrologic and ecologic functions. Wetland functions include hydrologic flux and storage, biological productivity, biogeochemical cycling and storage, decomposition, and community wildlife habitat. Wetland values are typically subjective, non-site specific benefits realized by society and individuals through natural wetland functions occurring in wetlands. Wetland values include water quality, flood water and storm water retention, public recreation and education, habitat, low-flow augmentation, carbon sequestration, and in some cases commercial uses. One of the more prominent wetlands in Story County is Hendrickson Marsh, located within the Hendrickson Marsh Wildlife Management Area, northeast of Collins.

Figure 26. Hendrickson Marsh

2. Watershed Assessment

2.1. 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, along with example names and codes from Story County.

Table 2-1: USGS Watershed Hierarchical System

Name	HUC Level	Average Size	Example name from Story County	Example code (HUC)
Region	2	177,560 sq-miles	Upper Mississippi River	07
Subregion	4	16,800 sq-miles	Upper Mississippi –Iowa-Skunk-Wapsipinicon	0708
Basin	6	10,596 sq-miles	Upper Mississippi –Skunk-Wapsipinicon	070801
Subbasin	8	700 sq-miles	South Skunk River	07080105
Watershed	10	40,000–250,000 acres	Squaw Creek	0708010503
Subwatershed	12	10,000–40,000 acres	Onion Creek	070801050305

Story County is hydrologically complex from a USGS watershed network standpoint. The County is entirely within the Upper Mississippi River Region but sits upon a divide between two Subregions: the Des Moines Subregion and the Upper Mississippi –Iowa-Skunk-Wapsipinicon Subregion. Within the latter Subregion, Story County also sits on a divide between two Basins: the Upper Mississippi –Skunk-Wapsipinicon Basin and the Iowa River Basin.

2.1.1. Subbasins (HUC-8)

Subbasins or HUC-8 watersheds within the USGS system are the watershed-scale typically used for watershed planning in Iowa. Story County sits within eight distinct watershed subbasins (HUC -8 scale watersheds). The majority of the County (88%) sits within the South Skunk Subbasin (Figure 27). Approximately 10% of the County is within the Upper Iowa Subbasin with the remainder of the County divided among the four other subbasins as shown in Table 2-2.

Table 2-2: Subbasins of Story County

Subbasin (HUC-8)	Area –Acres (% of County)
South Skunk	321,930 (87.8%)
North Skunk	1,115 (0.3%)
Upper Iowa	35,507 (9.7%)
Middle Iowa	2,876 (0.8%)
Lake Red Rock	5,269 (1.4%)
Middle Des Moines	173 (0.1%)

Figure 27. Story County HUC-8 Subbasins

2.1.2. Watersheds (HUC-10)

Story County sits within twelve distinct Watersheds as shown in Table 2-3 and Figure 28. Previous and on-going watershed management activities within Story County have been organized at the Watershed scale. This includes the;

Fourmile Creek Watershed Management Authority https://fourmilecreekwatershed.org/

Squaw Creek Watershed Management Authority http://www.prrcd.org/watershed_waterways/sqawcreekwatershedplan/

Keigley Branch-South Skunk River Watershed http://www.prrcd.org/watershed_waterways/keigley-branch-south-skunk-river-watershed/

Determining the appropriate scale for watershed management involves tradeoffs between planning and prioritizing among major resources of interest, diversity and physical distance of government entities and the importance of grass-roots, local initiatives for implementation.

Figure 28: HUC-10 Watersheds of Story County

2.1.3. 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 in the construction of hydrologic and water quality models. Story County has land within thirty-three unique Subwatersheds (HUC-12) as shown in Table 2-3 and Figure 28. Subwatersheds are the hydrologic-scale that is commonly used for implementation efforts. At this scale landowners are likely to have personal relationships and a small, dedicated group can have a meaningful role in improving the health of a subwatershed.

Table 2-3. Watersheds and Subwatersheds of Story County

Watershed (HUC-10)	% Within Story County	Subwatershed (HUC-12)	% Within Story County
Squaw Creek	19.00%	Lundys Creek	52.60%
		Onion Creek	15.50%
		Worle Creek	50.30%
Keigley Branch-South Skunk River	48.30%	Bear Creek	62.60%
		City of Ames	100.00%
		Headwaters Keigley Branch	17.00%
		Keigley Branch	78.40%
		Long Dick Creek	19.90%
		Miller Creek	24.40%
West Indian Creek	100%	Drainage Ditch 5	100.00%
		West Indian Creek	100.00%
East Indian Creek	92.50%	Dye Creek	100.00%
		Drainage Ditch 81	100.00%
		East Indian Creek	100.00%
		Headwaters East Indian Creek	53.80%
Clear Creek	40.10%	Mud Creek-Clear Creek	17.70%
		Headwaters Clear Creek	67.90%
Indian Creek	40.80%	Peoria Cemetery	21.90%
		Rock and Calamus Creeks	95.90%
		Wolf Creek	62.70%
Sugar Creek-South Skunk River	37.90%	Ballard Creek	91.20%
		Coon Creek	34.90%
		Drainage Ditch 13	100.00%
		Walnut Creek	86.70%
Headwaters North Skunk River	<1.0%	Headwaters North Skunk River	3.30%
Minerva Creek	33.40%	Hardin Story Drainage Ditch No 1	56.20%
		Headwaters Minerva Creek	3.90%
		Middle Minerva Creek	74.30%
		South Minerva Creek	47.40%
Linn Creek	6.90%	Headwaters Linn Creek	12.00%
Big Creek	<1.0%	Headwaters Big Creek	<1.0%
Fourmile Creek	6.90%	Upper Fourmile Creek	18.30%

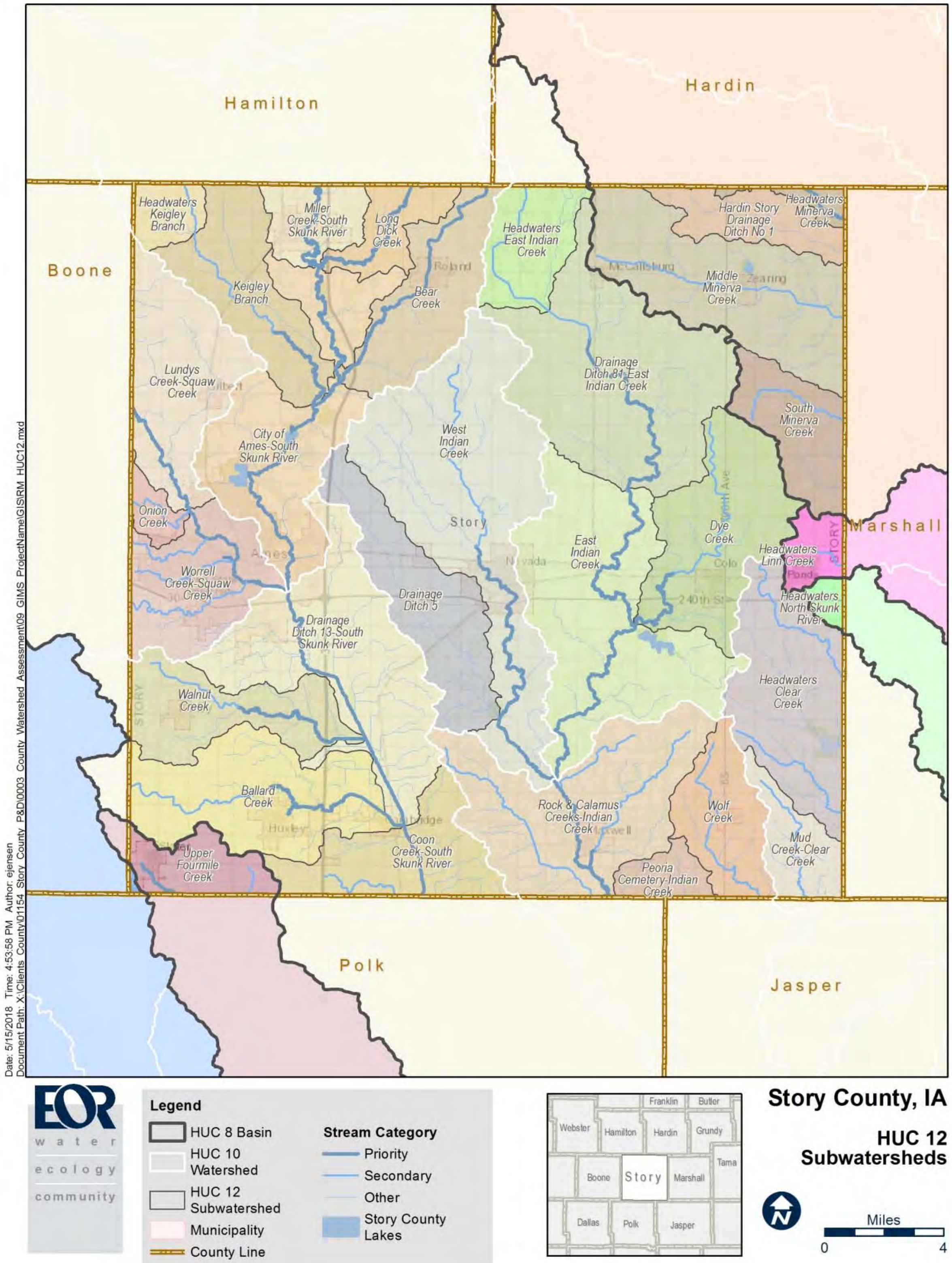


Figure 29. HUC-12 Watersheds of Story County

2.2. Land Cover

Land cover and use, both natural and human influenced, are the main factors driving the quality and character of water resources in Story County. Land use within Story County is predominately agricultural with development limited to some of the larger communities (Table 2-4 and Figure 30). The distribution of land cover in Story County was determined using Iowa's High Resolution Land Cover Dataset with a spatial resolution of one square meter. Figure 31 maps the location of the high resolution land cover dataset for all of Story County. This dataset illustrates that the forested/grassland riparian areas are primarily located along the major river corridors. 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 Watershed Pollutant Source Assessment discussion within this report.

Table 2-4. Story County – Land Cover

Land Cover	Acres	% of Watershed
Corn/Soybean	277,696	73.9%
Urban	14,755	3.9%
Grass/Pasture	47,694	12.7%
Other Cropland	3,214	0.9%
Forest	24,963	6.6%
Ponds/Wetlands	6,884	1.8%
Total	375,206	100%

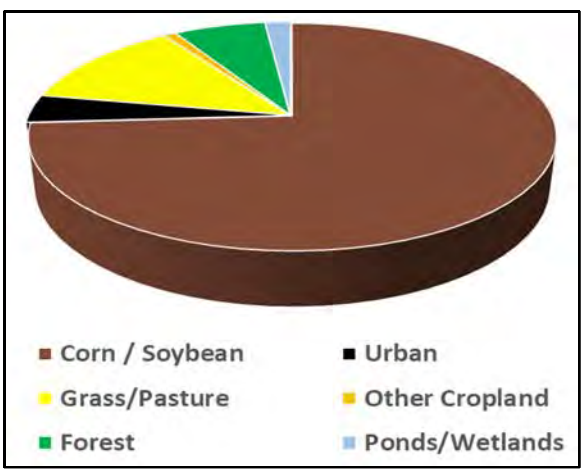


Figure 30. Story County – Land Cover

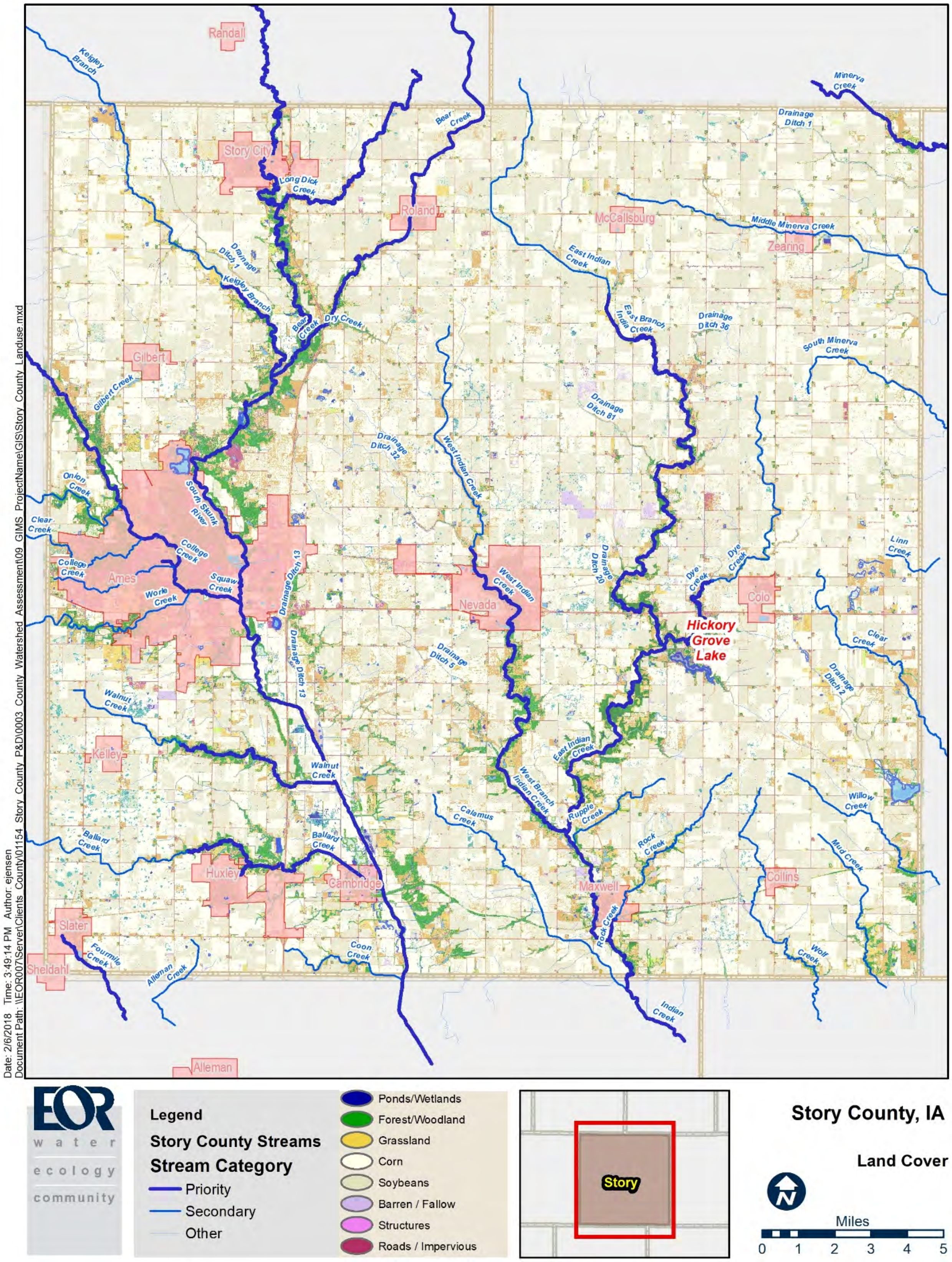


Figure 31. Story County - High Resolution Land Cover

2.3. Environmentally Sensitive Areas Inventory

Story County Conservation Board (SCC) worked with Scott Zager of Wildlands Ecological Services, to develop a strategy to map and inventory Story County of its remaining natural areas including forests, woodlands, savannas,

prairies, and wetlands. Remote sensing (aerial photos) techniques along with previously collected data (rare species occurrences, previous natural areas surveys) were used to evaluate the potential for ecologically sensitive areas. Potential sites were ranked from low to high priority for field assessment and inventory. Story County is in the process of conducting those field inventories. (Figure 32).

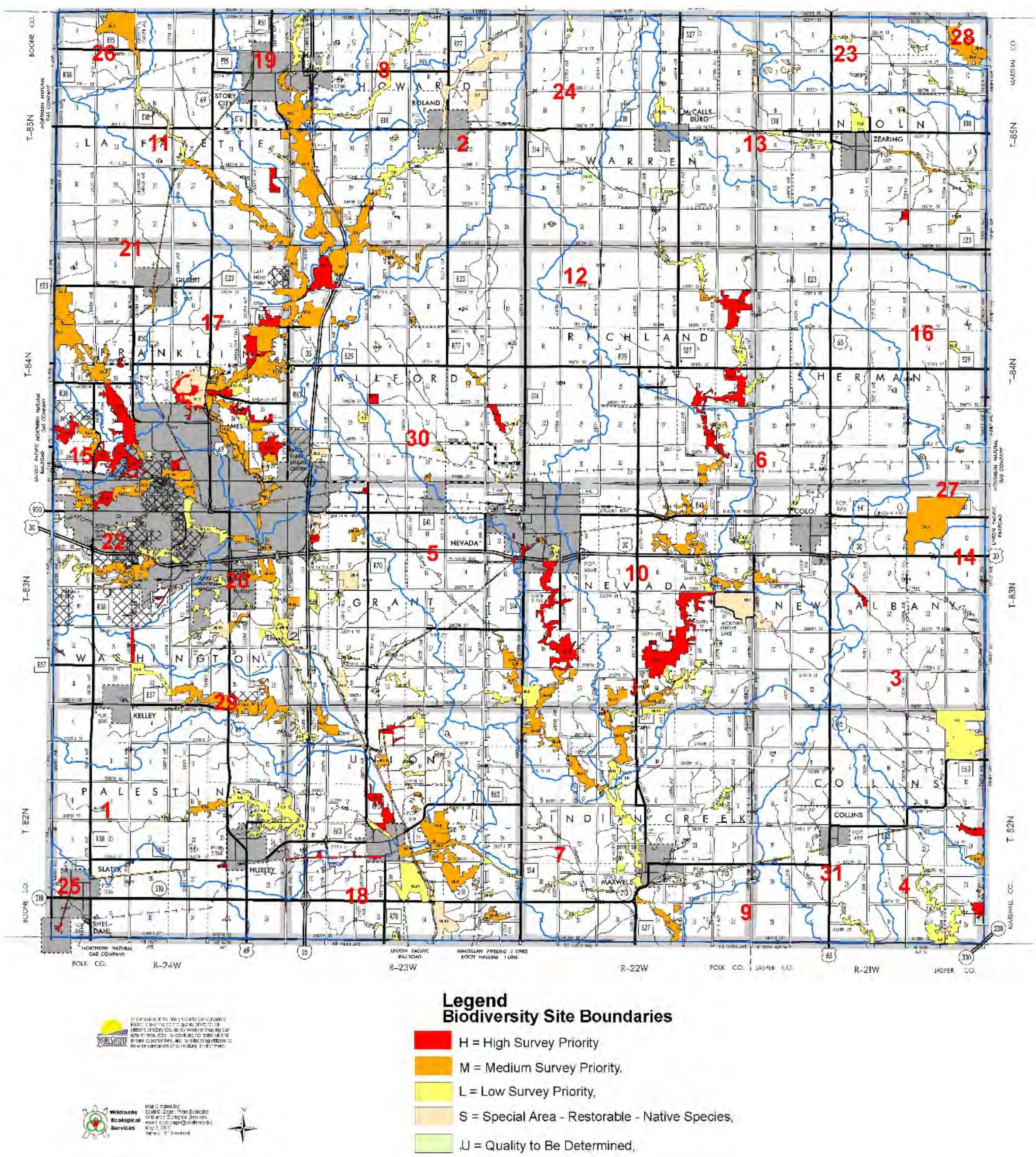


Figure 32. Environmentally Sensitive Areas

2.4. Topography

Figure 33 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 of the County has gentle, rolling slopes of less than 5%. Steeply sloped areas identified include those areas adjacent to major rivers, most notably, Ballard Creek, Bear Creek, Clear Creek, East Indian Creek, Onion Creek, Worle Creek, West Branch of Indian Creek, and the lower reaches of the South Skunk River. The highest point in the county is located within the Gary moraine, a remnant ridge from the Wisconsin Glaciation located in the northern part of the County with an altitude of 1,075 feet. The lowest elevation is on the flood plain of the South Skunk river where that stream leaves the county, at 830 feet.

The topography of the watershed was used as factor in developing recommendations for areas within the County 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.

Unnamed Creek in Huxley

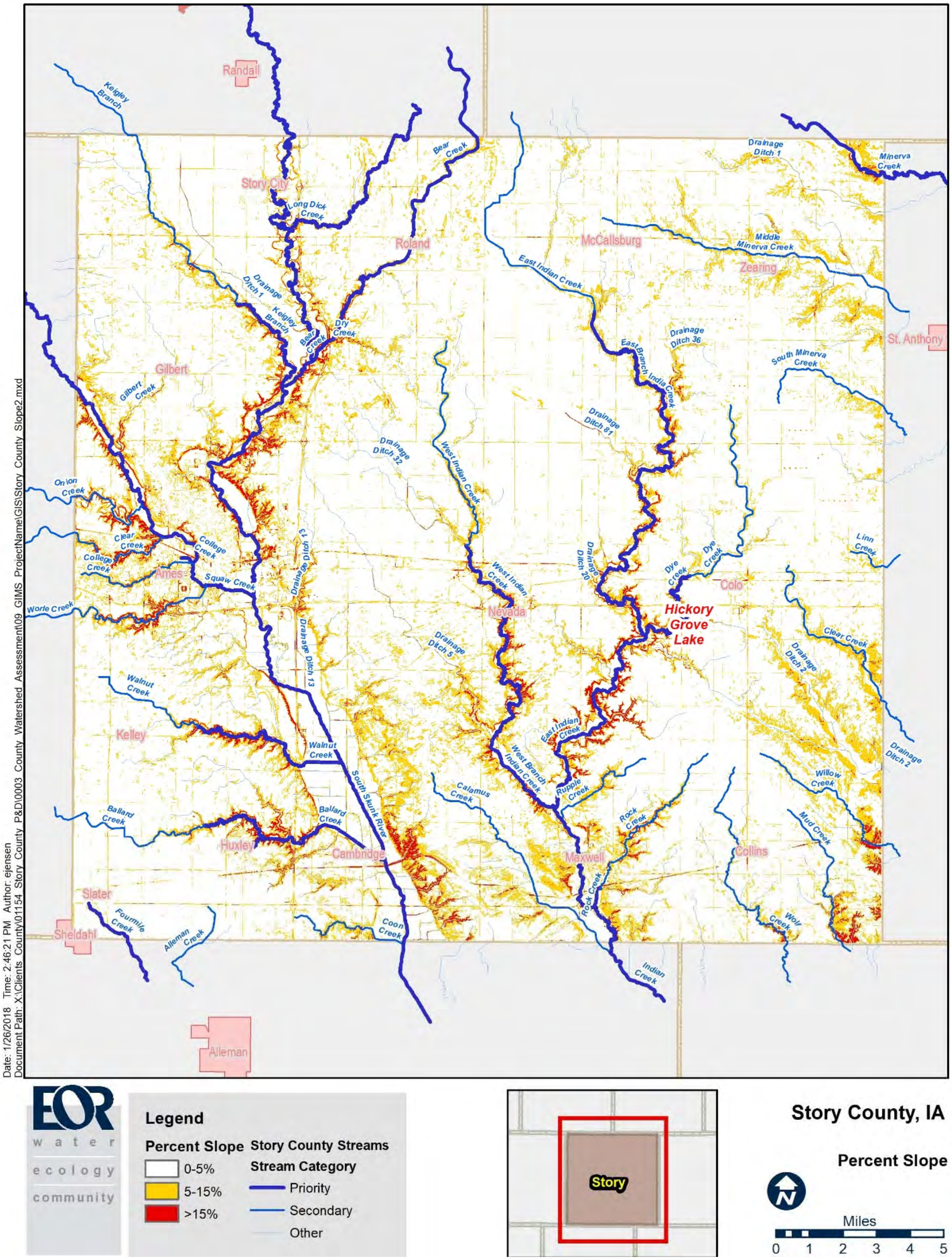


Figure 33. Story County – Percent Slope

2.5. Climate

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

2.5.1. Temperature

National Oceanic and Atmospheric Administration (NOAA) climate data from Ames, IA were summarized with corresponding average, maximum and minimum monthly temperatures plotted by month (Figure 34). There are two weather stations within the City of Ames: station 5 SE and station 8 WSW. These weather stations were chosen because the City of Ames is located within the County and because each station contains climatic data dating back to 1970'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 be harsh, 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 vary about 15-25° F.

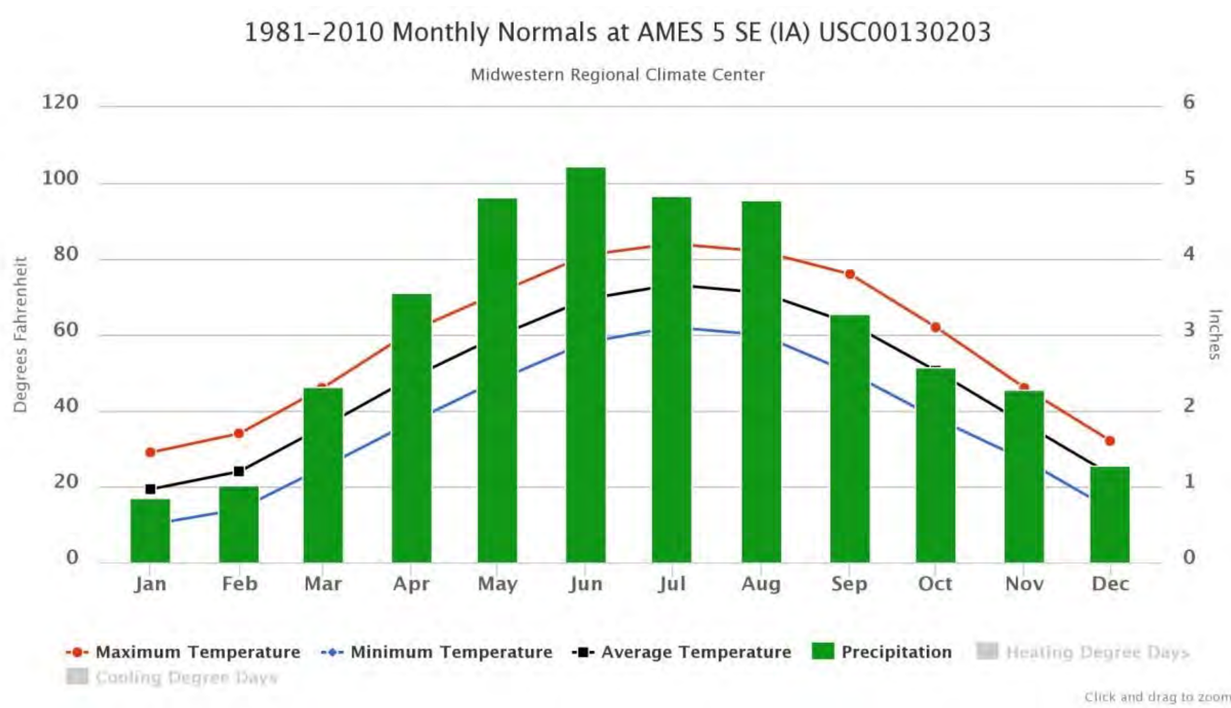


Figure 34. Average monthly climate data for Ames, IA. NOAA's Midwestern Regional Climate Center

It has been noted that average regional temperatures have increased over time. To evaluate this pattern, average annual minimum and maximum temperatures for Ames, IA (Station 8 WSW) were plotted for the time period 1970 to 2013 in Figure 34. While there can be seen a slight increase in average annual maximum temperatures, the increasing pattern is much more pronounced for the average annual minimum temperatures. Annual minimum temperature values have increased about 2-3 degrees F from 1970 to 2013. Other studies have also 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.)

2.5.2. Rainfall

Annual average rainfall totals 35.8 inches +/- 8.0 inches with the growing season typically having the highest rainfall totals of about 3.5 inches to 5 inches per month. Annual rainfall measured at the Ames, IA site during the 1970 – 2013 time period has varied from about 21 inches (1981) to 56.4 inches (1993 flood) (Figure 35). For the same time period, growing season (May-October) rainfall averaged about 21.5 +/- 6.9 inches with values that ranged from about 10.4 inches (1976) to 45.72 inches (1993) (Figure 36). Considerable variability in rainfall has also been noted over the past 10 years. Drier growing season conditions were noted in 2012-2013 with about 11.7 and 14.8 inches recorded, respectively. In contrast, 2010's growing season was noted to be 39.3 inches. Hence,

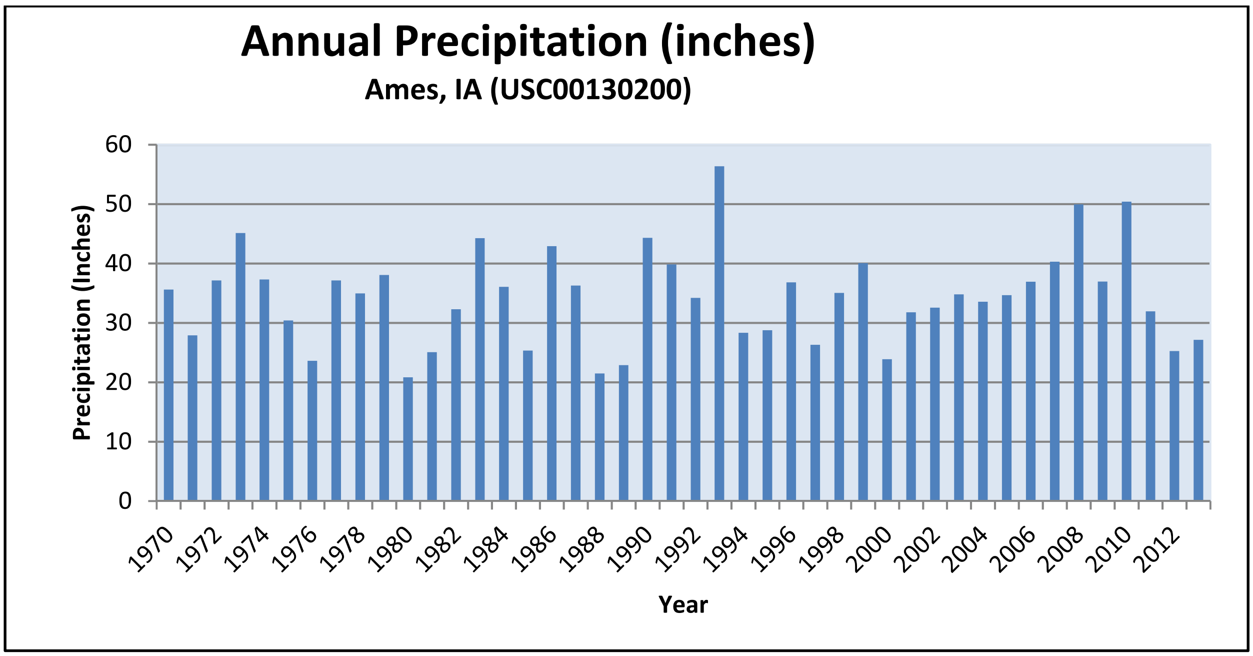


Figure 35. Annual Precipitation 1970-2013, Ames IA

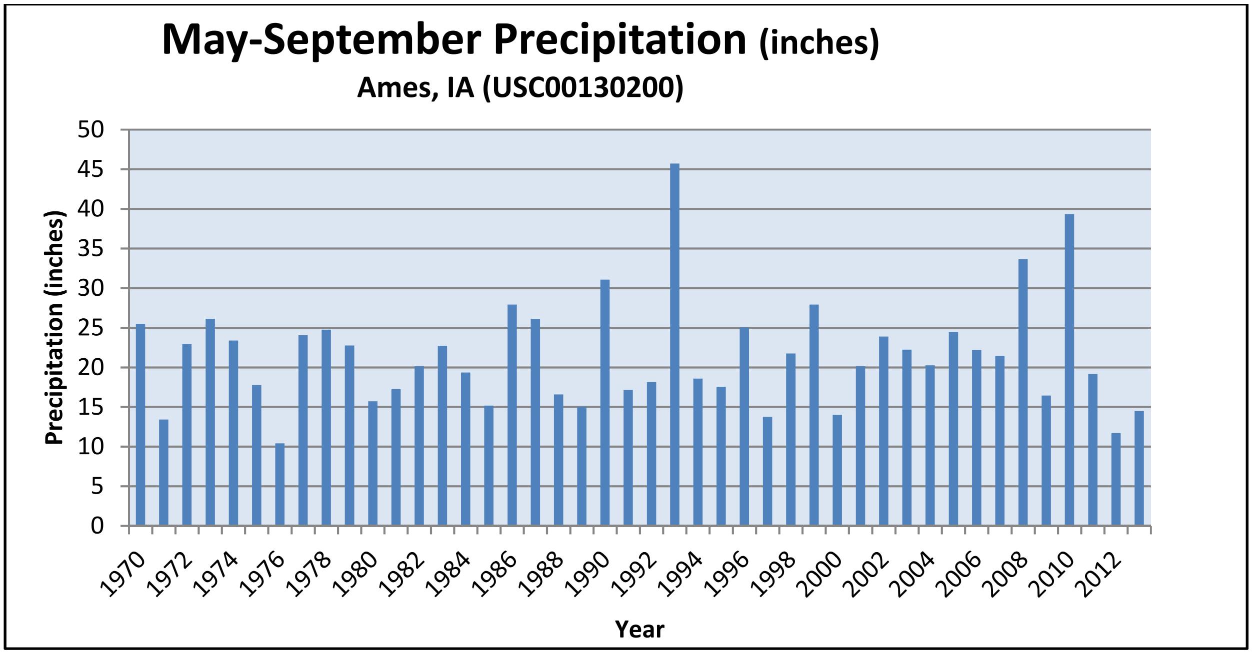


Figure 36. Growing Season (May-Sept) Precipitation 1970-2013, Ames IA

2.5.3. 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 common 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 Story County being smack 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. Story County is in the center of America's Heartland that is one of the most active weather areas of the world 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 15 days as defined from the Ames, IA weather record (1970-2013).
- 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 but 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 retain 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

2.6. Soils

The Soil Survey Geographic (SSURGO) soils GIS layer available from the United States Department of Agriculture (USDA) were clipped to the County boundary. The USDA SSURGO GIS layer contains tabular data including hydrologic soil group classification; the tabular data was joined to the spatial data via a common attribute (Map Unit Symbol). 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.

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 Story County are illustrated in Figure 37. 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 Cordova, 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.

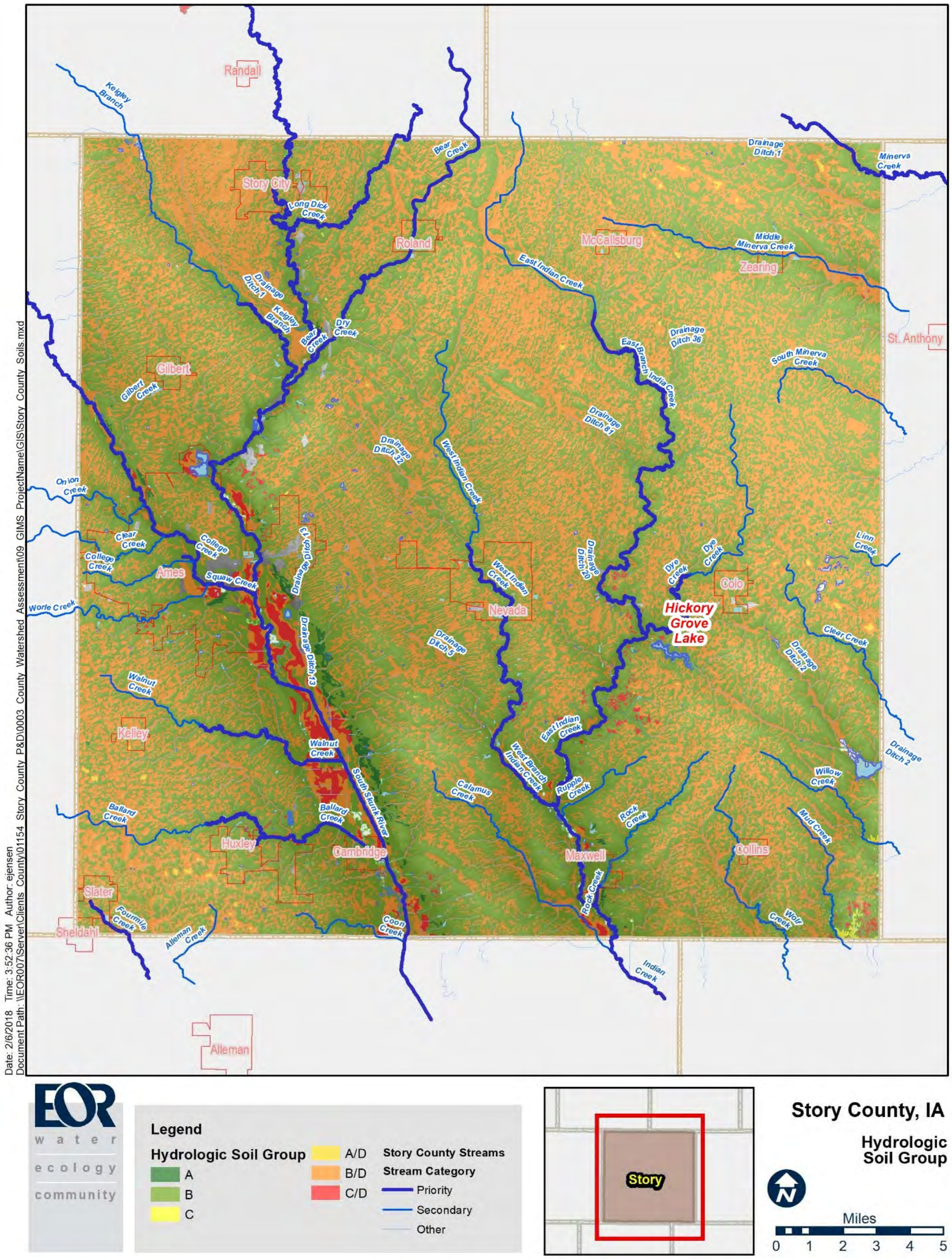


Figure 37. Story County –Hydrologic Soil Group

2.7. Geology and Groundwater Resources

The following is a summary of the groundwater resources and underlying geology of Story County based on available data included in a review of *Ground Water Resources – Story County,* a report compiled by Carol A. Thompson of the Iowa Geological Survey and data collected by the Iowa DNR. Approximately 80% of Story County residents rely on groundwater as their primary source of drinking water. Protecting groundwater quality and quantity is extremely important to Story County residents as groundwater availability in Story County is limited either due to poor water quality (high mineral content), distribution (distance to areas where it is needed), and yield (adequacy of overall available supply).

2.7.1. Surficial Hydrogeology

Story County 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 county, 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 Skunk River are shown in (Figure 38). In Story County, the Cambrian-Ordovician aquifer is covered by the Mississippian Aquifer which overlays a series of confining layers consisting of limestone, dolomite, and shale. In Story County, these confining layers include the Cherokee group, Meramec series, and Osage Series (Figure 39).

Recharge to the Mississippian aquifer is from: a) precipitation where the bedrock is at or near the surface, b) leakage to the aquifer from the South Skunk River and its tributaries, and c) groundwater inflow from areas outside of the Keigley Branch watershed. The Mississippian Aquifer is heavily used as a drinking and industrial water supply. The Devonian-Silurian Aquifer (Middle Bedrock Aquifer) is used by several communities and rural residents. The main water-producing units in the Devonian-Silurian are a series of limestones and dolostones.

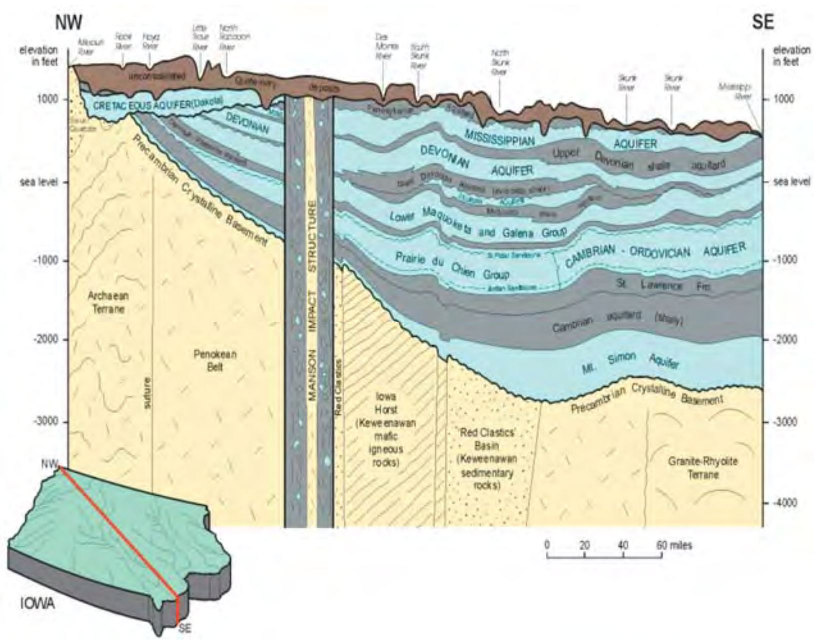


Figure 38. Generalized hydrogeological cross-section from northwestern to southeastern Iowa (modified from Prior and others, 2003).

2.7.2. 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 Story County makes it possible to see where groundwater protection issues are most relevant. Within Story County, there are five map unit classifications (Figure 40); groundwater quality, yield, and susceptibility to contamination is described below for each map unit:

Alluvial Aquifers: Areas underlain by sand and gravel aquifers situated beneath floodplains along stream valleys, alluvial deposits associated with stream terraces and benches, and glacial outwash deposits; natural water quality 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).

Thin Drift Confinement: Less than 100 feet of glacial drift overlie regional aquifers; most wells are deep and completed in the bedrock aquifers; high potential for aquifer contamination; high potential for well contamination.

Moderate Drift Confinement: 100 to 300 feet of glacial drift overlie regional aquifers; most wells are deep and completed in the bedrock aquifers; 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 aquifers; 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.

2.7.3. 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 should be prioritized as source water protection areas (Figure 39). The Iowa DNR operates a Source Water Protection Program which requires a Phase 1 Assessment which defines the source water area and susceptibility to contamination. Twenty-nine highly susceptible wells have been identified in 4 communities (Ames, Cambridge, Huxley, and Nevada) within Story County (Figure 40). Communities can coordinate with the IDNR to conduct a site investigation to determine if the contaminant is from a point or non-point source.


East Indian Creek at 295th Street

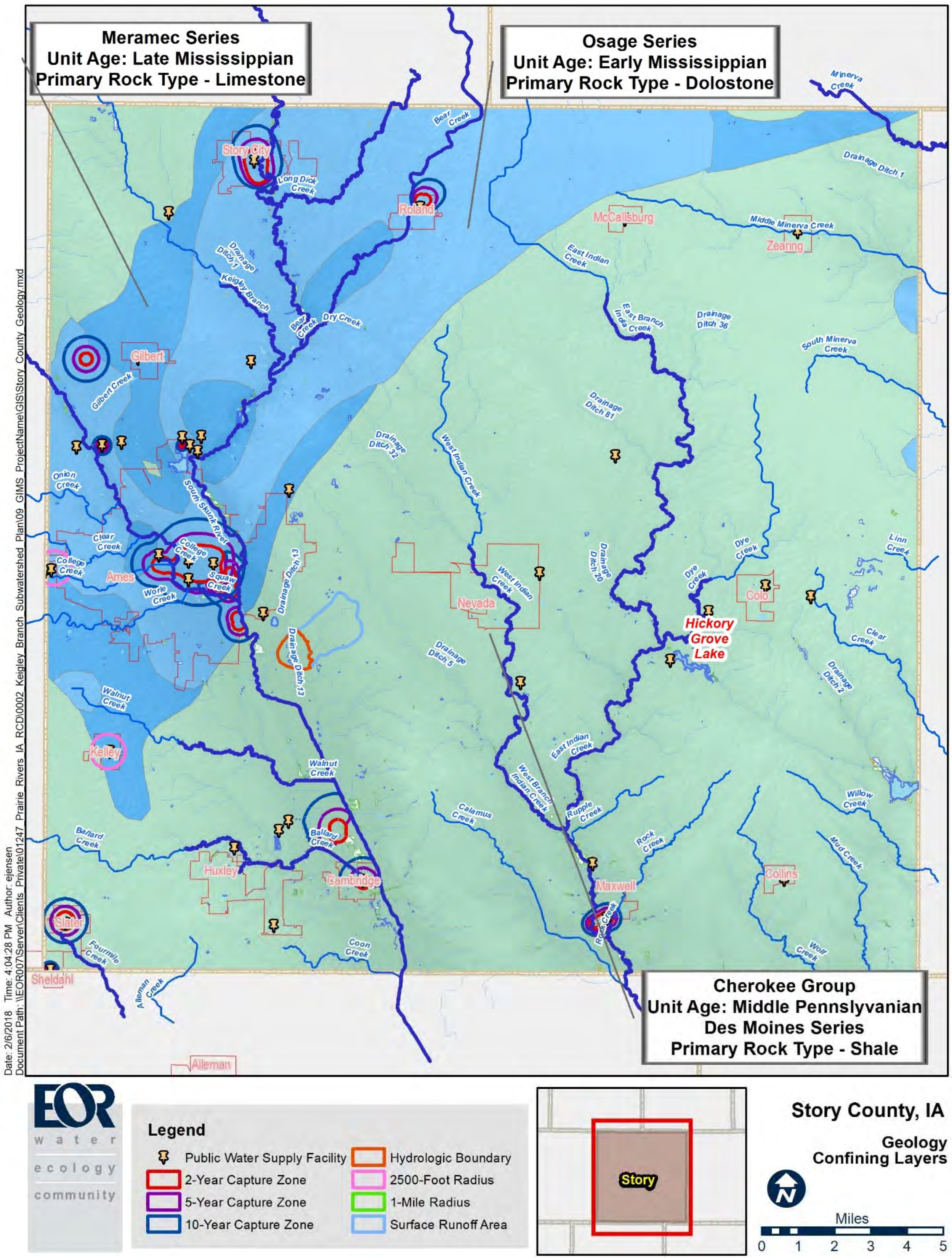


Figure 39. Source Water Protection Areas

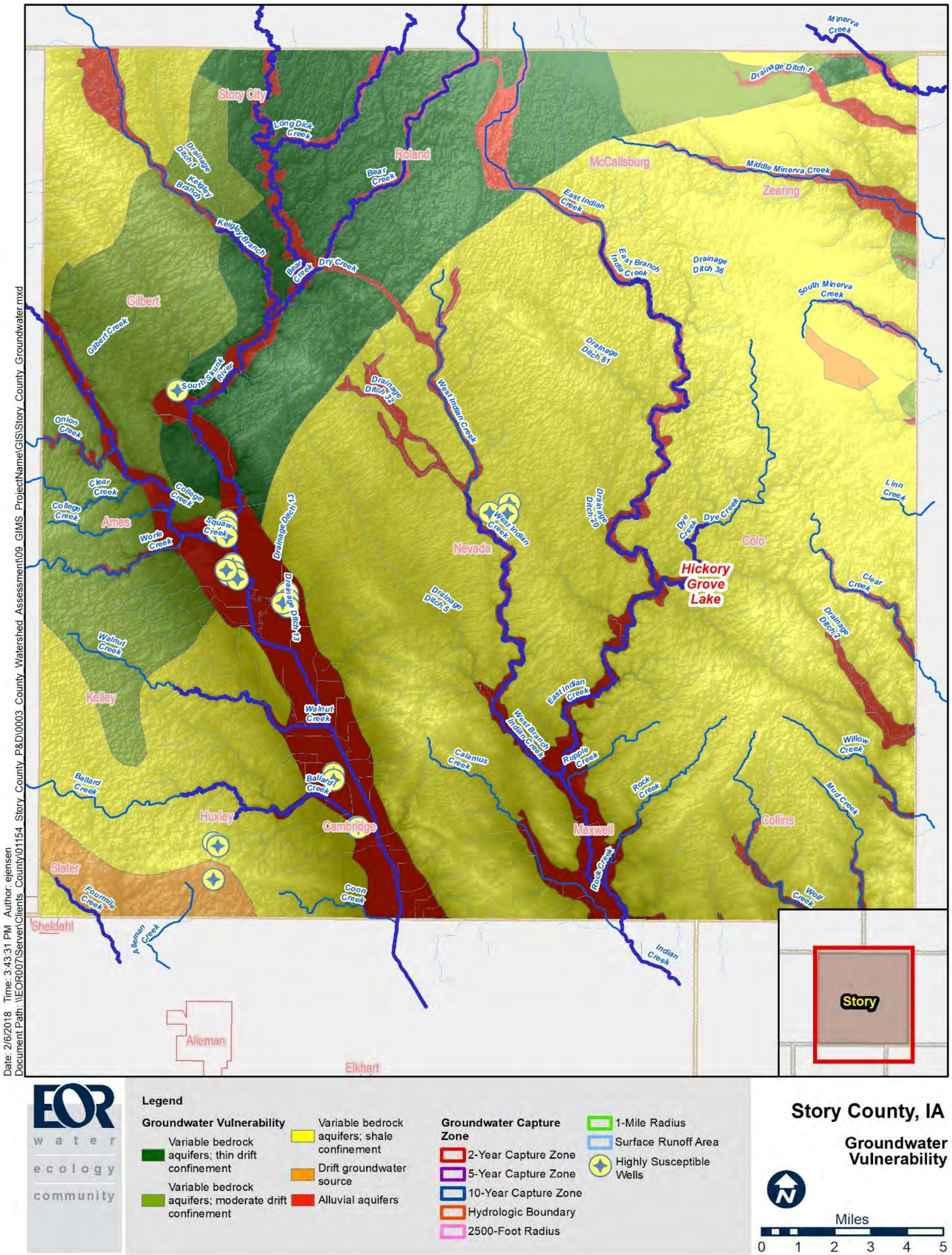


Figure 40. Story County Highly Susceptible Wells and Groundwater Vulnerability

2.8. Watershed Pollutant Source Assessment

2.8.1. 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 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 that float in the stream or are attached to rocks and substrates, increased organic matter, 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 that also can produce toxins such as microcystin that can affect wildlife and drinking water supplies.

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

Unit area loads (UALs) for total phosphorus (TP) were used to determine the source and magnitude of pollutant loading for each Subwatershed (HUC-12) within Story County. UALs are used to provide an estimate of how much load is typically derived from a given area for a particular land use. Site-specific UALs were available for the Squaw Creek Watershed which used a Soil and Water Assessment Tool (SWAT) Model to assess TP loads. Results from the SWAT model were compared to UALs from relevant literature to obtain recommended UALs for Story County. The recommended UALs are largely based on UALs from published UAL data from the Minnesota Pollution Control Agency, the U.S. Army Corps of Engineers, and UALs found in the EPA's pollutant loading application (PLOAD).

Multiplying the UAL for a particular land use by the total area of the selected land use within a given subwatershed (HUC-12) allows for a comparison of total load generated by subwatershed (HUC- 12), and the proportion of the total load generated by a given land use practice (Figure 41). Modeled TP loading rates for subwatersheds in Story County (0.40-0.56 pounds/acre/year) were within the range of observed average annual TP loading rates for watersheds in Story County. Data provided in the Iowa DNR 2004 report which contains nitrogen and phosphorus budgets for all Iowa Watersheds suggest watersheds in Story County such as the South Skunk River and Indian Creek have TP loading rates of 0.39-0.63 pounds/acre/year.

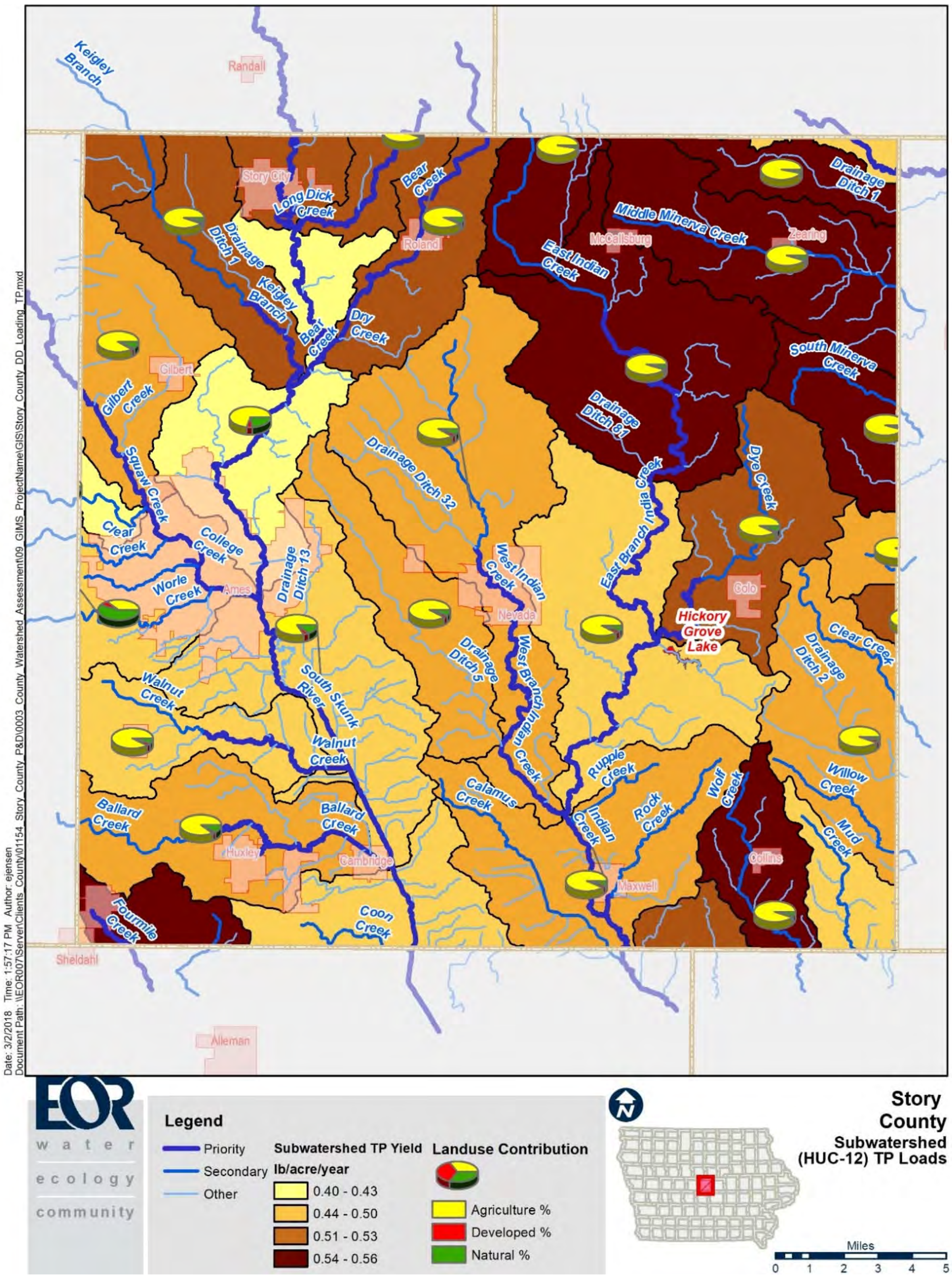


Figure 41. Story County Subwatershed (HUC-12) Total Phosphorus Yields (Lbs/Acre/Year)

2.8.2. Total Nitrogen

Nitrogen is an important measurement, particularly the dissolved forms, as it increases productivity on farm fields, urban lawns and streams/lakes. Nitrate 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 the combined nitrate plus nitrite nitrogen with concentrations that vary seasonally from biological activity and nutrient inputs (fertilizer, wastewater and urban runoff). While nitrate is one of the primary forms of nitrogen used by plants for growth, excess amounts to groundwater and streams can cause human health concerns. At concentrations greater than 10 mg/L, it has been linked to methemoglobinemia ("blue baby syndrome"). Hence ground water recharge areas associated with public drinking water sources can have drinking water source management area plans to limit nitrate and other drinking water pollutants. Secondly, as nitrate nitrogen is very soluble, it can be transported long distances downstream to large impoundments and the Gulf of Mexico as one of the primary contributors to low or no oxygen areas (hypoxic zones).

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.

Unit area loads (UALs) for total nitrogen (TN) were used to determine the source and magnitude of pollutant loading for each Subwatershed (HUC-12) within Story County. UALs are used to provide an estimate of how much load is typically derived from a given area for a particular land use.

Site-specific UALs were available for the Squaw Creek Watershed which used a Soil and Water Assessment Tool (SWAT) Model to assess TN loads. Results from the SWAT model were compared to UALs from relevant literature to obtain recommended UALs for Story County. The recommended UALs are largely based on UALs from published UAL data from the Minnesota Pollution Control Agency, the U.S. Army Corps of Engineers, and UALs found in the EPA's pollutant loading application (PLOAD).

Multiplying the UAL for a particular land use by the total area of the selected land use within a given Subwatershed (HUC-12) allows for a comparison of total load generated by Subwatershed (HUC- 12), and the proportion of the total load generated by a given land use practice (Figure 42). Modeled TN loading rates for subwatersheds in Story County (7-13.7 pounds/acre/year) were within the range of observed average annual TN loading rates for watersheds in Story County. Data provided in the Iowa DNR 2004 report which contains nitrogen and phosphorus budgets for all Iowa Watersheds suggest watersheds in Story County such as the South Skunk River and Indian Creek have TN loading rates of 9.3-19.4 pounds/acre/year.

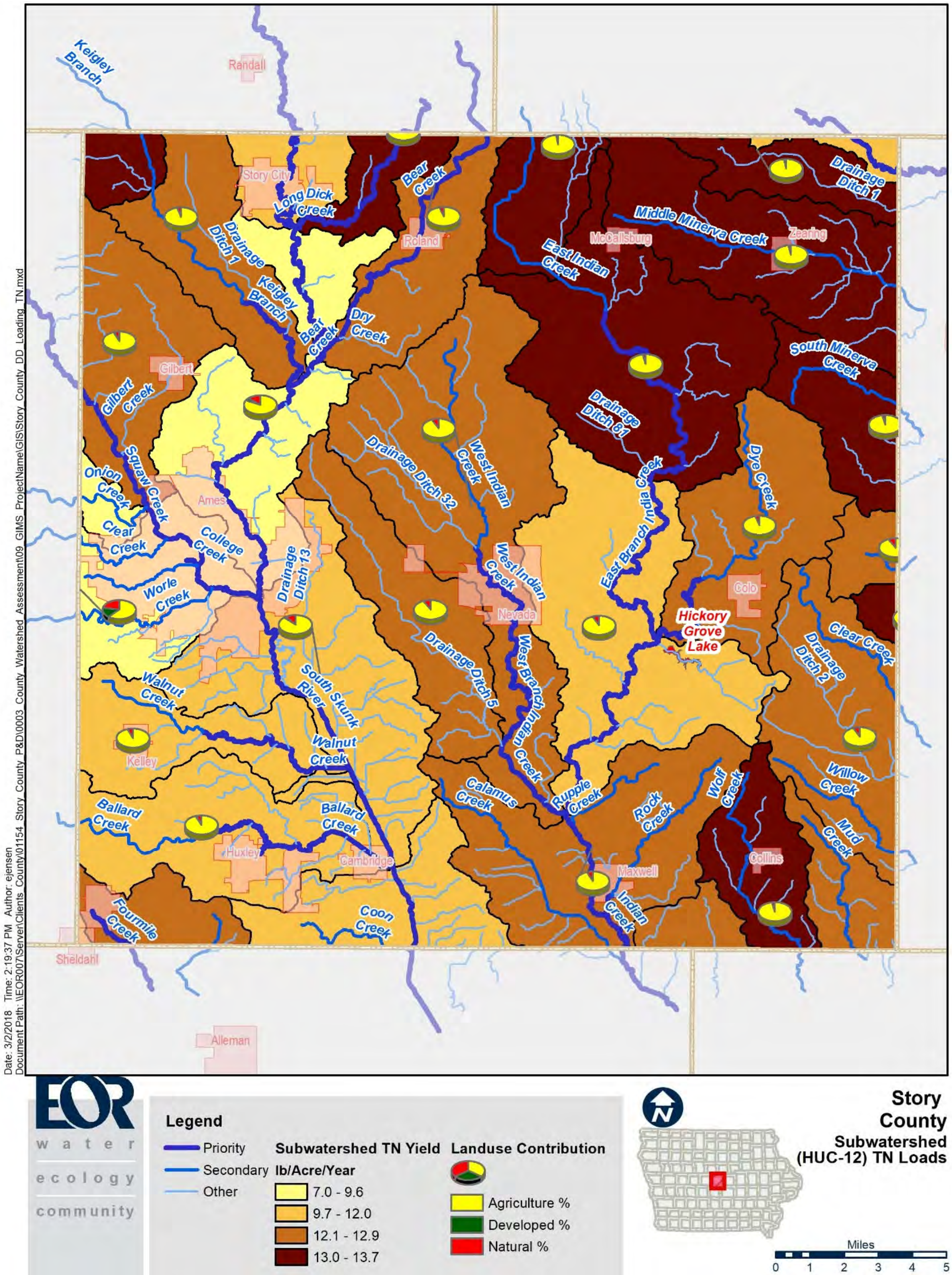


Figure 42. Story County Subwatershed (HUC-12) Total Nitrogen Yields (Lbs/Acre/Year)

2.8.3. Total Suspended Solids

Total suspended Solids is an important measurement of the amount of material suspended instream which is sometimes referred to as turbidity. As more material is suspended, less light can pass through, making it 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. Also, turbidity can 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.

Unit area loads (UALs) for total nitrogen (TN) were used to determine the source and magnitude of pollutant loading for each Subwatershed (HUC-12) within Story County. UALs are used to provide an estimate of how much load is typically derived from a given area for a particular land use.

Site-specific UALs were available for the Squaw Creek Watershed which used a Soil and Water Assessment Tool (SWAT) Model to assess TSS loads. Results from the SWAT model were compared to UALs from relevant literature to obtain recommended UALs for Story County. The recommended UALs are largely based on UALs from published UAL data from the Minnesota Pollution Control Agency, the U.S. Army Corps of Engineers, and UALs found in the EPA's pollutant loading application (PLOAD).

Multiplying the UAL for a particular land use by the total area of the selected land use within a given Subwatershed (HUC-12) allows for a comparison of total load generated by Subwatershed (HUC- 12), and the proportion of the total load generated by a given land use practice (Figure 43). Modeled TSS loading rates for subwatersheds in Story County (840-1880 pounds/acre/year; equivalent to 0.42-0.94 tons/acre/year) were within the range of observed average annual TSS loading rates for watersheds in Story County. Data provided in a 2006 Report of the Walnut Creek and Squaw Creek Watersheds found an average annual TSS loading rate of 0.65 and 0.69/tons/acre/year respectively.

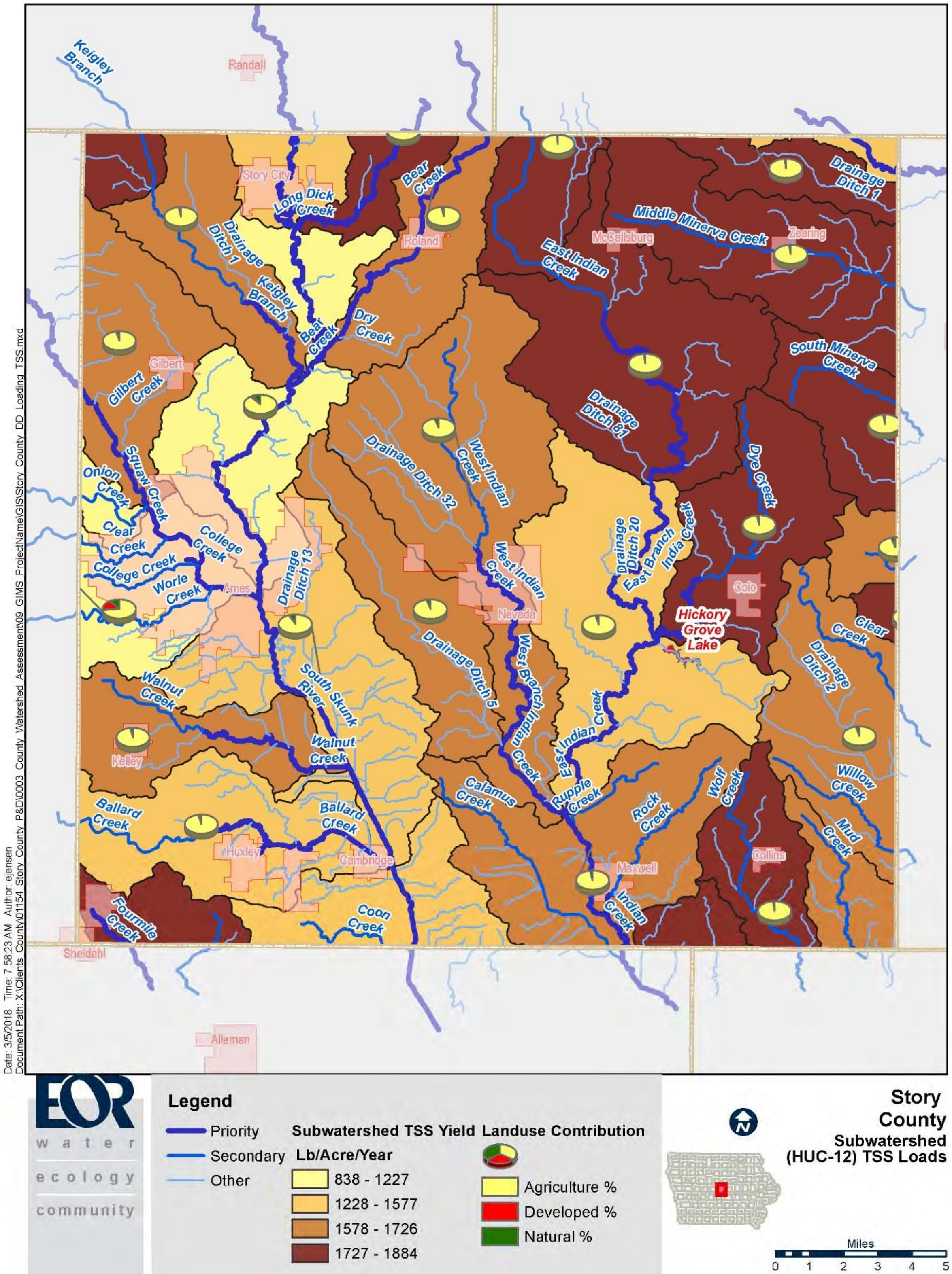


Figure 43. Story County Subwatershed (HUC-12) Total Suspended Solids Yield (Lbs/Acre/Year)

2.8.4. Bacteria

Humans, pets, livestock, and wildlife all contribute bacteria to the environment. These bacteria, after appearing 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 Story County. 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 Story County. This is typically a GIS exercise where population estimates are clipped to the individual subwatershed boundaries.

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 2-5. 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 based on 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 2-5. 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

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 Story County with surface water discharges are summarized in Table 2-6. Bacteria loads from NPDES-permitted WWTFs was estimated based on the design flow and permitted bacteria effluent limit of 126 org/ 100 mL (Table 2-6). According to available information on the DNR website, there are 29 NPDES permits for wastewater treatment, including 13 municipalities, four mobile home parks, one subdivision, and 11 miscellaneous dischargers. All discharges are in the Skunk River basin, with the exception of Zearing, which is located in the Iowa River basin and Slater, located in the Des Moines River basin.

Table 2-6. WWTP design flows and permitted bacteria loads

Subbasin	Name of WWTF	Permit #	Design Flow	Equivalent Bacteria Load as *E. coli*:
			[mgd]	(billion org/day)
Ballard Creek	City of Huxley	8538001	0.634	3.02
	City of Cambridge	8509001	0.271	1.29
Bear Creek	City of Roland	8570001	0.533	2.54
	Iowa Dot Rest Area #20 I35 Story City	8500903	0.004	0.02
City of Ames-South Skunk River	Hickory Grove Court, LLC	8500600	0.007	0.03
	Homestead Colony MHP	8500603	0.010	0.05
	Iowa Dot Rest Area #19 I35 Story City	8500902	0.005	0.02
Drainage Ditch 81-East Indian Creek	City of Mccallsburg	8552001	0.047	0.22
Dye Creek	City of Colo	8520001	0.175	0.83
	Country Living Court, LLC	8500601	0.007	0.03
Lundys Creek-Squaw Creek	City of Gilbert	8531001	0.125	0.60
	South Squaw Valley Association	8500302	0.020	0.10
Middle Minerva Creek	City of Zearing	8590001	0.120	0.57
Miller Creek-South Skunk River	City of Story City	8584001	0.948	4.52
Rock and Calamus Creeks-Indian Creek	City of Maxwell	8557001	0.450	2.15
	Rolling Hills MHP	8500606	0.021	0.10
Upper Fourmile Creek	City of Slater	8580001	0.920	4.39
Walnut Creek	Ames Water Pollution Control Facility	8503001	12.100	57.72
West Indian Creek	Couser Feedlot	8556450	0.000	0.00
	City of Nevada	8562001	2.390	11.40
Wolf Creek	City of Collins	8515001	0.072	0.34
Worle Creek-Squaw Creek	Crestview MHP	8500605	0.006	0.03

Current Compliance Status of Story County's WWTPs

Ames, Nevada, Huxley, and Story City have advanced treatment systems, including trickling filters, activated sludge, and a sequencing batch reactor. The remaining municipalities within Story County depend on lagoons for treatment. Comments regarding the current compliance status for individual facilities in Story County are shown below in Table 2-7. Orange highlights indicate a compliance schedule, and purple highlights indicate an expired permit, with the future permit having the potential for a compliance schedule.

Table 2-7. Compliance Status of Story County's WWTPs

Municipal Facility	Current Compliance Status
Ames	Trickling filter, also serves Kelley, expired permit, awaiting a DNR decision
Cambridge	Aerated lagoons, compliance schedule for ammonia N and E Coli by March 2019
Collins	Lagoons, expired permit awaiting stream designation
Colo	Lagoons, permit in compliance
Gilbert	Lagoons, expired permit awaiting stream designation
Huxley	Activated sludge, permit in compliance
Maxwell	Aerated lagoons, compliance schedule for ammonia N and E Coli by October 2020
McCallsburg	Lagoons, expired permit awaiting stream designation
Nevada	Trickling filter, compliance schedule for E Coli by October 2021
Roland	Aerated lagoons, compliance schedule for ammonia N and E Coli by September 2019
Slater	Aerated lagoons, also serves Sheldahl, compliance schedule for ammonia N, dissolved oxygen and E Coli by March 2019
Story City	Sequence Batch Reactor, permit in compliance
Zearing	Lagoons, permit in compliance

Current Compliance Status of Story County's Subdivision Facilities

There is one subdivision facility in Story County; the South Squaw Valley Subdivision which depends on activated sludge for treatment. The facility has a compliance schedule of March 2022 for ammonia N and *E. coli*.

Current Compliance Status of Story County's Mobile Home Communities

Three of the four mobile home communities within Story County depend on lagoons to provide wastewater treatment. Comments regarding the current compliance status for these facilities are shown below in Table 2-8. Facilities that rely on aerated lagoons for treatment often needed to be updated to provide for extended aeration to meet EPA requirements for ammonia-nitrogen. The fourth site contains a septic tank which discharges to a secondary treatment dual sand filter before discharging to an intermittent stream that drains to the South Skunk River. Orange highlights indicate a compliance schedule, and purple highlights indicate an expired permit, with the future permit having the potential for a compliance schedule.

Table 2-8. Compliance Status of Story County's Mobile Home Communities

Municipal Facility	Current Compliance Status
Country Living Court, Colo	Lagoons, compliance schedule for ammonia N and dissolved oxygen by November 2021
Hickory Grove Court, Ames	Septic tank to dual sand filter, compliance schedule for ammonia N and TRC by April 2019
Homestead Colony MHP	Lagoons, expired permit waiting on stream designation review
Rolling Hills MHP	Lagoons, expired permit waiting on stream designation review

Current Compliance Status of Story County's Miscellaneous Dischargers

The current compliance status for Story County's miscellaneous dischargers including stormwater and industrial facilities are shown below in Table 2-9. Purple highlights indicate an expired permit, with the future permit having the potential for a compliance schedule.

Table 2-9. Compliance Status of Story County's Miscellaneous Dischargers

Municipal Facility	Current Compliance Status
Ames Steam Electric Plant	No treatment, cooling tower, permit current
Ames Stormwater MS4, Ames	No treatment, permit current
Arctic Glacier, Ames	No treatment, cooling tower, permit current
Couser Cattle Company, Nevada	Various treatment, animal confinement, permit current
Dupont Cellulosic Ethanol, Nevada	Out of business

Municipal Facility	Current Compliance Status
Iowa DOT Rest Area, Story City	Lagoon, expired permit
Iowa DOT Rest Area, Story City	Lagoon, expired permit
ISU Stormwater MS4, Ames	No treatment, permit current
ISU Power Plant, Ames	Cooling tower, expired permit, wastewater allocation requested
Lincolnway Energy, Nevada	No treatment, expired permit
US Filter, Ames	Sand filter and plant backwash, expired permit

Based on the purple and orange highlighting, it appears that there is potential improvement for NPDES dischargers in the County. 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 Story County's Onsite Treatment Systems

Story County has approximately 3,300 developed parcels that are dependent on onsite wastewater treatment. Since 1972, when County permitting began, there have been 2,640 permits issued that are still active today. The remaining estimated 20% of the developed rural properties do not have any records of their systems. Experience shows that typically, if there are no records of systems filed with the County, the house wastewater flows to a septic tank, which discharges directly to a tile, ditch or stream. Anecdotally, the septic tanks were seldom, if ever pumped. Since the late 1980's, Story County has had an inspection program for time-of-transfer properties with onsite systems.

In 2009, Iowa passed regulations for a similar inspection program, 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), make it a faulty program. Exemptions include foreclosures, decedent's estates, consanguinity, or tax sales. Many of these exemptions are a subset of properties with inadequate systems.

Most onsite systems in the county have soil based secondary systems. In those situations where the soil is inadequate, the county issues permits for discharging systems such as sand filters, peat filters, coco filters, mechanical and aerated systems. Mechanical and aerated systems require maintenance contracts for the life of the system. Story County Environmental Health has issued a total of 162 permits for discharging systems since 1972; 30 of those were required to obtain an NPDES general permit #4. The requirements for dischargers to obtain an NPDES is site specific, based on water quality impact. The general permit #4 expires in August 2017, although DNR has indicated that the new permits will have the same discharge parameters. Permit duration is five years.

DNR is taking measures to bring the municipalities and other dischargers up to EPA standards. Story County Environmental Health is proactive with stringent design and inspection standards for onsite treatment. Story County has a history of having an aggressive wastewater program compared to other counties, and could be a leader by adopting regulations that require system maintenance.

Bacteria Loading Estimate: Failing Onsite Treatment Systems

Unsewered populations were determined using the 2016 Census data (U.S. Census Bureau 2017). Total unsewered population was obtained for each subwatershed using block groups; census block groups that overlap subwatershed boundaries were distributed between each applicable subwatershed on an area-weighted basis. Only rural populations were assumed to be unsewered. So, block groups that fell within the city limits of Ames, Cambridge, Colo, Gilbert, Huxley, Kelley, Maxwell, Nevada, Roland, Story City, and Zearing were not included. It was assumed that onsite treatment systems (OTS) were installed to treat raw sewage from this rural population. “Failing” OTS are specifically defined as systems that are failing to protect groundwater from contamination. Failing OTS were not considered a source of fecal pollution to surface water. However, systems which discharge partially treated sewage to the ground surface, road ditches, tile lines, and directly into streams, rivers and lakes are considered an imminent threat to public health and safety (ITPHS). ITPHS systems also include illicit discharges from unsewered communities (sometimes called “straight-pipes”). Straight pipes are illegal and pose an imminent threat to public health as they convey raw sewage from homes and businesses directly to surface water. Community straight pipes are more commonly found in small rural communities. The number and specific location of ITPHS are unknown for Story County so two thresholds were used so that the relative contribution from ITPHS to the total load of bacteria in the watershed could be determined (Table 2-10). This table is not intended to suggest that ITPHS systems contribute excess bacteria to Story County’s streams.

Table 2-10. Estimates of rural population based on 2010 Census data and ITPHS population in each subwatershed

Subwatershed - HUC 12	Estimated Rural Population	ITPHS Load 10% Failure Rate (billion org/day)	ITPHS Load 50% Failure Rate (billion org/day)
Ballard Creek	1585	199.7	998.5
Bear Creek	3175	400.0	2000.1
Dye Creek	617	77.7	388.4
Long Dick Creek	3510	442.2	2211.2

Subwatershed - HUC 12	Estimated Rural Population	ITPHS Load 10% Failure Rate (billion org/day)	ITPHS Load 50% Failure Rate (billion org/day)
Lundys Creek-Squaw Creek	1539	194.0	969.8
Miller Creek-South Skunk River	909	114.6	572.9
Mud Creek-Clear Creek	1363	171.8	858.9
South Minerva Creek	720	90.8	453.8
Walnut Creek	9066	1142.3	5711.6
West Indian Creek	6973	878.6	4392.9
Worle Creek-Squaw Creek	4434	558.7	2793.5

Livestock

The total number of livestock in each subwatershed was estimated by the Iowa DNR animal feeding operation (AFO) database. 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 25,290 cattle, 77,182 swine, and 3,418 poultry (chickens and turkeys) within Story County. 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 2-11. Livestock summary results by subwatershed in animal units

Subwatershed	Registered			Estimated Unregistered		
	Pigs (billion org/day)	Cows (billion org/day)	Poultry (billion org/day)	Cows (billion org/day)	Pigs (billion org/day)	Poultry (billion org/day)
Ballard Creek	8,567.5	0.0	0.0	2,161.3	10,506.6	3.6
Bear Creek	7,401.2	59,850.0	0.0	1,447.6	7,037.2	2.4
City of Ames-South Skunk River	1,289.6	12,395.3	2.2	2,459.5	11,956.0	4.1
Drainage Ditch 13-South Skunk River	0.0	239.0	0.0	2,841.9	13,814.7	4.8
Drainage Ditch 81-East Indian Creek	20,723.5	0.0	0.0	3,320.5	16,141.6	5.6
Dye Creek	0.0	0.0	0.0	1,988.2	9,664.7	3.3
East Indian Creek	6,582.6	0.0	0.0	3,321.8	16,147.6	5.6
Hardin Story Drainage Ditch No 1	8,287.1	0.0	0.0	765.9	3,723.0	1.3
Headwaters Clear Creek	4,014.6	5,231.5	0.0	2,042.2	9,927.3	3.4
Headwaters East Indian Creek	4,485.6	0.0	0.0	897.2	4,361.2	1.5
Headwaters Minerva Creek	16,148.2	0.0	0.0	170.4	828.5	0.3
Keigley Branch	19,063.8	0.0	41.2	1,495.6	7,270.2	2.5
Long Dick Creek	4,485.6	0.0	88.0	587.3	2,855.0	1.0
Middle Minerva Creek	35,811.9	0.0	0.0	2,483.7	12,073.7	4.2

Subwatershed	Registered			Estimated Unregistered		
	Pigs (billion org/day)	Cows (billion org/day)	Poultry (billion org/day)	Cows (billion org/day)	Pigs (billion org/day)	Poultry (billion org/day)
Miller Creek-South Skunk River	403.7	0.0	87.2	642.1	3,121.3	1.1
Mud Creek-Clear Creek	10,630.9	0.0	0.0	658.9	3,202.9	1.1
Rock and Calamus Creeks-Indian Creek	13,905.4	239.4	0.0	2,756.1	13,398.0	4.6
South Minerva Creek	22,786.8	0.0	0.0	1,018.5	4,950.9	1.7
Upper Fourmile Creek	196.2	0.0	0.0	658.7	3,202.0	1.1
West Indian Creek	20,213.2	60,612.3	0.0	3,953.6	19,219.1	6.6
Wolf Creek	560.7	0.0	0.0	1,042.2	5,066.3	1.7
Worle Creek-Squaw Creek	4,373.5	0.0	0.0	1,464.6	7,119.5	2.5


Cattle in Gilbert Creek

2.9. Existing Conservation Practices

Iowa DNR conducted a survey of agricultural conservation practice statewide. The inventory includes;

- Grassed Waterways
- Contour Buffer Strips
- Terraces
- Water and Sediment Control Basins (WASCOBs)
- Farm Pond Dams

The existing agricultural conservation practices in Story County are shown in Figure 44.

Bear Creek Demonstration Watershed Sign

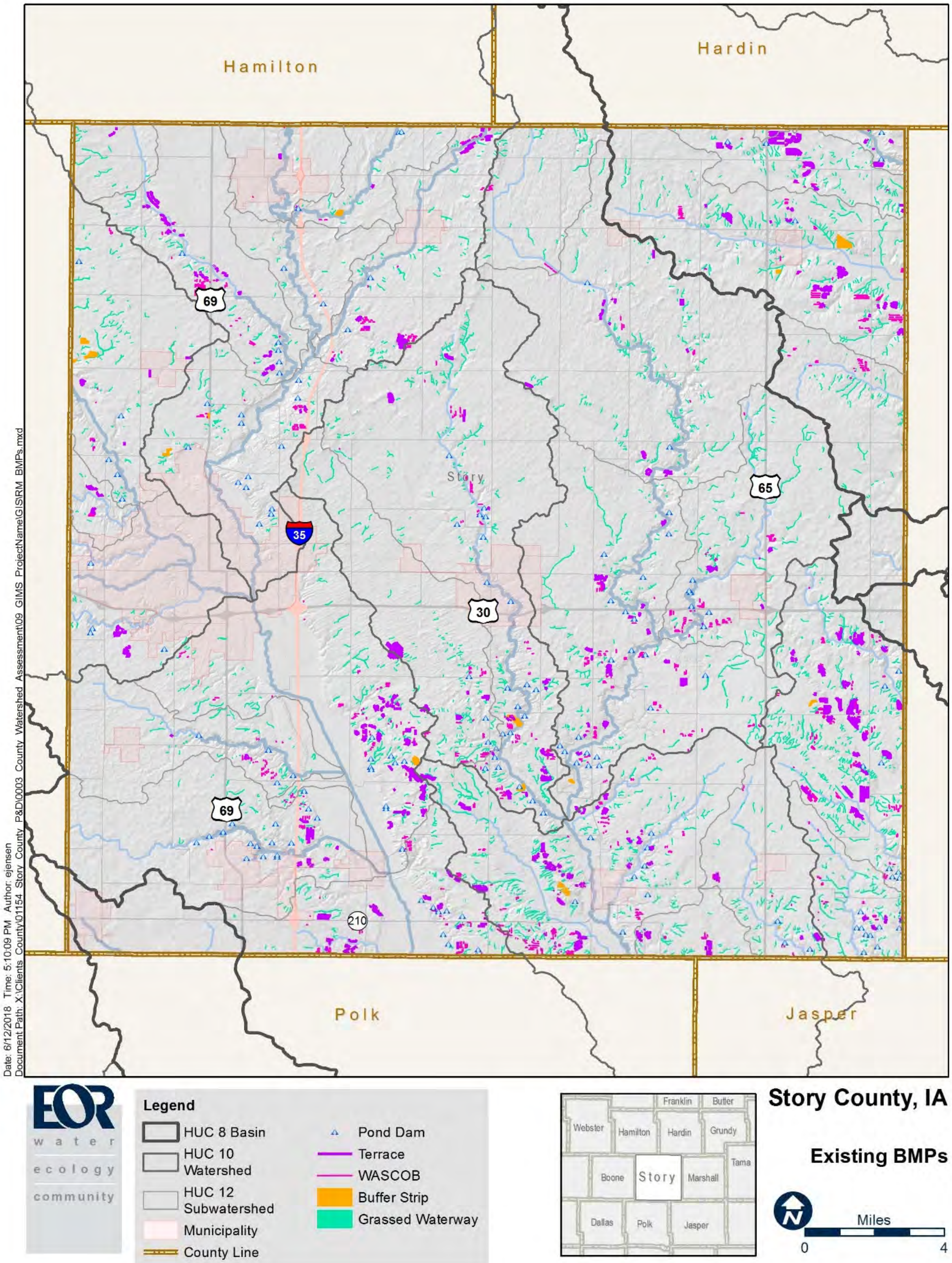


Figure 44. Existing Conservation Practices/BMPs in Story County

3. HUC-12 Subwatershed Prioritization

Using the findings of the watershed assessment, the HUC-12 Subwatersheds were prioritized based on several factors as summarized in the matrix shown in Table 3-1. The primary factor used was the presence of a priority stream with South Skunk River given the highest priority followed by East and West Indian Creeks. Subwatersheds containing or directly tributary to the South Skunk River were classified as highest priority with the exception of subwatersheds that have a small portion within Story County. The East and West Indian Creek Subwatersheds were also classified as highest priority due to the importance of these resources and the fact that the subwatersheds are wholly contained within Story County. Medium priority was given to subwatersheds that contained one of the remaining priority streams and also had a significant portion within the county. The lowest priority subwatersheds were selected either for a lack of priority streams or for having a very small portion within Story County. (Figure 45).

Stormwater Runoff in McCallsburg

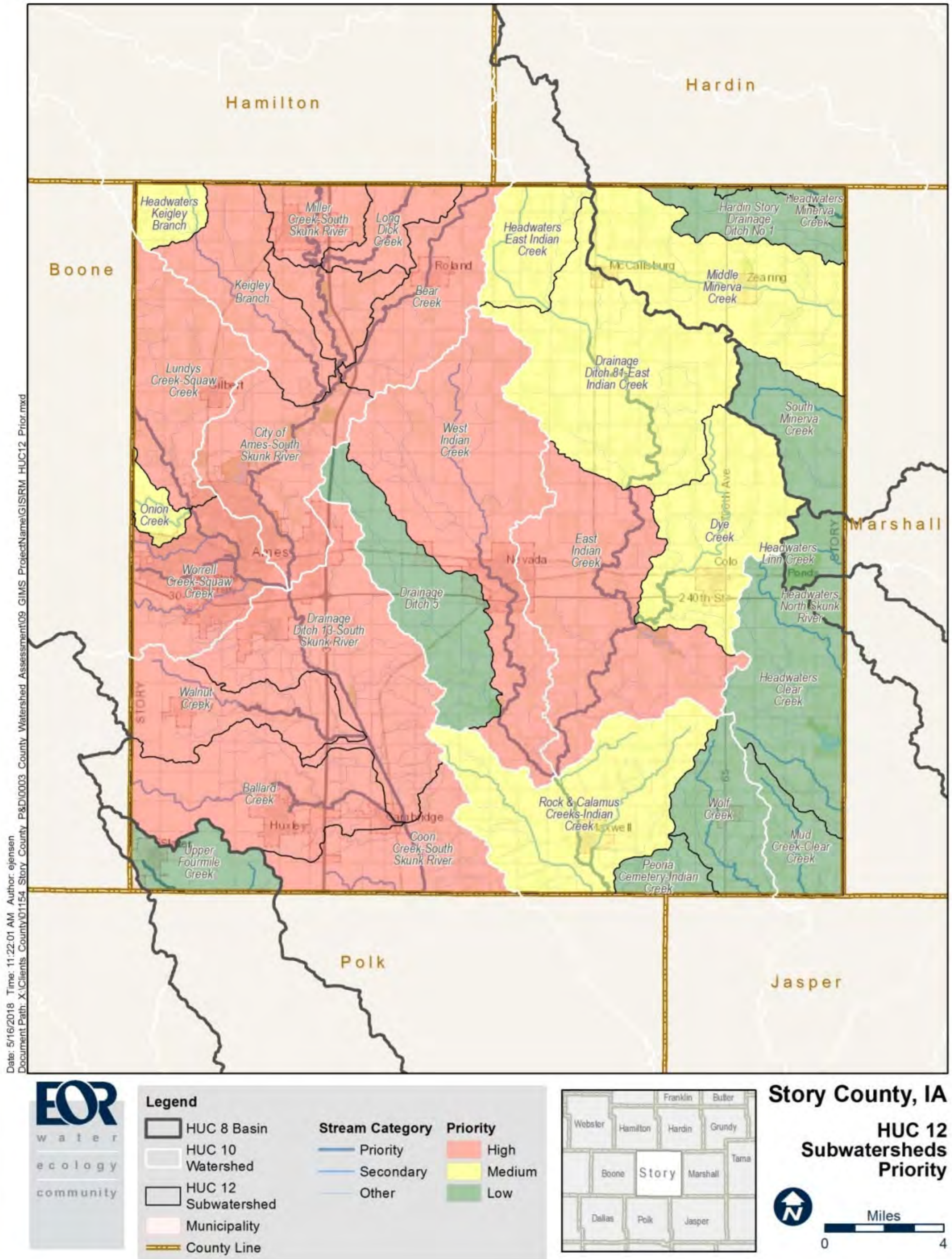


Figure 45. HUC-12 Subwatersheds by Priority

Table 3-1 HUC-12 Subwatershed Prioritization Matrix

HUC-10 Watershed	HUC-12 Subwatershed	Subwatershed Priority	Priority Streams (Impaired in Bold)	Secondary Streams	Other Streams	Lakes (Impaired in Bold)	Wetland (acres)	Bio. Sign. Natural Areas (acres)	TP Loading Rating	TN Loading Rating	TSS Loading Rating	Bacteria Loading Rating
Squaw Creek	Lundys Creek-Squaw Creek	High	Squaw Creek	NA	Gilbert Creek 6 Unnamed Creeks/Ditches,		63	341	Medium	Medium	Medium	Low
	Worle Creek-Squaw Creek	High	College Creek, Squaw Creek, Unnamed Creek Worle 1, Unnamed Creek Worle 2	Clear Creek, Onion Creek, Worle Creek	4 Unnamed Creeks/Ditches		80	289	Medium	Low	Low	Medium
Keigley Branch South Skunk	Long Dick Creek	High	**Long Dick Creek**	NA	1 Unnamed Creek/Ditch		3		Medium	Medium	Medium	Medium
	Miller Creek-South Skunk River	High	**South Skunk River**	NA	2 Unnamed Creeks/Ditches		90		Medium	Medium	Medium	Medium
	Bear Creek	High	Bear Creek	NA	Dry Creek, 1 Unnamed Creek/Ditch		8	36	Medium	Medium	Medium	High
	Keigley Branch	High	Keigley Branch, Lower Reach	Keigley Branch, Upper Reach	Drainage Ditch 1		33	73	Medium	Medium	Medium	High
	City of Ames-South Skunk River	High	**South Skunk River**	NA	9 Unnamed Creeks/Ditches	Ada Hayden Peterson Park Lakes, McFarland Pond	363	866	Low	Low	Low	Medium
West Indian Creek	West Indian Creek	High	West Indian Creek, Lower Reach	West Indian Creek, Upper Reach	Drainage Ditch 5, Drainage Ditch 32, 6 Unnamed Creeks/Ditches		224	684	Medium	Medium	Medium	High
East Indian Creek	East Indian Creek	High	East Indian Creek	NA	Drainage Ditch 20, 7 Unnamed Creeks/Ditches	**Hickory Grove Lake**	318	891	Low	Medium	Medium	Medium
Sugar Creek South Skunk	Walnut Creek	High	**Walnut Creek, Lower Reach**	Walnut Creek, Upper Reach	6 Unnamed Creeks/Ditches		45	42	Medium	Medium	Medium	Low
	Ballard Creek	High	**Ballard Creek, Lower Reach**	Ballard Creek, Upper Reach	10 Unnamed Creeks/Ditches		105	141	Medium	Medium	Medium	Medium
	Drainage Ditch 13-South Skunk River	High	**South Skunk River**	NA	Drainage Ditch 13, 20 Unnamed Creeks/Ditches		474	170	Low	Medium	Medium	Medium
	Coon Creek-South Skunk River	High	**South Skunk River**	Coon Creek	11 Unnamed Creeks/Ditches		152	37	Low	Medium	Medium	Low
Squaw Creek	Onion Creek	Medium	NA	Onion Creek	NA		3	330	Low	Low	Low	Low
Keigley Branch South Skunk	Headwaters Keigley Branch	Medium	NA	Keigley Branch	2 Unnamed Creeks/Ditches		35		Medium	High	High	Low
East Indian Creek	Headwaters East Indian Creek	Medium	NA	East Indian Creek	3 Unnamed Creeks/Ditches				High	High	High	Medium
	Drainage Ditch 81-East Indian Creek	Medium	East Indian Creek, Lower Reach	East Indian Creek, Upper Reach	Drainage Ditch 36, Drainage Ditch 81, 4 Unnamed Creeks/Ditches		5	558	High	High	High	Medium
	Dye Creek	Medium	Dye Creek, Lower Reach	Dye Creek, Upper Reach	3 Unnamed Creeks/Ditches		30		Medium	Medium	Medium	Medium

HUC-10 Watershed	HUC-12 Subwatershed	Subwatershed Priority	Priority Streams (Impaired in Bold)	Secondary Streams	Other Streams	Lakes (Impaired in Bold)	Wetland (acres)	Bio. Sign. Natural Areas (acres)	TP Loading Rating	TN Loading Rating	TSS Loading Rating	Bacteria Loading Rating
Indian Creek	Rock and Calamus Creeks-Indian Creek	Medium	**Indian Creek**	Rock Creek, Rupple Creek, Calamus Creek	15 Unnamed Creeks/Ditches		288		Medium	Medium	Medium	Medium
Minerva Creek	Middle Minerva Creek	Medium	NA	Middle Minerva Creek	11 Unnamed Creeks/Ditches		15	31	High	High	High	High
East Indian Creek	Drainage Ditch 5	Low	NA	NA	Drainage Ditch 5, 3 Unnamed Creeks/Ditches		21	28	Medium	Medium	Medium	Low
Clear Creek	Headwaters Clear Creek	Low	NA	Clear Creek	Drainage Ditch 2,	Hendrickson Marsh	144	111	Medium	Medium	Medium	Medium
	Mud Creek-Clear Creek	Low		Mud Creek	7 Unnamed Creeks/Ditches		15	61	Medium	Medium	Medium	High
Indian Creek	Wolf Creek	Low	NA	Wolf Creek	5 Unnamed Creeks/Ditches		9		High	High	High	Medium
	Peoria Cemetery-Indian Creek	Low	NA	NA	3 Unnamed Creeks/Ditches		16		Medium	Medium	Medium	Low
Headwaters North Skunk	Headwaters North Skunk River	Low	NA	NA	NA				Medium	Medium	Medium	Low
Minerva Creek	Hardin Story Drainage Ditch No 1	Low	NA		Drainage Ditch 1				High	High	High	High
	South Minerva Creek	Low		Soth Minerva Creek	2 Unnamed Creeks/Ditches				High	High	High	High
	Headwaters Minerva Creek	Low	Minerva Creek	NA	NA	Dakins Lake	10		Low	Medium	Medium	High
Linn Creek	Headwaters Linn Creek	Low	NA	Linn Creek	NA		117		Medium	Medium	Medium	Low
Big Creek	Headwaters Big Creek	Low	NA	NA	NA				High	High	High	Low
Fourmile Creek	Upper Fourmile Creek	Low	Fourmile Creek	Alleman Creek	1 Unnamed Creek/Ditch		17	14	High	Medium	Medium	Medium

4. Recommendations

4.1. Resource Protection

Areas recommended to be protected within Story County include public waterbodies, large tracts of natural land cover (forest, prairies), high quality native plant communities, and intact riparian buffers. Areas recommended to be protected are summarized by resource type, number of resources present in Story County, priority classification, and designated use (value) in Table 3-1. Priority protection areas within Story County are published in an interactive map found on the watershed management page of the Story County website (www.storycountyiowa.gov).

4.1.1. Stream Riparian Buffers

We strongly recommend that riparian buffer areas be established along the streams of Story County. The existing conditions of the stream riparian areas are shown in Section 1.4.1 and recommendations for improving the riparian areas are described in Section 4.2.3.

The County should work with private landowners to encourage establishment of naturally vegetated riparian buffers zones along Story County streams. This would be accomplished through preserving existing naturally vegetated riparian areas and restoration of degraded areas.

The following are recommended riparian area widths (measured from edge of stream) based on the category of stream as described in Section 1.4 and summarized in Table 1-4. Buffer widths were selected based on review of literature on the effectiveness of buffers in performing various functions (sediment trapping, nutrient removal, wildlife habitat, etc,) as well as a cursory review of the existing buffer widths seen in the County.

- Priority Streams – 75 feet
- Secondary Streams – 50 feet
- Other Streams – 25 feet

4.1.2. Wetland Areas

Wetlands provide downstream water quality protection, flood/storm water attenuation, and habitat for fish and wildlife. We recommend that the County work to achieve no net-loss in wetland acreage, function, or value and to maintain high quality land uses in riparian areas adjacent to wetlands when they are currently in existence.

4.1.3. Source Water Protection Areas

Any community (regardless of susceptibility to groundwater contamination) can choose to develop a Source Water Protection Plan, these plans are sometimes referred to as Phase 2 plans. Phase 2 plans usually entail monitoring/managing the land within the defined groundwater capture zone to improve natural water quality. The Conservation Districts of Iowa and the Iowa Rural Water Association provide experienced source water consultation and assistance for developing the SWP Plan, at no charge to the public water supply. The Iowa Association of Municipal Utilities may also provide assistance with certain aspects of the SWP Plan. A successful plan can reduce the necessary treatment by municipal water suppliers, and decrease the risk of a large contaminant spill affecting drinking water supplies. Currently, 7 of the 10 communities with municipal wells in Story County have prepared Phase 2 documents. Ames and Nevada are the only two highly susceptible communities without a Phase 2 plan.

4.2. Resource Restoration Opportunities

Restoration strategies are those that seek to restore or improve the quality of a resource which is currently not meeting a designated standard (*i.e.,* water quality standard) and has been identified as being impaired. Select restoration layers were published to an interactive map found on the watershed management page of the Story County website (www.storycountyiowa.gov). Areas to be prioritized for restoration strategies within Story County include impaired waterbodies, degraded (farmed, partially drained, ditched) wetlands, restorable natural plant communities, gullies and ravines, and steeply slope, unstable stream banks. Critical restoration areas and resources identified as needing restoration within Story County are summarized by resource type, number of resources present in Story County, priority classification, and designated use (value) requiring restoration in Table 4-1.

Table 4-1. Story County Priority Resources Requiring Restoration

Resource Description	Resources Present in Story County	Designated use (Value) Requiring Restoration
Impaired Streams	**7 Stream Reaches** - South Skunk River (3 Reaches) - Ballard Creek - Indian Creek - Long Dick Creek - Walnut Creek	Recreational uses described in Section 1.8
Impaired Lakes	1 – Hickory Grove Lake	Recreational uses described in Section 1.9
Modified wetlands in watersheds w/ impaired waters, AND greater than 5 acres OR HSG = C,D soils	32	Altered Wetland Hydrology Flood/ Stormwater Attenuation Downstream Water Quality Fish and Wildlife Habitat
Other Modified Wetlands	875 acres	
Potential Environmentally Sensitive Areas	495	Landscapes identified in the Environmentally Sensitive Areas Survey that have may have opportunity for restoration.
High Stream Power Index and >35% Slope Adjacent to Stream Channel	647	Active erosion problems (e.g., gullies, ravines) on the landscape that may be contributing to stream impairments
Critical Stream Bank Height and > 35% Slope	147*	Unstable banks that may be contributing to stream impairments

* The 147 sites represent the highest priority near channel locations with critical stream bank heights, high stream power index, and slopes exceeding 35%.

A GIS based analysis of the county was performed to help prioritize locations within the county for field inventory to identify ecologically sensitive areas i.e. where restoration strategies are potentially most critical. Terrain analysis techniques that combine existing land use information with elevation data and known natural resources were used to approximate the most critical areas in need of field assessment. These sites are referred to as Potential Ecologically Sensitive Areas on the on-line mapping tool. A field assessment of natural areas identified by SCC and Scott Zager of Wildlands Ecological Services is being performed to identify ecologically sensitive areas that are good candidates for restoration activities.

In summary, critical restoration sites include locations that are believed to either contribute a disproportionate amount of contaminants such as sediments, nutrients and pesticides or plant communities that are viable candidates for restoration.

4.2.1. Impaired Lakes and Streams

The primary objective in future watershed management activities in Story County should be that all its resources (lakes and streams) meet their designated uses as discussed in Section 1.3. The recommendations contained throughout this section are made in an effort to reduce bacteria and nutrient loading to the lakes and streams of the county.

4.2.2. Restorable Wetlands

Numerous historic wetland resources within the County have been ditched, drained, or otherwise altered in an effort to increase agricultural production land and for urban development. These areas represent opportunities for wetland restoration but due to their prevalence they were prioritized based on size, likelihood for a successful restoration and potential benefit.

To identify the County's most critical restoration sites the National Wetlands Inventory (NWI) layer was used to identify all modified (drained, ditched, or farmed) wetlands in Story County that were located in watersheds that contain impaired water resources and are larger than 5 acres or on Hydrologic Soil Group C or D soils. There are a total of 32 wetlands within Story County that meet these criteria. These restorable wetlands represent high priority targets for implementation of restoration measures. Restoring these drained/farmed wetlands to pre-drainage hydrology through implementing ditch checks, drain tile breaks, or ditch plugs can be a relatively cost effective way to achieve wetland mitigation credits. Altered wetlands and the priority wetland restoration sites are depicted in an interactive map found on the watershed management page of the Story County website (www.storycountyiowa.gov).

4.2.3. Stream Riparian Buffers

Riparian areas along streams provide water quality, flood storage and habitat benefits when they are in a healthy, naturally vegetated state. The existing condition of the stream riparian areas in Story County is presented in section 1.4.1. As part of this evaluation, areas where riparian restoration /buffers could be accomplished were identified. The evaluation of restorable riparian areas began with a reclassification of the Iowa DNR's High Resolution (1 square meter) Land Cover dataset to identify riparian areas planted in row crops. The dataset was derived from three dates of aerial imagery, and from elevation information derived from LiDAR elevation data. It has a spatial resolution of one meter, and a class resolution of 15 land cover classes. This layer was clipped to the boundaries of the recommended stream buffer zone, as described in Section 4.1, to identify riparian areas that are currently planted in cropland (corn/soybeans). This type of spatial information can be used to quickly visualize where implementing riparian buffers are most needed.

Various alternatives exist for restoring riparian areas based on the specific function the area serves. The Agricultural Conservation Practice Framework (ACPF) tools were used to determine which of the following functions each riparian area serves. In some case the riparian area restoration is designed to trap sediment and phosphorus laden surface runoff, which is important but not uniformly opportune along streams. In other cases the restoration is designed where vegetation roots can interact with the water table, carbon cycling and denitrification may be enhanced. In areas where the water table depth and overland runoff is high, stiff-stemmed grasses may be beneficial to intercept and reduce runoff and sediment from reaching the stream. Where appreciable amounts of neither runoff nor groundwater can be intercepted, benefits such as stream bank stabilization may be possible (Tomer et al. 2013).

The recommended techniques for restoring riparian buffers as determined through the ACPF analysis is difficult to map at the County scale so the areas are only included in the interactive map found on the watershed management page of the Story County website (www.storycountyiowa.gov).

4.2.4. Potentially Environmentally Sensitive Areas

All of Story County has been assessed for it's potential for containing environmentally sensitive natural resources. Figure 32 identifies land with that potential. Field assessments are now being conducted to determine if those potential areas are in fact sensitive areas. The purpose of this inventory is to identify the sensitive natural resources areas in the county and assist landowners with restoration opportunities.

The potentially environmentally sensitive areas are included in the interactive map found on the watershed management page of the Story County website (www.storycountyiowa.gov).

4.2.5. Eroded Streambanks

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 past 30 years contributing to sediment loading from streambanks. The sediment that is eroded contributes to water quality degradation and in-stream aquatic life.

LiDAR data was used to evaluate stream bank stability within Story County by combining Stream Power Index (SPI) with steeply sloped (>18%) near channel areas that were larger than 1 acre in size. 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. Results from this analysis identified 697 locations along almost every stream in Story County.

With the goal of identifying the highest priority sites in Story County, this analysis was refined to identify those locations that were greater than 35% slope, within 100’ of a road crossing or 500’ of a manmade structure, and intersected areas with high stream banks. High stream banks were identified using the University of Nevada’s Height above River (HAR) tool which uses LiDAR data to calculate the difference in height between the stream channel and the adjacent stream bank. The intersection of these layers identified 144 high priority sites (Figure 46). The large number of sites is a reflection of the “flashy” nature of Story County’s streams which tend to respond very quickly and dramatically to storm events especially during the periods of the year when row crops are not fully established. In flashy streams, periodic increases in flow depth and velocity result in an increase in the amount of force produced by flowing water against the streambank which can remove soil particles from the banks, and in some cases lead to bank failure, slumping, and overall bank instability. The NRCS GIS Engineering Toolbox for Arc GIS was used to identify critical slopes through calculation of stream power index (SPI). The stream power index (SPI) calculation measures the erosive power of overland flow as a function of local slope and upstream drainage area. High SPI values located in areas with slopes >35% are typically correlated with near-channel, active erosion problems (e.g., gullies, ravines) on the landscape. A Height Above River (HAR) layer was also created using a HAR *GIS Tool* developed by researchers at the University of Nevada. This tool uses LiDAR data to measure the difference in elevation between the stream channel and near stream areas. The published Restoration Layer identified near stream areas (within 175’ of stream centerline) with critical bank heights (> 30 feet) that intercepted areas with greater than 35% slope, and were also within 100 feet of any manmade structure or 500 feet of a road.

In addition to identification of priority streambank erosion sites using the analysis described above, the ACPF tool evaluates the stream riparian area to determine likely erosion areas. These areas are displayed in the Story County ACPF Web Map as ‘critical zone’ riparian areas.

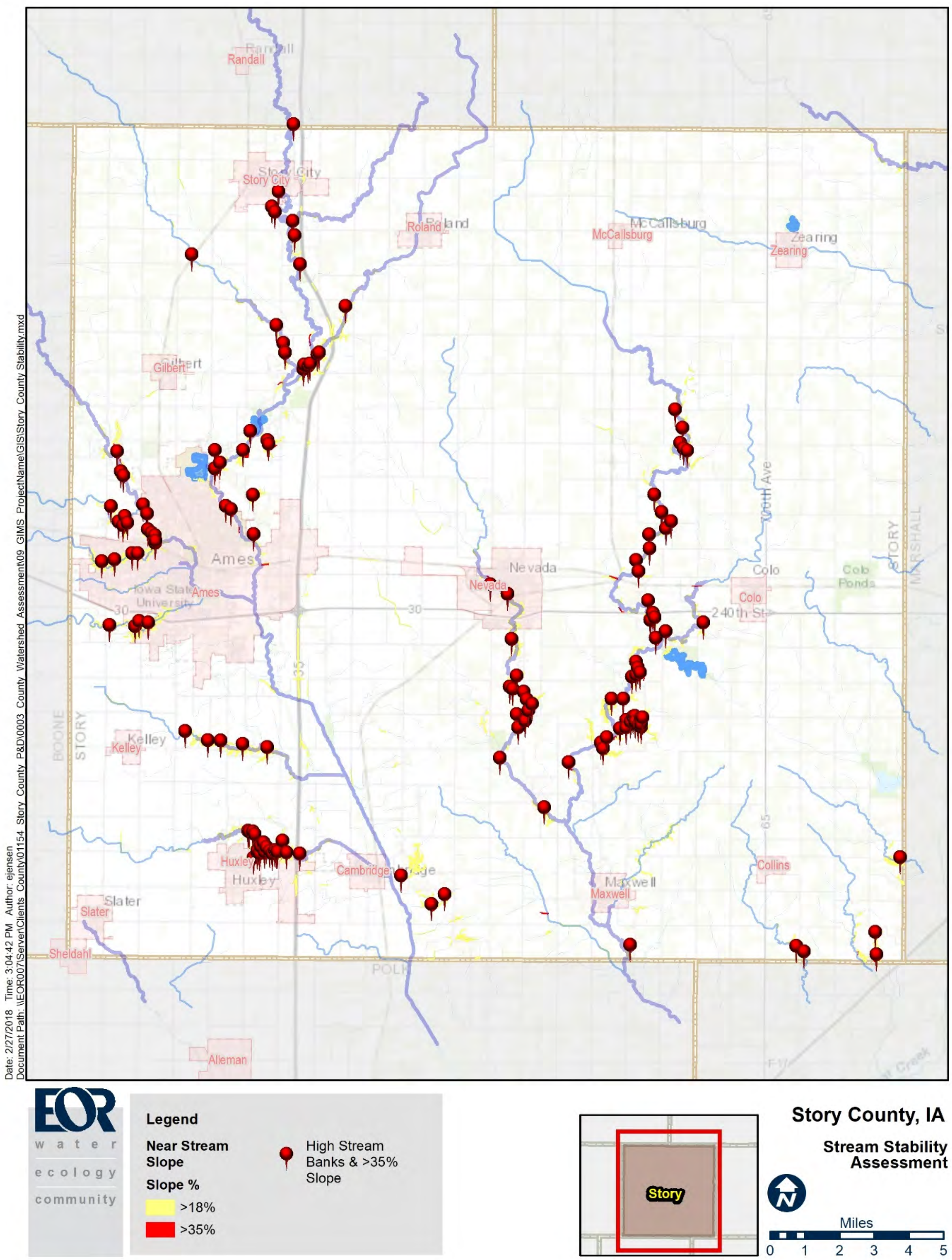
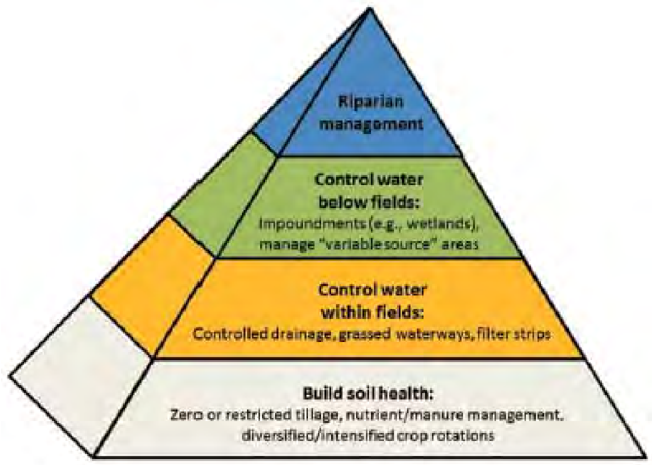


Figure 46. Priority Eroded Streambank Sites

4.3. Recommended Approaches for Agricultural Runoff



The Agricultural Conservation Planning Framework (ACPF) Version 2.2 was run for the HUC-12s within Story County not previous studied through past management plans. HUC-12 subwatersheds with a minimal footprint within Story County were not evaluated. The ACPF is a GIS-based tool developed by the Agricultural Research Service (USDA-ARS) that analyzes "soils, land use, and high-resolution topographic data to identify a broad range of opportunities to install conservation practices in fields and in watersheds".[i] The ACPF tools identify suitable locations for terrain-dependent conservation practices.

The follow agricultural conservation practices were sited across the County:

- Grassed Waterways
- Contour Buffer Strips
- Nutrient Removal Wetlands
- Edge-of-Field Bioreactors
- Water and Sediment Control Basins (WASCOB)
- Drainage Water Management
- Drainage Water Recycle
- Saturated Riparian Buffers

The results of the ACPF analysis are not suitable for printing in a report so a web-based mapping application was developed. The mapping tool can be viewed on an interactive map which can be found on the watershed management page of the Story County website (www.storycountyiowa.gov).

Additionally, the ACPF is useful for identifying both the fields that are most likely to contribute runoff to a stream, and the most appropriate vegetation type for riparian buffers – all based on their positions in the landscape. The outputs of the tool are stored in a file geodatabase, and useful attributes such as drainage area and footprint area are calculated and included.

Figure 47: Conservation practices in a watershed, conceptualized as a pyramid (Figure 1 from Tomer et al. 2013)

4.3.1. Soil Health Practices

Cover Crops: Cover crops is a term to describe any crop grown primarily for the benefit of the soil rather than the crop yield. 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 among various other 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. Due to 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 convert 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 early spring 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 take up more of the N.

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. To learn more, visit www.4RPlus.org.

4.3.2. In-field Management Practices

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. They alternate down the slope of a field with wider cropped strips. Established contour buffer strips can significantly reduce sheet and rill erosion. Strips 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 field with flat topography, typically one percent or less slope.

Drainage Water Recycling: Drainage water recycling (also commonly referred to as a Closed-Loop System), diverts surface and subsurface drainage water into on--farm ponds or reservoirs, where it is stored until it can be used by the crop later in the season. Tile drainage occurs mostly in the spring, while crop water use in mid- to late summer may result in periods when insufficient water is available. Drained water stored in the spring can provide value to crops in the summer. Drainage water recycling can be a closed loop system where the drained water from a field is recirculated onto the same field, or water drained from one field can be used to irrigate a different field. Irrigation may be through subirrigation that raises the soil water table by flooding the subsurface drain tiles (above), or sprinkler systems such as a center pivot, or other technologies.

Grassed Waterways: These are constructed channels that are seeded to grass and 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 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 (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. It is important to note that grassed waterways also 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, 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.

4.3.3. Edge of Field Practices

Denitrifying bioreactors: Denitrifying bioreactors are trenches in the ground packed with carbonaceous material such as wood chips that allow colonization of soil bacteria that convert nitrate in drainage water to nitrogen gas. Installed at the outlet of tile drainage systems, bioreactors usually treat 40-60 acres of farmland.

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 flood water retention (Crumpton et al., 2006).

Figure 48 – Nutrient Removal Wetlands like this one on Tim Minton's farm are larger, strategically placed wetlands being restored in the tile-drained region of North Central Iowa. Image courtesy of Clean Water Iowa

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, 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 filed. 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 (Minnesota Department of Agriculture).

Figure 49 Image of a typical WASCOB. Image courtesy of MN Natural Resource Conservation Service

4.3.4. Riparian Area Management

Saturated Buffers: Saturated buffers are a vegetated area, typically a riparian area along a stream or ditch where draintile water is dispersed in a manner that maximizes its contact with the soils and vegetation of the area. Draintile lines that typically discharge directly to the ditch or stream are intercepted and routed into a new draintile pipe that runs parallel to the ditch or stream. This allows drain water to exfiltrate and saturate the buffer area. The contact with soil and vegetation results in denitrification.

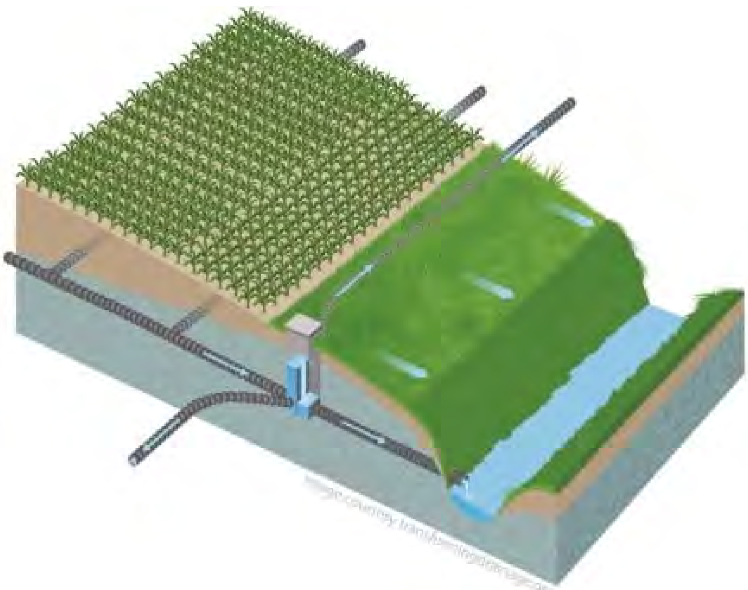


Figure 50 – Schematic of how a Saturated Buffer diverts flow into a buffer that absorbs nutrients before they can enter streams. Image courtesy for transformingdrainage.org

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

4.3.5. ACPF Analysis

The ACPF tools were run for each HUC-12 subwatershed and processed using a custom set of scripts written in the R programming language. Essentially, these scripts aggregated the individual BMP features and created a summary for each HUC-12 containing the total number of BMPs of each type, as well as total footprint and drainage areas.

Then, a spreadsheet tool was developed in Microsoft Excel that uses the BMP summaries to apply pollutant loading values to the drainage areas, along with pollutant reduction values that are unique to each BMP. The pollutant reduction estimates were derived from a combination of sources, but were primarily taken from the Iowa Nutrient Reduction Strategy (see Table 4-2). Existing BMP adoption rates were estimated using a combination of sources, including feedback for specific watersheds from the Black Hawk SWCD and the Iowa Soybean Association, as well as using the results from the Iowa BMP Mapping Project. After subtracting off the existing pollutant reductions using estimates for the existing adoption rate of each BMP, the Excel tool provides an overall estimate for each HUC-12 of the expected maximum nitrogen and phosphorus reduction potential assuming a 100% implementation rate of the individual BMPs. The results of this analysis are shown below in Table 4-3.

A specific conservation scenario was developed for each of the HUC-12 subwatersheds in Story County with the goal of reaching the Iowa Nutrient Reduction Strategy targets for Nitrogen and Phosphorus reductions on a countywide basis. The target adoption rates for each conservation practice is included in the subwatershed-specific management recommendations section.

Table 4-2: Individual BMP pollutant reduction assumptions.

BMP Type	BMP Name	Pollutant Reduction (%) N	Pollutant Reduction (%) P	Average Existing Adoption Rate (% of Eligible Area)
Soil Health Management	Cover crops	31%	0%	0%
	Extended rotations	42%	0%	1%
	Nitrogen management: nitrification inhibitor	9%	0%	0%
	Nitrogen management: rate control	10%	0%	0%
	Nitrogen management: source control	4%	0%	1%
	Nitrogen management: timing control	6%	0%	43%
	Phosphorus management: placement control	0%	30%	50%
	Phosphorus management: rate control	0%	17%	10%
	Phosphorus management: source control	0%	46%	20%
In-Field Management	Contour buffer strips	0%	77%	50%
	Drainage water management	33%	0%	20%
	Grassed waterways	0%	58%	0%
	No-Till	0%	90%	1%
Edge-of-Field Management	Denitrifying bioreactors	43%	0%	50%
	Nutrient removal wetlands	52%	0%	50%
	Perennial cover	85%	75%	50%
	WASCOBs	0%	85%	71%
Riparian Management	Riparian buffer: Critical zone buffer	91%	58%	69%
	Riparian buffer: Deep-rooted vegetation buffer	91%	58%	68%
	Riparian buffer: Multi-species buffer	91%	58%	73%
	Riparian buffer: Stiff stem grass buffer	0%	58%	75%
	Riparian buffer: Stream stabilization buffer	0%	58%	0%
	Saturated buffers	50%	0%	75%

Table 4-3: Potential area treatable by each BMP type remaining after accounting for estimated existing adoption rates. Quantities shown as percentages represent the % of total drainage area.

			Soil Health Management									In-Field Management				Edge-of-Field Management				Riparian Management					
Watershed Name	HUC12	Area (acres)	Cover crops (%)	Extended rotations (%)	Nitrogen management: nitrification inhibitor (%)	Nitrogen management: rate control (%)	Nitrogen management: source control (%)	Nitrogen management: timing control (%)	Phosphorus management: placement control (%)	Phosphorus management: rate control (%)	Phosphorus management: source control (%)	Contour buffer strips (miles)	Drainage water management (fields)	Grassed waterways (miles)	No-Till (%)	Denitrifying bioreactors (#)	Nutrient removal wetlands (#)	Perennial cover (%)	WASCOBs (#)	Riparian buffer: Critical zone buffer (miles)	Riparian buffer: Deep-rooted vegetation buffer (miles)	Riparian buffer: Multi-species buffer (miles)	Riparian buffer: Stiff stem grass buffer (miles)	Riparian buffer: Stream stabilization buffer (miles)	Saturated buffers (miles)
Onion Creek	070801050305	12,733	87%	87%	44%	79%	70%	44%	44%	44%	44%	18	77	8	70%	43	11	87%	0	0.1	2.8	1.0	0.5	2.3	22.5
Lundys Creek-Squaw Creek	070801050306	27,167	88%	88%	44%	80%	71%	44%	44%	44%	44%	23	132	20	71%	98	25	88%	0	0.2	2.6	0.9	0.9	3.1	17.7
Worrell Creek-Squaw Creek	070801050307	23,273	86%	86%	43%	78%	70%	43%	43%	43%	43%	10	94	5	70%	53	11	86%	0	0.2	2.6	1.7	0.8	2.6	13.0
Long Dick Creek	070801050401	23,565	96%	95%	48%	87%	77%	48%	48%	48%	48%	22	109	31	77%	53	21	95%	13	0.2	5.6	2.7	2.4	7.1	22.2
Miller Creek-South Skunk River	070801050402	21,038	93%	93%	47%	84%	75%	47%	47%	47%	47%	16	106	33	75%	54	25	93%	4	0.1	2.2	0.7	0.8	1.0	7.9
Bear Creek	070801050403	18,497	94%	94%	47%	85%	76%	47%	47%	47%	47%	40	54	28	76%	47	22	94%	0	0.1	5.6	2.6	2.1	5.7	20.3
Headwaters Keigley Branch	070801050404	18,108	97%	96%	49%	88%	78%	49%	49%	49%	49%	18	108	24	78%	40	34	96%	4	0.1	1.0	0.5	0.3	0.8	0.2
Keigley Branch	070801050405	15,254	91%	91%	46%	83%	74%	46%	46%	46%	46%	8	115	8	74%	45	14	91%	0	0.1	1.9	0.5	0.9	2.6	7.0
City of Ames-South Skunk River	070801050406	19,675	83%	83%	42%	75%	67%	42%	42%	42%	42%	15	78	11	67%	39	9	83%	11	0.1	4.7	1.5	0.9	2.2	2.8
Drainage Ditch 5	070801050501	13,230	93%	93%	47%	84%	75%	47%	47%	47%	47%	25	62	61	75%	68	26	93%	2	0.0	0.9	0.4	1.5	3.3	0.0
West Indian Creek	070801050502	31,628	92%	92%	46%	83%	74%	46%	46%	46%	46%	27	155	114	74%	114	27	92%	0	0.0	2.1	0.9	1.4	3.3	6.8
Headwaters East Indian Creek	070801050601	13,338	97%	97%	49%	88%	78%	49%	49%	49%	49%	21	66	57	78%	53	21	97%	11	0.2	3.7	0.9	1.9	6.9	5.0
Drainage Ditch 81-East Indian Creek	070801050602	26,563	93%	93%	47%	84%	75%	47%	47%	47%	47%	17	147	115	75%	115	25	93%	23	0.2	2.4	1.2	2.4	5.7	6.4
Dye Creek	070801050603	15,905	94%	94%	47%	85%	76%	47%	47%	47%	47%	6	60	57	76%	60	1	94%	0	0.0	0.6	0.2	1.2	2.9	4.3
East Indian Creek	070801050604	26,573	85%	85%	43%	77%	68%	43%	43%	43%	43%	22	119	71	68%	109	3	85%	0	0.0	2.0	0.6	2.8	7.0	7.5
Headwaters Clear Creek	070801050701	24,049	75%	75%	38%	68%	61%	38%	38%	38%	38%	134	21	11	61%	25	53	75%	68	0.2	3.1	1.4	3.3	7.7	3.7
Mud Creek-Clear Creek	070801050702	29,846	65%	65%	33%	59%	52%	33%	33%	33%	33%	206	52	0	52%	48	78	65%	87	0.3	1.2	0.3	5.2	18.4	18.0
Rock & Calamus Creeks-Indian Creek	070801050801	22,987	90%	90%	46%	82%	73%	46%	46%	46%	46%	63	76	62	73%	96	38	90%	0	0.0	1.5	0.6	3.8	12.7	1.2
Wolf Creek	070801050802	13,306	88%	88%	44%	80%	71%	44%	44%	44%	44%	27	47	38	71%	48	17	88%	12	0.3	0.6	0.6	0.4	3.0	2.3
Peoria Cemetery-Indian Creek	070801050803	13,275	87%	86%	44%	78%	70%	44%	44%	44%	44%	47	38	26	70%	44	12	86%	0	0.1	0.9	0.6	1.5	7.2	3.6
Walnut Creek	070801050901	12,507	90%	90%	46%	82%	73%	46%	46%	46%	46%	5	89	24	73%	48	4	90%	0	0.0	0.4	0.2	1.6	3.0	1.2
Ballard Creek	070801050902	18,963	90%	90%	45%	82%	73%	45%	45%	45%	45%	8	104	29	73%	67	14	90%	0	0.2	3.3	1.3	2.0	7.9	2.8
Drainage Ditch 13-South Skunk River	070801050903	22,734	85%	85%	43%	77%	69%	43%	43%	43%	43%	40	100	22	69%	74	31	85%	0	0.6	9.8	2.2	2.0	8.4	6.2
Coon Creek-South Skunk River	070801050904	31,384	85%	85%	43%	77%	69%	43%	43%	43%	43%	48	138	23	69%	100	19	85%	0	0.8	7.5	1.3	3.1	20.8	4.8
Headwaters North Skunk River	070801060102	34,183	91%	90%	46%	82%	73%	46%	46%	46%	46%	451	17	1	73%	13	49	90%	694	0.0	1.3	0.9	8.1	23.5	32.5
Hardin Story Drainage Ditch No 1	070802070801	10,901	96%	96%	48%	87%	77%	48%	48%	48%	48%	23	44	41	77%	57	6	96%	32	0.0	1.3	1.1	2.9	4.2	2.8
South Minerva Creek	070802070802	17,193	93%	92%	47%	84%	75%	47%	47%	47%	47%	79	51	85	75%	62	38	92%	97	0.0	0.9	0.7	2.4	5.6	21.6
Middle Minerva Creek	070802070803	26,732	93%	92%	47%	84%	75%	47%	47%	47%	47%	85	103	97	75%	92	52	92%	84	0.6	4.3	3.0	4.1	11.9	10.1
Headwaters Minerva Creek	070802070804	35,246	93%	92%	47%	84%	75%	47%	47%	47%	47%	163	87	140	75%	143	74	92%	89	0.0	4.9	4.3	3.2	11.8	35.7
Headwaters Linn Creek	070802080101	23,982	91%	91%	46%	82%	73%	46%	46%	46%	46%	309	16	91	73%	12	52	91%	277	0.1	1.6	1.0	4.1	9.3	21.9

4.4. Recommended Approaches for Stormwater Management

The most effective manner in which to address stormwater management for proposed land use development is to have a comprehensive stormwater ordinance in place. Through the development of this watershed assessment project, EOR developed recommendations for updating the county ordinances pertaining to erosion and sedimentation control and stormwater management. These recommendations can be found in Appendix A.

We have also developed a Model Stormwater Ordinance (Appendix D) that can be used by local municipalities in Story County. We recommend that the county work with local municipalities to adopt the model ordinance.

Low impact development (LID) practices are another tool to manage stormwater. Story County should encourage the use of LID practices in new development projects as well as 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 emphasis infiltrating stormwater runoff which reduces volumes.

4.4.1. Bioretention Basins

Bioretention basins 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 12 inches deep, with an overflow outlet to prevent flooding during heavy storms. Where soils are tight 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.

4.4.2. 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 the sandy 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. These practices are effective for pre-treatment of concentrated flows before discharge to a downstream LID practice. Although grass swales provide generally limited pollutant removal through gravity separation, they can be designed to enhance their stormwater pollutant removal effectiveness. High sediment load reductions have been observed in well-constructed swales. Properly designed grass swales 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 can be further 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 grass swales.

4.4.3. Box Planter

Box 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.

4.4.4. 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.

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.

4.4.5. 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 & 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.

4.4.6. 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 to surrounding neighborhoods. The drainage ways are larger than grassed swales, more engineered than natural waterways and may look like a small creek based on 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.

4.4.7. 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.

4.4.8. 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.

4.4.9. 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.

4.4.10. Tree Trenches

Tree trenches are a type of bioretention box planters (discussed earlier) that can be modular or dug along the length of roads or pathways and filled with a highly permeable aggregate integrated with relatively minimal soil. Impervious surfaces, or in some design permeable pavers, overlie the infiltration media. Trees are planted in designed, usually square, openings of the top layer, which thrive in the well-watered, oxygenated environment. Runoff is directed from surrounding impervious surfaces through curb cuts and surface drains to the tree trench where it percolates through the soil media to the underlying ground or underdrain. If the runoff exceeds the design capacity, the underdrain directs the excess stormwater to a storm sewer or downstream LID practices. Ideal for redevelopment or in the ultra-urban setting, tree trenches have been implemented around paved streets, parking lots, and buildings. Monitoring has indicated that tree trenches are capable of consistent and high pollutant removal for sediment, metals, and organic pollutants.

Trees reduce the volume of stormwater runoff in neighborhoods and ultimately community-wide. This function and benefit is especially important in developed settings with increased quantities of impervious surfaces, such as roads, driveways, homes, and parking areas, and in areas in close proximity to surface waters. A tree's surface area, particularly leaf and trunk surfaces, intercept and store rainfall. The tree's root system absorbs soil-stored water, thereby decreasing runoff. Trees also reduce stormwater runoff by intercepting raindrops before they hit the ground, thus, reducing soil compaction rates and improving soil absorptive properties. Additionally, trees intercept suburban contaminants such as oils, solvents, pesticides, and fertilizers which are often part of stormwater runoff, reducing pollutant discharges into vital waterways. Healthy tree canopies in urban setting offer many other ancillary benefits including reduced heat island effects, air filtering, aesthetics, inviting streetscapes, and natural habitat.

4.4.11. 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 or social norms 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.

4.4.12. 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 prairie will provide many benefits, conversion to turf grass or natural plantings may be more appropriate than native prairie in some settings.

4.4.13. 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 (US EPA, 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.

4.5. Recommended Approaches 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.

4.5.1. 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.

Story County 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.

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. Refer to Appendix A for recommendations related to improving existing county feedlot and manure application strategies, including the importance of enforcing current standards.

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 both, 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 and rural subwatersheds. The following section provides more detailed explanations of source controls and BMPs that are applicable 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 Story County. As mentioned above, efforts to reduce and eliminate bacteria sources should be conducted first, when possible.

4.5.2. Bacteria Recommendations for Urban Area

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).

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 Section for recommended sampling frequency). Monitor tributaries flowing into the stream and also consider monitoring stormwater outfalls (or at least the larger ones).
- 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, etc.) 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 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, sand filters) typically occurs on a smaller scale (5 acres 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.

- 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 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 turfgrass 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. Refer to Appendix B for further information on BMP effectiveness. 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 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) function better for bacteria removal 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.

4.5.3. 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.

4.6. HUC-12 Subwatershed-Specific Management Recommendations

The following sections summarize the recommended protection strategies and restoration opportunities for each of the HUC-12s within Story County.

4.6.1. Lundys Creek-Squaw Creek

Lundys Creek-Squaw Creek is a high priority subwatershed.

HUC-12 Subwatershed	HUC-10 Watershed	HUC-8 Subbasin	Priority Streams (impaired in bold)	Secondary Streams	Other Streams	Lakes
Lundys Creek-Squaw Creek 070801050306	Squaw Creek	South Skunk	Squaw Creek	NA		

Recommendations:

- Encourage adoption/installation of the following suite of agricultural conservation practices designed to meet the Iowa Nutrient Reduction Strategy goals for N (41%) and P (29%) reduction countywide

Soil Health	Cover crops	15%		5050 acres
	Extended rotations	2%		350 acres
	Nitrogen management: nitrification inhibitor	95%		15880 acres
	4Rs of Nutrient Management	90%		
In Field	Contour buffer strips	4.99	Miles	
	Terraces	NA		
	Drainage water management	66	Fields	
	Grassed waterways	6.34	Miles	
	No-Till	2%		1760 acres
Edge of Field	Denitrifying bioreactors	25	Reactors	
	Nutrient removal wetlands	10	Wetlands	
	Perennial cover	2%		350 acres
	WASCOBs	NA		
Riparian Management	Riparian Buffer	95%		
	Saturated Buffers	8.85	Miles	

- Continue active participation in the Squaw Creek WMA.
- Expand and enhance public access to the Squaw Creek Greenbelt through acquisition of key parcels identified as containing biologically significant native plant communities.
- Encourage the City of Gilbert to:

- Adopt the Model Stormwater Ordinance (Appendix D).
  - Incorporate Low Impact Development practices (Section 4.4) in public improvement projects.
- Encourage the City of Ames to:
  - Incorporate Low Impact Development practices (Section 4.4) in public improvement projects.

4.6.2. Worle Creek-Squaw Creek

Worle Creek-Squaw Creek is a high priority subwatershed.

HUC-12 Subwatershed	HUC-10 Watershed	HUC-8 Subbasin	Priority Streams (impaired in bold)	Secondary Streams	Other Streams	Lakes
Worle Creek-Squaw Creek 070801050307	Squaw Creek	South Skunk	College Creek Squaw Creek Unnamed Creek Worle 1 Unnamed Creek Worle 2	Clear Creek Onion Creek Worle Creek	4 Unnamed Creeks/Ditches	

Recommendations:

- Encourage adoption/installation of the following suite of agricultural conservation practices designed to meet the Iowa Nutrient Reduction Strategy goals for N (41%) and P (29%) reduction countywide

Soil Health	Cover crops	15%		2290 acres
	Extended rotations	2%		160 acres
	Nitrogen management: nitrification inhibitor	95%		7200 acres
	4Rs of Nutrient Management	90%		
In Field	Contour buffer strips	2.48	Miles	
	Terraces	NA		
	Drainage water management	47	Fields	
	Grassed waterways	0.90	Miles	
	No-Till	2%		800 acres
Edge of Field	Denitrifying bioreactors	13	Reactors	
	Nutrient removal wetlands	4	Wetlands	
	Perennial cover	2%		160 acres
	WASCOBs	NA		
Riparian	Riparian Buffer	95%		

Management	Saturated Buffers	6.52	Miles

- Continue Sentinel Site: Full monitoring at Lincoln Way site.
- Establish a Sentinel Site: General water quality monitoring station on College Creek at the Bridge Crossing at University Boulevard in Ames
- Establish a Sentinel Site: General water quality monitoring station on the Unnamed Creek tributary to Worle Creek at the Bridge Crossing near intersection of 6th Street and University Boulevard.
- Continue active participation in the Squaw Creek WMA.
- Encourage the City of Ames to:
    - Incorporate Low Impact Development practices (Section 4.4) in public improvement projects.
- Expand and enhance public access to the Squaw Creek Greenbelt through acquisition of key parcels identified as containing biologically significant native plant communities.

Squaw Creek Stream Restoration - Ames

4.6.3. Long Dick Creek

Long Dick Creek is a high priority subwatershed.

HUC-12 Subwatershed	HUC-10 Watershed	HUC-8 Subbasin	Priority Streams (impaired in bold)	Secondary Streams	Other Streams	Lakes
Long Dick Creek 070801050401	Keigley Branch-South Skunk River	South Skunk	**Long Dick Creek**	NA	1 Unnamed Creek/Ditch	

Recommendations:

- Establish a Watershed Management Authority to cover the Keigley Branch-South Skunk River HUC-10 as well as the two upstream HUC-10s in the upper portion of the South Skunk River HUC-8 (Headwaters South Skunk River and Drainage Ditch 71).
- Improve water quality in Long Dick Creek resulting in having it removed from the Iowa Impaired Waters List.
- Establish a Sentinel Site: General water quality monitoring station on Long Dick Creek at the IFC Gage: Long Dick Creek near Roland (LNGDCKCR01).
- Encourage adoption/installation of the following suite of agricultural conservation practices designed to meet the Iowa Nutrient Reduction Strategy goals for N (41%) and P (29%) reduction countywide.

Soil Health	Cover crops	15%		5050 acres
	Extended rotations	2%		350 acres
	Nitrogen management: nitrification inhibitor	95%		15880 acres
	4Rs of Nutrient Management	90%		
In Field	Contour buffer strips	4.91	Miles	
	Terraces	0.75		
	Drainage water management	54.5	Fields	
	Grassed waterways	19.38	Miles	
	No-Till	2%		1760 acres
Edge of Field	Denitrifying bioreactors	13	Reactors	
	Nutrient removal wetlands	8	Wetlands	
	Perennial cover	2%		350 acres
	WASCOBs	NA		
Riparian Management	Riparian Buffer	95%		
	Saturated Buffers	11.11	Miles	

4.6.4. Miller Creek-South Skunk River

Miller Creek-South Skunk River is a high priority subwatershed.

HUC-12 Subwatershed	HUC-10 Watershed	HUC-8 Subbasin	Priority Streams (impaired in bold)	Secondary Streams	Other Streams	Lakes
Miller Creek-South Skunk River 070801050402	Keigley Branch-South Skunk River	South Skunk	**South Skunk River**	NA	2 Unnamed Creeks/Ditches	

Recommendations:

- Encourage adoption/installation of the following suite of agricultural conservation practices designed to meet the Iowa Nutrient Reduction Strategy goals for N (41%) and P (29%) reduction countywide.

Soil Health	Cover crops	15%		3410 acres
	Extended rotations	2%		240 acres
	Nitrogen management: nitrification inhibitor	95%		10740 acres
	4Rs of Nutrient Management	90%		
In Field	Contour buffer strips	3.69	Miles	
	Terraces	0.43		
	Drainage water management	53	Fields	
	Grassed waterways	23.70	Miles	
	No-Till	2%		1190 acres
Edge of Field	Denitrifying bioreactors	14	Reactors	
	Nutrient removal wetlands	10	Wetlands	
	Perennial cover	2%		240 acres
	WASCOBs	NA		
Riparian Management	Riparian Buffer	95%		
	Saturated Buffers	3.96	Miles	

- Improve water quality in South Skunk River resulting in having it removed from the Iowa Impaired Waters List.
- Increase public awareness of kayaking, angling, and non-motorized recreational opportunities on the South Skunk River.

- Expand and enhance public access to the South Skunk River Greenbelt through acquisition of key parcels identified as containing biologically significant native plant communities. Focus on floodplain and upland timber habitat.
- Establish a Watershed Management Authority to cover the Keigley Branch-South Skunk River HUC-10 as well as the two upstream HUC-10s in the upper portion of the South Skunk River HUC-8 (Headwaters South Skunk River and Drainage Ditch 71).
- Encourage Story City to:
    - Adopt the Model Stormwater Ordinance (Appendix D).
    - Incorporate Low Impact Development practices (Section 4.4) in public improvement projects.
- Adopt the strategies that address bacteria pollution identified in Section 4.5.
- Follow the recommendations for bacteria contamination from rural areas.
    - Prioritize bacteria source controls that reduce direct sources of bacteria from livestock and manure runoff.
- Follow the recommendations for bacteria contamination from urban areas.
    - Prioritize bacteria source controls that reduce bacteria from pets and humans.

4.6.5. Bear Creek

Bear Creek is a high priority subwatershed.

HUC-12 Subwatershed	HUC-10 Watershed	HUC-8 Subbasin	Priority Streams (impaired in bold)	Secondary Streams	Other Streams	Lakes
Bear Creek 070801050403	Keigley Branch-South Skunk River	South Skunk	Bear Creek	NA	Dry Creek 1 Unnamed Creek/Ditch	

Recommendations:

- Establish a Watershed Management Authority to cover the Keigley Branch-South Skunk River HUC-10 as well as the two upstream HUC-10s in the upper portion of the South Skunk River HUC-8 (Headwaters South Skunk River and Drainage Ditch 71).
- Encourage the City of Roland to:
    - Adopt the Model Stormwater Ordinance (Appendix D).
    - Incorporate Low Impact Development practices (Section 4.4) in public improvement projects.
- Establish a Sentinel Site: General water quality monitoring station on Bear Creek at the IFC Gage south of Roland (BEARCREEK01)

- Encourage adoption/installation of the following suite of agricultural conservation practices designed to meet the Iowa Nutrient Reduction Strategy goals for N (41%) and P (29%) reduction countywide

Soil Health	Cover crops	15%		3830 acres
	Extended rotations	2%		270 acres
	Nitrogen management: nitrification inhibitor	95%		12050 acres
	4Rs of Nutrient Management	90%		
In Field	Contour buffer strips	9.34	Miles	
	Terraces	NA		
	Drainage water management	27	Fields	
	Grassed waterways	15.87	Miles	
	No-Till	2%		1340 acres
Edge of Field	Denitrifying bioreactors	12	Reactors	
	Nutrient removal wetlands	9	Wetlands	
	Perennial cover	2%		270 acres
	WASCOBs	NA		
Riparian Management	Riparian Buffer	95%		
	Saturated Buffers	10.17	Miles	

City of Roland

4.6.6. Keigley Branch

Keigley Branch is a high priority subwatershed.

HUC-12 Subwatershed	HUC-10 Watershed	HUC-8 Subbasin	Priority Streams (impaired in bold)	Secondary Streams	Other Streams	Lakes
Keigley Branch 070801050405	Keigley Branch-South Skunk River	South Skunk	Keigley Branch, Lower Reach	Keigley Branch, Upper Reach	Drainage Ditch 1	

Recommendations:

- Establish a Watershed Management Authority to cover the Keigley Branch-South Skunk River HUC-10 as well as the two upstream HUC-10s in the upper portion of the South Skunk River HUC-8 (Headwaters South Skunk River and Drainage Ditch 71).
- Establish a Sentinel Site: General water quality monitoring station on Keigley Branch at the existing USGS Station (05469990 Keigley Branch) near Story City, IA.
- Encourage adoption/installation of the following suite of agricultural conservation practices designed to meet the Iowa Nutrient Reduction Strategy goals for N (41%) and P (29%) reduction countywide

Soil Health	Cover crops	15%		3180 acres
	Extended rotations	2%		220 acres
	Nitrogen management: nitrification inhibitor	95%		9990 acres
	4Rs of Nutrient Management	90%		
In Field	Contour buffer strips	1.59	Miles	
	Terraces	NA		
	Drainage water management	57.5	Fields	
	Grassed waterways	3.75	Miles	
	No-Till	2%		1110 acres
Edge of Field	Denitrifying bioreactors	11	Reactors	
	Nutrient removal wetlands	6	Wetlands	
	Perennial cover	2%		220 acres
	WASCOBs	NA		
Riparian Management	Riparian Buffer	95%		
	Saturated Buffers	3.50	Miles	

4.6.7. City of Ames – South Skunk River

City of Ames – South Skunk River is a high priority subwatershed.

HUC-12 Subwatershed	HUC-10 Watershed	HUC-8 Subbasin	Priority Streams (impaired in bold)	Secondary Streams	Other Streams	Lakes
City of Ames-South Skunk River 070801050406	Keigley Branch-South Skunk River	South Skunk	**South Skunk River**	NA	9 Unnamed Creeks/Ditches	Ada Hayden Peterson Park Lakes McFarland Pond

Recommendations:

- Improve water quality in South Skunk River resulting in having it removed from the Iowa Impaired Waters List.
- Increase public awareness of kayaking, angling, and non-motorized recreational opportunities on the South Skunk River.
- Expand and enhance public access to the South Skunk River Greenbelt through acquisition of key parcels identified as containing biologically significant native plant communities. Focus on floodplain and upland timber habitat.
- Establish a Watershed Management Authority to cover the Keigley Branch-South Skunk River HUC-10 as well as the two upstream HUC-10s in the upper portion of the South Skunk River HUC-8 (Headwaters South Skunk River and Drainage Ditch 71).
- Protect Ada Hayden Lake from carp feeding activities.
- Evaluate implementation options for secondary treatment measures from watershed sources including the constructed wetlands.
- Further develop public use areas, road access, forest habitat and fisheries in the popular Skunk River Greenbelt.
- Support continued monitoring of Ada Hayden Lake.
- Consider establishing a Sentinel Site: Full monitoring station at South Skunk River near Ames Hwy E18 (USGS Station ESKI4)
- Develop citizen monitoring program for Peterson Park West Lake and McFarland Lake.
- Encourage the City of Ames to:
    - Incorporate Low Impact Development practices (Section 4.4) in public improvement projects.
- Adopt the strategies that address bacteria pollution identified in Section 4.5.
- Follow the recommendations for bacteria contamination from rural areas.
    - Prioritize bacteria source controls that reduce direct sources of bacteria from livestock and manure runoff.
- Follow the recommendations for bacteria contamination from urban areas.
    - Prioritize bacteria source controls that reduce bacteria from pets and humans.
- Prioritize conservation practices that reduce phosphorus loading.

- Encourage adoption/installation of the following suite of agricultural conservation practices designed to meet the Iowa Nutrient Reduction Strategy goals for N (41%) and P (29%) reduction countywide

Soil Health	Cover crops	15%		2130 acres
	Extended rotations	2%		150 acres
	Nitrogen management: nitrification inhibitor	95%		6710 acres
	4Rs of Nutrient Management	90%		
In Field	Contour buffer strips	3.22	Miles	
	Terraces	1.09		
	Drainage water management	39	Fields	
	Grassed waterways	5.45	Miles	
	No-Till	2%		750 acres
Edge of Field	Denitrifying bioreactors	10	Reactors	
	Nutrient removal wetlands	4	Wetlands	
	Perennial cover	2%		150 acres
	WASCOBs	NA		
Riparian Management	Riparian Buffer	95%		
	Saturated Buffers	1.40	Miles	

4.6.8. West Indian Creek

West Indian Creek is a high priority subwatershed.

HUC-12 Subwatershed	HUC-10 Watershed	HUC-8 Subbasin	Priority Streams (impaired in bold)	Secondary Streams	Other Streams	Lakes
West Indian Creek 070801050502	West Indian Creek	South Skunk	West Indian Creek, Lower Reach	West Indian Creek, Upper Reach	Drainage Ditch 5 Drainage Ditch 32 6 Unnamed Creeks/Ditches	

Recommendations:

- Extend the Indian Creek Greenbelt and trail from Nevada to Maxwell along West Indian Creek and to Hickory Grove Park.
- Establish a Sentinel Site: General water quality monitoring station on West Indian Creek at the Bridge Crossing at 640th Street near Robinson Wildlife Acres.
- Encourage the City of Nevada to:
  - Adopt the Model Stormwater Ordinance (Appendix D).
  - Incorporate Low Impact Development practices (Section 4.4) in public improvement projects.
- Encourage adoption/installation of the following suite of agricultural conservation practices designed to meet the Iowa Nutrient Reduction Strategy goals for N (41%) and P (29%) reduction countywide

Soil Health	Cover crops	15%		4620 acres
	Extended rotations	2%		320 acres
	Nitrogen management: nitrification inhibitor	95%		14540 acres
	4Rs of Nutrient Management	90%		
In Field	Contour buffer strips	6.41	Miles	
	Terraces	NA		
	Drainage water management	77.5	Fields	
	Grassed waterways	77.19	Miles	
	No-Till	2%		1620 acres
Edge of Field	Denitrifying bioreactors	29	Reactors	
	Nutrient removal wetlands	11	Wetlands	
	Perennial cover	2%		320 acres
	WASCOBs	NA		
Riparian Management	Riparian Buffer	95%		
	Saturated Buffers	3.42	Miles	

4.6.9. East Indian Creek

East Indian Creek is a high priority subwatershed.

HUC-12 Subwatershed	HUC-10 Watershed	HUC-8 Subbasin	Priority Streams (impaired in bold)	Secondary Streams	Other Streams	Lakes
East Indian Creek 070801050604	East Indian Creek	South Skunk	East Indian Creek	NA	Drainage Ditch 20 7 Unnamed Creeks/Ditches	**Hickory Grove Lake**

Recommendations:

- Encourage adoption/installation of the following suite of agricultural conservation practices designed to meet the Iowa Nutrient Reduction Strategy goals for N (41%) and P (29%) reduction countywide

Soil Health	Cover crops	15%		3680 acres
	Extended rotations	2%		260 acres
	Nitrogen management: nitrification inhibitor	95%		11580 acres
	4Rs of Nutrient Management	90%		
In Field	Contour buffer strips	4.77	Miles	
	Terraces	NA		
	Drainage water management	59.5	Fields	
	Grassed waterways	46.11	Miles	
	No-Till	2%		1290 acres
Edge of Field	Denitrifying bioreactors	27	Reactors	
	Nutrient removal wetlands	1	Wetlands	
	Perennial cover	2%		260 acres
	WASCOBs	NA		
Riparian Management	Riparian Buffer	95%		
	Saturated Buffers	3.73	Miles	

- Improve water quality in Hickory Grove Lake resulting in having it removed from the Iowa Impaired Waters List.
- Continue lake water quality monitoring on Hickory Grove Lake.
- Continue Sentinel Site: Full monitoring at 650th Avenue Site.
- Evaluate progress towards goals outlined in the Hickory Grove Lake Watershed Management Action Plan.

- Extend the Indian Creek Greenbelt within Nevada City limits to Hickory Grove Park along East Indian Creek.
- Encourage the City of Nevada to:
  - Adopt the Model Stormwater Ordinance (Appendix D).
  - Incorporate Low Impact Development practices (Section 4.4) in public improvement projects.
- Prioritize conservation practices that reduce phosphorus loading.

4.6.10. Walnut Creek

Walnut Creek is a high priority subwatershed.

HUC-12 Subwatershed	HUC-10 Watershed	HUC-8 Subbasin	Priority Streams (impaired in bold)	Secondary Streams	Other Streams	Lakes
Walnut Creek 070801050901	Sugar Creek-South Skunk River	South Skunk	**Walnut Creek, Lower Reach**	Walnut Creek, Upper Reach	6 Unnamed Creeks/Ditches	

Recommendations:

- Encourage adoption/installation of the following suite of agricultural conservation practices designed to meet the Iowa Nutrient Reduction Strategy goals for N (41%) and P (29%) reduction countywide

Soil Health	Cover crops	15%		2030 acres
	Extended rotations	2%		140 acres
	Nitrogen management:			
	nitrification inhibitor	95%		6400 acres
	4Rs of Nutrient Management	90%		
In Field	Contour buffer strips	0.99	Miles	
	Terraces	0.73		
	Drainage water management	44.5	Fields	
	Grassed waterways	16.44	Miles	
	No-Till	2%		710 acres
Edge of Field	Denitrifying bioreactors	12	Reactors	
	Nutrient removal wetlands	2	Wetlands	
	Perennial cover	2%		140 acres
	WASCOBs	NA		
Riparian Management	Riparian Buffer	95%		
	Saturated Buffers	0.62	Miles	

- Improve water quality in Walnut Creek resulting in having it removed from the Iowa Impaired Waters List.
- Establish a Sentinel Site: General water quality monitoring station on Walnut Creek near the former USGS Gaging Station: USGS 05471014 Walnut Creek near Cambridge, IA.
- Encourage the City of Kelley to:
    - Adopt the Model Stormwater Ordinance (Appendix D).
    - Incorporate Low Impact Development practices (Section 4.4) in public improvement projects.

4.6.11. Ballard Creek

Ballard Creek is a high priority subwatershed.

HUC-12 Subwatershed	HUC-10 Watershed	HUC-8 Subbasin	Priority Streams (impaired in bold)	Secondary Streams	Other Streams	Lakes
Ballard Creek 070801050902	Sugar Creek-South Skunk River	South Skunk Unnamed Creek Ballard	**Ballard Creek, Lower Reach**	Ballard Creek, Upper Reach	10 Unnamed Creeks/Ditches	

Recommendations:

- Encourage adoption/installation of the following suite of agricultural conservation practices designed to meet the Iowa Nutrient Reduction Strategy goals for N (41%) and P (29%) reduction countywide

Soil Health	Cover crops	15%		2580 acres
	Extended rotations	2%		180 acres
	Nitrogen management: nitrification inhibitor	95%		8110 acres
	4Rs of Nutrient Management	90%		
In Field	Contour buffer strips	1.75	Miles	
	Terraces	NA		
	Drainage water management	52	Fields	
	Grassed waterways	20.19	Miles	
	No-Till	2%		900 acres
Edge of Field	Denitrifying bioreactors	17	Reactors	
	Nutrient removal wetlands	6	Wetlands	
	Perennial cover	2%		180 acres
	WASCOBs	NA		
Riparian Management	Riparian Buffer	95%		
	Saturated Buffers	1.40	Miles	

- Improve water quality in Ballard Creek resulting in having it removed from the Iowa Impaired Waters list.
- Establish a Sentinel Site: General water quality monitoring station on Ballard Creek at the Bridge Crossing at 4th Street, Cambridge.
- Establish a Sentinel Site: General water quality monitoring station on the Unnamed Creek tributary to Ballard Creek upstream of confluence w/ Ballard Creek south of 310th Street, Huxley.
- Encourage the City of Huxley and the City of Cambridge to:
    - Adopt the Model Stormwater Ordinance (Appendix D).
    - Incorporate Low Impact Development practices (Section 4.4) in public improvement projects.

Ballard Creek Road Crossing

4.6.12. Drainage Ditch 13 – South Skunk River

Drainage Ditch 13 – South Skunk River is a high priority subwatershed.

HUC-12 Subwatershed	HUC-10 Watershed	HUC-8 Subbasin	Priority Streams (impaired in bold)	Secondary Streams	Other Streams	Lakes
Drainage Ditch 13-South Skunk River 070801050903	Sugar Creek-South Skunk River	South Skunk	**South Skunk River**	NA	Drainage Ditch 13 20 Unnamed Creeks/Ditches	

Recommendations:

- Improve water quality in South Skunk River resulting in having it removed from the Iowa Impaired Waters List.
- Increase public awareness of kayaking, angling, and non-motorized recreational opportunities on the South Skunk River.
- Expand and enhance public access to the South Skunk River Greenbelt through acquisition of key parcels identified as containing biologically significant native plant communities. Focus on floodplain and upland timber habitat.
- Consider establishing a Sentinel Site: Full monitoring station at the USGS flow gauging station below Squaw Creek, near Ames IA (Station 05471000)
- Encourage the City of Cambridge to:
    - Adopt the Model Stormwater Ordinance (Appendix D).
    - Incorporate Low Impact Development practices (Section 4.4) in public improvement projects.
- Encourage the City of Ames to:
    - Incorporate Low Impact Development practices (Section 4.4) in public improvement projects.
- Adopt the strategies that address bacteria pollution identified in Section 4.5.
- Follow the recommendations for bacteria contamination from rural areas.
    - Prioritize bacteria source controls that reduce direct sources of bacteria from livestock and manure runoff.
- Follow the recommendations for bacteria contamination from urban areas.
    - Prioritize bacteria source controls that reduce bacteria from pets and humans.
- Encourage adoption/installation of the following suite of agricultural conservation practices designed to meet the Iowa Nutrient Reduction Strategy goals for N (41%) and P (29%) reduction countywide

Soil Health	Cover crops	15%
	Extended rotations	2%

	Nitrogen management: nitrification inhibitor	95%		2820 acres
	4Rs of Nutrient Management	90%		200 acres
In Field	Contour buffer strips	9.11	Miles	8890 acres
	Terraces	NA		
	Drainage water management	50	Fields	
	Grassed waterways	9.70	Miles	
	No-Till	2%		
Edge of Field	Denitrifying bioreactors	19	Reactors	
	Nutrient removal wetlands	12	Wetlands	990 acres
	Perennial cover	2%		
	WASCOBs	NA		
Riparian Management	Riparian Buffer	95%		200 acres
	Saturated Buffers	3.11	Miles	

Skunk River Water Trail Sign

4.6.13. Coon Creek – South Skunk River

Coon Creek – South Skunk River is a high priority subwatershed.

HUC-12 Subwatershed	HUC-10 Watershed	HUC-8 Subbasin	Priority Streams (impaired in bold)	Secondary Streams	Other Streams	Lakes
Coon Creek-South Skunk River 070801050904	Sugar Creek-South Skunk River	South Skunk	**South Skunk River**	Coon Creek	11 Unnamed Creeks/Ditches	

Recommendations:

- Improve water quality in South Skunk River resulting in having it removed from the Iowa Impaired Waters List.
- Increase public awareness of kayaking, angling, and non-motorized recreational opportunities on the South Skunk River.
- Expand and enhance public access to the South Skunk River Greenbelt through acquisition of key parcels identified as containing biologically significant native plant communities. Focus on floodplain and upland timber habitat.
- Encourage the City of Cambridge to:
  - Adopt the Model Stormwater Ordinance (Appendix D).
  - Incorporate Low Impact Development practices (Section 4.4) in public improvement projects.
- Adopt the strategies that address bacteria pollution identified in Section 4.5.
- Follow the recommendations for bacteria contamination from rural areas.
  - Prioritize bacteria source controls that reduce direct sources of bacteria from livestock and manure runoff.
- Follow the recommendations for bacteria contamination from urban areas.
  - Prioritize bacteria source controls that reduce bacteria from pets and humans.
- Encourage adoption/installation of the following suite of agricultural conservation practices designed to meet the Iowa Nutrient Reduction Strategy goals for N (41%) and P (29%) reduction countywide

Soil Health	Cover crops	15%		4060 acres
	Extended rotations	2%		280 acres
	Nitrogen management: nitrification inhibitor	95%		12780 acres
	4Rs of Nutrient Management	90%		
In Field	Contour buffer strips	10.84	Miles	
	Terraces	NA		

	Drainage water management	69	Fields	
	Grassed waterways	10.72	Miles	
	No-Till	2%		1420 acres
Edge of Field	Denitrifying bioreactors	25	Reactors	
	Nutrient removal wetlands	8	Wetlands	
	Perennial cover	2%		280 acres
	WASCOBs	NA		
Riparian Management	Riparian Buffer	95%		
	Saturated Buffers	2.41	Miles	


South Skunk River

4.6.14. Onion Creek

Onion Creek is a medium priority subwatershed.

HUC-12 Subwatershed	HUC-10 Watershed	HUC-8 Subbasin	Priority Streams (impaired in bold)	Secondary Streams	Other Streams	Lakes
Onion Creek 070801050305	Squaw Creek	South Skunk	NA	Onion Creek	NA	

Recommendations:

- Continue active participation in the Squaw Creek WMA.
- Encourage the City of Ames to:
  - Incorporate Low Impact Development practices (Section 4.4) in public improvement projects.
- Encourage adoption/installation of the following suite of agricultural conservation practices designed to meet the Iowa Nutrient Reduction Strategy goals for N (41%) and P (29%) reduction countywide

Soil Health	Cover crops	15%		1980 acres
	Extended rotations	2%		140 acres
	Nitrogen management: nitrification inhibitor	95%		6220 acres
	4Rs of Nutrient Management	90%		
In Field	Contour buffer strips	4.16	Miles	
	Terraces	NA		
	Drainage water management	38.5	Fields	
	Grassed waterways	3.65	Miles	
	No-Till	2%		690 acres
Edge of Field	Denitrifying bioreactors	11	Reactors	
	Nutrient removal wetlands	4	Wetlands	
	Perennial cover	2%		140 acres
	WASCOBs	NA		
Riparian Management	Riparian Buffer	95%		
	Saturated Buffers	11.26	Miles	

4.6.15. Headwaters Keigley Branch

Headwaters Keigley Branch is a medium priority subwatershed.

HUC-12 Subwatershed	HUC-10 Watershed	HUC-8 Subbasin	Priority Streams (impaired in bold)	Secondary Streams	Other Streams	Lakes
Headwaters Keigley Branch 070801050404	Keigley Branch-South Skunk River	South Skunk	NA	Keigley Branch	2 Unnamed Creeks/Ditches	

Recommendations:

- Establish a Watershed Management Authority to cover the Keigley Branch-South Skunk River HUC-10 as well as the two upstream HUC-10s in the upper portion of the South Skunk River HUC-8 (Headwaters South Skunk River and Drainage Ditch 71).
  - Encourage adoption/installation of the following suite of agricultural conservation practices designed to meet the Iowa Nutrient Reduction Strategy goals for N (41%) and P (29%) reduction countywide

Soil Health	Cover crops	15%		4190 acres
	Extended rotations	2%		290 acres
	Nitrogen management: nitrification inhibitor	95%		13180 acres
	4Rs of Nutrient Management	90%		
In Field	Contour buffer strips	4.14	Miles	
	Terraces	0.20		
	Drainage water management	54	Fields	
	Grassed waterways	13.40	Miles	
	No-Till	2%		1460 acres
Edge of Field	Denitrifying bioreactors	10	Reactors	
	Nutrient removal wetlands	14	Wetlands	
	Perennial cover	2%		290 acres
	WASCOBs	NA		
Riparian Management	Riparian Buffer	95%		
	Saturated Buffers	0.08	Miles	

4.6.16. Headwaters East Indian Creek

Headwaters East Indian Creek is a medium priority subwatershed.

HUC-12 Subwatershed	HUC-10 Watershed	HUC-8 Subbasin	Priority Streams (impaired in bold)	Secondary Streams	Other Streams	Lakes
Headwaters East Indian Creek 070801050601	East Indian Creek	South Skunk	NA	East Indian Creek	3 Unnamed Creeks/Ditches	

Recommendations:

- Encourage adoption/installation of the following suite of agricultural conservation practices designed to meet the Iowa Nutrient Reduction Strategy goals for N (41%) and P (29%) reduction countywide

Soil Health	Cover crops	15%		2360 acres
	Extended rotations	2%		160 acres
	Nitrogen management: nitrification inhibitor	95%		7420 acres
	4Rs of Nutrient Management	90%		
In Field	Contour buffer strips	4.95	Miles	
	Terraces	0.84		
	Drainage water management	33	Fields	
	Grassed waterways	39.22	Miles	
	No-Till	2%		820 acres
Edge of Field	Denitrifying bioreactors	13	Reactors	
	Nutrient removal wetlands	8	Wetlands	
	Perennial cover	2%		160 acres
	WASCOBs	NA		
Riparian Management	Riparian Buffer	95%		
	Saturated Buffers	2.49	Miles	

4.6.17. Drainage Ditch 81 – East Indian Creek

Drainage Ditch 81 – East Indian Creek is a medium priority subwatershed.

HUC-12 Subwatershed	HUC-10 Watershed	HUC-8 Subbasin	Priority Streams (impaired in bold)	Secondary Streams	Other Streams	Lakes
Drainage Ditch 81-East Indian Creek 070801050602	East Indian Creek	South Skunk	East Indian Creek, Lower Reach	East Indian Creek, Upper Reach	Drainage Ditch 36 Drainage Ditch 81 4 Unnamed Creeks/Ditches	

Recommendations:

- Encourage adoption/installation of the following suite of agricultural conservation practices designed to meet the Iowa Nutrient Reduction Strategy goals for N (41%) and P (29%) reduction countywide

Soil Health	Cover crops	15%		4120 acres
	Extended rotations	2%		290 acres
	Nitrogen management: nitrification inhibitor	95%		12970 acres
	4Rs of Nutrient Management	90%		
In Field	Contour buffer strips	3.60	Miles	
	Terraces	NA		
	Drainage water management	73.5	Fields	
	Grassed waterways	80.52	Miles	
	No-Till	2%		1440 acres
Edge of Field	Denitrifying bioreactors	29	Reactors	
	Nutrient removal wetlands	10	Wetlands	
	Perennial cover	2%		290 acres
	WASCOBs	NA		
Riparian Management	Riparian Buffer	95%		
	Saturated Buffers	3.18	Miles	

4.6.18. Dye Creek

Dye Creek is a medium priority subwatershed.

HUC-12 Subwatershed	HUC-10 Watershed	HUC-8 Subbasin	Priority Streams (impaired in bold)	Secondary Streams	Other Streams	Lakes
Dye Creek 070801050603	East Indian Creek Unnamed Creek Dye	South Skunk	Dye Creek, Lower Reach	Dye Creek, Upper Reach	3 Unnamed Creeks/Ditches	

Recommendations:

- Establish a Sentinel Site: General water quality monitoring station on Dye Creek at the IFC Gage near Colo (DYECRK01)
- Establish a Sentinel Site: General water quality monitoring station on the Unnamed Creek tributary to Dye Creek upstream of confluence w/ Dye Creek near access to mobile home park.
- Encourage the City of Colo to:
    - Adopt the Model Stormwater Ordinance (Appendix D).
    - Incorporate Low Impact Development practices (Section 4.4) in public improvement projects.
- Encourage adoption/installation of the following suite of agricultural conservation practices designed to meet the Iowa Nutrient Reduction Strategy goals for N (41%) and P (29%) reduction countywide

Soil Health	Cover crops	15%		2560 acres
	Extended rotations	2%		180 acres
	Nitrogen management: nitrification inhibitor	95%		8050 acres
	4Rs of Nutrient Management	90%		
In Field	Contour buffer strips	1.45	Miles	
	Terraces	NA		
	Drainage water management	30	Fields	
	Grassed waterways	36.36	Miles	
	No-Till	2%		890 acres
Edge of Field	Denitrifying bioreactors	15	Reactors	
	Nutrient removal wetlands	0	Wetlands	
	Perennial cover	2%		180 acres
	WASCOBs	NA		
Riparian Management	Riparian Buffer	95%		
	Saturated Buffers	2.17	Miles	

4.6.19. Rock and Calamus Creeks-Indian Creek

Rock and Calamus Creeks-Indian Creek is a medium priority subwatershed.

HUC-12 Subwatershed	HUC-10 Watershed	HUC-8 Subbasin	Priority Streams (impaired in bold)	Secondary Streams	Other Streams	Lakes
Rock and Calamus Creeks-Indian Creek 070801050801	Indian Creek	South Skunk	**Indian Creek**	Rock Creek Rupple Creek Calamus Creek	15 Unnamed Creeks/Ditches	

Recommendations:

- Encourage adoption/installation of the following suite of agricultural conservation practices designed to meet the Iowa Nutrient Reduction Strategy goals for N (41%) and P (29%) reduction countywide

Soil Health	Cover crops	15%		3340 acres
	Extended rotations	2%		230 acres
	Nitrogen management: nitrification inhibitor	95%		10520 acres
	4Rs of Nutrient Management	90%		
In Field	Contour buffer strips	14.24	Miles	
	Terraces	NA		
	Drainage water management	38	Fields	
	Grassed waterways	32.44	Miles	
	No-Till	2%		1170 acres
Edge of Field	Denitrifying bioreactors	24	Reactors	
	Nutrient removal wetlands	15	Wetlands	
	Perennial cover	2%		230 acres
	WASCOBs	NA		
Riparian Management	Riparian Buffer	95%		
	Saturated Buffers	0.62	Miles	

- Improve water quality in Indian Creek resulting in having it removed from the Iowa Impaired Waters List.
- Establish a Sentinel Site: General water quality monitoring station on Indian Creek at the Bridge Crossing on Hwy. 210 South of Maxwell
- Establish a Sentinel Site: General water quality monitoring station on Rock Creek at the Bridge Crossing at South Street, Maxwell
- Encourage the City of Maxwell to:
  - Adopt the Model Stormwater Ordinance (Appendix D).

    - Incorporate Low Impact Development practices (Section 4.4) in public improvement projects.
- Adopt the strategies that address bacteria pollution identified in Section 4.5.
- Follow the recommendations for bacteria contamination from rural areas.
    - Prioritize bacteria source controls that reduce direct sources of bacteria from livestock and manure runoff.
- Follow the recommendations for bacteria contamination from urban areas.
    - Prioritize bacteria source controls that reduce bacteria from pets and humans.

City of Maxwell

4.6.20. Headwaters Clear Creek

Headwaters Clear Creek is a low priority subwatershed.

HUC-12 Subwatershed	HUC-10 Watershed	HUC-8 Subbasin	Priority Streams (impaired in bold)	Secondary Streams	Other Streams	Lakes
Headwaters Clear Creek 070801050701	Clear Creek	South Skunk	NA	Clear Creek Willow Creek	Drainage Ditch 2 9 Unnamed Creeks/Ditches	Hendrickson Marsh

Recommendations:

- Conduct lake water quality monitoring on Hendrickson Marsh.
- Prioritize conservation practices that reduce phosphorus loading.
- Encourage adoption/installation of the following suite of agricultural conservation practices designed to meet the Iowa Nutrient Reduction Strategy goals for N (41%) and P (29%) reduction countywide

Soil Health	Cover crops	15%		2920 acres
	Extended rotations	2%		200 acres
	Nitrogen management: nitrification inhibitor	95%		9180 acres
	4Rs of Nutrient Management	90%		
In Field	Contour buffer strips	27.95	Miles	
	Terraces	NA		
	Drainage water management	10.5	Fields	
	Grassed waterways	NA	Miles	
	No-Till	2%		1020 acres
Edge of Field	Denitrifying bioreactors	6	Reactors	
	Nutrient removal wetlands	21	Wetlands	
	Perennial cover	2%		200 acres
	WASCOBs	NA		
Riparian Management	Riparian Buffer	95%		
	Saturated Buffers	1.86	Miles	

4.6.21. Middle Minerva Creek

Middle Minerva Creek is a medium priority subwatershed.

HUC-12 Subwatershed	HUC-10 Watershed	HUC-8 Subbasin	Priority Streams (impaired in bold)	Secondary Streams	Other Streams	Lakes
Middle Minerva Creek 070802070803	Minerva Creek	Upper Iowa	NA	Middle Minerva Creek	11 Unnamed Creeks/Ditches	Dakins Lake

Recommendations:

- Develop citizen monitoring program for Dakins Lake.
- Encourage the City of Zearing and the City of McCallsburg to:
  - Adopt the Model Stormwater Ordinance (Appendix D).
  - Incorporate Low Impact Development practices (Section 4.4) in public improvement projects.
- Prioritize conservation practices that reduce phosphorus loading.
- Encourage adoption/installation of the following suite of agricultural conservation practices designed to meet the Iowa Nutrient Reduction Strategy goals for N (41%) and P (29%) reduction countywide

Soil Health	Cover crops	15%		4190 acres
	Extended rotations	2%		290 acres
	Nitrogen management: nitrification inhibitor	95%		13180 acres
	4Rs of Nutrient Management	90%		
In Field	Contour buffer strips	18.35	Miles	
	Terraces	NA		
	Drainage water management	51.5	Fields	
	Grassed waterways	59.04	Miles	
	No-Till	2%		1460 acres
Edge of Field	Denitrifying bioreactors	23	Reactors	
	Nutrient removal wetlands	21	Wetlands	
	Perennial cover	2%		290 acres
	WASCOBs	NA		
Riparian Management	Riparian Buffer	95%		
	Saturated Buffers	5.05	Miles	

4.6.22. Mud Creek-Clear Creek

Mud Creek-Clear Creek is low priority watershed.

HUC-12 Subwatershed	HUC-10 Watershed	HUC-8 Subbasin	Priority Streams (impaired in bold)	Secondary Streams	Other Streams	Lakes
Mud Creek-Clear Creek 070801050702	Clear Creek	South Skunk		Mud Creek	7 Unnamed Creeks/Ditches	

Recommendations:

- Encourage adoption/installation of the following suite of agricultural conservation practices designed to meet the Iowa Nutrient Reduction Strategy goals for N (41%) and P (29%) reduction countywide

Soil Health	Cover crops	15%		3190 acres
	Extended rotations	2%		220 acres
	Nitrogen management: nitrification inhibitor	95%		10030 acres
	4Rs of Nutrient Management	90%		
In Field	Contour buffer strips	30.94	Miles	
	Terraces	30.70		
	Drainage water management	26	Fields	
	Grassed waterways	NA	Miles	
	No-Till	2%		1110 acres
Edge of Field	Denitrifying bioreactors	12	Reactors	
	Nutrient removal wetlands	31	Wetlands	
	Perennial cover	2%		220 acres
	WASCOBs	NA		
Riparian Management	Riparian Buffer	95%		
	Saturated Buffers	9.01	Miles	

4.6.23. Drainage Ditch 5

Drainage Ditch 5 is a low priority subwatershed.

HUC-12 Subwatershed	HUC-10 Watershed	HUC-8 Subbasin	Priority Streams (impaired in bold)	Secondary Streams	Other Streams	Lakes
Drainage Ditch 5 070801050501	West Indian Creek	South Skunk	NA	NA	Drainage Ditch 5 3 Unnamed Creeks/Ditches	

Recommendations:

- Encourage the City of Nevada to:
  - Adopt the Model Stormwater Ordinance (Appendix D).
  - Incorporate Low Impact Development practices (Section 4.4) in public improvement projects.
- Encourage adoption/installation of the following suite of agricultural conservation practices designed to meet the Iowa Nutrient Reduction Strategy goals for N (41%) and P (29%) reduction countywide

Soil Health	Cover crops	15%		2150 acres
	Extended rotations	2%		150 acres
	Nitrogen management: nitrification inhibitor	95%		6770 acres
	4Rs of Nutrient Management	90%		
In Field	Contour buffer strips	5.62	Miles	
	Terraces	NA		
	Drainage water management	31	Fields	
	Grassed waterways	41.77	Miles	
	No-Till	2%		750 acres
Edge of Field	Denitrifying bioreactors	17	Reactors	
	Nutrient removal wetlands	10	Wetlands	
	Perennial cover	2%		150 acres
	WASCOBs	NA		
Riparian Management	Riparian Buffer	95%		
	Saturated Buffers	NA	Miles	

4.6.24. **Wolf Creek**

Wolf Creek is a low priority subwatershed.

HUC-12 Subwatershed	HUC-10 Watershed	HUC-8 Subbasin	Priority Streams (impaired in bold)	Secondary Streams	Other Streams	Lakes
Wolf Creek 070801050802	Indian Creek	South Skunk	NA	Wolf Creek	5 Unnamed Creeks/Ditches	

Recommendations:

- Encourage adoption/installation of the following suite of agricultural conservation practices designed to meet the Iowa Nutrient Reduction Strategy goals for N (41%) and P (29%) reduction countywide

Soil Health	Cover crops	15%		2000 acres
	Extended rotations	2%		140 acres
	Nitrogen management: nitrification inhibitor	95%		6310 acres
	4Rs of Nutrient Management	90%		
In Field	Contour buffer strips	6.13	Miles	
	Terraces	NA		
	Drainage water management	23.5	Fields	
	Grassed waterways	23.48	Miles	
	No-Till	2%		700 acres
Edge of Field	Denitrifying bioreactors	12	Reactors	
	Nutrient removal wetlands	7	Wetlands	
	Perennial cover	2%		140 acres
	WASCOBs	NA		
Riparian Management	Riparian Buffer	95%		
	Saturated Buffers	1.17	Miles	

4.6.25. Peoria Cemetery-Indian Creek

Peoria Cemetery-Indian Creek is a low priority subwatershed.

HUC-12 Subwatershed	HUC-10 Watershed	HUC-8 Subbasin	Priority Streams (impaired in bold)	Secondary Streams	Other Streams	Lakes
Peoria Cemetery-Indian Creek 070801050803	Indian Creek	South Skunk	NA	NA	3 Unnamed Creeks/Ditches	

Recommendations:

- Encourage adoption/installation of the following suite of agricultural conservation practices designed to meet the Iowa Nutrient Reduction Strategy goals for N (41%) and P (29%) reduction countywide

Soil Health	Cover crops	15%		1920 acres
	Extended rotations	2%		130 acres
	Nitrogen management: nitrification inhibitor	95%		6040 acres
	4Rs of Nutrient Management	90%		
In Field	Contour buffer strips	10.33	Miles	
	Terraces	NA		
	Drainage water management	19	Fields	
	Grassed waterways	12.22	Miles	
	No-Till	2%		670 acres
Edge of Field	Denitrifying bioreactors	11	Reactors	
	Nutrient removal wetlands	5	Wetlands	
	Perennial cover	2%		130 acres
	WASCOBs	NA		
Riparian Management	Riparian Buffer	95%		
	Saturated Buffers	1.79	Miles	

4.6.26. Headwaters North Skunk River

Headwaters North Skunk River is a low priority subwatershed.

HUC-12 Subwatershed	HUC-10 Watershed	HUC-8 Subbasin	Priority Streams (impaired in bold)	Secondary Streams	Other Streams	Lakes
Headwaters North Skunk River 070801060102	Headwaters North Skunk River	North Skunk	NA	NA	NA	

Recommendations:

- Encourage adoption/installation of the following suite of agricultural conservation practices designed to meet the Iowa Nutrient Reduction Strategy goals for N (41%) and P (29%) reduction countywide

Soil Health	Cover crops	15%		5150 acres
	Extended rotations	2%		360 acres
	Nitrogen management: nitrification inhibitor	95%		16210 acres
	4Rs of Nutrient Management	90%		
In Field	Contour buffer strips	83.94	Miles	
	Terraces	65.12		
	Drainage water management	8.5	Fields	
	Grassed waterways	0.00	Miles	
	No-Till	2%		1800 acres
Edge of Field	Denitrifying bioreactors	3	Reactors	
	Nutrient removal wetlands	20	Wetlands	
	Perennial cover	2%		360 acres
	WASCOBs	NA		
Riparian Management	Riparian Buffer	95%		
	Saturated Buffers	16.23	Miles	

4.6.27. Hardin Story Drainage Ditch No 1

Hardin Story Drainage Ditch No 1 is a low priority subwatershed.

HUC-12 Subwatershed	HUC-10 Watershed	HUC-8 Subbasin	Priority Streams (impaired in bold)	Secondary Streams	Other Streams	Lakes
Hardin Story Drainage Ditch No 1 070802070801	Minerva Creek	Upper Iowa			Drainage Ditch 1	

Recommendations:

- Encourage adoption/installation of the following suite of agricultural conservation practices designed to meet the Iowa Nutrient Reduction Strategy goals for N (41%) and P (29%) reduction countywide

Soil Health	Cover crops	15%		2050 acres
	Extended rotations	2%		140 acres
	Nitrogen management: nitrification inhibitor	95%		6460 acres
	4Rs of Nutrient Management	90%		
In Field	Contour buffer strips	5.02	Miles	
	Terraces	NA		
	Drainage water management	22	Fields	
	Grassed waterways	26.07	Miles	
	No-Till	2%		720 acres
Edge of Field	Denitrifying bioreactors	14	Reactors	
	Nutrient removal wetlands	2	Wetlands	
	Perennial cover	2%		140 acres
	WASCOBs	NA		
Riparian Management	Riparian Buffer	95%		
	Saturated Buffers	1.40	Miles	

4.6.28. South Minerva Creek

South Minerva Creek is a low priority subwatershed.

HUC-12 Subwatershed	HUC-10 Watershed	HUC-8 Subbasin	Priority Streams (impaired in bold)	Secondary Streams	Other Streams	Lakes
South Minerva Creek 070802070802	Minerva Creek	Upper Iowa		South Minerva Creek	2 Unnamed Creeks/Ditches	

Recommendations:

- Encourage adoption/installation of the following suite of agricultural conservation practices designed to meet the Iowa Nutrient Reduction Strategy goals for N (41%) and P (29%) reduction countywide

Soil Health	Cover crops	15%		2830 acres
	Extended rotations	2%		200 acres
	Nitrogen management: nitrification inhibitor	95%		8890 acres
	4Rs of Nutrient Management	90%		
In Field	Contour buffer strips	16.57	Miles	
	Terraces	9.49		
	Drainage water management	25.5	Fields	
	Grassed waterways	56.99	Miles	
	No-Till	2%		990 acres
Edge of Field	Denitrifying bioreactors	16	Reactors	
	Nutrient removal wetlands	15	Wetlands	
	Perennial cover	2%		200 acres
	WASCOBs	NA		
Riparian Management	Riparian Buffer	95%		
	Saturated Buffers	10.80	Miles	

4.6.29. **Headwaters Minerva Creek**

Headwaters Minerva Creek is a low priority subwatershed.

HUC-12 Subwatershed	HUC-10 Watershed	HUC-8 Subbasin	Priority Streams (impaired in bold)	Secondary Streams	Other Streams	Lakes
Headwaters Minerva Creek 070802070804	Minerva Creek	Upper Iowa	Minerva Creek	NA	NA	

Recommendations:

- Establish a Sentinel Site: General water quality monitoring station on Minerva Creek at the Bridge Crossing at 720th Avenue East of Zearing.
- Encourage adoption/installation of the following suite of agricultural conservation practices designed to meet the Iowa Nutrient Reduction Strategy goals for N (41%) and P (29%) reduction countywide

Soil Health	Cover crops	15%		5730 acres
	Extended rotations	2%		400 acres
	Nitrogen management: nitrification inhibitor	95%		18030 acres
	4Rs of Nutrient Management	90%		
In Field	Contour buffer strips	36.36	Miles	
	Terraces	6.49		
	Drainage water management	43.5	Fields	
	Grassed waterways	94.51	Miles	
	No-Till	2%		2000 acres
Edge of Field	Denitrifying bioreactors	36	Reactors	
	Nutrient removal wetlands	30	Wetlands	
	Perennial cover	2%		400 acres
	WASCOBs	NA		
Riparian Management	Riparian Buffer	95%		
	Saturated Buffers	17.86	Miles	

4.6.30. Headwaters Linn Creek

Headwaters Linn Creek is a low priority subwatershed.

HUC-12 Subwatershed	HUC-10 Watershed	HUC-8 Subbasin	Priority Streams (impaired in bold)	Secondary Streams	Other Streams	Lakes
Headwaters Linn Creek 070802080101	Linn Creek	Upper Iowa	NA	Linn Creek	NA	

Recommendations:

- Encourage adoption/installation of the following suite of agricultural conservation practices designed to meet the Iowa Nutrient Reduction Strategy goals for N (41%) and P (29%) reduction countywide

Soil Health	Cover crops	15%		3720 acres
	Extended rotations	2%		260 acres
	Nitrogen management: nitrification inhibitor	95%		11720 acres
	4Rs of Nutrient Management	90%		
In Field	Contour buffer strips	57.49	Miles	
	Terraces	NA		
	Drainage water management	8	Fields	
	Grassed waterways	49.16	Miles	
	No-Till	2%		1300 acres
Edge of Field	Denitrifying bioreactors	3	Reactors	
	Nutrient removal wetlands	21	Wetlands	
	Perennial cover	2%		260 acres
	WASCOBs	NA		
Riparian Management	Riparian Buffer	95%		
	Saturated Buffers	10.95	Miles	

4.6.31. Headwaters Big Creek

Headwaters Big Creek is a low priority subwatershed.

HUC-12 Subwatershed	HUC-10 Watershed	HUC-8 Subbasin	Priority Streams (impaired in bold)	Secondary Streams	Other Streams	Lakes
Headwaters Big Creek *71000040801*	Big Creek	Lake Red Rock	NA	NA	NA	

Recommendations:

- Encourage adoption/installation of agricultural conservation practices designed to meet the Iowa Nutrient Reduction Strategy goals for N (41%) and P (29%) reduction countywide

4.6.32. Upper Fourmile Creek

Upper Fourmile Creek is a low priority subwatershed simply for the fact that a very small portion of this subwatershed is within Story County.

HUC-12 Subwatershed	HUC-10 Watershed	HUC-8 Subbasin	Priority Streams (impaired in bold)	Secondary Streams	Other Streams	Lakes
Upper Fourmile Creek *71000080101*	Fourmile Creek	Middle Des Moines	Fourmile Creek	Alleman Creek	1 Unnamed Creek/Ditch	

Recommendations:

- Continue participation in the Fourmile Creek WMA.
- Encourage the City of Slater to:
  - Adopt the Model Stormwater Ordinance (Appendix D).
  - Incorporate Low Impact Development practices (Section 4.4) in public improvement projects.
- Establish a Sentinel Site: General water quality monitoring station on Fourmile Creek at the Bridge Crossing at 340th Street (County Line).
- Encourage adoption/installation of agricultural conservation practices designed to meet the Iowa Nutrient Reduction Strategy goals for N (41%) and P (29%) reduction countywide

5. Water Quality Monitoring

5.1. Existing Monitoring Sites

Stream and lake monitoring provides information to compare monitored conditions to stream and lake standards and criteria, 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.

5.1.1. Stream Monitoring

Monitoring efforts of Story County's streams have been ongoing since the 1960's and incorporate data collected by the United States Geological Survey (USGS), data collected by the University of Iowa through the Iowa Water Quality Information System (IWQIS- https://iwqis.iowawis.org/app/), and data collected by conservation programs that engage students and citizens in volunteer monitoring. Currently, there are 9 USGS stream monitoring sites and 8 IWQIS sites within Story County (Figure 51). The Iowa DNR also has an ambient stream monitoring site located on the South Skunk River near Cambridge (South Skunk WQ Site near Cambridge (https://programs.iowadnr.gov/iastoret/srchStationGIS.aspx?orgid=21iowa& storetid=10850002).

Table 5-1. Existing Monitoring Stations in Story County

Station	Station Type	HUC-12 Subwatershed	Data Collected
Long Dick Creek near Roland (LNGDCKCR01)	IFC Stream Gage	Long Dick Creek	Real time stream stage data in comparison with flood stage.
Bear Creek south of Roland (BEARCREEK01)	IFC Stream Gage	Bear Creek	Real time stream stage data in comparison with flood stage.
Gilbert Creek- 520th Avenue	IFC Stream Gage	Lundy's Creek – Squaw Creek	Real time stream stage data in comparison with flood stage.
Squaw Creek- Stange Road, Ames (SQWCR02)	IFC Stream Gage	Worle Creek – Squaw Creek	Real time stream stage data in comparison with flood stage.
South Skunk River East 13th Street, Ames (SSKNK03)	IFC Stream Gage	City of Ames – South Skunk River	Real time stream stage data in comparison with flood stage.
Squaw Creek South Duff Avenue, Ames (SQWCR01)	IFC Stream Gage	Worle Creek – Squaw Creek	Real time stream stage data in comparison with flood stage.
Dye Creek, Colo (DYECRK01)	IFC Stream Gage	Dye Creek	Real time stream stage data in comparison with flood stage.
East Indian Creek, Maxwell (EINDNCR01)	IFC Stream Gage	East Indian Creek	Real time stream stage data in comparison with flood stage.
Squaw Creek near Moore Memorial Park (WQS00038)	IWQIS	Worle Creek – Squaw Creek	Real time Nitrate + Nitrite as N, flow and discharge
Squaw Creek @ Lincoln Way	Automated Sampler	Worle Creek – Squaw Creek	Baseline measurements of water quality, stream stage, and extrapolated estimates of discharge and nutrient loading.
South Skunk River near Cambridge	IDNR Ambient Stream Monitoring Station	Drainage Ditch 13 – South Skunk River	Water quality information used in determining status and trends, to determine if Iowa's rivers support beneficial uses for which they are designated, to calculate nutrient loads, and to support development of new or revised water quality standards.
Hickory Grove Lake	IDNR Ambient	East Indian Creek	Water quality information used in

Station	Station Type	HUC-12 Subwatershed	Data Collected
	Lake Monitoring Station		determining status and trends, to determine if Iowa's lakes support beneficial uses for which they are designated, to calculate nutrient loads, and to support development of new or revised water quality standards.
East Indian Creek @ 650th Avenue	Automated Sampler	East Indian Creek	Baseline measurements of water quality, stream stage, and extrapolated estimates of discharge and nutrient loading.
USGS 05471000 South Skunk River below Squaw Creek near Ames, IA	USGS	Drainage Ditch 13 – South Skunk River	Up-to-date flow and discharge data with timeseries statistics and historical water quality data
USGS 05470000 South Skunk River near Ames, IA	USGS	City of Ames – South Skunk River	Up-to-date flow and discharge data with timeseries statistics and historical water quality data
USGS 05470500 Squaw Creek at Ames, IA	USGS	Worle Creek – Squaw Creek	Up-to-date flow and discharge data with timeseries statistics and historical water quality data
USGS 05471012 Walnut Creek at Kelley, IA	USGS	Walnut Creek	Historical flow and discharge data with timeseries statistics and historical water quality data from the 1990's
USGS 05471013 Walnut Creek near Kelley, IA	USGS	Walnut Creek	Historical flow and discharge data with timeseries statistics and historical water quality data from the 1990's
USGS 05471014 Walnut Creek near Kelley, IA	USGS	Walnut Creek	Historical flow and discharge data with timeseries statistics and historical water quality data from the 1990's
South Skunk River near Ames Hwy E18 ESKI4	USGS	City of Ames – South Skunk River	Up-to-date flow and discharge data with timeseries statistics and historical water quality data
Squaw Creek (Central IA) near Ames Cameron School Rd (CSRI4)	USGS	Lundy's Creek – Squaw Creek	Up-to-date flow and discharge data with timeseries statistics and historical water quality data
USGS 05469990 Keigley Branch near Story City, IA	USGS	Keigley	Up-to-date flow and discharge data with timeseries statistics and historical water quality data

The low number of water quality samples collected to date from these 17 sites inhibits the ability to directly assess trends in water quality. In general, observed nitrate and phosphorus concentrations indicate relatively high nutrient concentrations in relation to State standards throughout the County.

Squaw Creek and East Indian River Monitoring

Prairie Rivers of Iowa in partnership with the Squaw Creek Watershed Management Authority and Story County Conservation have installed two automated monitoring stations in an effort to establish a baseline assessment of water quality in Squaw Creek and East Indian Creek. Observed Total Phosphorus (TP) and Total Suspended Solids (TSS) concentrations were heavily correlated with rain events in both streams. Total Nitrogen as nitrate concentrations were highest during spring and fall baseflow events suggesting contributions from subsurface tile drainage resulting from a land use change to row crops.

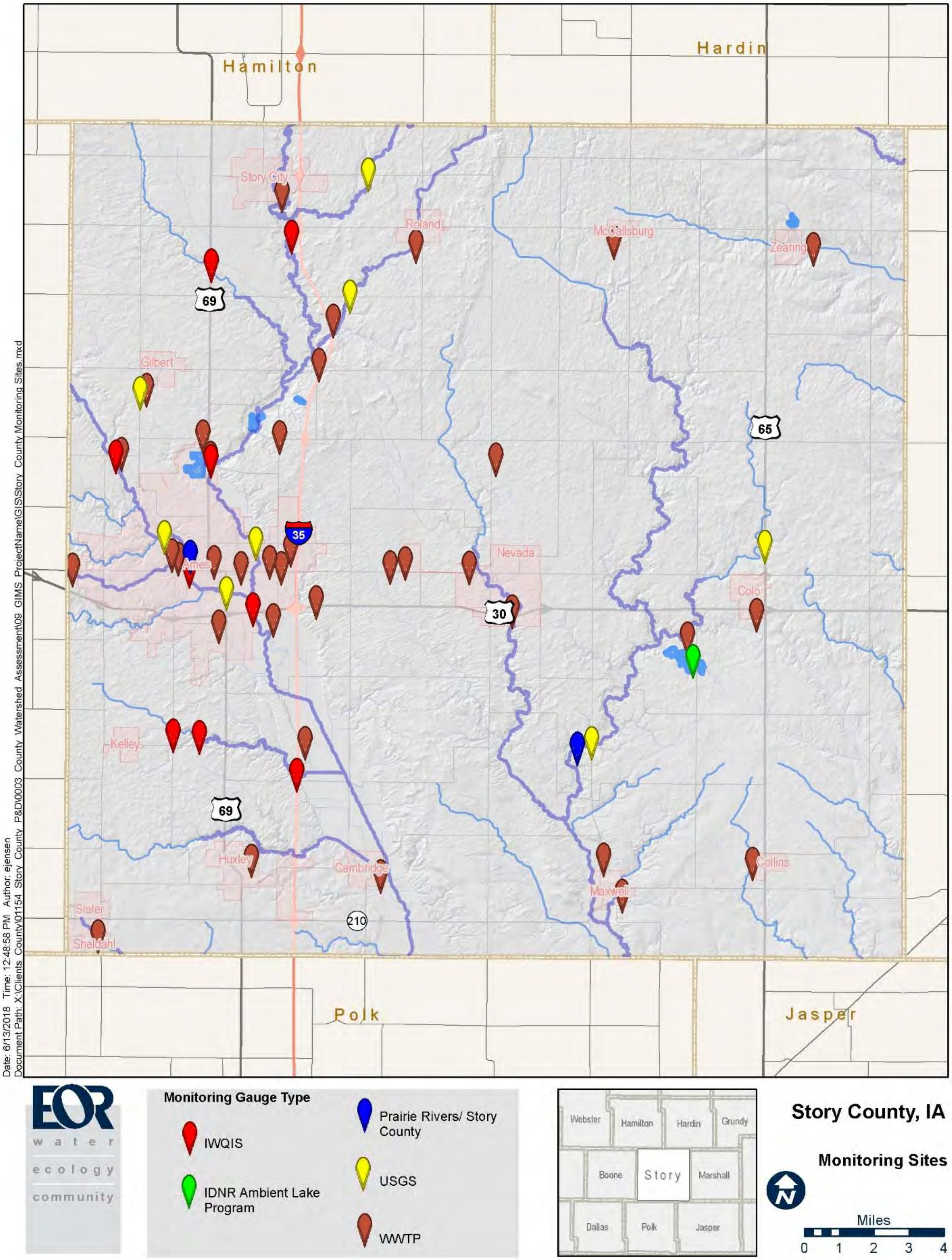


Figure 51. Story County Monitoring Sites

5.1.1. Lake Monitoring

Since 2000, the Iowa Department of Natural Resources Water Quality Monitoring and Assessment Section has collected water quality data on over 130 lakes in Iowa each summer as part of the Iowa DNR's Ambient Lake Monitoring Program. Data from this project is used to assess the health of Iowa's lakes including Hickory Grove Lake from which targeted restoration and watershed improvement activities were identified that have resulted in improved water quality in Hickory Grove Lake.

The City of Ames is working with the State Hygienic Laboratory to conduct water quality monitoring on Ada Hayden Lake in 2017 and 2018. Historical water quality data suggests good water quality near the surface but poor water quality near the bottom of the lake as well as the major tributaries to the lake.

5.1.2. Waste Water Treatment Plant (WWTP) Monitoring

There are 29 NPDES permits for wastewater treatment, including 13 municipalities, four mobile home parks, one subdivision, and 11 miscellaneous dischargers. A review of permit compliance suggests that there is room for improvement for NPDES dischargers in the County. Municipalities have the most significant wastewater discharge impact on water quality because of the sheer volume and variety of pollutants.

5.2. Future Monitoring Recommendations

Stream and lake monitoring provides valuable information which can be used to detect trends over time and support future resource management decisions. These decisions may be based on a comparison of monitored conditions to standards, changes detected from completed restoration and protection measures, or changing climate and land uses. The following paragraphs outline a stream and lake monitoring program tailored to Story County's water resources. Recommended monitoring strategies and proposed sampling locations for all Story County's water resources are presented in Table 5-2.

A critical element in stream water quality monitoring is determining the volume of flow within a stream, creek, or river. While the concentration of various pollutants (TSS, Nitrate, Phosphorus, Bacteria, etc.) found within the stream flow is useful information it is critical that the concentrations be applied to the flow within the stream so that a load, typically expressed as lbs/year, can be collected. Determining flow within the stream is also important for setting up the monitoring equipment in terms of trigger points and pacing of the sampler. The collection of flow data provides the ability to place the observed water quality result (concentrations) in the context of antecedent climatic conditions, thereby providing additional validity when comparing observed data to water quality standards. Two types of sentinel stream monitoring (Full Diagnostic, General) are discussed below.

5.2.1. Sentinel Site: Full Diagnostic

Full diagnostic monitoring represents an intense, focused monitoring effort, usually performed over several years and conducted only at strategically placed monitoring locations. The costs associated with purchasing the automated sampling equipment and laboratory analysis required to perform full diagnostic analysis can be high, therefore, conducting full diagnostic monitoring at secondary or “other” streams is not warranted.

Full diagnostic monitoring sites should be used to establish overarching trends which speak to improvements or reductions in the quality of a County’s water resources. The establishment of trend monitoring data requires more rigorous compiling of continuous daily flows along with the sampling data for calculation of loads such as with the USACE’s FLUX32 software. Chronic and acute standard exceedances (E.coli and dissolved oxygen) and loads can be assessed along the flow network stations identifying areas of concern or improvement over time. The end result of full diagnostic monitoring is the calculation of water flows and nutrient/sediment/bacteria losses (pollutant loads) from the land expressed as loads or pounds of phosphorus or sediment per acre per year. The collection of multiple years of data is required to account for changes in climatic conditions (i.e. rainfall totals) from year to year.

Pollutant loads (such as pounds of sediment or phosphorus per year) are calculated by multiplying stream flows by sampled pollutant concentrations or:

Flows X Pollutant Concentrations = Pounds Pollutant.

The calculation of annual pollutant loads requires measuring continuous daily stream flows. Grab samples (and automatic samplers) are used to define pollutant concentrations by sampling ~25+ times per year. Stream sampling can be refined after one year of data collection as to critical season or flows allowing greater sampling efficiencies. Wet years can have larger losses that may need to be adjusted for rainfall for inter-year comparisons (pounds P /acre/inch of precipitation). Very large storms can produce large amounts of runoff and associated pollutants and hence, the emphasis should be on evaluating average values for more typical years.

Currently, the Prairie Rivers of Iowa in partnership with the Squaw Creek Watershed Management Authority (WMA) and Story County Conservation maintains automated monitoring stations on Squaw Creek immediately downstream of the Lincoln Way crossing in Ames and on East Indian Creek at the 650th St. crossing, southeast of Nevada. As previously mentioned, data collected at these sites is being used to establish a baseline measurement of water quality. Continued monitoring at these sites will allow the County to assess trends in pollutant loading resulting from changes in watershed land use, and changes from watershed restoration, and from year-to-year climatic changes. The end result of this monitoring will be reasonably accurate estimates of pollutant loads over time. Future full diagnostic trend monitoring should continue at these two locations.

Additional full diagnostic trend monitoring should be conducted at the USGS flow gauging station below Squaw Creek, near Ames IA (Station 05471000). This site should be monitored as the long-term primary site for Story County because it is the most downstream USGS gauge within Story County. A second, upstream station on the South Skunk River can be added over time in a leap-frog method of identifying hot spots or areas of relatively good water quality.

5.2.2. Sentinel Site: General

General sentinel site monitoring is less intensive (relative to full diagnostic) and focuses on sampling select parameters for compliance with water quality standards and criteria. General site sampling methods are analogous to those used by the Iowa DNR as part of the Iowa DNR's Ambient Stream Monitoring Program. General sentinel site monitoring should be performed at all priority streams listed in Section 1.4 with the exception of those sites with a full diagnostic monitoring location. Recommended monitoring includes two types of compliance monitoring: (1) general diagnostics and (2) bacteria.

General Diagnostic Monitoring (dissolved oxygen, chlorophyll, BOD5, phosphorus, nitrogen)

General diagnostic monitoring should be conducted at least monthly, with a minimum sample size of 6-8 unique sampling events per year per site. One certified analytical laboratory should be used for all samples. Compliance to standards monitoring should include sampling over low, average and high flow conditions as feasible with two of the five monthly samples from baseflow conditions. Typically, this region of Iowa can expect 2 to 4 storms per month exceeding 0.5 inches per 24 hours. As possible, all samples should have instantaneous or daily average flow. These data are used for a number of purposes, such as determining status and trends, to determine if Iowa's rivers support beneficial uses for which they are designated, to calculate nutrient loads, and to support development of new or revised water quality standards.

Sentinel Monitoring Station: East Indian Creek

General diagnostic parameters include:

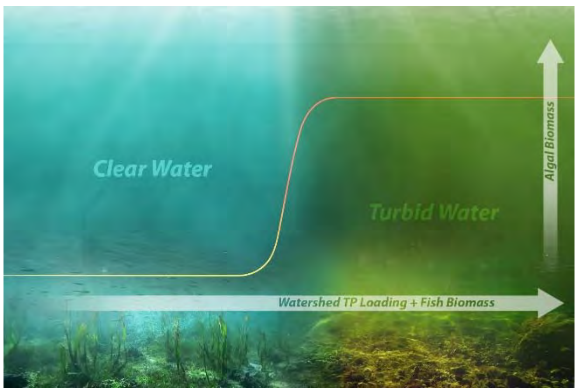
- Total phosphorus
- Chlorophyll-a, a measure of algae (floating and attached)
- Biochemical Oxygen Demand 5 day – amount of dissolved oxygen needed by aerobic biological organisms in a body of water to break down organic material present
- DO Flux: continuous oxygen concentrations monitored for 7-10 days to capture daily fluctuations of DO and pH. Iowa water quality standards for B(WW-2) waters specify a minimum DO value of 5.0 mg/L for at least 16 hours of every 24 hour period and a minimum value of 4.0 mg/L at any time.
- Nitrogen Total Kjeldahl (organic nitrogen) and nitrate plus Nitrite nitrogen

Bacteria (E.coli) Monitoring

Bacteria monitoring should be considered in the future, beginning with locations adjacent to existing USGS/IFIS sites. For comparison to standards, sampling should occur at least 5 times per month per site, from April through October, to obtain geometric mean concentrations for comparison to Iowa *E. coli* standards. A certified analytical laboratory should be used for all samples. Standardized sampling protocols have been established for monitoring *E. coli* in streams by the State Hygienic Laboratory.

5.2.3. Lake Monitoring

Lake monitoring of the County's five priority lakes outlined in Section 1.6 of this report should at a minimum, follow the lake sampling methods outlined by the Iowa DNR's ambient lake monitoring program. According to Iowa DNR methods, a minimum of three water quality samples per year should be collected from the deep spot of a given lake over a six week period starting in early summer (May) and ending in late summer (August/September). In-lake water quality data can be used to calculate the Carlson Trophic State Index which provides a baseline assessment of how eutrophic a given lake is.



Aquatic vegetation and fisheries surveys should also be conducted to provide additional information regarding the health and status of the aquatic plant, fisheries, zooplankton, and phytoplankton communities. Most Story County lakes, with the exception of Ada Hayden, are considered shallow waterbodies. Shallow lakes and waterbodies tend to exist in one of two phases: either exhibiting a 1) clear water, aquatic plant dominated state or 2) a turbid water, algae dominated state. In general, when aquatic plants are present, the water column clarity is good. Numerous studies have shown that native aquatic plants can sustain good light penetration and water quality, but the challenge is to establish aquatic plants if they are not present. The key to maintaining the clear water, aquatic plant dominated state is to control nutrients and other factors, especially fish disruptions that could limit plant establishment and growth. Conducting aquatic plant and fisheries survey in conjunction with the collection of water quality data helps to provide a holistic picture of in-lake interactions that is useful when evaluating and prioritizing future management actions. Furthermore, lake depth profiles of temperature and dissolved oxygen should also be collected to determine if a lake is thermally stratified which can help to approximate the impacts of internal nutrient loading. Future lake monitoring efforts should focus on the collection on in-lake water chemistry, fisheries, and aquatic vegetation communities within Peterson Park West Lakes, McFarland Pond, and Dakins Lake as in-lake water quality monitoring efforts are already in place on Hickory Grove Lake and Ada Hayden Lake as discussed previously.

5.2.4. Additional Monitoring Efforts

Project-Specific Monitoring

Urban and agricultural BMPs can also be assessed directly by monitoring of representative stormwater discharges with automated equipment to measure pollutant removals resulting from BMP implementation. This type of information is valuable in estimating the number of practices required to achieve recognized water quality goals.

Citizen-Led Monitoring

Volunteer (citizen) led water monitoring efforts have been a primary means for the DNR to empower local citizens to take ownership and increase resident awareness of the health of local waterbodies since 1998. Volunteer water monitoring is best able to inform local water quality goals if the decision-making and coordination is locally-led. Interested communities, watersheds, and counties can learn more about the Iowa DNR's approach to volunteer water monitoring at IDNR Volunteer Monitoring Program (http://www.iowadnr.gov/Environmental-Protection/Water-Quality/Water-Monitoring/Volunteer-Water-Monitoring). The primary focus for citizen-led monitoring should be on the collection of baseline stream data on secondary and "other" streams. This information will be useful in identifying small streams with either very good water quality and/or potential hot spots.

Furthermore, agricultural producers can help improve their bottom line by measuring Nitrates in ditches/draintile outflow as a way of seeing first-hand how much N is leaving their fields. This information is valuable to producers looking to reduce capital investments in fertilizers. There is a trial program to test a phone-app tool for this purpose Citizen Science Water Monitoring (http://www.iihr.uiowa.edu/blog/2018/01/08/citizen-science-water-monitoring/).

Recommendation

As discussed, stream and lake monitoring provides valuable information which can be used to detect trends over time and support future resource management decisions. While several USGS and IFIS stream flow gauge sites currently exist in the County, very little water quality data is available with regards to important stream health diagnostic factors such as nitrogen, phosphorus, and bacteria concentrations. Future monitoring efforts must emphasize the collection of stream water quality data in Story County. The ability of future monitoring efforts to detect such changes and the reliability of comparisons depends upon the nature and design of the monitoring program. Three main objectives are recommended for future Story County monitoring efforts: (1) pair water quality data with existing IFIS sites to evaluate compliance to water quality standards and criteria; (2) conduct more intense monitoring to assess county-wide trends and changes from restoration actions and variable climate at strategically designated full diagnostic monitoring locations and (3) engage citizens to conduct sampling efforts on secondary and "other" streams. It is recommended that monitoring be approached in a phased manner beginning with the collection of water quality data at existing USGS gages.

Table 5-2. Recommended monitoring type, water resource, and sampling location

Monitoring Type	Water Resource Name	Sampling Location
Sentinel Site: Full	Squaw Creek	Existing site at Lincoln Way
	East Indian Creek Lower Reach	Existing site at 650th Ave
	South Skunk River	USGS flow gauging station below Squaw Creek, near Ames IA (Station 05471000)
	South Skunk River	South Skunk River near Ames Hwy E18 (Station ESKI4)
Sentinel Site: General	Ballard Creek Lower Reach	Bridge Crossing at 4th Street, Cambridge
	Bear Creek	IFC Gage: Bear Creek south of Roland (BEARCREEK01)
	College Creek	Bridge Crossing at University Boulevard in Ames
	Dye Creek	IFC Gage: Dye Creek, Colo (DYECRK01)
	Fourmile Creek	Bridge Crossing at 340th Street (County Line)
	Indian Creek	Bridge Crossing on Hwy. 210 South of Maxwell
	Keigley Branch	USGS 05469990 Keigley Branch near Story City, IA
	Long Dick Creek	IFC Gage: Long Dick Creek near Roland (LNGDCKCR01)
	Minerva Creek	Bridge Crossing at 720th Avenue East of Zearing
	Rock Creek	Bridge Crossing at South Street, Maxwell
	Walnut Creek Lower Reach	Near former USGS Gaging Station: USGS 05471014 Walnut Creek near Cambridge, IA
	West Indian Creek Lower Reach	Bridge Crossing at 640th Street near Robinson Wildlife Acres
	Unnamed Creek Worle	Bridge Crossing near intersection of 6th Street and University Boulevard
	Unnamed Creek Ballard	Upstream of confluence w/ Ballard Creek south of 310th Street, Huxley
	Unnamed Creek Dye	Upstream of confluence w/ Dye Creek near access to mobile home park
Lakes	Ada Hayden	Deepest point of lake
	Hickory Grove	Deepest point of lake
	Peterson Park West Lakes	Deepest point of lake
	McFarland Pond	Deepest point of lake
	Dakins Lake	Deepest point of lake

Appendix A: Review of County Ordinances

The following is a narrative summary of an initial review of Story County's ordinances and feedlot management strategy. The review attempted to achieve three distinct goals. First, the County's land development regulations were analyzed to gauge the status and potential effectiveness of existing construction erosion and sediment control and stormwater management provisions. Second, the floodplain management ordinance was examined to understand its potential impact on implementing water quality and conservation practices within the floodplain and adjacent areas. Third, potential strategies for increasing County influence on animal feeding operations (feedlots) and manure application were researched. This memorandum is organized into three sections that correspond to the goals outlined above. Each section ends with a brief summary and a bulleted list of recommendations.

Erosion and Sediment Control and Stormwater Management in Story County

This section discusses a review of the County's Land Development, Zoning, and other relevant ordinances. The purpose of the review was to identify and understand the scope of existing erosion and sediment control and stormwater management provisions. Several gaps in the ordinances were identified during the review. Emmons and Olivier Resources recommends the County choose one of three options for improving county regulation of erosion and sediment control and stormwater management.

EOR staff reviewed all Land Development Regulations for erosion control and stormwater management provisions. The County's entire ordinance package was reviewed, but several ordinances were reviewed in detail: (1) Chapter 85 – General Provisions and Definitions; (2) Chapter 87 – Land Division Requirements; (3) Chapter 88 – General Site Planning Standards; and (4) Chapter 92 – Administration. Each of the four chapters was annotated, evaluated for potential effectiveness, and compared to leading examples of erosion and sediment control (ESC) and stormwater management (SWM) regulation (i.e. Minnesota's Minimal Impacts Design Standards (MIDS)). The ordinances were also analyzed using tools, including the U.S. Environmental Protection Agency's Water Quality Scorecard (https://www.epa.gov/smartgrowth/water-quality-scorecard), and the Center for Watershed Protection's (CWP) Codes and Ordinance Worksheet (http://owl.cwp.org/mdocs-posts/codes-ordinace-worksheet/). The following sections discuss the review's Findings and propose several Recommendations.

Findings

This section describes the County's existing erosion and sediment control and stormwater management regulations. The ESC and SWM regulations are scattered across several ordinance chapters. To simplify the discussion, the relevant provisions are described and analyzed according to topic.

Erosion and Sediment Control

Although preventing erosion caused by wind and rain is a stated purpose of the Land Development ordinances,[ii] very little actual regulation on the subject exists in Story County's ordinances. Land division planning and approval requirements (Chapter 87) do not mention erosion and sediment control planning or Best Management Practices (BMPs), even indirectly. Neither preliminary nor final plats for any type of land division are required to submit erosion and sediment control plans. Chapter 88 – General Site Planning Standards[iii] contains a few provisions related to erosion and sediment control. The first states that projects greater than one acre must obtain a National Pollutant Discharge Elimination System permit. This provision mandates the use of "temporary sediment barriers to prevent runoff," provides three examples of sediment barriers, and defines minimum barrier spacing. No other provisions exist in this chapter or any other chapter.

The provisions in Chapter 88 are inadequate for a number of reasons. First, sediment barriers are only one of a huge range of BMPs that should be used at construction sites to prevent sedimentation and erosion. There are other, significantly more effective BMPS. In addition, the term "temporary" is likely to be interpreted in a multitude of ways, and may even be interpreted in a way that fails to prevent any erosion or sedimentation. Second, several terms and concepts are used, but are undefined (i.e. temporary, filter, completed, etc). Third, the federal permit is relatively complicated and difficult to understand. This may result in incomplete designs or ineffective practices. Finally, while obtaining a National Pollutant Discharge Elimination System (NPDES) General Permit 2 is mandatory for sites over one acre, the County should implement additional standards that supplement the federal permit standards. The federal standards are only minimum standards.

Stormwater Management

The County's ordinances contain very limited stormwater management provisions. Chapter 88 contains the only provisions that mandate any stormwater-related action: (1) § 88.05(5) – "Storm water Management and Water Quality"; (2) § 88.02(2) – "Street Design Standards"; (3) § 88.03 – "Lots"; and (4) 88.11 – "Minimum Landscaping Standards." With the exception of the minimum landscaping standards none of these sections contain enforceable, objective targets.[iv] Instead, the provisions use vague, arguably unenforceable standards such as "achieve maximum capture" or "better replicate natural drainage patterns" or "shall incorporate [BMPs] as described in the Iowa Storm Water Management Manual." Like the vague erosion and sediment control provisions previously described, the lack of precision likely creates confusion, inconsistent interpretation, and ineffective application. It is unclear how many BMPs need to be adopted, where the practices should be located, or how rate, volume, or quality need to be controlled. The only other functional stormwater-related provision is located in the plat submission requirements of Chapter 87: § 87.08 – Minor Subdivision Plats; and § 87.09 – Major Subdivision Plats. However, these provisions do not actually mandate stormwater management planning or design features. The provisions only require plats to show "location and size of such sub-surface features such as existing or nearest available storm and sanitary sewers."

Several undefined terms are used throughout these provisions. For instance, in § 88.05(5) the term "predevelopment runoff" is used. For a first-time developer, this term is likely unintelligible without a definition in another chapter. Experienced subdivision developers may have trouble interpreting this term, and may even use the vagueness to design a new development to a significantly lower standard.

Design standards for various development elements (i.e. parking spaces) should be reviewed with Low Impact Development (LID) design tools.[v] In many cases, the sizes prescribed for these elements comply with industry practice, but are considerably larger than LID best practices.

Finally, and possibly most importantly, neither the erosion and sediment control nor the stormwater management provisions establish any meaningful planning process for these topics. Instead of integrating ESC and SWM as crucial issues that must be addressed from the very first design steps, the existing provisions likely cause developers to adopt ESC and SWM best practices at the very end of the design process. As a result, water resource protection is not a foundational goal of the design process, but rather a regulatory annoyance that can be satisfied by the least effort or creativity possible.

Recommendations

The County's ordinances are unlikely to produce development projects that effectively or efficiently protect water quality because they include very few ESC or SWM provisions. The County should consider either updating its existing ordinances or adopting an entirely new ordinance focused on ESC and SWM.

The review suggests three options for updating the County's ordinances:

- Update existing ordinances with new standards, definitions, and procedures.
- Adopt a new, "stand-alone" ordinance that draws from leading examples and resources.
- Make minor revisions to existing ordinances, and overhaul the County's standard Development Agreement to include strong ESC and SWM requirements.

Ultimately, the updated or new ordinance will comprehensively regulate both erosion and sediment control and stormwater management. The new ordinance will:

- Require erosion and stormwater management planning for all subdivision types;
    - LID will be the foundation of ESC and SWM planning and design;
    - LID will be incorporated from the very first design steps.
- Establish consistent, feasible regulatory triggers;
- Mandate ESC control practices from project initiation to final stabilization and revegetation;
- Require a comprehensive set of ESC best management practices for all construction sites;
- Establish objective stormwater volume, rate, and quality standards that achieve water resource protection goals;
- Obtain financial securities to ensure BMPs are properly installed and actively maintained;

- Require routine monitoring and maintenance of erosion and sediment control BMPs and stormwater facilities, as well as thorough documentation and reporting of such activities;
- Secure a contractually binding Maintenance Agreement to ensure stormwater facilities are monitored and maintained for the entire lifecycle of the facility;
- Actively consult and educate stakeholders about ESC and SWM planning, design, and best practices.

If the County is unable to update the existing ordinances or adopt a new ordinance, the County should optimize its use of Development Agreements. The ordinances already require the use of Development Agreements. These contract-like documents can be used to require a powerful range of conditions on new and redevelopment projects. In fact, Development Agreements can be tailored to a specific project, or standardized for particular categories, for example a range of sizes, or types of end use. Future efforts to improve ESC and SWM in the County should include reviewing and updating the standard forms and provisions used in Development Agreements.

Finally, the County should develop and initiate a multifaceted public outreach and participation campaign. Ordinances, whether existing or new, can only influence new development. Existing impervious surfaces on all land use types are the main contributors to stormwater pollution. However, property owners, businesses, and many others have numerous opportunities to reduce the amount of stormwater runoff, and the quality of runoff. A citizen outreach and education program has the potential to encourage the adoption of both erosion and stormwater management best practices on a huge number of properties.

Floodplain Management and Conservation Practices

This section briefly describes the County's Floodplain Management Ordinance and discusses its potential impact on implementing water quality and conservation practices in the floodplain. Potential practices primarily include saturated buffers and basic riparian buffers but could also include treatment wetlands or other practices. Other potential projects may include practices within ephemeral streams and ditches. For instance, these could include two-stage ditches, or rip-rap check dams built within the ditch. The buffer practices could be installed along all types of streams. In-stream practices would be limited to smaller ditches. These conservation practices may inundate small areas of the floodplain during small rain events. These practices *would not*, however, impact flood levels for larger storm events. All impacts will be supported by quantifiable hydrologic and hydrographic analysis showing projected impacts.

Findings

The ordinance is a somewhat flexible tool that could be applied in such a way to either permit or prohibit water quality and conservation in the regulated districts. The success of the recommendations described below is highly contingent on cultivating a favorable interpretation of the floodplain management ordinance. Please note that the review did not consider state or federal regulation of flooding. However, the arguments that the conservation practices will have minimal impact on flooding are very similar regardless of the audience.

The major regulatory goal of Story County's Floodplain Management ordinance is to protect floodplains from development that would "increase flood levels or impeded the free flow of flood waters."[vi] In other words, the ordinance prohibits any development that is vulnerable to damage as a result of floods, or that could increase flood heights or velocities, or restrict flood conveyance. A corollary of that purpose is to permit land uses that are not vulnerable to flood damage, do not restrict flood conveyance, and do not increase flood heights or velocities in the floodplain districts. Most importantly, restrictions on land use in the floodplain are not absolute. The ordinance explicitly allows land use in the floodplain if the use achieves "full compliance with the terms" of the ordinance.[vii]

The ordinance achieves its goals by requiring permits for all development located within the floodplain, and by establishing three regulatory districts: (1) Floodway district, (2) Floodway Fringe district, and (3) General Floodplain district. The actual boundaries of each district are provided by the County's Official Floodplain Map. These maps were developed as part of a comprehensive Flood Insurance Study (http://www.starr-team.com/starr/RegionalWorkspaces/RegionVII/StoryCounty/Shared%20Documents/19169CV000B.pdf).[viii] The Floodway and General Floodplain districts have specific "permitted uses" that could generally be considered open space uses (i.e. lawns, parking lots, parks, etc). Uses in Floodway and General Floodplain districts must also be permitted by the underlying zoning district (i.e. Residential). The Floodway Fringe district allows all uses permitted by the underlying zoning district. Each district also has "development standards" with which all land uses must comply. These range from specific residential construction practices and materials, to setbacks, to vehicular access standards.

The potential conservation practices discussed at the beginning of this section are likely permitted by all underlying zoning codes and the uses specified for the Floodway and General Floodplain districts. Although not specifically mentioned as a permitted use, strong arguments can be made that conservation practices are a permitted use. In Floodway districts, conservation practices would qualify as an "open-space use similar in nature" to the other listed uses.[ix] In the Floodway Fringe district the practices would be permitted as either a permitted use, or a conditional use, depending on the underlying zoning district.[x] Placing conservation practices in General Floodplain districts would likely require conversation with the County's Planning and Development Department and the Floodplain Manager. It is possible the practices could be considered "agricultural uses" or a "public recreational use."

The floodplain districts' development standards also do not appear to prohibit conservation practices. The most important standards involve the practices' influence on flood levels, minimizing damage caused by floods, channel alterations, reductions in conveyance capacity, and placement of fill. As previously stated, the conservation practices are specifically designed to not increase flood levels or contribute to flooding. These practices will also not reduce conveyance capacity or alter channels. Because the practices will not include above-ground structures, but will be open-space (buffers, wetlands, etc), they will not increase the potential for floods, or cause damage during a flood. In fact, many of the proposed practices may reduce flood levels, and the damage caused by floods. Practices such as treatment wetlands, in-ditch check dams, and riparian buffers reduce stormwater runoff volumes, decrease flow rates of drainage ditches and overland flow, and retain water on-site.

Recommendations

- County staff should review the interpretation and enforcement of the Floodplain Ordinance in relation to conservation practices.
- Initiate conversations with the Iowa Department of Natural Resources, about the County's intention to interpret and enforce the floodplain ordinance in this manner.
- Develop an education and outreach campaign about the operation of the Floodplain Management Ordinance, and the use of conservation practices in the floodplain.
- Train County staff about reviewing applications that include floodplain conservation practices.
- The County should consider incorporating water quality Best Management Practices (BMPs) in ditch maintenance projects.
- Watershed management authorities should consider installing practices within the riparian areas to supplement conservation efforts.

Feedlot and Manure Application Strategy

This section describes the regulatory background of Animal Feeding Operations and manure management practices in Iowa. After the legal review, this section recommends several options Story County has for exercising authority over the planning, permitting, and operation of animal feeding operations (AFOs).

Regulatory Background

Animal Feeding Operations, also known as feedlots or Concentrated Animal Feeding Operations (CAFO) are subject to federal and state regulation. The state has passed comprehensive legislation, and delegated regulatory responsibility to the DNR. The applicable state laws are codified in Iowa Code (2017) Chapters 459, 459A, and 459B. The DNR published its AFO rules in Chapter 65 of the Iowa Administrative Code. These rules are administered by the Environmental Protection Commission.

Under state law, AFOs are defined as agricultural operations that confine livestock in a specific area (lot, pen, barn, corral) and feed the animals for 45 days or more a year. There are two types: (1) Confinements, and (2) Open Feedlots. The former confine animals in an area that is totally roofed. The latter keep animals in either a partially roofed or unroofed area with no vegetative cover on the ground. Iowa law also recognizes two sizes of AFOs: "small farms" with less than 500 animal units; and "large farms" with more than 500 animal units.[xi]

Regardless of the type or size, the Iowa Department of Natural Resources regulates the planning, permitting, siting, and operation of AFOs. All AFOs must apply for a permit to establish a new operation, or to expand or modify an existing operation. Permits include conditions on various aspects of animal feeding operations, including setbacks from adjacent residential uses and wells, and properly retaining, storing, and disposing of manure. The regulations for Confinements and Open Feedlots are slightly different. Large confinements are required to develop and submit for approval a Manure Management Plan (MMP); small confinements can voluntarily adopt such plans. Manure Management Plans contain information on how manure will be stored between applications, and a plan for timing and method of manure application. Open Feedlots are subject to similar regulations on siting and construction, but must develop and comply with a Nutrient Management Plan.

Finally, the DNR maintains a comprehensive database of information on all feedlots in the state. The database contains information about location, animal type and numbers, completed environmental reviews, nutrient and manure management plans, and details about structures. Perhaps the most valuable informational tool available is the DNR's AFO Siting Atlas. This online GIS database locates all AFOs on an interactive map, and provides links to the available information.

Findings

Story County has almost no authority to regulate Animal Feeding Operations. The County has very little authority for two main reasons. First, state law grants all regulatory authority for AFOs to the DNR, and expressly prohibits Counties (and other local governments) from regulating AFOs. Second, case law (court rulings) have upheld these state laws, and overturned multiple attempts by local governments to use statutory or local authority to regulate AFOs. The following paragraphs will describe key laws and cases to detail the extent of the DNR's power and illustrate how local authority is extremely constrained.

In *Goodell v. Humboldt County*,[xii] the Iowa Supreme Court overturned four county ordinances as "inconsistent with applicable state law." The ordinances sought to regulate AFOs by requiring a county permit, obtain financial assurances, protect groundwater pollution, and prevent toxic air emissions. The county enacted these regulations using its Home Rule authority granted by the state's Constitution and laws.[xiii] The ordinances were challenged by a group of livestock producers and individual farmers as unconstitutional and as contrary to state law exempting agricultural uses from local zoning ordinances. Under state law, land, houses, and other structures that are "primarily adapted . . . for use for agricultural purposes" cannot be regulated by zoning ordinances. [xiv] However, the Court held that the zoning exemption did not apply because the ordinances were not zoning ordinances, but instead were "police powers" and applied to all uses regardless of the zoning district.

The Court also held that the local ordinances were "irreconcilable" with state legislation regarding feedlots. In a lengthy discussion of the subject, the Court found that state laws did not expressly preempt local regulation of feedlots. In fact, the state laws allowed local authorities to set higher standards than state regulation. The Court, however, determined the local ordinances were "inconsistent" with state law. The ordinances not only set higher standards, but "revise[d] the state regulatory scheme, and, by doing so, [became] irreconcilable with state law." Because the local ordinances conflicted with state laws, the ordinances were invalid and unenforceable.

In response to this legal battle, but before the Supreme Court issued its decision, the state legislature enacted new legislation that expressly prohibited Counties from regulating feedlots.[xv] This law states:

"A county shall not adopt or enforce county legislation regulating a condition or activity occurring on land used for the production, care, feeding, or housing of animals unless the regulation of the production, care, feeding, or housing of animals is expressly authorized by state law. County legislation adopted in violation of this section is void and unenforceable and any enforcement activity conducted in violation of this section is void."[xvi]

On its face, this law effectively prohibits local authorities from either adopting or enforcing any regulations that are not consistent with state law and regulations.

Worth County enacted an ordinance titled "County Rural Health and Family Farm Protection Ordinance." The intended purpose of this ordinance was to protect the residents and property of Worth County from toxic air emissions, protect feedlot workers from dangerous indoor air pollution, and prevent contamination of local groundwater resources. Almost immediately after the ordinance was enacted, several individuals and groups sued the county and asked the court to declare the ordinance invalid and unenforceable under state law. In *Worth County Friends v. Worth County*,[xvii] the Supreme Court of Iowa overturned the county ordinance. The Court held that the ordinance was "expressly preempted by state law."

Like the Court's decision in *Goodell v. Humboldt County*, the Supreme Court in *Worth County Friends* decided that the local health ordinances directly conflicted with the legislature's express delegation of complete authority to the DNR regarding AFOs. Thus, even though Worth County's ordinances were reasonable attempts to protect public health—a valid and traditional area of local concern—the state legislature had clearly and completely delegated all authority over feedlots to the DNR. The law's operation is very broad and prevents County from regulating "a condition or activity occurring on land used for the production, care, feeding or housing of animals." The ruling also affirmed the constitutionality of the law (Iowa Code § 331.304(A))

These Supreme Court decision leave very little authority to a County to regulate AFOs. Neither the *Goodell* nor the *Worth County* Friends decisions clarify the full extent of this law's operation. Both courts only discussed the application of the law to the specific ordinances before the court. However, the logic used to determine the county ordinance was preempted could easily be applied to nearly any regulation. The language used in § 331.304(A) is sufficiently broad to preempt nearly any County attempt to regulate feedlots. The phrase "regulating a condition or activity" likely includes any environmental, health, financial, construction, building code, or other regulation a County has authority to adopt. In addition, Counties can only regulate feedlots when "expressly authorized by state law."

The lack of official authority does not mean the County has zero options for influencing the construction and operation of feedlots. The county can prohibit feedlots within floodplains.[xviii] The county should also vigorously educate and inform its citizens about feedlot regulations and best practices. This could include training farmers or providing incentives for adopting feedlot operation and manure application best management practices, disseminating informational resources, and collaborating with partners (i.e. EOR, Iowa State University, etc) to engage and inform citizens and farmers. Story County should also frequently consult with state legislators and environmental protection groups to advocate for increased local authority or stronger state environmental standards for feedlots. Finally, Story County should optimize its influence on feedlots through existing regulatory processes. For instance, the County should ensure citizens are aware of existing laws and apply them appropriately on their own properly. There are several opportunities for the County to impact feedlots through DNR-led processes, including rigorous use of the Master Matrix, and providing public comment periods for all feedlot applications. Finally, the County should consider allocating human and financial resources to ensuring that all feedlots within the County's borders follow state laws and regulations.

Recommendations

- Consider adopting strict regulations (prohibition?) of confinements in the floodplain.
- Continue to delegate staff resources to monitoring feedlots and manure applications.
- Continue to report any known/suspected violations to the IDNR
- Inventory all protected resources, develop/use GIS tools (IDNR's AFO Siting Atlas) that clearly define resources and required buffers:
    - Designated areas: 200'
    - High-quality water resources: 800'
    - Residence (not owned by farmer), church, school, public areas: 750'
- Collect, review, comment on, and assist in enforcement of all Manure Management Plans
- Provide incentives for adopting more rigorous practices
- Widely publicize all MMPs/construction permit applications; hold public hearing for all permits applications and provide comments about relevant concerns to DNR
- Conduct public education and outreach to inform citizens of AFO rules and regulations; encourage a citizen led enforcement program (citizens monitor, report violations)
- Rigorously apply the Master Matrix to all permit applications
- ▪ Lobby DNR to strengthen MM standards.
- Develop public-private partnership with farmers, stakeholders in livestock value chain to voluntarily adopt/implement stronger standards/practices.
- Lobby legislators/governor (via ISAC, other interest groups) to
    - repeal § 331.304(A);
    - enact new environmental standards for feedlots;

- enact new laws granting counties more authority in permitting/regulating feedlots

Appendix B: County Role as Drainage District Trustees

The following recommendations are not known to contradict Iowa drainage law or county authority. If the County decides to adopt these measures in whole or part, legal counsel should be consulted.

Introduction

Currently, there are 122 Drainage Districts in Story County, which comprise ~48% of the land area of the County (Figure 52 Story County Drainage District Map). Drainage districts have been established for the drainage of surface waters from agricultural and other lands for the protection of said lands from overflow when said protection is a public benefit or is conducive to public health, convenience, and welfare (Section 468.2, State Code of Iowa).

The County Supervisors act as Drainage District Trustees, therefore they make decisions on district maintenance and improvements on behalf of the district landowners. County staff and contractors are responsible for maintaining and/or improving district facilities. Efforts are forced account labor against district balances (levies to district landowners).

The property owners within a drainage district's boundaries are the actual owners and they are financially responsible for the tile and the ditches in the district. The Drainage District clerk, and ultimately Story County is responsible for taking minutes at drainage district meetings and maintaining the county's drainage district maps and records. Generally, under the Code of Iowa, Chapter 468, the County Board of Supervisors acts as Drainage District Trustees in all district matters. However, the land owners of a particular district may, if they wish, elect their own trustees and maintain the district themselves. Property owners within a district pay for all its maintenance and repairs. The County Engineer's Office or an independent contractor hired by the trustees will do the work and bill the cost to the district. Members of the district pay based on the proportion of the original percent of benefit of their property to the original assessed benefit of the entire district. Drainage districts are established by the Drainage District Trustees at the request of the land owners within the proposed district (Section 468.6-468.8). Petitions and actions to establish are kept in the minute books in the county auditor's office.

The balance of the agricultural lands outside of a Drainage District are either undrained or privately drained. In this setting the County Auditor and subsequently the County is responsible for administering hearings when property owners who may be affected and determining any compensation to affected property owners. The County is also responsible for deciding disputes between adjoining landowners.

As County Supervisors administer drainage, increasingly more attention is being given to the environmental impacts of drainage restoration and improvement projects across Iowa, but only modest gains have been realized to date. To accelerate Story County on this front the following recommendations are advanced to foster more sustainable drainage within the confines of Iowa Drainage Law.

Background and Need[1]

Iowa is blessed with rich soils and climate that allows bountiful crop production for food and bio-fuel. Yet our croplands “leak” crop nutrients to Iowa streams and eventually to the Gulf of Mexico. In addition to adversely affecting water quality in Iowa, these crop nutrients contribute to hypoxia in the Gulf of Mexico. Addressing hypoxia requires reducing both nitrogen and phosphorus to the Gulf by 45%, which cannot be achieved by just reducing application of crop fertilizers. Large reductions in nitrogen and phosphorus pollution may, however, be achieved with a combination of: (1) reduced nutrient sources/availability; (2) increased plant uptake; (3) reduced runoff of nitrogen and phosphorus entering the stream; and (4) increased denitrification.

Flat, tile-drained lands are some of Iowa’s most productive soils. In the early 1900’s, Iowa landowners spent more to install the drainage tiles in Iowa’s 3,000 drainage districts than the entire U.S. investment in the Panama Canal. Tile-drained agricultural lands create less water quality problems overall than more steeply sloping soils. Yet tile-drained lands contribute a significant amount of the nitrate that enters streams and lakes. Iowa’s 3,000 drainage district systems are now nearly 100 years old, and are beginning to fail. Most will need to be replaced by 2050 at an estimated cost of $6 billion.

A redesigned multi-purpose drainage management system, which incorporates Best Management Practices, will contribute environmental benefits. Best Management Practices (BMPs) are structural and non-structural practices that minimize water quality and quantity impacts within a public drainage system, downstream streams and lakes, and the larger watershed. Benefits of BMPs include reduced surface runoff and stormwater generation, effective erosion and sediment control, reduced phosphorous delivery, and reduced transport of agricultural chemicals. Wetlands, buffers, and other Best Management Practices will significantly increase landscape diversity, increase habitat for fish and wildlife, create recreational opportunities, and provides significant water quality benefits.

Furthermore, a redesigned multi-purpose drainage management system may have the potential to increase the capacity of tile drainage outlets. Research from Iowa State University indicates Iowa’s drained lands are losing 7% to 20% of potential crop yields due to excessive soil wetness, especially in the spring. Increasing the capacity of tile drainage outlets will reduce these losses and increase yields and crop income, which serve as a market driver to achieve the related environmental and ecological service benefits.

With the pending rebuild of Iowa’s aging drainage infrastructure and the advancement in multi-purpose drainage management, the time to improve the environmental and economic condition both locally and regionally is upon the drainage districts of Iowa. To foster this change the following recommendations are advanced to Story County.

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[1] This section adopted from Iowa Wetland Landscape Systems Initiative

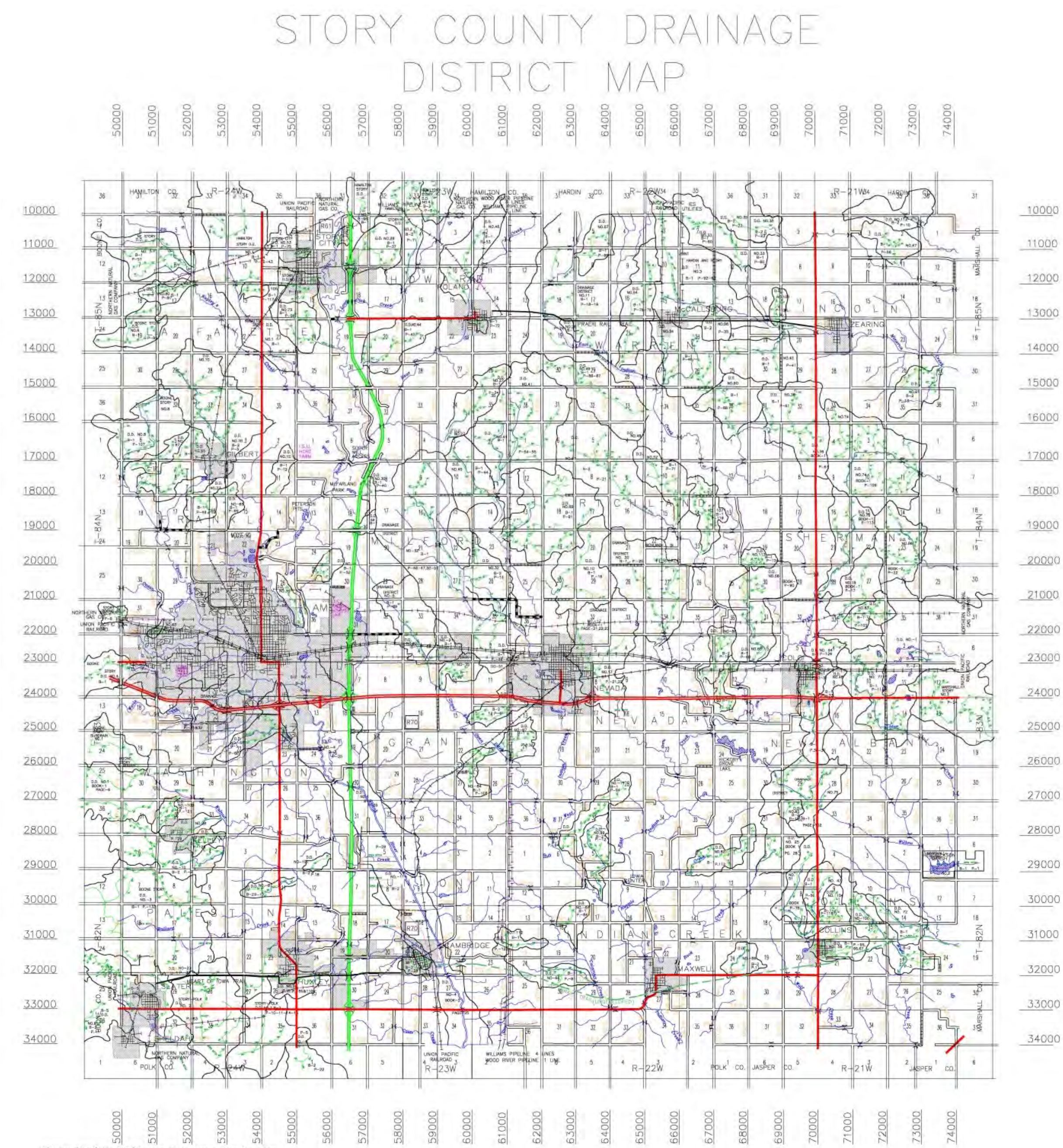

Figure 52 Story County Drainage District Map

Drainage Planning and Implementation

The 2017 Iowa Farm and Rural Life Poll[2] asked farmers “compared to other farm operations in your area, how well do you think your farm operation is performing in controlling soil erosion”? The responses seem to indicate that farmers resoundingly believe their practices were superior [69% above average] to their neighbors. This performance is not statistically possible and reinforces that further education,

[2] Iowa Farm and Rural Life Poll: 2017 Summary Report

incentives, professional assistance and likely regulation is necessary to foster further conservation. As such the following drainage planning and implementation recommendations are offered.

Information Gathering and Dissemination

Feasibility studies should be undertaken for all potential drainage restoration and improvement projects when the cost to implement will exceed $15,000 or 75% of the original assessed benefit of the district, whichever is greater[3]. The study shall identify options and estimate associated cost and benefits. Furthermore, the preliminary studies shall address the following requirements stated under the Information Gathering and Dissemination and Procedural Recommendations sections.

Create and publicly disseminate water quality and water quantity calculations/models of proposed drainage restorations and improvements to articulate the impacts and benefits of alternatives to project proposers and stakeholders. The information should also be readily available to the general public.

Planning Requirements – all planning documents should illustrate/address the following for the benefit of all stakeholders:

- Identify and describe animal feedlots and identify the risk to downstream resources.
- Identify the location, type and functions and values of all wetlands (farmed, non-farmed and all Circular 39 classes) within proposed/rehabilitated drainage area
- Lateral effect of drainage on wetlands
- Reference County erosion and sediment control ordinances and encourage/require the use of erosion and sediment control BMPs throughout construction activities

Procedural Recommendations

More specific expectations and requirements on erosion and sediment control from beginning construction to permanent establishment are warranted for all drainage projects.

- Erosion control BMPs (e.g. temporary seeding, phased construction, erosion control blanket, etc.) should be required for all drainage restoration and improvement projects.
- These requirements should be explicitly stated and codified in the County ordinance.

Encourage/require the use of buffers, to the maximum extent allowed by state law, on wetlands, streams and drainage ditches.

More specific requirements and standards on the establishment of permanent vegetative cover within the vicinity of the ditch are warranted. The following requirements should be advanced to maximize water quality and habitat returns:

- Utilize seed mixes comprised of suitable nurse crop and native herbaceous species sourced from local ecotype (within 200 mile radius of site). Given the common 'severe condition' of drainage ditches low diversity mixes comprised of less conservative species should be utilized.

- Establishment and maintenance plan submittal requirements noting the particular challenges with establishing native cover within drainage ditches.
- Stated expectations on timing (prompt cover establishment) and condition (species composition) of establishment.
- These requirements should be explicitly stated and codified in the County ordinance

Beyond encouraging landowners to consider multi-purpose drainage management, which incorporate BMPs, the County should establish expectations for such management associated with all drainage restoration and improvement projects. Such opportunities should be identified and accounted for via preliminary feasibility study(s).

Defining Roles and Responsibilities

The aforementioned Feasibility Study shall be undertaken by the respective Drainage District. Compliance is the responsibility of the County Drainage Clerk and ultimately the County Board of Supervisors. Proposals outside of a drainage district, shall be the responsibility of the County.

The County should establish authority to ensure erosion and sediment control is timely and effective implemented, that permanent vegetative cover is successfully established, that and stormwater is managed with Low Impact Development BMPs, in all public and private developments, to the maximum extent allowed by state law. This can be accomplished by adopting ordinances that allow the County to:

- Require financial assurances;
- Regularly inspect projects;
- Issue stop work orders;
- Take action to establish erosion and sediment control BMPs in emergencies and when BMPs are not adequately installed, maintained, or operated; and
- Assess the cost of remedial/emergency activities to the property owner

The County should promote multipurpose drainage management BMPs:

- Proactively identify projects,
- Articulate local water resource conditions and the need for and benefit of multipurpose drainage management, and
- Off-set cost share funding for landowners.

Multi-purpose drainage management systems are the individual practices suitable to this landscape, which could be integrated into drainage systems in order to reduce erosion and sedimentation, reduce peak flows and flooding, and improve water quality, while protecting drainage system efficiency and reducing drainage system maintenance. They are typically Edge-Of-Field practices, but note that a balanced drainage system should also include In-Field practices as well. Edge-Of-Field practices are typically larger, sometimes structural practices that are terrain dependent. In contrast to the in-field practices, these BMPs can only be installed in areas that support them.

The following BMPs, which are part of the Agricultural Conservation Practice Framework (ACPF) toolset and described in greater detail in Section 4.3, are strongly encouraged to be incorporated into the County's drainage systems:

- Drainage Water Management
- Nutrient Removal Wetlands
- Denitrification Bioreactors
- Water and Sediment Control Basins (WASCOBs)
- Riparian Buffers
- Grassed Waterways
- Saturated Buffers

In addition to the BMPs sited in the ACPF analysis, the following are alternative approaches for delivery of water to the ditch or options for refining ditch design to provide water quality, habitat and flood storage benefit.

- Drainage Water Recycling
- Two Stage Ditches

<u>Drainage Water Recycling:</u> Drainage water recycling (also commonly referred to as a Closed-Loop System), diverts surface and subsurface drainage water into on--farm ponds or reservoirs, where it is stored until it can be used by the crop later in the season. Tile drainage occurs mostly in the spring, while crop water use in mid- to late summer may result in periods when insufficient water is available. Drained water stored in the spring can provide value to crops in the summer. Drainage water recycling can be a closed loop system where the drained water from a field is recirculated onto the same field, or water drained from one field can be used to irrigate a different field. Irrigation may be through subirrigation that raises the soil water table by flooding the subsurface drain tiles (above), or sprinkler systems such as a center pivot, or other technologies.

<u>Two-Stage Ditch:</u> This design incorporates a floodplain zone, called benches, into the ditch by removing the ditch banks roughly 2-3 feet above the bottom for a width of about 10 feet on each side. This allows the water to have more area to spread out on and decreases the velocity - or energy - of the water. The flow of that water is a function of the velocity and area of the water. And since flow can be considered as the amount of water moving through the ditch, the design has actually increased the amount of water that the ditch can process by constructing the benches, or floodplain area. This not only improves the water quality, but also improves the biological conditions of the ditches where this is located.

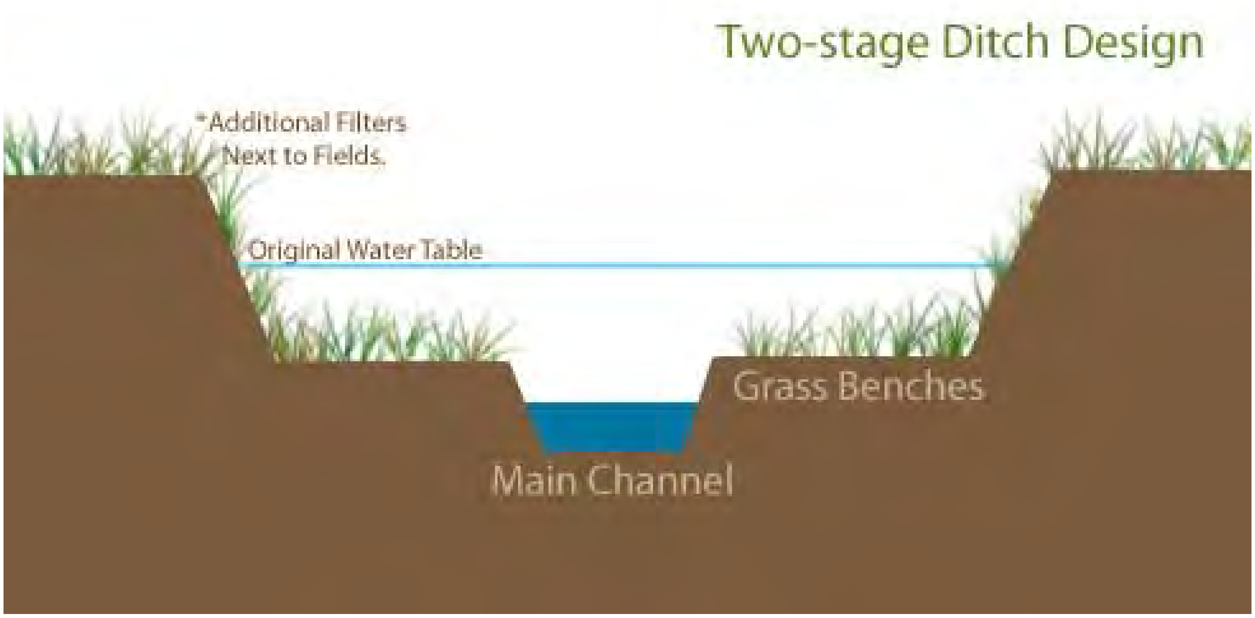

Figure 53 – Schematic cross section of a Two-Stage Ditch. Image courtesy of the Nature Conservancy.

Appendix C: County Road Authority Role: Stream Crossings[4]

Although public awareness of environmental issues is rapidly expanding across Iowa, few road authorities consider the effects of road crossings and other infrastructure on water quality and in-stream habitat. The design and condition of a stream crossing determines whether a stream behaves naturally and whether biota can survive along the stream corridor. Stream continuity is rarely considered in the design and construction of stream crossings like culverts and bridges. Many crossings are barriers to fish and wildlife. Even crossings that were not barriers when originally constructed may now be barriers because of stream erosion, mechanical breakdown of the crossings, or changes in the upstream or downstream channel shape. Fortunately, experience has taught specialists how to design stream crossings that allow wildlife unrestricted access to a watershed, maintain natural stream conditions, while also protecting roads and property from floods. There are three primary types of stream crossing problems: (1) undersized crossings, (2) shallow crossings, and (3) crossings that are perched. All three can be barriers to fish and wildlife and lead to negative consequences for water quality and stream habitat. Recognizing poor stream crossings and their consequences is an important step in evaluating whether a crossing should be fixed or replaced.

- Undersized crossings restrict natural stream flow, particularly during high flows, causing channel scouring and erosion, high velocity flows, clogging, ponding, and in some cases, washouts.
    - Crossings should be large enough to pass fish, wildlife, and high flows.
- Shallow crossings have water depths too low for many organisms to move through them and may lack appropriate bed material.
    - Crossings should have an open bottom or should be buried into the streambed to allow for substrate and water depths that are similar to the surrounding stream.
- Perched crossings are above the level of the stream bottom at the downstream end. Perching can result from either improper installation or from years of downstream bed erosion.
    - Crossings should be open-bottomed or sunk in the bed to prevent perching.

The following general guidance can accommodate wildlife and protect stream health while reducing expensive erosion and structural damage.

Type of Crossing

- General: Spans (bridges, 3-sided box culverts, open-bottom culverts or arches) are strongly preferred.
- Optimum: Use a bridge.

Embedment

- All culverts should be embedded (sunk into stream) a minimum of 2 feet below grade, and round pipe culverts at least 25% of the diameter of the pipe culvert.
    - If pipe culverts cannot be embedded this deep, then they should not be used.

[4] This section adopted from the Massachusetts Stream Crossings Handbook

- When embedment material includes elements > 15" diameter, embedment depths should be at least twice the D_{84} (particle width larger than 84% of particles) of the embedment material.

Crossing Span Length

- General: Spans channel width (a minimum of 1.2 times the bankfull width[5] of the stream).
- Optimum: Spans the streambed and banks (at least 1.2 times bankfull width[6]) with sufficient headroom to provide dry passage for terrestrial wildlife.

Openness

- General: Openness ratio (cross-sectional area/crossing length) of at least 0.82 feet. The crossing should be wide and high relative to its length. Optimum: Openness ratio of at least 1.64 feet and minimum height of 6 feet. If conditions significantly reduce wildlife passage near a crossing (e.g., steep embankments, high traffic volumes, and physical barriers), maintain a minimum height of 6 feet, and an openness ratio of 2.46 feet.

Substrate

- Natural bottom substrate should be used within the crossing and it should match the upstream and downstream substrates. The substrate and design should resist displacement during floods and maintain an appropriate bottom during normal flows.

Water Depth and Velocity

- Water depths and velocities are comparable to those found in the natural channel at a variety of flows.

[5] Channel width at bankfull discharge (the dominate channel forming flow with a recurrence interval seldom outside the 1 to 2 year range.

[6] Channel width at bankfull discharge (the dominate channel forming flow with a recurrence interval seldom outside the 1 to 2 year range.

Figure 54 Example of a well-executed stream crossing. Graphic courtesy of the Commonwealth of Massachusetts

Appendix D: Model Stormwater Ordinance

Model Stormwater Ordinance 2/23/2016

1) **Authorization, Purpose, Scope, and Interpretation**
   A) **Statutory authorization**
      1) This ordinance is adopted pursuant to the authorization and policies contained in Chapter 335 and Chapter 354 of the Code of Iowa, as amended.
      2) This ordinance is intended to meet the construction site erosion and sediment control and post-construction stormwater management regulatory requirements for construction activity and small construction activity (NPDES Permit) as defined in 40 CFR 122.26(b)(14)(x) and (b)(15), respectively.
   B) **Purpose**
      1) The purpose of this ordinance is to establish regulatory requirements for land development and land disturbing activities aimed at minimizing the threats to public health, safety, public and private property and natural resources within the [Local Jurisdiction] from construction site erosion and post-construction stormwater runoff. Specifically, the ordinance establishes regulatory requirements that:
         (1) Assist in meeting NPDES/SDS Construction Stormwater General Permit requirements;
         (2) Assist in meeting Total Maximum Daily Load (TMDL) plan waste load allocations for impaired waters through quantification of load reductions;
         (3) Protect life and property from dangers associated with flooding;
         (4) Protect public and private property and natural resources from damage resulting from stormwater runoff and erosion;
         (5) Ensure site design minimizes the generation of stormwater runoff and maximizes pervious areas for stormwater treatment within the context of the allowable use;
         (6) Provide a single, consistent set of performance goals that apply to all developments;
         (7) Protect water quality from pollutant loadings of sediment, suspended solids, nutrients, heavy metals, toxics, debris, bacteria, pathogens, biological impairments, thermal stress and other pollutants;
         (8) Promote infiltration and groundwater recharge;
         (9) Provide vegetated corridors (buffers) to protect water resources from development;
         (10) Protect functional values of all types of natural waterbodies (e.g. rivers, streams, wetlands, lakes, seasonal ponds); and
         (11) Sustain or enhance biodiversity (native plant and animal habitat) and support riparian ecosystems.
   C) **Scope**
      1) Land shall not be developed for any use without providing erosion and sediment control measures prevent erosion and sedimentation, and stormwater management measures that reduce and treat stormwater runoff.
   D) **Greater restrictions**

1) Relationship to other requirements - All stormwater management and erosion and sediment control activities shall comply with all applicable requirements of the relevant local, state, and federal authorities. In the case of conflict between provisions of this ordinance and other stormwater regulations, the strictest provisions shall apply.
2) Relationship to Existing Easements, Covenants, and Deed Restrictions – The provisions of this ordinance are not intended to repeal, abrogate, or impair any existing easements, covenants, or deed restrictions. However, where this ordinance imposes greater restrictions the provisions of this ordinance shall prevail.

E) **Severability**

1) The provisions of this ordinance are severable, and if any provision of this ordinance, or application of any provision of this ordinance to any circumstance, is held invalid, the application of such provision to other circumstances, and the remainder of this ordinance shall not be affected thereby.

2) Applicability

A) **Erosion and Sediment Control Plan**

1) Unless otherwise exempted by this ordinance, an Erosion and Sediment Control Plan (ESCP) shall be required as part of any Grading or Building Permit which proposes land development or land disturbing activity that meets any of the criteria in a. through d. below:
   (1) Any project undertaking grading, filling, or other land disturbing activities that involves 100 cubic yards of earth;
   (2) Any project that disturbs greater than 10,000 square feet of land;
   (3) Any project with wetland impacts, grading within public waters, grading within buffers; or grading within 40-feet of the bluff line;
   (4) A land disturbing activity, regardless of size, that the [Local Jurisdiction] determines is likely to cause an adverse impact to an environmentally sensitive area or other property, or may violate any other erosion and sediment control standard.

B) **Stormwater Management Plan**

1) Unless otherwise exempted by this ordinance, an approved Stormwater Management Plan (SMP) shall be required prior to land development or land disturbing activity that meets any of the criteria in a. through e. immediately below:
   (1) Any project that creates or reconstructs 6,000 square feet or more of impervious surface.
   (2) All major and minor subdivisions or subdivision of land that is part of a common plan of development.
   (3) Projects adjacent to Designated Waters that create or add 500 square feet or greater of additional impervious surface to a site.
   (4) Any project requiring a variance from the current local impervious surface zoning requirements for the property.
   (5) Any land development activity, regardless of size, that the [Local Jurisdiction] determines is likely to cause an adverse impact to an environmentally sensitive area or other property.

2) All stormwater management plans shall include an Erosion and Sediment Control Plan (ESC Plan).

C) **Buffers**

1) A buffer of unmowed, natural vegetation shall be required upslope of wetlands, lakes and streams prior to the approval of any proposed land development requiring a subdivision, lot split, rezoning, special use permit, or variance, unless otherwise exempted in this ordinance.

D) **Exemptions**

1) The following activities shall be exempt from all of the requirements of this ordinance:

(1) Emergency work necessary to protect life, limb, or property.

(2) Routine agricultural activity such as tilling, planting, harvesting, and associated activities. Other agricultural activities are not exempt, including activities such as construction of structures.

(3) Silviculture/forestry activity.

3) Definitions

1) Words or phrases used in this ordinance shall have the meanings as defined below.

2) If not defined in this ordinance, the words or phrases used in this ordinance shall be interpreted to have the meanings they have in Appendix B of the Iowa Construction Stormwater Permits.

3) Words or phrases used in this ordinance shall be interpreted so as to give this ordinance its most reasonable application.

4) For the purpose of this ordinance, the words "must", "shall", and "will" are mandatory and not permissive or discretionary.

Applicant. The owner of land submitting an application under the provisions of this ordinance for a Stormwater Management Permit (SMP) and/or Erosion and Sediment Control Plan (ESCP) to be issued by the community.

Best Management Practices (BMPs). The most effective and practicable means of erosion prevention and sediment control, and water quality management practices that are the most effective and practicable means to control, prevent, and minimize degradation of surface water, including avoidance of impacts, construction-phasing, minimizing the length of time soil areas are exposed, prohibitions, pollution prevention through good housekeeping, and other management practices published by state or designated area-wide planning agencies.

Better Site Design. The control and management of stormwater quantity and quality through the application of site design techniques as outlined in the current version of the Iowa Storm Water Manual. Better Site Design includes: preservation of natural areas; site reforestation; stream and shoreland buffers; open space design; disconnection of impervious cover; rooftop disconnection; grass channels; stormwater landscaping; compost and amended soils; impervious surface reduction; and trout stream protection.

Common Plan of Development or Sale. A contiguous area where multiple separate and distinct land disturbing activities may be taking place at different times, on different schedules, but under one proposed plan. One plan is broadly defined to include design, permit application, advertisement or physical demarcation indicating that land-disturbing activities may occur.

Construction Activity. Includes construction activity as defined in 40 CFR pt. 122.26(b)(14)(x) and small construction activity as defined in 40 CFR pt. 122.26(b)(15). This includes a disturbance to the land that results in a change in the topography, existing soil cover (both vegetative and non-vegetative), or the existing soil topography that may result in accelerated stormwater runoff, leading to soil erosion and movement of sediment into surface waters or drainage systems. Examples of construction activity may include clearing, grading, filling, and excavating. Construction activity includes the disturbance of less than one acre of total land area that is a part of a larger common plan of development or sale if the larger common plan will ultimately disturb one (1) acre or more. Construction activity does not include a disturbance to the land of less than five (5) acres for the purpose of routine maintenance that is performed to maintain the original line and grade, hydraulic capacity, or original purpose of the facility. (NOTE – The community may wish to change this to a smaller disturbance area. A smaller area is more restrictive than the state/federal requirements, so it would be allowable for a local government.)

Development, New. Any development that results in the conversion of land that is currently prairie, agriculture, forest, or meadow and has less than 15% impervious surface. Land that was previously developed, but now razed and vacant, will not be considered new development.

Erosion and Sediment Control Plan (ESC Plan). A plan for projects disturbing less than one acre or meets the standards described in Section 2. The plan identifies erosion prevention and sediment control practices, locations, and timelines for installation of best management practices. The plan also includes responsible parties, best management installation timelines, and descriptions of inspection and maintenance activities.

Erosion Prevention. Measures employed to prevent erosion. Examples include, but are not limited to: soil stabilization practices, limited grading, mulch, temporary erosion protection, silt fences, stabilized entrances, permanent cover, and construction phasing.

Fully Reconstructed Impervious Surface. Areas where impervious surfaces have been removed down to the underlying soils. Activities such as structure renovation, mill and overlay projects, and pavement rehabilitation projects that do not alter underlying soil material beneath the structure, pavement, or activity are not considered fully reconstructed impervious surfaces. Reusing the entire existing building foundation and re-roofing of an existing building are not considered fully reconstructed.

Impervious Surface. A constructed hard surface that either prevents or retards the entry of water into the soil and causes water to run off the surface in greater quantities and at an increased rate of flow than prior to development. Examples include rooftops, sidewalks, patios, driveways, parking lots, storage areas, and concrete, asphalt, or gravel roads.

Land Disturbance. Any activity that results in a change or alteration of the existing ground cover (both vegetative and non-vegetative) or the existing topography. Land disturbing activities include, but are not limited to, development, redevelopment, demolition, construction, reconstruction, clearing, grading, filling, stockpiling, excavation, and borrow pits. Routine vegetation management, and mill and overlay/resurfacing activities that do not alter the soil material beneath the pavement base, are not considered land disturbance. In addition, other maintenance activities such as catch basin and pipe repair/replacement, lighting, and pedestrian ramp improvements shall not be considered land disturbance for the purposes of determining permanent stormwater management requirements.

Linear Project. Construction or reconstruction of roads, trails, sidewalks, and rail lines that are not part of a common plan of development or sale. Mill, overlay and other resurfacing projects are not considered to be reconstruction.

Major Subdivision. All subdivisions not classified as minor subdivisions including, but not limited to, subdivisions of four (4) or more lots, or any size subdivision requiring any new street or extension of an existing street.

Minor Subdivision. Any subdivision containing three (3) or less lots fronting on an existing street, not part of a common plan of development nor involving any new street or road or the extension of municipal facilities.

National Pollutant Discharge Elimination System (NPDES). The program for issuing, modifying, revoking, reissuing, terminating, monitoring, and enforcing permits under the Clean Water Act (Sections 301, 318, 402, and 405) and United States Code of Federal Regulations Title 33, Sections 1317, 1328, 1342, and 1345.

Owner. The person or party possessing the title of the land on which the construction activities will occur; or if the construction activity is for a lease, easement, or mineral rights license holder, the party or individual identified as the leasee, easement or mineral rights license holder; or the contracting government agency responsible for the construction activity.

Permanent Cover. Surface types that will prevent soil failure under erosive conditions. Examples include: gravel, asphalt, concrete, rip rap, roof tops, perennial vegetation, or other landscaped material that will permanently arrest soil erosion. Permanent cover does not include the practices listed under temporary erosion protection.

Permittee. A person or persons, firm, or governmental agency or other entity that signs the application submitted to the [Local Jurisdiction] and is responsible for compliance with the terms and conditions of the permit.

Predevelopment State. The rate and volume of stormwater is unchanged. The calculation of predevelopment is based on native soils and vegetation.

Public Waters. All water basins and watercourses that are described in Iowa Code subsection 455B.262(3).

Redevelopment. Any development that is not considered new development.

Retain. Manage stormwater on site using a Low Impact Development (LID) approach so that the rate and volume of predevelopment stormwater reaching receiving waters is unchanged.

Saturated Soil. The highest seasonal elevation in the soil that is in a reduced chemical state because of soil voids being filled with water. Saturated soil is evidenced by the presence of redoximorphic features or other information.

Sediment Control. Methods employed to prevent sediment from leaving the site. Sediment control practices include: silt fences, sediment traps, earth dikes, drainage swales, check dams, subsurface drains, bio rolls, rock logs, compost logs, storm drain inlet protection, and temporary or permanent sedimentation basins.

Stormwater Facility. A stationary and permanent BMP that is designed, constructed, and operated to prevent or reduce the discharge of pollutants in stormwater.

Small Construction Activity. As defined in 40 CFR part 122.26(b)(15). Small construction activities include clearing, grading, and excavating that result in land disturbance equal to or greater than one acre and less than five acres. Small construction activity includes the disturbance of less than one (1) acre of total land area that is part of a larger common plan of development or sale if the larger common plan will ultimately disturb equal to or greater than one and less than five (5) acres.

Stabilized. Exposed ground surface covered by appropriate materials such as mulch, staked sod, riprap, erosion control blanket, mats, or other material that prevents soil erosion. Grass, agricultural crops, or other seeding alone is not stabilization. Mulch materials must achieve approximately 90 percent ground coverage (typically 2 ton/acre).

Stormwater. As defined by the Iowa Storm Water Manual, and includes precipitation runoff, stormwater runoff, snowmelt runoff, and any other surface runoff or drainage.

Stormwater Management Plan (SMP). A plan for stormwater discharge that includes temporary and permanent stormwater management systems that, when implemented, will reduce volumes and rates of stormwater discharge while also reducing the number and type of pollutants in stormwater discharges.

Surface Water(s). All streams, lakes, ponds, marshes, wetlands, reservoirs, springs, rivers, drainage systems, waterways, watercourses, and irrigation systems whether natural or artificial, public or private, except that surface waters do not include treatment basins or ponds that were constructed.

Temporary Erosion Protection. Methods employed to prevent erosion during development and land disturbing activities. Examples of temporary erosion protection include; straw, wood fiber blanket, wood chips, vegetation, mulch, and rolled erosion control products.

Underground Waters (Groundwater). Water contained below the surface of the earth in the saturated zone including, without limitation, all waters whether under confined, unconfined, or perched conditions, in near surface unconsolidated sediment or regolith, or in rock formations deeper underground. The term groundwater shall be synonymous with underground water.

Wetland(s). As defined in Iowa Code § 456B.1(5) and includes those areas that are inundated or saturated by surface water or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas. Constructed wetlands designed for wastewater treatment are not waters of the state. Wetlands must have the following attributes:

1) A predominance of hydric soils.
2) Inundated or saturated by surface water or groundwater at a frequency and duration sufficient to support a prevalence of hydrophytic vegetation typically adapted for life in a saturated soil condition.
3) Under normal circumstances support a prevalence of such vegetation.

2) Permit Review Process

A) Pre-application meeting

At the discretion of the Zoning Administrator, the [Local Jurisdiction] shall facilitate a pre-application meeting with the Applicant, [Local Jurisdiction] staff (or its authorized representative), and staff of relevant partner agencies (e.g. Iowa DNR, etc.). The purposes of the meeting are to understand the general parameters of the proposed project and to convey the ordinance's requirements.

B) Application completeness review

The [Local Jurisdiction] shall make a determination regarding the completeness of a permit application and notify the Applicant in writing if the application is not complete, including the reasons the application was deemed incomplete.

C) Application review

The Applicant shall not commence any construction activity subject to this ordinance until a permit has been authorized by the [Local Jurisdiction].

D) Permit authorization

If the [Local Jurisdiction] determines that the application meets the requirements of this ordinance, the [Local Jurisdiction] may issue approval authorizing the project or activity. The approval shall be valid for one year from the date of approval.

E) Permit denial

If the [Local Jurisdiction] determines the application does not meet the requirements of this ordinance the application must be denied. If the application is denied, the Applicant will be notified in writing including reasons for the denial. Once denied, a new application must be submitted for approval before any activity may begin.

F) Plan information requirements

The minimum information requirements of the application shall be consistent with the requirements in the most recent version of the NPDES/SDS Construction Stormwater General Permit and any other applicable local, state, or federal performance standards.

G) Modification of permitted plans

If any of the following circumstances occur on a site with an approved ESCP or SMP, the Applicant shall apply for an amendment to the associated permit(s), submitting all updated materials, reflecting the needed changes; the review of the amended materials shall use the same process as a new submittal, as designated in this ordinance:

1) There is a change in design, construction, operation, maintenance, weather or seasonal conditions that has a significant effect on the discharge of pollutants to surface water or underground water.
2) Inspections or investigations by site operators, local, state, or federal officials indicate the plans are not effective in eliminating or significantly minimizing the discharge of pollutants to surface water or underground water or that the discharges are causing water quality standard exceedances.
3) The plan is not achieving the general objectives of erosion and sediment control or minimizing pollutants in stormwater discharges associated with development or land disturbing activity.

H) Permit completion

Before work under the permit is deemed complete, the permittee must submit as-builts, a long-term maintenance plan, and information demonstrating that the stormwater facilities conform to design specifications.

3) Site Design and MIDS Calculator

A) Better Site Design

Whenever possible, development projects shall be designed using site design techniques and other site design best practices provided by the current version of the Iowa Department of Natural Resources Storm Water Manual.[7]

B) Unified Sizing Criteria

Final site design and choice of permanent stormwater practices shall be based on outcomes of the calculations provided by the Unified Sizing Criteria in Iowa DNR's Storm Water Manual (or other model that shows the performance goal can be met) and shall meet the standards in Section 7 of this ordinance.

4) Stormwater Volume Reduction Performance Standards

Any Applicant for a Stormwater Management Plan as defined in Section 2 of this ordinance must meet all of the following performance standards:

A) New development volume control

For new, nonlinear developments on sites without restrictions, stormwater runoff volumes will be controlled and the post-construction runoff volume shall be retained on site for 1.25 inches of runoff from all impervious surfaces on the site.

B) Redevelopment volume control

Nonlinear redevelopment projects on sites without restrictions that create or fully reconstruct impervious surfaces shall capture and retain on site 1.25 inches of runoff from all new or fully reconstructed impervious surfaces.

C) Linear development volume control

1) Linear projects on sites without restrictions that create new or fully reconstructed impervious surfaces, shall capture and retain the larger of the following:
    (1) 0.63 inches of runoff from the new and fully reconstructed impervious surfaces on the site
    (2) 1.25 inches of runoff from the net increase in impervious area on the site.

D) Flexible treatment alternatives for sites with restrictions

Applicant shall attempt to comply fully with the appropriate performance standards described above. Alternatives considered and presented shall examine the merits of relocating project elements to address, varying soil conditions and other constraints across the site. Volume reduction techniques considered shall include infiltration, reuse & rainwater harvesting, canopy interception and evapotranspiration, or other proven techniques. First priority shall be given to BMPs that include volume reduction. Second priority is to employ filtration techniques, followed by rate control BMPs.

If full compliance is not possible due to any of the factors listed below, the Applicant must document the reason. Applicant shall document the flexible treatment alternatives sequence starting with Alternative #1. If Alternative #1 cannot be met, then Alternative #2 shall be analyzed. Applicants must document the specific reasons why Alternative #1 cannot be met based on the factors listed below. If Alternative #2 cannot be met then Alternative #3 shall be met. Applicants must document the specific reasons why Alternative #2 cannot be met based on the factors listed

[7] Available at http://www.iowadnr.gov/Environmental-Protection/Water-Quality/NPDES-Storm-Water/Storm-Water-Manual.

below. When all of the conditions are fulfilled within an alternative, the flexible treatment alternatives sequence is complete.

Factors to be considered for each alternative will include:

1) Karst geology;
2) Shallow bedrock;
3) High groundwater;
4) Hotspots or contaminated soils;
5) Proximity to public or private water supply systems;
6) Zoning, setbacks, or other land use requirements; or
7) Poor soils (infiltration rates that are too low or too high, problematic urban soils)

If site constraints or restrictions limit the full treatment goal, the following flexible treatment alternatives shall be used:

Alternative #1

Applicant attempts to comply with the following conditions:

1) Achieve at least 0.63" volume reduction from all impervious surfaces if the site is new development or from the new and/or fully reconstructed impervious surfaces for a redevelopment or linear development site.
2) Remove 75% of the annual TP load from all impervious surfaces if the site is new development or from the new and/or fully reconstructed impervious surfaces for a redevelopment site.
3) Options considered and presented shall examine the merits of relocating project elements to address, varying soil conditions and other constraints across the site.

Alternative #2

Applicant attempts to comply with the following conditions:

1) Achieve volume reduction to the maximum extent practicable.
2) Remove 60% of the annual TP load from all impervious surfaces if the site is new development or from the new and/or fully reconstructed impervious surfaces for a redevelopment site.
3) Options considered and presented shall examine the merits of relocating project elements to address, varying soil conditions and other constraints across the site.

Alternative #3 – Off-site Treatment

Mitigation equivalent to the performance of 1.1 inches of volume reduction for new development, linear development or redevelopment as described above in this section, (including banking or cash) can be performed off-site to protect the receiving water body. Off-site treatment shall be achieved in areas selected in the following order of preference:

1) Locations that yield benefits to the same receiving water that receives runoff from the original construction activity.
2) Locations within the same Department of Natural Resource (DNR) catchment area (Hydrologic Unit 08) as the original construction activity.
3) Locations within the next adjacent DNR catchment area upstream.

4) Locations anywhere within the [Local Jurisdiction]'s jurisdiction.

7) **Stormwater Rate Control**

A) For new development, redevelopment and linear development sites the site design shall provide on-site treatment during construction and post-construction to ensure no increase from existing conditions in offsite peak discharge for the 1-year, 2-year, 10- year, and 100-year,

B) 24-hour storm events based on the standards defined by NOAA Atlas 14. For single family residential building lots not part of a common plan of development site rate control requirements do not apply.

8) **Other Design Standards**

A) All volume control and water quality and quantity Best Management Practice design specifications shall conform to the current version of the NPDES/SDS Construction Stormwater General Permit.

B) Site erosion and sediment control requirements: All erosion and sediment control requirements shall conform to the current requirements of NPDES/SDS Construction Stormwater General Permit.

C) Where applicable, a minimum of 20' shall be provided on all sides of all publicly owned stormwater facilities for facility access and maintenance.

D) A uniform perennial vegetative cover (e.g. evenly distributed, without large bare areas) with a density of 70% of the native background vegetative cover for the area must be established on all unpaved areas and areas not covered by permanent structures. Equivalent permanent stabilization measures may be used with the approval of the [Local Jurisdiction].

9) **Inspections and Maintenance**

A) Inspections and record keeping

1) Applicant responsibilities
2) The Applicant is responsible for inspections and record keeping during and after construction for all privately-owned stormwater treatment practices on the site.
3) [Local Jurisdiction] inspections
4) The [Local Jurisdiction] reserves the right to conduct inspections on a regular basis to ensure that both temporary and permanent stormwater management and erosion and sediment control measures are properly installed and maintained prior to construction, during construction, and at the completion of the project.

B) Right of entry and inspection

1) **Powers** - The issuance of a permit constitutes a right-of-entry for the [Local Jurisdiction] or its authorized representative to enter upon the construction site. The Applicant shall allow, upon presentation of credentials, the [Local Jurisdiction] and its authorized representatives to:

(1) Enter upon the permitted site for the purpose of obtaining information, examining records, and conducting investigations or surveys;

(2) Bring such equipment upon the permitted development as is necessary to conduct such surveys and investigations;

(3) Examine and copy any books, papers, records, or memoranda pertaining to activities or records required to be kept under the terms and conditions of the permit;

(4) Inspect the stormwater pollution control measures;

(5) Sample and monitor any items or activities pertaining to stormwater pollution control measures; and

(6) Correct deficiencies in stormwater and erosion and sediment control measures.

C) Fees

1) Fees will be applied per [Local Jurisdiction] Fee Schedule

D) Enforcement tools/stop work orders

1) The [Local Jurisdiction] reserves the right to issue construction stop work orders when cooperation with inspections is withheld, or when a violation has been identified that needs immediate attention to protect human health or the environment.

(1) **Construction stop work order:** The [Local Jurisdiction] may issue construction stop work orders until stormwater management measures meet specifications and the Applicant repairs any damage caused by stormwater runoff. An inspection by the [Local Jurisdiction] must follow before the construction project work can resume.

(2) **Other actions to ensure compliance:** The [Local Jurisdiction] can take any combination of the following actions in the event of a failure by Applicant to meet the terms of this ordinance:

(a) Withhold inspections or issuance of certificates or approvals.

(b) Revoke any permit issued by the [Local Jurisdiction] to the Applicant.

(c) Conduct remedial or corrective action on the development site or adjacent site affected by the failure.

(d) Charge Applicant for all costs associated with correcting the failure or remediating damage from the failure. If payment is not made within thirty days, payment will be made from the Applicant’s financial securities.

(e) Bring other actions against the Applicant to recover costs of remediation or meeting the terms of this ordinance.

E) Long term inspection and maintenance of stormwater facilities

1) Private stormwater facilities

(1) **Maintenance Plan Required:** No private stormwater facilities may be approved unless a maintenance agreement is provided that defines who will conduct the maintenance, the type of maintenance necessary to ensure effective performance, and the maintenance intervals.

(2) **Facility Access:** The Applicant shall obtain all necessary easements or other property interests to allow access to the facilities for inspection or maintenance for both the responsible party and the [Local Jurisdiction] or authorized representative.

(3) **Removal of Settled Materials**: All settled materials including settled solids, shall be removed from ponds, sumps, grit chambers, and other devices as necessary and disposed of properly.

(4) **Inspections:** All stormwater facilities shall be inspected by the property owner at a frequency consistent with the maintenance plan and the performance goals for which the facility was originally designed. Inspection reports shall be provided to the [Local Jurisdiction] upon request.

2) Public stormwater facilities
   (1) **Acceptance of Publicly Owned Facilities**: A final inspection shall be required before the [Local Jurisdiction] accepts ownership of the stormwater facilities. Before work under the permit is deemed complete; the permittee must submit as-builts demonstrating at the time of final stabilization that the stormwater facilities conform to design specifications and a Maintenance Plan.
   (2) **Maintenance:** The [Local Jurisdiction] shall perform maintenance of publicly owned stormwater facilities in accordance with applicable stormwater management plans, maintenance plans, and other regulatory requirements.

10) Financial Securities

A) Amount

At its sole discretion, the [Local Jurisdiction] may require a Financial Security from the Applicant in an amount sufficient to cover the entirety of the estimated costs of permitted and remedial work based on the final design, as established in set financial security schedule determined by the [Local Jurisdiction].

B) Release

The Financial Security shall not be released until all permitted and remedial work is completed.

C) Use by [Local Jurisdiction]

The Financial Security may be used by the [Local Jurisdiction] to complete work not completed by the Applicant.

D) Form of security

The form of the Financial Security shall be one or a combination of the following, to be determined by the [Local Jurisdiction]:

1) **Cash deposit -** The cash will be held by [Local Jurisdiction] in a separate account.
2) **Security deposit -** Either with the [Local Jurisdiction], a responsible escrow agent, or trust company, at the option of the [Local Jurisdiction], either:
   (1) An irrevocable letter of credit, negotiable bonds of the kind approved for securing deposits of public money, or other instruments of credit from one or more financial institutions, subject to regulation by the state and federal government wherein the financial institution pledges funds are on deposit and guaranteed for payment.
   (2) Cash in U.S. currency.
   (3) Other forms and securities (e.g. disbursing agreement) as approved by the [Local Jurisdiction].

E) Indemnity

This Financial Security shall hold the [Local Jurisdiction] free and harmless from all suits or claims for damages resulting from the negligent grading, filling, removal, and placement or storage of rock, sand, gravel, soil or other like material within the [Local Jurisdiction].

F) Maintaining the financial security

If at any time during the course of the work the balance of the Financial Security falls below 50% of the total required deposit, the Applicant shall make another deposit in the amount necessary to restore the cash deposit to the required amount. If the Applicant does not bring the financial security back up to the required amount within seven (7) days after notification by the [Local

Jurisdiction] that the amount has fallen below 50% of the required amount, the [Local Jurisdiction] may:

1) **Withhold inspections -** Withhold the scheduling of inspections and/or the issuance of a Certificate of Occupancy.
2) **Revoke permits -** Revoke any permit issued by the [Local Jurisdiction] to the Applicant for the site in question or any other of the Applicant's sites within the [Local Jurisdiction]'s jurisdiction.

G) Proportional reduction of the financial security

1) When more than one-third of the Applicant's maximum exposed soil area achieves final stabilization, the [Local Jurisdiction] can reduce the total required amount of the financial security by one-third of the initial amount. When more than two-thirds of the Applicant's maximum exposed soil area achieves final stabilization, the [Local Jurisdiction] can reduce the total required amount of the financial security to two-thirds of the initial amount. This reduction in financial security will be determined by the [Local Jurisdiction].

H) Returning the financial security

1) The Financial Security deposited with the [Local Jurisdiction] for faithful performance of the SMP or the ESCP and any related remedial work shall be released one full year after the completion of the installation of all stormwater pollution control measures, including vegetation establishment, as shown on the SMP or ESCP.

I) Action against the financial security

The [Local Jurisdiction] may access the Financial Security for emergency or remedial actions if any of the conditions listed below exist. The [Local Jurisdiction] shall use the Financial Security to pay for remedial work undertaken by the [Local Jurisdiction], or a private contractor under contract with the [Local Jurisdiction], or to reimburse the [Local Jurisdiction] for all costs incurred in the process of remedial work including, but not limited to, staff time and attorney's fees.

1) **Abandonment -** The Applicant ceases land disturbing activities and/or filling and abandons the work site prior to completion of the grading plan.
2) **Failure to implement the SWPPP or ESC Plan** - The Applicant fails to conform to the grading plan and/or the SWPPP as approved by the [Local Jurisdiction].
3) **Failure to perform -** The BMPs utilized on the project fail within one year of installation.
4) **Failure to reimburse [Local Jurisdiction]** - The Applicant fails to reimburse the **[Local Jurisdiction]** for corrective action taken.

J) Emergency action

If circumstances exist such that noncompliance with this ordinance poses an immediate danger to the public health, safety and welfare, as determined by the [Local Jurisdiction], the [Local Jurisdiction] may take emergency action. The [Local Jurisdiction] shall also take every reasonable action possible to contact and direct the Applicant to take any necessary action. Any cost to the [Local Jurisdiction] for emergency action may be recovered from the Applicant's financial security.

11) Enforcement

A) Notification of Noncompliance with the Permit

1) The [Local Jurisdiction] shall notify the permit holder of noncompliance with the permit's requirements.

2) Initial Contact - The initial contact will be to the party or parties listed on the application and/or the SMP as contacts. Except during an emergency action, forty-eight (48) hours after notification by the [Local Jurisdiction] or seventy-two (72) hours after the failure of erosion and sediment control measures, whichever is less, the [Local Jurisdiction] at its discretion, may begin corrective work.
3) Notification should be in writing, but if it is verbal, a written notification must follow as quickly as practical. If after making a good-faith effort to notify the responsible party or parties, the [Local Jurisdiction] has been unable to establish contact, the [Local Jurisdiction] may proceed with corrective work. There are conditions when time is of the essence in controlling erosion. During such a condition the [Local Jurisdiction] may take immediate action, and then notify the Applicant as soon as possible.
4) Erosion Off-site - If erosion breaches the perimeter of the site, the Applicant shall immediately develop a cleanup and restoration plan, obtain the right-of-entry from the adjoining property owner, and implement the cleanup and restoration plan within forty-eight (48) hours of obtaining the adjoining property owner's permission. In no case, unless written approval is received from the [Local Jurisdiction], may more than seven (7) calendar days pass without corrective action being taken. If, in the discretion of the [Local Jurisdiction], the permit holder does not repair the damage caused by the erosion, the [Local Jurisdiction] may undertake the required remedial work. When restoration to wetlands and other resources are required, the Applicant shall be required to work with the appropriate agencies to ensure the work is done properly.
5) Erosion into Streets, Wetlands, or Water Bodies - If eroded soils (including tracked soils from construction activities) enter or appear likely to enter streets, wetlands, or other water bodies, cleanup and repair shall be immediate. The Applicant shall provide all traffic control and flagging required to protect the traveling public during the cleanup operations.
6) Failure to do Corrective Work - When an Applicant fails to conform to any provision of this ordinance within the time stipulated, the [Local Jurisdiction] may take the following actions.
   (1) Stop Work Order - Issue a stop work order, withhold the scheduling of inspections, and/or withhold the issuance of a Certificate of Occupancy.
   (2) Permit Revocation - Revoke any permit issued by the [Local Jurisdiction] to the Applicant for the site in question or any other of the Applicant's sites within the [Local Jurisdiction]'s jurisdiction.
   (3) Correction by [Local Jurisdiction] - Correct the deficiency or hire a contractor to correct the deficiency.
      (a) The Applicant will be required to reimburse the [Local Jurisdiction] for all costs incurred in correcting ESCP or SMP deficiencies. If payment is not made within thirty (30) days after costs are incurred by the [Local Jurisdiction], payment will be made from the Applicant's financial securities as described above.
      (b) If the amount available in the Applicant's financial securities is insufficient, the [Local Jurisdiction] may assess the remaining amount against the property.

B) Misdemeanor.

1) Any person, firm, agency, or corporation failing to comply with, or violating any provision of this ordinance, shall be deemed guilty of a misdemeanor and be subject to a fine or imprisonment, or both.
2) All land use and building permits may be suspended until the Applicant has corrected the violation.
3) Each day that a violation exists shall constitute a separate offense.

References

[i] North Central Region Water Network. The Agricultural Conservation Planning Framework (ACPF): A Watershed Planning Tool. [accessed 2018 Apr 26]. http://northcentralwater.org/acpf/.
[ii] Land Development Regulations: General Provisions and Definitions, Chapter 85 § 85.02(3)(b).
[iii] Land Development Regulations: General Site Planning Standards, Chapter 88 § 88.05(4).
[iv] General Site Planning Standards, § 88.11. Even this standard is difficult to understand and is likely inconsistently interpreted and applied. For instance, is the minimum amount of landscaping 20% of the lot, 20% of the impervious surface, according to what standard is "designed and placed to achieve maximum capture and filtration" interpreted?
[v] A great example is the Center for Watershed Protection's Codes and Ordinance Worksheet.
[vi] Flood Management Program, Chapter 80 § 80.05.
[vii] *Id.* at § 80.05 "Compliance." This section reads: "No structure or land shall hereafter be used and no structure shall be located, extended, converted or structurally altered without full compliance with the terms of this chapter and other applicable regulations that apply to uses within the jurisdiction of this chapter."
[viii] *Id*. at § 88.03. This study is available at http://www.starr-team.com/starr/RegionalWorkspaces/RegionVII/StoryCounty/Shared%20Documents/19169CV000B.pdf
[ix] *Id*. at § 80.11(2)(E).
[x] *Id*. at § 80.12(2) and the permitted uses and conditional uses of the applicable zoning district (Land Development Regulations: District Requirements, Chapter 86; Land Development Regulations: Conditional Uses, Chapter 90).

[xi] An Animal Unit is defined as "a unit of measurement based upon the product of multiplying the number of animals of each category by a special equivalency factor." For instance, the special equivalency factor for "Mature Dairy Cattle" is 1.400; for sheep or lambs it is 0.100. See Iowa Code § 459.102 (2017).
[xii] *Goodell v. Humboldt County*, 575 N.W.2d 486 (Iowa 1998)
[xiii] Iowa Constitution, Article III, section 39A, *available at* http://publications.iowa.gov/9883/1/CONSTITUTION_OF_THE_STATE_OF_IOWA.pdf. Home rule powers are described by Iowa Code § 331.301. Home Rule is a legal concept that grants governmental subdivisions (i.e. counties, cities) significant authority over areas of law commonly understood as "local" in nature. Traditionally, and in many states still today, cities and counties are considered entities of the state, and can only exercise the powers *expressly* granted them by the state legislature.
[xiv] Iowa Code § 335.2.
[xv] Iowa Code § 331.304A.
[xvi] *Id*.
[xvii] *Worth County Friends v. Worth County*, 688 N.W.2d 257 (Iowa 2004).
[xviii]