Improvement & Resiliency Plan

English River Watershed Management Authority

August 2015

ENGLISH RIVER WATERSHED

"We shall never achieve harmony with the land, anymore than we shall achieve absolute justice or liberty for people. In these higher aspirations the important thing is not to achieve but to strive."

— *Aldo Leopold, Round River: From the Journals of Aldo Leopold*

Contact Information

The City of Kalona has donated office space for the English River Watershed Management Authority's (ERWMA) headquarters. The mailing address for the ERWMA is 511 C. Ave, P.O. Box 1213, Kalona, IA 52247. The phone number is (319) 656-2310. The ERWMA can also be emailed at englishriverwma@gmail.com.

Visit www.EnglishRiverWMA.org for more information about the organization, membership, and current projects.

Cover Photo: Cover crops pattern a portion of southeastern Iowa's rolling landscape.
Photo courtesy of Steve Berger.


Photo: Steve Berger

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Photo: Steve Berger

Acknowledgements

The English River Watershed Management Authority would like to thank our Member Organizations for their support of this project:

- City of Barnes City
- City of Grinnell
- City of Kalona
- City of Keswick
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- City of Wellman
- County of Keokuk
- County of Washington
- Iowa Soil and Water Conservation District
- Johnson Soil and Water Conservation District
- Keokuk Soil and Water Conservation District
- Poweshiek Soil and Water Conservation District
- Washington Soil and Water Conservation District

The following individuals contributed material for the English River Watershed Improvement & Resiliency Plan:

- Adam Kiel; State Water Resources Manager, Iowa Soybean Association
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- Elizabeth Minor; Graduate Student in Urban & Regional Planning, The University of Iowa
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- Mary Beth Stevenson; Iowa-Cedar River Basin Coordinator, Iowa Department of Natural Resources
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- Ryan Clark; Geologist, Iowa Geological Survey
- Vanessa Fixmer-Oraiz; Graduate Student in Urban & Regional Planning, The University of Iowa

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Members of the Technical Advisory Team

- Amy Bouska, Iowa Department of Agriculture and Land Stewardship
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- Wendell Jones, Johnson Soil and Water Conservation District

Members of the Community Advisory Team were also instrumental in the development of this plan. Interviews of the Community Advisory Team members provided links between the watershed's urban and rural landowners and project partners to ensure the interests of these watershed residents and landowners were represented in planning and educational programming.


Photo: WFAN

Development of the Plan

Comprehensive Watershed Assessment and Planning Project: Phases
The following tasks were identified early in the project as milestones to achieve during the comprehensive watershed assessment and planning project. Completion of these tasks occurred between December of 2013 and August of 2015. The project was funded primarily through a watershed planning grant from Iowa Department of Natural Resources, supplemented by contributions from member organizations and local organizations.

The English River Watershed Improvement & Resiliency Plan (hereby "The Plan"), was the collaborative product of research and input from the planning team consisting of project partners, the Technical and Community Advisory Teams, WMA member organizations, and those who contributed by participating in our *English River Watershed Landowner's Survey* (refer to Appendix C). A list of project partners and the Advisory Team members can be found in the Acknowledgements section.

Hire a WMA coordinator
A Watershed Coordinator was hired in December of 2013.

Develop technical and community planning teams
The Technical Advisory Team (TAT) included professionals from County Conservation, County Engineering, Iowa Department of Natural Resources, Iowa Department of Agriculture and Land Stewardship, Iowa Soybean Association, Iowa Flood Center, Iowa State University Extension, Pheasants Forever, Soil and Water Conservation Districts, The Nature Conservancy, United States Geological Survey, and the Iowa Geological Survey. The TAT met on March 19th and August 14th of 2014.

The Community Advisory Team (CAT) included individual residents and landowners from the watershed. Six of the individuals were from Washington County, 8 from Poweshiek County, 1 from Mahaska County, 2 from Iowa County, and 1 each from Keokuk County and Johnson County.

Physical Environment Inventory
A geographic information system (GIS) geodatabase was compiled by staff from Iowa Soybean Association (ISA) for the English River watershed. It includes GIS data of land use and land cover patterns, existing best management practices (BMPs) and structures, environmental and geological features, landownership patterns, and social demographics of the watershed.

Hydrological Simulation Modeling
Research staff at Iowa Flood Center (IFC) built a customized hydrologic model for the English River watershed and ran the model to simulate rainfall events to determine areas of vulnerability in the watershed for flood damage and water quality issues, as well as priority subwatersheds for future implementation projects.

Water Quality Snapshots

ISA completed water quality snapshots throughout 2014 at 20 subwatershed locations around the English River watershed. The first snapshot was an "event" sample taken during heavy spring rains on April 28, 2014. The second sample was taken July 17th, and the third in September of 2014. The snapshots measured chloride, nitrate (& nitrite), phosphate, sulfate, and turbidity levels at those locations.

Social Survey

The "English River Watershed Landowners Survey" was launched in June of 2014, and 680 randomly selected landowners in the watershed were invited by mail to participate. The survey had a return rate of 24.4 percent. The purpose of the survey was to help identify future outreach and education priorities by surveying landowners on the characteristics of their urban and rural properties, demographics, water resource usage, water quality and flood impacts, best management practices and barriers to implementation, as well as attitudes and perceptions on contemporary policy and practices.

Define Plan Goals and Objectives, Develop Implementation Plan

Recommendations were drafted by watershed staff and project partners that will provide guidelines for continuing watershed stewardship efforts beyond the planning phase. The recommendations were informed by the extensive watershed assessment and were developed to be consistent with statewide nutrient reduction and flood policies. The recommendations were finalized after a public comment period of 30 days and adopted by the English River Watershed Board of Directors. The recommendations in this plan should be re-evaluated at least every 5 years for relevance and applicability, as local and state priorities are subject to shift over time.

The implementation plan was developed to help stakeholders in the watershed identify the priority subwatersheds to target in developing watershed improvement projects. The implementation plan focuses on implementing Iowa Nutrient Reduction strategies and hazard mitigation in the priority subwatersheds, as welll as sustaining the efforts of the ERWMA in bringing partners together on these projects.

Ongoing Education and Engagement

Education and engagement events to date include, but are not limited to the following:

- English River Watershed Planning Open House / Kickoff Event
- Cover Crop Field Day with Iowa Learning Farms and the Poweshiek Conservation District
- Women, Food & Agriculture Network's "Women Caring for the Land" Soil Health Event
- "Where Does Your Watershed" Educational Event
- Booths at Keokuk County Expo, and the Washington, Johnson, and Poweshiek County Fairs
- "Cover Crop Cocktail" educational event with USDA-NRCS, Muscatine, Iowa and Johnson County SWCDs, and Midwestern cover crop experts
- "Working Upstream in the Watershed" webinar hosted by the Iowa Stormwater Education Project
- "Water Runoff in Iowa Communities: Learning from the Past, Managing for the Future" Educational Event
- Various presentations to community groups in watershed: Rotary, Optimists Club, Kiwanis, others, etc.
- Presentations for the state Watershed Planning Advisory Council, attendees at the Iowa Water Conference, and various soil and water resource professionals of Iowa

These events were intended to increase public education about water quality issues and flood mitigation, locally and statewide. The English River Watershed will continue to educate stakeholders on contemporary water resource issues, and promote best management practices into the future, a key component of implementing this plan.

1 | Executive Summary

Photo: Cover crops can be planted alongside traditional row crops to build soil and retain essential nutrients. *Photo courtesy of Steve Berger.*

Introduction

In recent decades, communities and property owners in the English River watershed have been increasingly impacted by flood events, although flooding in the watershed has been adversely impacting landowners, and prompting discussion of better watershed management as early as the 1920's (refer to Appendix I for more information). These events have been increasing in frequency and severity; and with each event, homes, farms, and infrastructure are damaged, costing millions of dollars to rebuild and repair. Historically, flood mitigation has consisted of improving drainage in one area, resulting in adverse impacts on downstream neighbors. Additionally, runoff in watersheds carry phos¬phorus-rich topsoil, nutrients and other water contaminants downstream, not only impacting water quality and wildlife habitat locally, but other larger watersheds, including the Gulf of Mexico.

Reducing flood impacts and improving soil and water quality in the English River Watershed (ERW) are the over-arching goals of the English River Watershed Management Authority (ERWMA), its members, and this plan. The ERWMA is committed to education and development of partnerships with key stakeholders to make this happen. Development of this plan required a science-based approach to determine the unique issues affecting the watershed, and then outlining a plan to address them. The plan is intended to educate watershed stakeholders about the opportunities and challenges ahead of us, and build the foundation upon which stakeholders will hopefully continue the momentum for collaborative watershed improvement efforts needed to protect our watershed communities, families, and farms.

Overview of the English River Watershed Management Authority

In 2010, the state of Iowa authorized Watershed Management Authorities (WMAs) to form as part of the Surface Water Protection & Flood Mitigation Act. WMAs are voluntary interagency partnerships of cities, counties, and soil & water conservation districts in Iowa, formed through a 28-E agreement, who collaborate on shared water resource concerns. These collaboratives are permitted by the state to assess and reduce flood risk and water quality issues; they can monitor federal flood risk planning; they educate the public on flood and water quality issues; and leverage available funds for watershed improvement efforts. State code prohibits WMAs from acquiring land through eminent domain or serving as a taxation authority.

Membership in the ERWMA

Iowa Code defines eligible WMA members as Cities, Counties, and Soil and Water Conservation Districts (SWCDs). At the time this watershed plan was completed, the ERWMA had 13 member organizations. The ERWMA is governed by its Board of Directors, and Representatives from the ERWMA's Member Organizations are given opportunities to serve on the Board at the annual meeting in November. Funding to support the ERWMA is primarily dependent on competitive grants, and donations its from Member Organizations. Membership in the ERWMA is completely voluntary, as is making financial contributions to the organization, and it gives organizations the opportunity to take part in planning and decision-making.

Overview of the Watershed Assessment and Improvement Planning Project

The primary goals of the watershed assessment were to establish baseline indicators of water quantity, flooding, and public awareness in the watershed; and, to identify watershed improvement priorities for the years to come. This plan is a voluntary call to action, and was informed through extensive research, primary and secondary data sources, and advisory team input. The recommendations of the plan are designed to guide stakeholders in the watershed to be stewards in protecting and improving this valuable local resource in the years to come.

Highlights from the English River Watershed (ERW) Assessment

Primary contributors of the watershed assessment were watershed staff and project partners from the Iowa Flood Center – IIHR Hydroscience and Engineering at the University of Iowa, Iowa Department of Natural Resources, Iowa Geological Survey, Iowa Department of Agriculture and Land Stewardship, and Iowa Soybean Association. The table below highlights some key research findings:

Table 1. Key Research Findings from Comprehensive Watershed Assessment	
General	The ERW is part of the Lower Iowa River watershed, and consists of 20 smaller tributary-sized subwatersheds
	About 409,000 acres of southeastern Iowa drain into the watershed (or 639 square miles)
	There are approximately 1,447 miles of rivers and streams in the watershed
	Nearly half of the land in the watershed is considered "Highly Erodible"
Demographics	The watershed covers portions of 6 counties, and includes 14 communities
	Kalona (population of 2,363) is the largest community in the watershed
	Of the approximately 21,700 residents in the watershed, 60% live in the rural areas
	The majority of those renting farmland in the watershed live within 5 miles of the land they rent out
	Slightly over half (16 of 30) of the townships in the watershed have experienced population decline in the last decade
Land Use	Row crop agriculture, primarily corn and soybeans, is the predominate land use in the watershed
	In the mid-1800s, the watershed landscape was approximately 83% prairie
	The average Corn Suitability Rating (CSR) across the watershed is about 50
Water Quality Indicators	Sediment loading in the watershed is higher than the statewide median, and indicates significant erosion from streambanks and upland
	Total phosphorus levels in the watershed have consistently exceeded EPA benchmark values in the last 28 years, and are higher than the statewide median
	Bacteria levels (E. coli) in the watershed have exceeded benchmark values over 50% of the time, since testing began in 1999
	Nitrate levels in the watershed have been consistently below the state median, and 1/3 of subwatersheds tested below the EPA drinking water standard (10ppm) in 2014
	Chloride levels in the watershed have been significantly declining over the last 14 years
	The Deer Creek and Town of Tilton subwatersheds are recommended *high* priority watersheds for nitrate
	Several subwatersheds, specifically Dugout Creek (aka North English Headwaters), Upper South English River, Upper English River, Jordan Creek, and Deep River subwatersheds are recommended *high* priority areas for phosphorus reduction
Flooding Indicators	Flooding events have occurred in 25 of the last 75 years, with most flood events occurring between the months of May and July
	Runoff has increased flood severity, due in part to the conversion of both urban and rural land from more absorbent land uses to less absorbent uses
	The upper third of the watershed is most vulnerable to runoff (and soil erosion), due to steeper slopes and a highly erodible landscape
	The convergence of the North and South English River is the largest area in the watershed highly prone to annual flooding events
	The Deep River, Deer Creek, Upper South English River, Town of Tilton, Dugout Creek (aka North English Headwaters), and Middle English River were identified as high priority subwatersheds for combined water quality improvement *and* flood reduction
Social Indicators	The majority of surveyed landowners in the watershed feel that the drinking water on their property is safe to drink
	The majority of those surveyed also agree that we need to improve water quality in the watershed
	Nearly 42 percent of landowners surveyed have been impacted by flooding in the last 10 years
	The most popular farming best management practices in the watershed are crop rotation, grassed waterways, and no-till
	Less than 10% of those surveyed indicated that they wanted to learn more about additional BMPs they could use on their urban and farm properties; barriers to practice include lack of cost-share incentives, project expense, education or technical assistance, and tenant farmers
	From a list of current "policy issues;" those surveyed were *most* likely to be "Very concerned" about soil erosion, loss of agricultural land, and soil fertility compared to other issues
	Policy issues those surveyed were *least* concerned about, included extreme temperatures, severe weather, and impacts of water quality on recreation and tourism
	The majority (70%) of those surveyed were unfamiliar with Iowa's Nutrient Reduction Strategy (NRS); 60% of those who identified as farmers were unfamiliar with the NRS

Going Forward: Summary of English River Watershed Improvement Priorities and Recommendations
The following recommendations (or goals) for future English River Watershed improvements are categorized by (1) water quality improvements, (2) disaster resiliency, and (3) capacity building, and are informed by the watershed assessment. Recommendations should be re-evaluated at least every 5 years, and adjusted as needed to keep pace with changing local, state, and federal priorities, and resources available to achieve these goals. In addition to resources lasting watershed improvements will also depend upon:

- Leadership in the watershed promoting and supporting these goals;
- Stakeholder commitment to stewardship of the watershed they live, do business, and farm in;
- Federal, state, and local priorities supportive of water and soil resources.

Responsibility for moving watershed improvement initiatives forward is that of all watershed stakeholders (both individual and organizational), but it is anticipated that the English River Watershed Management Authority will facilitate development of partnerships needed to make it happen, as well as providing leadership, and pursuing the resources needed to implement the plan.

Water Quality Improvements
Recommendation #X: Reduce nitrate loading in the English River watershed from non-point sources by 41% from 2010 levels.
A sustained commitment is needed in the watershed to educate stakeholders about Iowa's Nutrient Reduction Strategy (NRS) and the BMPs proven by science that can reduce nutrients from entering waterways. Collaboration with other organizations in programming, program evaluation and ongoing prioritization of subwatersheds for NRS-related implementation projects is recommended. The priority subwatersheds identified for nitrate reductions include: Deer, Dugout (headwaters of the Upper North English River), Camp and Lime Creeks; Lower, Middle and Upper South English Rivers; the Middle and Upper English River; Deep River, and Town of Tilton. Sustained water quality monitoring on the subwatershed level for nitrates is needed to evaluate effectiveness of subwatershed-level efforts, and to reprioritize target subwatersheds, if needed.

Recommendation #X: Reduce phosphorus loading in the English River watershed from non-point sources by 29% from 2010 levels.
Phosphorus reduction in the English River Watershed can be achieved through education on Iowa's current NRS, and proven BMPs that reduce erosion and resulting phosphorus loading in local waterways. As with a focus on reducing nitrates in our waterways, collaboration with other organizations in these efforts is key to efficient use of limited resources, and greater outreach and effectiveness. Current priority subwatersheds for phosphorus reduction are based on available erosion data and are the same priority watersheds for sediment reduction (below): Deer and Camp Creeks, the South and Upper South English Rivers. Additional priority subwatersheds include: Gritter, Dugout, Jordan, and Birch Creeks; and, Deep River, the Middle English, and Middle South English Rivers. Water quality monitoring on the subwatershed level for Total Phosphorus will assist stakeholders with evaluating the effectiveness of subwatershed-level efforts, and in reprioritizing target subwatersheds, if needed.

Recommendation #X: Reduce sediment loading in the English River watershed by 30% from current levels.

Reducing sediment loading in the English River Watershed through education and promotion of land uses and BMPs that reduce soil loss from streambanks, farm fields, and construction sites, is a vital component of this plan. Educational efforts should be directed towards improving soil health and promoting infiltration, which can bolster farm productivity, improve water quality, and aid in flood hazard reduction. Collaboration with other organizations in these efforts is essential to outreach and program effectiveness. The highest priority subwatersheds for sediment reduction implementation in the English River Watershed include: Deer and Camp Creeks, the South and Upper South English Rivers. Additional priority subwatersheds to consider include: Gritter, Dugout, Jordan, and Birch Creeks; and the Middle English, Middle South English, and Deep River.

Recommendation #X: Continue monitoring water quality parameters at the subwatershed level.

Ongoing water quality monitoring on the subwatershed level is needed to establish long-term water quality baselines, and provide opportunities for landowners and watershed stakeholders to participate in volunteer water monitoring programs (i.e. IOWATER, tile outlet monitoring programs for producers). Longer-term data accounts for more variability in weather, development, and farming trends and will help stakeholders reevaluate the priority subwatersheds for targeted efforts, evaluate the impact of projects on the subwatershed-level, and allow for resources to be redirected as needed. Stakeholders will also need easier access to public water quality data to assist them in making these decisions.

Disaster Resiliency

Recommendation #X: Reduce flood severity in the English River watershed through education and promotion of BMPs that reduce runoff in targeted subwatersheds.

Sustained efforts are needed to educate stakeholders on how their land use practices can impact flooding in the watershed, and the best management practices they can implement on their landscapes that can actually reduce the impacts of flooding on communities and farms during heavy rain events. Runoff reduction projects should target identified priority subwatershed for greater efficiency in application of limited resources. The priority subwatersheds for targeted runoff reduction include: Jordan, Birch, Deer and Dugout Creeks (aka headwaters of the North English River); as well as the Upper English, Upper South English, South English Rivers, and Deep River. To achieve these goals, the ERWMA should utilize existing partnerships, and develop new ones with organizations that can help increase access to financial and technical resources.

Recommendation #X: Reduce flood severity in the English River watershed through education and promotion of BMPs that increase water-holding capacity and promote infiltration on both urban and rural landscapes.

The ERW will conduct outreach on the practices that help reduce flood severity by promoting infiltration during rain events. Implementation of practices should focus on the subwatersheds most prone to flooding: the area where the English River at the English River Wildlife Area and the South English River converge, the area downstream of the English River/Gritter Creek convergence, and areas in the western section of the watershed where high runoff areas overlap with high annual flood areas (headwaters of the North English River, and Deep River). The ERW will utilize existing partnerships and grow new ones with landowners and local, state and federal organizations to increase available resources to implement projects, and utilize resources more efficiently. The existing hydrologic monitoring network should be expanded so more parts of the English River Watershed are included. The network is capable of providing data and tools that decision-makers and individual stakeholders can use to better understand the hydrology of their region. This data can also be used to evaluate projects and reprioritize efforts as needed.

Capacity Building

Recommendation #X: Expand partnerships for education, outreach, and project collaboration.
Partnerships are a key component of effective plan implementation. Increased collaboration with political, environmental, agricultural, community and other organizations can assist with streamlining messaging about watershed stewardship and localized projects, increasing outreach capacity through shared networks, engaging diverse stakeholder groups, and using limited resources more efficiently.

Recommendation #X: Increase the organizational capacity of the English River WMA.
The ERWMA needs sustained leadership and staff to facilitate networking, communication, engaging stakeholders, and project leadership in the watershed improvement initiatives proposed in this plan. The organization's Board of Directors can provide this leadership by directing watershed staff, holding regular, open meetings, and supporting ongoing opportunities for watershed stakeholders to participate in events and engage with the organization. The Board of Directors should consider reaching out to important stakeholder groups with opportunities to join the ERWMA and participate in decision-making. The ERWMA and its leadership should also be proactive in pursuing available technical and financial resources needed to support administrative functions and implementing the plan.

Conclusion

It is up to the watershed's stakeholders to determine the best way to implement the recommendations for improvements in their watershed. Locally-driven efforts are important to achieving buy-in from stakeholders. This locally developed watershed plan was designed to engage diverse stakeholders and promote water quality improvements in a cooperative manner that encourages voluntary action and collaboration, versus more top-down approaches. However, this strategy requires watershed stakeholders on the organizational and individual level to recognize the economic value of their local water resources, promote these resources, support and engage in outreach and education, adjust their land management practices as able, consider emerging science, and be open to change.

2 | Introduction

Photo: Wellman, Iowa is the third largest community in the English River watershed. *Photo courtesy of Ben Curtis.*

2.1 Geography of the Watershed

The English River Watershed is a 409,236 acre (639 square mile) watershed in southeastern Iowa (refer to Figure 1). It is home to around 21,700 people, the majority of whom live in several small communities around the watershed. Slightly over half of the townships that overlap with the watershed boundary have experienced declining population in the last decade. A clear majority of the residents in the watershed identify as White. The population is also aging. It is part of the larger Upper Lower Iowa watershed, and comprises over 1,400 miles of streams and tributaries. The majority of the watershed has been tiled and 2/3 of the landscape is utilized for row crops. A quarter of the area is grassland or pasture. Approximately 6 percent of the watershed is timber and another 6 percent is urban development.

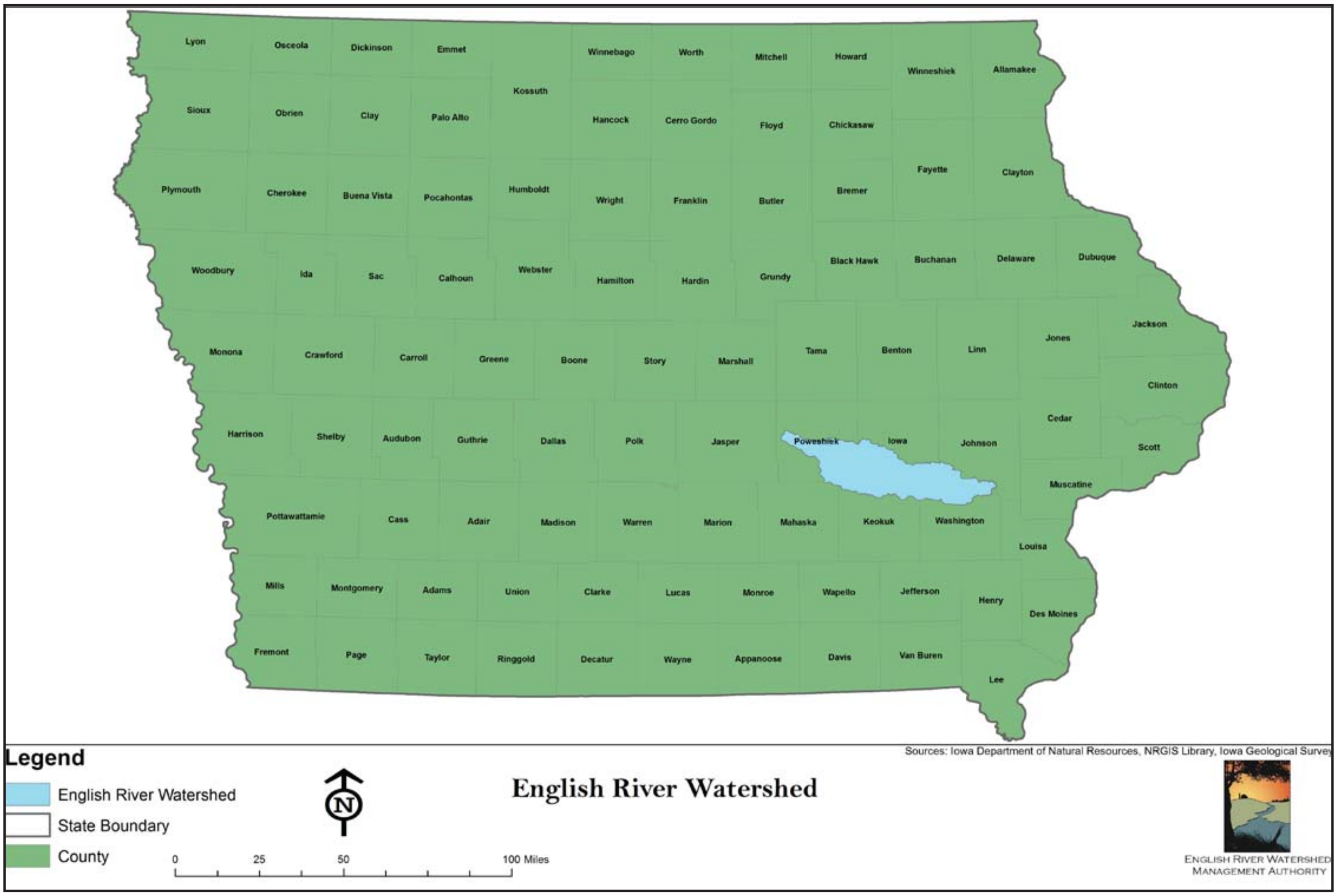


Figure 1. Location of the English River Watershed in Iowa

Small, scattered rural villages dot the landscape. The watershed covers portions of Poweshiek, Iowa, Johnson, Washington, and Keokuk Counties and includes portions, or all of the communities of: Grinnell, Guernsey, Montezuma, Barnes City, Deep River, Millersburg, Keswick, Webster, Kinross, North English, Parnell, Wellman, Kalona and Riverside (Figure 2).

Few wetlands have survived the last century of land use conversion and urban development. The watershed is characterized by a precarious combination of highly erodible land and fertile soils with high corn suitability ratings (CSR). Observations from the English River watershed are consistent with general Iowa population and watershed trends seen across the state.

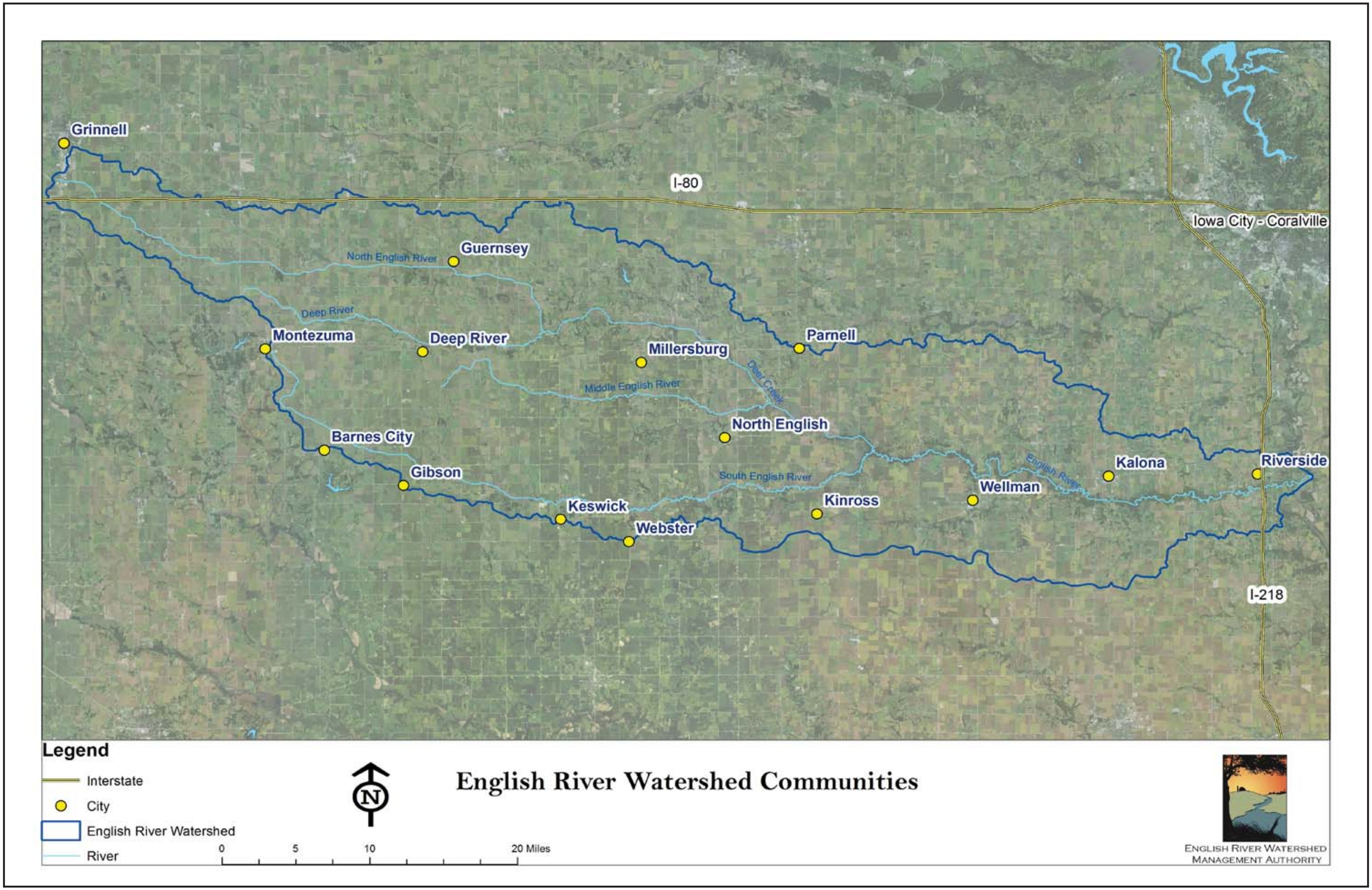
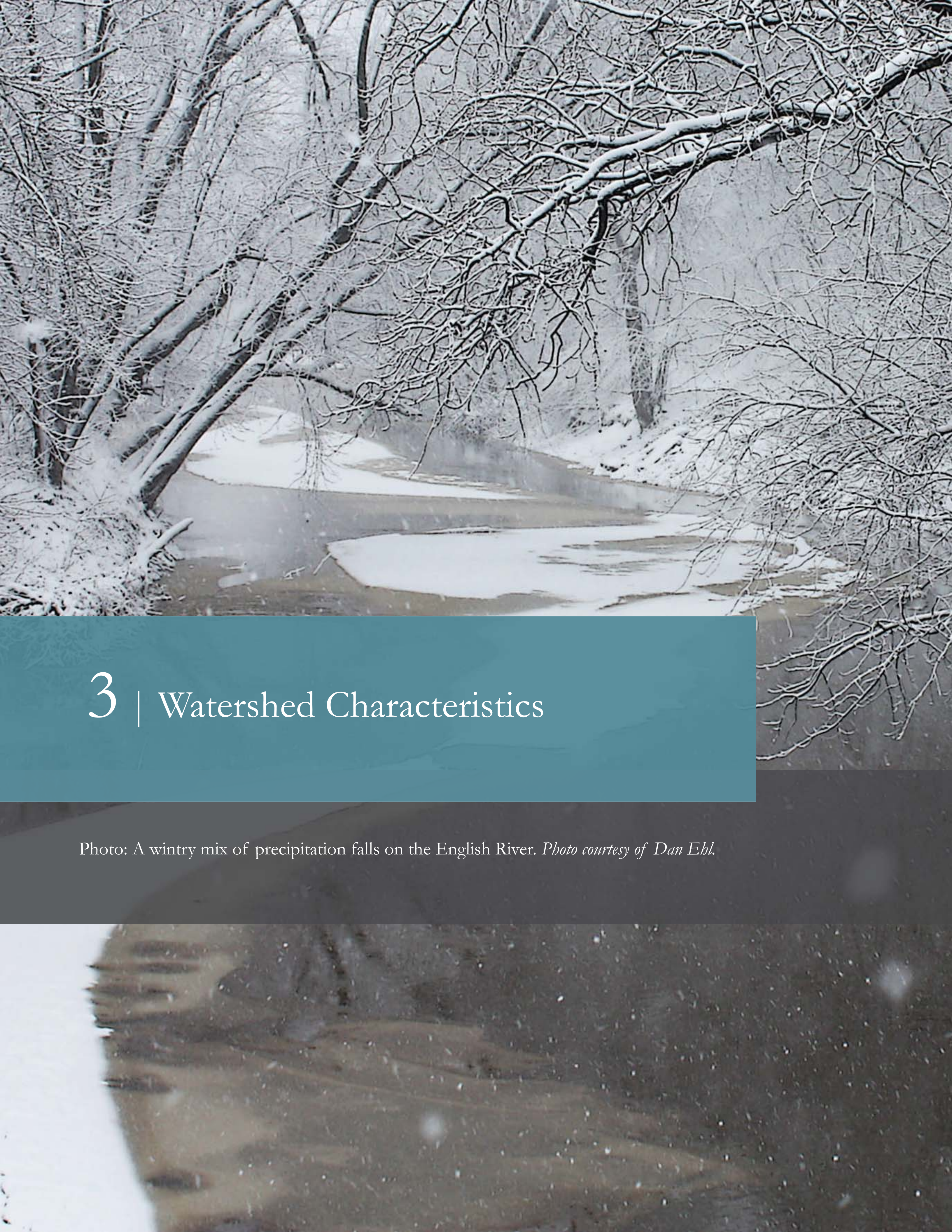


Figure 2. Communities in the English River Watershed



3 | Watershed Characteristics

Photo: A wintry mix of precipitation falls on the English River. *Photo courtesy of Dan Ehl*.

3.1 Land Use

Historic Land Use

The Government Land Office (GLO) conducted the original public land survey of Iowa between 1832 to 1859. Surveyors and their assistants produced both field notes and township maps that briefly described the land and its natural resources (vegetation, water, soil, landform, etc.) at the time of the survey. These maps and survey notes are one of the few data sources about vegetation distribution before much of Iowa changed to a landscape driven by intensive agriculture. The data presented in Figure 3 represents the observed vegetation by the deputy surveyors when laying out the public land surveys. At the time, the English River watershed was classified as 83 percent prairie, 16 percent timber, and 1 percent other.[1]

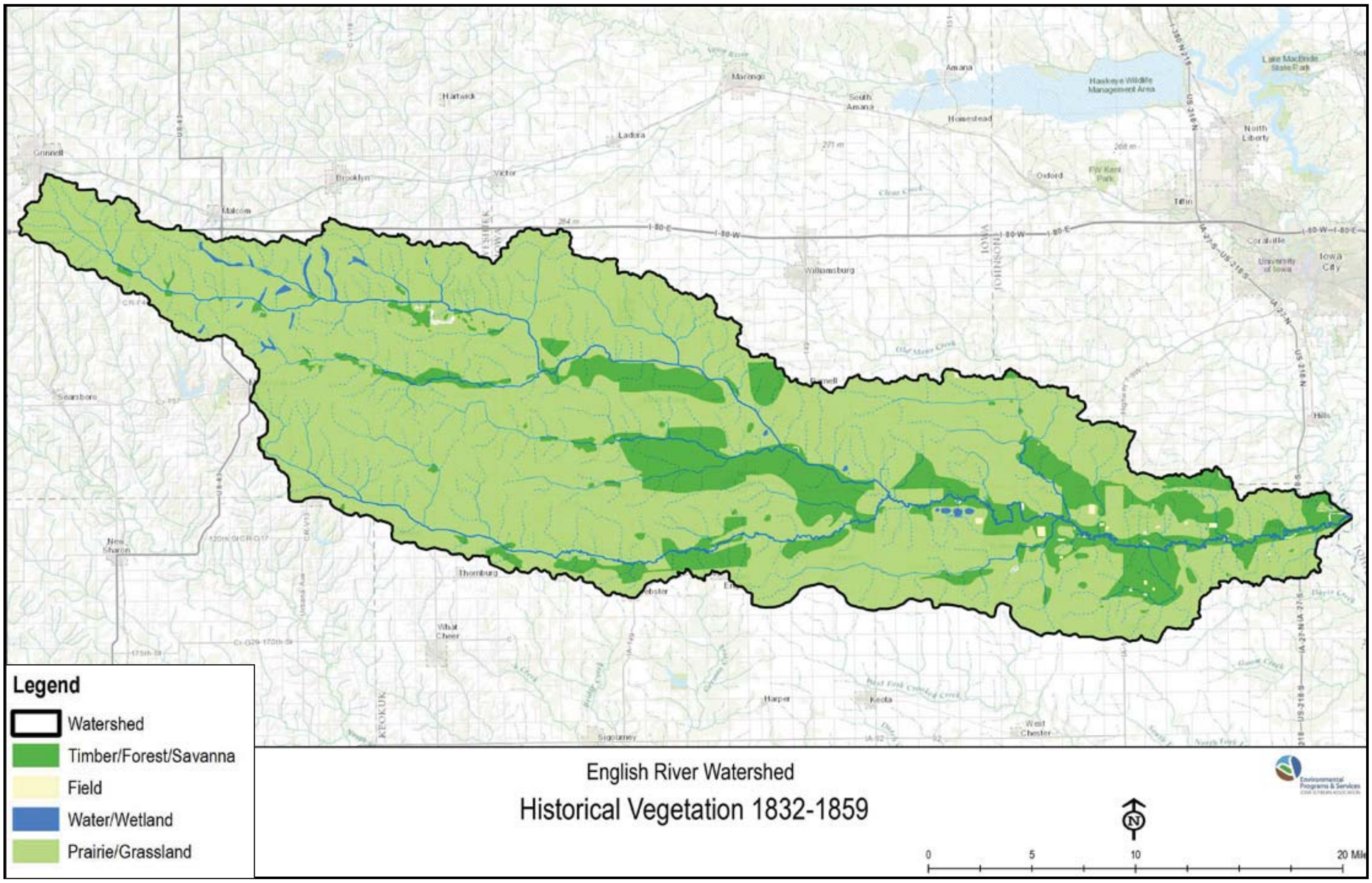


Figure 3. Historical Vegetation in the English River Watershed (1832 - 1859)

Current Land Use

Data from the 2013 United States Department of Agriculture (USDA) land cover survey suggests that soybean and corn acres comprised 57 percent of the landscape in the English River watershed (Table 2).[2] Grassland and pasture areas made up 25 percent of the watershed landscape, and developed areas (including open space and high to low intensity development) comprised slightly over 12 percent (Figure 4). In comparison to state averages, the English River watershed had a higher proportion of soybean acres than state averages, as well as a higher proportion of pasture/grassland areas. The same data suggests that the English River watershed had a smaller proportion of corn acres and urban development than average.

The vast majority of the watershed is privately owned; however, in addition to road right-of-ways, approximately 2,165 acres in the watershed are publically owned.

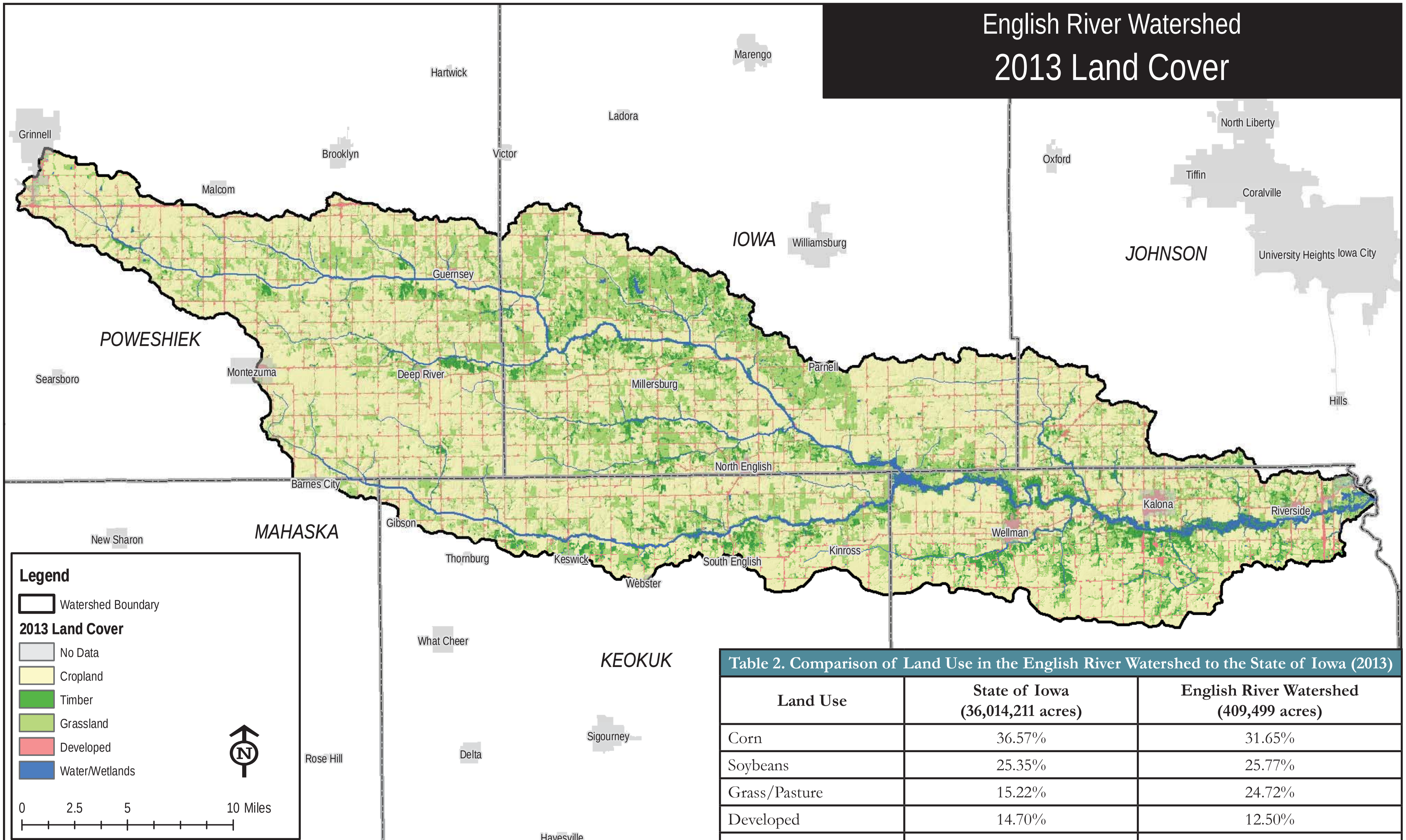


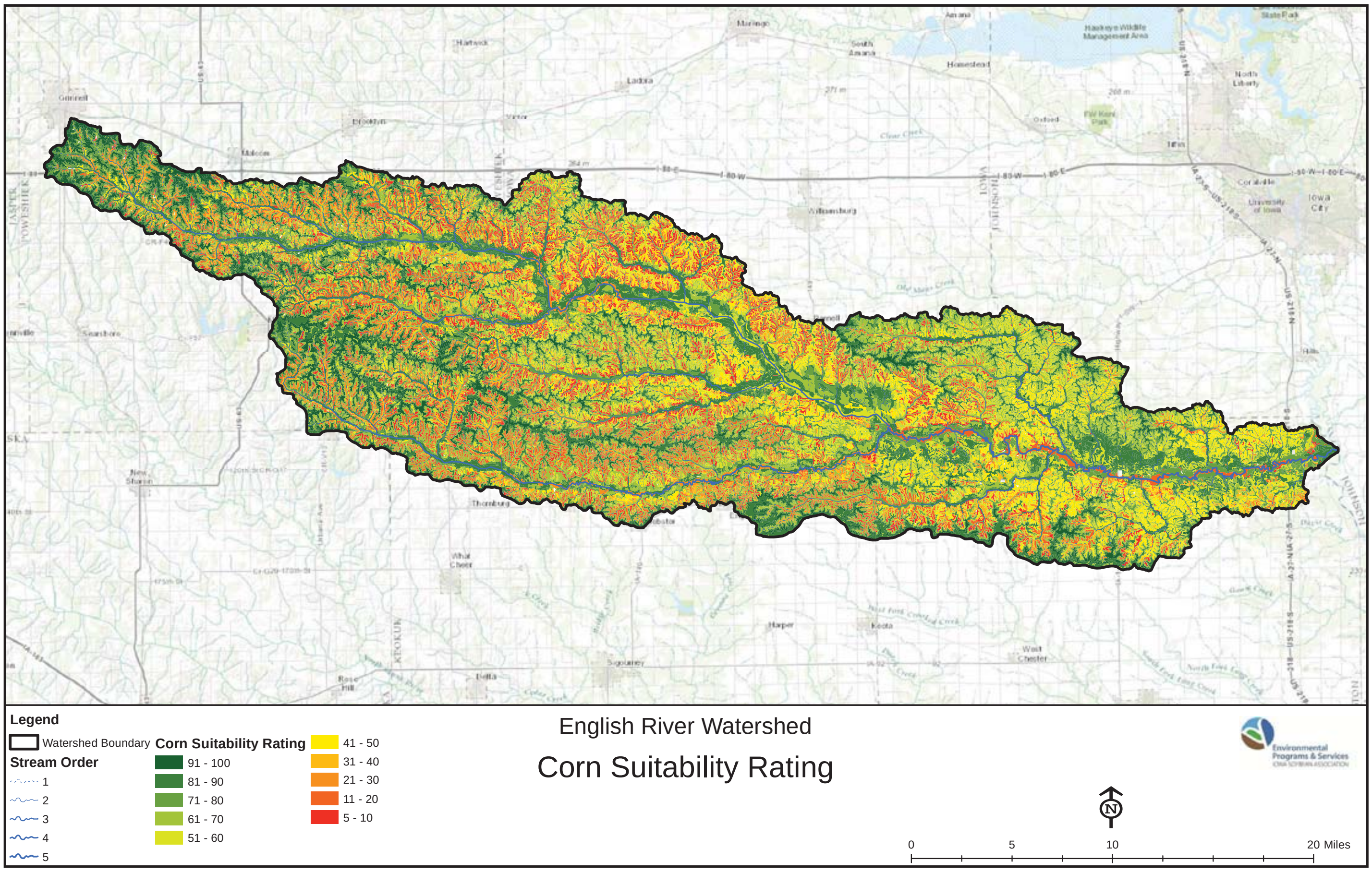
Figure 4. Current Land Use in the English River Watershed

Table 2. Comparison of Land Use in the English River Watershed to the State of Iowa (2013)

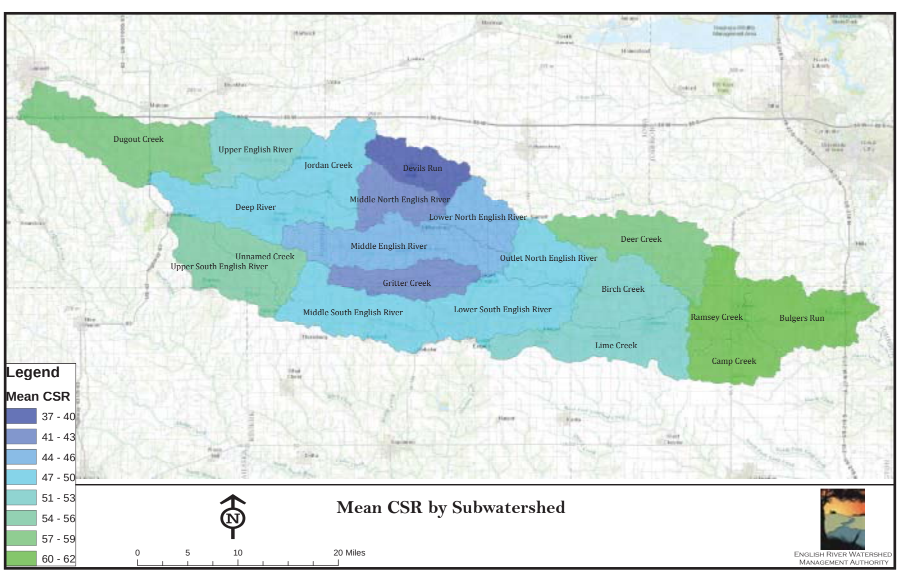
Land Use	State of Iowa (36,014,211 acres)	English River Watershed (409,499 acres)
Corn	36.57%	31.65%
Soybeans	25.35%	25.77%
Grass/Pasture	15.22%	24.72%
Developed	14.70%	12.50%
Deciduous Forest	8.48%	6.06%
Other Hay/Non Alfalfa	2.33%	1.38%
Alfalfa	1.20%	2.11%
Open Water	1.07%	0.25%
Woody Wetlands	1.03%	1.07%
Herbaceous Wetlands	0.64%	0.15%
Shrubland	0.28%	0.06%
Oats	0.20%	0.31%
Barren	0.06%	0.03%
Rye	0.02%	0.09%
TOTAL	**100%**	**100%**

Corn Suitability Rating

Figure 5 displays the corn suitability rating (CSR) for land located within the English River watershed. CSR provides a relative ranking of soils mapped in the state based on their potential to be utilized for intensive row crop production. The CSR is an index that can be used to rank one soil area's yield potential against another. Ratings range from 100 for soils that have no physical limitations, occur on minimal slopes, and can be continuously row cropped to as low as 5 for soils with severe limitations for row crops. The ratings assume a) adequate management, b) natural weather conditions, c) artificial drainage where required, d) that soils lower on the landscape are not affected by frequent floods, and e) no land-leveling or terracing.



Above: Figure 5. Corn suitability rating in the English River Watershed. Below: Figure 6. Mean corn suitability rating in the English River Watershed on the subwatershed level



The mean CSR rating for the ERW, including urban land and waterways, is 49.8. Of the 20 subwatersheds in the English River watershed, the Ramsey Creek subwatershed has the highest mean CSR value of 61.9. The Devils Run subwatershed has the lowest mean CSR value of 37.7. In general, higher mean CSR values are observed in subwatersheds located in the eastern and northwestern portions of the ERW, while lower mean CSR values are found in subwatersheds located in the central portion of the ERW (Figure 6).

Crop Productivity

The number of watershed acres used for raising corn has remained relatively steady in the last 11 years, between 120,000 and 140,000 acres (Figure 7). The number of acres used for raising soybeans has fluctuated slightly during the same time period, between approximately 80,000 and 110,000 acres.

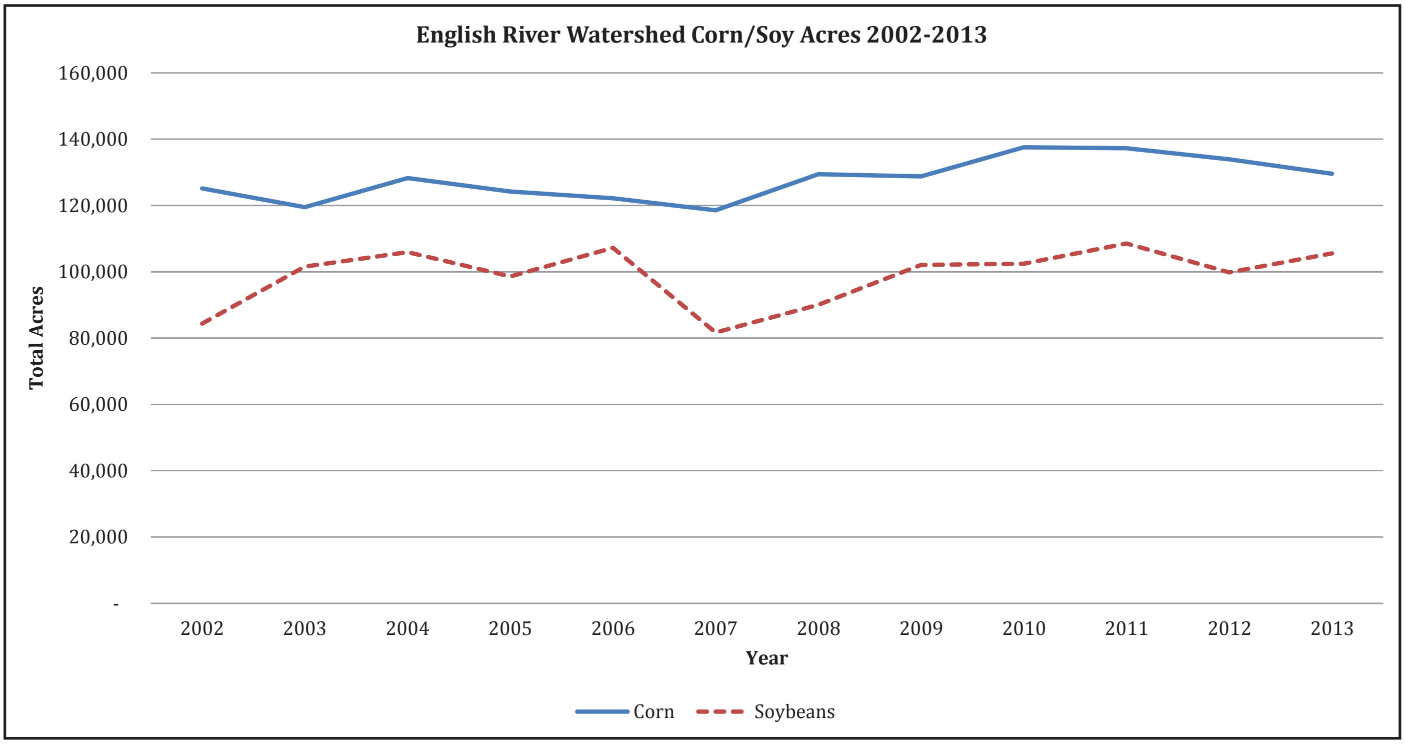


Figure 7. English River Watershed Corn / Soy Acres (2002 - 2013)

Livestock Productivity

As of 2014, there were 135 permitted animal feeding operations (AFOs) in the English River watershed.[3] Of these, 42 facilities are located within the Washington County area of the watershed, 34 facilities were within the Poweshiek County area in the watershed, 25 within Iowa County, 18 in Keokuk County, 12 in Johnson County, and 1 in Mahaska County. Combined, these permitted facilities housed approximately 124,045 animals. Approximately 91.5 percent of the livestock accounted for in these facilities were swine; 5.5 percent were poultry, 2.3 percent beef cattle, and less than 1 percent dairy cattle.

Land Tenure

Farmland owners in Iowa are aging, as is the general population. Land tenure trends in Iowa, captured every five years in a survey by Mike Duffy of Iowa State University Extension. In 2012, almost one third of Iowa farmland was owned by someone over the age of 75 in 2012. The percentage of land owned by people in this age category has been increasing since 1982, when only 12 percent of the land was owned by someone over the age of 75.[4]

Using property data, an analysis of the land tenure was conducted for English River watershed properties. The analysis showed that 73 percent of watershed properties are owned by individuals who live within 5 miles of the property. Another 10 percent of land is owned by landowners living between 5 and 50 miles of the property, and 5.5 percent of the land is owned by landowners living more than 50 miles away. Figure 8 on the following page shows the mailing address zip code locations for property owners in the English River watershed. These findings show impacts of the recent boom in land values.[4]

3.2 Soils

The English River watershed lies in the "Loess Ridges/Glacial Till" soil region of Iowa, which is characterized by soil developed in loess on broad, convex ridgetops and upper sideslopes. The Ladoga, Otley, Clinton, Colo and Gara soil associations comprise over half of the watershed area. The vast majority of soils in the English River watershed are categorized as hydrologic group B or C. Hydrologic groups are used to estimate runoff from precipitation. The hydrologic groups are categories of soils based on their intake of water when saturated and then receive additional precipitation from long-duration storms.

Hydrologic group B soils have a moderate infiltration rate; they consist mainly of moderately deep to well drained soils that have moderately fine to coarse texture.[5] Hydrologic group C soils have a slow infiltration rate because they typically have a layer that impedes the downward movement of water, these soils have a higher runoff potential than B or A soils.

Figure 9 shows where highly erodible land (HEL) is located within the English River watershed. HEL is any land that can erode at excessive rates because of its soil properties. Approximately 45 percent, or 184,156 acres of the watershed, is considered HEL or potentially HEL. The 2014 Iowa Farm Bill requirements specify that producers who participate in any programs offered by FSA, NRCS, or RMA (i.e. federal crop insurance premium subsidies, conservation subsidies, loans and disaster payments) are required to have an approved Natural Resource Conservation Service (NRCS) conservation plan to substantially reduce soil loss before planting on HEL; these provisions do not apply to those farming non-HEL land.[6] The same requirements apply to producers who grow crops on highly erodible land with no crop history prior to 1985, (known as "sod-busting").[7]

Elevation and Slope
The English River watershed is dominated by rolling terrain and valleys intersected by rivers and streams. LiDAR (Light Detection and Ranging) data indicates that the highest elevation in the watershed is 1,019 feet above sea level, and the lowest elevation within the watershed is 604 feet above sea level.

Table 3. Slopes in the English River Watershed[8]

Slope Classification	Range	Acres	Description	% of Total
A	0 – 2%	78,598	Level, or nearly level	19.2
B	2 – 5%	86,132	Gently sloping	21.0
C	5 – 9%	109,851	Moderately sloping	26.8
D	9 – 14%	84,417	Strongly sloping	20.6
E	14 – 18%	26,985	Moderately steep	6.6
F	18 – 25%	15,592	Steep	3.8
G	25 – 40%	7,649	Very Steep	1.9

The slope classification data provided in Table 3 was derived from a LiDAR elevation dataset for the watershed. The data suggests that the majority of land in the English River watershed can be classified as slope types A, B, C, or D. Less than 13 percent of the landscape has slopes exceeding 14 percent grade (steep) or higher.

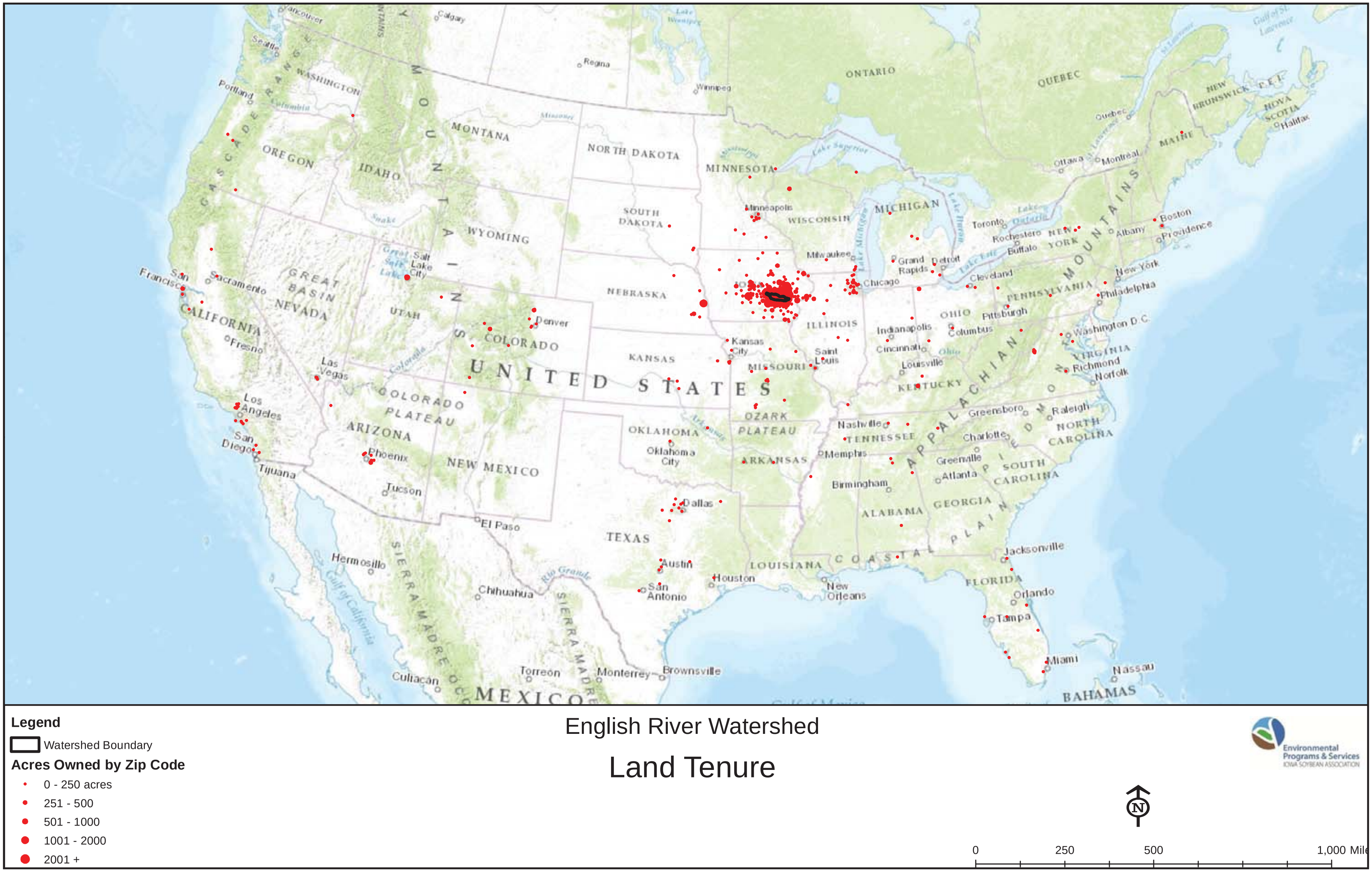


Figure 8. Land Tenure of English River Watershed properties

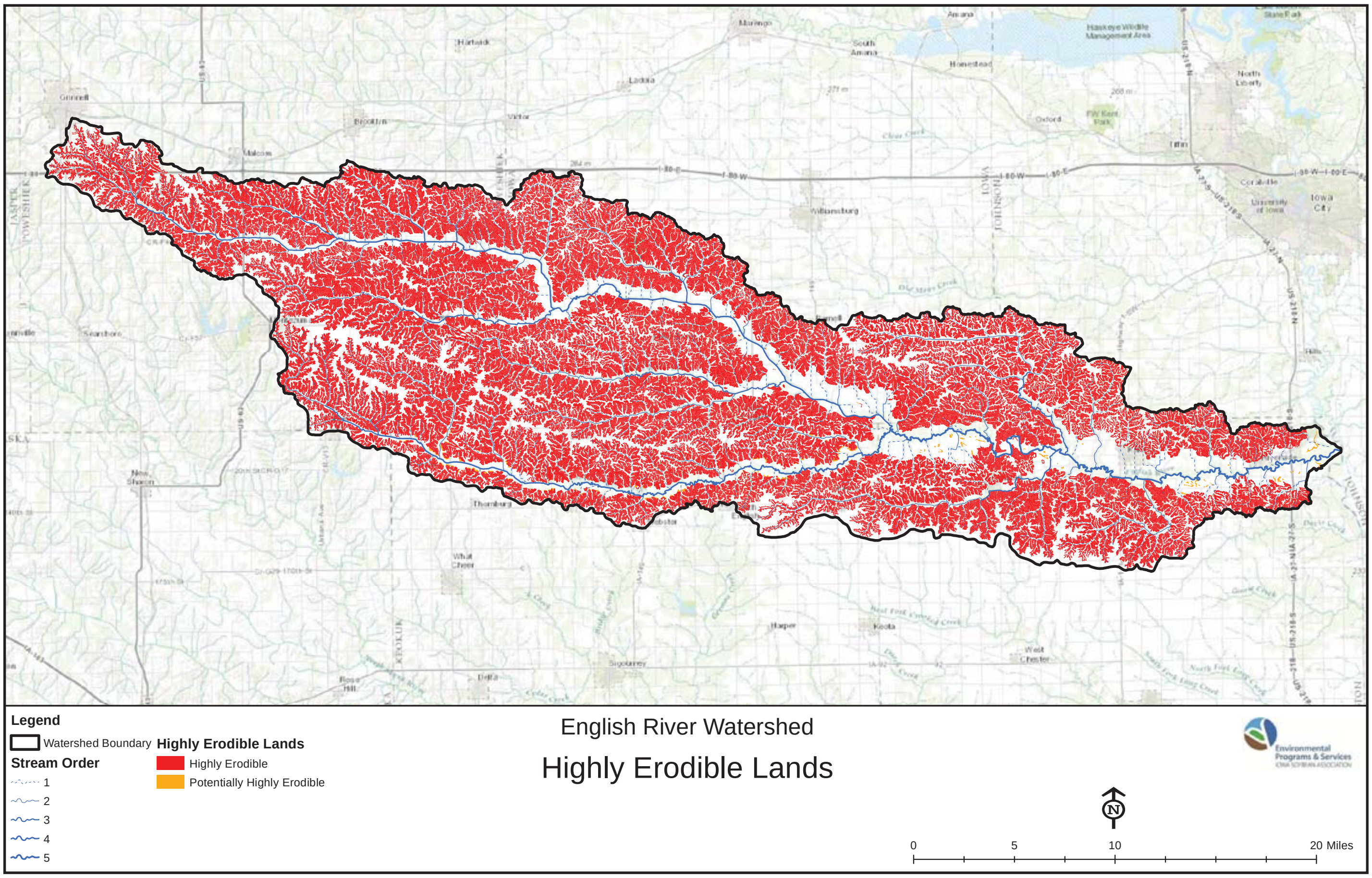


Figure 9. Highly erodible lands in the English River Watershed

3.3 Geology

Landform Regions

The English River Watershed (ERW) lies almost entirely within the Southern Iowa Drift Plain (SIDP), which is the largest of Iowa's seven distinct landform regions (Landform Regions of Iowa, Prior, J.C., 1991). The SIDP is typified by an undulating landscape with tabular uplands and a complex dendritic network of incised river and stream valleys. Mature soil development results from a generally thick cover of wind-blown glacial loess covering a thick package of Pre-Illinoisan till.

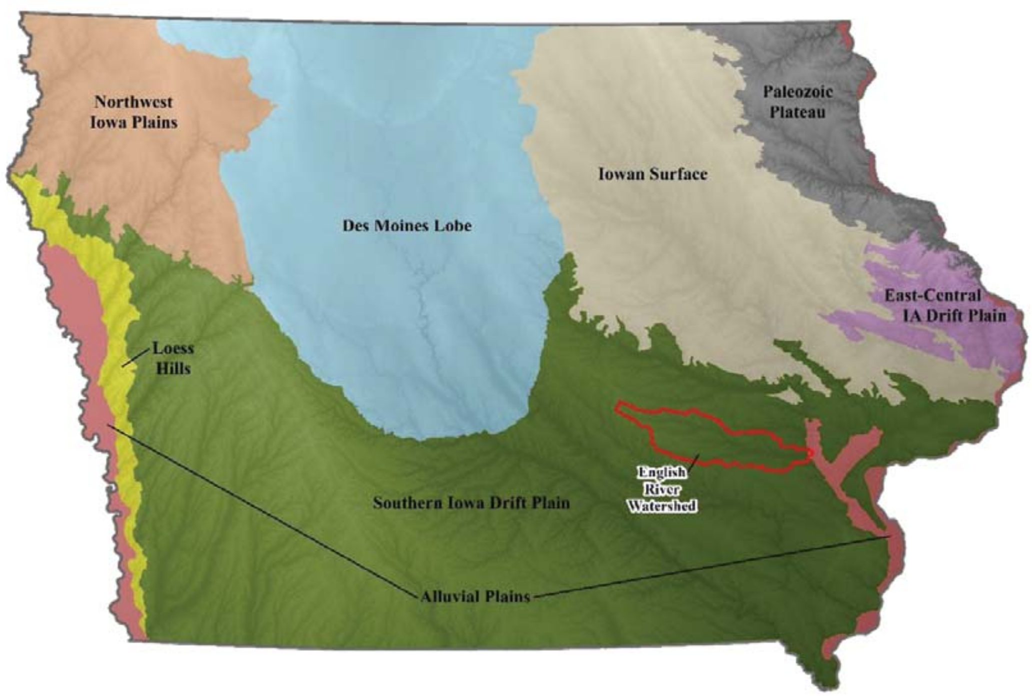


Figure 10. Map of the landform regions, modified from Landform Regions of Iowa (Prior, 1991) and showing the location of the English River Watershed (in red)

Bedrock

The bedrock geology of the ERW is highly variable and complex. The initial bedrock units within the ERW are Pennsylvanian, Mississippian, and Devonian in age, from youngest to oldest (Figure 11). General descriptions of the major bedrock units are listed below. The topography of the bedrock surface is just as dynamic as the surface, ranging in depth from at or near the surface to more than 450 deep (Figure 12).

The influence of bedrock geology varies greatly on local and regional scales. Generally speaking, at locations where bedrock is close to the surface there can be a direct communication between surface water and the groundwater held in bedrock aquifers, which is where the majority of potable water is sourced. In the ERW there are few places where bedrock is at or near the surface, mostly where rivers have cut down to the bedrock surface. From a groundwater quality perspective, the greater likelihood of this communication tends to increase the chances of negatively impacting the aquifer from surface contaminants (i.e. petroleum, fertilizers, pesticides, etc.). Where there is a thick cover of glacial till, or perhaps a shale layer, these bedrock aquifers are considered to be protected from surface contaminants, thus leading to improved water quality to those who use its water. In general, the ERW has enough cover to allow for the major bedrock aquifer units to be protected.

BEDROCK UNITS

Pennsylvanian System

- *Lower Cherokee Group* – Primarily consists of shale and sandstone with minor limestone lenses. The sand stones can be iron-rich and yield low to moderate quantities of water with typically poor quality. These are generally less than 100 feet thick within the English River Watershed.

Mississippian System

- *Pella/St. Louis Formations* – Primarily consists of dolomite and limestone with minor sand stone, shale, and chert. Part of the regional Mississippian aquifer system. Thickness varies from 45 to 130 feet.

- *Augusta Group* – Primarily consists of dolomite and fossiliferous limestone with minor cherty units and shale. Part of the regional Mississippian aquifer system. Has a maximum thickness of 200 feet.

- *Kinderhookian* – Primarily consists of dolomite, siltstone, and limestone with lesser amounts of shale, fossiliferous limestone, and chert. Part of the regional Mississippian aquifer system. These have a maximum thickness of 130 feet.

Devonian System

- *Fammenian* – Primarily consists of shale and siltstone with minor argillaceous limestone. These are generally considered to be a regional aquitard. These may reach thicknesses of up 300 feet.

- *Lime Creek Formation* – Primarily consists of shale and dolomite with minor amounts of argillaceous dolomite/limestone and siltstone. These are generally considered to be a re gional aquitard. They have a maximum thickness of 160 feet.

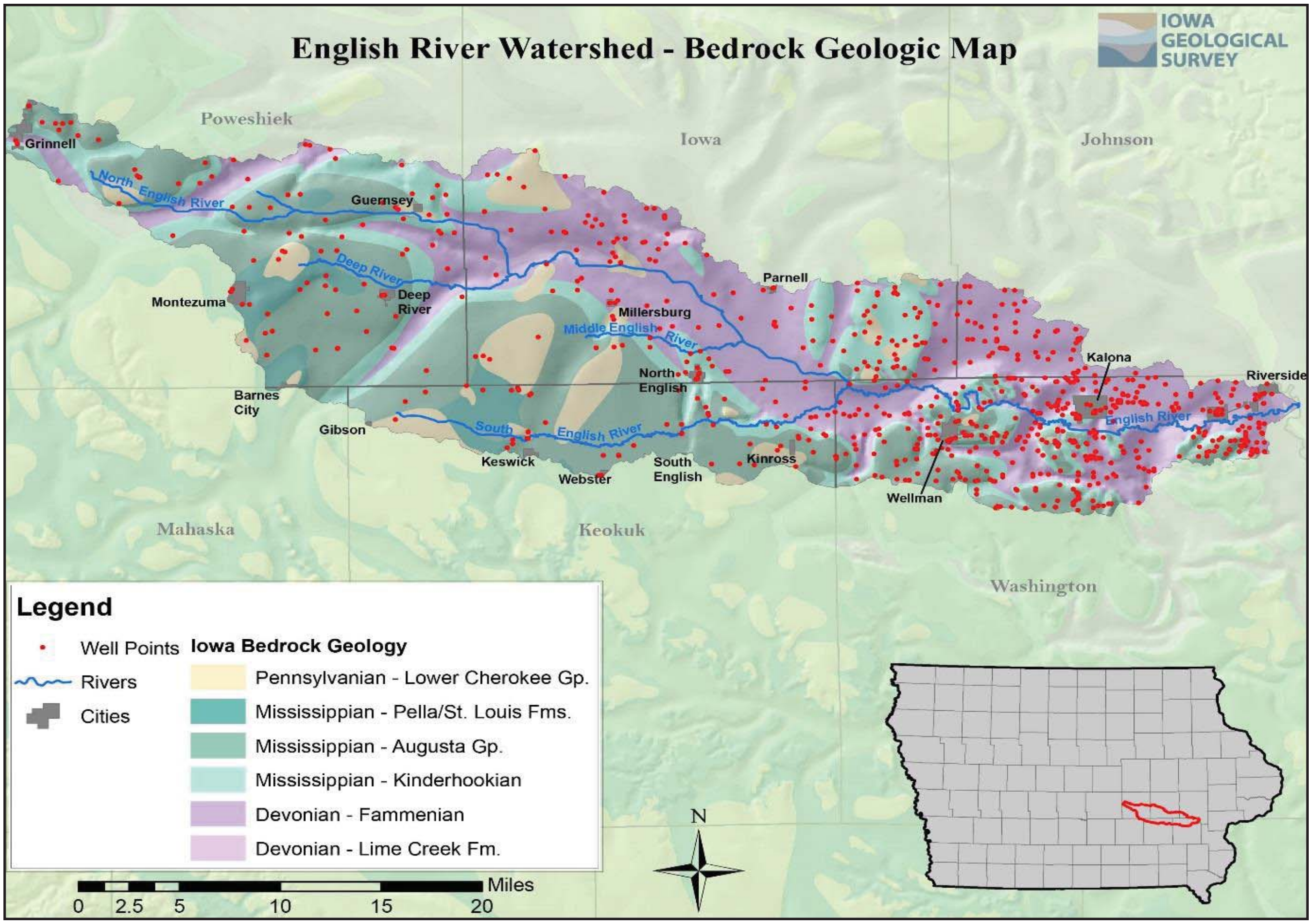


Figure 11. Map illustrating the bedrock geology of the ERW

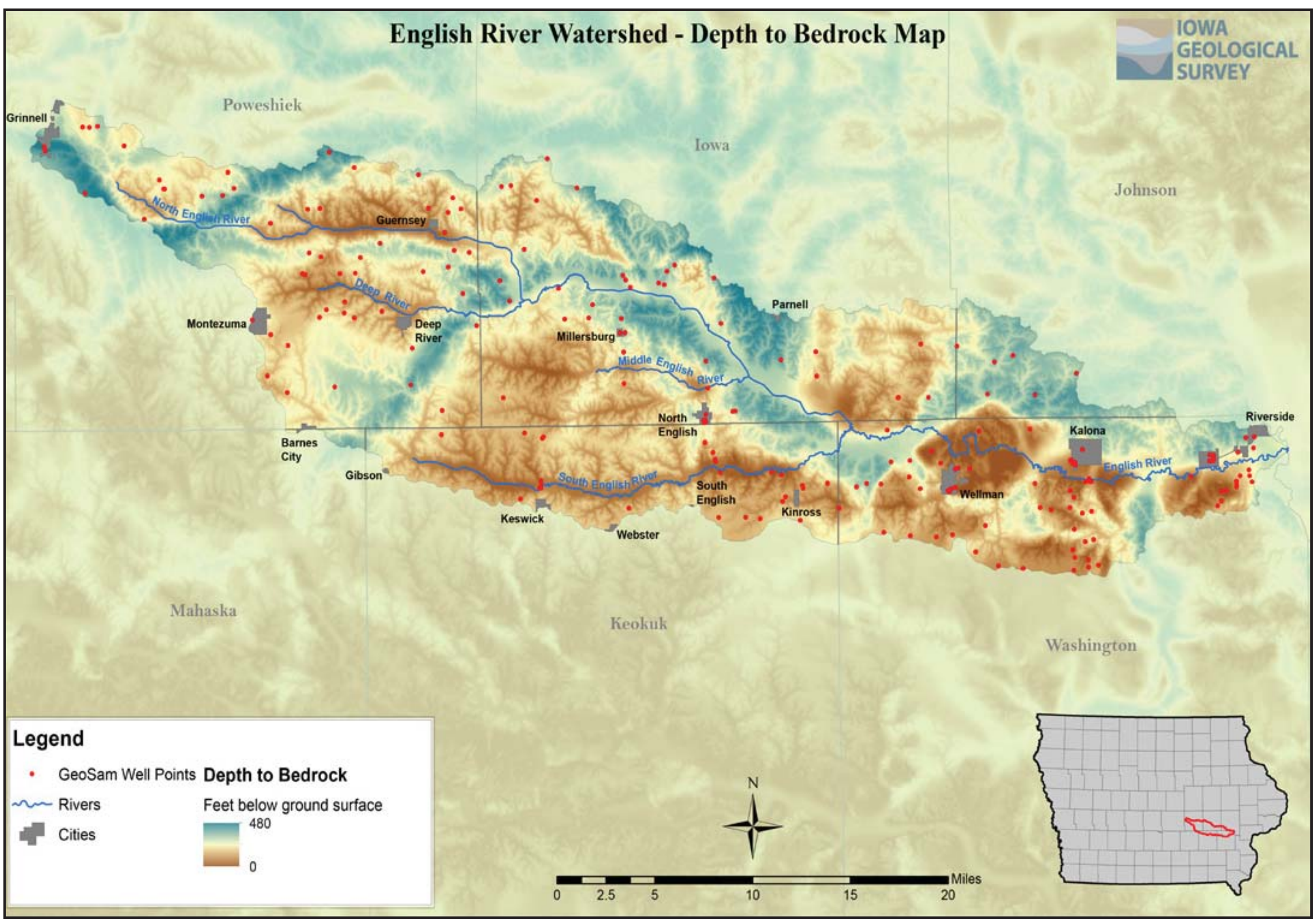


Figure 12. Map illustrating the depth to the surface of the bedrock in the ERW

3.4 Surface Water

The English River watershed is an interconnected series of tributaries and rivers totaling 1,447 miles in length, which is noted in Table 4. Around 409,000 acres of southeastern Iowa drain into it.

Table 4. General Watershed Data – English River (Waterbody ID Code IA02-IOW-0100)	
Location	Iowa, Johnson, Keokuk, Mahaska, Poweshiek, and Washington counties
Waterbody Type	River
Watershed Area	409,236 acres
Total River and Stream length	1,447 mi.
Dominant Land Use	Row Crop Agriculture
HUC 12 Watersheds	20 HUC-12 subwatersheds (ID Codes: Refer to Table 6)
HUC 10 Watershed	4 HUC-10 watersheds
HUC 8 Watershed	Part of the Lower Iowa (ID Code 07080209)

The English River begins as a series of tributary streams, originating in Poweshiek and Iowa counties. These tributary streams converge into the North English, Deep River, Middle English Rivers, and Deer Creek (Figure 13). The South English River begins in southeastern Poweshiek County. All of these rivers merge with the South English River in northwest Washington County to form the English River. The English River then flows east through Washington County before merging with the Iowa River, just east of Riverside.

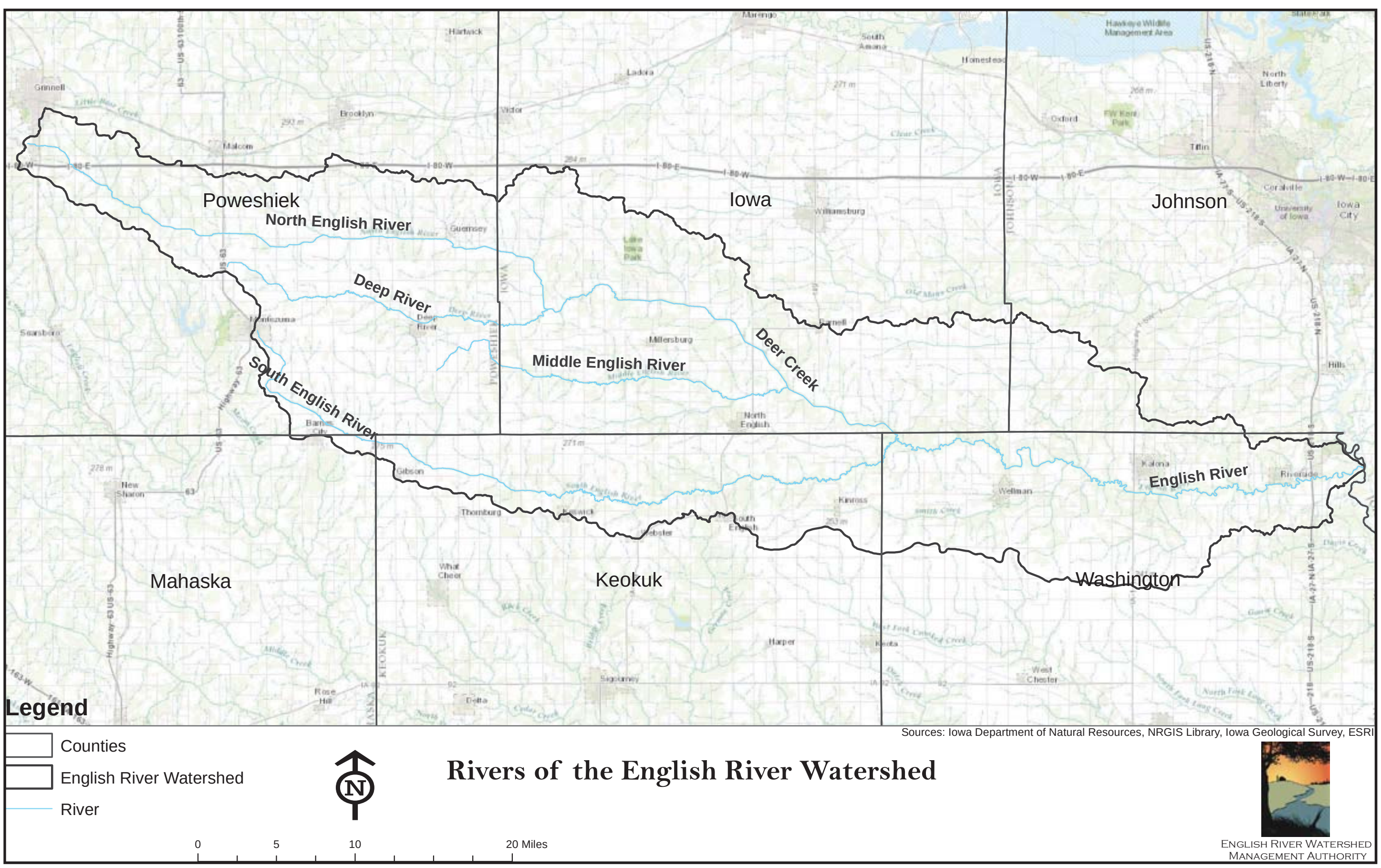


Figure 13. Rivers of the English River Watershed

Stream Order

A well-connected stream and river network is found within the English River watershed. The National Hydrography Dataset lists 568 miles of 1st order streams, 162 miles of 2nd order streams, 54 miles of 3rd order streams, 69 miles of 4th order streams, and 36 miles of 5th order streams in the watershed (Figure 14).

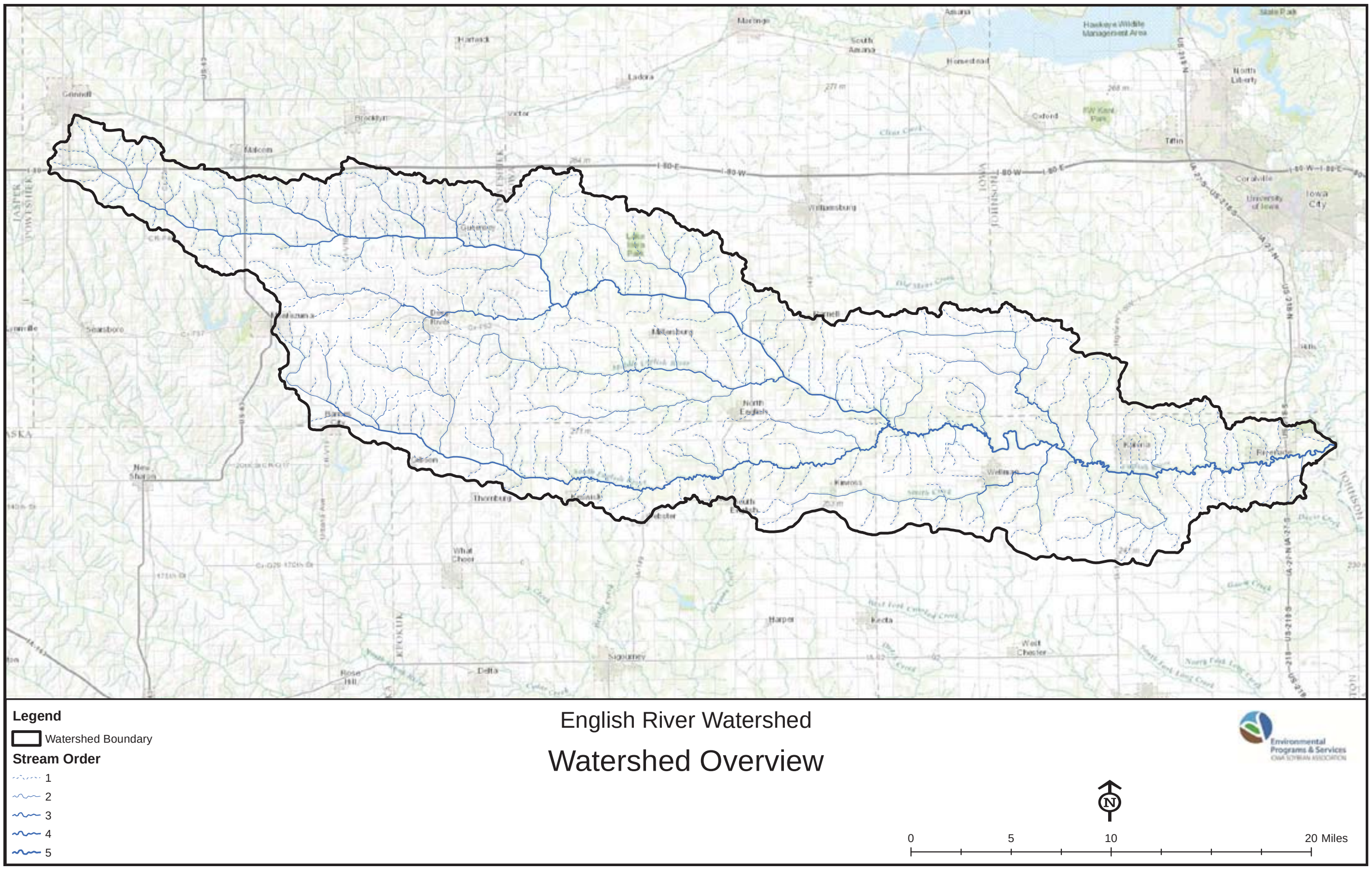


Figure 14. Stream order in the English River Watershed

Lakes

Lake Iowa is an 84 acre constructed lake in the north central region of the English River watershed. It is the only significant waterbody in the watershed besides the North, Middle and South English Rivers, Deer Creek, and Deep River. Lake Iowa is utilized primary for recreational uses, such as swimming and fishing. The lake's designated uses are Class A1 - primary contact recreation, Class B (LW) – aquatic life, and Class HH – human health (fish consumption). Lake Iowa was placed on the impaired waters list in 2008 by the Iowa Department of Natural Resources for impairments including algal blooms, mercury levels found in the fish, and pathogens (E. coli).[9]

A draft Total Maximum Daily Load (TMDL) has been developed by IDNR to address the nuisance algal blooms in Lake Iowa, and at the time of writing, the TMDL was open for public comment. The TMDL attributes the algal blooms, which cause the impairment of the primary contact recreation designated use, to excess total phosphorus loads. The total phosphorus is derived from non-point sources such as fertilizer and manure from row crops, sheet and rill erosion, and atmospheric deposition. A 79% reduction in total phosphorus loads is required in order to meet the TMDL. The final Lake Iowa Watershed Improvement Plan is anticipated to be available by the end of 2015.[10]

Wetlands

Currently, there are approximately 11,250 acres of wetland in the English River watershed (Table 5). Wetland inventory data suggests that of these, over half of the areas (61%) are wet due to temporary flooding. Almost 12 percent of additional wetland areas are intermittently exposed, and less than 5 percent of wetland areas are water-inundated year-round.

Table 5. English River Wetland Inventory		
Wetland Type	**Acres**	**Percent (%)**
Temporarily Flooded	6,908	61.4
Intermittently Exposed	1,298	11.5
Seasonally Flooded	1,257	11.2
Semi-permanently Flooded	665	5.9
Permanently Flooded	499	4.4
Intermittently Flooded	418	3.7
Unclassified Wetland	129	1.1
Artificially Flooded	76	0.7
Total	11,250	100%

Figure 15 shows areas containing identified wetlands in the English River watershed according to the National Wetland Inventory (NWI), a dataset developed by the U.S. Fish and Wildlife Service. The wetland locations were derived from aerial photo interpretation. The NWI maps do not show all wetlands, as the maps were derived from aerial photography with varying limitations due to scale, photo quality, inventory techniques, and other factors. Consequently, the maps tend to show wetlands that are interpreted through readily-accessible photos, with consideration given to photo quality and map scale.

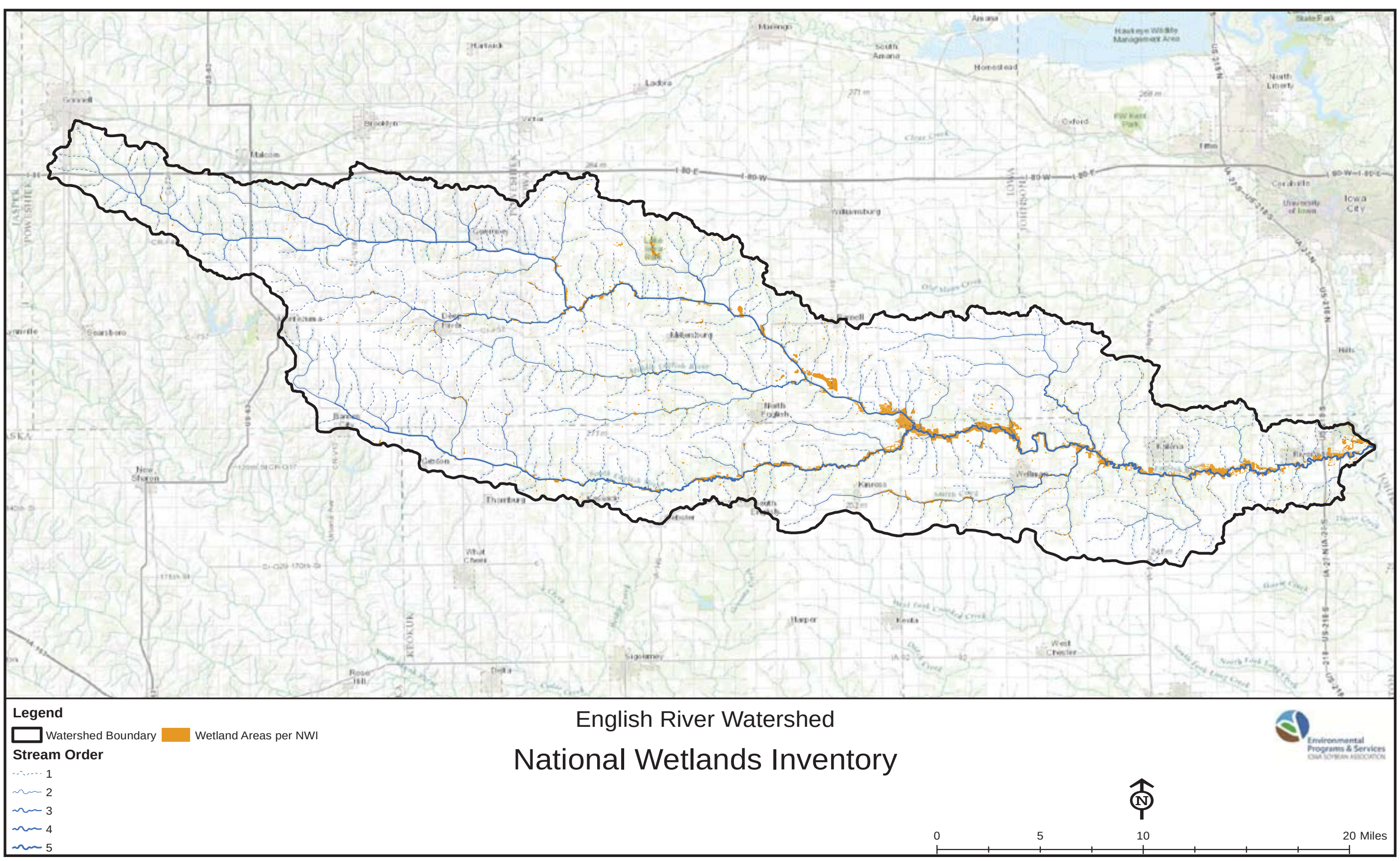


Figure 15. Inventory of wetlands in the English River Watershed

Watersheds

Watersheds in the United States are nested within one another and classified using Hydrologic Unit Codes (HUCs) based on their scope and size. Watersheds are divided into regional watersheds (HUC – 2) at the large end of the scale, and subdivided into watershed units as small as HUC – 12s. The Upper Mississippi Regional watershed (picured in blue) covers approximately 75 percent of Iowa (Figure 16). The entire area drains into the Mississippi River.

Regional watersheds can be divided into HUC – 8 watersheds. The English River watershed is part of the Lower Iowa Watershed, pictured in green (Figure 16).

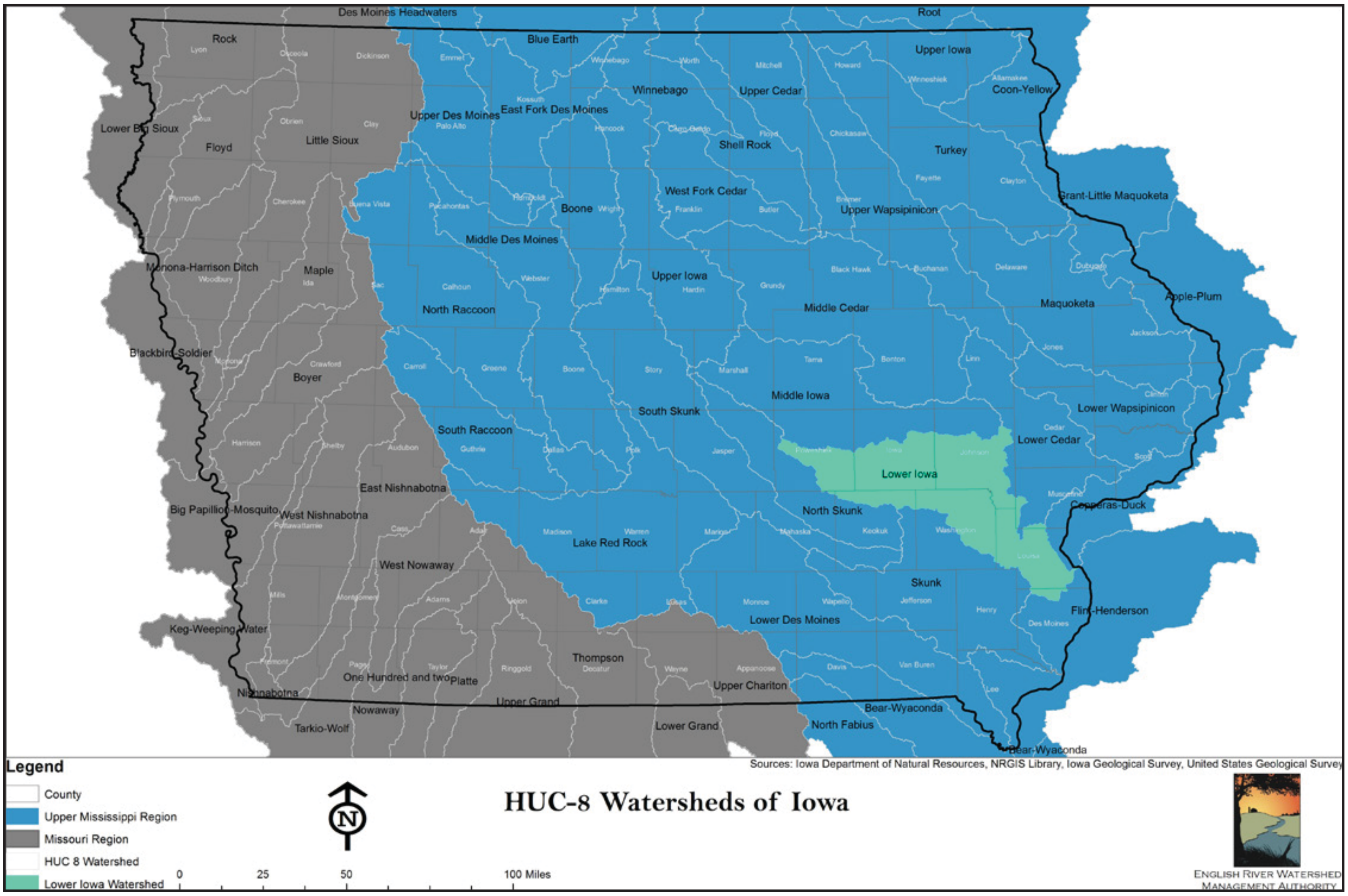


Figure 16. HUC – 8 watersheds, including the Lower Iowa watershed

Subwatersheds

The Lower Iowa Watershed can be broken down further into additional, smaller watersheds called HUC – 10s (Figure 17). Four of these HUC – 10 watersheds comprise the English River watershed. The HUC – 10 watersheds that make up the English River watershed are the North, Middle, and South English, and the English River subwatershed.

There are 20 subwatersheds (or HUC – 12s) that comprise the English River watershed. The Dugout Creek watershed is also known as the headwaters of the North English River, and is the largest HUC – 12 in the ERW with an area of 36,000 acres. In comparison, the smallest HUC – 12 in the ERW is a creek with no official name (known by the U.S. Geological Survey as the "Town of Tilton" subwatershed). Table 6 shows each HUC – 12 and their relative size in acres and square miles.

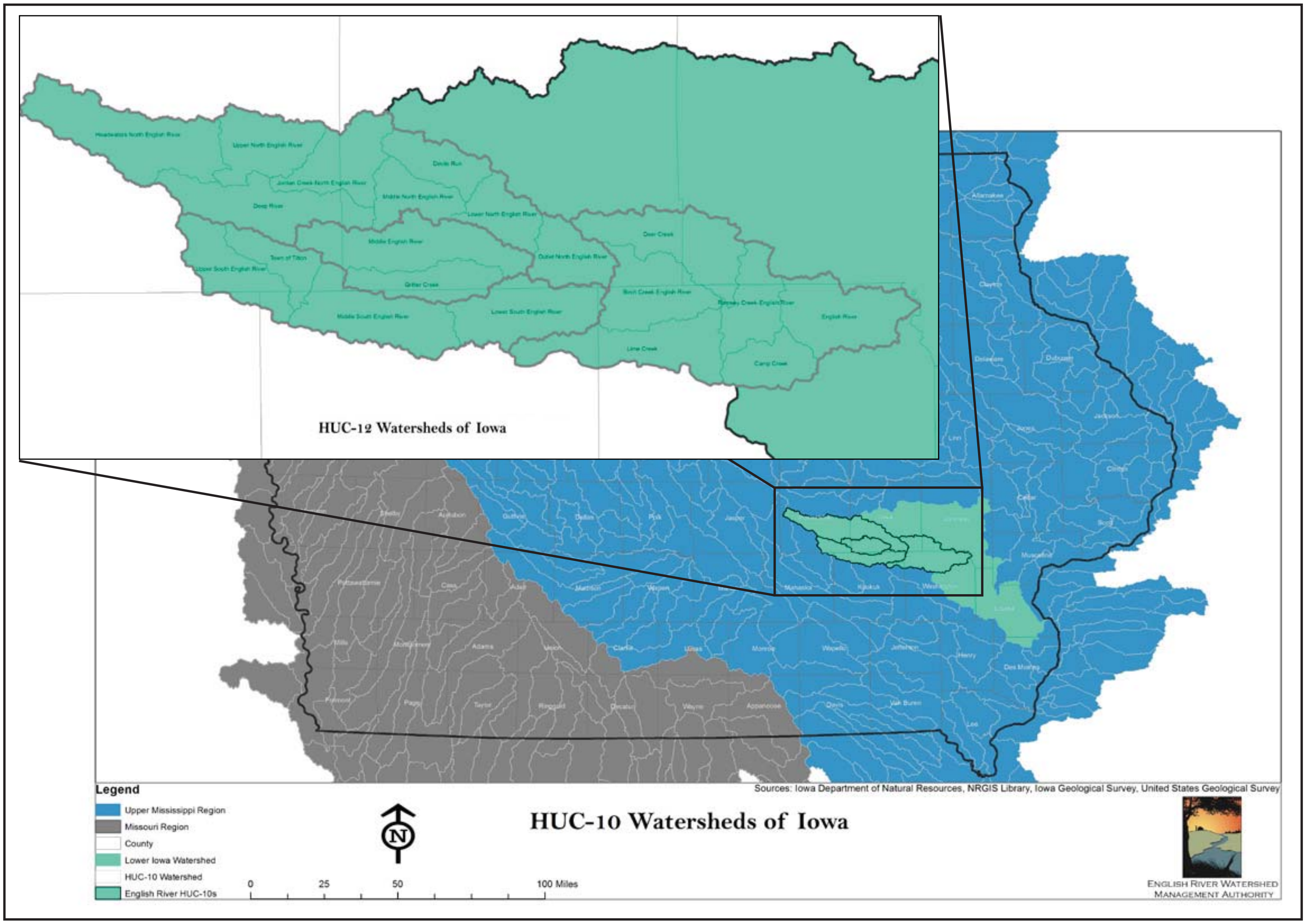


Figure 17. English River Watershed area and the other HUC — 10 subwatersheds of Iowa, including HUC — 12 wastersheds

Table 6. HUC – 12s of the English River Watershed				
HUC – 12 ID	**USGS HUC – 12 Name**	**IGS HU – 12 Name**	**Acres**	**Sq. Miles**
070802090401	Headwaters North English River	English River-Dugout Creek	36,075	56.3
070802090302	Middle English River	Middle English River	29,845	46.6
070802090503	Middle South English River	Middle South English River	27,397	42.8
070802090603	Deer Creek	Deer Creek-English River	26,571	41.5
070802090403	Deep River	Deep River	26,535	41.4
070802090601	Lime Creek	Lime Creek-English River	26,208	40.9
070802090504	Lower South English River	Lower South English River	25,728	40.2
070802090606	English River	English River-Bulger's Run	25,425	39.7
070802090602	Birch Creek-English River	English River-Birch Creek	21,928	34.2
070802090404	Jordan Creek-North English River	English River-Jordan Creek	19,540	30.5
070802090402	Upper North English River	Upper English River	19,076	29.8
070802090502	Uooer South English River	Upper South English River	18,411	28.7
070802090605	Ramsey Creek-English River	English River-Ramsey Creek	15,438	24.1
070802090301	Gritter Creek	Gritter Creek	14,836	23.2
070802090408	Outlet North English River	English River-Middle English River	14,193	22.2
070802090405	Devils Run	Devils Run	13,007	20.3
070802090406	Middle North English River	English River-Deep River	12,841	20.1
070802090604	Camp Creek	Camp Creek-English River	12,818	20.0
070802090407	Lower North English River	English River-Devils Run	12,611	19.7
070802090501	Town of Tilton	Unnamed Creek-South English River	11,016	17.2

3.5 Groundwater

Aquifers

Wells in the English River watershed typically serve one of three purposes: public or private drinking water sources, agricultural / livestock use. Water resources are tapped through shallow or deep wells, depending upon the aquifers readily available for the community or individual to access. The vast majority of available geologic and hydrogeologic data is collected when drilling water wells. The following are the types of aquifers in the English River Watershed:

- *Alluvial* – Unconsolidated sediments found within a natural river or stream floodplain. The average depth of the 12 alluvial wells in the ERW is 50 feet.
- *Buried Sand and Gravel* – Unconsolidated sand and gravel units found within the glacial till package. The average depth of the 30 buried sand and gravel wells in the ERW is 150 feet.
- *Cambrian - Ordovician* – Bedrock aquifer of Cambrian – Ordovician age, generally carbonate and sandstone. Depths of public wells in the ERW using the Cambrian - Ordovician aquifer range from about 1,700 feet to 1,950 feet.
- *Devonian* – Bedrock aquifer of Devonian age, generally carbonate. Depths of public wells in the ERW using the Devonian aquifer range from about 120 feet to 425 feet.
- *Mississippian* – Bedrock aquifer of Mississippian age, generally limestone and dolomite (carbonate). Depths of public wells in the ERW using the Mississippian aquifer range from about 100 feet to 400 feet.
- *Silurian* – Bedrock aquifer of Silurian age, generally carbonate. Depths of public wells in the ERW using the Silurian aquifer range from 640 feet to 825 feet.

Drinking Water Sources

There are approximately 3,076[11] wells in the English River watershed that are documented by the Iowa Department of Natural Resources (IDNR). Based on the Iowa Geological Survey (IGS) online geologic sampling database GEOSAM[12], there is data for 845 of the wells in the watershed. Among those are public water supply wells that serve the public. Table 7 shows the breakdown of aquifers being tapped by public wells in the watershed.

Table 7. Aquifer Use by Public Wells in the English River Watershed

Well Status	# of wells	Alluvial	Buried Sand & Gravel	Mississippian	Devonian	Silurian	Cambrian / Ordovician
Active	29	7	14	2	1	-	3
Not Used	32	3	15	6	3	3	1
Stand By	3	2	1	-	-	-	-
TOTAL	**64**	**12**	**30**	**8**	**4**	**3**	**4**

Some public water supplies in the watershed utilize *alluvial* aquifers, or shallow sand and gravel deposits associated with streams and rivers directly in their vicinity. Because of the shallow nature of these ground water sources, they are particularly vulnerable to contamination through surface level runoff, leaching of improperly stored chemicals, leaky storage tanks, or agricultural runoff.

The public water utilities in the watershed that are currently listed as having "Highly Susceptible Systems" are the Cities of Kalona, Riverside, the Shiloh residential development, and the regional water utility- Poweshiek Water Association. Poweshiek Water Association provides four communities in the English River watershed with drinking water: Barnes City, Gibson, Guernsey, and Millersburg. Communities with "Highly Susceptible Systems" have the option to develop and implement a Source Water Protection Plan. The Iowa Department of Natural Resources' Source Water Protection program helps participating communities identify ways to protect their drinking water resources from contamination before it is treated and distributed to consumers. The program offers assistance with planning to achieve this goal. The program's Phase 1 planning identifies basic information about a community's drinking water resources and well-capture zones. Phase 2 planning results in a more detailed analysis of drinking water resources, threats, and action steps for protecting drinking water at its source. The following English River watershed communities have completed Phase 1 Source Water Protection Assessments: Deep River, Grinnell, Kalona, Montezuma, North English, Parnell, Riverside, Webster, and Wellman. In addition to Phase 1 completion, the following communities have utilized the program to develop Phase 2 assessments: Grinnell, Montezuma, Riverside, and Wellman.

The majority of public drinking water sources in the watershed come from *buried sand and gravel aquifers*. These sources are deeper and as a result, better protected from surface contaminants or leaching.

Sandstone and limestone sources (such as the *Cambrian-Ordovician*, *Devonian*, and *Mississippian* aquifers) are utilized by a few public water suppliers in the watershed. These aquifers are deeper bedrock-level aquifers that are well protected from contamination. These drinking water resources are at risk of contamination in areas where sinkholes are more frequent (such as in the northeastern part of the state), however.

Agricultural Drainage Wells

Agricultural drainage wells are deep pits that collect drainage from large agricultural tiling systems. Agricultural drainage wells pose a risk to the safety of drinking water supplies; because of their depths they can allow field drainage to come into contact with, or leach into water aquifers used for drinking water by others. The IDNR estimates that approximately 350 agricultural drainage wells were in use before legislation passed in 1997 to protect groundwater sources and closed all but around 60 of these wells.[13] There are no reported agricultural drainage wells in the English River watershed.[14] Most agricultural drainage wells in Iowa exist primarily in north central Iowa, where the landscape is flat, and many of these have since been closed.

3.6 Climate & Precipitation

Climate data from the City of Williamsburg, approximately five miles north of the watershed, showed an average area precipitation of 36 inches per year between 1951 and 2013 (Figure 18). Year to year precipitation totals vary widely, however. During that 62 year time frame, a high of nearly 60 inches was recorded in 1993, and lows of 20 inches or less were recorded in 1953 and 1988.[15] These observations were consistent with historic state-wide weather events across Iowa, such as the floods of 1993 and a severe drought in 1988.

Monthly temperature data from the same period of time (1951 to 2013) suggest that on average, July and August are the hottest months of the year (Figure 19).[15] Not surprisingly, the data shows that December, January, and February are typically the coldest months of the year.

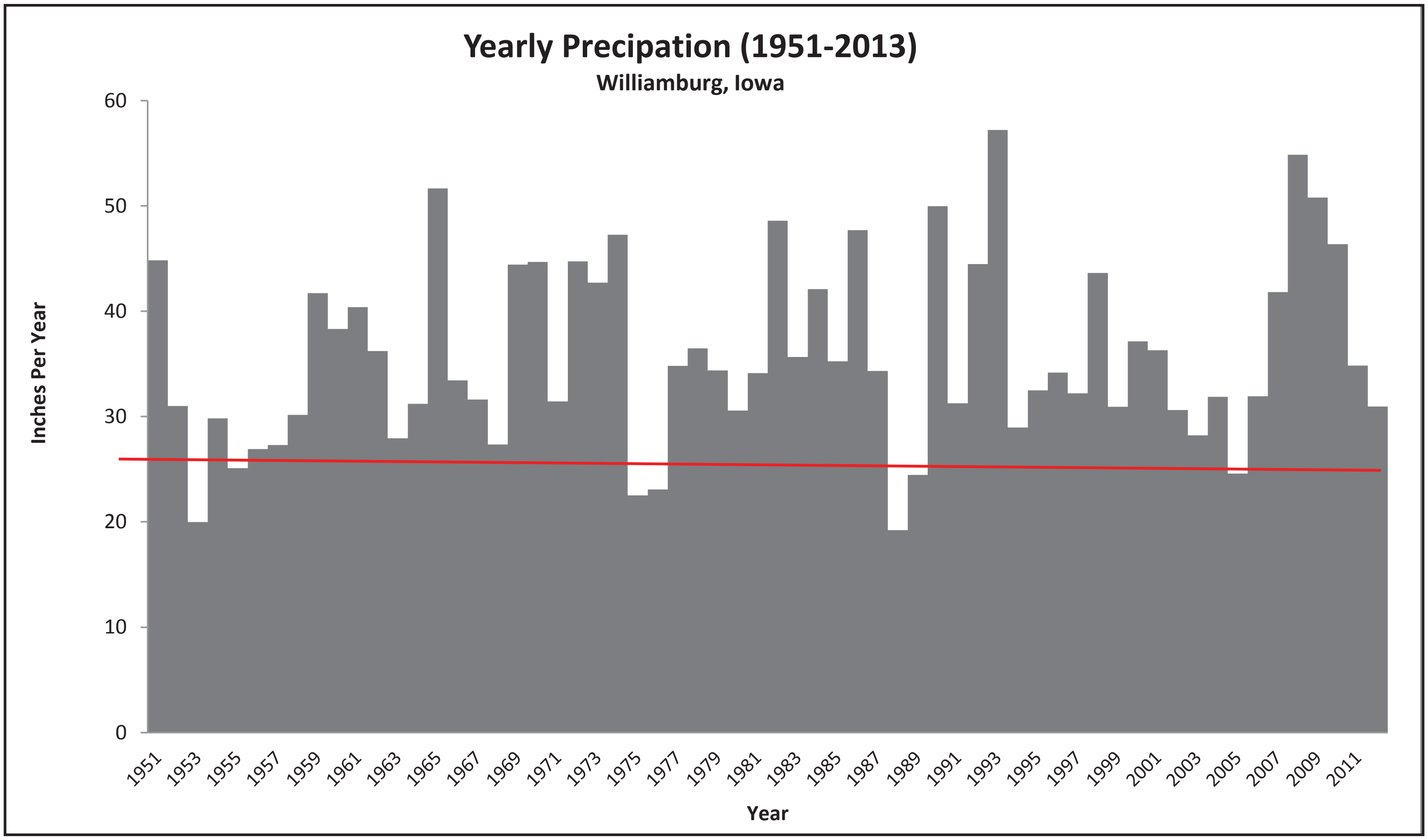


Figure 18. Yearly precipitation around the English River Watershed (1951 - 2013)

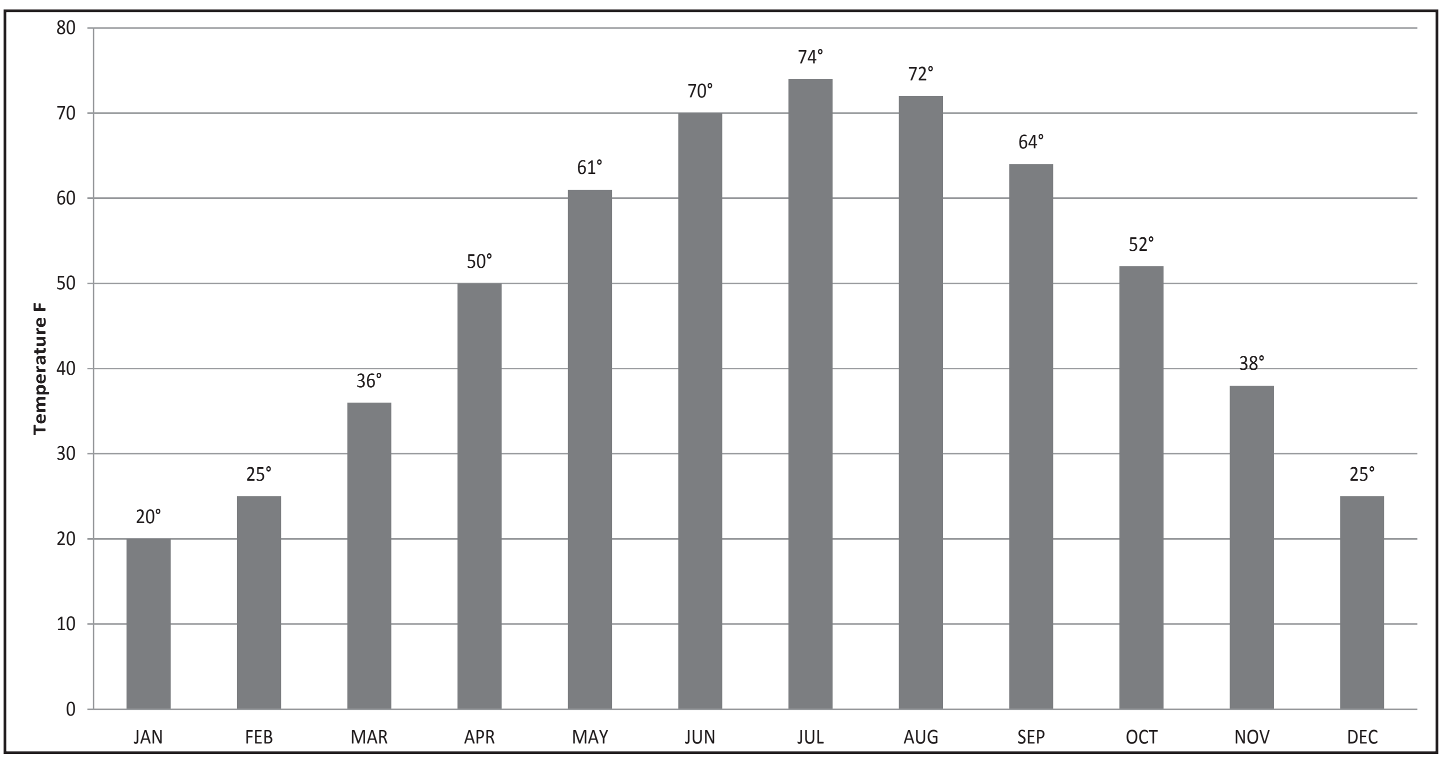


Figure 19. Average monthly temperatures in the English River Watershed (1951 - 2013) in Williamsburg, Iowa

3.7 Demographics

Population

Township population data from the 2010 Decennial Census analyzed with GIS (Geographic Information Systems) apportioning tools suggest that approximately that 21,699 people live in the English River watershed. This equates to approximately 33.9 people per square mile. The headwaters of the English River watershed begin in the southeastern end of the City of Grinnell, but technically, this community is not in the English River Watershed. As the data in Table 8 shows, the largest community in the English River watershed is actually Kalona (pop. 2,363) followed by Montezuma (pop. 1,462). The smallest communities in the watershed are Guernsey (pop. 63) and Gibson (pop. 61).

Urban/Rural

Of the approximately 21,699 people who reside within the watershed, about 40 percent, or 8,605 people, live in "urban" areas; within the corporate city limits of the watershed's 14 incorporated cities and towns (Table 8). Population density (or persons per square mile) in the watershed is actually greatest at the southeastern end. Although communities like Wellman and Riverside are smaller than Kalona or Montezuma, higher density is created by the presence of rural housing developments combined with the urban areas in these locations.

Table 8. Population in ERW Communities[16]

Incorporated Cities and Towns	2010 Population
Kalona	2,363
Montezuma	1,462
Wellman	1,408
North English	1,041
Riverside	993
Deep River	279
Keswick	246
Parnell	193
Barnes City	176
Millersburg	159
Webster	88
Kinross	73
Guernsey	63
Gibson	61
TOTAL	**8,605**

Recent Population Changes
Portions of 30 county townships overlap with the English River watershed area. Decennial Census data from 2000 and 2010 suggest that 14 of these townships experienced growth during this decade, while 16 townships experienced a population decline (refer to Figure 20).

Areas with the greatest gains are in the southeastern portion of the watershed: Iowa (26%) and Jackson Townships (23%); and in the central portion: Fillmore (20%) and Troy Townships (13%). The greatest population losses occurred in the southwestern area of the watershed, such as Pleasant Grove (-16%), Dayton (-18.5%), Adams (-19%) and Prairie (-20%) Townships.

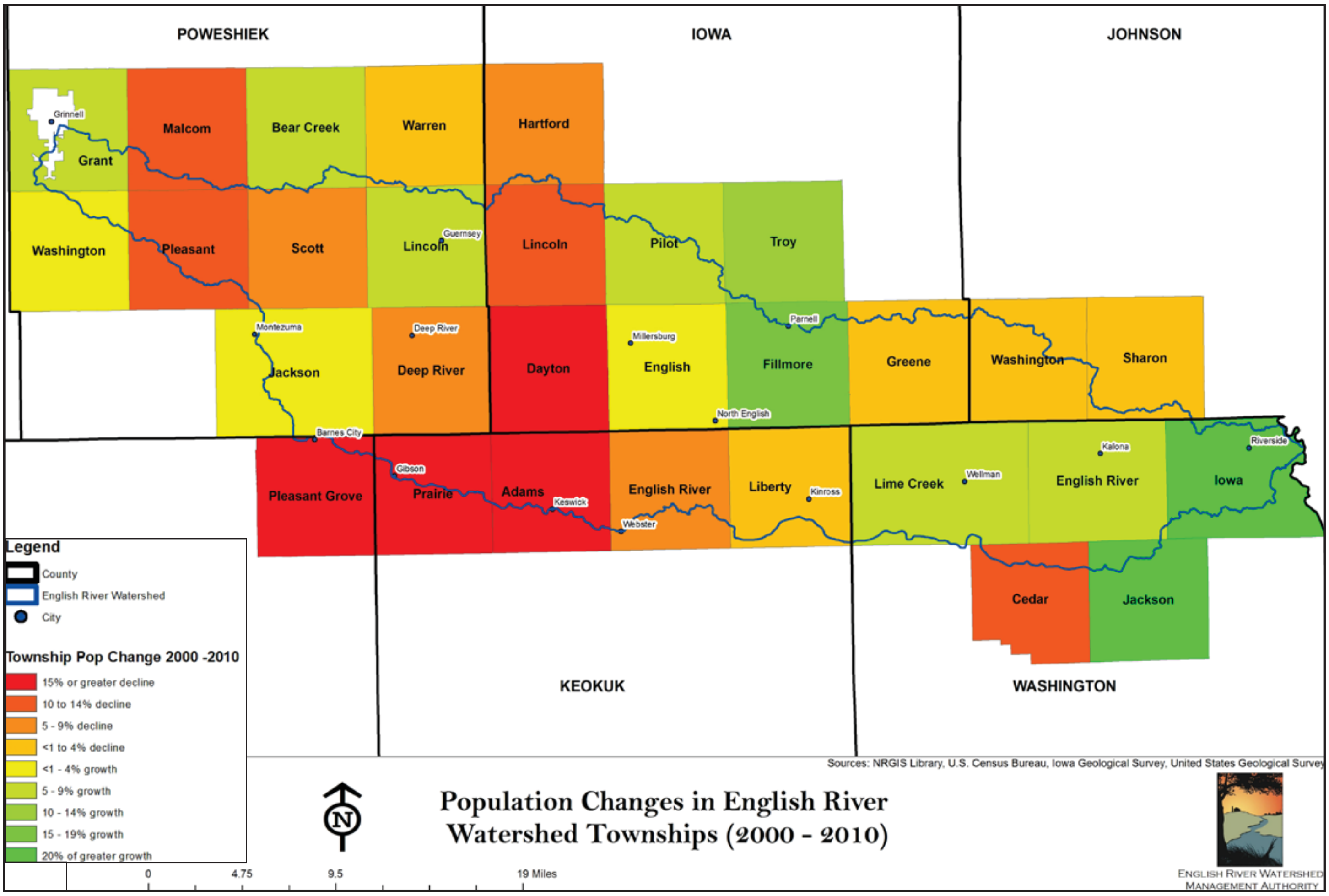


Figure 20. Population changes in townships within the watershed (2000 - 2010)

Age
Data from the 2010 Decennial Census, suggest that (in the watershed's townships) the average median age of watershed residents is 42 years (refer to Figure 20 for township boundaries). As the data in Table 9 indicates, Sharon Township in southwestern Johnson County has the lowest median age (27.5) and Dayton Township has the highest (47.7 years).

Diversity
On average, 98 percent of watershed residents identified themselves as "White" in the 2010 U.S. Census (Table 10). Warren Township (Poweshiek County) is the most diverse township in the watershed, with 4.4 percent of residents identifying with a racial or ethnic group other than "White."

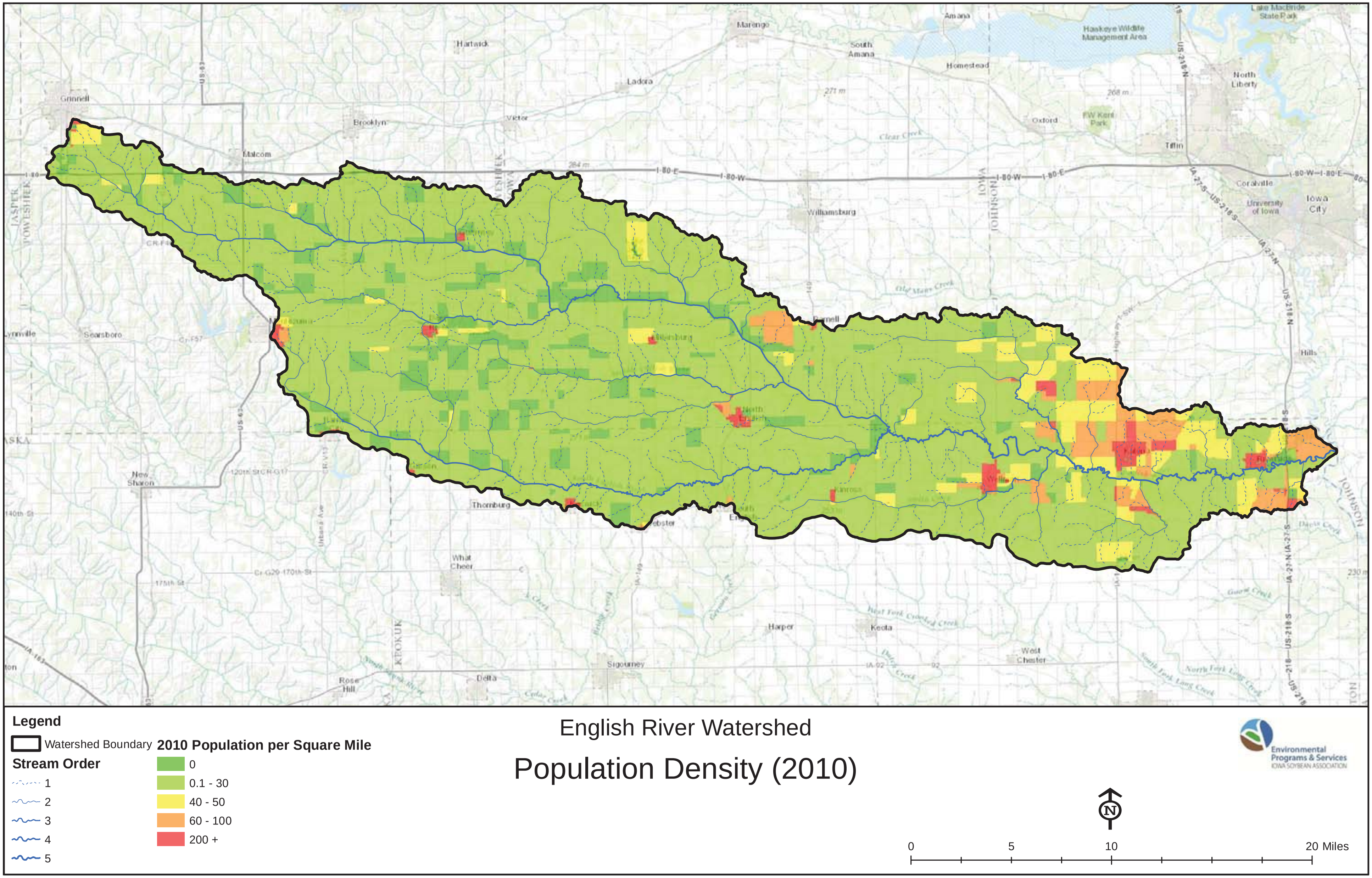


Figure 21. Population density in the English River watershed (2010)

Grant Township's diversity is likely heightened by students and staff affiliated with nearby Grinnell College. Deep River Township (Poweshiek County) is the only area in the watershed where 100 percent of residents identify as being "White."

Warren and Bear Creek Townships (Poweshiek County) have the highest proportion of residents identifying as either "Hispanic" or "Latino" (4.7%) than any other townships in the watershed. Some areas, such as Adams (Keokuk County) and Deep River (Poweshiek County) Townships, did not have any residents who identified as being either Hispanic or Latino in the 2010 Census (Table 10). It is possible that there may be residents who are Hispanic / Latino living in these areas, but they were overlooked or declined to participate in the Census.

Table 9. Median Age in English River Watershed Townships

Township	County	Total Population	Median Age
Dayton	Iowa	202	47.7
Malcom	Poweshiek	580	47.4
Pilot	Iowa	335	45.8
Adams	Keokuk	421	45.1
Lincoln	Poweshiek	285	45.1
Pleasant	Poweshiek	289	44.8
Prairie	Keokuk	351	44.8
Deep River	Poweshiek	473	44.4
Scott	Poweshiek	257	43.9
English	Iowa	1615	43.8
Cedar	Washington	288	43.6
Jackson	Poweshiek	1838	43.6
Pleasant Grove	Mahaska	297	43.6
Washington	Poweshiek	451	43.4
Warren	Poweshiek	430	43.3
Grant	Poweshiek	522	42.8
Hartford	Iowa	1294	42.4
Liberty	Keokuk	344	42.3
English River	Keokuk	584	42.2
Greene	Iowa	522	41.5
English River	Washington	3924	41.3
Filmore	Iowa	743	41.2
Lime Creek	Washington	2203	41.0
Troy	Iowa	3437	39.6
Lincoln	Iowa	243	39.5
Iowa	Washington	2262	39.3
Jackson	Washington	488	38.1
Bear Creek	Poweshiek	1820	37.6
Washington	Johnson	1200	34.2
Sharon	Johnson	1291	27.5

Table 10. Racial and Ethnic Diversity in the English River Watershed					
Township	**County**	**Total Population**	**White**	**Biracial**	**Hispanic/Latino**
Deep River	Poweshiek	473	100.0%	0.0%	0.0%
Lincoln	Iowa	243	99.6%	0.0%	0.4%
Jackson	Washington	488	99.4%	0.4%	2.0%
Prairie	Keokuk	351	99.4%	0.0%	1.7%
Lincoln	Poweshiek	285	99.3%	0.4%	0.7%
English	Iowa	1615	98.9%	0.5%	1.0%
Washington	Poweshiek	451	98.9%	0.4%	0.2%
Pilot	Iowa	335	98.8%	0.9%	0.3%
Sharon	Johnson	1291	98.5%	1.2%	1.6%
Troy	Iowa	3437	98.4%	0.8%	1.3%
Adams	Keokuk	421	98.3%	1.0%	0.0%
Jackson	Poweshiek	1838	98.3%	0.7%	1.1%
Liberty	Keokuk	344	98.3%	0.6%	1.5%
Malcom	Poweshiek	580	98.3%	0.9%	2.4%
Pleasant	Poweshiek	289	98.3%	1.0%	1.7%
Iowa	Washington	2262	98.1%	0.8%	0.9%
Hartford	Iowa	1294	98.0%	0.3%	0.9%
Scott	Poweshiek	257	97.7%	0.0%	2.7%
Cedar	Washington	288	97.6%	0.3%	1.4%
English River	Keokuk	584	97.6%	1.2%	2.1%
English River	Washington	3924	97.5%	0.9%	1.6%
Filmore	Iowa	743	97.3%	0.5%	2.6%
Greene	Iowa	522	97.3%	0.8%	2.9%
Lime Creek	Washington	2203	97.3%	1.3%	1.6%
Pleasant Grove	Mahaska	297	97.3%	0.0%	1.0%
Washington	Johnson	1200	97.2%	1.5%	0.5%
Grant	Poweshiek	522	96.7%	1.0%	0.4%
Dayton	Iowa	202	96.5%	1.5%	2.5%
Bear Creek	Poweshiek	1820	96.0%	0.9%	4.3%
Warren	Poweshiek	430	95.6%	1.2%	4.7%
AVERAGE		**966.3**	**98.0%**	**0.7%**	**1.5%**

Household Size
Average household size in watershed townships is 2.56 persons per household. Sharon and Washington Townships in southwestern Johnson County observe the largest average household sizes of 3.68 and 3.23 persons per household respectively. Average family household size may be a little larger in these areas because of the Amish community there. The Amish families tend to have larger families, and multigenerational households are more common. Pleasant Grove Township (Mahaska County) and Adams Township (Keokuk County) average the smallest households; 2.15 and 2.3 persons, respectively.

Education
Using estimates provided by the American Community Survey (2013), an average of 91 percent of watershed township residents have completed a high school education or the equivalent. Graduation rates are highest (at or near 100%) in Pilot and Lincoln Townships (Iowa County) and in Cedar Township (Washington County). Graduation rates were considerably lower (61%) in Sharon and Washington Townships (Johnson County) and Washington Township (80%) in Poweshiek County. The lower rates of high school completion in the Johnson County townships may be influenced by the large Amish community present; whose youth traditionally complete their formal education at 8th grade.

An average of 17 percent of residents in watershed townships have attained a Bachelor's degree or higher. Troy and Pilot Townships (Iowa County) average the largest percentage of 4-year degree earners at 29.2 and 28.1 percent respectively. An average of 28 percent of Iowa Township (Washington County) residents attain a 4-year degree or beyond. Townships on average with the fewest 4-year (or higher) degree earners are Dayton (Iowa County), Pleasant Grove (Mahaska County), and Lincoln (Poweshiek County), at rates of 10.9, 5.0, and 2.1 percent, respectively.

Household Income
Median annual earnings for employed watershed residents are $33,458 annually, per estimates provided by the American Community Survey. These salaries were adjusted for inflation. Median earnings were highest in Jackson (Washington County), Greene (Iowa County) and Washington Townships (Johnson County): $40,000 – $50,000. The lowest median earnings were in Pleasant and Scott Townships (Poweshiek County) and Pleasant Grove (Mahaska County): $16,000 – $20,000.

Median earnings among men were highest in Jackson and Iowa Townships in Washington County, and Washington Township in Johnson County: $51,000 – $78,000. They were lowest in Pilot (Iowa County), Pleasant (Poweshiek County), and Pleasant Grove (Mahaska County): $12,000 – $26,000. Median earnings of women were highest in Jackson (Washington County), Pilot (Iowa County), and Liberty Townships (Keokuk County) $35,000 – $36,000. They were lowest in Washington (Johnson County), Scott (Poweshiek County), and Pleasant Grove (Mahaska County): $13,000 – $15,000.

3.8 Watershed Habitat & Conservation

Fish & Wildlife Habitat
At one time, Iowa's landscape was characterized by abundant prairies, dense woodlands, and wetlands that provided habitat for diverse biological systems. Due to human impacts on the landscape from clearing, draining, plowing, hunting, and development, Iowa has lost over 75 percent of original forest and woodland areas, over 95 percent of its wetlands, and all but 1 percent of original prairie.[17] There are direct and indirect impacts of development on habitat. Humans impact habitat directly when they remove forests, pave roads, and build cities. Humans also indirectly impact remaining habitat when they allow sediment or chemicals to leach into aquatic environments, intentionally or unintentionally introduce invasive species into ecosystems, by overhunt, or fragment habitat areas.

Iowa has several native species of birds, mammals, reptiles, and other animals that are currently threatened or endangered. Species that are "endangered" are facing extinction, and as a result, are protected by law from hunting and removal of known habitat.[17] Species that are "threatened" have been projected to become endangered at some future point in time and are also protected by law.[18] Table 11 provides a list of species known to inhabit areas in the English River watershed that are currently classified as "endangered" in the state of Iowa. Some species are on federal registries as well.

Table 11. Endangered Species in English River Watershed Counties

		IOWA	JOHNSON	KEOKUK	POWESHIEK	WASHINGTON
Endangered	***BIRDS***	Barn Owl	Barn Owl King Rail Northern Harrier	Barn Owl	Barn Owl Piping Plover* Red-shouldered Hawk	Barn Owl
	MAMMALS	Indiana Bat**	Spotted Skunk	Indiana Bat**	Indiana Bat** Spotted Skunk	Indiana Bat** Spotted Skunk
	PLANTS	Eastern Prairie Fringed Orchid Ground Pine	Eastern Prairie Fringed Orchid* Ground Pine Pale Green Orchid Ricebutton Aster Waxleaf Meadowrue			
	REPTILES	Wood Turtle	Eastern Massasauga			Wood Turtle
	FISH		Freckled Madtom			Freckled Madtom
	FRESHWATER MUSSELS		Higgin's-eye Pearly Mussel** Pistolgrip Round Pigtoe Sheepnose Yellow Sandshell	Pistolgrip		Pistolgrip
	INSECTS		Byssus Skipper		Dakota Skipper	
	AMPHIBIANS					Blue-spotted Salamander

**Federal register of "Threatened" species*
***Federal register of "Endangered" species*

Photo: Endangered Barn Owl.

- The *Barn Owl*, endangered in every English River watershed county, relies on savanna habitat for nesting and hunting, and often roost in tree cavities or old barns or abandoned buildings near these savannas. The greatest threats to the Barn Owl are the loss of grassland areas they rely on for hunting, from poisoning due to use of rodenticides, and the removal of dead trees and old barns they utilize for nesting.

- The *Indiana Bat* relies on large trees with loose bark for roosting. They often choose trees close to water, because the water attracts the insects they feed on. Primary threats to this bat species are their colonial lifestyle that hastens the transmission of colony-wide infections, a loss of timber areas they rely on for nesting due to logging and development, poisoning from insecticides, and contaminated surface waters.

- The *Eastern Prairie Fringed Orchid* is native to tallgrass prairies and sedge meadows. Populations of this rare orchid have been greatly reduced by the conversion of prairie habitat to rowcrops, pressure created by invasive plant species, livestock overgrazing in grassland areas, and herbicide drift.

- The *Ground Pine* is a shady woodland tree that is sometimes found by roadsides. The population of this tree has been adversely impacted by urban development, the conversion of woodlands to cropland, and invasive species.

- The *Wood Turtle* and the *Pistolgrip Mussel* both rely on sandy or rocky-river-bottom habitat. Wood Turtles tend to nest in grassland buffers along streams and rivers. The Wood Turtle is greatly threatened by habitat fragmentation, loss of grasslands, and traffic from farm machinery and automobiles. The Pistolgrip Mussel is endangered because of sedimentation from dredging and gravel mining, and water pollution from residential and industrial discharges, herbicides and fertilizer runoff.

Photo: Endangered Wood Turtle. *Photo courtesy of Colin Osborn/USFWS.*

Table 12 provides a list of numerous plant, animals, and reptilian species that may become endangered in the future unless action is taken to restore habitat, reduce poaching, and remove invasive species responsible for their decline.

Table 12. Threatened Species in English River Watershed Counties

		IOWA	JOHNSON	KEOKUK	POWESHIEK	WASHINGTON
Threatened	***BIRDS***	Henslow's Sparrow		Henslow's Sparrow		Henslow's Sparrow
	FISH	Topeka Shiner**				
	PLANTS	Pink Milkwort* Showy Lady's Slipper Slender Ladies'-tresses Western Prairie Fringed Orchid Woodland Horsetail	Oak Fern Oval Ladies'-tresses Pinesap Pink Milkwort Showy Lady's Slipper Slender Ladies'-tresses Slim-leaved Panic Grass Wooly Milkweed	Slender Ladies'-tresses	Golden Corydalis Pink Milkwort Slender Ladies'-tresses	Downy Woodmint False Hellebore Slender Ladies'-tresses Sweet Indian Plantain Winged Monkey Flower
	MAMMALS			Southern Bog Lemming		
	REPTILES	Ornate Box Turtle	Blanding's Turtle Common Musk Turtle Ornate Box Turtle			Blanding's Turtle
	FISH		Orangethroat Darter			
	FRESHWATER MUSSELS		Butterfly Creeper Fat Pocketbook** Purple Wartyback			Creeper
	INSECTS				Poweshiek Skipperling	
	AMPHIBIANS					Central Newt

**Federal register of "Threatened" species*
***Federal register of "Endangered" species*

Conservation and Recreational Areas

The English River watershed contains roughly 3,900 combined acres of conservation and recreational areas (Table 13). Of these, approximately 2,738 acres can be classified as wildlife or wildlife management areas. These areas are maintained primarily for providing wildlife habitat with some recreational benefits for people such as wildlife viewing, hiking, and seasonal hunting or trapping. Typically motorized vehicles or boats, camping, and other activities that leave more of a human footprint are not allowed. Some of these areas are created through the Iowa Habitat Access Program (IHAP). Seasonal hunting on these properties may be permitted at times, but they are not generally open to the public. There are approximately 580 acres of IHAP in the English River Watershed. The Iowa Department of Natural Resources also maintains an additional 638 acre grassland area in Iowa County (Indiangrass Hills Easement) with limited public access.

There are 4 county parks in the watershed providing 1,123 acres of recreational options such as picnicking, fishing, camping, canoeing, hiking, or swimming. These areas are maintained by County Conservation Boards and designed for the purpose of creating both habitat and recreational areas. Iowa Township Park in northeastern Washington County is the only urban park amongst these recreational places managed on a county level.

There are three public river access points to the English River in the watershed. One is located just east of the tri-county English River Wildlife Area; there is one in Riverside and one east of Riverside, near the junction of the English and Iowa Rivers. The distance between the canoe access points at the English River Wildlife area and at the English – Iowa River junction is an approximately a 30-mile paddling trail (water-level permitting).

Table 13. Recreational & Wildlife Areas in the English River Watershed

Name	Type	Approx. Size	Unit
Indiangrass Hills Easement	Conservation Area	638	acres
Lake Iowa Park	County Park	441	acres
Coffman Woods Preserve	County Park	4	acres
Deep River Recreational Area	County Park	4	acres
Foster Woods	County Park	36	acres
English River Paddling Route	Paddling Route	30.2	miles
Iowa Habitat Access Program Tract	Private Wildlife Area	6	acres
Iowa Habitat Access Program Tract	Private Wildlife Area	574	acres
Canoe Access	Public River Access	0.5	acres
Riverside Access	Public River Access	0.5	acres
Iowa Township Park	Urban Park	25.38	acres
Butler Timber Wildlife Area	Wildlife Area	2	acres
Lantz Wildlife Preserve	Wildlife Area	35	acres
Berstler Woods	Wildlife Area	124	acres
English River Wildlife Area	Wildlife Area	1,434	acres
Lincoln Wildlife Management Area	Wildlife Area	4	acres
Cecil Rivers Timbers	Wildlife Area	89	acres
Deep River Timber Wildlife Area	Wildlife Area	396	acres
English River Access	Wildlife Area	25	acres
Pheasant Ridge	Wildlife Management Area	49	acres

3.9 Current Best Management Practices in the Watershed

Numerous farmers across the watershed have already installed or are in the process of implementing best management practices on their land. Currently, there are about 640 total miles of terraced-land in the English River Watershed. Additionally, there are 1,341 farm ponds that provide erosion control and other agricultural benefits on properties within the watershed, as shown in Table 14. Other non-structural best mangement practices such as buffers, cover crops, and no-till agriculture are difficult to identify because they cannot be delineated through aerial imagery.

Table 14. Best Management Practices in the Watershed

Practice	Total
Terraces	640.14 miles
Farm Ponds	1,341

4 | Water Quality & Quantity Conditions

Photo: The English River houses a diverse collection of plant and animal specices. *Photo courtesy of Dan Ehl.*

4.1 Water Quality Summary

Summarized data in this section came from two sources: historical data and 2014 snapshot data. The Iowa Department of Natural Resources (IDNR) has been collecting water samples from the English River at a site near Riverside, Iowa (site #1 in Figure 22) since 1986. The summary of historical data from these samples, provided by IOWATER program director Dr. Mary Skopec, is in Appendix E. The Iowa Soybean Association (ISA) conducted water quality snapshots at 20 locations across the watershed on April 28th, July 17th, and October 21st of 2014. The sampling locations across the watershed were taken at bridge crossings and other publicly accessible places as close as possible to outlet of subwatersheds (HUC-12s). ISA's full report can be found in Appendix A. Data in this summary is supplemented by information on the specific contaminant and any associated environmental and / or health implications associated, provided by the Iowa Department of Natural Resources, the Environmental Protection Agency, the State of Iowa Administrative Code, and other sources.

Contaminants
The following is a summary of the water quality data based on testing for ammonia, dissolved orthophosphorous or phosphate, nitrate and nitrite, chloride, dissolved oxygen, total phosphorus, turbidity, sediment, bacteria, and sulfate provided by the IDNR and ISA.

Ammonia[19]

Sources: Waste, fertilizers, and natural processes.

Standard: No data available on state or federal standards for ammonia.

Historical data: Ammonia levels at the IDNR sampling site have ranged from below detection levels to 2.68 parts per million (ppm). None of the samples exceeded levels that are acutely toxic to fish, but there is still potential for long-term impacts.

2014 Snapshots: Snapshot data was not available for ammonia.

Trends: The long-term trend for ammonia appears to be downward; however, the decline is not statistically significant.

Impact: Under certain temperatures and pH levels, ammonia can be toxic- causing fish kills. Non-acute levels can have chronic or long-term impacts on growth and development of aquatic life.

More information: Additional resources include EPA's Causal Analysis/Diagnosis Decision Information System (CADDIS).

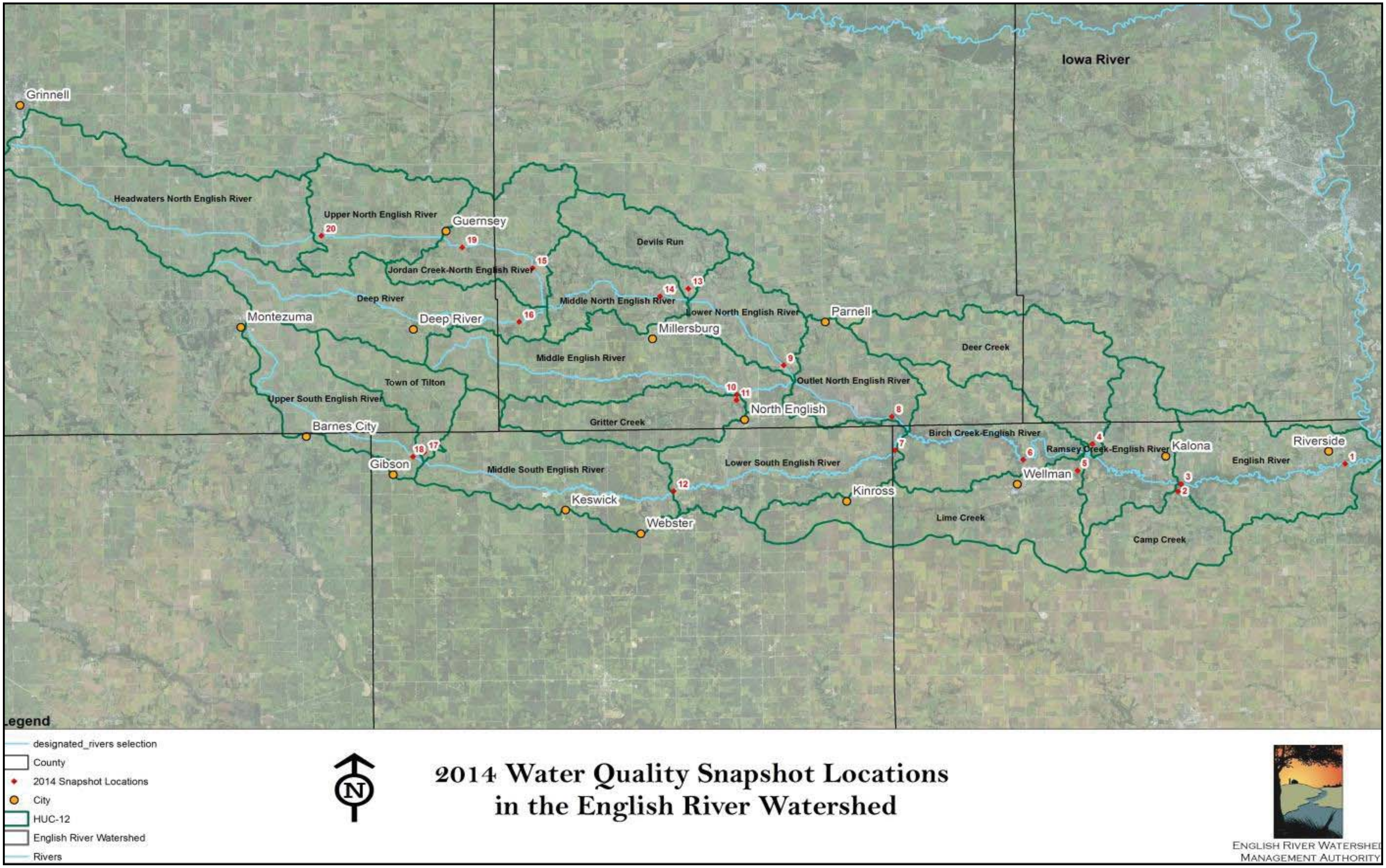


Figure 22. English River Watershed Water Sample Locations (the numbers on the map correspond with Site ID numbers provided by the Iowa Soybean Association). Site #1 (near Riverside) is also utilized by IOWATER staff for samples.

Dissolved Orthophosphorus (OP) or Phosphate[20]

Sources: Orthophosphate is dissolved phosphorus stemming from animal and human waste, and decomposition of plant material.

Standards: The state of Iowa has not established water quality standards for OP. It is typically present in very low concentrations.

Historical data: Levels of OP detected in the English River are comparable to streams statewide (median level of 0.10 ppm); however, OP has only been measured in the English River since 1998. The data suggests that the majority of the OP found in the English River is derived from sediment eroding from uplands and streambanks. The data also suggests that at times of low flow, animal and human waste is likely contributing to OP levels.

2014 Snapshots: Snapshot data indicates that OP (referred to as Phosphate in ISA's report) levels remained below detection levels (0.10 ppm) throughout 2014 for the majority of English River subwatersheds. A few subwatersheds saw OP spikes in July ranging from 0.17 to 0.31 ppm, which may be related to heavy rain events occurring that month: English River at Riverside, Ramsey Creek, Deer Creek, the Middle and Lower South English, the Middle and the Lower North English subwatersheds.

Trends: There has been a slight downward trend in OP in the English River watershed during the past 16 years, but the decline is not considered statistically significant.

Impact: Adverse plant growth, algal blooms.

More information: Additional resources include Vernier Labs' "Water Quality with Vernier: Phosphates."

Nitrate / Nitrite[21]

Sources: Organic matter, animal and human waste, decomposing plant matter, rodenticides, and fertilizers. Nitrite in water can indicate ammonia contamination.

Standards: The Environmental Protection Agency's drinking water standard for nitrate is 10 ppm, and 1 ppm for nitrite. The State of Iowa follows these standards for public drinking water supplies.

Historical data: Nitrate levels in the English River are consistent with trends in southern Iowa streams, which are generally below the drinking water standard. The statewide median (50th percentile) is roughly 5.4 ppm; the median nitrate level in the English River is 4.1 ppm.

2014 Snapshots: Snapshots conducted by ISA in 2014 indicated 7 of 20 subwatersheds in the English River valley with nitrate levels in excess of the 10 ppm standard (Figure 24). Samples from two locations in April were not obtained due to severe weather occurring. All but 1 of the subwatersheds indicated levels in excess of 5 ppm. Significant spikes were observed in April and July and may be correlated to significant heavy rain events that occurred during these months. The highest nitrate levels were found in the Upper North English, Camp and Deer Creek subwatersheds across multiple seasons.

Trends: Despite some high levels of nitrates found in portions of the watershed in 2014, the long-term trends appear to be slightly decreasing for nitrate, although the decline is not statistically significant.

Impact: Nitrogen is a naturally occurring plant nutrient, but in excess amounts, can increase adverse plant growth and changes in biological ecosystems. Nitrates in water also impact the pH and dissolved oxygen levels in a waterbody. Nitrates / nitrites are known to cause human health issues such as "blue baby syndrome," and are believed to be associated with leukemia and cancers of the nose and throat.

More information: Additional resources include EPA's "Nitrates and Nitrites: TEACH Chemical Summary."

Researchers at IIHR-Hydroscience and Engineering and the Iowa Flood Center (IFC) developed a model that can predict which of the 103 subwatershed areas in the English River watershed are prone to the greatest nutrient losses during heavy rain events, which is based on hydrologic patterns observed. The map below illustrates that the areas with the greatest concentration of nitrate runoff are part of the Deer and Camp Creek HUC-12s. The complete Hydrologic Modeling of the English River Watershed Report from the research team at IIHR and IFC can be found in Appendix B.

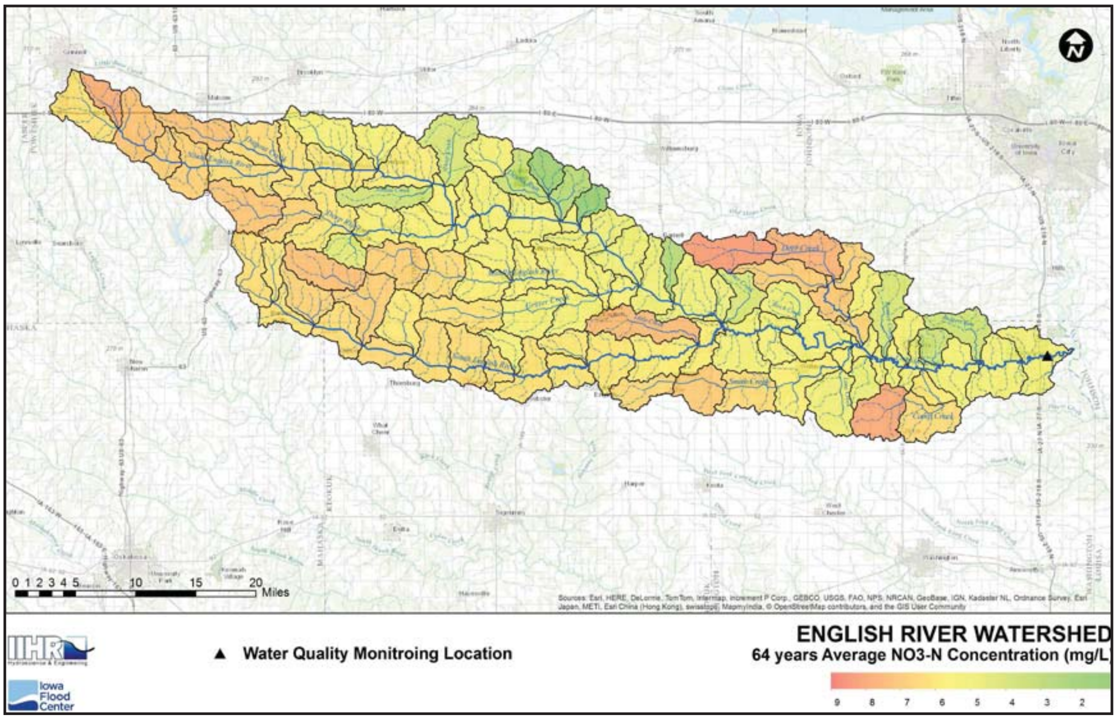


Figure 23. Current nitrate loading predictions for the English River watershed based on land use and hydrologic variables (map courtesy of the Iowa Flood Center)

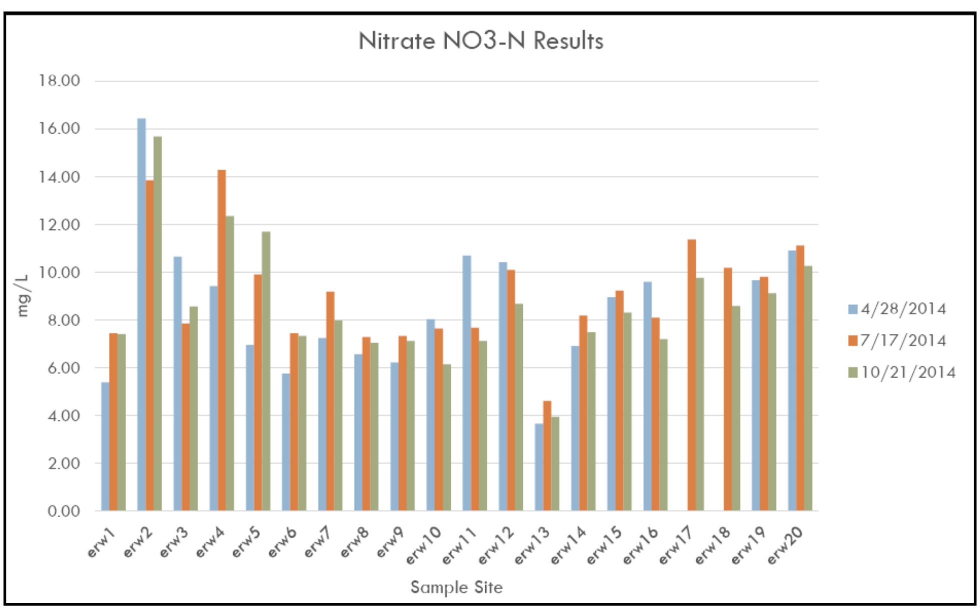


Figure 24. Nitrate data from 2014 Water Quality Snapshots (graph courtesy of Iowa Soybean Association)

Chloride[22]

Sources: Road salt, human or animal waste, fertilizers, oil and gas drilling, municipal or industrial wastewater discharge.

Standards: Acute toxicity levels for chloride are 629 ppm, and at 389 ppm (the maximum standard for warm water streams), chloride can create chronic, long-term impacts. The EPA lists chloride as having a "secondary standard," meaning that the contaminant has recommended, but not enforced standards. The recommended maximum chloride standard for drinking water is 250 ppm.

Historical data: Chloride levels have been monitored in the English River watershed since 2001. Data from the sampling site near Riverside indicate chloride levels ranging from 4 to 69 ppm. Average chloride values for Iowa streams range between 16 and 29 ppm, which means that some local samples registered higher than state averages. However, the observed values are still well below benchmark values.

2014 Snapshots: Snapshot data indicates chloride ranging from 9 to 39 ppm in the English River watershed during 2014.

Trends: Long-range data suggests that chloride levels have been significantly declining over time. The decline is statistically significant.

Impact: Toxicity to freshwater aquatic life.

More information: Additional resources include the *State of Iowa Environmental Protection Code,* Chapter 61: Water Quality Standards, and the EPA's *List of Drinking Water Contaminants and Ambient Water Quality Criteria for Chloride.*

Dissolved Oxygen (DO)[23]

Sources: DO is added to waterbodies physically through turbulence.

Standards: The minimum standard for DO in warm water streams is 5 ppm in warm water streams, and 7 ppm in cold water streams.

Historical data: On average, Iowa waterbodies had DO levels of 10.5ppm between 2000 and 2009. Data suggests that there were only two years where recorded DO levels in the English River were lower than the standard of 5 ppm, 1996 and 2014. However, in winter of 2013/2014, very low DO levels were recorded. It is unclear why that occurred.

2014 Snapshots: Snapshot data was not available for DO.

Trends: Long-range trends indicate that DO levels in the English River are declining.

Impact: DO is necessary for aquatic life. DO is removed from the water through decomposition or organic matter, through respiration, and through photosynthesis. Lower dissolved oxygen suggests that higher levels of pollutants are present.

More information: Additional resources include the IDNR's IOWATER *Chemical Assessment Manual.*

Total Phosphorus (TP)[24]

Sources: Human, animal and industrial waste; runoff from fertilized lawns and cropland.

Standards: The State of Iowa does not have water quality standards for TP; however, the EPA has established a benchmark value of 0.075 ppm for streams similar to the English River.

Historical data: Over 95% of English River watershed samples taken in the last 28 years have exceeded EPA benchmark values for TP (Figure 25). Maximum levels of TP in the English River approached 20 ppm, which is extremely high relative to the benchmark of 0.075 ppm. The median value of TP in the English River is 0.2 ppm, which is more than double the benchmark value, and is higher than median values for similar streams statewide. Between 2000 and 2009, the typical TP levels in Iowa rivers ranged between 0.11 to 0.34 ppm.

2014 Snapshots: Snapshot data was not available for TP.

Trends: A trend analysis for TP over time suggests little change over the years with consistently high levels indicated at the testing site near Riverside.

Impact: Excess TP can cause adverse plant growth and algal blooms, low dissolved oxygen levels, and hypoxia (oxygen deprivation causing death of aquatic life).

More information: Additional resources include the IDNR's IOWATER *Chemical Assessment Manual.*

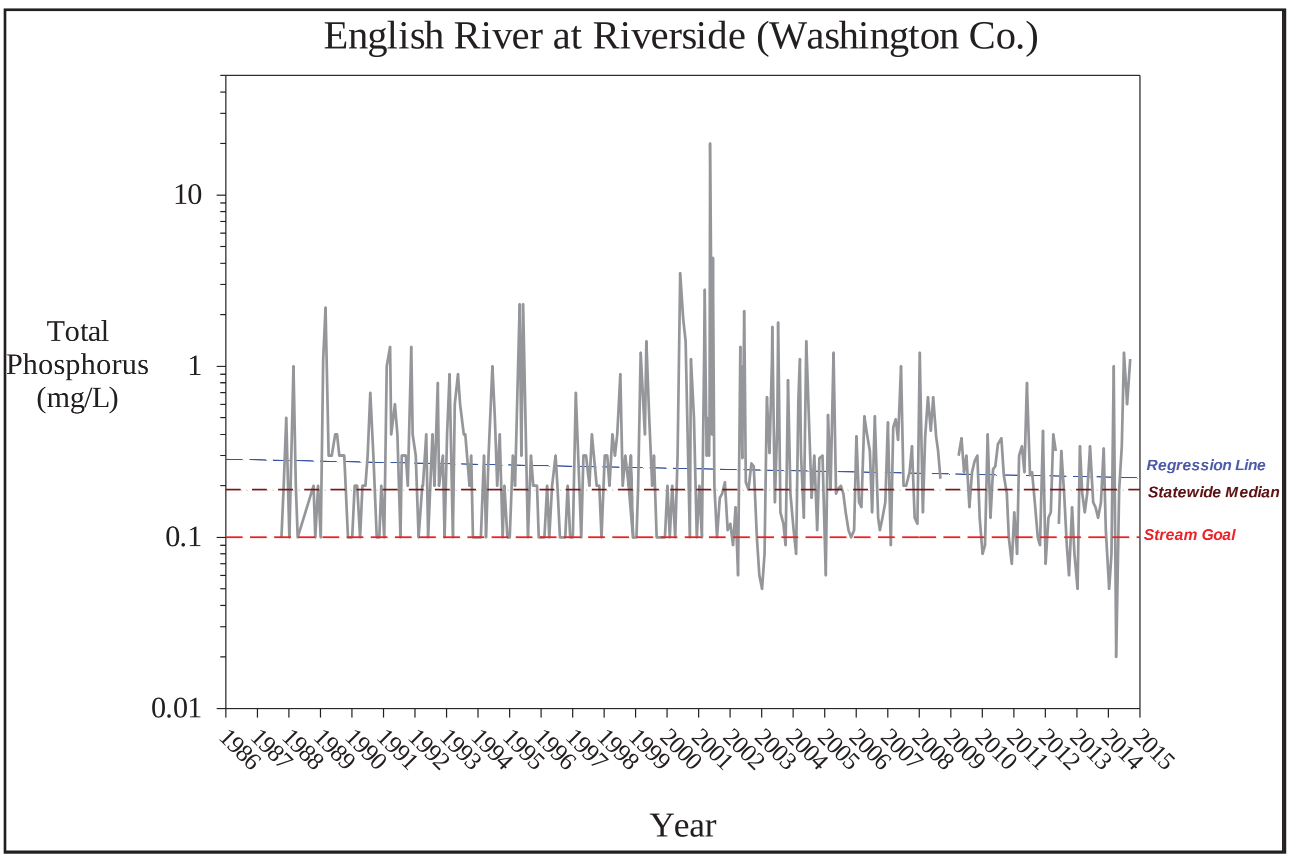


Figure 25. Phosphate data from 1988 – present (graph courtesy of IOWATER)

Turbidity[25]

Sources: Erosion, waste discharge, urban runoff, and large populations of bottom-feeding fish.

Standards: The State of Iowa follows EPA standards for turbidity of drinking water, which is that samples from filtered drinking water systems must not exceed 0.3 NTUs (Nephelometric Turbidity Units) at least 95 percent of the time, and no single sample can exceed 1.0 NTU.

Historical data: Long-range data for turbidity was not available.

2014 Snapshots: ISA conducted turbidity testing once in 2014, during a heavy rainfall event in April. Data from two locations was not obtained due to severe weather occurring. Observed turbidity levels ranged from 100 to over 900 NTUs during this event. Three of the subwatersheds indicated turbidity levels in excess of 500 NTUs: the Lower South English, the Middle South English, and Middle North English River areas (Figure 26).

Trends: No trends established at this time due to lack of historical data.

Impact: Turbidity in itself has no adverse health effects; however, higher turbidity is often associated with the presence of harmful microorganisms (viruses, parasites, and bacteria) that can cause illness.

More information: Additional resources include the EPA's *National Primary Drinking Water Regulations* and the IDNR's *State Public Drinking Water Annual Compliance Report 2012*.

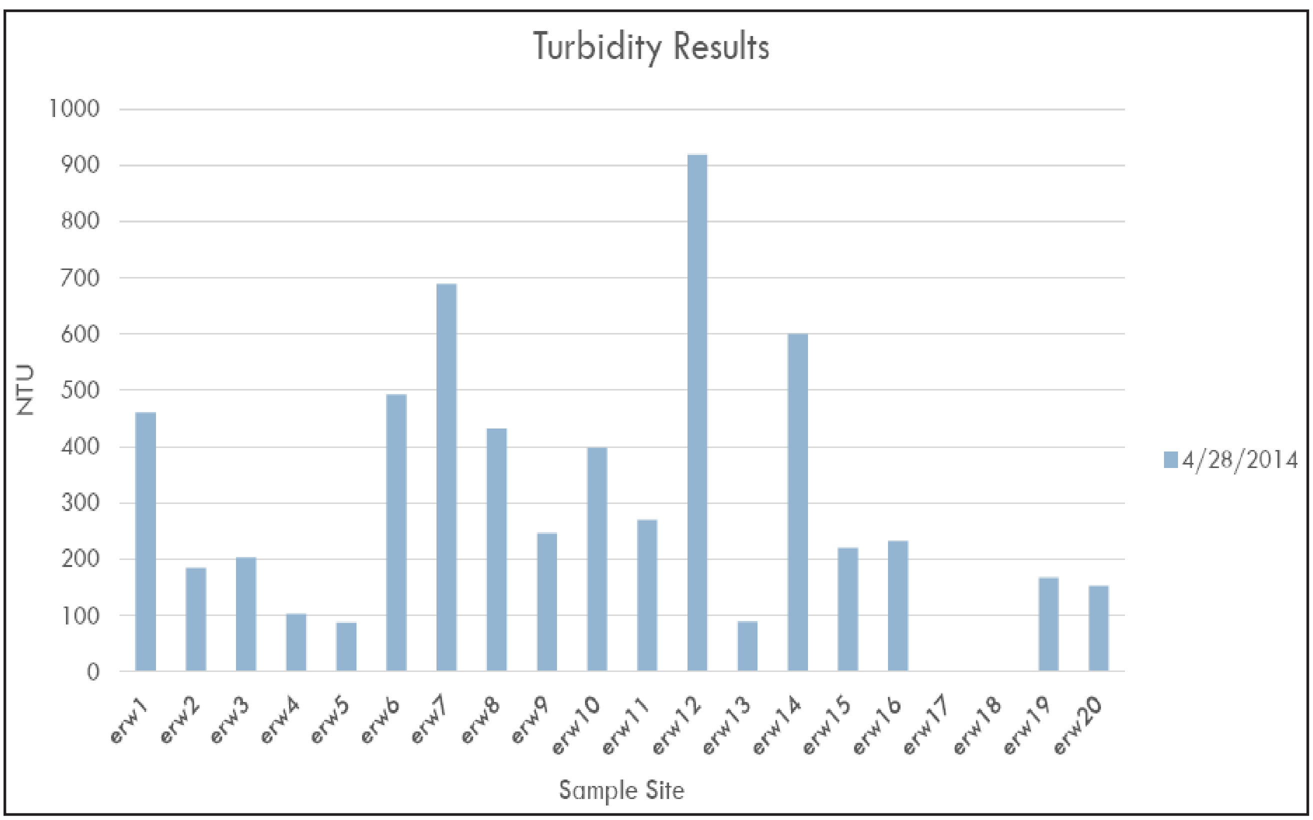


Figure 26. Turbidity data from 2014 Water Quality Snapshots (graph courtesy of Iowa Soybean Association)

Sediment (Total Suspended Solids - TSS)[26]

Sources: Silt, clay, decomposing plant material or algae.

Standards: The State of Iowa does not have water quality standards for sediment. South Dakota, however, as one example, has established a maximum of 158 ppm for warm water streams (like the English River). Sediment levels above 40 ppm negatively impact the aesthetics of a waterbody, especially for recreational uses like swimming.

Historical data: The median TSS value for the English River between 1986 and the present has been 43 ppm, and is higher than the state median of 33 (Figure 27). Approximately 25 percent of samples taken from this testing site indicated TSS levels of 197 ppm or higher. These high levels of TTS suggest that erosion from streambanks and upland areas is occurring in the watershed.

2014 Snapshots: Snapshot data was not available for TSS.

Trends: Long-range trends suggest consistent TSS levels recorded since data collection began, with no general upwards or downward trends occurring.

Impact: Sediment can decrease light, adversely impacting plant life. It can also smother fish spawning areas and macroinvertebrates, damage fish gills, and impact biological systems of a waterbody.

More information: Additional resources include the IDNR's *Water Quality Summary 2000-2012*.

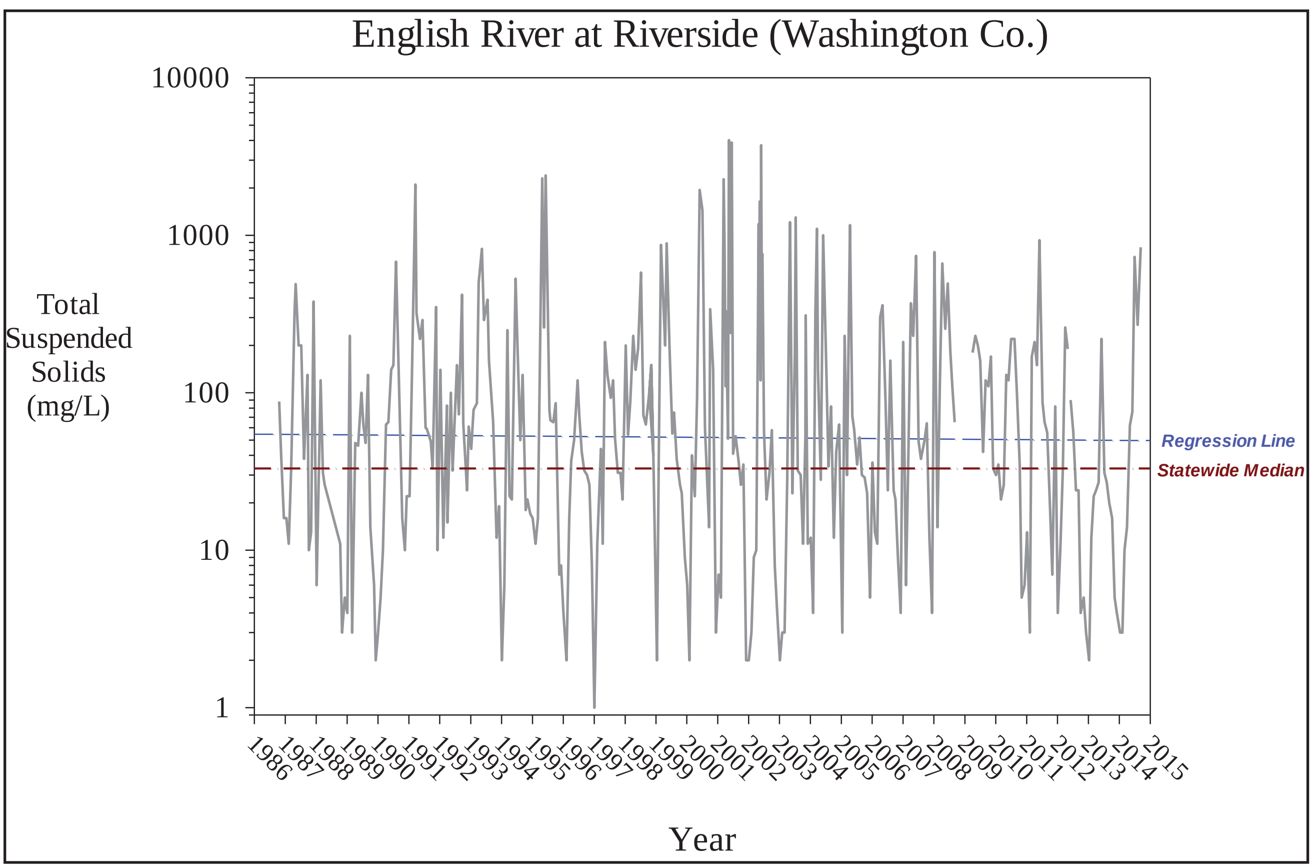


Figure 27. Total Suspended Solids (TSS) data from 1986 – present (graph courtesy of IOWATER)

Bacteria (Fecal Coliform)[27]

Sources: Human and animal waste.

Standards: The Iowa Administrative Code defines the 235 CFUs/100mL (colony forming units per 100 mL) as the benchmark for posing a health risk to humans, also referred to as a recreational standard.

Historical data: Testing for E. coli on the English River site near Riverside began in 1999. Historical water quality testing indicates that bacteria levels in the English River generally exceed state averages, and have exceeded the benchmark value more than 50 percent of the time (Figure 28). Bacteria peaks in the data appear to be correlated with rainy seasons and resultant erosion, since bacteria clings to sediment particles

2014 Snapshots: Snapshot data was not available for bacteria.

Trends: Long-range trends suggest that even though bacteria levels in the English River have been higher than state averages historically, bacteria levels have been trending downwards over the last 16 years.

Impact: Gastrointestinal illnesses.

More information: Additional resources include the IDNR's IOWATER *Bacteria Monitoring Manual.*

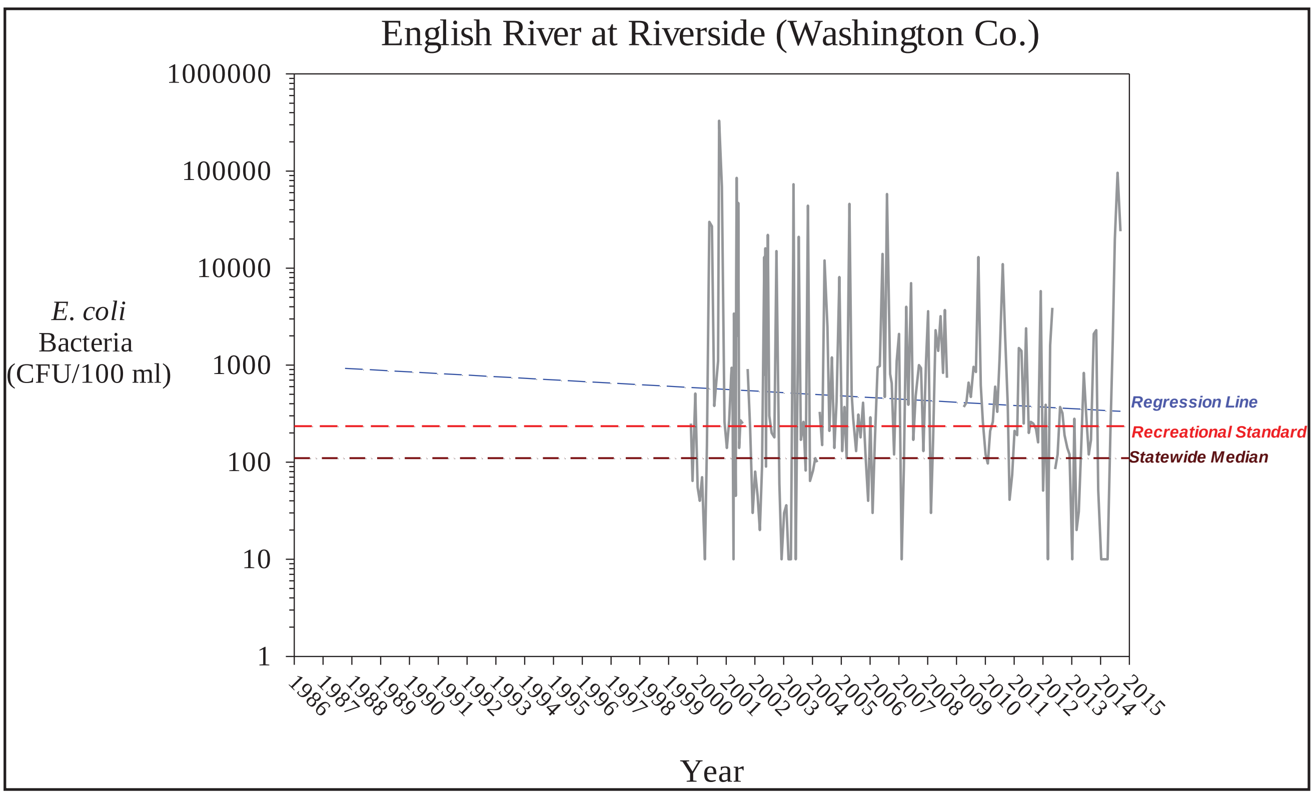


Figure 28. E. coli bacteria data from 1999 – present (graph courtesy of IOWATER)

Sulfate[28]

Sources: Sulfate is a naturally occurring substance in drinking water.

Standards: The EPA lists sulfate as having a "secondary standard" (recommended, but not enforced) drinking water maximum of 250 ppm.

Historical data: Median sulfate levels in Iowa waterbodies were 35 ppm in samples obtained from 2000 to 2012. Monitoring of sulfate in the English River watershed began in 2001, and water samples have shown sulfate levels ranging from from 4 to 83 ppm in the last 14 years. While some values in the English River were twice the state's median values, sulfate levels in the English River have remained well below the secondary standard for drinking water.

2014 Snapshots: Snapshot data from 2014 indicated ranges of sulfate from 12 to 62 ppm. For unknown reasons, water samples from the Lime Creek subwatershed (ERW5) shows sulfate levels nearly twice as high as those found in any other subwatershed (Figure 29).

Trends: Long-range data suggests that sulfate levels in the English River have been on the rise, but that rise is not found to be statistically significant.

Impact: Gastrointestinal upset in humans.

More information: Additional resources include the EPA's *List of Drinking Water Contaminants; Sulfate: An Innovative Approach to Regulating a Naturally Occurring Contaminant* (fact sheet); and, IDNR's *Water Quality Summary 2000-2012.*

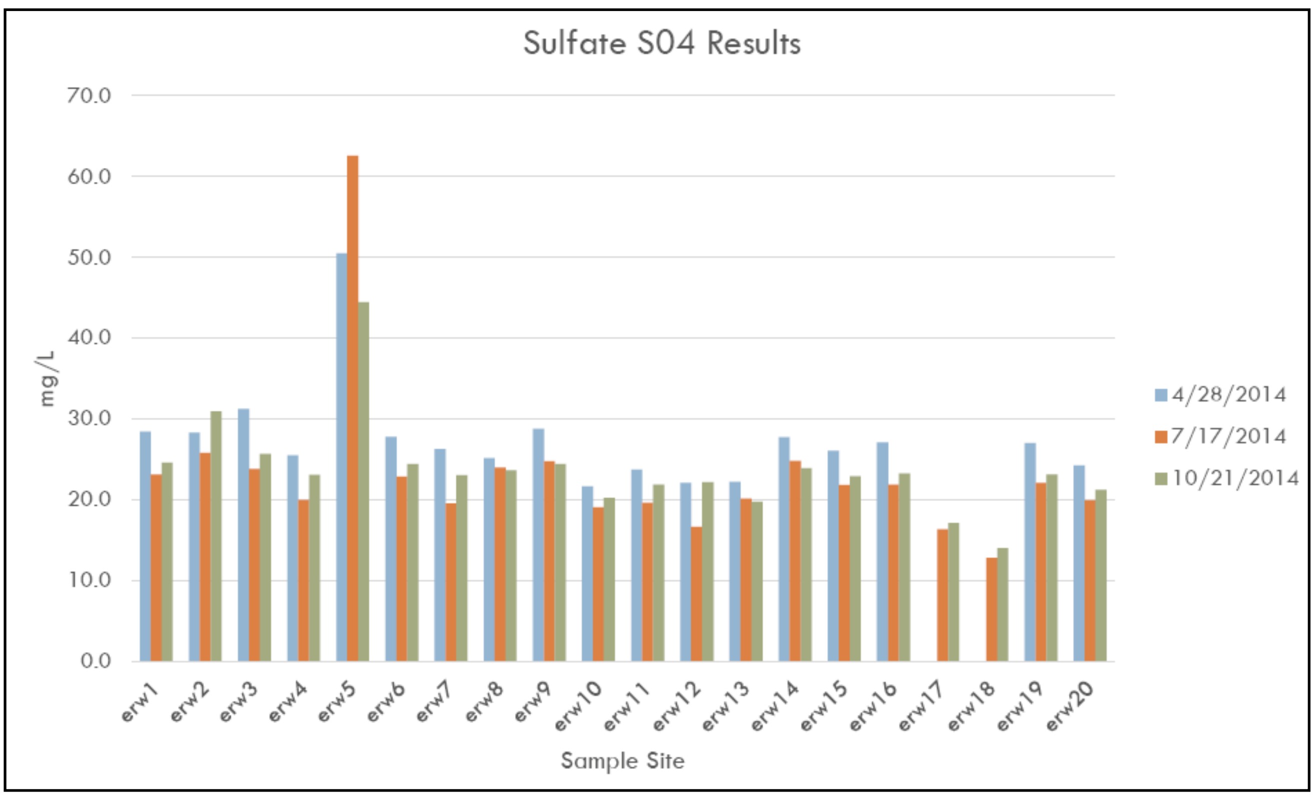


Figure 29. Sulfate data from 2014 Water Quality Snapshots (graph courtesy of Iowa Soybean Association)

4.2 Hydrologic Modeling Summary

The following is a summary of hydrologic assessment research by Dr. Allen Bradley, Jr., Ashok KC, Nicholas Leach, and Rachel Tokuhisa from the Iowa Flood Center and IIHR- Hydroscience and Engineering at the University of Iowa. The complete hydrologic modeling report can be found in Appendix B.

Based on historical data collected within the English River watershed:

KEY FINDINGS

1) Average annual precipitation in the English River watershed is 36.5 inches; of this amount, 69 percent evaporates into the atmosphere, and 31 percent ends up as runoff (in baseflow or surface flow form);

2) River flows are typically higher in the spring and early summer, then decrease through the growing season into the fall and winter; peak river flows often occur in March or April due to snowmelt, or in early summer due to heavy rainfall.

3) Iowa has seen *increased* precipitation since the 1970s, and *more frequent* heavy rain events;

4) In the last 75 years, flooding events have occurred in 1/3 of those years; 13 of those floods occurred between the months of May and July;

5) Runoff has increased significantly in Iowa due to:
   a) conversion of land from highly-absorbent prairie to much-less absorbent farmland;
   b) removal of forests and other native vegetation, replacement with less absorbent ground cover plant species;
   c) increases in annual and seasonal precipitation;
   d) and urban development and increased impervious surface areas (i.e. concrete, asphalt)

To perform this analysis, research staff also built a hydrologic model of the English River watershed using the Hydrological Simulation Program – FORTRAN (HSPF), which was developed to understand areas of the watershed most vulnerable to high runoff or high flood potential, and identify areas where increased water retention, or detention, could reduce flood severity.

High Runoff Areas

The percentage of precipitation that becomes runoff is known as the "runoff coefficient," and it is used to identify high runoff areas. The watershed was divided into smaller areas (subwatersheds), and the hydrological model predicted the runoff coefficient for each. Runoff in the English River watershed ranged as low as 24 percent of precipitation in low runoff areas, to as high as 36 percent in high runoff areas.

As Figure 30 shows, areas with high average runoff (in red) tend to be located in the upper portion of the watershed, including tributaries of the upper English River; Deep River; and the Upper and Middle South English Rivers in Poweshiek, Iowa, and Keokuk Counties. These areas overlap with the English River-Dugout Creek, Upper English River, English River-Jordan Creek, Deep River, Upper South English River, and the Unnamed Creek-South English River HUC – 12 watersheds. In addition, a few tributaries of the Deer and Birch Creek HUC – 12s (in Iowa and Johnson Counties) are also areas of high runoff. These areas are characterized with high levels of agricultural land uses, and fewer forest and grassland areas compared to other parts of the watershed. These are key areas for implementation of BMPs that can reduce runoff volume and velocity (which increases flood severity), such as detention ponds, which capture and store water temporarily allowing the flow to be released more slowly downstream. Additionally, these are key areas for BMPs promoting infiltration of runoff, such as cover crops, soil restoration, native vegetation, riparian areas, and development of wetlands and other conservation areas.

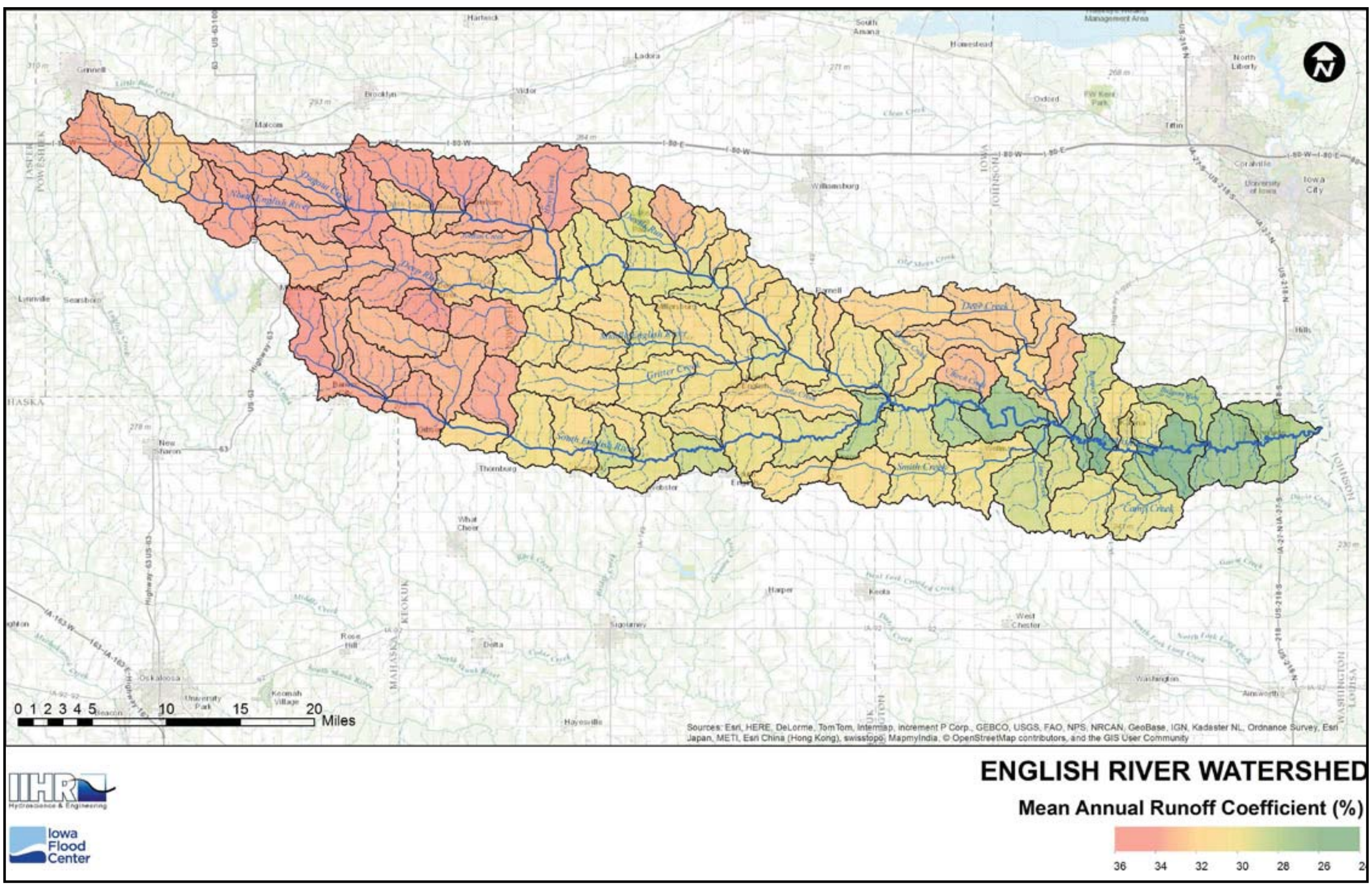


Figure 30: Mean annual runoff coefficient (percentage of precipitation that runs off) in the English River watershed. Areas prone to high runoff are shown in red.

Flooding

The mean annual flood is a measure of flood magnitude at a site. It is found by taking the largest peak discharge every year, and then computing the sample average (or mean). Mean annual floods tend to increase with drainage area; smaller drainage areas tend to have a smaller mean annual flood than larger drainage areas (Figure 31). The mean annual flood was calculated using the hydrologic model for the English River watershed to identify areas that are most vulnerable to flooding. The watershed was divided into areas with high mean annual floods (in red), areas of medium annual floods (yellow), and areas of low annual floods (green).

A comparison of Figure 30 and Figure 31 shows that some areas of high runoff overlap with high annual flood areas, but also that some areas with high runoff overlap with low annual flood areas.

One example of this is the area of the English River just west of Highway 63 in Poweshiek County, an area where runoff is high, but lower annual floods occur because the channel of the river is long and narrow, increasing the length of time flow requires to navigate downstream, which eases flood severity downstream. Shorter channels, on the other hand, tend to increase flooding magnitudes by decreasing the length of time flows need to navigate downstream. Areas of lower runoff but higher annual floods can be found in the Deep River area, immediately south of the Upper English River, and in the Lower South English River.

Areas of high flooding risk are areas where tributaries of similar size converge, and the timing of when their respective flows coincide. The areas in the English River watershed most prone to higher annual flooding risk include areas south of where the English River (at English River Wildlife Area) and the South English River converge. Another area prone to high annual flooding include the area downstream of the English River / Gritter Creek convergence, and areas in the western section of the watershed where high runoff areas overlap with high annual flood areas (headwaters of the North English River, and Deep River). These areas are key areas for future mitigation projects.

Photo: Flood waters rise in Kalona, Iowa in the spring of 2013. *Photo courtesy of Jody Bailey.*

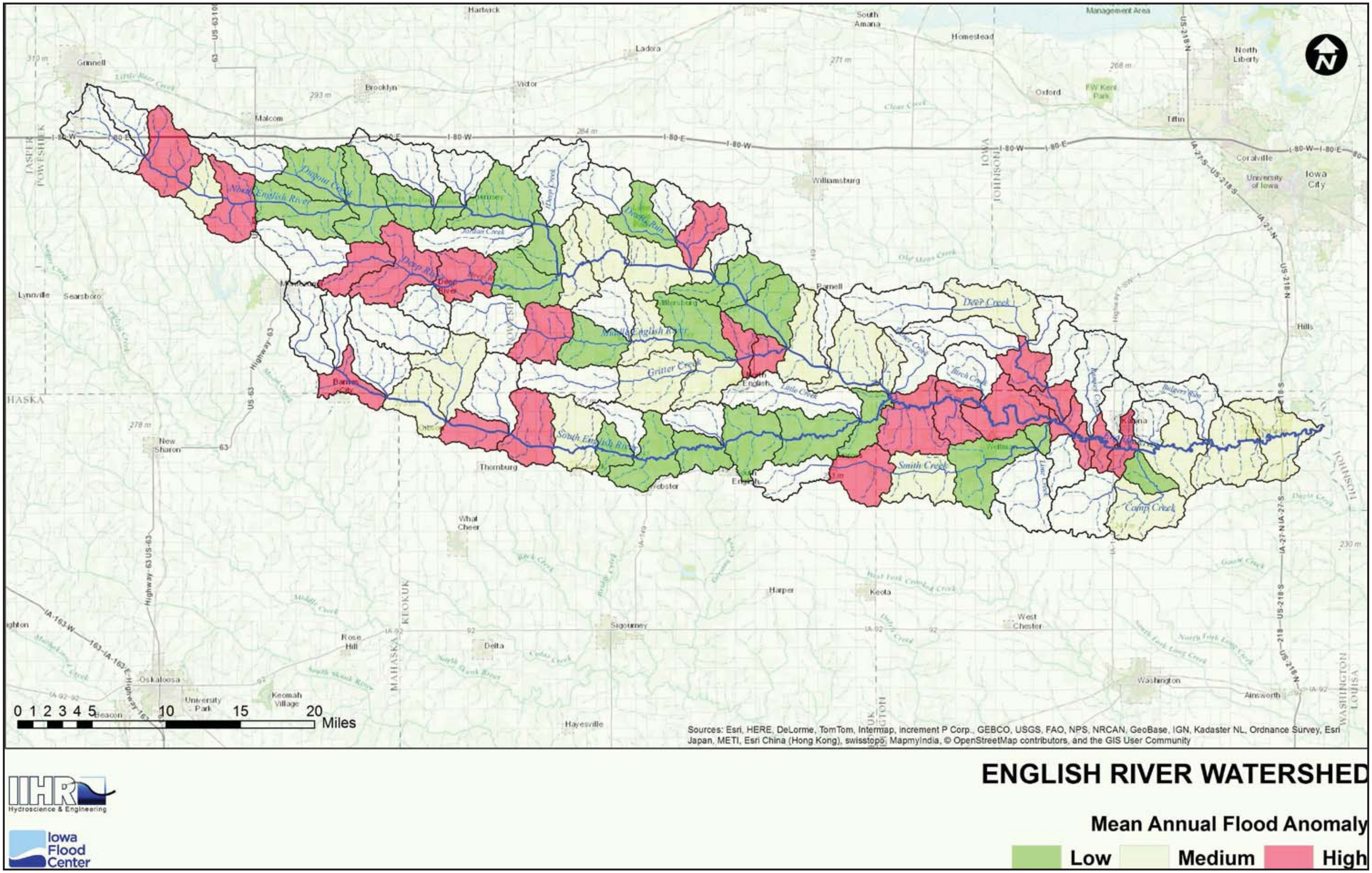


Figure 31: Mean annual flooding in the English River watershed. Areas prone to high mean annual floods are shown in red. Mean annual flood tendencies are not shown for headwater subbasins.

4.3 Social Survey Summary

During summer of 2014, watershed staff conducted a survey of watershed landowners to identify practice and policy trends in the English River valley. Of the 688 randomly sampled watershed landowners, for which the English River Watershed is home to approximately 21,600 residents, nearly 25 percent participated in the survey, providing their unique perspectives as farmers, urban homeowners, business owners, and taxpayers.

Without further analysis, it is difficult to determine to what degree the opinions of survey participants can be extrapolated to the entire population of watershed residents. However, the survey allowed the team to gather diverse feedback from watershed stakeholders across a large region. The information gathered was used in the development of watershed goals. We are appreciative of the many individuals who took the time to provide this feedback, which has been essential to the project.

Demographics
In summary, three-quarters of survey participants were male, and over half of participants were age 60 or older. While 55 percent had not attained a college degree, a third of those surveyed had attained a 4-year degree or higher. Less than 5 percent of respondents indicated that their household income was at or below poverty level for a family of 4. Seventy-five percent of properties in the watershed are characterized as farm properties, but just a little over half of participants identified as being farmers. Over half of those surveyed responded that they rent out some portion of land they own in the watershed.

Of the farm properties, 70 percent produced corn recently and 69 percent produced soybeans. Nearly three-quarters of landowners had owned their watershed property for over 10 years, and over half actually live within the English River watershed. Of the 54 landowners who stated that they do not live on their watershed properties, 56 percent of these "absentee landowners" live within 25 miles of their property, and 75 percent live within 50 miles.

Survey Highlights
The following boxes detail basic statistics discovered through the social survey process. Highlights are broken down into several categories: general, water quality, flooding, best management practices (BMPs), and policy-related questions. Table 15 provides an abridged version of fill-in comments received at the end of survey.

Photo: Residents socialize on an old bridge near North English. *Photo courtesy of Amy Greene.*

GENERAL

- The greatest percentage of participants agreed (either "strongly" or "somewhat") with the following statements:
    - o We need to improve water quality (85%)
    - o We need to improve soil health (84%)
    - o We need to provide more education for landowners on water quality issues (76%)
    - o We need to increase incentives for farmers to protect soil and water (71%)

- In comparison, the greatest percentage of participants disagreed (either "strongly" or "somewhat") with the following statements:
    - o We need to increase regulations for landowners to protect soil and water (40%)
    - o We need to reduce regulations on private property use (20%)
    - o We need to increase livestock production (17%)
    - o We need to reduce restrictions associated with conservation dollars (Environmental Quality incentives Program - EQIP, Conservation Reserve Program - CRP, Water Quality Improvement Plan - WQIP) (17%)

- Both farmers and non-farmers strongly supported the statements "We need to improve soil health," "We need to improve water quality," and "We need to provide more education for landowners on water quality issues." The groups diverged from one another on statements pertaining to financial incentives (for both farmers and communities) for conservation practices, protection/creation of wildlife habitat, and educating the public about flooding

WATER QUALITY

- 73% of survey participants believe that the drinking water on their watershed properties is safe to drink

- The majority of those surveyed felt that surface water quality in the watershed was "Good" (39%) or "Fair" (30%)

- Between 60 and 80 percent of participants felt that illegal dumping, agriculture, and / or livestock are the most "responsible" for Iowa's water quality issues

- Farmers were more likely to list (in order) illegal dumping or littering, agriculture, livestock or poultry; and non-farmers: construction erosion, livestock or poultry, and mining, as being the most responsible for the Iowa's water quality issues

- The majority (37%) of those surveyed were "unsure" whether enough is being done to address water quality issues in Iowa or not; 31 percent felt that "enough is being done," and 29 percent felt that "enough was not being done"

FLOODING

- Nearly 42 percent of those surveyed had watershed properties that were impacted by flooding in the last 10 years, but only 33 percent indicated that they were *concerned* about future flooding
- Nearly 49 percent believe that rainwater gets "absorbed by the land" after it falls on their properties, versus running off the land
- Most participants (42%) suggested that they were "unsure" about whether or not enough was being done to address flooding in Iowa; 27 percent felt that enough was not being done; and 24 percent felt enough is being done

BMPs

- Of 145 individuals who responded to the question about best management practices (BMPs) they have used in the last 5 years, 68 percent stated they use crop rotation, 64 percent grassed waterways, 55 percent no-till, and 51 percent make crop or fertilizer adjustments on their (farm) properties
- Nearly 30 percent of non-farm property owners stated they had maintained or replaced a septic system, 26 percent followed the instructions for lawn and garden products, and 24 percent have recycled household paint and chemicals
- Less than 10 percent of those surveyed agreed that they wanted to learn about additional BMPs they could use on their farm and urban properties to protect water quality
- Barriers to BMP implementation include lack of cost-share dollars, education, or technical assistance; tenant farmers; and deterrence by the scope and expense of desired projects

POLICY

- Of a given list of current "hot" policy topics, the top three items participants were "very concerned" about included soil erosion (45%), loss of agricultural land (38%), and loss of soil fertility (36%)
- The topics that survey participants were mostly "not concerned about" included extreme temperatures (39%), severe weather (34%), and the impact of water quality issues on recreation and tourism (32%)
- Of the policy topics participants were most likely to be "unsure" about (their level of concern), was Iowa's contribution to the dead zone in the Gulf of Mexico (15%)
- 70 percent of participants have not heard about Iowa's Nutrient Reduction Strategy; broken down, 90 percent of "non-farmers" and 60 percent of "farmers" stated that they were unfamiliar with the policy

Table 15. Social Survey Fill-in Comments (abriged)
"Good Luck! Volunteer efforts are better than top down regulation particularly egress is the EPA and COE and their proposed rewrite of the regulaitons (sic) concerning Waters of the US (WOTUS). Ephemeral drains and waterways are NOT WOTUS."
"Smith Creek has a continual flow of tires, glass and junk coming down it from somewhere."
"We are currently involved in the CSP program. Voluntary participation and education are more acceptable than forced participation. Seed money to enhance new concepts works!"
"You need more waterways, no-till, oats, hay and pasture, terracing, dry ponds, cover crops"
"Don't forget mother nature rules. Whatever you do if the ground is soaked wet and you get a 6" rain you are going to have floods."
"3/4 of the people who are going on and on about how the farmers are ruining the environment know very little about what they are talking about. But yet they are getting all of the headlines and the general public is believeing (sic) it. These people use information that is 10-15 years old to back up their information. In the last 15-20 years the farmers have made great strides in soil conservation but when you get 4-6 inches of rain in 10-12 hours, it doesn't matter what you have done. There will be erosion."
"1-4 lakes upstream would have the largest impact on flooding, water quality, and recreation in my opinion."
"I wish people would stop and look back at the long range history of our weather patterns and educate themselves on the fact that these events have happened before and will in fact happen again. Everything on earth happens in cycles, instead of looking at a snapshot in time and get all up in the air about things, and try to keep mother nature from taking her course"
"I think tiling farm fields should be restricted. More and more people are tiling all their cropland which causes rainwater to quickly run out of farmland into creeks and stream then on to larger fivers causing floods. Years ago before farmers tiled their fields there were a lot less damaging floods. Another factor that contributes to flooding is cleaning out and straightening small creeks and waterways, damming up small creeks and waterways would slow rainwater from entering streams and rivers thus preventing a lot of floods and lots of water damage. We cannot change the weather, but we can change how we react to it."
"This year will mark the first year out of the last five my neighbor didn't spread hog manure on his river bottom ground just to have it wash away in the spring flood. This seems like something that should stopped. It seems like the English has become a toilet bowl with all of the tiling that has occurred in the last few years. When it rains it flushes and floods and soon after it runs to a trickle. Seems like exactly what any sensible person would predict would happen if all the fields are tiled."
"Thanks for doing watershed work- we need to feel responsible for every drop of water that leaves our property and consider what it might be carrying."

5 | Watershed Improvement Goals

Photo: Roots from Cereal Rye, a common cover crop, grow deep in Iowa's soil. *Photo courtesy of Steve Berger.*

5.1 Introduction

This plan is intended to serve as a guide in decision-making and planning by the English River Watershed Management Authority (ERWMA), local agencies, local government, and citizens. Development of this watershed improvement plan was guided by 1) data obtained through the watershed assessment that took place between January 2014 and early 2015, 2) proven best management practices and emerging science, and 3) current local, state and federal soil and water resource priorities. The recommendations in this section were informed by the data, crafted by watershed staff and project partners, and refined through public feedback opportunities.

The recommendations in this plan reflect needs and priorities at the time this plan was developed. These needs and priorities may change over time. The recommendations of this plan should be re-evaluated at least every 5 years, and they may be adjusted as needed to keep pace with changing practice, policy, politics, science, as well as available staff support and financial resources. Success of these watershed improvements and resiliency recommendations will ultimately depend upon:

1) The willingness and capacity of leadership in the watershed to promote and support these goals and work together beyond political boundaries;
2) The willingness of watershed residents to become stewards of the watershed through education and a willingness to employ best management practices as able;
3) Federal, state, and local priorities that affirm the importance of Iowa's water and soil resources;
4) And the extent of resources available for stakeholders to participate in state soil and water quality initiatives.

Generally, the ERW is the responsible party for carrying out watershed improvement recommendations and efforts. The "ERW" refers to the collaborative of cities, counties, and soil and water conservation districts that comprise its membership. Successful watershed improvements require support of these recommendations, commitment to the ERWMA as an organization, and to its leadership and staff.

5.2 Watershed Improvement and Resiliency Recommendations

This section includes recommendations watershed stakeholder groups can follow in implementing water quality improvements and flood resiliency projects, over time, in the English River watershed. The first section presents recommendations that specifically focus on water quality improvements and disaster resiliency. For each of these recommendations, subwatersheds (or HUC-12s) from the English River watershed are ranked. The purpose of ranking is to encourage targeted project implementation with strategically developed partnerships and using limited resources more efficiently. Water quality baseline data, collected by the Iowa Soybean Association in 2014, were used to rank subwatersheds for nutrient reduction priorities. Flood modeling data provided by the Iowa Flood Center and University of Iowa's IIHR – Hydroscience and Engineering were used to rank the subwatersheds for flood reduction priorities. At the end of this section, the subwatersheds are prioritized using a simple scoring system that accounted for multiple indicators: water quality factors, as well as flooding.

In addition to ranking the subwatersheds, lists of best management practices (scientifically proven to help reduce nutrient loading and manage stormwater runoff) are also presented for the individual recommendations. It is expected that the English River Watershed, it's member organizations, and project partners will advance these watershed improvement goals by actively seeking available and relevant funding needed to implement projects, and engage stakeholders, at the subwatershed level. A sample subwatershed project workplan, which outlines the proposed scope of work for potential projects, can be found in Appendix H.

A

Water Quality Improvements: Nitrate Reduction

Recommendation: Reduce nitrate loading in the English River watershed from non-point sources by 41% from 2010 levels (an Iowa Nutrient Reduction Strategy target).*

The ERW will promote education about Iowa's water quality initiatives in nitrate reductions, and the best management practices (BMPs) proven to reduce nitrates from non-point sources entering waterways from urban and agricultural landscapes. The ERW will collaborate with other organizations to deliver nitrate-reduction programming, and target priority subwatersheds for nitrate-reduction projects. It is recommended that water quality monitoring occur on the subwatershed-level, and data used to re-evaluate and reprioritized as needed, going forward.

Action Step 1: Educate stakeholders on federal and state nutrient reduction science and strategies related to nitrate reduction;

Action Step 2: Educate stakeholders about emerging best management practices (Table 17) that can reduce nitrates from entering our waterways (i.e. cover crops, no-till, stream buffers, grassed waterways, terraces, ponds, wetlands, etc.);

Action Step 3: Grow partnerships with landowners, elected officials, environmental and agricultural stakeholder groups in education, outreach, and technical assistance in efforts to reduce nitrate losses on urban and rural properties;

Action Step 4: Target priority subwatersheds (Figure 32) for implementation projects, based on nitrate levels indicated by the hydrologic model**;

Action Step 5: Collect and utilize subwatershed-level water quality data to re-evaluate and reprioritize subwatershed project implementation for nitrate reduction, as needed;

Action Step 6: Highlight local / regional water quality champions and their successes in putting nutrient reduction strategies into practice.

Action Step 7: Track the progress (technical assistance) and implementation (cost-share partnerships) of best management practices by coordinating with local agencies.

* Non-point sources of pollution are contaminants that are indirectly introduced to waterways over a large area, such as through water runoff, seepage into aquifers, or through erosion. Point sources are introduced from a specific location, such as a wastewater discharge pipe. Iowa's Nutrient Reduction Strategy also calls for a 4% reduction in nutrient from point sources, but point sources are currently regulated, whereas non-point sources are not. Reduction of non-point sources at this time are dependent upon voluntary efforts by urban and rural landowners.

** The hydrologic model (developed by the Iowa Flood Center) utilizes numerous data from a 64 year period of time, and is presumed to be more accurate in estimating nitrate and runoff trend lines than the water sampling from one year. Therefore, data from the model is utilized in identifying priority subwatersheds when data is available to do so.

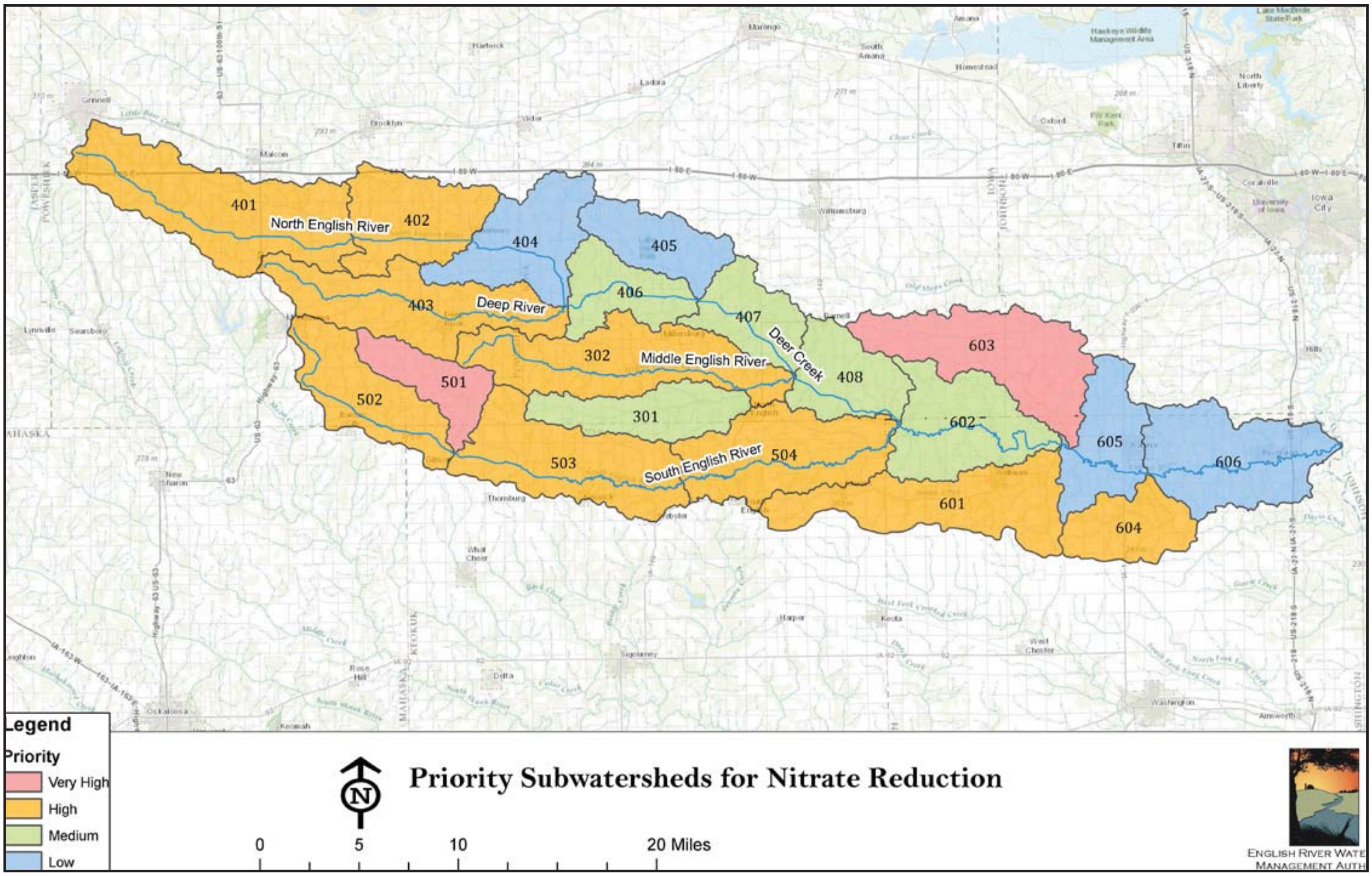


Figure 32: Priority subwatersheds for nitrate reduction in the English River Watershed

Table 16. Priority Subwatersheds for Nitrate Reduction			
ID (070802090###)	**Name**	**Priority**	**Estimated 64-year average NO3-N concentration (mg/L)**
603	Deer Creek	1 (Very High)	7.43
501	Unnamed Creek - Town of Tilton	2 (Very High)	7.00
401	Dugout Creek	3 (High)	6.75
504	Lower South English River	4 (High)	6.33
604	Camp Creek	5 (High)	6.33
502	Upper South English River	6 (High)	6.20
403	Deep River	7 (High)	6.00
503	Middle South English River	8 (High)	5.71
302	Middle English River	9 (High)	5.63
402	Upper English River	10 (High)	5.60
601	Lime Creek	11 (High)	5.60
301	Gritter Creek	12 (Medium)	5.33
406	Middle North English River	13 (Medium)	5.00
602	Birch Creek	14 (Medium)	4.80
408	Outlet North English River	15 (Medium)	4.25
407	Lower North English River	16 (Medium)	4.00
605	Ramsey Creek	17 (Low)	3.86
606	Bulgers Run	18 (Low)	3.80
404	Jordan Creek	19 (Low)	3.75
405	Devils Run	20 (Low)	2.75

Table 17. Best Management Practices (BMPs) for Nitrate Reduction*		
	Practice	**% Nitrate - N Load Reduction**
NITROGEN MANAGEMENT	Mulch - Kura clover	41%
	Cover crop - Rye	31%
	Cover crop - Oat	28%
	Nitrogen application rate - Nitrogen rate at MRTN (0.10 N:corn price ration) compared to current estimated application rate.	10%
	Nitrification inhibitor – Nitrapyrin in fall – compared to fall-applied without Nitrapyrin	9%
	Timing – Sidedress, compared to pre-plant application	8%
	Timing – Spring (versus fall) pre-plant application	6%
	Timing – Spring pre-plant/sidedress 40-60 split (compared to fall application)	5%
	Timing – Sidedress, soil test based compared to pre-plant	4%
	Source – Liquid swine manure compared to spring-applied fertilizer	4%
LAND USE CHANGE	Grazed pasture – Similar to CRP	85%
	Perennial – Land retirement (CRP) – compared to spring-applied fertilizer	85%
	Perennial – Energy crops, compared to spring applied fertilizer	72%
	Extended rotations – Minimum of 2 years alfalfa in 4 – 5 year rotation	42%
EDGE-OF-FIELD PRACTICES	Buffers – Only for water that interacts with the active zone below the buffer.	91%
	Wetlands – Targeted water quality	52%
	Bioreactors	43%
	Drainage water management – No impact on concentration	33%
	Shallow drainage – No impact on concentration	33%

*Refer to Iowa State University Extension and Outreach's *Iowa Strategy to Reduce Nutrient Loss - Nitrogen and Phosphorous Practices* in Appendix F for the Extended Version.

B

Water Quality Improvements: Phosphorus Reduction

Recommendation: Reduce phosphorus loading in the English River watershed from non-point sources by 29% from 2010 levels (an Iowa Nutrient Reduction Strategy target).

The English River Watershed will promote reduction of phosphorus in the English River Watershed through education about Iowa's water quality initiatives and best management practices proven to reduce phosphorus from non-point sources from entering our waterways. The English River Watershed will collaborate with other organizations to deliver programming, more efficiently utilize available resources, and target priority subwatersheds for implementation.* It is recommended that the water quality monitoring be conducted in the subwatersheds to evaluate program effectiveness and reprioritize subwatersheds, as needed.

Action Step 1: Educate stakeholders on federal and state nutrient reduction science and strategies related to reduction of phosphorus loading in state waterways;

Action Step 2: Educate stakeholders about emerging best management practices (Table 19) that can reduce phosphorus loading (i.e. no-till, cover crops, sediment basins, terracing, buffers, etc.);

Action Step 3: Develop partnerships with stakeholder groups (i.e. landowners, elected officials, environmental and agricultural) in education, outreach and technical assistance efforts to reduce phosphorus loading in urban and rural waterways;

Action Step 4: Target priority subwatersheds (Figure 33) for funding, partnerships, and project implementation, based on total and dissolved phosphorus levels indicated by current monitoring data;

Action Step 5: Collect and utilize subwatershed-level water quality data to evaluate and prioritize future subwatershed-level projects for phosphorus reduction, as needed;

Action Step 6: Highlight local / regional water quality champions and their efforts in putting nutrient reduction strategies into practice and sponsor an annual "English River Watershed Award."

* Phosphorus and erosion (sediment loading) in waterways are closely linked as phosphorus binds with sediment. Long-term water quality monitoring at the Riverside location in the ERW indicates that phosphorus levels have exceeded EPA benchmark values in over 95 percent of samples (taken over 28 years). However, we do not have data on phosphorus levels at the subwatershed level. Until this data becomes available, the assumption is made that priority subwatersheds for sediment reduction are also the same priority subwatersheds for phosphorus reduction. The subwatershed-level erosion data utilized to determine these priority subwatersheds were obtained from the USDA Agriculture Research Service's Revised Universal Soil Loss Equation tool (RUSLE).

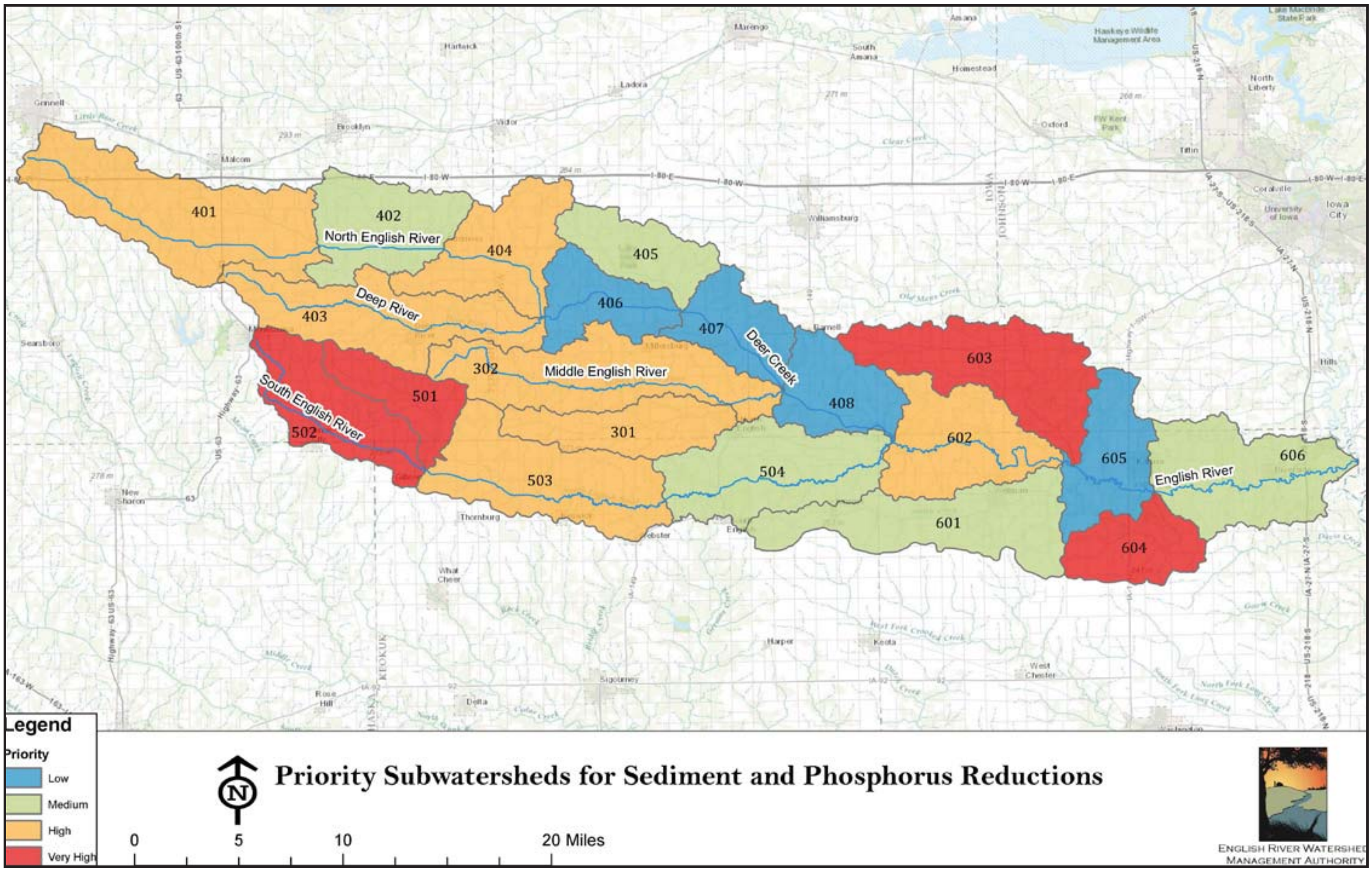


Figure 33: Priority subwatersheds for sediment and phosphorus reduction in the English River Watershed

Table 18. Priority Subwatersheds for Sediment and Phosphorus Reduction			
ID (070802090###)	Name	Priority	RUSLE mean value
603	Deer Creek	Very High	13.56
501	South English River	Very High	13.29
604	Camp Creek	Very High	12.48
502	Upper South English River	Very High	12.10
301	Gritter Creek	High	11.64
403	Deep River	High	11.63
302	Middle English River	High	11.42
401	Dugout Creek	High	11.33
404	Jordan Creek	High	11.26
602	Birch Creek	High	10.91
503	Middle South English River	High	10.80
601	Lime Creek	Medium	10.24
402	Upper English River	Medium	10.21
504	Lower South English River	Medium	9.33
405	Devils Run	Medium	9.15
606	Bulgers Run	Medium	8.81
605	Ramsey Creek	Low	8.27
408	Outlet North English River	Low	7.87
407	Lower North English River	Low	7.59
403	Middle North English River	Low	7.07

Table 19. Best Management Practices (BMPs) for Phosphorus and Sediment Reduction*		
	Practice	**% Phosphorus – P Load Reduction**
PHOSPHORUS MANAGEMENT PRACTICES	Tillage – No till compared to chisel plowing	90%
	Source of phosphorus – Liquid swine, dairy, and poultry manure compared to commercial fertilizer – runoff shortly after application	46%
	Source of phosphorus – Beef manure compared to commercial fertilizer – runoff shortly after application	46%
	Placement of phosphorus – Broadcast incorporated within 1 week compared to no incorporation, same tillage	36%
	Tillage – Conservation till – chisel plowing compared to moldboard plowing	33%
	Cover crops – Winter rye	29%
	Placement of phosphorus – With seed or knifed bands compared to surface application, no incorporation	24%
	Phosphorus application – Soil Test P, no P applied until STP drops to optimum	17%
LAND USE CHANGE	Perennial vegetation – Land Retirement (CRP)	75%
	Perennial vegetation – Grazed pastures	59%
	Perennial vegetation – Energy crops	34%
EROSION CONTROL & EDGE-OF-FIELD	Control – Sedimentation basin or ponds	85%
	Terraces	77%
	Buffers	58%

*Refer to Iowa State University Extension and Outreach's *Iowa Strategy to Reduce Nutrient Loss - Nitrogen and Phosphorous Practices* in Appendix F for the Extended Version.

C

Water Quality Improvements: Phosphorus Reduction

Recommendation: Reduce sediment loading in the English River Watershed by 30%.

The English River Watershed will promote reduction of sediment loading in the English River Watershed through education about land management practices that reduce soil loss from farm fields and construction sites, and best managment practices that reduce erosion from streambanks. Soil health quality will be a major component of the education effort. The English River Watershed will collaborate with other organizations to deliver programming, more efficiently utilize available resources, and target priority subwatersheds for implementation.

Action Step 1: Educate stakeholders on the agronomic benefits of soil health, and strategies for improving soil quality in farm fields;

Action Step 2: Educate stakeholders about best management practices (Figure 18) that can reduce sediment loading (i.e. no-till, cover crops, sediment basins, terracing, buffers, etc.);

Action Step 3: Develop partnerships with stakeholder groups (i.e. landowners, elected officials, environmental and agricultural) in education, outreach and technical assistance efforts to reduce sediment loading in urban and rural waterways;

Action Step 4: Identify priority subwatersheds for funding, partnerships, and project implementation, based on sediment delivery estimates indicated through land use assessments and geographic information (GIS) analysis;

Action Step 5: Collect and utilize subwatershed-level water quality data to evaluate and reprioritize subwatershed-level projects for sediment reduction, as needed;

Action Step 6: Conduct a RASCAL assessment to identify areas of excessive stream bank erosion or where best management practices would be beneficial;

Action Step 7: Work with urban areas to increase implementation of erosion control practices on construction sites;

Action Step 8: Highlight local / regional water quality champions and their efforts in putting nutrient reduction strategies into practice and sponsor an annual "English River Watershed Award."

D

Water Quality Improvements: Water Quality Monitoring

Recommendation: Continue monitoring water quality parameters at the subwatershed level.

Long-term water quality monitoring is essential to establishing reliable water quality baselines and changes over time and in assessing the effectiveness of targeted implementation projects. Engaging stakeholders in private or public water quality monitoring opportunities educates and promotes watershed stewardship. It is also important for publicly available water quality parameters to be accessible to the public, and in a user-friendly format.

Action Step 1: Promote the establishment of ongoing water quality monitoring at the subwatershed level, at locations consistent with sampling spots identified by and utilized by Iowa Soybean Association in 2014;

Action Step 2: Promote volunteer monitoring opportunities through programs such as IOWATER and Iowa Soybean Association's tile outlet monitoring program (for producers);

Action Step 3: Improve accessibility of local and state public water quality data through the English River Watershed website.

E

Disaster Resiliency: Flood Hazard Reduction

Recommendation: Reduce flood severity in the English River watershed through education and promotion of best management practices that reduce runoff in targeted subwatersheds.

As other long-term watershed projects (i.e. Soap Creek) in Iowa have shown, flood severity in a watershed can be reduced through targeted subwatershed-level projects that can reduce runoff and improve the water-holding capacity of the landscape (detention or retention basins, soils, vegetation). Across the watershed, cumulatively, these projects can mitigate flood damage to property and infrastructure by reducing the severity of flood events when they do occur.

The English River Watershed will conduct education and outreach on flood concerns in the watershed, and utilize emerging science to determine the best practices and targeted subwatersheds for flood reduction projects. Targeted subwatershed-level projects will also maximize efficient use of resources, and maximize results. The English River Watershed will utilize existing partnerships, and develop new ones on the local, state and federal level to increase access to the financial and technical resources needed to accomplish this task.

Action Step 1: Conduct outreach and education on flood impacts in the English River watershed;

Action Step 2: Promote emerging best management practices that can reduce flood runoff from urban and rural landscapes during heavy rain events;

Action Step 3: Target priority subwatersheds* for runoff reduction best management (Figure 30) for funding, partnerships, and project implementation;

Action Step 4: Utilize existing partnerships, and develop new ones to with landowners, elected officials, environmental and agricultural stakeholders in research and technical assistance, outreach / education, and project implementation to reduce flood impacts;

* Priority Subwatersheds in the English River Watershed for Runoff Reduction: Jordan, Birch, Deer and Dugout Creek (aka Headwaters of the North English River); as well as the Upper English, Deep, Upper South English, and South English Rivers.

F

Disaster Resiliency: Flood Hazard Reduction

Recommendation: Reduce flood severity in the English River Watershed through education and promotion of best management practices that increase water-holding capacity and promote infiltration on both urban and rural landscapes.

Flood severity in a watershed can be reduced through targeted subwatershed-level projects that can reduce improve the water-holding capacity of the landscape (i.e. improved soil health, vegetation or wetland areas that promotes infiltration, and detention). Across the watershed, cumulatively, these projects can mitigate flood damage to property and infrastructure by improving the capacity of the landscape to manage heavy precipitation. The English River Watershed will conduct education and outreach on soil health and land uses that promote infiltration, and land uses that facilitate reduction of flood severity, such as wetland areas. Targeted subwatershed-level projects in areas most prone to flooding will also maximize efficient use of resources, and project effectiveness. The English River Watershed will utilize existing partnerships, and develop new ones on the local, state and federal level to increase access to the financial and technical resources needed to accomplish this task. The English River Watershed will also promote expansion of a hydrological monitoring network in the watershed that can provide real-time flood-stage data from strategically placed sensors in the watershed, as well as providing tools for monitoring streamflow, precipitation, soil conditions, water quality, and groundwater resources. This data will be utilized to evaluate effectiveness of projects, and reprioritize subwatersheds for flood reduction projects, as needed.

Action Step 1: Conduct outreach and education on best management practices that promote infiltration during heavy rain events;

Action Step 2: Target priority subwatersheds* most prone to flooding (Figure 34) for funding, partnerships, and project implementation;

Action Step 3: Utilize existing partnerships, and develop new relationships with landowners, elected officials, environmental and agricultural stakeholders in research and technical assistance, outreach / education, and project implementation to reduce flood impacts;

Action Step 4: Encourage establishment of a hydrological monitoring network in the watershed, and promote access to emerging data and tools watershed stakeholders and decision-makers can use;

Action Step 5: Utilize collected data to re-evaluate and reprioritize subwatershed-level projects, as needed.

* Priority subwatersheds / areas for flood reduction projects include: the area where the English River at the English River Wildlife Area and the South English River converge, the area downstream of the English River / Gritter Creek convergence, and areas in the western section of the watershed where high runoff areas overlap with high annual flood areas (headwaters of the North English River, and Deep River).

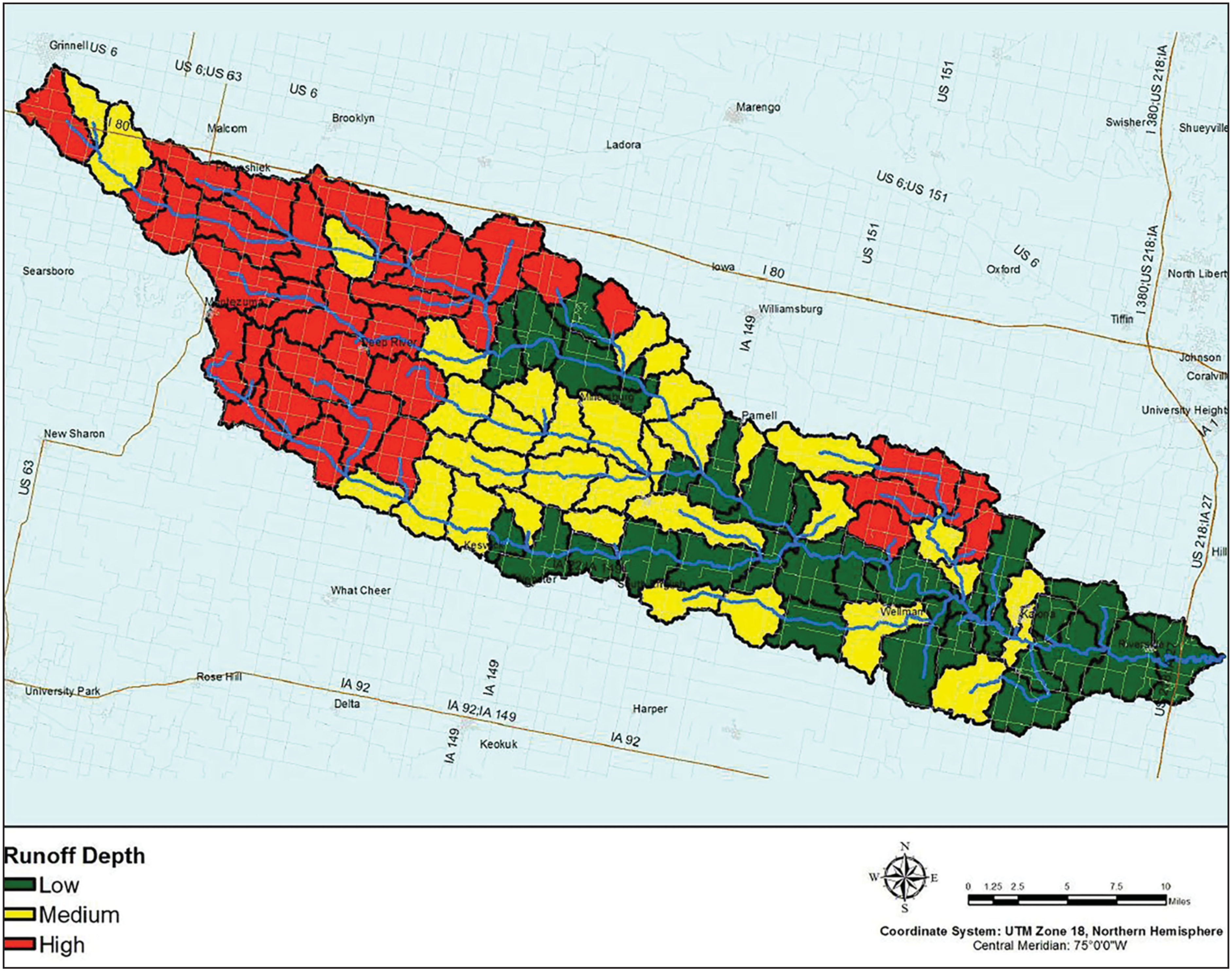


Figure 34. Priority Subwatersheds in the English River Watershed for Reduction of Mean Annual Flooding”

G

Capacity Building: Partnerships for More Effective and Efficient Outreach

Recommendation: Expand partnerships for education, outreach, and project collaboration.

The ERW will actively seek opportunities to expand partnerships with existing partners and develop new ones for project development and implementation to achieve the goals of this plan. Increased collaboration will help projects deliver more consistent messaging, increase their outreach capacity, identify and engage diverse stakeholder groups, and utilize available resources more efficiently.

Action Step 1: Seek opportunities for collaboration in program development (education and implementation), data sharing, project oversight, and evaluation.

Action Step 2: Apply for funding to support the recognition of waterways through signage on road passings over creeks and rivers in the watershed.

H

Capacity Building: Strengthen the English River Watershed Coalition through Membership, Awareness, and Resources

Recommendation: Increase the organizational capacity of the English River Watershed Managment Authority.

The ERW needs leadership and staff to have the organizational capacity required to facilitate communication, engage stakeholders, and provide project leadership in both its daily operations and on-the-ground improvement projects. Additionally, the organization needs to sustain its formal organization with leadership provided by the Board of Directors and routine meetings that are open to all watershed stakeholders. The ERWMA will continue efforts to grow the organization by reaching out to eligible member organizations, and engaging diverse stakeholder groups. Finally, the ERW will actively pursue technical and financial resources needed to sustain the administrative functions of the organization and implement the plan.

Action Step 1: Provide leadership and staffing for the English River Watershed to continue its momentum in watershed improvement initiatives;

Action Step 2: Maintain a Board of Directors and routine meetings that are open to all watershed stakeholders;

Action Step 3: Promote inclusivity of watershed stakeholders through outreach to potential member organizations and other stakeholder groups;

Action Step 4: Actively pursue technical and financial resources needed to sustain the basic administrative functions of the organization and to implement the recommendations in the plan.

5.3 Priority Subwatersheds for Combined Water Quality Improvement and Flood Hazard Indicators

The subwatersheds (HUC-12s) were ranked for priority, based on a combination of key indicators: nitrate and phosphorus (or runoff) reduction, and flooding hazard. Using values generated for each smaller subwatershed (HUC-14s) within the subwatersheds (HUC-12s) for each of the three indicators (nitrate, phosphorus/erosion, and flooding vulnerability)the subwatersheds were assigned an average point value between 1 and 4, where “1” indicates the subwatershed should be considered a “Low Priority,” and “4” indicates it should be considered a “Very High Priority.” The resultant score for each subwatershed were used to develop the priority rankings, which are listed in Table 19 and illustrated in Figure 35.

1. *Nitrates*. Nitrate (NO3-N) data was provided by the Iowa Flood Center (IFC), which is detailed in depth in the Hydrologic Modeling of the English River Watershed report (Appendix B) Data utilized for the subwatershed prioritization process was presented as a 64 year average NO3-N concentration (mg/L) on the HUC-14 level. This dataset can be found on page 53 of this plan.

2. *Phosphorus*. Phosphorus data was not specifically provided by simulations ran by the IFC. However, due to the movement of phosphorus across land, a runoff coefficient can be utilized as a proxy for areas more or less prone to runoff containing phosphorus. This dataset can be found on page 61 of this plan.

3. *Flooding*. Flooding data was provided by the IFC in the form of mean annual flooding chances on the HUC-14 level. This dataset can be found on page 63 of this report.

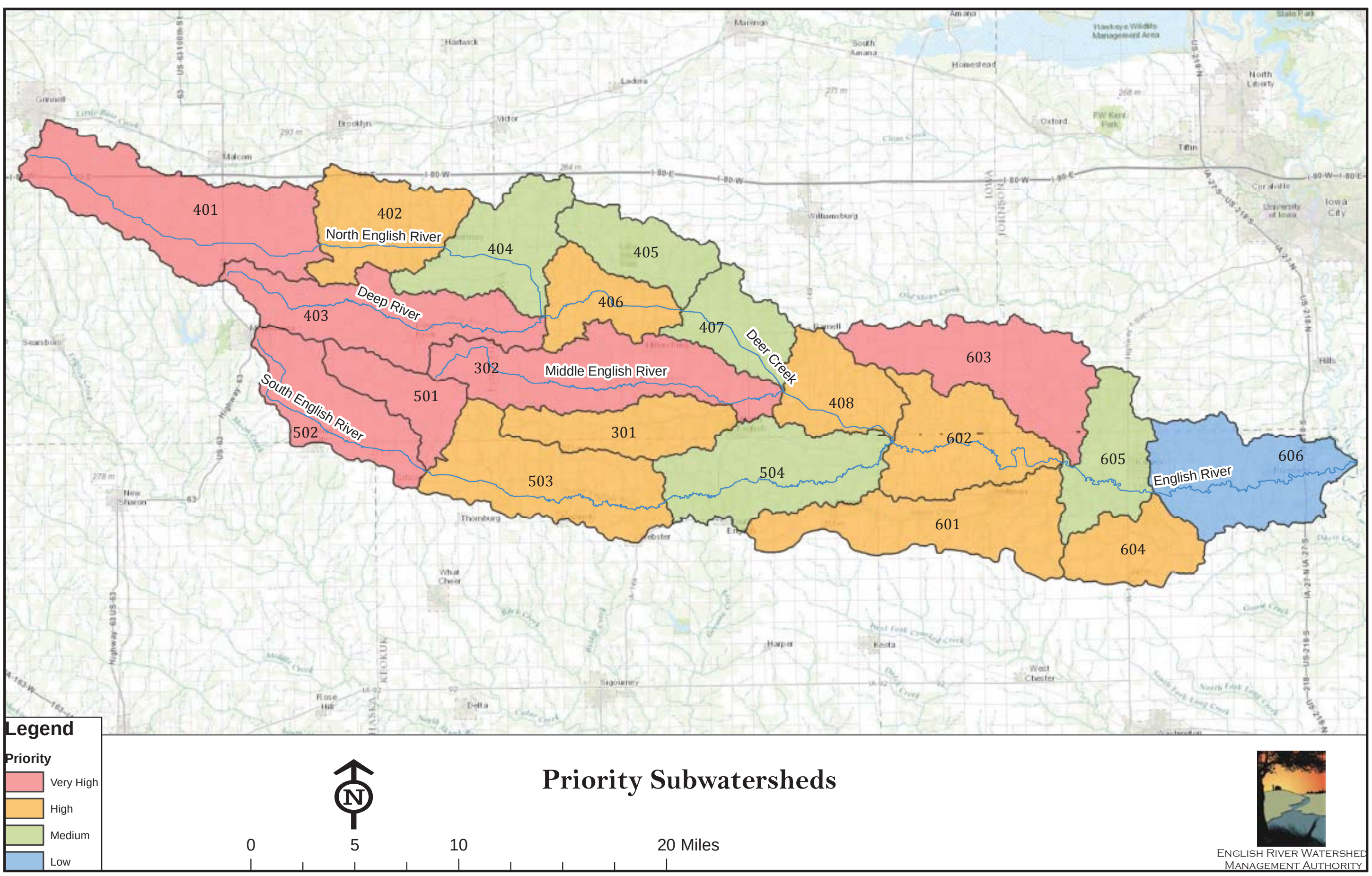


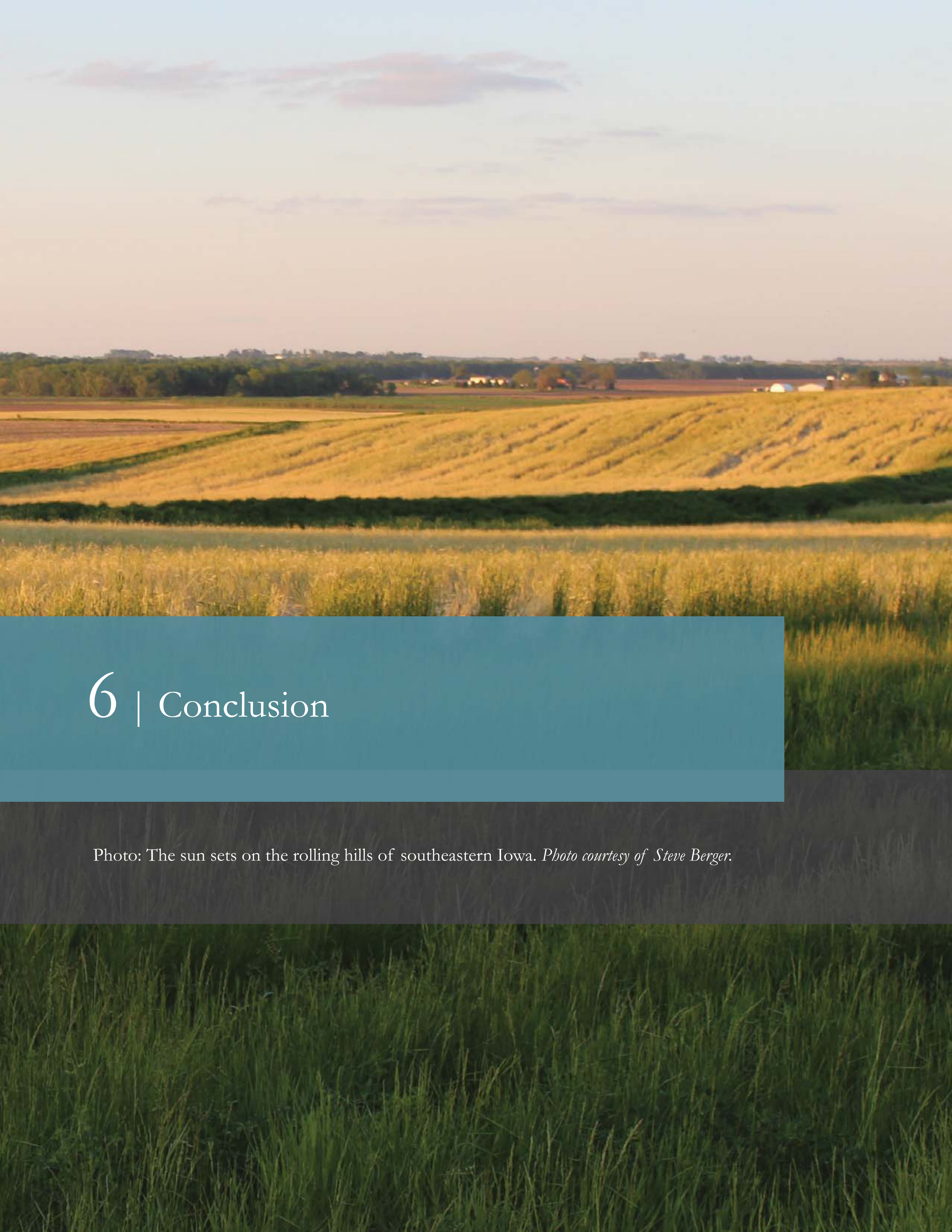
Figure 35: Priority Subwatersheds in the English River Watershed for Combined Water Quality Improvement and Flood Hazard Indicators

Table 12. Priority Subwatersheds for Combined Scoring			
ID (070802090###)	**Name**	**Priority**	**Total Score**
403	Deep River	1 (Very High)	11
603	Deer Creek	2 (Very High)	9
502	Upper South English River	3 (Very High)	9
501	Unamed Creek - Town of Tilton	4 (Very High)	9
401	Dugout Creek	5 (Very High)	9
302	Middle English River	6 (Very High)	9
602	Birch Creek	7 (High)	8
601	Lime Creek	8 (High)	8
503	Middle South English River	9 (High)	8
406	Middle North English River	10 (High)	8
402	Upper English River	11 (High)	8
604	Camp Creek	12 (High)	7
408	Outlet North English River	13 (High)	7
301	Gritter Creek	14 (High)	7
605	Ramsey Creek	15 (Medium)	6
504	Lower South English River	16 (Medium)	6
407	Lower North English River	17 (Medium)	6
405	Devils Run	18 (Medium)	6
404	Jordan Creek	19 (Medium)	6
606	Bulgers Run	20 (Low)	5

Based upon the given methodology, six subwatersheds fall into the “Very High” priority category. Deep River is ranked the highest priority for scoring high in nitrate concentration and for scoring the highest among annual flooding chances and susceptibility to phosphorus runoff. Also ranked in the “Very High” priority category is Deer Creek, Upper South English River, Unnamed Creek – Town of Tilton, Dugout Creek (headwaters of the Upper North English River), and the Middle English River subwatersheds. These subwatersheds, which are concentrated primarily near the western headwaters of the watershed, ranked high among each key variable of interest and should be the focus of watershed improvements through various best management practices detailed in this plan.

Conclusion

It is up to the watershed’s stakeholders to determine the best way to implement the recommendations for improvements in their watershed. Locally-driven efforts are important to achieving buy-in from stakeholders, and locally developed watershed plans, such as this one, can potentially be more effective in bringing about significant water quality improvements across Iowa than more “top-down” strategies. However, unless watershed stakeholders are sincerely committed to outreach and education, open to change in practice, providing leadership on the topic, and being proactive in obtaining resources for desired improvements, support for a cooperative, voluntary watershed improvement model will likely lose steam.



6 | Conclusion

Photo: The sun sets on the rolling hills of southeastern Iowa. *Photo courtesy of Steve Berger.*

Final Remarks

Like many other areas in state of Iowa, the English River watershed has been prone to more frequent and more extreme flooding events than before. These events have damaged public and private property, and can impair local economies. Additionally, the rivers of the English River watershed are being scoured (severe erosion) from a lack of protective vegetation along stream corridors, intensive farming, construction, and fast moving high-water events the tributaries are not equipped to handle. As topsoil is lost downstream, it carries phosphorus with it. The English River watershed has exceeded state averages in phosphorus contamination (and thus sediment).

Human health, property-loss risks, and economic hardship associated with severe flood events and water quality issues have increasingly become a concern in Iowa in recent decades. These issues have led state agencies, counties, municipalities, and private landowners to collaborate in efforts to strategically plan watershed improvements together. Watershed-level planning is a relatively new concept in Iowa. Watershed boundaries cross many geopolitical boundaries, and watershed-level coordination requires political jurisdictions to work with one another across political boundaries- a concept that has challenged conventional wisdom, and been met with a fair amount resistance. The bottom line, however, is that the flow of water, and land use impacts, do not stop at political boundaries. Watershed-level collaboration requires individuals, community and county leadership to recognize that their land ethic and land use patterns impact both upstream and downstream neighbors. Collaborative planning for watershed improvement provides opportunities for the entities to work together and espouse a "good neighbor" ethic. It also provides opportunities for all jurisdictions to have a seat at the table in planning and decision-making, regardless of an entity's size, population, or wealth.

> "Conservation is getting nowhere because it is incompatible with our Abrahamic concept of land. We abuse land because we regard it as a commodity belonging to us. When we see land as a community to which we belong, we may begin to use it with love and respect."
>
> — *Aldo Leopold*

The English River Watershed Resiliency and Improvement Plan is a non-regulatory roadmap for individuals and decision makers to use in the years to come. The Plan was informed by a lengthy assessment of the strengths and vulnerabilities of the watershed, stemming from a hydrologic assessment, and inventory of characteristics, water quality testing, a social survey, personal interviews, and a myriad of other research methods. The following project partners were essential in contributing to The Plan: Iowa Flood Center, Iowa Department of Natural Resources Watershed Improvement and IOWATER programs, Iowa Geological Survey, and the Iowa Soybean Association. These partners offer technical assistance and expertise, as well as tools the ERWMA has benefited from in this phase of watershed improvements, and will likely utilize again in future phases.

Concluding recommendations (or goals) for future English River Watershed improvements fall into three categories: water quality improvements, disaster resiliency, and capacity building of the ERWMA. The recommendations called for in this plan, and prioritized subwatersheds should be considered starting points for watershed improvements. Due to the scope of the entire watershed, and the potential for changing local, state, or federal watershed policy, and available resources, it is important that The Plan be viewed as a flexible document, subject to periodic reevaluation for relevancy and reprioritization as needed.

Watershed improvement is the responsibility of both urban and rural individuals and decision-makers. The majority of watershed stakeholder we heard from, both farmers and non-farmers, agree that improvements to water quality and soil are necessary. Flooding is a very real issue for some city and county leaders. It is the hope of this Plan to build momentum for significant improvements to water quality and flood mitigation, and not to become another relic left to collect dust in the archives of landowners and decision-makers. Success of the English River Watershed improvement project ultimately depends on:

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- The willingness and capacity of leadership in the watershed to promote and support watershed improve ment goals- and work together across political boundaries;
- The willingness of watershed residents to become stewards of the watershed through education and a willingness to employ best management practices as able;
- Federal, state, and local priorities that affirm the importance of Iowa's water and soil resources;
- And the extent of resources available for stakeholders to participate in state soil and water quality initia tives.

Responsibility for protecting this vital resource is that of all watershed stakeholders (both individual and organizational); the English River Watershed Management Authority will facilitate development of partnerships needed to make it happen, as well as providing leadership, and pursuing the resources needed to implement the plan. However, stakeholder participation in, and support of the ERWMA and partner effort to accomplish these tasks, are essential.

List of Abbreviations

Abbreviations	Term
AFO	Animal Feeding Operation
CFS	Cubic Feet per Second
Cl	Chloride
CM	Centimeters
CREP	Conservation Reserve Enhancement Program
CRP	Conservation Reserve Program
DFIRM	Digital Flood Insurance Rate Map
DO	Dissolved Oxygen
EQIP	Environmental Quality Incentives Program
FEMA	Federal Emergency Management Agency
FIS	Flood Insurance Study
GIS	Geographic Information System
GWW	Grassed Waterways
HA	Hectares
HUC	Hydrologic Unit Code
IA	Iowa
IDALS	Iowa Department of Agriculture and Land Stewardship
IDNR (DNR)	Iowa Department of Natural Resources
IFI	Iowa Flood Information System
INRS	Iowa Nutrient Reduction Strategy
ISU	Iowa State University
LID	Low Impact Development
LiDAR	Light Detection and Ranging
NFIP	National Flood Insurance Program
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resources Conservation Service (formerly known as SCS)
NWS	National Weather Service
RASCAL	Rapid Assessment of Stream Condition Along Length
SSURGO	Soil Survey Geographic Database
STRIPS	Science based Trails of Rowcrops Integrated with Prairie Strips
SUDAS	Statewide Urban Design and Specifications
SWAT	Soil and Water Assessment Tool
SWCD	Soil and Water Conservation District
TMDL	Total Maximum Daily Load
TP	Total Phosphorous
USACE	Unites States Army Corps of Engineers
USDA	United Stated Department of Agriculture
USEPA (EPA)	United States Environmental Protection Agency
USGS	United States Geological Survey
WASCOB	Water and Sediment Control Basin
WMA	Watershed Management Authority

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Appendix

Due to the various lengths of the following reports, each appendix item is provided digitally online at the English River Watershed's website in order to reduce paper consumption. Please visit www.EnglishRiverWMA.org to view the entire list of resources that accompany and supplement this plan.

Appendix A: English River Watershed Quality Snapshots 2014 - Keil, A., Iowa Soybean Association View the full report here: http://tinyurl.com/q4x2ve4
Appendix B: Hydrologic Modeling of the English River Watershed Report - Bradley, A. Jr., KC, A., Leach, N., Tokuhisa, R. View the full report here: http://tinyurl.com/q324nl2
Appendix C: English River Watershed Landowner Survey 2014 - Bailey, J. & Fixmer-Oraiz, V. View the full report here: http://tinyurl.com/oovpel6
Appendix D: Guide to Urban Stormwater Management - Bailey, J. & Fixmer-Oraiz, V. View the full report here: http://tinyurl.com/njaaulw
Appendix E: Historic English River Water Quality Summary - Skopec, M. View the full report here: http://tinyurl.com/pextm2l
Appendix F: Iowa Strategy to Reduce Nutrient Loss: Nitrogen and Phosphorus Practices - Iowa State University Extension and Outreach View the full report here: http://tinyurl.com/pq82u7f
Appendix G: Watershed Improvement Funding Resources List Revised 2.3.15 - Iowa Department of Agriculture and Land Stewardship, Iowa Department of Natural Resources View the full report here: http://tinyurl.com/puur35p
Appendix H: Sample Subwatershed WorkPlan - Iowa Department of Agriculture and Land Stewardship View the full report here: http://tinyurl.com/nsrgw83
Appendix I: The Straightening of the English River - Jackson, D, English Valleys History Center View the full report here: http://tinyurl.com/qdb6ko5