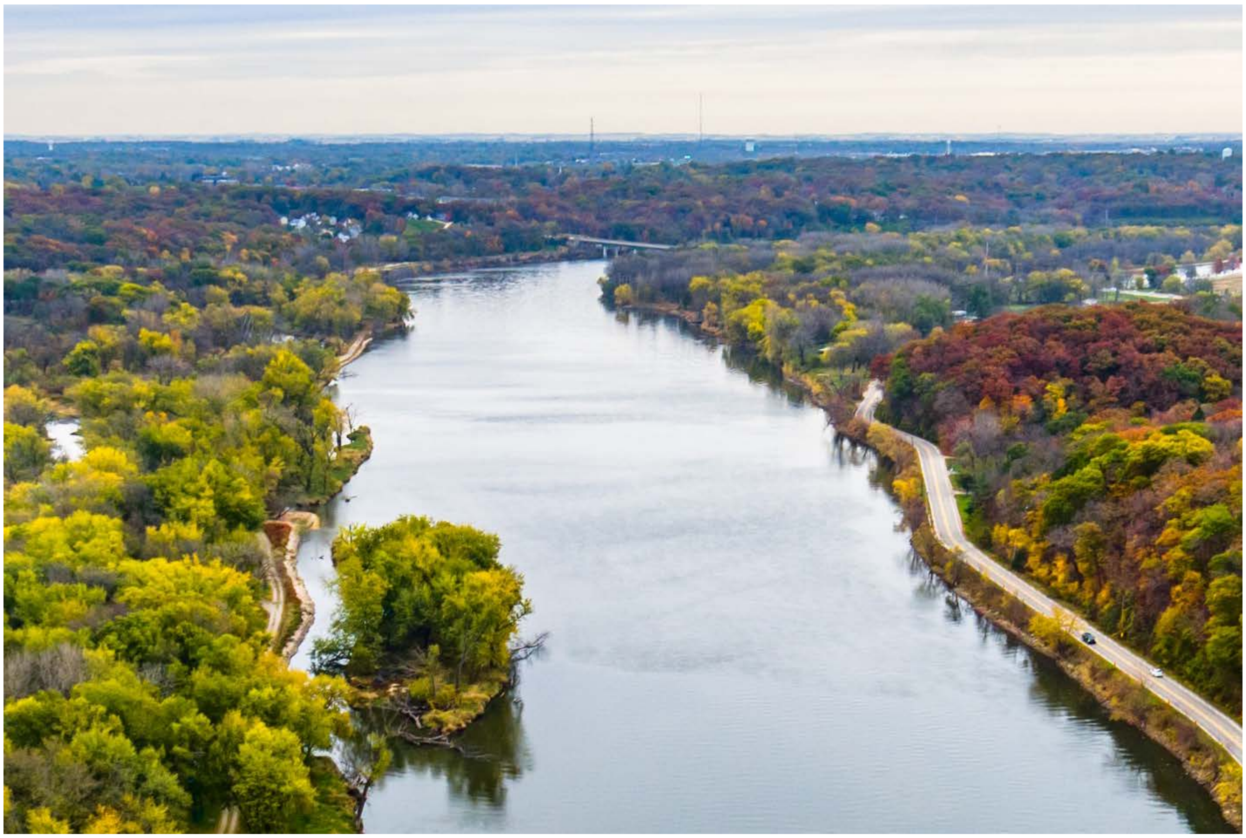
Prepared by: EOR

For the Middle Cedar Watershed Management Authority

Middle Cedar River Watershed Assessment



December 2019

Cover Image

Cedar River, CALCAM

Acknowledgement

Preparation of the Middle Cedar River Watershed Assessment was made possible by funding provided through The Iowa Watershed Approach for Urban and Rural Resilience, a program funded by the U.S. Department of Housing and Urban Development (HUD).

Additional information is at the following website: https://iowawatershedapproach.org/

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1. WATERSHED CHARACTERIZATION

The Middle Cedar River Watershed is one of six Hydrologic Unit Code (HUC)-8 watersheds that comprise the larger Cedar River Watershed (CRW). The CRW includes a 7,485 square mile area that begins in southern Minnesota near Austin, continuing southeastward to the Cedar River's outlet at the Iowa River near Columbus Junction.

The Middle Cedar Watershed (MCW) covers approximately 2,400 square miles (32% of the CRW) in East Central Iowa and spans 10 counties: Franklin, Hardin, Butler, Grundy, Marshall, Tama, Blackhawk, Buchanan, Benton, and Linn counties. The watershed consists of mostly agricultural lands but also includes many small towns (i.e. Vinton, Traer, and Grundy Center) and a substantial portion of Iowa's urban areas, including Cedar Rapids, Waterloo, and Cedar Falls. The watershed includes some of the richest farmland in the nation. Seventy-three percent of the land in the watershed is dedicated to row crop agriculture and seed corn production. The Iowa DNR estimates that $17.5 million is spent on river recreation annually on the Cedar River between Cedar Rapids and Waterloo. The Cedar River has a long history as a recreational destination. Current water quality conditions in the Watershed are the largest factor limiting recreation. Several reaches of the Cedar River and many of its tributaries have levels of bacterial contamination that pose a risk to human health (see Section 2.9.4, Table 2-13).

1.1. Hydrologic Setting

The United States Geological Survey (USGS) created a hierarchical system of watershed areas represented by a unique Hydrologic Unit Code (HUC) number. There are six levels in the hierarchy, represented by hydrologic unit codes from 2 to 12 digits long, called regions, subregions, basins, subbasins, watersheds, and subwatersheds. In this system the Middle Cedar Watershed is actually referred to as a Subbasin. Table 1-1 below describes the USGS system's hydrologic unit levels and their characteristics, along with example names and codes from the Middle Cedar Watershed. An illustration of the USGS HUC code system using the Middle Cedar examples in shown in Figure 1-1.

Table 1-1: USGS Watershed Hierarchical System

Name	HUC Level	Average Size	Example name from Middle Cedar	Example code (HUC)
Region	2	177,560 sq-mile	Upper Mississippi River	07
Subregion	4	16,800 sq-mile	Upper Mississippi -Iowa- Skunk-Wapsipinicon	0708
Basin	6	10,596 sq-mile	Iowa Basin	070802
Subbasin	8	700 sq-mile	Middle Cedar Watershed	07080205
Watershed	10	40,000–250,000 acres	Wolf Creek	0708020508
Subwatershed	12	10,000–40,000 acres	Village of Conrad-Wolf Creek	070802050803

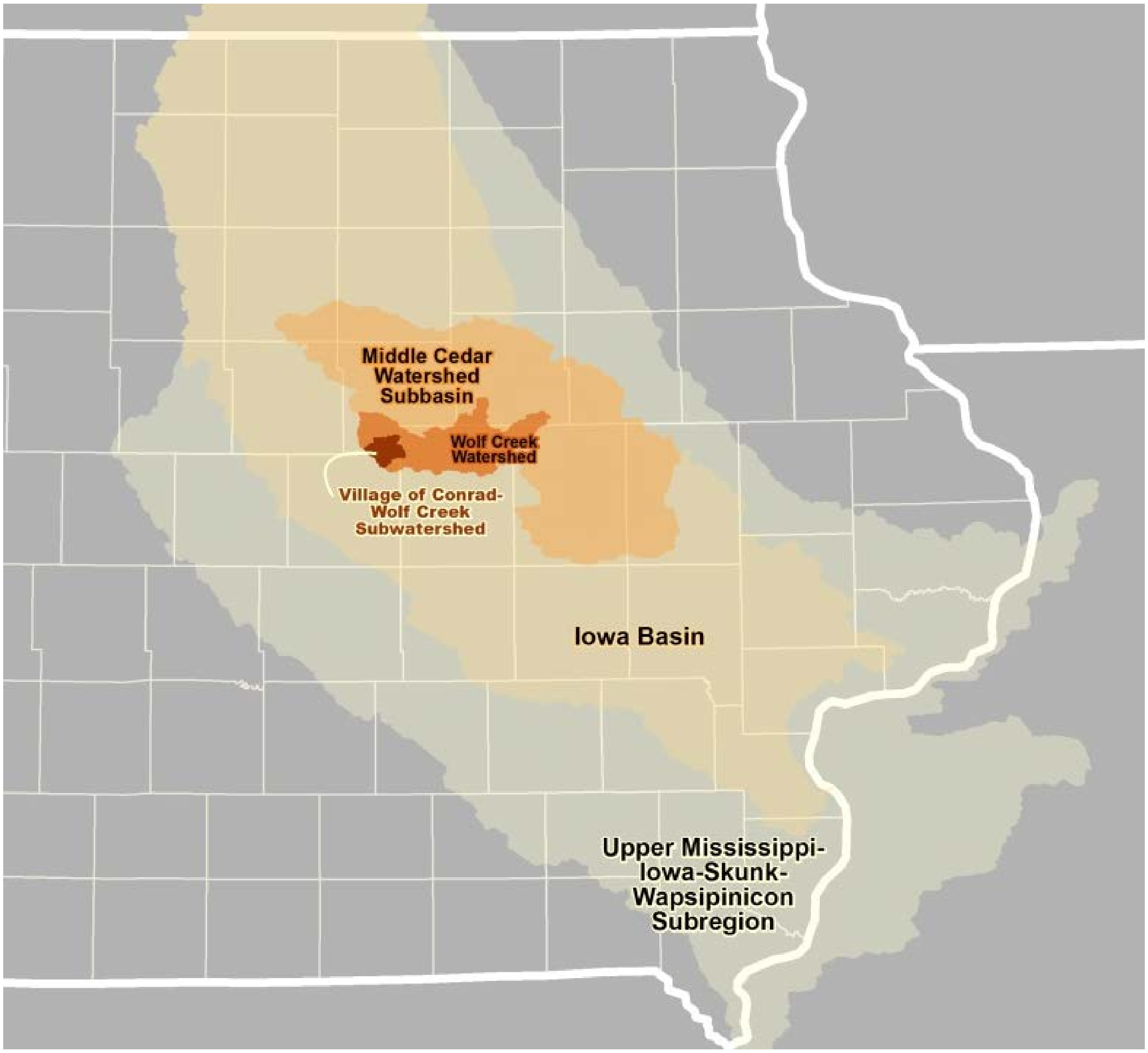

Figure 1-1: Illustration of USGS Hydrologic Unit Code Hierarchy

The Middle Cedar includes sixty eight HUC-12 subwatersheds within fifteen HUC-10 watersheds as shown in Figure 1-2 and Table 1-2. Subwatersheds are the smallest unit within the USGS system although many times these are further subdivided for a variety of purposes, particularly in the construction of hydrologic and water quality models. Subwatersheds are the hydrologic-scale that is commonly used for implementation efforts. At this scale landowners are likely to have personal relationships and a small, dedicated group can have a meaningful role in improving the health of a subwatershed. Previous watershed management planning in the Middle Cedar has occurred at the Subwatershed, or HUC-12 scale, although some of these efforts have involved multiple HUC-12s (Table 1-3).

Note that there are three HUC-10 watersheds associated with Beaver and Black Hawk Creeks which leads to some confusion as these areas are commonly referred to as 'watersheds'. These areas are the equivalent of a HUC-9, although that level does not formally exist within the USGS system. Currently a watershed management initiative is being organized for Black Hawk Creek which encompasses ten HUC-12 subwatersheds within three HUC-10 watersheds.

Table 1-2. HUC-10 Watersheds and HUC-12 Subwatersheds of the Middle Cedar WMA

<table>
<tr><th colspan="2">Watershed / (HUC-10)</th><th>Subwatershed (HUC-12)</th><th>Subwatershed Name (HUC-12)</th></tr>
<tr><td rowspan="11">Beaver Creek</td><td rowspan="3">South Beaver Creek</td><td>070802050101</td><td>Middle Fork South Beaver Creek</td></tr>
<tr><td>070802050102</td><td>Headwaters South Beaver Creek</td></tr>
<tr><td>070802050103</td><td>South Beaver Creek</td></tr>
<tr><td rowspan="4">Headwaters Beaver Creek</td><td>070802050201</td><td>Headwaters Beaver Creek</td></tr>
<tr><td>070802050202</td><td>North Middle Beaver Creek</td></tr>
<tr><td>070802050203</td><td>Drainage Ditch 148- Beaver Creek</td></tr>
<tr><td>070802050204</td><td>Gran Creek- Beaver Creek</td></tr>
<tr><td rowspan="4">Beaver Creek</td><td>070802050301</td><td>Johnson Creek</td></tr>
<tr><td>070802050302</td><td>Phelps Creek- Beaver Creek</td></tr>
<tr><td>070802050303</td><td>Max Creek- Beaver Creek</td></tr>
<tr><td>070802050304</td><td>Hammers Creek- Beaver Creek</td></tr>
<tr><td rowspan="10">Black Hawk Creek</td><td rowspan="3">North Fork Black Hawk Creek</td><td>070802050401</td><td>South Fork Black Hawk Creek</td></tr>
<tr><td>070802050402</td><td>Headwaters North Fork Black Hawk Creek</td></tr>
<tr><td>070802050403</td><td>North Fork Black Hawk Creek</td></tr>
<tr><td rowspan="5">Headwaters Black Hawk Creek</td><td>070802050501</td><td>Holland Creek</td></tr>
<tr><td>070802050502</td><td>Headwaters Black Hawk Creek</td></tr>
<tr><td>070802050503</td><td>Mosquito Creek</td></tr>
<tr><td>070802050504</td><td>Minnehaha Creek-Black Hawk Creek</td></tr>
<tr><td>070802050505</td><td>Village of Reinbeck-Black Hawk Creek</td></tr>
<tr><td rowspan="2">Black Hawk Creek</td><td>070802050601</td><td>Wilson Creek-Black Hawk Creek</td></tr>
<tr><td>070802050602</td><td>Prescotts Creek-Black Hawk Creek</td></tr>
<tr><td colspan="2" rowspan="3">Dry Run Creek</td><td>070802050701</td><td>Dry Run</td></tr>
<tr><td>070802050702</td><td>Waterloo Municipal Airport</td></tr>
<tr><td>070802050703</td><td>Black Hawk Park-Cedar River</td></tr>
<tr><td colspan="2" rowspan="9">Wolf Creek</td><td>070802050801</td><td>Headwaters Wolf Creek</td></tr>
<tr><td>070802050802</td><td>Little Wolf Creek</td></tr>
<tr><td>070802050803</td><td>Village of Conrad-Wolf Creek</td></tr>
<tr><td>070802050804</td><td>Fourmile Creek</td></tr>
<tr><td>070802050805</td><td>Coon Creek</td></tr>
<tr><td>070802050806</td><td>Rock Creek</td></tr>
<tr><td>070802050807</td><td>Twelvemile Creek</td></tr>
<tr><td>070802050808</td><td>Devils Run-Wolf Creek</td></tr>
<tr><td>070802050809</td><td>Wolf Creek</td></tr>
<tr><td colspan="2" rowspan="5">Miller Creek</td><td>070802050901</td><td>Elk Run</td></tr>
<tr><td>070802050902</td><td>Poyner Creek</td></tr>
<tr><td>070802050903</td><td>Indian Creek</td></tr>
<tr><td>070802050904</td><td>Headwaters Miller Creek</td></tr>
<tr><td>070802050905</td><td>Miller Creek</td></tr>
</table>

Watershed / (HUC-10)	Subwatershed (HUC-12)	Subwatershed Name (HUC-12)
	070802050906	Sink Creek-Cedar River
	070802050907	Mud Creek-Cedar River
Spring Creek	070802051001	Rock Creek-Cedar River
	070802051002	Spring Creek
	070802051003	Lime Creek
	070802051004	Bear Creek-Cedar River
	070802051005	McFarlane State Park-Cedar River
Pratt Creek	070802051101	Pratt Creek
	070802051102	Hinkle Creek
	070802051103	Prairie Creek-Cedar River
	70802051104	Mud Creek
	070802051105	Dudgeon Lake State WMA-Cedar River
Bear Creek	070802051201	Opossum Creek
	070802051202	Wildcat Creek
	070802051203	Little Bear Creek
	070802051204	Bear Creek
Otter Creek	070802051301	West Otter Creek
	070802051302	East Otter Creek-Otter Creek
Prairie Creek	070802051401	Headwaters Prairie Creek
	070802051402	Village of Van Horne-Prairie Creek
	070802051403	Mud Creek-Prairie Creek
	070802051404	Weasel Creek-Prairie Creek
	070802051405	Prairie Creek
Blue Creek	070802051501	East Branch Blue Creek
	070802051502	Blue Creek
	070802051503	Wildcat Bluff-Cedar River
	070802051504	Nelson Creek-Cedar River
	070802051505	Dry Creek
	070802051506	Morgan Creek
	070802051507	Silver Creek-Cedar River

Table 1-3. Past Watershed Planning Initiatives in the Middle Cedar Watershed

Past Planning Initiatives	USGS HUC Level	HUC-12 Subwatersheds Involved
Benton/Tama Nutrient Reduction Demonstration Project	3 HUC-12s	070802050809 Wolf Creek 070802051001 Rock Creek-Cedar River 070802051101 Pratt Creek
Miller Creek Water Quality Improvement Project	2 HUC-12s	070802050904 Headwaters Miller Creek 070802050905 Miller Creek
Lime Creek Watershed Improvement Association	HUC-12	070802051003 Lime Creek
Dry Run Creek Watershed Management Plan	HUC-12	070802050701 Dry Run
Black Hawk Creek Water and Soil Coalition	3 HUC-10s	070802050401 South Fork Black Hawk Creek 070802050402 Headwaters North Fork Black Hawk Creek 070802050403 North Fork Black Hawk Creek 070802050501 Holland Creek 070802050502 Headwaters Black Hawk Creek 070802050503 Mosquito Creek 070802050504 Minnehaha Creek-Black Hawk Creek 070802050505 Village of Reinbeck-Black Hawk Creek 070802050601 Wilson Creek-Black Hawk Creek 070802050602 Prescotts Creek-Black Hawk Creek

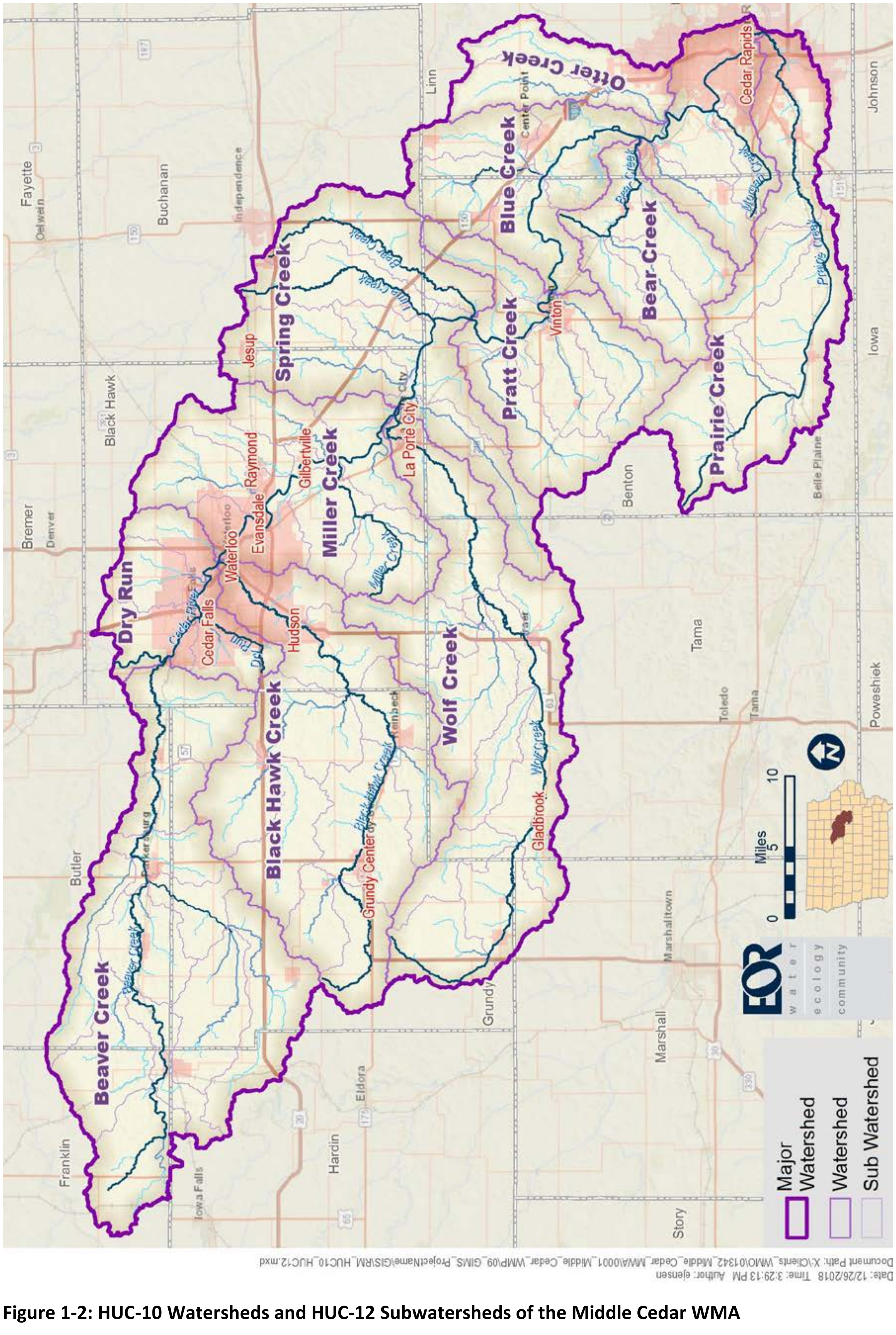

Figure 1-2: HUC-10 Watersheds and HUC-12 Subwatersheds of the Middle Cedar WMA

1.2. Demographics

The Middle Cedar Watershed covers approximately 1.5 million acres in East Central Iowa and spans 10 counties: Franklin, Hardin, Butler, Grundy, Marshall, Tama, Blackhawk, Buchanan, Benton, and Linn Counties. The Watershed population was estimated at approximately 300,000 people based on the 2010 Census as extrapolated to the watershed boundaries. Table 1-4 shows the estimated population by political subdivision within the watershed. Cedar Rapids is the political subdivision with the most people, accounting for 34% of the watershed population. Figure 1-3 depicts the population density (people per 1,000 acres) by subwatershed as well as the actual population estimate for each subwatershed.

Table 1-4. Estimated 2010 Population within the Middle Cedar Watershed by Political Subdivision

County	City	2010 Population in Watershed	Percent of Watershed Population	County/ City Acres in Watershed	Percent of Watershed Land Area
Benton		16,125	5%	385,613	25%
	Vinton	5,257	2%	3,086	0%
Black Hawk		9,495	3%	235,616	15%
	Cedar Falls	39,260	13%	18,931	1%
	Evansdale	4,751	2%	2,631	0%
	Gilbertville	712	0%	254	0%
	Hudson	2,282	1%	5,420	0%
	Jesup	117	0%	1,139	0%
	La Porte City	2,285	1%	1,675	0%
	Raymond	788	0%	1,044	0%
	Waterloo	68,406	23%	40,435	3%
Buchanan		2,178	1%	83,582	5%
	Jesup	2,403	1%	1,139	0%
Butler		4,851	2%	79,900	5%
Franklin		583	0%	49,512	3%
Grundy		9,495	3%	291,029	19%
	Grundy Center	2,706	1%	1,616	0%
Hardin		1,829	1%	26,080	2%
Linn		19,477	7%	130,850	8%
	Cedar Rapids	101,912	34%	33,433	2%
Marshall		147	0%	10,215	1%
Tama		3,632	1%	143,188	9%
	Gladbrook	945	0%	445	0%

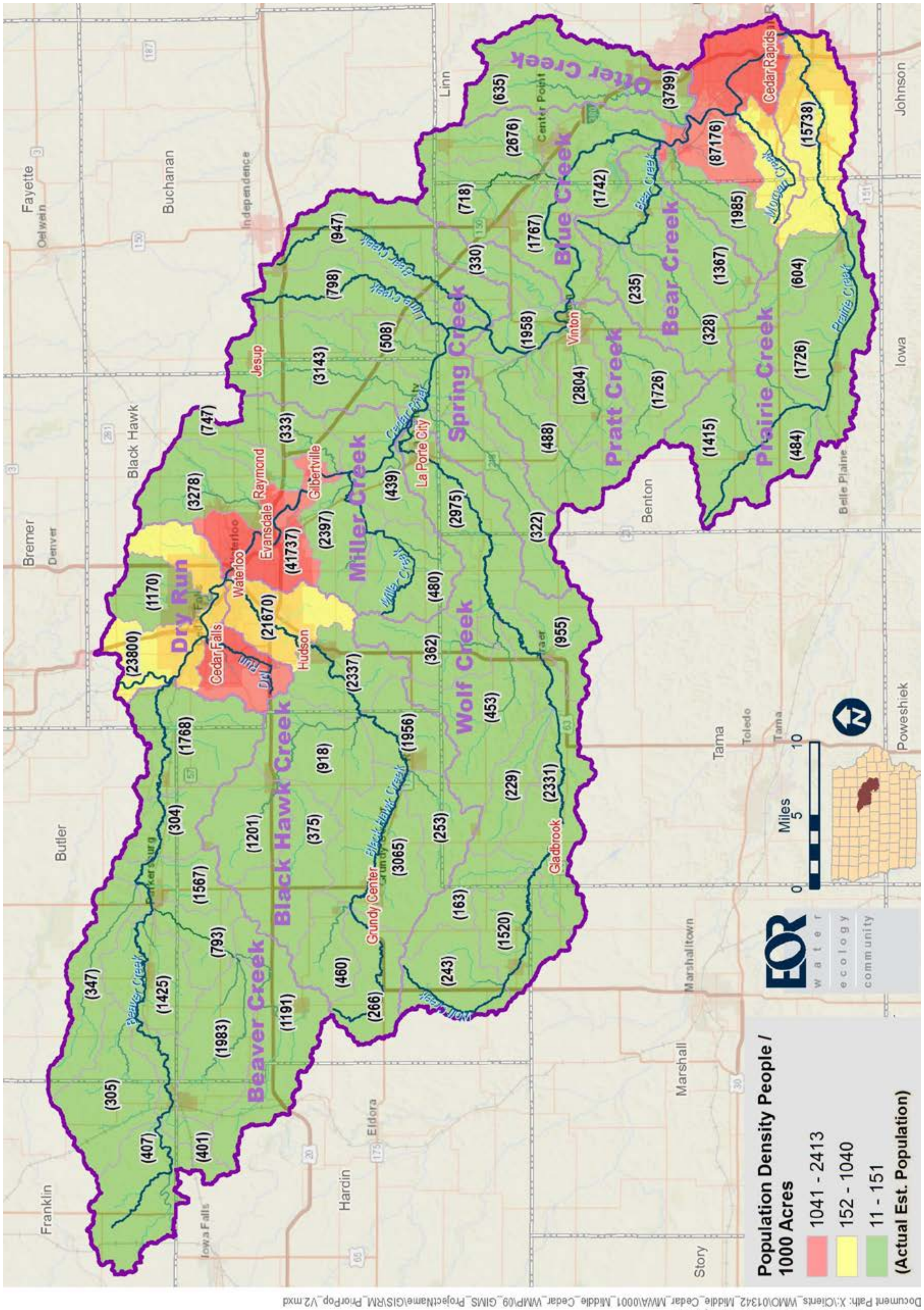

Figure 1-3. Estimated 2010 Population Density in the Middle Cedar Watershed by Subwatershed

1.3. Social Vulnerability Index

The social vulnerability Index (SVI) is a combined metric of 12 indicators: African American, language barrier, renters, unemployed, poverty, children, elderly, Hispanic, low education, female head of household, disabled, and no vehicle access. They represent a percent of the population at the census tract level. All data was retrieved from the U.S. Census Bureau using the 2016 ACS 5-year estimates. The data was developed by the Iowa Watershed Approach Flood Resilience Program at the census tract level. The data was then intersected with the HUC-12 subwatersheds within the Middle Cedar. Each subwatershed was than assigned the SVI score for the highest census tract it contained. See Figure 1-4.

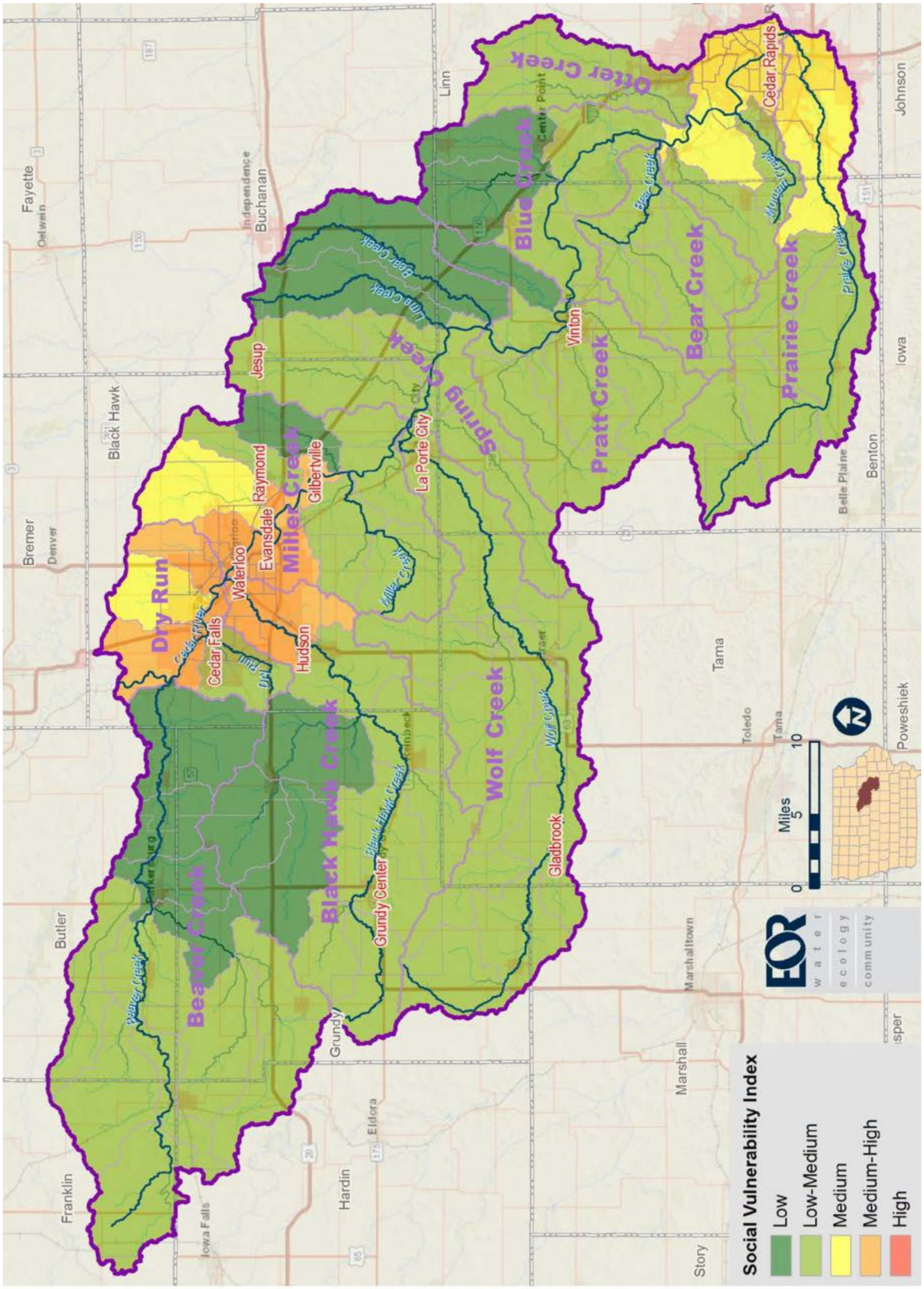

Figure 1-4. Social Vulnerability Index by Subwatershed in the Middle Cedar Watershed

1.4. Land Cover

Land cover and use, both natural and human influenced, are the main factors driving the quality and character of water resources in the Middle Cedar River Watershed. Land use within the Middle Cedar River Watershed is predominately (>73%) agricultural with development largely limited to the larger communities surrounding Waterloo in the northcentral portion of the watershed and Cedar Rapids in the eastern most portion of the watershed (Table 1-5 and Figure 1-5). The distribution of land cover in the Middle Cedar River Watershed was determined using Iowa's High Resolution Land Cover Dataset with a spatial resolution of one square meter (Figure 1-6). This dataset illustrates that the forested/grassland riparian areas are primarily located along the portion of Middle Cedar River between Waterloo and Cedar Rapids. The riparian areas within the Blue Creek watershed downstream of the City of Vinton contain the most intact riparian corridor; more than 40% of the Blue Creek watershed is either forested or grassland. Land cover is varied within the developed portions of the watershed.

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

Table 1-5. Middle Cedar River Watershed – Land Cover

HUC-10 Name*	% Forested	% Grassland	% Water/Wetland	% Row Crop	% Developed
Bear Creek	5%	15%	1%	76%	3%
Beaver Creek	4%	12%	1%	81%	2%
Black Hawk Creek	3%	11%	0%	82%	3%
Blue Creek	20%	21%	3%	48%	8%
Dry Run	16%	21%	3%	50%	10%
Miller Creek	8%	16%	2%	68%	6%
Otter Creek	11%	18%	1%	67%	4%
Prairie Creek	3%	14%	1%	77%	5%
Pratt Creek	7%	16%	1%	73%	3%
Spring Creek	6%	13%	1%	78%	2%
Wolf Creek	3%	12%	0%	82%	2%
Watershed Totals	**6.7%**	**14.3%**	**1.2%**	**73.8%**	**3.9%**

**Beaver Creek and Black Hawk Creek watersheds include multiple HUC-10 watersheds.*

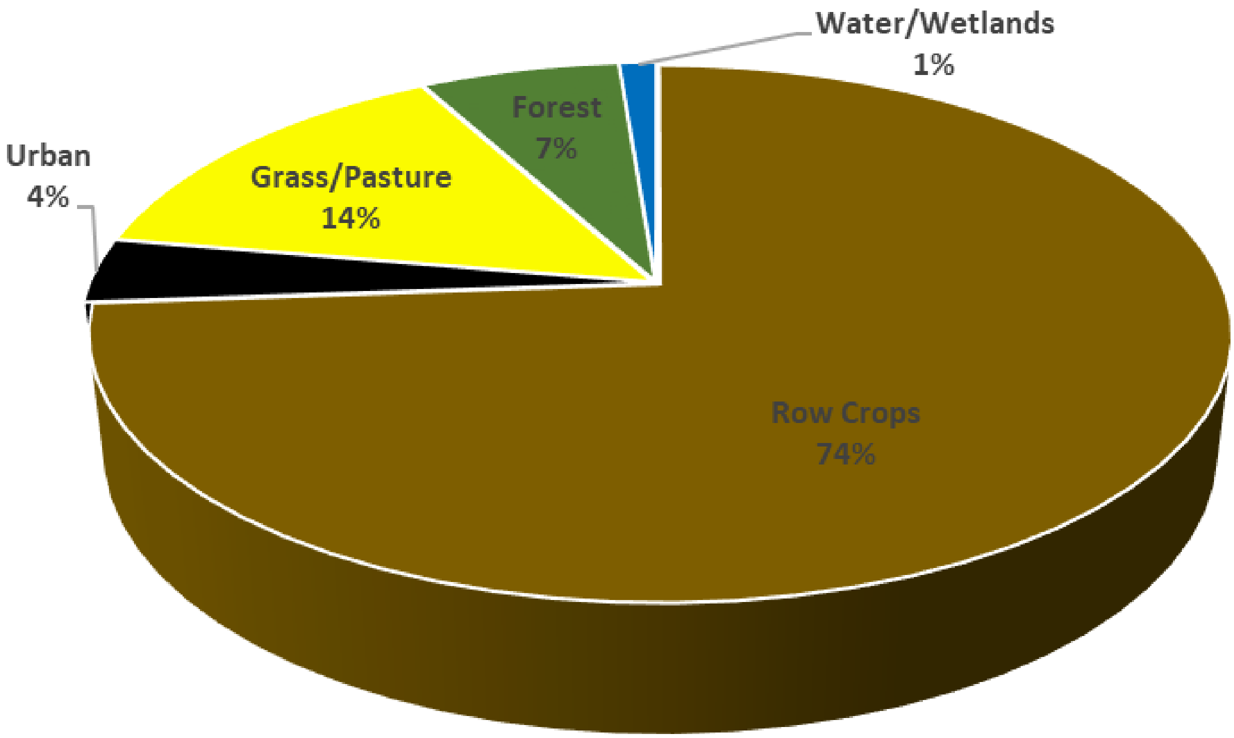

Figure 1-5. Land Cover Distribution in the Middle Cedar Watershed

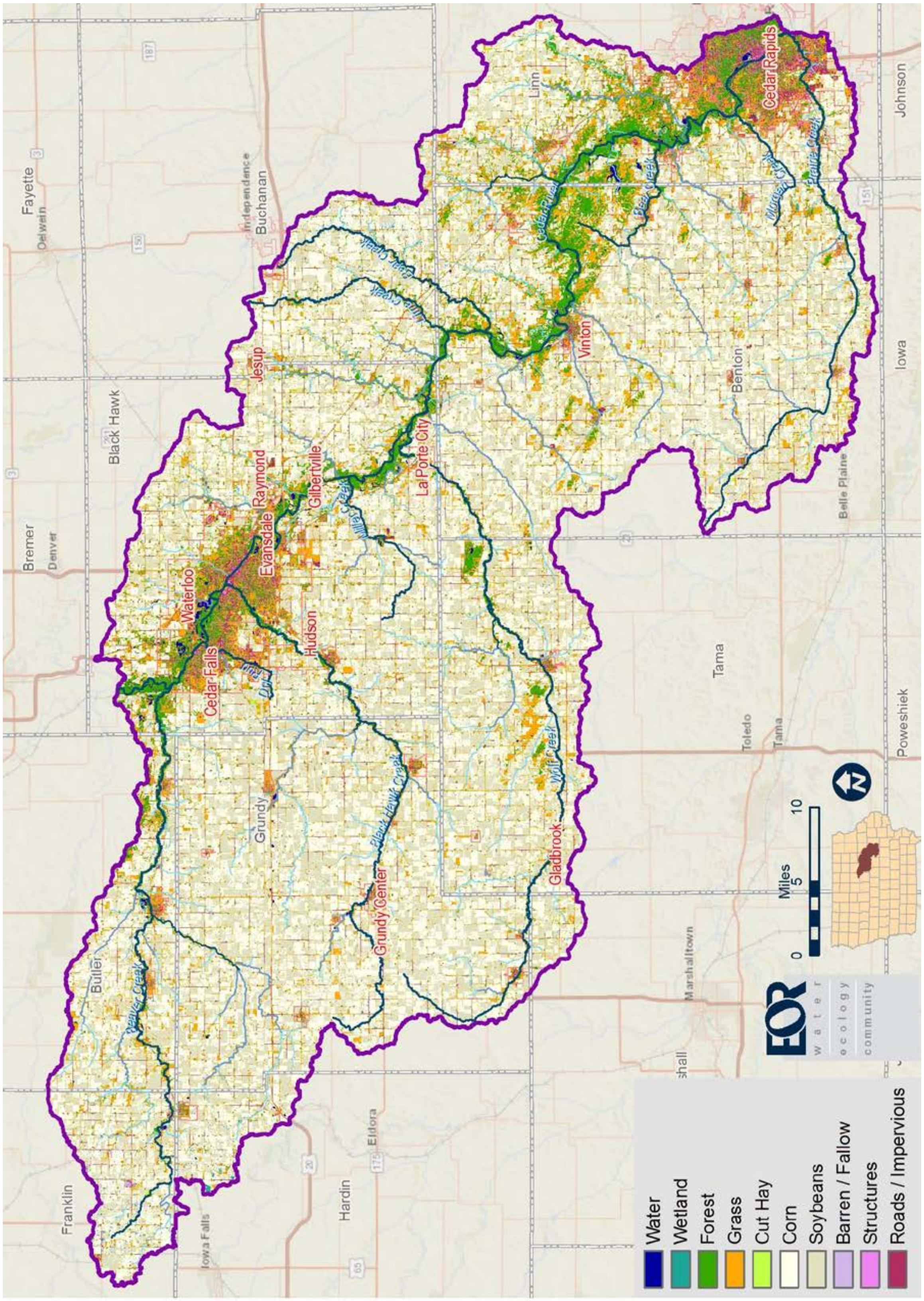

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Figure 1-6. Middle Cedar River Watershed – Land Cover Distribution

1.5. Soils

The Soil Survey Geographic (SSURGO) soils Geographic Information System (GIS) layer available from the United States Department of Agriculture (USDA) was compiled for the watershed. The USDA SSURGO GIS layer contains tabular data including hydrologic soil group classification; the tabular data was joined to the spatial data via a common attribute (Map Unit Symbol). Each Map Unit Symbol corresponds to a soil series description which describes the major characteristics of the soil profile for the given Map Unit.

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

Group B:
soils consist of silty loams or loams. These soils have moderately high infiltration rates and low runoff potential.

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

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

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

A Rapid Watershed Assessment of the Middle Cedar River Watershed (2009) reported that soils in the Middle Cedar River Watershed were comprised of a variety of different classes of loams including sandy loam, sandy clay loam, clay loam, silty clay loam, and silt loam. These soils formed primarily in glacial till, but are also derived from loess and alluvial deposits, and in some cases from the local bedrock. The drainage class of the soils in the watershed varies from poorly-drained to well-drained and is largely dependent on landscape position. The hydrologic soil groups in the Middle Cedar River Watershed are illustrated in Figure 1-8. The primary Hydrologic Soil Groups (HSG) immediately adjacent to the Middle Cedar River include well drained (HSG A and B), coarse, sandy loam soil series.

Soil series located within the many concave depressions associated with former prairie-pothole wetlands include deep, poorly drained, silty, clay-loams. Areas containing row crop (Corn/Soybean) land cover with B/D or C/D soils represent likely locations for subsurface tile drainage. The installation of subsurface tile drainage in areas with B/D and C/D soils has allowed for row crops to thrive in areas that were historically wetland.

Soil is a naturally occurring mixture of mineral and organic ingredients with a definite form, structure, and composition. The exact composition of soil changes from one location to another. A soil survey is a detailed report on the soils of an area. The soil survey has maps with soil boundaries and photos, descriptions, and tables of soil properties and features. Soil surveys are used by farmers, real estate agents, land use planners, engineers and others who desire information about the soil resource. The creatures living in the soil are critical to soil health. They affect soil structure and therefore soil erosion, runoff and water availability. They can protect crops from pests and diseases. They are central to decomposition and nutrient cycling and therefore affect plant growth and amounts of pollutants in the environment. Finally, the soil is home to a large proportion of the world's genetic diversity.

The Middle Cedar watershed encompasses many counties, so this plan will use Linn County as an example of a typical soil survey in the watershed. To find all of Iowa's soil surveys go to: https://www.nrcs.usda.gov/wps/portal/nrcs/surveylist/soils/survey/state/?stateId=IA.

To view the Linn County pdf manuscript go to: https://www.nrcs.usda.gov/Internet/FSE_MANUSCRIPTS/iowa/IA113/0/linn_text.pdf

The manuscript will typically show the following information, including;

1. Properties of soil map units like; color, permeability, stoniness, depth to bedrock, pH, structure, salinity, texture, slope, H2O availability, horizon thickness, engineering properties, erosion hazard, and other physical and chemical properties
2. Position on the Landscape
3. Percent Area in the Landscape
4. Capacities such as; Yield for crop, pasture, or vegetable, Suitability for recreation, wildlife and water infrastructure, engineering potentials and hazards

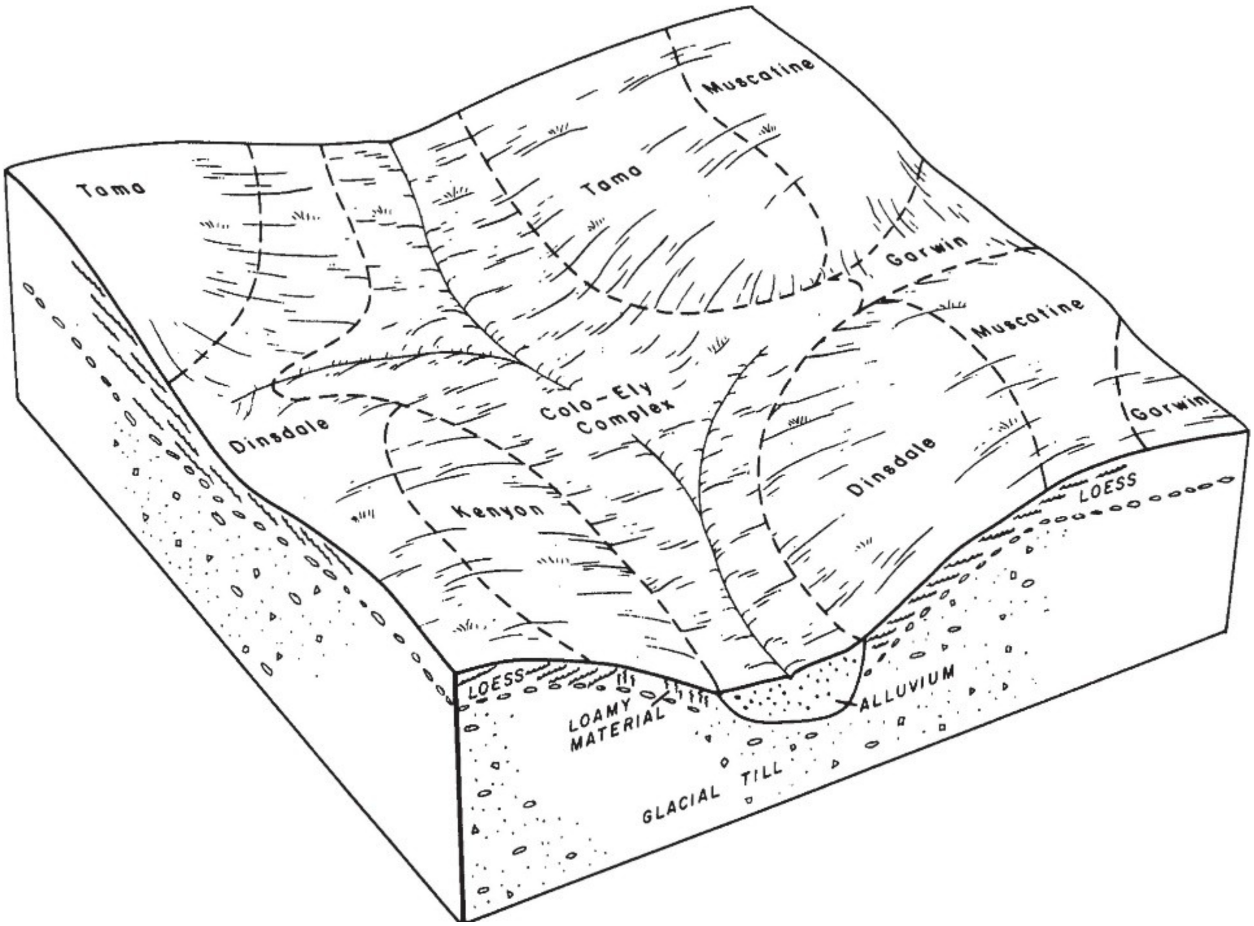


Figure 1-7. Relationship between Soil Mapping Units

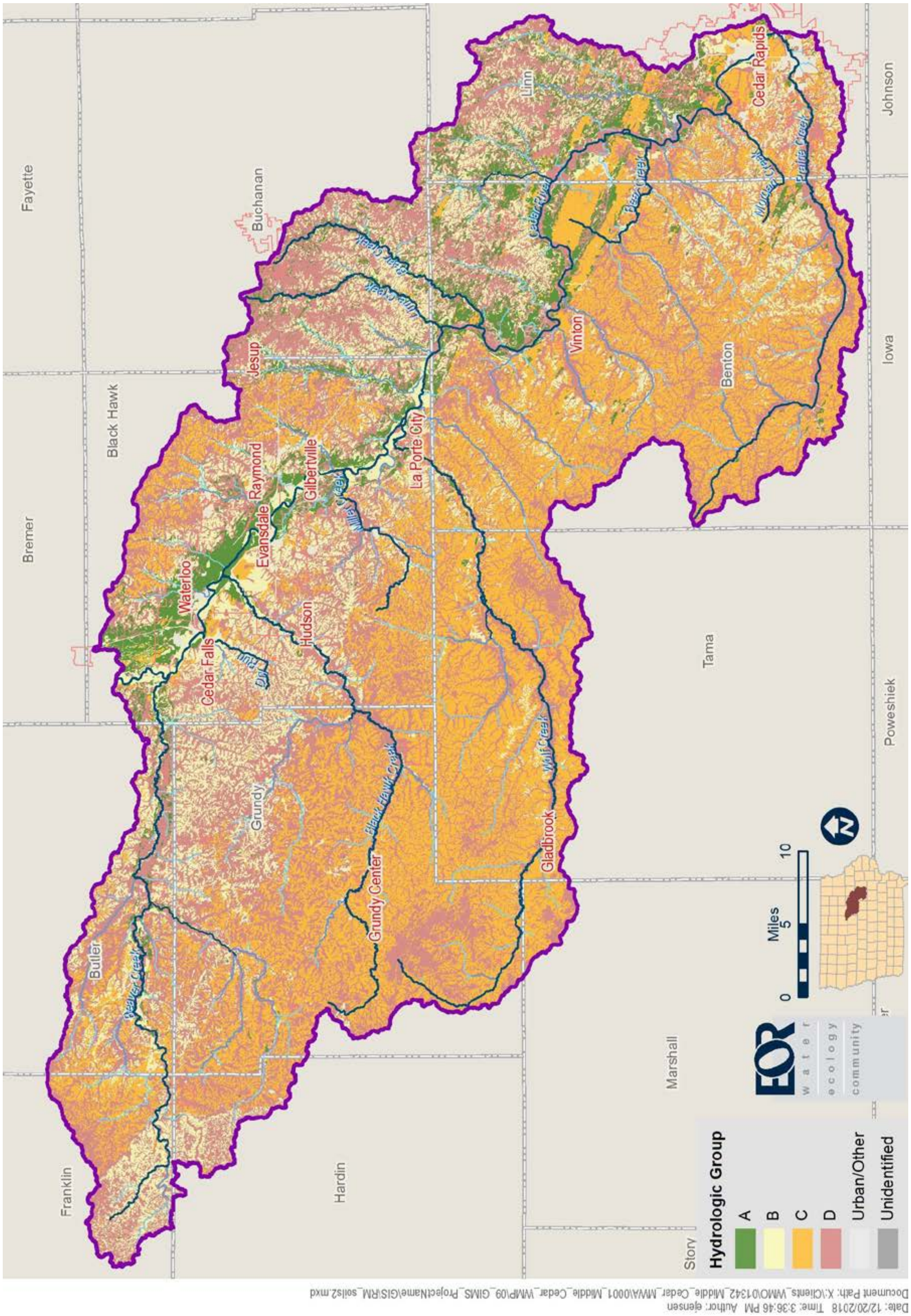


Figure 1-8. Middle Cedar River Watershed – Hydrologic Soil Group

1.6. Geology and Groundwater Resources

The following is a summary of the groundwater resources and underlying geology of the Middle Cedar River Watershed based on available data included in a review of the NRCS Rapid Watershed Assessment (USDA-NRCS 2009), *Geology of Grundy County* (Arey 1910), *Geology of Benton County* (Savage 1905), *Geology of Black Hawk County* (Arey 1906) , *Geology and Ground-Water Resources of Linn County, Iowa* (Hansen 1970), and data collected by the Iowa DNR. Approximately 80% of Iowa residents in both urban and rural settings rely on groundwater as their primary source of drinking water. In general, the portions of the watershed in Grundy County which includes the towns of Conrad, Dike, and Reinbeck contain abundant supplies of high quality (not requiring excessive treatment) drinking water sufficient for local domestic uses. The central portion of the watershed that falls within Black Hawk County contains a number of wells which provide a noteworthy abundance of high quality groundwater (low dissolved solids and organic matter). Most wells in the river valley are within 10-35 feet of the surface. Outside of the river valley, most wells are located from 60-280 feet of the surface. The City of Waterloo draws its water from 14 wells located in the Cedar Valley Aquifer, a limestone rock formation which contains a large supply of water. Well depths range from 76 to 225 feet. The southern portion of the watershed that falls within Benton County obtains groundwater from shallow wells (25-75 feet deep) that provide an ample supply of high quality groundwater. The town of Vinton obtains water from two deep well which penetrate the Saint Peter formation at a depth of more than 1,200 feet below the surface. The southeastern most portions of the watershed including the City of Cedar Rapids obtain groundwater from a shallow aquifers and artesian wells located next to the Cedar River. In Linn County, an ample supply of groundwater is available from both shallow drift aquifers in the alluvium of buried channels and in shallow bedrock aquifers where drift cover is thin.

1.6.1. Surficial Hydrogeology

The upper half of the Middle Cedar River Watershed is part of the Iowan Erosion Surface, this landscape consists of gently sloping till plains which are dissected by narrow, shallow stream valleys. The southeastern portion of the watershed (Benton, Linn counties) lies in the Southern Iowa Drift Plain. This area was largely unaffected by the Wisconsinan glaciation and contains steeply rolling hills and valleys. Outcroppings of Devonian and Mississippian limestone are visible in the portions of Butler and Franklin Counties that are adjacent to stream valleys.

The Cambrian-Ordovician aquifer covers nearly the entire state of Iowa and is the major deep aquifer in the watershed. It includes the St. Peter Sandstone, the Prairie du Chien dolomite, and the Jordan Sandstone, the last being the major water producer (Thompson 1982). The Cambrian-Ordovician aquifer is confined by a series of geologic units comprised of shale, dolomite and limestone that control downward groundwater transport to the aquifer. Generalized hydrogeological cross-sections for Iowa including the Des Moines River are shown in (Figure 1-9). In the Middle Cedar River Watershed, the Cambrian-Ordovician aquifer is covered by the Mississippian Aquifer which overlays a series of confining layers consisting of limestone, dolomite, and shale. In the Middle Cedar River Watershed, these confining layers include the Cedar Valley Group, the Lime Creek Formation, the Kinderhookian Group, and the Scotch Grove Formation (see Figure 1-10).

Recharge to the Mississippian aquifer is from: a) precipitation where the bedrock is at or near the surface, b) leakage to the aquifer from the Middle Cedar and its tributaries, and c) groundwater inflow from areas outside of the Middle Cedar River watershed. The Mississippian Aquifer is heavily used as a drinking and industrial water supply. The Devonian-Silurian Aquifer (Middle Bedrock Aquifer) is also used by several communities and rural residents. The main water-producing units in the Devonian-Silurian are a series of limestones and dolostones. There are also more than 200 shallow, quaternary and alluvial wells that are heavily used as both a drinking water source and industrial water supply.

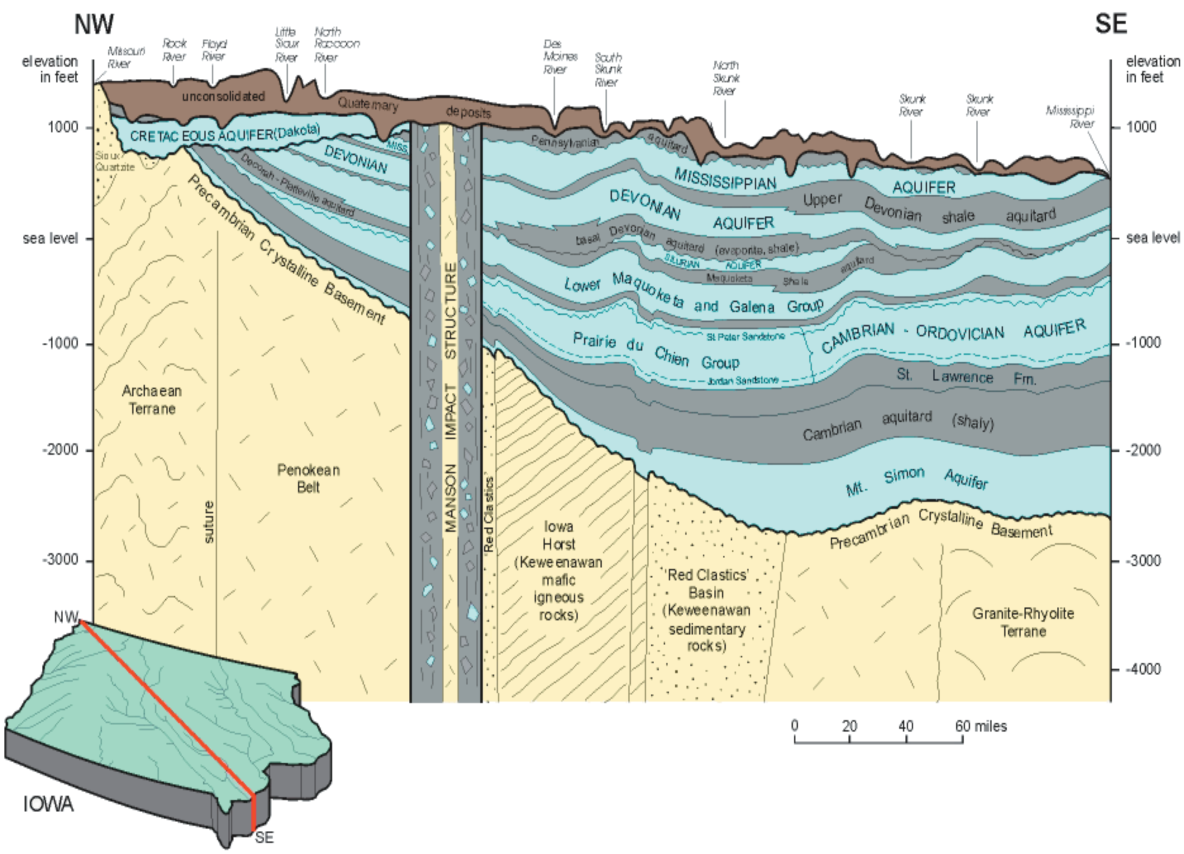


Figure 1-9. Generalized hydrogeological cross-section from northwestern to southeastern Iowa (modified from Prior and others, 2003).

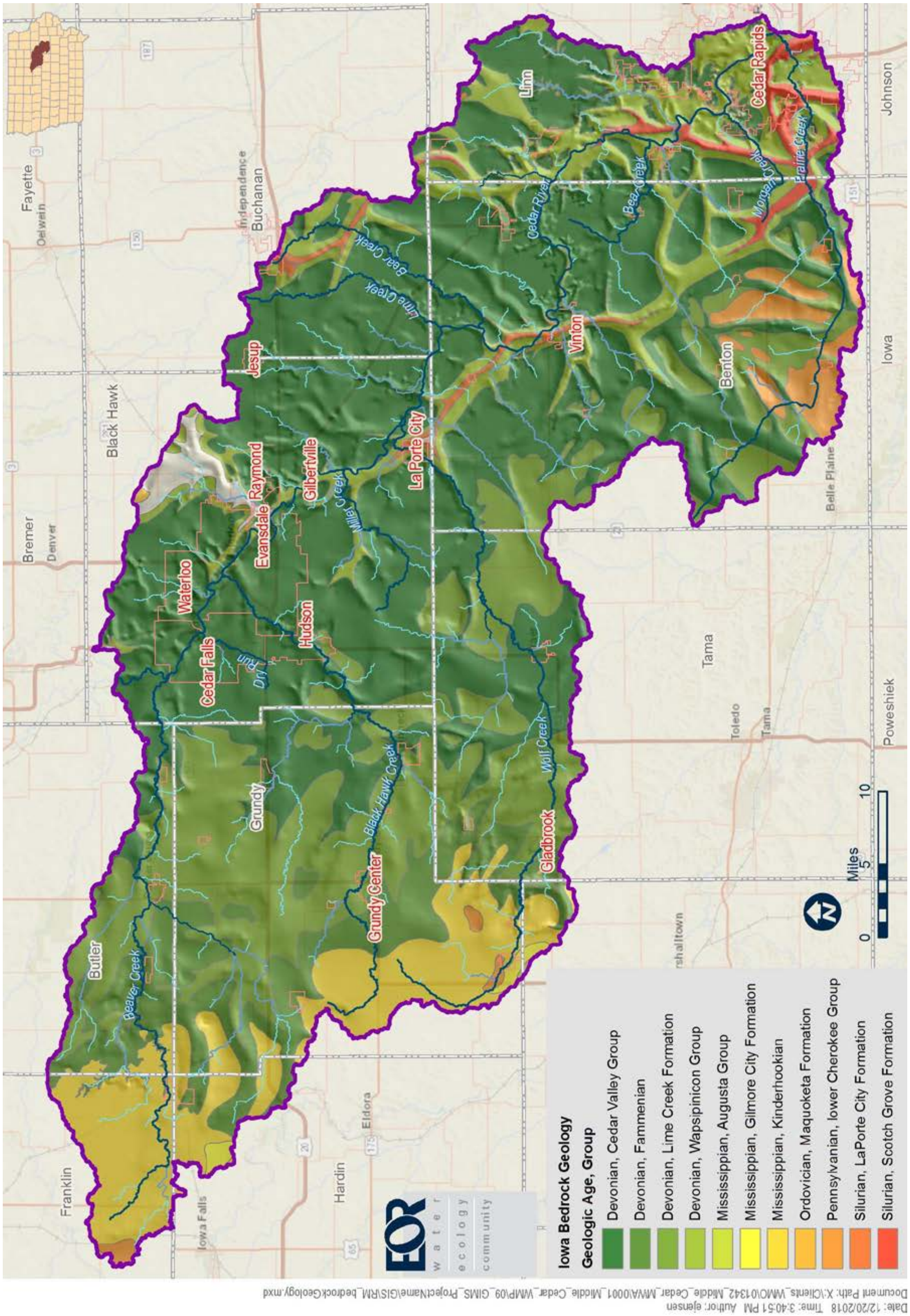


Figure 1-10. Bedrock Geologic Age and Group

1.6.2. Groundwater Vulnerability

In 1991, the Iowa DNR identified regions of Iowa with similar hydrogeological characteristics and classified these characteristics into 10 unique groups (map units) based on their relative vulnerability to groundwater contamination. Reviewing these classifications for the Middle Cedar River Watershed makes it possible to see where groundwater protection issues are most relevant (Figure 1-11). Groundwater quality, yield, and susceptibility to contamination is described below for each map unit:

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

Bedrock Aquifers:
Area underlain by regional bedrock aquifers, primarily fractured carbonate units; other regional aquifers usually available at various depths. Natural water quality usually excellent (less than 500 mg/L TDS) and high yields commonly available (greater than 100 GPM).

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

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

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

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

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

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

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

Sinkholes:
Naturally occurring depressions in the landscape caused by solution or the collapse of carbonate rocks; common where limestone is less than 30 feet below land surface. Contaminated surface water may enter the aquifer via sinkholes, contaminating the aquifer in a localized area; contaminant levels can fluctuate significantly during periods varying from minutes to weeks; increases contamination potential in areas with thin drift confinement.

Agricultural Drainage Wells:
Wells drilled to drain surface water and soil into carbonate aquifers; their presence allows contaminants in surface or tile water to enter the aquifers at much higher rates than naturally would be possible; increases contamination potential much like sinkholes.

Twenty-three highly susceptible wells and three priority communities (Waterloo, Cedar Falls, and Conrad) have been identified within the Middle Cedar River Watershed (Figure 1-11). Communities can coordinate with the Iowa DNR to conduct a site investigation to determine if the contaminant is from a point or nonpoint source.

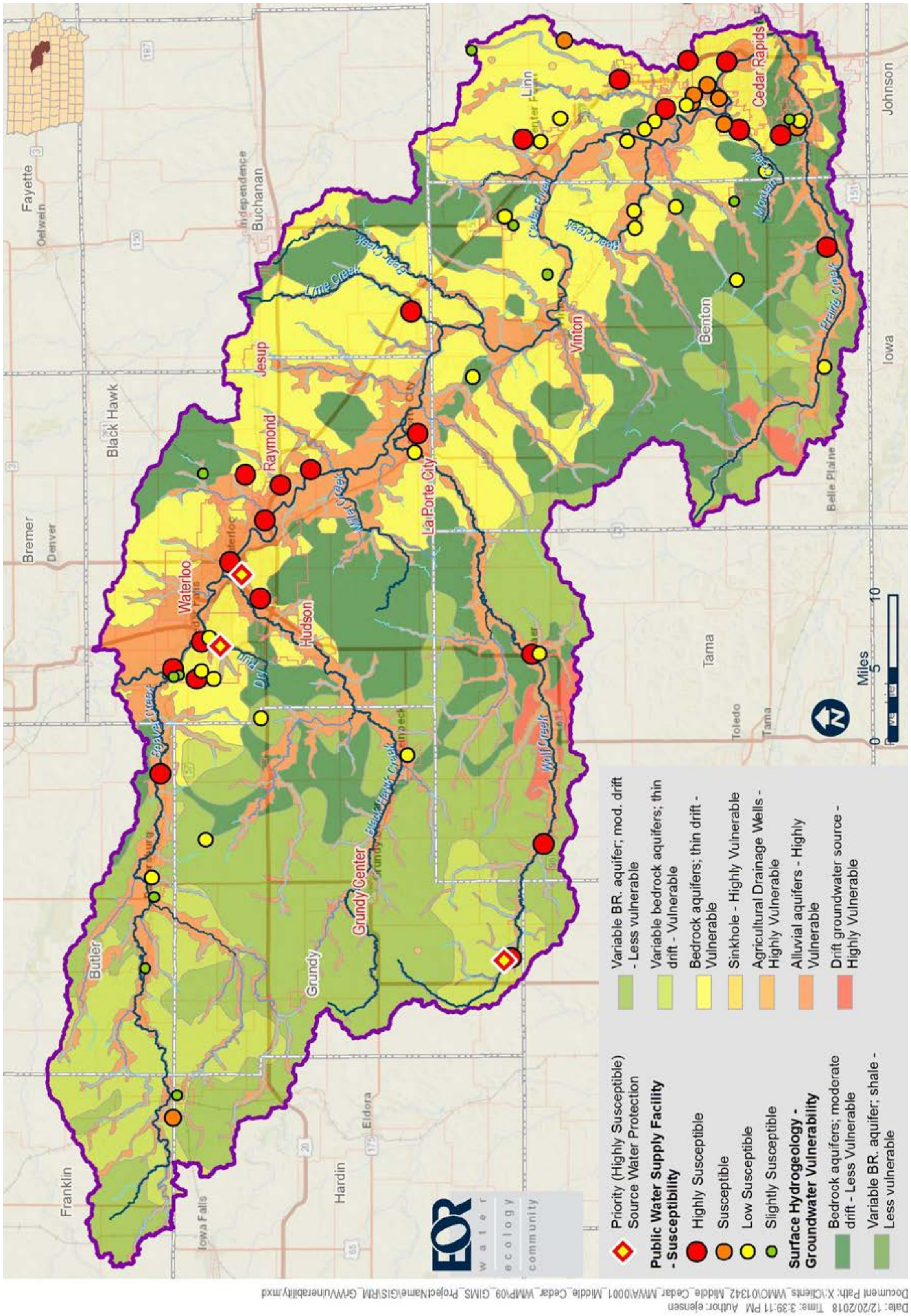


Figure 1-11. Middle Cedar River Watershed Highly Susceptible Wells and Groundwater Vulnerability

1.6.3. Source Water Protection Areas and Highly Vulnerable Groundwater Wells

The Iowa DNR has also developed a GIS layer depicting Groundwater capture zones – the land surface area that has been determined to provide water to a public water supply well based on available geologic and hydrogeologic information. Groundwater capture zones located in areas with high vulnerability for aquifer and well contamination and/or areas with high-observed pollutant concentrations (i.e., nitrate-nitrite concentrations exceeding 10 mg/L) should be prioritized as source water protection areas (Figure 1-12). The Iowa DNR operates a Source Water Protection Program, which requires a Phase 1 Assessment that defines the source water area and susceptibility to contamination. Gilbertville and Jesup have both completed the Phase 2 Storm Water Protection Plan (SWPP) and Cedar Rapids is currently working on their Phase 2 SWPP.

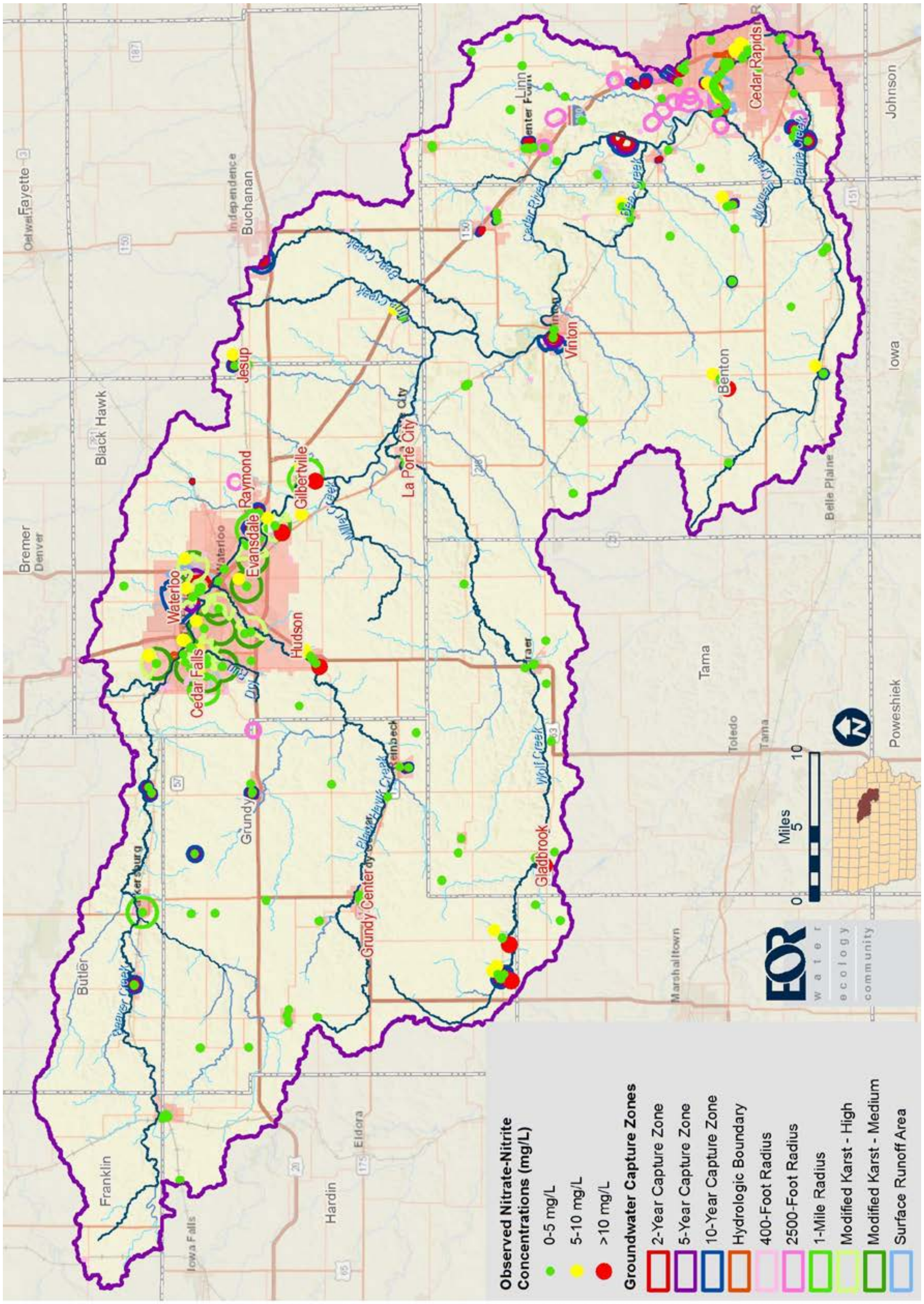


Figure 1-12. Groundwater Capture Zones and Observed Nitrate-Nitrite Concentrations

2. WATER RESOURCES

The following section describes the current state of lakes and streams within the Middle Cedar River Watershed. The section begins with a general summary of the stream network within the watershed followed by a discussion of water quality conditions of each streams.

2.1. Watershed Streams

The streams within the Middle Cedar River Watershed have been classified into the following management categories based on their designated uses and local significance.

Primary Streams:
Streams within the Middle Cedar River Watershed with a DNR Designated Use of Primary Recreation and/or Human Health are classified as "Primary streams" (see Figure 2-1). Primary streams should be managed to meet their designated use classifications; these streams represent the highest priority for protection and restoration measures. Unnamed streams with water quality impairments are included within the primary streams. In some cases, the management category for a given stream differs from the upper portion to the lower reaches.

Secondary Streams:
Named streams that maintain flow and/or pooled areas sufficient to maintain a viable aquatic community and support recreational uses that have not been assigned a designated use are classified as "Secondary streams" (see Figure 2-1). Secondary streams represent the major tributaries to the Middle Cedar River Watershed's Primary streams. Secondary streams represent the second highest priority for conservation measures.

Others Streams:
General use, unnamed streams within the Middle Cedar River Watershed are shown as "Other streams" in Figure 2-1. These "Other" streams area typically used for livestock and wildlife watering, aquatic life, noncontact recreation, and industrial, agricultural, or domestic withdrawal uses but do not represent the highest primary targets for implementation of conservation measures.

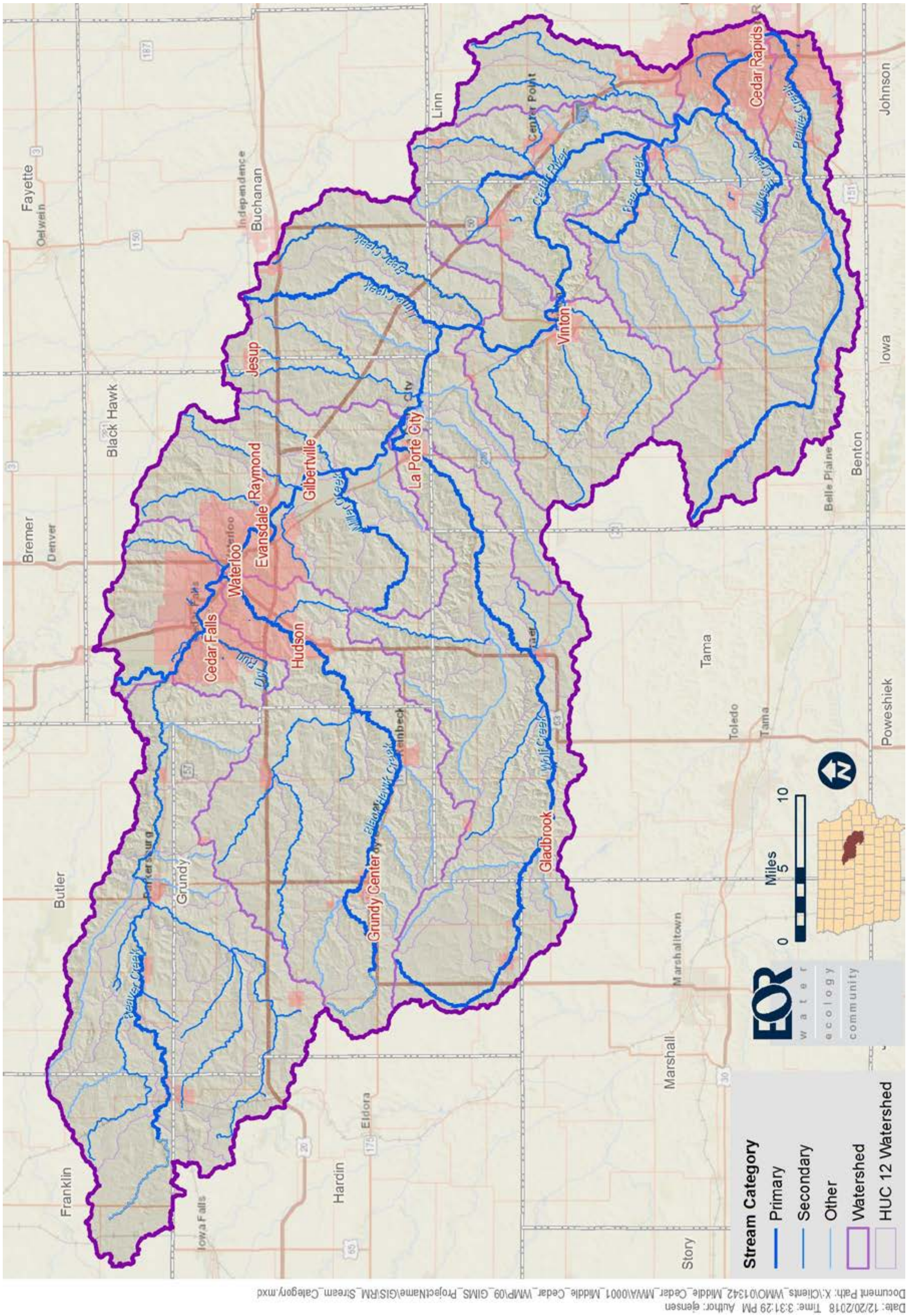


Figure 2-1. Middle Cedar River Watershed Streams

2.2. Watershed Lakes

There are eight public lakes larger than 10 acres in the Middle Cedar River Watershed, the largest of which is Pleasant Creek Lake, at approximately 404 acres (see Figure 2-2). Table 2-1 describes each lake's morphometry, recreational amenities, water quality trends, impairment status, and provides a link to the Iowa DNR's website, which provides additional information regarding recreational opportunities, as well as fish stocking information and bathymetric maps of the lake.

Pleasant Creek Lake recently underwent a $2.4 million restoration project which was funded through the Lake Restoration Program, marine fuel tax, coast guard funds, Resource Enhancement and Protection (REAP), and fishing license fees. The lake is now fully supportive of primary contact recreational uses and is being considered for potential de-listing from the Impaired Waters List.

While some designated uses are being met on Green Belt Lake, Rodgers Park Lake, and South Prairie Lake, an insufficient amount of data has been collected to date to determine whether the remaining uses are met. Similarly, an insufficient amount of information exists to determine whether any designated uses are met on George Wyth Lake and Mitchell Lake. A Total Maximum Daily Load Study (TMDL) is needed to address the Algal Growth and Chlorophyll-A Impairment on Meyers Lake.

Table 2-1. Middle Cedar River Watershed Public Lakes

Lake Name	Size (Acres)	Max. Depth (Feet)	Public Amenities								Trophic Status	Water Quality Trend (ADBNet)	2016 Impairment Category (ADBNet)
			Boat Access	Trails	Shore Fishing	Camping	Playground	Beach	Picnic	DNR Link			
Casey Lake (Hickory Hills)	36.9	22	✓	✓	✓	✓	✓		✓	Y	Eutrophic	Improving	4a
George Wyth Lake	74.87	18.7	✓	✓	✓	✓	✓	✓	✓	Y	Eutrophic	Improving	3
Green Belt Lake	18.67	N/A		✓	✓					Y	Eutrophic	Declining	2
Meyers Lake	31.04	27	✓		✓		✓		✓	Y	Eutrophic	Stable	5a
Mitchell Lake	12.61	N/A								N	Eutrophic	Stable	3
Pleasant Creek Lake	404.43	55	✓	✓	✓	✓	✓	✓	✓	Y	Eutrophic	Stable	5*
Rodgers Park Lake	21.25	18	✓	✓	✓	✓	✓	✓	✓	Y	Eutrophic	Unknown	2
South Prairie Lake	24.66	22	✓	✓	✓				✓	Y	Eutrophic	Stable	2

5* - 303(d)-impaired last cycle; fully supporting this cycle; potential de-listing

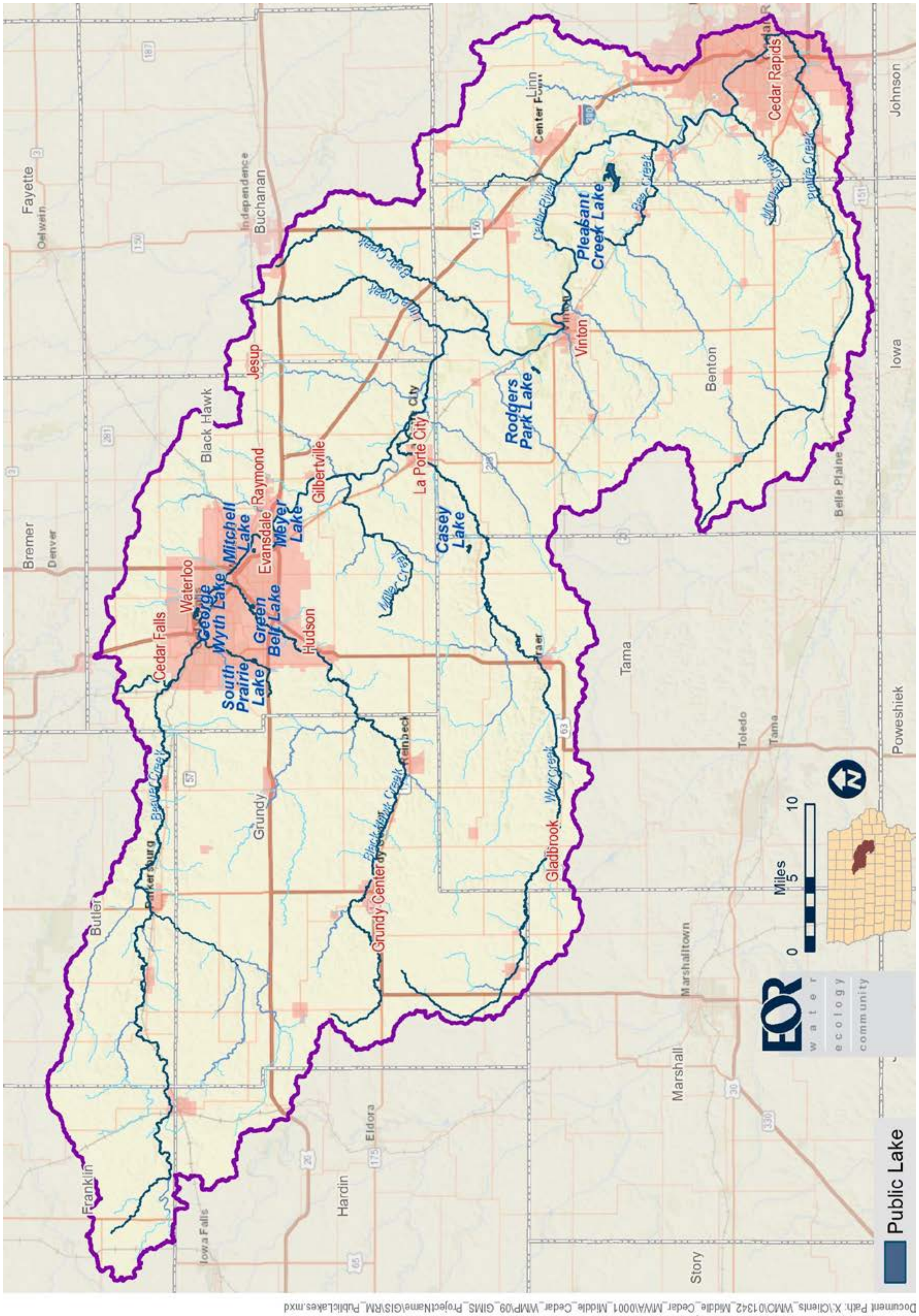


Figure 2-2. Public Lakes in the Middle Cedar Watershed

2.3. Iowa Waters Designated Uses

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

Designated use segments are water bodies which maintain flow throughout the year or contain sufficient pooled areas during intermittent flow periods to maintain a viable aquatic community. There are a total of 6 lakes and 106 stream segments in the Middle Cedar watershed, some of which have multiple designations. Designated use classifications for the streams of the Middle Cedar Watershed are shown in Table 2-2.

Primary contact recreational use: Class A1

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

There are 32 Class A1 stream designations and 4 Class A1 lake designations in the Middle Cedar Watershed.

Secondary contact recreational use: Class A2

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

There are 42 Class A2 stream designations in the Middle Cedar Watershed.

Children's recreational use: Class A3

Waters in which recreational uses by children are common. Class A3 waters are water bodies having definite banks and bed with visible evidence of the flow or occurrence of water. This type of use would primarily occur in urban or residential areas.

There are 20 Class A3 stream designations in the Middle Cedar Watershed.

Warm water Type 1: Class BWW-1

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

There are 16 Class BWW-1 stream designations in the Middle Cedar Watershed.

Warm water Type 2: Class BWW-2

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

There are 77 Class BWW-2 stream designations in the Middle Cedar Watershed.

Warm water Type 2: Class BWW-3

Waters in which flow persists during periods when antecedent soil moisture and groundwater discharge levels are adequate; however, aquatic habitat typically consists of nonflowing pools during dry periods of the year. These waters generally include small streams of marginally perennial aquatic habitat status. Such waters support a limited variety of native fish and invertebrate species that are adapted to survive in relatively harsh aquatic conditions.

There is one Class WW-3 stream designation in the Middle Cedar Watershed.

Drinking Water: Class C

Waters which are used as a raw water source of potable water supply.

There is one Class C stream designation in the Middle Cedar Watershed. It is the reach of the Cedar River from its confluence with McLoud Run to its confluence with Bear Creek.

Human health: Class HH

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

There are 16 Class HH stream designations and 2 Class HH lake designations in the Watershed.

General use: GU

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

Table 2-2. Surface Water Designated Use Classifications for Middle Cedar River Watershed Streams

Class	Sub-Class	Description	# of MCW Stream Designations	# of MCW Lake Designations
Class A	*A1*	Primary Contact Recreation (full body contact with the water, such as swimming or water skiing)	32	4
	A2	Secondary Contact Recreation (incidental contact with the water, such as fishing)	42	0
	A3	Children's Contact Recreation (limited contact with the water, such as wading or playing in the water)	20	0
Class B	*WW-1*	Larger rivers capable of supporting a wide variety of species, including game fish	16	0
	WW-2	Smaller streams with resident fish populations, but not usually game fish	77	0
	WW-3	Intermittently flowing streams with permanent pools capable of supporting a resident aquatic community in harsher conditions	1	0
Class C		Drinking water supply	1	0
Class HH		Human Health (waters in which fish are routinely harvested for human consumption)	16	2

2.4. Iowa Outstanding Waters

An Outstanding Iowa Water (OIW) is defined as the following: A surface water that the DNR has classified as an outstanding state resource water in the water quality standards. All OIW receive important protection referred to as Tier 2 ½ protection. Tier 2 ½ protection refers to the set of federal and state regulations that are designed to protect these high quality waters from unnecessary pollution. According to Dan Kirby, Iowa DNR Manchester District Fisheries Biologist, Lime and Bear Creek (Figure 2-3) qualify for as an OIW primarily due to observed exceptional fish community characteristics. Biological sampling conducted by the DNR on Lime Creek in 2008, 2010, and 2013 identified good to excellent communities of both fish and macroinvertebrates as well as several state-listed mussel species. Additional information on biological data collected to date on Lime Creek can be found on the Iowa DNR's ADBNET website (IDNR 2019a). Similarly, biological data collected in 2009, 2010, and 2013 identified good to excellent communities of both fish and macroinvertebrates in Bear Creek. It should be noted that the primary contact recreation uses in both streams are currently assessed as "not supported" due to high levels of indicator bacteria (*E. coli*).

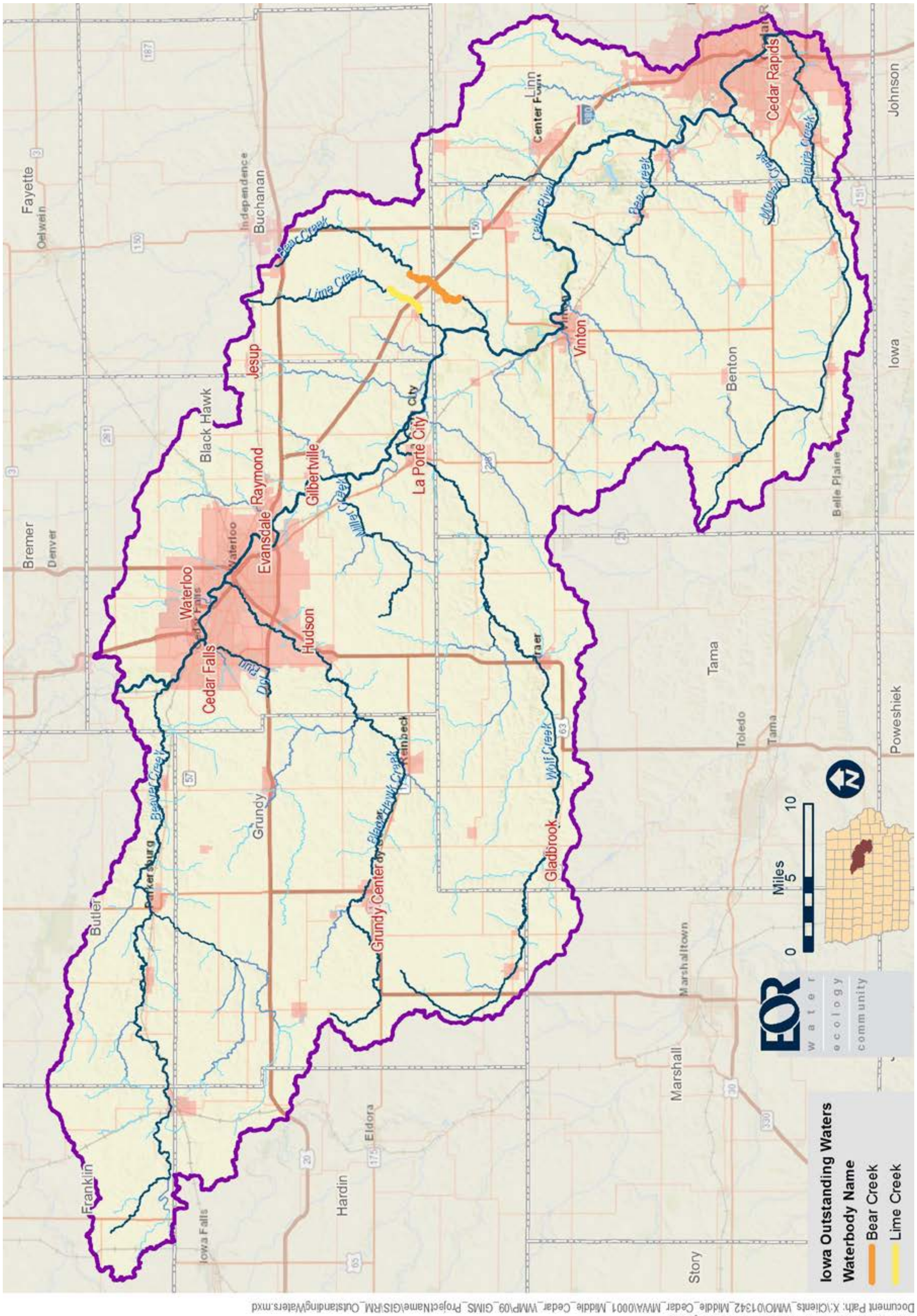


Figure 2-3. Outstanding waters of the Middle Cedar River Watershed.

2.5. Recreational Use

According to a survey conducted by Iowa State University, the Cedar River is one of the most heavily used rivers in the state (Ji et al., 2010). Furthermore, the Cedar River represents an ecologically significant resource as it provides habitat for a rich assemblage of fish species including many Species of Greatest Conservation Need, which are designated through the State Wildlife Action Plan (SWAP) process (Personal Communication Dan Kirby, Iowa DNR Manchester District Fisheries Biologist). Figure 2-4 identifies some of the most important recreational resources within the Middle Cedar Watershed including Iowa DNR Outstanding Waters, High Value Fisheries, Public parks, Wildlife Management Areas and Preserves larger than 50 acres, Hiking/Walking Trails, and Designated Paddling Routes.

Lime Creek and Bear Creek represent 2 of the 3 **warm-water** streams listed as "Outstanding Iowa Waters" in the entire state. More information about Outstanding Iowa Waters (including Lime Creek and Bear Creek) is presented in Section 2.4. Iowa DNR fisheries professionals provided a qualitative evaluation of streams in the watershed with regards to their importance as a fishery resource based on professional judgement. High value fisheries in the Middle Cedar River watershed include McLoud Run which is Iowa's only urban trout stream, Black Hawk Creek, which is an Iowa DNR designated Canoe Route, and Wolf Creek which is regularly used for canoeing and kayaking from La Porte City to the confluence with the Cedar River (Figure 2-4). There is a total of 156 river miles of designated paddling trails within the Middle Cedar River Watershed.

There are 77 publicly owned greenspaces larger than 50 acres in the watershed including 34 City/County Parks, 4 State Parks/Preserves, 1 State Off-Highway Vehicle Area, 1 State Recreation Area, 1 Historic Site, 1 Public Access (Falls Access), and 35 Wildlife Management Areas. Forty-four of the 77 publicly owned greenspaces are open to hunting, the remaining natural areas provide valuable greenbelts for wildlife and offer opportunities for a variety of recreational activities including cross-county skiing, hiking, walking, bird-watching, and geocaching.

An excellent resource for recreational users of Middle Cedar waters can be found on the Cedar Falls Tourism Website ((http://www.cedarfallstourism.org/webres/File/Trails/Cedar-Valley-Paddlers-Trail-Map-Iowa-DNR.pdf). The map was developed by the Cedar Valley Paddlers, Iowa DNR, Iowa Water Trails and Grundy County Conservation Board.

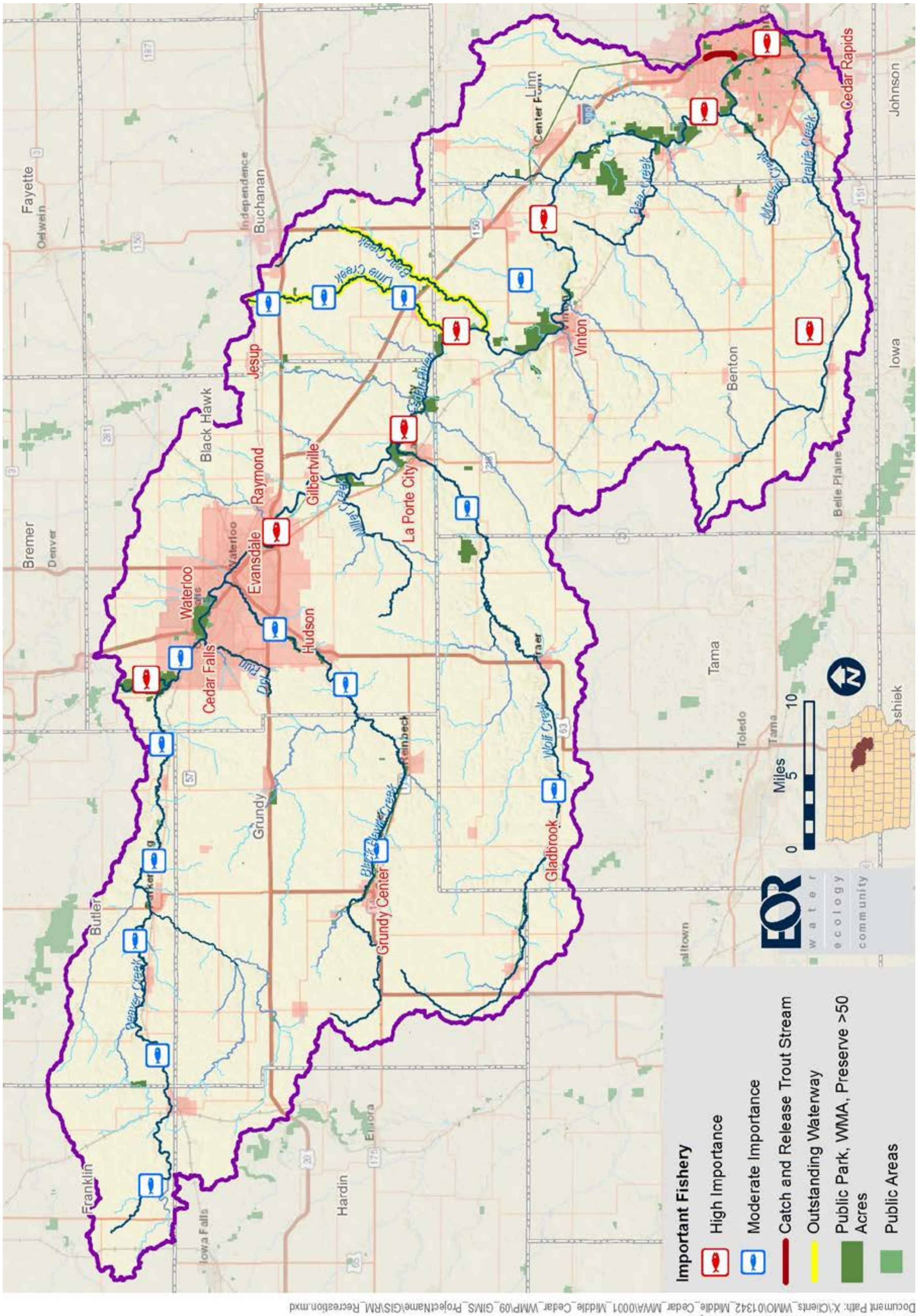


Figure 2-4. Recreational resources of the Middle Cedar River Watershed

2.6. Impaired Waters

The State of Iowa has developed State Water Quality Standards that are found in Chapter 61 of the Iowa Administrative Code. The water quality standards are based on the designated use of the receiving water. As water quality monitoring data is collected on streams and lakes, compliance to these standards determines whether or not given water body is meeting its designated use. In cases where the water body does not meet its designated use it is considered to be an impaired water. This process is prescribed under the Clean Water Act. The State of Iowa develops a list of impaired waters every two years that is presented to the US Environmental Protection Agency (US EPA). This list, referred to as the Impaired Waters List includes information on impaired use, the source of impairment and whether or not a TMDL Study will be required.

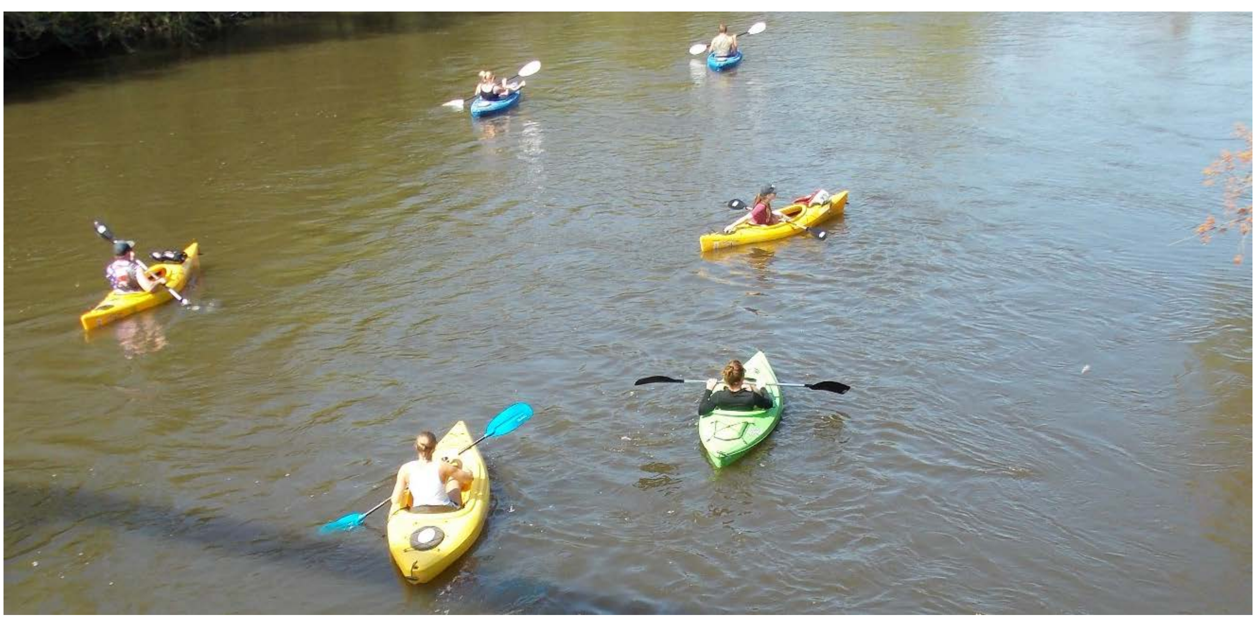
Category 1:
All designated uses (e.g., for water contact recreation, aquatic life, and/or drinking water) are met.

Category 2:
Some of the designated uses are met but insufficient information exists to determine whether the remaining uses are met.

Category 3:
Insufficient information exists to determine whether any uses are met.

Category 4:
The waterbody is impaired but a total maximum daily load (TMDL) is not required.

Category 5:
The waterbody is impaired and a total maximum daily load (TMDL) is required.



The most recent Impaired Waters List for the State of Iowa (2016) included 48 impaired waterbodies in the Middle Cedar Watershed; 35 primary contact recreation impairments (Table 2-3), 12 aquatic life impairments (Table 2-4) and one drinking water impairment. The impaired waters list was prepared according to U.S. EPA guidelines that combine (integrate) requirements of Sections 305(b), 303(d), and 314 of the federal Clean Water Act. These guidelines suggest that states place all their waters (lakes, wetlands, streams, and rivers) into one of five general categories of their Integrated Report (IDNR 2016):

Category 1:
All designated uses (e.g., for water contact recreation, aquatic life, and/or drinking water) are met.

Category 2:
Some of the designated uses are met but insufficient information exists to determine whether the remaining uses are met.

Category 3:
Insufficient information exists to determine whether any uses are met.

Category 4:
The waterbody is impaired but a total maximum daily load (TMDL) is not required.

Category 5:
The waterbody is impaired and a total maximum daily load (TMDL) is required.

The state of Iowa has further divided impaired waterbodies (Category 4, 5) into the subcategories described below. The relevant categories for all impaired streams and lakes in the Middle Cedar River Watershed are provided in Table 2-3.

Category 4a TMDL Completed:
A TMDL has been completed for the water-pollutant combination.

Category 4d:
Water is impaired due to a pollutant-caused fish kill and enforcement actions were taken against the party responsible for the kill: a TMDL is neither appropriate nor needed.

Category 5a TMDL Needed:
Water is impaired or threatened by a pollutant stressor and a TMDL is needed.

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

> ***5b-t [tentative]:***
> *The aquatic life uses of a stream segment with a watershed size within the calibration range of the IDNR biological assessment protocol (~10 to 500 square miles) are assessed as Section 303(d)-impaired based on an evaluated assessment. The reasons for residency in this subcategory include: 1) data quantity (only one of the two biological samples needed to identify an impairment have been collected), 2) data age (data older than five years), 3) data quality (marginal sampling conditions for biota), and 4) sampling frequency (multiple samples collected in same year, not multiple years).*
>
> ***5b-v [verified]:***
> *The aquatic life uses of a stream with a watershed size within the calibration range of IDNR biological assessment protocol (~10 to 500 square miles) are assessed as Section 303(d)-impaired based on results of the required two or more biological sampling events in multiple years within the previous five years needed to confirm the existence of a biological impairment.*

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

2.6.1. Drinking Water Supply Impairment

There is one drinking water supply impairment on the Cedar River. A TMDL has been completed for this reach as described in the Cedar River Nitrate TMDL (Section 3.7.1).

2.6.2. Primary Contact Impairments

There are thirty-one bacteria, one turbidity, two pH, and one algal growth impairments currently listed on Iowa's 303(d) list in the Middle Cedar River watershed which do not support the designated use of primary contact recreation (Figure 2-5). The Bacteria Impairments are based on monitoring data which show that the geometric mean *E. coli* concentrations exceeded the 126 organisms/100 mL standard. Bacteria TMDLs have been completed for Black Hawk Creek and two reaches of the Cedar River. A Turbidity TMDL has also been completed for Casey Lake (Hickory Hills Lake).

There are five streams identified as Impairment Category 5a waterbodies, a TMDL is needed to address the Bacteria Impairment on these 5 streams. A TMDL is needed to address the two segments of the Cedar River with pH impairments. The remaining 23 streams with Bacteria Impairments are listed as Impairment Category 5p waterbodies. Category 5p waterbodies are defined as waterbodies that are presumptively designated for Class A1 primary contact recreation use or Class B (WW1) aquatic life use. Due to changes in the Iowa Water Quality Standards that became effective in March 2006, all perennial streams are assumed to be capable of supporting the highest level of primary contact recreation use (Class A1) and the highest level of aquatic life use [Class B (WW1)]. A "use attainability analysis" or UAA must be conducted, including field investigations, to determine whether a presumptively-applied use is, in fact, the appropriate designated use for the stream segment in question. Until the time when a UAA has been conducted and the appropriate designated uses have been applied and approved by U.S. EPA, any impairments on presumptively-designated Iowa streams will be placed in IR Category 5p.

Table 2-3. Middle Cedar River Watershed Primary Contact Recreation Impaired Streams and Lakes

Waterbody	Segment ID	Year	Category	Impairment
Black Hawk Creek	545	2002	4a TMDL Completed	Bacteria: Indicator Bacteria, E. coli https://programs.iowadnr.gov/adbnet/Segments/545
Cedar River	461	2004	4a TMDL Completed	Bacteria: Indicator Bacteria, E. coli https://programs.iowadnr.gov/adbnet/Segments/461
Cedar River	468	2004	4a TMDL Completed	Bacteria: Indicator Bacteria, E. coli https://programs.iowadnr.gov/adbnet/Segments/468
Casey Lake	531	2014	4a TMDL Completed	Turbidity https://programs.iowadnr.gov/adbnet/Segments/531
Dry Run	554	2008	5a TMDL Needed	Bacteria: Indicator Bacteria, E. coli https://programs.iowadnr.gov/adbnet/Segments/554
Cedar River	456	2014	5a TMDL Needed	pH https://programs.iowadnr.gov/adbnet/Segments/456
Cedar River	457	2014	5a TMDL Needed	pH https://programs.iowadnr.gov/adbnet/Segments/457
Cedar River	462	2008	5a TMDL Needed	Bacteria: Indicator Bacteria, E. coli https://programs.iowadnr.gov/adbnet/Segments/462
Cedar River	469	2008	5a TMDL Needed	Bacteria: Indicator Bacteria, E. coli https://programs.iowadnr.gov/adbnet/Segments/469
Cedar River	470	2008	5a TMDL Needed	Bacteria: Indicator Bacteria, E. coli https://programs.iowadnr.gov/adbnet/Segments/470
Pleasant Creek Lake	459	2012	5a TMDL Needed	Bacteria: Indicator Bacteria, E. coli https://programs.iowadnr.gov/adbnet/Segments/459
Meyers Lake	463	2008	5a TMDL Needed	Algal Growth; Chlorophyll a https://programs.iowadnr.gov/adbnet/Segments/463
McLoud Run	508	2014	5p Presumptive Use	Bacteria: Indicator Bacteria, E. coli https://programs.iowadnr.gov/adbnet/Segments/508
Morgan Creek	513	2014	5p Presumptive Use	Bacteria: Indicator Bacteria, E. coli https://programs.iowadnr.gov/adbnet/Segments/513
Otter Creek	514	2014	5p Presumptive Use	Bacteria: Indicator Bacteria, E. coli https://programs.iowadnr.gov/adbnet/Segments/514
Bear Creek	517	2014	5p Presumptive Use	Bacteria: Indicator Bacteria, E. coli https://programs.iowadnr.gov/adbnet/Segments/517
Mud Creek	519	2014	5p Presumptive Use	Bacteria: Indicator Bacteria, E. coli https://programs.iowadnr.gov/adbnet/Segments/519
Bear Creek	523	2014	5p Presumptive Use	Bacteria: Indicator Bacteria, E. coli https://programs.iowadnr.gov/adbnet/Segments/523

Waterbody	Segment ID	Year	Category	Impairment
Lime Creek	524	2014	5p Presumptive Use	Bacteria: Indicator Bacteria, E. coli https://programs.iowadnr.gov/adbnet/Segments/524
Lime Creek	525	2014	5p Presumptive Use	Bacteria: Indicator Bacteria, E. coli https://programs.iowadnr.gov/adbnet/Segments/525
Wolf Creek	530	2008	5p Presumptive Use	Bacteria: Indicator Bacteria, E. coli https://programs.iowadnr.gov/adbnet/Segments/530
Black Hawk Creek	546	2008	5p Presumptive Use	Bacteria: Indicator Bacteria, E. coli https://programs.iowadnr.gov/adbnet/Segments/546
Black Hawk Creek	550	2008	5p Presumptive Use	Bacteria: Indicator Bacteria, E. coli https://programs.iowadnr.gov/adbnet/Segments/550
North Black Hawk Creek	551	2008	5p Presumptive Use	Bacteria: Indicator Bacteria, E. coli https://programs.iowadnr.gov/adbnet/Segments/551
Holland Creek	552	2008	5p Presumptive Use	Bacteria: Indicator Bacteria, E. coli https://programs.iowadnr.gov/adbnet/Segments/552
Dry Run (South Branch)	2062	2008	5p Presumptive Use	Bacteria: Indicator Bacteria, E. coli https://programs.iowadnr.gov/adbnet/Segments/2062
Dry Run (North Branch)	2063	2008	5p Presumptive Use	Bacteria: Indicator Bacteria, E. coli https://programs.iowadnr.gov/adbnet/Segments/2063
Blue Creek	518	2014	5p Presumptive Use	Bacteria: Indicator Bacteria, E. coli https://programs.iowadnr.gov/adbnet/Segments/518
Dry Run	6293	2012	5p Presumptive Use	Bacteria: Indicator Bacteria, E. coli https://programs.iowadnr.gov/adbnet/Segments/6293
Unnamed Tributary to Dry Run	6294	2012	5p Presumptive Use	Bacteria: Indicator Bacteria, E. coli https://programs.iowadnr.gov/adbnet/Segments/6294
Unnamed Tributary to Lime Creek	6432	2014	5p Presumptive Use	Bacteria: Indicator Bacteria, E. coli https://programs.iowadnr.gov/adbnet/Segments/6432
Middle Cedar River	555	2008	5p Presumptive Use	Bacteria: Indicator Bacteria, E. coli https://programs.iowadnr.gov/adbnet/Segments/555
Mosquito Creek	6489	2012	5p Presumptive Use	Bacteria: Indicator Bacteria, E. coli https://programs.iowadnr.gov/adbnet/Segments/6489
Minnehaha Creek	6490	2012	5p Presumptive Use	Bacteria: Indicator Bacteria, E. coli https://programs.iowadnr.gov/adbnet/Segments/6490
Holland Creek	6491	2012	5p Presumptive Use	Bacteria: Indicator Bacteria, E. coli https://programs.iowadnr.gov/adbnet/Segments/6491

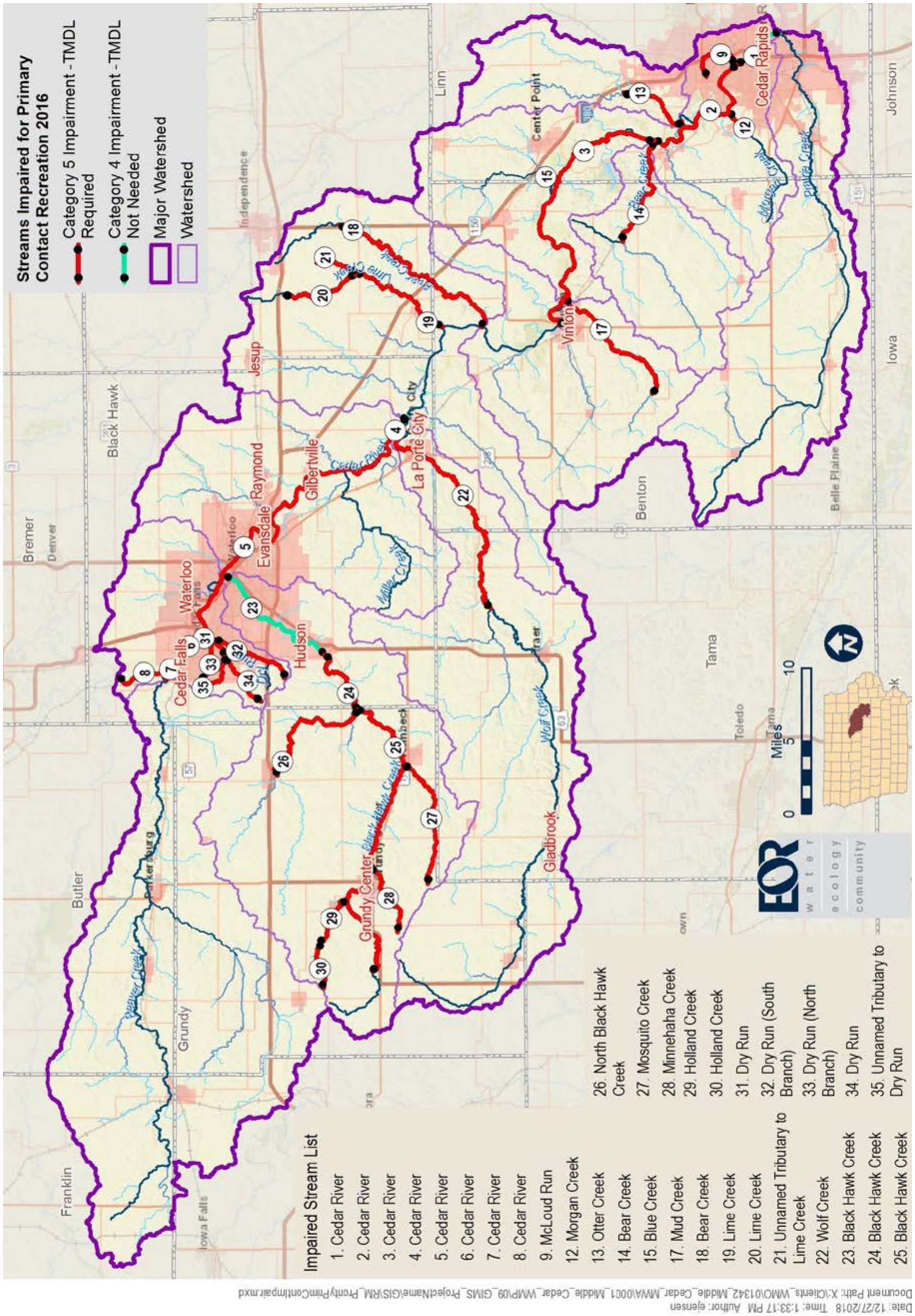


Figure 2-5. Middle Cedar Watershed Primary Contact Recreation Impaired Streams and Lakes

2.6.3. Aquatic Life Impairments

There are a total of 12 impairments to the Aquatic Life designated use (Figure 2-6). These include biologic sources / stressors that in some cases have led to fish kills: thermal, chlorine, low dissolved oxygen, ammonia, low index of biotic integrity (IBI), organic enrichment, and at least one unknown toxicity. TMDLs have been completed for McLoud Run (thermal modification) and Middle Fork South Beaver Creek (IBI). Two impairments do not require a TMDL, as they were caused by fish kills where enforcement action has been taken (unnamed tributary to McLoud Run and Prairie Creek). Lime Creek was de-listed in the 2016 cycle due to improved mussel biodiversity.

Table 2-4. Middle Cedar Watershed Aquatic Life Impaired Streams

Waterbody	Segment ID	Year	Category	Impairment
McLoud Run	508	2002	4a TMDL Completed	Fish Kill: Due To Thermal Modifications https://programs.iowadnr.gov/adbnet/Segments/508
Middle Fork South Beaver Creek	563	1998	4a TMDL Completed	Biological: low Biological Integrity https://programs.iowadnr.gov/adbnet/Segments/563
Prairie Creek	510	2004	4d TMDL not needed	Fish Kill: Caused By Animal Waste https://programs.iowadnr.gov/adbnet/Segments/510
Unnamed Tributary to McLoud Run	6302	2012	4d TMDL not needed	Fish Kill: Caused By Spill https://programs.iowadnr.gov/adbnet/Segments/6302
Cedar River	456	2014	5a TMDL needed	Biological: low Biological Integrity https://programs.iowadnr.gov/adbnet/Segments/456
Cedar River	457	2014	5a TMDL needed	Biological: low Biological Integrity https://programs.iowadnr.gov/adbnet/Segments/457
McLoud Run	508	2006	5b TMDL needed	Fish Kill: Due To Unknown Toxicity https://programs.iowadnr.gov/adbnet/Segments/508
McLoud Run	508	2014	5b TMDL needed	Fish Kill: Caused By Chlorine https://programs.iowadnr.gov/adbnet/Segments/508
East Branch Blue Creek	1880	2006	5b TMDL needed	Fish Kill: Caused By Fertilizer Spill https://programs.iowadnr.gov/adbnet/Segments/1880
Black Hawk Creek	546	2006	5b-t TMDL needed	Biological: low aquatic macroinvertebrate IBI https://programs.iowadnr.gov/adbnet/Segments/546
Dry Run	554	2004	5b-v TMDL needed	Biological: low fish & invert IBIs, cause unknown https://programs.iowadnr.gov/adbnet/Segments/554
Middle Cedar River	557	2008	5b-v TMDL needed	Biological: low aquatic macroinvertebrate IBI https://programs.iowadnr.gov/adbnet/Segments/557

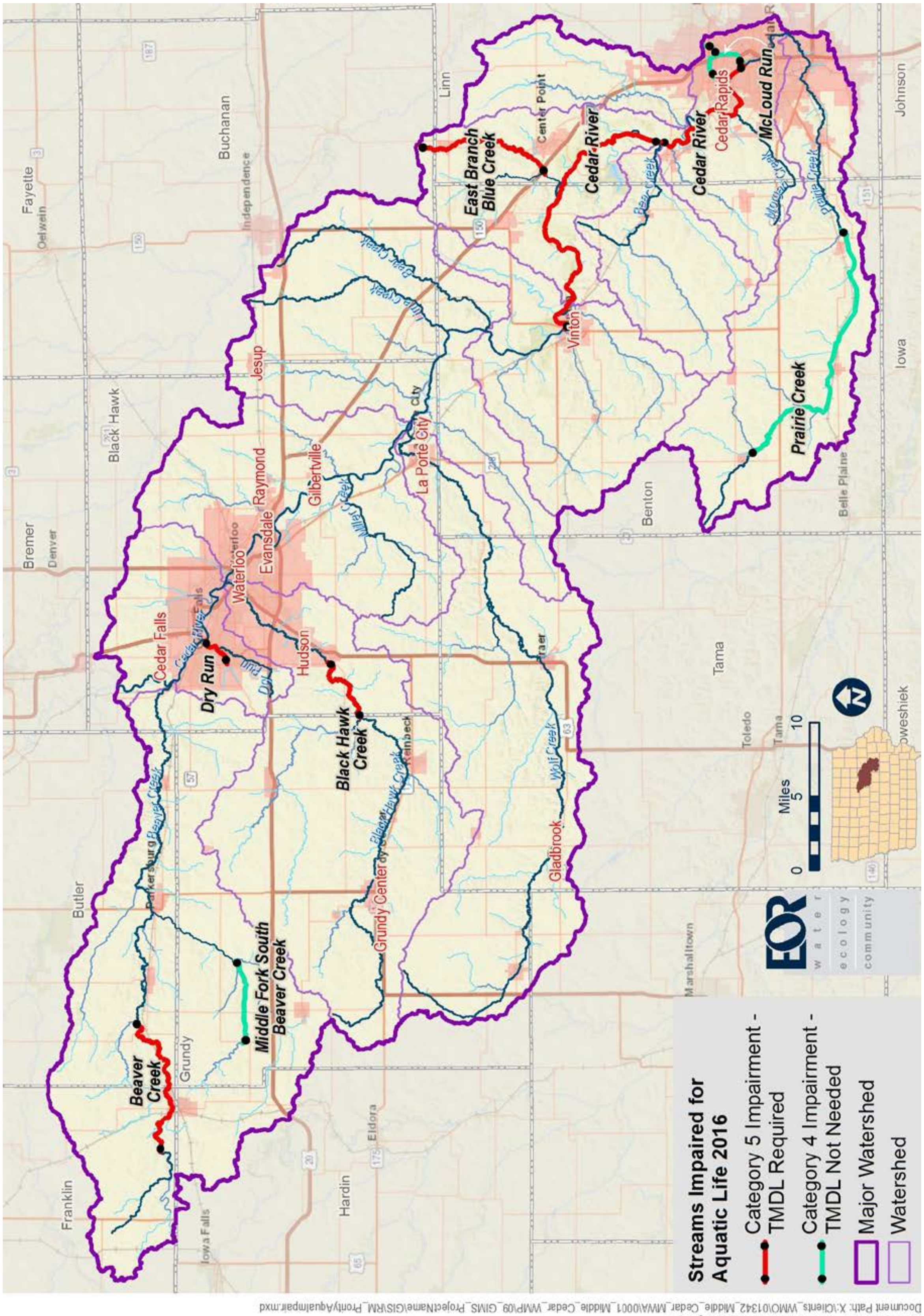


Figure 2-6. Middle Cedar Watershed Aquatic Life Impaired Streams

2.7. Total Maximum Daily Load Studies (TMDLs)

A TMDL Study is a determination of the maximum load of pollutant a given water body can receive and continue to meet water quality standards for that particular pollutant. TMDLs are conducted on water bodies where pollutant levels have been found to be in excess of water quality standards resulting in that water body failing to meet a designated use, also referred to as having an impairment. TMDL studies determine a pollutant reduction target and allocate a portion of the needed reductions to each source of pollutant, which all include a margin of safety. Pollutant sources are characterized as either point sources or nonpoint sources. Point sources receive a wasteload allocation (WLA) and include all sources that are subject to regulation under the National Pollutant Discharge Elimination System (NPDES) program, e.g. wastewater treatment facilities, stormwater discharges in Municipal Separate Storm Sewer System (MS4) Communities and concentrated animal feeding operations (CAFOs). Nonpoint sources receive a load allocation (LA) and include all remaining sources of the pollutant as well as natural background sources. There have been seven TMDLs developed in the Middle Cedar Watershed. The TMDLs vary in watershed area, impairment and pollutant as shown in Figure 2-7. TMDLs can be found on the IDNR website (IDNR 2019b).

Table 2-5. Summary of TMDLs within the Middle Cedar Watershed

TMDL	TMDL Targets	Applicable HUC-12s
Cedar River Watershed Bacteria	Unpermitted feedlots will control/ capture the first one-half inch of rain. Cropland bacteria loading will be reduced by 40% through proper timing and application of animal waste. Cattle in streams will be reduced by 40% Leaking septic systems will be eliminated	All Middle Cedar HUC-12s
Cedar River Nitrate	37% reduction in nitrate loading for nonpoint sources. The adjusted reduction (from the overall 35% target) accounts for wildlife, atmospheric deposition, and point sources	All Middle Cedar HUC-12s above the impaired reach. Excluded HUC-12s: *Headwaters Prairie Creek* *Village of Van Horne-Prairie Creek* *Mud Creek-Prairie Creek* *Weasel Creek-Prairie Creek* *Prairie Creek*
Black Hawk Creek Bacteria	85% reduction in rain driven surface runoff loads and a 98% reduction in continuous nonpoint source bacterial loads	South Fork Black Hawk Creek Headwaters North Fork Black Hawk Creek North Fork Black Hawk Creek Holland Creek Headwaters Black Hawk Creek Mosquito Creek Minnehaha Creek-Black Hawk Creek Village of Reinbeck-Black Hawk Creek Wilson Creek-Black Hawk Creek Prescotts Creek-Black Hawk Creek
Middle Fork South Beaver Creek Sediment and Phosphorus	59% annual loading reduction for sediment from nonpoint sources 40% annual loading reduction for phosphorus from nonpoint sources	Middle Fork South Beaver Creek
Casey Lake Algae and pH	89.5% target reduction in annual loading of total phosphorus from nonpoint sources	Wolf Creek (priority area: Casey Lake drainage area)
McLoud Run Thermal	Heat reductions for Cedar Rapids and Hiawatha NPDES Permits	Silver Creek-Cedar River (TMDL does not apply to nonpoint sources)
Dry Run Creek Biological Life	26% reduction in average streamflow rates associated with the 24 hour, 1.25 inch rain event will be set for the Dry Run Creek HUC-12 watershed	Dry Run Creek

2.7.1. Cedar River Nitrate TMDL

The Iowa DNR approved the Total Maximum Daily Load For Nitrate Cedar River, Linn County, Iowa in 2006. The TMDL was developed to address a reach of the Cedar River that had been identified as being impaired by excess nitrate. The impaired reach is defined as the Cedar River from its confluence with McLoud Run (S16, T83N, R07W) to the Cedar River confluence with Bear Creek (S21, T84N, R08W). Designated uses for the impaired segment are significant resource warm water (Class B(WW)), primary contact recreational use (Class A1) and drinking water supply (Class C). Excess nitrate loading has impaired the drinking water supply water quality criteria (567 IAC 61.3(3)) and hindered the designated use. The target of this TMDL is the drinking water nitrate concentration standard of less than 10.0 mg/L NO3-N.

The TMDL was written as a phased TMDL. Phasing TMDLs is an iterative approach to managing water quality that becomes necessary when the origin, nature and sources of water quality impairments are not well understood. In this first phase the waterbody load capacity, existing pollutant load in excess of this capacity, and the source load allocations were estimated based on the limited information available. A monitoring plan was then developed to determine if prescribed load reductions result in attainment of water quality standards and whether or not the target values are sufficient to meet designated uses. Monitoring activities may include routine sampling and analysis, biological assessment, fisheries studies, and watershed and/or waterbody modeling. A future phase of the TMDL will consist of implementing the monitoring plan, evaluating collected data, and readjusting target values if needed.

The targeted Nitrate reduction is 35%. This would equal a yearly reduction of 9,999 tons nitrate-N/year from the current loading of 28,561 tons nitrate-N/year. The TMDL states that the majority (91%) of the nitrate delivered downstream in the watershed is from nonpoint agricultural sources and sets a reduction target for nonpoint sources at 37%. The adjusted reduction (from the overall 35% target) accounts for wildlife, atmospheric deposition, and point sources.

The TMDL included an implementation plan that recommended use of incentive-based, best management practices (BMPs) focused on reducing surface water nitrate-N concentration. These practices include fertilizer reduction, wetland construction, and conservation reserve program (CRP) enrollment. The implementation plan further recommended focusing more heavily on subbasins that have higher nitrate loading per unit area.

Key Findings of the Cedar River Nitrate TMDL

- ✓ Model results indicate that the load of nitrate-nitrogen entering the Middle Cedar River (within the watershed) is greater than the load of nitrate leaving the Middle Cedar River by 4,000 tons/year; equivalent to 12% of the total annual nitrate-nitrogen load.
- ✓ Nitrate concentrations exhibit clear seasonality, with higher concentrations occurring during April, May and June as well as November and December.
- ✓ Observed nitrate concentrations from January, 2001- December, 2004 ranged from a high of 14.66 mg/L on June 13, 2003 to a low of 0.36 mg/L on September 3rd, 2003.
- ✓ The load duration curve clearly indicates that Nitrate-N exceedances occurred during wetter conditions and high flows of the Cedar River, and therefore are caused by nonpoint source pollution.
- ✓ Historical data indicates that nitrate loads in the Cedar River have increased dramatically in the past century (Iowa Geological Survey, 1955)
- ✓ Point sources contribute to 9 percent of the total nitrate load and nonpoint sources contribute 91 percent of the total nitrate load in the watershed.
- ✓ Established a target in-stream Nitrate concentration of 9.5 mg/l
- ✓ **The target nonpoint source nitrate reduction target of the Cedar River is less than the target established in the Iowa Nutrient Reduction Strategy (45%).**

2.7.2. Casey Lake Algae and pH TMDL

The Iowa DNR approved the Water Quality Improvement Plan for Casey Lake Tama County, Iowa: Total Maximum Daily Load for Algae and pH in 2012. The TMDL was developed to address impairments in Casey Lake, located six miles north of Dysart in Tama County. The impaired uses addressed in the TMDL are Class A1 (primary contact recreation) and Class B(WW) (aquatic life). The primary contact recreation use was determined to be 'not supported' due to aesthetically objectionable conditions caused by poor water transparency caused by algae blooms and violations of the Class A1 criteria for pH. The aquatic life use was determined to be "partially supported" due to violations of the Class B (WW) criterion for pH.

The TMDL found that excess algae blooms and subsequent chlorophyll-a concentrations and high pH levels were attributed to total phosphorus, therefore a target reduction in total phosphorus was developed. Cropland was identified as the major contributor (76%) of phosphorus to Casey Lake. An annual load reduction of 89.5% was established as a target for the lake.

Key Findings of the Casey Lake Algae and pH TMDL

A detailed implementation plan was developed as part of this TMDL that identified specific structural practices, watershed improvements and in-lake strategies for addressing total phosphorus loading to the lake.

The 89.5% target reduction in annual loading of total phosphorus established for this TMDL will be applied to the entire Wolf Creek (070802050809) HUC-12 subwatershed and the 748-acre drainage area to Casey Lake will be identified as a priority for implementation.

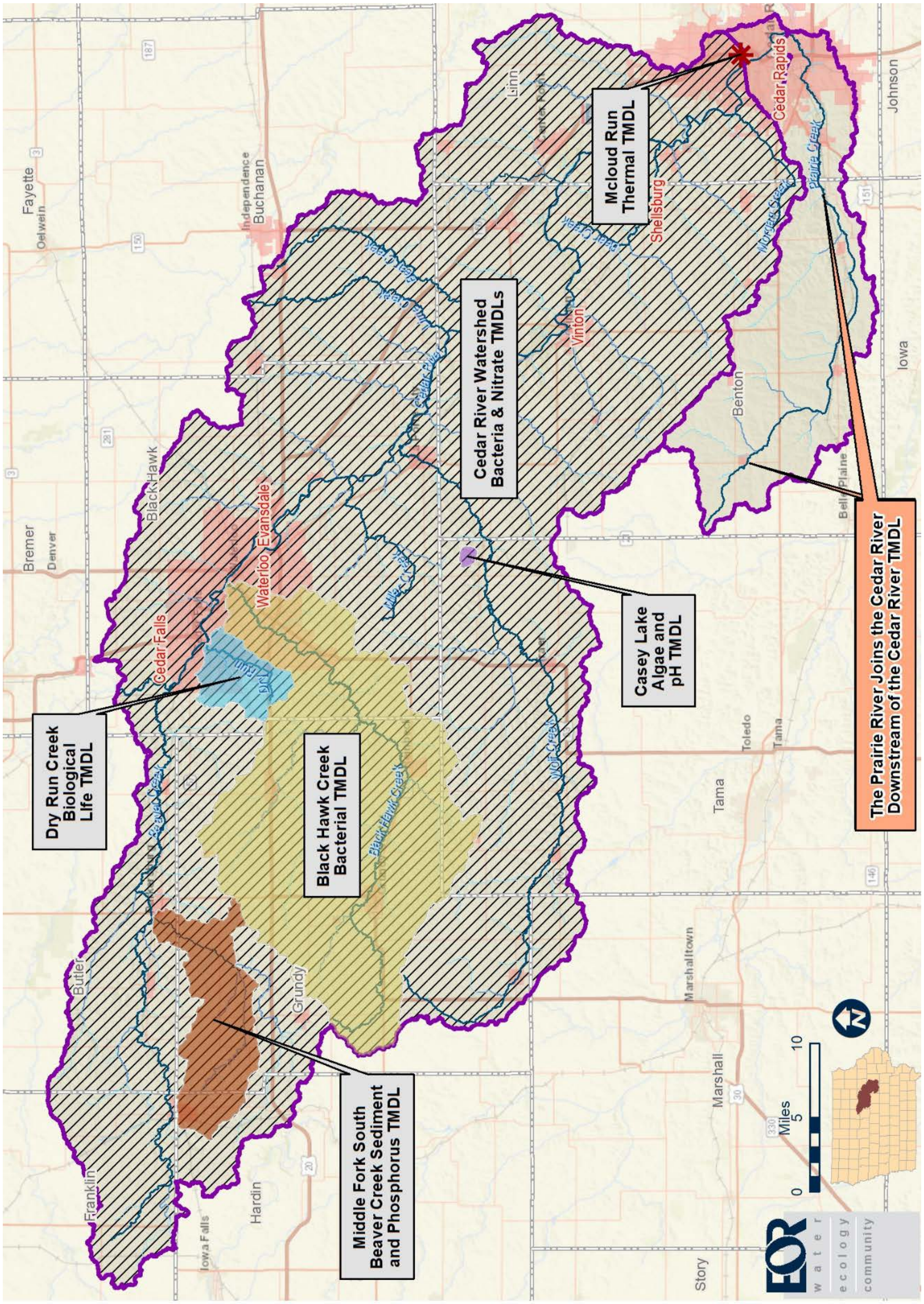


Figure 2-7. Completed TMDL Studies within the Middle Cedar Watershed

2.7.3. Cedar River Bacteria TMDL

EPA Region 7 developed the Total Maximum Daily Load Cedar River Watershed, Iowa for Indicator Bacteria, Escherichia coli (E. coli) in 2010. The TMDL covers the entire Cedar River watershed and includes four impaired reaches of the Cedar River within the Middle Cedar Watershed. Two additional reaches of the Cedar River downstream of the Middle Cedar are included in the TMDL which is relevant because the entire Middle Cedar Watershed drains to these impaired reaches and is subject to the TMDL. The primary contact recreation (Class A1) uses for each stream reach were determined to be impaired by the bacteria indicator Escherichia coli (E. coli). Based on a review of the flow and water quality data available throughout the watershed, it was determined that bacterial concentrations were primarily a function of flow, therefore; a flow-variable daily load was selected to represent these TMDLs. The TMDL establishes the level of bacteria reductions over a range of flows that would be needed for each reach to meet State water quality standards. The dominant source of bacteria to all nine reaches was open feedlots contributing over 80% of bacteria followed by manure application to cropland which contributed between 10-16% of bacteria to each reach. Point sources discharged bacteria to some reaches more than others, contributing less than 1% in some reaches and up to 8% at the Cedar River reach between Wolf Creek and Bridge Crossing in LaPorte City.

Key Findings of the Cedar River Bacteria TMDL

- ✓ Impaired Reaches within the Middle Cedar Watershed:
  - Cedar River from the Dam of Cedar Falls Impoundment to the Upper End of the Impoundment
  - Cedar River from Wolf Creek to Bridge Crossing in LaPorte City (IA 02-CED-0040_1)
  - Cedar River from McLoud Run to Confluence with Bear Creek (IA 02-CED-0030_2)
  - Cedar River from Prairie Creek to Confluence with McLoud Run (IA 02-CED-0030_1)
- ✓ Additional Impaired Reaches downstream of the Middle Cedar Watershed:
  - Cedar River from Highway 30 Bridge at Cedar Rapids to Confluence with Prairie Creek (IA 02-CED-0020_3)
  - Cedar River from Rock Run Creek to Highway 30 Bridge at Cedar Rapids (IA 02-CED-0020_2)

The TMDL includes an informational implementation plan. An implementation plan is not a requirement for a TMDL but Region 7 developed a model (Hydrologic Simulation Program Fortran HSPF) to test potential scenarios. The model determined that the following scenario will result in the river reaches meeting the Iowa water quality standards. This scenario assumes that all wastewater treatment plants (WWTP) effluent and rivers entering Iowa will have bacteria concentrations less than or equal to the Iowa water quality standard.

- Unpermitted feedlots will control/capture the first one-half inch of rain.
- Cropland bacteria loading will be reduced by 40 percent through proper timing and application of animal waste.
- Cattle in streams will be reduced by 40 percent.
- Leaking septic systems will be eliminated.

Since the entire Middle Cedar Watershed is subject to this TMDL, the specific targets identified is used as the strategy for addressing bacterial pollution for all 68 HUC-12 Subwatersheds.

2.7.4. Black Hawk Creek Bacteria TMDL

The Iowa DNR approved the Total Maximum Daily Load For Pathogen Indicators Black Hawk Creek, Iowa in 2006. The TMDL was developed to address a reach of Black Hawk Creek that had been identified as being impaired due to excessive indicator bacteria (fecal coliform). The 11.4 mile impaired reach is defined as the Black Hawk Creek from its mouth at the Cedar River in S22,T89N, R13W to the stream crossing at Highway 58 in E 1/2, S27, T88N, R14W in Black Hawk County. Designated uses for the impaired reach included: primary contact recreation and aquatic life. The Class A (primary contact recreation) uses remain assessed (monitored) as "not supported" due to consistently high levels of indicator bacteria. The Class B(WW) aquatic life uses were assessed (monitored) as "fully supported/threatened." The applicable water quality standards for bacteria are a season geometric mean of 126/100ml for E. coli and a single maximum value of 235 counts/100 ml.

The TMDL was written as a phased TMDL. Phasing TMDLs is an iterative approach to managing water quality that becomes necessary when the origin, nature and sources of water quality impairments are not well understood. In this first phase of the Black Hawk Creek watershed improvement plan, specific and quantified targets for pathogen indicator concentrations were set for the stream and allowable loads for all sources were allocated. The TMDL states that a future Phase 2 will require the participation of the watershed stakeholders in the implementation of pollutant controls and continued water quality evaluation.

Key Findings of the Black Hawk Creek Bacteria TMDL

To achieve the E. coli water quality standard for this reach of Black Hawk Creek there must be an 85% reduction in rain driven surface runoff loads and a 98% reduction in continuous nonpoint source bacterial loads (e.g., septics and cattle in the stream).

This TMDL does not include an implementation plan but states that "analysis and modeling of the Black Hawk Creek watershed shows that controlling livestock manure runoff and cattle in streams would need to be a large part of a plan to reduce bacteria. Best management practices include feedlot runoff control; fencing off livestock from streams; alternative livestock watering supply; and buffer strips along the stream and tributary corridors to slow and divert runoff. In addition to these sources, failed septic tank systems need to be repaired and wastewater treatment plants need to control the bacteria in their effluent."

2.7.5. Middle Fork South Beaver Creek Sediment and Phosphorus TMDL

The Iowa DNR approved the Water Quality Improvement Plan for Middle Fork South Beaver Creek Grundy County, Iowa: Total Maximum Daily Load for Sediment and Phosphorus in 2007. The TMDL was developed to address an impaired reach of South Beaver Creek that had been identified as having a chronic biological impairment due to excessive sediment and phosphorus. The impaired reach is defined as the Middle Fork South Beaver Creek, from its mouth in Grundy Co. (N ½, S28, T89N, R17W) to its headwaters in Hardin County (NW1/4, S15, T89N, R19W). The impaired use addressed in the TMDL is Warmwater aquatic life (Class B).

Iowa's water quality standards do not have numeric criteria for either sediment or phosphorus, therefore the decision criteria for water quality standards attainment in Middle Fork South Beaver Creek was based on meeting biological conditions typical of healthy reference streams for this ecoregion. Sediment loading criteria were based on siltation within the stream and phosphorus loading criteria were based on linkage to low dissolved oxygen.

Key Findings of the Middle Fork South Beaver Creek Sediment and Phosphorus TMDL

A detailed implementation plan was developed in this TMDL. The implementation plan identifies specific practices to address sediment and phosphorus loading to the impaired reach and prioritizes specific locations within the watershed for future action.

The targeted reductions for sediment (59% annual loading reduction) and total phosphorus (40% annual loading reduction) established in this TMDL will be applied to the HUC-12 subwatersheds that drain to this impaired reach of South Beaver Creek.

2.7.6. McLoud Run Thermal TMDL

The Iowa DNR approved the Water Quality Improvement Plan in 2007 for McLoud Run in Linn County, Iowa: Total Maximum Daily Load for Thermal Modifications. The TMDL was developed for the entirety of McLoud Run in Cedar Rapids from its mouth at the Cedar River (SW ¼ S16, T83N, and R7W) to its headwaters (SW ¼ S5, T83N, R7W). The impaired use designation is warmwater aquatic life (Class B) and the TMDL was conducted due to McLoud Run having been identified as a high priority stream. The impairment was found to be caused by temperature (heat) delivered via surface runoff. State water quality standards for all Class B streams allow for a maximum increase of 1°C per hour.

Key Findings of the McLoud Run Thermal TMDL

The TMDL establishes heat load reductions for the impervious surfaces in the McLoud Run drainage area. The entire McLoud Run drainage area is covered by the NPDES (MS4) permits for the Cities of Cedar Rapids and Hiawatha. As such, the TMDL includes point source reductions for these areas and does not include an allocation or reduction for nonpoint source areas.

The heat reduction targets established within this TMDL will be noted for the Silver Creek – Cedar River (070802051507) HUC-12 but will not be applied to the entire subwatershed since the target reduction only applies to point sources.

2.7.7. Dry Run Creek Biological Life TMDL Dry Run Creek Biological Life TMDL

(Still Pending EPA Approval)

The Iowa DNR developed a Water Quality Improvement Plan which included a TMDL study for Dry Run Creek in 2011. The 2.83 mile impaired reach is defined as Dry Run Creek from its mouth at S18, T89N, and R13W to the confluence with unnamed tributary in S23, T89N, and R14W in Black Hawk County. Designated uses for the impaired reach included: primary contact recreation and warm-water Type 2 aquatic life. The Class A (primary contact recreation) uses remain assessed (monitored) as "partially supporting" due to levels of indicator bacteria that exceed state water quality criteria. The Class B (WW2) aquatic life uses remain assessed (monitored) as "partially supported" (IR 5b-v) based on results of biological sampling in 2010, 2011 and 2013.

A stressor identification analysis determined that excess storm water runoff from Connected Impervious Surfaces (CIS) was the cause of the impairment. As such, the TMDL was developed using CIS as a surrogate for increased stormwater runoff and the array of pollutants associated with runoff derived from CIS. Multiple studies have shown that the quality (pollutant intolerant species) of macroinvertebrate and/or fish species per site and fish IBI scores sharply decline in watersheds with greater than 10 percent connected impervious surfaces.

To quantify the effects of CIS on stormwater flows, a Soil and Water Assessment Tool (SWAT) model was developed and ran for existing conditions and for the target of 10% CIS in subwatersheds with a higher percentage of CIS. The goal for Dry Run Creek is to decrease storm event runoff associated with CIS, which is based on attaining CIS of less than 10 percent for each subbasin in the Dry Run Creek watershed.

Key Findings of the Dry Run Creek Biological Life TMDL

The TMDL target was set to the 24-hour water quality event of 1.25 in. (+/- 0.125 inches) for this region of Iowa. A review of existing streamflow rates and flow rate reductions resulting from the modeled decrease of CIS to 10 percent suggests an average streamflow rate reduction of 26.18% will occur for the 1.25-inch rain event.

To achieve the goal of reducing CIS to 10%, the implementation plan calls for a combination of green infrastructure best management practices will need to be retrofitted into the urban areas of the Dry Run Creek subwatershed to include green roofs, rain tanks and cisterns, permeable pavement, bioretention (rain-gardens), and dry-swales.

The subwatershed conservation practices plan for the Dry Creek Subwatershed include green infrastructure best management practices that will work mitigate the impacts of impervious surfaces in the subwatershed.

2.8. Watershed Hydrology

Prior to evaluating nutrient and pollutant concentrations and loads it is important to understand the hydrology of the watershed. Five long-term USGS flow monitoring stations in the watershed provide a valuable dataset from which trends can be detected. The USGS station (05464500) located on the Cedar River at Cedar Rapids provides the most comprehensive dataset with stream flow data available from 1903-2017. Section 2.10.1 summarizes key findings from a Hydrologic Assessment performed for the Middle Cedar River Watershed. Perhaps the most important finding from this assessment was that the water cycle in the Middle Cedar River Watershed has changed due to land use changes as summarized in Table 2-6. Furthermore, heavy rainfall is increasing in intensity and frequency across the United States and globally and is expected to continue to increase over the next few decades.

Table 2-6. Land Use Changes and Hydrologic Impacts.

Timeline	Land use status, change, & interventions	Hydrologic effect(s)	Source
1830s–Prior	Native vegetation (tall-grass prairies and broad-leaved flowering plants) dominate the landscape	Baseflow dominated flows; slow response to precipitation events	Petersen (2010)
1830–1980	Continuous increase in agricultural production by replacement of perennial native vegetation with row crops 1940: <40% row crop (Raccoon) 1980: 75% row crop (statewide)	Elimination of water storage on the land; acceleration of the upland flow; expanded number of streams; increased stream velocity	Jones & Schilling (2011); Knox (2001)
1820–1930	Wetland drainage, stream channelization (straightening, deepening, relocation) leading to acceleration of the rate of change in channel positioning	Reduction of upland and in-stream water storage, acceleration of stream velocity	Winsor (1975); Thompson (2003); Urban & Rhoads (2003)
1890–1960 / **2000 – Present**	Reduction of natural ponds, potholes, wetlands; development of large-scale artificial drainage system (tile drains)	Decrease of water storage capacity, groundwater level fluctuations, river widening	Burkart (2010); Schottler et al. (2013)
1940–1980	Construction of impoundments and levees in Upper Mississippi Valley	Increased storage upland	Sayre (2010);
1950 – Present	Modernization/intensification of the cropping systems	Increased streamflow, wider streams	Zhang & Schilling (2006); Schottler et al. (2013)
1970 – Present	Conservation practices implementation: Conservation Reserve Program (CRP); Conservation Reserve Enhancement Program (CREP); Wetland Reserve Program (WRP)	Reduction of runoff and flooding; increase of upland water storage	Castle (2010); Schilling (2000); Schilling et al. (2008);
2001– Present	62% of Iowa's land surface is intensively managed to grow crops (dominated by corn and soybeans up to 63% of total)	About 25% to 50% of precipitation converted to runoff (when tiling is present)	Burkart (2010)

Source: IIHR

2.8.1. Flooding

Flooding is a naturally occurring problem that can and does happen anywhere. Reports on flooding events typically use probability statistics to assess the likelihood for a certain magnitude of flood to occur in any particular year. The probability of flooding can change based on a variety of factors including the amount of impervious surfaces, the diameter and length of storm sewers, the presence of natural detentions, the presence of drain tiles, and so one. The probability of a flood impacting an area include these factors, but also account for things like changing weather patterns or the existence of flood mitigation infrastructure. The ability to assess the probability of a flood and the level of accuracy for that assessment are both influenced by modeling methodology advancements, better knowledge, and longer periods of record for the water body in question.

In 2015, the Department of Homeland Security (DHS), Federal Emergency Management Agency's (FEMA) Risk Mapping, Assessment, and Planning (Risk MAP) program developed a Flood Risk Report (FRR) for the Middle Cedar River Watershed. The purpose of the FRR was to help local or tribal officials, floodplain managers, planners, emergency managers, and others better understand their flood risk, take steps to mitigate those risks, and communicate those risks to their citizens and local businesses. A key component of the FRR was to develop a Flood Risk Map (FRM). The FRM provides stakeholders within the Middle Cedar River watershed with a visual resource that highlights key areas of risk based on potential losses and exposed facilities. The Flood Risk Map for the Middle Cedar River Watershed is shown in Figure 2-8. Identifying areas of the watershed with higher runoff potential is the first step in selecting mitigation project sites. High runoff areas offer the greatest opportunity for retaining more water from large rainstorms on the landscape and reducing downstream flood peaks. Landowner willingness to participate is essential. Locations may have existing conservation practices in place or areas such as timber that should not be disturbed. Stakeholder knowledge of places with repetitive loss of crops or roads/ road structures is also valuable in selecting locations. Lastly, the geology of the area may limit the effectiveness or even prohibit application of certain mitigation projects. (Iowa Flood Center and IIHR 2019).

Water levels of the Middle Cedar River and its tributaries are monitored on an hourly basis. This stream gauge information is immediately uploaded to the Iowa Flood Information System (IFIS) in real-time, which is available to the public online at: http://ifis.iowafloodcenter.org/ifis/en/. The water level gauge information also includes updated flood stage information. This allows the user to observe the current water level and know the water level that would be considered a flood.

Furthermore, the Iowa Department of Natural Resources maintains Iowa Geodata (State of Iowa 2019) where GIS professionals can gain access to Flood Risk Products including the National Flood Hazard Layer (State of Iowa 2018) and the Flood Risk Boundaries of Iowa Layer (State of Iowa 2017) which depicts the boundaries for the 1-percent annual chance (100-yr) flood event, the 0.2 percent annual chance (500-yr) flood event, and areas of minimal flood risk; Figure 2-9 shows the location of the 100-yr and 500-yr floodplain boundaries within the Middle Cedar River Watershed. These boundaries, which are derived from the FEMA Flood Hazard and Flood Insurance Rate Maps, can be accessed at https://geodata.iowa.gov/dataset/flood-risk-areas. Additionally, the Iowa Flood Center has updated (but non-regulatory) statewide floodplains available at https://ifis.iowafloodcenter.org/ifis/app/.

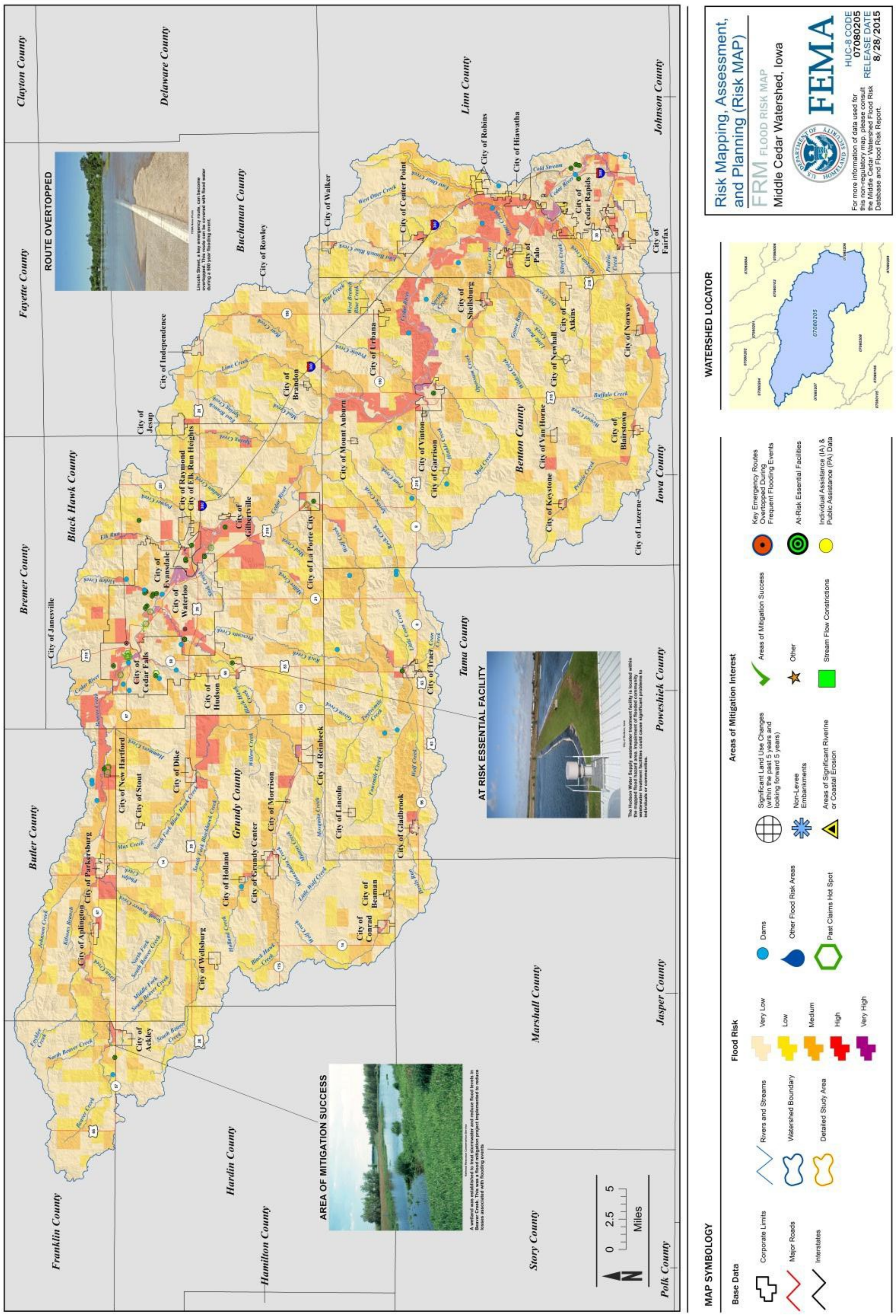


Figure 2-8. Middle Cedar River Watershed Flood Risk Map (FRM)

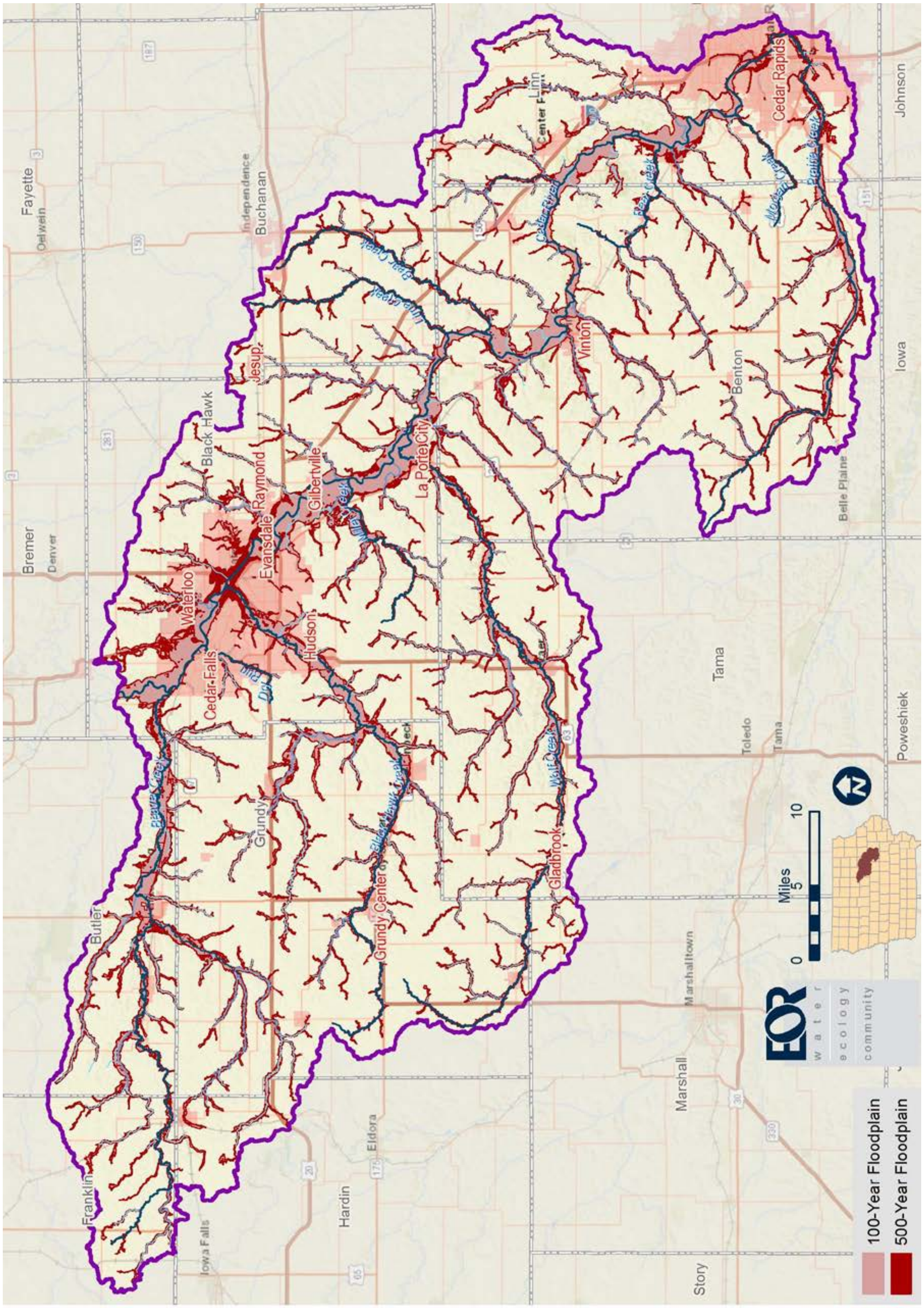


Figure 2-9. Middle Cedar River Watershed 100-year and 500-year floodplain boundaries.

2.8.2. Average Annual Flows

The average annual flow of water recorded on the Cedar River at Cedar Rapids (USGS station 05464500) has increased at a rate of 34 cubic feet per second per year from 1903-2017 with the most dramatic rise occurring since the 1950s. A 2013 study done by the USGS (Statistical Summaries of Selected Iowa Streamflow Data Through September 2013) reported that the average annual flow at this station for the entire period of record (1903 to 2013) was 3,980 cubic feet per second but when looking at the most recent 30 years the average annual discharge has been 5,520 cubic feet per second, an increase of nearly 40%. From 1984-2017, average annual flows exceeded the period of record annual flow average (3,980 cfs) in more than 70% of years (Table 2-7).

Additional USGS stations throughout the watershed show similar increases (Table 2-8). Figure 2-10, Figure 2-11, and Figure 2-12 depict the annual mean discharge for Black Hawk Creek at Hudson, Beaver Creek at New Hartford, and Cedar River at Waterloo respectively for the entire period of record (1953-2013 for Black Hawk Creek, 1946-2013 for Beaver Creek, and 1941-2013 for Cedar River) versus 1984-2013. In addition to the arithmetic mean, the 50% (or median) flow rate and the harmonic mean flow rate (a different method of averaging that is useful for rates) are also displayed.

Table 2-7. Cedar River at Cedar Rapids Annual Mean Discharge by Percentile Comparison (1984-2017) versus Period of Record.

Annual average flows by percentile (1903-2017)		Annual average flows by percentile (1984-2017)	
Percentile	Average Annual Flow (cfs)	Percentile	Average Annual Flow (cfs)
10%	1,618	10%	2,739
30%	2,662	30%	4,078
50%	3,621	50%	5,326
75%	5,211	75%	7,059
90%	6,749	90%	9,116

Table 2-8. Annual Mean Discharge Comparison (1984-2017) versus Period of Record.

Name of Site	Period of Record	Annual Mean Discharge (cfs) Period of Record	Annual Mean Discharge (cfs) 1984-2013	Percent Increase
Black Hawk at Hudson	1953-2013	212	270	27%
Beaver Creek at New Hartford	1946-2013	246	308	25%
Cedar River at Cedar Rapids	1903-2013	3,980	5,520	39%
Cedar River at Waterloo	1941-2013	3,520	4,290	22%

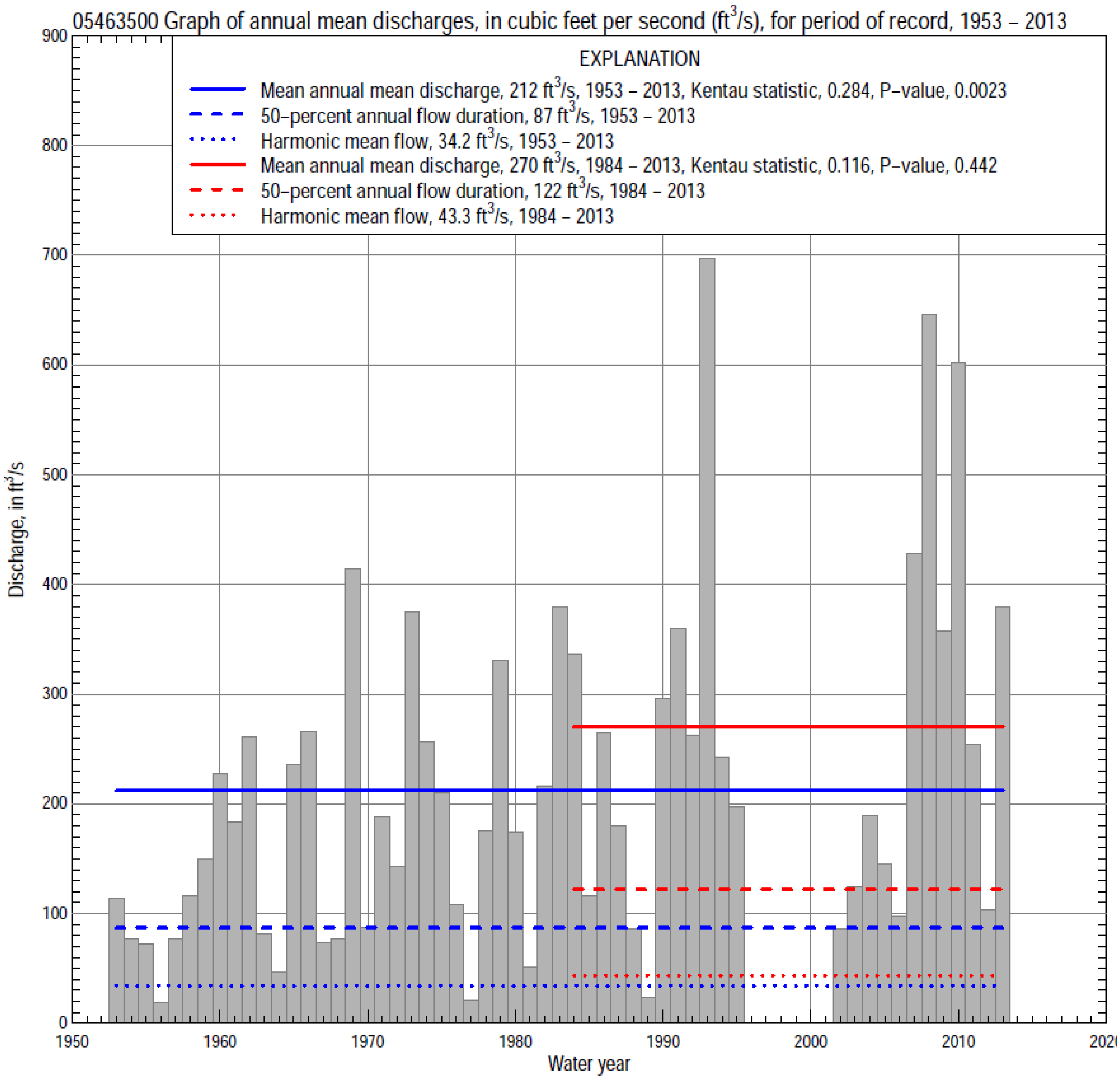


Figure 2-10. Black Hawk Creek at Hudson - Annual mean discharge for period of record (1953-2013) versus 1984-2013.

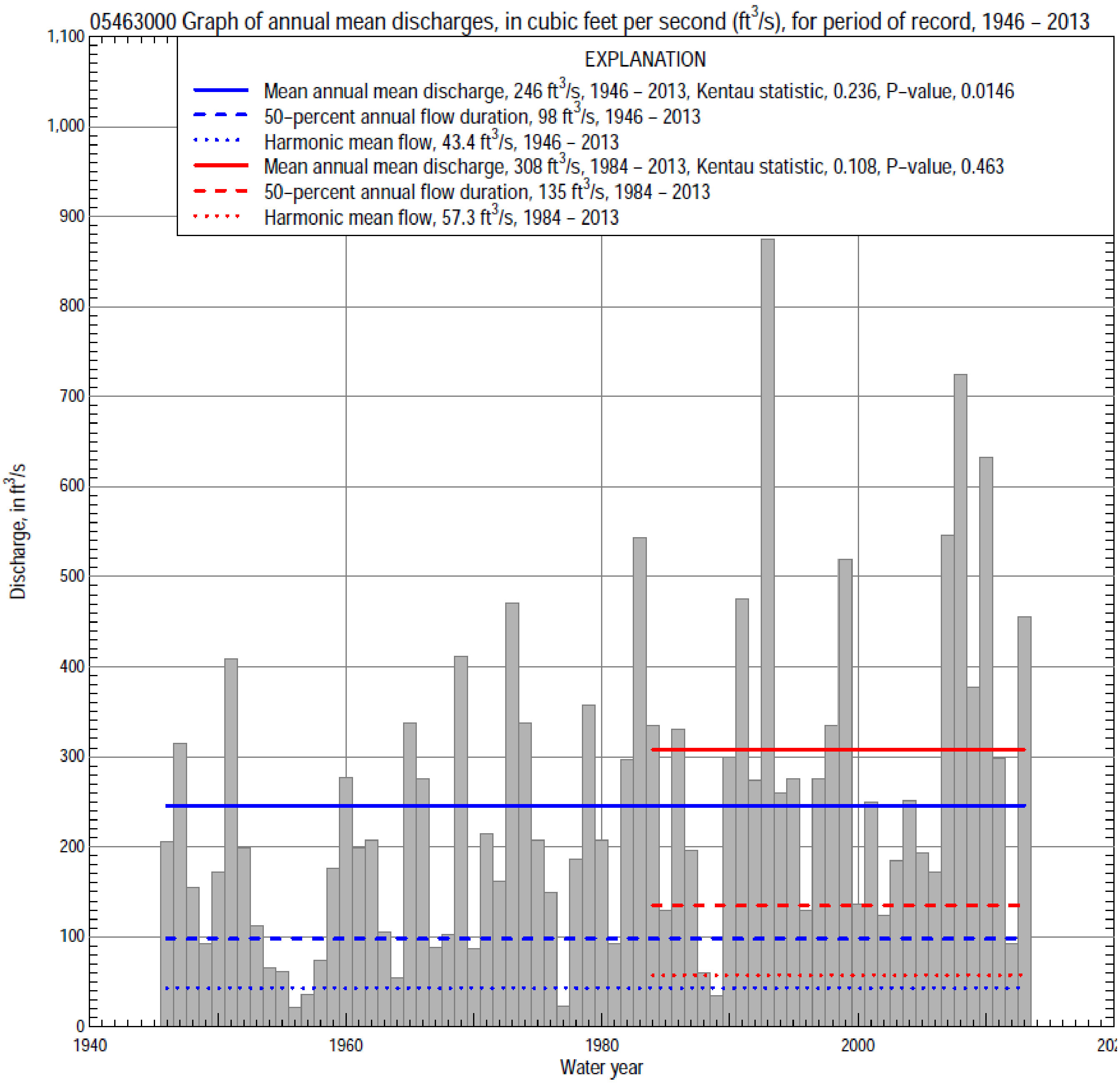


Figure 2-11. Beaver Creek at New Hartford - Annual mean discharge for period of record (1953-2013) versus 1984-2013.

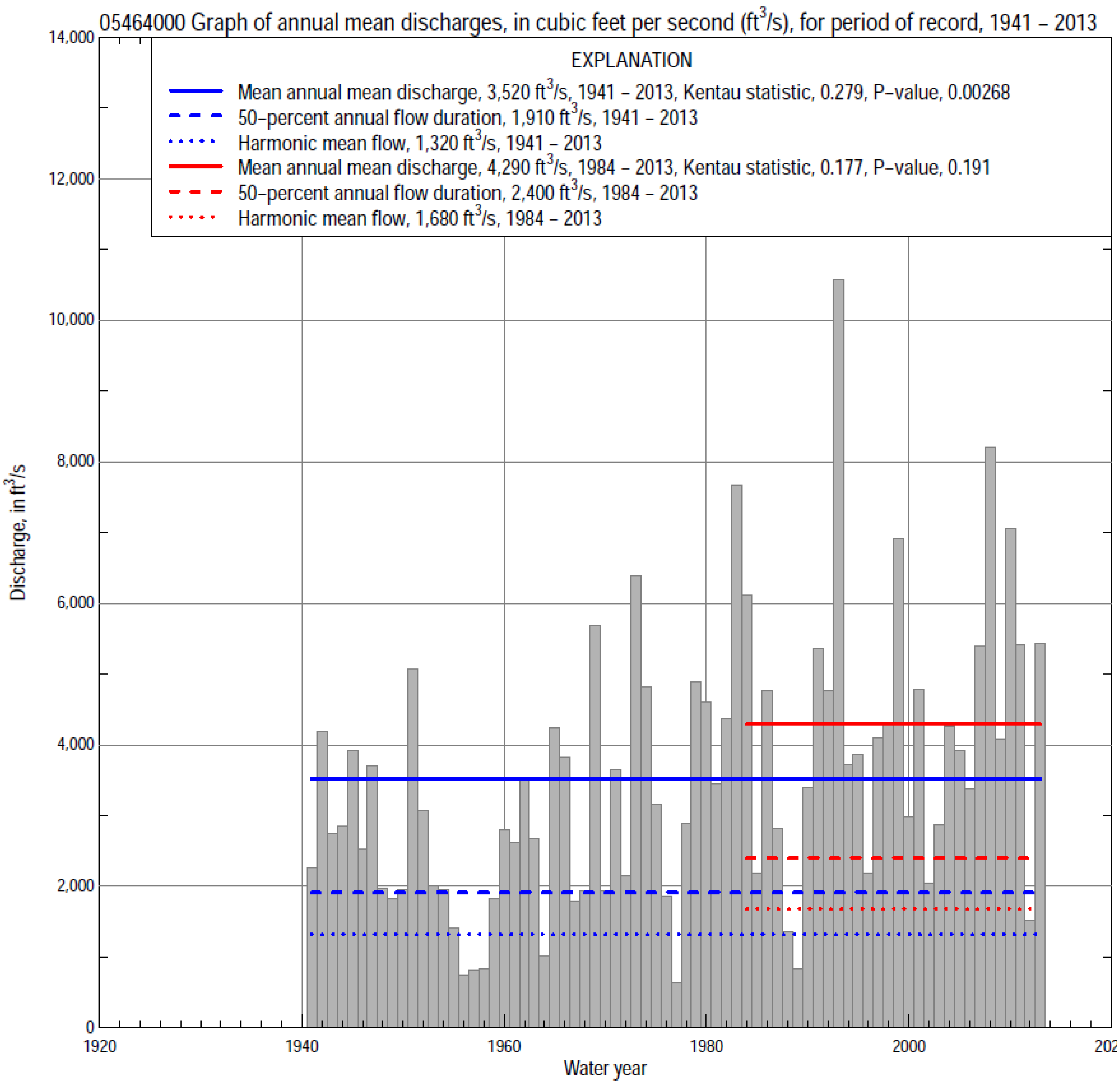


Figure 2-12. Cedar River at Waterloo - Annual mean discharge for period of record (1941-2013) versus 1984-2013.

2.8.3. Streamflow Variability (1983-2017)

In addition to annual increases in percent flow, Cedar River at Cedar Rapids (USGS station 05464500) shows considerable variability as estimated by average annual flows from 1984 to 2017. During this time period, average annual flows varied from 996 cubic feet per second (cfs) (1989) to 15,130 cfs (1993 Flood) with an overall annual median value of about 5,400 cfs (Figure 2-13).

Annual average flows show the considerable contrast of wet and dry years with 13 years having less than average flows and 4 years exceeding the median value by more than 150% (1.5 times the median value). Transitions appear abruptly shifting from dry to wet (1987-1990) and then from flood conditions noted in 1993 to much lower flow conditions of 1994-1997. The magnitude of the wet/dry shifts are of particular note as 1998/1999 experienced average annual low flows on the order of 996-1,729 cfs (or drier than about 95% of annual flows from 1984-2017) to the much higher flows of 1993, 2008, and 2016 which all had annual flows that exceeded 10,000 cfs. In this regard, wet and dry year flows differed by as much as a factor of 15 (1989 versus 1993). **This range of annual flows is extreme and indicates that the Middle Cedar River watershed has relatively low upland flow buffering capabilities from storage by wetlands, lakes or ponds.**

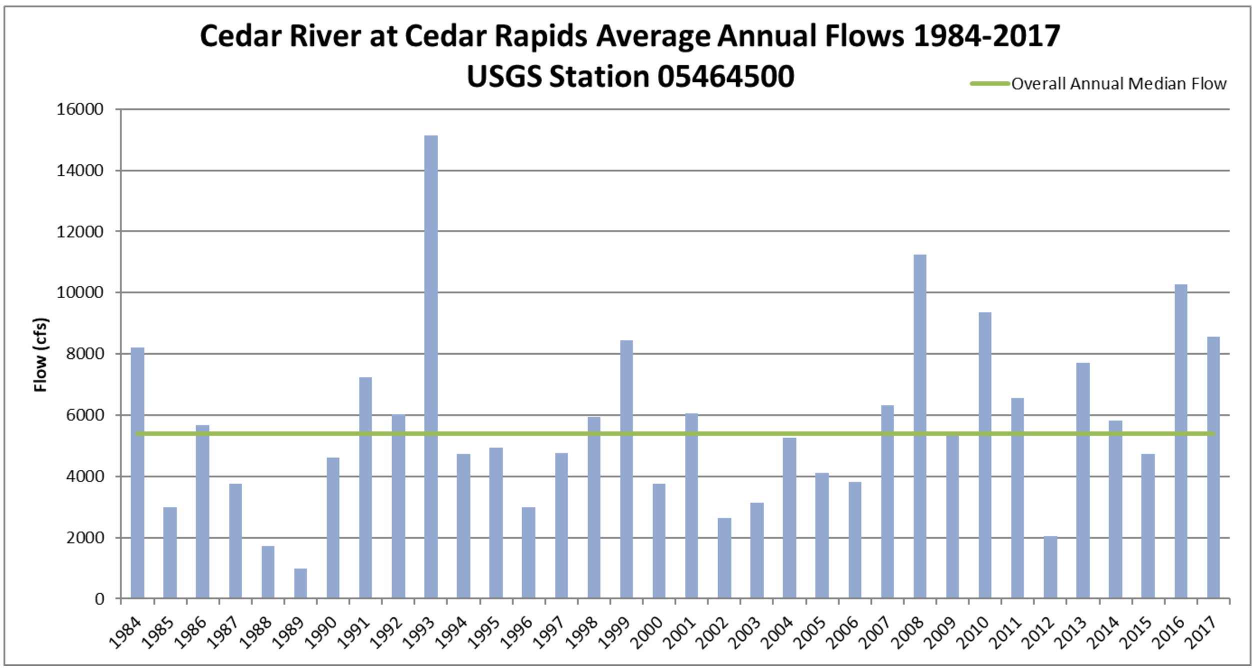


Figure 2-13. Cedar Rapids Average Annual Flows (1984-2017)

2.8.4. Average Monthly Flows

Shifting to a closer examination of Middle Cedar River watershed flows, average monthly values monitored from 1903-2017, reflect the climate and precipitation patterns noted previously. Average monthly flows increase significantly from winter flows of approximately 2,000 cfs to typical peak flows of about 7,000 cfs noted from March – June (Figure 2-14). Sharp declines in average monthly flows were noted for the last half of the growing season (July-September) when peak evapotranspirational losses are expected.

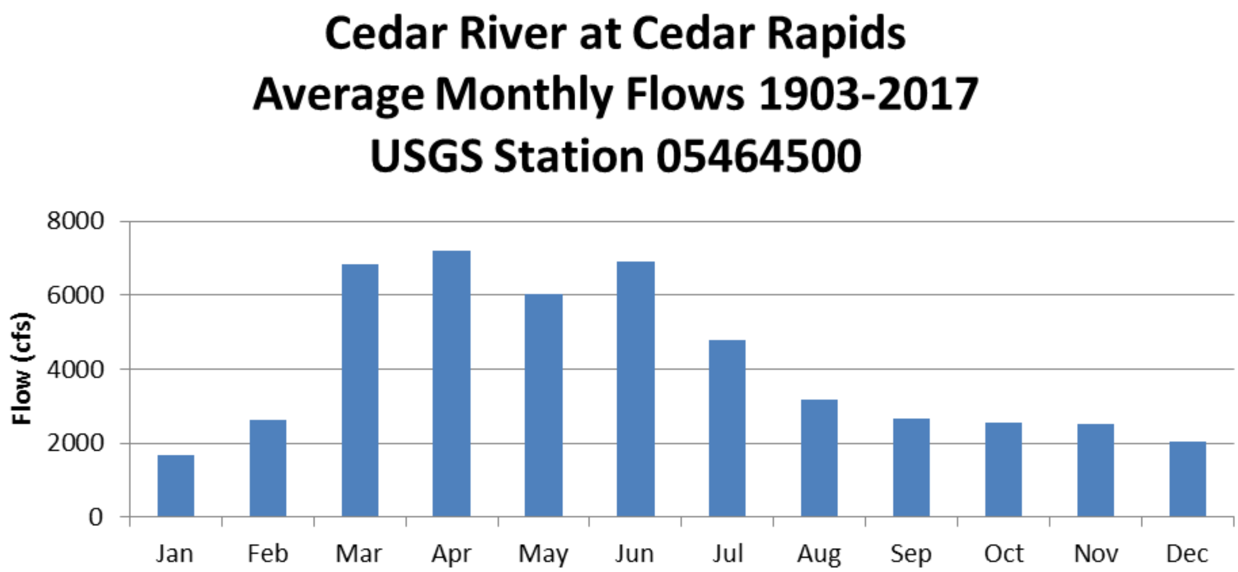


Figure 2-14. Cedar River at Cedar Rapids Average Monthly Flows

2.8.5. Historical Peak Events

From a flooding perspective, instantaneous peak flows are of particular interest. Generally, instantaneous peak flows of the most recent 15 (2001-2016) years with available data were attributable to snow melt (2001, 2006, 2010 and 2011) or due to back-to-back storms of the preceding approximately 14 days with rainfall totals ranging from about 2 inches to 8 inches (2002,2003, 2004, 2005, 2007, 2008, 2011, and 2013). The massive peak flow of June 13, 2008 was preceded by a very large amount of rainfall (about 9.5 inches) in the preceding approximately 14 days. **Back-to-back storms with total rainfalls of 2-6 inches appear to be a trigger for the large peak runoff events in the Middle Cedar River Watershed.**

Cedar River's peak flows were further summarized from the USGS flow gauging station data at Cedar Rapids (Station 05464500) in Figure 2-15 where dramatically increased peak events have occurred since approximately 1960. Peak events from 1918 through the 1920's and the 1950's were all less than approximately 60,000 cfs with the exception of one peak event in 1929. However, from 1961 to 2016, there were eight years with peak flows greater than 60,000 cfs. For perspective, flows greater than 60,000 cfs are approximately 10-15 times typical summer flows. **The range of peak to typical flows to intense rainfall events is indicative of the Middle Cedar River Watershed as having substantially 'flashy' or rapid runoff hydrology.**

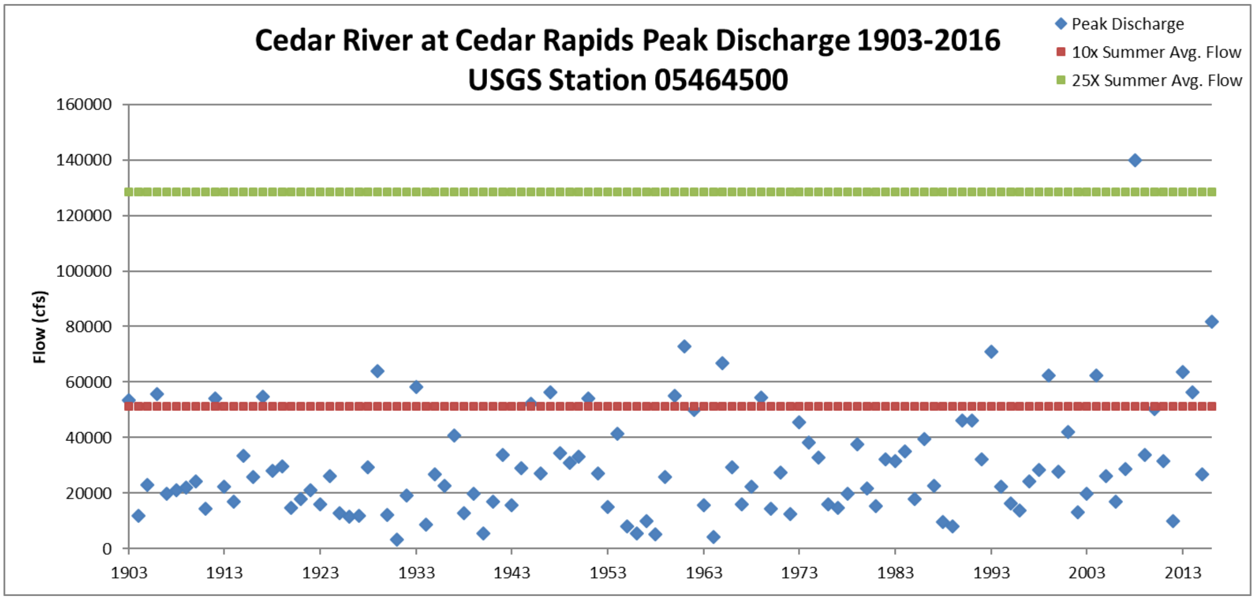


Figure 2-15. Cedar River at Cedar Rapids Annual Peak Discharge 1903-2016.

2.9. Water Quality

Stream and lake monitoring provides information to compare monitored conditions to stream and lake standards and criteria, detect changes over time, and support future watershed rehabilitation efforts. The ability of a monitoring program to detect such changes and the reliability of the comparisons depend upon the nature and design of the monitoring program. In the Middle Cedar River watershed, stream monitoring data has been collected annually during the growing season (May-August) from 2012-2017 by Coe College and the City of Cedar Rapids on tributaries to the Cedar River and the Cedar River itself (see Figure 2-44). A review of this information has yielded information regarding the long term average concentration of important environmental constituents including nitrogen, phosphorus and *E. coli* as well as distinct seasonal patterns in observed nutrient concentrations at tributaries.

Furthermore, the Iowa DNR has maintained water quality sampling stations on Beaver Creek, Black Hawk Creek, Wolf Creek, and the Cedar River from 2000-2017. While these two monitoring efforts have provided crucial information about water quality in the MCW, each study samples only a few select streams in the watershed and take a limited number of samples per year, leading to some data gaps. For a more complete understanding of the state of the watershed and water quality trends, monitoring over a larger extent of the watershed and more frequent sampling is necessary. A review of nitrogen, phosphorus, total suspended solids, and bacteria (*E. coli*) concentrations at each monitoring station is presented below.

2.9.1. Nitrogen

Nitrogen is an important measurement, particularly the dissolved forms, as it increases productivity on farm fields, urban lawns and streams/lakes. Nitrate nitrogen (NO_3-N) is the dominant dissolved fraction with typically very small amounts of nitrite nitrogen present (which can be quite ephemeral). Hence, discussion will focus on nitrate nitrogen. While NO_3-N is one of the primary forms of nitrogen used by plants for growth, excess amounts in groundwater and streams can cause human health concerns. At concentrations greater than 10 mg/L, it has been linked to methemoglobinemia ("blue baby syndrome") and some forms of cancer. The applicable water quality standard for (NO_3-N) is 10 milligrams per liter (mg/l). There are no numeric standards for NO_3-N aquatic life use.

Nonpoint sources are the dominant source of nitrogen in the Middle Cedar River Watershed and throughout the state. According to the Iowa Geological Survey, point sources account for about 8 percent of the stream nitrogen loads statewide, varying from 1 to 15 percent for individual watersheds (Libra et., al, 2004). Nonpoint sources account for the remainder. The primary source for surface water nitrate in Iowa is agriculture, specifically from the widespread use of anhydrous ammonia, application of livestock manure, legume fixation, and mineralization of soil nitrogen (Hallberg 1987; Goolsby et al. 1999). Previous studies have concluded that baseflow and agricultural tile drainage are the main conduits for nitrate to enter Iowa's streams (Hallberg 1987; 1989).

Coe College Results

Table 2-9 displays average annual growing season (NO_3-N) concentrations and the total number of samples collected by month at the Coe College monitoring stations from 2012-2016; average monthly (NO_3-N) concentrations are displayed as well. Observed average annual growing season (NO_3-N) concentrations ranged from a low of 7.6 mg/L (Blue Creek) to a high of 16.6 mg/L (Lime Creek – Hamilton Avenue).

Average monthly (NO_3-N) concentrations during the months of May and June exceeded the 10 mg/L standard along every stream reach with the exception of Blue Creek in May. In contrast, monthly (NO_3-N) concentrations during August were all below 10 mg/L. Observed seasonal changes in (NO_3-N) concentrations are reflective of a land use change from perennial grasslands to seasonal row crops which rely on subsurface tile drainage. Given tile drainage occurs mostly in the spring, it is not surpising to see elevated NO_3-N concentrations in the spring given that land use within the Middle Cedar River Watershed is predominately (>73%) agricultural. Similar seasonal patterns in nitrate concentrations have been observed throughout Iowa, including the Raccoon River watershed in west Central Iowa (Schilling and Lutz 2004).

Table 2-9. Average Monthly Nitrate Nitrogen Concentrations (2012-2016) for Tributaries to the Middle Cedar River – Source: Iowa Soybean Association/ Coe College.

Stream Reach Name	Average Monthly Nitrate Nitrogen Concentration (mg/L)								Average Nitrate Nitrogen (May-August) Concentration (mg/L)
	May		June		July		August		
	Avg.	# of Samples	Avg.	# of Samples	Avg.	# of Samples	Avg.	# of Samples	
Bear	10.5	14	10.3	23	7.8	22	5.0	5	8.4
Blue	9.8	14	10.2	23	6.2	22	4.1	7	7.6
Lime	15.7	30	15.0	44	10.6	44	6.9	16	12.1
Lime 240th Street	15.1	13	15.6	22	11.2	22	8.2	8	12.5
Lime 250th Street	14.8	13	15.3	22	10.6	22	7.7	8	12.1
Lime 290th Street	17.5	13	16.8	22	11.3	22	5.8	8	12.9
Lime Finley Avenue	15.9	13	16.0	22	10.8	22	6.8	8	12.4
Lime Hamilton Ave	18.8	13	19.7	22	14.5	22	9.6	8	15.6
Morgan	10.2	14	10.8	23	7.6	22	5.7	7	8.6
Mud	11.9	14	12.4	23	10.2	21	8.9	6	10.9
North Bear	14.6	14	13.5	23	10.6	22	8.4	7	11.8
Otter	10.0	14	10.1	23	7.1	22	5.1	7	8.1
Average	**13.7**	**15**	**13.8**	**24**	**9.9**	**24**	**6.9**	**8**	**11.1**

DNR Results - Annual Trends

The following paragraphs summarize trends in Nitrate + Nitrite concentrations at the four Iowa DNR monitoring sites within the Middle Cedar River Watershed with the most complete (non-missing) dataset. This analysis is based on data downloaded from the EPA's Water Quality Portal (WQP). The four monitoring stations include Beaver Creek near Cedar Falls, Black Hawk Creek at Waterloo, Wolf Creek at La Porte City, and the Cedar River upstream of Cedar Rapids.

Observed annual average Nitrate + Nitrite concentrations were consistently low across all four monitored streams in the Middle Cedar River watershed in 2012 (Figure 2-16). 2012 was the driest year on record from 2000-2017 as shown in Figure 2-13. Average annual Nitrate + Nitrite concentrations were highest across all four streams in 2007 (Figure 2-17). Average annual flows in 2007 were higher than the preceding 7-year period from 2000-2006 indicating that 2007 may have represented a flushing event, releasing excess nitrogen that had built up in agricultural soils during periods of drought.

A similar pattern of low Nitrate + Nitrite concentrations in 2012 during periods of low precipitation followed by high concentrations in 2013 during periods of increased precipitation intensity was observed at all four monitoring points (Figure 2-17). Similarly low nitrate concentrations in 2012 and high concentrations in 2013 were observed at the 12 Coe College monitoring sites. Observed patterns in Nitrate + Nitrite concentrations in 2012 and 2013 are not unique to the Middle Cedar River Watershed. According to the *Water Footprint Calculator*, "The highest nitrate concentrations in 2013 were in streams in Iowa, closely followed by southern Minnesota and central Illinois. Drought conditions in 2012 allowed excess nitrogen to build up in the soils until spring rains in 2013 flushed the nitrate into streams, leading to unusually high levels." There is a significant amount of evidence available which suggests that this pattern of drought followed by intense rainfalls is going to increase. The substantial correlation between precipitation totals and observed Nitrate + Nitrite concentrations in the Middle Cedar River Watershed across all four monitoring points suggests that nonpoint sources of pollution are the primary threat to the Watershed's water resources. The EPA considers nonpoint sources of pollution as the greatest threat to US waters, especially in watersheds like the Middle Cedar River Watershed that are comprised largely of agricultural uses. Of the four monitored streams, Wolf Creek had the highest overall (all samples from 2000-2017 included) average Nitrate + Nitrite concentration at 8.54 mg/L. The Cedar River monitoring station had the lowest overall average Nitrate + Nitrite concentration from 2000-2017 at 5.87 mg/L.

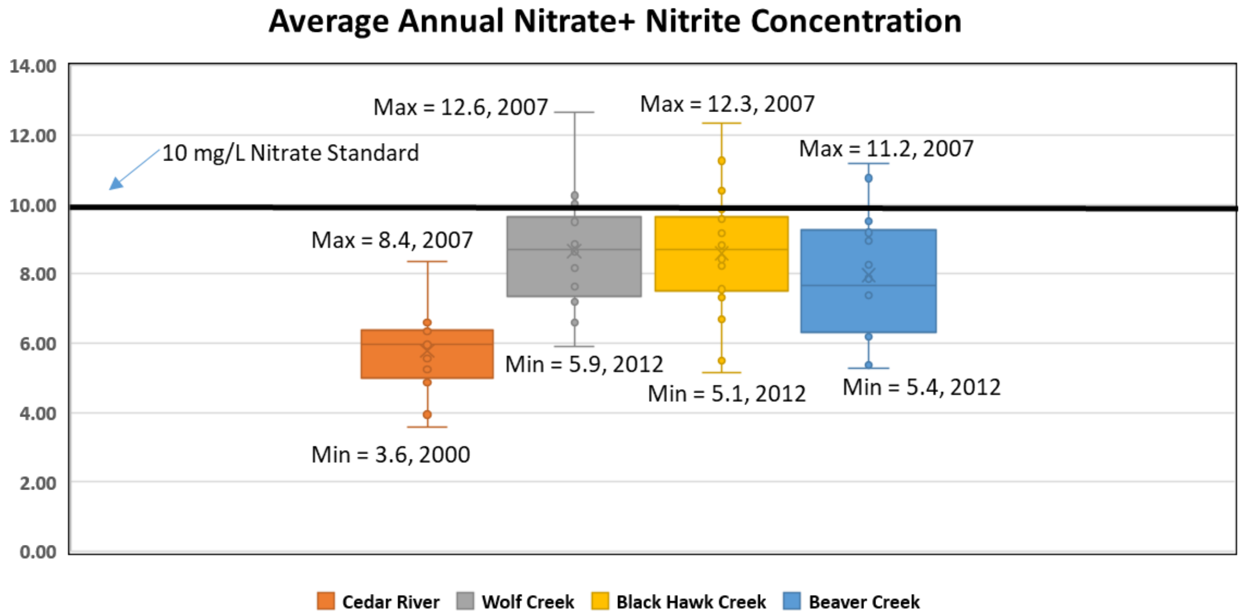


Figure 2-16. Average Annual Nitrate + Nitrite Concentrations.

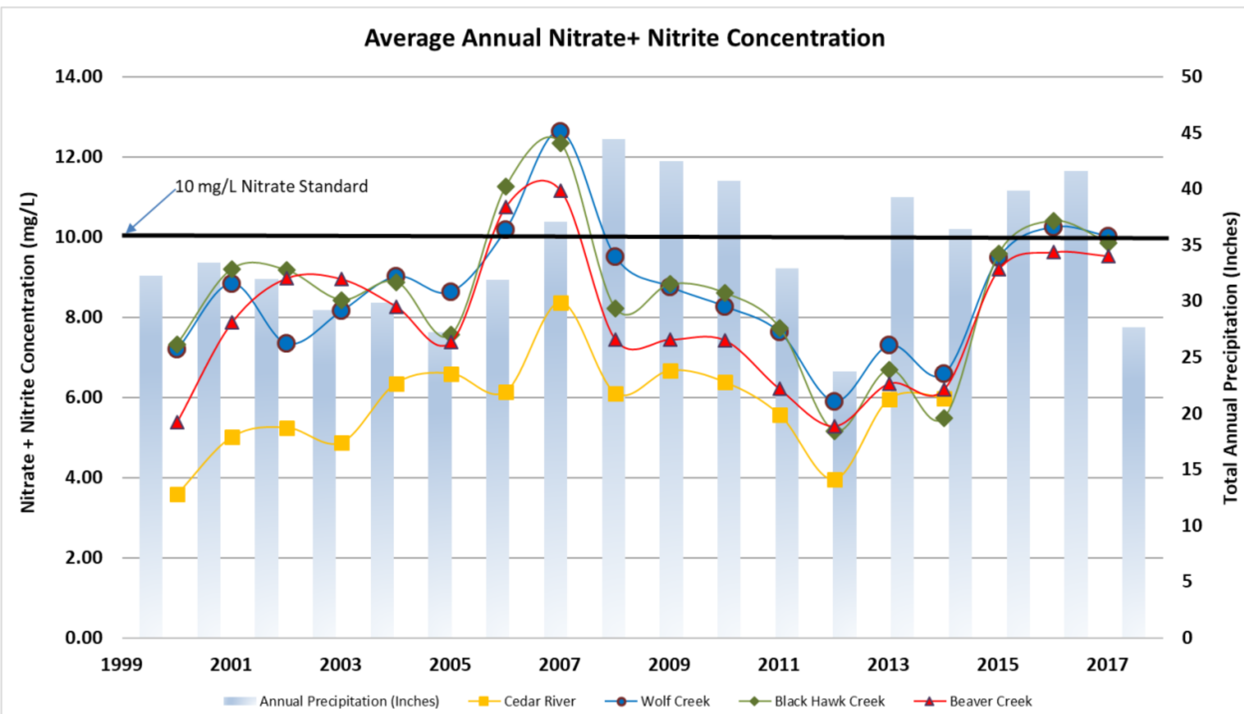


Figure 2-17. Average Annual Nitrate + Nitrite Concentrations with Annual Precipitation Totals.

DNR Results -Monthly Trends

Observed average monthly nitrate concentrations at the four DNR monitoring stations in the Middle Cedar River were separated into three categories: Good, Moderate, or Poor (Figure 2-18, Figure 2-19, Figure 2-20, and Figure 2-21). Each of these categories is associated with a water quality standard, for example the Iowa Drinking Water Standard for Nitrate of 10 mg/L. Nitrate concentrations exceeding 10 mg/L are commonly accepted as posing a human health concern, therefore, nitrate observations exceeding this standard were categorized as "Poor". Similarly, observed nitrate concentrations below the EPA's Western Corn Belt Ecoregion 25th percentile Nitrate concentration of 3.3 mg/L were categorized as "Good"; subsequently, samples between 3.3 mg/L and 10 mg/L were categorized as "Moderate".

Beaver Creek

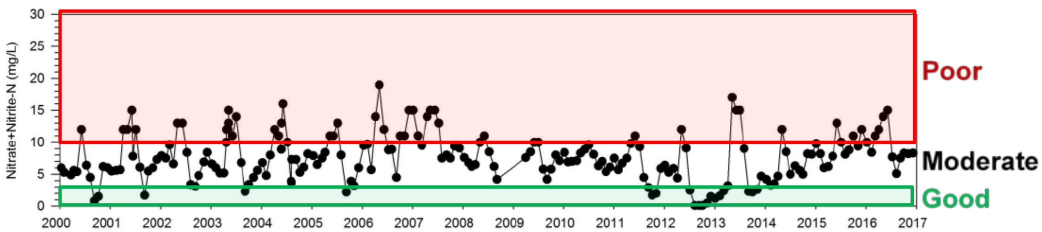


Figure 2-18. Observed average monthly Nitrate + Nitrite Concentration Beaver Creek 2000-2017.

Black Hawk Creek

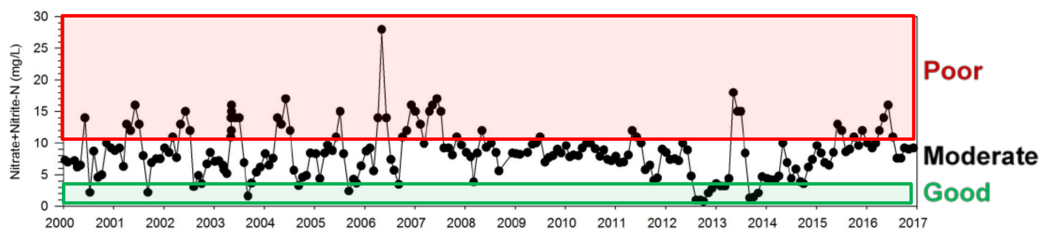


Figure 2-19. Observed average monthly Nitrate + Nitrite Concentration Black Hawk Creek 2000-2017.

Wolf Creek

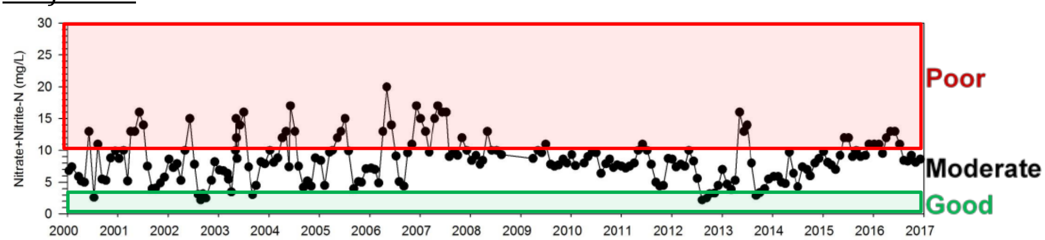


Figure 2-20. Observed average monthly Nitrate + Nitrite Concentration Wolf Creek 2000-2017.

Cedar River

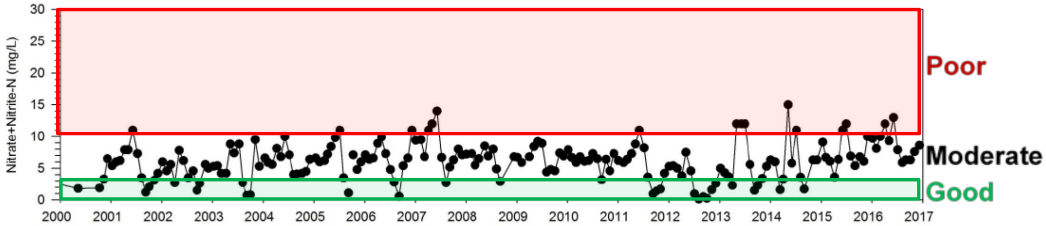


Figure 2-21. Observed average monthly Nitrate + Nitrite Concentration Cedar River 2000-2017.

2.9.2. Phosphorus

Phosphorus is typically monitored in two forms: dissolved phosphorus (forms most readily used by crops as well as algae and aquatic plants resulting in increased productivity); and total phosphorus (found in both dissolved and particulate forms). Nonpoint sources are the dominant source of phosphorus in the Middle Cedar River Watershed.

Table 2-10 displays the estimated phosphorus inputs (sources) and outputs for Iowa by category (Libra et., al, 2004). Phosphorus inputs are dominated almost entirely from fertilizer and manure whereas point sources discharges from human and industrial wastewaters are about 1 percent of the total. For phosphorus, ag-inputs include essentially all the manure-P, roughly 90 percent of the fertilizer, and about 95 percent of the total phosphorus input. Harvest and grazing account for an estimated 96 of the phosphorus removal (loss). Stream losses account for only about 4% of total phosphorus outputs.

Table 2-10. Estimated phosphorus inputs and outputs for Iowa. Source – Nitrogen and Phosphorus Budgets for Iowa and Iowa Watersheds (Libra et., al, 2004).

Phosphorus Inputs	Tons	Phosphorus Outputs	Tons
Fertilizer	126,954	Harvest	243,197
Manure	109,214	Grazing	22,545
Human	3,600	Streams	10,844
Industry	650		
Total	**240,418**	**Total**	**276,586**

Coe College Results

Table 2-11 displays average annual Dissolved Reactive Phosphorus (DRP) concentrations and average monthly DRP concentrations for the growing season for each station monitored by Coe College from 2012-2016. Average annual growing season DRP concentrations range from a low of 0.12 mg/L (Lime Creek – Hamilton Avenue) to a high of 0.33 mg/L (Mud Creek).

Phosphorus concentration in water is a primary focus of applied watershed management as this element drives a wide array of river, stream and lake biological responses affecting beneficial uses. Excess phosphorus concentrations lead to increased algae that float in the stream or are attached to rocks and substrates, increased organic matter, increased bacteria that lead to boom-bust daily oxygen concentration cycles that limit aquatic life. In severe cases, massive algal mats and scums can be generated by blue-green algae that also can produce toxins such as microcystin that can affect recreation, drinking water supplies, and wildlife habitat. Because DRP is in an inorganic form, it is readily assimilated by aquatic plants and algae. Even low concentrations of DRP can therefore have a dramatic impact on streams.

The Environmental Protection Agency (EPA) has developed national nutrient criteria recommendations by ecoregion based on nutrient data from a large number of the nation's lakes and rivers (US EPA 2000). Ecoregions are defined as areas of similar ecosystem and geography. The 25th percentile Total Phosphorus (TP) concentration for streams in the Western Corn Belt Plains ecoregion is 0.118 mg/L (the EPA associates the 25th percentile of a whole population of streams in an ecoregion with minimally impacted conditions.) When comparing the values in Table 2-11 to this ecoregion criteria, it is important to note that DRP represents only a small portion of the total amount of phosphorus present in a stream. The observation that the average annual and monthly DRP concentration consistantly exceeded the EPA 25th percentile TP criteria, provides evidence to suggest that the tributaries of the Middle Cedar River watershed are significantly impaired due to excessive nutrient contributions from the watershed.

Table 2-11. Average Monthly and Annual Dissolved Reactive Phosphorus Concentrations for Tributaries to the Middle Cedar River from 2012-2016 – Source: Iowa Soybean Association/ Coe College.

Stream Reach Name	Average Monthly Dissolved Reactive Phosphorus Concentration (mg/L)								Annual Growing Season Average Dissolved Reactive Concentration (mg/L)
	May		June		July		August		
	Avg.	#of Samples	Avg.	#of Samples	Avg.	#of Samples	Avg.	#of Samples	
Bear	0.19	14	0.32	23	0.19	22	0.19	5	0.22
Blue	0.13	14	0.20	23	0.11	22	0.11	7	0.14
Lime	0.10	30	0.26	44	0.21	44	0.19	16	0.19
Lime 240th Street	0.07	13	0.20	22	0.15	22	0.48	8	0.22
Lime 250th Street	0.08	13	0.19	22	0.15	22	0.20	8	0.15
Lime 290th Street	0.08	13	0.23	22	0.15	22	0.17	8	0.15
Lime Finley Avenue	0.08	13	0.23	22	0.19	22	0.20	8	0.17
Lime Hamilton Ave	0.06	13	0.17	22	0.13	22	0.13	8	0.12
Morgan	0.25	14	0.24	23	0.14	22	0.12	7	0.19
Mud	0.26	14	0.37	23	0.32	21	0.36	6	0.33
North Bear	0.08	14	0.22	23	0.16	22	0.12	7	0.14
Otter	0.21	14	0.26	23	0.23	22	0.16	7	0.21
Average	**0.17**	**15**	**0.21**	**24**	**0.11**	**24**	**0.19**	**8**	**0.19**

DNR Results- Annual Trends

The following paragraphs summarize trends in Total Phosphorus concentrations at the four Iowa DNR monitoring sites within the Middle Cedar River Watershed with the most complete (non-missing) dataset.

Observed annual average TP concentrations were lowest in 2010 on Beaver Creek, Black Hawk Creek and the Cedar River and in 2012 on Wolf Creek (Figure 2-22). 2012 was the driest year on record from 2000-2017. The low average TP concentration observed in Wolf Creek during 2012 suggests a correlation with nonpoint sources. In contrast, the 2010 calendar year produced above-normal annual rainfall levels including a large spring-time event on March 17th, 2010; however average annual phosphorus concentrations remained low in Beaver Creek, Black Hawk Creek, and the Cedar River. This observation may be the result of previous flushing events which occurred in 2008 and 2009, thus a significant amount of phosphorus had not previously accumulated in the watershed's soils.

Average annual TP concentrations were highest in 2004 on Beaver Creek and Wolf Creek. Although annual flow totals for 2004 were near-normal, a large late-spring precipitation event on May 26th and 27th, 2004 produced a large amount of runoff immediately following drought conditions resulting from two years of below-average rainfall in 2002 and 2003. Therefore, it appears that storm events which are preceded by periods of drought are the major driver in the export of phosphorus within the watershed. Observed TP concentrations at the Beaver Creek monitoring station were highest in 2008; 2008 was an extremely wet year with high average annual rainfall and intense rainfall events. Observed annual average TP concentrations at the Cedar River monitoring station were highest in 2014. Two data points collected within a three-week window in 2014 (March 11th, 2014, April 2nd, 2014) were amongst the top 6 highest TP concentrations observed throughout the entire seventeen-year monitoring period.

Of the four monitored streams, Wolf Creek had the highest overall average TP concentration from 2000-2017 at 0.249 mg/L, more than twice the EPA's 25th percentile value for the Western Corn Belt Ecoregion of 0.118 mg/L. The Beaver Creek monitoring station had the lowest overall average TP concentration from 2000-2017 at 0.175 mg/L.

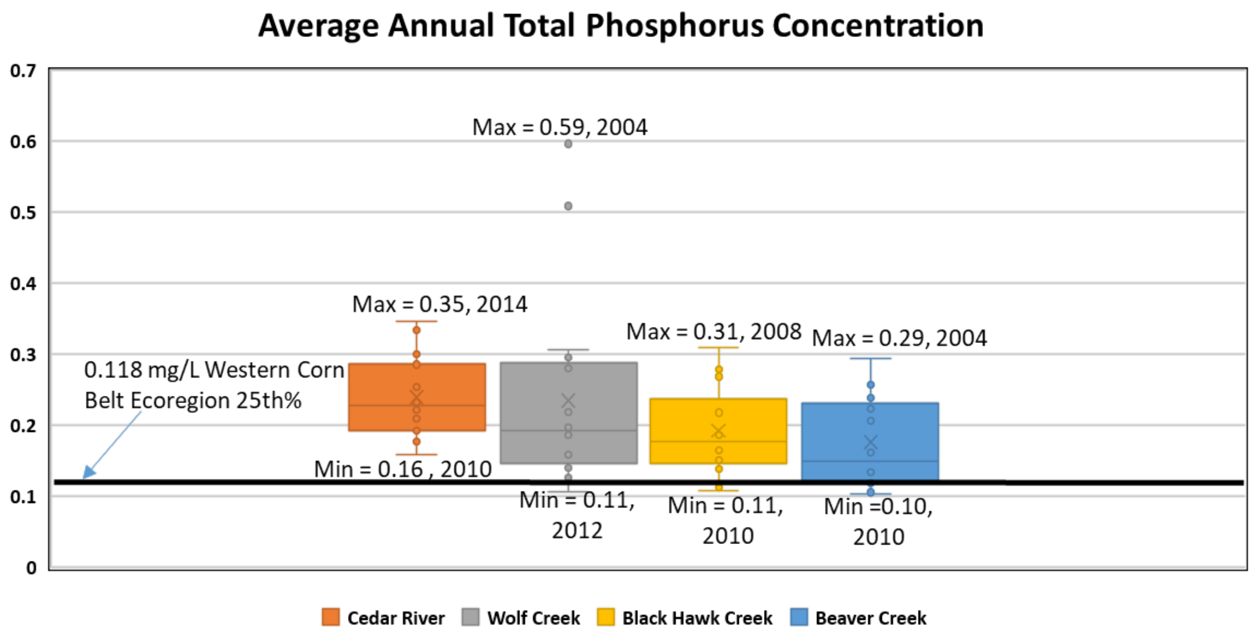


Figure 2-22. Average Annual Total Phosphorus Concentrations.

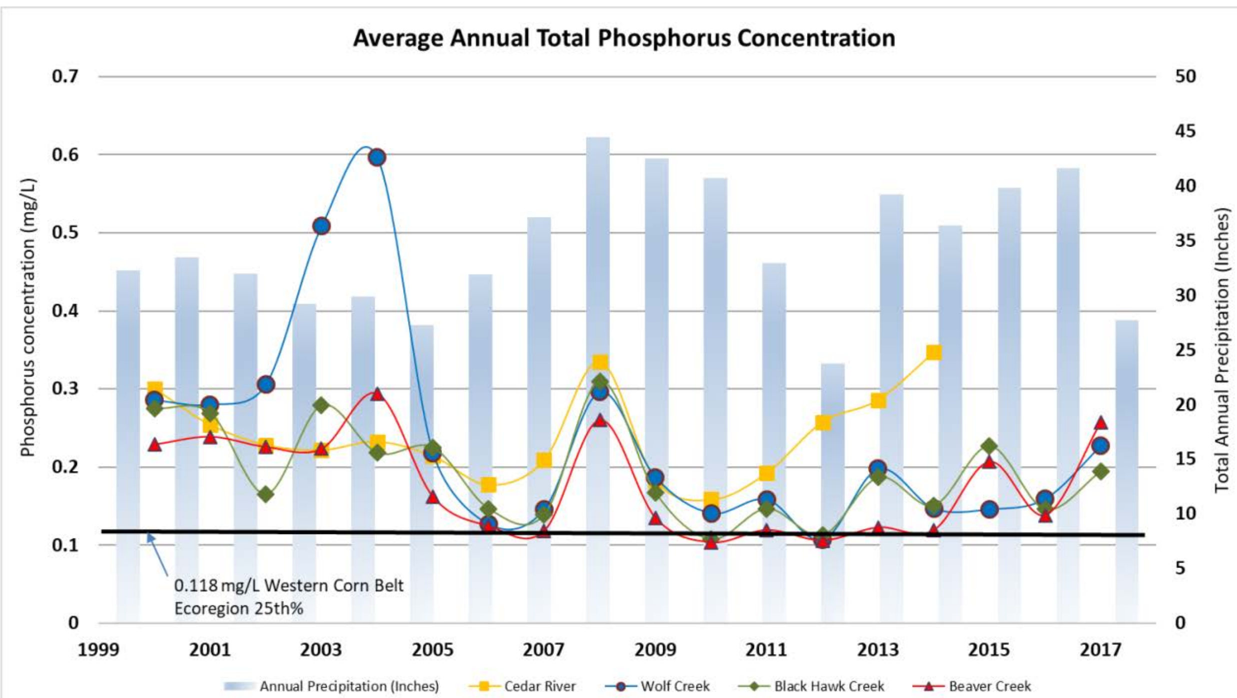


Figure 2-23. Average Annual Total Phosphorus Concentrations with Annual Precipitation Totals.

DNR Results -Monthly Trends

Observed average monthly Total Phosphorus (TP) concentrations at DNR monitoring stations in the Middle Cedar River were separated into three categories: Good, Moderate, or Poor (Figure 2-24, Figure 2-25, Figure 2-26, and Figure 2-27). The EPA's TP 25th percentile of 0.118 mg/L for the Western Corn Belt Ecoregion was used as a boundary for identifying "Poor" samples. Observed TP concentrations below 0.060 mg/L (60 ug/L) were categorized as "Good".

Beaver Creek

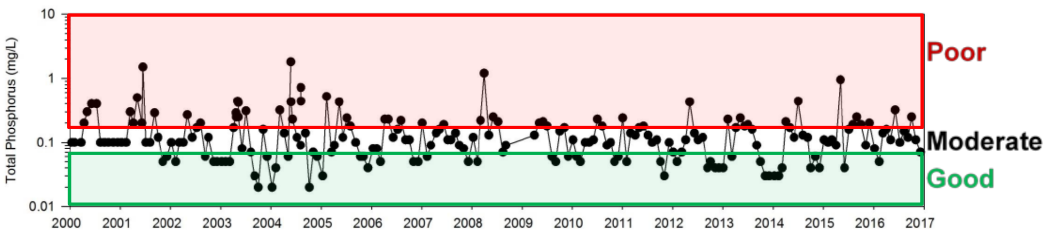


Figure 2-24. Observed *Average Monthly* Total Phosphorus Concentration Beaver Creek 2000-2017.

Black Hawk Creek

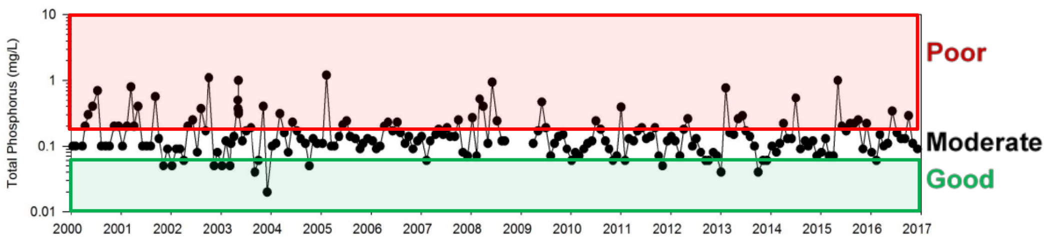


Figure 2-25. Observed *Average Monthly* Total Phosphorus Concentration Black Hawk Creek 2000-2017.

Wolf Creek

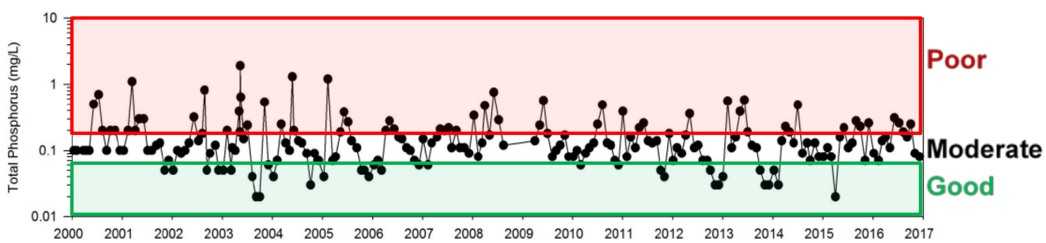


Figure 2-26. Observed *Average Monthly* Total Phosphorus Concentration Wolf Creek 2000-2017.

Cedar River

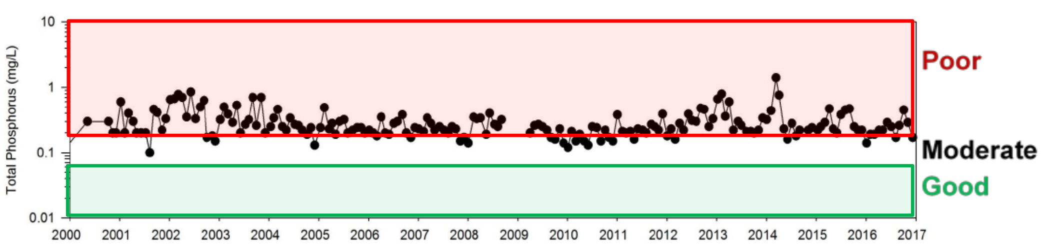


Figure 2-27. Observed Average Monthly Total Phosphorus Concentration Cedar River 2000-2017.

2.9.3. Total Suspended Solids

Total Suspended Solids (TSS) is an important measurement of the amount of material suspended instream which is sometimes referred to as turbidity. As more material is suspended, less light can pass through, making it less transparent. Suspended materials may include soil, algae, plankton, and microbes.

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

Coe College Results

Table 2-12 displays average annual growing season TSS concentrations and average monthly TSS concentrations for the growing season for each station monitored by Coe College from 2012-2016. Monthly TSS concentrations were highest during the months of May and June which correspond to the period of the year where row crops have not yet become established. In these periods of year, bare soil from agricultural fields is more likely to become detached during precipitation events given the rate and magnitude of water erosion is usually greatest during short-duration, high-intensity thunderstorms; during snowmelt; when soils have high moisture content; and when vegetative cover is minimal. Also, at this time of year, stream flow levels are high leading to increased streambank and streambed erosion, releasing sediment into the water.

Table 2-12. Average Monthly and Annual Total Suspended Solids Concentrations for Tributaries to the Middle Cedar River from 2012-2016 – Source: Iowa Soybean Association/ Coe College.

Stream Reach Name	Average Monthly Total Suspended Solids Concentration (mg/L)								Annual Growing Season Average Total Suspended Solids Concentration (mg/L)
	May		June		July		August		
	Avg.	#of Samples	Avg.	#of Samples	Avg.	#of Samples	Avg.	#of Samples	
Bear	35.6	14	67.2	23	14.0	22	8.5	5	31.3
Blue	15.1	14	32.0	23	9.5	22	9.0	7	16.4
Lime	4.0	30	19.2	44	8.1	44	5.7	16	9.2
Lime 240th Street	3.4	13	13.6	22	9.7	22	11.9	8	9.7
Lime 250th Street	8.1	13	15.8	22	11.5	22	9.4	8	11.2
Lime 290th Street	4.3	13	23.3	22	15.4	22	8.9	8	13.0
Lime Finley Avenue	6.5	13	16.8	22	7.2	22	4.8	8	8.8
Lime Hamilton Ave	6.1	13	15.4	22	15.5	22	18.7	8	13.9
Morgan	74.4	14	33.2	23	12.4	22	9.4	7	32.4
Mud	13.6	14	47.9	23	16.8	21	8.4	6	21.7
North Bear	8.9	14	22.9	23	7.4	22	4.2	7	10.8
Otter	40.8	14	35.3	23	13.3	22	5.3	7	23.7
Average	**18.4**	**15**	**28.6**	**24**	**11.7**	**24**	**8.7**	**8**	**16.8**

DNR Results - Annual Trends

The following paragraphs summarize trends in Total Suspended Solids concentrations at the four Iowa DNR monitoring sites within the Middle Cedar River Watershed with the most complete (non-missing) dataset.

Similar to observed TP concentrations, observed annual average Total Suspended Solids (TSS) concentrations were lowest in 2010 on Beaver Creek and the Cedar River despite above average rainfall (Figure 2-28). Observed annual TSS concentrations were lowest in 2005 on Black Hawk Creek and in 2014 in Wolf Creek. Observed annual average TSS concentrations were highest in Beaver Creek and Wolf Creek in 2004, again this is reflective of observed TP patterns. The combination of high TSS loading with high TP loading in 2004 provides evidence to suggest that the majority of the TP load from 2004 was from sediment bound phosphorus. Observed TSS concentrations at the Cedar River monitoring station were highest in 2008, an extremely wet year with high average annual rainfall and intense rainfall events. Of the four monitored streams, Wolf Creek had the highest overall (all samples from 2000-2017 included) average TSS concentration at 122 mg/L. The Beaver Creek monitoring station had the lowest overall average TSS concentration from 2000-2017 at 44 mg/L.

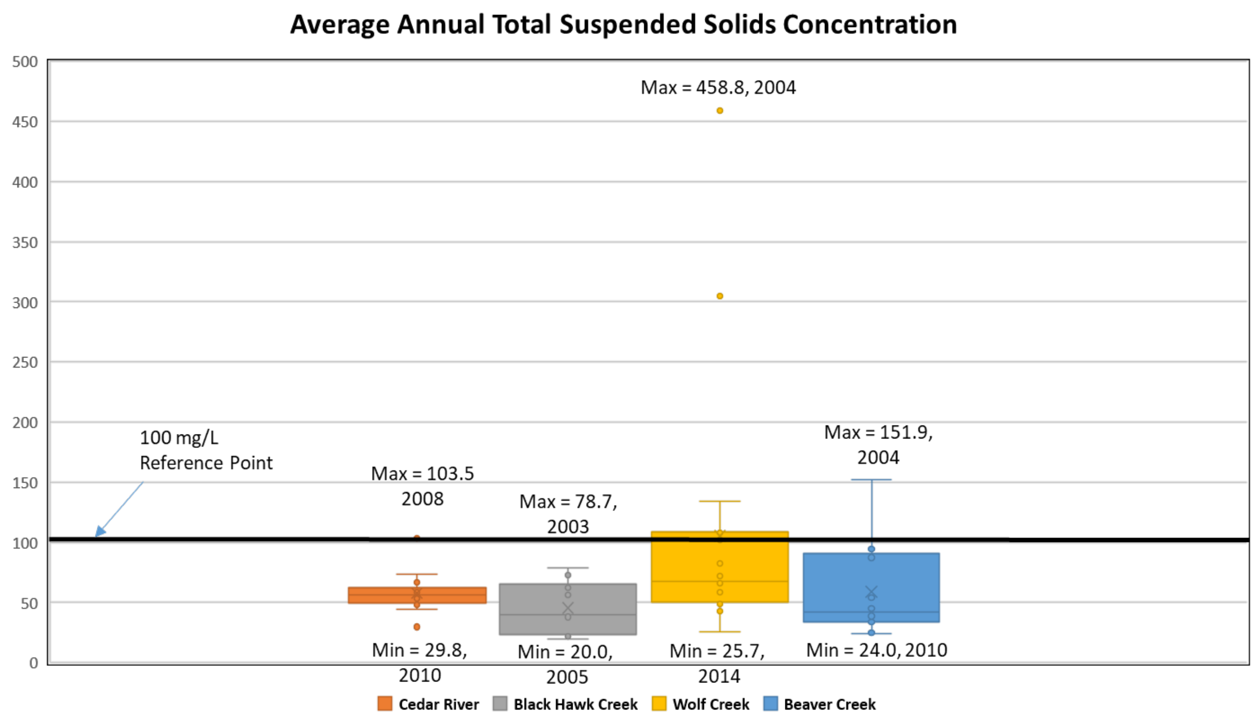


Figure 2-28. Average annual total suspended solids concentration.

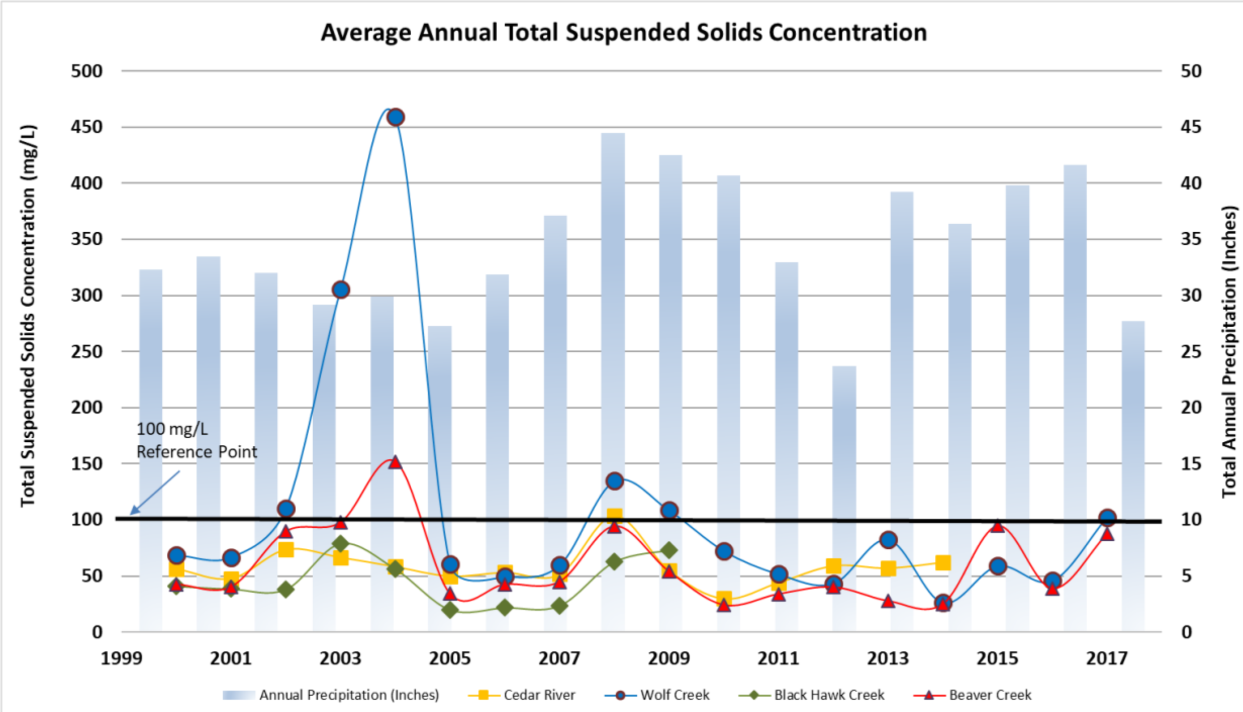


Figure 2-29. Average annual total suspended solids concentration with Annual Precipitation Totals.

DNR Results - Monthly Trends

Observed average monthly total suspended solids concentrations at DNR monitoring stations in the Middle Cedar River were separated into three categories: Good, Moderate, or Poor (Figure 2-30, Figure 2-31, Figure 2-32, and Figure 2-33). A value of 100 mg/L was used as the cutoff for identifying poor water quality based on observations made in southern Minnesota streams as outlined in the *Aquatic Life Water Quality Standards Draft Technical Support Document for Total Suspended Solids* (Markus 2011). Values below 66 mg/L were categorized as "Good"; subsequently, samples between 100 mg/L and 66 mg/L were categorized as "Moderate".

Beaver Creek

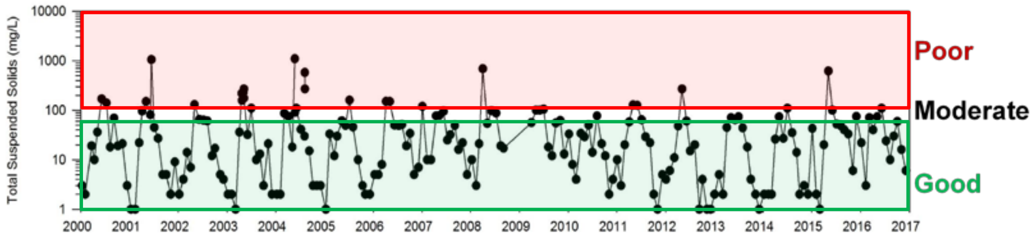


Figure 2-30. Observed Average Monthly Total Suspended Solids Concentration Beaver Creek 2000-2017.

Black Hawk Creek

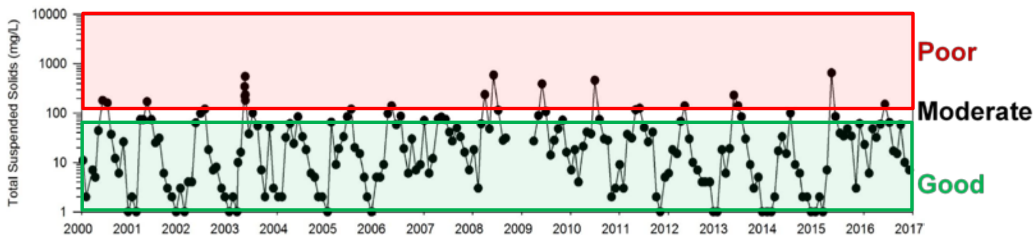


Figure 2-31. Observed Average Monthly Total Suspended Solids Concentration Black Hawk Creek 2000-2017.

Wolf Creek

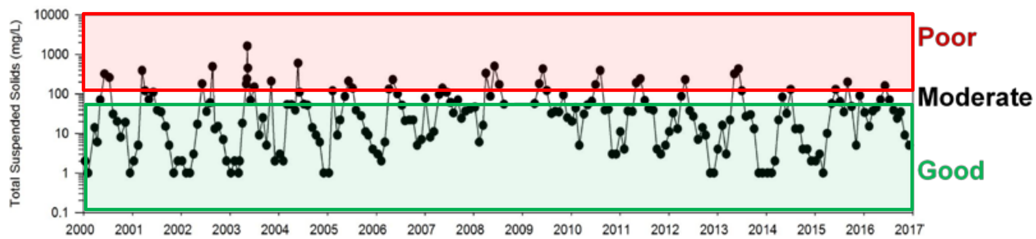


Figure 2-32. Observed Average Monthly Total Suspended Solids Concentration Wolf Creek 2000-2017.

Cedar River

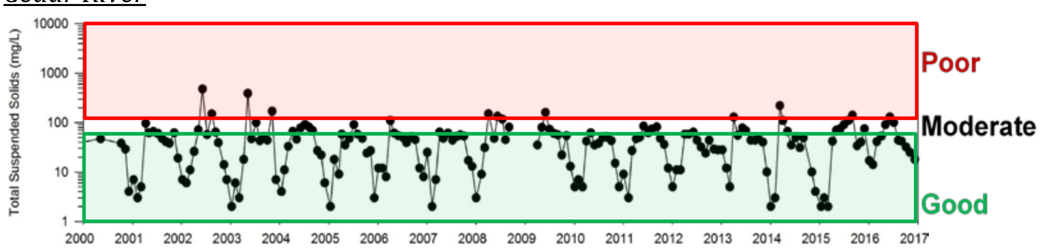


Figure 2-33. Observed Average Monthly Total Suspended Solids Concentration Cedar River 2000-2017.

2.9.4. Bacteria (E.coli)

Humans, pets, livestock, and wildlife all contribute bacteria to the environment. These bacteria, after appearing in animal waste, are dispersed throughout the environment by an array of mechanisms (LeFevre et. al., 2014). Bacteria fate and transport is affected by sewage disposal and treatment mechanisms, methods of manure reuse, imperviousness of land surfaces, and natural decay and die-off due to environmental factors such as ultraviolet (UV) exposure and detention time in the landscape (LeFevre et. al., 2014. The following discussion highlights sources of bacteria in the environment and mechanisms that drive the delivery of bacteria to surface waters.

Coe College Results

Table 2-13 displays average annual geometric mean bacteria (*E.coli*) concentrations for each station monitored by Coe College from 2012-2016. Annual geometric mean *E. coli* concentrations ranged from a high of 3003 Most Probable Number (MPN/100 ml) on Mud Creek in 2014 to a low of 352 (MPN/100 ml) on Blue Creek in 2012. The Iowa State Standard geometric mean MPN/100ml *E.coli* concentration is 126 MPN/100ml. Comparing observed data collected in the Middle Cedar River watershed with the 126 MPN/100ml State Standards suggests all tributaries are significantly impaired due to excessive bacteria contributions from the watershed. Based on data collected to date, there are likely additional stream bacteria impairments in the watershed. Many of the smaller streams and tributaries have an insufficient amount of monitoring information to be fully assessed for compliance with water quality standards. Additional monitoring, with an emphasis on bacteria data collection is needed on these unmonitored tributaries for comparison to water quality standards and criteria.

Table 2-13. Annual Geometric Mean *E. coli.* Concentration for Tributaries to the Middle Cedar River -Source: Iowa Soybean Association/ Coe College.

Stream Reach Name	Annual Geometric Mean *E. Coli* Concentration (organisms/100 ml)					Annual Geometric Mean *E. Coli* Concentration (organisms/100 ml)
	2012	2013	2014	2015	2016	
Bear	717	742	1,676	1,160	782	1,015
Blue	352	574	879	789	579	635
Lime	529	742	1,236	966	864	867
Lime 240th Street	511	438	514	439	758	532
Lime 250th Street	771	608	587	450	736	630
Lime 290th Street	1,018	1,044	1,484	758	1,405	1,142
Lime Finley Avenue	872	1,316	1,568	1,318	1,880	1,391
Lime Hamilton Ave	2,156	1,181	1,989	1,454	557	1,467
Morgan	391	416	902	982	820	702
Mud	453	588	3,003	1,103	700	1,169
North Bear	539	756	685	705	779	693
Otter	407	713	1,069	1,123	868	836
Average	726	760	1,299	937	894	923

DNR Results – Annual Geometric Mean Trends

The following paragraphs summarize annual and monthly trends in Total Suspended Solids concentrations at the four Iowa DNR monitoring sites within the Middle Cedar River Watershed with the most complete (non-missing) dataset.

Observed annual average E.coli concentrations were lowest in 2010 on the Cedar River despite above average rainfall (Figure 2-34). Observed annual E.coli concentrations were lowest in 2014 on Black Hawk Creek, Wolf Creek and Beaver Creek. Observed annual average E.coli concentrations were highest in Wolf Creek and Beaver Creek in 2003. Observed E.coli concentrations at the Cedar River monitoring station were highest in 2007. Of the four monitored streams, Wolf Creek had the highest overall (all samples from 2000-2017 included) average TSS concentration at 122 mg/L. The Cedar River monitoring station had the lowest geometric mean concentration from 2000-2017.

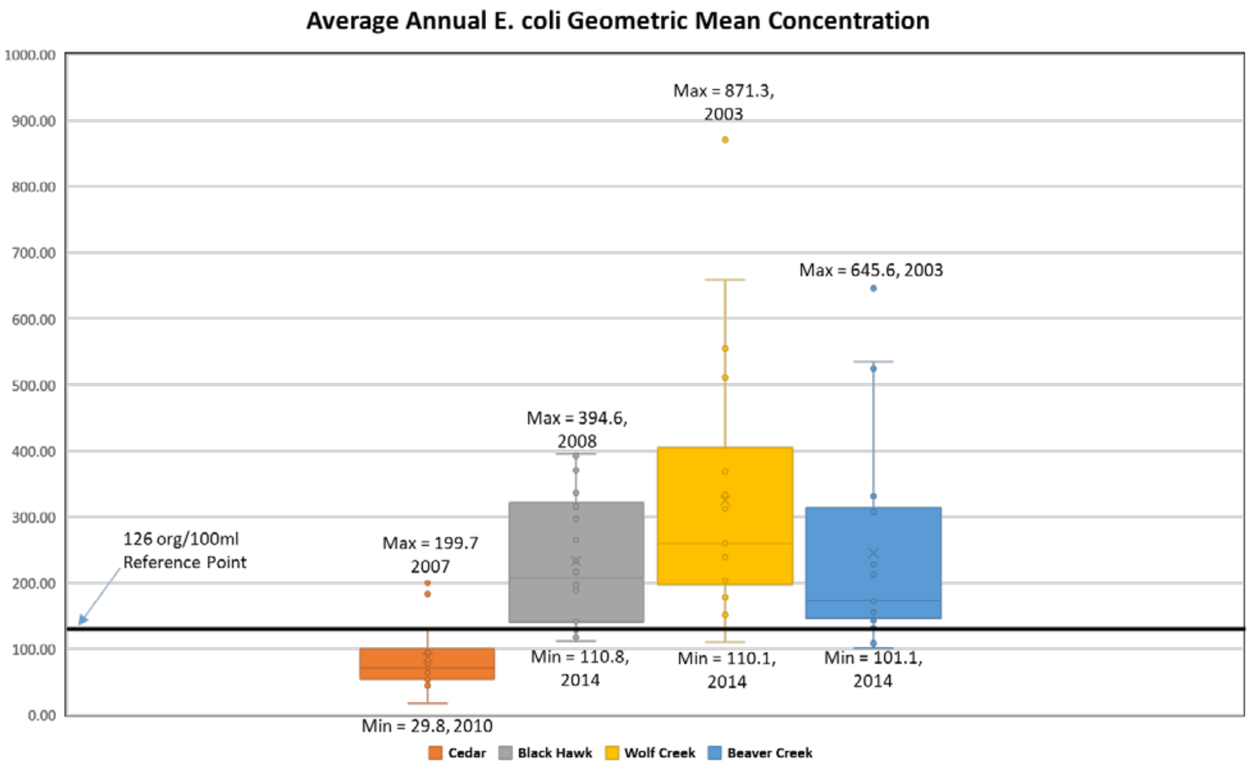


Figure 2-34. Average annual *E. coli* geometric mean concentrations.

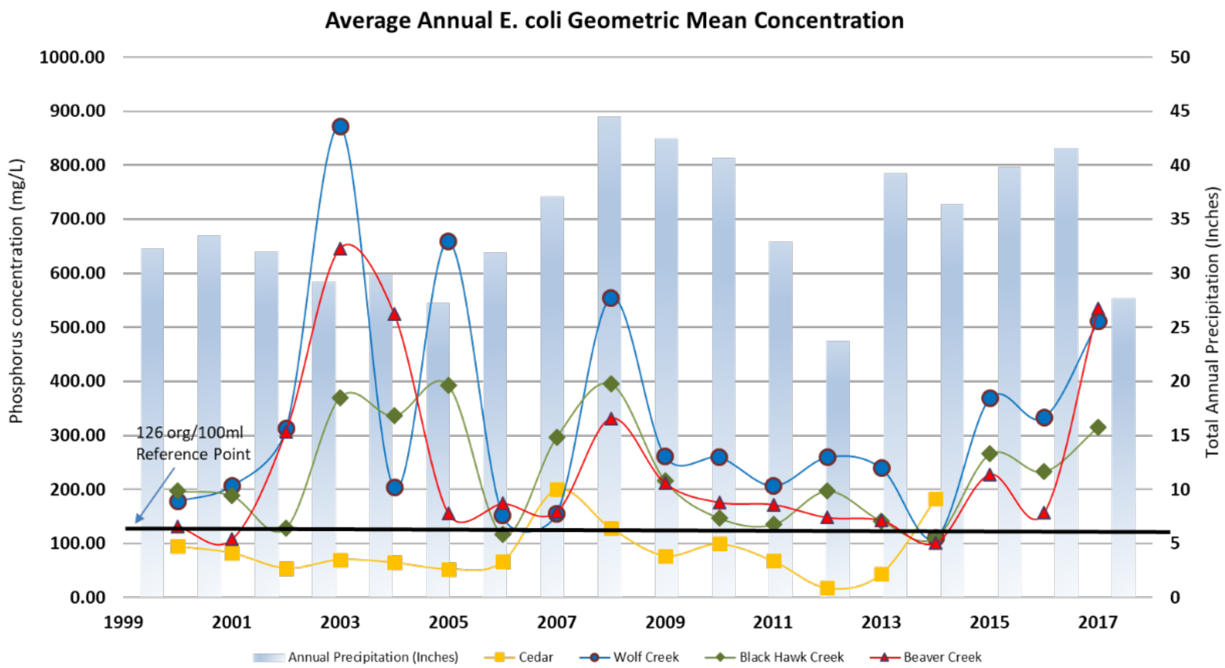


Figure 2-35. Average Annual *E. coli* Geometric Mean Concentrations with Annual Precipitation Totals (Inches)

DNR Results – Monthly Trends

Observed bacteria (E.coli) concentrations at DNR monitoring stations in the Middle Cedar River were separated into three categories: Good, Moderate, or Poor (Figure 2-36), (Figure 2-37), (Figure 2-38). For a point of reference, the Iowa State Geometric Mean Standard of 126 org/100ml was used as a boundary for identifying "Poor" samples. Observed E.coli concentrations below 20 org/100ml were categorized as "Good". Seasonal patterns in bacteria concentrations show elevated concentrations exceeding 126 org/100 ml from May through October. The lowest observed bacteria concentrations occur from November through April.

Beaver Creek

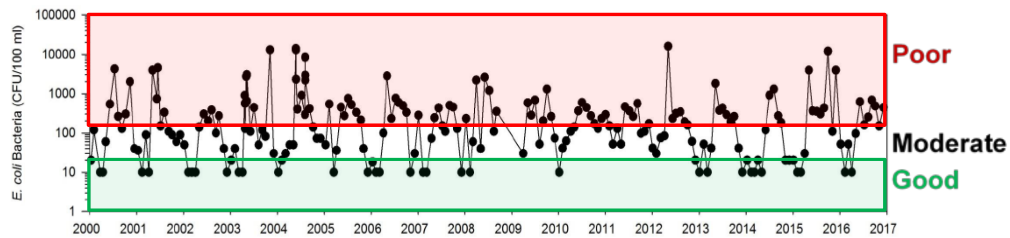


Figure 2-36. Observed Bacteria (*E. coli*) Concentration Beaver Creek 2000-2017.

Black Hawk Creek

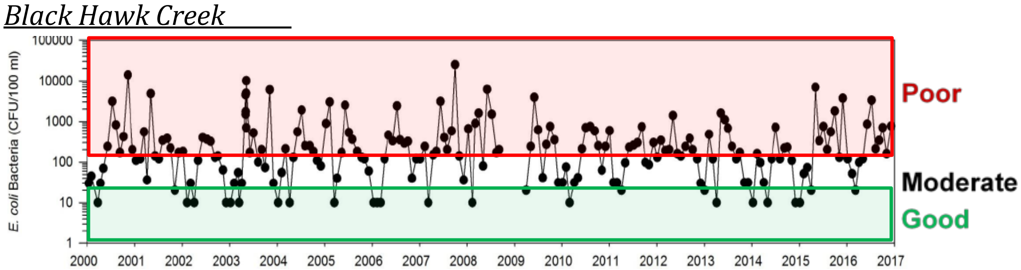


Figure 2-37. Observed Bacteria (E. coli) Concentration Black Hawk Creek 2000-2017.

Wolf Creek

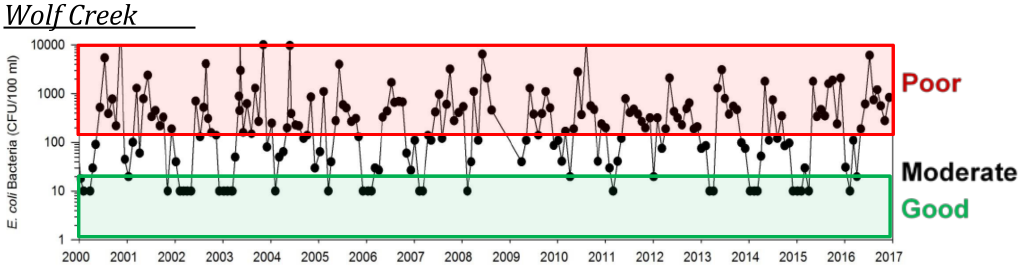


Figure 2-38. Observed Bacteria (*E. coli*) Concentration Wolf Creek 2000-2017.

Cedar River

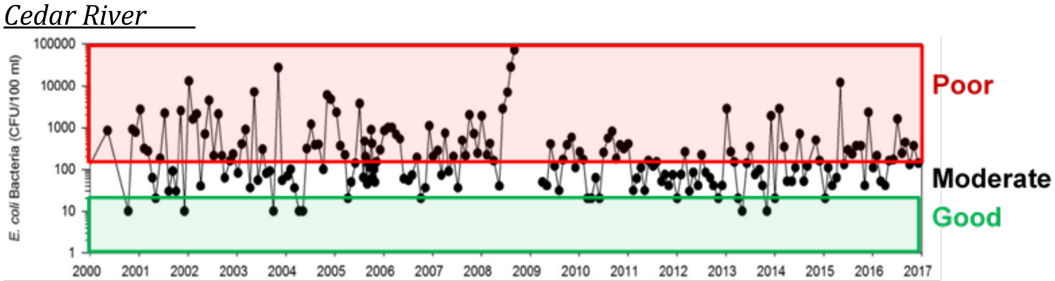


Figure 2-39. Observed Bacteria (E. coli) Concentration Cedar River 2000-2017.

2.9.5. Fish and Benthic Macroinvertebrate Evaluation

From 1994-2016, the Iowa DNR conducted biological assessments on 81 stream reaches within the Middle Cedar River Watershed. These 81 stream reaches were distributed over 29 of the 68 HUC-12 watersheds (43%). Biological assessment (bioassessment) is a key component of IDNR's water quality monitoring and assessment functions, including: problem investigation, project evaluation, status/trend monitoring, and Total Maximum Daily Load (TMDL) development. Biological data collected at each of the 81 sampling sites was used to calculate the Fish Index of Biotic Integrity (FIBI) and Benthic Macroinvertebrate Index of Biotic Integrity (BMIBI).

Both the FIBI and BMIBI are composite indexes in which twelve individual metrics (Table 3-14) are combined to provide a community-level assessment of stream biological conditions. Both indices were developed from a database of stream reference sites and test sites located in the eight ecological regions (Ecoregion) of Iowa. Reference sites were chosen to represent least impacted stream habitats in the ecoregions in which they are located. Test sites were chosen to represent common types of stream impacts (e.g., point source discharge; riparian livestock grazing), or they were chosen as part of a watershed assessment project.

The FIBI and BMIBI both have a possible scoring range from 0-100. Figure 2-40 and Figure 2-41 provide a general framework for relating FIBI/BMIBI scores to fish/macroinvertebrate assemblage observed. This framework is largely based on the biological criteria program of the U.S. EPA, the EPA has endorsed the adaptation of a multitiered biological condition gradient (Davies 2003; Jackson 2003). The gradient captures various levels of biological condition from natural (biological integrity) to highly impaired (i.e., not meeting Section 101(a) (2) Clean Water Act (CWA) "fishable" interim use goal). The biocondition gradient establishes a consistent framework for conveying biological information to resource managers and the public, and it can also serve as a template for refining water quality standards and aquatic life use designations.

Figure 2-42 shows the observed FIBI scores for the evaluated stream reaches of the Middle Cedar River Watershed. Twenty-six of 81 (32%) stream reaches contained fish communities with FIBI scores that would be considered excellent (FIBI exceeding 71). These excellent-rated stream reaches represent portions of Beaver Creek, Bear Creek, Dry Run Creek, Lime Creek, and West Otter Creek. No "poor" (FIBI below 25) fish communities were observed in the stretches of sampled streams in the Middle Cedar River Watershed.

Figure 2-43 shows the observed BMIBI scores for the evaluated stream reaches of the Middle Cedar River Watershed. Thirteen of 81 (16%) stream reaches contained benthic macroinvertebrate communities with BMIBI scores that would be considered excellent (BMIBI exceeding 76). These excellent stream reaches represent portions of Beaver Creek, Bear Creek, Lime Creek, and West Otter Creek. Five "poor" (FIBI below 25) macroinvertebrate communities were observed in the stretches of sampled streams in the Middle Cedar River Watershed. These poor-rated stream reaches represent portions of the Middle Fork South Beaver Creek, an unnamed tributary to the West Branch of Blue Creek, Miller Creek, and two unnamed tributaries to Lime Creek.

Table 2-14. Data metrics of the Benthic Macroinvertebrate Index of Biotic Integrity (BMIBI) and the Fish Index of Biotic Integrity (FIBI) – Source: Iowa DNR Biological Assessment of Iowa's Wadeable Streams

Benthic Macroinvertebrate Index of Biotic Integrity (BMIBI)	Fish Index of Biotic Integrity (FIBI)
1. MH*-taxa richness	1. # native fish species
2. SH*-taxa richness	2. # sucker species
3. MH-EPT richness	3. # sensitive species
4. SH-EPT richness	4. # benthic invertivore species
5. MH-sensitive taxa	5. % 3-dominant fish species
6. % 3-dominant taxa (SH)	6. % benthic invertivores
7. Biotic index (SH)	7. % omnivores
8. % EPT (SH)	8. % top carnivores
9. % Chironomidae (SH)	9. % simple lithophil spawners
10. % Ephemeroptera (SH)	10. fish assemblage tolerance index
11. % Scrapers (SH)	11. adjusted catch per unit effort
12. % Dom. functional feeding group (SH)	12. % fish with DELTs

* MH, Multi-habitat sample; SH, Standard-habitat sample.

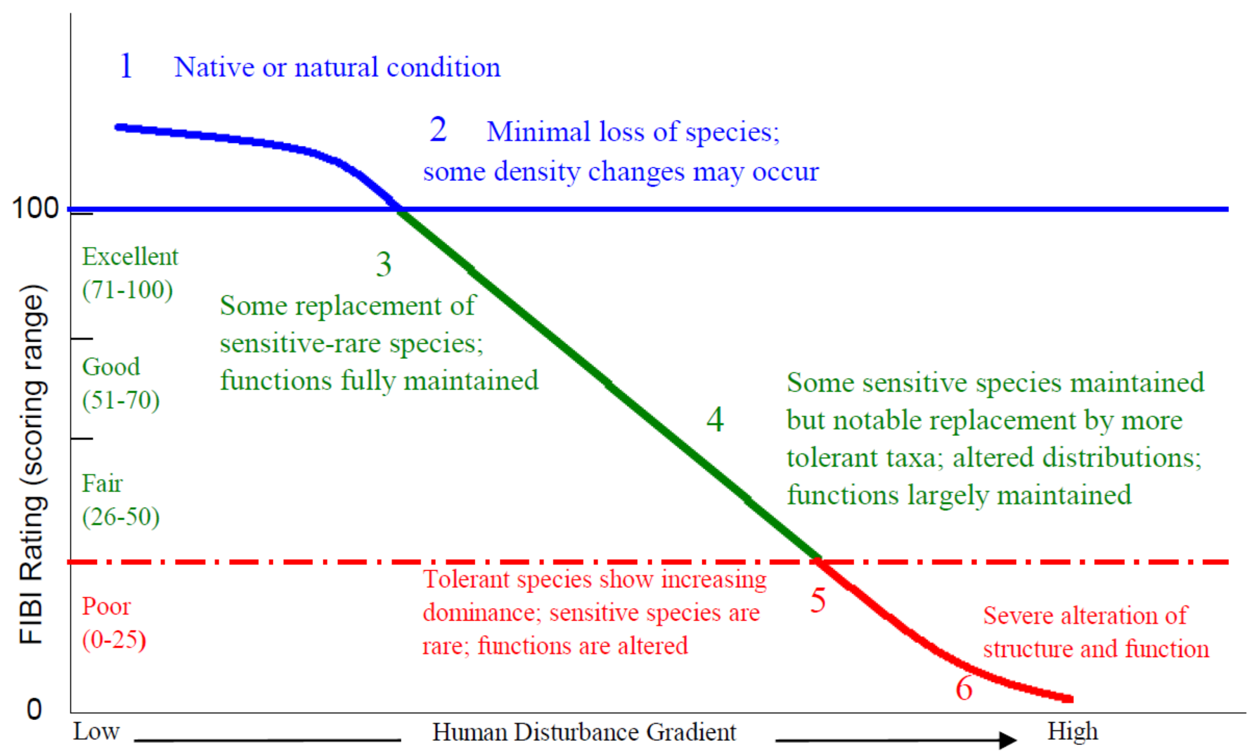


Figure 2-40. Fish Index of Biotic Integrity (FIBI) qualitative scoring ranges (excellent, good, fair, and poor) in relation to a conceptual tiered biological condition gradient (Adapted from Davies and Jackson 2006)

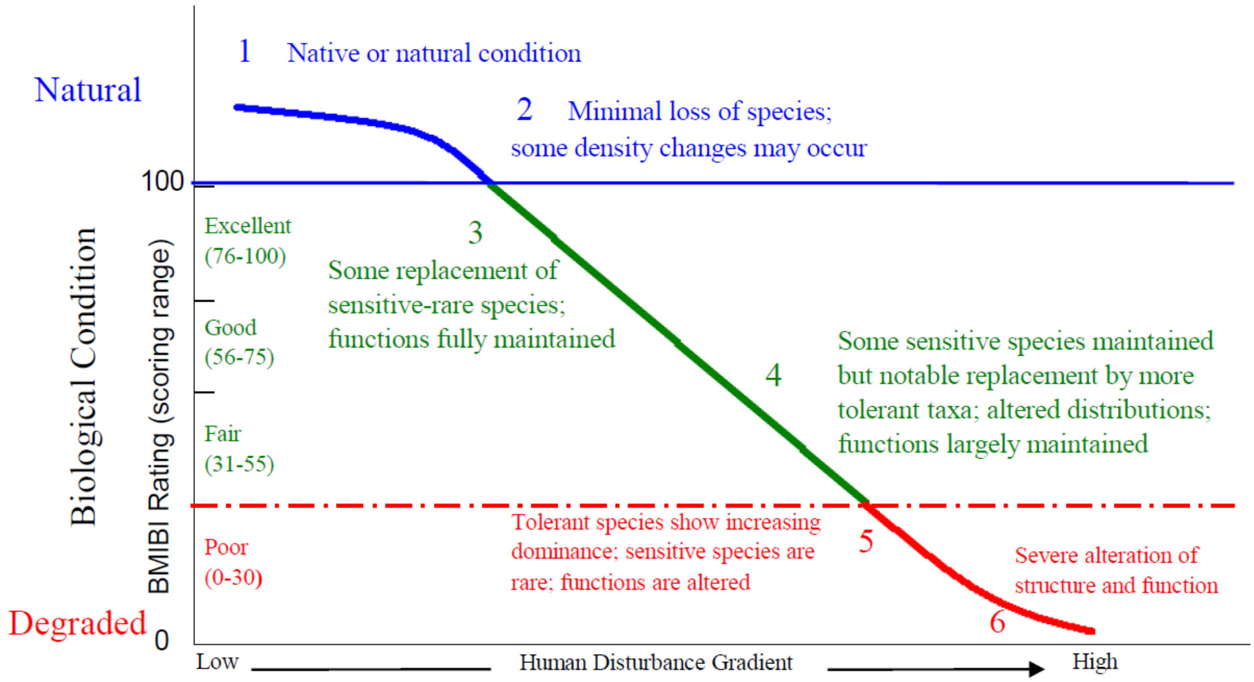


Figure 2-41. Benthic Macroinvertebrate Index of Biotic Integrity (BMIBI) qualitative scoring ranges (excellent, good, fair, and poor) in relation to a conceptual tiered biological condition gradient (Adapted from Davies and Jackson 2006)

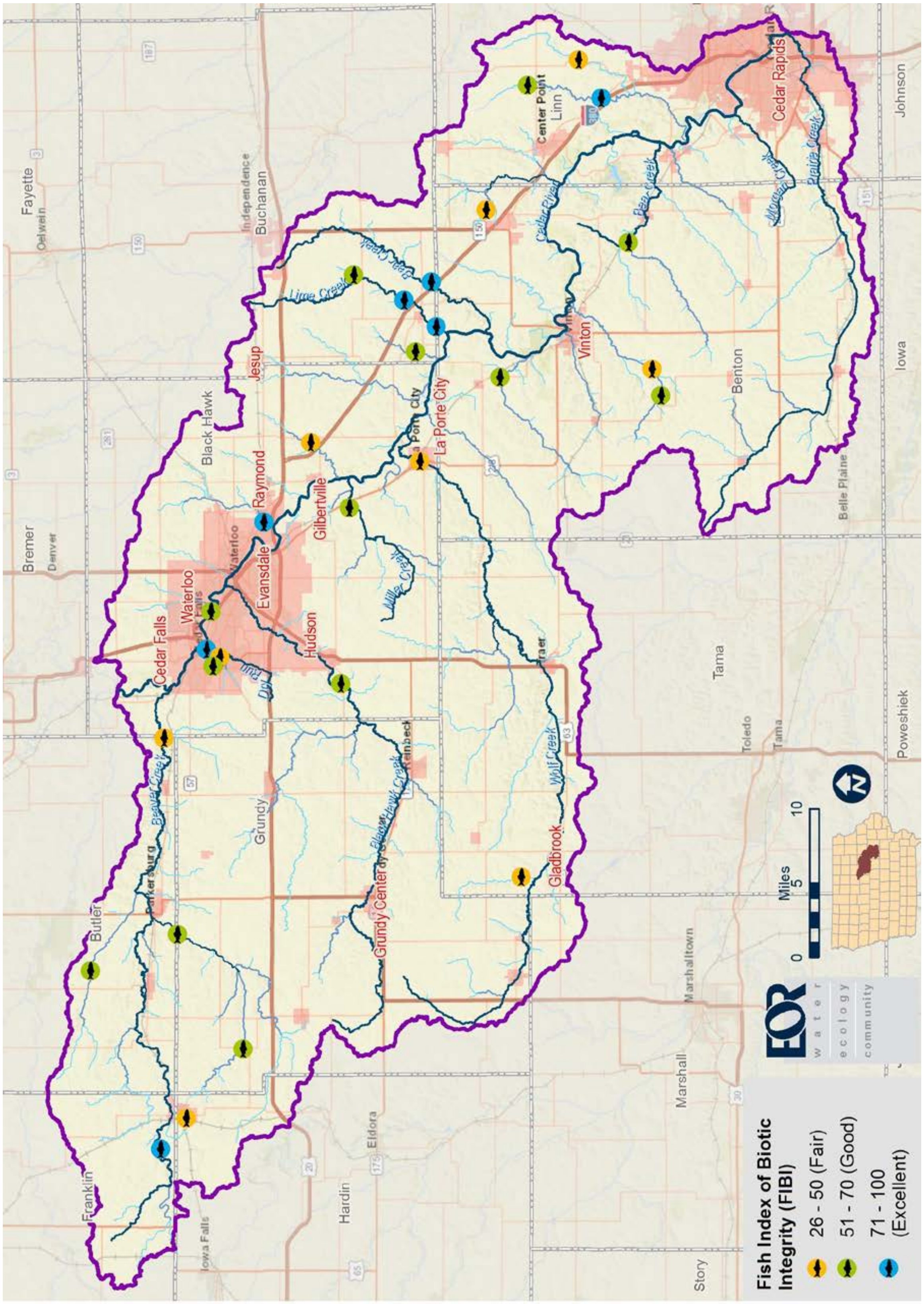


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Figure 2-42. Middle Cedar River Watershed Fish Index of Biotic Integrity (FIBI) Scores –1994-2016.

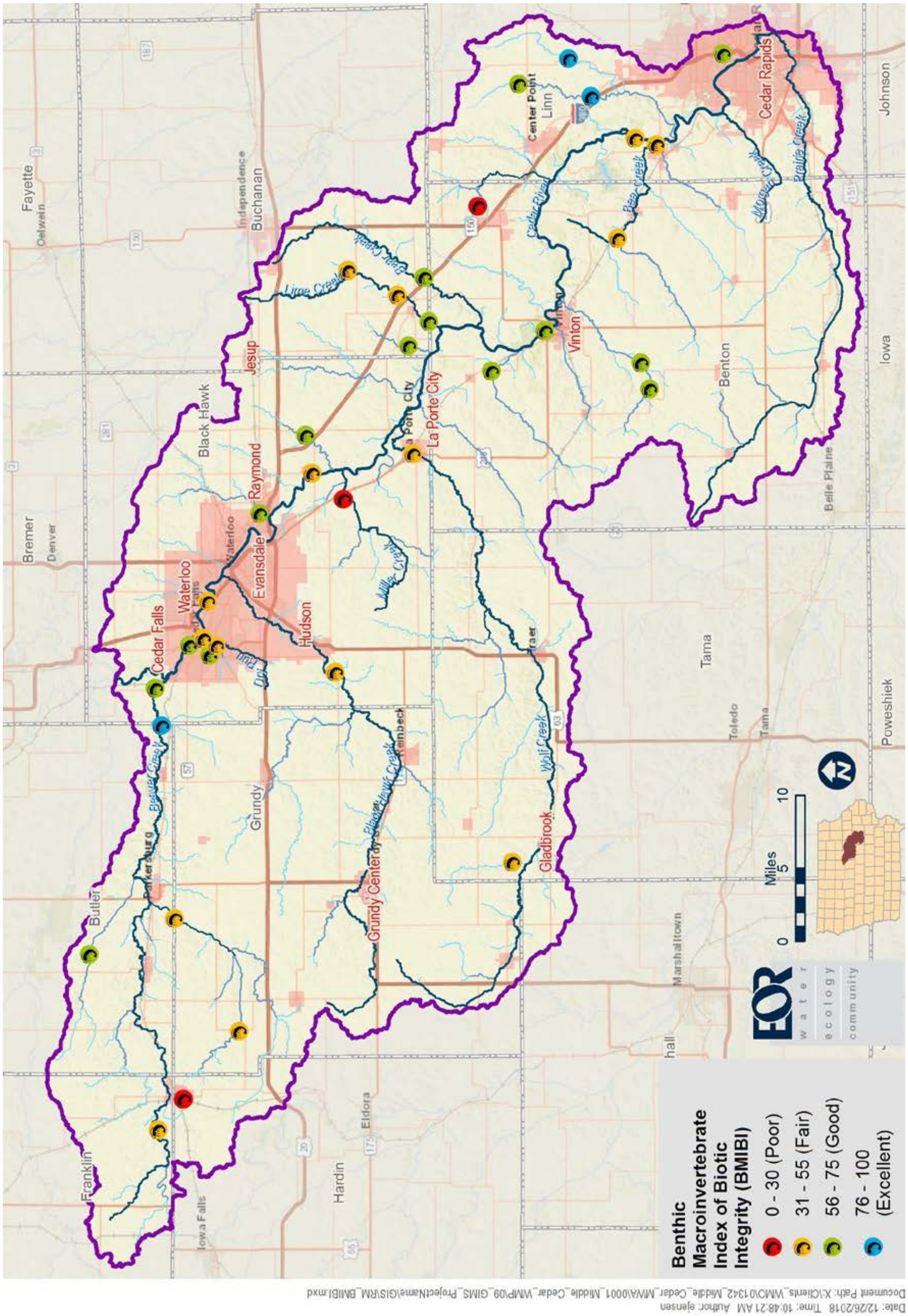


Figure 2-43. Middle Cedar River Watershed Benthic Macroinvertabrate Index of Biotic Integrity (BMIBI) Scores – 1994-2016.

2.9.6. Iowa Soybean Association Snapshot Monitoring

The ISA and Coe College have collaborated to collect more than 400 stream water samples from 60 locations in the Middle Cedar River watershed beginning in April of 2017. The objective of this monitoring effort was to execute a water quality monitoring snapshot of HUC-12s in the Middle Cedar River watershed to characterize the water quality conditions in subwatersheds in the Middle Cedar. The rationale is to collect data to inform watershed planning in the Middle Cedar and prioritization of HUC-12s for additional planning and implementation. Water quality sampling events in 2017 were limited to two sampling events, one in late April and a second event in June. In 2018, the intensity and frequency of sampling efforts increased to include the collection of samples over 2 consecutive days in each month from May through September. The results of the snapshot monitoring were provided to the city of Cedar Rapids. More information about the Middle Cedar Watershed Water Quality Snapshot program (Iowa Soybean Association 2017) is available on the ISA website (Figure 2-44). This monitoring program has helped to develop an understanding of the conditions of streams in the Middle Cedar Watershed and will be instrumental in the future as the program expands. With this program, the ISA has been able to gather large numbers of people to cover the whole watershed. Frequent sampling events over many years covering a broad extent of the watershed is the best way to assess the state of the watershed and measure the progress of MCWMA's initiatives. More information, including results from the 2018 monitoring season can be found by visiting the Middle Cedar Watershed 2018 Tributary Monitoring Results Story Map.

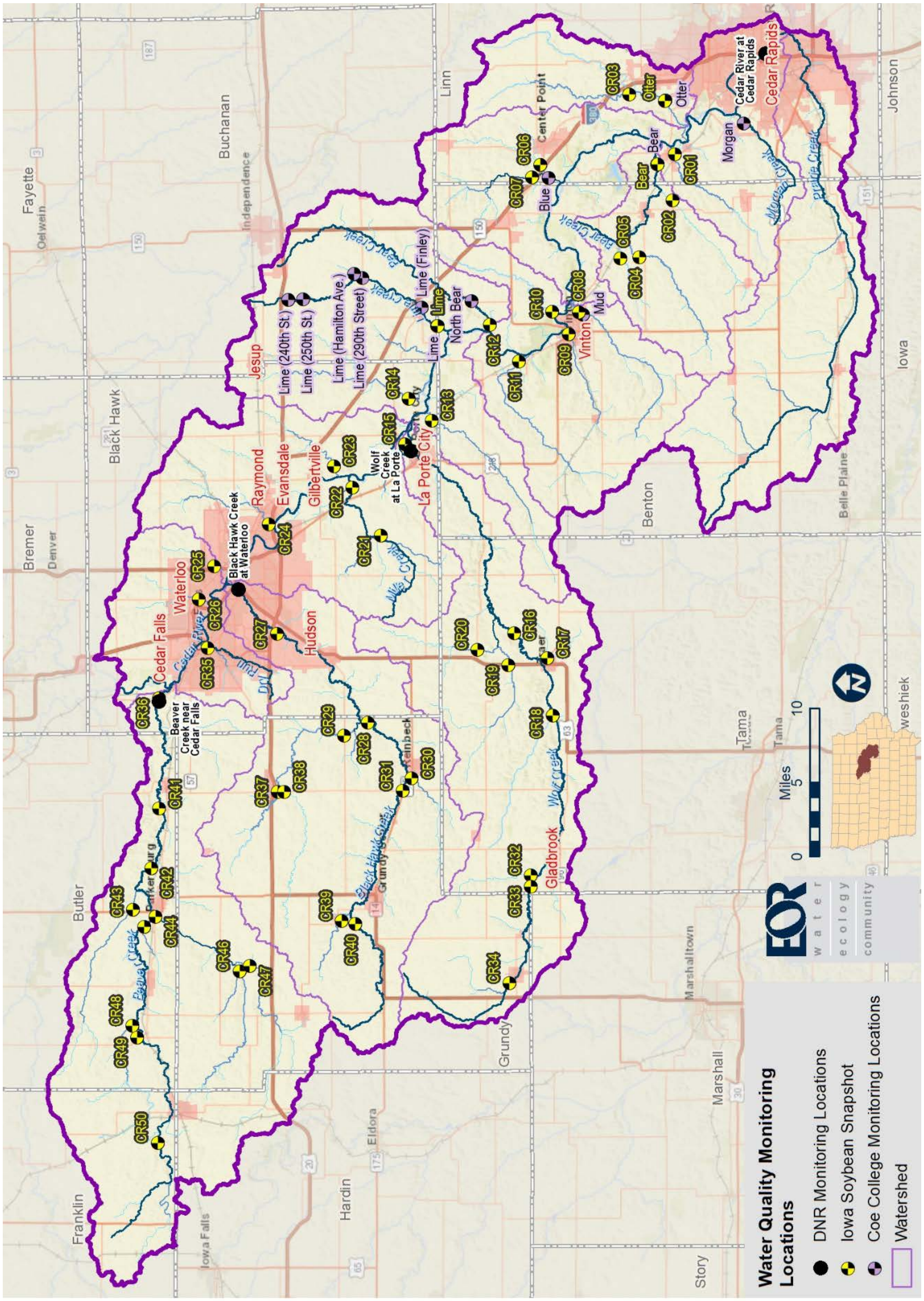


Figure 2-44. Water Quality Monitoring Locations

2.10. Pollutant Source Assessment

2.10.1. Hydrologic Assessment

As discussed in Section 1.1.1, a Hydrologic Assessment was performed by the University of Iowa IIHR- Hydroscience & Engineering Center/Iowa Flood Center for the Middle Cedar River Watershed. Key findings from this assessment are highlighted in the succeeding paragraphs.

Water Balance

Average annual precipitation for the Middle Cedar Watershed is approximately 36.0 inches. Of this precipitation amount, roughly 70% (25.0 inches) evaporates back into the atmosphere and the remaining 30% (11.0 inches) runs off the landscape into the streams and rivers. The majority of the runoff amount is baseflow (70% or 7.7 inches), and the rest is surface flow (30% or 3.3 inches). The soil distribution of the Middle Cedar shows that the watershed consists primarily of HSG B type soils (65.6%), which have a moderate runoff potential when saturated. Components of type B/D (27.1%) soils are present as well. Average monthly streamflow peaks in June, and decreases slowly through the summer growing season. In most years, the largest discharge observed during the year occurs in May or June, associated with heavy spring/summer rainfall events.

Water Balance Changes

The water cycle in the Middle Cedar River Watershed has changed due to land use and climate changes. Since the 1970s, Iowa has seen increases in precipitation, changes in timing of precipitation, and changes in the frequency of intense rain events. Streamflow records in Iowa (including those for the Middle Cedar watershed) suggest that average flows, low flows, and perhaps high flows have all increased and become more variable since the late 1960s or 1970s; however, the relative contributions of land use and climate changes are difficult to sort out.

Using land cover information obtained from well documented studies in 1859, 1875, and 2001, Wehmeyer et al. (2011) estimated that the increase in runoff potential in the first 30 years of settlement represents the majority of predicted change in the 1832 to 2001 study period. The study also outlines hydrologic alterations induced by climate change based on evidence provided in the recently released *The Climate Science Special Report* (USGCRP 2017). This study found that heavy rainfall is increasing in intensity and frequency across the United States and is expected to increase over the next few decades.

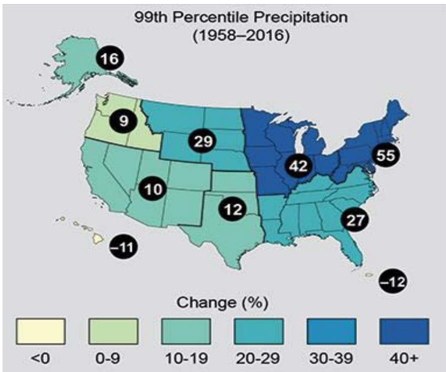


Figure 2-45. Observed change in heavy precipitation (the heaviest 1%) between 1958 and 2016. Figure taken from The Climate Science Special Report (USGCRP 2017)

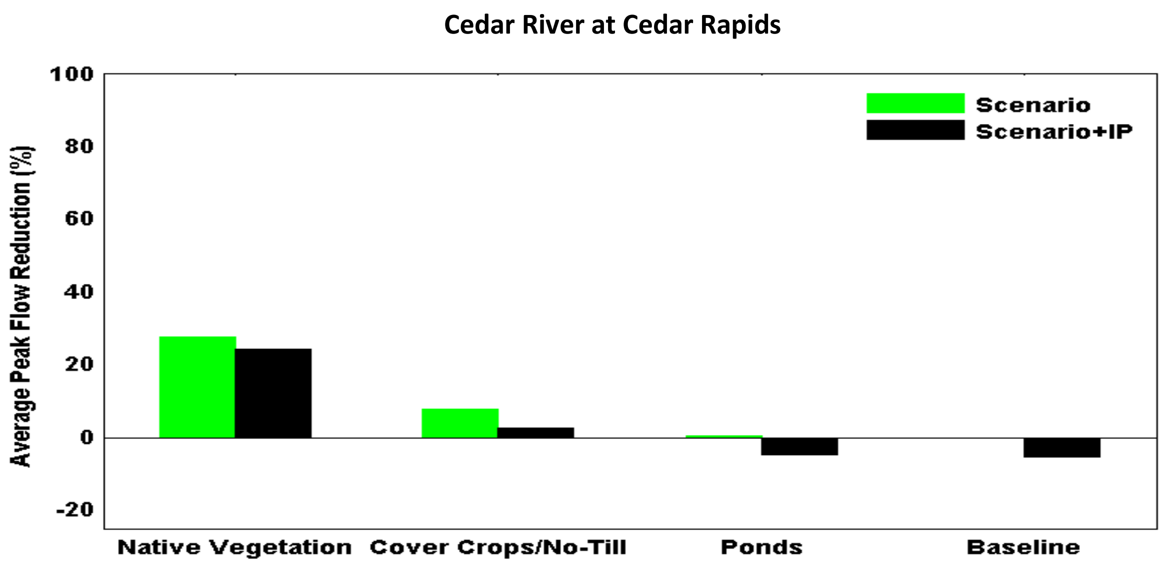
Generic Hydrologic Overland Subsurface Toolkit GHOST Model Results

To prioritize where practice implementation efforts are most needed, the University of Iowa's Hydroscience and Engineering Center (IIHR) used the Generic Hydrologic Overland Subsurface Toolkit (GHOST) to better understand high runoff potential areas and to evaluate potential flood mitigation strategies that can help to offset changes in the water cycle resulting from both land use and climate changes. Model results suggested that the eastern part of the watershed, with runoff coefficients of up to 47% (from 0% for no runoff to 100% when all rainfall is converted to runoff), had the highest runoff potential. Agricultural land use dominates the eastern areas of the watershed. To evaluate the impact of flood mitigation strategies on reducing the runoff potential within these high runoff potential areas and ultimately reduce downstream peak flood discharges, the following 3 scenarios were run within the GHOST model:

1. Conversion of 100% of the rowcrop acres to native vegetation.
2. Adoption of both no-till and cover crops in 100% of the rowcrop acres
3. A distributed storage system built with ponds (684) located in the headwater catchments.

Figure 2-46 summarizes the modeled results from each flood mitigation strategy in terms of the strategy's capacity to reduce peak discharges relative to other mitigation strategies at two different index points within the Middle Cedar River Watershed using both historic precipitation totals and increased precipitation totals associated with plausible future climate scenarios. The restoration of all agricultural lands to tallgrass prairie had the greatest flood reduction impact while distributed storage (implanting 684 ponds) had the lowest impact for both streams under both historic and future precipitation totals.

While it is unlikely that all row crops in the Middle Cedar Watershed will ever be converted to native grasslands, implementation of Cover Crops/No-Till is a feasible management practice that when implemented throughout agricultural watersheds shows potential to lead to important flood reduction benefits. Based on the Middle Cedar model results, implementation of Cover Crops/No-till shows average peak flood reductions of 40% with historic rain and 30% with increased precipitation at Wolf Creek near Dysart. Interestingly, while the 684 ponds associated with the distributed storage system scenario provide peak flow reductions of up to 15% in the tributaries with historic rain, when increased precipitation conditions were simulated model results show higher peak flows than those of the baseline condition (with historic rain). **This result suggests that more emphasis must be placed on practices that promote increases in infiltration that treat rainfall onsite rather than at downstream locations (i.e., stormwater ponds).**



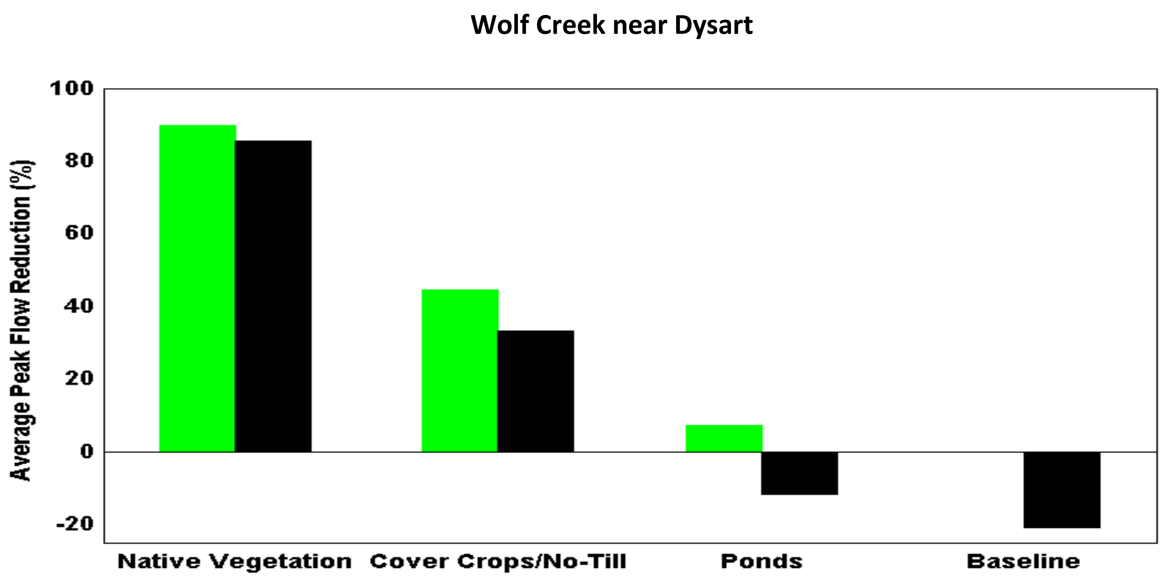


Figure 2-46. Average peak flow reductions for all the simulations at two different index points. Top: Cedar River at Cedar Rapids and bottom: Wolf Creek near Dysart. IP stands for increased precipitation associated with future predicted climate scenarios.(USGCRP 2017).

2.10.2. Soil and Water Assessment Tool (SWAT) Model

The Nature Conservancy (TNC), University of Minnesota, and World Wildlife Fund (WWF) partnered together in 2014 to conduct Soil and Water Assessment Tool (SWAT) modeling and optimization at multiple scales in the Middle Cedar River Watershed. This work began with the development of a fine resolution SWAT model for 14 Middle Cedar Partnership Project (MCPP) HUC-12 priority watersheds and a coarse resolution SWAT model for the entire Middle Cedar River Watershed Basin. The ultimate purpose is to develop an optimization tool that combines SWAT model (nutrient, sediment loads and crop yields) with an agricultural profit model to evaluate tradeoffs between environmental outcomes and agricultural revenue.

Since 2017, the team has worked to refine the model resolution for the entire Middle Cedar River Watershed including full hydrologic response unit coverage with Soil Survey Geographic Database (SSURGO) information. The modeling work is largely being led by the University of Minnesota and the WWF while the TNC plays a facilitator role between the Middle Cedar River Watershed Management Authority (WMA), and stakeholders in the watershed.

Currently, the modeling team is working to improve wetland representation in the SWAT model by incorporating local hydrology and nutrient transformation. Additional future model improvements include:

- Incorporate additional BMPs, i.e., saturated buffers
- Incorporate switchgrass and alfalfa plantings
- Improve economic models and valuations of ecosystem service benefits resulting from BMP implementation (water quality, air quality, climate change mitigation, etc.) Help to better define objective to achieve water quality goals
- User interface improvements of decision tool
    - Improve tool visualization or results to enhance usability by stakeholders. Incorporate commodity price and input uncertainty.

Existing results from the SWAT model have been integrated into this WMP and were used to develop maps which helped to visualize and prioritize future implementation efforts at the HUC-12 scale based on modeled nitrogen (Figure 2-47), tile nitrate (Figure 2-48), total phosphorus (Figure 2-49), sediment (Figure 2-50) loading, and average annual water yield (Figure 2-51) estimates.

Modeled total phosphorus loading rates as shown in Figure 2-49 were higher than reported in a review of typical phosphorus loading from literature values. A review of multiple literature sources including 1) MPCA's 2004 Detailed Assessment of Phosphorus Sources to Minnesota Watersheds, and 2) a technical memorandum to the Minnesota Board of Water and Soil Resources regarding the PTMApp toolset

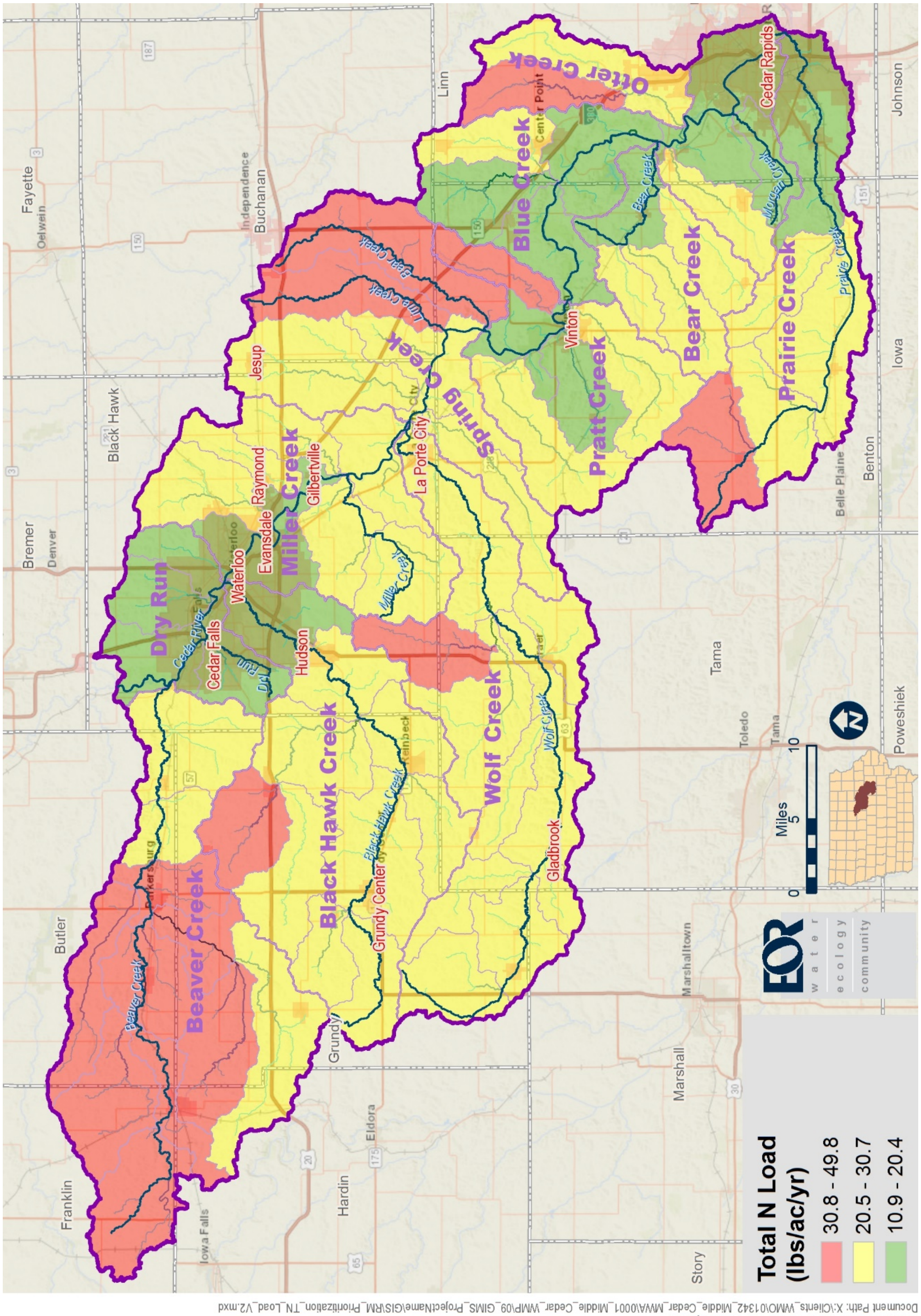


Figure 2-47. Average Annual Total Nitrogen Loading (SWAT Model)

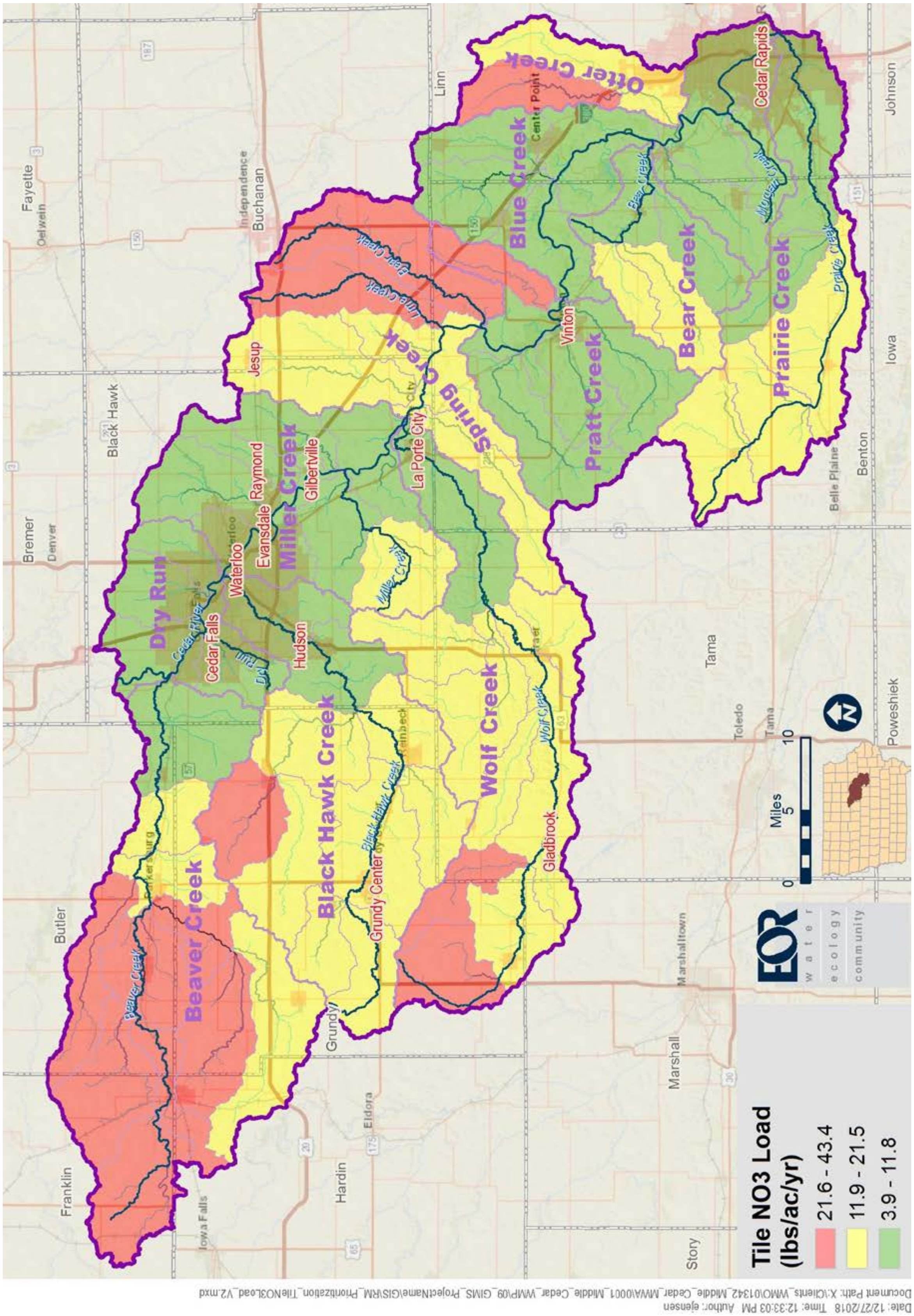


Figure 2-48. Average Annual Tile NO3 Loading (SWAT Model)

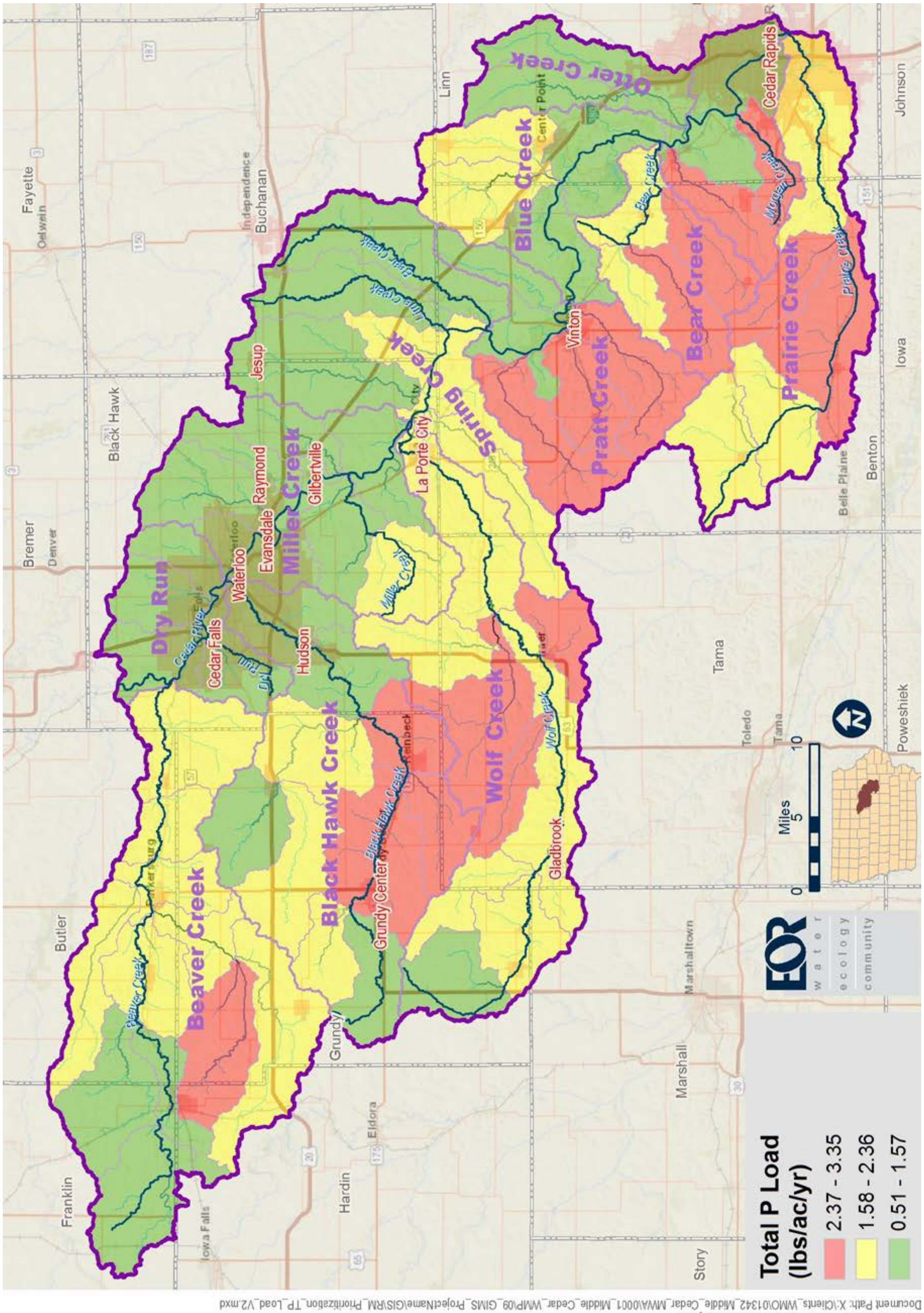


Figure 2-49. Average Annual Total Phosphorus Loading (SWAT Model)

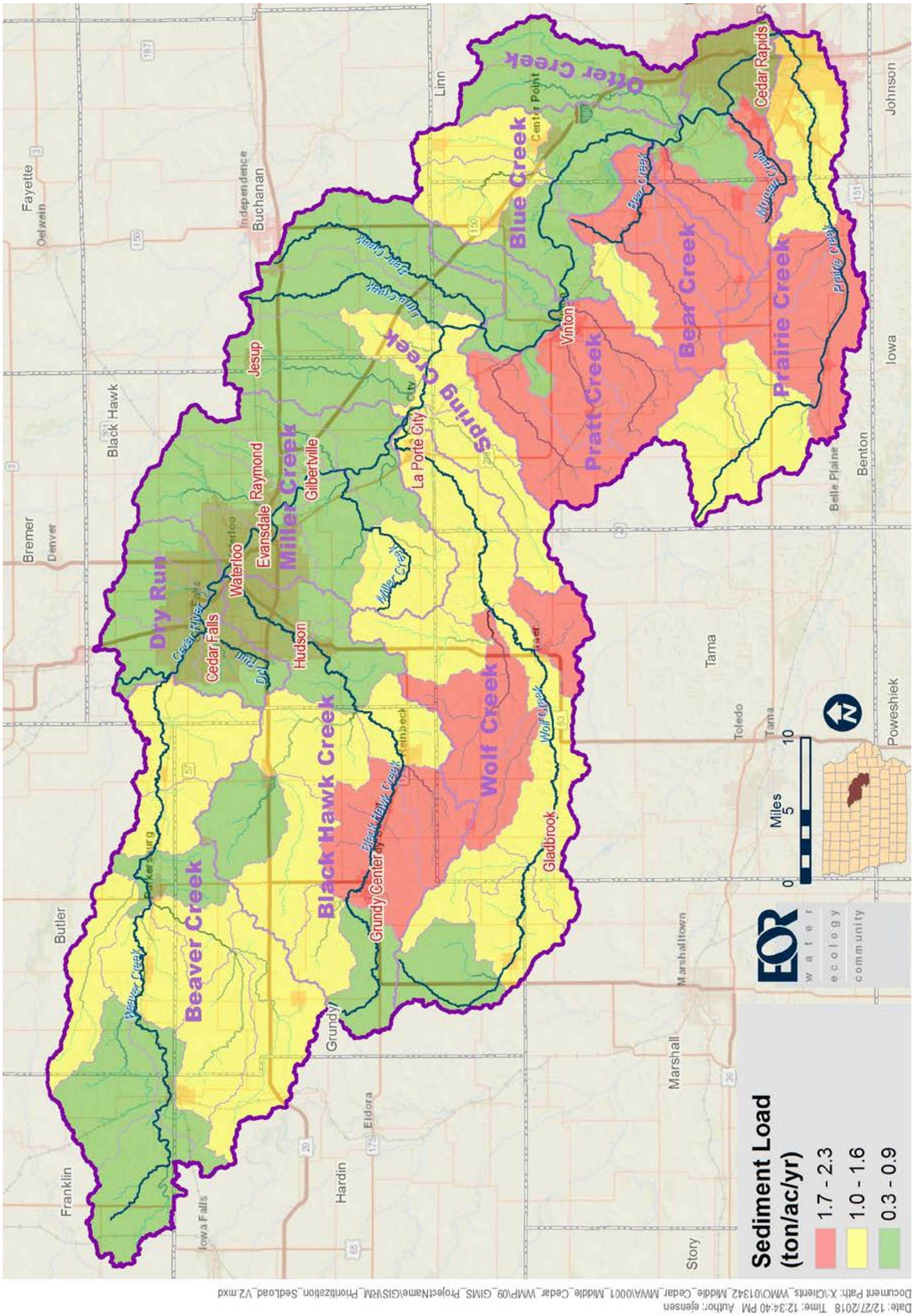


Figure 2-50. Average Annual Sediment Load (SWAT Model)

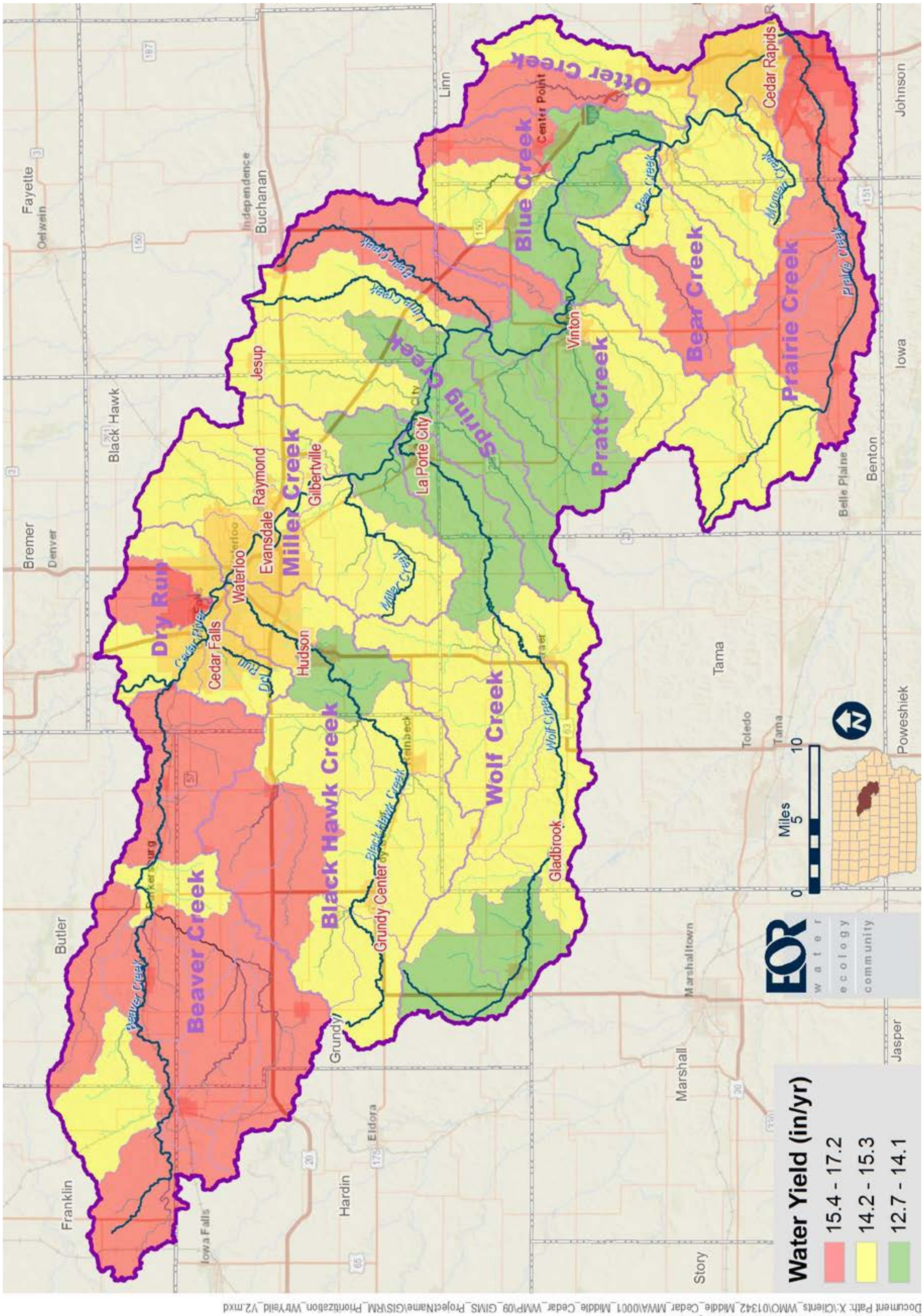


Figure 2-51. Average Annual Water Yield (SWAT Model)

2.10.3. Daily Erosion Project

The Daily Erosion Project (DEP) is a free online tool that allows users to understand how fast soil is being lost off the land. The tool arms farmers and conservation planner with the information needed to make effective decisions regarding resources. The tool takes precipitation data provided by the Next Generation Weather Radar (NEXRAD) and estimates the amount of soil erosion taking place on the land based on soil type, vegetative cover and slope on a daily basis. The tool also estimates Hillslope Soil Loss using the Water Erosion Prediction Project (WEPP) Model. The DEP addresses sheet and rill erosion but does not account for gully erosion, which may lead to an underestimation of erosion using this model. Further documentation of the Daily Erosion Project can be found on the project website (Iowa State University 2019).

DEP users can either view data for a single day or choose to enter a specific date range of interest. Data can be viewed for the entire State of Iowa (and beyond) or at the very local, HUC-12 subwatershed scale. An example of the DEP output for a single day is shown in Figure 2-52.

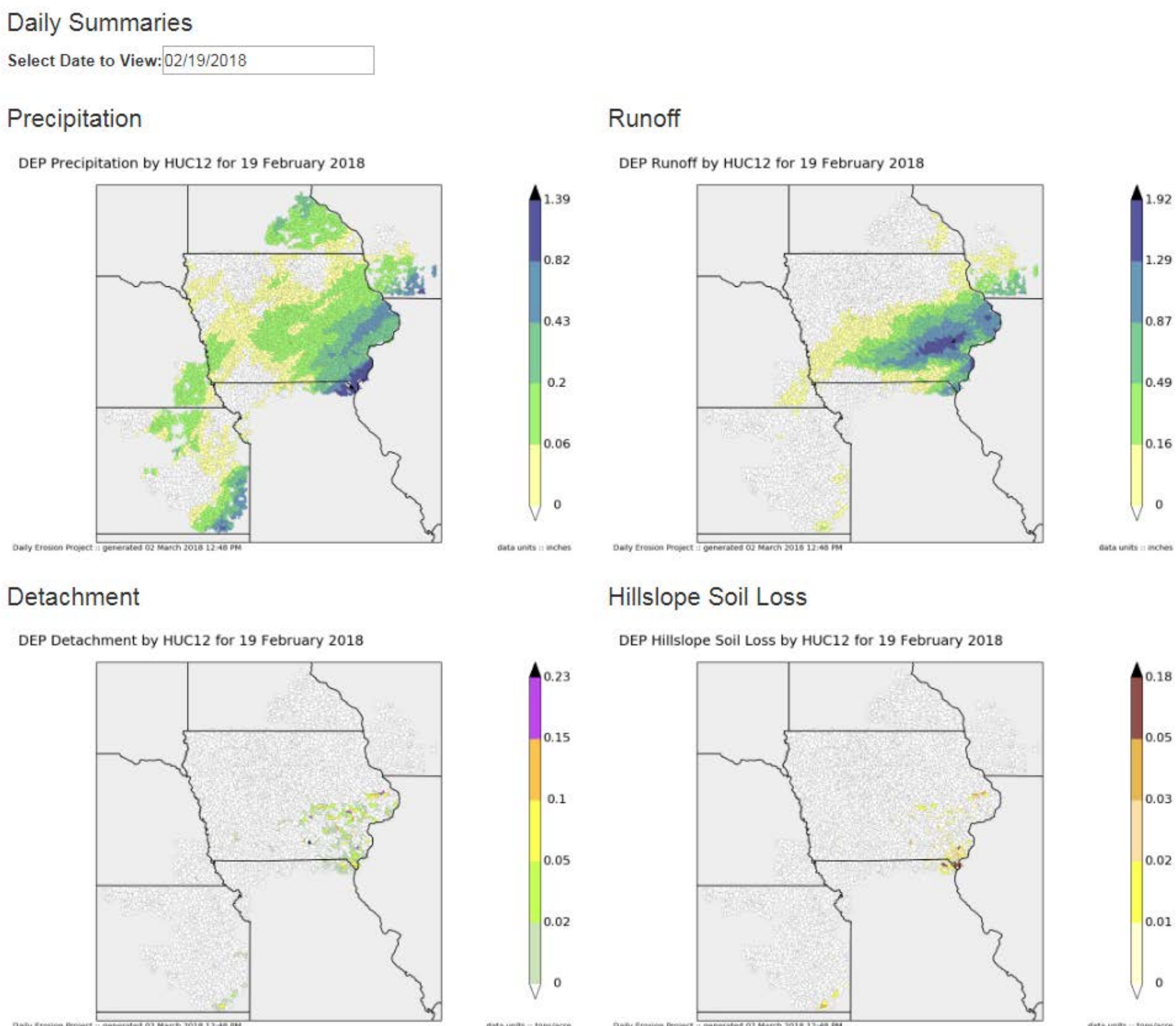


Figure 2-52. Example Output from the Daily Erosion Project (DEP) Website.

The DEP was run for the sixty-eight HUC-12 subwatersheds in the Middle Cedar Watershed for the ten year period 2008-2017. The results were used to determine the average annual soil detachment (Figure 2-53) and average annual hillslope soil loss (Figure 2-54) that has been estimated for each subwatershed.

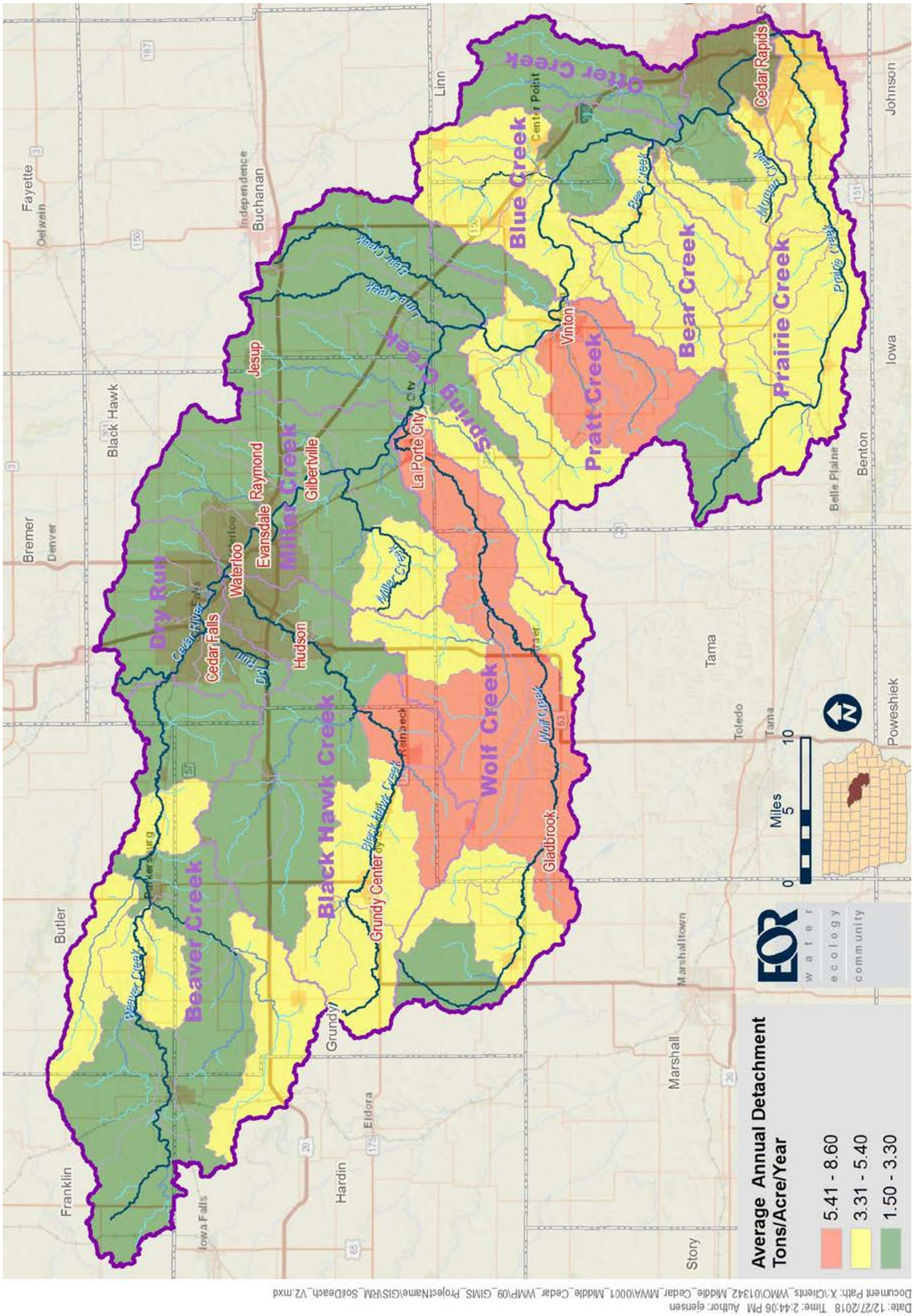


Figure 2-53: Average Annual Soil Detachment (Daily Erosion Project) 2008-2017

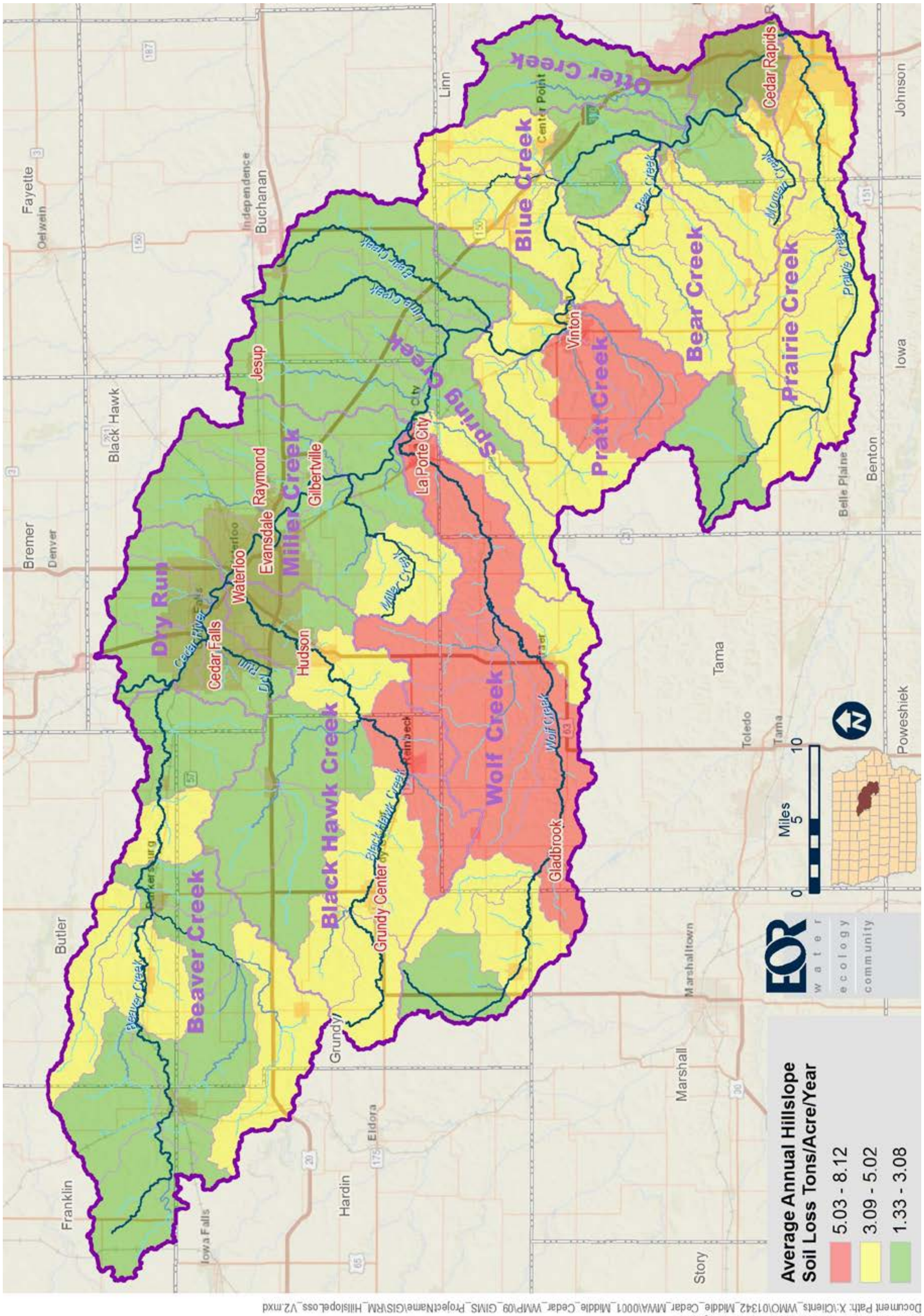


Figure 2-54. Average Annual Hillslope Soil Loss (Daily Erosion Project) 2008-2017

2.11. Existing Conservation Practices

The Iowa DNR in cooperation with Iowa State University conducted an inventory of agricultural conservation practices throughout Iowa .According to the DNR project website "The goal of the Iowa BMP (Best Management Practices) Mapping Project is to provide a complete baseline set of BMPs dating from the 2007-2010 timeframe for use in watershed modeling, historic occurrence, and future practice tracking. The BMPs being mapped are: Terraces, Water and Sediment Control Basins (WASCOB), Grassed Waterways, Pond Dams, Contour Strip Cropping and Contour Buffer Strips. We can't guarantee that mapped practices meet NRCS standards or that they are actually the indicated practice since no ground truthing is being performed. Data being utilized to digitize the BMPs include LiDAR derived products such as DEM, Hillshade and Slope grids; CIR aerial photography from the 2007-2010 timeframe, NAIP aerial photography and historic aerial photography. BMPs are being collected by 12-digit HUC and finished products can be downloaded from https://athene.gis.iastate.edu/consprac/consprac.html." This information was used to determine the existing adoption rates for each of the practices as we developed the conservation practice implementation plan for each subwatershed. The data is too detailed to map at the HUC-8 scale but a summary is included in Table 2-15.

This project was funded by the Iowa Department of Natural Resources, Iowa Department of Agriculture and Land Stewardship, Iowa Nutrient Research Center at ISU, National Laboratory for Agriculture and the Environment and Iowa Nutrient Research and Education Council.

Table 2-15. Existing Conservation Practices in the Middle Cedar Watershed: BMP Mapping Project

HUC -12 Name	# of WASCOBs	# of Pond Dams	Strip-cropping Acres	Terrace Feet	Contour Buffer Strip (Acres)	Grassed Waterways (Acres)
Middle Fork South Beaver Creek	110	6	0	20,322	0	366
Headwaters South Beaver Creek	90	9	0	97,627	0	351
South Beaver Creek	9	2	83	30,237	21	116
Headwaters Beaver Creek	43	4	30	183,154	201	240
North Beaver Creek	35	6	0	92,194	99	236
Drainage Ditch 148-Beaver Creek	126	3	0	32,169	28	135
Gran Creek-Beaver Creek	195	4	0	13,584	235	164
Johnson Creek	170	15	0	85,852	86	248
Phelps Creek-Beaver Creek	44	3	0	35,801	0	135
Max Creek- Beaver Creek	74	26	0	38,443	207	115
Hammers Creek- Beaver Creek	84	24	0	125,122	26	274
South Fork Black Hawk Creek	3	2	0	27,870	0	203
Headwaters N. Fork Black Hawk Crk	2	5	0	16,248	0	112
North Fork Black Hawk Creek	47	5	0	189,880	0	837
Holland Creek	12	1	0	1,422	0	175
Headwaters Black Hawk Creek	57	4	0	115,311	140	239
Mosquito Creek	14	3	0	38,363	11	352
Minnehaha Creek-Black Hawk Crk.	65	5	0	87,500	11	591
Village of Reinbeck-Black Hawk Crk.	63	0	0	56,070	0	278
Wilson Creek-Black Hawk Creek	88	4	228	127,494	150	281
Prescotts Creek-Black Hawk Creek	25	7	0	100,481	161	235

HUC -12 Name	# of WASCOBs	# of Pond Dams	Strip-cropping Acres	Terrace Feet	Contour Buffer Strip (Acres)	Grassed Waterways (Acres)
Dry Run	10	8	0	15,446	10	106
Waterloo Municipal Airport	34	15	0	25,719	0	138
Black Hawk Park-Cedar River	27	13	0	55,615	18	196
Headwaters Wolf Creek	8	0	0	45,555	0	188
Little Wolf Creek	19	1	117	39,369	85	207
Village of Conrad-Wolf Creek	27	1	0	12,285	0	419
Fourmile Creek	102	10	25	75,133	381	275
Coon Creek	34	1	0	8,196	129	302
Rock Creek	37	1	53	59,553	75	424
Twelvemile Creek	78	11	106	44,566	245	730
Devils Run-Wolf Creek	169	10	137	115,853	871	709
Wolf Creek	27	32	262	236,747	798	697
Elk Run	36	14	0	68,912	178	727
Poyner Creek	16	3	0	7,824	0	165
Indian Creek	19	5	0	17,911	28	206
Headwaters Miller Creek	19	3	0	82,702	79	485
Miller Creek	33	9	0	182,983	95	309
Sink Creek-Cedar River	40	3	0	4,856	0	138
Mud Creek-Cedar River	39	5	0	52,240	66	240
Rock Creek-Cedar River	81	7	0	119,467	239	460
Spring Creek	172	7	0	44,960	41	575
Lime Creek	22	17	0	72,361	120	438
Bear Creek-Cedar River	69	14	9	77,616	77	501
McFarlane State Park-Cedar River	48	18	0	106,357	122	406
Pratt Creek	13	11	0	320,255	564	610
Hinkle Creek	8	14	142	303,467	559	479
Prairie Creek-Cedar River	6	4	82	18,542	43	171
Mud Creek	26	6	0	167,854	461	575
Dudgeon Lake State Wildlife Management Area-Cedar River	0	6	0	65,045	317	86
Opossum Creek	2	2	0	15,967	0	169
Wildcat Creek	12	3	0	50,588	0	407
Little Bear Creek	31	7	53	27,815	165	330
Bear Creek	1	41	37	77,988	313	127
West Otter Creek	4	8	29	0	40	154
East Otter Creek-Otter Creek	13	27	0	13,927	32	148
Headwaters Prairie Creek	1	3	0	11,501	54	251
Village of Van Horne-Prairie Creek	1	4	32	27,348	314	409
Mud Creek-Prairie Creek	10	2	155	32,905	77	328
Weasel Creek-Prairie Creek	2	6	101	37,523	409	621
Prairie Creek	33	11	0	58,927	209	452
East Branch Blue Creek	28	11	0	55,140	232	232
Blue Creek	58	20	0	63,245	158	292
Wildcat Bluff-Cedar River	33	62	29	75,538	17	171
Nelson Creek-Cedar River	21	54	63	23,306	66	100

HUC -12 Name	# of WASCOBs	# of Pond Dams	Strip-cropping Acres	Terrace Feet	Contour Buffer Strip (Acres)	Grassed Waterways (Acres)
Dry Creek	14	1	20	34,065	95	253
Morgan Creek	3	8	28	15,835	70	213
Silver Creek-Cedar River	110	6	0	20,322	0	366
TOTAL	**2952**	**663**	**1821**	**4604473**	**9228**	**21668**

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