Redeye River Watershed Pollutant Reduction Project (Total Maximum Daily Load Study) For Bacteria

Minnesota Pollution Control Agency

September 2016

wq-iw8-48e

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Acronyms

AU	animal units
AUID	Assessment Unit ID
AVMA	American Veterinary Medical Association's
BMP	Best Management Practice
CAFO	Concentrated Animal Feeding Operation
cfs	cubic feet per second
cfu	colony-forming unit
CRP	Conservation Reserve Program
DO	Dissolved Oxygen
DNR	Minnesota Department of Natural Resources
EPA	Environmental Protection Agency
EQUIP	Environmental Quality Incentives Program
EQuIS	Environmental Quality Information System
HSPF	Hydrologic Simulation Program-Fortran
IBI	index of biological integrity
ITPHS	imminent threat to public health and safety
ITPHSS	imminent threat to public health septic systems
in/yr	inches per year
km^2	square kilometer
LA	Load Allocation
LDC	load duration curve
m	meter
mg/L	milligrams per liter
mg/m^2-day	milligram per square meter per day
mL	milliliter
MOS	Margin of Safety
MPCA	Minnesota Pollution Control Agency
MPN	Most Probable Number (of bacteria organisms)
MS4	Municipal Separate Storm Sewer Systems
NPDES	National Pollutant Discharge Elimination System
NWI	National Wetland Inventory
SDS	State Disposal System
SID	Stressor Identification
SSTS	Subsurface Sewage Treatment Systems
SWCD	Soil & Water Conservation District
SWPPP	Stormwater Pollution Prevention Plan
TMDL	Total Maximum Daily Load
TP	Total phosphorus
µg/L	microgram per liter
WLA	Wasteload Allocation
WRAPS	Watershed Restoration and Protection Strategies
WWTF	Wastewater Treatment Facility

Executive Summary

The Clean Water Act (1972) requires that each State develop a plan to identify and restore any waterbody that is deemed impaired by state regulations. A Total Maximum Daily Load Study (TMDL) is required by the Environmental Protection Agency (EPA) as a result of the federal Clean Water Act. A TMDL identifies the pollutant that is causing the impairment and how much of that pollutant can enter the waterbody and still meet water quality standards.

This TMDL study includes eight stream reaches located in the Redeye River Watershed (HUC 07010107), a tributary to the Mississippi River in central Minnesota, that are on the 2014 EPA 303(d) list of impaired waters due to elevated levels of bacteria.

Information from multiple sources was used to evaluate the ecological health of each waterbody:

- All available water quality data over the past 10 years
- Stream field surveys
- Stressor identification (SID) investigations
- Hydrologic Simulation Program-Fortran (HSPF) model
- Stakeholder input

The following pollutant sources were evaluated for each stream: watershed runoff, loading from upstream waterbodies, point sources, feedlots, and septic systems. An inventory of pollutant sources was used to develop a load duration curve (LDC) model for each impaired stream. These models were then used to determine the pollutant reductions needed for the impaired waterbodies to meet water quality standards.

The findings from this TMDL study will be used to aid the selection of implementation activities as part of the Redeye River Watershed Restoration and Protection Strategy (WRAPS) process. The purpose of the WRAPS report is to support local working groups and jointly develop scientifically-supported restoration and protection strategies to be used for subsequent implementation planning. Following completion, the WRAPS report will be publically available on the Minnesota Pollution Control Agency (MPCA) Redeye River Watershed website:

https://www.pca.state.mn.us/water/watersheds/redeye-river

1. Project Overview

1.1. Purpose

This TMDL study addresses aquatic recreation use impairments due to *E. coli* in eight stream reaches in the Redeye River Watershed located in central Minnesota. The goal of this TMDL is to provide wasteload allocations (WLAs) and load allocations (LAs) and to quantify the pollutant reductions needed to meet the state water quality standards. These TMDLs are being established in accordance with section 303(d) of the Clean Water Act, because the state of Minnesota has determined that these lakes and streams exceed the state established standards.

1.2. Identification of Waterbodies

This TMDL study addresses eight streams within the Redeye River Watershed (HUC 07010107) on the EPA 303(d) list of impaired waters for aquatic recreation use impairments due to elevated levels of *E. coli* (Table 1 and Figure 1). None of the streams with impaired fish or macroinvertebrates were determined to be primarily caused by a pollutant based stressor during the SID process (see Section 1.4) and will not be addressed in this TMDL study. These biological impairments will therefore be addressed through restoration strategies identified in the WRAPS report.

1.3. Priority Ranking

The MPCA's projected schedule for TMDL completions, as indicated on the 303(d) impaired waters list, implicitly reflects Minnesota's priority ranking of this TMDL. Ranking criteria for scheduling TMDL projects include, but are not limited to: impairment impacts on public health and aquatic life; public value of the impaired water resource; likelihood of completing the TMDL in an expedient manner, including a strong base of existing data and restorability of the waterbody; technical capability and willingness locally to assist with the TMDL; and appropriate sequencing of TMDLs within a watershed or basin.

Table 1. Impaired streams in the Redeye River Watershed. Shaded rows indicate an impairment addressed in this study.

AUID	Name	Location/Reach Description	Designated Use Class	Listing Year	Target Start/ Completion	Affected Use: Pollutant/ Stressor
07010107-503	Redeye River	Headwaters (Wolf Lk - Hay Cr.)	2B, 3C	2014	2011/2015	*Aquatic Recreation*: *Escherichia coli*
07010107-505	Leaf River	Oak Cr. to Wing River	2B, 3C	2014	2011/2015	
07010107-508	Union Creek	Whisky Cr. to Wing River	1B, 2A, 3B	2014	2011/2015	
07010107-514	Leaf River	Bluff Creek to Oak Creek	2B, 3C	2014	2011/2015	
07010107-515	Bluff Creek	Headwaters to Leaf River	2C	2014	2011/2015	
07010107-516	Oak Creek	Unnamed Ditch to T134 R36W S3, north line	2C	2014	2011/2015	
07010107-526	Un. Cr. (Hay Creek)	T134 R33W S18, west line to Leaf River	1B, 2A, 3B	2014	2011/2015	
07010107-560	Wing River	Hwy 210 Bridge to Leaf River	2B, 3C	2014	2011/2015	
07010107-508	Union Creek	Whisky Cr. to Wing River	1B, 2A, 3B	2016*	2011/2015	*Aquatic Life:* Fish or Macroinvertebrate Bioassessments
07010107-553	South Bluff Creek	Unnamed ditch to unnamed creek	2B, 3C	2014	2011/2015	
07010107-554	Unnamed Creek	CD 49 to East Leaf Lake	2B, 3C	2014	2011/2015	
07010107-557	Unnamed Creek	Unnamed creek to Leaf River	2B, 3C	2014	2011/2015	
07010107-559	Wing River	Headwaters to Hwy 210 bridge	2B, 3C	2014	2011/2015	

* Expected to be on the 2016 303(d) list

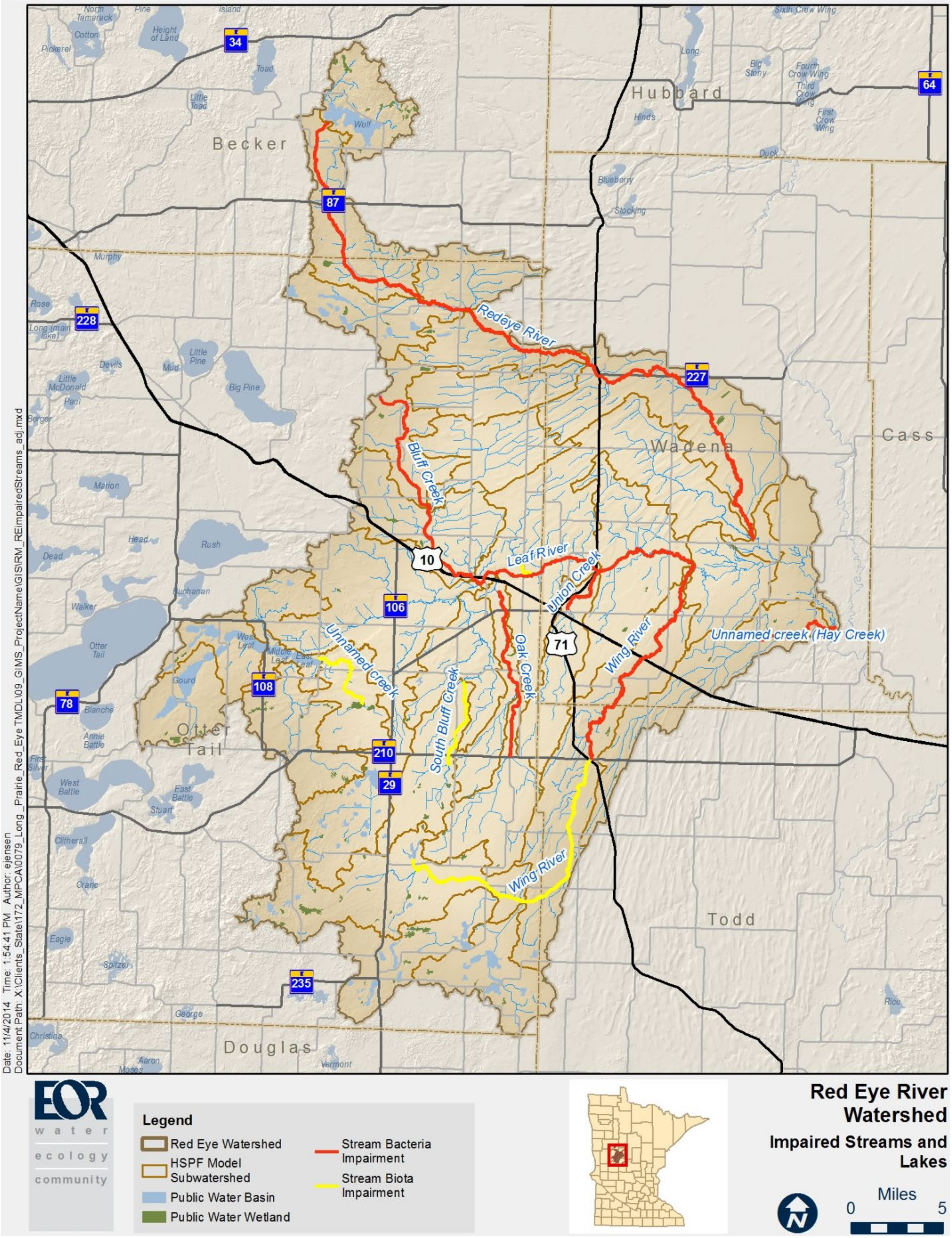


Figure 1. Redeye River Watershed impaired waters

1.4. Stressor Identification Summary

The fish or macroinvertebrate bioassessment impairments in the Redeye River Watershed were characterized by low IBI scores for fish and/or macroinvertebrates. The presence of a healthy, diverse, and reproducing aquatic community is a good indication that the aquatic life beneficial use is being supported by a lake, stream, or wetland. The aquatic community integrates the cumulative impacts of pollutants, habitat alteration, and hydrologic modification on a waterbody over time. Monitoring of the aquatic community is accomplished using an index of biological integrity (IBI) which incorporates multiple attributes of the aquatic community, called “metrics”, to evaluate complex biological systems. For further information regarding the development of stream IBIs, refer to the MPCA *Guidance Manual for Assessing the Quality of Minnesota Surface Waters for the Determination of Impairment: 305(b) Report and 303(d) List*.

A SID Study was completed by the MPCA (2014) to determine the cause of low fish and macroinvertebrate scores in the Redeye River Watershed, and is summarized in Table 2. Each Assessment Unit ID (AUID) has multiple stressors affecting the biology; however, no pollutant-based stressors (e.g., phosphorus) were identified through the SID process that require a TMDL. Low dissolved oxygen (DO) concentrations are a common theme in the impaired AUIDs throughout the Redeye River Watershed. Review of the impaired fish and macroinvertebrate communities show that the majority of the biological communities are dominated by species that can tolerate low DO concentrations. Lack of physical habitat is also a concern to the impaired biotic communities. The habitat tool used to evaluate this stressor is the MPCA Stream Habitat Assessment (MSHA) Score. This score was poor to fair at the stream stations sampled in each impaired AUID. Flow alteration caused by channelization and drainage is also playing an important role in the lack of biotic community structure in some AUIDs. The Wing River has a low head dam located at the Highway 210 Bridge, which is causing limited to no fish passage during the year.

Table 2. Redeye River Watershed Stressor Identification Study Summary

		Stressors						
Stream Name	Stream AUID	Low Dissolved Oxygen	Flow Alteration	Increased Sediment	Increased Bedded Sediment	Elevated Nutrients	Lack of Physical Habitat	Physical Connectivity
Union Creek	07010107-508	X						
South Bluff Creek	07010107-553	X	•		X		X	
Trib. To East Leaf Lake	07010107-554	X					X	•
Wing River	07010107-559	•	•			•		X
Trib. To Leaf River	07010107-557	•		X	•	•	X	

X is primary stressor
• is a secondary stressor

2. Applicable Water Quality Standards and Numeric Water Quality Targets

2.1. Designated Use

Each stream reach has a Designated Use Classification defined by the MPCA, which defines the optimal purpose for that waterbody (see Table 1). The streams addressed by this TMDL fall into one of the following three designated use classifications:

1B, 2A, 3B – drinking water use after approved disinfectant; a healthy cold water aquatic community; non-food industrial use with moderate treatment

2B, 3C – a healthy warm water aquatic community; industrial cooling and materials transport without a high level of treatment

2C – a healthy indigenous fish community

Class 1 waters are protected for aquatic consumption, Class 2 waters are protected for aquatic life and aquatic recreation, and Class 3 waters are protected for industrial consumption as defined by Minn. R. ch. 7050.0140. The most protective of these classes is 1B, however water bodies are not currently being assessed by the MPCA for the beneficial use of domestic consumption; therefore, water quality standards for the Class 1B waters are not presented here. The next most protective of these classes are 2A and 2B, for which water quality standards are provided below.

The Minnesota narrative water quality standard for all Class 2 waters (Minn. R. 7050.0150, subp. 3) states that "the aquatic habitat, which includes the waters of the state and stream bed, shall not be degraded in any material manner, there shall be no material increase in undesirable slime growths or aquatic plants, including algae, nor shall there be any significant increase in harmful pesticide or other residues in the waters, sediments, and aquatic flora and fauna; the normal fishery and lower aquatic biota upon which it is dependent and the use thereof shall not be seriously impaired or endangered, the species composition shall not be altered materially, and the propagation or migration of the fish and other biota normally present shall not be prevented or hindered by the discharge of any sewage, industrial waste, or other wastes to the waters."

2.2. Bacteria

Numeric water quality standards have been developed for bacteria (Minn. R. 7050.0222), in this case Escherichia coli (*E. coli*), which are protective concentrations for short- and long-term exposure to pathogens in water. The past fecal coliform and current *E. coli* numeric water quality standards for Class 2 waters are shown in Table 3. *E. coli* and fecal coliform are fecal bacteria used as indicators for waterborne pathogens that have the potential to cause human illness. Although most are harmless themselves, fecal indicator bacteria are used as an easy-to-measure surrogate to evaluate the suitability of recreational and drinking waters, specifically, the presence of pathogens and probability of illness. Pathogenic bacteria, viruses, and protozoa pose a health risk to humans, potentially causing illnesses with gastrointestinal symptoms (nausea, vomiting, fever, headache, and diarrhea), skin irritations, or other symptoms. Pathogen types and quantities vary among fecal sources; therefore, human health risk varies based on the source of fecal contamination.

This TMDL study will use the standard for *E. coli*. The change in the water quality standard from fecal coliform to *E. coli* is supported by an EPA guidance document on bacteriological criteria (EPA 1986). As of March 17, 2008, Minn. R. ch. 7050 water quality standards for *E. coli* are:

> *Escherichia (E.) coli - Not to exceed 126 organisms per 100 milliliters as a geometric mean of not less than five samples representative of conditions within any calendar month, nor shall more than 10% of all samples taken during any calendar month individually exceed 1,260 organisms per 100 milliliters. The standard applies only between April 1 and October 31.*

Although surface water quality standards are now based on *E. coli*, wastewater treatment facilities (WWTFs) are permitted based on fecal coliform (not *E. coli*) concentrations.

Geometric mean is used in place of arithmetic mean in order to measure the central tendency of the data, dampening the effect that very high or very low values have on arithmetic means. The MPCA's *Guidance Manual for Assessing the Quality of Minnesota Surface Waters for Determination of Impairment: 305(b) Report and 303(d) List* provides details regarding how waters are assessed for conformance to the *E. coli* standard (MPCA 2012).

Table 3. Past and current numeric water quality standards of bacteria (fecal coliform and *E. coli*) for the beneficial use of aquatic recreation (primary and secondary body contact).

Past Standard	Units	Current Standard	Units	Notes
Fecal coliform	200 orgs per 100 ml	*E. coli*	126 orgs per 100 ml	Geometric mean of ≥5 samples per month (April - October)
Fecal coliform	2,000 orgs per 100 ml	*E. coli*	1,260 orgs per 100 ml	<10% of all samples per month (April - October) that individually exceed

3. Watershed and Waterbody Characterization

The impaired streams included in this study are located within the Redeye River Watershed (HUC 07010107), a tributary to the Mississippi River in the Upper Mississippi River Basin in central Minnesota. The Redeye River Watershed drains approximately 899 square miles (575,360 acres) in all or parts of Becker, Otter Tail, Todd, and Wadena counties. The Redeye River begins at Wolf Lake and travels south where it joins the Leaf River and eventually joins the Crow Wing River north of the city of Staples. No tribal lands are located within the Redeye River Watershed.

3.1. Streams

The direct drainage and total watershed areas of the impaired stream reaches are listed in Table 4. Total watershed and direct drainage areas were delineated from HSPF subbasins (AquaTerra 2013) and USGS StreamStats (http://water.usgs.gov/osw/streamstats/). The direct drainage areas include only the area downstream of any upstream impaired stream.

Table 4. Impaired stream reach direct drainage and total watershed areas

AUID	Name	Direct Drainage Area (ac)	Total Watershed Area (ac)	Upstream Water body
07010107-503	Redeye River	116,167	**116,167**	N/A
07010107-505	Leaf River	55,456	**285,552**	Leaf River (-514), Oak Creek (-516), Union Creek (-508)
07010107-508	Union Creek	13,635	**13,635**	N/A
07010107-514	Leaf River	141,421	**190,728**	Bluff Creek (-515)
07010107-515	Bluff Creek	49,307	**49,307**	N/A
07010107-516	Oak Creek	25,733	**25,733**	N/A
07010107-526	Un. Cr. (Hay Creek)	21,946	**21,946**	N/A
07010107-560	Wing River	101,220	**101,220**	N/A

3.2. Subwatersheds

The individual impaired stream subwatersheds are illustrated in Figure 2 through Figure 9 below.

Figure 2. Redeye River (07010107-503) Subwatershed

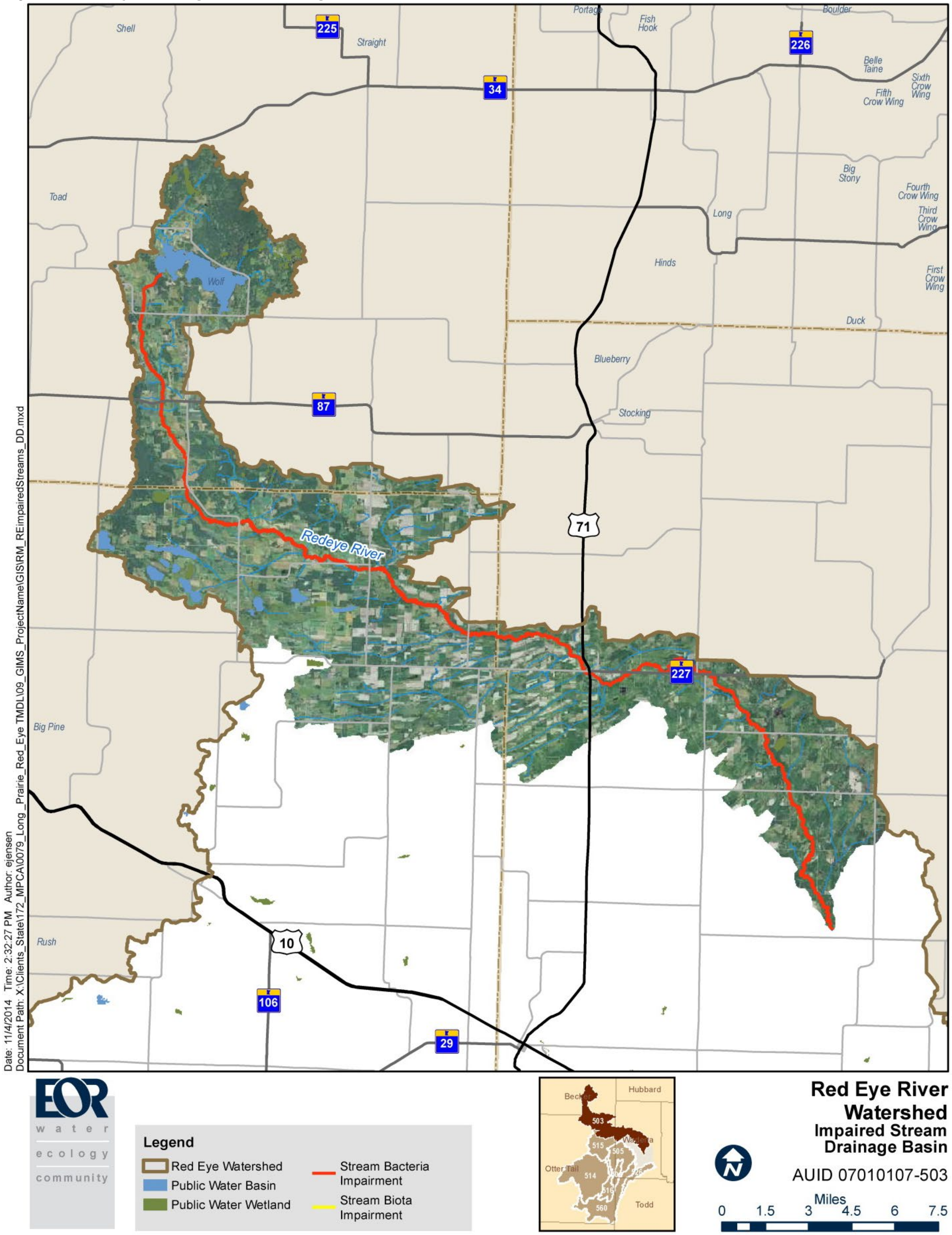


Figure 3. Leaf River (07010107-505) Subwatershed

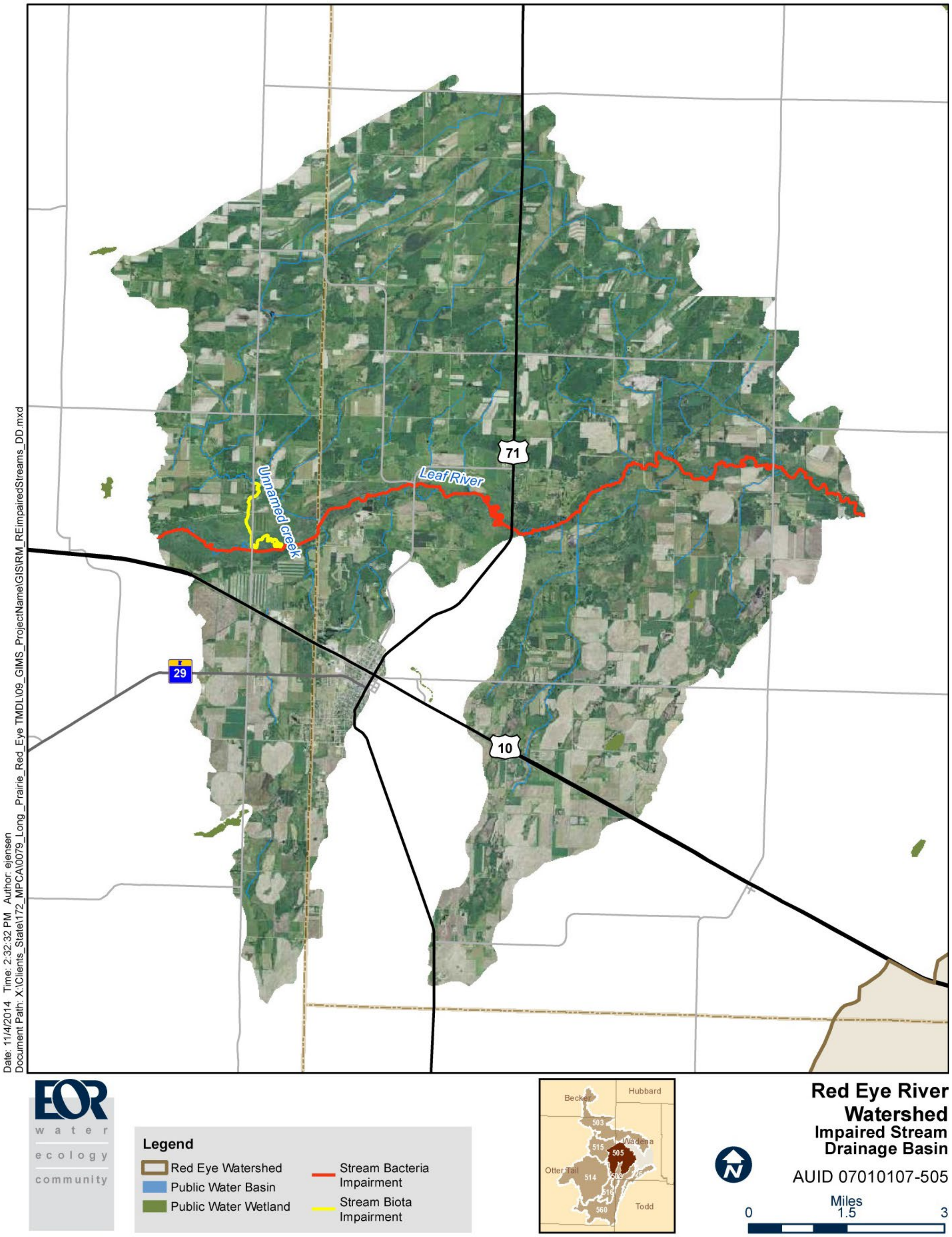


Figure 4. Union Creek (07010107-508) Subwatershed

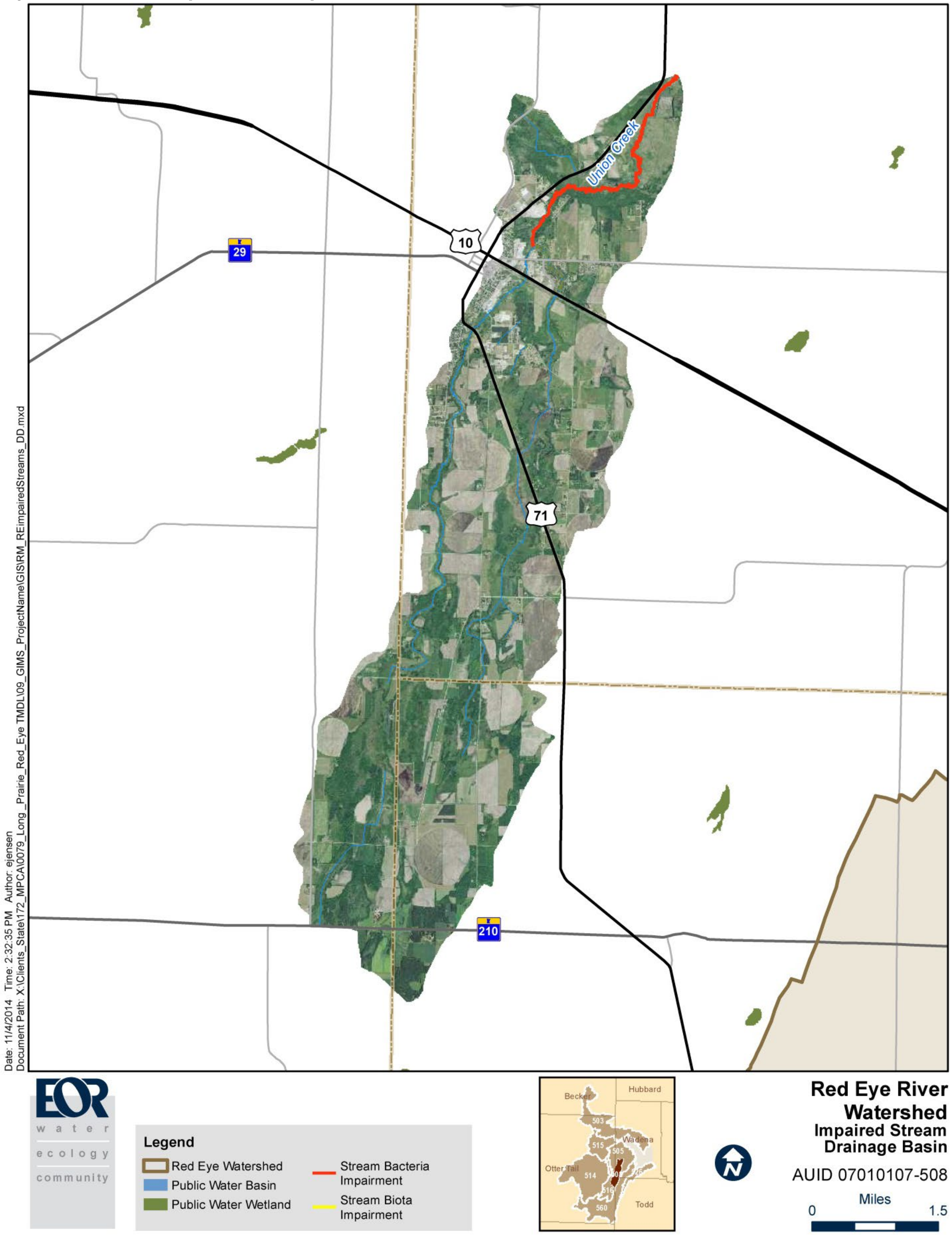


Figure 5. Leaf River (07010107-514) Subwatershed

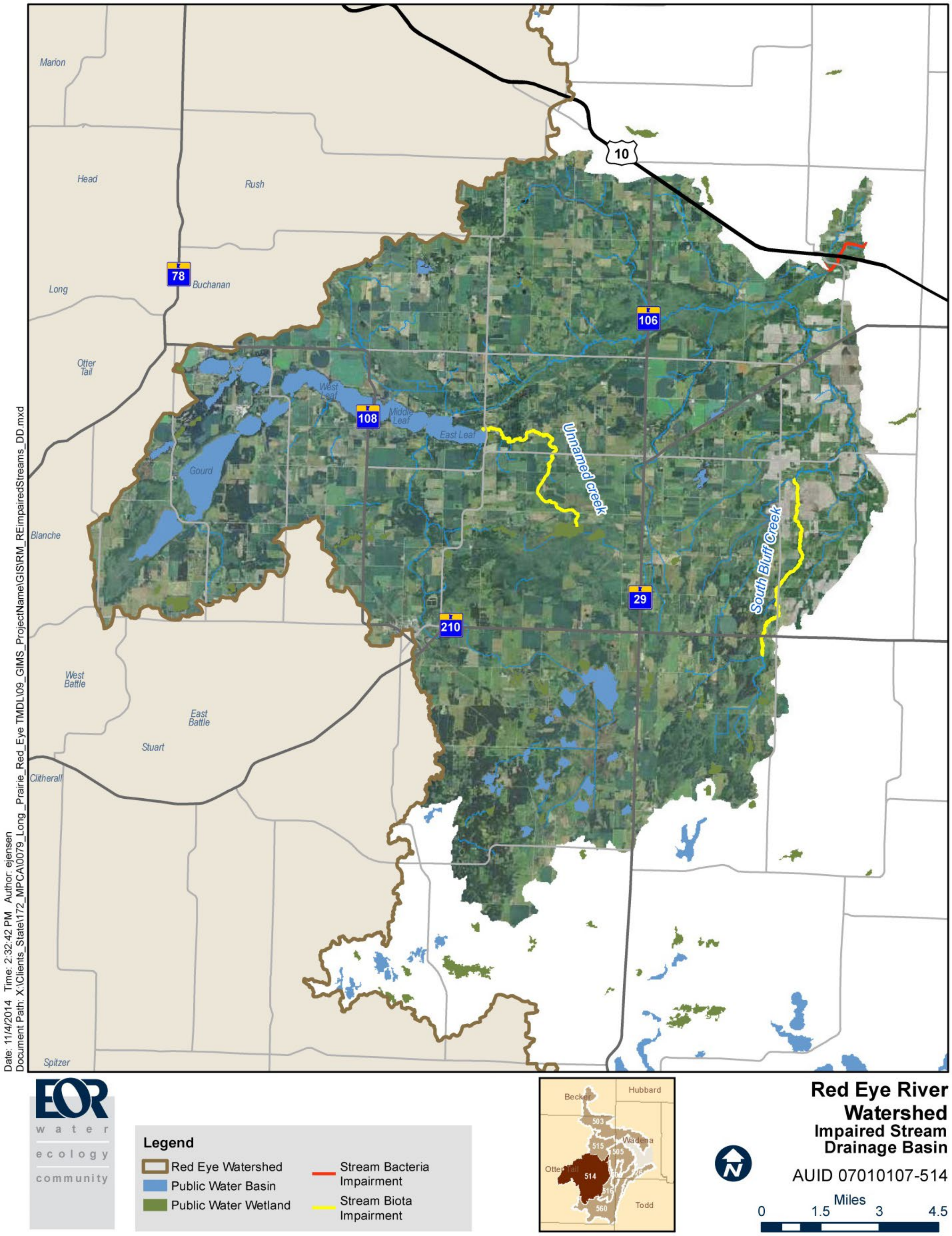


Figure 6. Bluff Creek (07010107-515) Subwatershed

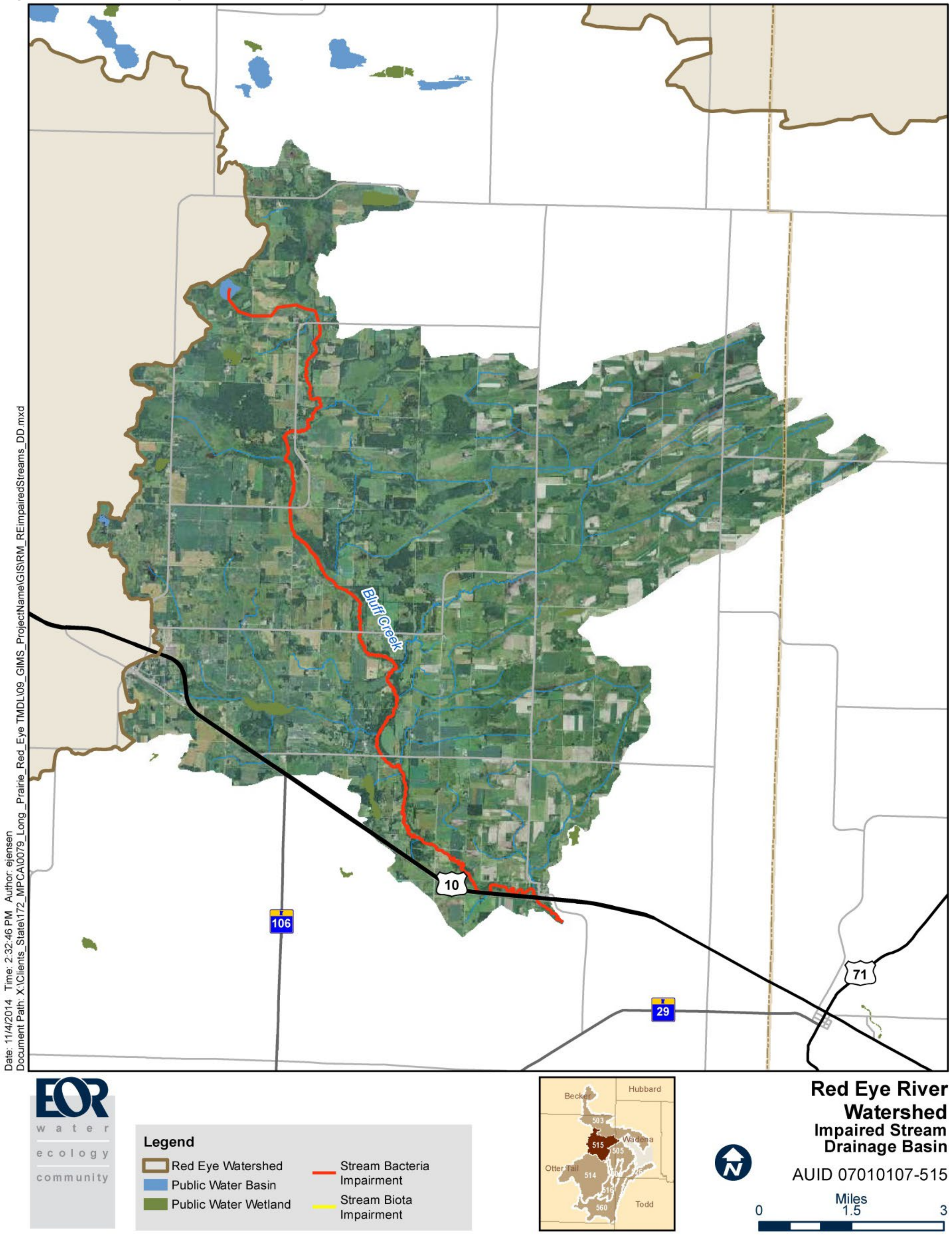


Figure 7. Oak Creek (07010107-516) Subwatershed

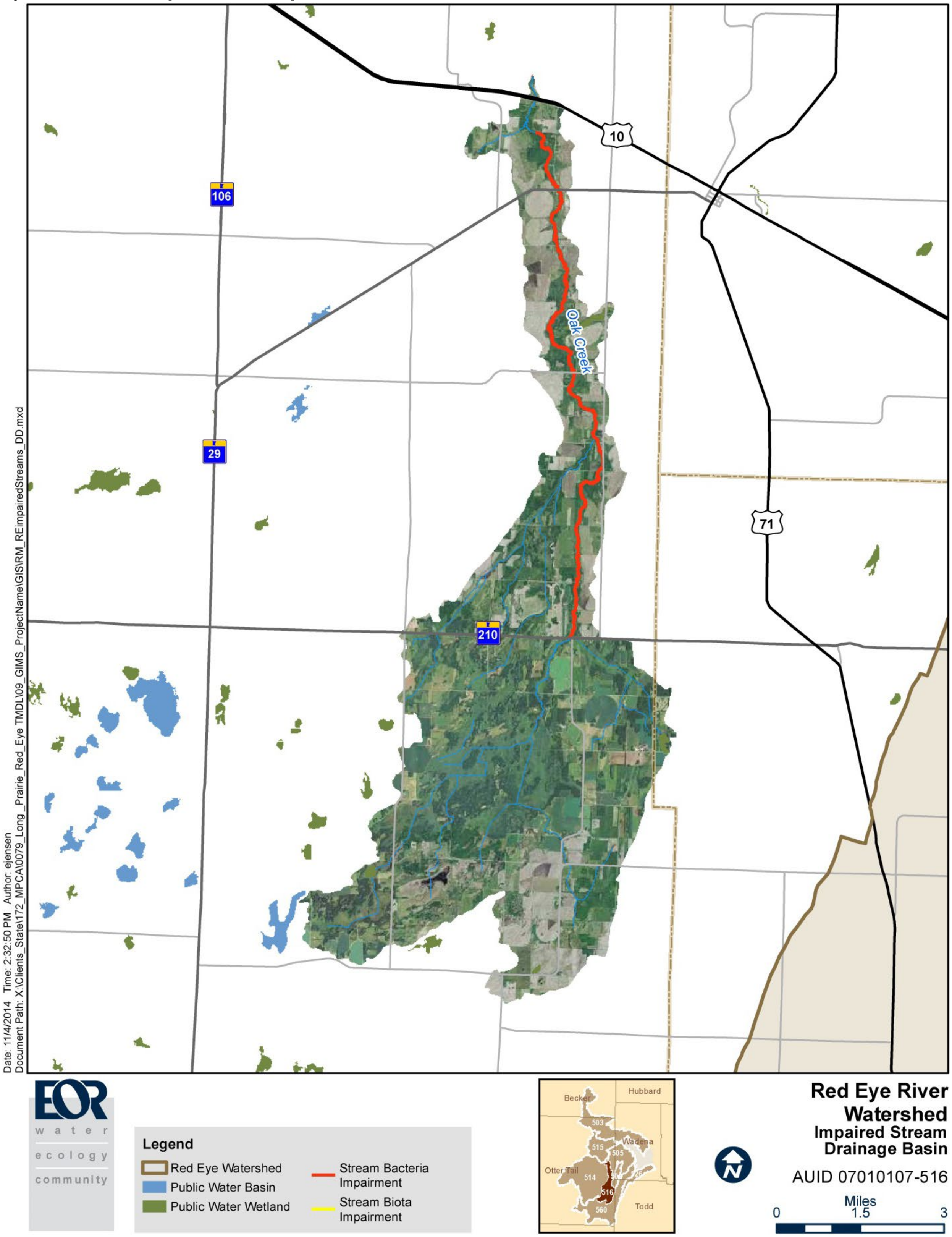


Figure 8. Unnamed Creek (Hay Creek; 07010107-526) Subwatershed

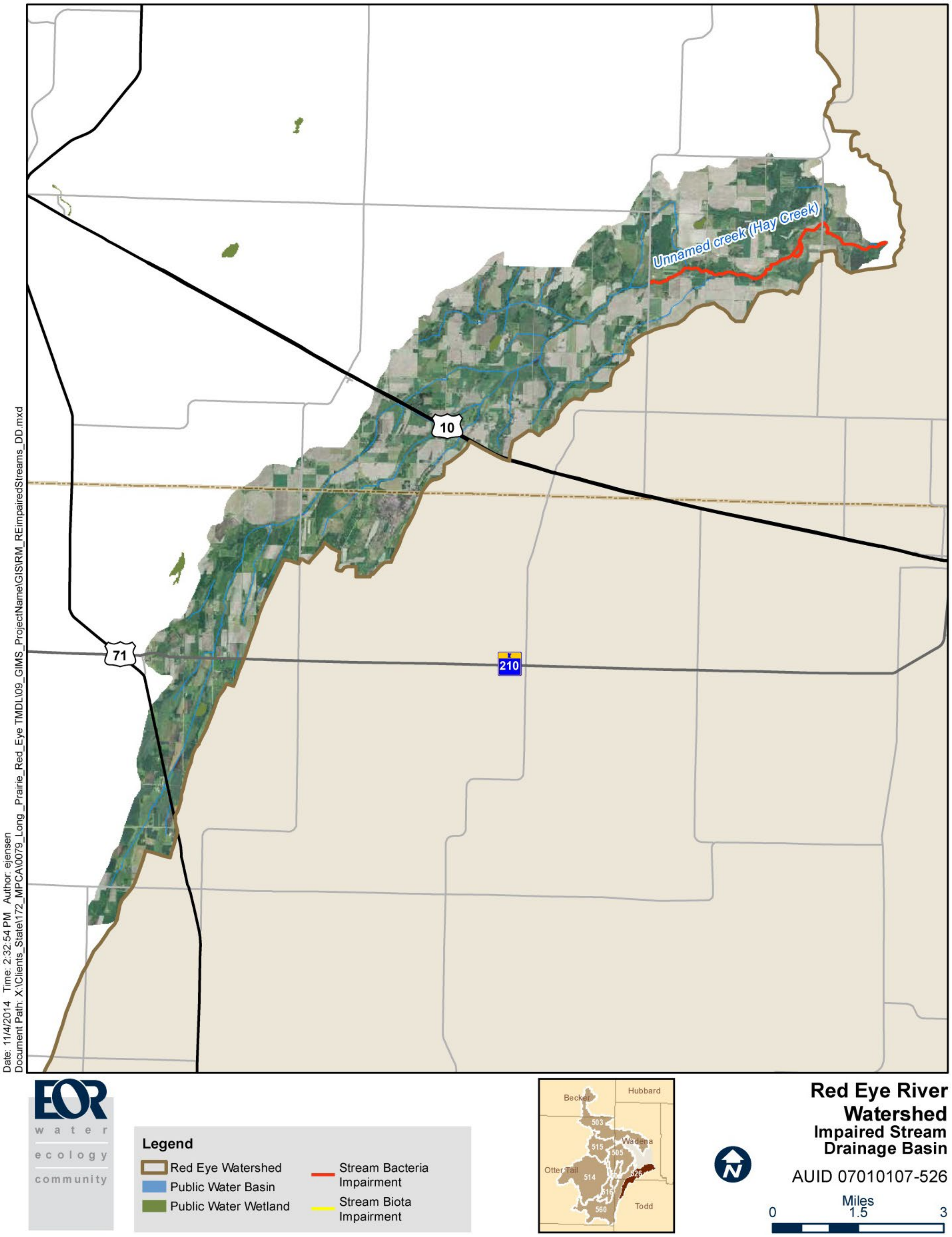
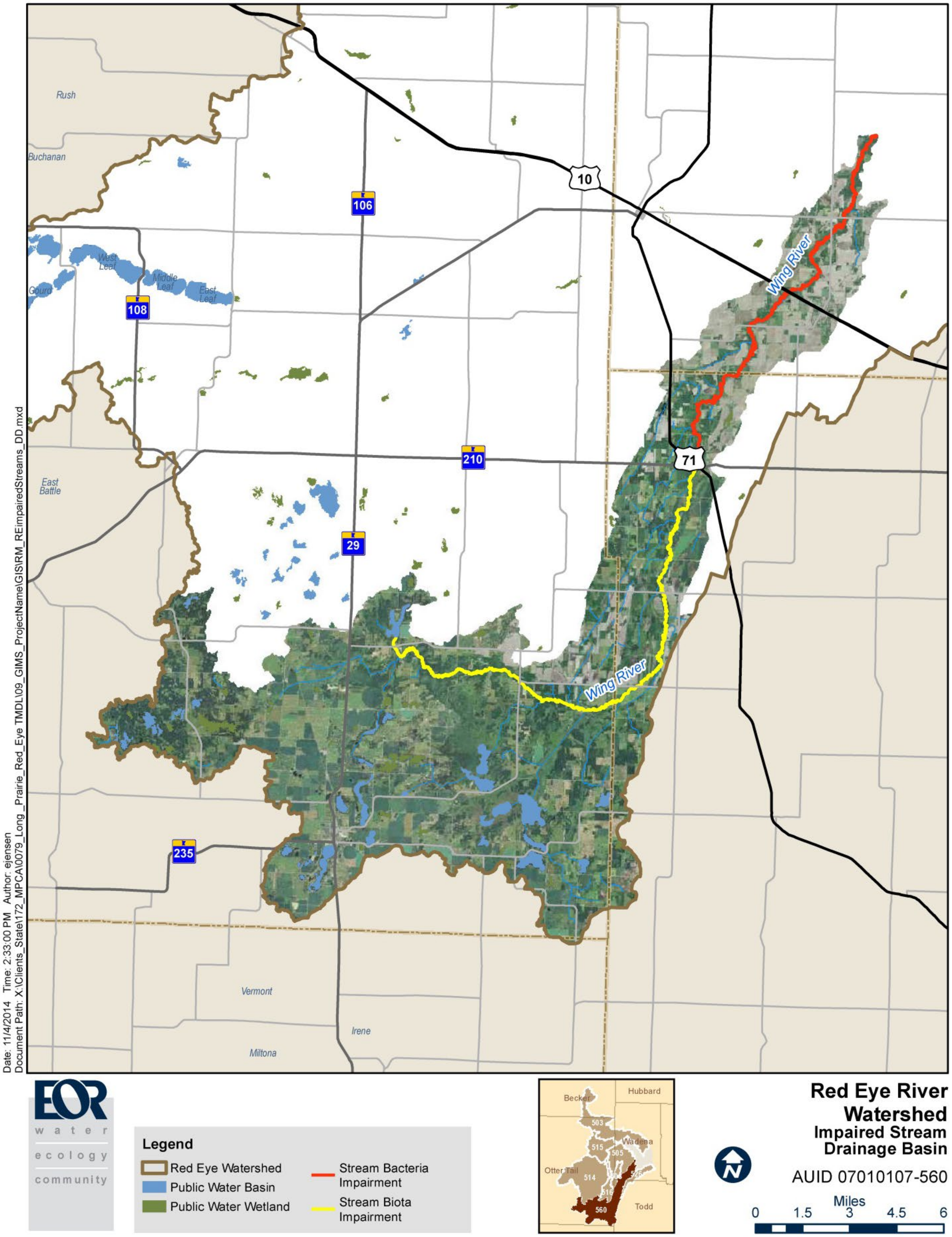


Figure 9. Wing River (07010107-560) Subwatershed



3.3. Land Use

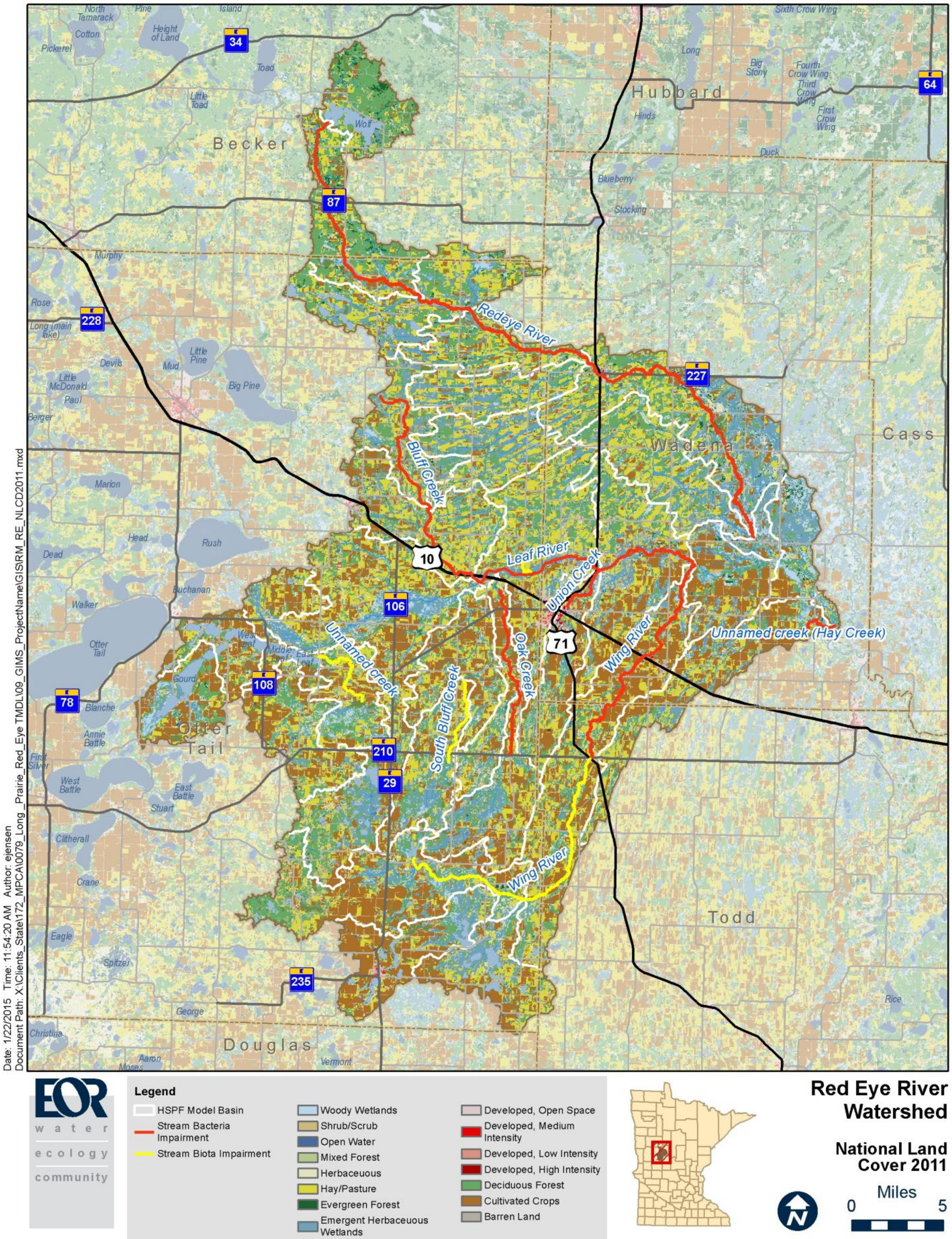
Land cover in the Redeye River Watershed was assessed using the Multi-Resolution Land Characteristics Consortium 2011 National Land Cover Dataset (NLCD) (http://www.mrlc.gov/nlcd2011.php). This information is necessary to draw conclusions about pollutant sources and best management practices (BMPs) that may be applicable within each subwatershed. The land cover distribution within impaired stream watersheds is summarized in Table 5 and Figure 10. This data was simplified to reduce the overall number of categories. Woodland includes: evergreen forests, deciduous forests, mixed forests, and shrub/scrub. Developed includes: developed open space, and low, medium and high density developed areas. Grassland includes: native grass stands. Pasture includes: alfalfa, clover, long term hay, and pasture. Cropland includes: all annually planted row crops (corn, soybeans, wheat, oats, barley, etc.), and fallow crop fields. Wetland includes: wetlands, and marshes. Open water includes: all lakes and rivers.

The primary land covers in the Redeye River Watershed are woodland (27.2%), cropland (25.3%), and pasture (20.6%).

Table 5. Redeye River Watershed and impaired waterbody subwatershed land cover (NLCD 2011)

Waterbody Name (AUID 07010107-XXX)	Developed	Cropland	Grassland	Pasture	Woodland	Open Water	Wetlands
Redeye River (-503)	3.9%	10.1%	3.9%	22.3%	38.7%	2.0%	19.1%
Leaf River (-505)	6.3%	21.4%	3.0%	27.7%	24.8%	0.1%	16.7%
Union Creek (-508)	11.2%	34.5%	4.2%	14.9%	22.2%	0.1%	12.9%
Leaf River (-514)	4.6%	31.7%	4.7%	18.8%	23.9%	2.6%	13.7%
Bluff Creek (-515)	5.1%	13.7%	2.3%	25.9%	33.4%	0.5%	19.2%
Oak Creek (-516)	4.1%	33.0%	5.0%	17.2%	24.6%	0.1%	15.9%
Un. Cr. (Hay Creek) (-526)	4.5%	39.6%	3.2%	23.4%	15.4%	0.1%	13.9%
Wing River (-560)	4.7%	37.2%	3.7%	17.9%	21.2%	2.5%	12.9%
Redeye River Watershed	**4.7%**	**25.3%**	**3.8%**	**20.6%**	**27.2%**	**1.6%**	**16.9%**

Figure 10. Land cover in the Redeye River Watershed (NLCD 2011)



3.4. Current/Historic Water Quality

3.4.1. Steam Bacteria (*E. coli*)

Using data from the most recent 10-year period (2004 through 2013), geometric mean *E. coli* concentrations were calculated by month for each impaired stream reach. The means that exceed the water quality standard are highlighted in bold red font. The data is also represented by the graphs in Figures 11 - 23.

3.4.1.1. Redeye River (07010107-503)

Table 6. 10-year geometric mean *E. coli* (org/100mL) concentrations by month in Redeye River (07010107-503), 2004-2013. Geometric means that exceed the water quality standard of 126 org/100mL for which there are at least 5 samples are highlighted in bold red font.

Monitoring Station (upstream to downstream)	Month	Number of Samples	Geometric Mean (org/100mL)	Min – Max (org/100mL)
S005-730	June	6	**345**	166-548
	July	5	**154**	77-687
	August	6	**219**	42-2,420
	September	2	171	36-816
S005-725	June	5	**344**	236-488
	July	5	**253**	112-866
	August	6	101	53-210
	September	2	139	37-517
S002-461	June	5	**154**	91-225
	July	5	**129**	66-308
	August	6	125	36-435
	September	2	185	42-816
S005-727	June	5	113	70-194
	July	5	104	49-488
	August	6	112	38-345
	September	2	111	34-365

Figure 11. ***E. coli*** **(MPN/100mL) by month in Redeye River (07010107-503) at station S005-730, 2004-2013**
The dashed line represents the stream water quality standard (126 org/100mL).

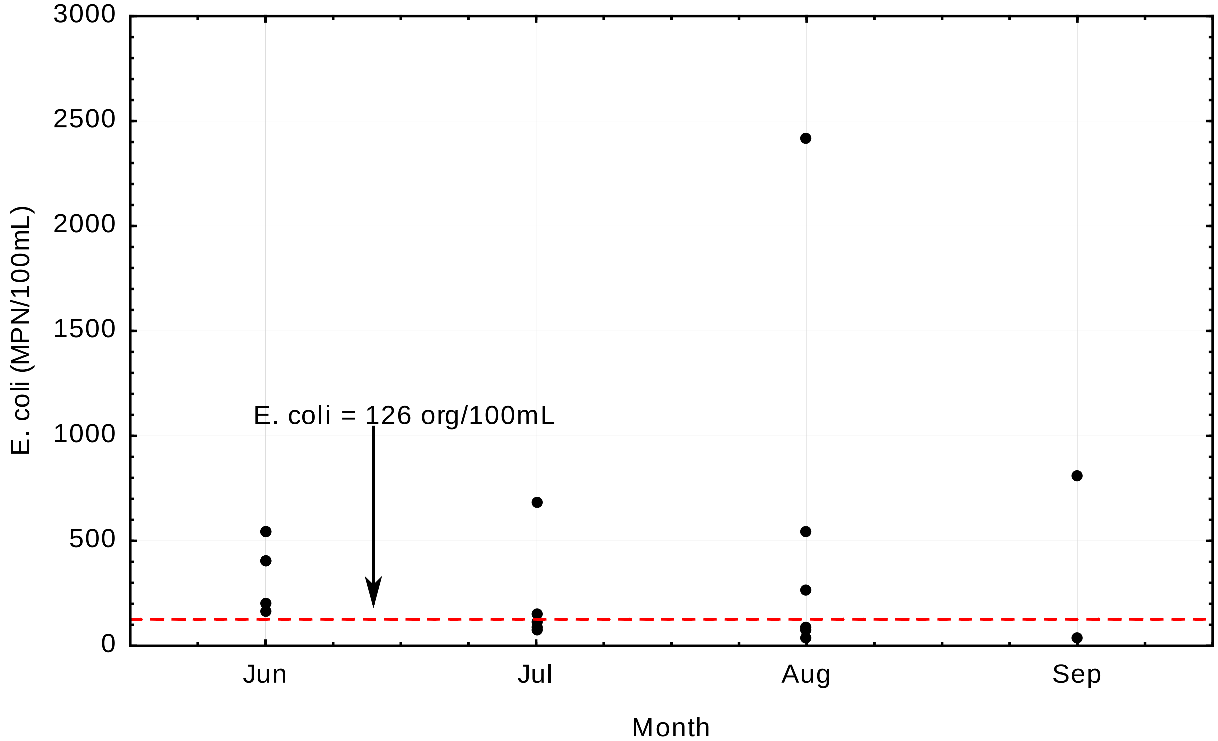


Figure 12. ***E. coli*** **(MPN/100mL) by month in Redeye River (07010107-503) at station S005-725, 2004-2013**
The dashed line represents the stream water quality standard (126 org/100mL).

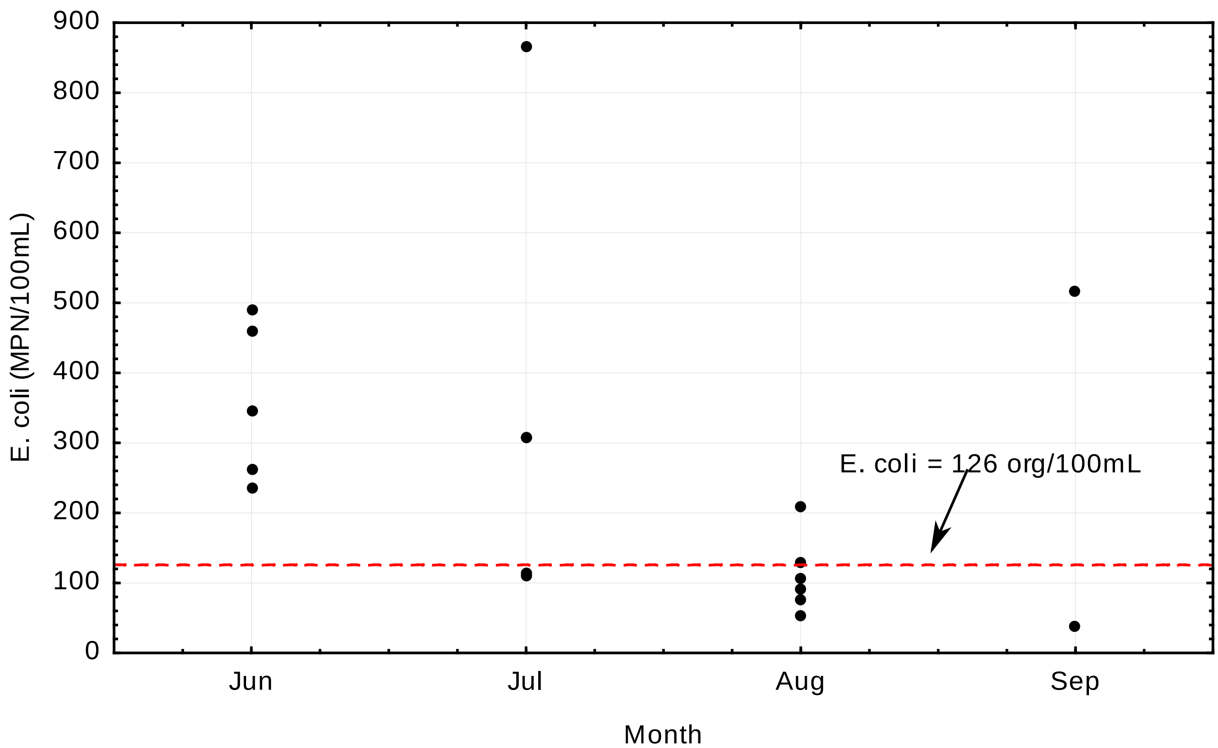


Figure 13. ***E. coli*** **(MPN/100mL) by month in Redeye River (07010107-503) at station S002-461, 2004-2013**
The dashed line represents the stream water quality standard (126 org/100mL)

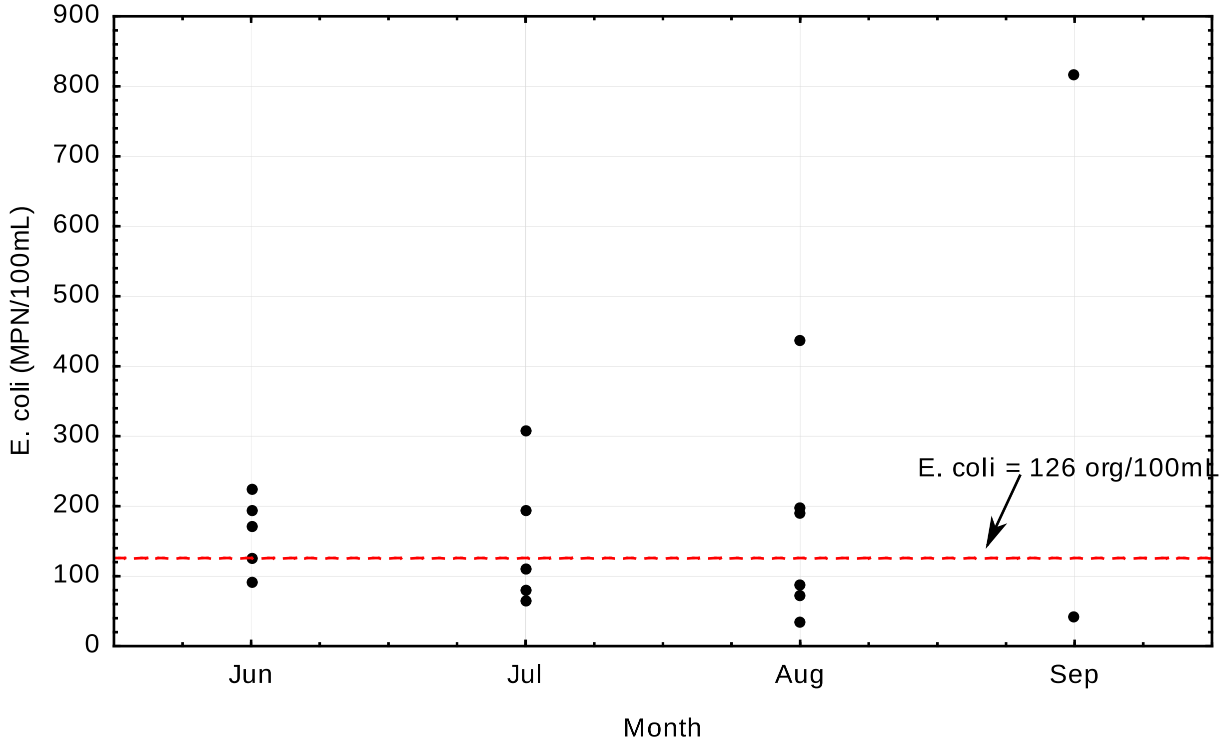
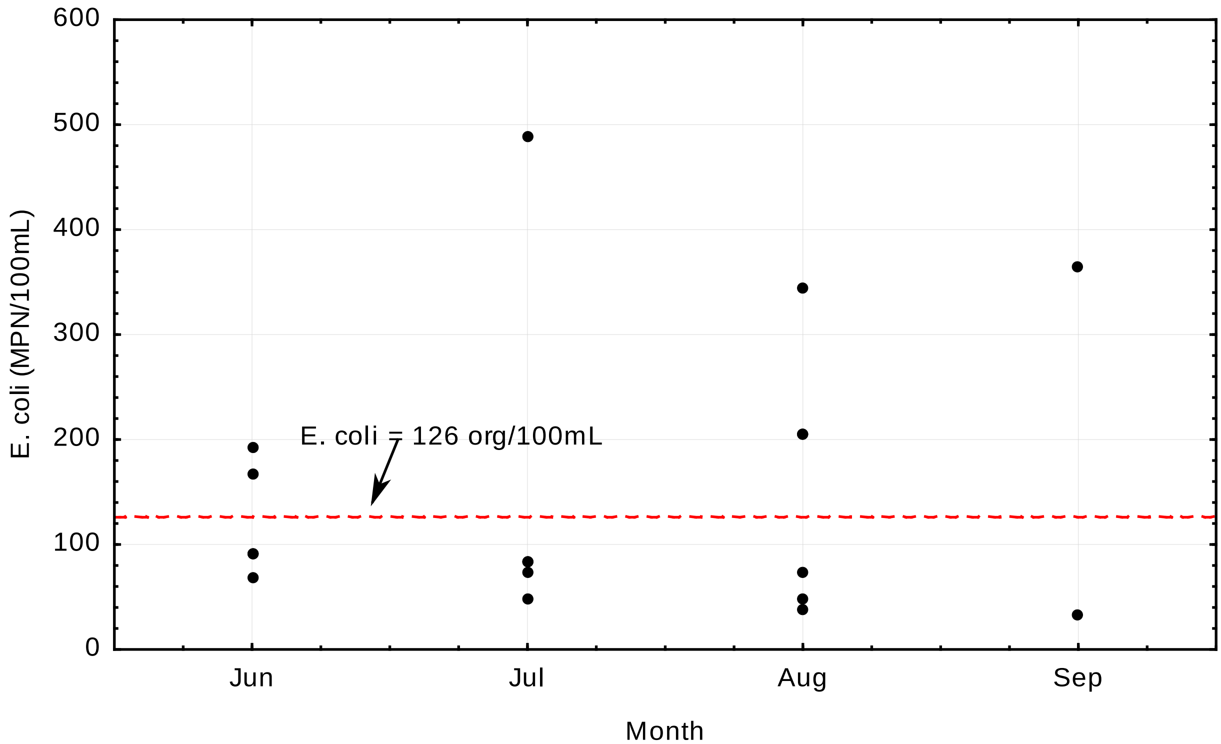


Figure 14. ***E. coli*** **(MPN/100mL) by month in Redeye River (07010107-503) at station S005-727, 2004-2013**
The dashed line represents the stream water quality standard (126 org/100mL).

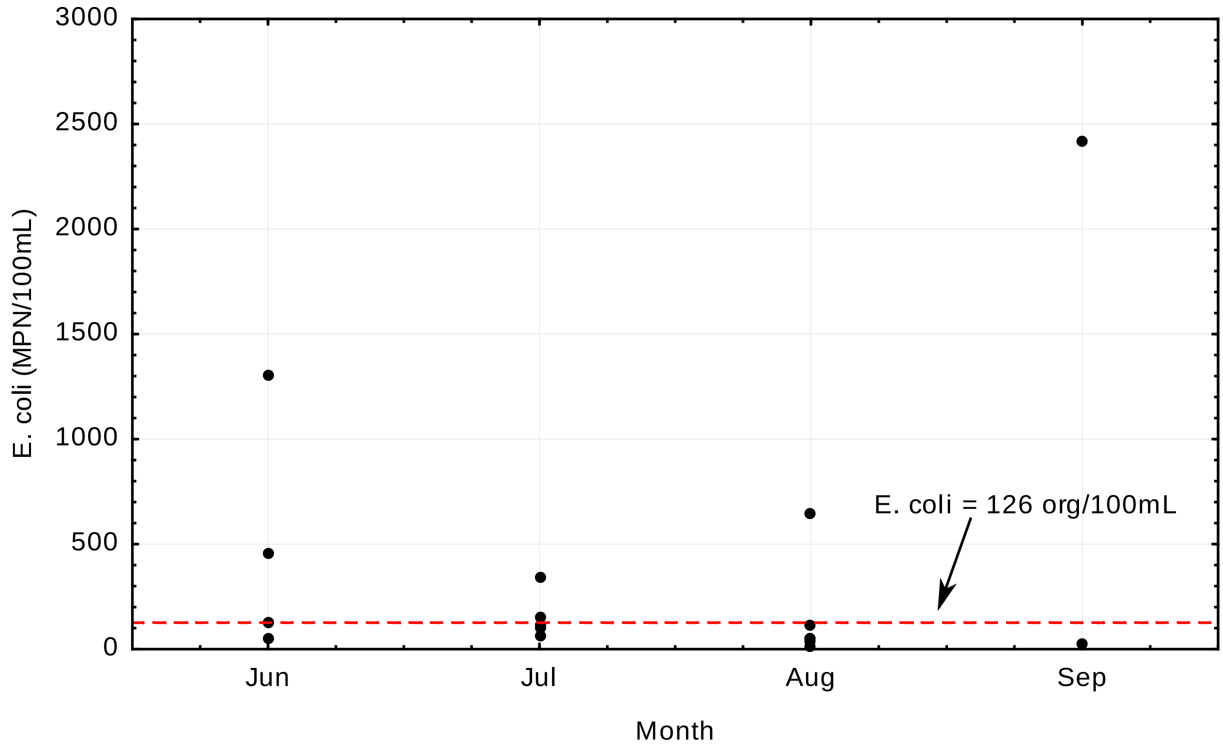


3.4.1.2. Leaf River (07010107-505)

Table 7. 10-year geometric mean *E. coli* (org/100mL) concentrations by month in Leaf River (07010107-505), 2004-2013. Geometric means that exceed the water quality standard of 126 org/100mL for which there are at least 5 samples are highlighted in bold red font.

Monitoring Station	Month	Number of Samples	Geometric Mean (org/100mL)	Min – Max (org/100mL)
S001-614	June	5	**225**	54-1,300
	July	5	**130**	62-344
	August	6	71	15-649
	September	2	242	24-2,420

Figure 15. *E. coli* (MPN/100mL) by month in Redeye River (07010107-505) at station S001-614, 2004-2013
The dashed line represents the stream water quality standard (126 org/100mL).

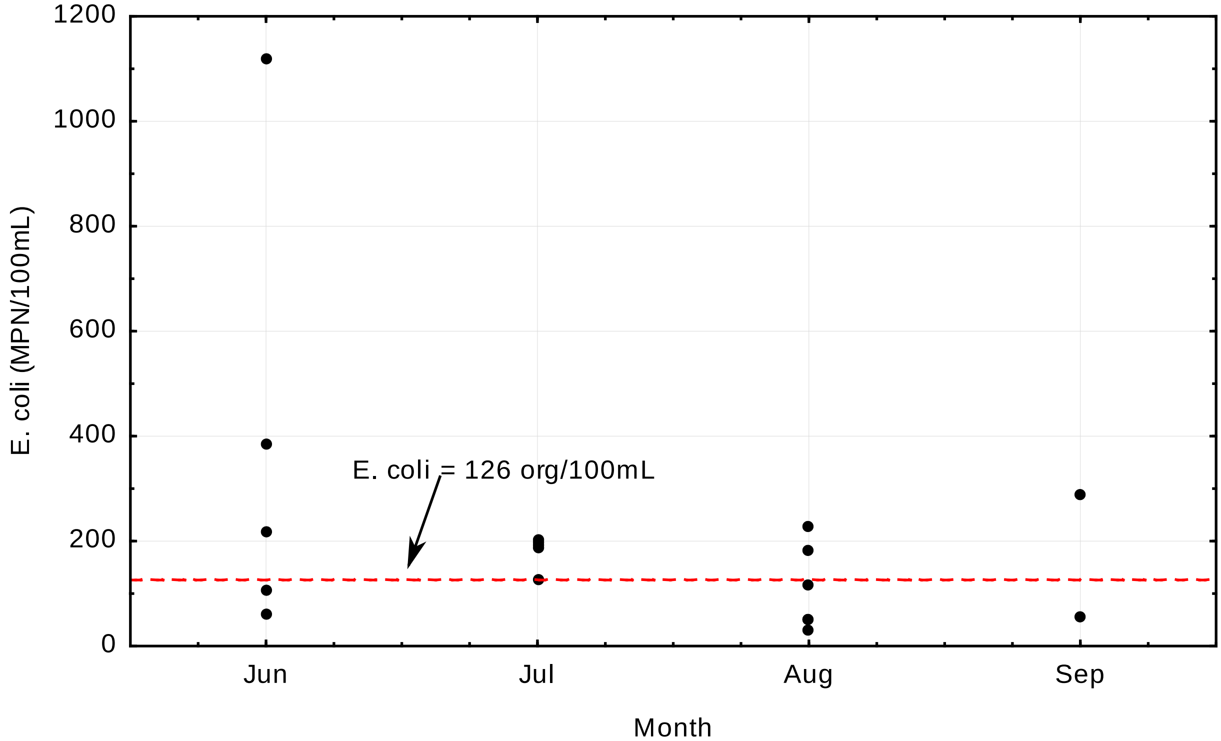


3.4.1.3. Union Creek (07010107-508)

Table 8. 10-year geometric mean *E. coli* (org/100mL) concentrations by month in Union Creek (07010107-508), 2004-2013. Geometric means that exceed the water quality standard of 126 org/100mL for which there are at least 5 samples are highlighted in bold red font.

Monitoring Station	Month	Number of Samples	Geometric Mean (org/100mL)	Min – Max (org/100mL)
S000-987	June	5	**230**	63-1,120
	July	5	**178**	125-201
	August	6	86	33-228
	September	2	130	58-291

Figure 16. *E. coli* (MPN/100mL) by month in Redeye River (07010107-508) at station S000-987, 2004-2013
The dashed line represents the stream water quality standard (126 org/100mL).

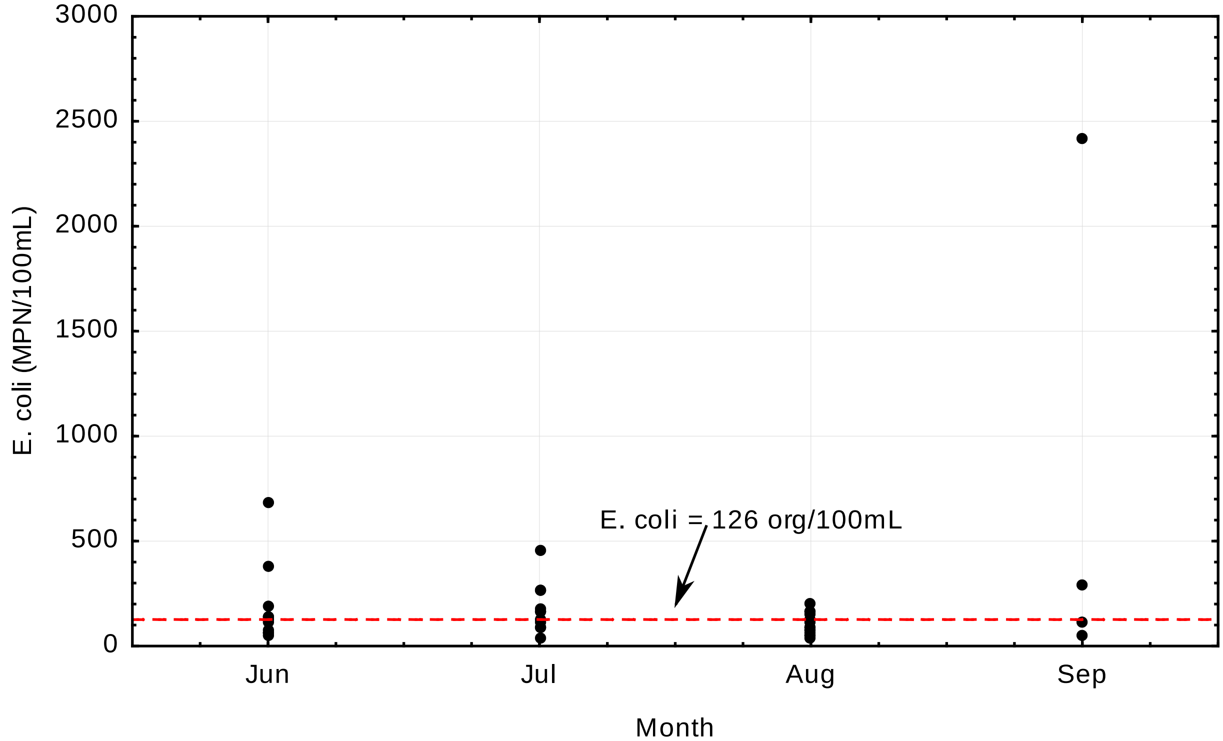


3.4.1.4. Leaf River (07010107-514)

Table 9. 10-year geometric mean *E. coli* (org/100mL) concentrations by month in Leaf River (07010107-514), 2004-2013. Geometric means that exceed the water quality standard of 126 org/100mL for which there are at least 5 samples are highlighted in bold red font.

Monitoring Station	Month	Number of Samples	Geometric Mean (org/100mL)	Min – Max (org/100mL)
S005-732	June	11	**135**	55-687
	July	11	**145**	34-461
	August	14	92	39-201
	September	4	253	50-2,420

Figure 17. *E. coli* (MPN/100mL) by month in Redeye River (07010107-514) at station S005-732, 2004-2013
The dashed line represents the stream water quality standard (126 org/100mL).

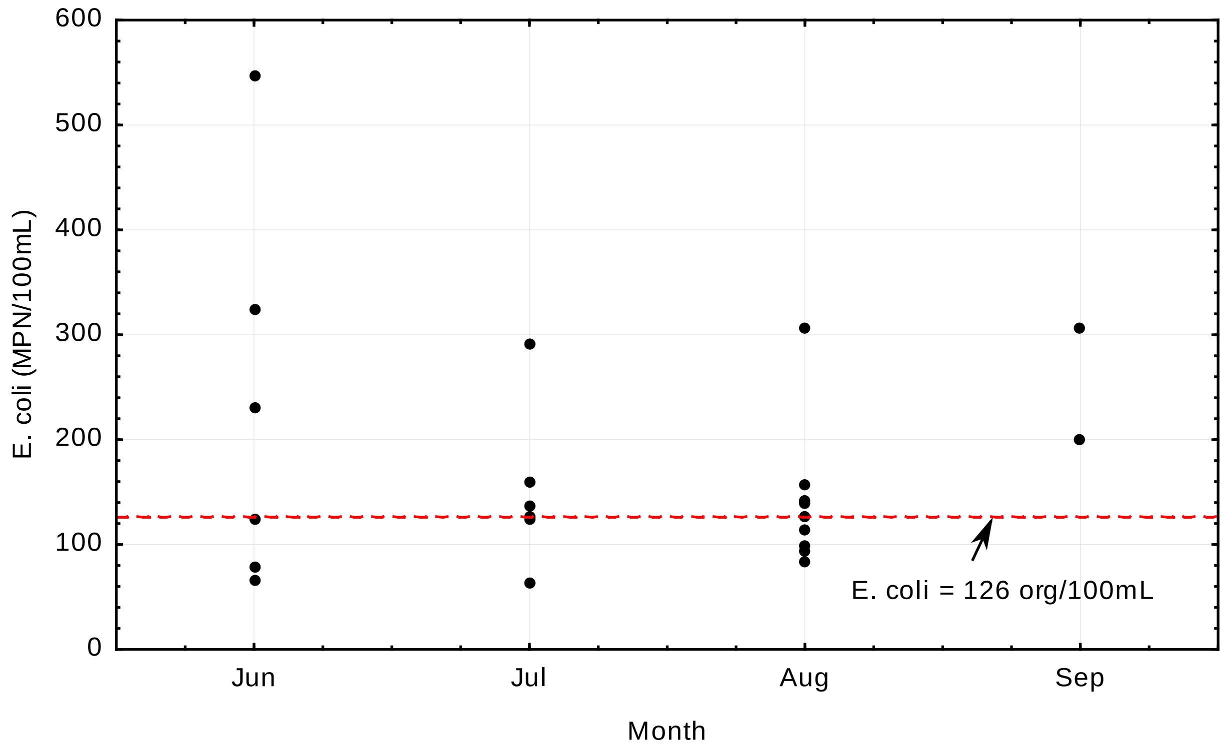


3.4.1.5. Bluff Creek (07010107-515)

Table 10. 10-year geometric mean *E. coli* (org/100mL) concentrations by month in Bluff Creek (07010107-515), 2004-2013. Geometric means that exceed the water quality standard of 126 org/100mL for which there are at least 5 samples are highlighted in bold red font.

Monitoring Station	Month	Number of Samples	Geometric Mean (org/100mL)	Min – Max (org/100mL)
S006-849	June	6	**173**	67-548
	July	6	**137**	64-291
	August	9	**130**	84-308
	September	2	249	201-308

Figure 18. *E. coli* (MPN/100mL) by month in Redeye River (07010107-515) at station S006-849, 2004-2013
The dashed line represents the stream water quality standard (126 org/100mL).

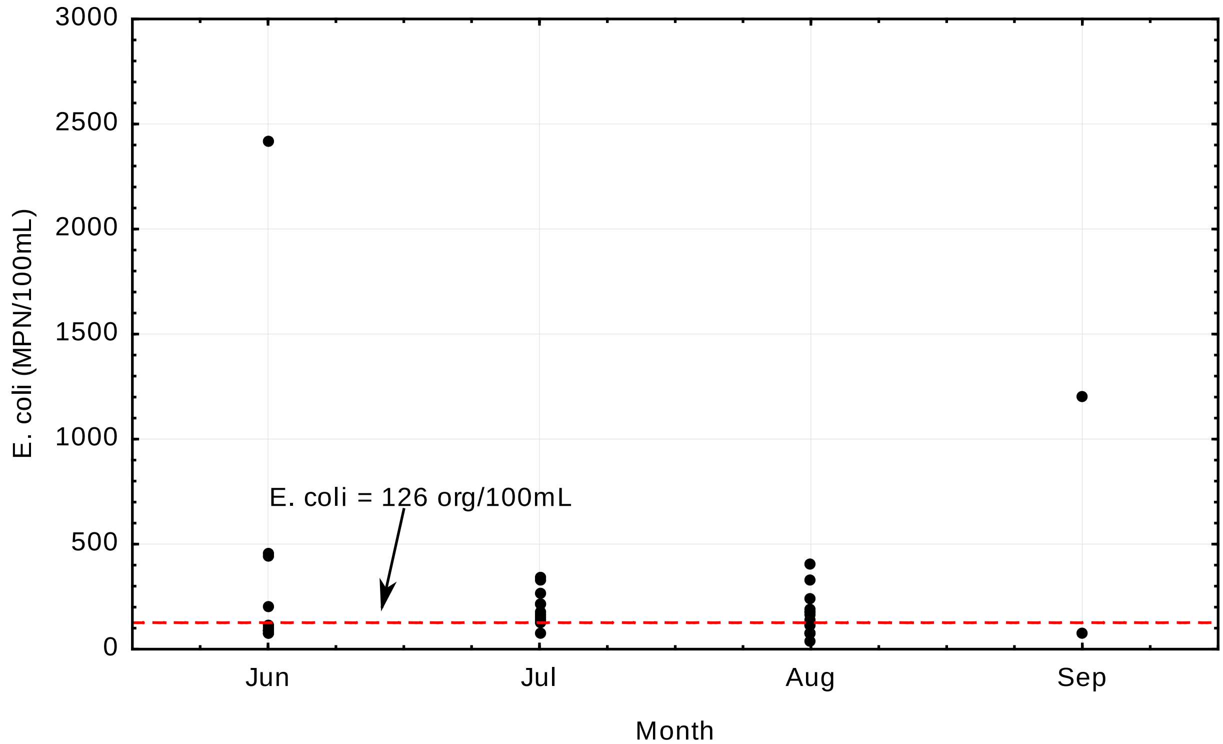


3.4.1.6. Oak Creek (07010107-516)

Table 11. 10-year geometric mean *E. coli* (org/100mL) concentrations by month in Oak Creek (07010107-516), 2004-2013. Geometric means that exceed the water quality standard of 126 org/100mL for which there are at least 5 samples are highlighted in bold red font.

Monitoring Station	Month	Number of Samples	Geometric Mean (org/100mL)	Min – Max (org/100mL)
S001-433	June	11	**175**	77-2,420
	July	11	**183**	72-354
	August	14	**139**	36-411
	September	2	313	81-1,203

Figure 19. *E. coli* (MPN/100mL) by month in Redeye River (07010107-516) at station S001-433, 2004-2013
The dashed line represents the stream water quality standard (126 org/100mL)

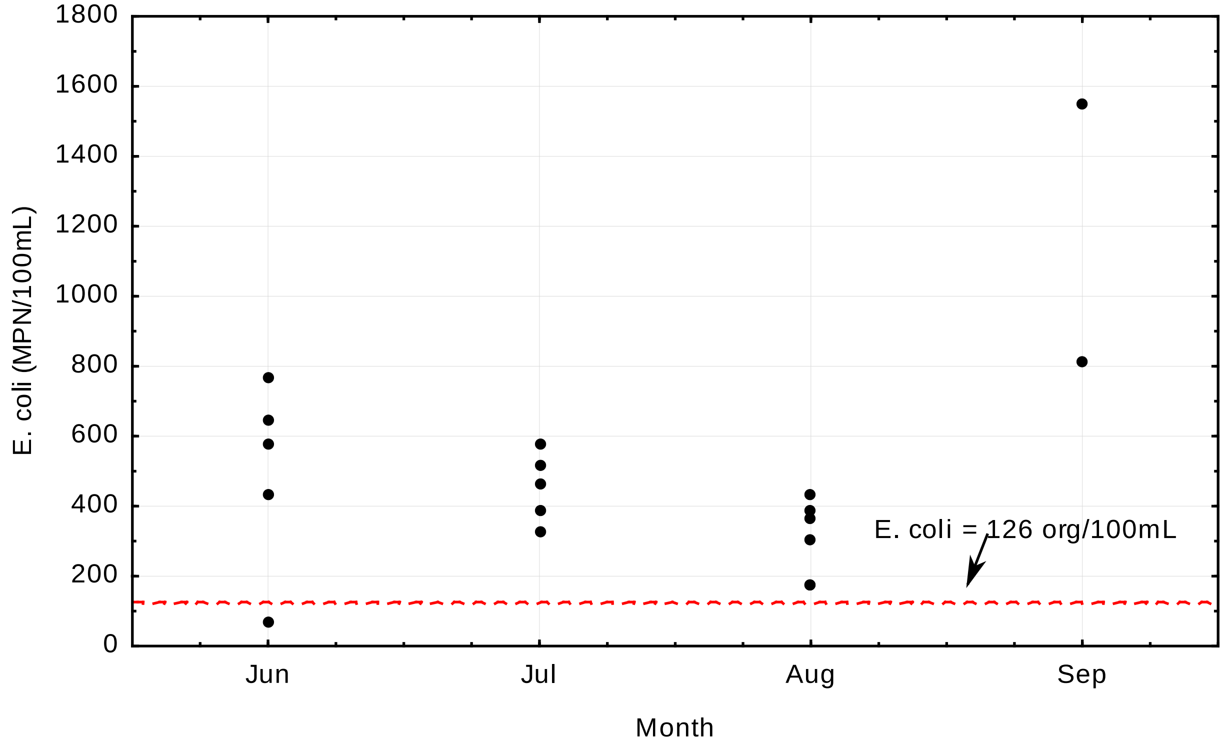


3.4.1.7. Unnamed Creek – Hay Creek (07010107-526)

Table 12. 10-year geometric mean *E. coli* (org/100mL) concentrations by month in Unnamed Creek – Hay Creek (07010107-526), 2004-2013. Geometric means that exceed the water quality standard of 126 org/100mL for which there are at least 5 samples are highlighted in bold red font.

Monitoring Station	Month	Number of Samples	Geometric Mean (org/100mL)	Min – Max (org/100mL)
S004-346	June	5	**386**	68-770
	July	5	**445**	326-579
	August	6	**289**	173-435
	September	2	1,126	816-1,553

Figure 20. *E. coli* (MPN/100mL) by month in Redeye River (07010107-526) at station S004-346, 2004-2013
The dashed line represents the stream water quality standard (126 org/100mL)



3.4.1.8. Wing River (07010107-560)

Table 13. 10-year geometric mean *E. coli* (org/100mL) concentrations by month in Wing River (07010107-560), 2004-2013. Geometric means that exceed the water quality standard of 126 org/100mL for which there are at least 5 samples are highlighted in bold red font.

Monitoring Station (upstream to downstream)	Month	Number of Samples	Geometric Mean (org/100mL)	Min – Max (org/100mL)
S005-401	June	5	**446**	236-2,420
	July	5	**187**	121-488
	August	6	**201**	79-436
	September	2	392	127-1,203
S002-958	June	6	**137**	71-579
	July	6	**283**	179-1,203
	August	8	**204**	84-435
S005-724	June	5	**187**	118-249
	July	5	**157**	93-308
	August	6	**206**	122-488
	September	2	432	77-2,420

Figure 21. ***E. coli*** **(MPN/100mL) by month in Redeye River (07010107-560) at station S005-401, 2004-2013**
The dashed line represents the stream water quality standard (126 org/100mL)

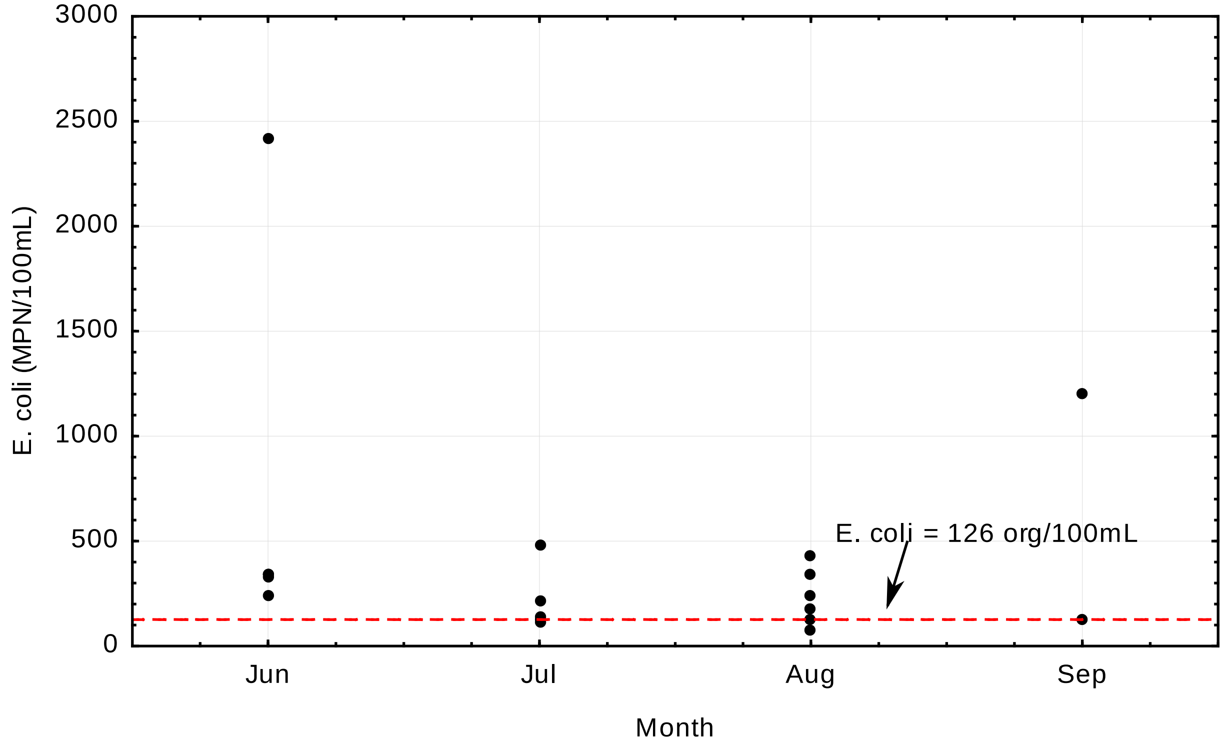


Figure 22. ***E. coli*** **(MPN/100mL) by month in Redeye River (07010107-560) at station S002-958, 2004-2013**
The dashed line represents the stream water quality standard (126 org/100mL)

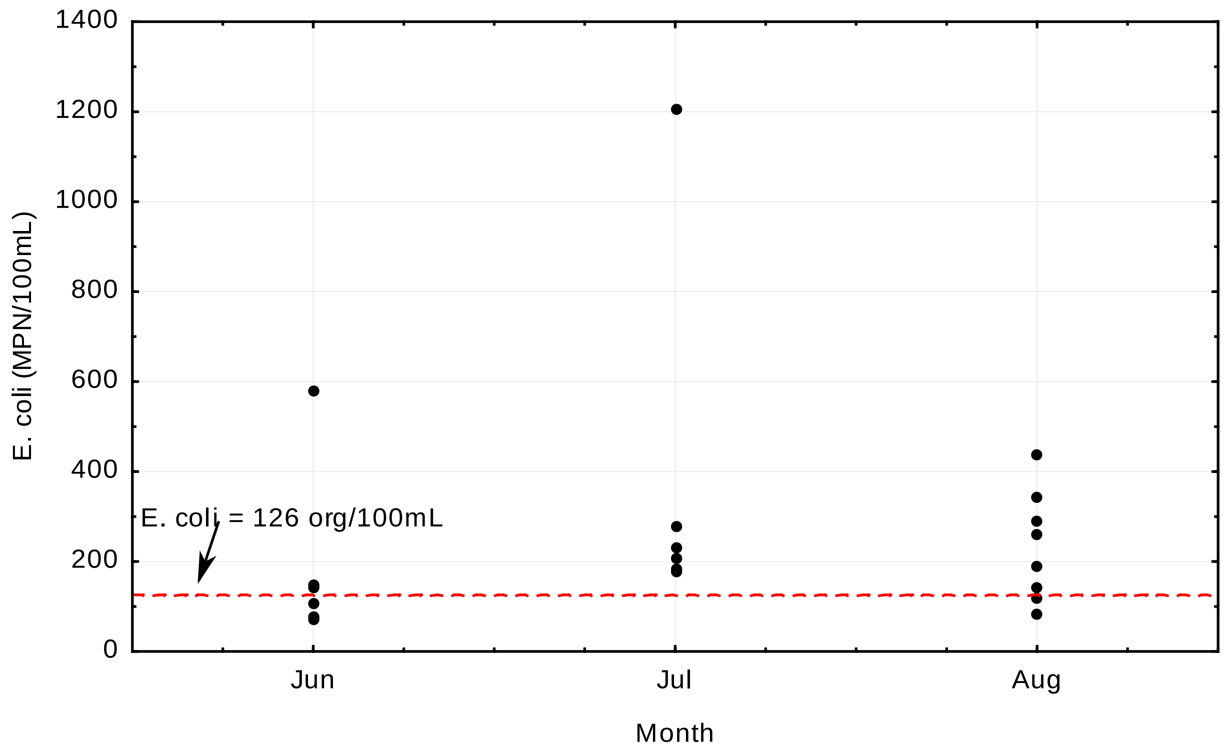
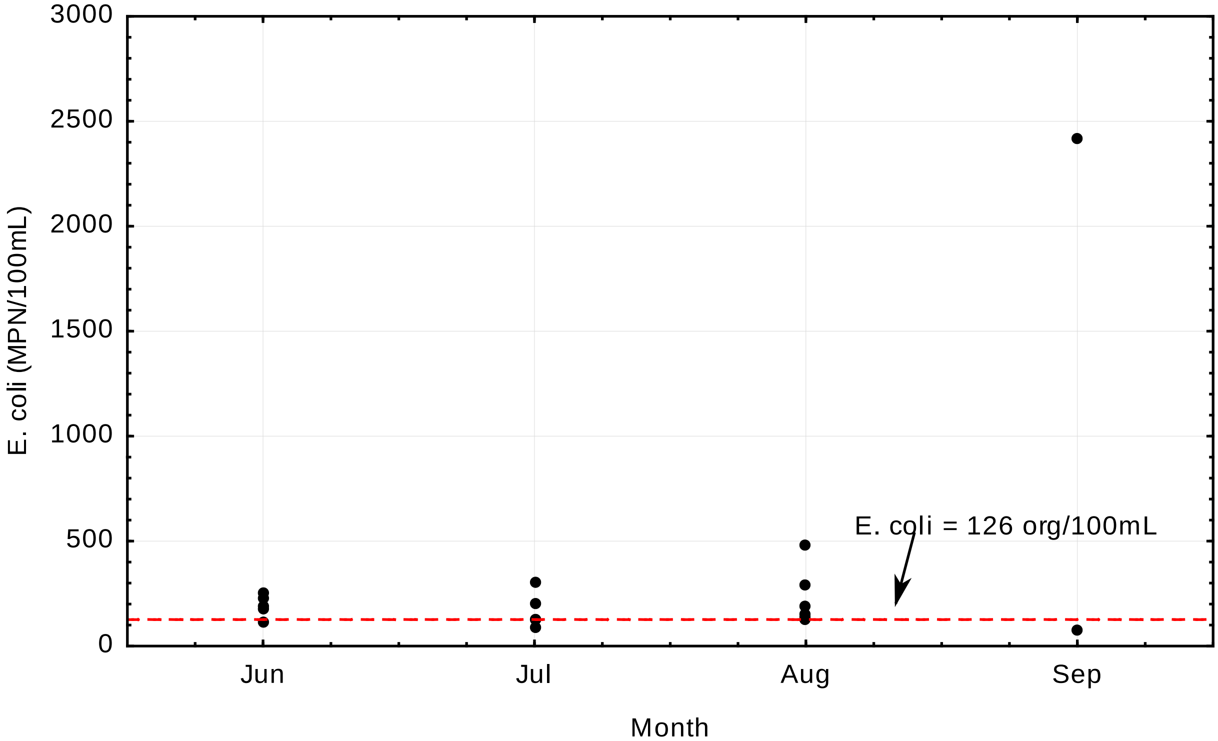


Figure 23. ***E. coli*** **(MPN/100mL) by month in Redeye River (07010107-560) at station S005-724, 2004-2013**
The dashed line represents the stream water quality standard (126 org/100mL)



3.5. Pollutant Source Summary

3.5.1. Stream Bacteria

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

To evaluate the potential sources of bacteria to surface waters a desktop analysis was conducted for sources that are potentially contributing *E. coli* in the watershed. These populations may include livestock, humans, companion animals (cats and dogs), and wildlife (deer, geese, ducks, and raccoons).

Populations were calculated using published estimates (references are provided in each individual source section below) for each source on an individual subwatershed basis in the TMDL Project Area. This is typically a GIS exercise where population estimates are clipped to the individual subwatershed boundaries. In some cases, these population estimates are clipped to individual land uses (defined using the 2006 National Land Cover Dataset, NLCD) within a subwatershed. For example, duck population estimates are assigned to open water land uses.

Bacteria production estimates are based on the bacteria content in feces and an average excretion rate (with units of colony forming units (cfu)/day-head; where *head* implies an individual animal). Bacteria content and excretion rates vary by animal type, as shown in Table 14. All production rates obtained from the literature are for fecal coliform rather than *E. coli* due to the lack of *E. coli* data. The fecal coliform production rates were converted to *E. coli* production rates based on 200 fecal coliforms to 126 *E. coli* per 100 mL (see discussion of *E. coli* water quality standard in Section 2.2).

Table 14. Bacteria production by source

Source Category	Producer	*E. coli* Production Rate [cfu/day-head]	Literature Source
Humans & Pets	Humans	1.26×10^{9}	Metcalf and Eddy 1991
	Dogs	3.15×10^{9}	Horsley and Witten 1996
Livestock	Horses	2.65×10^{10}	Zeckoski et al. 2005
	Cattle	2.08×10^{10}	Zeckoski et al. 2005
	Dairy Cows	1.58×10^{10}	Zeckoski et al. 2005
	Sheep	7.56×10^{9}	Zeckoski et al. 2005
	Hogs	6.93×10^{9}	Zeckoski et al. 2005
	Turkeys	5.86×10^{7}	Zeckoski et al. 2005
	Chickens	5.61×10^{7}	Zeckoski et al. 2005
Wildlife	Deer	2.21×10^{8}	Zeckoski et al. 2005
	Geese	5.04×10^{8}	Zeckoski et al. 2005
	Ducks	1.51×10^{9}	Zeckoski et al. 2005

3.5.1.1. Permitted

Wastewater Treatment Facilities (WWTFs)

The WWTFs are required to test fecal coliform bacteria levels in effluent on a weekly basis. Dischargers to Class 2 waters are required to disinfect from April through October. Wastewater disinfection is required during all months for dischargers within 25 miles of a water intake for a potable water supply system (Minn. R. ch. 7053.0215, subp. 1). The geometric mean for all samples collected in a month must not exceed 200 cfu/ 100 mL fecal coliform bacteria. The WWTFs located in the Redeye River Watershed with surface water discharges are summarized in Table 15.

Continuously discharging municipal WWTF flow is based on the average wet weather design flow, equivalent to the wettest 30-days of influent flow expected over the course of a year. Municipal controlled (pond) flow is based on a maximum of six inches of discharge from the secondary pond in a 24-hour period. Pond systems are only allowed to discharge between April 1 and June 30, and between September 1 and December 15, annually. The WWTF bacteria load was calculated based on the design flow and a permitted fecal coliform effluent limit of 200 org/ 100 mL.

Table 15. WWTF design flows and permitted bacteria loads

Impaired Reach	Facility Name	Permit #	Facility Type	Design Flow (mgd)	Permitted Bacteria Load as Fecal Coliform: 200 org/100 mL [billion org/day]	Equivalent Bacteria Load as *E. coli*: 126 org/100 mL [billion org/day]
-503	Sebeka WWTP	MN0024856	Pond	0.94	7.2	4.5
-508	Wadena WWTP	MN0020672	Continuous	0.75	5.7	3.6
-514	Deer Creek WWTP	MNG580180	Pond	0.52	3.9	2.5
-560	Hewitt WWTP	MNG580024	Pond	0.33	2.5	1.6

Land Application of Biosolids

The application of biosolids from WWTFs is highly regulated, monitored, and tracked (see Minn. R. ch. 7041, *Sewage Sludge Management*). Biosolids disposal methods that inject or incorporate within 24-hours of land application result in minimal possibility for mobilization of bacteria to downstream surface waters. While surface application could conceivably present a risk to surface waters, little to no runoff and bacteria transport is expected if permit restrictions are followed. Therefore, land application of biosolids was not included as a source of bacteria.

Animal Feeding Operations

Animal waste containing fecal bacteria can be transported in watershed runoff to surface waters. The MPCA regulates animal feedlots in Minnesota though counties may be delegated by the MPCA to administer the program for feedlots that are not under federal regulation. The primary goal of the state program for animal feeding operations is to ensure that surface waters are not contaminated by the runoff from feeding facilities, manure storage or stockpiles, and cropland with improperly applied manure. Livestock also occur at hobby farms, small-scale farms that are not large enough to require registration but may have small-scale feeding operations and associated manure application or stockpiles.

Livestock manure is often either surface applied or incorporated into farm fields as a fertilizer and soil amendment. This land application of manure has the potential to be a substantial source of fecal contamination, entering waterways from overland runoff and drain tile intakes. Minn. R. ch. 7020 contains manure application setback requirements based on research related to phosphorus transport, and not bacterial transport, and the effectiveness of these current setbacks on bacterial transport to surface waters is not known. However, recent research in Minnesota has shown that not all *E. coli* strains in streams originate from fecal matter and that many of these bacteria strains naturally occur in the sediments (http://www.mda.state.mn.us/protecting/cleanwaterfund/research/7milecreek.aspx). Therefore, the sources described here represent potential fecal sources of *E. coli* and should be field verified as part of the implementation process.

There are six active National Pollutant Discharge Elimination System (NPDES) permitted feedlot operations in the Redeye River Watershed, four of which are located in the subwatersheds of *E. coli* impaired streams and are Confined Animal Feeding Operations (CAFOs). Manure from these facilities is applied to nearby fields. The bacteria loads produced by animals at these operations were estimated based on the total number of animals (Table 16) and the bacteria production rate of each animal (Table 14).

Table 16. NPDES permitted feedlot operation number of animals

Stream Reach	Feedlot Name	Permit #	CAFO	Hog	Turkey
-503	Red/Eye Hogs LLC	MNG441172	Y	4,800	0
-505	Jennie-O Turkey – Wadena Farm	MNG440421	Y	0	129,000
-514	Jennie-O Turkey – Sandridge N.	MNG440212	Y	0	29,070
-560	Jennie-O Turkey – Verndale Farm	MNG440421	Y	0	370,500

3.5.1.2. Non-permitted

Humans

Sewered and unsewered populations and number of households were determined using the 2010 Census data (U.S. Census Bureau 2011). Total population and the number of households were obtained for each subwatershed using block groups[1]; census block groups that overlap subwatershed boundaries were distributed between each applicable subwatershed on an area-weighted basis. Populations located in a sewered community were estimated from census block group data and boundaries of municipalities serviced by a WWTF (Table 15). A summary of the sewered and unsewered population and households by subwatershed are shown in Table 17.

Table 17. Sewered and unsewered population and households by subwatershed

Stream Reach	Population			Households		
	Sewered	Unsewered	Total	Sewered	Unsewered	Total
-503	411	1,426	1,836	228	939	1,167
-505	325	956	1,281	163	452	615
-508	3	490	493	1	167	168
-514	5,918	3,635	9,553	2,866	1,570	4,435
-515	761	1,247	2,008	323	593	915
-516	0	458	458	0	203	203
-526	0	235	235	0	116	116
-560	711	1,213	1,924	364	563	927

Combined Sewer Overflows

Combined sewer systems are designed to collect sanitary sewage and stormwater runoff in a single pipe system. These systems overflow occasionally when heavy rain or melting snow causes the wastewater

[1] A census block in an urban area typically corresponds to individual city blocks bounded by streets; blocks in rural areas may include many square miles and may have some boundaries that are not streets. A block group is a group of census blocks. A block group is smaller than a census tract, which is a small statistical subdivision of a county (e.g. a municipality or a portion of a large city).

volume to exceed the capacity of the sewer system or treatment plant. An overflow event is called a combined sewer overflow or CSO, which entails a mix of raw sewage and stormwater runoff (from buildings, parking lots, and streets) flowing untreated into surface waters. The occurrence of CSOs is not known to be an issue in the Redeye River Watershed.

Illicit Discharges from Unsewered Communities

In many cases, onsite or small community cluster systems to treat wastewater are installed and forgotten until problems arise. Residential lots in small communities throughout Minnesota cannot accommodate modern septic systems that meet the requirements of current codes due to small lot size and/or inadequate soils. In addition, many small communities are characterized by outdated, malfunctioning septic systems serving older residences. Small lots, poor soils, and inadequate septic system designs and installations may be implicated in bacterial contamination of groundwater but the link to surface water contamination is tenuous.

"Failing" Subsurface Sewage Treatment Systems (SSTS) are specifically defined as systems that are failing to protect groundwater from contamination. Failing SSTS were not considered a source of fecal pollution to surface water. However, systems which discharge partially treated sewage to the ground surface, road ditches, tile lines, and directly into streams, rivers and lakes are considered an imminent threat to public health and safety (ITPHS). The ITPHS systems also include illicit discharges from unsewered communities (sometimes called "straight-pipes"). Straight pipes are illegal and pose an imminent threat to public health as they convey raw sewage from homes and businesses directly to surface water. Community straight pipes are more commonly found in small rural communities.

The MPCA's 2012 SSTS Annual Report identifies percent of systems in unsewered communities that are ITPHS for each county in Minnesota (MPCA 2013; Table 18). Bacteria load from ITPHS was estimated by subwatershed based on these percentages, the unsewered population (Table 17), and the bacteria production rate of humans (Table 14). Note that ITPHS data are derived from surveys of county staff and county level SSTS status inventories. The specific locations of ITPHS systems are not known. The table is not intended to suggest that ITPHS systems contribute excess bacteria to specific waterbodies addressed in this report; rather it suggests that, in general, ITPHS are believed to occur in the project area.

Table 18. Estimate of % Imminent Threat to Public Health Systems (ITPHSS) as reported by each county

County	%ITPHSS
Becker*	4%
Douglas	1%
Morrison*	4%
Otter Tail	5%
Todd	4%
Wadena	6%

*No data was available for Becker or Morrison Counties. The average failure rate of surrounding counties was applied.

Land Application of Septage

A state SSTS license applicable to the type of work being performed is required for any business that conducts work to design, install, repair, maintain, operate, or inspect all or part of an SSTS. A license is also required to land spread septage and operate a sewage collection system discharging to an SSTS. Disposal contractors are required to properly treat and disinfect septage through processing or lime stabilization. Treated septage may then be disposed of onto agricultural and forest lands. The EPA Standards Section 503 provides general requirements, pollutant limits, management practices, and operational standards for the final use or disposal of septage generated during the treatment of domestic sewage in a treatment works.

The MPCA does not directly regulate the land application of septage, but management guidelines entail site suitability requirements with respect to soil conditions, slope, and minimum separation distances (MPCA 2002). Some cities and townships have SSTS septage ordinances (a list is available at http://www.pca.state.mn.us/index.php/view-document.html?gid=10139); these were not reviewed as a part of this study, and application of septage was not included as a source of fecal pollution in this study.

Pets

Human pets (dogs and cats) can contribute bacteria to a watershed when their waste is not properly managed. When this occurs, bacteria can be introduced to waterways from dog parks, residential yard runoff (spring runoff after winter accumulation), rural areas where there are no pet cleanup ordinances, and animal elimination of excrement directly into waterbodies.

Dog waste can be a significant source of pathogen contamination of water resources (Geldreich 1996). Dog waste in the immediate vicinity of a waterway could be a significant local source with local water quality impacts. However, it is generally thought that these sources may be only minor contributors of fecal contamination on a watershed scale because the estimated magnitude of this source is very small compared to other sources. According to the American Veterinary Medical Association's (AVMA) 2006 data, 34.2% of Minnesota households own dogs with a mean number of 1.4 dogs in each of those households (AVMA 2007). In addition, it was assumed that only 38% of dog waste is not collected by owners and can contribute fecal pollution to surface waters (TBEP 2012). Bacteria load from dogs was estimated based on total households in each subwatershed (Table 17), the assumptions mentioned in this paragraph, and the bacteria production rate of dogs (Table 14).

Domestic cats, even those that spend some time outdoors, are most likely to have their waste collected indoors and were not considered a source of bacteria for this study. Feral cats may contribute significantly to bacteria levels in urban streams and rivers (Ram et al. 2007). However, feral cat populations are unknown and were not included in this study.

Livestock

Livestock have the potential to contribute bacteria to surface water through grazing activities or if their manure is not properly managed or stored. Livestock manure is typically collected and applied to nearby fields through injection, which significantly reduces the transport of bacteria contained in manure to surface waters. The population estimates provided in this study are meant to identify areas where large numbers of livestock are located. These areas should be monitored closely by each county to ensure proper management and storage of manure.

The bacteria load from livestock was estimated based on the number of animals registered with the MPCA (Table 19) and the bacteria production rate of those animals (Table 14). The number of feedlot animals registered by the MPCA tends to over-predict the total number of animals in a watershed and does not identify problem manure areas. A windshield survey of the entire Redeye River Watershed is currently in progress as part of the WRAPS process to obtain detailed information that can be used for specific implementation strategies.

Table 19. MPCA registered feedlot animals by impaired reach drainage area

Stream Reach	Beef	Dairy	Horses	Hog	Sheep	Turkey	Chickens
-503	4,110	7,057	33	4,862	775	30,500	44
-505	1,628	778	63	3,288	320	129,000	301
-508	45	399	7	0	180	0	0
-514	7,665	6,342	84	2,910	252	61,000	385
-515	1,023	2,681	24	30	590	0	182
-516	463	1,792	18	3,615	0	5	140
-526	2,367	0	21	100	275	200	500
-560	2,495	4,552	89	435	528	545,807	540

Wildlife

Bacteria can be contributed to surface water by wildlife (e.g. deer, geese, and ducks) dwelling in waterbodies, within conveyances to waterbodies, or when their waste is carried to stormwater inlets, creeks, and ditches during stormwater runoff events. Areas such as Minnesota Department of Natural Resources (DNR) designated Wildlife Management Areas, State Parks, National Parks, National Wildlife Refuges, golf courses, and State Forests provide wildlife habitat encouraging congregation and could be potential sources of higher fecal coliform due to the high densities of animals. There are likely many areas within the project area where wildlife congregates, especially in the wetland-dominated northeast portion of the watershed.

Wildlife populations were estimated based on DNR population data for permit areas and zones. Because permit areas or zones do not align with subwatershed boundaries, population data for any single permit area or zone were distributed among subwatersheds on an area-weighted basis (Table 20). Populations of wildlife (deer, ducks, and geese) were estimated from the data sources and assumptions listed in Table 21. Bacteria loads from wildlife were estimated based on the population (Table 20) and bacteria production rates of wildlife (Table 14).

Table 20. Wildlife population estimates by impaired reach drainage area

Stream reach	Deer	Ducks	Geese
-503	1,944	68	1,120
-505	1,485	50	208
-508	435	8	82
-514	6,826	134	493
-515	2,465	69	731
-516	1,207	23	29
-526	1,018	16	8
-560	3,918	77	34

Table 21. Population estimate data sources and habitat assumptions for wildlife.

Wildlife	Population Estimate Data Sources and Habitat Assumptions
Ducks	According to a presentation by Steve Cordts of the Minnesota DNR Wetland Wildlife Population and Research Group at the 2010 Minnesota DNR Roundtable, Minnesota's annual breeding duck population averaged 550,000 between the years 2005-2009. While the breeding range of the canvasback and lesser scaup is typically outside of the project area, the majority of the breeding duck population (including blue-winged teal, mallards, ring-necked ducks, and wood ducks) has a state-wide breeding range. Statewide there are approximately 90,555,611 acres of suitable open water National Wetland Inventory (NWI) habitat, equivalent to 0.061 ducks per acre of open water. This duck population density was distributed over all suitable open water NWI land covers plus a 100-foot buffer within each subwatershed on an area-weighted basis.
Deer	The DNR report Status of Wildlife Populations, Fall 2009, includes a collection of studies that estimate wildlife populations of various species (Dexter 2009). Pre-fawn deer densities were reported by DNR deer permit area. Permit area deer population densities are reported over all 2006 NLCD land covers except open water within each subwatershed on an area-weighted basis.
Geese	The DNR report Status of Wildlife Populations, Fall 2009, also includes a collection of studies that estimate wildlife populations of various species by Minnesota ecoregion (Dexter 2009). Geese population data were distributed over and within a 100 foot buffer of all open water areas (Public Waters Inventory (PWI) basins, streams, ditches and rivers, and 2006 NLCD *Open Water*) on an area-weighted basis within each subwatershed.

3.5.1.3. Strengths and Limitations

The bacteria production estimates are provided at the subwatershed scale. The results inform stakeholders as to the types and relative magnitude of bacteria produced in their watershed. This information is a valuable tool for the planning and management of water bodies with respect to bacteria contamination. The potential bacteria source estimates in the project area were calculated using a GIS-based approach. However, available data sources are at different scales and have different boundaries than that of the study subwatersheds. A limitation to the estimation process is that population data at a statewide or ecoregion scale must be distributed to the subwatershed scale based on average population density. As a result, there is a probable minimum scale at which bacteria production estimates are useful.

A significant portion of bacteria producers were accounted for in the potential bacteria sources. However, several animals were not included: birds other than geese and ducks (e.g. song birds and wading birds) and many wild animals (e.g. beavers, bear and wild turkey). Data, resource limitations, and consideration for the major bacteria producers in the project area led to the selected set of bacteria producers accounted for in these estimates. The project area estimates of potential bacteria sources is also limited by the fact that bacteria delivery is not addressed (e.g. treatment of human waste at WWTFs prior to discharge to receiving waters, pet waste management, zero discharge feedlot facilities, incorporation of manure into soil, geese gathering directly on stormwater ponds). The potential bacteria source estimates also do not account for the relative risk among different types of bacteria. Instead, *E. coli* production is estimated as an indicator of the likelihood of pathogen contamination of our waterbodies.

Two Minnesota studies described the potential for the presence of “naturalized” or “indigenous” *E. coli* in watershed soils (Ishii et al. 2006) and ditch sediment and water (Sadowsky et al. 2010). These studies suggest the presence of natural background *E. coli* and a fraction of *E. coli* may be present regardless of the control measures taken by traditional implementation strategies.

3.5.1.4. Summary

Refer to Section 3.2 for boundaries of the contributing watersheds to each impaired stream reach. Bacteria production estimates by subwatershed are listed by producer in Table 22 and for all producers in Table 23.

Table 22. Annual *E. coli* production estimates by producer

Stream Reach	Humans & Pets			Livestock							Wildlife		
	WWTF Effluent	ITPH SSTS	Dogs	Cattle	Dairy	Turkey	Chickens	Hogs	Sheep	Horses	Deer	Ducks	Geese
-503	3	108	655	85,447	111,148	1,787	2	33,694	5,859	873	1,206	163	35
-505	0	112	1,098	33,846	52,227	7,558	17	22,786	2,419	1,667	600	64	6
-508	2	39	555	936	5,969	0	0	0	1,361	185	100	19	14
-514	2	181	1,118	159,355	79,853	3,574	22	20,166	1,905	2,223	852	190	711
-515	0	55	441	21,268	54,605	0	10	208	4,460	635	550	54	9
-516	0	26	117	9,626	20,759	0	8	25,052	0	476	163	42	63
-526	0	25	124	49,210	10,679	12	28	693	2,079	556	206	32	4
-560	1	92	856	51,871	24,161	31,979	30	3,015	3,992	2,355	636	128	525

Table 23. Total annual *E. coli* production estimates

Stream Reach	Area	Total	Total	Humans	Livestock	Wildlife
	(ac)	(billion org/d)	(billion org/ac/d)	(% Total)		
-503	116,166	240,980	2.07	0%	99%	1%
-505	56,649	122,400	2.16	1%	98%	1%
-508	13,635	9,181	0.67	6%	92%	1%
-514	140,217	270,151	1.93	0%	99%	1%
-515	49,307	82,296	1.67	1%	99%	1%
-516	25,733	56,331	2.19	0%	99%	0%
-526	21,946	63,648	2.90	0%	99%	0%
-560	101,219	119,640	1.18	1%	98%	1%

4. TMDL Development

This section presents the overall approach to estimating the components of the TMDL. The pollutant sources were first identified and estimated in the pollutant source assessment. The loading capacity (TMDL) of each stream was then estimated using a LDC and was divided among WLAs and LAs. A TMDL for a waterbody that is impaired as the result of excessive loading of a particular pollutant can be described by the following equation:

$$\boxed{\mathbf{TMDL = LC = \sum WLA + \sum LA + MOS + RC}}$$

Where:

Loading capacity (LC): the greatest pollutant load a waterbody can receive without violating water quality standards;

Wasteload allocation (WLA): the pollutant load that is allocated to point sources, including WWTFs, regulated construction stormwater, and regulated industrial stormwater, all covered under NPDES permits for a current or future permitted pollutant source;

Load allocation (LA): the pollutant load that is allocated to sources not requiring NPDES permit coverage, including non-regulated stormwater runoff, atmospheric deposition, and internal loading;

Margin of Safety (MOS): an accounting of uncertainty about the relationship between pollutant loads and receiving water quality;

Reserve Capacity (RC): the portion of the loading capacity attributed to the growth of existing and future load sources.

4.1. Bacteria

4.1.1. Loading Capacity

The loading capacities for impaired stream reaches receiving an *E. coli* TMDL as a part of this study were determined using LDCs. Flow and LDCs are used to determine the flow conditions (flow regimes) under which exceedances occur. Flow duration curves provide a visual display of the variation in flow rate for the stream. The x-axis of the plot indicates the percentage of time that a flow exceeds the corresponding flow rate as expressed by the y-axis. LDCs take the flow distribution information constructed for the stream and factor in pollutant loading to the analysis. A standard curve is developed by applying a particular pollutant standard or criteria to the stream flow duration curve and is expressed as a load of pollutant per day. The standard curve represents the upper limit of the allowable in-stream pollutant load (loading capacity) at a particular flow. Monitored loads of a pollutant are plotted against this curve to display how they compare to the standard. Monitored values that fall above the curve represent an exceedance of the standard.

For the stream TMDL derivation, the MPCA gauged flows or HSPF modeled flows for the period 2000 through 2009 were used to develop flow duration curves. The loading capacities were determined by applying the *E. coli* water quality standard (126 org/ 100 mL) to the flow duration curve to produce a bacteria standard curve. Loading capacities presented in the allocation tables represent the median *E. coli* load (in billion org/day) along the bacteria standard curve within each flow regime. A bacteria LDC with modeled data and a TMDL allocation table are provided for each stream in Section 4.1.7. LDC data sources for each stream are reported in Appendix A. Where water quality and flow locations were significantly different, the flows from the impaired stream reach contributing drainage area were area-weighted to account for differences in flow volume at the two locations.

For each impaired stream reach, at least two years of consecutive water quality monitoring (*E. coli*) were conducted over the period 2009 through 2012. In the development of LDCs, the MPCA gauged flows with overlapping *E. coli* monitoring data wherever possible. When the MPCA gauged flow data did not exist, HSPF modeled flows were used. The sources of all water quality and stream flow data used in the development of LDCs are described in Appendix A at the end of this report.

The LDC method is based on an analysis that encompasses the cumulative frequency of historical flow data over a specified period. Because this method uses a long-term record of daily flow volumes virtually the full spectrum of allowable loading capacities is represented by the resulting curve. In the TMDL tables of this report, only five points on the entire loading capacity curve are depicted (the midpoints of the designated flow zones). However, it should be understood that the entire curve represents the TMDL and is what is ultimately approved by the EPA.

4.1.2. Load Allocation Methodology

The LAs represent the portion of the loading capacity that is designated for non-regulated sources of *E. coli*, as described in Section 3.5, that are located downstream of any other impaired waters with TMDLs located in the watershed. The remainder of the loading capacity (TMDL) after subtraction of the MOS and calculation of the WLA was used to determine the LA for each impaired stream, on an areal basis.

4.1.3. Watershed Allocation Methodology

4.1.3.1. Regulated Construction Stormwater

E. coli WLAs for regulated construction stormwater (Permit #MNR100001) were not developed since *E. coli* is not a typical pollutant from construction sites.

4.1.3.2. Regulated Industrial Stormwater

There are no *E. coli* benchmarks associated with the industrial stormwater permit because no industrial sectors regulated under the permit are known to be *E. coli* sources. Therefore, *E. coli* TMDLs will not include an industrial stormwater WLA. Since sites with MNG Permits are not known to be sources of *E. coli*, sites with MNG49 Nonmetallic Mining General NPDES Permits that are within the *E. coli* TMDL Subwatersheds will not receive an *E. coli* WLA.

4.1.3.3. MS4 Regulated Stormwater

There is no regulated MS4 stormwater in any of the impaired stream subwatersheds.

4.1.3.4. Feedlots Requiring NPDES/SDS Permit Coverage

An animal feeding operation (AFO) is a general term for an area intended for the confined holding of animals, where manure may accumulate, and where vegetative cover cannot be maintained within the enclosure due to the density of animals. Animal feeding operations that either (a) have a capacity of 1,000 animal units (AU) or more, or (b) meet or exceed the EPA's CAFO threshold and discharge to Waters of the United States, are required to apply for permit coverage through the MPCA. If item (a) is triggered, the permit can be a State Disposal System (SDS) or NPDES Permit; if item (b) is triggered, the permit must be an NPDES Permit. These permits require that the feedlots have zero discharge to surface water.

Based on a desktop review of the MPCA data there are four active NPDES permitted feedlots within an *E. coli* impaired stream reach drainage area, all of which are CAFOs (Table 16).

4.1.3.5. Municipal and Industrial Wastewater Treatment Systems

An individual WLA was provided for all NPDES-permitted WWTFs that have fecal coliform discharge limits (200 org/100mL, April 1 through October 31) and whose surface discharge stations fall within an impaired stream subwatershed. The WWTFs located in the Redeye River Watershed with surface water discharges are summarized in Table 24. WWTF design flows and permitted bacteria loads

Continuously discharging municipal WWTF flow is based on the average wet weather design flow, equivalent to the wettest 30-days of influent flow expected over the course of a year. Municipal controlled (pond) flow is based on a maximum of 6 inches of discharge from the secondary pond in a 24-hour period. Pond systems are only allowed to discharge between April 1 and June 30, and between September 1 and December 15, annually. The WLA was calculated based on the design flow and a permitted fecal coliform effluent limit of 200 org/ 100 mL. The WLAs are based on *E. coli* loads even though the facilities' discharge limits are based on fecal coliform. If a discharger is meeting the fecal coliform limits of their permit, it is assumed that they are also meeting the *E. coli* WLA in these TMDLs.

Table 24. WWTF design flows and permitted bacteria loads

Impaired Reach	Facility Name	Permit #	Facility Type	Design Flow (mgd)	Permitted Bacteria Load as Fecal Coliform: 200 org/100 mL [billion org/day]	Equivalent Bacteria Load as *E. coli*: 126 org/100 mL [billion org/day]
-503	Sebeka WWTP	MN0024856	Pond	0.94	7.2	4.5
-508	Wadena WWTP	MN0020672	Continuous	0.75	5.7	3.6
-514	Deer Creek WWTP	MNG580180	Pond	0.52	3.9	2.5
-560	Hewitt WWTP	MNG580024	Pond	0.33	2.5	1.6

4.1.4. Margin of Safety

An explicit MOS equal to 10% of the loading capacity was used for the stream TMDLs based on the following considerations:

- Most of the uncertainty in flow is a result of extrapolating flows from the hydrologically-nearest stream gage. The explicit MOS, in part, accounts for this.
- Allocations are a function of flow, which varies from high to low flows. This variability is accounted for through the development of a TMDL for each of five flow regimes.

- With respect to the *E. coli* TMDLs, the load duration analysis does not address bacteria re-growth in sediments, die-off, and natural background levels. The MOS helps to account for the variability associated with these conditions.

4.1.5. Seasonal Variation

Use of these water bodies for aquatic recreation occurs from April through October, which includes all or portions of the spring, summer and fall seasons. *E. coli* loading varies with the flow regime and season. Spring is associated with large flows from snowmelt, the summer is associated with the growing season as well as periodic storm events and receding streamflows, and the fall brings increasing precipitation and rapidly changing agricultural landscapes.

Critical conditions and seasonal variation are addressed in this TMDL through several mechanisms. The *E. coli* standard applies during the recreational period, and data was collected throughout this period. The water quality analysis conducted on these data evaluated variability in flow through the use of five flow regimes: from high flows, such as flood events, to low flows, such as baseflow. Through the use of LDCs and monthly summary figures, *E. coli* loading was evaluated at actual flow conditions at the time of sampling (and by month), and monthly *E. coli* concentrations were evaluated against precipitation and streamflow.

4.1.6. Future Growth Consideration/Reserve Capacity

Potential changes in population and land use over time in the Redeye River Watershed could result in changing sources of pollutants. Possible changes and how they may or may not impact TMDL allocations are discussed below.

4.1.6.1. New or Expanding Permitted MS4 WLA Transfer Process

Future transfer of watershed runoff loads in this TMDL may be necessary if any of the following scenarios occur within the project watershed boundaries:

1. New development occurs within a regulated Municipal Separate Storm Sewer Systems (MS4). Newly developed areas that are not already included in the WLA must be transferred from the LA to the WLA to account for the growth.
2. One regulated MS4 acquires land from another regulated MS4. Examples include annexation or highway expansions. In these cases, the transfer is WLA to WLA.
3. One or more non-regulated MS4s become regulated. If this has not been accounted for in the WLA, then a transfer must occur from the LA.
4. Expansion of a U.S. Census Bureau Urban Area encompasses new regulated areas for existing permittees. An example is existing state highways that were outside an Urban Area at the time the TMDL was completed, but are now inside a newly expanded Urban Area. This will require either a WLA to WLA transfer or a LA to WLA transfer.
5. A new MS4 or other stormwater-related point source is identified and is covered under a NPDES Permit. In this situation, a transfer must occur from the LA.

Load transfers will be based on methods consistent with those used in setting the allocations in this TMDL (see Section 4.1.3). One transfer rate was defined for each impaired stream as the total WLA (billion org/day) divided by the watershed area downstream of any upstream impaired waterbody (acres). In the case of a load transfer, the amount transferred from LA to WLA will be based on the area (acres) of land coming under permit coverage multiplied by the transfer rate (billion org/ac-day). The MPCA will make these allocation shifts. In cases where WLA is transferred from or to a regulated MS4, the permittees will be notified of the transfer and have an opportunity to comment. Individual transfer rates for each stream TMDL are listed in Table 25.

Table 25. Transfer rates for any future MS4 discharger in the impaired stream watersheds

Stream name	AUID	LA to WLA transfer rates (million org/acre/day)				
		High	Wet	Mid	Dry	Low
Redeye River	07010107-503	6.05	2.37	1.07	0.48	0.19
Leaf River	07010107-505	30.37	11.64	5.07	2.16	0.76
Union Creek	07010107-508	8.81	2.77	1.01	0.32	0.01
Leaf River	07010107-514	11.02	4.59	2.71	1.14	0.61
Bluff Creek	07010107-515	9.78	2.26	0.91	0.31	0.12
Oak Creek	07010107-516	6.32	2.64	1.47	0.72	0.25
Unnamed Creek	07010107-526	8.34	2.93	1.35	0.59	0.30
Wing River	07010107-560	5.62	2.91	1.63	1.00	0.24

4.1.6.2. New or Expanding Wastewater

The MPCA, in coordination with the EPA Region 5, has developed a streamlined process for setting or revising WLA for new or expanding wastewater discharges to waterbodies with an EPA approved TMDL (MPCA 2012). This procedure will be used to update WLAs in approved TMDLs for new or expanding wastewater dischargers whose permitted effluent limits are at or below the in-stream target and will ensure that the effluent concentrations will not exceed applicable water quality standards or surrogate measures. The process for modifying any and all WLAs will be handled by the MPCA, with input and involvement by the EPA, once a permit request or reissuance is submitted. The overall process will use the permitting public notice process to allow for the public and EPA to comment on the permit changes based on the proposed WLA modification(s). Once any comments or concerns are addressed, and the MPCA determines that the new or expanded wastewater discharge is consistent with the applicable water quality standards, the permit will be issued and any updates to the TMDL WLA(s) will be made.

For more information on the overall process visit the MPCA's TMDL Policy and Guidance webpage.

4.1.7. TMDL Summary

The individual impaired stream TMDL and allocations are summarized in table format in the following sections. The LDCs used in the determination of loading capacity are included in these sections. For detailed information on potential sources of *E. coli* in watershed runoff see the Bacterial Source Assessment, Section 3.5.1. Refer to Section 10. Appendix A: LDC Supporting information for flow and water quality data sources used.

The LDC method is based on an analysis that encompasses the cumulative frequency of historic flow data over a specified period. Because this method uses a long-term record of daily flow volumes virtually the full spectrum of allowable loading capacities is represented by the resulting curve. In the TMDL equation tables of this report only five points on the entire loading capacity curve are depicted (the midpoints of the designated flow zones). However, it should be understood that the entire curve represents the TMDL and is what is ultimately approved by the EPA.

4.1.7.1. Redeye River (07010107-503) *E. coli* TMDL

Figure 24. Redeye River (07010107-503) *E. coli* Load Duration Curve

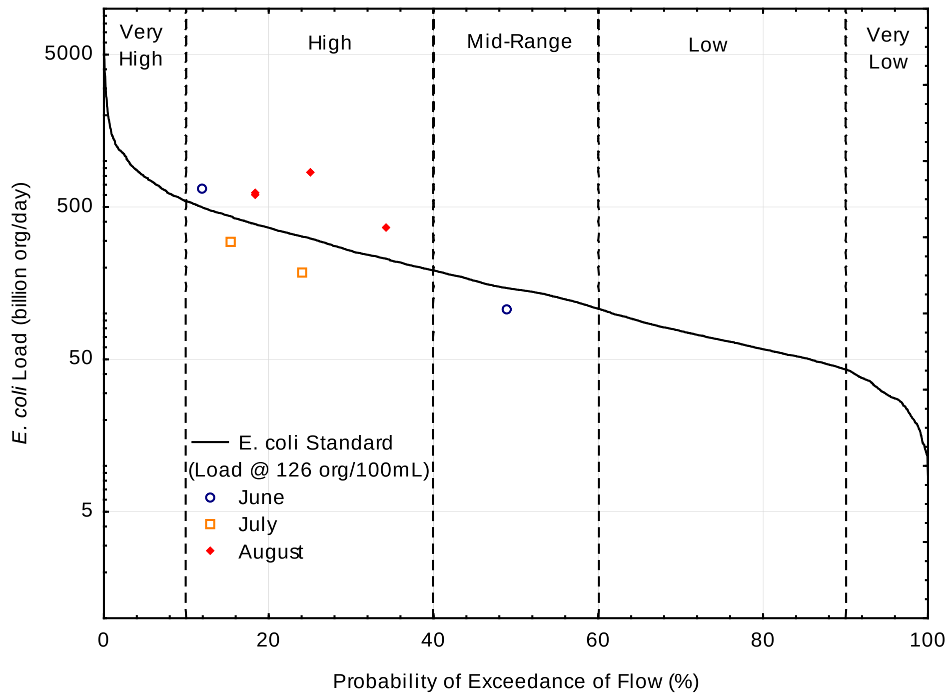


Table 26. Redeye River (07010107-503) *E. coli* TMDL and Allocations

Redeye River 07010107-503 Load Component		Flow Regime				
		Very High	High	Mid	Low	Very Low
		Billion organisms per day				
Existing Load		*No Data*	*459.8*	*105.8*	*No Data*	*No Data*
Wasteload Allocations	*Sebeka WWTP (MN0024856)*	*4.5*	*4.5*	*4.5*	*4.5*	*4.5*
	Red/Eye Hogs LLC (MNG441172)	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*
	Total WLA	**4.5**	**4.5**	**4.5**	**4.5**	**4.5**
Load Allocations	*Watershed runoff*	*703.1*	*275.5*	*124.9*	*55.6*	*22.0*
	Total LA	**703.1**	**275.5**	**124.9**	**55.6**	**22.0**
10% MOS		**78.6**	**31.1**	**14.4**	**6.7**	**2.9**
Total Loading Capacity		**786.2**	**311.1**	**143.8**	**66.8**	**29.4**
Estimated Load Reduction		*n/a*	*148.6*	*0*	*n/a*	*n/a*
		n/a	*32%*	*0%*	*n/a*	*n/a*

4.1.7.2. Leaf River (07010107-505) *E. coli* TMDL

Figure 25. Leaf River (07010107-505) *E. coli* Load Duration Curve

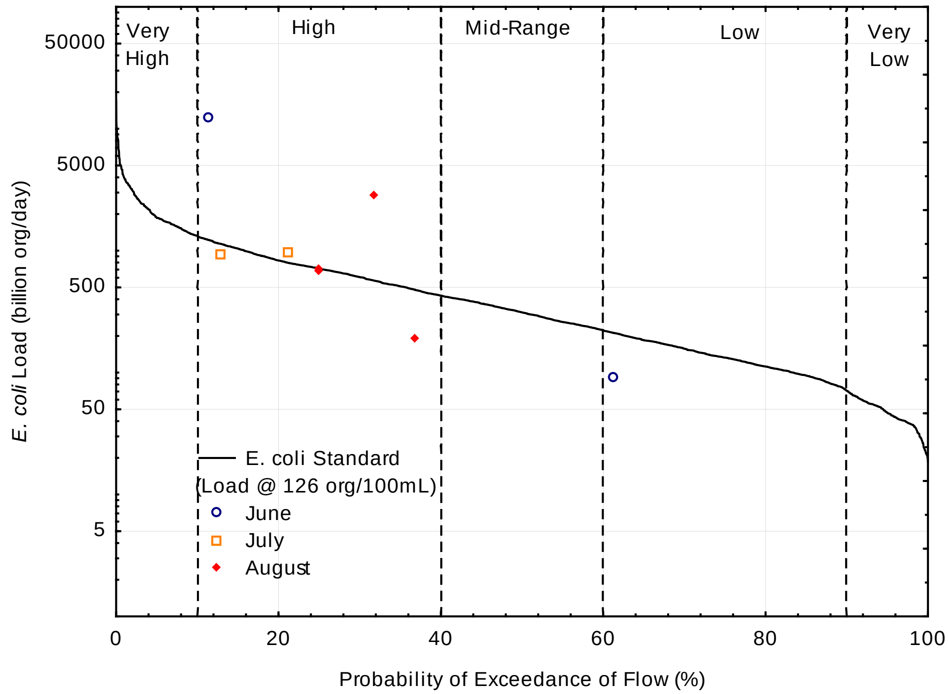


Table 27. Leaf River (07010107-505) *E. coli* TMDL and Allocations

Leaf River 07010107-505 Load Component		Flow Regime				
		Very High	High	Mid	Low	Very Low
		Billion organisms per day				
Existing Load		*No Data*	*1,179.3*	*No Data*	*90.8*	*No Data*
Wasteload Allocations	*Jennie-O Turkey – Wadena Farm (MNG440421)*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*
	Total WLA	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Load Allocations	*Leaf River (-514)**	*1,540.3*	*590.1*	*257.1*	*109.3*	*38.5*
	*Oak Creek (-516)**	*109.7*	*34.8*	*13.3*	*5.5*	*2.0*
	Watershed runoff	*34.4*	*20.4*	*10.7*	*4.7*	*1.6*
	Total LA	**1,684.4**	**645.3**	**281.1**	**119.5**	**42.1**
10% MOS		**187.2**	**71.7**	**31.2**	**13.3**	**4.7**
Total Loading Capacity		**1,871.6**	**717.0**	**312.3**	**132.8**	**46.8**
Estimated Load Reduction		*n/a*	*462.3*	*n/a*	*0*	*n/a*
		n/a	*39%*	*n/a*	*0%*	*n/a*

* The upstream impaired reach LA is based on HSPF modeled flows available for the same time period used to develop the impaired stream LDC. However, the loading capacity for these impaired stream reaches is based on gauged flow data for a different time period, and therefore does not equal the LA presented in this table.

4.1.7.3. Union Creek (07010107-508) *E. coli* TMDL

Figure 26. Union Creek (07010107-508) *E. coli* Load Duration Curve

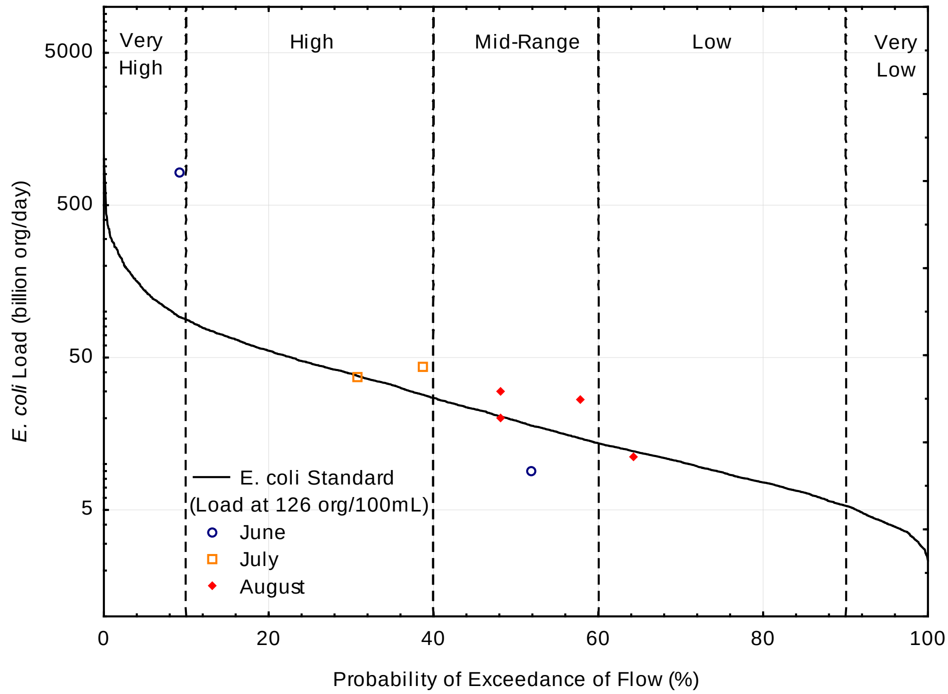


Table 28. Union Creek (07010107-508) *E. coli* TMDL and Allocations

Union Creek 07010107-508 Load Component		Flow Regime				
		Very High	High	Mid	Low	Very Low
		Billion organisms per day				
Existing Load		*818.6*	*40.4*	*19.6*	*11.3*	*No Data*
Wasteload Allocations	*Wadena WWTP (MN0020672)*	*3.6*	*3.6*	*3.6*	*3.6*	*3.6*
	Total WLA	**3.6**	**3.6**	**3.6**	**3.6**	**3.6**
Load Allocations	*Watershed runoff*	*120.1*	*37.8*	*13.8*	*4.4*	*0.1*
	Total LA	**120.1**	**37.8**	**13.8**	**4.4**	**0.1**
10% MOS		**13.7**	**4.6**	**1.9**	**0.9**	**0.4**
Total Loading Capacity		**137.4**	**46.0**	**19.3**	**8.9**	**4.1**
Estimated Load Reduction		*681.2*	*0*	*0.3*	*2.4*	*n/a*
		83%	*0%*	*1.5%*	*21%*	*n/a*

4.1.7.4. Leaf River (07010107-514) *E. coli* TMDL

Figure 27. Leaf River (07010107-514) *E. coli* Load Duration Curve

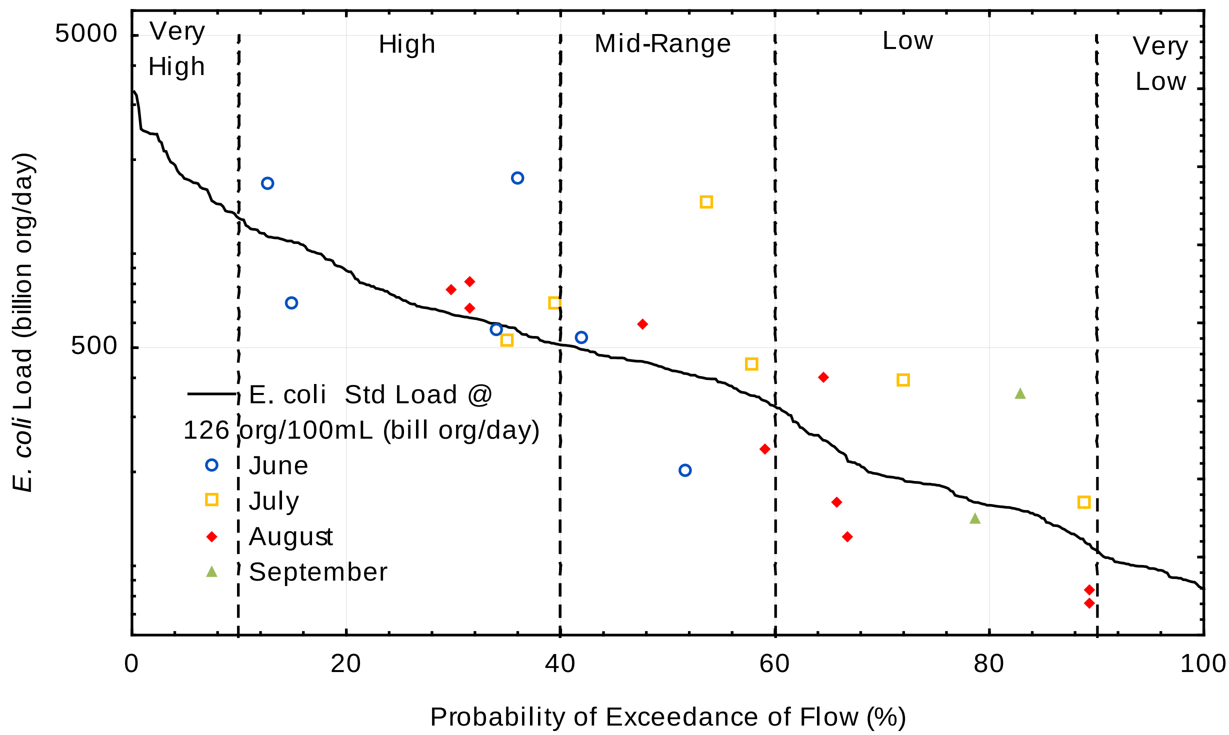


Table 29. Leaf River (07010107-514) *E. coli* TMDL and Allocations

Leaf River 07010107-514 Load Component		Flow Regime				
		Very High	High	Mid	Low	Very Low
		Billion organisms per day				
Existing Load		*No Data*	*826.2*	*465.4*	*176.4*	*No Data*
Wasteload Allocations	*Deer Creek WWTP (MNG580180)*	2.5	2.5	2.5	2.5	2.5
	Jennie-O Turkey Sandridge N. (MNG440212)	0.0	0.0	0.0	0.0	0.0
	Total WLA	**2.5**	**2.5**	**2.5**	**2.5**	**2.5**
Load Allocations	*Bluff Creek (-515)*	482.4	111.2	44.8	15.1	5.8
	Watershed runoff	1,076.8	538.4	337.8	146.2	80.0
	Total LA	**1,559.2**	**649.6**	**382.6**	**161.3**	**85.8**
10% MOS		**173.5**	**72.5**	**42.8**	**18.2**	**9.8**
Total Loading Capacity		**1,735.2**	**724.6**	**427.9**	**182.0**	**98.1**
Estimated Load Reduction		n/a	101.6	37.5	0	n/a
		n/a	12%	8%	0%	n/a

4.1.7.5. Bluff Creek (07010107-515) *E. coli* TMDL

Figure 28. Bluff Creek (07010107-515) *E. coli* Load Duration Curve

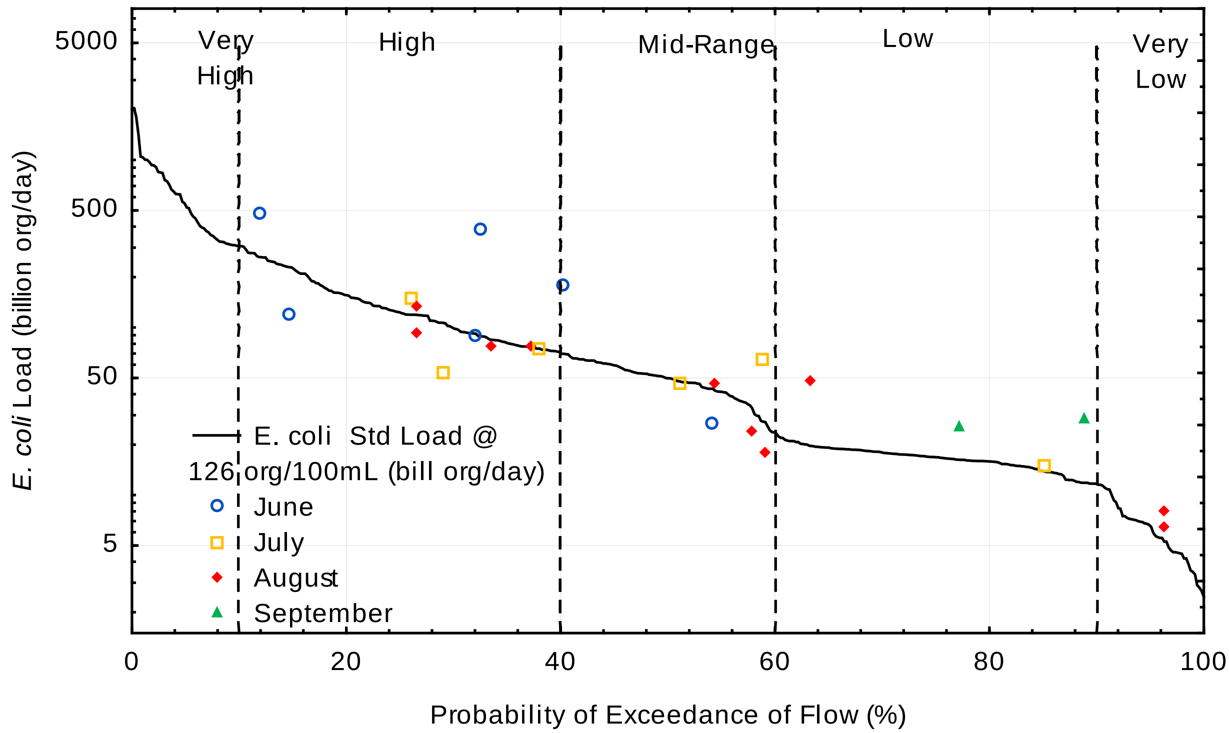


Table 30. Bluff Creek (07010107-515) *E. coli* TMDL and Allocations

Bluff Creek 07010107-515 Load Component		Flow Regime				
		Very High	High	Mid	Low	Very Low
		Billion organisms per day				
Existing Load		*No Data*	*122.9*	*43.6*	*27.2*	*7.3*
Wasteload Allocations	*None*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*
	Total WLA	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Load Allocations	*Watershed runoff*	*482.4*	*111.2*	*44.8*	*15.1*	*5.8*
	Total LA	**482.4**	**111.2**	**44.8**	**15.1**	**5.8**
10% MOS		**53.6**	**12.4**	**5.0**	**1.7**	**0.6**
Total Loading Capacity		**536.0**	**123.6**	**49.8**	**16.8**	**6.4**
Estimated Load Reduction		*n/a*	*0*	*0*	*10.4*	*0.9*
		n/a	*0%*	*0%*	*38%*	*14%*

4.1.7.6. Oak Creek (07010107-516) *E. coli* TMDL

Figure 29. Oak Creek (07010107-516) *E. coli* Load Duration Curve

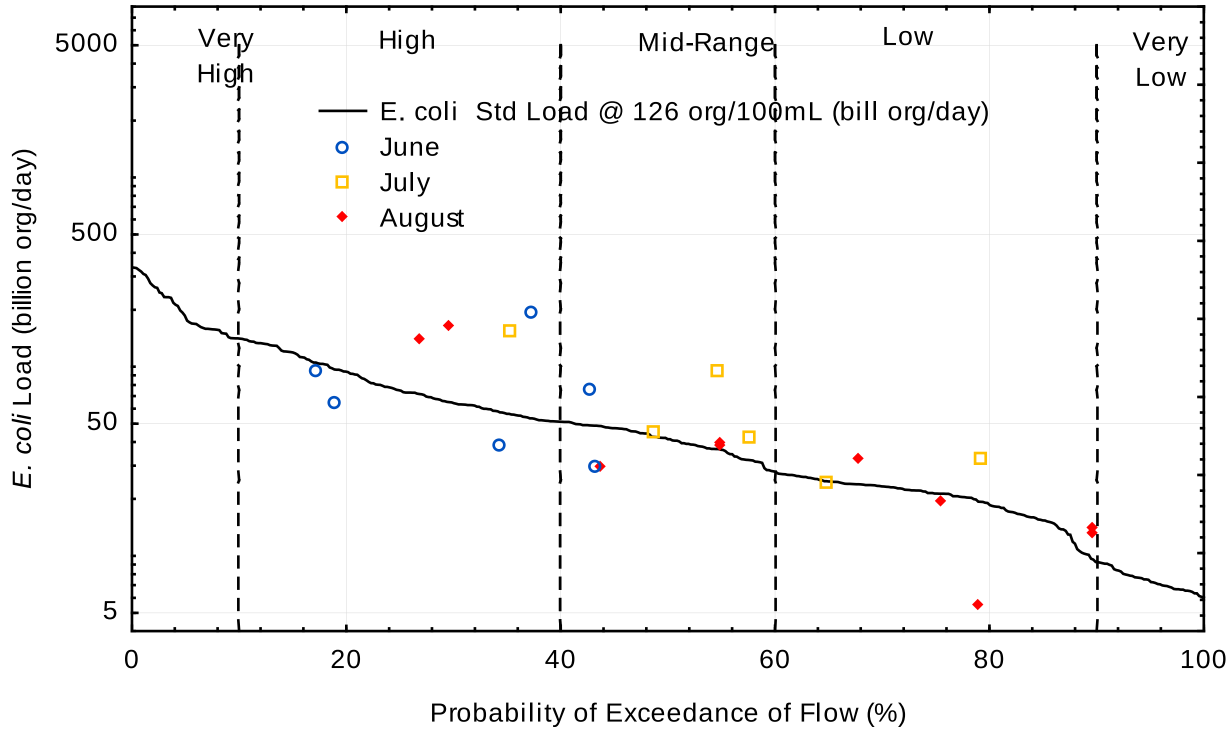


Table 31. Oak Creek (07010107-516) *E. coli* TMDL and Allocations

Oak Creek 07010107-516 Load Component		Flow Regime: Very High	High	Mid	Low	Very Low
		Billion organisms per day				
Existing Load		*No Data*	*108.0*	*46.0*	*17.8*	*No Data*
Wasteload Allocations	*None*	0.0	0.0	0.0	0.0	0.0
	Total WLA	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Load Allocations	*Watershed runoff*	162.7	67.9	37.9	18.5	6.5
	Total LA	**162.7**	**67.9**	**37.9**	**18.5**	**6.5**
10% MOS		**18.1**	**7.5**	**4.2**	**2.1**	**0.7**
Total Loading Capacity		**180.8**	**75.4**	**42.1**	**20.6**	**7.2**
Estimated Load Reduction		n/a	32.6	3.9	0	n/a
		n/a	30%	8.5%	0%	n/a

4.1.7.7. Unnamed Creek (Hay Creek) (07010107-526) *E. coli* TMDL

Figure 30. Unnamed Creek (Hay Creek) (07010107-526) *E. coli* Load Duration Curve

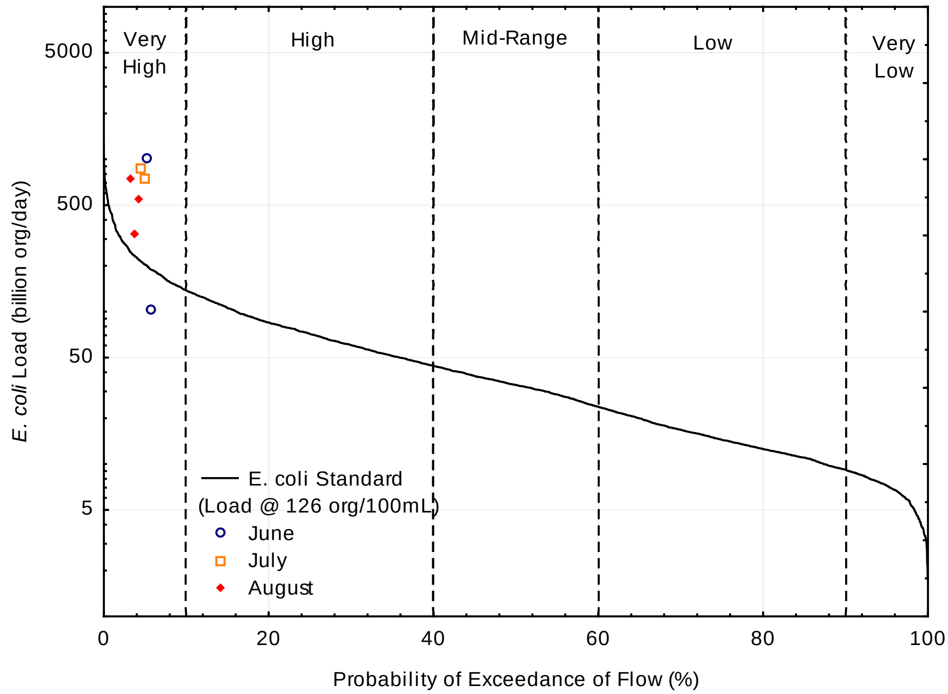


Table 32. Unnamed Creek (Hay Creek) (07010107-526) *E. coli* TMDL and Allocations

Unnamed Creek - Hay Creek 07010107-526 Load Component		Flow Regime				
		Very High	High	Mid	Low	Very Low
		Billion organisms per day				
Existing Load		*485.0*	*No Data*	*No Data*	*No Data*	*No Data*
Wasteload Allocations	*None*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*
	Total WLA	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Load Allocations	*Watershed runoff*	*183.0*	*64.3*	*29.7*	*13.0*	*6.5*
	Total LA	**183.0**	**64.3**	**29.7**	**13.0**	**6.5**
10% MOS		**20.3**	**7.1**	**3.3**	**1.4**	**0.7**
Total Loading Capacity		**203.3**	**71.4**	**33.0**	**14.4**	**7.2**
Estimated Load Reduction		*281.7*	*n/a*	*n/a*	*n/a*	*n/a*
		58%	*n/a*	*n/a*	*n/a*	*n/a*

4.1.7.8. Wing River (07010107-560) *E. coli* TMDL

Figure 31. Wing River (07010107-560) *E. coli* Load Duration Curve

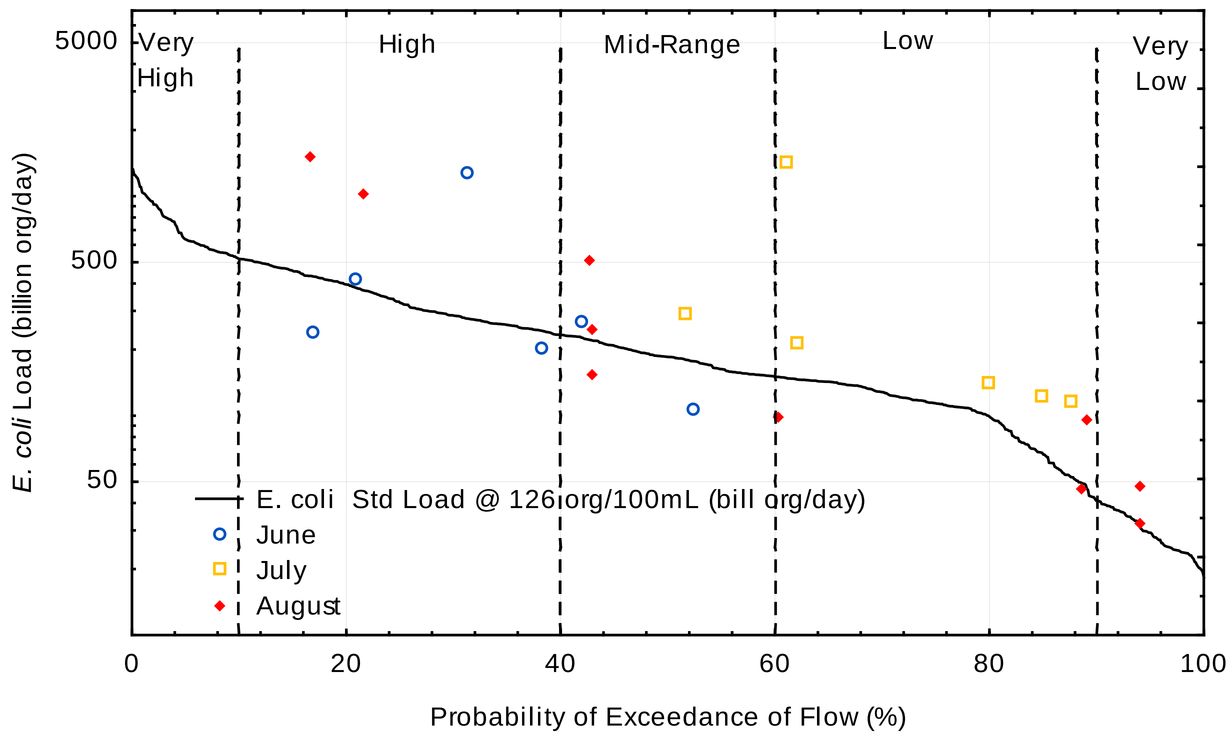


Table 33. Wing River (07010107-560) *E. coli* TMDL and Allocations

Wing River 07010107-560 Load Component		Flow Regime				
		Very High	High	Mid	Low	Very Low
		Billion organisms per day				
Existing Load		***No Data***	***585.6***	***233.1***	***151.2***	***39.3***
Wasteload Allocations	*Hewitt WWTP (MNG580024)*	*1.6*	*1.6*	*1.6*	*1.6*	*1.6*
	Jennie-O Turkey - Verndale Farm (MNG440421)	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*
	Total WLA	**1.6**	**1.6**	**1.6**	**1.6**	**1.6**
Load Allocations	*Watershed runoff*	*569.3*	*294.1*	*165.3*	*101.0*	*24.8*
	Total LA	**569.3**	**294.1**	**165.3**	**101.0**	**24.8**
10% MOS		**63.4**	**32.8**	**18.5**	**11.4**	**2.9**
Total Loading Capacity		**634.3**	**328.5**	**185.4**	**114.0**	**29.3**
Estimated Load Reduction		*n/a*	*257.1*	*47.7*	*37.2*	*10.0*
		n/a	*44%*	*20%*	*25%*	*25%*

4.1.8. TMDL Baseline Years

The TMDLs are based on water quality data through 2013. Any activities implemented during or after 2013 that lead to a reduction in *E. coli* loads to an impaired stream, or an improvement in stream water quality, may be considered as progress towards meeting a WLA or LA.

5. Reasonable Assurance

5.1. Non-regulatory

At the local level, the Becker Soil & Water Conservation District (SWCD), Otter Tail SWCD, Todd SWCD and Wadena SWCD and other local entities currently implement programs that target improving water quality and have been actively involved in projects to improve water quality in the past. Willing landowners within this watershed have implemented many practices in the past including: conservation tillage, buffer strips, urban BMPs, gully stabilizations, prescribed grazing, manure management, etc. It is assumed that these activities will continue. Potential state funding of restoration and protection projects includes Clean Water Fund grants. At the federal level, funding can be provided through Section 319 grants that provide cost-share dollars to implement activities in the watershed. Various other funding and cost-share sources exist, which will be listed in the Redeye River WRAPS Report. The implementation strategies briefly described in this plan as well as the detailed strategies outlined in the Redeye River WRAPS have demonstrated to be effective in reducing bacteria in streams. There are programs in place within the watershed to continue implementing the recommended activities. Monitoring will continue and adaptive management will be used to evaluate the progress made towards achieving water quality goals

5.2. Regulatory

5.2.1. Municipal Separate Storm Sewer System (MS4) Permits

Stormwater discharges associated with MS4s are regulated through NPDES/SDS Permits. The Stormwater Program for MS4s is designed to reduce the amount of sediment and pollution that enters surface and ground water from storm sewer systems to the maximum extent practicable. The MS4 Permits require the implementation of BMPs to address WLAs. In addition, the owner or operator is required to develop a Stormwater Pollution Prevention Plan (SWPPP) that incorporates BMPs applicable to their MS4. The SWPPP must cover six minimum control measures:

- Public education and outreach;
- Public participation/involvement;
- Illicit discharge, detection and elimination;
- Construction site runoff control;
- Post-construction site runoff control; and
- Pollution prevention/good housekeeping.

5.2.2. Wastewater & State Disposal System (SDS) Permits

The MPCA issues permits for WWTFs that discharge into waters of the state. The permits have site specific limits on bacteria that are based on water quality standards. Permits regulate discharges with the goals of 1) protecting public health and aquatic life, and 2) assuring that every facility treats wastewater. In addition, SDS permits set limits and establish controls for land application of sewage.

5.2.3. Subsurface Sewage Treatment Systems Program (SSTS)

The SSTS, commonly known as septic systems, are regulated by Minn. Stat. 115.55 and 115.56.

These regulations detail:

- Minimum technical standards for individual and mid-size SSTS;
- A framework for local administration of SSTS programs and;
- Statewide licensing and certification of SSTS professionals, SSTS product review and registration, and establishment of the SSTS Advisory Committee.

5.2.4. Feedlot Rules

The MPCA regulates the collection, transportation, storage, processing and disposal of animal manure and other livestock operation wastes. The MPCA Feedlot Program implements rules governing these activities, and provides assistance to counties and the livestock industry. The feedlot rules apply to most aspects of livestock waste management including the location, design, construction, operation and management of feedlots and manure handling facilities.

There are two primary concerns about feedlots in protecting water:

- Ensuring that manure on a feedlot or manure storage area does not run into water;
- Ensuring that manure is applied to cropland at a rate, time and method that prevents bacteria and other possible contaminants from entering streams, lakes and ground water.

6. Monitoring Plan

6.1. Lake and Stream Monitoring

Lake associations and other groups participate in monitoring activities to meet their specific needs. Volunteers throughout the watershed conduct stream and lake condition monitoring through the MPCA Volunteer Monitoring Program. The MPCA currently monitors the Leaf River at the CSAH #29 Bridge for Flow, Total Phosphorus, Ortho Phosphorus, Nitrite + Nitrate Nitrogen, Total Kjeldahl Nitrogen, Total Suspended Solids, Turbidity, and Total Volatile Solids. Future monitoring at this site and other sites will take place as part of the next Intensive Watershed Monitoring cycle for this watershed (2021).

Specific locations for future monitoring are outlined in section 3.3 of the Redeye River WRAPS. If funding is available, the SWCDs will set up a monitoring program to monitor for nutrients, *E. coli*, and flow. Ideally it would be a twice per month plus storm event program. If funding is not available for new monitoring programs, the monitoring that is completed will be done following MPCA's 10-year monitoring cycle.

The DNR conducts lake and stream surveys to collect information about game fish populations, which are then used to evaluate abundance, relative abundance size (length and weight), condition, age and growth, natural reproduction/recruitment, and effects of management actions (stocking and regulations).

6.2. BMP Monitoring

On-site monitoring of implementation practices by local partners is another method to better assess BMP effectiveness. A variety of criteria such as land use, soil type, and other watershed characteristics, as well as monitoring feasibility, will be used to determine which BMPs to monitor. Under these criteria, monitoring of a specific type of implementation practice can be accomplished at one site but can be applied to similar practices under similar criteria and scenarios. Effectiveness of other BMPs can be extrapolated based on monitoring results.

7. Implementation Strategy Summary

7.1. Permitted Sources

7.1.1. Wastewater

No reductions are needed from WWTF discharge as they discharge at or below the water quality standard. The WWTFs will continue to provide discharge monitoring records to MPCA to track their treatment performance.

7.2. Non-Permitted Sources

The high percentage of rangeland and cropland appear to be having an effect on bacteria levels throughout the Redeye River Watershed. The *E. coli* levels exceeded the standard in five of the six watersheds where it was sampled. All of the bacteria impairments were a result of two or three exceedances of the geometric mean; no individual samples exceeded the one-time sample standard of 1260 MPN/100ml. The Redeye River WRAPS provides detailed information on restoration activities to improve stream water quality by identifying practices to reduce *E.coli* levels to meet the state standard. The two main sources identified were runoff from manure applied as fertilizer as well as livestock grazing in riparian areas. Failing septic systems were identified as a minor pollutant source to these streams.

The WRAPS document also provides implementation strategies to protect lakes and streams that are not currently impaired. The implementation plan outlined in the WRAPS is divided into HUC12 watersheds. Each waterbody within the HUC12 where implementation strategies are needed, are specifically identified. Management goals, specific strategies (BMPS), responsible party, timelines and milestones are identified for each waterbody.

7.2.1. Adaptive Management

The response of the streams will be evaluated as management practices are implemented. This evaluation will occur on a 10-year cycle for the next 25 years. Data will be evaluated and decisions will be made as to how to proceed for the next five years. The management approach to achieving the goals should be adapted as new information is collected and evaluated.

7.2.2. Best Management Practices

A variety of BMPs to restore and protect the lakes and streams within the Redeye Watershed have been outlined and prioritized in the WRAPS report. Controlling access of livestock to streams, increasing riparian buffers, reviewing manure management plans and inspecting SSTS for compliance will be the types strategies used to reduce bacteria levels in streams. The WRAP prioritizes and targets strategies and BMPs within the watershed to focus implementation efforts in order to achieve results in water quality improvement.

The top priority in the WRAPS targets the riparian areas in the rural areas of the watershed, (which is the majority of the Redeye River Watershed). The goal is to prevent manure from entering streams by keeping it in storage or below the soil surface and limiting access of animals to lakes, streams and wetlands. This will be achieved by improved field manure (nutrient) management, adhere or increase fertilizer/manure application setbacks, improve feedlot runoff control, rotational grazing, and livestock exclusion.

The second priority in the WRAPS targets the subwatershed near the town of Wadena. The strategies that will be added in addition to those previously discussed, include reducing urban bacteria by limiting exposure of pet or waterfowl waste through pet waste management and increasing filter strips and buffers along the stream. Another strategy includes fixing septic systems so that on-site sewage is not released to surface waters by inspecting SSTS systems, replacing failing systems and maintaining compliant systems.

7.2.3. Education and Outreach

A crucial part in the success of the WRAPS to clean up the impaired streams and protect the non-impaired water bodies will be participation from local citizens. In order to gain support from these citizens, education and civic engagement opportunities will be necessary. A variety of educational avenues can and will be used throughout the watershed. These include (but are not limited to): press releases, meetings, workshops, focus groups, trainings, websites, etc. Local staff (conservation district, watershed, county, etc.) and board members work to educate the residents of the watersheds about ways to clean up their lakes and streams on a regular basis. Education will continue throughout the watershed.

7.2.4. Technical Assistance

The counties and SWCDs within the watershed provide assistance to landowners for a variety of projects that benefit water quality. Assistance provided to landowners varies from agricultural and rural BMPs to urban and lakeshore BMPs. This technical assistance includes education and one-on-one training. Many opportunities for technical assistance are as a result of educational workshops of trainings. It is important that these outreach opportunities for watershed residents continue. Marketing is necessary to motivate landowners to participate in voluntary cost-share assistance programs.

Programs such as state cost share, Clean Water Legacy funding, Environmental Quality Incentives Program (EQIP), and Conservation Reserve Program (CRP) are available to help implement the best conservation practices that each parcel of land is eligible for to target the best conservation practices per site. Conservation practices may include, but are not limited to: stormwater bioretention, septic system upgrades, feedlot improvements, wastewater treatment practices, agricultural and rural BMPs and internal loading reduction. More information about types of practices and implementation of BMPs will be discussed in the Redeye River WRAPS Report.

7.2.5. Partnerships

Partnerships with counties, cities, townships, citizens, businesses, watersheds, and lake associations are one mechanism through which the Becker SWCD, Otter Tail SWCD, Todd SWCD and Wadena SWCD will protect and improve water quality. Strong partnerships with state and local government to protect and improve water resources and to bring waters within the Redeye River Watershed into compliance with state standards will continue. A partnership with local government units and regulatory agencies such as cities, townships and counties may be formed to develop and update ordinances to protect the areas water resources.

7.3. Cost

The Clean Water Legacy Act requires that a TMDL include an overall approximation of the cost to implement a TMDL [Minn. Stat. 2007 § 114D.25]. The cost estimate for bacteria load reduction is based on unit costs for the two major sources of bacteria: livestock and imminent threat to public health septic systems (ITPHSS). The unit cost for bringing AU under manure management plans and feedlot lot runoff controls is $350/AU. This value is based on USDA EQIP payment history and includes buffers, livestock access control, manure management plans, waste storage structures, and clean water diversions. Repair or replacement of ITPHSS was estimated at $7,500 per system (EPA 2011). Multiplying those unit costs by an estimated 238 ITPHSS (the total number of households in the watershed found in Table 17 multiplied by the estimated percent ITPHSS pro-rated by county (Table 18) and 61,896 AU (the number of AU for beef, dairy, horses, hogs, and sheep found in Table 19) in the impaired reach subwatersheds provides a total cost of approximately $23.5M.

8. Public Participation

8.1. Steering Committee Meetings

The Redeye Watershed is made up of numerous local partners who have been involved at various levels throughout the project. The steering committee is made up of members representing the DNR, Department of Agriculture, Counties and SWCD within the watershed, The Nature Conservancy, and the Board of Water and Soil Resources. The following meetings occurred regarding the Redeye Watershed monitoring, TMDL development, and WRAPS report planning:

- 12/12/12 Quarterly Meeting, Wadena County Courthouse Wadena
- 4/10/13 Quarterly Meeting (Assessment Focus), MPCA Office Brainerd
- 5/2/13 Quarterly Meeting (Stressor ID Focus), SWCD office in Perham
- 6/16/13 Quarterly Meeting (HSPF Focus) , MPCA Office Brainerd
- 4/23/14 Quarterly Meeting (TMDL Focus), Wadena County Courthouse Wadena

8.2. Public Meetings

The MPCA along with the local partners and agencies in the Redeye Watershed recognize the importance of public involvement in the watershed process. The following list outlines the opportunities used to engage the public and targeted stakeholders in the Watershed.

- 4/12/11 Watershed Project Kick-off - Community Center, Parkers Prairie
- 3/20/12 County Producer Meeting - VFW, Wadena
- 9/19/12 County Water Plan Meeting – Wadena County Courthouse, Wadena
- 3/28/13 County Producer Meeting – VFW, Wadena
- 7/10/13 County Water Plan Meeting - Wadena County Courthouse, Wadena
- 3/4/14 County Producer Meeting – VFW, Wadena
- 10/22/14 County Water Plan Meeting - Wadena County Courthouse, Wadena

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10. Appendix A: LDC Supporting information

Impaired Reach Name/AUID	Standard Load		Existing Load	
	Flow Data Source	Flow Data Range	Water Quality Station	Water Quality Data Range
Redeye River 07010107-503	**HSPF subbasin 128**	2000-2009	**S005-727**	2009-2010
Leaf River 07010107-505	**HSPF subbasin 115**	2000-2009	**S001-614**	2009-2010
Union Creek 07010107-508	**HSPF subbasin 116**	2000-2009	**S000-987**	2009-2010
Leaf River 07010107-514	**MPCA H13060001 near Bluffton at Cty 77**	2011-2013	**S005-732**	2009-2012
Bluff Creek 07010107-515	**MPCA H13029001 near Bluffton**	2011-2013	**S006-849**	2011-2012
Oak Creek 07010107-516	**MPCA H13023001 at US 10**	2011-2013	**S001-433**	2009-2012
Un. Cr. (Hay Creek) 07010107-526	**HSPF subbasin 132**	2000-2009	**S004-346**	2009-2010
Wing River 07010107-560	**MPCA H13003001 near Verndale at Cty 23**	2010-2013	**S002-958**	2011-2012