### *Water Quality Improvement Plan*
### *For the*

# Yellow River Basin

## Yellow River – Four Segments
## Nine Tributaries:

**North Fork Yellow River, Hecker Creek,**
**Norfolk Creek, Unnamed Creek, Williams Creek, Hickory Creek,**
**Bear Creek, Suttle Creek, Dousman Creek**

## Winneshiek and Allamakee Counties, Iowa

Total Maximum Daily Loads for:
Pathogen Indicators (*E. coli*)

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clean water
starts with you.
IOWA DNR WATERSHED IMPROVEMENT

# Table of Contents

# List of Figures

# List of Tables

# General Report Summary

## What is the purpose of this report?

This Water Quality Improvement Plan has two purposes. First, it is a resource to be used by watershed planners, water quality action groups, individual citizens, and local and state government staff. It serves as a guide to help these groups understand and identify the causes of the Yellow River Basin water quality problems and to guide locally driven water quality improvement efforts. The problems addressed in this report are high bacteria concentration in both warm water and cold water streams. Second, this report satisfies the Federal Clean Water Act obligation to establish a Total Maximum Daily Load (TMDL) for waterbodies on the 303(d) impaired waters list.

## What's wrong with the Yellow River and its tributaries?

Three segments of the Yellow River and nine of its tributaries have bacteria concentrations that exceed the Water Quality Standards (WQS). This problem inhibits and reduces recreational use of the river in the impaired reaches. An additional segment of the Yellow River is included in this report because it is between two Yellow River segments that are impaired. It has not been included on the impaired waters list because there was insufficient monitoring data for listing.

## What is causing the problem?

Three segments of the Yellow River and nine of its tributaries are impaired for bacteria in streams designated for primary contact recreation. The bacteria problem, measured by *E. coli* concentration, is caused by overflowing sewers, undisinfected wastewater treatment plant discharges, runoff from developed areas, grazing livestock, open feedlots, manure applied to cropland, poorly functioning septic tank systems, and wildlife.

## What can be done to improve the Yellow River and its tributaries?

To improve the water quality of these Yellow River Basin streams, delivered bacteria loads must be reduced. A combination of the following management practices can be implemented to achieve these reductions:

- Management of manure application methods, timing, and quantity and the adoption of techniques that reduce runoff
- Restricting cattle and other livestock from direct access to streams
- Inspecting, repairing, and maintaining septic tank systems to comply with state design standards
- Eliminating sanitary sewer overflows
- Disinfecting wastewater discharges
- Controlling bacteria in runoff

## Who is responsible for a cleaner Yellow River Basin?

Everyone who lives, works, or plays in the watershed has a role in water quality improvement.

Unregulated nonpoint sources in the watershed need to incorporate voluntary management of livestock and manure applications to achieve positive results. Cities need to take responsibility for sanitary sewer overflows and disinfection of wastewater discharges.

Much of the land draining to the river is in agricultural production, and financial assistance is often available from government agencies to individual landowners willing to adopt changes in livestock and manure management. Improving Yellow River Basin water quality will require the collaboration of citizens and agencies with an interest in protecting the river now and in the future.

# Required Elements of the TMDL

This Water Quality Improvement Plan has been prepared in compliance with the current regulations for TMDL development that were promulgated in 1992 as 40 CFR Part 130.7 in compliance with the Clean Water Act. These regulations and consequent TMDL development are summarized below in Table 1.

## Table 1-1 Required TMDL Elements

| | |
|---|---|
| Name and geographic location of the impaired or threatened waterbodies for which the TMDLs are being established: | Yellow River - four contiguous impaired segments,<br>• IA 01-YEL-0080-segment 3<br>• IA 01-YEL-0080-segment 2<br>• IA 01-YEL-0080-segment 1<br>• IA 01-YEL-0070-segment 0<br>Nine tributaries of the Yellow River<br>• IA 01-YEL-0160_0 North Fork Yellow River<br>• IA 01-YEL-0155_0 Unnamed (Hecker Creek)<br>• IA 01-YEL-0130_0 Norfolk Creek<br>• IA 01-YEL-0150_0 Unnamed (Ludlow Creek)<br>• IA 01-YEL-0125_0 Williams Creek<br>• IA 01-YEL-0120_1 Hickory Creek<br>• IA 01-YEL-0110 _0 Unnamed (Bear Creek)<br>• IA 01-YEL-0100_0 Suttle Creek<br>• IA 01-YEL-0090_0 Dousman Creek |
| Surface water classification and designated uses: | Class A1, primary contact recreation<br>Class B (WW), warm water aquatic life<br>Class B (CW), cold water aquatic life (Dousman, Bear, Suttle, Hickory, Yellow 80_2)<br>Class HH, human health, fish consumption |
| Impaired beneficial uses: | Class A1, primary contact recreation (March 15 to November 15) |
| TMDL priority level: | High Priority. |
| Identification of the pollutants and applicable Water Quality Standards (WQS): | Pathogen Indicator, *E. coli*. Primary contact recreational use (Class A1) is not supported due to violation of the *E. coli* Water Quality Standard criteria of 126 organisms/100 ml for the geometric mean and 235 organisms/100 ml for the single sample maximum. |
| Quantification of the pollutant loads that may be present in the waterbody and still allow attainment and maintenance of water quality | Pathogen Indicator, *E. coli*. The targets for the four Yellow River segments and its tributaries are the Iowa WQS numeric limits for *E. coli*, a |

| | |
|---|---|
| standards: | geometric mean of 126 *E. coli* organisms/100 ml or a single sample maximum of 235 *E. coli* organisms /100ml. Tables 4-3 and 4-4 through Tables 16-3 and 16-4 list the load capacities for the impaired segments and tributaries |
| Quantification of the amount or degree by which the current pollutant loads in the waterbody, including the pollutants from upstream sources that are being accounted for as background loading, deviate from the pollutant loads needed to attain and maintain water quality standards: | Pathogen Indicator, *E. coli*. The *E. coli* load departure from capacity has been calculated for five flow recurrence intervals for each of the four Yellow River segments and the nine tributaries for the GM and the SSM. Tables 4-11 through Table 16-11 list the existing loads and departures from capacity by section for the impaired segments and tributaries |
| Identification of pollution sources: | Point and nonpoint sources. |
| Wasteload allocations (WLA) for pollutants from point sources: | Pathogen Indicator, *E. coli*. The wasteload allocations for the four wastewater treatment facilities are listed in Table 3-6 and the one open feedlot in the Yellow River basin is listed in Table 3-7. |
| Load allocations for pollutants from nonpoint sources (NPS): | Pathogen Indicator, *E. coli*. The load allocations for each of the four Yellow River segments and the nine tributaries at the five flow recurrence intervals at both the geometric mean and single sample maximum criteria are listed by section in Tables 4-12 and 4-13 through Tables 16-12 and 16-13. |
| Margin of safety (MOS): | Pathogen Indicator, *E. coli*. The MOS are an explicit ten percent of the TMDLs and are listed by section in Tables 4-12 and 4-13 through Tables 16-12 and 16-13. |
| Consideration of seasonal variation: | Pathogen Indicator, *E. coli*. These TMDLs were developed based on the Iowa WQS primary contact recreation season that runs from March 15 to November 15. |
| Allowance for reasonably foreseeable increases in pollutant loads: | Pathogen Indicator, *E. coli*. An allowance for increased pathogen indicator loading was not included in this TMDL. All discharges into the impaired Yellow River segments and tributaries are expected to comply with the Iowa WQS. Any new permitted point source discharge |

| | |
|---|---|
| | would be required to meet the WQS limits. Any new nonpoint sources would be expected to meet the *E. coli* limits. |
| Implementation plan: | A general implementation plan is provided in this document to guide local citizens, government, and water quality groups. *E. coli* reduction will be accomplished through a combination of regulatory and non-regulatory activities. Point sources will be regulated through the National Pollutant Discharge Elimination System (NPDES) permitting process. Nonpoint source pollutants will be addressed using available programs, technical advice, information and education, and financial incentives. |

# 1. Introduction

The Federal Clean Water Act requires states to assess their waterbodies every even numbered year and incorporate these assessments into the 305(b) Water Quality Assessment Report. Assessed lakes and streams that do not meet the Iowa Water Quality Standards (WQS)criteria are placed on the 303(d) Impaired Waters List. Subsequently, a Total Maximum Daily Load (TMDL) for each pollutant must be calculated and a Water Quality Improvement Plan written for each impaired water body.

A TMDL is a calculation of the daily maximum amount of a pollutant a waterbody can receive without exceeding the water quality standards. The total maximum daily load is allocated to permitted point sources (wasteload allocations), nonpoint sources (load allocations), and to a margin of safety that accounts for uncertainty in the calculations.

This TMDL report is for four segments and nine tributaries of the Yellow River in Winneshiek and Allamakee Counties. Three Yellow River segments and nine tributary streams are on the 2010 impaired waters list. A fourth Yellow River segment was not assessed because there was not any data for that segment at the time of the assessment. It is between two of the impaired segments and is presumed to be impaired as well. Additionally, data collected in 2009 indicates that this segment has high *E. coli* concentrations during runoff conditions.

There are two primary purposes of this report: 1) Satisfy federal TMDL requirements for impaired waters, and 2) Serve as a resource for guiding water quality improvement projects in the Yellow River Basin that address bacteria problems. Local citizens, water quality groups, and government agencies will find it a useful account of the causes and solutions to Yellow River Basin water quality concerns.

A TMDL report has some limitations:

- The 305(b) water quality assessment is developed with available data that may not adequately describe water quality. Additional targeted monitoring is often expensive and requires time. Assumptions and simplifications on the nature, extent, and causes of impairment can cause uncertainty in calculated values.
- A TMDL may not efficiently manage nonpoint pollutant sources that are unregulated. Reduction of nonpoint sources pollutant loads is challenging when significant contributions can only be addressed through voluntary tactics.

This document can guide local water quality improvement projects that are coordinated and targeted to address pollutant sources within the entire watershed. Yellow River Basin water quality mirrors the land that drains to it and reflects how well that land is managed. Local landowners, tenants, and other stakeholders often have the greatest influence in determining water quality.

This report consists of a TMDL for each of the four contiguous segments of the Yellow River and the nine impaired tributary segments. These segments are listed in Table 2-1.

# 2. Description of the Yellow River Basin

The area draining to the Yellow River is about 240 square miles in Allamakee, Clayton, and Winneshiek Counties. Basin elevation ranges from 655 feet above mean sea level at the Mississippi River confluence to 1,250 feet at the boundary of the watershed and is one of the steeper river gradients in Iowa. The valley is generally rugged with steep slopes, rock outcrops, and high limestone bluffs. It flows through Yellow River State Forest and Effigy Mounds National Monument, the only national monument in Iowa.

## 2.1. The Yellow River and its tributaries

The Yellow River originates in the southeast corner of Winneshiek County and flows through southern Allamakee County 51 miles to the Mississippi River. A segment of the Yellow River (0080_2) and five of its tributaries have been designated cold water streams (Table 2-1). The basin is an area of karst topography where limestone bedrock has dissolved forming caves, sinkholes, springs, and disappearing streams. Stream flow disappears and reappears through basin sinkholes and springs allowing surface water and groundwater to blend. The stream system draining the Yellow River Basin is shown in Figure 2-1.

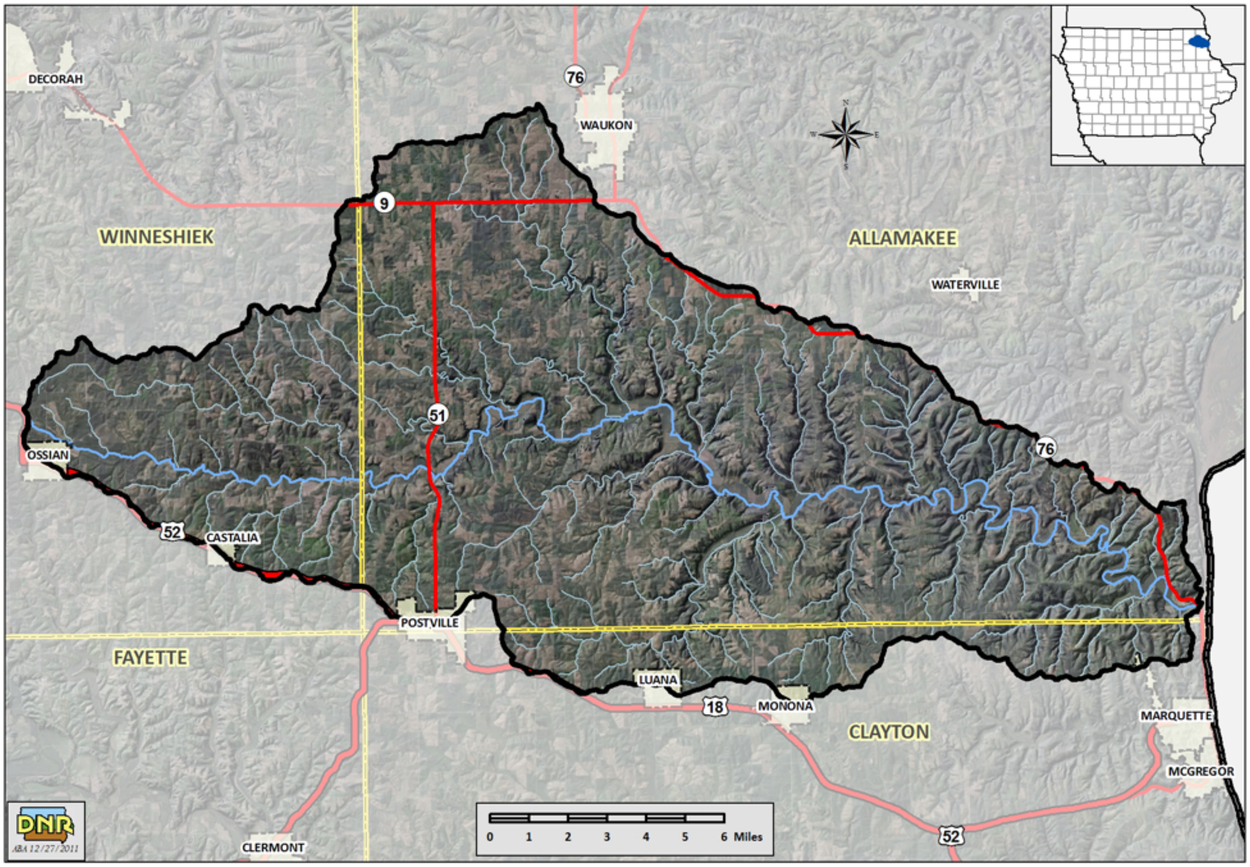

Figure 2-1 The Yellow River and its major tributaries

Impaired segments that are listed in Table 2-1, ordered from the confluence with the Mississippi River to the headwaters upstream in Winneshiek County.

**Table 2-1 Four impaired Yellow River segments and nine impaired tributaries requiring TMDLs**

| Yellow River Basin Impaired Segment | Segment identification | Segment length, mi. | Impairments |
|---|---|---|---|
| Yellow River | IA 01-YEL-0070_0 | 21.7 | bacteria |
| Yellow River | IA 01-YEL-0080_1 | 10.0 | biological |
| Yellow River | IA 01-YEL-0080_2 | 8.9 | Low CWDO[1], bacteria, biological |
| Yellow River | IA 01-YEL-0080_3 | 5.8 | Low DO, bacteria |
| Dousman Creek | IA 01-YEL-0090_0 | 3.5 | Low CWDO[1], bacteria |
| Suttle Creek | IA 01-YEL-0100_0 | 4.0 | Low CWDO[1], bacteria |
| Bear Creek | IA 01-YEL-0110_0 | 2.0 | Low CWDO[1], bacteria |
| Hickory Creek | IA 01-YEL-0120_1 | 3.3 | low CWDO[1], bacteria |
| Williams Creek | IA 01-YEL-0125_0 | 1.8 | bacteria |
| Norfolk Creek | IA 01-YEL-0130_0 | 5.0 | Low CWDO[1], bacteria |
| Ludlow Creek | IA 01-YEL-0150_0 | 2.0 | bacteria |
| Hecker Creek | IA 01-YEL-0155_0 | 4.1 | biological and bacteria |
| North Fork Yellow River | IA 01-YEL-0160_0 | 3.7 | low DO, bacteria |

1. Cold water dissolved oxygen – The criteria for minimum cold water dissolved oxygen concentration in the WQS is higher than that for warm water. See Appendix B.

The Yellow River segment 0070_0 runs 21.7 miles from the mouth of the Yellow River (S34, T96N, R3W, Allamakee County) to the County Road (CR) X-26 bridge (S24, T96N, R5W, Allamakee County). This segment drains three of the HUC 12s in the Yellow River Basin; Lower Yellow River, Middle Yellow River, and Hickory Creek. Four tributaries that flow into this segment are impaired; Dousman Creek, Suttle Creek, Bear Creek, and Hickory Creek. The only USGS gage in the basin is located on this Yellow River segment, as is one municipal wastewater treatment facility for the City of Luana.

The Yellow River segment 0080_1 runs 10.0 miles from CR X-26 (S24, T96N, R5W, Allamakee County) to old Hwy 51 crossing in (NE 1/4, S11, T96N, R6W, Allamakee County). This segment drains parts of three HUC 12 subbasins; Middle Yellow River, Norfolk Creek, and Upper Yellow River. Two tributaries that flow into this segment are impaired, Williams Creek and Norfolk Creek. There is one municipal wastewater treatment facility for the City of Postville that is located in the subwatershed draining to this segment.

The Yellow River segment 0080_2 runs 8.9 miles from the old Hwy 51 crossing (NE 1/4, S11, T96N, R6W, Allamakee County) to its confluence with the North Fork Yellow River (S13, T96N, R7W, Winneshiek County). This segment drains parts of two HUC 12 subbasins, Upper Yellow River and Yellow River Headwaters. Three tributaries that flow into this segment are impaired: an unnamed tributary, Hecker Creek, and North Fork Yellow River. There is one industrial wastewater treatment facility located in this Yellow River segment for the AgriStarr Company.

The Yellow River segment 0080_3 runs 5.8 miles from its confluence with the North Fork Yellow River (S13, T96N, R7W, Allamakee County) to its confluence with an unnamed tributary (SE 1/4, S8, T96N, R7W, Winneshiek County). This segment drains the Yellow River Headwaters HUC 12. There are not any impaired tributaries that flow into this segment. There is one municipal wastewater treatment plant for the City of Castalia.

*Hydrology*.
Yellow River information for the four impaired segments is shown in Table 2-2. These segments run from the confluence with the Mississippi River to the headwaters in Winneshiek County. Tables 2-3 to 2-11 show Yellow River tributary information.

### Table 2-2 The Yellow River, four segments

| | |
|---|---|
| Waterbody Name: | Yellow River |
| Hydrologic Unit Code: | 0706000109 |
| IDNR Waterbody ID: | IA 01YEL 0070 to 0080 |
| Location: | Confluence with Mississippi River (S34, T96N, R3W, Allamakee County) west to confluence with unnamed tributary (SE 1/4, S8, T96N, R7W, Winneshiek County) |
| WQS Designated Uses[1]: | |
| IA 01-YEL-0070_0 | Class A1, Class B(WW-1), Class HH |
| IA 01-YEL-0080_1 | Class A1, Class B(WW-1), Class HH |
| IA 01-YEL-0080_2 | Class A1, Class A2, Class B(CW-1), Class HH |
| IA 01-YEL-0080_3 | Class A1, Class B(WW-2) |
| Major Tributaries: | Dousman Creek, Suttle Creek, Dry Hollow Creek, Bear Creek, Hickory Creek, Williams Creek, Norfolk Creek, unnamed creek, Hecker Creek, North Fork Yellow River. |
| Receiving Waterbody: | Mississippi River |
| Stream Length: | 51 miles |

1. See Appendix B

### Table 2-3 Dousman Creek

| | |
|---|---|
| Waterbody Name: | Dousman Creek |
| Hydrologic Unit Code: | 070600010906 |
| IDNR Waterbody ID: | IA 01-YEL-0090_0 |
| Location: | Cr. mouth - S33, T96N, R3W, Allamakee Co. |
| WQS Designated Uses: | Class A1, Class A2, Class B(CW-1), Class HH |
| Major Tributaries: | none |
| Receiving Waterbody: | Yellow River |
| Stream Segment Length: | 3.5 miles |

### Table 2-4 Suttle Creek

| | |
|---|---|
| Waterbody Name: | Suttle Creek |
| Hydrologic Unit Code: | 070600010905 |
| IDNR Waterbody ID: | IA 01-YEL-0100_0 |
| Location: | Cr. mouth - S17, T96N, R4W, Allamakee Co. |
| WQS and Designated Uses: | Class A1, Class A2, Class B(CW-1), Class HH |
| Major Tributaries: | none |
| Receiving Waterbody: | Yellow River |
| Stream Segment Length: | 4.0 miles |

### Table 2-5 Bear Creek

| | |
|---|---|
| Waterbody Name: | Bear Creek (unnamed creek) |
| Hydrologic Unit Code: | 070600010905 |
| IDNR Waterbody ID: | IA 01-YEL-0110_0 |
| Location: | Cr. mouth - S13, T96N, R5W, Allamakee Co. |
| WQS Designated Uses: | Class A1, Class A2, Class B(CW-1), Class HH |
| Major Tributaries: | none |
| Receiving Waterbody: | Yellow River |
| Stream Segment Length: | 2.0 miles |

### Table 2-6 Hickory Creek

| | |
|---|---|
| Waterbody Name: | Hickory Creek |
| Hydrologic Unit Code: | 070600010904 |
| IDNR Waterbody ID: | IA 01-YEL-0120_1 |
| Location: | Cr. mouth - S23, T96N, R5W, Allamakee Co. |
| WQS Designated Uses: | Class A1, Class A2, Class B(CW-1), Class HH |
| Major Tributaries: | none |
| Receiving Waterbody: | Yellow River |
| Stream Segment Length: | 3.3 miles |

### Table 2-7 Williams Creek

| | |
|---|---|
| Waterbody Name: | Williams Creek |
| Hydrologic Unit Code: | 070600010905 |
| IDNR Waterbody ID: | IA 01-YEL-0125_0 |
| Location: | Cr. Mouth - S9, T96N, R5W, Allamakee Co. |
| WQS Designated Uses: | Class A1, Class B(WW-2) |
| Major Tributaries: | none |
| Receiving Waterbody: | Yellow River |
| Stream Segment Length: | 1.8 miles |

### Table 2-8 Norfolk Creek

| | |
|---|---|
| Waterbody Name: | Norfolk Creek |
| Hydrologic Unit Code: | 070600010903 |
| IDNR Waterbody ID: | IA 01-YEL-0130_0 |
| Location: | Cr. mouth - S6, T96N, R5W, Allamakee Co. |
| WQS Designated Uses: | Class A1, Class A2, Class B(CW-1), Class HH |
| Major Tributaries: | Teeple Creek |
| Receiving Waterbody: | Yellow River |
| Stream Segment Length: | 5.0 miles |

### Table 2-9 Unnamed Creek (Ludlow Creek)

| | |
|---|---|
| Waterbody Name: | Unnamed Creek (Ludlow Creek) |
| Hydrologic Unit Code: | 070600010902 |
| IDNR Waterbody ID: | IA 01-YEL-0150_0 |
| Location: | Cr. mouth - S2, T96N, R6W, Allamakee Co |
| WQS Designated Uses: | Class A1, Class B(WW-2) |
| Major Tributaries: | none |
| Receiving Waterbody: | Yellow River |
| Stream Segment Length: | 2.0 miles |

### Table 2-10 Hecker Creek

| | |
|---|---|
| Waterbody Name: | Hecker Creek |
| Hydrologic Unit Code: | 070600010902 |
| IDNR Waterbody ID: | IA 01-YEL-0155_0 |
| Location: | Cr. mouth -. S17,T96N,R06W, Allamakee Co |
| WQS Designated Uses: | Class A1, Class B(WW-1) |
| Major Tributaries: | none |
| Receiving Waterbody: | Yellow River |
| Stream Segment Length: | 4.1 miles |

### Table 2-11 North Fork Yellow River

| | |
|---|---|
| Waterbody Name: | North Fork Yellow River |
| Hydrologic Unit Code: | 070600010901 |
| IDNR Waterbody ID: | IA 01-YEL-0160_0 |
| Location: | Cr. mouth -.S13,T96N,R7W, Winneshiek Co |
| WQS Designated Uses: | Class A1, Class B(WW-2) |
| Major Tributaries: | none |
| Receiving Waterbody: | Yellow River |
| Stream Segment Length: | 3.7 miles |

## 2.2. The Yellow River Watershed

The watershed draining to the Yellow River and its tributaries is 154,500 acres and consists of six HUC 12 sub-watersheds. The HUC 12 sub watersheds are listed in Table 2-12 and shown in the Yellow River Basin map in Figure 2-2.

### Table 2-12 Yellow River Basin HUC 12 sub watersheds

| HUC 12 Name | Area, acres | HUC 12 |
|---|---|---|
| Norfolk Creek | 15,026 | 070600010 903 |
| Upper Yellow River | 30,464 | 070600010 902 |
| Middle Yellow River | 38,258 | 070600010 905 |
| Yellow River Headwaters | 26,054 | 070600010 901 |
| Lower Yellow River | 30,192 | 070600010 906 |
| Hickory Creek-Yellow River | 14,936 | 070600010 904 |

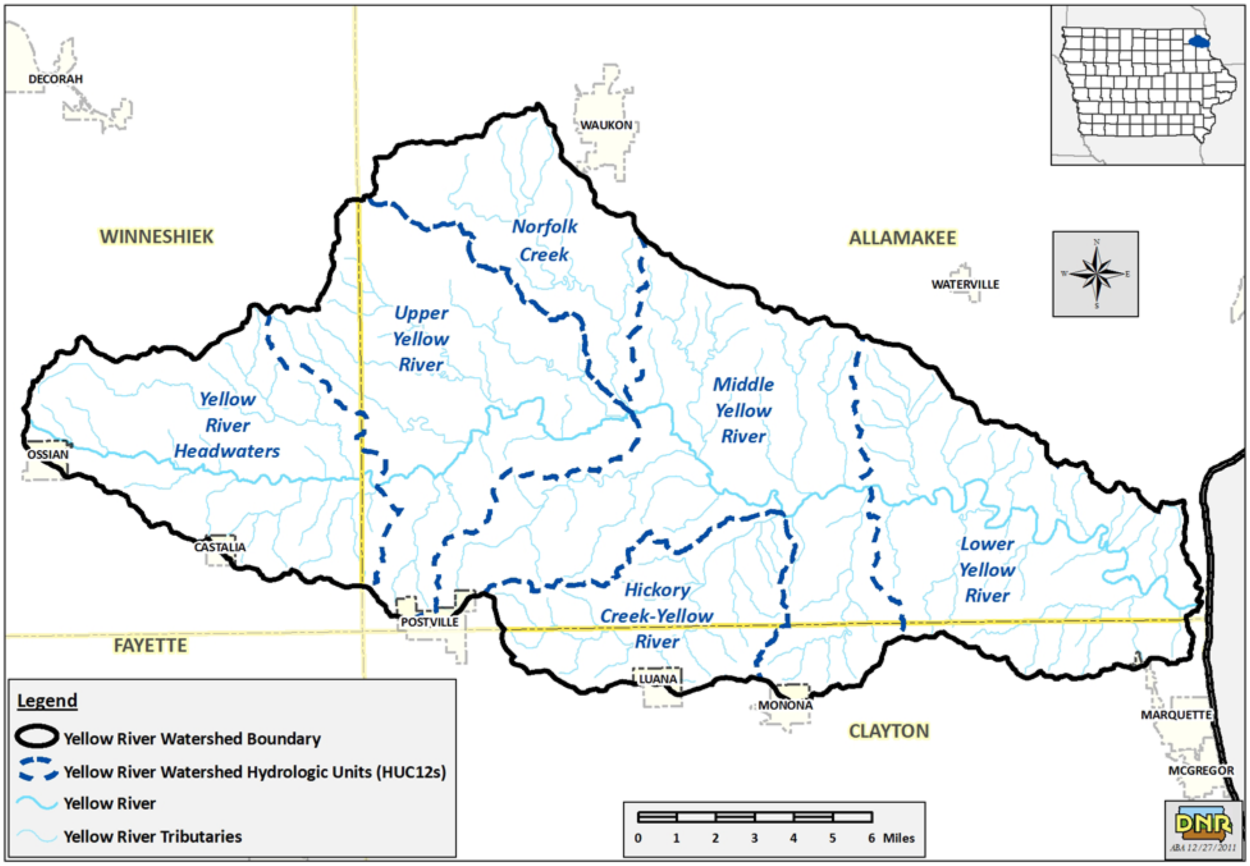

Figure 2-2 Yellow River Basin HUC 12 sub-watersheds

*Land Use.*

The land use coverage was developed by intersecting the 2002 land cover grid and the Common Land Unit (CLU) boundaries for the Yellow River watershed. The major land cover category was the assigned to each CLU. The 2008 NAIP photography, LiDAR, other historical photography, and a color infra-red SPOT image from the spring of 2010 was used to reclassify the CLUs to more current conditions. About half of the basin is in row crop and almost 40 percent is in forest or ungrazed grass, unusual for Iowa but typical of the Paleozoic plateau. The seven landuses shown in Table 2-13 were aggregated from the seventeen in the GIS land coverage. The landuse characteristics for each impaired segment can be found in Sections 4 through 16.

**Table 2-13 Yellow River Basin Landuse**

| Landuse | Area, acres | Fraction of total |
|---|---:|---:|
| Water/wetland | 435.6 | 0.28% |
| Forest | 30,384.2 | 19.62% |
| Ungrazed/CRP/hay | 29,149.2 | 18.82% |
| Grazed | 14,162.1 | 9.14% |
| Row crop | 75,525.0 | 48.75% |
| Roads | 3,988.9 | 2.57% |
| Commercial/residential | 1,273.2 | 0.82% |
| **Total** | **154,918.2** | **100.00%** |

*Landform, ecoregion and climate.*
The Yellow River Basin lies entirely in one landform region, the Paleozoic Plateau or Driftless Region, as shown in Figure 2-3. This region is one where there have not been any geologically recent glacial deposits and bedrock is at or near the surface.

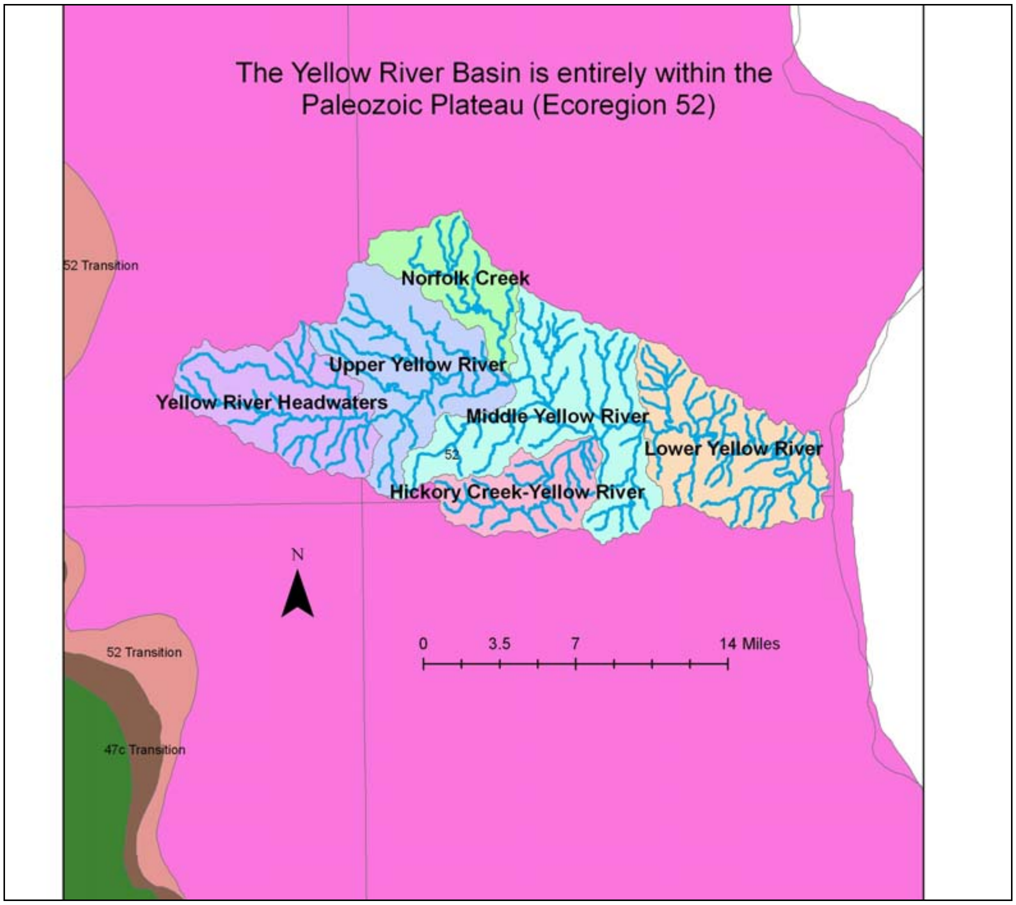

Figure 2-3 The six HUC 12 subbasins that make up Yellow River Basin lie within the Paleozoic Plateau ecoregion

Ecoregions denote areas of general similarity in ecosystems and in the type, quality, and quantity of environmental resources. An ecoregion is identified through patterns and composition of both biological and physical characteristics, including geology, physiography, vegetation, climate, soils, land use, wildlife, and hydrology. The interactions and relative importance of each of these components varies between ecoregions, creating a unique ecosystem within each region. The ecoregion of the watershed and its relationship to other state ecoregions is shown in Figure 2-4 where the Yellow River Basin is the blue area in the Paleozoic Plateau in the north east corner of the state.

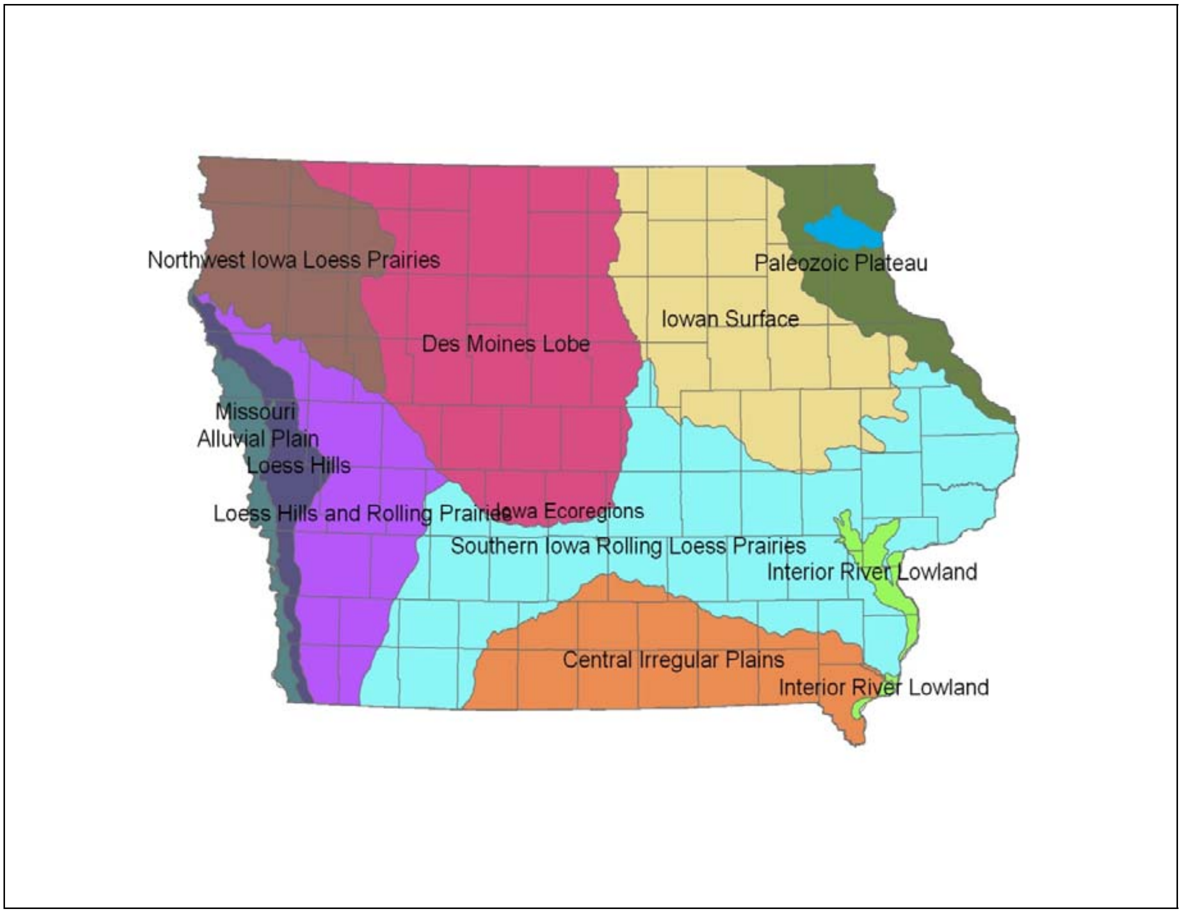

Figure 2-4 Iowa Ecoregion map

*Soils.*
The major soil series found within the Yellow River watershed are Fayette (34%), Downs (24.5%), Nordness (8.4%), and Dubuque (7.1%). Seventy-six other soil series make up the remaining 26.4 percent of the area. The four major soils are all alfisols, soils which developed under forest covers in humid mid-latitudes. Fayette, Downs and Dubuque soils were formed in loess.

The Fayette series consists of very deep, well drained, fine silty alfisol formed in loess. These convex crests, interfluves (gully boundary lines) and side slopes are on uplands and on treads and risers on high stream terraces. Slopes range from 0 to 60 percent. These are well drained soils. Saturation does not occur within a depth of 6 feet during the wettest periods of the normal year. Surface runoff potential is negligible to high. The native vegetation is deciduous trees, mainly oak and hickory. These soils occur throughout the steeper portion of the Yellow River drainage basin along the Yellow River itself.

The Downs series consists of very deep, well drained, fine silty alfisol formed in loess. These soils are on interfluves and side slopes on uplands and on treads and risers of stream terraces. Slopes range from 0 to 25 percent. These are well drained soils. Saturation does not occur within a depth of 6 feet during the wettest periods of normal years. Surface runoff potential is negligible to high. The native vegetation is big bluestem, little bluestem, switchgrass, other grasses of tall grass prairie and widely spaced oak and hickory. These soils occur in the uplands of the tributaries and the upper reaches of the watershed.

The Nordness series consists of shallow, well drained, loamy alfisol formed in loamy or silty material and a paleosol over limestone rock. These soils are on high structural benches, crests, and convex sides slopes on uplands. Slopes range from 2 to 40 percent. These are well drained soils. Saturation does not occur within a depth of 6 feet during the wettest period of most years. Surface runoff potential is low to high. The native vegetation is deciduous trees, dominantly hickory and oak. These soils are found in the tributary valleys.

The Dubuque series consists of moderately deep, well drained, fine silty alfisol formed in 18 to 36 inches of loess and a thin layer of residuum from limestone bedrock or reddish paleosol high in clay overlying limestone bedrock. These soils are on ridges of narrow interfluves and side slopes on uplands and high structural benches. Slopes range from 2 to 60 percent. These are well drained soils. Saturation does not occur within a depth of 6 feet during the wettest period of most years. Surface runoff potential is low to high. The native vegetation is deciduous trees. These soils are found along the steep edges of the lower watershed valleys and the upper watershed valleys.

Precipitation data comes from three sites in the Yellow River Basin. These rain gages were used to develop models and estimate stream flow and are in or near the cities of Postville, Waukon, and Prairie du Chien. Table 2-14 shows the average annual precipitation at the three gages for the years for which bacteria data was collected, from 2004 to 2009.

**Table 2-14 Average annual precipitation at the three Yellow River Basin rain gages**

| Year | Prairie du Chien, precip., in | Postville precip, in | Waukon precip, in |
|---|---|---|---|
| 2005 | 30.6 | 29.8 | 34.7 |
| 2006 | 32.8 | 39.8 | 33.5 |
| 2007 | 52.2 | 49.4 | 55.6 |
| 2008 | 37.8 | 42.4 | 47.3 |
| 2009 | 36.3 | 35.4 | 43.5 |
| **Average** | **36.9** | **39.5** | **41.7** |

# 3. Yellow River Basin Total Maximum Daily Loads for Pathogen Indicators – Four Segments and Nine Tributaries

Total Maximum Daily Loads (TMDL) are required by the Federal Clean Water Act for each of three segments of the Yellow River and nine of its tributaries for the pathogen indicator *E. coli*. A TMDL has also been developed for a segment of the Yellow River (0080_1) between two segments that are impaired for *E. coli* (0080_2 and 0070_1). This segment was classified as "not assessed" because there no data was available at the time of the assessment for the 2010 305(b) report. Since that assessment, segment data has become available showing that there are high *E. coli* concentrations as in upstream and downstream segments. Figure 3-1 shows the Yellow River watershed and the nine impaired tributaries and four Yellow River segments.

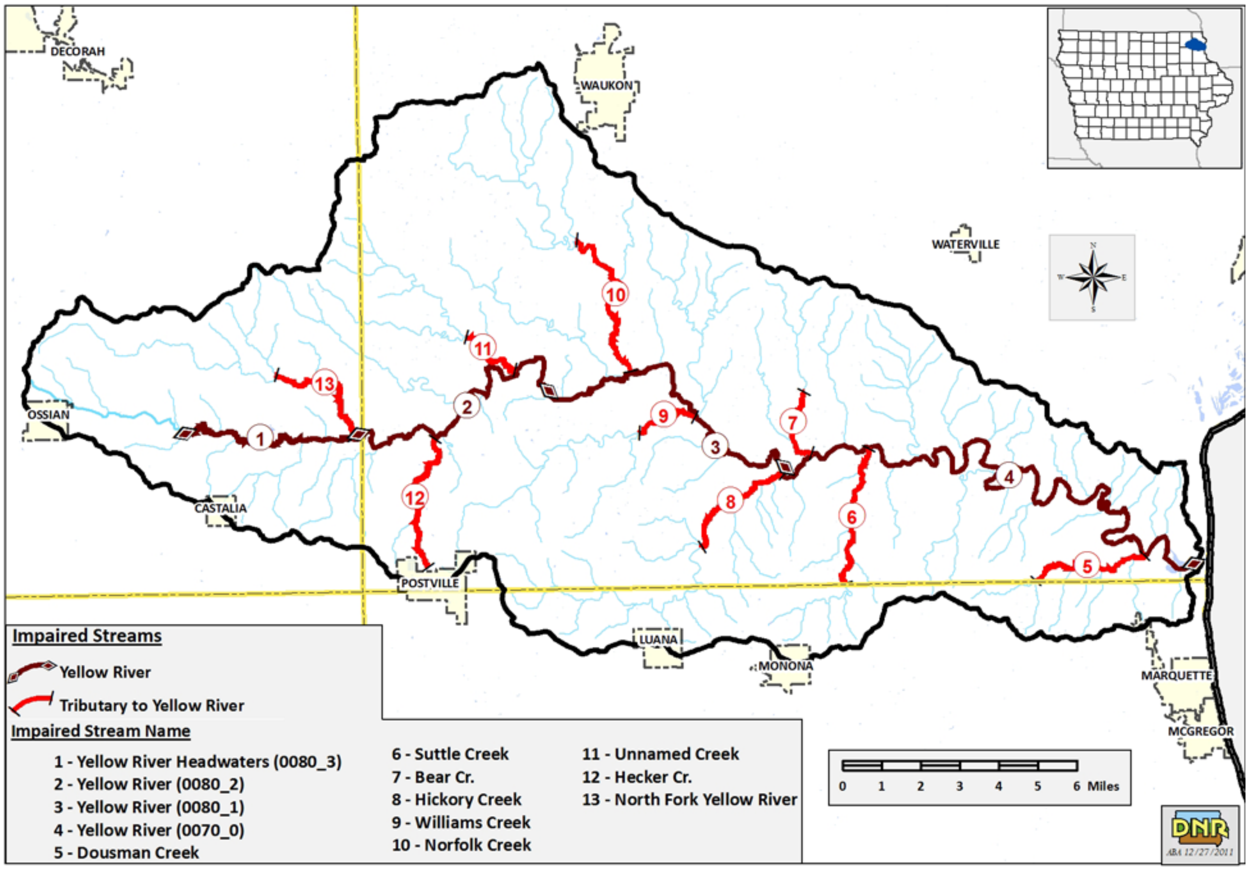

Figure 3-1 Yellow River watershed and impaired tributaries and segments

This section includes watershed information on monitoring sites, relevant water quality standards, data sources, and data interpretation, particularly the use and construction of duration curves. It also includes descriptions of point and nonpoint *E. coli* sources, and the derivation of target loads, wasteload allocations and load allocations.

Sections 4 through 16 quantify the maximum daily *E. coli* load for each of Yellow River segments and tributaries that does not violate the state's water quality standards. The existing loads, load allocations, and margins of safety are also calculated.

## 3.1. Problem Identification

*Applicable water quality standards.*
The applicable designated uses and water quality standards for pathogen indicators are found in *Iowa Administrative Code 567, Chapter 61, Water Quality Standards.* Table 3-1 summarizes the water quality standards for pathogen indicators for the Class A1 use.

**Table 3-1 *E. coli* Bacteria Criteria for Class A1 uses (organisms/100 ml of water)**

| ***Use*** | ***Geometric Mean*** | ***Sample Maximum*** |
|---|---|---|
| ***Class A1*** | | |
| *3/15 – 11/15* | *126* | *235* |
| *11/16 – 3/14* | *Does not apply* | *Does not apply* |

*Problem statement.*
For twelve of the Yellow River Basin stream segments covered by this TMDL report, Class A1 uses are assessed as "not supported" based on results of monitoring for indicator bacteria (*E. coli*). According to IDNR assessment and impaired listing methodology, if monitoring shows that greater than ten percent of samples exceed the single sample maximum or if the geometric mean is exceeded, a stream is partially supported for Class A1 use and is impaired. The 2010 305(b) Water Quality Assessments for the twelve impaired segments can be found in Appendix E of this report.

*Data sources.*
Several monitoring efforts have been undertaken in the Yellow River watershed in the last ten years. These have included flow monitoring by USGS and IDNR, sampling and analysis by IDNR and SHL and temperature measurements by IDNR Fisheries at sites throughout the watershed.

The monitoring data used to make the 2010 assessment of the streams in the Yellow River basin was collected between 2004 and 2008 at thirteen sites, four on the Yellow River and nine on the primary tributaries. Figure 3-2 shows where the thirteen sites are located and they are listed in Table 3-2.

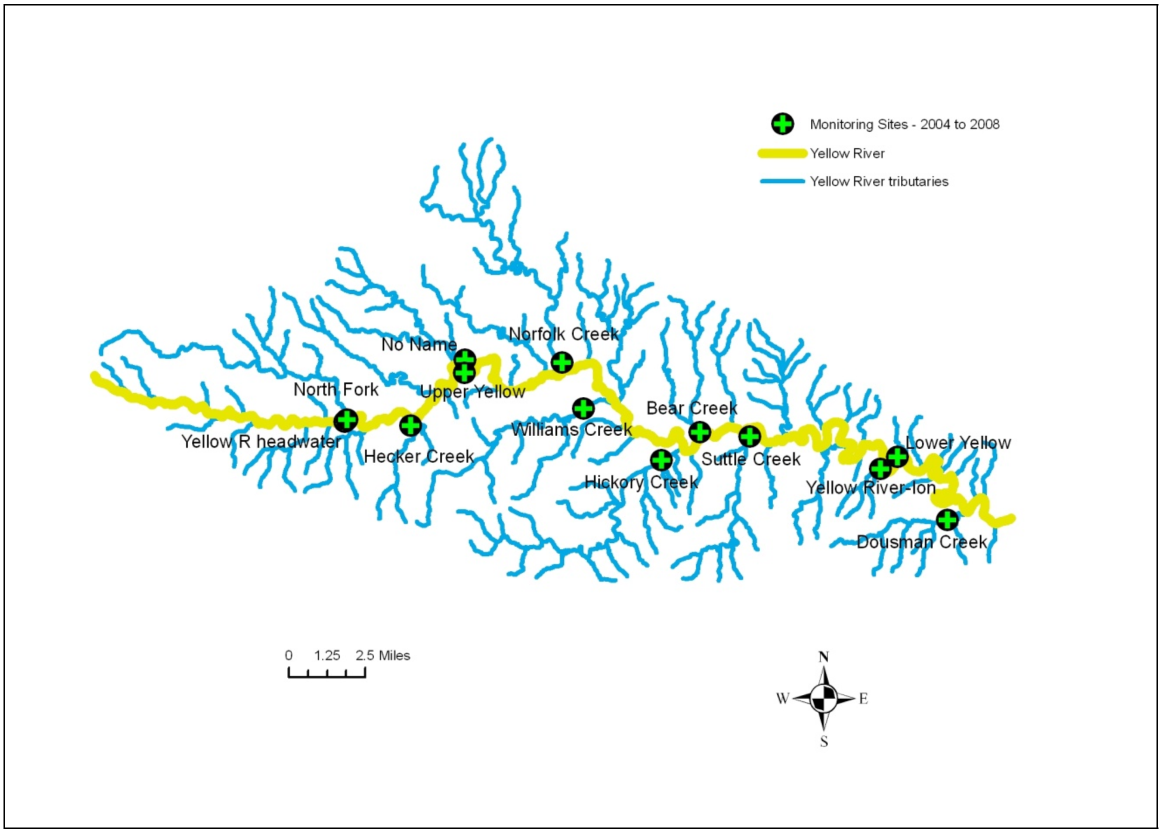

Figure 3-2 Thirteen sites monitored from 2004 to 2008 - the USGS gage station is at the Yellow River Ion site

**Table 3-2 2004 to 2008 monitoring sites**

| Site Name | Location |
|---|---|
| Yellow River headwater | Yellow River at 107th Ave. |
| North Fork Yellow River | North Fork Yellow River at Maple Valley Rd. |
| Hecker Creek | Hecker Creek at Co. Rd. W4B |
| Ludlow Creek | Ludlow Creek at Co. Rd. W60 |
| Upper Yellow River | Yellow River at Co. Rd. W60 |
| Norfolk Creek | Norfolk Creek at Yellow River Dr |
| Williams Creek | Williams Creek nr. Co. Rd. X16 |
| Hickory Creek | Hickory Creek at Hickory Creek Rd. |
| Bear Creek | Bear Creek at Co. Rd. X26 |
| Suttle Creek | Suttle Creek at Suttle Creek Rd |
| Yellow River-Ion | Yellow River near Volney |
| Lower Yellow River | Yellow R. at canoe access on Old Mission Rd. |
| Dousman Creek | Dousman Creek at Dousman Creek Rd |

More recently, monitoring was done in 2009 at seven sites in preparation for this report. Fewer sites were monitored than in the 2004 to 2008 project but stage was continuously measured and translated into flow for each site and automatic samplers collected samples hourly during rain events. Figure 3-3 shows the locations of the 2009 monitoring sites and Table 3-3 lists the sites.

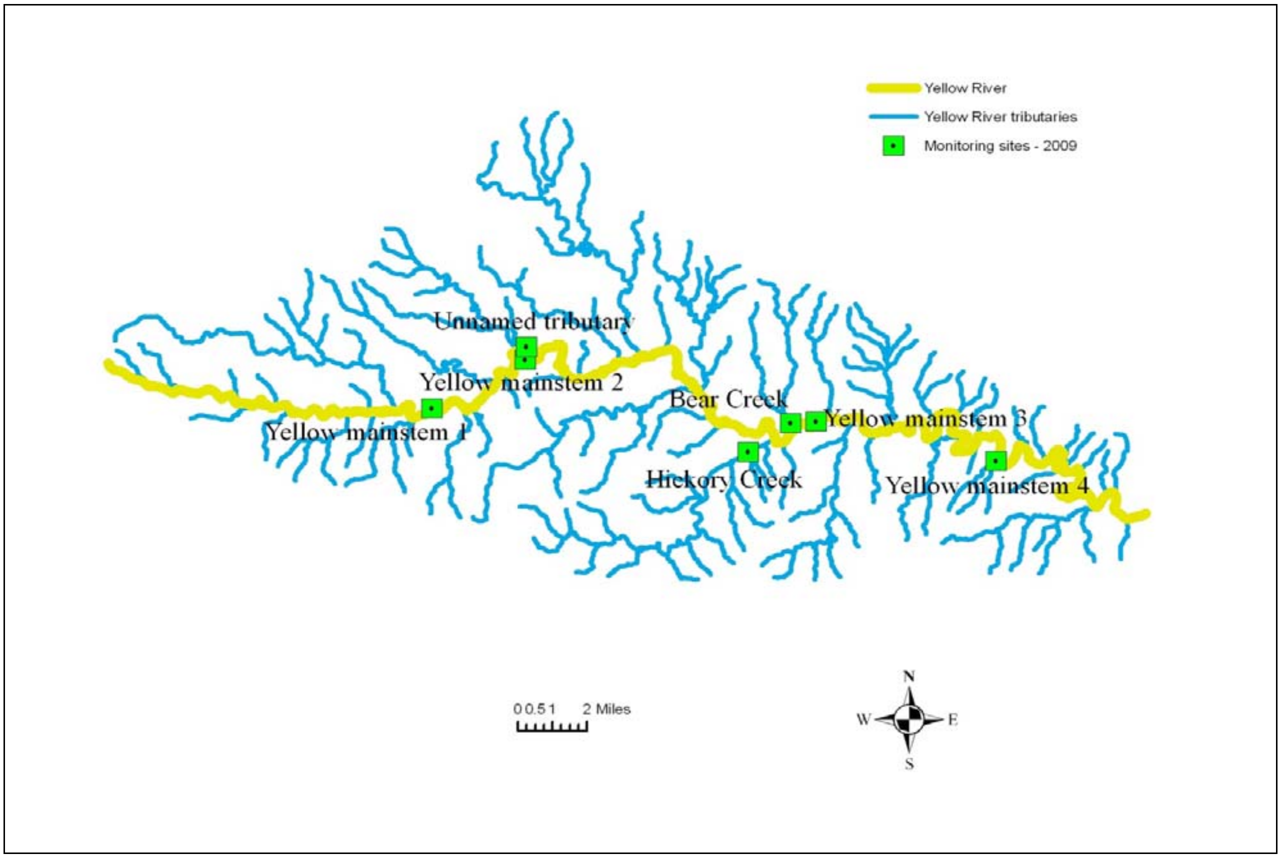

Figure 3-3 Seven sites monitored in 2009 – the USGS gage station is at the Yellow mainstem 4 site at Ion.

**Table 3-3 2009 monitoring sites**

| Site Name | Location |
|---|---|
| Yellow River 4[1] | Yellow River at USGS Ion gage |
| Yellow River 3 | Yellow River at Suttle Rd |
| Yellow River 2[1] | Yellow River at Co. Rd. W60 |
| Yellow River 1 | Yellow River at Empire Drive |
| Bear Creek[1] | Bear Creek at Co. Rd. X26 (Volney Rd) |
| Hickory Creek[1] | Hickory Creek at Hickory Creek Rd. |
| Unnamed Creek (Ludlow)[1] | No Name at Co. Rd. W60 (Old Stage Rd) |

1. Location is the same as site for 2004 to 2008 monitoring project.

Primary flow data was collected at a USGS gage located near Ion from October 1, 2004 to the present. This data includes continuous stage and discharge information that has been used for hydrologic calibration of the watershed and water quality models. As noted, flow data from the 2009 monitoring by automatic samplers using bubblers and evaluation of periodic direct flow measurements was used as a check of other flow data. The automatic samplers collect during precipitation events.

Two other data sets have been used to develop these *E. coli* TMDLs. The first is the monthly samples that are collected for the IDNR Ambient Monitoring Program at the USGS Ion gage site. These samples were collected from 2000 to 2010.
The second is a separate IDNR project that collected biweekly samples at the USGS Ion gage site and at the Hecker Creek site from 2006 to 2008.

*Interpreting Yellow River Basin data.*
Flow and load duration curves were used to establish the occurrence of water quality standards violations, to establish compliance targets, and to set pollutant allocations and margins of safety. Duration curves are derived from flows plotted as a percentage of their recurrence. *E. coli* loads are calculated from *E. coli* concentrations and flow volume at the time the sample was collected.

Load duration methods have been applied to the Yellow River Basin data to establish the existing and target *E. coli* loads for five flow conditions (see Appendix D). The five flow recurrence intervals represent conditions that can be interpreted to suggest pollutant sources. The flow interval medians are the quartiles (25, 50, and 75 percent) of the flow recurrences and are often associated with flow and load duration analysis. The five flow conditions are described in Table 3-4.

**Table 3-4 Five flow conditions used to establish existing and target loads**

| Flow condition | Description |
|---|---|
| 0 – 10 % interval, high flow | Runoff conditions predominate and flows and loads are primarily from nonpoint sources available for washoff. |
| 10 - 40 % interval, moist conditions | Runoff conditions are decreasing as is their contribution to bacteria loading. |
| 40 – 60 % interval, mid-range | Runoff loads are still an important fraction but groundwater and interflow are a growing part of the total. Loads originate from local runoff and continuous septic tank, cattle in the stream, and wastewater treatment plants. |
| 60 – 90 % interval, dry conditions | Runoff loads are a disappearing fraction of streamflow. Groundwater and interflow are most of the total. Loads are from local runoff and continuous septic tank, cattle in the stream, and wastewater treatment plants. |
| 90 – 100 % interval, low flow | The low flow to no flow condition. Loads are nearly all from local continuous sources although the delivery of these loads can be reduced in the driest conditions. |

The flow and load duration curves were developed using six years (all that is available) of USGS gage flow data to calculate an area-ratio daily flow estimate, i.e., the area of the subbasin(s) of the impaired segment or tributary divided by the area upstream of the USGS gage at Ion. This fraction has been multiplied by the average daily discharge at the gage to get the daily flow estimate for the impaired segment or tributary.

To construct the flow duration curves, the *E. coli* monitoring data and the Water Quality Standard (WQS) sample max (235 *E. coli* organisms/100 ml) were plotted with the flow duration percentile. The charts show the data that exceeds the WQS criteria at each of the five flow conditions. High flow violations indicate that the problem occurs during run-off conditions when bacteria are washing off from nonpoint sources. Criteria exceeded during low or base flow, when runoff is generally not occurring, indicate that continuous sources such as septic tanks, livestock in the stream, riparian wildlife, and wastewater treatment plants are the problem.

## 3.2. TMDL Target

The target for this TMDL is the WQS for Class A1, Primary Contact Recreational Use. The criteria are a geometric mean (GM) of 126 *E. coli* organisms/100ml and a single sample maximum (SSM) of 235 *E. coli* organisms/100ml. The loads associated with these concentrations are based on the average daily stream flows. The criteria used to determine attainment of the WQS are explained in the 305(b) report assessment protocol in Appendix E.

*General description of the pollutant.*
Potential point sources of *E. coli* for the thirteen impaired stream segments are undisinfected wastewater treatment plant discharges.

The nonpoint *E. coli* sources for the impaired segments are runoff from developed areas, grazing livestock, manure applied to fields, wildlife, and failed onsite septic tank systems. These nonpoint sources can be divided into two components. One is episodic and consists of livestock and wildlife fecal material periodically transported during precipitation events. The other is continuous discharges from leaking septic tank systems and manure from cattle in and near streams. Additionally, E. coli from nonpoint sources can be resuspended from stream sediment at times when runoff is not occurring.

*Selection of environmental conditions.*
The recreation season in the Iowa WQS for Class A1 runs from March 15 through November 15 and for ClassA2 coldwater is year round. It has been assumed for these TMDLs in the Yellow River Basin that all streams must meet the GM and SSM standards year round.

*Decision criteria for water quality standards attainment.*
Water Quality Standards will be attained in the thirteen Yellow River Basin stream segments when the monitored *E. coli* concentrations meets the criteria of a geometric mean (GM) of 126 org/100 ml and a single sample maximum (SSM) concentration of 235 org/100 ml.

## 3.3. Pollutant Source Assessment

Bacteria sources include wastewater treatment plant and urban storm sewer discharges, failed septic tank systems, wildlife, grazing livestock, runoff from fields where manure has been applied, and feedlots. Nonpoint source bacteria problems often accompany heavy rainfall events. Point sources of bacteria, such as wastewater treatment plants, usually discharge continuously.

*Existing load.*

The existing loads are derived from the data measured at the twelve TMDL sites described in the water quality assessment 305(b) report. These data are the monitored points shown in the flow and load duration curves in the following sections for the specific impaired waterbodies. The monitored *E. coli* concentrations are multiplied by the average daily flow to get the daily loads that are plotted with the load duration curves. The maximum allowable loads for a given flow equal the flow multiplied by the WQS limits for the geometric mean or single sample maximum. Monitored data that exceed the WQS criteria are above the WQS limit curves.

The maximum existing load occurs during events when maximum runoff and bacteria concentrations are highest often causing bacteria concentrations to exceed the criteria. The other condition leading to criteria violations occurs during dry low flow periods when continuous loads from livestock in the stream, local wildlife, septic tanks, and wastewater treatment plants cause bacteria problems.

The assessment methodology used to evaluate pathogen indicator criteria assume that if 10 percent or more of samples exceed the SSM *E. coli* criteria then the waterbody is not supporting recreational use. The 90th percentile of observed concentrations within each flow condition is multiplied by the median flow for each condition to estimate existing loads.

*Identification of pollutant sources.*

There are two categories of pollutant sources evaluated for TMDL development. One of these categories is permitted point sources and includes municipal and industrial wastewater treatment facilities that have NPDES permits. The second category is nonpoint sources that include all discharges that are not regulated. Nonpoint sources are often of a diffuse nature such as runoff from agricultural areas.

*Point Sources.*

The point sources in the Yellow River Basin impaired stream segments includes three municipal wastewater treatment plants (WWTP) one industrial wastewater treatment plant, and one open feedlot with National Pollutant Discharge Elimination System (NPDES) permits.

The four permitted wastewater treatment plants in the watershed that currently have NPDES permits are listed in Table 3-5 and their locations are shown in Figure 3-4. Waste stabilization lagoons are controlled discharge lagoon (CDL) processes that usually discharge twice a year when receiving stream flows are high. All other facilities discharge continuously.

### Table 3-5 NPDES permitted wastewater treatment plants in the Yellow River Basin

| City Name | EPA NPDES ID | Iowa DNR NPDES ID | Receiving Stream | Treatment type | Design BOD population equivalents[1] |
|---|---|---|---|---|---|
| Postville | IA0058904 | 0375001 | Williams Cr. | Biofilter | 1906 (324 lb/d) |
| Castalia | IA0076236 | 9620001 | Yellow River | 3 cell CDL | 218 (37 lb/d) |
| Luana | IA0027685 | 2254001 | Hickory Cr | 2 cell CDL | 389 (65 lb/d) |
| AgriStarr Meat and Poultry | IA0077135 | 0375102 | Hecker Cr | Activated sludge | NA |

1. Biochemical Oxygen Demand (BOD) average daily per capita load is 0.17 lb/day

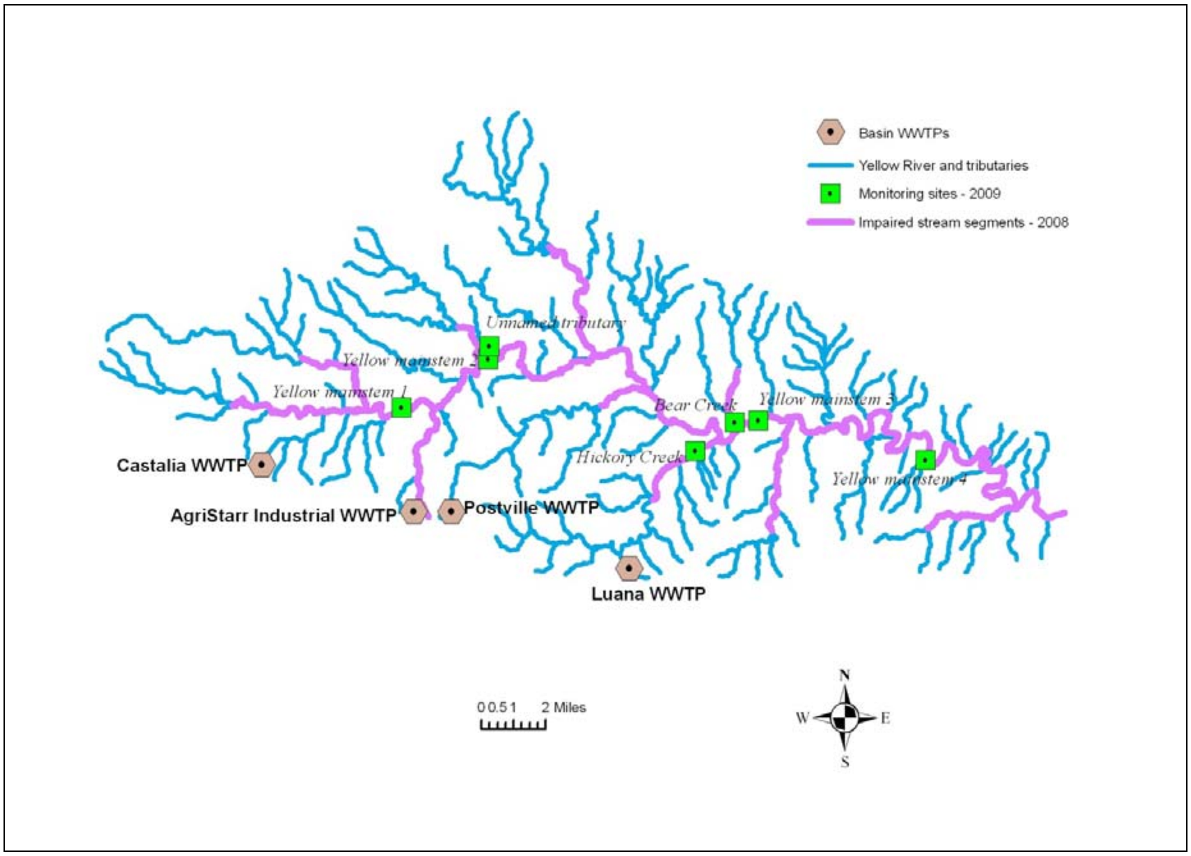

Figure 3-4 NPDES permitted WWTP location map

*Nonpoint Sources.*

The nonpoint sources of pathogen indicators include contributors that do not have localized points of release into a stream. In the watershed these sources are:

- Grazing animals
- Cattle contributions directly deposited in a stream
- Land application of manure
- Built-up and urban area runoff
- Wildlife
- Faulty septic tank systems

The nonpoint source *E. coli* loads have been estimated for each of the impaired tributaries and Yellow River segments based on the sources in the streams subbasin(s). The nonpoint sources for each of the impaired tributaries and river segments are described in the following sections. Charts showing the load fractions for the major sources for each stream are also shown in these. The largest bacteria contributions occur during high flow conditions. As noted, there are two components of the bacteria load for most of the flow conditions:

- continuous loads from failed septic tanks and livestock in streams and,
- runoff carrying bacteria available for washoff when it rains.

Continuous loads are fairly constant in volume and concentration. Runoff loads have high bacteria concentrations and usually occur with elevated streamflow but can occur during any precipitation event where there is runoff.

*Allowance for increases in pollutant loads.*
An allowance for increased pathogen indicator loading was not included in this TMDL. All discharges into the impaired Yellow River Basin stream segments are expected to comply with the Iowa Water Quality Standards. Any new permitted point source discharge would be required to meet the WQS limits. Any new nonpoint sources would be expected to meet the *E. coli* limits.

## 3.4. Pollutant Allocations

*Wasteload allocations.*
The wasteload allocations (WLA) for the four wastewater treatment facilities discharging to the Yellow River tributaries are in Table 3-6. It is currently assumed that all of the wastewater treatment plants in the watershed discharge to a Class A1 stream. The wasteload allocations for the discharges are the Class A1 *E. coli* concentration WQS; a geometric mean (GM) of 126-organisms/100 ml and a single sample maximum (SSM) of 235-organisms/100 ml. These concentration criteria are multiplied by the design flow to obtain the wasteload allocations for each facility.

**Table 3-6 Permitted Wastewater Treatment Plant discharge Wasteload Allocations**

| City Name | Design Flow, l/day[1] | GM[2], *E. coli*, orgs/100 ml | SSM[2], *E. coli*, orgs/100 ml | GM3[3], *E. coli*, orgs/day | SSM[3], *E. coli*, orgs/day |
|---|---|---|---|---|---|
| Postville | 1,082,132 | 126 | 235 | 1.36E+09 | 2.54E+09 |
| Castalia | 123,770 | 126 | 235 | 1.56E+09 | 2.91E+09 |
| Luana | 220,855 | 126 | 235 | 2.78E+09 | 5.19E+09 |
| AgriStarr Meat and Poultry | 3,330,000 | 126 | 235 | 4.20E+09 | 7.83E+09 |

1. The design is a 30 day average wet weather flow (AWW) for a continuously discharging wastewater treatment plant and a 180 day AWW for a controlled discharge lagoon (CDL).

2. These are the water quality standard *E. coli* concentration WLAs for the 30 day geometric mean and single sample maximum.
3. Number of *E. coli* organisms (load) allowed at the design discharge flows.
4. These controlled discharge waste stabilization lagoons usually discharge twice a year for a relatively short time. They are permitted to discharge at a rate that is ten times the 180 day AWW flow. The daily *E. coli* load WLAs for these facilities are the WQS concentrations multiplied by ten times the 180 day AWW.

There is one permitted open feedlot in the Yellow River basin. The wasteload allocation for this is in Table 3-7.

**Table 3-7 NPDES Permitted Open Feedlot Operation Wasteload Allocation**

| Facility Name | Facility ID | NPDES permit # | EPA # | Township and range | Sec | 1/4 Sec | WLA[1] |
|---|---|---|---|---|---|---|---|
| Johnson Farms Feedlot | 64003 | Permit #0300305 | IA0080 632 | T97N R6W | 24 | NW | Zero |

1. No discharge resulting from precipitation events less than or equal to the 25 year, 24 hour precipitation event.

There are three quarries in the Yellow River basin that discharge under Iowa DNR NPDES General Permit #5. These quarries are listed in Table 3-8.

**Table 3-8 NPDES Permitted Quarries Covered under General Permit 5**

| Facility Name | NPDES General Permit #5 | County | Township | Range | Section |
|---|---|---|---|---|---|
| Elsbernd Quarry | IA-G140458 | Allamakee | T97N | R06W | 16 |
| Green Quarry | IA-G140070 | Allamakee | T96N | R06W | 20,29 |
| Doerring Quarry | IA-G140388 | Clayton | T95N | R06W | 05 |

1. Quarries are not sources of bacteria and these are listed in order to include all NPDES permitted facilities in the Yellow River Basin.

## 3.5. Development of the Model Subbasins

The Yellow River watershed subbasins shown in Figure 3-5 are based on a digital elevation model constructed in GIS using the Soil and Water Analysis Tool (SWAT). The subbasins conform with the watershed drainage and each of the nine impaired tributaries is its own subbasin. The headwater of the Yellow River, Segment 0080_3, is also its own subbasin. The three downstream Yellow River segments collect drainage from an increasing number of subbasins as you go downstream. There are also several subbasins not designated as impaired, most likely because they have not been monitored. These are shaded in Figure 3-5 and are all unnamed streams.

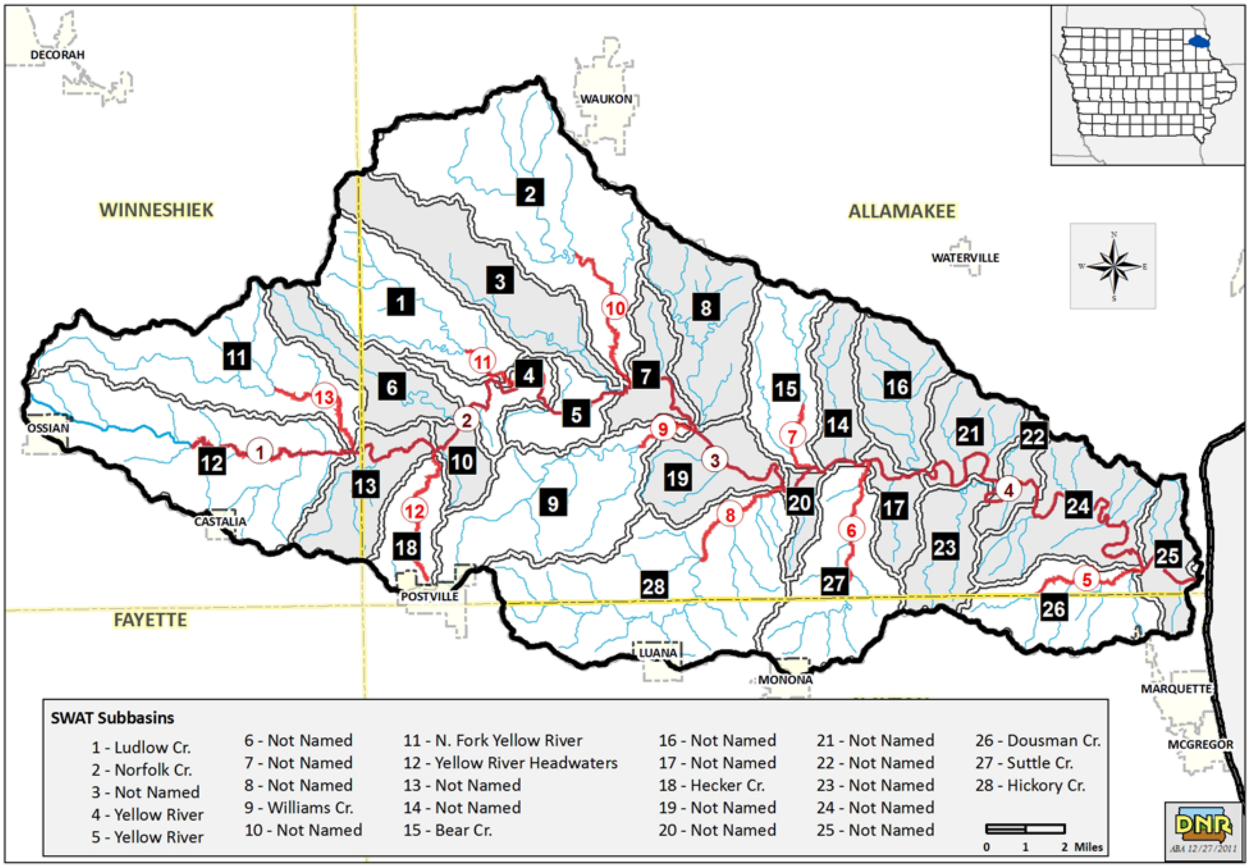

Figure 3-5 Yellow River SWAT subbasins map

## 3.6. Reasonable Assurance

EPA guidance (EPA 440/4-91-001) and policy (EPA Memorandum 8/8/97) calls for reasonable assurance that TMDLs can be implemented. Reasonable assurance indicates confidence that the goals outlined in the TMDL can be achieved, whether in the form of wasteload allocations or load allocations. For the Yellow River Basin, regulations and programs exist that can be utilized to implement TMDLs.

Reasonable assurance is a demonstration that the wasteload and load allocations will be realized through regulation or implementation of non-regulatory actions. For waterbodies such as the segments of the Yellow River and its tributaries impaired by both point and nonpoint sources, wasteload allocations assume anticipated reductions of *E. coli* from nonpoint sources will occur (40CFR 130.2g).

For point sources, Code of Federal Regulations Title 40 (40 CFR) 122.44(d)(1)(vii)(B) requires effluent limitations for an NPDES permit to be consistent with the assumptions and requirements of any available WLA for the discharge prepared by the state and approved by EPA including those in TMDLs. Furthermore, EPA has authority to object to issuance of a NPDES permit that is inconsistent with the WLAs established for that point source. These wasteload allocations are implemented through the Iowa NPDES permitting procedure following state rules in Iowa Administrative Code (IAC) 567-64.

For nonpoint sources, funding assistance from programs such as the Clean Water Act Section 319 grants are available These programs address nonpoint source load allocations by providing funds to implement best management practices (BMP) for nonpoint source pollutants.  Measures that benefit nonpoint source control efforts include development of the Iowa Nonpoint Source Management Program document, and watershed group activities for river restoration.

Reasonable assurance for nonpoint sources will be accomplished through methods and projects that reduce the impacts of livestock, manure applications to fields, and failed septic tank systems.

## 4. Yellow River 4 USGS Ion gage (0070_0)

The Yellow River 4 segment has the only monitoring location with a USGS flow gage in the Yellow River basin. This gage has been the primary source used to provide data for the area-ratio method of estimating daily flow as well as to calibrate the SWAT watershed model hydrology. Data collected at the gage site is representative of the water quality in the 21.7 mile Yellow River reach IA 01-YEL-0070-0 from the confluence with the Mississippi River to the bridge at County Road X-26. It drains three of the HUC 12s in the Yellow River Basin; Lower Yellow River, Middle Yellow River, and Hickory Creek. Figure 4-1 shows average daily flow at the gage since 2006.

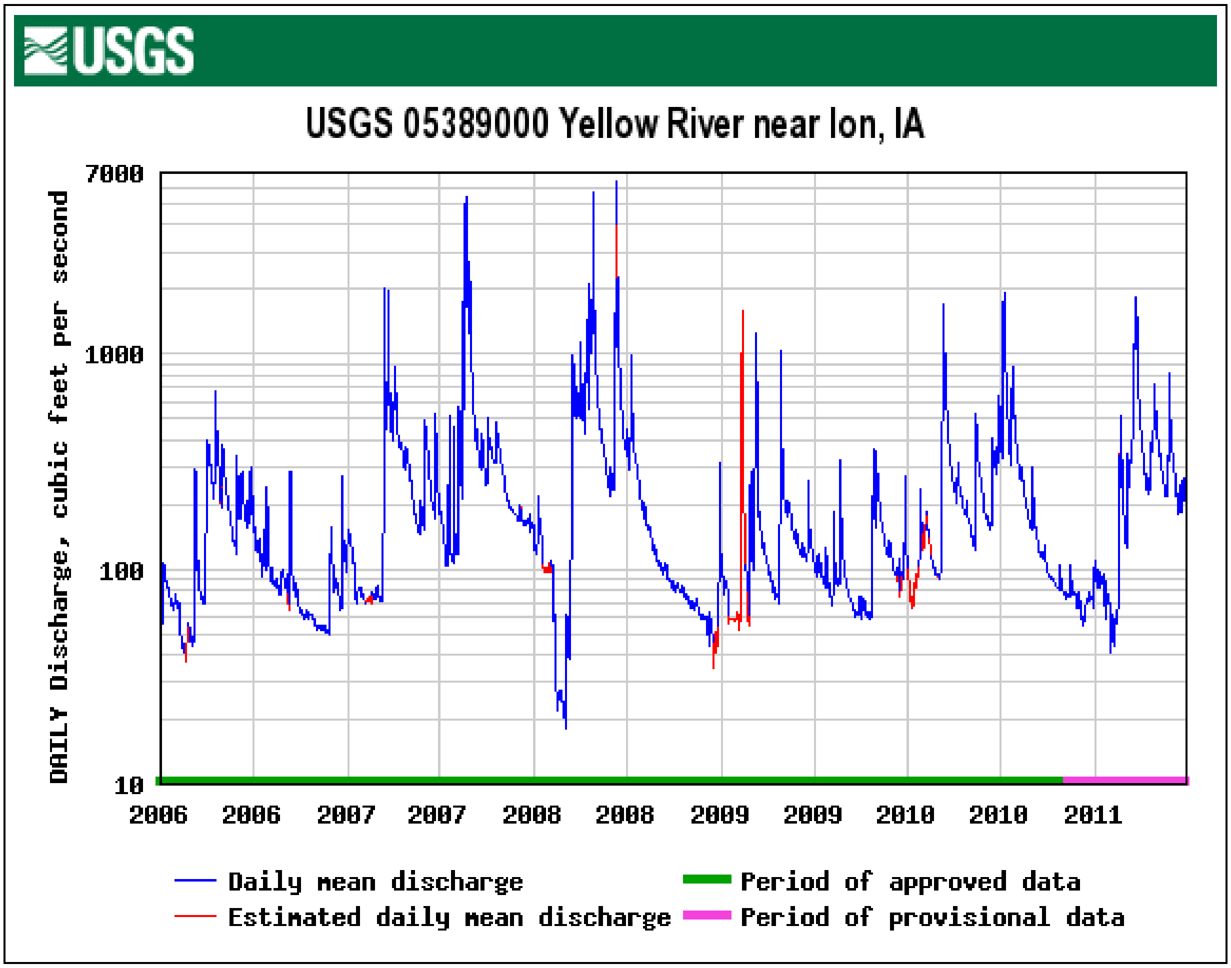

Figure 4-1 Ion USGS gage daily discharge from installation to present

Four tributaries that flow into this segment are impaired; Dousman Creek, Suttle Creek, Bear Creek, and Hickory Creek. There is one municipal wastewater treatment facility for the City of Luana that discharges to a tributary of this segment. This facility is a controlled discharge lagoon that releases effluent at higher flows twice per year in the spring and fall. Figure 4-2 shows a map of the Yellow River 4 segment and Table 4-1 shows the land use for all of the Yellow River subbasins since this segment discharges into the Mississippi River.

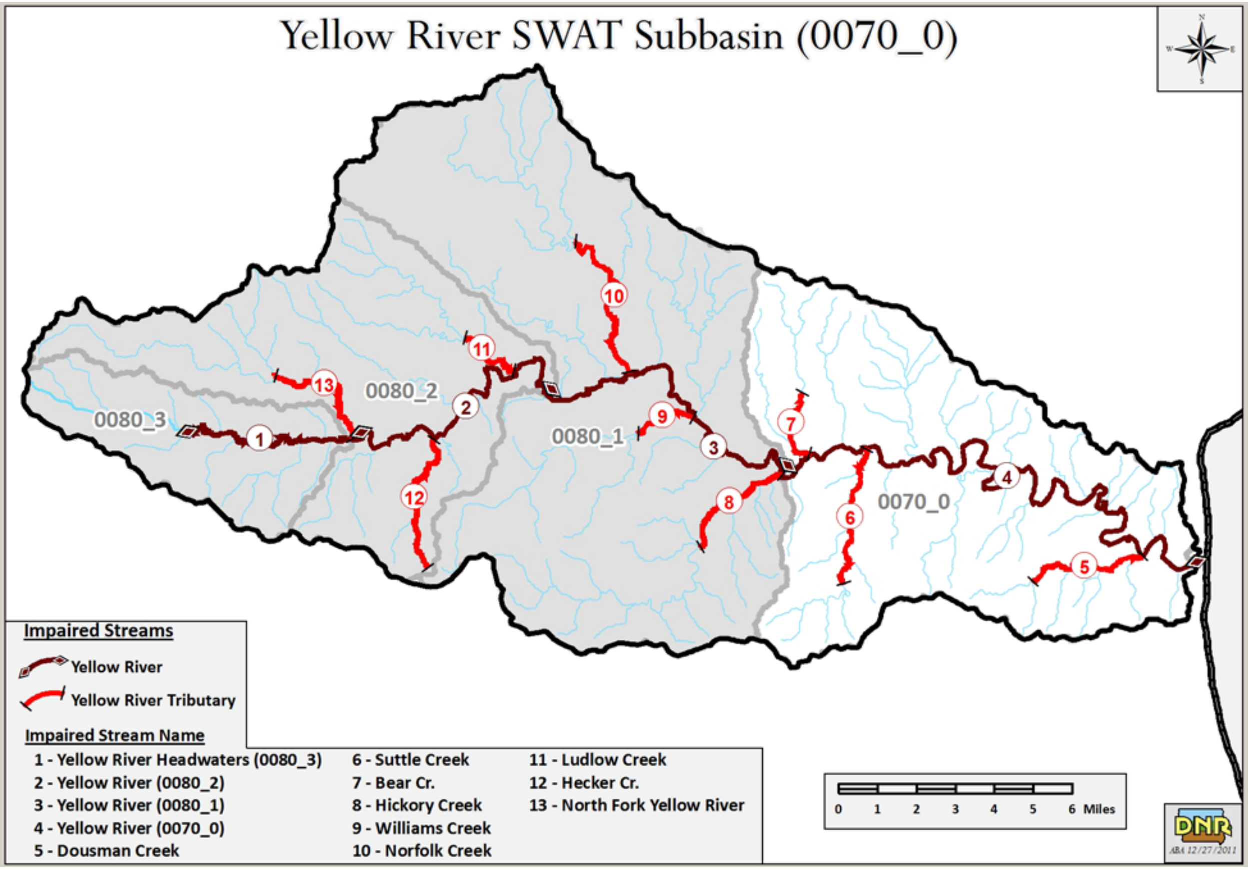

Figure 4-2 Yellow River 4 (0070_0) segment map

### Table 4-1 Yellow River 4 Basin land use

| Landuse | Area, acres | Fraction of total |
|---|---:|---:|
| Water/wetland | 435.6 | 0.28% |
| Forest | 30384.2 | 19.61% |
| Ungrazed/CRP/hay | 29149.2 | 18.82% |
| Grazed | 14162.1 | 9.14% |
| Row crop | 75525.0 | 48.76% |
| Roads | 3988.9 | 2.57% |
| Commercial/residential | 1273.2 | 0.82% |
| **Total** | **154918.2** | **100.00%** |

## 4.1. Water body pollutant loading capacity (TMDL)

The *E. coli* organism load capacity is the number of organisms that can be in a volume and meet the water quality criteria. The loading capacity for each of the five flow conditions is calculated by multiplying the interval midpoint flow and *E. coli* criteria concentrations to get the total number for a given volume or flow rate. Table 4-2 shows the median, maximum, and minimum flows for the five flow conditions.

## Table 4-2 Yellow River 4 USGS Ion gage maximum, minimum and median flows

| Flow description | Recurrence interval range (mid %) | Midpoint of flow range, cfs | Maximum of flow range, cfs | Minimum of flow range, cfs |
|---|---|---|---|---|
| **High flow** | **0 to 10% (5)** | 594 | 6370 | 379 |
| **Moist conditions** | **10% to 40% (25)** | 187 | 379 | 117 |
| **Mid-range** | **40% to 60% (50)** | 94 | 117 | 78 |
| **Dry conditions** | **60% to 90% (75)** | 63 | 78 | 51 |
| **Low flow** | **90% to 100% (95)** | 42 | 51 | 18 |

Flow and load duration curves were used to establish the occurrence of water quality standards violations, to establish compliance targets, and to set pollutant allocations and margins of safety. Duration curves are derived from flows plotted as a percentage of their recurrence. *E. coli* loads are calculated from *E. coli* concentrations and flow volume at the time the sample was collected.

To construct the flow duration curves, the bacteria monitoring data and the Water Quality Standard (WQS) sample max (235 *E. coli* organisms/100 ml) were plotted with the flow duration percentile. Figure 4-3 shows the data that exceed the WQS criteria at four of the five flow conditions. High flow violations indicate that the problem occurs during run-off conditions when bacteria are washing off from nonpoint sources. Criteria exceeded during low or base flow, when little or no runoff is occurring, indicate that continuous sources such as septic tanks, livestock in the stream, riparian wildlife, and wastewater treatment plants are the problem.

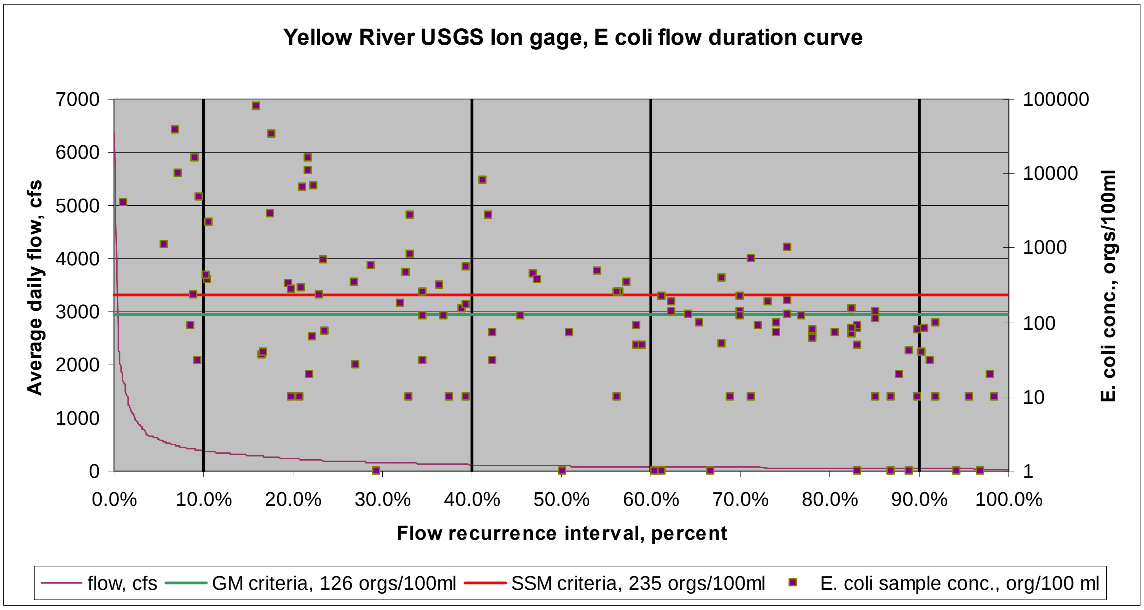

Figure 4-3 Yellow River 4 flow duration curve at the USGS gage near Ion

Load duration curves were used to evaluate the five flow conditions for this Yellow River segment. The load duration curve is shown in Figure 4-4. In the figure, the lower curve shows the maximum *E. coli* count for the GM criteria and the upper curve shows the maximum *E. coli* count for the SSM criteria at a continuum of flow recurrence percentage. The individual points are the observed (monitored) *E. coli* concentrations converted to loads based on daily flow for the day they were collected. Points above the load duration curves are violations of the WQS criteria and exceed the loading capacity.

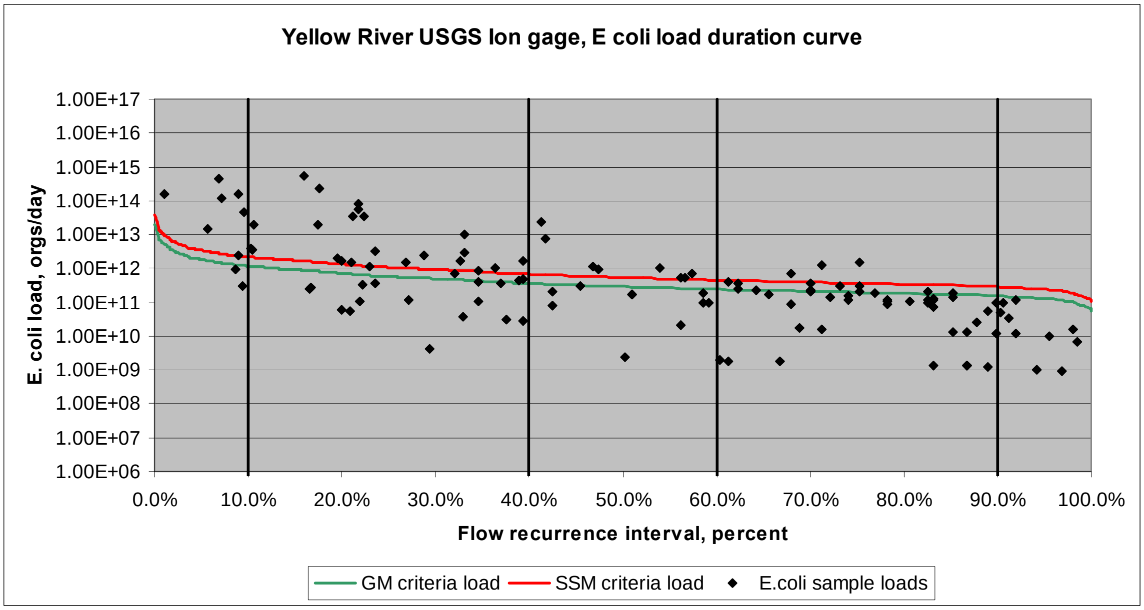

Figure 4-4 Yellow River 4, USGS Ion gage load duration curve

Tables 4-3 and 4-4 show the load capacities (targets) for each of the midpoint flow conditions at the GM and SSM criteria, respectively.

**Table 4-3 Yellow River 4, USGS Ion gage GM load capacity**

| Flow condition | Recurrence interval | Associated midpoint flow, cfs | Estimated flow interval load capacity, *E. coli* orgs/day |
|---|---|---|---|
| **High flow** | **0 to 10%** | 594 | 1.8E+12 |
| **Moist conditions** | **10% to 40%** | 187 | 5.8E+11 |
| **Mid-range** | **40% to 60%** | 94 | 2.9E+11 |
| **Dry conditions** | **60% to 90%** | 63 | 1.9E+11 |
| **Low flow** | **90% to 100%** | 42 | 1.3E+11 |

**Table 4-4 Yellow River 4, USGS Ion gage SSM load capacity**

| Flow condition | Recurrence interval | Associated midpoint flow, cfs | Estimated flow interval load capacity, *E. coli* orgs/day |
|---|---|---|---|
| **High flow** | **0 to 10%** | 594 | 3.4E+12 |
| **Moist conditions** | **10% to 40%** | 187 | 1.1E+12 |
| **Mid-range** | **40% to 60%** | 94 | 5.4E+11 |
| **Dry conditions** | **60% to 90%** | 63 | 3.6E+11 |
| **Low flow** | **90% to 100%** | 42 | 2.4E+11 |

## 4.2 Existing load.

The existing loads are derived from the data measured at the USGS gage site. These data are the sample values shown in the flow and load duration curves. The *E. coli* concentrations are multiplied by the average daily flow to get the daily loads. The daily loads are plotted with the load duration curves. The allowable loads for a given flow equal the flow multiplied by the WQS limits for the geometric mean or single sample maximum. Monitored data that exceed the limits are above the criteria curves.

The maximum existing loads occur during major rains when runoff and bacteria concentrations are highest. Concentrations exceed the criteria during these high flow events. Other conditions leading to criteria violations occur during dry low flow periods when continuous loads from livestock in the stream, local wildlife, septic tanks, and wastewater treatment plants can cause bacteria problems.

The assessment standard used to evaluate streams is the *E. coli* geometric mean criteria. Since the load duration approach precludes the calculation of a geometric mean, the 90th percentile of observed concentrations within each flow condition is multiplied by the median flow to estimate existing loads. Table 4-5 shows the existing loads for each flow condition.

**Table 4-5 Yellow River 4, Ion gage site, existing loads**

| Flow condition, percent recurrence | Recurrence interval range (mid %) | Associated median flow, cfs | Existing 90th percentile *E. coli* conc., org/100ml | Estimated existing load, *E. coli* org/day |
|---|---|---|---|---|
| **High** | **0 to 10% (5)** | 594 | 20600 | 2.99E+14 |
| **Moist conditions** | **10% to 40% (25)** | 187 | 6900 | 3.16E+13 |
| **Mid-range** | **40% to 60% (50)** | 94 | 1183 | 2.72E+12 |
| **Dry conditions** | **60% to 90% (75)** | 63 | 210 | 3.24E+11 |
| **Low flow** | **90% to 100% (95)** | 42 | 84 | 8.61E+10 |

*Identification of pollutant sources.*
The sources of bacteria in the Yellow River 4 watershed come from all 28 of the subbasins in the Yellow River Basin since this is the downstream segment. These sources include failed septic tank systems, pastured cattle, cattle in the stream, wildlife, and manure applied to fields from animal confinement operations. Since the outlet to the Mississippi River (Subbasin 25) is far downstream from many of the bacteria sources, the loads are diminished by die-off and other losses. The loads from all these sources are incorporated into the SWAT watershed model and are listed in Tables 4-6 to 4-10.

Non functional septic tank systems. There are an estimated 1,171 onsite septic tank systems in the subbasin based on aerial photography with an average of 2.5 persons per household. IDNR staff estimates that 50 percent are not functioning properly and that these are year-round continuous discharges. Septic tank loads are entered into the SWAT model as a continuous source by subbasin.

### Table 4-6 Yellow River 4 (0070_0) septic tank system E. coli orgs/day

| | |
|---|---:|
| Rural population of Yellow River watershed | 2,927 |
| Total initial E.coli, orgs/day [1] | 3.66E+12 |
| Septic tank flow, $m^3$/day [2] | 776 |
| **E. coli delivered to stream, orgs/day [3]** | **2.42E+09** |

1. Assumes initial 1.25E+09 E. coli orgs/day per capita
2. Assumes 70 gallons/day/capita
3. Assumes septic discharge concentration reaching stream is 625 orgs/100 ml and a 50% failure rate

Cattle in stream. Of the 8,749 cattle in pastures with stream access, one to six percent of those are assumed to be in the stream on a given day. The number on pasture and the fraction in the stream varies by month. Cattle in the stream have a high potential to deliver bacteria since bacteria are deposited directly in the stream with or without rainfall. Subbasin cattle in the stream bacteria have been input in the SWAT model as a continuous source varying by month.

### Table 4-7 Yellow River 4 (0070_0) Cattle in the stream E. coli orgs/day

| | |
|---|---:|
| Pasture area with stream access, acre[1] | 11,217 |
| Number of cattle in stream (6% of total)[2] | 525 |
| Dry manure, kg/day [3] | 1,627 |
| **E. coli load, orgs/day [4]** | **2.15E+13** |

1. The basin CIS are estimated from the pasture area with stream access at 0.78 cattle/acre.
2. It is estimated that cattle spend 6% of their time in streams in July and August, 3% in June and September, and 1% in May and October. The loads shown in this table are for July and August. The loads for the other 4 months when cattle are in streams have been incorporated into the SWAT modeling.
3. Cattle generate 3.1 kg/head/day of dry manure.
4. Manure has 1.32E+07 E coli orgs/gram dry manure.

Grazing livestock. The estimated number of cattle in the basin is 10,564. It is assumed that they are on pasture from April to November. The potential for bacteria delivery to the stream occurs with precipitation causing runoff. Manure available for washoff is applied in the SWAT model at 6 kg/ha in the pasture landuse.

### Table 4-8 Yellow River 4 (0070_0) manure from pastured cattle, maximum E. coli available for washoff, orgs/day

| | |
|---|---:|
| Pasture area, ha | 14,169 |
| Number of cattle on pasture[1] | 10,564 |
| Dry manure, kg/day[2] | 32,749 |
| Maximum E. coli load, orgs/day[3] | 4.32E+14 |
| Maximum E. coli available for washoff, orgs[4] | 7.78E+14 |

1. The number of pastured cattle is 0.78 cattle/acre.
2. Cattle generate 3.1 kg/head/day of dry manure.
3. Manure has 1.32E+07 E. coli orgs/gram dry manure
4. The load available for washoff is the daily load times 1.8.

Wildlife manure. The number of deer in Allamakee County is about 9,000 located primarily in forested land adjacent to streams. Another 1,000 have been added to account for other wildlife such as raccoons and waterfowl for a total estimate of 10,000. This works out to 0.024 deer per acre. Using this procedure, there are 3,718 deer in the subbasins concentrated in the forest and grassland areas. The deer are in the subbasins year round.

### Table 4-9 Yellow River 4 (0070_0) watershed wildlife manure loads available for washoff, orgs/day

| Number of deer[1] | Forest and brome grass area, ha | SWAT manure loading rate, kg/ha/day[2] | Total E. coli available for washoff, orgs[3] |
|---|---|---|---|
| 3,718 | 13,863 | 0.386 | 3.34E+12 |

1. Deer numbers are 0.024 deer/ha for the entire subbasin concentrated to 0.268 deer/ha in the forest land use. All wildlife loads are applied to the forest landuse in the SWAT model. The county deer numbers have been increased by 10% to account for other wildlife in the subbasin.
2. Assumes 1.44 kg/deer/day and 3.47E+05 orgs/gram.
3. Assumes that the maximum E. coli available for washoff is 1.8 times the daily load.

Field applications of CAFO manure.

There are about 1,942 dairy cows, 349,650 chickens, and 42,000 swine in confinement in the upstream subbasins. The manure is stored and land applied to cropland. The manure is distributed to fields in the fall after soybean harvest and in the spring prior to corn planting in year two of a two year rotation. The relatively brief fall and spring timing of manure application and incorporation in the soil significantly reduces the E. coli organisms from these sources. Manure application has been put in the SWAT model by subbasin as a load available at the end of October and the beginning of April.

### Table 4-10 Yellow River 4 (0070_0) watershed confined livestock manure applications

| Livestock type | Swine | Chickens | Dairy cows | **Total** |
|---|---|---|---|---|
| Number of animals | 42,001 | 349,650 | 1,942 | **NA** |
| Manure applied, kg/year[1] | 17,323,312 | 3,828,668 | 4,493,982 | **25,645,962** |
| Application area, ha[2] | 822.8 | 146.8 | 174.4 | **NA** |
| Manure applied, kg/ha/day[3] | 2127 | 2326 | 2631 | **NA** |
| Basin E. coli, orgs/day | 4.63E+15 | 2.02E+14 | 9.20E+14 | **5.75E+15** |
| Basin E. coli available for washoff, orgs/day[4] | 8.33E+15 | 3.63E+14 | 1.66E+15 | **1.04E+16** |

1. Manure is calculated based on number of animals * dry manure (kg/animal/day)*365 days/year.
2. The area the manure is applied to is based on the manure's nitrogen content. Manure is applied at a rate equivalent to 201.6 kg N/ha/yr. Swine manure is applied at 2127 kg/ha, dairy manure at 2631 kg/ha and chicken manure at 2326 kg/ha. The E. coli content of manure for swine is 1.32E+07 orgs/gram, for dairy cows is 1.00E+07 orgs/gram, and for chickens is 2.96E+06 orgs/gram.
3. Manure is assumed to be applied to fields twice a year over 5 days on October 30 and April 1. It is incorporated in the soil and it is assumed that only 10% of bacteria are viable and available after storage and incorporation.
4. Maximum *E. coli* available for washoff are 1.8 times the daily maximum available load.

Seasonal variation of sources.
The relative impacts of the bacteria sources are shown in Figures 4-5 and 4-6. Figure 4-5 shows the relative loads delivered by the "continuous" sources, those sources present with or without rainfall and runoff. These are the failed septics that are assumed to be a problem every day of the year and the loads from cattle in the stream that vary by month from May to October. It can be seen in this figure that the impacts from cattle in the stream are much more significant than those from failed septic tank systems.

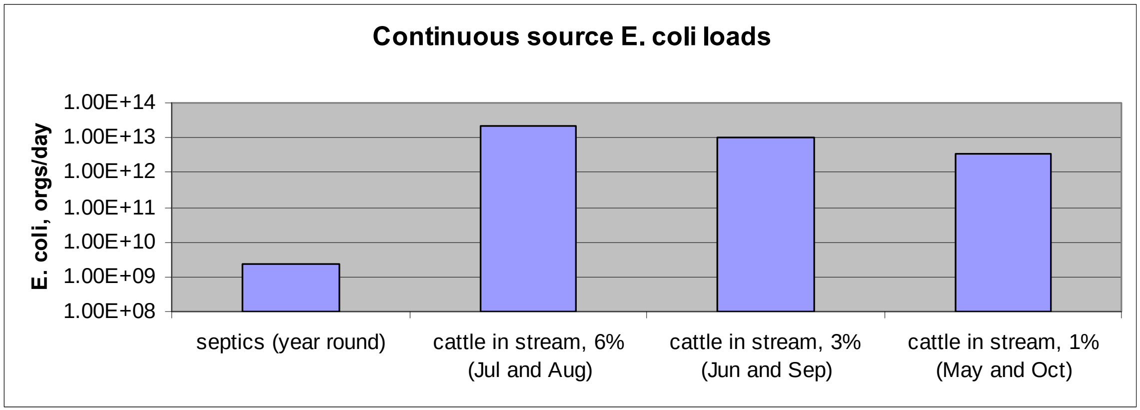

Figure 4-5 Yellow River 4 (0070_0) *E. coli* loads from "continuous" sources

The three general washoff sources of bacteria in the subbasin are shown in Figure 4-6. The wildlife source consists primarily of deer and smaller animals such as raccoons and waterfowl. These are year round sources. Pastured cattle consist of grazing cattle and small poorly managed feedlot-like operations. The grazing season is modeled as lasting 168 days starting May 1. Manure from confined animal feeding operations (CAFO) is applied to cropland twice a year for a relatively brief time. Most field applied manure is assumed to be incorporated into the soil and most bacteria in it are not available. Confinement animals are swine, chickens and dairy cattle.

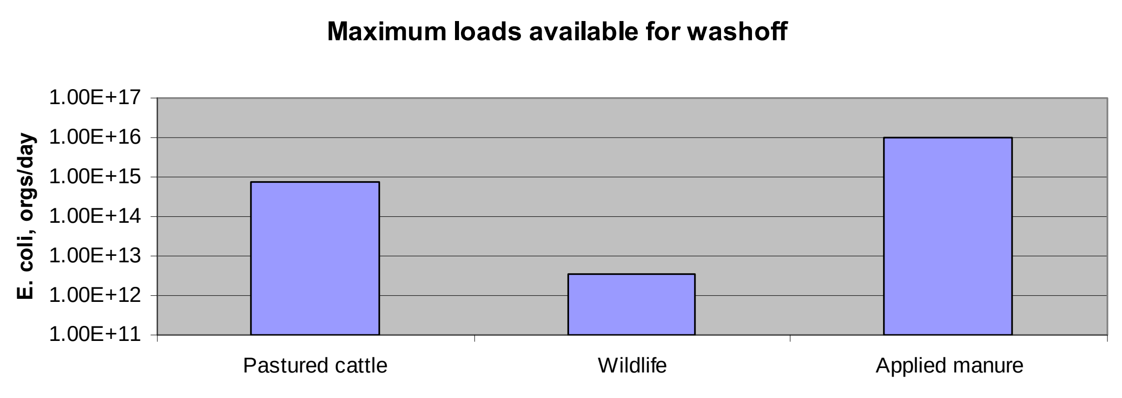

Figure 4-6 Maximum *E. coli* loads available for washoff

The maximum bacteria load to the stream occurs when the continuous source load plus the precipitation driven washoff load are combined. In general, the more rainfall the

higher the flow rate and the more elevated the concentration. High flow rate and elevated concentration equal peak loads. In July and August, the potential maximum load is 7.81E+14 orgs/day available for washoff plus the continuous load of 2.15E+13 orgs/day for a total of 8.03E+14 orgs/day.

Flow interval load source analysis. Based on the load duration curve analysis the maximum existing load occurring during the zero to forty percent recurrence interval runoff conditions is 6.64E+13 orgs/day and the total available load based on the potential sources (including fall and spring manure application) is 1.11E+16 orgs/day. Generally, the maximum load in the stream, delivered in April when runoff is occurring, is estimated to be one percent of the bacteria available for washoff. At the zero to ten percent maximum existing load of 2.99E+14 orgs/day and with the same load available for washoff the stream load is three percent of the available load.

## 4.3. Departure from load capacity

The departure from load capacity is the difference between the existing load and the load capacity. This varies for each of the five flow conditions. Table 4-11 shows this difference. The existing and target loads for the five flow conditions are shown graphically in Figure 4-7.

### Table 4-11 Yellow River 4, USGS Ion gage, departure from load capacity

| Design flow condition, percent recurrence | Recurrence interval range (mid %) | Existing *E. coli* orgs/day | Load capacity, orgs/day | Departure from capacity, orgs/day[1] |
|---|---|---|---|---|
| **High flows** | **0 to 10% (5)** | 2.99E+14 | 3.4E+12 | 2.96E+14 |
| **Moist conditions** | **10% to 40% (25)** | 3.16E+13 | 1.1E+12 | 3.05E+13 |
| **Mid-range** | **40% to 60% (50)** | 2.72E+12 | 5.4E+11 | 2.18E+12 |
| **Dry conditions** | **60% to 90% (75)** | 3.24E+11 | 3.6E+11 | -3.85E+10 |
| **Low flow** | **90% to 100% (95)** | 8.61E+10 | 2.4E+11 | -1.55E+11 |

1. Negative values indicate that the existing load is less than the target load.

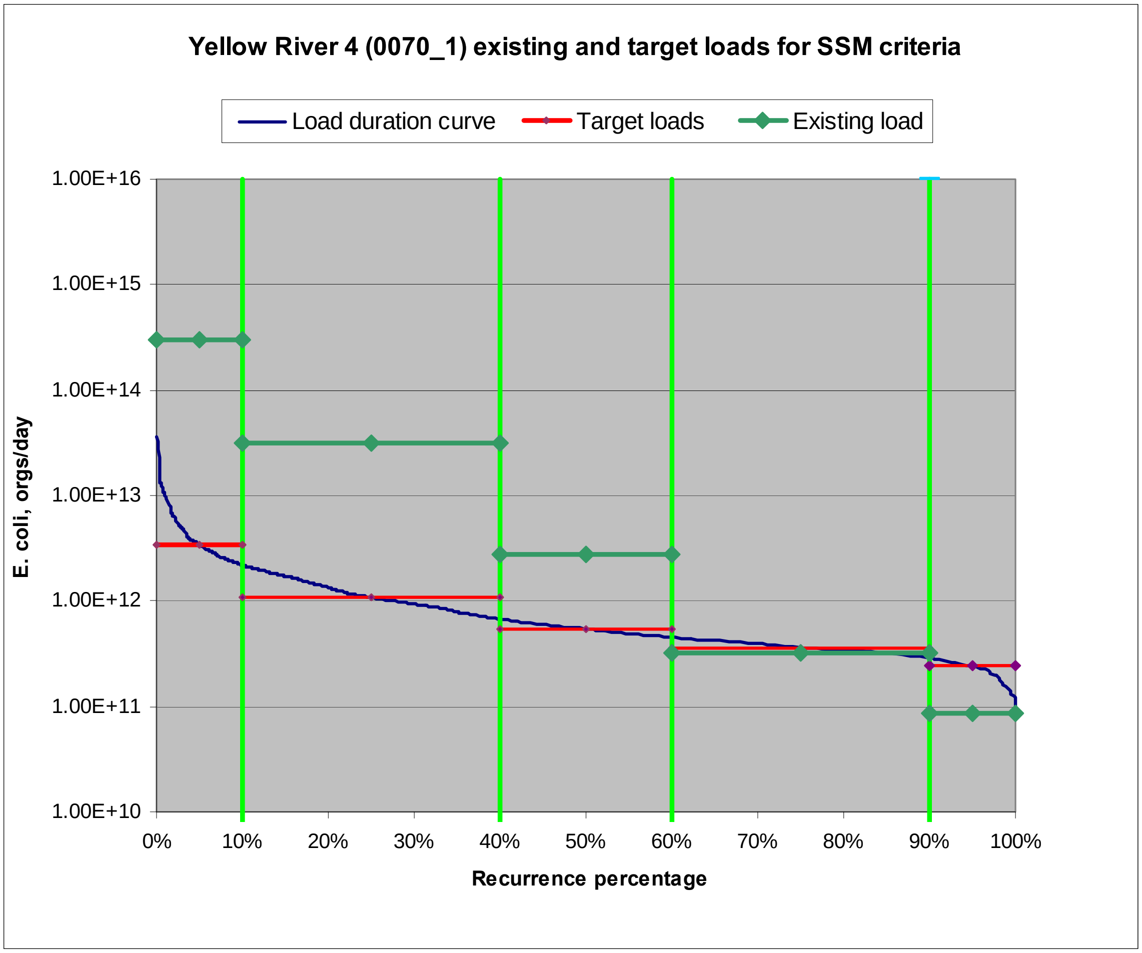

Figure 4-7 Difference between existing and target loads

## 4.4. Pollutant Allocations

*Wasteload allocations.*

The wasteload allocations for the four wastewater treatment facilities discharging to the Yellow River Basin are shown in Table 3-6 and again in the TMDL calculations for the Yellow River tributaries directly receiving wastewater treatment effluent. It is assumed for these TMDL's that the wastewater treatment plants in the watershed discharge to a Class A1 stream. The wasteload allocations for the discharges are the Class A1 *E. coli* water quality standards, a geometric mean (GM) of 126-organisms/100 ml and a single sample maximum (SSM) of 235-organisms/100 ml. These concentration criteria have been multiplied by the 180day average wet weather (AWW) flow divided by ten to mimic the episodic and controlled discharge. The wasteload allocation summation for this segment (0070_0) is zero.

*Load allocation.*

The load allocations for *E. coli* TMDLs are the load capacity less an explicit 10 percent margin of safety (MOS) less the total WLA for the flow condition for the geometric mean

or single sample maximum. There is a separate load allocation set for each of the target recurrence intervals. The load allocations are shown in Tables 4-12 and 4-13.

**Table 4-12 Yellow River Site 4, USGS Ion gage, GM *E. coli* load allocations**

| Flow condition, percent recurrence | GM target (TMDL) *E. Coli*, orgs/day | GM MOS *E. Coli*, orgs/day | Total WLA GM *E. coli*, orgs/day² | LA GM *E. coli*, orgs/day |
|---|---|---|---|---|
| **High flows** | 1.8E+12 | 1.8E+11 | zero | 1.6E+12 |
| **Moist conditions** | 5.8E+11 | 5.8E+10 | zero | 5.2E+11 |
| **Mid-range flow** | 2.9E+11 | 2.9E+10 | zero | 2.6E+11 |
| **Dry conditions** | 1.9E+11 | 1.9E+10 | zero | 1.7E+11 |
| **Low flow** | 1.3E+11 | 1.3E+10 | zero | 1.2E+11 |

1. Based on geometric mean standard of 126 *E. coli* organisms/100 ml
2. Not applicable – The wasteload allocations for the four wastewater treatment plants in the Yellow River basin have been developed for the individual tributaries that directly receive their discharges. Each WLA is derived from the E. coli WQS for GM and SSM concentration and is listed in Table 3-6.

**Table 4-13 Yellow River Site 4, USGS Ion gage, SSM *E. coli* load allocations**

| Flow condition, percent recurrence | SSM target (TMDL) *E. Coli*, orgs/day | SSM MOS *E. Coli*, orgs/day | Total WLA GM *E. coli*, orgs/day² | LA SSM *E. coli*, orgs/day |
|---|---|---|---|---|
| **High flow** | 3.4E+12 | 3.4E+11 | zero | 3.1E+12 |
| **Moist conditions** | 1.1E+12 | 1.1E+11 | zero | 9.7E+11 |
| **Mid-range flow** | 5.4E+11 | 5.4E+10 | zero | 4.9E+11 |
| **Dry conditions** | 3.6E+11 | 3.6E+10 | zero | 3.3E+11 |
| **Low flow** | 2.4E+11 | 2.4E+10 | zero | 2.2E+11 |

1. Based on single sample maximum standard of 235 *E. coli* organisms/100 ml.
2. Not applicable – The wasteload allocations for the four wastewater treatment plants in the Yellow River basin have been developed for the individual tributaries that directly receive their discharges. Each WLA is derived from the E. coli WQS for GM and SSM concentration and is listed in Table 3-6.

*Margin of safety.*
The margin of safety for *E. coli* is an explicit ten percent of the load capacity at each of the design recurrence intervals as shown in Tables 4-12 and 4-13.

## 4.5. TMDL Summary

The following equation shows the total maximum daily load (TMDL) and its components for the impaired IA 01-YEL-0070-0 segment of the Yellow River .

**Total Maximum Daily Load = Σ Load Allocations + Σ Wasteload Allocations +MOS**

A Total Maximum Daily Load calculation has been made at design flow conditions for the GM and SSM of this segment and these are shown in Tables 4-14 and 4-15 and Figures 4-8 and 4-9.

**Table 4-14 Yellow River IA 01-YEL-0070-0 *E. coli* TMDL for GM**

| Flow condition | Σ LA, orgs/day | Σ WLA, orgs/day[1] | MOS, orgs/day | TMDL, orgs/day |
|---|---|---|---|---|
| **High flow** | 1.6E+12 | zero | 1.8E+11 | 1.8E+12 |
| **Moist condition** | 5.2E+11 | zero | 5.8E+10 | 5.8E+11 |
| **Mid-range flow** | 2.6E+11 | zero | 2.9E+10 | 2.9E+11 |
| **Dry conditions** | 1.7E+11 | zero | 1.9E+10 | 1.9E+11 |
| **Low flow** | 1.2E+11 | zero | 1.3E+10 | 1.3E+11 |

1. Not applicable – The wasteload allocations for the four wastewater treatment plants in the Yellow River basin have been developed for the individual tributaries that directly receive their discharges. Each WLA is derived from the E. coli WQS for GM and SSM concentration and is listed in Table 3-6.

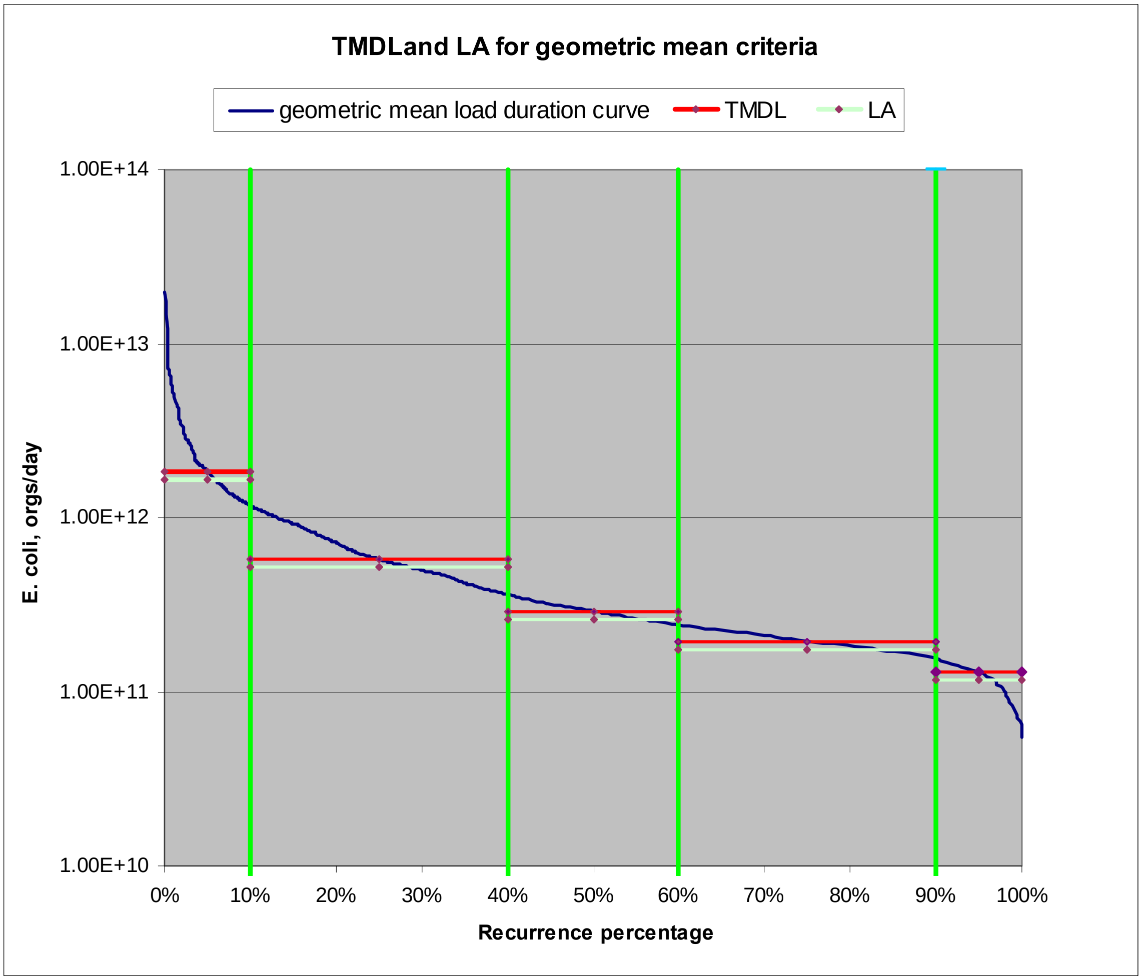

Figure 4-8 GM TMDL at WQS of 126 orgs/100 ml for the five flow conditions

### Table 4-15 Yellow River IA 01-YEL-0070-0 *E. coli* TMDL for SSM

| Flow condition | Σ LA, orgs/day | Σ WLA, orgs/day[1] | MOS, orgs/day | TMDL, orgs/day |
|---|---|---|---|---|
| High flow | 3.1E+12 | zero | 3.4E+11 | 3.4E+12 |
| Moist condition | 9.7E+11 | zero | 1.1E+11 | 1.1E+12 |
| Mid-range flow | 4.9E+11 | zero | 5.4E+10 | 5.4E+11 |
| Dry conditions | 3.3E+11 | zero | 3.6E+10 | 3.6E+11 |
| Low flow | 2.2E+11 | zero | 2.4E+10 | 2.4E+11 |

1. Not applicable – The wasteload allocations for the four wastewater treatment plants in the Yellow River basin have been developed for the individual tributaries that directly receive their discharges. Each WLA is derived from the E. coli WQS for GM and SSM concentration and is listed in Table 3-6.

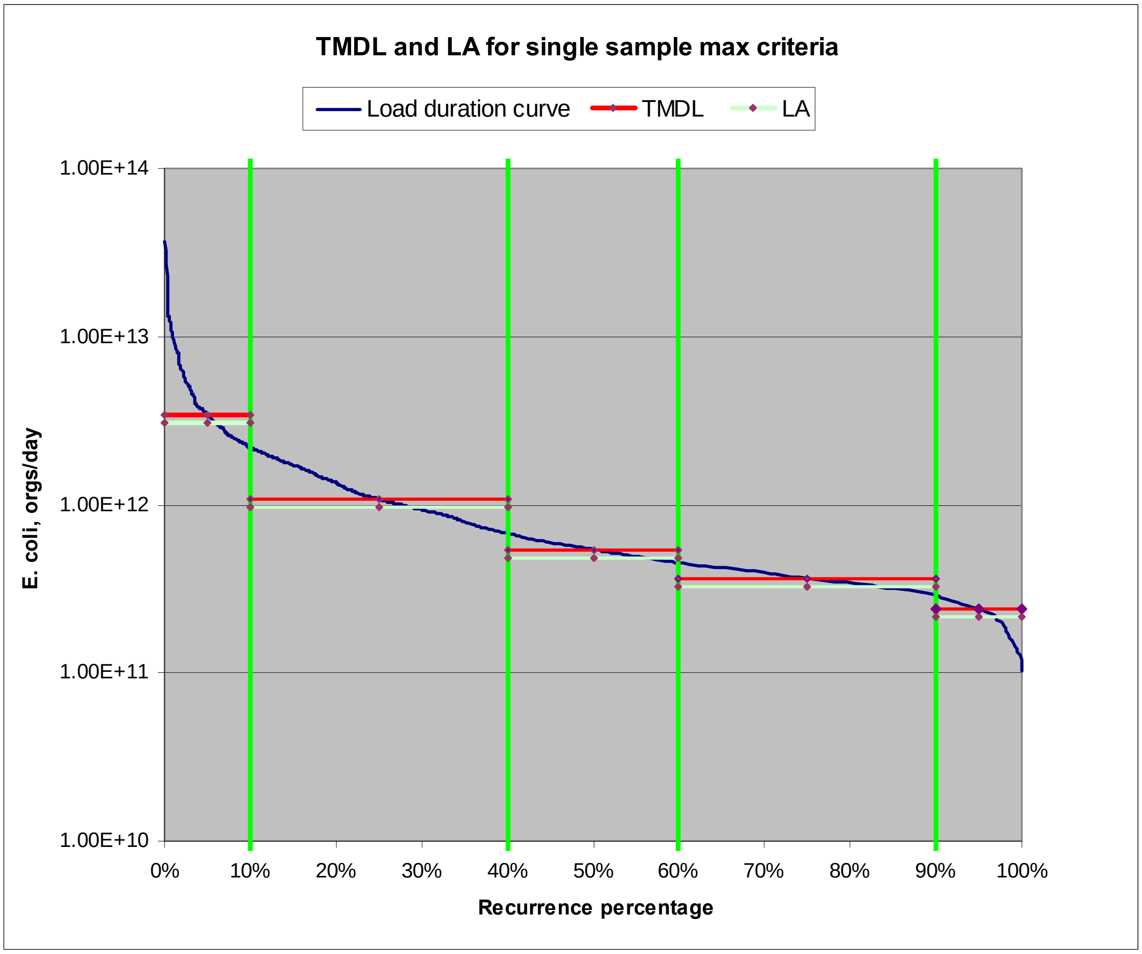

Figure 4-9 SSM TMDL at the WQS of 235 orgs/100 ml for the five flow conditions

## 4.6. Implementation Analysis

The modeled systematic reduction of the loads by source provides the initial evaluation of proposed implementation plans for the subbasin. The SWAT model has been run for five scenarios in which loads have been reduced for the most significant sources. The source analysis identified the primary source of bacteria as cattle in the stream and field applied manure from CAFOs. Figures 4-10a and 4-10b show the SWAT model output concentrations for the stream with monitored concentrations also plotted on the chart. The target concentration of 235 *E. coli* orgs/100 ml (red horizontal line) is frequently exceeded by both monitoring data and SWAT simulated values.

The concentration scale has been shown at two different scales so that the relationship between high sample values, simulated values and target values are apparent. The scale in Figure 4-10a has been set to a maximum of 40,000 orgs/100 ml and for Figure 4-10b has been set to 10,000 orgs/100 ml. Even at the lower maximum, the SSM target is not apparent. There is one monitoring value that exceeds 40,000 orgs/100 ml (79,000). Event sampling done in 2009 indicates that concentrations are much higher during elevated flow than is shown for scheduled monitoring.

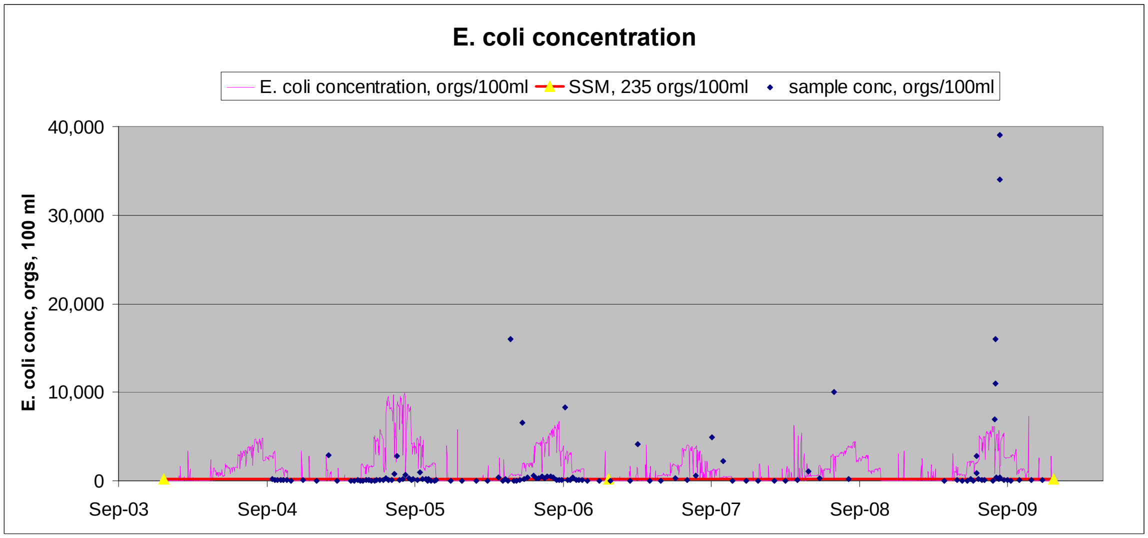

Figure 4-10a SWAT output for existing *E. coli* concentrations with the maximum concentration scale at 40,000 orgs/100 ml

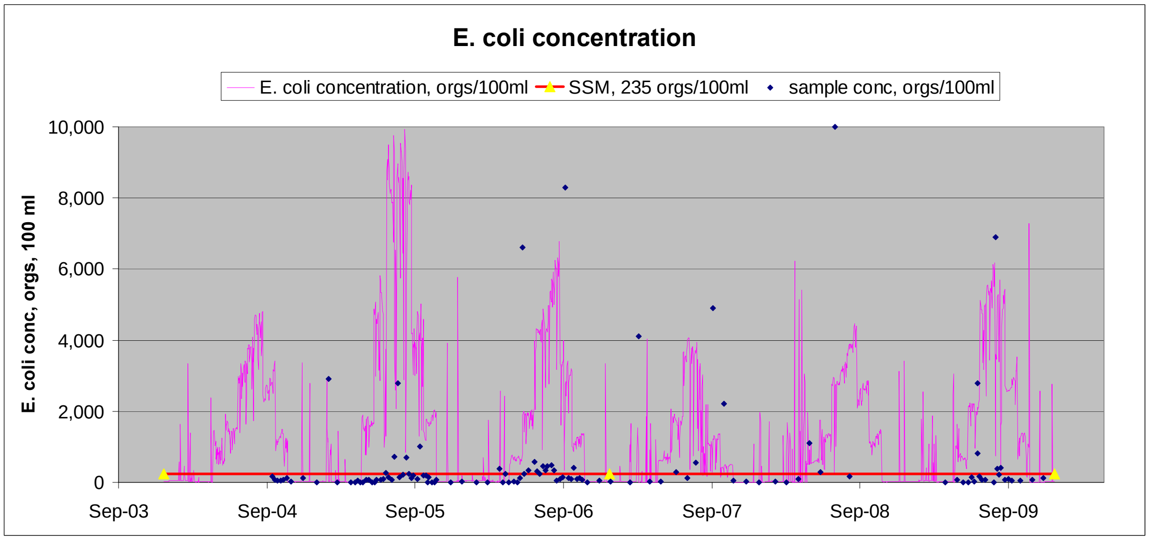

Figure 4-10b SWAT output for existing *E. coli* concentrations with the maximum concentration scale at 10,000 orgs/100 ml

The second scenario, Figure 4-11, removes half of the cattle in the stream from the Yellow River watershed. This reduces concentrations but they are still higher than the SSM standard during the grazing season. There are spikes of runoff related concentration in all five scenarios.

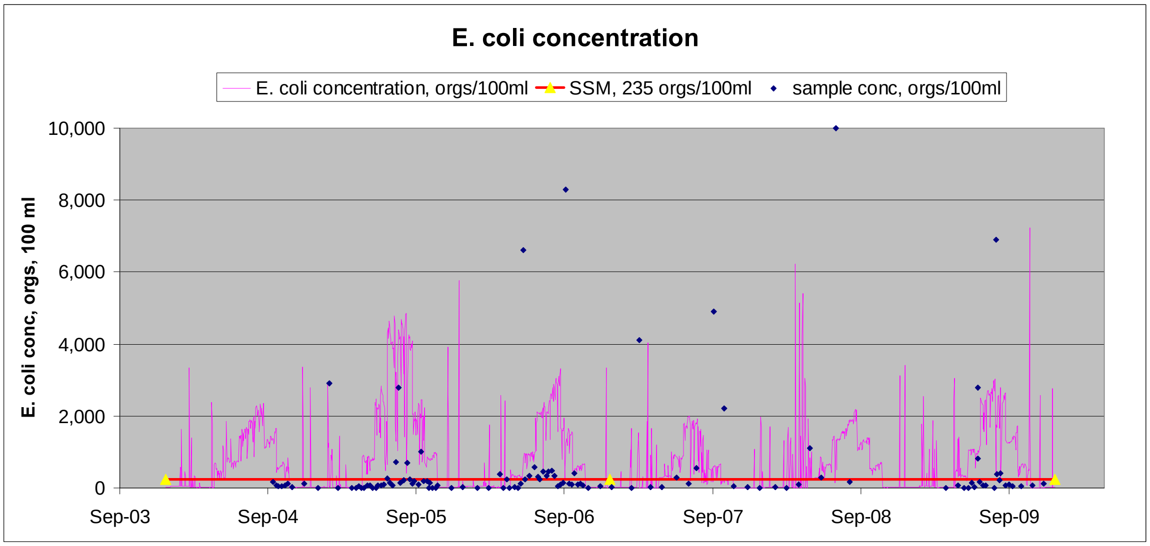

Figure 4-11 SWAT output for half reduction of CIS *E. coli* concentrations

The third scenario, shown in Figure 4-12, eliminates cattle in the stream as a source. This drops the concentration during the grazing season but there remain instances of high bacteria concentration from runoff. Much of this is associated with field application of manure from confined animal operations and the assumption that it is done in the spring when rain is frequent and intense.

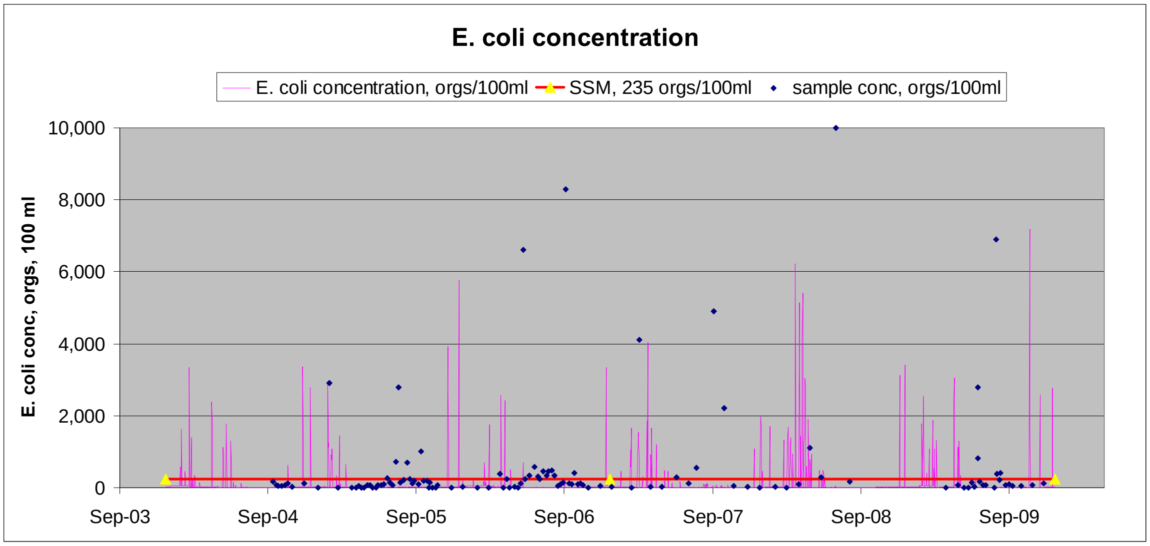

Figure 4-12 SWAT output for complete reduction of CIS *E. coli* with the concentration scale maximum set at 10,000 orgs/100 ml

The fourth scenario, shown in Figure 4-13, assumes that the field applications of manure are cut in half. This brings bacteria concentrations from these applications down some but they still exceed the target.

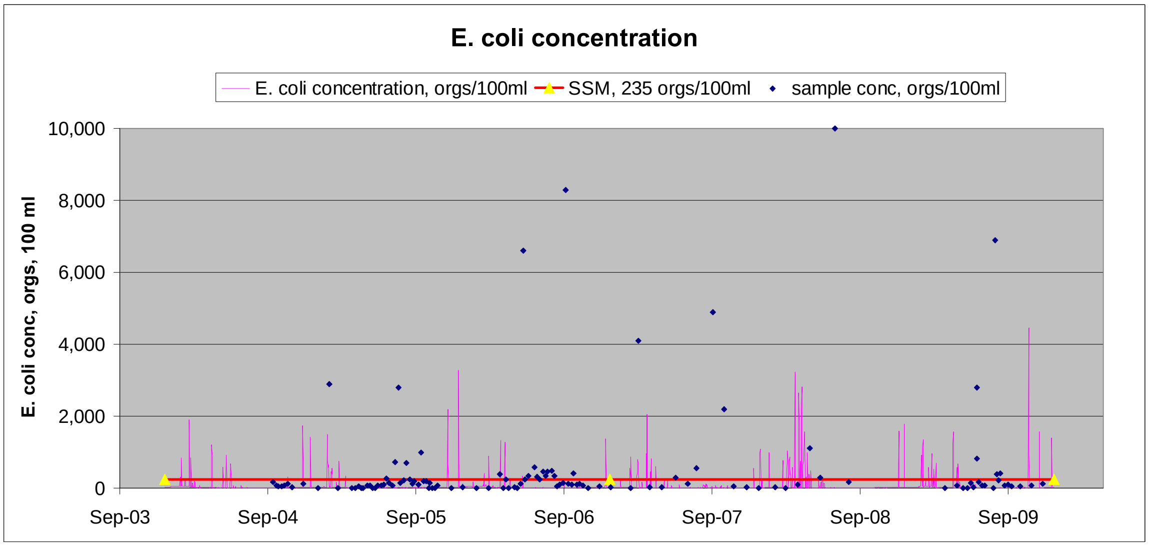

Figure 4-13 SWAT output for complete reduction of CIS *E. coli* and half of applied manure from CAFOs

The fifth scenario, shown in Figure 4-14, in addition to previous reductions, decreases the manure from cattle on pasture by two thirds. This pasture manure reduction showed a minor decrease in bacteria concentration in the stream.

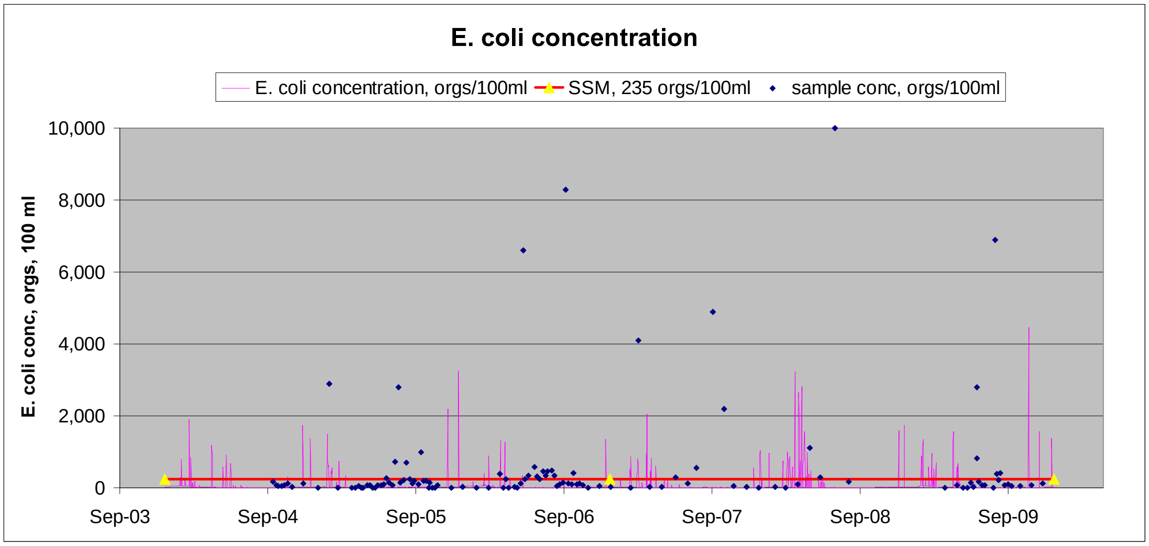

Figure 4-14 SWAT output for complete reduction of CIS *E. coli* and half of applied manure from CAFOs and a two thirds reduction of manure from cattle on pasture

There are several combinations of source reductions that can be simulated. The five scenarios described here reduce bacteria loads from the sources that have been modeled to have the greatest impact on stream outlet bacteria concentrations. The sources that are not reduced in these scenarios may have important episodic or local effect on *E. coli* organism numbers.

## 5. Yellow River 3 (0080_1)

The Yellow River 3 segment is associated with IA 01 YEL 0080_1. This segment is not listed as impaired in the 2010 305(b) assessment for Class A uses because there was not data available at the time of the assessment. The segment runs 10.0 miles from X-26 (S24, T96N, R5W, Allamakee County) to the old Hwy 51 crossing (NE 1/4, S11, T96N, R6W, Allamakee County). This segment drains flow from parts of three HUC 12 subbasins, Middle Yellow River, Norfolk Creek, and Upper Yellow River. Two tributaries that flow into this segment are impaired, Williams Creek and Norfolk Creek. There is one municipal wastewater treatment facility for the City of Postville discharging to Williams Creek. The flow used in the development of the TMDL for this segment is derived from an area ratio flow based on the Ion USGS gage data. Figure 5-1 shows a map of the Yellow River 3 segment and Table 5-1 shows the land use for the upstream Yellow River subbasins.

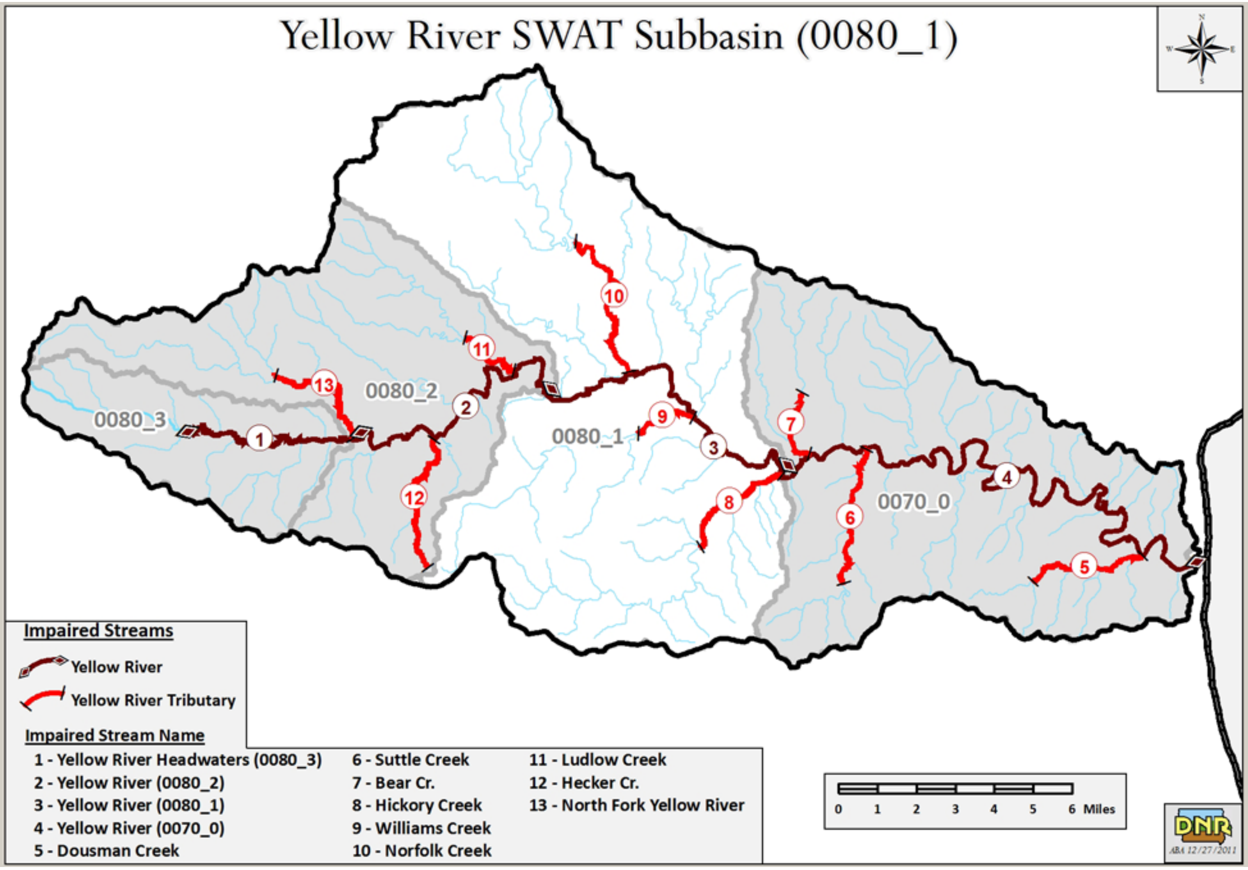

Figure 5-1 Yellow River 3 (0080_1) segment map

### Table 5-1 Yellow River 3 subbasin land use

| Landuse | Area, acres | Fraction of total |
|---|---:|---:|
| Water/wetland | 137.1 | 0.15% |
| Forest | 11479.7 | 12.28% |
| Ungrazed/CRP/hay | 18213.3 | 19.48% |
| Grazed | 6271.7 | 6.71% |
| Row crop | 53702.4 | 57.45% |
| Roads | 2701.0 | 2.89% |
| Commercial/residential | 971.3 | 1.04% |
| **Total[1]** | **93476.5** | **100.00%** |

1. There is a small discrepancy between the area delineated by previous Iowa DNR developed GIS landuse coverages and those subbasins delineated by SWAT modeling.

## 5.1. Water body pollutant loading capacity (TMDL)

The *E. coli* organism load capacity is the number of organisms that can be in a volume and meet the water quality criteria. The loading capacity for each of the five flow conditions is calculated by multiplying the midpoint flow and *E. coli* criteria concentrations. Table 5-2 shows the median, maximum, and minimum flows for the five recurrence intervals.

### Table 5-2 Yellow River 3 maximum, minimum and median flows

| Flow description | Recurrence interval range (mid %) | Midpoint of flow range, cfs | Maximum of flow range, cfs | Minimum of flow range, cfs |
|---|---|---:|---:|---:|
| **High flow** | **0 to 10% (5)** | 486 | 5211 | 310 |
| **Moist conditions** | **10% to 40% (25)** | 154 | 310 | 97 |
| **Mid-range** | **40% to 60% (50)** | 77 | 97 | 64 |
| **Dry conditions** | **60% to 90% (75)** | 52 | 64 | 42 |
| **Low flow** | **90% to 100% (95)** | 34 | 42 | 15 |

Flow and load duration curves were used to establish the occurrence of water quality standards violations, to establish compliance targets, and to set pollutant allocations and margins of safety. Duration curves are derived from flows plotted as a percentage of their recurrence. *E. coli* loads are calculated from *E. coli* concentrations and flow volume at the time the sample was collected.

To construct the flow duration curves, the bacteria monitoring data and the Water Quality Standard (WQS) single sample maximum (235 *E. coli* organisms/100 ml) were plotted with the flow duration percentile. Figure 5-2 shows the data that exceed the WQS criteria at each of the five flow conditions. High flow violations indicate that the problem occurs during run-off conditions when bacteria are washing off from nonpoint sources. Criteria exceeded during low or base flow, when little or no runoff is occurring, indicate that continuous sources such as septic tanks, livestock in the stream, riparian wildlife, and wastewater treatment plants are the problem.

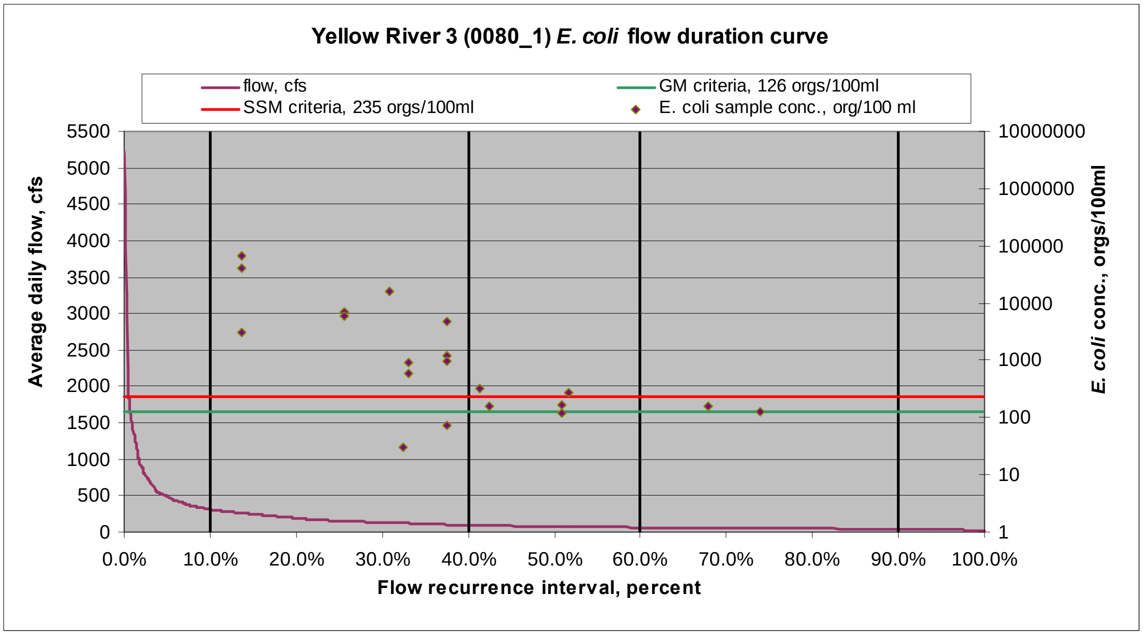

Figure 5-2 Yellow River 3 flow duration curve

Load duration curves were used to evaluate the five flow conditions for this Yellow River segment. The load duration curve is shown in Figure 5-3. In the figure, the lower curve shows the maximum *E. coli* count for the GM criteria and the upper curve shows the maximum *E. coli* count for the SSM criteria at a continuum of flow recurrence. The individual points are the observed (monitored) *E. coli* concentrations converted to loads based on average flow for the day they were collected. Points above the load duration curves are violations of the WQS criteria and exceed the loading capacity.

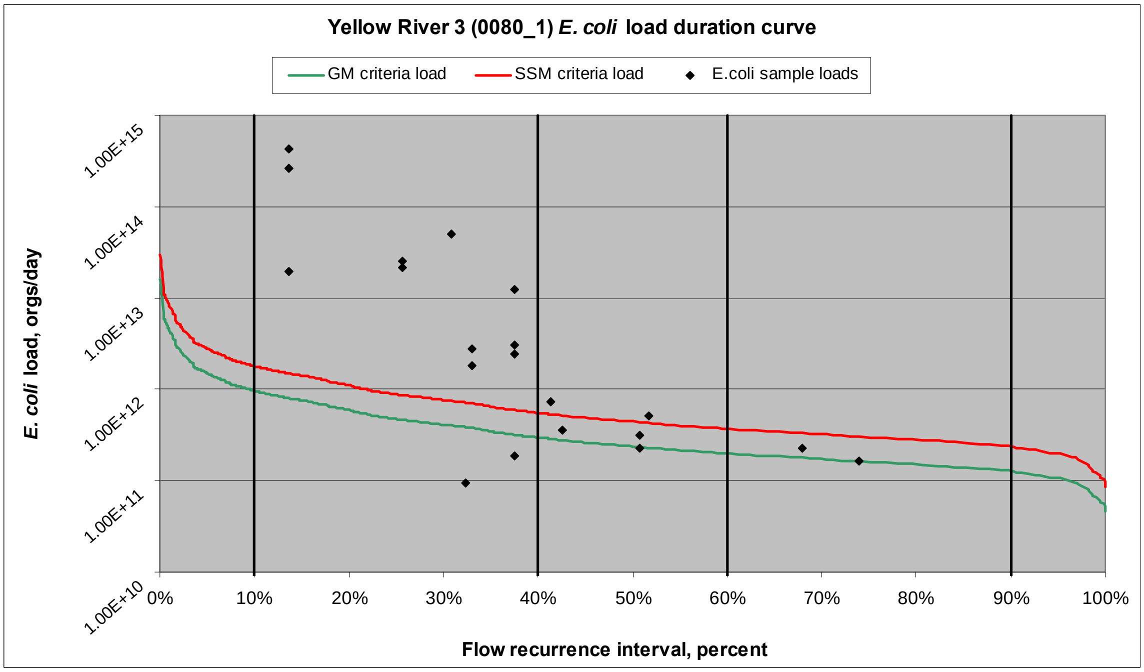

Figure 5-3 Yellow River 3 load duration curve

Tables 5-3 and 5-4 show the load capacities (targets) for each of the midpoint flow conditions at the GM and SSM criteria, respectively.

**Table 5-3 Yellow River 3 GM load capacity**

| Flow condition | Recurrence interval | Associated midpoint flow, cfs | Estimated flow interval load capacity, *E. coli* orgs/day |
|---|---|---|---|
| High flow | 0 to 10% | 486 | 1.5E+12 |
| Moist conditions | 10% to 40% | 154 | 4.7E+11 |
| Mid-range | 40% to 60% | 77 | 2.4E+11 |
| Dry conditions | 60% to 90% | 52 | 1.6E+11 |
| Low flow | 90% to 100% | 34 | 1.1E+11 |

**Table 5-4 Yellow River 3 SSM load capacity**

| Flow condition | Recurrence interval | Associated midpoint flow, cfs | Estimated flow interval load capacity, *E. coli* orgs/day |
|---|---|---|---|
| High flow | 0 to 10% | 486 | 2.8E+12 |
| Moist conditions | 10% to 40% | 154 | 8.8E+11 |
| Mid-range | 40% to 60% | 77 | 4.4E+11 |
| Dry conditions | 60% to 90% | 52 | 3.0E+11 |
| Low flow | 90% to 100% | 34 | 2.0E+11 |

## 5.2. Existing load

The existing loads are derived from the sampling data collected in the Yellow River 3 segment. These data are the sample values shown in the flow and load duration curves. The *E. coli* concentrations are multiplied by the simulated daily flow to get the daily loads. The daily loads are plotted with the load duration curves. The allowable loads for a given flow equal the flow multiplied by the WQS limits for the geometric mean or single sample maximum. Monitored data that exceed the limits are above the criteria curves.

The maximum existing loads occur during major rains when runoff and bacteria concentrations are highest. Concentrations exceed the criteria during these high flow events. Other conditions leading to criteria violations occur during dry low flow periods when continuous loads from livestock in the stream, local wildlife, septic tanks, and wastewater treatment plants can cause bacteria problems.

The assessment standard used to evaluate streams is the *E. coli* geometric mean criteria. Since the load duration approach precludes the calculation of a geometric mean, the 90th percentile of observed concentrations within each flow condition is multiplied by the median flow to estimate existing loads. This procedure has been used to evaluate impaired segments. Table 5-5 shows the existing loads for each flow condition.

### Table 5-5 Yellow River 3 existing loads

| Flow condition, percent recurrence | Recurrence interval range (mid %) | Associated median flow, cfs | Existing 90th percentile *E. coli* conc., org/100ml | Estimated existing load, *E. coli* org/day |
|---|---|---|---|---|
| **High flows** | **0 to 10% (5)** | 486 | no data available | no data available |
| **Moist conditions** | **10% to 40% (25)** | 154 | 36000 | 1.35E+14 |
| **Mid-range** | **40% to 60% (50)** | 77 | 304 | 5.72E+11 |
| **Dry conditions** | **60% to 90% (75)** | 52 | 157 | 1.98E+11 |
| **Low flow** | **90% to 100% (95)** | 34 | no data available | no data available |

*Identification of pollutant sources.*
The sources of bacteria in the Yellow River 3 (0080_1) subbasin (SWAT Subbasins 1 to 13, 18, and 19) is the sum of all of the upstream sources including failed septic tank systems, pastured cattle, cattle in the stream, wildlife, and manure applied to fields from animal confinement operations. The loads from these sources have been incorporated into the SWAT watershed model and are listed in Tables 5-6 to 5-10.

Non functional septic tank systems. There are an estimated 756 onsite septic tank systems in the subbasin (2.5 persons/household). IDNR estimates that 50 percent are not functioning properly. It is assumed that these are continuous year round discharges. Septic tank loads have been put into the SWAT model as a continuous source by subbasin.

### Table 5-6 Yellow River 3 (0080_1) septic tank system E. coli orgs/day

| | |
|---|---|
| Rural population of Dousman Creek subbasin | 1,891 |
| Total initial E.coli, orgs/day [1] | 2.36E+12 |
| Septic tank flow, $m^3$/day [2] | 501.1 |
| **E. coli delivered to stream, orgs/day [3]** | **1.57E+09** |

1. Assumes 1.25E+09 E. coli orgs/day per capita
2. Assumes 70 gallons/day/capita
3. Assumes septic discharge concentration reaching stream is 625 orgs/100 ml and a 50% failure rate

Cattle in stream. Of the 3,719 cattle in pastures with stream access, one to six percent are assumed to be in the stream on a given day. The number on pasture and the fraction in the stream varies by month. Cattle in the stream have a high delivery potential since bacteria are deposited directly in the stream with or without rainfall. Cattle in the stream (CIS) loads have been put in the SWAT model as a continuous source varying by month.

### Table 5-7 Yellow River 3 (0080_1) Cattle in the stream E. coli orgs/day

| | |
|---|---|
| Pasture area with stream access, acre | 4,768 |
| Number of cattle in stream (6% of total) | 223 |
| Dry manure, kg/day [1] | 692 |
| **E. coli load, orgs/day [2]** | **9.13E+12** |

1. The subbasin CIS are estimated from the pasture area with stream access at 0.78 cattle/acre.

2. It is estimated that cattle spend 6% of their time in streams in July and August, 3% in June and September, and 1% in May and October. The loads shown in this table are for July and August. The loads for the other 4 months when cattle are in streams have been incorporated into the SWAT modeling.
3. Cattle generate 3.1 kg/head/day of dry manure.
4. Manure has 1.32E+07 E coli orgs/gram dry manure.

Grazing livestock. The estimated number of cattle in the subbasin is 3,719. It is assumed that they are on pasture from April to November. The potential for bacteria delivery to the stream occurs with precipitation causing runoff. Manure available for washoff is applied in the SWAT model at 6 kg/ha in the pasture landuse.

**Table 5-8 Yellow River 3 (0080_1) manure from pastured cattle, maximum E. coli available for washoff, orgs/day**

| | |
|---|---:|
| Pasture area, acre | 6,327 |
| Number of cattle on pasture[1] | 4,712 |
| Dry manure, kg/day[2] | 14,606 |
| Maximum E. coli load, orgs/day[3] | 1.93E+14 |
| Maximum E. coli available for washoff, orgs[4] | 3.47E+14 |

1. The number of pastured cattle is 0.78 cattle/acre.
2. Cattle generate 3.1 kg/head/day of dry manure.
3. Manure has 1.32E+07 E. coli orgs/gram dry manure
4. The load available for washoff is the daily load times 1.8.

Wildlife manure. The number of deer in Allamakee County is about 9,000 located primarily in forested land adjacent to streams. Another 1,000 have been added to account for other wildlife such as raccoons and waterfowl for a total estimate of 10,000. This works out to 0.024 deer per acre. Using this procedure, there are 2,243 deer in the subbasin concentrated in the forested and grass areas. The deer are in the subbasin year round.

**Table 5-9 Yellow River 3 (0080_1) watershed wildlife manure loads available for washoff, orgs/day**

| Number of deer[1] | Forested area, ha | SWAT manure loading rate, kg/ha/day[2] | Total E. coli available for washoff, orgs[3] |
|:---:|:---:|:---:|:---:|
| 2,243 | 5,144 | 0.628 | 2.02E+12 |

1. Deer numbers are 0.024 deer/ha for the entire subbasin concentrated to 0.436 deer/ha in the forest land use. All wildlife loads are applied to the forest landuse in the SWAT model. The county deer numbers have been increased by 10% to account for other wildlife in the subbasin.
2. Assumes 1.44 kg/deer/day and 3.47E+05 orgs/gram.
3. Assumes that the maximum E. coli available for washoff is 1.8 times the daily load.

Field applications of CAFO manure.
There are about 26,978 swine, 1,072 dairy cows, and 249,750 chickens in confinement in the Yellow River 3 subbasins. The manure is stored and land applied to cropland. The manure is distributed to the fields in the subbasin in the fall after soybean harvest and in the spring prior to corn planting in year two of a two year rotation. The relatively brief

fall and spring timing of manure application and incorporation in the soil significantly reduces the *E. coli* organisms from these sources. Manure application has been put in the SWAT model by subbasin as a load available at the end of October and the beginning of April.

### Table 5-10 Yellow River 3 (0080_1) watershed confined livestock manure applications

| Livestock type | Swine | Chickens | Dairy cows | **Total** |
|---|---|---|---|---|
| Number of animals | 26,978 | 249,750 | 1,072 | **NA** |
| Manure applied, kg/year[1] | 11,127,076 | 2,480,715 | 2,734,763 | **16,342,554** |
| Application area, ha[2] | 528.5 | 96.3 | 104.8 | **NA** |
| Manure applied, kg/ha/d[3] | 2127 | 2326 | 2631 | **NA** |
| Subbasin E. coli, orgs/day | 2.97E+15 | 1.44E+14 | 5.08E+14 | **3.63E+15** |
| Subbasin E. coli available for washoff, orgs/day[4] | 5.35E+15 | 2.59E+14 | 9.14E+14 | **6.53E+15** |

1. Manure is calculated based on number of animals * dry manure (kg/animal/day)*365 days/year.
2. The area the manure is applied to is based on the manure's nitrogen content. Manure is applied at a rate equivalent to 201.6 kg N/ha/yr. Swine manure is applied at 2127 kg/ha, dairy manure at 2631 kg/ha and chicken manure at 2326 kg/ha. The E. coli content of manure for swine is 1.32E+07 orgs/gram, for dairy cows is 1.00E+07 orgs/gram, and for chickens is 2.96E+06 orgs/gram.
3. Manure is assumed to be applied to fields twice a year over 5 days on October 30 and April 1. It is incorporated in the soil and it is assumed that only 10% of bacteria are viable and available after storage and incorporation.
4. Maximum *E. coli* available for washoff are 1.8 times the daily maximum available load.

<u>Seasonal variation of sources</u>.

The relative impacts of the bacteria sources are shown in Figures 5-4 and 5-5. Figure 5-4 shows the relative loads delivered by the "continuous" sources, those sources present with or without rainfall and runoff. These are the failed septics that are assumed to be a problem every day of the year and the loads from cattle in the stream that vary by month from May to October. It can be seen in this figure that the impacts from cattle in the stream are much more significant than those from failed septic tank systems.

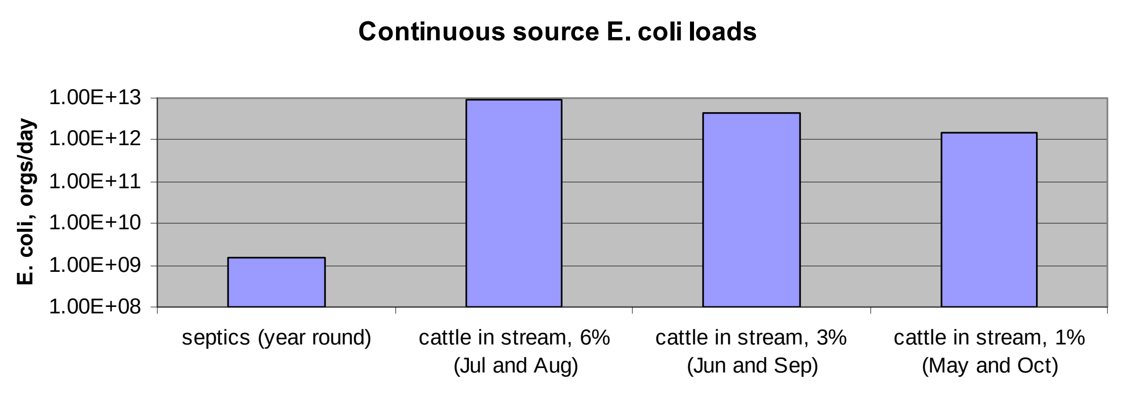

Figure 5-4 *E. coli* loads from "continuous" sources

The three general washoff sources of bacteria in the subbasin are shown in Figure 5-5. The wildlife source consists primarily of deer and smaller animals such as raccoons and waterfowl. These are year round sources. Pastured cattle consist of grazing cattle and small poorly managed feedlot-like operations. The grazing season is modeled as lasting 168 days starting May 1. Manure from confined animal feeding operations (CAFO) is applied to cropland twice a year for a relatively brief time. Most field applied manure is assumed to be incorporated into the soil and most bacteria in it are not available. Confinement animals are swine, chickens and dairy cattle.

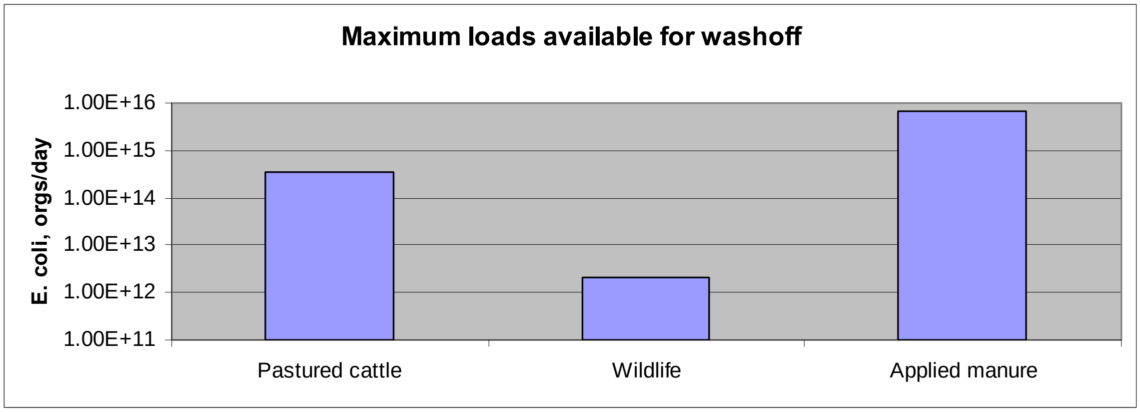

Figure 5-5 Maximum *E. coli* loads available for washoff

The maximum bacteria load to the stream occurs when the continuous source load plus the precipitation driven washoff load are combined. In general, the more rainfall the higher the flow rate and the more elevated the concentration. High flow rate and elevated concentration equal peak loads. In July and August, the potential maximum load based on this analysis is 3.49E+14 orgs/day available for washoff plus the continuous load of 9.13E+12 orgs/day for a total of 3.58E+14 orgs/day.

Flow interval load source analysis. Based on the load duration curve analysis the maximum existing load occurring during the zero to forty percent recurrence interval runoff conditions, is 1.35E+14 orgs/day and the total available load based on the potential sources, including fall and spring manure applications, is 6.88E+15 orgs/day. Generally the maximum load in the stream, delivered in April when runoff is occurring, is estimated to be about two percent of the bacteria available for washoff. No monitoring data is available for the zero to ten percent flow recurrence interval.

## 5.3 Departure from load capacity.

The departure from load capacity is the difference between the existing load and the load capacity. This varies for each of the five flow conditions. Table 5-11 shows this difference. The existing and target loads for the five flow conditions are shown graphically in Figure 5-6.

**Table 5-11 Yellow River 3 departure from load capacity**

| Design flow condition, percent recurrence | Recurrence interval range (mid %) | Existing *E. coli* orgs/day | Load capacity, orgs/day | Departure from capacity, orgs/day[1] |
|---|---|---|---|---|
| **High flow** | **0 to 10% (5)** | no data available | 2.8E+12 | no data available |
| **Moist conditions** | **10% to 40% (25)** | 1.35E+14 | 8.8E+11 | 1.35E+14 |
| **Mid-range flow** | **40% to 60% (50)** | 5.72E+11 | 4.4E+11 | 1.30E+11 |
| **Dry conditions** | **60% to 90% (75)** | 1.98E+11 | 3.0E+11 | -9.84E+10 |
| **Low flow** | **90% to 100% (95)** | no data available | 2.0E+11 | no data available |

1. Negative values indicate that the existing load is less than the target load.

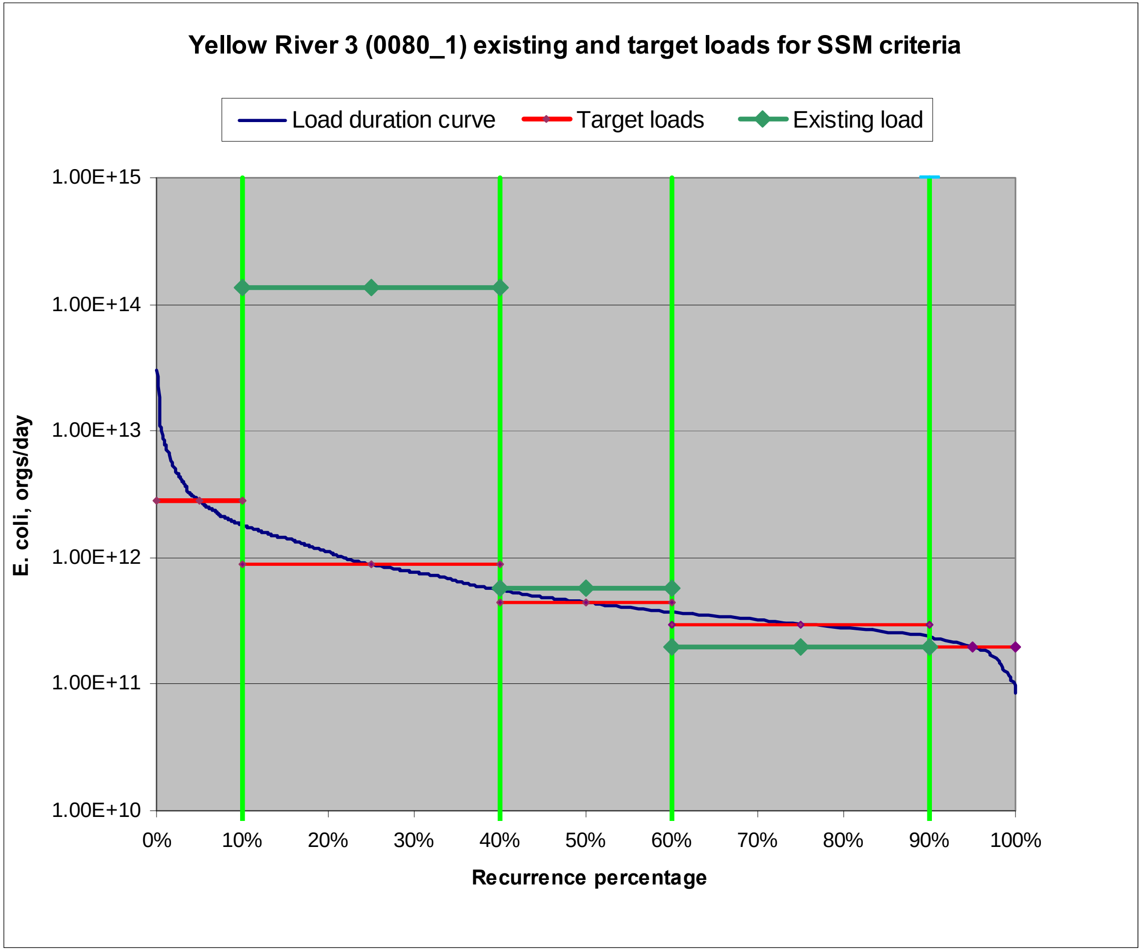

Figure 5-6 Difference between existing and target loads. There was no data available for the high and low flow conditions.

## 5.4. Pollutant Allocations

*Wasteload allocations.*

The wasteload allocations for the four wastewater treatment facilities discharging to the Yellow River Basin are shown in Table 3-6 and again in the TMDL calculations for the Yellow River tributaries directly receiving wastewater treatment effluent. It is assumed that the wastewater treatment plants in the watershed discharge to a Class A1 stream.

The wasteload allocations for the discharges are the Class A1 *E. coli* water quality standards, a geometric mean (GM) of 126-organisms/100 ml and a single sample maximum (SSM) of 235-organisms/100 ml. These concentration criteria have been multiplied by the 30 day average wet weather (AWW) flow to calculate the WWTP *E. coli* allocations. The wasteload allocation summation for this segment (0080_1) is zero.

*Load allocation.*
The load allocations for *E. coli* TMDLs are the load capacity less an explicit 10 percent margin of safety (MOS) less the total WLA for the flow condition for the geometric mean or single sample maximum. There is a separate load allocation set for each of the target recurrence intervals. The load allocations are shown in Tables 5-12 and 5-13.

**Table 5-12 Yellow River 3 GM *E. coli* load allocations**

| Flow condition, percent recurrence | GM target (TMDL) *E. Coli,* orgs/day | GM MOS *E. Coli,* orgs/day | Total WLA GM *E. coli*, orgs/day[2] | LA GM *E. coli,* orgs/day |
|---|---|---|---|---|
| **High flows** | 1.5E+12 | 1.5E+11 | zero | 1.3E+12 |
| **Moist conditions** | 4.7E+11 | 4.7E+10 | zero | 4.3E+11 |
| **Mid-range flow** | 2.4E+11 | 2.4E+10 | zero | 2.1E+11 |
| **Dry conditions** | 1.6E+11 | 1.6E+10 | zero | 1.4E+11 |
| **Low flow** | 1.1E+11 | 1.1E+10 | zero | 9.5E+10 |

1. Based on geometric mean standard of 126 *E. coli* organisms/100 ml
2. Not applicable – The wasteload allocations for the four wastewater treatment plants in the Yellow River basin have been developed for the individual tributaries that directly receive their discharges. Each WLA is derived from the E. coli WQS for GM and SSM concentration and is listed in Table 3-6.

**Table 5-13 Yellow River 3 SSM *E. coli* load allocations**

| Flow condition, percent recurrence | SSM target (TMDL) *E. Coli,* orgs/day | SSM MOS *E. Coli,* orgs/day | Total WLA SSM *E. coli*, orgs/day[2] | LA SSM *E. coli,* orgs/day |
|---|---|---|---|---|
| **High flow** | 2.8E+12 | 2.8E+11 | zero | 2.5E+12 |
| **Moist conditions** | 8.8E+11 | 8.8E+10 | zero | 8.0E+11 |
| **Mid-range flow** | 4.4E+11 | 4.4E+10 | zero | 4.0E+11 |
| **Dry conditions** | 3.0E+11 | 3.0E+10 | zero | 2.7E+11 |
| **Low flow** | 2.0E+11 | 2.0E+10 | zero | 1.8E+11 |

1. Based on single sample maximum standard of 235 *E. coli* organisms/100 ml
2. Not applicable – The wasteload allocations for the four wastewater treatment plants in the Yellow River basin have been developed for the individual tributaries that directly receive their discharges. Each WLA is derived from the E. coli WQS for GM and SSM concentration and is listed in Table 3-6.

*Margin of safety.*
The margin of safety for *E. coli* is an explicit 10 percent of the load capacity at each of the design recurrence intervals as shown in Tables 5-12 and 5-13.

## 5.5. TMDL Summary

The following equation shows the total maximum daily load (TMDL) and its components for the impaired IA 01-YEL-0080-1 segment of the Yellow River.

**Total Maximum Daily Load = Σ Load Allocations + Σ Wasteload Allocations +MOS**

A Total Maximum Daily Load calculation has been made at design flow conditions for the GM and SSM of this segment and these are shown in Tables 5-14 and 5-15 and Figures 5-7 and 5-8.

**Table 5-14 Yellow River IA 01-YEL-0080-1 *E. coli* TMDL for GM**

| Flow condition | Σ LA, orgs/day | Σ WLA[1], orgs/day | MOS, orgs/day | TMDL, orgs/day |
|---|---|---|---|---|
| **High flow** | 1.3E+12 | zero | 1.5E+11 | 1.5E+12 |
| **Moist condition** | 4.3E+11 | zero | 4.7E+10 | 4.7E+11 |
| **Mid-range flow** | 2.1E+11 | zero | 2.4E+10 | 2.4E+11 |
| **Dry conditions** | 1.4E+11 | zero | 1.6E+10 | 1.6E+11 |
| **Low flow** | 9.5E+10 | zero | 1.1E+10 | 1.1E+11 |

1. Not applicable – The wasteload allocations for the four wastewater treatment plants in the Yellow River basin have been developed for the individual tributaries that directly receive their discharges. Each WLA is derived from the E. coli WQS for GM and SSM concentration and is listed in Table 3-6.

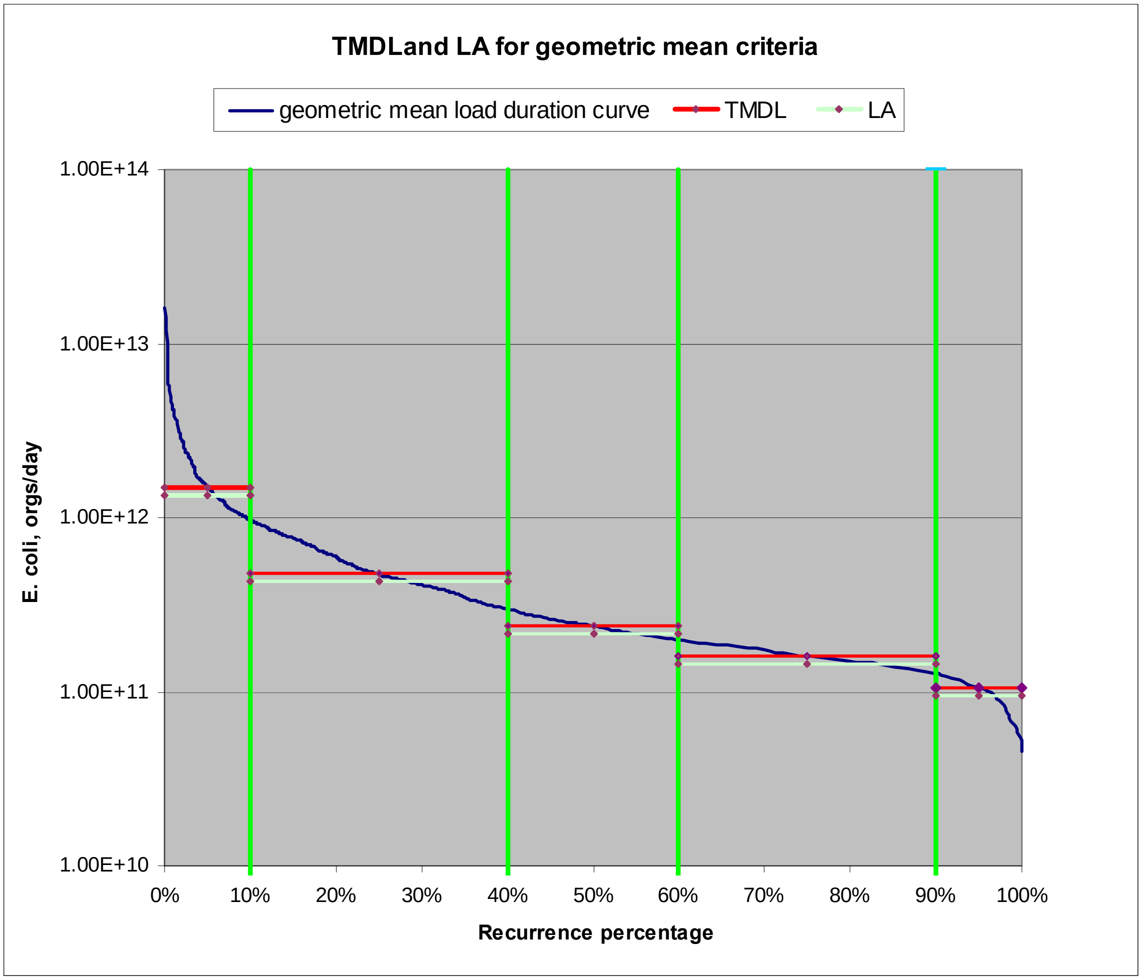

Figure 5-7 GM TMDL at WQS of 126 orgs/100 ml for the five flow conditions

**Table 5-15 Yellow River IA 01-YEL-0080-1 *E. coli* TMDL for SSM**

| **Flow condition** | **Σ LA, orgs/day** | **Σ WLA, orgs/day[1]** | **MOS, orgs/day** | **TMDL, orgs/day** |
|---|---|---|---|---|
| High flow | 2.5E+12 | zero | 2.8E+11 | 2.8E+12 |
| Moist condition | 8.0E+11 | zero | 8.8E+10 | 8.8E+11 |
| Mid-range flow | 4.0E+11 | zero | 4.4E+10 | 4.4E+11 |
| Dry conditions | 2.7E+11 | zero | 3.0E+10 | 3.0E+11 |
| Low flow | 1.8E+11 | zero | 2.0E+10 | 2.0E+11 |

1. Not applicable – The wasteload allocations for the four wastewater treatment plants in the Yellow River basin have been developed for the individual tributaries that directly receive their discharges. Each WLA is derived from the E. coli WQS for GM and SSM concentration and is listed in Table 3-6.

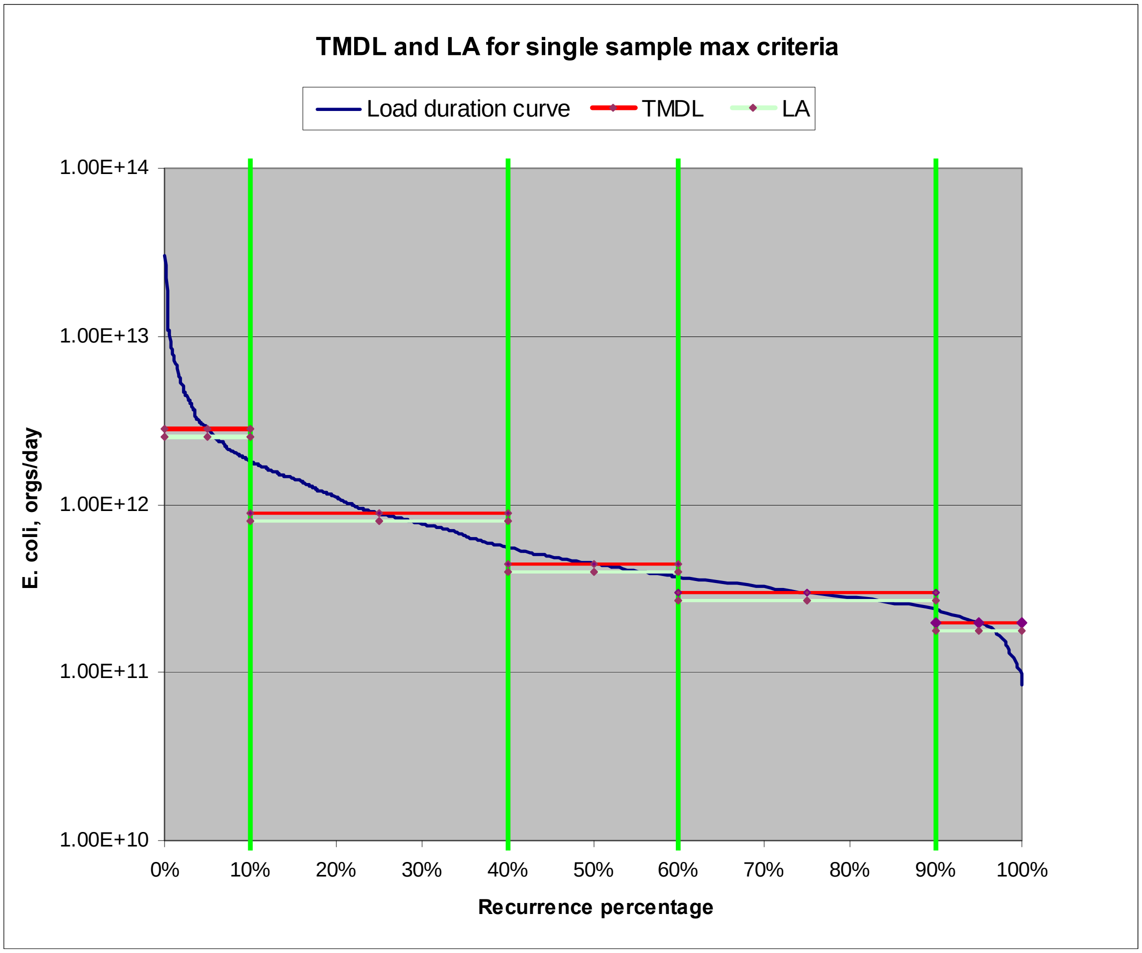

Figure 5-8 SSM TMDL at the WQS of 235 orgs/100 ml for the five flow conditions

## 5.6. Implementation Analysis

The modeled systematic reduction of the loads by source provides the initial evaluation of proposed implementation plans for the subbasin. The SWAT model has been run for five scenarios in which loads have been reduced for the most significant sources. The source analysis identified the primary source of bacteria as cattle in the stream and field applied manure from CAFOs. Figures 5-9a and 5-9b show the SWAT model output concentrations for the stream with monitored concentrations also plotted on the chart. The only monitoring for this Yellow River segment was done in 2009. The target concentration of 235 *E. coli* orgs/100 ml is frequently exceeded by both monitoring data and SWAT simulated values.

The concentration scale has been shown at two different scales so that the relationship between high sample values, simulated values and target values are apparent. The scale in Figure 5-9a has been set to a maximum of 80,000 orgs/100 ml and for Figure 5-9b has been set to 18,000. Even at the lower maximum scale the SSM target is not apparent. There are two sample values that exceed 18,000 orgs/100 ml (41,000, and 68,000). Event sampling done in 2009 indicates that concentrations are much higher during elevated flow than is shown by scheduled monitoring.

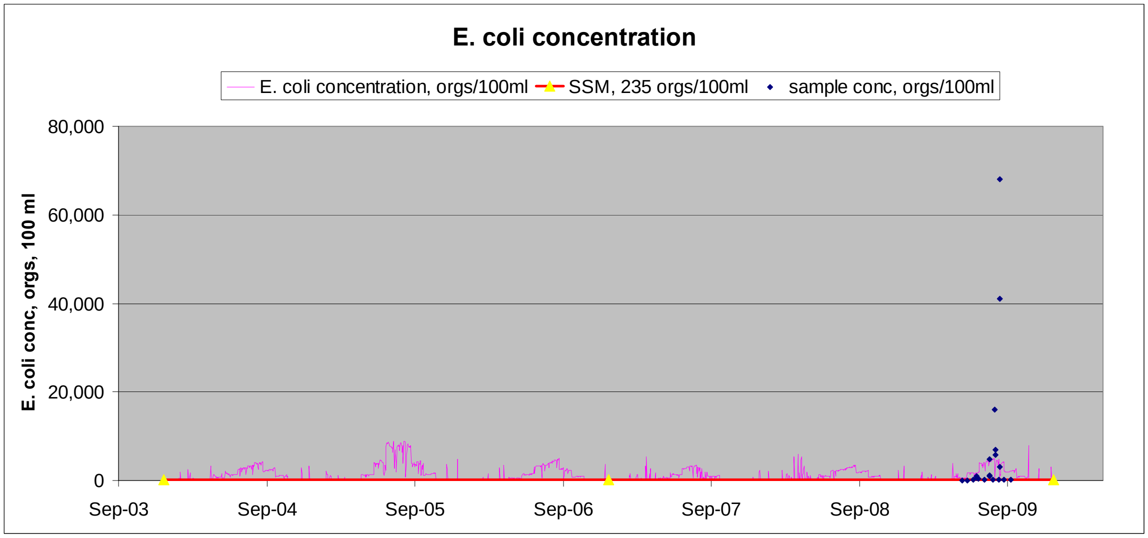

Figure 5-9a SWAT output for existing *E. coli* concentrations with the maximum concentration scale at 80,000 orgs/100 ml

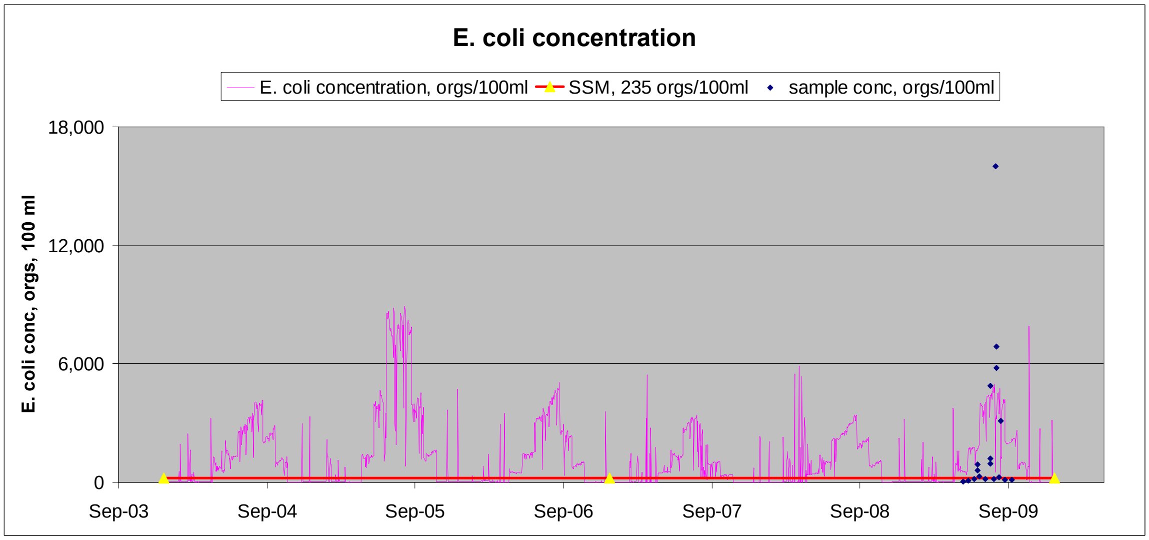

Figure 5-9b SWAT output for existing *E. coli* concentrations with the maximum concentration scale at 18,000 orgs/100 ml

The second scenario, Figure 5-10, removes half of the cattle in the stream from the subbasin and reduces the scale maximum concentration from 18,000 to 8,000 orgs/100 ml. The simulated concentrations are still much higher than the SSM standard during the grazing season. The runoff related concentration are not effected and spike in all scenarios.

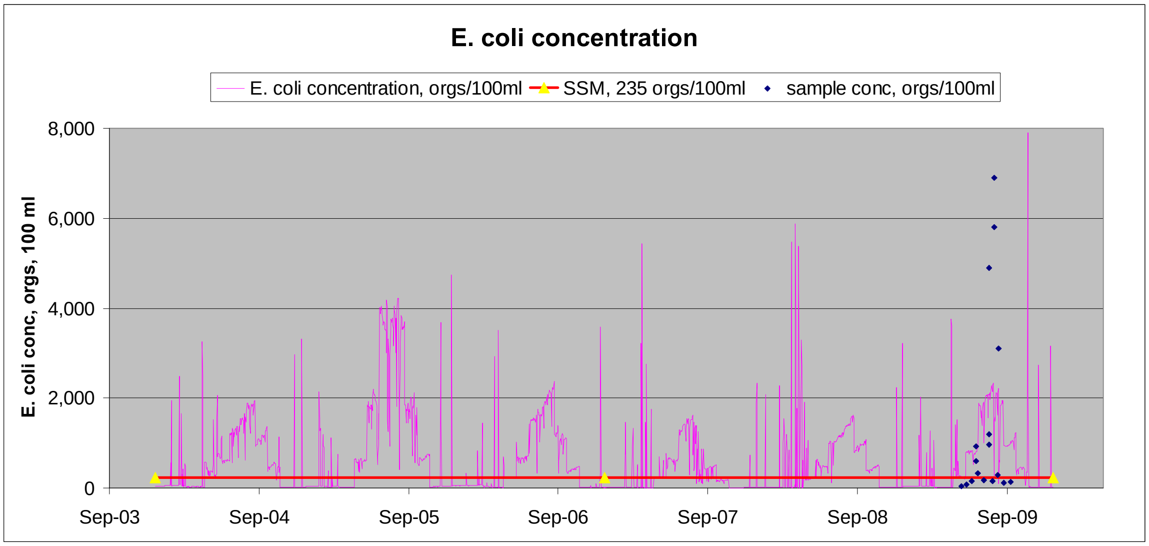

Figure 5-10 SWAT output for half reduction of CIS *E. coli* concentrations with the maximum concentration scale at 8,000 orgs/100 ml

The third scenario, shown in Figure 5-11, eliminates cattle in the stream as a source. This lowers concentration during the grazing season but there remain instances of high bacteria concentration from runoff. Most of this is associated with field application of manure from confined animal operations done in the spring when rain is frequent and intense.

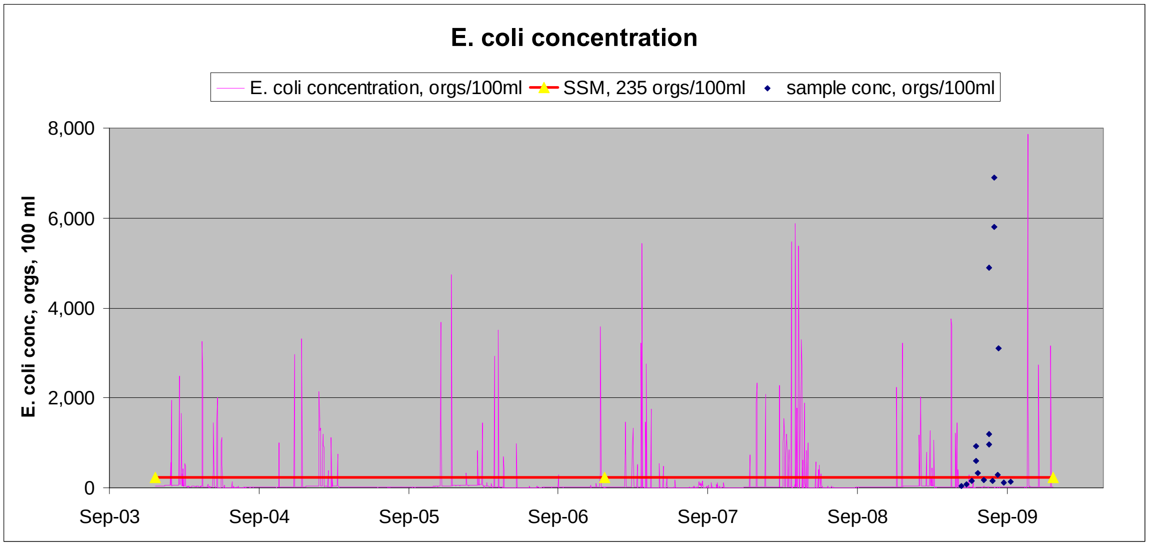

Figure 5-11 SWAT output for complete reduction of CIS *E. coli* with the concentration scale maximum set at 8,000 orgs/100 ml

The fourth scenario, shown in Figure 5-12, assumes that the field applications of manure are cut in half. This brings bacteria concentrations from these applications down but they still exceed the target.

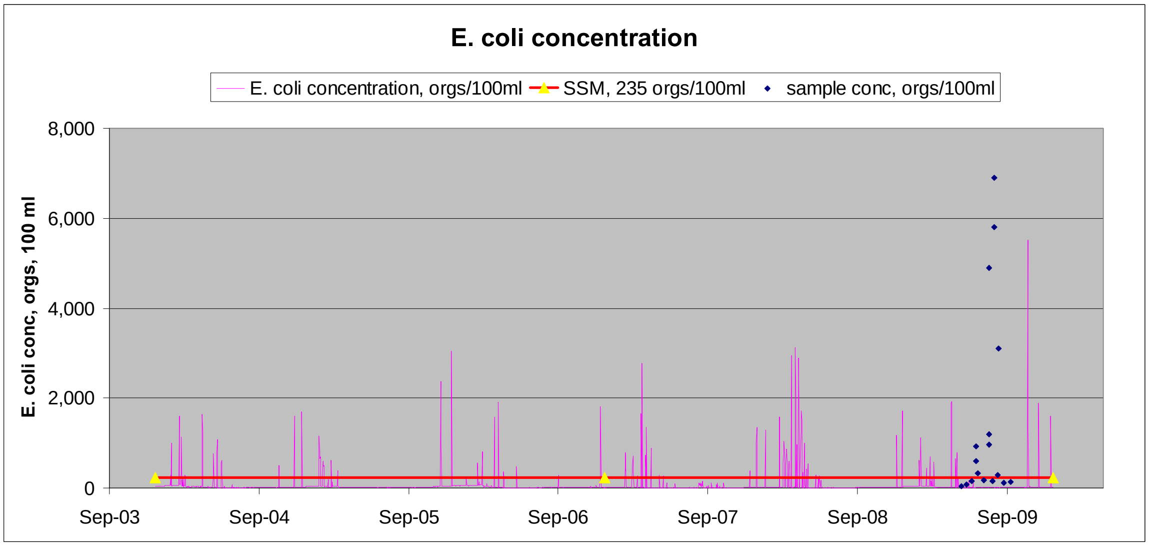

Figure 5-12 SWAT output for complete reduction of CIS *E. coli* and half of applied manure from CAFOs

The fifth scenario, shown in Figure 5-13, in addition to previous reductions, decreases the manure from cattle on pasture by two thirds. This pasture manure reduction showed a minor decrease in bacteria concentration in the stream.

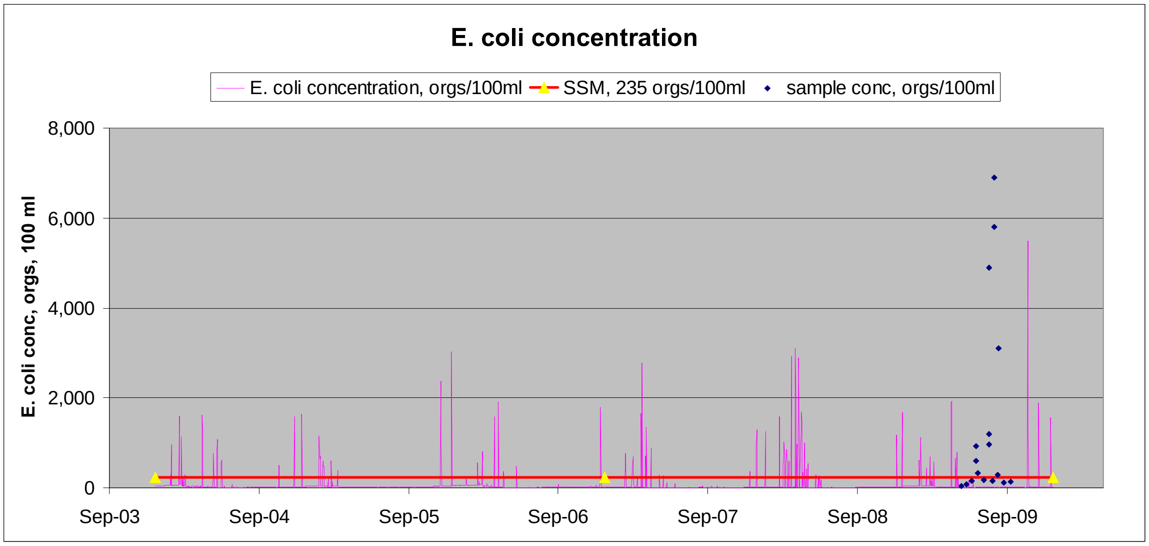

Figure 5-13 SWAT output for complete reduction of CIS *E. coli* and half of applied manure from CAFOs and a two thirds reduction of manure from cattle on pasture

There are several combinations of source reductions that can be simulated. The five scenarios described here reduce bacteria loads from the sources that have been modeled to have the greatest impact on stream outlet bacteria concentrations. The sources that are not reduced in these scenarios may have important episodic or local effect on *E. coli* organism numbers.

# 6. Yellow River 2 (0080_2)

Yellow River 2 has two monitoring locations associated with the impaired segment IA 01 YEL 0080_2. The segment runs 8.9 miles from the old Hwy 51 crossing (NE 1/4, S11, T96N, R6W, Allamakee County) to its confluence with the North Fork Yellow River (S13, T96N, R7W, Winneshiek County). This segment receives flow from parts of two HUC 12 subbasins, Upper Yellow River and Yellow River Headwaters. In addition to the upstream headwaters segment of the Yellow River, three tributaries that flow into this segment are impaired: Ludlow Creek, Hecker Creek, and North Fork Yellow River. There is one industrial wastewater treatment facility for AgriStarr Company located on Hecker Creek near Postville.

The two monitoring locations are labeled Site 1 (Yellow River at Pole Line Road) and Site 2 (Yellow River at County Road W60) going downstream. Site 1 is 1.7 miles downstream of the Yellow River confluence with the North Fork Yellow River. Site 2 is 4.8 miles downstream of Site 1 and 2.5 miles upstream from the end of this impaired Yellow River segment. Both Site 1 and Site 2 were monitored during the 2009 sampling. Only Site 2 was monitored during the 2004 to 2007 monitoring effort and this is the only site used to develop the TMDL values. The flows for both sites were estimated based on the area ratio method using the Ion USGS gage data. Figure 6-1 shows a map of Yellow River 2 and Table 6-1 shows the land use in its upstream subbasins.

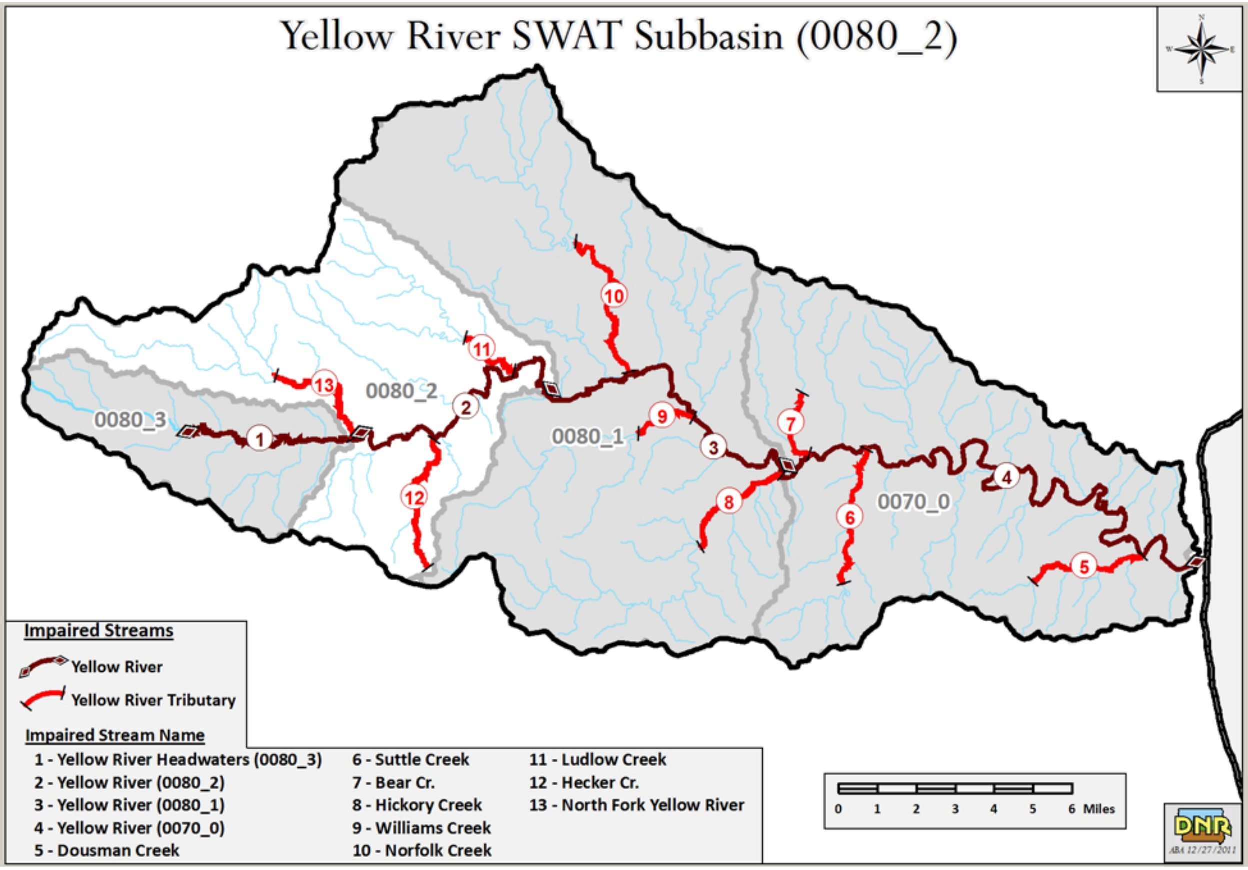

Figure 6-1 Yellow River 2 (0080_2)

**Table 6-1 Yellow River 2 subbasins land use**

| Landuse | Area, acres | Fraction of total |
|---|---:|---:|
| Water/wetland | 5.8 | 0.01% |
| Forest | 4475.7 | 9.77% |
| Ungrazed/CRP/hay | 7357.9 | 16.07% |
| Grazed | 3401.1 | 7.43% |
| Row crop | 28634.1 | 62.53% |
| Roads | 1287.2 | 2.81% |
| Commercial/residential | 634.0 | 1.38% |
| **Total** | **45795.8** | **100.00%** |

In the Yellow River 2 watershed 63 percent of the area is row crop and 26 percent is forest or ungrazed grass.

### 6.1. Water body pollutant loading capacity (TMDL)

The *E. coli* load capacity is the number of organisms for a flow volume that can meet the water quality criteria. The loading capacity for each of the five flow conditions is calculated by multiplying the midpoint flow and *E. coli* criteria concentrations. Table 6-2 shows the median, maximum, and minimum flows for the five flow conditions for Site 2 used for calculation of the LA and MOS for this segment.

**Table 6-2 Yellow River 2 - Site 2, maximum, minimum and median flows**

| Flow description | Recurrence interval range (mid %) | Midpoint of flow range, cfs | Maximum of flow range, cfs | Minimum of flow range, cfs |
|---|---|---:|---:|---:|
| **High flow** | **0 to 10% (5)** | 162.8 | 1745.4 | 103.8 |
| **Moist conditions** | **10% to 40% (25)** | 51.5 | 103.8 | 32.3 |
| **Mid-range** | **40% to 60% (50)** | 25.8 | 32.3 | 21.6 |
| **Dry conditions** | **60% to 90% (75)** | 17.3 | 21.6 | 14.0 |
| **Low flow** | **90% to 100% (95)** | 11.5 | 14.0 | 4.9 |

Flow and load duration curves were used to establish the occurrence of water quality standards violations, to establish compliance targets, and to set pollutant allocations and margins of safety. Duration curves are derived from flows plotted as a percentage of their recurrence. *E. coli* loads are calculated from *E. coli* concentrations and flow volume at the time the sample was collected.

To construct the flow duration curves, the bacteria monitoring data and the Water Quality Standard (WQS) sample max (235 *E. coli* organisms/100 ml) were plotted with the flow duration percentile. Figure 6-2 shows the data that exceed the WQS criteria at each of the five flow conditions. High flow violations indicate that the problem occurs during run-off conditions when bacteria are washing off from nonpoint sources. Criteria exceeded during low or base flow, when little or no runoff is occurring, indicate that continuous sources such as septic tanks, livestock in the stream, riparian wildlife, and wastewater treatment plants are the problem.

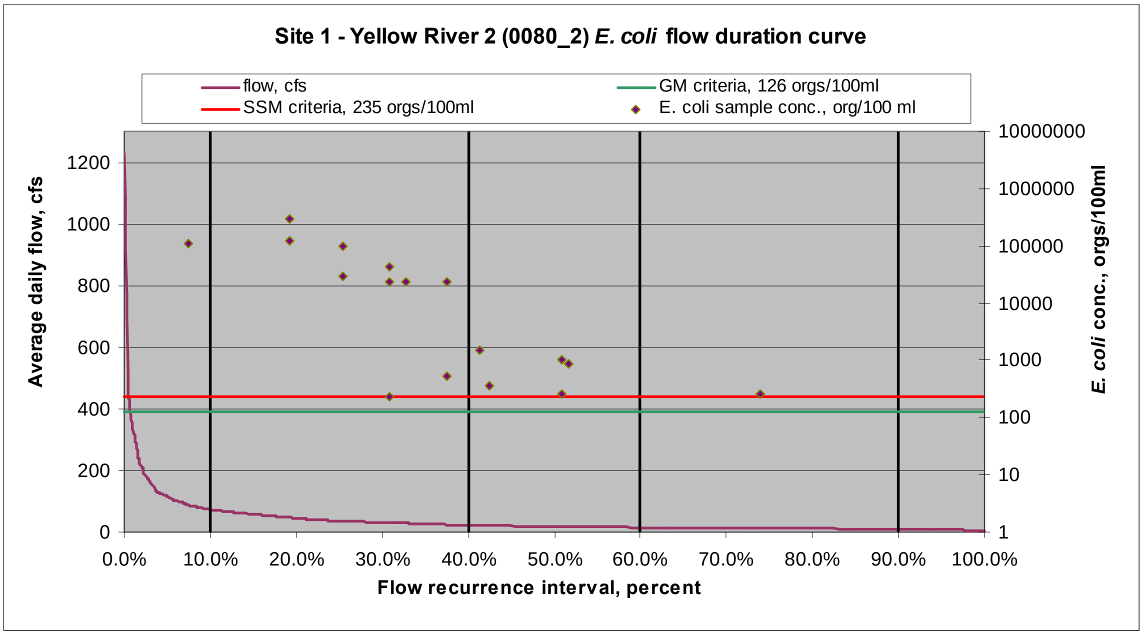

Figure 6-2 Yellow River 2 – Site 1, flow duration curve

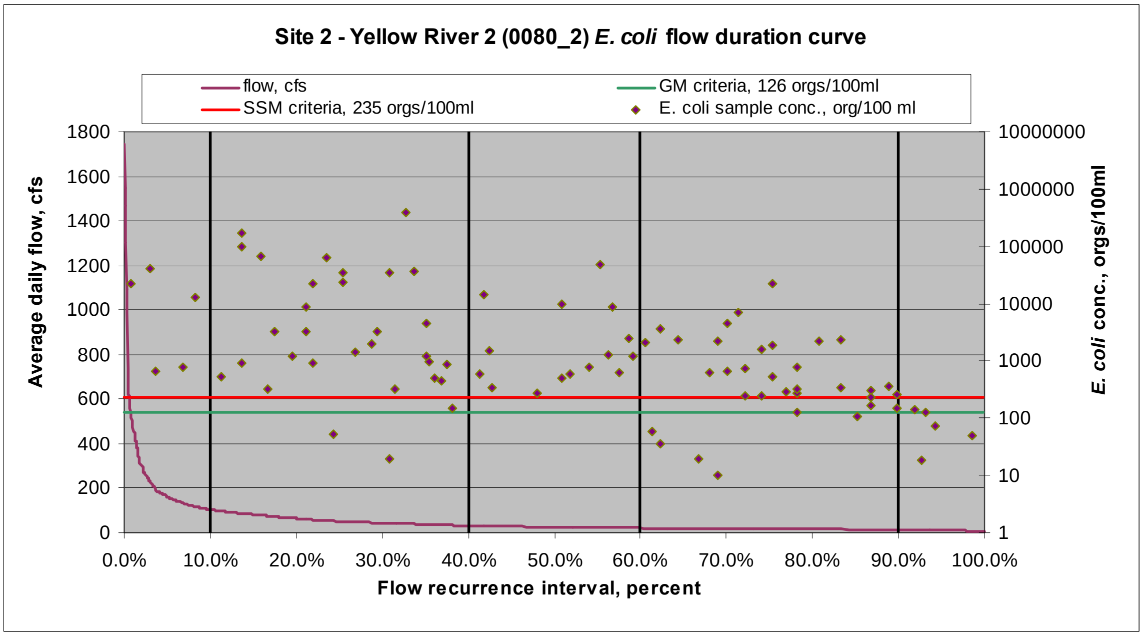

Figure 6-3 Yellow River 2 – Site 2, flow duration curve

Load duration curves were used to evaluate the five flow conditions for this Yellow River segment. The load duration curve is shown in Figure 6-5. In the figure, the lower curve shows the maximum *E. coli* count for the GM criteria and the upper curve shows the maximum *E. coli* count for the SSM criteria at a continuum of flow recurrence percentage. The individual points are the observed (monitored) *E. coli* concentrations converted to loads based on daily flow for the day they were collected. Points above the load duration curves are violations of the WQS criteria and exceed the loading capacity.

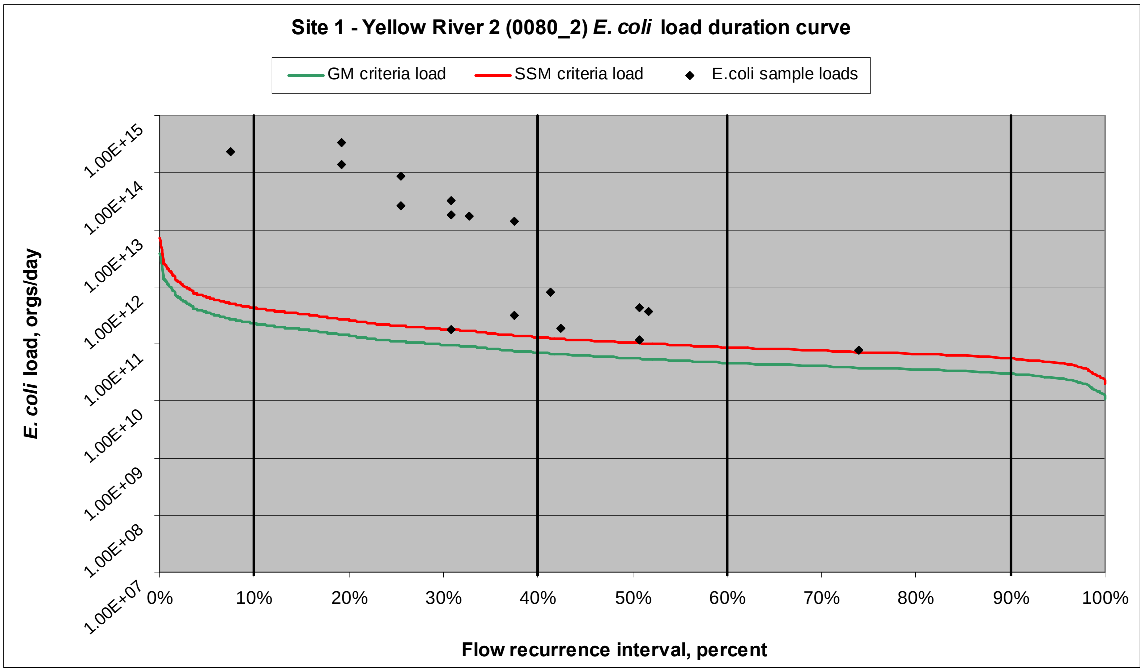

Figure 6-4 Yellow River 2 - Site 1, load duration curve

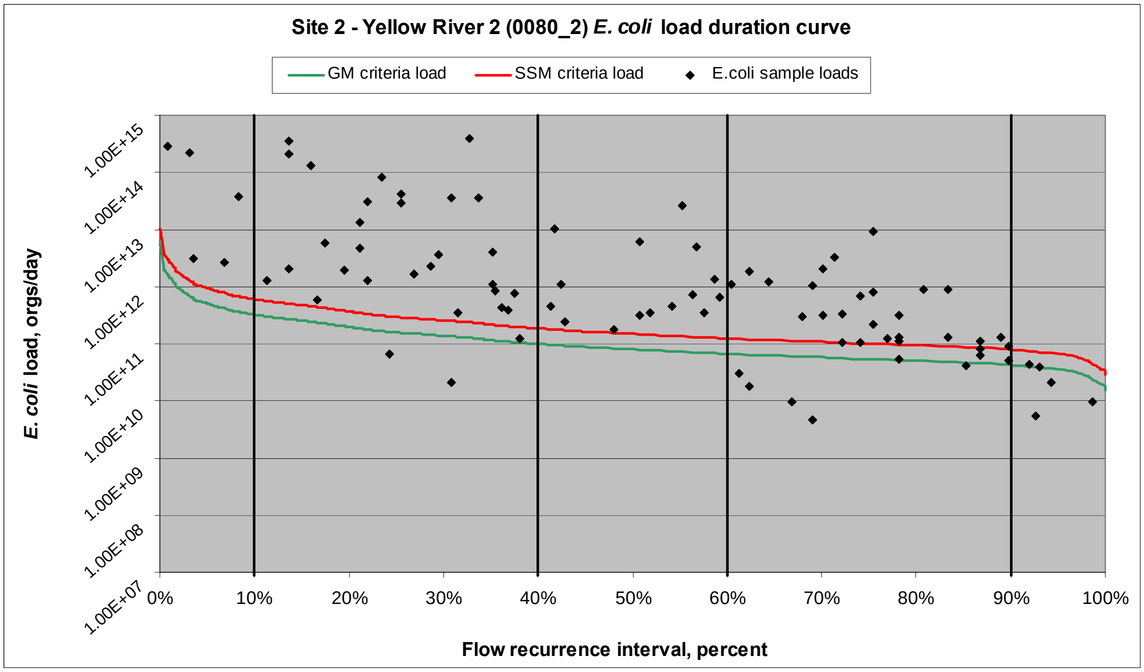

Figure 6-5 Yellow River 2 - Site 2, load duration curve

Tables 6-3 and 6-4 show the load capacities (targets) for each of the midpoint flow conditions at the GM and SSM criteria, respectively, for Site 2.

### Table 6-3 Yellow River 2 - Site 2 GM load capacity

| Flow condition | Recurrence interval | Associated midpoint flow, cfs | Estimated flow interval load capacity, *E. coli* orgs/day |
|---|---|---|---|
| **High flow** | **0 to 10%** | 162.8 | 5.0E+11 |
| **Moist conditions** | **10% to 40%** | 51.5 | 1.6E+11 |
| **Mid-range** | **40% to 60%** | 25.8 | 7.9E+10 |
| **Dry conditions** | **60% to 90%** | 17.3 | 5.3E+10 |
| **Low flow** | **90% to 100%** | 11.5 | 3.5E+10 |

### Table 6-4 Yellow River 2 - Site 2 SSM load capacity

| Flow condition | Recurrence interval | Associated midpoint flow, cfs | Estimated flow interval load capacity, *E. coli* orgs/day |
|---|---|---|---|
| **High flow** | **0 to 10%** | 162.8 | 9.4E+11 |
| **Moist conditions** | **10% to 40%** | 51.5 | 3.0E+11 |
| **Mid-range** | **40% to 60%** | 25.8 | 1.5E+11 |
| **Dry conditions** | **60% to 90%** | 17.3 | 9.9E+10 |
| **Low flow** | **90% to 100%** | 11.5 | 6.6E+10 |

## 6.2. Existing load

The existing loads are derived from the sampling data collected at Yellow River 2 Site 2. These data are the sample values shown in the flow and load duration curves. The *E. coli* concentrations are multiplied by the simulated daily flow to get the daily loads. The daily loads are plotted with the load duration curves. The allowable loads for a given flow equal the flow multiplied by the WQS limits for the geometric mean or single sample maximum. Monitored data that exceed the limits are above the criteria curves.

The maximum existing loads occur during major rains when runoff and bacteria concentrations are highest. Concentrations exceed the criteria during these high flow events. Other conditions leading to criteria violations occur during dry low flow periods when continuous loads from livestock in the stream, local wildlife, septic tanks, and wastewater treatment plants can cause bacteria problems.

The assessment standard used to evaluate streams is the *E. coli* geometric mean criteria. Since the load duration approach precludes the calculation of a geometric mean, the 90th percentile of observed concentrations within each flow condition is multiplied by the median flow to estimate existing loads. This procedure has been used to evaluate impaired segments. Table 6-5 shows the existing loads for each flow condition.

### Table 6-5 Yellow River 2 - Site 2 existing loads

| Flow condition, percent recurrence | Recurrence interval range (mid %) | Associated median flow, cfs | Existing 90th percentile *E. coli* conc., org/100ml | Estimated existing load, *E. coli* org/day |
|---|---|---|---|---|
| **High flows** | **0 to 10% (5)** | 162.8 | 33400 | 1.33E+14 |
| **Moist conditions** | **10% to 40% (25)** | 51.5 | 68000 | 8.57E+13 |
| **Mid-range** | **40% to 60% (50)** | 25.8 | 12320 | 7.76E+12 |
| **Dry conditions** | **60% to 90% (75)** | 17.3 | 3240 | 1.37E+12 |
| **Low flow** | **90% to 100% (95)** | 11.5 | 136 | 3.83E+10 |

*Identification of pollutant sources.*
The of bacteria load in the mainstem Yellow River 2 segment basin (SWAT Subbasins 1, 4, 6, 10, 11, 12, 13, and 18) is the sum of all of the upstream sources including failed septic tank systems, pastured cattle, cattle in the stream, wildlife, and manure applied to fields from animal confinement operations. The loads from these sources have been incorporated into the SWAT watershed model and are listed in Tables 6-6 to 6-10.

Non functional septic tank systems. There are an estimated 352 onsite septic tank systems in the Yellow River 2 subbasins (2.5 persons/household). IDNR estimates that 50 percent are not functioning properly. It is assumed that these are continuous year round discharges. Septic tank loads have been put into the SWAT model as a continuous source by subbasin.

**Table 6-6 Yellow River 2 (0080_2) septic tank system E. coli orgs/day**

| | |
|---|---:|
| Rural population of Yellow River subbasin | 881 |
| Total initial E.coli, orgs/day [1] | 1.10E+12 |
| Septic tank flow, $m^3$/day [2] | 233.5 |
| **E. coli delivered to stream, orgs/day [3]** | **7.30E+08** |

1. Assumes 1.25E+09 E. coli orgs/day per capita
2. Assumes 70 gallons/day/capita
3. Assumes septic discharge concentration reaching stream is 625 orgs/100 ml and a 50% failure rate

Cattle in stream. Of the 2,125 cattle in pastures with stream access, one to six percent of those are assumed to be in the stream on a given day. The number on pasture and the fraction in the stream varies by month. Cattle in the stream have a high potential to deliver bacteria since bacteria are deposited directly in the stream with or without rainfall. Subbasin cattle in the stream bacteria have been input in the SWAT model as a continuous source varying by month.

**Table 6-7 Yellow River 2 (0080_2) Creek Cattle in the stream E. coli orgs/day**

| | |
|---|---:|
| Pasture area with stream access, acre[1] | 2,724 |
| Number of cattle in stream (6% of total)[2] | 128 |
| Dry manure, kg/day [3] | 395 |
| **E. coli load, orgs/day [4]** | **5.22E+12** |

1. The subbasin CIS are estimated from the pasture area with stream access at 0.78 cattle/acre.
2. It is estimated that cattle spend 6% of their time in streams in July and August, 3% in June and September, and 1% in May and October. The loads shown in this table are for July and August. The loads for the other 4 months when cattle are in streams have been incorporated into the SWAT modeling.
3. Cattle generate 3.1 kg/head/day of dry manure.
4. Manure has 1.32E+07 E coli orgs/gram dry manure.

Grazing livestock. The estimated number of cattle in the Yellow River 2 subbasins is 2,551. It is assumed that they are on pasture from April to November. The potential for bacteria delivery to the stream occurs with precipitation causing runoff. Manure available for washoff is applied in the SWAT model at 6 kg/ha in the pasture landuse.

### Table 6-8 Yellow River 2 (0080_2) manure from pastured cattle, maximum E. coli available for washoff, orgs/day

| | |
|---|---:|
| Pasture area, acre | 2,724 |
| Number of cattle on pasture[1] | 2,551 |
| Dry manure, kg/day[2] | 7,909 |
| Maximum E. coli load, orgs/day[3] | 1.04E+14 |
| Maximum E. coli available for washoff, orgs[4] | 1.88E+14 |

1. The number of pastured cattle is 0.78 cattle/acre.
2. Cattle generate 3.1 kg/head/day of dry manure.
3. Manure has 1.32E+07 E. coli orgs/gram dry manure
4. The load available for washoff is the daily load times 1.8.

Wildlife manure. The number of deer in Allamakee County is about 9,000 located primarily in forested land adjacent to streams. Another 1,000 have been added to account for other wildlife such as raccoons and waterfowl for a total estimate of 10,000. This works out to 0.024 deer per acre. Using this procedure, there are 1,099 deer in the Yellow River 2 subbasins concentrated in the forested and grass areas. The deer are present year round.

### Table 6-9 Yellow River 2 (0080_2) watershed wildlife manure loads available for washoff, orgs/day

| Number of deer[1] | Forest and grass area, ha | SWAT manure loading rate, kg/ha/day[2] | Total E. coli available for washoff, orgs[3] |
|:---:|:---:|:---:|:---:|
| 1099 | 1,994 | 0.794 | 9.89E+11 |

1. Deer numbers are 0.024 deer/ha for the entire subbasin concentrated to 0.551 deer/ha in the forest and grass land uses. All wildlife loads are applied to the forest and brome grass landuses in the SWAT model. The county deer numbers have been increased by 10% to account for other wildlife in the subbasin.
2. Assumes 1.44 kg/deer/day and 3.47E+05 orgs/gram.
3. Assumes that the maximum *E. coli* available for washoff is 1.8 times the daily load.

Field applications of CAFO manure.

There are about 19,000 swine and 249,750 chickens in confinement in the Yellow River 2 subbasins. The manure is stored and land applied to cropland. The manure is distributed to the fields in the subbasin in the fall after soybean harvest and in the spring prior to corn planting in year two of a two year rotation. The relatively brief fall and spring timing of manure application and incorporation in the soil significantly reduces the *E. coli* organisms from these sources. Manure application has been put in the SWAT model by subbasin as a load available at the end of October and the beginning of April.

### Table 6-10 Yellow River 2 (0080_2) watershed confined livestock manure applications

| Livestock type | Swine | Chickens | Dairy cows |
|---|---|---|---|
| Number of animals | 19,000 | 249,750 | 0 |
| Manure applied, kg/year[1] | 7,836,550 | 2,734,763 | 0 |
| Application area, ha[2] | 372 | 105 | 0 |
| Manure applied, kg/ha/day[3] | 2,127 | 2,326 | 0 |
| Subbasin *E. coli*, orgs/day | 2.09E+15 | 1.44E+14 | 0 |
| Subbasin E. coli available for washoff, orgs/day[4] | 3.77E+15 | 2.59E+14 | 0 |

1. Manure is calculated based on number of animals * dry manure (kg/animal/day)*365 days/year.
2. The area the manure is applied to is based on the manure's nitrogen content. Manure is applied at a rate equivalent to 201.6 kg N/ha/yr. Swine manure is applied at 2127 kg/ha, dairy manure at 2631 kg/ha and chicken manure at 2326 kg/ha. The E. coli content of manure for swine is 1.32E+07 orgs/gram, for dairy cows is 1.00E+07 orgs/gram, and for chickens is 2.96E+06 orgs/gram.
3. Manure is assumed to be applied to fields twice a year over 5 days on October 30 and April 1. It is incorporated in the soil and it is assumed that only 10% of bacteria are viable and available after storage and incorporation.
4. Maximum *E. coli* available for washoff are 1.8 times the daily maximum available load.

The total maximum *E. coli* available for washoff for swine and chickens is **4.03E+15 orgs/day**. This is the theoretical highest *E. coli* that could be delivered.

Seasonal variation of sources.
The relative impacts of the bacteria sources are shown in Figures 6-6 and 6-7. Figure 6-6 shows the relative loads delivered by the "continuous" sources, those sources present with or without rainfall and runoff. These are the failed septics that are assumed to be a problem every day of the year and the loads from cattle in the stream that vary by month from May to October. It can be seen in this figure that the impacts from cattle in the stream are much more significant than from failed septic tank systems.

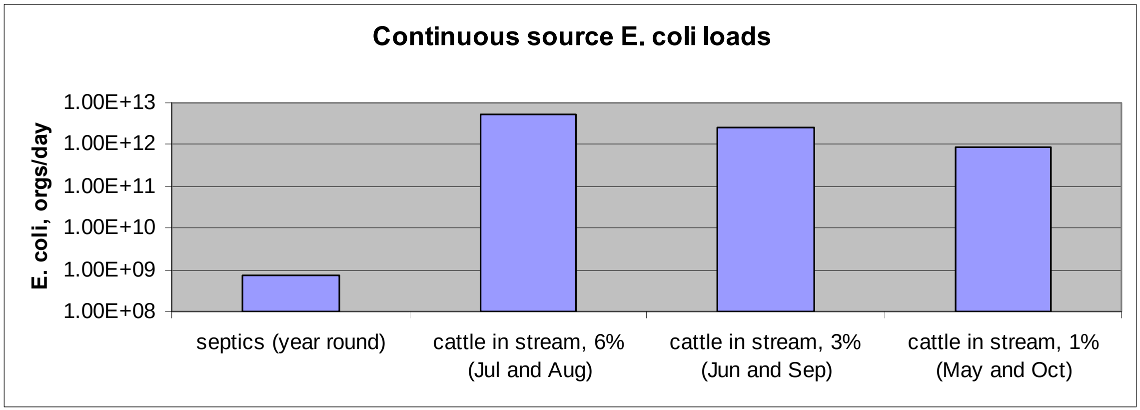

Figure 6-6 *E. coli* loads from "continuous" sources

The three general washoff sources of bacteria in the subbasin are shown in Figure 6-7. The wildlife source consists primarily of deer and smaller animals such as raccoons and waterfowl. These are year round sources. Pastured cattle consist of grazing cattle and

small poorly managed feedlot-like operations. The grazing season is modeled as lasting 168 days starting May 1. Manure from confined animal feeding operations (CAFO) is applied to cropland twice a year for a relatively brief time. Most field applied manure is assumed to be incorporated into the soil and most bacteria in it are not available. Confinement animals are swine, chickens and dairy cattle.

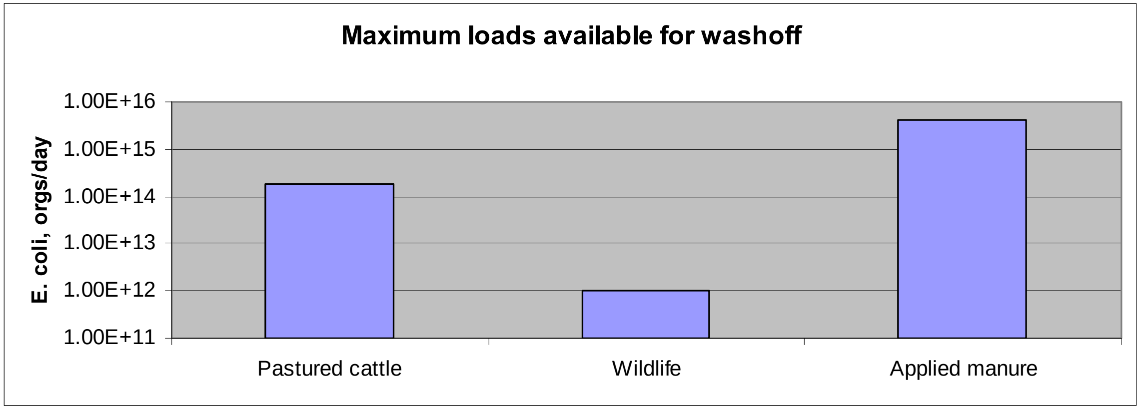

Figure 6-7 Maximum *E. coli* loads available for washoff

The maximum bacteria load to the stream occurs when the continuous source load plus the precipitation driven washoff load are combined. In general, the more rainfall the higher the flow rate and the more elevated the concentration. High flow rate and elevated concentration equal peak loads. In July and August, the potential maximum load based on this analysis is 1.89E+14 orgs/day available for washoff plus the continuous load of 5.23E+12 orgs/day for a total of 1.94E+14 orgs/day.

<u>Flow interval load source analysis</u>. Based on the load duration curve analysis the maximum existing load occurring during the zero to forty percent recurrence interval runoff conditions, is 1.04E+14 orgs/day and the total available load based on the potential sources, including fall and spring manure applications, is 4.22E+15 orgs/day. Generally the maximum load in the stream, delivered in April when runoff is occurring, is estimated to be two percent of the bacteria available for washoff. At the zero to ten percent maximum existing load of 1.33E+14 orgs/day and with the same load available for washoff the stream load is three percent of the available load.

### 6.3. Departure from load capacity

The departure from load capacity is the difference between the existing load and the load capacity. This varies for each of the five flow conditions. Table 6-11 shows this difference. The existing and target loads for the five flow conditions are shown graphically in Figure 6-8.

### Table 6-11 Yellow River 2 - Site 2 departure from load capacity

| Design flow condition, percent recurrence | Recurrence interval range (mid %) | Existing *E. coli* orgs/day | Load capacity, orgs/day | Departure from capacity, orgs/day |
|---|---|---|---|---|
| High flow | 0 to 10% (5) | 1.33E+14 | 9.4E+11 | 1.32E+14 |
| Moist conditions | 10% to 40% (25) | 8.57E+13 | 3.0E+11 | 8.54E+13 |
| Mid-range flow | 40% to 60% (50) | 7.76E+12 | 1.5E+11 | 7.62E+12 |
| Dry conditions | 60% to 90% (75) | 1.37E+12 | 9.9E+10 | 1.27E+12 |
| Low flow | 90% to 100% (95) | 3.83E+10 | 6.6E+10 | -2.79E+10 |

1. Negative values indicate that the existing load is less than the target load.

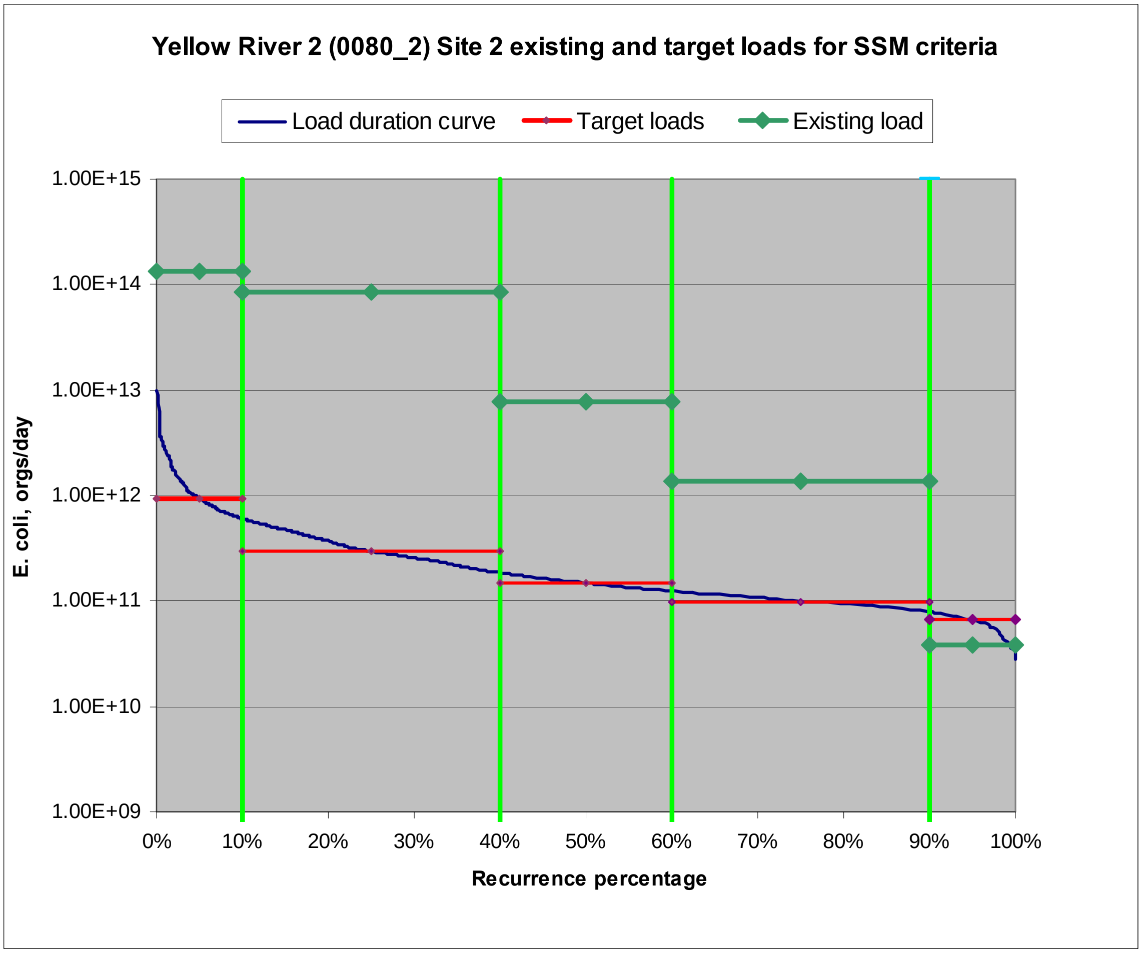

Figure 6-8 Difference between existing and target loads

## 6.4 Pollutant Allocations

*Wasteload allocations.*

The wasteload allocations for the four wastewater treatment facilities discharging to the Yellow River Basin are shown in Table 3-6 and again in the TMDL calculations for the Yellow River tributaries directly receiving wastewater treatment effluent. It is assumed that all of the wastewater treatment plants in the watershed discharge to a Class A1 stream. The wasteload allocations for the discharges are the Class A1 *E. coli* water quality standards, a geometric mean (GM) of 126-organisms/100 ml and a single sample maximum (SSM) of 235-organisms/100 ml. These concentration criteria have been multiplied by the 30 day average wet weather (AWW) flow to calculate the WWTP *E. coli* allocations. The wasteload allocation summation for this segment (0080_2) is zero.

*Load allocation.*

The load allocations for *E. coli* TMDLs are the load capacity less an explicit 10 percent margin of safety (MOS) less the total WLA for the flow condition for the geometric mean or single sample maximum. There is a separate load allocation set for each of the target recurrence intervals. The load allocations are shown in Tables 6-12 and 6-13.

**Table 6-12 Yellow River 2 - Site 2 GM *E. coli* load allocations**

| Flow condition, percent recurrence | GM target (TMDL) *E. Coli*, orgs/day | GM MOS *E. Coli*, orgs/day | Total WLA GM *E. coli*, orgs/day$^2$ | LA GM *E. coli*, orgs/day |
|---|---|---|---|---|
| **High flows** | 5.0E+11 | 5.0E+10 | zero | 4.5E+11 |
| **Moist conditions** | 1.6E+11 | 1.6E+10 | zero | 1.4E+11 |
| **Mid-range flow** | 7.9E+10 | 7.9E+09 | zero | 7.1E+10 |
| **Dry conditions** | 5.3E+10 | 5.3E+09 | zero | 4.8E+10 |
| **Low flow** | 3.5E+10 | 3.5E+09 | zero | 3.2E+10 |

1. Based on geometric mean standard of 126 *E. coli* organisms/100 ml
2. Not applicable – The wasteload allocations for the four wastewater treatment plants in the Yellow River basin have been developed for the individual tributaries that directly receive their discharges. Each WLA is derived from the E. coli WQS for GM and SSM concentration and is listed in Table 3-6.

**Table 6-13 Yellow River 2- Site 2 SSM *E. coli* load allocations**

| Flow condition, percent recurrence | SSM target (TMDL) *E. Coli*, orgs/day | SSM MOS *E. Coli*, orgs/day | Total WLA SSM *E. coli*, orgs/day$^2$ | LA SSM *E. coli*, orgs/day |
|---|---|---|---|---|
| **High flow** | 9.4E+11 | 9.4E+10 | zero | 8.4E+11 |
| **Moist conditions** | 3.0E+11 | 3.0E+10 | zero | 2.7E+11 |
| **Mid-range flow** | 1.5E+11 | 1.5E+10 | zero | 1.3E+11 |
| **Dry conditions** | 9.9E+10 | 9.9E+09 | zero | 8.9E+10 |
| **Low flow** | 6.6E+10 | 6.6E+09 | zero | 6.0E+10 |

1. Based on single sample maximum standard of 235 *E. coli* organisms/100 ml
2. Not applicable – The wasteload allocations for the four wastewater treatment plants in the Yellow River basin have been developed for the individual tributaries that directly receive their discharges. Each WLA is derived from the E. coli WQS for GM and SSM concentration and is listed in Table 3-6.

*Margin of safety.*

The margin of safety for *E. coli* is an explicit 10 percent of the load capacity at each of the design recurrence intervals as shown in Tables 6-12 and 6-13.

## 6.5. TMDL Summary

The following equation shows the total maximum daily load (TMDL) and its components for the impaired IA 01-YEL-0080-2 segment of the Yellow River.

**Total Maximum Daily Load = Σ Load Allocations + Σ Wasteload Allocations +MOS**

A Total Maximum Daily Load calculation has been made at design flow conditions for the GM and SSM of this segment and these are shown in Tables 6-14 and 6-15 and Figures 6-9 and 6-10.

**Table 6-14 Yellow River IA 01-YEL-0080-2 *E. coli* TMDL for GM**

| Flow condition | Σ LA, orgs/day | Σ WLA, orgs/day[1] | MOS, orgs/day | TMDL, orgs/day |
|---|---|---|---|---|
| **High flow** | 4.5E+11 | zero | 5.0E+10 | 5.0E+11 |
| **Moist condition** | 1.4E+11 | zero | 1.6E+10 | 1.6E+11 |
| **Mid-range flow** | 7.1E+10 | zero | 7.9E+09 | 7.9E+10 |
| **Dry conditions** | 4.8E+10 | zero | 5.3E+09 | 5.3E+10 |
| **Low flow** | 3.2E+10 | zero | 3.5E+09 | 3.5E+10 |

1. Not applicable – The wasteload allocations for the four wastewater treatment plants in the Yellow River basin have been developed for the individual tributaries that directly receive their discharges. Each WLA is derived from the E. coli WQS for GM and SSM concentration and is listed in Table 3-6.

Figure 6-9 GM TMDL at WQS of 126 orgs/100 ml for the five flow conditions

**Table 6-15 Yellow River IA 01-YEL-0080-2 *E. coli* TMDL for SSM**

| Flow condition | Σ LA, orgs/day | Σ WLA, orgs/day[1] | MOS, orgs/day | TMDL, orgs/day |
|---|---|---|---|---|
| High flow | 8.4E+11 | zero | 9.4E+10 | 9.4E+11 |
| Moist condition | 2.7E+11 | zero | 3.0E+10 | 3.0E+11 |
| Mid-range flow | 1.3E+11 | zero | 1.5E+10 | 1.5E+11 |
| Dry conditions | 8.9E+10 | zero | 9.9E+09 | 9.9E+10 |
| Low flow | 6.0E+10 | zero | 6.6E+09 | 6.6E+10 |

1. Not applicable – The wasteload allocations for the four wastewater treatment plants in the Yellow River basin have been developed for the individual tributaries that directly receive their discharges. Each WLA is derived from the E. coli WQS for GM and SSM concentration and is listed in Table 3-6.

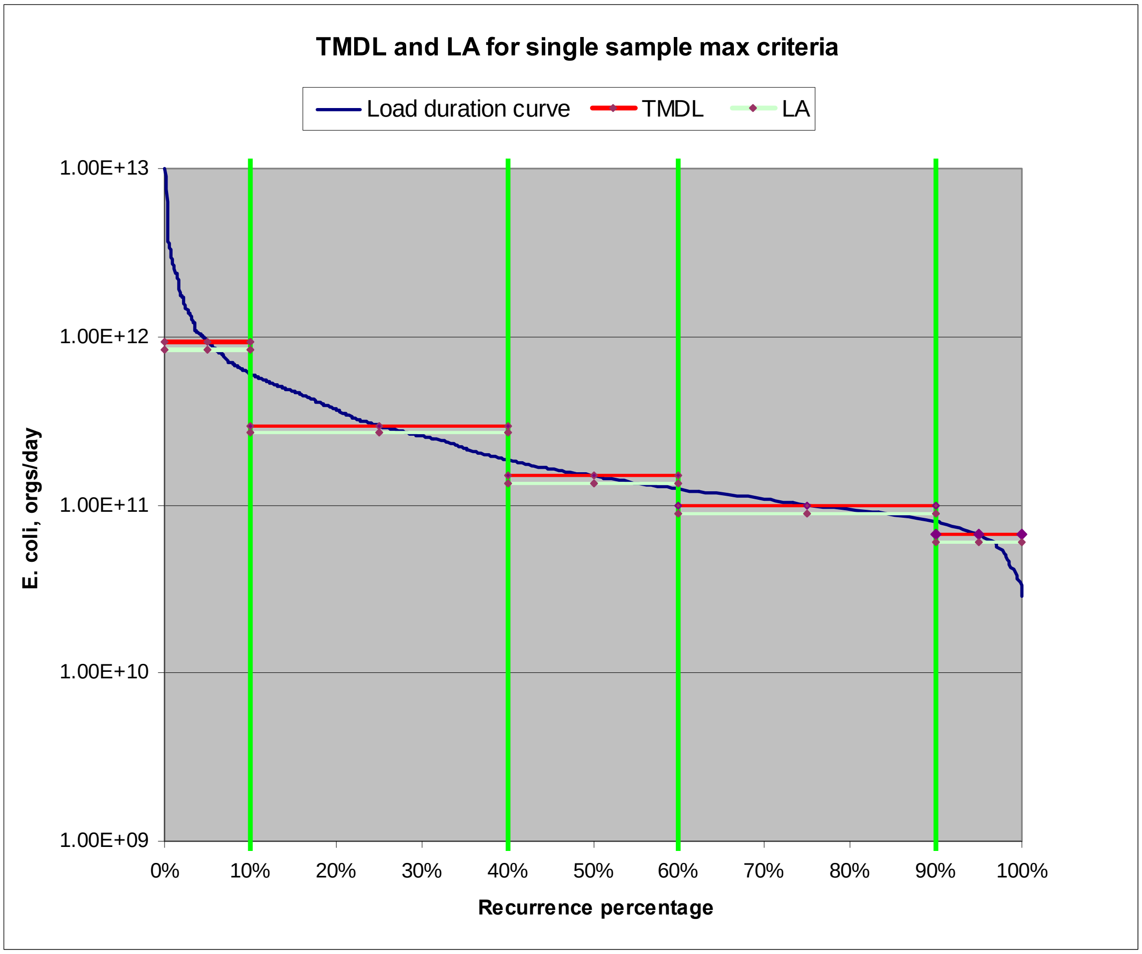

Figure 6-10 SSM TMDL at the WQS of 235 orgs/100 ml for the five flow conditions

## 6.6. Implementation Analysis

The modeled systematic reduction of the loads by source provides the initial evaluation of proposed implementation plans for the subbasin. The SWAT model has been run for five scenarios in which loads have been reduced for the most significant sources. The source analysis identified the primary source of bacteria and as cattle in the stream and field applied manure from CAFOs. Figures 6-11a and 6-11b show the SWAT model output concentrations for the stream with monitored concentrations also plotted on the chart. The target concentration of 235 *E. coli* orgs/100 ml is frequently exceeded by both monitoring data and SWAT simulated values.

The concentration scale has been shown at two different scales so that the relationship between the several high sample values, the simulated values and the target. The scale in Figure 6-11a has been set to a maximum of 120,000 orgs/100 ml and for Figure 6-11b has been set to 40,000. Even at the lower maximum the SSM target is not apparent in the chart. There are two monitoring values that exceed 120,000 orgs/100 ml (380,000, and 170,000). Event sampling done in 2009 indicates that concentrations are much higher during elevated flow than is often shown by scheduled monitoring.

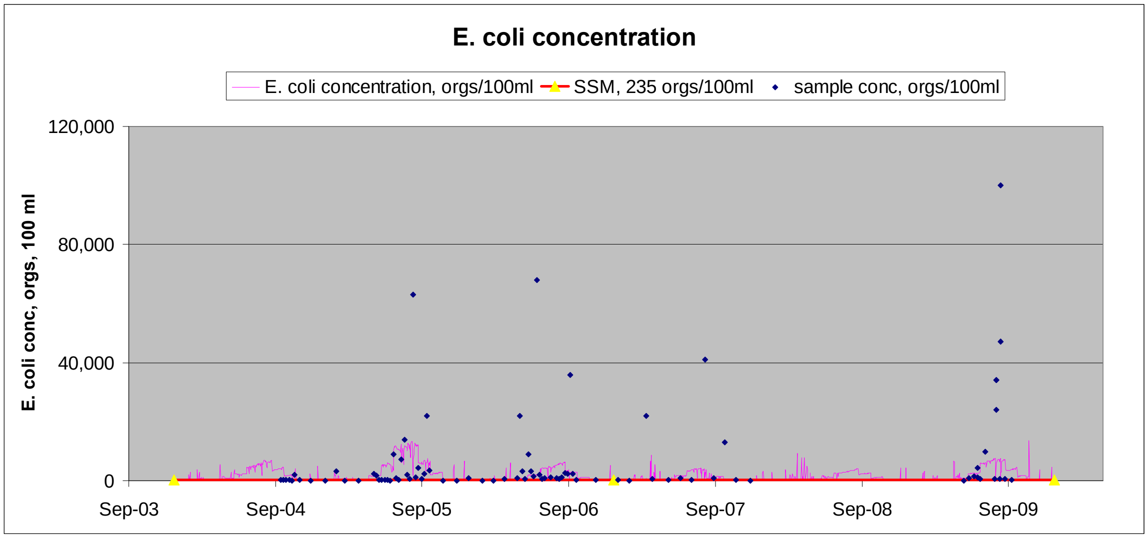

Figure 6-11a SWAT output for existing *E. coli* concentrations with the maximum concentration scale at 120,000 orgs/100 ml

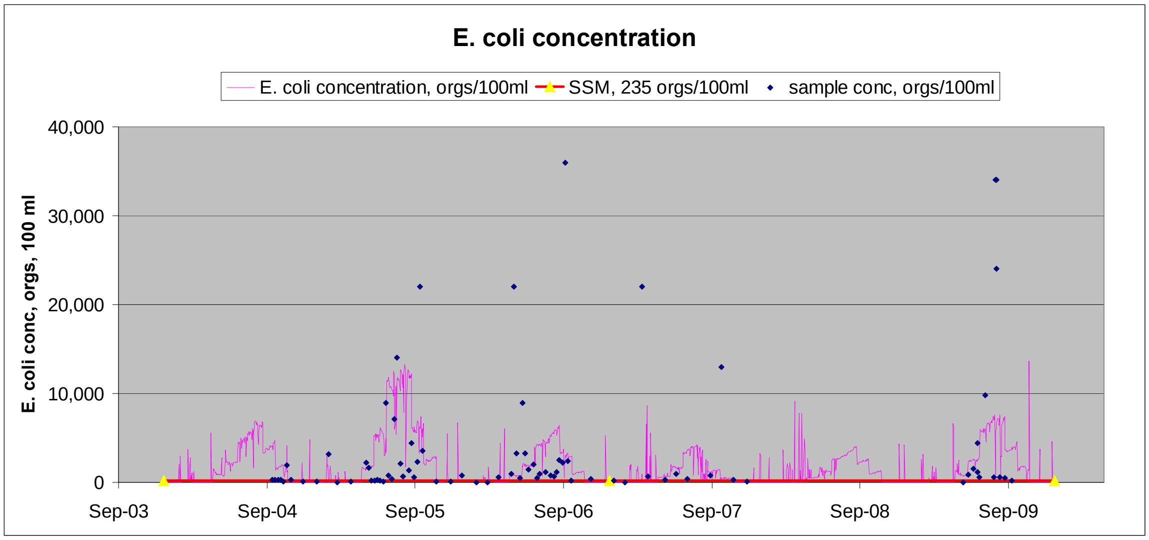

Figure 6-11b SWAT output for existing *E. coli* concentrations with the maximum concentration scale at 40,000 orgs/100ml

The second scenario, Figure 6-12, removes half of the cattle in the stream from the subbasin. This generates reduced concentrations that are higher than the SSM standard during the grazing season. The runoff related concentration spikes in all scenarios.

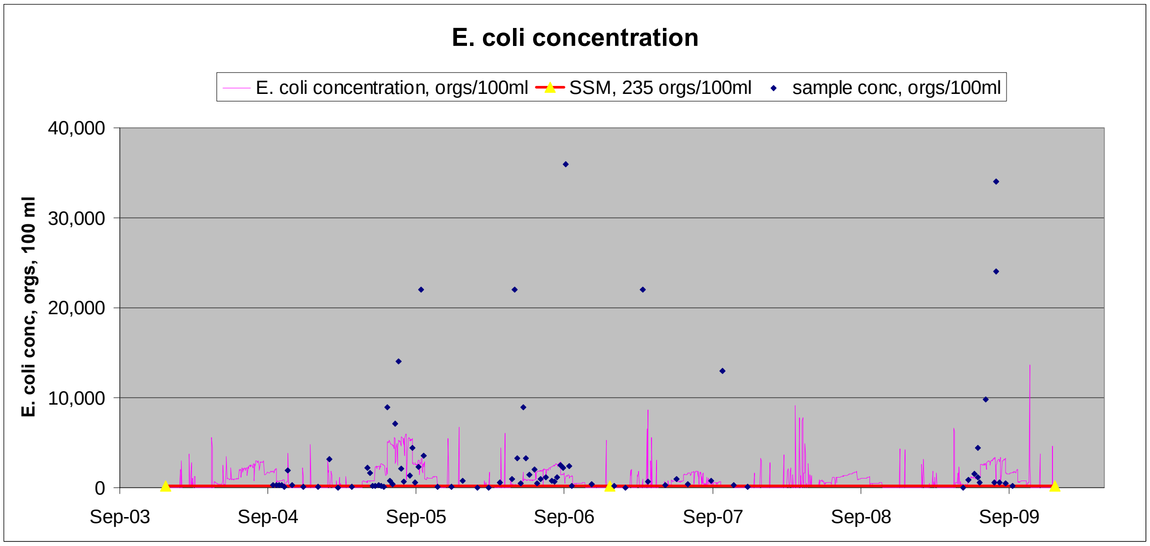

Figure 6-12 SWAT output for half reduction of CIS *E. coli* concentrations with the maximum concentration scale at 40,000 orgs/100ml

The third scenario, shown in Figures 6-13a and 6-13b, eliminates cattle in the stream as a source. This drops the concentration during the grazing season but there remain instances of high bacteria concentration from runoff. Much of this is associated with field application of manure from confined animal operations done in the spring when rain is frequent and intense. The two figures show the same simulation values at two different maximum values in the Y-axis scale.

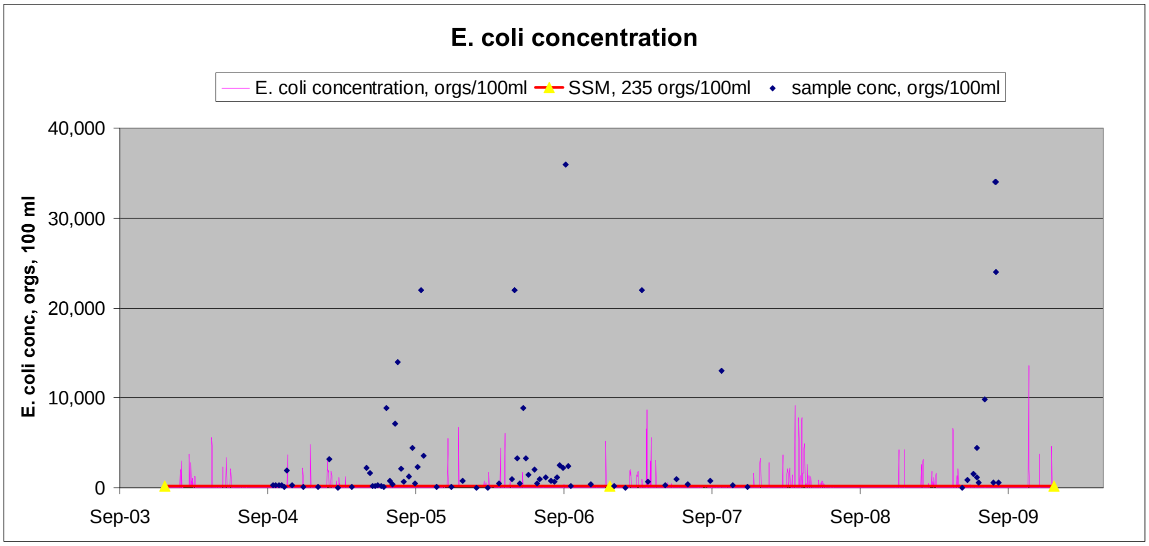

Figure 6-13a SWAT output for complete reduction of CIS *E. coli* with the concentration scale maximum set at 40,000 orgs/100 ml

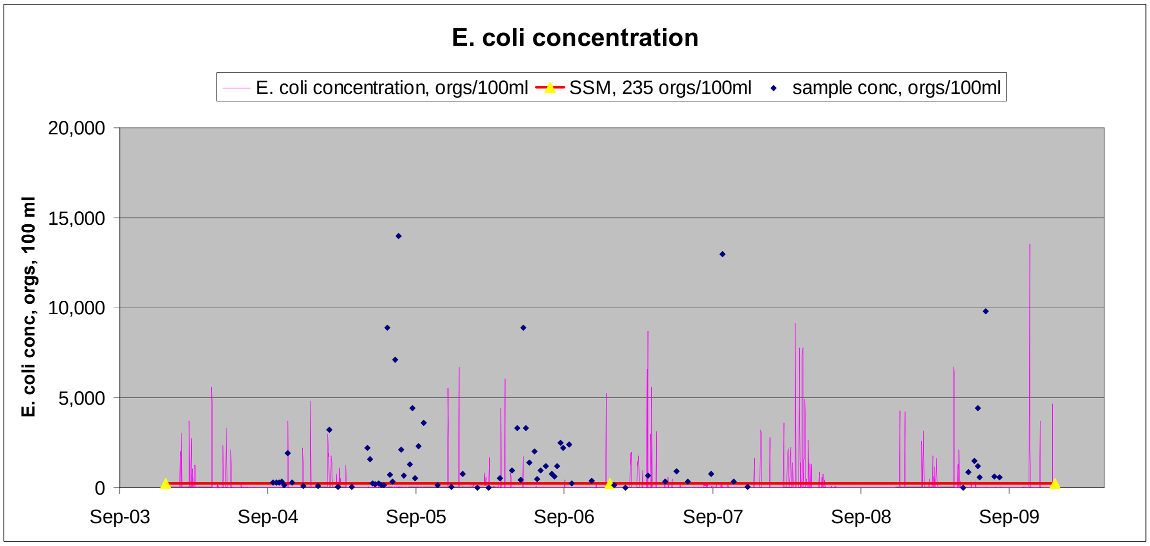

Figure 6-13b SWAT output for complete reduction of CIS *E. coli* with the concentration scale maximum set at 20,000 orgs/100 ml

The fourth scenario, shown in Figure 6-14, assumes that the field applications of manure are cut in half. This brings bacteria concentrations from these applications down some but they still exceed the target. Figure 6-13b has the same Y-axis scale maximum (20,000 orgs/100 ml) as Figures 6-14 and 6-15.

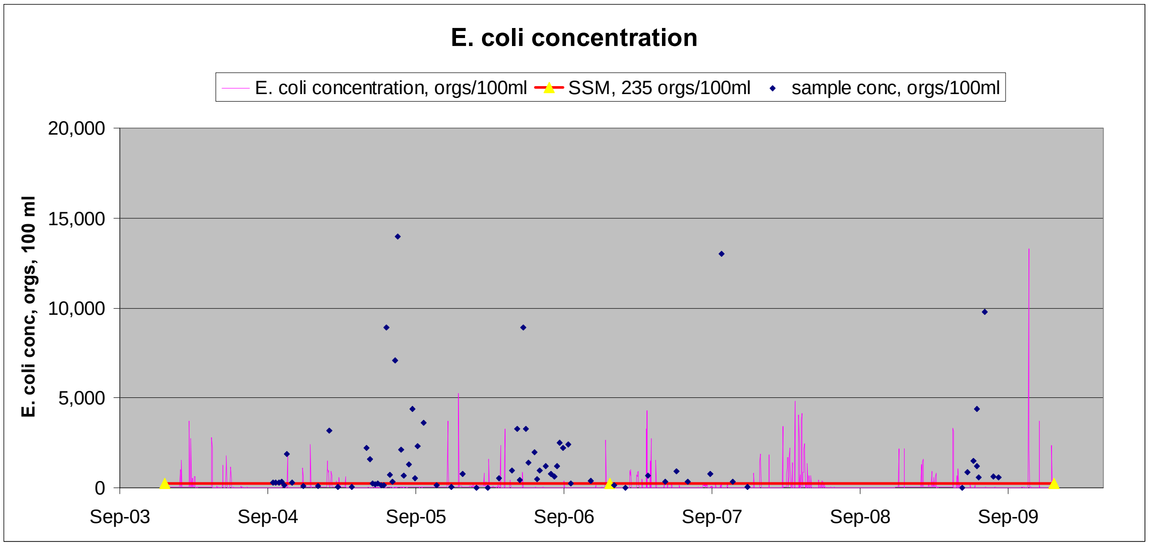

Figure 6-14 SWAT output for complete reduction of CIS *E. coli* and half of applied manure from CAFOs

The fifth scenario, shown in Figure 6-15, in addition to previous reductions, decreases the manure from cattle on pasture by two thirds. This pasture manure reduction showed a minor decrease in bacteria concentration in the stream.

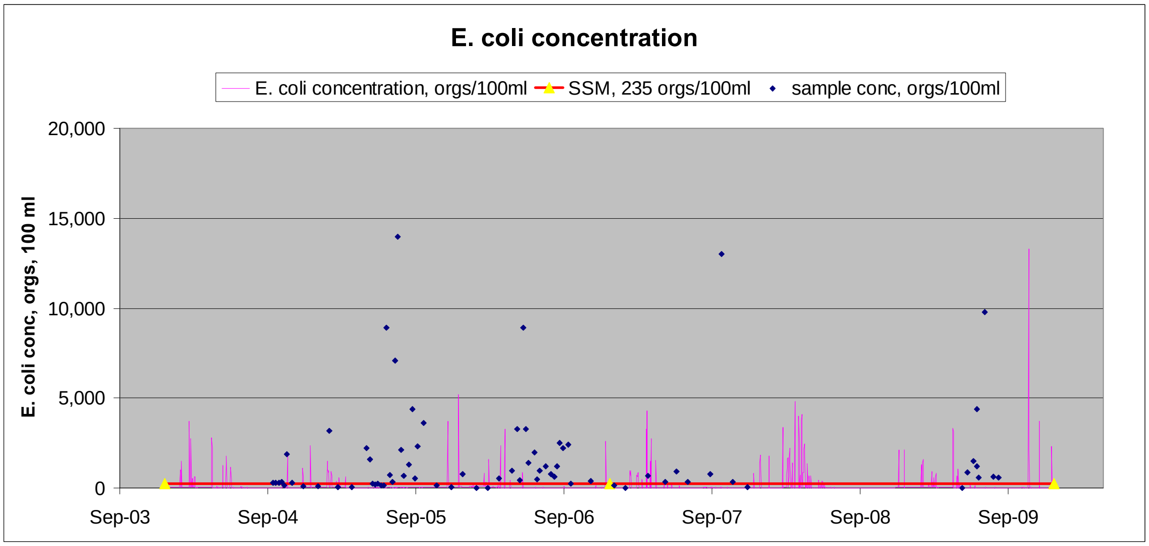

Figure 6-15 SWAT output for complete reduction of CIS *E. coli* and half of applied manure from CAFOs and a two thirds reduction of manure from cattle on pasture

There are several combinations of source reductions that can be simulated. The five scenarios described here reduce bacteria loads from the sources that have been modeled to have the greatest impact on stream outlet bacteria concentrations. The sources that are not reduced in these scenarios may have important episodic or local effect on *E. coli* organism numbers.

# 7. Yellow River 1 (0080_3)

Yellow River 1 is the monitoring location associated with the impaired segment IA 01 YEL 0080_3. It runs 5.8 miles from its confluence with the North Fork Yellow River (S13, T96N, R7W, Allamakee County) to its confluence with an unnamed tributary (SE 1/4, S8, T96N, R7W, Winneshiek County). This segment receives flow from the Yellow River Headwaters HUC 12. Figure 7-1 shows this upstream segment of the Yellow River.

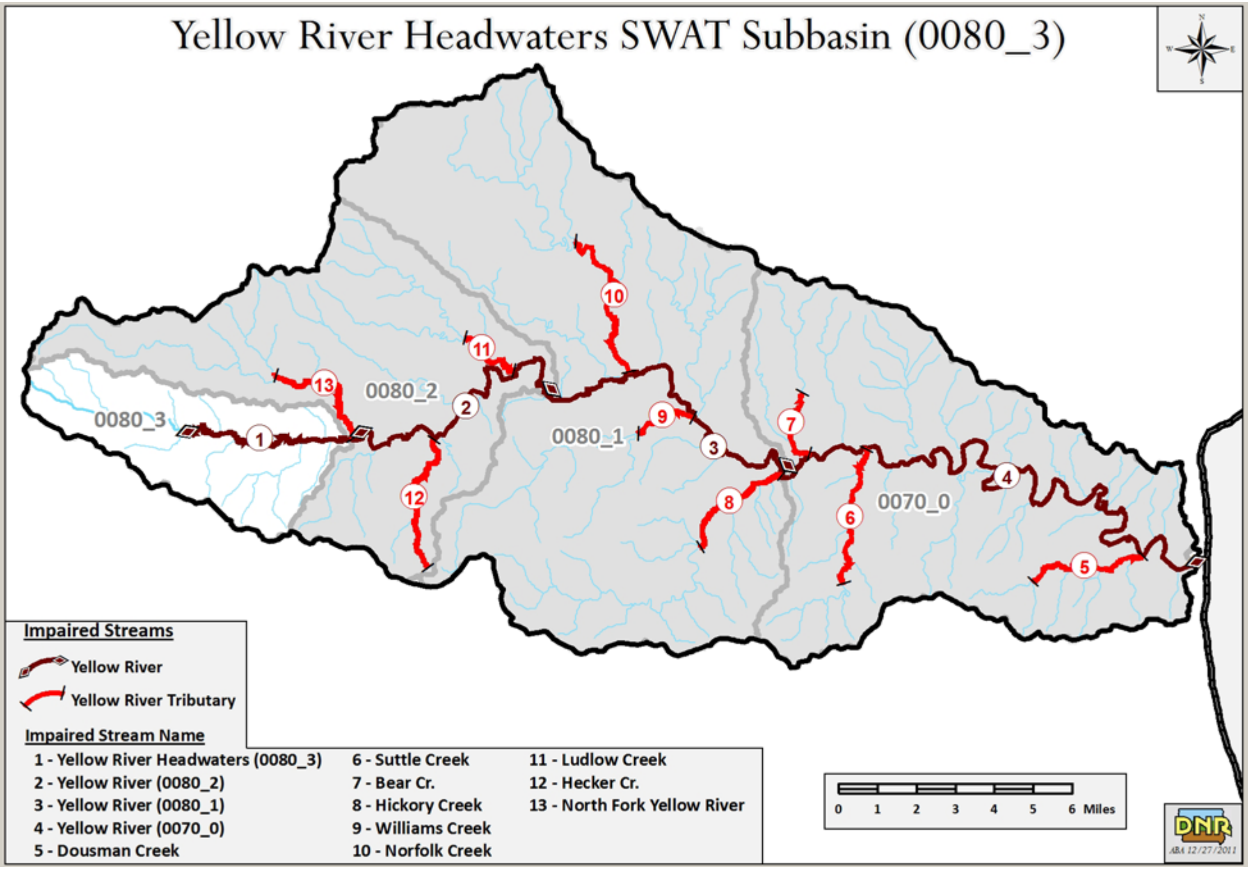

Figure 7-1 Yellow River 1 (0080_3) –SWAT Subbasin 12

There are no impaired tributaries that flow into this segment. There is one municipal wastewater treatment facility for the City of Castalia that discharges to a tributary of this segment. This facility is a controlled discharge lagoon that releases effluent at higher flows twice per year in the spring and fall. The stream flow used in the development of the TMDL for this segment is derived from the area ratio flow based on the Ion USGS gage data. A SWAT watershed model developed for the Yellow River watershed labels the headwaters segment Subbasin 12. Figure 7-2 shows a map of the Yellow River 1 segment and Table 7-1 lists the land use in its subbasin.

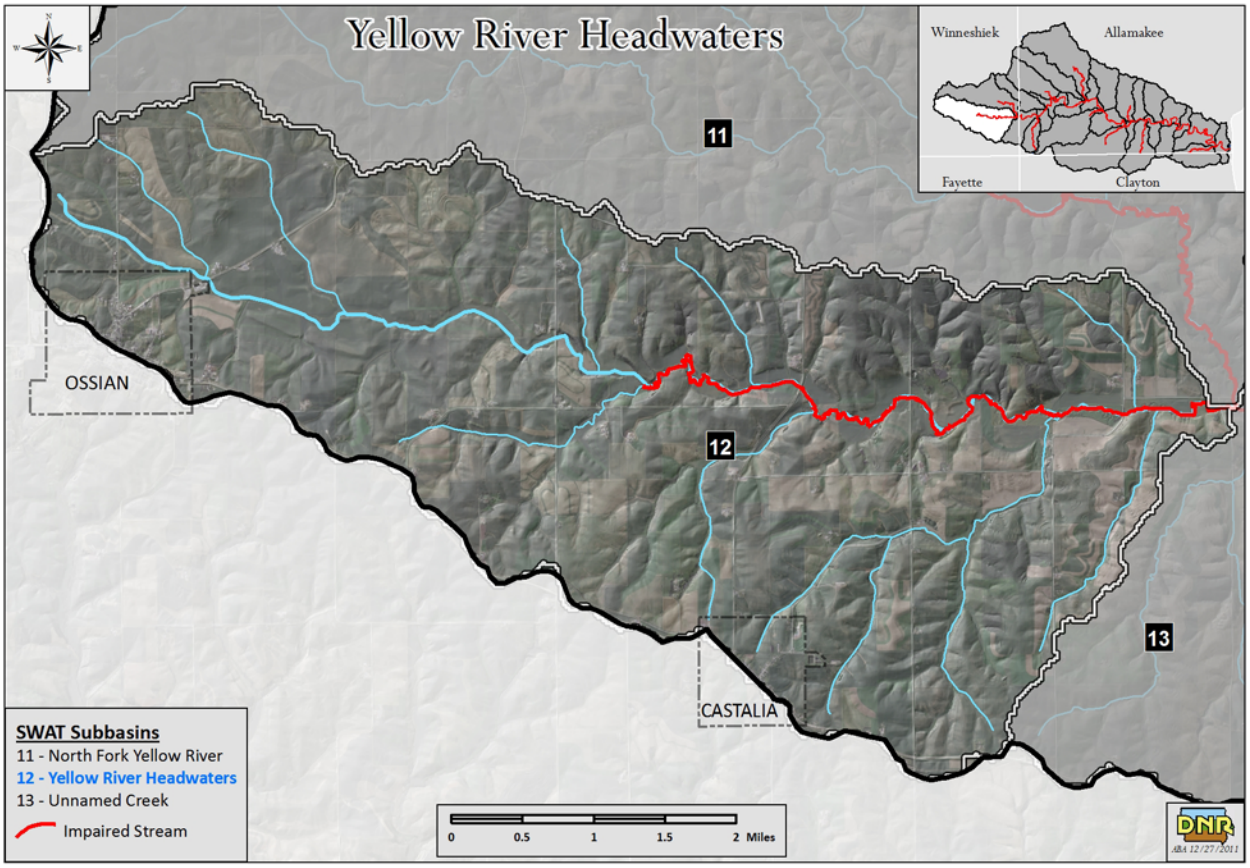

Figure 7-2 Yellow River 1 (0080_3) –SWAT Subbasin 12 – Yellow River Headwaters. The impaired segment is shown in red.

**Table 7-1 Yellow River 1 subbasin land use**

| Landuse | Area, acres | Fraction of total |
|---|---:|---:|
| Water/wetland | 0.0 | 0.00% |
| Forest | 640.3 | 4.92% |
| Ungrazed/CRP/hay | 2252.0 | 17.29% |
| Grazed | 1261.7 | 9.69% |
| Row crop | 8332.9 | 63.99% |
| Roads | 342.6 | 2.63% |
| Commercial/residential | 193.7 | 1.49% |
| **Total** | **13023.2** | **100.00%** |

In Yellow River Subbasin 12, sixty four percent of the watershed is row crop and 22 percent is forest or ungrazed grass. This subbasin consists of the Yellow River headwaters, an upland area that is heavily row cropped. There is also a significant fraction of the subbasin that is in ungrazed grassland.

### 7.1 Water body pollutant loading capacity (TMDL).

The *E. coli* organism load capacity is the number of organisms that can be in a volume and meet the water quality criteria. The loading capacity for each of the five flow conditions is calculated by multiplying the midpoint flow and *E. coli* criteria concentrations. Table 7-2 shows the median, maximum, and minimum flows for the five recurrence intervals.

### Table 7-2 Yellow River 1 maximum, minimum and median flows

| Flow description | Recurrence interval range (mid %) | Midpoint of flow range, cfs | Maximum of flow range, cfs | Minimum of flow range, cfs |
|---|---|---|---|---|
| **High flow** | **0 to 10% (5)** | 55.5 | 592.4 | 35.7 |
| **Moist conditions** | **10% to 40% (25)** | 17.5 | 35.7 | 11.0 |
| **Mid-range** | **40% to 60% (50)** | 8.7 | 11.0 | 7.3 |
| **Dry conditions** | **60% to 90% (75)** | 5.9 | 7.3 | 4.7 |
| **Low flow** | **90% to 100% (95)** | 3.9 | 4.7 | 1.7 |

Flow and load duration curves were used to establish the occurrence of water quality standards violations, to establish compliance targets, and to set pollutant allocations and margins of safety. Duration curves are derived from flows plotted as a percentage of their recurrence. *E. coli* loads are calculated from *E. coli* concentrations and flow volume at the time the sample was collected.

To construct the flow duration curves, the bacteria monitoring data and the Water Quality Standard (WQS) sample max (235 *E. coli* organisms/100 ml) were plotted with the flow duration percentile. Figure 7-3 shows the data that exceed the WQS criteria at each of the five flow conditions. High flow violations indicate that the problem occurs during run-off conditions when bacteria are washing off from nonpoint sources. Criteria exceeded during low or base flow, when little or no runoff is occurring, indicate that continuous sources such as septic tanks, livestock in the stream, riparian wildlife, and wastewater treatment plants are the problem.

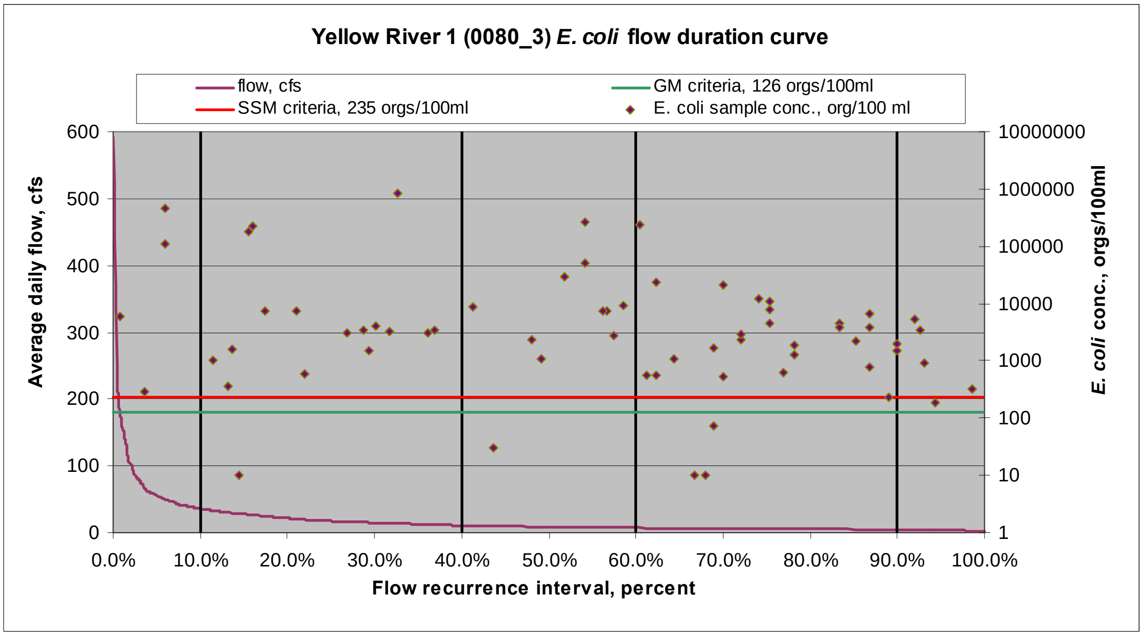

Figure 7-3 Yellow River 1 flow duration curve

Load duration curves were used to evaluate the five flow conditions for this segment. The load duration curve is shown in Figure 7-4. In the figure, the lower curve shows the maximum *E. coli* count for the GM criteria and the upper curve shows the maximum *E. coli* count for the SSM criteria at a continuum of flow recurrence percentage. The individual points are the observed (monitored) *E. coli* concentrations converted to loads based on average daily flow for the day they were collected. Points above the load duration curves are violations of the WQS criteria and exceed the loading capacity.

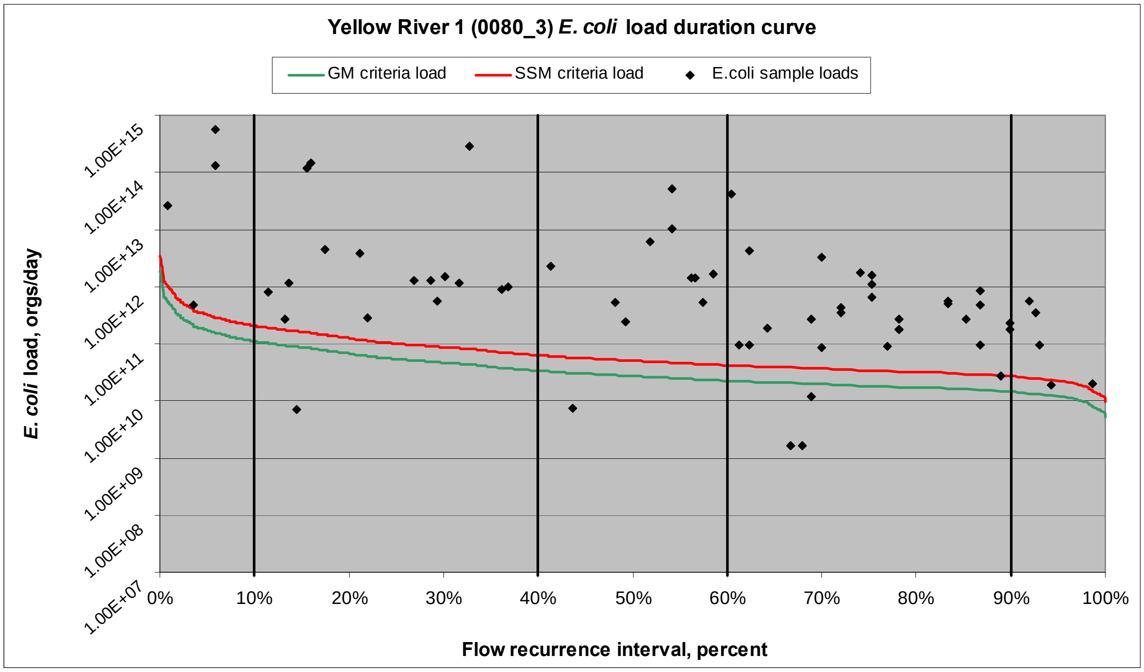

Figure 7-4 Yellow River 1, load duration curve

Tables 7-3 and 7-4 show the load capacities (targets) for each of the midpoint flow conditions at the GM and SSM criteria, respectively.

### Table 7-3 Yellow River 1, GM load capacity

| Flow condition | Recurrence interval | Associated midpoint flow, cfs | Estimated flow interval load capacity, *E. coli* orgs/day |
|---|---|---|---|
| **High flow** | **0 to 10%** | 55.5 | 1.7E+11 |
| **Moist conditions** | **10% to 40%** | 17.5 | 5.4E+10 |
| **Mid-range** | **40% to 60%** | 8.7 | 2.7E+10 |
| **Dry conditions** | **60% to 90%** | 5.9 | 1.8E+10 |
| **Low flow** | **90% to 100%** | 3.9 | 1.2E+10 |

### Table 7-4 Yellow River 1, SSM load capacity

| Flow condition | Recurrence interval | Associated midpoint flow, cfs | Estimated flow interval load capacity, *E. coli* orgs/day |
|---|---|---|---|
| **High flow** | **0 to 10%** | 55.5 | 3.2E+11 |
| **Moist conditions** | **10% to 40%** | 17.5 | 1.0E+11 |
| **Mid-range** | **40% to 60%** | 8.7 | 5.0E+10 |
| **Dry conditions** | **60% to 90%** | 5.9 | 3.4E+10 |
| **Low flow** | **90% to 100%** | 3.9 | 2.2E+10 |

## 7.2. Existing load

The existing loads are derived from the sampling data collected at Yellow River 1. These data are the sample values shown in the flow and load duration curves. The *E. coli* concentrations are multiplied by the simulated daily flow to get the daily loads. The daily loads are plotted with the load duration curves. The allowable loads for a given flow equal the flow multiplied by the WQS limits for the geometric mean or single sample maximum. Monitored data that exceed the limits are above the criteria curves.

The maximum existing loads occur during major rains when runoff and bacteria concentrations are highest. Concentrations exceed the criteria during these high flow events. Other conditions leading to criteria violations occur during dry low flow periods when continuous loads from livestock in the stream, local wildlife, septic tanks, and wastewater treatment plants can cause bacteria problems.

The assessment standard used to evaluate streams is the *E. coli* geometric mean criteria. Since the load duration approach precludes the calculation of a geometric mean, the 90th percentile of observed concentrations within each flow condition is multiplied by the median flow to estimate existing loads. This procedure has been used to evaluate impaired segments. Table 7-5 shows the existing loads for each flow condition.

### Table 7-5 Yellow River 1, existing loads

| Flow condition, percent recurrence | Recurrence interval range (mid %) | Associated median flow, cfs | Existing 90th percentile *E. coli* conc., org/100ml | Estimated existing load, *E. coli* org/day |
|---|---|---|---|---|
| **High flows** | **0 to 10% (5)** | 55.5 | 348000 | 4.73E+14 |
| **Moist conditions** | **10% to 40% (25)** | 17.5 | 196000 | 8.39E+13 |
| **Mid-range** | **40% to 60% (50)** | 8.7 | 52000 | 1.11E+13 |
| **Dry conditions** | **60% to 90% (75)** | 5.9 | 12900 | 1.85E+12 |
| **Low flow** | **90% to 100% (95)** | 3.9 | 4540 | 4.34E+11 |

*Identification of pollutant sources.*

The sources of bacteria in the Yellow River headwaters subbasin (SWAT subbasin 12) are nonpoint sources including failed septic tank systems, pastured cattle, cattle in the stream, wildlife, and manure applied to fields from animal confinement operations. The loads from these sources are incorporated into the SWAT watershed model and are listed in Tables 7-6 to 7-10.

<u>Non functional septic tank systems</u>. There are about 95 onsite septic tank systems in the subbasin (2.5 persons/household). IDNR estimates that 50 percent are not functioning properly. It is assumed that these are continuous year round discharges. Septic tank loads have been put into the SWAT model as a continuous point source by subbasin.

### Table 7-6 Yellow River 1 headwaters septic tank system E. coli orgs/day

| | |
|---|---:|
| Population of Yellow River headwaters | 237 |
| Total initial E.coli, orgs/day [1] | 2.96E+11 |
| Septic tank flow, $m^3$/day [2] | 62.8 |
| **E. coli delivered to stream, orgs/day [3]** | **1.96E+08** |

1. Assumes 1.25E+09 E. coli orgs/day per capita
2. Assumes 70 gallons/day/capita
3. Assumes septic discharge concentration reaching stream is 625 orgs/100 ml and a 50% failure rate

Cattle in stream. Of the 680 cattle in pastures with stream access, one to six percent of those are assumed to be in the stream on a given day. The number on pasture and the fraction in the stream varies by month. Cattle in the stream have a high potential to deliver bacteria since bacteria are deposited directly in the stream with or without rainfall. Subbasin cattle in the stream bacteria have been put in the SWAT model as a continuous point source varying by month.

### Table 7-7 Yellow River 1 cattle in the stream E. coli orgs/day

| | |
|---|---:|
| Pasture area with stream access, acre[1] | 871 |
| Number of cattle in stream/day[2] | 41 |
| Dry manure, kg/day[3] | 126 |
| **E. coli load, orgs/day[4]** | **1.67E+12** |

1. The subbasin CIS are estimated from the pasture area with stream access at 0.78 cattle/acre.
2. It is estimated that cattle spend 6% of their time in streams in July and August, 3% in June and September, and 1% in May and October. The loads shown in this table are for July and August. The loads for the other 4 months when cattle are in streams have been incorporated into the SWAT modeling.
3. Cattle generate 3.1 kg/head/day of dry manure.
4. Manure has 1.32E+07 E. coli orgs/gram dry manure.

Grazing livestock. The number of cattle in the subbasin is estimated to be 680 and that the cattle are on pasture from May to November. The potential for the delivery of bacteria to the stream occurs with precipitation causing runoff. Manure available for washoff is put in the SWAT model at 6 kg/ha in the pasture HRU's.

### Table 7-8 Yellow River 1 manure from pastured cattle, maximum E. coli available for washoff, orgs/day

| | |
|---|---:|
| Pasture area, acres | 1269 |
| Number of cattle on pasture[1] | 949 |
| Dry manure, kg/day[2] | 2943 |
| Maximum E. coli load, orgs/day[3] | 3.88E+13 |
| Maximum E. coli available for washoff, orgs[4] | 6.99E+13 |

1. The number of pastured cattle is 0.78 cattle/acre.
2. Cattle generate 3.1 kg/head/day of dry manure.
3. Manure has 1.32E+07 E. coli orgs/gram dry manure
4. The load available for washoff is the daily load times 1.8.

Wildlife manure. The number of deer in Allamakee County is about 9,000 located primarily in forested land adjacent to streams. Another 1,000 have been added to account for other wildlife such as raccoons and waterfowl for a total estimate of 10,000. This works out to 0.024 deer per acre. The area of the Yellow River headwater subbasin is 13,023 acres for a total of 313 deer. In the subbasin the deer are assumed to be concentrated in the ungrazed grassland and are in the subbasin year round.

### Table 7-9 Yellow River 1 wildlife manure loads available for washoff

| Number of deer[1] | Grassland area, ha | SWAT manure loading rate, kg/ha/day[2] | Total E. coli available for washoff, orgs[3] |
|---|---|---|---|
| 313 | 305 | 1.48 | 2.81E+11 |

1. Deer numbers are 0.059 deer/ha (2.47 acre per ha) for the entire subbasin concentrated to 1.025 deer/ha in the forest land use. All wildlife loads are applied to the forest landuse in the SWAT model. The county deer numbers have been increased by 10% to account for other wildlife in the subbasin.
2. Assumes 1.44 kg/deer/day and 3.47E+05 orgs/gram.
3. Assumes that the maximum E. coli available for washoff is 1.8 times the daily load.

Field applications of CAFO manure.

There are about 4,000 swine in confinement in the subbasin. The manure is stored and land applied to cropland. The manure is distributed to the fields in the subbasin in the fall after soybean harvest and in the spring prior to corn planting in year 2 of a two year rotation. The relatively brief fall and spring timing of manure application and incorporation in the soil significantly reduces the *E. coli* organisms from these sources. Manure application has been entered in the SWAT model by subbasin as a load available at the end of October and the beginning of April.

### Table 7-10 Yellow River 1 confined livestock manure applications

| Livestock type | Swine | Chickens | Dairy cows |
|---|---|---|---|
| Number of animals | 4,000 | 0 | 0 |
| Manure applied, kg/application[1] | 1,649,800 | 0 | 0 |
| Application area, acres[2] | 194 | 0 | 0 |
| Manure applied, kg/ha/day[3] | 2,127 | 0 | 0 |
| Subbasin E. coli, orgs/day | 4.41E+14 | 0 | 0 |
| Subbasin E. coli available for washoff, orgs/day[4] | 7.94E+14 | 0 | 0 |

1. Manure is calculated based on number of animals * dry manure (kg/animal/day)*365 days/year.
2. The area the manure is applied to is based on the manure's nitrogen content. Manure is applied at a rate equivalent to 201.6 kg N/ha/yr. Swine manure is applied at 2127 kg/ha, dairy manure at 2631 kg/ha and chicken manure at 2326 kg/ha. The E. coli content of manure for swine is 1.32E+07 orgs/gram, for dairy cows is 1.00E+07 orgs/gram, and for chickens is 2.96E+06 orgs/gram.
3. Manure is assumed to be applied to fields twice a two year rotation year on October 30 and April 1. It is incorporated in the soil and it is assumed that only 10% of bacteria are viable and available after storage and incorporation.
4. Maximum E. coli available for washoff are 1.8 times the daily maximum available load.

Seasonal variation of sources.

The relative impacts of the bacteria sources are shown in Figures 7-5 and 7-6. Figure 7-5 shows the relative loads delivered by the "continuous" sources, those sources present with or without rainfall and runoff. These are the failed septics that are assumed to be a problem every day of the year and the loads from cattle in the stream that vary by month from May to October. It can be seen in this figure that the impacts from cattle in the stream are much more significant than those from failed septic tank systems.

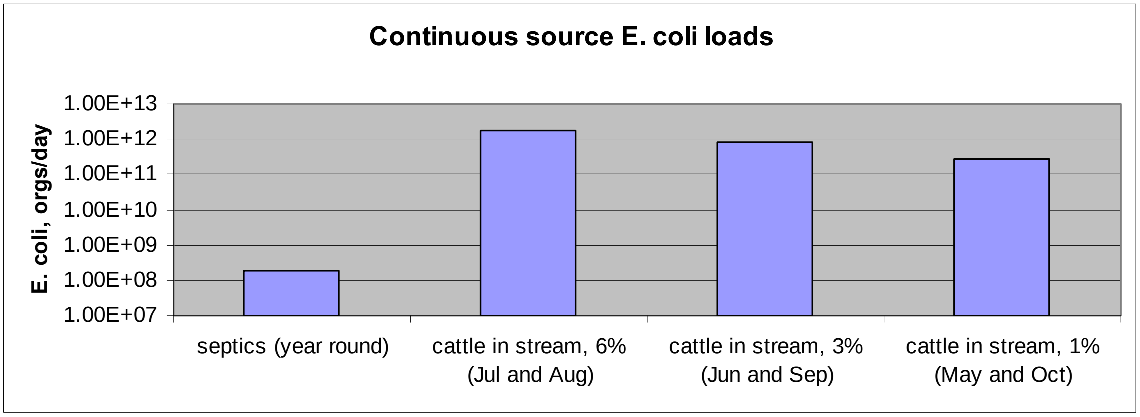

Figure 7-5 E. coli loads from "continuous" sources

The three general washoff sources of bacteria in the subbasin are shown in Figure 7-6. The wildlife source consists primarily of deer and smaller animals such as raccoons and waterfowl. These are year round sources. Pastured cattle consist of grazing cattle and small poorly managed feedlot-like operations. The grazing season is modeled as lasting 168 days starting May 1. Manure from confined animal feeding operations (CAFO) is applied to cropland twice a year for a relatively brief time assumed to be a few days. Most field applied manure is assumed to be incorporated into the soil and most bacteria in it are not available. Confinement animals are swine, chickens and dairy cattle.

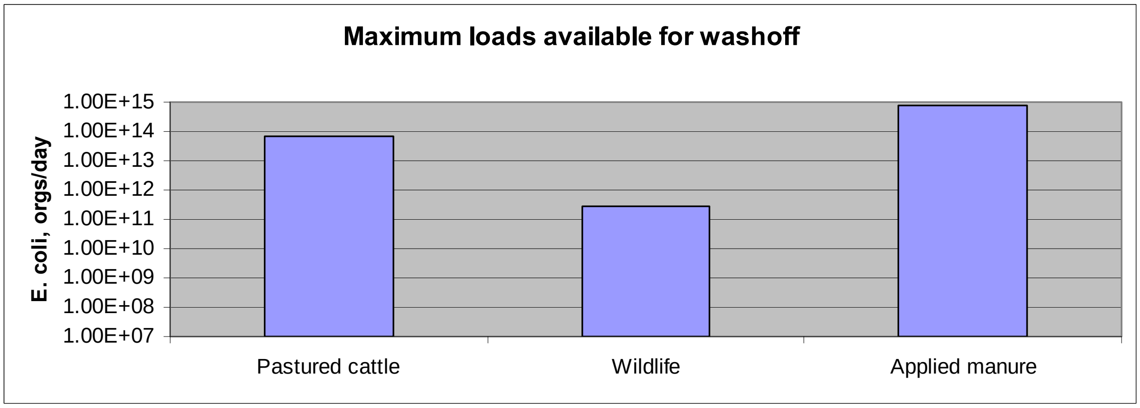

Figure 7-6 Maximum E. coli loads available for washoff

The maximum bacteria load to the stream occurs when the continuous source load plus the precipitation driven washoff load are combined. In general, the more rainfall the higher the flow rate and the more elevated the concentration. High flow rate and elevated concentration equal peak loads. The potential maximum load based on this analysis is 7.02E+13 orgs/day available for washoff plus the continuous load of 1.67E+12 orgs/day in July and August for a total of 7.19E+13 orgs/day.

Flow interval load source analysis. Based on the load duration curve analysis the maximum existing load occurring during the zero to forty percent recurrence interval runoff conditions is 1.18E+14 orgs/day and the total available load based on the potential sources, including fall and spring manure applications, is 8.64E+14 orgs/day. Generally the maximum load in the stream, delivered in April when runoff is occurring, is approximately fourteen percent of the bacteria available for washoff. At the zero to ten percent maximum existing load of 4.73E+14 and the same load available for washoff, the stream load is fifty-five percent of the available loads.

## 7.3. Departure from load capacity

The departure from load capacity is the difference between the existing load and the load capacity. This varies for each of the five flow conditions. Table 7-11 shows this difference. The existing and target loads for the five flow conditions are shown graphically in Figure 7-7.

**Table 7-11 Yellow River 1, departure from load capacity**

| Design flow condition, percent recurrence | Recurrence interval range (mid %) | Existing *E. coli* orgs/day | Load capacity, orgs/day | Departure from capacity, orgs/day |
|---|---|---|---|---|
| **High flow** | **0 to 10% (5)** | 4.73E+14 | 3.2E+11 | 4.72E+14 |
| **Moist conditions** | **10% to 40% (25)** | 8.39E+13 | 1.0E+11 | 8.38E+13 |
| **Mid-range flow** | **40% to 60% (50)** | 1.11E+13 | 5.0E+10 | 1.11E+13 |
| **Dry conditions** | **60% to 90% (75)** | 1.85E+12 | 3.4E+10 | 1.82E+12 |
| **Low flow** | **90% to 100% (95)** | 4.34E+11 | 2.2E+10 | 4.11E+11 |

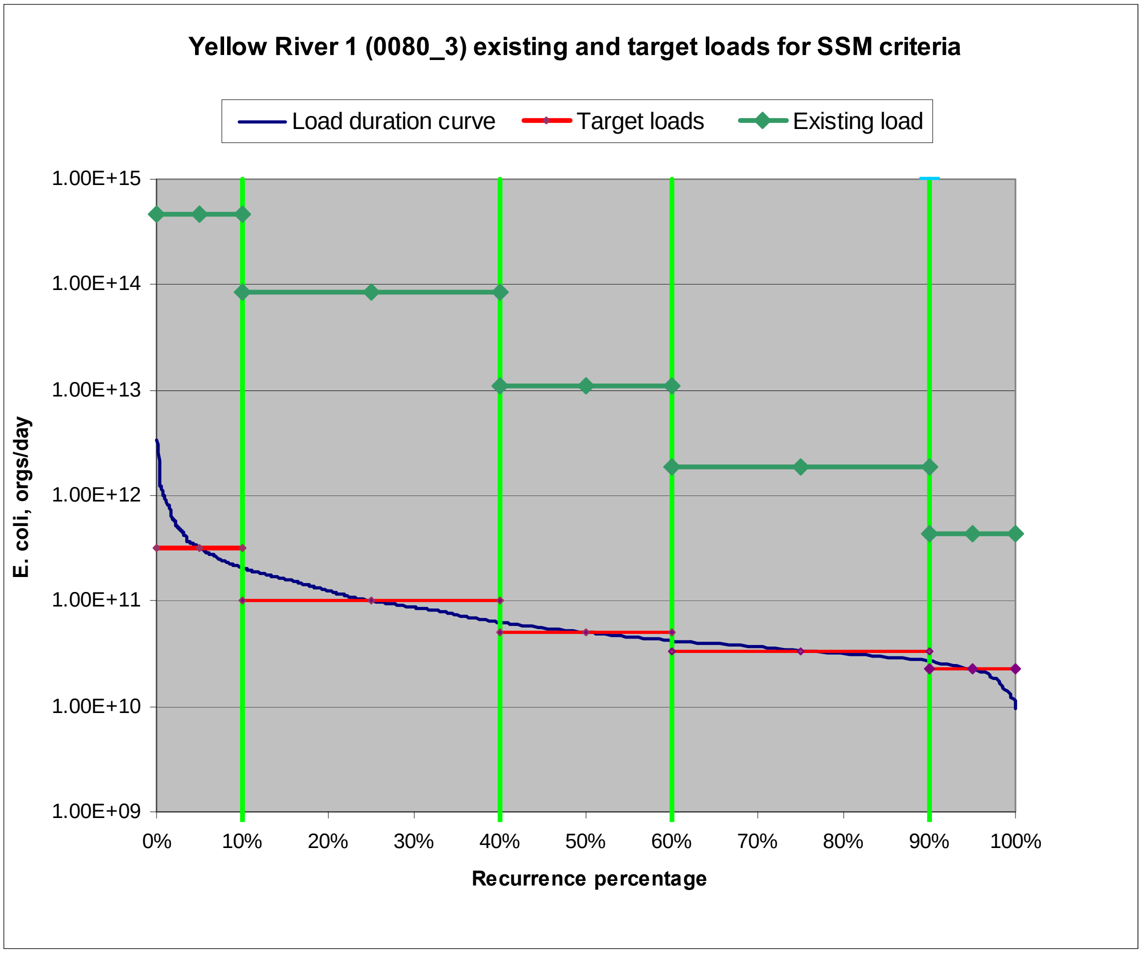

Figure 7-7 Difference between existing and target loads

## 7.4. Pollutant Allocations

*Wasteload allocations.*

The wasteload allocations for the Castalia municipal wastewater treatment facility that discharges to an unnamed tributary to the Yellow River are shown in Table 3-6 and again in Tables 7-12 and 7-13 which show the GM and SSM TMDL calculations. It is currently assumed that all of the wastewater treatment plants in the watershed discharge to a Class A1 stream. The wasteload allocations for the discharges are the Class A1 *E. coli* water quality standards, a geometric mean (GM) of 126-organisms/100 ml and a single sample maximum (SSM) of 235-organisms/100 ml. These concentration criteria have been multiplied by the 180day average wet weather (AWW) flow divided by ten to mimic the episodic and controlled discharge.

*Load allocation.*

The load allocations for *E. coli* TMDLs are the load capacity less an explicit 10 percent margin of safety (MOS) less the total WLA for the flow condition for the geometric mean or single sample maximum. There is a separate load allocation set for each of the target recurrence intervals. The load allocations are shown in Tables 7-12 and 7-13.

### Table 7-12 Yellow River IA 01-YEL-0080-3 GM *E. coli* load allocations

| Flow condition, percent recurrence | GM target (TMDL) *E. Coli*, orgs/day | GM MOS *E. Coli*, orgs/day | Total WLA GM *E. coli*, orgs/day | LA GM *E. coli*, orgs/day |
|---|---|---|---|---|
| **High flows** | 1.7E+11 | 1.7E+10 | 1.56E+09 | 1.5E+11 |
| **Moist conditions** | 5.4E+10 | 5.4E+09 | 1.56E+09 | 4.7E+10 |
| **Mid-range flow** | 2.7E+10 | 2.7E+09 | 1.56E+09 | 2.3E+10 |
| **Dry conditions** | 1.8E+10 | 1.8E+09 | 1.56E+09 | 1.5E+10 |
| **Low flow** | 1.2E+10 | 1.2E+09 | 1.56E+09 | 9.3E+09 |

1. Based on geometric mean standard of 126 *E. coli* organisms/100 ml

### Table 7-13 Yellow River IA 01-YEL-0080-3 SSM *E. coli* load allocations

| Flow condition, percent recurrence | SSM target (TMDL) *E. Coli*, orgs/day | SSM MOS *E. Coli*, orgs/day | Total WLA SSM *E. coli*, orgs/day | LA SSM *E. coli*, orgs/day |
|---|---|---|---|---|
| **High flow** | 3.2E+11 | 3.2E+10 | 2.91E+09 | 2.8E+11 |
| **Moist conditions** | 1.0E+11 | 1.0E+10 | 2.91E+09 | 8.8E+10 |
| **Mid-range flow** | 5.0E+10 | 5.0E+09 | 2.91E+09 | 4.2E+10 |
| **Dry conditions** | 3.4E+10 | 3.4E+09 | 2.91E+09 | 2.7E+10 |
| **Low flow** | 2.2E+10 | 2.2E+09 | 2.91E+09 | 1.7E+10 |

1. Based on single sample maximum standard of 235 *E. coli* organisms/100 ml

*Margin of safety.*

The margin of safety for *E. coli* is an explicit 10 percent of the load capacity at each of the design recurrence intervals as shown in Tables 7-12 and 7-13.

## 7.5. TMDL Summary

The following equation shows the total maximum daily load (TMDL) and its components for the impaired IA 01-YEL-0080-3 segment of the Yellow River.

**Total Maximum Daily Load = Σ Load Allocations + Σ Wasteload Allocations +MOS**

A Total Maximum Daily Load calculation has been made at design flow conditions for the GM and SSM of this segment and these are shown in Tables 7-14 and 7-15 and Figures 7-8 and 7-9.

### Table 7-14 Yellow River IA 01-YEL-0080-3 *E. coli* TMDL for GM

| Flow condition | Σ LA, orgs/day | Σ WLA, orgs/day | MOS, orgs/day | TMDL, orgs/day |
|---|---|---|---|---|
| **High flow** | 1.5E+11 | 1.56E+09 | 1.7E+10 | 1.7E+11 |
| **Moist condition** | 4.7E+10 | 1.56E+09 | 5.4E+09 | 5.4E+10 |
| **Mid-range flow** | 2.3E+10 | 1.56E+09 | 2.7E+09 | 2.7E+10 |
| **Dry conditions** | 1.5E+10 | 1.56E+09 | 1.8E+09 | 1.8E+10 |
| **Low flow** | 9.3E+09 | 1.56E+09 | 1.2E+09 | 1.2E+10 |

Figure 7-8 GM TMDL at WQS of 126 orgs/100 ml for the five flow conditions

**Table 7-15 Yellow River IA 01-YEL-0080-3 *E. coli* TMDL for SSM**

| Flow condition | Σ LA, orgs/day | Σ WLA, orgs/day | MOS, orgs/day | TMDL, orgs/day |
|---|---|---|---|---|
| High flow | 2.8E+11 | 2.91E+09 | 3.2E+10 | 3.2E+11 |
| Moist condition | 8.8E+10 | 2.91E+09 | 1.0E+10 | 1.0E+11 |
| Mid-range flow | 4.2E+10 | 2.91E+09 | 5.0E+09 | 5.0E+10 |
| Dry conditions | 2.7E+10 | 2.91E+09 | 3.4E+09 | 3.4E+10 |
| Low flow | 1.7E+10 | 2.91E+09 | 2.2E+09 | 2.2E+10 |

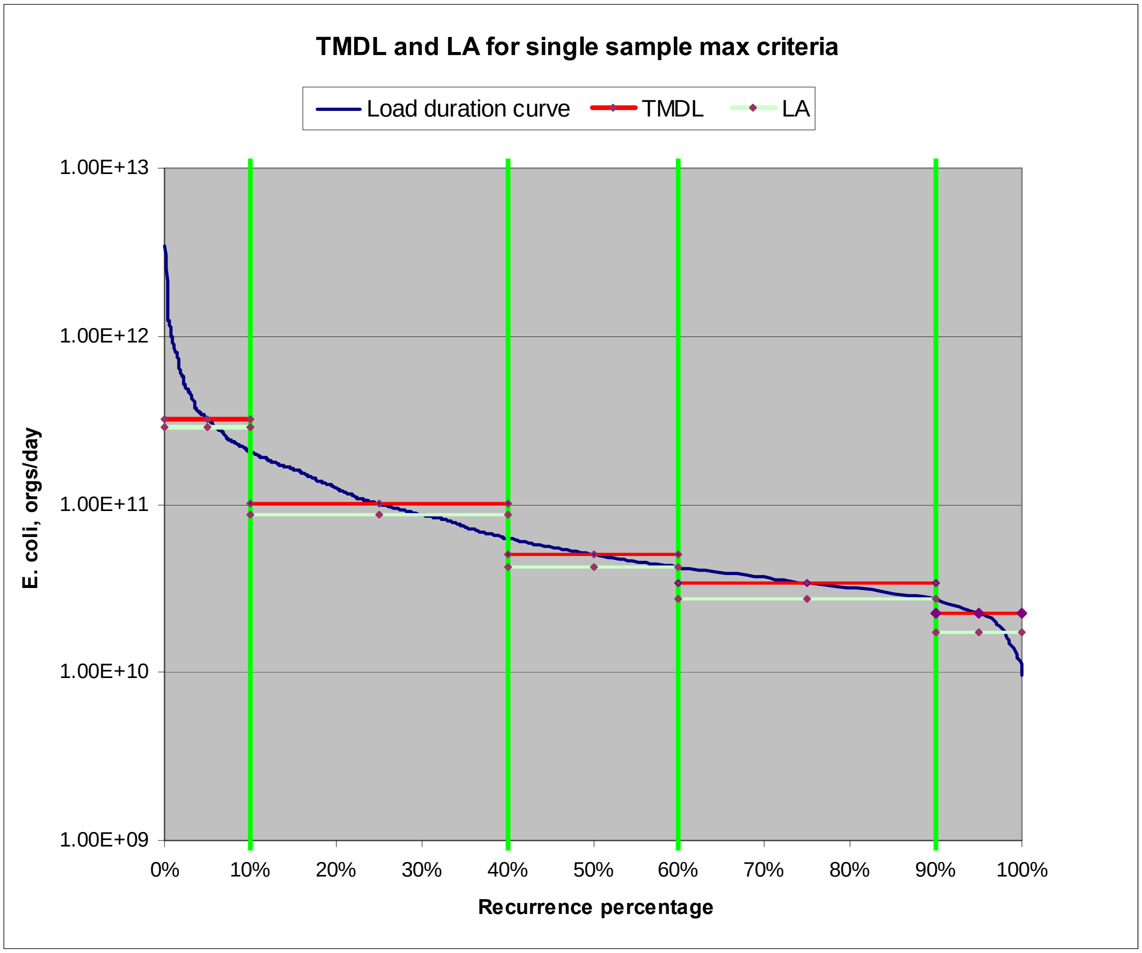

Figure 7-9 SSM TMDL at the WQS of 235 orgs/100 ml for the five flow conditions

## 7.6. Implementation Analysis

The modeled systematic reduction of the loads by source provides the initial evaluation of proposed implementation plans for the subbasin. The SWAT model has been run in five scenarios in which loads have been reduced for the most significant sources. The source analysis identified the primary source of bacteria and as cattle in the stream and field applied manure from CAFOs. Figure 7-10 shows the first scenario SWAT model output concentrations for the stream. Monitored concentrations are also plotted on the chart. The target concentration of 235 E. coli orgs/100 ml is frequently exceeded by both monitored data and SWAT simulated values.

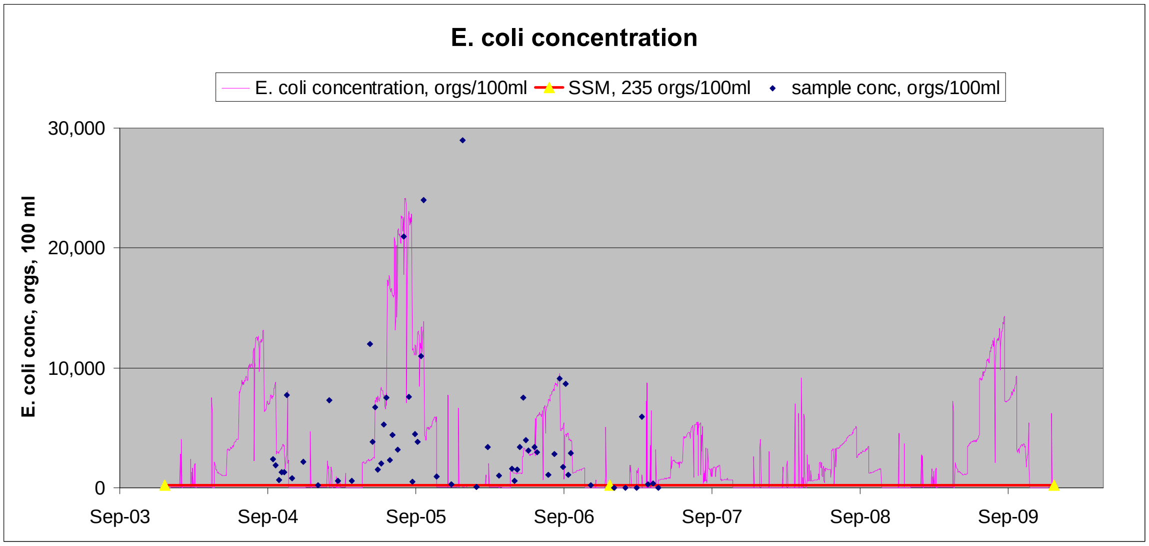

Figure 7-10 SWAT Scenario 1 output for existing E. coli concentrations

The second scenario, shown in Figure 7-11, removes half of the cattle in the stream from the subbasin. This generates concentrations that are much lower but that are still very high compared to the SSM standard.

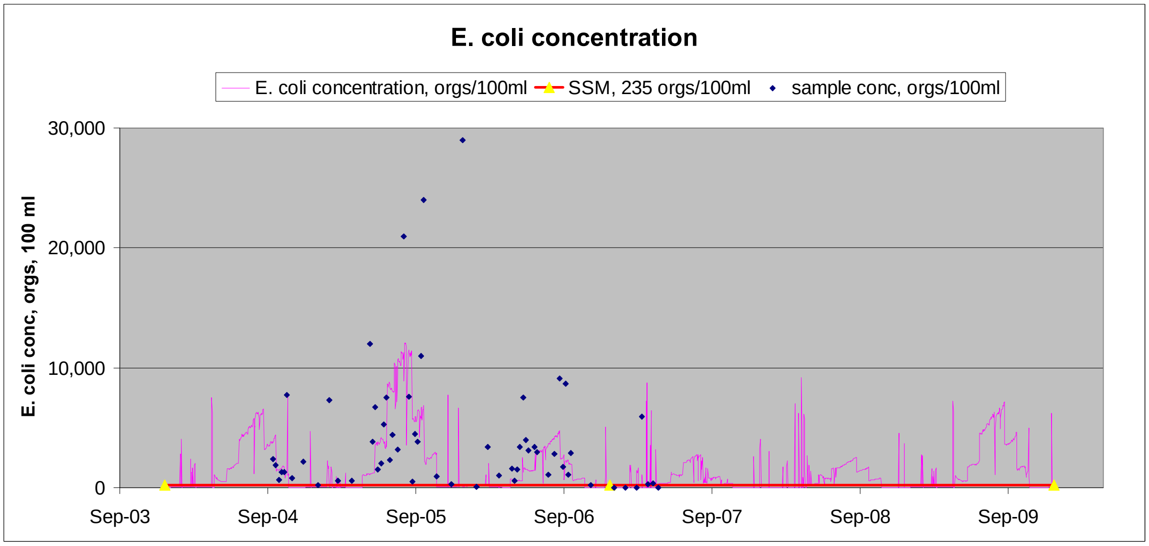

Figure 7-11 SWAT Scenario 2 output for half reduction of CIS E. coli concentrations

The third scenario, shown in Figure 7-12, eliminates cattle in the stream altogether as a source. This drops the concentration during the grazing season but there remain quite a few instances of high bacteria concentration from runoff. Much of this is associated with field application of manure from confined animal operations and the assumption that it is often done in the spring when it rains harder and more often.

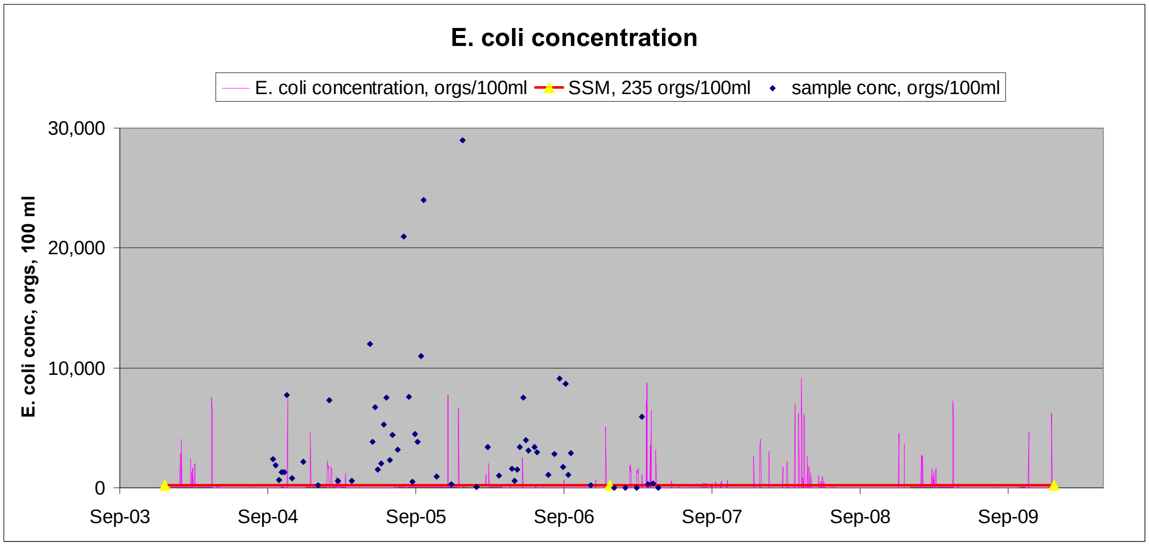

Figure 7-12 SWAT Scenario 3 output for complete reduction of CIS E. coli

The fourth scenario, shown in Figure 7-13, assumes that the field applications of manure are cut in half. This brings bacteria concentrations down from these applications quite a bit but they still exceed the target.

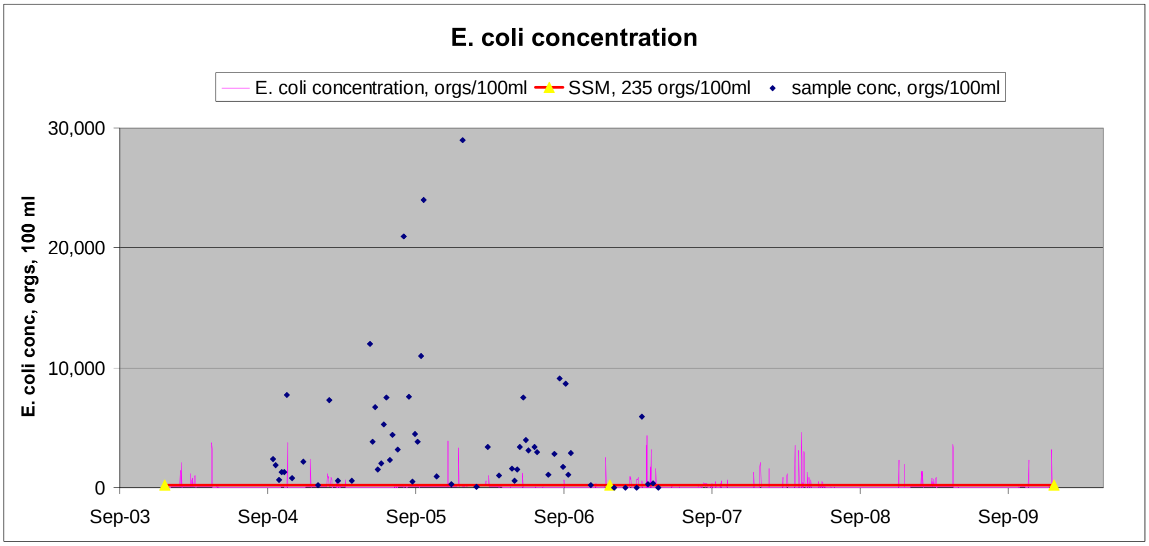

Figure 7-13 SWAT output for complete reduction of CIS E. coli and half of applied manure from CAFOs

The fifth scenario, shown in Figure 7-14, in addition to the previous reductions, reduces the manure from cattle on pasture by two thirds. This pasture manure reduction showed less than a one percent decrease in bacteria concentration in the stream.

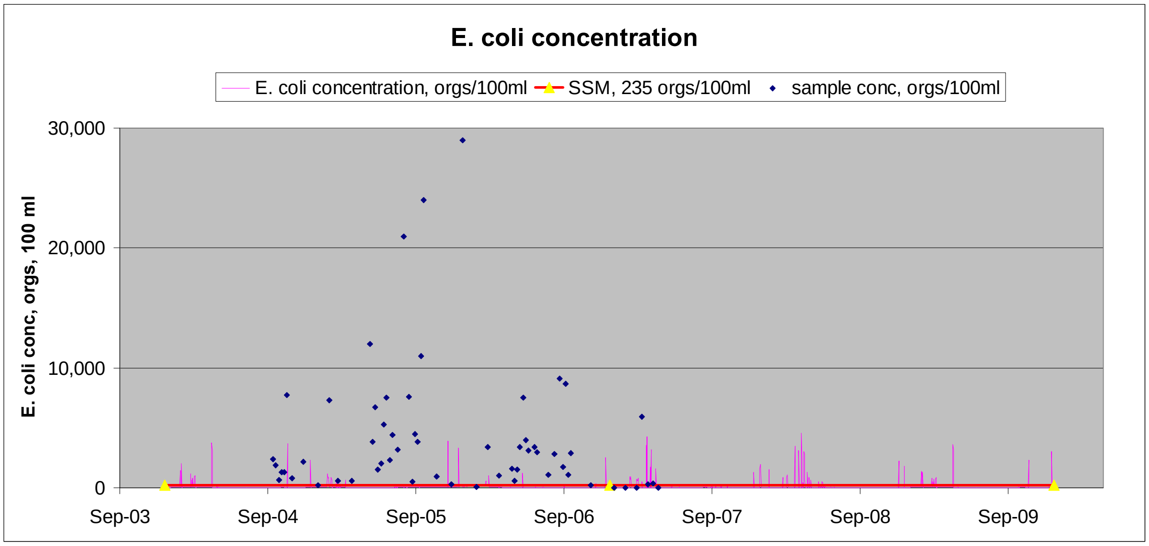

Figure 7-14 SWAT output for complete reduction of CIS E. coli and half of applied manure from CAFOs and a two thirds reduction of manure from cattle on pasture

There are several combinations of source reductions that can be simulated. The five scenarios described here reduce bacteria loads from the sources that have been modeled to have the greatest impact on stream outlet bacteria concentrations. It is worth noting that sources that are not reduced in these scenarios may have important episodic or local effect on *E. coli* organism numbers.

## 8. Dousman Creek

Dousman Creek (IA 01-YEL-0090_0) is the first impaired Yellow River tributary upstream from the Yellow River confluence with the Mississippi. The classified segment runs southwest 3.5 miles upstream from its confluence with the Yellow River (S33, T96N, R3W, Allamakee County). There are no permitted sources that discharges to this segment. The stream flow used in the development of the TMDL for this segment is derived from the area ratio flow based on the Ion USGS gage data. A SWAT watershed model developed for the Yellow River watershed labels Dousman Creek Subbasin 26. Figure 8-1 shows a map of Dousman Creek and Table 8-1 shows the land use in its subbasin.

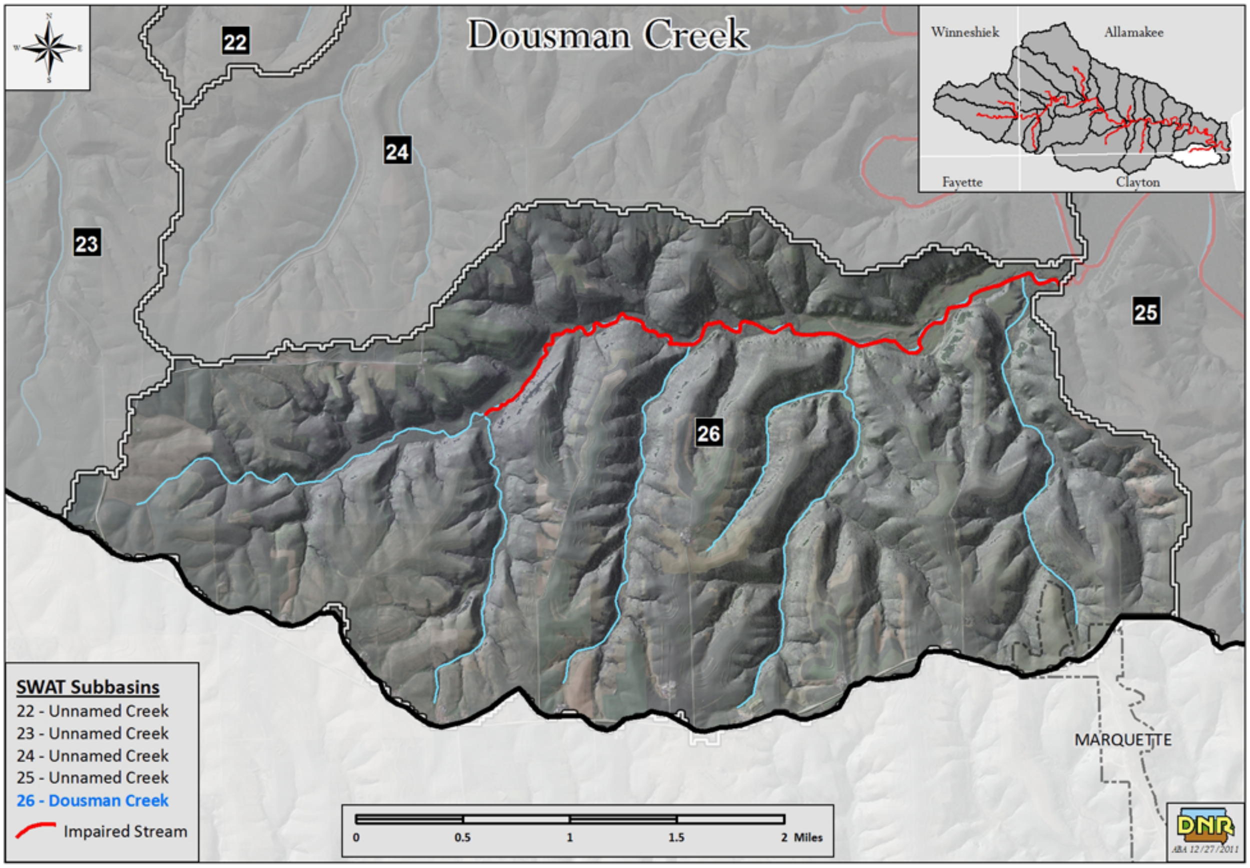

Figure 8-1 Dousman Creek (0090_0)

**Table 8-1 Dousman Creek subbasin land use**

| Landuse | Area, acres | Fraction of total |
|---|---:|---:|
| Water/wetland | 0.4 | 0.01% |
| Forest | 2859.1 | 50.90% |
| Ungrazed/CRP/hay | 619.3 | 11.02% |
| Grazed | 615.9 | 10.96% |
| Row crop | 1455.5 | 25.91% |
| Roads | 66.9 | 1.19% |
| Commercial/residential | 0.4 | 0.01% |
| **Total** | **5617.5** | **100.00%** |

In the Dousman Creek watershed, half of the area is forest and only a quarter of it is row crop, an unusual condition for the subbasins in the Yellow River Basin.

## 8.1. Water body pollutant loading capacity (TMDL)

The *E. coli* organism load capacity is the number of organisms that can be in a volume and meet the water quality criteria. The loading capacity for each of the five flow conditions is calculated by multiplying the midpoint flow and *E. coli* criteria concentrations. Table 8-2 shows the median, maximum, and minimum flows for the five flow conditions.

**Table 8-2 Dousman Creek maximum, minimum and median flows**

| Flow description | Recurrence interval range (mid %) | Midpoint of flow range, cfs | Maximum of flow range, cfs | Minimum of flow range, cfs |
|---|---|---|---|---|
| **High flow** | **0 to 10% (5)** | 24.8 | 254.8 | 15.4 |
| **Moist conditions** | **10% to 40% (25)** | 7.6 | 15.4 | 4.8 |
| **Mid-range** | **40% to 60% (50)** | 3.8 | 4.8 | 3.2 |
| **Dry conditions** | **60% to 90% (75)** | 2.5 | 3.2 | 2.0 |
| **Low flow** | **90% to 100% (95)** | 1.7 | 2.0 | 0.7 |

Flow and load duration curves were used to establish the occurrence of water quality standards violations, to establish compliance targets, and to set pollutant allocations and margins of safety. Duration curves are derived from flows plotted as a percentage of their recurrence. *E. coli* loads are calculated from *E. coli* concentrations and flow volume at the time the sample was collected.

To construct the flow duration curves, the bacteria monitoring data and the Water Quality Standard (WQS) sample max (235 *E. coli* organisms/100 ml) were plotted with the flow duration percentile. Figure 8-2 shows the data that exceed the WQS criteria at each of the five flow conditions. High flow violations indicate that the problem occurs during run-off conditions when bacteria are washing off from nonpoint sources. Criteria exceeded during low or base flow, when little or no runoff is occurring, indicate that continuous sources such as septic tanks, livestock in the stream, riparian wildlife, and wastewater treatment plants are the problem.

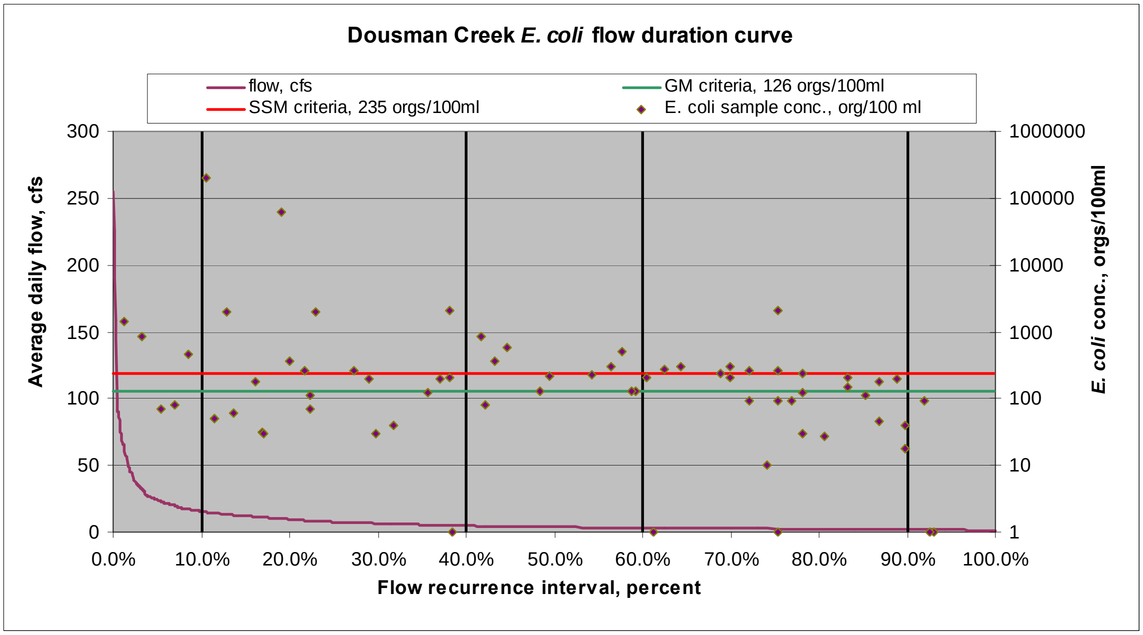

Figure 8-2 Dousman Creek flow duration curve

Load duration curves were used to evaluate the five flow conditions for this Yellow River segment. The load duration curve is shown in Figure 8-3. In the figure, the lower curve shows the maximum *E. coli* count for the GM criteria and the upper curve shows the maximum *E. coli* count for the SSM criteria at a continuum of flow recurrence percentage. The individual points are the observed (monitored) *E. coli* concentrations converted to loads based on average daily flow the day they were collected. Points above the load duration curves are violations of the WQS criteria and exceed the load capacity.

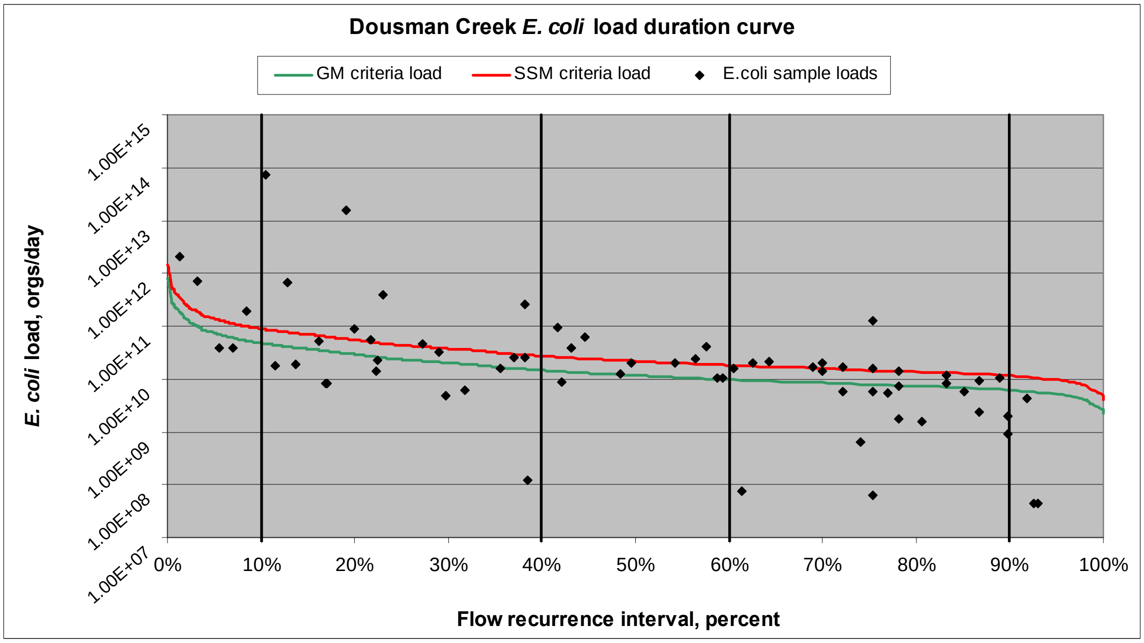

Figure 8-3 Dousman Creek load duration curve

Tables 8-3 and 8-4 show the load capacities (targets) for each of the midpoint flow conditions at the GM and SSM criteria, respectively.

**Table 8-3 Dousman Creek GM load capacity**

| Flow condition | Recurrence interval | Associated midpoint flow, cfs | Estimated flow interval load capacity, *E. coli* orgs/day |
|---|---|---|---|
| **High flow** | **0 to 10%** | 24.8 | 7.6E+10 |
| **Moist conditions** | **10% to 40%** | 7.6 | 2.3E+10 |
| **Mid-range** | **40% to 60%** | 3.8 | 1.2E+10 |
| **Dry conditions** | **60% to 90%** | 2.5 | 7.8E+09 |
| **Low flow** | **90% to 100%** | 1.7 | 5.2E+09 |

**Table 8-4 Dousman Creek SSM load capacity**

| Flow condition | Recurrence interval | Associated midpoint flow, cfs | Estimated flow interval load capacity, *E. coli* orgs/day |
|---|---|---|---|
| **High flow** | **0 to 10%** | 24.8 | 1.4E+11 |
| **Moist conditions** | **10% to 40%** | 7.6 | 4.4E+10 |
| **Mid-range** | **40% to 60%** | 3.8 | 2.2E+10 |
| **Dry conditions** | **60% to 90%** | 2.5 | 1.4E+10 |
| **Low flow** | **90% to 100%** | 1.7 | 9.7E+09 |

## 8.2. Existing load

The existing loads are derived from the sampling data collected in Dousman Creek. These data are the sample values shown in the flow and load duration curves. The *E. coli* concentrations are multiplied by the simulated daily flow to get the daily loads. The daily loads are plotted with the load duration curves. The allowable loads for a given flow equal the flow multiplied by the WQS limits for the geometric mean or single sample maximum. Monitored data that exceed the limits are above the criteria curves.

The maximum existing loads occur during major rains when runoff and bacteria concentrations are highest. Concentrations exceed the criteria during these high flow events. Other conditions leading to criteria violations occur during dry low flow periods when continuous loads from livestock in the stream, local wildlife, septic tanks, and wastewater treatment plants can cause bacteria problems.

The assessment standard used to evaluate streams is the *E. coli* geometric mean criteria. Since the load duration approach precludes the calculation of a geometric mean, the 90th percentile of observed concentrations within each flow condition is multiplied by the median flow to estimate existing loads. This procedure has been used to evaluate impaired segments. Table 8-5 shows the existing loads for each flow condition.

### Table 8-5 Dousman Creek existing loads

| Flow condition, percent recurrence | Recurrence interval range (mid %) | Associated median flow, cfs | Existing 90th percentile *E. coli* conc., org/100ml | Estimated existing load, *E. coli* org/day |
|---|---|---|---|---|
| **High flows** | **0 to 10% (5)** | 24.8 | 1184 | 7.17E+11 |
| **Moist conditions** | **10% to 40% (25)** | 7.6 | 2090 | 3.89E+11 |
| **Mid-range** | **40% to 60% (50)** | 3.8 | 590 | 5.49E+10 |
| **Dry conditions** | **60% to 90% (75)** | 2.5 | 285 | 1.76E+10 |
| **Low flow** | **90% to 100% (95)** | 1.7 | 76 | 3.11E+09 |

*Identification of pollutant sources.*
The sources of bacteria in the Dousman Creek subbasin (SWAT Subbasin 26) are all nonpoint sources. These include failed septic tank systems, pastured cattle, cattle in the stream, wildlife, and manure applied to fields from animal confinement operations. The loads from these sources are incorporated into the SWAT watershed model and are listed in Tables 8-6 to 8-10.

Non functional septic tank systems. There are an estimated 34 onsite septic tank systems in the subbasin (2.5 persons/household). IDNR estimates that 50 percent are not functioning properly. It is assumed that these are continuous year round discharges. Septic tank loads have been put into the SWAT model as a continuous source by subbasin.

### Table 8-6 Dousman Creek septic tank system E. coli orgs/day

| | |
|---|---|
| Rural population of Dousman Creek subbasin | 84 |
| Total initial E.coli, orgs/day [1] | 1.05E+11 |
| Septic tank flow, $m^3$/day [2] | 22.3 |
| **E. coli delivered to stream, orgs/day [3]** | **6.96E+07** |

1. Assumes 1.25E+09 E. coli orgs/day per capita
2. Assumes 70 gallons/day/capita
3. Assumes septic discharge concentration reaching stream is 625 orgs/100 ml and a 50% failure rate

Cattle in stream. Of the 182 cattle in pastures with stream access, one to six percent of those are assumed to be in the stream on a given day. The number on pasture and the fraction in the stream varies by month. Cattle in the stream have a high potential to deliver bacteria since bacteria are deposited directly in the stream with or without rainfall. Subbasin cattle in the stream bacteria have been put in the SWAT model as a continuous source varying by month.

### Table 8-7 Dousman Creek Cattle in the stream E. coli orgs/day

| | |
|---|---|
| Pasture area with stream access, acre[1] | 234 |
| Number of cattle in stream (6% of total)[2] | 11 |
| Dry manure, kg/day[3] | 34 |
| **E. coli load, orgs/day[4]** | **4.48E+11** |

1. The subbasin CIS are estimated from the pasture area with stream access at 0.78 cattle/acre.

2. It is estimated that cattle spend 6% of their time in streams in July and August, 3% in June and September, and 1% in May and October. The loads shown in this table are for July and August. The loads for the other 4 months when cattle are in streams have been incorporated into the SWAT modeling.
3. Cattle generate 3.1 kg/head/day of dry manure.
4. Manure has 1.32E+07 E coli orgs/gram dry manure.

Grazing livestock. The estimated number of cattle in the subbasin is 182. It is assumed that they are on pasture from April to November. The potential for bacteria delivery to the stream occurs with precipitation causing runoff. Manure available for washoff is applied in the SWAT model at 6 kg/ha in the pasture landuse.

### Table 8-8 Dousman Creek manure from pastured cattle, maximum E. coli available for washoff, orgs/day

| | |
|---|---:|
| Pasture area, acre | 620 |
| Number of cattle on pasture[1] | 473 |
| Dry manure, kg/day[2] | 1466 |
| Maximum E. coli load, orgs/day[3] | 1.93E+13 |
| Maximum E. coli available for washoff, orgs[4] | 3.48E+13 |

1. The number of pastured cattle is 0.78 cattle/acre.
2. Cattle generate 3.1 kg/head/day of dry manure.
3. Manure has 1.32E+07 E. coli orgs/gram dry manure
4. The load available for washoff is the daily load times 1.8.

Wildlife manure. The number of deer in Allamakee County is about 9,000 located primarily in forested land adjacent to streams. Another 1,000 have been added to account for other wildlife such as raccoons and waterfowl for a total estimate of 10,000. This works out to 0.024 deer per acre. Using this procedure, there are 135 deer in the subbasin concentrated in the forested areas. The deer are in the subbasin year round.

### Table 8-9 Dousman Creek watershed wildlife manure loads available for washoff, orgs/day

| Number of deer[1] | Forested area, ha | SWAT manure loading rate, kg/ha/day[2] | Total *E. coli* available for washoff, orgs[3] |
|:---:|:---:|:---:|:---:|
| 135 | 1,200 | 0.162 | 1.21E+11 |

1. Deer numbers are 0.024 deer/ha for the entire subbasin concentrated to 0.112 deer/ha in the forest land use. All wildlife loads are applied to the forest landuse in the SWAT model. The county deer numbers have been increased by 10% to account for other wildlife in the subbasin.
2. Assumes 1.44 kg/deer/day and 3.47E+05 orgs/gram.
3. Assumes that the maximum E. coli available for washoff is 1.8 times the daily load.

Field applications of CAFO manure.
There are about 420 dairy cows in confinement in the subbasin. The manure is stored and land applied to cropland. The manure is distributed to the fields in the subbasin in the fall after soybean harvest and in the spring prior to corn planting in year two of a two year rotation. The relatively brief fall and spring timing of manure application and incorporation in the soil significantly reduces the *E. coli* organisms from these sources.

Manure application has been put in the SWAT model by subbasin as a load available at the end of October and the beginning of April.

### Table 8-10 Dousman Creek watershed confined livestock manure applications

| Livestock type | Swine | Chickens | Dairy cows |
|---|---|---|---|
| Number of animals | 0 | 0 | 420 |
| Manure applied, kg/year[1] | 0 | 0 | 971,922 |
| Application area, ha[2] | 0 | 0 | 38 |
| Manure applied, kg/ha/day[3] | 0 | 0 | 2,631 |
| Subbasin E. coli, orgs/day | 0 | 0 | 1.19E+14 |
| Subbasin E. coli available for washoff, orgs/day[4] | 0 | 0 | 3.58E+14 |

1. Manure is calculated based on number of animals * dry manure (kg/animal/day)*365 days/year.
2. The area the manure is applied to is based on the manure's nitrogen content. Manure is applied at a rate equivalent to 201.6 kg N/ha/yr. Swine manure is applied at 2127 kg/ha, dairy manure at 2631 kg/ha and chicken manure at 2326 kg/ha. The E. coli content of manure for swine is 1.32E+07 orgs/gram, for dairy cows is 1.00E+07 orgs/gram, and for chickens is 2.96E+06 orgs/gram.
3. Manure is assumed to be applied to fields twice a year over 5 days on October 30 and April 1. It is incorporated in the soil and it is assumed that only 10% of bacteria are viable and available after storage and incorporation.
4. Maximum *E. coli* available for washoff are 1.8 times the daily maximum available load.

Seasonal variation of sources.

The relative impacts of the bacteria sources are shown in Figures 8-4 and 8-5. Figure 8-4 shows the relative loads delivered by the "continuous" sources, those sources present with or without rainfall and runoff. These are the failed septics that are assumed to be a problem every day of the year and the loads from cattle in the stream that vary by month from May to October. It can be seen in this figure that the impacts from cattle in the stream are much more significant than those from failed septic tank systems.

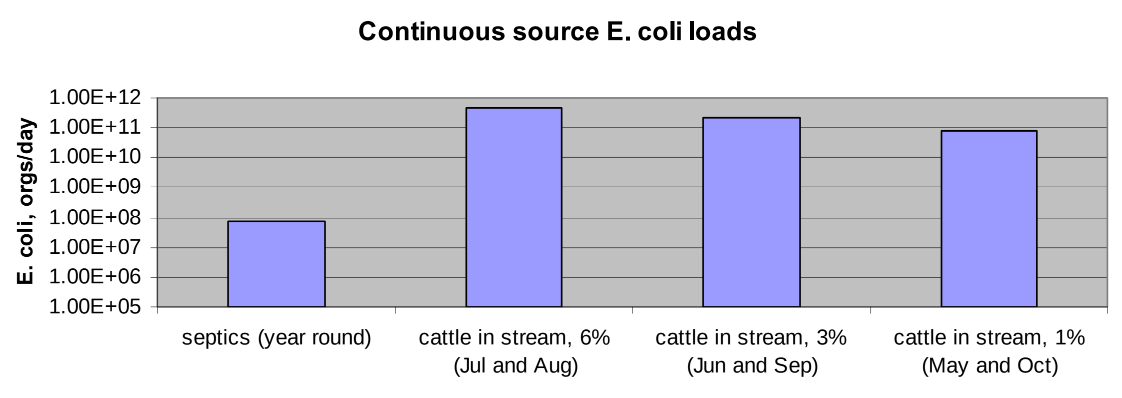

Figure 8-4 *E. coli* loads from "continuous" sources

The three general washoff sources of bacteria in the subbasin are shown in Figure 8-5. The wildlife source consists primarily of deer and smaller animals such as raccoons and waterfowl. These are year round sources. Pastured cattle consist of grazing cattle and

small poorly managed feedlot-like operations. The grazing season is modeled as lasting 168 days starting May 1. Manure from confined animal feeding operations (CAFO) is applied to cropland twice a year for a relatively brief time. Most field applied manure is assumed to be incorporated into the soil and most bacteria in it are not available. Confinement animals are swine, chickens and dairy cattle.

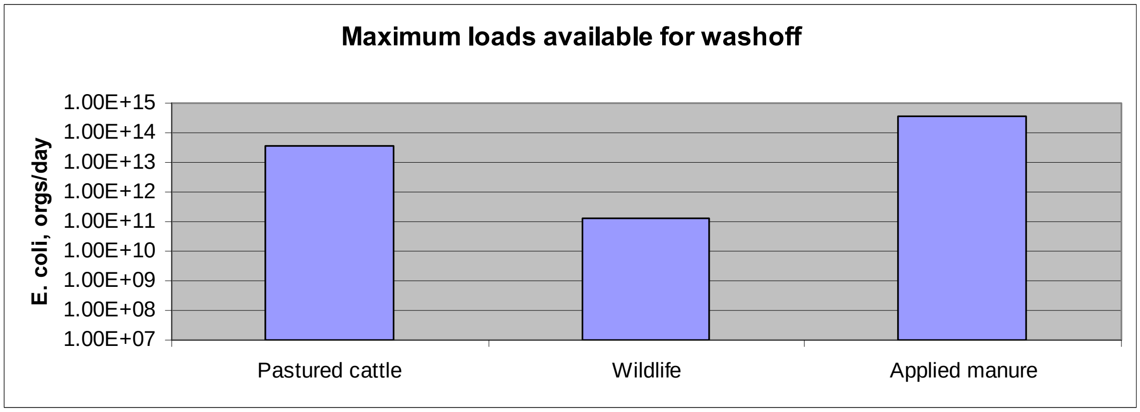

Figure 8-5 Maximum *E. coli* loads available for washoff

The maximum bacteria load to the stream occurs when the continuous source load plus the precipitation driven washoff load are combined. In general, the more rainfall the higher the flow rate and the more elevated the concentration. High flow rate and elevated concentration equal peak loads. In July and August, the potential maximum load based on this analysis is 3.49E+13 orgs/day available for washoff plus the continuous load of 4.49E+11 orgs/day for a total of 3.54E+13 orgs/day.

Flow interval load source analysis. Based on the load duration curve analysis the maximum existing load occurring during the zero to forty percent recurrence interval runoff conditions, is 4.79E+11 orgs/day and the total available load based on the potential , including fall and spring manure applications sources, including fall and spring manure applications, is 3.93E+14 orgs/day. Generally the maximum load in the stream, delivered in April when runoff is occurring, is estimated to be less than one percent of the bacteria available for washoff. At the zero to ten percent maximum existing load of 7.17E+11 orgs/day and with the same load available for washoff the stream load is still less than one percent of the available load.

## 8.3. Departure from load capacity

The departure from load capacity is the difference between the existing load and the load capacity. This varies for each of the five flow conditions. Table 8-11 shows this difference for the SSM. The existing and target loads for the five flow conditions are shown graphically in Figure 8-6.

### Table 8-11 Dousman Creek SSM departure from load capacity

| Design flow condition, percent recurrence | Recurrence interval range (mid %) | Existing *E. coli* orgs/day | Load capacity, orgs/day | Departure from capacity, orgs/day |
|---|---|---|---|---|
| High flow | 0 to 10% (5) | 7.17E+11 | 1.4E+11 | 5.75E+11 |
| Moist conditions | 10% to 40% (25) | 3.89E+11 | 4.4E+10 | 3.45E+11 |
| Mid-range flow | 40% to 60% (50) | 5.49E+10 | 2.2E+10 | 3.30E+10 |
| Dry conditions | 60% to 90% (75) | 1.76E+10 | 1.4E+10 | 3.08E+09 |
| Low flow | 90% to 100% (95) | 3.11E+09 | 9.7E+09 | -6.55E+09 |

1. Negative values indicate that the existing load is less than the target load.

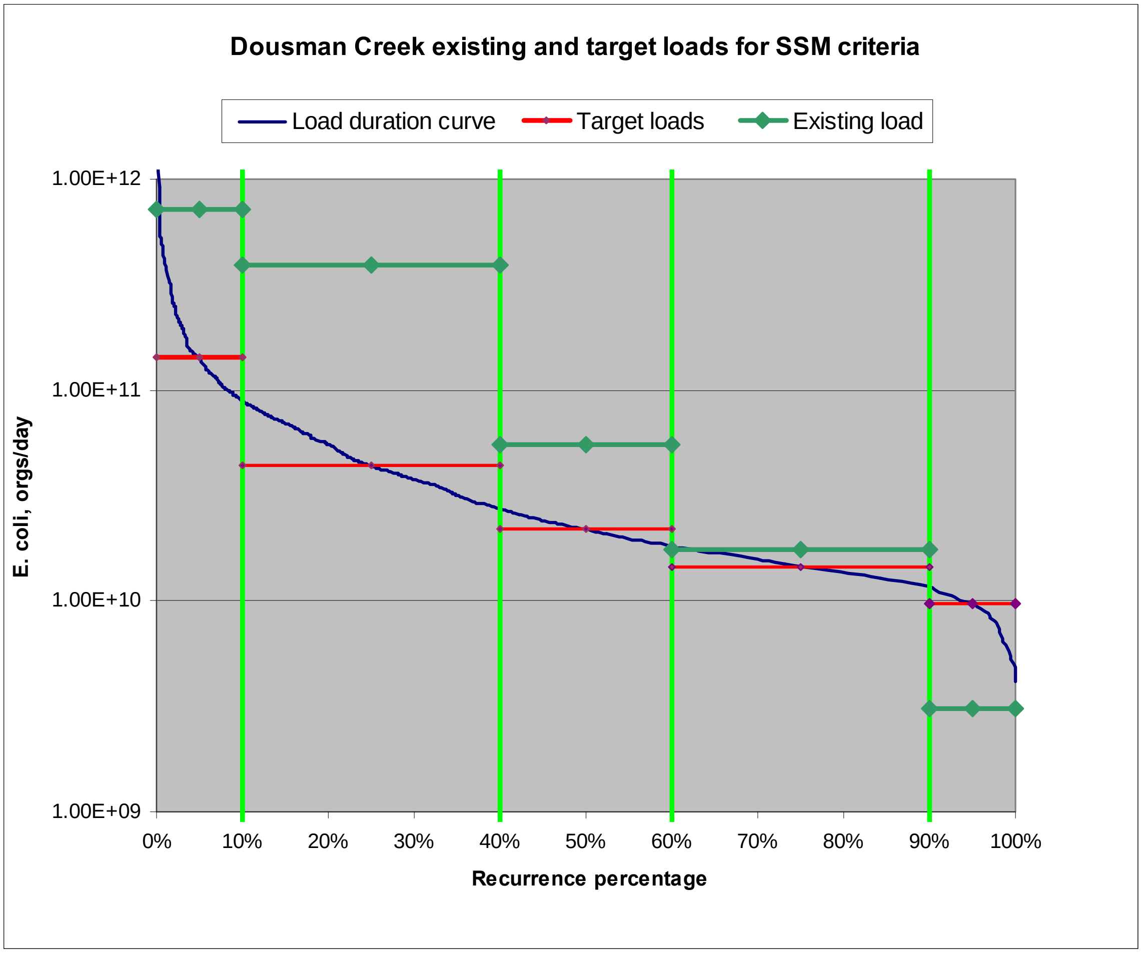

Figure 8-6 Difference between existing and target loads

## 8.4 Pollutant Allocations

*Wasteload allocations.*
Since there are no permitted discharges to Dousman Creek there are no wasteload allocations.

*Load allocation.*
The load allocations for *E. coli* TMDLs are the load capacity less an explicit 10 percent margin of safety (MOS) less the total WLA for the flow condition for the geometric mean

or single sample maximum. There is a separate load allocation set for each of the target recurrence intervals. The load allocations are shown in Tables 8-12 and 8-13.

**Table 8-12 Dousman Creek, GM *E. coli* load allocations**

| Flow condition, percent recurrence | GM target (TMDL) *E. Coli*, orgs/day | GM MOS *E. Coli*, orgs/day | Total WLA GM *E. coli*, orgs/day | LA GM *E. coli*, orgs/day |
|---|---|---|---|---|
| **High flows** | 7.6E+10 | 7.6E+09 | zero | 6.9E+10 |
| **Moist conditions** | 2.3E+10 | 2.3E+09 | zero | 2.1E+10 |
| **Mid-range flow** | 1.2E+10 | 1.2E+09 | zero | 1.1E+10 |
| **Dry conditions** | 7.8E+09 | 7.8E+08 | zero | 7.0E+09 |
| **Low flow** | 5.2E+09 | 5.2E+08 | zero | 4.7E+09 |

1. Based on geometric mean standard of 126 *E. coli* organisms/100 ml

**Table 8-13 Dousman Creek, SSM *E. coli* load allocations**

| Flow condition, percent recurrence | SSM target (TMDL) *E. Coli*, orgs/day | SSM MOS *E. Coli*, orgs/day | Total WLA SSM *E. coli*, orgs/day | LA SSM *E. coli*, orgs/day |
|---|---|---|---|---|
| **High flow** | 1.4E+11 | 1.4E+10 | zero | 1.3E+11 |
| **Moist conditions** | 4.4E+10 | 4.4E+09 | zero | 3.9E+10 |
| **Mid-range flow** | 2.2E+10 | 2.2E+09 | zero | 2.0E+10 |
| **Dry conditions** | 1.4E+10 | 1.4E+09 | zero | 1.3E+10 |
| **Low flow** | 9.7E+09 | 9.7E+08 | zero | 8.7E+09 |

1. Based on single sample maximum standard of 235 *E. coli* organisms/100 ml

*Margin of safety.*

The margin of safety for *E. coli* is an explicit 10 percent of the load capacity at each of the design recurrence intervals as shown in Tables 8-12 and 8-13.

## 8.5. TMDL Summary

The following equation shows the total maximum daily load (TMDL) and its components for the impaired IA 01-YEL-0090_0 segment of Dousman Creek.

**Total Maximum Daily Load = Σ Load Allocations + Σ Wasteload Allocations +MOS**

A Total Maximum Daily Load calculation has been made at design flow conditions for the GM and SSM of this segment and these are shown in Tables 8-14 and 8-15 and Figures 8-7 and 8-8.

### Table 8-14 Dousman Creek (IA 01-YEL-0090_0) *E. coli* TMDL for GM

| Flow condition | Σ LA, orgs/day | Σ WLA, orgs/day | MOS, orgs/day | TMDL, orgs/day |
|---|---|---|---|---|
| **High flow** | 6.9E+10 | zero | 7.6E+09 | 7.6E+10 |
| **Moist condition** | 2.1E+10 | zero | 2.3E+09 | 2.3E+10 |
| **Mid-range flow** | 1.1E+10 | zero | 1.2E+09 | 1.2E+10 |
| **Dry conditions** | 7.0E+09 | zero | 7.8E+08 | 7.8E+09 |
| **Low flow** | 4.7E+09 | zero | 5.2E+08 | 5.2E+09 |

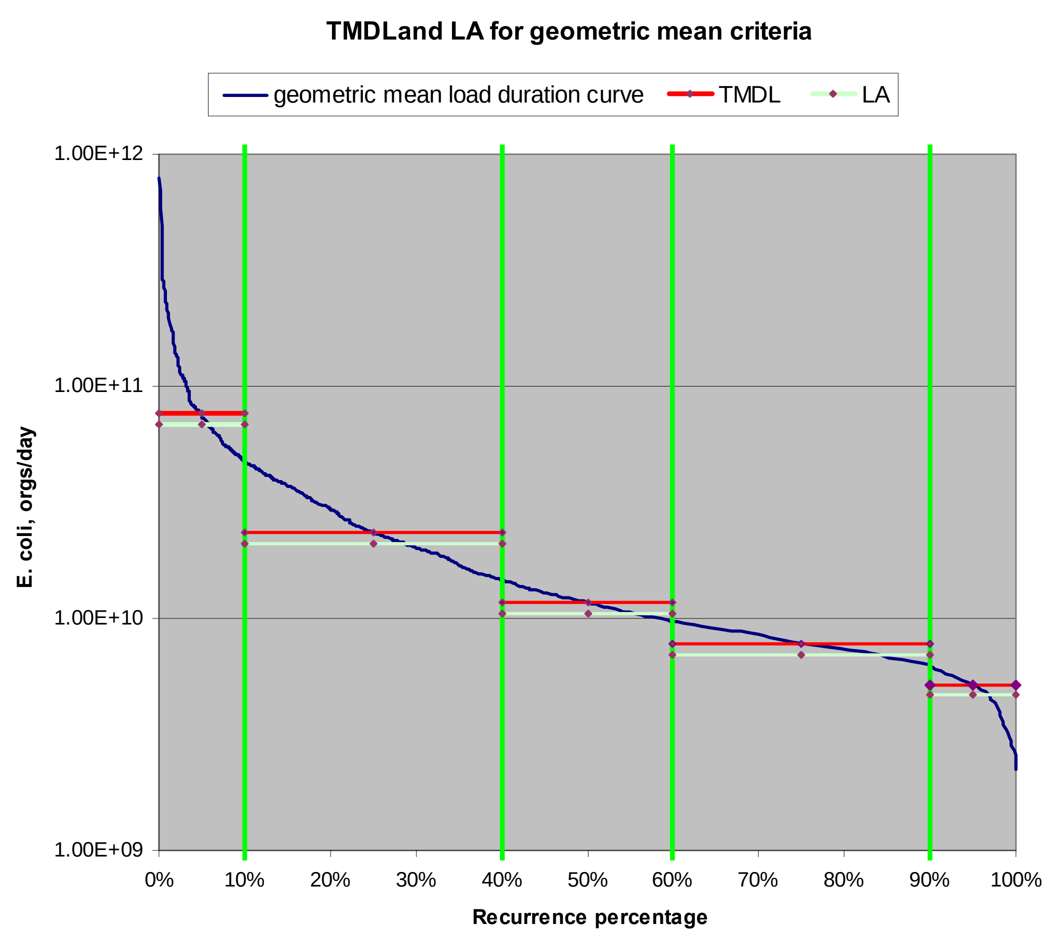

Figure 8-7 GM TMDL at WQS of 126 orgs/100 ml for the five flow conditions

### Table 8-15 Dousman Creek (IA 01-YEL-0090_0) *E. coli* TMDL for SSM

| Flow condition | Σ LA, orgs/day | Σ WLA, orgs/day | MOS, orgs/day | TMDL, orgs/day |
|---|---|---|---|---|
| High flow | 1.3E+11 | zero | 1.4E+10 | 1.4E+11 |
| Moist condition | 3.9E+10 | zero | 4.4E+09 | 4.4E+10 |
| Mid-range flow | 2.0E+10 | zero | 2.2E+09 | 2.2E+10 |
| Dry conditions | 1.3E+10 | zero | 1.4E+09 | 1.4E+10 |
| Low flow | 8.7E+09 | zero | 9.7E+08 | 9.7E+09 |

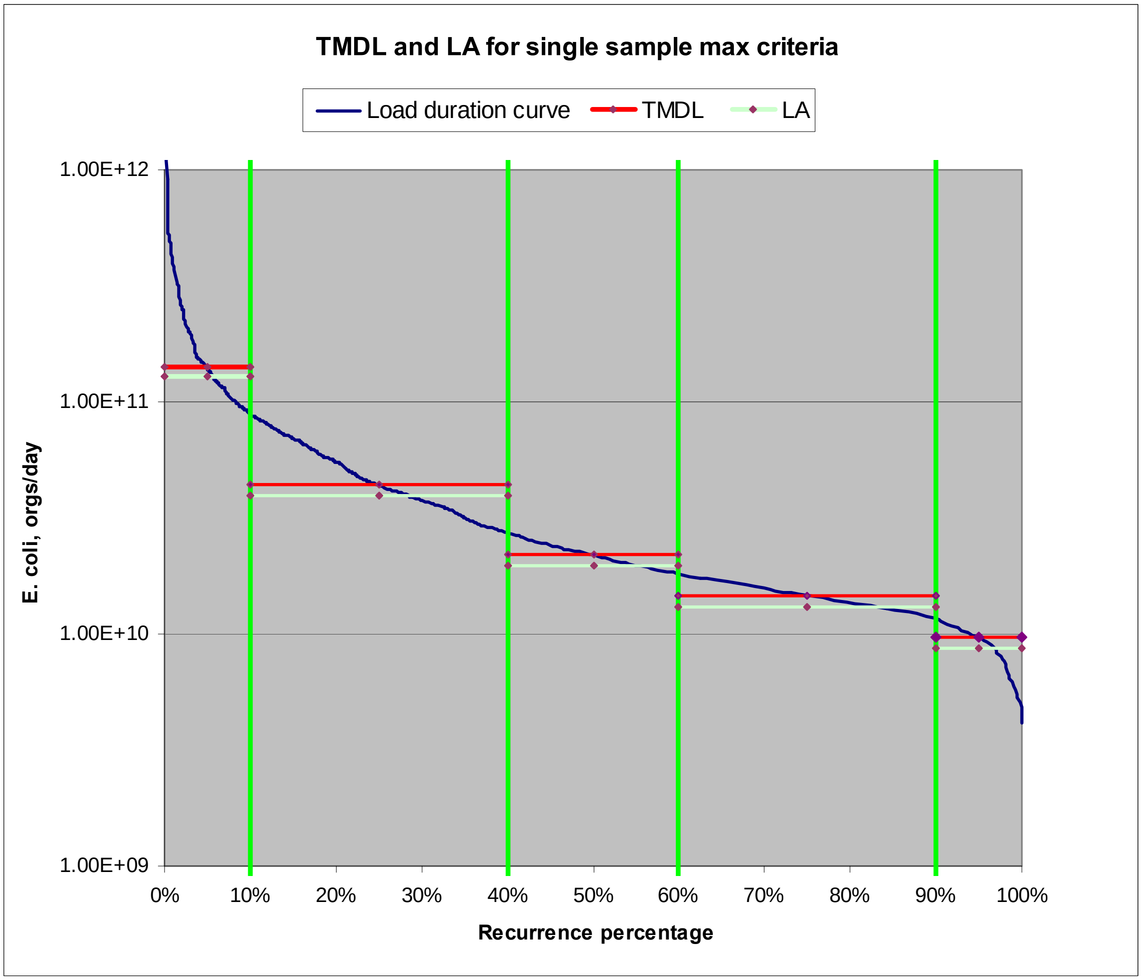

Figure 8-8 SSM TMDL at the WQS of 235 orgs/100 ml for the five flow conditions

## 8.6. Implementation Analysis

The modeled systematic reduction of the loads by source provides the initial evaluation of proposed implementation plans for the subbasin. The SWAT model has been run for five scenarios in which loads have been reduced for the most significant sources. The source analysis identified the primary source of bacteria and as cattle in the stream and field applied manure from CAFOs. Figure 8-9 shows the SWAT model output concentrations for the stream with monitored concentrations also plotted on the chart. The target concentration of 235 *E. coli* orgs/100 ml is frequently exceeded by both monitoring data and SWAT simulated values.

The concentration scale has been set to a maximum of 12,000 orgs/100 ml so that monitoring and simulation values are apparent when compared to the SSM. There are two monitoring values that exceed 12,000 orgs/100 ml (62,000, and 200,000). These two high values were measured during rainfall events. Event sampling indicates that concentrations may be much higher during elevated flow than is shown by scheduled monitoring.

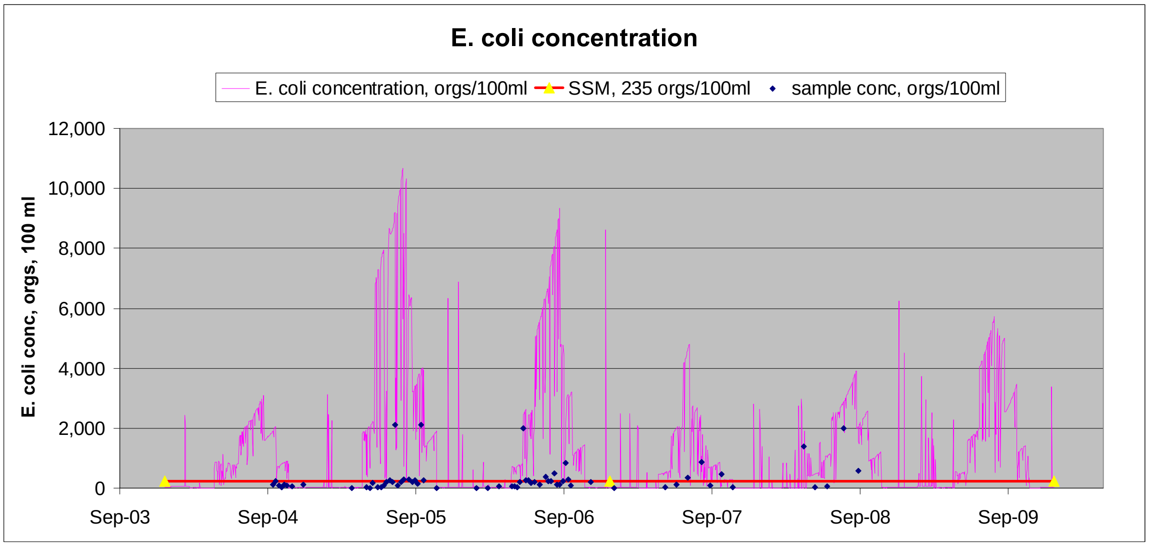

Figure 8-9 SWAT output for existing *E. coli* concentrations

The second scenario, Figure 8-10, removes half of the cattle in the stream from the subbasin. This generates reduced concentrations that are still higher than the SSM standard during the grazing season. The runoff related concentration spikes in all five scenarios.

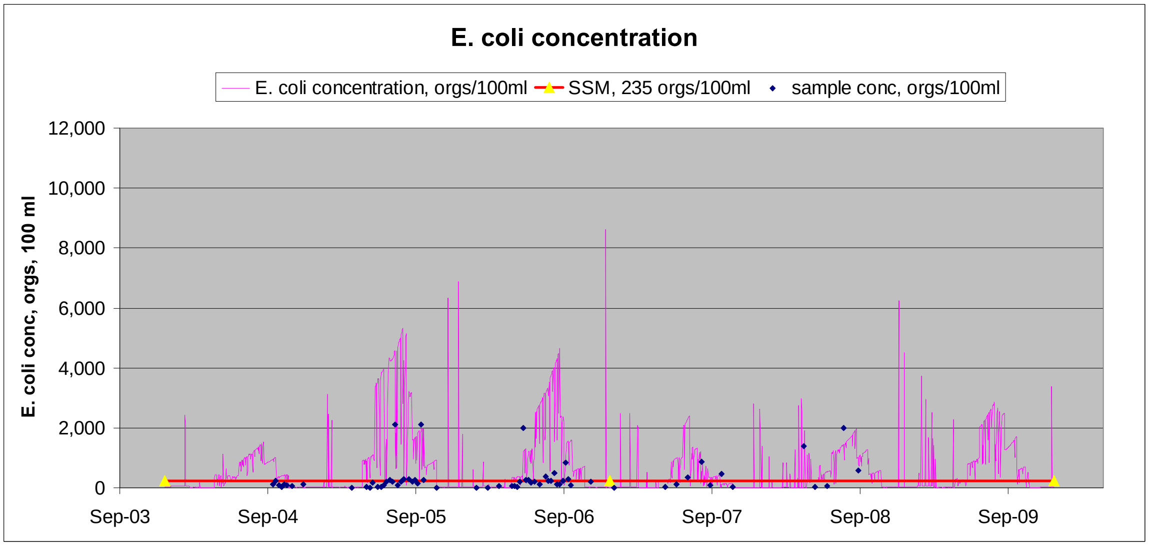

Figure 8-10 SWAT output for half reduction of CIS *E. coli* concentrations

The third scenario, shown in Figures 8-11a and 8-11b, eliminates cattle in the stream as a source. This drops the concentration during the grazing season but there remain instances of high bacteria concentration from runoff. Much of this is associated with field application of manure from confined animal operations and the assumption that it is done in the spring when rain is frequent and intense. The two figures show the same simulation values at two different maximum values in the Y-axis scale. This scale transition clarifies the effects of source reductions and their relation to the target concentration.

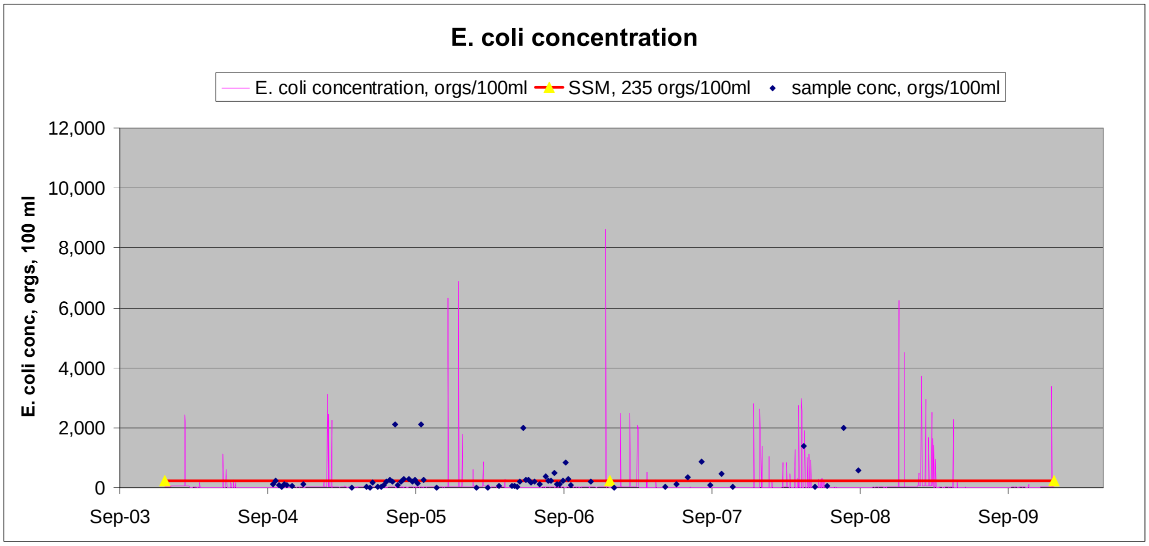

Figure 8-11a SWAT output for complete reduction of CIS *E. coli* with the concentration scale maximum set at 25,000 orgs/100 ml

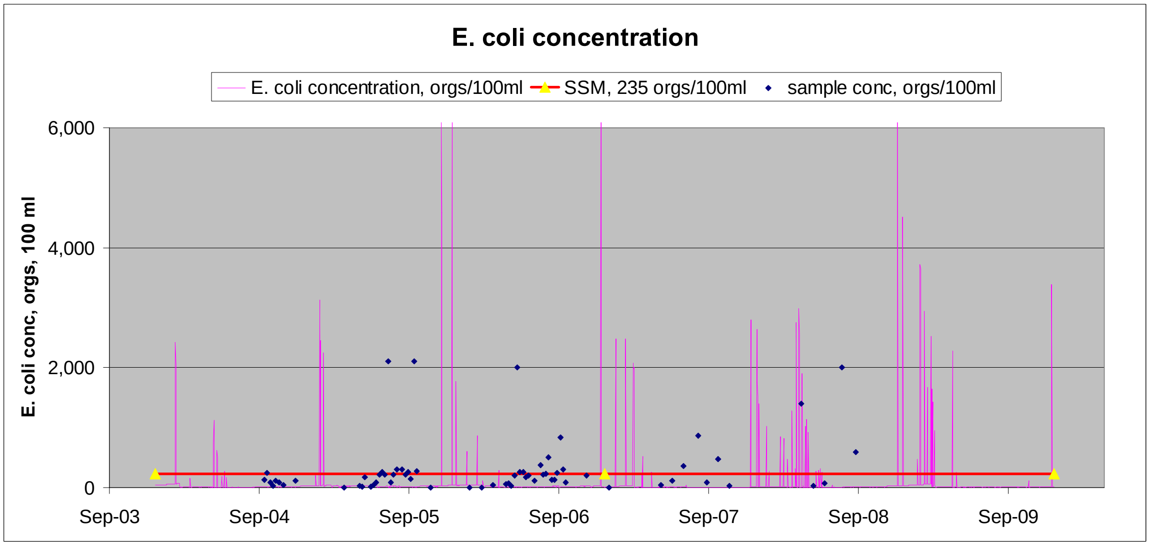

Figure 8-11b SWAT output for complete reduction of CIS *E. coli* with the concentration scale maximum set at 6,000 orgs/100 ml

The fourth scenario, shown in Figure 8-12, assumes that the field applications of manure are cut in half. This brings bacteria concentrations from these applications down some but they still exceed the target. Figure 8-11a has the same Y-axis scale maximum (10,000 orgs/100 ml) as Figures 8-12 and 8-13.

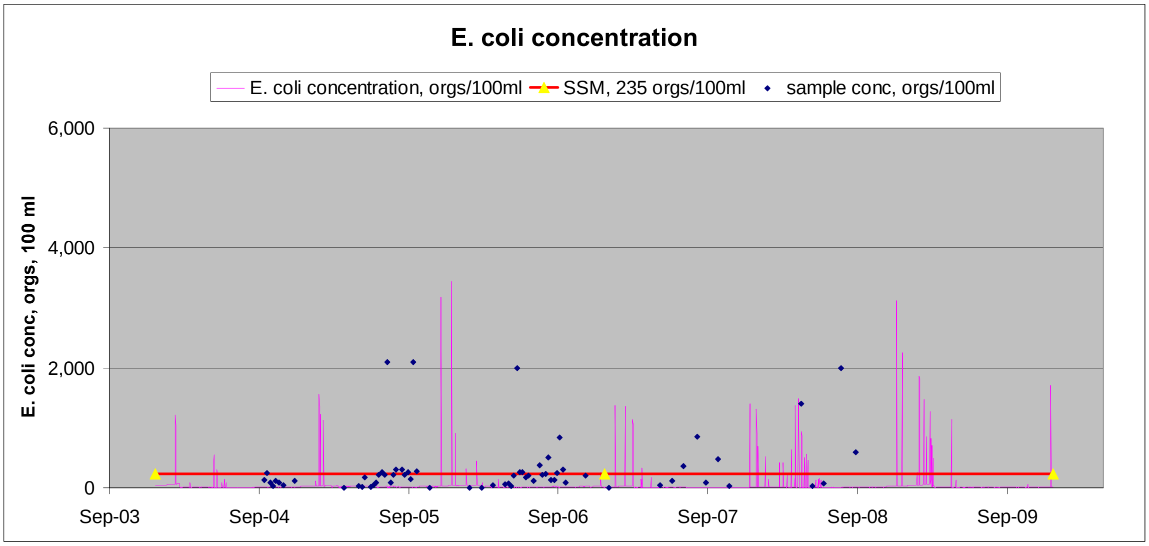

Figure 8-12 SWAT output for complete reduction of CIS *E. coli* and half of applied manure from CAFOs

The fifth scenario, shown in Figure 8-13, in addition to previous reductions, decreases the manure from cattle on pasture by two thirds. This pasture manure reduction showed a minor decrease in bacteria concentration in the stream.

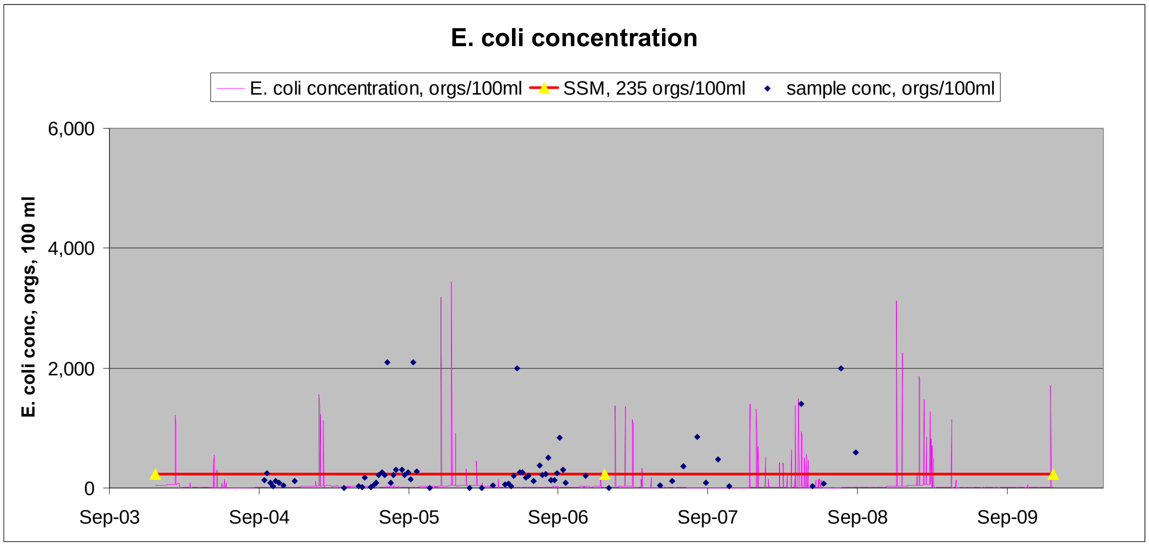

Figure 8-13 SWAT output for complete reduction of CIS *E. coli* and half of applied manure from CAFOs and a two thirds reduction of manure from cattle on pasture

There are several combinations of source reductions that can be simulated. The five scenarios described here reduce bacteria loads from the sources that have been modeled to have the greatest impact on stream outlet bacteria concentrations. The sources that are not reduced in these scenarios may have important episodic or local effect on *E. coli* organism numbers.

# 9. Suttle Creek

Suttle Creek (IA 01-YEL-0100_0) is the second impaired Yellow River tributary upstream from the Yellow River confluence with the Mississippi. The classified segment runs south 4.0 miles upstream from its confluence with the Yellow River (S17, T96N, R4W, Allamakee County). There are no permitted sources that discharge to this segment. The stream flow used in the development of the segment TMDL is derived from the area ratio flow based on the Ion USGS gage data. A SWAT watershed model developed for the Yellow River watershed labels Suttle Creek Subbasin 27. Figure 9-1 shows a map of Suttle Creek and Table 9-1 shows the land use in its subbasin.

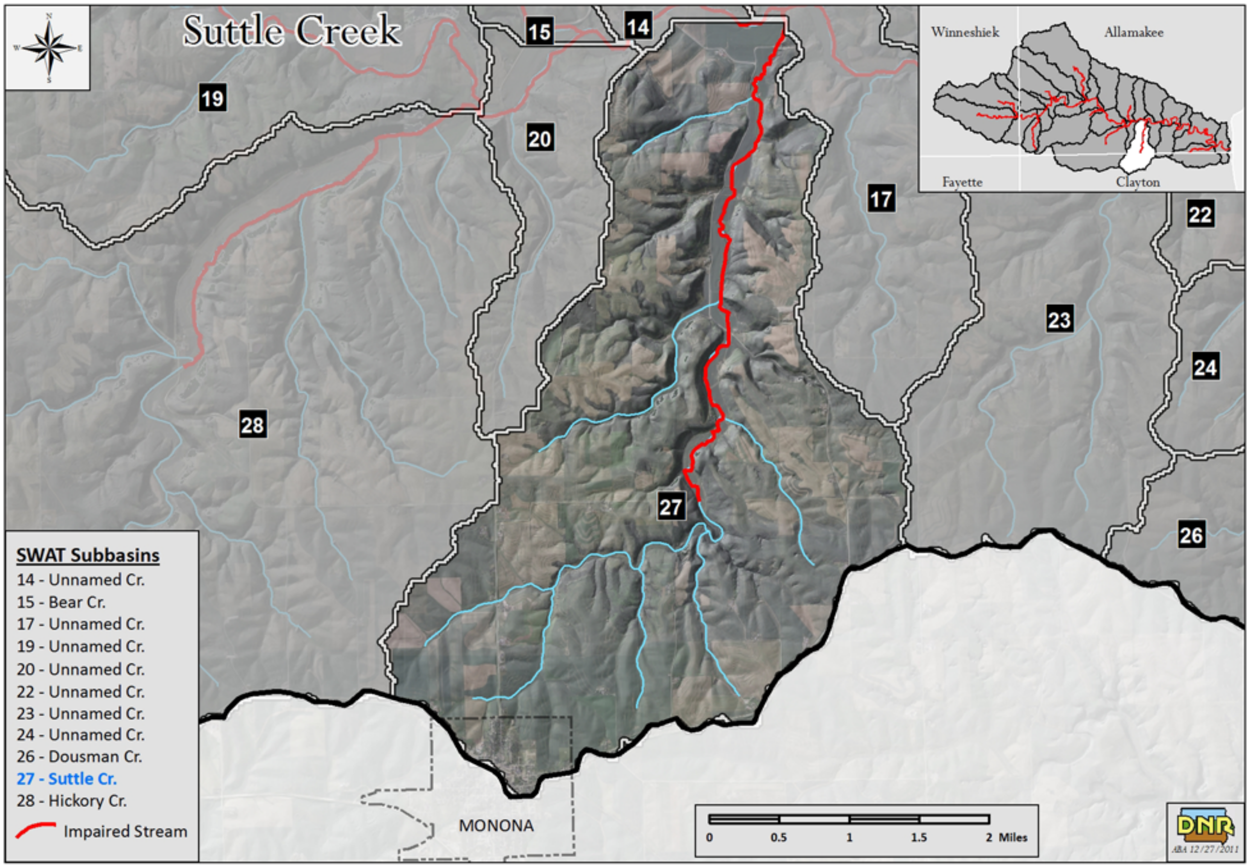

Figure 9-1 Suttle Creek (0100_0)

**Table 9-1 Suttle Creek subbasin land use**

| Landuse | Area, acres | Fraction of total |
|---|---:|---:|
| Water/wetland | 4.3 | 0.06% |
| Forest | 1102.5 | 15.22% |
| Ungrazed/CRP/hay | 1170.1 | 16.16% |
| Grazed | 744.9 | 10.28% |
| Row crop | 3945.4 | 54.48% |
| Roads | 116.7 | 1.61% |
| Commercial/residential | 158.4 | 2.19% |
| **Total** | **7242.3** | **100.00%** |

In the Suttle Creek watershed over half of the area is row crop and a third is forest or ungrazed grass.

### 9.1. Water body pollutant loading capacity (TMDL)

The *E. coli* load capacity is the number of organisms that can be in a volume and meet the water quality criteria. The loading capacity for each of the five flow conditions is calculated by multiplying the midpoint flow and *E. coli* criteria concentrations. Table 9-2 shows the median, maximum, and minimum flows for the five flow conditions.

**Table 9-2 Suttle Creek maximum, minimum and median flows**

| Flow description | Recurrence interval range (mid %) | Midpoint of flow range, cfs | Maximum of flow range, cfs | Minimum of flow range, cfs |
|---|---|---|---|---|
| **High flow** | **0 to 10% (5)** | 32.4 | 331.2 | 20.2 |
| **Moist conditions** | **10% to 40% (25)** | 10.0 | 20.2 | 6.1 |
| **Mid-range** | **40% to 60% (50)** | 4.9 | 6.1 | 4.1 |
| **Dry conditions** | **60% to 90% (75)** | 3.3 | 4.1 | 2.7 |
| **Low flow** | **90% to 100% (95)** | 2.2 | 2.7 | 0.9 |

Flow and load duration curves were used to establish the occurrence of water quality standards violations, to establish compliance targets, and to set pollutant allocations and margins of safety. Duration curves are derived from flows plotted as a percentage of their recurrence. *E. coli* loads are calculated from *E. coli* concentrations and flow volume at the time the sample was collected.

To construct the flow duration curves, the bacteria monitoring data and the Water Quality Standard (WQS) sample max (235 *E. coli* organisms/100 ml) were plotted with the flow duration percentile. Figure 9-2 shows the data that exceed the WQS criteria at each of the five flow conditions. High flow violations indicate that the problem occurs during run-off conditions when bacteria are washing off from nonpoint sources. Criteria exceeded during low or base flow, when little or no runoff is occurring, indicate that continuous sources such as septic tanks, livestock in the stream, riparian wildlife, and wastewater treatment plants are the problem.

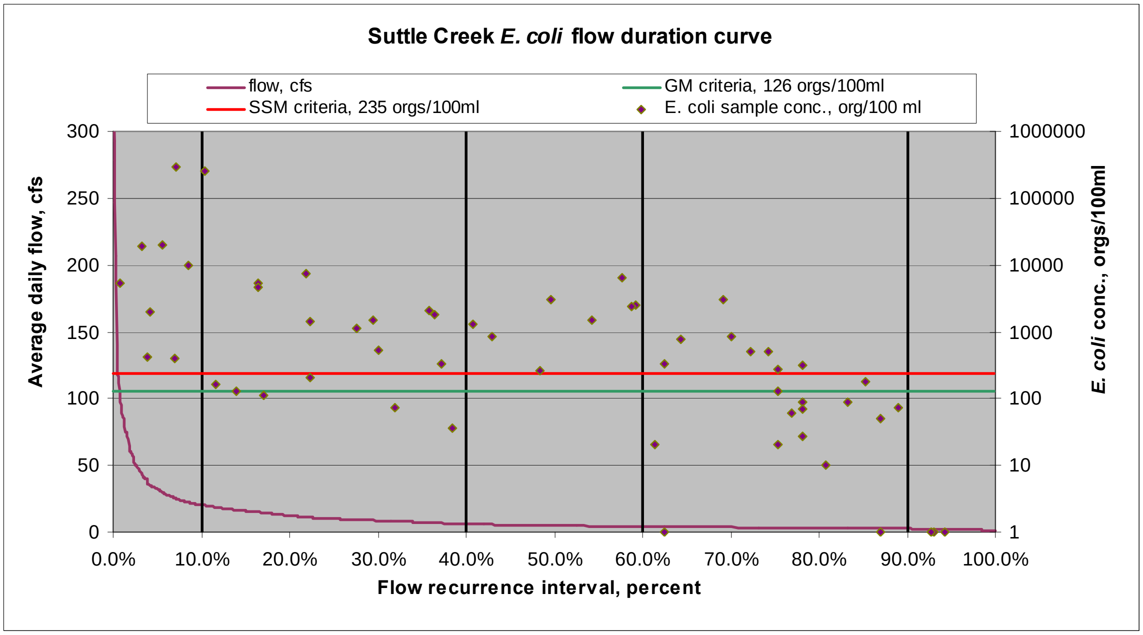

Figure 9-2 Suttle Creek flow duration curve

Load duration curves were used to evaluate the five flow conditions for Suttle Creek. The load duration curve is shown in Figure 9-3. In the figure, the lower curve shows the maximum *E. coli* count for the GM criteria and the upper curve shows the maximum *E. coli* count for the SSM criteria at a continuum of flow recurrence percentage. The individual points are the observed (monitored) *E. coli* concentrations converted to loads based on average daily flow for the day they were collected. Points above the load duration curves are violations of the WQS criteria and exceed the loading capacity.

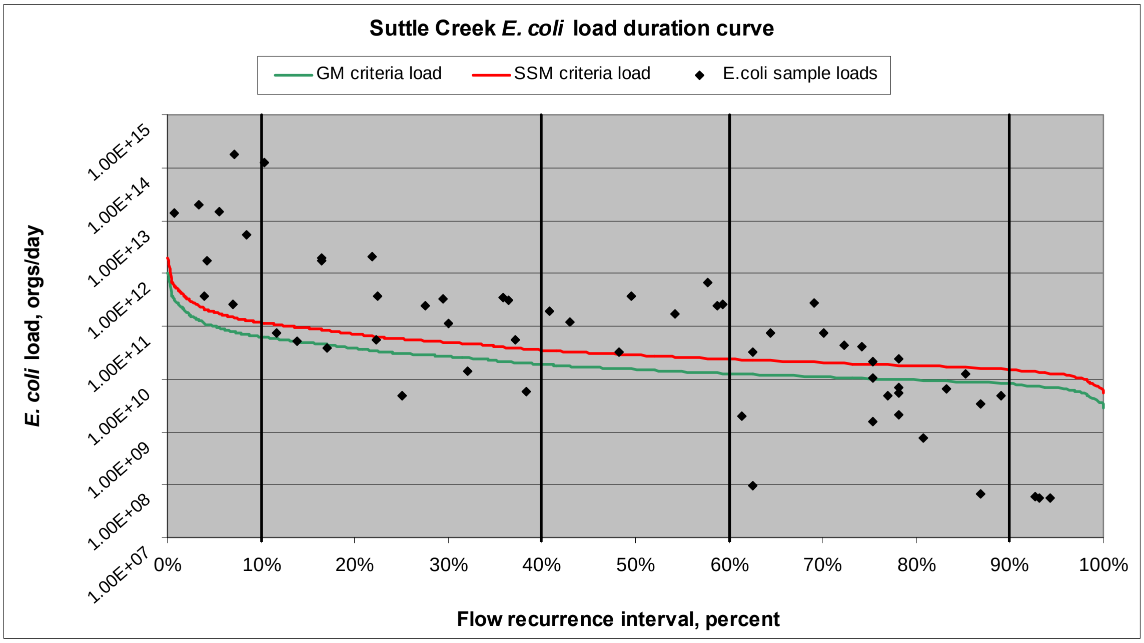

Figure 9-3 Suttle Creek load duration curve

Tables 9-3 and 9-4 show the load capacities (targets) for each of the midpoint flow conditions at the GM and SSM criteria, respectively.

**Table 9-3 Suttle Creek GM load capacity**

| Flow condition | Recurrence interval | Associated midpoint flow, cfs | Estimated flow interval load capacity, *E. coli* orgs/day |
|---|---|---|---|
| High flow | 0 to 10% | 32.4 | 1.0E+11 |
| Moist conditions | 10% to 40% | 10.0 | 3.1E+10 |
| Mid-range | 40% to 60% | 4.9 | 1.5E+10 |
| Dry conditions | 60% to 90% | 3.3 | 1.0E+10 |
| Low flow | 90% to 100% | 2.2 | 6.7E+09 |

**Table 9-4 Suttle Creek SSM load capacity**

| Flow condition | Recurrence interval | Associated midpoint flow, cfs | Estimated flow interval load capacity, *E. coli* orgs/day |
|---|---|---|---|
| High flow | 0 to 10% | 32.4 | 1.9E+11 |
| Moist conditions | 10% to 40% | 10.0 | 5.7E+10 |
| Mid-range | 40% to 60% | 4.9 | 2.8E+10 |
| Dry conditions | 60% to 90% | 3.3 | 1.9E+10 |
| Low flow | 90% to 100% | 2.2 | 1.3E+10 |

## 9.2. Existing load

The existing loads are derived from the sampling data collected at the Suttle Creek Site. These data are the sample values shown in the flow and load duration curves. The *E. coli* concentrations are multiplied by the average daily flow to get the daily loads. The daily loads are plotted with the load duration curves. The allowable loads for a given flow equal the flow multiplied by the WQS limits for the geometric mean or single sample maximum. Monitored data that exceed the limits are above the criteria curves.

The maximum existing loads occur during major rains when runoff and bacteria concentrations are highest. Concentrations exceed the criteria during these high flow events. Other conditions leading to criteria violations occur during dry low flow periods when continuous loads from livestock in the stream, local wildlife, septic tanks, and wastewater treatment plants can cause bacteria problems.

The assessment standard used to evaluate streams is the *E. coli* geometric mean criteria. Since the load duration approach precludes the calculation of a geometric mean, the 90th percentile of observed concentrations within each flow condition is multiplied by the median flow to estimate existing loads. This procedure has been used to evaluate impaired segments. Table 9-5 shows the existing loads for each flow condition.

### Table 9-5 Suttle Creek existing loads

| Flow condition, percent recurrence | Recurrence interval range (mid %) | Associated median flow, cfs | Existing 90th percentile *E. coli* conc., org/100ml | Estimated existing load, *E. coli* org/day |
|---|---|---|---|---|
| **High flows** | **0 to 10% (5)** | 16.88 | 26600 | 1.10E+13 |
| **Moist conditions** | **10% to 40% (25)** | 9.45 | 2000 | 4.63E+11 |
| **Mid-range** | **40% to 60% (50)** | 5.39 | 4610 | 6.08E+11 |
| **Dry conditions** | **60% to 90% (75)** | 4.22 | 2950 | 3.05E+11 |
| **Low flow** | **90% to 100% (95)** | 2.80 | 4410 | 3.02E+11 |

*Identification of pollutant sources.*
The sources of bacteria in the Suttle Creek subbasin (SWAT Subbasin 27) are all nonpoint sources. These include failed septic tank systems, pastured cattle, cattle in the stream, wildlife, and manure applied to fields from animal confinement operations. The loads from these sources are incorporated into the SWAT watershed model and are listed in Tables 9-6 to 9-10.

Non functional septic tank systems. There are an estimated 56 onsite septic tank systems in the subbasin (2.5 persons/household). IDNR estimates that 50 percent are not functioning properly. It is assumed that these are continuous year round discharges. Septic tank loads have been put into the SWAT model as a continuous source by subbasin.

### Table 9-6 Suttle Creek septic tank system E. coli orgs/day

| | |
|---|---|
| Rural population of Suttle Creek subbasin | 139 |
| Total initial E.coli, orgs/day [1] | 1.74E+11 |
| Septic tank flow, $m^3$/day [2] | 36.8 |
| **E. coli delivered to stream, orgs/day [3]** | **1.15E+08** |

1. Assumes 1.25E+09 E. coli orgs/day per capita
2. Assumes 70 gallons/day/capita
3. Assumes septic discharge concentration reaching stream is 625 orgs/100 ml and a 50% failure rate

Cattle in stream. Of the 577 cattle in pastures with stream access, one to six percent of those are assumed to be in the stream on a given day. The number on pasture and the fraction in the stream varies by month. Cattle in the stream have a high potential to deliver bacteria since bacteria are deposited directly in the stream with or without rainfall. Subbasin cattle in the stream bacteria have been put in the SWAT model as a continuous source varying by month.

### Table 9-7 Suttle Creek Cattle in the stream E. coli orgs/day

| | |
|---|---|
| Pasture area with stream access, acres[1] | 740 |
| Number of cattle in stream (6% of total)[2] | 35 |
| Dry manure, kg/day [3] | 107 |
| **E. coli load, orgs/day [4]** | **1.42E+12** |

1. The subbasin CIS are estimated from the pasture area with stream access at 0.78 cattle/acre.

2. It is estimated that cattle spend 6% of their time in streams in July and August, 3% in June and September, and 1% in May and October. The loads shown in this table are for July and August. The loads for the other 4 months when cattle are in streams have been incorporated into the SWAT modeling.
3. Cattle generate 3.1 kg/head/day of dry manure.
4. Manure has 1.32E+07 E coli orgs/gram dry manure.

Grazing livestock. The estimated number of cattle in the subbasin is 577. It is assumed that they are on pasture from April to November. The potential for bacteria delivery to the stream occurs with precipitation causing runoff. Manure available for washoff is applied in the SWAT model at 6 kg/ha in the pasture landuse.

### Table 9-8 Suttle Creek manure from pastured cattle, maximum E. coli available for washoff, orgs/day

| | |
|---|---:|
| Pasture area, ha | 740 |
| Number of cattle on pasture[1] | 542 |
| Dry manure, kg/day[2] | 1682 |
| Maximum E. coli load, orgs/day[3] | 2.22E+13 |
| Maximum E. coli available for washoff, orgs[4] | 4.00E+13 |

1. The number of pastured cattle is 0.78 cattle/acre.
2. Cattle generate 3.1 kg/head/day of dry manure.
3. Manure has 1.32E+07 E. coli orgs/gram dry manure
4. The load available for washoff is the daily load times 1.8.

Wildlife manure. The number of deer in Allamakee County is about 9,000 located primarily in forested land adjacent to streams. Another 1,000 have been added to account for other wildlife such as raccoons and waterfowl for a total estimate of 10,000. This works out to 0.024 deer per acre. Using this procedure, there are 118 deer in the subbasin concentrated in the forested areas. The deer are in the subbasin year round.

### Table 9-9 Suttle Creek watershed wildlife manure loads available for washoff, orgs/day

| Number of deer[1] | Forested area, ha | SWAT manure loading rate, kg/ha/day[2] | E. coli available for washoff, orgs[3] |
|:---:|:---:|:---:|:---:|
| 174 | 499 | 0.502 | 1.56E+11 |

1. Deer numbers are 0.024 deer/ha for the entire subbasin concentrated to 0.348 deer/ha in the forest land use. All wildlife loads are applied to the forest landuse in the SWAT model. The county deer numbers have been increased by 10% to account for other wildlife in the subbasin.
2. Assumes 1.44 kg/deer/day and 3.47E+05 orgs/gram
3. Assumes that the maximum E. coli available for washoff is 1.8 times the daily load.

Field applications of CAFO manure.
There are about 99,900 chickens in confinement in the subbasin. The manure is stored and land applied to cropland. The manure is distributed to the fields in the subbasin in the fall after soybean harvest and in the spring prior to corn planting in year two of a two year rotation. The relatively brief fall and spring timing of manure application and incorporation in the soil significantly reduces the *E. coli* organisms from these sources.

Manure application has been put in the SWAT model by subbasin as a load available at the end of October and the beginning of April.

**Table 9-10 Suttle Creek watershed confined livestock manure applications**

| Livestock type | Swine | Chickens | Dairy cows |
|---|---|---|---|
| Number of animals | 0 | 99,900 | 0 |
| Manure applied, kg/year[1] | 0 | 1,093,905 | 0 |
| Application area, ha[2] | 0 | 42 | 0 |
| Manure applied, kg/ha/day[3] | 0 | 2,326 | 0 |
| Subbasin E. coli, orgs/day | 0 | 5.76E+13 | 0 |
| Subbasin E. coli available for washoff, orgs/day[4] | 0 | 1.04E+14 | 0 |

1. Manure is calculated based on number of animals * dry manure (kg/animal/day)*365 days/year.
2. The area the manure is applied to is based on the manure's nitrogen content. Manure is applied at a rate equivalent to 201.6 kg N/ha/yr. Swine manure is applied at 2127 kg/ha, dairy manure at 2631 kg/ha and chicken manure at 2326 kg/ha. The E. coli content of manure for swine is 1.32E+07 orgs/gram, for dairy cows is 1.00E+07 orgs/gram, and for chickens is 2.96E+06 orgs/gram.
3. Manure is assumed to be applied to fields twice a year over 5 days on October 30 and April 1. It is incorporated in the soil and it is assumed that only 10% of bacteria are viable and available after storage and incorporation.
4. Maximum *E. coli* available for washoff are 1.8 times the daily maximum available load.

Seasonal variation of sources.
The relative impacts of the bacteria sources are shown in Figures 9-4 and 9-5. Figure 9-4 shows the relative loads delivered by the "continuous" sources, those sources present with or without rainfall and runoff. These are the failed septics that are assumed to be a problem every day of the year and the loads from cattle in the stream that vary by month from May to October. It can be seen in this figure that the impacts from cattle in the stream are much more significant than those from failed septic tank systems.

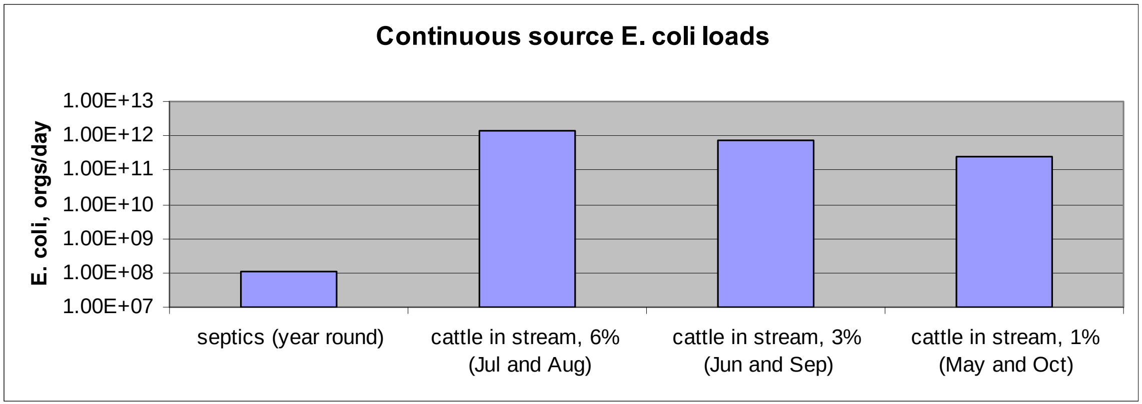

Figure 9-4 *E. coli* loads from "continuous" sources

The three general washoff sources of bacteria in the subbasin are shown in Figure 9-5. The wildlife source consists primarily of deer and smaller animals such as raccoons and waterfowl. These are year round sources. Pastured cattle consist of grazing cattle and small poorly managed feedlot-like operations. The grazing season is modeled as lasting

168 days starting May 1. Manure from confined animal feeding operations (CAFO) is applied to cropland twice a year for a relatively brief time. Most field applied manure is assumed to be incorporated into the soil and most bacteria in it are not available. Confinement animals are swine, chickens and dairy cattle.

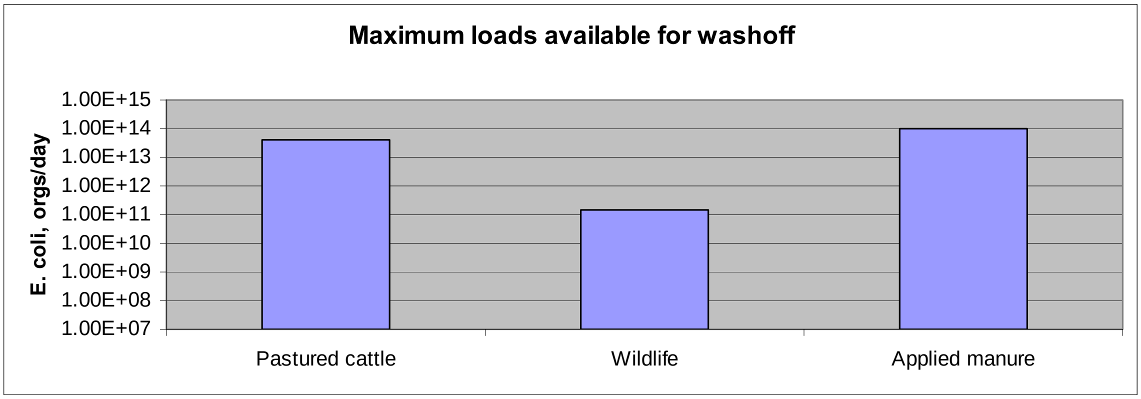

Figure 9-5 Maximum *E. coli* loads available for washoff

The maximum bacteria load to the stream occurs when the continuous source load plus the precipitation driven washoff load are combined. In general, the more rainfall the higher the flow rate and the more elevated the concentration. High flow rate and elevated concentration equal peak loads. In July and August, the potential maximum load based on this analysis is 4.01E+13 orgs/day available for washoff plus the continuous load of 1.42E+12 orgs/day for a total of 4.15E+13 orgs/day.

Flow interval load source analysis. Based on the load duration curve analysis, the maximum existing load occurring during the zero to forty percent recurrence interval runoff conditions is 5.87E+12 orgs/day and the total available load based on the potential sources, including fall and spring manure applications, is 1.44E+14 orgs/day. Generally the maximum load in the stream, delivered in April when runoff is occurring, is approximately four percent of the bacteria available for washoff. At the zero to ten percent maximum existing load of 8.02E+13 orgs/day and with the same load available for washoff the stream load is fifty-five percent of the available load.

## 9.3. Departure from load capacity

The departure from load capacity is the difference between the existing load and the load capacity. This varies for each of the five flow conditions. Table 9-11 shows this difference. The existing and target loads for the five flow conditions are shown graphically in Figure 9-6.

**Table 9-11 Suttle Creek departure from load capacity**

| Design flow condition, percent recurrence | Recurrence interval range (mid %) | Existing *E. coli* orgs/day | Load capacity, orgs/day | Departure from capacity, orgs/day |
|---|---|---|---|---|
| **High flow** | **0 to 10% (5)** | 8.02E+13 | 1.9E+11 | 8.00E+13 |
| **Moist conditions** | **10% to 40% (25)** | 1.47E+12 | 5.7E+10 | 1.41E+12 |
| **Mid-range flow** | **40% to 60% (50)** | 4.90E+11 | 2.8E+10 | 4.61E+11 |
| **Dry conditions** | **60% to 90% (75)** | 5.96E+10 | 1.9E+10 | 4.08E+10 |
| **Low flow** | **90% to 100% (95)** | 5.34E+07 | 1.3E+10 | -1.25E+10 |

1. Negative values indicate that the existing load is less than the target load.

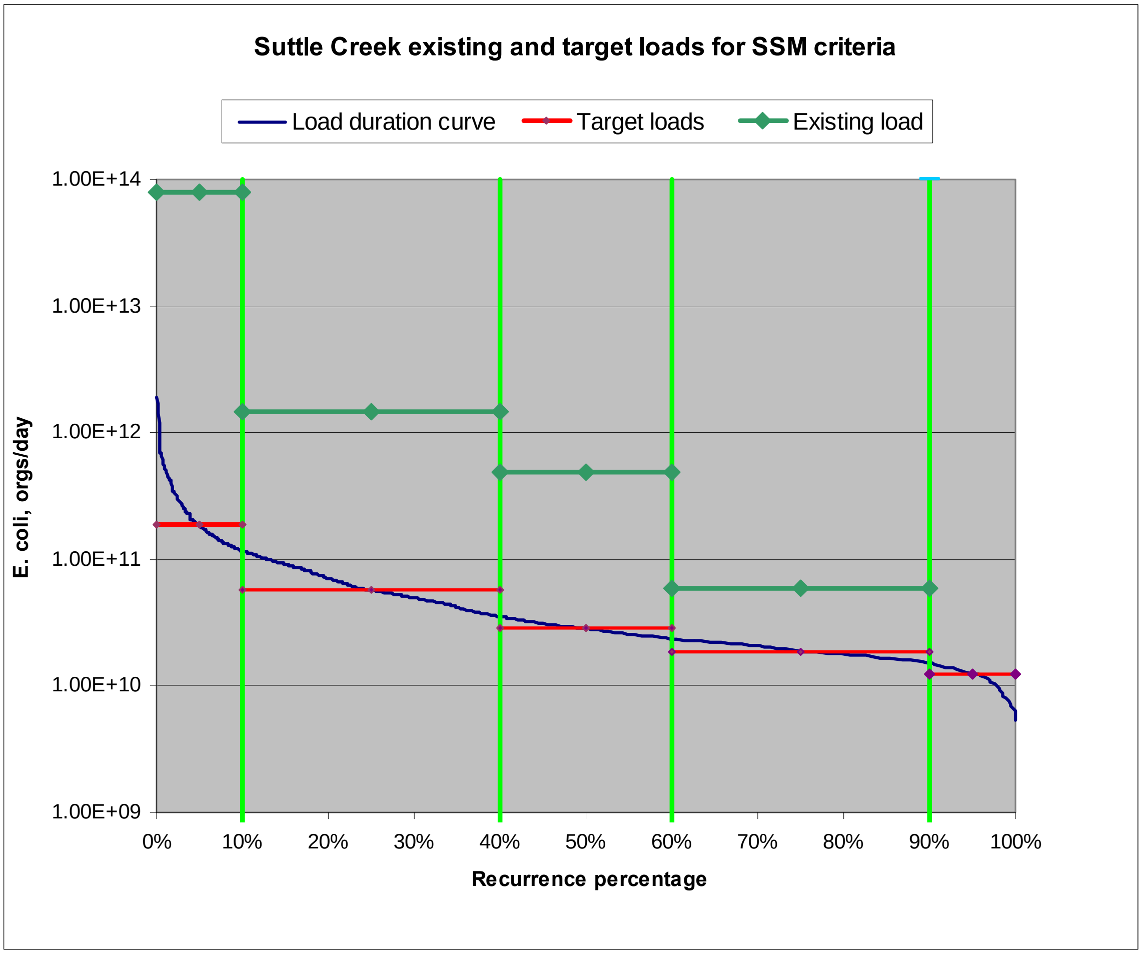

Figure 9-6 Difference between existing and target loads

## 9.4. Pollutant Allocations

*Wasteload allocations.*
Since there are no permitted discharges to Suttle Creek there are no wasteload allocations.

*Load allocation.*
The load allocations for *E. coli* TMDLs are the load capacity less an explicit 10 percent margin of safety (MOS) less the total WLA for the flow condition for the geometric mean

or single sample maximum. There is a separate load allocation set for each of the target recurrence intervals. The load allocations are shown in Tables 9-12 and 9-13.

### Table 9-12 Suttle Creek GM *E. coli* load allocations

| Flow condition, percent recurrence | GM target (TMDL) *E. Coli*, orgs/day | GM MOS *E. Coli*, orgs/day | Total WLA GM *E. coli*, orgs/day | LA GM *E. coli*, orgs/day |
|---|---|---|---|---|
| **High flows** | 1.0E+11 | 1.0E+10 | zero | 9.0E+10 |
| **Moist conditions** | 3.1E+10 | 3.1E+09 | zero | 2.8E+10 |
| **Mid-range flow** | 1.5E+10 | 1.5E+09 | zero | 1.4E+10 |
| **Dry conditions** | 1.0E+10 | 1.0E+09 | zero | 9.1E+09 |
| **Low flow** | 6.7E+09 | 6.7E+08 | zero | 6.1E+09 |

1. Based on geometric mean standard of 126 *E. coli* organisms/100 ml

### Table 9-13 Suttle Creek SSM *E. coli* load allocations

| Flow condition, percent recurrence | SSM target (TMDL) *E. Coli*, orgs/day | SSM MOS *E. Coli*, orgs/day | Total WLA SSM *E. coli*, orgs/day | LA SSM *E. coli*, orgs/day |
|---|---|---|---|---|
| **High flow** | 1.9E+11 | 1.9E+10 | zero | 1.7E+11 |
| **Moist conditions** | 5.7E+10 | 5.7E+09 | zero | 5.2E+10 |
| **Mid-range flow** | 2.8E+10 | 2.8E+09 | zero | 2.6E+10 |
| **Dry conditions** | 1.9E+10 | 1.9E+09 | zero | 1.7E+10 |
| **Low flow** | 1.3E+10 | 1.3E+09 | zero | 1.1E+10 |

1. Based on single sample maximum standard of 235 *E. coli* organisms/100 ml

*Margin of safety.*

The margin of safety for *E. coli* is an explicit 10 percent of the load capacity at each of the design recurrence intervals as shown in Tables 9-12 and 9-13.

## 9.5. TMDL Summary

The following equation shows the total maximum daily load (TMDL) and its components for the impaired IA 01-YEL-0100_0 segment of Suttle Creek.

**Total Maximum Daily Load = Σ Load Allocations + Σ Wasteload Allocations +MOS**

A Total Maximum Daily Load calculation has been made at design flow conditions for the GM and SSM of this segment and these are shown in Tables 9-14 and 9-15 and Figures 9-7 and 9-8.

### Table 9-14 Suttle Creek (IA 01-YEL-0100_0) *E. coli* TMDL for GM

| Flow condition | Σ LA, orgs/day | Σ WLA, orgs/day | MOS, orgs/day | TMDL, orgs/day |
|---|---|---|---|---|
| **High flow** | 9.0E+10 | zero | 1.0E+10 | 1.0E+11 |
| **Moist condition** | 2.8E+10 | zero | 3.1E+09 | 3.1E+10 |
| **Mid-range flow** | 1.4E+10 | zero | 1.5E+09 | 1.5E+10 |
| **Dry conditions** | 9.1E+09 | zero | 1.0E+09 | 1.0E+10 |
| **Low flow** | 6.1E+09 | zero | 6.7E+08 | 6.7E+09 |

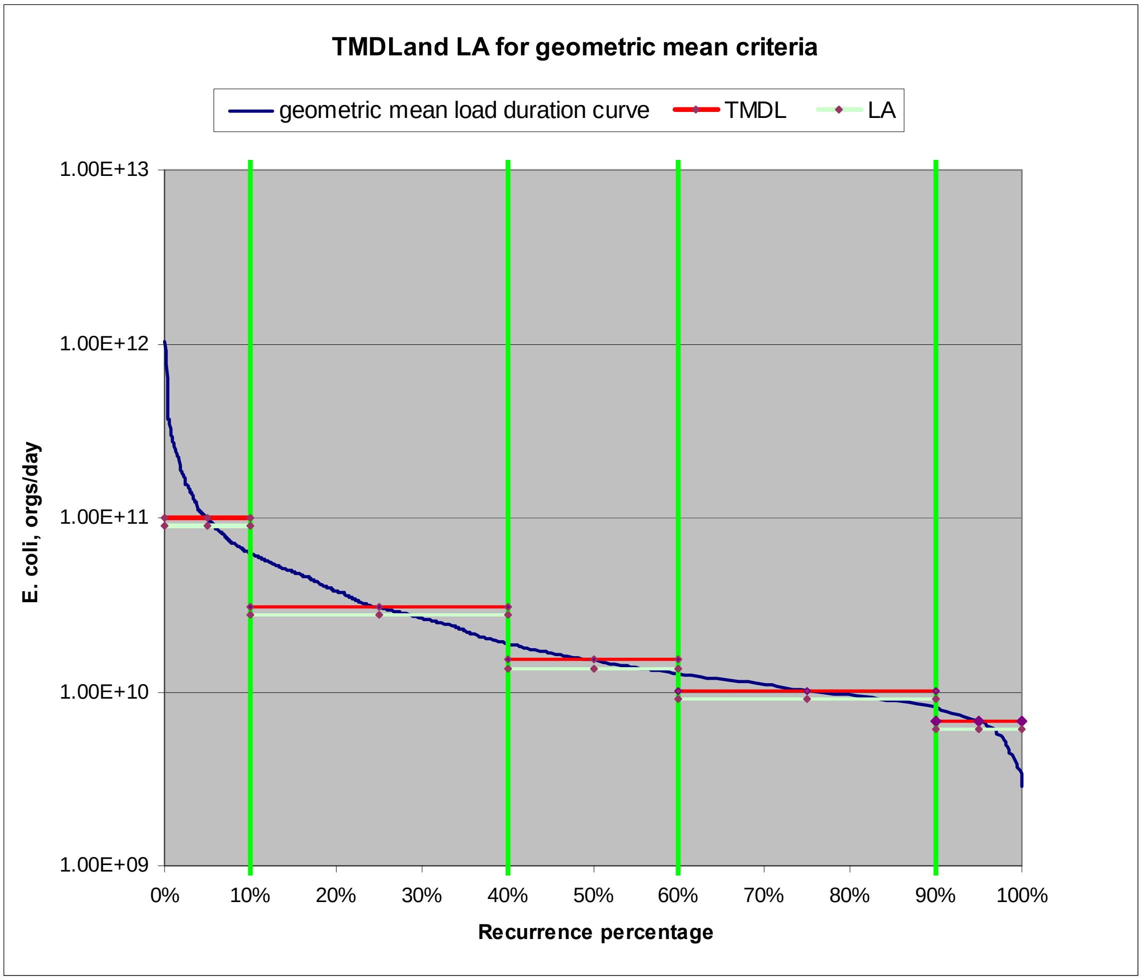

Figure 9-7 GM TMDL at WQS of 126 orgs/100 ml for the five flow conditions

**Table 9-15 Suttle Creek (IA 01-YEL-0100_0) *E. coli* TMDL for SSM**

| Flow condition | Σ LA, orgs/day | Σ WLA, orgs/day | MOS, orgs/day | TMDL, orgs/day |
|---|---|---|---|---|
| High flow | 1.7E+11 | zero | 1.0E+10 | 1.9E+11 |
| Moist condition | 5.2E+10 | zero | 3.1E+09 | 5.7E+10 |
| Mid-range flow | 2.6E+10 | zero | 1.5E+09 | 2.8E+10 |
| Dry conditions | 1.7E+10 | zero | 1.0E+09 | 1.9E+10 |
| Low flow | 1.1E+10 | zero | 6.7E+08 | 1.3E+10 |

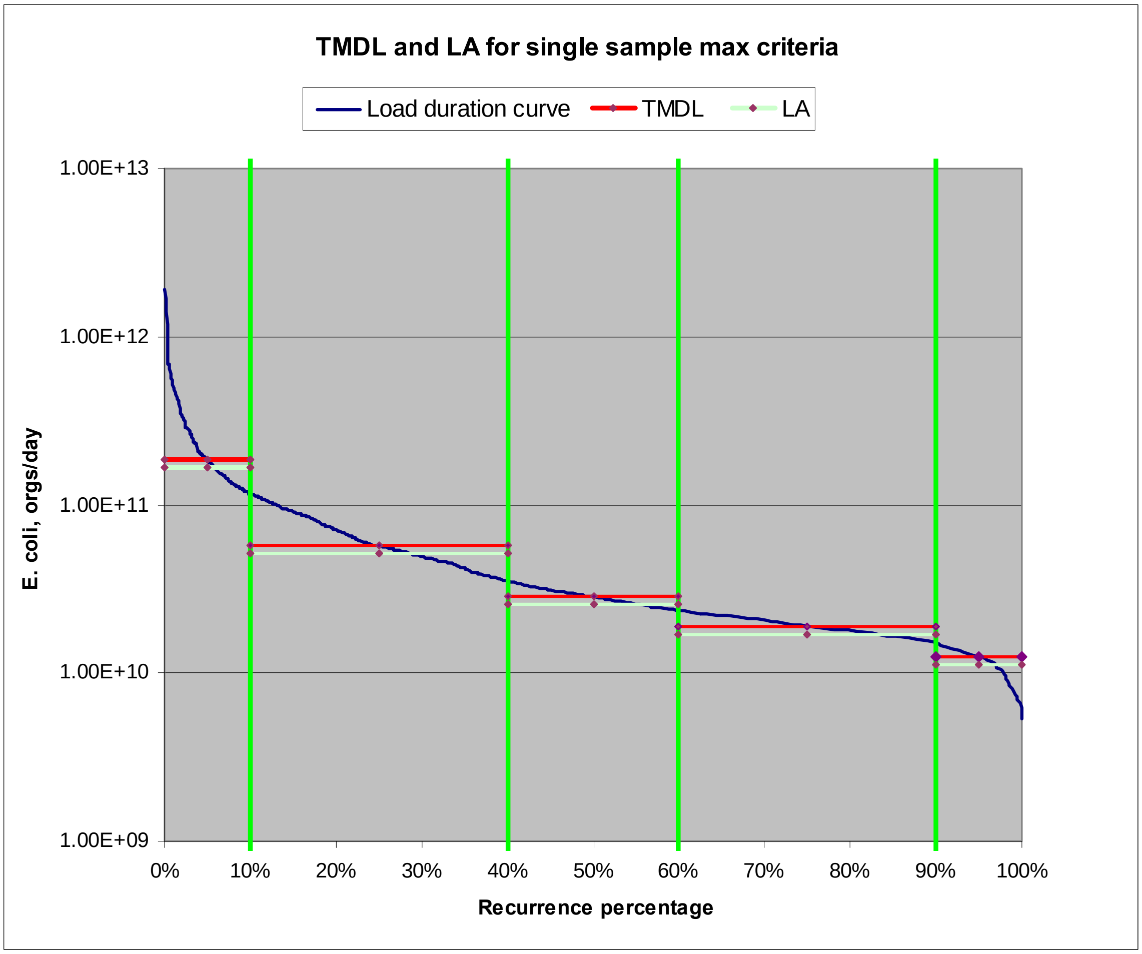

Figure 9-8 SSM TMDL at the WQS of 235 orgs/100 ml for the five flow conditions

## 9.6. Implementation Analysis

The modeled systematic reduction of the loads by source provides the initial evaluation of proposed implementation plans for the subbasin. The SWAT model has been run for five scenarios in which loads have been reduced for the most significant sources. The source analysis identified the primary source of bacteria as cattle in the stream and field applied manure from CAFOs. Figure 9-9 shows the SWAT model output concentrations for the stream with monitored concentrations also plotted on the chart. The target concentration of 235 *E. coli* orgs/100 ml is frequently exceeded by both monitoring data and SWAT simulated values.

The concentration scale has been set to a maximum of 25,000 orgs/100 ml so that monitoring and simulation values are apparent when compared to the SSM. There are two monitoring values that exceed 25,000 orgs/100 ml (260,000, and 290,000). These two high values were measured a week apart in 2006 during rainfall events. Event sampling indicates that concentrations may be much higher during elevated flow than is shown by scheduled monitoring.

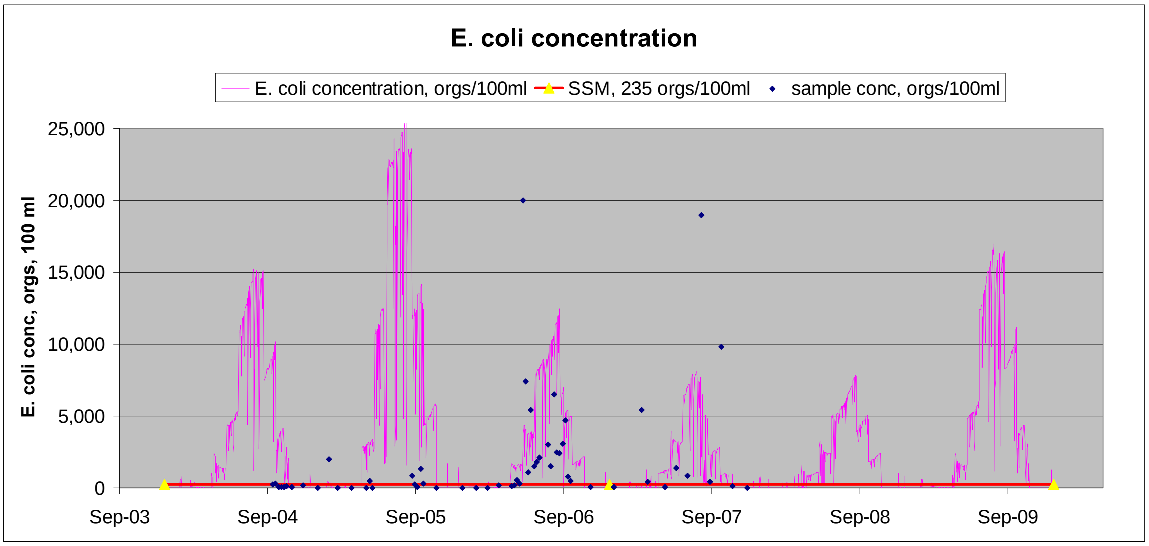

Figure 9-9 SWAT output for existing *E. coli* concentrations

The second scenario, Figure 9-10, removes half of the cattle in the stream from the subbasin. This generates reduced concentrations that are still higher than the SSM standard during the grazing season. The runoff related concentration spikes in all five scenarios.

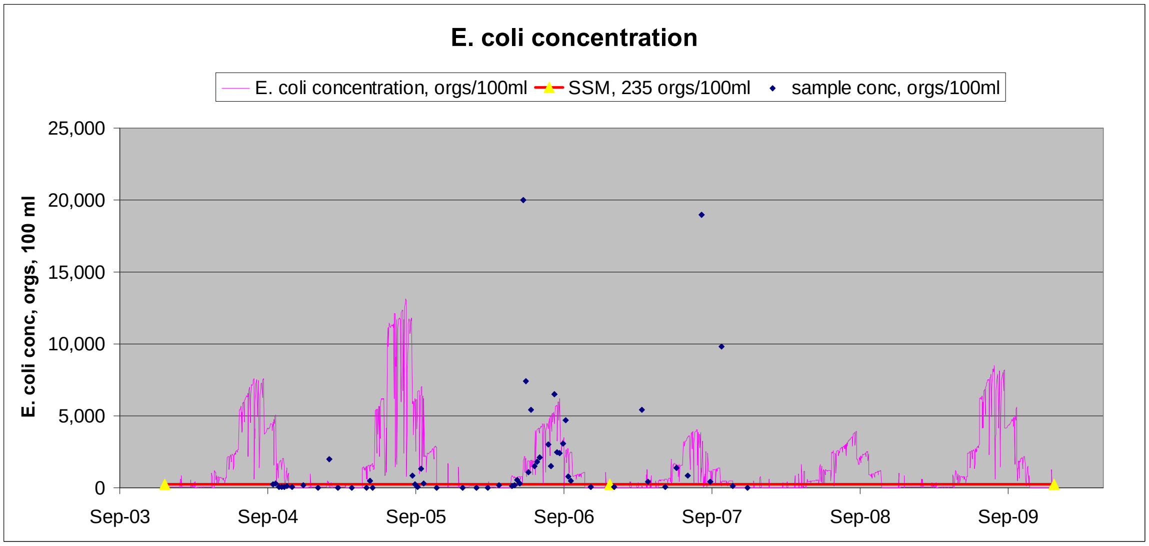

Figure 9-10 SWAT output for half reduction of CIS *E. coli* concentrations

The third scenario, shown in Figures 9-11a and 9-11b, eliminates cattle in the stream as a source. This drops the concentration during the grazing season but there remain instances of high bacteria concentration from runoff. Much of this is associated with field application of manure from confined animal operations and the assumption that it is done in the spring when rain is frequent and intense. The two figures show the same simulation values at two different maximum values in the Y-axis scale. This scale transition clarifies the effects of source reductions and their relation to the target concentration.

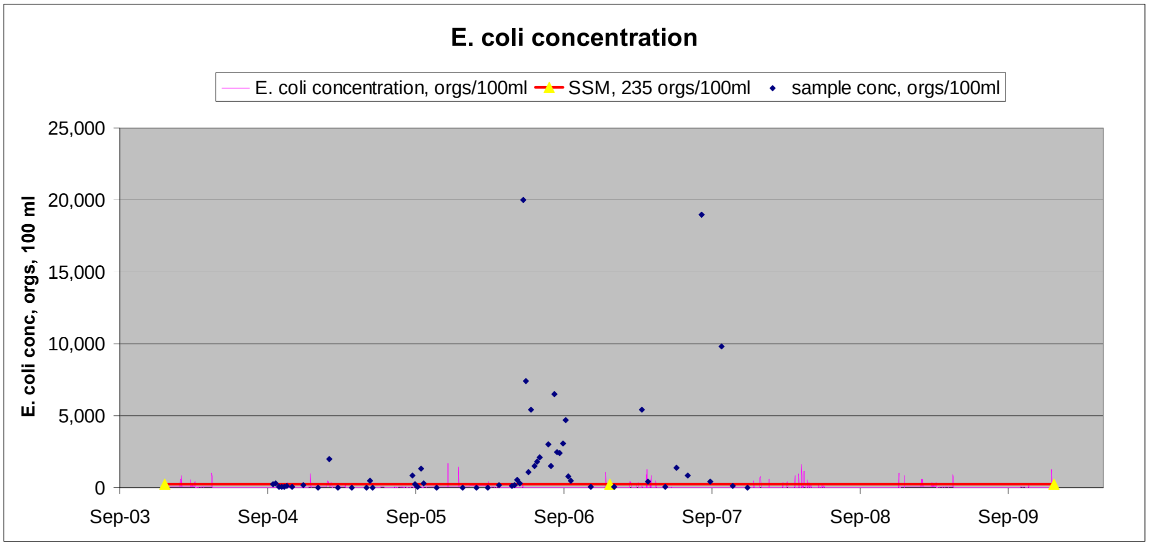

Figure 9-11a SWAT output for complete reduction of CIS *E. coli* with the concentration scale maximum set at 25,000 orgs/100 ml

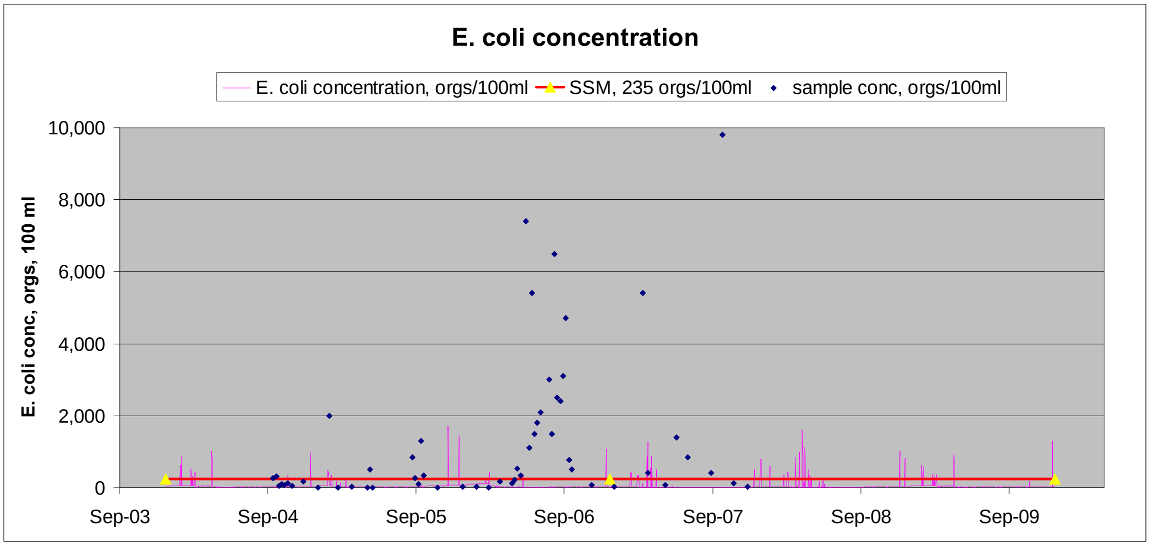

Figure 9-11b SWAT output for complete reduction of CIS *E. coli* with the concentration scale maximum set at 10,000 orgs/100 ml

The fourth scenario, shown in Figure 9-12, assumes that the field applications of manure are cut in half. This brings bacteria concentrations from these applications down but they still exceed the target. Figure 9-11a has the same Y-axis scale maximum (10,000 orgs/100 ml) as Figures 9-12 and 9-13.

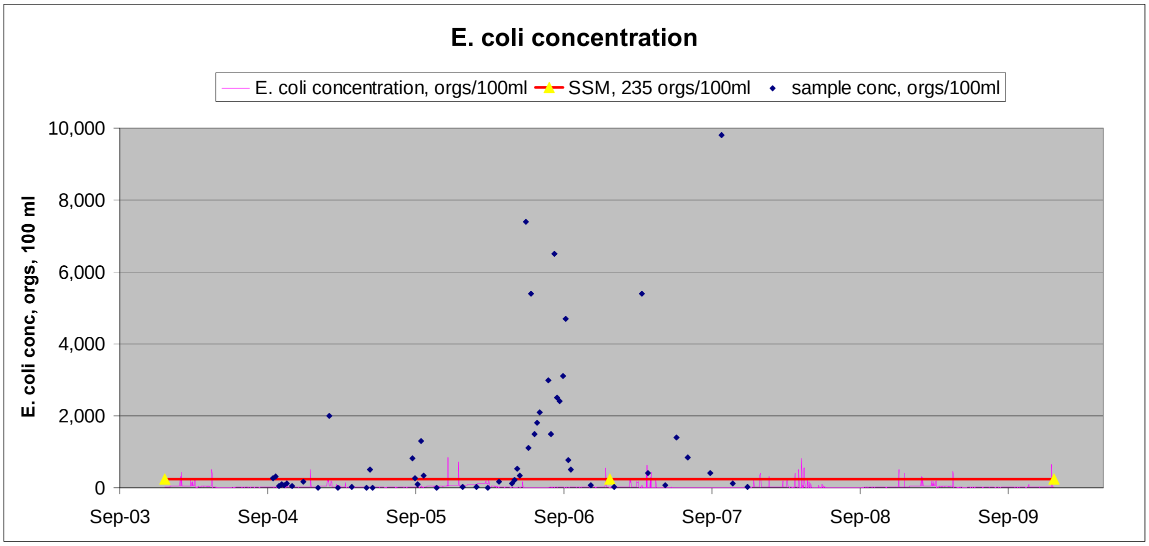

Figure 9-12 SWAT output for complete reduction of CIS *E. coli* and half of applied manure from CAFOs

The fifth scenario, shown in Figure 9-13, in addition to previous reductions, decreases the manure from cattle on pasture by two thirds. This pasture manure reduction showed a minor decrease in stream bacteria concentration.

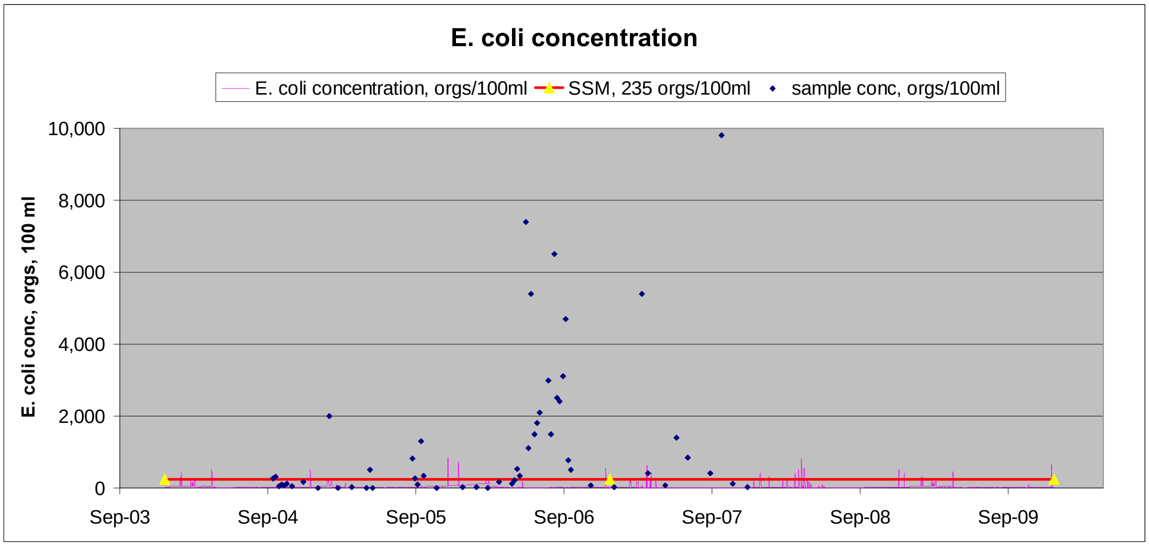

Figure 9-13 SWAT output for complete reduction of CIS *E. coli* and half of applied manure from CAFOs and a two thirds reduction of manure from cattle on pasture

There are several combinations of source reductions that can be simulated. The five scenarios described here reduce bacteria loads from the sources that have been modeled to have the greatest impact on stream outlet bacteria concentrations. The sources that are not reduced in these scenarios may have important episodic or local effect on *E. coli* organism numbers.

# 10. Bear Creek

Bear Creek (IA 01-YEL-0110_0) is the third impaired Yellow River tributary upstream from the Yellow River confluence with the Mississippi. The classified segment runs north 2.0 miles upstream from its confluence with the Yellow River (S13, T96N, R5W, Allamakee County). There are no permitted sources that discharges to this segment. The stream flow used in the development of the TMDL for this segment is derived from the area ratio flow based on the Ion USGS gage data. A SWAT watershed model developed for the Yellow River watershed labels Bear Creek Subbasin 15. Figure 10-1 shows a map of Bear Creek and Table 10-1 shows the land use in its subbasin.

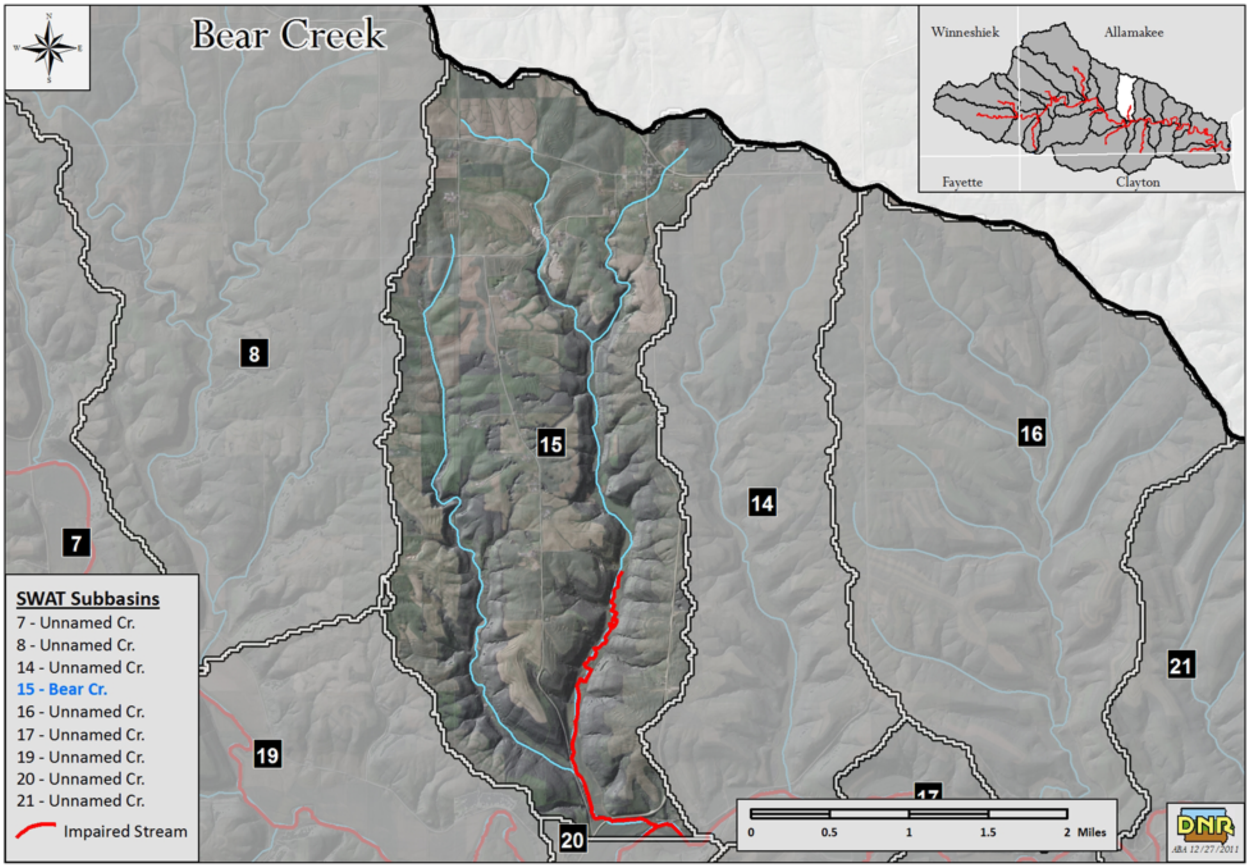

Figure 10-1 Bear Creek (0110_0)

**Table 10-1 Bear Creek subbasin land use**

| Landuse | Area, acres | Fraction of total |
|---|---:|---:|
| Water/wetland | 1.8 | 0.04% |
| Forest | 821.2 | 16.72% |
| Ungrazed/CRP/hay | 1120.7 | 22.81% |
| Grazed | 729.1 | 14.84% |
| Row crop | 2016.1 | 41.03% |
| Roads | 199.7 | 4.07% |
| Commercial/residential | 23.8 | 0.49% |
| **Total** | **4912.4** | **100.00%** |

In the Bear Creek watershed about 40 percent of the area is forest and ungrazed grass and about 40 percent is row crop.

## 10.1. Water body pollutant loading capacity (TMDL)

The *E. coli* organism load capacity is the number of organisms that can be in a volume and meet the water quality criteria. The loading capacity for each of the five flow conditions is calculated by multiplying the midpoint flow and *E. coli* criteria concentrations. Table 10-2 shows the median, maximum, and minimum flows for the five flow conditions.

### Table 10-2 Bear Creek maximum, minimum and median flows

| Flow description | Recurrence interval range (mid %) | Midpoint of flow range, cfs | Maximum of flow range, cfs | Minimum of flow range, cfs |
|---|---|---|---|---|
| **High flow** | **0 to 10% (5)** | 22.0 | 400.0 | 14.5 |
| **Moist conditions** | **10% to 40% (25)** | 6.9 | 14.5 | 4.3 |
| **Mid-range** | **40% to 60% (50)** | 3.4 | 4.3 | 2.8 |
| **Dry conditions** | **60% to 90% (75)** | 2.2 | 2.8 | 1.8 |
| **Low flow** | **90% to 100% (95)** | 1.5 | 1.8 | 0.6 |

Flow and load duration curves were used to establish the occurrence of water quality standards violations, to establish compliance targets, and to set pollutant allocations and margins of safety. Duration curves are derived from flows plotted as a percentage of their recurrence. *E. coli* loads are calculated from *E. coli* concentrations and flow volume at the time the sample was collected.

To construct the flow duration curves, the bacteria monitoring data and the Water Quality Standard (WQS) sample max (235 *E. coli* organisms/100 ml) were plotted with the flow duration percentile. Figure 10-2 shows the data that exceed the WQS criteria at each of the five flow conditions. High flow violations indicate that the problem occurs during run-off conditions when bacteria are washing off from nonpoint sources. Criteria exceeded during low or base flow, when little or no runoff is occurring, indicate that continuous sources such as septic tanks, livestock in the stream, riparian wildlife, and wastewater treatment plants are the problem.

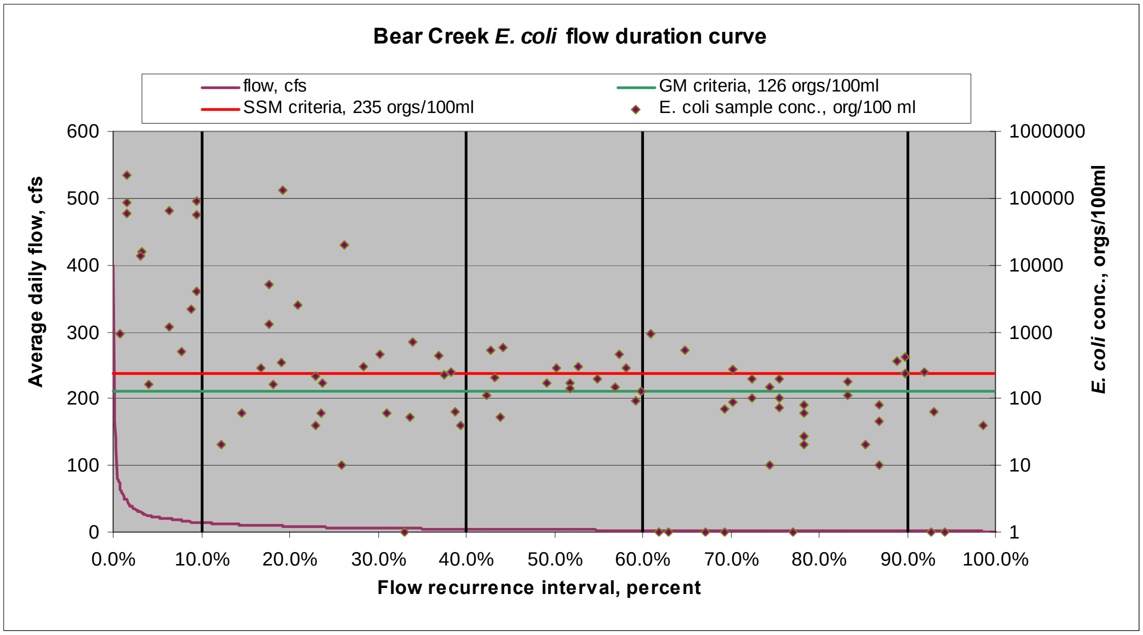

Figure 10-2 Bear Creek flow duration curve

Load duration curves were used to evaluate the five flow conditions for Bear Creek. The load duration curve is shown in Figure 10-3. In the figure, the lower curve shows the maximum *E. coli* count for the GM criteria and the upper curve shows the maximum *E. coli* count for the SSM criteria at a continuum of flow recurrence percentage. The individual points are the observed (monitored) *E. coli* concentrations converted to loads based on daily flow for the day they were collected. Points above the load duration curves are violations of the WQS criteria and exceed the loading capacity.

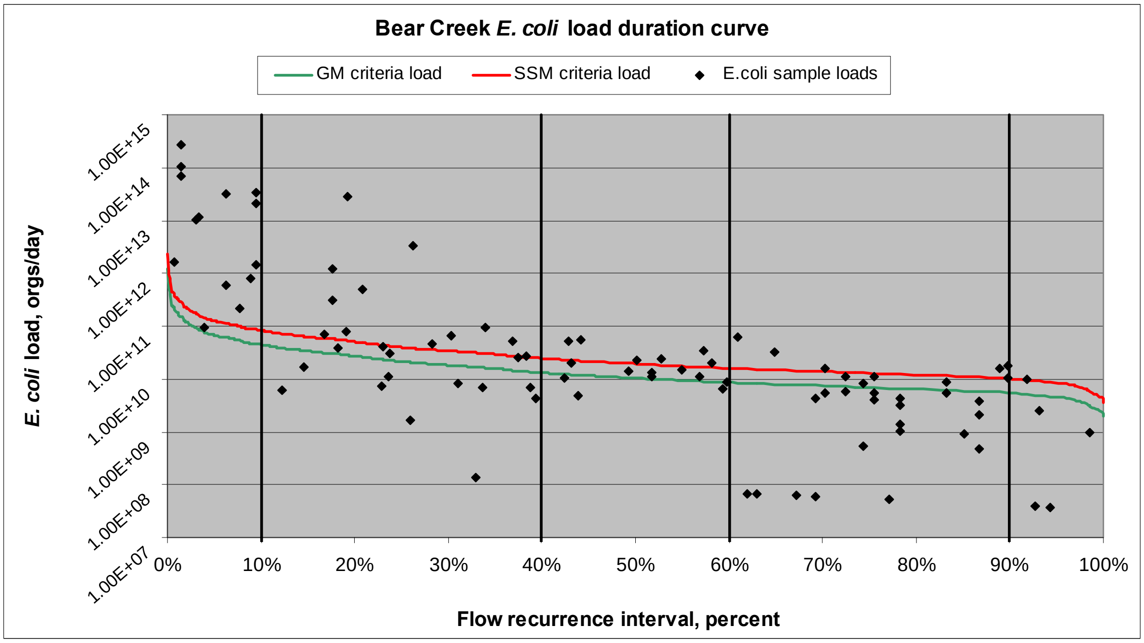

Figure 10-3 Bear Creek load duration curve

Tables 10-3 and 10-4 show the load capacities (targets) for each of the midpoint flow conditions at the GM and SSM criteria, respectively.

### Table 10-3 Bear Creek GM load capacity

| Flow condition | Recurrence interval | Associated midpoint flow, cfs | Estimated flow interval load capacity, *E. coli* orgs/day |
|---|---|---|---|
| **High flow** | **0 to 10%** | 22.0 | 6.8E+10 |
| **Moist conditions** | **10% to 40%** | 6.9 | 2.1E+10 |
| **Mid-range** | **40% to 60%** | 3.4 | 1.0E+10 |
| **Dry conditions** | **60% to 90%** | 2.2 | 6.9E+09 |
| **Low flow** | **90% to 100%** | 1.5 | 4.5E+09 |

### Table 10-4 Bear Creek SSM load capacity

| Flow condition | Recurrence interval | Associated midpoint flow, cfs | Estimated flow interval load capacity, *E. coli* orgs/day |
|---|---|---|---|
| **High flow** | **0 to 10%** | 22.0 | 1.3E+11 |
| **Moist conditions** | **10% to 40%** | 6.9 | 4.0E+10 |
| **Mid-range** | **40% to 60%** | 3.4 | 1.9E+10 |
| **Dry conditions** | **60% to 90%** | 2.2 | 1.3E+10 |
| **Low flow** | **90% to 100%** | 1.5 | 8.5E+09 |

## 10.2. Existing load

The existing loads are derived from the sampling data collected at the Bear Creek Site. These data are the sample values shown in the flow and load duration curves. The *E. coli* concentrations are multiplied by the simulated daily flow to get the daily loads. The daily loads are plotted with the load duration curves. The allowable loads for a given flow equal the flow multiplied by the WQS limits for the geometric mean or single sample maximum. Monitored data that exceed the limits are above the criteria curves.

The maximum existing loads occur during major rains when runoff and bacteria concentrations are highest. Concentrations exceed the criteria during these high flow events. Other conditions leading to criteria violations occur during dry low flow periods when continuous loads from livestock in the stream, local wildlife, septic tanks, and wastewater treatment plants can cause bacteria problems.

The assessment standard used to evaluate streams is the *E. coli* geometric mean criteria. Since the load duration approach precludes the calculation of a geometric mean, the 90th percentile of observed concentrations within each flow condition is multiplied by the median flow to estimate existing loads. This procedure has been used to evaluate impaired segments. Table 10-5 shows the existing loads for each flow condition.

### Table 10-5 Bear Creek existing loads

| Flow condition, percent recurrence | Recurrence interval range (mid %) | Associated median flow, cfs | Existing 90th percentile *E. coli* conc., org/100ml | Estimated existing load, *E. coli* org/day |
|---|---|---|---|---|
| **High flows** | **0 to 10% (5)** | 22.0 | 90800 | 4.88E+13 |
| **Moist conditions** | **10% to 40% (25)** | 6.9 | 3800 | 6.44E+11 |
| **Mid-range** | **40% to 60% (50)** | 3.4 | 505 | 4.15E+10 |
| **Dry conditions** | **60% to 90% (75)** | 2.2 | 365 | 2.00E+10 |
| **Low flow** | **90% to 100% (95)** | 1.5 | 176 | 6.32E+09 |

*Identification of pollutant sources.*

The sources of bacteria in the Bear Creek subbasin (SWAT Subbasin 15) are all nonpoint sources. These include failed septic tank systems, pastured cattle, cattle in the stream, wildlife, and manure applied to fields from animal confinement operations. The loads from these sources are incorporated into the SWAT watershed model and are listed in Tables 10-6 to 10-10.

Non functional septic tank systems. There are an estimated 70 onsite septic tank systems in the subbasin (2.5 persons/household). IDNR estimates that 50 percent are not functioning properly. It is assumed that these are continuous year round discharges. Septic tank loads have been put into the SWAT model as a continuous source by subbasin.

### Table 10-6 Bear Creek septic tank system E. coli orgs/day

| | |
|---|---|
| Rural population of Bear Creek subbasin | 176 |
| Total initial E.coli, orgs/day [1] | 2.20E+11 |
| Septic tank flow, $m^3$/day [2] | 46.6 |
| **E. coli delivered to stream, orgs/day [3]** | **1.46E+08** |

1. Assumes 1.25E+09 E. coli orgs/day per capita
2. Assumes 70 gallons/day/capita
3. Assumes septic discharge concentration reaching stream is 625 orgs/100 ml and a 50% failure rate

Cattle in stream. Of the 460 cattle in pastures with stream access, one to six percent of those are assumed to be in the stream on a given day. The number on pasture and the fraction in the stream varies by month. Cattle in the stream have a high potential to deliver bacteria since bacteria are deposited directly in the stream with or without rainfall. Subbasin cattle in the stream bacteria have been input in the SWAT model as a continuous source varying by month.

### Table 10-7 Bear Creek Cattle in the stream E. coli orgs/day

| | |
|---|---|
| Pasture area with stream access, ha[1] | 590 |
| Number of cattle in stream (6% of total)[2] | 28 |
| Dry manure, kg/day [3] | 86 |
| **E. coli load, orgs/day [4]** | **1.13E+12** |

1. The subbasin CIS are estimated from the pasture area with stream access at 0.78 cattle/acre.

2. It is estimated that cattle spend 6% of their time in streams in July and August, 3% in June and September, and 1% in May and October. The loads shown in this table are for July and August. The loads for the other 4 months when cattle are in streams have been incorporated into the SWAT modeling.
3. Cattle generate 3.1 kg/head/day of dry manure.
4. Manure has 1.32E+07 E coli orgs/gram dry manure.

Grazing livestock. The estimated number of cattle in the subbasin is 540. It is assumed that they are on pasture from April to November. The potential for bacteria delivery to the stream occurs with precipitation causing runoff. Manure available for washoff is applied in the SWAT model at 6 kg/ha in the pasture landuse.

### Table 10-8 Bear Creek manure from pastured cattle, maximum E. coli available for washoff, orgs/day

| | |
|---|---:|
| Pasture area, acre | 727 |
| Number of cattle on pasture[1] | 540 |
| Dry manure, kg/day[2] | 1673 |
| Maximum E. coli load, orgs/day[3] | 2.21E+13 |
| Maximum E. coli available for washoff, orgs[4] | 3.97E+13 |

1. The number of pastured cattle is 0.78 cattle/acre.
2. Cattle generate 3.1 kg/head/day of dry manure.
3. Manure has 1.32E+07 E. coli orgs/gram dry manure
4. The load available for washoff is the daily load times 1.8.

Wildlife manure. The number of deer in Allamakee County is about 9,000 located primarily in forested land adjacent to streams. Another 1,000 have been added to account for other wildlife such as raccoons and waterfowl for a total estimate of 10,000. This works out to 0.024 deer per acre. Using this procedure, there are 118 deer in the subbasin concentrated in the forested areas. The deer are in the subbasin year round.

### Table 10-9 Bear Creek watershed wildlife manure loads available for washoff

| Number of deer[1] | Forested area, ha | SWAT manure loading rate, kg/ha/day[2] | E. coli available for washoff, orgs[3] |
|---|---|---|---|
| 118 | 505 | 0.336 | 1.06E+11 |

1. Deer numbers are 0.024 deer/ha for the entire subbasin concentrated to 0.234 deer/ha in the forest land use. All wildlife loads are applied to the forest landuse in the SWAT model. The county deer numbers have been increased by 10% to account for other wildlife in the subbasin.
2. Assumes 1.44 kg/deer/day and 3.47E+05 orgs/gram.
3. Assumes that the maximum E. coli available for washoff is 1.8 times the daily load.

Field applications of CAFO manure.
There are about 4,400 hogs in confinement in the subbasin. The manure is stored and land applied to cropland. The manure is distributed to the fields in the subbasin in the fall after soybean harvest and in the spring prior to corn planting in year two of a two year rotation. The relatively brief fall and spring timing of manure application and incorporation in the soil significantly reduces the *E. coli* organisms from these sources.

Manure application has been put in the SWAT model by subbasin as a load available at the end of October and the beginning of April.

**Table 10-10 Bear Creek watershed confined livestock manure applications**

| Livestock type | Swine | Chickens | Dairy cows |
|---|---|---|---|
| Number of animals | 4,400 | 0 | 0 |
| Manure applied, kg/year[1] | 1,814,780 | 0 | 0 |
| Area applied to, ha[2] | 86.2 | 0 | 0 |
| Manure applied, kg/ha/day[3] | 2,127 | 0 | 0 |
| Subbasin E. coli, orgs/day | 4.85E+14 | 0 | 0 |
| Subbasin E. coli available for washoff, orgs/day[4] | 8.73E+14 | 0 | 0 |

1. Manure is calculated based on number of animals * dry manure (kg/animal/day)*365 days/year.
2. The area the manure is applied to is based on the manure's nitrogen content. Manure is applied at a rate equivalent to 201.6 kg N/ha/yr. Swine manure is applied at 2127 kg/ha, dairy manure at 2631 kg/ha and chicken manure at 2326 kg/ha. The E. coli content of manure for swine is 1.32E+07 orgs/gram, for dairy cows is 1.00E+07 orgs/gram, and for chickens is 2.96E+06 orgs/gram.
3. Manure is assumed to be applied to fields twice a year over 5 days on October 30 and April 1. It is incorporated in the soil and it is assumed that only 10% of bacteria are viable and available after storage and incorporation.
4. Maximum *E. coli* available for washoff are 1.8 times the daily maximum available load.

<u>Seasonal variation of sources</u>.

The relative impacts of the bacteria sources are shown in Figures 10-4 and 10-5. Figure 10-4 shows the relative loads delivered by the "continuous" sources, those sources present with or without rainfall and runoff. These are the failed septics that are assumed to be a problem every day of the year and the loads from cattle in the stream that vary by month from May to October. It can be seen in this figure that the impacts from cattle in the stream are much more significant than those from failed septic tank systems.

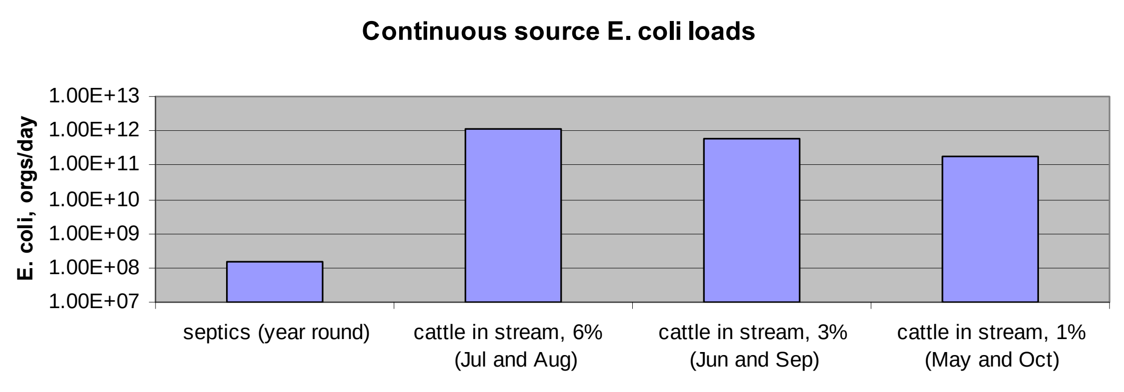

Figure 10-4 E. coli loads from "continuous" sources

The three general washoff sources of bacteria in the subbasin are shown in Figure 10-5. The wildlife source consists primarily of deer and smaller animals such as raccoons and waterfowl. These are year round sources. Pastured cattle consist of grazing cattle and small poorly managed feedlot-like operations. The grazing season is modeled as lasting

168 days starting May 1. Manure from confined animal feeding operations (CAFO) is applied to cropland twice a year for a relatively brief time. Most field applied manure is assumed to be incorporated into the soil and most soil bacteria are not available. Confinement animals are swine, chickens and dairy cattle.

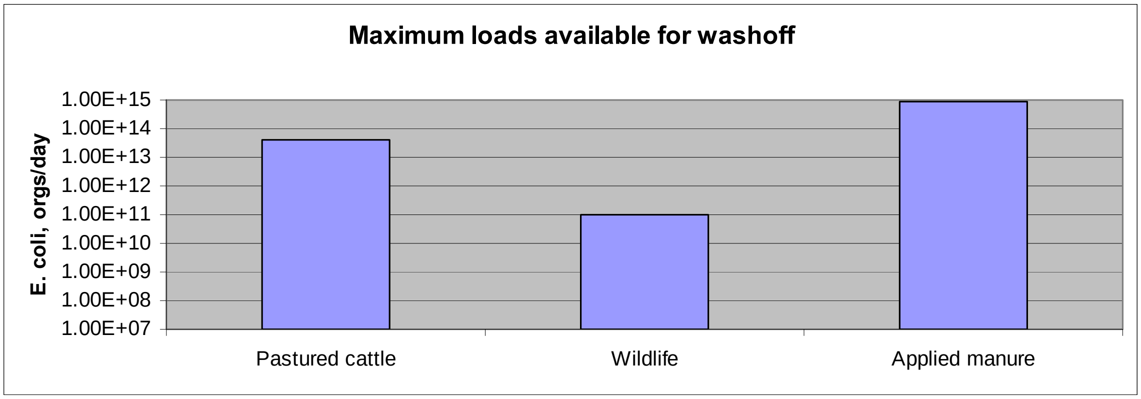

Figure 10-5 Maximum E. coli loads available for washoff

The maximum bacteria load to the stream occurs when the continuous source load plus the precipitation driven washoff load are combined. In general, the more rainfall the higher the flow and the more elevated the concentration. High flow and elevated concentration equal peak loads. In July and August, the potential maximum load based on this analysis is 3.98E+13 orgs/day available for washoff plus the continuous load of 1.13E+12 orgs/day for a total of 4.10E+13 orgs/day.

Flow interval load source analysis. Based on the load duration curve analysis, the maximum existing load occurring during the zero to forty percent recurrence interval runoff conditions is 1.45E+13 orgs/day and the total available load based on potential sources, including fall and spring manure applications, is 9.13E+14 orgs/day. Generally the maximum load in the stream, delivered in April when runoff is occurring, is approximately two percent of the bacteria available for washoff. At the zero to ten percent maximum existing load of 4.88E+13 orgs/day and with the same load available for washoff the stream load is five percent of the available load.

## 10.3 Departure from load capacity

The departure from load capacity is the difference between the existing load and the load capacity. This varies for each of the five flow conditions. Table 10-11 shows this difference. The existing and target loads for the five flow conditions are shown graphically in Figure 10-6.

### Table 10-11 Bear Creek departure from load capacity

| Design flow condition, percent recurrence | Recurrence interval range (mid %) | Existing *E. coli* orgs/day | Load capacity, orgs/day | Departure from capacity, orgs/day |
|---|---|---|---|---|
| **High flow** | **0 to 10% (5)** | 4.88E+13 | 1.3E+11 | 4.87E+13 |
| **Moist conditions** | **10% to 40% (25)** | 6.44E+11 | 4.0E+10 | 6.05E+11 |
| **Mid-range flow** | **40% to 60% (50)** | 4.15E+10 | 1.9E+10 | 2.22E+10 |
| **Dry conditions** | **60% to 90% (75)** | 2.00E+10 | 1.3E+10 | 7.13E+09 |
| **Low flow** | **90% to 100% (95)** | 6.32E+09 | 8.5E+09 | -2.14E+09 |

1. Negative values indicate that the existing load is less than the target load.

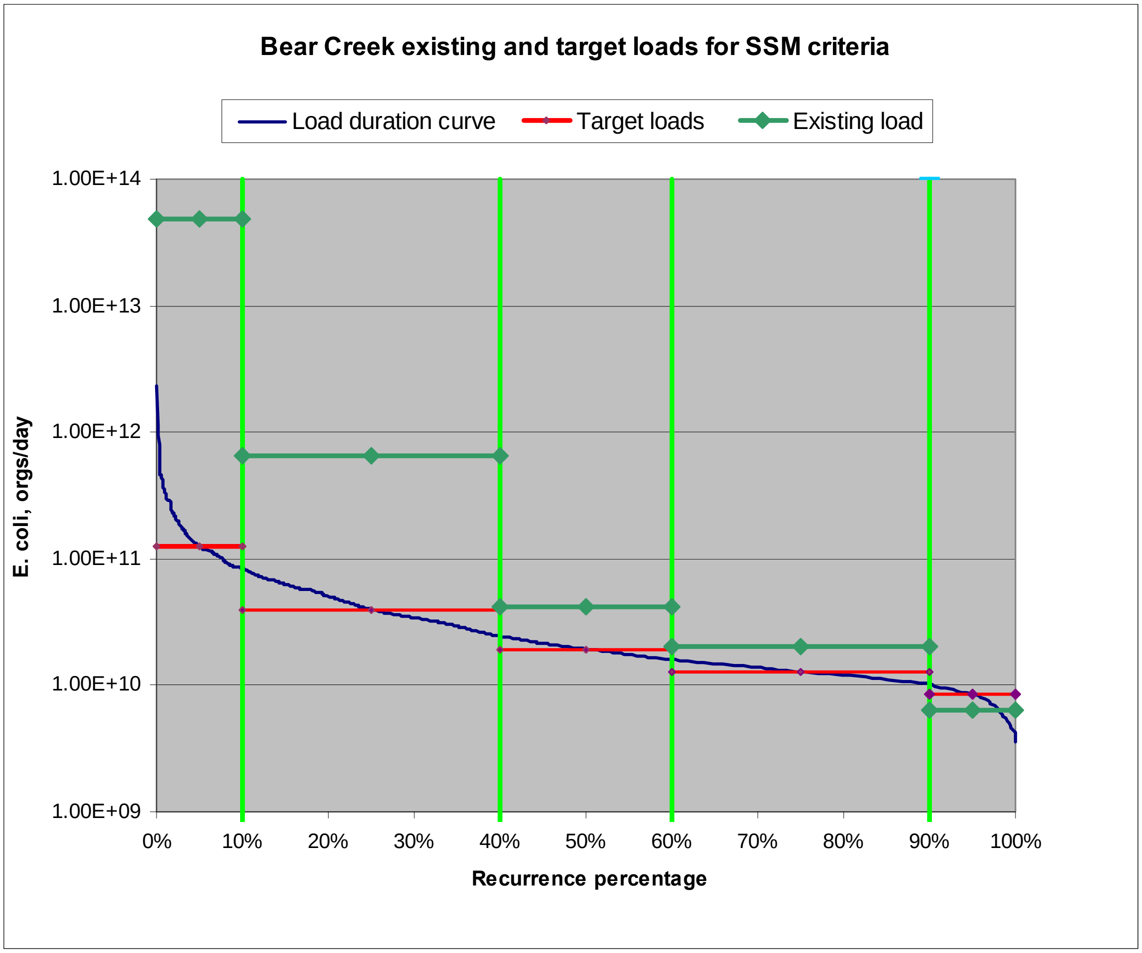

Figure 10-6 Difference between existing and target loads

## 10.4. Pollutant Allocations

*Wasteload allocations.*

Since there are not any permitted discharges to Bear Creek there are not any wasteload allocations.

*Load allocation.*

The load allocations for *E. coli* TMDLs are the load capacity less an explicit 10 percent margin of safety (MOS) less the total WLA for the flow condition for the geometric mean

or single sample maximum. There is a separate load allocation set for each of the target recurrence intervals. The load allocations are shown in Tables 10-12 and 10-13.

### Table 10-12 Bear Creek GM *E. coli* load allocations

| Flow condition, percent recurrence | GM target (TMDL) *E. Coli*, orgs/day | GM MOS *E. Coli*, orgs/day | Total WLA GM *E. coli*, orgs/day | LA GM *E. coli*, orgs/day |
|---|---|---|---|---|
| **High flows** | 6.8E+10 | 6.8E+09 | zero | 6.1E+10 |
| **Moist conditions** | 2.1E+10 | 2.1E+09 | zero | 1.9E+10 |
| **Mid-range flow** | 1.0E+10 | 1.0E+09 | zero | 9.3E+09 |
| **Dry conditions** | 6.9E+09 | 6.9E+08 | zero | 6.2E+09 |
| **Low flow** | 4.5E+09 | 4.5E+08 | zero | 4.1E+09 |

1. Based on geometric mean standard of 126 *E. coli* organisms/100 ml

### Table 10-13 Bear Creek SSM *E. coli* load allocations

| Flow condition, percent recurrence | SSM target (TMDL) *E. Coli*, orgs/day | SSM MOS *E. Coli*, orgs/day | Total WLA SSM *E. coli*, orgs/day | LA SSM *E. coli*, orgs/day |
|---|---|---|---|---|
| **High flow** | 1.3E+11 | 1.3E+10 | zero | 1.1E+11 |
| **Moist conditions** | 4.0E+10 | 4.0E+09 | zero | 3.6E+10 |
| **Mid-range flow** | 1.9E+10 | 1.9E+09 | zero | 1.7E+10 |
| **Dry conditions** | 1.3E+10 | 1.3E+09 | zero | 1.2E+10 |
| **Low flow** | 8.5E+09 | 8.5E+08 | zero | 7.6E+09 |

1. Based on single sample maximum standard of 235 *E. coli* organisms/100 ml

*Margin of safety.*

The margin of safety for *E. coli* is an explicit 10 percent of the load capacity at each of the design recurrence intervals as shown in Tables 10-12 and 10-13.

## 10.5. TMDL Summary

The following equation shows the total maximum daily load (TMDL) and its components for the impaired IA 01-YEL-0110_0 segment of Bear Creek.

**Total Maximum Daily Load = Σ Load Allocations + Σ Wasteload Allocations +MOS**

A Total Maximum Daily Load calculation has been made at design flow conditions for the GM and SSM of this segment and these are shown in Tables 10-14 and 10-15 and Figures 10-7 and 10-8.

### Table 10-14 Bear Creek *E. coli* TMDL for GM

| Flow condition | Σ LA, orgs/day | Σ WLA, orgs/day | MOS, orgs/day | TMDL, orgs/day |
|---|---|---|---|---|
| **High flow** | 6.1E+10 | zero | 6.8E+09 | 6.8E+10 |
| **Moist condition** | 1.9E+10 | zero | 2.1E+09 | 2.1E+10 |
| **Mid-range flow** | 9.3E+09 | zero | 1.0E+09 | 1.0E+10 |
| **Dry conditions** | 6.2E+09 | zero | 6.9E+08 | 6.9E+09 |
| **Low flow** | 4.1E+09 | zero | 4.5E+08 | 4.5E+09 |

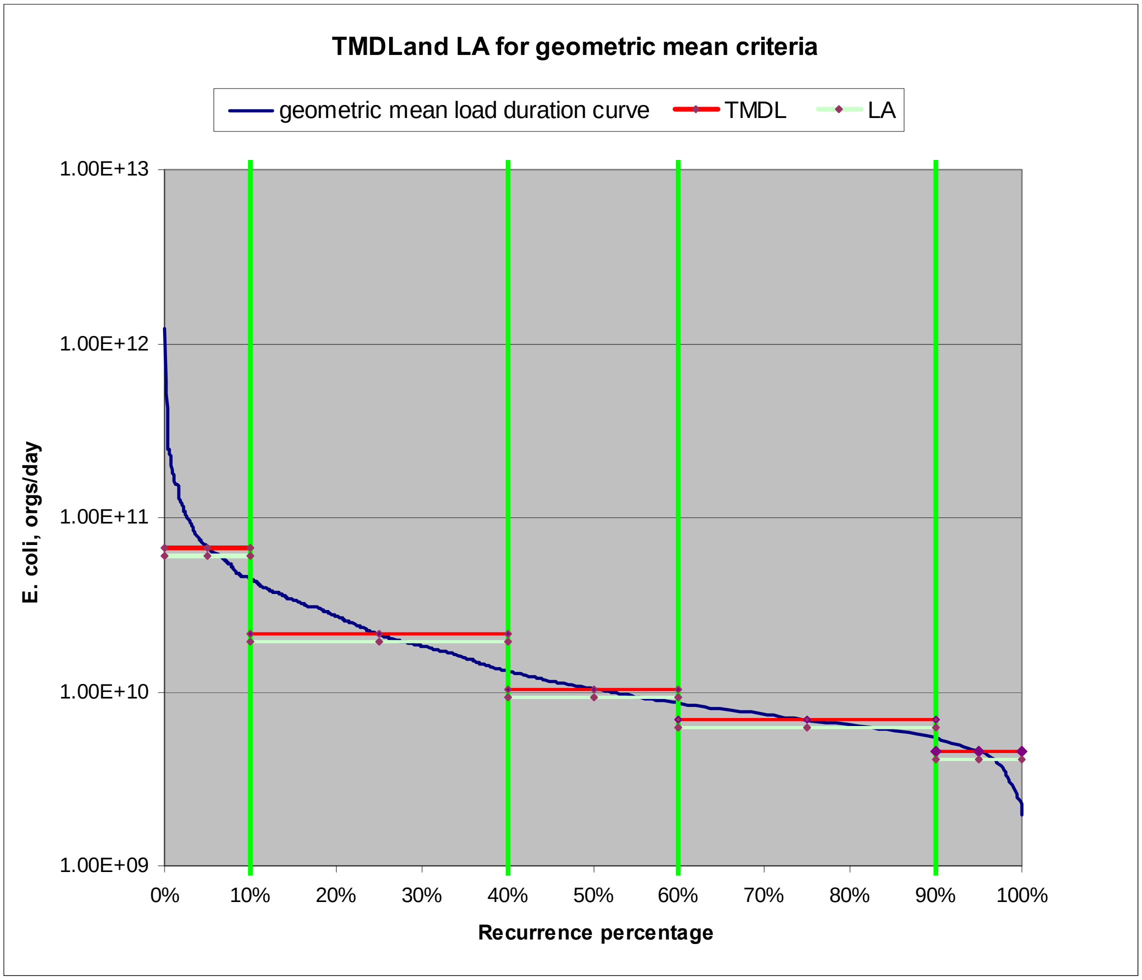

Figure 10-7 GM TMDL at WQS of 126 orgs/100 ml for the five flow conditions

**Table 10-15 Bear Creek *E. coli* TMDL for SSM**

| Flow condition | Σ LA, orgs/day | Σ WLA, orgs/day | MOS, orgs/day | TMDL, orgs/day |
|---|---|---|---|---|
| High flow | 1.1E+11 | zero | 1.3E+10 | 1.3E+11 |
| Moist condition | 3.6E+10 | zero | 4.0E+09 | 4.0E+10 |
| Mid-range flow | 1.7E+10 | zero | 1.9E+09 | 1.9E+10 |
| Dry conditions | 1.2E+10 | zero | 1.3E+09 | 1.3E+10 |
| Low flow | 7.6E+09 | zero | 8.5E+08 | 8.5E+09 |

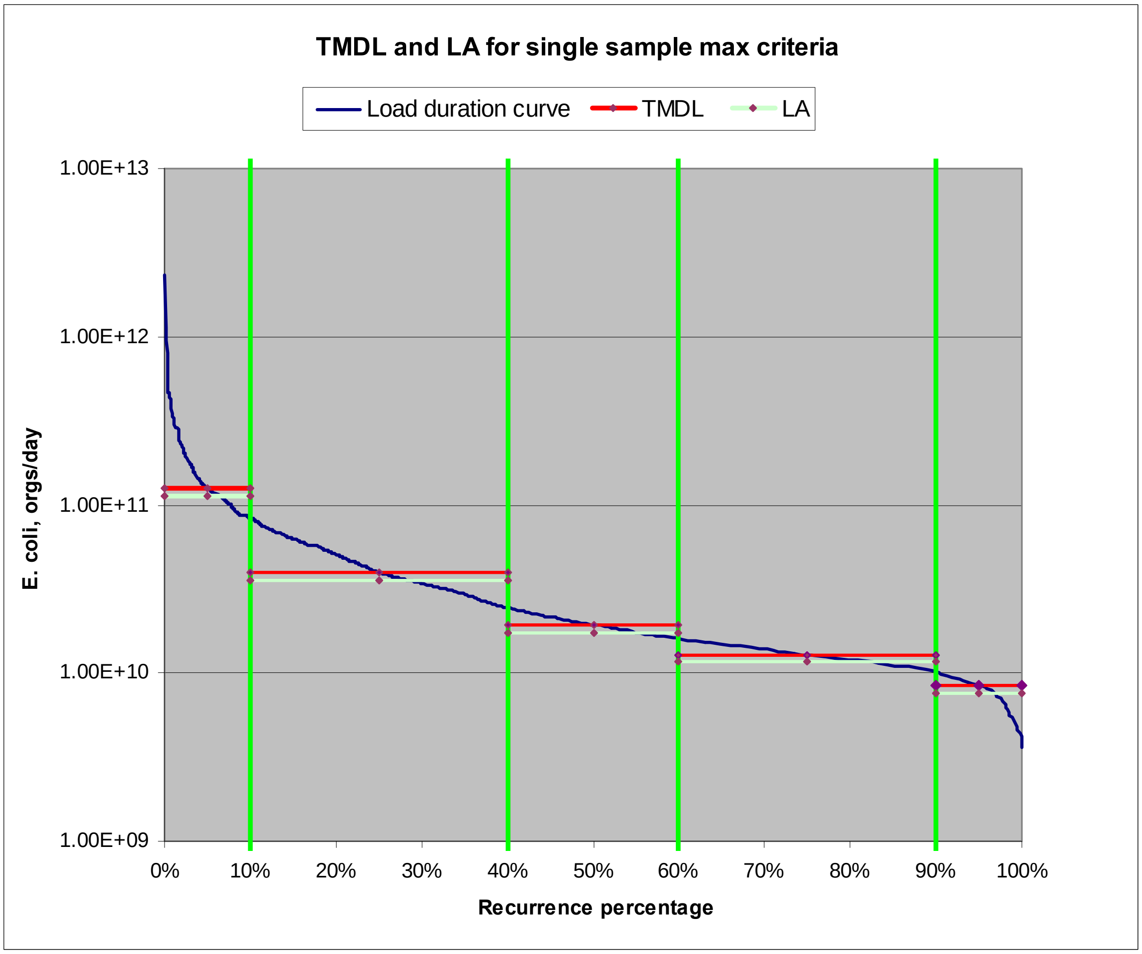

Figure 10-8 SSM TMDL at WQS of 235 orgs/100 ml for the five flow conditions

## 10.6. Implementation Analysis

The modeled systematic reduction of the loads by source provides the initial evaluation of proposed implementation plans for the subbasin. The SWAT model has been run for five scenarios in which loads have been reduced for the most significant sources. The source analysis identified the primary source of bacteria and as cattle in the stream and field applied manure from CAFOs. Figure 10-9 shows the SWAT model output concentrations for the stream with monitored concentrations also plotted on the chart. The target concentration of 235 *E. coli* orgs/100 ml is frequently exceeded by both monitoring data and SWAT simulated values.

The concentration scale has been set to 25,000 orgs/100 ml so that monitoring and simulation values are apparent when compared to the SSM. There are seven monitoring values that exceed 25,000 (57,000, 58,000, 65,000, 88,000, 92,000, 130,000, and 160,000). All of these high values were obtained from the 2009 storm event sampling and may indicate that concentrations are higher during elevated flow than is shown by previous monitoring.

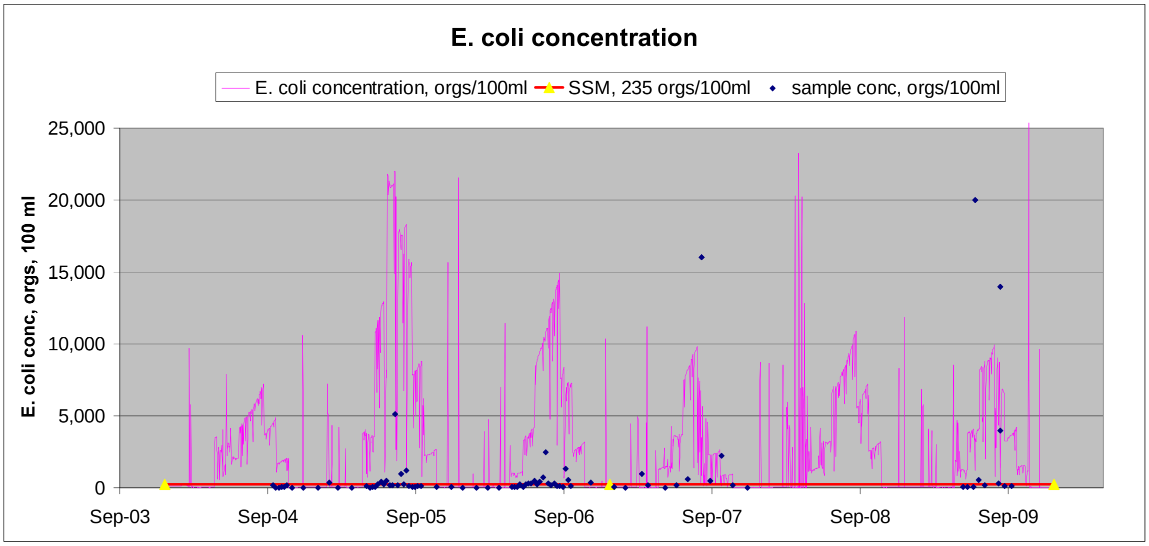

Figure 10-9 SWAT output for existing *E. coli* concentrations

The second scenario, Figure 10-10, removes half of the cattle in the stream from the subbasin. This generates lower concentrations but still higher than the SSM standard during the grazing season. The runoff related concentration spikes in all five scenarios.

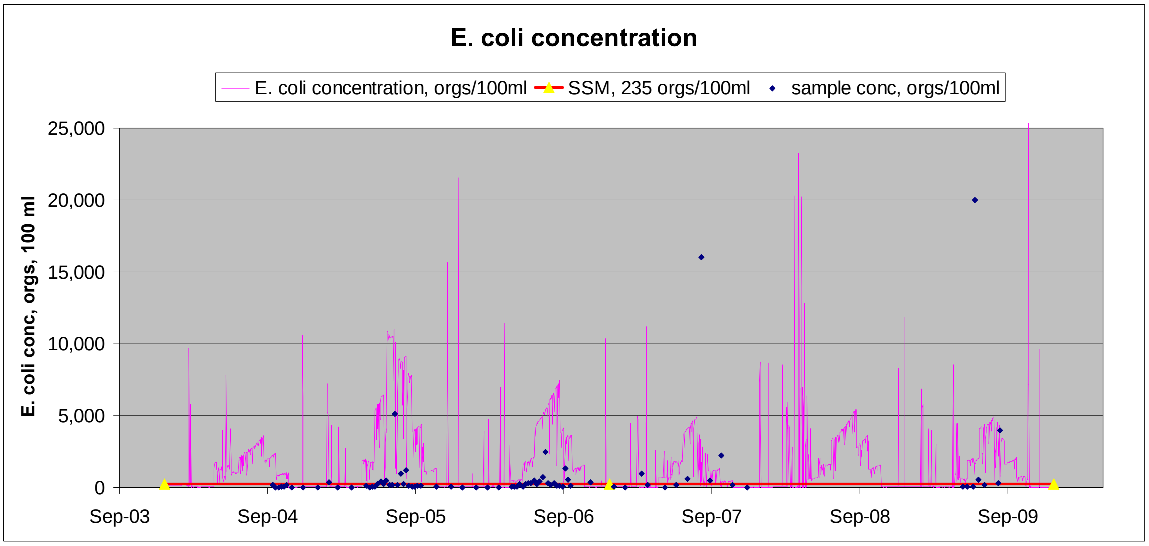

Figure 10-10 SWAT output for half reduction of CIS *E. coli* concentrations

The third scenario, shown in Figures 10-11a and 10-11b, eliminates cattle in the stream altogether as a source. This drops the grazing season concentration but there remain many instances of high bacteria concentration from runoff. Much of this is associated with field application of manure from confined animal operations and the assumption that it is often done in the spring when it rains frequently at high intensity. The two figures show the same simulation values at two different maximum values in the Y-axis scale. This scale transition clarifies the effects of source reductions and their relation to the target concentration.

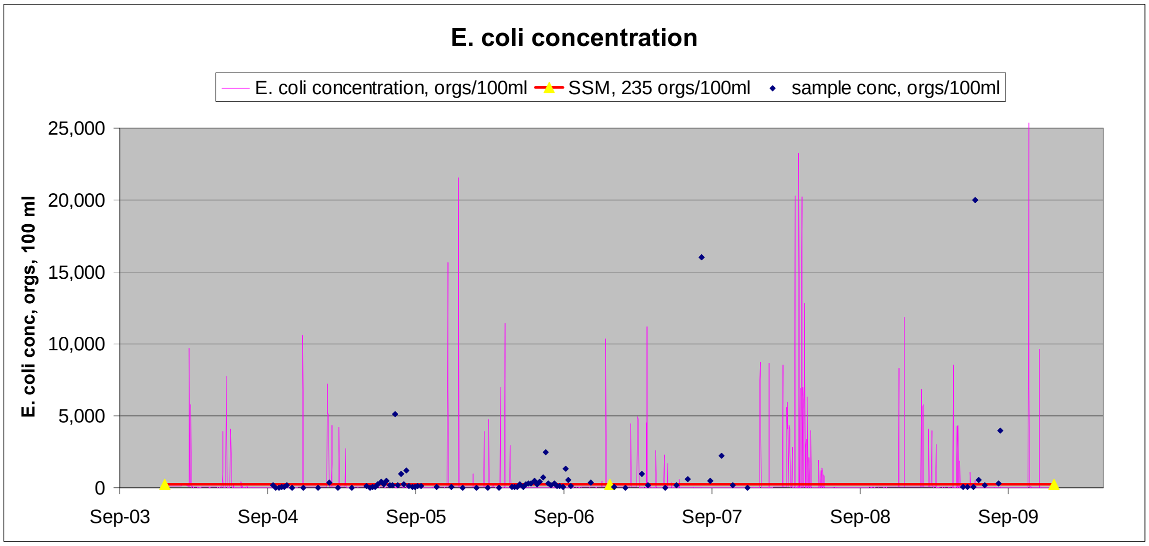

Figure 10-11a SWAT output for complete reduction of CIS *E. coli* with the concentration scale maximum set at 25,000 orgs/100 ml

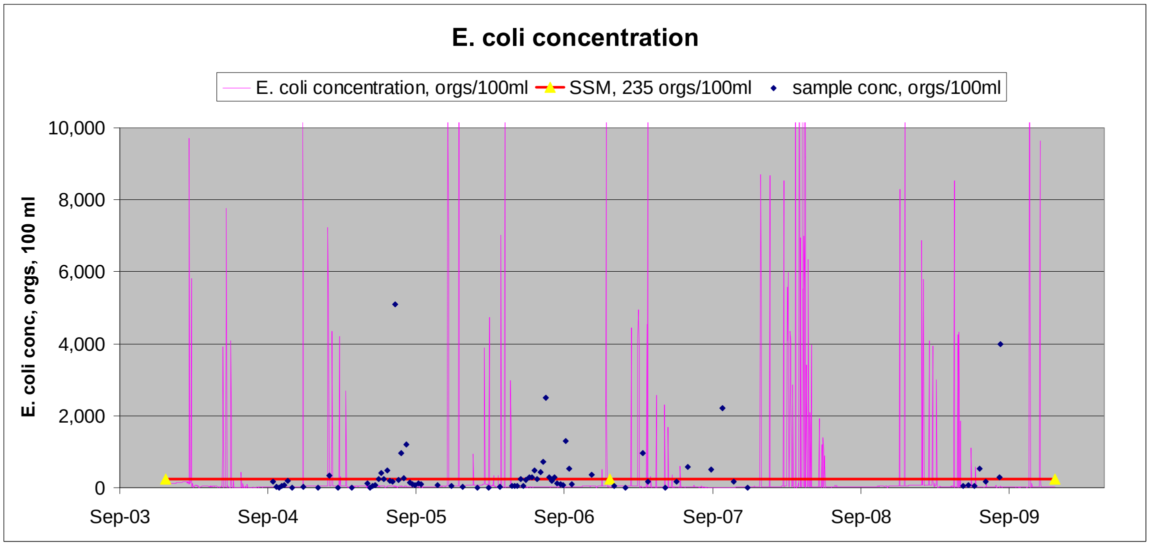

Figure 10-11b SWAT output for complete reduction of CIS *E. coli* with the concentration scale maximum set at 10,000 orgs/100 ml

The fourth scenario, shown in Figure 10-12, assumes that the field applications of manure are cut in half. This brings bacteria concentrations down from these applications quite a bit but they still exceed the target. Figure 10-11a has the same Y-axis scale maximum (10,000 orgs/100 ml) as Figures 10-12 and 10-13.

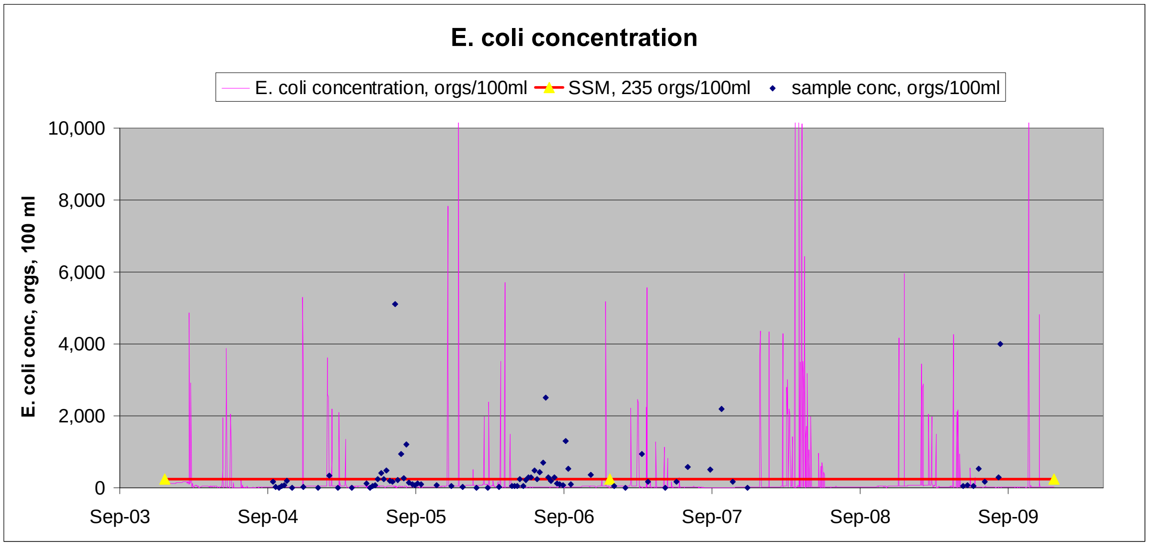

Figure 10-12 SWAT output for complete reduction of CIS *E. coli* and half of applied manure from CAFOs

The fifth scenario, shown in Figure 10-13, in addition to previous reductions, decreases the manure from cattle on pasture by two thirds. This pasture manure reduction showed a minor decrease in bacteria concentration in the stream.

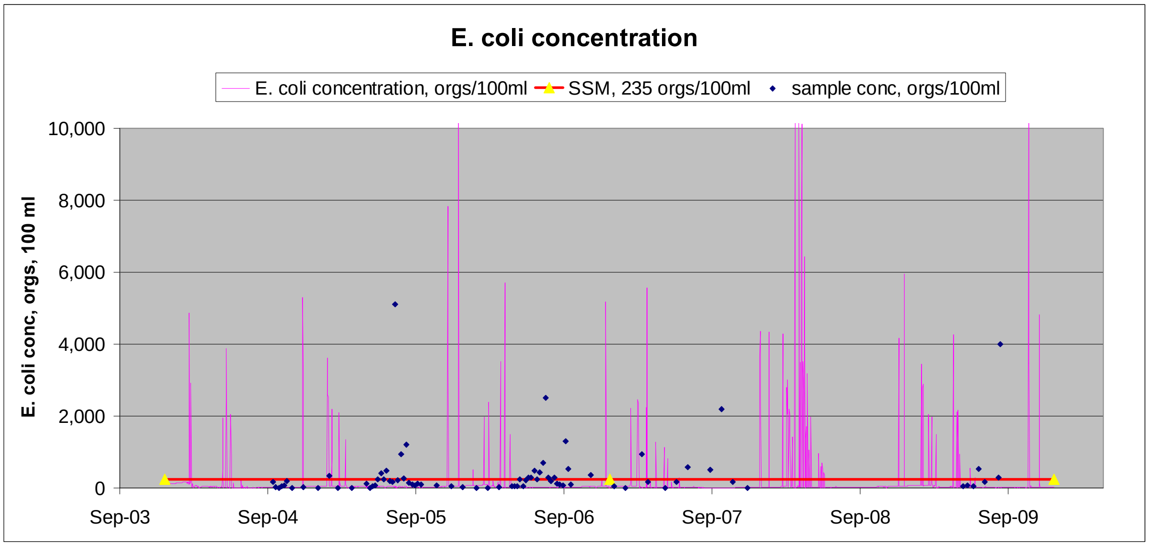

Figure 10-13 SWAT output for complete reduction of CIS *E. coli* and half of applied manure from CAFOs and a two thirds reduction of manure from cattle on pasture

There are several combinations of source reductions that can be simulated. The five scenarios described here reduce bacteria loads from the sources that have been modeled to have the greatest impact on stream outlet bacteria concentrations. The sources that are not reduced in these scenarios may have important episodic or local effect on *E. coli* organism numbers.

# 11. Hickory Creek

Hickory Creek (IA 01-YEL-0120_1) is the fourth impaired Yellow River tributary upstream from the Yellow River confluence with the Mississippi. The classified segment runs southwest 3.3 miles upstream from its confluence with the Yellow River (S23, T96N, R5W, Allamakee County). There is one municipal wastewater treatment facility for the City of Luana that discharges to a tributary of this segment. This facility is a controlled discharge lagoon that releases effluent at higher flows twice per year in the spring and fall. The stream flow used in the development of the TMDL for this segment is derived from the area ratio flow based on the Ion USGS gage data. A SWAT watershed model developed for the Yellow River watershed labels Hickory Creek Subbasin 28. Figure 11-1 shows a map of Hickory Creek and Table 11-1 shows the land use in its subbasin.

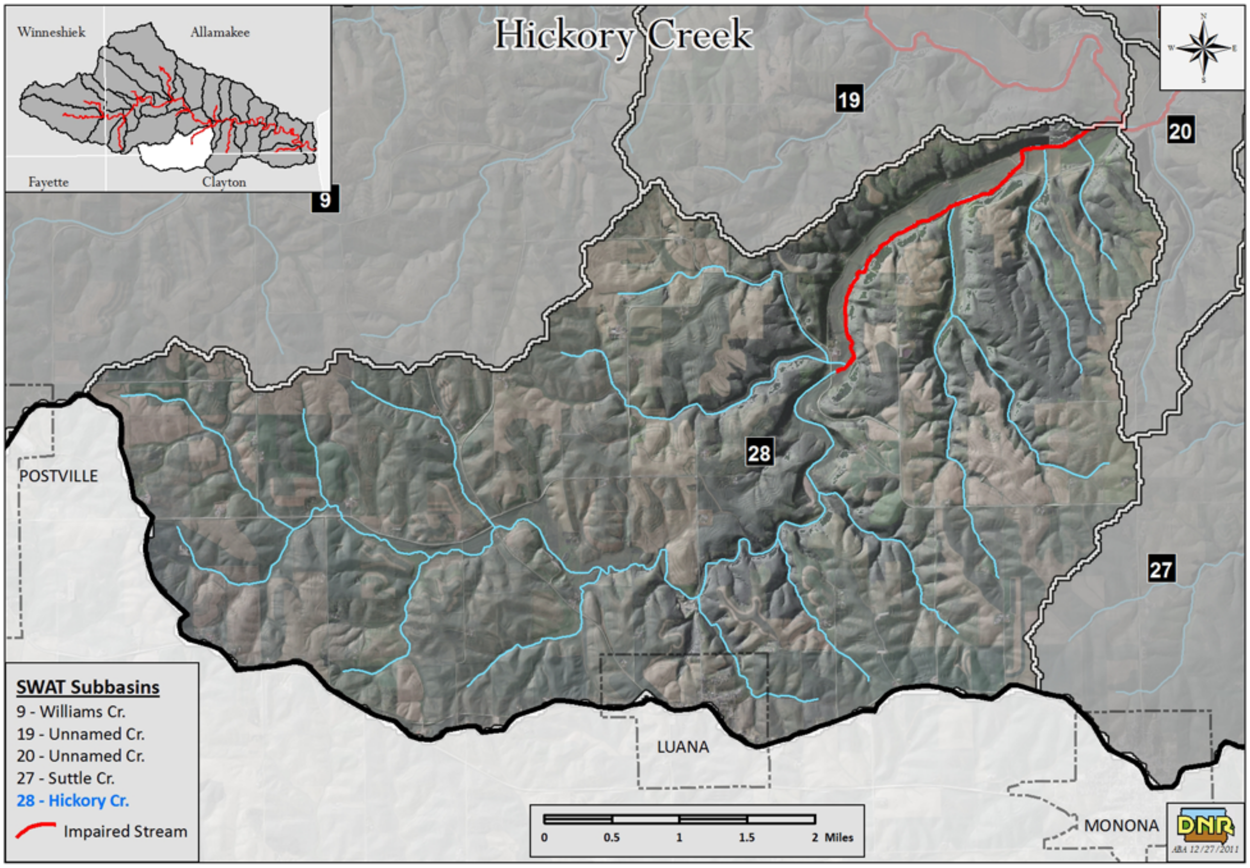

Figure 11-1 Hickory Creek (0120_1)

### Table 11-1 Hickory Creek subbasin land use

| Landuse | Area, acres | Fraction of total |
|---|---|---|
| Water/wetland | 28.0 | 0.19% |
| Forest | 2789.8 | 18.64% |
| Ungrazed/CRP/hay | 2170.9 | 14.50% |
| Grazed | 857.3 | 5.73% |
| Row crop | 8627.5 | 57.63% |
| Roads | 398.6 | 2.66% |
| Commercial/residential | 97.1 | 0.65% |
| **Total** | **14969.0** | **100.00%** |

In the Hickory Creek watershed a third of the area is forest and ungrazed grass and 58 percent is row crop.

## 11.1. Water body pollutant loading capacity (TMDL)

The *E. coli* organism load capacity is the number of organisms that can be in a volume and meet the water quality criteria. The loading capacity for each of the five flow conditions is calculated by multiplying the midpoint flow and *E. coli* criteria concentrations. Table 11-2 shows the median, maximum, and minimum average daily flows for the five flow conditions.

### Table 11-2 Hickory Creek maximum, minimum and median flows

| Flow description | Recurrence interval range (mid %) | Midpoint of flow range, cfs | Maximum of flow range, cfs | Minimum of flow range, cfs |
|---|---|---|---|---|
| **High flow** | **0 to 10% (5)** | 65.3 | 681.6 | 41.4 |
| **Moist conditions** | **10% to 40% (25)** | 20.2 | 41.4 | 12.7 |
| **Mid-range** | **40% to 60% (50)** | 10.2 | 12.7 | 8.5 |
| **Dry conditions** | **60% to 90% (75)** | 6.7 | 8.5 | 5.5 |
| **Low flow** | **90% to 100% (95)** | 4.5 | 5.5 | 1.9 |

Flow and load duration curves were used to establish the occurrence of water quality standards violations, to establish compliance targets, and to set pollutant allocations and margins of safety. Duration curves are derived from flows plotted as a percentage of their recurrence. *E. coli* loads are calculated from *E. coli* concentrations and flow volume at the time the sample was collected.

To construct the flow duration curves, the bacteria monitoring data and the Water Quality Standard (WQS) sample max (235 *E. coli* organisms/100 ml) were plotted with the flow duration percentile. Figure 11-2 shows the data that exceed the WQS criteria at each of the five flow conditions. High flow violations indicate that the problem occurs during run-off conditions when bacteria are washing off from nonpoint sources. Criteria exceeded during low or base flow, when little or no runoff is occurring, indicate that continuous sources such as septic tanks, livestock in the stream, riparian wildlife, and wastewater treatment plants are the problem.

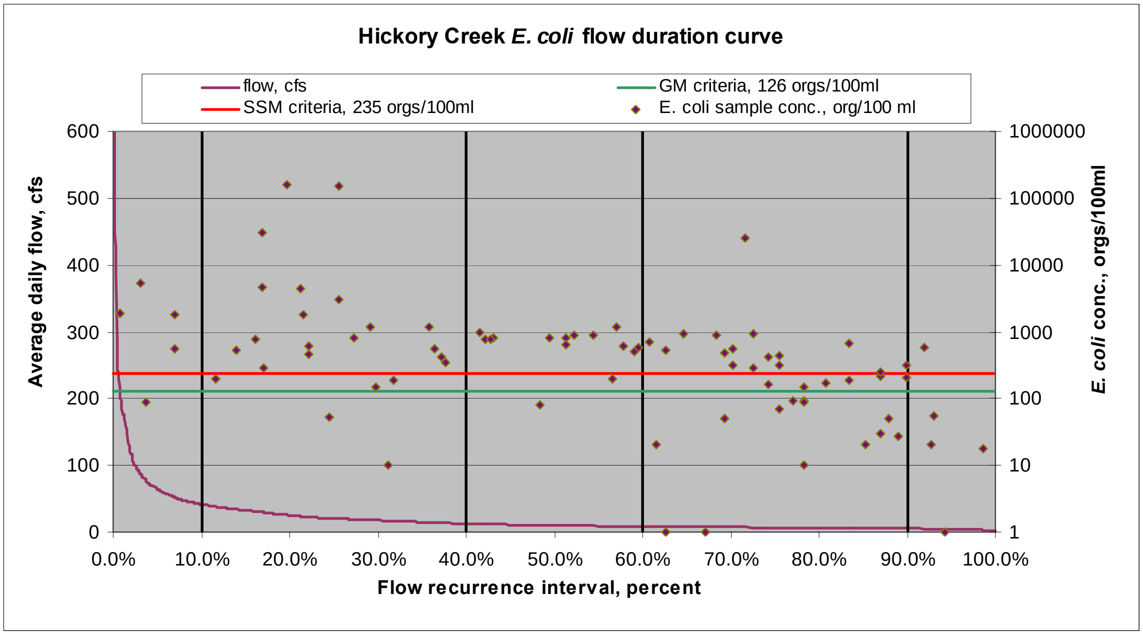

Figure 11-2 Hickory Creek flow duration curve

Load duration curves were used to evaluate the five flow conditions for Hickory Creek. The load duration curve is shown in Figure 11-3. In the figure, the lower curve shows the maximum *E. coli* count for the GM criteria and the upper curve shows the maximum *E. coli* count for the SSM criteria at a continuum of flow recurrence percentage. The individual points are the observed (monitored) *E. coli* concentrations converted to loads based on average daily flow for the day they were collected. Points above the load duration curves are violations of the WQS criteria and exceed the loading capacity.

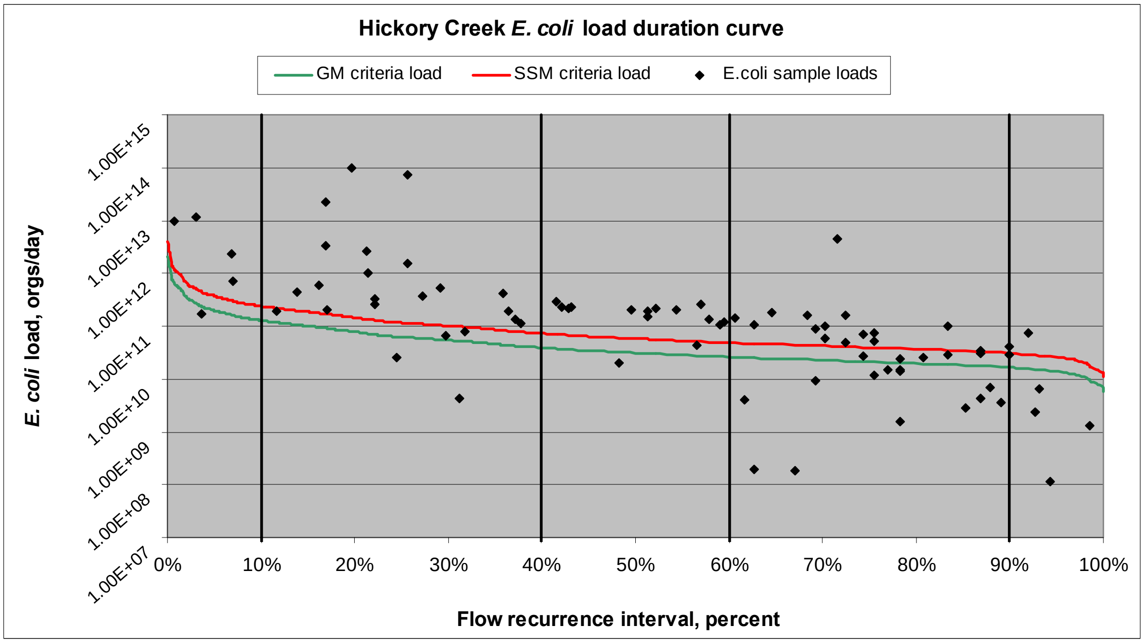

Figure 11-3 Hickory Creek load duration curve

Tables 11-3 and 11-4 show the load capacities (targets) for each of the midpoint flow conditions at the GM and SSM criteria, respectively.

**Table 11-3 Hickory Creek GM load capacity**

| Flow condition | Recurrence interval | Associated midpoint flow, cfs | Estimated flow interval load capacity, *E. coli* orgs/day |
|---|---|---|---|
| **High flow** | **0 to 10%** | 65.3 | 2.0E+11 |
| **Moist conditions** | **10% to 40%** | 20.2 | 6.2E+10 |
| **Mid-range** | **40% to 60%** | 10.2 | 3.1E+10 |
| **Dry conditions** | **60% to 90%** | 6.7 | 2.1E+10 |
| **Low flow** | **90% to 100%** | 4.5 | 1.4E+10 |

**Table 11-4 Hickory Creek SSM load capacity**

| Flow condition | Recurrence interval | Associated midpoint flow, cfs | Estimated flow interval load capacity, *E. coli* orgs/day |
|---|---|---|---|
| **High flow** | **0 to 10%** | 65.3 | 3.8E+11 |
| **Moist conditions** | **10% to 40%** | 20.2 | 1.2E+11 |
| **Mid-range** | **40% to 60%** | 10.2 | 5.8E+10 |
| **Dry conditions** | **60% to 90%** | 6.7 | 3.9E+10 |
| **Low flow** | **90% to 100%** | 4.5 | 2.6E+10 |

## 11.2. Existing load

The existing loads are derived from the sampling data collected in Hickory Creek. These data are the sample values shown in the flow and load duration curves. The *E. coli* concentrations are multiplied by the simulated daily flow to get the daily loads. The daily loads are plotted with the load duration curves. The allowable loads for a given flow equal the flow multiplied by the WQS limits for the geometric mean or single sample maximum. Monitored data that exceed the limits are above the criteria curves.

The maximum existing loads occur during major rains when runoff and bacteria concentrations are highest. Concentrations exceed the criteria during these high flow events. Other conditions leading to criteria violations occur during dry low flow periods when continuous loads from livestock in the stream, local wildlife, septic tanks, and wastewater treatment plants can cause bacteria problems.

The assessment standard used to evaluate streams is the *E. coli* geometric mean criteria. Since the load duration approach precludes the calculation of a geometric mean, the 90th percentile of observed concentrations within each flow condition is multiplied by the median flow to estimate existing loads. This procedure has been used to evaluate impaired segments. Table 11-5 shows the existing loads for each flow condition.

### Table 11-5 Hickory Creek existing loads

| Flow condition, percent recurrence | Recurrence interval range (mid %) | Associated median flow, cfs | Existing 90th percentile *E. coli* conc., org/100ml | Estimated existing load, *E. coli* org/day |
|---|---|---|---|---|
| **High flows** | **0 to 10% (5)** | 65.3 | 3940 | 6.29E+12 |
| **Moist conditions** | **10% to 40% (25)** | 20.2 | 25720 | 1.27E+13 |
| **Mid-range** | **40% to 60% (50)** | 10.2 | 958 | 2.38E+11 |
| **Dry conditions** | **60% to 90% (75)** | 6.7 | 812 | 1.34E+11 |
| **Low flow** | **90% to 100% (95)** | 4.5 | 376 | 4.13E+10 |

*Identification of pollutant sources.*
The sources of bacteria in the Hickory Creek subbasin (SWAT Subbasin 28) are all nonpoint sources, with the exception of the Luana municipal wastewater treatment plant. These include failed septic tank systems, pastured cattle, cattle in the stream, wildlife, and manure applied to fields from animal confinement operations. The loads from these sources are incorporated into the SWAT watershed model and are listed in Tables 11-6 to 11-10.

Non functional septic tank systems. There are an estimated 89 onsite septic tank systems in the subbasin (2.5 persons/household). IDNR estimates that 50 percent are not functioning properly. It is assumed that these are continuous year round discharges. Septic tank loads have been put into the SWAT model as a continuous source by subbasin.

### Table 11-6 Hickory Creek septic tank system E. coli orgs/day

| | |
|---|---|
| Rural population of Hickory Creek subbasin | 222 |
| Total initial E.coli, orgs/day [1] | 2.78E+11 |
| Septic tank flow, $m^3$/day [2] | 58.8 |
| **E. coli delivered to stream, orgs/day [3]** | **1.84E+08** |

1. Assumes 1.25E+09 E. coli orgs/day per capita
2. Assumes 70 gallons/day/capita
3. Assumes septic discharge concentration reaching stream is 625 orgs/100 ml and a 50% failure rate

Cattle in stream. Of the 536 cattle in pastures with stream access, one to six percent of those are assumed to be in the stream on a given day. The number on pasture and the fraction in the stream varies by month. Cattle in the stream have a high potential to deliver bacteria since bacteria are deposited directly in the stream with or without rainfall. Subbasin cattle in the stream bacteria have been input in the SWAT model as a continuous source varying by month.

### Table 11-7 Hickory Creek Cattle in the stream E. coli orgs/day

| | |
|---|---|
| Pasture area with stream access, acre[1] | 688 |
| Number of cattle in stream (6% of total)[2] | 32 |
| Dry manure, kg/day [3] | 100 |
| **E. coli load, orgs/day [4]** | **1.32E+12** |

1. The subbasin CIS are estimated from the pasture area with stream access at 0.78 cattle/acre.

2. It is estimated that cattle spend 6% of their time in streams in July and August, 3% in June and September, and 1% in May and October. The loads shown in this table are for July and August. The loads for the other 4 months when cattle are in streams have been incorporated into the SWAT modeling.
3. Cattle generate 3.1 kg/head/day of dry manure.
4. Manure has 1.32E+07 E coli orgs/gram dry manure.

Grazing livestock. The estimated number of cattle in the subbasin is 637. It is assumed that they are on pasture from April to November. The potential for bacteria delivery to the stream occurs with precipitation causing runoff. Manure available for washoff is applied in the SWAT model at 6 kg/ha in the pasture landuse.

### Table 11-8 Hickory Creek manure from pastured cattle, maximum E. coli available for washoff, orgs/day

| | |
|---|---:|
| Pasture area, ha | 859 |
| Number of cattle on pasture[1] | 637 |
| Dry manure, kg/day[2] | 1976 |
| Maximum E. coli load, orgs/day[3] | 2.61E+13 |
| Maximum E. coli available for washoff, orgs[4] | 4.70E+13 |

1. The number of pastured cattle is 0.78 cattle/acre.
2. Cattle generate 3.1 kg/head/day of dry manure.
3. Manure has 1.32E+07 E. coli orgs/gram dry manure
4. The load available for washoff is the daily load times 1.8.

Wildlife manure. The number of deer in Allamakee County is about 9,000 located primarily in forested land adjacent to streams. Another 1,000 have been added to account for other wildlife such as raccoons and waterfowl for a total estimate of 10,000. This works out to 0.024 deer per acre. Using this procedure, there are 359 deer in the subbasin concentrated in the forested areas. The deer are in the subbasin year round.

### Table 11-9 Hickory Creek watershed wildlife manure loads available for washoff

| Number of deer[1] | Forested area, ha | SWAT manure loading rate, kg/ha/day[2] | E. coli available for washoff, orgs[3] |
|:---:|:---:|:---:|:---:|
| 359 | 1,237 | 0.418 | 3.23E+11 |

1. Deer numbers are 0.024 deer/ha for the entire subbasin concentrated to 0.290 deer/ha in the forest land use. All wildlife loads are applied to the forest landuse in the SWAT model. The county deer numbers have been increased by 10% to account for other wildlife in the subbasin.
2. Assumes 1.44 kg/deer/day and 3.47E+05 orgs/gram.
3. Assumes that the maximum E. coli available for washoff is 1.8 times the daily load.

Field applications of CAFO manure.
There are about 4,300 hogs in confinement in the subbasin. The manure is stored and land applied to cropland. The manureis distributed to the fields in the subbasin in the fall after soybean harvest and in the spring prior to corn planting in year two of a two year rotation. The relatively brief fall and spring timing of manure application and incorporation in the soil significantly reduces the *E. coli* organisms from these sources.

Manure application has been put in the SWAT model by subbasin as a load available at the end of October and the beginning of April.

**Table 11-10 Hickory Creek watershed confined livestock manure applications**

| Livestock type | Swine | Chickens | Dairy cows |
|---|---|---|---|
| Number of animals | 4,300 | 0 | 0 |
| Manure applied, kg/application[1] | 1,773,535 | 0 | 0 |
| Application area, ha[2] | 84.2 | 0 | 0 |
| Manure applied, kg/ha/day[3] | 2,127 | 0 | 0 |
| Subbasin E. coli, orgs/day | 4.74E+14 | 0 | 0 |
| Subbasin E. coli available for washoff, orgs/day[4] | 8.53E+14 | 0 | 0 |

1. Manure is calculated based on number of animals * dry manure (kg/animal/day)*365 days/year.
2. The area the manure is applied to is based on the manure's nitrogen content. Manure is applied at a rate equivalent to 201.6 kg N/ha/yr. Swine manure is applied at 2127 kg/ha, dairy manure at 2631 kg/ha and chicken manure at 2326 kg/ha. The E. coli content of manure for swine is 1.32E+07 orgs/gram, for dairy cows is 1.00E+07 orgs/gram, and for chickens is 2.96E+06 orgs/gram.
3. Manure is assumed to be applied to fields twice a year on October 30 and April 1. It is incorporated in the soil and it is assumed that only 10% of bacteria are viable and available after storage and incorporation.
4. Maximum *E. coli* available for washoff are 1.8 times the daily maximum available load.

<u>Seasonal variation of sources</u>.
The relative impacts of the bacteria sources are shown in Figures 11-4 and 11-5. Figure 11-4 shows the relative loads delivered by the "continuous" sources, those present with or without rainfall and runoff. These are the failed septics that are assumed to be a problem every day of the year and the loads from cattle in the stream that vary by month from May to October. It can be seen in this figure that the impacts from cattle in the stream are much more significant than those from failed septic tank systems.

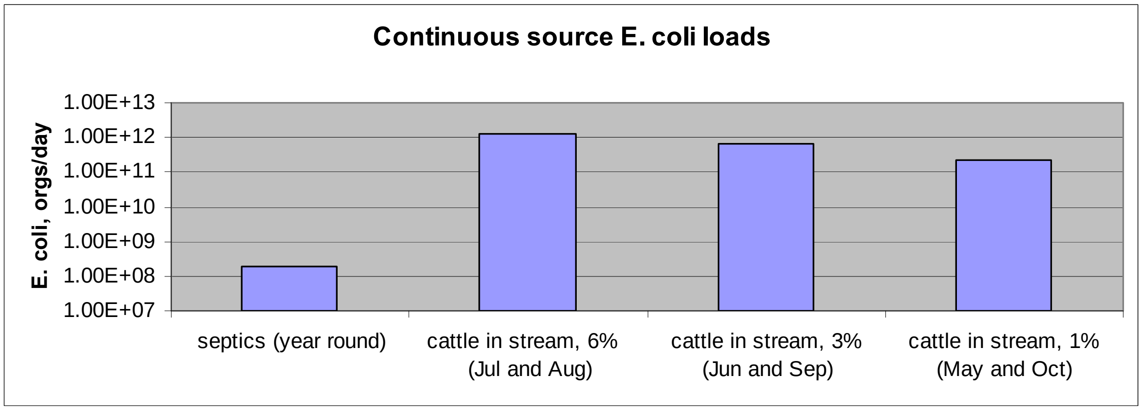

Figure 11-4 E. coli loads from "continuous" sources

The three general washoff sources of bacteria in the subbasin are shown in Figure 11-5. The wildlife source consists primarily of deer and smaller animals such as raccoons and waterfowl. These are year round sources. Pastured cattle consist of grazing cattle and small poorly managed feedlot-like operations. The grazing season is modeled as lasting

168 days starting May 1. Manure from confined animal feeding operations (CAFO) is applied to cropland twice a year for a relatively brief time. Most field applied manure is assumed to be incorporated into the soil and most bacteria in it are not available. Confinement animals are swine, chickens and dairy cattle.

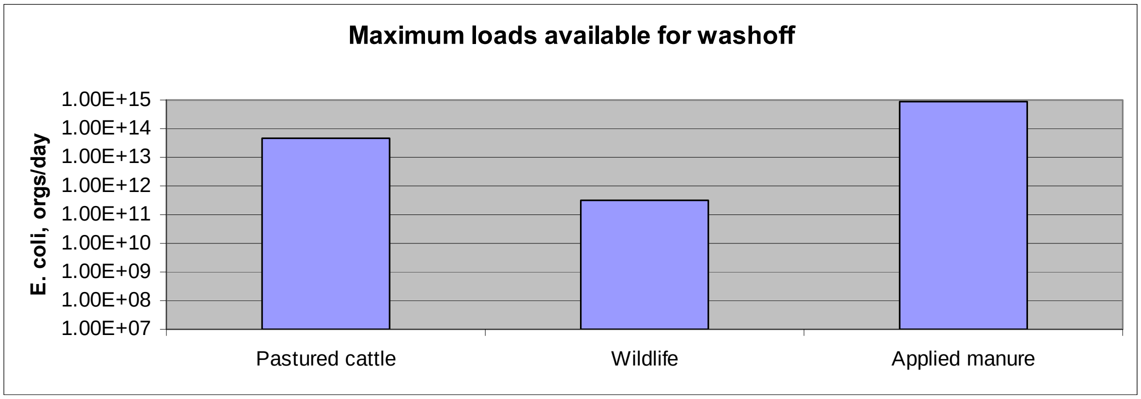

Figure 11-5 Maximum E. coli loads available for washoff

The maximum bacteria load to the stream occurs when the continuous source load plus the precipitation driven washoff load are combined. In general, the more rainfall the higher the flow rate and the more elevated the concentration. High flow rate and elevated concentration equal peak loads. In July and August, the potential maximum load based on this analysis is 4.73E+13 orgs/day available for washoff plus the continuous load of 1.32E+12 orgs/day for a total of 4.86E+13 orgs/day.

Flow interval load source analysis. Based on the load duration curve analysis, the maximum existing load occurring during the zero to forty percent recurrence interval runoff conditions, is 8.12E+12 orgs/day and the total available load based on potential sources, including fall and spring manure applications, is 9.01E+14 orgs/day. Therefore, the maximum load in the stream, delivered in April when runoff is occurring, is approximately one percent of the bacteria available for washoff.

At the zero to ten percent maximum existing load of 6.29E+12 orgs/day and with the same maximum load available for washoff, the stream load is 0.7 percent of the available load. The highest concentration values in the monitoring data set for this subbasin are in the moist (10 to 40% interval) so that the existing load for the moist interval (1.27E+13 orgs/day) is larger than that of the high flow interval (0 to 10%, 8.12E+12 orgs/day).

## 11.3. Departure from load capacity

The departure from load capacity is the difference between the existing load and the load capacity. This varies for each of the five flow conditions. Table 11-11 shows this difference. The existing and target loads for the five flow conditions are shown graphically in Figure 11-6.

**Table 11-11 Hickory Creek departure from load capacity**

| Design flow condition, percent recurrence | Recurrence interval range (mid %) | Existing *E. coli* orgs/day | Load capacity, orgs/day | Departure from capacity, orgs/day |
|---|---|---|---|---|
| **High flow** | **0 to 10% (5)** | 6.29E+12 | 3.8E+11 | 5.92E+12 |
| **Moist conditions** | **10% to 40% (25)** | 1.27E+13 | 1.2E+11 | 1.26E+13 |
| **Mid-range flow** | **40% to 60% (50)** | 2.38E+11 | 5.8E+10 | 1.80E+11 |
| **Dry conditions** | **60% to 90% (75)** | 1.34E+11 | 3.9E+10 | 9.52E+10 |
| **Low flow** | **90% to 100% (95)** | 4.13E+10 | 2.6E+10 | 1.55E+10 |

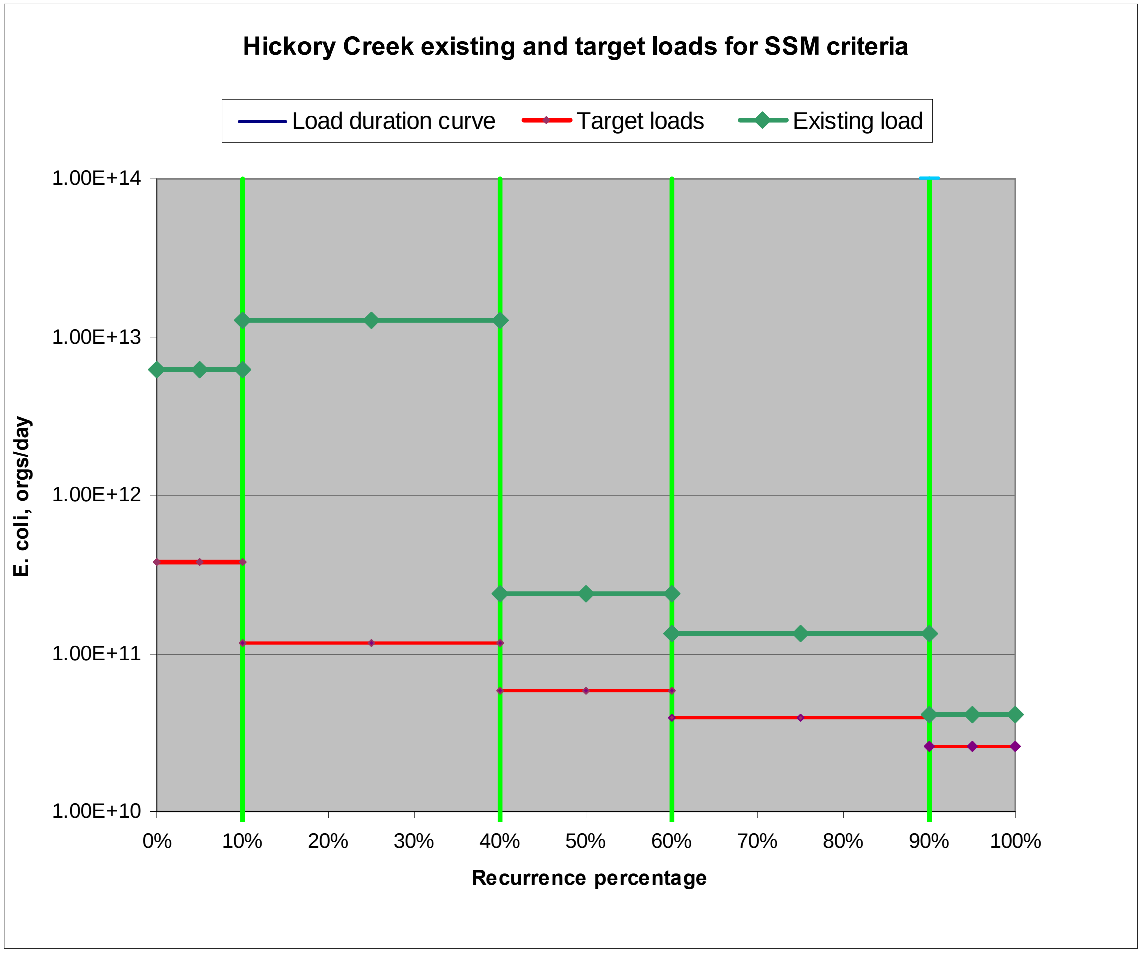

Figure 11-6 Difference between existing and target loads

## 11.4. Pollutant Allocations

*Wasteload allocations.*

The wasteload allocations for the City of Luana wastewater treatment facility discharging to Hickory Creek are shown in Table 3-6 and again in Tables 11-12 and 11-13 which are the GM and SSM TMDL calculations. It is currently assumed that all of the wastewater treatment plants in the watershed discharge to a Class A1 stream. The wasteload allocations for the discharges are the Class A1 *E. coli* water quality standards, a geometric mean (GM) of 126-organisms/100 ml and a single sample maximum (SSM) of 235-organisms/100 ml. These concentration criteria have been multiplied by the 180 day average wet weather (AWW) flow divided by ten to mimic the episodic and controlled discharge.

*Load allocation.*
The load allocations for *E. coli* TMDLs are the load capacity less an explicit 10 percent margin of safety (MOS) less the total WLA for the flow condition for the geometric mean or single sample maximum. There is a separate load allocation set for each of the target recurrence intervals. The load allocations are shown in Tables 11-12 and 11-13.

**Table 11-12 Hickory Creek GM *E. coli* load allocations**

| Flow condition, percent recurrence | GM target (TMDL) *E. Coli*, orgs/day | GM MOS *E. Coli*, orgs/day | Total WLA GM *E. coli*, orgs/day | LA GM *E. coli*, orgs/day |
|---|---|---|---|---|
| **High flows** | 2.0E+11 | 2.0E+10 | 2.78E+09 | 1.8E+11 |
| **Moist conditions** | 6.2E+10 | 6.2E+09 | 2.78E+09 | 5.3E+10 |
| **Mid-range flow** | 3.1E+10 | 3.1E+09 | 2.78E+09 | 2.5E+10 |
| **Dry conditions** | 2.1E+10 | 2.1E+09 | 2.78E+09 | 1.6E+10 |
| **Low flow** | 1.4E+10 | 1.4E+09 | 2.78E+09 | 9.7E+09 |

1. Based on geometric mean standard of 126 *E. coli* organisms/100 ml

**Table 11-13 Hickory Creek SSM *E. coli* load allocations**

| Flow condition, percent recurrence | SSM target (TMDL) *E. Coli*, orgs/day | SSM MOS *E. Coli*, orgs/day | Total WLA SSM *E. coli*, orgs/day | LA SSM *E. coli*, orgs/day |
|---|---|---|---|---|
| **High flow** | 3.8E+11 | 3.8E+10 | 5.19E+09 | 3.3E+11 |
| **Moist conditions** | 1.2E+11 | 1.2E+10 | 5.19E+09 | 9.9E+10 |
| **Mid-range flow** | 5.8E+10 | 5.8E+09 | 5.19E+09 | 4.7E+10 |
| **Dry conditions** | 3.9E+10 | 3.9E+09 | 5.19E+09 | 3.0E+10 |
| **Low flow** | 2.6E+10 | 2.6E+09 | 5.19E+09 | 1.8E+10 |

1. Based on single sample maximum standard of 235 *E. coli* organisms/100 ml

*Margin of safety.*
The margin of safety for *E. coli* is an explicit 10 percent of the load capacity at each of the design recurrence intervals as shown in Tables 11-12 and 11-13.

## 11.5. TMDL Summary

The following equation shows the total maximum daily load (TMDL) and its components for the impaired IA 01-YEL-0120_1 segment of Hickory Creek.

**Total Maximum Daily Load = Σ Load Allocations + Σ Wasteload Allocations +MOS**

A Total Maximum Daily Load calculation has been made at design flow conditions for the GM and SSM of this segment and these are shown in Tables 11-14 and 11-15 and Figures 11-7 and 11-8.

**Table 11-14 Hickory Creek IA 01-YEL-0120_1 *E. coli* TMDL for GM**

| Flow condition | Σ LA, orgs/day | Σ WLA, orgs/day | MOS, orgs/day | TMDL, orgs/day |
|---|---|---|---|---|
| **High flow** | 1.8E+11 | 2.78E+09 | 2.0E+10 | 2.0E+11 |
| **Moist condition** | 5.3E+10 | 2.78E+09 | 6.2E+09 | 6.2E+10 |
| **Mid-range flow** | 2.5E+10 | 2.78E+09 | 3.1E+09 | 3.1E+10 |
| **Dry conditions** | 1.6E+10 | 2.78E+09 | 2.1E+09 | 2.1E+10 |
| **Low flow** | 9.7E+09 | 2.78E+09 | 1.4E+09 | 1.4E+10 |

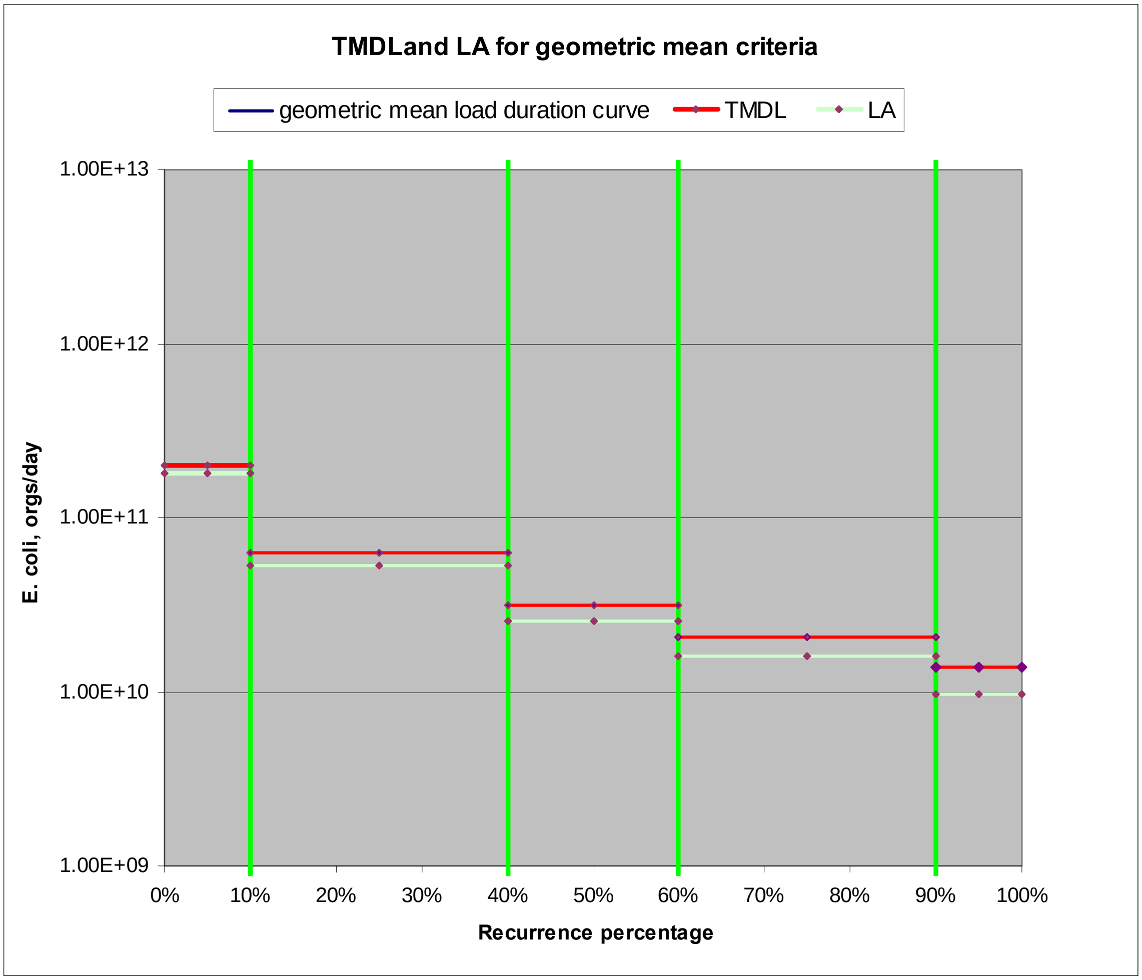

Figure 11-7 GM TMDL at WQS of 126 orgs/100 ml for the five flow conditions

**Table 11-15 Hickory Creek IA 01-YEL-0120_1 *E. coli* TMDL for SSM**

| Flow condition | Σ LA, orgs/day | Σ WLA, orgs/day | MOS, orgs/day | TMDL, orgs/day |
|---|---|---|---|---|
| High flow | 3.3E+11 | 5.19E+09 | 3.8E+10 | 3.8E+11 |
| Moist condition | 9.9E+10 | 5.19E+09 | 1.2E+10 | 1.2E+11 |
| Mid-range flow | 4.7E+10 | 5.19E+09 | 5.8E+09 | 5.8E+10 |
| Dry conditions | 3.0E+10 | 5.19E+09 | 3.9E+09 | 3.9E+10 |
| Low flow | 1.8E+10 | 5.19E+09 | 2.6E+09 | 2.6E+10 |

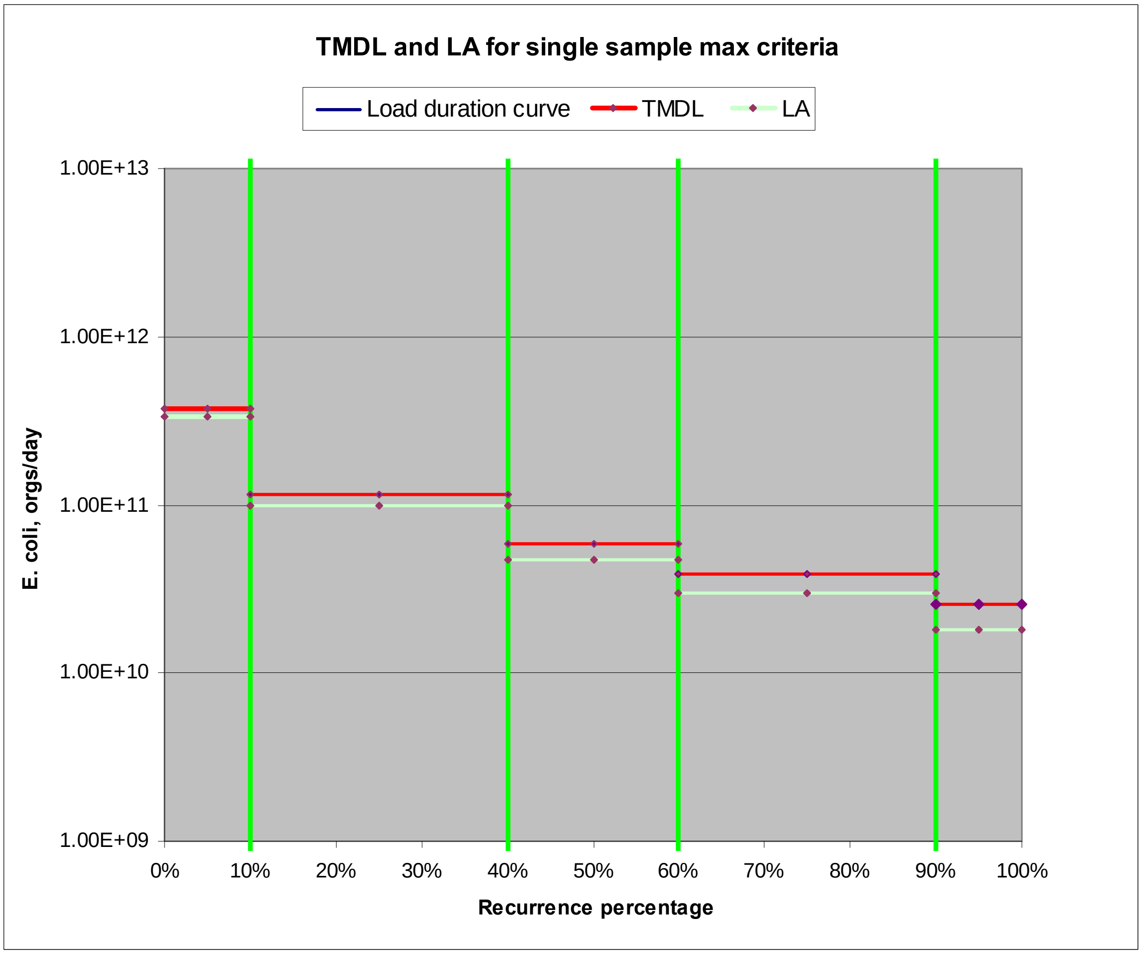

Figure 11-8 SSM TMDL at WQS of 235 orgs/100 ml for the five flow conditions

## 11.6. Implementation Analysis

The modeled systematic reduction of the loads by source provides the initial evaluation of proposed implementation plans for the subbasin. The SWAT model has been run for five scenarios in which loads have been reduced for the most significant sources. The source analysis identified the primary source of bacteria and as cattle in the stream and field applied manure from CAFOs. Figure 11-9 shows the SWAT model output concentrations for the stream with monitored concentrations also plotted on the chart. The target concentration of 235 E. coli orgs/100 ml is frequently exceeded by both monitoring data and SWAT simulated values.

The concentration scale has been cut off at 12,000 orgs/100 ml so that the numerous monitoring and simulation values are apparent when compared to the SSM. There are four monitoring values that exceed this (25,000, 31,000, 150,000, and 160,000).

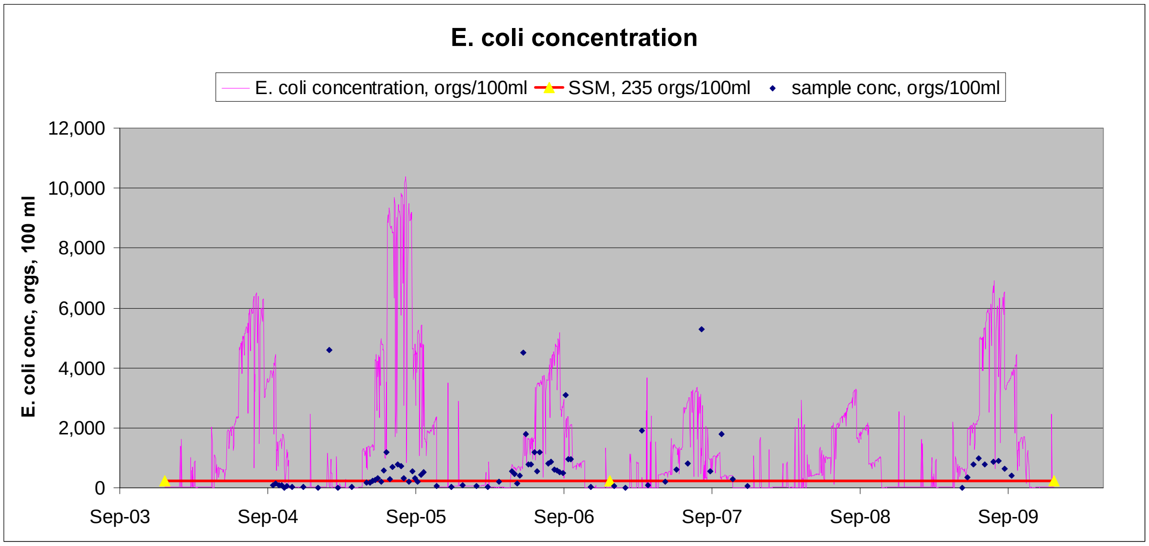

Figure 11-9 SWAT output for existing E. coli concentrations

The second scenario, Figure 11-10, removes half of the cattle in the stream from the subbasin. This generates lower concentrations that are still higher than the SSM standard during the grazing season. The runoff related concentration spikes in all five scenarios.

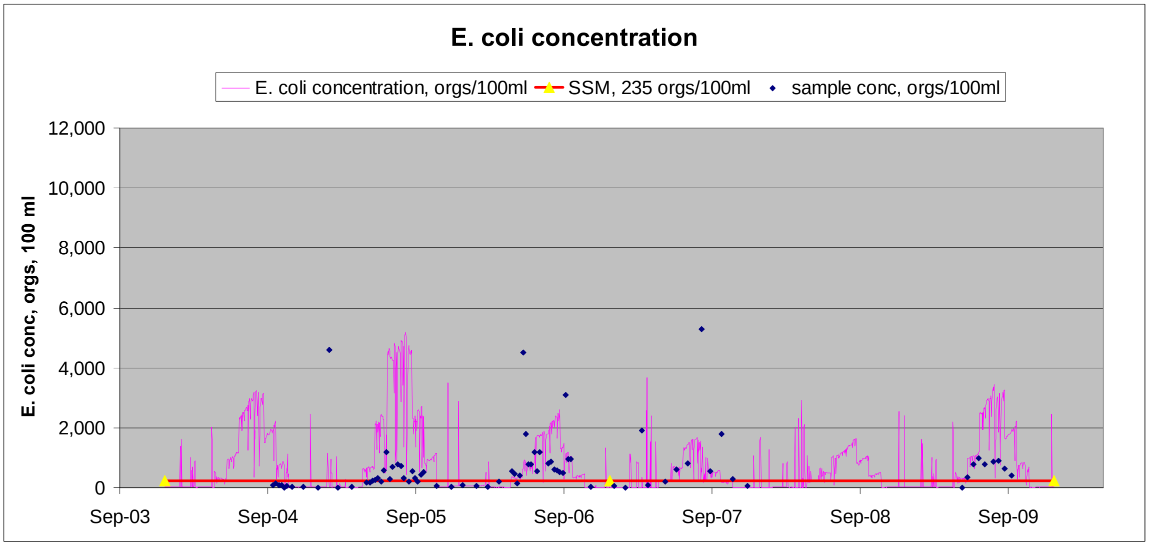

Figure 11-10 SWAT output for half reduction of CIS *E. coli* load

The third scenario, shown in Figures 11-11a and 11-11b, eliminates cattle in the stream altogether as a source. This drops the concentration during the grazing season but there remain quite a few instances of high bacteria concentration from runoff. Much of this is associated with field application of manure from confined animal operations and the assumption that it is spread in the spring when it rains frequently and intensely. The two figures show the same simulation values at two different Y-axis maximum values. This scale transition clarifies the effects of source reductions and their relation to the target concentration.

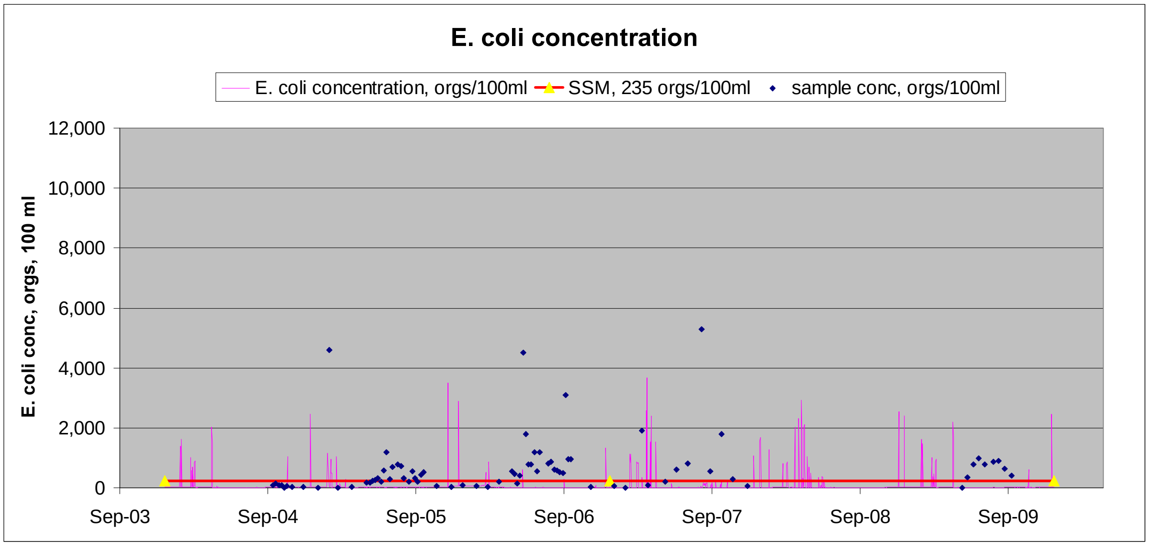

Figure 11-11a SWAT output for complete reduction of CIS *E. coli* with the concentration scale maximum set at 12,000 orgs/100 ml

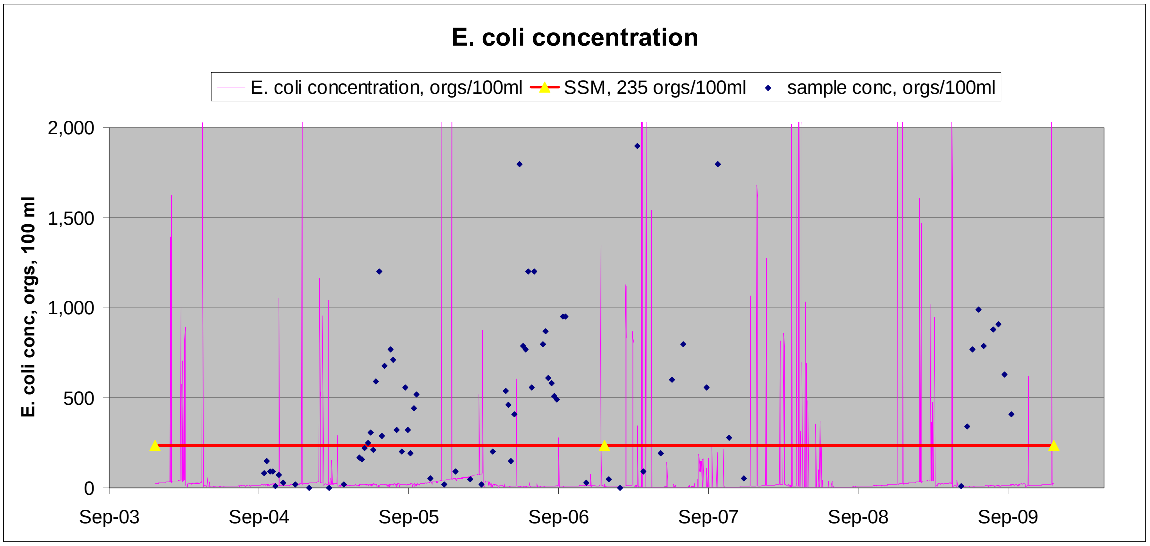

Figure 11-11b SWAT output for complete reduction of CIS *E. coli* with the concentration scale maximum set at 2,000 orgs/100 ml

The fourth scenario, shown in Figure 11-12, assumes that the field applications of manure are cut in half. This brings bacteria concentrations from these applications down quite a bit, but they still exceed the target. Figure 11-11a has the same maximum Y-axis scale maximum (2,000 orgs/100 ml) as Figures 11-12 and 11-13.

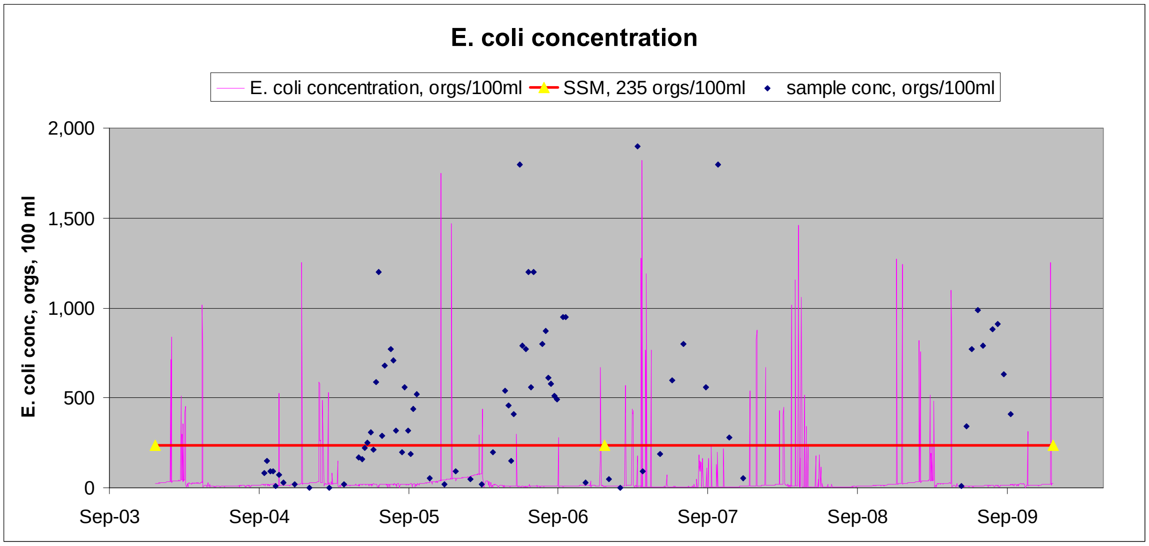

Figure 11-12 SWAT output for complete reduction of CIS E. coli and half of applied manure from CAFOs

The fifth scenario, shown in Figure 11-13, in addition to previous reductions, decreases the manure from cattle on pasture by two thirds. This pasture manure reduction showed a minor decrease in bacteria concentration in the stream.

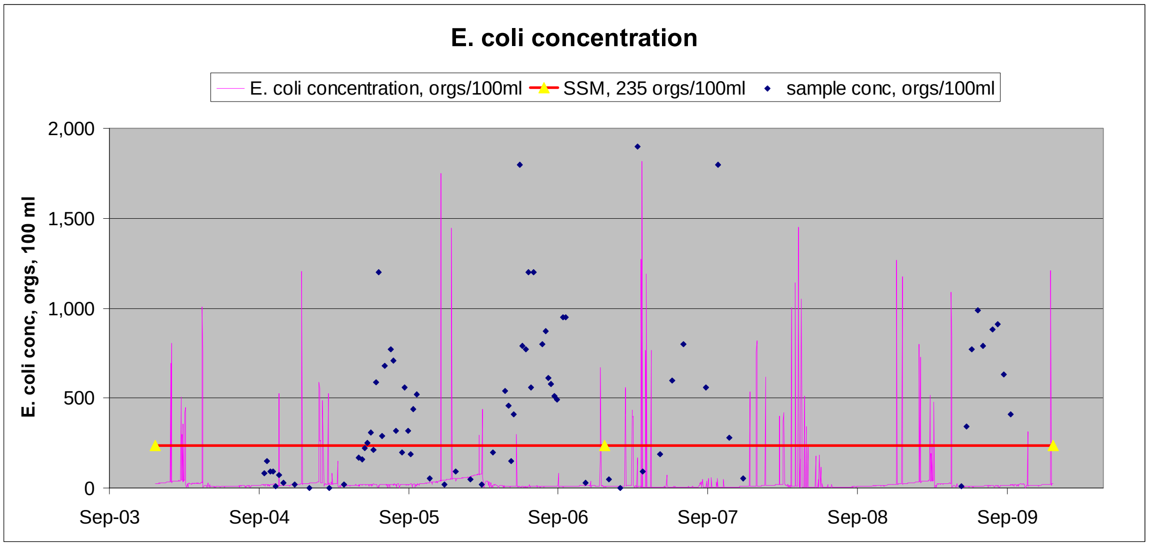

Figure 11-13 SWAT output for complete reduction of CIS *E. coli* and half of applied manure from CAFOs and a two-thirds reduction of manure from cattle on pasture

There are several combinations of source reductions that can be simulated. The five scenarios described here reduce bacteria loads from the sources that have been modeled to have the greatest impact on stream outlet bacteria concentrations. The other sources that are not reduced in these scenarios may have important episodic or local effect on *E. coli* organism numbers.

# 12. Williams Creek

Williams Creek (IA 01-YEL-0125_0) is the fifth impaired Yellow River tributary upstream from the Yellow River confluence with the Mississippi. The classified segment runs southwest 1.8 miles upstream from its confluence with the Yellow River (S9, T96N, R5W, Allamakee County). There is one municipal wastewater treatment facility for the City of Postville discharging to Williams Creek. The stream flow used in the development of the TMDL for this segment is derived from the area ratio flow based on the Ion USGS gage data. A SWAT watershed model developed for the Yellow River watershed labels Williams Creek Subbasin 9. Figure 12-1 shows a map of Williams Creek and Table 12-1 shows the land use in its subbasin.

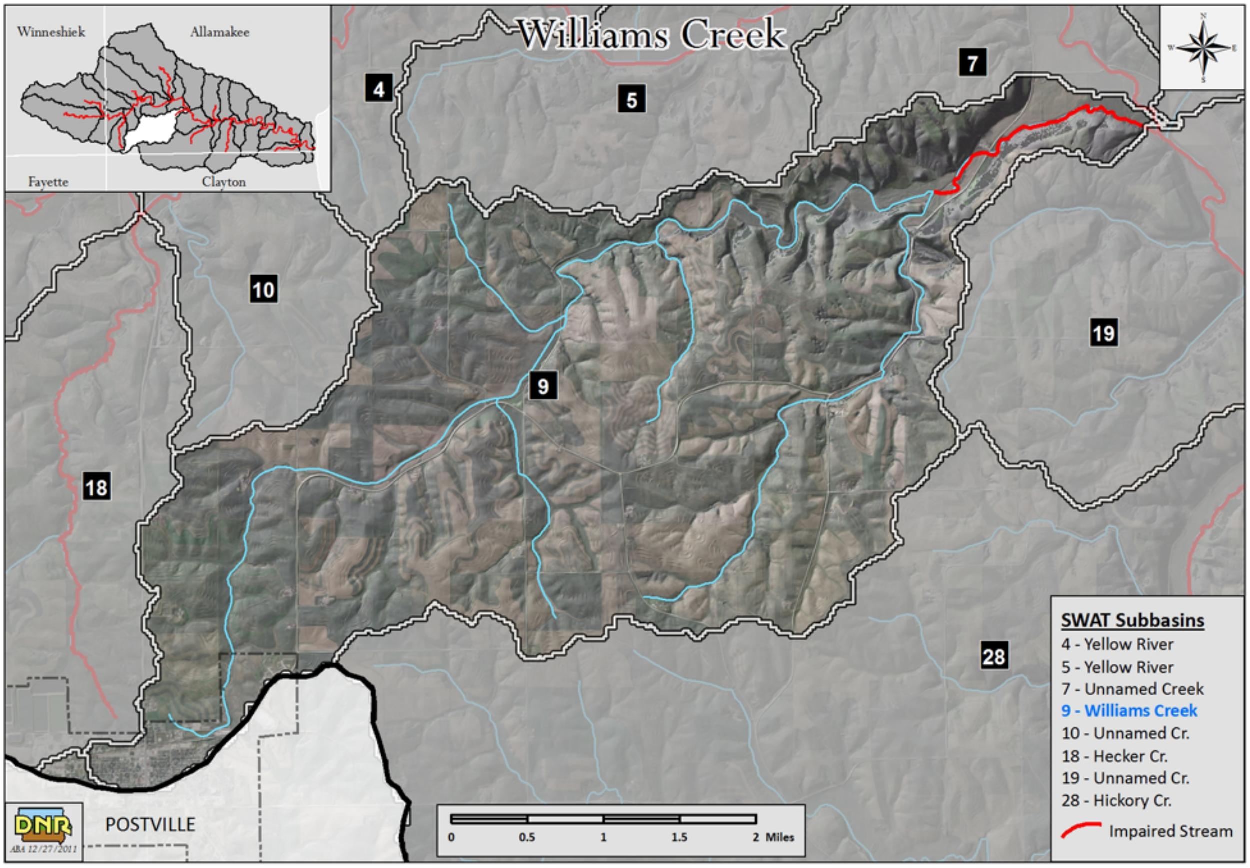

Figure 12-1 Williams Creek (0125_0)

**Table 12-1 Williams Creek subbasin land use**

| Landuse | Area, acres | Fraction of total |
|---|---:|---:|
| Water/wetland | 1.6 | 0.02% |
| Forest | 1084.3 | 11.81% |
| Ungrazed/CRP/hay | 1156.8 | 12.60% |
| Grazed | 319.9 | 3.48% |
| Row crop | 6139.9 | 66.84% |
| Roads | 242.9 | 2.64% |
| Commercial/residential | 239.6 | 2.61% |
| **Total** | **9184.8** | **100.00%** |

In the Williams Creek watershed two-thirds of the area is row crop and a quarter of it is forest and ungrazed grass.

### 12.1. Water body pollutant loading capacity (TMDL)

The *E. coli* load capacity is the number of organisms that can be in a volume and meet the water quality criteria. The loading capacity for each of the five flow conditions is calculated by multiplying the midpoint flow and *E. coli* criteria concentrations. Table 12-2 shows the median, maximum, and minimum flows for the five flow conditions.

**Table 12-2 Williams Creek maximum, minimum and median flows**

| Flow description | Recurrence interval range (mid %) | Midpoint of flow range, cfs | Maximum of flow range, cfs | Minimum of flow range, cfs |
|---|---|---|---|---|
| **High flow** | **0 to 10% (5)** | 40.0 | 420.4 | 25.3 |
| **Moist conditions** | **10% to 40% (25)** | 12.6 | 25.3 | 7.8 |
| **Mid-range** | **40% to 60% (50)** | 6.3 | 7.8 | 5.2 |
| **Dry conditions** | **60% to 90% (75)** | 4.2 | 5.2 | 3.4 |
| **Low flow** | **90% to 100% (95)** | 2.8 | 3.4 | 1.2 |

Flow and load duration curves were used to establish the occurrence of water quality standards violations, compliance targets, and to set pollutant allocations and margins of safety. Duration curves are derived from flows plotted as a percentage of their recurrence. *E. coli* loads are calculated from *E. coli* concentrations and flow volume at the time the sample was collected.

To construct the flow duration curves, the bacteria monitoring data and the Water Quality Standard (WQS) sample max (235 *E. coli* organisms/100 ml) were plotted with the flow duration percentile. Figure 12-2 shows the data that exceed the WQS criteria at each of the five flow conditions. High flow violations indicate that the problem occurs during run-off conditions when bacteria are washing off from nonpoint sources. Criteria exceeded during low or base flow, when little or no runoff is occurring, indicate that continuous sources such as septic tanks, livestock in the stream, riparian wildlife, and wastewater treatment plants are the problem.

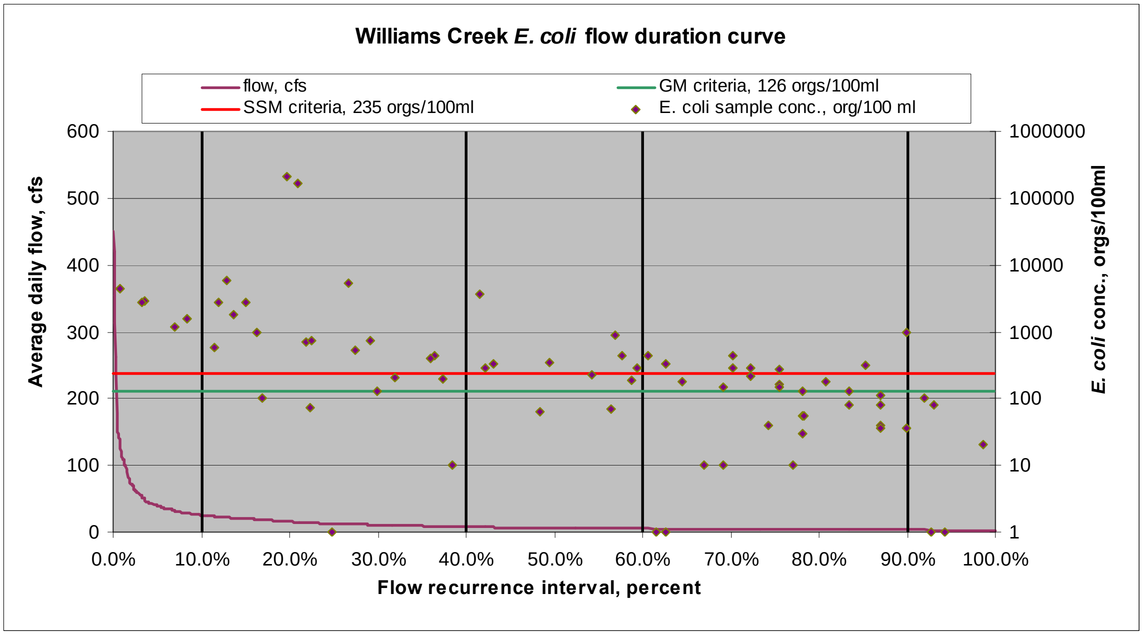

Figure 12-2 Williams Creek flow duration curve

Load duration curves were used to evaluate the five flow conditions for Williams Creek. The load duration curve is shown in Figure 12-3. In the figure, the lower curve shows the maximum *E. coli* count for the GM criteria and the upper curve shows the maximum *E. coli* count for the SSM criteria at a continuum of flow recurrence percentage. The individual points are the observed (monitored) *E. coli* concentrations converted to loads based on average daily flow for the day they were collected. Points above the load duration curves are violations of the WQS criteria and exceed the loading capacity.

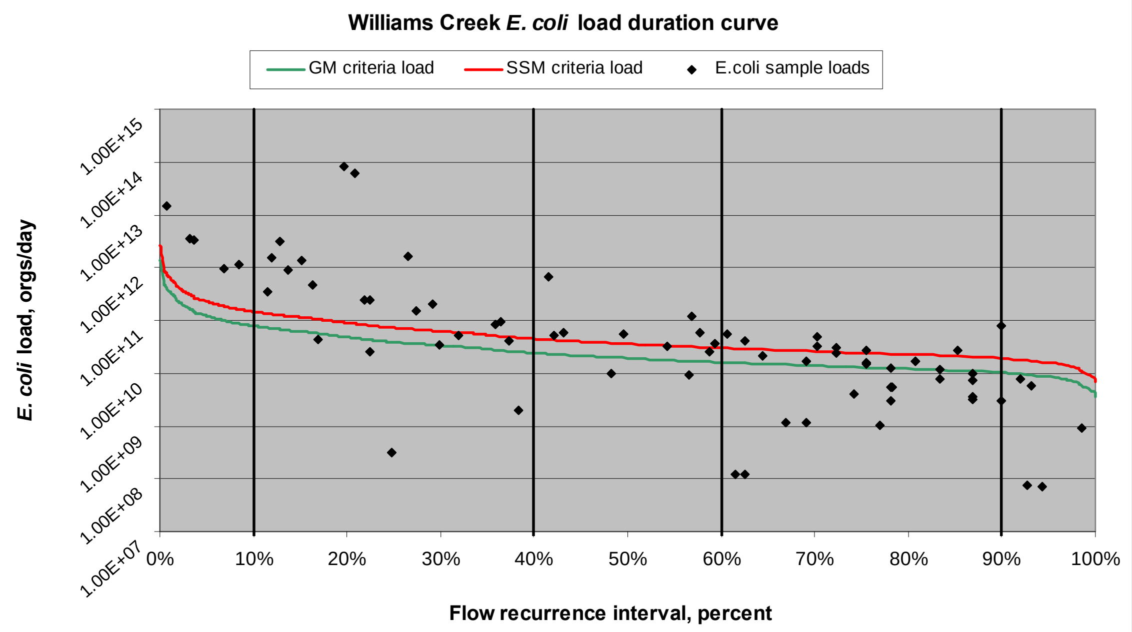

Figure 12-3 Williams Creek load duration curve

Tables 12-3 and 12-4 show the load capacities (targets) for each of the midpoint flow conditions at the GM and SSM criteria, respectively.

**Table 12-3 Williams Creek GM load capacity**

| Flow condition | Recurrence interval | Associated midpoint flow, cfs | Estimated flow interval load capacity, *E. coli* orgs/day |
|---|---|---|---|
| **High flow** | **0 to 10%** | 40.0 | 1.2E+11 |
| **Moist conditions** | **10% to 40%** | 12.6 | 3.9E+10 |
| **Mid-range** | **40% to 60%** | 6.3 | 1.9E+10 |
| **Dry conditions** | **60% to 90%** | 4.2 | 1.3E+10 |
| **Low flow** | **90% to 100%** | 2.8 | 8.5E+09 |

**Table 12-4 Williams Creek SSM load capacity**

| Flow condition | Recurrence interval | Associated midpoint flow, cfs | Estimated flow interval load capacity, *E. coli* orgs/day |
|---|---|---|---|
| **High flow** | **0 to 10%** | 40.0 | 2.3E+11 |
| **Moist conditions** | **10% to 40%** | 12.6 | 7.2E+10 |
| **Mid-range** | **40% to 60%** | 6.3 | 3.6E+10 |
| **Dry conditions** | **60% to 90%** | 4.2 | 2.4E+10 |
| **Low flow** | **90% to 100%** | 2.8 | 1.6E+10 |

## 12.2. Existing load

The existing loads are derived from the sampling data collected in Williams Creek. These data are the sample values shown in the flow and load duration curves. The *E. coli* concentrations are multiplied by the simulated daily flow to get the daily loads. The daily loads are plotted with the load duration curves. The allowable loads for a given flow equal the flow multiplied by the WQS limits for the geometric mean or single sample maximum. Monitored data that exceed the limits are above the criteria curves.

The maximum existing loads occur during major rains when runoff and bacteria concentrations are highest. Concentrations exceed the criteria during these high flow events. Other conditions leading to criteria violations occur during dry low flow periods when continuous loads from livestock in the stream, local wildlife, septic tanks, and wastewater treatment plants can cause bacteria problems.

The assessment standard used to evaluate streams is the *E. coli* geometric mean criteria. Since the load duration approach precludes the calculation of a geometric mean, the 90th percentile of observed concentrations within each flow condition is multiplied by the median flow to estimate existing loads. This procedure has been used to evaluate impaired segments. Table 12-5 shows the existing loads for each flow condition.

## Table 12-5 Williams Creek existing loads

| Flow condition, percent recurrence | Recurrence interval range (mid %) | Associated median flow, cfs | Existing 90th percentile *E. coli* conc., org/100ml | Estimated existing load, *E. coli* org/day |
|---|---|---|---|---|
| **High flows** | **0 to 10% (5)** | 40.0 | 3,860 | 3.78E+12 |
| **Moist conditions** | **10% to 40% (25)** | 12.6 | 5,850 | 1.80E+12 |
| **Mid-range** | **40% to 60% (50)** | 6.3 | 900 | 1.38E+11 |
| **Dry conditions** | **60% to 90% (75)** | 4.2 | 330 | 3.36E+10 |
| **Low flow** | **90% to 100% (95)** | 2.8 | 92 | 6.24E+09 |

*Identification of pollutant sources.*
The sources of bacteria in the Williams Creek subbasin (SWAT Subbasin 9) are all nonpoint sources, with the exception of the Postville municipal wastewater treatment plant. These include failed septic tank systems, pastured cattle, cattle in the stream, wildlife, and manure applied to fields from animal confinement operations. The loads from these sources are incorporated into the SWAT watershed model and are listed in Tables 12-6 to 12-10.

Non functional septic tank systems. There are an estimated 62 onsite septic tank systems in the subbasin (2.5 persons/household). IDNR estimates that 50 percent are not functioning properly. It is assumed that these are continuous year round discharges. Septic tank loads have been put into the SWAT model as a continuous source by subbasin.

## Table 12-6 Williams Creek septic tank system E. coli orgs/day

| | |
|---|---|
| Rural population of Williams Creek subbasin | 155 |
| Total initial E.coli, orgs/day [1] | 1.94E+11 |
| Septic tank flow, $m^3$/day [2] | 41.1 |
| **E. coli delivered to stream, orgs/day [3]** | **1.28+08** |

1. Assumes 1.25E+09 E. coli orgs/day per capita
2. Assumes 70 gallons/day/capita
3. Assumes septic discharge concentration reaching stream is 625 orgs/100 ml and a 50% failure rate

Cattle in stream. Of the 229 cattle in pastures with stream access, one to six percent of those are assumed to be in the stream on a given day. The number on pasture and the fraction in the stream varies by month. Cattle in the stream have a high potential to deliver bacteria since bacteria are deposited directly in the stream with or without rainfall. Subbasin cattle in the stream bacteria have been input in the SWAT model as a continuous source varying by month.

## Table 12-7 Williams Creek Cattle in the stream E. coli orgs/day

| | |
|---|---|
| Pasture area with stream access, acre[1] | 294 |
| Number of cattle in stream (6% of total)[2] | 14 |
| Dry manure, kg/day [3] | 43 |
| **E. coli load, orgs/day [4]** | **5.63E+11** |

1. The subbasin CIS are estimated from the pasture area with stream access at 0.78 cattle/acre.

2. It is estimated that cattle spend 6% of their time in streams in July and August, 3% in June and September, and 1% in May and October. The loads shown in this table are for July and August. The loads for the other 4 months when cattle are in streams have been incorporated into the SWAT modeling.
3. Cattle generate 3.1 kg/head/day of dry manure.
4. Manure has 1.32E+07 E coli orgs/gram dry manure.

<u>Grazing livestock</u>. The estimated number of cattle in the subbasin is 229. It is assumed that they are on pasture from April to November. The potential for bacteria delivery to the stream occurs with precipitation causing runoff. Manure available for washoff is applied in the SWAT model at 6 kg/ha in the pasture landuse.

### Table 12-8 Williams Creek manure from pastured cattle, maximum E. coli available for washoff, orgs/day

| | |
|---|---:|
| Pasture area, acre | 325 |
| Number of cattle on pasture[1] | 239 |
| Dry manure, kg/day[2] | 742 |
| Maximum E. coli load, orgs/day[3] | 9.80E+12 |
| Maximum E. coli available for washoff, orgs[4] | 1.76E+13 |

1. The number of pastured cattle is 0.78 cattle/acre.
2. Cattle generate 3.1 kg/head/day of dry manure.
3. Manure has 1.32E+07 E. coli orgs/gram dry manure
4. The load available for washoff is the daily load times 1.8.

<u>Wildlife manure</u>. The number of deer in Allamakee County is about 9,000 located primarily in forested land adjacent to streams. Another 1,000 have been added to account for other wildlife such as raccoons and waterfowl for a total estimate of 10,000. This works out to 0.024 deer per acre. Using this procedure, there are 363 deer in the subbasin concentrated in the forested areas. The deer are in the subbasin year round.

### Table 12-9 Williams Creek watershed wildlife manure loads available for washoff

| Number of deer[1] | Forested area, ha | SWAT manure loading rate, kg/ha/day[2] | E. coli available for washoff, orgs[3] |
|:---:|:---:|:---:|:---:|
| 220 | 481 | 0.661 | 1.98E+11 |

1. Deer numbers are 0.024 deer/ha for the entire subbasin concentrated to 0.459 deer/ha in the forest land use. All wildlife loads are applied to the forest landuse in the SWAT model. The county deer numbers have been increased by 10% to account for other wildlife in the subbasin.
2. Assumes 1.44 kg/deer/day and 3.47E+05 orgs/gram.
3. Assumes that the maximum E. coli available for washoff is 1.8 times the daily load.

<u>Field applications of CAFO manure</u>.
It is probable that there are not any animals in confinement in the Williams Creek subbasin and that no manure is applied to cropland.

Seasonal variation of sources.
The relative impacts of the bacteria sources are shown in Figures 12-4 and 12-5. Figure 12-4 shows the relative loads delivered by the "continuous" sources, those sources present with or without rainfall and runoff. These are the failed septics that are assumed to be a problem every day of the year and the loads from cattle in the stream that vary by month from May to October. It can be seen in this figure that the impacts from cattle in the stream are much more significant than those from failed septic tank systems.

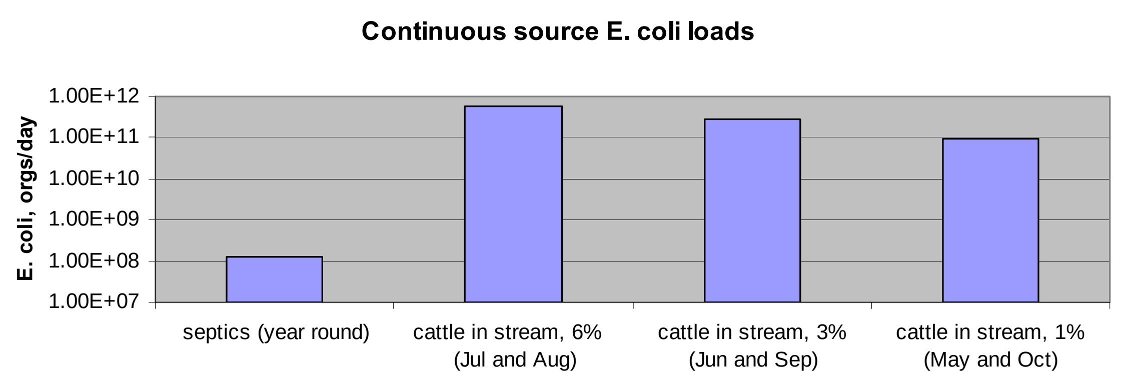

Figure 12-4 E. coli loads from "continuous" sources

The three general washoff sources of bacteria in the subbasin are shown in Figure 12-5. The wildlife source consists primarily of deer and smaller animals such as raccoons and waterfowl. These are year round sources. Pastured cattle consist of grazing cattle and small poorly managed feedlot-like operations. The grazing season is modeled as lasting 168 days starting May 1. Manure from confined animal feeding operations (CAFO) is applied to cropland twice a year for a relatively brief time. Most field applied manure is assumed to be incorporated into the soil and most bacteria in it are not available. Confinement animals are swine, chickens and dairy cattle. It is assumed that no CAFO livestock are in the Williams Creek subbasin.

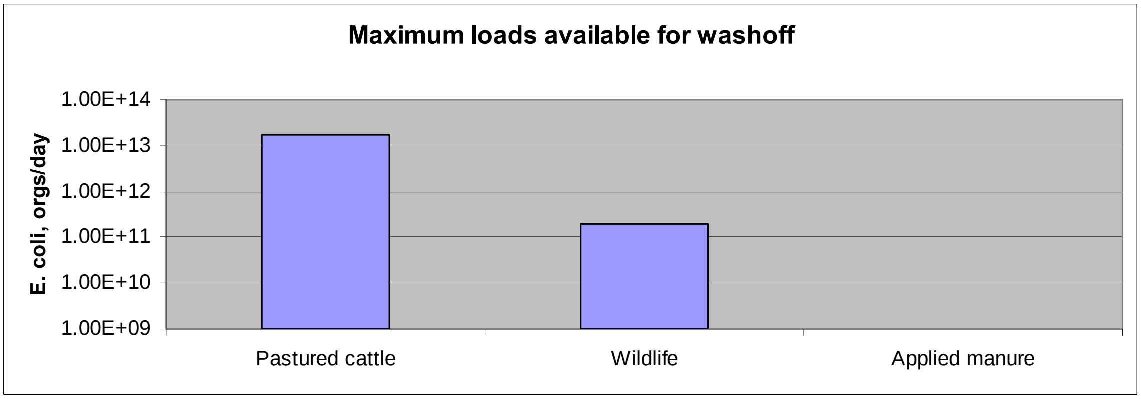

Figure 12-5 Maximum E. coli loads available for washoff

The maximum bacteria load to the stream occurs when the continuous source load plus the precipitation driven washoff load are combined. In general, the more rainfall the

higher the flow rate and the more elevated the concentration. High flow rate and elevated concentration equal peak loads. In July and August, the potential maximum load based on this analysis is 1.78E+13 orgs/day available for washoff plus the continuous load of 5.63E+11 orgs/day for a total of 1.84E+13 orgs/day.

Flow interval load source analysis. Based on the load duration curve analysis the maximum existing load occurring during the zero to forty percent recurrence interval runoff conditions, is 2.14E+12 orgs/day and the total available load based on the potential sources, including fall and spring manure application, is 1.79E+13 orgs/day. Generally the maximum load in the stream, delivered in July when runoff is occurring, is approximately twelve percent of the bacteria available for washoff. At the zero to ten percent maximum existing load of 3.78E+12 orgs/day and the same load available for washoff the stream load is 21 percent of the available load.

### 12.3. Departure from load capacity

The departure from load capacity is the difference between the existing load and the load capacity. This varies for each of the five flow conditions. Table 12-10 shows this difference. The existing and target loads for the five flow conditions are shown graphically in Figure 12-4.

**Table 12-10 Williams Creek, departure from load capacity**

| Design flow condition, percent recurrence | Recurrence interval range (mid %) | Existing *E. coli* orgs/day | Load capacity, orgs/day | Departure from capacity, orgs/day |
|---|---|---|---|---|
| **High flow** | **0 to 10% (5)** | 3.78E+12 | 2.3E+11 | 3.55E+12 |
| **Moist conditions** | **10% to 40% (25)** | 1.80E+12 | 7.2E+10 | 1.73E+12 |
| **Mid-range flow** | **40% to 60% (50)** | 1.38E+11 | 3.6E+10 | 1.02E+11 |
| **Dry conditions** | **60% to 90% (75)** | 3.36E+10 | 2.4E+10 | 9.67E+09 |
| **Low flow** | **90% to 100% (95)** | 6.24E+09 | 1.6E+10 | -9.70E+09 |

1. Negative values indicate that the existing load is less than the target load.

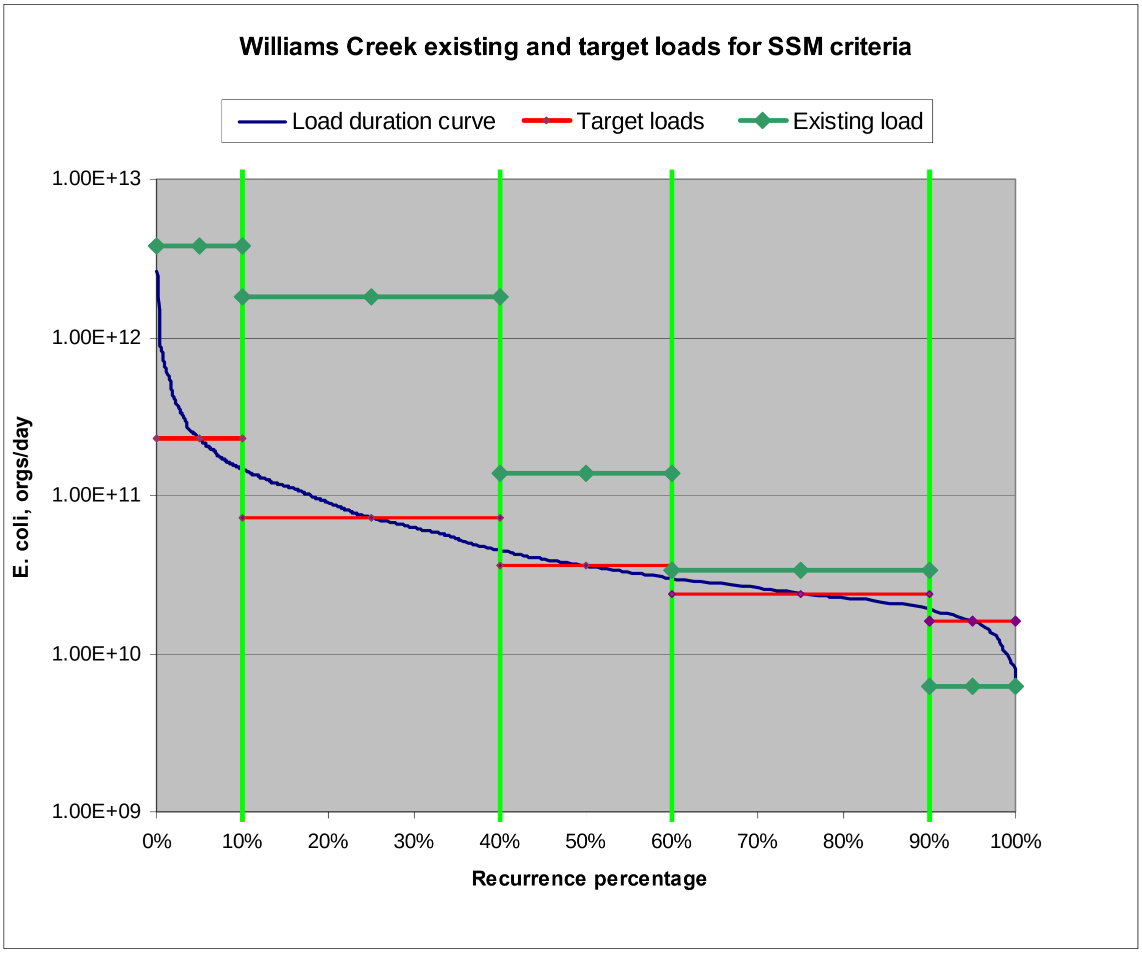

Figure 12-6 Difference between existing and target loads

## 12.4. Pollutant Allocations

*Wasteload allocations.*
The wasteload allocations for the City of Postville wastewater treatment facility that discharges to Williams Creek are shown in Table 3-6 and again in Tables 12-11 and 12-12 which show the GM and SSM TMDL calculations. It is currently assumed that all of the wastewater treatment plants in the watershed discharge to a Class A1 stream. The wasteload allocations for the discharges are the Class A1 *E. coli* water quality standards, a geometric mean (GM) of 126-organisms/100 ml and a single sample maximum (SSM) of 235-organisms/100 ml. These concentration criteria have been multiplied by the 30 day average wet weather (AWW) flow to calculate the WWTP *E. coli* allocations.

*Load allocation.*
The load allocations for *E. coli* TMDLs are the load capacity less an explicit 10 percent margin of safety (MOS) less the total WLA for the flow condition for the geometric mean or single sample maximum. There is a separate load allocation set for each of the target recurrence intervals. The load allocations are shown in Tables 12-11 and 12-12.

### Table 12-11 Williams Creek GM *E. coli* load allocations

| Flow condition, percent recurrence | GM target (TMDL) *E. Coli,* orgs/day | GM MOS *E. Coli,* orgs/day | Total WLA GM *E. coli*, orgs/day | LA GM *E. coli,* orgs/day |
|---|---|---|---|---|
| **High flows** | 1.2E+11 | 1.2E+10 | 1.36E+09 | 1.1E+11 |
| **Moist conditions** | 3.9E+10 | 3.9E+09 | 1.36E+09 | 3.4E+10 |
| **Mid-range flow** | 1.9E+10 | 1.9E+09 | 1.36E+09 | 1.6E+10 |
| **Dry conditions** | 1.3E+10 | 1.3E+09 | 1.36E+09 | 1.0E+10 |
| **Low flow** | 8.5E+09 | 8.5E+08 | 1.36E+09 | 6.3E+09 |

1. Based on geometric mean standard of 126 *E. coli* organisms/100 ml

### Table 12-12 Williams Creek SSM *E. coli* load allocations

| Flow condition, percent recurrence | SSM target (TMDL) *E. Coli,* orgs/day | SSM MOS *E. Coli,* orgs/day | Total WLA SSM *E. coli*, orgs/day | LA SSM *E. coli,* orgs/day |
|---|---|---|---|---|
| **High flow** | 2.3E+11 | 2.3E+10 | 2.54E+09 | 2.0E+11 |
| **Moist conditions** | 7.2E+10 | 7.2E+09 | 2.54E+09 | 6.3E+10 |
| **Mid-range flow** | 3.6E+10 | 3.6E+09 | 2.54E+09 | 3.0E+10 |
| **Dry conditions** | 2.4E+10 | 2.4E+09 | 2.54E+09 | 1.9E+10 |
| **Low flow** | 1.6E+10 | 1.6E+09 | 2.54E+09 | 1.2E+10 |

1. Based on single sample maximum standard of 235 *E. coli* organisms/100 ml

*Margin of safety.*
The margin of safety for *E. coli* is an explicit 10 percent of the load capacity at each of the design recurrence intervals as shown in Tables 12-11 and 12-12.

## 12.5. TMDL Summary

The following equation shows the total maximum daily load (TMDL) and its components for the impaired IA 01-YEL-0125_0 segment of Williams Creek.

**Total Maximum Daily Load = Σ Load Allocations + Σ Wasteload Allocations +MOS**

A Total Maximum Daily Load calculation has been made at design flow conditions for the GM and SSM of this segment and these are shown in Tables 12-13 and 12-14 and Figures 12-7 and 12-8.

### Table 12-13 Williams Creek IA 01-YEL-0125_0 *E. coli* TMDL for GM

| Flow condition | Σ LA, orgs/day | Σ WLA, orgs/day | MOS, orgs/day | TMDL, orgs/day |
|---|---|---|---|---|
| **High flow** | 1.1E+11 | 1.36E+09 | 1.2E+10 | 1.2E+11 |
| **Moist condition** | 3.4E+10 | 1.36E+09 | 3.9E+09 | 3.9E+10 |
| **Mid-range flow** | 1.6E+10 | 1.36E+09 | 1.9E+09 | 1.9E+10 |
| **Dry conditions** | 1.0E+10 | 1.36E+09 | 1.3E+09 | 1.3E+10 |
| **Low flow** | 6.3E+09 | 1.36E+09 | 8.5E+08 | 8.5E+09 |

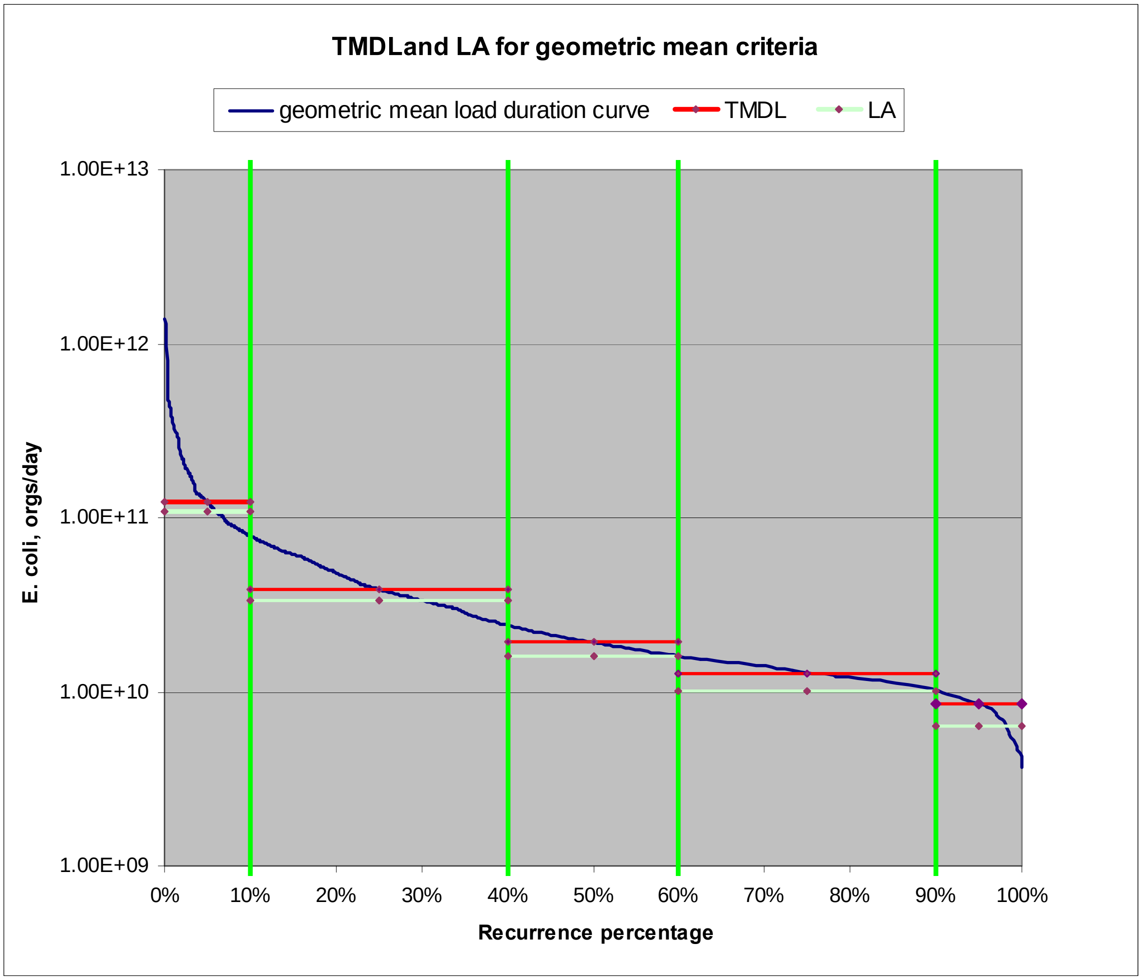

Figure 12-7 GM TMDL at WQS of 126 orgs/100 ml for the five flow conditions

**Table 12-14 Williams Creek IA 01-YEL-0125_0 *E. coli* TMDL for SSM**

| Flow condition | Σ LA, orgs/day | Σ WLA, orgs/day | MOS, orgs/day | TMDL, orgs/day |
|---|---|---|---|---|
| High flow | 2.0E+11 | 2.54E+09 | 2.3E+10 | 2.3E+11 |
| Moist condition | 6.3E+10 | 2.54E+09 | 7.2E+09 | 7.2E+10 |
| Mid-range flow | 3.0E+10 | 2.54E+09 | 3.6E+09 | 3.6E+10 |
| Dry conditions | 1.9E+10 | 2.54E+09 | 2.4E+09 | 2.4E+10 |
| Low flow | 1.2E+10 | 2.54E+09 | 1.6E+09 | 1.6E+10 |

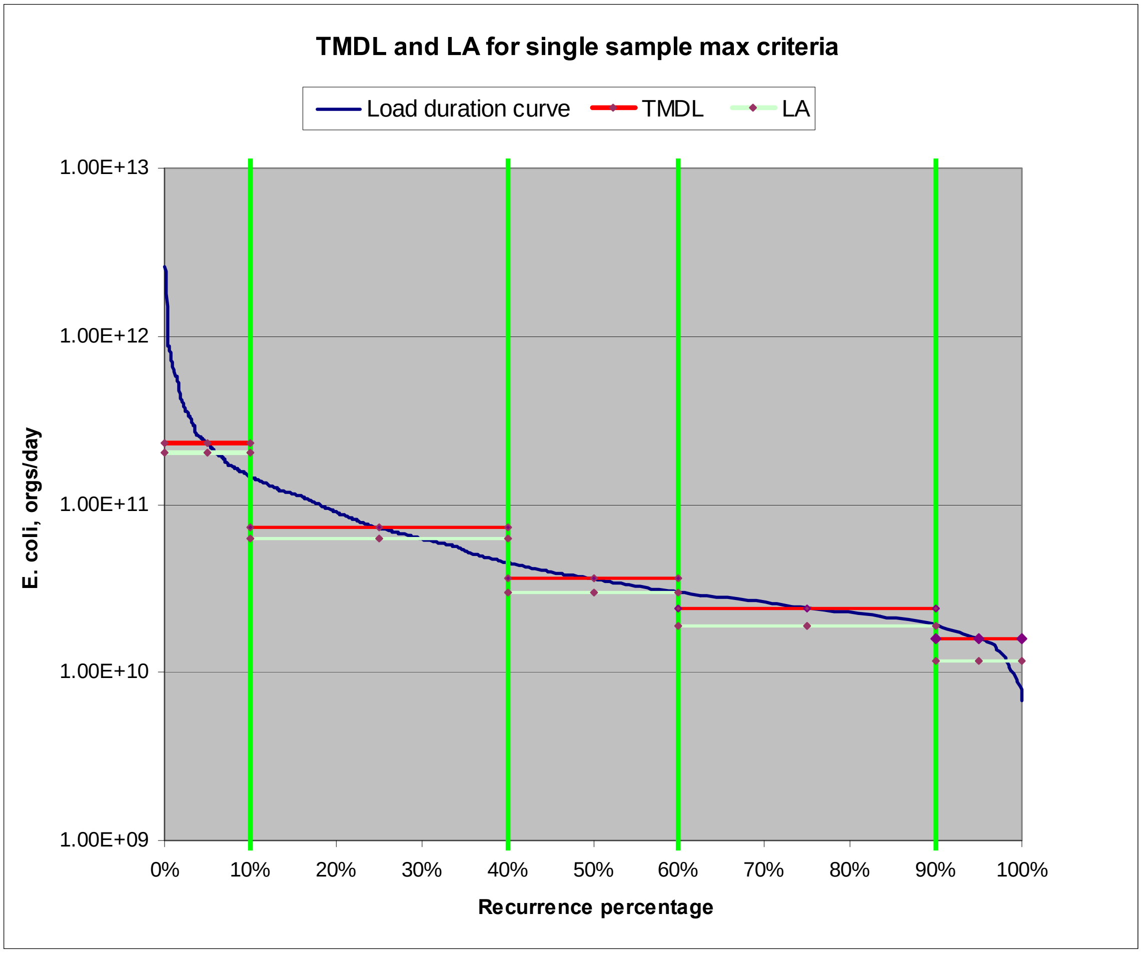

Figure 12-8 SSM TMDL at WQS of 235 orgs/100 ml for the five flow conditions

## 12.6. Implementation Analysis

The modeled systematic reduction of the loads by source provides the initial evaluation of proposed implementation plans for the subbasin. The SWAT model has been run for four scenarios in which loads have been reduced for the most significant sources. The source analysis identified the primary source of bacteria as cattle in the stream and cattle on pasture. Figure 12-9 shows the SWAT model output concentrations for the stream with monitored concentrations also plotted on the chart. The target concentration of 235 *E. coli* orgs/100 ml is frequently exceeded by both monitoring data and SWAT simulated values. The concentration scale has been set at twelve thousand because there are two samples much higher (170,000 and 210,000 orgs/100 ml) than the other sample values. The advantage is that sample and simulated values are visually comparable to the SSM without a log scale.

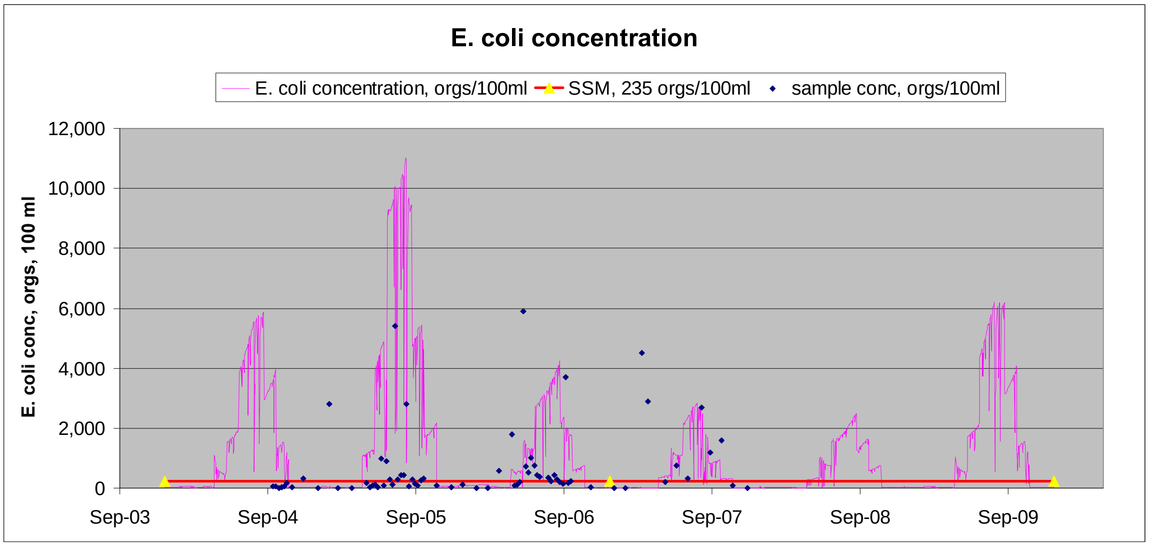

Figure 12-9 SWAT output for existing E. coli concentrations

The second scenario, Figure 12-10, removes half of the cattle in the stream from the subbasin. This generates lower concentrations that are still higher than the SSM standard during the grazing season. The runoff related concentration spikes seen in other Yellow River basin subbasins are not present here since there are not any CAFOs with field applied manure in the Williams Creek subbasin.

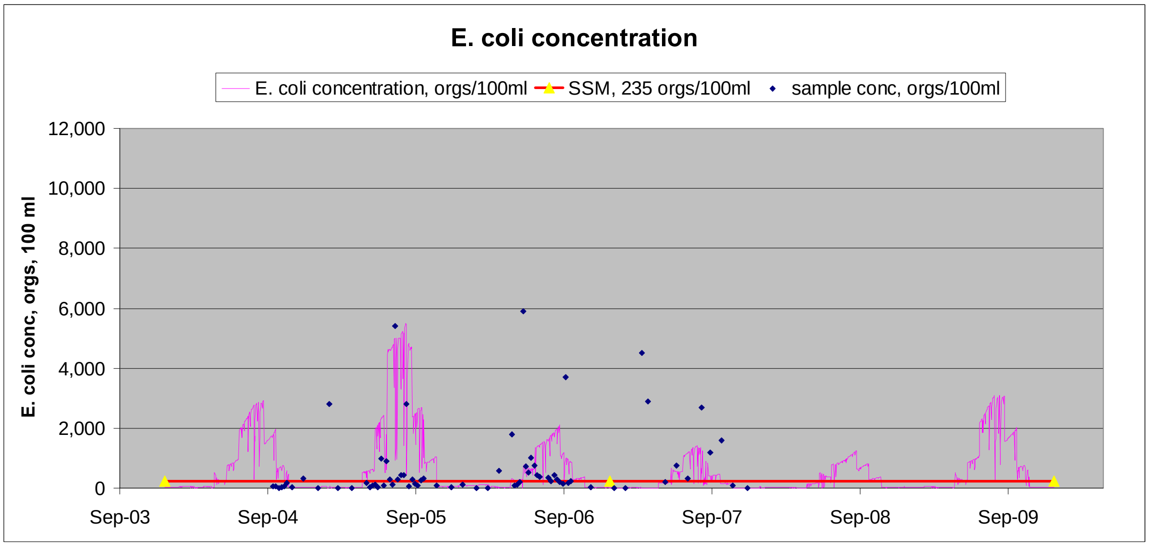

Figure 12-10 SWAT output for half reduction of CIS E. coli concentrations

The third scenario, shown in Figure 12-11, eliminates cattle in the stream altogether as a source. This drops the concentration below the water quality standard for all conditions. The concentration scale has been dropped to two thousand so that the relationship between the simulated concentrations and the E. coli standard are clearer.

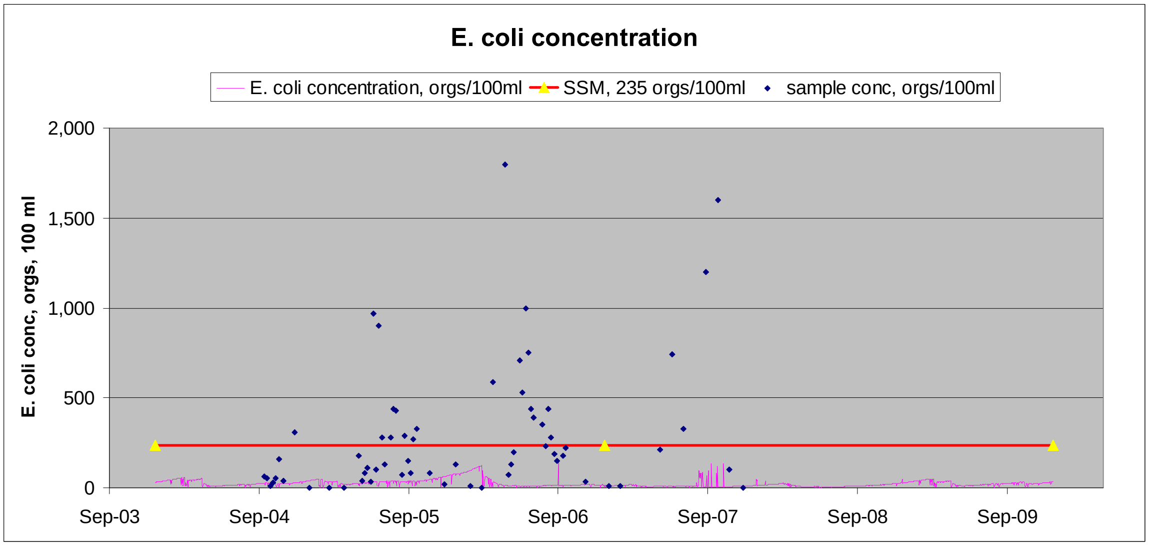

Figure 12-11 SWAT output for complete reduction of CIS E. coli

The fourth scenario, shown in Figure 12-12, assumes that in addition to the previous reductions, the manure from cattle on pasture is reduced by two thirds. This pasture manure reduction further drops the simulated stream concentration. The concentration scale here has a maximum value of two thousand as in Figure 12-11.

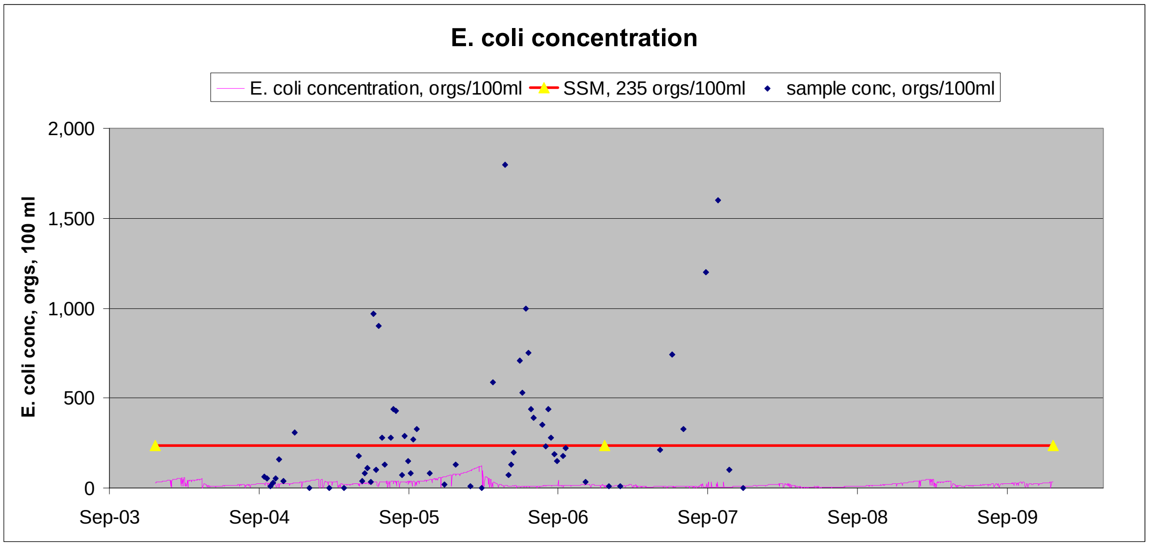

Figure 12-12 SWAT output for complete reduction of CIS E. coli and half of applied manure from CAFOs

There are several combinations of source reductions that can be simulated. The four scenarios described here reduce bacteria loads from the sources that have been modeled to have a significant impact on stream bacteria concentrations. Some sources that are not reduced in these scenarios, such as wildlife and septic tank systems, may have important episodic or local effect on *E. coli* organism numbers.

## 13. Norfolk Creek

Norfolk Creek (IA 01-YEL-0130_0) is the sixth impaired Yellow River tributary upstream from the Yellow River confluence with the Mississippi. The classified segment runs northwest 5.0 miles upstream from its confluence with the Yellow River (S6, T96N, R5W, Allamakee County). There are no permitted sources that discharges to this segment. The stream flow used in the development of the TMDL for this segment is derived from the area ratio flow based on the Ion USGS gage data. A SWAT watershed model developed for the Yellow River watershed labels Norfolk Creek Subbasin 2. Figure 13-1 shows a map of Norfolk Creek and Table 13-1 shows the land use in its subbasin.

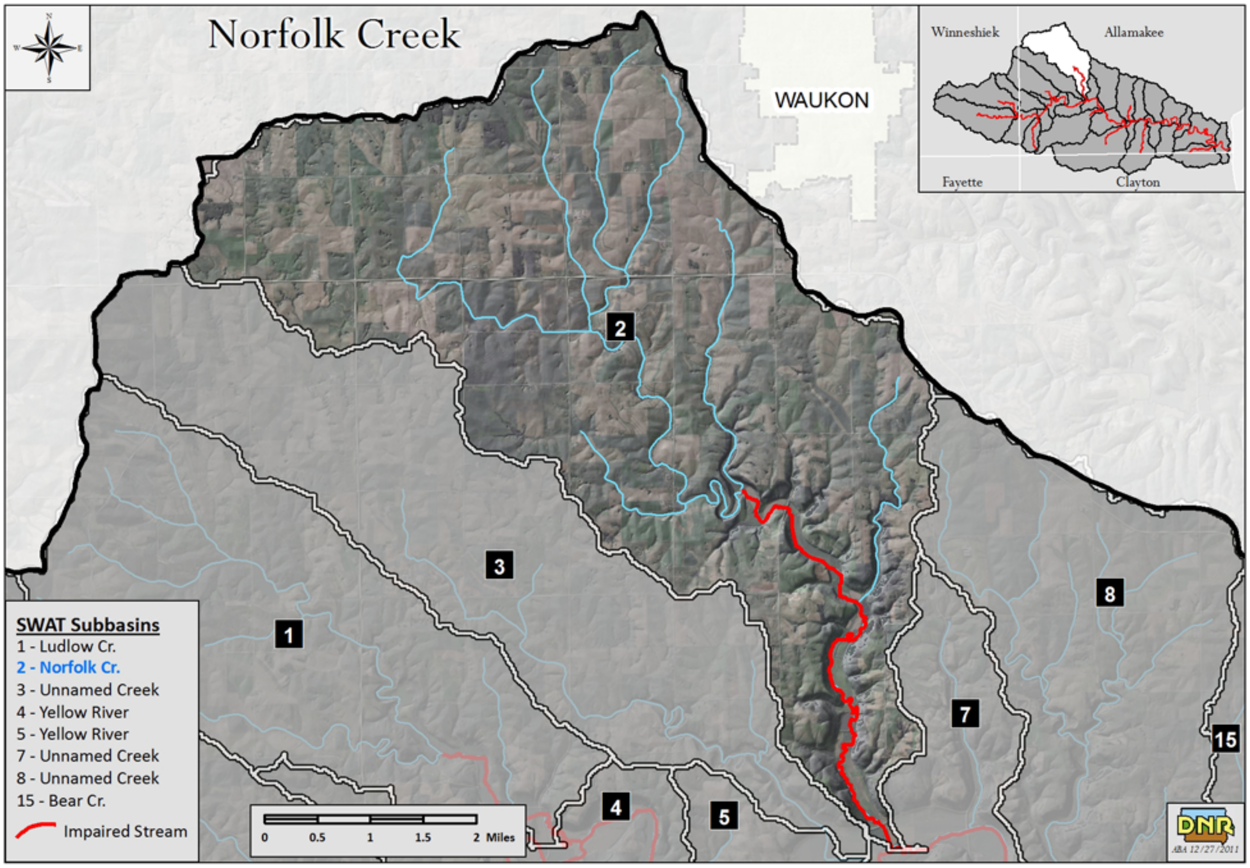

Figure 13-1 Norfolk Creek (0130_0)

### Table 13-1 Norfolk Creek subbasin land use

| Landuse | Area, acres | Fraction of total |
|---|---|---|
| Water/wetland | 10.6 | 0.07% |
| Forest | 1941.3 | 12.85% |
| Ungrazed/CRP/hay | 3280.0 | 21.71% |
| Pasture | 634.3 | 4.20% |
| Row crop | 8706.7 | 57.62% |
| Roads | 481.7 | 3.19% |
| Commercial/residential | 54.9 | 0.36% |
| **Total** | **15109.5** | **100.00%** |

In the Norfolk Creek watershed more than a third of the area is forest and ungrazed grass and 58 percent is row crop.

## 13.1. Water body pollutant loading capacity (TMDL)

The *E. coli* organism load capacity is the number of organisms that can be in a volume and meet the water quality criteria. The loading capacity for each of the five flow conditions is calculated by multiplying the midpoint flow and *E. coli* criteria concentrations. Table 13.2 shows the median, maximum, and minimum flows for the five flow conditions.

### Table 13.2 Norfolk Creek maximum, minimum and median flows

| Flow description | Recurrence interval range (mid %) | Midpoint of flow range, cfs | Maximum of flow range, cfs | Minimum of flow range, cfs |
|---|---|---|---|---|
| **High flow** | **0 to 10% (5)** | 64.5 | 688.0 | 41.0 |
| **Moist conditions** | **10% to 40% (25)** | 20.3 | 41.0 | 12.6 |
| **Mid-range** | **40% to 60% (50)** | 10.2 | 12.6 | 8.4 |
| **Dry conditions** | **60% to 90% (75)** | 6.8 | 8.4 | 5.5 |
| **Low flow** | **90% to 100% (95)** | 4.5 | 5.5 | 1.9 |

Flow and load duration curves were used to establish the occurrence of water quality standards violations, to establish compliance targets, and to set pollutant allocations and margins of safety. Duration curves are derived from flows plotted as a percentage of their recurrence. *E. coli* loads are calculated from *E. coli* concentrations and flow volume at the time the sample was collected.

To construct the flow duration curves, the bacteria monitoring data and the Water Quality Standard (WQS) sample max (235 *E. coli* organisms/100 ml) were plotted with the flow duration percentile. Figure 13-2 shows the data that exceed the WQS criteria at each of the five flow conditions. High flow violations indicate that the problem occurs during run-off conditions when bacteria are washing off from nonpoint sources. Criteria exceeded during low or base flow, when little or no runoff is occurring, indicate that continuous sources such as septic tanks, livestock in the stream, riparian wildlife, and wastewater treatment plants are the problem.

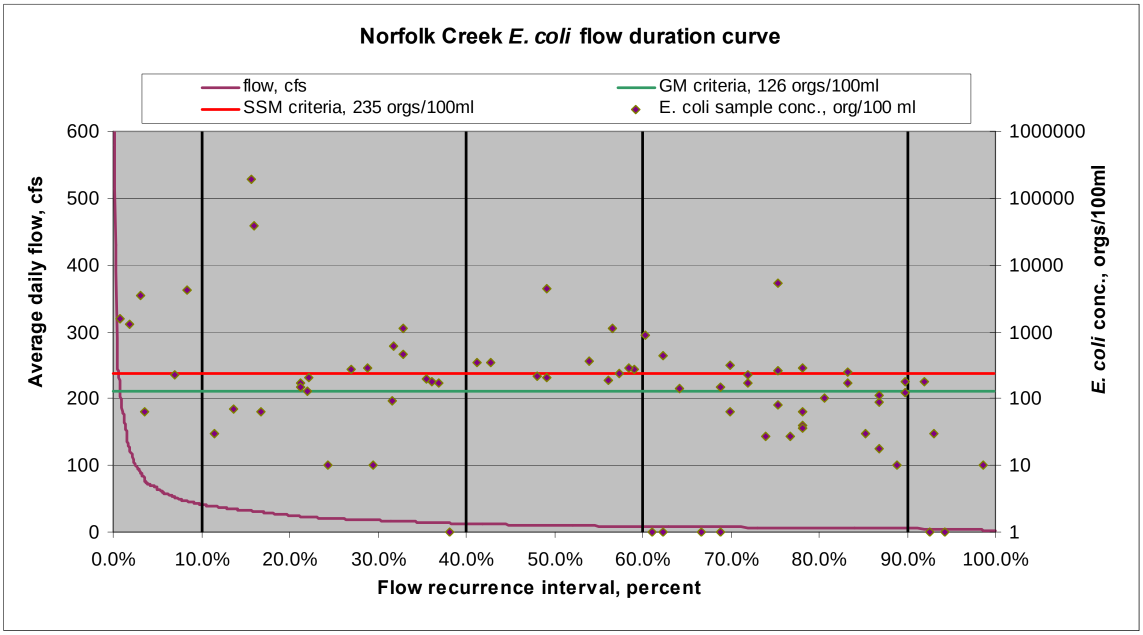

Figure 13-2 Norfolk Creek flow duration curve

Load duration curves were used to evaluate the five flow conditions for Norfolk Creek. The load duration curve is shown in Figure 13-3. In the figure, the lower curve shows the maximum *E. coli* count for the GM criteria and the upper curve shows the maximum *E. coli* count for the SSM criteria at a continuum of flow recurrence percentage. The individual points are the observed (monitored) *E. coli* concentrations converted to loads based on daily flow for the day they were collected. Points above the load duration curves are violations of the WQS criteria and exceed the loading capacity.

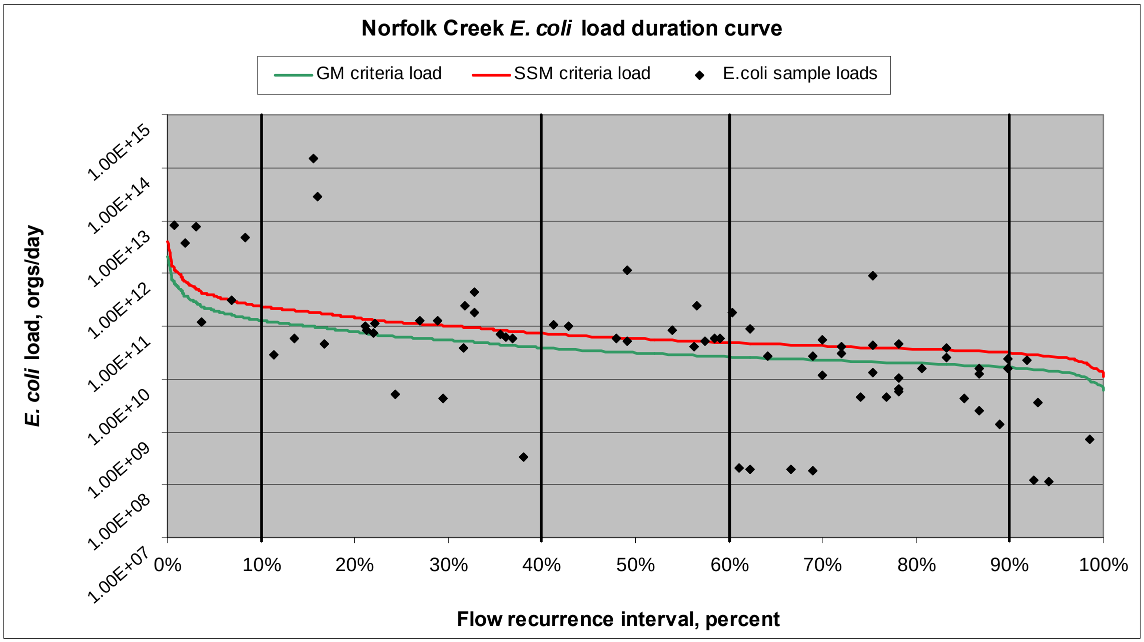

Figure 13-3 Norfolk Creek load duration curve

Tables 13-3 and 13-4 show the load capacities (targets) for each of the midpoint flow conditions at the GM and SSM criteria, respectively.

### Table 13-3 Norfolk Creek GM load capacity

| Flow condition | Recurrence interval | Associated midpoint flow, cfs | Estimated flow interval load capacity, *E. coli* orgs/day |
|---|---|---|---|
| **High flow** | **0 to 10%** | 64.5 | 2.0E+11 |
| **Moist conditions** | **10% to 40%** | 20.3 | 6.3E+10 |
| **Mid-range** | **40% to 60%** | 10.2 | 3.1E+10 |
| **Dry conditions** | **60% to 90%** | 6.8 | 2.1E+10 |
| **Low flow** | **90% to 100%** | 4.5 | 1.4E+10 |

### Table 13-4 Norfolk Creek SSM load capacity

| Flow condition | Recurrence interval | Associated midpoint flow, cfs | Estimated flow interval load capacity, *E. coli* orgs/day |
|---|---|---|---|
| **High flow** | **0 to 10%** | 64.5 | 3.7E+11 |
| **Moist conditions** | **10% to 40%** | 20.3 | 1.2E+11 |
| **Mid-range** | **40% to 60%** | 10.2 | 5.8E+10 |
| **Dry conditions** | **60% to 90%** | 6.8 | 3.9E+10 |
| **Low flow** | **90% to 100%** | 4.5 | 2.6E+10 |

## 13.2. Existing load

The existing loads are derived from the sampling data collected in Norfolk Creek. These data are the sample values shown in the flow and load duration curves. The *E. coli* concentrations are multiplied by the simulated daily flow to get the daily loads. The daily loads are plotted with the load duration curves. The allowable loads for a given flow equal the flow multiplied by the WQS limits for the geometric mean or single sample maximum. Monitored data that exceed the limits are above the criteria curves.

The maximum existing loads occur during major rains when runoff and bacteria concentrations are highest. Concentrations exceed the criteria during these high flow events. Other conditions leading to criteria violations occur during dry low flow periods when continuous loads from livestock in the stream, local wildlife, septic tanks, and wastewater treatment plants can cause bacteria problems.

The assessment standard used to evaluate streams is the *E. coli* geometric mean criteria. Since the load duration approach precludes the calculation of a geometric mean, the 90th percentile of observed concentrations within each flow condition is multiplied by the median flow to estimate existing loads. This procedure has been used to evaluate impaired segments. Table 13-5 shows the existing loads for each flow condition.

## Table 13-5 Norfolk Creek existing loads

| Flow condition, percent recurrence | Recurrence interval range (mid %) | Associated median flow, cfs | Existing 90th percentile *E. coli* conc., org/100ml | Estimated existing load, *E. coli* org/day |
|---|---|---|---|---|
| **High flows** | **0 to 10% (5)** | 64.5 | 3850 | 6.07E+12 |
| **Moist conditions** | **10% to 40% (25)** | 20.3 | 1100 | 5.47E+11 |
| **Mid-range** | **40% to 60% (50)** | 10.2 | 1100 | 2.73E+11 |
| **Dry conditions** | **60% to 90% (75)** | 6.8 | 310 | 5.16E+10 |
| **Low flow** | **90% to 100% (95)** | 4.5 | 120 | 1.33E+10 |

*Identification of pollutant sources.*
The sources of bacteria in the Norfolk Creek subbasin (SWAT Subbasin 2) are all nonpoint sources including failed septic tank systems, pastured cattle, cattle in the stream, wildlife, and manure applied to fields from animal confinement operations. The loads from these sources are incorporated into the SWAT watershed model and are listed in Tables 13-6 to 13-10.

Non functional septic tank systems. There are an estimated 159 onsite septic tank systems in the subbasin (2.5 persons/household). IDNR estimates that 50 percent are not functioning properly. It is assumed that these are continuous year round discharges. Septic tank loads have been put into the SWAT model as a continuous source by subbasin.

## Table 13-6 Norfolk Creek septic tank system E. coli orgs/day

| | |
|---|---|
| Rural population of Norfolk Creek subbasin | 397 |
| Total initial E.coli, orgs/day [1] | 4.96E+11 |
| Septic tank flow, $m^3$/day [2] | 105 |
| **E. coli delivered to stream, orgs/day [3]** | **3.29E+08** |

1. Assumes 1.25E+09 E. coli orgs/day per capita
2. Assumes 70 gallons/day/capita
3. Assumes septic discharge concentration reaching stream is 625 orgs/100 ml and a 50% failure rate

Cattle in stream. Of the 301 cattle in pastures with stream access, one to six percent of those are assumed to be in the stream on a given day. The number on pasture and the fraction in the stream varies by month. Cattle in the stream have a high potential to deliver bacteria since bacteria are deposited directly in the stream with or without rainfall. Subbasin cattle in the stream bacteria have been input in the SWAT model as a continuous source varying by month.

## Table 13-7 Norfolk Creek Cattle in the stream E. coli orgs/day

| | |
|---|---|
| Pasture area, acre[1] | 386 |
| Number of cattle in stream (6% of total)[2] | 18 |
| Dry manure, kg/day [3] | 56 |
| **E. coli load, orgs/day [3]** | **7.39E+11** |

1. The subbasin CIS are estimated from the pasture area with access to streams at 0.78 cattle/acre.

2. It is estimated that cattle spend 6% of their time in streams in July and August, 3% in June and September, and 1% in May and October. The loads shown in this table are for July and August. The loads for the other 4 months when cattle are in streams have been incorporated into the SWAT modeling.
3. Cattle generate 3.1 kg/head/day of dry manure.
4. Manure has 1.32E+07 E coli orgs/gram dry manure.

Grazing livestock. The estimated number of cattle in the subbasin is 481. It is assumed that they are on pasture from April to November. The potential for bacteria delivery to the stream occurs with precipitation causing runoff. Manure available for washoff is applied in the SWAT model at 6 kg/ha in the pasture landuse.

### Table 13-8 Norfolk Creek manure from pastured cattle, maximum E. coli available for washoff, orgs/day

| | |
|---|---:|
| Pasture area, acre | 640 |
| Number of cattle on pasture[1] | 481 |
| Dry manure, kg/day[2] | 1,491 |
| Maximum E. coli load, orgs/day[3] | 1.97E+13 |
| Maximum E. coli available for washoff, orgs[4] | 3.54E+13 |

1. The number of pastured cattle is 0.78 cattle/acre.
2. Cattle generate 3.1 kg/head/day of dry manure.
3. Manure has 1.32E+07 E. coli orgs/gram dry manure
4. The load available for washoff is the daily load times 1.8.

Wildlife manure. The number of deer in Allamakee County is about 9,000 located primarily in forested land adjacent to streams. Another 1,000 have been added to account for other wildlife such as raccoons and waterfowl for a total estimate of 10,000. This works out to 0.024 deer per acre. Using this procedure, there are 363 deer in the subbasin concentrated in the forested areas. The deer are in the subbasin year round.

### Table 13-9 Norfolk Creek watershed wildlife manure loads available for washoff

| Number of deer[1] | Forested area, ha | SWAT manure loading rate, kg/ha/day[2] | E. coli available for washoff, orgs[3] |
|:---:|:---:|:---:|:---:|
| 363 | 868 | 0.602 | 3.26E+11 |

1. Deer numbers are 0.024 deer/ha for the entire subbasin concentrated to 0.418 deer/ha in the forest land use. All wildlife loads are applied to the forest landuse in the SWAT model. The county deer numbers have been increased by 10% to account for other wildlife in the subbasin.
2. Assumes 1.44 kg/deer/day and 3.47E+05 orgs/gram.
3. Assumes that the maximum E. coli available for washoff is 1.8 times the daily load.

Field applications of CAFO manure.
There are about 1,200 hogs in confinement in the subbasin. The manure is stored and land applied to cropland. The manure is distributed to the fields in the subbasin in the fall after soybean harvest and in the spring prior to corn planting in year two of a two year rotation. The relatively brief fall and spring timing of manure application and incorporation in the soil significantly reduces the *E. coli* organisms from these sources.

Manure application has been put in the SWAT model by subbasin as a load available at the end of October and the beginning of April.

### Table 13-10 Norfolk Creek watershed confined livestock manure applications

| Livestock type | Swine | Chickens | Dairy cows |
|---|---|---|---|
| Number of animals | 1,200 | 0 | 0 |
| Manure applied, kg/application[1] | 494,940 | 0 | 0 |
| Application area, ha[2] | 23.5 | 0 | 0 |
| Manure applied, kg/ha/day[3] | 2,127 | 0 | 0 |
| Subbasin E. coli, orgs/day | 1.32E+14 | 0 | 0 |
| Subbasin E. coli available for washoff, orgs/day[4] | 2.38E+14 | 0 | 0 |

1. Manure is calculated based on number of animals * dry manure (kg/animal/day)*365 days/year.
2. The area the manure is applied to is based on the manure's nitrogen content. Manure is applied at a rate equivalent to 201.6 kg N/ha/yr. Swine manure is applied at 2127 kg/ha, dairy manure at 2631 kg/ha and chicken manure at 2326 kg/ha. The E. coli content of manure for swine is 1.32E+07 orgs/gram, for dairy cows is 1.00E+07 orgs/gram, and for chickens is 2.96E+06 orgs/gram.
3. Manure is assumed to be applied to fields twice a year over 5 days on October 30 and April 1. It is incorporated in the soil and it is assumed that only 10% of bacteria are viable and available after storage and incorporation.
4. Maximum *E. coli* available for washoff are 1.8 times the daily maximum available load.

Seasonal variation of sources.
The relative impacts of the bacteria sources are shown in Figures 13-4 and 13-5. Figure 13-4 shows the relative loads delivered by the "continuous" sources, those sources present with or without rainfall and runoff. These are the failed septics that are assumed to be a problem every day of the year and the loads from cattle in the stream that vary by month from May to October. It can be seen in this figure that the impacts from cattle in the stream are much more significant than those from failed septic tank systems.

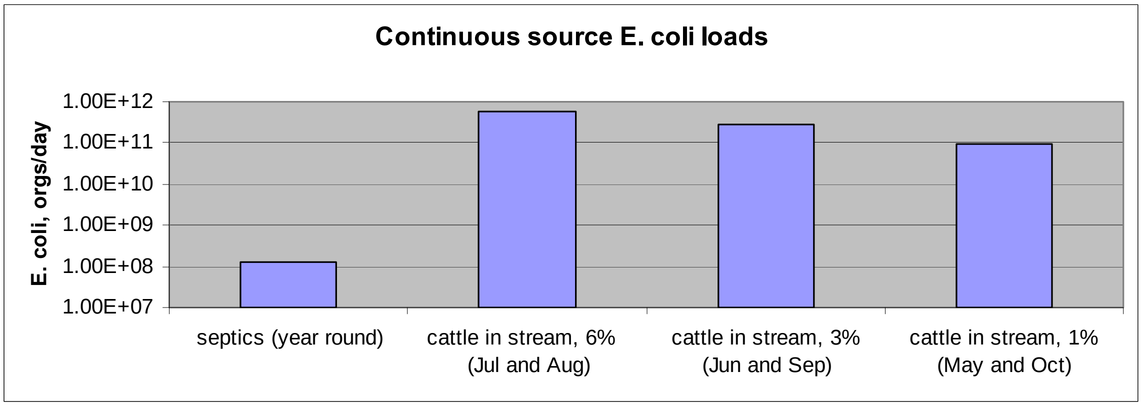

Figure 13-4 E. coli loads from "continuous" sources

The three general washoff sources of bacteria in the subbasin are shown in Figure 13-5. The wildlife source consists primarily of deer and smaller animals such as raccoons and waterfowl. These are year round sources. Pastured cattle consist of grazing cattle and

small poorly managed feedlot-like operations. The grazing season is modeled as lasting 168 days starting May 1. Manure from confined animal feeding operations (CAFO) is applied to cropland twice a year for a relatively brief time. Most field applied manure is assumed to be incorporated into the soil and most bacteria in it are not available. Confinement animals are swine, chickens and dairy cattle.

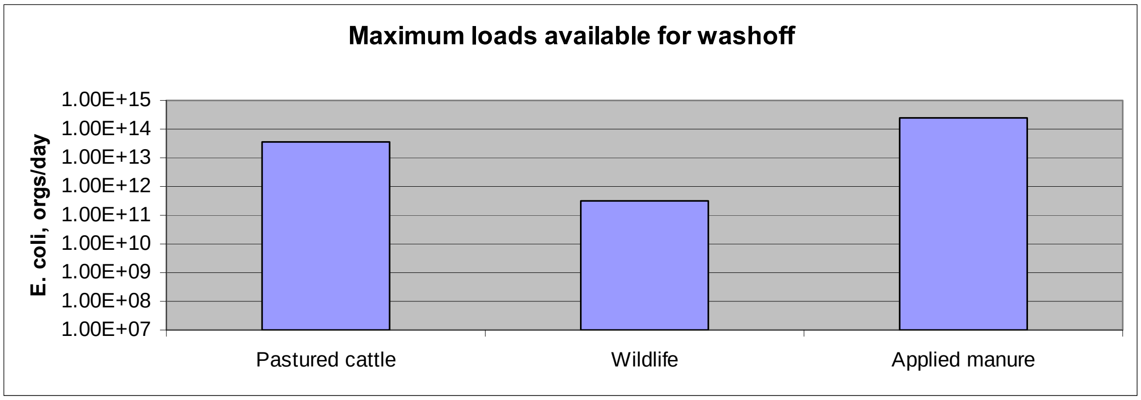

Figure 13-5 Maximum E. coli loads available for washoff

The maximum bacteria load to the stream occurs when the continuous source load plus the precipitation driven washoff load are combined. In general, the more rainfall the higher the flow and the more elevated the concentration. High flow and elevated concentration equal peak loads. In July and August, the potential maximum load based on this analysis is 3.58E+13 orgs/day available for washoff plus the continuous load of 7.40E+11 orgs/day for a total of 3.65E+13 orgs/day.

<u>Flow interval load source analysis</u>. Based on the load duration curve analysis the maximum existing load occurring during the zero to forty percent recurrence interval runoff conditions, is 2.36E+12 orgs/day and the total available load based on the potential sources, including fall and spring manure applications, is 2.74E+14 orgs/day. Generally the maximum load in the stream, delivered in April when runoff is occurring, is approximately one percent of the bacteria available for washoff. At the zero to ten percent maximum existing load of 6.07E+12 orgs/day and the same load available for washoff the stream load is two percent of the available load.

## 13.3. Departure from load capacity

The departure from load capacity is the difference between the existing load and the load capacity. This varies for each of the five flow conditions. Table 13-11 shows this difference. The existing and target loads for the five flow conditions are shown graphically in Figure 13-6.

**Table 13-11 Norfolk Creek departure from load capacity**

| Design flow condition, percent recurrence | Recurrence interval range (mid %) | Existing *E. E. coli* orgs/day | Load capacity, orgs/day | Departure from capacity, orgs/day[1] |
|---|---|---|---|---|
| **High flow** | **0 to 10% (5)** | 6.07E+12 | 3.7E+11 | 5.70E+12 |
| **Moist conditions** | **10% to 40% (25)** | 5.47E+11 | 1.2E+11 | 4.30E+11 |
| **Mid-range flow** | **40% to 60% (50)** | 2.73E+11 | 5.8E+10 | 2.15E+11 |
| **Dry conditions** | **60% to 90% (75)** | 5.16E+10 | 3.9E+10 | 1.25E+10 |
| **Low flow** | **90% to 100% (95)** | 1.33E+10 | 2.6E+10 | -1.28E+10 |

1. Negative values indicate that the existing load is less than the target load.

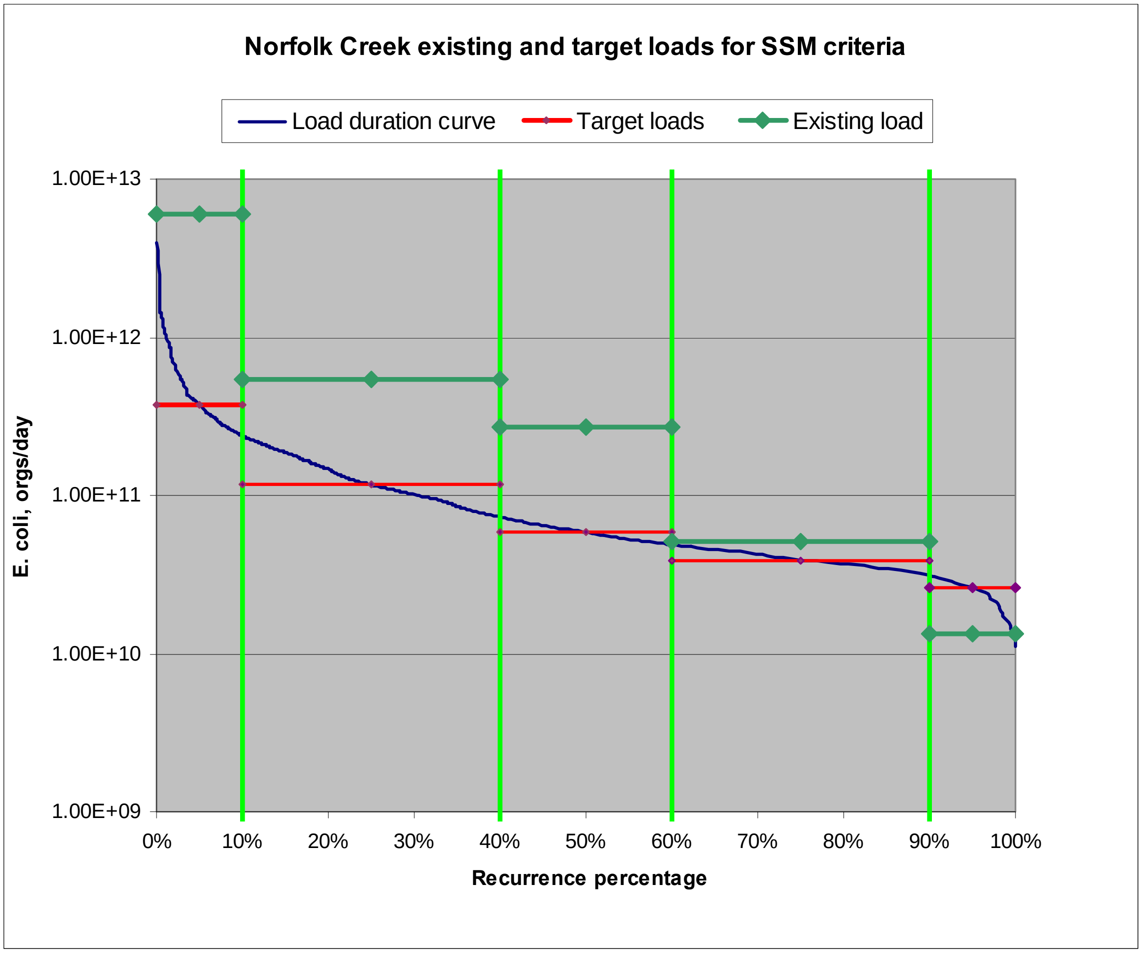

Figure 13-6 Difference between existing and target loads

## 13.4. Pollutant Allocations

*Wasteload allocations.*
Since there are no permitted discharges to Norfolk Creek, only a non-discharging feedlot operation, the summation of the wasteload allocations is zero.

*Load allocation.*
The load allocations for *E. coli* TMDLs are the load capacity less an explicit 10 percent margin of safety (MOS) less the total WLA for the flow condition for the geometric mean

or single sample maximum. There is a separate load allocation set for each of the target recurrence intervals. The load allocations are shown in Tables 13-12 and 13-13.

**Table 13-12 Norfolk Creek GM *E. coli* load allocations**

| Flow condition, percent recurrence | GM target (TMDL) *E. Coli*, orgs/day | GM MOS *E. Coli*, orgs/day | Total WLA GM *E. coli*, orgs/day | LA GM *E. coli*, orgs/day |
|---|---|---|---|---|
| **High flows** | 2.0E+11 | 2.0E+10 | zero | 1.8E+11 |
| **Moist conditions** | 6.3E+10 | 6.3E+09 | zero | 5.6E+10 |
| **Mid-range flow** | 3.1E+10 | 3.1E+09 | zero | 2.8E+10 |
| **Dry conditions** | 2.1E+10 | 2.1E+09 | zero | 1.9E+10 |
| **Low flow** | 1.4E+10 | 1.4E+09 | zero | 1.3E+10 |

1. Based on geometric mean standard of 126 *E. coli* organisms/100 ml

**Table 13-13 Norfolk Creek SSM *E. coli* load allocations**

| Flow condition, percent recurrence | SSM target (TMDL) *E. Coli*, orgs/day | SSM MOS *E. Coli*, orgs/day | Total WLA SSM *E. coli*, orgs/day | LA SSM *E. coli*, orgs/day |
|---|---|---|---|---|
| **High flow** | 3.7E+11 | 3.7E+10 | zero | 3.3E+11 |
| **Moist conditions** | 1.2E+11 | 1.2E+10 | zero | 1.1E+11 |
| **Mid-range flow** | 5.8E+10 | 5.8E+09 | zero | 5.3E+10 |
| **Dry conditions** | 3.9E+10 | 3.9E+09 | zero | 3.5E+10 |
| **Low flow** | 2.6E+10 | 2.6E+09 | zero | 2.3E+10 |

1. Based on single sample maximum standard of 235 *E. coli* organisms/100 ml

*Margin of safety.*
The margin of safety for *E. coli* is an explicit 10 percent of the load capacity at each of the design recurrence intervals as shown in Tables 13-12 and 13-13.

## 13.5. TMDL Summary

The following equation shows the total maximum daily load (TMDL) and its components for the impaired IA 01-YEL-0130_0 segment of Norfolk Creek.

**Total Maximum Daily Load = Σ Load Allocations + Σ Wasteload Allocations +MOS**

A Total Maximum Daily Load calculation has been made at design flow conditions for the GM and SSM of this segment and these are shown in Tables 13-14 and 13-15 and Figures 13-7 and 13-8.

**Table 13-14 Norfolk Creek IA 01-YEL-0130_0 *E. coli* TMDL for GM**

| Flow condition | Σ LA, orgs/day | Σ WLA, orgs/day | MOS, orgs/day | TMDL, orgs/day |
|---|---|---|---|---|
| **High flow** | 1.8E+11 | zero | 2.0E+10 | 2.0E+11 |
| **Moist condition** | 5.6E+10 | zero | 6.3E+09 | 6.3E+10 |
| **Mid-range flow** | 2.8E+10 | zero | 3.1E+09 | 3.1E+10 |
| **Dry conditions** | 1.9E+10 | zero | 2.1E+09 | 2.1E+10 |
| **Low flow** | 1.3E+10 | zero | 1.4E+09 | 1.4E+10 |

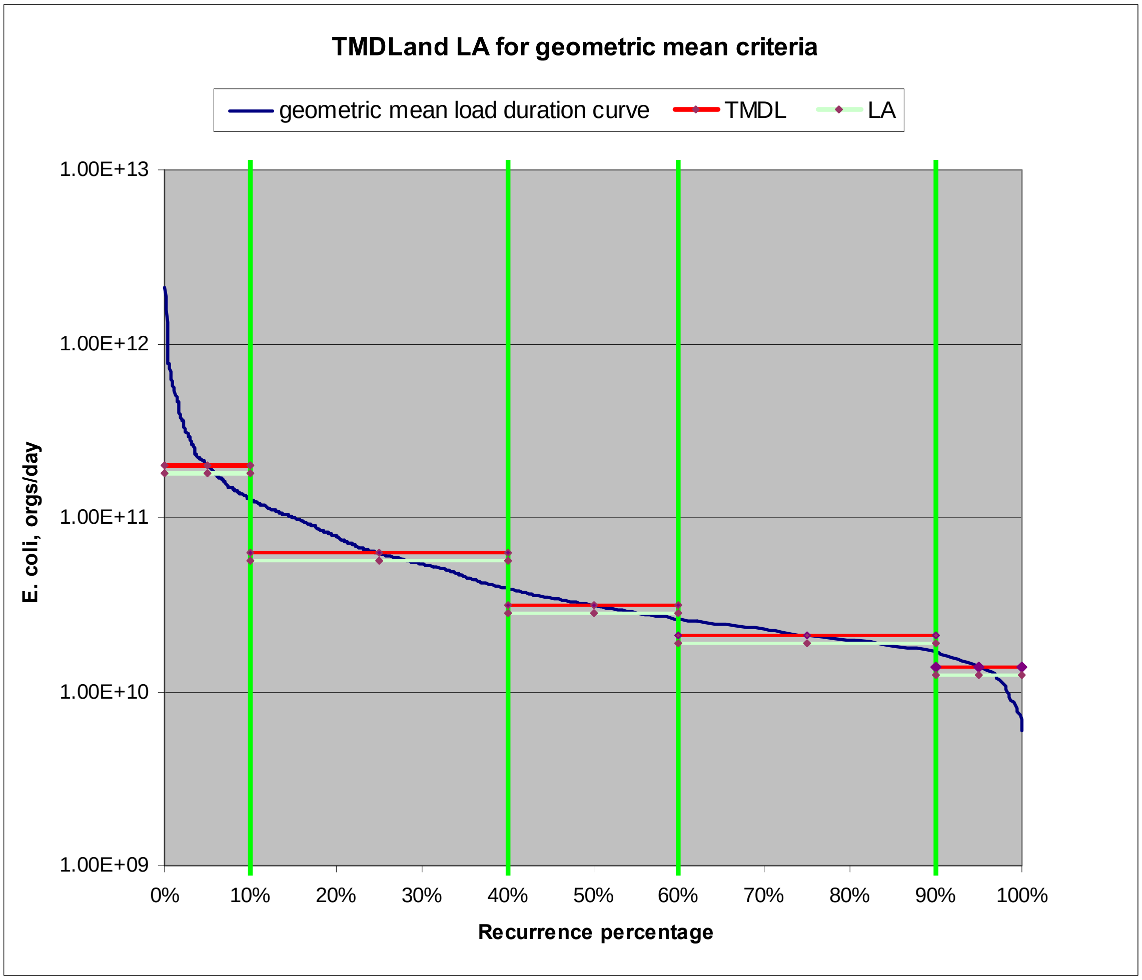

Figure 13-7 GM TMDL at WQS of 126 orgs/100 ml for the five flow conditions

**Table 13-15 Norfolk Creek IA 01-YEL-0130_0 *E. coli* TMDL for SSM**

| Flow condition | Σ LA, orgs/day | Σ WLA, orgs/day | MOS, orgs/day | TMDL, orgs/day |
|---|---|---|---|---|
| High flow | 3.3E+11 | zero | 3.7E+10 | 3.7E+11 |
| Moist condition | 1.1E+11 | zero | 1.2E+10 | 1.2E+11 |
| Mid-range flow | 5.3E+10 | zero | 5.8E+09 | 5.8E+10 |
| Dry conditions | 3.5E+10 | zero | 3.9E+09 | 3.9E+10 |
| Low flow | 2.3E+10 | zero | 2.6E+09 | 2.6E+10 |

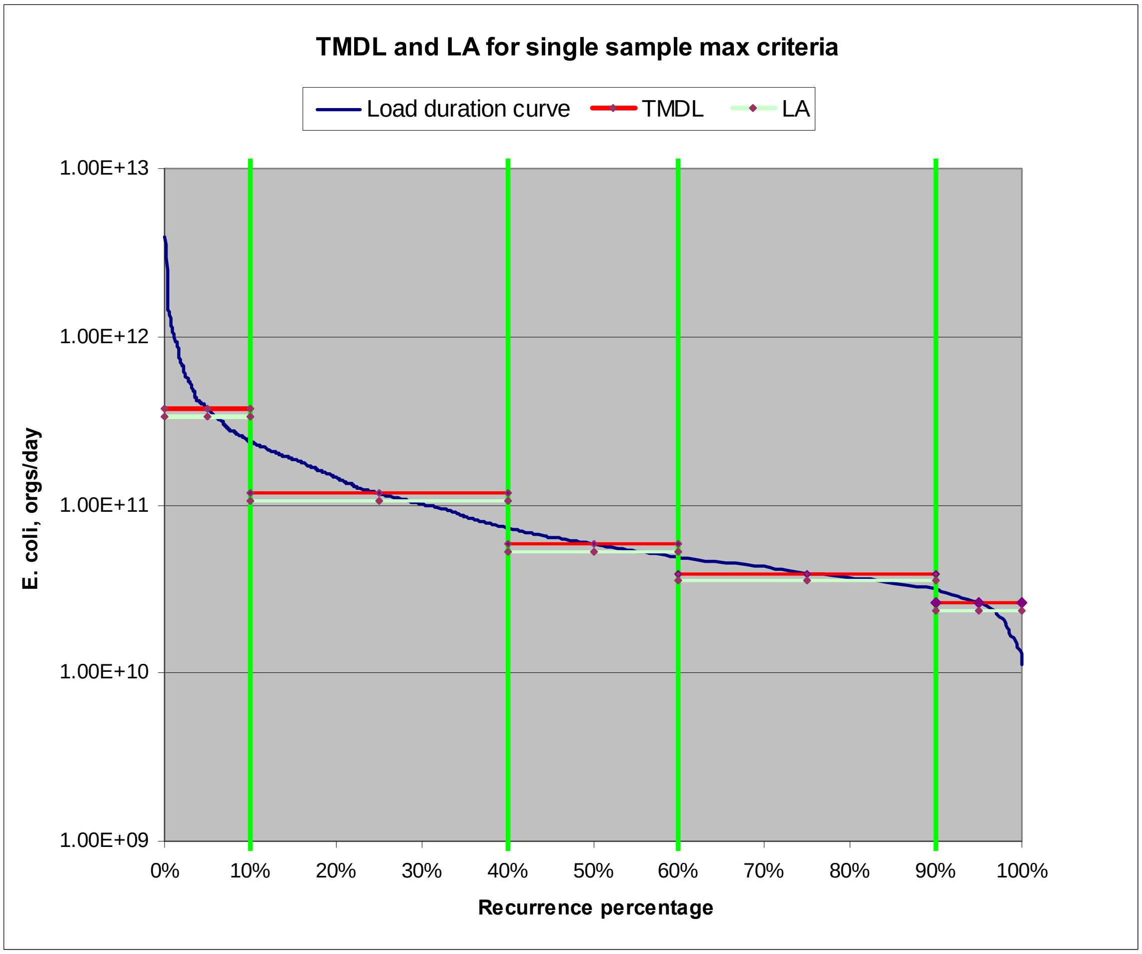

Figure 13-8 SSM TMDL at WQS of 235 orgs/100 ml for the five flow conditions

## 13.6. Implementation Analysis

The modeled systematic reduction of the loads by source provides the initial evaluation of proposed implementation plans for the subbasin. The SWAT model has been run for five scenarios in which loads have been reduced for the most significant sources. The source analysis identified the primary source of bacteria as cattle in the stream and field applied manure from CAFOs. Figure 13-9 shows the SWAT model output concentrations for the stream with monitored concentrations also plotted on the chart. The target concentration of 235 *E. coli* orgs/100 ml is frequently exceeded by both monitoring data and SWAT simulated values. The concentration scale has been cut off at six thousand orgs/100 ml so that the much more numerous monitoring and simulation values are apparent when compared to the SSM. There are two monitoring values that exceed this (38,000 and 190,000).

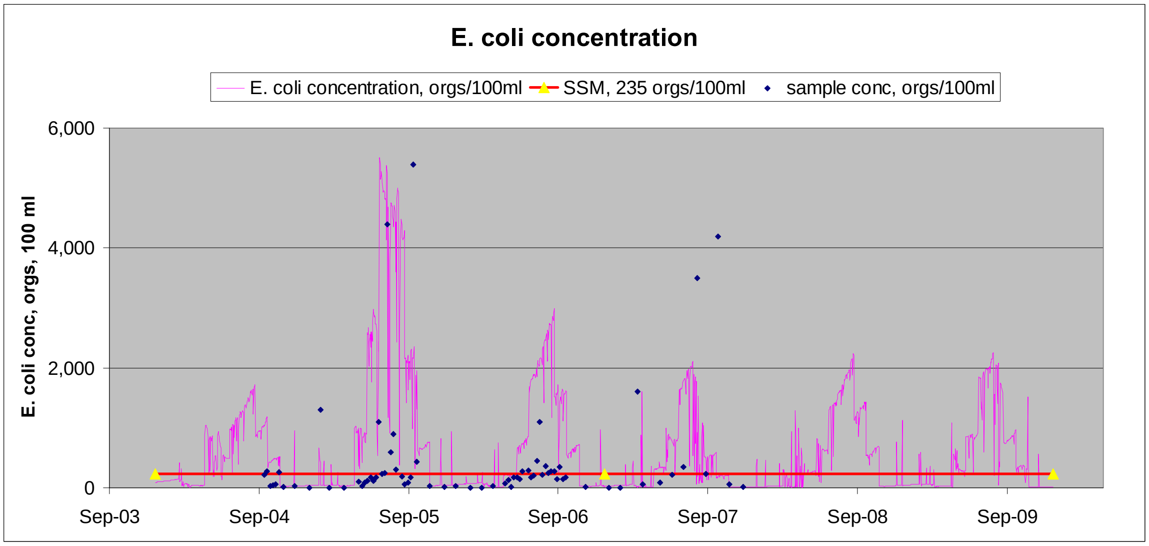

Figure 13-9 SWAT output for existing E. coli concentrations

The second scenario, Figure 13-10, removes half of the cattle in the stream from the subbasin. This generates lower concentrations that are still higher than the SSM standard during the grazing season. The runoff related concentration spikes in all five scenarios.

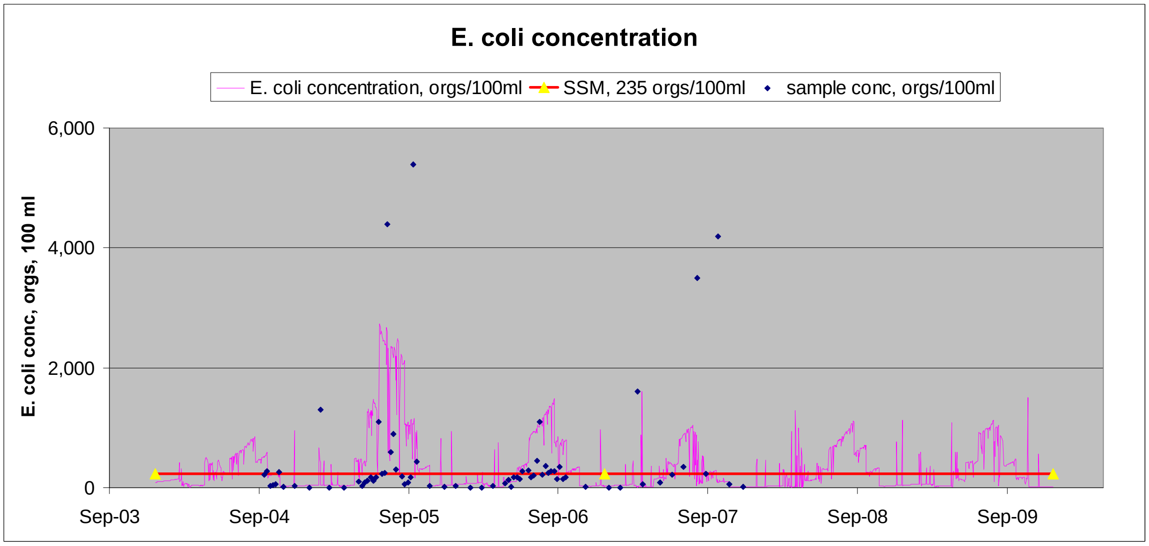

Figure 13-10 SWAT output for half reduction of CIS E. coli concentrations

The third scenario, shown in Figure 13-11, eliminates cattle in the stream altogether as a source. This drops the concentration during the grazing season but there remain many instances of high bacteria concentration from runoff. Much of this is associated with field application of manure from confined animal operations and the assumption that it is often done in the spring when it rains frequently and at high intensity.

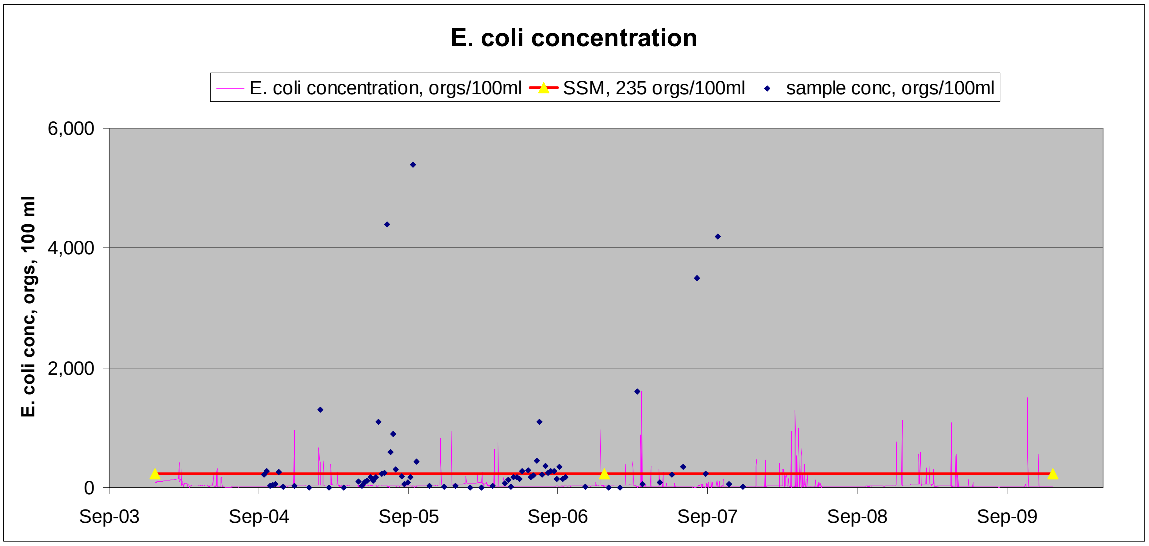

Figure 13-11 SWAT output for complete reduction of CIS E. coli

The fourth scenario, shown in Figure 13-12, assumes that the field applications of manure are cut in half. This brings bacteria concentrations down from these applications but they still exceed the target.

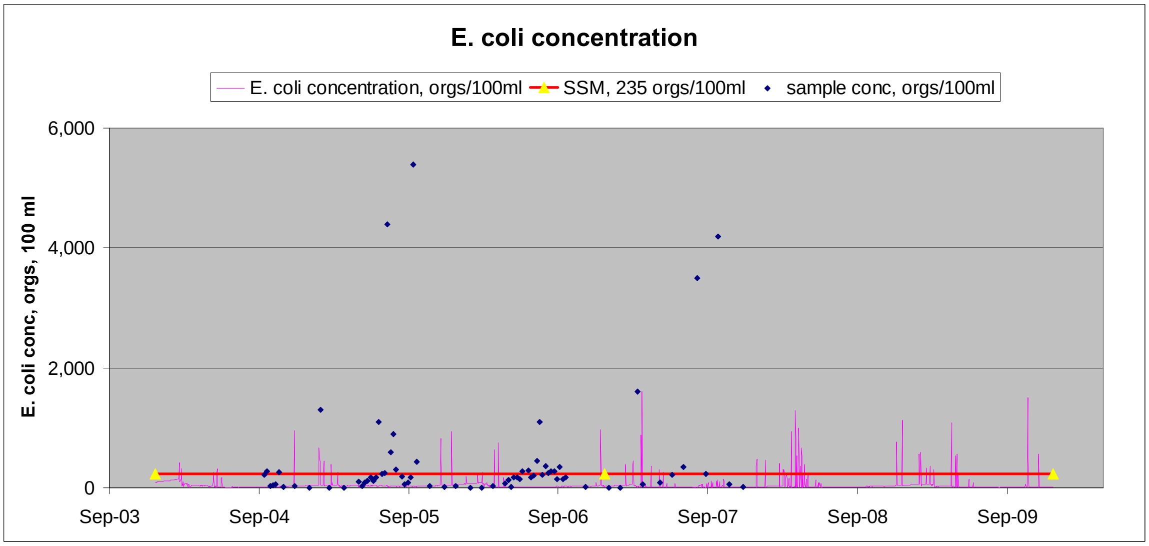

Figure 13-12 SWAT output for complete reduction of CIS E. coli and half of applied manure from CAFOs

The fifth scenario, shown in Figure 13-13, in addition to the previous reductions, reduces the manure from cattle on pasture by two thirds. This pasture manure reduction showed less than a one percent decrease in bacteria concentration in the stream.

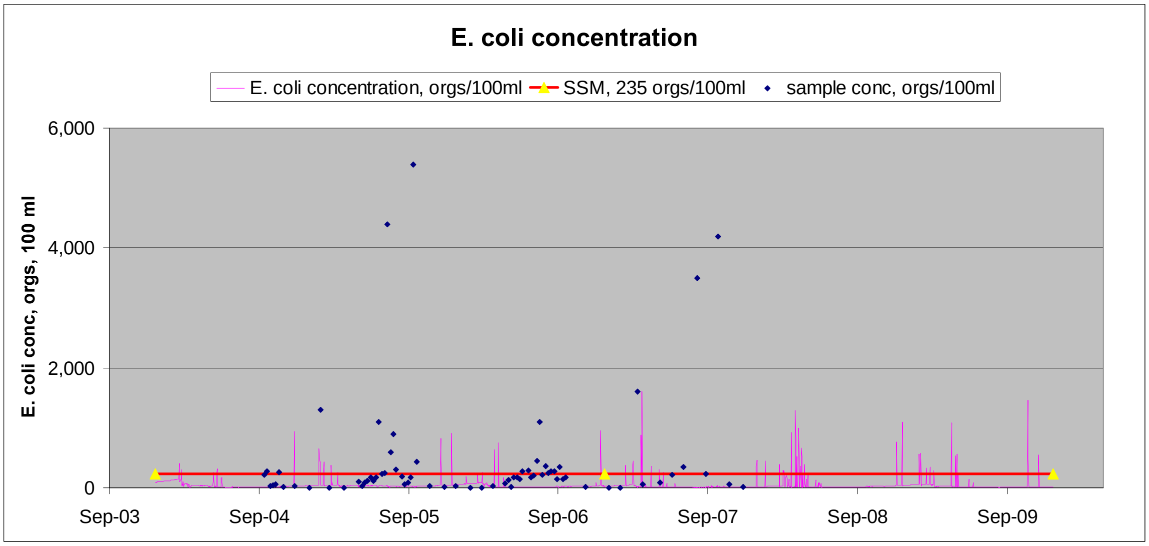

Figure 13-13 SWAT output for complete reduction of CIS E. coli and half of applied manure from CAFOs and a two thirds reduction of manure from cattle on pasture

There are several combinations of source reductions that can be simulated. The five scenarios described here reduce bacteria loads from the sources that have been modeled to have the greatest impact on stream outlet bacteria concentrations. It is worth noting that sources that are not reduced in these scenarios may have important episodic or local effect on *E. coli* organism numbers.

# 14. Ludlow Creek

Ludlow Creek (IA 01-YEL-0150_0) is the seventh impaired Yellow River tributary upstream from the Yellow River confluence with the Mississippi. The classified segment runs northwest 2.0 miles upstream from its confluence with the Yellow River (S2, T96N, R6W, Allamakee County). There are no permitted sources that discharge to this segment. The stream flow used in the development of the TMDL for this segment is derived from the area ratio flow based on the Ion USGS gage data. A SWAT watershed model developed for the Yellow River watershed labels Ludlow Creek Subbasin 1. Figure 14-1 shows a map of Ludlow Creek and Table 14-1 shows the land use in its subbasin.

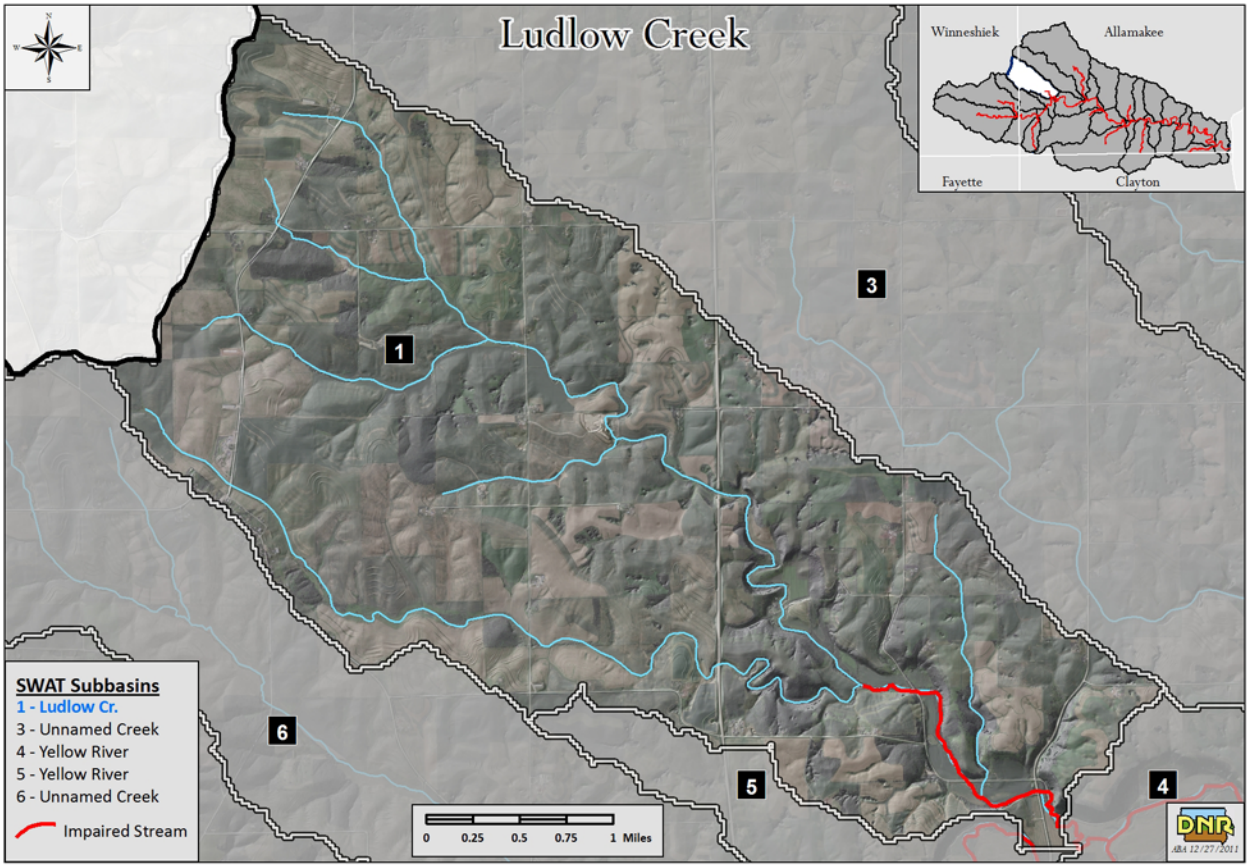

Figure 14-1 Ludlow Creek (0150_0)

**Table 14-1 Ludlow Creek subbasin land use**

| Landuse | Area, acres | Fraction of total |
|---|---|---|
| Water/wetland | 0.0 | 0.00% |
| Forest | 1143.8 | 15.46% |
| Ungrazed/CRP/hay | 1186.6 | 16.03% |
| Grazed | 114.4 | 1.55% |
| Row crop | 4654.9 | 62.90% |
| Roads | 229.3 | 3.10% |
| Commercial/residential | 71.4 | 0.97% |
| **Total** | **7400.4** | **100.00%** |

In the Ludlow Creek watershed almost a third of the area is forest and ungrazed grass and 63 percent is row crop.

## 14.1. Water body pollutant loading capacity (TMDL)

The *E. coli* organism load capacity is the number of organisms that can be in a volume and meet the water quality criteria. The loading capacity for each of the five flow conditions is calculated by multiplying the midpoint flow and *E. coli* criteria concentrations. Table 14-2 shows the median, maximum, and minimum flows for the five flow conditions.

### Table 14-2 Ludlow Creek maximum, minimum and median flows

| Flow description | Recurrence interval range (mid %) | Midpoint of flow range, cfs | Maximum of flow range, cfs | Minimum of flow range, cfs |
|---|---|---|---|---|
| **High flow** | **0 to 10% (5)** | 32.3 | 337.6 | 20.1 |
| **Moist conditions** | **10% to 40% (25)** | 10.0 | 20.1 | 6.3 |
| **Mid-range** | **40% to 60% (50)** | 5.0 | 6.3 | 4.2 |
| **Dry conditions** | **60% to 90% (75)** | 3.3 | 4.2 | 2.7 |
| **Low flow** | **90% to 100% (95)** | 2.2 | 2.7 | 1.0 |

Flow and load duration curves were used to establish the occurrence of water quality standards violations, to establish compliance targets, and to set pollutant allocations and margins of safety. Duration curves are derived from flows plotted as a percentage of their recurrence. *E. coli* loads are calculated from *E. coli* concentrations and flow volume at the time the sample was collected.

To construct the flow duration curves, the bacteria monitoring data and the Water Quality Standard (WQS) sample max (235 *E. coli* organisms/100 ml) were plotted with the flow duration percentile. Figure 14-2 shows the data that exceed the WQS criteria at each of the five flow conditions. High flow violations indicate that the problem occurs during run-off conditions when bacteria are washing off from nonpoint sources. Criteria exceeded during low or base flow, when little or no runoff is occurring, indicate that continuous sources such as septic tanks, livestock in the stream, riparian wildlife, and wastewater treatment plants are the problem.

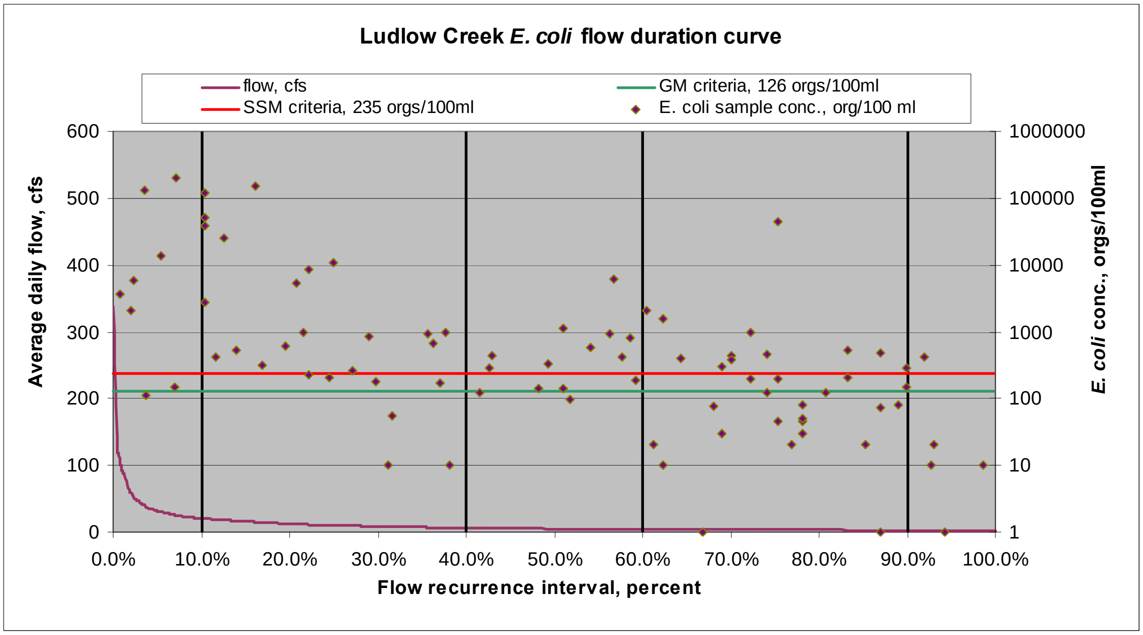

Figure 14-2 Ludlow Creek flow duration curve

Load duration curves were used to evaluate the five flow conditions for Ludlow Creek. The load duration curve is shown in Figure 14-3. In the figure, the lower curve shows the maximum *E. coli* count for the GM criteria and the upper curve shows the maximum *E. coli* count for the SSM criteria at a continuum of flow recurrence percentage. The individual points are the observed (monitored) *E. coli* concentrations converted to loads based on daily flow for the day they were collected. Points above the load duration curves are violations of the WQS criteria and exceed the loading capacity.

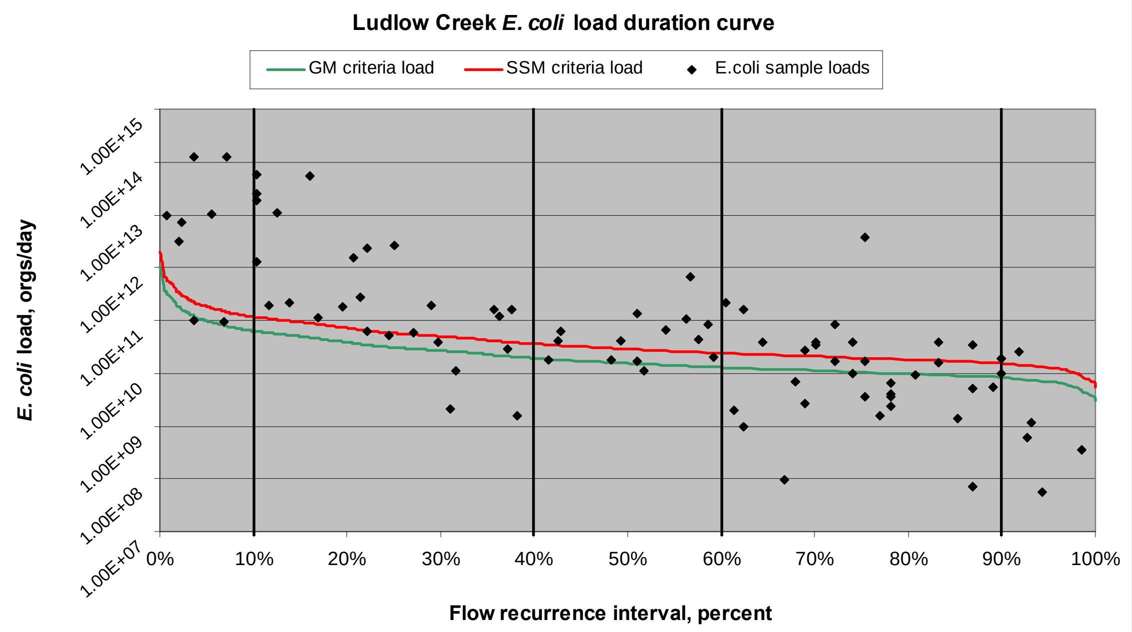

Figure 14-3 Ludlow Creek load duration curve

Tables 14-3 and 14-4 show the load capacities (targets) for each of the midpoint flow conditions at the GM and SSM criteria, respectively.

### Table 14-3 Ludlow Creek GM load capacity

| Flow condition | Recurrence interval | Associated midpoint flow, cfs | Estimated flow interval load capacity, *E. coli* orgs/day |
|---|---|---|---|
| High flow | 0 to 10% | 32.3 | 1.0E+11 |
| Moist conditions | 10% to 40% | 10.0 | 3.1E+10 |
| Mid-range | 40% to 60% | 5.0 | 1.6E+10 |
| Dry conditions | 60% to 90% | 3.3 | 1.0E+10 |
| Low flow | 90% to 100% | 2.2 | 6.9E+09 |

### Table 14-4 Ludlow Creek SSM load capacity

| Flow condition | Recurrence interval | Associated midpoint flow, cfs | Estimated flow interval load capacity, *E. coli* orgs/day |
|---|---|---|---|
| High flow | 0 to 10% | 32.3 | 1.9E+11 |
| Moist conditions | 10% to 40% | 10.0 | 5.8E+10 |
| Mid-range | 40% to 60% | 5.0 | 2.9E+10 |
| Dry conditions | 60% to 90% | 3.3 | 1.9E+10 |
| Low flow | 90% to 100% | 2.2 | 1.3E+10 |

## 14.2. Existing load

The existing loads are derived from the sampling data collected at the Ludlow Creek Site. These data are the sample values shown in the flow and load duration curves. The *E. coli* concentrations are multiplied by the simulated daily flow to get the daily loads. The daily loads are plotted with the load duration curves. The allowable loads for a given flow equal the flow multiplied by the WQS limits for the geometric mean or single sample maximum. Monitored data that exceed the limits are above the criteria curves.

The maximum existing loads occur during major rains when runoff and bacteria concentrations are highest. Concentrations exceed the criteria during these high flow events. Other conditions leading to criteria violations occur during dry low flow periods when continuous loads from livestock in the stream, local wildlife, septic tanks, and wastewater treatment plants can cause bacteria problems.

The assessment standard used to evaluate streams is the *E. coli* geometric mean criteria. Since the load duration approach precludes the calculation of a geometric mean, the 90th percentile of observed concentrations within each flow condition is multiplied by the median flow to estimate existing loads. This procedure has been used to evaluate impaired segments. Table 14-5 shows the existing loads for each flow condition.

### Table 14-5 Ludlow Creek existing loads

| Flow condition, percent recurrence | Recurrence interval range (mid %) | Associated median flow, cfs | Existing 90th percentile *E. coli* conc., org/100ml | Estimated existing load, *E. coli* org/day |
|---|---|---|---|---|
| **High flows** | **0 to 10% (5)** | 32.3 | 151000 | 1.19E+14 |
| **Moist conditions** | **10% to 40% (25)** | 10.0 | 44500 | 1.09E+13 |
| **Mid-range** | **40% to 60% (50)** | 5.0 | 1055 | 1.30E+11 |
| **Dry conditions** | **60% to 90% (75)** | 3.3 | 906 | 7.40E+10 |
| **Low flow** | **90% to 100% (95)** | 2.2 | 254 | 1.38E+10 |

*Identification of pollutant sources.*
The sources of bacteria in the Ludlow Creek subbasin (SWAT Subbasin 1) are all nonpoint sources including failed septic tank systems, pastured cattle, cattle in the stream, wildlife, and manure applied to fields from animal confinement operations. The loads from these sources are incorporated into the SWAT watershed model and are listed in Tables 14-6 to 14-10.

Non functional septic tank systems. There are an estimated 72 onsite septic tank systems in the subbasin (2.5 persons/household). IDNR estimates that 50 percent are not functioning properly. It is assumed that these are continuous year round discharges. Septic tank loads have been put into the SWAT model as a continuous source by subbasin.

### Table 14-6 Ludlow Creek septic tank system E. coli orgs/day

| | |
|---|---|
| Rural population of Ludlow Creek subbasin | 179 |
| Total initial E.coli, orgs/day [1] | 2.24E+11 |
| Septic tank flow, $m^3$/day [2] | 47.4 |
| **E. coli delivered to stream, orgs/day [3]** | **1.48E+08** |

1. Assumes 1.25E+09 E. coli orgs/day per capita
2. Assumes 70 gallons/day/capita
3. Assumes septic discharge concentration reaching stream is 625 orgs/100 ml and a 50% failure rate

Cattle in stream. Of the 44 cattle in pastures with stream access, one to six percent of those are assumed to be in the stream on a given day. The number on pasture and the fraction in the stream varies by month. Cattle in the stream have a high delivery potential since bacteria deposit directly in the stream with or without rainfall. Subbasin cattle in the stream bacteria have been put in the SWAT model as a continuous source varying by month.

### Table 14-7 Ludlow Creek cattle in the stream, E. coli orgs/day

| | |
|---|---|
| Pasture area with stream access, acre[1] | 57 |
| Number of cattle in stream (6% of total)[2] | 3 |
| Dry manure, lb [3] | 8 |
| **E. coli load, orgs/day [4]** | **1.08E+11** |

1. The subbasin CIS are estimated from the pasture area with access to streams at 0.78 cattle/acre.

2. It is estimated that cattle spend 6% of their time in streams in July and August, 3% in June and September, and 1% in May and October. The loads shown in this table are for July and August. The loads for the other 4 months when cattle are in streams have been incorporated into the SWAT modeling.
3. Cattle generate 3.1 kg/head/day of dry manure.
4. Manure has 1.32E+07 *E. coli* orgs/gram dry manure.

Grazing livestock. The number of cattle in the subbasin is estimated to be 83 and it is assumed that the cattle are on pasture from April to November. The potential for the delivery of bacteria to the stream occurs with precipitation causing runoff. Manure available for washoff is put in the SWAT model at 6 kg/ha in the pasture HRU's.

### Table 14-8 Ludlow Creek manure from pastured cattle, maximum E. coli available for washoff, orgs/day

| | |
|---|---:|
| Pasture area, acres | 110 |
| Total number of cattle[1] | 83 |
| Dry manure, kg[2] | 258 |
| Maximum E. coli load, orgs/day[3] | 3.40E+12 |
| **Maximum E. coli available for washoff, orgs[4]** | **6.13E+12** |

1. The number of pastured cattle is 0.78 cattle/acre.
2. Cattle generate 3.1 kg/head/day of dry manure.
3. Manure has 1.32E+07 *E. coli* orgs/gram dry manure
4. The load available for washoff is the daily load times 1.8.

Wildlife manure. The number of deer in Allamakee County is about 9,000 located primarily in forested land adjacent to streams. Another 1,000 have been added to account for other wildlife such as raccoons and waterfowl for a total estimate of 10,000. This works out to 0.024 deer per acre. Using this procedure, there are 178 deer in the subbasin concentrated in the forested areas. The deer are in the subbasin year round.

### Table 14-9 Ludlow Creek watershed wildlife manure loads available for washoff

| Number of deer[1] | Forested area, ha | SWAT manure loading rate, kg/ha/day[2] | E. coli available for washoff, orgs[3] |
|:---:|:---:|:---:|:---:|
| 178 | 509 | 0.503 | 1.60E+11 |

1. Deer numbers are 0.024 deer/ha for the entire subbasin concentrated to 0.349 deer/ha in the forest land use. All wildlife loads are applied to the forest landuse in the SWAT model. The county deer numbers have been increased by 10% to account for other wildlife in the subbasin.
2. Assumes 1.44 kg/deer/day and 3.47E+05 orgs/gram.
3. Assumes that the maximum E. coli available for washoff is 1.8 times the daily load.

Field applications of CAFO manure.
There are about 6,000 hogs in confinement in the subbasin. The manure is stored and land applied to cropland. The manure is distributed to the fields in the subbasin in the fall after soybean harvest and in the spring prior to corn planting in year 2 of a two year rotation. The relatively brief fall and spring timing of manure application and incorporation in the soil significantly reduces the E. coli organisms from these sources.

Manure application has been put in the SWAT model by subbasin as a load available at the end of October and the beginning of April.

### Table 14-10 Ludlow Creek watershed confined livestock manure applications

| Livestock type | Swine | Chickens | Dairy cows |
|---|---|---|---|
| Number of animals | 6,000 | 0 | 0 |
| Manure applied, kg/application[1] | 2,474,700 | 0 | 0 |
| Application area, acres[2] | 290.3 | 0 | 0 |
| Manure applied, kg/ha/day[3] | 2127 | 0 | 0 |
| Subbasin E. coli, orgs/day | 6.61E+14 | 0 | 0 |
| Subbasin E. coli available for washoff, orgs/day[4] | 1.19E+15 | 0 | 0 |

1. Manure is calculated based on number of animals * dry manure (kg/animal/day)*365 days/year.
2. The area the manure is applied to is based on the manure's nitrogen content. Manure is applied at a rate equivalent to 201.6 kg N/ha/yr. Swine manure is applied at 2127 kg/ha, dairy manure at 2631 kg/ha and chicken manure at 2326 kg/ha. The E. coli content of manure for swine is 1.32E+07 orgs/gram, for dairy cows is 1.00E+07 orgs/gram, and for chickens is 2.96E+06 orgs/gram.
3. Manure is assumed to be applied to fields twice a year over 5 days on October 30 and April 1. It is incorporated in the soil and it is assumed that only 10% of bacteria are viable and available after storage and incorporation.
4. Maximum *E. coli* available for washoff are 1.8 times the daily maximum available load.

<u>Seasonal variation of sources</u>.

The relative impacts of the bacteria sources are shown in Figures 14-4 and 14-5. Figure 14-4 shows the relative loads delivered by the "continuous" sources, those sources present with or without rainfall and runoff. These are the failed septics that are assumed to be a problem every day of the year and the loads from cattle in the stream that vary by month from May to October. It can be seen in this figure that the impacts from cattle in the stream are much more significant than those from failed septic tank systems.

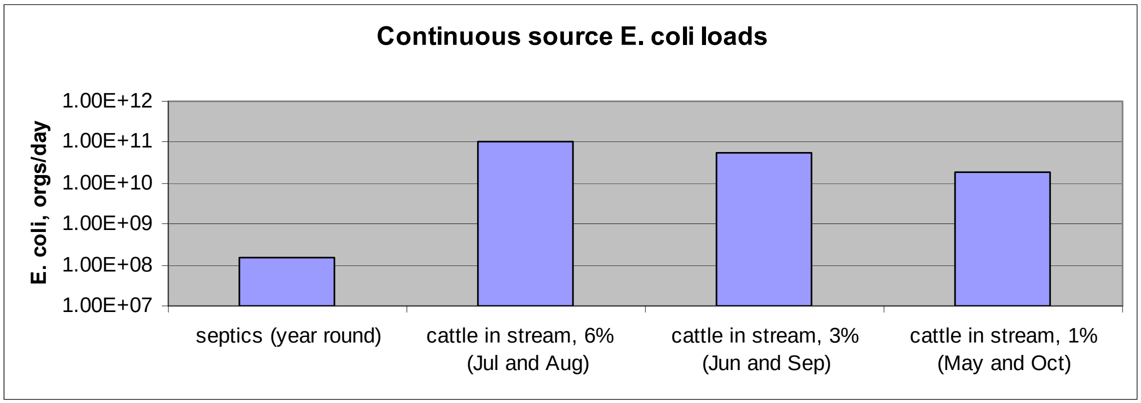

Figure 14-4 E. coli loads from "continuous" sources

The three general washoff sources of bacteria in the subbasin are shown in Figure 14-5. The wildlife source consists primarily of deer and smaller animals such as raccoons and waterfowl. These are year round sources. Pastured cattle consist of grazing cattle and

small poorly managed feedlot-like operations. The grazing season is modeled as lasting 168 days starting May 1. Manure from confined animal feeding operations (CAFO) is applied to cropland twice a year for a relatively brief time. Most field applied manure is assumed to be incorporated into the soil and most bacteria in it are not available. Confinement animals are swine, chickens and dairy cattle.

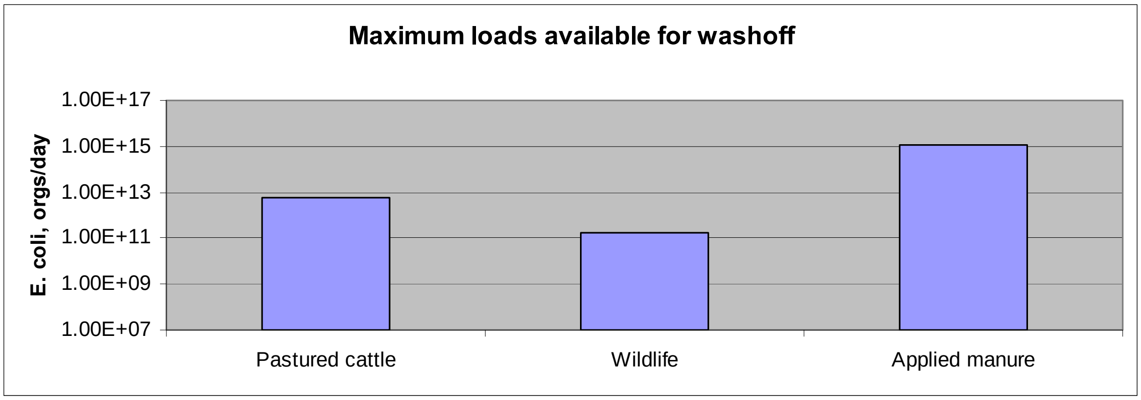

Figure 14-5 Maximum E. coli loads available for washoff

The maximum bacteria load to the stream occurs when the continuous source load plus the precipitation driven washoff load are combined. In general, the more rainfall the higher the flow and the more elevated the concentration. High flow and elevated concentration equal peak loads. The potential maximum load based on this analysis is 6.29E+12 orgs/day available for washoff plus the continuous load of 1.11E+11 orgs/day in July and August for a total of 6.40E+12 orgs/day.

Flow interval load source analysis. Based on the load duration curve analysis the maximum existing load occurring during the zero to forty percent recurrence interval runoff conditions, is 3.06E+13 orgs/day and the total available load based on the potential sources, including fall and spring manure applications, is 1.20E+15 orgs/day. Generally the maximum load in the stream, delivered in April when runoff is occurring, is approximately three percent of the bacteria available for washoff. At the zero to ten percent maximum existing load of 1.19E+14 orgs/day and the same load available for washoff the stream load is ten percent of the available load.

## 14.3. Departure from load capacity

The departure from load capacity is the difference between the existing load and the load capacity. This varies for each of the five flow conditions. Table 14-11 shows this difference. The existing and target loads for the five flow conditions are shown graphically in Figure 14-6.

**Table 14-11 Ludlow Creek departure from load capacity**

| Design flow condition, percent recurrence | Recurrence interval range (mid %) | Existing *E. coli* orgs/day | Load capacity, orgs/day | Departure from capacity, orgs/day |
|---|---|---|---|---|
| **High flow** | **0 to 10% (5)** | 1.19E+14 | 1.9E+11 | 1.19E+14 |
| **Moist conditions** | **10% to 40% (25)** | 1.09E+13 | 5.8E+10 | 1.08E+13 |
| **Mid-range flow** | **40% to 60% (50)** | 1.30E+11 | 2.9E+10 | 1.01E+11 |
| **Dry conditions** | **60% to 90% (75)** | 7.40E+10 | 1.9E+10 | 5.48E+10 |
| **Low flow** | **90% to 100% (95)** | 1.38E+10 | 1.3E+10 | 1.03E+09 |

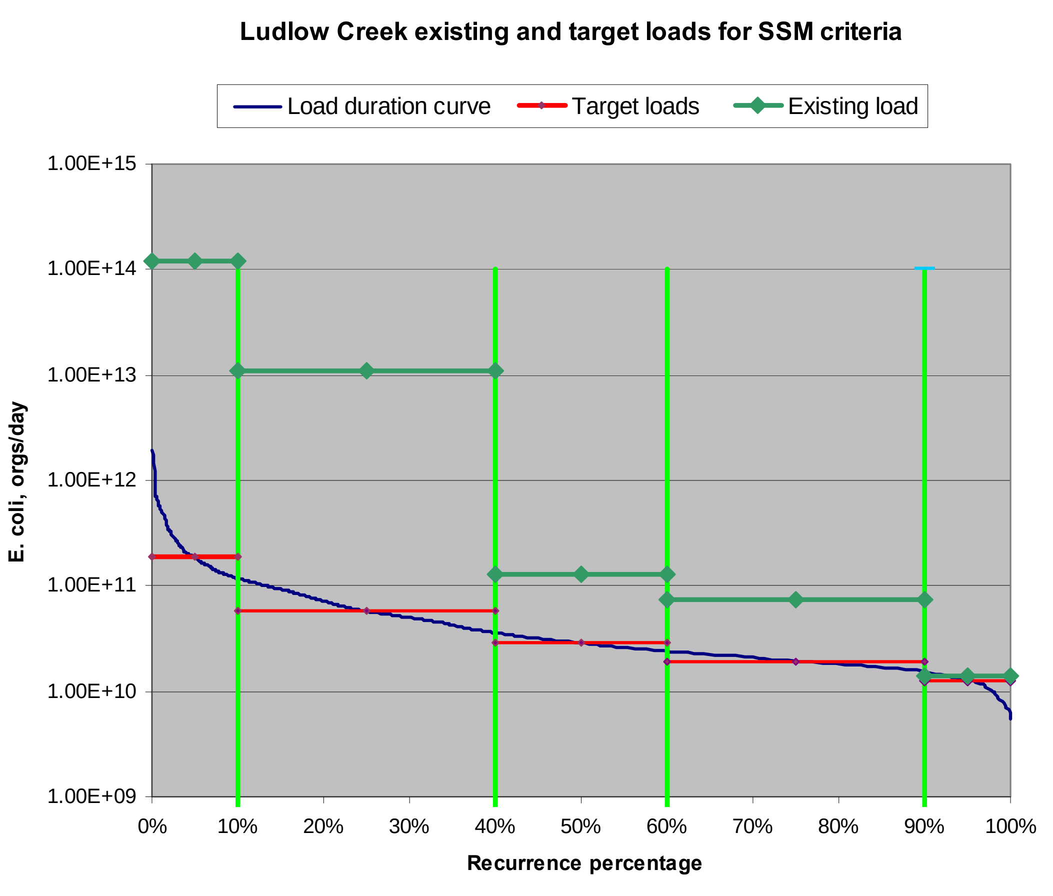

Figure 14-6 Difference between existing and target loads

## 14.4. Pollutant Allocations

*Wasteload allocations.*
Since there are no permitted discharges to Ludlow Creek there are no wasteload allocations.

*Load allocation.*
The load allocations for *E. coli* TMDLs are the load capacity less an explicit 10 percent margin of safety (MOS) less the total WLA for the flow condition for the geometric mean

or single sample maximum. There is a separate load allocation set for each of the target recurrence intervals. The load allocations are shown in Tables 14-12 and 14-13.

**Table 14-12 Ludlow Creek GM *E. coli* load allocations**

| Flow condition, percent recurrence | GM target (TMDL) *E. Coli*, orgs/day | GM MOS *E. Coli*, orgs/day | Total WLA GM *E. coli*, orgs/day | LA GM *E. coli*, orgs/day |
|---|---|---|---|---|
| **High flows** | 1.0E+11 | 1.0E+10 | zero | 9.0E+10 |
| **Moist conditions** | 3.1E+10 | 3.1E+09 | zero | 2.8E+10 |
| **Mid-range flow** | 1.6E+10 | 1.6E+09 | zero | 1.4E+10 |
| **Dry conditions** | 1.0E+10 | 1.0E+09 | zero | 9.3E+09 |
| **Low flow** | 6.9E+09 | 6.9E+08 | zero | 6.2E+09 |

1. Based on geometric mean standard of 126 *E. coli* organisms/100 ml

**Table 14-13 Ludlow Creek SSM *E. coli* load allocations**

| Flow condition, percent recurrence | SSM target (TMDL) *E. Coli*, orgs/day | SSM MOS *E. Coli*, orgs/day | Total WLA SSM *E. coli*, orgs/day | LA SSM *E. coli*, orgs/day |
|---|---|---|---|---|
| **High flow** | 1.9E+11 | 1.9E+10 | zero | 1.7E+11 |
| **Moist conditions** | 5.8E+10 | 5.8E+09 | zero | 5.2E+10 |
| **Mid-range flow** | 2.9E+10 | 2.9E+09 | zero | 2.6E+10 |
| **Dry conditions** | 1.9E+10 | 1.9E+09 | zero | 1.7E+10 |
| **Low flow** | 1.3E+10 | 1.3E+09 | zero | 1.2E+10 |

1. Based on single sample maximum standard of 235 *E. coli* organisms/100 ml

*Margin of safety.*
The margin of safety for *E. coli* is an explicit 10 percent of the load capacity at each of the design recurrence intervals as shown in Tables 14-12 and 14-13.

## 14.5. TMDL Summary

The following equation shows the total maximum daily load (TMDL) and its components for the impaired IA 01-YEL-0150_0 segment of Ludlow Creek.

**Total Maximum Daily Load = Σ Load Allocations + Σ Wasteload Allocations +MOS**

A Total Maximum Daily Load calculation has been made at design flow conditions for the GM and SSM of this segment and these are shown in Tables 14-14 and 14-15 and Figures 14-7 and 14-8.

**Table 14-14 Ludlow Creek IA 01-YEL-0150_0 *E. coli* TMDL for GM**

| Flow condition | Σ LA, orgs/day | Σ WLA, orgs/day | MOS, orgs/day | TMDL, orgs/day |
|---|---|---|---|---|
| **High flow** | 9.0E+10 | zero | 1.0E+10 | 1.0E+11 |
| **Moist condition** | 2.8E+10 | zero | 3.1E+09 | 3.1E+10 |
| **Mid-range flow** | 1.4E+10 | zero | 1.6E+09 | 1.6E+10 |
| **Dry conditions** | 9.3E+09 | zero | 1.0E+09 | 1.0E+10 |
| **Low flow** | 6.2E+09 | zero | 6.9E+08 | 6.9E+09 |

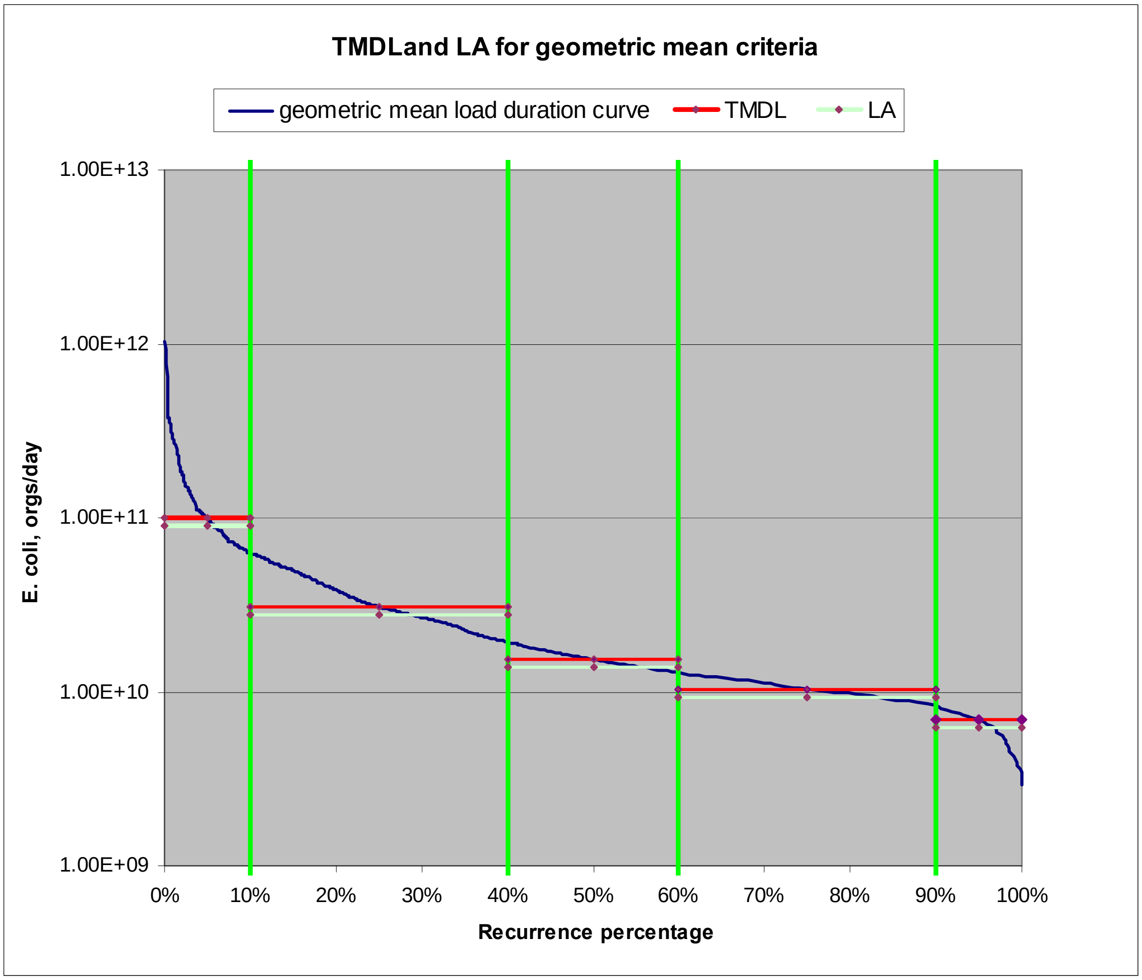

Figure 14-7 GM TMDL at WQS of 126 orgs/100 ml for the five flow conditions

**Table 14-15 Ludlow Creek IA 01-YEL-0150_0 *E. coli* TMDL for SSM**

| Flow condition | Σ LA, orgs/day | Σ WLA, orgs/day | MOS, orgs/day | TMDL, orgs/day |
|---|---|---|---|---|
| High flow | 1.7E+11 | zero | 1.9E+10 | 1.9E+11 |
| Moist condition | 5.2E+10 | zero | 5.8E+09 | 5.8E+10 |
| Mid-range flow | 2.6E+10 | zero | 2.9E+09 | 2.9E+10 |
| Dry conditions | 1.7E+10 | zero | 1.9E+09 | 1.9E+10 |
| Low flow | 1.2E+10 | zero | 1.3E+09 | 1.3E+10 |

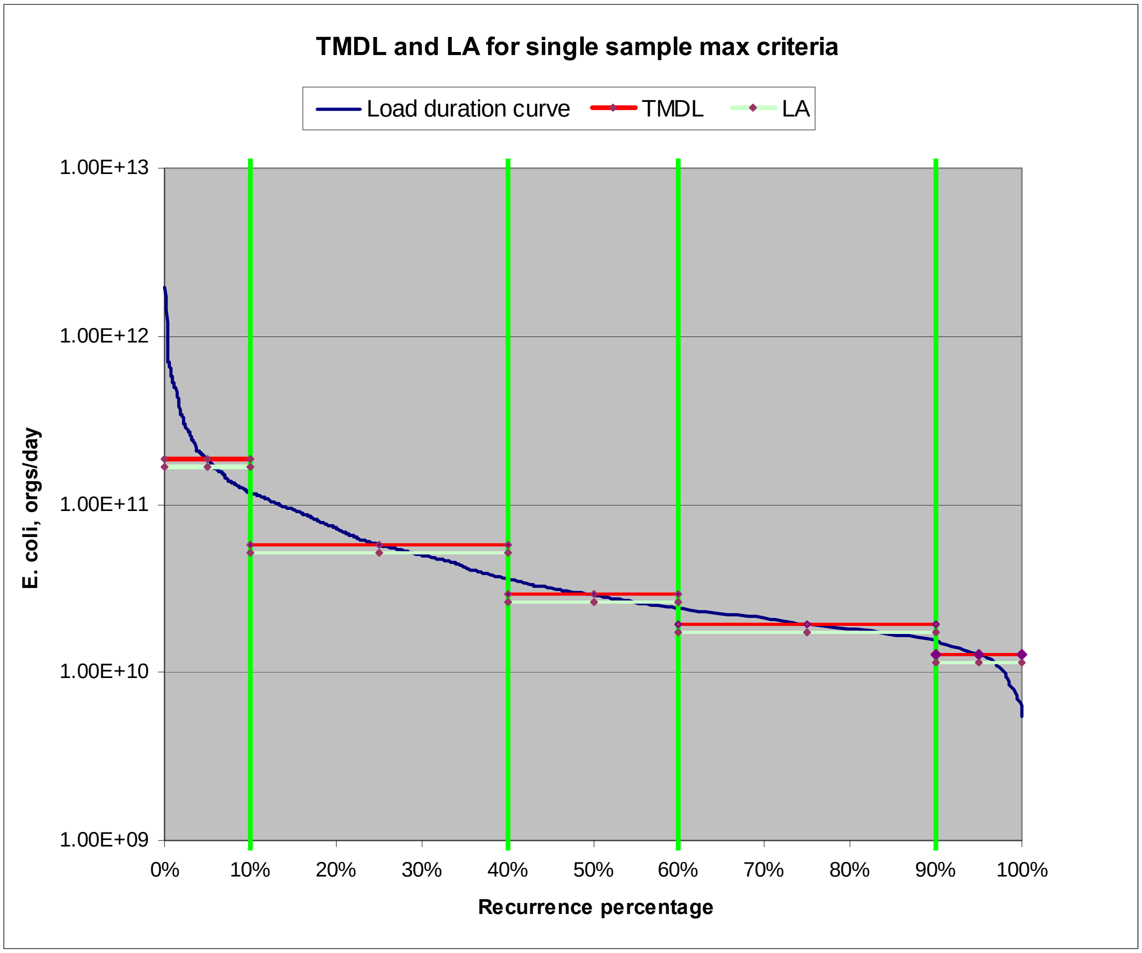

Figure 14-8 SSM TMDL at WQS of 235 orgs/100 ml for the five flow conditions

## 14.6. Implementation Analysis

The modeled systematic reduction of the loads by source provides the initial evaluation of proposed implementation plans for the subbasin. The SWAT model has been run for five scenarios in which loads have been reduced for the most significant sources. The source analysis identified the primary source of bacteria as cattle in the stream and field applied manure from CAFOs. Figure 14-9 shows the SWAT model output concentrations for the stream with monitored concentrations also plotted on the chart. The target concentration of 235 *E. coli* orgs/100 ml is frequently exceeded by both monitoring data and SWAT simulated values. The concentration scale has been cut off at ten thousand so that the much more numerous monitoring and simulation values are apparent when compared to the SSM.

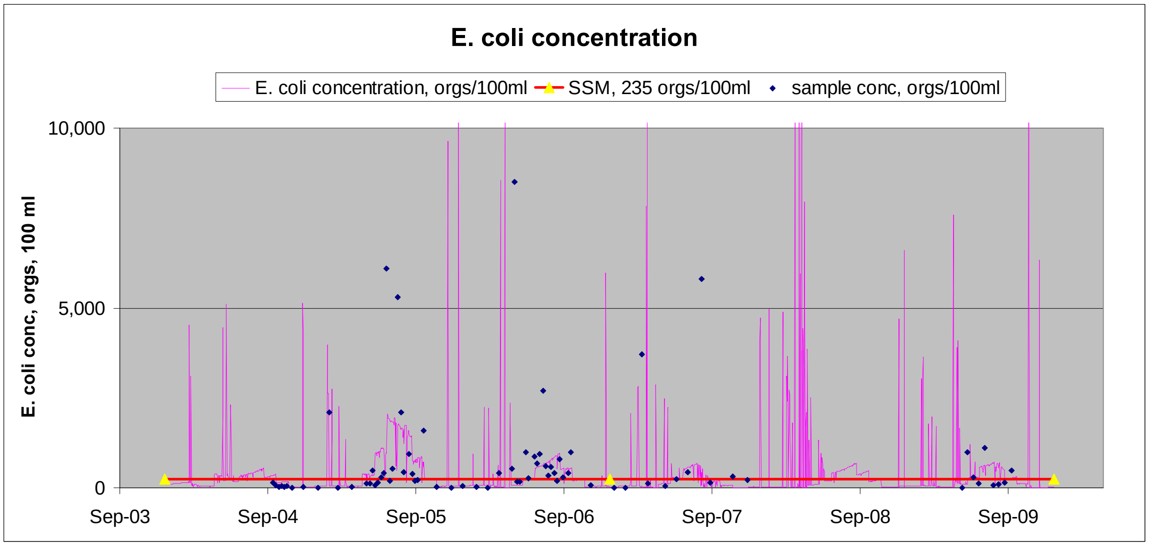

Figure 14-9 SWAT output for existing E. coli concentrations

The second scenario, Figure 14-10, removes half of the cattle in the stream from the subbasin. This generates concentrations that are lower but that are still higher than the SSM standard during the grazing season. The runoff related concentration spikes in all five scenarios.

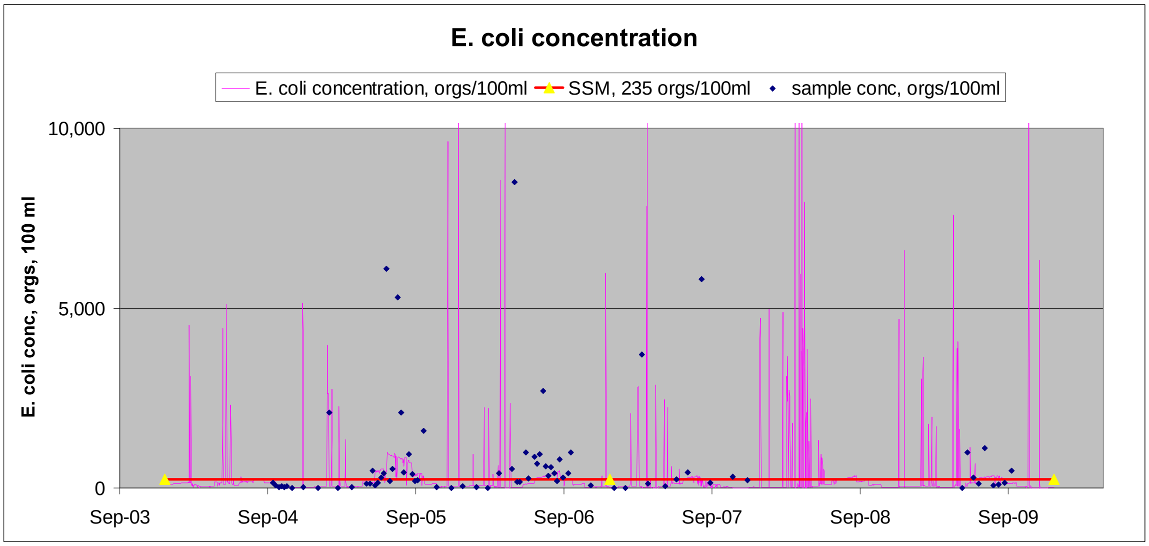

Figure 14-10 SWAT output for half reduction of CIS E. coli concentrations

The third scenario, shown in Figure 14-11, eliminates cattle in the stream altogether as a source. This drops the concentration during the grazing season but there remain instances of high bacteria concentration from runoff. Much of this is associated with field application of manure from confined animal operations and the assumption that it is often done in the spring when it rains frequently and intensely.

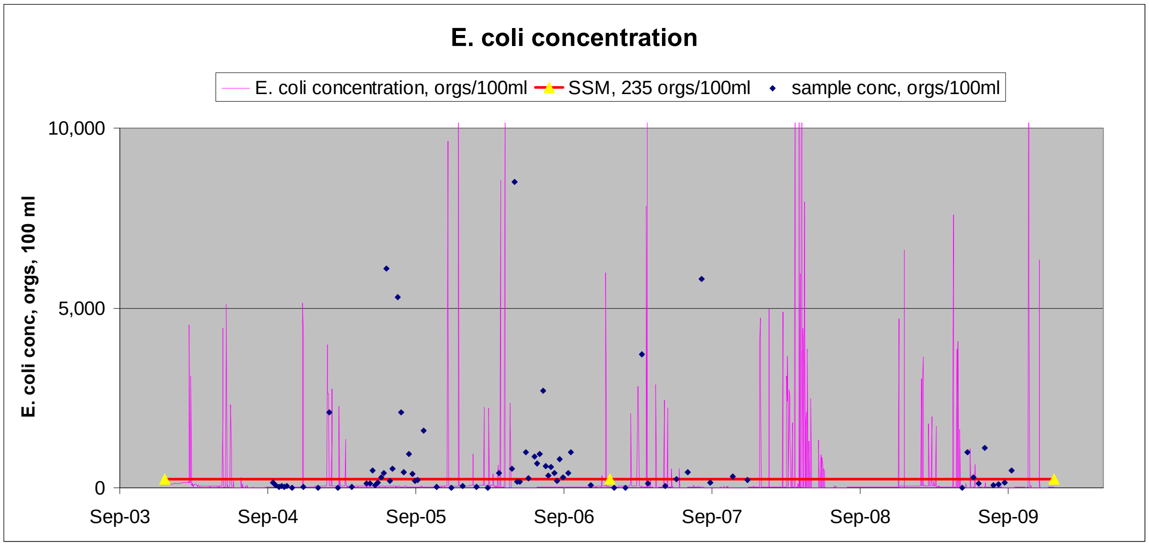

Figure 14-11 SWAT output for complete reduction of CIS E. coli

The fourth scenario, shown in Figure 14-12, assumes that the field applications of manure are cut in half. This lowers bacteria concentrations but they still exceed the target.

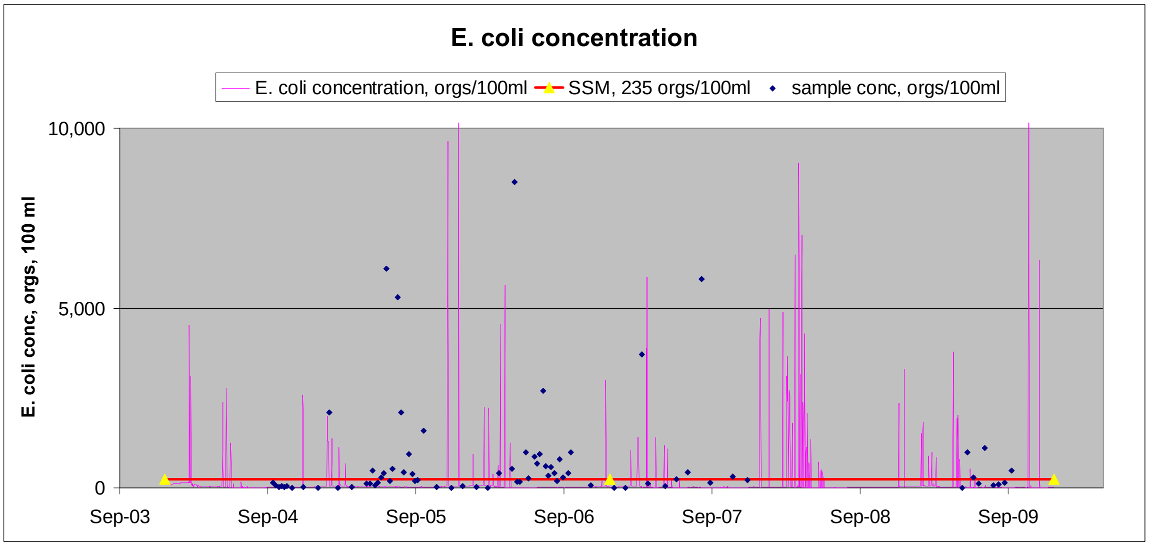

Figure 14-12 SWAT output for complete reduction of CIS E. coli and half of applied manure from CAFOs

The fifth scenario, shown in Figure 14-13, in addition to the previous reductions, reduces the manure from cattle on pasture by two thirds. This manure reduction results in a minor decrease in stream bacteria concentrations.

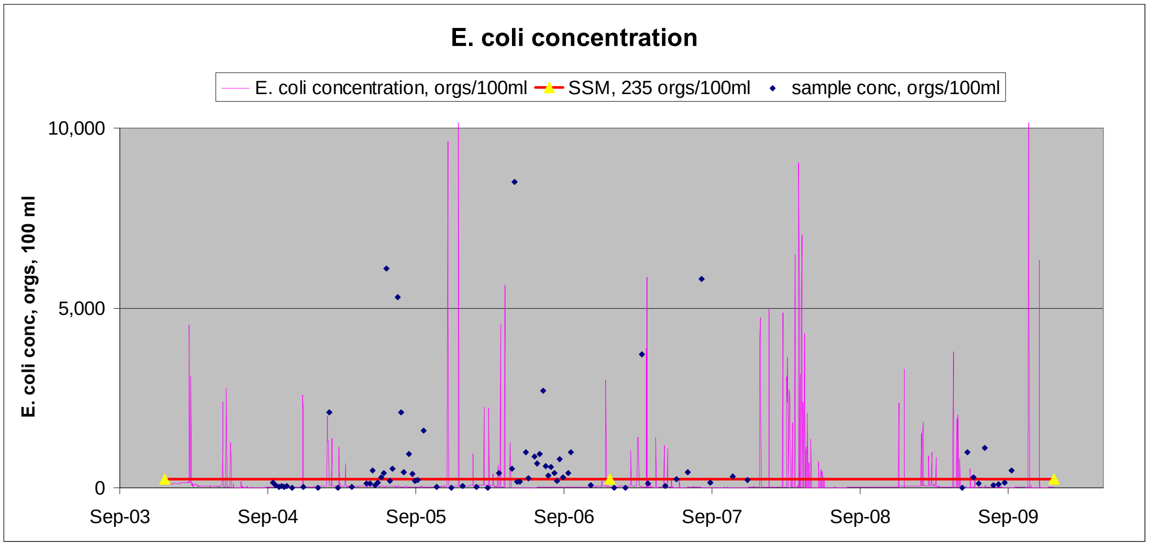

Figure 14-13 SWAT output for complete reduction of CIS E. coli and half of applied manure from CAFOs and a two thirds reduction of manure from cattle on pasture

There are several combinations of source reductions that can be simulated. The five scenarios described here reduce bacteria loads from the sources that have been modeled to have the greatest impact on stream outlet bacteria concentrations. It is worth noting that sources that are not reduced in these scenarios may have important episodic or local effect on *E. coli* organism numbers.

## 15. Hecker Creek

Hecker Creek (IA 01-YEL-0155_0) is the eighth impaired Yellow River tributary upstream from the Yellow River confluence with the Mississippi. The classified segment runs south 4.1 miles upstream from its confluence with the Yellow River (S17, T96N, R6W, Allamakee County). There is one industrial wastewater treatment facility that discharges to Hecker Creek for the AgriStarr Company. The stream flow used in the development of the TMDL for this segment is derived from the area ratio flow based on the Ion USGS gage data. A SWAT watershed model developed for the Yellow River watershed labels Hecker Creek Subbasin 18. Figure 15-1 shows a map of Hecker Creek and Table 15-1 shows the land use in its subbasin.

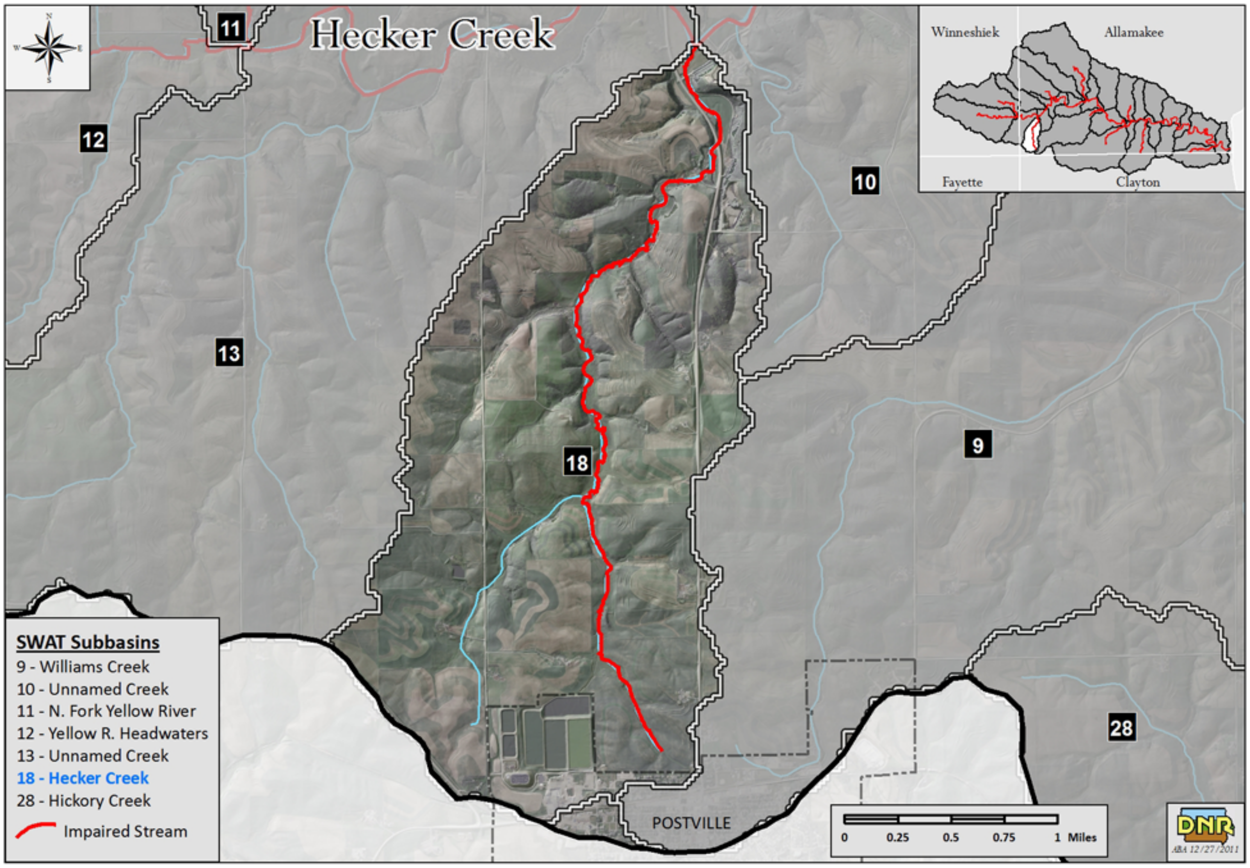

Figure 15-1 Hecker Creek (0155_0)

### Table 15-1 Hecker Creek subbasin land use

| Landuse | Area, acres | Fraction of total |
|---|---|---|
| Water/wetland | 0.0 | 0.00% |
| Forest | 189.7 | 6.39% |
| Ungrazed/CRP/hay | 653.1 | 21.99% |
| Grazed | 456.4 | 15.37% |
| Row crop | 1350.5 | 45.48% |
| Roads | 65.3 | 2.20% |
| Commercial/residential | 254.5 | 8.57% |
| **Total** | **2969.5** | **100.00%** |

In the Hecker Creek watershed 28 percent of the area is forest and ungrazed grass and 45% is row crop.

### 15.1. Water body pollutant loading capacity (TMDL)

The *E. coli* organism load capacity is the number of organisms that can be in a volume and meet the water quality criteria. The loading capacity for each of the five flow conditions is calculated by multiplying the midpoint flow and *E. coli* criteria concentrations. Table 15.2 shows the median, maximum, and minimum flows for the five flow conditions.

**Table 15-2 Hecker Creek maximum, minimum and median flows**

| Flow description | Recurrence interval range (mid %) | Midpoint of flow range, cfs | Maximum of flow range, cfs | Minimum of flow range, cfs |
|---|---|---|---|---|
| **High flow** | **0 to 10% (5)** | 12.8 | 133.8 | 8.1 |
| **Moist conditions** | **10% to 40% (25)** | 4.0 | 8.1 | 2.5 |
| **Mid-range** | **40% to 60% (50)** | 2.0 | 2.5 | 1.6 |
| **Dry conditions** | **60% to 90% (75)** | 1.3 | 1.6 | 1.1 |
| **Low flow** | **90% to 100% (95)** | 0.9 | 1.1 | 0.4 |

Flow and load duration curves were used to establish the occurrence of water quality standards violations, to establish compliance targets, and to set pollutant allocations and margins of safety. Duration curves are derived from flows plotted as a percentage of their recurrence. *E. coli* loads are calculated from *E. coli* concentrations and flow volume at the time the sample was collected.

To construct the flow duration curves, the bacteria monitoring data and the Water Quality Standard (WQS) sample max (235 *E. coli* organisms/100 ml) were plotted with the flow duration percentile. Figure 15-2 shows the data that exceed the WQS criteria at each of the five flow conditions. High flow violations indicate that the problem occurs during run-off conditions when bacteria are washing off from nonpoint sources. Criteria exceeded during low or base flow, when little or no runoff is occurring, indicate that continuous sources such as septic tanks, livestock in the stream, riparian wildlife, and wastewater treatment plants are the problem.

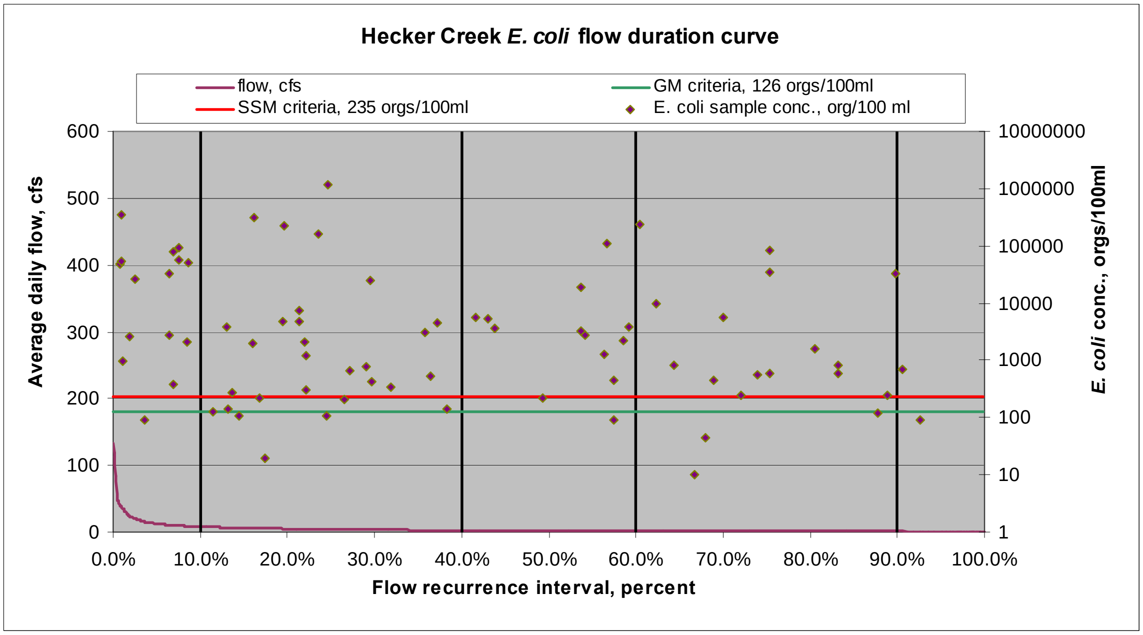

Figure 15-2 Hecker Creek flow duration curve

Load duration curves were used to evaluate the five flow conditions for Hecker Creek. The load duration curve is shown in Figure 15-3. In the figure, the lower curve shows the maximum *E. coli* count for the GM criteria and the upper curve shows the maximum *E. coli* count for the SSM criteria at a continuum of flow recurrence percentage. The individual points are the observed (monitored) *E. coli* concentrations converted to loads based on daily flow for the day they were collected. Points above the load duration curves are violations of the WQS criteria and exceed the loading capacity.

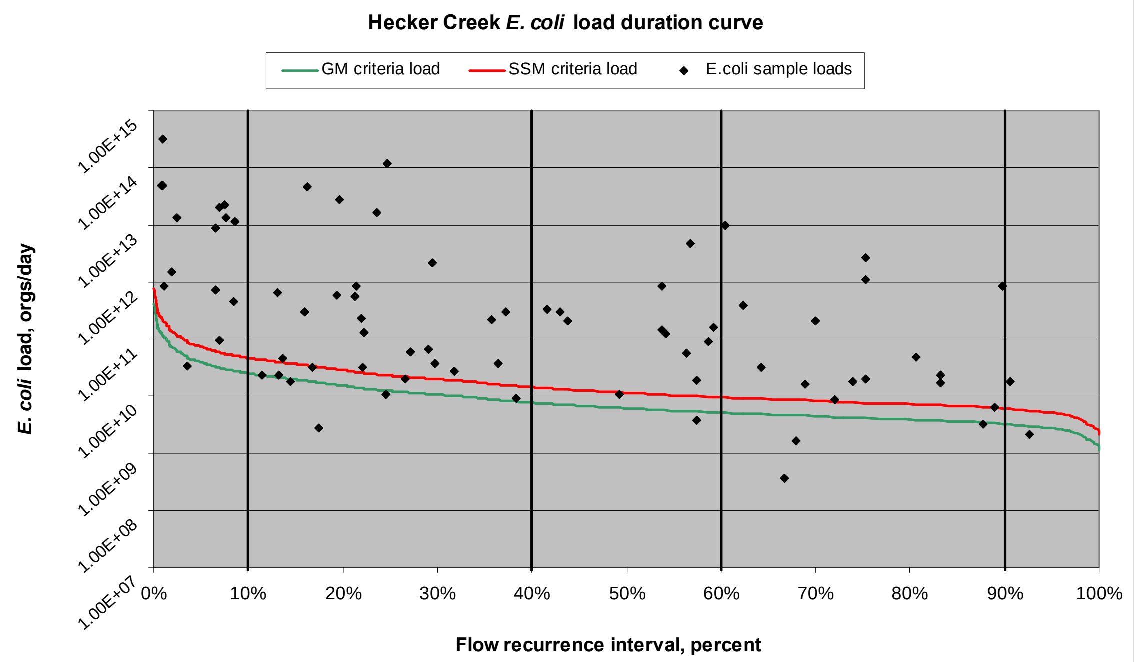

Figure 15-3 Hecker Creek load duration curve

Tables 15-3 and 15-4 show the load capacities (targets) for each of the midpoint flow conditions at the GM and SSM criteria, respectively.

**Table 15-3 Hecker Creek GM load capacity**

| Flow condition | Recurrence interval | Associated midpoint flow, cfs | Estimated flow interval load capacity, *E. coli* orgs/day |
|---|---|---|---|
| **High flow** | **0 to 10%** | 12.8 | 3.9E+10 |
| **Moist conditions** | **10% to 40%** | 4.0 | 1.2E+10 |
| **Mid-range** | **40% to 60%** | 2.0 | 6.2E+09 |
| **Dry conditions** | **60% to 90%** | 1.3 | 4.1E+09 |
| **Low flow** | **90% to 100%** | 0.9 | 2.7E+09 |

**Table 15-4 Hecker Creek SSM load capacity**

| Flow condition | Recurrence interval | Associated midpoint flow, cfs | Estimated flow interval load capacity, *E. coli* orgs/day |
|---|---|---|---|
| **High flow** | **0 to 10%** | 12.8 | 7.4E+10 |
| **Moist conditions** | **10% to 40%** | 4.0 | 2.3E+10 |
| **Mid-range** | **40% to 60%** | 2.0 | 1.1E+10 |
| **Dry conditions** | **60% to 90%** | 1.3 | 7.6E+09 |
| **Low flow** | **90% to 100%** | 0.9 | 5.1E+09 |

## 15.2. Existing load

The existing loads are derived from the sampling data collected in Hecker Creek. These data are the sample values shown in the flow and load duration curves. The *E. coli* concentrations are multiplied by the average daily flow to get the daily loads. The daily loads are plotted with the load duration curves. The allowable loads for a given flow equal the flow multiplied by the WQS limits for the geometric mean or single sample maximum. Monitored data that exceed the limits are above the criteria curves.

The maximum existing loads occur during major rains when runoff and bacteria concentrations are highest. Concentrations exceed the criteria during these high flow events. Other conditions leading to criteria violations occur during dry low flow periods when continuous loads from livestock in the stream, local wildlife, septic tanks, and wastewater treatment plants can cause bacteria problems.

The assessment standard used to evaluate streams is the *E. coli* geometric mean criteria. Since the load duration approach precludes the calculation of a geometric mean, the 90th percentile of observed concentrations within each flow condition is multiplied by the median flow to estimate existing loads. This procedure has been used to evaluate impaired segments. Table 15-5 shows the existing loads for each flow condition.

## Table 15-5 Hecker Creek existing loads

| Flow condition, percent recurrence | Recurrence interval range (mid %) | Associated median flow, cfs | Existing 90th percentile *E. coli* conc., org/100ml | Estimated existing load, *E. coli* org/day |
|---|---|---|---|---|
| **High flows** | **0 to 10% (5)** | 12.8 | 86800 | 2.72E+13 |
| **Moist conditions** | **10% to 40% (25)** | 4.0 | 174000 | 1.70E+13 |
| **Mid-range** | **40% to 60% (50)** | 2.0 | 16320 | 7.97E+11 |
| **Dry conditions** | **60% to 90% (75)** | 1.3 | 49000 | 1.59E+12 |
| **Low flow** | **90% to 100% (95)** | 0.9 | 639 | 1.38E+10 |

*Identification of pollutant sources.*
The sources of bacteria in the Hecker Creek subbasin (SWAT Subbasin 18) are all nonpoint sources. These include failed septic tank systems, pastured cattle, cattle in the stream, wildlife, and manure applied to fields from animal confinement operations. The loads from these sources are incorporated into the SWAT watershed model and are listed in Tables 15-6 to 15-10.

Non functional septic tank systems. There are an estimated 20 onsite septic tank systems in the subbasin (2.5 persons/household). IDNR estimates that 50 percent are not functioning properly. It is assumed that these are continuous year round discharges. Septic tank loads have been put into the SWAT model as a continuous source by subbasin.

## Table 15-6 Hecker Creek septic tank system E. coli orgs/day

| | |
|---|---|
| Rural population of Hecker Creek subbasin | 51 |
| Total initial E.coli, orgs/day [1] | 6.38E+10 |
| Septic tank flow, $m^3$/day [2] | 13.5 |
| **E. coli delivered to stream, orgs/day [3]** | **4.22E+07** |

1. Assumes 1.25E+09 E. coli orgs/day per capita
2. Assumes 70 gallons/day/capita
3. Assumes septic discharge concentration reaching stream is 625 orgs/100 ml and a 50% failure rate

Cattle in stream. Of the 357 cattle in pastures, one to six percent of those are assumed to be in the stream on a given day. The number on pasture and the fraction in the stream varies by month. Cattle in the stream have a high potential to deliver bacteria since bacteria are deposited directly in the stream with or without rainfall. Subbasin cattle in the stream bacteria have been input in the SWAT model as a continuous source varying by month.

## Table 15-7 Hecker Creek Cattle in the stream E. coli orgs/day

| | |
|---|---|
| Pasture area with stream access, acre[1] | 458 |
| Number of cattle in stream (6% of total)[2] | 21 |
| Dry manure, kg/day [3] | 66 |
| **E. coli load, orgs/day [4]** | **8.76E+11** |

1. The subbasin CIS are estimated from the pasture area with stream access at 0.78 cattle/acre.

2. It is estimated that cattle spend 6% of their time in streams in July and August, 3% in June and September, and 1% in May and October. The loads shown in this table are for July and August. The loads for the other 4 months when cattle are in streams have been incorporated into the SWAT modeling.
3. Cattle generate 3.1 kg/head/day of dry manure.
4. Manure has 1.32E+07 *E coli* orgs/gram dry manure.

Grazing livestock. The estimated number of cattle in the subbasin is 357. It is assumed that they are on pasture from April to November. The potential for bacteria delivery to the stream occurs with precipitation causing runoff. Manure available for washoff is applied in the SWAT model at 6 kg/ha in the pasture landuse.

### Table 15-8 Hecker Creek manure from pastured cattle, maximum E. coli available for washoff, orgs/day

| | |
|---|---:|
| Pasture area, acres | 458 |
| Number of cattle on pasture[1] | 336 |
| Dry manure, kg/day[2] | 1041 |
| Maximum E. coli load, orgs/day[3] | 1.37E+13 |
| **Maximum E. coli available for washoff, orgs[4]** | **2.47E+13** |

1. The number of pastured cattle is 0.78 cattle/acre.
2. Cattle generate 3.1 kg/head/day of dry manure.
3. Manure has 1.32E+07 *E. coli* orgs/gram dry manure
4. The load available for washoff is the daily load times 1.8.

Wildlife manure. The number of deer in Allamakee County is about 9,000 located primarily in forested land adjacent to streams. Another 1,000 have been added to account for other wildlife such as raccoons and waterfowl for a total estimate of 10,000. This works out to 0.024 deer per acre. Using this procedure, there are 71 deer in the subbasin concentrated in the forested areas. The deer are in the subbasin year round.

### Table 15-9 Hecker Creek watershed wildlife manure loads available for washoff, orgs/day

| Number of deer[1] | Forested area, ha | SWAT manure loading rate, kg/ha/day[2] | E. coli available for washoff, orgs[3] |
|:---:|:---:|:---:|:---:|
| 71 | 84 | 1.215 | 6.41E+10 |

1. Deer numbers are 0.024 deer/ha for the entire subbasin concentrated to 0.844 deer/ha in the forest land use. All wildlife loads are applied to the forest landuse in the SWAT model. The county deer numbers have been increased by 10% to account for other wildlife in the subbasin.
2. Assumes 1.44 kg/deer/day and 3.47E+05 orgs/gram.
3. Assumes that the maximum *E. coli* available for washoff is 1.8 times the daily load.

Field applications of CAFO manure.
It is assumed that there are not any confinement livestock in the subbasin.

Seasonal variation of sources.

The relative impacts of the bacteria sources are shown in Figures 15-4 and 15-5. Figure 15-4 shows the relative loads delivered by the "continuous" sources, those sources present with or without rainfall and runoff. These are the failed septics that are assumed to be a problem every day of the year and the loads from cattle in the stream that vary by month from May to October. It can be seen in this figure that the impacts from cattle in the stream are much more significant than those from failed septic tank systems.

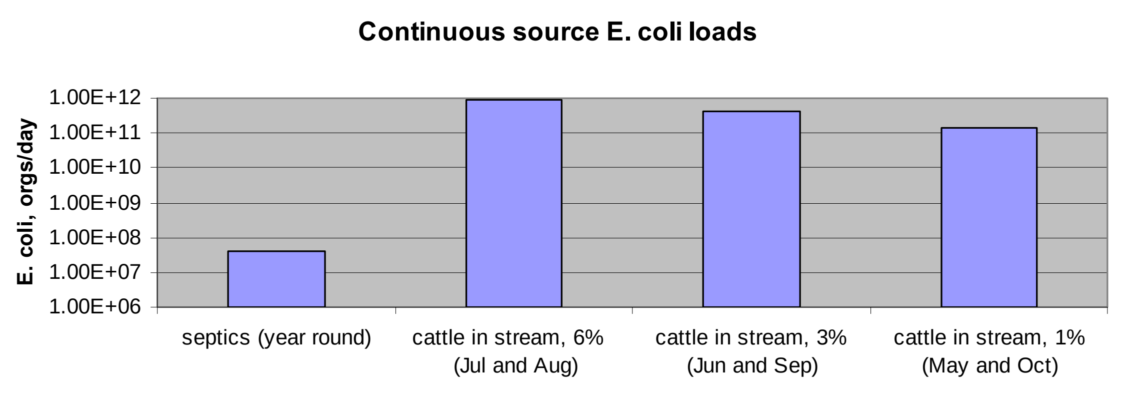

Figure 15-4 *E. coli* loads from "continuous" sources

The three general washoff sources of bacteria in the subbasin are shown in Figure 15-5. The wildlife source consists primarily of deer and smaller animals such as raccoons and waterfowl. These are year round sources. Pastured cattle consist of grazing cattle and small poorly managed feedlot-like operations. The grazing season is modeled as lasting 168 days starting May 1. Manure from confined animal feeding operations (CAFO) is applied to cropland twice a year for a relatively brief time. Most field applied manure is assumed to be incorporated into the soil and most bacteria in it are not available. Confinement animals are swine, chickens and dairy cattle. It is assumed that there are no confinement livestock in the subbasin.

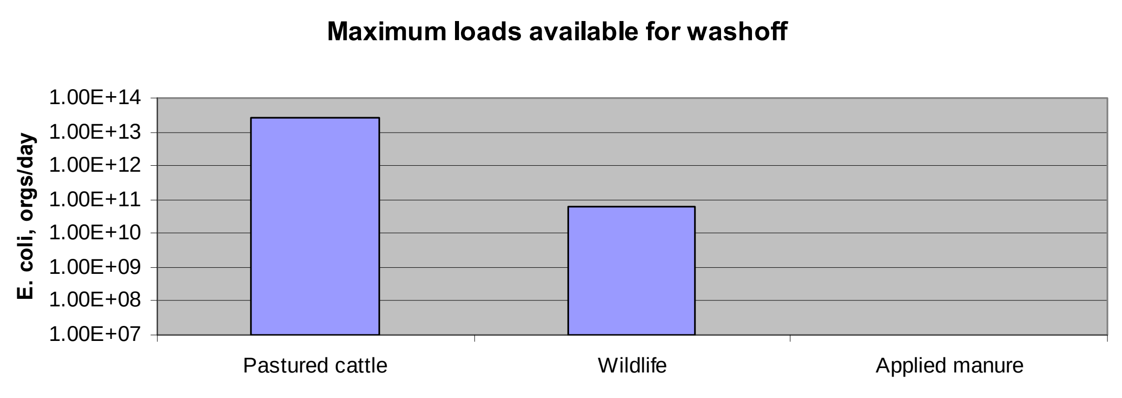

Figure 15-5 Maximum *E. coli* loads available for washoff

The maximum bacteria load to the stream occurs when the continuous source load plus the precipitation driven washoff load are combined. In general, the more rainfall the

higher the flow and the more elevated the concentration.  High flow and elevated concentration equal peak loads.  In July and August, the maximum potential load based on this analysis is 2.48E+13 orgs/day available for washoff plus the continuous load of 8.76E+11 orgs/day for a total of 2.57E+13 orgs/day.

Flow interval load source analysis.  Based on the load duration curve analysis the maximum existing load occurring during the zero to forty percent recurrence interval runoff conditions, is 1.71E+13 orgs/day and the total available load based on potential sources is 2.57E+13 orgs/day.  Generally, the maximum load in the stream, delivered when runoff is occurring, is estimated to be .67 percent of bacteria available for washoff. At the zero to ten percent maximum load of 2.72E+13 orgs/day and with the same load available for washoff the stream load is essentially one hundred percent of the available load.  This reflects the absence of applied manure from CAFOs on subbasin fields.

## 15.3. Departure from load capacity

The departure from load capacity is the difference between the existing load and the load capacity.  This varies for each of the five flow conditions.  Table 15-10 shows this difference.  The existing and target loads for the five flow conditions are shown graphically in Figure 15-6.

**Table 15-10 Hecker Creek departure from load capacity**

| Design flow condition, percent recurrence | Recurrence interval range (mid %) | Existing *E. coli* orgs/day | Load capacity, orgs/day | Departure from capacity, orgs/day |
|---|---|---|---|---|
| **High flow** | **0 to 10% (5)** | 2.72E+13 | 7.4E+10 | 2.71E+13 |
| **Moist conditions** | **10% to 40% (25)** | 1.70E+13 | 2.3E+10 | 1.70E+13 |
| **Mid-range flow** | **40% to 60% (50)** | 7.97E+11 | 1.1E+10 | 7.85E+11 |
| **Dry conditions** | **60% to 90% (75)** | 1.59E+12 | 7.6E+09 | 1.58E+12 |
| **Low flow** | **90% to 100% (95)** | 1.38E+10 | 5.1E+09 | 8.72E+09 |

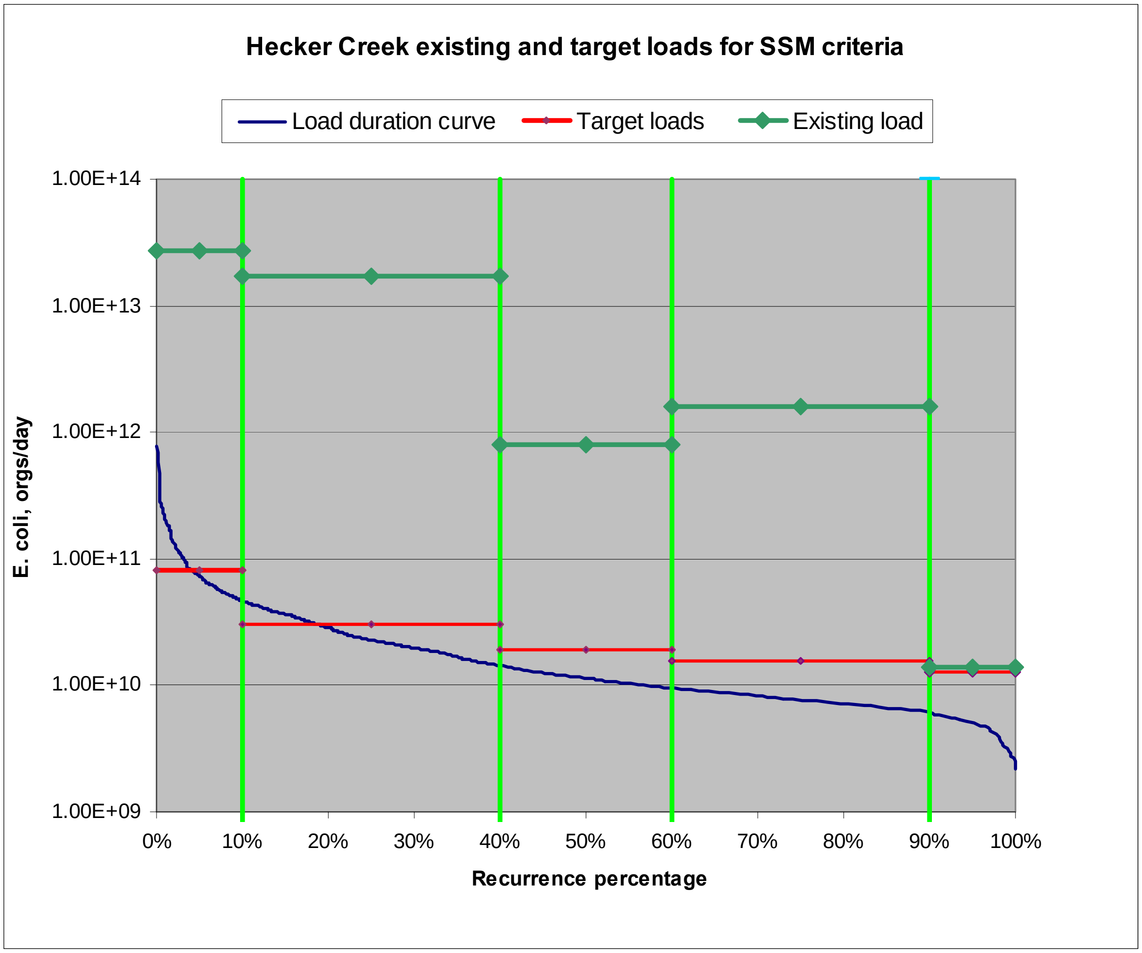

Figure 15-6 Difference between existing and target loads

## 15.4. Pollutant Allocations

*Wasteload allocations.*
The wasteload allocations for the AgriStarr industrial wastewater treatment facility that discharges to Hecker Creek are shown in Table 3-6 and again in Tables 15-11 and 15-12 that show the GM and SSM TMDL calculations. It is currently assumed that all of the wastewater treatment plants in the watershed discharge to a Class A1 stream. The wasteload allocations for the discharges are the Class A1 *E. coli* water quality standards, a geometric mean (GM) of 126-organisms/100 ml and a single sample maximum (SSM) of 235-organisms/100 ml. These concentration criteria have been multiplied by the design flow to calculate the WWTP *E. coli* allocations.

*Load allocation.*
The load allocations for *E. coli* TMDLs are the load capacity less an explicit 10 percent margin of safety (MOS) less the total WLA for the flow condition for the geometric mean and single sample maximum. There is a separate load allocation set for each of the target recurrence intervals.

Hecker Creek includes the discharge from the AgriStarr wastewater treatment facility and at dry and low flow conditions this dominates streamflow. The WLA for Hecker Creek is the AgriStarr design flow times the GM and SSM WQS concentrations. The LA is the WQS concentrations times the interval median flow less the MOS. Generally, low flow conditions occur in late fall and winter when there are few cattle in the stream. Allocations are shown in Tables 15-11 and 15-12.

**Table 15-11 Hecker Creek GM *E. coli* load allocations[1]**

| Flow condition, percent recurrence | GM target (TMDL) *E. Coli*, orgs/day | GM MOS *E. Coli*, orgs/day | Total WLA GM *E. coli*, orgs/day[2] | LA GM *E. coli*, orgs/day |
|---|---|---|---|---|
| **High flows** | 4.4E+10 | 3.9E+09 | 4.20E+09 | 3.6E+10 |
| **Moist conditions** | 1.6E+10 | 1.2E+09 | 4.20E+09 | 1.1E+10 |
| **Mid-range flow** | 1.0E+10 | 6.2E+08 | 4.20E+09 | 5.5E+09 |
| **Dry conditions** | 8.3E+09 | 4.1E+08 | 4.20E+09 | 3.7E+09 |
| **Low flow** | 6.9E+09 | 2.7E+08 | 4.20E+09 | 2.4E+09 |

1. Based on geometric mean standard of 126 *E. coli* organisms/100 ml
2. The AgriStarr WWTP contribution is disinfected effluent with counts below WQSs.

**Table 15-12 Hecker Creek SSM *E. coli* load allocations[1]**

| Flow condition, percent recurrence | SSM target (TMDL) *E. Coli*, orgs/day | SSM MOS *E. Coli*, orgs/day | Total WLA SSM *E. coli*, orgs/day[2] | LA SSM *E. coli*, orgs/day |
|---|---|---|---|---|
| **High flow** | 8.1E+10 | 7.4E+09 | 7.83E+09 | 6.6E+10 |
| **Moist conditions** | 3.1E+10 | 2.3E+09 | 7.83E+09 | 2.1E+10 |
| **Mid-range flow** | 1.9E+10 | 1.1E+09 | 7.83E+09 | 1.0E+10 |
| **Dry conditions** | 1.5E+10 | 7.6E+08 | 7.83E+09 | 6.8E+09 |
| **Low flow** | 1.3E+10 | 5.1E+08 | 7.83E+09 | 4.6E+09 |

1. Based on single sample maximum standard of 235 *E. coli* organisms/100 ml
2. The AgriStarr WWTP contribution is disinfected effluent with counts below WQSs.

*Margin of safety.*
The margin of safety for *E. coli* is an explicit 10 percent of the load capacity at each of the design recurrence intervals as shown in Tables 15-11 and 15-12.

## 15.5. TMDL Summary

The following equation shows the total maximum daily load (TMDL) and its components for the impaired IA 01-YEL-0155_0 segment of Hecker Creek.

**Total Maximum Daily Load = Σ Load Allocations + Σ Wasteload Allocations +MOS**

A Total Maximum Daily Load calculation has been made at design flow conditions for the GM and SSM of this segment and these are shown in Tables 15-13 and 15-14 and Figures 15-7 and 15-8.

**Table 15-13 Hecker Creek IA 01-YEL-0155_0 *E. coli* TMDL for GM**

| Flow condition | Σ LA, orgs/day | Σ WLA, orgs/day[1] | MOS, orgs/day | TMDL, orgs/day |
|---|---|---|---|---|
| **High flow** | 3.6E+10 | 4.20E+09 | 3.9E+09 | 4.4E+10 |
| **Moist condition** | 1.1E+10 | 4.20E+09 | 1.2E+09 | 1.6E+10 |
| **Mid-range flow** | 5.5E+09 | 4.20E+09 | 6.2E+08 | 1.0E+10 |
| **Dry conditions** | 3.7E+09 | 4.20E+09 | 4.1E+08 | 8.3E+09 |
| **Low flow** | 2.4E+09 | 4.20E+09 | 2.7E+08 | 6.9E+09 |

1. The AgriStarr WWTP contribution is disinfected effluent with counts below WQSs.

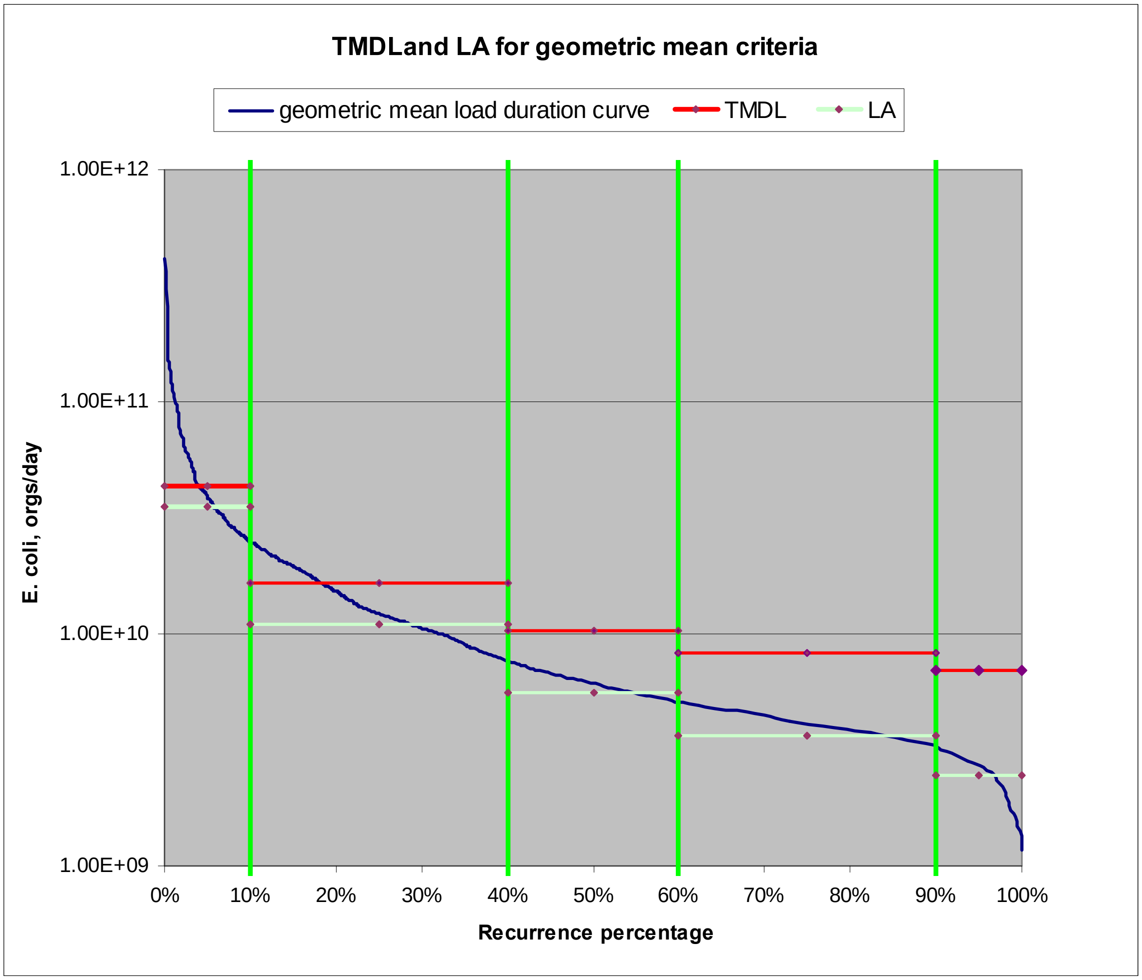

Figure 15-7 GM TMDL at WQS of 126 orgs/100 ml for the five flow conditions

**Table 15-14 Hecker Creek IA 01-YEL-0155_0 *E. coli* TMDL for SSM**

| Flow condition | Σ LA, orgs/day | Σ WLA, orgs/day[1] | MOS, orgs/day | TMDL, orgs/day |
|---|---|---|---|---|
| High flow | 6.6E+10 | 7.83E+09 | 7.4E+09 | 8.1E+10 |
| Moist condition | 2.1E+10 | 7.83E+09 | 2.3E+09 | 3.1E+10 |
| Mid-range flow | 1.0E+10 | 7.83E+09 | 1.1E+09 | 1.9E+10 |
| Dry conditions | 6.8E+09 | 7.83E+09 | 7.6E+08 | 1.5E+10 |
| Low flow | 4.6E+09 | 7.83E+09 | 5.1E+08 | 1.3E+10 |

1. The AgriStarr WWTP contribution is disinfected effluent with counts below WQSs.

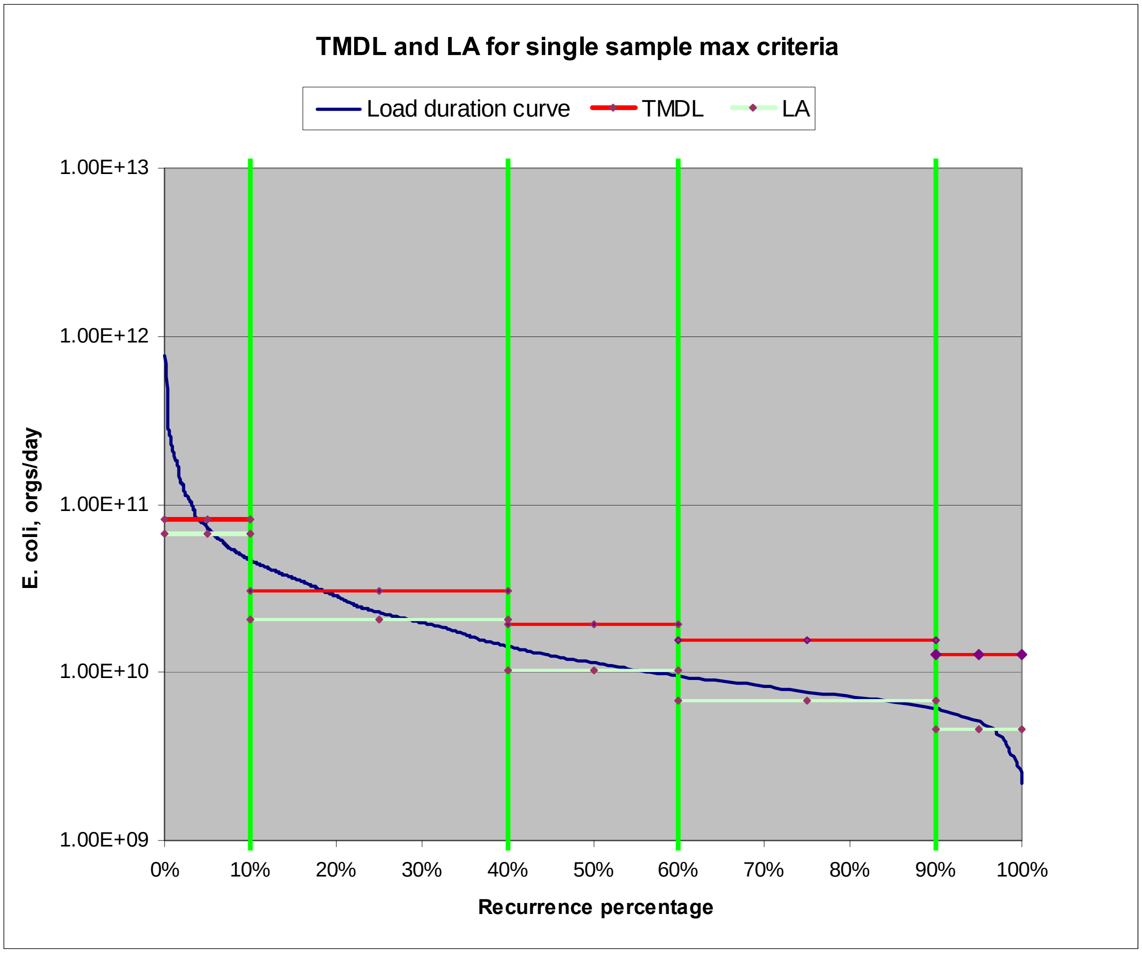

Figure 15-8 SSM TMDL at WQS of 235 orgs/100 ml for the five flow conditions

## 15.6. Implementation Analysis

The modeled systematic reduction of the loads by source provides the initial evaluation of proposed implementation plans for the subbasin. The SWAT model has been run for four scenarios in which loads have been reduced for the most significant sources. The source analysis identified the primary source of bacteria as cattle in the stream and cattle on pasture.

Figures 15-9a and 15-9b show the SWAT model output concentrations for the existing loads. Monitored concentrations also plotted on the charts. Two different concentration scale maximums are shown, 400,000 and 100,000 orgs/day, respectively. The target concentration of 235 *E. coli* orgs/100 ml is frequently exceeded by both monitoring data and SWAT simulated values.

The Figure 15-9a concentration scale has been set to a maximum of 400,000 orgs/100 ml because there are so many high sample values. This makes it difficult to see the target SSM concentration on the chart. There is one monitoring value that exceeds 400,000 orgs/100 ml (1,200,000).

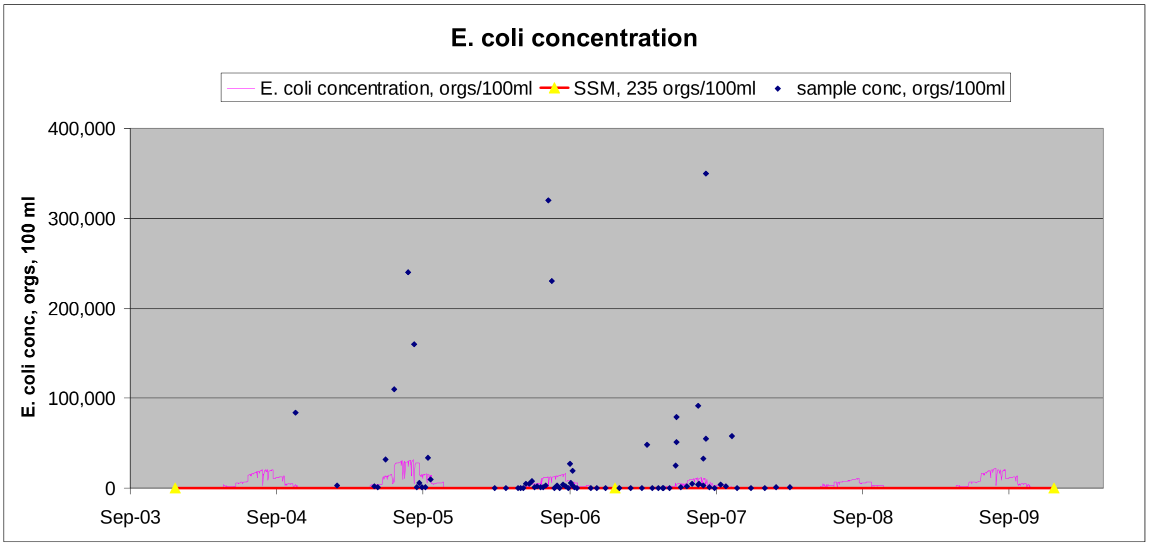

Figure 15-9a SWAT output for existing *E. coli* concentrations

At the 100,000 orgs/day scale the details of the simulated output are clearer, however, the target line is still hard to see.

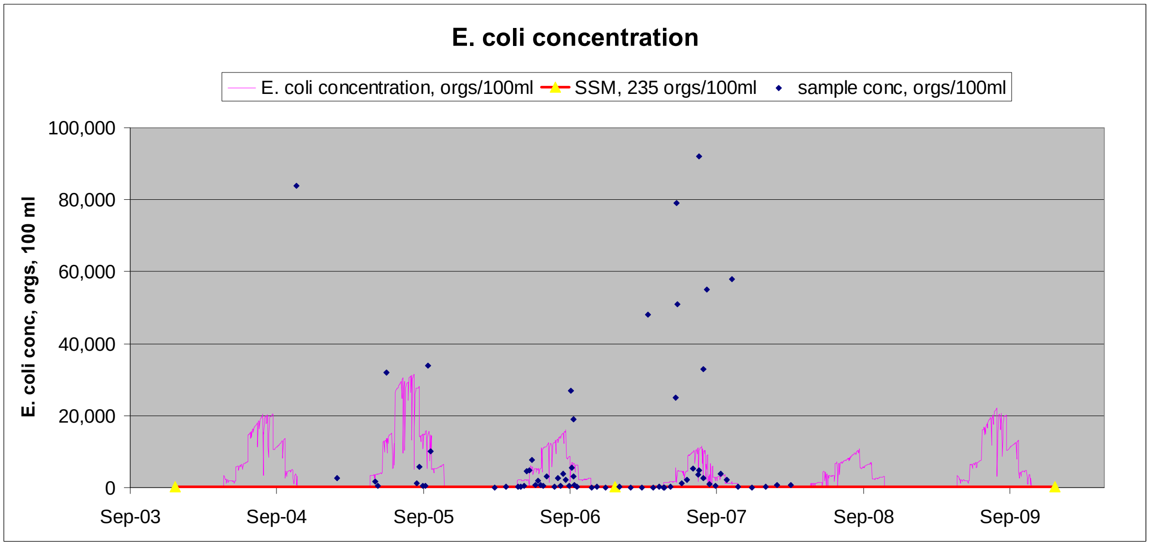

Figure 15-9b SWAT output for existing *E. coli* concentrations

The second scenario, Figure 15-10, removes half of the cattle in the stream from the subbasin. This generates reduced concentrations that are still higher than the SSM standard during the grazing season. The maximum on the concentration scale is the same as in Figure 15-9b, 100,000 orgs/day.

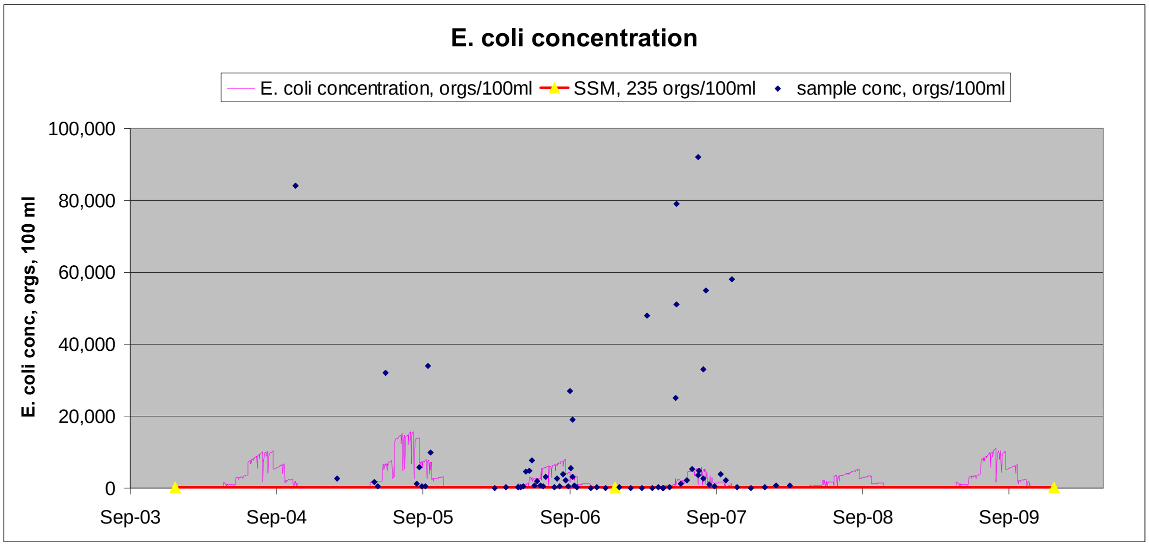

Figure 15-10 SWAT output for half reduction of CIS *E. coli* concentrations

The third scenario, shown in Figures 15-11a and 15-11b, eliminates cattle in the stream as a source. This lowers the concentration during the grazing season but there remain instances of high bacteria concentration from runoff, mostly associated with cattle on pasture. The two figures show the same simulation values at two different maximum values in the Y-axis scale. This scale transition clarifies the effects of source reductions and their relation to the target concentration.

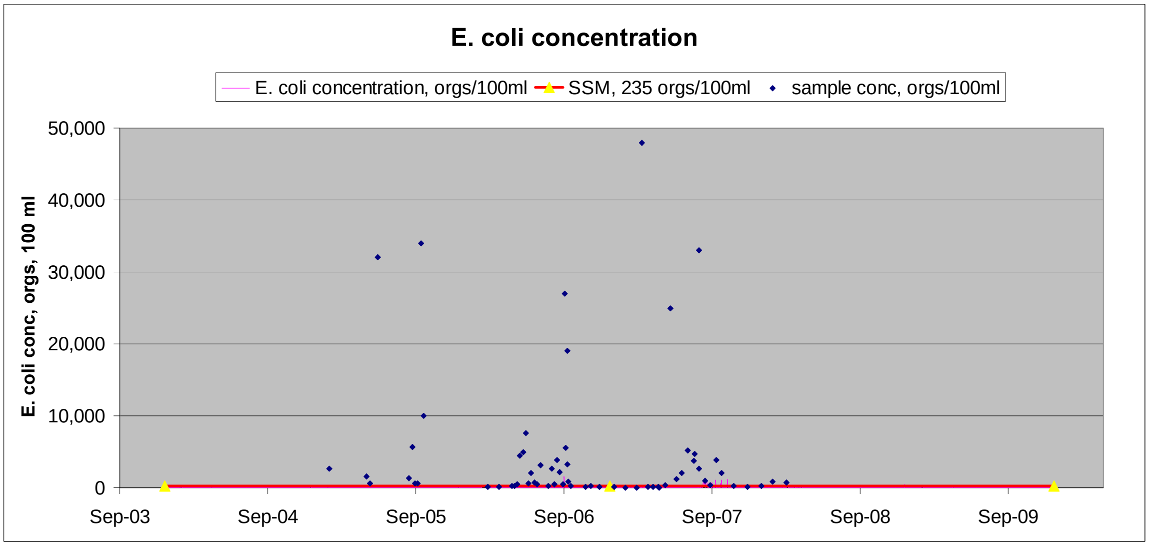

Figure 15-11a SWAT output for complete reduction of CIS *E. coli* with the concentration scale maximum set at 50,000 orgs/100 ml

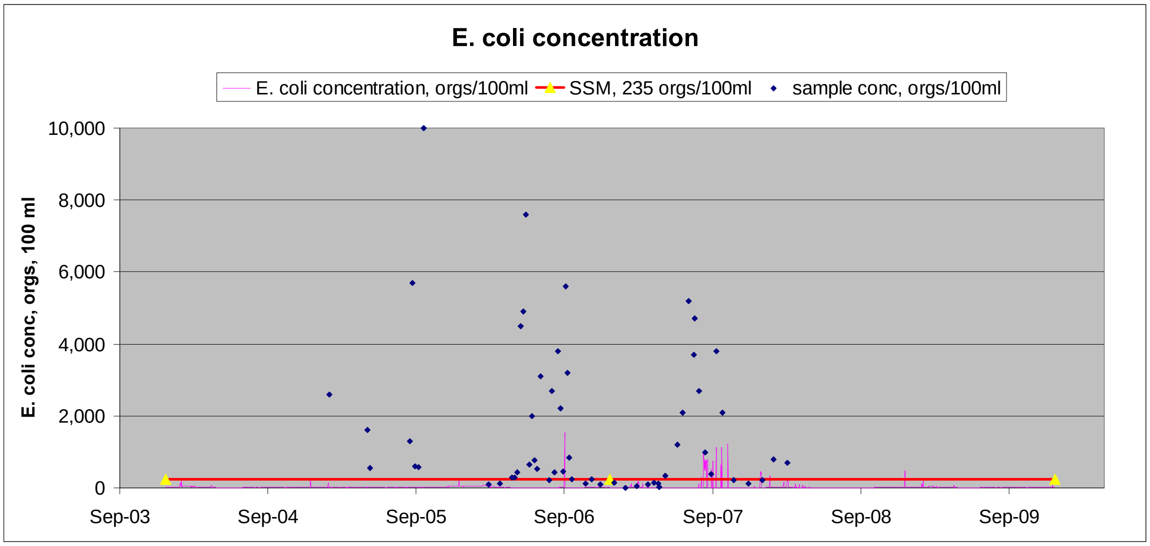

Figure 15-11b SWAT output for complete reduction of CIS *E. coli* with the concentration scale maximum set at 10,000 orgs/100 ml

The fourth scenario, shown in Figures 15-12a and 15-12b, in addition to previous reductions, decreases the manure from cattle on pasture by two thirds. This brings simulated concentrations below the target concentration.

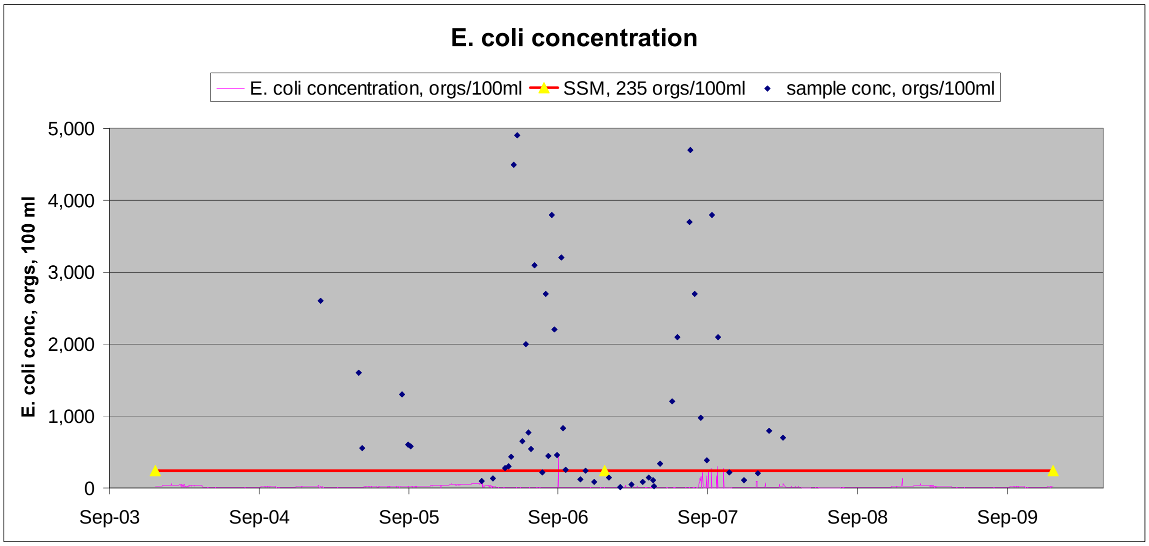

Figure 15-12a SWAT output for complete reduction of CIS *E. coli* and a two thirds reduction of manure from cattle on pasture with the concentration scale maximum set at 5,000 orgs/100 ml

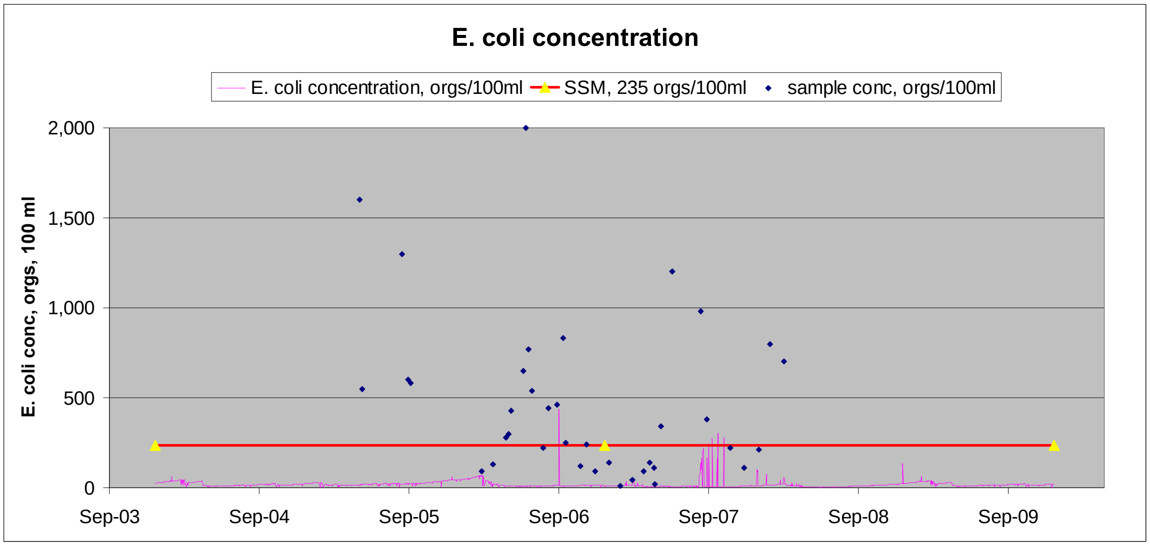

Figure 15-12b SWAT output for complete reduction of CIS *E. coli* and a two thirds reduction of manure from cattle on pasture with the concentration scale maximum set at 2000 orgs/100 ml

There are other combinations of source reductions that can be simulated. The four scenarios described here reduce bacteria loads from the sources that have been modeled to have the greatest impact on stream outlet bacteria concentrations. The sources that are not reduced in these scenarios may have important episodic or local effect on *E. coli* organism numbers.

# 16. North Fork Yellow River

North Fork Yellow River (IA 01-YEL-0160_0) is the ninth impaired Yellow River tributary upstream from the Yellow River confluence with the Mississippi. The classified segment runs northwest 3.7 miles upstream from its confluence with the Yellow River (S13, T96N, R7W, Winneshiek County). There are no permitted sources that discharges to this segment. The stream flow used in the development of the TMDL for this segment is derived from the area ratio flow based on the Ion USGS gage data. A SWAT watershed model developed for the Yellow River watershed labels North Fork Yellow River Subbasin 11. Figure 16-1 shows a map of the North Fork Yellow River and Table 16-1 shows the land use in its subbasin.

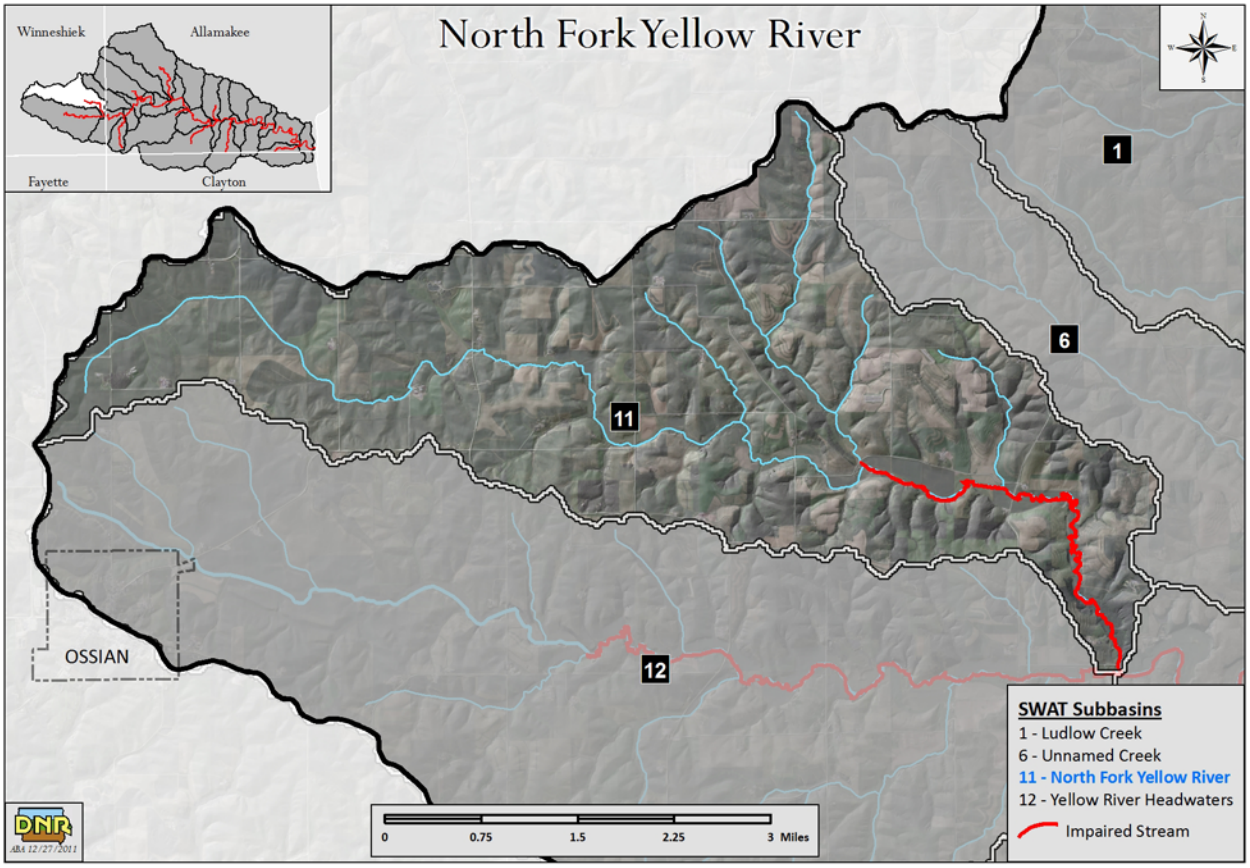

Figure 16-1 North Fork Yellow River (0160_0)

**Table 16-1 North Fork Yellow River subbasin land use**

| Landuse | Area, acres | Fraction of total |
|---|---|---|
| Water/wetland | 4.5 | 0.05% |
| Forest | 956.1 | 9.84% |
| Ungrazed/CRP/hay | 1318.2 | 13.57% |
| Grazed | 843.1 | 8.68% |
| Row crop | 6290.3 | 64.74% |
| Roads | 271.3 | 2.79% |
| Commercial/residential | 32.5 | 0.33% |
| **Total** | **9715.8** | **100.00%** |

In the North Fork Yellow River watershed, 23 percent of the area is forest and ungrazed grass and 65 percent is row crop.

### 16.1. Water body pollutant loading capacity (TMDL)

The *E. coli* organism load capacity is the number of organisms that can be in a volume and meet the water quality criteria. The loading capacity for each of the five flow conditions is calculated by multiplying the midpoint flow and *E. coli* criteria concentrations. Table 16-2 shows the median, maximum, and minimum flows for the five flow conditions.

### Table 16-2 North Fork Yellow River maximum, minimum and median flows

| Flow description | Recurrence interval range (mid %) | Midpoint of flow range, cfs | Maximum of flow range, cfs | Minimum of flow range, cfs |
|---|---|---|---|---|
| **High flow** | **0 to 10% (5)** | 41.0 | 439.5 | 26.2 |
| **Moist conditions** | **10% to 40% (25)** | 13.0 | 26.2 | 8.1 |
| **Mid-range** | **40% to 60% (50)** | 6.5 | 8.1 | 5.4 |
| **Dry conditions** | **60% to 90% (75)** | 4.3 | 5.4 | 3.5 |
| **Low flow** | **90% to 100% (95)** | 2.9 | 3.5 | 1.2 |

Flow and load duration curves were used to establish the occurrence of water quality standards violations, compliance targets, and to set pollutant allocations and margins of safety. Duration curves are derived from flows plotted as a percentage of their recurrence. *E. coli* loads are calculated from *E. coli* concentrations and flow volume at the time the sample was collected.

To construct the flow duration curves, the bacteria monitoring data and the Water Quality Standard (WQS) sample max (235 *E. coli* organisms/100 ml) were plotted with the flow duration percentile. Figure 16-2 shows the data that exceed the WQS criteria at each of the five flow conditions. High flow violations indicate that the problem occurs during run-off conditions when bacteria are washing off from nonpoint sources. Criteria exceeded during low or base flow, when little or no runoff is occurring, indicate that continuous sources such as septic tanks, livestock in the stream, riparian wildlife, and wastewater treatment plants are the problem.

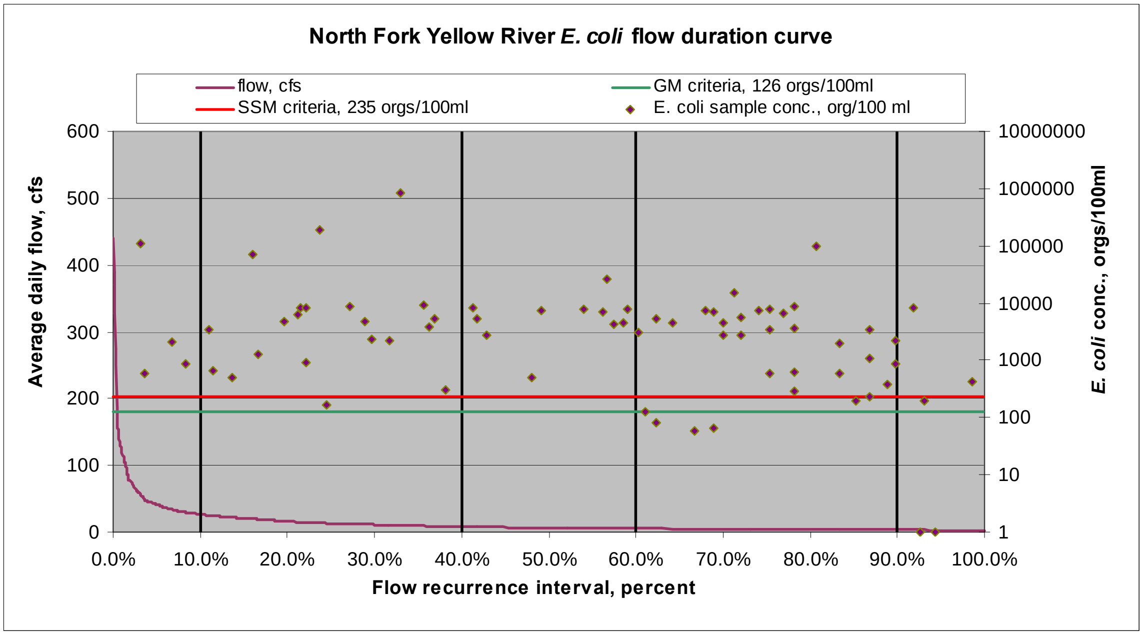

Figure 16-2 North Fork Yellow River flow duration curve

Load duration curves were used to evaluate the five flow conditions for North Fork Yellow River. The load duration curve is shown in Figure 16-3. In the figure, the lower curve shows the maximum *E. coli* count for the GM criteria and the upper curve shows the maximum *E. coli* count for the SSM criteria at a continuum of flow recurrence percentage. The individual points are the observed (monitored) *E. coli* concentrations converted to loads based on average daily flow for the day they were collected. Points above the curves violate the WQS criteria and exceed the loading capacity.

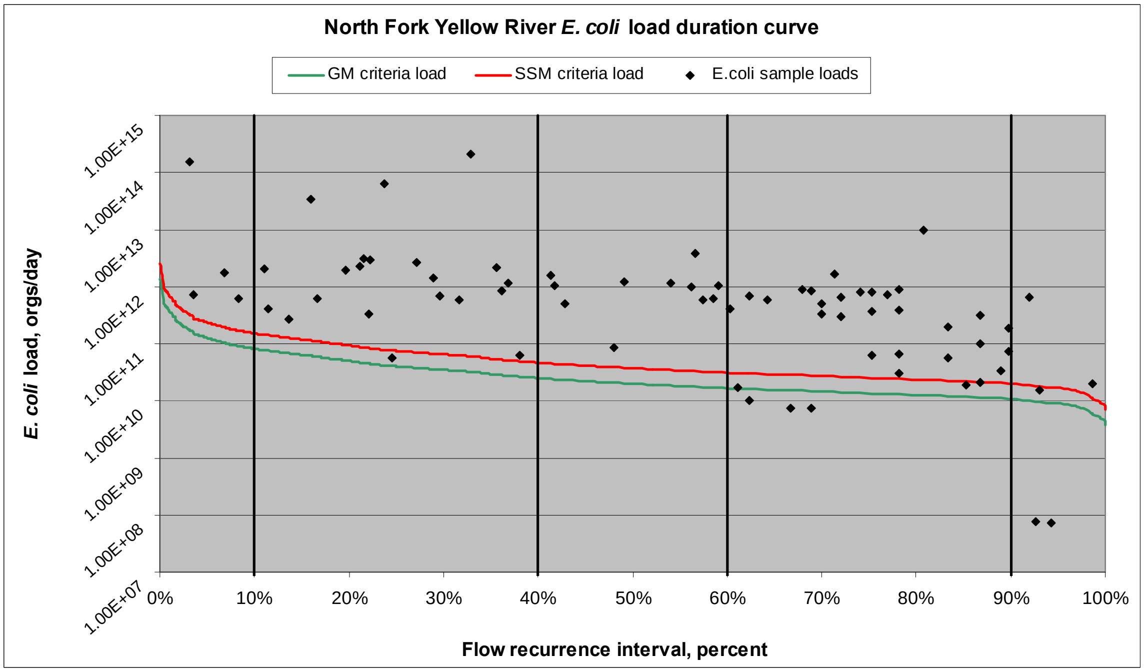

Figure 16-3 North Fork Yellow River load duration curve

Tables 16-3 and 16-4 show the load capacities (targets) for each of the midpoint flow conditions at the GM and SSM criteria, respectively.

**Table 16-3 North Fork Yellow River GM load capacity**

| Flow condition | Recurrence interval | Associated midpoint flow, cfs | Estimated flow interval load capacity, *E. coli* orgs/day |
|---|---|---|---|
| High flow | 0 to 10% | 41.0 | 1.3E+11 |
| Moist conditions | 10% to 40% | 13.0 | 4.0E+10 |
| Mid-range | 40% to 60% | 6.5 | 2.0E+10 |
| Dry conditions | 60% to 90% | 4.3 | 1.3E+10 |
| Low flow | 90% to 100% | 2.9 | 8.9E+09 |

**Table 16-4 North Fork Yellow River SSM load capacity**

| Flow condition | Recurrence interval | Associated midpoint flow, cfs | Estimated flow interval load capacity, *E. coli* orgs/day |
|---|---|---|---|
| High flow | 0 to 10% | 41.0 | 2.4E+11 |
| Moist conditions | 10% to 40% | 13.0 | 7.5E+10 |
| Mid-range | 40% to 60% | 6.5 | 3.7E+10 |
| Dry conditions | 60% to 90% | 4.3 | 2.5E+10 |
| Low flow | 90% to 100% | 2.9 | 1.7E+10 |

## 16.2. Existing load

The existing loads are derived from the sampling data collected in the North Fork Yellow River. These data are the sample values shown in the flow and load duration curves. The *E. coli* concentrations are multiplied by the average daily flow to get the daily loads. The daily loads are plotted with the load duration curves. The allowable loads for a given flow equal the flow multiplied by the WQS limits for the geometric mean or single sample maximum. Monitored data that exceed the limits are above the criteria curves.

The maximum existing loads occur during major rains when runoff and bacteria concentrations are highest. Concentrations exceed the criteria during these high flow events. Other conditions leading to criteria violations occur during dry low flow periods when continuous loads from livestock in the stream, local wildlife, septic tanks, and wastewater treatment plants can cause bacteria problems.

The assessment standard used to evaluate streams is the *E. coli* geometric mean criteria. Since the load duration approach precludes the calculation of a geometric mean, the 90th percentile of observed concentrations within each flow condition is multiplied by the median flow to estimate existing loads. This procedure has been used to evaluate impaired segments. Table 16-5 shows the existing loads for each flow condition.

### Table 16-5 North Fork Yellow River existing loads

| Flow condition, percent recurrence | Recurrence interval range (mid %) | Associated median flow, cfs | Existing 90th percentile *E. coli* conc., org/100ml | Estimated existing load, *E. coli* org/day |
|---|---|---|---|---|
| **High flows** | **0 to 10% (5)** | 41.0 | 77630 | 7.79E+13 |
| **Moist conditions** | **10% to 40% (25)** | 13.0 | 70000 | 2.23E+13 |
| **Mid-range** | **40% to 60% (50)** | 6.5 | 8300 | 1.32E+12 |
| **Dry conditions** | **60% to 90% (75)** | 4.3 | 7680 | 8.17E+11 |
| **Low flow** | **90% to 100% (95)** | 2.9 | 5032 | 3.57E+11 |

*Identification of pollutant sources.*
The sources of bacteria in the North Fork Yellow River subbasin (SWAT Subbasin11) are all nonpoint sources including failed septic tank systems, pastured cattle, cattle in the stream, wildlife, and manure applied to fields from animal confinement operations. The loads from these sources are incorporated into the SWAT watershed model and are listed in Tables 16-6 to 16-10.

Non functional septic tank systems. There are an estimated 69 onsite septic tank systems in the subbasin (2.5 persons/household). IDNR estimates that 50 percent are not functioning properly. It is assumed that these are continuous year round discharges. Septic tank loads have been put into the SWAT model as a continuous source by subbasin.

### Table 16-6 North Fork Yellow River septic tank system E. coli orgs/day

| | |
|---|---|
| Population of N. F. Yellow River subbasin | 172 |
| Total initial E.coli, orgs/day [1] | 2.15E+11 |
| Septic tank flow, $m^3$/day [2] | 45.58 |
| **E. coli delivered to stream, orgs/day [3]** | **1.42E+08** |

1. Assumes 1.25E+09 E. coli orgs/day per capita
2. Assumes 70 gallons/day/capita
3. Assumes septic discharge concentration reaching stream is 625 orgs/100 ml and a 50% failure rate

Cattle in stream. Of the 512 cattle in pastures with stream access, one to six percent of those are assumed to be in the stream on a given day. The number on pasture and the fraction in the stream varies by month. Cattle in the stream have a high potential to deliver bacteria since bacteria are deposited directly in the stream with or without rainfall. Subbasin cattle in the stream bacteria have been put in the SWAT model as a continuous source varying by month.

### Table 16-7 North Fork Yellow River Cattle in the stream E. coli orgs/day[1]

| | |
|---|---|
| Pasture area with stream access, acre[1] | 657 |
| Number of cattle in stream/day[2] | 31 |
| Dry manure, kg/day[3] | 95 |
| **E. coli load, orgs/day[4]** | **1.26E+12** |

1. The subbasin CIS are estimated from the pasture area with access to streams at 0.78 cattle/acre.

2. It is estimated that cattle spend 6% of their time in streams in July and August, 3% in June and September, and 1% in May and October. The loads shown in this table are for July and August. The loads for the other 4 months when cattle are in streams have been incorporated into the SWAT modeling.
3. Cattle generate 3.1 kg/head/day of dry manure.
4. Manure has 1.32E+07 *E. coli* orgs/gram dry manure.

Grazing livestock. The number of cattle in the subbasin is estimated to be 617 and it is assumed that the cattle are on pasture from April to November. The potential for the delivery of bacteria to the stream occurs with precipitation causing runoff. Manure available for washoff is put in the SWAT model at 6 kg/ha in the pasture HRU's.

### Table 16-8 North Fork Yellow River manure from pastured cattle, maximum E. coli available for washoff, orgs/day[1]

| | |
|---|---:|
| Pasture area, acres | 830 |
| Number of cattle on pasture[1] | 617 |
| Dry manure, kg[2] | 1912 |
| Maximum E. coli load, orgs/day[3] | 2.52E+13 |
| **Maximum E. coli available for washoff, orgs[4]** | **4.54E+13** |

1. The number of pastured cattle is 0.78 cattle/acre.
2. Cattle generate 3.1 kg/head/day of dry manure.
3. Manure has 1.32E+07 *E. coli* orgs/gram dry manure
4. The load available for washoff is the daily load times 1.8.

Wildlife manure. The number of deer in Allamakee County is about 9,000 located primarily in forested land adjacent to streams. Another 1,000 have been added to account for other wildlife such as raccoons and waterfowl for a total estimate of 10,000. This works out to 0.024 deer per acre. Using this procedure, there are 233 deer in the subbasin in the concentrated in the forested areas. The deer are in the subbasin year round.

### Table 16-9 North Fork Yellow River watershed wildlife manure loads available for washoff

| Number of deer[1] | Forested area, ha | SWAT manure loading rate, kg/ha/day[2] | E. coli available for washoff, orgs[3] |
|:---:|:---:|:---:|:---:|
| 233 | 420 | 0.799 | 2.10E+11 |

1. Deer numbers are 0.024 deer/ha for the entire subbasin concentrated to 0.555 deer/ha in the forest land use. All wildlife loads are applied to the forest landuse in the SWAT model. The county deer numbers have been increased by 10% to account for other wildlife in the subbasin.
2. Assumes 1.44 kg/deer/day and 3.47E+05 orgs/gram.
3. Assumes that the maximum E. coli available for washoff is 1.8 times the daily load.

Field applications of CAFO manure.

There are about 2,400 hogs and 250,000 chickens in confinement in the subbasin. The manure from these is stored and land applied to cropland. The manure is distributed to the fields in the subbasin in the fall after soybean harvest and in the spring prior to corn planting in year 2 of a two year rotation. The relatively brief fall and spring timing of manure application and incorporation in the soil significantly reduces the E. coli organisms from these sources. Manure application is put in the SWAT model by subbasin as a load available at the end of October and the beginning of April.

**Table 16-10 North Fork Yellow River watershed confined livestock manure applications**

| Livestock type | Swine | Chickens | Dairy cows |
|---|---|---|---|
| Number of animals | 2,400 | 52,200 | 0 |
| Manure applied, kg/application[1] | 989,880 | 2,734,763 | 0 |
| Area applied to, acres[2] | 116 | 259 | 0 |
| Manure applied, kg/ha/day[3] | 2,127 | 2,326 | 0 |
| Subbasin E. coli, orgs/day | 2.65E+14 | 1.44E+14 | 0 |
| Subbasin E. coli available for washoff, orgs/day[4] | 4.76E+14 | 2.59E+14 | 0 |

1. Manure is calculated based on number of animals * dry manure (kg/animal/day)*365 days/year.
2. The area the manure is applied to is based on the manure's nitrogen content. Manure is applied at a rate equivalent to 201.6 kg N/ha/yr. Swine manure is applied at 2127 kg/ha, dairy manure at 2631 kg/ha and chicken manure at 2326 kg/ha. The E. coli content of manure for swine is 1.32E+07 orgs/gram, for dairy cows is 1.00E+07 orgs/gram, and for chickens is 2.96E+06 orgs/gram.
3. Manure is assumed to be applied to fields twice a year over 5 days on October 30 and April 1. It is incorporated in the soil and it is assumed that only 10% of bacteria are viable and available after storage and incorporation.
4. Maximum *E. coli* available for washoff are 1.8 times the daily maximum available load.

Seasonal variation of sources.
The relative impacts of the bacteria sources are shown in Figures 16-4 and 16-5. Figure 16-4 shows the relative loads delivered by the "continuous" sources, those sources present with or without rainfall and runoff. These are the failed septics that are assumed to be a problem every day of the year and the loads from cattle in the stream that vary by month from May to October. It can be seen in this figure that the impacts from cattle in the stream are much more significant than those from failed septic tank systems.

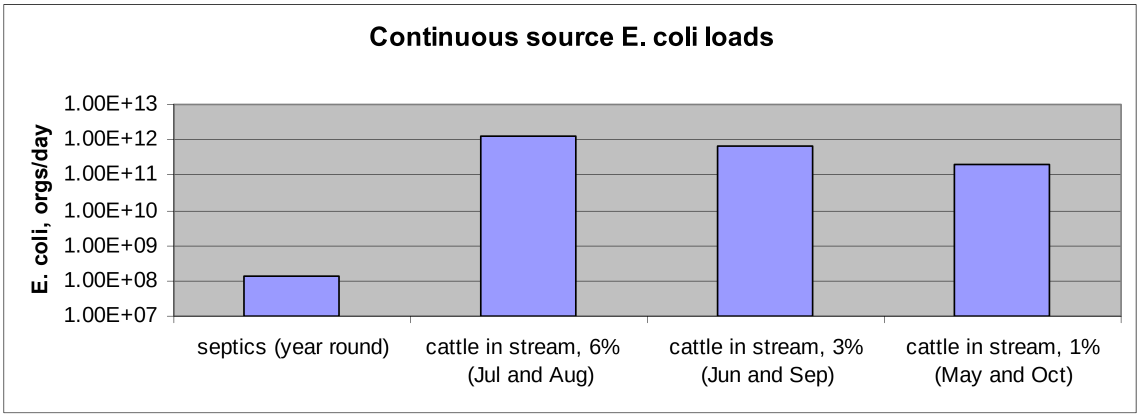

Figure 16-4 E. coli loads from "continuous" sources

The three general washoff sources of bacteria in the subbasin are shown in Figure 16-5. The wildlife source consists primarily of deer and smaller animals such as raccoons and waterfowl. These are year round sources. Pastured cattle consist of grazing cattle and

small poorly managed feedlot-like operations. The grazing season is modeled as lasting 168 days starting May 1. Manure from confined animal feeding operations (CAFO) is applied to cropland twice a year for a relatively brief time. Most field applied manure is assumed to be incorporated into the soil and most bacteria in it are not available. Confinement animals are swine, chickens and dairy cattle.

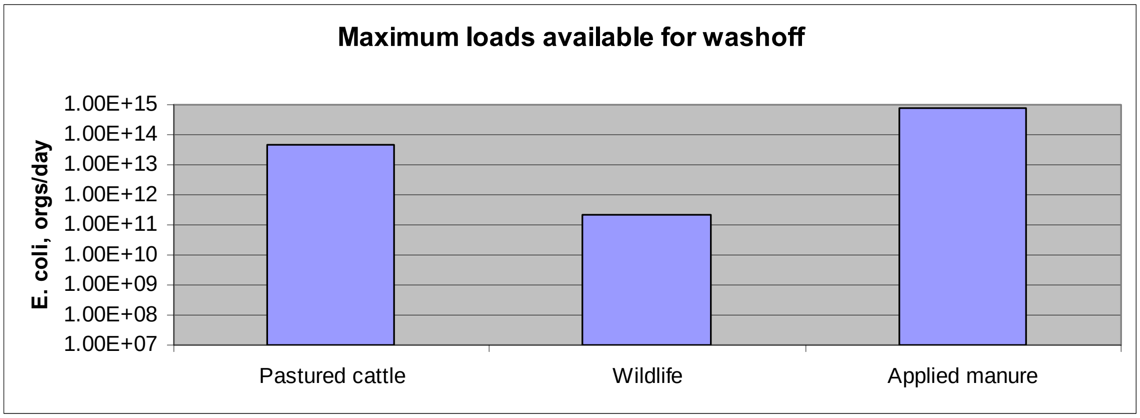

Figure 16-5 Maximum E. coli loads available for washoff

The maximum bacteria load to the stream occurs when the continuous source load plus the precipitation driven washoff load are combined. In general, the more rainfall the higher the flow and the more elevated the concentration. High flow and elevated concentration equal peak loads. The maximum potential load based on this analysis is 4.56E+13 orgs/day available for washoff plus the continuous load of 1.26E+12 orgs/day in July and August for a total of 4.69E+13 orgs/day.

<u>Flow interval load source analysis</u>. Based on the load duration curve analysis, the maximum existing load occurring during the zero to forty percent recurrence interval runoff condition is 3.77E+13 orgs/day and the total available load based on the potential sources, including fall and spring manure applications, is 7.81E+14 orgs/day. Generally, the maximum load in the stream, delivered in April when runoff is occurring, is approximately five percent of the bacteria available for washoff. At the zero to ten percent maximum existing load of 7.79E+13 orgs/day and the same load available for washoff, the stream load is ten percent of the available load.

### 16.3. Departure from load capacity

The departure from load capacity is the difference between the existing load and the load capacity. This varies for each of the five flow conditions. Table 16-11 shows this difference. The existing and target loads for the five flow conditions are shown graphically in Figure 16-6.

**Table 16-11 North Fork Yellow River departure from load capacity**

| Design flow condition, percent recurrence | Recurrence interval range (mid %) | Existing *E. coli* orgs/day | Load capacity, orgs/day | Departure from capacity, orgs/day |
|---|---|---|---|---|
| High flow | 0 to 10% (5) | 7.79E+13 | 2.4E+11 | 7.76E+13 |
| Moist conditions | 10% to 40% (25) | 2.23E+13 | 7.5E+10 | 2.23E+13 |
| Mid-range flow | 40% to 60% (50) | 1.32E+12 | 3.7E+10 | 1.28E+12 |
| Dry conditions | 60% to 90% (75) | 8.17E+11 | 2.5E+10 | 7.92E+11 |
| Low flow | 90% to 100% (95) | 3.57E+11 | 1.7E+10 | 3.40E+11 |

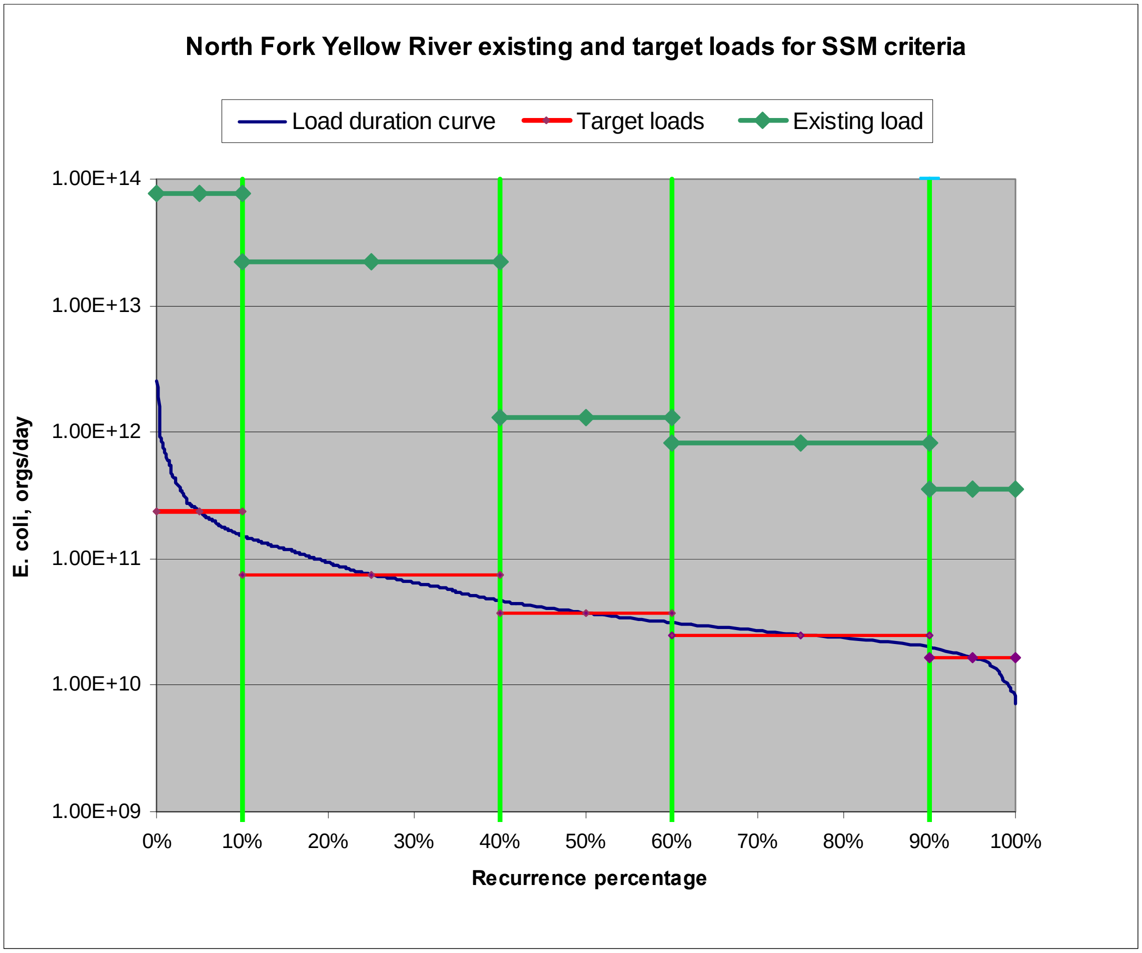

Figure 16-6 Difference between existing and target loads

## 16.4. Pollutant Allocations

*Wasteload allocations.*

Since there are no permitted discharges to North Fork Yellow River there are no wasteload allocations.

*Load allocation.*

The load allocations for *E. coli* TMDLs are the load capacity less an explicit 10 percent margin of safety (MOS) less the total WLA for the flow condition for the geometric mean

or single sample maximum. There is a separate load allocation set for each of the target recurrence intervals. The load allocations are shown in Tables 16-12 and 16-13.

### Table 16-12 North Fork Yellow River GM *E. coli* load allocations

| Flow condition, percent recurrence | GM target (TMDL) *E. Coli*, orgs/day | GM MOS *E. Coli*, orgs/day | Total WLA GM *E. coli*, orgs/day | LA GM *E. coli*, orgs/day |
|---|---|---|---|---|
| **High flows** | 1.3E+11 | 1.3E+10 | zero | 1.1E+11 |
| **Moist conditions** | 4.0E+10 | 4.0E+09 | zero | 3.6E+10 |
| **Mid-range flow** | 2.0E+10 | 2.0E+09 | zero | 1.8E+10 |
| **Dry conditions** | 1.3E+10 | 1.3E+09 | zero | 1.2E+10 |
| **Low flow** | 8.9E+09 | 8.9E+08 | zero | 8.0E+09 |

1. Based on geometric mean standard of 126 *E. coli* organisms/100 ml

### Table 16-13 North Fork Yellow River SSM *E. coli* load allocations

| Flow condition, percent recurrence | SSM target (TMDL) *E. Coli*, orgs/day | SSM MOS *E. Coli*, orgs/day | Total WLA SSM *E. coli*, orgs/day | LA SSM *E. coli*, orgs/day |
|---|---|---|---|---|
| **High flow** | 2.4E+11 | 2.4E+10 | zero | 2.1E+11 |
| **Moist conditions** | 7.5E+10 | 7.5E+09 | zero | 6.7E+10 |
| **Mid-range flow** | 3.7E+10 | 3.7E+09 | zero | 3.4E+10 |
| **Dry conditions** | 2.5E+10 | 2.5E+09 | zero | 2.2E+10 |
| **Low flow** | 1.7E+10 | 1.7E+09 | zero | 1.5E+10 |

1. Based on single sample maximum standard of 235 *E. coli* organisms/100 ml

*Margin of safety*.
The margin of safety for *E. coli* is an explicit 10 percent of the load capacity at each of the design recurrence intervals as shown in Tables 16-12 and 16-13.

## 16.5. TMDL Summary

The following equation shows the total maximum daily load (TMDL) and its components for the impaired IA 01-YEL-0160_0 segment of the North Fork Yellow River.

**Total Maximum Daily Load = Σ Load Allocations + Σ Wasteload Allocations+ MOS**

A Total Maximum Daily Load calculation has been made at design flow conditions for the GM and SSM of this segment and these are shown in Tables 16-14 and 16-15 and Figures 16-6 and 16-7.

### Table 16-14 North Fork Yellow River IA 01-YEL-0160_0 *E. coli* TMDL for GM

| Flow condition | Σ LA, orgs/day | Σ WLA, orgs/day | MOS, orgs/day | TMDL, orgs/day |
|---|---|---|---|---|
| **High flow** | 1.1E+11 | zero | 1.3E+10 | 1.3E+11 |
| **Moist condition** | 3.6E+10 | zero | 4.0E+09 | 4.0E+10 |
| **Mid-range flow** | 1.8E+10 | zero | 2.0E+09 | 2.0E+10 |
| **Dry conditions** | 1.2E+10 | zero | 1.3E+09 | 1.3E+10 |
| **Low flow** | 8.0E+09 | zero | 8.9E+08 | 8.9E+09 |

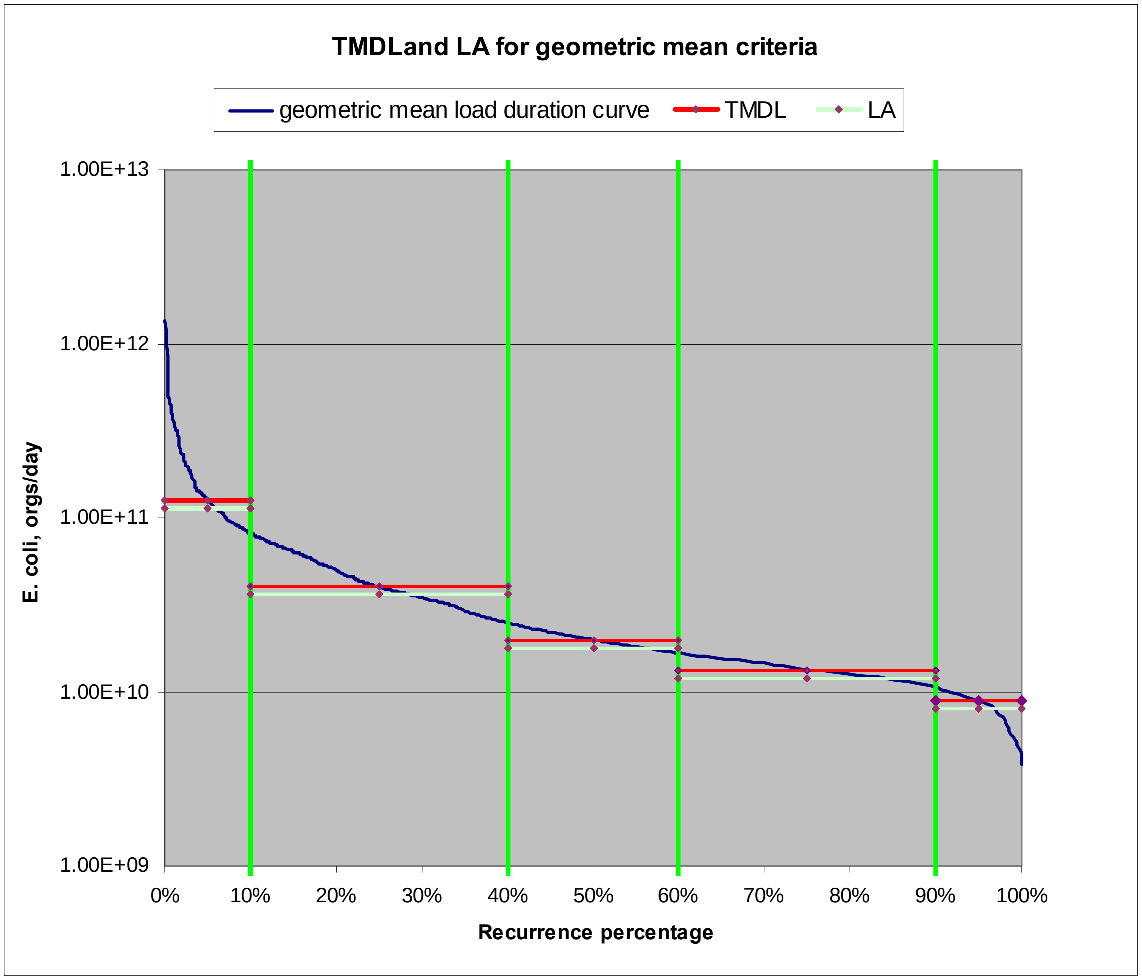

Figure 16-7 GM TMDL at WQS of 126 orgs/100 ml for the five flow conditions

### Table 16-15 North Fork Yellow River IA 01-YEL-0160_0 *E. coli* TMDL for SSM

| Flow condition | Σ LA, orgs/day | Σ WLA, orgs/day | MOS, orgs/day | TMDL, orgs/day |
|---|---|---|---|---|
| High flow | 2.1E+11 | zero | 2.4E+10 | 2.4E+11 |
| Moist condition | 6.7E+10 | zero | 7.5E+09 | 7.5E+10 |
| Mid-range flow | 3.4E+10 | zero | 3.7E+09 | 3.7E+10 |
| Dry conditions | 2.2E+10 | zero | 2.5E+09 | 2.5E+10 |
| Low flow | 1.5E+10 | zero | 1.7E+09 | 1.7E+10 |

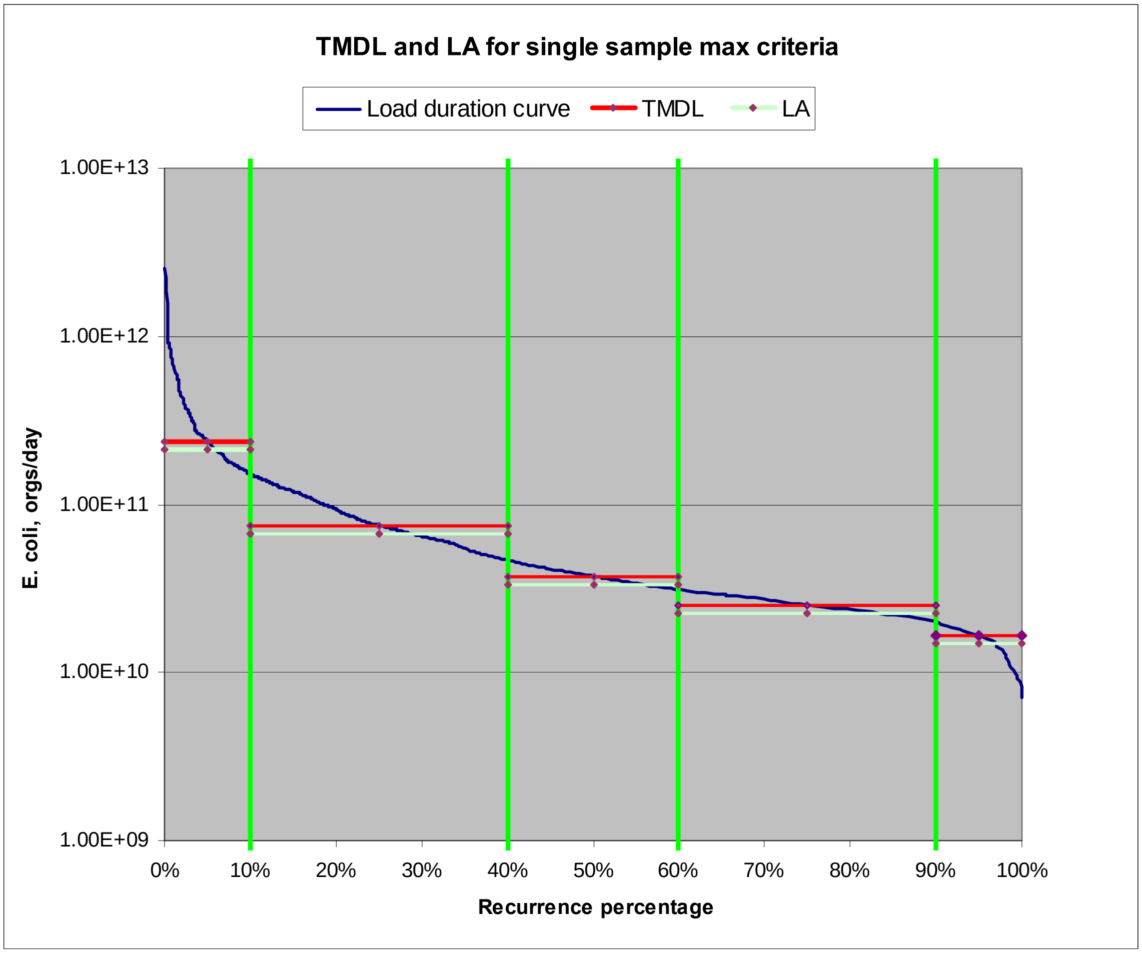

Figure 16-8 SSM TMDL at WQS of 235 orgs/100 ml for the five flow conditions

## 16.6. Implementation Analysis

The modeled systematic reduction of the loads by source provides the initial evaluation of proposed implementation plans for the subbasin. The SWAT model has been run in five scenarios in which loads have been reduced for the most significant sources. The source analysis identified the primary source of bacteria as cattle in the stream and field applied manure from CAFOs. Figure 16-9 shows the SWAT model output concentrations for the stream with monitored concentrations also plotted on the chart. The target concentration of 235 *E. coli* orgs/100 ml is frequently exceeded by both monitored data and SWAT simulated values.

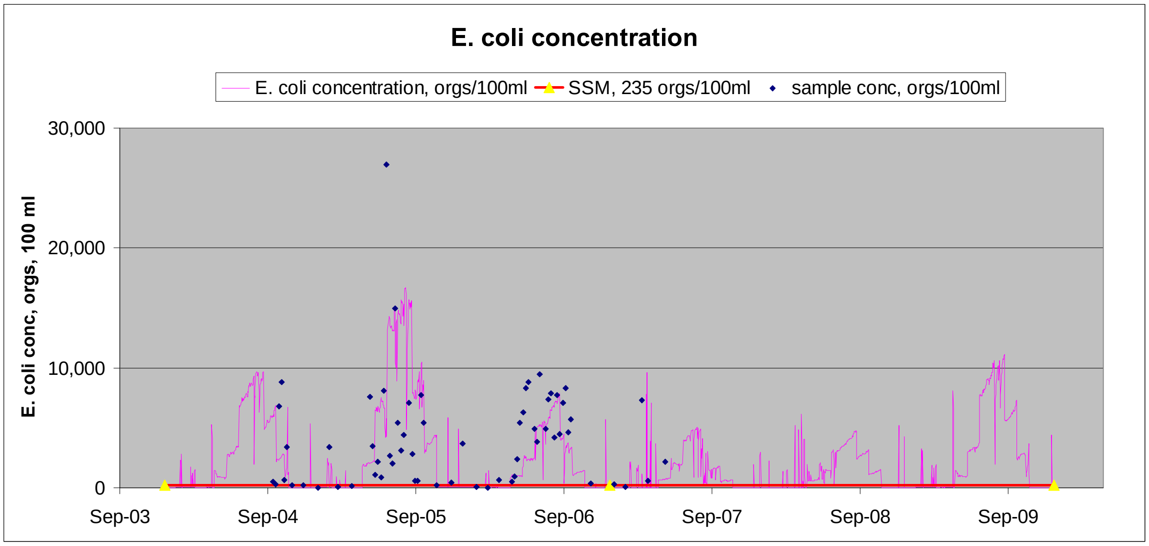

Figure 16-9 SWAT output for existing E. coli concentrations

The second scenario, Figure 16-10, removes half of the cattle in the stream from the subbasin. This generates concentrations that are much lower but that are still high compared to the SSM standard.

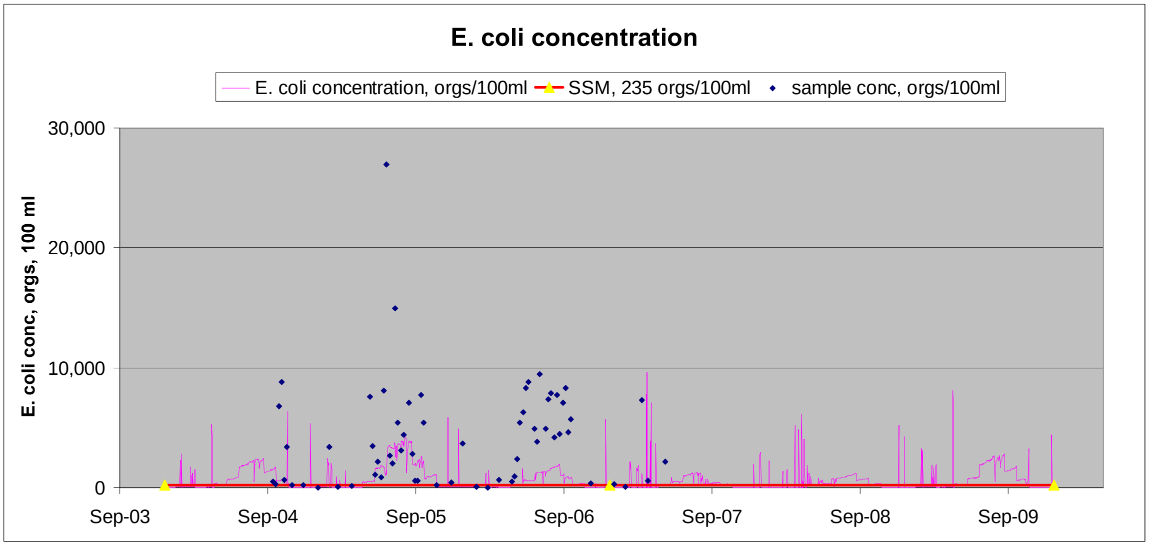

Figure 16-10 SWAT output for half reduction of CIS E. coli concentrations

The third scenario, shown in Figure 16-11, eliminates cattle in the stream altogether as a source. This drops the concentration during the grazing season but there remain quite a few instances of high bacteria concentration from runoff. Much of this is associated with field application of manure from confined animal operations and the assumption that it is often done in the spring when it rains harder and more often.

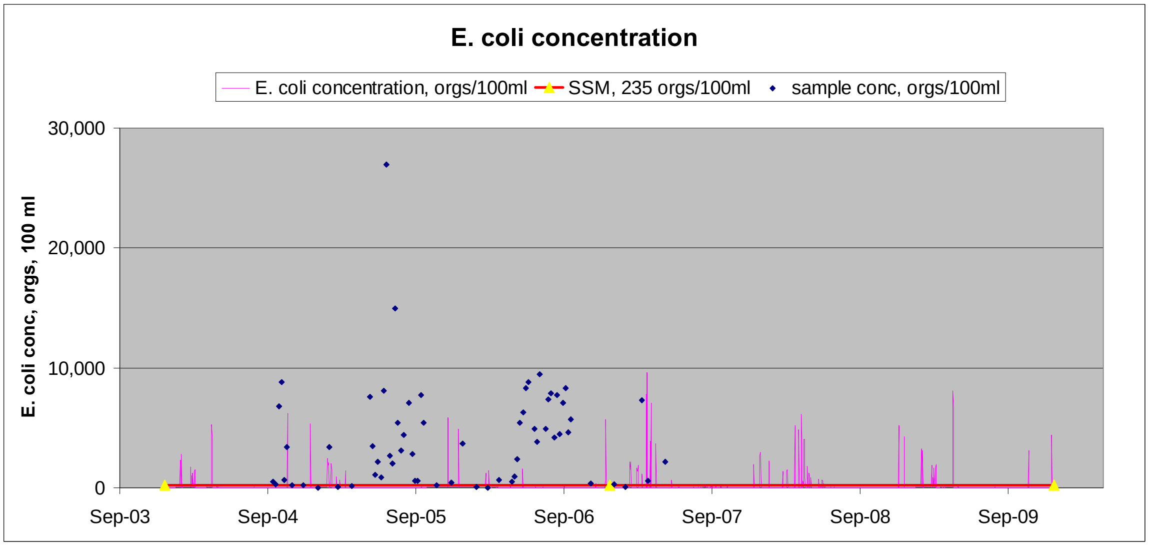

Figure 16-11 SWAT output for complete reduction of CIS E. coli

The fourth scenario, shown in Figure 16-12, assumes that the field applications of manure are cut in half. This reduces bacteria concentrations from these applications quite a bit but they still exceed the target.

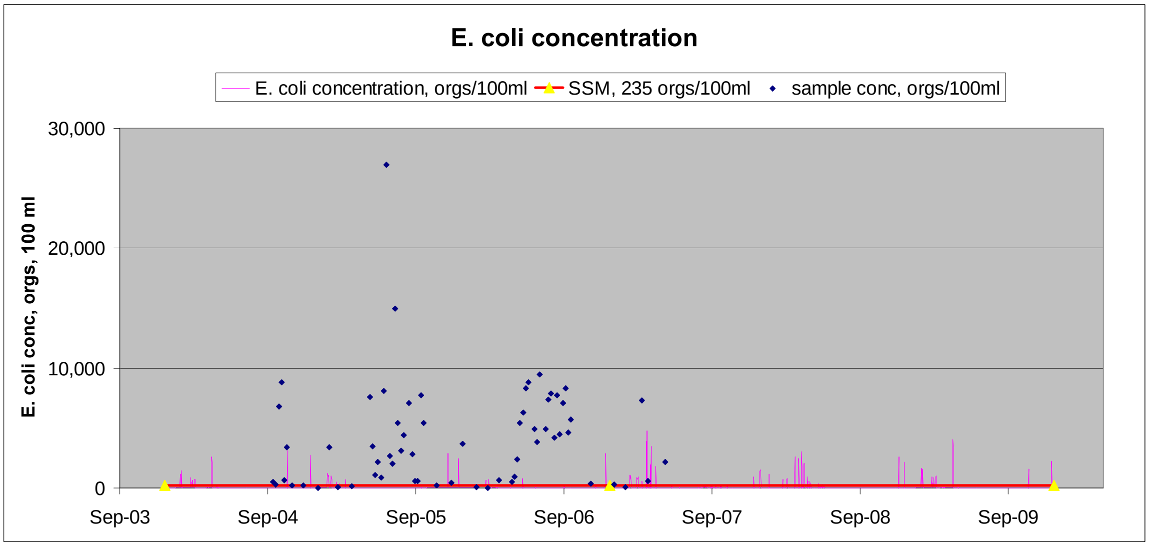

Figure 16-12 SWAT output for complete reduction of CIS E. coli and half of applied manure from CAFOs

The fifth scenario, shown in Figure 16-13, in addition to the previous reductions, cuts manure from cattle on pasture by two thirds. This pasture manure reduction showed a modest decrease in stream bacteria concentration.

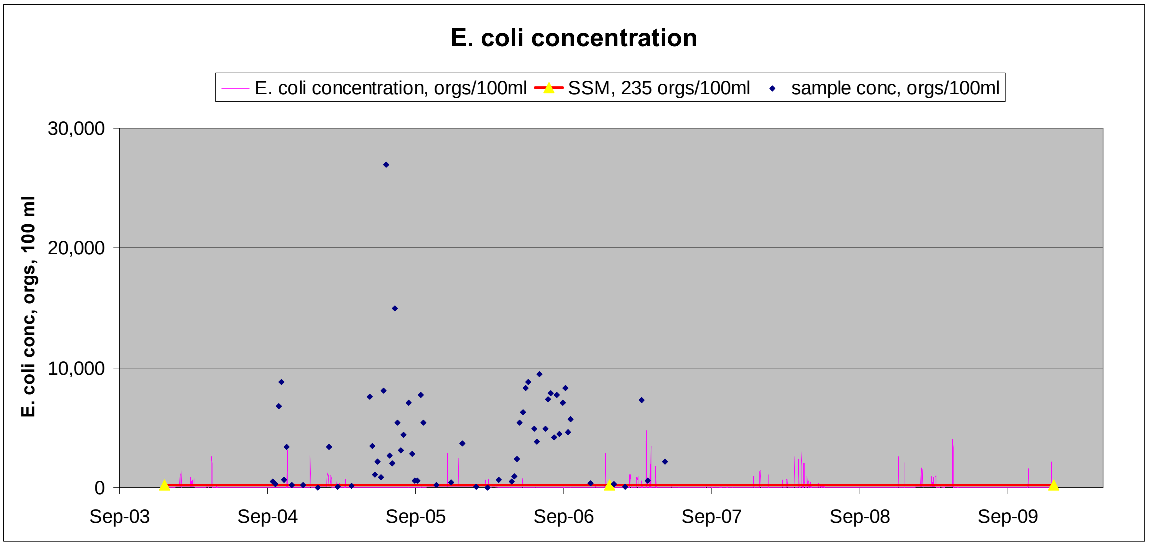

Figure 16-13 SWAT output for complete reduction of CIS E. coli and half of applied manure from CAFOs and a two thirds reduction of manure from cattle on pasture

There are several combinations of source reductions that can be simulated. The five scenarios described here reduce bacteria loads from the sources that have been modeled to have the greatest impact on stream outlet bacteria concentrations. It is worth noting that sources that are not reduced in these scenarios may have important episodic or local effect on *E. coli* organism numbers.

# 17. Implementation Plan

An implementation plan is not a required component of a TMDL document but it is a useful and logical extension of TMDL development. It provides IDNR staff, partners, and other watershed stakeholders with a general idea of how a specific strategy and work plan can be developed. This strategy should guide stakeholders and the IDNR in the development of a detailed and priority-based plan that implements best management practices, improves Yellow River Basin water quality, and moves towards meeting the TMDL water quality goals.

This water quality improvement plan sets targets for *E. coli* for the impaired segments of the Yellow River Basin. Watershed stakeholders, including municipalities and agricultural interests, will need to participate in the implementation of bacteria controls and continuing evaluation to accomplish water quality improvement goals. It will take an ongoing effort to develop best management practices in the watershed through projects funded by a variety of county, state and federal water quality improvement programs.

As a start, it would be useful to create a local watershed advisory committee to help identify high priority areas where resources can be concentrated for the greatest effect. This would facilitate the organization and provide direction for monitoring specific stream sites to identify significant pollutant sources and to plan water quality improvement activities.

## 17.1. Implementation Approach and Timeline

The bacteria impairments for the Yellow River Basin waterbodies occur at most flow conditions. Therefore, solutions need to be implemented for sources that are driven by runoff and continuous sources such as cattle in streams and failed septic systems. Stakeholders will need to participate in the implementation of pollutant controls and to continue evaluating water quality. Reductions in loads will require changes in the way manure and other waste is managed and these changes will take time to implement.
This will require:

- A systematic assessment of pollutant sources showing source location, magnitude, and relative impact based on proximity to streams and existing runoff controls. Requires field people in the watershed to evaluate and inventory bacteria sources.
- Continued water quality monitoring that builds on previous efforts and additional monitoring at the USGS gage.
- Support analysis that provides an understanding of watershed activities and practices contributing to bacteria problems.
- Application of watershed and water quality modeling to the design and evaluation of best management practices and where they can be most effectively implemented.

If goals are to be achieved then a schedule with milestones must be set. Below is an example of specific objectives and a timetable that suggests how Yellow River Basin water quality might be improved.

1. Identify, assess, and rank the potential nonpoint sources within one half mile of the Yellow River and its tributaries. Select best management practices for each source. Complete this as a first step.
2. Begin implementation of the best management practices by ranking for the nonpoint sources identified in step 1. Reduce the identified nonpoint source pathogen loading by 25 percent.
3. Continue the process of identifying, assessing and ranking nonpoint sources and selecting BMPs outward from the streams in half-mile increments every three to five years until the entire watershed has been covered.

## 17.2. Best Management Practices

Some best management practices for reducing pathogen indicators are:

- Limiting livestock access to waterways in pastures and providing alternate watering sources.
- Controlling manure runoff. Manure application should utilize incorporation or subsurface application of manure while controlling soil erosion. Incorporation physically separates fecal material from surface runoff. Buffer strips should be installed and maintained along the streams and tributaries to slow and divert runoff.
- Identifying, repairing, or replacing improperly connected and malfunctioning septic tank systems with on-site systems that meet state design standards.
- Discharges from all wastewater treatment facilities should be sampled for pathogen indicators and disinfected if they do not meet water quality standard *E. coli* criteria.

Table 17-1 lists best management practices that can be applied to the different categories of bacteria sources and an estimate of the impact the BMP would have if implemented.

**Table 17-1 Best Management Practices and associated efficiency[1]**

| **Best Management Practice** | **Efficiency** | **Notes** |
|---|---|---|
| **Agricultural BMPs** | | |
| Grass riparian Buffer | 40% | Bacteria efficiency assumed equal to sediment reduction efficiency. |
| Forested riparian buffer | 40% | Bacteria efficiency assumed equal to sediment reduction efficiency. |
| Cover crop | 20% | Bacteria efficiency assumed equal to sediment reduction efficiency. |
| Manure injection | 90% | Reduces manure in runoff |
| Manure storage facility, beef and dairy | 75% | Bacteria reduction occurs over time due to die-off |
| Poultry litter storage facility | 75% | Bacteria reduction occurs over time due to die-off |
| Livestock exclusion fencing | 100% | Eliminates or reduces cattle in stream bacteria. |
| Improved pasture management | 50% | Reduces runoff to streams |
| Wetland development and enhancement | 30% | Includes creation and restoration |
| Stream bank protection and stabilization | 40% | |
| Detention ponds/basins | 25% | Reduces runoff to streams |
| **On-site septic tank systems** | | |
| Septic system pump-out | 5% | Should be routine maintenance |
| Connect to public sewer | 100% | Requires sewer availability |
| Septic system repair | 100% | |
| Replacement of failed septic systems | 100% | |

1. Guidance Manual for TMDL Implementation Plans. Virginia Department of Environmental Quality. 2003

# 18. Monitoring

Monitoring is a critical element in assessing the current status of Yellow River Basin water resources and tracking water quality trends. Monitoring is also necessary to evaluate the effectiveness of watershed water quality improvements and to document the achievement of total maximum daily loads.

To improve water quality, this report must be followed by stakeholder driven solutions and more effective management practices. Continuing monitoring plays an important role in determining what practices result in load reductions and the attainment of water quality standards. Continued monitoring will:

- Assess the future beneficial use status;
- Determine if water quality is improving, getting worse, or staying the same;
- Evaluate the effectiveness of implemented best management practices.

Phased implementation is an iterative approach to managing water quality used when the origin, nature and sources of water quality impairments are not completely understood. Initially, the stream load capacity, existing pollutant load in excess of this capacity, and the source load allocations are based on the resources and information available. Future action will require monitoring that informs water quality changes.

## 18.1. Monitoring Plan

Due to resource limitations, existing monitoring described in this report is insufficient for detailed and comprehensive modeling and evaluation of Yellow River Basin water quality. Some beneficial additions to the monitoring design include the following:

- Frequent sampling at the USGS gage will improve the data sets used to indentify pollutant sources.
- Frequent sampling at the thirteen sites monitored from 2004 to 2007 at wider range of flow conditions, especially at high flows during the rising part of the hydrograph. This can provide a clearer picture of runoff nonpoint source bacteria loads.
- Install autosamplers and continuous flow meters at the same monitoring sites previously used. Sampling without continuous flow measurement is insufficient to provide load estimates for varying flow conditions.

## 18.2. Monitoring to Support Watershed Improvement Projects

Perform an annual load estimate trend analysis to evaluate the effectiveness of implemented BMPs. This should be part of an ongoing data analysis program that includes a statistical design for the number of samples required to achieve desired confidence in the results.

Monitoring for evaluation of BMP effectiveness should be targeted and designed to address loads from specific sources at different flow conditions where the mechanisms of delivery affect the load delivered. Precipitation driven runoff should be measured during and immediately after it rains so that runoff loads can be estimated.

# 19. Public Participation

Public involvement is important in the TMDL process since it is the landowners, tenants, municipalities and citizens who directly manage the land and live in the watershed that determine the water quality in the Yellow River Basin. IDNR has put together a plan to inform the public and stakeholders and receive input and comments on the Yellow River Basin water quality improvement plan.

## 19.1. Public Meetings

Three initial public information meetings were held at three locations in the watershed. The dates and locations of these three public information meetings were:

- September 26, 1 to 3 pm at the Yellow River State Forest Visitor Center, 729 State Forest Road, Harpers Ferry.
- September 26, 6 to 8 pm at the Allamakee County NRCS Office, 635 Ninth St. NW, Waukon.
- September 27, 9 to 11 am at the Ossian Community Building, 123 West Main St., Ossian.

## 19.2. Written Comments

The IDNR received no public comments during the public comment period, which took place from September 6, 2012, to October 8, 2012.

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# 21. Appendices

## Appendix A --- Glossary of Terms and Acronyms

| | |
|---|---|
| **303(d) list:** | Refers to section 303(d) of the Federal Clean Water Act, which requires a listing of all public surface water bodies (creeks, rivers, wetlands, and lakes) that do not support their general and/or designated uses. Also called the state's "Impaired Waters List." |
| **305(b) assessment:** | Refers to section 305(b) of the Federal Clean Water Act, it is a assessment of the state's water bodies ability to support their general and designated uses. Those found to be not supporting their uses are placed on the 303(d) list. |
| **319:** | Refers to Section 319 of the Federal Clean Water Act, the Nonpoint Source Management Program. States receive EPA grants to provide technical & financial assistance, education, and monitoring for local nonpoint source water quality improvement projects. |
| **AFO:** | Animal Feeding Operation. A livestock operation, either open or confined, where animals are kept in small areas (unlike pastures) allowing manure and feed to become concentrated. |
| **Base flow:** | The of stream flow from ground water. |
| **BMP:** | Best Management Practice. A general term for any structural or upland soil or water conservation practice. Examples are terraces, grass waterways, sediment retention ponds, and reduced tillage systems. |
| **CAFO:** | Confinement Animal Feeding Operation. An animal feeding operation in which livestock are confined and totally covered by a roof. |
| **Designated use(s):** | Refer to the type of economic, social, or ecologic activities that a specific water body is intended to support. See Appendix B for a description of general and designated uses. |
| **DNR (or IDNR):** | Iowa Department of Natural Resources. |
| **Ecoregion:** | A system used to classify geographic areas based on similar physical characteristics such as soils and geologic material, terrain, and drainage features. |
| **EPA (or USEPA):** | United States Environmental Protection Agency. |
| **FSA:** | Farm Service Agency (United States Department of Agriculture). Federal agency responsible for implementing farm policy, commodity, and conservation programs. |
| **General use(s):** | Refer to narrative water quality criteria that all public water bodies must meet to satisfy public needs and expectations. See Appendix B for a description of general and designated uses. |
| **GIS:** | Geographic Information System(s). A collection of map-based data and tools for creating, managing, and analyzing spatial information. |

| | |
|---|---|
| **LA:** | Load Allocation. The waterbody pollutant load that comes from *nonpoint sources* in a watershed. |
| **Load:** | The total amount (mass) of a particular pollutant in a waterbody. |
| **MOS:** | Margin of Safety. In a total maximum daily load (TMDL) report, it is a set-aside amount of a pollutant load to allow for any uncertainties in the data or modeling. |
| **Nonpoint source pollutants:** | Contaminants that originate from diffuse sources not covered by NPDES permits. |
| **NPDES:** | National Pollution Discharge Elimination System. A federal system of regulatory discharge controls that sets pollutant limits in permits for point source discharges to waters of the United States. |
| **NRCS:** | Natural Resources Conservation Service (United States Department of Agriculture). Federal agency that provides technical assistance for the conservation and enhancement of natural resources. |
| **Phytoplankton:** | Collective term for all suspended photosynthetic organisms that are the base of the aquatic food chain. Includes algae and cyano-bacteria. |
| **Point source pollution:** | NPDES permits regulate point sources. Point source discharges are usually from a location of flow concentration such as an outfall pipe. |
| **PPB:** | Parts per billion. A measure of concentration that is the equivalent of micrograms per liter (µg/l). |
| **PPM:** | Parts per million. A measure of concentration that is the equivalent of milligrams per liter (mg/l). |
| **Riparian:** | The area near water associated with streambanks and lakeshores and the physical, chemical, and biological characteristics that cause them to be different from dry upland sites. |
| **Sediment delivery ratio (SDR):** | The fraction of total eroded soil that is actually delivered to the stream or lake. |
| **Seston:** | All suspended particulate matter (organic and inorganic) in the water column. |
| **Sheet & rill erosion** | Water eroded soil loss that occurs diffusely over large flatter landscapes before the runoff concentrates. |
| **Storm flow (or stormwater):** | The fraction of stream flow that is direct surface runoff from precipitation. |
| **SWCD:** | Soil and Water Conservation District. Agency that provides local assistance for soil conservation and water quality project implementation, with support from the Iowa Department of Agriculture and Land Stewardship. |
| **TMDL:** | Total Maximum Daily Load. The maximum allowable amount of a pollutant that can be in a waterbody and still comply with the Iowa Water Quality Standards and support designated uses. |
| **TSS:** | Total Suspended Solids. The quantitative measure of seston, all materials, organic and inorganic, which are held in the water |

| | |
|---|---|
| | column. It is defined by the lab filtration procedures used to measure it. |
| **Turbidity:** | A measure of the scattering and absorption of light in water caused by suspended particles. |
| **UHL:** | University Hygienic Laboratory (University of Iowa). Collects field samples and does lab analysis of water for assessment of water quality. |
| **USGS:** | United States Geologic Survey. Federal agency responsible for flow gauging stations on Iowa streams. |
| **Watershed:** | The land surface that drains to a particular body of water or outlet. |
| **WLA:** | Waste Load Allocation. The allowable pollutant load that an NPDES permitted point source may discharge and not violate water quality standards. |
| **WQS**: | Water Quality Standards. Defined in Chapter 61 of Environmental Protection Commission [567] of the Iowa Administrative Code, they are the criteria by for water quality in Iowa. |
| **WWTP:** | Waste Water Treatment Plant. A facility that treats municipal and/or industrial wastewater so that the effluent complies with NPDES permit limits. |

**Scientific Notation**: Scientific notation is the way that scientists easily handle very large numbers or very small numbers. For example, instead of writing 45,000,000,000 we write 4.5E+10. So, how does this work?

We can think of 4.5E+10 as the product of two numbers: 4.5 (the digit term) and E+10 (the exponential term).

Here are some examples of scientific notation.

| | |
|---|---|
| 10,000 = 1E+4 | 24,327 = 2.4327E+4 |
| 1,000 = 1E+3 | 7,354 = 7.354E+3 |
| 100 = 1E+2 | 482 = 4.82E+2 |
| 1/100 = 0.01 = 1E-2 | 0.053 = 5.3E-2 |
| 1/1,000 = 0.001 = 1E-3 | 0.0078 = 7.8E-3 |
| 1/10,000 = 0.0001 = 1E-4 | 0.00044 = 4.4E-4 |

As you can see, the exponent is the number of places the decimal point must be shifted to give the number in long form. A **positive** exponent shows that the decimal point is shifted that number of places to the right. A **negative** exponent shows that the decimal point is shifted that number of places to the left.

# Appendix B --- General and Designated Uses of Iowa's Waters

## Introduction

Iowa's Water Quality Standards (Environmental Protection Commission [567], Chapter 61 of the Iowa Administrative Code) provide the narrative and numerical criteria used to assess water bodies for support of their aquatic life, recreational, and drinking water uses. There are different criteria for different waterbodies depending on their designated uses. All waterbodies must support the general use criteria.

## General Use Segments

A general use water body does not have perennial flow or permanent pools of water in most years, i.e. ephemeral or intermittent waterways. General use water bodies are defined in IAC 567-61.3(1) and 61.3(2). General use waters are protected for livestock and wildlife watering, aquatic life, non-contact recreation, crop irrigation, and industrial, agricultural, domestic and other incidental water withdrawal uses.

## Designated Use Segments

Designated use water bodies maintain year-round flow or pools of water sufficient to support a viable aquatic community. In addition to being protected for general use, perennial waters are protected for three specific uses, primary contact recreation (Class A), aquatic life (Class B), and drinking water supply (Class C). Within these categories there are thirteen designated use classes as shown in Table B1. Water bodies can have more than one designated use. The designated uses are found in IAC 567-61.3(1).

**Table B-1. Designated use classes for Iowa water bodies.**

| Class prefix | Class | Designated use | Comments |
|---|---|---|---|
| A | A1 | Primary contact recreation | Supports swimming, water skiing, etc. |
| | A2 | Secondary contact recreation | Limited/incidental contact occurs, such as boating |
| | A3 | Children's contact recreation | Urban/residential waters that are attractive to children |
| B | B(CW1) | Cold water aquatic life – Type 2 | Able to support coldwater fish (e.g. trout) populations |
| | B(CW2) | Cold water aquatic life – Type 2 | Typically unable to support consistent trout populations |
| | B(WW-1) | Warm water aquatic life – Type 1 | Suitable for game and nongame fish populations |
| | B(WW-2) | Warm water aquatic life – Type 2 | Smaller streams where game fish populations are limited by physical conditions & flow |
| | B(WW-3) | Warm water aquatic life – Type 3 | Streams that only hold small perennial pools which extremely limit aquatic life |
| | B(LW) | Warm water aquatic life – Lakes and Wetlands | Artificial and natural impoundments with "lake-like" conditions |
| C | C | Drinking water supply | Used for raw potable water |
| Other | HQ | High quality water | Waters with exceptional water quality |
| | HQR | High quality resource | Waters with unique or outstanding features |
| | HH | Human health | Fish are routinely harvested for human consumption |

# Appendix C --- Water Quality Data

The data sets in this appendix include all of the E. coli data collected at each of the monitoring sites described in Section 3.1. These primarily consist of the monitoring done from 2004 to 2008 at 13 sites and the TMDL monitoring done in 2009 at seven sites. The monitoring sites are labeled as the impaired segments they are associated with and include the estimated average daily flow used in the development of the flow and load duration curves.

## Yellow River 4 (0070_0)

The site USGS gage monitoring site at Ion (Yellow River 4 (0070_0) is the only site that has data collected for the IDNR ambient monitoring program. This monthly monitoring began in 1999 and continues today. Two other sets of E. coli data were combined with the ambient program data in Table C-1. These were the IDNR monitoring from 2004 to 2008 and the IDNR 2009 TMDL monitoring. The combined data are in chronological order.

**Table C-1 Yellow River 4, USGS gage site, combined *E. coli* data from 1999 to 2010**

| Date | E. Coli, orgs/100 ml | Mean daily flow estimate, cfs |
|---:|---:|---:|
| 05/11/99 | 160 | 250 |
| 08/17/99 | 180 | 170 |
| 10/07/99 | 60 | 91 |
| 11/08/99 | 20 | 62 |
| 12/07/99 | 1 | 65 |
| 01/13/00 | 1 | 45 |
| 02/23/00 | 2800 | 190 |
| 03/21/00 | 20 | 90 |
| 04/20/00 | 100 | 72 |
| 05/16/00 | 390 | 70 |
| 06/14/00 | 260000 | 1000 |
| 07/12/00 | 5400 | 180 |
| 08/16/00 | 250 | 100 |
| 09/20/00 | 120 | 52 |
| 10/09/00 | 50 | 49 |
| 11/09/00 | 2300 | 105 |
| 12/12/00 | 20 | 65 |
| 01/09/01 | 1 | 80 |
| 02/07/01 | 1 | 40 |
| 03/08/01 | 1 | 71 |
| 04/09/01 | 91 | 500 |
| 05/03/01 | 82000 | 900 |
| 06/07/01 | 810 | 210 |
| 07/05/01 | 70 | 130 |
| 08/01/01 | 45 | 89 |
| 09/12/01 | 2600 | 130 |
| 10/02/01 | 340 | 69 |
| 11/06/01 | 10 | 85 |
| 12/04/01 | 20 | 83 |
| 01/02/02 | 1 | 61 |
| 02/05/02 | 1 | 57 |
| 03/05/02 | 1 | 74 |
| 04/02/02 | 1 | 88 |

| Date | E. Coli, orgs/100 ml | Mean daily flow estimate, cfs |
|---:|---:|---:|
| 05/07/02 | 40 | 120 |
| 06/04/02 | 5200 | 280 |
| 07/01/02 | 1 | 100 |
| 08/06/02 | 5000 | 250 |
| 09/11/02 | 82 | 89 |
| 10/01/02 | 36 | 67 |
| 11/05/02 | 1 | 72 |
| 12/03/02 | 1 | 20 |
| 01/07/03 | 1 | 45 |
| 02/04/03 | 1 | 35 |
| 03/04/03 | 10 | 49 |
| 04/01/03 | 1 | 62 |
| 05/06/03 | 25000 | 220 |
| 06/03/03 | 10 | 120 |
| 07/08/03 | 360 | 150 |
| 08/05/03 | 80 | 58 |
| 09/02/03 | 10 | 47 |
| 10/07/03 | 10 | 39 |
| 11/04/03 | 380 | 85 |
| 12/02/03 | 1 | 38 |
| 01/06/04 | 1 | 35 |
| 02/03/04 | 1 | 40 |
| 03/02/04 | 1200 | 300 |
| 04/06/04 | 1 | 78 |
| 05/04/04 | 1 | 48 |
| 05/20/04 | 160 | 104 |
| 05/27/04 | 1100 | 586 |
| 06/01/04 | 2100 | 1000 |
| 06/17/04 | 8800 | 495 |
| 06/24/04 | 260 | 322 |
| 07/01/04 | 50 | 213 |
| 07/06/04 | 130000 | 1100 |
| 07/15/04 | 890 | 215 |
| 07/22/04 | 12000 | 228 |
| 07/29/04 | 230 | 149 |
| 08/03/04 | 8800 | 160 |
| 08/12/04 | 310 | 137 |
| 08/19/04 | 160 | 113 |
| 08/26/04 | 110 | 106 |
| 09/02/04 | 150 | 100 |
| 09/07/04 | 91 | 80 |
| 09/16/04 | 10 | 84 |
| 09/23/04 | 180 | 98 |
| 09/30/04 | 70 | 61 |
| 10/05/04 | 50 | 57 |
| 10/14/04 | 60 | 61 |
| 10/21/04 | 80 | 61 |
| 10/28/04 | 130 | 63 |
| 11/09/04 | 20 | 53 |
| 12/07/04 | 110 | 55 |
| 01/11/05 | 1 | 43 |
| 02/08/05 | 2900 | 268 |
| 03/01/05 | 10 | 55 |
| 04/05/05 | 1 | 78 |
| 04/14/05 | 1 | 77 |
| 04/21/05 | 50 | 81 |
| 04/28/05 | 10 | 67 |

| Date | E. Coli, orgs/100 ml | Mean daily flow estimate, cfs |
|---:|---:|---:|
| 05/03/05 | 1 | 54 |
| 05/12/05 | 73 | 59 |
| 05/19/05 | 72 | 64 |
| 05/26/05 | 1 | 54 |
| 06/02/05 | 10 | 54 |
| 06/07/05 | 70 | 58 |
| 06/16/05 | 80 | 51 |
| 06/23/05 | 100 | 47 |
| 06/30/05 | 260 | 83 |
| 07/06/05 | 140 | 69 |
| 07/14/05 | 82 | 57 |
| 07/21/05 | 730 | 67 |
| 07/28/05 | 2800 | 112 |
| 08/02/05 | 140 | 76 |
| 08/11/05 | 220 | 69 |
| 08/18/05 | 700 | 197 |
| 08/25/05 | 250 | 84 |
| 09/01/05 | 120 | 69 |
| 09/05/05 | 200 | 63 |
| 09/15/05 | 91 | 57 |
| 09/22/05 | 1000 | 63 |
| 09/29/05 | 190 | 76 |
| 10/06/05 | 190 | 65 |
| 10/11/05 | 1 | 57 |
| 10/13/05 | 150 | 58 |
| 10/20/05 | 10 | 51 |
| 10/27/05 | 10 | 47 |
| 11/01/05 | 82 | 49 |
| 12/06/05 | 10 | 29 |
| 01/03/06 | 30 | 48 |
| 02/07/06 | 10 | 70 |
| 03/07/06 | 1 | 52 |
| 04/04/06 | 380 | 370 |
| 04/13/06 | 10 | 237 |
| 04/20/06 | 230 | 412 |
| 04/27/06 | 10 | 222 |
| 05/02/06 | 16000 | 410 |
| 05/11/06 | 20 | 210 |
| 05/18/06 | 1 | 165 |
| 05/25/06 | 120 | 128 |
| 06/01/06 | 6600 | 218 |
| 06/05/06 | 230 | 200 |
| 06/15/06 | 340 | 177 |
| 06/22/06 | 79000 | 287 |
| 06/29/06 | 570 | 168 |
| 07/06/06 | 320 | 130 |
| 07/12/06 | 250 | 140 |
| 07/20/06 | 460 | 151 |
| 07/27/06 | 330 | 239 |
| 08/01/06 | 450 | 100 |
| 08/10/06 | 490 | 87 |
| 08/17/06 | 340 | 82 |
| 08/24/06 | 50 | 80 |
| 08/31/06 | 91 | 81 |
| 09/07/06 | 140 | 55 |
| 09/14/06 | 8300 | 113 |
| 09/21/06 | 130 | 74 |

| Date | E. Coli, orgs/100 ml | Mean daily flow estimate, cfs |
|---|---|---|
| 09/28/06 | 90 | 66 |
| 10/04/06 | 400 | 71 |
| 10/12/06 | 100 | 64 |
| 10/19/06 | 120 | 62 |
| 10/26/06 | 82 | 58 |
| 11/08/06 | 10 | 41 |
| 12/07/06 | 40 | 50 |
| 01/04/07 | 30 | 140 |
| 02/21/07 | 1 | 72 |
| 03/13/07 | 4100 | 1650 |
| 04/10/07 | 30 | 400 |
| 05/08/07 | 36 | 280 |
| 06/13/07 | 290 | 220 |
| 07/12/07 | 120 | 140 |
| 08/02/07 | 550 | 120 |
| 09/12/07 | 4900 | 390 |
| 10/09/07 | 2200 | 368 |
| 11/01/07 | 40 | 277 |
| 12/04/07 | 27 | 176 |
| 01/03/08 | 10 | 126 |
| 02/12/08 | 20 | 33 |
| 03/10/08 | 1 | 38 |
| 04/09/08 | 90 | 422 |
| 05/07/08 | 1100 | 541 |
| 06/03/08 | 280 | 237 |
| 07/09/08 | 10000 | 466 |
| 08/13/08 | 180 | 154 |
| 04/06/09 | 1 | 94 |
| 05/06/09 | 75 | 196 |
| 05/20/09 | 10 | 150 |
| 06/01/09 | 10 | 120 |
| 06/10/09 | 150 | 121 |
| 06/15/09 | 31 | 110 |
| 06/24/09 | 820 | 149 |
| 06/24/09 | 2800 | 149 |
| 06/29/09 | 170 | 120 |
| 07/06/09 | 74 | 93 |
| 07/13/09 | 74 | 110 |
| 08/04/09 | 10 | 84 |
| 08/08/09 | 6900 | 205 |
| 08/09/09 | 16000 | 214 |
| 08/09/09 | 11000 | 214 |
| 08/11/09 | 380 | 99 |
| 08/17/09 | 220 | 77 |
| 08/20/09 | 420 | 374 |
| 08/20/09 | 39000 | 487 |
| 08/21/09 | 34000 | 266 |
| 08/31/09 | 73 | 93 |
| 09/08/09 | 97 | 73 |
| 09/17/09 | 41 | 52 |
| 10/08/09 | 52 | 71 |
| 11/05/09 | 63 | 207 |
| 12/03/09 | 120 | 103 |
| 01/06/10 | 10 | 71 |
| 02/03/10 | 75 | 149 |
| 03/01/10 | 20 | 92 |
| 04/05/10 | 31 | 206 |

| Date | E. Coli, orgs/100 ml | Mean daily flow estimate, cfs |
|---:|---:|---:|
| 05/03/10 | 95 | 157 |
| 06/03/10 | 190 | 186 |
| 07/07/10 | 34000 | 1910 |
| 08/05/10 | 180 | 293 |

## Yellow River 3 (0080_1)

The data collected to represent this segment are from a site that is downstream of the segment since there were not any other sites within it. Only data from 2009 TMDL monitoring is available.

### Table C-2 Yellow River 3 *E. coli* data from 2009

| Date | E. Coli, orgs/100 ml | Mean daily flow estimate, cfs |
|---:|---:|---:|
| 5/20/2009 10:30 | 31 | 125 |
| 6/1/2009 14:20 | 74 | 103 |
| 6/15/2009 13:00 | 160 | 90 |
| 6/24/2009 11:30 | 600 | 123 |
| 6/24/2009 11:45 | 930 | 123 |
| 6/29/2009 13:20 | 320 | 92 |
| 7/13/2009 10:40 | 170 | 76 |
| 7/26/2009 9:10 | 1200 | 103 |
| 7/26/2009 11:10 | 960 | 103 |
| 7/26/2009 13:15 | 4900 | 103 |
| 8/4/2009 11:35 | 160 | 58 |
| 8/8/2009 21:55 | 16000 | 130 |
| 8/9/2009 7:55 | 6900 | 151 |
| 8/9/2009 9:05 | 5800 | 151 |
| 8/17/2009 11:05 | 280 | 74 |
| 8/20/2009 4:25 | 3100 | 260 |
| 8/21/2009 2:25 | 68000 | 260 |
| 8/21/2009 9:40 | 41000 | 260 |
| 8/31/2009 13:00 | 120 | 76 |
| 9/17/2009 11:10 | 130 | 52 |

## Yellow River 2 (0080_2)

There are two sites on this segment where monitoring was done. The most upstream of the these is Site 1 where most of the flow is from Yellow River 1 segment. The other is Site 2 and is towards the downstream end of the segment. Site 1 monitoring only consists of data collected for the 2009 TMDL monitoring.

### Table C-3 Yellow River 2 Site 1 - *E. coli* data from 2009

| Date | E. Coli, orgs/100 ml | Mean daily flow estimate, cfs |
|---:|---:|---:|
| 5/19/2009 10:20 | 230 | 31 |
| 6/1/2009 8:40 | 530 | 24 |
| 6/15/2009 9:00 | 360 | 21 |
| 6/29/2009 8:30 | 1500 | 22 |
| 7/13/2009 8:00 | 260 | 18 |
| 7/25/2009 1:26 | 24000 | 31 |
| 7/25/2009 17:26 | 24000 | 29 |
| 7/26/2009 10:35 | 24000 | 24 |
| 8/8/2009 14:26 | 44000 | 31 |
| 8/9/2009 6:26 | 98000 | 36 |

| Date | E. Coli, orgs/100 ml | Mean daily flow estimate, cfs |
|---:|---:|---:|
| 8/9/2009 7:30 | 30000 | 36 |
| 8/17/2009 16:04 | 870 | 18 |
| 8/19/2009 21:26 | 110000 | 87 |
| 8/20/2009 17:26 | 290000 | 47 |
| 8/20/2009 17:30 | 120000 | 47 |
| 8/31/2009 8:45 | 1000 | 18 |
| 9/17/2009 9:00 | 260 | 12 |

### Table C-4 Yellow River 2 Site 2 – all *E. coli* data, 2004 to 2009

| Date | E. Coli, orgs/100 ml | Mean daily flow estimate, cfs |
|---:|---:|---:|
| 5/20/2004 | 770 | NA |
| 5/27/2004 | 1500 | NA |
| 6/3/2004 | 1500 | NA |
| 6/10/2004 | 52000 | NA |
| 6/17/2004 | 80000 | NA |
| 6/24/2004 | 900 | NA |
| 7/1/2004 | 530 | NA |
| 7/8/2004 | 43000 | NA |
| 7/15/2004 | 2200 | NA |
| 7/22/2004 | 84000 | NA |
| 7/29/2004 | 2000 | NA |
| 8/5/2004 | 20000 | NA |
| 8/12/2004 | 420 | NA |
| 8/19/2004 | 550 | NA |
| 8/26/2004 | 750 | NA |
| 9/2/2004 | 480 | NA |
| 9/9/2004 | 210 | NA |
| 9/16/2004 | 490 | NA |
| 9/23/2004 | 270 | 27 |
| 9/30/2004 | 270 | 17 |
| 10/7/2004 | 290 | 17 |
| 10/14/2004 | 320 | 17 |
| 10/21/2004 | 130 | 17 |
| 10/28/2004 | 1900 | 17 |
| 11/9/2004 | 310 | 15 |
| 12/7/2004 | 110 | 15 |
| 1/11/2005 | 73 | 12 |
| 2/8/2005 | 3200 | 50 |
| 3/1/2005 | 36 | 21 |
| 4/5/2005 | 60 | 21 |
| 5/12/2005 | 2200 | 16 |
| 5/19/2005 | 1600 | 18 |
| 5/26/2005 | 230 | 15 |
| 6/2/2005 | 170 | 15 |
| 6/9/2005 | 260 | 14 |
| 6/16/2005 | 150 | 14 |
| 6/23/2005 | 140 | 13 |
| 6/30/2005 | 8900 | 23 |
| 7/7/2005 | 730 | 18 |
| 7/14/2005 | 340 | 16 |
| 7/21/2005 | 7100 | 18 |
| 7/28/2005 | 14000 | 28 |
| 8/4/2005 | 2100 | 21 |
| 8/11/2005 | 670 | 19 |
| 8/18/2005 | 63000 | 40 |

| Date | E. Coli, orgs/100 ml | Mean daily flow estimate, cfs |
|---:|---:|---:|
| 8/25/2005 | 1300 | 23 |
| 9/1/2005 | 4400 | 19 |
| 9/8/2005 | 530 | 17 |
| 9/15/2005 | 2300 | 16 |
| 9/22/2005 | 22000 | 17 |
| 9/29/2005 | 3600 | 21 |
| 11/1/2005 | 130 | 12 |
| 12/6/2005 | 50 | 8 |
| 1/3/2006 | 760 | 20 |
| 2/7/2006 | 10 | 19 |
| 3/7/2006 | 18 | 13 |
| 4/4/2006 | 530 | 65 |
| 5/4/2006 | 940 | 55 |
| 5/11/2006 | 22000 | 40 |
| 5/18/2006 | 3300 | 38 |
| 5/25/2006 | 440 | 35 |
| 6/1/2006 | 8900 | 40 |
| 6/8/2006 | 3300 | 45 |
| 6/15/2006 | 1400 | 48 |
| 6/22/2006 | 68000 | 79 |
| 6/29/2006 | 2000 | 46 |
| 7/6/2006 | 490 | 36 |
| 7/13/2006 | 950 | 37 |
| 7/20/2006 | 380000 | 41 |
| 7/27/2006 | 1200 | 50 |
| 8/10/2006 | 770 | 24 |
| 8/17/2006 | 640 | 22 |
| 8/24/2006 | 1200 | 22 |
| 8/31/2006 | 2500 | 22 |
| 9/7/2006 | 2200 | 19 |
| 9/14/2006 | 36000 | 40 |
| 9/21/2006 | 2400 | 20 |
| 9/28/2006 | 240 | 18 |
| 11/16/2006 | 370 | 14 |
| 1/11/2007 | 150 | 30 |
| 2/8/2007 | 20 | 20 |
| 3/22/2007 | 22000 | 200 |
| 4/5/2007 | 670 | 110 |
| 5/17/2007 | 330 | 43 |
| 6/14/2007 | 930 | 56 |
| 7/12/2007 | 340 | 30 |
| 8/16/2007 | 41000 | 180 |
| 9/6/2007 | 790 | 136 |
| 10/4/2007 | 13000 | 100 |
| 11/1/2007 | 320 | 76 |
| 12/6/2007 | 52 | 53 |
| 5/19/2009 12:50 | 20 | 44 |
| 6/1/2009 10:10 | 880 | 35 |
| 6/15/2009 10:00 | 1500 | 30 |
| 6/24/2009 10:00 | 4400 | 31 |
| 6/24/2009 10:15 | 1200 | 31 |
| 6/29/2009 9:40 | 590 | 26 |
| 7/13/2009 8:45 | 9800 | 25 |
| 8/4/2009 9:30 | 620 | 19 |
| 8/8/2009 17:26 | 34000 | 50 |
| 8/9/2009 9:50 | 24000 | 40 |
| 8/9/2009 10:26 | 34000 | 40 |

| Date | E. Coli, orgs/100 ml | Mean daily flow estimate, cfs |
|---|---|---|
| 8/17/2009 15:30 | 580 | 25 |
| 8/19/2009 22:56 | 47000 | 23 |
| 8/20/2009 18:56 | 170000 | 60 |
| 8/20/2009 19:10 | 100000 | 60 |
| 8/31/2009 9:45 | 510 | 25 |
| 9/17/2009 9:30 | 240 | 18 |

### Yellow River 1 (0080_3)

The Yellow River headwaters monitoring consists only of that done by IDNR from 2004 to 2007. This site was not sampled for the 2009 TMDL monitoring.

### Table C-5 Yellow River 1 - *E. coli* data, 2004 to 2007

| Date | E. Coli, orgs/100 ml | Mean daily flow estimate, cfs |
|---|---|---|
| 5/20/2004 | 5,200 | NA |
| 5/27/2004 | 1,100 | NA |
| 6/3/2004 | 400 | NA |
| 6/10/2004 | 110,000 | NA |
| 6/17/2004 | 240,000 | NA |
| 6/24/2004 | 2,000 | NA |
| 7/1/2004 | 2,400 | NA |
| 7/8/2004 | 5,400 | NA |
| 7/15/2004 | 2,200 | NA |
| 7/22/2004 | 360,000 | NA |
| 7/29/2004 | 20,000 | NA |
| 8/5/2004 | 9,600 | NA |
| 8/12/2004 | 2,500 | NA |
| 8/19/2004 | 77,000 | NA |
| 8/26/2004 | 15,000 | NA |
| 9/2/2004 | 6,800 | NA |
| 9/9/2004 | 5,400 | NA |
| 9/16/2004 | 6,000 | NA |
| 9/23/2004 | 2,400 | 9 |
| 9/30/2004 | 1,900 | 6 |
| 10/7/2004 | 640 | 6 |
| 10/14/2004 | 1,300 | 6 |
| 10/21/2004 | 1,300 | 6 |
| 10/28/2004 | 7,700 | 6 |
| 11/9/2004 | 780 | 5 |
| 12/7/2004 | 2,200 | 5 |
| 1/11/2005 | 190 | 4 |
| 2/8/2005 | 7,300 | 30 |
| 3/1/2005 | 550 | 7 |
| 4/5/2005 | 550 | 7 |
| 5/12/2005 | 270,000 | 8 |
| 5/19/2005 | 12,000 | 6 |
| 5/26/2005 | 3,800 | 5 |
| 6/2/2005 | 6,700 | 5 |
| 6/9/2005 | 1,500 | 5 |
| 6/16/2005 | 2,000 | 5 |
| 6/23/2005 | 5,300 | 4 |
| 6/30/2005 | 7,500 | 8 |
| 7/7/2005 | 2,300 | 6 |
| 7/14/2005 | 4,400 | 5 |

| Date | E. Coli, orgs/100 ml | Mean daily flow estimate, cfs |
|---|---|---|
| 7/21/2005 | 52,000 | 8 |
| 7/28/2005 | 3,200 | 14 |
| 8/4/2005 | 240,000 | 7 |
| 8/11/2005 | 21,000 | 6 |
| 8/18/2005 | 180,000 | 28 |
| 8/25/2005 | 7,600 | 8 |
| 9/1/2005 | 540 | 6 |
| 9/8/2005 | 4,500 | 6 |
| 9/15/2005 | 3,800 | 5 |
| 9/22/2005 | 11,000 | 6 |
| 9/29/2005 | 24,000 | 7 |
| 11/1/2005 | 920 | 4 |
| 12/6/2005 | 320 | 3 |
| 1/3/2006 | 29,000 | 8 |
| 2/7/2006 | 73 | 7 |
| 3/7/2006 | 3,400 | 4 |
| 4/4/2006 | 1,000 | 23 |
| 5/4/2006 | 1,600 | 20 |
| 5/11/2006 | 600 | 14 |
| 5/18/2006 | 1,500 | 13 |
| 5/25/2006 | 3,400 | 12 |
| 6/1/2006 | 7,500 | 20 |
| 6/8/2006 | 4,000 | 15 |
| 6/15/2006 | 3,100 | 12 |
| 6/22/2006 | 220,000 | 20 |
| 6/29/2006 | 3,400 | 9 |
| 7/6/2006 | 3,000 | 6 |
| 7/20/2006 | 830,000 | 14 |
| 8/3/2006 | 1,100 | 9 |
| 8/17/2006 | 2,800 | 8 |
| 8/31/2006 | 9,100 | 8 |
| 9/7/2006 | 1,700 | 7 |
| 9/12/2006 | 110,000 | 50 |
| 9/12/2006 | 450,000 | 50 |
| 9/14/2006 | 8,700 | 11 |
| 9/21/2006 | 1,100 | 7 |
| 9/28/2006 | 2,900 | 6 |
| 11/16/2006 | 230 | 5 |
| 1/11/2007 | 30 | 10 |
| 2/8/2007 | 10 | 7 |
| 3/8/2007 | 10 | 7 |
| 3/22/2007 | 5,900 | 50 |
| 4/5/2007 | 290 | 39 |
| 4/19/2007 | 360 | 29 |
| 4/30/2007 | 10 | 27 |

## Dousman Creek (0090_0)

Dousman Creek monitoring consists of that done by IDNR from 2004 to 2007. This site was not sampled for the 2009 TMDL monitoring and is the only impaired stream subbasin that is downstream of the USGS gage at Ion. Dousman Creek was sampled weekly from May through September.

## Table C-6 Dousman Creek - *E. coli* data, 2004 to 2007

| Date | E. Coli, orgs/100 ml | Mean daily flow estimate, cfs |
|---|---|---|
| 5/20/2004 | 2000 | 5 |
| 5/27/2004 | 120 | 6 |
| 6/3/2004 | 82 | 5 |
| 6/10/2004 | 180 | 6 |
| 6/17/2004 | 12000 | 32 |
| 6/24/2004 | 300 | 5 |
| 7/1/2004 | 55 | 4 |
| 7/8/2004 | 10 | 4 |
| 7/15/2004 | 55 | 4 |
| 7/22/2004 | 2400 | 17 |
| 7/29/2004 | 680 | 5 |
| 8/5/2004 | 1100 | 14 |
| 8/12/2004 | 120 | 5 |
| 8/19/2004 | 90 | 6 |
| 8/26/2004 | 82 | 5 |
| 9/2/2004 | 270 | 5 |
| 9/9/2004 | 170 | 5 |
| 9/16/2004 | 63 | 5 |
| 9/23/2004 | 130 | 5 |
| 9/30/2004 | 240 | 5 |
| 10/7/2004 | 91 | 5 |
| 10/14/2004 | 30 | 5 |
| 10/21/2004 | 120 | 5 |
| 10/28/2004 | 91 | 5 |
| 11/9/2004 | 45 | 5 |
| 12/7/2004 | 110 | 9 |
| 4/5/2005 | 1 | 3 |
| 5/12/2005 | 27 | 3 |
| 5/19/2005 | 10 | 6 |
| 5/26/2005 | 180 | 3 |
| 6/9/2005 | 18 | 2 |
| 6/16/2005 | 40 | 2 |
| 6/23/2005 | 91 | 2 |
| 6/30/2005 | 210 | 41 |
| 7/7/2005 | 260 | 2 |
| 7/14/2005 | 210 | 2 |
| 7/21/2005 | 2100 | 7 |
| 7/28/2005 | 81 | 2 |
| 8/4/2005 | 210 | 6 |
| 8/11/2005 | 300 | 3 |
| 8/18/2005 | 20000 | 91 |
| 8/25/2005 | 300 | 2 |
| 9/1/2005 | 210 | 2 |
| 9/8/2005 | 260 | 2 |
| 9/15/2005 | 150 | 2 |
| 9/22/2005 | 2100 | 2 |
| 9/29/2005 | 270 | 9 |
| 11/1/2005 | 1 | 2 |
| 2/6/2006 | 1 | 2 |

| Date | E. Coli, orgs/100 ml | Mean daily flow estimate, cfs |
|---:|---:|---:|
| 3/7/2006 | 1 | 2 |
| 4/4/2006 | 50 | 4 |
| 5/4/2006 | 60 | 3 |
| 5/11/2006 | 70 | 2 |
| 5/18/2006 | 30 | 2 |
| 5/25/2006 | 200 | 2 |
| 6/1/2006 | 2000 | 6 |
| 6/8/2006 | 260 | 2 |
| 6/15/2006 | 260 | 3 |
| 6/22/2006 | 180 | 4 |
| 6/29/2006 | 200 | 3 |
| 7/13/2006 | 120 | 3 |
| 7/20/2006 | 6200 | 11 |
| 7/27/2006 | 370 | 4 |
| 8/3/2006 | 220 | 3 |
| 8/10/2006 | 230 | 3 |
| 8/17/2006 | 500 | 3 |
| 8/24/2006 | 130 | 3 |
| 8/31/2006 | 130 | 3 |
| 9/7/2006 | 240 | 3 |
| 9/14/2006 | 840 | 11 |
| 9/21/2006 | 300 | 3 |
| 9/28/2006 | 91 | 3 |
| 11/16/2006 | 200 | 2 |
| 1/11/2007 | 1 | 2 |
| 5/17/2007 | 40 | 3 |
| 6/14/2007 | 110 | 4 |
| 7/12/2007 | 360 | 4 |
| 8/16/2007 | 860 | 30 |
| 9/6/2007 | 80 | 6 |
| 10/4/2007 | 470 | 13 |
| 11/1/2007 | 31 | 9 |
| 4/24/2008 | 1400 | 9 |
| 5/22/2008 | 30 | 9 |
| 6/19/2008 | 70 | 10 |
| 7/31/2008 | 2000 | 10 |
| 9/4/2008 | 590 | 10 |

## Suttle Creek (0100_0)

Suttle Creek monitoring consists of that done by IDNR from 2004 to 2007. This site was not sampled for the 2009 TMDL monitoring. Suttle Creek was sampled weekly from May through September.

## Table C-7 Suttle Creek - *E. coli* data, 2004 to 2007

| Date | E. Coli, orgs/100 ml | Mean daily flow estimate, cfs |
|---|---|---|
| 5/20/2004 | 880 | |
| 5/27/2004 | 2,600 | |
| 6/3/2004 | 490 | |
| 6/10/2004 | 550 | |
| 6/17/2004 | 1,500 | |
| 6/24/2004 | 1,100 | |
| 7/1/2004 | 3,800 | |
| 7/8/2004 | 1,100 | |
| 7/15/2004 | 3,100 | |
| 7/22/2004 | 22,000 | |
| 7/29/2004 | 2,000 | |
| 8/5/2004 | 8,800 | |
| 8/12/2004 | 650 | |
| 8/19/2004 | 600 | |
| 8/26/2004 | 720 | |
| 9/2/2004 | 2,100 | |
| 9/9/2004 | 260 | |
| 9/16/2004 | 810 | |
| 9/23/2004 | 260 | |
| 9/30/2004 | 310 | |
| 10/7/2004 | 60 | |
| 10/14/2004 | 90 | |
| 10/21/2004 | 70 | |
| 10/28/2004 | 130 | |
| 11/9/2004 | 50 | |
| 12/7/2004 | 180 | |
| 1/11/2005 | 1 | |
| 2/8/2005 | 2,000 | |
| 3/1/2005 | 1 | |
| 4/5/2005 | 20 | |
| 5/12/2005 | 10 | |
| 5/19/2005 | 510 | |
| 5/26/2005 | 1 | |
| 9/1/2005 | 830 | |
| 9/8/2005 | 270 | |
| 9/15/2005 | 90 | |
| 9/22/2005 | 1,300 | |
| 9/29/2005 | 330 | |
| 11/1/2005 | 1 | |
| 1/3/2006 | 27 | |
| 2/6/2006 | 20 | |
| 3/7/2006 | 1 | |
| 4/4/2006 | 160 | |
| 5/4/2006 | 130 | |
| 5/11/2006 | 210 | |
| 5/18/2006 | 530 | |
| 5/25/2006 | 330 | |
| 6/1/2006 | 20,000 | |
| 6/8/2006 | 7,400 | |
| 6/15/2006 | 1,100 | |

| Date | E. Coli, orgs/100 ml | Mean daily flow estimate, cfs |
|---|---|---|
| 6/22/2006 | 5,400 | |
| 6/29/2006 | 1,500 | |
| 7/6/2006 | 1,800 | |
| 7/13/2006 | 2,100 | |
| 7/20/2006 | 29,000 | |
| 7/27/2006 | 26,000 | |
| 8/3/2006 | 3,000 | |
| 8/10/2006 | 1,500 | |
| 8/17/2006 | 6,500 | |
| 8/24/2006 | 2,500 | |
| 8/31/2006 | 2,400 | |
| 9/7/2006 | 3,100 | |
| 9/14/2006 | 4,700 | |
| 9/21/2006 | 770 | |
| 9/28/2006 | 510 | |
| 11/16/2006 | 73 | |
| 1/11/2007 | 36 | |
| 3/22/2007 | 5,400 | |
| 4/5/2007 | 410 | |
| 5/17/2007 | 73 | |
| 6/14/2007 | 1,400 | |
| 7/12/2007 | 840 | |
| 8/16/2007 | 19,000 | |
| 9/6/2007 | 400 | |
| 10/4/2007 | 9,800 | |
| 11/1/2007 | 110 | |
| 12/6/2007 | 20 | |

## Bear Creek (0100_0)

Bear Creek monitoring consists of that done by IDNR weekly from May through September from 2004 to 2007 and the 2009 TMDL monitoring.

### Table C-8 Bear Creek - *E. coli* data, 2004 to 2007

| Date | E. Coli, orgs/100 ml | Mean daily flow estimate, cfs |
|---|---|---|
| 5/20/2004 | 64 | |
| 5/27/2004 | 670 | |
| 6/3/2004 | 590 | |
| 6/10/2004 | 69000 | |
| 6/17/2004 | 890 | |
| 6/24/2004 | 300 | |
| 7/1/2004 | 45 | |
| 7/8/2004 | 64 | |
| 7/15/2004 | 150 | |
| 7/22/2004 | 630 | |
| 7/29/2004 | 610 | |
| 8/5/2004 | 410 | |
| 8/12/2004 | 630 | |
| 8/19/2004 | 91 | |
| 8/26/2004 | 60 | |
| 9/2/2004 | 190 | |
| 9/9/2004 | 120 | |

| Date | E. Coli, orgs/100 ml | Mean daily flow estimate, cfs |
|---|---|---|
| 9/16/2004 | 91 | |
| 9/23/2004 | 170 | |
| 9/30/2004 | 20 | |
| 10/7/2004 | 0 | |
| 10/14/2004 | 60 | |
| 10/21/2004 | 80 | |
| 10/28/2004 | 200 | |
| 11/9/2004 | 10 | |
| 12/7/2004 | 20 | |
| 1/11/2005 | 0 | |
| 2/8/2005 | 340 | |
| 3/1/2005 | 0 | |
| 4/5/2005 | 0 | |
| 5/12/2005 | 110 | |
| 5/19/2005 | 10 | |
| 5/26/2005 | 45 | |
| 6/2/2005 | 82 | |
| 6/9/2005 | 240 | |
| 6/16/2005 | 410 | |
| 6/23/2005 | 250 | |
| 6/30/2005 | 470 | |
| 7/7/2005 | 200 | |
| 7/14/2005 | 180 | |
| 7/21/2005 | 5100 | |
| 7/28/2005 | 210 | |
| 8/4/2005 | 950 | |
| 8/11/2005 | 270 | |
| 8/18/2005 | 1200 | |
| 8/25/2005 | 150 | |
| 9/1/2005 | 90 | |
| 9/8/2005 | 73 | |
| 9/15/2005 | 110 | |
| 9/22/2005 | 100 | |
| 11/1/2005 | 64 | |
| 12/6/2005 | 40 | |
| 1/3/2006 | 27 | |
| 2/7/2006 | 0 | |
| 3/7/2006 | 0 | |
| 4/4/2006 | 20 | |
| 5/4/2006 | 60 | |
| 5/11/2006 | 60 | |
| 5/18/2006 | 60 | |
| 5/25/2006 | 250 | |
| 6/1/2006 | 40 | |
| 6/8/2006 | 220 | |
| 6/15/2006 | 300 | |
| 6/22/2006 | 290 | |
| 6/29/2006 | 470 | |
| 7/6/2006 | 230 | |
| 7/13/2006 | 440 | |
| 7/20/2006 | 710 | |
| 7/27/2006 | 2500 | |
| 8/3/2006 | 280 | |
| 8/10/2006 | 200 | |
| 8/17/2006 | 280 | |
| 8/24/2006 | 130 | |
| 8/31/2006 | 91 | |

| Date | E. Coli, orgs/100 ml | Mean daily flow estimate, cfs |
|---:|---:|---:|
| 9/7/2006 | 70 | |
| 9/14/2006 | 1300 | |
| 9/21/2006 | 520 | |
| 9/28/2006 | 100 | |
| 11/16/2006 | 360 | |
| 1/11/2007 | 40 | |
| 2/8/2007 | 0 | |
| 3/22/2007 | 950 | |
| 4/5/2007 | 160 | |
| 5/17/2007 | 0 | |
| 6/14/2007 | 170 | |
| 7/12/2007 | 580 | |
| 8/16/2007 | 16000 | |
| 9/6/2007 | 510 | |
| 10/4/2007 | 2200 | |
| 11/1/2007 | 160 | |
| 12/6/2007 | 10 | |
| 5/20/2009 9:30 | 52 | 4.5 |
| 6/1/2009 13:30 | 63 | 4.0 |
| 6/15/2009 12:20 | 52 | 4.0 |
| 6/20/2009 0:26 | 130000 | 14.0 |
| 6/20/2009 11:00 | 20000 | 7.0 |
| 6/29/2009 12:40 | 540 | 4.0 |
| 7/13/2009 10:15 | 170 | 4.0 |
| 8/8/2009 9:11 | 65000 | 20.0 |
| 8/9/2009 6:11 | 92000 | 15.0 |
| 8/9/2009 8:35 | 57000 | 10.0 |
| 8/17/2009 12:10 | 300 | 7.0 |
| 8/19/2009 23:41 | 4000 | 10.0 |
| 8/20/2009 16:41 | 220000 | 20.0 |
| 8/20/2009 19:41 | 88000 | 15.0 |
| 8/20/2009 22:41 | 58000 | 10.0 |
| 8/21/2009 9:10 | 14000 | 15.0 |
| 8/31/2009 11:00 | 140 | 4.0 |
| 9/17/2009 10:50 | 150 | 4.0 |

## Hickory Creek (0120_1)

Hickory Creek monitoring consists of that done by IDNR weekly from May through September from 2004 to 2007 and the 2009 TMDL monitoring. No rainfall events were captured in the 2009 monitoring.

### Table C-9 Hickory Creek - *E. coli* data, 2004 to 2007

| Date | E. Coli, orgs/100 ml | Mean daily flow estimate, cfs |
|---:|---:|---:|
| 5/20/2004 | 560 | 16 |
| 5/27/2004 | 950 | 15 |
| 6/3/2004 | 650 | 15 |
| 6/10/2004 | 2300 | 15 |
| 6/17/2004 | 23000 | 15 |
| 6/24/2004 | 1300 | 14 |
| 7/1/2004 | 560 | 14 |
| 7/8/2004 | 8800 | 14 |
| 7/15/2004 | 600 | 14 |
| 7/22/2004 | 53000 | 14 |
| 7/29/2004 | 1400 | 14 |

| Date | E. Coli, orgs/100 ml | Mean daily flow estimate, cfs |
|---:|---:|---:|
| 8/5/2004 | 3200 | 13 |
| 8/12/2004 | 2800 | 14 |
| 8/19/2004 | 730 | 14 |
| 8/26/2004 | 440 | 14 |
| 9/2/2004 | 450 | 14 |
| 9/9/2004 | 270 | 13 |
| 9/16/2004 | 170 | 13 |
| 9/23/2004 | 80 | 13 |
| 9/30/2004 | 150 | 13 |
| 10/7/2004 | 91 | 13 |
| 10/14/2004 | 91 | 12 |
| 10/21/2004 | 10 | 12 |
| 10/28/2004 | 70 | 13 |
| 11/9/2004 | 30 | 13 |
| 12/7/2004 | 20 | 11 |
| 1/11/2005 | 1 | 11 |
| 2/8/2005 | 4600 | 30 |
| 3/1/2005 | 1 | 10 |
| 4/5/2005 | 20 | 10 |
| 5/12/2005 | 170 | 10 |
| 5/19/2005 | 160 | 10 |
| 5/26/2005 | 220 | 9 |
| 6/2/2005 | 250 | 9 |
| 6/9/2005 | 310 | 9 |
| 6/16/2005 | 210 | 9 |
| 6/23/2005 | 590 | 9 |
| 6/30/2005 | 1200 | 10 |
| 7/7/2005 | 290 | 10 |
| 7/14/2005 | 680 | 10 |
| 7/21/2005 | 25000 | 10 |
| 7/28/2005 | 770 | 10 |
| 8/4/2005 | 710 | 10 |
| 8/11/2005 | 320 | 10 |
| 8/18/2005 | 31000 | 31 |
| 8/25/2005 | 200 | 10 |
| 9/1/2005 | 560 | 10 |
| 9/8/2005 | 320 | 10 |
| 9/15/2005 | 190 | 9 |
| 9/22/2005 | 440 | 9 |
| 9/29/2005 | 520 | 9 |
| 11/1/2005 | 54 | 9 |
| 12/6/2005 | 18 | 8 |
| 1/3/2006 | 90 | 7 |
| 2/7/2006 | 50 | 6 |
| 3/7/2006 | 20 | 5 |
| 4/4/2006 | 200 | 20 |
| 5/4/2006 | 540 | 20 |
| 5/11/2006 | 460 | 15 |
| 5/18/2006 | 150 | 12 |
| 5/25/2006 | 410 | 8 |
| 6/1/2006 | 4500 | 25 |
| 6/8/2006 | 1800 | 12 |
| 6/15/2006 | 790 | 12 |
| 6/22/2006 | 770 | 20 |
| 6/29/2006 | 1200 | 12 |
| 7/6/2006 | 560 | 12 |
| 7/13/2006 | 1200 | 10 |

| Date | E. Coli, orgs/100 ml | Mean daily flow estimate, cfs |
|---:|---:|---:|
| 7/20/2006 | 150000 | 20 |
| 7/27/2006 | 160000 | 25 |
| 8/3/2006 | 800 | 9 |
| 8/10/2006 | 870 | 9 |
| 8/17/2006 | 610 | 9 |
| 8/24/2006 | 580 | 9 |
| 8/31/2006 | 510 | 9 |
| 9/7/2006 | 490 | 9 |
| 9/14/2006 | 3100 | 15 |
| 9/21/2006 | 950 | 9 |
| 9/28/2006 | 950 | 10 |
| 11/16/2006 | 27 | 10 |
| 1/11/2007 | 50 | 11 |
| 2/8/2007 | 1 | 11 |
| 3/22/2007 | 1900 | 80 |
| 4/5/2007 | 90 | 35 |
| 5/17/2007 | 190 | 14 |
| 6/14/2007 | 600 | 15 |
| 7/12/2007 | 800 | 13 |
| 8/16/2007 | 5300 | 45 |
| 9/6/2007 | 560 | 35 |
| 10/4/2007 | 1800 | 35 |
| 11/1/2007 | 280 | 22 |
| 12/6/2007 | 52 | 23 |
| 5/19/2009 15:10 | 10 | 19 |
| 6/1/2009 12:00 | 340 | 16 |
| 6/15/2009 11:40 | 770 | 13 |
| 6/29/2009 11:20 | 990 | 10 |
| 7/13/2009 9:45 | 790 | 9 |
| 8/4/2009 10:30 | 880 | 7 |
| 8/17/2009 13:05 | 910 | 7 |
| 8/31/2009 11:45 | 630 | 6 |
| 9/17/2009 10:30 | 410 | 6 |

## Williams Creek (0125_0)

Williams Creek monitoring consists of that done by IDNR weekly from May through September from 2004 to 2007.

### Table C-10 Williams Creek - *E. coli* data, 2004 to 2007

| Date | E. Coli, orgs/100 ml | Mean daily flow estimate, cfs |
|---:|---:|---:|
| 5/20/2004 | 440 | 6 |
| 5/27/2004 | 650 | 14 |
| 6/3/2004 | 190 | 6 |
| 6/10/2004 | 4000 | 6 |
| 6/17/2004 | 2000 | 9 |
| 6/24/2004 | 1400 | 6 |
| 7/1/2004 | 710 | 6 |
| 7/8/2004 | 2600 | 6 |
| 7/15/2004 | 420 | 6 |
| 7/22/2004 | 4700 | 6 |
| 7/29/2004 | 530 | 7 |
| 8/5/2004 | 890 | 6 |
| 8/12/2004 | 160 | 6 |
| 8/19/2004 | 960 | 12 |

| Date | E. Coli, orgs/100 ml | Mean daily flow estimate, cfs |
|---:|---:|---:|
| 8/26/2004 | 140 | 6 |
| 9/2/2004 | 70 | 6 |
| 9/9/2004 | 130 | 6 |
| 9/16/2004 | 210 | 6 |
| 9/23/2004 | 64 | 6 |
| 9/30/2004 | 54 | 6 |
| 10/7/2004 | 10 | 6 |
| 10/14/2004 | 30 | 6 |
| 10/21/2004 | 55 | 7 |
| 10/28/2004 | 160 | 5 |
| 11/9/2004 | 40 | 5 |
| 12/7/2004 | 310 | 5 |
| 1/11/2005 | 1 | 3 |
| 2/8/2005 | 2800 | 20 |
| 3/1/2005 | 1 | 5 |
| 4/5/2005 | 1 | 4 |
| 5/12/2005 | 180 | 4 |
| 5/19/2005 | 40 | 4 |
| 5/26/2005 | 82 | 4 |
| 6/2/2005 | 110 | 4 |
| 6/9/2005 | 36 | 4 |
| 6/16/2005 | 970 | 4 |
| 6/23/2005 | 100 | 4 |
| 6/30/2005 | 900 | 10 |
| 7/7/2005 | 280 | 5 |
| 7/14/2005 | 130 | 5 |
| 7/21/2005 | 5400 | 13 |
| 7/28/2005 | 280 | 6 |
| 8/4/2005 | 440 | 5 |
| 8/11/2005 | 430 | 5 |
| 8/18/2005 | 2800 | 20 |
| 8/25/2005 | 70 | 5 |
| 9/1/2005 | 290 | 4 |
| 9/8/2005 | 150 | 4 |
| 9/15/2005 | 82 | 4 |
| 9/22/2005 | 270 | 4 |
| 9/29/2005 | 330 | 6 |
| 11/1/2005 | 80 | 4 |
| 12/6/2005 | 20 | 2 |
| 1/3/2006 | 130 | 4 |
| 2/7/2006 | 10 | 3 |
| 3/7/2006 | 1 | 3 |
| 4/4/2006 | 590 | 5 |
| 5/4/2006 | 1800 | 15 |
| 5/11/2006 | 73 | 5 |
| 5/18/2006 | 130 | 5 |
| 5/25/2006 | 200 | 5 |
| 6/1/2006 | 5900 | 15 |
| 6/8/2006 | 710 | 8 |
| 6/15/2006 | 530 | 8 |
| 6/22/2006 | 1000 | 12 |
| 6/29/2006 | 750 | 8 |
| 7/6/2006 | 440 | 6 |
| 7/13/2006 | 390 | 6 |
| 7/20/2006 | 170000 | 20 |
| 7/27/2006 | 210000 | 15 |
| 8/3/2006 | 350 | 5 |

| Date | E. Coli, orgs/100 ml | Mean daily flow estimate, cfs |
|---:|---:|---:|
| 8/10/2006 | 230 | 4 |
| 8/17/2006 | 440 | 4 |
| 8/24/2006 | 280 | 4 |
| 8/31/2006 | 190 | 4 |
| 9/7/2006 | 150 | 4 |
| 9/14/2006 | 3700 | 15 |
| 9/21/2006 | 180 | 4 |
| 9/28/2006 | 220 | 4 |
| 11/16/2006 | 36 | 5 |
| 1/11/2007 | 10 | 5 |
| 2/8/2007 | 10 | 6 |
| 3/22/2007 | 4500 | 50 |
| 4/5/2007 | 2900 | 20 |
| 5/17/2007 | 210 | 10 |
| 6/14/2007 | 740 | 10 |
| 7/12/2007 | 330 | 9 |
| 8/16/2007 | 2700 | 25 |
| 9/6/2007 | 1200 | 10 |
| 10/4/2007 | 1600 | 25 |
| 11/1/2007 | 100 | 14 |
| 12/6/2007 | 1 | 15 |

## Norfolk Creek (0130_0)

Norfolk Creek monitoring consists of that done by IDNR weekly from May through September from 2004 to 2007. This site was not included in the 2009 TMDL monitoring.

### Table C-11 Norfolk Creek - *E. coli* data, 2004 to 2007

| Date | E. Coli, orgs/100 ml | Mean daily flow estimate, cfs |
|---:|---:|---:|
| 9/23/2004 | 220 | 11.59 |
| 9/30/2004 | 280 | 8.00 |
| 10/7/2004 | 27 | 8.00 |
| 10/14/2004 | 40 | 8.00 |
| 10/21/2004 | 64 | 8.00 |
| 10/28/2004 | 260 | 8.00 |
| 11/9/2004 | 18 | 7.00 |
| 12/7/2004 | 30 | 5.00 |
| 1/11/2005 | 1 | 4.00 |
| 2/8/2005 | 1300 | 25.00 |
| 3/1/2005 | 1 | 10.00 |
| 4/5/2005 | 1 | 10.00 |
| 5/12/2005 | 100 | 7.00 |
| 5/19/2005 | 27 | 8.00 |
| 5/26/2005 | 90 | 7.00 |
| 6/2/2005 | 110 | 6.00 |
| 6/9/2005 | 180 | 6.00 |
| 6/16/2005 | 120 | 6.00 |
| 6/23/2005 | 180 | 6.00 |
| 6/30/2005 | 1100 | 9.00 |
| 7/7/2005 | 230 | 9.00 |
| 7/14/2005 | 250 | 8.00 |
| 7/21/2005 | 4400 | 7.00 |
| 7/28/2005 | 600 | 15.00 |
| 8/4/2005 | 900 | 8.4 |
| 8/11/2005 | 310 | 7.5 |

| Date | E. Coli, orgs/100 ml | Mean daily flow estimate, cfs |
|---:|---:|---:|
| 8/18/2005 | 190000 | 20.00 |
| 8/25/2005 | 190 | 9.1 |
| 9/1/2005 | 64 | 7.5 |
| 9/8/2005 | 80 | 6.8 |
| 9/15/2005 | 170 | 6.2 |
| 9/22/2005 | 5400 | 6.8 |
| 9/29/2005 | 440 | 8.2 |
| 11/1/2005 | 30 | 6.00 |
| 12/6/2005 | 10 | 3.0 |
| 1/3/2006 | 36 | 6.6 |
| 2/7/2006 | 1 | 7.6 |
| 3/7/2006 | 1 | 5.0 |
| 4/4/2006 | 30 | 25.00 |
| 5/4/2006 | 70 | 23.00 |
| 5/11/2006 | 130 | 21.00 |
| 5/18/2006 | 10 | 17.8 |
| 5/25/2006 | 170 | 13.8 |
| 6/1/2006 | 170 | 20.00 |
| 6/8/2006 | 150 | 23.4 |
| 6/15/2006 | 270 | 19.1 |
| 6/22/2006 | 38000 | 20.00 |
| 6/29/2006 | 290 | 15.00 |
| 7/6/2006 | 180 | 13.00 |
| 7/13/2006 | 200 | 12.00 |
| 7/20/2006 | 450 | 12.00 |
| 7/27/2006 | 1100 | 11.00 |
| 8/3/2006 | 210 | 10.00 |
| 8/10/2006 | 360 | 9.00 |
| 8/17/2006 | 240 | 9.00 |
| 8/24/2006 | 270 | 9.00 |
| 8/31/2006 | 280 | 8.7 |
| 9/7/2006 | 150 | 7.6 |
| 9/14/2006 | 350 | 12.2 |
| 9/21/2006 | 140 | 8.0 |

## Ludlow Creek (0150_0)

Ludlow Creek monitoring consists of that done by IDNR weekly from May through September from 2004 to 2007 and the 2009 TMDL monitoring.

**Table C-12 Ludlow Creek - *E. coli* data, 2004 to 2007**

| Date | E. Coli, orgs/100 ml | Mean daily flow estimate, cfs |
|---:|---:|---:|
| 9/23/2004 | 140 | 5 |
| 9/30/2004 | 82 | 3 |
| 10/7/2004 | 20 | 3 |
| 10/14/2004 | 45 | 3 |
| 10/21/2004 | 30 | 3 |
| 10/28/2004 | 45 | 3 |
| 11/9/2004 | 1 | 3 |
| 12/7/2004 | 20 | 3 |
| 1/11/2005 | 1 | 2 |
| 2/8/2005 | 2100 | 25 |
| 3/1/2005 | 10 | 4 |
| 4/5/2005 | 20 | 4 |
| 5/12/2005 | 120 | 3 |

| Date | E. Coli, orgs/100 ml | Mean daily flow estimate, cfs |
|---:|---:|---:|
| 5/19/2005 | 120 | 3 |
| 5/26/2005 | 480 | 3 |
| 6/2/2005 | 72 | 3 |
| 6/9/2005 | 150 | 3 |
| 6/16/2005 | 280 | 3 |
| 6/23/2005 | 410 | 2 |
| 6/30/2005 | 6100 | 4 |
| 7/7/2005 | 200 | 3 |
| 7/14/2005 | 530 | 3 |
| 7/21/2005 | 11000 | 10 |
| 7/28/2005 | 5300 | 12 |
| 8/4/2005 | 2100 | 4 |
| 8/11/2005 | 440 | 4 |
| 8/18/2005 | 200000 | 15 |
| 8/25/2005 | 950 | 4 |
| 9/1/2005 | 380 | 4 |
| 9/8/2005 | 200 | 3 |
| 9/15/2005 | 210 | 3 |
| 9/22/2005 | 45000 | 3 |
| 9/29/2005 | 1600 | 4 |
| 11/1/2005 | 20 | 2 |
| 12/6/2005 | 10 | 1 |
| 1/3/2006 | 50 | 3 |
| 2/7/2006 | 30 | 4 |
| 3/7/2006 | 10 | 2 |
| 4/4/2006 | 410 | 19 |
| 5/4/2006 | 520 | 17 |
| 5/11/2006 | 8500 | 11 |
| 5/18/2006 | 180 | 9 |
| 5/25/2006 | 170 | 7 |
| 6/1/2006 | 25000 | 18 |
| 6/8/2006 | 990 | 12 |
| 6/15/2006 | 260 | 9 |
| 6/22/2006 | 150000 | 15 |
| 6/29/2006 | 860 | 9 |
| 7/6/2006 | 680 | 7 |
| 7/13/2006 | 930 | 7 |
| 7/20/2006 | 2700 | 10 |
| 7/27/2006 | 600 | 13 |
| 8/3/2006 | 330 | 5 |
| 8/10/2006 | 590 | 5 |
| 8/17/2006 | 420 | 4 |
| 8/24/2006 | 190 | 4 |
| 8/31/2006 | 800 | 4 |
| 9/7/2006 | 300 | 4 |
| 9/14/2006 | 120000 | 20 |
| 9/21/2006 | 400 | 4 |
| 9/28/2006 | 1000 | 3 |
| 11/16/2006 | 80 | 3 |
| 1/11/2007 | 10 | 7 |
| 2/8/2007 | 1 | 4 |
| 3/22/2007 | 3700 | 40 |
| 4/5/2007 | 110 | 30 |
| 5/17/2007 | 55 | 8 |
| 6/14/2007 | 230 | 10 |
| 7/12/2007 | 440 | 6 |
| 8/16/2007 | 5800 | 35 |

| Date | E. Coli, orgs/100 ml | Mean daily flow estimate, cfs |
|---:|---:|---:|
| 9/6/2007 | 150 | 26 |
| 10/4/2007 | 14000 | 40 |
| 11/1/2007 | 320 | 15 |
| 12/6/2007 | 210 | 10 |
| 5/19/2009 13:40 | 10 | 8 |
| 6/1/2009 11:00 | 1000 | 7 |
| 6/15/2009 11:00 | 280 | 6 |
| 6/29/2009 10:20 | 120 | 6 |
| 7/13/2009 9:00 | 1100 | 5 |
| 8/4/2009 9:50 | 75 | 4 |
| 8/17/2009 14:40 | 95 | 5 |
| 8/19/2009 21:41 | 38000 | 20 |
| 8/20/2009 18:41 | 130000 | 40 |
| 8/20/2009 18:20 | 51000 | 20 |
| 8/31/2009 10:10 | 140 | 5 |
| 9/17/2009 9:50 | 470 | 3 |

## Hecker Creek (0155_0)

Hecker Creek monitoring consists of that done by IDNR weekly from May through September from 2004 to 2007. In addition to this monitoring, Hecker Creek was monitored for a Stressor Identification investigation. The results of this monitoring are shown separately towards the bottom of the table.

### Table C-13 Hecker Creek - *E. coli* data, 2004 to 2007

| Date | E. Coli, orgs/100 ml | Mean daily flow estimate, cfs |
|---:|---:|---:|
| 10/28/2004 | 84000 | 4.0 |
| 2/8/2005 | 2600 | 8.0 |
| 5/12/2005 | 1600 | 2.7 |
| 5/19/2005 | 550 | 2.2 |
| 6/9/2005 | 32000 | 2.2 |
| 6/30/2005 | 110000 | 3.6 |
| 7/21/2005 | 1200000 | 4.5 |
| 8/4/2005 | 240000 | 2.2 |
| 8/18/2005 | 160000 | 7.1 |
| 8/25/2005 | 1300 | 1.8 |
| 9/1/2005 | 5700 | 1.8 |
| 9/8/2005 | 600 | 1.7 |
| 9/15/2005 | 580 | 1.7 |
| 9/22/2005 | 34000 | 1.7 |
| 9/29/2005 | 10000 | 2.4 |
| 3/7/2006 | 91 | 1.3 |
| 4/4/2006 | 130 | 2.0 |
| 5/4/2006 | 280 | 4.0 |
| 5/11/2006 | 300 | 3.0 |
| 5/18/2006 | 430 | 2.0 |
| 5/25/2006 | 4500 | 2.0 |
| 6/1/2006 | 4900 | 8.0 |
| 6/8/2006 | 7600 | 2.0 |
| 6/15/2006 | 650 | 3.0 |
| 6/22/2006 | 2000 | 4.0 |
| 6/29/2006 | 770 | 2.0 |
| 7/6/2006 | 540 | 2.8 |

| Date | E. Coli, orgs/100 ml | Mean daily flow estimate, cfs |
|---:|---:|---:|
| 7/20/2006 | 320000 | 7.0 |
| 8/3/2006 | 220 | 2.1 |
| 8/17/2006 | 440 | 2.1 |
| 8/31/2006 | 2200 | 2.2 |
| 9/7/2006 | 460 | 2.2 |
| 9/12/2006 | 27000 | 20.0 |
| 9/14/2006 | 5600 | 5.0 |
| 9/18/2006 | 19000 | 2.4 |
| 9/18/2006 | 3200 | 2.4 |
| 9/21/2006 | 830 | 2.3 |
| 9/28/2006 | 250 | 2.4 |
| 11/16/2006 | 240 | 2.0 |
| 1/11/2007 | 140 | 2.7 |
| 2/8/2007 | 10 | 2.0 |
| 3/8/2007 | 45 | 2.7 |
| 3/22/2007 | 48000 | 20.0 |
| 4/5/2007 | 90 | 6.0 |
| 4/19/2007 | 140 | 4.0 |
| 4/30/2007 | 110 | 4.0 |
| **Stressor ID monitoring** | **Grab samples** | |
| 7/13/2006 | 3100 | 2.8 |
| 7/27/2006 | 230000 | 5.0 |
| 8/10/2006 | 2700 | 2.1 |
| 8/24/2006 | 3800 | 2.2 |
| 11/2/2006 | 120 | 2.6 |
| 12/7/2006 | 90 | 2.0 |
| 5/2/2007 | 20 | 4.0 |
| 5/17/2007 | 340 | 3.4 |
| 5/31/2007 | 25000 | 3.9 |
| 6/14/2007 | 1200 | 3.5 |
| 6/28/2007 | 2100 | 3.6 |
| 7/12/2007 | 5200 | 2.3 |
| 7/26/2007 | 3700 | 3.7 |
| 8/8/2007 | 2700 | 8.0 |
| 8/23/2007 | 980 | 20.0 |
| 9/6/2007 | 380 | 8.0 |
| 9/20/2007 | 3800 | 6.0 |
| 10/4/2007 | 2100 | 8.0 |
| 10/18/2007 | 58000 | 12.1 |
| 11/1/2007 | 220 | 5.5 |
| 12/6/2007 | 110 | 5.6 |
| 1/10/2008 | 210 | 6.0 |
| 2/7/2008 | 800 | 1.2 |
| 3/12/2008 | 700 | 25.0 |
| **Stressor ID monitoring** | **Event samples** | |
| 6/2/2007 | 79000 | 9.2 |
| 6/3/2007 | 51000 | 7.7 |
| 7/27/2007 | 92000 | 10.3 |
| 7/28/2007 | 4700 | 4.4 |
| 8/8/2007 | 33000 | 8.0 |
| 8/15/2007 | 350000 | 20.0 |
| 8/15/2007 | 55000 | 20.0 |

## North Fork Yellow River (0160_0)

North Fork Yellow River monitoring consists of that done by IDNR weekly from May through September from 2004 to 2007. This site was not included in the 2009 TMDL monitoring.

## Table C-14 North Fork Yellow River - *E. coli* data, 2004 to 2007

| Date | E. Coli, orgs/100 ml | Mean daily flow estimate, cfs |
|---:|---:|---:|
| 9/23/2004 | 510 | 6.8 |
| 9/30/2004 | 290 | 4.2 |
| 10/7/2004 | 6800 | 4.3 |
| 10/14/2004 | 8800 | 4.2 |
| 10/21/2004 | 640 | 4.2 |
| 10/28/2004 | 3400 | 4.3 |
| 11/9/2004 | 230 | 3.7 |
| 12/7/2004 | 200 | 3.8 |
| 1/11/2005 | 1 | 3.0 |
| 2/8/2005 | 3400 | 18.0 |
| 3/1/2005 | 81 | 5.2 |
| 4/5/2005 | 130 | 5.3 |
| 5/12/2005 | 97000 | 4.1 |
| 5/19/2005 | 7600 | 4.4 |
| 5/26/2005 | 3500 | 3.7 |
| 6/2/2005 | 1100 | 3.7 |
| 6/9/2005 | 2200 | 5.7 |
| 6/16/2005 | 850 | 3.5 |
| 6/23/2005 | 8100 | 3.2 |
| 6/30/2005 | 27000 | 5.7 |
| 7/7/2005 | 2700 | 4.6 |
| 7/14/2005 | 2000 | 3.9 |
| 7/21/2005 | 15000 | 4.6 |
| 7/28/2005 | 5400 | 5.6 |
| 8/4/2005 | 3100 | 5.6 |
| 8/11/2005 | 4400 | 4.8 |
| 8/18/2005 | 190000 | 13.6 |
| 8/25/2005 | 7100 | 5.8 |
| 9/1/2005 | 2800 | 4.8 |
| 9/8/2005 | 580 | 4.3 |
| 9/15/2005 | 600 | 3.9 |
| 9/22/2005 | 7700 | 5.0 |
| 9/29/2005 | 5400 | 5.2 |
| 11/1/2005 | 200 | 3.1 |
| 12/6/2005 | 430 | 1.9 |
| 1/3/2006 | 3700 | 4.0 |
| 2/7/2006 | 64 | 3.5 |
| 3/7/2006 | 1 | 3.2 |
| 4/4/2006 | 660 | 20.0 |
| 5/4/2006 | 510 | 15.0 |
| 5/11/2006 | 930 | 8.0 |
| 5/18/2006 | 2400 | 6.0 |
| 5/25/2006 | 5400 | 4.0 |
| 6/1/2006 | 6300 | 15.0 |
| 6/8/2006 | 8300 | 15.0 |
| 6/15/2006 | 8800 | 12.2 |
| 6/22/2006 | 70000 | 4.0 |
| 6/29/2006 | 4900 | 4.0 |

| Date | E. Coli, orgs/100 ml | Mean daily flow estimate, cfs |
|---:|---:|---:|
| 7/6/2006 | 3800 | 9.1 |
| 7/13/2006 | 9500 | 9.2 |
| 7/20/2006 | 820000 | 15.0 |
| 7/27/2006 | 4900 | 16.5 |
| 8/3/2006 | 7400 | 6.6 |
| 8/10/2006 | 7900 | 4.4 |
| 8/17/2006 | 4200 | 4.5 |
| 8/24/2006 | 7700 | 4.6 |
| 8/31/2006 | 4500 | 4.7 |
| 9/7/2006 | 7100 | 4.7 |
| 9/14/2006 | 8300 | 7.8 |
| 9/21/2006 | 4600 | 5.1 |
| 9/28/2006 | 5700 | 4.6 |
| 11/16/2006 | 390 | 3.6 |
| 1/11/2007 | 300 | 6.6 |
| 2/8/2007 | 60 | 5.0 |
| 3/22/2007 | 7300 | 4.9 |
| 4/5/2007 | 600 | 25.0 |
| 5/17/2007 | 2200 | 10.8 |
| 6/14/2007 | 8300 | 14.4 |
| 7/12/2007 | 2700 | 7.5 |
| 8/16/2007 | 110000 | 40.0 |
| 9/6/2007 | 2100 | 18.0 |
| 10/4/2007 | 860 | 22.0 |
| 11/1/2007 | 1300 | 13.4 |
| 12/6/2007 | 170 | 13.2 |

# Appendix D -- Analysis and Modeling

This water quality improvement plan was developed using two primary analytical tools. The first on flow and load duration curves used to estimate existing and target loads and concentrations following procedures described in EPA guidance. The flow and load duration curves use existing monitoring data and flows from the USGS gage on the Yellow River.

The second analytical method is the *Soil and Water Assessment Tool (SWAT).* This is a watershed model that has been calibrated to the Yellow River USGS gage and has bacteria sources input by subbasin. The SWAT model simulates washoff and transport of bacteria from the sources to the thirteen impaired segments. A number of spreadsheets were used for data analysis, tributary and segment flow estimates, and load distribution by subbasin. These are briefly described in Table D-1.

**Table D-1 Descriptions of the primary tools and methods used for the Yellow River Basin Bacteria TMDLs**

| Model | Type and purpose | Time frame | Description |
|---|---|---|---|
| Flow and load duration curves | Multi-year flow and load analysis for *E. coli* | Multi-year | Transforms daily flow to recurrence intervals and inputs monitored *E. coli* data to calculate existing and target loads at five flow intervals. Generates TMDL equation components. |
| SWAT | Watershed model used to simulate hydrology and bacteria decay. | Annual, monthly, daily | Provides linkage of sources and pollutant impacts on the thirteen impaired tributaries and Yellow River segments. Estimates bacteria loss between sources and streams. |
| Supporting spreadsheets | Bacteria source loads available for washoff and those continuously discharged. | Varies | Estimates bacteria loads available from watershed sources for washoff and output of continuous discharges from cattle in the stream and faulty septic tank systems. |

## D.1. Flow and Load Duration Curves

The flow and load duration curves for the impaired waterbodies, found in Sections 4 through 16, have been used to make the load allocations, margins of safety, existing loads, and total maximum daily loads for the tributaries and segments. The daily flow data from the USGS gage at Ion has been related to the area of the watershed as daily average cfs/hectare. An area ratio has been generated from this to estimate the daily flow for each subbasin. These flow estimates generate the flow and load duration curves found in the impaired waterbody TMDL sections.

Multiplying the daily flow times the GM and SSM target concentrations calculates a daily load. Plotting it as a percent recurrence generates the curve representing the target load. The average daily flow estimates and sample concentration data has been plotted with the *E. coli* target concentrations and loads in the flow and load duration curves, respectively. The flow and load duration curves have been divided into five flow conditions that are represented as the percent recurrence interval and are described in Table 3-4 of the main report. These flow regions are shown in Table D-2.

**Table D-2 Flow conditions for recurrence intervals**

| Recurrence Interval | Flow condition |
|---|---|
| 0-10% | High flows - runoff dominated |
| 10-40% | Moist conditions |
| 40-60% | Mid-range flow |
| 60-90% | Dry conditions - mostly base flow |
| 90-100% | Low (base) flow |

Bacteria concentrations exceeding the criteria at high flow are mostly from the washoff of nonpoint sources and criteria exceeded at low flow are usually from continuous discharges sources such as wastewater treatment plants. Between these two extreme flow conditions, there is a continuum of sources from moist conditions when bacteria are delivered by runoff from rainfall, to dry conditions when bacteria delivery is predominately from continuously discharging sources.

The flow and load duration curves for each of the impaired tributaries and Yellow River segments can be found in subsections 4.1 through 16.1 headed **Water body Pollutant Loading Capacity (TMDL)**. The monitored *E. coli* concentrations are shown in the flow duration curves and the sample loads (monitored concentration * flow) are shown in the load duration curves.

The midpoints of the five flow conditions occur at recurrences of 95%, 75%, 50%, 25%, and 5%. The median *E. coli* count for each flow condition is calculated at the two criteria concentrations (126 and 235 orgs/100 ml) for each interval midpoint flow. This calculation becomes the target for the flow condition interval. The TMDL targets are listed in the **TMDL Summary** subsections of each impaired waterbody with the LA, WLA, and MOS. The TMDL and LA are displayed graphically in these same subsections for the GM and SSM target E. coli concentrations.

The existing loads are estimated by calculating the 90th percentile the monitored *E. coli* concentration values and multiplying them by the midpoint flow at each of the five flow recurrence intervals. Charts showing the existing and target can be found in each of the thirteen waterbody sections (4 through 16) in the **Departure from Load Capacity** sub-sections.

*Duration Curve Hydrology – Area ratio flow*

The flow estimates for the impaired segments and three upstream Yellow River segments were derived from the average daily discharge at the USGS gage located near Ion. The flow for each tributary and upstream Yellow River segment has been estimated using the ratio of the total watershed area to the subbasin area and applying this ratio to the total average daily flow measured at the USGS gage, i.e., *subbasin area/watershed area* *upstream of the gage: subbasin flow/gage flow*. Table D-3 lists the 28 subbasins and their areas and area ratios and Figure D-1 (aka Figure 3-5) shows their locations in the watershed. The total area used to derive the area ratios excludes the subbasins downstream of the USGS Ion gage. These are subbasins 24, 25, and 26. The area of the watershed above the gage is 56,577 hectares. All of the impaired tributaries are unshaded and one of these, Dousman Creek is downstream of the gage.

### Table D-3 Subbasin areas and area ratios

| Subbasin | Stream segment | Area, ha | Area Ratio, % |
|---|---|---|---|
| 1 | Ludlow Creek | 2,996 | 5.3% |
| 2 | Norfolk Creek | 6,117 | 10.8% |
| 3 | Unnamed | 3,056 | |
| 4 | Yellow River 2 (0080_2)[1] | 15,545(985) | 27.4% |
| 5 | Yellow River | 1,095 | |
| 6 | Unnamed | 1,767 | |
| 7 | Unnamed | 1,139 | |
| 8 | Unnamed | 2,510 | |
| 9 | Williams Creek | 3,719 | 6.6% |
| 10 | Unnamed | 668 | |
| 11 | North Fork Yellow River | 3,934 | 6.9% |
| 12 | Yellow River 1 (headwaters) | 5,273 | 9.3% |
| 13 | Unnamed | 1,717 | |
| 14 | Unnamed | 1,203 | |
| 15 | Bear Creek | 1,989 | 3.5% |
| 16 | Unnamed | 1,762 | |
| 17 | Unnamed | 878 | |
| 18 | Hecker Creek | 1,202 | 2.1% |
| 19 | Yellow River 3 (0080_3)[1] | 46,385 (1,668) | 81.8% |
| 20 | Unnamed | 491 | |
| 21 | Unnamed | 1,427 | |
| 22 | Unnamed | 725 | |
| 23 | Unnamed | 1,363 | |
| 24 | Unnamed | 2,652 | |
| 25 | Unnamed | 1,115 | |
| 26 | Dousman Creek | 2,274 | 4.0% |
| 27 | Suttle Creek | 2,932 | 5.2% |
| 28 | Hickory Creek | 6,060 | 10.7% |
| | **Total Yellow River Basin** | **62,718** | |

1. The two mainstem Yellow River segments between the headwaters segment and the most downstream segment include all of the subbasins upstream from each segment monitoring location. Segment Yellow River 3 (0080_1) includes subbasins 1 through 13, 15, 18, 19, 20, and 28. Segment Yellow River 2 (0080_2) includes subbasins 4, 6, 10 through 13, and 18.

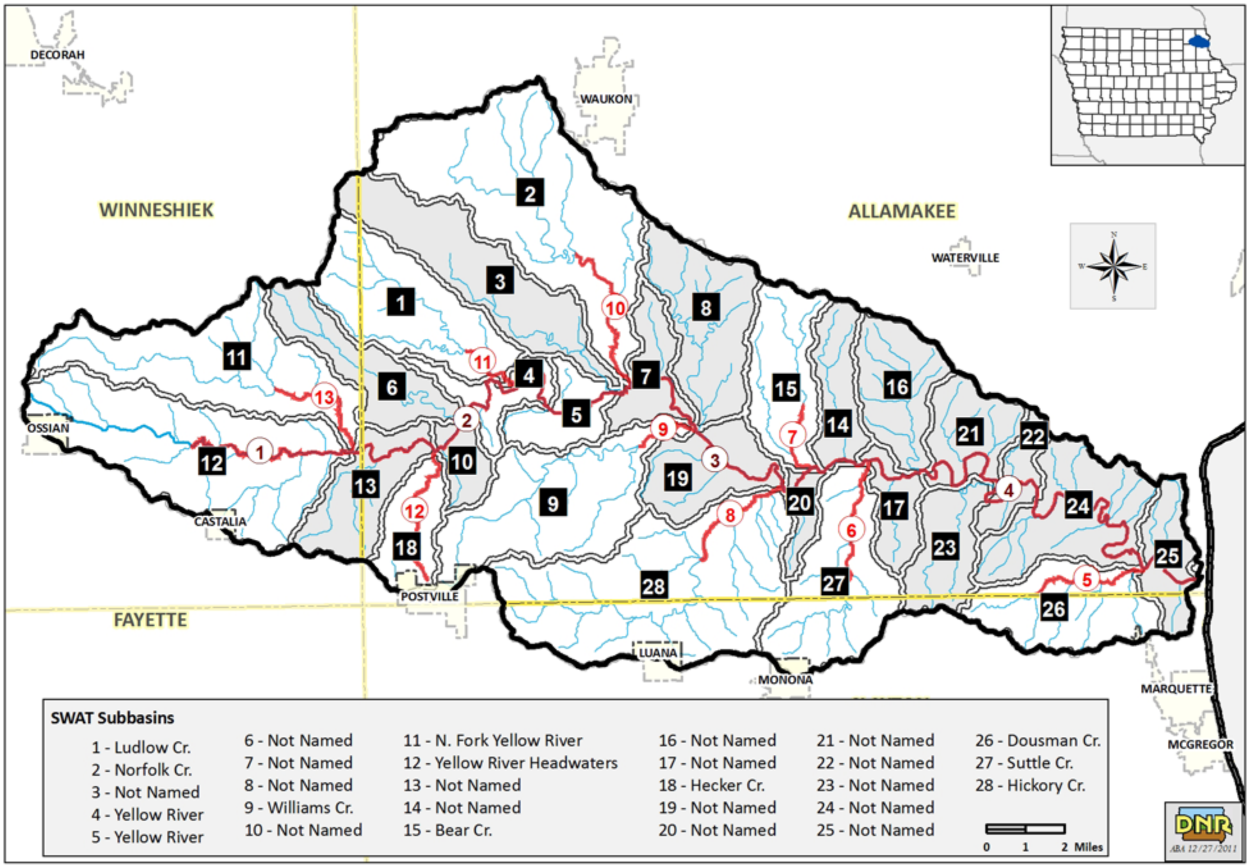

Figure D-1 Yellow River SWAT subbasins map

## D.2. Watershed Modeling – SWAT

The SWAT model for the impaired waterbodies in this report has not been used to set any of the load allocations, margins of safety, or TMDLs. These have been calculated using the previously discussed duration curve methods based on the area ratio hydrology. The purpose of the SWAT model is to provide a framework that will:

- locate and input bacteria sources,
- provide a link between these sources and water quality,
- make available a tool that predicts impacts of load reduction from sources, and
- facilitate the design of implementation activities and watershed planning.

The SWAT model produced the 28 subbasins used in the development of this water quality improvement plan for the Yellow River watershed. It uses daily precipitation and temperature data from three weather reporting stations near or in the watershed. These are located in the cities of Prairie du Chien, Waukon and Postville. The land use information comes from recent watershed assessments and aerial photography. The soil information is from the Iowa SSURGO database. The procedures used to simulate the Yellow River watershed hydrology consist of:

- Obtaining the daily precipitation and temperature data from the three weather stations and inputting it into the SWAT model. The period used as weather input to the model was January 1, 2004 to December 31, 2009.

- Curve numbers based on landuse, soils, and previously calibrated SWAT models near the watershed.
- Stream delineation based on a state digital elevation model was used to establish the 28 SWAT subbasins. The 28 SWAT subbasins are shown in Figure D-1.
- Defining hydrologic response units (HRU) with unique soil, landuse, and slope. There are 2,251 HRU in the 28 subbasins.
- Entering the point source flows and bacteria loads from cattle in the stream and faulty septic tank systems derived from census data and GIS aerial photography coverages.
- Running the SWAT model to obtain daily simulated flow from the Yellow River and its tributaries and calibrating flow to the USGS gage.
- Simulating *E. coli* concentration and loads and quantifying bacteria sources.

*Yellow River Basin SWAT Model Parameters*
The primary hydrologic parameters used in this model are listed in Table D-4. These parameters are the same for each of the subbasins and HRU's.

**Table D-4 SWAT hydrologic calibration parameters**

| Parameter | Input Description | Value |
|---|---|---|
| Curve Number | Corn | 71 |
| | Soybeans | 72 |
| | Forest | 60 |
| | Pasture | 63 |
| | CRP | 53 |
| | Alfalfa | 53 |
| | Meadow bromegrass | 59 |
| | Urban | 59 |
| IPET | Potential Evapotranspiration Method | Penman/Monteith |
| ESCO | Soil Evaporation Compensation | 0.87 |
| EPCO | Plant Uptake Compensation Factor | 1.0 |
| ICN | Daily curve number calculation method | Plant ET method |
| CNCOEF | Plant ET curve number coefficient | 0.5 |
| SURLAG | Surface Runoff Lag | 4 days |
| IRTE | Channel Routing Method | Variable Storage |
| GW_DELAY | Groundwater Delay | 100 days |
| ALPH_BF | Alpha Base Flow Factor | 0.3 days |
| GW_REVAP | Groundwater revap coefficient | 0.02 |

The bacteria related parameters are listed in Table D-5. These values are the same for all of the subbasins in the watershed.

### Table D-5 SWAT bacteria parameters

| SWAT Parameter | Input Description | Value |
|---|---|---|
| WDPQ | Die-off in soil solution | 0.05 |
| WDPS | Die-off for soil adsorbed bacteria | 0.05 |
| BACTKDQ | Bacteria partition coefficient | 10 |
| THBACT | Die-off rate temperature adjustment factor | 1.07 |
| WOF_P | Wash-off fraction | 0.75 |
| WDPF | Die-off on foliage | 0.05 |
| BACT_SWF | Fraction of applied manure with viable bacteria | 0.5 |
| BACT_MX | Bacteria percolation coefficient | 7 |
| BACTMINP | Minimum daily bacteria loss | 0.1 |
| WDPRCH | Die-off in streams moving water at 20C | 0.5 |
| WDPRES | Die-off in still water at 20C | 0.5 |
| RK5 | Coliform die-off in the reach at 20C | 2 |

The Yellow River USGS gage at Ion was used to calibrate the SWAT model flow, specifically the discharge from Subbasin 22 because the discharge from Subbasin 22 is located near the USGS gage. The daily time step used for this calibration allows for a better correspondence between the precipitation transport mechanism and the bacterial water quality. Figure D-2, showing the gage versus the SWAT average daily flows from September 2004 to December 2009, visually demonstrates that there is an acceptable correspondence between the two. Statistics for the comparison are listed in Table D-6. These reflect a reasonable correspondence of the SWAT simulated flows to the USGS gage flows, especially for average daily flows.

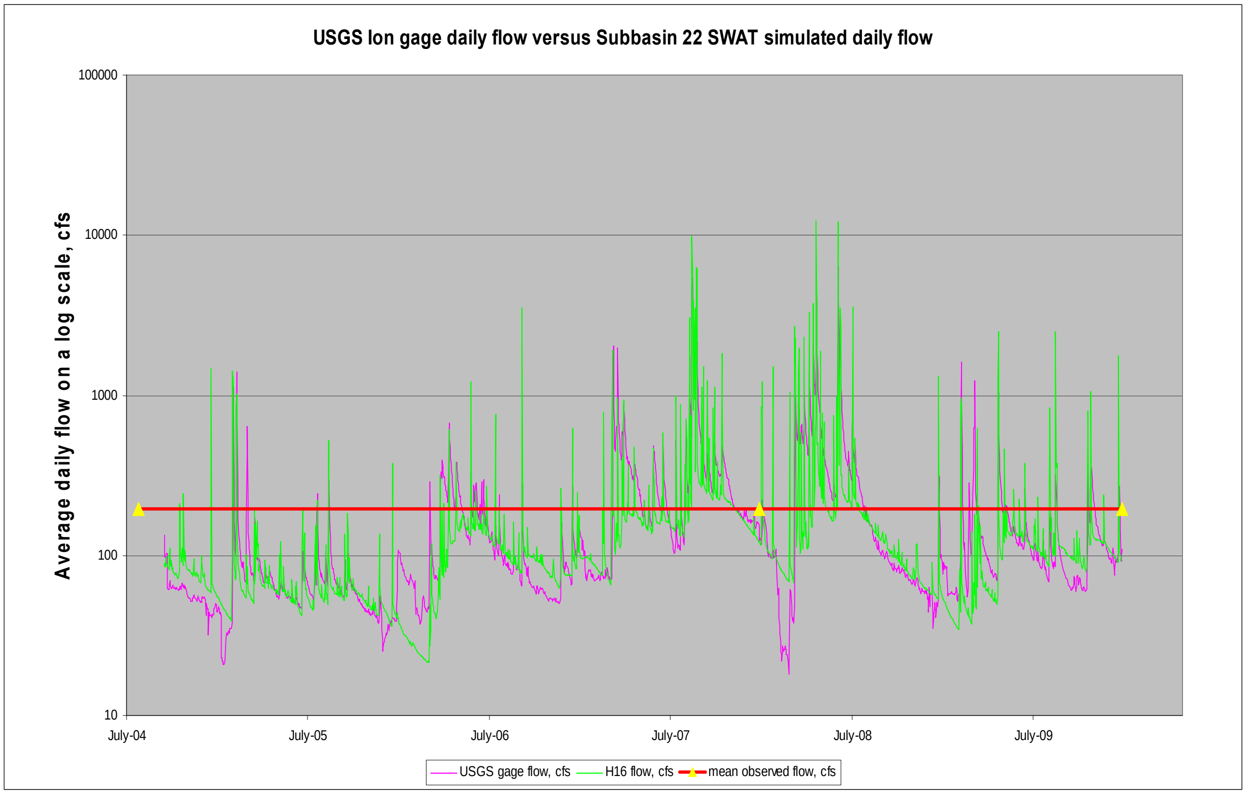

Figure D-2 USGS gage daily flow compared to SWAT simulated daily flow

**Table D-6 Daily USGS gage flow versus SWAT simulated flow statistics**

| **Statistic** | **Value** | **Interpretation**[1] |
|---|---|---|
| R-squared | 0.64 | Good |
| Nash-Sutcliff Efficiency (log) | 0.53 | Satisfactory (0.50 to 0.65) |
| Root Mean Square Error | 0.68 | Satisfactory (0.60 to 0.70) |
| Percent Bias | 1.74 | Very Good (less than10) |

1. The range for these model evaluation statistics consists of four categories, very good, good, satisfactory, and unsatisfactory. (Moriasi)

*Yellow River Basin E. coli sources and SWAT modeling.*
The bacteria sources in the subbasins of the impaired tributaries and Yellow River segments are detailed in Sections 4 through 16. The sources in the SWAT model input are the continuous septic tank and CIS loads and the manure available for washoff from pastured cattle, wildlife, and manure applied to fields from confinement and feedlot operations.

The point sources have been entered into the model as database files for each of the 28 subbasins. These files consist of daily flow from the septic systems and an E. coli concentration for each month of the year from the septics and CIS and from November to April consist only of septic system loads. During the grazing season the number of cattle in the stream peaks in July and August and falls in September and October and is unchanged through the period of simulation. These sources are assumed to be present daily through the periods that they are significant. For cattle in the stream, the monthly adjustments account for cattle spending more time in the stream during the warmer months. For failed septic tank systems, the loads are continual and year round.

The bacteria loads for the pastured cattle are put in the individual pasture HRU's through the management parameters tab as a grazing operation beginning May1 and running for 168 days. The existing manure load is 6 kg/ha/day for all pasture HRU's. Pasture bacteria decays over time so the coincidence of precipitation and runoff with manure application influences how much available *E. coli* washes to the stream. The pasture animal loading rate was calculated using 2007 Ag Census animal numbers and pasture acreage for Allamakee, Clayton and Winneshiek counties. An average loading rate of 0.78 cows per hectare was then applied to all pasture in the Yellow River watershed.

Livestock sources in the watershed were estimated using assessments made by IDNR staff based on aerial photography and monthly livestock statistics for each county. The livestock estimates used in the SWAT model for each of the sub watersheds are shown in Table D-7:

**Table D-7 Grazing cattle by subbasin**

| Subbasin | Pasture with stream access, acres | Total pasture, acres | Cattle in stream, 6% of pasture cattle with stream access | Cattle on pasture | Dry manure in pasture, kg/d |
|---|---|---|---|---|---|
| Ludlow Cr 1 | 57 | 110 | 3 | 83 | 258 |
| Norfolk Cr 2 | 386 | 640 | 18 | 481 | 1,491 |
| 3 | 74 | 210 | 3 | 160 | 497 |
| Yellow R 4 | 242 | 242 | 11 | 177 | 550 |
| 5 | 282 | 408 | 13 | 305 | 945 |
| 6 | 200 | 200 | 9 | 147 | 455 |
| 7 | 178 | 318 | 8 | 240 | 743 |
| 8 | 740 | 835 | 35 | 617 | 1,912 |
| Williams Cr 9 | 294 | 325 | 14 | 239 | 742 |
| 10 | 121 | 161 | 6 | 120 | 372 |
| N Fork Yellow R 11 | 657 | 830 | 31 | 617 | 1,912 |
| Yellow R 12 | 871 | 1,269 | 41 | 949 | 2,943 |
| 13 | 120 | 164 | 6 | 122 | 379 |
| 14 | 719 | 840 | 34 | 622 | 1,927 |
| Bear Cr 15 | 590 | 727 | 28 | 540 | 1,673 |
| 16 | 570 | 688 | 27 | 510 | 1,582 |
| 17 | 42 | 120 | 2 | 92 | 285 |
| Hecker Cr 18 | 458 | 458 | 21 | 336 | 1,041 |
| Yellow R 19 | 89 | 157 | 4 | 118 | 366 |
| 20 | 0 | 0 | 0 | 0 | 0 |
| 21 | 847 | 939 | 40 | 693 | 2,149 |
| 22 | 254 | 467 | 12 | 353 | 1,093 |
| 23 | 486 | 486 | 23 | 357 | 1,106 |
| Yellow R lon gage24 | 850 | 973 | 40 | 719 | 2,228 |
| Yellow R outlet 25 | 429 | 429 | 20 | 315 | 975 |
| Dousman Cr 26 | 234 | 620 | 11 | 473 | 1,466 |
| Suttle Cr 27 | 740 | 740 | 35 | 543 | 1,683 |
| Hickory Cr 28 | 688 | 859 | 32 | 637 | 1,976 |
| **Total** | **11,217** | **14,168.7** | **525** | **10,564** | **32,749** |

Wildlife bacteria loads get to the stream in the same way as pastured cattle loads do, in runoff when it rains. The wildlife loads are entered in the model through the management parameters tab as a 365 days/year grazing operation in forest and brome grass HRU's. The loading rate varies by the area of the subbasin relative to the total area of the forested and grassed land uses since the number of deer is estimated based on the total area of the subbasin. The deer estimates used in the SWAT model for each of the subbasins are shown in Table D-8:

**Table D-8 Deer by subbasin**

| subbasin number | subbasin area, ha | forest and ungrazed brome area, ha | deer in subbasin | manure mass, kg/ha/day |
|---|---|---|---|---|
| 1 | 2,996 | 509 | 178 | 0.503 |
| 2 | 6,117 | 868 | 363 | 0.602 |
| 3 | 3,056 | 329 | 181 | 0.793 |
| 4 | 985 | 241 | 58 | 0.348 |
| 5 | 1,095 | 212 | 65 | 0.442 |
| 6 | 1,767 | 171 | 105 | 0.882 |
| 7 | 1,139 | 374 | 68 | 0.260 |
| 8 | 2,510 | 349 | 149 | 0.614 |
| 9 | 3,719 | 481 | 220 | 0.661 |
| 10 | 668 | 113 | 40 | 0.506 |
| 11 | 3,934 | 420 | 233 | 0.799 |
| 12 | 5,273 | 305 | 313 | 1.476 |
| 13 | 1,717 | 151 | 102 | 0.974 |
| 14 | 1,203 | 212 | 71 | 0.485 |
| 15 | 1,989 | 505 | 118 | 0.336 |
| 16 | 1,762 | 650 | 104 | 0.231 |
| 17 | 878 | 357 | 52 | 0.210 |
| 18 | 1,202 | 84 | 71 | 1.215 |
| 19 | 1,668 | 539 | 99 | 0.264 |
| 20 | 491 | 255 | 29 | 0.165 |
| 21 | 1,427 | 545 | 85 | 0.223 |
| 22 | 725 | 297 | 43 | 0.208 |
| 23 | 1,363 | 421 | 81 | 0.276 |
| 24 | 2,652 | 1,720 | 157 | 0.132 |
| 25 | 1,115 | 820 | 66 | 0.116 |
| 26 | 2,274 | 1,200 | 135 | 0.162 |
| 27 | 2,932 | 499 | 174 | 0.502 |
| 28 | 6,060 | 1,237 | 359 | 0.418 |
| **Totals** | **62718** | **13863** | **3718** | **Average 0.493** |

For fields with manure, the manure is applied in the fall after soybean harvest and again in the spring before corn is planted. Swine manure is applied at 2127 kg/ha, dairy manure at 2631 kg/ha and chicken manure at 2326. Manure is applied at a rate equivalent to 201.6 kg N/ha/yr. Hay ground is modeled as 6 year rotation with 3 years of alfalfa followed by corn-beans-corn. The soybeans are fertilized in the spring with 175 kg/ha DAP and 170 kg/ha NH3 is applied in the fall after harvest for the corn crop the next year. In a corn-soybean rotation with no manure, ammonia is applied in the fall after soybean harvest at 170 kg/ha and DAP is applied in the spring before soybeans at 175 kg/ha.

In the SWAT model, the ratio of available to delivered *E. coli* is estimated using the existing load from the duration analysis at each of the TMDL streams for the five duration curve flow conditions. For figuring delivery at decreasing flow values, it is assumed that, as loads from runoff diminish, the load fraction from continuous sources increases until it is the entire watershed load.

*Estimating existing delivered load*

The washoff delivered load that has accumulated on the ground has been estimated using a ratio of the load available for washoff to the delivered load as estimated by the duration curve procedure at the five different flow conditions. Delivery ratios are the ratio of the load measured in the stream by monitoring and the load at the sources as estimated with the SWAT model.

These ratios estimate the nonpoint source load delivered by runoff. The ratio is the percentage of the estimated load available for washoff from livestock and wildlife manure on croplands, pasture, and forest and runoff from built-up areas. It is assumed that some fraction (the delivery ratio) of the load available for washoff from each source is delivered to the Yellow River or one of its tributaries.

## Analysis Documentation and Guide

The data, analysis, and modeling spreadsheets for the Yellow River Basin bacteria TMDLs are organized by impaired tributary and Yellow River segment. Tables D-9 through D-22 list the folders and files that contain the data and analysis spreadsheet and model input files. The data and information in these folders and files used to develop this water quality improvement plan are located in the S*upport Documentation* folder.

The first table, D-9, lists files that are relevant to the entire Yellow River basin including weather data from the three stations and the discharge data from the USGS gage at Ion. The next thirteen tables, D-10 through D-22, list files that are specific to a stream or segment.

### Table D-9 Yellow River Basin

| Folder and file name | Description of contents |
|---|---|
| **Basin Data and Analysis** (folder) | **Data and analysis spreadsheets** |
| Gage and weather data (subfolder) | |
| YR_ion_gage.xls | Yellow River flow data from the USGS gage at Ion. Data from this gage is used for the area-ratio method of flow estimating for the impaired waterbodies. It was also used to calibrate the SWAT model and develop duration curves for TMDL analysis. |
| *pcp.xls | Excel files with precipitation data for the three stations |
| *tmp.dbf | Database files with temperature data for the three stations |
| Monitoring data (subfolder) | |
| 2009 ISCO data (sub-subfolder) | Excel files contain data collected in 2009 at 7 sites by automatic samplers. Includes continuous flow and event monitoring. |
| data 2009 (sub-subfolder) | Excel files contain data continuously collected in 2009 at 7 sites for 2 weeks by in-stream data-sondes. Includes DO and temp. as well as direct flow during deployment and retrieval. |
| 3 sites langel 04 to 08.xls | Data collected by IDNR at two Yellow River stations and Dousman Creek from 2004 to 2008. |
| ion ecoli addl langel 03 to 06.xls | Bacteria data collected by IDNR from 2003 to 2006 at the Yellow River USGS gage station. |
| ion gage Ambient Data 1999-2010.xls | All data collected by the IDNR ambient monitoring program at the Yellow River gage station from 1999 to 2010. Includes many parameters. |
| Yellow River 2004-2007 lisa.xls | All data collected at 13 tributary and Yellow River stations from 2004 through 2007. This is the primary data set used to develop this document and includes many parameters. |
| WWTP Basin Wasteload Allocations (subfolder) | WLA calculations for the four WWTP discharging to the Yellow River Basin |
| wwtp calcs.xls | WLA for basin WWTPs |

**Table D-10 Bear Creek**

| Folder and file name | Description of contents |
|---|---|
| **Data and Duration Curves** (folder) | **Data and analysis spreadsheets** |
| new Bear SWAT_SUBBASINS.xls | Bear Creek daily flow estimates from the area –ratio procedure based on data from the USGS gage at Ion. Used to develop duration curves for TMDL analysis. |
| new Bear duration curves.xls | Load and flow duration curve analysis that includes sample load calculations. |
| **TMDL LA and MOS calcs** (folder) | **Load analysis spreadsheets** |
| new Bear Creek load calcs.xls | Calculation of the existing and target loads for the site. |
| new Bear Creek TMDL and charts.xls | Chart showing existing and target loads for each flow condition with a load duration curve. |
| **Load Sources and SWAT Input**(folder) | **Estimates of pollutant source loads.** |
| bear sources3.xls | *E. coli* source evaluation for septic tanks, pasture cattle, cattle in the stream, wildlife, and field applied manure. Includes load charts |
| **SWAT Model** (folder) | **Watershed modeling of source load delivery for existing sources and scenarios for load reductions.** |
| Point Sources (subfolder) | Input into the SWAT model as sources that change monthly |
| Sub15.dbf | Inputs septic tank and cattle in the stream sources for Bear Creek (subbasin 15) |
| Output Analysis (subfolder) | SWAT flow and E. coli output for 5 scenarios. |
| YR_sub15.xls | Spreadsheet showing the output of 5 SWAT scenarios and charts showing SWAT loads and concentrations over time plotted with sample loads and concentrations. |
| YR_all_sub15.xls | Daily flow and E. coli concentration output from SWAT model scenario that includes all estimated subbasin loads. |
| YR_halfCIS_sub15.xls | Daily flow and E. coli concentration output from SWAT model scenario that includes all estimated subbasin loads except half of CIS load. |
| YR_noCIS_sub15.xls | Daily flow and E. coli concentration output from SWAT model scenario that includes all estimated subbasin loads without any CIS load. |
| YR_noCIS_halfapplied_sub15.xls | Daily flow and E. coli concentration output from SWAT model scenario that includes all estimated subbasin loads without any CIS load and only half of the field applied manure. |
| YR_noCIS_halfapplied_2kgpast_sub15.xls | Daily flow and E. coli concentration output from SWAT model scenario that includes all estimated subbasin loads without any CIS load, half of the field applied manure, and one-third of pasture cattle manure. |

**Table D-11 Dousman Creek**

| Folder and file name | Description of contents |
|---|---|
| **Data and Duration Curves** (folder) | **Data and analysis spreadsheets** |
| new Dousman ratio SUBBASINS.xls | Dousman Creek daily flow estimates from the area –ratio procedure based on data from the USGS gage at Ion. Used to develop duration curves for TMDL analysis. |
| new dousman ecoli and flow.xls | Flow and E. coli concentration estimates |
| new Dousman duration curves.xls | Load and flow duration curve analysis that includes sample load calculations. |
| **TMDL LA and MOS calcs** (folder) | **Load analysis spreadsheets** |
| new dousman creek  load calcs.xls | Calculation of the existing and target loads for the site. |
| new Dousman Creek TMDL and charts.xls | Chart showing existing and target loads for each flow condition with a load duration curve. |
| **Load Sources and SWAT Input**(folder) | **Estimates of pollutant source loads.** |
| dousman sources.xls | *E. coli* source evaluation for septic tanks, pasture cattle, cattle in the stream, wildlife, and field applied manure. Includes load charts |
| **SWAT Model** (folder) | **Watershed modeling of source load delivery for existing sources and scenarios for load reductions.** |
| Point Sources (subfolder) | Input into the SWAT model as sources that change monthly |
| Sub26.dbf | Inputs septic tank and cattle in the stream sources for Dousman Creek (subbasin 26) |
| Output Analysis (subfolder) | SWAT flow and E. coli output for 5 scenarios. |
| YR_sub 26.xls | Spreadsheet showing the output of 5 SWAT scenarios and charts showing SWAT loads and concentrations over time plotted with sample loads and concentrations. |
| YR_all_sub26.xls | Daily flow and E. coli concentration output from SWAT model scenario that includes all estimated subbasin loads. |
| YR_halfCIS_sub26.xls | Daily flow and E. coli concentration output from SWAT model scenario that includes all estimated subbasin loads except half of CIS load. |
| YR_noCIS_sub26.xls | Daily flow and E. coli concentration output from SWAT model scenario that includes all estimated subbasin loads without any CIS load. |
| YR_noCIS_halfapplied_sub26.xls | Daily flow and E. coli concentration output from SWAT model scenario that includes all estimated subbasin loads without any CIS load and only half of the field applied manure. |
| YR_noCIS_halfapplied_2kgpast_sub26.xls | Daily flow and E. coli concentration output from SWAT model scenario that includes all estimated subbasin loads without any CIS load, half of the field applied manure, and one-third of pasture cattle manure. |

**Table D-12 Hecker Creek**

| Folder and file name | Description of contents |
|---|---|
| **Data and Duration Curves** (folder) | **Data and analysis spreadsheets** |
| new Hecker subbasin flow.xls | Hecker Creek daily flow estimates from the area –ratio procedure based on data from the USGS gage at Ion. Used to develop duration curves for TMDL analysis. |
| new Hecker duration curves.xls | Load and flow duration curve analysis that includes sample load calculations. |
| **TMDL LA and MOS calcs** (folder) | **Load analysis spreadsheets** |
| New2 Hecker Creek load calcs.xls | Calculation of the existing and target loads for the site. |
| New2 Hecker Creek TMDL and charts.xls | Chart showing existing and target loads for each flow condition with a load duration curve. |
| **Load Sources and SWAT Input**(folder) | **Estimates of pollutant source loads.** |
| Hecker sources.xls | *E. coli* source evaluation for septic tanks, pasture cattle, cattle in the stream, wildlife, and field applied manure. Includes load charts |
| **SWAT Model** (folder) | **Watershed modeling of source load delivery for existing sources and scenarios for load reductions.** |
| Point Sources (subfolder) | Input into the SWAT model as sources that change monthly |
| Sub18.dbf | Inputs septic tank and cattle in the stream sources for Hecker Creek (subbasin 18) |
| Output Analysis (subfolder) | SWAT flow and E. coli output for 5 scenarios. |
| YR_sub18.xls | Spreadsheet showing the output of 5 SWAT scenarios and charts showing SWAT loads and concentrations over time plotted with sample loads and concentrations. |
| YR_all_sub18.xls | Daily flow and E. coli concentration output from SWAT model scenario that includes all estimated subbasin loads. |
| YR_halfCIS_sub18.xls | Daily flow and E. coli concentration output from SWAT model scenario that includes all estimated subbasin loads except half of CIS load. |
| YR_noCIS_sub18.xls | Daily flow and E. coli concentration output from SWAT model scenario that includes all estimated subbasin loads without any CIS load. |
| YR_noCIS_halfapplied_sub18.xls | Daily flow and E. coli concentration output from SWAT model scenario that includes all estimated subbasin loads without any CIS load and only half of the field applied manure. |
| YR_noCIS_halfapplied_2kgpast_sub18.xls | Daily flow and E. coli concentration output from SWAT model scenario that includes all estimated subbasin loads without any CIS load, half of the field applied manure, and one-third of pasture cattle manure. |

**Table D-13 Hickory Creek**

| **Folder and file name** | **Description of contents** |
|---|---|
| **Data and Duration Curves** (folder) | **Data and analysis spreadsheets** |
| new Hickory SWAT_SUBBASINS.xls | Hickory Creek daily flow estimates from the area –ratio procedure based on data from the USGS gage at Ion. Used to develop duration curves for TMDL analysis. |
| new Hickory duration curves.xls | Load and flow duration curve analysis that includes sample load calculations. |
| **TMDL LA and MOS calcs** (folder) | **Load analysis spreadsheets** |
| new Hickory Creek load calcs.xls | Calculation of the existing and target loads for the site. |
| new Hickory Creek TMDL and charts.xls | Chart showing existing and target loads for each flow condition with a load duration curve. |
| **Load Sources and SWAT Input**(folder) | **Estimates of pollutant source loads.** |
| Hickory sources3.xls | *E. coli* source evaluation for septic tanks, pasture cattle, cattle in the stream, wildlife, and field applied manure. Includes load charts |
| **SWAT Model** (folder) | **Watershed modeling of source load delivery for existing sources and scenarios for load reductions.** |
| Point Sources (subfolder) | Input into the SWAT model as sources that change monthly |
| Sub28.dbf | Inputs septic tank and cattle in the stream sources for Hickory Creek (subbasin 28) |
| Output Analysis (subfolder) | SWAT flow and E. coli output for 5 scenarios. |
| YR_sub28.xls | Spreadsheet showing the output of 5 SWAT scenarios and charts showing SWAT loads and concentrations over time plotted with sample loads and concentrations. |
| YR_all_sub28.xls | Daily flow and E. coli concentration output from SWAT model scenario that includes all estimated subbasin loads. |
| YR_halfCIS_sub28.xls | Daily flow and E. coli concentration output from SWAT model scenario that includes all estimated subbasin loads except half of CIS load. |
| YR_noCIS_sub28.xls | Daily flow and E. coli concentration output from SWAT model scenario that includes all estimated subbasin loads without any CIS load. |
| YR_noCIS_halfapplied_sub28.xls | Daily flow and E. coli concentration output from SWAT model scenario that includes all estimated subbasin loads without any CIS load and only half of the field applied manure. |
| YR_noCIS_halfapplied_2kgpast_sub28.xls | Daily flow and E. coli concentration output from SWAT model scenario that includes all estimated subbasin loads without any CIS load, half of the field applied manure, and one-third of pasture cattle manure. |

## Table D-14 Ludlow Creek

| Folder and file name | Description of contents |
|---|---|
| **Data and Duration Curves** (folder) | **Data and analysis spreadsheets** |
| new Ludlow Subbasin.xls | Ludlow Creek daily flow estimates from the area –ratio procedure based on data from the USGS gage at Ion. Used to develop duration curves for TMDL analysis. |
| new Ludlow duration curves.xls | Load and flow duration curve analysis that includes sample load calculations. |
| **TMDL LA and MOS calcs** (folder) | **Load analysis spreadsheets** |
| new Ludlow Creek load calcs.xls | Calculation of the existing and target loads for the site. |
| new Ludlow Creek TMDL and charts.xls | Chart showing existing and target loads for each flow condition with a load duration curve. |
| **Load Sources and SWAT Input**(folder) | **Estimates of pollutant source loads.** |
| Ludlow sources3.xls | *E. coli* source evaluation for septic tanks, pasture cattle, cattle in the stream, wildlife, and field applied manure. Includes load charts |
| **SWAT Model** (folder) | **Watershed modeling of source load delivery for existing sources and scenarios for load reductions.** |
| Point Sources (subfolder) | Input into the SWAT model as sources that change monthly |
| Sub1.dbf | Inputs septic tank and cattle in the stream sources for Ludlow Creek (subbasin 1) |
| Output Analysis (subfolder) | SWAT flow and E. coli output for 5 scenarios. |
| YR_sub01.xls | Spreadsheet showing the output of 5 SWAT scenarios and charts showing SWAT loads and concentrations over time plotted with sample loads and concentrations. |
| YR_all_sub01.xls | Daily flow and E. coli concentration output from SWAT model scenario that includes all estimated subbasin loads. |
| YR_halfCIS_sub01.xls | Daily flow and E. coli concentration output from SWAT model scenario that includes all estimated subbasin loads except half of CIS load. |
| YR_noCIS_sub01.xls | Daily flow and E. coli concentration output from SWAT model scenario that includes all estimated subbasin loads without any CIS load. |
| YR_noCIS_halfapplied_sub01.xls | Daily flow and E. coli concentration output from SWAT model scenario that includes all estimated subbasin loads without any CIS load and only half of the field applied manure. |
| YR_noCIS_halfapplied_2kgpast_sub01.xls | Daily flow and E. coli concentration output from SWAT model scenario that includes all estimated subbasin loads without any CIS load, half of the field applied manure, and one-third of pasture cattle manure. |

**Table D-15 North Fork Yellow River**

| Folder and file name | Description of contents |
|---|---|
| **Data and Duration Curves** (folder) | **Data and analysis spreadsheets** |
| new North Fork YR subbasin flow.xls | North Fork Yellow River daily flow estimates from the area –ratio procedure based on data from the USGS gage at Ion. Used to develop duration curves for TMDL analysis. |
| new North Fork Yellow duration curves.xls | Load and flow duration curve analysis that includes sample load calculations. |
| **TMDL LA and MOS calcs** (folder) | **Load analysis spreadsheets** |
| new North Fork Yellow load calcs.xls | Calculation of the existing and target loads for the site. |
| new North Fork Yellow TMDL and charts.xls | Chart showing existing and target loads for each flow condition with a load duration curve. |
| **Load Sources and SWAT Input**(folder) | **Estimates of pollutant source loads.** |
| NF Yellow sources3.xls | *E. coli* source evaluation for septic tanks, pasture cattle, cattle in the stream, wildlife, and field applied manure. Includes load charts |
| **SWAT Model** (folder) | **Watershed modeling of source load delivery for existing sources and scenarios for load reductions.** |
| Point Sources (subfolder) | Input into the SWAT model as sources that change monthly |
| Sub11.dbf | Inputs septic tank and cattle in the stream sources for North Fork Yellow River (subbasin 11) |
| Output Analysis (subfolder) | SWAT flow and E. coli output for 5 scenarios. |
| YR_sub11.xls | Spreadsheet showing the output of 5 SWAT scenarios and charts showing SWAT loads and concentrations over time plotted with sample loads and concentrations. |
| YR_all2sub11.xls | Daily flow and E. coli concentration output from SWAT model scenario that includes all estimated subbasin loads. |
| YR_halfCISsub11.xls | Daily flow and E. coli concentration output from SWAT model scenario that includes all estimated subbasin loads except half of CIS load. |
| YR_noCISsub11.xls | Daily flow and E. coli concentration output from SWAT model scenario that includes all estimated subbasin loads without any CIS load. |
| YR_noCIS_halfappliedsub11.xls | Daily flow and E. coli concentration output from SWAT model scenario that includes all estimated subbasin loads without any CIS load and only half of the field applied manure. |
| YR_noCIS_halfapplied_2kgpastsub11.xls | Daily flow and E. coli concentration output from SWAT model scenario that includes all estimated subbasin loads without any CIS load, half of the field applied manure, and one-third of pasture cattle manure. |

**Table D-16 Norfolk Creek**

| Folder and file name | Description of contents |
|---|---|
| **Data and Duration Curves** (folder) | **Data and analysis spreadsheets** |
| new Norfolk Subbasin flow.xls | Norfolk Creek daily flow estimates from the area –ratio procedure based on data from the USGS gage at Ion. Used to develop duration curves for TMDL analysis. |
| new Norfolk duration curves.xls | Load and flow duration curve analysis that includes sample load calculations. |
| **TMDL LA and MOS calcs** (folder) | **Load analysis spreadsheets** |
| newNorfolk Creek load calcs.xls | Calculation of the existing and target loads for the site. |
| newNorfolk Creek TMDL and charts.xls | Chart showing existing and target loads for each flow condition with a load duration curve. |
| **Load Sources and SWAT Input**(folder) | **Estimates of pollutant source loads.** |
| norfolk sources3.xls | *E. coli* source evaluation for septic tanks, pasture cattle, cattle in the stream, wildlife, and field applied manure. Includes load charts |
| **SWAT Model** (folder) | **Watershed modeling of source load delivery for existing sources and scenarios for load reductions.** |
| Point Sources (subfolder) | Input into the SWAT model as sources that change monthly |
| Sub2.dbf | Inputs septic tank and cattle in the stream sources for Norfolk Creek (subbasin 2) |
| Output Analysis (subfolder) | SWAT flow and E. coli output for 5 scenarios. |
| YR_sub02.xls | Spreadsheet showing the output of 5 SWAT scenarios and charts showing SWAT loads and concentrations over time plotted with sample loads and concentrations. |
| YR_all2sub02.xls | Daily flow and E. coli concentration output from SWAT model scenario that includes all estimated subbasin loads. |
| YR_halfCIS_sub02.xls | Daily flow and E. coli concentration output from SWAT model scenario that includes all estimated subbasin loads except half of CIS load. |
| YR_noCIS_sub02.xls | Daily flow and E. coli concentration output from SWAT model scenario that includes all estimated subbasin loads without any CIS load. |
| YR_noCIS_halfapplied_sub02.xls | Daily flow and E. coli concentration output from SWAT model scenario that includes all estimated subbasin loads without any CIS load and only half of the field applied manure. |
| YR_noCIS_halfapplied_2kgpast_sub02.xls | Daily flow and E. coli concentration output from SWAT model scenario that includes all estimated subbasin loads without any CIS load, half of the field applied manure, and one-third of pasture cattle manure. |

**Table D-17 Suttle Creek**

| Folder and file name | Description of contents |
|---|---|
| **Data and Duration Curves** (folder) | **Data and analysis spreadsheets** |
| new Suttle SWAT_SUBBASINS.xls | Suttle Creek daily flow estimates from the area –ratio procedure based on data from the USGS gage at Ion. Used to develop duration curves for TMDL analysis. |
| new Suttle duration curves.xls | Load and flow duration curve analysis that includes sample load calculations. |
| **TMDL LA and MOS calcs** (folder) | **Load analysis spreadsheets** |
| new Suttle Creek load calcs.xls | Calculation of the existing and target loads for the site. |
| new Suttle Creek TMDL and charts.xls | Chart showing existing and target loads for each flow condition with a load duration curve. |
| **Load Sources and SWAT Input**(folder) | **Estimates of pollutant source loads.** |
| Suttle sources3.xls | *E. coli* source evaluation for septic tanks, pasture cattle, cattle in the stream, wildlife, and field applied manure. Includes load charts |
| **SWAT Model** (folder) | **Watershed modeling of source load delivery for existing sources and scenarios for load reductions.** |
| Point Sources (subfolder) | Input into the SWAT model as sources that change monthly |
| Sub27.dbf | Inputs septic tank and cattle in the stream sources for Suttle Creek (subbasin 27) |
| Output Analysis (subfolder) | SWAT flow and E. coli output for 5 scenarios. |
| YR_sub27.xls | Spreadsheet showing the output of 5 SWAT scenarios and charts showing SWAT loads and concentrations over time plotted with sample loads and concentrations. |
| YR_all_sub27.xls | Daily flow and E. coli concentration output from SWAT model scenario that includes all estimated subbasin loads. |
| YR_halfCIS_sub27.xls | Daily flow and E. coli concentration output from SWAT model scenario that includes all estimated subbasin loads except half of CIS load. |
| YR_noCIS_sub27.xls | Daily flow and E. coli concentration output from SWAT model scenario that includes all estimated subbasin loads without any CIS load. |
| YR_noCIS_halfapplied_sub27.xls | Daily flow and E. coli concentration output from SWAT model scenario that includes all estimated subbasin loads without any CIS load and only half of the field applied manure. |
| YR_noCIS_halfapplied_2kgpast_sub27.xls | Daily flow and E. coli concentration output from SWAT model scenario that includes all estimated subbasin loads without any CIS load, half of the field applied manure, and one-third of pasture cattle manure. |

### Table D-18 Williams Creek

| Folder and file name | Description of contents |
|---|---|
| **Data and Duration Curves** (folder) | **Data and analysis spreadsheets** |
| newWilliamsSubbasin.xls | Williams Creek daily flow estimates from the area –ratio procedure based on data from the USGS gage at Ion. Used to develop duration curves for TMDL analysis. |
| new Williams duration curves.xls | Load and flow duration curve analysis that includes sample load calculations. |
| **TMDL LA and MOS calcs** (folder) | **Load analysis spreadsheets** |
| new Williams Creek load calcs.xls | Calculation of the existing and target loads for the site. |
| new Williams Creek TMDL and charts.xls | Chart showing existing and target loads for each flow condition with a load duration curve. |
| **Load Sources and SWAT Input**(folder) | **Estimates of pollutant source loads.** |
| williams sources3.xls | *E. coli* source evaluation for septic tanks, pasture cattle, cattle in the stream, wildlife, and field applied manure. Includes load charts |
| **SWAT Model** (folder) | **Watershed modeling of source load delivery for existing sources and scenarios for load reductions.** |
| Point Sources (subfolder) | Input into the SWAT model as sources that change monthly |
| Sub9.dbf | Inputs septic tank and cattle in the stream sources for Williams Creek (subbasin 9) |
| Output Analysis (subfolder) | SWAT flow and E. coli output for 5 scenarios. |
| YR_sub09.xls | Spreadsheet showing the output of 5 SWAT scenarios and charts showing SWAT loads and concentrations over time plotted with sample loads and concentrations. |
| YR_all_sub09.xls | Daily flow and E. coli concentration output from SWAT model scenario that includes all estimated subbasin loads. |
| YR_halfCIS_sub9.xls | Daily flow and E. coli concentration output from SWAT model scenario that includes all estimated subbasin loads except half of CIS load. |
| YR_noCIS_sub09.xls | Daily flow and E. coli concentration output from SWAT model scenario that includes all estimated subbasin loads without any CIS load. |
| YR_noCIS_halfapplied_sub09.xls | Daily flow and E. coli concentration output from SWAT model scenario that includes all estimated subbasin loads without any CIS load and only half of the field applied manure. |
| YR_noCIS_halfapplied_2kgpast_sub09.xls | Daily flow and E. coli concentration output from SWAT model scenario that includes all estimated subbasin loads without any CIS load, half of the field applied manure, and one-third of pasture cattle manure. |

**Table D-19 Yellow River 1 (headwaters – 0080_3)**

| **Folder and file name** | **Description of contents** |
|---|---|
| **Data and Duration Curves** (folder) | **Data and analysis spreadsheets** |
| new YR1 0080_3 SUBBASINS.xls | Yellow River 1 (headwaters) daily flow estimates from the area –ratio procedure based on data from the USGS gage at Ion. Used to develop duration curves for TMDL analysis. |
| new YR1 (0080_3) duration curves.xls | Load and flow duration curve analysis that includes sample load calculations. |
| **TMDL LA and MOS calcs** (folder) | **Load analysis spreadsheets** |
| new Yellow 1 0080_3 load calcs.xls | Calculation of the existing and target loads for the site. |
| new Yellow 1 0080_3 TMDL and charts.xls | Chart showing existing and target loads for each flow condition with a load duration curve. |
| **Load Sources and SWAT Input**(folder) | **Estimates of pollutant source loads.** |
| YR1 0080_3 sources3.xls | *E. coli* source evaluation for septic tanks, pasture cattle, cattle in the stream, wildlife, and field applied manure. Includes load charts |
| **SWAT Model** (folder) | **Watershed modeling of source load delivery for existing sources and scenarios for load reductions.** |
| Point Sources (subfolder) | Input into the SWAT model as sources that change monthly |
| Sub12.dbf | Inputs septic tank and cattle in the stream sources for Yellow River 1 (headwaters) (subbasin 12) |
| Output Analysis (subfolder) | SWAT flow and E. coli output for 5 scenarios. |
| YR_sub12.xls | Spreadsheet showing the output of 5 SWAT scenarios and charts showing SWAT loads and concentrations over time plotted with sample loads and concentrations. |
| YR_all_sub12.xls | Daily flow and E. coli concentration output from SWAT model scenario that includes all estimated subbasin loads. |
| YR_halfCIS_sub12.xls | Daily flow and E. coli concentration output from SWAT model scenario that includes all estimated subbasin loads except half of CIS load. |
| YR_noCIS_sub12.xls | Daily flow and E. coli concentration output from SWAT model scenario that includes all estimated subbasin loads without any CIS load. |
| YR_noCIS_halfapplied_sub12.xls | Daily flow and E. coli concentration output from SWAT model scenario that includes all estimated subbasin loads without any CIS load and only half of the field applied manure. |
| YR_noCIS_halfapplied_2kgpast_sub12.xls | Daily flow and E. coli concentration output from SWAT model scenario that includes all estimated subbasin loads without any CIS load, half of the field applied manure, and one-third of pasture cattle manure. |

**Table D-20 Yellow River 2 (0080_2)**

| Folder and file name | Description of contents |
|---|---|
| **Data and Duration Curves** (folder) | **Data and analysis spreadsheets** |
| new YR2 0080_2 SUBBASINS.xls | Yellow River 2 (0080_2) daily flow estimates from the area –ratio procedure based on data from the USGS gage at Ion. Used to develop duration curves for TMDL analysis. |
| new Site 2 YR2 (0080_2) duration curves.xls | Load and flow duration curve analysis that includes sample load calculations. |
| **TMDL LA and MOS calcs** (folder) | **Load analysis spreadsheets** |
| new Yellow 2 0080_2 site 2 load calcs.xls | Calculation of the existing and target loads for the site. |
| new Yellow 2 0080_2 TMDL and charts.xls | Chart showing existing and target loads for each flow condition with a load duration curve. |
| **Load Sources and SWAT Input**(folder) | **Estimates of pollutant source loads.** |
| YR2 0080_2 sources3.xls | *E. coli* source evaluation for septic tanks, pasture cattle, cattle in the stream, wildlife, and field applied manure. Includes load charts |
| **SWAT Model** (folder) | **Watershed modeling of source load delivery for existing sources and scenarios for load reductions.** |
| Point Sources (subfolder) | Input into the SWAT model as sources that change monthly |
| Sub4.dbf | Inputs septic tank and cattle in the stream sources for Yellow River 2 (0080_2) (subbasin 4) |
| Output Analysis (subfolder) | SWAT flow and E. coli output for 5 scenarios. |
| YR_sub4.xls | Spreadsheet showing the output of 5 SWAT scenarios and charts showing SWAT loads and concentrations over time plotted with sample loads and concentrations. |
| YR_all_sub4.xls | Daily flow and E. coli concentration output from SWAT model scenario that includes all estimated subbasin loads. |
| YR_halfCIS_sub4.xls | Daily flow and E. coli concentration output from SWAT model scenario that includes all estimated subbasin loads except half of CIS load. |
| YR_noCIS_sub4.xls | Daily flow and E. coli concentration output from SWAT model scenario that includes all estimated subbasin loads without any CIS load. |
| YR_noCIS_halfapplied_sub4.xls | Daily flow and E. coli concentration output from SWAT model scenario that includes all estimated subbasin loads without any CIS load and only half of the field applied manure. |
| YR_noCIS_halfapplied_2kgpast_sub4.xls | Daily flow and E. coli concentration output from SWAT model scenario that includes all estimated subbasin loads without any CIS load, half of the field applied manure, and one-third of pasture cattle manure. |

**Table D-21 Yellow River 3 (0080_1)**

| Folder and file name | Description of contents |
|---|---|
| **Data and Duration Curves** (folder) | **Data and analysis spreadsheets** |
| new YR3 0080_1 sUBBASINS.xls | Yellow River 3 (0080_1) daily flow estimates from the area –ratio procedure based on data from the USGS gage at Ion. Used to develop duration curves for TMDL analysis. |
| new YR3 (0080_1) duration curves.xls | Load and flow duration curve analysis that includes sample load calculations. |
| **TMDL LA and MOS calcs** (folder) | **Load analysis spreadsheets** |
| new Yellow 3 0080_1 load calcs.xls | Calculation of the existing and target loads for the site. |
| new Yellow 3 0080_1 TMDL and charts.xls | Chart showing existing and target loads for each flow condition with a load duration curve. |
| **Load Sources and SWAT Input**(folder) | **Estimates of pollutant source loads.** |
| YR3 0080_1 sources3.xls | *E. coli* source evaluation for septic tanks, pasture cattle, cattle in the stream, wildlife, and field applied manure. Includes load charts |
| **SWAT Model** (folder) | **Watershed modeling of source load delivery for existing sources and scenarios for load reductions.** |
| Point Sources (subfolder) | Input into the SWAT model as sources that change monthly |
| Sub19.dbf | Inputs septic tank and cattle in the stream sources for Yellow River 3 (0080_1) (subbasin 19) |
| Output Analysis (subfolder) | SWAT flow and E. coli output for 5 scenarios. |
| YR_sub19.xls | Spreadsheet showing the output of 5 SWAT scenarios and charts showing SWAT loads and concentrations over time plotted with sample loads and concentrations. |
| YR_all_sub19.xls | Daily flow and E. coli concentration output from SWAT model scenario that includes all estimated subbasin loads. |
| YR_halfCIS_sub19.xls | Daily flow and E. coli concentration output from SWAT model scenario that includes all estimated subbasin loads except half of CIS load. |
| YR_noCIS_sub19.xls | Daily flow and E. coli concentration output from SWAT model scenario that includes all estimated subbasin loads without any CIS load. |
| YR_noCIS_halfapplied_sub19.xls | Daily flow and E. coli concentration output from SWAT model scenario that includes all estimated subbasin loads without any CIS load and only half of the field applied manure. |
| YR_noCIS_halfapplied_2kgpast_sub19.xls | Daily flow and E. coli concentration output from SWAT model scenario that includes all estimated subbasin loads without any CIS load, half of the field applied manure, and one-third of pasture cattle manure. |

## Table D-22 Yellow River 4 (USGS gage-0070_0)

| Folder and file name | Description of contents |
|---|---|
| **Data and Duration Curves** (folder) | **Data and analysis spreadsheets** |
| ion gage Ambient Data 1999-2010.xls | Yellow River 4 (USGS gage-0070_0) IDNR ambient monitoring program monthly data from the at the USGS gage from 1999 to 2010. |
| ion ecoli addl langel 03 to 06.xls | Yellow River 4 (USGS gage-0070_0) additional sampling data by IDNR from 2003 to 2006. |
| YR_ion_gage.xls | Yellow River flow data from the USGS gage. Used to calibrate SWAT and develop duration curves for TMDL analysis. |
| new Ion duration curves.xls | Load and flow duration curve analysis that includes sample load calculations. |
| **TMDL LA and MOS calcs** (folder) | **Load analysis spreadsheets** |
| new ion yellow_4 load calcs.xls | Calculation of the existing and target loads for the site. |
| new ion Yellow 4 0070_1 TMDL and charts.xls | Chart showing existing and target loads for each flow condition with a load duration curve. |
| **Load Sources and SWAT Input**(folder) | **Estimates of pollutant source loads.** |
| YR4 0070_0 sources3.xls | *E. coli* source evaluation for septic tanks, pasture cattle, cattle in the stream, wildlife, and field applied manure. Includes load charts |
| **SWAT Model** (folder) | **Watershed modeling of source load delivery for existing sources and scenarios for load reductions.** |
| Point Sources (subfolder) | Input into the SWAT model as sources that change monthly |
| Sub25.dbf | Inputs septic tank and cattle in the stream sources for Yellow River 4 (USGS gage-0070_0) (subbasin 15) |
| Output Analysis (subfolder) | SWAT flow and E. coli output for 5 scenarios. |
| YR4_sub25.xls | Spreadsheet showing the output of 5 SWAT scenarios and charts showing SWAT loads and concentrations over time plotted with sample loads and concentrations. |
| YR4_all_sub25.xls | Daily flow and E. coli concentration output from SWAT model scenario that includes all estimated subbasin loads. |
| YR4_halfCIS_sub25.xls | Daily flow and E. coli concentration output from SWAT model scenario that includes all estimated subbasin loads except half of CIS load. |
| YR4_noCIS_sub25.xls | Daily flow and E. coli concentration output from SWAT model scenario that includes all estimated subbasin loads without any CIS load. |
| YR4_noCIS_halfapplied_sub25.xls | Daily flow and E. coli concentration output from SWAT model scenario that includes all estimated subbasin loads without any CIS load and only half of the field applied manure. |
| YR4_noCIS_halfapplied_2kgpast_sub25.xls | Daily flow and E. coli concentration output from SWAT model scenario that includes all estimated subbasin loads without any CIS load, half of the field applied manure, and one-third of pasture cattle manure. |

# Appendix E --- Water Quality Assessments, 305 (b) Report

The Water Quality Assessment 305 (b) Reports for the four segments of the Yellow River and the nine tributaries included in this WQIP are given below. These assessments are from the 2008 Water Quality Assessment Report and include assessments for all segment impairments. They are sequenced from the Yellow River headwater segment, IA 01-YEL 0080-3 to the segment ending at the confluence with the Mississippi River, IA 01-YEL 0070-0. The tributaries are sequenced from the Yellow River confluence with the Mississippi River to the headwaters of the Yellow River.

**Yellow River, IA 01-YEL 0080-3**
[Note: Prior to the 2008 Section 305(b) cycle, this stream segment was designated only for Class B(LR) aquatic life uses. Due to changes in Iowa's surface water classification that were approved by U.S. EPA in February, this segment is now presumptively designated for Class A1 (primary contact recreation) uses. The stream remains designated for aquatic life uses (now termed Class B(WW2) aquatic life uses). Thus, for the current (2010) assessment, the available water quality monitoring data will be compared to the applicable Class A1 and Class B(WW2) water quality criteria.]

SUMMARY: The presumptive Class A1 (primary contact recreation) uses are assessed (monitored) as “not supported” due to levels of indicator bacteria that far exceed state water quality criteria. The assessment of the Class B(WW2) aquatic life uses of this stream segment remains “partially supported” for the current (2010) cycle based on the biological data. New data indicate that the previous aquatic life impairment due to low levels of dissolved oxygen no longer exists; thus, this impairment is de-listed for the current (2010) cycle. The sources of data for this assessment include (1) results of IDNR/UHL biological monitoring in 2006 and 2007 conducted as part of the IDNR/UHL stream biological sampling, (2) results of IDNR/UHL water quality monitoring from January 2006 to June 2008 at station 15960002 (107th Avenue crossing) as part of the Yellow River watershed project, and (3) results of IDNR bacteria monitoring from January 2006 to September 2008 at station 15960002.

EXPLANATION: The Class A1 (primary contact recreation) uses are assessed (monitored) as “not supported” due to violations of Iowa's water quality criteria for indicator bacteria. The geometric mean of E. coli in the 27 samples collected at IDNR/UHL station 15960002 during the recreational seasons of 2006 through 2008 was 3,665 orgs/100 ml. This geometric mean far exceeds the Class A1 criterion of 126 orgs/100 ml. Twenty-six of the 27 samples (96%) exceeded Iowa's Class A1 single-sample maximum criterion of 235 orgs/100 ml. According to U.S. EPA guidelines for Section 305(b) reporting and IDNR's assessment/listing methodology, if the geometric mean of E. coli is greater than the applicable state criterion, the primary contact recreation uses should be assessed as "not supported". Thus, because the geometric mean for IDNR/UHL station 15960002 exceeds the Class A1 criterion, the primary contact recreation uses are assessed as “not supported.”

**Yellow River, IA 01-YEL 0080-2**
Note: Prior to the 2008 Section 305(b) cycle, this stream segment was designated only for Class B(CW) aquatic life uses. Due to changes in Iowa's surface water classification that were approved by U.S. EPA in February 2008, this segment is also now presumptively designated for Class A1 (primary contact recreation) and Class A2 (secondary contact recreation) uses. This segment remains designated for coldwater aquatic life use (now termed Class B(CW1) uses), and for fish consumption uses (now termed Class HH (human health/fish consumption) uses.]

SUMMARY: The presumptive Class A1 (primary contact recreation) uses and the presumptive Class A2 (secondary contact recreation) uses are both assessed (monitored) as "not supported" due to levels of indicator bacteria that exceed state water quality criteria. The Class B(CW1) aquatic life uses remain assessed (monitored) as "not supported" due to violations of water quality criterion for dissolved oxygen. Fish consumption uses remain "not assessed" due to the lack of fish contaminant monitoring in this stream segment. Sources of data for this assessment include (1) results of IDNR/UHL chemical/physical water quality monitoring conducted from May 2004 through November 2006 as part of the Yellow River watershed project at the County Road W60 crossing (station 15030003), (2) results of IDNR/UHL bacteria monitoring conducted from January 2006 through September 2008 as part of the Yellow River watershed project at the County Road W60 crossing (station 15030003), and (3) results of an investigation of a fish kill that occurred in March 2000, and (4) results of IDNR/UHL biological monitoring in 2000 and 2004.

EXPLANATION: Both the Class A1 (primary contact recreation) and Class A2 (secondary contact recreation) uses are assessed (monitored) as "not supported" due to violations of Iowa's water quality criteria for indicator bacteria. The geometric mean of E. coli in the 37 samples collected at IDNR/UHL station 15030003 during the recreational seasons of 2006 through 2008 was 1,871 orgs/100 ml. This geometric mean far exceeds the Class A1 criterion of 126 orgs/100 ml. Thirty-six of the 37 samples (97%) exceeded Iowa's Class A1 single-sample maximum criterion of 235 orgs/100 ml. The geometric mean of the 46 samples collected at this station during calendar years of 2006 through 2008 was 991; this geometric mean exceeds the Class A2 criterion of 630 orgs/100 ml. Ten of the 46 samples (22%) exceeded Iowa's Class A2 single-sample maximum criterion (2,880 orgs/100 ml.). According to U.S. EPA guidelines for Section 305(b) reporting and IDNR's assessment/listing methodology, if the geometric mean of E. coli is greater than the applicable state criterion, the primary contact recreation uses should be assessed as "not supported". Thus, because the geometric means for IDNR/UHL station 15030003 exceeds both the Class A1 and Class A2 criteria, these uses are assessed as "not supported."

**Yellow River, IA 01-YEL 0080-1**
[Note: Prior to the 2008 Section 305(b) cycle, this stream segment was designated only for Class B(WW) aquatic life uses, including fish consumption uses. Due to changes in Iowa's surface water classification that were approved by U.S. EPA in February 2008, this segment is also now presumptively designated for Class A1 (primary contact

recreation) uses. This segment remains designated for warmwater aquatic life use (now termed Class B(WW1) uses), and for fish consumption uses (now termed Class HH (human health/fish consumption uses).]

SUMMARY/EXPLANATION: The presumptive Class A1 (primary contact recreation) uses remain "not assessed" due to the lack of information upon which to base an assessment.

**Yellow River, IA 01-YEL 0070-0**
SUMMARY: The Class A1 (primary contact recreation) uses are assessed (monitored) as "not supported" due to high levels of indicator bacteria that violate state water quality standards. The Class B(WW1) aquatic life uses are assessed (monitored) as "fully supported" based on results of (1) biological monitoring in 2002 and 2004 and on results of ambient chemical/physical water quality monitoring from 2006-2008. Fish consumption uses remain “not assessed” due to the lack of fish contaminant monitoring in this river reach. The sources of data used for this assessment include (1) results of IDNR/UHL monthly ambient water quality monitoring conducted on the Yellow River near Volney (station 10030002) during the 2006-2008 assessment period, (2) results of fixed station water quality monitoring conducted at station YL01.5M from 2004 through 2006 by IDNR staff of the Upper Mississippi River "Long-Term Resource Monitoring Program (LTRMP) at Bellevue, IA., and (3) IDNR/UHL biological monitoring conducted in 2002 and 2004.

EXPLANATION: The Class A1 (primary contact recreation) uses are assessed (monitored) as "not supported" due to violations of Iowa’s water quality criteria for indicator bacteria. The geometric mean of E. coli in the 39 samples collected from the IDNR/UHL ambient monitoring station near Volney (10030002) during the recreational seasons of 2006 through 2008 was 306 orgs/100 ml; 21 of the 39 samples (54%) exceeded Iowa’s single-sample maximum criterion of 235 orgs/100 ml. This geometric mean exceeds the state water quality criterion of 126 orgs/100 ml. According to U.S. EPA guidelines for Section 305(b) reporting and according to IDNR’s assessment/listing methodology, if the geometric mean level of E. coli is greater than the state criterion of 126 orgs/100 ml., the primary contact recreation uses should be assessed as "not supported".

**Dousman Creek - Waterbody ID Code: IA 01-YEL-0090_0**
[Note: Prior to the 2008 Section 305(b) cycle, this stream segment was designated only for Class B(CW) aquatic life uses. Due to changes in Iowa’s surface water classification that were approved by U.S. EPA in February 2008, this segment is also now presumptively designated for Class A1 (primary contact recreation) and Class A2 (secondary contact recreation) uses. This segment remains designated for coldwater aquatic life use (now termed Class B(CW1) uses), and for fish consumption uses (now termed Class HH (human health/fish consumption) uses.]

SUMMARY: The Class A1 (primary contact recreation) uses are assessed (monitored) as “not supported” due to levels of indicator bacteria that exceed state water quality criteria.

The Class A2 (secondary contact recreation) uses are assessed (monitored) as “fully supported.” The Class B(CW1) coldwater aquatic life uses remain assessed (monitored) as "partially supported" based on results of chemical/physical monitoring for dissolved oxygen. Fish consumption uses remain "not assessed" due to the lack of fish contaminant monitoring in this stream segment. Sources of data for this assessment include (1) results of IDNR/UHL bacterial monitoring conducted from February 2006 to September 2008 at STORET station 15030004 monitored as part of the Yellow River Watershed Project (YRWP); (2) results of IDNR/UHL chemical/physical monitoring at station 15030004 from May 2004 through November 2006, (3) information from the May 2006 summary of trout reproduction in Iowa streams prepared by the IDNR Fisheries Bureau and (4) 2003 UHL special project biological sampling.

EXPLANATION: The Class A1 (primary contact recreation) uses are assessed (monitored) as impaired due to violations of Iowa’s water quality criteria for indicator bacteria. The Class A2 (secondary contact recreation) uses are assessed (monitored) as “fully supported.” The geometric mean of E. coli in the 34 samples collected at YRWP site 15030004 during the recreational seasons of 2006 through 2008 was 231 orgs/100 ml. This geometric mean exceeds the Class A1 criterion of 126 orgs/100 ml. Fifteen of the 34 samples (44%) exceeded Iowa’s Class A1 single-sample maximum criterion of 235 orgs/100 ml. According to U.S. EPA guidelines for Section 305(b) reporting and IDNR’s assessment/listing methodology, if the geometric mean of E. coli is greater than the applicable state criterion, the primary contact recreation uses should be assessed as "not supported".

The geometric mean of the 38 samples collected at this station during calendar years of 2006 through 2008 was 180 orgs/100 ml; this geometric mean is well below the Class A2 criterion of 630 orgs/100 ml. Only one of the 38 samples (3%) exceeded Iowa’s Class A2 single-sample maximum criterion (2,880 orgs/100 ml.). According to U.S. EPA guidelines for Section 305(b) reporting, if the geometric mean is less than the applicable state criterion, and if less than 10% of samples exceed the single-sample maximum criterion, the contact recreation uses should be assessed as "fully supported".

**Suttle Creek - Waterbody ID Code: IA 01-YEL-0100_0**
[Note: Prior to the 2008 Section 305(b) cycle, this stream segment was designated only for Class B(CW) aquatic life uses. Due to changes in Iowa’s surface water classification that were approved by U.S. EPA in February 2008, this segment is also now presumptively designated for Class A1 (primary contact recreation) and Class A2 (secondary contact recreation) uses. This segment remains designated for coldwater aquatic life use (now termed Class B(CW1) uses), and for fish consumption uses (now termed Class HH (human health/fish consumption) uses.]

SUMMARY: The presumptive Class A1 (primary contact recreation) uses and the presumptive Class A2 (secondary contact recreation) uses are both assessed (monitored) as “not supported” due to levels of indicator bacteria that exceed state water quality criteria. The Class B(CW1) aquatic life uses remain assessed (monitored) as "not supported" due to violations of the water quality criterion for dissolved oxygen. Sources of data for this assessment include (1) the results of IDNR/UHL chemical/physical water quality monitoring conducted from May 2004 through November 2006 at IDNR/UHL station 15030005 monitored as part of the Yellow River Watershed Project (YRWP) and (2) results of IDNR/UHL bacterial monitoring conducted at station 15030005 from April 2006 through September 2008. Note: water quality monitoring was also conducted on Suttle Creek at IDNR/UHL station 15030014 at Suttle Creek Road from September 2005 through March 2006. Because only eight samples were collected during this period, and because IDNR assessment guidelines state that at least 10 samples are needed to develop a “monitored” water quality assessment, the data from this station will not be used for the 2008 305(b) assessment.

EXPLANATION: Both the Class A1 (primary contact recreation) and Class A2 (secondary contact recreation) uses are assessed (monitored) as “not supported” due to violations of Iowa’s water quality criteria for indicator bacteria. The geometric mean of E. coli in the 38 samples collected at IDNR/UHL station 15030003 during the recreational seasons of 2006 through 2008 was 1,175 orgs/100 ml. This geometric mean far exceeds the Class A1 criterion of 126 orgs/100 ml. Thirty-one of the 38 samples (82%) exceeded Iowa’s Class A1 single-sample maximum criterion of 235 orgs/100 ml.

The geometric mean of the 43 samples collected at this station during calendar years of 2006 through 2008 was 1,154 orgs/100 ml; this geometric mean exceeds the Class A2 criterion of 630 orgs/100 ml. Fourteen of the 43 samples (33%) exceeded Iowa’s Class A2 single-sample maximum criterion (2,880 orgs/100 ml.). According to U.S. EPA guidelines for Section 305(b) reporting and IDNR’s assessment/listing methodology, if the geometric mean of E. coli is greater than the applicable state criterion, the contact recreation uses should be assessed as "not supported" (see pgs 3-33 to 3-35of U.S. EPA 1997b). Thus, because the geometric means for IDNR/UHL station 15030005 exceeds both the Class A1 and Class A2 criteria, these uses are assessed as “not supported.”

**Unnamed Creek (aka Bear Cr.) - Waterbody ID Code: IA 01-YEL-0110_0**
[Note: Prior to the 2008 Section 305(b) cycle, this stream segment was designated only for Class B(CW) aquatic life uses. Due to changes in Iowa’s surface water classification that were approved by U.S. EPA in February 2008, this segment is also now presumptively designated for Class A1 (primary contact recreation) and Class A2 (secondary contact recreation) uses. This segment remains designated for coldwater aquatic life use (now termed Class B(CW1) uses), and for fish consumption uses (now termed Class HH (human health/fish consumption) uses. This stream segment also remains identified as“HQR” (high quality resource) water.]

SUMMARY: The presumptive Class A1 (primary contact recreation) uses are assessed (monitored) as “not supported” due to levels of indicator bacteria that exceed state water quality criteria. The Class A2 (secondary contact recreation) uses, however, are assessed (monitored) as “fully supported.” The Class B(CW1) aquatic life uses remain assessed (monitored) as "not supported" due to violations of the water quality criterion for dissolved oxygen. The sources of data for this assessment are (1) the results of IDNR/UHL chemical/physical water quality monitoring conducted from May 2004 to

November 2006 at the IDNR/UHL station near county road X26 (STORET station 15030006) as part of the Yellow River Watershed Project and (2) results of IDNR/UHL bacterial monitoring conducted at station 150030006 from April 2006 through September 2008.

EXPLANATION: The presumptive Class A1 (primary contact recreation) uses are assessed (monitored) as impaired due to violations of Iowa's water quality criteria for indicator bacteria. The Class A2 (secondary contact recreation) uses, however, are assessed (monitored) as "fully supported." The geometric mean of E. coli in the 38 samples collected at YRWP site near county road X26 (station 15030006) during the recreational seasons of 2006 through 2008 was 236 orgs/100 ml. This geometric mean exceeds the Class A1 criterion of 126 orgs/100 ml. Nineteen of the 38 samples (50%) exceeded Iowa's Class A1 single-sample maximum criterion of 235 orgs/100 ml. According to U.S. EPA guidelines for Section 305(b) reporting and IDNR's assessment/listing methodology, if the geometric mean of E. coli is greater than the applicable state criterion, the primary contact recreation uses should be assessed as "not supported" (see pgs 3-33 to 3-35of U.S. EPA 1997b).

The geometric mean of the 47 samples collected at this station during calendar years of 2006 through 2008 was 147 orgs/100 ml; this geometric mean is well-below the Class A2 criterion of 630 orgs/100 ml. Only one of the 47 samples (2%) exceeded Iowa's Class A2 single-sample maximum criterion (2,880 orgs/100 ml.). According to U.S. EPA guidelines for Section 305(b) reporting, if the geometric mean is less than the applicable state criterion, and if less than 10% of samples exceed the single-sample maximum criterion, the contact recreation uses should be assessed as "fully supported" (see pgs 3-33 to 3-35 of U.S. EPA 1997b). Thus, because both the Class A2 geometric mean and single-sample criteria were met, these results suggest that the Class A2 uses should be assessed as "fully supported."

**Hickory Creek - Waterbody ID Code: IA 01-YEL-0120_1**

[Note: Prior to the 2008 Section 305(b) cycle, this stream segment was designated only for Class B(CW) aquatic life uses. Due to changes in Iowa's surface water classification that were approved by U.S. EPA in February 2008, this segment is also now presumptively designated for Class A1 (primary contact recreation) and Class A2 (secondary contact recreation) uses. This segment remains designated for coldwater aquatic life use (now termed Class B(CW1) uses), and for fish consumption uses (now termed Class HH (human health/fish consumption) uses. This stream segment also remains identified as"HQ" (high quality) water.]

SUMMARY: The presumptive Class A1 (primary contact recreation) uses are assessed (monitored) as "not supported" due to levels of indicator bacteria that exceed state water quality criteria. The Class A2 (secondary contact recreation) uses, however, are assessed (monitored) as "fully supported." The Class B(CW1) aquatic life uses remain assessed (monitored) as "partially supported" based on results of water quality monitoring from 2004-2006 that show violations of Class B(CW1) criteria for dissolved oxygen. The source of data for this assessment is (1) the results of IDNR/UHL chemical/physical water quality monitoring conducted from May 2004 to November 2006 at the Hickory Creek Road crossing (STORET station 15030007) as part of the Yellow River Watershed Project and (2) the results of IDNR/UHL bacterial monitoring at this monitoring station from April 2006 through September 2008.

EXPLANATION: The presumptive Class A1 (primary contact recreation) uses are assessed (monitored) as impaired due to violations of Iowa’s water quality criteria for indicator bacteria. The presumptive Class A2 (secondary contact recreation) uses, however, are assessed (monitored) as “fully supported.” The geometric mean of E. coli in the 38 samples collected at YRWP site at Hickory Creek Road (station 15030007) during the recreational seasons of 2006 through 2008 was 948 orgs/100 ml. This geometric mean far exceeds the Class A1 criterion of 126 orgs/100 ml. Thirty-three of the 38 samples (87%) exceeded Iowa’s Class A1 single-sample maximum criterion of 235 orgs/100 ml. According to U.S. EPA guidelines for Section 305(b) reporting and IDNR’s assessment/listing methodology, if the geometric mean of E. coli is greater than the applicable state criterion, the primary contact recreation uses should be assessed as "not supported".

The geometric mean of the 47 samples collected at this station during calendar years of 2006 through 2008 was 505 orgs/100 ml; this geometric mean is below the Class A2 criterion of 630 orgs/100 ml. Five of the 47 samples (11%) exceeded Iowa’s Class A2 single-sample maximum criterion (2,880 orgs/100 ml.). According to U.S. EPA guidelines for Section 305(b) reporting, if the geometric mean is less than the applicable state criterion, the contact recreation uses should be assessed as "fully supported".

**Williams Creek - Waterbody ID Code: IA 01-YEL-0125_0**

Note: Prior to the 2008 Section 305(b) cycle, this stream segment was designated only for Class B(LR) aquatic life uses. Due to changes in Iowa’s surface water classification that were approved by U.S. EPA in February 2008, this segment is now presumptively designated for Class A1 (primary contact recreation) uses. The stream remains designated for aquatic life uses (now termed Class B(WW2) aquatic life uses). Thus, for the current (2010) assessment, the available water quality monitoring data will be compared to the applicable Class A1 and Class B(WW2) water quality criteria.

SUMMARY: The presumptive Class A1 (primary contact recreation) uses are assessed (monitored) as “not supported” due to levels of indicator bacteria that exceed state water quality criteria. The Class B(WW2) aquatic life uses are assessed (evaluated) as "partially supported" due to occurrence of a fish kill in April 2002 (impairment moves from IR Category 4d to IR Category 3b). Sources of data for this assessment include (1) results of the investigation of the April 2002 fish kill, (2) results of IDNR/UHL monitoring for dissolved oxygen from May 2004 to November 2006 at the County Road X16 crossing (station 15030011) as part of the Yellow River Watershed Project, and (3) results of IDNR/UHL monitoring for indicator bacteria at station 15030011 from January 2006 through September 2008.

EXPLANATION: The presumptive Class A1 (primary contact recreation) uses are assessed (monitored) as "not supported" due to violations of Iowa’s water quality criteria for indicator bacteria. The geometric mean of E. coli in the 38 samples collected at the monitoring station near county road X16 during the recreational seasons of 2006 through 2008 was 826 orgs/100 ml. Twenty-seven of the 38 samples (71%) exceeded Iowa’s single-sample maximum criterion of 235 orgs/100 ml. According to U.S. EPA guidelines for Section 305(b) reporting and IDNR’s assessment/listing methodology, if the geometric mean of E. coli is greater than the state criterion of 126 orgs/100 ml., the primary contact recreation uses should be assessed as "not supported".

**Norfolk Creek - Waterbody ID Code: IA 01-YEL-0130_0**
[Note: Prior to the 2008 Section 305(b) cycle, this stream segment was designated only for Class B(CW) aquatic life uses. Due to changes in Iowa’s surface water classification that were approved by U.S. EPA in February 2008, this segment is also now presumptively designated for Class A1 (primary contact recreation) and Class A2 (secondary contact recreation) uses. This segment remains designated for coldwater aquatic life use (now termed Class B(CW1) uses), and for fish consumption uses (now termed Class HH (human health/fish consumption) uses. This stream segment also remains identified as“HQR” (high quality resource) water.]

SUMMARY: The presumptive Class A1 (primary contact recreation) uses are assessed (monitored) as “not supported” due to levels of indicator bacteria that exceed state water quality criteria. The presumptive Class A2 (secondary contact recreation) uses, however, are assessed (monitored) as “fully supported.” The Class B(CW1) aquatic life uses remain assessed (monitored) as "not supported" due to violations of the water quality criterion for dissolved oxygen. Fish consumption uses remain “not assessed” due to the lack of fish contaminant monitoring in this stream segment. The source of data for this assessment is (1) the results of IDNR/UHL chemical/physical water quality monitoring conducted from May 2004 to November 2006 at the County Road W4B crossing (STORET station 15030008) as part of the Yellow River Watershed Project and (2) results of IDNR/UHL monitoring for indicator bacteria at station 15030008 from April 2006 to September 2008.

EXPLANATION: The presumptive Class A1 (primary contact recreation) uses are assessed (monitored) as impaired due to violations of Iowa’s water quality criteria for indicator bacteria. The Class A2 (secondary contact recreation) uses, however, are assessed (monitored) as “fully supported.” The geometric mean of E. coli in the 38 samples collected at the YRWP site at county road W4B (station 15030008) during the recreational seasons of 2006 through 2008 was 278 orgs/100 ml. This geometric mean exceeds the Class A1 criterion of 126 orgs/100 ml. Seventeen of the 38 samples (45%) exceeded Iowa’s Class A1 single-sample maximum criterion of 235 orgs/100 ml. According to U.S. EPA guidelines for Section 305(b) reporting and IDNR’s assessment/listing methodology, if the geometric mean of E. coli is greater than the applicable state criterion, the primary contact recreation uses should be assessed as "not supported".

The geometric mean of the 47 samples collected at this station during calendar years of 2006 through 2008 was 149 orgs/100 ml; this geometric mean is far below the Class A2 criterion of 630 orgs/100 ml. Three of the 47 samples (6%) exceeded Iowa's Class A2 single-sample maximum criterion (2,880 orgs/100 ml.). According to U.S. EPA guidelines for Section 305(b) reporting, if the geometric mean is less than the applicable state criterion, the contact recreation uses should be assessed as "fully supported".

**Unnamed Creek (aka Ludlow Creek)- Waterbody ID Code: IA 01-YEL-0150_0**
Note: Prior to the 2008 Section 305(b) cycle, this stream segment was designated only for Class B(LR) aquatic life uses. Due to changes in Iowa's surface water classification that were approved by U.S. EPA in February 2008, this segment is now also presumptively designated for Class A1 (primary contact recreation) uses. The stream remains designated for aquatic life uses (now termed Class B(WW2) aquatic life uses). Thus, for the current (2010) assessment, the available water quality monitoring data will be compared to the applicable Class A1 and Class B(WW2) water quality criteria.]

SUMMARY: The presumptive Class A1 (primary contact recreation) uses are assessed (monitored) as “not supported” due to levels of indicator bacteria that exceed state water quality criteria. The Class B(WW2) aquatic life uses are assessed (evaluated) as "partially supported" based on results of IDNR/UHL biological monitoring 2006 and 2007. Data sources include (1) results of IDNR/UHL monitoring conducted from 2004-2006 at the County Road W60 crossing (STORET station 15030009) as part of the Yellow River Watershed Project, (2) results of IDNR/UHL monitoring for indicator bacteria from January 2006 to September 2008 at station 15030009, and (3) results of IDNR/UHL biological monitoring in 2006 and 2007.

EXPLANATION: The presumptive Class A1 (primary contact recreation) uses are assessed (monitored) as "not supported" due to violations of Iowa's water quality criteria for indicator bacteria. The geometric mean of E. coli in the 38 samples collected at the monitoring station near county road W60 crossing during the recreational seasons of 2006 through 2008 was 781 orgs/100 ml. This geometric mean far exceeds the Class A1 criterion of 126 orgs/100 ml. Twenty-eight of the 38 samples (74%) exceeded Iowa's single-sample maximum criterion of 235 orgs/100 ml. According to U.S. EPA guidelines for Section 305(b) reporting and IDNR's assessment/listing methodology, if the geometric mean of E. coli is greater than the state criterion of 126 orgs/100 ml., the primary contact recreation uses should be assessed as "not supported".

**Unnamed Creek (aka Hecker Cr.) - Waterbody ID Code: IA 01-YEL-0155_0**
Note: Prior to the 2008 Section 305(b) cycle, this stream segment was classified only for general uses. Due to changes in Iowa's surface water classification that were approved by EPA in February 2008, this segment is now presumptively designated for Class A1 (primary contact recreation) uses and for Class B(WW1) aquatic life uses. According to the Iowa Water Quality Standards, all perennial rivers and streams and all intermittent streams with perennial pools that are not specifically listed in the Iowa surface water classification are designated as Class A1 and Class B(WW1) waters. Thus, for the

current (2010) assessment, the available water quality monitoring data will be compared to the applicable Class A1 and Class B(WW1) water quality criteria.

SUMMARY: The presumptive Class A1 (primary contact recreation) uses are assessed (monitored) as “not supported” due to levels of indicator bacteria that exceed state water quality criteria.  The presumptive Class B(WW1) aquatic life uses remain assessed (evaluated) as “partially supported” based on results of a fish kill investigation in March 2000.  Results from the IDNR/UHL biological monitoring in 2000, 2006 and 2007 continue to suggest a potential impairment of the aquatic life uses.  An additional potential impairment remains based on results from the IDNR/UHL water quality monitoring from 2006 through 2008 that show high levels of chloride in this stream.  The sources of data for this assessment include (1) results of IDNR/UHL chemical and physical monitoring from March 2006 to June 2008 conducted at the County Road W4B crossing (STORET station 15030010) as part of the Yellow River Watershed Project, (2) results of IDNR/UHL bacteria monitoring at station 1530010 from April 2006 to September 2008 as part of the Yellow River Watershed Project, (3) results of an IDNR fish kill investigation in March 2000, and (4) results of IDNR/UHL biological monitoring conducted in 2000, 2006 and 2007.

EXPLANATION: The presumptive Class A1 (primary contact recreation) uses are assessed (monitored) as "not supported" due to violations of Iowa’s water quality criteria for indicator bacteria.  The geometric mean of E. coli in the 49 samples collected at the monitoring station near the county road W4B crossing (station 15030010) during the recreational seasons of 2006 through 2008 was 2,335 orgs/100 ml.  This geometric mean far exceeds the Class A1 criterion of 126 orgs/100 ml.  Forty-three of the 50 samples (88%) exceeded Iowa’s single-sample maximum criterion of 235 orgs/100 ml.  According to EPA guidelines for Section 305(b) reporting and IDNR’s assessment/listing methodology, if the geometric mean of E. coli is greater than the state criterion of 126 orgs/100 ml., the primary contact recreation uses should be assessed as "not supported".

**North Fork Yellow River - Waterbody ID Code: IA 01-YEL-0160_0**
Note: Prior to the 2008 Section 305(b) cycle, this stream segment was designated only for Class B(LR) aquatic life uses.  Due to changes in Iowa’s surface water classification that were approved by U.S. EPA in February 2008, this segment is now also presumptively designated for Class A1 (primary contact recreation) uses.  The stream remains designated for aquatic life uses (now termed Class B(WW2) aquatic life uses).  Thus, for the current (2010) assessment, the available water quality monitoring data will be compared to the applicable Class A1 and Class B(WW2) water quality criteria.

SUMMARY: The presumptive Class A1 (primary contact recreation) uses are assessed (monitored) as “not supported” due to levels of indicator bacteria that far exceed state water quality criteria.  The Class B(WW2) aquatic life uses remain assessed (monitored) as "partially supported" due to violations of criteria for dissolved oxygen.  The sources of data for this assessment are the results of (1) IDNR/UHL chemical/physical water quality monitoring conducted from May 2004 to November 2006 at the Maple Valley Road crossing (STORET station 15960001) and (2) results of IDNR/UHL bacteria monitoring at station 15960001 from January 2006 through September 2008. Both of these datasets were generated as part of the Yellow River Watershed Project.

EXPLANATION: The presumptive Class A1 (primary contact recreation) uses are assessed (monitored) as "not supported" due to violations of Iowa’s water quality criteria for indicator bacteria. Results of IDNR/UHL monitoring continue to suggest extremely high levels of indicator bacteria in this stream segment. The geometric mean of E. coli in the 38 samples collected at the monitoring station at Maple Valley Road (station 15960001) during the recreational seasons of 2006 through 2008 was 5,308 orgs/100 ml. This geometric mean far exceeds the Class A1 criterion of 126 orgs/100 ml. All 38 samples (100%) exceeded Iowa’s single-sample maximum criterion of 235 orgs/100 ml. According to U.S. EPA guidelines for Section 305(b) reporting and IDNR’s assessment/listing methodology, if the geometric mean of E. coli is greater than the state criterion of 126 orgs/100 ml., the primary contact recreation uses should be assessed as "not supported".

# Appendix F --- Public Comments

The DNR received no public comments during the September 6, 2012 to October 8, 2012 public comment period.