PHASE I
WATERSHED ASSESSMENT FINAL REPORT
AND TMDLs

NORTH-CENTRAL BIG SIOUX RIVER
BROOKINGS, HAMLIN, DEUEL, AND CODINGTON COUNTIES
SOUTH DAKOTA

South Dakota Watershed Protection Program
Division of Financial and Technical Assistance
South Dakota Department of Environment and Natural Resources
Steven M. Pirner, Secretary

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Project Sponsor and Prepared By

East Dakota Water Development District

State of South Dakota
Mike Rounds, Governor

December 2005

This project was conducted in cooperation with the State of South Dakota and the United States Environmental Protection Agency, Region 8.

EPA Grants # C9998185-96 and # C9998185-00

EXECUTIVE SUMMARY

PROJECT TITLE: North-Central Big Sioux River Watershed Assessment

START DATE: April 01, 2001 **COMPLETION DATE:** 12/31/06

FUNDING:	**TOTAL BUDGET:** $330,576 (projected)
TOTAL EPA GRANT:	$150,243
TOTAL EXPENDITURES OF EPA FUNDS:	$150,243 (through 12/31/06)
TOTAL SECTION 319 MATCH ACCRUED:	$205,846.36 (through 12/31/06)
BUDGET REVISIONS:	
Original EPA Grant:	$172,243
Grant Reductions:	$ 22,000
Revised EPA Grant:	$150,243
TOTAL EXPENDITURES:	$356,089.36 (through 12/31/06)

SUMMARY ACCOMPLISHMENTS

The North-Central Big Sioux River watershed assessment project began in April of 2001 and continued through December of 2005 when data analysis and compilation into a final report was completed. The assessment was conducted as a result of this area of the Big Sioux River watershed being placed on the 1998 303(d) list for total suspended solids (TSS) problems. The project met all of its milestones in a timely manner, with the exception of completing the final report. This was delayed while completion of TMDL reports for an additional watershed (the Central Big Sioux River Watershed Assessment) was completed.

An EPA section 319 grant provided a majority of the funding for this project. The Department of Environment and Natural Resources and East Dakota Water Development District provided matching funds for the project.

Water quality monitoring and watershed modeling resulted in the identification of several sources of impairment. These sources may be addressed through best management practices (BMPs) and the construction of several waste management systems at animal feeding operations.

The long term goal for this project was to locate and document sources of non-point source pollution in the North-Central Big Sioux River (BSR) watershed and provide feasible restoration alternatives to improve water quality. Through identification of sources of impairment in the watershed, this goal was accomplished.

ACKNOWLEDGEMENTS

The cooperation of the following organizations and individuals is gratefully appreciated. The assessment of the North-Central Big Sioux River and its watershed could not have been completed without the cooperation of the landowners in the study area - their cooperation is greatly appreciated.

Brookings County Conservation District
Codington County Conservation District
Deuel County Conservation District
Hamlin County Conservation District
Natural Resource Solutions
Sioux Falls Health Lab
South Dakota Cattlemen's Association
South Dakota Corn Growers Association
South Dakota Department of Environment and Natural Resources
South Dakota Department of Game, Fish and Parks
South Dakota Soybean Association
South Dakota State University, Department of Wildlife and Fisheries, GAP Analysis Lab
South Dakota Geological Survey
South Dakota State University, Water Resource Institute
United States Department of Agriculture, Farm Service Agency, Brookings
United States Department of Agriculture, Farm Service Agency, Watertown
United States Department of Agriculture, Natural Resource Conservation Service
United States Environmental Protection Agency
United States Fish and Wildlife Service
United States Geological Survey

East Dakota Water Development staff that contributed to the development of this report:
Technical Staff: Deb Springman, Becky Banks, Mark Hanson, Craig Milewski, Dray Walter
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ABBREVIATIONS

AFOs	Animal Feeding Operations – *facility where animals are confined, fed, or maintained for a total of 45 days in any 12 month period, and where vegetation is not sustained in the normal growing season over any portion of the lot or facility*
ARSD	Administrative Rules of South Dakota – *legal statutes that specify standards or requirements*
AGNPS	Agricultural Non-Point Source – *an event-based, watershed-scale model developed to simulate runoff, sediment, chemical oxygen demand, and nutrient transport in surface runoff from ungaged agricultural watersheds*
BMP	Best Management Practice – *an agricultural practice that has been determined to be an effective, practical means of preventing or reducing nonpoint source pollution*
BSR	Big Sioux River
CFU	Colony Forming Units - *a count of the number of active bacterial cells*
CV	Coefficient of Variance – *a statistical term used to describe the amount of variation within a set of measurements for a particular test*
DO	Dissolved Oxygen
EDWDD	East Dakota Water Development District
IBI	Index of Biological Integrity
IPI	Index of Physical Integrity
MOS	Margin of Safety – *an index indicating the amount beyond the minimum necessary*
MPN	Most Probably Number - *a term used to signify that the number of bacteria was determined by means of the multiple-tube fermentation technique*
NGP	Northern Glaciated Plains
NPDES	National Pollution Discharge Elimination System
NPS	Non-point Source
NRCS	Natural Resources Conservation Service
NTU	Nephelometric Turbidity Units – *measure of the concentration of size of suspended particles (cloudiness) based on the scattering of light transmitted or reflected by the medium*
SD	South Dakota
SDDENR	South Dakota Department of Environment and Natural Resources
SDGFP	South Dakota Department of Game Fish & Parks
SDSU	South Dakota State University
TKN	Total Kjeldahl Nitrogen
TMDL	Total Maximum Daily Load – *a calculation of the maximum amount of a pollutant that a waterbody can receive and still meet water quality standards, and an allocation of the amount to the pollutant's sources*
TSS	Total Suspended Solids
µmhos/cm	microhmos/centimeter – *unit of measurement for conductivity*
USFWS	United States Fish and Wildlife Service
USGS	United States Geologic Survey
WQ	Water Quality – *term used to describe the chemical, physical, and biological characteristics of water, usually in respect to its suitability for a particular purpose*
WRI	Water Resource Institute

INTRODUCTION

PURPOSE

The purpose of this assessment is to determine sources of impairment and develop restoration alternatives for the north-central Big Sioux River (BSR) and its major tributaries in Brookings, Hamlin, Deuel and Codington Counties of South Dakota (Figure 1).

Direct runoff to the river, as well as perennial and intermittent tributaries, contributes loadings of sediment, nutrients, and fecal coliform bacteria primarily related to seasonal snow melt or rainfall events. In the 1998 and 2000 South Dakota 305(b) Water Quality Assessment Report and the 1998 and 2002 303(d) Waterbody List, the north-central portion of the Big Sioux River was listed as partially supporting its designated uses because of excess total suspended solids, pathogens, nutrients, and organic enrichment. In the 2004 Integrated Report for Surface Water Quality Assessment, the north-central portion from the confluence of Willow Creek and the Big Sioux River to the City of Brookings is not supporting its designated uses due to excessive suspended solids, fecal coliform bacteria, and nitrates. Table 1 shows those locations identified as not meeting water quality criteria. Through water quality monitoring (chemical and biological), stream gaging, and land use analysis, sources of impairment can be determined and feasible alternatives for restoration efforts can be developed.

Because of its listing in the South Dakota 303(d) Waterbody List, this portion of the Big Sioux River is identified as a priority for the development of Total Maximum Daily Loads (TMDLs) for the pollutants of concern. This final assessment report and associated TMDLs will serve as the foundation for restoration projects that can be developed and implemented to meet the designated uses and water quality standards of the north-central portion of the Big Sioux River and its tributaries. This project is intended to be the initial phase of a series of watershed-wide restoration implementation projects.

Table 1. 303(d) Listing of Locations Not Meeting Water Quality Criteria

Years Listed	Segment or Lake	EDWDD Sites	Basis	Cause	Source
1998 2002 2004	Willow Creek to Stray Horse Creek (segment of the BSR)	R17, R18	DENR460740	Nitrates Fecal Coliform Bacteria Organic Enrichment TSS	Crop Production, Livestock, Municipal PS Discharge, Industrial PS Discharge
1998 2002 2004	Near Volga to Brookings (segment of the BSR)	R20, R01	DENR460662	Fecal Coliform Bacteria Organic Enrichment TSS	Crop Production, Grazing in Riparian Zones, Animal Feeding Operations

GENERAL WATERSHED DESCRIPTION

The north-central BSR watershed is approximately 502,894 acres (203,521 hectares) in size and lies within the Big Sioux Basin (Figure 1). The BSR is a permanent, natural river that flows north to south along the eastern edge of South Dakota and drains into the Missouri River at Sioux City, Iowa. The BSR is supplied by numerous intermittent tributaries, which carry water primarily during spring snowmelt or rainfall events. The North-Central BSR Watershed Project extends from the USGS gaging station north of Watertown (near the confluence with Mud Creek) south to the confluence with North Deer Creek (southeast of Volga). Within the study area, the Big Sioux

River rarely becomes intermittent; however, wet-dry cycles have prominent effects on annual discharge. Major tributaries often become intermittent during dry phases.

The river and its tributaries drain portions of Codington, Deuel, Hamlin and Brookings Counties. The river also receives storm sewer discharges or additional runoff from several communities along its course, including the cities of Watertown, Castlewood, Estelline, and Brookings. Direct runoff to the river, as well as perennial and intermittent tributaries, contributes loadings of sediment and nutrients. The river and tributaries also recharge shallow aquifers found adjacent to these water bodies. These shallow aquifers are the principle source of drinking water for the residents of the region. Other flow alterations of the BSR include channelization, culverts, and bridges at numerous road crossings of the river and tributaries.

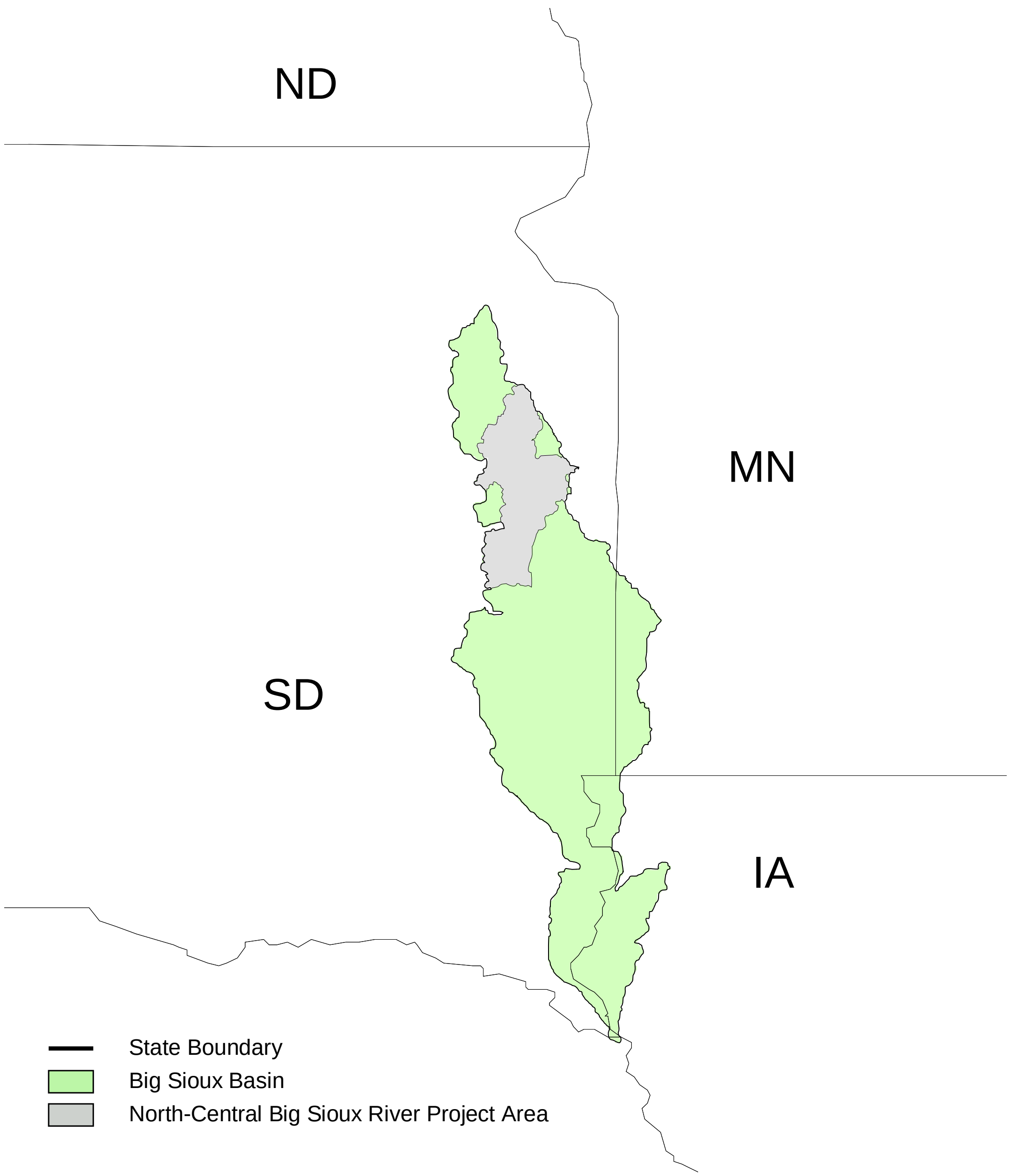


Figure 1. The Big Sioux Basin Boundary and Location of the NCBSRW

Geology and Soils

Based on the relative age of the landscape, the surficial character of the watershed can be divided into two parts: 1) along the valley of the BSR and the eastern tributaries where drainage is well developed and un-drained depressions are rare; 2) to the west of the river, including the Oakwood Lakes area where drainage is poor and there are many potholes, sloughs, and lakes. Land elevation ranges from nearly 2,050 feet above mean sea level in the northeastern part of the study area to about 1,600 feet in the southern edge of the project area.

Soils within the watershed area are derived from a variety of parent materials. Upland soils are relatively fine-grained, and have developed over glacial till or eolian (loess) deposits. Coarse-grained soils are found along present or former water courses, and are derived from glacial outwash or alluvial sediments. Surficial materials and bedrock mainly consist of glacial till over Cretaceous shales.

Climate

The average annual precipitation in the north-central BSR watershed is 23.2 inches, of which 76 percent typically falls during the growing season in April through September (Figures 2 and 3). Tornadoes and severe thunderstorms strike occasionally. These storms are often local in extent, short in duration, and occasionally produce heavy rainfall. The average seasonal snowfall is 36.5 inches per year (SDSU 2003).

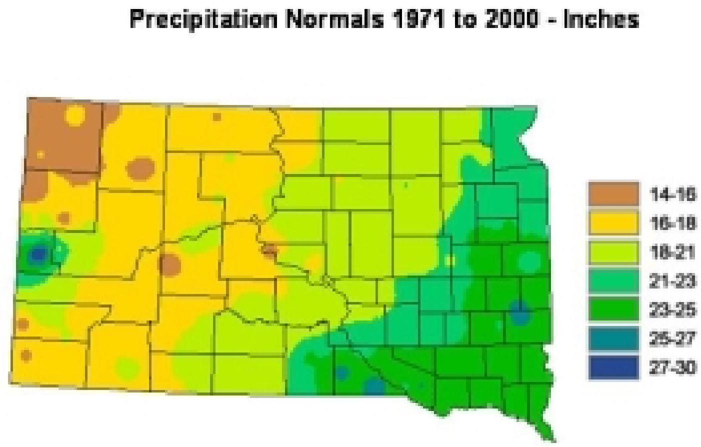


Figure 2. South Dakota Precipitation Normals in Inches from 1971 to 2000

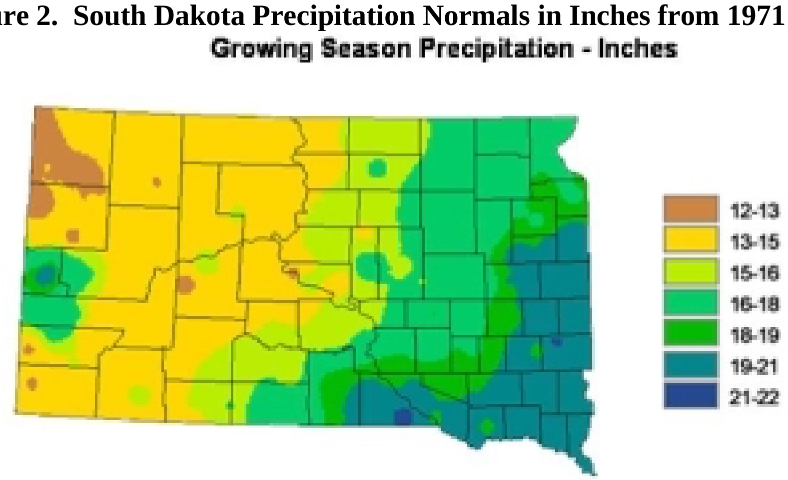


Figure 3. South Dakota Growing Season Precipitation in Inches from 1971 to 2000

Land Use

Land use in the watershed is predominantly agricultural (Figure 4). Approximately 73 percent of the area is cropland, with corn, soybeans, and small grains, and 23 percent is grassland and pastureland. As part of the assessment, 371 animal feeding operations in the watershed were evaluated. More than 74,000 animals were documented. Of this number, 93 percent were cattle, four percent were sheep, two percent were pigs, and the remaining were horses. Urban development and growth has taken place in and around the community of Watertown. Smaller communities in the region are also experiencing expanding growth.

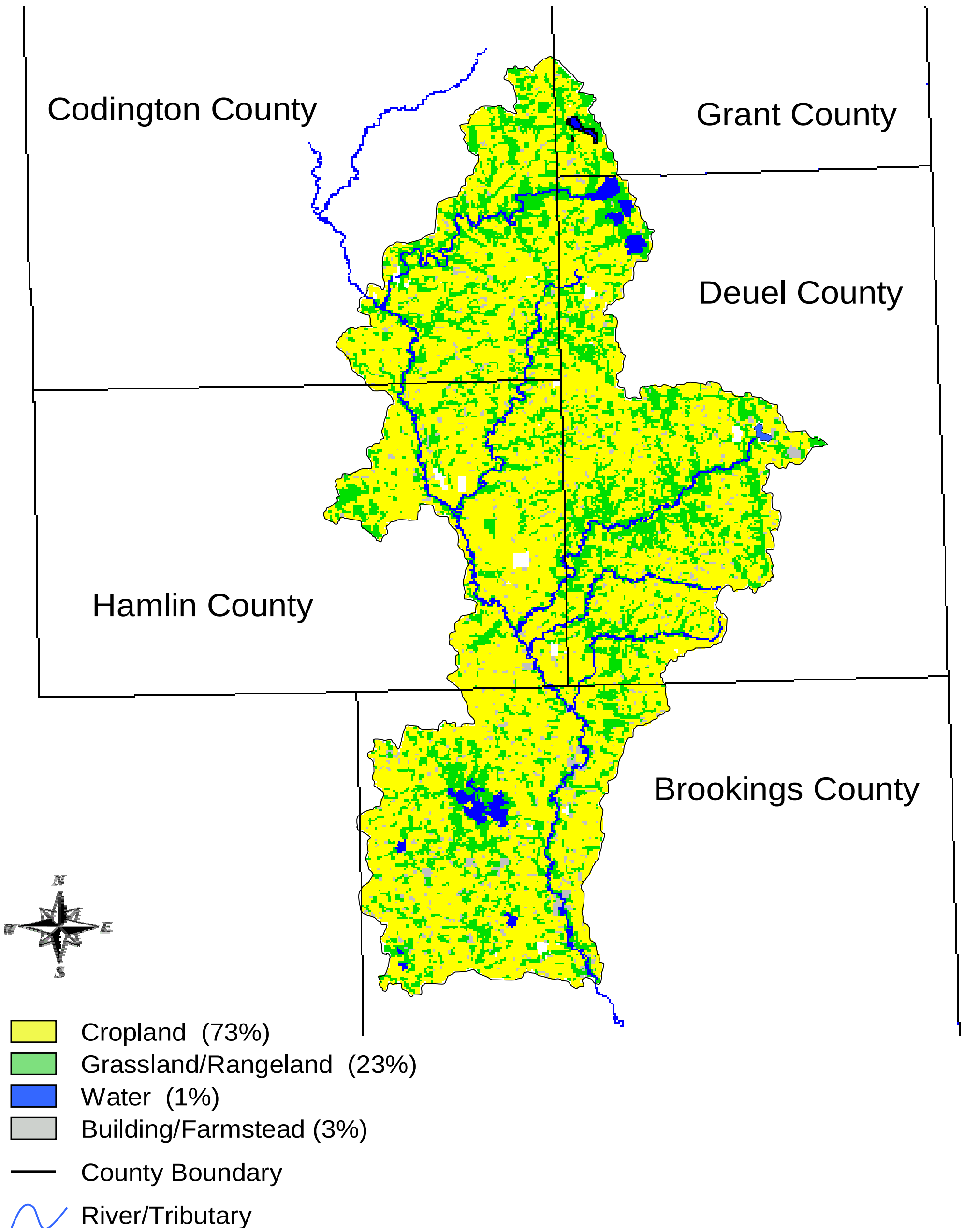


Figure 4. Landuse in the NCBSRW

Population

A majority of the population in the North-Central Big Sioux River study area lives within Codington County (sixth largest in the state). The fourth largest city in the state of South Dakota, Watertown, lies within this county. Other towns located in the study area include Kranzburg in Codington County; Estelline and Castlewood in Hamlin County; Bemis, Altamont, Goodwin, and Clear Lake in Deuel County; and Bruce and Volga in Brookings County. Table 2 shows the land area of each county, the people per square mile, and the population based on the 2000 Census.

Table 2. Land Area and Population of Codington, Hamlin, Deuel and Brookings Counties

	Codington	Hamlin	Deuel	Brookings	South Dakota
Land Area (sq. mi)	688	507	624	794	75885
People (sq. mi)	37.7	10.9	7.2	35.5	9.9
Population (2000)	25929	5615	4364	28265	754844

History

The Big Sioux River, like most rivers across the Midwest, have watersheds that have been converted from tallgrass prairies and deciduous hardwoods to a matrix of intensive agricultural uses with areas of urban sprawl. This conversion has resulted in large-scale alterations to watershed level processes. Primarily, the alteration has been an increase in overland flow of energy and material resources resulting from a decrease in ground-water infiltration/subsurface recharge. An increase in surface runoff has associated increases in the non-point source transport of sediment, nutrient, agricultural and residential chemicals, and feedlot runoff.

PROJECT DESCRIPTION

The boundaries of the north-central Big Sioux River watershed in eastern South Dakota study area were defined by the boundaries of tributaries that enter the Big Sioux River between USGS gaging station north of Watertown (near the confluence with Mud Creek) south to the confluence with North Deer Creek (southeast of Volga). This 502,894 acre area lies within the Northern Glaciated Plains (NGP) ecoregion (Level III). Within the NGP, two Level IV ecoregions are represented in the assessment area: the Big Sioux Basin (46m) and the Prairie Coteau (46l) (Figure 5). Descriptions of the two Level IV ecoregions are provided in Table 3.

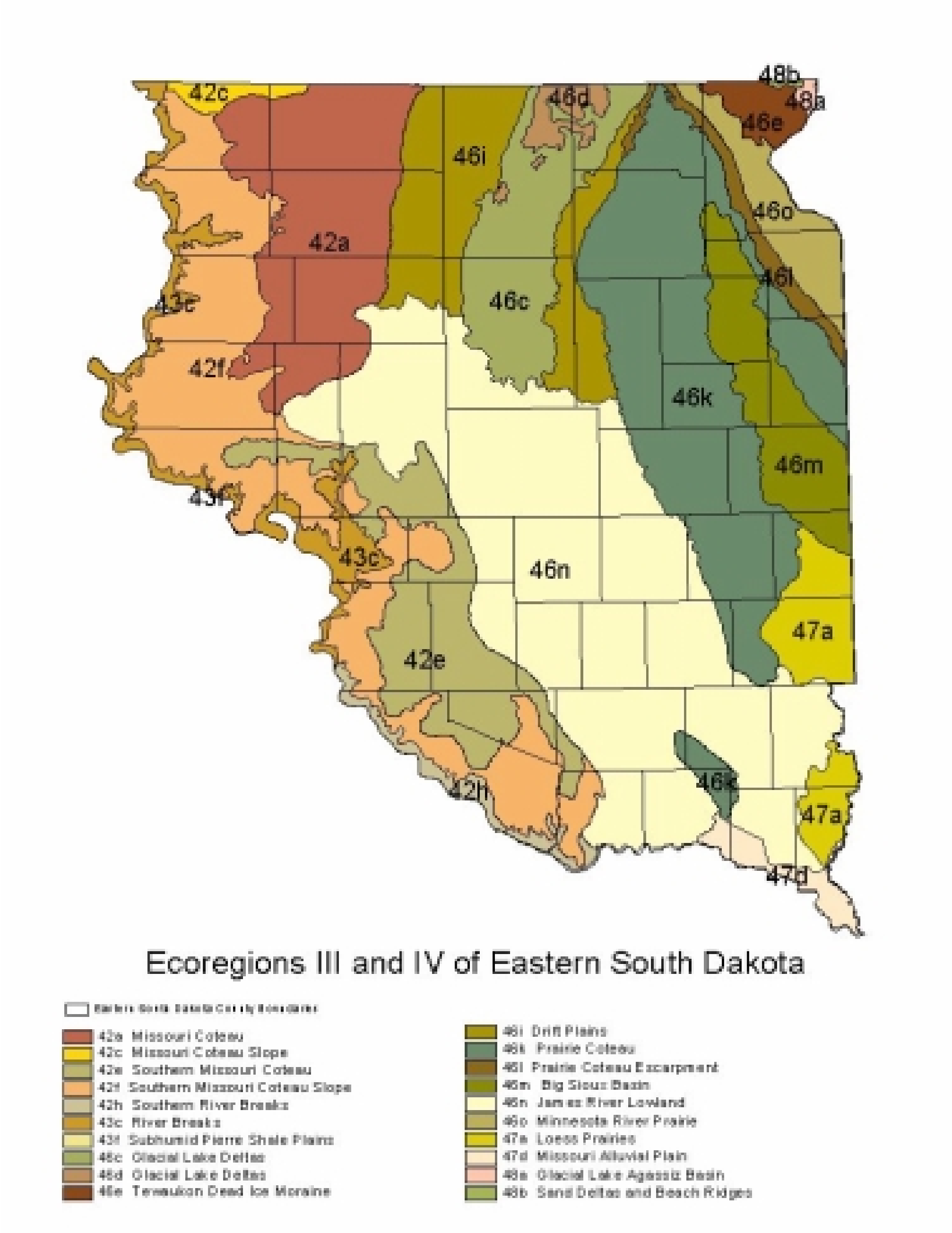
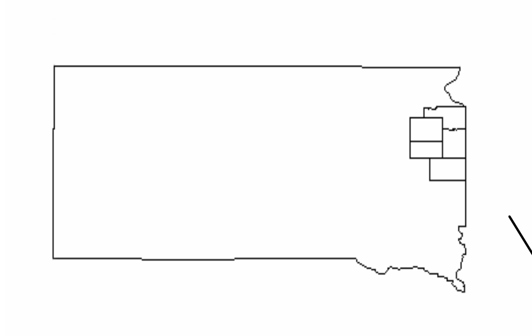


Figure 5. Ecoregions III and IV of Eastern South Dakota

Table 3. Description of Level IV Ecoregions *Within* the North-Central Big Sioux River Watershed (Omernik et al. 1987)

Ecoregion	Physiography	Potential Natural Vegetation	Land Use and Land Cover	Climate	Soil Order
Northern Glaciated Plains (46)					
Prairie Coteau (46l)	Surficial geology of glacial till. Hummocky, rolling landscape with high concentration of lakes and wetlands and poorly defined stream network.	Big bluestem, little bluestem, switchgrass, indiangrass, and blue gramma.	Rolling portions of landscape primarily in pastureland. Flatter portions of landscape in row crop, primarily of corn and soybeans. Some small grain and alfalfa.	Mean annual rainfall of 20-22 inches. Frost-free from 110-140 free days.	Mollisols
Big Sioux Basin (46m)	Surficial geology of glacial till. Rolling landscape with defined stream network and few wetlands.	Tallgrass prairie: Big bluestem, little bluestem, switchgrass, indiangrass, sideoats gramma, and lead plant. Riparian areas: willows and cordgrass to the north and some woodland south.	Row crop agriculture of mostly corn and soybean. Some small grain and alfalfa.	Mean annual rainfall of 20-22 inches. Frost-free from 110-140 free days.	Mollisols



Monitoring site locations were dispersed among 10 tributary locations and eight river locations throughout the study area. Figure 6 shows the locations of the tributary and river sites. The shaded area (delineated watershed) was generated based on hydrography and topography. Although sampled, tributary Site T34 and river Sites R14 and R15 were not included in this shaded area, as they were modeled during the Upper Big Sioux River Watershed Assessment (Williams and Mullen 2002). The feedlot assessment boundary was hand drawn based on our monitoring site locations and watershed boundaries. River Site R01 was omitted from this area because a feedlot assessment was completed during the Central Big Sioux River Watershed Assessment Project for this area. See Appendix A for monitoring site details.

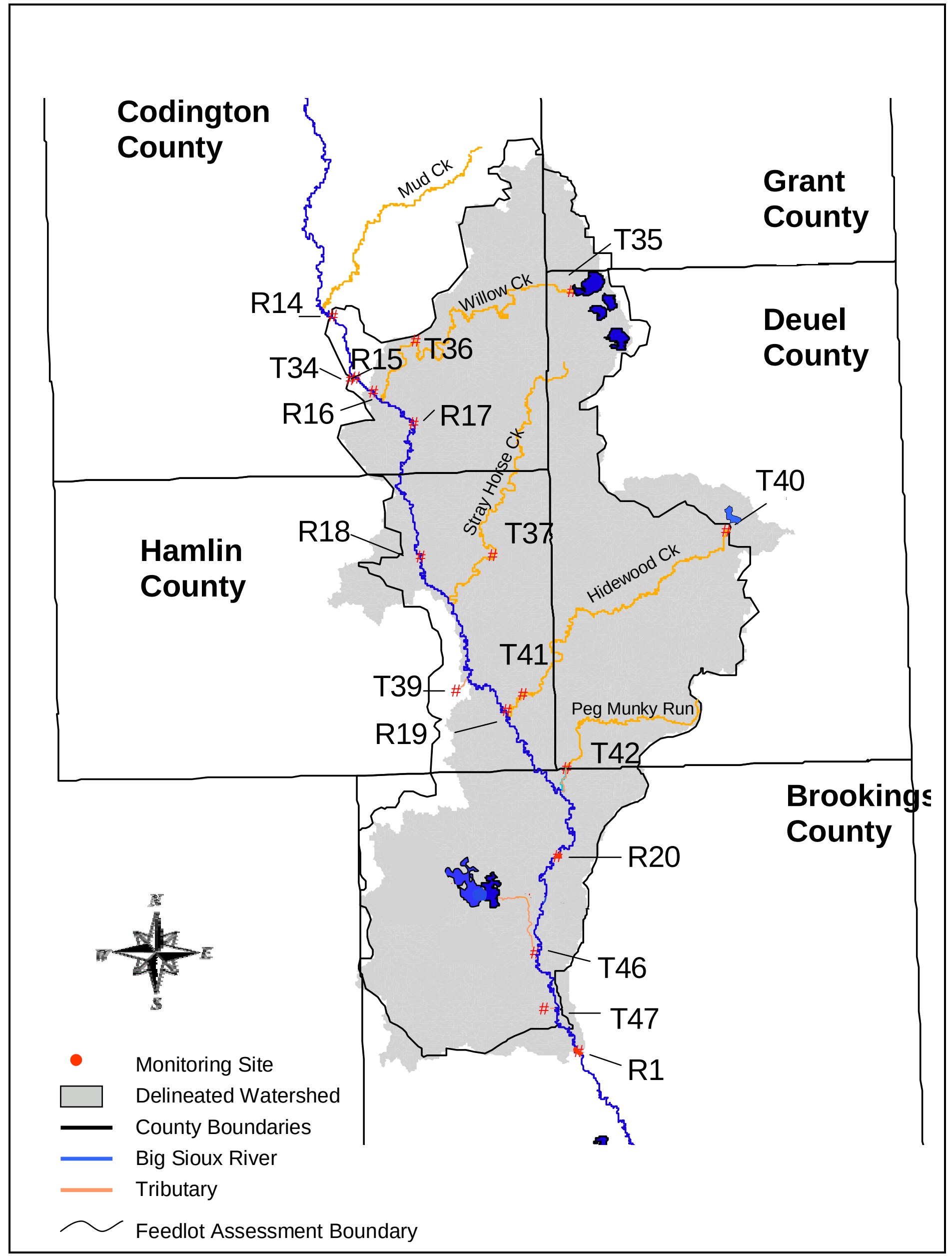


Figure 6. Location of Monitoring Sites

BENEFICIAL USES

The State of South Dakota has assigned all water bodies that are situated within its borders a set of beneficial uses. Beneficial use means the purpose or benefit to be derived from a water body. Under state and federal law the beneficial use of water is to be protected from degradation. Of the eleven beneficial uses, two are assigned to all streams in the state; (9) fish and wildlife propagation, recreation and stock watering, and (10) irrigation. A set of standards is applied to the BSR and its major tributaries. These standards must be met to maintain the beneficial uses for a particular water body.

In the 1998 and 2000 South Dakota 305(b) water quality assessment several designated beneficial uses of the North-Central Big Sioux River are impaired by total suspended solids (TSS), low dissolved oxygen, pH, and ammonia. These impairments were documented by the surface water quality monitoring program to regularly exceed standards. The 2004 Integrated Report for Surface Water Quality Assessment also shows the north-central portion of the Big Sioux River to be impaired by nitrates and fecal coliform bacteria.

Probable pollutant source categories identified in the report for the BSR are on-site wastewater systems, agricultural livestock, and municipal/industrial discharges. Much of the Big Sioux River is classified as “non-support” for both aquatic life and limited contact recreation. The 1998 and 2002 South Dakota 303(d) waterbody list, as well as the 2004 Integrated Report listing, included the Big Sioux River near Watertown, Castlewood, Estelline, Bruce and Volga. The designated beneficial uses of the north-central Big Sioux River near these cities are assigned numeric water quality standards that are not to be exceeded (Table 4).

All river sites are assigned beneficial uses one, five, eight, nine, and ten. All tributaries are assigned beneficial uses nine and ten. Willow Creek (T35 and T36), Stray Horse Creek (T37), Hidewood Creek (T40 and T41), and Peg Munky Run (T42) are also assigned beneficial uses six and eight (Table 5). Table 4 depicts the numeric criteria assigned to the beneficial uses.

Table 4. Numeric Criteria Assigned to Beneficial Uses of Surface Waters for the North-Central Big Sioux River and Tributaries

Parameters (mg/L) except where noted	**1** Domestic water supply	**5** Warmwater semi permanent fish life propagation	**6** Warmwater marginal fish life propagation	**8** Limited contact recreation	**9** Fish & wildlife propagation, recreation & stock watering	**10** Irrigation
Fecal Coliform (per 100 mL) May 1 - Sept. 30				≤ 1,000 (geomean) ≤ 2,000 (single sample)		
Specific Conductivity (umhos/cm @ 25° C)					≤ 4,000[1]/ 7,000[2]	≤ 2,500[1]/ 4,375[2]
Total Ammonia Nitrogen as N		≤ result of the Equation[3]	≤ result of the Equation[3]			
Nitrogen, Nitrates as N	≤10.0				≤ 50[1]/ 88[2]	
Dissolved oxygen		≥ 5.0	≥ 4.0	≥ 5.0		
pH (standard units)	≥ 6.5 - ≤ 9.0	≥ 6.5 - ≤ 9.0	≥ 6.0 - ≤ 9.0		≥ 6.0 - ≤ 9.5	
Suspended solids		≤ 90[1]/ 158[2]	≤ 150[1]/ 263[2]			
Total dissolved solids	≤ 1,000[1]/ 1,750[2]				≤ 2,500[1]/ 4,375[2]	
Temperature (°F)		≤ 90	≤ 90			

Note: [1] 30-day average [2] daily maximum [3] $(0.411 \div (1+10^{7.204-pH}) + (58.4 \div 1+10^{pH-7.204}))$ in accordance with ARSD 74:51:01, Appendix A, Equation 2

Table 5. Monitoring Sites and Their Beneficial Use Classification

		Beneficial Use Classification					
Water Body	**Site ID**	**1**	**5**	**6**	**8**	**9**	**10**
BSR nr Brookings	R1						
BSR at Watertown	R14						
BSR at Braoadway	R15						
BSR 20th Ave	R16						
BSR below Watertown	R17						
BSR nr Castlewood	R18						
BSR nr Estelline	R19						
BSR nr Bruce	R20						
Lake Pelican Weir	T34						
Willow Creek (nr Waverly)	T35						
Willow Creek (nr Watertown)	T36						
Stray Horse Creek	T37						
Lake Poinsett Outlet	T39						
Hidewood Creek (nr Clear Lake)	T40						
Hidewood Creek (nr Estelline)	T41						
Peg Munky Run	T42						
East Oakwood Lake Outlet 1	T45						
East Oakwood Lake Outlet 2	T46						
Unnamed Creek (nr Volga)	T47						

RECREATIONAL USE

State, county, and local parks are located throughout the north-central region of the Big Sioux River Watershed (Table 6).

Table 6. Public Recreation Areas Within the NCBSRW Study Area

County	**City**	**Public Recreational Areas**
Brookings	Volga	Oakwood Lakes State Park
Codington	Watertown	Sandy Shore Recreation Area Bramble Park Discovery Center & Zoo City Park-Belmont, Harper, Jackson, Lincoln Mallard Cove, McKinley, Morningside, Nelson, Pelican, Riverside, Skate, and Sioux
Deuel	Goodwin	Bullhead Lake Public Access School Lake Public Access Round Lake Public Access
	Clear Lake	Lake Cochrane Recreation Area

THREATENED AND ENDANGERED SPECIES

The following table (Table 7) of threatened and endangered species and their location by county within NCBSR watershed study area was constructed using information from South Dakota Game, Fish, and Parks, USGS, and the USFWS. Specie status within the study area is identified as endangered, threatened, rare, or candidate with the county of occurrence is listed. Topeka shiners (*Notropis topeka)* were identified in two of the monitored tributary sites. The whooping crane, banded killifish, American burying beetle, Dakota skipper, and western prairie fringed orchid have historically been found in the NCBSRW and could possibly still be in the area. The bald eagle, piping plover, central mudminnow, northern redbelly dace, northern redbelly snake, and regal fritillary are listed species that are commonly found within the area. However, none of these species were encountered during the study.

Table 7. Endangered, Threatened, and Candidate Species of the NCBSRW Area

Name	***Scientific Name***	***Category***	*Status*		***County Location***	***Occurrence***
			Federal	***State***		
Whooping crane	*Grus americana*	Bird	FE	SE	Brookings, Codington	Rare
Bald eagle	*Haliaeetus leucocephalus*	Bird	FT	ST	Brookings	Common
Topeka shiner	*Notrophis topeka*	Fish	FE		Brookings, Codington, Deuel, Hamlin, Grant	Common
Piping Plover	*Charadrius melodus*	Bird	FT	ST	Codington	Common
Banded killifish	*Fundulus diaphanus*	Fish		SE	Deuel	Rare
Central mudminnow	*Umbra limi*	Fish		SR	Brookings, Deuel	Common
Trout perch	*Percopsis omiscomaycus*	Fish		SR	Codington	Common
Northern redbelly dace	*Phoxinus eos*	Fish		ST	Brookings, Deuel, Grant	Common
American burying beetle	*Nicrophorus americanus*	Insect	FE	SR	Brookings	Rare
Dakota skipper	*Hesperia dacotae*	Insect	FC	SR	Brookings, Codington, Deuel, Hamlin, Grant	Rare
Northern redbelly Snake	*Storeria occipitomaculata occipitomaculata*	Reptile		SR	Brookings, Codington, Deuel, Hamlin, Grant	Common
Western prairie fringed orchid	*Plantanthera praeclara*	Plant	FT	SR	Brookings	Rare

KEY TO CODES:
FE= Federal Endangered
SE=State Endangered
FT= Federal Threatened
ST=State Threatened
FC=Federal Candidate
SR=State Rare

PROJECT GOALS, OBJECTIVES, AND MILESTONES

GOALS

The goals of this assessment project are to:

1) Determine and document sources of impairment to the north-central portion of the BSR watershed
2) Identify feasible restoration alternatives to support watershed implementation projects to improve water quality impairments within the watershed
3) Develop TMDLs based on identified pollutants

Impairments cited in the 1998 and the 2000 305(b) Water Quality Assessment Report and the 1998 and 2002 South Dakota 303(d) Waterbody List for this portion of the BSR watershed were excessive suspended solids, pathogens (fecal coliform bacteria), nutrients, and organic enrichment.

Goals were accomplished through the collection of tributary and river data, aided by the completion of the FLUX, AnnAGNPS, and the Agricultural Non-Point Source (AGNPS) watershed modeling tools. Through data analysis and modeling, the identification of impairment sources was possible. The identification of these impairment sources will aid the state's non-point source (NPS) program by allowing strategic targeting of funds to portions of the watershed that will provide the greatest benefit per expenditure.

OBJECTIVES

Objective 1. Water Quality Assessment

Water sampling of river and tributary sites began in April 2001 and in June 2001, respectively. Water samples were collected at Big Sioux River sites from April 2001 to October 2001, April 2002 to October 2002, and again from May 2004 to September 2004. Water samples were collected from tributary sites from June 2001 to October 2001 and from April 2002 to October 2002 (Table 8).

Detailed level and flow data were entered into a database that was used to assess the nutrient and solids loadings. Solinst leveloggers and Thalmedies hydrometers (OTTs) were installed at the pre-selected monitoring sites along the tributaries.

Objective 2. Quality Assurance/ Quality Control (QA/QC)

Ten percent of the water quality samples were collected as duplicate and blank samples. These samples provide defendable proof that sample data were collected in a scientific and reproducible manner. QA/QC data collection began in April of 2001 and was completed on schedule in October of 2002. Additional Big Sioux River samples were collected in 2004 and also included QA/QC samples (Table 8).

Objective 3. Watershed Modeling

Three models were used in this project to analyze and predict loadings. The FLUX model was used to calculate loadings and concentrations in monthly, yearly, and daily increments. The AnnAGNPS model was used to predict sediment and nutrient loads based on 1-year, 10-year, and 25-year simulated periods. This model was also used to determine potential sediment and nutrient loading reductions with the implementation of BMPs. AGNPS was used to model feedlot runoff loads and to help pinpoint areas of concern. Load duration intervals and hydrologic conditions were used to calculate fecal coliform loads and predict the reductions needed to meet water quality standards (Table 8).

Objective 4. Information and Outreach

Several field trips were organized which provided knowledge about the project, as well as demonstrations of field operations. An assessment of the condition of the animal feeding operations located within the project area was conducted by contacting landowners individually. Press releases were also provided to local papers at various times throughout the project (Table 8).

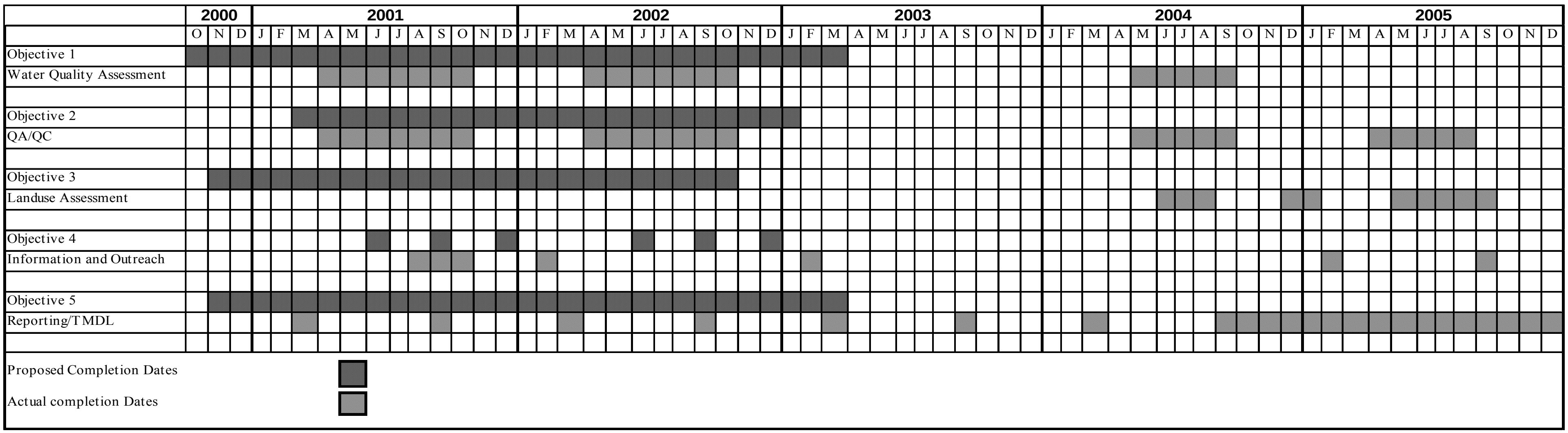
Objective 5. Reporting/TMDL Determination

When a waterbody is listed on the state's 303(d) list, TMDLs must be developed for that waterbody to meet water quality standards. A TMDL is a tool or target value that is based on the linkages between water quality conditions and point and non-point sources of pollution. Based upon these linkages, maximum allowable levels of pollution are allocated to the different sources of pollution so that water quality standards are attainable. Sources that exceed maximum allowable levels (or loadings) must be addressed in an implementation plan that calls for management actions that reduce loadings (1998, 2002 303(d) Waterbody List and the 2004 SD Integrated Report). Furthermore, an implementation plan can call for protection of areas that are below allowable levels. Identifying the causes and sources of water quality impairments is a continuation of the process that placed the waterbody on the 303(d) list. In the case of the North-Central Big Sioux River watershed, high levels of fecal coliform bacteria and the probable non-point sources identified in the 305(b) water quality assessment, guided the strategy of this assessment.

MILESTONES

The North-Central Big Sioux River Watershed Assessment Project was scheduled to start in October 2000; however, actual monitoring was delayed until April of 2001 due to monitoring equipment needing to be installed and additional staff hired. The following table shows the proposed completion dates versus the actual completion dates of the project goals, objectives, and activities.

Table 8. Milestones - Proposed and Actual Objective Completion Dates



METHODS

ENVIRONMENTAL INDICATORS

Water Quality Monitoring

Water samples were collected from eight river sites and 10 tributary sites. The sample collection was scheduled to coincide with spring runoff, storm events, and during base flow conditions. A total of 420 samples were collected over three sampling seasons from April 2001 through October 2004. This included 266 standard samples, 30 blank standard samples, and 30 duplicate standard samples, and 80 additional river fecal samples with 7 duplicate and 7 blank samples. An example of the water quality data sheet used is located in Appendix C.

Sampling occurred April through October of 2001 and again April through October of 2002 at Sites T34, T35, T36, T37, T39, T40, T41, T42, T46, and T47, R01, R14, R15, R16, R17, R18, R19, and R20. The SD DENR suggested the collection of extra fecal coliform samples from the Big Sioux River sites, which was accomplished in 2004.

Field measurements included dissolved oxygen, pH, turbidity, air temperature, water temperature, conductivity, salinity, stage, and general climatic information. A Hanna Instruments 9025 meter was used to measure pH. Salinity, dissolved oxygen, water temperature, and conductivity were measured using a YSI 85 meter. Turbidity was measured using a LaMotte 2020 turbidity meter and a mercury thermometer was used to measure air temperature.

The Water Resource Institute (WRI) at South Dakota State University (SDSU) in Brookings, South Dakota, performed analysis on samples for total solids, total suspended solids (TSS), ammonia, nitrate-N, total Kjeldahl nitrogen, organic nitrogen, total phosphorus, and total dissolved phosphorous that were collected during 2001 and 2002. The Sioux Falls Health Laboratory in Sioux Falls, South Dakota, analyzed all fecal coliform bacteria samples collected in 2001 and 2002. Water quality samples collected in 2004 were analyzed by the State Health Lab in Pierre, South Dakota. Appendix B contains all grab sample data for each monitoring site.

Two of the river sites (R01 and R14) were also monitored by the state of South Dakota as part of the SD DENR Ambient Surface Water Quality Monitoring program. Two other ambient monitoring sites were located within 1.5 miles of project Sites R17 and R19. The TSS, ammonia, and fecal coliform data was incorporated into our database and analyzed in conjunction with our data. Historical flow data monitored by the USGS was also utilized in our analysis. Table 9 depicts the USGS and SD DENR sites that coincided with EDWDD monitoring sites.

Table 9. Project Sites Coinciding with DENR and USGS Monitoring Locations

EDWDD Site	DENR Site	USGS Site
R01	WQM 62	
R14	WQM 55	6479500
R15		6479512
R17	WQM 1 (1 mi N)	6479520
R18		6479525
R19	BS08 (1.5 mi S)	
R20		6479770
T36		6479515

Description of Parameters

Water quality was sampled according to the SD DENR WRAP protocols (Stueven et al. 2000). Water quality analyses provided concentrations for a standard suite of parameters (Tables 10 and 11). The detection limits are set by the lab based on lab equipment sensitivity.

Table 10. Water Quality Parameters Analyzed and Laboratory Detect Limits for WRI and the Sioux Falls Health Lab

Parameter	Units	Lower Detect Limit
Total suspended solids	mg/L	1
Total solids	mg/L	1
Nitrates	mg/L	0.01
Ammonia-nitrogen	mg/L	0.01
Organic nitrogen	mg/L	0.01
TKN	mg/L	0.01
Total phosphorus	mg/L	0.01
Total dissolved phosphorus	mg/L	0.01
Fecal Coliform*	cfu/100 mL	<1, <10, <100

* tested by Sioux Falls Health Lab

Table 11. Water Quality Parameters and Lab Detect Limits for the State Health Lab

Parameter	Units	Abbreviation	Lower Detect Limit
Alkalinity-M	mg/L	Alk-M	< 6.0
Alkalinity-P	mg/L	Alk-P	0
Total suspended solids	mg/L	TSS	< 1.0
Total solids	mg/L	TotSol	< 7.0
Volatile Total Suspended Solids	mg/L	VTSS	< 1.0
Nitrates	mg/L	NO2NO3	< 0.1
Ammonia-nitrogen	mg/L	NH3N	< 0.02
TKN	mg/L	TKN	< 0.11
Total phosphorus	mg/L	TPO4	< 0.002
Total dissolved phosphorus	mg/L	TDPO4	< 0.003
Fecal coliform bacteria	cfu/100 mL	Fecal	< 10.0
E coli	mpn/100 mL	Ecoli	< 1.0

Water Quality Parameter Definitions

Alkalinity

Alkalinity is a measure of the buffering capacity of water, or the capacity of water to neutralize acid. Measuring alkalinity is important in determining a stream's ability to neutralize acidic pollution from rainfall or wastewater. Alkalinity does not refer to pH, but instead refers to the ability of water to resist change in pH. Waters with low alkalinity are very susceptible to changes in pH. Waters with high alkalinity are able to resist major changes in pH. Lakes with high alkalinity have high pH values while lakes with low alkalinity have low pH values. The hardness of the water is usually determined by the amount of calcium and magnesium salts present in water and is associated with the presence of carbonates. Hard water lakes are generally more productive than soft water lakes and can accept more input of salts, nutrients, and acids to their system without change than can soft water lakes. The range of pH values associated with M-alkalinity (methyl orange indicator) is 4.2 to 4.5. The range of pH values associated with P-alkalinity (phenolphthalein indicator) is 8.2 to 8.5.

Total Suspended Solids

TSS is the portion of total solids that are suspended in solution, whereas dissolved solids make up the rest of the total. Higher TSS can increase surface water temperature and decrease water clarity. Suspended solids are the materials that do not pass through a filter such as silt and clay particles, plankton, algae, fine organic debris, and other particulate matter. Subtracting suspended solids from total solids derives total dissolved solids concentrations. Suspended volatile solids are that portion of suspended solids that are organic (organic matter that burns in a 500^{o} C muffle furnace).

Total Solids

Total Solids are materials, suspended or dissolved, present in natural water. Sources of total solids include industrial discharges, sewage, fertilizers, road runoff, and soil erosion.

Volatile Total Suspended Solids

Volatile solids are those solids lost on ignition (heating to 550 degrees C.). Volatile solids measure the sediments which are able to be burned off of a dried sediment sample. Volatile total suspended solids are useful because they give a rough approximation of the amount of organic matter present in the water sample. ‘‘Fixed solids’’ is the term applied to the residue of total, suspended, or dissolved solids after heating to dryness for a specified time at a specified temperature. The weight loss on ignition is called ‘‘volatile solids.’’

Nitrate-Nitrite

Nitrate and nitrite are inorganic forms of nitrogen easily assimilated by algae and other macrophytes. Sources of nitrate and nitrite can be from agricultural practices and direct input from septic tanks, precipitation, groundwater, and from decaying organic matter. Nitrate-nitrite can also be converted from ammonia through denitrification by bacteria. The process increases with increasing temperature and decreasing pH.

Ammonia

Ammonia is the byproduct of bacterial decomposition of organic matter. Source of this form of nitrogen, most readily available for plant uptake, may come from animal feeding areas, decaying organic matter, bacterial conversion of other nitrogen compounds, or industrial and municipal surface water discharges.

Total Ammonia Nitrogen as N

Ammonia nitrogen is present in surface and ground water supplies. Ammonia nitrogen is a dissolved inorganic form of nitrogen. This nitrogen associated with ammonia is a nutrient for algae and macrophytes. High levels may indicate excessive algae growth, macrophyte growth, and/or presence of sanitary waste, and can be detrimental to aquatic life.

Total Kjeldahl Nitrogen

Total Kjeldahl Nitrogen (TKN) is used to calculate organic nitrogen. TKN minus ammonia derives organic nitrogen. Sources of organic nitrogen can include release from dead or decaying organic matter, septic systems or agricultural waste. Organic nitrogen is broken down to more usable ammonia and other forms of inorganic nitrogen by bacteria.

Total Nitrogen

Total nitrogen is the sum of nitrate-nitrite and TKN concentrations. Total nitrogen is used mostly in determining the limiting nutrient, either nitrogen or phosphorus. Nitrogen was analyzed in four forms: nitrate/ nitrite, ammonia, and Total Kjeldahl Nitrogen (TKN). From these four forms, total, organic, and inorganic nitrogen may be calculated. Nitrate and nitrite levels are usually caused from fertilizer application runoff. High ammonia concentrations are directly related to sewage and fecal runoff. Nitrogen is difficult to manage because it is highly soluble and very mobile in water.

Total Phosphorus

Phosphorus differs from nitrogen in that is not as water-soluble and will attach to fine sediments and other substrates. Once attached, it is less available for uptake and utilization. Phosphorus can be natural from geology and soil, from decaying organic matter, waste from septic tanks or agricultural runoff. Nutrients such as phosphorus and nitrogen tend to accumulate during low flows because they are associated with fine particles whose transport is dependent upon discharge (Allan 1995). These nutrients are also retained and released on stream banks and floodplains within the watershed. Phosphorus will remain in the sediments unless released by increased stage or discharge.

Total Dissolved Phosphorus

Total dissolved phosphorus is the fraction of total phosphorus that is readily available for use by algae. Dissolved phosphorus will attach to suspended materials if they are present in the water column and if they are not already saturated with phosphorus. Dissolved phosphorus is readily available to algae for uptake and growth.

Fecal Coliform Bacteria

Fecal coliform are bacteria that are found in the environment and are used as indicators of possible sewage contamination because they are commonly found in human and animal feces. They indicate the possible presence of pathogenic bacteria, viruses, and protozoans that also live in human and animal digestive systems. These bacteria can enter the river and tributaries by runoff from feedlots, pastures, sewage treatment plants, and seepage from septic tanks.

E. Coli

Escherichia coli is a type of fecal coliform bacteria that is found in the intestines of healthy humans and animals. The presence of *E. coli* in water is a strong indication of recent sewage or animal waste contamination, which may contain disease causing organisms.

Dissolved Oxygen

Dissolved oxygen is important for the growth and reproduction of fish and other aquatic life. Solubility of oxygen generally increases as temperature decreases, and decreases with lowing atmospheric pressure. Stream morphology, turbulence, and flow can also have an affect on oxygen concentrations. Dissolved oxygen concentrations are not uniform within or between stream reaches. A stream with running water will contain more dissolved oxygen than still water. Cold water holds more oxygen than warm water. Dissolved oxygen levels of at least 4-5 mg/L are needed to support a wide variety of aquatic life. Very few species can exist at levels below 3 mg/L.

pH

pH is based on a scale from 0 to 14. On this scale, 0 is the most acidic value, 14 is the most alkaline value, and 7 represents neutral. A change of 1 pH unit represents a 10-fold change in acidity or alkalinity. The range of freshwater is 2-12. pH is a measure of hydrogen ion activity, the more free hydrogen ions (more acidic), the lower the pH in water. Values outside the standard (pH 6.0 – 9.5) do not meet South Dakota's water quality standards.

Water Temperature

Water temperature affects aquatic productivity and water chemistry, including the levels of DO and un-ionized ammonia. Temperature extremes are especially important in determining productivity of aquatic life from algae to fish.

Conductivity

In streams and rivers, conductivity is affected primarily by the geology of the area through which the water flows. Streams that run through areas with granite bedrock tend to have lower conductivity, and areas with clay soils tend to have higher conductivity. In lakes, geology of the watershed establishes the ranges of conductivity. In general, a higher conductivity indicates that more material is dissolved material, which may contain more contaminants.

Specific Conductivity

Also known as temperature compensated conductivity which automatically adjusts the reading to a calculated value which would have been read if the sample had been at 25^{o} C. The ability of water to conduct an electrical current, which is the measure of the quantity of ions in the water. It is determined by the presence of inorganic dissolved solids, such as salts. Specific conductivity is generally found to be a good measure of the concentration of total dissolved solids (TDS) and salinity.

Salinity

Salinity is the natural concentration of salts in water. This is influenced by the geologic formations underlying the area. Salinity is lower in areas underlain by igneous formations and higher in areas underlain by sedimentary formations.

Turbidity (NTU)

Turbidity or water clarity is a measure of how much the passage of light is restricted by suspended particles. Turbidity is measured in nephelometric turbidity units (NTUs). High NTU levels may increase temperatures; lower dissolved oxygen levels, and reduce photosynthesis. High NTU levels can clog fish gills, which lowers growth rate and resistance to disease; and it can smother fish eggs and macro invertebrates. Sources of turbidity include soil erosion, waste discharge, urban runoff, eroding stream banks, and excessive algae growth.

Flow and Discharge Gaging

A total of 10 tributary monitoring sites were established along the Big Sioux River and continuous stream flow was collected using stage recorders. The sites were selected to determine which portions of the watershed were contributing the greatest amount of nutrient and sediment load to the river. Six tributary sites were equipped with OTT Thalimedes hydrometers, two were installed with Solinst model 3001 leveloggers, one site was monitored by the USGS, and one site was monitored by the City of Watertown. All sites, except one, were monitored for two seasons because of high water conditions. Site T39 (Lake Poinsett Outlet) was only monitored the second season because high water prohibited the installation of equipment during 2001. Stage recorder start and end dates can be found in Appendix D. Water stage was recorded to the nearest 1/100th of a foot for each of the sites. A USGS top setting wading rod, with either a Price AA or pygmy current meter attached, and a CMD 9000 digimeter were used to determine flows at various stages. In the much larger streams, a USGS Type A crane equipped with a Price AA current meter attached to a four-wheel truck was used to record flow data.

All sites were also installed with USGS Style C staff gauges as a quality control check for the continuous meters. Recorded stages and flows were used to create stage-discharge tables and curves for each site (Gordon et al. 1992). USGS gaging station data was acquired for all the river sites. Streamflow records for non-gauged river sites were derived using interpolation methods (Gordon et al. 1992). Stage to discharge tables and curves can be found in Appendix E. Equations used to find discharges for each monitoring site can be found in Appendix F.

Flow Duration Intervals

Flow duration intervals were constructed for fecal coliform bacteria at all monitored sites. America's Clean Water Foundation was consulted regarding the calculation of fecal coliform bacteria reductions with the limited data set. It was suggested that flow duration intervals using flow duration curve zones would meet the requirements of our report (Cleland 2003). This method calculates fecal coliform bacteria in a way similar to the FLUX model, (concentration) x (flow), except it is less complex using zones based on hydrologic conditions and the median fecal coliform concentrations. By defining hydrologic conditions, specific restoration efforts could be targeted. The five hydrologic conditions are (1) High Flows (0-10 percent), (2) Moist Conditions (10-40 percent), (3) Mid-Range Flows (40-60 percent), (4) Dry Conditions (60-90percent), and (5) Low Flows (90-100 percent) (Figure 7). For example, if several samples exceeded the target load during dry conditions, restoration efforts may be targeted at in-stream livestock, riparian areas, or discharges from industries.

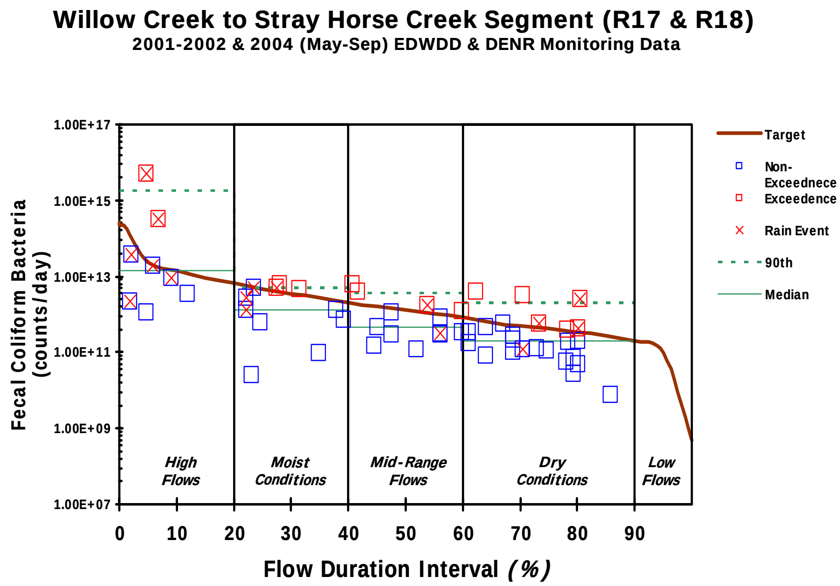


Figure 7. Sample Result Flow Duration Interval with Zones and Plotted Grab Samples (Sites R17 and R18 merged).

Two sets of data were used to calculate reductions: (1) discharge data and (2) water quality samples. Appendix G lists the years of record used for the construction of the flow duration interval graphs. Figure 7 is an example of a flow duration interval, separated into zones, with seasonal fecal grab samples plotted. Seasonal months include May, June, July, August, and September.

The target line was graphed along 21 points representing the entire range of flows using percentiles of the target load at matching flows. Similarly, grab samples were plotted against instantaneous flow at the time the sample was taken. Medians and 90th percentiles were calculated, per zone, for grab sample data. Samples collected during rain events are indicated with an 'X'. Those samples indicated with a red box are exceedences of the allowable load.

To find the existing load in each zone, the median concentration of the grab samples was multiplied by the median flow.

(median concentration of zone) × (median flow of zone) = existing load in that zone

To find the percent reduction per hydrologic condition, the median of the allowable load within a hydrologic zone (target) was divided by the median of the sampled load at that particular hydrologic condition (site value) and then subtracted from 100.

$$100 - (\text{Target} \div \text{Site Value} \times 100) = \%\ \text{reduction}$$

To find the reduction with a 10% margin of safety applied the following equation was used:

$$100 - [(\text{Target} \div 1.1) \div (\text{Site Value})] \times 100 = \%\ \text{reduction with MOS}$$

Table 12 shows an example of these calculations. Reduction calculation tables for all the monitoring sites can be found in Appendix V. These tables are separated into five hydrologic zones regardless of the number of samples per zone. In some instances where few samples were taken, hydrologic zones were combined to the find percent reduction required to meet water quality standards. Monitoring sites on the same stream or river segment were merged (not averaged) to find the percent reduction for the TMDLs. Specific tables can be found in the TMDL reports which are located in Appendices DD through JJ. When considering management options for fecal coliform bacteria reductions, these tables will be useful in targeting hydrologic conditions exceeding their allowable loads.

Table 12 also shows reductions for Site R17 and R18 as well as the outcome when the data was merged from both sites. Figure 7 shows both sites merged together and where samples fall within each zone of the combined flow duration curve.

Merging datasets from multiple sites within each segment allowed the data from the entire segment to be used to determine impairment status and reductions rather than a single downstream monitoring station. In this example, the number of samples within each flowzone was increased as is shown in Figure 7. Sampling was conducted on the same date on many sites and as bacteria die-off as they progress downstream using all of the data within the reach is more reflective of the entire segment.

Although the mid-range to low flows show no reduction is required, the reductions needed to achieve full support status are in the high conditions (0-10%) zone. Best Management Practices will be used targeting both high and low flow conditions within the entire segment and should achieve full support. In this example a 10% reduction will be targeted for the entire segment rather than a specific monitoring location (SDDENR-Central Big Sioux Watershed Assessment Final Report, 2008).

Table 12. Sample Result of Fecal Coliform Bacteria Reduction Calculation from Figure 7.

Site R17 Reductions Median	High (0-20)	Moist (20-40)	Mid-Range (40-60)	Dry (60-90)	Low Flows (90-100)
% Reduction	26	0	0	0	-----
% Reduction with MOS	33	0	0	0	-----
Site R18 Reductions Median	**High (0-20)**	**Moist (20-40)**	**Mid-Range (40-60)**	**Dry (60-90)**	**Low Flows (90-100)**
% Reduction	0	0	3	7	-----
% Reduction with MOS	0	0	11	16	-----

	Merged Site Reductions Median	High (0-20)	Moist (20-40)	Mid-Range (40-60)	Dry (60-90)	Low Flows (90-100)
	Median Concentration (counts/day)	4.97E+10	1.90E+10	1.81E+10	2.35E+10	------
X	Flow Median (cfs)	290	70	26	8.4	1.9
=	Existing	1.44E+13	1.33E+12	4.70E+11	1.97E+11	------
	Target Load (at 2,000 cfu/100mL)	1.42E+13	3.43E+12	1.27E+12	4.11E+11	9.30E+10
	% Reduction w/MOS	10	0	0	0	------

Load duration curves are developed using an average daily, long-term record of stream flow. Several of the mainstem BSR sites have been, or are currently, monitored by the USGS (Table 13). Daily average flows for ungaged mainstem sites were derived using the drainage-area ratio method. This method is commonly used to find flow of an ungaged site that is in close proximity to a gauged site on the same stream. The drainage area of the ungaged site should be within 0.5 and 1.5 times the drainage area of the gaged site.

Table 13. Descriptions of Stream Gaging Stations Analyzed with the Drainage-Area Ratio Method

EDWDD Site	USGS Site evaluated	Period of Record	Drainage Area mi^2	Ungaged DA/ Gaged DA ratio	Ecoregion
R01	06480000	---	3190	1.22	NGP
R14	* 06479500	1945-present	1129	---	NGP
R15	* 06479512 (used 06479520)	flood data only	1277	1.49	NGP
R16	06479520	---	~1797	0.95	NGP
R17	* 06479520	1994-present	1902	---	NGP
R18	* 06479525	1976-present	1997	---	NGP
R19	06479525	---	~2435	1.22	NGP
R20	* 06479770	2000-present	2800	---	NGP

* USGS Station and Monitoring Site Coincided

Sites should also be located within the same ecoregion and have similar topography (FDEP 2003). The following calculation was used:

To find flow per area of the gaged site:

$$\text{gaged site flow} \div \text{gaged site drainage area mi}^2 = \text{gaged site flow per area (mi}^2\text{)}$$

To find the flow of the ungaged site:

$$\text{gaged site flow per area} \times \text{ungaged site drainage area mi}^2 = \text{ungaged site flow}$$

Daily average flows over approximately a 20-year period of time were ranked from highest to lowest. The percent of days each flow was exceeded was calculated by dividing each rank by the number of flow data points.

$$\text{rank} \div \text{number of data points} = \text{percent of days the flow was exceeded}$$

Next, the load was calculated by multiplying each average daily flow by the water quality standard for the parameter and multiplying by the conversion factor.

$$\text{flow (cfs)} \times \text{standard (mg/L)} \times \text{conversion factor} = \text{load}$$

The conversion factor for converting the mg/L to pounds per day for TSS is 5.396, as shown by the following formula:

$$\frac{\text{mg}}{\text{L}} \times \frac{1\text{ L}}{0.0353146667\text{ ft}^3} \times \frac{86400\text{ sec}}{1\text{ day}} \times \frac{\text{ft}^3}{\text{sec}} \times \frac{1\text{ lb}}{453592.37\text{ mg}} = \text{lbs/day}$$

The conversion factor for converting cfu/100mL to colonies per day for fecal coliform bacteria is 24,468,480 as shown by the following formula:

$$\frac{\text{cfu}}{100\text{mL}} \times \frac{28320\text{ mL}}{1\text{ ft}^3} \times \frac{86400\text{ sec}}{1\text{ day}} \times \frac{\text{ft}^3}{\text{sec}} = \text{col/day}$$

Biological Monitoring

The biological assessment framework used in this study was previously developed during the Central Big Sioux River Watershed Assessment. This framework uses a multimetric approach to analyze biological data (Barbour et al. 1999). This approach involves two phases with the process and rationale outlined in Table 14.

Table 14. Process of Developing Biological Indicators for the NCBSRW

Phase I. Development of Biological Indicators	
1. Stream Classification	Stream classifications group sites that share similar physical and chemical characteristics. Grouped sites are expected to have similar biology under natural conditions and respond similarly to human disturbances (i.e. streams vs rivers).
2. Candidate Metric Identification	A list of candidate metrics (i.e., biological traits) that have the potential to be responsive to stressors is developed. This list is composed of metrics that are relevant to the region's stream ecology and represents aspects of community richness, composition, tolerance, trophic structure, and individual health.
3. Select Core Metrics	Metrics from the candidate list are selected based on their ability to discriminate between least-impacted sites and most-impacted sites. A set of core metrics is produced that represents aspects of community richness, composition, tolerance, trophic structure, and individual health.
4. Index Development	An index is an aggregate of scores from selected core metrics. However, prior to aggregation, metric values must be transformed to standardized metric scores that are unitless because each metric may have different units (e.g., integers, percentages). Once scores are transformed and aggregated into an index, the ability of the index to discriminate between least impaired and most impaired sites is tested.
5. Index Thresholds Established	The range of site index scores reflects a range of biological impairment (e.g., poor, fair, good). This range of biological impairment is subdivided into classes based on thresholds. The thresholds are index scores that define the upper and lower limits on classes.
Phase II. Indicator Use in Assessment and Monitoring	
Assessment and Monitoring	With the above completed, the index is ready to use as a tool for assessing and monitoring the health of streams.

Fish Sampling

Fish were sampled in four of the tributaries (Site T36, Site T37, Site T41, and Site T42) with bag seines (5 mm mesh) ranging from 15 to 30 feet in length. Pools and runs were sampled in a downstream direction with a seine that reached from bank to bank. A block net (8 mm mesh) was placed across the stream at the lower end of the reach to prevent fish from escaping. Riffles were usually sampled by kicking through the substrate in a downstream direction toward a bag seine placed across the stream at the bottom of the riffle. Collected fish were placed in holding crates, identified to species, and a representative number of each species measured (25 to 50 individuals), noting external diseases, anomalies, fin damage, and parasites. Weighing 100 individuals and using their average weight to divide into bulk weights of uncounted individuals, estimated the number of abundant species. Collections were taken for voucher jars.

Fish Index of Biological Integrity (IBI)

The index of biological integrity for fish was constructed using methods contained in the Rapid Bioassessment Protocol IV (RBPIV) by Barbour et al. (1999), Karr's (1981) fish community assessment, and Plafkin et al. (1989) RBP protocol for macroinvertebrates and fishes. Candidate metrics representative of the Midwest region were chosen to represent richness/composition, headwater/pioneering attributes, tolerance/intolerance, trophic guilds, and reproduction (Table 15). Core metrics were chosen in each category through a process of comparative descriptive analysis. Appendix H describes metrics recommended for use within the Midwest region. These metrics in conjunction with the descriptive analysis were used in the selection of the best possible core metrics. The ability of each metric to discriminate between sites least impacted and sites most impacted. Comparative descriptive analysis was accomplished using box and whisker plots, analyzing all monitoring sites at the same time for metrics in each of the five categories (richness/composition, headwater/pioneering attributes, tolerance, trophic guilds, and reproduction). Box plots that yielded a good spread (based on best professional judgment) and differing means were chosen as core metrics in each category (Table 16). Coefficients of variation (CVs) also aided in the selection of the core metrics (Appendix I). Each metric was chosen based upon its discriminatory power in terms of distinguishing least impaired to most impaired sites.

Once the core metrics in Table 16 were chosen, best value percentiles were calculated. The 95th percentile was used as a basis for best value for those metrics that decreased with impairment. Those metrics that increased with impairment were given a 5th percentile as a basis for best value. Once either the 95th or 5th percentile standard was set for each metric, the actual measured metric value was compared to the standard best value to find the standardized metric score. Standardized metric scores range from 0 to 100, with 0 being very poor and 100 being excellent.

Decrease in response to impairment:

$$\text{(measured metric value)} \div \text{(standard best value} - 0) \times 100 = \text{standardized metric score}$$

Increase in response to impairment:

$$(100 - \text{measured metric value}) \div (100 - \text{standard best value}) \times 100 = \text{standardized metric score}$$

Table 15. Candidate Fish Metrics Calculated for the NCBSRW

Category	#	**Metric**	**Response to Disturbance**
Species Richness and Composition	1	Total Species Richness	Decrease
	2	Native Species Richness	Decrease
	3	Native Minnow Species Richness	Decrease
	4	Water Column Species Richness	Decrease
	5	Benthic Species Richness	Decrease
	6	Benthic Insectivore Richness	Decrease
Headwater/Pioneering Attributes	7	Headwater Species Richness	Decrease
	8	% Headwater Species	Decrease
	9	% Headwater Species Biomass	Decrease
	10	% Pioneering Species	Increase
	11	% Pioneering Species Biomass	Increase
Intolerant/Tolerant Attributes	12	Intolerant Species Richness	Decrease
	13	% Intolerant Species	Decrease
	14	% Intolerant Species Biomass	Decrease
	15	Sensitive Species Richness	Decrease
	16	% Sensitive Species	Decrease
	17	% Sensitive Species Biomass	Decrease
	18	% Green Sunfish	Increase
	19	% Green Sunfish Biomass	Increase
	20	% Tolerant Species	Increase
	21	% Tolerant Species Biomass	Increase
Trophic Guilds	22	% Insectivorous Minnows	Decrease
	23	% Insectivorous Minnows Biomass	Decrease
	24	% Insectivores	Decrease
	25	% Insectivore Biomass	Decrease
	26	% Predators	Increase
	27	% Predator Biomass	Increase
	28	% Omnivores	Increase
	29	% Omnivore Biomass	Increase
	30	% Herbivores	Decrease
	31	% Herbivore Biomass	Decrease
Reproduction	31	% Simple Lithophils	Decrease
	32	% Simple Lithophil Biomass	Decrease

Table 16. Core Fish Metrics for the NCBSRW

Category	#	Metric	Response to Disturbance
Species Richness and Composition	1	Total Species Richness	Decrease
	2	Water Column Species Richness	Decrease
	3	Benthic Species Richness	Decrease
Headwater/Pioneering Attributes	4	% Headwater Species	Decrease
	5	% Pioneer Species Biomass	Increase
Intolerant/Tolerant Attributes	6	% Intolerant Species	Decrease
	7	% Sensitive Species	Decrease
	8	% Tolerant Species Biomass	Increase
Trophic Guilds	9	% Insectivorous Minnows	Decrease
	10	% Insectivorous Biomass	Decrease
	11	% Omnivore	Increase
Reproduction	12	% Simple Lithophil Biomass	Decrease

Table 17 is an example of a tributary score sheet outlining the metrics and the score allocated to each metric. After each of the twelve metrics was scored, the standardized metric scores were averaged for each monitoring site and served as the final index value for that site. Score sheets for fish (by monitoring site) can be found in the Results Section.

Table 17. Sample Score Sheet for Fishes

Site T36					
Metric	**Response to Impairment**	**Percentile for "best" value**	**Standard (best value)**	**Measured metric value**	**Standardized Metric score**
Species Richness	Decrease	95th	21	11.0	52
Water Column Species Richness	Decrease	95th	8	4.0	50
Benthic Species Richness	Decrease	95th	10	5.0	50
% Headwater Species	Decrease	95th	31.7	9.0	28
% Pioneer Species Biomass	Increase	5th	28.5	41.0	83
% Intolerant Species	Decrease	95th	13.6	0.0	0
% Sensitive Species	Decrease	95th	27.2	9.0	33
% Tolerant Species Biomass	Increase	5th	31.3	72.5	40
% Insectivorous Minnows	Decrease	95th	94.2	68.5	73
% Insectivorous Biomass	Decrease	95th	77.1	55.0	71
% Omnivore	Increase	5th	12.7	42.1	66
% Simple Lithophil Biomass	Decrease	95th	59.6	49.5	83
			Final index value for this site:		**52**

Macroinvertebrate Sampling

Sampling of macroinvertebrates with rock baskets occurred in both the tributary and the river sites from late August to mid October of 2002. Four baskets were placed at each site for a period of 45 days ± 3 days (Table 18). Construction, deployment, and retrieval of rock baskets were conducted according to the SD DENR protocols (Stueven et al. 2000). Sorting, identification, and enumeration of macroinvertebrates occurred at the lowest practical taxonomic level (See Appendix J for outsource contracts and laboratory procedures). Three of the four baskets at each site were chosen for collection and were composited, with the exception of six sites. Six sites were chosen to represent the least impacted and the most impacted sampling sites based on water chemistry and visual evaluations. Although six sites had separate voucher jars for each rock basket collected, without having prior established reference type sites to base the results, there was not enough information from only three baskets and only six sites to make a good analysis. Thus, the results from the separate jars at each of the six sites were combined, per site, so they could be evaluated together with all the other sites. Candidate metrics (Table 15) were calculated and reduced to a set of core metrics for scoring (Table 16).

Table 18. Deployment and Retrieval Dates for Rock Baskets by Site

Site	Site Name	Method	Deployment Date	Retrieval Date	#Days Colonized
T34	Lake Pelican Weir	Cone	8/19/2002	10/3/2002	46
T35	Willow Creek (nr Waverly)	Cone	8/19/2002	10/2/2002	45
T36	Willow Creek (nr Watertown)	Cone	8/19/2002	10/3/2002	46
T37	Stray Horse Creek	Cone	8/26/2002	10/8/2002	44
T38	Boswell Diversion Ditch	------------ decomissioned ------------			
T39	Lake Poinsett Outlet	Cone	8/28/2002	10/9/2002	43
T40	Hidewood Creek (nr Clear Lake)	Cone	8/19/2002	10/2/2002	45
T41	Hidewood Creek (nr Estelline)	-------------------- DRY -----------------------			
T42	Peg Munky Run	-------------------- DRY -----------------------			
T45	East Oakwood Lake Outlet 1	Flat	8/28/2002	10/10/2002	44
T46	East Oakwood Lake Outlet 2	Flat	8/29/2002	10/11/2002	44
T47	Unnamed Creek (nr Volga)	Flat	8/29/2002	10/11/2002	44
T48	E. Oakwood Lake Inlet 3	Cone	8/29/2002	10/11/2002	44
R01	BSR nr Brookings	Cone	8/28/2002	10/10/2002	44
R14	BSR at Watertown	Cone	8/20/2002	10/7/2002	49
R15	BSR at Braoadway	Flat	8/19/2002	10/3/2002	46
R16	BSR 20th Ave	Cone	8/20/2002	10/7/2002	49
R17	BSR below Watertown	Cone	8/20/2002	10/7/2002	49
R18	BSR nr Castlewood	Cone	8/27/2002	10/8/2002	43
R19	BSR nr Estelline	Cone	8/27/2002	10/8/2002	43
R20	BSR nr Bruce	Cone	8/28/2002	10/9/2002	43

Macroinvertebrate Index of Biological Integrity (IBI)

The development of the macroinvertebrate index of biotic integrity (IBI) followed the process outlined in Table 14. There were no established reference sites; therefore, the following steps were taken to develop an index score for each site. In addition, a set of core metrics was chosen for the Big Sioux River sites and a separate table of core metrics was chosen for the tributary sites.

Candidate metrics (Table 19) were chosen to represent the categories of abundance richness, composition, tolerance/intolerance, and feeding. The EPA Rapid Bioassessment Protocols for Use in Streams and Rivers (Barbour et al. 1999) aided in developing these procedures. Core metrics (Table 20) were then chosen in each category through a process of comparative descriptive analysis, similar to the fish analysis. Comparative descriptive analysis was done using box and whisker plots (Appendix K), analyzing all data from all the monitoring sites at the same time for each of the five categories (abundance, richness, composition, tolerance, and feeding).

Table 19. Candidate Macroinvertebrate Metrics Calculated for the NCBSRWA

Category	#	Metric	Response to Disturbance
Abundance Measures	1	Abundance	Decrease
	2	Corrected Abundance	Variable
	3	EPT Abundance	Decrease
Richness Measures	4	Total No. Taxa	Decrease
	5	Number of EPT Taxa	Decrease
	6	Number of Ephemeroptera Taxa	Decrease
	7	Number of Trichoptera Taxa	Decrease
	8	Number of Plecoptera Taxa	Decrease
	9	Number of Diptera Taxa	Decrease
	10	Number of Chironomidae Taxa	Decrease
Composition Measures	11	Ratio EPT/Chironomidae Abundance	Decrease
	12	% EPT	Decrease
	13	% Ephemeroptera	Decrease
	14	% Plecoptera	Decrease
	15	% Trichoptera	Decrease
	16	% Coleoptera	Decrease
	17	% Diptera	Increase
	18	% Oligochaeta	Variable
	19	% Baetidae	Increase
	20	% Hydropsychidae	Increase
	21	% Chironomidae	Increase
	22	% Gastropoda	Decrease
	23	Shannon-Weiner Index	Decrease
Tolerance/Intolerance Measures	24	Number of Intolerant Taxa	Decrease
	25	% Intolerant Organisms	Decrease
	26	Number of Tolerant Taxa	Increase
	27	% Tolerant Organisms	Increase
	28	% Burrowers	Increase
	29	% Chironimidae + Olgochaeta	Increase
	30	Hilsenhoff Biotic Index	Increase
	31	% Dominant Taxon	Increase
	32	% Hydropsychidae to Trichoptera	Increase
	33	% Baetidae to Ephemeroptera	Increase
Feeding Measures	34	% individuals as Gatherers and filterers	Decrease
	35	% Gatherers	Decrease
	36	% Filterers	Increase
	37	% Shredders	Decrease
	38	% Scrapers	Decrease
	39	Ratio Scrapers/(Scrapers+Filterers)	Decrease
	40	Number of Gatherer Taxa	Decrease
	41	Number of Filterer Taxa	Decrease
	42	Number of Shredder Taxa	Decrease
	43	Number of Scraper Taxa	Decrease
	44	Individuals as Clingers	Decrease
	45	Number of Clinger Taxa	Decrease
	46	% Clingers	Decrease
	47	Number of Predator Organisms	Variable
	48	Number of Predator Taxa	Variable
	49	% Predators	Variable

Table 20. Core Macroinvertebrate Metrics Calculated for the BSR and Tributaries in the NCBSRW

Category	#	Metric	Response to Disturbance
Abundance Measures	1	Abundance	Decrease
Richness Measures	2	Total Number of Taxa	Decrease
	3	Number of EPT Taxa	Decrease
	4	Number of Diptera Taxa	Decrease
Composition Measures	5	% EPT	Decrease
	6	% Diptera	Increase
	7	% Chironomidae	Increase
Tolerance/Intolerance Measures	8	% Tolerant Organisms	Increase
	9	% Chironomidae + Oligochaeta	Increase
	10	% Hydropsychidae/Trichoptera	Increase
Feeding Measures	11	% Gatherers	Decrease
	12	% Filterers	Increase
	13	% Clingers	Decrease

Once the core metrics in Table 20 were chosen, best value percentiles were calculated. The 95th percentile was used as a basis for best value for those metrics that decreased with impairment. Those metrics that increased with impairment were given a 5th percentile as a basis for best value. Once either the 95th or 5th percentile standard was set for each metric, the actual measured metric value was compared to the standard best value to find the standardized metric score. Standardized metric scores range from 0 to 100, with 0 being very poor and 100 being excellent.

Decrease in response to impairment:

measured metric value ÷ (standard best value – 0) x 100 = standardized metric score

Increase in response to impairment:

(100 - measured metric value) ÷ (100 - standard best value) x 100 = standardized metric score

Table 21 is an example of a tributary score sheet that outlines the metrics and the score assigned to each metric. After each of the core metrics were scored, the standardized metric scores were averaged for each monitoring site and served as the final index value for that site. Score sheets for the tributary and river sites can be found in Appendix L.

Table 21. Sample Score Sheet for Macroinvertebrates

Site R15					
Metric	**Response to Impairment**	**Percentile for "best" value**	**Standard (best value)**	**Measured metric value**	**Standardized Metric score**
Abundance	Decrease	95th	323	274	85
Taxa Richness	Decrease	95th	33	34	100
EPT Richness	Decrease	95th	11	5	45
Diptera Richness	Decrease	95th	11	11	100
% EPT	Decrease	95th	69.2	5.8	8
% Diptera	Increase	5th	28.1	36.9	88
% Chironomidae	Increase	5th	26.8	35.0	89
% Tolerant	Increase	5th	8.3	80.3	21
% Chironomidae + Oligochaeta	Increase	5th	27.8	64.2	50
% Hydropsychidae/Trichoptera	Increase	5th	0	15.4	85
% Gatherers	Decrease	95th	70.4	57.3	81
% Filterers	Increase	5th	2.8	12.0	91
% Clingers	Decrease	95th	37.9	6.9	18
			Final index value for this site:		**66**

Physical Habitat

The physical characteristics of wadeable streams were synthesized from many sources including Simonson et al. (1994) and Platts et al. (1983). The data are compatible with available physical assessments (Barbour et al. 1999; Stueven et al. 2000). A list of terms and definitions are provided in Appendix M to aid use of the following procedures.

Near each monitoring site, a reach was selected that had one type and intensity of riparian landuse, and where bridges and dams appeared to have minimal impact. Data collection consisted of five components: physical, discharge, water surface slope, water quality, and reach classification.

Habitat Assessment

Field measurements of physical characteristics using a transect method were adapted from Simonson et al. (1994) and Platts et al. (1983). Field data sheets are provided in Appendix N. Reaches were selected within one type of riparian land use in most cases, and where bridges and dams appeared to have minimal impact. Once a site was selected, a preliminary mean stream width (PMSW) was obtained and used to determine transect spacing and reach length (Simonson et al. 1994). When low flows restricted stream width to a small portion of the streambed, streambed channel width was used to determine transect spacing. Transects were marked with flags. Data collection began on the upstream end of the reach and proceeded downstream.

Transect data collection was divided into three practical components. The first suite of data was collected according to visual estimates and counts. On either end of a transect the riparian land use, dominant vegetation type, animal vegetation use, dominant bank substrate, and bank slumping (presence/absence) were recorded. Where a transect crossed the stream, dominant macrohabitat type was designated as pool, riffle, or run. Bed substrate data was collected using the Wolman “pebble count” by visually dividing the transect into eight “cells”. Within each cell, substrate size was measured and the class size recorded. This method objectively classified substrates in clear streams and was a necessity in turbid streams where visual estimates were not possible (Wolman 1954).

A second suite of data focused on stream bank and riparian features and was measured with a graduated pole and angle finder. After identifying the break point between the bank and channel bottom, measurements related to stream bank length, bank angle, and bank height were recorded (Figure 8). The length of bank that was vegetated, eroded, and depositional was measured. Vegetated portions were that length of bank where root structure contributed to bank stability, eroded portions were that length with no root structure support, and depositional portions were that length where recent deposition dominated the bank surface. Riparian-related cover types were measured at the end of each transect as the horizontal length of overhanging vegetation (OHV) and undercut bank (UCB) extending over the streambed.

A third suite of data focused on horizontal and vertical point measurements which were used to calculate stream width, depth and velocity; channel bottom and top width; and bankfull width, depth, and width:depth ratio. At most sites, point data were obtained by staking a tape measure from left top bank to the right top bank. In some cases, the tape measure was staked at left bankfull and right bankfull. Moving from left to right, key channel features (i.e., location codes) were identified and the distance from the left stake was recorded. Vertical measurements were bankfull depth, water depth, and water velocity. Bankfull depths were measured at the water edge and at three points within the stream. Water depth and velocity were measured at the three points within the stream (1/4, 1/2, and 3/4 of the distance across the stream surface).

At each site, data were also collected on large woody debris (LWD), discharge, water surface slope, and water quality. The number of LWD was tallied for the entire reach. Length, diameter, and angle to streambank measurements of all LWD were measured and used to calculate the volume of LWD within the reach. Flow data were collected at a single transect or other stream cross-sections where flow was uniform. The velocity-area method was used to calculated discharge (Gordon et al. 1992). Water surface slope (%) was calculated by dividing the drop in water surface from transect one to transect 13 by the longitudinal stream distance using a surveying level.

Water temperature, air temperature, turbidity, pH, dissolved oxygen, and conductivity were measured once at each reach.

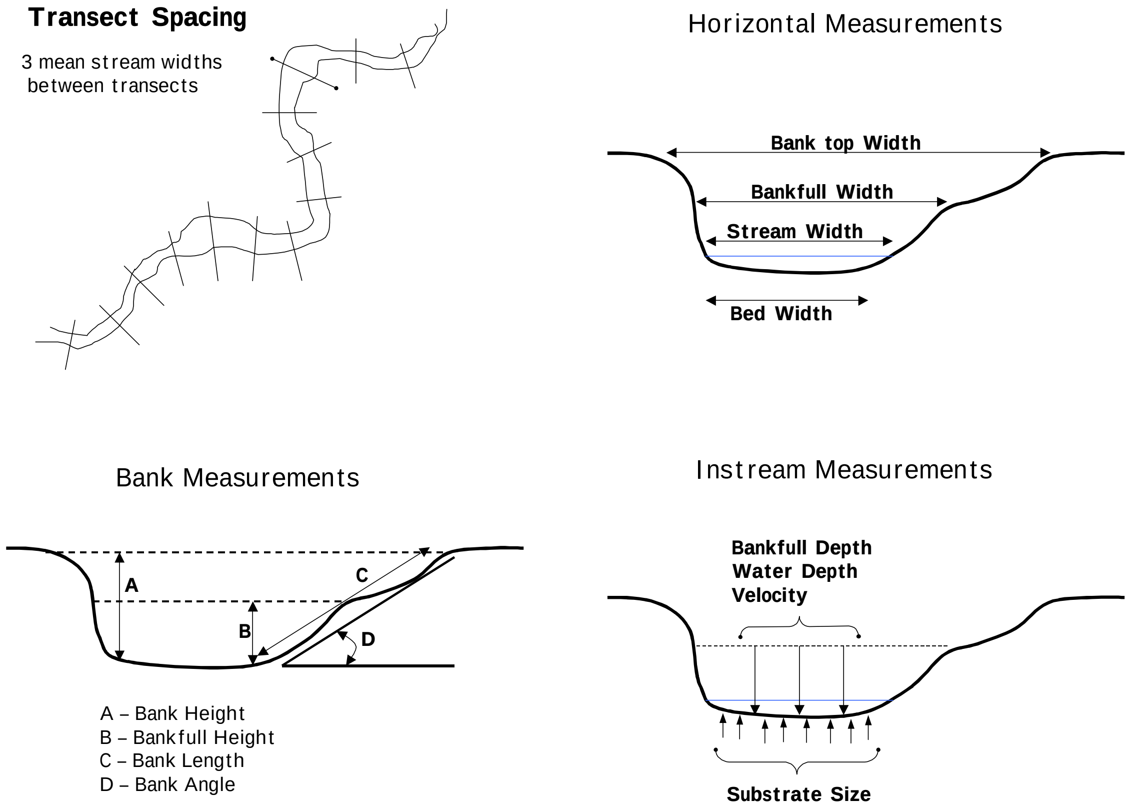


Figure 8. Diagrams of Transect Spacing, Horizontal, Bank, and In-stream Measurements

Index of Physical Integrity (IPI)

The physical habitat index for the NCBSRWAP was developed based on EPA's Rapid Bioassessment of substrate, channel morphology, bank structure, and riparian vegetation (Barbour et al. 1999). Parameters and scoring of each site was modified to suit this project. The following table (Table 22) outlines the parameters and the score assigned to each rating. By using the information collected on the field data sheets, each monitoring site was rated individually using the eight parameters. Scores ranged from 0 to 100 (Table 23). After each site was scored, a standardized metric score based on the 'best value', was calculated. This served as the final index value for that site as shown in Table 24.

Table 22. Parameters and Scores Used to Rate the Physical Habitat Measurements

Physical Parameter	Rating				
	Excellent	**Good**	**Fair**	**Poor**	**Very Poor**
1. Channel Flow Status	Perrenial streamflow. Water surface reaches base of both lower banks, and minimal amount of channel substrate is exposed.	Perrenial streamflows. Water surface covers <100% but >75% of the available channel bottom.	Perrenial streamflows. Water surface covers 50-75% of the available channel bottom.	Perrenial streamflows. Water surface covers >50% of the available channel bottom.	Average Stream Width about 1/3 channel bottom width. Intermittent.
SCORE	**10**	**7.5**	**5**	**2.5**	**0**
2. Physical Complexity	high	high/moderate	moderate	moderate/low	low
	≥8 hydrologic units, usually at least 3 riffles present	6 to 7 hydrologic units, usually 2 to 4 riffles present	4 to 5 hydrologic units, usually 1 to 3 riffles present	2 to 3 hydrologic units, usually 0 to 1 riffles present	1 hydrologic units, no riffles present
SCORE	**10**	**7.5**	**5**	**2.5**	**0**
3. Coefficient of Variation of Velocity	≥1.2	0.9 to 1.2	0.6 to 0.9	0.3 to 0.6	<0.3
SCORE	**10**	**7.5**	**5**	**2.5**	**0**
4. Bed Composition	≥ 75% gravel and larger	≥ 75% gravel and sand (at least 50% gravel)	≥ 75% coarse gravel, sand, and silt	≥ 75% sand and silt (at least 50% sand)	> 75% silt or smaller
SCORE *	**16**	**12**	**8**	**4**	**0**
* Add 4 points if cobble size and larger comprise 10% of substrate					
5. Measure of Incision	Mean Bank Full Height is ≥70% of mean Bank Height.	Mean Bank Full Height is ≥60 to 69% of mean Bank Height.	Mean Bank Full Height is ≥50 to 59% of mean Bank Height.	Mean Bank Full Height is ≥40 to 49% of mean Bank Height.	Mean Bank Full Height is <40% of mean Bank Height.
SCORE	**10**	**7.5**	**5**	**2.5**	**0**
6. Bank Stability	>80% bank vegetated; the remaining erosional or depositional.	≥60 to 80% bank vegetated; the remaining erosional or depositional.	≥40 to 60% bank vegetated; the remaining erosional or depositional.	≥20 to 40% bank vegetated; the remaining erosional or depositional.	<20% bank vegetated; the remaining erosional or depositional.
SCORE	**20**	**15**	**10**	**5**	**0**
7. Overhanging Vegetation	Average amount ≥0.5 m	≥0.3 - 0.49 m	≥0.2 - 0.29 m	≥0.1 - 0.19 m	<0.1 m
SCORE	**10**	**7.5**	**5**	**2.5**	**0**
8. Animal Vegetation Use	No Use: All the potential plant biomass is present.	Light Use: Almost all of the potential plant biomass is present.	Moderate Use: About 1/2 of plant biomass is present. Plant stubble about half potential height.	High Use: Less than 1/2 of plant biomass is present. Plant stubble greater than 2 inches.	Very High Use: Nearly all plant biomass removed. Plant stubble less than 2 inches.
SCORE	**10**	**7.5**	**5**	**2.5**	**0**

Table 23. Sample Score Sheet for Physical Habitat

SiteID: T36 **Site Name:** Willow Creek (near Watertown))

	Parameter	Score
1	Channel Flow Status (10)	10
2	Hydrologic Complexity (10)	2.5
3	CV of Velocity (10)	10
4	Bed Composition (20)	8
5	Channel Incision (10)	7.5
6	Bank Stability (20)	20
7	Overhanging Vegetation (10)	2.5
8	Animal Vegetation Use (10)	0
	Total =	**60.5**

From the above sample, Site T36 scored a 60.5. This was repeated for each site that had a physical habitat assessment field data sheet. There are no established reference sites within South Dakota. All sites were ranked and the 95th percentile was used as the standard. The following calculation was used to find the metric score for each of the eight physical habitat parameters (Table 24).

$$(\text{measured metric value}) \div (\text{standard best value}) \times 100 = \text{standardized metric score}$$

The final index value was found by averaging the eight standardized metric scores. The values range from 0 (very poor) to 100 (excellent). Score sheets for each site can be found in the Results Section.

Table 24. Sample Final Score Sheet for Physical Habitat

Site T36

Metric	Percentile for "best" value	Standard (best value)	Measured metric value	Standardized Metric score
Channel Flow Status	95th	10	10	100
Physical Complexity	95th	10	2.5	25
CV of Velocity	95th	10	10	100
Bed Composition	95th	19	8	44
Measure of Incision	95th	10	7.5	75
Bank Stability	95th	19	20	100
Overhanging Vegetation	95th	2.5	2.5	33
Animal Vegetation Use	95th	10	0	0
		Final index value for this site:		**60**

Quality Assurance and Data Management

Quality Assurance/Quality Control (QA/QC) samples were collected for at least 10% of the samples taken. A total of 420 water samples were collected from 18 monitoring sites. Total QA/QC samples were 74, with 37 being duplicates and 37 blanks.

QA/QC results were entered into a computer database and screened for data errors. Overall, the duplicates produced very similar results to the sample itself, with the exception of fecal coliform counts, TSS, ammonia, and nitrate-nitrite. Variations among duplicate bacteria samples may have occurred because of natural variability. Differences in the results from 2001-2002 containing nitrogen (nitrate-nitrite, organic nitrogen, TKN) may be attributed to the use of reverse osmosis water for cleaning and filtering and also due to faulty lab equipment used in analysis. Unfortunately, the lab director was unable to come up with a correction factor due to the randomness of the errors. See copy of WRI lab director's memo in Appendix O.

Field blanks consistently registered detectable limits of nutrients and sediments. Sediment detects may be due to inadequate rinsing of bottles or the quality of rinsing water. Sources of the nitrogen problems may have been the quality of the rinsing water, but more likely due to faulty lab equipment used for the analysis. See Appendix P for field duplicates and blanks.

ASSESSMENT OF SOURCES

Point Sources

Wastewater Treatment Facilities (NPDES)

Data for all permitted NPDES facilities was obtained from DENR personnel in Pierre (pers comm. SD DENR). Each facility was matched to a monitoring location within the study area. Each facility was evaluated to determine its percent contribution of fecal coliform bacteria and TSS to the downstream monitoring sites for the study period. This was accomplished by the following equations:

30-day average flow (mean) × 30-day average concentration (mean) × # of days discharged = total load

(total facility load ÷ total monitored load) × 100 = percent facility load

Urban Stormwater Runoff

Stormwater impacts were estimated for the City of Watertown by using a mass-balance approach because there was only a limited amount of monitoring data. To calculate the relative contribution, Site R16 (BSR at 20th Ave) was isolated by subtracting off monitored sites upstream (Figure 9). This included subtracting Site R14 (BSR at Watertown) and Site T34 (Lake Pelican Weir). The remainder was assumed to be the contribution from the City of Watertown's immediate area.

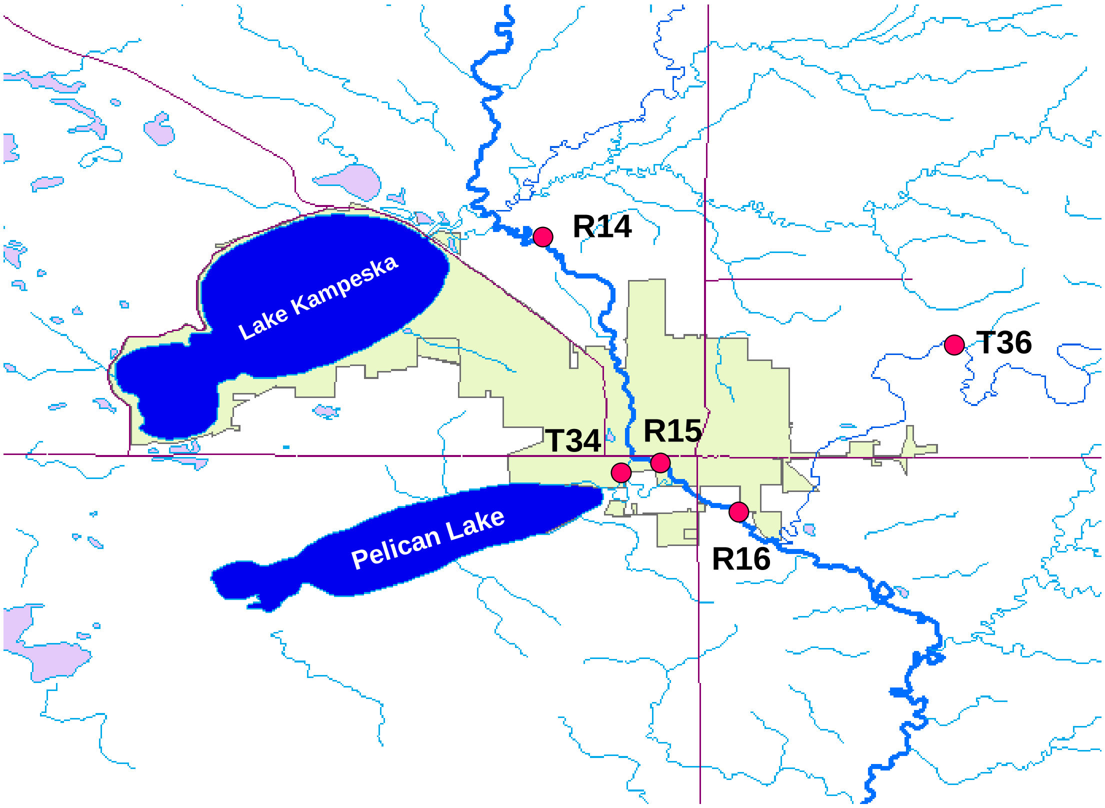


Figure 9. City of Watertown Area and the Monitoring Sites Used to Figure Stormwater Runoff

Non Point Sources

Agricultural Runoff

Agricultural runoff was taken into account when the AnnAGNPS model calculated landuse scenarios for TSS and nutrient reductions. The AGNPS model was used to perform ratings on the feedlots in the study area. This information was then incorporated as part of the process of prioritizing watershed areas for fecal reduction.

Background Wildlife Contribution

Fecal coliform bacteria contributions from wildlife was considered to be background. A general estimate of wildlife fecal coliform bacteria loading was derived from assessing total deer contributions. Deer are the largest of the wild animals occupying the study area and factual information was readily available for this animal. Using 2002 deer population numbers (Huxoll 2002) per square mile for Brookings, Deuel, Hamlin, and Codington Counties, estimations of deer per square mile were calculated. The five monitoring sites used to calculate this contribution were chosen because they were not influence by any other monitoring locations within the study area.

The average deer per square mile was multiplied by the square miles of the township where the monitoring sites (T36, T37, T41, T42, and T46) were located, giving number of deer per township.

deer/square mile × square miles/township = deer/township

Then the number of deer per township was multiplied by the number of days monitored and then multiplied by the CFU/deer/day (MPCA 2002) to calculate total CFU's per township from deer.

deer/township × # monitoring days × CFU/deer/day = CFU’s per township (from deer)

To determine the percent deer contribution of fecal coliform bacteria, CFU’s per township per deer were divided by the total CFU’s monitored, multiplied by 100.

[CFU’s per township ÷ CFU’s monitored] × 100 = % deer contribution of fecal coliform bacteria

Failing Septic Systems Contribution

The fecal coliform background contribution from rural households was calculated using the Census 2000 Housing Units (US Census Bureau 2000). Housing unit numbers for each township where monitoring Sites T36, T37, T41, T42, and T46 are located were used to calculate failing septic system contribution. These particular monitoring sites were chosen because they represented rural areas throughout the study area.

According to the US EPA (2002a) failure rates of onsite septic systems ranged from 10 to 20 percent, with the majority of these failures occurring with systems 30 or more years old. Therefore, 20 percent of the households for each monitoring site area were used to figure septic contribution. The average number of people per household (MPCA 2002) was multiplied by the number of households (20 percent) for the five monitoring site areas, giving a total number of people.

average number of people per household × # of households (20%) = total number of people

Then the total number of people per township area of the monitored site was multiplied by the number of days monitored and then multiplied by the CFU/person/day to calculate total CFU’s per monitored site.

total number of people per area × # monitoring days ×CFU/people/day = CFU’s per area (from people)

To determine the percent septic contribution of fecal coliform bacteria, CFU’s per area per person were divided by the total CFU’s monitored, multiplied by 100.

[CFU’s per area ÷ CFU’s monitored] × 100 = % septic system contribution of fecal coliform bacteria

Modeling

The strategy for selecting modeling and assessment techniques for the North-Central Big Sioux River watershed was based on the need to:

1) balance the cost of modeling intensity with the need to cover a broad geographic area in a timely manner,
2) link the transport of total suspended solids (TSS) with watershed processes and land uses,
3) link the transport of fecal coliform bacteria with feedlot density, proximity, and ratings, and land uses,

4) link the transport of nutrients (phosphorus and nitrates) with watershed processes and land uses, and
5) generate key information that integrates the relationship of cumulative effects and watershed health (indices of biological integrity) with the choices and consequences of human decisions in watershed protection and restoration.

These needs conform to the advantages of performing an assessment on a large scale (Barbour et al. 1999). Specific advantages include being able to address cumulative effects by accounting for large-scale watershed processes to guide management approaches.

Six basic modeling and assessment techniques were used. Each technique generates an independent set of information (Table 25). The IPI and IBI assessment techniques have previously been described. This section will focus on the three models (FLUX, AGNPS, and AnnAGNPS) used to assess water quality in the study area.

Table 25. Modeling and Assessment Techniques and Outputs Used for the NCBSRWAP

Modeling Technique	Outputs
FLUX Model	Loadings for WQ Parameters Concentrations for WQ Parameters
AGNPS - Feedlot Rating Model	Total P & N, chemical oxygen demand (COD), and a feedlot rating
Flow Duration Interval Zones	Hydrologic Condition Targets and Loads % reduction for fecal coliform bacteria
AnnAGNPS Model	Sediment Yield Nutrient Yield Land Use Scenarios
Assessment Technique	**Outputs**
Physical Assessment	Index of Physical Integrity (IPI)
Biological Assessment	Fish Index of Biological Integrity (IBI) Macroinvertebrate Index of Biological Integrity IBI)

FLUX Model

Total nutrient and sediment loads were calculated with the use of the Army Corps of Engineers Eutrophication Model known as FLUX (Walker 1999). FLUX uses six different loading calculation methods with individual sample data in conjunction with daily discharges. For each monitoring site, nutrient and sediment loadings were calculated with the model. The FLUX model uses 1) grab-sample water quality concentrations with an instantaneous flow and 2) continuous flow records. Loadings and concentrations were calculated by month and stratified into low and high flows to distinguish between base flow and runoff flow. Coefficients of variation (CV) were used to determine what method of calculation was appropriate for each parameter at each site (Appendix Q). Each water quality parameter was computed by site as daily, monthly and yearly concentrations and loadings. See Appendix R for monthly concentrations by site and Appendix S for monthly loadings by site.

Water quality was sampled according to Stueven et al. (2000) and analyzed at South Dakota State University, Water Quality Laboratory and the State Health Laboratory. Water quality analyses provided concentrations for a standard suite of parameters. Continuous streamflow records for tributary sites were derived using stage records and stage-discharge curves (Appendix E). Continuous streamflow records for river sites coinciding with USGS monitoring locations were obtained. Using these records, continuous streamflows for monitored BSR sites between gaging stations were derived using interpolation methods (Gordon 1992).

AGNPS Feedlot Model

The Agricultural Non-Point Source Pollution (AGNPS) model is a GIS-integrated water quality model that predicts non-point source pollutant loadings within agricultural watersheds. ArcView GIS software was used to spatially analyze feedlots and their pollution potential.

Watersheds dominated by agricultural uses (i.e. pastured cattle in stream drainages, runoff from manure application, and runoff from concentrated animal feeding operations) can influence the amount of fecal coliform bacteria entering nearby surface waters. Assessment of the feedlots, using the AGNPS model, assumed the probable sources of fecal coliform bacteria loadings were related to agricultural land use (upland and riparian), animal feeding operations, and the use of streams for stock watering.

The methods used in the NCBSRWA to determine loadings and reductions of fecal coliform bacteria, could serve as an integrated measure of runoff from feedlots and land uses. Pollutant frequency was measured using the density of feedlots located upstream of a monitoring site. Using feedlot scores based on proximity to the receiving waters provided an indicator of potential input of all feedlots. Upland and riparian land uses provided an indicator of the availability of upland areas available for pastured livestock. A complete methodology report can be found in Appendix T.

AnnAGNPS Landuse Model

The AnnAGNPS model expands the capabilities of the AGNPS model. This model was to be used as a tool to evaluate non-point source pollution from agricultural watersheds ranging in size up to 740,000 acres. With this model the watershed is divided into homogenous land areas or cells based on soil type, land use, and land management. AnnAGNPS simulates the transport of surface water, sediment, nutrients, and pesticides through the watershed. The current condition of the watershed can be modeled and used to compare the effects of implementing various conservation alternatives over time within the watershed.

RESULTS

WATER QUALITY MONITORING

Water quality data collected during the NCBSRWAP was evaluated based on the specific criteria that the DENR developed for listing water bodies in the 1998 and 2002 South Dakota 303(d) Waterbody List, and the 2004 Integrated Report. The EPA approved listing criteria used by the state of South Dakota during the assessment, to determine if a waterbody is meeting its beneficial uses, is contained in the following paragraph. It should be noted that EPA guidance, in reference to TMDL targets, are based on the acute criteria of any one sample, which was used in establishing targets for the TMDLs of this assessment.

Use support was based on the frequency of exceedences of water quality standards (if applicable) for the following chemical and field parameters. A stream segment with only a slight exceedence (10 percent or less violations for each parameter) is considered to meet water quality criteria for that parameter. The EPA established the following general criteria in the 1992 305(b) Report Guidelines (SDDENR 2000) suitable for determining use support of monitored streams.

Fully supporting	≤ 10.0 % of samples violate standards
Not supporting	> 10.0 % of samples violate standards

This general criteria is based on having 20 or more samples for a monitoring location. Many of the monitoring sites were sampled less than 20 times. For those monitoring sites with less than 20 samples, the following criteria will apply:

Fully supporting	≤ 25.0 % samples violate standards
Not supporting	> 25.0 % of samples violate standards

Use support assessment for fish life propagation primarily involved monitoring levels of the following major parameters: dissolved oxygen, total ammonia nitrogen as N, water temperature, pH, and suspended solids. Use support for swimmable uses and limited contact recreation involved monitoring the levels fecal coliform bacteria (May 1 – September 30) and dissolved oxygen. If more than one beneficial use is assigned for the same parameter (i.e. fecal coliform bacteria) at a particular monitoring site, the more stringent criteria was applied. The use support for monitoring sites will be discussed further in the Assessment Section. The results for the following parameters are summarized below for all the tributary and river sites (T34, T35, T36, T37, T39, T40, T41, T42, T46, T47, R01, R14, R15, R16, R17, R18, R19, and R20). See Appendix U for detailed information about means, minimums, maximums, medians, percent violations, and use support of each monitoring site and parameter.

Chemical Parameters

Table 26 shows a summary of the minimum and maximum results from the chemical parameter sampling of the tributaries and the rivers. More specific details of the sampling follow after the table.

Table 26. Summary of Chemical Parameters Sampled in the Tributaries and River

		Tributaries		River	
Parameter	Unit	min	max	min	max
Fecals	cfu/100mL	no detect	930,000	no detect	410,000
TotSol	mg/L	222	2,113	122	1,587
TSS	mg/L	1	202	1	328
TDS	mg/L	172	2,084	112	613
TAmmN	mg/L	no detect	7.850	0.022	0.789
NO2NO3	mg/L	no detect	3.515	no detect	11.404
TKN	mg/L	0.438	10.946	0.539	4.108
OrgNtr	mg/L	0.404	7.037	0.447	3.352
TPO4	mg/L	0.038	2.016	0.047	2.956
TDPO4	mg/L	0.009	1.493	0.012	2.797

Fecal Coliform Bacteria

Fecal coliform bacteria ranged from non-detect at T34 (Lake Pelican Weir) and T39 (Lake Poinsett Outlet) to a maximum of 930,000 cfu/100mL (T35-Willow Creek) for the tributary sites (Figure 10). The lowest median of 235 cfu/100mL was at Site T34 and the highest median of 4,250 cfu/100mL was at Site T42.

Fecal coliform bacteria ranged from non-detect at several sites to a maximum of 410,000 cfu/100ml (R18-BSR near Castlewood) for the river sites (Figure 10). The lowest median of 180 cfu/100mL was at Site R01 and the highest median of 1,800 cfu/100mL was at Site R18.

A single grab sample daily maximum of ≤ 2,000 cfu/100mL was used to determine the percent violations and assess for the beneficial use support of (8) Limited Contact Recreation for all tributary and river sites. Using this criterion, tributary Sites T35, T36, T37, T41, T42 and rivers Sites R14, R16, R17, and R18 are not supporting for this parameter. Sites that are fully supporting include T40, R01, R15, and R19. Tributary Sites T34, T39, T46, and T47 are not assigned numeric criteria for fecal coliform bacteria.

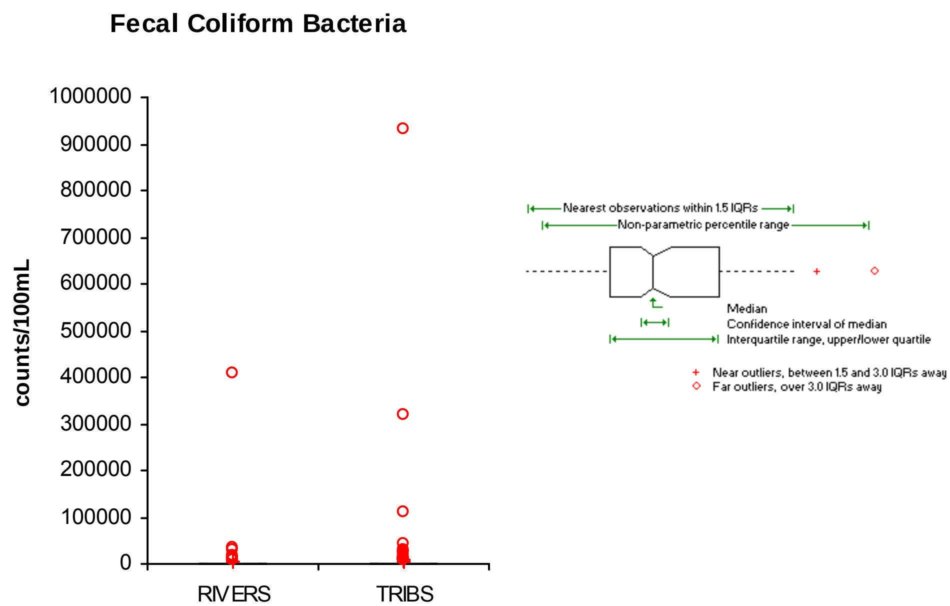


Figure 10. Box and Whisker Plot of Fecal Coliform Bacteria for River and Tributary Sites

Total Solids

Total solids ranged from a minimum of 222 mg/L (T25-Willow Creek) to a maximum of 2,113 mg/L (T40-Hidewood Creek) for the tributary sites (Figure 11). The lowest median of 415 mg/L was at Site T35 and the highest median of 1,046 mg/L was at Site T40.

Total solids ranged from a minimum of 122 mg/L (R14-BSR at Watertown) to a maximum 1,587 mg/L (R20-BSR near Bruce) for the river sites (Figure 11). The lowest median of 480 mg/L was at Site R14 and the highest median of 680 mg/L was at Site R01.

There is no standard or assigned beneficial use for this parameter.

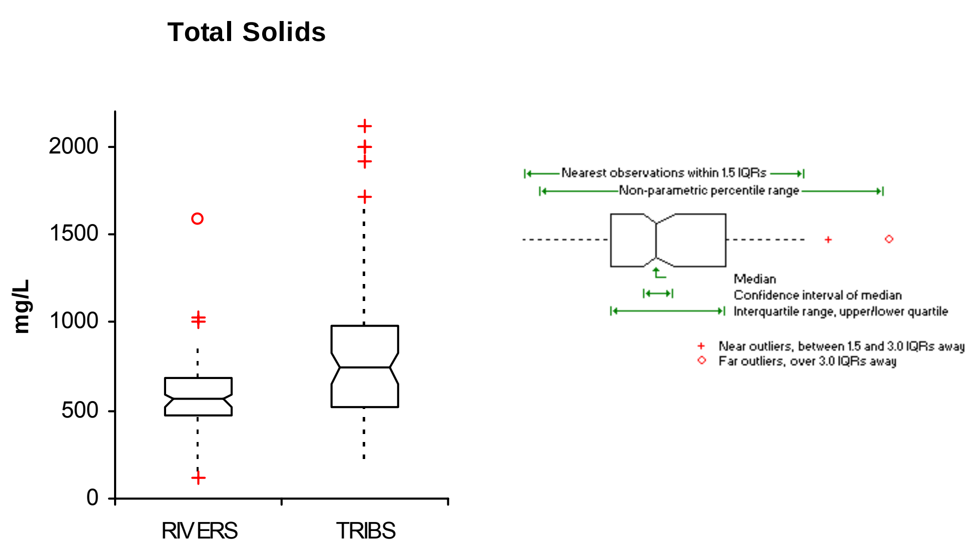


Figure 11. Box and Whisker Plot of Total Solids for River and Tributary Sites

Total Suspended Solids

Total suspended solids ranged from a minimum of 1 mg/L (T47-Unnamed Creek near Volga) to a maximum of 202 mg/L (T36-Willow Creek near Watertown) for the tributary sites (Figure 12). The lowest median of 7 mg/L was at Site T47 and the highest median of 42 mg/L was at Site T39.

Total suspended solids ranged from a minimum of 1 mg/L at R17 (BSR below Watertown) and at R19 (BSR near Estelline) to a maximum of 328 mg/L (R20-BSR near Bruce) for the river sites (Figure 12). The lowest median of 22 mg/L was at Site R16 and the highest median of 72 mg/L was at Site R01.

A single grab sample daily maximum of ≤ 158 mg/L was used to determine the percent violations and assess for the beneficial use support of (5) Warm Water Semi-Permanent Fish Life Propagation for river Sites R01, R14, R15, R16, R17, R18, R19, and R20. These river sites are fully supporting for this parameter. A single grab sample daily maximum of ≤ 263 mg/L was used to determine the percent violations and assess for the beneficial use support of (6) Warm Water Marginal Fish Life Propagation for tributary Sites T35, T36, T37, T40, T41, and T42. These tributaries are fully supporting of this parameter. Based on the existing standard for total suspended solids, tributary Sites T34, T39, T46, and T47 are not assigned numeric criteria.

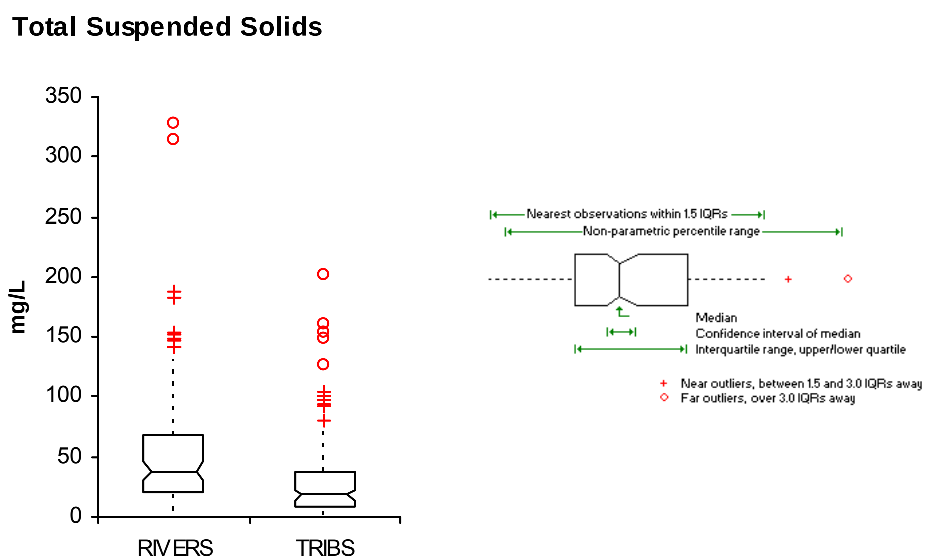


Figure 12. Box and Whisker Plot of TSS for River and Tributary Sites

Total Dissolved Solids (TDS)

TDS ranged from a minimum of 172 mg/L (T37-Stray Horse Creek) to a maximum of 2,084 mg/L (T40-Hidewood Creek) for the tributary sites (Figure 13). The lowest median of 384 mg/L was at Site T35 and the highest median of 982 mg/L at Site T40.

TDS ranged from a minimum of 112 mg/L at Site R14 (BSR at Watertown) and R15 (BSR at Broadway) to a maximum of 613 mg/L (R19-BSR near Estelline) for the river sites (Figure 13). The lowest median of 444 mg/L was at Site R14 and the highest median of 613 mg/L was at Site R19.

A single grab sample daily maximum of ≤ 4,375 mg/L was used to determine the percent violations and assess for the beneficial use support of (9) Fish and Wildlife, Propagation, Recreation and Stock Watering for the tributary sites. A single grab sample daily maximum of ≤ 1,750 mg/L was used to determine the percent violations and assess for the beneficial use support of (1) Domestic Water Supply for the river sites. Using this criterion, all tributary sites and all river sites are fully supporting for this parameter.

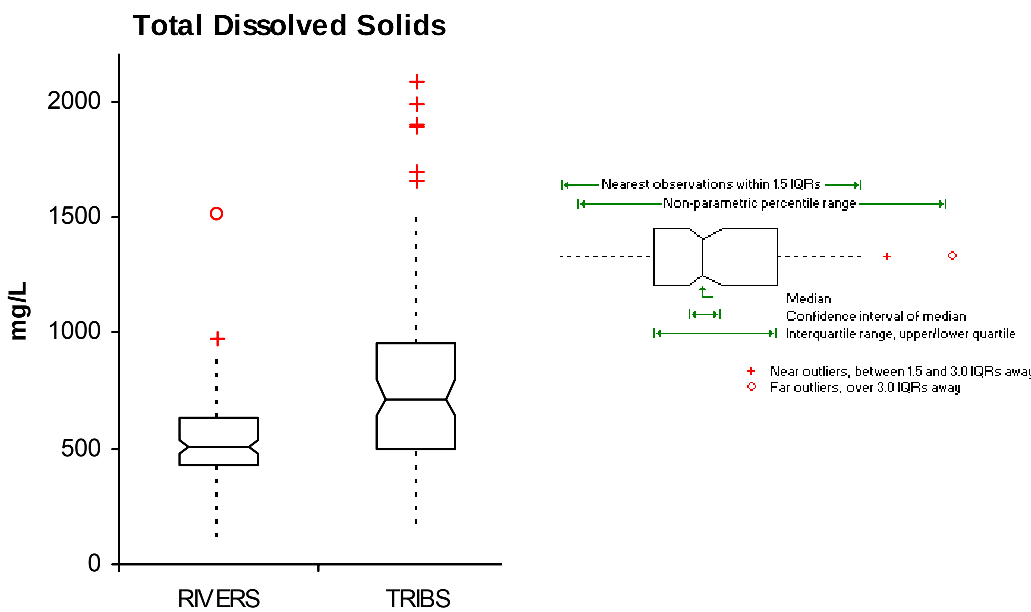


Figure 13. Box and Whisker Plot of Total Dissolved Solids for River and Tributary sites

Total Ammonia Nitrogen as N

Total ammonia nitrogen as N ranged from a non-detect (T47-Unamed Creek near Volga) to a maximum of 7.85 mg/L (T40-Hidewood Creek) for the tributary sites (Figure 14). The lowest median of 0.059 mg/L was at Site T42 and the highest median of 0.401 mg/L was at Site T40.

Total ammonia nitrogen as N ranged from a minimum of 0.022 (R20-BSR near Bruce) to a maximum 0.798 mg/L (R18-BSR near Castlewood) for all river sites (Figure 14). The lowest median of 0.100 mg/L was at Site R01 and the highest median of 0.214 mg/L was at Site R15.

To calculate a single grab sample daily maximum, an equation (equation 2 in Appendix A to Chapter 74:51:01 of the South Dakota Administrative Rules) based on pH was used. This was used to determine the percent violations and assess for the beneficial use support (5) Warmwater Semi-permanent Fish Life Propagation for the river and lake monitoring sites. This same process was used to determine the percent violations and assess for the beneficial use support (6) Warmwater Marginal Fish Life Propagation for tributary Sites T35, T36, T37, T40, T41, and T42. Using this criterion, all tributary sites and all river sites are fully supporting for this parameter.

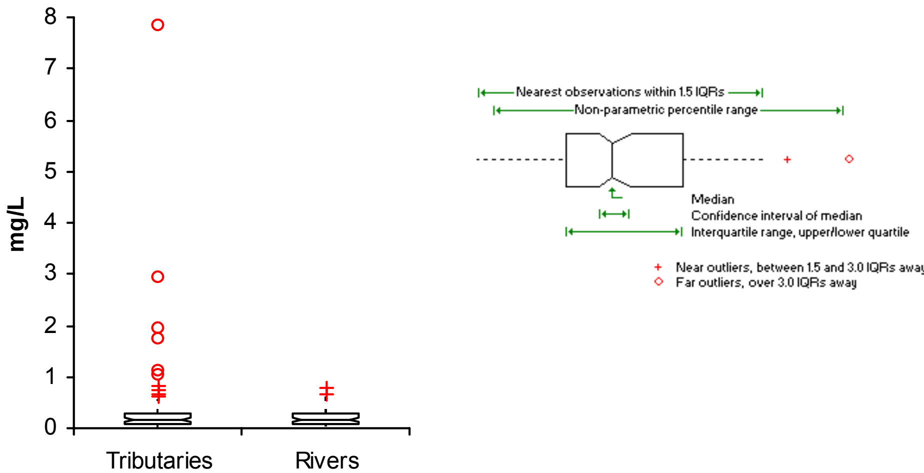


Figure 14. Box and Whisker Plot of Total Ammonia Nitrogen as N for River and Tributary Sites

Nitrate-Nitrite

Nitrate-nitrite ranged from a non-detect at T39 (Lake Poinsett Outlet) to a maximum of 3.515 mg/L (T40-Hidewood Creek) for the tributary sites (Figure 15). The lowest median of 0.062 mg/L was at T39, and the highest median of 0.779 mg/L was at Site T41.

Nitrate-nitrite ranged from a non-detect at R19 (BSR near Estelline) to a maximum of 11.404 mg/L (R16-BSR at 20th Ave) for the river sites (Figure 15). The lowest median of 0.144 mg/L was at Site R14 and the highest median of 1.365 mg/L was at Site R18.

A single grab sample daily maximum of ≤ 88 mg/L was used to determine the percent violations and assess for the beneficial use support of (9) Fish and Wildlife Propagation, Recreation and Stock Watering for the tributary sites. A single grab sample daily maximum of 10 mg/L was used to determine the percent violations and assess for the beneficial use support of (1) Domestic Water Supply for the river sites. Using this criterion, all tributary and all river sites are fully supporting of this parameter.

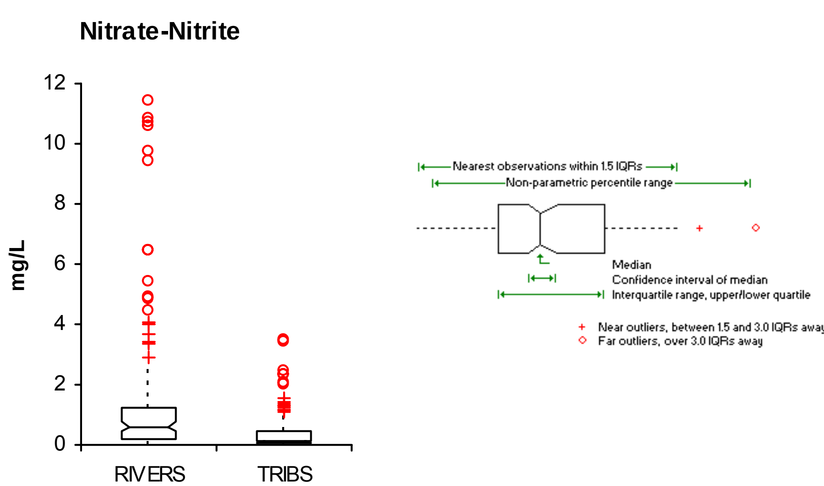


Figure 15. Box and Whisker Plot of Nitrate-Nitrite for River and Tributary Sites

Total Kjeldahl Nitrogen (TKN)

TKN ranged from a minimum of 0.438 mg/L (T42-Peg Munky Run) to a maximum of 10.946 mg/L (T40-Hidewood Creek) for the tributary sites (Figure 16). The lowest median of 0.703 mg/L was at Site T42 and the highest median of 1.949 mg/L was at Site T37.

TKN ranged from a minimum of 0.539 mg/L (R15-BSR at Broadway) to a maximum 4.108 mg/L (R18-BSR near Castlewood) for the river sites (Figure 16). The lowest median of 1.107 mg/L was at Site R15 and the highest median of 1.691 mg/L was at Site R19.

There is no standard or assigned beneficial use for this parameter.

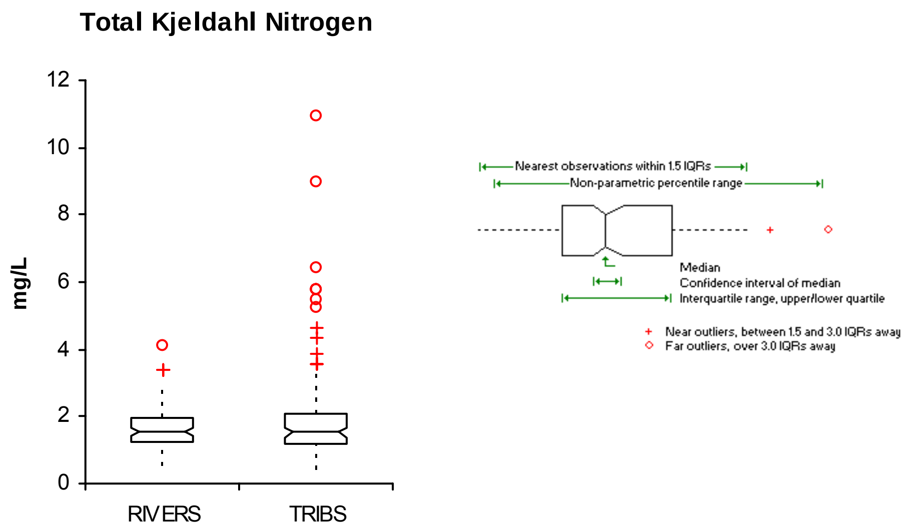


Figure 16. Box and Whisker Plot of Total Kjeldahl Nitrogen for River and Tributary Sites

Organic Nitrogen

Organic nitrogen ranged from a minimum of 0.404 mg/L (T42-Peg Munky Run) to a maximum of 7.037 mg/L (T47-Unnamed Creek near Volga) for the tributary sites (Figure 17). The lowest median of 0.662 mg/L was at Site T42 and the highest median of 1.714 mg/L was at Site T37.

Organic nitrogen ranged from a minimum of 0.447 mg/L (R14-BSR at Broadway) to a maximum 3.352 mg/L (R19-BSR near Estelline) for the river sites (Figure 17). The lowest median of 0.957 mg/L was at Site R15 and the highest median of 1.606 mg/L was at Site R19.

There is no standard or assigned beneficial use for this parameter.

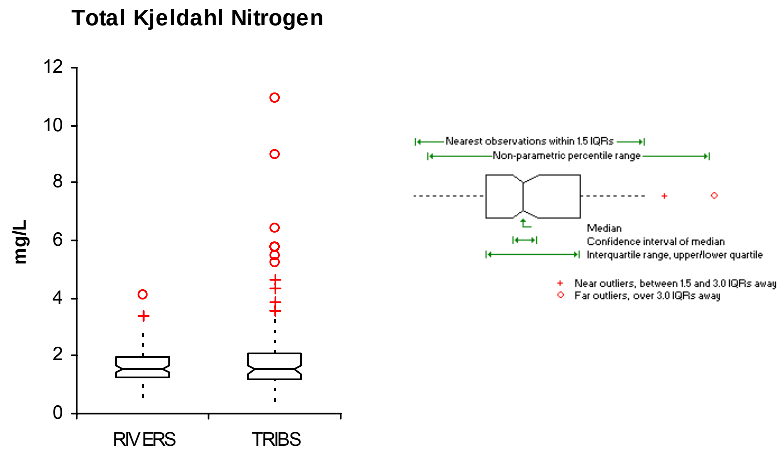


Figure 17. Box and Whisker Plot of Organic Nitrogen for River and Tributary Sites

Total Phosphorus

Total phosphorus ranged from a minimum of 0.038 mg/L (T34-Lake Pelican Weir) to a maximum of 2.016 mg/L (T47-Unnamed Creek near Volga) for the tributary sites (Figure 18). The lowest median of 0.093 mg/L was at Site T41 and the highest median of 0.618 mg/L was at Site T47.

Total phosphorus ranged from a minimum of 0.047 mg/L (R14-BSR at Watertown) to a maximum 2.956 mg/L (R16-BSR at 20th Ave) for the river sites (Figure 18). The lowest median of 0.181 mg/L was at Site R15 and the highest median of 0.608 mg/L was at Site R16.

There is no standard or assigned beneficial use for this parameter. However, phosphorous is an essential nutrient for the production of crops and comes from commercial fertilizers and livestock waste. It is also the primary nutrient for algae growth in lakes and streams. Since a standard for total phosphorous has not been established, data was compared to the ecoregion mean for phosphorus in Minnesota (Fandrei et al. 1988). In this report, according to Table 3, Northern Glaciated Plains, the summer reference mean for total phosphorus is 0.25 mg/L.

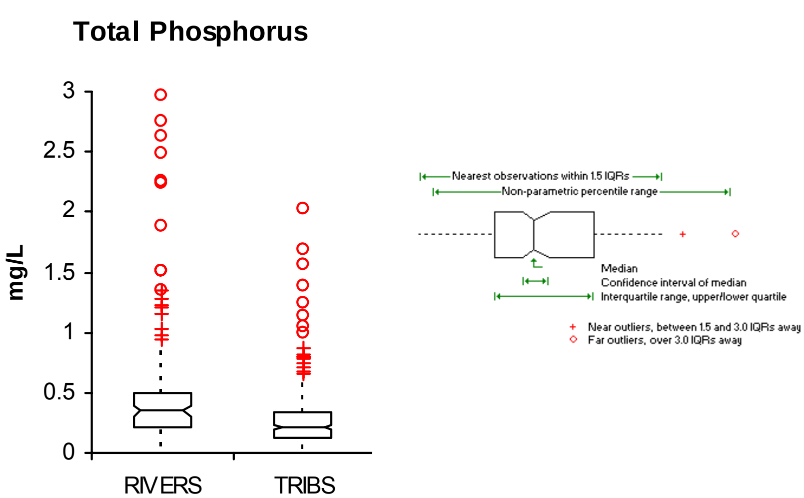


Figure 18. Box and Whisker Plot of Total Phosphorus for River and Tributary Sites

Total Dissolved Phosphorus

Total dissolved phosphorus ranged from a minimum of 0.009 mg/L (T41-Hidewood Creek) to a maximum of 1.493 mg/L (T47-Unnamed Creek near Volga) for the tributary sites (Figure 19). The lowest median of 0.036 mg/L was at Site T34 and the highest median of 0.591 mg/L was at Site T47.

Total dissolved phosphorus ranged from a minimum of 0.012 mg/L (R20-BSR near Bruce) to a maximum 2.797 mg/L (R16-BSR at 20th Ave) for the river sites (Figure 19). The lowest median of 0.080 mg/L was at Site R14 and the highest median of 0.517 mg/L was at Site R16.

There is no standard or assigned beneficial use for this parameter.

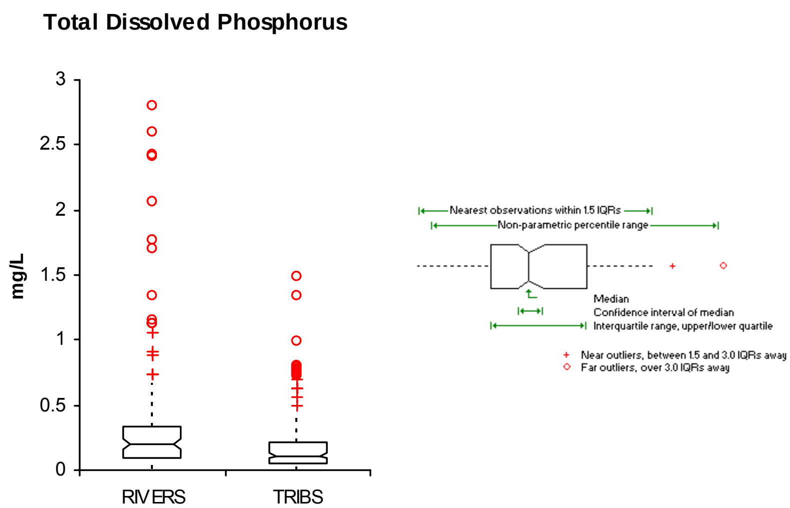


Figure 19. Box and Whisker Plot of Total Dissolved Phosphorus for River and Tributary Sites

Field Parameters

Table 27 shows a summary of the minimum and maximum results from the field parameter sampling of the tributaries and the rivers. More specific details of the sampling follow after the table.

Table 27. Summary of Field Parameters Sampled in the Tributaries and River

		Tributaries		River	
Parameter	**Unit**	**min**	**max**	**min**	**max**
DO	mg/L	1.4	20.0	1.4	20.0
pH	units	7.4	8.7	7.3	9
Atemp	°C	2.0	36.5	-0.5	32.3
Wtemp	°C	1.1	27.3	2.2	26.4
Cond	µmhos/cm	118	2132	89	1136
SpeCond	µmhos/cm	234	3068	159	1175
Sal	ppt	0.1	0.3	0.1	0.6
Turbidity	NTU	0.0	5.0	1.8	340.0

Dissolved Oxygen

Dissolved oxygen ranged from a minimum of 1.4 mg/L (T40-Hidewood Creek and T47 Unnamed Creek near Volga) to a maximum of 20.0 mg/L (T47-Unnamed Creek near Volga) for the tributary sites (Figure 20). The lowest median of 7.4 mg/L at T40, and the highest median of 14.2 mg/L were at Site T41.

Dissolved oxygen ranged from a minimum of 1.4 mg/L (R19-BSR near Estelline and R20-BSR near Bruce) to a maximum of 20 mg/L (R18-BSR near Castelwood) for the river sites (Figure 20). The lowest median of 7.6 mg/L was at Site R15 and the highest median of 10.2 mg/L was at Site R18.

A single grab sample daily maximum of ≥ 5 mg/L (most stringent) was used to determine the percent violations and assess for the beneficial use support of (5), (6), (7) and (8) for all river sites and tributary Sites T35, T36, T37, T40, T41, and T42.

Tributary sites assigned this criteria that are fully supporting of this parameter include T36, T37, T41, and T42. Tributary sites that are not supporting include T35, and T40. All river sites are fully supporting of this parameter. Based on the existing standard for dissolved oxygen, tributary Sites T34, T39, T46, and T47 are not assigned a beneficial use.

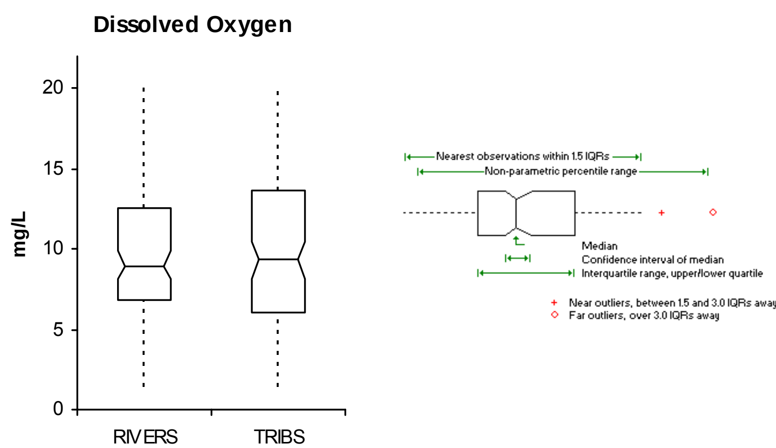


Figure 20. Box and Whisker Plot of Dissolved Oxygen for River and Tributary Sites

pH

pH ranged from a minimum of 7.4 at several sites, to a maximum of 8.7 at several tributary sites (Figure 21). The lowest median of 7.9 was at several sites, and the highest median of 8.4 was at Site T39.

pH ranged from a minimum of 7.3 (R18-BSR near Castlewood) to a maximum of 9.0 (R01-BSR near Brookings) for the river sites (Figure 21). The lowest median of 8.0 was at Sites R15 and R16, and the highest median of 8.4 was at Sites R01 and R20.

A single grab sample daily maximum of the most restrictive standard of ≥ 6.0 to ≤ 9.0 was used to determine the percent violations at and assess for the beneficial use support of (6) and (9) for tributary Sites T35, T36, T37, T40, T41, and T42. Tributary sites assigned beneficial use (9) used the criteria of 6.0 to 9.5 include T34, T39, T46, and T47. A single grab sample daily maximum of the most restrictive standard of ≥ 6.5 to ≤ 9.0 was used to determine the percent violations at and assess for the beneficial use support of (1), (5), and (9) for all the river Sites R01, R14-R20. Using this criterion, all tributary sites and all river sites are fully supporting of this parameter. Based on the existing standard for pH, tributary Sites T34 and T39 are not assigned a beneficial use.

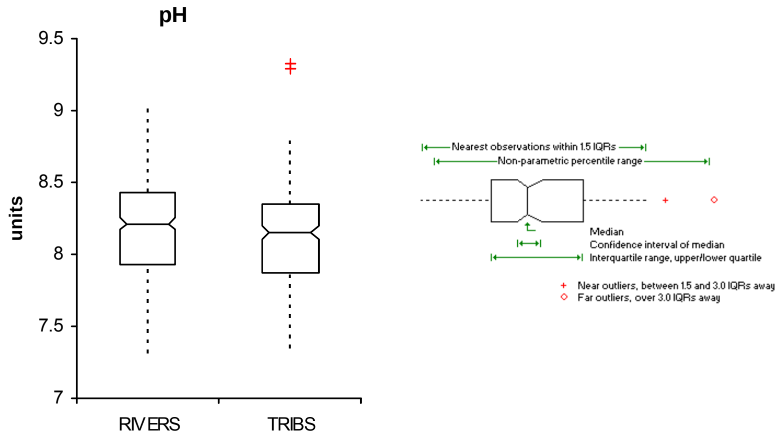


Figure 21. Box and Whisker Plot of pH for River and Tributary Sites

Air Temperature

Air temperature ranged from a minimum of 2.0^{o} C (T39-Lake Poinsett Outlet) to a maximum of 36.5^{o} C (T46-East Oakwood Lake Outlet) for the tributary sites (Figure 22). The lowest median temperature of 16.0^{o} C was at Site T36 and T41, and the highest median temperature of 21.1^{o} C was at Site T46.

Air temperature ranged from a minimum of -0.5^{o} C (R17-BSR below Watertown) to a maximum 32.3^{o} C (R20-BSR near Bruce) for the river sites (Figure 22). The lowest median temperature of 14.0^{o} C was at Sites R14 and R15, and the highest median temperature of 17.0^{o} C was at Sites R01 and R20. There is no standard or assigned beneficial use for this parameter.

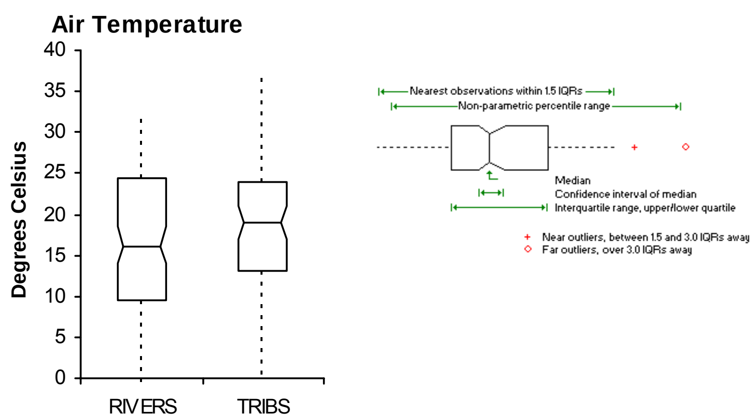


Figure 22. Box and Whisker Plot for Air Temperature for River and Tributary Sites

Water Temperature

Water temperature ranged from a minimum of 1.1^{o} C (T36-Willow Creek) to a maximum of 27.3^{o} C (T34-Lake Pelican Weir) for the tributary sites (Figure 23). The lowest median temperature of 12.4^{o} C was at Sites T36 and T42, and the highest median temperature of 20.4^{o} C was at T46.

Water temperature ranged from a minimum of 2.2° C (R15-BSR at Broadway) to a maximum of 26.4° C (R17-BSR below Watertown) for the river sites (Figure 23). The lowest median temperature of 11.5° C at R14 and the highest median temperature of 15.8° C were at Site R01.

A single grab sample daily maximum temperature of ≤ 32.2° C was used to determine the percent violations and assess for the beneficial use support of (5) for all of the river sites. A single grab sample daily maximum of ≤ 32.2° C was used to determine the percent violations and assess for the beneficial use support of (6) for tributary Sites T35, T36, T37, T40, T41, and T42. All tributary sites and all river sites using this criterion are fully supporting of this parameter. Based on the existing standard for water temperature, tributary Sites T34, T39, T46, and T47 are not assigned a beneficial use or standard.

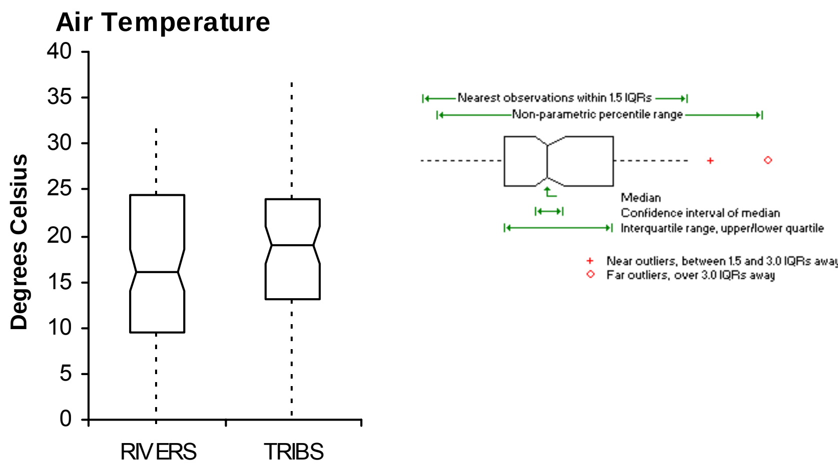


Figure 23. Box and Whisker Plot of Water Temperature for River and Tributary Sites

Conductivity

Conductivity ranged from a minimum of 118 µmhos/cm (T36-Willow Creek) to a maximum of 2,132 µmhos/cm (T40-Hidewood Creek) for the tributary sites (Figure 24). The lowest median of 464 µmhos/cm was at Site T35 and the highest median of 1,169 µmhos/cm was at Site T40.

Conductivity ranged from a minimum of 89 µmhos/cm (R15-BSR at Broadway) to a maximum 1,136 µmhos/cm (R01-BSR near Brookings) for the river sites (Figure 24). The lowest median of 511 µmhos/cm was at Site R14 and the highest median of 708 µmhos/cm was at Site R01. There is no standard or assigned beneficial use for this parameter.

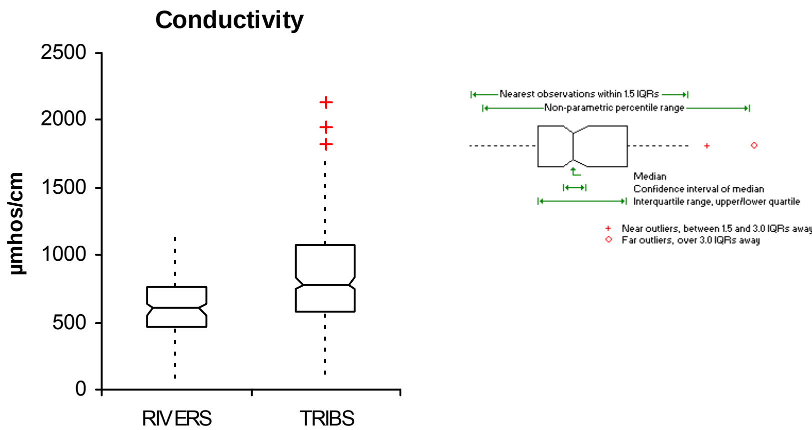


Figure 24. Box and Whisker Plot of Conductivity for Rivers and Tributary Sites

Specific Conductivity

Specific conductivity ranged from a minimum of 234 µmhos/cm (T37-Stray Horse Creek) to a maximum of 3,068 µmhos/cm (T40-Hidewood Creek) for the tributary sites (Figure 25). The lowest median of 545 µmhos/cm was at Site T35, and the highest median of 1,281 µmhos/cm was at T46.

Specific conductivity ranged from a minimum of 159 µmhos/cm (R15-BSR at Broadway) to a maximum of 1,175 µmhos/cm (R01-BSR near Brookings) for the river sites (Figure 25). The lowest median of 664 µmhos/cm at R14 and the highest median of 869 µmhos/cm were at Site R19.

A single grab sample daily maximum of the most restrictive standard of ≤ 4,375 µmhos/cm was used to determine the percent violations and assess for the beneficial use support of (9) Fish and Wildlife Propagation, Recreation, and Stock Watering and (10) Irrigation for the tributary and river sites. Using this criterion, all tributary sites and all river sites are fully supporting of this parameter.

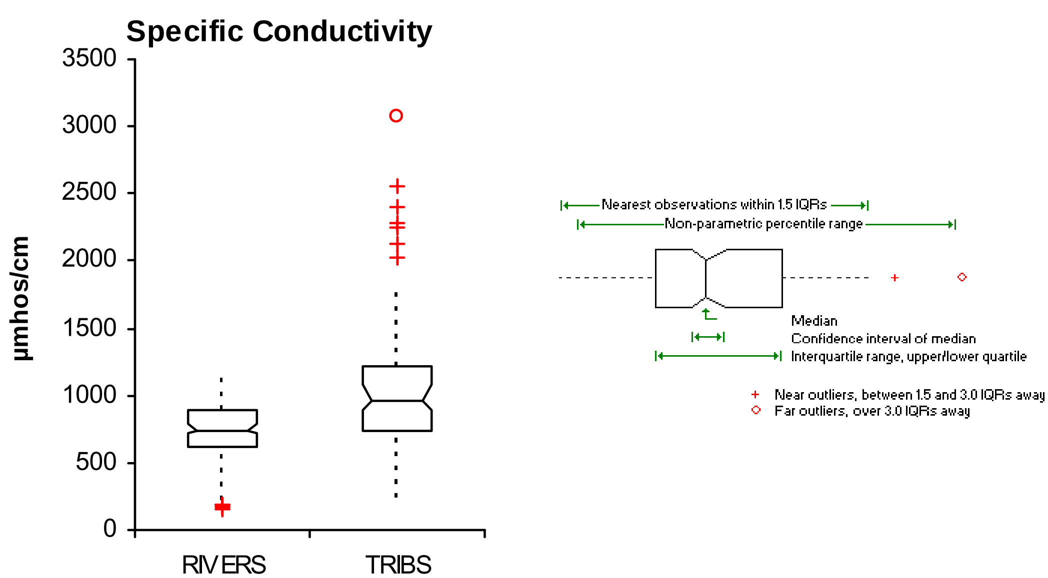


Figure 25. Box and Whisker Plot of Specific Conductivity for Rivers and Tributary Sites

Salinity

Salinity ranged from a minimum of 0.1 ppt at several sites, to a maximum of 0.3 ppt (T46-East Oakwood Lake Outlet and T47-Unnamed Creek near Volga) for the tributary sites (Figure 26). The lowest median of 0.3 ppt was at Sites T34 and T35, and the highest median of 0.7 ppt was at Site T46.

Salinity ranged from a minimum of 0.1 ppt (several sites), to a maximum 0.6 ppt (several sites) for the river sites (Figure 26). The lowest median was 0.3 ppt (several sites) and the highest median was 0.4 ppt (several sites). There is no standard or assigned beneficial use for this parameter.

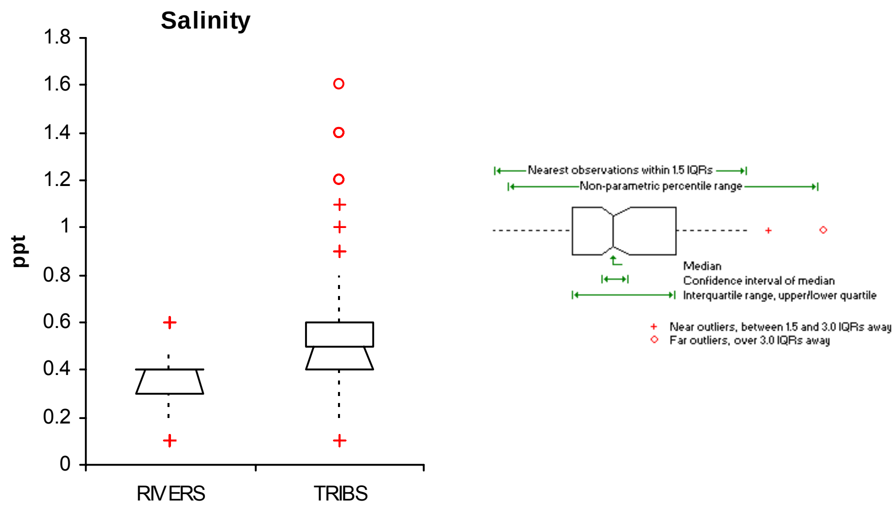


Figure 26. Box and Whisker Plot of Salinity for River and Tributary Sites

Turbidity – NTU

Turbidity ranged from a minimum of 0.0 NTU (T47-Unnamed Creek near Volga) to a maximum of 5.0 NTU (T41-Hidewood Creek) for the tributary sites (Figure 27). The lowest median of 6.5 NTU was at Site T42 and the highest median of 24.7 NTU was at Site T46.

Turbidity ranged from a minimum of 1.8 NTU (R15-BSR at Broadway) to a maximum 340 NTU (R18-BSR near Castlewood) for the river sites (Figure 27). The lowest median of 10.0 NTU was at Site R16 and the highest median of 37.0 NTU at Site R01. There is no standard or assigned beneficial use for this parameter.

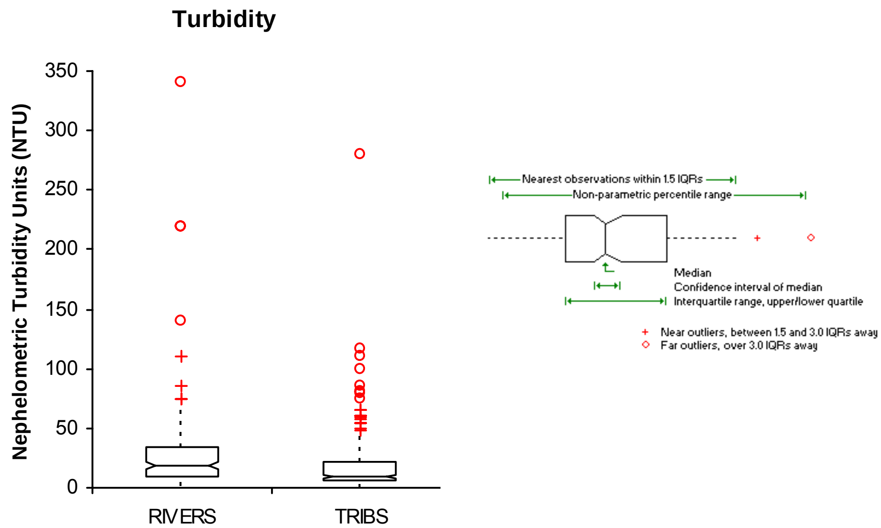


Figure 27. Box and Whisker Plot of Turbidity (NTU) for River and Tributary Sites

Flow Duration Intervals

Flow duration intervals divided into hydrologic zones and plotted with seasonal fecal coliform bacteria grab samples were used to find the seasonal loadings and reductions of fecal coliform bacteria at each monitoring site. Target loadings based on the water quality standards and the current load for each monitoring site is shown for each hydrologic zone along with reductions, including a 10 percent margin of safety (MOS) applied. These loads and percent reductions are presented in Appendix V. Sample data collected during this project, as well as by the DENR were utilized in the calculation of the fecal coliform bacteria.

Each graph corresponds to the fecal exceedence tables located in Appendix W, and serves as a visual aid in determining if there are non-point source, point source, and/or unmanageable problems. The line on the graphs represents the ≤ 2000 cfu/100mL water quality standard for beneficial use (8) Limited Contact Recreation. The ≤ 2000 cfu/100mL standard was applied to all river sites and applicable tributary sites.

BIOLOGICAL MONITORING

Fish Sampling

Data from the fish surveys at each site were compiled into a fisheries collection report, which was submitted to the SD GFP for each year of sampling (Appendix X). Also, the life history designation for fish found during the NCBSRWAP is located in Appendix Y. Fish were surveyed at tributary sites T36 (Willow Creek), T37 (Stray Horse Creek), T41 (Hidewood Creek), and T42 (Peg Munky Run). The other tributaries in the study area were very intermittent and became dry before sampling could be completed. The Big Sioux River sites were not surveyed for fish. Results of the candidate fish metrics can be found in Appendix Z.

Fish index scores from each monitoring site were compiled (Table 28, 29, 30, and 31). Because only four sites were sampled, categories were based on those used in the CBSRWAP. These categories were derived by first ordering the final index scores for each monitoring site, from highest to lowest and calculating the percent rank. The three categories designated for fish during the Central Big Sioux River watershed assessment were 24-51 (poor), 52-72 (fair), and 73-90 (good). These same categories were applied to this project. Although Site T37 scored a 92 (outside the good category) it was included in the good category for this assessment. Any site scoring above 94 would have been classified as least-impaired. Two of the sites (T36 and T41) fell into the fair category, and two sites (T37 and T42) fell into the good category. In comparison with the three other sites, T36 scored very poorly.

It should be noted that reference sites concerning fish have not been designated nor sampled. The classification of sites into one of the three impairment categories is based solely on the fisheries data collected during the Central and North Central Watershed Assessment Projects. The sites were compared to themselves and not to a known biological benchmark.

Table 28. Fish Score for Site T36

Site T36 - Willow Creek (near Watertown)

Metric	Response to Impairment	Percentile for "best" value	Standard (best value)	Measured metric value	Standardized Metric score
Species Richness	Decrease	95th	21	11.0	52
Water Column Species Richness	Decrease	95th	8	4.0	50
Benthic Species Richness	Decrease	95th	10	5.0	50
% Headwater Species	Decrease	95th	31.7	9.0	28
% Pioneer Species Biomass	Increase	5th	28.5	41.0	83
% Intolerant Species	Decrease	95th	13.6	0.0	0
% Sensitive Species	Decrease	95th	27.2	9.0	33
% Tolerant Species Biomass	Increase	5th	31.3	72.5	40
% Insectivorous Minnows	Decrease	95th	94.2	68.5	73
% Insectivorous Biomass	Decrease	95th	77.1	55.0	71
% Omnivore	Increase	5th	12.7	42.1	66
% Simple Lithophil Biomass	Decrease	95th	59.6	49.5	83
				Final index value for this site:	**52**

Table 29. Fish Score for Site T37

Site T37 - Stray Horse Creek

Metric	Response to Impairment	Percentile for "best" value	Standard (best value)	Measured metric value	Standardized Metric score
Species Richness	Decrease	95th	21	22.0	100
Water Column Species Richness	Decrease	95th	8	9.0	100
Benthic Species Richness	Decrease	95th	10	10.0	100
% Headwater Species	Decrease	95th	31.7	22.7	72
% Pioneer Species Biomass	Increase	5th	28.5	26.8	100
% Intolerant Species	Decrease	95th	13.6	13.6	100
% Sensitive Species	Decrease	95th	27.2	27.3	100
% Tolerant Species Biomass	Increase	5th	31.3	31.3	100
% Insectivorous Minnows	Decrease	95th	94.2	95.3	100
% Insectivorous Biomass	Decrease	95th	77.1	64.3	83
% Omnivore	Increase	5th	12.7	58.7	47
% Simple Lithophil Biomass	Decrease	95th	59.6	60.4	100
				Final index value for this site:	**92**

Table 30. Fish Score for Site T41

Metric	Response to Impairment	Percentile for "best" value	Standard (best value)	Measured metric value	Standardized Metric score
Site T41 - Hidewood Creek (near Estelline)					
Species Richness	Decrease	95th	21	15.0	71
Water Column Species Richness	Decrease	95th	8	5.0	63
Benthic Species Richness	Decrease	95th	10	8.0	80
% Headwater Species	Decrease	95th	31.7	20.0	63
% Pioneer Species Biomass	Increase	5th	28.5	37.9	87
% Intolerant Species	Decrease	95th	13.6	0.0	0
% Sensitive Species	Decrease	95th	27.2	6.7	25
% Tolerant Species Biomass	Increase	5th	31.3	31.5	100
% Insectivorous Minnows	Decrease	95th	94.2	87.6	93
% Insectivorous Biomass	Decrease	95th	77.1	73.9	96
% Omnivore	Increase	5th	12.7	12.7	100
% Simple Lithophil Biomass	Decrease	95th	59.6	55.1	92
			Final index value for this site:		**72**

Table 31. Fish Score for Site T42

Metric	Response to Impairment	Percentile for "best" value	Standard (best value)	Measured metric value	Standardized Metric score
Site T42 - Peg Munky Run					
Species Richness	Decrease	95th	21	15.0	71
Water Column Species Richness	Decrease	95th	8	5.0	63
Benthic Species Richness	Decrease	95th	10	8.0	80
% Headwater Species	Decrease	95th	31.7	33.3	105
% Pioneer Species Biomass	Increase	5th	28.5	60.3	56
% Intolerant Species	Decrease	95th	13.6	13.3	98
% Sensitive Species	Decrease	95th	27.2	26.7	98
% Tolerant Species Biomass	Increase	5th	31.3	54.4	66
% Insectivorous Minnows	Decrease	95th	94.2	80.0	85
% Insectivorous Biomass	Decrease	95th	77.1	77.7	100
% Omnivore	Increase	5th	12.7	12.7	100
% Simple Lithophil Biomass	Decrease	95th	59.6	33.0	55
			Final index value for this site:		**81**

Rare, Threatened, and Endangered Species

Rare, threatened and endangered fish species were documented during the assessment of the North-Central BSR watershed. The Topeka shiner (*Notropis Topeka*), which is listed as federally endangered by the US Fish and Wildlife service, was found in Peg Munky Run and Stray Horse Creek (Table 32).

Table 32. Numbers and Locations of Topeka Shiners

Stream	Date	Legal Description	Numbers	Comments
Stray Horse Creek (near Castlewood)	6/25/02	T115N, R51W, SE ¼ of Sec 28	311	3 ½ miles east of Castlewood on north side of hwy 22
Peg Munky Run	7/18/01	T113N, R50W, SE1/4 of NW1/4 of Sec 23	29	5 miles west and ½ mile north of Estelline, upstream from road

Macroinvertebrate Sampling

Macroinvertebrate sampling occurred within all the tributary and river sites, with the exception of T41 and T42. These three sites are intermittent streams and became dry before macroinvertebrates were collected. Laboratory work and compilation of the results for each metric were outsourced to the researchers at Natural Resource Solutions. These results can be found in Appendix AA.

Macroinvertebrate index scores from each monitoring site, n=16, were compiled and graphed. Figure 28 visually shows the category in which each site fell. The categories are 25-51 (poor), 52-63 (fair), 65-71 (good). The majority of the sites fell within the fair and good categories. Sites T35, T36, T39, and T40 fell into the poor category; all of these are lake outlets except T36. Although, T36 is close to being in the fair category, the poor macroinvertebrate score should be of concern.

It should be noted that reference sites concerning macroinvertebrates have not been designated nor sampled. The classification of sites into one of the three impairment categories is based solely on the biological data collected during the Central and North Central Watershed Assessment Projects. The sites were compared to themselves and not to a known biological benchmark.

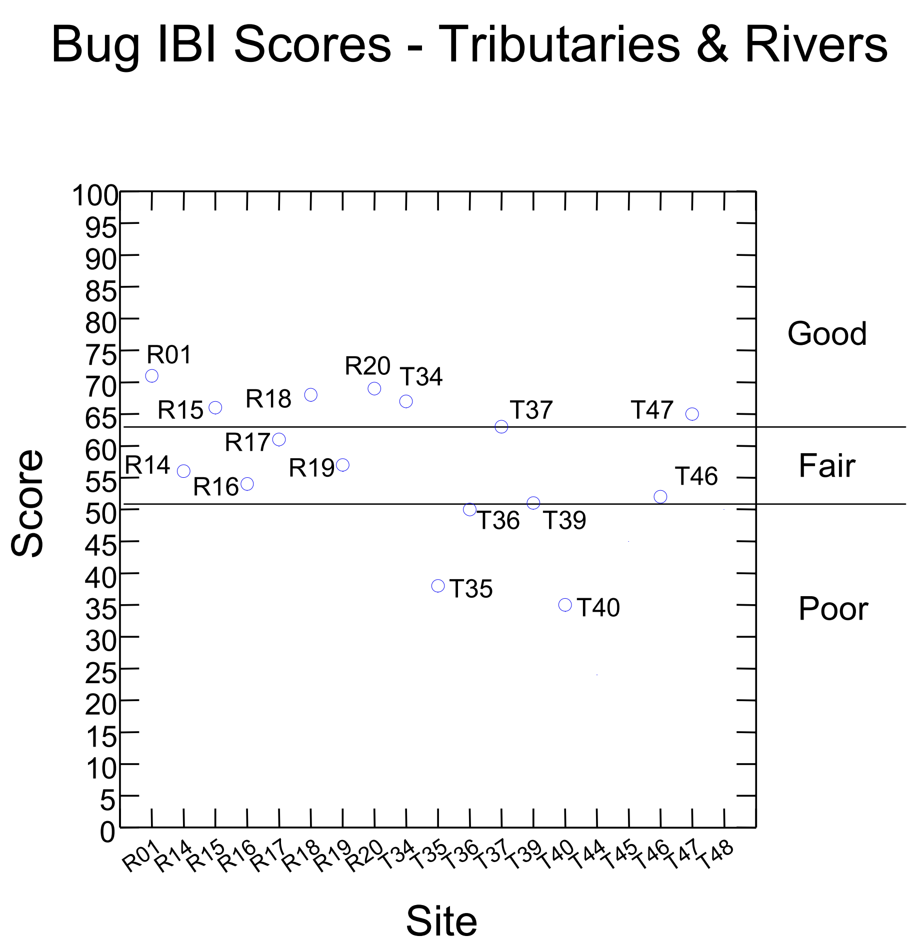


Figure 28. Scatterplot of Macroinvertbrate IBI Scores

PHYSICAL HABITAT MONITORING

Habitat Assessment

Physical habitat sampling occurred within the tributary sites where fish were collected. These sites included T36, T37, T41, and T42. The Big Sioux River sites were not surveyed for fish or physical habitat. Physical habitat scores from each monitoring site were compiled (Tables 33, 34, 35, and 36). Because only four sites were sampled, categories were based on the CBSRWAP. These categories were derived by first ordering the final index scores for each monitoring site, from highest to lowest and calculating the percent rank. The three categories designated for physical habitat during the central Big Sioux River watershed assessment were 31-46 (poor), 50-64 (fair), and 65-80 (good). These same categories were applied to this project. Although Site T37 scored a 94 (outside the good category) it was included in the good category for this assessment. All sites fell into the good category.

It should be noted that reference sites regarding physical habitat have not been designated nor sampled. The classification of sites into one of the three impairment categories is based solely on the biological data collected during the Central and North Central Watershed Assessment Projects. The sites were compared to themselves and not to a known biological benchmark.

Table 33. Physical Habitat Score for Site T36

Site T36 - Willow Creek near Watertown				
Metric	**Percentile for "best" value**	**Standard (best value)**	**Measured metric value**	**Standardized Metric score**
Channel Flow Status	95th	10	10	100
Physical Complexity	95th	10	2.5	25
CV of Velocity	95th	10	10	100
Bed Composition	95th	19	8	42
Measure of Incision	95th	10	7.5	75
Bank Stability	95th	19	20	100
Overhanging Vegetation	95th	2.5	2.5	100
Animal Vegetation Use	95th	10	0	0
		Final index value for this site:		**68**

Table34. Physical Habitat Score for Site T37

Site T37 - Stray Horse Creek				
Metric	**Percentile for "best" value**	**Standard (best value)**	**Measured metric value**	**Standardized Metric score**
Channel Flow Status	95th	10	10	100
Physical Complexity	95th	10	10	100
CV of Velocity	95th	10	10	100
Bed Composition	95th	19	20	100
Measure of Incision	95th	10	10	100
Bank Stability	95th	19	10	53
Overhanging Vegetation	95th	2.5	2.5	100
Animal Vegetation Use	95th	10	10	100
		Final index value for this site:		**94**

Table 35. Physical Habitat Score for Site T41

Site T41 - Hidewood Creek near Estelline				
Metric	**Percentile for "best" value**	**Standard (best value)**	**Measured metric value**	**Standardized Metric score**
Channel Flow Status	95th	10	10	100
Physical Complexity	95th	10	2.5	25
CV of Velocity	95th	10	7.5	75
Bed Composition	95th	19	8	42
Measure of Incision	95th	10	5	50
Bank Stability	95th	19	10	53
Overhanging Vegetation	95th	2.5	2.5	100
Animal Vegetation Use	95th	10	10	100
		Final index value for this site:		**68**

Table 36. Physical Habitat Score for Site T42

Site T42 - Peg Munky Run				
Metric	**Percentile for "best" value**	**Standard (best value)**	**Measured metric value**	**Standardized Metric score**
Channel Flow Status	95th	10	10	100
Physical Complexity	95th	10	7.5	75
CV of Velocity	95th	10	7.5	75
Bed Composition	95th	19	16	84
Measure of Incision	95th	10	2.5	25
Bank Stability	95th	19	15	79
Overhanging Vegetation	95th	2.5	2.5	100
Animal Vegetation Use	95th	10	5	50
		Final index value for this site:		**74**

ASSESSMENT OF SOURCES

Point Sources

Wastewater Treatment Facilities (NPDES)

Table 37 represents the percent contribution of TSS from each wastewater treatment facility in the study area. The ‘Ave L/day’ column is calculated by the following:

(average millions of gallons a day) × (conversion from millions gallons a day to cubic feet per second) × (seconds in a day) × (conversion from cubic feet to liters)

The ‘Total mg’ column is calculated multiplying the following columns:

(Ave L/day) × (Ave mg/L) × (Days Discharge)

The ‘% of Total’ column is calculated by the following columns:

(Total kg ÷ Total TSS (kg) from FLUX) ×100

Table 38 represents the percent contribution of fecal coliform bacteria from each wastewater treatment facility in the study area. The ‘Ave ft^3/day’ column is calculated by the following:

> (average millions of gallons a day) × (conversion from millions of gallons a day to cubic feet per second) × (seconds in a day)

The ‘CFU’s’ column is calculated by multiplying the following columns:

(Ave ft^3/day) × (Ave Conc) × (Days Discharge)

The ‘% of Total’ column is calculated by the following columns:

(CFUs ÷ Total CFU from FLUX) ×100

Urban Stormwater Runoff

Based on the method described in the methods section, under Urban Stormwater Runoff, calculations resulted in a 37 percent relative contribution of TSS for the City of Watertown. This percentage represents the well-developed residential, commercial, and industrial areas; however, this percentage could increase with increased construction erosion activities if proper stormwater management is not implemented. For the purpose of this study, the City of Watertown is considered background contribution since no violations of TSS standards were found.

Table 37. NPDES Percent Contributions of TSS

Drains to	Name	NPID	Total Retention	Ave MGD	Ave ft3/day	Ave Conc	Days Discharge	Total mg	Total kg	Total TSS (kg) from	% of Total	Remarks
R17	Benchmark Foam Inc.	SD0025895	*	NA	--------	NA	--------	--------	--------	--------	--------	
R01	Bruce, City	SD0025224	***	NA	--------	NA	--------	--------	--------	--------	--------	
R19	Castlewood, City	SD0021580	***	NA	--------	NA	--------	--------	--------	--------	--------	
T40	Clear Lake, City (001A)	SD0020699	No	0.342857	45833.37	14.48571	90	5.98E+07	5.98E+01	9.26E+04	0.064503	discharge varies from 1 to 3 months a yr TSS 30 Day avg Limit 30
R14	Dakota Sioux Casino	SD0026921	***	NA	--------	NA	--------	--------	--------	--------	--------	
R20	Estelline, City	SD0022144	*	NA	--------	NA	--------	--------	--------	--------	--------	
T37	Goodwin, City	SD0024716	***	NA	--------	NA	--------	--------	--------	--------	--------	
T37	Kranzburg, Town	SD0024724	**	NA	--------	NA	--------	--------	--------	--------	--------	
T39	Lake Poinsett Sanitary District	SD0026450	***	NA	--------	NA	--------	--------	--------	--------	--------	
T47	Land O'Lakes	SD0025836	***	NA	--------	NA	--------	--------	--------	--------	--------	
R14	Northern Con-Agg, Inc.	SD0026182	***	NA	--------	NA	--------	--------	--------	--------	--------	
R16	Oak Valley Farms (001A)	SD0027324	No	0.1936	25880.58	5.169091	365	4.88E+07	4.88E+01	4.32E+06	0.001131	TSS 30 Day avg, Limit 30
R16	Oak Valley Farms (002A)	SD0027324	No	0.020857	2788.197	none	--------	--------	--------	--------	--------	no TSS data
T34	Technical Ordinance, Inc.	SD0026301	***	NA	--------	NA	--------	--------	--------	--------	--------	
R01	Volga, City (001A)	SD0021920	No	0.391831	52380.2	17.44615	90	8.22E+07	8.22E+01	4.74E+07	0.000173	discharge varies from 2 to 4 months a yr TSS 30 Day avg Limit 90
R16	Watertown, City (002A)	SD0023370	No	2.886923	385925.8	6.410714	365	9.03E+08	9.03E+02	4.32E+06	0.020911	TSS 30 Day avg, Limit 30

* Reported no discharge from 2001 to Present
** Reported no discharge for the life of the facility
*** Reported either total retention or no discharge

Daily loadings for each NPDES permit holder can be found in each TMDL watershed where the facility is located (Appendix DD-JJ).

Table 38. NPDES Percent Contributions of Fecal Coliform Bacteria

Drains to	Name	NPID	Total Retention	Ave MGD 30 day avg	Ave ft3/day	Ave Conc	Days Discharge (with fecal) per year	CFU's	Total CFU from flux	% of Total	Remarks
R17	Benchmark Foam Inc.	SD0025895	*	NA	--------	NA	--------	--------	--------	--------	No Discharges
R01	Bruce, City	SD0025224	***	NA	--------	NA	--------	--------	--------	--------	
R19	Castlewood, City	SD0021580	***	NA	--------	NA	--------	--------	--------	--------	
T40	Clear Lake, City (001A)	SD0020699	No	0.3428571	45833.37	none	--------	--------	--------	--------	no fecal data
R14	Dakota Sioux Casino	SD0026921	***	NA	--------	NA	--------	--------	--------	--------	
R20	Estelline, City	SD0022144	*	NA	--------	NA	--------	--------	--------	--------	No Discharges
T37	Goodwin, City	SD0024716	***	NA	--------	NA	--------	--------	--------	--------	
T37	Kranzburg, Town	SD0024724	**	NA	--------	NA	--------	--------	--------	--------	No Discharges
T39	Lake Poinsett Sanitary District	SD0026450	***	NA	--------	NA	--------	--------	--------	--------	
T47	Land O'Lakes	SD0025836	***	NA	--------	NA	--------	--------	--------	--------	
R14	Northern Con-Agg, Inc.	SD0026182	***	NA	--------	NA	--------	--------	--------	--------	
R16	Oak Valley Farms (001A)	SD0027324	No	0.1936	25880.58	1.3478261	150	5.23E+06	3.92E+14	0.000001	Fecal 30 day geo Limit 1000
R16	Oak Valley Farms (002A)	SD0027324	No	0.0208571	2788.197	none	--------	--------	--------	--------	no fecal data
T34	Technical Ordinance, Inc.	SD0026301	***	NA	--------	NA	--------	--------	--------	--------	
R01	Volga, City (001A)	SD0021920	No	0.3918308	52380.2	none	--------	--------	--------	--------	no fecal data
R16	Watertown, City (002A)	SD0023370	No	2.8869231	385925.8	54.913043	150	3.18E+09	3.92E+14	0.000811	Fecal 30 day geo Limit 1000

* Reported no discharge from 2001 to Present
** Reported no discharge for the life of the facility
*** Reported either total retention or no discharge

Daily loadings for each NPDES permit holder can be found in each TMDL watershed where the facility is located (Appendix DD-JJ).

Non-Point Sources

Agricultural Runoff

Sediment and nutrient loadings from agricultural runoff was calculated by the AnnAGNPS model using different land use scenarios. Agricultural runoff was also taken into account when the AGNPS model was used to perform ratings on the feedlots in the study area. This information was then incorporated in the process of prioritizing watershed areas for fecal reduction.

Background Wildlife Contribution

The average contribution from deer is 16.5 percent, watershed wide (Table 39). The 16.5 percent will be used as an average when assessing each monitoring site. This number assumes a 100 percent contribution of fecal coliform bacteria is delivered into the receiving waters. Therefore, due to its unrealistic 100 percent delivery only for deer, it will represent all wildlife contributions in this watershed for this project.

Table 39. Wildlife Contribution of Fecal Coliform Bacteria

Wildlife Background CFU's								
Site	Deer/Sq. Mile	Sq. Miles	Deer	Days	CFU's/deer/day	CFU's	Total CFU's	% deer
T36	4.56	32	146	306	5.00E+08	2.23E+13	3.04E+14	7.3
T37	4.81	35.9	173	269	5.00E+08	2.32E+13	1.28E+15	1.8
T41	4.81	52.9	254	210	5.00E+08	2.67E+13	1.03E+14	25.9
T42	5.06	36	182	194	5.00E+08	1.77E+13	4.19E+13	42.2
T46	3.41	35.1	120	278	5.00E+08	1.66E+13	3.31E+14	5.0
							Average	16.5

Failing Septic Systems Contribution

The calculated contribution from failing septic systems is 25.6 percent, watershed wide (Table 40). The 25.6 percent will be used as an average when assessing each monitoring site. However, this percentage is very high because it assumes that all failing rural septic systems are reaching the receiving waters. The number of onsite septic systems in the study area is unknown. However, according to the US EPA (2002a) failure rates of onsite septic systems range from 10 to 20 percent, with a majority of these failures occurring with systems 30 or more years old. Until there is better factual data on the conditions of the rural septic systems in this study area, the 25.6 percent average was used. Although, assumptions that only a small percentage of this number (25.6 percent) is actual failing septic systems may be warranted in circumstances where livestock situations are clearly the predominant factor in the fecal coliform bacteria loadings.

Table 40. Failing Septic System Contribution of Fecal Coliform Bacteria

Failing Septic Contribution									
Site	**People/household**	**# households**	**20%**	**people**	**Days**	**CFU's/person/day**	**CFU's**	**Total CFU's**	**% people**
T36	2.5	113	22.6	57	306	2.00E+09	3.46E+13	3.04E+14	11.4
T37	2.5	86	17.2	43	269	2.00E+09	2.31E+13	1.28E+15	1.8
T41	2.5	344	68.8	172	210	2.00E+09	7.22E+13	1.03E+14	70.1
T42	2.5	65	13	33	194	2.00E+09	1.26E+13	4.19E+13	30.1
T46	2.5	176	35.2	88	278	2.00E+09	4.89E+13	3.31E+14	14.8
								Average	25.6

Modeling

FLUX Modeling

The FLUX Model (Army Corps of Engineers Loading Model) was used to estimate the nutrient loadings for each site. Annual loads from the project period and their standard errors (CV) are presented in Appendix P. Data collected during this project, an earlier project (CBSRWAP), as well as by the United States Geological Survey (USGS) were utilized in the calculation of the loads and concentrations. Results from the FLUX model were also used to find the percent reduction in TSS for each monitoring location (Appendix BB).

AGNPS Feedlot Model

The Brookings County Conservation District evaluated 371 animal feeding operations within the North-Central BSR watershed. The AGNPS model ranked the feedlots on a scale from 0 to 100 with larger numbers indicating a greater potential to pollute nearby surface waters. Of the feedlots evaluated, the AGNPS model rated 147 of the animal feeding operations ≥ 50. Outputs from the model also include total phosphorus, total nitrogen, and chemical oxygen demand (Appendix CC).

AnnAGNPS Modeling

The AnnAGNPS Model was setup to compare sediment, nitrogen, and phosphorus loadings from the watershed (502,894 acre drainage area) for 1-year, 10-year, and 25-year simulated periods. Several landuse scenarios were modeled which included 1) present condition, 2) changing cropland (corn and soybeans) to grass, 3) removing the feedlots, 4) removing any impoundments, and 5) changing cropping practices to no-tillage. Due to the size of the watershed, the area was delineated into three watersheds, Estelline-South, Castlewood to Estelline, and Castlewood-North. Tables 41, 42, and 43 show the results of these scenarios during 1-year, 10-year, and 25-year simulated periods, respectively. The percent differences and indicators of increasing or decreasing differences are at the bottom of each table using equation ((larger number – smaller number) ÷ larger number) × 100 to find percent difference or (smaller number ÷ larger number) then minus from one and multiply by 100. As indicated by all three tables, feedlots in the watershed are not having as great as an affect on sediment and nutrients as the agricultural practices.

During the 1-year simulated period, removal of all feedlots reduced nutrient loading from 3 to 4 percent in the Castlewood North area and had a negligible affect to the Castlewood to Estelline and the Estelline South areas. Changes in cropping practices to conservative tillage resulted in a 9 percent and 11 percent reduction in nitrogen and phosphorus loading, respectively. No-tillage practices have the greatest affect on attached nitrogen and attached phosphorus reductions (Table 41). A 25 percent reduction in sediment loads were estimated for the Castlewood to Estelline and the Estelline South areas when no-tillage practices were applied. Removing row cropping virtually eliminates any sediment problems; however, this would not be a feasible option.

During the 10-year simulated period (Table 42), feedlot removal exhibited the greatest reduction in nutrients for the Castlewood North area, but in contrast had the least affect on the Estelline South area. No tillage application had the same affect on nutrients throughout the entire North Central Big Sioux River Watershed constituting a 16 percent and 20 percent reduction in nitrogen and phosphorus, respectively.

During the 25-year simulated period (Table 43), reductions in sediment and nutrients were significantly less than what was exhibited during the 10-year period with the removal of feedlots or when no-tillage practices were applied.

Areas of the watershed are more defined in regards to the load reductions of nutrients and sediment in the applicable TMDL reports located in Appendices DD through JJ. It should be noted that the water quality of the North Central Big Sioux River Watershed did not exhibit problems with total suspended solids.

Table 41. AnnAGNPS Output for a 1-Year Simulated Period

Castlewood North Watershed - 1 Year Simulation Period

Scenerio	Sediment Load (tons/acre/year)	Nitrogen Load (unit area) (lbs/acre/yr)	Attached Nitrogen Load (lbs/acre/yr)	Dissolved Nitrogen Load (lbs/acre/yr)	Total Phosphorus Load (unit area) (lbs/acre/yr)	Attached Phosphorus Load (lbs/acre/yr)	Dissolved Phosphorus Load (lbs/acre/yr)
Present Condition	0.0000	0.319	0.157	0.162	0.065	0.022	0.042
All Grass	0.0000	0.210	0.131	0.079	0.030	0.014	0.016
No Feedlots	0.0000	0.308	0.151	0.156	0.063	0.022	0.041
No Impoundments	0.0152	0.587	0.362	0.225	0.092	0.040	0.053
No Tillage	0.0000	0.306	0.106	0.200	0.056	0.014	0.042
	Percent Difference from Present Condition						
All Grass	0	34 ↓	17 ↓	51 ↓	54 ↓	36 ↓	62 ↓
No Feedlots	0	3 ↓	4 ↓	4 ↓	3 ↓	0	2 ↓
No Impoundments	100 ↑	46 ↑	57 ↑	28 ↑	29 ↑	45 ↑	21 ↑
No Tillage	0	9 ↓	42 ↓	9 ↑	11 ↓	47 ↓	0

Castlewood to Estelline Watershed - 1 Year Simulation Period

Scenerio	Sediment Load (tons/acre/year)	Nitrogen Load (unit area) (lbs/acre/yr)	Attached Nitrogen Load (lbs/acre/yr)	Dissolved Nitrogen Load (lbs/acre/yr)	Total Phosphorus Load (unit area) (lbs/acre/yr)	Attached Phosphorus Load (lbs/acre/yr)	Dissolved Phosphorus Load (lbs/acre/yr)
Present Condition	0.0167	0.726	0.394	0.332	0.135	0.053	0.083
All Grass	0.0000	0.085	0.041	0.044	0.016	0.006	0.009
No Feedlots	0.0167	0.723	0.393	0.330	0.135	0.053	0.082
No Impoundments	0.0175	0.743	0.404	0.339	0.143	0.054	0.089
No Tillage	0.0062	0.546	0.174	0.372	0.110	0.022	0.088
	Percent Difference from Present Condition						
All Grass	100 ↓	88 ↓	90 ↓	87 ↓	88 ↓	89 ↓	89 ↓
No Feedlots	0	0 ↓	0 ↓	1 ↓	0	0	1 ↓
No Impoundments	5 ↑	2 ↑	2 ↑	2 ↑	6 ↑	2 ↑	7 ↑
No Tillage	25 ↓	9 ↓	42 ↓	9 ↑	11 ↓	47 ↓	6 ↑

Estelline South Watershed - 1 Year Simulation Period

Scenerio	Sediment Load (tons/acre/year)	Nitrogen Load (unit area) (lbs/acre/yr)	Attached Nitrogen Load (lbs/acre/yr)	Dissolved Nitrogen Load (lbs/acre/yr)	Total Phosphorus Load (unit area) (lbs/acre/yr)	Attached Phosphorus Load (lbs/acre/yr)	Dissolved Phosphorus Load (lbs/acre/yr)
Present Condition	0.0072	0.915	0.452	0.464	0.252	0.056	0.195
All Grass	0.0000	0.205	0.059	0.146	0.059	0.008	0.050
No Feedlots	0.0072	0.912	0.450	0.462	0.251	0.056	0.195
No Impoundments	0.0098	1.032	0.521	0.510	0.331	0.066	0.265
No Tillage	0.0032	0.777	0.230	0.547	0.230	0.026	0.204
	Percent Difference from Present Condition						
All Grass	100 ↓	78 ↓	87 ↓	69 ↓	77 ↓	86 ↓	74 ↓
No Feedlots	0 ↓	0 ↓	0 ↓	0 ↓	0 ↓	0	0
No Impoundments	27 ↑	11 ↑	13 ↑	9 ↑	24 ↑	15 ↑	26 ↑
No Tillage	25 ↓	9 ↓	42 ↓	9 ↑	11 ↓	47 ↓	4 ↑

Table 42. AnnAGNPS Output for a 10-Year Simulated Period

Castlewood North Watershed - 10 Year Simulation Period

Scenerio	Sediment Load (tons/acre/year)	Nitrogen Load (unit area) (lbs/acre/yr)	Attached Nitrogen Load (lbs/acre/yr)	Dissolved Nitrogen Load (lbs/acre/yr)	Total Phosphorus Load (unit area) (lbs/acre/yr)	Attached Phosphorus Load (lbs/acre/yr)	Dissolved Phosphorus Load (lbs/acre/yr)
Present Condition	0.0000	0.346	0.203	0.143	0.163	0.050	0.113
All Grass	0.0000	0.187	0.084	0.103	0.078	0.017	0.061
No Feedlots	0.0000	0.307	0.176	0.131	0.157	0.047	0.110
No Impoundments	0.0192	0.631	0.428	0.203	0.179	0.057	0.122
No Tillage	0.0000	0.295	0.124	0.171	0.122	0.023	0.100
Percent Difference from Present Condition							
All Grass	0	46 ↓	59 ↓	28 ↓	52 ↓	66 ↓	46 ↓
No Feedlots	0	11 ↓	13 ↓	8 ↓	4 ↓	6 ↓	3 ↓
No Impoundments	100 ↑	45 ↑	53 ↑	30 ↑	9 ↑	12 ↑	7 ↑
No Tillage	0	16 ↓	40 ↓	13 ↑	20 ↓	58 ↓	10 ↓

Castlewood to Estelline Watershed - 10 Year Simulation Period

Scenerio	Sediment Load (tons/acre/year)	Nitrogen Load (unit area) (lbs/acre/yr)	Attached Nitrogen Load (lb/acre/yr)	Dissolved Nitrogen Load (lb/acre/yr)	Total Phosphorus Load (unit area) (lb/acre/yr)	Attached Phosphorus Load (lbs/acre/yr)	Dissolved Phosphorus Load (lbs/acre/yr)
Present Condition	0.0000	0.298	0.200	0.097	0.233	0.069	0.165
All Grass	0.0000	0.095	0.040	0.055	0.078	0.010	0.069
No Feedlots	0.0000	0.265	0.175	0.090	0.229	0.066	0.163
No Impoundments	0.0221	0.617	0.474	0.143	0.274	0.085	0.189
No Tillage	0.0000	0.252	0.129	0.123	0.179	0.031	0.148
Percent Difference from Present Condition							
All Grass	0	68 ↓	80 ↓	43 ↓	67 ↓	86 ↓	58 ↓
No Feedlots	0	11 ↓	13 ↓	7 ↓	2 ↓	4 ↓	1 ↓
No Impoundments	100 ↑	52 ↑	58 ↑	32 ↑	15 ↑	19 ↑	13 ↑
No Tillage	0	16 ↓	40 ↓	13 ↑	20 ↓	58 ↓	10 ↓

Estelline South Watershed - 10 Year Simulation Period

Scenerio	Sediment Load (tons/acre/year)	Nitrogen Load (unit area) (lbs/acre/yr)	Attached Nitrogen Load (lbs/acre/yr)	Dissolved Nitrogen Load (lbs/acre/yr)	Total Phosphorus Load (unit area) (lbs/acre/yr)	Attached Phosphorus Load (lbs/acre/yr)	Dissolved Phosphorus Load (lbs/acre/yr)
Present Condition	0.0000	0.638	0.328	0.310	0.405	0.079	0.325
All Grass	0.0000	0.305	0.070	0.235	0.190	0.012	0.178
No Feedlots	0.0000	0.614	0.311	0.303	0.401	0.078	0.323
No Impoundments	0.0147	1.200	0.765	0.435	0.532	0.114	0.418
No Tillage	0.0000	0.577	0.218	0.359	0.340	0.039	0.301
Percent Difference from Present Condition							
All Grass	0	52 ↓	79 ↓	24 ↓	53 ↓	85 ↓	45 ↓
No Feedlots	0	4 ↓	5 ↓	2 ↓	1 ↓	1 ↓	1 ↓
No Impoundments	100 ↑	47 ↑	57 ↑	29 ↑	24 ↑	31 ↑	22 ↑
No Tillage	0	16 ↓	40 ↓	13 ↑	20 ↓	58 ↓	10 ↓

Table 43. AnnAGNPS Output for a 25-Year Simulated Period

Castlewood North Watershed - 25 Year Simulation Period

Scenerio	Sediment Load (tons/acre/year)	Nitrogen Load (unit area) (lbs/acre/yr)	Attached Nitrogen Load (lbs/acre/yr)	Dissolved Nitrogen Load (lbs/acre/yr)	Total Phosphorus Load (unit area) (lbs/acre/yr)	Attached Phosphorus Load (lbs/acre/yr)	Dissolved Phosphorus Load (lbs/acre/yr)
Present Condition	0.0000	0.288	0.161	0.127	0.209	0.045	0.164
All Grass	0.0000	0.147	0.058	0.089	0.103	0.013	0.090
No Feedlots	0.0000	0.256	0.139	0.117	0.205	0.043	0.162
No Impoundments	0.0148	0.511	0.334	0.177	0.223	0.050	0.174
No Tillage	0.0000	0.253	0.101	0.152	0.175	0.021	0.154
Percent Difference from Present Condition							
All Grass	0	49 ↓	64 ↓	30 ↓	51 ↓	71 ↓	45 ↓
No Feedlots	0	11 ↓	14 ↓	8 ↓	2 ↓	4 ↓	1 ↓
No Impoundments	100 ↑	44 ↑	52 ↑	28 ↑	6 ↑	10 ↑	6 ↑
No Tillage	0	13 ↓	40 ↓	17 ↑	12 ↓	58 ↓	5 ↓

Castlewood to Estelline Watershed - 25 Year Simulation Period

Scenerio	Sediment Load (tons/acre/year)	Nitrogen Load (unit area) (lbs/acre/yr)	Attached Nitrogen Load (lbs/acre/yr)	Dissolved Nitrogen Load (lbs/acre/yr)	Total Phosphorus Load (unit area) (lbs/acre/yr)	Attached Phosphorus Load (lbs/acre/yr)	Dissolved Phosphorus Load (lbs/acre/yr)
Present Condition	0.0000	0.236	0.155	0.081	0.291	0.064	0.228
All Grass	0.0000	0.072	0.027	0.044	0.111	0.008	0.103
No Feedlots	0.0000	0.210	0.135	0.075	0.288	0.062	0.226
No Impoundments	0.0170	0.496	0.376	0.120	0.328	0.075	0.253
No Tillage	0.0000	0.210	0.103	0.107	0.250	0.029	0.220
Percent Difference from Present Condition							
All Grass	0	69 ↓	83 ↓	46 ↓	62 ↓	88 ↓	55 ↓
No Feedlots	0	11 ↓	13 ↓	7 ↓	1 ↓	3 ↓	1 ↓
No Impoundments	100 ↑	52 ↑	59 ↑	33 ↑	11 ↑	15 ↑	10 ↑
No Tillage	0	13 ↓	40 ↓	17 ↑	12 ↓	58 ↓	5 ↓

Estelline South Watershed - 25 Year Simulation Period

Scenerio	Sediment Load (tons/acre/year)	Nitrogen Load (unit area) (lbs/acre/yr)	Attached Nitrogen Load (lbs/acre/yr)	Dissolved Nitrogen Load (lbs/acre/yr)	Total Phosphorus Load (unit area) (lbs/acre/yr)	Attached Phosphorus Load (lbs/acre/yr)	Dissolved Phosphorus Load (lbs/acre/yr)
Present Condition	0.0000	0.519	0.256	0.264	0.466	0.069	0.397
All Grass	0.0000	0.243	0.051	0.192	0.242	0.010	0.231
No Feedlots	0.0000	0.500	0.242	0.258	0.464	0.068	0.395
No Impoundments	0.0115	0.963	0.594	0.369	0.592	0.095	0.497
No Tillage	0.0000	0.488	0.173	0.314	0.421	0.035	0.385
Percent Difference from Present Condition							
All Grass	0	53 ↓	80 ↓	27 ↓	48 ↓	86 ↓	42 ↓
No Feedlots	0	4 ↓	5 ↓	2 ↓	0 ↓	1 ↓	1 ↓
No Impoundments	100 ↑	46 ↑	57 ↑	28 ↑	21 ↑	27 ↑	20 ↑
No Tillage	0	13 ↓	40 ↓	17 ↑	12 ↓	58 ↓	5 ↓

Approximately 54,395 acres in the Castlewood North area, 107,756 acres in the Castlewood to Estelline area, and 94,224 acres in the Estelline South area were converted from cropland to grassland to run the 'all grass' scenario. Sediment loading only showed a marked decrease during the 1-year simulation period when cropland was converted to grassland, and no-tillage practices were applied. However, there were decreases in phosphorus loads during all three scenarios (Table 44).

Table 44. Phosphorus Reduction Results After Converting Cropland to Grassland

Phosphorus Results Conversion of Crops to Grassland (lbs/acre/year reductions)			
	1-Year	**10-Year**	**25-Year**
Castlewood North	0.035	0.085	0.106
Castlewood to Estelline	0.119	0.155	0.180
Estelline South	0.193	0.215	0.224

Approximately 2,994 acres of impoundments (10 acres or larger) in the Castlewood North area, 1,885 acres of impoundments (10 acres or larger) in the Castlewood to Estelline area, and 6,318 acres of impoundments (10 acres or larger) in the Estelline South area were removed to run the 'no impoundments' scenario. The removal of the impoundments caused increases in nitrogen and phosphorus loadings in all three scenarios. This demonstrates the importance of impoundments in filtering out nutrients.

Approximately 73 percent of the total watershed area (367,113 acres) is in agricultural cropland. Converting all agricultural cropping practices to no-tillage (no-till planter and no-till drill) achieved sediment reductions during the 1-year simulated period. The 1-year simulated period showed a 25 percent difference in sediment in the Castlewood to Estelline area and the Estelline South area (Table 41). Decreases in nutrients (9-20% load, 40-58% attached, and 4-17% dissolved) could be achieved if more no-tillage practices were implemented in all three watershed areas.

ANALYSIS AND SUMMARY

SUMMARY OF POLLUTANT LOADINGS

The large watershed area involved (approximately 500,000 acres) necessitated the division of the watershed into smaller sub-watersheds for analysis (Figure 29). The sections are (1) "Castlewood North" - the Town of Castlewood to the northern most end of the watershed (126,321 acres), (2) "Castlewood to Estelline" - the City of Castlewood to the Town of Estelline (193,530 acres), and (3) "Estelline South" - the Town of Estelline to the southern most end of the watershed (183,043 acres). Landuse, water quality, biological and physical aspects, and source linkage were compiled and presented in this section for each watershed area. A separate assessment report has been completed for the Oakwood chain of lakes located in the 'Estelline South' watershed area. Additionally, a separate watershed assessment was completed in 2005 for the chain of lakes (Wigdale Lake, School Lake, Bullhead Lake, and Round Lake) in the Castlewood North area in northwest Deuel County.

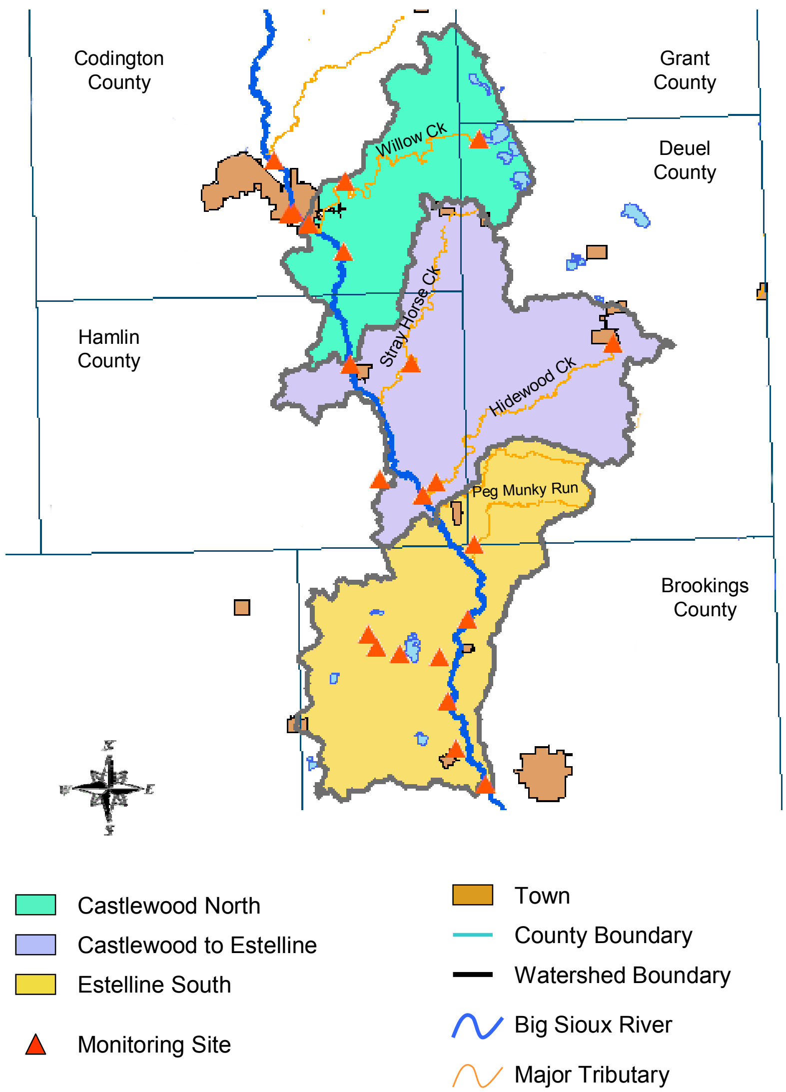


Figure 29. The Three Major Watersheds of the North-Central Study Area

Castlewood North

This map (Figure 30) shows the location of the area designated as the Castlewood North area.

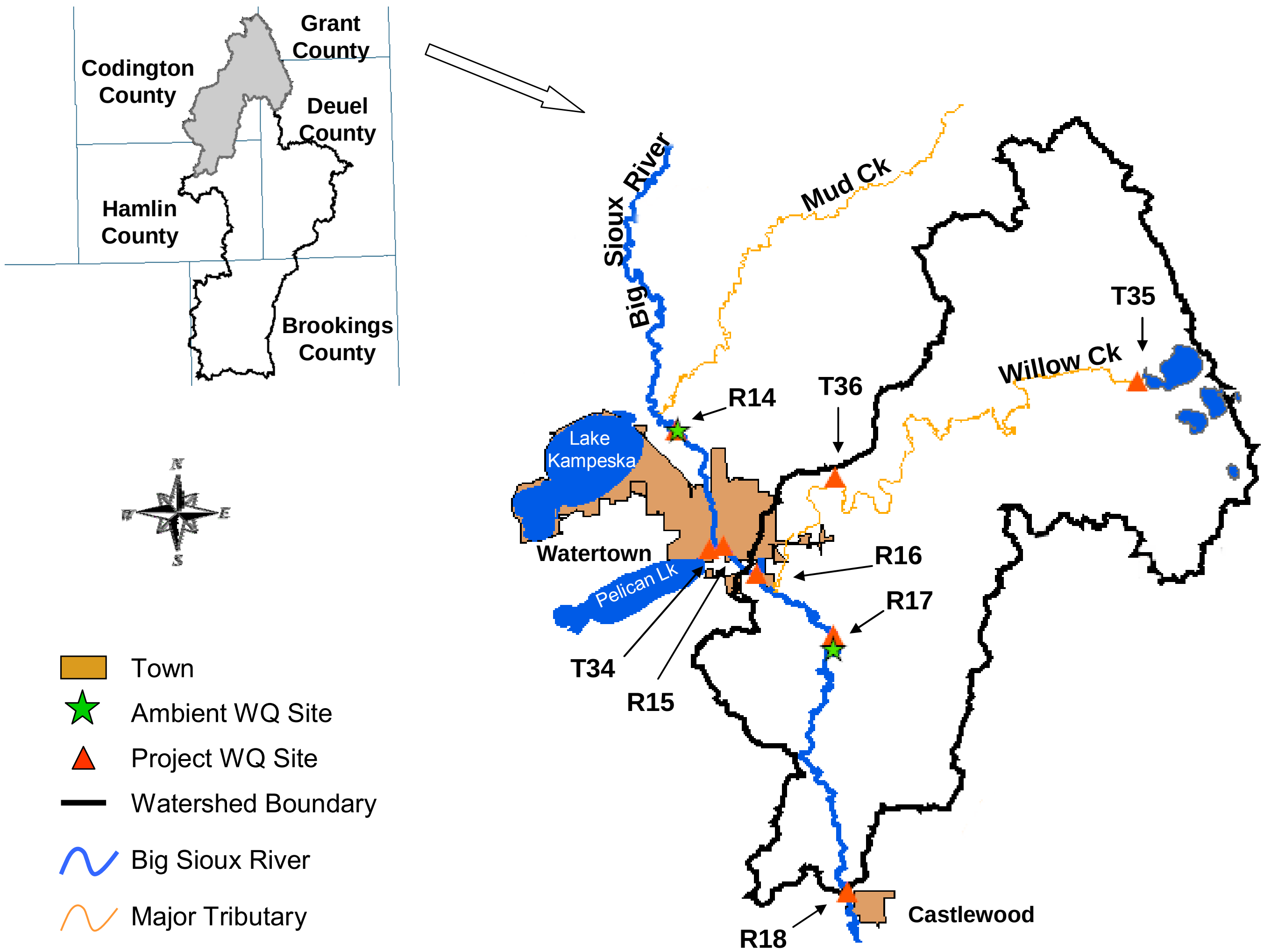


Figure 30. Castlewood North Location Map

Land Use

This area includes the Lake Pelican Weir (Site T34), Willow Creek (Sites T35 and T36), and the Big Sioux River monitoring sites R16, R17, and R18. The Big Sioux River Sites R14 and R15 will also be included in this analysis section. AnnAGNPS modeling was completed on this area during the Upper Big Sioux River Watershed Assessment completed in March 2002. The watersheds of School Lake, Bullhead Lake, Round Lake, and Wigdale Lake, in northwestern Deuel County and part of Grant County, are also located in this region. A separate watershed assessment was completed on these four lakes in 2005.

Willow Creek drains this chain of lakes and enters the Big Sioux River south of the City of Watertown. Specific lake related data can be found in the School Lake Watershed Assessment Report.

The Castlewood North area is located in the Northern Glaciated Plains and encompasses approximately 126,321 acres. Land use in this area is predominantly agricultural (Figure 31). Approximately 68 percent of the area is cropland, such as corn and soybeans, and 28 percent is grassland and pastureland. There are 81 animal feeding operations in this area, with approximately 99 percent of the livestock consisting of cattle (Figure 32. There are four NPDES permitted facilities identified in this portion of the North-Central watershed which includes the City of Watertown, Northern Con-Agg, Inc., Oak Valley Farms, and the Dakota Sioux Casino. However, Northern Con-Ag, Inc. and the Dakota Sioux Casino are not located directly within the designated watershed (Tables 37 and 38).

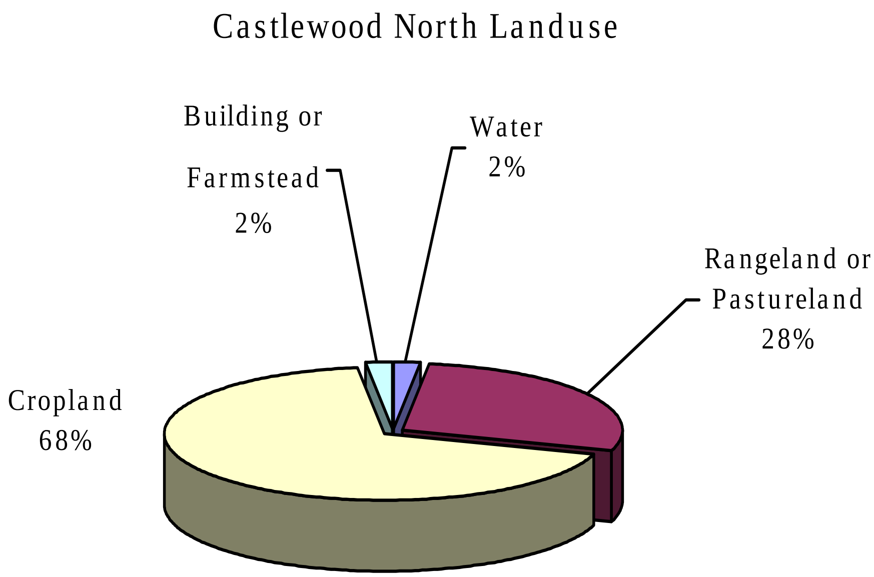


Figure 31. Castlewood North Area Landuse

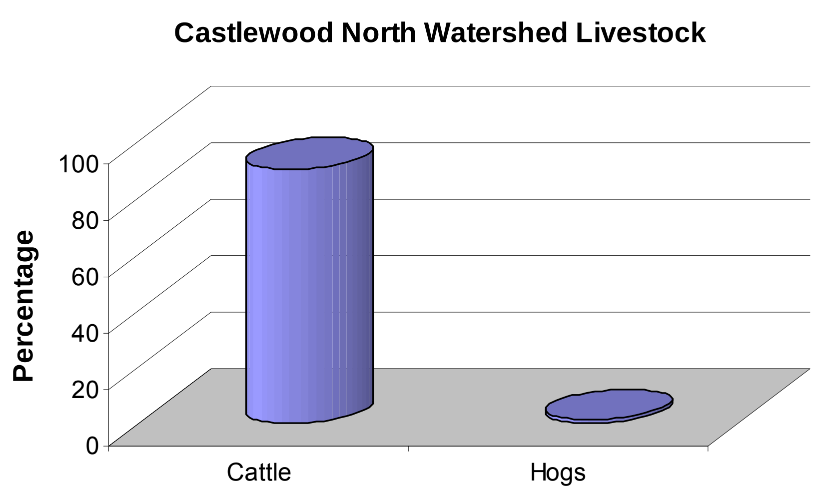


Figure 32. Castlewood North Watershed Livestock

Water Quality Summary

Beneficial uses for river Sites R14, R15, R16, R17, and R18 are 1, 5, 8, 9, and 10. Willow Creek (Sites T35 and T36) is assigned beneficial uses 6, 8, 9, and 10 and the Lake Pelican Weir (T34) is assigned beneficial uses 9 and 10. Table 45 is a summary of the beneficial uses classes assigned to each monitoring site and whether they are meeting or not meeting water quality criteria.

(1) Domestic Water Supply
(5) Warmwater Semi-permanent Fish Life Propagation
(6) Warmwater Marginal Fish Life Propagation
(8) Limited Contact Recreation
(9) Fish and Wildlife Propagation, Recreation and Stock Watering
(10) Irrigation

Table 45. Summary of Beneficial Use Class by Site

	Beneficial Use Class					
Site	**(1)**	**(5)**	**(6)**	**(8)**	**(9)**	**(10)**
R14	✓	✓	-	×	✓	✓
R15	✓	✓	-	✓	✓	✓
R16	✓	✓	-	×	✓	✓
R17	✓	✓	-	×	✓	✓
R18	✓	✓	-	×	✓	✓
T34	-	-	-	-	✓	✓
T35	-	-	×	×	✓	✓
T36	-	-	✓	×	✓	✓

✓ meeting
- not applicable
× not meeting

Based on the results from the water quality criteria established by DENR as described in the Results Section under Water Quality Monitoring, all the river sites (R14, R15, R16, R17, and R18) are meeting the water quality criteria for beneficial uses (1) Domestic Water Supply, (5) Warmwater Semi-permanent Fish Life Propagation, (9) Fish and Wildlife Propagation, Recreation and Stock Watering, and (10) Irrigation (Figures 33 and 34).

Tributary Sites T34, T35 and T36 are meeting the water quality criteria for beneficial uses (9) and (10). For beneficial use (6) Warmwater Marginal Fish Life Propagation, Sites T35 and T36 are meeting the criteria as described in the 303(d) waterbody listing for water temperature, TSS, pH, and total ammonia as nitrogen. Site T36 meets the water quality criteria for dissolved oxygen, but T35 does not (Figure 35).

For beneficial use (8) Limited Contact Recreation, all sites, except T35, meet the water quality criteria for dissolved oxygen. Site R15 is the only site meeting the water quality criteria for fecal coliform bacteria, all other sites (T35, T36, R14, R16, R17, and R18) are not meeting. The numeric criteria for fecal coliform bacteria is $\leq$ 2000 cfu/100mL and for dissolved oxygen it is $\geq$ 5 mg/L.

Fecal Coliform Bacteria Results

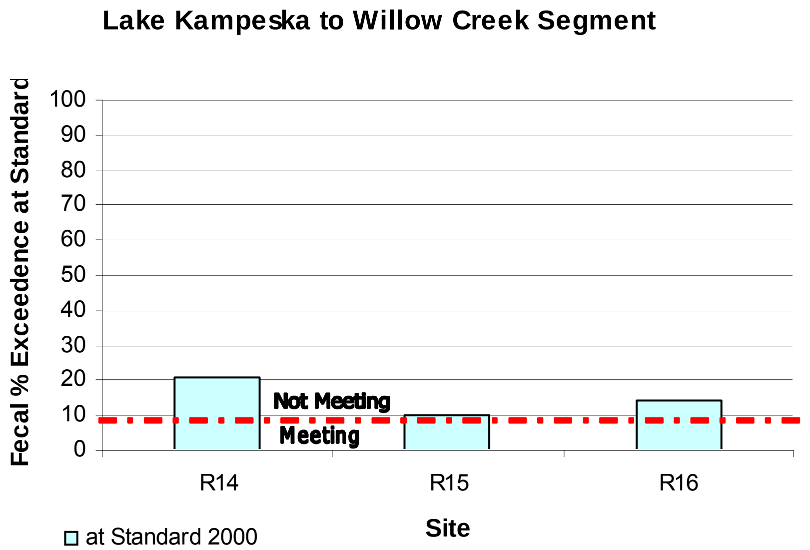


Figure 33. Fecal Coliform Bacteria Percent Exceedence at Standard ≤ 2000 cfu/100mL for the Lake Kampeska to Willow Creek Segment of the Big Sioux River

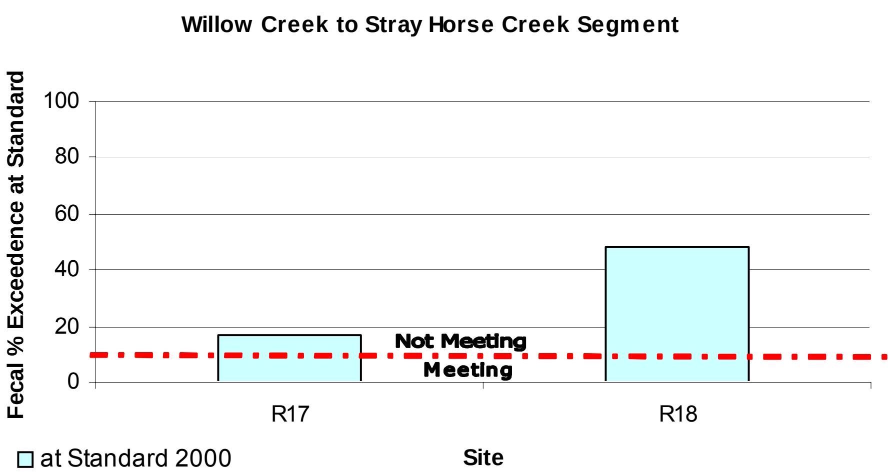


Figure 34. Fecal Coliform Bacteria Percent Exceedence at Standard ≤ 2000 cfu/100mL in the Willow Creek to Stray Horse Creek Segment of the Big Sioux River

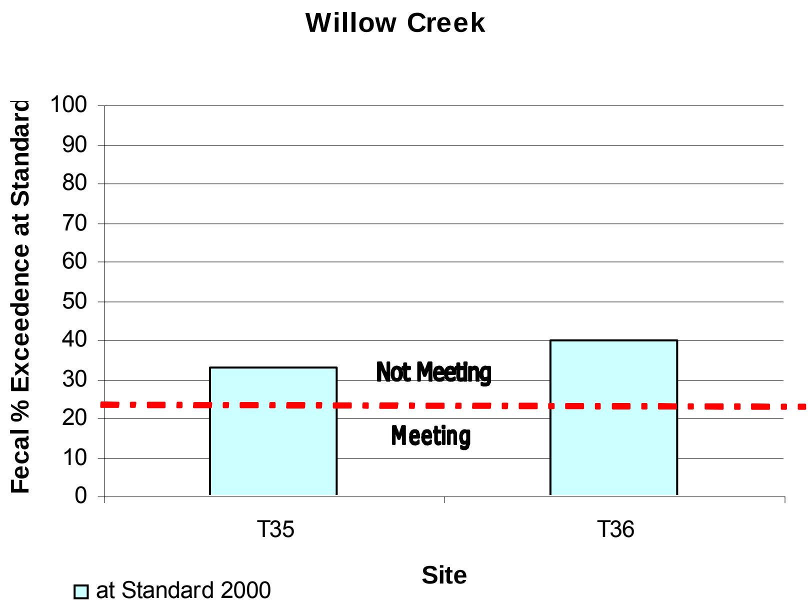


Figure 35. Fecal Coliform Bacteria Percent Exceedence at Standard ≤ 2000 cfu/100mL in Willow Creek

The average discharge and seasonal grab sample data were used to develop the graphs shown in Figure 36. Graphs showing the monitored loadings and the allowable target loads within each of the five hydrologic conditions at the ≤ 2000 cfu/100mL water quality standard are found in Figure 36. Scatterplots of the fecal coliform bacteria grab samples are shown in Figure 37.

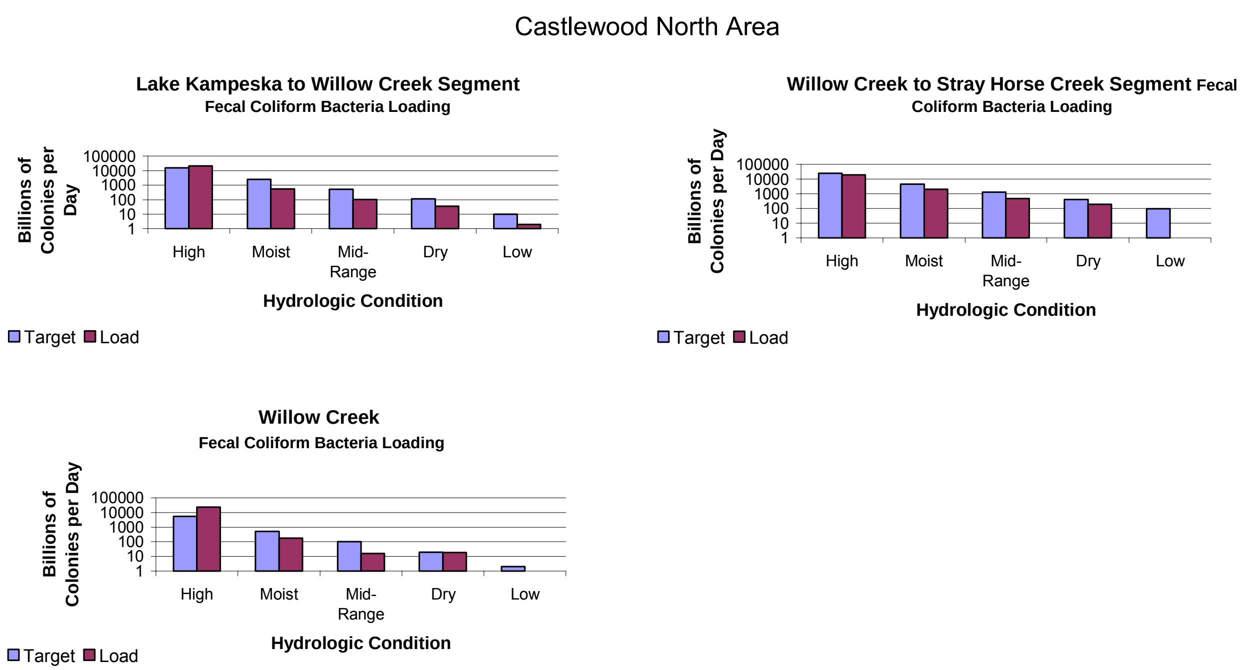


Figure 36. Fecal Coliform Bacteria in Billions of Colonies per Day Monitored vs the Standard in the Castlewood North Area

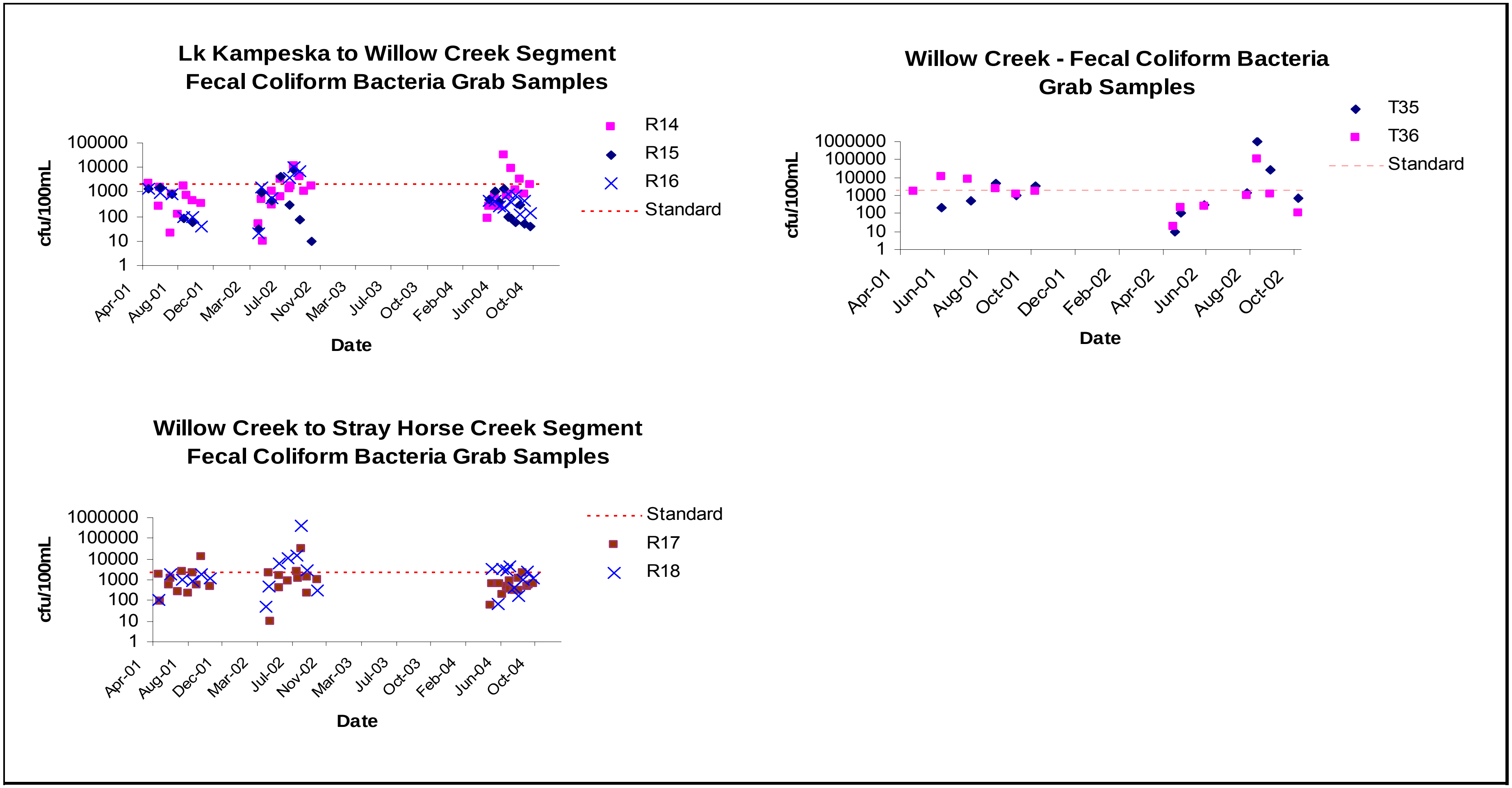


Figure 37. Scatterplots of Fecal Coliform Bacteria Grab Samples for River Sites (R14-R18) and Willow Creek (T35 and T36)

Figure 38 shows the fecal coliform bacteria grab samples for the Lake Pelican Weir (T34). Although the Lake Pelican Weir is not assigned a numeric standard for fecal coliform bacteria, this graph shows the amount flowing into and out of the lake.

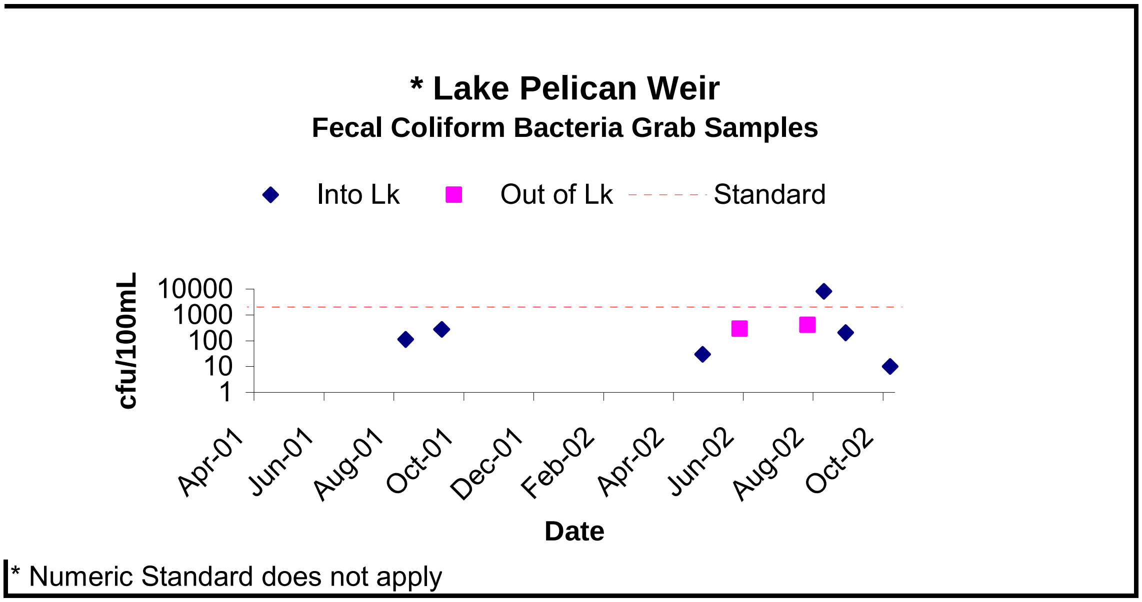


Figure 38. Scatterplots of Fecal Coliform Bacteria Grab Samples for the Lake Pelican Weir (T34)

Trends in fecal coliform bacteria are shown in Figures 39 and 40. SD DENR ambient grab sample data for R14 (WQM55) and R17 (WQM1) was used to construct these figures. The seasonal (May through Sept) medians for each year, from 1980 to 2004, were calculated. The statistical significance of a trend was determined to occur at an R^2 value of 0.25 or greater, due to the large sample size of 25 years of data.

Figure 39 does not show trend in fecal coliform bacteria, $R^2 = 0.1636$, for monitoring Site R14. This area is not meeting the water quality criteria for fecal coliform bacteria and should be monitored for trends over the next several years.

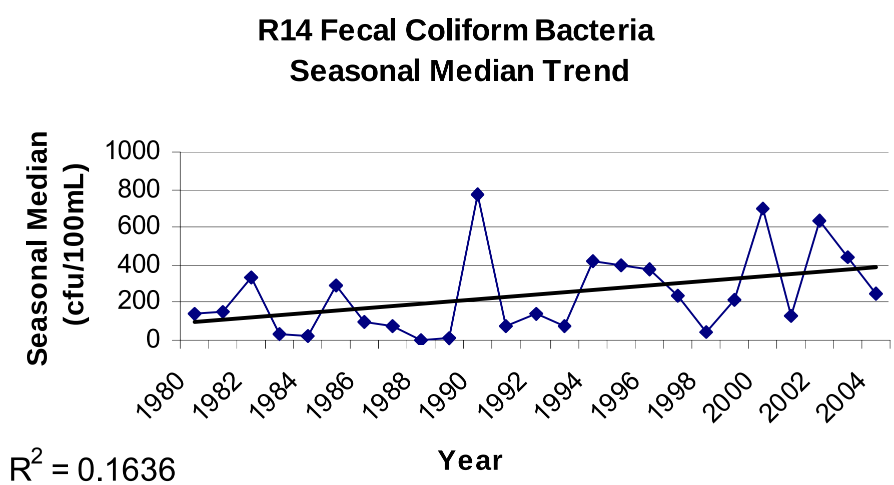


Figure 39. 25-Year Trend (1980-2004) of Yearly Seasonal Medians of Fecal Coliform Bacteria at R14

Figure 40 shows no significant trend for fecal coliform bacteria, $R^2 = 0.0048$, at monitoring Site R17. This area is not meeting the water quality criteria for fecal coliform bacteria.

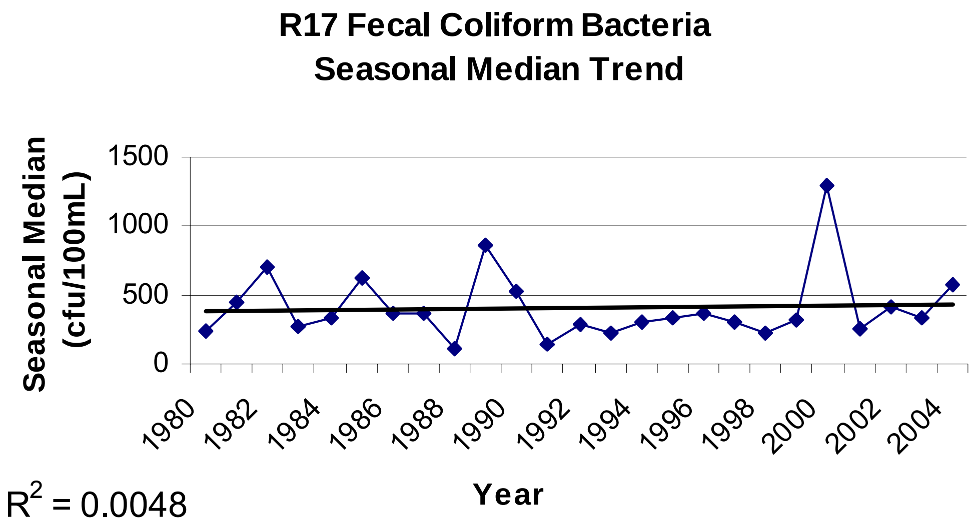


Figure 40. 25-Year Trend (1980-2004) of Yearly Seasonal Medians of Fecal Coliform Bacteria at R17

Total Suspended Solids Results

Of the sites assigned a numeric standard for TSS, there was only one exceedence of 314 mg/L which occurred at R18. Based on FLUX model results, Figure 41 shows the estimated TSS loadings for the Big Sioux River sites (R14, R15, R16, R17, and R18) and the Willow Creek sites (T35 and T36) as compared to the allowable load of ≤ 158 mg/L for the river sites and ≤ 263 mg/L for Willow Creek.

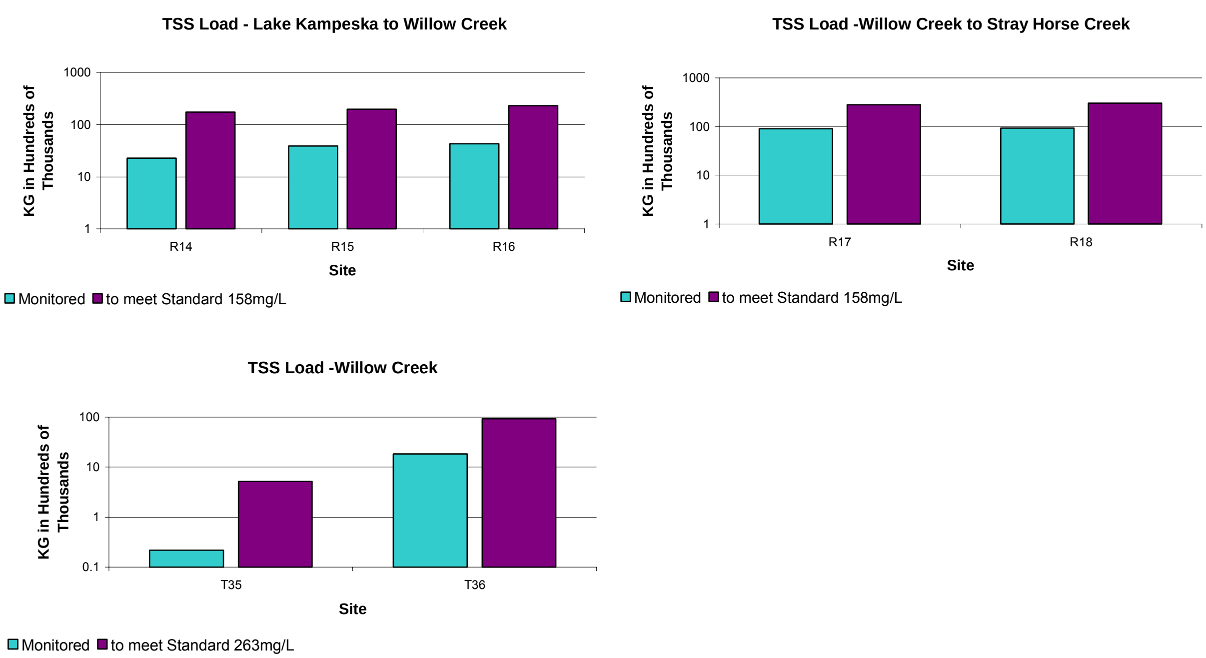


Figure 41. TSS in kg Monitored vs the Standard in the Castlewood North Area

Scatterplots of the TSS grab samples are shown in Figure 42.

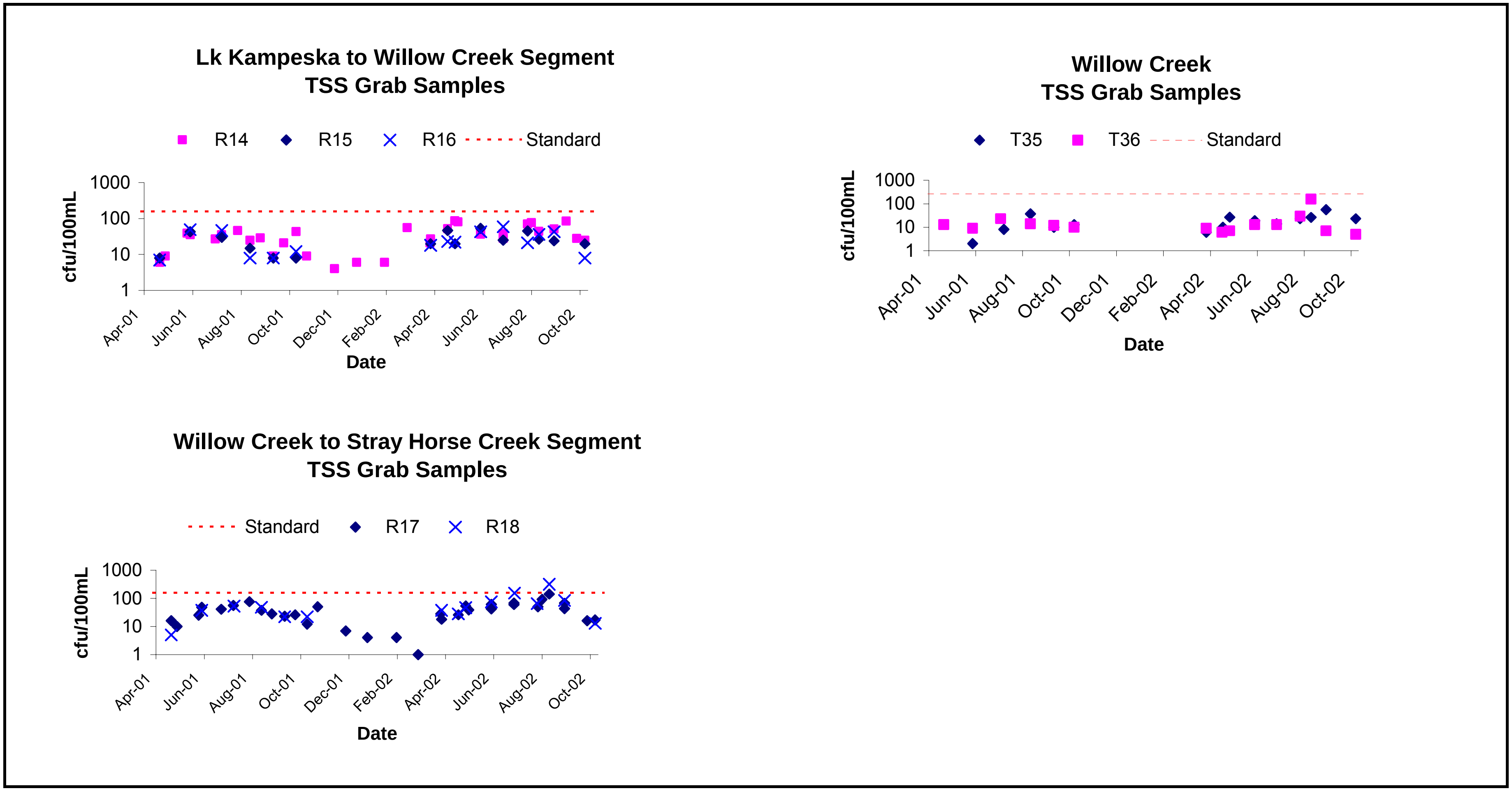


Figure 42. Scatterplots of TSS Grab Samples for River Sites (R14-R18) and Willow Creek (T35 and T36)

Figure 43 shows the TSS grab samples for the Lake Pelican Weir (T34). Although the Lake Pelican Weir is not assigned a numeric standard for TSS, this graph shows the amount going into and coming out of the lake.

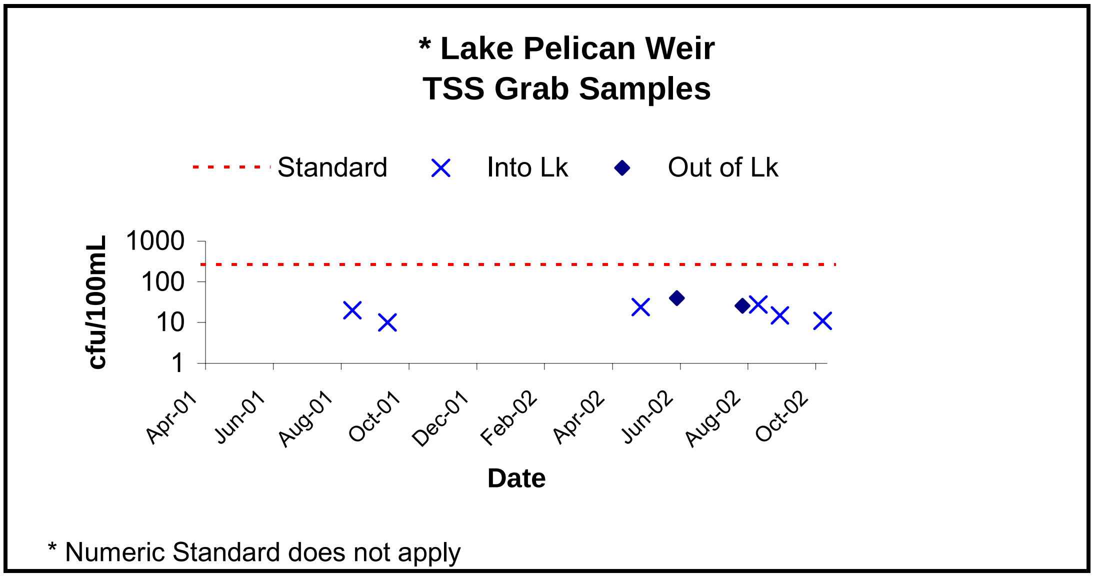


Figure 43. Scatterplot of TSS Grab Samples for the Lake Pelican Weir (T34)

Data Summary

The following table (Table 46) summarizes the ranges of fecal coliform bacteria cfu/100mL, TSS mg/L, and the percent exceedences. It also shows the summer mean of total PO4 mg/L for each river monitoring site.

Table 46. Ranges and Percent Exceedences of Fecal Coliform Bacteria, TSS, and Summer Means of Total PO4 in the Castlewood North Area

Site	Fecal cfu/100mL	% fecal exceedence	TSS mg/L	% TSS exceedence	Summer Mean Total PO4 mg/L
R14	nd-31,000	21%	4-87	0%	0.202
R15	40-8,000	10%	8-53	0%	0.186
R16	90-10,000	14%	7-59	0%	1.433
R17	10-33,000	14%	1-141	0%	0.772
R18	70-410,000	48%	5-314	6%	0.718
T34	nd-8,000	NA	6-40	NA	0.154
T35	110-930,000	33%	2-56	0%	0.445
T36	230-110,000	40%	5-202	0%	0.319

The summer mean concentrations of total phosphorus at Sites R16, R17, R18, T35, and T36 exceed the NGP ecoregion mean of 0.25 mg/L (Fandrei et al. 1988). The summer mean concentrations of total phosphorus at Site R17 and Site R18 are three times greater than the ecoregion mean and Site R16 is almost six times greater. These higher numbers can be attributed to sources such as urban stormwater runoff, livestock waste, streambank erosion, commercial fertilizers, construction site erosion, and/or urban stormwater runoff.

Willow Creek is meeting water quality criteria for beneficial use (9) Fish and Wildlife Propagation, Recreation, and Stock Watering, and (10) Irrigation. However, for beneficial use (6) Warmwater Marginal Fish Life Propagation , and (8) Limited Contact Recreation, Willow Creek is not meeting water quality criteria for dissolved oxygen (≥ 5 mg/L) at Site T35 (Figure 44). Together, Site T35 and Site T36 are at 19 percent violation and is not within the numeric standards for this creek. Dissolved oxygen ranged from 3.2 mg/L to 19.3 mg/L. A scatterplot of the dissolved oxygen grab samples is shown in Figure 45.

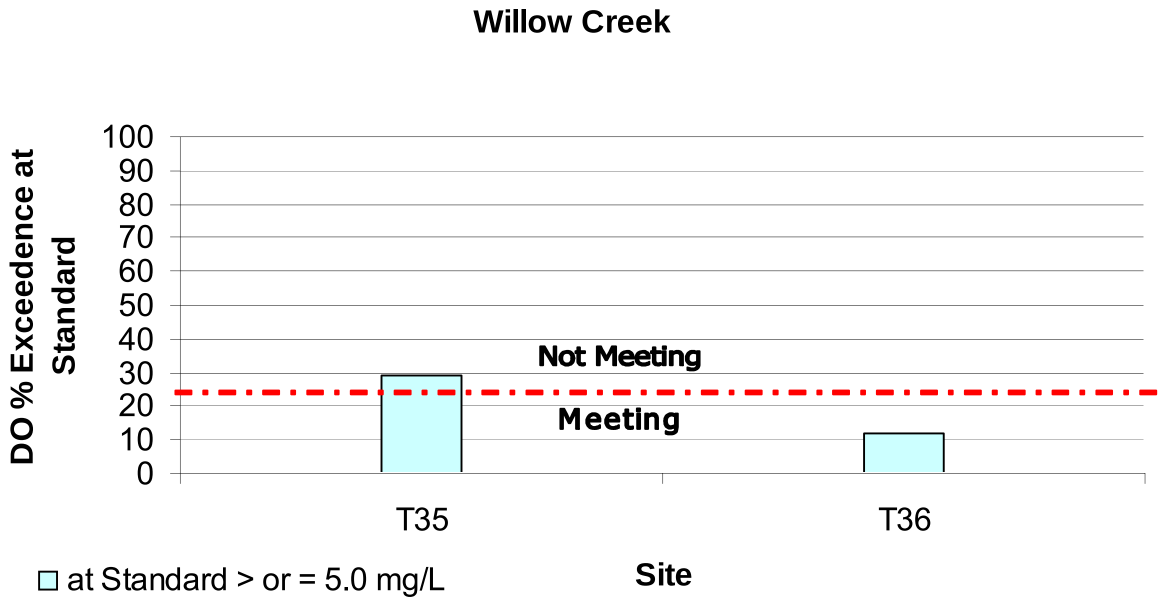


Figure 44. Dissolved Oxygen Percent Exceedence at Standard ≥ 5 mg/L in Willow Creek

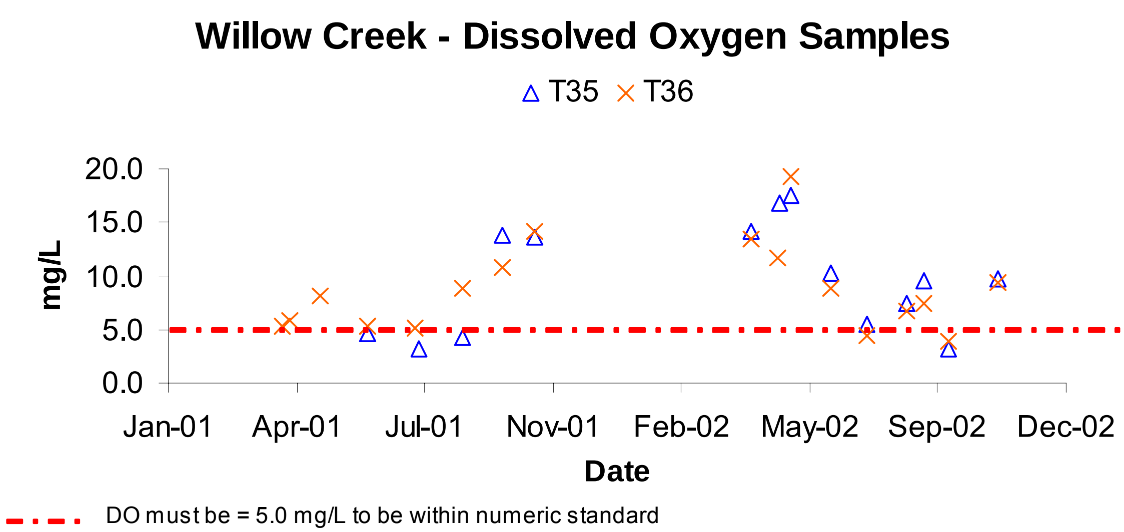


Figure 45. Scatterplot of Dissolved Oxygen Samples for Willow Creek

Biological and Physical Habitat Summary

Fish and physical habitat measurements were not completed on any of the Big Sioux River mainstem sites. The only site surveyed for fish and physical habitat in the Castlewood North area was Site T36. Macroinvertebrates were collected at all the sites in this area. The following table summarizes the scores and suggested site impairment based on the macroinvertebrate data. Score sheets for each site can be found in Appendix L.

Moderately impacted sites (R18, T34, and T36) had moderately high taxa richness; however, tolerant organisms dominated. Intolerant taxa such as Ephemeroptera and Trichoptera were found, but not in abundance. The most dominant organism at Site T36 was Chronomid *Glyptotendipes* sp. which is a highly tolerant filterer with a tolerance of 10. HBI's ranged from 7.4 to 8.5. A more tolerant benthic community may indicate higher silt levels, lower flows, higher temperatures, and/or impaired habitat/substrate.

River Sites R14, R15, R16, and R17 and tributary Site T35 suggest severe impairment with a significantly higher number of very tolerant species and HBI's of 9.0 to 9.5. Abundant filamentous algae were present at Site R14. The most severely impaired site is R16 with an HBI of 9.5, the top two dominant taxa were *Dicrotendipes* sp. and Tubificidae, and no intolerant taxa present (Table 47). A highly tolerant benthic community may indicate organic pollution and/or excessive sedimentation.

Fish and physical habitat were only assessed at Site T36. This site scored the lowest in both categories a compared with the other assessed sites in the NCBSRW. The most abundant fish species was the fathead minnow, which is indicative of a degraded stream. Physical habitat of this site lacked physical complexity, had poor bed substrate, and the immediate area was heavily grazed.

Table 47. Bugs, Fish, and Habitat Final Index Values and Suggested Impairment for the Sites in the Castlewood North Area

Site	Macroinverts	Fish	Habitat	Suggested Impairment (based on bug data)
R14	56	-----	-----	Severe
R15	66	-----	-----	Severe
R16	54	-----	-----	Severe
R17	61	-----	-----	Severe
R18	68	-----	-----	Moderate
T34*	67	-----	-----	Moderate to Severe
T35*	38	-----	-----	Severe
T36	50	52	60	Moderate

----- not sampled * lake outlet

Source Linkage and Conclusion

Fecal Coliform Bacteria Reductions and Sources

Based on modeling and loading calculations, fecal coliform bacteria (Table 48) would need the following reductions at each site:

Table 48. Percent Fecal Coliform Bacteria Reduction in the Castlewood North Area

Site	Numeric Criteria	Fecal % Reduction *(Flow)	Event vs Base Flow
R14	≤ 2000	0%	NA
R15	≤ 2000	9% (H)	Both
R16	≤ 2000	59% (H)	Both
R17	≤ 2000	33% (H)	Both
R18	≤ 2000	11% (MR), 16% (D)	Both
T34	-----	-----	NA
T35	≤ 2000	44% (MR), 100% (D)	Both
T36	≤ 2000	77% (H), 77% (MR)	Both

* Flow Ranges
H=High Flows (0-10%) M=Moist Conditions (10-40%)
MR=Mid-Range Flows (40-60%) D=Dry Conditions (60-90%)
L=Low Flows (90-100%)

The monitoring data shows high fecal concentration during runoff events and at base flows. Potential non-background non-point sources of fecal coliform bacteria would be failing septic systems, pastured livestock, improper manure application, feedlot runoff, and urban runoff. According to the feedlot inventory, 36 of the 81 animal feeding operations in this area rated 50 or greater on a 0 to 100 scale. Higher ratings indicate a greater potential for the operation to pollute nearby surface waters. Livestock waste would contribute to the higher fecal counts during runoff events; whereas, livestock in the stream and failing septic systems contribute to the higher fecal counts during low flows. There are five known NPDES permitted facilities within the drainage area. Of these five, two were identified as point sources that discharged during the sampling period (Table 38). Their contributions were calculated and determined to be insignificant. Reductions of fecal coliform bacteria should focus on non-point sources (See Target Reductions and Future Activity Recommendations Section).
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Castlewood to Estelline

This map (Figure 46) shows the area and location designated as the Castlewood to Estelline area.

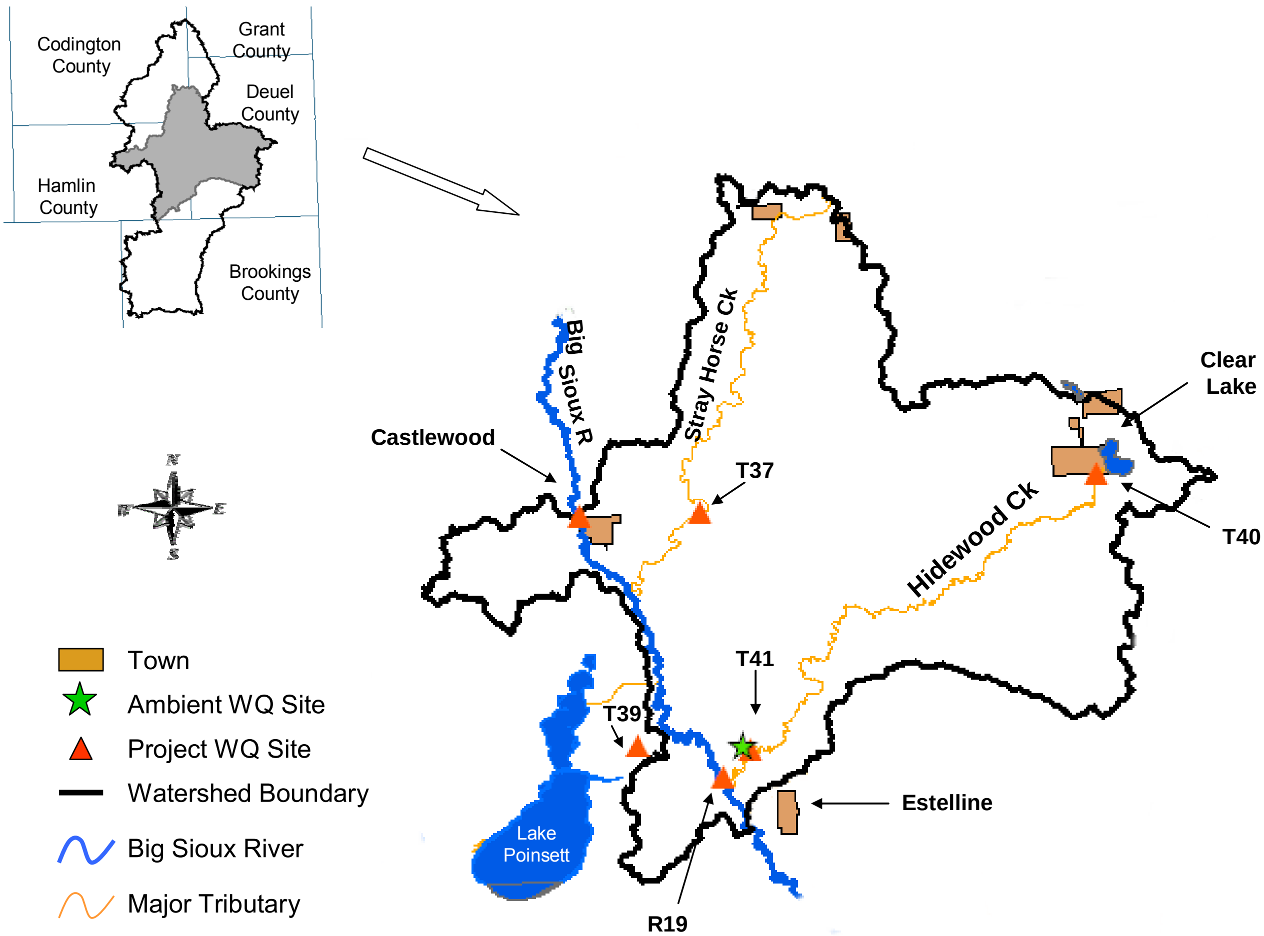


Figure 46. Castlewood to Estelline Location Map

Land Use Summary

This area includes the Lake Poinsett Outlet (Site T39), Stray Horse Creek (Site T37), Hidewood Creek (Sites T40 and T41), and the Big Sioux River Site R19. The Castlewood to Estelline area is located in the Northern Glaciated Plains and encompasses approximately 193,530 acres. Land use in this area is predominantly agricultural (Figure 47). Approximately 75 percent of the area is cropland, such as corn and soybeans, and 23 percent is grassland and pastureland. There are 145 animal feeding operations in this area, with approximately 94 percent of the livestock consisting of cattle (Figure 48). There are six NPDES permitted facilities located within this watershed (Table 37 and 38). They include the City of Castlewood, the City of Clear Lake, the Town of Kranzburg, the Lake Poinsett Sanitary District, and Technical Ordinance, Inc.

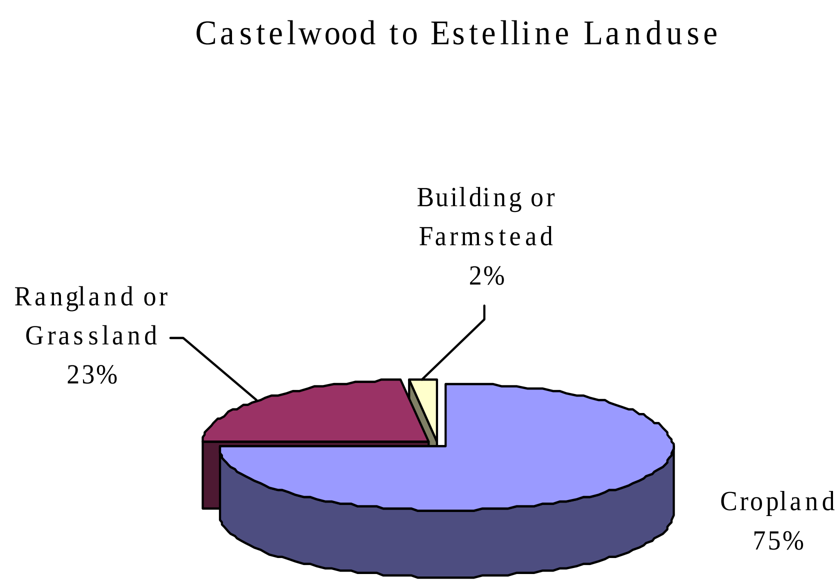


Figure 47. Castlewood to Estelline Area Landuse

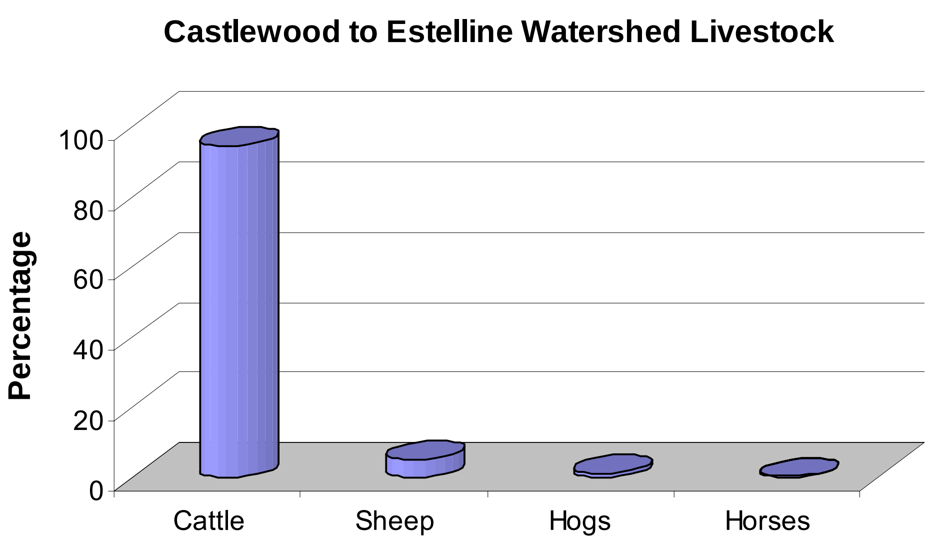


Figure 48. Castlewood to Estelline Watershed Livestock

Water Quality Summary

The beneficial uses assigned to Big Sioux River Site R19 are 1, 5, 8, 9, and 10. Stray Horse Creek (Site T37) and Hidewood Creek (Sites T40 and 41) are assigned beneficial uses 6, 8, 9, and 10, and the Lake Poinsett Outlet (T39) is assigned beneficial uses 9 and 10. Table 49 is a summary of the beneficial uses classes assigned to each monitoring site and whether they are meeting or not meeting water quality criteria.

(1) Domestic Water Supply
(5) Warmwater Semi-permanent Fish Life Propagation
(6) Warmwater Marginal Fish Life Propagation
(8) Limited Contact Recreation
(9) Fish and Wildlife Propagation, Recreation and Stock Watering
(10) Irrigation

Table 49. Summary of Beneficial Use Class by Site

Site	Beneficial Use Class (1)	(5)	(6)	(8)	(9)	(10)
R19	✓	✓	-	✓	✓	✓
T37	-	-	✓	×	✓	✓
T39	-	-	-	-	✓	✓
T40	-	-	×	×	✓	✓
T41	-	-	✓	×	✓	✓

✓ meeting
- not applicable
× not meeting

Based on the results from the water quality criteria established by DENR as described in the Results Section under Water Quality Monitoring, river Site R19 is meeting all the water quality criteria for all its assigned beneficial uses (Figure 49).

Tributary Sites T37, T39, T40, and T41 are meeting the water quality criteria for beneficial uses (9) and (10). For beneficial use (6) Warmwater Marginal Fish Life Propagation , Sites T37, T40, and T41 are meeting the criteria as described in the 303(d) waterbody listing for water temperature, TSS, pH, and total ammonia as nitrogen. Site T37 and T41 meet the water quality criteria for dissolved oxygen, but T40 does not.

All tributary sites, except T40, meet the water quality criteria for dissolved oxygen under beneficial use (8) Limited Contact Recreation. Site T40 is the only tributary site meeting the water quality criteria for fecal coliform bacteria; all others (T37 and T41) are not meeting (Figures 50 and 51). The numeric criteria for fecal coliform bacteria is $\leq$ 2000 cfu/100mL and for dissolved oxygen it is $\geq$ 5 mg/L.

Fecal Coliform Bacteria Results

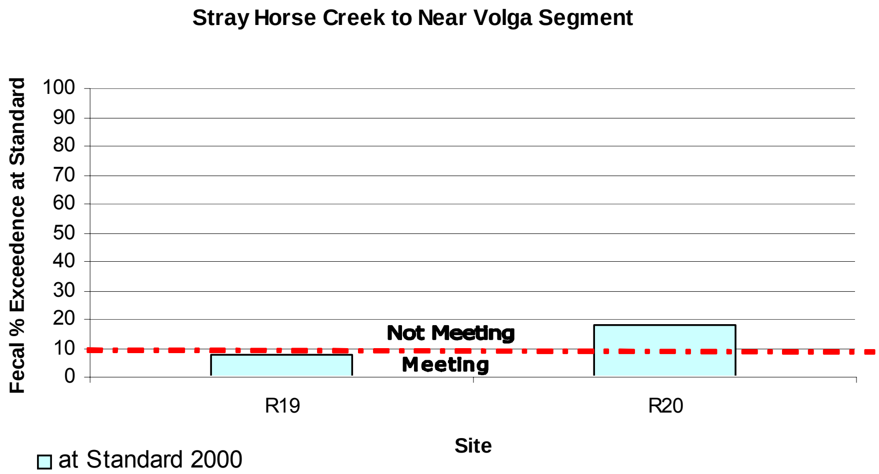


Figure 49. Fecal Coliform Bacteria Percent Exceedence at Standard ≤ 2000cfu/100mL in the Stray Horse Creek to Near Volga Segment of the Big Sioux River

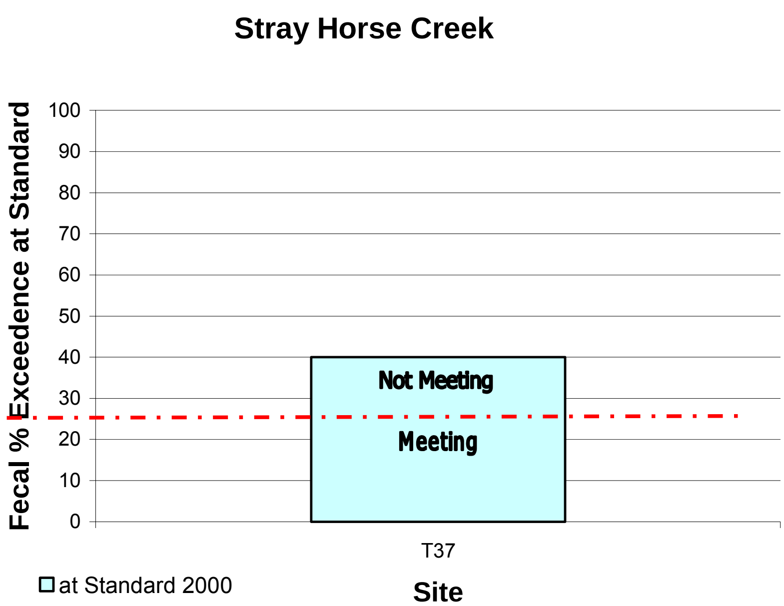


Figure 50. Fecal Coliform Bacteria Percent Exceedence at Standard ≤ 2000cfu/100mL in Stray Horse Creek

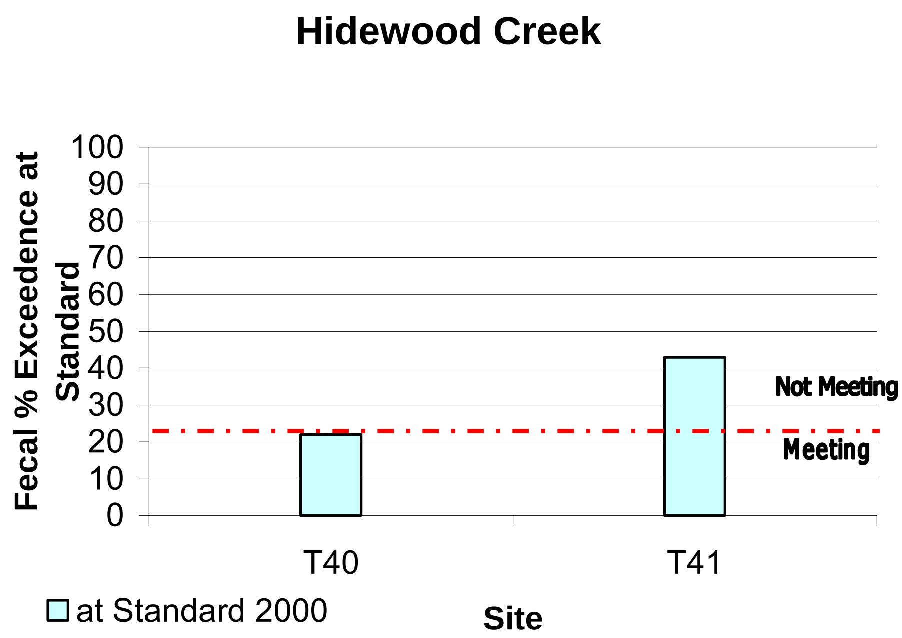


Figure 51. Fecal Coliform Bacteria Percent Exceedence at Standard ≤ 2000cfu/100mL in Hidewood Creek

Graphs were constructed showing the monitored loadings and the allowable target loads of fecal coliform bacteria at the ≤ 2000 cfu/100mL water quality standard, within each of the five hydrologic conditions (Figure 52). Scatterplots of the fecal coliform bacteria grab samples are shown in Figure 53.

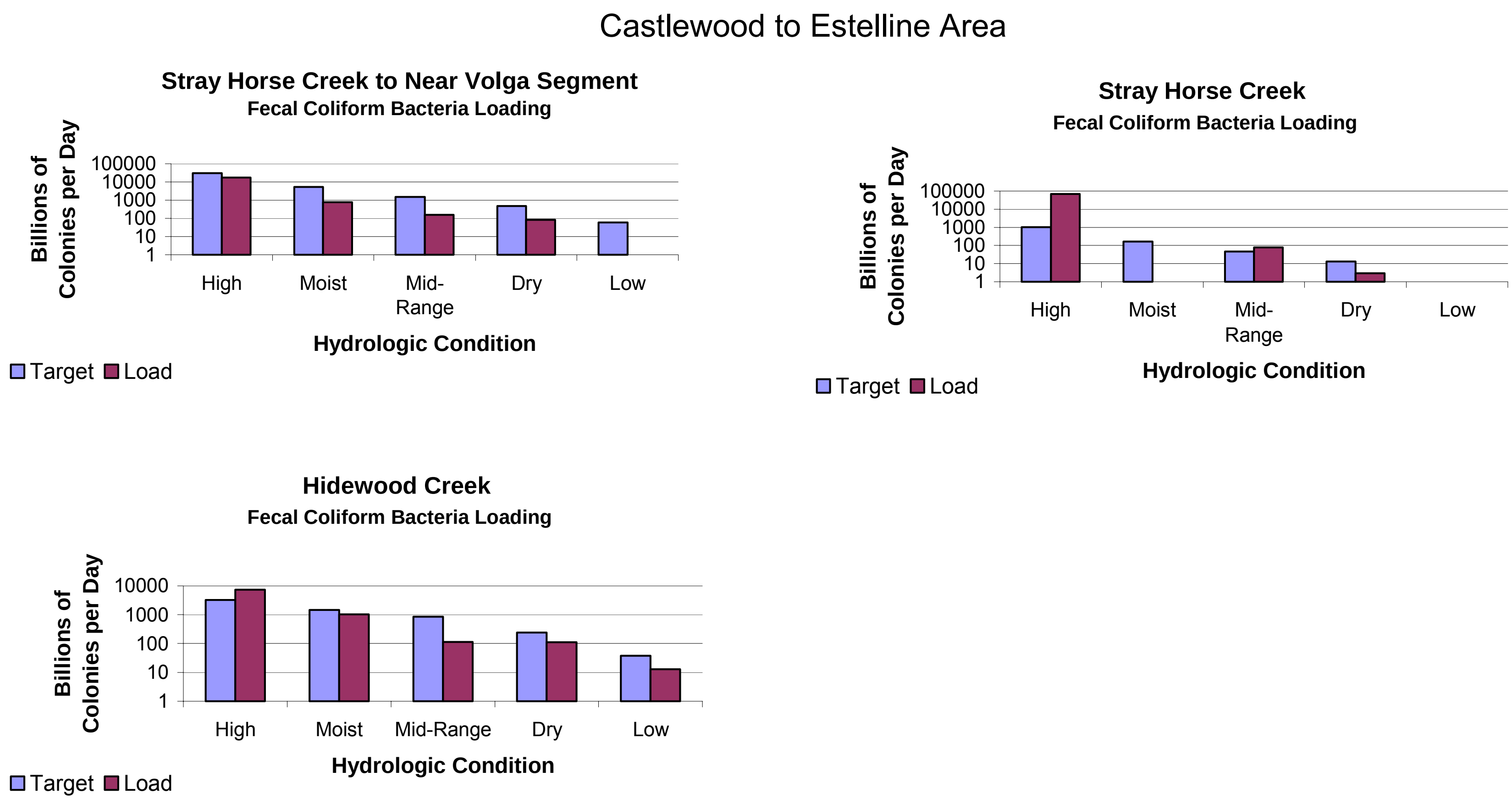


Figure 52. Fecal Coliform Bacteria in Billions of Colonies per Day Monitored vs the Standard in the Castlewood to Estelline Area

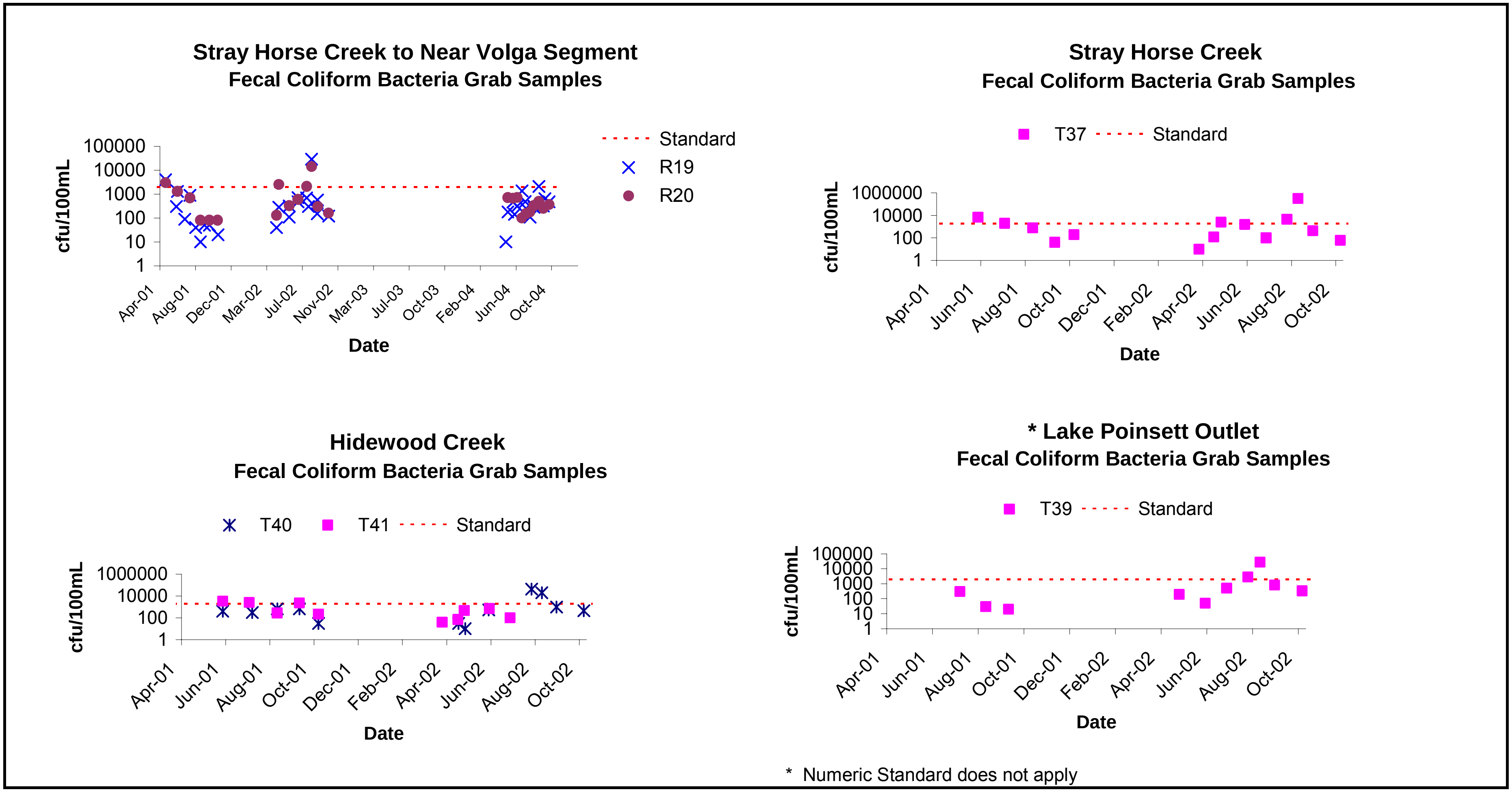


Figure 53. **Scatterplots of Fecal Coliform Bacteria Grab Samples for River Site R19, Stray Horse Creek (T37), Hidewood Creek (T40 and T41), and the Lake Poinsett Outlet (T39)**

Total Suspended Solids Results

A sample of 188 mg/L of TSS was collected at Site R19 and was the only violation of the TSS daily maximum standard of ≤ 158 mg/L in this watershed. Figure 54 shows the estimated TSS FLUX loadings for the Big Sioux River Site (R19), Stray Horse Creek (T37), and Hidewood Creek (T40 and T41) as compared to the allowable load of ≤ 158 mg/L for the river site and ≤ 263 mg/L for Stray Horse Creek and Hidewood Creek. Scatterplots of the TSS grab samples are shown in Figure 55.

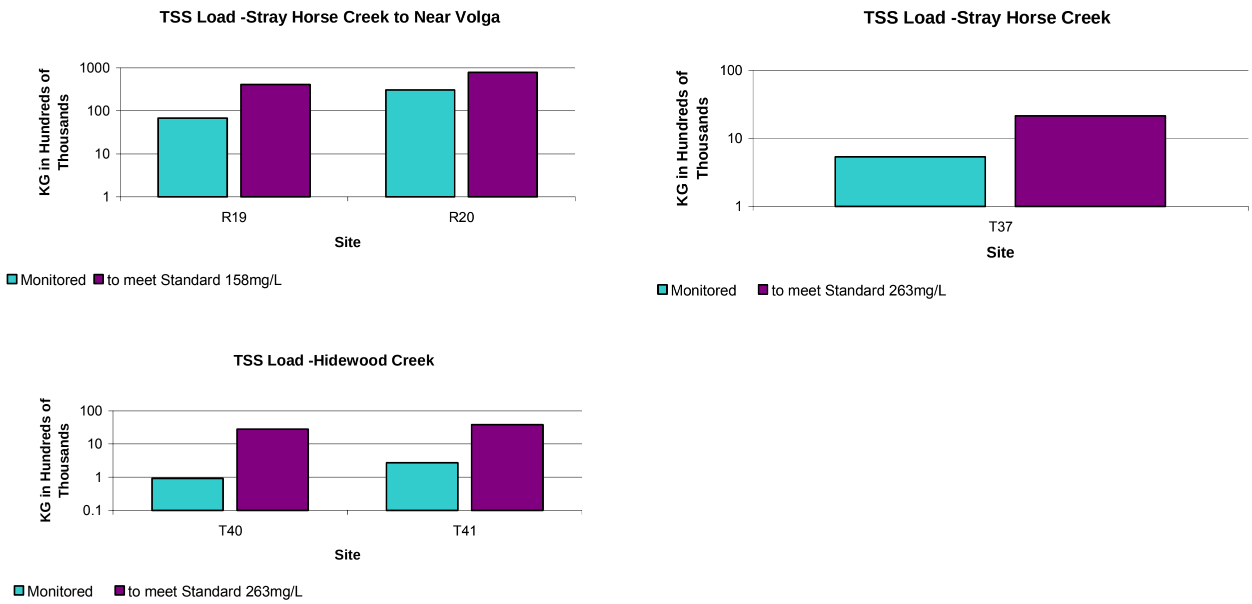


Figure 54. TSS in kg Monitored vs the Standard in the Castlewood to Estelline Area

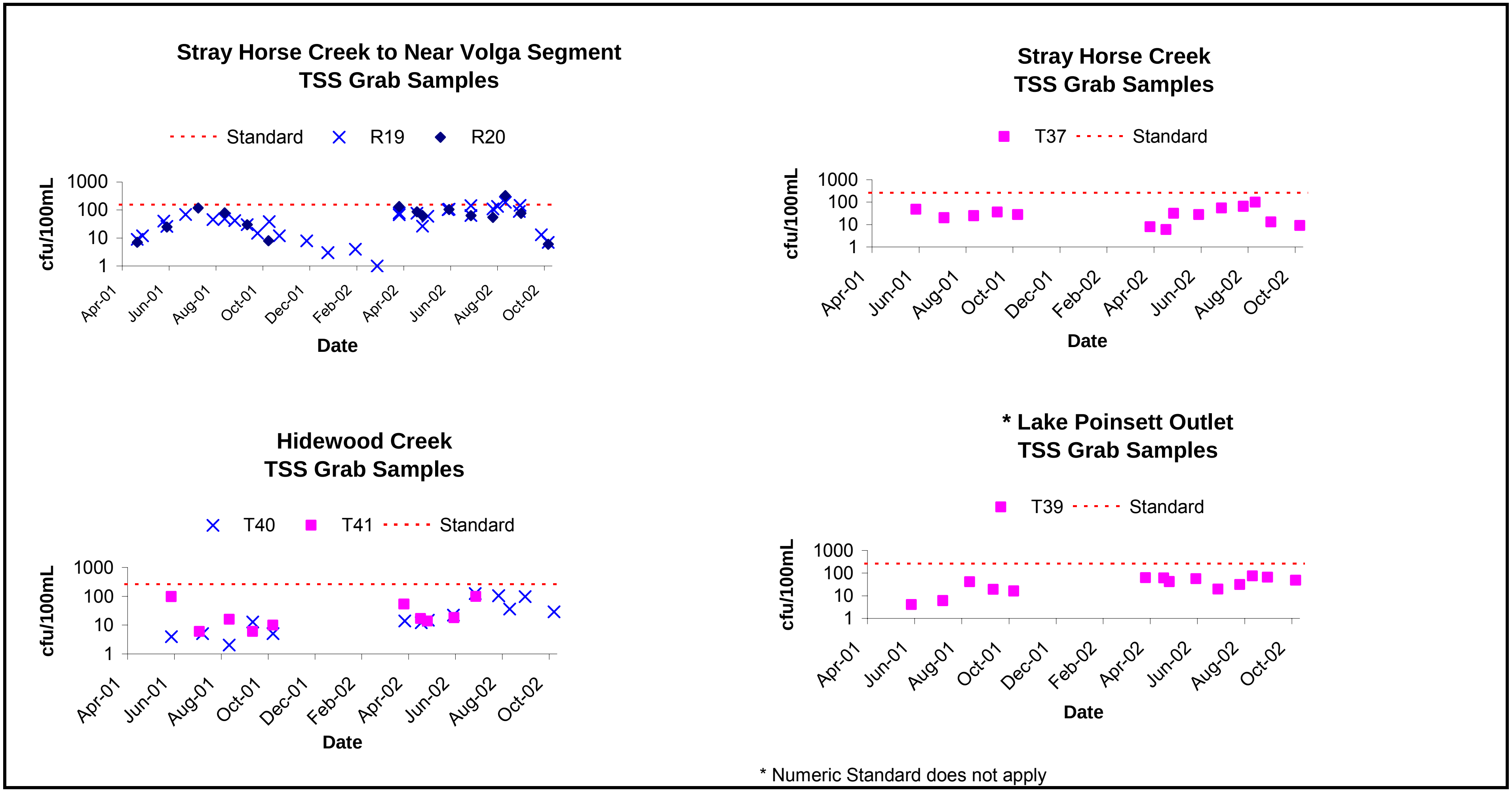


Figure 55. Scatterplots of TSS Grab Samples for the Stray Horse Creek to Near Volga Segment of the Big Sioux River, Stray Horse Creek, Hidewood Creek, and the Lake Poinsett Outlet

Data Summary

Table 50 summarizes the ranges of fecal coliform bacteria cfu/100mL, TSS mg/L, and the percent exceedences. It also shows the summer mean of total PO4 mg/L.

Table 50. Ranges and Percent Exceedences of Fecal Coliform Bacteria, TSS, and Summer Means of Total PO4 in the Castlewood to Estelline Area

Site	Fecal cfu/100mL	% fecal exceedence	TSS mg/L	% TSS exceedence	Summer Mean Total PO4 mg/L
R19	nd-29,000	8%	1-188	3%	0.417
T37	40-320,000	40%	6-100	0%	0.340
T39	nd-27,000	NA	4-76	NA	0.404
T40	10-42,000	22%	2-126	0%	0.479
T41	100-3,300	43%	6-100	0%	0.135

The summer mean concentrations of total phosphorus at Sites R19, T37, T39, and T40 exceed the NGP ecoregion mean of 0.25 mg/L (Fandrei et al. 1988). These higher numbers can be attributed to sources such as runoff, livestock waste, streambank erosion, commercial fertilizers, and/or construction site erosion.

Hidewood Creek is meeting water quality criteria for beneficial use (9) Fish and Wildlife Propagation, Recreation, and Stock Watering, and (10) Irrigation. However, for beneficial use (6) Warmwater Marginal Fish Life Propagation , and (8) Limited Contact Recreation, Hidewood Creek is not meeting water quality criteria for dissolved oxygen (≥ 5 mg/L) at Site T40 (Figure 56). Together, Site T40 and Site T41 are at 25 percent violation and not within numeric standards. Dissolved oxygen ranged from 1.4 mg/L to 17.6 mg/L. A scatterplot of the dissolved oxygen grab samples are shown in Figure 57.

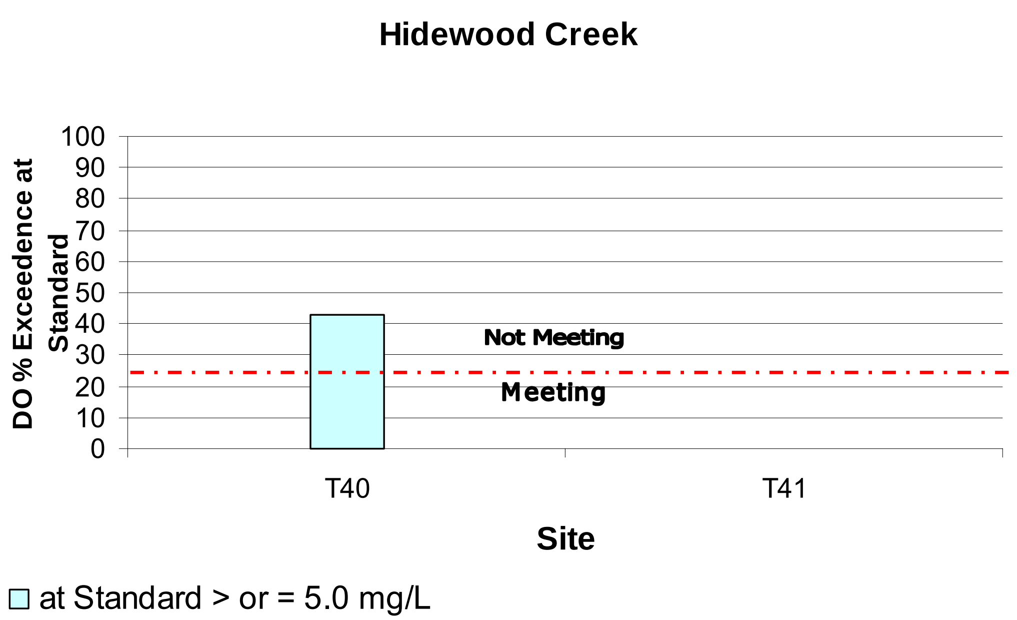


Figure 56. Dissolved Oxygen Percent Exceedence at Standard ≥ 5 mg/L in Hidewood Creek

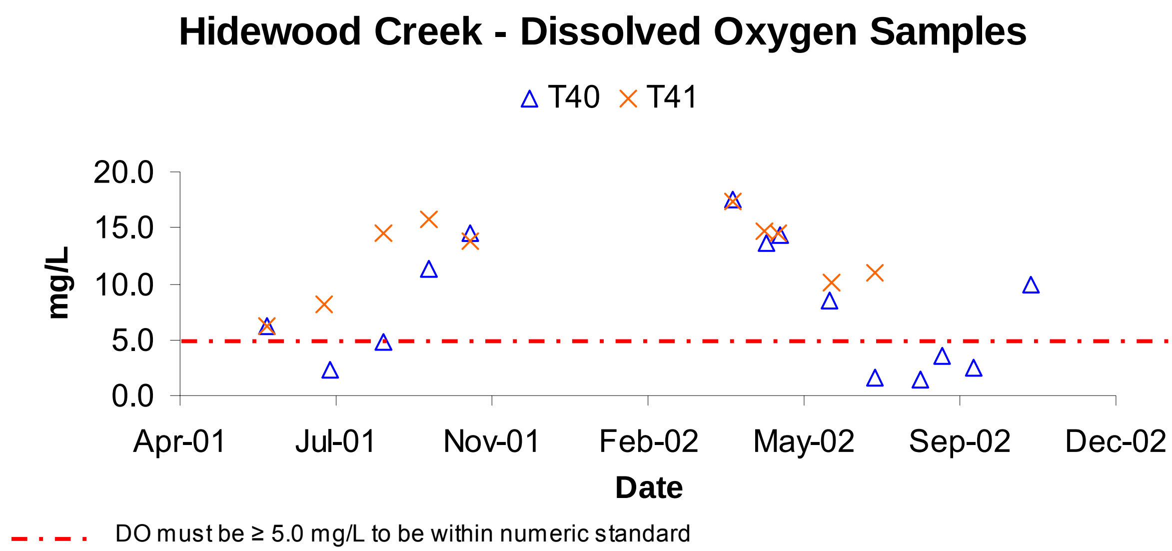


Figure 57. Scatterplot of Dissolved Oxygen Samples for Hidewood Creek

Biological and Physical Habitat Summary

The only sites surveyed for fish and physical habitat in the Castlewood to Estelline area were Site T37 and Site T41. Macroinvertebrates were collected at all the sites in this area, with the exception of Site T41, due to dry stream conditions. The following table (Table 51) summarizes the scores and suggested site impairment based on the macroinvertebrate data. Score sheets for each site can be found in Appendix L.

Moderate to severely impacted sites (R19, T37, and T39) consisted mainly of tolerant organisms. Intolerant organisms were non-existent at Site R19. HBI scores ranged from 7.4 to 8.7. EPT richness and abundance measures were very low. A more tolerant benthic community may indicate higher silt levels, lower flows, higher temperatures, and/or impaired habitat/substrate. The results of Site T40 suggest severe impairment with Chironomidae dominating and an HBI of 9.8. This location also showed a significant amount of filamentous algae. Ephemeroptera and Trichoptera were not present.

Site T41 scored lower than T37 in physical habitat due to poor bank stability and lack of physical complexity. Site T37 scored very well, only lacking in the area of bank stability. The fish survey indicated a healthy fish community at Site T37 with 21 species sampled. Site T41 scored in the fair category with only 15 species identified with a very low percentage of sensitive species and an absence of intolerant species. The sensitive/intolerant species are usually the first to be affected by major sources of degradation such as siltation, low dissolved oxygen, reduced flow, and/or chemical contamination. However, the most abundant species at Site T41 were common shiners, creek chubs, sand shiners, and stonerollers. These species are indicators of a healthy stream. Topeka Shiners were found at Site T37 (311 in number). Topeka Shiners are associated with lower water temperatures and isolated instream pools influenced by groundwater (Kerns 1999).

Table 51. Bugs, Fish, and Habitat Final Index Values and Suggested Impairment in the Castlewood to Estelline Area

Site	Macroinverts	Fish	Habitat	Suggested Impairment (based on bug data)
R19	57	------	------	Moderate to Severe
T37	63	92	94	Moderate to Severe
T39**	51	------	------	Moderate to Severe
T40**	35	------	------	Severe
T41	*	72	68	------

* dry stream
----- not sampled ** lake outlet

Source Linkage and Conclusion

Fecal Coliform Bacteria Reductions and Sources

Based on modeling and loading calculations, fecal coliform bacteria (Table 52) would need the following reductions at each site:

Table 52. Percent Fecal Coliform Bacteria Reduction in the Castlewood to Estelline Area

Site	Numeric Standard	Fecal % Reduction *(Flow)	Event vs Base Flow
R19	≤ 2000	58% (H)	Both
T37	≤ 2000	99% (H)	Event
T39	NA	-------	NA
T40	≤ 2000	89% (L)	Event
T41	≤ 2000	86% (H), 24% (M)	Both

* Flow Ranges
H=High Flows (0-10%) M=Moist Conditions (10-40%)
MR=Mid-Range Flows (40-60%) D=Dry Conditions (60-90%)
L=Low Flows (90-100%)

The monitoring data shows high fecal concentration during runoff events and at low flows. Potential sources of fecal coliform bacteria would be failing septic systems, pastured livestock, inadequate manure application, and feedlot runoff. According to the feedlot inventory, 66 of the 145 animal feeding operations within this area rated 50 or greater on a 0 to 100 scale. Higher ratings indicate a greater potential of the operation to pollute nearby surface waters. Livestock waste would contribute to the higher fecal counts during runoff events; whereas, livestock in the stream and failing septic systems contribute to the higher fecal counts during low flows. There are six NPDES permitted facilities within the drainage area. One was identified as a point source that discharged during the sampling period; however, no fecal coliform data was documented (Table 38). Reductions in fecal coliform bacteria should focus on non-point sources (See Target Reductions and Future Activity Recommendations Section).

Estelline South

This map (Figure 58) shows the area and location designated as the Estelline South area.

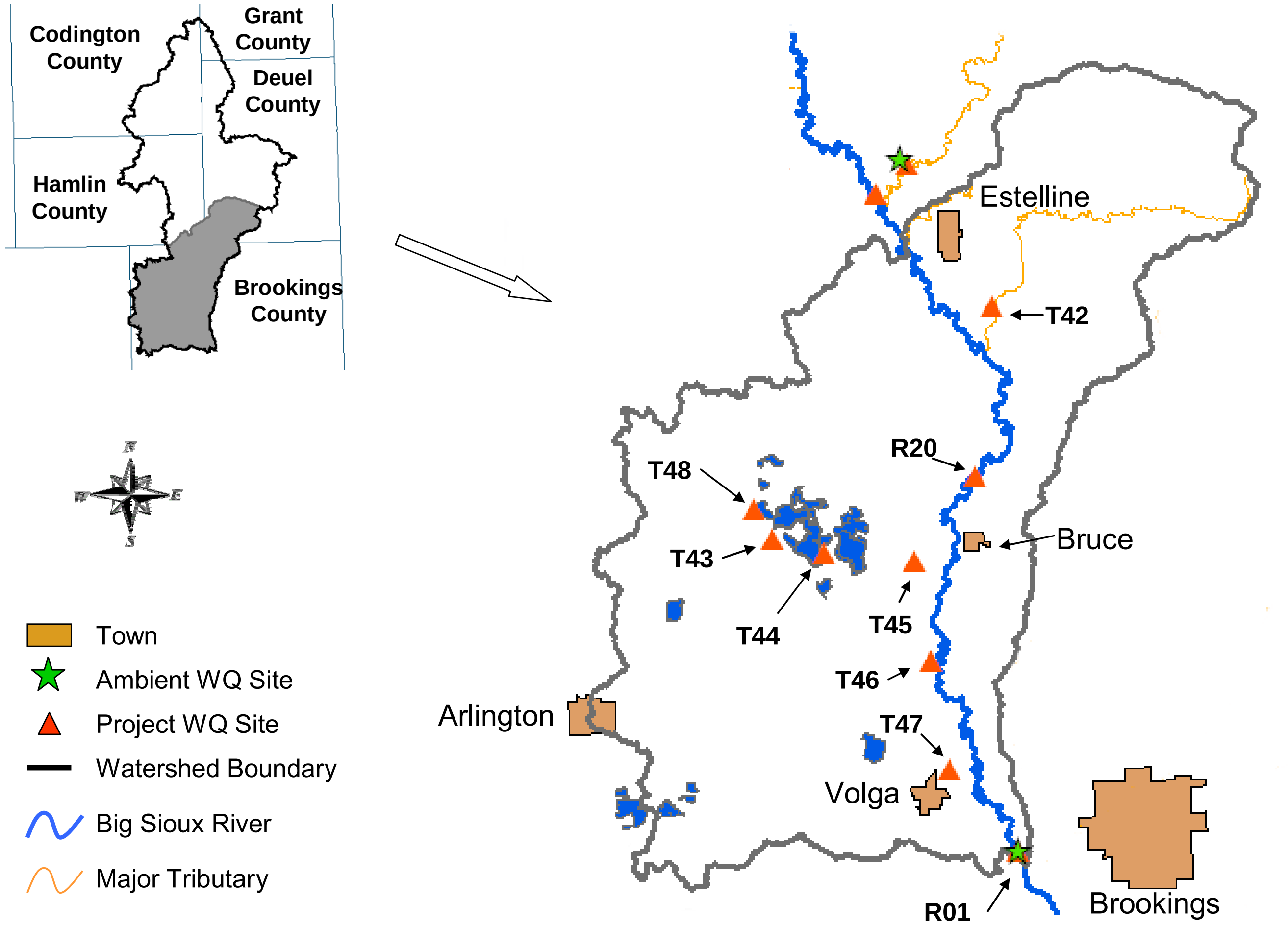


Figure 58. Estelline South Location Map

Land Use Summary

This area includes Peg Munky Run (Site T42), an Unnamed Creek Near Volga (Site T47), and Big Sioux River Sites R20 and R01. The Oakwood Lakes watershed is located in this area and includes inlet and outlet Sites T43, T44, T45, and T48. There is a separate assessment report for the Oakwood chain of lakes that addresses these monitoring sites. The Estelline South area is located in the Northern Glaciated Plains and encompasses approximately 183,043 acres. Land use in the watershed is predominantly agricultural (Figure 59). Approximately 76 percent of the area is cropland, such as corn and soybeans, and 18 percent is grassland and pastureland. There are 130 animal feeding operations in this area, with approximately 89 percent of the livestock consisting of cattle (Figure 60). There are three NPDES permitted facilities located within this watershed (Tables 37 and 38). They include the City of Bruce, the City of Estelline, and the City of Volga.

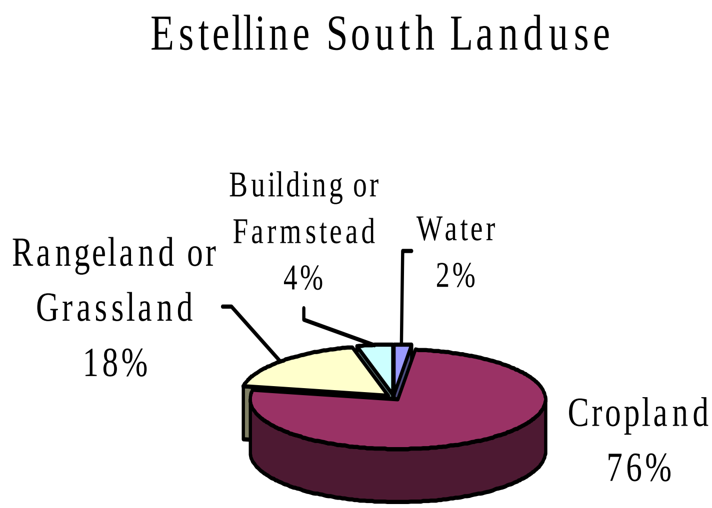


Figure 59. Estelline South Area Landuse

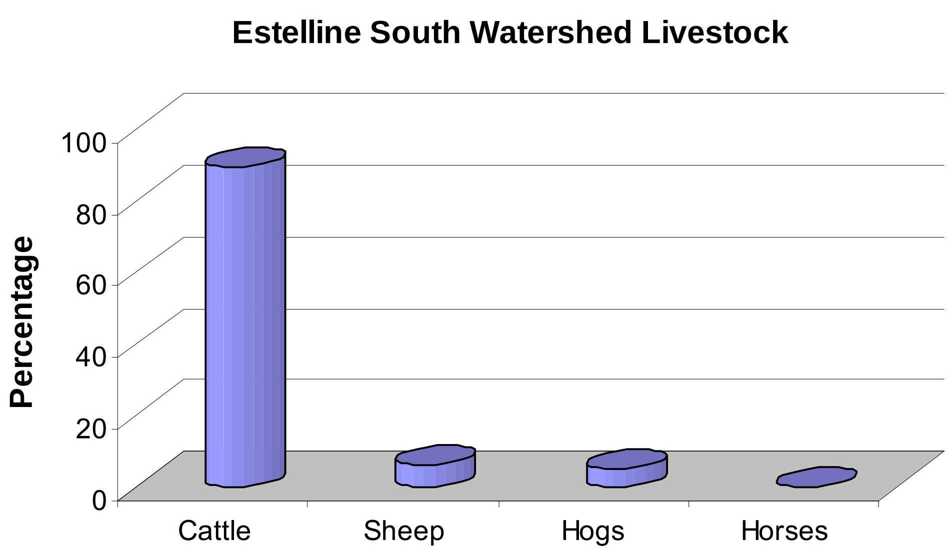


Figure 60. Estelline South Watershed Livestock

Water Quality Summary

Beneficial uses for river sites R20 and R01 are 1, 5, 8, 9, and 10. Peg Munky Run (Site T42) is assigned beneficial uses 6, 8, 9, and 10, and the Unnamed Creek near Volga (T47) is assigned beneficial uses 9 and 10. Table 53 is a summary of the beneficial uses classes assigned to each monitoring site and whether they are meeting or not meeting water quality criteria.

(1) Domestic Water Supply
(5) Warmwater Semi-permanent Fish Life Propagation
(6) Warmwater Marginal Fish Life Propagation
(8) Limited Contact Recreation
(9) Fish and Wildlife Propagation, Recreation and Stock Watering
(10) Irrigation

Table 53. Summary of Beneficial Use Class by Site

	Beneficial Use Class					
Site	**(1)**	**(5)**	**(6)**	**(8)**	**(9)**	**(10)**
R20	✓	✓	-	×	✓	✓
R01	✓	✓	-	✓	✓	✓
T42	-	-	✓	×	✓	✓
T47	-	-	-	-	✓	✓

✓ meeting
- not applicable
× not meeting

Based on the results from the water quality criteria established by DENR as described in the Results Section under Water Quality Monitoring, all the river sites (R20 and R01) are meeting the water quality criteria for beneficial uses (1) Domestic Water Supply, (5) Warmwater Semi-permanent Fish Life Propagation, (9) Fish and Wildlife Propagation, Recreation and Stock Watering, and (10) Irrigation.

Tributary sites T42 and T47 are meeting the water quality criteria for beneficial uses (9) and (10) and T42 is meeting for beneficial use (6).

For beneficial use (8) Limited Contact Recreation, all sites meet the water quality criteria for dissolved oxygen. Site R01 is the only site meeting the water quality criteria for fecal colifom bacteria; all other sites (R20, T47 and T42) are not meeting (Figures 61, 62, and 63). The numeric criteria for dissolved oxygen is $\geq$ 5 mg/L and for fecal coliform bacteria it is $\leq$ 2000 cfu/100mL.

Fecal Coliform Bacteria Results

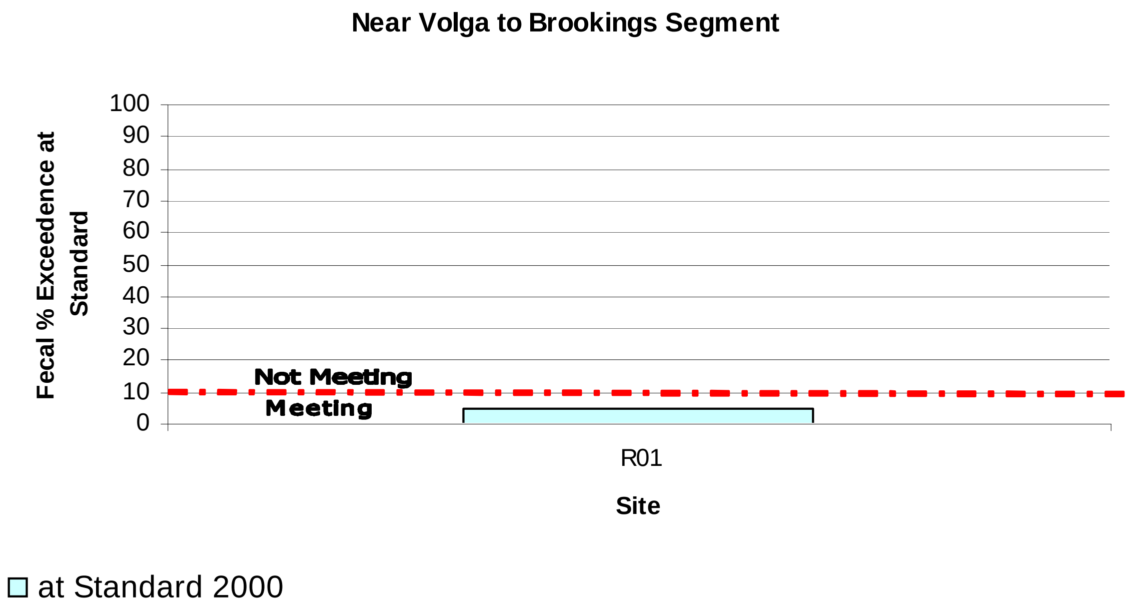


Figure 61. Fecal Coliform Bacteria Percent Exceedence at Standard ≤ 2000cfu/100mL in the Near Volga to Brookings Segment of the Big Sioux River

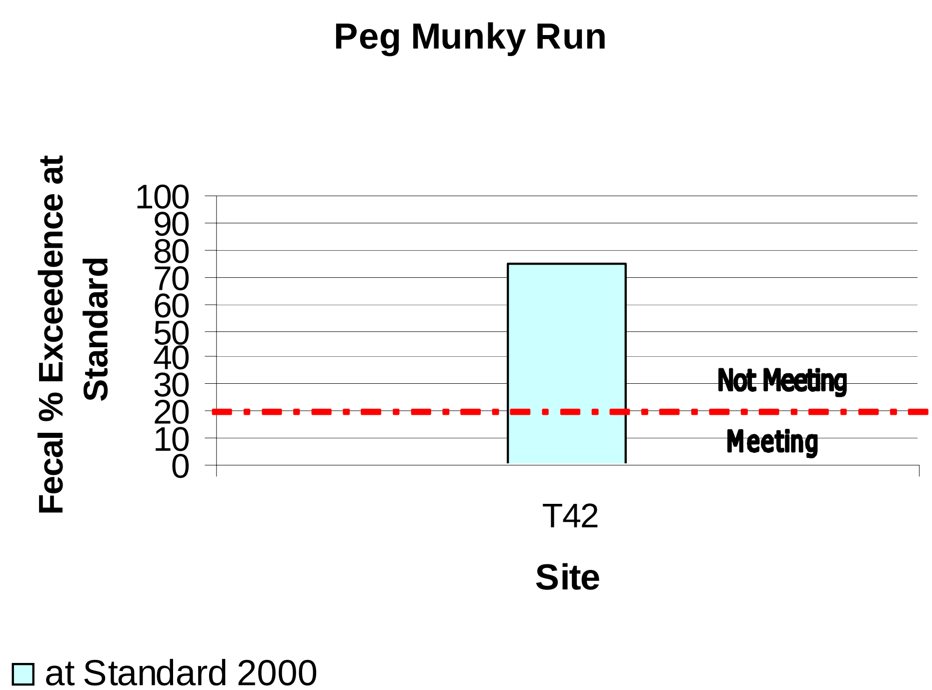


Figure 62. Fecal Coliform Bacteria Percent Exceedence at Standard ≤ 2000cfu/100mL in Peg Munky Run

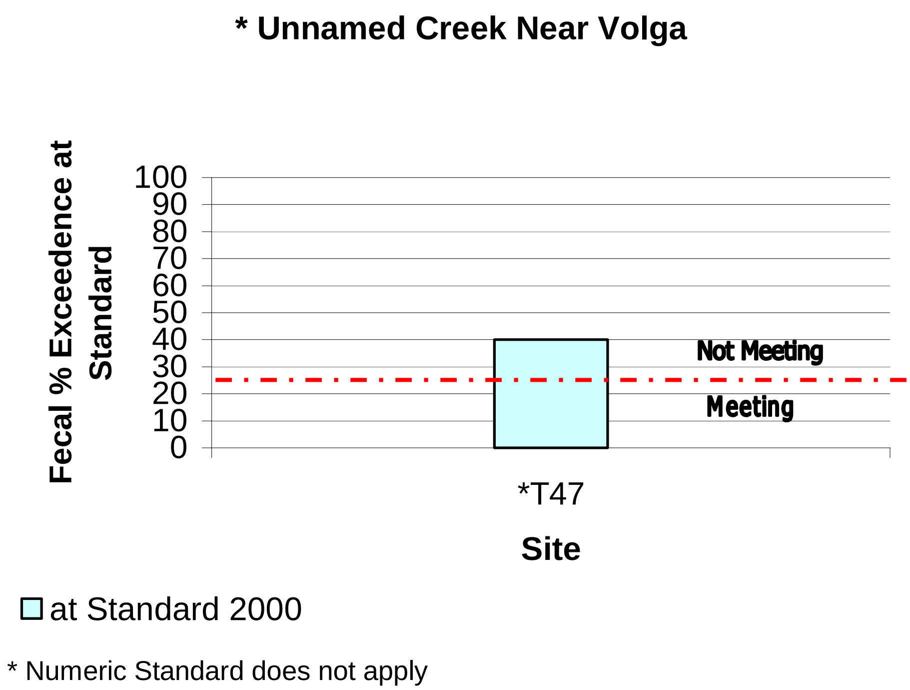
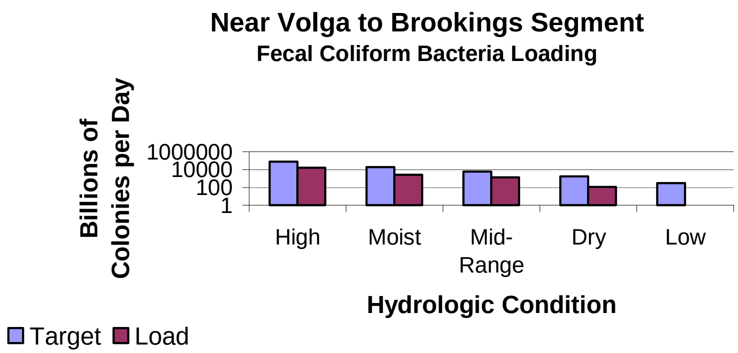
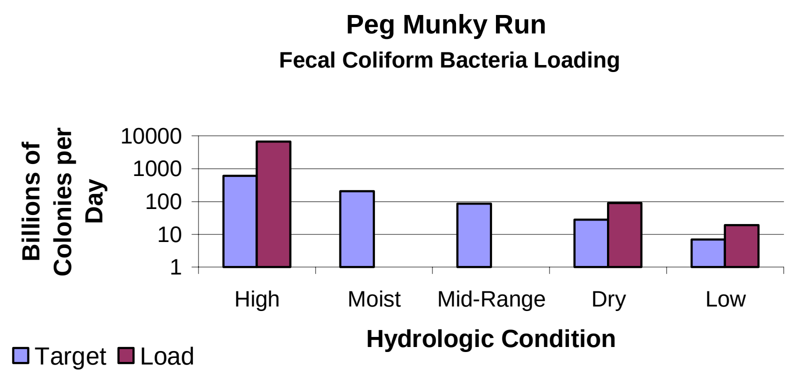


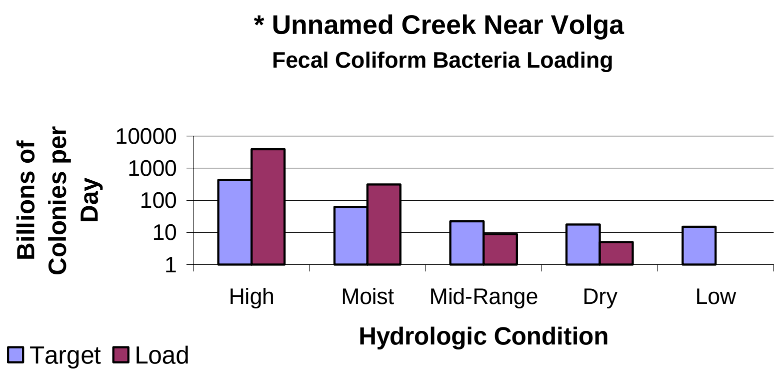
Figure 63. Fecal Coliform Bacteria Percent Exceedence at Standard ≤ 2000cfu/100mL in Unnamed Creek Near Volga

Average daily discharge and seasonal grab sample data were used to construct load duration curves for the Big Sioux River segment Near Volga to Brookings (R01) and also for Peg Munky Run (T42), and the Unnamed Creek Near Volga (T47). These bar charts show the monitored loadings and the allowable target loads within each of the five hydrologic conditions at the ≤ 2000 cfu/100mL water quality standard (Figure 64). Scatterplots of the fecal coliform bacteria grab samples are shown in Figure 65.

Estelline South Area







* Numeric Standard does not apply

Figure 64. Fecal Coliform Bacteria in Billions of Colonies per Day Monitored vs the Standard in the Estelline South Area

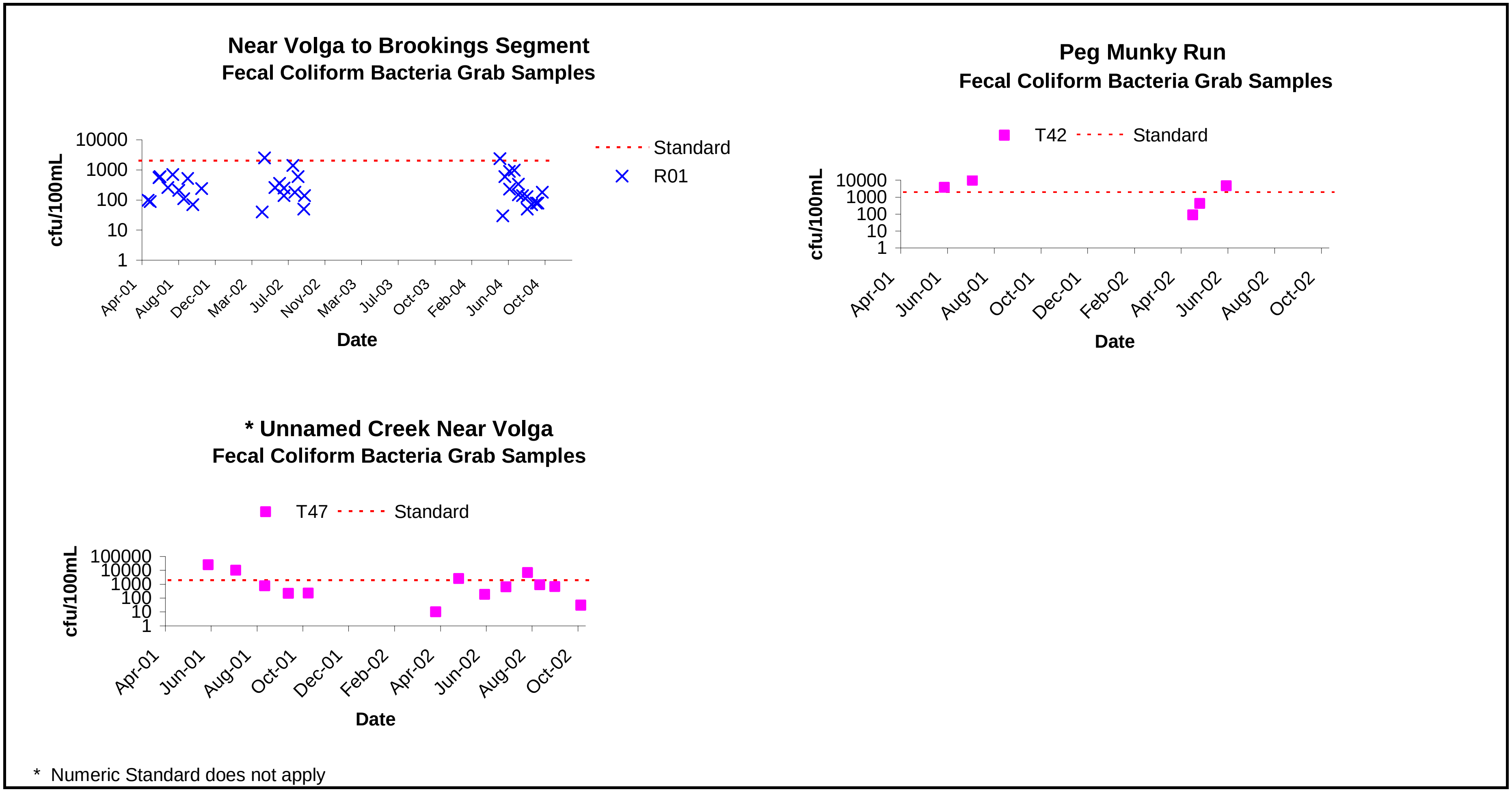


Figure 65. Scatterplot s of Fecal Coliform Bacteria Grab Samples for River Site R01, Peg Munky Run (T42), and the Unnamed Creek Near Volga (T47)

Trends in fecal coliform bacteria are shown in Figure 66. DENR ambient grab sample data for R01 (WQM62) was used to construct these figures. The seasonal (May through Sept) medians for each year, from 1980 to 2004, were calculated. The statistical significance of a trend was determined to occur at an R^2 value of 0.25 or greater, due to the large sample size of 25 years of data.

Figure 66 does not constitute a significant trend, at monitoring site R01, in fecal coliform bacteria with an R^2 = 0.2260. This area is currently meeting the water quality criteria for fecal coliform bacteria. The current trend line seems to indicate a progressive downward trend in fecal coliform bacteria. This site should continue to be monitored for trends over the next several years.

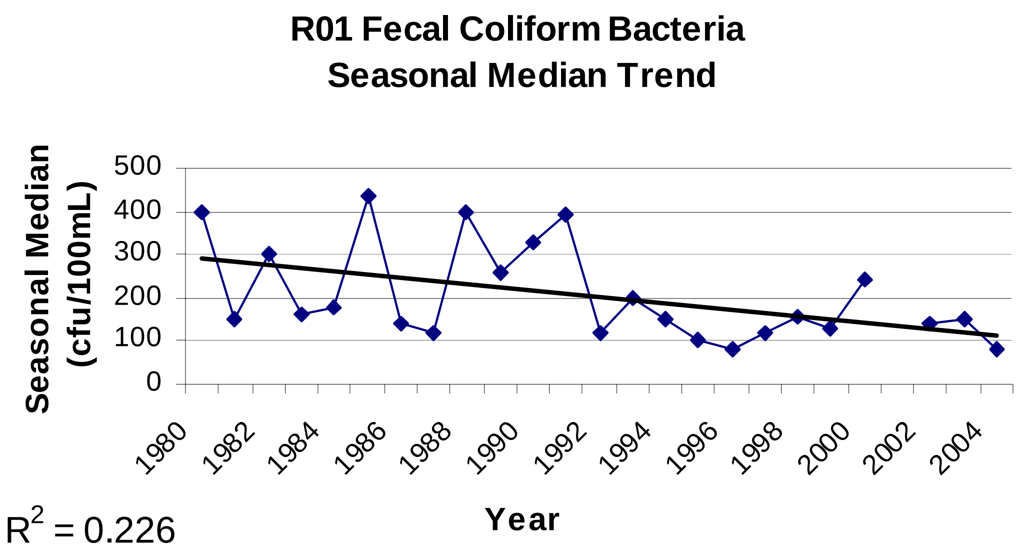
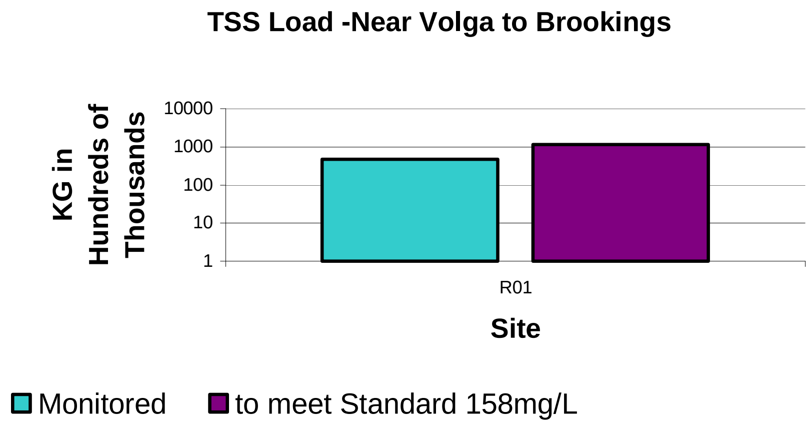


Figure 66. 25-Year Trend (1980-2004) of Yearly Seasonal Medians of Fecal Coliform Bacteria at R01

Total Suspended Solids Results

Of the sites assigned a numeric standard for TSS, there was one exceedence at Site R20 of 314 mg/L, and three exceedences at Site R01 of 182 mg/L, 174 mg/L, and 190 mg/L. Based on FLUX model results, Figure 67 shows the estimated TSS loadings for the Big Sioux River Site (R01), and Peg Munky Run (T32) as compared to the allowable load of ≤ 158 mg/L for the river site and ≤ 263 mg/L for Peg Munky Run. Scatterplots of the TSS grab samples are shown in Figure 68.



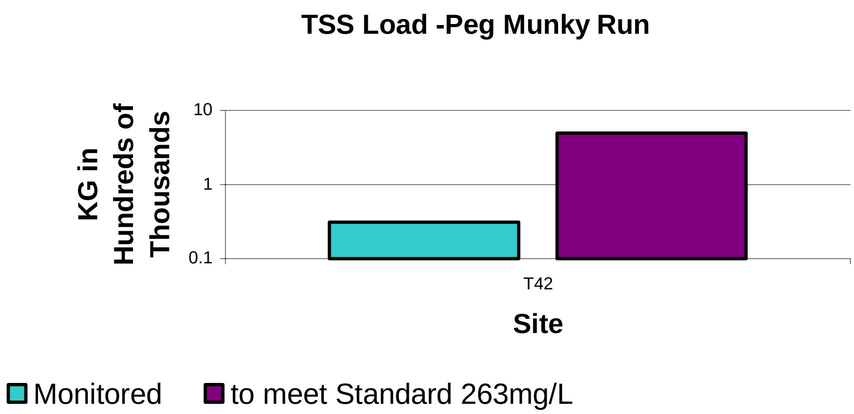
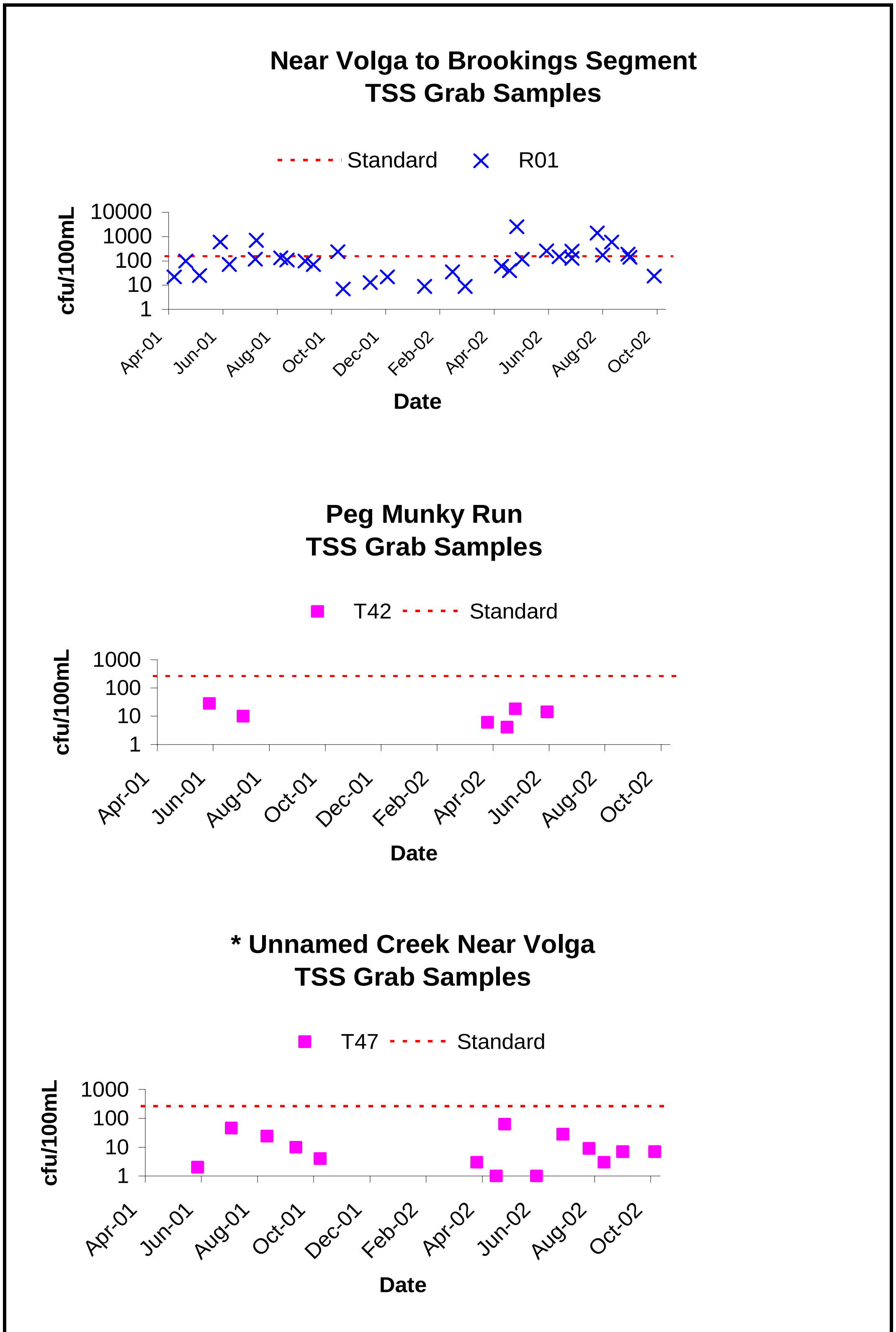


Figure 67. TSS in kg Monitored vs the Standard in the Estelline South Area



* Numeric Standard does not apply

Figure 68. Scatterplots of TSS Grab Samples for River Site R01, Peg Munky Run (T42), and the Unnamed Creek near Volga (T47)

Data Summary

The following table (Table 54) summarizes the ranges of fecal coliform bacteria cfu/100mL, TSS mg/L, and the percent exceedences. It also shows the summer mean of total PO4 mg/L. The summer mean concentrations for total phosphorus at each site fall within the ecoregion mean of 0.25 mg/L (Fandrei et al. 1988).

Table 54. Ranges and Percent Exceedences of Fecal Coliform Bacteria, TSS, and Summer Means of Total PO4 in the Estelline South Area

Site	Fecal cfu/100mL	% fecal exceedence	TSS mg/L	% TSS exceedence	Summer Mean Total PO4 mg/L
R01	nd->2,500	5%	7-190	8%	0.366
R20	80-14,000	18%	6-328	6%	0.338
T42	420-10,000	75%	4-28	0%	0.194
T47	180-25,000	-----	1-62	-----	0.854
-- water quality criteria not applicable					

The summer mean concentrations of total phosphorus at sites R01, R20, and T47 exceed the NGP ecoregion mean of 0.25 mg/L (Fandrei et al. 1988). Site T47 exceeded the ecoregion mean by almost three and half times. These higher numbers can be attributed to sources such as runoff, livestock waste, streambank erosion, commercial fertilizers, and/or construction site erosion.

Biological and Physical Habitat Summary

The only site surveyed for fish and physical habitat in the Estelline South area was Site T42. Macroinvertebrates were collected at all the sites in this area, with the exception of T42, due to dry stream conditions. Biological and physical data suggested impairment. Impairment ranged from minimal to severe (Table 55). Score sheets for each site can be found in Appendix L.

Based on macroinvertebrate collection, Sites R01 and R20 showed the best overall biotic health and the least impairment of the 33 macroinvertebrate samples collected in the NCBSRW. Both locations had a high percentage of EPT and a moderate amount of intolerant taxa. Several species of Ephemeroptera were found at Site R20. In addition, shredders, scrapers, clingers, and filterers were abundant at both locations. HBI's ranged from 4.9 to 5.0 suggesting minimal to moderate impairment (Table 55). Communities at these sites indicate lower silt levels, higher flows, cooler temperatures, and/or more complex substrates.

Suggested impairment for Site T47 was moderate to severe. EPT richness and abundance were low with primarily tolerant Chironomidae, Dipteria, and Oligochaeta present. No intolerant organisms. The dominant organism was Tubificidae which has a tolerance value of 10. This community indicates higher silt levels, lower flows, higher temperatures, and/or impaired habitat/substrate.

Site T42 went dry before macroinvertebrates could be sampled; however fish and physical habitat were assessed. This site ranked fairly high in habitat and good in fish community. Improvements in bank stability and limiting animal vegetation use could improve the physical attributes of this site. Twenty-nine Topeka Shiners were found at Site T42, along with abundant common shiners, creek chubs and stonerollers.

Table 55. Bugs, Fish, and Habitat Final Index Values and Suggested Impairment for the Estelline South Area

Site	Macroinverts	Fish	Habitat	Suggested Impairment (based on bug data)
R01	69	------	------	Minimal to Moderate
R20	71	------	------	Minimal to Moderate
T42	*	81	65	------
T47	65	------	------	Moderate to Severe

----- not sampled
* dry

Source Linkage and Conclusion

Fecal Coliform Bacteria Reductions and Sources

Based on modeling and loading calculations, fecal coliform bacteria (Table 56) would need the following reductions at each site:

Table 56. Percent Fecal Coliform Bacteria Reduction in the Estelline South Area

Site	Numeric Standard	Fecal % Reduction *(Flow)	Event vs Base Flow
R01	≤ 2000	0%	Event
R20	≤ 2000	36% (H)	Event
T42	≤ 2000	92% (H), 72% (D)	Both
T47	NA	-----	-----

-- numeric standard not applicable
* Flow Ranges
H=High Flows (0-10%) M=Moist Conditions (10-40%)
MR=Mid-Range Flows (40-60%)
D=Dry Conditions (60-90%) L=Low Flows (90-100%)

The monitoring data shows high fecal concentration during runoff events and non-event flows. Potential non-background non-point sources of fecal coliform bacteria would be failing septic systems, pastured livestock, inadequate manure application, and feedlot runoff. According to the feedlot inventory, 43 of the 130 animal feeding operations in this area rated 50 or greater on a 0 to 100 scale. Higher ratings indicate a greater potential of the operation to pollute nearby surface waters. Livestock waste would contribute to the higher fecal counts during runoff events; whereas, livestock in the stream and failing septic systems contribute to the higher fecal counts during low flows. There are four known NPDES permitted facilities within the drainage area. Of these four, one was identified as a point source that discharged during the sampling period; however, no fecal coliform data was documented (Table 38). Reductions of fecal coliform bacteria should focus on non-point sources (See Target Reductions and Future Activity Recommendations Section).

WATER QUALITY GOALS

Water quality goals are based on beneficial uses and standards to meet those uses. Based on monitoring results of the Big Sioux River and its tributaries fecal coliform bacteria and dissolved oxygen were the two parameters found not meeting the standards. Willow Creek and Hidewood Creek are the two locations with low dissolved oxygen levels. Both streams drain into the BSR. Round Lake serves as the headwaters for Willow Creek and Clear Lake serves as the headwaters for Hidewood Creek. The goals for these sites are to increase the dissolved oxygen levels by reducing phosphorus loadings and increasing streambank vegetation. These activities should reduce the excessive algae growth and provide shading which will reduce water temperatures. However, as mentioned earlier in the Analysis and Summary Section, future biological oxygen demand (BOD) sampling will need to be accomplished prior to TMDL development.

Based on reducing loadings or concentrations to acceptable levels, goals were established for river segments or tributaries not meeting the fecal coliform bacteria water quality criteria. In order for the river segments and the tributaries to meet the water quality goals for fecal coliform bacteria, a numeric standard of ≤ 2000 cfu/100mL must be applied. Likewise, to meet the water quality goals for dissolved oxygen, concentrations of ≥ 5 will need to be achieved. To meet the goals for dissolved oxygen, concentrations would need to be increased.

Figure 69 shows the percent exceedence of the standard (≤ 2000 cfu/100mL) for fecal coliform bacteria by river or tributary site. The next figure (Figure 70) shows the river segments and major tributaries assigned a fecal coliform bacteria standard and the percent exceedence of that standard. Peg Munky Run, Stray Horse Creek, and Hidewood Creek are the top three violators of the fecal coliform bacteria criteria in the North-Central Big Sioux River watershed.

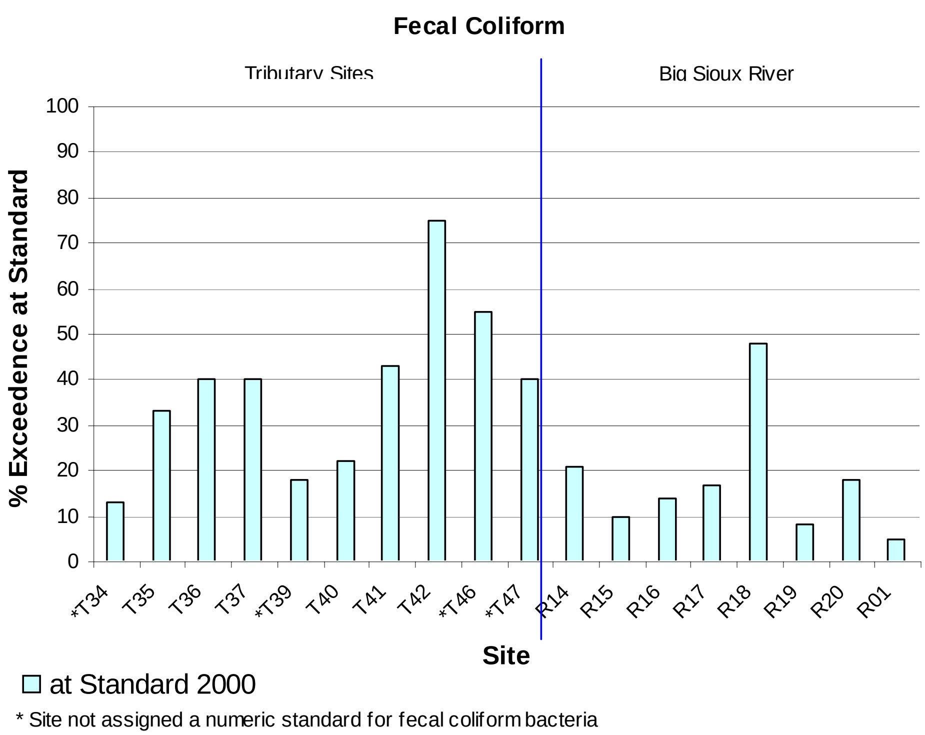


Figure 69. Percent Exceedence of Fecal Coliform Bacteria by Site

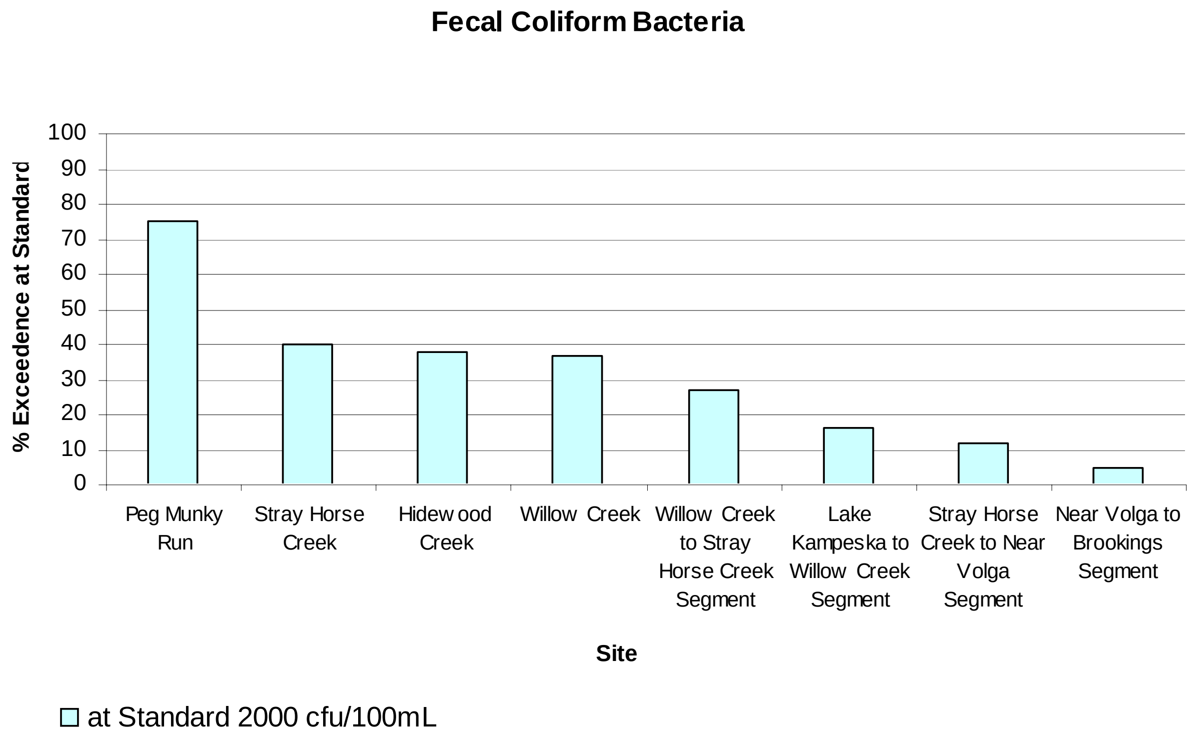
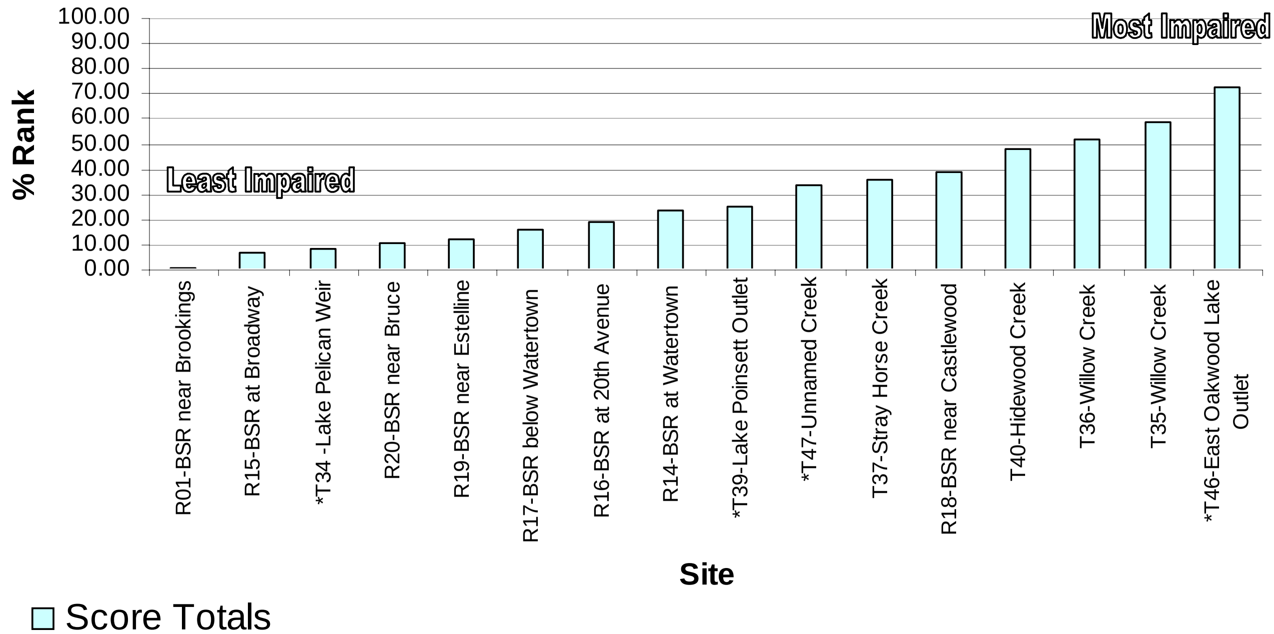


Figure 70. Percent Exceedence of TSS by Big Sioux River Segment or by Major Tributary

Collection of the physical and biological data is important because it helps to show the long-term effects of what is happening in the watershed. Macroinvertebrates and fishes are sensitive to their environments. Thus, biological indicators can be a useful tool in monitoring the health of streams and can ultimately assist in the establishment of management initiatives to help resolve water quality problems throughout the watershed.

To determine relative impairment of a site (least impaired to most impaired), scores from the IBI (macroinvertebrates) and standardized reductions of fecal coliform bacteria were totaled. The site receiving the highest score became the least impaired, and the site receiving the lowest score became the most impaired.

Figure 71 shows the monitoring sites from least to most impaired, based on a percent rank derived from total scores. The only two sites not represented are T41 (Hidewood Creek near Estelline) and T42 (Peg Munky Run) because these streams went dry before macroinvertebrates could be collected. This is unfortunate since T42 seems to be a major violator in fecal coliform bacteria samples. The higher concentrations of fecal coliform bacteria at these sites may be directly related to the low and intermittent stream flows and/or instream cattle.



* Site not assigned a numeric standard for fecal coliform bacteria

Figure 71. Least Impaired to Most Impaired Monitoring Sites

TARGET REDUCTIONS AND FUTURE ACTIVITY RECOMMENDATIONS

The following fecal coliform bacteria priority management table (Table 57) has been categorized into five hydrologic conditions; (1) High Flows, (2) Moist Conditions, (3) Mid-Range Flows, (4) Dry Conditions, and (5) Low Flows. The percent reductions needed for each condition are indicated.

Table 57. Priority Management Table for River Segments and Major Tributaries in the North-Central Big Sioux River Watershed

	Hydrologic Condition				
Major Tributary	**High Flows**	**Moist Conditions**	**Mid-Range Flows**	**Dry Conditions**	**Low Flows**
Willow Creek	----------78%----------			----------5%----------	
Stray Horse Creek	----------99%----------				
Hidewood Creek	----------59%----------				
Peg Munky Run			----------38%----------		
Big Sioux River Segment					
Lake Kampeska to Willow Creek	---------33%---------				
Willow Creek to Stray Horse Creek	---------10%---------				
Stray Horse Creek to Near Volga	--2 grab samples --				

For the purpose of this assessment, TMDLs will be approached on a segment by segment basis, assuming the TMDL of the preceding segment will be reached. Table 58 shows the proposed TMDL list. At this time, seven TMDLs for fecal coliform bacteria are proposed. The reports will focus on the segments that were listed in the 305 (b) Water Quality Assessment, and any others not meeting their water quality criteria. The TMDL reports can be found in Appendices DD through JJ. Figure 72 shows the locations of these impaired waters.

Table 58. Proposed TMDL Listing of Areas Not Meeting Water Quality Criteria

Segment	Affected Sites	Cause	Tributary	Affected Sites	Cause
Lake Kampeska to Willow Creek	R14-R16	Fecal	Willow Creek	T35-T36	Fecal
Willow Creek to Stray Horse Creek	R17-R18	Fecal	Stray Horse Creek	T37	Fecal
Stray Horse Creek to Near Volga	R19-R20	Fecal	Hidewood Creek	T40-T41	Fecal
			Peg Munky Run	T42	Fecal

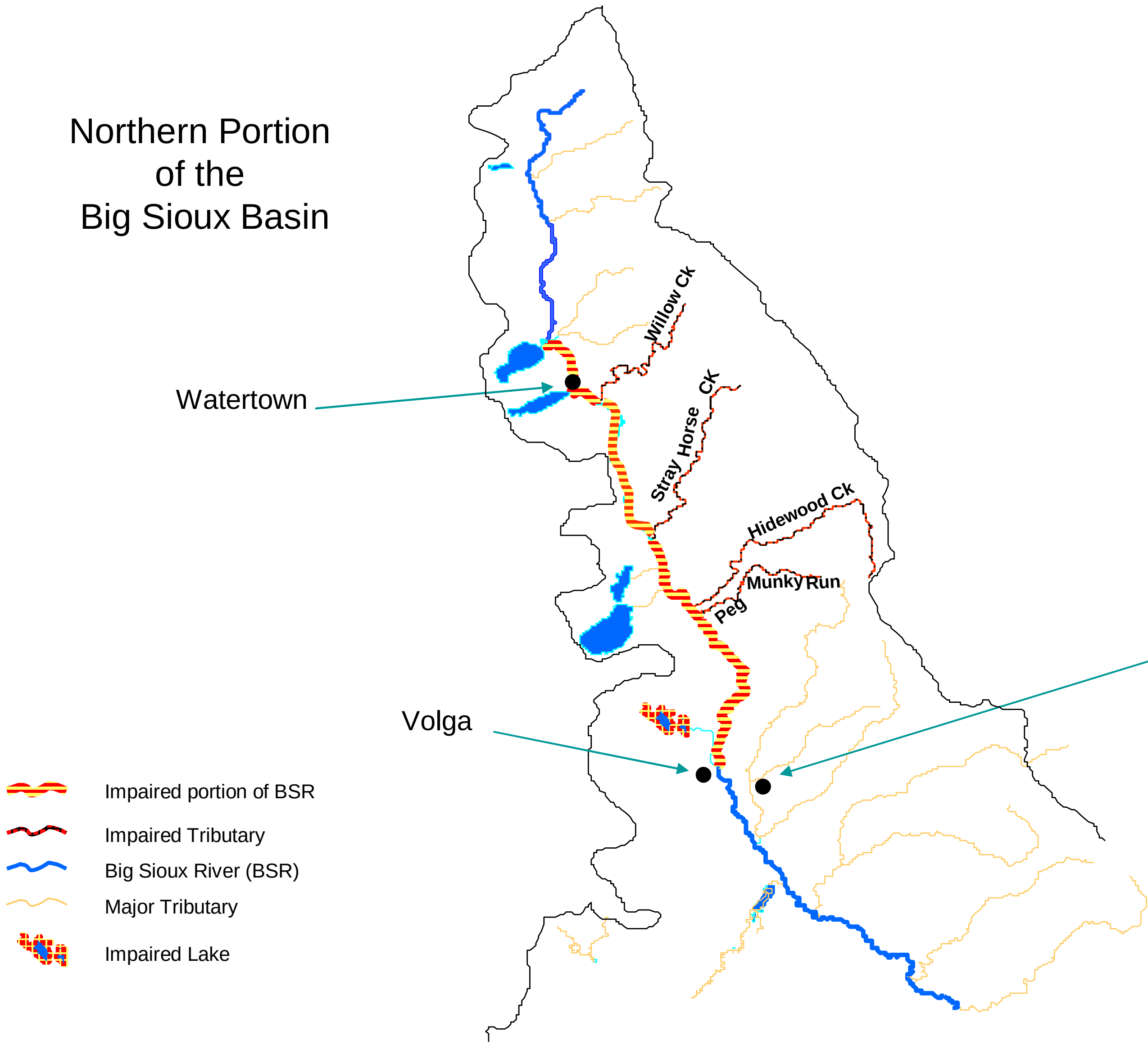


Figure 72. Targeted TMDL for the Big Sioux River Segments, Major Tributaries, and Lakes

BEST MANAGEMENT PRACTICES

Table 59 contains a recommended list of reductions that were selected based on fecal coliform bacteria and nutrients needed for each site. Nutrients are listed because they are directly correlated to the reductions of fecal and TSS.

Table 59. Best Management Practices for Fecal Coliform Bacteria and Nutrient Problems

BMP	Fecal	Nutrients	Potential Reduction
(1) Feedlot Runoff Containment	X	X	High
(2) Manure Management	X	X	High
(3) Grazing Management	X	X	Moderate
(4) Alternative Livestock Watering	X	X	Moderate
(5) Contour Farming		X	Moderate
(6) Contour Strip Farming		X	High
(7) Terracing		X	High
(8) Conservation Tillage (30% residue)		X	Moderate
(9) No Till		X	High
(10) Grassed Waterways		X	Moderate
(11) Buffer/Filter Strips	X	X	Moderate
(12) Commercial Fertilizer Management		X	Moderate
(13) Streambank Stabilization		X	High
(14) Urban Runoff Controls			
(14a) Pet Waste Control	X	X	High
(14b) Lawn Fertilizer Control		X	High
(14c) Construction Erosion Control		X	High
(14d) Street Sweeping		X	High
(14e) Stormwater Ponds	X	X	High
(15) Wetland Restoration or Creation	X	X	High
(16) Riparian Vegetation Restoration	X	X	High
(17) Conservation Easements	X	X	High
(18) Livestock Exclusion	X	X	High

Note: approximate range of reductions:
Low = 0-25% Moderate = 25-75% High = 75-100%

Most of these BMPs are further explained in Table 60 with an explanation of the benefits of using a particular BMP and the reduction that can be achieved when put to use. This table was adapted from an MPCA sources (MPCA 1990).

Table 60. Percent Reduction Achievable by Best Management Practice

BMP	Benefits	Achievable Reduction
Manure Management	• Reduces Nutrient Runoff • Significant Source of Fertilizer	50-100% reduction of nutrient runoff
Buffer/Filter Strips	• Controls sediment, phosphorus, nitrogen, organic matter, and pathogens	50% sediment and nutrient delivery reduction
Conservation Tillage	• Reduces runoff • Reduces wind erosion • More efficient in use of labor, time, fuel, and equipment	30-70% pollutant reduction 50% nutrient loss reduction (depends on residue and direction of rows and contours)
Contouring	• Control erosion of cropland and pasture • Reduces runoff and conserves moisture • Can increase yields	30-50% erosion reduction 25% nutrient reduction 10-50% runoff reduction (based on 2-12 % slope)
Confinement Ponds	• Sediment/nutrient reduction • Reduction in peak flow runoff • Increase in wildlife habitat	60-90% sediment trapping 10-40% nutrient trapping
Fencing	• Reduces erosion • Increases vegetation • Stabilized banks • Improves aquatic habitat	Up to 70% erosion reduction
Grassed Waterways	• Reduces gulley and channel erosion • Reduces sediment associated nutrient runoff • Increases wildlife habitat	10-50% sediment delivery reduction (broad) 0-10% sediment deliver reduction (narrow)
Strip Cropping	• Reduces erosion and sediment loss • Reduces field loss of sediment associated nutrients	High quality sod strips filter out 75% of eroded soil from cultivated strips
Terraces with Contours	• High reduction of erosion • Reduces loss of sediment associated nutrients	50-100% sediment reduction 25-45% nutrient reduction (2-12 degree slopes)

FECAL COLIFORM BACTERIA BMP RECOMMENDATIONS BY HYDROLOGIC CONDITION

The options necessary to meet the goals of beneficial use (8) Limited Contact Recreation for the Big Sioux River segments as well as for the major tributaries include 1) ensuring the proposed TMDLs will meet the goals, and/or 2) ensuring the tributaries within the watershed are supporting the goals of the Big Sioux River and if they are not, then an evaluation of their standards may be necessary.

Table 61 breaks down the five hydrologic conditions and the possible sources of fecal coliform bacteria and the recommended management practices to help reduce loads. High flow is representative of conditions when precipitation intensity exceeds the rate of water infiltration into the soil, and which may eventually cause flooding. Moist conditions are representative of those periods when the soils are already saturated and where runoff is occurring. Mid-range flows are representative of subsequent rain events, and of a time when saturation is beginning to lessen. Dry conditions are representative of those times when rain is sparse, although may still occur. Low flows are representative of conditions when rain is absent and when there is a drought or drought-like situation.

Table 61. Recommended Management Practices for Fecal Coliform Bacteria Reduction by Hydrological Condition

Hydrologic Condition	Source of Pollutant	Possible Contributing Source Areas	Recommended Management Practices
High Flows (0-10)	*Nonpoint Source*	**Absent/Poor Riparian Areas**	**Riparian buffers**- riparian forest buffers, filter strips, grassed waterways, shelterbelts, field windbreaks, living snow fences, contour grass strips, wetland restoration
		Sewer System Overflows/Stormwater	**Sewer and NPDES Inspection**
		Manure Runoff/Concentrated Feedlots	**Feedlot Runoff Containment**
Moist Conditions (10-40)	*Nonpoint Source*	**Absent/Poor Riparian Areas**	**Riparian buffers**- riparian forest buffers, filter strips, grassed waterways, shelterbelts, field windbreaks, living snow fences, contour grass strips, wetland restoration
		Incorrect Land Application of Livestock waste	**Fertilizer Management**
		Livestock In-stream	**Alternative Livestock Watering**
		Manure Runoff/Concentrated Feedlots	**Feedlot Runoff Containment**
		Pastured Livestock	**Fencing, Channel crossing, Grazing Management**
		Sewer System Overflows/Stormwater	**Sewer and NPDES Inspection**
		Urban Runoff	**Pet Waste Management**

Table 61 continued

Hydrologic Condition	Source of Pollutant	Possible Contributing Source Areas	Recommended Management Practices
Mid-range Flows (40-60)	*Nonpoint Source*	**Absent/Poor Riparian Areas**	**Riparian buffers**- riparian forest buffers, filter strips, grassed waterways, shelterbelts, field windbreaks, living snow fences, contour grass strips, wetland restoration
		Incorrect Land Application of Livestock Waste	**Fertilizer Management**
		Livestock In-Stream	**Fencing, Channel crossing, Alternative Livestock Watering**
		Manure Runoff/Concentrated Feedlots Pastured Livestock	**Feedlot Runoff Containment Grazing Management**
		Urban Runoff	**Pet Waste Management**
Dry Conditions (60-90)	*Nonpoint/Point Source*	**Absent/Poor Riparian Areas**	**Riparian buffers**- riparian forest buffers, filter strips, grassed waterways, shelterbelts, field windbreaks, living snow fences, contour grass strips, wetland restoration
		Discharge from Wastewater Treatment Plants or Industries	**Point Source Inspection**
		Incorrect Land Application of Livestock Waste	**Fertilizer Management**
		Livestock In-Stream	**Fencing, Channel Crossing, Alternative Livestock Watering**
		Manure Runoff/Concentrated Feedlots	**Feedlot Runoff Containment**
		Pastured Livestock	**Grazing Management**
		Septic System Failure	**Septic System Inspection**

Table 61 continued

Hydrologic Condition	Source of Pollutant	Possible Contributing Source Areas	Recommended Management Practices
Low Flows (90-100)	*Point Source*	**Discharge from Wastewater Treatment Plants or Industries**	**Point Source Inspection**
		Livestock In-Stream	**Fencing, Channel Crossing, Alternative Livestock Watering**
		Manure Runoff/Concentrated Feedlots	**Feedlot Runoff Containment**
		Pastured Livestock	**Grazing Management**
		Septic System Failure	**Septic System Inspection**
		Straight-Pipe Septic Systems	**Septic System Replacement**

Furthermore, BMPs for fecal coliform bacteria reduction can be found on the BMP table (Table 59). A combination of BMPs from this table could be applied to achieve the fecal coliform bacteria reductions with the exception of 5-10, 12, 13, 14b, 14c, and 14d (See Appendix V for fecal coliform bacteria loadings and reductions). Monitoring locations requiring immediate attention within each hydrologic condition is discussed.

High Flows

Probable sources of fecal coliform bacteria within the high flows hydrologic condition may be related to absent or poor riparian areas, stormwater runoff, feedlot runoff, and overflowing sewer systems (Table 61). Exceedences contributing to the fecal coliform bacteria problems during the high flows are occurring during rain events. The applicable BMPs for these areas may be 1, 2, 11, 14e, 15, 16, and 17 (Table 59). The higher percentages of reductions are needed in the high flow hydrologic condition (Table 61). Six of the seven river and tributary segments need reductions in high flows.

Moist Conditions

Probable sources of fecal coliform bacteria within the moist conditions hydrologic condition may be related to absent or poor riparian areas, stormwater runoff, overflowing sewer systems, urban runoff, incorrect land application of livestock waste, in-stream livestock, pastured livestock, and concentrated feedlots (Table 61). The applicable BMPs for these areas may be 1, 2, 3, 4, 11, 15, 16, 17 and 18 (Table 59).

Mid-Range Flows

Probable sources of fecal coliform bacteria within the mid-range flows hydrologic condition may be related to absent or poor riparian areas, urban runoff, incorrect land application of livestock waste, in-stream livestock, pastured livestock, and concentrated feedlots (Table 61). The applicable BMPs for this area may be 1, 2, 3, 4, 11, 16, 17 and 18 (Table 59). Fencing, channel crossing, alternative livestock watering, and grazing management are recommended for those sites affected by non-rain periods.

Dry Conditions

Probable sources of fecal coliform bacteria within the dry conditions hydrologic condition may be related to absent or poor riparian areas, incorrect land application of livestock waste, in-stream livestock, pastured livestock, concentrated feedlots, discharge from wastewater treatment plants, and septic system failure (Table 61). Applicable BMPs for these areas may be 2, 3, 4, and 18 (Table 59). Fencing, channel crossing, alternative livestock watering, and grazing management are recommended for those sites affected by non-rain periods.

Low Flows

Probable sources of fecal coliform bacteria within the low flow hydrologic condition may be related to in-stream livestock, concentrated feedlots, discharge from wastewater treatment plants, straight pipes, and septic system failure (Table 61). The applicable BMPs for this area may be 2, 3, 4, and 18 (Table 59). Willow Creek and Peg Munky Run indicated problems during low flows and during non-rain periods. This may indicate problems septic leakage and/or in-stream livestock. Fencing, channel crossing, alternative livestock watering, and grazing management are recommended.

PUBLIC INVOLVEMENT AND COORDINATION

STATE AGENCIES

The SD DENR was the primary state agency involved in the completion of this assessment. They provided equipment as well as technical assistance throughout the project. They also provided ambient water quality data for several of the Big Sioux River sites.

FEDERAL AGENCIES

The Environmental Protection Agency (EPA) provided the primary source of funds for the completion of the assessment of the Big Sioux River watershed.

The United States Geological Survey (USGS) provided historical stream flow data for the watershed.

The Natural Resource Conservation Service (NRCS) provided technical assistance

LOCAL GOVERNMENTS, OTHER GROUPS, AND GENERAL PUBLIC

The EDWDD provided the sponsorship that made this project possible on a local basis. In addition to providing administrative sponsorship, EDWDD also provided local matching funds and personnel to complete the assessment.

Public involvement consisted of individual meetings with landowners that provided a great deal of historic perspective on the watershed.

OTHER SOURCES OF FUNDS

In addition to funds supplied by the East Dakota Water Development District (EDWDD) and the Environmental Protection Agency (EPA), financial support was provided by the Brookings County Conservation District (BCCD) and the South Dakota Conservation Commission (SDCC). The inventory of the animal feeding operations (AFOs) and assessment of the potential environmental risk posed by each was work completed by BCCD using these funds in support of the overall project. The inventory and assessment of the AFOs was funded by EPA 319, EDWDD, and the SDCC grant.

ASPECTS OF THE PROJECT THAT DID NOT WORK WELL

Most of the objectives proposed for the project were met in an acceptable fashion and in a reasonable time frame. Due to delays in obtaining a properly working AnnAGNPS program and delays in receiving water quality results from the WRI lab, the related tasks of this project fell behind schedule. Additionally, another sizeable 319 funded watershed assessment project was being completed as the same time this project was beginning. East Oakwood Lake was included as part of the North-Central Big Sioux Watershed Assessment Project. Three years into this project, two additional lakes were added and needed to be sufficiently assessed. It was decided in 2006 that a separate assessment report be written for these lakes.

The fish and macroinvertebrate sampling would have told us more if we could have sampled during each year of the project or at least twice in the one year it was done. Many of the sites chosen were very intermittent and became dry before fish and/or macroinvertebrates could be collected. Macroinvertebrates were not collected until mid-October making it difficult to compare bugs with the fecal coliform data, as the standards only apply during May through September.

Rock baskets may be misleading to the types of macroinvertebrates inhabiting a stream at a particular site. It would only be valuable if the substrate of that stream included rocks. For example, a rock basket within a silt-bottom stream may collect bugs that are not typically seen or inhabit that area of the stream due to rocks not ordinarily being in the area. Another more effective method of sampling macroinvertebrates in these heavily silted streams should have been used (i.e. D-net sampler).

Many of the monitoring sites are classified as intermittent streams and yielded very few fecal coliform results before they went dry. Perhaps additional monthly sampling should have been scheduled on these more intermittent streams.

Sampling and analysis methods could be improved in future projects by

- coordinating macroinvertebrate, fish, and water sampling
- sampling more than once for fish and macroinvertebrates through the project period
- determining if rock baskets are adequate for sampling sites with a bed substrate of silt or clay
- separating and analyzing the data by subwatershed level or by stream order
- increasing the number of instantaneous discharge measurements at ungaged sites
- having reference sites to compare data to

Overall, taking into consideration the size of this project, the assessment went as well as expected.

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Appendix A.
Monitoring Site Locations

North-Central Big Sioux River Watershed Assessment Project
Water Quality Sampling/Stream Gaging Sites

Location Number	*Descriptive Name*	*Latitude*	*Longitude*	*WQ Samples*	*Gaging Station*	*Miscellaneous Information*
R14	Big Sioux River at Watertown	44 56 30	097 08 50	Yes	Yes	DENR WQM Station 55, USGS Gage 06479500
R15	BSR @ Broadway @ Watertown	44 53 22	097 07 07	Yes	Yes	USGS Gage 06479512
R16	BSR @ 20th Avenue @ Watertown	44 52 36	097 05 51	Yes	Yes	
R17	Big Sioux River below Watertown	44 50 32	097 02 57	Yes	Yes	DENR WQM Station 1, USGS Gage 06479520
R18	Big Sioux River near Castlewood	44 43 54	097 02 39	Yes	Yes	USGS Gage 06479525
R19	Big Sioux River near Estelline	44 34 25	096 55 45	Yes	No	DENR WQM Station 8
R20	Big Sioux River near Bruce	44 25 40	096 54 15	Yes	Yes	Planned USGS Gage 06479770
R1	Big Sioux River near Brookings	44 17 50	096 52 04	Yes	No	DENR WQM Station 62
T34	Lake Pelican Outlet Weir	44 53 24	097 07 28	Yes	Yes	City of Watertown Gage
T35	Willow Creek near Waverly	44 57 57	096 52 55	Yes	Yes	
T36	Willow Creek near Watertown	44 55 08	097 02 43	Yes	Yes	USGS Station 06479515
T37	Stray Horse Creek near Castlewood	44 43 52	096 57 23	Yes	Yes	Former USGS Station 06479529
T38	Boswell Diversion Ditch	44 38 15	097 01 35	Yes	Yes	Discontinued Site due to inoperable diversion gates
T39	Lake Poinsett outlet	44 36 05	097 00 45	Yes	Yes	Former Lake Poinsett assessment site
T40	Hidewood Creek near Clear Lake	44 44 50	096 40 10	Yes	Yes	
T41	Hidewood Creek near Estelline	44 36 42	096 54 17	Yes	Yes	Former USGS Station 06479640
T42	Peg Munky Run near Estelline	44 34 22	096 51 15	Yes	Yes	Former USGS Station 06479750
T46	East Oakwood Lake outlet creek II	44 23 05	096 55 05	Yes	Yes	Former DENR WQM site
T47	Unnnamed creek near Volga	44 20 05	096 54 30	Yes	Yes	

Appendix B.
WQ Grab Sample Data

North-Central Big Sioux River Watershed Water Quality - - 2001 through 2002

Site	Site Name	Date	Time	Lab#	Runoff?	Water Temp C˚	Air Temp C˚	Conductivity µs/cm	Specific Conductivity µs/cm	Salinity ppt	Dissolved Oxygen mg/L	pH units	Turbidity NTU	Fecal Coliform cfu/100mL	TSS mg/L	Tot Solids mg/L	Dissolved Solids mg/L	Nitrates mg/L	Ammonia mg/L	Organic Nitrogen mg/L	TKN mg/L	Tot PO4 mg/L	TotDis PO4 mg/L
T34	Lake Pelican Weir	07/25/01	1045	01-6310	Y	24.8	24.5	587	588	0.3	9.9	8.7	19	<100	25	425	400	0.038	0.077	1.710	1.787	0.160	0.036
T34	Lake Pelican Weir	08/27/01	1100	01-6324	N	23.3	24.5	775	803	0.4	6.3	7.7	16	110	20	544	524	0.244	0.301	1.292	1.593	0.219	0.125
T34	Lake Pelican Weir	09/27/01	1020	01-6398	N	14.1	17.0	571	718	0.4	11.5	8.0	10	270	10	482	472	0.262	0.142	0.580	0.722	0.119	0.103
T34	Lake Pelican Weir	10/22/01	1230	01-6444	N	9.9	15.0	505	718	0.4	11.5	8.3	7	20	6	390	384	0.232	0.076	0.430	0.506	0.038	0.021
T34	Lake Pelican Weir	04/09/02	1200	02-6021	N	5.2	9.8	330	528	0.3	19.5	8.5	5	<10	12	380	368	0.119	0.059	1.090	1.149	0.122	0.068
T34	Lake Pelican Weir	04/30/02	1115	02-6043	Y	10.4	13.0	512	708	0.3	17.3	8.4	11	<10	24	512	488	0.047	0.059	0.834	0.893	0.107	0.030
T34	Lake Pelican Weir	05/09/02	1245	02-6080	Y	7.0	4.8	455	692	0.3	16.9	8.4	10	30	24	476	452	0.068	0.199	0.982	1.181	0.112	0.020
T34	Lake Pelican Weir	06/10/02	1045	02-6096	N	22.2	25.0	627	663	0.3	6.4	8.3	17	290	40	424	384	0.084	0.166	1.140	1.306	0.149	0.083
T34	Lake Pelican Weir	07/08/02	1135	02-6127	N	27.3	27.0	644	616	0.3	4.5	8.1	18	-----	30	450	420	0.096	0.312	1.351	1.663	0.197	0.137
T34	Lake Pelican Weir	08/07/02	1030	02-6169	Y	23.0	24.5	610	635	0.3	9.3	8.3	23	400	26	472	446	0.791	0.098	1.125	1.223	0.125	0.030
T34	Lake Pelican Weir	08/21/02	1100	02-6187	Y	18.8	22.5	274	311	0.2	7.4	7.8	45	8000	28	240	212	0.423	0.355	0.742	1.097	0.242	0.132
T34	Lake Pelican Weir	09/09/02	1145	02-6209	N	22.8	26.3	774	806	0.4	7.4	8.0	22	200	15	539	524	0.360	0.090	0.618	0.708	0.062	0.023
T34	Lake Pelican Weir	10/17/02	1115	02-6250	N	7.5	5.0	506	760	0.4	7.5	------	4	10	11	471	460	0.519	0.083	0.747	0.830	0.048	0.032
T35	Willow Creek (nr Waverly)	06/14/01	1100	01-6216	Y	20.0	15.0	473	522	0.3	4.6	8.0	7	200	2	357	355	0.056	0.102	1.080	1.182	0.159	0.100
T35	Willow Creek (nr Waverly)	07/24/01	1030	01-6301	Y	23.3	19.0	498	514	0.2	3.2	8.2	9	500	8	360	352	0.036	0.080	1.205	1.285	0.122	0.089
T35	Willow Creek (nr Waverly)	08/27/01	1000	01-6322	N	20.9	29.0	494	540	0.3	4.2	8.6	24	4400	37	409	372	0.040	0.104	1.900	2.004	0.224	0.138
T35	Willow Creek (nr Waverly)	09/26/01	1100	01-6393	N	12.7	20.0	454	596	0.3	13.8	8.7	7	1000	10	430	420	0.029	0.143	1.371	1.514	1.679	0.124
T35	Willow Creek (nr Waverly)	10/22/01	1030	01-6442	N	6.8	14.0	430	664	0.3	13.7	8.4	12	3600	13	513	500	0.110	0.288	1.468	1.756	0.210	0.172
T35	Willow Creek (nr Waverly)	04/09/02	1045	02-6018	N	2.7	8.0	206	359	0.2	14.2	7.8	2	<10	6	222	216	0.153	0.150	0.883	1.033	0.181	0.132
T35	Willow Creek (nr Waverly)	04/30/02	1000	02-6039	Y	7.8	12.5	396	590	0.3	16.8	8.3	6	10	10	434	424	0.071	0.120	1.041	1.161	0.088	0.065
T35	Willow Creek (nr Waverly)	05/09/02	1100	02-6077	Y	5.9	10.5	387	611	0.3	17.6	8.6	9	110	27	439	412	0.067	0.070	1.121	1.191	0.103	0.055
T35	Willow Creek (nr Waverly)	06/10/02	1000	02-6093	N	21.2	22.5	582	627	0.3	10.2	8.5	4	290	19	383	364	0.046	0.100	1.186	1.286	0.081	0.053
T35	Willow Creek (nr Waverly)	07/08/02	945	02-6125	N	23.4	21.0	520	536	0.3	5.5	8.5	6	-----	14	410	396	0.050	0.156	1.072	1.228	0.079	0.071
T35	Willow Creek (nr Waverly)	08/07/02	910	02-6166	Y	20.8	26.0	504	549	0.3	7.4	8.1	22	1300	23	475	452	0.070	0.408	1.956	2.364	0.156	0.033
T35	Willow Creek (nr Waverly)	08/21/02	915	02-6184	Y	18.0	22.0	229	265	0.1	9.5	7.4	55	930000	26	274	248	0.900	0.366	2.726	3.092	1.562	1.341
T35	Willow Creek (nr Waverly)	09/09/02	1000	02-6206	N	19.9	18.9	479	531	0.3	3.2	8.1	100	28000	56	420	364	0.060	0.583	2.076	2.659	0.280	0.111
T35	Willow Creek (nr Waverly)	10/17/02	945	02-6245	N	3.8	4.0	366	618	0.3	9.8	------	12	700	23	471	448	0.132	0.218	1.260	1.478	0.110	0.080
T36	Willow Creek (nr Watertown)	04/08/01	1400	01-6040	Y	1.1	10.0	118	------	0.1	5.3	7.7	75	1700	202	390	188	1.344	0.808	2.467	3.275	0.792	0.404
T36	Willow Creek (nr Watertown)	04/13/01	915	01-6072	Y	4.3	12.0	294	485	0.2	5.8	7.7	25	1000	50	345	295	2.022	0.740	1.609	2.349	0.562	0.389
T36	Willow Creek (nr Watertown)	05/08/01	920	01-6151	Y	10.8	12.0	433	594	0.3	8.1	8.1	8	1800	13	437	424	0.564	0.125	1.166	1.291	0.218	0.208
T36	Willow Creek (nr Watertown)	06/14/01	1130	01-6217	Y	19.5	16.0	761	849	0.4	5.3	8.1	10	12000	9	619	610	0.335	0.316	1.355	1.671	0.297	0.260
T36	Willow Creek (nr Watertown)	07/20/01	1215	01-6284	Y	24.2	24.0	714	725	0.4	5.1	7.9	22	8100	23	631	608	0.553	0.238	1.528	1.766	0.329	0.244
T36	Willow Creek (nr Watertown)	08/27/01	1040	01-6323	N	20.3	------	746	822	0.4	8.9	8.0	10	2500	14	566	552	0.402	0.192	1.204	1.396	0.202	0.143
T36	Willow Creek (nr Watertown)	09/26/01	1140	01-6394	N	12.4	22.0	683	914	0.5	10.8	8.2	7	1200	12	652	640	0.286	0.092	1.016	1.108	0.101	0.022
T36	Willow Creek (nr Watertown)	10/22/01	1130	01-6443	N	8.8	16.0	645	939	0.5	14.2	8.2	6	1800	10	642	632	0.354	0.096	0.850	0.946	0.064	0.019
T36	Willow Creek (nr Watertown)	04/09/02	1115	02-6019	N	4.8	8.2	291	477	0.2	13.5	8.2	6	<10	9	333	324	0.564	0.292	0.718	1.010	0.160	0.116
T36	Willow Creek (nr Watertown)	04/29/02	915	02-6029	Y	5.3	6.5	505	816	0.4	11.7	8.4	3	20	6	602	596	0.044	0.018	0.804	0.822	0.068	0.050
T36	Willow Creek (nr Watertown)	05/09/02	1145	02-6078	Y	2.1	8.5	488	774	0.4	19.3	8.4	3	230	7	559	552	0.038	0.056	1.152	1.208	0.070	0.045
T36	Willow Creek (nr Watertown)	06/10/02	1020	02-6094	N	21.5	23.5	714	765	0.4	8.8	8.3	7	260	13	505	492	0.069	0.031	1.065	1.096	0.165	0.123
T36	Willow Creek (nr Watertown)	07/08/02	1050	02-6126	N	23.9	25.2	849	866	0.4	4.4	8.1	9	-----	13	699	686	0.126	0.298	1.402	1.700	0.474	0.393
T36	Willow Creek (nr Watertown)	08/07/02	945	02-6167	Y	21.4	23.8	762	818	0.4	6.6	8.1	15	1000	29	689	660	0.088	0.203	1.686	1.889	0.265	0.128
T36	Willow Creek (nr Watertown)	08/21/02	1015	02-6185	Y	18.0	23.0	280	323	0.2	7.5	7.9	280	110000	160	410	250	0.662	0.345	2.705	3.050	1.247	0.773
T36	Willow Creek (nr Watertown)	09/09/02	1045	02-6207	N	21.2	24.8	840	905	0.4	3.9	8.0	13	1100	7	651	644	0.102	0.216	0.990	1.206	0.145	0.082
T36	Willow Creek (nr Watertown)	10/17/02	1015	02-6246	N	5.9	9.0	554	864	0.4	9.5	------	2	100	5	641	636	0.124	0.122	0.658	0.780	0.045	0.022

Site	Site Name	Date	Time	Lab#	Runoff?	Water Temp C°	Air Temp C°	Conductivity µs/cm	Specific Conductivity µs/cm	Salinity ppt	Dissolved Oxygen mg/L	pH units	Turbidity NTU	Fecal Coliform cfu/100mL	TSS mg/L	Tot Solids mg/L	Dissolved Solids mg/L	Nitrates mg/L	Ammonia mg/L	Organic Nitrogen mg/L	TKN mg/L	Tot PO4 mg/L	TotDis PO4 mg/L
T37	Stray Horse Creek	06/14/01	1230	01-6219	Y	19.6	15.0	604	674	0.3	5.5	7.8	48	6900	48	680	632	3.423	0.378	2.348	2.726	0.603	0.435
T37	Stray Horse Creek	07/20/01	1230	01-6285	Y	24.8	27.0	960	962	0.5	5.1	8.0	15	2000	20	756	736	0.772	0.344	1.644	1.988	0.271	0.103
T37	Stray Horse Creek	08/27/01	1140	01-6325	N	23.9	32.5	766	788	0.4	12.5	8.5	18	810	25	545	520	0.510	0.060	1.974	2.034	0.191	0.029
T37	Stray Horse Creek	09/26/01	1215	01-6395	N	14.3	22.0	741	936	0.5	9.6	8.5	19	40	37	673	636	0.522	0.126	1.873	1.999	0.125	0.028
T37	Stray Horse Creek	10/22/01	1315	01-6445	N	9.2	17.0	717	1026	0.5	12.5	8.3	13	190	28	724	696	1.080	0.082	1.582	1.664	0.108	0.036
T37	Stray Horse Creek	04/09/02	1400	02-6026	N	6.0	9.0	402	633	0.3	13.8	8.2	4	10	8	400	392	0.934	0.343	1.247	1.590	0.211	0.149
T37	Stray Horse Creek	04/29/02	1000	02-6030	Y	5.8	13.0	691	1084	0.5	13.4	8.3	3	120	6	758	752	0.260	0.041	0.883	0.924	0.066	0.022
T37	Stray Horse Creek	05/09/02	1015	02-6075	Y	5.3	3.5	716	1150	0.6	11.4	8.3	19	>2500	32	924	892	0.450	0.270	2.205	2.475	0.500	0.264
T37	Stray Horse Creek	06/10/02	1245	02-6101	N	22.1	24.7	979	1038	0.5	10.2	8.3	8	1600	28	780	752	0.056	0.154	1.456	1.610	0.157	0.038
T37	Stray Horse Creek	07/09/02	1100	02-6140	N	24.8	27.0	940	947	0.5	8.3	8.3	14	100	56	794	738	0.148	0.126	1.783	1.909	0.252	0.077
T37	Stray Horse Creek	08/06/02	930	2-6155	Y	21.1	20.0	780	841	0.4	9.1	8.3	55	4500	65	749	684	0.039	0.089	2.728	2.817	0.290	0.036
T37	Stray Horse Creek	08/21/02	1230	02-6191	Y	18.5	23.5	205	234	0.1	7.0	7.7	110	320000	100	272	172	0.436	0.538	1.991	2.529	0.815	0.391
T37	Stray Horse Creek	09/10/02	1115	02-6217	N	19.9	23.3	772	854	0.4	6.0	8.2	16	430	13	653	640	0.043	0.195	1.249	1.444	0.196	0.088
T37	Stray Horse Creek	10/17/02	1315	02-6255	N	6.4	6.5	612	946	0.5	8.2	------	3	60	9	673	664	0.086	0.097	0.942	1.039	0.102	0.032
T39	Lake Poinsett Outlet	06/14/01	1310	01-6221	Y	20.5	16.0	1054	1152	0.6	5.2	7.6	5	<1	4	888	884	0.136	0.484	1.536	2.020	0.237	0.228
T39	Lake Poinsett Outlet	07/24/01	1300	01-6307	Y	25.4	21.0	1175	1164	0.6	2.6	7.8	7	300	6	934	928	0.061	1.102	1.309	2.411	0.286	0.247
T39	Lake Poinsett Outlet	08/27/01	1230	01-6326	N	23.9	27.0	1186	1212	0.6	10.7	8.3	12	30	41	1037	996	0.058	0.156	1.476	1.632	0.228	0.182
T39	Lake Poinsett Outlet	09/26/01	1300	01-6396	N	15.8	22.0	996	1215	0.6	14.1	8.7	9	20	19	1027	1008	0.048	0.191	1.342	1.533	0.259	0.201
T39	Lake Poinsett Outlet	10/22/01	1345	01-6447	N	10.9	15.5	896	1238	0.6	5.2	8.6	9	<10	16	932	916	0.130	0.222	1.173	1.395	0.224	0.194
T39	Lake Poinsett Outlet	04/08/02	1450	02-6012	N	9.4	10.5	844	1200	0.6	16.5	8.4	23	<10	63	971	908	0.174	0.273	1.403	1.676	0.288	0.103
T39	Lake Poinsett Outlet	05/01/02	1100	02-6054	Y	10.4	13.0	899	1245	0.6	10.7	8.5	28	<10	60	1028	968	0.062	0.161	1.909	2.070	0.201	0.080
T39	Lake Poinsett Outlet	05/08/02	1145	02-6066	Y	8.3	8.0	795	1166	0.6	12.1	8.5	13	190	42	882	840	0.106	0.134	1.488	1.622	0.187	0.060
T39	Lake Poinsett Outlet	06/11/02	830	02-6104	N	18.8	16.0	1089	1235	0.6	7.1	8.5	16	50	56	984	928	0.050	0.193	1.574	1.767	0.281	0.156
T39	Lake Poinsett Outlet	07/09/02	1215	02-6142	N	24.8	29.0	1302	1319	0.7	7.9	8.4	12	500	20	1080	1060	0.088	0.128	1.632	1.760	0.502	0.363
T39	Lake Poinsett Outlet	08/06/02	940	02-6156	Y	19.3	21.0	839	941	0.5	6.2	8.6	23	2800	31	743	712	0.038	0.128	1.658	1.786	0.987	0.691
T39	Lake Poinsett Outlet	08/22/02	1045	02-6201	Y	20.4	21.0	260	285	0.1	2.5	7.7	80	27000	76	312	236	0.520	0.304	1.567	1.871	0.612	0.425
T39	Lake Poinsett Outlet	09/10/02	1200	02-6218	N	19.1	22.0	692	783	0.4	8.9	8.3	50	800	67	645	578	0.004	0.168	3.014	3.182	0.665	0.214
T39	Lake Poinsett Outlet	10/16/02	1000	02-6241	N	4.9	2.0	583	946	0.5	7.3	------	20	330	48	720	672	0.036	0.124	2.055	2.179	0.261	0.013
T40	Hidewood Creek (nr Clear Lake)	06/14/01	945	01-6215	Y	20.2	17.0	511	560	0.2	6.2	7.6	9	400	4	394	390	0.284	0.466	1.068	1.534	0.219	0.173
T40	Hidewood Creek (nr Clear Lake)	07/24/01	945	01-6300	Y	24.3	19.0	672	680	0.3	2.2	7.9	3	300	5	477	472	0.075	0.189	1.168	1.357	0.245	0.192
T40	Hidewood Creek (nr Clear Lake)	08/27/01	930	01-6319	N	19.8	22.5	1190	1210	0.6	4.7	7.5	5	670	2	1022	1020	0.066	0.136	1.220	1.356	0.292	0.217
T40	Hidewood Creek (nr Clear Lake)	09/26/01	1000	01-6392	N	10.9	19.0	1697	2395	0.8	11.3	7.7	8	680	13	1665	1652	0.104	0.522	0.740	1.262	0.181	0.108
T40	Hidewood Creek (nr Clear Lake)	10/22/01	930	01-6441	N	6.9	11.0	1364	2131	1.1	14.5	7.8	6	30	5	1517	1512	1.268	0.336	0.762	1.098	0.151	0.097
T40	Hidewood Creek (nr Clear Lake)	04/09/02	1000	02-6017	N	2.9	7.0	402	697	0.3	17.6	8.1	4	<10	14	498	484	0.186	0.110	1.792	1.902	0.189	0.094
T40	Hidewood Creek (nr Clear Lake)	04/30/02	930	02-6038	Y	7.4	10.5	500	751	0.4	13.7	8.1	4	30	12	492	480	0.106	0.054	1.102	1.156	0.101	0.047
T40	Hidewood Creek (nr Clear Lake)	05/09/02	1045	02-6076	Y	5.9	7.4	523	822	0.4	14.4	8.2	5	10	15	555	540	0.139	0.118	1.031	1.149	0.111	0.054
T40	Hidewood Creek (nr Clear Lake)	06/10/02	835	02-6091	N	20.4	24.0	880	965	0.5	8.6	7.9	8	520	22	702	680	0.057	0.116	1.854	1.970	0.267	0.143
T40	Hidewood Creek (nr Clear Lake)	07/08/02	900	02-6124	N	22.9	20.0	1147	1205	0.6	1.7	7.9	22	------	126	1070	944	0.074	2.936	2.808	5.744	1.043	0.375
T40	Hidewood Creek (nr Clear Lake)	08/07/02	830	02-6163	Y	19.9	24.7	1651	1829	0.9	1.4	7.6	26	42000	104	1628	1524	0.094	7.850	3.096	10.946	1.134	0.790
T40	Hidewood Creek (nr Clear Lake)	08/21/02	845	02-6182	Y	17.6	25.0	1954	2287	1.2	3.6	7.4	23	20000	36	1920	1884	3.515	0.630	2.951	3.581	0.575	0.353
T40	Hidewood Creek (nr Clear Lake)	09/10/02	1030	02-6214	N	16.4	18.0	2132	2550	1.4	2.5	8.0	85	990	98	1994	1896	0.084	1.030	3.612	4.642	0.718	0.127
T40	Hidewood Creek (nr Clear Lake)	10/17/02	900	02-6244	N	3.9	4.0	1822	3068	1.6	9.9	------	9	440	29	2113	2084	0.740	0.521	0.876	1.397	0.212	0.128
T41	Hidewood Creek (nr Estelline)	06/14/01	1330	01-6222	Y	19.3	16.0	379	425	0.2	6.2	7.8	116	3300	98	450	352	2.302	0.184	1.914	2.098	0.417	0.175
T41	Hidewood Creek (nr Estelline)	07/20/01	1315	01-6286	Y	24.4	------	800	810	0.4	8.2	8.2	5	2500	6	526	520	0.905	0.088	0.742	0.830	0.103	0.090
T41	Hidewood Creek (nr Estelline)	08/27/01	1215	01-6327	N	23.9	27.0	782	819	0.4	14.5	8.0	10	270	16	592	576	1.138	0.027	1.162	1.189	0.083	0.017
T41	Hidewood Creek (nr Estelline)	09/26/01	1330	01-6397	N	13.4	25.0	647	833	0.4	15.8	8.4	5	2300	6	502	496	1.131	0.034	0.906	0.940	0.048	0.009
T41	Hidewood Creek (nr Estelline)	10/22/01	1430	01-6448	N	9.8	16.0	654	927	0.5	13.9	8.3	7	220	10	618	608	1.554	0.054	0.582	0.636	0.047	0.038
T41	Hidewood Creek (nr Estelline)	04/08/02	1515	02-6013	N	6.4	11.0	330	513	0.2	17.4	8.1	21	40	54	362	308	0.652	0.328	1.076	1.404	0.243	0.115
T41	Hidewood Creek (nr Estelline)	04/29/02	1015	02-6031	Y	7.3	12.0	550	834	0.4	14.7	8.3	6	70	17	585	568	0.090	0.045	0.756	0.801	0.072	0.025
T41	Hidewood Creek (nr Estelline)	05/08/02	1230	02-6067	Y	7.6	9.7	525	787	0.4	14.6	8.2	5	460	14	522	508	0.271	0.050	1.220	1.270	0.065	0.013
T41	Hidewood Creek (nr Estelline)	06/11/02	845	02-6105	N	18.0	19.0	777	896	0.4	10.1	8.2	8	700	18	610	592	0.312	0.186	0.891	1.077	0.124	0.045
T41	Hidewood Creek (nr Estelline)	07/09/02	1030	02-6139	N	22.7	24.0	780	826	0.4	11.1	8.5	11	100	100	732	632	0.116	0.086	1.400	1.486	0.108	0.038
T41	Hidewood Creek (nr Estelline)	08/06/02	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY

Site	Site Name	Date	Time	Lab#	Runoff?	Water Temp C°	Air Temp C°	Conductivity µs/cm	Specific Conductivity µs/cm	Salinity ppt	Dissolved Oxygen mg/L	pH units	Turbidity NTU	Fecal Coliform cfu/100mL	TSS mg/L	Tot Solids mg/L	Dissolved Solids mg/L	Nitrates mg/L	Ammonia mg/L	Organic Nitrogen mg/L	TKN mg/L	Tot PO4 mg/L	TotDis PO4 mg/L
T42	Peg Munky Run	06/14/01	1400	01-6223	Y	20.1	------	475	525	0.3	5.1	7.8	23	3800	28	400	372	0.515	0.182	1.617	1.799	0.515	0.410
T42	Peg Munky Run	07/20/01	1320	01-6287	Y	24.2	29.0	785	799	0.4	7.5	8.0	10	10000	10	534	524	0.074	0.070	0.484	0.554	0.105	0.065
T42	Peg Munky Run	04/08/02	1345	02-6011	N	4.6	13.0	264	435	0.2	19.1	8.2	2	<10	6	294	288	0.618	0.170	1.118	1.288	0.156	0.146
T42	Peg Munky Run	04/29/02	1130	02-6032	Y	6.7	21.5	588	904	0.4	16.9	8.3	2	90	4	532	528	0.032	0.034	0.606	0.640	0.069	0.055
T42	Peg Munky Run	05/08/02	1300	02-6068	Y	7.7	9.4	570	850	0.4	14.2	8.2	6	420	18	534	516	0.082	0.048	0.717	0.765	0.100	0.063
T42	Peg Munky Run	06/11/02	930	02-6107	N	17.0	19.7	707	834	0.4	11.6	8.1	7	4700	14	538	524	0.028	0.034	0.404	0.438	0.054	0.048
T42	Peg Munky Run	08/06/02	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY
T46	East Oakwood Lake Outlet 2	06/14/01	1130	01-6912	Y	20.4	20.0	683	749	0.4	3.0	7.5	8	6000	4	572	568	0.506	0.230	1.711	1.941	0.328	0.294
T46	East Oakwood Lake Outlet 2	07/20/01	1415	01-6290	Y	24.3	29.0	818	828	0.4	3.5	7.4	8	8000	28	638	610	0.541	0.222	1.282	1.504	0.474	0.413
T46	East Oakwood Lake Outlet 2	08/27/01	1400	01-6332	N	25.3	36.5	1248	1240	0.6	7.9	7.6	45	2200	11	991	980	0.343	0.200	1.992	2.192	0.326	0.166
T46	East Oakwood Lake Outlet 2	09/27/01	1215	01-6403	N	14.8	28.0	1011	1263	0.6	9.7	8.2	30	1300	52	1036	984	0.089	0.158	2.181	2.339	0.215	0.091
T46	East Oakwood Lake Outlet 2	10/23/01	1150	01-6456	N	9.1	16.5	918	1316	0.7	15.1	8.2	25	90	31	1003	972	0.074	0.227	1.716	1.943	0.235	0.098
T46	East Oakwood Lake Outlet 2	04/08/02	1200	02-6005	N	5.8	8.0	758	1197	0.6	17.4	7.9	5	<10	25	921	896	0.090	0.234	1.052	1.286	0.121	0.113
T46	East Oakwood Lake Outlet 2	05/01/02	1230	02-6057	Y	9.9	14.0	913	1299	0.7	12.0	8.0	3	20	13	925	912	0.043	0.019	0.982	1.001	0.066	0.029
T46	East Oakwood Lake Outlet 2	05/08/02	930	02-6062	Y	8.0	10.0	446	660	0.3	10.6	7.8	65	>2500	148	624	476	0.642	0.306	2.046	2.352	0.596	0.264
T46	East Oakwood Lake Outlet 2	06/11/02	1200	02-6114	N	21.0	24.0	1101	1193	0.6	12.7	8.2	9	520	45	941	896	0.067	0.076	1.236	1.312	0.159	0.094
T46	East Oakwood Lake Outlet 2	07/09/02	830	02-6135	N	22.3	25.0	1256	1327	0.7	4.0	7.9	40	3000	58	1098	1040	0.063	0.216	1.910	2.126	0.219	0.096
T46	East Oakwood Lake Outlet 2	08/06/02	1120	02-6160	Y	21.4	21.2	1388	1492	0.8	9.9	8.1	55	13000	80	1332	1252	0.344	0.217	2.188	2.405	0.418	0.054
T46	East Oakwood Lake Outlet 2	08/22/02	900	02-6197	Y	20.3	21.0	1345	1480	0.7	6.0	7.7	24	1500	54	1350	1296	0.064	0.100	1.082	1.182	0.160	0.053
T46	East Oakwood Lake Outlet 2	09/11/02	1200	02-6224	N	21.0	29.0	1260	1366	0.7	------	7.6	32	190	34	1178	1144	0.109	0.326	1.690	2.016	0.236	0.055
T46	East Oakwood Lake Outlet 2	10/15/02	1345	02-6235	N	9.7	11.5	1136	1607	0.8	11.1	------	3	240	30	1370	1340	0.044	0.125	1.157	1.282	0.095	0.022
T47	Unnamed Creek (nr Volga)	06/14/01	1100	01-6911	Y	19.2	20.0	759	854	0.4	3.0	7.6	5	25000	2	650	648	0.209	0.450	1.055	1.505	0.803	0.755
T47	Unnamed Creek (nr Volga)	07/20/01	1430	01-6291	Y	23.8	31.0	627	643	0.3	1.4	7.6	58	>10000	46	550	504	2.306	1.956	7.037	8.993	2.016	1.493
T47	Unnamed Creek (nr Volga)	08/27/01	1420	01-6333	N	25.2	35.0	1194	1189	0.6	10.4	8.0	8	760	24	900	876	0.083	0.170	1.006	1.176	0.589	0.491
T47	Unnamed Creek (nr Volga)	09/27/01	1230	01-6404	N	12.8	26.0	861	1138	0.6	8.7	8.3	7	220	10	812	802	0.484	0.120	0.581	0.701	0.350	0.338
T47	Unnamed Creek (nr Volga)	10/23/01	1215	01-6457	N	7.7	17.0	758	1135	0.6	16.1	8.5	4	230	4	856	852	0.678	0.044	0.491	0.535	0.235	0.222
T47	Unnamed Creek (nr Volga)	04/08/02	1130	02-6004	N	2.3	12.5	379	670	0.3	16.9	7.8	1	10	3	459	456	0.940	0.095	1.185	1.280	0.200	0.198
T47	Unnamed Creek (nr Volga)	04/29/02	1100	02-6033	Y	7.3	13.0	622	943	0.5	20.0	8.2	0	<10	1	641	640	0.758	0.047	0.560	0.607	0.189	0.185
T47	Unnamed Creek (nr Volga)	05/08/02	845	02-6061	Y	7.8	9.0	398	594	0.3	7.8	7.8	81	>2500	62	502	440	1.290	1.725	4.050	5.775	1.392	0.995
T47	Unnamed Creek (nr Volga)	06/11/02	1115	02-6113	N	18.0	22.0	893	1032	0.5	10.9	8.0	1	180	1	773	772	0.060	0.100	0.618	0.718	0.646	0.625
T47	Unnamed Creek (nr Volga)	07/09/02	805	02-6134	N	20.9	25.0	996	1089	0.5	6.2	7.9	8	630	28	876	848	0.112	0.090	0.943	1.033	0.679	0.627
T47	Unnamed Creek (nr Volga)	08/06/02	1140	02-6161	Y	20.8	27.0	812	882	0.4	7.5	7.8	9	7000	9	745	736	0.427	0.100	1.347	1.447	0.799	0.770
T47	Unnamed Creek (nr Volga)	08/22/02	845	02-6196	Y	19.1	19.0	822	927	0.5	8.7	7.9	7	900	3	749	746	0.156	0.011	0.527	0.538	0.533	0.556
T47	Unnamed Creek (nr Volga)	09/11/02	1215	02-6225	N	16.4	28.0	806	965	0.5	------	7.8	8	660	7	767	760	0.160	0.000	0.478	0.478	0.737	0.718
T47	Unnamed Creek (nr Volga)	10/15/02	1315	02-6234	N	7.1	15.5	701	1064	0.5	7.1	------	2	30	7	807	800	0.371	0.052	0.489	0.541	0.278	0.239

Site	Site Name	Date	Time	Lab#	Runoff?	Water Temp C°	Air Temp C°	Conductivity µs/cm	Specific Conductivity µs/cm	Salinity ppt	Dissolved Oxygen mg/L	pH units	Turbidity NTU	Fecal Coliform cfu/100mL	TSS mg/L	Tot Solids mg/L	Dissolved Solids mg/L	Nitrates mg/L	Ammonia mg/L	Organic Nitrogen mg/L	TKN mg/L	Tot PO4 mg/L	TotDis PO4 mg/L
R01	BSR near Brookings	04/09/01	730	01-6049	Y	4.6	4.0	209	341.2	0.2	9.0	8.2	39	650	56	284	228	1.470	0.585	1.674	2.259	0.508	0.411
R01	BSR near Brookings	04/13/01	1300	01-6093	Y	6.7	14.0	261	403.0	0.2	5.4	9.0	18	140	37	327	290	1.202	0.320	1.150	1.470	0.390	0.311
R01	BSR near Brookings	05/08/01	900	01-6159	Y	12.9	16.0	677	891.0	0.4	6.8	7.4	6	100	14	578	564	0.039	0.066	0.945	1.011	0.168	0.130
R01	BSR near Brookings	06/15/01	1000	01-6921	Y	17.6	17.0	583	679.0	0.3	7.1	7.7	18	600	28	492	464	0.867	0.202	1.336	1.538	0.391	0.332
R01	BSR near Brookings	07/25/01	1000	01-6314	Y	24.2	20.0	884	897.0	0.4	5.1	7.8	24	700	72	728	656	0.554	0.254	1.423	1.677	0.390	0.292
R01	BSR near Brookings	08/28/01	1300	01-6341	N	23.3	31.5	1136	1175.0	0.6	13.8	8.5	31	110	107	1007	900	0.083	0.029	1.750	1.779	0.276	0.141
R01	BSR near Brookings	09/26/01	1245	01-6389	N	15.8	16.0	891	1083.0	0.5	15.7	8.5	16	70	40	904	864	0.496	0.042	1.291	1.333	0.246	0.171
R01	BSR near Brookings	10/23/01	1230	01-6458	N	9.7	20.0	820	1157.0	0.6	15.8	8.7	4	240	9	845	836	0.168	0.040	1.022	1.062	0.141	0.091
R01	BSR near Brookings	04/08/02	1045	02-6003	Y	7.2	7.5	499	754.0	0.4	11.7	8.5	44	<10	146	638	492	0.952	0.400	1.440	1.840	0.463	0.230
R01	BSR near Brookings	05/01/02	1330	02-6058	Y	11.7	14.0	715	959.0	0.5	9.6	8.3	56	40	130	766	636	0.282	0.042	1.393	1.435	0.358	0.080
R01	BSR near Brookings	05/09/02	750	02-6072	Y	5.9	3.5	454	715.0	0.3	13.9	8.1	67	>2500	182	666	484	0.694	0.258	1.697	1.955	0.578	0.239
R01	BSR near Brookings	06/11/02	1230	02-6115	N	20.9	28.0	877	952.0	0.5	15.2	8.5	50	260	154	798	644	0.041	0.067	2.056	2.123	0.417	0.033
R01	BSR near Brookings	07/09/02	1245	02-6143	N	25.8	29.0	827	814.0	0.4	10.9	8.5	60	250	129	717	588	0.074	0.100	1.896	1.996	0.400	0.074
R01	BSR near Brookings	08/06/02	1200	02-6162	Y	22.6	26.0	706	739.0	0.4	12.4	8.4	37	1400	78	590	512	0.070	0.106	1.486	1.592	0.296	0.037
R01	BSR near Brookings	08/22/02	815	02-6195	Y	21.8	19.0	750	798.0	0.4	7.2	8.0	55	600	100	680	580	0.034	0.090	1.678	1.768	0.426	0.037
R01	BSR near Brookings	09/11/02	1245	02-6226	N	20.8	26.8	708	770.0	0.4	------	8.3	65	140	98	650	552	0.040	0.176	1.994	2.170	0.445	0.067
R01	BSR near Brookings	10/15/02	1300	02-6233	N	8.2	7.5	632	930.0	0.5	13.9	------	5	<10	14	694	680	0.098	0.098	1.130	1.228	0.218	0.082
R14	BSR at Watertown	04/08/01	1510	01-6042	Y	3.9	10.0	111	185	0.1	8.4	8.3	18	250	10	122	112	0.866	0.306	1.133	1.439	0.430	0.349
R14	BSR at Watertown	04/13/01	1000	01-6086	Y	4.8	13.0	168	274	0.1	5.0	7.8	11	30	5	200	195	0.914	0.252	0.904	1.156	0.303	0.285
R14	BSR at Watertown	05/08/01	1000	01-6152	Y	10.8	13.0	546	748	0.4	7.7	8.2	5	2200	6	494	488	0.144	0.096	1.532	1.628	0.111	0.077
R14	BSR at Watertown	06/15/01	1030	01-6227	Y	17.3	19.0	523	613	0.3	6.7	7.9	11	1500	35	475	440	0.235	0.312	1.212	1.524	0.237	0.172
R14	BSR at Watertown	07/24/01	1100	01-6302	Y	23.2	19.0	778	803	0.4	7.0	8.2	17	800	35	583	548	0.116	0.131	1.379	1.510	0.235	0.087
R14	BSR at Watertown	08/28/01	930	01-6334	N	19.1	27.5	682	760	0.4	8.2	8.2	22	1800	25	525	500	0.168	0.069	1.633	1.702	0.153	0.082
R14	BSR at Watertown	09/26/01	1020	01-6384	N	11.1	14.0	511	700	0.3	7.2	8.3	7	430	9	469	460	0.196	0.076	0.578	0.654	0.057	0.035
R14	BSR at Watertown	10/24/01	930	01-6461	N	3.9	1.0	138	235	0.1	16.4	8.6	18	320	43	439	396	0.140	0.041	0.596	0.637	0.106	0.030
R14	BSR at Watertown	04/09/02	1130	02-6020	Y	6.3	9.0	320	494	0.1	14.9	8.2	11	<10	27	331	304	0.596	0.159	0.820	0.979	0.161	0.080
R14	BSR at Watertown	04/30/02	1045	02-6042	Y	11.5	11.0	504	678	0.3	11.0	8.2	17	50	52	496	444	0.086	0.119	0.946	1.065	0.153	0.039
R14	BSR at Watertown	05/09/02	1215	02-6079	Y	6.8	6.0	480	740	0.4	15.7	8.5	24	520	87	559	472	0.086	0.116	1.226	1.342	0.214	0.032
R14	BSR at Watertown	06/10/02	1030	02-6095	N	21.9	25.0	599	638	0.3	11.4	8.5	13	1000	36	428	392	0.063	0.059	1.152	1.211	0.148	0.060
R14	BSR at Watertown	07/08/02	1200	02-6128	N	24.5	28.5	611	617	0.3	9.5	8.4	16	3400	28	464	436	0.078	0.048	1.605	1.653	0.185	0.083
R14	BSR at Watertown	08/07/02	1015	02-6168	Y	21.9	24.0	650	691	0.3	8.5	8.1	60	1300	70	598	528	0.122	0.339	1.978	2.317	0.320	0.080
R14	BSR at Watertown	08/21/02	1045	02-6186	Y	19.0	25.5	471	531	0.3	8.2	8.0	50	11000	44	480	436	0.164	0.124	1.253	1.377	0.341	0.207
R14	BSR at Watertown	09/09/02	1115	02-6208	N	22.3	26.0	630	664	0.3	5.3	8.4	65	4500	51	495	444	0.076	0.244	1.533	1.777	0.216	0.058
R14	BSR at Watertown	10/17/02	1045	02-6249	N	5.0	4.5	450	728	0.4	7.7	------	7	1700	25	517	492	0.185	0.036	0.522	0.558	0.047	0.021
R15	BSR at Braoadway	04/08/01	1555	01-6043	Y	2.2	9.0	89	159	0.1	6.0	7.9	30	260	47	159	112	0.714	0.331	1.070	1.401	0.376	0.282
R15	BSR at Braoadway	04/13/01	1015	01-6087	Y	5.4	11.0	196	317	0.2	6.2	7.9	11	<10	12	242	230	0.961	0.214	0.867	1.081	0.312	0.256
R15	BSR at Braoadway	05/08/01	1030	01-6153	Y	13.0	14.0	527	718	0.4	6.1	8.0	4	1400	8	484	476	0.114	0.051	1.058	1.109	0.126	0.072
R15	BSR at Braoadway	06/15/01	1100	01-6226	Y	18.0	18.5	522	602	0.3	6.6	7.9	18	1600	43	495	452	0.212	0.301	1.338	1.639	0.239	0.136
R15	BSR at Braoadway	07/24/01	1130	01-6303	Y	25.7	20.0	716	707	0.3	5.3	8.5	21	800	30	526	496	0.164	0.125	1.146	1.271	0.181	0.111
R15	BSR at Braoadway	08/28/01	1000	01-6335	N	21.0	29.0	750	812	0.4	8.5	7.9	13	80	15	571	556	0.262	0.292	1.251	1.543	0.220	0.127
R15	BSR at Braoadway	09/26/01	1000	01-6383	N	13.3	14.0	578	743	0.4	11.6	8.3	6	60	8	532	524	0.208	0.201	0.640	0.841	0.141	0.081
R15	BSR at Braoadway	10/24/01	1000	01-6462	N	6.3	1.5	459	707	0.3	16.5	8.4	6	<10	8	452	444	0.174	0.092	0.447	0.539	0.069	0.050
R15	BSR at Braoadway	04/09/02	1220	02-6022	Y	6.3	8.5	322	500	0.2	17.3	8.1	8	<10	20	330	310	0.454	0.095	0.826	0.921	0.163	0.096
R15	BSR at Braoadway	04/30/02	1130	02-6044	Y	11.1	11.0	548	745	0.4	14.2	8.3	15	30	46	570	524	0.066	0.072	0.957	1.029	0.154	0.049
R15	BSR at Braoadway	05/09/02	1315	02-6081	Y	6.3	5.5	466	724	0.4	16.6	8.3	8	890	20	504	484	0.098	0.117	0.842	0.959	0.105	0.045
R15	BSR at Braoadway	06/10/02	1115	02-6097	N	22.2	25.2	624	659	0.3	8.2	8.3	21	410	53	437	384	0.076	0.213	1.158	1.371	0.192	0.065
R15	BSR at Braoadway	07/08/02	1230	02-6129	N	25.3	28.0	693	690	0.3	7.5	8.1	13	4000	25	497	472	0.496	0.292	1.206	1.498	0.207	0.114
R15	BSR at Braoadway	08/07/02	1045	02-6170	Y	22.7	25.0	670	701	0.3	6.8	8.0	20	300	45	521	476	0.558	0.375	1.012	1.387	0.212	0.091
R15	BSR at Braoadway	08/21/02	1120	02-6188	Y	18.7	23.0	329	374	0.2	7.6	7.7	40	8000	27	263	236	0.660	0.398	0.709	1.107	0.239	0.114
R15	BSR at Braoadway	09/09/02	1230	02-6210	N	22.8	28.0	822	858	0.4	7.1	7.8	22	70	24	572	548	1.064	0.278	0.767	1.045	0.179	0.090
R15	BSR at Braoadway	10/17/02	1130	02-6251	N	6.7	5.5	577	886	0.4	11.1	------	2	10	20	604	584	1.851	0.320	0.656	0.976	0.097	0.039

Site	Site Name	Date	Time	Lab#	Runoff?	Water Temp C°	Air Temp C°	Conductivity µs/cm	Specific Conductivity µs/cm	Salinity ppt	Dissolved Oxygen mg/L	pH units	Turbidity NTU	Fecal Coliform cfu/100mL	TSS mg/L	Tot Solids mg/L	Dissolved Solids mg/L	Nitrates mg/L	Ammonia mg/L	Organic Nitrogen mg/L	TKN mg/L	Tot PO4 mg/L	TotDis PO4 mg/L
R16	BSR 20th Ave	04/08/01	1615	01-6044	Y	3.1	8.0	97	168	0.1	7.3	7.6	32	450	34	166	132	0.718	0.350	1.004	1.354	0.360	0.253
R16	BSR 20th Ave	04/13/01	1040	01-6088	Y	5.1	11.0	196	315	0.1	4.9	8.1	10	50	9	239	230	0.972	0.202	0.892	1.094	0.329	0.295
R16	BSR 20th Ave	05/08/01	1100	01-6154	Y	11.2	14.0	513	695	0.3	7.5	8.2	3	1300	7	483	476	0.094	0.068	0.986	1.054	0.145	0.113
R16	BSR 20th Ave	06/15/01	1120	01-6228	Y	18.0	15.5	537	620	0.3	6.1	7.8	21	900	49	469	420	0.264	0.348	1.358	1.706	0.341	0.215
R16	BSR 20th Ave	07/24/01	1145	01-6304	Y	24.9	20.0	758	757	0.4	5.6	8.2	22	800	46	562	516	0.571	0.208	1.218	1.426	0.404	0.299
R16	BSR 20th Ave	08/28/01	1040	01-6336	N	19.8	28.5	1002	1114	0.6	15.8	7.7	6	100	8	736	728	9.761	0.130	1.942	2.072	2.492	2.413
R16	BSR 20th Ave	09/26/01	930	01-6382	N	15.3	12.0	901	1107	0.6	8.3	7.8	4	90	8	768	760	10.718	0.277	1.724	2.001	2.623	2.595
R16	BSR 20th Ave	10/24/01	1030	01-6463	N	9.4	0.5	556	792	0.4	15.3	8.3	8	40	12	636	624	6.462	0.132	1.403	1.535	1.886	1.705
R16	BSR 20th Ave	04/09/02	1245	02-6023	Y	8.2	10.0	370	545	0.3	9.9	8.2	8	<10	18	390	372	0.636	0.209	0.828	1.037	0.202	0.111
R16	BSR 20th Ave	04/30/02	1145	02-6045	Y	12.2	16.0	580	768	0.4	14.4	8.2	9	20	23	535	512	0.204	0.034	1.314	1.348	0.212	0.135
R16	BSR 20th Ave	05/09/02	1320	02-6082	Y	6.9	5.5	487	744	0.4	12.3	8.3	9	1500	22	518	496	0.188	0.106	0.876	0.982	0.233	0.126
R16	BSR 20th Ave	06/10/02	1130	02-6098	N	20.6	25.0	706	762	0.4	9.6	8.1	16	580	43	523	480	4.457	0.186	1.856	2.042	0.982	0.914
R16	BSR 20th Ave	07/08/02	1300	02-6130	N	21.8	28.0	1004	1073	0.5	12.1	7.9	10	-----	59	771	712	11.404	0.166	2.232	2.398	2.751	2.426
R16	BSR 20th Ave	08/07/02	1115	02-6171	Y	21.1	25.5	1029	1115	0.6	11.1	7.9	12	3500	21	753	732	10.823	0.248	2.202	2.450	2.956	2.797
R16	BSR 20th Ave	08/21/02	1200	02-6190	Y	18.6	24.1	315	361	0.2	6.5	7.7	70	10000	36	284	248	0.968	0.252	0.852	1.104	0.608	0.517
R16	BSR 20th Ave	09/09/02	1245	02-6211	N	21.4	30.0	758	813	0.4	6.3	7.5	29	6900	43	583	540	9.414	0.440	2.502	2.942	2.232	1.766
R16	BSR 20th Ave	10/17/02	1145	02-6252	N	12.0	4.0	844	1122	0.6	9.2	------	3	<10	8	738	730	10.550	0.232	1.680	1.912	2.256	2.068
R17	BSR below Watertown	04/08/01	1640	01-6045	Y	3.4	7.0	112	191	0.1	3.6	7.4	47	500	74	201	127	0.978	0.550	1.358	1.908	0.537	0.360
R17	BSR below Watertown	04/13/01	1100	01-6089	Y	4.9	12.0	214	348	0.2	5.1	-----	15	190	21	226	205	1.214	0.292	1.098	1.390	0.329	0.294
R17	BSR below Watertown	05/08/01	1120	01-6155	Y	11.2	14.0	499	677	0.3	7.6	8.3	6	1900	16	448	432	0.316	0.114	1.064	1.178	0.203	0.158
R17	BSR below Watertown	06/15/01	1145	01-6229	Y	18.0	15.0	594	685	0.3	6.3	8.0	20	1200	48	552	504	0.500	0.318	1.317	1.635	0.342	0.256
R17	BSR below Watertown	07/24/01	1200	01-6305	Y	23.2	21.0	736	763	0.4	6.8	8.2	29	2500	56	560	504	1.096	0.184	1.402	1.586	0.477	0.338
R17	BSR below Watertown	08/28/01	1100	01-6337	N	20.4	28.0	786	858	0.4	6.5	8.4	23	2000	37	677	640	2.882	0.094	1.852	1.946	0.764	0.507
R17	BSR below Watertown	09/26/01	1100	01-6385	N	12.6	15.0	552	702	0.3	7.4	8.3	19	13200	23	699	676	5.391	0.181	1.480	1.661	1.202	1.131
R17	BSR below Watertown	10/24/01	1045	01-6464	N	4.5	-0.5	628	1031	0.5	14.7	8.6	11	470	12	684	672	4.893	0.145	1.273	1.418	1.221	1.146
R17	BSR below Watertown	04/09/02	1300	02-6024	Y	8.2	11.0	405	598	0.3	12.3	8.2	7	<10	18	422	404	1.203	0.238	0.903	1.141	0.315	0.209
R17	BSR below Watertown	04/30/02	1215	02-6046	Y	12.1	15.0	610	807	0.4	14.2	8.4	6	<10	26	590	564	0.635	0.046	1.052	1.098	0.285	0.198
R17	BSR below Watertown	05/09/02	1330	02-6083	Y	6.8	6.0	481	737	0.4	17.8	8.4	6	2000	54	530	476	0.758	0.150	1.148	1.298	0.353	0.206
R17	BSR below Watertown	06/10/02	1145	02-6099	N	22.1	24.5	780	826	0.4	10.9	8.3	15	1600	42	538	496	2.600	0.383	1.412	1.795	0.811	0.620
R17	BSR below Watertown	07/08/02	1315	02-6131	N	26.4	29.0	970	941	0.5	12.5	8.5	9	-----	60	728	668	4.854	0.338	2.295	2.633	1.159	1.056
R17	BSR below Watertown	08/07/02	1130	02-6172	Y	22.6	24.5	715	750	0.4	9.9	8.2	33	2600	50	566	516	3.395	0.488	1.560	2.048	1.357	1.123
R17	BSR below Watertown	08/21/02	1145	02-6189	Y	18.7	25.0	403	458	0.2	6.9	7.7	110	33000	141	481	340	0.432	0.203	1.635	1.838	0.550	0.201
R17	BSR below Watertown	09/09/02	1330	02-6212	N	23.6	29.1	954	992	0.5	6.3	8.2	37	1300	43	687	644	4.059	0.254	1.826	2.080	1.273	1.121
R17	BSR below Watertown	10/17/02	1215	02-6253	N	7.0	10.5	688	1046	0.5	7.4	------	7	960	17	669	652	6.478	0.191	1.328	1.519	1.511	1.342
R18	BSR nr Castlewood	04/08/01	1730	01-6046	Y	5.3	8.0	172	276	0.1	4.5	7.3	43	650	53	229	176	1.386	0.675	1.730	2.405	0.691	0.509
R18	BSR nr Castlewood	04/13/01	1130	01-6090	Y	5.1	12.0	217	349	0.2	5.3	8.3	14	1400	6	196	190	1.204	0.387	1.352	1.739	0.462	0.381
R18	BSR nr Castlewood	05/08/01	1200	01-6156	Y	13.9	14.0	519	658	0.3	7.5	8.1	2	100	5	421	416	0.036	0.072	1.303	1.375	0.230	0.189
R18	BSR nr Castlewood	06/15/01	1230	01-6230	Y	17.8	17.0	614	711	0.3	7.3	7.9	15	1800	37	549	512	0.936	0.281	1.408	1.689	0.427	0.344
R18	BSR nr Castlewood	07/25/01	1130	01-6311	Y	22.8	25.0	780	815	0.4	10.3	8.0	21	1000	53	581	528	1.178	0.178	1.161	1.339	0.460	0.338
R18	BSR nr Castlewood	08/28/01	1130	01-6338	N	19.8	28.0	872	969	0.5	18.0	8.4	26	800	48	708	660	1.413	0.065	1.858	1.923	0.442	0.286
R18	BSR nr Castlewood	09/26/01	1130	01-6386	N	13.4	15.0	725	933	0.5	10.2	8.3	19	1700	22	702	680	3.699	0.131	1.303	1.434	0.726	0.629
R18	BSR nr Castlewood	10/24/01	1100	01-6465	N	4.7	0.5	620	1011	0.5	14.9	8.5	15	1100	22	682	660	3.374	0.058	1.190	1.248	0.934	0.740
R18	BSR nr Castlewood	04/09/02	1330	02-6025	Y	8.6	9.5	427	623	0.3	12.4	8.3	13	<10	37	421	384	1.560	0.326	1.131	1.457	0.394	0.277
R18	BSR nr Castlewood	04/30/02	1245	02-6047	Y	12.7	13.0	600	784	0.4	20.0	8.5	8	50	28	506	478	0.590	0.049	1.147	1.196	0.296	0.183
R18	BSR nr Castlewood	05/09/02	940	02-6074	Y	5.1	8.7	414	668	0.3	16.6	8.3	19	480	46	522	476	1.132	0.292	1.127	1.419	0.426	0.285
R18	BSR nr Castlewood	06/10/02	1230	02-6100	N	22.0	24.3	815	864	0.4	9.0	8.3	65	6500	74	602	528	1.854	0.387	1.860	2.247	0.834	0.529
R18	BSR nr Castlewood	07/09/02	1145	02-6141	N	23.9	29.0	911	931	0.5	9.6	8.4	55	11200	152	800	648	1.546	0.148	2.315	2.463	1.344	0.740
R18	BSR nr Castlewood	08/06/02	900	02-6153	Y	19.6	18.0	878	980	0.5	7.9	7.8	22	16000	65	701	636	1.365	0.382	1.816	2.198	1.038	0.883
R18	BSR nr Castlewood	08/21/02	1245	02-6192	Y	18.7	20.8	180	220	0.1	7.1	7.7	340	410000	314	498	184	0.698	0.798	3.310	4.108	1.502	0.674
R18	BSR nr Castlewood	09/09/02	1400	02-6213	N	25.0	31.0	916	915	0.4	11.4	8.8	35	2900	84	686	602	1.234	0.150	2.366	2.516	0.470	0.208
R18	BSR nr Castlewood	10/17/02	1300	02-6254	N	7.4	8.0	679	1026	0.5	12.7	------	3	300	13	681	668	4.018	0.116	1.156	1.272	0.706	0.622

Site	Site Name	Date	Time	Lab#	Runoff?	Water Temp C°	Air Temp C°	Conductivity µs/cm	Specific Conductivity µs/cm	Salinity ppt	Dissolved Oxygen mg/L	pH units	Turbidity NTU	Fecal Coliform cfu/100mL	TSS mg/L	Tot Solids mg/L	Dissolved Solids mg/L	Nitrates mg/L	Ammonia mg/L	Organic Nitrogen mg/L	TKN mg/L	Tot PO4 mg/L	TotDis PO4 mg/L
R19	BSR nr Estelline	04/08/01	1750	01-6047	Y	4.7	9.0	149	244	0.1	2.6	7.9	55	600	75	255	180	1.516	0.576	1.652	2.228	0.488	0.306
R19	BSR nr Estelline	04/13/01	1200	01-6091	Y	5.5	13.0	268	429	0.2	5.4	7.7	22	800	32	332	300	1.705	0.442	1.738	2.180	0.385	0.292
R19	BSR nr Estelline	05/08/01	1230	01-6157	Y	12.4	16.0	632	831	0.4	7.7	8.2	5	4000	9	573	564	0.194	0.104	1.113	1.217	0.222	0.158
R19	BSR nr Estelline	06/15/01	1130	01-6923	Y	18.1	20.0	610	701	0.3	8.5	7.9	16	1300	26	504	478	1.000	0.248	1.443	1.691	0.377	0.287
R19	BSR nr Estelline	07/25/01	1200	01-6312	Y	24.3	28.0	981	993	0.5	6.3	7.8	24	900	-----	------	-----	0.525	0.595	1.720	2.315	0.396	0.262
R19	BSR nr Estelline	08/28/01	1200	01-6339	N	24.0	30.5	975	995	0.5	10.1	8.6	21	10	48	1024	976	0.150	0.062	1.606	1.668	0.143	0.131
R19	BSR nr Estelline	09/26/01	1145	01-6387	N	15.2	16.0	411	509	0.2	8.3	8.6	17	50	30	866	836	0.433	0.079	1.361	1.440	0.285	0.208
R19	BSR nr Estelline	10/24/01	1130	01-6466	N	6.1	2.0	723	1152	0.6	13.7	8.5	13	20	39	875	836	0.624	0.108	1.535	1.643	0.281	0.149
R19	BSR nr Estelline	04/08/02	1345	02-6010	Y	7.7	9.0	462	690	0.3	17.7	8.1	24	<10	79	547	468	1.105	0.332	1.244	1.576	0.385	0.192
R19	BSR nr Estelline	05/01/02	1030	02-6053	Y	10.8	13.0	699	960	0.5	12.6	8.5	34	40	77	725	648	0.321	0.055	1.326	1.381	0.275	0.085
R19	BSR nr Estelline	05/08/02	1245	02-6069	Y	7.7	8.5	638	956	0.5	10.0	8.3	11	280	27	675	648	0.656	0.168	1.276	1.444	0.243	0.126
R19	BSR nr Estelline	06/11/02	900	02-6106	N	18.7	17.5	889	1011	0.5	9.0	8.3	31	320	109	777	668	1.214	0.273	1.709	1.982	0.456	0.240
R19	BSR nr Estelline	07/09/02	1000	02-6138	N	23.3	23.0	840	869	0.4	8.8	8.9	220	710	142	764	622	0.082	0.058	3.352	3.410	0.615	0.240
R19	BSR nr Estelline	08/06/02	1000	2-6157	Y	19.9	22.7	807	895	0.4	8.9	8.5	75	700	111	715	604	0.075	0.128	1.944	2.072	0.540	0.267
R19	BSR nr Estelline	08/22/02	1145	02-6202	Y	20.9	21.0	255	279	0.1	1.4	7.7	140	29000	188	400	212	0.526	0.384	1.836	2.220	0.924	0.405
R19	BSR nr Estelline	09/10/02	1215	02-6219	N	19.5	21.0	655	730	0.4	18.8	8.7	85	570	148	628	480	0.002	0.144	2.388	2.532	0.532	0.056
R19	BSR nr Estelline	10/16/02	1030	02-6242	N	5.0	2.0	574	926	0.5	9.2	------	4	120	7	631	624	1.598	0.046	0.915	0.961	0.232	0.170
R20	BSR nr Bruce	04/08/01	1830	01-6048	Y	5.3	8.0	150	243	0.1	2.2	7.9	75	1200	91	263	172	1.612	0.600	1.898	2.498	0.543	0.332
R20	BSR nr Bruce	04/13/01	1230	01-6092	Y	6.8	15.0	244	375	0.2	5.1	8.2	22	580	29	299	270	1.472	0.445	1.136	1.581	0.384	0.301
R20	BSR nr Bruce	05/08/01	1300	01-6158	Y	12.8	18.0	628	820	0.4	7.9	8.1	5	3000	7	591	584	0.128	0.095	1.540	1.635	0.190	0.172
R20	BSR nr Bruce	06/15/01	1100	01-6922	Y	18.1	17.0	495	574	0.3	8.7	7.9	19	1300	25	405	380	1.384	0.198	1.838	2.036	0.353	0.283
R20	BSR nr Bruce	07/25/01	1030	01-6313	Y	24.1	22.0	935	953	0.5	5.8	7.9	41	700	118	802	684	0.634	0.468	1.597	2.065	0.454	0.244
R20	BSR nr Bruce	08/28/01	1230	01-6340	N	23.9	32.3	1129	1163	0.6	4.9	8.5	30	80	79	1587	1508	0.168	0.139	1.476	1.615	0.278	0.118
R20	BSR nr Bruce	09/26/01	1215	01-6388	N	14.7	16.0	694	866	0.4	9.5	8.5	17	80	30	834	804	0.440	0.023	1.226	1.249	0.271	0.190
R20	BSR nr Bruce	10/23/01	1015	01-6451	N	8.9	7.5	539	785	0.4	16.5	8.8	4	80	8	800	792	0.383	0.067	1.068	1.135	0.146	0.121
R20	BSR nr Bruce	04/08/02	1600	02-6014	Y	9.9	13.0	448	647	0.3	16.1	8.1	40	<10	132	546	414	0.997	0.300	1.258	1.558	0.427	0.184
R20	BSR nr Bruce	05/01/02	1145	02-6055	Y	11.1	14.0	535	729	0.4	14.6	8.5	40	130	87	703	616	0.306	0.059	1.371	1.430	0.299	0.083
R20	BSR nr Bruce	05/08/02	1345	02-6070	Y	8.0	9.0	597	886	0.4	15.4	8.4	16	>2500	62	640	578	0.590	0.138	1.164	1.302	0.241	0.079
R20	BSR nr Bruce	06/11/02	1000	02-6108	N	18.6	18.5	846	965	0.5	12.1	8.4	35	330	105	749	644	0.694	0.113	1.772	1.885	0.450	0.107
R20	BSR nr Bruce	07/09/02	930	02-6137	N	23.8	22.0	808	827	0.4	9.3	8.6	38	600	64	660	596	0.052	0.088	1.578	1.666	0.370	0.155
R20	BSR nr Bruce	08/06/02	1045	2-6158	Y	21.2	25.0	689	744	0.4	13.0	8.4	35	2100	55	583	528	0.028	0.022	1.515	1.537	0.328	0.012
R20	BSR nr Bruce	08/22/02	1215	02-6203	Y	20.7	22.5	415	452	0.2	4.1	7.7	220	14000	328	632	304	0.942	0.500	2.902	3.402	0.411	0.152
R20	BSR nr Bruce	09/11/02	930	02-6221	N	18.4	23.0	626	716	0.4	------	8.6	55	300	76	572	496	0.252	0.062	1.972	2.034	0.407	0.047
R20	BSR nr Bruce	10/16/02	1100	02-6243	N	5.2	3.0	549	883	0.4	12.8	------	3	160	6	562	556	0.288	0.060	0.932	0.992	0.152	0.082

Extra Big Sioux River Samples Taken in 2004

Site	Site Name	Date	Time	Runoff ?	Water Temp C˚	Air Temp C˚	Conductivity µs/cm	Specific Conductivity µs/cm	Salinity ppt	Dissolved Oxygen mg/L	pH units	Turbidity NTU	Fecal Coliform cfu/100mL
R01	Big Sioux River nr Brookings	05/17/04	1315	y	13.5	15.0	612	-----	-----	8.64	-----	24	2400
R01	Big Sioux River nr Brookings	06/02/04	1300	n	15.8	21.0	779	950	0.4	4.98	7.31	21	600
R01	Big Sioux River nr Brookings	06/16/04	1330	n	19.2	17.0	743	835	0.4	8.22	8.32	34	900
R01	Big Sioux River nr Brookings	07/01/04	1215	n	24.7	34.0	873	880	0.4	9.13	8.25	11	980
R01	Big Sioux River nr Brookings	07/14/04	1210	n	25.0	28.0	777	798	0.4	9.60	8.46	40	340
R01	Big Sioux River nr Brookings	07/27/04	210	n	24.0	33.0	834	849	0.4	11.29	7.71	40	140
R01	Big Sioux River nr Brookings	08/10/04	1443	n	20.3	-----	741	815	0.4	13.54	7.97	40	130
R01	Big Sioux River nr Brookings	08/25/04	917	n	20.1	21.0	779	830	0.2	9.51	8.39	37	70
R01	Big Sioux River nr Brookings	09/08/04	1528	n	22.4	23.4	354	432	0.2	11.46	8.84	40	80
R01	Big Sioux River nr Brookings	09/27/04	1445	n	17.7	22.1	650	765	0.4	8.74	8.16	32	180
R14	Big Sioux River at Watertown	05/17/04	1020	y	11.1	-----	573	-----	-----	9.65	-----	10	260
R14	Big Sioux River at Watertown	06/02/04	930	n	13.4	19.0	663	850	0.4	5.21	7.24	24	710
R14	Big Sioux River at Watertown	06/16/04	1030	n	18.8	16.0	695	789	0.4	6.72	7.91	14	250
R14	Big Sioux River at Watertown	07/01/04	915	n	22.0	24.0	654	693	0.3	4.60	8.01	9	31000
R14	Big Sioux River at Watertown	07/17/04	915	n	21.1	23.0	589	638	0.3	2.31	7.52	8	820
R14	Big Sioux River at Watertown	07/27/04	1130	n	20.2	26.0	660	730	0.4	8.06	7.56	35	8700
R14	Big Sioux River at Watertown	08/09/04	1313	n	16.3	15.0	628	756	-----	8.90	8.49	23	1200
R14	Big Sioux River at Watertown	08/25/04	1205	n	20.0	26.5	677	748	0.4	8.96	8.30	23	3100
R14	Big Sioux River at Watertown	09/08/04	1251	y	18.2	23.0	600	695	0.3	10.98	7.57	33	790
R14	Big Sioux River at Watertown	09/27/04	1230	n	15.4	19.5	675	826	0.4	9.27	7.99	11	2000
R15	Big Sioux River at Broadway St.	05/17/04	1045	y	12.9	17.0	449	-----	-----	11.07	-----	12	510
R15	Big Sioux River at Broadway St.	06/02/04	1000	n	14.9	18.0	606	760	0.4	4.46	7.23	23	1100
R15	Big Sioux River at Broadway St.	06/16/04	1055	n	19.5	18.0	709	806	0.4	4.55	7.93	14	370
R15	Big Sioux River at Broadway St.	07/01/04	935	n	22.2	27.0	533	563	0.3	4.75	7.78	13	1300
R15	Big Sioux River at Broadway St.	07/14/04	940	n	22.9	23.0	763	795	0.4	4.68	7.53	16	90
R15	Big Sioux River at Broadway St.	07/27/04	1150	n	21.5	25.0	805	863	0.4	10.25	7.62	10	80
R15	Big Sioux River at Broadway St.	08/09/04	1428	n	18.0	15.8	713	821	-----	11.00	8.12	17	60
R15	Big Sioux River at Broadway St.	08/25/04	1145	n	20.9	24.0	588	638	0.3	4.21	8.03	12	300
R15	Big Sioux River at Broadway St.	09/08/04	1313	y	18.2	28.0	599	688	0.3	6.18	7.66	15	50
R15	Big Sioux River at Broadway St.	09/27/04	1300	n	16.4	19.5	758	907	0.4	7.60	7.73	7	40
R16	Big Sioux River at 20th Ave	05/17/04	1100	y	13.2	15.0	752	-----	-----	10.50	-----	8	440
R16	Big Sioux River at 20th Ave	06/02/04	1015	n	13.2	17.0	798	1028	0.5	5.75	7.15	7	460
R16	Big Sioux River at 20th Ave	06/16/04	1115	n	16.4	18.0	847	1009	0.5	7.20	7.82	7	260
R16	Big Sioux River at 20th Ave	07/01/04	955	n	17.9	27.0	1068	1245	0.6	7.81	7.50	10	230
R16	Big Sioux River at 20th Ave	07/14/04	955	n	18.2	24.0	1027	1182	0.6	7.23	7.47	9	810
R16	Big Sioux River at 20th Ave	07/27/04	1210	n	18.9	25.0	1031	1206	0.6	10.22	7.48	12	380
R16	Big Sioux River at 20th Ave	08/09/04	1448	n	17.4	13.5	1025	1203	-----	8.50	7.73	12	710
R16	Big Sioux River at 20th Ave	08/25/04	1130	n	18.4	23.5	1052	1203	0.6	8.04	7.69	10	120
R16	Big Sioux River at 20th Ave	09/08/04	1330	y	18.8	28.0	946	1071	0.5	9.43	7.92	7	420
R16	Big Sioux River at 20th Ave	09/27/04	1315	n	16.7	21.7	937	1114	0.6	7.40	7.65	7	140

Site	Site Name	Date	Time	Runoff ?	Water Temp C°	Air Temp C°	Conductivity µs/cm	Specific Conductivity µs/cm	Salinity ppt	Dissolved Oxygen mg/L	pH units	Turbidity NTU	Fecal Coliform cfu/100mL
R17	Big Sioux River below Watertown	05/17/04	1120	y	13.9	14.0	553	-----	-----	6.32	-----	26	650
R17	Big Sioux River below Watertown	06/02/04	1040	n	14.3	17.0	704	887	0.4	5.41	7.22	25	660
R17	Big Sioux River below Watertown	06/16/04	1140	n	18.0	16.0	841	971	0.5	6.04	8.09	22	190
R17	Big Sioux River below Watertown	07/01/04	1010	n	23.2	26.0	1124	1163	0.6	6.75	8.04	10	460
R17	Big Sioux River below Watertown	07/14/04	1015	n	23.0	23.0	930	965	0.5	7.85	8.26	12	370
R17	Big Sioux River below Watertown	07/27/04	1225	n	22.6	25.0	1065	1122	0.6	13.04	7.70	18	310
R17	Big Sioux River below Watertown	08/09/04	1518	n	17.4	14.0	957	1134	-----	13.95	8.63	21	300
R17	Big Sioux River below Watertown	08/25/04	1108	n	20.1	20.5	533	584	0.3	12.61	8.43	33	2200
R17	Big Sioux River below Watertown	09/08/04	1348	y	20.7	29.0	652	708	0.4	11.13	8.42	37	500
R17	Big Sioux River below Watertown	09/27/04	1330	n	16.7	20.3	560	936	0.5	8.10	7.98	38	600
R18	Big Sioux River nr Castlewood	05/17/04	1150	y	13.6	16.0	818	-----	-----	9.49	-----	13	3300
R18	Big Sioux River nr Castlewood	06/02/04	1120	n	14.9	20.0	748	928	0.5	7.09	7.28	3	70
R18	Big Sioux River nr Castlewood	06/16/04	1205	n	18.6	16.0	735	837	0.4	8.06	8.32	10	3200
R18	Big Sioux River nr Castlewood	07/01/04	1035	n	23.7	26.0	1031	1056	0.5	5.92	8.56	6	2800
R18	Big Sioux River nr Castlewood	07/14/04	1040	n	24.2	25.0	876	893	0.5	5.88	8.32	21	4400
R18	Big Sioux River nr Castlewood	07/27/04	1250	n	24.0	25.0	954	977	0.5	13.47	7.90	60	420
R18	Big Sioux River nr Castlewood	08/09/04	1550	n	18.0	15.0	785	907	-----	9.10	9.75	40	160
R18	Big Sioux River nr Castlewood	08/25/04	1045	n	19.7	19.5	1090	1213	0.6	10.61	8.95	18	980
R18	Big Sioux River nr Castlewood	09/08/04	1414	y	21.4	30.0	700	744	0.4	12.24	8.94	15	2500
R18	Big Sioux River nr Castlewood	09/27/04	1350	n	17.0	20.5	784	926	0.5	8.30	8.08	45	1100
R19	Big Sioux River nr. Estelline	05/17/04	1220	y	14.0	16.0	618	-----	-----	11.40	-----	23	180
R19	Big Sioux River nr. Estelline	06/02/04	1145	n	14.8	20.0	750	1932	0.5	5.58	7.39	16	460
R19	Big Sioux River nr. Estelline	06/16/04	1230	n	18.0	15.0	798	919	0.5	7.07	8.14	17	310
R19	Big Sioux River nr. Estelline	07/01/04	1105	n	22.7	32.0	768	843	0.4	8.49	8.35	6	1340
R19	Big Sioux River nr. Estelline	07/14/04	1105	n	23.0	26.0	778	810	0.4	10.51	8.76	35	250
R19	Big Sioux River nr. Estelline	07/27/04	120	n	22.6	31.0	795	835	0.4	12.48	7.78	130	110
R19	Big Sioux River nr. Estelline	08/09/04	1626	n	18.1	15.0	679	784	-----	6.80	9.18	150	310
R19	Big Sioux River nr. Estelline	08/25/04	1010	n	18.3	18.0	360	413	0.2	16.92	8.66	75	2100
R19	Big Sioux River nr. Estelline	09/08/04	1430	n	21.0	26.0	733	793	0.4	12.40	9.21	110	320
R19	Big Sioux River nr. Estelline	09/27/04	1400	n	16.8	19.8	757	903	0.4	8.40	7.94	26	470
R20	Big Sioux River nr Bruce	05/17/04	1245	y	15.1	17.0	575	-----	-----	13.80	-----	16	710
R20	Big Sioux River nr Bruce	06/02/04	1240	n	15.3	20.0	593	728	0.4	7.04	7.52	13	670
R20	Big Sioux River nr Bruce	06/16/04	1300	n	19.2	16.0	758	851	0.4	6.08	8.12	8	730
R20	Big Sioux River nr Bruce	07/01/04	1140	n	24.3	32.0	816	827	0.4	10.17	8.39	3	100
R20	Big Sioux River nr Bruce	07/14/04	1130	n	24.7	26.0	757	761	0.4	7.90	8.52	8	150
R20	Big Sioux River nr Bruce	07/27/04	145	n	23.7	32.0	805	826	0.4	10.53	7.76	25	180
R20	Big Sioux River nr Bruce	08/09/04	1710	n	18.8	16.0	634	723	-----	5.80	9.12	45	330
R20	Big Sioux River nr Bruce	08/25/04	950	n	18.2	18.0	682	784	0.4	4.12	7.77	20	490
R20	Big Sioux River nr Bruce	09/08/04	1502	n	22.0	24.5	330	370	0.1	12.61	8.95	20	250
R20	Big Sioux River nr Bruce	09/27/04	1445	n	16.8	19.9	696	826	0.4	8.74	8.09	35	360

Appendix C.
WQ Field Data Sheet

North-Central Big Sioux River Watershed Assessment
East Dakota Water Development District
Water Quality Data

Lab No.
Site Location Code:
Samples Collected By:
Staff Gage Reading:
Type of Sample: Grab / Time Comp / Depth Integrated

Source: Tributary / River
Site Name:
Date: Time:
Sample Depth:

Visual Observations
Precipitation – none light moderate heavy
Wind (&direction) – calm moderate strong
Odor – yes no
Septic - yes no
Dead Fish - yes no
Film - yes no
Color -
Width -
Depth -
Ice Cover - yes no

Field Analysis	
Parameter	**Measure**
Water Temperature	
Air Temperature	
Conductivity	
Salintiy	
Dissolved Oxygen	
pH	
Secchi	
Turbidity	

Lab Analysis	Field Preparation				
Parameter	Cool to 4ºC	2mL conc H_2SO_4 Cool to 4ºC	2mL conc H_2SO_4 Cool to 4ºC	Filtered, 2mL conc H_2SO_4 Cool to 4ºC	$Na_2S_2O_3$
	Bottle A	Bottle B	Bottle C	Bottle D	Bottle E
Total Solids	XXX				
Total Suspended Solids	XXX				
Ammonia-N		XXX			
Total Kjeldahl-N		XXX			
Nitrate-N		XXX			
Total Phosphorus			XXX		
Total Dissolved Phosphorus				XXX	
Fecal Coliform					XXX

Field Observations:

Appendix D.
Stage Recorder Start and End Dates

Stage Recorder Start and End Dates

Site	Site Name	Start Date	End Date	Recorder Type
T34	Lake Pelican Weir	-------------------	City of Watertown	--------------------
T35	Willow Creek (nr Waverly)	05/29/01	10/30/01	OTT Thalimedes Hydrometer
		04/08/02	10/31/02	OTT Thalimedes Hydrometer
T36	Willow Creek (nr Watertown)	-----------------------	USGS	---------------------------
T37	Stray Horse Creek	06/07/01	10/30/01	Solinst Levelogger
		04/08/02	10/31/02	Solinst Levelogger
T38	* Boswell Diversion Ditch	05/30/01	10/30/01	OTT Thalimedes Hydrometer
T39	Lake Poinsett Outlet	04/16/02	10/31/02	OTT Thalimedes Hydrometer
T40	Hidewood Creek (nr Clear Lake)	06/08/01	10/30/01	Solinst Levelogger
		04/05/02	10/31/02	Solinst Levelogger
T41	Hidewood Creek (nr Estelline)	05/29/01	10/30/01	OTT Thalimedes Hydrometer
		04/08/02	10/31/02	OTT Thalimedes Hydrometer
T42	Peg Munky Run	05/21/01	10/30/01	OTT Thalimedes Hydrometer
		04/05/02	10/31/02	OTT Thalimedes Hydrometer
T46	East Oakwood Lake Outlet 2	05/29/01	10/30/01	OTT Thalimedes Hydrometer
		04/05/02	10/31/02	OTT Thalimedes Hydrometer
T47	Unnamed Creek (nr Volga)	05/29/01	10/30/01	OTT Thalimedes Hydrometer
		04/05/02	10/31/02	OTT Thalimedes Hydrometer

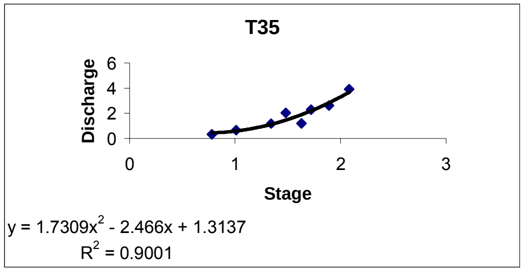
* Site decomissioned due to unoperable flood gates

Appendix E.
Stage-Discharge Curves

Stage – Discharge Curves

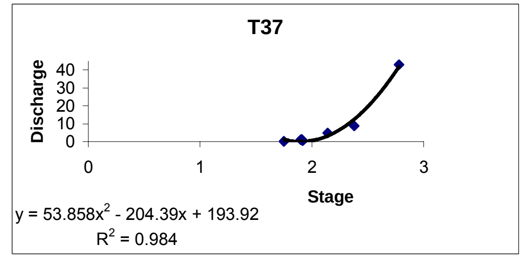
T35

Stage	Discharge
0.78	0.338
1.01	0.656
1.34	1.173
1.48	2.035
1.63	1.189
1.72	2.287
1.89	2.62
2.08	3.902



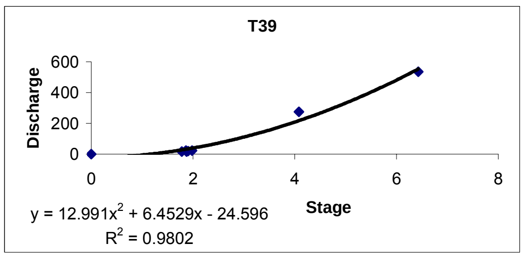
T37

Stage	Discharge
2.38	8.742
2.14	4.869
1.92	0.463
1.9	1.122
1.91	1.341
1.91	0.939
1.75	0.237
1.75	0.288
1.75	0.141
2.78	43.021



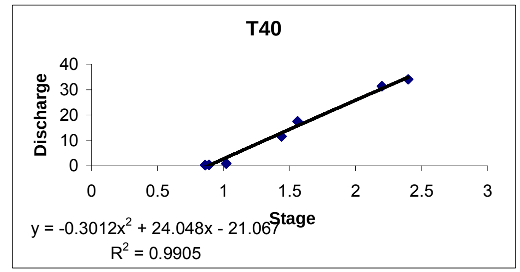
T39

Stage	Discharge
1.78	17.996
1.86	24.727
1.87	16.016
1.9	20.013
1.97	5.144
1.98	23.432
2.18	1.761
4.08	275.935
6.429	536.114



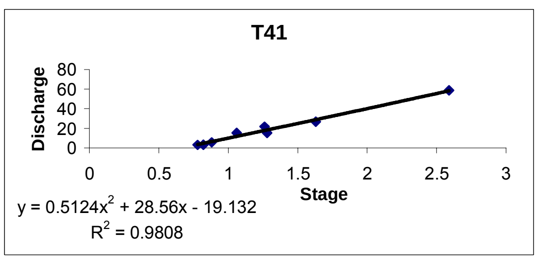
T40

Stage	Discharge
0.86	0.23
0.86	0.168
0.89	0.371
1.02	0.828
1.44	11.514
1.56	17.476
2.2	31.343
2.4	34.049



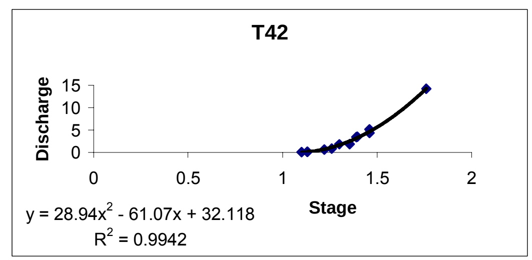
T41

Stage	Discharge
0.78	3.05
0.82	3.273
0.88	5.552
1.06	15.214
1.26	21.661
1.28	15.298
1.63	26.496
2.59	58.644



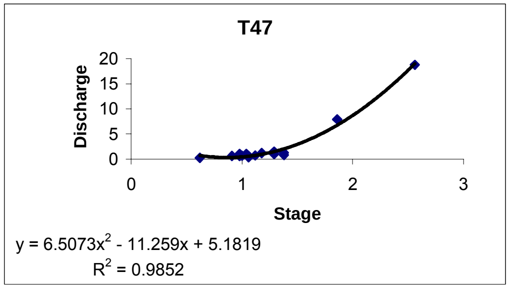
T42

Stage	Discharge
1.1	0.042
1.13	0.116
1.13	0.095
1.22	0.613
1.26	0.856
1.3	1.817
1.355	1.837
1.39	3.403
1.395	3.492
1.46	4.364
1.46	5.124
1.76	14.221



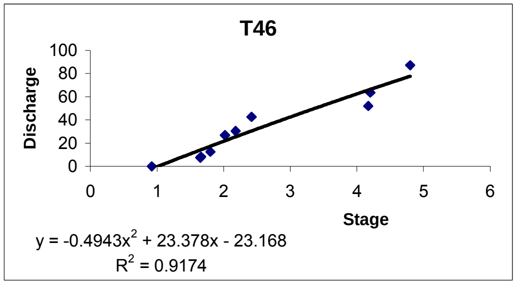
T47

Stage	Discharge
1.29	0.999
0.98	1.036
1.12	0.719
1.06	0.366
1.38	0.81
0.62	0.232
1.29	1.502
2.56	18.805
1.86	7.934
1.38	1.266
1.18	1.221
1.06	0.594
1	0.656
0.98	0.569
0.91	0.619
1.04	1.056



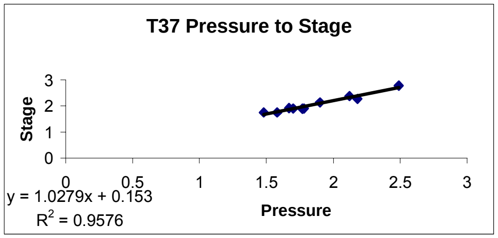
T46

Stage	Discharge
0.92	0.057
1.65	7.409
1.66	8.306
1.8	12.645
2.02	26.928
2.18	30.493
2.42	42.651
4.17	51.993
4.2	63.595
4.8	87.183



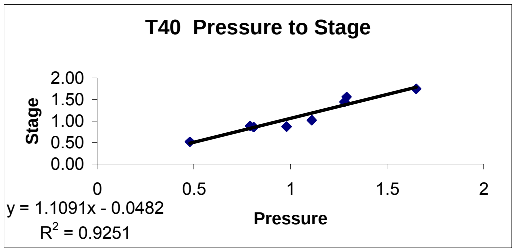
T37

Pressure	Stage
2.18	2.28
2.12	2.38
1.9	2.14
1.67	1.92
1.77	1.9
1.78	1.91
1.70	1.91
1.58	1.75
1.48	1.75
2.49	2.78



T40

Pressure	Stage
0.98	0.87
1.29	1.56
1.65	1.75
1.28	1.44
1.11	1.02
0.79	0.89
0.81	0.86
0.81	0.86
0.48	0.52



Appendix E

Appendix F.
Equations used to Calculate Discharges

Equations used to Calculate Discharges

Stream Flow - Stage Relationships		
SiteID	Equation	R^2
T35	$y = 1.7309x^2 - 2.466x + 1.3137$	0.900
T36	City of Watertown	
T37	$y = 53.858x^2 - 204.39x + 193.92$	0.984
T39	$y = 12.991x^2 +6.4529x - 24.596$	0.980
T40	$y = -0.3012x^2 - 24.048x - 21.067$	0.991
T41	$y = 0.5124x^2 + 28.56x - 19.132$	0.981
T42	$y = 28.94x^2 - 61.07x + 32.118$	0.994
T46	$y = -0.4943x^2 + 23.378x - 23.168$	0.917
T47	$y = 6.5073x^2 - 11.259x + 5.1819$	0.985
R01	USGS provided	
R14	USGS provided	
R15	USGS provided	
R16	USGS provided	
R17	USGS provided	
R18	USGS provided	
R19	USGS provided	
R20	USGS provided	

Appendix G.
Flow Duration Interval Graph Data

Fecal Coliform Bacteria Flow Duration Interval Graph Data

Site	Grab Data (May-Sep) Years		Discharge Data Years		Remarks
	EDWDD	DENR	EDWDD	USGS	
* T34	2001-2002	----	**	----	** Discharge data from the City of Watertown (2001-2004)
T35	2001-2002	----	2001-2002	----	
T36	2001-2002	----	----	1971-1986 2000-2005	USGS Station # 06479515
T37	2001-2002	----	2001-2002	----	
* T39	2001-2002	----	2001-2002	----	
T40	2001-2002	----	2001-2002	----	
T41	2001-2002	----	2001-2002	----	
T42	2001-2002	----	2001-2002	----	
* T46	2001-2002	----	2001-2002	----	
* T47	2001-2002	----	2001-2002	----	

* Numeric Standard for Fecal Coliform Bacteria Does Not Apply

Fecal Coliform Bacteria Load Duration Interval Graph Data

Site	Grab Data (May-Sep) Dates		Discharge Data Dates		Remarks
	EDWDD	DENR	EDWDD	USGS	
R01	2001-2002 2004	2001-2002 2004	----	1980-Present	Discharge data derived from USGS Station # 06480000
R14	2001-2002 2004	2001-2002 2004	----	1945-Present	Station #06479500
R15	2001-2002 2004	----	----	1994-Present	Discharge data derived from USGS Station # 06479520
R16	2001-2002 2004	----	----	1994-Present	Discharge data derived from USGS Station # 06479520
R17	2001-2002 2004	2001-2002 2004	----	1994-Present	Station #06479520
R18	2001-2002 2004	----	----	1976-Present	Station #06479525
R19	2001-2002 2004	2001-2002 2004	----	1976-Present	Discharge data derived from USGS Station #06479525
R20	2001-2002 2004	----	----	2000-Present	Station #06479770

Appendix H.
Terms and Definitions of the Core Fish Metrics

Terms and Definitions of the Core Fish Metrics

Knowledge of historical indigenous fish distributions can be valuable to selection of candidate metrics. A comparison of recent fish distributions in the Big Sioux River with those summarized in Bailey and Allum (1962) indicate that no loss of species has occurred. All species have been persistent over a documented period of 50 to 60 years.

Non-indigenous fish introductions and distributions need to be understood before candidate metrics are selected. In some states, non-indigenous introductions have significant effects on the stream ecology. In South Dakota, the distributions of most non-indigenous fishes are minimal. Non-indigenous species, based on recent collections, rarely comprise a significant number or biomass of fishes in samples from headwater and wadable sites.

Climatic and geologic factors influence streamflow patterns and faunal diversity, and therefore, must form part of the basis for metric selection. Stream flow patterns in eastern South Dakota are influenced by cycling of wet and dry phases over 10-20 year periods. During dry phases, headwaters, and quite often, entire tributaries become intermittent. Theoretically, fish community structure and function in these environments are less diverse than communities in perennial stream environments. Additionally, the diversity of the regional fish fauna in the Big Sioux River, which flows to the Missouri River, is lower than regional fish faunas in rivers that flow to the Mississippi River.

The following metrics and their definitions are those recommended to be used when assessing the Midwest region. These metrics weighed heavily on which candidate metrics would be chosen as the core metrics. Though, box plots were used to further differentiate what the overall final core metrics for fishes would be used. After each metric description, the core metric it corresponds to is in parenthesis.

Metric : Total number of fish species
As originally intended this metric has been accepted as an indicator of overall stream health. The most common alternative in warm water streams is number of native fish species, which will be tested. (Core Metric 1 – Total Species Richness)

Metric: Number and identity of darter species
Darters represent a diverse taxonomic group that inhabits benthic habitats. These species decline when benthic habitat is subject ed to sedimentation and reduced oxygen. In the Big Sioux River system, only three darters species occur with the blackside darter rarely collected in either historic or recent surveys. Karr suggested that other benthic taxon could replace darters in regions outside the range of darters. Alternative metrics to be tested are number of benthic species, and number of benthic insectivore species. (Core Metric 3 – Benthic Species Richness)

Metric: Number and identity of sunfish species
Sunfishes represent a diverse taxanomic group that inhabits pools. These species decline when pool habitats are degraded and pool cover is reduced. Only two sunfish species are native to the Big Sioux River system. Therefore, alternative metrics must be selected that incorporate a more diverse array of non-benthic species. For

headwater sites, the number of headwater species and the proportion of individuals as headwater species were selected for testing. For headwater and wadable sites, the number of minnow species and the number of water column species was tested. (Core Metric 2 – Water Column Species Richness, Core Metric 4 – % Headwater Species)

Metric: Number and identity of sucker species
Suckers are sensitive to physical and chemical degradation and integrate disturbances over many years because they are long lived (Karr et al. 1986). In headwater and wadable sites of the Big Sioux River system, the white sucker is the only wide spread species, and the shorthead redhorse is occasionally found in very low numbers. An alternative has been number of minnow species, which is listed as an alternative for metric 3. No other taxon in headwater or wadable streams has the multi-year attributes of suckers, but several semelparous minnow species commonly live 3 or 4 years. In prairie streams, if several of these species exhibit three or more discrete size classes, then this could be an indication of a healthy stream. Therefore, the number of semelparous minnow species that exhibit multiple size classes will be tested.

M*etric: Number and identity of intolerant species*
Intolerant species are the first to be affected by major sources of degradation such as siltation, low dissolved oxygen, reduced flow and chemical contamination. Intolerant designations should compose only 5 to 10% of the fish community and, generally, should represent species found only in streams at or near their natural potential. However, intolerant species may rarely occur in headwaters. An alternative metric for headwater sites is the number of sensitive species (OEPA 1987), which include highly intolerant species and some moderately intolerant species. The number of sensitive species has also been applied to wadable and non-wadable streams. This metric has potential for streams in the Big Sioux River system, because intolerant species in headwaters, and possibly wadable streams during dry years, may naturally become scarce. (Core Metric 6 - % Intolerant Species, Core Metric 7 – % Sensitive Species)

Metric: Proportion of individuals as green sunfish
Green sunfish in Midwestern streams were designated by Karr as a species that is tolerant and becomes dominant in the most degraded streams. Karr suggested that other tolerant species that become dominant in degraded conditions can be used as substitutes, or that the proportion of tolerant species can be used to avoid weighting this metric on one species. The latter is frequently selected as a substitute and was chosen as a potential alternative for the Big Sioux River. (Core Metric 8- % Tolerant Species Biomass)

Metric: Proportion of individuals as omnivores
Omnivores increase in streams where the physical and chemical environment becomes degraded. In degraded environments, the food source becomes less reliable, thus giving omnivores an advantage over more specialized species. An alternative is the proportion of total biomass as omnivores, which may be a more sensitive metric in prairie streams that theoretically have fewer semelparous specialists and a simpler trophic structure compared to systems of the original metrics. By measuring biomass of omnivores, biases associated with differentiation of young-of-year from adults at the field level may be ameliorated. (Core Metric 11- % Omnivore)

Metric: Proportion of individuals as insectivorous minnows
Insectivores decrease in streams where the physical and chemical environments become degraded, because the invertebrate food base becomes less reliable. An alternative is the proportion of total biomass as insectivorous minnows. For the same reason given for metric 8, biomass may be a more sensitive metric in prairie streams. (Core Metric 9 - % Insectivorous Minnows, Core Metric 10 - % Insectivorous Biomass)

Metric: Proportion of individuals as piscivores
This metric represents the upper trophic level in streams. However, in prairie streams of the Big Sioux River system, piscivores are not as diverse as streams that flow into the Mississippi River. Headwater streams and wadable streams do not typically support a persistent adult piscivore assemblage. In contrast, they often support a persistent assemblage of pioneer species, which may indicate either unstable or degraded conditions. The proportion of pioneering was selected as an alternative metric for headwater and wadable streams. (Core Metric 5 - % Pioneering Species Biomass)

Metric: Number of individuals in sample
This metric is based on the concept that the number of individuals sampled per unit length or area of stream decreases as stream degradation increases. An alternative to be tested is biomass of fish per unit area of stream.

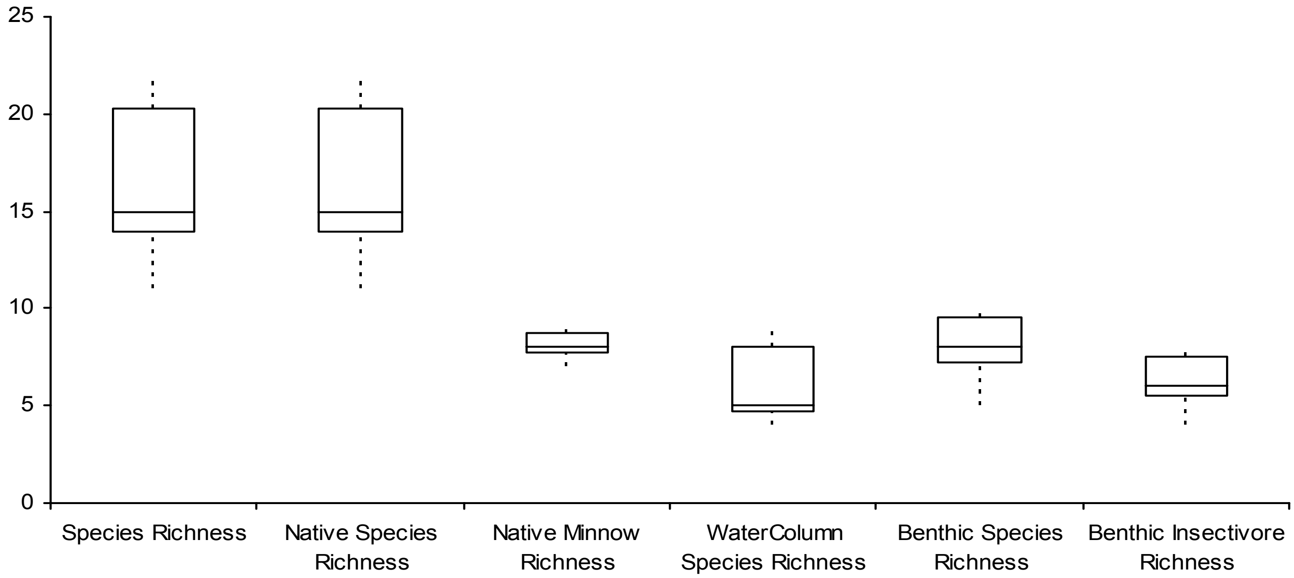
Metric: Proportion of individuals as hybrids
This metric evaluates the habitat degradation as it influences reproduction of stream fishes. Generally, as stream degradation increases, reproductive isolation breaks down and hybridization increases. Hybridization can be difficult to determine and does occur among minnows in streams that are not degraded. Alternatives often selected are proportion of individuals as simple lithophils or number of simple lithophilic species, which were selected also for the Big Sioux River system. (Core Metric 12 - % Simple Lithophil Biomass)

Metric: Proportion of individuals with disease, tumors, fin damage, and skeletal anomalies
This metric is sensitive to the factors that cause poor health to a large proportion of individuals. A large proportion of individuals found in poor health are usually an indication of sub-acute effects of chemical pollution (Plafkin et al. 1989). This metric is usually retained in its original form. No alternatives are proposed for testing.

Appendix I.
Box Plots of Fish Metrics

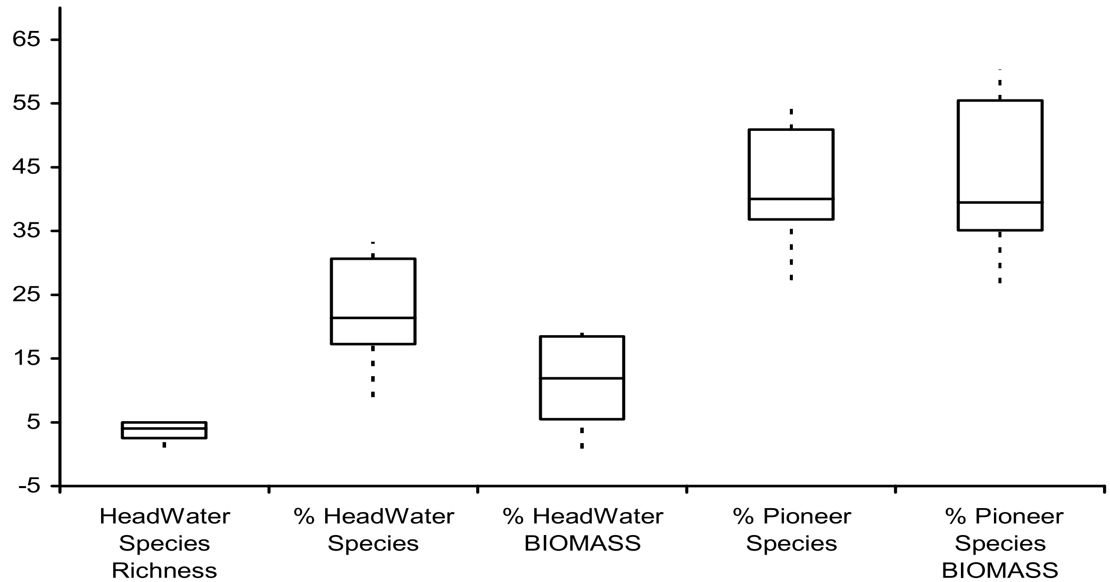
Box and Whisker Plots of the Fish Metrics

Species Richness and Composition



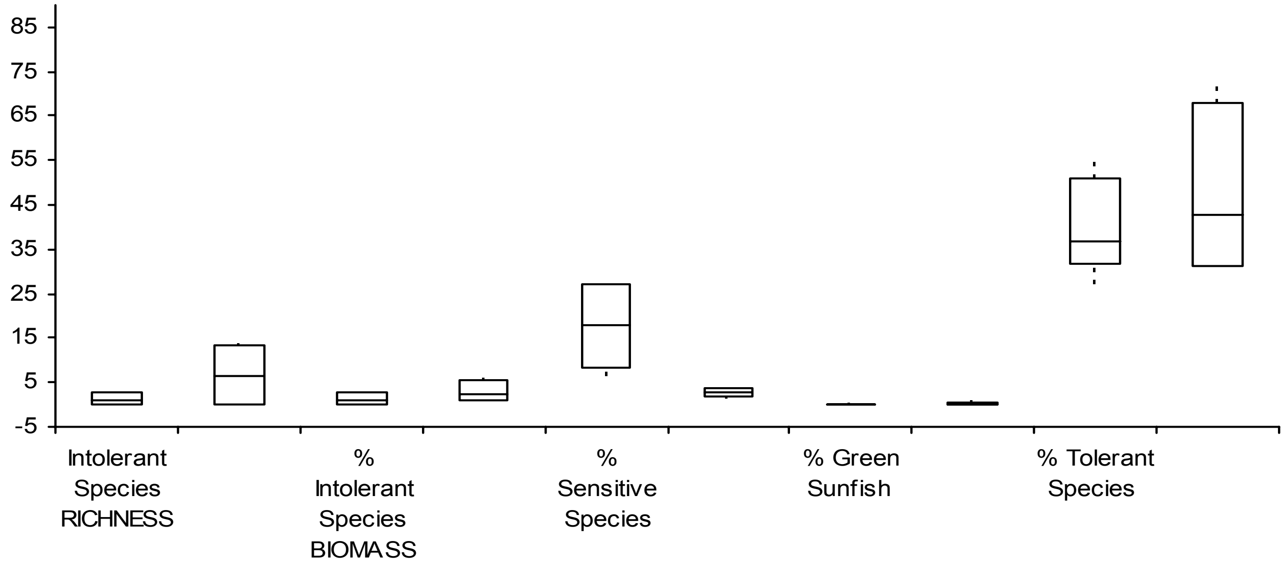
Metric	n	CV	Mean	SD	SE	95% CI of Mean			Median	IQR
Species Richness	4	0.290	15.75	4.57	2.29	8.47	to	23.03	15.00	6.25
Native Species Richness	4	0.290	15.75	4.57	2.29	8.47	to	23.03	15.00	6.25
Native Minnow Richness	4	0.102	8.00	0.82	0.41	6.70	to	9.30	8.00	1.00
WaterColumn Species Richness	4	0.386	5.75	2.22	1.11	2.22	to	9.28	5.00	3.25
Benthic Species Richness	4	0.266	7.75	2.06	1.03	4.47	to	11.03	8.00	2.25
Benthic Insectivore Richness	4	0.272	6.00	1.63	0.82	3.40	to	8.60	6.00	2.00

Headwater/Pioneering Attributes



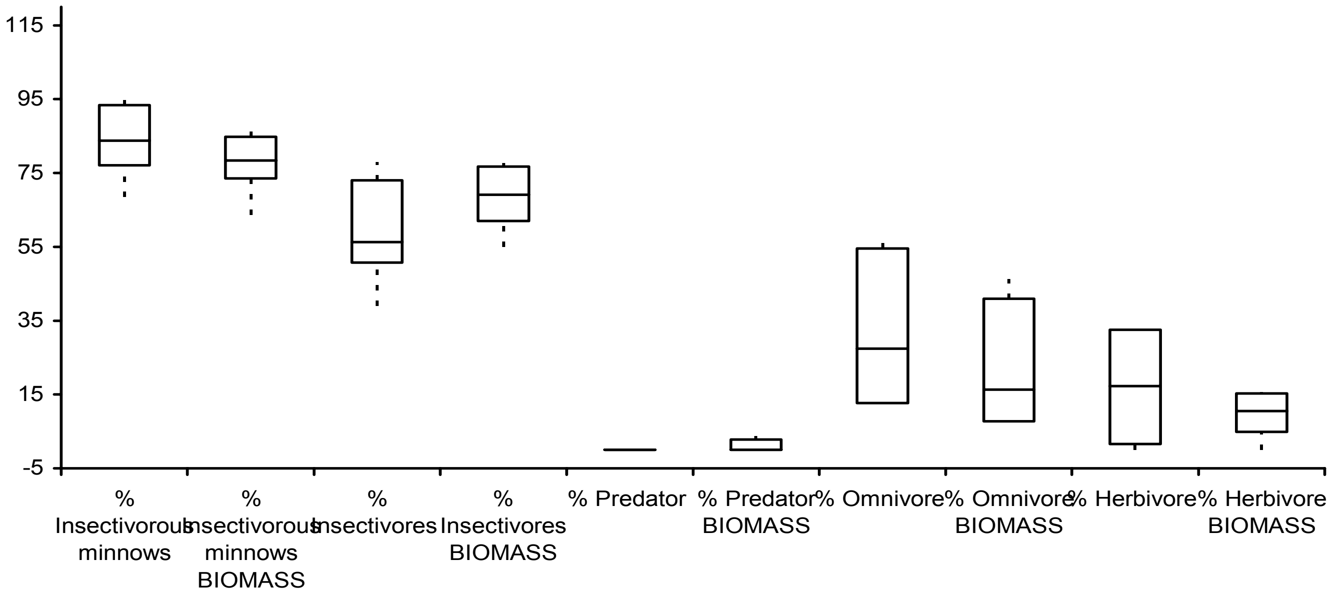
Metric	n	CV	Mean	SD	SE	95% CI of Mean			Median	IQR
HeadWater Species Richness	4	0.547	3.50	1.91	0.96	0.45	to	6.55	4.00	2.50
% HeadWater Species	4	0.470	21.25	9.98	4.99	5.37	to	37.13	21.35	13.40
% HeadWater BIOMASS	4	0.776	10.93	8.48	4.24	-2.57	to	24.42	11.90	12.98
% Pioneer Species	4	0.275	40.45	11.12	5.56	22.76	to	58.14	40.00	14.05
% Pioneer Species BIOMASS	4	0.336	41.50	13.94	6.97	19.32	to	63.68	39.45	20.35

Intolerant/Tolerant Attributes



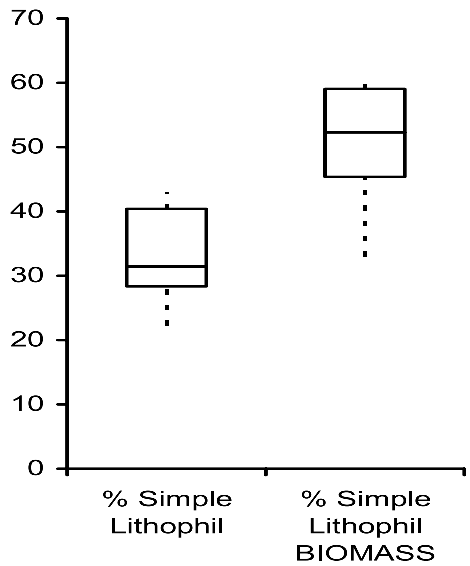
Metric	n	CV	Mean	SD	SE	95% CI of Mean			Median	IQR
Intolerant Species RICHNESS	4	1.200	1.25	1.50	0.75	-1.14	to	3.64	1.00	2.75
% Intolerant Species	4	1.155	6.73	7.77	3.88	-5.63	to	19.08	6.65	13.53
% Intolerant Species BIOMASS	4	1.184	1.25	1.48	0.74	-1.10	to	3.61	1.05	2.70
Sensitive Species Richness	4	0.816	3.00	2.45	1.22	-0.90	to	6.90	2.50	4.50
% Sensitive Species	4	0.637	17.43	11.10	5.55	-0.24	to	35.09	17.85	18.73
% Sensitive Species BIOMASS	4	0.400	2.60	1.04	0.52	0.95	to	4.25	2.70	1.50
% Green Sunfish	4	0.671	0.16	0.11	0.05	-0.01	to	0.34	0.14	0.20
% Green Sunfish BIOMASS	4	1.123	0.32	0.36	0.18	-0.25	to	0.90	0.18	0.57
% Tolerant Species	4	0.302	38.78	11.70	5.85	20.16	to	57.39	36.65	19.08
% Tolerant Species Biomass	4	0.420	47.43	19.93	9.96	15.72	to	79.13	42.95	36.53

Trophic Guilds



Metric	n	CV	Mean	SD	SE	95% CI of Mean			Median	IQR
% Insectivorous minnows	4	0.138	82.85	11.43	5.71	64.67	to	101.03	83.80	16.25
% Insectivorous minnows BIOMASS	4	0.125	76.73	9.56	4.78	61.52	to	91.93	78.40	11.28
% Insectivores	4	0.279	57.40	16.03	8.01	31.90	to	82.90	56.30	22.20
% Insectivores BIOMASS	4	0.150	67.73	10.19	5.09	51.52	to	83.93	69.10	14.78
% Predator	4	2.000	0.01	0.01	0.01	-0.01	to	0.02	0.00	0.02
% Predator BIOMASS	4	2.000	0.93	1.85	0.93	-2.02	to	3.87	0.00	2.78
% Omnivore	4	0.723	31.55	22.80	11.40	-4.72	to	67.83	27.40	41.85
% Omnivore BIOMASS	4	0.846	21.68	18.33	9.17	-7.49	to	50.84	16.35	33.28
% Herbivore	4	1.084	16.78	18.18	9.09	-12.15	to	45.70	17.30	30.93
% Herbivore BIOMASS	4	0.801	9.15	7.33	3.66	-2.51	to	20.81	10.50	10.45

Reproduction



Metric	n	CV	Mean	SD	SE	95% CI of Mean			Median	IQR
% Simple Lithophil	4	0.266	32.05	8.52	4.26	18.49	to	45.61	31.45	12.00
% Simple Lithophil BIOMASS	4	0.240	49.50	11.87	5.93	30.62	to	68.38	52.30	13.70

Appendix J.
Natural Resource Solutions Contract
and
Laboratory Procedures

Contract No. 2, Natural Resource Solutions, Inc. and East Dakota Water Development District

Contract for Services

This agreement, made the 28th day of October 2002 is between Natural Resource Solutions and East Dakota Water Development District, referred to in this document as the District.

A. **Scope of Services**: Natural Resource Solutions agrees to provide macroinvertebrate identifications and metric calculations for samples collected from sites in the North-Central Big Sioux River Watershed Assessment by the District. The level of taxonomic resolution will be equivalent to or below the taxonomic level (generally species) previously identified by the South Dakota Department of Environment and Natural Resources (SDDENR). Results will include the following:

1. Macroinvertebrate will be identified and enumerated for 31 rock basket samples collected at 19 sites in 2002. Thirteen of these samples are composite samples of 3 rock baskets per site for 13 sites. Eighteen of these samples comprise 3 individually preserved rock baskets per site for 6 sites.

2. Calculation of the 39 metrics in Table 1 will be completed for the 31 samples. These metrics will be subject to review for appropriateness for assessment and monitoring of the Big Sioux River. The District Manager at EDWDD and Natural Resource Solutions must agree upon any changes.

3. A report will be prepared that includes a description of the major taxonomic groups and water quality conditions they are usually associated with.

4. Hard and electronic copies (Electronic Data Deliverables-EDD) will be required for the data. The data will be entered into the EDAS database.

5. The functional feeding group assignments, i.e. gatherer, shredder, piercer etc., will be included for each genus/species in the EDD.

6. The biotic index value (tolerance values) will be included for each genus species in the EDD.

7. Standard laboratory protocols for the SDDENR will be followed in the analysis (Appendix A).

8. Standard QA/QC protocols be followed in the future if deemed necessary (Appendix A).

9. The voucher collection described in the standard laboratory protocols (Appendix A) will include a set of permanent slides of the head capsules and/or whole mounts of the identified chironomidae genus/species.

10. A summary of the methods, equipment and keys used to identify macroinvertebrate samples will be provided.

Results for all samples submitted to Natural Resource Solutions by November 15, 2002 will be provided to the District by September 1, 2003. A five-percent reduction in per sample price will be deducted for every week delay in receipt of results.

A summary of cost is presented in Table 2.

B. **Responsibilities of the District:** The District agrees to provide general direction and necessary District coordination and contracts relating to the Scope of Services outlined in paragraph A. The District will provide macroinvertebrate samples collected during the 2002 North-Central Big Sioux River Watershed Assessment in one group.

C. **Compensation:** The District agrees to pay Natural Resource Solutions $220.00/sample for professional services rendered. This covers four items: $40.00/sample for sorting, $50.00/sample for benthic identification, $80.00/sample for chironomid and oligochaete identification, $15.00/sample electronic data compilation and $35.00 /sample for metric calculation, compilation, and analysis. A detailed report for $450.00 will be prepared. In addition, for macroinvertebrates that would be new additions to the District's collection a reference/voucher collection for $25.00, and a slide-mounted reference collection of Chironomidaes and Oligochaetas for $25.00 will also be provided. The total contract will not exceed $7320.00. Natural Resource Solutions will send a monthly invoice to the District for services completed by the end of each month of the contract with a description of sample items completed. The District will pay Natural Resource Solutions within 30 days of receipt of each monthly invoice.

D. **Other Conditions:** The District will be reimbursed for these costs through Environmental Protection Agency 319 funds for the Central Big Sioux River Watershed assessment.

E. **Federal Aid Requirements:** Natural Resource Solutions agrees with the following federal aid requirements:

1. To comply with Executive order 11246, concerning Equal Employment Opportunity.
2. Complete, sign and return the MBE/WBE forms (attached).

F. **Amendments:** This contract may be amended with written approval of both parties.

G. **Terms:** This contract shall run from Novemeber 15, 2002 to September 1, 2003.

H. **Additional Work:** For additional services other than those listed in Section A, a separate contract will be negotiated between the District and Natural Resource Solutions on a per sample basis.

I. **Hold Harmless:** The Natural Resource Solutions agrees to hold harmless and indemnify the East Dakota Water Development District, its officers, agents and employees, from and against any and all actions, suits, damages, liability or other proceedings which may arise as a result of performing services hereunder. This section does not require the Natural Resource Solutions to be responsible for or defend against claims or damages arising solely from acts or omissions of the East Dakota Water Development District, its officers or employees.

J. **Insurance Provision:** Does the State agency require an insurance provision?
YES __X__ NO _____

If YES, does the Natural Resource Solutions agree, at its sole cost and expense, to maintain adequate general liability, worker's compensation, professional liability and automobile liability insurance during the period of this Agreement? YES __X__ NO ______

K. **Termination:** The District can terminate this agreement if the District determines that adequate progress is not being made. The District shall give a two week written notice of any such termination, and shall pay for all services performed and expenses incurred up through the effective date of such termination.

All parties find this contract in order and agree to comply with the responsibilities and conditions outlined.

______________________________________ ____________________

Rebecca L. Spawn-Stroup, Owner Date
Natural Resource Solutions

Natural Resource Solutions - Tax ID #

Jay Gilbertson, Manager Date
East Dakota Water Development District

I certify that I am a …
(sign and check all that apply)

___X___Minority Business Enterprise

___X_ _Woman Business Enterprise

FOR AGENCY USE

-State Agency Coding (MSA Center)______________________________________

-State Agency MSA company from which contract is to be paid

____

-Object/subject MSA Account to which voucher(s) will be coded

____

Table 1. The following metrics will be calculated for the rock basket samples collected in 2002.		
Category	**Number**	**Metric**
Abundance Measures	1	Corrected abundance
	2	EPT abundance
Richness Measures	3	Total number of taxa
	4	Number of EPT taxa
	5	Number of Ephemeroptera taxa
	6	Number of Trichoptera taxa
	7	Number of Plecoptera taxa
	8	Number of Diptera taxa
	9	Number of Chironomidae taxa
Composition Measures	10	Ratio EPT/Chironomidae Abundance
	11	%EPT
	12	%Ephemeroptera
	13	%Plecoptera
	14	%Trichoptera
	15	% Coleoptera
	16	% Diptera
	17	% Oligochaeta
	18	% Baetidae
	19	% Hydropsychidae
	20	% Chironomidae
	21	% Simuliidae
	22	Shannon-Wiener Index
Tolerance/Intolerance Measures	23	No. of Intolerant Taxa
	24	% Tolerant Organisms
	25	% Sediment Tolerant Organisms
	26	Hilsenhoff Biotic Index
	27	% Dominant Taxon
	28	% Hydropsychidae to Trichoptera
	29	% Baetidae to Ephemeroptera
Feeding Measures	30	% individuals as gatherers and filterers
	31	% gatherers
	32	% filterers
	33	% shredders
	34	% grazers and scrapers
	35	Ratio scrapers/(scrapers+filterers)
	36	Number of gatherer taxa
	37	Number of filterer taxa
	38	Number of shredder taxa
	39	Number of grazer/scraper taxa

Table 2. Summary of cost for contract work.

Activity	Quantity	Cost	Total
Sample Processing	31 samples	$220.00/sample	$6820.00
Report Preparation	1	$450.00	$450.00
General Reference Collection[1]	1	$25.00	$25.00
Slide-mounted Reference Collection[1]	1	$25.00	$25.00
		Grand Total	**$7320.00**

[1]Only macroinvertebrates that would be new additions to the District's collection.

APPENDIX A.
MACROINVERTEBRATE ENUMERATION AND IDENTIFICATION

Laboratory Procedures for Macroinvertebrate Enumeration

1. Prior to processing any samples in a lot (i.e., samples within a collection date, specific watershed, or project), complete the sample log-in sheet to verify that all samples have arrived at the laboratory, and are in proper condition for processing.

2. Thoroughly rinse sample in a 500 μm-mesh sieve to remove preservative and fine sediment. Large organic material (whole leaves, twigs, algal or macrophyte mats, etc.) not removed in the field should be rinsed, visually inspected, and discarded. If the samples have been preserved in alcohol, it will be necessary to soak the sample contents in water for about 15 minutes to hydrate the benthic organisms, which will prevent them from floating on the water surface during sorting. If the sample was stored in more than one container, the contents of all containers for given sample should be combined at this time. Gently mix the sample by hand while rinsing to make homogeneous.

3. Floating and picking the sample can be completed if there is an inordinate amount of organic debris within the sample. This can be completed by various methods as long as visible degradation on the organisms within the sample does not occur. There are a variety of flotation methods available and any one can be used, i.e. sugar or epsom salts. Other methodologies may be employed so long as the individual organisms within the samples are not significantly damaged which may hinder the identification process.

4. After washing, spread the sample evenly across a pan marked with grids approximately 6 cm x 6 cm. On the laboratory bench sheet, note the presence of large or obviously abundant organisms; do not remove them from the pan. However, Vinson and Hawkins (1996) present an argument for including these large organisms in the count, because of the high probability that these organisms will be excluded from the targeted grids.

5. Use a random numbers table to select 4 numbers corresponding to squares (grids) within the gridded pan. Remove all material (organisms and debris) from the four gird squares, and place the material into a shallow white pan and add a small amount of water to facilitate sorting. If there appear (through a cursory count or observation) to be 100 organisms ± 20% (cumulative of 4 grids), then subsampling is complete.

   Any organism that is lying over a line separating two grids is considered to be on the grid containing its head. In those instances where it may not be possible to determine the location of the head (worms for instance), the organisms is considered to be in the gird containing most of its body.

   If the density of organisms is high enough that many more than 100/200/300 organisms are contained in the 4 grids, transfer the contents of the 4 grids to a second gridded pan. Randomly select grids for this second level of sorting as was done for the first, sorting grids one at a time until 100/200/300 organisms ± 20% are found. If picking through the entire next grid is likely to result in a subsample of greater than 120/240/360 organisms, then that grid may be subsampled in the sample manner as before to decrease the likelihood of exceeding 120/240/360 organisms. That is, spread the contents of the last grid into another gridded pan. Pick grids one at a time until the desired number is reached. The total number of grids for each subsorting level should be noted on the laboratory bench sheet.

6. Save the sorted debris residue in a separate container. Add a label that includes the words “sorted residue” in addition to all prior sample label information and preserve in 95% ethanol. Save the remaining unsorted sample debris residue in a separate container labeled “sample residue”; this container should include the original sample label. Length of storage and archival is determined by the laboratory or benthic section supervisor.

7. Place the sorted 100/200/300-organism (±20%) subsample into glass vials, and preserve in 70% ethanol. Label the vials inside with the sample identifier or lot number, date, stream name, sampling location and taxonomic group. If more than one vial is needed, each should be labeled separately and numbered (e.g., 1 of 2, 2 of 2). For convenience in reading the labels inside the vials, insert the labels left-edge first. If identification is to occur immediately after sorting, a petri dish or watch glass can be used instead of vials.

8. Midges (Chironomidae) should be mounted on slides in an appropriate medium (e.g., Euperal, CMC-10); slides should be labeled with the site identifier, date collected, and the first initial and last name of the collector. As with midges, worms (Oligochaeta) must also be mounted on slides and should be appropriately labeled.

9. Fill out header information on Laboratory Bench Sheet as in field sheets. Also check subsample target number. Complete back of sheet for subsampling/sorting information. Note number of grids picked, time expenditure, and number of organisms. If on the back of the laboratory Bench Sheet. Calculate sorting efficiency to determine whether sorting effort passes or fails.

10. Record date of sorting and slide monitoring, if applicable, on Log-In Sheet as documentation of progress and status of sample lot.

Quality Control (QC) for Sorting

1. Ten Percent of the sorted samples in each lot should be examined by laboratory QC personnel or a qualified co-worker. (A lot is defined as a special study, basin study, entire index period, or individual sorter.) The QC worker will examine the grids chosen and tray used for sorting and will look for organisms missed by the sorter. Organisms found will be added to the sample vials. If the QC worker finds less than 10 organisms (or 10% in larger subsamples) remaining in the grids or sorting tray, the sample passes; if more than 10 (or 10%) are found, the sample fails. If the first 10% of the sample lot fails, a second 10% of the sample lot will be checked by the QC worker. Sorter in-training will have their samples 100% checked until the trainer decides that training is complete.

2. After laboratory processing is complete for a given sample, all sieves, pans, trays, etc., that have come in contact with sample will be rinsed thoroughly, examined carefully, and picked free of organisms or debris; organisms found will be added to the sample residue.

Identification of Macroinvertebrates

Taxonomy can be at any level, but should be consistent among samples. In the original RBPs, two levels of identification were suggested – family (RBP II) and genus/species (RBP III) level (Plafkin et al. 1989). Genus/species will provide more accurate information on ecological/environmental relationships and sensitivity to impairment. Family level will provide a higher degree of precision among samples and taxonomists, requires less expertise to perform, and accelerates assessment results. In either case, only those taxonomic keys that have been peer reviewed and are published in some way to be available to other taxonomists should be used. Unnamed species (i.e., species A, B, 1 or 2) may be ecologically informative, but will contribute to variability and inconsistency when a statewide database is being developed.

1. Most organisms are identified to the lowest practical level (generally genus or species) by a qualified taxonomist using a dissecting microscope. Midges (Diptera: Chironomidae) are mounted on slides in an appropriate medium and identified using a compound microscope. Each taxon found in a sample is recorded and enumerated in a laboratory bench notebook and then transcribed to the laboratory bench sheet for subsequent reports. Any difficulties encountered during identification (e.g., missing gills) are noted on these sheets.

2. Labels with specific taxa names (and taxonomist's initials) are added to the vials of specimens by the taxonomist. Individual specimens may be extracted from the sample to be included in a reference collection or to be verified by a 2nd taxonomist. Slides are initialed by the identifying taxonomist. A separate label may be added to slides to include the taxon (taxa) name(s) for use in a voucher or reference collection.

3. Record the identity and number of organisms on the Laboratory Bench Sheet. Either a tally counter or "slash" marks on the bench sheet can be done to keep track of the cumulative count. Also, record the life stage of the organisms, taxonomist's initials and taxonomic certainty rating (TCR) as a measure of confidence.

4. Complete the back of the bench sheet to explain certain TCR ratings or condition of organisms. Other comments can be included to provide additional insights for data interpretation. If QC was performed, record on back of sheet.

5. For archiving samples, specimen vials, grouped by station and date, are placed in jars with a small amount of denatured 70% ethanol and tightly capped. The ethanol level in these jars must be examined periodically and replenished as needed, before ethanol loss from the specimen vials takes place. A stick-on label is placed on the outside of the jar indicating sample identifier, date, and preservative (denatured 70% ethanol).

Identification QA/QC Procedures of Macroinvertebrates

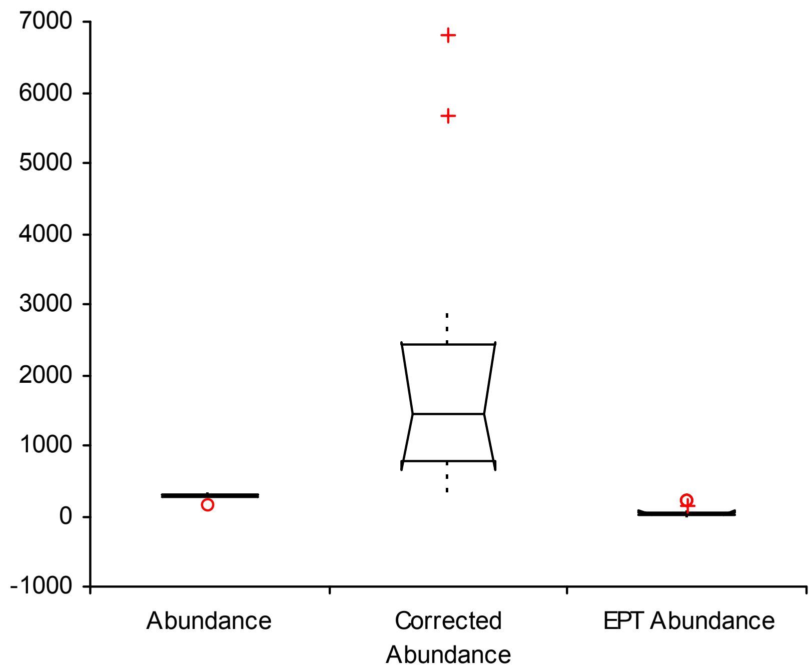
1. A voucher collection of all samples and subsamples should be maintained. These specimens should be properly labeled, preserved, and stored in the laboratory for future reference. A taxonomist (the reviewer) not responsible for the original identifications should spot check samples corresponding to the identifications on the bench sheet.

2. The reference collection of each identified taxon should also be maintained and verified by a second taxonomist. The word "val." and the 1st initial and last name of the person validating the identification should be added to the vial label. Specimens sent out for taxonomic validations should be recorded in a "Taxonomy Validation Notebook" showing the label information and the date sent out. Upon return of the specimens, the date received and the finding should also be recorded in the notebook along with the name of the person who performed the validation.

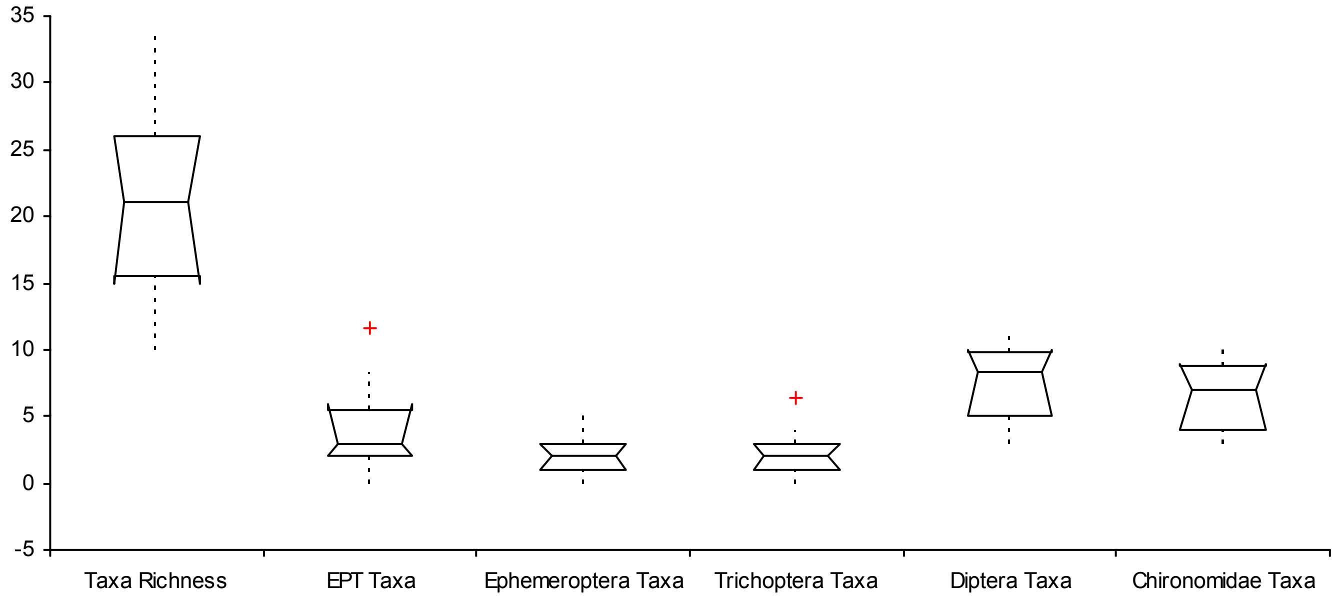
3. Information on samples completed (through the identification process) will be recorded in the "sample log" notebook to track the progress of each sample within the sample lot. Tracking of each sample will be updated as each step is completed (i.e., subsampling and sorting, mounting of midges and worms, taxonomy).

Appendix K.
Box Plots of Macroinvertebrate Metrics

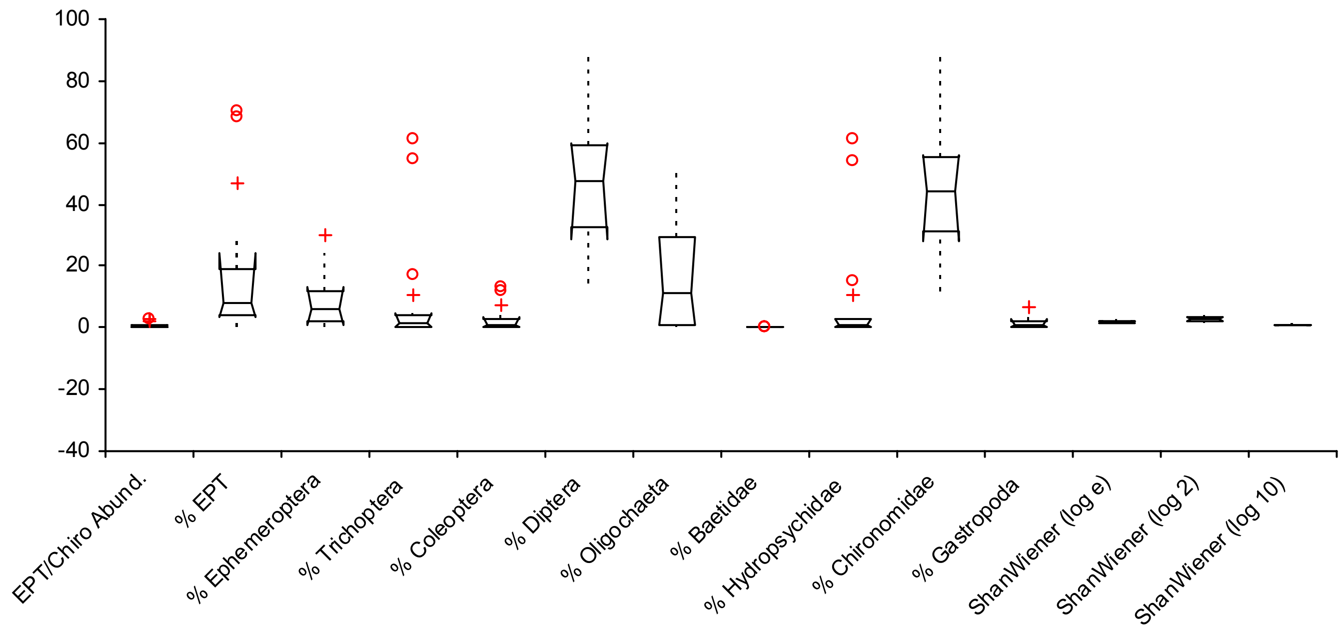
Box and Whisker Plots of the Macroinvertebrate Candidate Metrics
(includes monitoring sites for both the North-Central BSR assessment and the Oakwood Lakes assessment)



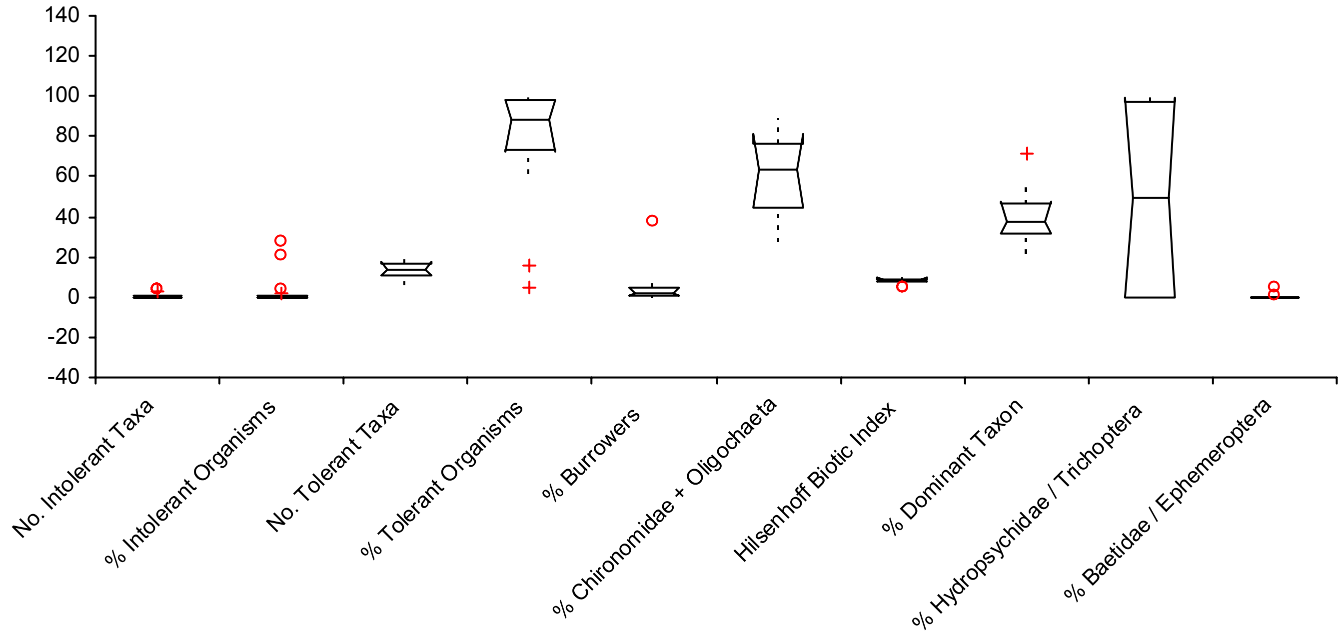
Metric	n	CV	Mean	SD	SE	95% CI of Mean			Median	IQR	95% CI of Median		
Abundance	19	0.14	290.84	39.60	9.09	271.7	to	309.9	299.7	31.2	277.0	to	312.0
Corrected Abundance	19	0.89	1931.52	1726.93	396.18	1099.2	to	2763.9	1440.0	1655.1	661.4	to	2466.0
EPT Abundance	19	1.31	50.96	66.70	15.30	18.8	to	83.1	25.0	42.8	9.0	to	69.7



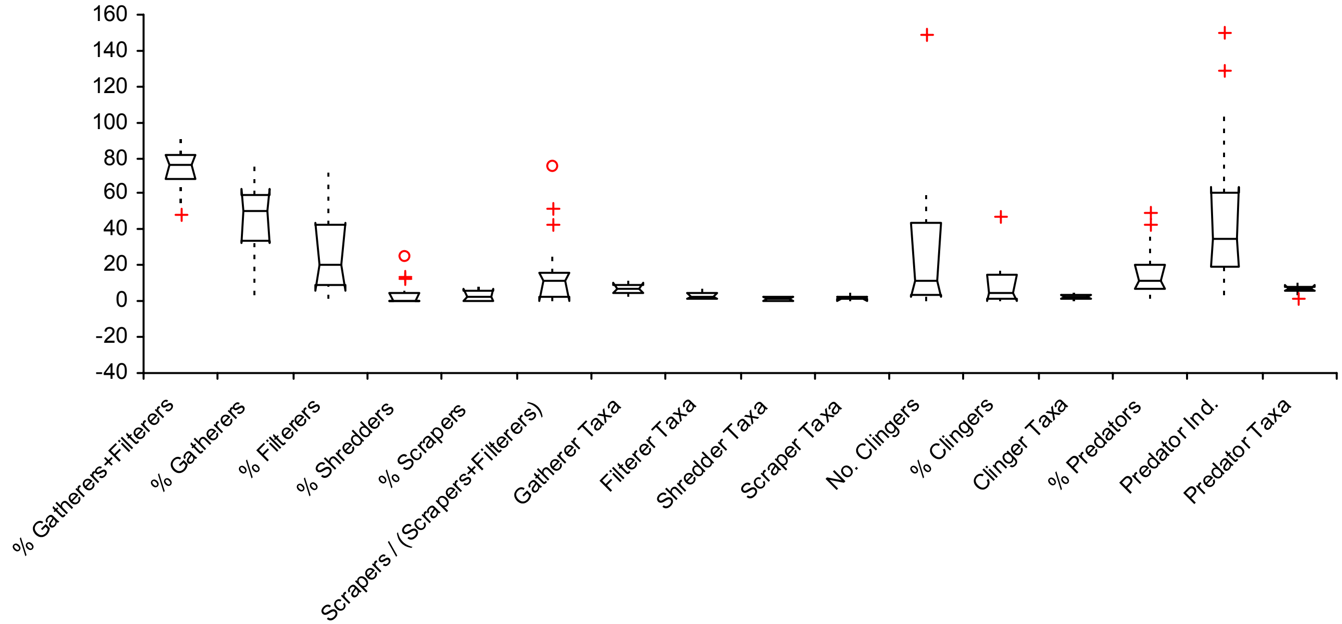
Metric	n	CV	Mean	SD	SE	95% CI of Mean			Median	IQR	95% CI of Median		
Taxa Richness	19	0.31	21.18	6.64	1.52	18.0	to	24.4	21.0	10.5	15.0	to	26.0
EPT Taxa	19	0.72	4.01	2.89	0.66	2.6	to	5.4	3.0	3.5	2.0	to	6.0
Ephemeroptera Taxa	19	0.70	2.07	1.45	0.33	1.4	to	2.8	2.0	2.0	1.0	to	3.0
Trichoptera Taxa	19	0.82	1.95	1.60	0.37	1.2	to	2.7	2.0	2.0	1.0	to	3.0
Diptera Taxa	19	0.37	7.42	2.74	0.63	6.1	to	8.7	8.3	4.8	5.0	to	10.0
Chironomidae Taxa	19	0.40	6.40	2.55	0.59	5.2	to	7.6	7.0	4.8	4.0	to	9.0



Metric	n	CV	Mean	SD	SE	95% CI of Mean			Median	IQR	95% CI of Median		
EPT/Chiro Abund.	19	1.52	0.63	0.96	0.22	0.2	to	1.1	0.2	0.6	0.1	to	1.0
% EPT	19	1.28	16.89	21.62	4.96	6.5	to	27.3	7.6	14.8	3.3	to	24.1
% Ephemeroptera	19	0.98	8.29	8.10	1.86	4.4	to	12.2	6.3	10.1	1.1	to	13.0
% Trichoptera	19	2.08	8.60	17.87	4.10	0.0	to	17.2	1.3	4.0	0.3	to	4.7
% Coleoptera	19	1.53	2.59	3.96	0.91	0.7	to	4.5	0.6	2.8	0.1	to	3.7
% Diptera	19	0.44	48.45	21.14	4.85	38.3	to	58.6	47.5	26.0	28.9	to	60.0
% Oligochaeta	19	1.08	14.81	15.98	3.67	7.1	to	22.5	11.4	28.5	0.6	to	29.5
% Baetidae	19	3.33	0.02	0.07	0.02	0.0	to	0.1	0.0	0.0	0.0	to	0.0
% Hydropsychidae	19	2.25	7.95	17.92	4.11	-0.7	to	16.6	0.7	2.7	0.0	to	2.9
% Chironomidae	19	0.45	45.47	20.65	4.74	35.5	to	55.4	44.3	24.0	28.3	to	56.0
% Gastropoda	19	1.21	1.75	2.10	0.48	0.7	to	2.8	1.0	2.1	0.0	to	2.5
ShanWiener (log e)	19	0.23	1.94	0.44	0.10	1.7	to	2.2	2.0	0.5	1.7	to	2.2
ShanWiener (log 2)	19	0.23	2.80	0.63	0.14	2.5	to	3.1	2.8	0.7	2.4	to	3.2
ShanWiener (log 10)	19	0.23	0.84	0.19	0.04	0.8	to	0.9	0.8	0.2	0.7	to	1.0



Metric	n	CV	Mean	SD	SE	95% CI of Mean			Median	IQR	95% CI of Median		
No. Intolerant Taxa	19	1.92	0.68	1.31	0.30	0.1	to	1.3	0.0	0.8	0.0	to	1.0
% Intolerant Organisms	19	2.65	2.91	7.69	1.77	-0.8	to	6.6	0.0	0.5	0.0	to	0.7
No. Tolerant Taxa	19	0.31	13.61	4.16	0.95	11.6	to	15.6	14.0	5.7	11.0	to	18.0
% Tolerant Organisms	19	0.34	78.62	26.73	6.13	65.7	to	91.5	87.9	24.7	72.5	to	97.9
% Burrowers	19	1.98	4.25	8.40	1.93	0.2	to	8.3	1.5	4.1	0.6	to	5.1
% Chironomidae + Oligochaeta	19	0.34	60.28	20.73	4.76	50.3	to	70.3	63.0	31.3	44.6	to	81.2
Hilsenhoff Biotic Index	19	0.16	8.37	1.38	0.32	7.7	to	9.0	8.7	1.0	8.0	to	9.3
% Dominant Taxon	19	0.31	39.27	12.20	2.80	33.4	to	45.1	37.4	14.7	31.3	to	47.1
% Hydropsychidae / Trichoptera	19	0.89	47.81	42.65	9.78	27.3	to	68.4	50.0	97.2	0.0	to	98.8
% Baetidae / Ephemeroptera	19	3.98	0.27	1.09	0.25	-0.3	to	0.8	0.0	0.0	0.0	to	0.0


160
140
120
100
80
60
40
20
0
-20
-40
% Gatherers+Filterers
% Gatherers
% Filterers
% Shredders
% Scrapers
Scrapers / (Scrapers+Filterers)
Gatherer Taxa
Filterer Taxa
Shredder Taxa
Scraper Taxa
No. Clingers
% Clingers
Clinger Taxa
% Predators
Predator Ind.
Predator Taxa

Metric	n	CV	Mean	SD	SE	95% CI of Mean			Median	IQR	95% CI of Median		
% Gatherers+Filterers	19	0	74.64	12.33	2.83	68.7	to	80.6	76.8	13.2	67.9	to	82.2
% Gatherers	19	0	46.28	21.76	4.99	35.8	to	56.8	50.3	26.1	32.1	to	62.4
% Filterers	19	1	28.36	23.13	5.31	17.2	to	39.5	20.4	33.7	6.3	to	44.0
% Shredders	19	2	3.96	6.53	1.50	0.8	to	7.1	0.6	4.6	0.0	to	4.9
% Scrapers	19	1	3.41	3.62	0.83	1.7	to	5.2	2.0	5.7	0.3	to	6.5
Scrapers / (Scrapers+Filterers)	19	1	15.83	20.14	4.62	6.1	to	25.5	10.9	13.6	0.8	to	16.1
Gatherer Taxa	19	0	7.67	3.07	0.70	6.2	to	9.1	7.0	4.3	5.0	to	10.0
Filterer Taxa	19	1	3.04	2.13	0.49	2.0	to	4.1	2.0	2.7	1.0	to	4.3
Shredder Taxa	19	1	1.26	1.08	0.25	0.7	to	1.8	1.7	2.0	0.0	to	2.0
Scraper Taxa	19	1	1.75	1.42	0.33	1.1	to	2.4	1.3	2.0	0.7	to	3.0
No. Clingers	19	1	26.90	35.93	8.24	9.6	to	44.2	11.0	39.8	2.0	to	44.0
% Clingers	19	1	8.91	11.50	2.64	3.4	to	14.5	4.2	13.0	0.7	to	14.8
Clinger Taxa	19	1	2.94	1.62	0.37	2.2	to	3.7	3.0	2.5	1.0	to	4.0
% Predators	19	1	16.29	13.62	3.12	9.7	to	22.9	11.8	13.2	6.7	to	20.4
Predator Ind.	19	1	46.12	41.42	9.50	26.2	to	66.1	34.3	41.0	19.0	to	64.0
Predator Taxa	19	0	6.95	2.57	0.59	5.7	to	8.2	7.0	2.7	5.3	to	9.0

Appendix L.
Macroinvertebrate Score Sheets

Macroinvertebrate Score Sheets – River Sites

Site R01

Metric	Response to Impairment	Percentile for "best" value	Standard (best value)	Measured metric value	Standardized Metric score
Abundance	Decrease	95th	323	304	94
Taxa Richness	Decrease	95th	33	23	70
EPT Richness	Decrease	95th	11	12	100
Diptera Richness	Decrease	95th	11	8	73
% EPT	Decrease	95th	69.2	69.9	100
% Diptera	Increase	5th	28.1	28.9	99
% Chironomidae	Increase	5th	26.8	28.3	98
% Tolerant	Increase	5th	8.3	15.6	92
% Chironomidae + Oligochaeta	Increase	5th	27.8	28.6	99
% Hydropsychidae/Trichoptera	Increase	5th	0	98.8	1
% Gatherers	Decrease	95th	70.4	5.7	8
% Filterers	Increase	5th	2.8	66.7	34
% Clingers	Decrease	95th	37.9	20.3	54
			Final index value for this site:		**71**

Site R14

Metric	Response to Impairment	Percentile for "best" value	Standard (best value)	Measured metric value	Standardized Metric score
Abundance	Decrease	95th	323	300	93
Taxa Richness	Decrease	95th	33	27	82
EPT Richness	Decrease	95th	11	3	27
Diptera Richness	Decrease	95th	11	10	91
% EPT	Decrease	95th	69.2	13.3	19
% Diptera	Increase	5th	28.1	60.0	56
% Chironomidae	Increase	5th	26.8	59.3	56
% Tolerant	Increase	5th	8.3	92.0	9
% Chironomidae + Oligochaeta	Increase	5th	27.8	71.3	40
% Hydropsychidae/Trichoptera	Increase	5th	0	0.0	100
% Gatherers	Decrease	95th	70.4	42.7	61
% Filterers	Increase	5th	2.8	12.0	91
% Clingers	Decrease	95th	37.9	2.7	7
			Final index value for this site:		**56**

Site R15

Metric	Response to Impairment	Percentile for "best" value	Standard (best value)	Measured metric value	Standardized Metric score
Abundance	Decrease	95th	323	274	85
Taxa Richness	Decrease	95th	33	34	100
EPT Richness	Decrease	95th	11	5	45
Diptera Richness	Decrease	95th	11	11	100
% EPT	Decrease	95th	69.2	5.8	8
% Diptera	Increase	5th	28.1	36.9	88
% Chironomidae	Increase	5th	26.8	35.0	89
% Tolerant	Increase	5th	8.3	80.3	21
% Chironomidae + Oligochaeta	Increase	5th	27.8	64.2	50
% Hydropsychidae/Trichoptera	Increase	5th	0	15.4	85
% Gatherers	Decrease	95th	70.4	57.3	81
% Filterers	Increase	5th	2.8	12.0	91
% Clingers	Decrease	95th	37.9	6.9	18
			Final index value for this site:		**66**

Site R16

Metric	Response to Impairment	Percentile for "best" value	Standard (best value)	Measured metric value	Standardized Metric score
Abundance	Decrease	95th	323	300	93
Taxa Richness	Decrease	95th	33	19	58
EPT Richness	Decrease	95th	11	1	9
Diptera Richness	Decrease	95th	11	8	73
% EPT	Decrease	95th	69.2	0.4	1
% Diptera	Increase	5th	28.1	52.3	66
% Chironomidae	Increase	5th	26.8	51.6	66
% Tolerant	Increase	5th	8.3	92.0	9
% Chironomidae + Oligochaeta	Increase	5th	27.8	88.9	15
% Hydropsychidae/Trichoptera	Increase	5th	0	0.0	100
% Gatherers	Decrease	95th	70.4	74.7	100
% Filterers	Increase	5th	2.8	6.1	97
% Clingers	Decrease	95th	37.9	4.2	11
			Final index value for this site:		**54**

Site R17

Metric	Response to Impairment	Percentile for "best" value	Standard (best value)	Measured metric value	Standardized Metric score
Abundance	Decrease	95th	323	288	89
Taxa Richness	Decrease	95th	33	29	88
EPT Richness	Decrease	95th	11	5	45
Diptera Richness	Decrease	95th	11	11	100
% EPT	Decrease	95th	69.2	9.4	14
% Diptera	Increase	5th	28.1	38.2	86
% Chironomidae	Increase	5th	26.8	35.4	88
% Tolerant	Increase	5th	8.3	91.0	10
% Chironomidae + Oligochaeta	Increase	5th	27.8	68.1	44
% Hydropsychidae/Trichoptera	Increase	5th	0	66.7	33
% Gatherers	Decrease	95th	70.4	56.6	80
% Filterers	Increase	5th	2.8	1.0	100
% Clingers	Decrease	95th	37.9	3.8	10
			Final index value for this site:		**61**

Site R18

Metric	Response to Impairment	Percentile for "best" value	Standard (best value)	Measured metric value	Standardized Metric score
Abundance	Decrease	95th	323	293	91
Taxa Richness	Decrease	95th	33	31	94
EPT Richness	Decrease	95th	11	8	73
Diptera Richness	Decrease	95th	11	11	100
% EPT	Decrease	95th	69.2	24.1	35
% Diptera	Increase	5th	28.1	28.3	100
% Chironomidae	Increase	5th	26.8	26.5	100
% Tolerant	Increase	5th	8.3	61.6	42
% Chironomidae + Oligochaeta	Increase	5th	27.8	45.3	76
% Hydropsychidae/Trichoptera	Increase	5th	0	95.6	4
% Gatherers	Decrease	95th	70.4	42.4	60
% Filterers	Increase	5th	2.8	27.6	74
% Clingers	Decrease	95th	37.9	14.8	39
			Final index value for this site:		**68**

Site R19

Metric	Response to Impairment	Percentile for "best" value	Standard (best value)	Measured metric value	Standardized Metric score
Abundance	Decrease	95th	323	327	100
Taxa Richness	Decrease	95th	33	24	73
EPT Richness	Decrease	95th	11	6	55
Diptera Richness	Decrease	95th	11	9	82
% EPT	Decrease	95th	69.2	10.7	15
% Diptera	Increase	5th	28.1	72.8	38
% Chironomidae	Increase	5th	26.8	65.4	47
% Tolerant	Increase	5th	8.3	73.7	29
% Chironomidae + Oligochaeta	Increase	5th	27.8	65.4	48
% Hydropsychidae/Trichoptera	Increase	5th	0	57.1	43
% Gatherers	Decrease	95th	70.4	62.4	89
% Filterers	Increase	5th	2.8	14.4	88
% Clingers	Decrease	95th	37.9	13.8	36
			Final index value for this site:		**57**

Site R20

Metric	**Response to Impairment**	**Percentile for "best" value**	**Standard (best value)**	**Measured metric value**	**Standardized Metric score**
Abundance	Decrease	95th	323	315	98
Taxa Richness	Decrease	95th	33	17	52
EPT Richness	Decrease	95th	11	7	64
Diptera Richness	Decrease	95th	11	5	45
% EPT	Decrease	95th	69.2	67.9	98
% Diptera	Increase	5th	28.1	27.9	100
% Chironomidae	Increase	5th	26.8	27.3	99
% Tolerant	Increase	5th	8.3	4.4	100
% Chironomidae + Oligochaeta	Increase	5th	27.8	27.3	100
% Hydropsychidae/Trichoptera	Increase	5th	0	100.0	0
% Gatherers	Decrease	95th	70.4	4.1	6
% Filterers	Increase	5th	2.8	63.8	37
% Clingers	Decrease	95th	37.9	47.3	100
			Final index value for this site:		**69**

Macroinvertebrate Score Sheets – Tributary

Site T34

Metric	Response to Impairment	Percentile for "best" value	Standard (best value)	Measured metric value	Standardized Metric score
Abundance	Decrease	95th	324	334	100
Taxa Richness	Decrease	95th	26	26	79
EPT Richness	Decrease	95th	5	6	55
Diptera Richness	Decrease	95th	10	7	64
% EPT	Decrease	95th	37.4	7.5	11
% Diptera	Increase	5th	16.4	18.6	100
% Chironomidae	Increase	5th	15.1	18.6	100
% Tolerant	Increase	5th	70.6	97.9	2
% Chironomidae + Oligochaeta	Increase	5th	35.5	29.9	97
% Hydropsychidae/Trichoptera	Increase	5th	0	50.0	50
% Gatherers	Decrease	95th	74.4	68.6	97
% Filterers	Increase	5th	5.1	6.3	96
% Clingers	Decrease	95th	17.9	7.2	19
			Final index value for this site:		**67**

Site T35

Metric	Response to Impairment	Percentile for "best" value	Standard (best value)	Measured metric value	Standardized Metric score
Abundance	Decrease	95th	324	144	45
Taxa Richness	Decrease	95th	26	10	30
EPT Richness	Decrease	95th	5	1	9
Diptera Richness	Decrease	95th	10	4	36
% EPT	Decrease	95th	37.4	0.8	1
% Diptera	Increase	5th	16.4	51.6	67
% Chironomidae	Increase	5th	15.1	50.4	68
% Tolerant	Increase	5th	70.6	98.0	2
% Chironomidae + Oligochaeta	Increase	5th	35.5	81.2	26
% Hydropsychidae/Trichoptera	Increase	5th	0	0.0	100
% Gatherers	Decrease	95th	74.4	39.5	56
% Filterers	Increase	5th	5.1	44.0	58
% Clingers	Decrease	95th	17.9	0.5	1
			Final index value for this site:		**38**

Site T36

Metric	Response to Impairment	Percentile for "best" value	Standard (best value)	Measured metric value	Standardized Metric score
Abundance	Decrease	95th	324	277	86
Taxa Richness	Decrease	95th	26	26	79
EPT Richness	Decrease	95th	5	4	36
Diptera Richness	Decrease	95th	10	10	91
% EPT	Decrease	95th	37.4	13.7	20
% Diptera	Increase	5th	16.4	57.8	59
% Chironomidae	Increase	5th	15.1	56.0	60
% Tolerant	Increase	5th	70.6	79.8	22
% Chironomidae + Oligochaeta	Increase	5th	35.5	60.3	55
% Hydropsychidae/Trichoptera	Increase	5th	0	100.0	0
% Gatherers	Decrease	95th	74.4	32.1	46
% Filterers	Increase	5th	5.1	49.5	52
% Clingers	Decrease	95th	17.9	15.9	42
			Final index value for this site:		**50**

Site T37

Metric	Response to Impairment	Percentile for "best" value	Standard (best value)	Measured metric value	Standardized Metric score
Abundance	Decrease	95th	324	307	95
Taxa Richness	Decrease	95th	26	21	64
EPT Richness	Decrease	95th	5	4	36
Diptera Richness	Decrease	95th	10	10	91
% EPT	Decrease	95th	37.4	46.8	68
% Diptera	Increase	5th	16.4	47.5	73
% Chironomidae	Increase	5th	15.1	47.1	72
% Tolerant	Increase	5th	70.6	68.7	34
% Chironomidae + Oligochaeta	Increase	5th	35.5	48.1	72
% Hydropsychidae/Trichoptera	Increase	5th	0	35.4	65
% Gatherers	Decrease	95th	74.4	25.7	37
% Filterers	Increase	5th	5.1	40.3	61
% Clingers	Decrease	95th	17.9	19.9	53
			Final index value for this site:		**63**

Site T39

Metric	Response to Impairment	Percentile for "best" value	Standard (best value)	Measured metric value	Standardized Metric score
Abundance	Decrease	95th	324	306	95
Taxa Richness	Decrease	95th	26	17	52
EPT Richness	Decrease	95th	5	2	18
Diptera Richness	Decrease	95th	10	5	45
% EPT	Decrease	95th	37.4	4.9	7
% Diptera	Increase	5th	16.4	68.5	44
% Chironomidae	Increase	5th	15.1	42.6	78
% Tolerant	Increase	5th	70.6	72.5	30
% Chironomidae + Oligochaeta	Increase	5th	35.5	63.0	51
% Hydropsychidae/Trichoptera	Increase	5th	0	0.0	100
% Gatherers	Decrease	95th	74.4	35.3	50
% Filterers	Increase	5th	5.1	13.4	89
% Clingers	Decrease	95th	17.9	0.1	0
			Final index value for this site:		**51**

Site T40

Metric	Response to Impairment	Percentile for "best" value	Standard (best value)	Measured metric value	Standardized Metric score
Abundance	Decrease	95th	324	312	97
Taxa Richness	Decrease	95th	26	13	39
EPT Richness	Decrease	95th	5	0	0
Diptera Richness	Decrease	95th	10	3	27
% EPT	Decrease	95th	37.4	0.0	0
% Diptera	Increase	5th	16.4	88.5	16
% Chironomidae	Increase	5th	15.1	88.5	16
% Tolerant	Increase	5th	70.6	99.0	1
% Chironomidae + Oligochaeta	Increase	5th	35.5	89.1	15
% Hydropsychidae/Trichoptera	Increase	5th	0	0.0	100
% Gatherers	Decrease	95th	74.4	55.8	79
% Filterers	Increase	5th	5.1	36.5	65
% Clingers	Decrease	95th	17.9	0.6	2
			Final index value for this site:		**35**

Site T46

Metric	Response to Impairment	Percentile for "best" value	Standard (best value)	Measured metric value	Standardized Metric score
Abundance	Decrease	95th	324	280	87
Taxa Richness	Decrease	95th	26	16	48
EPT Richness	Decrease	95th	5	2	18
Diptera Richness	Decrease	95th	10	5	45
% EPT	Decrease	95th	37.4	1.4	2
% Diptera	Increase	5th	16.4	40.4	83
% Chironomidae	Increase	5th	15.1	33.9	90
% Tolerant	Increase	5th	70.6	87.9	13
% Chironomidae + Oligochaeta	Increase	5th	35.5	84.6	21
% Hydropsychidae/Trichoptera	Increase	5th	0	0.0	100
% Gatherers	Decrease	95th	74.4	56.8	81
% Filterers	Increase	5th	5.1	20.4	82
% Clingers	Decrease	95th	17.9	3.6	9
			Final index value for this site:		**52**

Site T47

Metric	Response to Impairment	Percentile for "best" value	Standard (best value)	Measured metric value	Standardized Metric score
Abundance	Decrease	95th	324	275	85
Taxa Richness	Decrease	95th	26	24	73
EPT Richness	Decrease	95th	5	3	27
Diptera Richness	Decrease	95th	10	9	82
% EPT	Decrease	95th	37.4	28.0	40
% Diptera	Increase	5th	16.4	14.2	100
% Chironomidae	Increase	5th	15.1	11.6	100
% Tolerant	Increase	5th	70.6	85.1	16
% Chironomidae + Oligochaeta	Increase	5th	35.5	41.1	82
% Hydropsychidae/Trichoptera	Increase	5th	0	72.7	27
% Gatherers	Decrease	95th	74.4	77.8	100
% Filterers	Increase	5th	5.1	4.4	98
% Clingers	Decrease	95th	17.9	4.7	12
			Final index value for this site:		**65**

Appendix M.
Terms and Definitions of the Physical Habitat Measurements

Terms and Definitions of the Physical Habitat Measurements

Definitions and measurements procedures for site variables (adapted from Wolman 1954; Hughes and Omernik 1981; Platts etal. 1983; Schumm et al. 1984, Robison and Beschta 1990; Gordon et al. 1992; Simonson et al. 1994, Harrelson et al. 1994, and Rosgen 1996).

Transect – A line that extends from the left bank to the right bank, perpendicular to stream flow.

Channel bank (stream bank) – The sides of the channel (or stream) that typically restrict lateral movement of water and sediment.

Channel bottom (stream bed) – The bottom portion of the channel (or stream) that typically does not restrict lateral movement of sediment and water.

Bankfull – That point on the channel bank where flows begin to crest that bank and move onto the floodplain.

Bank top – Often the same point as bankfull except in streams that are incised.

Incised – Describes channels or streams with bottoms that have or are in the process of downcutting into the landscape. High, steep, eroding banks are often associated with incised streams.

<u>Channel Morphometry</u>

Stream width (m) - Horizontal distance along transect, measured perpendicular to stream flow from left edge of water to right edge of water at existing water surface, to nearest 0.1 m.

Stream depth (m) - Vertical distance from existing water surface to channel bottom; measured at three equally spaced points along transect, to nearest 0.1 m.

Channel bottom depth (m) - Horizontal distance along transects, measured perpendicular to stream flow, measured as that section classified as stream bed not stream bank, to the nearest 0.1 m.

Bankfull width (m) - Horizontal distance along transects, measured perpendicular to stream flow, from top of low bank to a point of equal height on opposite bank, to nearest 0.1m. See Harrelson et al. (1994) for useful indicators of bankfull.

Bankfull depth (m) - Vertical distance from the plane of bankfull with to the channel bottom or bank, measured at a number of equally spaced points along the transect to adequately describe mean bankfull depth and cross-section, to the nearest 0.1 m.

Width:depth ratio - An index of cross-sectional shape, where both width and depth are measured at the bankfull level, unitless.

Bank height (m) - Vertical distance along transect from edge of channel bottom to level land on top of bank, measured to the nearest 0.1 m. Does not refer to bankfull height.
Stream bottom slope (%) - The amount of vertical drop per unit of horizontal distance along the channel bottom, measured with surveyor's level.

Stream surface slope (%) - The amount of vertical drop per unit of horizontal distance along the water surface, measured with surveyor's level.

Bed and Bank Material

It is very important to distinguish between clay and silt. Although both are composed of very fine particles, their properties are quite different. For example, clay can be very resistant to erosion, where particles of silt can be easily eroded. These properties can play a strong role in channel morphometry.

Channel bed substrate - Composition of bed material classified into size categories similar to Wolman's pebble count. A substrate particle is selected off the bed surface (except for fine substrates) at 8 equal distances along each transect in the channel and placed into one of the following categories:

Detritus (organic matter)
Clay (< 0.004 mm; inorganic matter; retains shape when compressed)
Silt (0.004-0.062 mm; inorganic matter does not retain shape when compressed)
Sand (0.062-2 mm)
Very Fine Gravel (2-4 mm)
Fine Gravel (4-8 mm)
Medium Gravel (8-16 mm)
Coarse Gravel (16-32 mm)
V. Coarse Gravel (32-64 mm)
Cobble (64-128 mm)
Large Cobble (128-256 mm)
Boulder (256-512 mm)
Large Boulder (>512 mm)

Streambed substrate - If the channel is not completely inundated, then this is the composition of bed material with the wetted channel classified in to size categories similar to Wolman's Pebble count. A substrate particle is selected off the inundated bed surface at eight equal distances along each transect in the stream and placed into one of the categories listed above.

Bank substrate - Composition of bank material classified into size categories similar to Wolman's Pebble Count.

Streambank and Riparian Characteristics

Streambank length - the linear distance along the transect from the junction of the stream bed and the stream bank to the top of the bank, measured to the nearest 0.1 m.

Streambank vegetation - A measurement of bank resistance to erosion due to vegetation, measured as the linear distance along the streambank length, which is vegetated by perennial herbaceous plants (grasses, forbs and aquatic species), shrubs or trees.

Streambank erosion - A measurement of bank instability along the transect line measured as the linear distance of exposed and eroded bank soils having very little to no structural support from vegetation during high flows. This does not include area of deposition where soils can be bare.

Streambank deposition - The Stream bank length that is neither vegetated not eroded.

Streambank slope (degree) - The angle formed by the downward slope of the stream bank and the horizontal stream bottom.

Riparian buffer with (m) - The condition of the land contour on the horizontal distance along the transect line from the stream's edge out 10 m. If the land is completely disturbed, then the riparian buffer is 0. If the land is completely undisturbed, then the buffer width is recorded as >10m. It may be appropriate to measure or approximate buffer widths beyond 10 m. Buffer widths <10 m should be measured to the nearest 1 m.

Riparian land use - The land use on the bank contour over the horizontal distance along the transect line from the stream's edge out 10 m. Land use classes are adapted from Simonson et al. (1994).

Vegetation use by animals - The condition of the vegetation by any land use (but primarily grazing and row cropping) on the transect line over the contour of the bank from the stream's edge out 10 m. Rating procedures are described by Platts et al. (1983).

<u>Streamflow Characteristics</u>

Streamflow (Q, cms) - The volume of water moving past a given stream cross section per unit of time.

<u>Physical Fish Cover</u>

Overhanging vegetation - If present, the bankside, banktop, and non-inundated vegetation that currently overhangs the water surface. Measured as the horizontal distance along the transect line from the water's edge to the furthest point over the water surface that the vegetation protrudes, to the nearest 0.1 m.

Undercut bank - If present, the horizontal distance along the transect line from the furthest point of bank protrusion and the furthest undercut of the bank, to the nearest 0.1 m.

Instream vegetation - If present the inundated macrophytic vegetation (submergent or emergent) within the stream channel. Measured as the total horizontal distance along the transect that has instream vegetation present as described, to the nearest 0.1 m.

Large woody debris (LWD), occurrence of - Generally, LWD are pieces of wood that are minimally 10 cm in diameter and 3 m long that occur within the bankfull channel providing potential cover for organisms. Measured along the transect and within one mean stream width separately as the number of pieces within the stream different zones.

Large woody debris (LWD), volume and orientation - Volume (cubic meters) of those same pieces within four zones calculated by measuring length and diameter of each piece of LWD. Orientation is recorded as the degrees to which the woody debris is predominately orientated with respect to the channel. Woody debris orientated completely upstream (i.e., root wad on downstream end) would be recorded as 180 while that orientated perpendicular to the channel would be recorded as 90, and that orientated completely downstream (i.e., root wad on upstream end) would be recorded as 0. See Robison and Beshta (1990).

Dominant habitat type along the transect is designated as pool, riffle, or run.

Stream bank and riparian features include several variables. A certain amount of ambiguity will occur when attempting to identify features used as endpoints for measuring this suite of linear features. One ambiguity is the breakpoint between the channel bank and channel bottom. Measurements related to stream bank length, bank angle, and bank height will be affected by location of this point. Another ambiguity is the demarcation between the vegetated and non-vegetated portions of the channel bank. The vegetated portion contributes a root structure that holds bank soil together.

Riparian-related cover types include five linear cover measurements that depend on the type and health of riparian vegetation: overhanging vegetation, undercut bank, submergent macrophytes, emergent macrophytes and large woody debris. When a piece of LWD or log jam is encountered, data entries include: transect space, log jam number (if applicable), LWD piece number, zone, meander location, habitat association, orientation (angle), and volume measurements (length and diameter). Transect space is simply the section between two consecutive transects. Zone, meander location, and habitat association are described on the data sheet. Volume measurements are the length and diameter of each piece of LWD. A graduated pole is more useful than a tape measure. One diameter measurement is made at the mid-section of the debris.

Bed and bank substrate data collection procedures follow the Wolman “pebble count” method. Along the transect, the bed is visually divided into eight cells using the tape measure as a guide. Within each cell, a crew member reaches to the bottom of the stream with one finger extended and eyes averted. The first piece of substrate touched is lifted to the surface. The substrate size is measured and the class size recorded. This method provides a way to objectively classify substrates in clear streams and is a necessity in turbid streams where visual estimates are not possible. Also, more than

100 substrates points can be combined from all transects, categorized and analyzed according to common fluvial methods or user needs.

Transect point data are measurements associated with a series of points lined up on an imaginary from left bank to the right bank. Each point has a location code, which identifies the channel feature at the point, and station number which is the point's horizontal distance from the left bank along the transect. Transect point data aid characterization of channel morphology, and are used to calculate the width if the stream surface, the channel bottom, and the width at bankfull. Point measurements include depth measurements. Depth measurements are used in conjunction with bankfull width to calculate width:depth ratios. Depth measurements and velocities are taken at three points in the stream (1/4, 1/2, and 3/4 of the distance across the stream surface) to characterize the physical conditions of the stream habitat at the time of sampling.

Discharge.—Discharge data is collected at a single transect or other stream cross-section where flows are uniform. The velocity-area method described in Gordon et al. (1992) is used.

Water Surface Slope (%) —Using a surveying level and tripod, or other method, the drop in water surface slope from transect one to transect 13 is measured and divided by the horizontal stream distance.

Water Quality.—Water quality data include easily measured parameters that are basic to a minimal assessment of the suitability of the site to fishes. Parameters are listed in Table 1.

Reach Classification.—For each reach, stream type (Rosgen 1996) and stage of channel evolution (Schumm et al. 1984) characterized level of stability and potential channel sources of sediment through bed and bank erosion.

Appendix N.
Field Data Sheets

On Site Description Data

Project Site ID:________________ Stream Name:

m/d/yr_____________

T______, R_____, ______1/4 of Sec______

GPS coordinates (utm): Transect 1,
Northing__________________________Easting________________________
Downstream Transect,
Northing__________________________Easting________________________

Investigators:____
____

Rosgen Classification (field level evaluation):____

Habitats Available number of each	Pool______ Run______ Riffle______ Other (describe) _______________________ Lengths of Riffle(s):_______, _______, _______, _______, _______. Total=________

Preliminary Mean Stream Width	
Width Number	Width (0.1 m)
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
Sum	
PMSW	

Transect Spacing:_______________

Water Quality	
Parameter	Reading
Time (2400)	
Water Temperature (^{o}C)	
Air Temperature (^{o}C)	
Turbidity (NTU)	
Secchi (cm)	
Dissolved Oxygen (mg/L)	
Specific Conductance (uS/cm)	
Conductivity (uS/cm)	

Visual Observations:

Odor - yes no

Septic - yes no

Deadfish - yes no

Surface Film - yes no

Color:______________________________

Reach Length:

____

Weather Conditions:

Current	Past 24 h	
9	9	Clear/sunny
9	9	Partly cloudy
9	9	Intermittent showers
9	9	Steady rain
9	9	Heavy rain

Ice Cover - yes no

Map, Slope Measurements, and Photo-documentation Data

Project Site ID:_______________ Stream Name:
m/d/yr:____________

Water Surface Slope Measurements for Reach						
Transect #	Height of Inst. (cm)	Rod Reading from water surface (cm)	Elevation Difference (0.01 m)	Horizontal Distance (reach length above)	Slope (m/m)	Slope (%)

Draw a map of the site with location of most upstream and most downstream transects. Include locations of photographic points, direction of photograph, and frame number.

Bed Substrate Composition

Project Site ID:_______________ Stream Name:
m/d/yr:____________

Organic Substrates			
	Description	Tally	Number
Detritus	sticks, wood, coarse plant material (CPOM)		
Muck-Mud	black, very fine organic (FPOM)		
Inorganic Substrates			
	Diameter	Tally	Number
Clay	<0.004 (slick)		
Silt	0.004-0.062		
Sand	0.062-2 (gritty)		
Very Fine Gravel	>2-4		
Fine Gravel	>4-8		
Medium Gravel	>8-16		
Coarse Gravel	>16-32		
Very Coarse Gravel	>32-64		
Cobble	>64-128		
Large Cobble	>128-256		
Boulder	>256-512		
Large Boulder	>512		
		Total Number:	

Transect Data

Project Site ID:___________ Stream Name:
m/d/yr:___________________ Transect Number _______of ________ Habitat Type Along Transect (circle one): pool riffle run

Streambank and Riparian Features	Left Bank	Right Bank
Bank Substrate (dominant)		
Bank Slumpage (present, p or absent, a)		
Bank Height (0.1 m)		
Bankfull Height (0.1)		
Bank Angle (degrees)		
Streambank length (0.1 m)		
Length of Streambank Vegetated (0.1 m)		
Length of Streambank Eroded (0.1 m)		
Length of Streambank Deposition (0.1 m)		
Riparian landuse (circle one)	cropland, woodland/forested, pasture/rangeland, barnyard, prairie, developed, wetland, other-specify, shrub	cropland, woodland/forested, pasture/rangeland, barnyard, prairie, developed, wetland, other-specify, shrub
Animal Vegetation Use (circle one)	none, moderate, low, high	none, moderate, low, high
Riparian Vegetation Type (Dominant)	sedge/rush, willows, cottonwoods, silver maple, grass/forb, shrubs, green ash, other__________	sedge/rush, willows, cottonwoods, silver maple, grass/forb, shrubs, green ash, other__________
Riparian Age Class(es) of Trees, if present	seedling/sprout, decadent, young/sapling, dead, mature	seedling/sprout, decadent, young/sapling, dead, mature
Riparian Buffer Width (m)		
Overhanging Vegetation (0.1 m)		
Undercut Bank (0.1 m)		
Submergent Macrophytes (0.1 m)		
Emergent Macrophytes (0.1 m)		

Transect Data and Depth Velocity Data
(record units under the heading for each column)

Location Code	Station	Bankfull Depth	Water Depth	Velocity
LTB				
LBF				
LEW				
LCB				
STR (@1/4)				
STR (@1/2)				
STR (@3/4)				
RCB				
REW				
RBF				
RTB				

Location Codes:

LTB left top bank
RTB right top bank
LBF left bankfull
RBF right bankfull
LCB left channel bottom
RCB right channel bottom
LEW left edge water
REW right edge water
STR stream

Bank top width (RTB-LTB) =____________

Bankfull width (RBF-LBF)=____________

Channel Bottom Width (RCB-LCB)=____________

Stream Width (REW-LEW)=____________

Average Bank Full Depth = ______________

Seine Fish Data

Project Site ID:_______Stream Name:_________________________m/d/yr:___________Page ________of______

Method of Collection	9 Upstream 9 Downstream 9 Cross-stream 9 Kick Bag attached? Yes No Mesh Size________ Block nets used? Yes No
Habitat Sample ID #	
Habitat(s) Sampled for ID # listed above	9 Pool 9 Run 9 Riffle 9 Composite (entire reach) 9 Other (describe)____
Transect spacing for above ID #	Starting Transect____________ Ending Transect____________
Pass #	_____________of_______________

Fish Data

Species Code	Bulk #	Length (mm)	Bulk weight (g)	Parasites &Anomalies	Species Code	Bulk #	Length (mm)	Bulk weight (g)	Parasites &Anomalies

Parasites & Anomalies Code: D= deformed, EF=eroded fin, FG=fungus, LE=lesions, AW=anchor worm, BS=blackspot, EM=emaciated, O=other.

Project Site ID _______ Stream Name:____________________________m/d/yr:
Page_____of_______

Habitat Sample ID #______________________Pass #:__________of __________

Fish Data

Species Code	Bulk #	Length (mm)	Bulk weight (g)	Parasites &Anomalies	Species Code	Bulk #	Length (mm)	Bulk weight (g)	Parasites &Anomalies

Parasites & Anomalies Code: D= deformed, EF=eroded fin, FG=fungus, LE=lesions, AW=anchor worm, BS=blackspot, EM=emaciated, O=other.

Large Woody Debris Data

Project Site ID:__________ Stream Name:
m/d/yr:_____________ Page ____of ___

Transect Spacing	Log Jam Number	LWD Number	Zone	Meander Location	Habitat Association	Angle	Length	Diameter

Zone: B=bank, C=mid-channel
Meander Location: IM=inside meander, OM=outside meander, CO=crossover, SS=straight section
Habitat Association: PL=pool, RF=riffle, RN=run

Discharge (record units under the heading for each column)

Project Site ID:_______________ Stream Name:
m/d/yr:_____________

Staff Gauge Reading:___________________

Number	Cell Spacing	Station	Cell Width (W)	Cell Depth (D)	Velocity (V)	Cell Discharge (W x D x V)
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
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22						
23						
24						
25						
26						
27						
28						
29						
30						
					Total Discharge = Sum=	

Macroinvertebrate Rock Basket Information

Project Site ID:__________ Site Location:______________________________

Canopy Cover (circle one): 0-25% 26-50% 51-75% 76-100%

Rock Basket Placement Conditions

Date:______________ Time:________ Placed By:_____________________

Number of Rock Baskets Placed:__________ Design (circle one): Cone Flat

Basket Number	Water Depth	Water Velocity	Habitat Type	Comments
1				
2				
3				
4				
5				

Interim Conditions

Date:______________ Time:________

Basket Number	Water Depth	Water Velocity	Habitat Type	Comments
1				
2				
3				
4				
5				

Rock Basket Retrieval Conditions

Date:______________ Time:________ Recovered By:__________________

Number of Rock Baskets Recovered:_______ Colonization Days:______________

Litter Packs(circle one): Absent/Rare Common Abundant

Basket Number	Water Depth	Water Velocity	Habitat Type	Comments
1				
2				
3				
4				
5				

(over)

Macroinvertebrate Rock Basket Information

Project ______________________________

Project Site ID _______________________

Site Name __________________________

Date of Placement ____________________	Date of Retrieval ___________________
DO __________________	DO _______________________
Water Temp ____________________	Water Temp ________________________
Conductivity ____________________	Conductivity ________________________
pH ___________________	pH ____________________
Turbidity __________________	Turbidity ___________________

Basket Location Map:

Appendix O.
WRI Lab Memo

To: East Dakota Water Development District project staff 1/17/03

From: David German

Re: QA/QC problems with the Kjeldahl Unit

A malfunction of the Kjeldahl unit in the Water Resources Institute's Water Quality Laboratory (WQL) was identified in October 2002. The decision has been made to replace the unit. A call for bids is going out next week. The new unit should be on-line by mid-March 2003.

The Kingsbury Lakes project staff first reported hits on blanks they had submitted to the lab in 2001. Water Quality Lab staff ran additional blanks on the instrument to check for errors at that time. Results were good and the hits were assumed to be due to sample preparation and handling. Source water, acid preservative, and bottles are all possible sources of nitrogen in blanks.

For example, source water was a problem for East Dakota Water Development District (EDWDD) blanks submitted in July and August 2002, which had small but detectable concentrations of dissolved solids. The reverse osmosis (R.O.) unit in the WQL had reduced efficiency during this period until the membrane was replaced. The best source water for blanks is water produced by the Nanopure system. This unit produces small quantities of very high quality water, which should be used for all blanks and preparation of known additions to blanks. R.O. water is adequate for washing and rinsing but may contain small amounts of nitrate and other constituents.

It is my understanding that the Kingsbury Lakes project staff took a series of steps to identify the problem causing detections in the blanks. In September 2002 project leaders became convinced the problem was in the WQL rather than in sample preparation. A series of test runs were completed to diagnose the problem. The results of those test runs are included in Tables 1 and 2. The results of these tests indicated a malfunction of the Kendal unit.

Table 1 includes the results of samples mostly submitted by the Kingsbury Lakes project. Results of analysis from blanks and knowns ran by the WQL are presented in Table 2. I met with the Kingsbury Lakes project staff to discuss a plan to determine the source of the malfunction. Two lab blanks were analyzed on 9-23-02 (Table 2). A significant hit (.424 ppm) was observed on burner #5. A set of samples submitted by Kingsbury Lakes project staff as actual lake samples were also analyzed on 9-24-02 and 9-25-02. Hits were observed on burners 5 and 6 (Table 1) but results were inconsistent. For example, a hit was observed on burner 5 on 9-25-02, but not on 9-24-02 (Table 1).

The intermittent nature of the problem was evident in the QA/QC samples submitted by the Kingsbury Lake project earlier in the year also (Table 1). For example, a hit was observed on burner 3 on 7-30-02 but not on 7-29-02.

Analysis of the QA/QC data in Table 1 indicated intermittent problems with burners 3, 5, 6, and 11. Most of the blanks analyzed in 2002 for both the Kingsbury Lakes project and the EDWDD were analyzed on these four burners.

Following the set of blanks submitted as samples by the Kingsbury Lakes project staff a series of test runs were conducted by the WQL. The additional blanks were analyzed by the WQL to determine if a pattern could be established that would allow for correction of the data. The results are presented in Table 2. Burners 5 and 6 appear to be the most likely to produce hits, although not consistently. Burner 3 was also suspect based on hits in July (Table 1) but was not included in the test phase because it went out of service on September 17th and the parts needed for repair were out of stock.

The lack of consistency of hits on a particular burner may be due to the amount of ammonia in the air in the lab. According to the manufacturer, the distillation unit consists of a stacked apparatus with seals between the parts. A failure in these seals may allow distillation of ammonia from the air in the lab into a blank sample. This may account for the lack of hits in the ammonia analysis (the first distillation of the day) when compared to the organic ammonia distillation (the second distillation of the day). More ammonia in the air around the instrument in the afternoon is available to leak into the distillation unit on the second distillation. This may also explain why lower hits were observed when full sets of blanks were run (Table 2).

After reviewing the results from the series of runs using lab blanks I still had some questions about how the problem affects actual sample values. Blanks seem to have an error of approximately .4 ppm increase in concentration when run with actual samples. The concentration seems to be less when a full set of blanks is run even on #6 (Table 2). Over the Christmas break I started to wonder if having samples on the other burners could cause a blank to cause higher blanks so I talked to Shirley about doing a blank and a dup in a sample run. On 12/31/02 she ran a dup on #4 (3.13 ppm) and #6 (3.21 ppm) and a blank on #5 (.03ppm) (Table 1). These results show a slight increase in concentration on 5 & 6 but the magnitude is less than we see in blanks submitted by both projects.

A full set of samples of known concentration were analyzed on 1-2-03. The knowns were handled exactly like a set of samples. Results were acceptable (table 2). The actual value was 1.13 ppm and the test results ranged from 1.03 to 1.15 from burners 4 through 11.

Blanks were also included with runs of samples on 1-6-03, 1-7-03, and 1-8-03 on burners 5 and 6. Hits were observed but were an order of magnitude below what had been observed in some blanks in earlier QA/QC runs (Table 2) and in project blanks. It seems difficult to reproduce the concentrations observed in blanks submitted by the project staff in test runs of lab blanks that have been analyzed so far by the WQL. This has been troubling me for a while now and has caused me to wonder what is missing. As I studied the most recent data I realized we had not completed a test run with actual samples and blanks combined that included both the distillation for ammonia and organic nitrogen.

When a separate result for ammonia is not required, a digestion step is followed by a distillation step (the first of the day) which produces a result for TKN. Analyses that were conducted this way are labeled TKN only in the comments column (Table 2). It seems that fewer problems were observed when the separate distillation to determine ammonia was not done prior to the digestion of the organic nitrogen. A test run using actual samples and blanks combined that included both the distillation for ammonia and organic nitrogen may be helpful to recreate the type of hits observed in the project blanks.

The question is "can any of this information help determine correction factors for the data produced during the time the instrument exhibited intermittent problems?"

1. The problem is probably caused by leaky seals in the distillation apparatus which allows ammonia from the air to be condensed into the sample so quantity in the blank may be a function of the amount in the lab air.

2. The problems with blanks seemed to occur most often at the beginning of runs (burners # 3,5 or 6) where the blanks were often placed but there were exceptions.

3. A correction factor is unlikely to increase the accuracy of the data because of the intermittent nature of the problem and the difficulty of determining the burner position of a given sample.

4. A higher than normal error rate in the data occurred for samples submitted in 2001 and 2002.

I am not confident enough about the specific location of the problem on the instrument to identify correction factors that could be applied to specific samples. I think the best course of action at this point is to report the data as is, with the qualification that an error of approximately .4 ppm may be present in some TKN results due to instrument malfunctions.

Appendix P.
QA/QC
Water Quality Duplicates & Blanks

QA/QC Duplicates and Blanks for the North-Central BSR WQ - - 2001 through 2002

StreamName	Time	Sample	Depth	Date	Site	Lab#	Water Temp C°	Air Temp C°	DO mg/L	Field pH su	Fecal Coliform cfu/100mL	Total Suspended Solids mg/L	Total Solids mg/L	Total Dissolved Solids mg/L	NO2NO3 mg/L	NH3N mg/L	OrgNtr mg/L	TKN mg/L	Tot PO4 mg/L	TotDis PO4 mg/L
BSR at Brkgs	730	Grab	Surface	04/09/01	R01	01-6049	4.6	4	9	8.17	650	56	284	228	1.470	0.59	1.67	2.26	0.558	0.434
Duplicate		Grab	Surface			01-6050					450	56	412	356	1.554	0.58	1.67	2.25	0.508	0.411
Absolute Difference											200	0	128	226	0.892	1.08	0.57	1.75	0.147	0.434
Percent Difference											31	0	31	36	5.4	1.2	0.4	0.6	8.925	5.304
Willow Creek near Watertown	915	Grab	Surface	04/13/01	T36	01-6072	4.3	12	5.8	7.74	1000	50	345	295	2.022	0.74	1.61	2.35	0.562	0.389
Duplicate		Grab	Surface			01-6084					1400	55	410	355	2.004	0.75	1.66	2.40	0.498	0.357
Absolute Difference											400	5	65	60	0.018	0.01	0.05	0.05	0.064	0.032
Percent Difference											29	9	16	17	0.9	0.8	2.8	2.2	11.4	8.2
Willow Creek nr Watertown	920	Grab	Surface	05/08/01	T36	01-6151	10.8	12	8.1	8.14	1800	13	437	424	0.564	0.13	1.17	1.29	0.218	0.208
Duplicate		Grab	Surface			01-6149					2200	17	479	462	0.559	0.14	1.21	1.35	0.199	0.193
Absolute Difference											400	4	42	38	0.005	0.01	0.04	0.06	0.020	0.015
Percent Difference											18	24	9	8	0.9	9.4	3.6	4.2	8.9	7.3
Hidewood Creek (nr Clear Lake)	945	Grab	Surface	06/14/01	T40	01-6215	20.2	17	6.2	7.57	400	4	394	390	0.284	0.47	1.07	1.52	0.219	0.173
Duplicate		Grab	Surface			01-6114					500	3	371	368	0.272	0.49	1.53	2.01	0.233	0.177
Absolute Difference											100	1	23	22	0.012	0.02	0.46	0.49	0.014	0.004
Percent Difference											20	25	6	6	4.2	4.1	30.1	24.3	6.0	2.3
BSR at Watertown	1030	Grab	Surface	06/15/01	R14	01-6227	17.3	19	6.7	7.91	1500	35	475	440	0.235	0.31	1.21	1.52	0.237	0.172
Duplicate		Grab	Surface			01-6225					1300	29	429	400	0.250	0.36	1.23	1.59	0.249	0.171
Absolute Difference											200	6	46	40	0.015	0.05	0.01	0.07	0.012	0.001
Percent Difference											13	17	10	9	6.0	14.3	1.1	4.2	4.8	0.6
Hidewood Creek (nr Clear Lake)	945	Grab	Surface	07/24/01	T40	01-6300	24.3	19	2.2	7.85	300	5	477	472	0.075	0.19	1.17	1.36	0.245	0.192
Duplicate		Grab	Surface			01-6298					<100	7	451	444	0.066	0.21	1.16	1.37	0.240	0.195
Absolute Difference											300	2	26	28	0.009	0.02	0.01	0.01	0.005	0.003
Percent Difference											100	29	5	6	12.0	10.4	0.7	1.0	2.0	1.5
Hidewood Creek (nr Clear Lake)	930	Grab	Surface	08/27/01	T40	01-6319	19.8	22.5	4.7	7.53	670	2	1022	1020	0.066	0.14	1.22	1.36	0.292	0.217
Duplicate		Grab	Surface			01-6320					600	4	1068	1064	0.050	0.10	1.25	1.36	0.279	0.204
Absolute Difference											70	2	46	44	0.016	0.03	0.03	0	0.013	0.013
Percent Difference											10	50	4	4	24.2	23.5	2.6	0	4.5	6.0
BSR nr Brookings	1300	Grab	Surface	08/28/01	R01	01-6341	23.3	31.5	13.8	8.51	110	107	1007	900	0.083	0.03	1.75	1.78	0.276	0.141
Duplicate		Grab	Surface			01-6343					50	106	966	860	0.077	0.01	1.76	1.78	0.274	0.149
Absolute Difference											60	1	41	40	0.006	0.02	0.01	0.00	0.002	0.008
Percent Difference											55	1	4	4	7.2	51.7	0.8	0.1	0.7	5.4
Hidewood Creek (nr Clear Lake)	1000	Grab	Surface	09/26/01	T40	01-6392	10.9	19	11.3	7.66	680	13	1665	1652	0.104	0.52	0.74	1.26	0.181	0.108
Duplicate		Grab	Surface			01-6391					900	12	1536	1524	0.100	0.53	0.75	1.29	0.184	0.110
Absolute Difference											220	1	129	128	0.004	0.01	0.01	0.02	0.003	0.002
Percent Difference											24	8	8	8	3.8	1.9	1.7	1.8	1.6	1.8
BSR @ 20th Ave	930	Grab	Surface	09/26/01	R16	01-6382	15.3	12	8.3	7.78	90	8	768	760	10.718	0.28	1.72	2.00	2.595	2.623
Duplicate		Grab	Surface			01-6381					110	8	760	752	10.450	0.28	1.68	1.96	2.599	2.525
Absolute Difference											20	0	8	8	0.268	0.00	0.04	0.04	0.004	0.098
Percent Difference											18	0	1	1	2.5	0.7	2.4	2.2	0.2	3.7
Hidewood Creek (nr Clear Lake)	930	Grab	Surface	10/22/01	T40	01-6441	6.9	11	14.5	7.79	30	5	1517	1512	1.268	0.34	0.76	1.10	0.151	0.097
Duplicate		Grab	Surface			01-6440					80	5	1577	1572	1.343	0.36	0.77	1.13	0.175	0.072
Absolute Difference											50	0	60	60	0.075	0.03	0.01	0.03	0.024	0.025
Percent Difference											63	0	4	4	5.6	6.9	0.7	2.7	13.7	25.8

StreamName	Time	Sample	Depth	Date	Site	Lab#	Water Temp C°	Air Temp C°	DO mg/L	Field pH su	Fecal Coliform cfu/100mL	Total Suspended Solids mg/L	Total Solids mg/L	Total Dissolved Solids mg/L	NO2NO3 mg/L	NH3N mg/L	OrgNtr mg/L	TKN mg/L	Tot PO4 mg/L	TotDis PO4 mg/L
BSR nr Bruce	1015	Grab	Surface	10/23/01	R20	01-6451	8.9	7.5	16.5	8.79	80	8	800	792	0.383	0.07	1.07	1.14	0.146	0.121
Duplicate		Grab	Surface			01-6450					70	8	788	780	0.387	0.13	0.99	1.12	0.150	0.130
Absolute Difference											10	0	12	12	0.004	0.07	0.08	0.01	0.004	0.009
Percent Difference											13	0	2	2	1.0	49.6	7.2	1.0	2.7	6.9
BSR @ Watertown	930	Grab	Surface	10/24/01	R14	01-6461	3.9	1	16.4	8.63	320	43	439	396	0.140	0.04	0.60	0.64	0.106	0.030
Duplicate		Grab	Surface			01-6460					390	30	418	388	0.140	0.04	0.66	0.70	0.140	0.018
Absolute Difference											70	13	21	8	0	0	0.06	0.06	0.034	0.012
Percent Difference											18	30	5	2	0	0	9.1	8.6	24.3	40.0
BSR nr Brookings	1045	Grab	Surface	04/08/02	R01	2-6003	7.2	7.5	11.7	8.53	<10	146	638	492	0.952	0.40	1.44	1.84	0.463	0.230
Duplicate		Grab	Surface			2-6001					<10	160	636	476	0.958	0.40	1.52	1.92	0.450	0.266
Absolute Difference											0	14	2	16	0.006	0.00	0.08	0.08	0.013	0.036
Percent Difference											0	9	0	3	0.6	1.0	5.1	4.3	2.8	13.5
Hidewood ck nr Clear Lk	1000	Grab	Surface	04/09/02	T40	2-6017	2.9	7	17.6	8.12	<10	14	498	484	0.186	0.11	1.79	1.90	0.189	0.094
Duplicate		Grab	Surface			2-6016					<10	15	507	492	0.184	0.08	1.34	1.42	0.185	0.074
Absolute Difference											0	1	9	8	0.002	0.03	0.46	0.49	0.004	0.020
Percent Difference											0	7	2	2	1.1	26.4	25.4	25.5	2.1	21.3
Hidewood ck nr Clear Lk	930	Grab	Surface	04/30/02	T40	2-6038	7.4	10.5	13.7	8.1	30	12	492	480	0.106	0.05	1.10	1.16	0.101	0.047
Duplicate		Grab	Surface			2-6037					10	11	443	432	0.110	0.06	1.31	1.37	0.104	0.052
Absolute Difference											20	1	49	48	0.004	0.00	0.21	0.21	0.003	0.005
Percent Difference											67	8	10	10	3.6	6.9	15.7	15.4	2.9	9.6
Willow Ck nr Waverly	1000	Grab	Surface	04/30/02	T35	2-6039	7.8	12.5	16.8	8.3	10	10	434	424	0.071	0.12	1.04	1.16	0.088	0.065
Duplicate		Grab	Surface			2-6041					<10	9	393	384	0.068	0.06	1.04	1.10	0.097	0.060
Absolute Difference											10	1	41	40	0.003	0.06	0.00	0.06	0.009	0.005
Percent Difference											100	10	9	9	4.2	48.3	0.3	5.3	9.3	7.7
No Name Ck nr Volga	845	Grab	Surface	05/08/02	T47	2-6061	7.8	9	7.8	7.81	TNTC	62	502	440	1.290	1.73	4.05	5.78	1.392	0.995
Duplicate		Grab	Surface			2-6060					TNTC	52	492	440	1.295	1.73	4.07	5.80	1.411	0.988
Absolute Difference												10	10	0	0.005	0.01	0.02	0.03	0.019	0.007
Percent Difference												16	2	0	0.4	0.4	0.5	0.5	1.3	0.7
BSR nr Brookings	750	Grab	Surface	05/09/02	R01	2-6072	5.9	3.5	13.9	8.11	TNTC	182	666	484	0.694	0.26	1.70	1.96	0.578	0.239
Duplicate		Grab	Surface			2-6071					TNTC	178	710	532	0.704	0.33	1.64	1.97	0.583	0.227
Absolute Difference												4	44	48	0.010	0.07	0.06	0.01	0.005	0.012
Percent Difference												2	6	9	1.4	21.8	3.4	0.7	0.9	5.0
Hidewood Ck nr Clear Lk	835	Grab	Surface	06/10/02	T40	2-6091	20.4	24	8.6	7.9	520	22	702	680	0.057	0.12	1.85	1.97	0.267	0.143
Duplicate		Grab	Surface			2-6090					470	19	683	664	0.058	0.22	1.36	1.58	0.262	0.145
Absolute Difference											50	3	19	16	0.001	0.100	0.49	0.39	0.005	0.002
Percent Difference											10	14	3	2	1.7	47.3	26.5	19.7	1.9	1.4
Lake Poinsett Outlet	830	Grab	Surface	06/11/02	T39	2-6104	18.8	16	7.1	8.49	50	56	984	928	0.050	0.19	1.57	1.77	0.281	0.156
Duplicate		Grab	Surface			2-6103					60	52	952	900	0.049	0.19	1.64	1.83	0.243	0.171
Absolute Difference											10	4	32	28	0.001	0.00	0.06	0.07	0.038	0.015
Percent Difference											17	7	3	3	2.0	0.5	3.9	3.5	13.5	8.8
Hidewood ck nr Clear Lk	900	Grab	Surface	07/08/02	T40	2-6124	22.9	20	1.7	7.93	-------	126	1070	944	0.074	2.94	2.81	5.74	1.043	0.375
Duplicate		Grab	Surface			2-6122						170	1126	956	0.070	2.82	3.16	5.98	1.007	0.493
Absolute Difference												44	56	12	0.004	0.12	0.36	0.24	0.036	0.118
Percent Difference												26	5	1	5.4	4.0	11.3	4.0	3.5	23.9

StreamName	Time	Sample	Depth	Date	Site	Lab#	Water Temp C°	Air Temp C°	DO mg/L	Field pH su	Fecal Coliform cfu/100mL	Total Suspended Solids mg/L	Total Solids mg/L	Total Dissolved Solids mg/L	NO2NO3 mg/L	NH3N mg/L	OrgNtr mg/L	TKN mg/L	Tot PO4 mg/L	TotDis PO4 mg/L
Unamed Ck nr Volga	805	Grab	Surface	07/09/02	T47	2-6134	20.9	25	6.2	7.94	630	28	876	848	0.112	0.09	0.94	1.03	0.679	0.627
Duplicate		Grab	Surface			2-6133					580	64	900	836	0.110	0.07	0.87	0.94	0.686	0.644
Absolute Difference											50	36	24	12	0.002	0.02	0.07	0.09	0.007	0.017
Percent Difference											8	56	3	1	1.8	17.8	7.7	8.6	1.0	2.6
BSR nr Castlrwood	900	Grab	Surface	8/6/2002	R18	2-6153	19.6	18	7.9	7.78	16000	65	701	636	1.365	0.38	1.82	2.20	1.038	0.883
Duplicate		Grab	Surface			2-6154					17000	41	721	680	1.358	0.41	1.87	2.28	1.219	0.856
Absolute Difference											1000	24	20	44	0.007	0.03	0.05	0.08	0.181	0.027
Percent Difference											6	37	3	6	0.5	6.1	2.9	3.5	14.8	3.1
Hidewood ck nr Clear Lk	830	Grab	Surface	08/07/02	T40	2-6163	19.9	24.7	1.4	7.57	42000	104	1628	1524	0.094	7.85	3.10	10.95	1.134	0.790
Duplicate		Grab	Surface			2-6164					30200	54	1570	1516	0.086	7.78	3.24	11.02	1.397	0.814
Absolute Difference											11800	50	58	8	0.008	0.07	0.15	0.07	0.263	0.024
Percent Difference											28	48	4	1	8.5	0.9	4.5	0.7	18.8	2.9
Hidewood ck nr Clear Lk	845	Grab	Surface	08/21/02	T40	2-6182	17.6	25	3.6	7.35	20000	36	1920	1884	3.515	0.6300	2.9510	3.5810	0.575	0.353
Duplicate		Grab	Surface			2-6181					21000	54	1974	1920	3.488	0.4800	2.6700	3.1500	0.687	0.352
Absolute Difference											1000	18	54	36	0.027	0.15	0.28	0.43	0.112	0.001
Percent Difference											5	33	3	2	0.8	23.8	9.5	12.0	16.3	0.3
BSR nr Brookings	815	Grab	Surface	08/22/02	R01	2-6195	21.8	19	7.2	8.03	600	100	680	580	0.034	0.0900	1.6780	1.7680	0.426	0.037
Duplicate		Grab	Surface			2-6193					1000	10	742	732	0.034	0.1160	1.6600	1.7760	0.416	0.006
Absolute Difference											400	90	62	152	0	0.03	0.02	0.01	0.010	0.031
Percent Difference											40	90	8	21	0	22.4	1.1	0.5	2.3	83.8
Willow Ck nr Waverly	1000	Grab	Surface	09/09/02	T35	2-6206	19.9	18.9	3.2	8.13	28000	56	420	364	0.060	0.5830	2.0760	2.6590	0.280	0.111
Duplicate		Grab	Surface			2-6205					26000	58	402	344	0.058	0.5980	2.2660	2.8640	0.291	0.122
Absolute Difference											2000	2	18	20	0.002	0.02	0.19	0.21	0.011	0.011
Percent Difference											7	3	4	5	3.3	2.5	8.4	7.2	3.8	9.0
Hidewood ck nr Clear Lk	1030	Grab	Surface	09/10/02	T40	2-6214	16.4	18	2.5	8	990	98	1994	1896	0.084	1.0300	3.6120	4.6420	0.718	0.127
Duplicate		Grab	Surface			2-6215					1100	86	1986	1900	0.070	0.9940	3.5630	4.5570	0.670	0.108
Absolute Difference											110	12	8	4	0.014	0.04	0.05	0.09	0.048	0.019
Percent Difference											10	12	0	0	16.7	3.5	1.4	1.8	6.7	15.0
Willow Ck nr Watertown	1015	Grab	Surface	10/17/02	T36	2-6246	5.9	9	9.45	4.53	100	5	641	636	0.124	0.1220	0.6580	0.7800	0.045	0.022
Duplicate		Grab	Surface			2-6247					100	4	616	612	0.126	0.1450	0.7060	0.8510	0.039	0.014
Absolute Difference											0	1	25	24	0.002	0.02	0.05	0.07	0.006	0.008
Percent Difference											0	20	4	4	1.6	15.9	6.8	8.3	13.3	36.4

Name	Date	Lab #	Fecal Coliform cfu/100mL	Total Suspended Solids mg/L	Total Solids mg/L	Total Dissolved Solids mg/L	NO2NO3 mg/L	NH3N mg/L	OrgNtr mg/L	TKN mg/L	Tot PO4 mg/L	TotDis PO4 mg/L
BLANK	04/09/01	01-6051	<1	1.50	20.00	18.50	0.04	0.02	0.51	0.53	<0.01	<0.01
BLANK	04/13/01	01-6085	<10	0.50	0.50	<1	0.04	<0.01	0.31	0.31	<0.01	<0.01
BLANK	05/08/01	01-6150	<100	0.50	0.50	0.00	0.04	0.01	0.04	0.04	0.01	0.01
BLANK	06/14/01	01-6214	<10	<1	<1	<1	0.06	<0.01	0.45	0.45	<0.01	<0.01
BLANK	06/15/01	01-6218	<1	<1	<1	<1	0.03	<0.01	0.02	0.02	<0.01	<0.01
BLANK	07/24/01	01-6299	<10	<1	<1	<1	0.03	<0.01	0.01	0.01	<0.01	<0.01
BLANK	08/27/01	01-6321	<1	<1	16.00	16.00	0.04	<0.01	0.35	0.35	<0.01	<0.01
BLANK	08/28/01	01-6342	<10	<1	<1	<1	0.05	<0.01	0.31	0.31	0.02	<0.01
BLANK	09/26/01	01-6390	<10	<1	<1	<1	0.04	<0.01	0.47	0.47	<0.01	<0.01
BLANK	09/26/01	01-6380	<10	<1	24.00	24.00	0.04	<0.01	0.38	0.39	<0.01	<0.01
BLANK	10/22/01	01-6439	<10	<1	<1	<1	0.06	<0.01	0.37	0.37	0.02	<0.01
BLANK	10/23/01	01-6449	<10	<1	<1	<1	0.06	<0.01	0.34	0.35	<0.01	<0.01
BLANK	10/24/01	01-6459	<10	<1	<1	<1	0.04	<0.01	0.39	0.39	<0.01	<0.01
BLANK	04/08/02	2-6002	<10	<1	<1	<1	0.03	<0.01	0.01	0.01	<0.01	0.03
BLANK	04/09/02	2-6015	<10	<1	<1	<1	0.03	<0.01	<0.01	<0.01	<0.01	0.016
BLANK	04/30/02	2-6036	<10	<1	<1	<1	0.04	<0.01	0.36	0.36	<0.01	<0.01
BLANK	04/30/02	2-6040	<10	<1	<1	<1	0.05	0.01	0.47	0.49	<0.01	<0.01
BLANK	05/08/02	2-6059	10	<1	<1	<1	0.06	0.01	0.46	0.47	<0.01	<0.01
BLANK	05/09/02	2-6052	<10	<1	<1	<1	0.04	<0.01	<0.01	<0.01	0.007	0.011
BLANK	06/10/02	2-6092	<10	<1	<1	<1	0.02	<0.01	0.45	0.45	<0.01	<0.01
BLANK	06/11/02	2-6102	<10	<1	<1	<1	0.05	<0.01	0.40	0.40	<0.01	<0.01
BLANK	07/08/02	2-6123	----	<1	40	40	0.06	<0.01	0.33	0.34	<0.01	<0.01
BLANK	07/09/02	2-6132	<10	<1	12	12	0.06	<0.01	0.42	0.42	0.016	<0.01
BLANK	08/06/02	2-6152	<10	2	2	<1	0.03	<0.01	0.33	0.33	<0.01	<0.01
BLANK	08/07/02	2-6165	<100	<1	<1	<1	0.07	<0.01	0.40	0.40	0.011	<0.01
BLANK	08/21/02	2-6183	<1	<1	2	<1	0.05	<0.01	0.15	0.15	<0.01	<0.01
BLANK	08/22/02	2-6194	<1	<1	<1	<1	0.03	<0.01	0.36	0.36	<0.01	0.012
BLANK	09/09/02	2-6204	<10	<1	<1	<1	0.02	<0.01	0.31	0.31	0.025	0.019
BLANK	09/10/02	2-6216	<10	<1	<1	<1	<0.01	<0.01	0.32	0.32	<0.01	<0.01
BLANK	10/17/02	2-6248	<10	<1	<1	<1	0.01	0.03	0.30	0.33	<0.01	0.018

QA/QC Duplicates and Blanks for Extra River Samples in 2004

Stream	Time	Sample	Depth	Date	SiteID	Water Temp C°	Air Temp C°	Dissolved Oxygen mg/L	Field pH su	Fecal Coliform cfu/100mL
BSR nr Estelline	1230	Grab	Surface	06/16/04	R19	18	15	7.07	8.14	310
Duplicate		Grab	Surface							440
Absolute Difference										130
Percent Difference										29.5
BSR nr Estelline	1105	Grab	Surface	07/01/04	R19	22.7	32	8.49	8.35	1340
Duplicate		Grab	Surface							1550
Absolute Difference										210
Percent Difference										13.5
BSR below Watertown	1225	Grab	Surface	07/27/04	R17	22.6	25	13.04	7.7	310
Duplicate		Grab	Surface							340
Absolute Difference										30
Percent Difference										8.8
BSR nr Brookings	1443	Grab	Surface	08/10/04	R01	20.3		13.54	7.97	130
Duplicate		Grab	Surface							120
Absolute Difference										10
Percent Difference										7.7
BSR nr Brookings	917	Grab	Surface	08/25/04	R01	20.1	21	9.51	8.39	70
Duplicate		Grab	Surface							60
Absolute Difference										10
Percent Difference										14.3
BSR at Broadway	1313	Grab	Surface	09/08/04	R15	18.2	28	6.18	7.66	50
Duplicate		Grab	Surface							80
Absolute Difference										30
Percent Difference										37.5
BSR at Watertown	1230	Grab	Surface	09/27/04	R14	15.4	19.5	9.27	7.99	2000
Duplicate		Grab	Surface							1800
Absolute Difference										200
Percent Difference										10.0

Name	Date	Fecal Coliform cfu/100mL
BLANK	06/16/04	<10
BLANK	07/01/04	<10
BLANK	07/27/04	<10
BLANK	08/09/04	<2
BLANK	08/25/04	<10
BLANK	09/08/04	<10
BLANK	09/27/04	<10

Appendix Q.
WQ Parameters
FLUX Yearly Loads, Concentrations, and CV’s

R01

Parameter	Concentration (ppb)	FLUX Load Kg/Yr	CV
SuspSol	64970	40574980	0.126
TotSol	564093	352288000	0.065
DisSol	491709	307082900	0.095
NO2NO3	811	506245	0.128
NH3N	272	169858	0.235
Orgntr	1410	880602	0.083
TKN	1678	1047893	0.105
TotPO4	394	249431	0.123
TotDisPO4	259	161646	0.121
Fecal	579109	258521800	0.301
DO	8598	5369705	0.066

R14

Parameter	Concentration (ppb)	FLUX Load Kg/Yr	CV
SuspSol	20549	1977510	0.257
TotSol	231576	22285280	0.184
DisSol	218691	21045310	0.202
NO2NO3	741	71326	0.086
NH3N	248	23821	0.108
Orgntr	1082	104113	0.106
TKN	1385	133263	0.073
TotPO4	322	30997	0.185
TotDisPO4	265	25514	0.125
Fecal	750434	51065520	0.448
DO	8032	772971	0.105

R15

Parameter	Concentration (ppb)	FLUX Load Kg/Yr	CV
SuspSol	31193	3336901	0.386
TotSol	344217	36823160	0.142
DisSol	306642	32803470	0.174
NO2NO3	630	67348	0.137
NH3N	242	25887	0.216
Orgntr	988	105712	0.069
TKN	1230	131599	0.089
TotPO4	258	27554	0.095
TotDisPO4	170	18231	0.099
Fecal	1815160	137316800	0.409
DO	7283	779061	0.052

R16

Parameter	Concentration (ppb)	FLUX Load Kg/Yr	CV
SuspSol	24539	3694030	0.339
TotSol	342533	51564140	0.123
DisSol	316194	47599250	0.149
NO2NO3	899	135271	0.172
NH3N	246	37022	0.255
Orgntr	1022	153910	0.043
TKN	1268	190932	0.075
TotPO4	385	57888	0.103
TotDisPO4	301	45270	0.116
Fecal	1800286	191649400	0.473
DO	7233	1088787	0.082

R17

Parameter	Concentration (ppb)	FLUX Load Kg/Yr	CV
SuspSol	48409	7765081	0.226
TotSol	386598	60160200	0.050
DisSol	330893	51491720	0.103
NO2NO3	1019	158585	0.102
NH3N	305	47420	0.240
Orgntr	1254	195087	0.070
TKN	1609	250377	0.107
TotPO4	433	67376	0.168
TotDisPO4	290	45182	0.088
Fecal	3169811	358720000	0.692
DO	7453	1195439	0.137

R18

Parameter	Concentration (ppb)	FLUX Load Kg/Yr	CV
SuspSol	48254	8054271	0.379
TotSol	426650	71213180	0.034
DisSol	515921	86113730	0.125
NO2NO3	1124	187572	0.082
NH3N	441	73607	0.264
Orgntr	1584	264377	0.088
TKN	2040	340489	0.119
TotPO4	586	97775	0.162
TotDisPO4	414	69063	0.134
Fecal	54160500	6522125000	0.961
DO	7693	1284014	0.500

R19

Parameter	Concentration (ppb)	FLUX Load Kg/Yr	CV
SuspSol	54340	11045010	0.208
TotSol	459882	93475030	0.097
DisSol	352286	71605180	0.198
NO2NO3	1221	248220	0.141
NH3N	366	74370	0.163
Orgntr	1600	325131	0.040
TKN	2022	410938	0.066
TotPO4	426	86478	0.111
TotDisPO4	268	54518	0.067
Fecal	4132999	605588600	0.556
DO	7718	1568751	0.163

R20

Parameter	Concentration (ppb)	FLUX Load Kg/Yr	CV
SuspSol	61553	26729770	0.288
TotSol	756395	328470100	0.115
DisSol	662074	287510600	0.148
NO2NO3	1071	465174	0.210
NH3N	337	146454	0.257
Orgntr	1618	702738	0.098
TKN	1870	812223	0.099
TotPO4	377	163658	0.146
TotDisPO4	250	108771	0.096
Fecal	2558944	824558600	0.307
DO	10543	4578372	0.173

T34 (From BSR Into Lake Pelican)

Parameter	Concentration (ppb)	FLUX Load Kg/Yr	CV
SuspSol	16352	443555	0.167
TotSol	465834	12635950	0.061
DisSol	449482	12192400	0.063
NO2NO3	204	5540	0.328
NH3N	134	3631	0.184
Orgntr	883	23960	0.073
TKN	982	26643	0.072
TotPO4	119	3225	0.090
TotDisPO4	63	1711	0.226
Fecal	309367	8391730	0.615
DO	13710	371897	0.141

T35

Parameter	Concentration (ppb)	FLUX Load Kg/Yr	CV
SuspSol	11015	21965	0.193
TotSol	377269	752293	0.043
DisSol	364881	727591	0.040
NO2NO3	75	149	0.237
NH3N	140	278	0.125
Orgntr	1222	2438	0.046
TKN	1362	2716	0.047
TotPO4	178	355	0.149
TotDisPO4	111	222	0.183
Fecal	21813080	43496390	0.927
DO	8452	16853	0.129

T36

Parameter	Concentration (ppb)	FLUX Load Kg/Yr	CV
SuspSol	52183	1572160	0.133
TotSol	418349	12604010	0.021
DisSol	372289	11216330	0.063
NO2NO3	1159	34910	0.093
NH3N	504	15199	0.226
Orgntr	1710	51509	0.083
TKN	211508	63745	0.101
TotPO4	677	20399	0.100
TotDisPO4	378	11388	0.122
Fecal	30082920	906337900	0.859
DO	7300	219926	0.107

T37

Parameter	Concentration (ppb)	FLUX Load Kg/Yr	CV
SuspSol	65229	552074	0.385
TotSol	628719	5321203	0.312
DisSol	577384	4886732	0.358
NO2NO3	1487	12589	0.723
NH3N	419	3548	0.188
Orgntr	2065	17480	0.081
TKN	2505	21201	0.037
TotPO4	574	4856	0.148
TotDisPO4	351	2970	0.061
Fecal	34378480	290964600	0.936
DO	6825	57762	0.125

T39

Parameter	Concentration (ppb)	FLUX Load Kg/Yr	CV
SuspSol	23347	3165099	0.276
TotSol	883994	119838900	0.060
DisSol	864681	117220800	0.067
NO2NO3	132	17877	0.294
NH3N	525	71135	0.332
Orgntr	1455	197200	0.043
TKN	1980	268435	0.064
TotPO4	282	38242	0.120
TotDisPO4	233	31640	0.084
Fecal	4330912	587121200	0.944
DO	6372	863851	0.211

T40

Parameter	Concentration (ppb)	FLUX Load Kg/Yr	CV
SuspSol	8590	96398	0.202
TotSol	582418	6535813	0.024
DisSol	529551	5942545	0.016
NO2NO3	229	2567	0.356
NH3N	148	1658	0.191
Orgntr	1326	14881	0.137
TKN	1474	16539	0.122
TotPO4	254	2854	0.142
TotDisPO4	114	1275	0.300
Fecal	7310430	82036600	0.505
DO	7700	86413	0.267

T41

Parameter	Concentration (ppb)	FLUX Load Kg/Yr	CV
SuspSol	19150	386145	0.294
TotSol	549584	11081810	0.063
DisSol	537926	10846730	0.074
NO2NO3	1029	20742	0.291
NH3N	91	1843	0.325
Orgntr	992	20012	0.194
TKN	1065	21471	0.189
TotPO4	96	1946	0.237
TotDisPO4	43	872	0.193
Fecal	1085459	21887200	0.395
DO	14046	283226	0.058

T42

Parameter	Concentration (ppb)	FLUX Load Kg/Yr	CV
SuspSol	16502	46316	0.344
TotSol	462875	1299145	0.024
DisSol	447097	1254862	0.034
NO2NO3	277	778	0.237
NH3N	108	302	0.254
Orgntr	1087	3050	0.222
TKN	1194	3352	0.223
TotPO4	276	775	0.465
TotDisPO4	220	617	0.464
Fecal	6658630	18688700	0.641
DO	11086	31116	0.331

T46

Parameter	Concentration (ppb)	FLUX Load Kg/Yr	CV
SuspSol	51535	1012483	0.541
TotSol	780717	15338260	0.018
DisSol	765524	15039770	0.023
NO2NO3	438	8605	0.067
NH3N	228	4477	0.089
Orgntr	1567	30791	0.077
TKN	1782	35020	0.074
TotPO4	374	7343	0.164
TotDisPO4	248	4878	0.119
Fecal	4068350	79928300	0.231
DO	9224	181219	0.229

T47

Parameter	Concentration (ppb)	FLUX Load Kg/Yr	CV
SuspSol	35615	58631	0.256
TotSol	591686	974060	0.042
DisSol	556071	915429	0.059
NO2NO3	1216	2003	0.277
NH3N	1172	1929	0.133
Orgntr	3598	5924	0.274
TKN	4769	7852	0.299
TotPO4	1227	2019	0.172
TotDisPO4	923	1520	0.174
Fecal	9640370	15870400	0.415
DO	14679	24165	0.246

Appendix R.
Monthly Concentrations - FLUX

FLUX calculated Monthly Concentrations (parts per billion)

Site	Stream	Year	Month	SuspSol	TotSol	DisSol	NO2NO3	NH3N	OrgNtr	TKN	Tot PO4	TotDis PO4	Fecal	DO
R01	BSR nr Brookings	2001	4	54004	504180	442399	924	308	1386	1688	413	294	308055	7751
R01	BSR nr Brookings	2001	5	53604	501993	440599	928	309	1385	1688	413	295	503928	7720
R01	BSR nr Brookings	2001	6	53604	501993	440599	928	309	1385	1688	413	295	763962	7720
R01	BSR nr Brookings	2001	7	73882	612786	531785	719	243	1430	1670	389	230	1473700	9286
R01	BSR nr Brookings	2001	8	104556	780379	669721	402	143	1498	1642	352	133	719867	11655
R01	BSR nr Brookings	2001	9	104556	780379	669721	402	143	1498	1642	352	133	218307	11655
R01	BSR nr Brookings	2001	10	104556	780379	669721	402	143	1498	1642	352	133	332355	11655
R01	BSR nr Brookings	2002	4	88170	690852	596037	571	196	1462	1657	371	185	800285	10390
R01	BSR nr Brookings	2002	5	79209	641893	555742	664	226	1442	1665	382	214	655283	9698
R01	BSR nr Brookings	2002	6	104556	780379	669721	402	143	1498	1642	352	133	338177	11655
R01	BSR nr Brookings	2002	7	104556	780379	669721	402	143	1498	1642	352	133	1210037	11655
R01	BSR nr Brookings	2002	8	104556	780379	669721	402	143	1498	1642	352	133	881666	11655
R01	BSR nr Brookings	2002	9	104556	780379	669721	402	143	1498	1642	352	133	1695302	11655
R01	BSR nr Brookings	2002	10	104556	780379	669721	402	143	1498	1642	352	133	1232280	11655
R14	BSR at Watertown	2001	4	16951	196844	188725	815	265	1081	1412	341	293	317323.1	7822
R14	BSR at Watertown	2001	5	16915	196500	188428	816	265	1081	1412	341	293	1191381	7298
R14	BSR at Watertown	2001	6	20229	228489	216027	748	249	1082	1387	324	268	2277369	7603
R14	BSR at Watertown	2001	7	46796	484901	437252	203	121	1091	1186	184	60	1180642	11443
R14	BSR at Watertown	2001	8	46796	484901	437252	203	121	1091	1186	184	60	480777.9	10227
R14	BSR at Watertown	2001	9	46796	484901	437252	203	121	1091	1186	184	60	1774371	9112
R14	BSR at Watertown	2001	10	46796	484901	437252	203	121	1091	1186	184	60	1312328	9186
R14	BSR at Watertown	2002	4	46796	484901	437252	203	121	1091	1186	184	60	158653.8	11034
R14	BSR at Watertown	2002	5	46796	484901	437252	203	121	1091	1186	184	60	145554.8	11156
R14	BSR at Watertown	2002	6	46796	484901	437252	203	121	1091	1186	184	60	340318.9	10360
R14	BSR at Watertown	2002	7	46796	484901	437252	203	121	1091	1186	184	60	3798551	8992
R14	BSR at Watertown	2002	8	46796	484901	437252	203	121	1091	1186	184	60	10853010	8101
R14	BSR at Watertown	2002	9	46796	484901	437252	203	121	1091	1186	184	60	7129428	7939
R14	BSR at Watertown	2002	10	46796	484901	437252	203	121	1091	1186	184	60	2942496	8582
R15	BSR at Broadway	2001	4	31652	260441	277178	702	262	999	1261	301	219	916775	6253
R15	BSR at Broadway	2001	5	31675	385805	275702	705	263	999	1263	242	143	2750136	6202
R15	BSR at Broadway	2001	6	31113	505843	311740	617	238	986	1225	193	94	6276087	7461
R15	BSR at Broadway	2001	7	28777	473695	461603	251	134	933	1067	158	73	1699493	12696
R15	BSR at Broadway	2001	8	28777	500038	461603	251	134	933	1067	162	79	533776.1	12697
R15	BSR at Broadway	2001	9	28777	531593	461603	251	134	933	1067	166	86	1414516	12696
R15	BSR at Broadway	2001	10	28777	534476	461603	251	134	933	1067	166	86	1526883	12696
R15	BSR at Broadway	2002	4	29330	483778	426094	338	159	946	1105	167	79	1743229	11456
R15	BSR at Broadway	2002	5	28777	479582	461603	251	134	933	1067	159	74	228462.1	12697
R15	BSR at Broadway	2002	6	28777	506206	461603	251	134	933	1067	162	80	574732.9	12697
R15	BSR at Broadway	2002	7	28777	529005	461603	251	134	933	1067	165	85	1431313	12696
R15	BSR at Broadway	2002	8	30010	471143	382522	444	189	961	1151	187	97	3484626	9934
R15	BSR at Broadway	2002	9	28777	530653	461603	251	134	933	1067	166	86	1335909	12697
R15	BSR at Broadway	2002	10	28777	529544	461603	251	134	933	1067	166	85	1343673	12696
R16	BSR 20th Ave	2001	4	24054	305416	279210	613	263	979	1242	342	264	885381.4	6559
R16	BSR 20th Ave	2001	5	24030	303556	277357	599	264	976	1241	340	262	2654405	6525
R16	BSR 20th Ave	2001	6	24623	348955	322594	948	243	1030	1273	392	307	6057621	7349
R16	BSR 20th Ave	2001	7	27088	537747	510712	2398	154	1252	1407	607	496	1713599	10775
R16	BSR 20th Ave	2001	8	27088	537747	510712	2398	154	1252	1407	607	496	758317.3	10775
R16	BSR 20th Ave	2001	9	27088	537747	510711	2398	154	1252	1407	607	496	2009554	10775
R16	BSR 20th Ave	2001	10	27088	537747	510712	2398	154	1252	1407	607	496	2169190	10775

Site	Stream	Year	Month	SuspSol	TotSol	DisSol	NO2NO3	NH3N	OrgNtr	TKN	Tot PO4	TotDis PO4	Fecal	DO
R16	BSR 20th Ave	2002	5	27088	537747	510712	2398	154	1252	1407	607	496	324568.3	10775
R16	BSR 20th Ave	2002	6	27088	537747	510711	2398	154	1252	1407	607	496	816503.3	10775
R16	BSR 20th Ave	2002	7	27088	537747	510712	2398	154	1252	1407	607	496	2033417	10775
R16	BSR 20th Ave	2002	8	25787	438123	411444	1633	201	1135	1336	493	396	3585081	8967
R16	BSR 20th Ave	2002	9	27088	537747	510712	2398	154	1252	1407	607	496	1897881	10775
R16	BSR 20th Ave	2002	10	27088	537747	510711	2398	154	1252	1407	607	496	1908911	10775
R17	BSR below Watertown	2001	4	50028	265636	294121	939	329	1259	1644	413	268	1597353	6325
R17	BSR below Watertown	2001	5	50108	447794	294121	939	329	1259	1644	413	268	4791494	7355
R17	BSR below Watertown	2001	6	47885	630393	325549	1007	308	1254	1614	430	287	10934670	9043
R17	BSR below Watertown	2001	7	40023	527356	516290	1423	183	1227	1431	533	404	2972087	11268
R17	BSR below Watertown	2001	8	40023	586166	516290	1423	183	1227	1431	533	404	966812.9	10549
R17	BSR below Watertown	2001	9	40023	659599	516290	1423	183	1227	1431	533	404	2562070	9770
R17	BSR below Watertown	2001	10	40023	666469	516290	1423	183	1227	1431	533	404	2765597	9702
R17	BSR below Watertown	2002	4	41950	535363	516290	1423	183	1227	1431	533	404	3048203	10605
R17	BSR below Watertown	2002	5	40023	540222	516290	1423	183	1227	1431	533	404	413806.6	11099
R17	BSR below Watertown	2002	6	40023	599769	516290	1423	183	1227	1431	533	404	1040997	10377
R17	BSR below Watertown	2002	7	40023	653799	516290	1423	183	1227	1431	533	404	2592495	9839
R17	BSR below Watertown	2002	8	44314	555822	421780	1217	245	1241	1522	482	346	6104769	9413
R17	BSR below Watertown	2002	9	40023	656609	516290	1423	183	1227	1431	533	404	2399388	9795
R17	BSR below Watertown	2002	10	40023	653434	516290	1423	183	1227	1431	533	404	2393410	9833
R18	BSR nr Castlewood	2001	4	48571	284110	249735	1173	490	1647	2151	606	429	30794200	6444
R18	BSR nr Castlewood	2001	5	48581	497432	685814	877	491	1649	2154	607	430	82176260	6405
R18	BSR nr Castlewood	2001	6	48541	703418	1234745	731	485	1641	2140	604	428	152680200	6562
R18	BSR nr Castlewood	2001	7	46743	509987	227696	1315	209	1283	1510	487	341	100042200	13657
R18	BSR nr Castlewood	2001	8	46743	594483	644952	1618	209	1283	1510	487	341	1925577	13657
R18	BSR nr Castlewood	2001	9	46743	687007	1455155	1962	209	1283	1510	487	341	4344527	13657
R18	BSR nr Castlewood	2001	10	46743	691122	1492290	1977	209	1283	1510	487	341	4455400	13657
R18	BSR nr Castlewood	2002	4	46743	540303	319236	1421	209	1283	1510	487	341	58097830	13657
R18	BSR nr Castlewood	2002	5	46743	538396	317547	1414	209	1283	1510	487	341	948071.8	13657
R18	BSR nr Castlewood	2002	6	46743	606360	655355	1659	209	1283	1510	487	341	1956635	13657
R18	BSR nr Castlewood	2002	7	46743	660191	1439762	1866	209	1283	1510	487	341	4298570	13657
R18	BSR nr Castlewood	2002	8	47877	571774	965068	1161	383	1509	1908	561	396	87037960	9180
R18	BSR nr Castlewood	2002	9	46743	694307	1530975	1989	209	1283	1510	487	341	4570897	13657
R18	BSR nr Castlewood	2002	10	46743	685730	1439554	1957	209	1283	1510	487	341	4239549	13657
R19	BSR nr Estelline	2001	4	51448	410338	293267	1346	457	1615	2071	442	288	2324890	6935
R19	BSR nr Estelline	2001	5	51360	408822	291462	1350	325	1615	2072	442	289	6203045	7260
R19	BSR nr Estelline	2001	6	51716	414934	298742	1334	260	1613	2066	440	286	11525020	7544
R19	BSR nr Estelline	2001	7	67880	691895	628669	638	305	1528	1793	348	175	7603881	10083
R19	BSR nr Estelline	2001	8	67880	691895	628668	638	196	1528	1793	348	175	344729.4	10802
R19	BSR nr Estelline	2001	9	67880	691894	628668	638	121	1528	1793	348	175	777785.7	11541
R19	BSR nr Estelline	2001	10	67880	691894	628668	638	118	1528	1793	348	175	799145.3	11575
R19	BSR nr Estelline	2002	4	64525	634413	560194	783	266	1546	1850	367	198	4453624	9714
R19	BSR nr Estelline	2002	5	67880	691894	628668	638	257	1528	1793	348	175	169730	10334
R19	BSR nr Estelline	2002	6	67880	691894	628668	638	178	1528	1793	348	175	346930.8	10900
R19	BSR nr Estelline	2002	7	67880	691895	628669	638	152	1528	1793	348	175	769558.3	11312
R19	BSR nr Estelline	2002	8	57681	517140	420494	1077	261	1582	1965	406	245	6715882	8719
R19	BSR nr Estelline	2002	9	67880	691894	628668	638	116	1528	1793	348	175	818311.4	11598
R19	BSR nr Estelline	2002	10	67880	691895	628669	638	122	1528	1793	348	175	758991.6	11531
R20	BSR nr Bruce	2001	4	47835	360658	317790	1201	375	1623	1971	390	280	1381629	5001
R20	BSR nr Bruce	2001	5	47835	583596	514231	1201	375	1623	1971	390	280	1977291	8092
R20	BSR nr Bruce	2001	6	47835	775317	683164	1201	375	1623	1971	390	280	2626863	10750
R20	BSR nr Bruce	2001	7	47835	1241919	1094306	1201	375	1623	1971	390	280	4207763	17220

Site	Stream	Year	Month	SuspSol	TotSol	DisSol	NO2NO3	NH3N	OrgNtr	TKN	Tot PO4	TotDis PO4	Fecal	DO
R16	BSR 20th Ave	2002	5	27088	537747	510712	2398	154	1252	1407	607	496	324568.3	10775
R16	BSR 20th Ave	2002	6	27088	537747	510711	2398	154	1252	1407	607	496	816503.3	10775
R16	BSR 20th Ave	2002	7	27088	537747	510712	2398	154	1252	1407	607	496	2033417	10775
R16	BSR 20th Ave	2002	8	25787	438123	411444	1633	201	1135	1336	493	396	3585081	8967
R16	BSR 20th Ave	2002	9	27088	537747	510712	2398	154	1252	1407	607	496	1897881	10775
R16	BSR 20th Ave	2002	10	27088	537747	510711	2398	154	1252	1407	607	496	1908911	10775
R17	BSR below Watertown	2001	4	50028	265636	294121	939	329	1259	1644	413	268	1597353	6325
R17	BSR below Watertown	2001	5	50108	447794	294121	939	329	1259	1644	413	268	4791494	7355
R17	BSR below Watertown	2001	6	47885	630393	325549	1007	308	1254	1614	430	287	10934670	9043
R17	BSR below Watertown	2001	7	40023	527356	516290	1423	183	1227	1431	533	404	2972087	11268
R17	BSR below Watertown	2001	8	40023	586166	516290	1423	183	1227	1431	533	404	966812.9	10549
R17	BSR below Watertown	2001	9	40023	659599	516290	1423	183	1227	1431	533	404	2562070	9770
R17	BSR below Watertown	2001	10	40023	666469	516290	1423	183	1227	1431	533	404	2765597	9702
R17	BSR below Watertown	2002	4	41950	535363	516290	1423	183	1227	1431	533	404	3048203	10605
R17	BSR below Watertown	2002	5	40023	540222	516290	1423	183	1227	1431	533	404	413806.6	11099
R17	BSR below Watertown	2002	6	40023	599769	516290	1423	183	1227	1431	533	404	1040997	10377
R17	BSR below Watertown	2002	7	40023	653799	516290	1423	183	1227	1431	533	404	2592495	9839
R17	BSR below Watertown	2002	8	44314	555822	421780	1217	245	1241	1522	482	346	6104769	9413
R17	BSR below Watertown	2002	9	40023	656609	516290	1423	183	1227	1431	533	404	2399388	9795
R17	BSR below Watertown	2002	10	40023	653434	516290	1423	183	1227	1431	533	404	2393410	9833
R18	BSR nr Castlewood	2001	4	48571	284110	249735	1173	490	1647	2151	606	429	30794200	6444
R18	BSR nr Castlewood	2001	5	48581	497432	685814	877	491	1649	2154	607	430	82176260	6405
R18	BSR nr Castlewood	2001	6	48541	703418	1234745	731	485	1641	2140	604	428	152680200	6562
R18	BSR nr Castlewood	2001	7	46743	509987	227696	1315	209	1283	1510	487	341	100042200	13657
R18	BSR nr Castlewood	2001	8	46743	594483	644952	1618	209	1283	1510	487	341	1925577	13657
R18	BSR nr Castlewood	2001	9	46743	687007	1455155	1962	209	1283	1510	487	341	4344527	13657
R18	BSR nr Castlewood	2001	10	46743	691122	1492290	1977	209	1283	1510	487	341	4455400	13657
R18	BSR nr Castlewood	2002	4	46743	540303	319236	1421	209	1283	1510	487	341	58097830	13657
R18	BSR nr Castlewood	2002	5	46743	538396	317547	1414	209	1283	1510	487	341	948071.8	13657
R18	BSR nr Castlewood	2002	6	46743	606360	655355	1659	209	1283	1510	487	341	1956635	13657
R18	BSR nr Castlewood	2002	7	46743	660191	1439762	1866	209	1283	1510	487	341	4298570	13657
R18	BSR nr Castlewood	2002	8	47877	571774	965068	1161	383	1509	1908	561	396	87037960	9180
R18	BSR nr Castlewood	2002	9	46743	694307	1530975	1989	209	1283	1510	487	341	4570897	13657
R18	BSR nr Castlewood	2002	10	46743	685730	1439554	1957	209	1283	1510	487	341	4239549	13657
R19	BSR nr Estelline	2001	4	51448	410338	293267	1346	457	1615	2071	442	288	2324890	6935
R19	BSR nr Estelline	2001	5	51360	408822	291462	1350	325	1615	2072	442	289	6203045	7260
R19	BSR nr Estelline	2001	6	51716	414934	298742	1334	260	1613	2066	440	286	11525020	7544
R19	BSR nr Estelline	2001	7	67880	691895	628669	638	305	1528	1793	348	175	7603881	10083
R19	BSR nr Estelline	2001	8	67880	691895	628668	638	196	1528	1793	348	175	344729.4	10802
R19	BSR nr Estelline	2001	9	67880	691894	628668	638	121	1528	1793	348	175	777785.7	11541
R19	BSR nr Estelline	2001	10	67880	691894	628668	638	118	1528	1793	348	175	799145.3	11575
R19	BSR nr Estelline	2002	4	64525	634413	560194	783	266	1546	1850	367	198	4453624	9714
R19	BSR nr Estelline	2002	5	67880	691894	628668	638	257	1528	1793	348	175	169730	10334
R19	BSR nr Estelline	2002	6	67880	691894	628668	638	178	1528	1793	348	175	346930.8	10900
R19	BSR nr Estelline	2002	7	67880	691895	628669	638	152	1528	1793	348	175	769558.3	11312
R19	BSR nr Estelline	2002	8	57681	517140	420494	1077	261	1582	1965	406	245	6715882	8719
R19	BSR nr Estelline	2002	9	67880	691894	628668	638	116	1528	1793	348	175	818311.4	11598
R19	BSR nr Estelline	2002	10	67880	691895	628669	638	122	1528	1793	348	175	758991.6	11531
R20	BSR nr Bruce	2001	4	47835	360658	317790	1201	375	1623	1971	390	280	1381629	5001
R20	BSR nr Bruce	2001	5	47835	583596	514231	1201	375	1623	1971	390	280	1977291	8092
R20	BSR nr Bruce	2001	6	47835	775317	683164	1201	375	1623	1971	390	280	2626863	10750
R20	BSR nr Bruce	2001	7	47835	1241919	1094306	1201	375	1623	1971	390	280	4207763	17220

Site	Stream	Year	Month	SuspSol	TotSol	DisSol	NO2NO3	NH3N	OrgNtr	TKN	Tot PO4	TotDis PO4	Fecal	DO
R20	BSR nr Bruce	2001	8	86412	893525	782907	835	269	1609	1687	352	197	5523623	12444
R20	BSR nr Bruce	2001	9	116085	589071	506996	554	188	1598	1469	323	133	1036711	8318
R20	BSR nr Bruce	2001	10	116085	942895	811520	554	188	1598	1469	323	133	1659407	13315
R20	BSR nr Bruce	2002	4	104907	718773	622892	660	219	1602	1551	334	157	1924495	10097
R20	BSR nr Bruce	2002	5	116085	743577	639974	554	188	1598	1469	323	133	1308628	10500
R20	BSR nr Bruce	2002	6	116085	1652326	1422106	554	188	1598	1469	323	133	2907941	23333
R20	BSR nr Bruce	2002	7	116085	4316593	3715160	554	188	1598	1469	323	133	7596805	60955
R20	BSR nr Bruce	2002	8	116085	2561573	2204668	554	188	1598	1469	323	133	5962960	36172
R20	BSR nr Bruce	2002	9	116085	5960564	5130075	554	188	1598	1469	323	133	10490040	84170
R20	BSR nr Bruce	2002	10	116085	5224097	4496220	554	188	1598	1469	323	133	9349250	73770
T35	Willow Creek (nr Waverly)	2001	5	4994	366737	358145	63	102	1087	1190	137	90	123991	5739
T35	Willow Creek (nr Waverly)	2001	6	4662	366737	358145	63	102	1087	1190	137	90	115750	5358
T35	Willow Creek (nr Waverly)	2001	7	7842	366737	358145	63	102	1087	1190	137	90	194710	9013
T35	Willow Creek (nr Waverly)	2001	8	14305	397582	377873	97	211	1483	1694	258	152	40436140	8610
T35	Willow Creek (nr Waverly)	2001	9	33567	416658	390074	118	278	1728	2006	334	190	151916100	9063
T35	Willow Creek (nr Waverly)	2001	10	39380	416658	390074	118	278	1728	2006	334	190	178223200	10632
T35	Willow Creek (nr Waverly)	2002	4	11650	366737	358145	63	102	1087	1190	137	90	289260	13389
T35	Willow Creek (nr Waverly)	2002	5	10205	366737	358145	63	102	1087	1190	137	90	253360	11728
T35	Willow Creek (nr Waverly)	2002	6	11535	388472	372047	87	179	1366	1545	222	134	20332540	9340
T35	Willow Creek (nr Waverly)	2002	7	18908	416658	390074	118	278	1728	2006	334	190	85571840	5105
T35	Willow Creek (nr Waverly)	2002	8	22768	411271	386628	112	259	1659	1918	312	179	96401990	7445
T35	Willow Creek (nr Waverly)	2002	9	28326	416658	390074	118	278	1728	2006	334	190	128197900	7648
T35	Willow Creek (nr Waverly)	2002	10	35372	416658	390074	118	278	1728	2006	334	190	160084000	9550
T36	Willow Creek (nr Watertown)	2001	4	58360	395064	348538	1300	666	1813	2262	759	422	18460330	6301
T36	Willow Creek (nr Watertown)	2001	5	55181	407046	360760	1227	280	1760	2187	717	399	65452600	7320
T36	Willow Creek (nr Watertown)	2001	6	40366	462890	417724	888	165	1512	1836	521	295	75135340	9592
T36	Willow Creek (nr Watertown)	2001	7	8477	583090	540335	159	138	977	1082	99	70	1100140	11116
T36	Willow Creek (nr Watertown)	2001	8	8477	583090	540335	159	178	977	1082	99	70	3874740	9423
T36	Willow Creek (nr Watertown)	2001	9	8477	583090	540335	159	233	977	1082	99	70	12353590	7841
T36	Willow Creek (nr Watertown)	2001	10	8477	583090	540335	159	233	977	1082	99	70	11238460	7775
T36	Willow Creek (nr Watertown)	2002	4	33200	489903	445279	725	198	1392	1667	426	244	32143830	10392
T36	Willow Creek (nr Watertown)	2002	5	8477	583090	540335	159	101	977	1082	99	70	304000	13724
T36	Willow Creek (nr Watertown)	2002	6	8477	583090	540335	159	167	977	1082	99	70	2943100	9863
T36	Willow Creek (nr Watertown)	2002	7	8477	583090	540335	159	227	977	1082	99	70	12522330	8070
T36	Willow Creek (nr Watertown)	2002	8	52452	417334	371254	1165	374	1714	2122	681	380	34810990	7243
T36	Willow Creek (nr Watertown)	2002	9	8477	583090	540335	159	266	977	1082	99	70	22349620	7129
T36	Willow Creek (nr Watertown)	2002	10	8477	583090	540335	159	245	977	1082	99	70	14254140	7524
T37	Stray Horse Creek	2001	6	71120	598769	546413	1408	450	2116	2590	616	396	39372400	6730
T37	Stray Horse Creek	2001	7	63710	640257	588571	1509	411	2052	2483	563	339	33090420	6849
T37	Stray Horse Creek	2001	8	29433	811090	777029	1968	232	1756	1988	315	77	4029890	7403
T37	Stray Horse Creek	2001	9	29433	739494	705553	1968	232	1756	1988	315	77	4029890	7403
T37	Stray Horse Creek	2001	10	29433	812712	778641	1968	232	1756	1988	315	77	4029890	7403
T37	Stray Horse Creek	2002	4	37871	821017	807412	1855	276	1829	2110	376	141	11183690	7267
T37	Stray Horse Creek	2002	5	40642	815112	807251	1817	290	1853	2150	396	163	13532830	7222
T37	Stray Horse Creek	2002	6	29433	760151	726155	1968	232	1756	1988	315	77	4029890	7403
T37	Stray Horse Creek	2002	7	58867	748962	764616	1573	386	2010	2413	528	302	28984290	6928
T37	Stray Horse Creek	2002	8	69921	584879	519099	1425	444	2106	2573	608	387	38356190	6749
T37	Stray Horse Creek	2002	9	29433	791719	757649	1968	232	1756	1988	315	77	4029890	7403
T37	Stray Horse Creek	2002	10	29433	837947	803872	1968	232	1756	1988	315	77	4029890	7403
T40	Hidewood Creek (nr Clear Lake)	2001	6	3589	485369	476570	126	124	1303	1427	252	105	6700260	3720
T40	Hidewood Creek (nr Clear Lake)	2001	7	5710	485369	476571	126	124	1303	1427	252	105	6700260	5920
T40	Hidewood Creek (nr Clear Lake)	2001	8	9781	1044400	781753	716	261	1435	1696	268	153	10215040	8254

Site	Stream	Year	Month	SuspSol	TotSol	DisSol	NO2NO3	NH3N	OrgNtr	TKN	Tot PO4	TotDis PO4	Fecal	DO
T40	Hidewood Creek (nr Clear Lake)	2001	9	16841	1607838	1089342	1310	399	1567	1966	284	201	13757540	8445
T40	Hidewood Creek (nr Clear Lake)	2001	10	42114	1607838	1089342	1310	399	1567	1966	284	201	13757540	21116
T40	Hidewood Creek (nr Clear Lake)	2002	4	12292	485369	476570	126	124	1303	1427	252	105	6700260	12742
T40	Hidewood Creek (nr Clear Lake)	2002	5	14530	591115	534298	238	150	1328	1478	255	114	7365110	14878
T40	Hidewood Creek (nr Clear Lake)	2002	6	15394	1607838	1089342	1310	399	1567	1966	284	201	13757540	7719
T40	Hidewood Creek (nr Clear Lake)	2002	7	2087206	1607838	1089342	1310	399	1567	1966	284	201	13757540	1046549
T40	Hidewood Creek (nr Clear Lake)	2002	8	154085	1607838	1089342	1310	399	1567	1966	284	201	13757540	77260
T40	Hidewood Creek (nr Clear Lake)	2002	9	0	0	0	0	0	0	0	0	0	0	0
T40	Hidewood Creek (nr Clear Lake)	2002	10	390898	1607838	1089342	1310	399	1567	1966	284	201	13757540	196001
T41	Hidewood Creek (nr Estelline)	2001	5	21982	547545	561349	890	130	994	1126	129	76	850523	12977
T41	Hidewood Creek (nr Estelline)	2001	6	18681	525642	534046	1052	85	992	1055	91	68	1124372	14223
T41	Hidewood Creek (nr Estelline)	2001	7	20707	547299	550801	953	113	993	1098	115	70	956323	13458
T41	Hidewood Creek (nr Estelline)	2001	8	21982	574578	561349	890	130	994	1126	129	75	850523	12977
T41	Hidewood Creek (nr Estelline)	2001	9	19282	555715	539016	1022	93	993	1068	98	33	1074525	13996
T41	Hidewood Creek (nr Estelline)	2001	10	18392	542592	531656	1066	81	992	1049	88	27	1148342	14332
T41	Hidewood Creek (nr Estelline)	2002	4	18392	557957	531656	1066	81	992	1049	88	19	1148342	14332
T41	Hidewood Creek (nr Estelline)	2002	5	18392	563704	531656	1066	81	992	1049	88	16	1148342	14332
T41	Hidewood Creek (nr Estelline)	2002	6	21111	596921	554141	933	118	994	1107	119	58	922823	13306
T41	Hidewood Creek (nr Estelline)	2002	7	21982	689333	561349	890	130	994	1126	129	68	850523	12977
T42	Peg Munky Run	2001	5	4093	532145	527820	33	35	599	635	70	55	6658630	14545
T42	Peg Munky Run	2001	6	21939	432524	411728	384	139	1300	1439	367	292	6658630	9571
T42	Peg Munky Run	2001	7	13694	478548	465362	222	91	976	1068	230	183	6658630	11869
T42	Peg Munky Run	2001	8	4093	532145	527820	33	35	599	635	70	55	6658630	14545
T42	Peg Munky Run	2001	9	0	0	0	0	0	0	0	0	0	0	0
T42	Peg Munky Run	2001	10	4093	532145	527820	33	35	599	635	70	55	6658630	14545
T42	Peg Munky Run	2002	4	6665	517784	511085	84	50	700	751	113	89	6658630	13828
T42	Peg Munky Run	2002	5	8913	505236	496463	128	63	789	852	150	119	6658630	13202
T42	Peg Munky Run	2002	6	4093	532145	527820	33	35	599	635	70	55	6658630	14545
T42	Peg Munky Run	2002	7	0	0	0	0	0	0	0	0	0	0	0

Site	Stream	Year	Month	SuspSol	TotSol	DisSol	NO2NO3	NH3N	OrgNtr	TKN	Tot PO4	TotDis PO4	Fecal	DO
T47	Unnamed Creek (nr Volga)	2001	5	32805	606344	573539	1140	1065	3327	4390	1157	881	29775240	33593
T47	Unnamed Creek (nr Volga)	2001	6	37901	579764	541864	1278	1259	3819	5078	1284	957	16162840	21541
T47	Unnamed Creek (nr Volga)	2001	7	43986	548022	504037	1443	1492	4406	5898	1435	1048	8185810	11672
T47	Unnamed Creek (nr Volga)	2001	8	31812	611523	579711	1113	1027	3231	4257	1132	867	17415180	22378
T47	Unnamed Creek (nr Volga)	2001	9	7002	740946	733944	441	78	836	911	515	497	4156890	9924
T47	Unnamed Creek (nr Volga)	2001	10	17956	683807	665852	738	497	1893	2388	787	660	10707440	17395
T47	Unnamed Creek (nr Volga)	2002	4	31207	614681	583473	1097	1003	3173	4175	1117	858	15891590	23526
T47	Unnamed Creek (nr Volga)	2002	5	43172	552266	509093	1421	1461	4328	5788	1415	1036	6689690	11235
T47	Unnamed Creek (nr Volga)	2002	6	11914	715322	703407	574	266	1310	1573	637	570	5939790	15307
T47	Unnamed Creek (nr Volga)	2002	7	7002	740946	733944	441	78	836	911	515	497	5202740	8881
T47	Unnamed Creek (nr Volga)	2002	8	7002	740946	733944	441	78	836	911	515	497	3885070	10701
T47	Unnamed Creek (nr Volga)	2002	9	7002	740946	733944	441	78	836	911	515	497	5618920	8466
T47	Unnamed Creek (nr Volga)	2002	10	11909	715352	703444	574	266	1309	1572	637	570	9438170	15476

** flux runs done for T34 but not displayed here due to reliabilty (T34 in and out flows)

Appendix S.
Monthly Loadings - FLUX

FLUX Calculated Monthly Loadings (Kg)

Site	Stream	Year	Month	SuspSol	TotSol	DisSol	NO2NO3	NH3N	Orgntr	TKN	Tot PO4	TotDis PO4	Fecal	DO
R01	BSR nr Brookings	2001	4	13072770	122046900	107091500	223635	74476	335399	408558	99878	71103	74570920	1876362
R01	BSR nr Brookings	2001	5	8464515	79269230	69574520	146537	48789	218649	266571	65229	46584	79574870	1219122
R01	BSR nr Brookings	2001	6	5403293	50601230	44412650	93541	31144	139574	170165	41639	29737	77007940	778222
R01	BSR nr Brookings	2001	7	3989372	33088380	28714630	38801	13120	77213	90169	20987	12445	79574870	501431
R01	BSR nr Brookings	2001	8	3416589	25500550	21884560	13131	4678	48966	53667	11493	4341	23523200	380854
R01	BSR nr Brookings	2001	9	1866468	13930850	11955440	7173	2556	26750	29318	6279	2372	3897082	208059
R01	BSR nr Brookings	2001	10	1266854	9455474	8114682	4869	1735	18156	19899	4262	1610	4026985	141219
R01	BSR nr Brookings	2002	4	3919799	30713380	26498160	25387	8735	64991	73668	16514	8225	35578470	461897
R01	BSR nr Brookings	2002	5	3432607	27817030	24083580	28757	9779	62484	72159	16565	9253	28397270	420260
R01	BSR nr Brookings	2002	6	1204882	8992932	7717733	4631	1650	17268	18926	4053	1531	3897082	134311
R01	BSR nr Brookings	2002	7	347961	2597090	2228822	1337	476	4987	5466	1171	442	4026985	38788
R01	BSR nr Brookings	2002	8	477556	3564358	3058931	1835	654	6844	7501	1607	607	4026985	53234
R01	BSR nr Brookings	2002	9	240348	1793899	1539523	924	329	3445	3775	809	305	3897082	26792
R01	BSR nr Brookings	2002	10	331630	2475206	2124220	1275	454	4753	5209	1116	421	4026985	36968
R14	BSR at Watertown	2001	4	1101605	12792720	12265090	52961	17215	70230	91768	22166	19055	20622560	508366
R14	BSR at Watertown	2001	5	376628	4375267	4195547	18161	5902	24061	31447	7599	6535	26527340	162504
R14	BSR at Watertown	2001	6	228034	2575634	2435163	8429	2808	12194	15637	3650	3017	25671620	85701
R14	BSR at Watertown	2001	7	184233	1909019	1721429	800	476	4295	4669	723	238	4648102	45051
R14	BSR at Watertown	2001	8	42881	444331	400668	186	111	1000	1087	168	55	440553	9371
R14	BSR at Watertown	2001	9	11244	116511	105062	49	29	262	285	44	15	426341	2190
R14	BSR at Watertown	2001	10	15710	162783	146787	68	41	366	398	62	20	440553	3084
R14	BSR at Watertown	2002	4	96410	999002	900835	419	249	2248	2443	379	124	326862	22733
R14	BSR at Watertown	2002	5	141638	1467655	1323436	615	366	3302	3590	556	183	440553	33767
R14	BSR at Watertown	2002	6	58625	607469	547776	255	151	1367	1486	230	76	426341	12978
R14	BSR at Watertown	2002	7	5427	56238	50712	24	14	127	138	21	7	440553	1043
R14	BSR at Watertown	2002	8	1900	19683	17749	8	5	44	48	8	3	440553	329
R14	BSR at Watertown	2002	9	2798	28997	26148	12	7	65	71	11	4	426341	475
R14	BSR at Watertown	2002	10	6800	70464	63540	30	18	159	172	27	9	440553	1247
R15	BSR at Broadway	2001	4	2161035	17781460	18924160	47899	17918	68182	86101	20559	14967	62592190	426931
R15	BSR at Broadway	2001	5	826692	10069120	7195549	18404	6876	26078	32954	6304	3744	71775780	161855
R15	BSR at Broadway	2001	6	344346	5598403	3450174	6830	2639	10917	13556	2131	1045	69460430	82571
R15	BSR at Broadway	2001	7	129909	2138442	2083855	1132	607	4212	4819	713	331	7672167	57317
R15	BSR at Broadway	2001	8	43341	753111	695225	378	202	1405	1608	243	119	803925	19122
R15	BSR at Broadway	2001	9	15827	292379	253884	138	74	513	587	91	47	777992	6983
R15	BSR at Broadway	2001	10	15151	281409	243041	132	71	491	562	88	46	803925	6685
R15	BSR at Broadway	2002	4	128650	2121971	1868954	1481	698	4148	4846	732	348	7646234	50248
R15	BSR at Broadway	2002	5	101261	1687579	1624314	883	473	3284	3756	558	262	803925	44677
R15	BSR at Broadway	2002	6	38954	685230	624853	340	182	1263	1445	220	109	777992	17187
R15	BSR at Broadway	2002	7	16163	297126	259269	141	76	524	600	93	48	803925	7131
R15	BSR at Broadway	2002	8	46356	727782	590887	686	292	1485	1777	289	150	5382754	15345
R15	BSR at Broadway	2002	9	16759	309036	268823	146	78	543	622	97	50	777992	7394
R15	BSR at Broadway	2002	10	16603	305519	266321	145	78	538	616	96	49	803925	7325
R16	BSR 20th Ave	2001	4	2311027	29343100	26825370	58933	25299	94028	119327	32886	25330	85063860	630175
R16	BSR 20th Ave	2001	5	882537	11148590	10186390	22003	9703	35863	45566	12493	9615	97487330	239656
R16	BSR 20th Ave	2001	6	383479	5434696	5024144	14763	3783	16041	19824	6103	4783	94342580	114458
R16	BSR 20th Ave	2001	7	172081	3416124	3244379	15237	981	7956	8937	3855	3149	10885920	68449
R16	BSR 20th Ave	2001	8	57411	1139703	1082404	5083	327	2654	2982	1286	1051	1607181	22836
R16	BSR 20th Ave	2001	9	20965	416200	395276	1856	120	969	1089	470	384	1555336	8340
R16	BSR 20th Ave	2001	10	20070	398424	378393	1777	114	928	1042	450	367	1607181	7983
R16	BSR 20th Ave	2002	4	163592	3043053	2877167	12683	1083	7405	8487	3431	2784	10834080	61496

Site	Stream	Year	Month	SuspSol	TotSol	DisSol	NO2NO3	NH3N	Orgntr	TKN	Tot PO4	TotDis PO4	Fecal	DO
R16	BSR 20th Ave	2002	5	134133	2662787	2528915	11877	765	6201	6966	3005	2455	1607181	53355
R16	BSR 20th Ave	2002	6	51599	1024340	972841	4569	294	2386	2680	1156	944	1555336	20525
R16	BSR 20th Ave	2002	7	21410	425027	403658	1896	122	990	1112	480	392	1607181	8516
R16	BSR 20th Ave	2002	8	56054	952361	894367	3550	437	2467	2904	1072	861	7792999	19492
R16	BSR 20th Ave	2002	9	22199	440690	418534	1966	127	1026	1153	497	406	1555336	8830
R16	BSR 20th Ave	2002	10	21992	436588	414638	1947	125	1017	1142	493	403	1607181	8748
R17	BSR below Watertown	2001	4	5087368	24848090	27512620	87828	30770	117756	153808	38651	25043	162434400	643139
R17	BSR below Watertown	2001	5	1947844	17406910	11433240	36498	12787	48935	63917	16062	10407	186257800	285922
R17	BSR below Watertown	2001	6	789354	10391540	5366410	16607	5081	20678	26607	7090	4732	180249500	149061
R17	BSR below Watertown	2001	7	269112	3545864	3471459	9570	1228	8253	9621	3582	2719	19983880	75762
R17	BSR below Watertown	2001	8	89782	1314911	1158164	3193	410	2753	3210	1195	907	2168795	23664
R17	BSR below Watertown	2001	9	32787	540340	422942	1166	150	1006	1172	436	331	2098834	8003
R17	BSR below Watertown	2001	10	31387	522648	404877	1116	143	963	1122	418	317	2168795	7609
R17	BSR below Watertown	2002	4	274058	2829460	2728658	7522	965	6487	7563	2815	2137	19913920	69279
R17	BSR below Watertown	2002	5	209766	2831347	2705919	7460	957	6433	7500	2792	2120	2168795	58171
R17	BSR below Watertown	2002	6	80694	1209242	1040932	2870	368	2475	2885	1074	815	2098834	20922
R17	BSR below Watertown	2002	7	33482	546947	431911	1191	153	1027	1197	446	338	2168795	8231
R17	BSR below Watertown	2002	8	101954	1278802	970408	2801	563	2855	3501	1109	797	14045500	21657
R17	BSR below Watertown	2002	9	35010	574360	451618	1245	160	1074	1252	466	354	2098834	8568
R17	BSR below Watertown	2002	10	31485	514025	406141	1120	144	966	1126	419	318	1958912	7736
R18	BSR nr Castlewood	2001	4	4662016	27269910	23970520	112613	46989	158081	206450	58208	41181	2955741000	618544
R18	BSR nr Castlewood	2001	5	1934341	19806260	27307090	34926	19553	65655	85779	24172	17102	3272015000	255046
R18	BSR nr Castlewood	2001	6	1006704	14588350	25607650	15158	10058	34033	44391	12537	8868	3166467000	136091
R18	BSR nr Castlewood	2001	7	396523	4326280	1931570	11157	1773	10882	12808	4133	2891	848669900	115855
R18	BSR nr Castlewood	2001	8	139990	1780419	1931570	4844	626	3842	4522	1459	1021	5766919	40902
R18	BSR nr Castlewood	2001	9	60045	882515	1869262	2520	268	1648	1940	626	438	5580890	17544
R18	BSR nr Castlewood	2001	10	60502	894565	1931570	2559	271	1660	1954	631	441	5766919	17677
R18	BSR nr Castlewood	2002	4	237205	2741878	1620027	7210	1060	6510	7662	2472	1729	427032000	69306
R18	BSR nr Castlewood	2002	5	284326	3274948	1931570	8603	1271	7803	9184	2963	2073	5766919	83074
R18	BSR nr Castlewood	2002	6	124435	1614213	1744644	4415	556	3415	4019	1297	907	5208831	36357
R18	BSR nr Castlewood	2002	7	62710	885706	1931570	2504	280	1721	2026	654	457	5766919	18322
R18	BSR nr Castlewood	2002	8	177045	2114350	3568700	4295	1417	5579	7055	2075	1463	321855400	33948
R18	BSR nr Castlewood	2002	9	57071	847723	1869262	2429	255	1566	1844	595	416	5580890	16675
R18	BSR nr Castlewood	2002	10	58672	860740	1806953	2456	262	1610	1895	612	428	5580890	17143
R19	BSR nr Estelline	200105	4	6021282	48024170	34322700	157499	53450	189000	242324	51728	33719	272095300	811651
R19	BSR nr Estelline	200105	5	2493522	19848350	14150480	65520	15770	78426	100596	21483	14017	301158400	352490
R19	BSR nr Estelline	200106	6	1307802	10492820	7554568	33739	6573	40801	52245	11138	7239	291443600	190767
R19	BSR nr Estelline	200107	7	702131	7156755	6502763	6600	3158	15805	18550	3601	1811	78652320	104293
R19	BSR nr Estelline	200108	8	247882	2526642	2295755	2330	714	5580	6549	1271	639	1258874	39445
R19	BSR nr Estelline	200109	9	106322	1083731	984699	999	189	2393	2809	545	274	1218265	18077
R19	BSR nr Estelline	200110	10	106930	1089924	990326	1005	186	2407	2825	548	276	1258874	18234
R19	BSR nr Estelline	200204	4	578299	5685838	5020662	7013	2381	13853	16580	3292	1776	39914980	87064
R19	BSR nr Estelline	200205	5	503460	5131725	4662784	4732	1910	11333	13301	2582	1298	1258874	76646
R19	BSR nr Estelline	200206	6	238364	2429622	2207601	2241	624	5366	6298	1222	615	1218265	38276
R19	BSR nr Estelline	200207	7	111041	1131828	1028401	1044	248	2500	2934	569	286	1258874	18505
R19	BSR nr Estelline	200208	8	260081	2331746	1895976	4857	1177	7133	8862	1832	1106	30281420	39312
R19	BSR nr Estelline	200209	9	101057	1030061	935933	950	173	2275	2670	518	261	1218265	17267
R19	BSR nr Estelline	200210	10	103892	1058960	962191	977	187	2339	2745	533	268	1218265	17649
R20	BSR nr Bruce	2001	4	6433844	48509020	42743300	161591	50400	218343	265149	52507	37660	201382000	672606
R20	BSR nr Bruce	2001	5	5359040	65381720	57610530	134597	41981	181868	220855	43736	31369	221520700	906556
R20	BSR nr Bruce	2001	6	3903730	63272630	55752130	98045	30580	132480	160879	31859	22850	214374900	877312
R20	BSR nr Bruce	2001	7	2518294	65381720	57610530	63249	19727	85463	103783	20552	14741	221520700	906556

Site	Stream	Year	Month	SuspSol	TotSol	DisSol	NO2NO3	NH3N	Orgntr	TKN	Tot PO4	TotDis PO4	Fecal	DO
R20	BSR nr Bruce	2001	8	2957345	30579680	26793930	28585	9218	55066	57749	12060	6742	189038400	425891
R20	BSR nr Bruce	2001	9	2181415	11069570	9527239	10403	3539	30029	27605	6072	2502	19481420	156314
R20	BSR nr Bruce	2001	10	1408263	11438560	9844814	6716	2285	19386	17821	3920	1615	20130800	161525
R20	BSR nr Bruce	2002	4	2123571	14549780	12608900	13354	4430	32431	31402	6764	3182	38970760	204381
R20	BSR nr Bruce	2002	5	1785750	11438560	9844814	8516	2897	24582	22598	4971	2048	20130800	161525
R20	BSR nr Bruce	2002	6	777697	11069570	9527239	3709	1262	10706	9841	2165	892	19481420	156314
R20	BSR nr Bruce	2002	7	307614	11438560	9844814	1467	499	4235	3893	856	353	20130800	161525
R20	BSR nr Bruce	2002	8	518370	11438560	9844814	2472	841	7136	6560	1443	595	26627250	161525
R20	BSR nr Bruce	2002	9	215585	11069570	9527239	1028	350	2968	2728	600	247	19481420	156314
R20	BSR nr Bruce	2002	10	245977	11069570	9527239	1173	399	3386	3113	685	282	20130800	156314
T35	Willow Creek (nr Waverly)	2001	5	265	19460	19004	3	5	58	63	7	5	6579	305
T35	Willow Creek (nr Waverly)	2001	6	2650	208445	203562	36	58	618	676	78	51	65800	3045
T35	Willow Creek (nr Waverly)	2001	7	2738	128048	125048	22	36	380	415	48	32	68000	3147
T35	Willow Creek (nr Waverly)	2001	8	1638	45524	43267	11	24	170	194	30	17	4630000	986
T35	Willow Creek (nr Waverly)	2001	9	1275	15821	14811	5	11	66	76	13	7	5768300	344
T35	Willow Creek (nr Waverly)	2001	10	1275	13485	12625	4	9	56	65	11	6	5768300	344
T35	Willow Creek (nr Waverly)	2002	4	2032	63951	62453	11	18	190	208	24	16	50400	2335
T35	Willow Creek (nr Waverly)	2002	5	2738	98407	96102	17	28	292	319	37	24	68000	3147
T35	Willow Creek (nr Waverly)	2002	6	1871	62996	60333	14	29	222	251	36	22	3297200	1515
T35	Willow Creek (nr Waverly)	2002	7	1317	29023	27171	8	19	120	140	23	13	5960600	356
T35	Willow Creek (nr Waverly)	2002	8	1363	24618	23143	7	16	99	115	19	11	5770500	446
T35	Willow Creek (nr Waverly)	2002	9	1275	18748	17552	5	13	78	90	15	9	5768300	344
T35	Willow Creek (nr Waverly)	2002	10	1275	15013	14056	4	10	62	72	12	7	5768300	344
T36	Willow Creek (nr Watertown)	2001	4	1297519	8783466	7749044	28903	14807	40312	50288	16870	9372	410428700	140100
T36	Willow Creek (nr Watertown)	2001	5	308990	2279271	2020090	6872	1566	9855	12245	4013	2235	366504500	40990
T36	Willow Creek (nr Watertown)	2001	6	94610	1084924	979063	2082	387	3543	4304	1221	691	176102700	22481
T36	Willow Creek (nr Watertown)	2001	7	2852	196173	181789	54	46	329	364	33	24	370100	3740
T36	Willow Creek (nr Watertown)	2001	8	810	55699	51615	15	17	93	103	10	7	370100	900
T36	Willow Creek (nr Watertown)	2001	9	246	16907	15667	5	7	28	31	3	2	358200	227
T36	Willow Creek (nr Watertown)	2001	10	279	19204	17796	5	8	32	36	3	2	370100	256
T36	Willow Creek (nr Watertown)	2002	4	76002	1121507	1019350	1659	452	3186	3816	975	559	73585000	23790
T36	Willow Creek (nr Watertown)	2002	5	10321	709934	657877	194	124	1190	1318	121	85	370100	16709
T36	Willow Creek (nr Watertown)	2002	6	1032	70965	65761	19	20	119	132	12	9	358200	1200
T36	Willow Creek (nr Watertown)	2002	7	251	17235	15971	5	7	29	32	3	2	370100	239
T36	Willow Creek (nr Watertown)	2002	8	44692	355592	316329	993	318	1461	1808	580	324	29660900	6172
T36	Willow Creek (nr Watertown)	2002	9	136	9345	8660	3	4	16	17	2	1	358190	114
T36	Willow Creek (nr Watertown)	2002	10	213	14652	13578	4	6	25	27	3	2	358190	189
T37	Stray Horse Creek	2001	6	255458	2150742	1962681	5059	1617	7601	9303	2214	1422	141423300	24172
T37	Stray Horse Creek	2001	7	91502	919549	845317	2166	591	2948	3566	808	487	47525120	9837
T37	Stray Horse Creek	2001	8	2776	76499	73286	186	22	166	188	30	7	380081	698
T37	Stray Horse Creek	2001	9	587	14737	14061	39	5	35	40	6	2	80311	148
T37	Stray Horse Creek	2001	10	2940	81183	77780	197	23	176	199	31	8	402552	740
T37	Stray Horse Creek	2002	4	5869	127228	125120	287	43	284	327	58	22	1733065	1126
T37	Stray Horse Creek	2002	5	10011	200787	198851	448	72	457	530	98	40	3333554	1779
T37	Stray Horse Creek	2002	6	846	21856	20879	57	7	51	57	9	2	115868	213
T37	Stray Horse Creek	2002	7	8246	104907	107099	220	54	282	338	74	42	4059809	970
T37	Stray Horse Creek	2002	8	146476	1225249	1087447	2984	930	4412	5389	1273	810	80351470	14138
T37	Stray Horse Creek	2002	9	2185	58764	56235	146	17	130	148	23	6	299112	550
T37	Stray Horse Creek	2002	10	5152	146667	140703	344	41	307	348	55	13	705357	1296
T40	Hidewood Creek (nr Clear Lake)	2001	6	14167	1916072	1881338	499	489	5145	5634	993	416	26450300	14686
T40	Hidewood Creek (nr Clear Lake)	2001	7	19094	1622952	1593531	423	415	4358	4772	841	352	22404000	19794
T40	Hidewood Creek (nr Clear Lake)	2001	8	6738	719536	538586	493	180	988	1168	184	106	7037600	5686

Site	Stream	Year	Month	SuspSol	TotSol	DisSol	NO2NO3	NH3N	Orgntr	TKN	Tot PO4	TotDis PO4	Fecal	DO
T40	Hidewood Creek (nr Clear Lake)	2001	9	3034	289606	196214	236	72	282	354	51	36	2478000	1521
T40	Hidewood Creek (nr Clear Lake)	2001	10	3034	115815	78467	94	29	113	142	20	15	991000	1521
T40	Hidewood Creek (nr Clear Lake)	2002	4	14167	559382	549241	146	143	1502	1645	290	121	7722000	14686
T40	Hidewood Creek (nr Clear Lake)	2002	5	17035	693014	626404	279	176	1557	1733	299	134	8634800	17442
T40	Hidewood Creek (nr Clear Lake)	2002	6	3034	316846	214669	258	79	309	387	56	40	2711100	1521
T40	Hidewood Creek (nr Clear Lake)	2002	7	3135	2415	1636	2	1	2	3	0	0	20700	1572
T40	Hidewood Creek (nr Clear Lake)	2002	8	3135	32709	22161	27	8	32	40	6	4	279900	1572
T40	Hidewood Creek (nr Clear Lake)	2002	9	3034	0	0	0	0	0	0	0	0	0	1521
T40	Hidewood Creek (nr Clear Lake)	2002	10	3034	12477	8454	10	3	12	15	2	2	106800	1521
T41	Hidewood Creek (nr Estelline)	2001	5	3472	86480	88660	141	21	157	178	20	12	134333	2050
T41	Hidewood Creek (nr Estelline)	2001	6	59068	1662036	1688610	3325	269	3137	3335	288	216	3555172	44973
T41	Hidewood Creek (nr Estelline)	2001	7	31552	833932	839268	1451	172	1514	1673	175	106	1457173	20507
T41	Hidewood Creek (nr Estelline)	2001	8	17386	454432	443970	704	103	786	890	102	59	672676	10263
T41	Hidewood Creek (nr Estelline)	2001	9	36761	1059453	1027616	1949	178	1892	2035	187	63	2048547	26694
T41	Hidewood Creek (nr Estelline)	2001	10	52158	1538720	1507709	3022	230	2813	2974	249	78	3256550	40645
T41	Hidewood Creek (nr Estelline)	2002	4	29636	899045	856666	1717	130	1598	1690	141	30	1850341	23094
T41	Hidewood Creek (nr Estelline)	2002	5	36075	1105670	1042810	2090	159	1946	2057	172	32	2252401	28112
T41	Hidewood Creek (nr Estelline)	2002	6	10324	291904	270983	456	58	486	541	58	29	451274	6507
T41	Hidewood Creek (nr Estelline)	2002	7	558	17504	14254	23	3	25	29	3	2	21597	330
T42	Peg Munky Run	2001	5	40	5148	5106	0	0	6	6	1	1	64400	141
T42	Peg Munky Run	2001	6	24428	481582	458427	428	155	1447	1603	408	325	7413900	10656
T42	Peg Munky Run	2001	7	2374	82948	80662	39	16	169	185	40	32	1154200	2057
T42	Peg Munky Run	2001	8	61	7866	7802	1	1	9	9	1	1	98400	215
T42	Peg Munky Run	2001	9	0	0	0	0	0	0	0	0	0	0	0
T42	Peg Munky Run	2001	10	17	2194	2176	0	0	3	3	0	0	27500	60
T42	Peg Munky Run	2002	4	1788	138871	137074	23	14	188	201	30	24	1785900	3709
T42	Peg Munky Run	2002	5	2280	129231	126986	33	16	202	218	38	31	1703200	3377
T42	Peg Munky Run	2002	6	209	27150	26929	2	2	31	32	4	3	339700	742
T42	Peg Munky Run	2002	7	0	0	0	0	0	0	0	0	0	0	0

Site	Stream	Year	Month	SuspSol	TotSol	DisSol	NO2NO3	NH3N	Orgntr	TKN	Tot PO4	TotDis PO4	Fecal	DO
T47	Unnamed Creek (nr Volga)	2001	5	271	5011	4740	9	9	28	36	10	7	246100	278
T47	Unnamed Creek (nr Volga)	2001	6	6862	104972	98110	232	228	692	919	232	173	2926400	3900
T47	Unnamed Creek (nr Volga)	2001	7	15749	196216	180467	517	534	1578	2112	514	375	2930900	4179
T47	Unnamed Creek (nr Volga)	2001	8	2803	53877	51074	98	90	285	375	100	76	1534300	1972
T47	Unnamed Creek (nr Volga)	2001	9	225	23767	23543	14	3	27	29	17	16	133300	318
T47	Unnamed Creek (nr Volga)	2001	10	1004	38245	37240	41	28	106	134	44	37	598900	973
T47	Unnamed Creek (nr Volga)	2002	4	4798	94500	89702	169	154	488	642	172	132	2443100	3617
T47	Unnamed Creek (nr Volga)	2002	5	24923	318819	293896	821	843	2499	3342	817	598	3861900	6486
T47	Unnamed Creek (nr Volga)	2002	6	734	44089	43354	35	16	81	97	39	35	366100	944
T47	Unnamed Creek (nr Volga)	2002	7	185	19623	19437	12	2	22	24	14	13	137800	235
T47	Unnamed Creek (nr Volga)	2002	8	248	26278	26029	16	3	30	32	18	18	137800	380
T47	Unnamed Creek (nr Volga)	2002	9	166	17583	17417	11	2	20	22	12	12	133300	201
T47	Unnamed Creek (nr Volga)	2002	10	462	27748	27286	22	10	51	61	25	22	366100	600

** flux runs done for T34 but not displayed here due to data reliabilty (T34 in and out flows)

Appendix T.
Methodology of the AGNPS Feedlot Model

T-1

Feedlot Inventory for the North-Central Big Sioux River Watershed Assessment Project

1. Methodology

1.1. Introduction

Objectives outlined in the project summary were to document sources of non-point source pollution in the North-Central Big Sioux River Watershed to drive a watershed implementation project directed towards improving water quality. Preliminary water quality sampling suggested that impairments to the watershed were in the form of fecal coliform bacteria. Based on this information, the Brookings County Conservation District drove all township, county, state and interstate roads within the watershed boundaries to locate Animal Feeding Operations (AFO's) and other potential sources of impairments. Since the landuse was largely agricultural, efforts were focused towards un-regulated (AFO's) which could be a potential source of organic material and fecal coliform bacteria loading during runoff events.

During large rainfall events, (> 2 inches/24 hours), which is a common occurrence for the area, organic material and fecal coliform bacteria found in the water samples was thought to be the result of all three: confined operations, pastured livestock along stream corridors and manure application. During dry periods, loading from confined operations would be minimal as compared to the potential input from pastured livestock with access to streams and poorly placed manure applications. With this in mind, a key to distinguish between the loading potential of livestock confinement operations vs. pastured livestock and land based manure applications lay in the water quality samples with their respective rainfall data.

1.2. Watershed Delineation

The watershed map was formulated with a starting point of the watershed located North West of Watertown at the outlet of Lake Kampeska and an endpoint where the Big Sioux River intersected highway 14 between Brookings and Volga at the start of the Central Big Sioux River Watershed. Watershed boundaries were delineated using 1:42,000 topographic maps and ground truthing. East Dakota Water Development District further broke the watershed down into major watersheds for later analysis. Boundary lines were transferred to Arc-View, a computer based software program, to enable future compilation and manipulation of database information spatially (Figure 1). Other layers for the Arc-View database included: Digital Ortho-Quadrangles (DOQ's), Streams, Roads, Soils, Township Boundaries and Section lines. The watershed encompassed approximately 473,985 acres of predominantly agricultural land in Eastern South Dakota (See Figure 2).

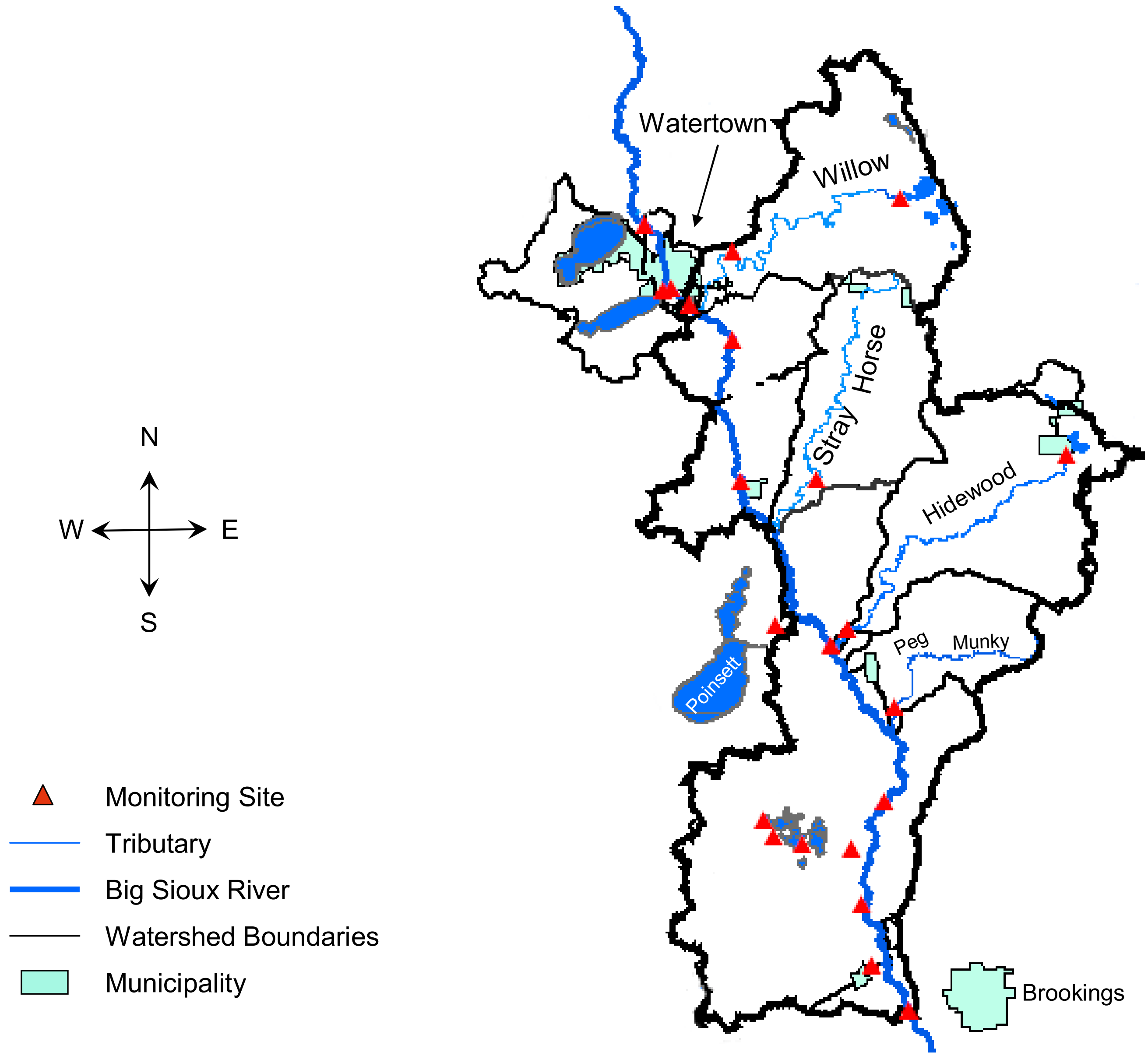


Figure 1. North-Central Big Sioux River Watershed Separated into Sub-watersheds

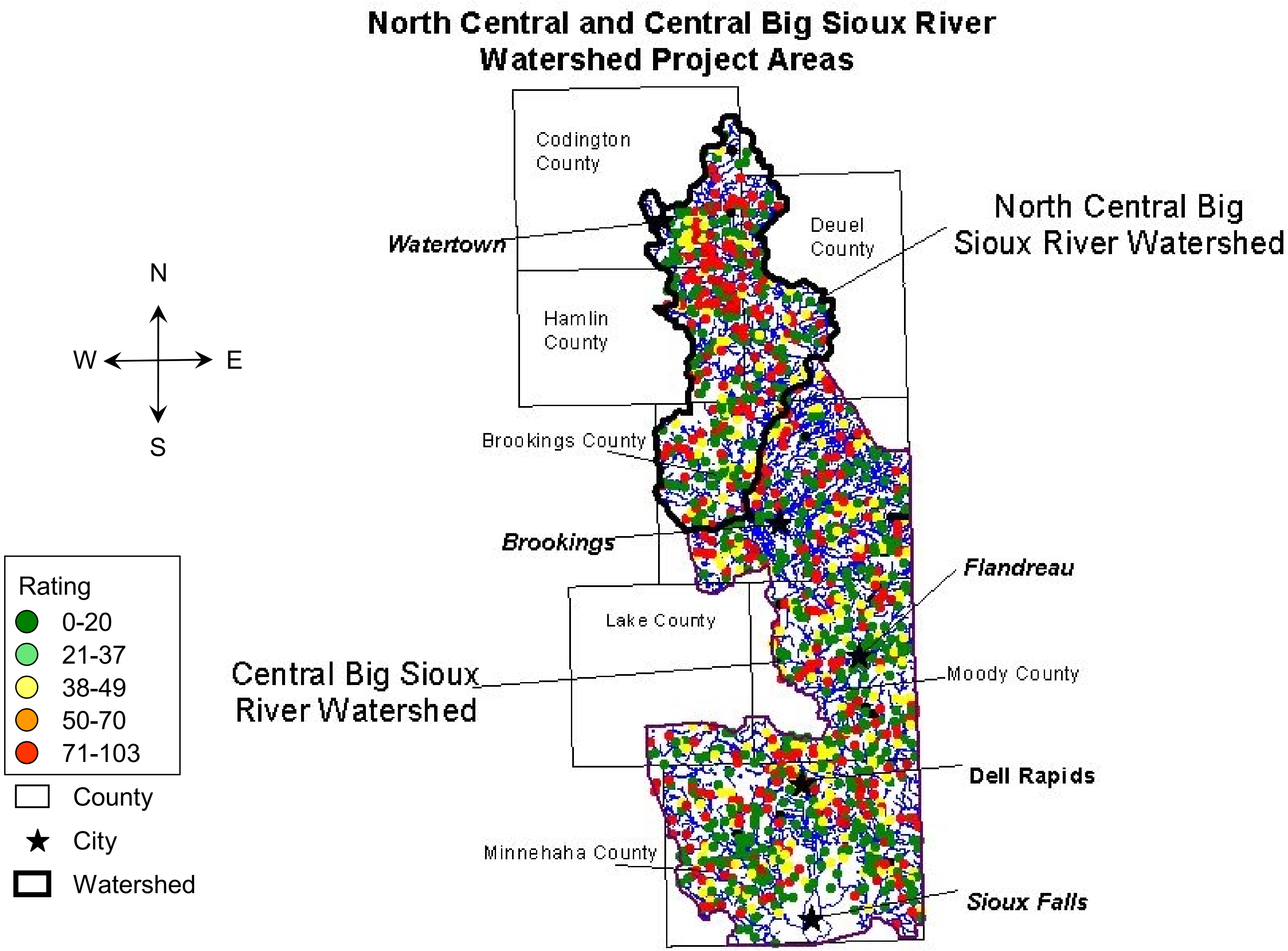


Figure 2. North-Central Big Sioux River Watershed Location Map

1.3. Feedlot Model

All livestock operations within watershed boundaries were highlighted on copies of the latest plat book directories for future contacts. Arc-View was then used to produce an enlarged image (usually on a 1:1,400 scale) of all highlighted operations from 2003 DOQ's that were donated to the project from the Natural Resource Conservation Service (NRCS). These enlarged photos would later serve as templates and data sheets for collection of the operations' information (Figure 3). Each producer was given a chance to volunteer information about their operation through direct visits, phone calls or letters left in their doors. If a producer was willing to volunteer information for the assessment, they were shown the DOQ printout and asked for data to satisfy inputs for Agricultural Non-Point Source (AGNPS) pollution model's feedlot module. Information collected from each producer is shown in (Table 1).

Figure 3. Digital Ortho-Quadrangles used for Operator Surveys

Feeding operations with potential for runoff were assessed using the AGNPS feedlot module. Operations confining <40 animal units (AU's) and exhibiting no potential for runoff were excluded from the model and simply marked on Arc-View as a green dot. There were a few operations confining <40 AU's that were included in the investigation only because they were located within a short distance from a major tributary or the Big Sioux River itself and exhibited a potential to have runoff occur. Any feeding operation with >40 AU's was modeled using AGNPS. Extra effort was made to contact and interview every producer with a livestock operation personally in the watershed in order to collect good quality information. Gaining trust with producers and access to their operations made this possible. 371 operations were evaluated in the watershed for potential to contribute runoff to surface waters. Of the 371 operations, 297 animal feeding operations were assessed using AGNPS Feedlot Module. The remaining 74 operations did not rate high enough during a preliminary investigation to warrant an assessment. During our investigation, several of the operations visited fit the criteria for a Concentrated Animal Feeding Operation (CAFO). Large CAFO's that were permitted or had a waste system in place were inventoried, and labeled in the database, but were not subjected to the feedlot model itself. Most of the CAFO's had some type of waste storage system in place, and some had obtained coverage under the general permit. A portion of the operations believed to be CAFO's though did not have any waste storage or coverage under the general permit. A few of the operations assessed fit the definition of either small or medium CAFO's according to the South Dakota Department of Environment and Natural Resources Web site describing conditions.

Table 1. Information Collected From Each Producer

ID	Area	Acres	Animal	Number	Animal2	Number2	Code	Waste System	Months	Buffer	Buffer
1	10544.9	2.6	BEEF CATTLE	40		0	T1NDCK	NONE	0	0	
3	13461.9	3.3	BEEF CATTLE	180		0	T1NDCK	NONE	0	0	
4	8563.8	2.1	BEEF CATTLE	150		0	T1NDCK	NONE	0	0	
6	10335.7	2.6	BEEF CATTLE	100	DAIRY	50	T1NDCK	NONE	0	300	
7	3923.6	1.0	SOWS	120		0	T1NDCK	NONE	0	0	
9	8941.7	2.2	BEEF CATTLE	100		0	T1NDCK	NONE	0	0	
12	11324.7	2.8	BEEF CATTLE	80		0	T1NDCK	NONE	0	0	
16	24571.4	6.1	BEEF CATTLE	150		0	T1NDCK	NONE	0	0	
20	28591.4	7.1	BEEF CATTLE	200		0	T4SXMCK	NONE	12	50	PASTURE
21	22427.3	5.5	BEEF CATTLE	400		0	T3SXMCK	NONE	0	0	
21	18234.2	4.5	BEEF CATTLE	250		0	T3SXMCK	NONE	0	0	
22	16959.6	4.2	BEEF CATTLE	300		0	T3SXMCK	NONE	0	0	
26	12447.3	3.1	BUFFALO	50		0	T3SXMCK	NONE	0	450	
1000	10850.9	2.7	DAIRY CATTLE	120		0	T1NDCK	NONE	0	0	

1.4. Arc-View Model

Geographic Information Systems (GIS) ARC-View was then used to create a watershed distribution map of all operations with their respective information. Four shape files were created to handle the data from the assessments for each of the operations. The first shape file created was the Operator theme (Table 2). It contained location information as well as summary information that were added back to the theme table after the AGNPS feedlot module was run for all of the operations. The second shape file created was the Feedlot theme. It was used to capture the size and number of head each lot contained for each operation. The third shape file was the roof theme. It allowed us to measure the area of roof involved in adding water to the feedlot that AGNPS required as an input. The last shape file was the Watershed theme. This theme was used to digitize the area and landuse type that comprised the 2a and 3a areas that were also inputs needed in the AGNPS module (Figure 4).

Table 2. Table Used to Create the Operator Theme in ArcView

ID	Distance	LMU	Code	PO4 (ppm)	COD (ppm)	PO4 (lbs)	COD (lbs)	SURFACER	GROUNDR	CAFO
1	16295.4	1	T1NDCK	13.0	689.7	37.5	1987.5	39	1	NO
2	15896.2	1	T1NDCK	18.4	974.0	153.3	8113.1	60	1	NO
3	15656.0	1	T1NDCK	46.0	2432.4	187.2	9909.4	61	1	NO
4	14799.1	1	T1NDCK	60.1	3184.0	140.5	7436.1	56	1	NO
5	11833.9	1	T1NDCK	85.0	4500.0	135.8	7189.3	54	1	NO
6	9110.4	1	T1NDCK	19.2	1214.6	57.0	3609.4	47	1	NO
7	8315.9	1	T1NDCK	28.4	946.4	31.8	1061.2	29	2	NO
8	10646.6	3	T3SXMCK	11.4	590.0	123.9	6436.9	58	1	NO
9	4404.9	1	T1NDCK	57.7	3054.3	131.5	6959.7	55	1	NO
10	21366.8	2	T2NDCK	8.9	1412.8	11.2	1786.0	36	3	NO
11	21896.0	2	T2NDCK	85.0	4500.0	248.7	13163.7	264	2	NO
12	20032.4	2	T2NDCK	36.4	1928.6	132.2	7000.0	56	2	NO
13	19321.8	2	T2NDCK	2.7	430.4	15.3	2429.0	43	2	NO
14	18128.7	2	T2NDCK	54.8	2900.7	209.4	11077.1	62	2	NO
15	18175.1	2	T2NDCK	51.2	2692.8	194.1	10210.1	61	2	NO
16	22194.9	2	T2NDCK	9.9	463.9	55.1	2571.3	44	1	NO

ArcView Image of Digitized Feedlots

Figure 4. ArcView Image of Digitized Feedlots

Figure 5 shows a simple drawing that illustrates the basic interactions that needed to be taken in consideration when gathering information for the AGNPS feedlot module (USDA AGNPS Feedlot Manual). After digitizing each operation for the operator location; feedlot locations and size; roof area; watershed landuse and size; all required inputs were satisfied for the AGNPS feedlot module.

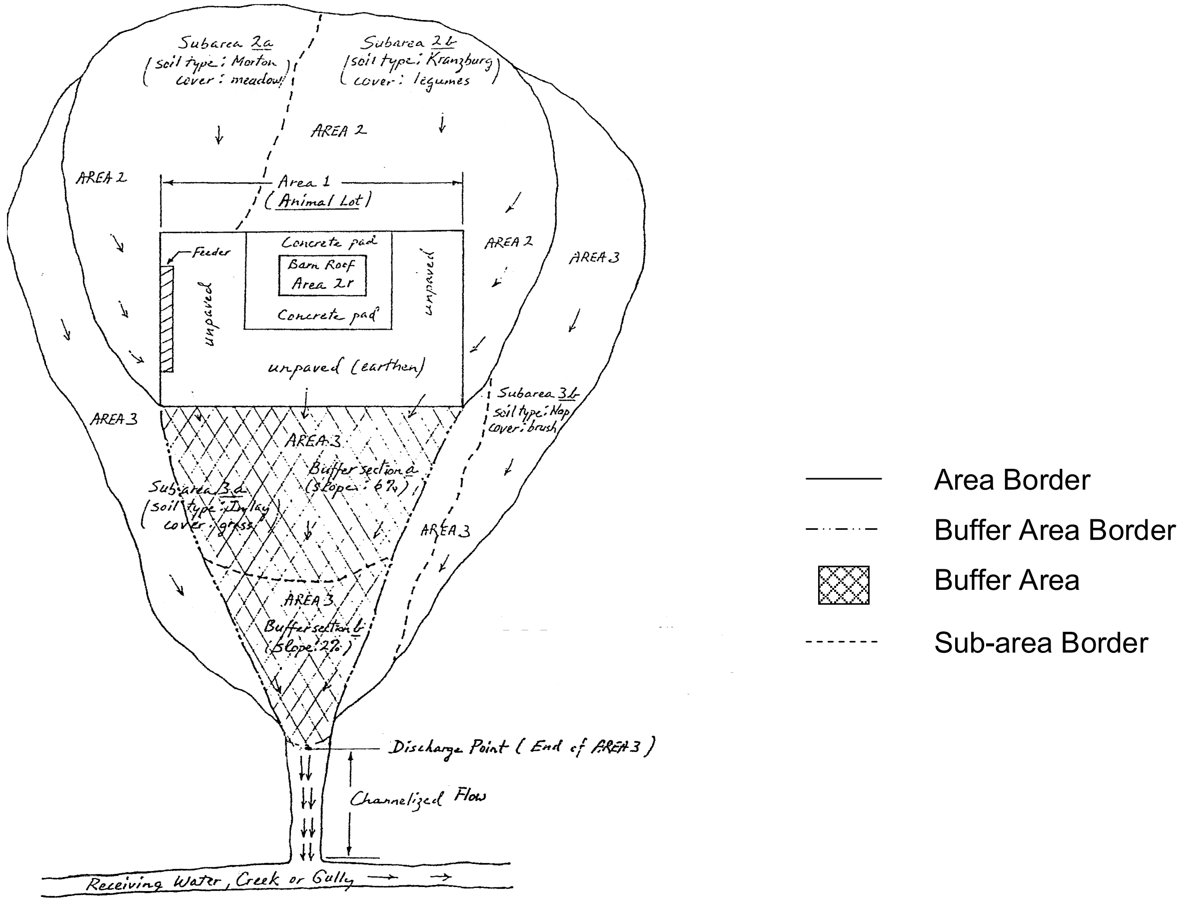


Figure 5. Example of an Animal Lot with Surrounding Watershed

1.5. Combining Arc-View and the AGNPS Feedlot Module

Data was then entered separately for each operation from the Arc-View themes into the AGNPS feedlot module. The module was run to simulate a 25 year 24 hour rainstorm event that was currently a requirement of the general permit for construction of waste storage facilities. Some of the inputs were indexes, so they were standardized to simplify data entry with the thinking that differences in the output would be caused by interactions taking place for each operation's unique situation. After all of the operations were run through AGNPS, the output data was entered back into the operator theme to allow a means of differentiating between feeding operations with a high potential to have runoff from those with little or no potential. AGNPS surface ratings for runoff potential ranged from 0 – 103 for the facilities assessed. AGNPS Phosphorus loading potentials ranged from 0.0 lbs. – 1,513 lbs. for any single animal feeding operation. By using Arc-View, a watershed map could easily be made with feedlots geo-referenced and categorized by a graduated color scheme representing various potential to have runoff occurring. Operations exhibiting low potential were color coded green while intermediate potential sites were given a light green or yellow color. Medium high to high potential operations were color coded orange and red (Figure 2). By coding each operation with a unique value representative of the monitoring site that it eventually flowed to allowed us to count the number of feedlots in a particular sub-watershed and compare it to water quality data from that point. Depending on runoff potentials of the feedlots affecting any monitoring site, we were able to make a prediction of which sites should exhibit good or poor water quality downstream.

The joining of the AGNPS feedlot module and GIS feedlot databases created a comprehensive watershed model that could simulate various scenarios in order to better predict interactions taking place in the watershed.

Managers could use the model as a tool to test “what if” circumstances and make changes to get more desirable outcomes. While working with producers during the implementation phase, simulations could be run to see what effects one might achieve by planning for certain practices (e.g. filters, sediment basins or complete waste management systems). Implementation of best management practices in high pollution potential areas could be the key to improving water quality in the North Central Big Sioux River Watershed.

Appendix U.
Min, Max, Median, Percent Violation by Parameter for BSR and Tributaries

Fecal Coliform Bacteria cfu/100mL (May-Sept)

Site	Stream	# of Samples	Mean	Min	Max	Median	Violations of WQS	Percent Violating	Use Support
T34	Lake Pelican Weir	8	1163	nd	8000	235	----**	----	----
T35	Willow Creek (nr Waverly)	9	107311	110	930000	1000	3	33	Not
T36	Willow Creek (nr Watertown)	10	13819	230	110000	1500	4	40	Not
T37	Stray Horse Creek	10	33888	40	320000	1800	4	40	Not
T39	Lake Poinsett Outlet	11	2881	nd	27000	190	----**	----	----
T40	Hidewood Creek (nr Clear Lake)	9	7286	10	42000	670	2	22	Full
T41	Hidewood Creek (nr Estelline)	7	1376	100	3300	700	3	43	Not
T42	Peg Munky Run	4	4730	420	10000	4250	3	75	Not
T46	East Oakwood Lake Outlet 2	11	3476	20	13000	2200	----**	----	----
T47	Unnamed Creek (nr Volga)	10	4785	180	25000	830	----**	----	----
R1	BSR nr Brookings	37	419	nd	>2500	180	2	5	Full
R14	BSR at Watertown	34	2445	nd	31000	795	7	21	Not
R15	BSR at Broadway	21	1024	40	8000	370	2	10	Full
R16	BSR 20th Ave	21	1482	90	10000	520	3	14	Not
R17	BSR below Watertown	35	2144	10	33000	620	5	14	Not
R18	BSR nr Castlewood	21	22448	70	410000	1800	10	48	Not
R19	BSR nr Estelline	37	1265	nd	29000	300	3	8	Full
R20	BSR nr Bruce	22	1322	80	14000	425	4	18	Not

Fecal coliform data includes May 01 to Sept. 02 and May 04 to Sept. 04
NOTE: For beneficial use (8) standard is 2000 cfu/100mL
---- denotes no standard or beneficial use assigned
----** denotes violations if beneficial use (8) were applicable

Water Temperature C°

Site	Stream	# of Samples	Mean	Min	Max	Median	Violations of WQS	Percent Violating	Use Support
T34	Lake Pelican Weir	13	16.6	5.2	27.3	18.8	----	----	----
T35	Willow Creek (nr Waverly)	14	14.8	2.7	23.4	19.0	0	0	Full
T36	Willow Creek (nr Watertown)	17	13.3	1.1	24.2	12.4	0	0	Full
T37	Stray Horse Creek	14	15.8	5.3	24.8	19.1	0	0	Full
T39	Lake Poinsett Outlet	14	16.6	4.9	25.4	19.0	----	----	----
T40	Hidewood Creek (nr Clear Lake)	14	14.2	2.9	24.3	17.0	0	0	Full
T41	Hidewood Creek (nr Estelline)	10	15.3	6.4	24.4	15.7	0	0	Full
T42	Peg Munky Run	6	13.4	4.6	24.2	12.4	0	0	Full
T46	East Oakwood Lake Outlet 2	14	16.7	5.8	25.3	20.4	----	----	----
T47	Unnamed Creek (nr Volga)	14	14.9	2.3	25.2	17.2	----	----	----
R1	BSR nr Brookings	17	15.3	4.6	25.8	15.8	0	0	Full
R14	BSR at Watertown	17	13.7	3.9	24.5	11.5	0	0	Full
R15	BSR at Broadway	17	14.5	2.2	25.7	13.3	0	0	Full
R16	BSR 20th Ave	17	14.7	3.1	24.9	15.3	0	0	Full
R17	BSR below Watertown	17	14.5	3.4	26.4	12.6	0	0	Full
R18	BSR nr Castlewood	17	14.5	4.7	25.0	13.9	0	0	Full
R19	BSR nr Estelline	17	14.3	4.7	24.3	15.2	0	0	Full
R20	BSR nr Bruce	17	14.8	5.2	24.1	14.7	0	0	Full

NOTE: 32.2 C is standard for those sites with beneficial use (5) and (6)
---- denotes no standard or beneficial use assigned

Air Temperature C°

Site	Stream	# of Samples	Mean	Min	Max	Median	Violations of WQS	Percent Violating	Use Support
T34	Lake Pelican Weir	13	18.4	4.8	27.0	22.5	----	----	----
T35	Willow Creek (nr Waverly)	14	17.3	4.0	29.0	19.0	----	----	----
T36	Willow Creek (nr Watertown)	16	16.5	6.5	25.2	16.0	----	----	----
T37	Stray Horse Creek	14	18.9	3.5	32.5	21.0	----	----	----
T39	Lake Poinsett Outlet	14	17.4	2.0	29.0	18.5	----	----	----
T40	Hidewood Creek (nr Clear Lake)	14	16.4	4.0	25.0	18.5	----	----	----
T41	Hidewood Creek (nr Estelline)	9	17.7	9.7	27.0	16.0	----	----	----
T42	Peg Munky Run	5	18.5	9.4	29.0	19.7	----	----	----
T46	East Oakwood Lake Outlet 2	14	21.0	8.0	36.5	21.1	----	----	----
T47	Unnamed Creek (nr Volga)	14	21.4	9.0	35.0	21.0	----	----	----
R1	BSR nr Brookings	17	17.6	3.5	31.5	17.0	----	----	----
R14	BSR at Watertown	17	16.2	1.0	28.5	14.0	----	----	----
R15	BSR at Broadway	17	16.3	1.5	29.0	14.0	----	----	----
R16	BSR 20th Ave	17	16.3	0.5	30.0	15.5	----	----	----
R17	BSR below Watertown	17	16.8	-0.5	29.1	15.0	----	----	----
R18	BSR nr Castlewood	17	16.6	0.5	31.0	15.0	----	----	----
R19	BSR nr Estelline	17	16.0	2.0	30.5	16.0	----	----	----
R20	BSR nr Bruce	17	16.8	3.0	32.3	17.0	----	----	----

---- denotes no standard or beneficial use assigned

Conductivity µS/cm

Site	Stream	# of Samples	Mean	Min	Max	Median	Violations of WQS	Percent Violating	Use Support
T34	Lake Pelican Weir	13	552	274	775	571	----	----	----
T35	Willow Creek (nr Waverly)	14	430	206	582	464	----	----	----
T36	Willow Creek (nr Watertown)	17	569	118	849	645	----	----	----
T37	Stray Horse Creek	14	706	205	979	729	----	----	----
T39	Lake Poinsett Outlet	14	901	260	1302	898	----	----	----
T40	Hidewood Creek (nr Clear Lake)	14	1175	402	2132	1169	----	----	----
T41	Hidewood Creek (nr Estelline)	10	622	330	800	651	----	----	----
T42	Peg Munky Run	6	565	264	785	579	----	----	----
T46	East Oakwood Lake Outlet 2	14	1020	446	1388	1056	----	----	----
T47	Unnamed Creek (nr Volga)	14	759	379	1194	783	----	----	----
R1	BSR nr Brookings	17	684	209	1136	708	----	----	----
R14	BSR at Watertown	17	481	111	778	511	----	----	----
R15	BSR at Broadway	17	523	89	822	548	----	----	----
R16	BSR 20th Ave	17	627	97	1029	580	----	----	----
R17	BSR below Watertown	17	596	112	970	610	----	----	----
R18	BSR nr Castlewood	17	608	172	916	620	----	----	----
R19	BSR nr Estelline	17	622	149	981	638	----	----	----
R20	BSR nr Bruce	17	607	150	1129	597	----	----	----

---- denotes no standard or beneficial use assigned

NTU

Site	Stream	# of Samples	Mean	Min	Max	Median	Violations of WQS	Percent Violating	Use Support
T34	Lake Pelican Weir	13	15.9	3.9	45.0	15.9	----	----	----
T35	Willow Creek (nr Waverly)	14	19.6	2.3	100.0	8.9	----	----	----
T36	Willow Creek (nr Watertown)	17	29.5	1.6	280.0	9.0	----	----	----
T37	Stray Horse Creek	14	24.6	2.8	110.0	15.4	----	----	----
T39	Lake Poinsett Outlet	14	21.9	4.8	80.0	14.6	----	----	----
T40	Hidewood Creek (nr Clear Lake)	14	15.6	3.4	85.0	8.1	----	----	----
T41	Hidewood Creek (nr Estelline)	10	19.4	5.0	116.0	7.2	----	----	----
T42	Peg Munky Run	6	8.3	1.6	23.1	6.5	----	----	----
T46	East Oakwood Lake Outlet 2	14	25.2	3.1	65.1	24.7	----	----	----
T47	Unnamed Creek (nr Volga)	14	14.1	0.0	80.9	6.8	----	----	----
R1	BSR nr Brookings	17	35.0	4.3	67.1	37.0	----	----	----
R14	BSR at Watertown	17	21.9	5.4	65.0	16.7	----	----	----
R15	BSR at Broadway	17	15.2	1.8	40.0	13.4	----	----	----
R16	BSR 20th Ave	17	16.0	2.6	70.0	10.0	----	----	----
R17	BSR below Watertown	17	23.5	5.8	110.0	15.0	----	----	----
R18	BSR nr Castlewood	17	42.1	2.4	340.0	19.1	----	----	----
R19	BSR nr Estelline	17	46.8	3.7	220.0	23.7	----	----	----
R20	BSR nr Bruce	17	40.8	3.3	220.0	35.0	----	----	----

---- denotes no standard or beneficial use assigned

pH units

Site	Stream	# of Samples	Mean	Min	Max	Median	Violations of WQS	Percent Violating	Use Support
T34	Lake Pelican Weir	12	8.2	7.7	8.7	8.3	----	----	----
T35	Willow Creek (nr Waverly)	13	8.2	7.4	8.7	8.3	0	0	Full
T36	Willow Creek (nr Watertown)	15	8.1	7.7	8.4	8.1	0	0	Full
T37	Stray Horse Creek	13	8.2	7.7	8.5	8.3	0	0	Full
T39	Lake Poinsett Outlet	13	8.3	7.6	8.7	8.4	----	----	----
T40	Hidewood Creek (nr Clear Lake)	13	7.8	7.4	8.2	7.9	0	0	Full
T41	Hidewood Creek (nr Estelline)	10	8.2	7.8	8.5	8.2	0	0	Full
T42	Peg Munky Run	6	8.1	7.8	8.3	8.1	0	0	Full
T46	East Oakwood Lake Outlet 2	13	7.8	7.4	8.2	7.9	0	0	Full
T47	Unnamed Creek (nr Volga)	13	7.9	7.6	8.5	7.9	0	0	Full
R1	BSR nr Brookings	16	8.3	7.4	9.0	8.4	0	0	Full
R14	BSR at Watertown	16	8.2	7.8	8.6	8.2	0	0	Full
R15	BSR at Broadway	16	8.1	7.7	8.5	8.0	0	0	Full
R16	BSR 20th Ave	16	8.0	7.5	8.3	8.0	0	0	Full
R17	BSR below Watertown	15	8.2	7.4	8.6	8.3	0	0	Full
R18	BSR nr Castlewood	16	8.2	7.3	8.8	8.3	0	0	Full
R19	BSR nr Estelline	16	8.3	7.7	8.9	8.3	0	0	Full
R20	BSR nr Bruce	16	8.3	7.7	8.8	8.4	0	0	Full

Most restrictive standard is 6.5-9.0 for River sites with beneficial use 1, 5, and 9
Most restrictive standard is 6.0-9.0 for tributary sites with beneficial use 6 and 9
Standard of 6.0-9.5 for tributary sites with beneficial use of only 9
---- denotes no standard or beneficial use assigned

Salinity ppt

Site	Stream	# of Samples	Mean	Min	Max	Median	Violations of WQS	Percent Violating	Use Support
T34	Lake Pelican Weir	13	0.3	0.2	0.4	0.3	----	----	----
T35	Willow Creek (nr Waverly)	14	0.3	0.1	0.3	0.3	----	----	----
T36	Willow Creek (nr Watertown)	17	0.4	0.1	0.5	0.4	----	----	----
T37	Stray Horse Creek	14	0.4	0.1	0.6	0.5	----	----	----
T39	Lake Poinsett Outlet	14	0.5	0.1	0.7	0.6	----	----	----
T40	Hidewood Creek (nr Clear Lake)	14	0.7	0.2	1.6	0.6	----	----	----
T41	Hidewood Creek (nr Estelline)	10	0.4	0.2	0.5	0.4	----	----	----
T42	Peg Munky Run	6	0.4	0.2	0.4	0.4	----	----	----
T46	East Oakwood Lake Outlet 2	14	0.6	0.3	0.8	0.7	----	----	----
T47	Unnamed Creek (nr Volga)	14	0.5	0.3	0.6	0.5	----	----	----
R1	BSR nr Brookings	17	0.4	0.2	0.6	0.4	----	----	----
R14	BSR at Watertown	17	0.3	0.1	0.4	0.3	----	----	----
R15	BSR at Broadway	17	0.3	0.1	0.4	0.3	----	----	----
R16	BSR 20th Ave	17	0.4	0.1	0.6	0.4	----	----	----
R17	BSR below Watertown	17	0.4	0.1	0.5	0.4	----	----	----
R18	BSR nr Castlewood	17	0.4	0.1	0.5	0.4	----	----	----
R19	BSR nr Estelline	17	0.4	0.1	0.6	0.4	----	----	----
R20	BSR nr Bruce	17	0.4	0.1	0.6	0.4	----	----	----

---- denotes no standard or beneficial use assigned

Dissolved Oxygen mg/L

Site	Stream	# of Samples	Mean	Min	Max	Median	Violations of WQS	Percent Violating	Use Support
T34	Lake Pelican Weir	13	10.4	4.5	19.5	9.3	----**	----	----
T35	Willow Creek (nr Waverly)	14	9.5	3.2	17.6	9.7	4	29	Not
T36	Willow Creek (nr Watertown)	17	8.7	3.9	19.3	8.1	2	12	Full
T37	Stray Horse Creek	14	9.5	5.1	13.8	9.4	0	0	Full
T39	Lake Poinsett Outlet	14	8.4	2.5	16.5	7.6	----**	----	----
T40	Hidewood Creek (nr Clear Lake)	14	8.0	1.4	17.6	7.4	6	43	Not
T41	Hidewood Creek (nr Estelline)	10	12.6	6.2	17.4	14.2	0	0	Full
T42	Peg Munky Run	6	12.4	5.1	19.1	12.9	0	0	Full
T46	East Oakwood Lake Outlet 2	13	9.5	3.0	17.4	9.9	----**	----	----
T47	Unnamed Creek (nr Volga)	13	9.6	1.4	20.0	8.7	----**	----	----
R1	BSR nr Brookings	35	10.3	4.3	15.8	9.7	1	3	Full
R14	BSR at Watertown	36	9.4	4.6	16.4	8.8	1	3	Full
R15	BSR at Broadway	17	9.6	5.3	17.3	7.6	0	0	Full
R16	BSR 20th Ave	17	9.5	4.9	15.8	9.2	1	6	Full
R17	BSR below Watertown	36	10.2	3.6	19.3	10.1	1	3	Full
R18	BSR nr Castlewood	17	10.9	4.5	20.0	10.2	1	6	Full
R19	BSR nr Estelline	30	10.4	1.4	18.9	9.5	2	7	Full
R20	BSR nr Bruce	36	10.8	1.4	18.9	10.1	2	6	Full

Most restrictive standard for DO is ≥ 5.0 mg/L for beneficial uses 5, 7, and 8

----** denotes no standard or beneficial use assigned for DO, but there are violations if standard were applied

---- denotes no standard or beneficial use assigned

Ammonia mg/L

Site	Stream	# of Samples	Mean	Min	Max	Median	Violations of WQS	Percent Violating	Use Support
T34	Lake Pelican Weir	13	0.155	0.059	0.355	0.098	----	----	----
T35	Willow Creek (nr Waverly)	14	0.206	0.070	0.583	0.147	----	----	----
T36	Willow Creek (nr Watertown)	17	0.246	0.018	0.808	0.203	----	----	----
T37	Stray Horse Creek	14	0.203	0.041	0.538	0.140	----	----	----
T39	Lake Poinsett Outlet	14	0.269	0.124	1.102	0.180	----	----	----
T40	Hidewood Creek (nr Clear Lake)	14	1.072	0.054	7.850	0.401	----	----	----
T41	Hidewood Creek (nr Estelline)	10	0.108	0.027	0.328	0.070	----	----	----
T42	Peg Munky Run	6	0.090	0.034	0.182	0.059	----	----	----
T46	East Oakwood Lake Outlet 2	14	0.190	0.019	0.326	0.217	----	----	----
T47	Unnamed Creek (nr Volga)	14	0.354	nd	1.956	0.098	----	----	----
R1	BSR nr Brookings	17	0.169	0.0290	0.585	0.100	----	----	----
R14	BSR at Watertown	17	0.149	0.0360	0.339	0.119	----	----	----
R15	BSR at Broadway	17	0.222	0.0510	0.398	0.214	----	----	----
R16	BSR 20th Ave	17	0.211	0.034	0.440	0.208	----	----	----
R17	BSR below Watertown	17	0.245	0.046	0.550	0.203	----	----	----
R18	BSR nr Castlewood	17	0.264	0.049	0.798	0.178	----	----	----
R19	BSR nr Estelline	17	0.224	0.046	0.595	0.144	----	----	----
R20	BSR nr Bruce	17	0.199	0.022	0.600	0.113	----	----	----

---- denotes no standard or beneficial use assigned

Total Dissolved Phosphorous mg/L

Site	Stream	# of Samples	Mean	Min	Max	Median	Violations of WQS	Percent Violating	Use Support
T34	Lake Pelican Weir	13	0.065	0.020	0.137	0.036	----	----	----
T35	Willow Creek (nr Waverly)	14	0.183	0.033	1.341	0.095	----	----	----
T36	Willow Creek (nr Watertown)	17	0.201	0.019	0.773	0.128	----	----	----
T37	Stray Horse Creek	14	0.123	0.022	0.435	0.058	----	----	----
T39	Lake Poinsett Outlet	14	0.226	0.013	0.691	0.198	----	----	----
T40	Hidewood Creek (nr Clear Lake)	14	0.207	0.047	0.790	0.136	----	----	----
T41	Hidewood Creek (nr Estelline)	10	0.057	0.009	0.175	0.038	----	----	----
T42	Peg Munky Run	6	0.131	0.048	0.410	0.064	----	----	----
T46	East Oakwood Lake Outlet 2	14	0.132	0.022	0.413	0.095	----	----	----
T47	Unnamed Creek (nr Volga)	14	0.587	0.185	1.493	0.591	----	----	----
R1	BSR nr Brookings	17	0.162	0.033	0.411	0.130	----	----	----
R14	BSR at Watertown	17	0.104	0.021	0.349	0.080	----	----	----
R15	BSR at Broadway	17	0.107	0.039	0.282	0.091	----	----	----
R16	BSR 20th Ave	17	1.103	0.111	2.797	0.517	----	----	----
R17	BSR below Watertown	17	0.604	0.158	1.342	0.360	----	----	----
R18	BSR nr Castlewood	17	0.460	0.183	0.883	0.381	----	----	----
R19	BSR nr Estelline	17	0.210	0.056	0.405	0.208	----	----	----
R20	BSR nr Bruce	17	0.157	0.012	0.332	0.152	----	----	----

---- denotes no standard or beneficial use assigned

Total Phosphorous mg/L

Site	Stream	# of Samples	Mean	Min	Max	Median	Violations of WQS	Percent Violating	Use Support
T34	Lake Pelican Weir	13	0.131	0.038	0.242	0.122	----	----	----
T35	Willow Creek (nr Waverly)	14	0.360	0.079	1.679	0.158	----	----	----
T36	Willow Creek (nr Watertown)	17	0.306	0.045	1.247	0.202	----	----	----
T37	Stray Horse Creek	14	0.278	0.066	0.815	0.204	----	----	----
T39	Lake Poinsett Outlet	14	0.373	0.187	0.987	0.271	----	----	----
T40	Hidewood Creek (nr Clear Lake)	14	0.388	0.101	1.134	0.232	----	----	----
T41	Hidewood Creek (nr Estelline)	10	0.131	0.047	0.417	0.093	----	----	----
T42	Peg Munky Run	6	0.167	0.054	0.515	0.103	----	----	----
T46	East Oakwood Lake Outlet 2	14	0.261	0.066	0.596	0.227	----	----	----
T47	Unnamed Creek (nr Volga)	14	0.675	0.189	2.016	0.618	----	----	----
R1	BSR nr Brookings	17	0.359	0.141	0.578	0.390	----	----	----
R14	BSR at Watertown	17	0.201	0.047	0.430	0.185	----	----	----
R15	BSR at Broadway	17	0.189	0.069	0.376	0.181	----	----	----
R16	BSR 20th Ave	17	1.236	0.145	2.956	0.608	----	----	----
R17	BSR below Watertown	17	0.746	0.203	1.511	0.550	----	----	----
R18	BSR nr Castlewood	17	0.670	0.230	1.502	0.470	----	----	----
R19	BSR nr Estelline	17	0.399	0.143	0.924	0.385	----	----	----
R20	BSR nr Bruce	17	0.336	0.146	0.543	0.353	----	----	----

---- denotes no standard or beneficial use assigned

Organic Nitrogen mg/L

Site	Stream	# of Samples	Mean	Min	Max	Median	Violations of WQS	Percent Violating	Use Support
T34	Lake Pelican Weir	13	0.972	0.430	1.710	0.982	----	----	----
T35	Willow Creek (nr Waverly)	14	1.453	0.883	2.726	1.233	----	----	----
T36	Willow Creek (nr Watertown)	17	1.316	0.658	2.705	1.166	----	----	----
T37	Stray Horse Creek	14	1.708	0.883	2.728	1.714	----	----	----
T39	Lake Poinsett Outlet	14	1.653	1.173	3.014	1.552	----	----	----
T40	Hidewood Creek (nr Clear Lake)	14	1.720	0.740	3.612	1.194	----	----	----
T41	Hidewood Creek (nr Estelline)	10	1.065	0.582	1.914	0.991	----	----	----
T42	Peg Munky Run	6	0.824	0.404	1.617	0.662	----	----	----
T46	East Oakwood Lake Outlet 2	14	1.588	0.982	2.188	1.701	----	----	----
T47	Unnamed Creek (nr Volga)	14	1.455	0.478	7.037	0.781	----	----	----
R1	BSR nr Brookings	17	1.492	0.945	2.056	1.440	----	----	----
R14	BSR at Watertown	17	1.177	0.522	1.978	1.212	----	----	----
R15	BSR at Broadway	17	0.938	0.447	1.338	0.957	----	----	----
R16	BSR 20th Ave	17	1.463	0.828	2.502	1.358	----	----	----
R17	BSR below Watertown	17	1.412	0.903	2.295	1.358	----	----	----
R18	BSR nr Castlewood	17	1.620	1.127	3.310	1.352	----	----	----
R19	BSR nr Estelline	17	1.656	0.915	3.352	1.606	----	----	----
R20	BSR nr Bruce	17	1.544	0.932	2.902	1.515	----	----	----

---- denotes no standard or beneficial use assigned

Total Kjeldahl Nitrogen mg/L

Site	Stream	# of Samples	Mean	Min	Max	Median	Violations of WQS	Percent Violating	Use Support
T34	Lake Pelican Weir	13	1.128	0.506	1.787	1.149	----	----	----
T35	Willow Creek (nr Waverly)	14	1.660	1.033	3.092	1.382	----	----	----
T36	Willow Creek (nr Watertown)	17	1.563	0.780	3.275	1.291	----	----	----
T37	Stray Horse Creek	14	1.911	0.924	2.817	1.949	----	----	----
T39	Lake Poinsett Outlet	14	1.922	1.395	3.182	1.777	----	----	----
T40	Hidewood Creek (nr Clear Lake)	14	2.792	1.098	10.946	1.466	----	----	----
T41	Hidewood Creek (nr Estelline)	10	1.173	0.636	2.098	1.133	----	----	----
T42	Peg Munky Run	6	0.914	0.438	1.799	0.703	----	----	----
T46	East Oakwood Lake Outlet 2	14	1.777	1.001	2.405	1.942	----	----	----
T47	Unnamed Creek (nr Volga)	14	1.809	0.478	8.993	0.876	----	----	----
R1	BSR nr Brookings	17	1.661	1.011	2.259	1.677	----	----	----
R14	BSR at Watertown	17	1.325	0.558	2.317	1.377	----	----	----
R15	BSR at Broadway	17	1.160	0.539	1.639	1.107	----	----	----
R16	BSR 20th Ave	17	1.674	0.982	2.942	1.535	----	----	----
R17	BSR below Watertown	17	1.657	1.098	2.633	1.635	----	----	----
R18	BSR nr Castlewood	17	1.884	1.196	4.108	1.689	----	----	----
R19	BSR nr Estelline	17	1.880	0.961	3.410	1.691	----	----	----
R20	BSR nr Bruce	17	1.742	0.992	3.402	1.615	----	----	----

---- denotes no standard or beneficial use assigned

Nitrate-Nitrite as Nitrogen mg/L

Site	Stream	# of Samples	Mean	Min	Max	Median	Violations of WQS	Percent Violating	Use Support
T34	Lake Pelican Weir	13	0.253	0.038	0.791	0.232	0	0	Full
T35	Willow Creek (nr Waverly)	14	0.130	0.029	0.900	0.064	0	0	Full
T36	Willow Creek (nr Watertown)	17	0.452	0.038	2.022	0.335	0	0	Full
T37	Stray Horse Creek	14	0.626	0.039	3.423	0.443	0	0	Full
T39	Lake Poinsett Outlet	14	0.108	nd	0.520	0.062	0	0	Full
T40	Hidewood Creek (nr Clear Lake)	14	0.485	0.057	3.515	0.105	0	0	Full
T41	Hidewood Creek (nr Estelline)	10	0.847	0.090	2.302	0.779	0	0	Full
T42	Peg Munky Run	6	0.225	0.028	0.618	0.078	0	0	Full
T46	East Oakwood Lake Outlet 2	14	0.216	0.043	0.642	0.090	0	0	Full
T47	Unnamed Creek (nr Volga)	14	0.574	0.060	2.306	0.399	0	0	Full
R1	BSR nr Brookings	17	0.421	0.034	1.470	0.168	0	0	Full
R14	BSR at Watertown	17	0.249	0.063	0.914	0.144	0	0	Full
R15	BSR at Broadway	17	0.478	0.066	1.851	0.262	0	0	Full
R16	BSR 20th Ave	17	4.600	0.094	11.404	0.972	4	24	Full
R17	BSR below Watertown	17	2.452	0.316	6.478	1.214	0	0	Full
R18	BSR nr Castlewood	17	1.601	0.036	4.018	1.365	0	0	Full
R19	BSR nr Estelline	17	0.690	nd	1.705	0.526	0	0	Full
R20	BSR nr Bruce	17	0.610	0.028	1.612	0.440	0	0	Full

Most restrictive standard is ≤ 10 for River sites with beneficial use (1) and (9)
All tributary sites have a standard of ≤ 88 for beneficial use (9)

Total Dissolved Solids mg/L

Site	Stream	# of Samples	Mean	Min	Max	Median	Violations of WQS	Percent Violating	Use Support
T34	Lake Pelican Weir	13	426	212	524	446	0	0	Full
T35	Willow Creek (nr Waverly)	14	380	216	500	384	0	0	Full
T36	Willow Creek (nr Watertown)	17	517	188	686	596	0	0	Full
T37	Stray Horse Creek	14	636	172	892	674	0	0	Full
T39	Lake Poinsett Outlet	14	831	236	1060	912	0	0	Full
T40	Hidewood Creek (nr Clear Lake)	14	1112	390	2084	982	0	0	Full
T41	Hidewood Creek (nr Estelline)	10	516	308	632	544	0	0	Full
T42	Peg Munky Run	6	459	288	528	520	0	0	Full
T46	East Oakwood Lake Outlet 2	14	955	476	1340	976	0	0	Full
T47	Unnamed Creek (nr Volga)	14	706	440	876	753	0	0	Full
R1	BSR nr Brookings	17	587	228	900	580	0	0	Full
R14	BSR at Watertown	17	417	112	548	444	0	0	Full
R15	BSR at Broadway	17	430	112	584	476	0	0	Full
R16	BSR 20th Ave	17	512	132	760	512	0	0	Full
R17	BSR below Watertown	17	501	127	676	504	0	0	Full
R18	BSR nr Castlewood	17	496	176	680	528	0	0	Full
R19	BSR nr Estelline	16	572	180	976	613	0	0	Full
R20	BSR nr Bruce	17	584	172	1508	578	0	0	Full

Most restrictive standard is 1750 mg/L for River sites with beneficial use (1)
All tributary sites have a standard of 4375 mg/L for beneficial use (9)

Total Suspended Solids mg/L

Site	Stream	# of Samples	Mean	Min	Max	Median	Violations of WQS	Percent Violating	Use Support
T34	Lake Pelican Weir	13	21	6	40	24	----	----	Full
T35	Willow Creek (nr Waverly)	14	20	2	56	17	0	0	Full
T36	Willow Creek (nr Watertown)	17	34	5	202	13	0	0	Full
T37	Stray Horse Creek	14	34	6	100	28	0	0	Full
T39	Lake Poinsett Outlet	14	39	4	76	42	----	----	Full
T40	Hidewood Creek (nr Clear Lake)	14	35	2	126	15	0	0	Full
T41	Hidewood Creek (nr Estelline)	10	34	6	100	17	0	0	Full
T42	Peg Munky Run	6	13	4	28	12	0	0	Full
T46	East Oakwood Lake Outlet 2	14	44	4	148	33	0	0	Full
T47	Unnamed Creek (nr Volga)	14	15	1	62	7	0	0	Full
R1	BSR nr Brookings	36	78	7	190	72	3	8	Full
R14	BSR at Watertown	36	34	4	87	29	0	0	Full
R15	BSR at Broadway	17	27	8	53	24	0	0	Full
R16	BSR 20th Ave	17	26	7	59	22	0	0	Full
R17	BSR below Watertown	36	40	1	141	38	0	0	Full
R18	BSR nr Castlewood	17	62	5	314	46	1	6	Full
R19	BSR nr Estelline	35	57	1	188	44	1	3	Full
R20	BSR nr Bruce	17	77	6	328	64	1	6	Full

Note for beneficial use (5) standard is 158 mg/L; for beneficial use (6) standard is 263 mg/L
----denotes no standard or beneficial use assigned

Total Solids mg/L

Site	Stream	# of Samples	Mean	Min	Max	Median	Violations of WQS	Percent Violating	Use Support
T34	Lake Pelican Weir	13	447	240	544	471	----	----	----
T35	Willow Creek (nr Waverly)	14	400	222	513	415	----	----	----
T36	Willow Creek (nr Watertown)	17	551	333	699	602	----	----	----
T37	Stray Horse Creek	14	670	272	924	702	----	----	----
T39	Lake Poinsett Outlet	14	870	312	1080	933	----	----	----
T40	Hidewood Creek (nr Clear Lake)	14	1146	394	2113	1046	----	----	----
T41	Hidewood Creek (nr Estelline)	10	550	362	732	556	----	----	----
T42	Peg Munky Run	6	472	294	538	533	----	----	----
T46	East Oakwood Lake Outlet 2	14	999	572	1370	997	----	----	----
T47	Unnamed Creek (nr Volga)	14	721	459	900	758	----	----	----
R1	BSR nr Brookings	17	669	284	1007	680	----	----	----
R14	BSR at Watertown	17	452	122	598	480	----	----	----
R15	BSR at Broadway	17	456	159	604	497	----	----	----
R16	BSR 20th Ave	17	539	166	771	535	----	----	----
R17	BSR below Watertown	17	545	201	728	560	----	----	----
R18	BSR nr Castlewood	17	558	196	800	581	----	----	----
R19	BSR nr Estelline	17	643	255	1024	653	----	----	----
R20	BSR nr Bruce	17	661	263	1587	632	----	----	----

---- denotes no standard or beneficial use assigned

Specific Conductivity µS/cm

Site	Stream	# of Samples	Mean	Min	Max	Median	Violations of WQS	Percent Violating	Use Support
T34	Lake Pelican Weir	13	657	311	806	692	0	0	Full
T35	Willow Creek (nr Waverly)	14	537	265	664	545	0	0	Full
T36	Willow Creek (nr Watertown)	17	746	323	939	817	0	0	Full
T37	Stray Horse Creek	14	865	234	1150	941	0	0	Full
T39	Lake Poinsett Outlet	14	1079	285	1319	1183	0	0	Full
T40	Hidewood Creek (nr Clear Lake)	14	1510	560	3068	1208	0	0	Full
T41	Hidewood Creek (nr Estelline)	9	767	425	927	823	0	0	Full
T42	Peg Munky Run	6	724	435	904	817	0	0	Full
T46	East Oakwood Lake Outlet 2	14	1216	660	1607	1281	0	0	Full
T47	Unnamed Creek (nr Volga)	14	938	594	1189	954	0	0	Full
R1	BSR nr Brookings	17	827	341	1175	814	0	0	Full
R14	BSR at Watertown	17	594	185	803	664	0	0	Full
R15	BSR at Broadway	17	641	159	886	707	0	0	Full
R16	BSR 20th Ave	17	757	168	1122	762	0	0	Full
R17	BSR below Watertown	17	730	191	1046	750	0	0	Full
R18	BSR nr Castlewood	17	749	220	1026	815	0	0	Full
R19	BSR nr Estelline	17	775	244	1152	869	0	0	Full
R20	BSR nr Bruce	17	743	243	1163	785	0	0	Full

NOTE: For beneficial uses of (9) and (10) the more strict standard of 4375 umhos/cm is applied

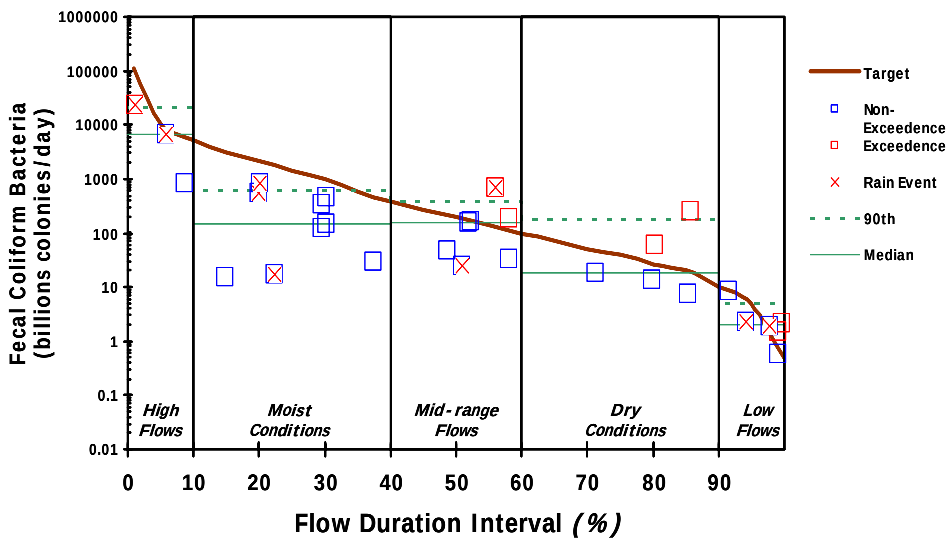
** In addition to EDWDD water quality samples, SD DENR ambient water quality monitoring data was also used to assess fecal coliform bacteria, total suspended solids, and dissolved oxygen

Appendix V.
Flow Duration Intervals
and
Reductions by Site

V-1

R14 - Big Sioux River at Watertown, SD

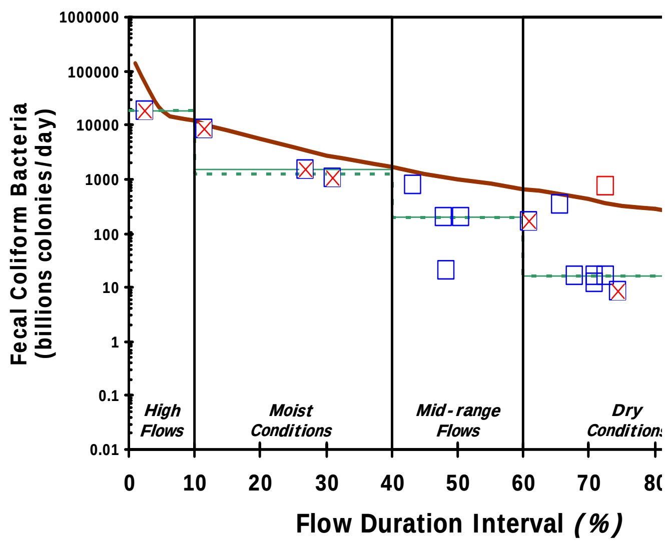
2001-2002 & 2004 (May-Sep) Monitoring Data



R14 - 2000 cfu/100mL					
Median	High Flows (0-10)	Moist (10-40)	Mid-Range (40-60)	Dry (60-90)	Low Flows (90-100)
Target	9935	1419	196	39	5
Site Value	6680	144	154	18	2
% Reduction					
	0	0	0	0	0
% Reduction with MOS					
	0	0	0	0	0
Note: units in billions of colonies per day					

R15 - Big Sioux River at Broadway

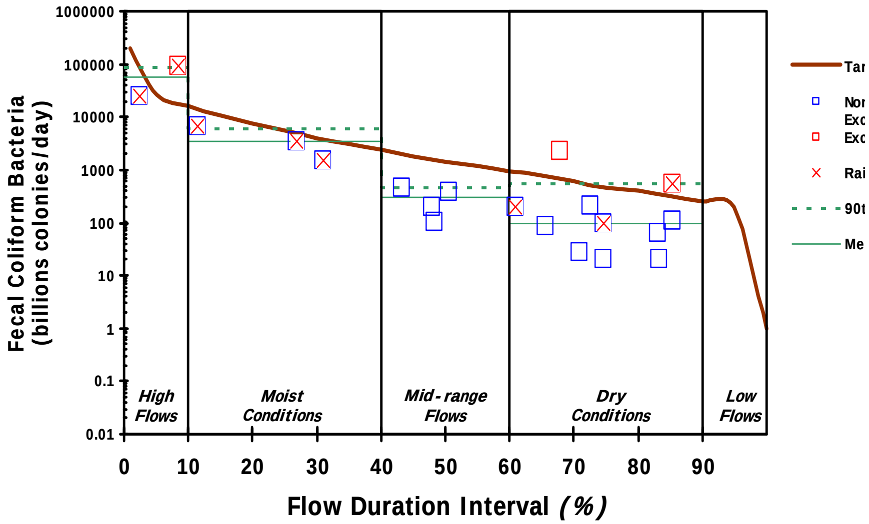
2001-2002 & 2004 (May-Sep) Monitoring Da



R15 - 2000 cfu/100mL				
Median	High Flows (0-10)	Moist (10-40)	Mid-Range (40-60)	(6
Target	18867	3943	986	
Site Value	18876	1492	198	
% Reduction				
	0	0	0	
% Reduction with MOS				
	9	0	0	
Note: units in billions of colonies per day				

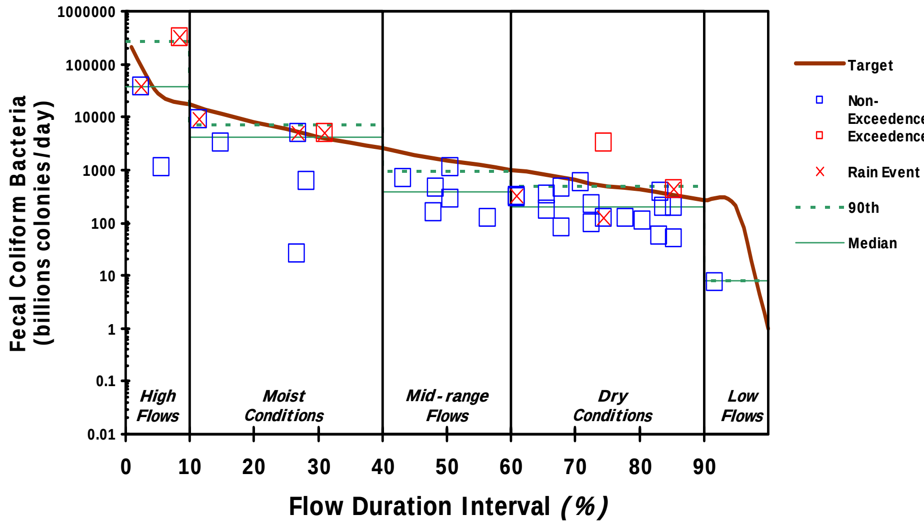
R16 - Big Sioux River at 20th Avenue, SD

2001-2002 & 2004 (May-Sep) Monitoring Data



R17 - Big Sioux River below Watertown, SD

2001-2002 & 2004 (May-Sep) Monitoring Data
EDWDD & DENR WQ data



R16 - 2000 cfu/100mL

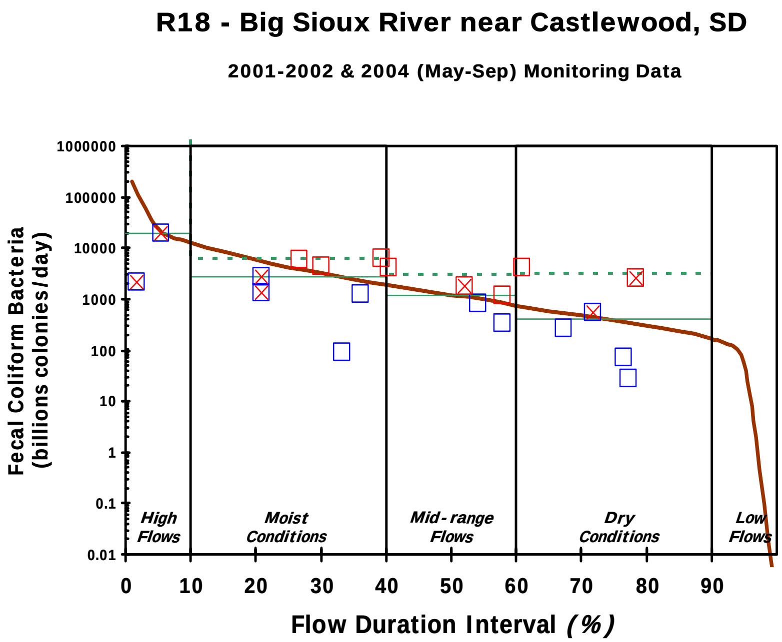
Median	High Flows (0-10)	Moist (10-40)	Mid-Range (40-60)	Dry (60-90)	Low Flows (90-100)
Target	26550	7722	1387	462	194
Site Value	58591	3538	294	97	-----
% Reduction					
	55	0	0	0	-----
% Reduction with MOS					
	59	0	0	0	-----

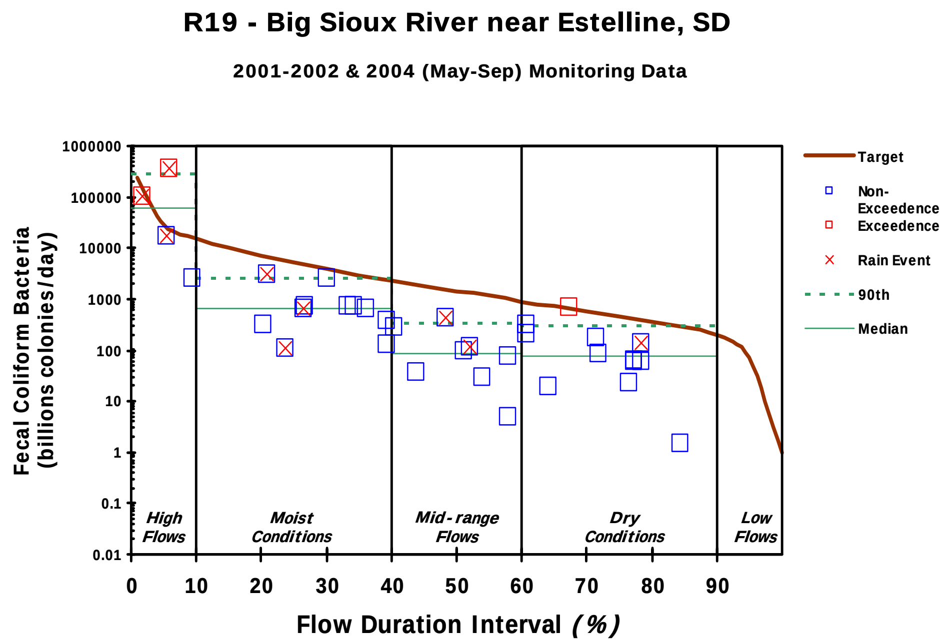
Note: units in billions of colonies per day

R17 - 2000 cfu/100mL

Median	High Flows (0-10)	Moist (10-40)	Mid-Range (40-60)	Dry (60-90)	Low Flows (90-100)
Target	28101	5873	1468	489	206
Site Value	38171	4098	380	200	-----
% Reduction					
	26	0	0	0	-----
% Reduction with MOS					
	33	0	0	0	-----

Note: units in billions of colonies per day





R18 - 2000 cfu/100mL

Median	High Flows (0-10)	Moist (10-40)	Mid-Range (40-60)	Dry (60-90)	Low Flows (90-100)
Target	23051	4209	1175	377	59
Site Value	19556	2765	1206	407	-----
% Reduction	0	0	3	7	-----
% Reduction with MOS	0	0	11	16	-----

Note: units in billions of colonies per day

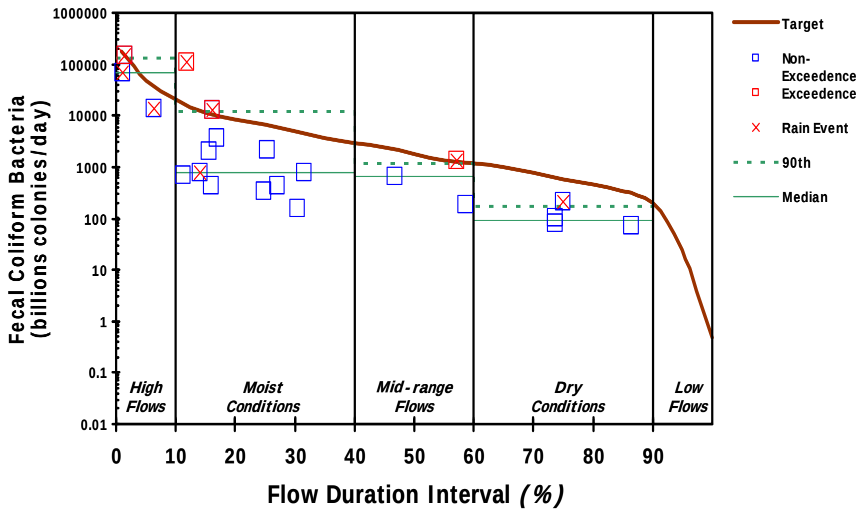
R19 - 2000 cfu/100mL

Median	High Flows (0-10)	Moist (10-40)	Mid-Range (40-60)	Dry (60-90)	Low Flows (90-100)
Target	28106	5132	1432	459	72
Site Value	61065	659	87	75	-----
% Reduction	54	0	0	0	-----
% Reduction with MOS	58	0	0	0	-----

Note: units in billions of colonies per day

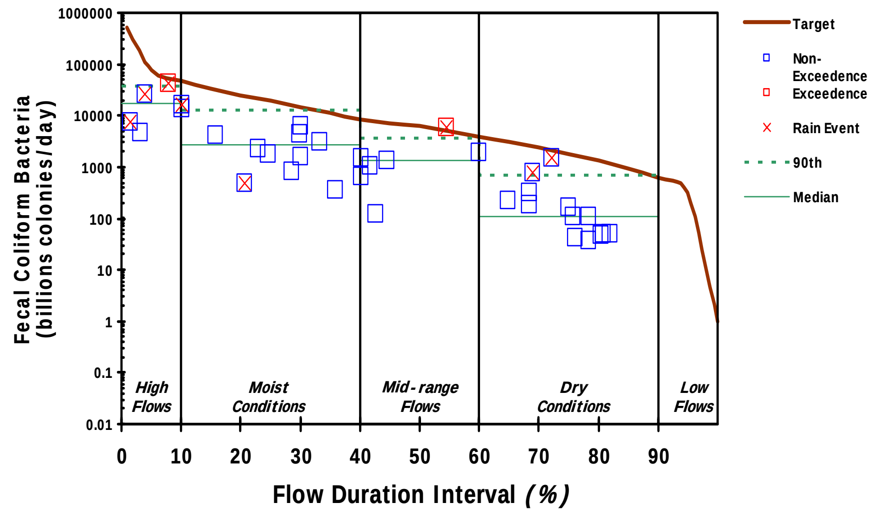
R20 - Big Sioux River near Bruce, SD

2001-2002 & 2004 (May-Sep) Monitoring Data



R01 – Big Sioux River Near Brookings

2001-2002 & 2004 (May-Sep) EDWDD & DENR Monitoring Data



R20 - 2000 cfu/100mL

Median	High Flows (0-10)	Moist (10-40)	Mid-Range (40-60)	Dry (60-90)	Low Flows (90-100)
Target	46885	6754	1762	587	24
Site Value	66803	786	646	92	-----
% Reduction					
	30	0	0	0	-----
% Reduction with MOS					
	36	0	0	0	-----

Note: units in billions of colonies per day

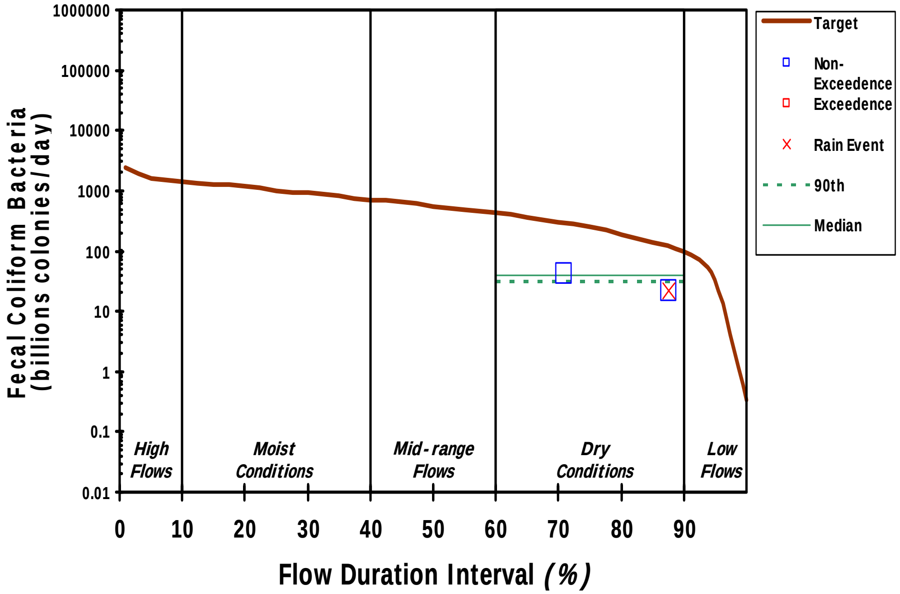
R01 - 2000 cfu/100mL

Median	High Flows (0-10)	Moist (10-40)	Mid-Range (40-60)	Dry (60-90)	Low Flows (90-100)
Target	75696	19285	6128	1802	320
Site Value	26310	1766	1471	162	-----
% Reduction					
	0	0	0	0	-----
% Reduction with MOS					
	0	0	0	0	-----

Note: units in billions of colonies per day

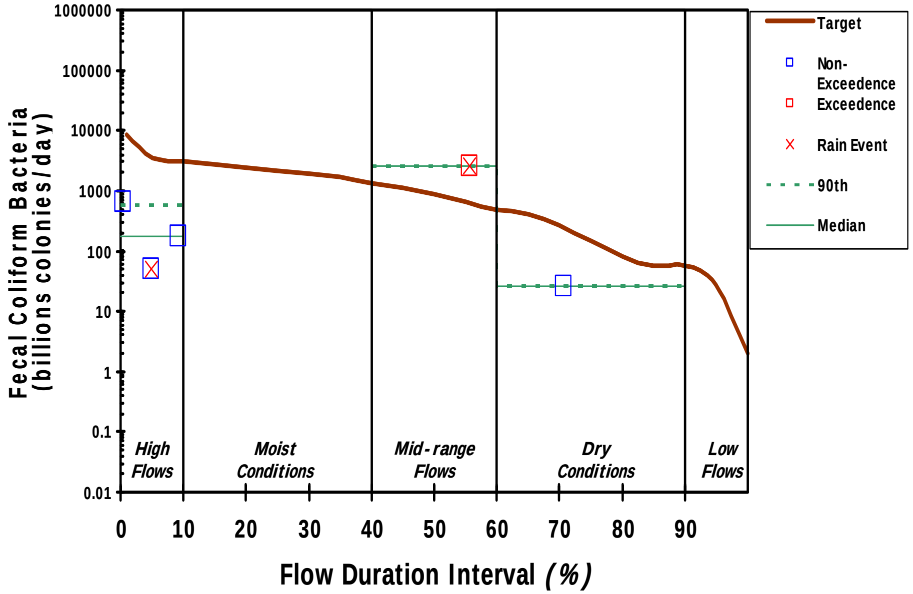
T34* – Lake Pelican Weir (Flow out of Lake)

* numeric standard does not apply

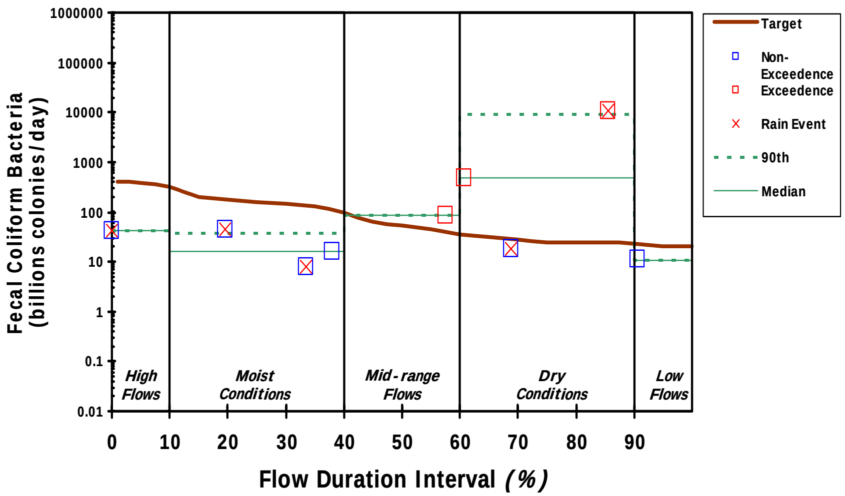


T34* – Lake Pelican Weir (Flow into Lake)

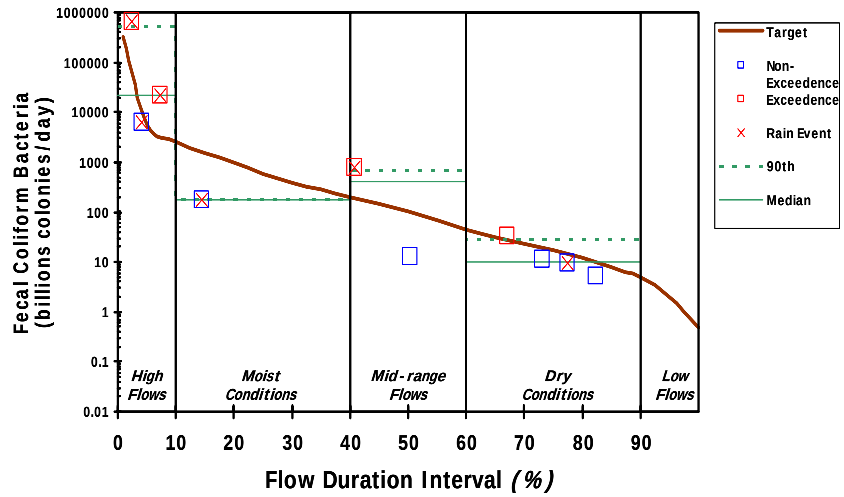
* numeric standard does not apply



T35 – Willow Creek near Waverly, SD



T36 – Willow Creek near Watertown, SD



T35 - 2000 cfu/100mL

Median	High Flows (0-10)	Moist (10-40)	Mid-Range (40-60)	Dry (60-90)	Low Flows (90-100)
Target	372	161	54	25	21
Site Value	41	16	88	495	11
% Reduction					
	0	0	39	95	0
% Reduction with MOS					
	0	0	44	95	0

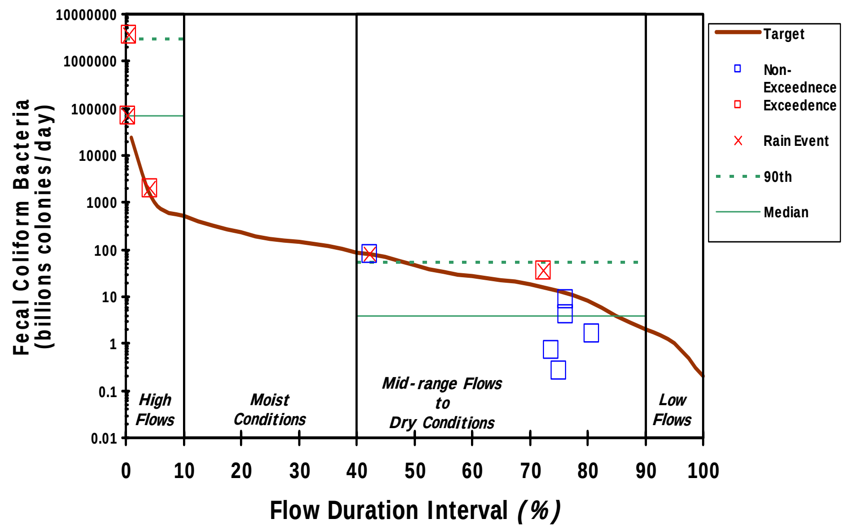
Note: units in billions of colonies per day

T36 - 2000 cfu/100mL

Median	High Flows (0-10)	Moist (10-40)	Mid-Range (40-60)	Dry (60-90)	Low Flows (90-100)
Target	5530	587	103	17	2
Site Value	22317	175	403	10	-----
% Reduction					
	75	0	74	0	-----
% Reduction with MOS					
	77	0	77	0	-----

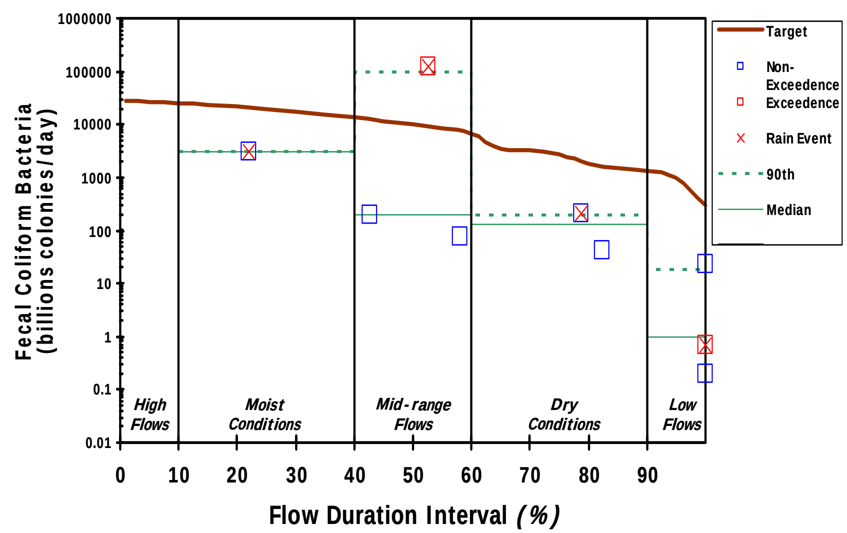
Note: units in billions of colonies per day

T37 – Stray Horse Creek



T39* – Lake Poinsett Outlet

* numeric standard does not apply



T37 - 2000 cfu/100mL

Median	High Flows (0-10)	Moist (10-40)	Mid-Range to Dry (40-90)	Low Flows (90-100)
Target	1029	167	71	1
Site Value	70407	----	4	-----
% Reduction				
	99	0	0	-----
% Reduction with MOS				
	99	0	0	-----

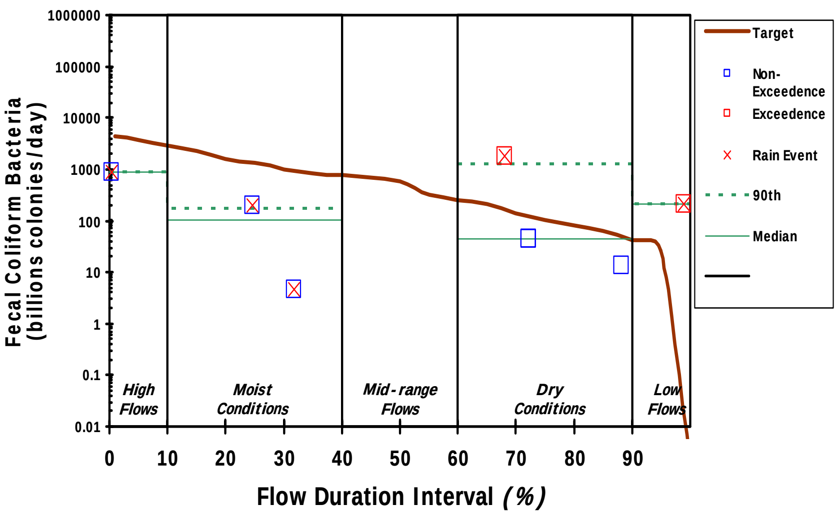
Note: units in billions of colonies per day

T39 - 2000 cfu/100mL

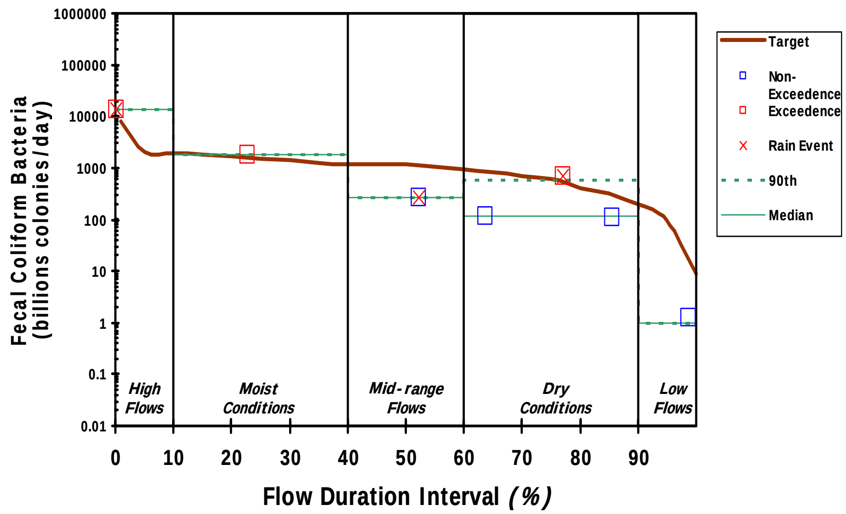
Median	High Flows (0-10)	Moist (10-40)	Mid-Range (40-60)	Dry (60-90)	Low Flows (90-100)
Target	26716	19668	9891	2793	977
Site Value	----	3154	193	129	1
% Reduction					
	-----	0	0	0	-----
% Reduction with MOS					
	-----	0	0	0	-----

Note: units in billions of colonies per day

T40 – Hidewood Creek near Clear Lake



T41 – Hidewood Creek near Estelline



T40 - 2000 cfu/100mL

Median	High Flows (0-10)	Moist (10-40)	Mid-Range (40-60)	Dry (60-90)	Low Flows (90-100)
Target	3589	1310	581	101	26
Site Value	858	102	----	44	206
% Reduction					
	0	0	----	0	87
% Reduction with MOS					
	0	0	-----	0	89

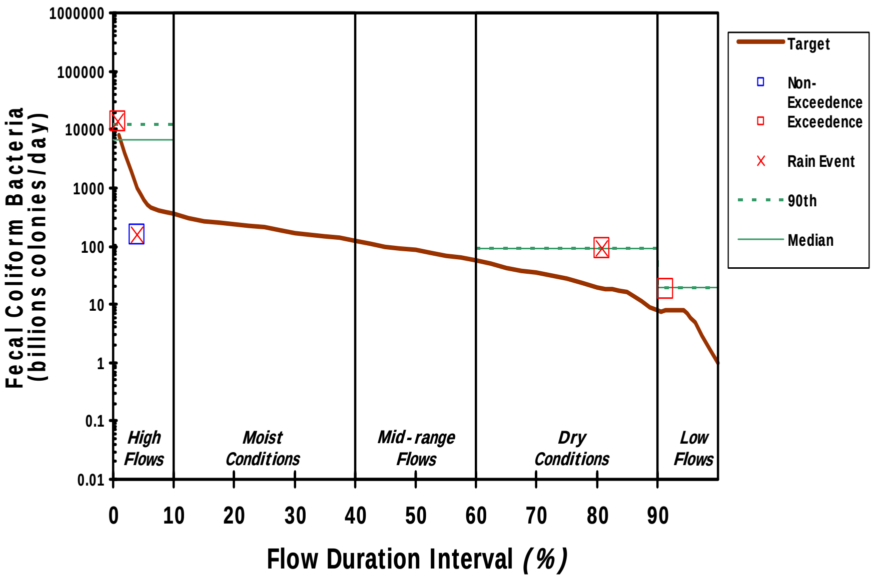
Note: units in billions of colonies per day

T41 - 2000 cfu/100mL

Median	High Flows (0-10)	Moist (10-40)	Mid-Range (40-60)	Dry (60-90)	Low Flows (90-100)
Target	2024	1547	1187	626	99
Site Value	13588	1842	263	115	1
% Reduction					
	85	16	0	0	0
% Reduction with MOS					
	86	24	0	0	0

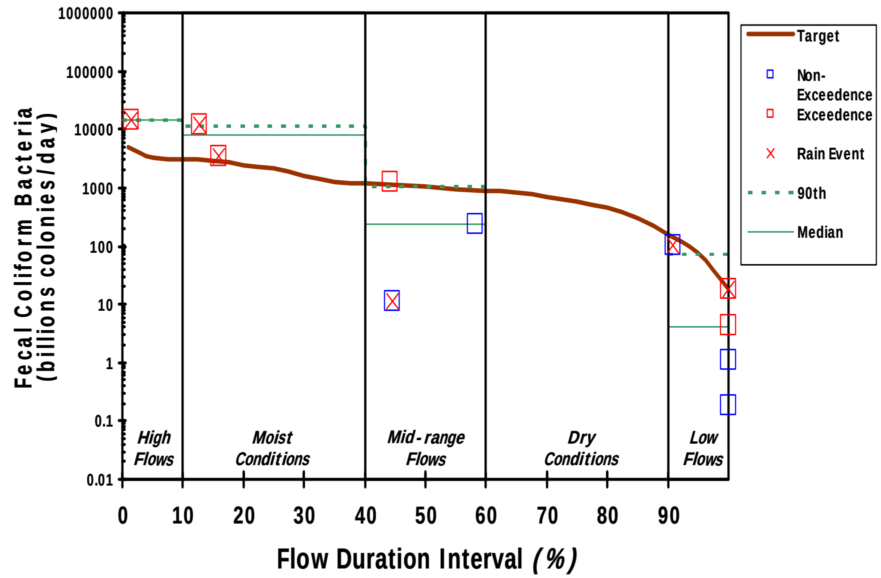
Note: units in billions of colonies per day

T42 – Peg Munky Run



T46* – East Oakwood Lake Outlet 2

* numeric standard does not apply



T42 - 2000 cfu/100mL

Median	High Flows (0-10)	Moist (10-40)	Mid-Range (40-60)	Dry (60-90)	Low Flows (90-100)
Target	604	205	85	28	7
Site Value	6736	----	----	91	19
% Reduction					
	91	----	----	69	63
% Reduction with MOS					
	92	-----	-----	72	67

Note: units in billions of colonies per day

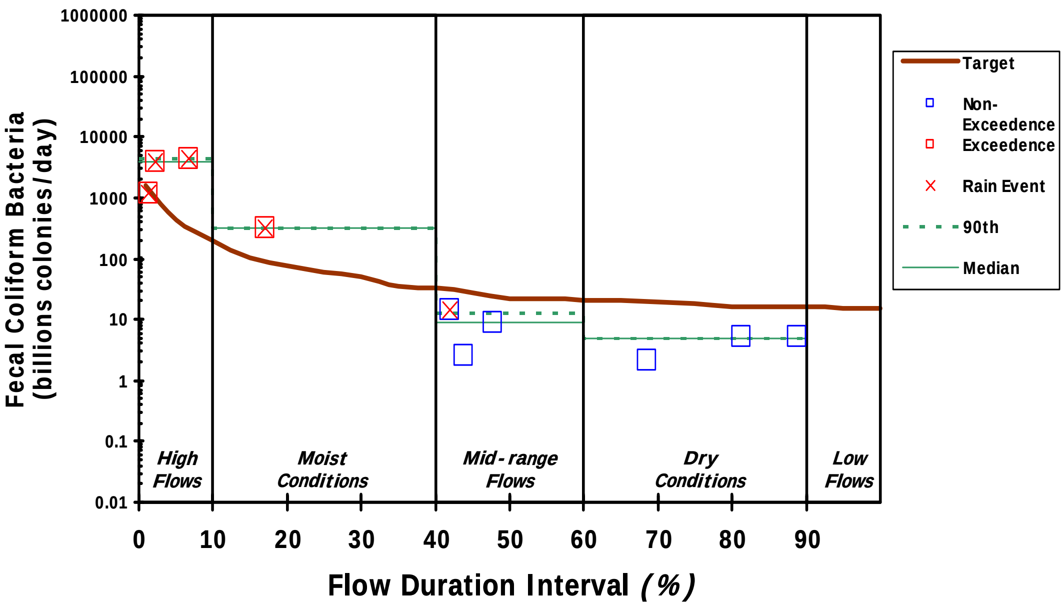
T46 - 2000 cfu/100mL

Median	High Flows (0-10)	Moist (10-40)	Mid-Range (40-60)	Dry (60-90)	Low Flows (90-100)
Target	3339	2114	1063	585	78
Site Value	14168	7763	237	----	4
% Reduction					
	76	73	0	----	0
% Reduction with MOS					
	79	75	0	-----	0

Note: units in billions of colonies per day

T47* – Unnamed Creek near Volga, SD

*** numeric standard does not apply**



T47 - 2000 cfu/100mL					
Median	**High Flows** ***(0-10)***	**Moist** ***(10-40)***	**Mid-Range** ***(40-60)***	**Dry** ***(60-90)***	**Low Flows** ***(90-100)***
Target	426	62	22	18	15
Site Value	3926	316	9	5	----
% Reduction					
	89	80	0	0	----
% Reduction with MOS					
	90	82	0	0	-----
Note: units in billions of colonies per day					

Appendix W.
Fecal Coliform Bacteria Exceedences

Fecal Coliform Bacteria Exceedences

Site	Location	Start Date	End Date	# of Samples	Min	Median	Max	Violations of WQS	Percent Violating	Numeric Standard	Use Support TMDL
T34	Lake Pelican Weir	Jul 01	Sep 02	8	nd	235	8000	---	---	---	---
T35	Willow Creek	Jun 01	Sep 02	9	110	1000	930000	3	33	2000	Not
T36	Willow Creek	May 01	Sep 02	10	230	1500	110000	4	40	2000	Not
T37	Stray Horse Creek	Jun 01	Sep 02	10	40	1800	320000	4	40	2000	Not
T39	Lake Poinsett Outlet	Jun 01	Sep 02	11	nd	190	27000	---	---	---	---
T40	Hidewood Creek	Jun 01	Sep 02	9	10	670	42000	2	22	2000	Full
T41	Hidewood Creek	Jun 01	Aug 02	7	100	700	3300	3	43	2000	Not
T42	Peg Munky Run	Jun 01	Aug 02	4	420	4250	10000	3	75	2000	Not
T46	East Oakwood Lake Outlet	Jun 01	Sep 02	11	20	2200	13000	---	---	---	---
T47	Unnamed Creek	Jun 01	Sep 02	10	180	830	25000	---	---	---	---

R01*	BSR near Brookings	May 01	Sep 04	37	nd	180	>2500	2	5	2000	Full
R14*	BSR at Watertown	May 01	Sep 04	34	nd	795	31000	7	21	2000	Not
R15	BSR at Broadway	May 01	Sep 04	21	40	370	8000	2	10	2000	Full
R16	BSR at 20th Avenue	May 01	Sep 04	21	90	520	10000	3	14	2000	Not
R17*	BSR below Watertown	May 01	Sep 04	35	10	620	33000	5	14	2000	Not
R18	BSR near Castlewood	May 01	Sep 04	21	70	1800	410000	10	48	2000	Not
R19*	BSR near Estelline	May 01	Sep 04	37	nd	300	29000	3	8	2000	Full
R20	BSR near Bruce	May 01	Sep 04	22	80	425	14000	4	18	2000	Not

Note: --- denotes beneficial use and/or standard has not been set for this site for this water quality parameter
* SDDENR ambient WQ data included (includes May – Sept 2001-2002, 2004 data)

Appendix X.
Fishes Collected During the NCBSRWAP

South Dakota Scientific Collector's Permit Report Form
Monitored Species Only

Permittee: East Dakota Water Development District **Permit Number:** 30

Locations of **Topeka shiners** collected for the NCBSRWAP in 2001.					
Stream	Date	Legal Description	Numbers	Comments	Disposition
Peg Munky Run	7/18/01	T113N, R50W, SE1/4 of NW1/4 of Sec 23	29	5 miles west and ½ mile north of Estelline, upstream from road	Released in good condition

Locations of **Topeka shiners** collected during the NCBSRWAP in 2002.					
Stream	Date	Legal Description	Numbers	Comments	Disposition
Stray Horse Creek nr Castlewood	6/25/02	T115N, R51W, SE ¼ of Sec 28	311	3 ½ miles east of Castlewood on north side of hwy 22	Released in good condition

South Dakota Scientific Collector's Permit Report Form
Non-Listed Species

Permittee: East Dakota Water Development District **Permit Number:** 30

Non-listed fish species collected during the North-Central Big Sioux River Watershed Assessment Project in 2001	
Location	Peg Munky Run nr Estelline, SD
County	Brookings
Date / Species	18-Jul-01
Black Bullhead	6
Black Crappie	0
Bigmouth Shiner	17
Blacknose Dace	24
Bluntnose Minnow	0
Brassy Minnow	8
Brook Stickleback	1
Channel Catfish	0
Common Shiner	46
Common Carp	0
Creek Chub	38
Emerald Shiner	0
Fathead Minnow	3
Green Sunfish	1
Iowa Darter	2
Johnny Darter	17
Largemouth Bass	0
Northern Pike	0
Orange spotted Sunfish	0
Red Shiner	0
River Carpsucker	0
Sand Shiner	0
Smallmouth Bass	0
Shorthead Redhorse	0
Stonecat	0
Stoneroller	102
Tadpole Madtom	4
Walleye	0
White Sucker	40
Yellow Perch	0

Non-listed fish species collected during the North-Central Big Sioux River Watershed Assessment Project in 2002.			
Location	Stray Horse Creek nr Castlewood, SD	Hidewood Creek nr Estelline, SD	Willow Creek nr Watertown, SD
County	Hamlin	Hamlin	Codington
Date / Species	25-Jun-02	02-Jul-02	16-Jul-02
Black Bullhead	27	8	3
Bigmouth Shiner	93	113	238
Blacknose Dace	2	32	0
Brassy Minnow	2	0	0
Brook Stickleback	1	0	0
Bluntnose Minnow	0	0	15
Channel Catfish	0	2	0
Common Shiner	2665	736	262
Creek Chub	60	280	205
Fathead Minnow	5228	53	547
Green Sunfish	7	4	1
Iowa Darter	1	0	0
Johnny Darter	102	83	53
Northern Pike	2	0	0
Orange spotted Sunfish	69	0	0
Red Shiner	38	1	0
Sand Shiner	13	294	95
Shorthead Redhorse	2	0	0
Stonecat	8	0	0
Stoneroller	189	282	0
Tadpole Madtom	4	45	20
White Sucker	75	110	76
Yellow Perch	130	1	0

Appendix Y.
Fish Life History Designations

Life History Designations for Fishes Found During NCBSRWAP

Common Name	Scientific name	Trophic	Tolerance	Sensitive	Habitat Guild (B or WC)	Headwater	Pioneer	Simple Lithophil
Carps and Minnows	**Cyprinidae**							
Central stoneroller	*Campostoma anomalum*	H	M		B	H	p	
Red shiner	*Cyprinella lutrensis*	I	T		G			
Brassy minnow	*Hybognathus hankinsoni*	H	M		G			
Common shiner	***Luxilus cornutus***	I	M		WC			SL
Bigmouth shiner	*Notropis dorsalis*	I	M		B			
Sand shiner	*Notropis stramineus*	I	M		WC			
Topeka shiner	*Notropis topeka*	I	I	S	WC			
Bluntnose minnow	*Pimephales notatus*	O	T		G		P	
Fathead minnow	*Pimephales promelas*	O	T		G		P	
Blacknose dace	*Rhinichthys atratulus*	I	M		B	H		SL
Creek chub	*Semotilus atromaculatus*	I	T		WC		P	
Suckers	**Catostomidae**							
White sucker	*Catostomus commersoni*	O	T		B			SL
Shorthead redhorse	*Moxostoma macrolepidotum*	I	M	S	B			SL
Bullhead/Catfishes	**Ictaluridae**							
Black bullhead	*Ameiurus melas*	I	M		B		P	
Channel catfish	*Ictalurus punctatus*	I	M		B			
Stonecat	*Noturus flavus*	I	I	S	B			
Tadpole madtom	*Noturus gyrinus*	I	M	S	B			
Pikes	**Esocidae**							
Northern pike	*Esox lucius*	P	M		WC			
Sticklebacks	**Gasterosteidae**							
Brook stickleback	*Culaea inconstans*	I	M	S	WC	H		
Sunfishes	**Centrarchidae**							
Green sunfish	*Lepomis cyanellus*	I	T		WC		P	
Orangespotted sunfish	*Lepomis humilis*	I	M		WC			
Perches	**Percidae**							
Iowa darter	*Etheostoma exile*	I	I	S	B	H		
Johnny darter	*Etheostoma nigrum*	I	M		B	H	P	
Yellow perch	*Perca flavescens*	I	M		WC			

Trophic	Tolerance	Habitat Guild
H = Herbivore	I = Intolerant	B = Benthic
I = Insectivore	M = Moderately Tolerant	G = Generalist
O = Omnivore	T = Tolerant	WC = Water Column
P = Predator		

Appendix Z.
Fishes Candidate Metric Results

SiteID	Species Richness	Native Species Richness	Native Minnow Richness	WaterColumn Species Richness	Benthic Species Richness	Benthic Insectivore Richness	HeadWater Species Richness	% HeadWater Species	% HeadWater BIOMASS	% Pioneer Species	% Pionee Species BIOMASS
T36	11	11	7	4	5	4	1	9	1	55	4
T37	22	22	9	9	10	8	5	22.7	7	27.3	26.
T41	15	15	8	5	8	6	3	20	16.8	40	37.
T42	15	15	8	5	8	6	5	33.3	19	40	60.

SiteID	% Intolerant Species	% Intolerant Species BIOMASS	Sensitive Species Richness	% Sensitive Species	% Sensitive Species BIOMASS	% Green Sunfish	% Green Sunfish BIOMASS	% Tolerant Species	% Tolerant Species Biomass	% Insectivorous minnows	% Insectivorou minnows BIOMASS
T36	0	0	1	9	2.3	0.07	0.08	54.5	72.5	68.5	63.
T37	13.6	2.9	6	27.3	3.1	0.08	0.14	27.3	31.3	95.3	76.
T41	0	0	1	6.7	1.3	0.2	0.21	40	31.5	87.6	86.
T42	13.3	2.1	4	26.7	3.7	0.3	0.86	33.3	54.4	80	8

SiteID	% Insectivores BIOMASS	% Predator	% Predator BIOMASS	% Omnivore	% Omnivore BIOMASS	% Herbivore	% Herbivore BIOMASS	% Simple Lithophil	% Simple Lithophil BIOMASS
T36	55	0	0	42.1	46.3	0	0	22.3	49.5
T37	64.3	0.02	3.7	58.7	25	2.1	6.5	30.4	60.4
T41	73.9	0	0	12.7	7.7	32.5	15.6	43	55.1
T42	77.7	0	0	12.7	7.7	32.5	14.5	32.5	33

Appendix AA
Macroinvertebrate Candidate Metric Results

AA-1

Metric 1 and 2			
StationID	c.f.	**Abundance**	**Corrected Abundance**
R01	8.47	283	2,397
R01	11.08	331	3,667
R01	6	298	1,788
R14	4.8	300	1,440
R15	9	274	2,466
R16	1	250	250
R16	1.14	337	384
R16	3.43	312	1,070
R17	3.6	288	1,037
R18	3	325	975
R18	4.8	281	1,349
R18	2.18	274	597
R19	9	327	2,943
R20	21.6	315	6,804
T34	7.2	334	2,405
T35	5.14	309	1,588
T35	2.25	287	646
T35	1	70	70
T35	1	22	22
T35	1	33	33
T36	2.18	277	604
T37	12.46	296	3,688
T37	36	286	10,296
T37	9	340	3,060
T39	6.86	326	2,236
T39	4.8	289	1,387
T39	4	304	1,216
T40	2.12	312	661
T44	3.43	299	1,026
T45	7.2	276	1,987
T46	1.24	280	347
T47	3.27	275	899
T48	6.86	314	2,154

Metric 3	
StationID	**EPT Abundance**
R01	224
R01	262
R01	153
R14	40
R15	16
R16	2
R16	1
R16	0
R17	27
R18	49
R18	137
R18	23
R19	35
R20	214
T34	25
T35	3
T35	4
T35	1
T35	0
T35	0
T36	38
T37	128
T37	155
T37	146
T39	15
T39	15
T39	15
T40	0
T44	16
T45	9
T46	4
T47	77
T48	24

Metric 4	
StationID	**Taxa Richness**
R01	18
R01	25
R01	26
R14	27
R15	34
R16	22
R16	26
R16	10
R17	29
R18	34
R18	30
R18	29
R19	24
R20	17
T34	26
T35	11
T35	13
T35	13
T35	6
T35	7
T36	26
T37	27
T37	11
T37	25
T39	19
T39	15
T39	17
T40	13
T44	15
T45	15
T46	16
T47	24
T48	15

Metric 5	
StationID	**EPT Taxa**
R01	9
R01	14
R01	12
R14	3
R15	5
R16	2
R16	1
R16	0
R17	5
R18	9
R18	10
R18	6
R19	6
R20	7
T34	6
T35	1
T35	1
T35	1
T35	0
T35	0
T36	4
T37	4
T37	3
T37	5
T39	3
T39	1
T39	1
T40	0
T44	3
T45	2
T46	2
T47	3
T48	3

Metric 6	
StationID	**Ephemeroptera Taxa**
R01	3
R01	6
R01	7
R14	2
R15	2
R16	1
R16	1
R16	0
R17	3
R18	4
R18	6
R18	5
R19	3
R20	3
T34	3
T35	1
T35	1
T35	1
T35	0
T35	0
T36	3
T37	2
T37	1
T37	3
T39	3
T39	1
T39	1
T40	0
T44	1
T45	1
T46	1
T47	1
T48	1

Metric 7	
StationID	**Trichoptera Taxa**
R01	6
R01	8
R01	5
R14	1
R15	3
R16	1
R16	0
R16	0
R17	2
R18	5
R18	4
R18	1
R19	3
R20	4
T34	3
T35	0
T35	0
T35	0
T35	0
T35	0
T36	1
T37	2
T37	2
T37	2
T39	0
T39	0
T39	0
T40	0
T44	2
T45	1
T46	1
T47	2
T48	2

Metric 8	
StationID	**Plecoptera Taxa**
R01	0
R01	0
R01	0
R14	0
R15	0
R16	0
R16	0
R16	0
R17	0
R18	0
R18	0
R18	0
R19	0
R20	0
T34	0
T35	0
T35	0
T35	0
T35	0
T35	0
T36	0
T37	0
T37	0
T37	0
T39	0
T39	0
T39	0
T40	0
T44	0
T45	0
T46	0
T47	0
T48	0

Metric 9	
StationID	**Diptera Taxa**
R01	8
R01	7
R01	10
R14	10
R15	11
R16	9
R16	12
R16	4
R17	11
R18	12
R18	10
R18	11
R19	9
R20	5
T34	7
T35	4
T35	5
T35	4
T35	3
T35	2
T36	10
T37	11
T37	7
T37	11
T39	6
T39	4
T39	5
T40	3
T44	5
T45	6
T46	5
T47	9
T48	4

Metric 10	
StationID	**Chironomidae Taxa**
R01	7
R01	6
R01	8
R14	9
R15	9
R16	9
R16	11
R16	4
R17	10
R18	10
R18	9
R18	10
R19	8
R20	4
T34	7
T35	4
T35	5
T35	3
T35	2
T35	2
T36	9
T37	10
T37	6
T37	10
T39	5
T39	3
T39	4
T40	3
T44	4
T45	4
T46	4
T47	7
T48	3

Metric 11			
StationID	EPT Abund	Chiro Abund	**EPT/Chiro Abund.**
R01	224	57	3.93
R01	262	62	4.23
R01	153	137	1.12
R14	40	178	0.22
R15	16	96	0.17
R16	2	137	0.01
R16	1	160	0.01
R16	0	164	0.00
R17	27	102	0.26
R18	49	63	0.78
R18	137	60	2.28
R18	23	106	0.22
R19	35	214	0.16
R20	214	86	2.49
T34	25	62	0.40
T35	3	273	0.01
T35	4	216	0.02
T35	1	27	0.04
T35	0	7	0.00
T35	0	6	0.00
T36	38	155	0.25
T37	128	138	0.93
T37	155	129	1.20
T37	146	169	0.86
T39	15	201	0.07
T39	15	104	0.14
T39	15	92	0.16
T40	0	276	0.00
T44	16	262	0.06
T45	9	150	0.06
T46	4	95	0.04
T47	77	32	2.41
T48	24	139	0.17

Metric 12	
StationID	**% EPT**
R01	79.15
R01	79.15
R01	51.34
R14	13.33
R15	5.84
R16	0.80
R16	0.30
R16	0.00
R17	9.38
R18	15.08
R18	48.75
R18	8.39
R19	10.70
R20	67.94
T34	7.49
T35	0.97
T35	1.39
T35	1.43
T35	0.00
T35	0.00
T36	13.72
T37	43.24
T37	54.20
T37	42.94
T39	4.60
T39	5.19
T39	4.93
T40	0.00
T44	5.35
T45	3.26
T46	1.43
T47	28.00
T48	7.64

Metric 13	
StationID	**% Ephemeroptera**
R01	6.01
R01	15.11
R01	24.83
R14	13.00
R15	1.09
R16	0.40
R16	0.30
R16	0.00
R17	8.33
R18	7.08
R18	25.27
R18	7.30
R19	8.56
R20	6.98
T34	6.29
T35	0.97
T35	1.39
T35	1.43
T35	0.00
T35	0.00
T36	11.19
T37	42.23
T37	9.09
T37	38.24
T39	4.60
T39	5.19
T39	4.93
T40	0.00
T44	4.01
T45	2.90
T46	1.07
T47	24.00
T48	5.73

Metric 14	
StationID	**% Plecoptera**
R01	0.00
R01	0.00
R01	0.00
R14	0.00
R15	0.00
R16	0.00
R16	0.00
R16	0.00
R17	0.00
R18	0.00
R18	0.00
R18	0.00
R19	0.00
R20	0.00
T34	0.00
T35	0.00
T35	0.00
T35	0.00
T35	0.00
T35	0.00
T36	0.00
T37	0.00
T37	0.00
T37	0.00
T39	0.00
T39	0.00
T39	0.00
T40	0.00
T44	0.00
T45	0.00
T46	0.00
T47	0.00
T48	0.00

Metric 15	
StationID	**% Trichoptera**
R01	73.14
R01	64.05
R01	26.51
R14	0.33
R15	4.74
R16	0.40
R16	0.00
R16	0.00
R17	1.04
R18	8.00
R18	23.49
R18	1.09
R19	2.14
R20	60.95
T34	1.20
T35	0.00
T35	0.00
T35	0.00
T35	0.00
T35	0.00
T36	2.53
T37	1.01
T37	45.10
T37	4.71
T39	0.00
T39	0.00
T39	0.00
T40	0.00
T44	1.34
T45	0.36
T46	0.36
T47	4.00
T48	1.91

Metric 16	
StationID	**% Coleoptera**
R01	0.35
R01	0.60
R01	0.34
R14	4.67
R15	3.65
R16	2.00
R16	0.30
R16	0.00
R17	2.43
R18	8.92
R18	8.90
R18	4.74
R19	11.62
R20	2.22
T34	0.30
T35	0.32
T35	0.35
T35	1.43
T35	0.00
T35	0.00
T36	13.00
T37	1.01
T37	0.00
T37	0.88
T39	0.31
T39	0.00
T39	0.00
T40	0.64
T44	0.00
T45	0.00
T46	0.00
T47	0.73
T48	0.00

Metric 17	
StationID	**% Diptera**
R01	20.49
R01	19.34
R01	46.98
R14	60.00
R15	36.86
R16	54.80
R16	49.55
R16	52.56
R17	38.19
R18	20.62
R18	21.71
R18	42.70
R19	72.78
R20	27.94
T34	18.56
T35	88.35
T35	75.26
T35	40.00
T35	36.36
T35	18.18
T36	57.76
T37	46.96
T37	45.45
T37	50.00
T39	65.03
T39	75.09
T39	65.46
T40	88.46
T44	87.96
T45	55.43
T46	40.36
T47	14.18
T48	44.90

Metric 18	
StationID	**% Oligochaeta**
R01	0.00
R01	0.30
R01	0.67
R14	12.00
R15	29.20
R16	28.00
R16	40.65
R16	43.27
R17	32.64
R18	22.15
R18	8.90
R18	25.55
R19	0.00
R20	0.00
T34	11.38
T35	5.18
T35	12.20
T35	27.14
T35	45.45
T35	63.64
T36	4.33
T37	2.36
T37	0.35
T37	0.29
T39	23.93
T39	15.92
T39	21.38
T40	0.64
T44	1.00
T45	1.09
T46	50.71
T47	29.45
T48	0.32

Metric 19			
StationID	No.Baetidae	Totl.Indiv	**% Baetidae**
R01	0	283	0.00
R01	0	331	0.00
R01	1	298	0.34
R14	0	300	0.00
R15	0	274	0.00
R16	0	250	0.00
R16	0	337	0.00
R16	0	312	0.00
R17	0	288	0.00
R18	0	325	0.00
R18	0	281	0.00
R18	0	274	0.00
R19	0	327	0.00
R20	0	315	0.00
T34	1	334	0.30
T35	0	309	0.00
T35	0	287	0.00
T35	0	70	0.00
T35	0	22	0.00
T35	0	33	0.00
T36	0	277	0.00
T37	0	296	0.00
T37	0	286	0.00
T37	0	340	0.00
T39	0	326	0.00
T39	0	289	0.00
T39	0	304	0.00
T40	0	312	0.00
T44	0	299	0.00
T45	0	276	0.00
T46	0	280	0.00
T47	0	275	0.00
T48	0	314	0.00

Metric 20			
StationID	No.Hydrop	Totl.Indiv	**%Hydropsychidae**
R01	205	283	72.44
R01	209	331	63.14
R01	78	298	26.17
R14	0	300	0.00
R15	2	274	0.73
R16	0	250	0.00
R16	0	337	0.00
R16	0	312	0.00
R17	2	288	0.69
R18	23	325	7.08
R18	65	281	23.13
R18	3	274	1.09
R19	4	327	1.22
R20	192	315	60.95
T34	2	334	0.60
T35	0	309	0.00
T35	0	287	0.00
T35	0	70	0.00
T35	0	22	0.00
T35	0	33	0.00
T36	7	277	2.53
T37	0	296	0.00
T37	129	286	45.10
T37	1	340	0.29
T39	0	326	0.00
T39	0	289	0.00
T39	0	304	0.00
T40	0	312	0.00
T44	4	299	1.34
T45	1	276	0.36
T46	0	280	0.00
T47	8	275	2.91
T48	1	314	0.32

Metric 21	
StationID	**%Chironomidae**
R01	20.14
R01	18.73
R01	45.97
R14	59.33
R15	35.04
R16	54.80
R16	47.48
R16	52.56
R17	35.42
R18	19.38
R18	21.35
R18	38.69
R19	65.44
R20	27.30
T34	18.56
T35	88.35
T35	75.26
T35	38.57
T35	31.82
T35	18.18
T36	55.96
T37	46.62
T37	45.10
T37	49.71
T39	61.66
T39	35.99
T39	30.26
T40	88.46
T44	87.63
T45	54.35
T46	33.93
T47	11.64
T48	44.27

Metric 22	
StationID	**%Gastropoda**
R01	0.00
R01	0.00
R01	0.00
R14	1.33
R15	5.47
R16	0.40
R16	0.59
R16	0.00
R17	2.08
R18	8.31
R18	1.07
R18	4.01
R19	0.31
R20	0.63
T34	6.59
T35	0.00
T35	0.00
T35	0.00
T35	0.00
T35	0.00
T36	5.05
T37	0.68
T37	0.00
T37	2.35
T39	3.07
T39	0.00
T39	1.32
T40	1.60
T44	0.00
T45	0.00
T46	2.50
T47	0.00
T48	0.32

Metric 23				Metric 24	
StationID	ShanWiener (log e)	ShanWiener (log 2)	ShanWiener (log 10)	StationID	No. Intolerant Taxa
R01	2.00	2.89	0.87	R01	3
R01	2.31	3.33	1.00	R01	6
R01	2.34	3.38	1.02	R01	3
R14	2.31	3.34	1.00	R14	0
R15	2.70	3.90	1.17	R15	1
R16	2.16	3.12	0.94	R16	0
R16	1.91	2.75	0.83	R16	0
R16	1.08	1.56	0.47	R16	0
R17	2.19	3.16	0.95	R17	0
R18	2.77	4.00	1.20	R18	2
R18	2.89	4.18	1.26	R18	4
R18	2.58	3.72	1.12	R18	1
R19	2.15	3.10	0.93	R19	0
R20	1.83	2.65	0.80	R20	4
T34	2.05	2.95	0.89	T34	0
T35	0.80	1.16	0.35	T35	0
T35	1.15	1.66	0.50	T35	0
T35	2.07	2.99	0.90	T35	0
T35	1.51	2.18	0.66	T35	0
T35	1.50	2.16	0.65	T35	0
T36	2.11	3.04	0.92	T36	0
T37	2.07	2.99	0.90	T37	0
T37	1.73	2.49	0.75	T37	1
T37	2.07	2.98	0.90	T37	1
T39	2.09	3.02	0.91	T39	0
T39	1.80	2.60	0.78	T39	0
T39	1.94	2.80	0.84	T39	0
T40	1.26	1.82	0.55	T40	0
T44	1.20	1.73	0.52	T44	1
T45	1.68	2.42	0.73	T45	0
T46	1.79	2.59	0.78	T46	0
T47	2.23	3.22	0.97	T47	0
T48	1.37	1.98	0.59	T48	0

Metric 25		Metric 26		Metric 27	
StationID	**% Intolerant Organisms**	StationID	**No. Tolerant Taxa**	StationID	**% Tolerant Organisms**
R01	34.98	R01	3	R01	10.25
R01	34.14	R01	8	R01	15.41
R01	14.77	R01	10	R01	21.14
R14	0.00	R14	18	R14	92.00
R15	0.36	R15	19	R15	80.29
R16	0.00	R16	15	R16	93.20
R16	0.00	R16	20	R16	86.94
R16	0.00	R16	7	R16	95.83
R17	0.00	R17	20	R17	90.97
R18	0.62	R18	16	R18	58.15
R18	3.56	R18	15	R18	52.67
R18	1.09	R18	15	R18	74.09
R19	0.00	R19	15	R19	73.70
R20	20.63	R20	6	R20	4.44
T34	0.00	T34	20	T34	97.90
T35	0.00	T35	9	T35	99.03
T35	0.00	T35	12	T35	99.65
T35	0.00	T35	10	T35	95.71
T35	0.00	T35	5	T35	95.45
T35	0.00	T35	7	T35	100.00
T36	0.00	T36	18	T36	79.78
T37	0.00	T37	18	T37	95.61
T37	11.19	T37	6	T37	17.48
T37	0.29	T37	18	T37	92.94
T39	0.00	T39	14	T39	95.09
T39	0.00	T39	12	T39	59.86
T39	0.00	T39	12	T39	62.50
T40	0.00	T40	11	T40	99.04
T44	0.67	T44	10	T44	97.66
T45	0.00	T45	12	T45	98.19
T46	0.00	T46	13	T46	87.86
T47	0.00	T47	14	T47	85.09
T48	0.00	T48	11	T48	98.41

Metric 28 (% Sediment Tolerant - Partial)	
StationID	**% Burrowers**
R01	0.35
R01	1.21
R01	0.34
R14	7.00
R15	5.11
R16	25.60
R16	35.91
R16	50.64
R17	1.74
R18	2.15
R18	0.36
R18	1.46
R19	7.65
R20	0.00
T34	1.50
T35	2.59
T35	1.05
T35	0.00
T35	0.00
T35	0.00
T36	6.14
T37	7.43
T37	0.00
T37	5.59
T39	1.53
T39	0.00
T39	0.33
T40	0.00
T44	3.68
T45	0.72
T46	0.00
T47	0.00
T48	2.23

Metric 29 (% Sediment Tolerant - Partial)			
StationID	%Chiro	%Oligo	**% Chironomidae + Oligochaeta**
R01	20.1	0.0	20.1
R01	18.7	0.3	19.0
R01	46.0	0.7	46.6
R14	59.3	12.0	71.3
R15	35.0	29.2	64.2
R16	54.8	28.0	82.8
R16	47.5	40.7	88.1
R16	52.6	43.3	95.8
R17	35.4	32.6	68.1
R18	19.4	22.2	41.5
R18	21.4	8.9	30.2
R18	38.7	25.5	64.2
R19	65.4	0.0	65.4
R20	27.3	0.0	27.3
T34	18.6	11.4	29.9
T35	88.3	5.2	93.5
T35	75.3	12.2	87.5
T35	38.6	27.1	65.7
T35	31.8	45.5	77.3
T35	18.2	63.6	81.8
T36	56.0	4.3	60.3
T37	46.6	2.4	49.0
T37	45.1	0.3	45.5
T37	49.7	0.3	50.0
T39	61.7	23.9	85.6
T39	36.0	15.9	51.9
T39	30.3	21.4	51.6
T40	88.5	0.6	89.1
T44	87.6	1.0	88.6
T45	54.3	1.1	55.4
T46	33.9	50.7	84.6
T47	11.6	29.5	41.1
T48	44.3	0.3	44.6

Metric 30	
StationID	**Hilsenhoff Biotic Index**
R01	4.73
R01	4.82
R01	5.60
R14	9.00
R15	8.53
R16	9.37
R16	9.24
R16	9.82
R17	9.04
R18	7.27
R18	6.72
R18	8.18
R19	8.59
R20	4.89
T34	8.41
T35	9.83
T35	9.72
T35	9.33
T35	9.45
T35	9.76
T36	8.53
T37	8.25
T37	5.58
T37	8.31
T39	9.57
T39	8.18
T39	8.25
T40	9.76
T44	9.63
T45	9.06
T46	9.31
T47	8.01
T48	8.80

Metric 31	
StationID	**% Dominant Taxon**
R01	28.27
R01	24.17
R01	25.84
R14	36.67
R15	23.72
R16	25.60
R16	35.91
R16	50.64
R17	31.25
R18	20.92
R18	15.66
R18	27.01
R19	40.67
R20	40.95
T34	50.00
T35	82.20
T35	70.03
T35	30.00
T35	40.91
T35	48.48
T36	45.49
T37	38.85
T37	33.92
T37	33.24
T39	21.47
T39	39.10
T39	35.20
T40	49.68
T44	71.57
T45	35.14
T46	47.14
T47	26.18
T48	41.40

Metric 32	
StationID	**% Hydropsychidae / Trichoptera**
R01	99.03
R01	98.58
R01	98.73
R14	0.00
R15	15.38
R16	0.00
R16	0.00
R16	0.00
R17	66.67
R18	88.46
R18	98.48
R18	100.00
R19	57.14
R20	100.00
T34	50.00
T35	0.00
T35	0.00
T35	0.00
T35	0.00
T35	0.00
T36	100.00
T37	0.00
T37	100.00
T37	6.25
T39	0.00
T39	0.00
T39	0.00
T40	0.00
T44	100.00
T45	100.00
T46	0.00
T47	72.73
T48	16.67

Metric 33	
StationID	**% Baetidae / Ephemeroptera**
R01	0.00
R01	0.00
R01	1.35
R14	0.00
R15	0.00
R16	0.00
R16	0.00
R16	0.00
R17	0.00
R18	0.00
R18	0.00
R18	0.00
R19	0.00
R20	0.00
T34	4.76
T35	0.00
T35	0.00
T35	0.00
T35	0.00
T35	0.00
T36	0.00
T37	0.00
T37	0.00
T37	0.00
T39	0.00
T39	0.00
T39	0.00
T40	0.00
T44	0.00
T45	0.00
T46	0.00
T47	0.00
T48	0.00

Metric 34	
StationID	**% Gatherers+Filterers**
R01	83.04
R01	80.06
R01	54.36
R14	54.67
R15	69.34
R16	69.20
R16	77.45
R16	95.83
R17	57.64
R18	64.62
R18	66.55
R18	78.83
R19	76.76
R20	67.94
T34	74.85
T35	98.06
T35	97.56
T35	62.86
T35	77.27
T35	81.82
T36	81.59
T37	75.68
T37	59.09
T37	63.24
T39	69.94
T39	35.99
T39	40.13
T40	92.31
T44	93.31
T45	76.81
T46	77.14
T47	82.18
T48	92.04

Metric 35	
StationID	**% Gatherers**
R01	1.41
R01	5.74
R01	10.07
R14	42.67
R15	57.30
R16	55.20
R16	74.48
R16	94.55
R17	56.60
R18	44.31
R18	32.03
R18	50.73
R19	62.39
R20	4.13
T34	68.56
T35	15.86
T35	27.53
T35	32.86
T35	54.55
T35	66.67
T36	32.13
T37	48.65
T37	0.35
T37	28.24
T39	51.53
T39	23.53
T39	30.92
T40	55.77
T44	20.40
T45	71.01
T46	56.79
T47	77.82
T48	50.32

Metric 36	
StationID	**% Filterers**
R01	81.63
R01	74.32
R01	44.30
R14	12.00
R15	12.04
R16	14.00
R16	2.97
R16	1.28
R17	1.04
R18	20.31
R18	34.52
R18	28.10
R19	14.37
R20	63.81
T34	6.29
T35	82.20
T35	70.03
T35	30.00
T35	22.73
T35	15.15
T36	49.46
T37	27.03
T37	58.74
T37	35.00
T39	18.40
T39	12.46
T39	9.21
T40	36.54
T44	72.91
T45	5.80
T46	20.36
T47	4.36
T48	41.72

Metric 37	
StationID	**% Shredders**
R01	8.48
R01	3.63
R01	26.17
R14	0.33
R15	2.92
R16	11.60
R16	2.97
R16	0.00
R17	1.39
R18	2.46
R18	4.98
R18	1.09
R19	0.61
R20	24.76
T34	5.99
T35	0.65
T35	0.00
T35	0.00
T35	0.00
T35	0.00
T36	0.36
T37	5.41
T37	29.37
T37	6.76
T39	0.00
T39	0.00
T39	0.00
T40	0.00
T44	0.00
T45	0.00
T46	0.00
T47	4.36
T48	0.00

Metric 38	
StationID	**% Scrapers**
R01	6.01
R01	11.18
R01	15.10
R14	2.00
R15	9.12
R16	1.60
R16	0.89
R16	0.00
R17	3.13
R18	13.23
R18	11.74
R18	5.11
R19	2.75
R20	6.03
T34	6.59
T35	0.00
T35	0.00
T35	0.00
T35	0.00
T35	0.00
T36	6.50
T37	0.68
T37	0.00
T37	2.65
T39	3.07
T39	0.00
T39	1.32
T40	1.60
T44	0.00
T45	0.00
T46	2.50
T47	0.00
T48	0.32

Metric 39			
StationID	Scrapers	Filterers	**Scrapers / (Scrapers+Filterers)**
R01	17	231	6.85
R01	37	246	13.07
R01	45	132	25.42
R14	6	36	14.29
R15	25	33	43.10
R16	4	35	10.26
R16	3	10	23.08
R16	0.00	4	0.00
R17	9	3	75.00
R18	43	66	39.45
R18	33	97	25.38
R18	14	77	15.38
R19	9	47	16.07
R20	19	201	8.64
T34	22	21	51.16
T35	0.00	254	0.00
T35	0.00	201	0.00
T35	0.00	21	0.00
T35	0.00	5	0.00
T35	0.00	5	0.00
T36	18	137	11.61
T37	2	80	2.44
T37	0.00	168	0.00
T37	9	119	7.03
T39	10	60	14.29
T39	0.00	36	0.00
T39	4	28	12.50
T40	5	114	4.20
T44	0.00	218	0.00
T45	0.00	16	0.00
T46	7	57	10.94
T47	0.00	12	0.00
T48	1	131	0.76

Metric 40	
StationID	**Gatherer Taxa**
R01	3
R01	6
R01	8
R14	14
R15	12
R16	8
R16	8
R16	6
R17	9
R18	13
R18	12
R18	13
R19	7
R20	3
T34	11
T35	6
T35	7
T35	6
T35	3
T35	3
T36	10
T37	8
T37	1
T37	7
T39	11
T39	6
T39	6
T40	5
T44	5
T45	6
T46	6
T47	9
T48	5

Metric 41	
StationID	**Filterer Taxa**
R01	7
R01	9
R01	7
R14	1
R15	5
R16	1
R16	1
R16	1
R17	2
R18	7
R18	4
R18	2
R19	2
R20	8
T34	3
T35	1
T35	1
T35	1
T35	1
T35	1
T36	4
T37	4
T37	5
T37	5
T39	1
T39	1
T39	1
T40	1
T44	3
T45	2
T46	2
T47	3
T48	2

Metric 42	
StationID	**Shredder Taxa**
R01	1
R01	2
R01	2
R14	1
R15	2
R16	3
R16	2
R16	0
R17	3
R18	3
R18	4
R18	2
R19	2
R20	2
T34	2
T35	1
T35	0
T35	0
T35	0
T35	0
T36	1
T37	3
T37	2
T37	2
T39	0
T39	0
T39	0
T40	0
T44	0
T45	0
T46	0
T47	2
T48	0

Metric 43	
StationID	**Scraper Taxa**
R01	3
R01	3
R01	2
R14	2
R15	4
R16	2
R16	2
R16	0
R17	2
R18	5
R18	4
R18	4
R19	3
R20	3
T34	2
T35	0
T35	0
T35	0
T35	0
T35	0
T36	4
T37	1
T37	0
T37	3
T39	1
T39	0
T39	1
T40	1
T44	0
T45	0
T46	1
T47	0
T48	1

Metric 44	
StationID	**No. Clingers**
R01	82
R01	85
R01	19
R14	8
R15	19
R16	28
R16	5
R16	0
R17	11
R18	46
R18	71
R18	14
R19	45
R20	149
T34	24
T35	2
T35	1
T35	1
T35	0
T35	0
T36	44
T37	20
T37	119
T37	39
T39	1
T39	0
T39	0
T40	2
T44	2
T45	1
T46	10
T47	13
T48	6

Metric 45	
StationID	**Clinger Taxa**
R01	3
R01	5
R01	4
R14	3
R15	4
R16	4
R16	3
R16	0
R17	4
R18	6
R18	5
R18	3
R19	5
R20	5
T34	5
T35	1
T35	1
T35	1
T35	0
T35	0
T36	4
T37	4
T37	3
T37	5
T39	1
T39	0
T39	0
T40	1
T44	1
T45	1
T46	2
T47	3
T48	2

Metric 46	
StationID	**% Clingers**
R01	28.98
R01	25.68
R01	6.38
R14	2.67
R15	6.93
R16	11.20
R16	1.48
R16	0.00
R17	3.82
R18	14.15
R18	25.27
R18	5.11
R19	13.76
R20	47.30
T34	7.19
T35	0.65
T35	0.35
T35	1.43
T35	0.00
T35	0.00
T36	15.88
T37	6.76
T37	41.61
T37	11.47
T39	0.31
T39	0.00
T39	0.00
T40	0.64
T44	0.67
T45	0.36
T46	3.57
T47	4.73
T48	1.91

Metric 47	
StationID	**Predator Ind.**
R01	4
R01	9
R01	10
R14	129
R15	49
R16	43
R16	47
R16	13
R17	106
R18	23
R18	24
R18	33
R19	65
R20	4
T34	38
T35	4
T35	7
T35	26
T35	5
T35	6
T36	20
T37	22
T37	4
T37	21
T39	88
T39	185
T39	178
T40	19
T44	20
T45	64
T46	57
T47	37
T48	24

Metric 48	
StationID	**Predator Taxa**
R01	3
R01	4
R01	6
R14	9
R15	10
R16	7
R16	11
R16	3
R17	12
R18	5
R18	4
R18	6
R19	10
R20	1
T34	7
T35	3
T35	5
T35	6
T35	2
T35	3
T36	6
T37	9
T37	1
T37	6
T39	6
T39	8
T39	9
T40	6
T44	7
T45	7
T46	7
T47	10
T48	7

Metric 49	
StationID	**% Predators**
R01	1.41
R01	2.72
R01	3.36
R14	43.00
R15	17.88
R16	17.20
R16	13.95
R16	4.17
R17	36.81
R18	7.08
R18	8.54
R18	12.04
R19	19.88
R20	1.27
T34	11.38
T35	1.29
T35	2.44
T35	37.14
T35	22.73
T35	18.18
T36	7.22
T37	7.43
T37	1.40
T37	6.18
T39	26.99
T39	64.01
T39	58.55
T40	6.09
T44	6.69
T45	23.19
T46	20.36
T47	13.45
T48	7.64

Appendix BB.
TSS Loading and Reductions by Site

Total Suspended Solids Loading

					Modeled				Reduct.
					Loading		Max. 10%MOS		Monthly
Site ID	StreamName	Year	Month	Q (hm3)	Conc (ppb)	Mass (kg)	Conc (ppb)	Mass (kg)	Ave. (%)
R01	BSR nr Brookings	2001	4	242.07	54004	13072770	158000	34770055	-166
R01	BSR nr Brookings	2001	5	157.91	53604	8464515	158000	22681475	-168
R01	BSR nr Brookings	2001	6	100.80	53604	5403293	158000	14478689	-168
R01	BSR nr Brookings	2001	7	54.00	73882	3989372	158000	7755933	-94
R01	BSR nr Brookings	2001	8	32.68	104556	3416589	158000	4693605	-37
R01	BSR nr Brookings	2001	9	17.85	104556	1866468	158000	2564053	-37
R01	BSR nr Brookings	2001	10	12.12	104556	1266854	158000	1740442	-37
R01	BSR nr Brookings	2002	4	44.46	88170	3919799	158000	6385642	-63
R01	BSR nr Brookings	2002	5	43.34	79209	3432607	158000	6224625	-81
R01	BSR nr Brookings	2002	6	11.52	104556	1204882	158000	1655265	-37
R01	BSR nr Brookings	2002	7	3.33	104556	347961	158000	478022	-37
R01	BSR nr Brookings	2002	8	4.57	104556	477556	158000	655987	-37
R01	BSR nr Brookings	2002	9	2.30	104556	240348	158000	330220	-37
R01	BSR nr Brookings	2002	10	3.17	104556	331630	158000	455615	-37
				730.11		47434644		104869627	-121
R14	BSR at Watertown	2001	4	64.99	16951	1101605	158000	9334784	-747
R14	BSR at Watertown	2001	5	22.27	16915	376628	158000	3198207	-749
R14	BSR at Watertown	2001	6	11.27	20229	228034	158000	1619069	-610
R14	BSR at Watertown	2001	7	3.94	46796	184233	158000	565496	-207
R14	BSR at Watertown	2001	8	0.92	46796	42881	158000	131571	-207
R14	BSR at Watertown	2001	9	0.24	46796	11244	158000	34473	-207
R14	BSR at Watertown	2001	10	0.34	46796	15710	158000	48262	-207
R14	BSR at Watertown	2002	4	2.06	46796	96410	158000	295891	-207
R14	BSR at Watertown	2002	5	3.03	46796	141638	158000	434787	-207
R14	BSR at Watertown	2002	6	1.25	46796	58625	158000	179976	-207
R14	BSR at Watertown	2002	7	0.12	46796	5427	158000	16662	-207
R14	BSR at Watertown	2002	8	0.04	46796	1900	158000	5889	-210
R14	BSR at Watertown	2002	9	0.06	46796	2798	158000	8618	-208
R14	BSR at Watertown	2002	10	0.15	46796	6800	158000	20827	-206
				110.66		2273933		15894513	-599
R15	BSR at Broadway	2001	4	68.27	31652	2161035	158000	9806629	-354
R15	BSR at Broadway	2001	5	26.10	31675	826692	158000	3748765	-353
R15	BSR at Broadway	2001	6	11.07	31113	344346	158000	1589624	-362
R15	BSR at Broadway	2001	7	4.51	28777	129909	158000	648375	-399
R15	BSR at Broadway	2001	8	1.51	28777	43341	158000	216316	-399
R15	BSR at Broadway	2001	9	0.55	28777	15827	158000	79000	-399
R15	BSR at Broadway	2001	10	0.53	28777	15151	158000	75696	-400
R15	BSR at Broadway	2002	4	4.39	29330	128650	158000	629989	-390
R15	BSR at Broadway	2002	5	3.52	28777	101261	158000	505456	-399
R15	BSR at Broadway	2002	6	1.35	28777	38954	158000	194484	-399
R15	BSR at Broadway	2002	7	0.56	28777	16163	158000	80724	-399
R15	BSR at Broadway	2002	8	1.55	30010	46356	158000	221918	-379
R15	BSR at Broadway	2002	9	0.58	28777	16759	158000	83596	-399
R15	BSR at Broadway	2002	10	0.58	28777	16603	158000	82878	-399
				125.06		3901046		17963451	-360

					Modeled				Reduct.
					Loading		Max. 10%MOS		Monthly
Site ID	StreamName	Year	Month	Q (hm3)	Conc (ppb)	Mass (kg)	Conc (ppb)	Mass (kg)	Ave. (%)
R16	BSR 20th Ave	2001	4	96.08	24054	2311027	158000	13800007	-497
R16	BSR 20th Ave	2001	5	36.73	24030	882537	158000	5275333	-498
R16	BSR 20th Ave	2001	6	15.57	24623	383479	158000	2236993	-483
R16	BSR 20th Ave	2001	7	6.35	27088	172081	158000	912522	-430
R16	BSR 20th Ave	2001	8	2.12	27088	57411	158000	304365	-430
R16	BSR 20th Ave	2001	9	0.77	27088	20965	158000	111175	-430
R16	BSR 20th Ave	2001	10	0.74	27088	20070	158000	106435	-430
R16	BSR 20th Ave	2002	4	6.17	26504	163592	158000	886524	-442
R16	BSR 20th Ave	2002	5	4.95	27088	134133	158000	711287	-430
R16	BSR 20th Ave	2002	6	1.91	27088	51599	158000	273627	-430
R16	BSR 20th Ave	2002	7	0.79	27088	21410	158000	113473	-430
R16	BSR 20th Ave	2002	8	2.17	25787	56054	158000	312265	-457
R16	BSR 20th Ave	2002	9	0.82	27088	22199	158000	117782	-431
R16	BSR 20th Ave	2002	10	0.81	27088	21992	158000	116633	-430
				175.99		4318550		25278420	-485
R17	BSR below Watertown	2001	4	101.69	50028	5087368	158000	14606382	-187
R17	BSR below Watertown	2001	5	38.87	50108	1947844	158000	5583576	-187
R17	BSR below Watertown	2001	6	16.48	47885	789354	158000	2367702	-200
R17	BSR below Watertown	2001	7	6.72	40023	269112	158000	965811	-259
R17	BSR below Watertown	2001	8	2.24	40023	89782	158000	322176	-259
R17	BSR below Watertown	2001	9	0.82	40023	32787	158000	117638	-259
R17	BSR below Watertown	2001	10	0.78	40023	31387	158000	112611	-259
R17	BSR below Watertown	2002	4	6.53	41950	274058	158000	938376	-242
R17	BSR below Watertown	2002	5	5.24	40023	209766	158000	752798	-259
R17	BSR below Watertown	2002	6	2.02	40023	80694	158000	289571	-259
R17	BSR below Watertown	2002	7	0.84	40023	33482	158000	120224	-259
R17	BSR below Watertown	2002	8	2.30	44314	101954	158000	330507	-224
R17	BSR below Watertown	2002	9	0.88	40023	35010	158000	125682	-259
R17	BSR below Watertown	2002	10	0.79	40023	31485	158000	113042	-259
				186.21		9014083		26746096	-197
R18	BSR nr Castlewood	2001	4	95.98	48571	4662016	158000	13786793	-196
R18	BSR nr Castlewood	2001	5	39.82	48581	1934341	158000	5719169	-196
R18	BSR nr Castlewood	2001	6	20.74	48541	1006704	158000	2978875	-196
R18	BSR nr Castlewood	2001	7	8.48	46743	396523	158000	1218467	-207
R18	BSR nr Castlewood	2001	8	3.00	46743	139990	158000	430191	-207
R18	BSR nr Castlewood	2001	9	1.29	46743	60045	158000	184573	-207
R18	BSR nr Castlewood	2001	10	1.29	46743	60502	158000	185865	-207
R18	BSR nr Castlewood	2002	4	5.08	46743	237205	158000	728955	-207
R18	BSR nr Castlewood	2002	5	6.08	46743	284326	158000	873740	-207
R18	BSR nr Castlewood	2002	6	2.66	46743	124435	158000	382360	-207
R18	BSR nr Castlewood	2002	7	1.34	46743	62710	158000	192760	-207
R18	BSR nr Castlewood	2002	8	3.70	47877	177045	158000	531167	-200
R18	BSR nr Castlewood	2002	9	1.22	46743	57071	158000	175380	-207
R18	BSR nr Castlewood	2002	10	1.26	46743	58672	158000	180264	-207
				191.93		9261584		27568558	-198

					Modeled				Reduct.
					Loading		Max. 10%MOS		Monthly
Site ID	StreamName	Year	Month	Q (hm3)	Conc (ppb)	Mass (kg)	Conc (ppb)	Mass (kg)	Ave. (%)
R19	BSR nr Estelline	2001	4	117.04	51448	6021282			
R19	BSR nr Estelline	2001	5	48.55	51360	2493522	158000	6973545	-180
R19	BSR nr Estelline	2001	6	25.29	51716	1307802	158000	3632276	-178
R19	BSR nr Estelline	2001	7	10.34	67880	702131	158000	1485775	-112
R19	BSR nr Estelline	2001	8	3.65	67880	247882	158000	524560	-112
R19	BSR nr Estelline	2001	9	1.57	67880	106322	158000	224935	-112
R19	BSR nr Estelline	2001	10	1.58	67880	106930	158000	226227	-112
R19	BSR nr Estelline	2002	4	8.96	64525	578299	158000	1287269	-123
R19	BSR nr Estelline	2002	5	7.42	67880	503460	158000	1065351	-112
R19	BSR nr Estelline	2002	6	3.51	67880	238364	158000	504451	-112
R19	BSR nr Estelline	2002	7	1.64	67880	111041	158000	234989	-112
R19	BSR nr Estelline	2002	8	4.51	57681	260081	158000	647656	-149
R19	BSR nr Estelline	2002	9	1.49	67880	101057	158000	213875	-112
R19	BSR nr Estelline	2002	10	1.53	67880	103892	158000	219907	-112
				120.03		6860782		17240816	-151
R20	BSR nr Bruce	2001	4	134.50	47835	6433844	158000	19319378	-200
R20	BSR nr Bruce	2001	5	112.03	47835	5359040	158000	16091869	-200
R20	BSR nr Bruce	2001	6	81.61	47835	3903730	158000	11722020	-200
R20	BSR nr Bruce	2001	7	52.65	47835	2518294	158000	7561880	-200
R20	BSR nr Bruce	2001	8	34.22	86412	2957345	158000	4915811	-66
R20	BSR nr Bruce	2001	9	18.79	116085	2181415	158000	2699215	-24
R20	BSR nr Bruce	2001	10	12.13	116085	1408263	158000	1742453	-24
R20	BSR nr Bruce	2002	4	20.24	104907	2123571	158000	2907631	-37
R20	BSR nr Bruce	2002	5	15.38	116085	1785750	158000	2209558	-24
R20	BSR nr Bruce	2002	6	6.70	116085	777697	158000	962220	-24
R20	BSR nr Bruce	2002	7	2.65	116085	307614	158000	380636	-24
R20	BSR nr Bruce	2002	8	4.47	116085	518370	158000	641336	-24
R20	BSR nr Bruce	2002	9	1.86	116085	215585	158000	266733	-24
R20	BSR nr Bruce	2002	10	2.12	116085	245977	158000	304365	-24
				499.35		30736496		71725105	-133

Total Suspended Solids Loading										
					Modeled				Reduct.
					Loading		Max. 10%MOS		Monthly
Site ID	StreamName	Year	Month	Q (hm3)	Conc (ppb)	Mass (kg)	Conc (ppb)	Mass (kg)	Ave. (%)
T35	Willow Creek (nr Waverly)	2001	5	0.05	4994	265	263000	12672	-4682
T35	Willow Creek (nr Waverly)	2001	6	0.57	4662	2650	263000	135804	-5025
T35	Willow Creek (nr Waverly)	2001	7	0.35	7842	2738	263000	83443	-2947
T35	Willow Creek (nr Waverly)	2001	8	0.12	14305	1638	263000	27495	-1579
T35	Willow Creek (nr Waverly)	2001	9	0.04	33567	1275	263000	9085	-613
T35	Willow Creek (nr Waverly)	2001	10	0.03	39380	1275	263000	7651	-500
T35	Willow Creek (nr Waverly)	2002	4	0.17	11650	2032	263000	41602	-1948
T35	Willow Creek (nr Waverly)	2002	5	0.27	10205	2738	263000	64076	-2240
T35	Willow Creek (nr Waverly)	2002	6	0.16	11535	1871	263000	38733	-1971
T35	Willow Creek (nr Waverly)	2002	7	0.07	18908	1317	263000	16736	-1171
T35	Willow Creek (nr Waverly)	2002	8	0.06	22768	1363	263000	14345	-953
T35	Willow Creek (nr Waverly)	2002	9	0.05	28326	1275	263000	10759	-744
T35	Willow Creek (nr Waverly)	2002	10	0.04	35372	1275	263000	8607	-575
				1.97		21710		471009	-2070
T36	Willow Creek (nr Watertown)	2001	4	22.23	58360	1297519	263000	5315708	-310
T36	Willow Creek (nr Watertown)	2001	5	5.60	55181	308990	263000	1338909	-333
T36	Willow Creek (nr Watertown)	2001	6	2.34	40366	94610	263000	560429	-492
T36	Willow Creek (nr Watertown)	2001	7	0.34	8477	2852	263000	80335	-2717
T36	Willow Creek (nr Watertown)	2001	8	0.10	8477	810	263000	22953	-2734
T36	Willow Creek (nr Watertown)	2001	9	0.03	8477	246	263000	6934	-2721
T36	Willow Creek (nr Watertown)	2001	10	0.03	8477	279	263000	7890	-2726
T36	Willow Creek (nr Watertown)	2002	4	2.29	33200	76002	263000	547279	-620
T36	Willow Creek (nr Watertown)	2002	5	1.22	8477	10321	263000	291213	-2722
T36	Willow Creek (nr Watertown)	2002	6	0.12	8477	1032	263000	29169	-2727
T36	Willow Creek (nr Watertown)	2002	7	0.03	8477	251	263000	7173	-2762
T36	Willow Creek (nr Watertown)	2002	8	0.85	52452	44692	263000	203705	-356
T36	Willow Creek (nr Watertown)	2002	9	0.02	8477	136	263000	3825	-2715
T36	Willow Creek (nr Watertown)	2002	10	0.03	8477	213	263000	5977	-2706
				35.22		1837953		8421499	-358
T37	Stray Horse Creek	2001	6	3.59	71120	255458	263000	858815	-236
T37	Stray Horse Creek	2001	7	1.44	63710	91502	263000	343335	-275
T37	Stray Horse Creek	2001	8	0.09	29433	2776	263000	22475	-710
T37	Stray Horse Creek	2001	9	0.02	29433	587	263000	4782	-715
T37	Stray Horse Creek	2001	10	0.10	29433	2940	263000	23909	-713
T37	Stray Horse Creek	2002	4	0.16	37871	5869	263000	37059	-531
T37	Stray Horse Creek	2002	5	0.25	40642	10011	263000	58816	-487
T37	Stray Horse Creek	2002	6	0.03	29433	846	263000	6934	-719
T37	Stray Horse Creek	2002	7	0.14	58867	8246	263000	33473	-306
T37	Stray Horse Creek	2002	8	2.10	69921	146476	263000	500895	-242
T37	Stray Horse Creek	2002	9	0.07	29433	2185	263000	17693	-710
T37	Stray Horse Creek	2002	10	0.18	29433	5152	263000	41841	-712
				8.16		532047		1950025	-267

Total Suspended Solids Loading									
					Modeled				Reduct.
					Loading		Max. 10%MOS		Monthly
Site ID	StreamName	Year	Month	Q (hm3)	Conc (ppb)	Mass (kg)	Conc (ppb)	Mass (kg)	Ave. (%)
T39	Lake Poinsett Outlet	2001	6	23.05	11914	274548	263000	5509850	-1907
T39	Lake Poinsett Outlet	2001	7	36.20	13829	500647	263000	8655569	-1629
T39	Lake Poinsett Outlet	2001	8	27.39	18278	500647	263000	6548700	-1208
T39	Lake Poinsett Outlet	2001	9	17.88	27092	484497	263000	4275902	-783
T39	Lake Poinsett Outlet	2001	10	8.49	29184	247720	263000	2029404	-719
T39	Lake Poinsett Outlet	2002	4	2.20	28618	62952	263000	526000	-736
T39	Lake Poinsett Outlet	2002	5	4.02	32348	130100	263000	961624	-639
T39	Lake Poinsett Outlet	2002	6	1.95	64672	125903	263000	465510	-270
T39	Lake Poinsett Outlet	2002	7	0.02	8575395	130100	263000	3586	97
T39	Lake Poinsett Outlet	2002	8	0.92	154645	142053	263000	219725	-55
				130.27		3131213		31145895	-895
T40	Hidewood Creek (nr Clear Lake)	2001	6	3.95	3589	14167	263000	943931	-6563
T40	Hidewood Creek (nr Clear Lake)	2001	7	3.34	5710	19094	263000	799520	-4087
T40	Hidewood Creek (nr Clear Lake)	2001	8	0.69	9781	6738	263000	164734	-2345
T40	Hidewood Creek (nr Clear Lake)	2001	9	0.18	16841	3034	263000	43036	-1319
T40	Hidewood Creek (nr Clear Lake)	2001	10	0.07	42114	3034	263000	17215	-467
T40	Hidewood Creek (nr Clear Lake)	2002	4	1.15	12292	14167	263000	275433	-1844
T40	Hidewood Creek (nr Clear Lake)	2002	5	1.17	14530	17035	263000	280215	-1545
T40	Hidewood Creek (nr Clear Lake)	2002	6	0.20	15394	3034	263000	47101	-1453
T40	Hidewood Creek (nr Clear Lake)	2002	7	0.00	2087206	3135	263000	478	85
T40	Hidewood Creek (nr Clear Lake)	2002	8	0.02	154085	3135	263000	4782	-53
T40	Hidewood Creek (nr Clear Lake)	2002	9	0.00	0	3034	263000	0	100
T40	Hidewood Creek (nr Clear Lake)	2002	10	0.01	390898	3034	263000	1913	37
				10.78		92637		2578356	-2683
T41	Hidewood Creek (nr Estelline)	2001	5	0.16	21982	3472	263000	37776	-988
T41	Hidewood Creek (nr Estelline)	2001	6	3.16	18681	59068	263000	756005	-1180
T41	Hidewood Creek (nr Estelline)	2001	7	1.52	20707	31552	263000	364375	-1055
T41	Hidewood Creek (nr Estelline)	2001	8	0.79	21982	17386	263000	189121	-988
T41	Hidewood Creek (nr Estelline)	2001	9	1.91	19282	36761	263000	455707	-1140
T41	Hidewood Creek (nr Estelline)	2001	10	2.84	18392	52158	263000	678062	-1200
T41	Hidewood Creek (nr Estelline)	2002	4	1.61	18392	29636	263000	385175	-1200
T41	Hidewood Creek (nr Estelline)	2002	5	1.96	18392	36075	263000	468857	-1200
T41	Hidewood Creek (nr Estelline)	2002	6	0.49	21111	10324	263000	116915	-1033
T41	Hidewood Creek (nr Estelline)	2002	7	0.03	21982	558	263000	5977	-971
				14.46		276988		3457972	-1148
T42	Peg Munky Run	2001	5	0.01	4093	40	263000	2391	-5938
T42	Peg Munky Run	2001	6	1.11	21939	24428	263000	266108	-989
T42	Peg Munky Run	2001	7	0.17	13694	2374	263000	41363	-1643
T42	Peg Munky Run	2001	8	0.02	4093	61	263000	3586	-5828
T42	Peg Munky Run	2001	10	0.00	4093	17	263000	956	-5559
T42	Peg Munky Run	2002	4	0.27	6665	1788	263000	64076	-3484
T42	Peg Munky Run	2002	5	0.26	8913	2280	263000	61207	-2585
T42	Peg Munky Run	2002	6	0.05	4093	209	263000	12194	-5740
				1.89		31195		451882	-1349

Appendix CC.
AgNPS Model Outputs for Feedlots in the NCBSRW Study

AgNPS Model Output for Feedlots in the NCBSRW Study Area

Site	Density	Mean PO4 (ppm)	Mean COD (ppm)	Mean PO4 (lbs)	Mean COD (lbs)	Sum Phos (ppm)	Sum COD (ppm)	Sum Phos (lbs)	Sum COD (lbs)
R1	22	11.6	624.6	46.2	2,558.2	255.5	13,741.8	1,016.1	56,279.7
R17	7	4.7	244.4	15.4	750.7	33.0	1,711.0	108.0	5,255.0
R18	40	39.7	2,203.0	112.8	655.8	1,588.0	88,118.0	4,512.0	26,232.6
R19	49	31.5	1,710.4	120.3	6,972.4	1,543.0	83,808.0	5,897.0	341,650.0
R20	36	28.5	1,490.5	177.4	9,146.3	1,025.2	53,656.2	6,386.9	329,265.5
T35	2	24.0	2,633.5	89.0	9,435.0	48.0	5,267.0	178.0	18,870.0
T36	24	31.2	1,980.0	174.8	11,352.1	749.0	47,521.0	4,194.0	272,450.0
T37	53	30.1	1,731.9	142.1	8,341.3	1,592.7	91,789.0	7,532.5	442,087.0
T39	2	75.0	3,981.0	129.5	6,852.0	150.0	7,962.0	259.0	13,704.0
T41	39	36.8	1,880.9	138.7	6,961.7	1,437.0	73,357.0	5,410.0	271,505.0
T42	19	21.3	1,065.3	63.6	2,942.4	405.0	20,241.0	1,209.0	55,905.0
T46	11	12.9	826.7	46.5	2,935.5	142.0	9,094.0	511.0	32,291.0
T47	11	29.5	1,731.7	112.0	7,689.8	325.0	19,049.0	1,232.0	84,588.0

Appendix DD.
TMDL – Lake Kampeska to Willow Creek
(Fecal Coliform Bacteria)

DRAFT

To be Submitted at a Later Date

DRAFT

To be Submitted at a Later Date

TOTAL MAXIMUM DAILY LOAD EVALUATION
(Fecal Coliform Bacteria)

for the

Big Sioux River
(Lake Kampeska to Willow Creek)

(HUC 10170202)

Codington County, South Dakota

East Dakota Water Development District
Brookings, South Dakota

December 2005

Lake Kampeska to Willow Creek Total Maximum Daily Load

Waterbody Type:	River Segment
Assessment Unit ID:	SD-BS-R-BIG_SIOUX_02
303(d) Listing Parameter:	Fecal Coliform Bacteria
Designated Uses:	Warmwater Semi-permanent Fish Life Propagation Domestic Water Supply Limited Contact Recreation Fish and Wildlife Propagation Recreation and Stock Watering Irrigation
Size of Waterbody:	9.6 miles
Size of Watershed:	8,061 acres
Water Quality Standards:	Narrative and Numeric
Indicators:	Water Chemistry
Analytical Approach:	Modeling and Assessment Techniques used include Flow Duration Interval
Location:	HUC Code: 10170202
Goal:	Reduce the fecal coliform counts per day by 33 percent during high flow conditions
Target:	≤ 2000 cfu/100mL of fecal coliform bacteria (any one sample) during the months of May through September

Objective

The intent of this summary is to clearly identify the components of the TMDL submittal to support adequate public participation and facilitate the US Environmental Protection Agency (EPA) review and approval. The TMDL was developed in accordance with Section 303(d) of the federal Clean Water Act and guidance developed by EPA.

Introduction

The section of the Big Sioux River from Lake Kampeska to Willow Creek is a 9.6 mile segment with a watershed of approximately 8,061 acres and is located within the Big Sioux River Basin (HUC 10170202) in the south-central part of Codington County, South Dakota. The watershed of this segment lies within Codington County as shown by the shaded region in Figure 1 and is included as part of the North-Central Big Sioux River Watershed Assessment Project. The entire study area for this project is also outlined in Figure 1.

The North-Central Big Sioux River Watershed Assessment Project identified the Big Sioux River segment Lake Kampeska to Willow Creek for TMDL development due to not supporting of its beneficial use limited contact recreation because of excessive fecal coliform bacteria. Information supporting this listing was derived from East Dakota Water Development District monitoring data and SD DENR ambient water quality data. Appendix B of the assessment report summarizes the data collected during the North-Central Big Sioux River Watershed Assessment Project from April 2001 through October 2002, and from May 2004 through September 2004.

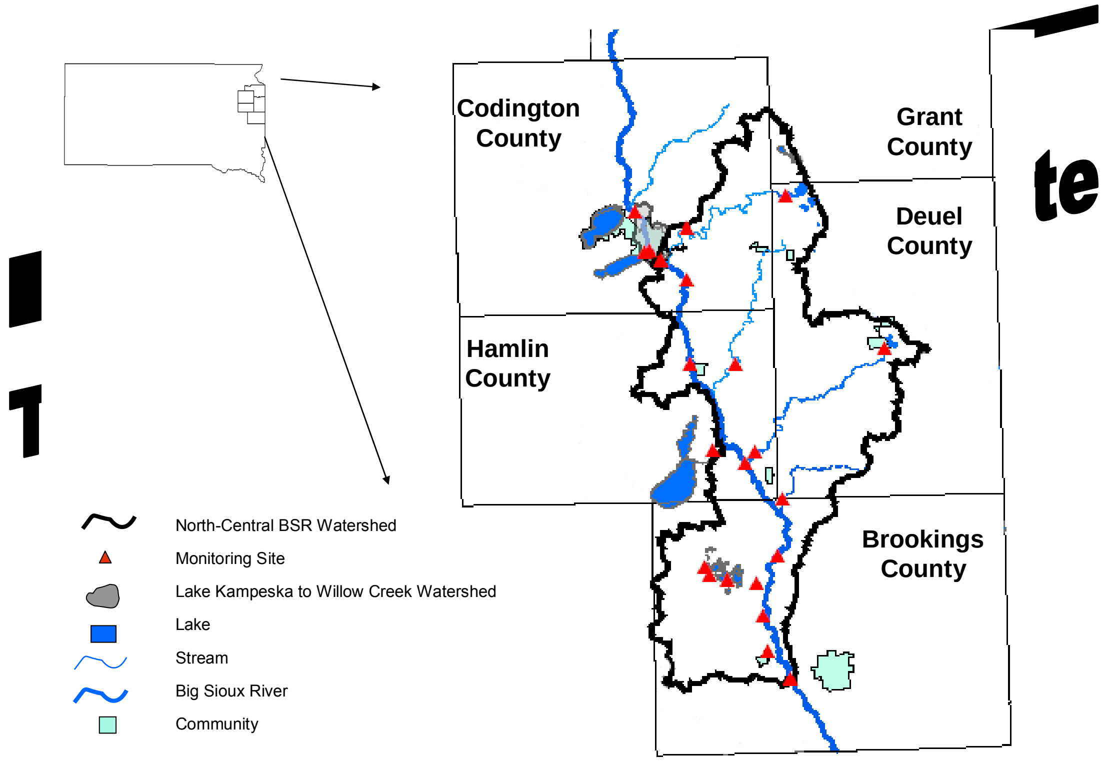


Figure 1. Location of the Lake Kampeska to Willow Creek Segment and its Watershed in South Dakota.

Problem Identification

The Lake Kampeska to Willow Creek segment is a small portion of the Big Sioux River, starting near the confluence of Mud Creek and the Big Sioux River just north of monitoring site R14 and ending at the confluence of the Big Sioux River and Willow Creek. The watershed area shown in Figure 2 drains approximately 61 percent grass/grazing land and cropland acres. The municipality of Watertown is located in this area.

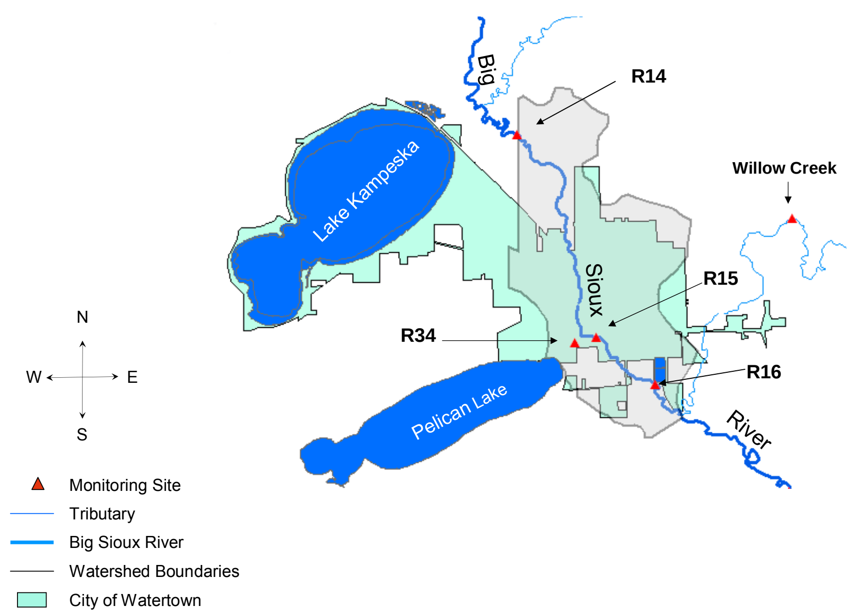


Figure 2. Big Sioux River Segment (Lake Kampeska to Willow Creek) Watershed

The river segment Lake Kampeska to Willow Creek (R14-R16) was found to contain fecal coliform bacteria which degrades water quality. This segment is considered impaired because more than 10 percent of the values (of 20 or more samples) exceeded the numeric criteria of ≤ 2000 counts per 100 milliliters of fecal coliform bacteria. This segment requires reducing the fecal coliform counts per day by 33 percent during high flow conditions. Table 1 displays the fecal coliform data collected from May 2003 to September 2003 and from May 2004 to September 2004.

Table 1. Summary of Fecal Coliform Data for the Lake Kampeska to Willow Creek Segment.

Parameter Causing Impairment	Number of Samples (May-Sep)	Percent of Samples > 2000 counts/100mL	Minimum Concentration (counts/100mL)	Maximum Concentration (counts/100mL)
Fecal Coliform	76	16	no detect	31,000

Description of Applicable Water Quality Standards & Numeric Water Quality Targets

The Big Sioux River segment from Lake Kampeska to Willow Creek has been assigned beneficial uses by the state of South Dakota Surface Water Quality Standards regulations (See page 12 of the Assessment Report). Along with these assigned uses are narrative and numeric criteria that define the desired water quality of this river segment. These criteria must be maintained for the segment to satisfy its assigned beneficial uses, which are listed below:

- Domestic water supply
- Warmwater semi-permanent fish propagation
- Limited contact recreation
- Fish and wildlife propagation, recreation and stock watering
- Irrigation

Individual parameters determine the support of beneficial uses. Use support for limited contact recreation involved monitoring the levels of fecal coliform from May 1 through September 30. This segment experiences excess loading of fecal coliform bacteria due to poor riparian areas, in-stream livestock, stormwater runoff, feedlot/manure runoff, and NPDES systems. Administrative Rules of South Dakota Article 74:51 contains numeric and narrative standards to be applied to the surface waters (i.e. streams, rivers) of the state. To assess the status of the beneficial uses for this river segment, water samples were obtained using SD DENR standard operating procedures and the results were compared to the applicable water quality criteria. Water samples from both the East Dakota Water Development District and the SD DENR ambient water quality monitoring program were utilized.

The Lake Kampeska to Willow Creek Big Sioux River Segment is currently assigned a numeric standard of ≤ 2000 cfu/100mL for fecal coliform bacteria. A flow duration interval with hydrologic zones approach was used to assess this segment. This methodology, developed by Dr. Bruce Cleland, was used in order to target restoration efforts by dividing the range of flows into hydrologic conditions. For example, if all the exceedences occurred during low-flow conditions, point sources of the pollutant should be suspected. Conversely, if all the exceedences occurred during higher flow periods, then non-point sources of pollution should be suspected. Using Dr. Cleland's approach, the following five hydrologic conditions were utilized:

High Flows (0 to 10 percent), Moist Conditions (10-40 percent), Mid-Range Flows (40-60 percent), Dry Conditions (60-90 percent), and Low Flows (90-100 percent). The methodology of flow duration intervals is explained further in the Methods section of the Assessment Report.

Three monitoring locations (R14, R[illegible], and R[illegible]) were setup on this segment and one SD DENR ambient water quality monitoring site (WQM 55) existed on this segment of the Big Sioux River. Of the 76 water samples that were collected, 12 (or 16 percent) violated the water quality standard for fecal coliform bacteria. Based on the water quality violations, this segment is currently not supporting its limited contact recreation beneficial use. This segment requires reducing the fecal coliform counts per day by 33 percent during high flow conditions (Table 2).

Table 2. Lake Kampeska to Willow Creek Fecal Coliform Bacteria Reductions

	Median	High (0-10)	Moist (10-40)	Mid-Range (40-60)	Dry (60-90)	Low Flows (90-100)
	Median Concentration (counts/day)	6.59E+10	1.05E+10	9.45E+09	1.52E+10	1.00E+10
X	Flow Median (cfs)	323	52	11	2.3	0.2
=	Existing	2.13E+13	5.47E+11	1.04E+11	3.50E+10	2.00E+09
	Target Load (at 2,000 cfu/100mL)	1.58E+13	2.54E+12	5.38E+11	1.13E+11	9.79E+09
	% Reduction w/MOS	33	0	0	0	0
Note: units are counts/day						

Pelican Lake outlet was assessed as a potential source of fecal coliform bacteria into this segment of the Big Sioux River. A monitoring site (T34) was located at the Pelican Lake Weir. This inlet/outlet is not assigned numeric criteria for fecal coliform bacteria. However, its water quality was assessed at the ≤ 2000 cfu/100 mL standard for fecal coliform bacteria. Results show there is a very low potential that Pelican Lake is having an influence on the fecal coliform bacteria problems in the Lake Kampeska to Willow Creek segment of the Big Sioux River. Table 3 displays the fecal coliform data collected from May 2001 through September 2002. Of the six samples collected when the direction of flow was into the lake, one exceeded the ≤ 2000 cfu/100 mL limit. There were no fecal coliform bacteria exceedences when the direction of flow was out of the lake.

Table 3. Summary of Fecal Coliform Data for the Pelican Lake Weir

Parameter Causing Impairment	Number of Samples (May-Sep)	Percent of Samples > 2000 counts/100mL	Minimum Concentration (counts/100mL)	Maximum Concentration (counts/100mL)
Fecal Coliform	8	13	no detect	8,000

Pollutant Assessment

Point Sources

NPDES facilities taken into consideration within this area include the City of Watertown, Oak Valley Farms, and Glacial Lakes Ethanol. Total fecal coliform bacteria contribution from these facilities during the study period was insignificant at 0.00008 percent. Calculations used total colonies from the facility divided by the total colonies at the nearest downstream monitoring location.

Non-point Sources

Non-point source pollution, unlike pollution from municipalities and NPDES facilities, comes from many diffuse sources. Potential non-point sources of fecal coliform bacteria include loadings from surface runoff, wildlife, livestock, and failing septic tanks.

Wildlife

Wildlife deposit their feces onto land surfaces and in some cases directly into the water. The bacteria load from naturally occurring wildlife is assumed to be background. In addition, any strategy employed to control this source would probably have a negligible impact on attaining water quality standards.

Agriculture

Agricultural animals are the source of several types of non-point sources as indicated in the Target Reductions & Future Activity Recommendations section of the Assessment Report. Agricultural activities, including runoff from pastureland and cattle in streams, can affect water quality. There were no feedlots identified within this watershed area. However, during the assessment project, cattle were observed within the Big Sioux River near monitoring site R14. In addition, the 1995 Pelican Lake Assessment Project rated five feedlots within the Pelican Lake watershed 50 or greater on a 0 to 100 scale. A higher rating indicates a greater potential of the feedlot to pollute nearby surface waters.

Septic Systems

Data for septic tanks is discussed in the Assessment Report on page 65. Contributions from septic systems were estimated based on rural households because a direct accounting of the number of septic systems in use in the TMDL watershed was unavailable. The 25.6 percent contribution from septic systems was determined by assuming 20 percent of all rural septic systems in the North-Central Big Sioux River watershed area were failing. This percentage does not account for die-off or attenuation of fecal coliform bacteria between failing septic systems and the stream. In general, failing septic systems discharge over land for some distance, where a portion of the fecal coliform bacteria may be absorbed on the soil and surface vegetation before reaching the stream. It is assumed that failing septic systems constitute a diminutive amount of the overall contribution because not all of the failing systems would be reaching the receiving waters. These results will not directly affect the TMDL allocations. Therefore, it is implied that comparatively, failing septic systems are having an insignificant affect on the excess fecal coliform loading and will be included in the margin of safety portion of the TMDL.

Urban Areas

Fecal coliform bacteria in urban and suburban areas may be attributed to stormwater runoff, overflow of sewer systems, illicit discharge of sanitary waste, leaking septic systems, and pets.

Land Use

Landuse in the watershed was derived from digitized county common land unit (CLU) maps. Table 4 shows that 61 percent of the area is grassland or cropland.

Table 4. Land Use in the Lake Kampeska to Willow Creek Segment

LandUse	Percent	Acres
Cropland	43%	3,483
* Urban	37%	2,985
Rangeland/Grassland	18%	1,423
Building/Farmstead	2%	170

* approximation (City of Watertow n)

Linkage Analysis

Water quality data was collected at three project monitoring sites (R14, R15, and R16) and one SD DENR ambient site on the Big Sioux River. Samples were collected according to South Dakota's EPA approved Standard Operating Procedures for Field Samplers. The fecal coliform bacteria water samples were analyzed by the Sioux Falls Health Lab (2001-2002) in Sioux Falls, South Dakota and by the State Health Lab (2004) in Pierre, South Dakota. Quality Assurance/Quality Control samples were collected on 10% of the samples according to South Dakota's EPA approved Non-point Source Quality Assurance/Quality Control Plan. Details concerning water sampling techniques, analysis, and quality control are addressed in the assessment final report.

The Flow Duration Interval method calculates fecal coliform bacteria loading, (concentration) × (flow), using zones based on hydrologic conditions. Reductions are calculated using the median of the fecal coliform bacteria samples in each zone. This method shows that while a TMDL may be expressed as a single point it can also be thought of as a continuum of points representing the criterion value and various flow values. In order to assess the impact of fecal coliform bacteria for this segment of the Big Sioux River, the flow duration interval curve was divided into "flow zones". The purpose of the zones is to differentiate hydrologic conditions, between peak and low flows, as ranges. For this segment, the ranges or flow zones are High (0-10), Moist (10-40), Mid-Range (40-60), Dry (60-90) and Low (90-100). Load duration curves were calculated using the following equation:

(flow) × (conversion factor) × (state criteria) = quantity/day or daily load

This curve represents the threshold of the load. As seen in Figure 3, any samples occurring above this line is an exceedence of the water quality standard and represented by a red box (Table 5). Table 6 depicts the allowable coliform bacteria load during the study for peak flow, low flow, and 5th percentile increments in flow.

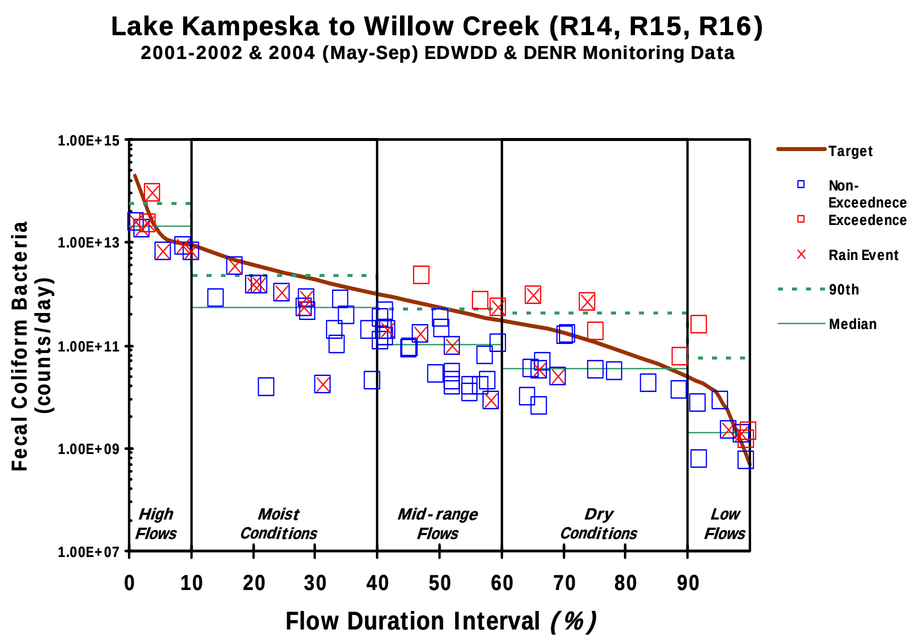


Figure 3. Flow Duration Interval for the Lake Kampeska to Willow Creek Segment

Table 5. Exceedences of the Water Quality Standard (≤ 2000 cfu/100mL)

Station	Sample Date	Sample Time	Flow (cubic feet per second - cfs)	Flow [illegible]	Flow Rank (percent)	Fecal Coliform (counts/100mL)	Fecal Coliform Load (counts/day)
R14	07/01/04	915	[illegible]	[illegible]	91.85	31000	[illegible]
R14	08/21/02	1045	[illegible]	0.738	73.79	11000	[illegible]
R16	[illegible]	1200	378.00	0.038	3.82	[illegible]	9.25E+13
R14	[illegible]	1130	0.01	[illegible]	[illegible]	8700	2.13E+09
R15	[illegible]	1120	4.80	[illegible]	65.20	8000	9.40E+11
R16	09/09/02	1245	[illegible]	[illegible]	47.24	6900	2.23E+12
R14	09/09/02	[illegible]	[illegible]	0.888	88.79	4500	5.95E+10
R15	[illegible]	[illegible]	7.40	0.567	56.67	4000	7.24E+11
R16	[illegible]	1115	6.40	0.595	59.47	3500	5.48E+11
R14	07/08/02	1200	2.20	0.753	75.28	3400	1.83E+11
R14	08/25/04	1205	0.02	0.994	99.43	3100	1.52E+09
R14	05/08/01	1000	442.00	0.030	3.02	2200	2.38E+13

Table 6. Fecal Coliform Target Loads for Flow

		Allowable Loads 2000 cfu/100mL	
Flow Rank (percent)	**cfs**	**fecal Coliform (counts/day)**	**Flow Conditions**
0.019	4666.97	2.28E+14	Peak
0.1	4294.82	2.10E+14	
0.274	4156.86	2.03E+14	
1	4109.86	2.01E+14	
5	323.00	1.58E+13	
10	184.96	9.05E+12	
15	113.00	5.53E+12	
20	75.00	3.67E+12	
25	52.00	2.54E+12	
30	38.74	1.90E+12	
35	28.00	1.37E+12	
40	20.14	9.86E+11	
45	15.12	7.40E+11	
50	11.00	5.38E+11	
55	8.06	3.94E+11	
60	6.20	3.03E+11	
65	4.83	2.37E+11	
70	3.56	1.74E+11	
75	2.30	1.13E+11	
80	1.50	7.34E+10	
85	0.90	4.40E+10	
90	0.50	2.45E+10	
95	0.20	9.79E+09	
100	0.01	4.89E+08	Low

TMDL Allocations

TMDL

Zone	TMDL			[illegible]	Non-Point Source		
					100% =	2% [illegible]	98%
	TMDL	10%[illegible]	[illegible]ations	WLA	LA	[illegible]	Other NPS
High	[illegible]	1.58[illegible]	1.42E+13	3.31E+11	1.39[illegible]	[illegible].78E+11	1.36E+13
Moist	2.54E+[illegible]	2.54[illegible]+11	2.29E+12	3.[illegible]1E+11	[illegible].96[illegible]	3.91E+10	1.92E+12
Mid-Rang[illegible]	[illegible]	5.38E+10	4.84E+11	[illegible]1E+[illegible]	[illegible].53E+11	3.06E+09	1.50E+11
Dry	1.13E+11	1.13E+10	1.02[illegible]	[illegible]1E+[illegible]	-2.29E+11	-4.59E+09	-2.25E+11
Low	9.79E+09	9.[illegible]E+08	[illegible]	3.31E+11	-3.22E+11	-6.44E+09	-3.16E+11
Note: units are counts/day							

Wasteload Allocations (WLAs)

NPDES facilities are permitted to discharge effluent at the bacteria standard. When operating properly, they will not cause or contribute to water quality violations. Their contributions are relatively small in comparison to the total loading of the segment. The worst case scenario of all point source waste loads within this segment would be approximately 3.31×10^{11} fecal counts if all the facilities discharged their maximum amount at the same time. This amount is unlikely since most dischargers operate well within their permit limits and discharge smaller loads than allowed. In order to find the TMDL, the waste load allocation (point source) was added to the allowable load (non-point source) and a 10 percent margin of safety was applied. New or increases in discharges affecting this segment will be required to meet bacterial standards prior to discharge. This ensures these additions of load will not cause violations of water quality standards. The identified point sources in this watershed are contributing an insignificant amount to the fecal coliform loading. Therefore, the “wasteload allocation” component is of no consequence, as indicated in the above TMDL.

Load Allocations (LAs)

Load allocations account for the portion of the TMDL assigned to non-point sources. Natural background constitutes two percent of the total and the remainder of the LA is assigned to those land uses likely to contribute fecal coliform bacteria loads at rates above natural background. This includes cropland, pastureland, and residential areas. Based on the flow duration interval method, a 33 percent reduction is needed from non-point sources during high flow conditions, as was shown in Table 2.

Seasonal Variation

Different seasons of the year can yield differences in water quality due to changes in precipitation and agricultural practices. When a rainfall event occurs, fecal coliform bacteria that have built up on the land surface under dry conditions are washed off and finally deposited into lakes, rivers, and wetlands. To determine seasonal differences, runoff events were noted for the East Dakota Water Development District samples. The ambient water quality samples from the SD DENR were compared to historic precipitation data. Monitoring sites R14, R15, and R16 of the Lake Kampeska to Willow Creek segment of the Big Sioux River are not meeting the water quality criteria for fecal coliform bacteria. Of the 12 samples that were exceeding the ≤ 2000 cfu/100mL standard, five (or 42 percent) were during rain events.

Margin of Safety

The margin of safety (MOS) is a portion of the loading capacity that is set aside to prevent the exceedence of a water quality standard as a means of accounting for the uncertainty involved in developing a TMDL. The MOS for this TMDL is explicit, meaning a specific quantity, in this case 10%, of the loading is set aside. This explicit MOS takes into consideration the uncertainties associated with flow and non-point sources.

Critical Conditions

The critical condition for fecal coliform loading in any watershed depends on the presence of point sources and land use within that watershed. During a dry period, typically the critical condition is non-point sources followed by a rainfall event. During the rainfall event, fecal coliform bacteria that have built up on the land surface can wash into the stream, causing wet weather exceedences.

Follow-Up Monitoring

Monitoring and evaluation efforts will be targeted toward the effectiveness of implemented BMPs. Sample sites will be based on BMP site selection and include the parameter of fecal coliform bacteria.

Once the implementation project is completed, post-implementation monitoring will be necessary to assure that the TMDL has been reached and improvement to the beneficial uses occurs. This will be achieved by recurrent water quality sampling at the original monitoring sites.

Public Participation

Efforts taken to gain public education, review, and comment during development of the TMDL involved:

1. East Dakota Water Development District monthly board meetings
2. Field demonstrations for the public
3. Articles in the local newspapers

The findings from these public meetings and comments have been taken into consideration in development of the Big Sioux River Segment – Lake Kampeska to Willow Creek TMDL.

Implementation Plan

The TMDL analysis was performed using the best data available to specify the fecal coliform reductions necessary to achieve water quality criteria. The intent of meeting the criteria is to support the designated use classifications of this segment. A detailed implementation plan is not included in this TMDL. The involvement of local land owners and agencies will be needed in order to develop an implementation plan. In general, reductions in fecal coliform bacteria should be sought through identification and installation of agricultural and urban BMPs to reduce loads during runoff events.

Appendix EE.
TMDL –Willow Creek to Stray Horse Creek
(Fecal Coliform Bacteria)

TOTAL MAXIMUM DAILY LOAD EVALUATION
(Fecal Coliform Bacteria)

for the

Big Sioux River
(Willow Creek to Stray Horse Creek)

(HUC 10170202)

Codington and Hamlin Counties, South Dakota

East Dakota Water Development District
Brookings, South Dakota

December 2005

Willow Creek to Stray Horse Creek Total Maximum Daily Load

Waterbody Type:	River Segment
Assessment Unit ID:	SD-BS-R-BIG_SIOUX_03
303(d) Listing Parameter:	Fecal Coliform Bacteria
Designated Uses:	Warmwater Semi-permanent Fish Life Propagation Domestic Water Supply Limited Contact Recreation Fish and Wildlife Propagation Recreation and Stock Watering Irrigation
Size of Waterbody:	22.4 miles
Size of Watershed:	144,371 acres
Water Quality Standards:	Narrative and Numeric
Indicators:	Water Chemistry
Analytical Approach:	Modeling and Assessment Techniques used include Flow Duration Interval, AGNPS Model, and AnnAGNPS Model
Location:	HUC Code: 10170202
Goal:	Full Support of the Limited Contact Recreation Beneficial Use during the months of May through September
Target:	≤ 2000 cfu/100mL of fecal coliform bacteria (any one sample) during the months of May through September

Objective

The intent of this summary is to clearly identify the components of the TMDL submittal to support adequate public participation and facilitate the US Environmental Protection Agency (EPA) review and approval. The TMDL was developed in accordance with Section 303(d) of the federal Clean Water Act and guidance developed by EPA.

Introduction

The section of the Big Sioux River from Willow Creek to Stray Horse Creek is a 22.4 mile segment with a watershed of approximately 144,371 acres and is located within the Big Sioux River Basin (HUC 10170202) in the south-central part of Codington County and the north-central part of Hamlin County, South Dakota. The watershed of this segment lies within Hamlin, Codington, Grant, and Deuel Counties as shown by the shaded region in Figure 1 and is included as part of the North-Central Big Sioux River Watershed Assessment Project. This watershed area includes the Willow Creek watershed. The entire study area for this project is also outlined in Figure 1.

Initially, the 1998 South Dakota 303 (d) Waterbody List identified the segment Willow Creek to Stray Horse Creek to be partially supporting of its beneficial uses. It was subsequently listed as partially supporting in the 2002 South Dakota 303 (d) Waterbody List. In the 2004 and 2006 South Dakota Integrated Report, the Willow Creek to Stray Horse Creek segment was identified as not supporting its beneficial use limited contact recreation due to excessive fecal coliform bacteria. This segment is influenced by the Willow Creek tributary. Information supporting this listing was derived from statewide ambient monitoring data. Furthermore, the North-Central Big

Sioux River Watershed Assessment Project identified this segment as impaired for fecal coliform bacteria. Appendix B of the assessment report summarizes the data collected during the North-Central Big Sioux River Watershed Assessment Project from April 2001 through October 2002, and from May 2004 through September 2004.

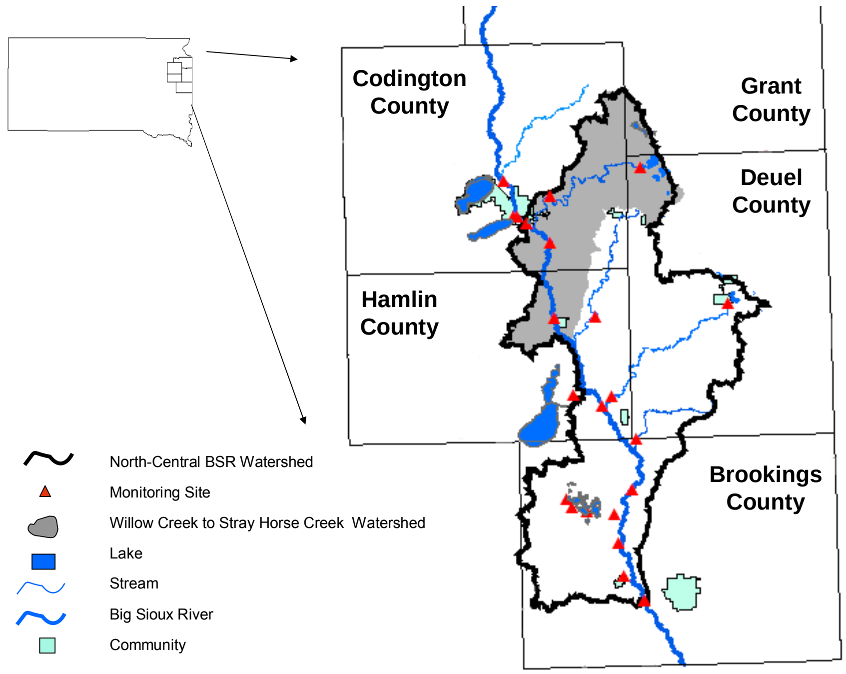


Figure 1. Location of the Willow Creek to Stray Horse Creek Segment and its Watershed in South Dakota.

Problem Identification

The Willow Creek to the Stray Horse Creek segment is a small portion of the Big Sioux River, starting near the confluence of the Big Sioux River and Willow Creek and ending at the confluence of the Big Sioux River and Stray Horse Creek. The watershed area shown in Figure 2 drains approximately 96 percent grass/grazing land and cropland acres. The municipality of Castlewood is located within this area.

The river segment Willow Creek to Stray Horse Creek (Site R17 and Site R18) was found to carry fecal coliform bacteria which degrades water quality. This segment is considered impaired because more than 10 percent of the values (of 20 or more samples) exceeded the numeric criteria of ≤ 2000 counts per 100 milliliters of fecal coliform bacteria. Table 1 displays the fecal coliform data collected from May 2001 to September 2002 and from May 2004 to September 2004.

Table 1. Summary of Fecal Coliform Data for the Willow Creek to Stray Horse Creek Segment

Parameter Causing Impairment	Number of Samples (May-Sep)	Percent of Samples > 2000 counts/100mL	Minimum Concentration (counts/100mL)	Maximum Concentration (counts/100mL)
Fecal Coliform	56	27	10	410,000

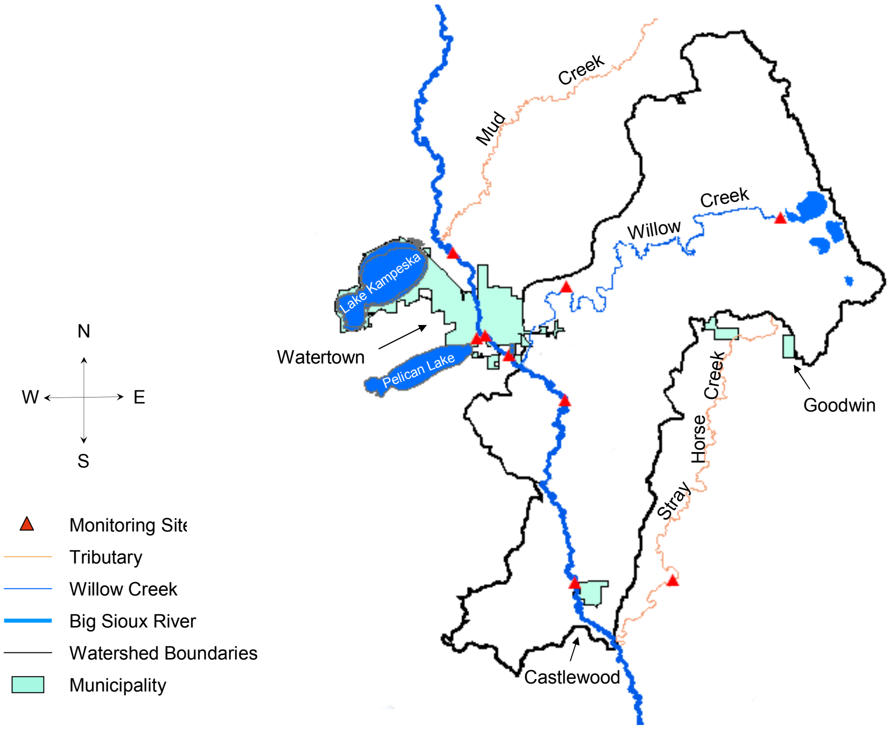


Figure 2. Big Sioux River Segment (Willow Creek to Stray Horse Creek) Watershed

Description of Applicable Water Quality Standards & Numeric Water Quality Targets

The Big Sioux River segment from Willow Creek to Stray Horse Creek has been assigned beneficial uses by the state of South Dakota Surface Water Quality Standards regulations (See page 12 of the Assessment Report). Along with these assigned uses are narrative and numeric criteria that define the desired water quality of this river segment. These criteria must be maintained for the segment to satisfy its assigned beneficial uses, which are listed below:

- Domestic water supply
- Warmwater semi-permanent fish propagation
- Limited contact recreation
- Fish and wildlife propagation, recreation and stock watering
- Irrigation

Individual parameters determine the support of beneficial uses. Use support for limited contact recreation involved monitoring the levels of fecal coliform from May 1 through September 30. This segment experiences excess loading of fecal coliform bacteria due to poor riparian areas, in-stream livestock, feedlot/manure runoff, and/or overflowing sewer systems. Administrative Rules of South Dakota Article 74:51 contains numeric and narrative standards to be applied to the surface waters (i.e. streams, rivers) of the state. To assess the status of the beneficial uses for this river segment, water samples were obtained using SD DENR standard operating procedures and the results were compared to the applicable water quality criteria. Water samples from both the East Dakota Water Development District and the SD DENR ambient water quality monitoring program were utilized.

The Willow Creek to Stray Horse Creek Big Sioux River Segment is currently assigned a numeric standard of ≤ 2000 cfu/100mL for fecal coliform bacteria. A flow duration interval with hydrologic zones approach was used to assess this segment. This methodology, developed by Bruce Cleland, was used in order to target restoration efforts by dividing the range of flows into hydrologic conditions. For example, if all the exceedences occurred during low-flow conditions, point sources of the pollutant should be suspected. Conversely, if all the exceedences occurred during higher flow periods, then non-point sources of pollution should be suspected. Using Cleland's approach, the following five hydrologic conditions were utilized: High Flows (0-20 percent), Moist Conditions (20-40 percent), Mid-range Flows (40-60 percent), Dry Conditions (60-90 percent), and Low Flows (90-100 percent). Flow duration interval methodology is explained further in the Methods section of the Assessment Report.

Two monitoring locations (Site R17 and Site R18) were setup on this segment and one SD DENR ambient water quality monitoring site (WQM 1) existed on this segment of the Big Sioux River. Of the 56 water samples that were collected, 15 (or 27 percent) violated the water quality standards for fecal coliform bacteria. Based on the water quality violations, this segment is currently not supporting its limited contact recreation beneficial use.

One tributary, Willow Creek (Site T35 and Site T36), joins the upper end of this segment and was also assessed for its level of fecal coliform loading. This tributary is also assigned a numeric standard of ≤ 2000 cfu/100mL for fecal coliform bacteria and currently does not support its beneficial uses. Table 2 displays the fecal coliform data collected from May 2001 through September 2002 at Willow Creek.

Table 2. Summary of Fecal Data for Willow Creek

Parameter Causing Impairment	Number of Samples (May-Sep)	Percent of Samples > 2000 counts/100mL	Minimum Concentration (counts/100mL)	Maximum Concentration (counts/100mL)
Fecal Coliform	19	37	110	930,000

At ≤ 2000 cfu/100mL Willow Creek needs reductions of fecal coliform bacteria during high flows and dry conditions. A separate TMDL for Willow Creek has been initiated. It is expected the TMDL for Willow Creek will satisfy the requirements of this TMDL in regards to the load it is contributing to the Willow Creek to Stray Horse Creek segment of the Big Sioux River.

Pollutant Assessment

Point Sources

NPDES facilities taken into consideration within this area include the City of Castlewood and Benchmark Foam, Inc. (Table 3). Total fecal coliform bacteria contribution from these facilities during the study period was zero. Both facilities do not discharge.

Table 3. NPDES Facilities

Permit Number	Facility Name	Fecal Coliform WLA (counts/day)
SD0021580	Castlewood, City of	0.00E+00
SD0025895	Benchmark Foam, Inc.	0.00E+00

Non-point Sources

Non-point source pollution, unlike pollution from municipalities and NPDES facilities, comes from many diffuse sources. Potential non-point sources of fecal coliform bacteria include loadings from surface runoff, wildlife, livestock, and leaking septic tanks.

Wildlife

Wildlife deposit their feces onto land surfaces and in some cases directly into the water. The bacterial load from naturally occurring wildlife is assumed to be background. In addition, any strategy employed to control this source would probably have a negligible impact on attaining water quality standards.

Agricultural

Agricultural animals are the source of several types of non-point sources as indicated in the Target Reductions & Future Activity Recommendations section of the Assessment Report. Agricultural activities, including runoff from pastureland and cattle in streams, can affect water quality. Livestock data collected during AGNPS Feedlot modeling in this watershed (including the Willow Creek watershed) are listed in Table 4.

Table 4. Livestock Distribution for Willow Creek to Stray Horse Creek Watershed

Livestock Distribution	# in Watershed
Beef Cattle/Calves	19,289
Dairy Cattle/Calves	3,294
Heifers	1,970
Dry Dairy	375
Pigs	300
Bulls	150

Septic Systems

Data for septic tanks is discussed in the Assessment Report on page 65. Contributions from septic systems were estimated based on rural households because a direct accounting of the number of septic systems in use in the TMDL watershed was unavailable. The 25.6 percent contribution from septic systems was determined by assuming 20 percent of all rural septic systems in the North-Central Big Sioux River watershed area were failing. This percentage does not account for die-off or attenuation of fecal coliform bacteria between failing septic systems and the stream. In general, failing septic systems discharge over land for some distance, where a portion of the fecal coliform bacteria may be absorbed on the soil and surface vegetation before reaching the stream. It is assumed that failing septic systems constitute a diminutive amount of the overall contribution because not all of the failing systems would be reaching the receiving waters. These results will not directly affect the TMDL allocations. Therefore, it is implied that comparatively, failing septic systems are having an insignificant affect on the excess fecal coliform loading and will be included in the margin of safety portion of the TMDL.

Urban Areas

Fecal coliform bacteria in urban and suburban areas may be attributed to stormwater runoff, overflow of sewer systems, illicit discharge of sanitary waste, leaking septic systems, and pets.

Land Use

Landuse in the watershed was derived using the AnnAGNPS Model. Table 5 shows that 96 percent of the area is grass or cropland.

Table 5. Land Use in the Willow Creek to Stray Horse Creek Segment

LandUse	Percent	Acres
Cropland	70%	100,548
Rangeland/Grassland	26%	38,226
Water	2%	2,887
Building/Farmstead	2%	2,364
None	0%	347

Linkage Analysis

Water quality data was collected at two project monitoring sites (Site R17 and Site R18) and one SD DENR ambient site on the Big Sioux River (WQM 1). Data was also collected at two additional sites from the entering tributary (Willow Creek, Site T35 and Site T36). Samples were collected according to South Dakota's EPA approved Standard Operating Procedures for Field Samplers. The fecal coliform bacteria water samples were analyzed by the Sioux Falls Health Lab (2001-2002) in Sioux Falls, South Dakota and by the State Health Lab (2004) in Pierre, South Dakota. Quality Assurance/Quality Control samples were collected on 10% of the samples according to South Dakota's EPA approved Non-point Source Quality Assurance/ Quality Control Plan. Details concerning water sampling techniques, analysis, and quality control are addressed in the assessment final report.

The Flow Duration Interval method calculates fecal coliform bacteria loading, (concentration) × (flow), using zones based on hydrologic conditions. Reductions are calculated using the median of the fecal coliform bacteria samples in each zone. This method shows that while a TMDL may be expressed as a single point it can also be thought of as a continuum of points representing the criterion value and various flow values. In order to assess the impact of fecal coliform bacteria for this segment of the Big Sioux River, the flow duration interval curve was divided into "flow zones". The purpose of the zones is to differentiate hydrologic conditions, between peak and low flows, as ranges. For this segment, the ranges or flow zones are High (0-20), Moist (20-40), Mid-range (40-60), Dry (60-90), and Low (90-100). Load duration curves were calculated using the following equation:

(flow) × (conversion factor) × (state criteria) = quantity/day or daily load

This curve represents the threshold of the load. As seen in Figure 3, any samples occurring above this line is an exceedence of the water quality standard and represented by a red box (Table 6). Table 7 depicts the allowable coliform bacteria load during the study for peak flow, low flow, and 5th percentile increments in flow. A flow duration interval graph and fecal exceedence table was also constructed for Willow Creek (Attachment 1).

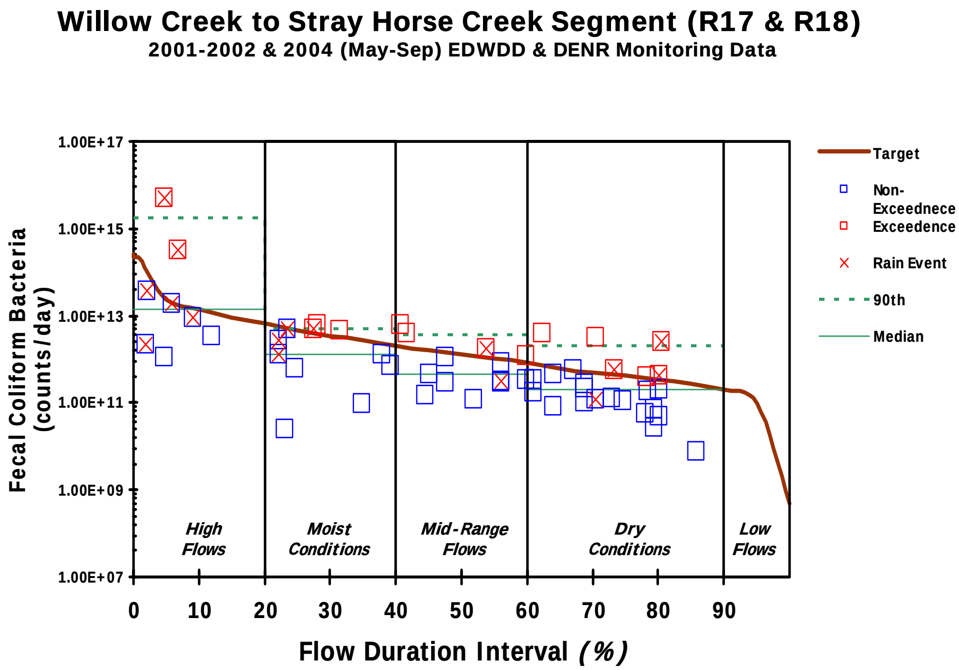


Figure 3. Flow Duration Interval for the Willow Creek to Stray Horse Creek Segment

Table 6. Exceedences of the Water Quality Standard (≤ 2000 cfu/100mL)

Station	Sample Date	Sample Time	Flow (cubic feet per second - cfs)	Flow Rank	Flow Rank (percent)	Fecal Coliform (counts/100mL)	Fecal Coliform Load (counts/day)
R18	08/21/02	1245	513.00	0.048	4.78	410000	5.15E+15
R17	08/21/02	1145	400.00	0.068	6.84	33000	3.23E+14
R18	08/06/02	900	6.70	0.804	80.42	16000	2.62E+12
R17	09/26/01	1100	10.00	0.705	70.46	13200	3.23E+12
R18	07/09/02	1145	15.00	0.624	62.38	11200	4.11E+12
R18	06/10/02	1230	40.00	0.408	40.78	6500	6.36E+12
R18	07/14/04	1040	38.00	0.418	41.76	4400	4.09E+12
R18	05/17/04	1150	22.00	0.538	53.78	3300	1.78E+12
R18	06/16/04	1205	78.00	0.281	28.07	3200	6.11E+12
R18	09/09/02	1400	17.00	0.598	59.79	2900	1.21E+12
R18	07/01/04	1035	65.00	0.314	31.41	2800	4.45E+12
R17	08/07/02	1130	6.80	0.801	80.08	2600	4.33E+11
R17	07/24/01	1200	80.00	0.275	27.48	2500	4.89E+12
R18	09/08/04	1414	9.00	0.733	73.26	2500	5.51E+11
R17	08/25/04	1108	7.30	0.782	78.18	2200	3.93E+11

Table 7. Fecal Coliform Target Loads for Flow

		Allowable Loads	2000 cfu/100mL
Flow Rank (percent)	**cfs**	**fecal Coliform (counts/day)**	**Flow Conditions**
0.019	5197.78	2.54E+14	Peak
0.1	4640.00	2.27E+14	
0.274	4432.00	2.17E+14	
1	4350.00	2.13E+14	
5	500.00	2.45E+13	
10	290.00	1.42E+13	
15	185.00	9.05E+12	
20	132.00	6.46E+12	
25	93.00	4.55E+12	
30	70.00	3.43E+12	
35	55.00	2.69E+12	
40	41.00	2.01E+12	
45	32.00	1.57E+12	
50	26.00	1.27E+12	
55	21.00	1.03E+12	
60	17.00	8.32E+11	
65	13.00	6.36E+11	
70	10.00	4.89E+11	
75	8.40	4.11E+11	
80	6.80	3.33E+11	
85	5.50	2.69E+11	
90	4.00	1.96E+11	
95	1.90	9.30E+10	
100	0.01	4.89E+08	Low

The Agricultural Non-Point Source Pollution (AGNPS) model is a GIS-integrated water quality model that predicts non-point source loadings within agricultural watersheds. ArcView GIS software was used to spatially analyze animal feeding operations and their pollution potential. The feedlot assessment assumed the probable sources of fecal coliform bacteria loadings within the NCBSR watershed were agricultural related and rated the feedlots based on runoff potential. Feedlot ratings ranged from 0-102. Table 8 lists the 44 feedlots rating 50 or greater and the watershed in which each is located. A rating of 50 or greater warrants concern in regards to potential pollution problems. A map identifying the region of concern is shown in Figure 4. A complete methodology report can be found in Appendix T of the Assessment Report.

Table 8. Feedlot ratings ≥ 50 in the Willow Creek to Stray Horse Creek Watershed

ID	Rating	Watershed	ID	Rating	Watershed
1162	50	BSR Segment	1278	61	Willow
1280	51	Willow	1338	62	Willow
1305	51	BSR Segment	1347	65	Willow
1359	52	Willow	1138	66	BSR Segment
1179	52	BSR Segment	1269	67	Willow
1181	52	BSR Segment	1275	67	Willow
1183	52	BSR Segment	1178	67	BSR Segment
1273	53	Willow	1288	68	BSR Segment
1292	54	BSR Segment	1293	68	BSR Segment
1348	55	Willow	1345	71	Willow
1350	55	Willow	1321	71	BSR Segment
1327	55	BSR Segment	1344	73	Willow
1362	56	Willow	1361	73	Willow
1149	56	BSR Segment	1290	75	BSR Segment
1176	56	BSR Segment	1310	77	BSR Segment
1163	57	BSR Segment	1342	78	Willow
1272	58	Willow	1341	79	Willow
1351	58	Willow	1319	81	BSR Segment
1151	58	BSR Segment	1366	89	Willow
1304	58	BSR Segment	1367	97	Willow
1279	59	Willow	1346	103	Willow
1358	60	Willow			
1328	60	BSR Segment			

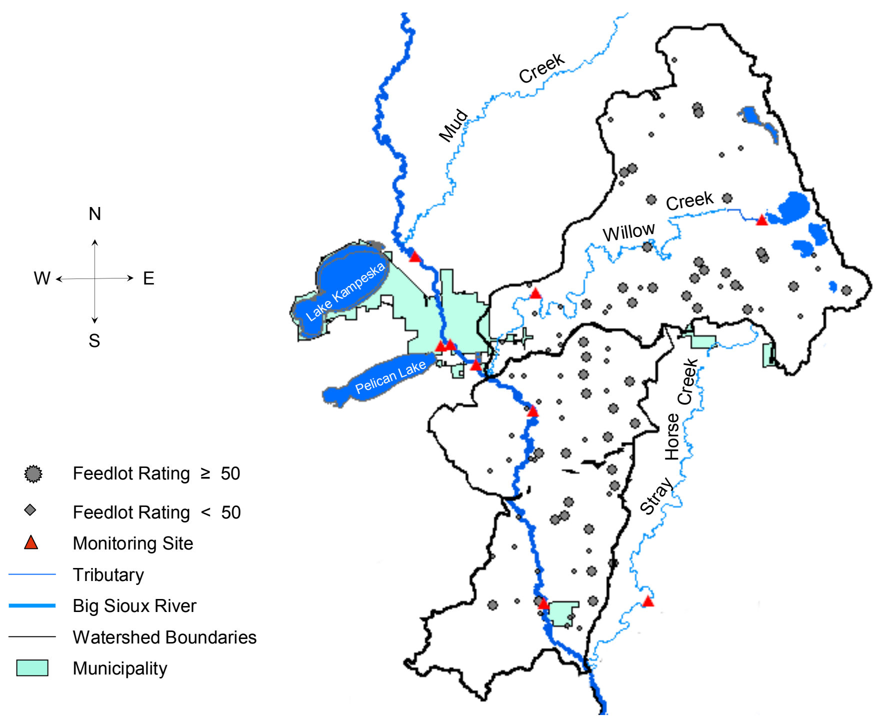


Figure 4. Location of Feedlots in the Willow Creek to Stray Horse Creek Watershed

TMDL Allocations

TMDL

Segment ID	Name	TMDL Component	Duration Curve Zone (Expressed as counts/day)				
			High	Moist	Mid-Range	Dry	Low
SD-BS-R-Big_Sioux_03		TMDL	1.42E+13	3.43E+12	1.27E+12	4.11E+11	9.30E+10
		10% MOS	1.42E+12	3.43E+11	1.27E+11	4.11E+10	9.30E+09
		Total Allocations	1.28E+13	3.09E+12	1.15E+12	3.70E+11	8.37E+10
		LA	1.28E+13	3.09E+12	1.15E+12	3.70E+11	8.37E+10
	Castlewood, City of	WLA	-	-	-	-	-
	Benchmark Foam, Inc.	WLA	-	-	-	-	-
		Background	2.56E+11	6.17E+10	2.29E+10	7.40E+09	1.67E+09
		Other NPS	1.25E+13	3.03E+12	1.12E+12	3.63E+11	8.20E+10

Wasteload Allocations (WLAs)

NPDES facilities are permitted to discharge effluent at the bacteria standard. When operating properly, they will not cause or contribute to water quality violations. Their contributions are relatively small in comparison to the total loading of the segment. Most dischargers operate well within their permit limits and discharge smaller loads than allowed. New or increases in discharges affecting this segment will be required to meet bacterial standards prior to discharge. This ensures these additions of load will not cause violations of water quality standards. Identified point sources in this watershed currently do not discharge. Therefore, the “wasteload allocation” component of this TMDL will be zero.

Load Allocations (LAs)

Load allocations account for the portion of the TMDL assigned to non-point sources. Natural background constitutes two percent of the total and the remainder of the LA is assigned to those land uses likely to contribute fecal coliform bacteria loads at rates above natural background. This includes cropland, pastureland, and residential areas. Based on the flow duration interval method, reductions are needed from non-point sources during high flow conditions.

Seasonal Variation

Different seasons of the year can yield differences in water quality due to changes in precipitation and agricultural practices. When a rainfall event occurs, fecal coliform bacteria that have built up on the land surface under dry conditions are washed off and finally deposited into lakes, rivers, and wetlands. To determine seasonal differences, runoff events were noted for the East Dakota Water Development District samples. The ambient water quality samples from the SD DENR were compared to historic precipitation data. Monitoring sites R17 and R18 on the Willow Creek to Stray Horse Creek segment of the Big Sioux River are not meeting the water quality criteria for fecal coliform bacteria. Of the 15 samples that were exceeding the ≤ 2000 cfu/100mL standard, seven (or 47 percent) occured during rain events.

Margin of Safety

The margin of safety (MOS) is a portion of the loading capacity that is set aside to prevent the exceedence of a water quality standard as a means of accounting for the uncertainty involved in developing a TMDL. The MOS for this TMDL is explicit, meaning a specific quantity, in this case 10%, of the loading is set aside. This explicit MOS takes into consideration the uncertainties associated with flow and non-point sources.

Critical Conditions

The critical condition for fecal coliform loadings in any watershed depends on the presence of point sources and land use within that watershed. During a dry period, typically the critical condition is non-point sources followed by a rainfall event. During the rainfall event, fecal coliform bacteria that have built up on the land surface can wash into the stream, causing wet weather exceedences.

Follow-Up Monitoring

Monitoring and evaluation efforts will be targeted toward the effectiveness of implemented BMPs. Sample sites will be based on BMP site selection and include the parameter of fecal coliform bacteria.

Once the implementation project is completed, post-implementation monitoring will be necessary to assure that the TMDL has been reached and improvement to the beneficial uses occurs. This will be achieved by recurrent water quality sampling at the original monitoring sites.

Public Participation

Efforts taken to gain public education, review, and comment during development of the TMDL involved:

1. East Dakota Water Development District monthly board meetings
2. Field demonstrations for the public
3. Articles in the local newspapers

The findings from these public meetings and comments have been taken into consideration in development of the Big Sioux River Segment –Willow Creek to Stray Horse Creek TMDL.

Implementation Plan

The TMDL analysis was performed using the best data available to specify the fecal coliform reductions necessary to achieve water quality criteria. The intent of meeting the criteria is to support the designated use classifications of this segment. A detailed implementation plan is not included in this TMDL. The involvement of local land owners and agencies will be needed in order to develop an implementation plan. In general, reductions in fecal coliform bacteria should be sought through identification and installation of agricultural and urban BMPs to reduce loads during runoff events.

To guide implementation efforts the existing condition was calculated by multiplying the median concentration by the median of the flow from each flowzone. The target load is the median of the flow multiplied by the numeric standard (≤ 2,000 cfu/100mL) for fecal coliform bacteria. The percent reduction is the difference between the existing and target load with a 10% MOS for uncertainties due to variation in flow. Using this baseline, this segment requires reducing the fecal coliform counts per day by 10 percent during high flow conditions (Table 9). Additional controls may be needed in order to achieve the applicable water quality standards and meet the TMDL goal for this segment as the median concentration is used here as a starting point.

Willow Creek was the only one tributary affecting this segment, with an assigned numeric standard for fecal coliform bacteria. It was also assessed at ≤ 2,000 cfu/100mL numeric standard (Table 10). The high flow and dry condition reductions shown in Table 10 are based on the median concentration from flowzone.

Table 9. Willow Creek to Stray Horse Creek Fecal Coliform Bacteria Reductions

	Median	High (0-20)	Moist (20-40)	Mid-Range (40-60)	Dry (60-90)	Low Flows (90-100)
	Median Concentration (counts/day)	4.97E+10	1.90E+10	1.81E+10	2.35E+10	------
X	Flow Median (cfs)	290	70	26	8.4	1.9
=	Existing	1.44E+13	1.33E+12	4.70E+11	1.97E+11	------
	Target Load (at 2,000 cfu/100mL)	1.42E+13	3.43E+12	1.27E+12	4.11E+11	9.30E+10
	% Reduction w/MOS	10	0	0	0	------

Note: units are counts/day

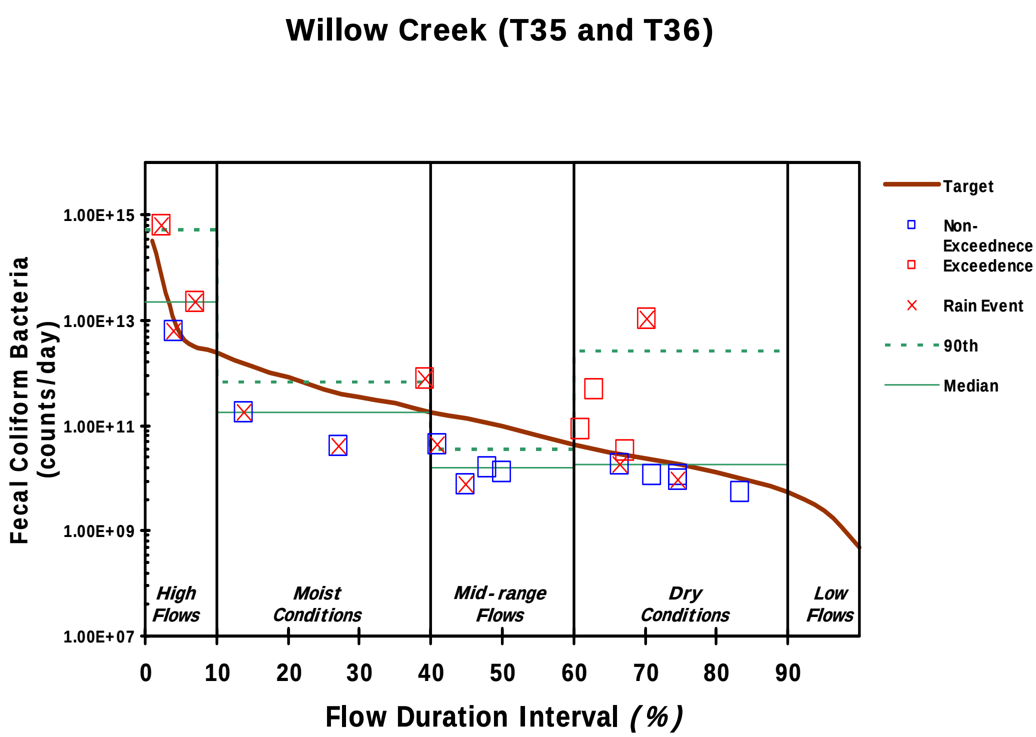
Table 10. Willow Creek Fecal Coliform Bacteria Reductions

	Median	High (0-10)	Moist (10-40)	Mid-Range (40-60)	Dry (60-90)	Low Flows (90-100)
	Median Concentration (counts/day)	2.05E+11	1.74E+10	7.20E+09	4.45E+10	------
X	Flow Median (cfs)	109	10	2	0.4	0.05
=	Existing	2.23E+13	1.74E+11	1.44E+10	1.78E+10	------
	Target Load (at 2,000 cfu/100mL)	5.33E+12	4.89E+11	9.79E+10	1.86E+10	2.45E+09
	% Reduction w/MOS	78	0	0	5	------

Note: units are counts/day

Willow Creek
Exceedence Table & Flow Duration Interval

Station	Sample Date	Sample Time	Flow (cubic feet per second - cfs)	Flow Rank	Flow Rank (percent)	Fecal Coliform (counts/100mL)	Fecal Coliform Load (counts/day)
T35	08/21/02	915	0.48	0.700	70.30	930000	1.09E+13
T36	08/21/02	1015	242.00	0.023	2.28	110000	6.51E+14
T35	09/09/02	1000	0.72	0.630	62.96	28000	4.95E+11
T36	06/14/01	1130	76.00	0.069	6.94	12000	2.23E+13
T36	07/20/01	1215	4.00	0.392	39.20	8100	7.93E+11
T35	08/27/01	1000	0.81	0.611	61.06	4400	8.76E+10
T36	08/27/01	1040	0.54	0.673	67.26	2500	3.30E+10



Appendix FF.
TMDL –Willow Creek
(Fecal Coliform Bacteria)

TOTAL MAXIMUM DAILY LOAD EVALUATION
(Fecal Coliform Bacteria)

for

Willow Creek

(HUC 10170202)

Deuel and Codington Counties, South Dakota

East Dakota Water Development District
Brookings, South Dakota

December 2005

Willow Creek Total Maximum Daily Load

Waterbody Type:	Stream
Assessment Unit ID:	SD-BS-R-WILLOW_01
303(d) Listing Parameter:	Fecal Coliform Bacteria
Designated Uses:	Warmwater Marginal Fish Life Propagation Limited Contact Recreation Fish and Wildlife Propagation Recreation and Stock Watering Irrigation
Size of Waterbody:	25.2 miles (approximately)
Size of Watershed:	79,931 acres
Water Quality Standards:	Narrative and Numeric
Indicators:	Water Chemistry
Analytical Approach:	Modeling and Assessment Techniques used include Flow Duration Interval, AGNPS Model, and AnnAGNPS Model
Location:	HUC Code: 10170202
Goal:	Full Support of the Limited Contact Recreation Beneficial Use during the months of May through September
Target:	≤ 2000 cfu/100mL of fecal coliform bacteria (any one sample) during the months of May through September

Objective

The intent of this summary is to clearly identify the components of the TMDL submittal to support adequate public participation and facilitate the US Environmental Protection Agency (EPA) review and approval. The TMDL was developed in accordance with Section 303(d) of the federal Clean Water Act and guidance developed by EPA.

Introduction

The mainstem of Willow Creek is approximately 25.2 miles in length with a watershed of approximately 79,931 acres. This tributary is located within the Big Sioux River Basin (HUC 10170202) in the eastern part of Codington County and northwestern Deuel County, South Dakota. The watershed of this stream lies within Grant, Deuel, and Codington Counties as shown by the shaded region in Figure 1 and is included as part of the North-Central Big Sioux River Watershed Assessment Project. The entire study area for this project is also outlined in Figure 1.

The North-Central Big Sioux River Watershed Assessment Project identified Willow Creek for TMDL development due to not meeting the water quality criteria for fecal coliform bacteria. Information supporting this listing was derived from East Dakota Water Development District monitoring data. Willow Creek was not on any 303(d) State Waterbody lists prior to this assessment. Appendix B of the assessment report summarizes the data collected during the North-Central Big Sioux River Watershed Assessment Project from April 2001 through October 2002.

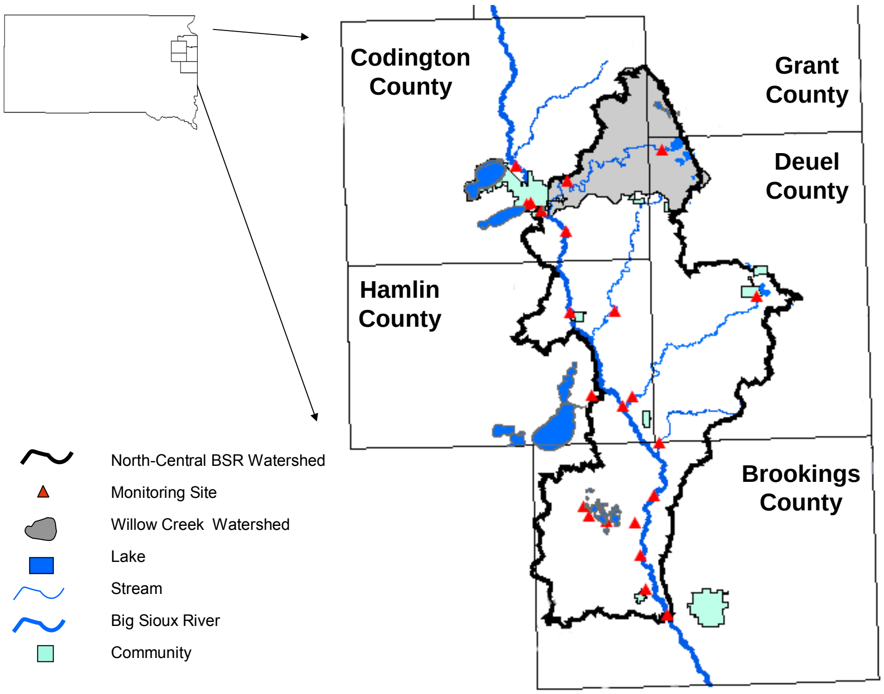


Figure 1. Location of Willow Creek and its Watershed in South Dakota.

Problem Identification

Willow Creek begins at the outlet of Round Lake and then joins the Big Sioux River about 1 mile south of the City of Watertown. The watershed area shown in Figure 2 drains approximately 95 percent grass/grazing land and cropland acres. The municipality of Watertown borders this area.

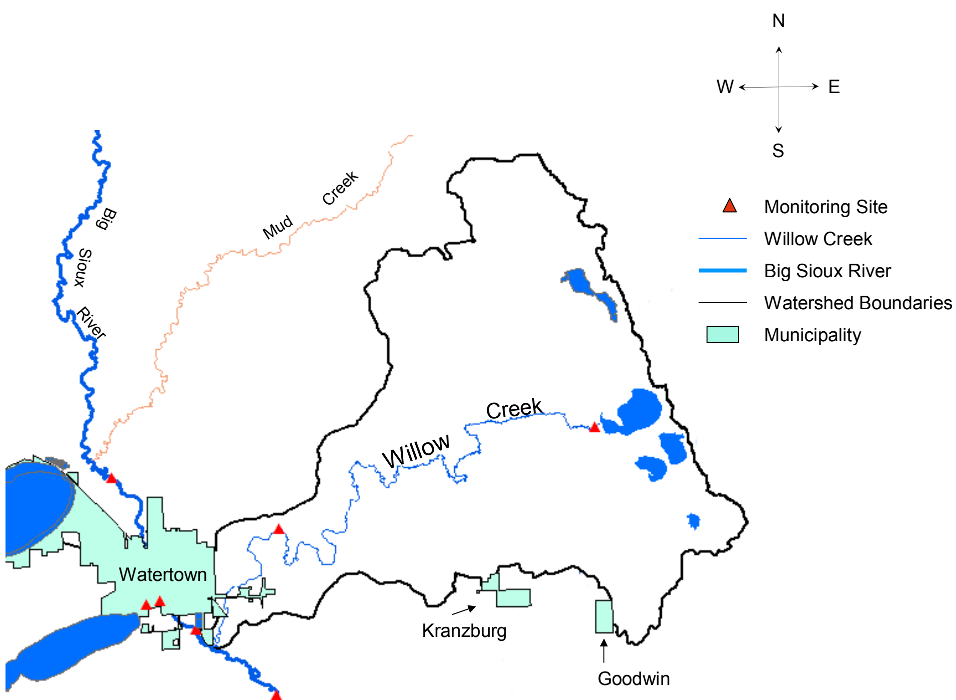


Figure 2. Willow Creek Watershed

Willow Creek (Site T35 and Site T36) was found to carry fecal coliform bacteria which degrades water quality. This stream is considered impaired because more than 25 percent of the values (of less than 20 samples) exceeded the numeric criteria of ≤ 2000 counts per 100 milliliters of fecal coliform bacteria. This stream requires reducing the fecal coliform counts per day during high flow and dry conditions. Table 1 displays the fecal coliform data collected from May 2001 through September 2002.

Table 1. Summary of Fecal Coliform Data for the Willow Creek

Parameter Causing Impairment	Number of Samples (May-Sep)	Percent of Samples > 2000 counts/100mL	Minimum Concentration (counts/100mL)	Maximum Concentration (counts/100mL)
Fecal Coliform	19	37	110	930,000

Description of Applicable Water Quality Standards & Numeric Water Quality Targets

Willow Creek has been assigned beneficial uses by the state of South Dakota Surface Water Quality Standards regulations (See page 12 of the Assessment Report). Along with these assigned uses are narrative and numeric criteria that define the desired water quality of this stream. These criteria must be maintained for the stream to satisfy its assigned beneficial uses, which are listed below:

- Warmwater marginal fish life propagation
- Limited contact recreation
- Fish and wildlife propagation, recreation and stock watering
- Irrigation

Individual parameters determine the support of beneficial uses. Use support for limited contact recreation involved monitoring the levels of fecal coliform from May 1 through September 30. This stream experiences excess loading of fecal coliform bacteria due to poor riparian areas, in-stream livestock, feedlot/manure runoff, and/or overflowing sewer systems. Administrative Rules of South Dakota Article 74:51 contains numeric and narrative standards to be applied to the surface waters (i.e. streams, rivers) of the state. To assess the status of the beneficial uses for this stream, water samples were obtained using SD DENR standard operating procedures and the results were compared to the applicable water quality criteria.

Willow Creek is currently assigned a numeric standard of ≤ 2000 cfu/100mL for fecal coliform bacteria. A flow duration interval with hydrologic zones approach was used to assess this stream. This methodology, developed by Bruce Cleland, was used in order to target restoration efforts by dividing the range of flows into hydrologic conditions. For example, if all the exceedences occurred during low-flow conditions, point sources of the pollutant should be suspected. Conversely, if all the exceedences occurred during higher flow periods, then non-point sources of pollution should be suspected. Using Cleland's approach, the following five hydrologic conditions were utilized: High Flows (0-10 percent), Moist Conditions (10-40 percent), Mid-Range Flows (40-60 percent), Dry Conditions (60-90 percent), and Low Flows (90-100 percent). The methodology of flow duration intervals is explained further in the Methods section of the Assessment Report.

Two monitoring locations (Site T35 and Site T36) were setup on this stream. Of the 19 water samples that were collected, seven (or 37 percent) violated the water quality standards for fecal coliform bacteria. Based on the water quality violations, this stream is currently not supporting its limited contact recreation beneficial use.

Pollutant Assessment

Point Sources

Benchmark Foam, Inc., was the only identified NPDES facility within this area taken into consideration. Total fecal coliform bacteria contribution from this facility during the study period was zero. This facility did not discharge during this period.

Table 2. NPDES Facilities

Permit Number	Facility Name	Fecal Coliform WLA (counts/day)
SD0025895	Benchmark Foam, Inc.	0.00E+00

Non-point Sources

Non-point source pollution, unlike pollution from municipalities and NPDES, comes from many diffuse sources. Potential non-point sources of fecal coliform bacteria include loadings from surface runoff, wildlife, livestock, and leaking septic tanks.

Wildlife

Wildlife deposit their feces onto land surfaces and in some cases directly into the water. The bacterial load from naturally occurring wildlife is assumed to be background. In addition, any strategy employed to control this source would probably have a negligible impact on attaining water quality standards.

Agricultural

Agricultural animals are the source of several types of non-point sources as indicated in the Target Reductions & Future Activity Recommendations section of the Assessment Report. Agricultural activities, including runoff from pastureland and cattle in streams, can affect water quality. Livestock data collected in watershed during AGNPS Feedlot assessment are listed in Table 3.

Table 3. Livestock Distribution for the Willow Creek Watershed

Livestock Distribution	Willow Creek (T35, T36)
Beef Cattle/Calves	8140
Dairy Cattle	1479
Heifers	615
Dry Dairy	50

Septic Systems

Data for septic tanks is discussed in the Assessment Report on page 65. Contributions from septic systems were estimated based on rural households because a direct accounting of the number of septic systems in use in the TMDL watershed was unavailable. The 25.6 percent contribution from septic systems was determined by assuming 20 percent of all rural septic systems in the North-Central Big Sioux River watershed area were failing. This percentage does not account for die-off or attenuation of fecal coliform bacteria between failing septic systems and the stream. In general, failing septic systems discharge over land for some distance, where a portion of the fecal coliform bacteria may be absorbed on the soil and surface vegetation before reaching the stream. It is assumed that failing septic systems constitute a diminutive amount of the overall contribution because not all of the failing systems would be reaching the receiving waters. These results will not directly affect the TMDL allocations. Therefore, it is implied that comparatively, failing septic systems are having an insignificant affect on the excess fecal coliform loading and will be included in the margin of safety portion of the TMDL.

Urban Areas

Fecal coliform bacteria in urban and suburban areas may be attributed to stormwater runoff, overflow of sewer systems, illicit discharge of sanitary waste, leaking septic systems, and pets.

Land Use

Landuse in the watershed was derived using the AnnAGNPS Model. Table 4 shows that 95 percent of the area is grass or cropland.

Table 4. Land Use in the Willow Creek Watershed

LandUse	Percent	Acres
Cropland	62%	49,319
Rangeland/Grassland	33%	26,511
Water	4%	2,887
Building/Farmstead	1%	1,168
None	0%	46

Linkage Analysis

Water quality data was collected at two project monitoring sites (Site T35 and Site T36) on Willow Creek. Samples were collected according to South Dakota's EPA approved Standard Operating Procedures for Field Samplers. The fecal coliform bacteria water samples were analyzed by the Sioux Falls Health Lab (2001-2002) in Sioux Falls, South Dakota. Quality Assurance/Quality Control samples were collected on 10% of the samples according to South Dakota's EPA approved Non-point Source Quality Assurance/ Quality Control Plan. Details concerning water sampling techniques, analysis, and quality control are addressed in the assessment final report.

The Flow Duration Interval method calculates fecal coliform bacteria loading, (concentration) × (flow), using zones based on hydrologic conditions. Reductions are calculated using the median of the fecal coliform bacteria samples in each zone. This method shows that while a TMDL may be expressed as a single point it can also be thought of as a continuum of points representing the criterion value and various flow values. In order to assess the impact of fecal coliform bacteria for this stream, the flow duration interval curve was divided into "flow zones". The purpose of the zones is to differentiate hydrologic conditions, between peak and low flows, as ranges. For this stream, the ranges or flow zones are High (0-10), Moist (10-40), Mid-Range (40-60), Dry (60-90), and Low (90-100). Load duration curves were calculated using the following equation:

(flow) × (conversion factor) × (state criteria) = quantity/day or daily load

This curve represents the threshold of the load. As seen in Figure 3, any samples occurring above this line is an exceedence of the water quality standard and represented by a red box (Table 5). Table 6 depicts the allowable coliform bacteria load during the study for peak flow, low flow, and 5th percentile increments in flow.

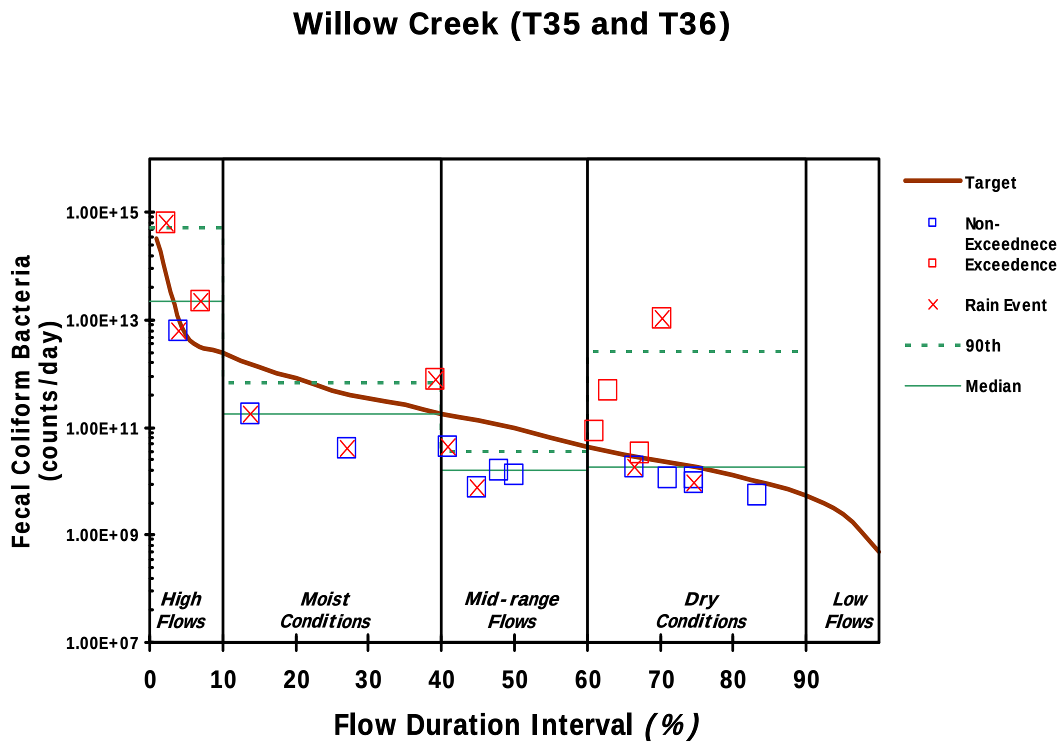


Figure 3. Flow Duration Interval for Willow Creek

Table 5. Exceedences of the Water Quality Standard (≤ 2000 cfu/100mL)

Station	Sample Date	Sample Time	Flow (cubic feet per second - cfs)	Flow Rank	Flow Rank (percent)	Fecal Coliform (counts/100mL)	Fecal Coliform Load (counts/day)
T35	08/21/02	915	0.48	0.700	70.30	930000	1.09E+13
T36	08/21/02	1015	242.00	0.023	2.28	110000	6.51E+14
T35	09/09/02	1000	0.72	0.630	62.96	28000	4.95E+11
T36	06/14/01	1130	76.00	0.069	6.94	12000	2.23E+13
T36	07/20/01	1215	4.00	0.392	39.20	8100	7.93E+11
T35	08/27/01	1000	0.81	0.611	61.06	4400	8.76E+10
T36	08/27/01	1040	0.54	0.673	67.26	2500	3.30E+10

Table 6. Fecal Coliform Target Loads for Flow

		Allowable Loads	2000 cfu/100mL
Flow Rank (percent)	**cfs**	**fecal Coliform (counts/day)**	**Flow Conditions**
0.019	6913.84	3.38E+14	Peak
0.1	6700.00	3.28E+14	
0.274	6659.46	3.26E+14	
1	6651.00	3.25E+14	
5	109.00	5.33E+12	
10	49.00	2.40E+12	
15	27.00	1.32E+12	
20	17.00	8.32E+11	
25	10.00	4.89E+11	
30	7.10	3.47E+11	
35	5.30	2.59E+11	
40	3.71	1.81E+11	
45	2.80	1.37E+11	
50	2.00	9.79E+10	
55	1.30	6.36E+10	
60	0.88	4.31E+10	
65	0.64	3.13E+10	
70	0.48	2.35E+10	
75	0.38	1.86E+10	
80	0.27	1.32E+10	
85	0.18	8.81E+09	
90	0.11	5.38E+09	
95	0.05	2.45E+09	
100	0.01	4.89E+08	Low

The Agricultural Non-Point Source Pollution (AGNPS) model is a GIS-integrated water quality model that predicts non-point source loadings within agricultural watersheds. ArcView GIS software was used to spatially analyze animal feeding operations and their pollution potential. The feedlot assessment assumed the probable sources of fecal coliform bacteria loadings within the NCBSR watershed were agricultural related and rated the feedlots based on runoff potential. Feedlot ratings ranged from 0-102. Table 7 lists the 23 feedlots rating 50 or greater. A rating of 50 or greater warrants concern in regards to potential pollution problems. A map identifying the region of concern is shown in Figure 4. A complete methodology report can be found in Appendix T of the Assessment Report.

Table 7. Feedlot ratings ≥ 50 in the Willow Creek Watershed

ID	Rating	ID	Rating
1280	51	1347	65
1359	52	1269	67
1273	53	1275	67
1348	55	1345	71
1350	55	1344	73
1362	56	1361	73
1272	58	1342	78
1351	58	1341	79
1279	59	1366	89
1358	60	1367	97
1278	61	1346	103
1338	62		

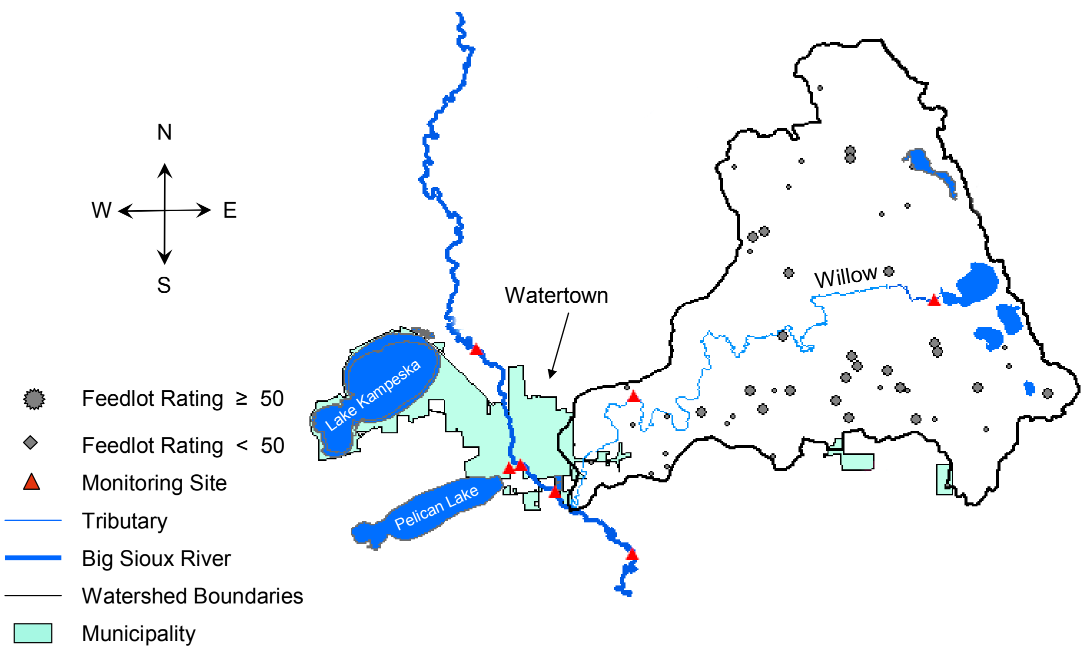


Figure 4. Location of Feedlots in the Willow Creek Watershed

TMDL Allocations

TMDL

Segment ID	Name	TMDL Component	**Duration Curve Zone** (Expressed as counts/day)				
			High	**Moist**	**Mid-Range**	**Dry**	**Low**
SD-BS-R-WILLOW_01		TMDL	5.33E+12	4.89E+11	9.79E+10	1.86E+10	2.45E+09
		10% MOS	5.33E+11	4.89E+10	9.79E+09	1.86E+09	2.45E+08
		Total Allocations	4.80E+12	4.40E+11	8.81E+10	1.67E+10	2.21E+09
		LA	4.80E+12	4.40E+11	8.81E+10	1.67E+10	2.21E+09
	Benchmark Foam, Inc.	WLA	-	-	-	-	-
		Background	9.59E+10	8.80E+09	1.76E+09	3.35E+08	4.41E+07
		Other NPS	4.70E+12	4.31E+11	8.63E+10	1.64E+10	2.16E+09

Wasteload Allocations (WLAs)

NPDES facilities are permitted to discharge effluent at the bacteria standard. When operating properly, they will not cause or contribute to water quality violations. Their contributions are relatively small in comparison to the total loading of the stream. Most dischargers operate well within their permit limits and discharge smaller loads than allowed. New or increases in discharges affecting this stream will be required to meet bacterial standards prior to discharge. This ensures these additions of load will not cause violations of water quality standards. Identified point sources in this watershed currently do not discharge. Therefore, the “wasteload allocation” component of this TMDL will be zero.

Load Allocations (LAs)

Load allocations account for the portion of the TMDL assigned to non-point sources. Natural background constitutes two percent of the total and the remainder of the LA is assigned to those land uses likely to contribute fecal coliform bacteria loads at rates above natural background. This includes cropland, pastureland, and residential areas. Based on the flow duration interval method, reductions will be needed during high flow and dry conditions from non-point sources.

Seasonal Variation

Different seasons of the year can yield differences in water quality due to changes in precipitation and agricultural practices. When a rainfall event occurs, fecal coliform bacteria that have built up on the land surface under dry conditions are washed off and finally deposited into lakes, rivers, and wetlands. To determine seasonal differences, runoff events were noted for the East Dakota Water Development District samples. Monitoring sites T35 and T36 on Willow Creek are not meeting the water quality criteria for fecal coliform bacteria. Of the seven samples that were exceeding the ≤ 2000 cfu/100mL standard, four (or 57 percent) occurred during rain events.

Margin of Safety

The margin of safety (MOS) is a portion of the loading capacity that is set aside to prevent the exceedence of a water quality standard as a means of accounting for the uncertainty involved in developing a TMDL. The MOS for this TMDL is explicit, meaning a specific quantity, in this case 10%, of the loading is set aside. This explicit MOS takes into consideration the uncertainties associated with flow and non-point sources.

Critical Conditions

The critical condition for fecal coliform loadings in any watershed depends on the presence of point sources and land use within that watershed. During a dry period, typically the critical condition is non-point sources followed by a rainfall event. During the rainfall event, fecal coliform bacteria that have built up on the land surface can wash into the stream, causing wet weather exceedences.

Follow-Up Monitoring

Monitoring and evaluation efforts will be targeted toward the effectiveness of implemented BMPs. Sample sites will be based on BMP site selection and include the parameter of fecal coliform bacteria.

Once the implementation project is completed, post-implementation monitoring will be necessary to assure that the TMDL has been reached and improvement to the beneficial uses occurs. This will be achieved by recurrent water quality sampling at the original monitoring sites.

Public Participation

Efforts taken to gain public education, review, and comment during development of the TMDL involved:

1. East Dakota Water Development District monthly board meetings
2. Field demonstrations for the public
3. Articles in the local newspapers

The findings from these public meetings and comments have been taken into consideration in development of the Willow Creek TMDL.

Implementation Plan

The TMDL analysis was performed using the best data available to specify the fecal coliform reductions necessary to achieve water quality criteria. The intent of meeting the criteria is to support the designated use classifications of this stream. A detailed implementation plan is not included in this TMDL. The involvement of local land owners and agencies will be needed in order to develop an implementation plan. In general, reductions in fecal coliform bacteria should be sought through identification and installation of agricultural BMPs to reduce loads during runoff events and during dry periods.

To guide implementation efforts the existing condition was calculated by multiplying the median concentration by the median of the flow from each flowzone. The target load is the median of the flow multiplied by the numeric standard (≤ 2,000 cfu/100mL) for fecal coliform bacteria. The percent reduction is the difference between the existing and target load with a 10% MOS for uncertainties due to variation in flow. Using this baseline, this segment requires reducing the fecal coliform counts per day by 78 percent during high flow conditions and 5 percent during dry conditions (Table 9). Additional controls may be needed in order to achieve the applicable water quality standards and meet the TMDL goal for this segment as the median concentration is used here as a starting point.

Table 8. Willow Creek Fecal Coliform Bacteria Reductions

	Median	**High (0-10)**	**Moist (10-40)**	**Mid-Range (40-60)**	**Dry (60-90)**	**Low Flows (90-100)**
	Median Concentration (counts/day)	2.05E+11	1.74E+10	7.20E+09	4.45E+10	------
X	Flow Median (cfs)	109	10	2	0.4	0.05
=	Existing	2.23E+13	1.74E+11	1.44E+10	1.78E+10	------
	Target Load (at 2,000 cfu/100mL)	5.33E+12	4.89E+11	9.79E+10	1.86E+10	2.45E+09
	% Reduction w/MOS	78	0	0	5	------

Note: units are counts/day

Appendix GG.
TMDL – Stray Horse Creek
(Fecal Coliform Bacteria)

TOTAL MAXIMUM DAILY LOAD EVALUATION
(Fecal Coliform Bacteria)

for

Stray Horse Creek

(HUC 10170202)

Hamlin and Codington Counties, South Dakota

East Dakota Water Development District
Brookings, South Dakota

December 2005

Stray Horse Creek Total Maximum Daily Load

Waterbody Type:	Stream
Assessment Unit ID:	SD-BS-R-STRAYHORSE_01
303(d) Listing Parameter:	Fecal Coliform Bacteria
Designated Uses:	Warmwater Marginal Fish Life Propagation Limited Contact Recreation Fish and Wildlife Propagation Recreation and Stock Watering Irrigation
Size of Waterbody:	23.2 miles (approximately)
Size of Watershed:	57,548 acres
Water Quality Standards:	Narrative and Numeric
Indicators:	Water Chemistry
Analytical Approach:	Modeling and Assessment Techniques used include Flow Duration Interval, AGNPS Model, and AnnAGNPS Model
Location:	HUC Code: 10170202
Goal:	Full Support of the Limited Contact Recreation Beneficial Use durin the months of May through September
Target:	≤ 2000 cfu/100mL of fecal coliform bacteria (any one sample) during the months of May through September

Objective

The intent of this summary is to clearly identify the components of the TMDL submittal to support adequate public participation and facilitate the US Environmental Protection Agency (EPA) review and approval. The TMDL was developed in accordance with Section 303(d) of the federal Clean Water Act and guidance developed by EPA.

Introduction

The mainstem of Stray Horse Creek, beginning south of Kranzburg, is approximately 23.2 miles with a watershed of approximately 57,548 acres. This tributary is located within the Big Sioux River Basin (HUC 10170202) in the north-central part of Hamlin County and southeastern Codington County, South Dakota. The watershed of this stream lies within Hamlin, Deuel, and Codington Counties as shown by the shaded region in Figure 1 and is included as part of the North-Central Big Sioux River Watershed Assessment Project. The entire study area for this project is also outlined in Figure 1.

The North-Central Big Sioux River Watershed Assessment Project identified Stray Horse Creek for TMDL development due to not meeting the water quality criteria for fecal coliform bacteria. Information supporting this listing was derived from East Dakota Water Development District monitoring data. Stray Horse Creek has not been on any 303(d) State Waterbody lists prior to this assessment. Appendix B of the assessment report summarizes the data collected during the North-Central Big Sioux River Watershed Assessment Project from June 2001 through October 2002.

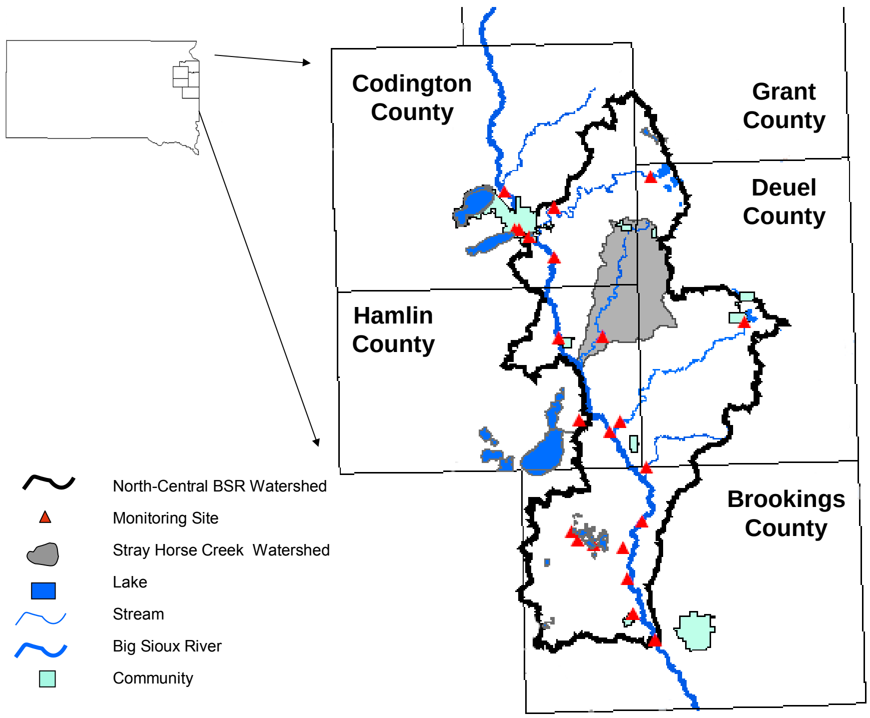


Figure 1. Location of Stray Horse Creek and its Watershed in South Dakota.

Problem Identification

Stray Horse Creek begins near the City of Kranzburg and then joins the Big Sioux River about two miles southeast of Castlewood. The watershed area shown in Figure 2 drains approximately 97 percent grass/grazing land and cropland acres. The municipalities of Kranzburg and Goodwin are located in this area.

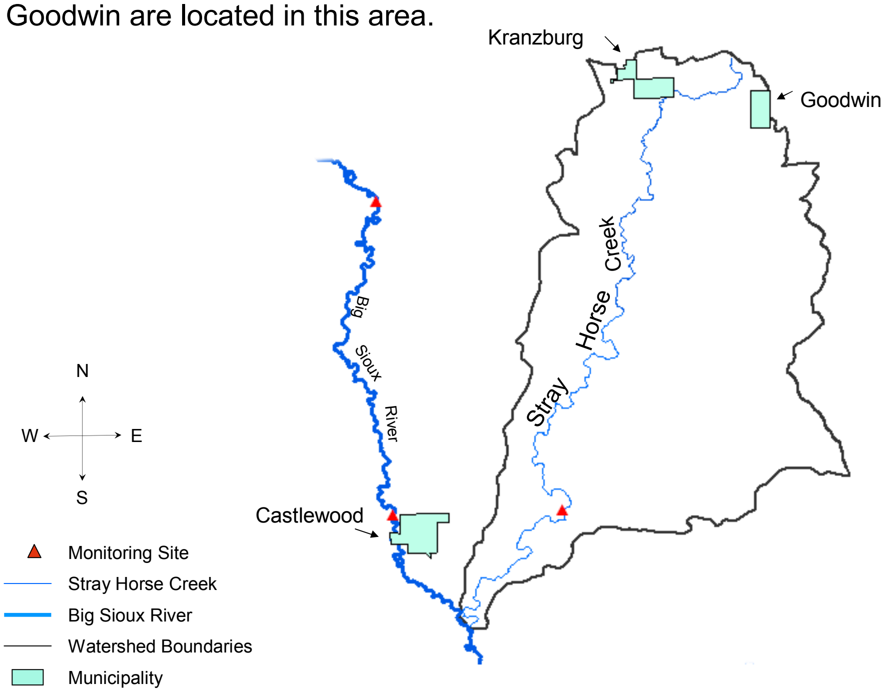


Figure 2. Stray Horse Creek Watershed

Stray Horse Creek (Site T37) was found to carry fecal coliform bacteria which degrades water quality. This stream is considered impaired because more than 25 percent of the values (of less than 20 samples) exceeded the numeric criteria of ≤ 2000 counts per 100 milliliters of fecal coliform bacteria. This stream requires reducing the fecal coliform counts per day during high flows. Table 1 displays the fecal coliform data collected from June 2001 through September 2002.

Table 1. Summary of Fecal Coliform Data for the Stray Horse Creek

Parameter Causing Impairment	Number of Samples (May-Sep)	Percent of Samples > 2000 counts/100mL	Minimum Concentration (counts/100mL)	Maximum Concentration (counts/100mL)
Fecal Coliform	10	40	40	320,000

Description of Applicable Water Quality Standards & Numeric Water Quality Targets

Stray Horse Creek has been assigned beneficial uses by the state of South Dakota Surface Water Quality Standards regulations (See page 12 of the Assessment Report). Along with these assigned uses are narrative and numeric criteria that define the desired water quality of this stream. These criteria must be maintained for the stream to satisfy its assigned beneficial uses, which are listed below:

- Warmwater marginal fish life propagation
- Limited contact recreation
- Fish and wildlife propagation, recreation and stock watering
- Irrigation

Individual parameters determine the support of beneficial uses. Use support for limited contact recreation involved monitoring the levels of fecal coliform from May 1 through September 30. This stream experiences excess loading of fecal coliform bacteria due to poor riparian areas, in-stream livestock, feedlot/manure runoff, and/or overflowing sewer systems. Administrative Rules of South Dakota Article 74:51 contains numeric and narrative standards to be applied to the surface waters (i.e. streams, rivers) of the state. To assess the status of the beneficial uses for this stream, water samples were obtained using SD DENR standard operating procedures and the results were compared to the applicable water quality criteria.

Stray Horse Creek is currently assigned a numeric standard of ≤ 2000 cfu/100mL for fecal coliform bacteria. A flow duration interval with hydrologic zones approach was used to assess this stream. This methodology, developed by Bruce Cleland, was used in order to target restoration efforts by dividing the range of flows into hydrologic conditions. For example, if all the exceedences occurred during low-flow conditions, point sources of the pollutant should be suspected. Conversely, if all the exceedences occurred during higher flow periods, then non-point sources of pollution should be suspected. Using Cleland's approach, the following four hydrologic conditions were utilized: High Flows (0-10 percent), Moist Conditions (10-40 percent), Mid-Range Flows to Dry Conditions (40-90 percent), and Low Flows (90-100 percent). The methodology of flow duration intervals is explained further in the Methods section of the Assessment Report.

One monitoring locations (Site T37) was setup on this stream. Of the 10 water samples that were collected, four (or 40 percent) violated the water quality standards for fecal coliform bacteria. Based on the water quality violations, this stream is currently not supporting its limited contact recreation beneficial use.

Pollutant Assessment

Point Sources

NPDES facilities taken into consideration within this area include the Town of Kranzburg and the City of Goodwin (Table 2). Total fecal coliform bacteria contribution from these facilities during the study period was zero. Both facilities do not discharge.

Table 2. NPDES Facilities

Permit Number	Facility Name	Fecal Coliform WLA (counts/day)
SD0024724	Kranzburg, City of	0.00E+00
SDG824716	Goodwin, City of	0.00E+00

Non-point Sources

Non-point source pollution, unlike pollution from municipalities and NPDES facilities, comes from many diffuse sources. Potential non-point sources of fecal coliform bacteria include loadings from surface runoff, wildlife, livestock, and leaking septic tanks.

Wildlife

Wildlife deposit their feces onto land surfaces and in some cases directly into the water. The bacterial load from naturally occurring wildlife is assumed to be background. In addition, any strategy employed to control this source would probably have a negligible impact on attaining water quality standards.

Agricultural

Agricultural animals are the source of several types of non-point sources as indicated in the Target Reductions & Future Activity Recommendations section of the Assessment Report. Agricultural activities, including runoff from pastureland and cattle in streams, can affect water quality. Livestock data collected in the watershed during AGNPS Feedlot assessment are listed in Table 3.

Table 3. Livestock Distribution for the Stray Horse Creek watershed

Livestock Distribution	Stray Horse Creek (T37)
Beef Cattle/Calves	12761
Dairy Cattle	2350
Heifers	1495
Sheep	1200
Steers	917
Pigs	260
Horses	27

Septic Systems

Data for septic tanks is discussed in the Assessment Report on page 65. Contributions from septic systems were estimated based on rural households because a direct accounting of the number of septic systems in use in the TMDL watershed was unavailable. The 25.6 percent contribution from septic systems was determined by assuming 20 percent of all rural septic systems in the North-Central Big Sioux River watershed area were failing. This percentage does not account for die-off or attenuation of fecal coliform bacteria between failing septic systems and the stream. In general, failing septic systems discharge over land for some distance, where a portion of the fecal coliform bacteria may be absorbed on the soil and surface vegetation before reaching the stream. It is assumed that failing septic systems constitute a diminutive amount of the overall contribution because not all of the failing systems would be reaching the receiving waters. These results will not directly affect the TMDL allocations. Therefore, it is implied that comparatively, failing septic systems are having an insignificant affect on the excess fecal coliform loading and will be included in the margin of safety portion of the TMDL.

Urban Areas

Fecal coliform bacteria in urban and suburban areas may be attributed to stormwater runoff, overflow of sewer systems, illicit discharge of sanitary waste, leaking septic systems, and pets.

Land Use

Landuse in the watershed was derived from the AnnAGNPS Model. Table 4 shows that 97 percent of the area is grass or cropland.

Table 4. Land Use in the Stray Horse Creek Watershed

LandUse	Percent	Acres
Cropland	79%	45,629
Rangeland/Grassland	18%	10,412
Building/Farmstead	2%	1,044
None	1%	463

Linkage Analysis

Water quality data was collected at one project monitoring site (Site T37) on Stray Horse Creek. Samples were collected according to South Dakota's EPA approved Standard Operating Procedures for Field Samplers. Fecal coliform bacteria water samples were analyzed by the Sioux Falls Health Lab (2001-2002) in Sioux Falls, South Dakota. Quality Assurance/Quality Control samples were collected on 10% of the samples according to South Dakota's EPA approved Non-point Source Quality Assurance/ Quality Control Plan. Details concerning water sampling techniques, analysis, and quality control are addressed in the assessment final report.

The Flow Duration Interval method calculates fecal coliform bacteria loading, (concentration) × (flow), using zones based on hydrologic conditions. Reductions are calculated using the median of the fecal coliform bacteria samples in each zone. This method shows that while a TMDL may be expressed as a single point it can also be thought of as a continuum of points representing the criterion value and various flow values. In order to assess the impact of fecal coliform bacteria for this stream, the flow duration interval curve was divided into "flow zones". The purpose of the zones is to differentiate hydrologic conditions, between peak and low flows, as ranges. For this stream, the ranges or flow zones are High (0-10), Moist (10-40), Mid-Range to Dry (40-90), and Low (90-100). Load duration curves were calculated using the following equation:

(flow) × (conversion factor) × (state criteria) = quantity/day or daily load

This curve represents the threshold of the load. As seen in Figure 3, any samples occurring above this line is an exceedence of the water quality standard and represented by a red box (Table 5). Table 6 depicts the allowable coliform bacteria load during the study for peak flow, low flow, and 5th percentile increments in flow.

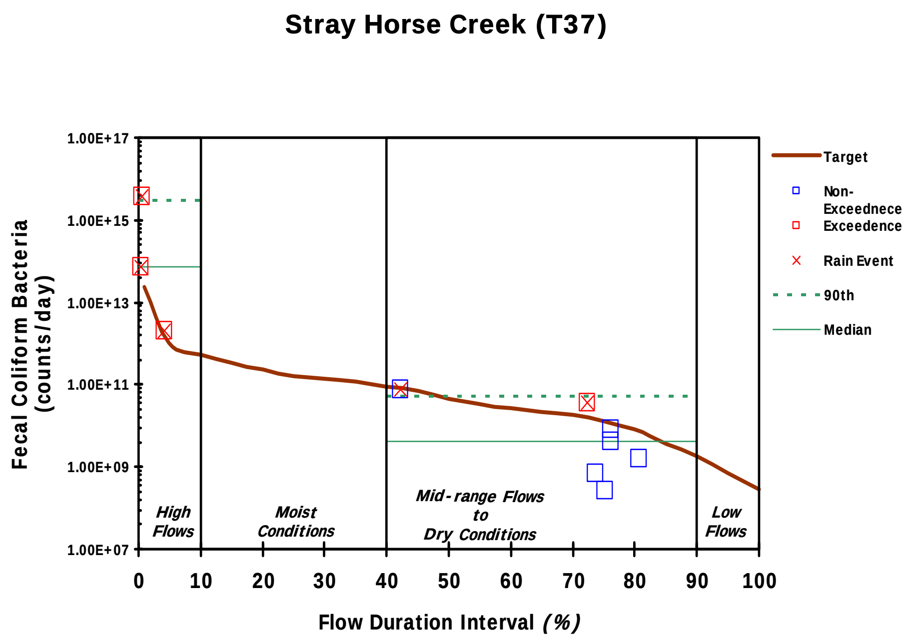


Figure 3. Flow Duration Interval for Stray Horse Creek

Table 5. Exeedences of the Water Quality Standard (≤ 2000 cfu/100mL)

Station	Sample Date	Sample Time	Flow (cubic feet per second - cfs)	Flow Rank	Flow Rank (percent)	Fecal Coliform (counts/100mL)	Fecal Coliform Load (counts/day)
T37	08/21/02	1230	474.61	0.005	0.50	320000	3.72E+15
T37	06/14/01	1230	416.99	0.004	0.40	6900	7.04E+13
T37	08/06/02	930	0.33	0.724	72.40	4500	3.63E+10
T37	05/09/02	1015	32.15	0.042	4.20	2500	1.97E+12

Table 6. Fecal Coliform Target Loads for Flow

		Allowable Loads	2000 cfu/100mL
Flow Rank (percent)	**cfs**	**fecal Coliform (counts/day)**	**Flow Conditions**
0.019	580.30	2.84E+13	Peak
0.1	503.44	2.46E+13	
0.274	496.25	2.43E+13	
1	492.97	2.41E+13	
5	21.02	1.03E+12	
10	10.47	5.13E+11	
15	6.87	3.36E+11	
20	4.75	2.32E+11	
25	3.40	1.67E+11	
30	2.94	1.44E+11	
35	2.41	1.18E+11	
40	1.79	8.77E+10	
45	1.44	7.07E+10	
50	0.94	4.61E+10	
55	0.70	3.44E+10	
60	0.56	2.76E+10	
65	0.45	2.19E+10	
70	0.37	1.83E+10	
75	0.27	1.30E+10	
80	0.17	8.28E+09	
85	0.08	3.71E+09	
90	0.04	1.79E+09	
95	0.01	6.75E+08	
100	0.01	2.96E+08	Low

The Agricultural Non-Point Source Pollution (AGNPS) model is a GIS-integrated water quality model that predicts non-point source loadings within agricultural watersheds. ArcView GIS software was used to spatially analyze animal feeding operations and their pollution potential. The feedlot assessment assumed the probable sources of fecal coliform bacteria loadings within the NCBSR watershed were agricultural related and rated the feedlots based on runoff potential. Feedlot ratings ranged from 0-102. Table 7 lists the 32 feedlots rating 50 or greater. A rating of 50 or greater warrants concern in regards to potential pollution problems. A map identifying the region of concern is shown in Figure 4. A complete methodology report can be found in Appendix T of the Assessment Report.

Table 7. Feedlot ratings ≥ 50 in the Stray Horse Creek Watershed

ID	Rating	ID	Rating	ID	Rating
1153	51	1283	62	1261	72
1286	52	1154	63	1260	74
1289	52	1249	63	1174	75
1285	53	1161	64	1262	75
1171	55	1251	64	1152	78
1160	57	1303	64	1159	79
1172	58	1301	65	1175	81
1265	58	1284	67	1268	81
1156	60	1302	67	1170	85
1313	60	1155	71	1168	86
1299	61	1258	72		

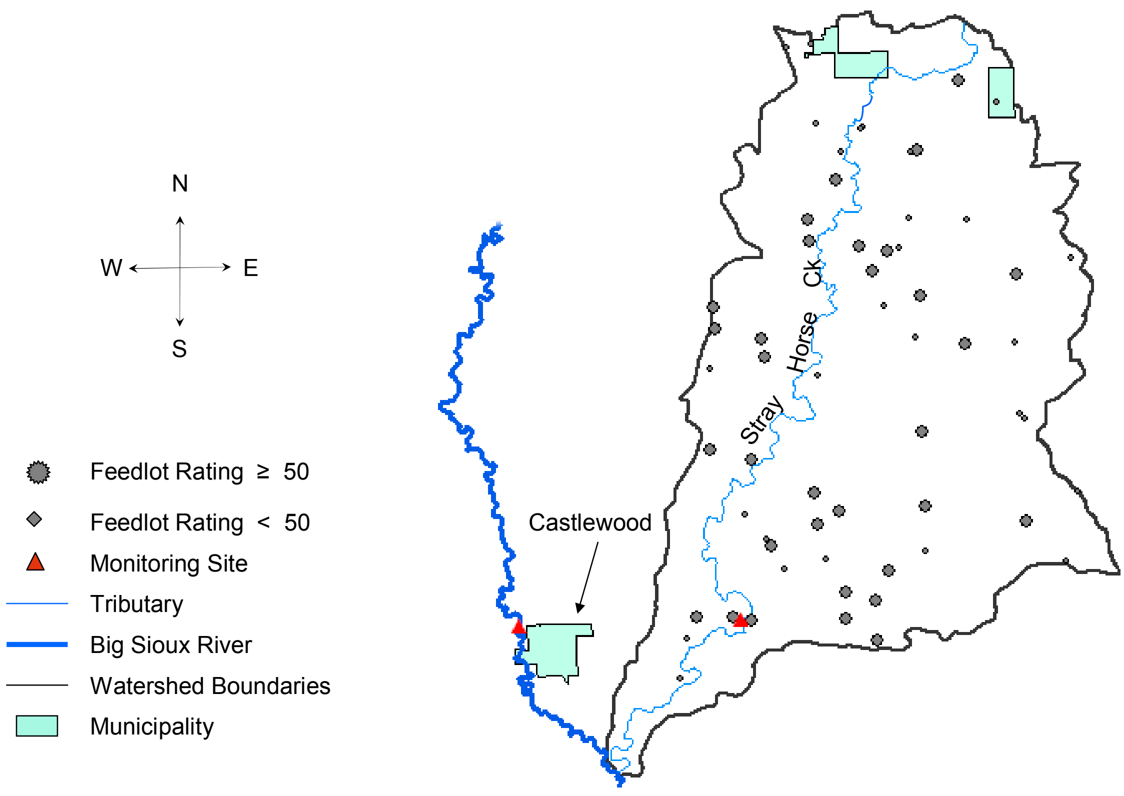


Figure 4. Location of Feedlots in the Stray Horse Creek Watershed

TMDL Allocations

TMDL

Segment ID	Name	TMDL Component	Duration Curve Zone (Expressed as counts/day)			
			High	Moist	Mid-Range/Dry	Low
SD-BS-R-STRAYHORSE_01		TMDL	1.03E+12	1.67E+11	2.19E+10	6.75E+08
		10% MOS	1.03E+11	1.67E+10	2.19E+09	6.75E+07
		Total Allocations	9.27E+11	1.50E+11	1.97E+10	6.08E+08
		LA	9.27E+11	1.50E+11	1.97E+10	6.08E+08
	Goodwin, City of	WLA	-	-	-	-
	Kranzburg, City of	WLA	0.00E+00	0.00E+00	0.00E+00	0.00E+00
		Background	1.85E+10	3.01E+09	3.94E+08	1.22E+07
		Other NPS	9.08E+11	1.47E+11	1.93E+10	5.95E+08

Wasteload Allocations (WLAs)

NPDES facilities are permitted to discharge effluent at the bacteria standard. When operating properly, they will not cause or contribute to water quality violations. Their contributions are relatively small in comparison to the total loading of the stream. Most dischargers operate well within their permit limits and discharge smaller loads than allowed. New or increases in discharges affecting this stream will be required to meet bacterial standards prior to discharge. This ensures these additions of load will not cause violations of water quality standards. Identified point sources in this watershed currently do not discharge. Therefore, the "wasteload allocation" component of this TMDL will be zero.

Load Allocations (LAs)

Load allocations account for the portion of the TMDL assigned to non-point sources. Natural background constitutes two percent of the total and the remainder of the LA is assigned to those land uses likely to contribute fecal coliform bacteria loads at rates above natural background. This includes cropland, pastureland, and residential areas. Based on the flow duration interval method, reductions during high flows are needed from non-point sources.

Seasonal Variation

Different seasons of the year can yield differences in water quality due to changes in precipitation and agricultural practices. When a rainfall event occurs, fecal coliform bacteria that have built up on the land surface under dry conditions are washed off and finally deposited into lakes, rivers, and wetlands. To determine seasonal differences, runoff events were noted for the East Dakota Water Development District samples. Monitoring site T37 on Stray Horse Creek is not meeting the water quality criteria for fecal coliform bacteria. Of the four samples that were exceeding the ≤ 2000 cfu/100mL standard, four (or 100 percent) were during rain events.

Margin of Safety

The margin of safety (MOS) is a portion of the loading capacity that is set aside to prevent the exceedence of a water quality standard as a means of accounting for the uncertainty involved in developing a TMDL. The MOS for this TMDL is explicit, meaning a specific quantity, in this case 10%, of the loading is set aside. This explicit MOS takes into consideration the uncertainties associated with flow and non-point sources.

Critical Conditions
The critical condition for fecal coliform loadings in any watershed depends on the presence of point sources and land use within that watershed. During a dry period, typically the critical condition is non-point sources followed by a rainfall event. During the rainfall event, fecal coliform bacteria that have built up on the land surface can wash into the stream, causing wet weather exceedences.

Follow-Up Monitoring
Monitoring and evaluation efforts will be targeted toward the effectiveness of implemented BMPs. Sample sites will be based on BMP site selection and include the parameter of fecal coliform bacteria.

Once the implementation project is completed, post-implementation monitoring will be necessary to assure that the TMDL has been reached and improvement to the beneficial uses occurs. This will be achieved by recurrent water quality sampling at the original monitoring sites.

Public Participation
Efforts taken to gain public education, review, and comment during development of the TMDL involved:

1. East Dakota Water Development District monthly board meetings
2. Field demonstrations for the public
3. Articles in the local newspapers

The findings from these public meetings and comments have been taken into consideration in development of the Stray Horse Creek TMDL.

Implementation Plan
The TMDL analysis was performed using the best data available to specify the fecal coliform reductions necessary to achieve water quality criteria. The intent of meeting the criteria is to support the designated use classifications of this stream. A detailed implementation plan is not included in this TMDL. The involvement of local land owners and agencies will be needed in order to develop an implementation plan. In general, reductions in fecal coliform bacteria should be sought through identification and installation of agricultural BMPs to reduce loads during runoff events and wet weather conditions.

To guide implementation efforts the existing condition was calculated by multiplying the median concentration by the median of the flow from each flowzone. The target load is the median of the flow multiplied by the numeric standard (≤ 2,000 cfu/100mL) for fecal coliform bacteria. The percent reduction is the difference between the existing and target load with a 10% MOS for uncertainties due to variation in flow. Using this baseline, this segment requires reducing the fecal coliform counts per day by 99 percent during high flow conditions (Table 8). Additional controls may be needed in order to achieve the applicable water quality standards and meet the TMDL goal for this segment as the median concentration is used here as a starting point.

Table 8. Stray Horse Creek Fecal Coliform Bacteria Reductions

	Median	High (0-10)	Moist (10-40)	Mid-Range to Dry (40-90)	Low Flows (90-100)
	Median Concentration (counts/day)	3.35E+12	------	8.58E+09	------
X	Flow Median (cfs)	21	3.4	0.5	0.01
=	Existing	7.04E+13	------	4.29E+09	------
	Target Load (at 2,000 cfu/100mL)	1.03E+12	1.67E+11	2.19E+10	6.75E+08
	% Reduction w/MOS	99	------	0	------

Note: units are counts/day

Appendix HH.
TMDL – Hidewood Creek
(Fecal Coliform Bacteria)

TOTAL MAXIMUM DAILY LOAD EVALUATION
(Fecal Coliform Bacteria)

for

Hidewood Creek

(HUC 10170202)

Hamlin and Deuel Counties, South Dakota

East Dakota Water Development District
Brookings, South Dakota

December 2005

Hidewood Creek Total Maximum Daily Load

Waterbody Type:	Stream
Assessment Unit ID:	SD-BS-R-HIDEWOOD_01
303(d) Listing Parameter:	Fecal Coliform Bacteria
Designated Uses:	Warmwater Marginal Fish Life Propagation Limited Contact Recreation Fish and Wildlife Propagation Recreation and Stock Watering Irrigation
Size of Waterbody:	25.7 miles (approximately)
Size of Watershed:	85,815 acres
Water Quality Standards:	Narrative and Numeric
Indicators:	Water Chemistry
Analytical Approach:	Modeling and Assessment Techniques used include Flow Duration Interval, AGNPS Model, and AnnAGNPS Model
Location:	HUC Code: 10170202
Goal:	Full Support of the Limited Contact Recreation Beneficial Use during the months of May through September
Target:	≤ 2000 cfu/100mL of fecal coliform bacteria (any one sample) during the months of May through September

Objective

The intent of this summary is to clearly identify the components of the TMDL submittal to support adequate public participation and facilitate the US Environmental Protection Agency (EPA) review and approval. The TMDL was developed in accordance with Section 303(d) of the federal Clean Water Act and guidance developed by EPA.

Introduction

Hidewood Creek is a 25.7 mile tributary with a watershed of approximately 85,815 acres, located within the Big Sioux River Basin (HUC 10170202) in the south-eastern part of Hamlin County and southwestern Deuel County, South Dakota. The watershed of this stream lies within Hamlin and Deuel Counties as shown by the shaded region in Figure 1 and is included as part of the North-Central Big Sioux River Watershed Assessment Project. The entire study area for this project is also outlined in Figure 1.

The North-Central Big Sioux River Watershed Assessment Project identified Hidewood Creek for TMDL development due to not meeting the water quality criteria for fecal coliform bacteria. Information supporting this listing was derived from East Dakota Water Development District monitoring data. Hidewood Creek has not been on any 303(d) State Waterbody lists prior to this assessment including the 2006 list. Appendix B of the assessment report summarizes the data collected during the North-Central Big Sioux River Watershed Assessment Project from June 2001 through October 2002.

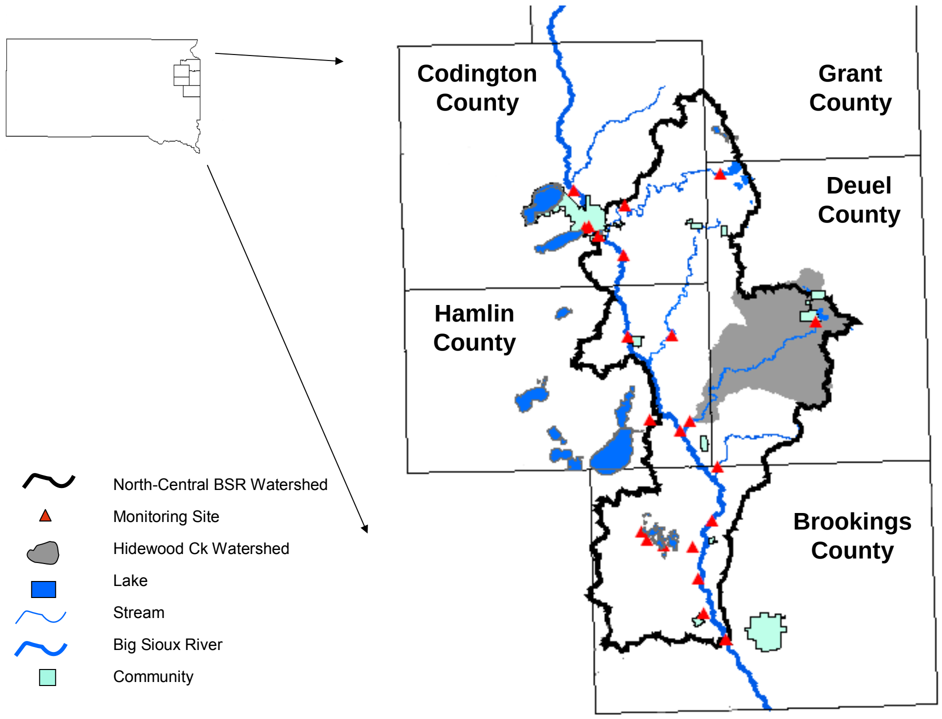


Figure 1. Location of Hidewood Creek and its Watershed in South Dakota.

Problem Identification

Hidewood Creek begins at the outlet of Clear Lake and then joins the Big Sioux River about two miles northwest of the City of Estelline. The watershed area shown in Figure 2 drains approximately 98 percent grass/grazing land and cropland acres. The municipality of Clear Lake is located in this area.

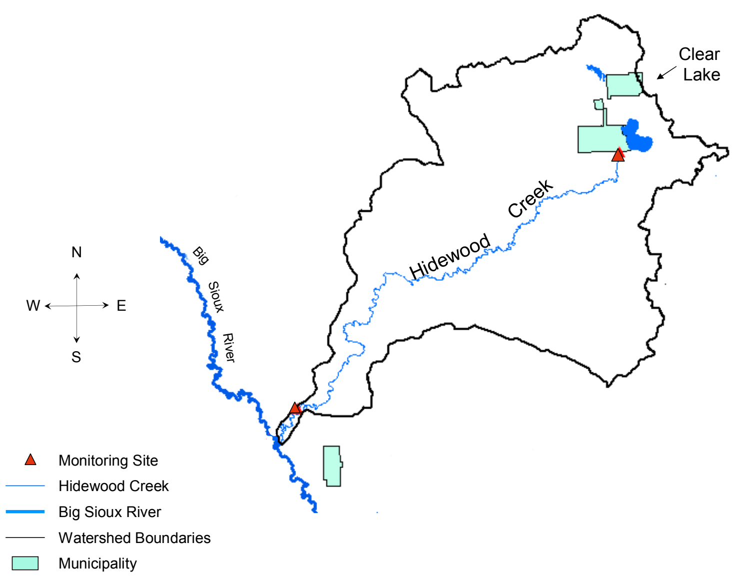


Figure 2. Hidewood Creek Watershed

Hidewood Creek (Site T40 and Site T41) was found to carry fecal coliform bacteria which degrades water quality. This stream is considered impaired because more than 25 percent of the values (of less than 20 samples) exceeded the numeric criteria of ≤ 2000 counts per 100 milliliters of fecal coliform bacteria. This stream requires reductions during high flows. Table 1 displays the fecal coliform data collected from June 2001 through September 2002.

Table 1. Summary of Fecal Coliform Data for the Hidewood Creek

Parameter Causing Impairment	Number of Samples (May-Sep)	Percent of Samples > 2000 counts/100mL	Minimum Concentration (counts/100mL)	Maximum Concentration (counts/100mL)
Fecal Coliform	16	31	10	42,000

Description of Applicable Water Quality Standards & Numeric Water Quality Targets

Hidewood Creek has been assigned beneficial uses by the state of South Dakota Surface Water Quality Standards regulations (See page 12 of the Assessment Report). Along with these assigned uses are narrative and numeric criteria that define the desired water quality of this stream. These criteria must be maintained for the stream to satisfy its assigned beneficial uses, which are listed below:

- Warmwater marginal fish life propagation
- Limited contact recreation
- Fish and wildlife propagation, recreation and stock watering
- Irrigation

Individual parameters determine the support of beneficial uses. Use support for limited contact recreation involved monitoring the levels of fecal coliform bacteria from May 1 through September 30. This stream experiences fecal coliform bacteria due to poor riparian areas, in-stream livestock, feedlot/manure runoff, NPDES systems, and/or overflowing sewer systems. Administrative Rules of South Dakota Article 74:51 contains numeric and narrative standards to be applied to the surface waters (i.e. streams, rivers) of the state. To assess the status of the beneficial uses for this stream, water samples were obtained using SD DENR standard operating procedures and the results were compared to the applicable water quality criteria.

Hidewood Creek is currently assigned a numeric standard of ≤ 2000 cfu/100mL for fecal coliform bacteria. A flow duration interval with hydrologic zones approach was used to assess this stream. This methodology, developed by Bruce Cleland, was used in order to target restoration efforts by dividing the range of flows into hydrologic conditions. For example, if all the exceedences occurred during low-flow conditions, point sources of the pollutant should be suspected. Conversely, if all the exceedences occurred during higher flow periods, then non-point sources of pollution should be suspected. Using Cleland's approach, the following five hydrologic conditions were utilized: High Flows (0-10 percent), Moist Conditions (10-40 percent), Mid-Range Flows (40-60), Dry Conditions (60-90 percent), and Low Flows (90-100 percent). The methodology of flow duration intervals is explained further in the Methods section of the Assessment Report.

Two monitoring locations (Site T40 and Site T41) were setup on this stream. Of the 16 water samples that were collected, five (or 31 percent) violated the water quality standards for fecal coliform bacteria. Based on the water quality violations, this stream is currently not supporting its limited contact recreation beneficial use.

Pollutant Assessment

Point Sources

NPDES facilities taken into consideration within this area include the City of Clear Lake and Technical Ordinance, Inc. (Table 2). Total fecal coliform bacteria contribution from these facilities during the study period was zero. Technical Ordinance, Inc did not discharge during this period and the City of Clear Lake did not discharge fecal coliform bacteria.

Table 2. NPDES Facilities

Permit Number	Facility Name	Fecal Coliform WLA (counts/day)
SD0020699	Clear Lake, City of	7.03E+10
SD0026301	Technical Ordinance, Inc.	0.00E+00

Non-point Sources

Non-point source pollution, unlike pollution from municipalities and NPDES, comes from many diffuse sources. Potential non-point sources of fecal coliform bacteria include loadings from surface runoff, wildlife, livestock, and leaking septic tanks.

Wildlife

Wildlife deposit their feces onto land surfaces and in some cases directly into the water. The bacterial load from naturally occurring wildlife is assumed to be background. In addition, any strategy employed to control this source would probably have a negligible impact on attaining water quality standards.

Agricultural

Agricultural animals are the source of several types of non-point sources as indicated in the Target Reductions & Future Activity Recommendations section of the Assessment Report. Agricultural activities, including runoff from pastureland and cattle in streams, can affect water quality. Livestock data collected in this watershed during the AGNPS Feedlot assessment are listed in Table 4.

Table 3. Livestock Distribution for the Hidewood Creek Watershed

Livestock Distribution	Hidewood Creek (T40, T41)
Beef Cattle	6380
Dairy Cattle	325
Heifers	300

Septic Systems

Data for septic tanks is discussed in the Assessment Report on page 65. Contributions from septic systems were estimated based on rural households because a direct accounting of the number of septic systems in use in the TMDL watershed was unavailable. The 25.6 percent contribution from septic systems was determined by assuming 20 percent of all rural septic systems in the North-Central Big Sioux River watershed area were failing. This percentage does not account for die-off or attenuation of fecal coliform bacteria between failing septic systems and the stream. In general, failing septic systems discharge over land for some distance, where a portion of the fecal coliform bacteria may be absorbed on the soil and surface vegetation before reaching the stream. It is assumed that failing septic systems constitute a diminutive amount of the overall contribution because not all of the failing systems would be reaching the receiving waters. These results will not directly affect the TMDL allocations. Therefore, it is implied that comparatively, failing septic systems are having an insignificant affect on the excess fecal coliform loading and will be included in the margin of safety portion of the TMDL.

Urban Areas

Fecal coliform bacteria in urban and suburban areas may be attributed to stormwater runoff, overflow of sewer systems, illicit discharge of sanitary waste, leaking septic systems, and pets.

Land Use

Landuse in the watershed was derived using the AnnAGNPS Model. Table 4 shows that 98 percent of the area is in grass or cropland.

Table 4. Land Use in the Hidewood Creek Watershed

LandUse	Percent	Acres
Cropland	68%	58,318
Rangeland/Grassland	30%	25,752
Building/Farmstead	2%	1,711
None	0%	34

Linkage Analysis

Water quality data was collected at two project monitoring sites (Site T40 and Site T41) on Hidewood Creek. Samples were collected according to South Dakota's EPA approved Standard Operating Procedures for Field Samplers. The fecal coliform bacteria water samples were analyzed by the Sioux Falls Health Lab (2001-2002) in Sioux Falls, South Dakota. Quality Assurance/Quality Control samples were collected on 10% of the samples according to South Dakota's EPA approved Non-point Source Quality Assurance/ Quality Control Plan. Details concerning water sampling techniques, analysis, and quality control are addressed in the assessment final report.

The Flow Duration Interval method calculates fecal coliform bacteria loading, (concentration) × (flow), using zones based on hydrologic conditions. Reductions are calculated using the median of the fecal coliform bacteria samples in each zone. This method shows that while a TMDL may be expressed as a single point it can also be thought of as a continuum of points representing the criterion value and various flow values. In order to assess the impact of fecal coliform bacteria for this stream, the flow duration interval curve was divided into “flow zones”. The purpose of the zones is to differentiate hydrologic conditions, between peak and low flows, as ranges. For this stream, the ranges or flow zones are High (0-10), Moist (10-40), Mid-Range (40-60), Dry (60-90), and Low (90-100). Load duration curves were calculated using the following equation:

(flow) × (conversion factor) × (state criteria) = quantity/day or daily load

This curve represents the threshold of the load. As seen in Figure 3, any samples occurring above this line is an exceedence of the water quality standard and represented by a red box (Table 5). Table 6 depicts the allowable coliform bacteria load during the study for peak flow, low flow, and 5th percentile increments in flow.

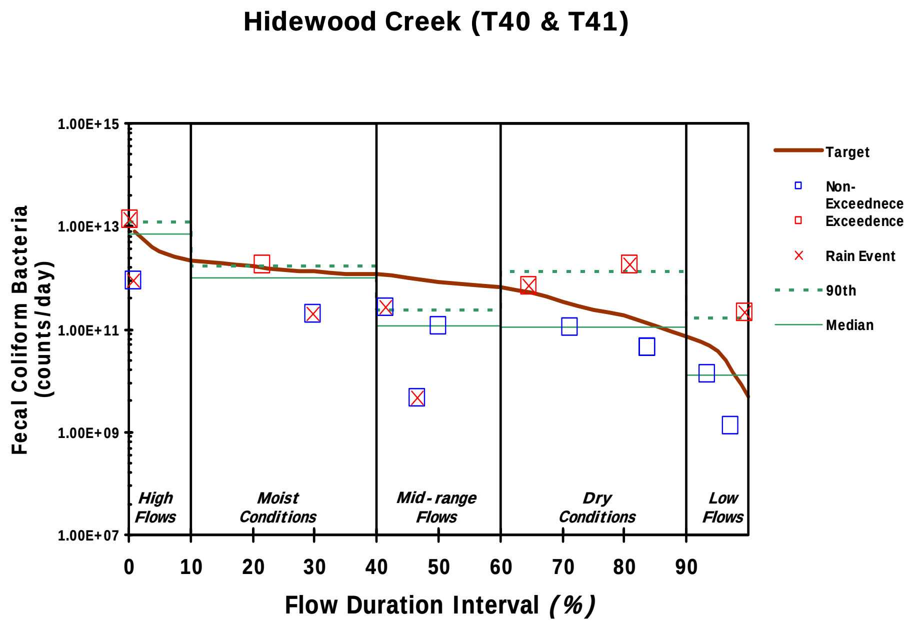


Figure 3. Flow Duration Interval for Hidewood Creek

Table 5. Exceedances of the Water Quality Standard (≤ 2000 cfu/100mL)

Station	Sample Date	Sample Time	Flow (cubic feet per second - cfs)	Flow Rank	Flow Rank (percent)	Fecal Coliform (counts/100mL)	Fecal Coliform Load (counts/day)
T40	08/07/02	830	0.20	0.994	99.37	42000	2.06E+11
T40	08/21/02	845	3.62	0.809	80.85	20000	1.77E+12
T41	06/14/01	1330	167.90	0.002	0.19	3300	1.36E+13
T41	07/20/01	1315	11.12	0.646	64.55	2500	6.81E+11
T41	09/26/01	1330	32.72	0.215	21.51	2300	1.84E+12

Table 6. Fecal Coliform Target Loads for Flow

		Allowable Loads	2000 cfu/100mL
Flow Rank (percent)	**cfs**	**fecal Coliform (counts/day)**	**Flow Conditions**
0.019	243.93	1.19E+13	Peak
0.1	206.81	1.01E+13	
0.274	192.57	9.42E+12	
1	163.93	8.02E+12	
5	66.59	3.26E+12	
10	42.88	2.10E+12	
15	38.67	1.89E+12	
20	33.75	1.65E+12	
25	29.41	1.44E+12	
30	26.70	1.31E+12	
35	24.56	1.20E+12	
40	24.26	1.19E+12	
45	20.25	9.91E+11	
50	17.36	8.50E+11	
55	15.28	7.48E+11	
60	13.34	6.53E+11	
65	10.62	5.20E+11	
70	6.99	3.42E+11	
75	4.93	2.41E+11	
80	3.82	1.87E+11	
85	2.34	1.15E+11	
90	1.43	7.02E+10	
95	0.77	3.78E+10	
100	0.10	5.05E+09	Low

Table 7. Feedlot ratings ≥ 50 in the Hidewood Creek Watershed

ID	Rating
1233	55
1247	59
1255	59
1215	62
1223	62
1244	62
1246	63
1227	66
1242	66
2132	67
1221	71
1230	73
1113	74
1229	79
1237	98

The Agricultural Non-Point Source Pollution (AGNPS) model is a GIS-integrated water quality model that predicts non-point source loadings within agricultural watersheds. ArcView GIS software was used to spatially analyze animal feeding operations and their pollution potential. The feedlot assessment assumed the probable sources of fecal coliform bacteria loadings within the NCBSR watershed were agricultural related and rated the feedlots based on runoff potential. Feedlot ratings ranged from 0-102. Table 7 lists the 15 feedlots rating 50 or greater. A rating of 50 or greater warrants concern in regards to potential pollution problems. A map identifying the region of concern is shown in Figure 4. A complete methodology report can be found in Appendix T of the Assessment Report.

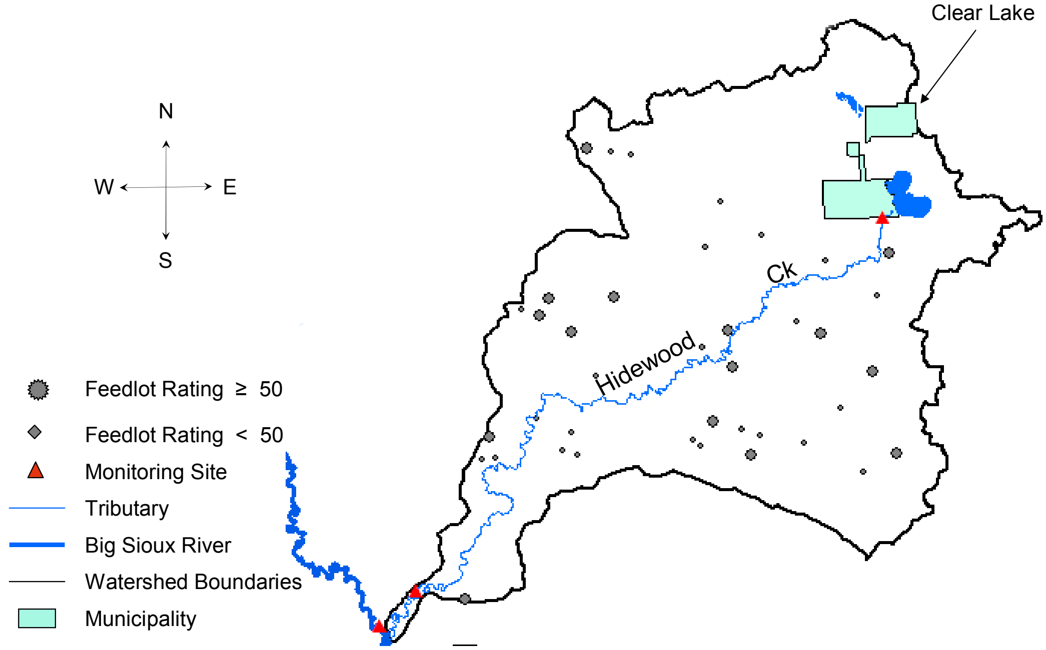


Figure 3. Location of Feedlots in the Hidewood Creek Watershed

TMDL Allocations

TMDL

Segment ID	Name	TMDL Component	Duration Curve Zone (Expressed as counts/day)				
			High	Moist	Mid-Range	Dry	Low
SD-BS-R-HIDEWOOD_01		TMDL	3.62E+12	1.44E+12	8.50E+11	2.41E+11	3.78E+10
		10% MOS	3.62E+11	1.44E+11	8.50E+10	2.41E+10	3.78E+09
		Total Allocations	3.26E+12	1.30E+12	7.65E+11	2.17E+11	3.40E+10
		LA	3.19E+12	1.23E+12	6.95E+11	1.47E+11	-3.63E+10
	Clear Lake, City of	WLA	7.03E+10	7.03E+10	7.03E+10	7.03E+10	7.03E+10
	Technical Ordinance, Inc.	WLA	-	-	-	-	-
		Background	6.38E+10	2.45E+10	1.39E+10	2.93E+09	-7.26E+08
		Other NPS	3.12E+12	1.20E+12	6.81E+11	1.44E+11	-3.56E+10

Wasteload Allocations (WLAs)

NPDES facilities are permitted to discharge effluent at the bacteria standard. When operating properly, they will not cause or contribute to water quality violations. Their contributions are relatively small in comparison to the total loading of the stream. The worst case scenario of all point source waste loads within this stream would be approximately 7.03×10^{10} fecal counts if the facilities discharged their maximum amount at the same time. This amount is unlikely since most dischargers operate well within their permit limits and discharge smaller loads than allowed. In order to find the TMDL, the waste load allocation (point source) was added to the allowable load (non-point source) and a 10 percent margin of safety was applied. New or increases in discharges affecting this stream will be required to meet bacterial standards prior to discharge. This ensures these additions of load will not cause violations of water quality standards. Identified point sources in this watershed are contributing an insignificant amount to the fecal coliform loading. Therefore, the “wasteload allocation” component is of no consequence, as indicated in the above TMDL.

Load Allocations (LAs)

Load allocations account for the portion of the TMDL assigned to non-point sources. Natural background constitutes two percent of the total and the remainder of the LA is assigned to those land uses likely to contribute fecal coliform bacteria loads at rates above natural background. This includes cropland, pastureland, and residential areas. Based on the flow duration interval method, reductions during high flows will be needed from non-point sources.

Seasonal Variation

Different seasons of the year can yield differences in water quality due to changes in precipitation and agricultural practices. When a rainfall event occurs, fecal coliform bacteria that have built up on the land surface under dry conditions are washed off and finally deposited into lakes, rivers, and wetlands. To determine seasonal differences, runoff events were noted for the East Dakota Water Development District samples. Monitoring sites T40 and T41 on Hidewood Creek are not meeting the water quality criteria for fecal coliform bacteria. Of the five samples that were exceeding the ≤ 2000 cfu/100mL standard, four (or 80 percent) were during rain events.

Margin of Safety

The margin of safety (MOS) is a portion of the loading capacity that is set aside to prevent the exceedence of a water quality standard as a means of accounting for the uncertainty involved in developing a TMDL. The MOS for this TMDL is explicit, meaning a specific quantity, in this case 10%, of the loading is set aside. This explicit MOS takes into consideration the uncertainties associated with flow and non-point sources.

Critical Conditions

The critical condition for fecal coliform loadings in any watershed depends on the presence of point sources and land use within that watershed. During a dry period, typically the critical condition is non-point sources followed by a rainfall event. During the rainfall event, fecal coliform bacteria that have built up on the land surface can wash into the stream, causing wet weather exceedences.

Follow-Up Monitoring

Monitoring and evaluation efforts will be targeted toward the effectiveness of implemented BMPs. Sample sites will be based on BMP site selection and include the parameter of fecal coliform bacteria.

Once the implementation project is completed, post-implementation monitoring will be necessary to assure that the TMDL has been reached and improvement to the beneficial uses occurs. This will be achieved by recurrent water quality sampling at the original monitoring sites.

Public Participation

Efforts taken to gain public education, review, and comment during development of the TMDL involved:

1. East Dakota Water Development District monthly board meetings
2. Field demonstrations for the public
3. Articles in the local newspapers

The findings from these public meetings and comments have been taken into consideration in development of the Hidewood Creek TMDL.

Implementation Plan

The TMDL analysis was performed using the best data available to specify the fecal coliform reductions necessary to achieve water quality criteria. The intent of meeting the criteria is to support the designated use classifications of this stream. A detailed implementation plan is not included in this TMDL. The involvement of local land owners and agencies will be needed in order to develop an implementation plan. In general, reductions in fecal coliform bacteria should be sought through identification and installation of agricultural and urban BMPs to reduce loads during runoff events.

To guide implementation efforts the existing condition was calculated by multiplying the median concentration by the median of the flow from each flowzone. The target load is the median of the flow multiplied by the numeric standard (≤ 2,000 cfu/100mL) for fecal coliform bacteria. The percent reduction is the difference between the existing and target load with a 10% MOS for uncertainties due to variation in flow. Using this baseline, this segment requires reducing the fecal coliform counts per day by 59 percent during high flow conditions (Table 8). Additional controls may be needed in order to achieve the applicable water quality standards and meet the TMDL goal for this segment as the median concentration is used here as a starting point.

Table 8. Hidewood Creek Fecal Coliform Bacteria Reductions

	Median	High (0-10)	Moist (10-40)	Mid-Range (40-60)	Dry (60-90)	Low Flows (90-100)
	Median Concentration (counts/day)	1.08E+11	3.52E+10	6.76E+09	2.20E+10	1.63E+10
X	Flow Median (cfs)	67	29	17	5	0.8
=	Existing	7.21E+12	1.02E+12	1.15E+11	1.10E+11	1.30E+10
	Target Load (at 2,000 cfu/100mL)	3.26E+12	1.44E+12	8.50E+11	2.41E+11	3.78E+10
	% Reduction w/MOS	59	0	0	0	0

Note: units are counts/day

DRAFT

To be Submitted at a Later Date

Appendix II.
TMDL – Peg Munky Run
(Fecal Coliform Bacteria)

TOTAL MAXIMUM DAILY LOAD EVALUATION (Fecal Coliform Bacteria)

for

Peg Munky Run

(HUC 10170202)

Brookings and Deuel Counties, South Dakota

East Dakota Water Development District
Brookings, South Dakota

December 2005

Peg Munky Run Total Maximum Daily Load

Waterbody Type:	Stream
303(d) Listing Parameter:	Fecal Coliform Bacteria
Designated Uses:	Warmwater Marginal Fish Life Propagation Limited Contact Recreation Fish and Wildlife Propagation Recreation and Stock Watering Irrigation
Size of Waterbody:	13.8 miles (approximately)
Size of Watershed:	36,698 acres
Water Quality Standards:	Narrative and Numeric
Indicators:	Water Chemistry
Analytical Approach:	Modeling and Assessment Techniques used include Flow Duration Interval, AGNPS Model, and AnnAGNPS Model
Location:	HUC Code: 10170202
Goal:	Reduce the fecal coliform counts per day by 38% overall flow conditions
Target:	≤ 2000 cfu/100mL of fecal coliform bacteria (any one sample) during the months of May through September

Objective
The intent of this summary is to clearly identify the components of the TMDL submittal to support adequate public participation and facilitate the US Environmental Protection Agency (EPA) review and approval. The TMDL was developed in accordance with Section 303(d) of the federal Clean Water Act and guidance developed by EPA.

Introduction
Peg Munky Run is a 13.8 mile tributary with a watershed of approximately 36,698 acres, located within the Big Sioux River Basin (HUC 10170202) in the north-central part of Brookings County and southwestern Deuel County, South Dakota. The watershed of this stream lies within Hamlin, Deuel, and Brookings Counties as shown by the shaded region in Figure 1 and is included as part of the North-Central Big Sioux River Watershed Assessment Project. The entire study area for this project is also outlined in Figure 1.

The North-Central Big Sioux River Watershed Assessment Project identified Peg Munky Run for TMDL development due to not meeting the water quality criteria for fecal coliform bacteria. Information supporting this listing was derived from East Dakota Water Development District monitoring data. Appendix B of the assessment report summarizes the data collected during the North-Central Big Sioux River Watershed Assessment Project from June 2001 through June 2002.

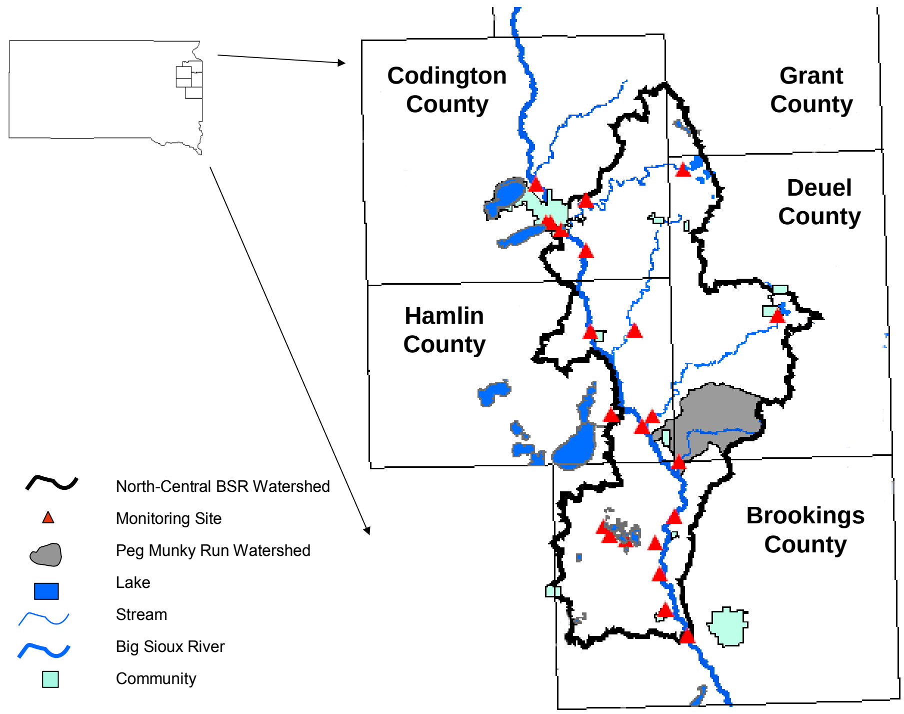


Figure 1. Location of Peg Munky Run and its Watershed in South Dakota.

Problem Identification

Peg Munky Run begins three miles northwest of the City of Toronto and then joins the Big Sioux River approximately six miles north of the City of Bruce. The watershed area shown in Figure 2 drains approximately 98 percent grass/grazing land and cropland acres. The municipality of Estelline is located in this area.

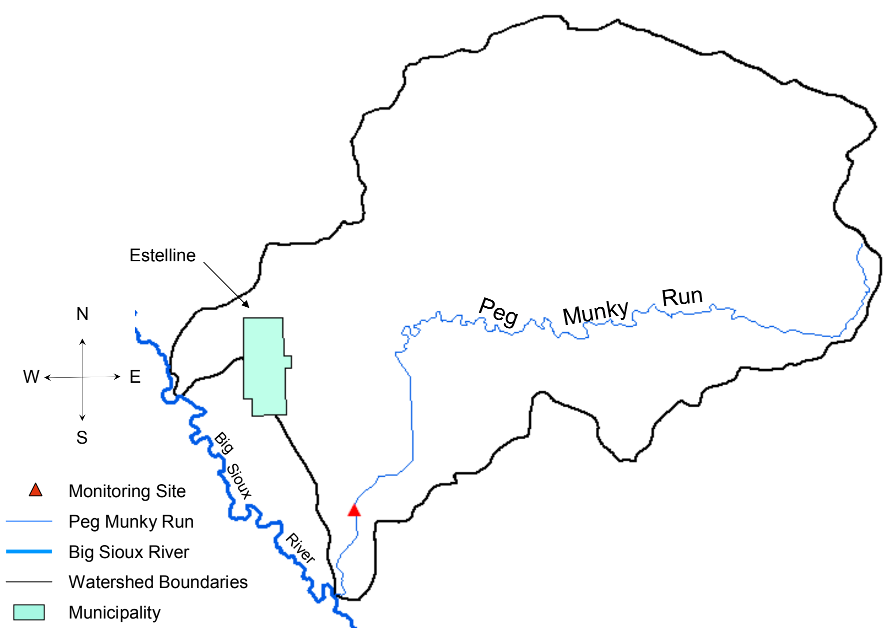


Figure 2. Peg Munky Run Watershed

Peg Munky Run (Site T42) was found to carry fecal coliform bacteria which degrades water quality. This stream is considered impaired because more than 25 percent of the values (of less than 20 samples) exceeded the numeric criteria of ≤ 2000 counts per 100 milliliters of fecal coliform bacteria. This stream requires reducing the fecal coliform counts per day by 38 percent overall flow conditions. Table 1 displays the fecal coliform data collected from June 2001 through June 2002.

Table 1. Summary of Fecal Coliform Data for the Peg Munky Run

Parameter Causing Impairment	Number of Samples (May-Sep)	Percent of Samples > 2000 counts/100mL	Minimum Concentration (counts/100mL)	Maximum Concentration (counts/100mL)
Fecal Coliform	4	75	420	10,000

Description of Applicable Water Quality Standards & Numeric Water Quality Targets

Peg Munky Run has been assigned beneficial uses by the state of South Dakota Surface Water Quality Standards regulations (See page 12 of the Assessment Report). Along with these assigned uses are narrative and numeric criteria that define the desired water quality of this stream. These criteria must be maintained for the stream to satisfy its assigned beneficial uses, which are listed below:

- Warmwater marginal fish life propagation
- Limited contact recreation
- Fish and wildlife propagation, recreation and stock watering
- Irrigation

Individual parameters determine the support of beneficial uses. Use support for limited contact recreation involved monitoring the levels of fecal coliform from May 1 through September 30. This stream experiences fecal coliform bacteria due to poor riparian areas, in-stream livestock, feedlot/manure runoff, and/or overflowing sewer systems. Administrative Rules of South Dakota Article 74:51 contains numeric and narrative standards to be applied to the surface waters (i.e. streams, rivers) of the state. To assess the status of the beneficial uses for this stream, water samples were obtained using SD DENR standard operating procedures and the results were compared to the applicable water quality criteria.

Peg Munky Run is currently assigned a numeric standard of ≤ 2000 cfu/100mL for fecal coliform bacteria. A flow duration interval with hydrologic zones approach was used to assess this stream. This methodology, developed by Dr. Bruce Cleland, was used in order to target restoration efforts by dividing the range of flows into hydrologic conditions. For example, if all the exceedences occurred during low-flow conditions, point sources of the pollutant should be suspected. Conversely, if all the exceedences occurred during higher flow periods, then non-point sources of pollution should be suspected. Using Dr. Cleland's approach, the following five hydrologic conditions were utilized: High Flows (0 to 10 percent), Moist Conditions (10-40 percent), Mid-Range Flows (40-60), Dry Conditions (60-90 percent), and Low Flows (90-100 percent). However, due to the low number of samples, all zones were combined to assess the overall fecal coliform bacteria problem. The methodology of flow duration intervals is explained further in the Methods section of the Assessment Report.

One monitoring location (Site T42) was setup on this stream. Of the four water samples that were collected, three (or 75 percent) violated the water quality standards for fecal coliform bacteria. Based on the water quality violations, this stream is currently not supporting its limited contact recreation beneficial use. This stream requires reducing the fecal coliform counts per day, over all hydrologic conditions, by 38 percent. However, the problems seem to be occurring during high flows and during dry to low conditions (Table 2).

Table 2. Peg Munky Run Fecal Coliform Bacteria Reductions

	Median	Overall (0-100)
	Median Concentration (counts/day)	7.18E+10
X	Flow Median (cfs)	1.74
=	Existing	1.25E+11
	Target Load (at 2,000 cfu/100mL)	8.50E+10
	% Reduction w/MOS	38
Note: units are counts/day		

Pollutant Assessment

Point Sources

The City of Estelline was the only identified NPDES facility within this area taken into consideration. Total fecal coliform bacteria contribution from this facility during the study period was zero. This facility did not discharge during this period.

Non-point Sources

Non-point source pollution, unlike pollution from municipalities and NPDES, comes from many diffuse sources. Potential non-point sources of fecal coliform bacteria include loadings from surface runoff, wildlife, livestock, and leaking septic tanks.

Wildlife

Wildlife deposit their feces onto land surfaces and in some cases directly into the water. The bacterial load from naturally occurring wildlife is assumed to be background. In addition, any strategy employed to control this source would probably have a negligible impact on attaining water quality standards.

Agricultural

Agricultural animals are the source of several types of non-point sources as indicated in the Target Reductions & Future Activity Recommendations section of the Assessment Report. Agricultural activities, including runoff from pastureland and cattle in streams, can affect water quality. Livestock data collected in this watershed during AGNPS Feedlot assessment are listed in Table 3.

Table 3. Livestock Distribution for the Peg Munky Run Watershed

Livestock Distribution	Peg Munky Run (T42)
Beef Cattle	3628
Beef Calves	190
Heifers	80
Dairy Cattle	50
Sheep	50

Septic Systems

Data for septic tanks is discussed in the Assessment Report on page 65. Contributions from septic systems were estimated based on rural households because a direct accounting of the number of septic systems in use in the TMDL watershed was unavailable. The 25.6 percent contribution from septic systems was determined by assuming 20 percent of all rural septic systems in the North-Central Big Sioux River watershed area were failing. This percentage does not account for die-off or attenuation of fecal coliform bacteria between failing septic systems and the stream. In general, failing septic systems discharge over land for some distance, where a portion of the fecal coliform bacteria may be absorbed on the soil and surface vegetation before reaching the stream. It is assumed that failing septic systems constitute a diminutive amount of the overall contribution because not all of the failing systems would be reaching the receiving waters. These results will not directly affect the TMDL allocations. Therefore, it is implied that comparatively, failing septic systems are having an insignificant affect on the excess fecal coliform loading and will be included in the margin of safety portion of the TMDL.

Urban Areas

Fecal coliform bacteria in urban and suburban areas may be attributed to stormwater runoff, overflow of sewer systems, illicit discharge of sanitary waste, leaking septic systems, and pets.

Land Use

Landuse in the watershed was derived from the AnnAGNPS Model. Table 4 shows that 98 percent of the area is in grass or cropland.

Table 4. Land Use in the Peg Munky Run Watershed

LandUse	Percent	Acres
Cropland	77%	28,374
Rangeland/Grassland	21%	7,549
Building/Farmstead	2%	775

Linkage Analysis

Water quality data was collected at one project monitoring site (T42) on Peg Munky Run. Samples were collected according to South Dakota's EPA approved Standard Operating Procedures for Field Samplers. The fecal coliform bacteria water samples were analyzed by the Sioux Falls Health Lab (2001-2002) in Sioux Falls, South Dakota. Quality Assurance/Quality Control samples were collected on 10% of the samples according to South Dakota's EPA approved Non-point Source Quality Assurance/ Quality Control Plan. Details concerning water sampling techniques, analysis, and quality control are addressed in the assessment final report.

The Flow Duration Interval method calculates fecal coliform bacteria loading, (concentration) × (flow), using zones based on hydrologic conditions. Reductions are calculated using the median of the fecal coliform bacteria samples in each zone. This method shows that while a TMDL may be expressed as a single point it can also be thought of as a continuum of points representing the criterion value and various flow values. In order to assess the impact of fecal coliform bacteria for this stream, the flow duration interval curve was divided into "flow zones". The purpose of the zones is to differentiate hydrologic conditions, between peak and low flows, as ranges. The typical flow zones are High (0-10), Moist (10-40), Mid-Range (40-60), Dry (60-90), and Low (90-100). However, because of the limited sample data, the overall condition of the hydrologic zones was evaluated. Excessive fecal coliform loadings are occurring during high flows and during dry to low flows. Load duration curves were calculated using the following equation:

(flow) × (conversion factor) × (state criteria) = quantity/day or daily load

This curve represents the threshold of the load. As seen in Figure 3, any samples occurring above this line is an exceedence of the water quality standard and represented by a red box (Table 5). Table 6 depicts the allowable coliform bacteria load during the study for peak flow, low flow, and 5th percentile increments in flow.

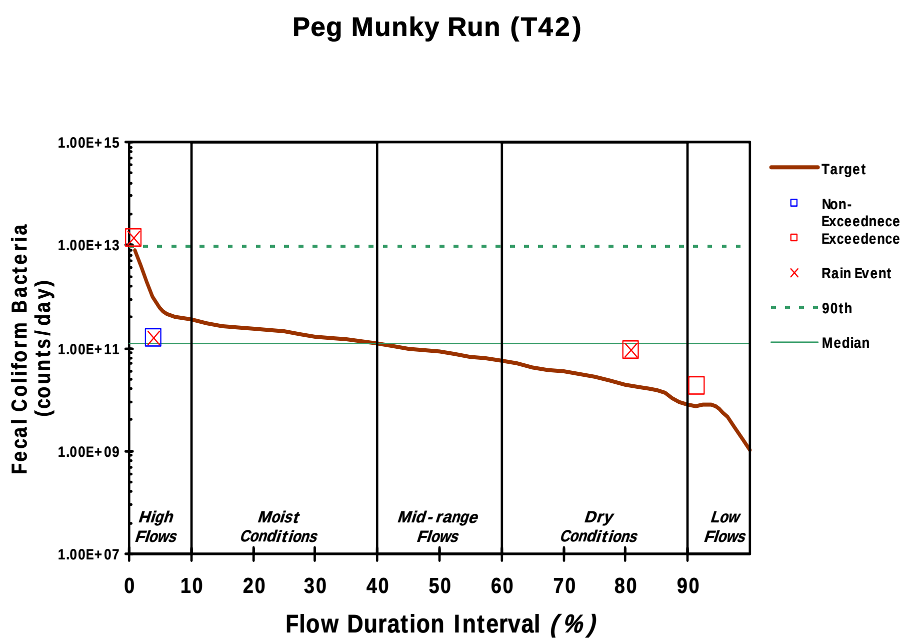


Figure 3. Flow Duration Interval for Peg Munky Run

Table 5. Exceedences of the Water Quality Standard ≤ 2000 cfu/100mL

Station	Sample Date	Sample Time	Flow (cubic feet per second - cfs)	Flow Rank	Flow Rank (percent)	Fecal Coliform (counts/100mL)	Fecal Coliform Load (counts/day)
T42	07/20/01	1320	0.37	0.809	80.90	10000	9.05E+10
T42	06/11/02	930	0.16	0.914	91.40	4700	1.85E+10
T42	06/14/01	1400	143.16	0.008	0.80	3800	1.33E+13

Table 6. Fecal Coliform Target Loads for Flow

		Allowable Loads 2000 cfu/100mL	
Flow Rank (percent)	**cfs**	**fecal Coliform (counts/day)**	**Flow Conditions**
0.019	190.50	9.32E+12	Peak
0.1	174.96	8.56E+12	
0.274	171.27	8.38E+12	
1	167.41	8.19E+12	
5	12.35	6.04E+11	
10	7.54	3.69E+11	
15	5.49	2.69E+11	
20	4.83	2.36E+11	
25	4.19	2.05E+11	
30	3.36	1.64E+11	
35	3.02	1.48E+11	
40	2.46	1.20E+11	
45	2.03	9.92E+10	
50	1.74	8.50E+10	
55	1.41	6.90E+10	
60	1.17	5.70E+10	
65	0.84	4.10E+10	
70	0.73	3.57E+10	
75	0.57	2.81E+10	
80	0.40	1.94E+10	
85	0.32	1.55E+10	
90	0.16	7.86E+09	
95	0.14	6.81E+09	
100	0.02	1.07E+09	Low

The Agricultural Non-Point Source Pollution (AGNPS) model is a GIS-integrated water quality model that predicts non-point source loadings within agricultural watersheds. ArcView GIS software was used to spatially analyze animal feeding operations and their pollution potential. The feedlot assessment assumed the probable sources of fecal coliform bacteria loadings within the NCBSR watershed were agricultural related and rated the feedlots based on runoff potential. Feedlot ratings ranged from 0-102. Table 7 lists the eight feedlots rating 50 or greater. A rating of 50 or greater warrants concern in regards to potential pollution problems. A map identifying the region of concern is shown in Figure 4. A complete methodology report can be found in Appendix T of the Assessment Report.

Table 7. Feedlot ratings ≥ 50 in the Peg Munky Run Watershed

ID	Rating
1201	51
1203	51
1199	62
1193	64
1202	67
1211	76
1207	81
1206	85

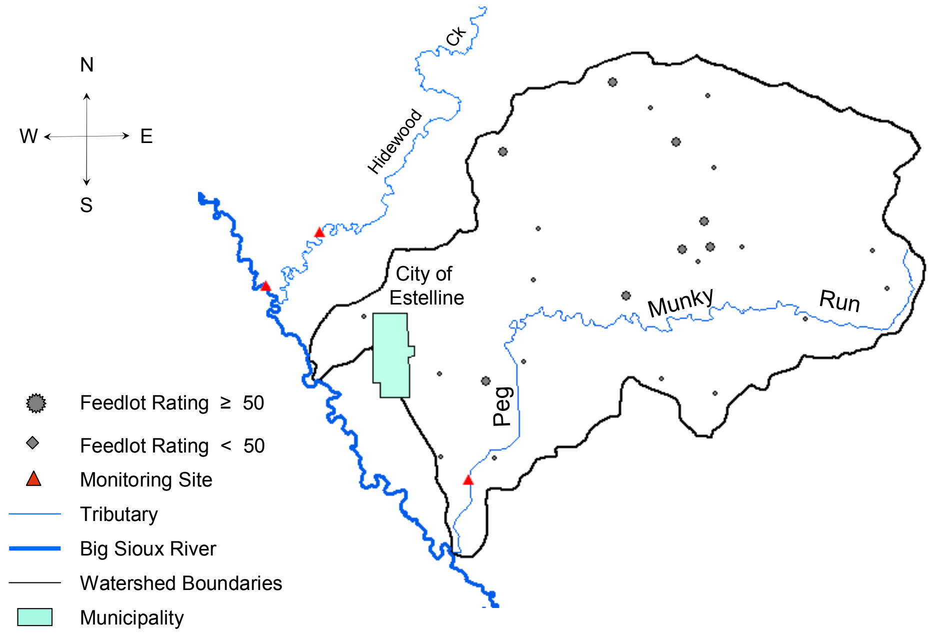


Figure 4. Location of Feedlots in the Peg Munky Run Watershed

TMDL Allocations

TMDL

Zone	TMDL			Point Source	Non-Point Source		
					100% =	2% +	98%
	TMDL	10% MOS	Total Allocations	WLA	LA	% Background	Other NPS
Overall Conditons	8.50E+10	8.50E+09	7.65E+10	0.00E+00	7.65E+10	1.53E+09	7.50E+10
Note: units are counts/day							

Wasteload Allocations (WLAs)

NPDES facilities are permitted to discharge effluent at the bacteria standard. When operating properly, they will not cause or contribute to water quality violations. Their contributions are relatively small in comparison to the total loading of the segment. Most dischargers operate well within their permit limits and discharge smaller loads than allowed. New or increases in discharges affecting this segment will be required to meet bacterial standards prior to discharge. This ensures these additions of load will not cause violations of water quality standards. Identified point sources in this watershed currently do not discharge. Therefore, the “wasteload allocation” component of this TMDL will be zero.

Load Allocations (LAs)

Load allocations account for the portion of the TMDL assigned to non-point sources. Natural background constitutes two percent of the total and the remainder of the LA is assigned to those land uses likely to contribute fecal coliform bacteria loads at rates above natural background. This includes cropland, pastureland, and residential areas. Based on the flow duration interval method, a 38 percent reduction is needed from non-point sources, as was shown in Table 2.

Seasonal Variation

Different seasons of the year can yield differences in water quality due to changes in precipitation and agricultural practices. When a rainfall event occurs, fecal coliform bacteria that have built up on the land surface under dry conditions are washed off and finally deposited into lakes, rivers, and wetlands. To determine seasonal differences, runoff events were noted for the East Dakota Water Development District samples. Monitoring site T42 on Peg Munky Run is not meeting the water quality criteria for fecal coliform bacteria. Of the three samples that were exceeding the ≤ 2000 cfu/100mL standard, two (or 67 percent) were during rain events.

Margin of Safety

The margin of safety (MOS) is a portion of the loading capacity that is set aside to prevent the exceedence of a water quality standard as a means of accounting for the uncertainty involved in developing a TMDL. The MOS for this TMDL is explicit, meaning a specific quantity, in this case 10%, of the loading is set aside. This explicit MOS takes into consideration the uncertainties associated with flow and non-point sources.

Critical Conditions

The critical condition for fecal coliform loadings in any watershed depends on the presence of point sources and land use within that watershed. During a dry period, typically the critical condition is non-point sources followed by a rainfall event. During the rainfall event, fecal coliform bacteria that have built up on the land surface can wash into the stream, causing wet weather exceedences.

Follow-Up Monitoring

Monitoring and evaluation efforts will be targeted toward the effectiveness of implemented BMPs. Sample sites will be based on BMP site selection and include the parameter of fecal coliform bacteria.

Once the implementation project is completed, post-implementation monitoring will be necessary to assure that the TMDL has been reached and improvement to the beneficial uses occurs. This will be achieved by recurrent water quality sampling at the original monitoring sites.

Public Participation

Efforts taken to gain public education, review, and comment during development of the TMDL involved:

1. East Dakota Water Development District monthly board meetings
2. Field demonstrations for the public
3. Articles in the local newspapers

The findings from these public meetings and comments have been taken into consideration in development of the Peg Munky Run TMDL.

Implementation Plan

The TMDL analysis was performed using the best data available to specify the fecal coliform reductions necessary to achieve water quality criteria. The intent of meeting the criteria is to support the designated use classifications of this stream. A detailed implementation plan is not included in this TMDL. The involvement of local land owners and agencies will be needed in order to develop an implementation plan. In general, reductions in fecal coliform bacteria should be sought through identification and installation of agricultural and urban BMPs to reduce loads during runoff events.

Appendix JJ.
Public Notice TMDL Comments and SDDENR Response to Comments Fecal Coliform

North Central Big Sioux River TMDLs - Public Notice Comments from EPA

- The Introduction section (p. 1), the body of the assessment report and the individual TMDLs should be updated to reflect the most recent listing information from the 2006 303(d) list. Also, each individual TMDL (i.e., Appendix DD – JJ) should include the State's assessment unit ID(s) for the segment(s) covered, and a statement as to whether the segment covered by the TMDL is on the 2006 303(d) list or not.

SDDENR Response - The assessment unit IDs have been added to each segment and language has been added to reflect the 2006 IR. Assessment unit IDs for the smaller waterbodies not specifically listed in the 2006 IR will be created and added to the TMDL language.

EPA response: OK

- The equations referenced in the Flow Duration Interval section (p. 22) seem to have errors in them. We recommend copying the equations from the Central Big Sioux River report (p. 46). Also, it seems that by using these equations and the data provided in Table 12, the percent reduction for each of the zones would not be zero. This table seems to match the LDC table for site R14 in Appendix V, however the rows labeled "Existing" and "Target Load" should be reversed. Because Table 12 is meant to be an example of the percent reduction calculations it might be better to use data from a site that requires some reductions. Also, the example conversion for cfu/100mL to col/day (p. 24) should start with cfu/100mL rather than col/day.

SDDENR Response – Equations on pg 22 and 24 have been corrected. Table 12 is only an example to reflect a site with actual reductions. This table has been changed.

EPA response: OK

- The Assessment of Sources sections (pp. 37, 64, 65) as well as Appendix DD refers to stormwater contributions from the City of Watertown. Both sections include this source in the non point source grouping. The City of Watertown has a municipal separate storm sewer system (MS4) permit from SD DENR for their stormwater discharges. This makes the stormwater fecal coliform contributions from Watertown a point source according to the various EPA regulations and guidance. Subsequently, this source needs to be included in the Point Source section of the assessment report and in the TMDL for the segment of the Big Sioux River that includes the City of Watertown (i.e., Appendix DD; TMDL for the Big Sioux River from Lake Kampeska to Willow Creek). Also, the TMDL for this segment needs to include a separate WLA for stormwater for the City of Watertown in accordance with EPA's guidance (See EPA's memorandum: "Establishing Total Maximum Daily Load (TMDL) Wasteload Allocations (WLAs) for Storm Water Sources and NPDES Permit Requirements Based on Those WLAs," November 22, 2002 - http://www.epa.gov/npdes/pubs/final-wwtmdl.pdf). Also, the TMDL should be clear on whether the City of Watertown will need to reduce their fecal coliform loading from stormwater.

SDDENR Response – When the TMDL was initiated, an MS4 Phase II was not necessary. Watertown was not included as an MS4 because of this. However, with the existing flow and loading data, as part of this assessment, DENR can allocate a WLA to city of Watertown for their MS4. However, at this time the City of Watertown has not been contacted regarding the potential and Fecal WLA for their MS4 permit for the Kampeska to Willow Creek Segment. Until the city has been given time to comment on the WLA, this TMDL will be withheld for final approval at this time.

EPA response: OK

- The Assessment of Sources section (p. 62) includes tables that list the NPDES percent contributions of TSS and fecal coliform. However, neither these tables nor the individual TMDLs list the WLAs, as a daily load, for each one of the discharging facilities. As a result of the TMDL program's evolution and issues related to the Anacostia lawsuit, EPA must now have the NPDES permit numbers and WLAs for each TMDL approval. We must subsequently enter that information into our national TMDL tracking system. The loading tables in each TMDL need to be revised to include the individual WLA for each point source discharge that is contributing a load to that segment, rather than the combined WLA as is currently included (See Tables 2-2 and 5-4 in EPA's Aug 2007 load duration curve guidance. The full reference is given below).

SDDENR Response –. Note under each table states that the units are in pounds or colonies per day. DENR has added the permit numbers and individual WLA for each TMDL.

EPA response: OK

- The load duration curves used in each of the TMDLs (Appendix DD – JJ) seem to have been created by combining two or more curves to form a single curve. For example, the Big Sioux River segment from Willow Creek to Stray Horse Creek has two monitoring stations – R17 & R18. The LDC for R17 requires a 33% reduction at high flow only, and the LDC for R18 requires an 11% reduction at mid-range flow and a 16% reduction at dry flow (all percentages include a 10% MOS). However, when both of these curves are combined in the TMDL (Appendix EE) the result is LDC that requires a 10% reduction at high flow only. This may be a result of **averaging** the flows from both curves to create a single curve.

Requiring only a 10% reduction at high flow, as specified in the TMDL for this segment, does not appear to protect the water quality at station R17 which requires a 33% reduction at high flow, or at R18 which requires reductions for both mid-range and dry flows. Also, by **averaging** flows from multiple stations to form a single curve, the new curve does not correspond to the flows at any of the individual stations (i.e., a theoretical curve has been created to derive the necessary TMDL loads). We do not recommend combining multiple curves in a segment into a single curve. Often, when there are multiple monitoring stations within a segment, the LDC for the monitoring station nearest the end of the segment is used to derive the TMDL loads (as was done for most of the TMDLs in the Central Big Sioux report), because it may best represent the reductions needed in that segment rather than the contributions from the upstream segment. We recommend using the curve from the monitoring station that is closest to the end of the segment to derive the loading capacity and revise the TMDLs for the each one Central Big Sioux river segments and tributaries.

SDDENR Response – Multiple curves were combined for the fecal coliform TMDLs because of the random distribution of the samples. There was no relationship between the flow and concentration for fecal coliform. Samples were clustered together resulting in flowzones with little to no data that could be used to calculate an existing load or reduction. The samples and flows between both sites were then used to calculate an existing load. If they were not combined this would not be possible. BMPs used to achieve the reductions at the high flow zone will have similar effects in the lower zones as well, i.e. animal waste management systems and/or exclusionary fencing. Through implementation efforts at the high flowzone TMDLs will be met at all zones.

The problem is with the variability of the fecal coliform bacteria. The TMDL needs to be written for the entire reach/segment rather than for individual stations. Sampling was conducted on the same day on many sites so this method of combining data within a "reach" is more reflective and more protective the that entire segment. A TMDL should not be based on the individual sampling stations within a segment. In the end the reductions are high enough that the implementation will target those areas of concern.

EPA response: (Same as Central Big Sioux Coments) Berry made the comment that we then need to clarify (in the document not the individual TMDLs) the process used to merge the data sets by adding a couple of paragraphs. He thinks he saw something in document that said the data was averaged and averaging is not acceptable for them. Will need to search document to determine if this wording exists and update it if it does.

Ruppel asked how far apart the stations were and Deb said they were about 15-18 stream miles apart. He said they will "think about this" (merging the data) to see if there will be a problem. He said "there may not be a problem" but he doesn't know and wants to think about it.

- The TMDL for the Big Sioux River segment from Stray Horse Creek to near Volga (Appendix FF) requires reducing the fecal coliform counts per day by two grab samples as the TMDL goal. As is mentioned in the comment below, these reductions will mostly be used to guide post-TMDL implementation; however this is not an acceptable goal. See the comment below on our recommendations for use of the percent reduction goals as a guide to revising this TMDL (i.e., either remove the goal or use the percent reduction from R20 as part of the implementation discussion).

SDDENR Response – Further review of the EDWDD data with DENR's ambient data indicates that this particular segment does not require a TMDL. This segment has never been listed for impairment of the limited contact beneficial use (1998-2006). It is currently meeting this beneficial use so DENR has decided not to submit this particular TMDL for approval.

EPA response: OK. Berry states, "if it's not impaired, it's not impaired"

- The TMDL for Peg Munky Run (Appendix JJ) is based on four data points from one monitoring station – T42. These 4 data points represent only 3 of the 5 flow ranges. It appears that due to the limited data set, it was decided to use the median concentration for all four data points, rather than the median within each individual flow zone, to derive the necessary reduction percentage/load. As is mentioned in the comment below, these reductions will mostly be used to guide post-TMDL implementation. However, with the very limited amount of data for this stream, a high level of uncertainty is built into the LDC for this segment. Even if the 90th percentile data line were used to derive the reduction goal, the margin of error is likely to be high. We recommend delaying the TMDL for this stream until more data can be collected.

SDDENR Response – According to DENR methodology four samples is insufficient data for listing and developing a TMDL. The intent of the sampling was to develop load allocations and reductions for the implementation of other TMDLs in the watershed. Sampling is continuing via the implementation project and a TMDL will be developed if data shows the need. This is the same issue with Bachelor Creek.

EPA response: Berry talked a little bit about this. How much data is needed to develop a load duration curve and a TMDL? Berry said they don't have the answer to that but 4 samples doesn't seem to be enough.

- The Flow Duration Interval section (pp. 21 – 24) and the individual TMDLs mention that the existing loads and the reductions goals are based on the median concentration of the fecal coliform bacteria samples from each flow zone. While we recognize that use of the median concentration data is largely used to as a guide for post-TMDL implementation, we are concerned that each TMDL uses the calculated percent reductions as the TMDL "goal." The amount of load reduction necessary to achieve the water quality standards is likely higher than the values derived using the median concentrations. The LDC guidance document (See: "An Approach for Using Load Duration Curves in the Development of TMDLs," EPA 841-B-07-006, August 2007 - http://www.epa.gov/owow/tmdl/duration_curve_guide_aug2007.pdf), and training modules developed by Bruce Cleland mention using the 90th percentile values of the data within each flow zone. Using the 90th percentile values ensures that no more than 10 percent of the data will exceed the applicable water quality standard. This approach is consistent with the assessment methodologies of many states which allow up to a 10 percent exceedance of the WQS before listing the water body as impaired. We recommend either: 1) removing the percent reductions from the TMDLs entirely (Appendices DD – JJ) – specifically remove them as the "Goal" for each TMDL and remove the reduction tables within each TMDL; 2) use the 90th percentile values to be consistent with DENR's assessment methodology and the examples in the LDC guidance; or 3) move the percent reduction tables and percent reduction goals to the Implementation section of each TMDL. Also, include a statement in the Implementation section that the reductions derived from the median concentrations will be used as a starting point to begin implementation, but that additional controls may be needed in order to achieve the applicable water quality standards and meet the loads specified in the TMDL.

SDDENR Response –The percent reduction tables and goals were moved to the implementation section. A new goal was set for each TMDL stating "Full Support of the Beneficial Uses".

EPA response: OK with Option 3. See previous comment from Central Big Sioux.

- The phosphorus TMDLs that were developed to address the TSI impairments in East Oakwood Lake and West Oakwood Lake are well written. Based on the data collected during the assessment it appears that East Oakwood Lake may be impaired for dissolved oxygen and pH. The pH impairment is mentioned in the assessment report, but the dissolved oxygen results do not recognize the impairments. Table 53 (p. 47) indicates that 7 of the 59 dissolved oxygen samples taken in East Oakwood Lake exceed the WQS – an 11.9% violation rate. Based on this violation rate we recommend adding a dissolved oxygen target to the East Oakwood Lake TMDL, and a dissolved oxygen/phosphorus linkage analysis (similar to what UT DEQ has used – see other recently developed lake TMDLs developed by SD DENR). These revisions would allow the phosphorus TMDL to address the dissolved oxygen violations.

SDDENR Response – DENR needs to review the profile data collected at the time these DO samples were collected to see if the language you mention in your comment is applicable.

EPA response: Alan said they aren't going to count the bottom DO measurements and they were going to review the profile data. Stacy mentioned that the WQS for DO were going to be changed this year with the triennial review of the WQS. I'm not sure EPA is in agreement but at this point we'd been on the phone for 1 ½ hours! Ugh… We need to review the assessment methodology of the IR with regard to DO surface and bottom measurements. If there are enough violations we will have to insert language regarding refuge which we've done with several lake TMDLs already.

4 TMDLs to be Submitted for Final Approval:

Appendix EE.	Willow Creek to Stray Horse Creek Segment (Fecal Coliform)
Appendix GG.	Willow Creek (Fecal Coliform)
Appendix HH.	Stray Horse Creek (Fecal Coliform)
Appendix II.	Hidewood Creek (Fecal Coliform)

3 TMDLs to be withheld at this time:

Appendix DD.	Lake Kampeska to Willow Creek Segment (Fecal Coliform Bacteria) for MS4 Reasons (Watertown)
Appendix FF.	Stray Horse Creek to Near Volga Segment (Fecal Coliform) has never been identified as impaired and will not be submitted.
Appendix JJ.	Peg Munky Run (Fecal Coliform) does not have enough data. More sampling will be conducted.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 8
1595 Wynkoop Street
DENVER, CO 80202-1129
Phone 800-227-8917
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DEPT. OF ENVIRONMENT AND NATURAL RESOURCES, SECRETARY'S OFFICE

JUN 4 2008

Ref: 8EPR-EP

Steven M. Pirner, Secretary
Department of Environment & Natural Resources
Joe Foss Building
523 East Capitol
Pierre, SD 57501-3181

Re: TMDL Approvals
Big Sioux River; SD-BS-R-BIG_SIOUX_03
Willow Creek; SD-BS-R-WILLOW_01
Stray Horse Creek; SD-BS-R-STRAYHORSE_01
Hidewood Creek; SD-BS-R-HIDEWOOD_01

Dear Mr. Pirner:

We have completed our review of the total maximum daily loads (TMDLs) as submitted by your office for the waterbodies listed in the enclosure to this letter. In accordance with the Clean Water Act (33 U.S.C. 1251 *et. seq.*), we approve all aspects of the TMDLs as developed for the water quality limited waterbodies as described in Section 303(d)(1). Based on our review, we feel the separate elements of the TMDLs listed in the enclosed table adequately address the pollutants of concern as given in the table, taking into consideration seasonal variation and a margin of safety.

Some of the TMDLs listed in the enclosed table may be for waters not found on the State's current Section 303(d) waterbody list. EPA understands that such waters would have been included on the list had the state been aware, at the time the list was compiled, of the information developed in the context of calculating these TMDLs. This information demonstrates that the non-listed water is in fact a water quality limited segment in need of a TMDL. The state need not include these waters that have such TMDLs associated with them on its next Section 303(d) list for the pollutant covered by the TMDL.

Thank you for submitting these TMDLs for our review and approval. If you have any questions, the most knowledgeable person on my staff is Vern Berry and may be reached at (303) 312-6234.

Sincerely,

for Carol L. Campbell
Acting Assistant Regional Administrator
Office of Ecosystems Protection
and Remediation

Enclosures

APPROVED TMDLS

4 Pollutant TMDLs completed
4 causes addressed from the 2008 303(d) list
0 Determinations made that no pollutant TMDL was needed

Waterbody Name & AU ID	TMDL Parameter / Pollutant (303(d) list cause)	Water Quality Goal/Endpoint	TMDL WLA / LA / MOS	Supporting Documentation (not an exhaustive list of supporting documents)
Big Sioux River (from Willow Creek to Stray Horse Creek)* SD-BS-R-BIG_SIOUX_03	Fecal Coliform (Fecal coliform)	Fecal coliform ≤ 2,000 cfu/100 mL in any one sample from May - September	1.42E+13 cfu/day fecal coliform (high flow)** LA = 1.28E+13 cfu/day (high flow) WLA = 0 cfu/day MOS = 1.42E+12 cfu/day (high flow)	■ Watershed Assessment Final Report and TMDLs, North-Central Big Sioux River, Brookings, Hamlin, Deuel and Codington Counties, South Dakota (SD DENR, December 2005)
Willow Creek* SD-BS-R-WILLOW_01	Fecal Coliform (Fecal coliform)	Fecal coliform ≤ 2,000 cfu/100 mL in any one sample from May - September	5.33E+12 cfu/day fecal coliform (high flow)** LA = 4.80E+12 cfu/day (high flow) WLA = 0 cfu/day MOS = 5.33E+11 cfu/day (high flow)	■ Watershed Assessment Final Report and TMDLs, North-Central Big Sioux River, Brookings, Hamlin, Deuel and Codington Counties, South Dakota (SD DENR, December 2005)
Stray Horse Creek* SD-BS-R-STRAYHORSE_01	Fecal Coliform (Fecal coliform)	Fecal coliform ≤ 2,000 cfu/100 mL in any one sample from May - September	1.03E+12 cfu/day fecal coliform (high/moist flow)** LA = 9.27E+11 cfu/day (high/moist flow) WLA = 0 cfu/day MOS = 1.03E+11 cfu/day (high/moist flow)	■ Watershed Assessment Final Report and TMDLs, North-Central Big Sioux River, Brookings, Hamlin, Deuel and Codington Counties, South Dakota (SD DENR, December 2005)

Waterbody Name & AU ID	TMDL Parameter / Pollutant (303(d) list cause)	Water Quality Goal/Endpoint	TMDL WLA / LA / MOS	Supporting Documentation (not an exhaustive list of supporting documents)
Hidewood Creek* SD-BS-R-HIDEWOOD_01	Fecal Coliform (Fecal coliform)	Fecal coliform ≤ 2,000 cfu/100 mL in any one sample from May - September	3.62E+12 cfu/day fecal coliform (high/moist flow)** LA = 3.19E+12 cfu/day (high/moist flow) WLA = 7.03E+10 cfu/day MOS = 3.62E+11 cfu/day (high/moist flow)	■ Watershed Assessment Final Report and TMDLs, North-Central Big Sioux River, Brookings, Hamlin, Deuel and Codington Counties, South Dakota (SD DENR, December 2005)

* Indicates that the waterbody has been included on the State's Section 303(d) list of waterbodies in need of TMDLs.
** Loads for high or high/moist flows were chosen to represent the TMDL because they are the most likely to require the largest load reductions. TMDL loads for other flow conditions are provided in the TMDL document for each segment.

ENCLOSURE 2

EPA REGION VIII TMDL REVIEW FORM

Document Name:	**North Central Big Sioux River - Watershed Assessment Final Report and TMDLs**
Submitted by:	**Gene Stueven, SD DENR**
Date Received:	**April 21, 2008**
Review Date:	**May 15, 2008**
Reviewer:	**Vern Berry, EPA**
Formal or Informal Review?	**Formal – Final Approval**

This document provides a standard format for EPA Region 8 to provide comments to the South Dakota Department of Environment and Natural Resources on TMDL documents provided to the EPA for either official formal or informal review. All TMDL documents are measured against the following 11 review criteria:

1. Water Quality Impairment Status
2. Water Quality Standards
3. Water Quality Targets
4. Significant Sources
5. Technical Analysis
6. Margin of Safety and Seasonality
7. Total Maximum Daily Load
8. Allocation
9. Public Participation
10. Monitoring Strategy
11. Restoration Strategy

Each of the 11 review criteria are described below to provide the rational for the review, followed by EPA's comments. This review is intended to ensure compliance with the Clean Water Act and also to ensure that the reviewed documents are technically sound and the conclusions are technically defensible.

1. Water Quality Impairment Status

Criterion Description – Water Quality Impairment Status
TMDL documents must include a description of the listed water quality impairments. While the 303(d) list identifies probable causes and sources of water quality impairments, the information contained in the 303(d) list is generally not sufficiently detailed to provide the reader with an adequate understanding of the impairments. TMDL documents should include a thorough description/summary of all available water quality data such that the water quality impairments are clearly defined and linked to the impaired beneficial uses and/or appropriate water quality standards.

☒ Satisfies Criterion
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☐ Not a required element in this case. Comments or questions provided for informational purposes.

SUMMARY – The Big Sioux River (BSR) is a natural stream that flows north to south along the eastern edge of South Dakota and drains into the Missouri River at Sioux City, Iowa. The north-central Big Sioux River watershed is approximately 502,894 acres in size in South Dakota and is a portion of the larger Big Sioux River basin. The river and its tributaries drain much of Codington, Deuel, Hamlin and Brookings Counties, and parts of western Minnesota. Approximately 73% of the landuse in the watershed is cropland and 23% is grassland and pastureland. Many animal feeding operations are located in the watershed – more than 74,000 animals were documented. The river receives stormwater discharges or additional runoff from urban areas around the communities of Watertown, Castlewood, Estelline and Brookings.

The north-central Big Sioux River segments that are addressed by the assessment report covers the portion of the BSR and its tributaries from the USGS gaging station north of Watertown to the confluence with North Deer Creek (southeast of Volga). The 2008 303(d) list includes three (3) segments of the north-central Big Sioux River, and a few of the tributaries, as impaired due to elevated nitrates, TSS and pathogen concentrations, and assigned these waters as high or medium priority for TMDL development. The North-Central Big Sioux River assessment report includes TMDLs for a few tributaries to the BSR that were determined to be impaired based on the data collected during development of the report. A total of 4 final TMDLs are included for approval with this report.

The waters for which final TMDLs have been developed include:

- BSR from Willow Creek to Stray Horse Creek (SD-BS-R-BIG_SIOUX_03) - 22.4 mi segment (Fecal coliform)
- Willow Creek (SD-BS-R-WILLOW_01) - 25.2 mi segment (Fecal Coliform)
- Stray Horse Creek (SD-BS-R-STRAYHORSE_01) - 23.2 mi segment (Fecal Coliform)
- Hidewood Creek from BSR to U.S. Highway 77 (SD-BS-R-HIDEWOOD_01) - 25.7 mi segment (Fecal Coliform)

The development of TMDLs for the following 2008 303(d) impaired waters in the north-central Big Sioux River watershed have been delayed or will be developed at a later date:

- Big Sioux River from Lake Kampeska to Willow Creek (SD-BS-R-BIG_SIOUX_02) - 9.6 mi segment (Nitrates, Fecal coliform)

- Big Sioux River from Willow Creek to Stray Horse Creek (SD-BS-R-BIG_SIOUX_03) - 22.4 mi segment (Nitrates)
- Big Sioux River from Stray Horse Creek to near Volga (SD-BS-R-BIG_SIOUX_04) - 49.8 mi segment (TSS)
- Peg Munky Run (SD-BS-R-PEG_MUNKY_RUN) - 13.8 mi segment (Fecal Coliform)

2. Water Quality Standards

Criterion Description – Water Quality Standards

The TMDL document must include a description of all applicable water quality standards for all affected jurisdictions. TMDLs result in maintaining and attaining water quality standards. Water quality standards are the basis from which TMDLs are established and the TMDL targets are derived, including the numeric, narrative, use classification, and antidegradation components of the standards.

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SUMMARY – The north-central Big Sioux River watershed segments addressed by these TMDLs are impaired by fecal coliform. South Dakota has applicable numeric standards for fecal coliform that may be applied to these stream segments. The numeric standards being implemented in these TMDLs are: fecal coliform $\leq$ 2000 cfu/100ml single sample based on the limited contact recreation beneficial uses of the stream segments included in these TMDLs. Other applicable standards are included on pages 9 - 10 of the assessment report.

3. Water Quality Targets

Criterion Description – Water Quality Targets

Quantified targets or endpoints must be provided to address each listed pollutant/water body combination. Target values must represent achievement of applicable water quality standards and support of associated beneficial uses. For pollutants with numeric water quality standards, the numeric criteria are generally used as the TMDL target. For pollutants with narrative standards, the narrative standard must be translated into a measurable value. At a minimum, one target is required for each pollutant/water body combination. It is generally desirable, however, to include several targets that represent achievement of the standard and support of beneficial uses (e.g., for a sediment impairment issue it may be appropriate to include targets representing water column sediment such as TSS, embeddeness, stream morphology, up-slope conditions and a measure of biota).

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SUMMARY – Water quality targets for these TMDLs are based on the numeric water quality standards for fecal coliform. The TMDL documents for fecal coliform include fecal coliform targets of $\leq$2000 cfu/100 mL based on the limited contact recreation beneficial use classification of the stream segments. Reduction targets (expressed as percentages) are also specified in the Implementation section of the TMDL summaries, and are based upon the median fecal coliform values plotted above the load duration curves for each of the TMDL segments. The fecal coliform reduction targets will be used as a starting point to guide implementation, however the water quality targets derived from the water quality standards are the ultimate goal for each TMDL.

4. Significant Sources

Criterion Description – Significant Sources

TMDLs must consider all significant sources of the stressor of concern. All sources or causes of the stressor must be identified or accounted for in some manner. The detail provided in the source assessment step drives the rigor of the allocation step. In other words, it is only possible to specifically allocate quantifiable loads or load reductions to each significant source when the relative load contribution from each source has been estimated. Ideally, therefore, the pollutant load from each significant source should be quantified. This can be accomplished using site-specific monitoring data, modeling, or application of other assessment techniques. If insufficient time or resources are available to accomplish this step, a phased/adaptive management approach can be employed so long as the approach is clearly defined in the document.

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SUMMARY – The TMDLs identify the major sources of fecal coliform that originate from various point and nonpoint sources within the Big Sioux watershed. A landuse analysis was completed for the watershed using the AnnAGNPS model. As part of the overall watershed assessment 371 animal feeding operations were evaluated and more than 74,000 animals were documented. Approximately 93 percent of the animals were cattle, 4 percent sheep, 2 percent pigs and the remainder horses. In general, the main fecal coliform sources include agricultural runoff from pasture and croplands, urban runoff, failing septic systems, wildlife and permitted NPDES facilities. Approximately 73% of the landuse in the watershed is cropland and 23% is grassland and pastureland.

Several point source dischargers are located within the Big Sioux River watershed. Some of the largest include Watertown, Castlewood, Estelline and Clear Lake. There are also several smaller municipalities and industries in the watershed. The facilities within the Big Sioux River watershed that have point-source discharge permits for wastewater treatment effluent are indicated in the TMDLs. Some of the smaller municipalities have non-discharge wastewater treatment facilities. These point sources are not significant sources of fecal coliform in the watershed, however, the final TMDLs include WLAs for all of the permitted point sources at their current loading levels. The City of Watertown also has a point source NPDES permit for their stormwater discharges.

5. Technical Analysis

Criterion Description – Technical Analysis
*TMDLs must be supported by an appropriate level of technical analysis. It applies to **all** of the components of a TMDL document. It is vitally important that the technical basis for **all** conclusions be articulated in a manner that is easily understandable and readily apparent to the reader. Of particular importance, the cause and effect relationship between the pollutant and impairment and between the selected targets, sources, TMDLs, and allocations needs to be supported by an appropriate level of technical analysis.*

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SUMMARY – The purpose of the technical analysis is to describe the cause and effect relationship between the identified pollutant sources, the numeric targets, and achievement of water quality standards. It should also include a description of the analytical processes used, results from water quality modeling, assumptions and other pertinent information. The technical analysis for the north-central Big Sioux River TMDLs describes the procedures used to derive the fecal coliform loading levels needed to achieve the water quality standards in each impaired river or tributary segment.

Flow duration curves were used to derive allowable fecal coliform loads and necessary load reductions for each hydrologic flow regime.

The AGNPS model was used to rank 371 feedlots within the north-central BSR watershed. The model ranked the feedlots on a scale from 0 to 100 with the higher numbers indicating a greater potential of pollutant release. Also the AnnAGNPS model was used as a tool to evaluate non-point source pollution in the watershed. The current condition of the watershed can be modeled and used to compare the effects of implementing various best management practices within the watershed.

6. Margin of Safety and Seasonality

Criterion Description – Margin of Safety/Seasonality
A margin of safety (MOS) is a required component of the TMDL that accounts for the uncertainty about the relationship between the pollutant loads and the quality of the receiving water body (303(d)(1)(c)). The MOS can be implicitly expressed by incorporating a margin of safety into conservative assumptions used to develop the TMDL. In other cases, the MOS can be built in as a separate component of the TMDL (in this case, quantitatively, a TMDL = WLA + LA + MOS). In all cases, specific documentation describing the rational for the MOS is required. *Seasonal considerations, such as critical flow periods (high flow, low flow), also need to be considered when establishing TMDLs , targets, and allocations.*

☒ Satisfies Criterion

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SUMMARY – An explicit MOS is included in each of the TMDLs by reserving 10% of the loading capacity derived from the load duration curves for fecal coliform for each stream segment. Additionally, more BMPs were specified than are necessary to meet the targets, and ongoing monitoring has been proposed to assure water quality goals are achieved.

Seasonality was adequately considered by evaluating the cumulative impacts of the various seasons on water quality and by proposing BMPs that can be tailored to seasonal needs. The load duration curve analysis looks at five different flow regimes (i.e., high, moist, mid-range, dry and low) and determines load reductions based on those flows.

7. TMDL

Criterion Description – Total Maximum Daily Load

TMDLs include a quantified pollutant reduction target. According to EPA regulations (see 40 CFR 130.2(i)). TMDLs can be expressed as mass per unit of time, toxicity, % load reduction, or other measure. TMDLs must address, either singly or in combination, each listed pollutant/water body combination.

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SUMMARY – TMDLs were calculated for one (1) listed segment of the Big Sioux River and for three (3) listed tributary segments. The TMDLs for each impaired segment specify the fecal coliform loads (cfu/day) needed to meet the applicable water quality standards. The TMDL loads were derived from the load duration curves for each stream segment and include values for loading capacity, wasteload allocation and load allocation for each flow regime shown on the curve. Reduction targets (expressed as percentages) are also specified in the Implementation section of the TMDL summaries, and are based upon the median fecal coliform values plotted above the load duration curves for each of the TMDL segments. The fecal coliform reduction targets will be used as a starting point to guide implementation.

8. Allocation

Criterion Description – Allocation

TMDLs apportion responsibility for taking actions or allocate the available assimilative capacity among the various point, nonpoint, and natural pollutant sources. Allocations may be expressed in a variety of ways such as by individual discharger, by tributary watershed, by source or land use category, by land parcel, or other appropriate scale or dividing of responsibility. A performance based allocation approach, where a detailed strategy is articulated for the application of BMPs, may also be appropriate for nonpoint sources. For these reasons, every effort should be made to be as detailed as possible and also, to base all conclusions on the best available scientific principles.

In cases where there is substantial uncertainty regarding the linkage between the proposed allocations and achievement of water quality standards, it may be necessary to employ a phased or adaptive management approach (e.g., establish a monitoring plan to determine if the proposed allocations are, in fact, leading to the desired water quality improvements).

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SUMMARY – These TMDLs address the need to achieve reductions fecal coliform bacteria loading in order to attain water quality standards in the north-central Big Sioux River watershed. The Hidewood Creek TMDL includes both a load allocation and a wasteload allocation attributed to nonpoint sources and point sources respectively as specified in the TMDL. The TMDLs for the three other stream segments only have a load allocation because there are no point sources discharging directly to the impaired segments. The nonpoint source allocations and the specified reductions of fecal coliform concentrations can be achieved through the implementation of BMPs that are specified in the assessment report.

9. Public Participation

Criterion Description – Public Participation

The fundamental requirement for public participation is that all stakeholders have an opportunity to be part of the process. Notifications or solicitations for comments regarding the TMDL should clearly identify the product as a TMDL and the fact that it will be submitted to EPA for review. When the final TMDL is submitted to EPA for review, a copy of the comments received by the state should be also submitted to EPA..

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SUMMARY – The State's submittal includes a summary of the public participation process that occurred during the TMDL development process, and describes the ways the public was been given an opportunity to be involved. In particular, efforts were taken to gain public education, review, and comment during development of the TMDLs including local newspaper articles, field demonstrations for the public, and East Dakota Water Development District board meetings. The comments/findings from these public events were taken into consideration during the development of the TMDLs. The State also posted the draft TMDLs on the internet for review and comment, and solicited comments using public notice announcements in newspapers.

10. Monitoring Strategy

Criterion Description – Monitoring Strategy

TMDLs may have significant uncertainty associated with selection of appropriate numeric targets and estimates of source loadings and assimilative capacity. In these cases, a phased TMDL approach may be necessary. For Phased TMDLs, it is EPA's expectation that a monitoring plan will be included as a component of the TMDL documents to articulate the means by which the TMDL will be evaluated in the field, and to provide supplemental data in the future to address any uncertainties that may exist when the document is prepared.

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SUMMARY – The TMDLs describe the plans for follow-up monitoring. Monitoring and evaluation efforts will be targeted toward the effectiveness of implemented BMPs. Sample sites will be selected based on locations of implemented BMPs. Post-implementation monitoring will be necessary to assure that the TMDL targets have been achieved and the designated beneficial uses are being attained.

11. Restoration Strategy

Criterion Description – Restoration Strategy

At a minimum, sufficient information should be provided in the TMDL document to demonstrate that if the TMDL were implemented, water quality standards would be attained or maintained. Adding additional detail regarding the proposed approach for the restoration of water quality *__is not__* *currently a regulatory requirement, but is considered a value added component of a TMDL document.*

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SUMMARY – Detailed implementation plans have not yet been developed for the north-central Big Sioux watershed TMDLs. The involvement of local landowners and agencies will be needed in order to develop implementation plans. In general, reduction in fecal coliform loads will be sought through identification and installation of agricultural BMPs to reduce loads during higher flow events.