Total Suspended Solids Total Maximum Daily Load (TMDL) for Three Segments of the Lower Big Sioux River South Dakota and Iowa

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Total Maximum Daily Load Summary

Lower Big Sioux -Segment R15, Segment R16, and Segment R17 (South Dakota and Iowa)

Waterbody Type:	River/Stream
303(d) Listing Parameter:	Total Suspended Solids (TSS)
Designated Uses (SD):	Warmwater semipermanent fish life propagation waters, immersion recreation waters, limited-contact recreation waters, fish and wildlife propagation, recreation, and stock watering
Designated Uses (IA):	Primary contact recreational use, aquatic life use (Class B Warm Water Type 1), human health use, and general use
Size of Impaired Waterbody:	Segment R15 - Approximately 32 km in length Segment R16 - Approximately 27 km in length Segment R17 - Approximately 96 km in length
Size of Watershed:	Segment R15 - 462,397 hectares (ha) Iowa: 443,124 ha SD: 19,274 ha Segment R16 - 74,919 ha Iowa: 10,898 ha SD: 64,021 ha Segment R17 - 144,439 ha Iowa: 47,393 ha SD: 97,046 ha
Indicator(s):	Concentration of total suspended solids
Analytical Approach:	FLUX and ANNAGNPS Modeling with Load Duration Curve
Location:	Hydrologic Unit Codes (8-digit HUC): 10170203
Goal:	Meet applicable water quality standards for total suspended solids
TMDL Priority Ranking:	Priority 1 for all three segments (2008 IR)
Target (Water Quality Standards):	Maximum daily concentration of ≤ 158 mg/L and a concentration of ≤ 90 mg/L for a thirty-day average of three consecutive grab or composite samples taken on separate weeks.
Reach Number:	SD-BS-R-BIG_SIOUX_15 SD-BS-R-BIG_SIOUX_16 SD-BS-R-BIG_SIOUX_17

1.0 Objective

The intent of this document is to clearly identify the components of the TMDL, support adequate public participation, and facilitate the US Environmental Protection Agency (US EPA) review. The TMDL was developed in accordance with Section 303(d) of the federal Clean Water Act and guidance developed by US EPA. This TMDL document addresses the total suspended solids impairment of Segment R15, Segment R16, and Segment R17 of the Lower Big Sioux River (Fairview, SD to Mouth), which have all been assigned to priority category 1 (high-priority) in the 2008 impaired waterbodies list.

Many of the ongoing adjustments to the Big Sioux River system involve events and/or past perturbations associated with the various stages of stream evolution. It is important to identify the potentially stable stream type of the existing river after the root cause of impairment has been determined. Rates of sediment supply, bank erosion rates and other characteristics identified in this Big Sioux River TMDL report represent the first steps towards a stable (quasi-equilibrium) geomorphic condition for the Big Sioux River.

2.0 Watershed Characteristics

2.1 General

The project area for this report is shown in Figure 1. The Lower Big Sioux River drains approximately 661,418 acres (1,033 miles^2) and 919,040 acres (1,436 miles^2) in South Dakota (SD) and Iowa, respectively. The main tributary draining into the Lower Big Sioux River or that portion below the city of Sioux Falls, SD is the Rock River. The Rock River drains approximately 4,355 km^2 (1682 mi^2) from northwestern Iowa and southwestern Minnesota (Figure 1). The Big Sioux River is tributary of the Missouri River and drains approximately 7,461 mi^2 (19,324 km^2) at the confluence with the Missouri River near Sioux City, IA.

The Big Sioux River watershed is located in the Northern Glaciated Plains and Western Corn Belt Plains ecoregions. A flat to gently rolling landscape composed of glacial drift characterizes the Northern Glaciated Plains ecoregion. The Western Corn Belt Plains ecoregion is composed of level to gently rolling glacial-till plains with areas of moraine hills and loess deposits (Bryce et al., 1996 and Chapman et al., 2001). Wildlife species present in the area include whitetail deer, red fox, beavers, raccoons, ring-necked pheasants, mourning doves, and numerous other species of songbirds, waterfowl, reptiles, and amphibians (SD Game, Fish, and Parks, 2002).

Both Segment R15 and R16 are found within the Level IV Ecoregion 47a-Loess Prairies. Ecoregion 47a can be described as gently rolling hills with Loess deposits over Cretaceous sandstone, shale, and Sioux quartzite. Originally dominated by a tallgrass prairie it has since been converted to intensive row crop agriculture. The northern half of Segment R17 is also found within 47a but transitions into 47d-Missouri River Alluvial Floodplain and 47m-Western Loess Hills (Chapman, et. al, 2001). Ecoregion 47d is characterized as a level floodplain alluvium that intensively farmed for corn and soybeans. Ecoregion 47m-Western Loess Hills is dominated by a thick layer loess characterized by a mosaic of bur-oak woodland and big Bluestem-Indian grass prairie. The cropland is dominated by corn, soybeans and other feed grains that is interspersed with pastureland.

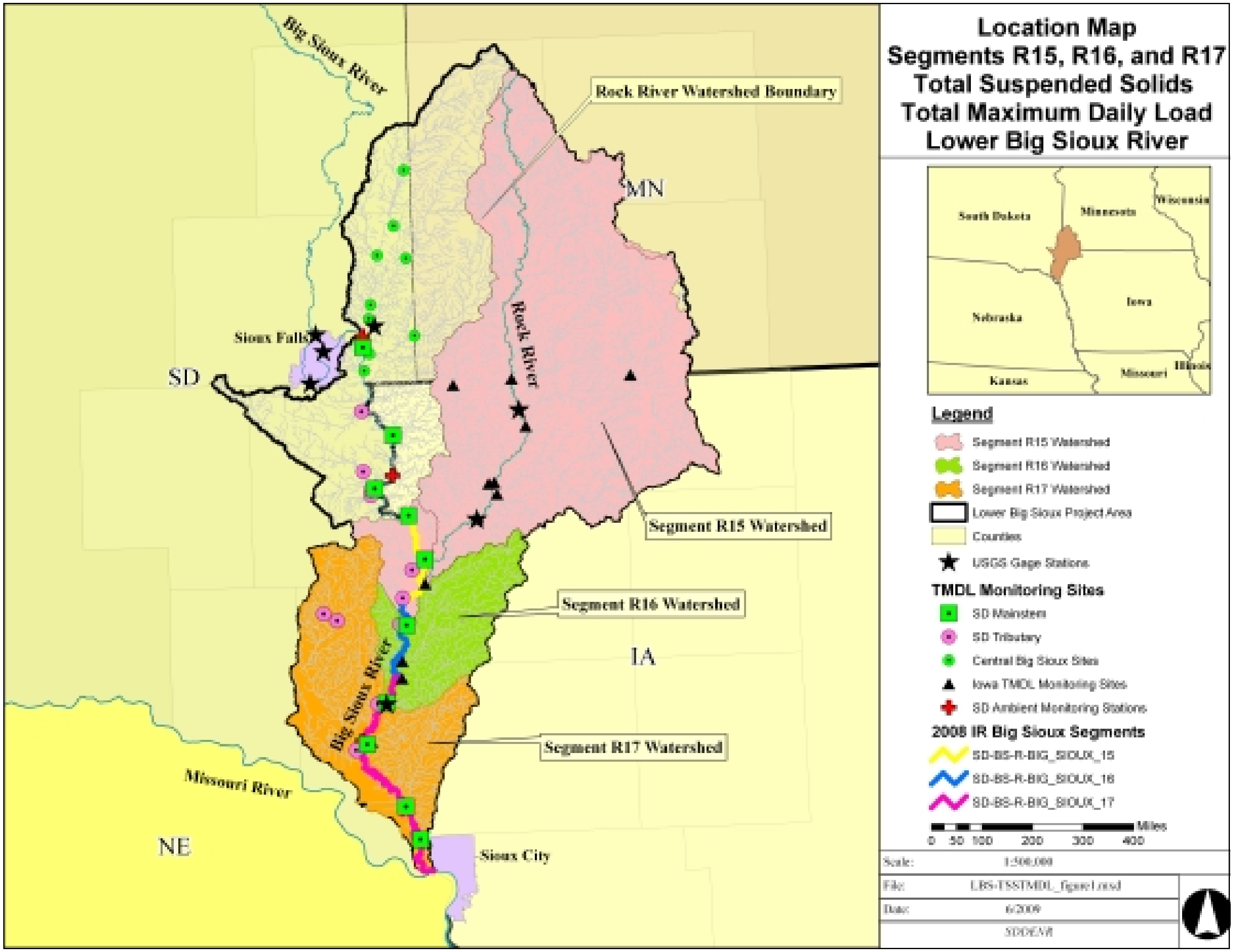


Figure 1. Location of Segments R15, R16, and R17 subwatersheds of the Lower Big Sioux River (Minnesota, Iowa and South Dakota).

Table 1. Big Sioux River Assessment Reach and Segment Designations.

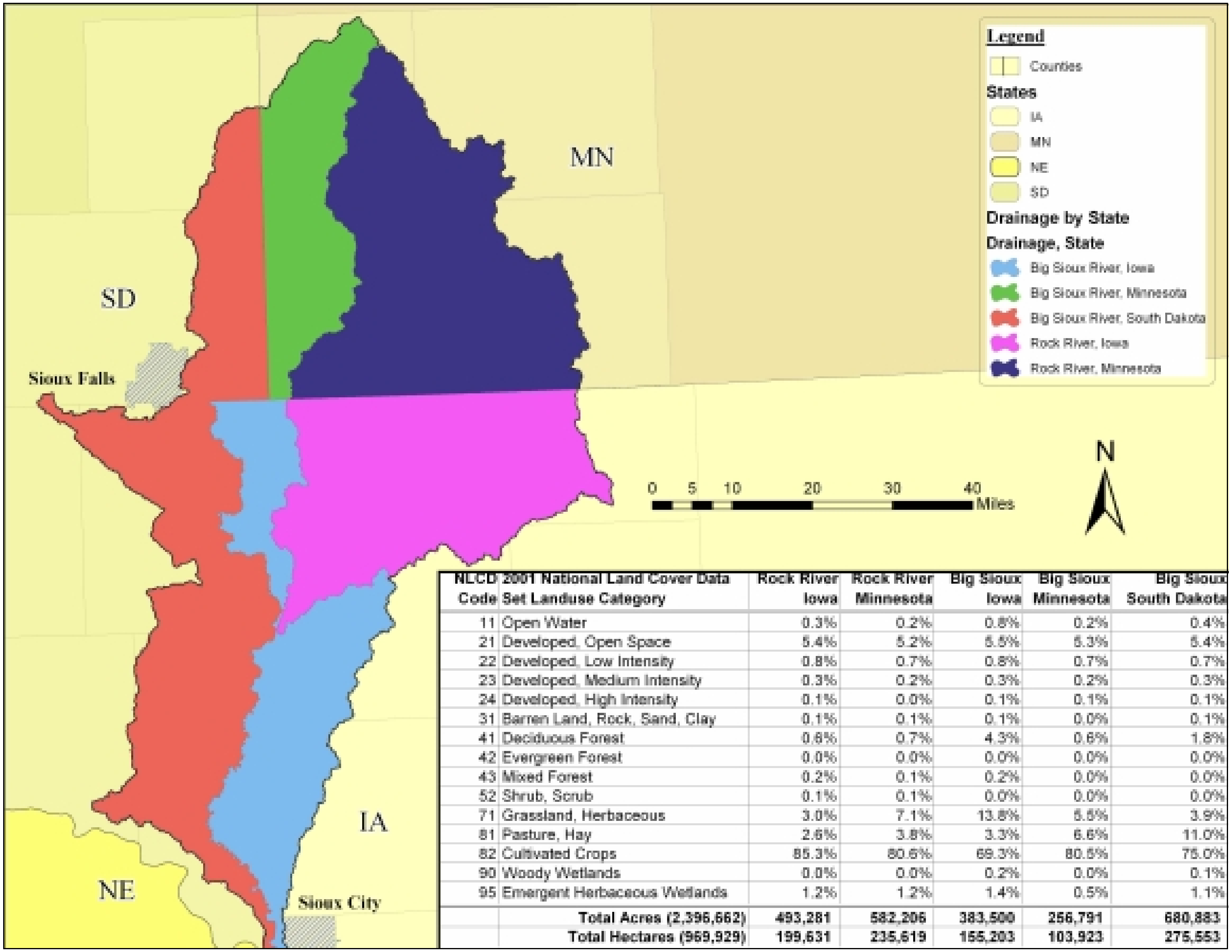
Segment	Length, miles	Description	South Dakota Monitoring Stations for Mainstem River		
			Mainstem Sites	Tributary Sites (SD)	Tributary Sites (IA)
SD-BS-R-BIG_SIOUX_13	15.8	Above Brandon, SD to Nine Mile Creek (SD)	LBSM01	LBST02	
SD-BS-R-BIG_SIOUX_14	33.2	Nine Mile Creek (SD) to near Fairview, SD	LBSM03, LBSM05, LBSM08	LBST04, LBST06, LBST07	
SD-BS-R-BIG_SIOUX_15	20.0	Near Fairview, SD to near Alcester, SD	LBSM08, LBSM09, LBSM13	LBST10, LBST11	Rock River sites (IA01 through IA07), and ambient station 975005 designated as IA12 for this report.
SD-BS-R-BIG_SIOUX_16	16.6	Near Alcester, SD to Indian Creek (IA)	LBSM13 LBSM17	LBST12	IA08 and IA09
SD-BS-R-BIG_SIOUX_17	59.9	Indian Creek (IA) to mouth	LBSM17, LBSM19, LBSM20, LBSM21	LBST14, LBST15, LBST16, LBST18	IA10 and IA11

Land uses in the various HUC 12 drainage areas in SD are generally similar. The majority of these areas are dominated by a combination of grassland, hay, pasture, corn, and soybeans land uses, followed by high intensity commercial, and industrial land uses. There is relatively limited residential area within these drainage areas and therefore impacts from these land uses are expected to be minimal (Figure 2).

Land uses in the various HUC 12 drainage areas within Iowa are generally similar. With the exception of a few drainage areas, where land uses are dominated by ungrazed pasture/forest land use, all of the remaining HUC 12 drainage areas within South Dakota and Iowa are dominated by cropland, follow by ungrazed pasture/forest land and pastureland. There are generally limited built-up land uses within the HUC 12s areas draining into both the LBS River and the Rock River. Figure 2 shows the landuse for the entire Lower Big Sioux drainage categorized by state including Minnesota. In all three states approximately 70% or greater of the watershed is dominated by cultivated crops, i.e. corn and soybeans.

The average rainfall in the lower Big Sioux Watershed is approximately 25 inches per year with 78% falling during the growing season. The average annual snowfall is approximately 34 inches but varies widely from year to year. As shown on Figure 1, there were 10 SD monitoring stations located along the main stem segments (LBSM).

The Lower Big Sioux River is divided into five main segments running from Brandon, SD to the mouth near Sioux City, IA (Figure 1, Table 1). All five segments were placed on the Iowa and South Dakota 303d Impaired Waterbody List for immersion recreational use impairment caused by pathogens. A Pathogen (fecal coliform and *E. coli*) TMDL was developed by the Iowa Department of Natural Resources (IDNR) in conjunction with the South Dakota Department of



NLCD Code	2001 National Land Cover Data Set Landuse Category	Rock River Iowa	Rock River Minnesota	Big Sioux Iowa	Big Sioux Minnesota	Big Sioux South Dakota
11	Open Water	0.3%	0.2%	0.8%	0.2%	0.4%
21	Developed, Open Space	5.4%	5.2%	5.5%	5.3%	5.4%
22	Developed, Low Intensity	0.8%	0.7%	0.8%	0.7%	0.7%
23	Developed, Medium Intensity	0.3%	0.2%	0.3%	0.2%	0.3%
24	Developed, High Intensity	0.1%	0.0%	0.1%	0.1%	0.1%
31	Barren Land, Rock, Sand, Clay	0.1%	0.1%	0.1%	0.0%	0.1%
41	Deciduous Forest	0.6%	0.7%	4.3%	0.6%	1.8%
42	Evergreen Forest	0.0%	0.0%	0.0%	0.0%	0.0%
43	Mixed Forest	0.2%	0.1%	0.2%	0.0%	0.0%
52	Shrub, Scrub	0.1%	0.1%	0.0%	0.0%	0.0%
71	Grassland, Herbaceous	3.0%	7.1%	13.8%	5.5%	3.9%
81	Pasture, Hay	2.6%	3.8%	3.3%	6.6%	11.0%
82	Cultivated Crops	85.3%	80.6%	69.3%	80.5%	75.0%
90	Woody Wetlands	0.0%	0.0%	0.2%	0.0%	0.1%
95	Emergent Herbaceous Wetlands	1.2%	1.2%	1.4%	0.5%	1.1%
	Total Acres (2,396,662)	493,281	582,206	383,500	256,791	680,883
	Total Hectares (969,929)	199,631	235,619	155,203	103,923	275,553

Figure 2. Landuse for the entire Lower Big Sioux River Watershed (2001 NLCD).

Environment and Natural Resources (SDDENR), EPA Region VII and VIII. This TMDL was formally approved by both EPA Region VII and Region VIII in 2008 (EPA, 2008). Three of the same impaired segments in South Dakota extending from above the City of Fairview, SD to the mouth of the river have been identified as impaired for the warm water semipermanent fish life beneficial use (TSS criterion). This TMDL report addresses these three lower segments listed for this impairment.

Land use/land cover characteristics are a determinant in identifying and quantifying sources of sediment within a watershed. The table in Figure 2 shows the significant percentages of the 15-land use categories taken from the 2001 National Land Cover Data set (NLCD, 2001) for the Lower Big Sioux River and Rock River drainage areas in Iowa, South Dakota, and Minnesota. These table lists both the total acreage and the percent land uses. Table 2 shows the landuse breakout by segment by state.

2.2 Segment R15

Segment R15 runs approximately 20 miles from Fairview, SD to near Alcester, SD. Major tributaries to this segment from SD include Pattee Creek (Site LBST10) and Finnie Creek (Site LBST11). Iowa tributaries include the Rock River (Site IA12) which drains approximately 4,355 km^2 (1682 mi^2) from northwestern Iowa and southwestern Minnesota (Figure 5). The Iowa part does not include any wastewater treatment facilities (WWTF) that drain directly into the Big Sioux River.

Landuse for the Iowa subwatershed (Rock River) consists of greater than 80% cultivated crops. The immediate subwatershed draining the SD portion is somewhat less at 72% cropland with significantly more pastureland (Table 2).

2.3 Segment R16

Segment R16 runs approximately 17 miles from near Alcester, SD to Indian Creek which drains into the Big Sioux River just north of Akron, IA (Figure 6). Major tributaries to this segment from SD include Green Creek (Site LBST12). Iowa tributaries include Six Mile Creek (Site IA08) and Indian Creek (Site IA09). The Iowa part includes one WWTF that discharges directly into the Big Sioux River. There are no WWTF from SD that drain directly into the Big Sioux River.

This segment has an immediate subwatershed (area draining directly into the segment) of 74,919 hectares (10,898 ha from Iowa and 64,021 ha from SD). Landuse is dominated by cultivated crops for both Iowa and SD at 84% and 63%, respectively. More pastureland is present in the SD portion of this watershed (16%) versus Iowa (1.75%) (Table 2).

2.4 Segment R17

Segment R17 runs 59.9 miles from Indian Creek, which is just north of Akron, IA, to the mouth of the Big Sioux River (Figure 7). Major tributaries to this segment from SD include Brule Creek (Site LBST18), Union Creek (Site LBST16), and Big Ditch Creek. Iowa tributaries include Broken Kettle Creek (Site IA11) and Westfield Creek (Site IA10). Segment R17 of the Big Sioux River runs to the confluence with the Missouri River near North Sioux City, SD

(Figure 7). The Iowa part includes seven HUC12 sub-watersheds and one WWTF that discharges directly into the Big Sioux River. Broken Kettle, Rock, and Westfield Creeks drain this watershed. The SD part includes 11 HUC12 sub-watersheds and no WWTF that discharge directly into the Big Sioux River.

Segment R17 has an immediate subwatershed (area draining directly into the segment) of 144,439 hectares (47,393 hectares from SD and 97,046 hectares from Iowa).

All three subwatershed characteristics show that the Lower Big Sioux River is a moderately sized river draining a highly agriculture landscape in extreme southeastern South Dakota and northwestern Iowa (Figure 1 and Figure 2).

Table 2. Landuse for three segments of the Lower Big Sioux River.

NLCD Code	2001 National Land Cover Data Set Landuse Category	Segment R15		Segment R16		Segment R17	
		Iowa*	SD	Iowa	SD	Iowa	SD
11	Open Water	0.29%	0.97%	0.33%	0.88%	1.11%	0.32%
21	Developed, Open Space	5.37%	5.20%	5.63%	3.84%	5.20%	5.43%
22	Developed, Low Intensity	0.78%	0.25%	0.69%	0.11%	0.87%	0.60%
23	Developed, Medium Intensity	0.27%	0.06%	0.32%	0.03%	0.22%	0.32%
24	Developed, High Intensity	0.05%	0.01%	0.08%	0.00%	0.05%	0.07%
31	Barren Land, Rock, Sand, Clay	0.08%	0.01%	0.06%	0.00%	0.05%	0.03%
41	Deciduous Forest	0.71%	3.13%	0.75%	2.82%	8.53%	1.42%
42	Evergreen Forest	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
43	Mixed Forest	0.14%	0.01%	0.13%	0.05%	0.27%	0.08%
52	Shrub, Scrub	0.07%	0.00%	0.03%	0.00%	0.11%	0.00%
71	Grassland, Herbaceous	5.30%	4.31%	4.44%	8.93%	27.89%	3.19%
81	Pasture, Hay	3.24%	11.41%	1.75%	16.30%	2.19%	9.07%
82	Cultivated Crops	82.48%	72.95%	84.26%	62.99%	50.97%	78.19%
90	Woody Wetlands	0.03%	0.16%	0.12%	0.90%	0.44%	0.17%
95	Emergent Herbaceous Wetlands	1.20%	1.52%	1.42%	3.14%	2.09%	1.11%
Total Acres per Segment per State		1,094,943	47,625	26,928	158,195	117,106	239,797
Total Hectares per Segment per State		443,124	19,274	10,898	64,022	47,393	97,046

* includes Minnesota portion of the Rock River

The major soil associations on the Iowa side of Segment R17 include Kennebec-Radford-Colo, Ida-Galva, Ida-Hamburg, and Ida-Monona associations. All associations can be generalized to include nearly level and steep silty soils that are moderately well drained to poorly drained.

Segment R16 and R17 major soil associations on the SD side are found in the glacial drift and till on the uplands in nearly level areas include the Wentworth-Shindler-Worthing and the Wakonda-Worthing-Chancellor associations. Soils found in the loess are deep, well-drained soils form on narrow bottom lands along small streams found in gently sloping to strongly sloping areas (Moddy-Nora-Alcester and Crofton-Nora-Alcester Associations). Other associations formed in alluvium on stream terraces and bottom lands can be found on moderately high terraces along the Big Sioux River (Graceville-Dempster association). The other six alluvium associations are found along bottom lands along the Missouri River, Brule Creek, and the Big Sioux River, i.e. Sarpy-Grable-Haynie and Calco-Kennebec associations. Some of these soils are highly mobile and are susceptible to wind erosion (NRCS, Lincoln and Union County, SD Soil Survey, 1971 and 1978, respectively).

The geology for southern one-third of Union County is in the flood plain of the Missouri River. A sharp escarpment of up to 80 feet separates this lower plain from the rest of the James Basin. The SD side is a flood plain reaching nearly 10 miles wide and displays a complex array of abandoned river channels and associated features. Oxbow lakes, abandoned sandbars, and dune fields provide more than 30 feet of local relief to the otherwise flat surface (McCormick and Hammond, 2004).

3.0 Problem Identification

Sediment sources are overland runoff from nearby croplands and feedlots, inflow from tributaries, and streambank erosion. Potential for severe soil erosion appears to be particularly high in a approximately 50-mile reach of the Big Sioux south of Canton, SD, where the river channel borders an extensive hilly area of highly erosive soils. This situation promotes bank erosion and high sediment runoff in the Big Sioux and tributaries in the area.

Segments R15 through R17 of the Lower Big Sioux River have a history of exceedance of the SD total suspended solids (TSS) water quality criterion. Initially listed in 1998 due to warmwater semipermanent beneficial use impairment, these three segments have consistently been listed in 2002, 2004, 2006, and 2008 for this same impairment in SD. Other studies and TMDLs that have cited the increased sediment load in the Big Sioux River include the Central Big Sioux Final Report and related TMDLs (EDWDD, 2008), and the National Sedimentation Laboratory final report on bank stability (Bankhead, et al., 2009). Iowa does not have a TSS water quality criterion and, therefore, has not listed these segments as impaired from sediment.

The ambient sampling stations located near Hudson (SD), Hawarden (IA), and Richland (SD), have all been sampled monthly since 1974. Existing flow information from the USGS Gage #06485500 located at Akron, IA (TMDL Site LBSM17) is approximately 14 miles upstream of the Richland location. This site was used to calculate the daily average flows for the downstream sites (LBSM19, 20, and 21). Using this flow data and the ambient monthly data the LOWESS procedure, as described in Helsel and Hirsch (2002), for trend detection (TSS vs. time) did not indicate an increasing or decreasing trend ($P>0.05$). Figure 3 shows TSS concentrations sampled from LBSM19 for the period 1974 through 2004. Although a trend (increasing or decreasing) was not detected the concentrations seem to indicate the same level of TSS impairment at least since 1974.

Figure 4 shows the TSS concentrations categorized by flow. Four flowzones for Site LBSM19 (STORET Site WQM460832) are shown: High, Moist, Mid Range, and Dry. Violations of the TSS criterion are clearly driven by flow. In fact, the most significant violations were sampled during storm events (>50% stormflow) (Figure 4). Higher flowzone violations are indicative of streambank erosion in both the mainstem and tributaries along with sheet and rill erosion from farm field runoff during moist conditions (Cleland, 2003). Lower flow violations can be attributed to sediment delivered from tributaries from smaller storm events, continued bank erosion, and the existing sediment load contained within the river.

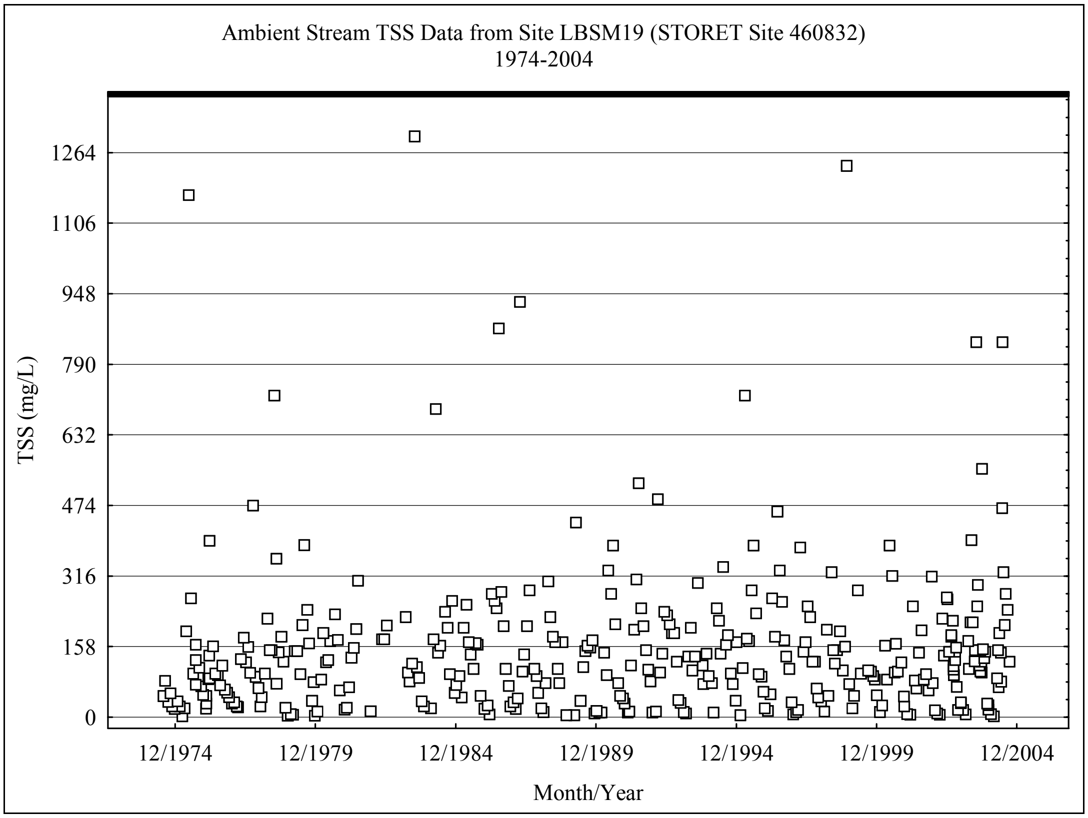


Figure 3. Longterm TSS Concentrations for Site LBMS19 (STORET Site 460832).

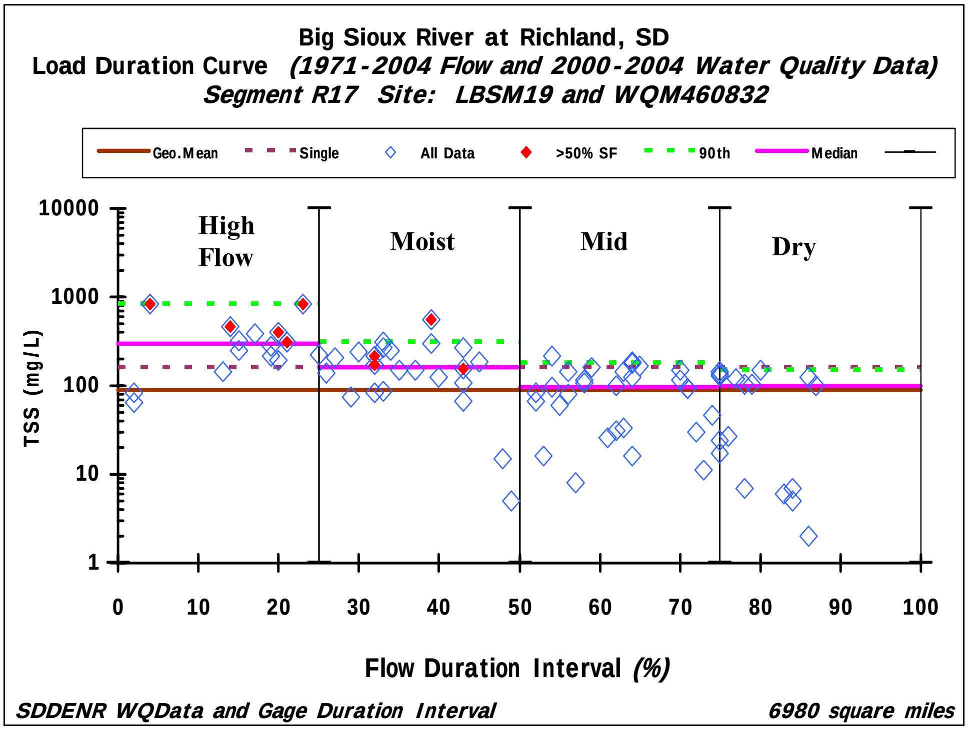


Figure 4. Site LBSM19 TSS concentrations for each of the four flowzones.

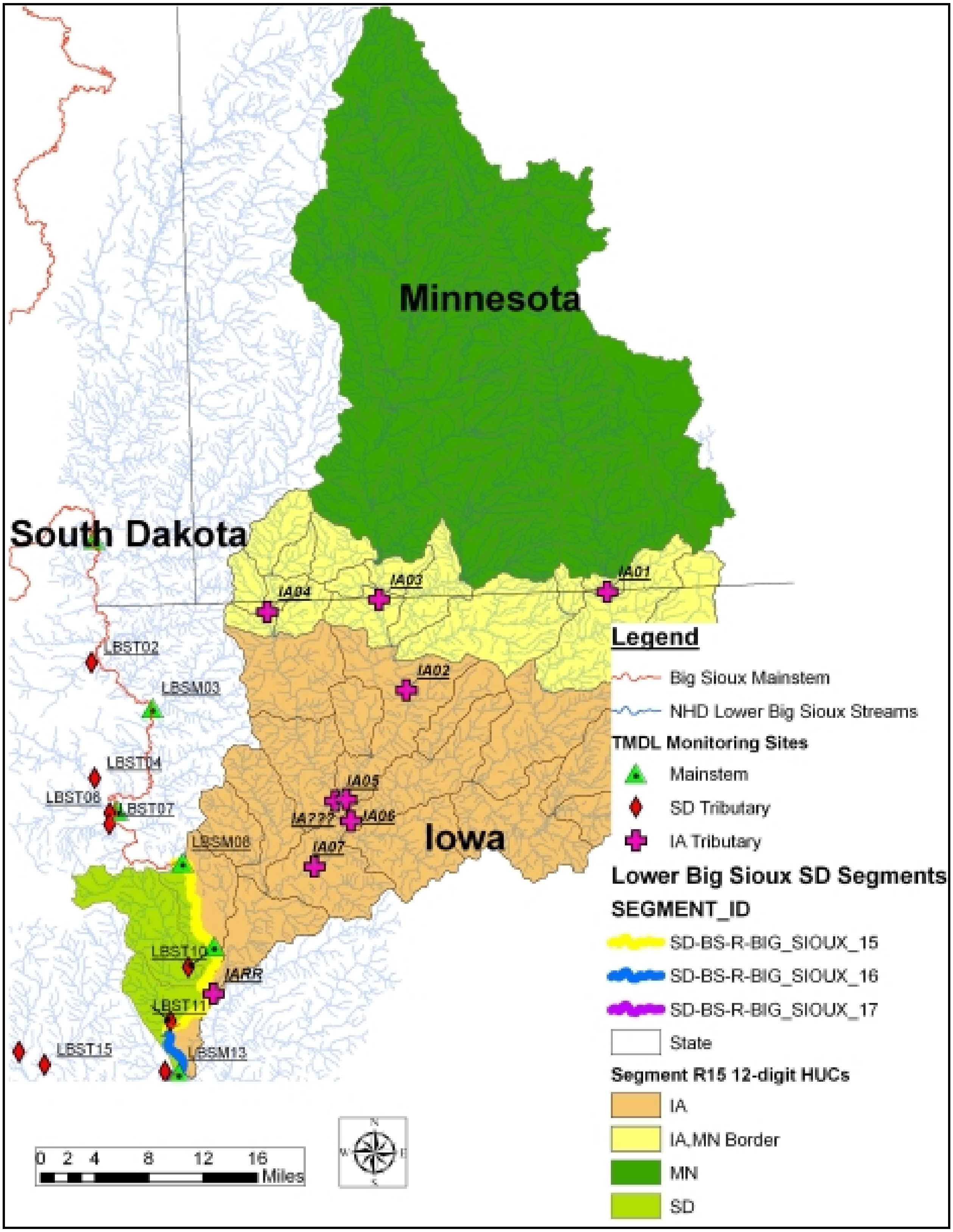


Figure 5. Segment R15 Subwatershed.

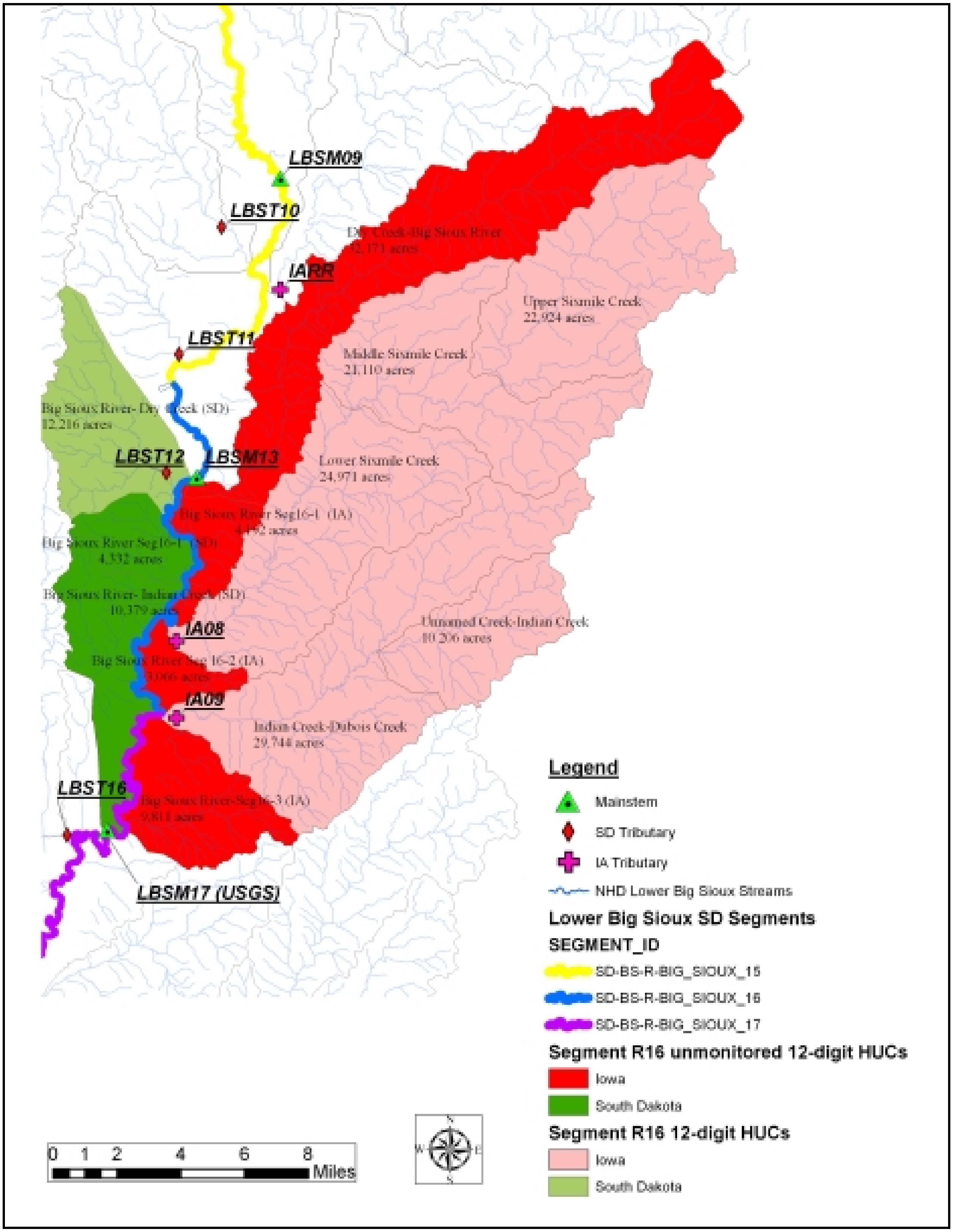


Figure 6. Segment R16 Subwatershed.

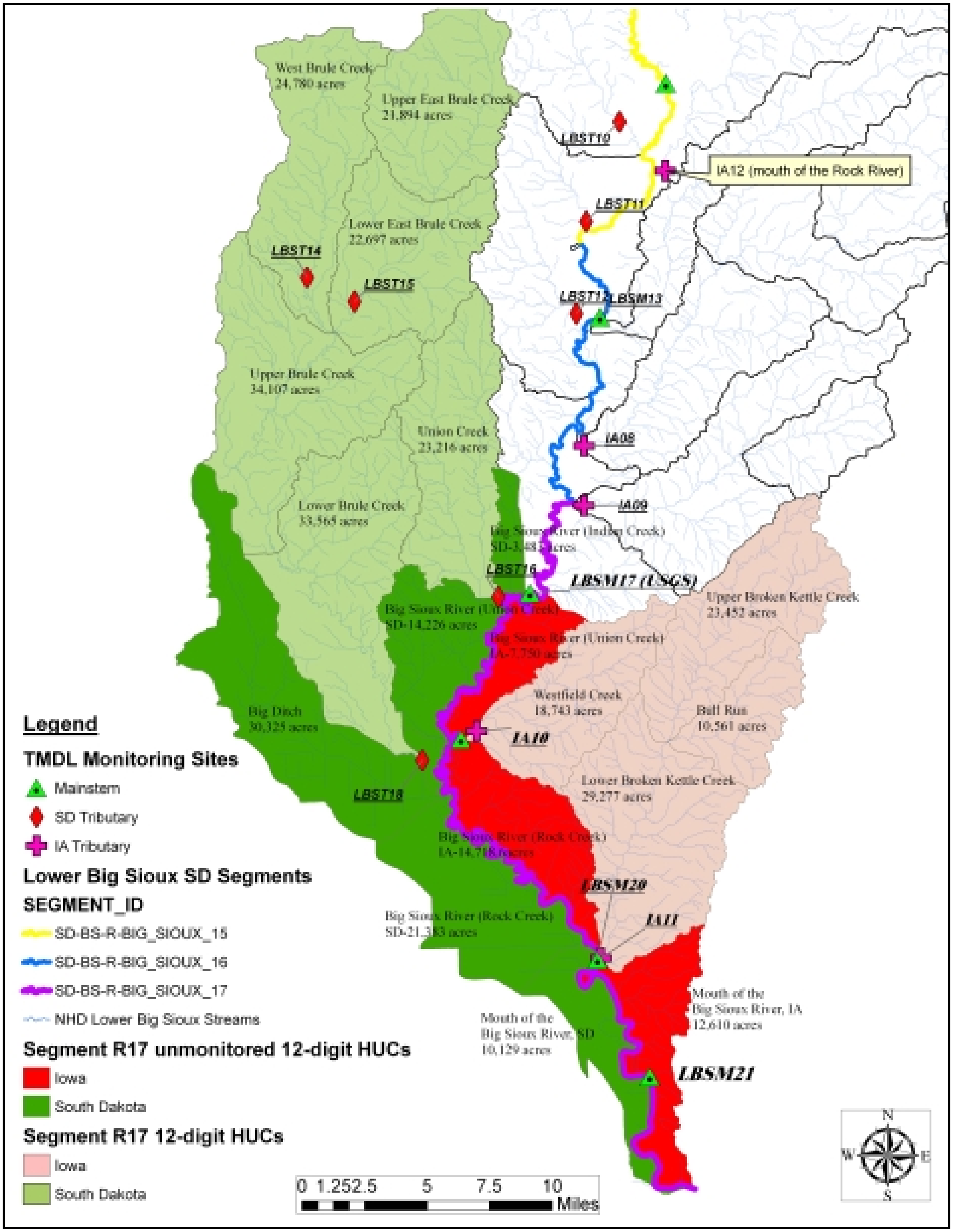


Figure 7. Segment R17 Subwatershed.

4.0 Description of Applicable Water Quality Standards & Numeric Water Quality Targets (South Dakota and Iowa)

4.1 South Dakota Water Quality Standards

Each waterbody within SD are assigned designated or beneficial uses. All waters (both lakes and streams) within SD are designated with the use of fish and wildlife propagation, recreation, and stock watering. All streams are assigned the use of irrigation. Additional uses are assigned by the state based on a beneficial use analysis of each waterbody. Water quality standards have been defined in SD state statutes in support of these uses. These standards consist of suites of criteria that provide physical and chemical benchmarks from which management decisions can be developed.

For SD, all three Lower Big Sioux Segments R15, R16, and R17 have been assigned the following beneficial uses: warmwater semipermanent fish life propagation, immersion recreation, limited contact recreation, fish and wildlife propagation, recreation and stock watering, and irrigation. Table 5 lists the criteria that must be met to support the specified beneficial uses. When multiple criteria exist for a particular parameter, the most stringent criterion is used.

Individual parameters, determine the support of these beneficial uses (Table 3). South Dakota has numeric standards applied to the excessive rates of sedimentation. The criteria set forth in the Administrative Rules of South Dakota (ARSD) Article 74:51:01:48 for warmwater semipermanent fish life propagation waters prohibit elevated levels of suspended solids in the water column. Suspended solids have significant acute and chronic effects on the biological community. For fish, this includes effects on feeding and growth, cover and risk of predation, avoidance and displacement, egg development and survival, primary and secondary productivity through factors such as temperature, particle size and angularity, and duration of exposure.

4.2 Iowa Water Quality Standards

All surface waters in Iowa are classified for protection of general uses. In addition, many waters are also classified for designated uses. Surface waters classified for designated uses maintain flow throughout the year or contain sufficient pooled areas during intermittent flow periods to maintain a viable aquatic community.

For Iowa, all three Lower Big Sioux Segments R15, R16, and R17 have been assigned the following designated uses:

Primary contact recreational use (Class "A1"): Waters in which recreational or other uses may result in prolonged and direct contact with the water, involving considerable risk of ingesting water in quantities sufficient to pose a health hazard. Such activities would include, but not be limited to, swimming, diving, water skiing, and water contact recreational canoeing.

Table 3. South Dakota surface water quality standards for the three segments of the Lower Big Sioux River, Lincoln and Union Counties, South Dakota.

Parameter	Criteria	Unit of Measure	Special Conditions
Total alkalinity as calcium carbonate	≤ 750	mg/L	30-day average
	≤ 1313	mg/L	daily maximum
Chlorides (warm water semipermanent)	≤ 100	mg/L	30-day average
	≤ 175	mg/L	daily maximum
Dissolved oxygen (warm water semipermanent)	≥ 5.0	mg/L	
Total ammonia nitrogen as N (warm water semipermanent)	Equal to or less than the result from Equation 3 in Appendix A	mg/L	30-day average March 1 - October 31
	Equal to or less than the result from Equation 4 in Appendix A	mg/L	30-day average November 1 - February 29
	Equal to or less than the result from Equation 2 in Appendix A	mg/L	daily maximum
Fecal coliform (May 1 – September 30) (immersion recreation)	≤ 200	/100 mL	geometric mean based on a minimum of 5 samples obtained during separate 24-hour periods for any 30-day period
	≤ 400		in any one sample
Conductivity at 25°C	≤ 2,500	micromhos/cm	30-day average
	≤ 4,375	micromhos/cm	daily maximum
pH (warm water permanent)	≥ 6.5 and ≤ 9.0	standard units	
Nitrates as N	≤ 88	mg/L	daily maximum
	≤ 50	mg/L	30-day average
Total dissolved solids	≤ 2,500	mg/L	30-day average
	≤ 4,375	mg/L	daily maximum
	≤ 158	mg/L	daily maximum
Total Suspended Solids (warm water semipermanent)	≤ 90	mg/L	30-day average
	≤ 158	mg/L	daily maximum
Temperature (warm water semipermanent)	≤ 90	°F	see § 74:51:01:31
Undisassociated hydrogen sulfide	≤ 0.002	mg/L	
Total petroleum hydrocarbon	≤ 10	mg/L	see § 74:51:01:10
Oil and grease	≤ 10	mg/L	see § 74:51:01:10
Sodium adsorption ratio	≤ 10		

Aquatic life use (Class B "WW1"): uses of waters by fish, aquatic and semi aquatic species, and wildlife. Surface waters in Iowa designated for aquatic life uses are termed Class "B" waters for which there are four different designated aquatic life uses. The Class B uses are protected by criteria for dissolved oxygen, pH, temperature, ammonia, toxic metals, toxic organic and inorganic compounds, and heat.

Human Health use - (Class "HH"). Waters in which fish are routinely harvested for human consumption or waters both designated as a drinking water supply and in which fish are routinely harvested for human consumption.

Table 4 lists some of the criteria that must be met to support these specified uses. When multiple criteria exist for a particular parameter, the most stringent criterion is used. To provide human health criteria for parameters not having numerical values listed in IAC Chapter 61.3(3) Table 1, 2, or 3, the required criteria will be based on the rationale contained in EPA criteria documents listed on page 1 of Chapter 61.

Table 4. Iowa Designated Uses and Surface Water Quality Standards for the Big Sioux River from the mouth (Woodbury County) to the Iowa-Minnesota state line (Chapter 61 of IAC).

Use	Parameter	Criteria	Unit of Measure	Special Conditions
A1	*Escherichia coli* (3/15– 11/15)	≤ 126	/100 mL	• Samples must be spaced over one calendar month. • No more than one sample can be collected on any one day. • There must be a minimum of two days between each sample. • No more than two samples may be collected in a period of seven consecutive days.
		≤ 235		in any one sample (Sample Maximum)
B (WW1)	Dissolved Oxygen	5.0	mg/L	Minimum value for at least 16 hours of every 24-hour period
		5.0	mg/L	Minimum value at any time during every 24-hour period
	pH	≥ 6.5 and ≤ 9.0	standard units	The maximum change permitted as a result of a waste discharge shall not exceed 0.5 pH units.
	Temperature	≤ 90	°F	No heat shall be added to the Big Sioux River that would cause an increase of more than 3°C. The rate of temperature change shall not exceed 1°C per hour. In no case shall heat be added in excess of that amount that would raise the stream temperature above 32°C.
HH	See Table 1, pg 14 of Chapter 61 (IAC) http://www.legis.state.ia.us/aspx/ACODocs/DOCS/11-18-2009.567.61.pdf			
Note: Other criteria for chemical constituents can be found in Table 1,2, and 3 (pg14-24) of Chapter 61 of the Iowa Administrative Code (IAC).				

Chapter 61 of the IAC does not contain specific WQ standards, narrative or numeric, that directly apply to sedimentation or ambient turbidity. The narrative standards in Chapter 61 (http://www.iowadnr.gov/water/standards/files/chapter61.pdf) apply to all Iowa surface waters and do not exist specifically for streams and rivers. The only turbidity-related standard is included in the narrative standards under Section 61.3(2), General Water Quality Criteria:

"f. The turbidity of the receiving water shall not be increased by more than 25 Nephelometric turbidity units by any point source discharge."

4.3 Water Quality Targets

Of all the assessed parameters for which surface water quality criteria are established (Tables 3 and 4), fecal coliform and total suspended solids (TSS) exceeded criteria for the immersion recreation and warmwater semipermanent fish life propagation beneficial uses on the Lower Big Sioux Segments. The joint (Iowa and SD) pathogen (fecal coliform and E. coli) TMDL for five segments of the Lower Big Sioux River was formally approved in early 2008 by both EPA Region 7 (Iowa) and Region 8 (SD). Additional TMDLs for sediment and pathogens will be submitted for individual tributaries draining to the Big Sioux River from SD regarding impairments to the recreational or warmwater fishery uses. The sediment caused warmwater fishery use impairment will be addressed by this TMDL. The sediment TMDL only involves SD water quality standards based on the existing total suspended solids standards outlined in the previous two sections.

Total suspended solids water quality criteria for the warmwater semipermanent fishery beneficial use requires that 1) no sample exceeds the daily maximum of 158 mg/L and 2) the arithmetic mean of a minimum of three (3) consecutive grab or composite samples taken on separate weeks in a 30-day period must not exceed 90 mg/L. Both criterion are applicable year round (ARSD 74:51:01:42). The appropriate target for the sediment TMDL for Segment R15, R16, and R17 of the Big Sioux River will be based on the 30-day average chronic criteria for total suspend solids.

During this study, each site shown in Table 6 (pg 18) exhibited several samples that exceeded the TSS daily maximum criterion (158 mg/L). Total Suspended Solids was listed as the cause of impairment for all three reaches in the SD 2008 Impaired Waterbodies List. Table 5 shows significant differences in violations rates between flowzones. There is a significant relationship between high flows (storm events) and high concentrations of TSS.

The numeric TMDL targets established herein for Segments R15, R16, and R17 warmwater semipermanent fish life propagation is based on South Dakota's 30-day average TSS criterion for the fishery use.

Table 5. Exceedance Rate of the TSS Daily Maximum Criterion for all three Lower Big Sioux River Segments (158 mg/L).

Segment	Site		High	Moist	Mid	Dry
Segment R15	LBSM08	Samples per Zone	4	5	13	10
		Exceedances per Zone	4	3	4	0
		%Violation	100%	60%	31%	0%
	LBSM09	Samples per Zone	14	22	30	24
		Exceedances per Zone	10	12	4	0
		%Violation	71%	55%	13%	0%
	LBSM13	Samples per Zone	16	25	33	17
		Exceedances per Zone	10	12	4	0
Segment R16		%Violation	63%	48%	12%	0%
Segment R17	LBSM17	Samples per Zone	5	12	9	5
		Exceedances per Zone	5	10	2	1
		%Violation	100%	83%	22%	20%
	LBSM19	Samples per Zone	14	24	31	17
		Exceedances per Zone	11	12	6	0
		%Violation	79%	50%	19%	0%
	LBSM20	Samples per Zone	7	9	12	5
		Exceedances per Zone	7	8	5	0
		%Violation	100%	89%	42%	0%
	LBSM21	Samples per Zone	3	9	12	5
		Exceedances per Zone	3	6	2	1
		%Violation	100%	67%	17%	20%

5.0 Data Collection Method

5.1 Water Quality Data and Discharge Information

Stream discharge information collected from 34 sites was used to develop stage/discharge curves for each monitoring site. Both targeted TMDL sites and ambient (monthly) monitoring data were used to assess TSS impairment and develop trend information. Table 6 shows sites used and numbers of samples collected during the project period.

The design of the assessment project was to estimate the sediment and nutrient loadings within the Lower Big Sioux River and major individual tributaries in the watershed through hydrologic, chemical and biological monitoring. The information was not only used to develop a TMDL for the Lower Big Sioux River but also locate critical areas in the watershed to be targeted for implementation.

A continuous stage record for the project period, with the exception of winter months after freeze up was maintained for each site. Discrete discharge measurements were taken on a regular schedule and during storm surges. Discharge measurements were taken with a hand-held current velocity meter under wadeable conditions or from a bridge crane during high flows using methods outlined by the U.S. Geological Survey (USGS). Discharge measurements and water level data were used to calculate a stage/discharge table for all stream systems.

Samples were collected during spring runoff, storm events, and monthly base flows. Locations of sites monitoring tributaries and the Big Sioux River mainstem can be found in Figure 1 and Figure 5-7 as well as Appendix C. Sampling was conducted on a temporal basis over the course of three years (Jan'02 – August'04). Six ambient stations were also used to conduct long-term (1974 to Present) trend analysis (TSS vs. time). Samples were collected during the spring snowmelt runoff, and baseflow conditions for spring (March 1 to May 31), summer (June 1 to September 15), and fall (September 16 to November 15). Baseflow was defined as no significant increase in flow.

Storm event samples for each season were collected at or as near as possible to the peak discharge. During the second year of the project the USGS was contracted to collect storm event samples on the 10 mainstem sites. The original consultant collected all other samples for the SD tributary and mainstem sites. The University Hygienic Lab (UHL) personnel from Iowa City, IA were contracted by the Iowa Department of Natural Resources (IDNR) to conduct all sampling for the Iowa sites (Table 6). Autosamplers were used to collect all samples for the 11 Iowa tributary sites. The autosamplers were programmed to collect composite samples over the course of a storm event. Baseflow or monthly samples were also collected from each Iowa monitoring site.

All sampling and discharge data collection conducted during this project were done with methods in accordance with the South Dakota *Standard Operating Procedures for Field Samplers* developed by the Water Resource Assistance Program and approved by USEPA Region VIII. All samples collected by in SD, including the mainstem, were sent to the State Health Laboratory in Pierre, SD for analysis. Samples collected by UHL personnel were analyzed by the UHL in Iowa City, IA.

Table 6. Site and sample description, and sample numbers collected as part of the Lower Big Sioux TSS TMDL Project (2002-2005).

StationID	Description	Monthly	Event (IA)	Grab	Integrated Flow	Duplicate	Grand Total
460117*	WQM 117 - Big Sioux River Near Sioux Falls WWTF	43					43
IA01	Little Rock @ Minn/IA Border	18	2				20
IA02	Rock River below Rock Rapids, IA	18	4				22
IA03	Rock River @ Minn/IA Border	18	2				20
IA04	Mud Creek near Minn/IA Border	19	2				21
IA05	Mud Creek near Doon, IA	18	6				24
IA06	Little Rock River near Doon, IA	18	3				21
IA07	Rock River @ Rock Valley, IA (USGS #06483500)	18	3				21
IA08	Six Mile Creek (IA)	18	8				26
IA09	Indian Creek (IA)	18	4				22
IA10	Westfield Creek near Westfield, IA	18	8				26
IA11	Broken Kettle Creek near Jefferson, SD	18	17				35
IA12**	Mouth of Rock River north of Hawarden, IA (STORETID-10840001)	54					54
LBSM01*	Big Sioux Rec Area Near Brandon, SD (WQM-31)	45		25	25	12	107
LBSM03	Big Sioux @ Klondike Dam north of Canton, SD			18	22	3	43
LBSM05*	Big Sioux at Canton, SD (Hiway18) (WQM-65)	46		14	34	2	96
LBSM08	Big Sioux at Fairview, SD			22	25	1	48
LBSM09*	Big Sioux at Hudson, SD (WQM-66)	47		23	23	2	95
LBSM13*	Big Sioux at Hawarden, IA (WQM-67)	45		16	32	3	96
LBSM17	USGS Gaging Station (#06485500) at Akron, IA			16	26	1	43
LBSM19*	Big Sioux at Richland, SD (WQM-32)	46		13	29		88
LBSM20	Big Sioux near Jefferson, SD			13	32	1	46
LBSM21	Big Sioux north Edge of Sioux City			6	27	1	34
LBST02	Lake Alvin Outlet			25		7	32
LBST04	Beaver Creek 1mile upstream of Canton, SD			35			35
LBST06	Beaver Creek 1mile below Canton, SD			44	4	1	49
LBST07	Little Beaver Creek 2 miles South of Canton, SD			38	1	10	49
LBST10	Patte Creek Outlet near Hudson, SD			46	2	2	50
LBST11	Finnie Creek north Alcester, SD			42	3	2	47
LBST12	Green Creek west of Hawarden, IA			37	5	5	47
LBST14	West Brule Creek west of Alcester, SD			38	2	2	42
LBST15	East Brule Creek west of Alcester, SD			34	5	4	43
LBST16	Union Creek Outlet (SD) near Akron, IA			35	4	2	41
LBST18	Brule Creek Outlet near Richland, SD			40	8	6	54
	Grand Total	525	59	580	309	67	1541

* - monthly ambient stations as well as TMDL storm and baseflow sample sites. ** - mouth of the Rock River was an ambient Site only.

5.2 FLUX Loadings

Average daily discharge (cfs) calculated from the stage/discharge tables were used in conjunction with the sediment concentration data to develop daily sediment loadings for each station shown in Table 6. FLUX is a statistical modeling program that allows estimation of tributary mass discharges (loadings) from sample concentration data and daily flow records. Five estimation methods are available and potential errors in estimates are quantified. The most robust method exhibiting the lowest coefficient of variation (cv) was typically used for the site specific daily loading calculation. FLUX modeling setup for each site can be found in Appendix H. Analysis completed with the FLUX model was done according to the most recent version of the Water Quality Modeling in South Dakota document.

5.3 Annualized AGNPS Modeling

Sediment and nutrient impacts on the surface water quality of the Lower Big Sioux Watershed were evaluated through the use of the Annualized Agricultural Nonpoint Source (ANN-AGNPS) model. The Rock River was divided into seven analysis regions consisting of several 12-digit Hydrologic Units (HUCs). Each of the remaining 12-digit HUCs within South Dakota (e.g. Brule Creek), Iowa (e.g. Broken Kettle Creek), and Minnesota (e.g. Blood Run Creek) were modeled separately. Appendix – I shows the results for each watershed and how it statistically compares to the other watersheds in the basin. Implementation targeting will focus on those HUCs that rank statistically higher by using watershed metrics such as the sediment export coefficient (tons/acre).

Ann-AGNPS Simulations

Initial Condition
Basic assumptions are that primary crop rotations are corn and soybean with sporadic small grain plantings. Tillage practices assume very little no till farming, but a significant amount of reduced tillage practices with the most common consisting of fall chisel with a spring disk or ground breaking deferred entirely until spring. Pasture and grassland conditions are assumed to be in fair to good condition.

No-Till
Basic assumptions are identical to Initial condition with the exception of all crops managed with no-till equipment and maximum residues left on the fields.

Presettlement
Basic assumptions are that the landscape was dominated by tallgrass prairie.

Grass conditions Poor
Basic assumption is that most grass is located on critical slopes frequently used for grazing and that this small percentage of the watershed is critical to maintain in good conditions. Crop and tillage acres are the same as initial conditions

This standardized modeling approach is outlined in the most recent version of the Water Quality Modeling in South Dakota Document.

5.4 Rapid Geomorphic Assessments

Physical and habitat assessments including Rapid Geomorphic assessments were completed for all mainstem and South Dakota tributary sites during the course of the project. These assessments were done in accordance with the South Dakota *Standard Operating Procedures for Field Samplers* developed by the Water Resource Assistance Program and approved by USEPA Region VIII.

The Rapid Geomorphic Assessment evaluates degradation, aggradation, widening, and planform adjustment processes on the RGA field form. The RGA provides a method to document the current adjustment processes occurring in a segment (or reach) and to determine the stage of channel evolution that best describes the set of current and historic adjustment processes observed. RGA scores were compared to determine overall conditions for each monitoring site on the mainstem. FLUX loadings, Ann-AGNPS and the RGA results were all used to help determine sources of sediment. Results can be found in Appendix I.

5.5 Source Allocation Methodology

There were four flowzones used in the development of the TMDL for each segment. These are the same flowzones used in the pathogen TMDL approved for five Lower Big Sioux Segments in 2008. Within each of these flowzones the median (50^{th} percentile) flow was calculated. This flow was then multiplied by the 30-day average (chronic) standard for TSS (90 mg/L) to establish a water quality target for each flowzone.

To calculate the existing condition for each segment the most downstream site within each segment was used. The existing condition was calculated by using the average of the observed TSS loads within each flowzone. The TSS load was calculated by multiplying the concentration by the observed flow when the sample was collected. Each observed load was placed in the appropriate flowzone based on the observed flowrank from the flow distribution for that site.

To allocate sources for each segment, FLUX loadings were calculated for both tributary and mainstem sites. A mass balance approach using the relative percent contribution from all sources per segment was used for the allocation process. The daily flows used to establish the segment TMDL were separated in the one of four flowzones.

Table 7 shows an excerpt from the EXCEL table used to calculate percent contribution from each source for Segment R16. Site LBSM17 flows were sorted based on flowzone. Each daily output load from Site LBSM17 had a corresponding load from all inputs (tributaries and HUC12s) draining to this segment including the most upstream mainstem site in the segment (Site LBSM13). Daily loadings from each input source were summed for the entire flowzone so that a total input load for each segment could be calculated. Percent contribution for each source was then calculated.

Table 7. Example of Source Allocation Methodology (Segment R16)

			95th Percentile flow per zone				Notes: Daily Loadings for days where high flows were observed from Site LBSM17. Daily loadings were summed for each site. For those HUC12s where no monitoring data was available daily estimates were derived from the nearest monitored tributary by using the export coefficient (kg/acre/day) with acres of the unmonitored HUC.							
		CFS	**14300**	**1790**	**694**	**239**					**Used Site I08 (kg/acre/day)**	**Used Site LBST12 (kg/acre/day)**	**Used Site LBST12 (kg/acre/day)**	**Used Site LBST12 (kg/acre/day)**
		# of days per zone	43	134	190	36				HUC# -→	**1017020329**	**1017020329**	**1017020329**	**101702032001**
		Flowzones	**0**	**0.25**	**0.5**	**0.75**		**Acres-→**	**12,216**	**69,004**	**32,171**	**4,192**	**9,811**	**4,332**
Date	**USGS LBSM17 Q**	**Average DailyQ Flow Rank**	**High**	**Moist**	**Mid**	**Dry**	**Input LBSM13**	**Output LBSM17**	**Input LBST12 Green Creek**	**Input IA08 Six Mile Creek**	**Input Dry Creek-Big Sioux River**	**Input Big Sioux River - Seg16-1**	**Input Big Sioux River-Seg16-3**	**Input Big Sioux River- Dry Creek-Seg16-2**
5/15/2002	3,390	12.8%	3,390				2,539,413	2,757,929	1,131	39,097	8,046	1,049	2,454	1,083
5/14/2002	3,270	13.5%	3,270				2,448,859	2,660,303	1,162	47,143	9,384	1,223	2,862	1,264
5/16/2002	3,180	14.0%	3,180				2,380,944	2,587,084	1,260	33,859	7,366	960	2,246	992
8/24/2002	2,900	15.6%	2,900				2,169,653	2,359,291	36	19,386	3,120	407	951	420
6/28/2003	2,900	15.6%	2,900				2,169,653	2,359,291	467	24,519	53,024	6,910	16,170	7,140
5/13/2002	2,890	15.7%	2,890				2,162,107	2,351,155	1,260	71,011	13,292	1,732	4,053	1,790
4/22/2003	2,880	15.7%	2,880				2,154,561	2,343,019	609	38,567	6,810	887	2,077	917
8/23/2002	2,850	16.0%	2,850				2,131,923	2,318,613	47	21,816	3,531	460	1,077	475
7/9/2003	2,840	16.1%	2,840				2,124,377	2,310,477	77,884	27,486	96,062	12,519	29,296	12,936
5/17/2002	2,780	16.5%	2,780				2,079,100	2,261,665	1,365	32,023	7,086	923	2,161	954
5/15/2003	2,730	16.8%	2,730				2,041,369	2,220,987	593	170,411	41,999	5,473	12,808	5,656
5/14/2003	2,660	17.2%	2,660				1,988,547	2,164,039	20,868	127,481	47,050	6,131	14,349	6,336
5/16/2003	2,660	17.2%	2,660				1,988,547	2,164,039	563	150,865	36,950	4,815	11,268	4,976
			High Flow Zone Sum				28,379,053	30,857,892	107,243	803,662	333,720	43,489	101,773	44,939

5.6 Bed and Bank Erosion

For Segment R17 all input sources of sediment were summed within each flowzone. The total mass from all input sources was compared to Site LBSM21 (total output). The difference (output-input) was considered to be bed or bank erosion. Segment R17 inputs were much greater than outputs across all flowzones due to excessive bank erosion. RGA's show significant mass wasting along this reach. It should be noted that Segment R17 is also located in a transition zone between two different level IV ecoregions.

Segment R15 and R16 are found within the Level IV Ecoregion 47a-Loess Prairies. Ecoregion 47a can be described as gently rolling hills with Loess deposits over Cretaceous sandstone, shale, and Sioux quartzite. Originally dominated by a tallgrass prairie it has since been converted to intensive row crop agriculture. The northern half of Segment R17 is also found within 47a but transitions into 47d-Missouri River Alluvial Floodplain and 47m-Western Loess Hills (Chapman, et. al, 2001). Ecoregion 47d is characterized as a level floodplain alluvium that intensively farmed for corn and soybeans. Ecoregion 47m-Western Loess Hills is dominated by a thick layer loess characterized by a mosaic of bur-oak woodland and big Bluestem-Indian grass prairie. This transition to the Western Loess Hills and Missouri River Alluvial Floodplain seems to be where a significant jump in bank erosion begins.

The difference between the inputs and outputs for Segments R15 and R16 were insignificant. Estimates for bed and bank erosion were derived using methods described in special project completed in 2009 by the National Sedimentation Laboratory for the Big Sioux River. The overall objective of this study was to determine rates and loadings of sediment from streambank erosion along main stem reaches of the Big Sioux River. One of the areas modeled was located just north of Sioux Falls, SD in the same Level IV Ecoregion (47a-Loess Prairie) as Segment R15 and R16. Contributions of streambank erosion were calculated between 10-25% of the total suspended-sediment load. During a wet or high flow year, 25% of the total suspended sediment load over the 300 km study reach north of Sioux Falls was estimated from streambanks. Annual average contributions from streambanks were estimated at approximately 15% (Bankhead, et.al., 2009). This follows discussion by Cleland, 2003 regarding TSS load duration curves where higher flows result in larger contributions from streambank erosion.

5.7 Natural Background Sources

The percent contribution of the sediment from natural background sources were estimated by using the Ann-AGNPS results. Loading output from the model runs from the initial conditions scenarios was compared to the loadings output from Presettlement conditions modeling scenario. The percent difference, which was <1.00%, was used as an estimate of natural background sources.

6.0 Source Assessment and Allocation

6.1 Point Sources

For Segments R15-R17 there are three point sources located directly on the river. There are several other National Pollution Discharge Elimination System (NPDES) permittees within both Iowa and SD but these drain into tributaries of the Big Sioux River. A WLA will be quantified for these TMDLs on those specific waterbodies. For Iowa, many of these NPDES permittees are either zero discharge facilities or are located a long distance away from the Big Sioux River. They provide an insignificant contribution of sediment relative to nonpoint sources. Although these facilities were included with the Pathogen TMDL in 2008, they will not be included in these TSS TMDLs.

The City of Hudson, SD (NPDES Permit# SDG822471) is located approximately in the middle of Segment R15. Although Hudson is a NPDES permitted facility it does not discharge and, therefore, will not be included as part of the waste load allocation for Segment R15.

Hawarden, IA (NPDES Permit# 8434001) is a municipal activated sludge wastewater treatment facility (WWTF) located in Segment R16 which runs from near Alcester to Indian Creek. The Hawarden WWTF outfall discharges directly to the Big Sioux River, which is listed as the receiving stream in the permit. Their permit identifies a series of effluent limitations including total suspended solids. The TSS contribution from this facility to the Big Sioux River is insignificant (<1.0%). It is listed here as part of the TMDL because the Big Sioux River is listed as the receiving waterbody in the NDPES Permit.

Akron, IA (NPDES Permit# 7509001) is a three-cell waste stabilization lagoon system that has a controlled discharge to Segment R17 of the Big Sioux River. Stipulations as part of the permit include discharging in the spring and fall when the flow is not at its minimum. Effluent limitations are also outlined in the permit. The TSS contribution from this facility to the Big Sioux River is insignificant (<1.0%).

These three WWTFs are located directly on the Big Sioux River and contribute the greatest albeit insignificant point source TSS load to the Lower Big Sioux River. There are other permitted facilities located in the watershed (see Pathogen TMDL for the Big Sioux River - 2008). These other facilities will not be included here because: 1) they are located in subwatersheds that require individual TSS or Pathogen TMDLs, or 2) they are located further up in the watershed that the their cumulative impact on the TSS loadings to segments of the Big Sioux River are insignificant relative to the nonpoint source contributions.

Table 8. Source Allocation for all inputs to Segment R15.

Source Allocation	Percent Contribution of all inputs for Segment R15 per flowzone				Area	Ann-AGNPS Export Coefficients[2]
Subwatershed or 12-digit HUC	**High**	**Moist**	**Mid**	**Dry**	**acres**	**tons/acre**
LBSM08 (Mainstem – Upstream)	61.12%	64.12%	58.82%	56.29%		n/a
IA12 (Rock River-IA)	11.95%	18.01%	22.70%	22.24%	1,075,297	1.436
LBST10 (Pattee Creek-SD)	0.18%	0.43%	0.75%	0.34%	25,926	6.104
LBST11 (Finnie Creek-SD)	0.33%	0.60%	0.66%	2.46%	13,668	13.843
Big Sioux River 1017020329 (IA)	0.08%	0.16%	0.20%	0.51%	5,243	n/a
Big Sioux River- Pattee Creek 101702031804 (SD)	0.12%	0.24%	0.31%	0.77%	8,031	n/a
Big Sioux River-Seg15 1017020322 (IA)	0.22%	0.44%	0.56%	1.39%	14,403	n/a
Bed/Bank[1]	25.00%	15.00%	15.00%	15.00%		n/a
Natural Background (AnnAGNPS estimate)	1.00%	1.00%	1.00%	1.00%		n/a
WLA	n/a	n/a	n/a	n/a		n/a
Sum of Inputs	100.00%	100.00%	100.00%	100.00%		
LBSM13 (Mainstem - Downstream)	100.00%	100.00%	100.00%	100.00%		

Notes:
1. For pollutant assessment: An estimate of 25% added into the inputs for the high flowzone and 15% for all other flowzones. Based on Bankhead and Simon's 2009 Report on Bank Stability for the Big Sioux River.
2. AnnAGNPS estimates based on initial or current conditions.

6.2 Nonpoint Sources

A review of available information and communication with local Natural Resources Conservation Service (NRCS) representatives, water quality and discharge data, FLUX loadings, Annualized-AGNPS modeling results, Rapid Geomorphic Assessments (RGAs), literature values, and load duration curves were used to identify nonpoint sources of sediment. The primary nonpoint sources of TSS for all three segments of the Big Sioux River watershed include: 1) sheet and rill erosion from the agriculturally dominated landscape, and 2) bed and bank erosion from the various tributaries as well as the Big Sioux River mainstem. Using the best available information, loadings were estimated from each of these sources within the four flowzones identified for each segment of the river.

Flux loadings were used to determine percent contribution from each possible source of sediment for all four flowzones. Estimates for bed and bank contributions were calculated from Bankhead and Simons 2009 Report for the Central Big Sioux River for Segment R15 and Segment R16. A mass balance approach was used for Segment R17 (Inputs – Outputs). Annualized-AGNPS modeling outputs were used where possible as another measure of input from sheet and rill erosional sources. Natural background was also estimated through Annualized-AGNPS. See Source Allocation Methodology Section for further discussion.

6.2.1 Segment R15 – Near Fairview,SD to Near Alcester, SD

Table 8 shows the percent contribution of sediment derived from the FLUX loadings from monitored tributary and mainstem sites. Estimates for unmonitored 12-digit HUCs were derived by using the FLUX export coefficients (daily kg/acre) from the nearest monitored tributary and applying them to the HUC surface area (acres).

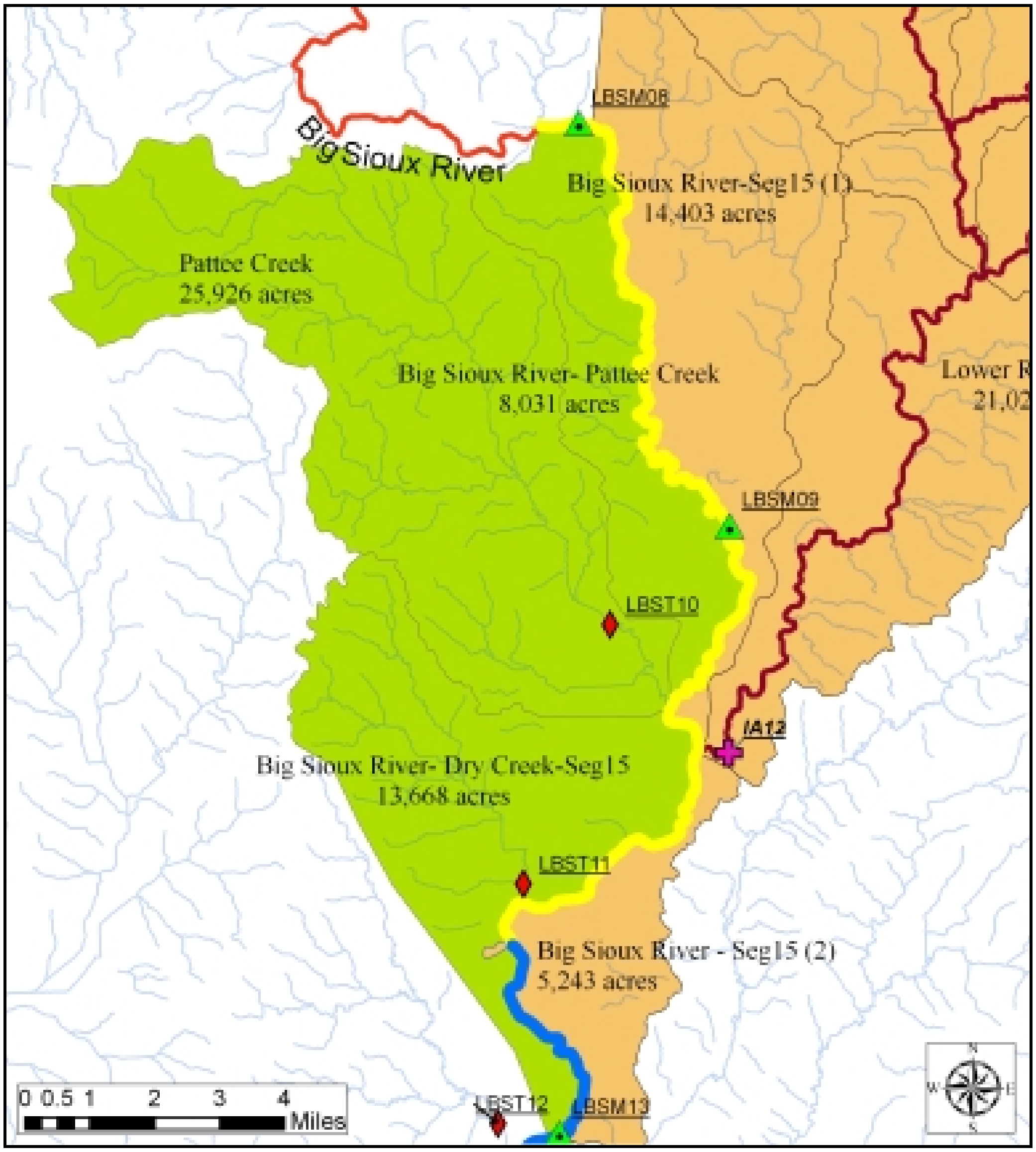


Figure 8. Segment R15 showing unmonitored 12-digit HUCs.

The upstream mainstem site (Site LBSM08) was the largest contributor of sediment. Of the remaining sources bed/bank, the Rock River, Finnie Creek, and Pattee Creek were the largest contributors of sediment within all four flowzones. Figure 8 shows the immediate subwatershed area (12-digit HUCs) draining to Segment R15 excluding the Rock River. Ann-AGNPS export coefficients suggest that within SD, implementation efforts should focus in the Pattee and Finnie

Creek drainage areas. See Appendix – I for the full listing of the Ann-AGNPS results for the Rock River 12 digit HUCs.

6.2.2 Segment R16 – Near Alcester, SD to Indian Creek (IA)

Table 9 shows the percent contribution of sediment derived from the FLUX loadings from monitored tributary and mainstem sites. Estimates for unmonitored 12-digit HUCs were derived by using the FLUX export coefficients (daily kg/acre) from the nearest monitored tributary and applying them to the HUC surface area (acres).

The upstream mainstem site (Site LBSM13) was the largest contributor of sediment. However, of the remaining sources bed/bank, Six Mile, Indian, Dry and Green Creeks were the largest contributors of sediment within all four flowzones. Figure 6 shows the immediate subwatershed area draining to Segment R16 including the unmonitored 12-digit HUCs. Ann-AGNPS export coefficients suggest that implementation efforts should focus in the drainages mentioned above especially Green and Indian Creeks. See Appendix – I for the full listing of the Ann-AGNPS results.

Table 9. Source Allocation for all inputs to Segment R16.

Source Allocation	Percent Contribution of all inputs for Segment R16 per flowzone				Area	Ann-AGNPS Export Coefficients[2]
Subwatershed or 12-digit HUC	**High**	**Moist**	**Mid**	**Dry**	**acres**	**tons/acre**
LBSM13 (Mainstem - Upstream)	66.4%	71.4%	52.6%	28.1%	n/a	n/a
LBST12 (Green Creek-SD)	0.16%	1.19%	0.37%	0.22%	12,216	12.551
IA08 (Sixmile Creek-IA)	2.78%	4.82%	22.47%	41.7%	69,004	2.729
IA09 (Indian Creek-IA)	2.31%	1.95%	0.47%	0.2%	39,950	4.999
Dry Creek-Big Sioux River (IA) 101702039	1.21%	2.35%	4.24%	7.05%	32,171	2.411
Big Sioux River - Seg16-1 (IA) 101702039	0.16%	0.30%	0.51%	0.9%	4,192	n/a
Big Sioux River-Seg16-2 (IA) 101702039	0.11%	0.22%	0.38%	0.6%	3,066	n/a
Big Sioux River-Seg16-3 (IA) 101702039	0.36%	0.71%	1.20%	2.1%	9,811	n/a
Big Sioux River- Indian Creek (SD) 101702032201	0.39%	0.75%	1.27%	2.2%	10,379	n/a
Big Sioux River- Dry Creek-Seg16-1 (SD) 101702032001	0.16%	0.31%	0.53%	0.91%	4,332	n/a
Natural Background (Ann-AGNPS estimate)	1.00%	1.00%	1.00%	1.00%		
Bed/Bank[1]	25.00%	15.00%	15.00%	15.00%		
WLA	n/a	n/a	n/a	n/a		
Sum of Inputs	100%	100%	100%	100%		
LBSM17 (Mainstem - Downstream)	100%	100%	100%	100%		

Notes:
1. For pollutant assessment: An estimate of 25% added into the inputs for the high flowzone and 15% for all other flowzones. Based on Bankhead and Simon's 2009 Report on Bank Stability for the Big Sioux River.
2. AnnAGNPS estimates based on initial or current conditions.

6.2.3 Segment R17 – Indian Creek (IA) to mouth

Table 10 shows the percent contribution of sediment derived from the FLUX loadings from monitored tributary and mainstem sites. Estimates for unmonitored 12-digit HUCs were derived by using the FLUX export coefficients (daily kg/acre) from the nearest monitored tributary and applying them to the HUC surface area (acres).

The upstream mainstem site (Site LBSM17) was the largest contributor of sediment. However, of the remaining sources bed/bank, Broken Kettle, Brule, Rock Creek, Union, and Big Ditch Creeks were the largest contributors of sediment within all four flowzones. Figure 7 shows the immediate subwatershed area draining to Segment R17 including the unmonitored 12-digit HUCs. Ann-AGNPS export coefficients suggest that implementation efforts should focus in the drainages mentioned above especially Union and Westfield Creeks. See Appendix – I for the full listing of the Ann-AGNPS results.

Table 10. Source Allocation for all inputs to Segment R17.

Source Allocation	Percent Contribution of all inputs for Segment R17 per flowzone				Area	Ann-AGNPS Export Coefficients[2]
Subwatershed or 12-digit HUC	**High**	**Low**	**Mid**	**Dry**	**acres**	**tons/acre**
LBSM17 (Mainstem – Upstream)	51.61%	43.16%	18.91%	13.26%	n/a	
LBST18 (Brule Creek from SD)	9.83%	6.93%	6.15%	1.15%	137,024	2.512
IA11 (Broken Kettle from Iowa)	13.94%	12.94%	6.37%	4.45%	63,340	3.138
IA10 (Westfield Creek from Iowa)	0.08%	0.18%	0.90%	0.67%	18,764	9.889
LBST16 (Union Creek from SD)	1.47%	0.61%	1.44%	0.67%	23,217	9.545
Big Sioux River -Indian Creek (SD) 101702032201	0.44%	0.18%	0.42%	0.20%	6,867	n/a
Big Sioux - Rock Creek (IA) 101702032205	3.24%	3.01%	1.48%	1.03%	14,719	n/a
Big Sioux - Rock Creek (SD) 101702032205	1.53%	1.08%	0.96%	0.18%	21,383	n/a
Big Sioux Mouth (IA) 101702032207	2.77%	2.58%	1.27%	0.89%	12,610	n/a
Big Sioux Mouth (SD) 101702032207	0.73%	0.51%	0.45%	0.09%	10,129	n/a
Big Sioux River - Union Creek (IA) 101702032203	0.10%	0.23%	0.97%	0.82%	17,560	n/a
Big Sioux River - Union Creek (SD) 101702032203	0.90%	0.37%	0.88%	0.41%	14,226	n/a
Big Ditch (SD) 101702032206	2.18%	1.53%	1.36%	0.25%	30,325	0.585
Natural Background (Ann-AGNPS estimate)	1.00%	1.00%	1.00%	1.00%	n/a	
Bed/Bank[1]	10.22%	25.76%	57.56%	75.12%	n/a	
WLA	n/a	n/a	n/a	n/a	n/a	
Sum of Inputs	100.0%	100.0%	100.0%	100.0%	n/a	
LBSM21 (Mainstem – Downstream mouth)	100.0%	100.0%	100.0%	100.0%	n/a	

Notes:
1. Bed/Bank Erosion Calculated by mass balance approach. Hence the greater amounts at lower flowzones.
2. AnnAGNPS estimates based on initial or current conditions.

7.0 Linkage Analyses

7.1 Load Duration Curve Analysis

The three TSS TMDLs were developed using a Load Duration Curve (LDC) approach resulting in a flow-variable target that considers the entire flow regime. In the Big Sioux River, TSS was positively related to stream flow. This is shown in Table 6 and Figures 9-11 with increasing exceedance rates exhibited in the higher flowzones. Thus, the LDC approach was deemed an appropriate method for setting a flow-variable TSS TMDL similar to the pathogen TMDL established for the Lower Big Sioux River Segments in 2008.

The LDC is a dynamic expression of the allowable load for any given day. To aid in interpretation and implementation of the TMDL, the LDC flow intervals were grouped into four flow zones representing high flows (0–25 percent), moist conditions (25-50 percent), mid-range flows (50–75 percent), and dry/low conditions (75–100 percent) according to EPA's *An Approach for Using Load Duration Curves in the Development of TMDLs* (USEPA, 2006). These four zones were also used the Pathogen TMDL developed in 2006 for the Lower Big Sioux River (Iowa, 2008).

For Segment R15, instantaneous loads were calculated by multiplying the TSS concentrations collected from SD DENR TMDL Site and long-term ambient monitoring Station LBSM13 (WQM ID67 near Hawarden, IA) by the daily average flow, and a units conversion factor.

For Segment R16, instantaneous loads were calculated by multiplying the TSS concentrations collected from SD DENR TMDL Site LBSM17 (USGS Gage #06485500 near Akron, IA) by the daily average flow, and a units conversion factor.

For Segment R17, instantaneous loads were calculated by multiplying the TSS concentrations collected from SD DENR TMDL Site LBSM21 (North Sioux City, SD) by the daily average flow, and a units conversion factor.

When the instantaneous loads are plotted on the LDC, characteristics of the water quality impairment are shown in each segment. Instantaneous loads that plot above the curve are exceeding the TMDL, while those below the curve are in compliance. As all three plots show, TSS samples collected from each segment of Lower Big Sioux River exceed the daily maximum criterion mostly during high to mid-range flow conditions where flowrank exceeds the 50th percentile (Figure 12-14). Only Segment R17 exhibits a significant number of violations at the lower flowzones primarily due to the excessive bank erosion problems (Figure 14). While loads exceeding the criteria in the low flow zone typically indicate point source load contributions, the bank erosion problems and the transition into a different level IV ecoregion with more alluvial and mobile soils reflect potential nonpoint source contributions throughout all four flowzones (Cleland, 2003).

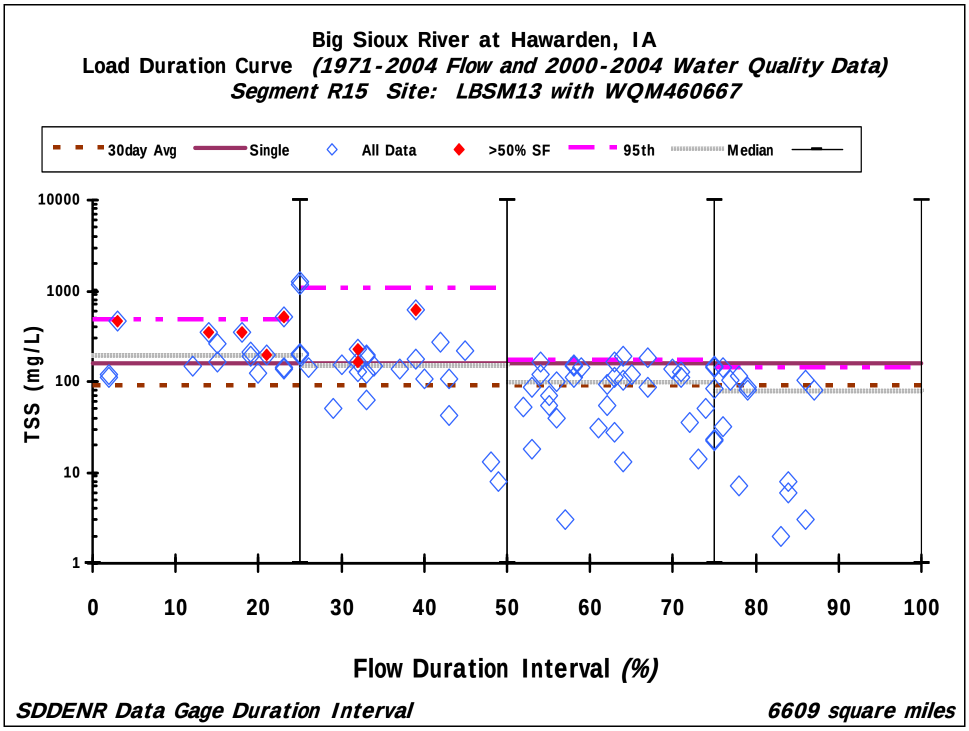


Figure 9. Segment R15 (Site LBSM13) sampled TSS Concentrations compared to the daily maximum (≤ 158 mg/L) and 30 day average (≤90 mg/L) TSS Criteria.

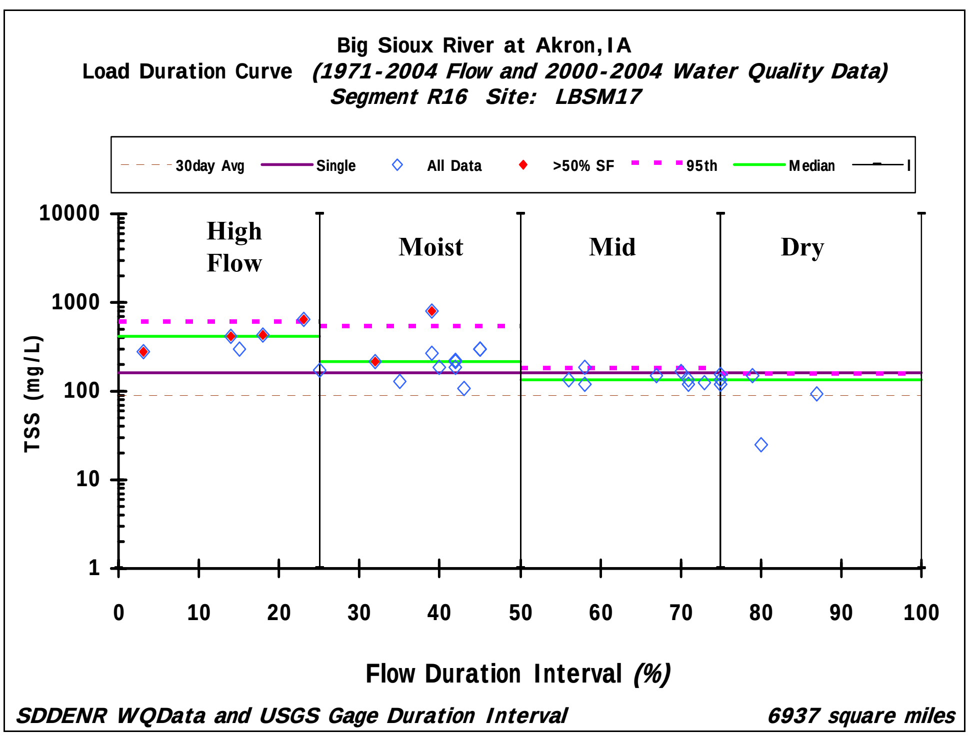


Figure 10. Segment R16 (Site LBSM17) sampled TSS Concentrations compared to the daily maximum (≤ 158 mg/L) and 30 day average (≤90 mg/L) TSS Criteria.

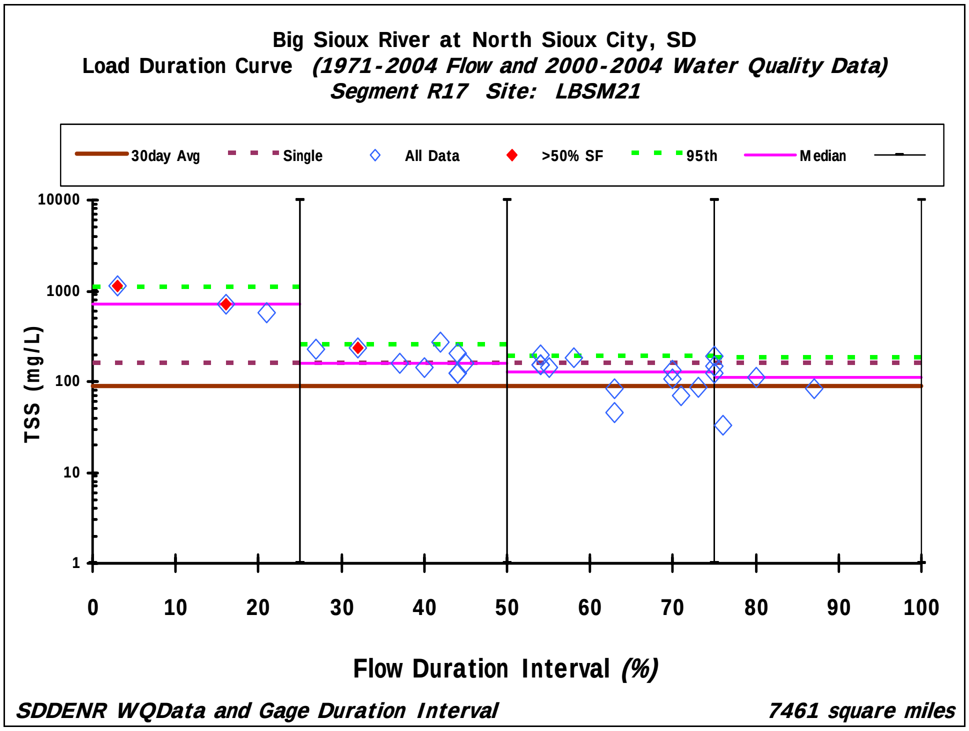


Figure 11. Segment R17 (Site LBSM21) sampled TSS Concentrations compared to the daily maximum (≤ 158 mg/L) and 30 day average (≤90 mg/L) TSS Criteria.

8.0 TMDL Allocations

8.1 TMDL Allocations - Segment R15

The LDC (Table 11 and Figure 12) represents the dynamic expression of the TSS TMDL for Segment R15, resulting in a unique maximum daily load that corresponds to a measured average daily flow. To aid in the implementation of the TMDL and estimation of needed TSS load reductions, Table 11 presents a combination of allocations for each of four flow zones. Methods used to calculate the TMDL components are discussed below. This TMDL is in effect from year round and is based on daily flow and the chronic (30-day average) water quality standard.

Table 11. Segment R15 – TSS Total Maximum Daily Load (TMDL) allocations by flow zone (Site LBSM13).

TMDL Component	Flow Zone (expressed as tons/day)			
	High 0-25% Flow	**Moist 25-50% Flow**	**Mid 50-75% Flow**	**Dry 75-100% Flow**
	1,697 – 46,772 cfs	**634 - 1,696 cfs**	**208 - 633 cfs**	**0.2 - 207 cfs**
50th Percentile Flow Per Zone	3,139.9	1,022.1	417.3	115.8
LA	684.1	222.7	90.9	25.2
WLA*	negligible	negligible	negligible	negligible
MOS (10% Explicit)	76.0	24.7	10.1	2.8
TMDL	**760.2**	**247.4**	**101.0**	**28.0**
*WLA inputs are negligible for this segment.				
Existing Condition				
Average Load per Zone**	2,285.9	902.9	104.0	29.7
Load Reduction	**67%**	**73%**	**3%**	**6%**
Average Concentration per Zone	231	244	93	62
Number of Values	16	25	33	17
* *Current Load or existing condition is the average of observed TSS loads for each flow zone.				
Runoff with 50th Percentile Flow/Area				
mm/day	0.45	0.15	0.06	0.02
cfs/sqmile	0.48	0.15	0.06	0.02

8.1.1 Load Allocation (LA)

To develop the TSS load allocation (LA), the loading capacity (LC) was first determined. The LC for Segment R15 (near Fairview to near Alcester) was calculated by multiplying the 30-day average (90 mg/L) TSS criterion by the daily average flow measured at Site LBSM13 near Hawarden, IA. Site LBSM13 is the most downstream site within this segment. There were three mainstem sites located within this segment (Site LBSM08-upstream, LBSM09, and LBSM13-downstream, Figure 5). Table 11 can be found for each site in Appendix – B.

The 30-day average criterion (90 mg/L) was used for the calculation of the LC, rather than the daily maximum criterion (158 mg/L) because the chronic criterion is considered more protective. The 30-day average, as defined in ARSD § 74:51:01:01, is the arithmetic mean of a minimum of three consecutive grab or composite samples taken on separate weeks in a 30-day period. The 30-day average TSS criteria (ARSD § 74:51:01:48) applies at all times but compliance can only be determined when a minimum of three samples are obtained during separate weeks for any 30-day period. In many instances, only one or two samples were collected during any 30-day period, so the average criterion was applied to each flowzone in Figure 12. Although the daily maximum criteria are exceeded, to be conservative it was decided to use the average criterion to develop the loading capacity of the stream in order to ensure that the most stringent water quality standards are met. Additional data is needed to accurately assess compliance with the 30-day average criterion. The loading capacities and reductions derived from the available data are estimates (i.e., the calculated loading capacities and reductions may be higher or lower if/when a more extensive data set is collected to fully assess compliance with the chronic standard). For each of the four flow zones, the 50th percentile (median) of the range of LCs within a zone was set as the flow zone goal. TSS loads experienced during the largest stream flows (e.g. top 5 percent) cannot be feasibly controlled by practical management practices. Setting the flow zone goal at the 50th percentile while using the average (90 mg/L) criterion within each flowzone will protect the warmwater semipermanent fish life propagation beneficial use and allow for the natural variability of the system (Figure 12).

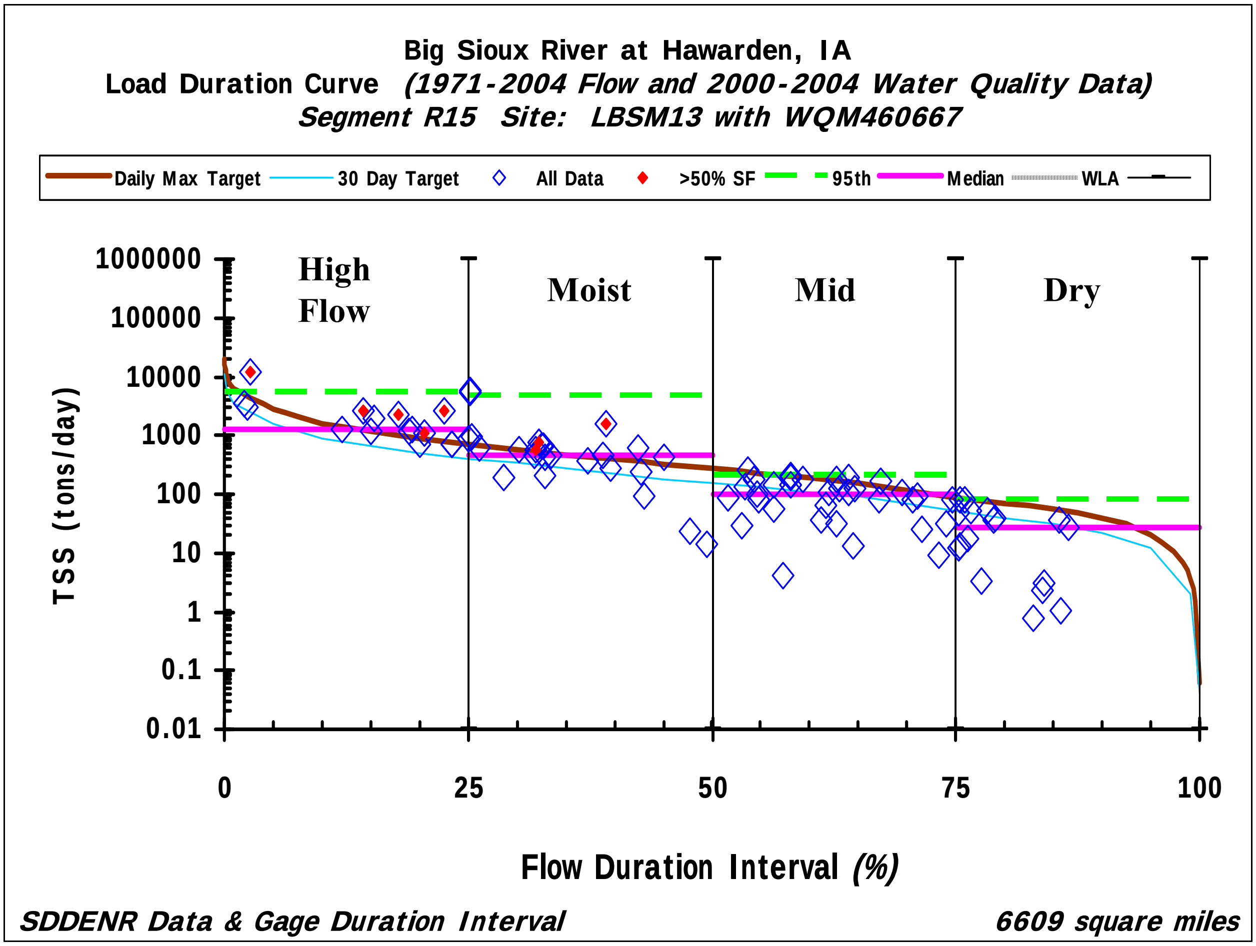


Figure 12. Segment R15 - Load duration curve representing allowable daily TSS loads based on the 30-day average and daily maximum criteria (≤90 mg/L and ≤158 mg/L, respectively). Plot showing median and 95th percentiles, and daily loads for each flow zone. The 30-day average was used to determine the loading capacity for the Segment R16 and the TMDL. Observed TSS concentrations are also displayed.

Portions of the LC were allocated to point sources as a waste-load allocation (WLA) and nonpoint sources as a load allocation (LA). A fraction of the LC was also reserved as a margin of safety (MOS) to account for uncertainty in the calculations of these load allocations. The method used to calculate the MOS is discussed below. The LA was determined by subtracting the WLA and MOS from the LC. Thus, the TMDL (and LC) is the sum of WLA, LA, and MOS.

8.1.2 Waste Load Allocation (WLA)

There are no facilities or NPDES Permit holders discharging directly into this segment of the Lower Big Sioux River. The city of Hudson, SD is located on the Big Sioux River in this segment but their WWTF is classified as a zero discharge facility. The WLA is constant across all flow conditions and ensures that water quality standards will be attained.

8.1.3 Iowa and South Dakota TSS Loading

For the immediate watershed of Segment R15 the drainage from Iowa and South Dakota constitutes 96% and 4% of the total surface area, respectively (Figure 5 and Table 8). Loadings from Iowa and South Dakota are assumed to be based on the percent contribution outlined in the source allocation table (Table 8, page 25). Although South Dakota has no authority in regulating pollution from Iowa, reductions from both states in TSS loadings are assumed in this TMDL scenario. Clearly, reductions from both Iowa and South Dakota are critical for meeting water quality standards for this segment of the Big Sioux River.

Table 12. Segment R15 reduction inputs for each subwatershed.

Reductions	**Percent Reductions for each input for Segment R15 per flowzone (based on reductions in Table 11)**			
Subwatershed or 12-digit HUC	**High**	**Moist**	**Mid**	**Dry**
LBSM08 (Mainstem – Upstream)	41.0%	46.8%	1.8%	3.4%
IA12 (Rock River-IA)	8.0%	13.1%	0.7%	1.3%
LBST10 (Pattee Creek-SD)	0.1%	0.3%	0.0%	0.0%
LBST11 (Finnie Creek-SD)	0.2%	0.4%	0.0%	0.1%
Big Sioux River 1017020329 (IA)	0.1%	0.1%	0.0%	0.0%
Big Sioux River- Pattee Creek 101702031804 (SD)	0.1%	0.2%	0.0%	0.0%
Big Sioux River-Seg15 1017020322 (IA)	0.1%	0.3%	0.0%	0.1%
Bed/Bank[1]	16.8%	11.0%	0.5%	0.9%
Natural Background (AnnAGNPS estimate)	0.7%	0.7%	0.0%	0.1%
Total Reductions	**67.0%**	**73.0%**	**3.0%**	**6.0%**

8.2 TMDL Allocations - Segment R16

The LDC (Table 13 and Figure 13) represents the dynamic expression of the TSS TMDL for Segment R16, resulting in a unique maximum daily load that corresponds to a measured average daily flow. To aid in the implementation of the TMDL and estimation of needed TSS load reductions, Table 13 presents a combination of allocations for each of four flow zones. Methods used to calculate the TMDL components are discussed below. This TMDL is in effect from year round and is based on daily flow and the chronic (30-day average) water quality standard.

Table 13. Segment R16 – TSS Total Maximum Daily Load (TMDL) allocations by flow zone (Site LBSM17).

TMDL Component	Flow Zone (expressed as tons/day)			
	High 0-25% Flow	**Moist 25-50% Flow**	**Mid 50-75% Flow**	**Dry 75-100% Flow**
	1,860 - 50,600 cfs	**710 - 1,859 cfs**	**250 - 709 cfs**	**4 - 249 cfs**
50th Percentile Flow Per Zone	3,420.0	1,130.0	476.0	150.0
LA	745.1838	246.2	103.7	32.7
WLA*	negligible	negligible	negligible	negligible
MOS (10% Explicit)	82.8	27.4	11.5	3.6
TMDL	**828.0**	**273.6**	**115.2**	**36.3**
* WLA inputs are negligible for this segment.				
Existing Condition				
Average Load per Zone**	3,968.7	749.5	151.7	65.8
Load Reduction	**79%**	**64%**	**24%**	**45%**
Average Concentration per Zone	410	260	139	112
Number of Values	5	12	9	5
* *Current Load or existing condition is the average of observed TSS loads for each flow zone.				
Runoff with 50th Percentile Flow/Area				
mm/day	0.47	0.15	0.06	0.02
cfs/sqmile	0.49	0.16	0.07	0.02

8.2.1 Load Allocation (LA)

To develop the TSS load allocation (LA), the loading capacity (LC) was first determined. The LC for Segment R16 (near Alcester to Indian Creek) was calculated by multiplying the 30-day average (90 mg/L) TSS criterion by the daily average flow measured at Site LBSM17 near Akron, IA. Site LBSM17 is the most downstream site within this segment. There were only two mainstem sites located within this segment (Site LBSM13-upstream and Site LBSM17-downstream, Figure 6). Table 13 can be found for each site in Appendix – B.

The 30-day average criterion (90 mg/L) was used for the calculation of the LC, rather than the daily maximum criterion (158 mg/L) because the chronic criterion is considered more protective. The 30-day average, as defined in ARSD § 74:51:01:01, is the arithmetic mean of a minimum of three consecutive grab or composite samples taken on separate weeks in a 30-day period. The 30-day average TSS criteria (ARSD § 74:51:01:48) applies at all times but compliance can only be determined when a minimum of three samples are obtained during separate weeks for any 30-day period. In many instances, only one or two samples were collected during any 30-day period, so the average criterion was applied to each flowzone in Figure 13. Although the daily maximum criteria are exceeded, to be conservative it was decided to use the average criterion to develop the loading capacity of the stream in order to ensure that the most stringent water quality standards are met. Additional data is needed to accurately assess compliance with the 30-day average criterion. The loading capacities and reductions derived from the available data are estimates (i.e., the calculated loading capacities and reductions may be higher or lower if/when a more extensive data set is collected to fully assess compliance with the chronic standard). For each of the four flow zones, the 50th percentile (median) of the range of LCs within a zone was set as the flow zone goal. TSS loads experienced during the largest stream flows (e.g. top 5 percent) cannot be feasibly controlled by practical management practices. Setting the flow zone goal at the 50th percentile while using the average (90 mg/L) criterion within each flowzone will protect the warmwater semipermanent fish life propagation beneficial use and allow for the natural variability of the system (Figure 13).

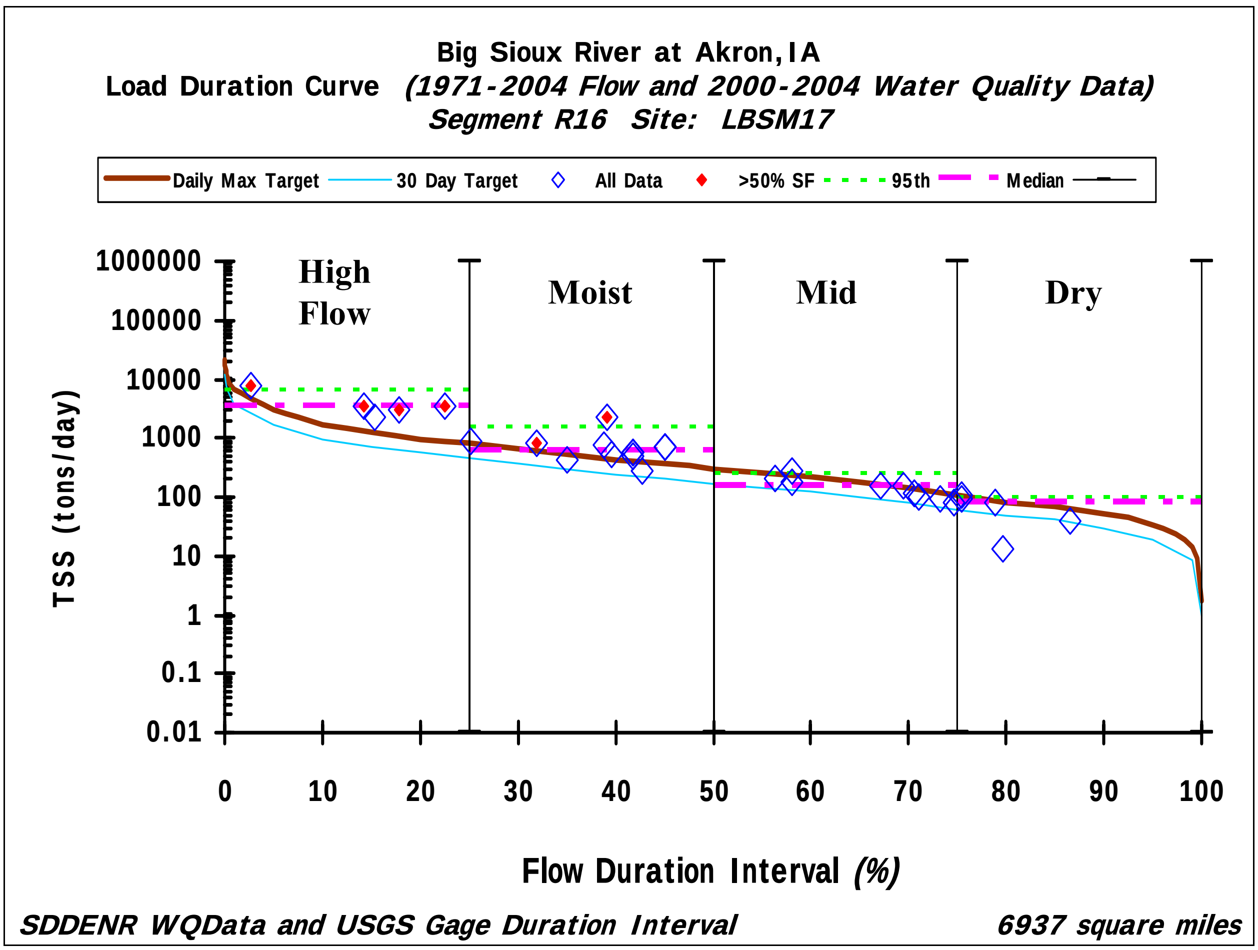


Figure 13. Segment R16 – Load duration curve representing allowable daily TSS loads based on the 30-day average and daily maximum criteria (≤90 mg/L and ≤158 mg/L, respectively). Plot showing median nd 95th percentiles, and daily loads for each flow zone. The 30-day average was used to determine the loading capacity for the Segment R16 and the TMDL. Observed TSS concentrations are also displayed.

Portions of the LC were allocated to point sources as a waste-load allocation (WLA) and nonpoint sources as a load allocation (LA). A fraction of the LC was also reserved as a margin of safety (MOS) to account for uncertainty in the calculations of these load allocations. The method used to calculate the MOS is discussed below. The LA was determined by subtracting the WLA and MOS from the LC. Thus, the TMDL (and LC) is the sum of WLA, LA, and MOS.

8.2.2 Waste Load Allocation (WLA)

Although the City of Hawarden, IA has an activated sludge wastewater treatment facility (WWTF) that discharges to the Big Sioux River, the contribution from the facility is negligible. The IDNR is the regulatory authority for this facility and will continue to ensure that it meets the conditions outlined in the NPDES permit.

Table 14. Discharge characteristics of the wastewater treatment facility for the city of Hawarden, IA.

EPA NPDES ID	Facility Name	Population Equivalent	Design AWW Flow (MGD)	Maximum Design Flow (MGD)
IA0021083	City of Hawarden, IA	14,197	0.672	0.806

8.2.3 Iowa and South Dakota TSS Loading

For the immediate watershed of Segment R16 the drainage from Iowa and South Dakota constitutes 15% and 85% of the total surface area, respectively (Figure 6 and Table 9). Loadings from Iowa and South Dakota are assumed to be based on the percent contribution outlined in the source allocation table (Table 9, page 27). Although South Dakota has no authority in regulating pollution from Iowa, reductions from both states in TSS loadings are assumed in this TMDL scenario. Clearly, reductions from both Iowa and South Dakota are critical for meeting water quality standards for this segment of the Big Sioux River.

Table 15. Segment R16 reduction inputs for each subwatershed.

Reductions	**Percent Reductions for each input for Segment R16 per flowzone (based on reductions in Table 13)**			
Subwatershed or 12-digit HUC	**High**	**Moist**	**Mid**	**Dry**
LBSM13 (Mainstem - Upstream)	52.46%	45.70%	12.62%	12.65%
LBST12 (Green Creek-SD)	0.13%	0.76%	0.09%	0.10%
IA08 (Sixmile Creek-IA)	2.20%	3.08%	5.39%	18.77%
IA09 (Indian Creek-IA)	1.82%	1.25%	0.11%	0.09%
Dry Creek-Big Sioux River (IA) 101702039	0.96%	1.50%	1.02%	3.17%
Big Sioux River - Seg16-1 (IA) 101702039	0.13%	0.19%	0.12%	0.41%
Big Sioux River-Seg16-2 (IA) 101702039	0.09%	0.14%	0.09%	0.27%
Big Sioux River-Seg16-3 (IA) 101702039	0.28%	0.45%	0.29%	0.95%
Big Sioux River- Indian Creek (SD) 101702032201	0.31%	0.48%	0.30%	0.99%
Big Sioux River- Dry Creek-Seg16-1 (SD) 101702032001	0.13%	0.20%	0.13%	0.41%
Natural Background (Ann-AGNPS estimate)	0.79%	0.64%	0.24%	0.45%
Bed/Bank	19.75%	9.60%	3.60%	6.75%
Total Reductions	**79%**	**64%**	**24%**	**45%**

8.3 TMDL Allocations - Segment R17

The LDC (Table 16 and Figure 14) represents the dynamic expression of the TSS TMDL for Segment R17, resulting in a unique maximum daily load that corresponds to a measured average daily flow. To aid in the implementation of the TMDL and estimation of needed TSS load reductions, Table 16 presents a combination of allocations for each of four flow zones. Methods used to calculate the TMDL components are discussed below. This TMDL is in effect from year round and is based on daily flow.

Table 16. Segment R17 – TSS Total Maximum Daily Load (TMDL) allocations by flow zone (Site LBSM21).

TMDL Component	Flow Zone (expressed as tons/day)			
	High 0-25% Flow	**Moist 25-50% Flow**	**Mid 50-75% Flow**	**Dry 75-100% Flow**
	2,492 - 53,393 cfs	**1,149 - 2,491 cfs**	**612 - 1,148 cfs**	**325 - 611cfs**
(50^{th}) Average flow per flowzone	4,312.8	1,627.6	871.1	495.2
LA	939.7	357.2	190.8	107.9
WLA	negligible	negligible	negligible	negligible
MOS	104.4	39.7	21.2	12.0
TMDL	**1,044.1**	**396.9**	**212.0**	**119.9**
* WLA inputs are negligible for this segment.				
Existing Condition				
Average Load per flowzone	16,461.4	801.2	296.5	178.0
Load Reduction	**94%**	**50%**	**28%**	**33%**
Average Concentration per flowzone	817	183	123	114
Number of Values	3	9	12	5
* Current Load or existing condition is the average flow per flowzone of observed TSS loads for each flow zone. Runoff for Average Flow per flowzone (Flow/Area)				
mm/day	0.55	0.21	0.11	0.06
cfs/sqmile	0.58	0.22	0.12	0.07

8.3.1 Load Allocation (LA)

To develop the TSS load allocation (LA), the loading capacity (LC) was first determined. The LC for Segment R17 (Indian Creek to Mouth) was calculated by multiplying the daily maximum TSS criterion by the daily average flow measured at Site LBSM21 near the mouth of the river (North Sioux City, SD). Site LBSM21 is the most downstream site within this segment. There were four mainstem sites located within the segment (Sites LBSM17-upstream, LBSM19, LBSM20, and LBSM21-downstream, Figure 7). Site LBSM19 located at Richland, SD is also a longterm ambient station used to determine impairment or support of beneficial uses (Table 16 can be found for each site in Appendix – B).

The 30-day average criterion (90 mg/L) was used for the calculation of the LC, rather than the daily maximum criterion (158 mg/L) because the chronic criterion is considered more protective. The 30-day average, as defined in ARSD § 74:51:01:01, is the arithmetic mean of a minimum of three consecutive grab or composite samples taken on separate weeks in a 30-day period. The 30-day average TSS criteria (ARSD § 74:51:01:48) applies at all times but compliance can only be determined when a minimum of three samples are obtained during separate weeks for any 30-day period. In many instances, only one or two samples were collected during any 30-day period, so the average criterion was applied to each flowzone in Figure 14. Although the daily maximum criteria are exceeded, to be conservative it was decided to use the average criterion to develop the loading capacity of the stream in order to ensure that the most stringent water quality standards are met. Additional data is needed to accurately assess compliance with the 30-day average criterion. The loading capacities and reductions derived from the available data are estimates (i.e., the calculated loading capacities and reductions may be higher or lower if/when a more extensive data set is collected to fully assess compliance with the chronic standard). For each of the four flow zones, the 50th percentile (median) of the range of LCs within a zone was set as the flow zone goal. TSS loads experienced during the largest stream flows (e.g. top 5 percent) cannot be feasibly controlled by practical management practices. Setting the flow zone goal at the 50th percentile while using the average (90 mg/L) criterion within each flowzone will protect the warmwater semipermanent fish life propagation beneficial use and allow for the natural variability of the system (Figure 14).

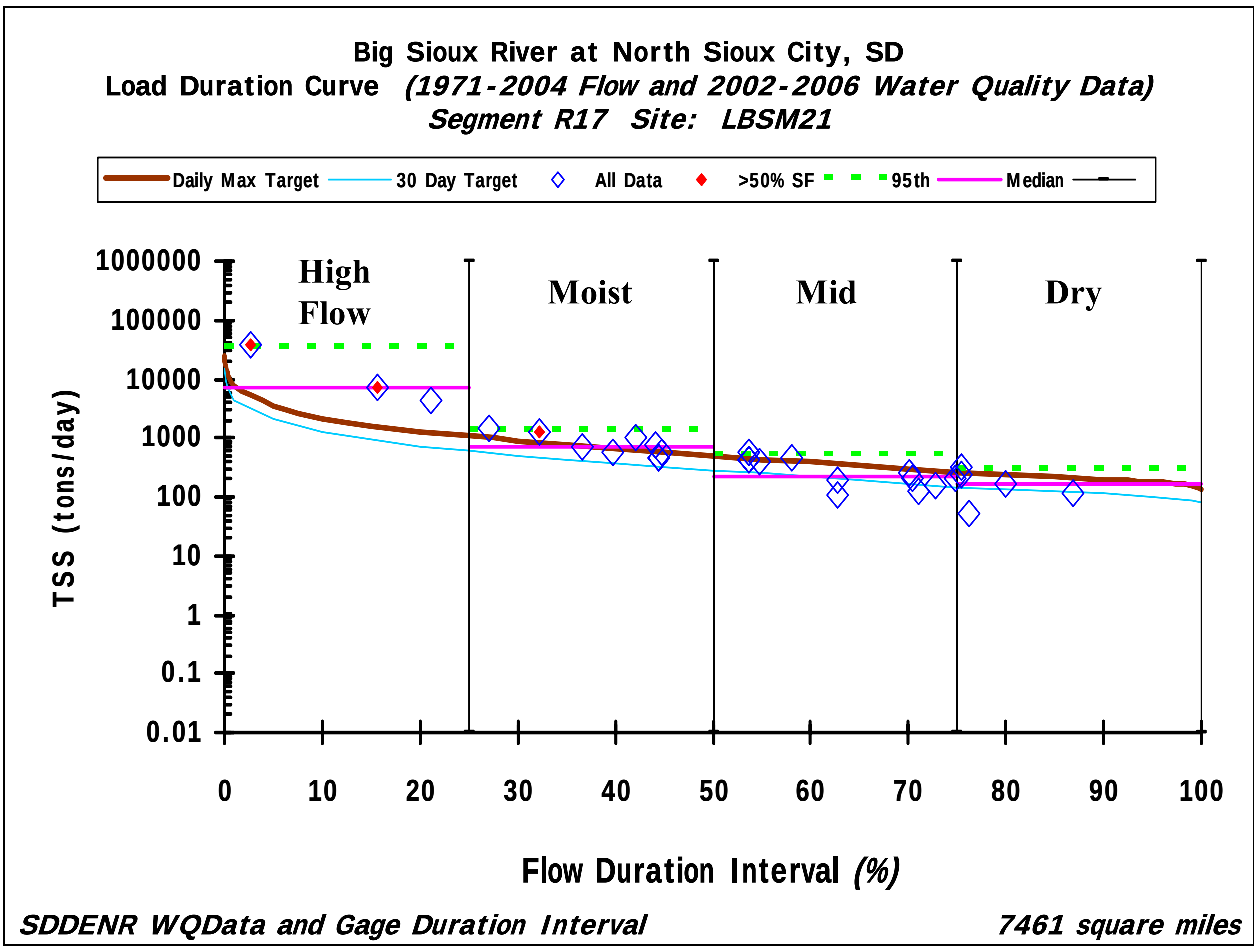


Figure 14. Segment R17 - Load duration curve representing allowable daily TSS loads based on the 30-day average and daily maximum criteria (≤90 mg/L and ≤158 mg/L, respectively). Plot showing median and 95th percentiles, and daily loads for each flow zone. The 30-day average was used to determine the loading capacity for the Segment R16 and the TMDL. Observed TSS concentrations are also displayed.

Portions of the LC were allocated to point sources as a waste-load allocation (WLA) and nonpoint sources as a load allocation (LA). A fraction of the LC was also reserved as a margin of safety (MOS) to account for uncertainty in the calculations of these load allocations. The method used to calculate the MOS is discussed below. The LA was determined by subtracting the WLA and MOS from the LC. Thus, the TMDL (and LC) is the sum of WLA, LA, and MOS.

8.3.2 Iowa TSS Loading

Although the City of Akron, IA is a three-cell waste stabilization lagoon system that periodically discharges to the Big Sioux River. The contribution from the facility is negligible. The IDNR is the regulatory authority for this facility and will continue to ensure that it meets the conditions outlined in the NPDES permit.

Table 17. Discharge characteristics of the wastewater treatment facility for the city of Akron, IA.

EPA NPDES ID	Facility Name	Population Equivalent	Design AWW Flow (MGD)	Maximum Design Flow (MGD)
IA0035211	City of Akron, IA	2,216	na	2.17

8.3.3 Iowa and South Dakota TSS Loading

For the immediate watershed of Segment R17 the drainage from Iowa and South Dakota constitutes 33% and 67% of the total surface area, respectively (Figure 6 and Table 9). Loadings from Iowa and South Dakota are assumed to be based on the percent contribution outlined in the source allocation table (Table 10, page 28). Although South Dakota has no authority in regulating pollution from Iowa, reductions from both states in TSS loadings are assumed in this TMDL scenario. Clearly, reductions from both Iowa and South Dakota are critical for meeting water quality standards for this segment of the Big Sioux River.

Table 18. Segment R17 reduction inputs for each subwatershed.

Reductions	**Percent Reductions for each input for Segment R17 per flowzone (based on reductions in Table 16)**			
Subwatershed or 12-digit HUC	**High**	**Low**	**Mid**	**Dry**
LBSM17 (Mainstem – Upstream)	48.51%	21.58%	5.29%	4.38%
LBST18 (Brule Creek from SD)	9.24%	3.47%	1.72%	0.38%
IA11 (Broken Kettle from Iowa)	13.10%	6.47%	1.78%	1.47%
IA10 (Westfield Creek from Iowa)	0.08%	0.09%	0.25%	0.22%
LBST16 (Union Creek from SD)	1.38%	0.31%	0.40%	0.22%
Big Sioux River -Indian Creek (SD) 101702032201	0.41%	0.09%	0.12%	0.07%
Big Sioux - Rock Creek (IA) 101702032205	3.05%	1.51%	0.41%	0.34%
Big Sioux - Rock Creek (SD) 101702032205	1.44%	0.54%	0.27%	0.06%
Big Sioux Mouth (IA) 101702032207	2.60%	1.29%	0.36%	0.29%
Big Sioux Mouth (SD) 101702032207	0.69%	0.26%	0.13%	0.03%
Big Sioux River - Union Creek (IA) 101702032203	0.09%	0.12%	0.27%	0.27%
Big Sioux River - Union Creek (SD) 101702032203	0.85%	0.19%	0.25%	0.14%
Big Ditch (SD) 101702032206	2.05%	0.77%	0.38%	0.08%
Natural Background (Ann-AGNPS estimate)	0.94%	0.50%	0.28%	0.33%
Bed/Bank[1]	9.61%	12.88%	16.12%	24.79%
Total Reductions	**94%**	**50%**	**28%**	**33%**

9.0 Margin of Safety (MOS) – All Segments

In accordance with the regulations, a margin of safety was established to account for uncertainty in the data analyses. A margin of safety may be provided (1) by using conservative assumptions in the calculation of the loading capacity of the waterbody and (2) by establishing allocations that in total are lower than the defined loading capacity. In the case of the Lower Big Sioux analysis, the latter approach was used to establish a safety margin.

An 10% explicit MOS was calculated within the duration curve framework to account for uncertainty (e.g., loads from tributary streams, effectiveness of controls, etc.). This 10% explicit MOS was calculated from the TMDL within each flowzone and reserved as unallocated assimilative capacity. The remaining assimilative capacity was attributed nonpoint sources (LA) or point sources (WLA).

As new information becomes available and the TMDL is revisited, this unallocated capacity may be attributed to nonpoint sources and added to the load allocation, or the unallocated capacity may be attributed to point sources and become part of the waste load allocation.

10.0 Seasonal Variation – All Segments

Discharge in the Big Sioux River (USGS gage# 06485500, Akron, IA) displayed seasonal variation for the period of record (10/1/71 to 9/30/08). Highest stream flows typically occur during spring with highest monthly average stream flow reported in April (4,269.4 cfs), and lowest stream flows occur during the winter months with lowest monthly average stream flow reported in January (427.0 cfs). Total suspended solids concentrations also displayed seasonal variation relative to flow, i.e. positively correlated with stream flow. By using the LDC approach to develop the TMDL allocations, seasonal variability in total suspended loads is taken into account.

In addition, although the TMDL displays seasonality through flow, it is effective throughout the entire year.

11.0 Critical Conditions – All Segments

Critical conditions occur within the basin during the spring and summer storm events. Typically, during severe thunderstorms the largest concentrations are highest in the basin during the summer months. Combined with the peak in tillage for agricultural crops, high-intensity rainstorm events, which are common during the spring and summer, produce a significant amount of sheet and rill erosion. The excessive flows and changing channel dynamics also increase the bed and bank erosion along the tributaries and mainstem of the river.

12.0 Follow-Up Monitoring

During and after the implementation of management practices, monitoring will be necessary to assure attainment of the TMDL. Stream water quality monitoring will be accomplished through SD DENR’s ambient water quality monitoring stations throughout the river basin especially for the three impaired segments addressed in this report: Segment R15 - Site LBSM09 (WQM66) at Hudson, SD, Segment R16 - Site LBSM13 (WQM67) at Hawarden, IA, and Segment R17 - Site LBSM19 (WQM32) at Richland, SD. These stations are sampled on a monthly basis.

Additional monitoring and evaluation efforts will be targeted toward the effectiveness of implemented BMPs. Sample sites will be based on BMP site selection and parameters will be based on a product-specific basis.

13.0 Public Participation

Efforts taken to gain public education, review, and comment during development of the TMDL involved:

1. Various public meetings were held during the assessment phase.
2. A webpage was developed and used during the course of the assessment.
3. Presentations to local groups on the findings of the assessment.

4. 30-day public notice (PN) period for public review and comment.

The findings from these public meetings, the webpage, and 30-day PN comments have been taken into consideration in development of the Big Sioux River TMDL.

14.0 Implementation

Currently, there is an implementation project targeting areas outlined in the Lower Big Sioux Pathogen TMDL. During the next Section 319 funding round an expansion of the project will be proposed to include BMPs targeting streambank erosion and sheet and rill erosion..

Several types of BMPs should be considered in the development of a water quality management implementation plan for watershed draining the impaired segments of the Lower Big Sioux River. The results of the FLUX loadings indicate that an estimated 25% or greater of the total suspended solids load originates from bank erosion in varying flowzones. Additional analysis through the Annualized AGNPS suggests that multiple drainages in both South Dakota and Iowa provide increased water and sediment loadings. A list of the 12-digit HUCs and their sediment export coefficients is presented in Appendix I. While several types of control measures are available for reducing sediment loads, the practicable control measures listed and discussed below are recommended to address these identified sources.

Example TMDL Summary Using Duration Curve Framework (Cleland, 2003).

TMDL SUMMARY	Loads expressed as *(tons per day)*				
	High	**Moist**	**Mid-Range**	**Dry**	**Low**
TMDL[1]	173.35	67.20	40.21	27.57	18.96
Allocations	118.32	48.24	34.47	21.83	6.90
Margin of Safety	55.03	18.96	5.74	5.74	12.06
Implementation Opportunities	***Post Development BMPs***				
	Streambank Stabilization				
	Erosion Control Program	***Erosion Control Program***	***Erosion Control Program***		
		Riparian Buffer Protection	***Riparian Buffer Protection***	***Riparian Buffer Protection***	
				Municipal WWTP	***Municipal WWTP***

Note: 1. Expressed as a *"daily load"*; represents the upper range of conditions needed to attain and maintain applicable water quality standards

- Livestock access to streams should be reduced, and livestock should be provided sources of water away from streams.
- Unstable stream banks should be protected by enhancing the riparian vegetation that provides erosion control and filters runoff of pollutants into the stream.
- Filter strips should be installed along the stream bordering cropland and pastureland.
- Animal confinement facilities should implement proper animal waste management systems.

- A terrace maintenance program should be implemented to repair or replace failing terracing systems.
- An assessment of the effect of tiling on peak flows and bank erosion should completed for the tributaries draining into these three segments of the Big Sioux River.

Since this basin involves multiple states, a joint effort should be undertaken through South Dakota and Iowa to implement the necessary control measures needed to reduce sediment impacts on the Big Sioux River.

Funds to implement watershed water quality improvements can be obtained through SD DENR. SD DENR administers three major funding programs that provide low interest loans and grants for projects that protect and improve water quality in South Dakota. They include: Consolidated Water Facilities Construction program, Clean Water State Revolving Fund (SRF) program, and the Section 319 Nonpoint Source program.

15.0 Literature Cited

Bankhead, Natasha and Andrew Simon. 2009. Analysis of Ban Stability and Potential Load Reduction Along Reaches of the Big Sioux River, South Dakota. National Sedimentation Laboratory Report 64.

Bryce, S.A., Omernik, J.M., Pater, D.A., Ulmer, M., Schaar, J., Freeouf, J., Johnson, R., Kuck, P., and Azevedo, S.H., 1996, Ecoregions of North Dakota and South Dakota, (color poster with map, descriptive text, summary tables, and photographs): Reston, Virginia, U.S. Geological Survey (map scale 1:1,500,000). (http://www.epa.gov/wed/pages/ecoregions/ndsd_eco.htm)

Chapman, Shannen S., Omernik, James M., Freeouf, Jerry A., Huggins, Donald G., McCauley, James R., Freeman, Craig C., Steinauer, Gerry, Angelo, Robert T., and Schlepp, Richard L., 2001, Ecoregions of Missouri and Iowa (color poster with map, descriptive text, summary tables, and photographs): Reston, Virginia, U.S. Geological Survey (map scale 1:1,950,000). (http://www.epa.gov/wed/pages/ecoregions/moia_eco.htm)

Chapra, Steven, 1997, Surface Water Quality Modeling

Cleland, B.R. 2003. TMDL Development from the "Bottom Up"-Part III: Duration Curves and Wet-Weather Assessments. America's Clean Water Foundation. Washington D.C.

Cleland, B.R. 2003. TMDL Development Workshop – North and South Dakota, Watertown, SD. June 23, 2004.

Helsel, D.R. and R. M. Hirsch, 2002. **Statistical Methods in Water Resources** Techniques of Water Resources Investigations, Book 4, chapter A3. U.S. Geological Survey. 522 pages.

Iowa Department of Natural Resources (IDNR). (2002). Iowa's Final 2002 Impaired Water List, http://wqm.igsb.uiowa.edu/WQA/303d.html

IDNR. 2002 and 2004. 2002, 2004, 2006, and 2008 Section 305(b) Water Quality Reports.

Iowa General Assembly (2009). Iowa Administrative Code, Chapter 567-61: Water Quality Standards, http://www.legis.state.ia.us/IAC.html

Metcalf & Eddy, Inc. (2005). Wastewater Engineering Treatment and Reuse (Fourth Edition)

McCormick, K.A., and R. H. Hammond. 2004. Geology of Lincoln and Union Counties, South Dakota. South Dakota Department of Environment and Natural Resources, Geological Survey. Bulletin 39.

Novotny and Chesters. 1981. Handbook of Nonpoint Pollution Sources and Management.

SDDENR 2001. Lake Alvin (Lincoln County) Phase I Watershed Assessment Final Report and TMDL. 133 pp.

SDDENR (South Dakota Department of Environment and Natural Resources). 2002a. Grant Application and Section 104(b)(3) Workplan for the Lower Big Sioux River Watershed Assessment. Pierre, SD.

SDDENR. 2002b. South Dakota Total Maximum Daily Load Waterbody List 2002. Pierre, SD.

SDDENR 2004. The 2004 South Dakota Integrated Report for Surface Water Quality Assessment. South Dakota Department of Environment and Natural Resources, Pierre, South Dakota. 219 pp.

SDDENR 2006. The 2006 South Dakota Integrated Report for Surface Water Quality Assessment. South Dakota Department of Environment and Natural Resources, Pierre, South Dakota. 211 pp.

SDDENR 2008. The 2008 South Dakota Integrated Report for Surface Water Quality Assessment. South Dakota Department of Environment and Natural Resources, Pierre, South Dakota. 269 pp.

Simon, A., L. Klimetz, and J. Schwartz. 2008. Characterization of"Reference" Suspended-Sediment Transport and Bed Material Conditions for Selected Ecoregions in EPA Region 8: The Mountains and Plains. ARS (Agricultural Research Service) National Sedimentation Laboratory Technical Report 61.

South Dakota Surface Water Quality Standards. Beneficial Uses of Waters Established, Administrative Rules of South Dakota, Chapter 74:51:01:42. State of South Dakota, Pierre, SD.

South Dakota Game, Fish, and Parks. 2002. South Dakota Game Report No. 2003-11-2002 County Wildlife Assessments. Pierre, SD.

USDA (United States Dept. of Agriculture – Soil Conservation Service) 1976. Soil Survey of Lincoln County, South Dakota.

USDA (United States Dept. of Agriculture – Soil Conservation Service) 1976. Soil Survey of Union County, South Dakota.

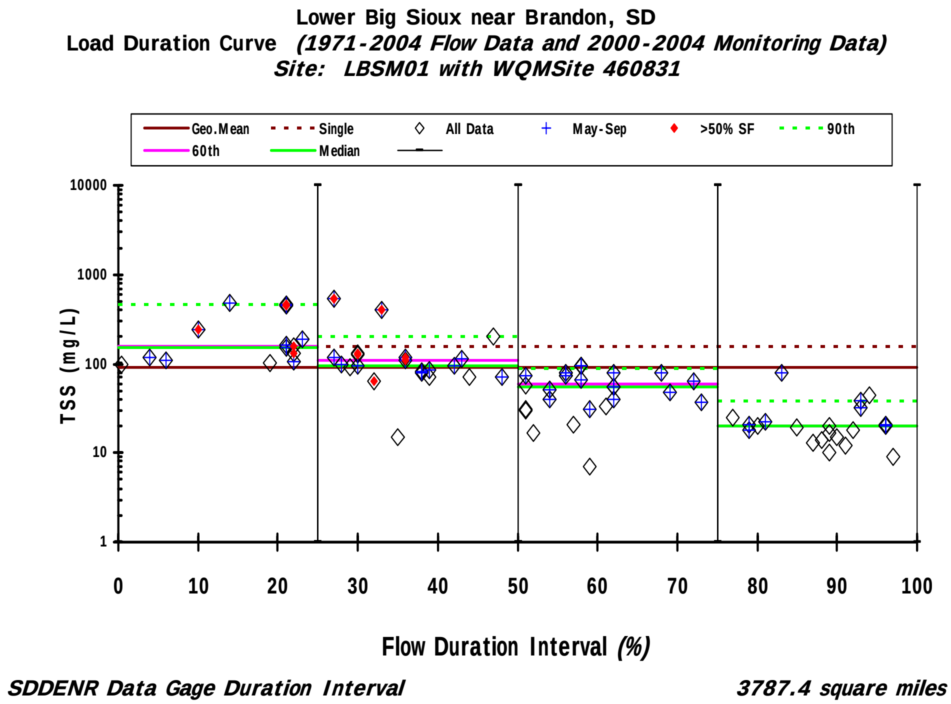
USEPA. (U.S. Environmental Protection Agency) 2001. EPA 841-R-00-002. Protocol for Developing Pathogen TMDLs, First Edition.

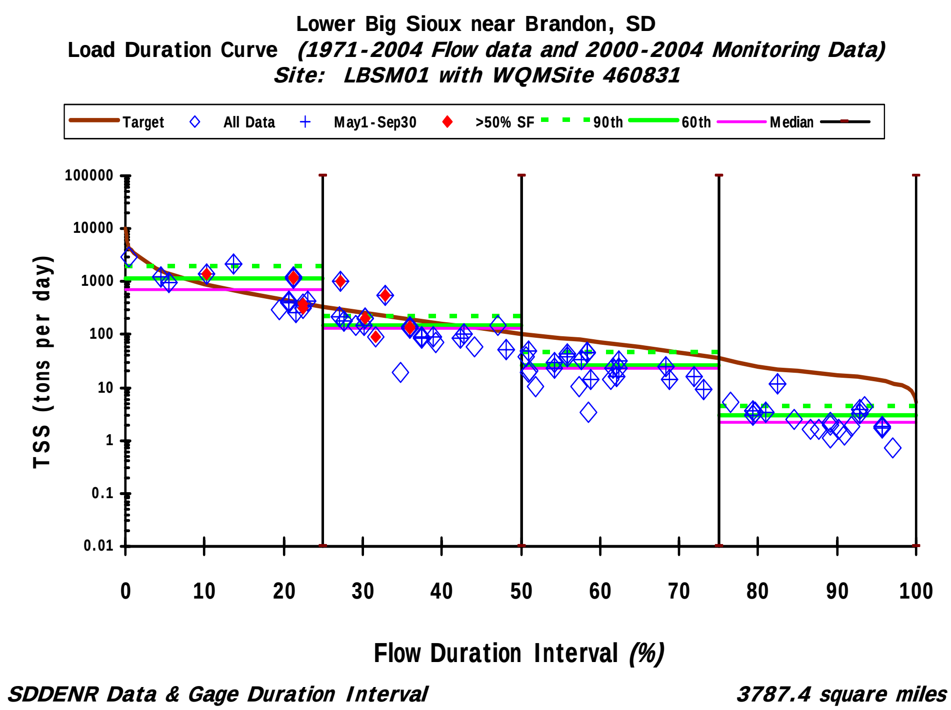
USEPA. 2006. An Approach for Using Load Duration Curves in Developing TMDLs. U.S. Environmental Protection Agency, Office of Wetlands, Oceans and Watersheds, Washington, DC.

USEPA 2008. Lower Big Sioux Pathogen TMDL . Office of Water. EPA-823-B01-003. http://www.epa.gov/Region7/water/pdf/lower_big_sioux_review_20080123.pdf

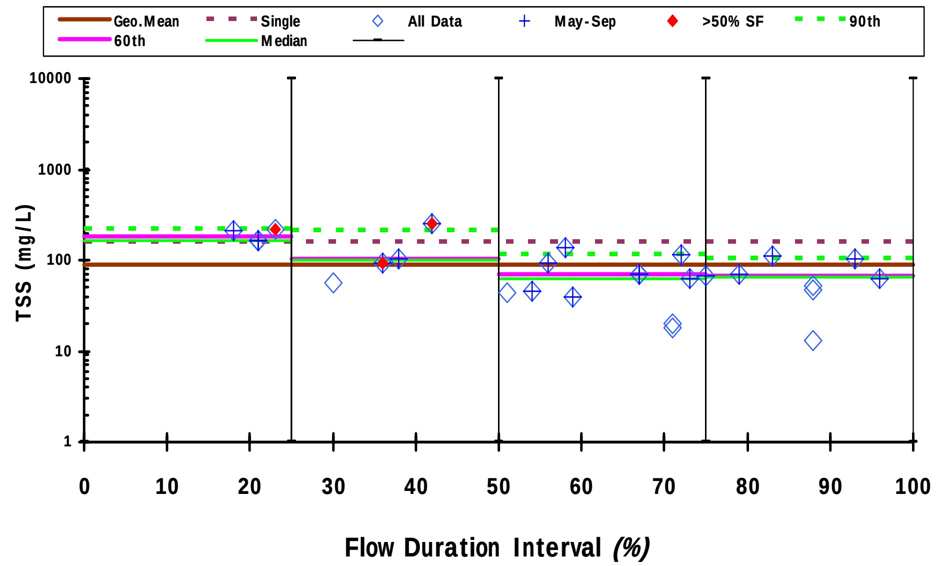
United States Geological Survey (USGS) (2005). Earth Resources Observation and Science (EROS) Database, http://edc.usgs.gov/geodata/

16.0 APPENDIX A: Load Duration Curves and Water Quality Assessment Graphs for all Mainstem Sites


Lower Big Sioux near Brandon, SD
Load Duration Curve (1971-2004 Flow Data and 2000-2004 Monitoring Data)
Site: LBSM01 with WQMSite 460831
Geo.Mean
Single
All Data
May-Sep
>50% SF
90th
60th
Median
TSS (mg/L)
10000
1000
100
10
1
0
10
20
30
40
50
60
70
80
90
100
Flow Duration Interval (%)
SDDENR Data Gage Duration Interval
3787.4 square miles

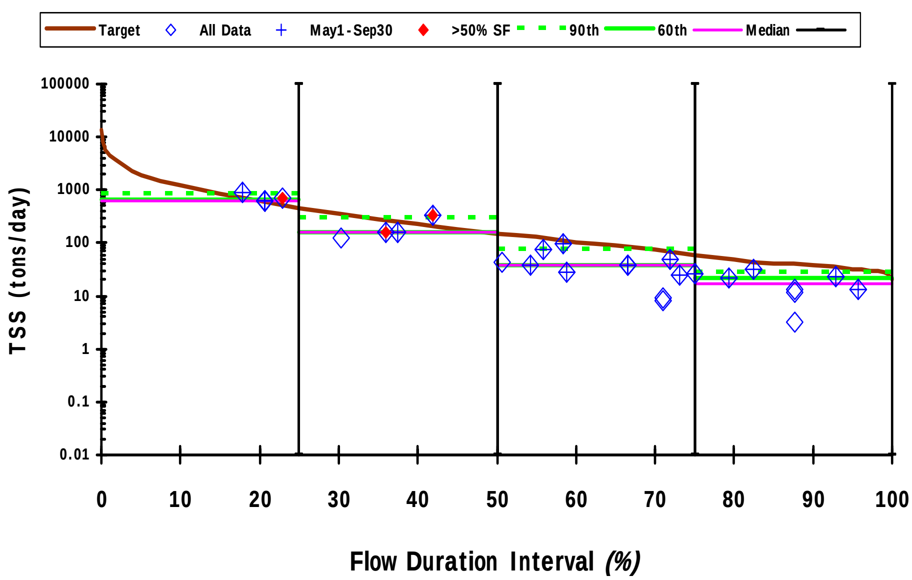

Lower Big Sioux near Brandon, SD
Load Duration Curve (1971-2004 Flow data and 2000-2004 Monitoring Data)
Site: LBSM01 with WQMSite 460831
Target
All Data
May1-Sep30
>50% SF
90th
60th
Median
TSS (tons per day)
100000
10000
1000
100
10
1
0.1
0.01
0
10
20
30
40
50
60
70
80
90
100
Flow Duration Interval (%)
SDDENR Data & Gage Duration Interval
3787.4 square miles

Lower Big Sioux at Klondike Dam, SD
Load Duration Curve ***(1971-2004 Flow data and 2000-2004 Monitoring Data)***
Site: LBSM03

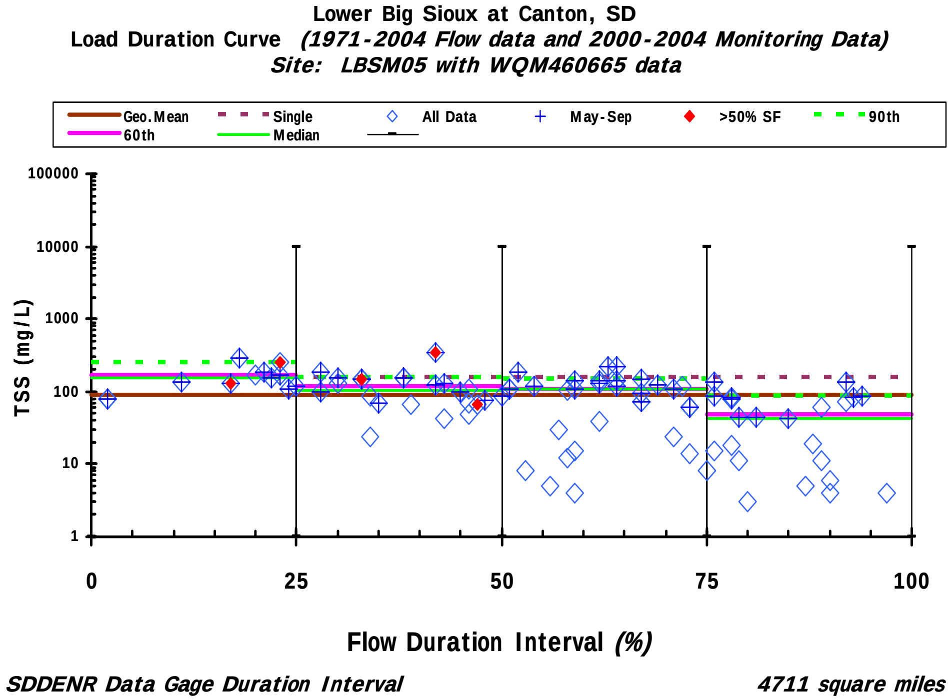


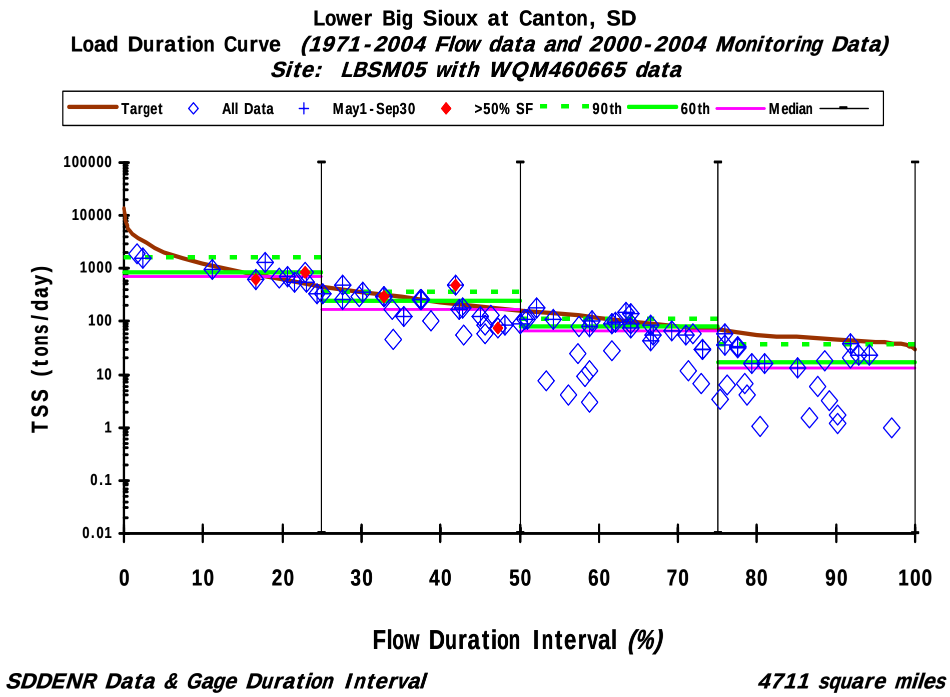
SDDENR Data Gage Duration Interval ***3787.4 square miles***

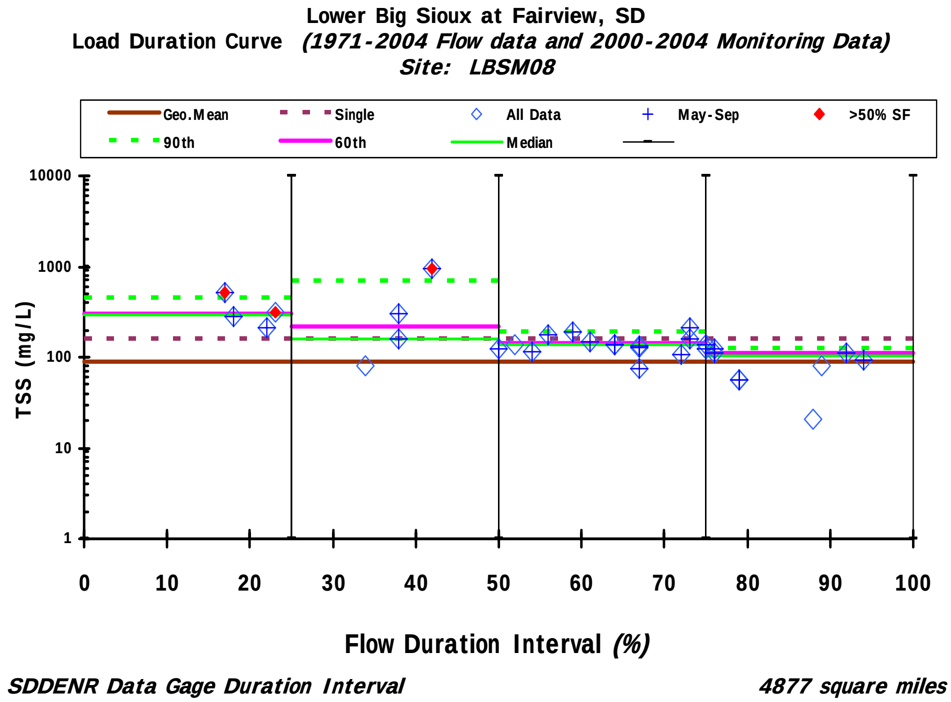
Lower Big Sioux Klondike Dam, SD
Load Duration Curve ***(1971-2004 Flow data and 2000-2004 Monitoring Data)***
Site: LBSM03

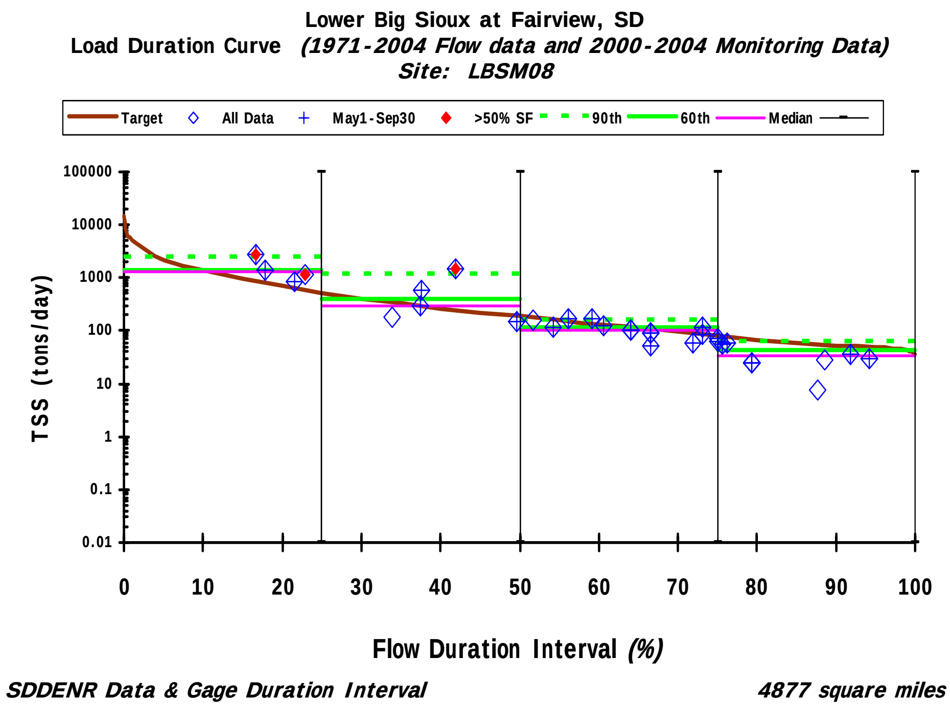


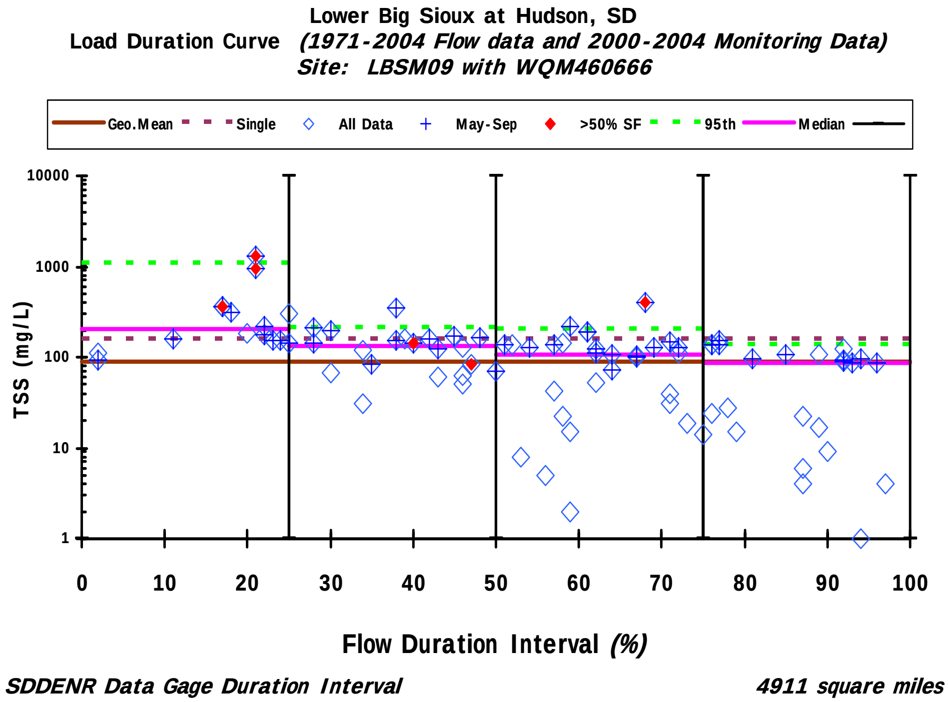
SDDENR Data & Gage Duration Interval ***3787.4 square miles***

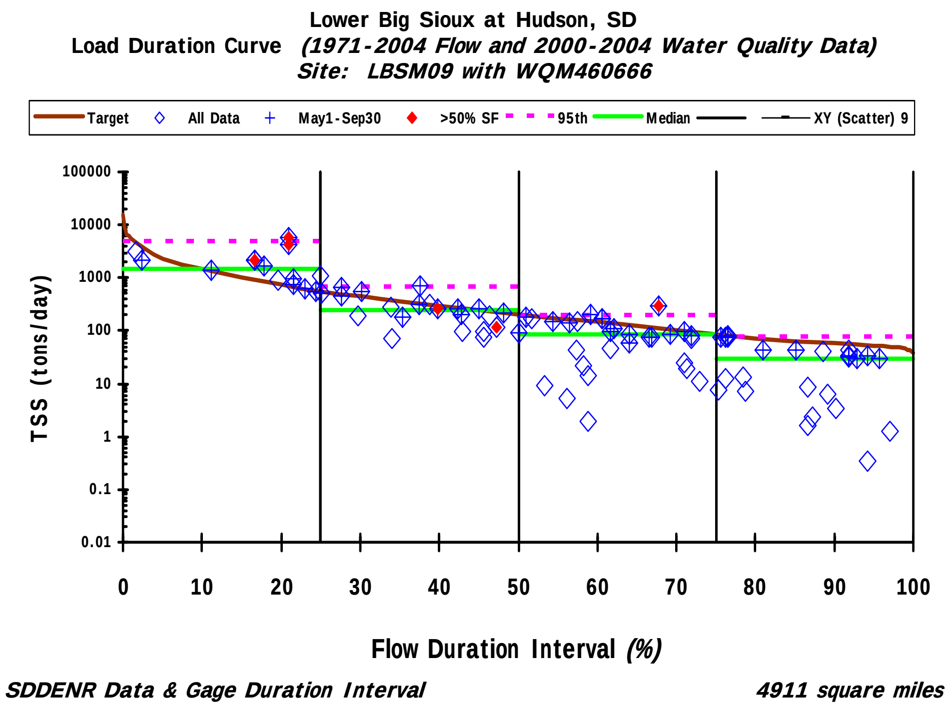

Lower Big Sioux at Canton, SD
Load Duration Curve (1971-2004 Flow data and 2000-2004 Monitoring Data)
Site: LBSM05 with WQM460665 data
Geo.Mean
Single
All Data
May-Sep
>50% SF
90th
60th
Median
TSS (mg/L)
100000
10000
1000
100
10
1
0
25
50
75
100
Flow Duration Interval (%)
SDDENR Data Gage Duration Interval
4711 square miles

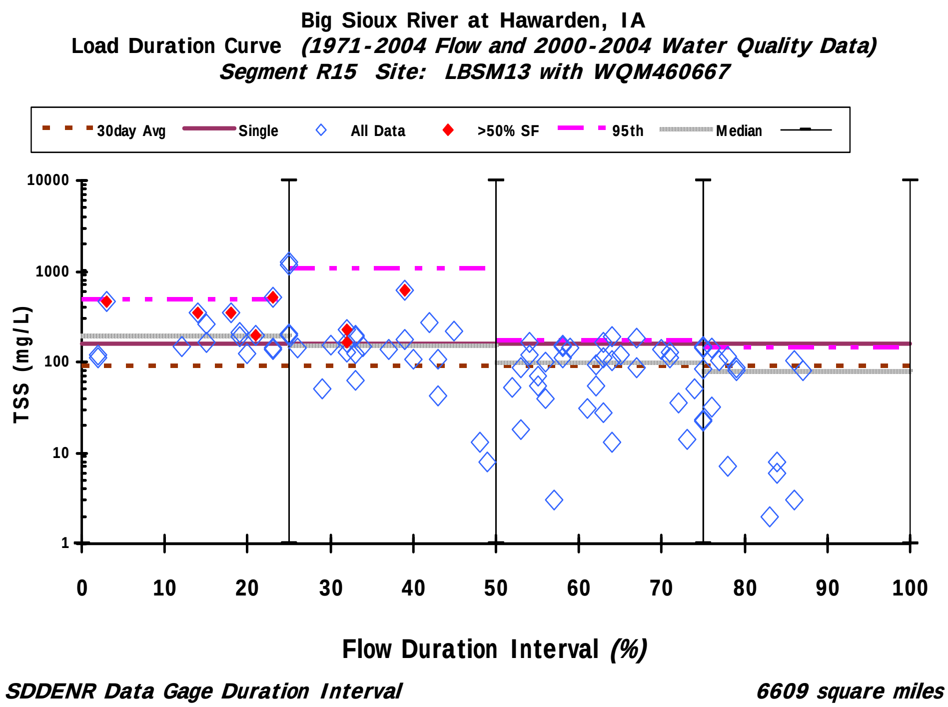

Lower Big Sioux at Canton, SD
Load Duration Curve (1971-2004 Flow data and 2000-2004 Monitoring Data)
Site: LBSM05 with WQM460665 data
Target
All Data
May1-Sep30
>50% SF
90th
60th
Median
TSS (tons/day)
100000
10000
1000
100
10
1
0.1
0.01
0
10
20
30
40
50
60
70
80
90
100
Flow Duration Interval (%)
SDDENR Data & Gage Duration Interval
4711 square miles

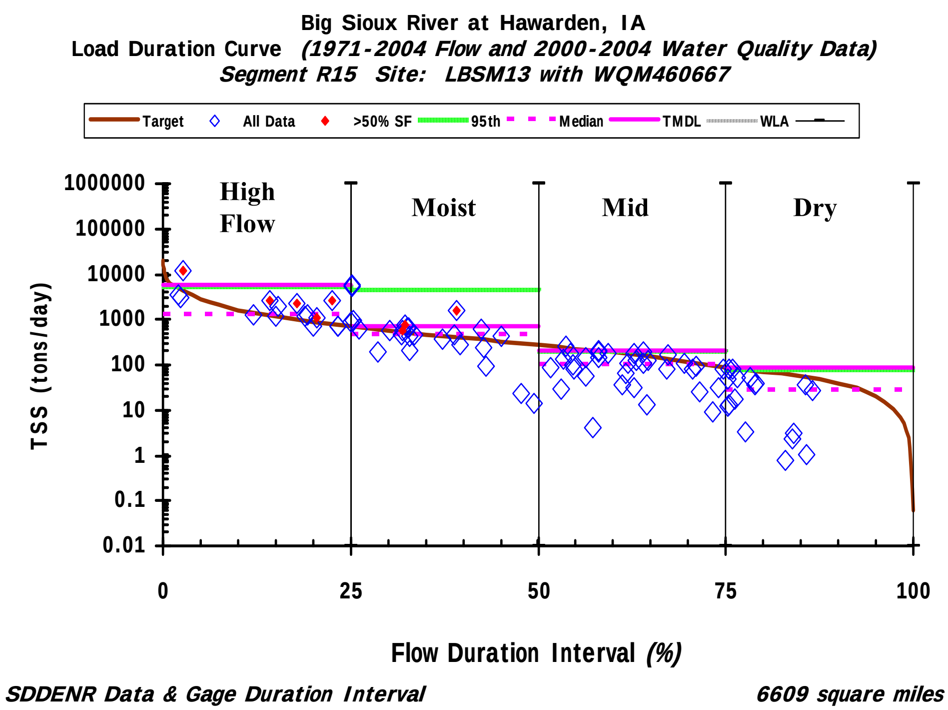

Lower Big Sioux at Fairview, SD
Load Duration Curve (1971-2004 Flow data and 2000-2004 Monitoring Data)
Site: LBSM08
Geo.Mean
Single
All Data
May-Sep
>50% SF
90th
60th
Median
TSS (mg/L)
10000
1000
100
10
1
0
10
20
30
40
50
60
70
80
90
100
Flow Duration Interval (%)
SDDENR Data Gage Duration Interval
4877 square miles

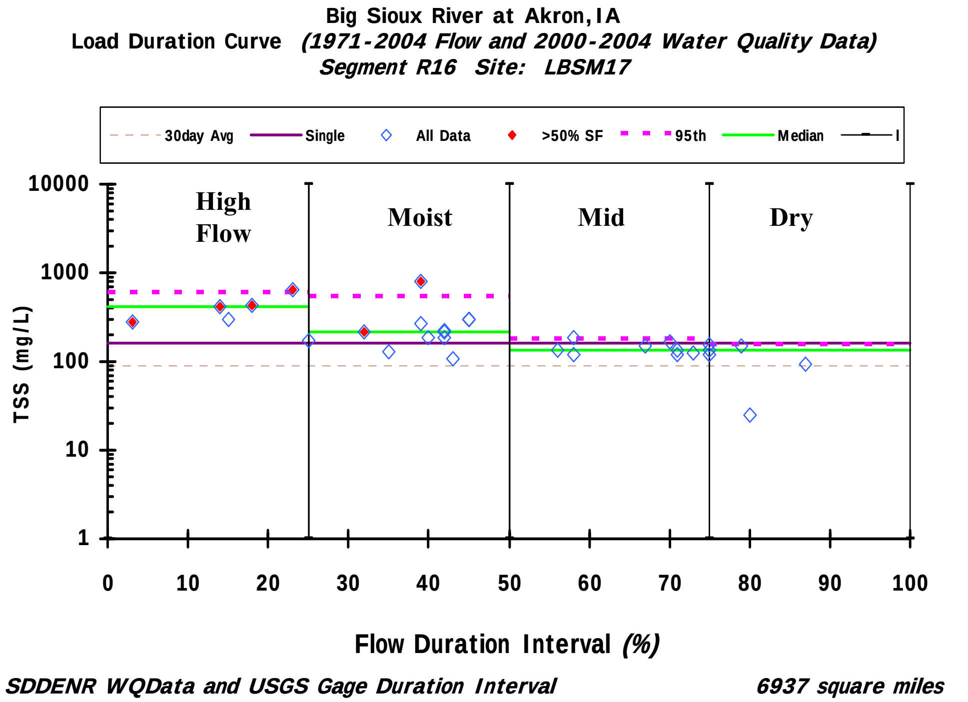

Lower Big Sioux at Fairview, SD
Load Duration Curve (1971-2004 Flow data and 2000-2004 Monitoring Data)
Site: LBSM08
Target
All Data
May1-Sep30
>50% SF
90th
60th
Median
TSS (tons/day)
100000
10000
1000
100
10
1
0.1
0.01
0
10
20
30
40
50
60
70
80
90
100
Flow Duration Interval (%)
SDDENR Data & Gage Duration Interval
4877 square miles

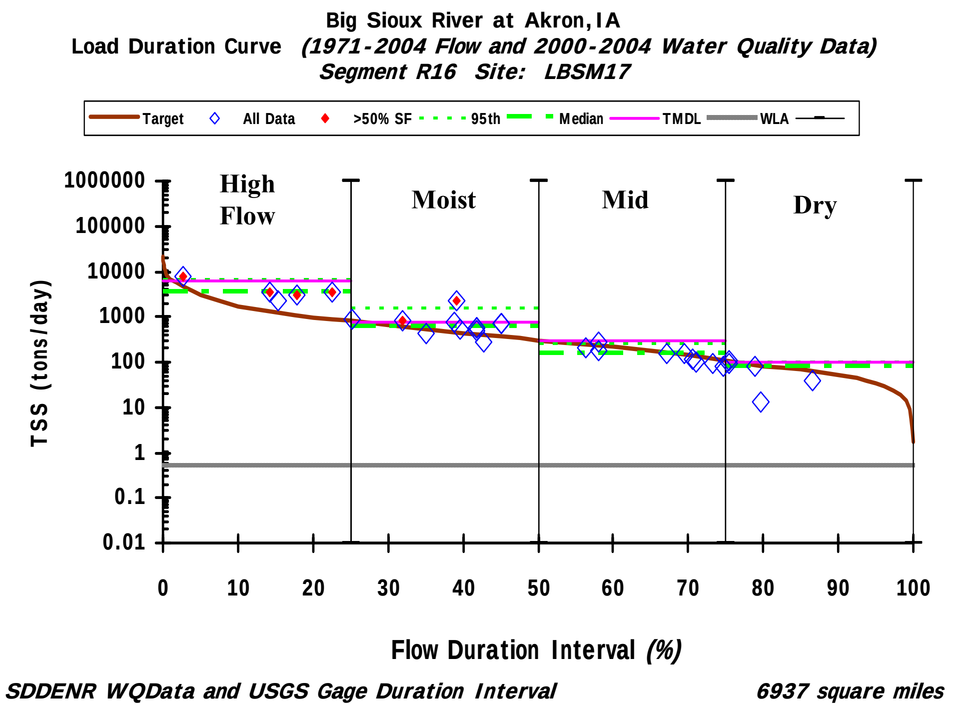

Lower Big Sioux at Hudson, SD
Load Duration Curve (1971-2004 Flow data and 2000-2004 Monitoring Data)
Site: LBSM09 with WQM460666
Geo.Mean
Single
All Data
May-Sep
>50% SF
95th
Median
TSS (mg/L)
Flow Duration Interval (%)
SDDENR Data Gage Duration Interval
4911 square miles

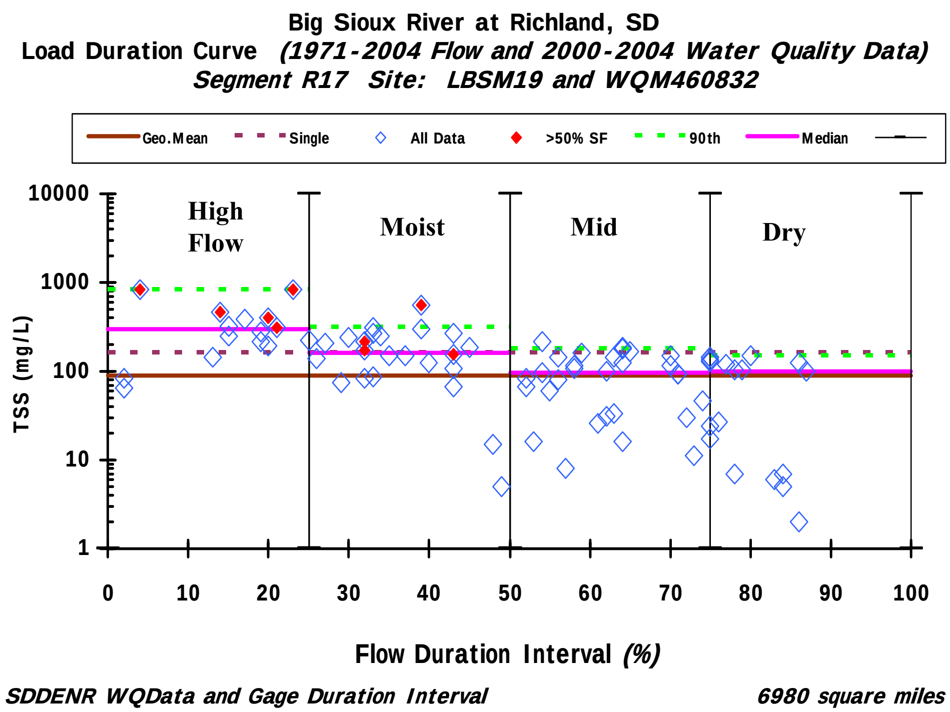

Lower Big Sioux at Hudson, SD
Load Duration Curve (1971-2004 Flow and 2000-2004 Water Quality Data)
Site: LBSM09 with WQM460666
Target
All Data
May1-Sep30
>50% SF
95th
Median
XY (Scatter) 9
TSS (tons/day)
Flow Duration Interval (%)
SDDENR Data & Gage Duration Interval
4911 square miles

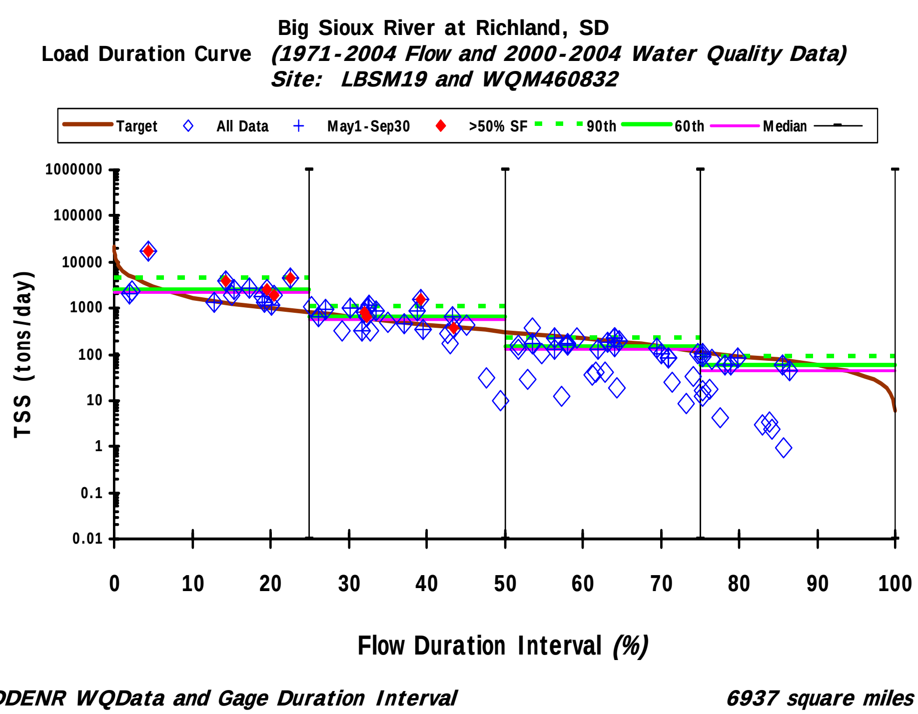

Big Sioux River at Hawarden, IA
Load Duration Curve (1971-2004 Flow and 2000-2004 Water Quality Data)
Segment R15 Site: LBSM13 with WQM460667
30day Avg
Single
All Data
>50% SF
95th
Median
TSS (mg/L)
10000
1000
100
10
1
0
10
20
30
40
50
60
70
80
90
100
Flow Duration Interval (%)
SDDENR Data Gage Duration Interval
6609 square miles

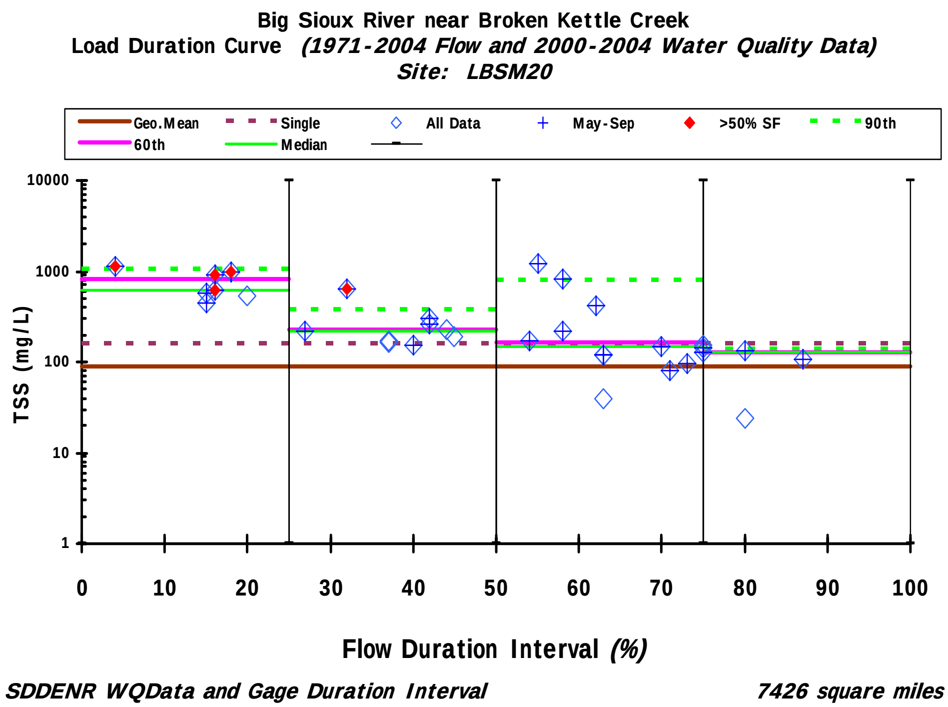

Big Sioux River at Hawarden, IA
Load Duration Curve (1971-2004 Flow and 2000-2004 Water Quality Data)
Segment R15 Site: LBSM13 with WQM460667
Target
All Data
>50% SF
95th
Median
TMDL
WLA
TSS (tons/day)
1000000
100000
10000
1000
100
10
1
0.1
0.01
High Flow
Moist
Mid
Dry
0
25
50
75
100
Flow Duration Interval (%)
SDDENR Data & Gage Duration Interval
6609 square miles

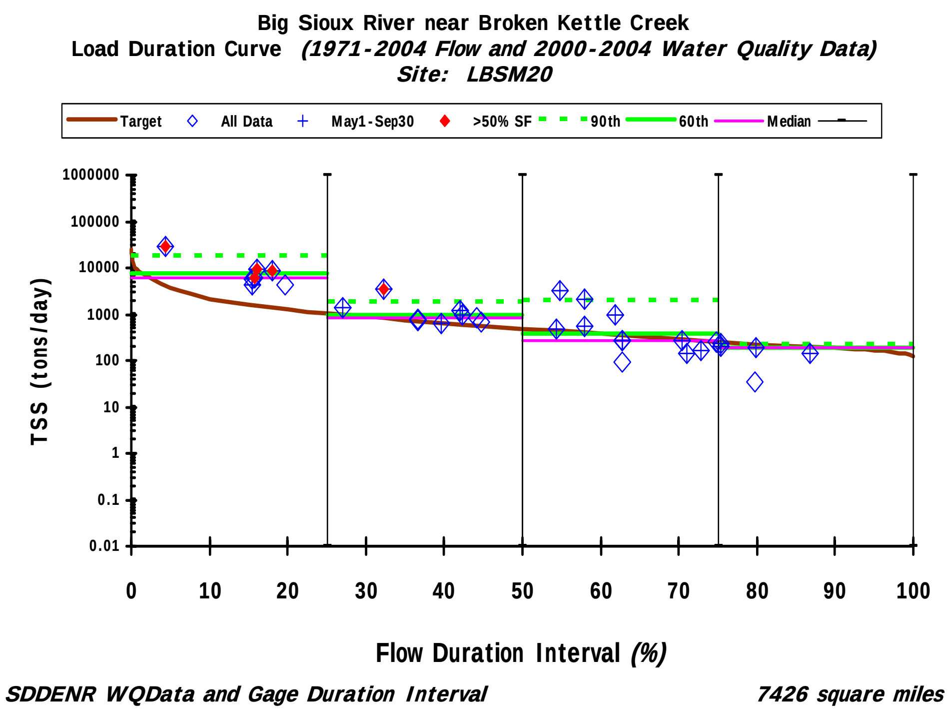

Big Sioux River at Akron, IA
Load Duration Curve (1971-2004 Flow and 2000-2004 Water Quality Data)
Segment R16 Site: LBSM17
30day Avg
Single
All Data
>50% SF
95th
Median
High Flow
Moist
Mid
Dry
TSS (mg/L)
10000
1000
100
10
1
0
10
20
30
40
50
60
70
80
90
100
Flow Duration Interval (%)
SDDENR WQData and USGS Gage Duration Interval
6937 square miles

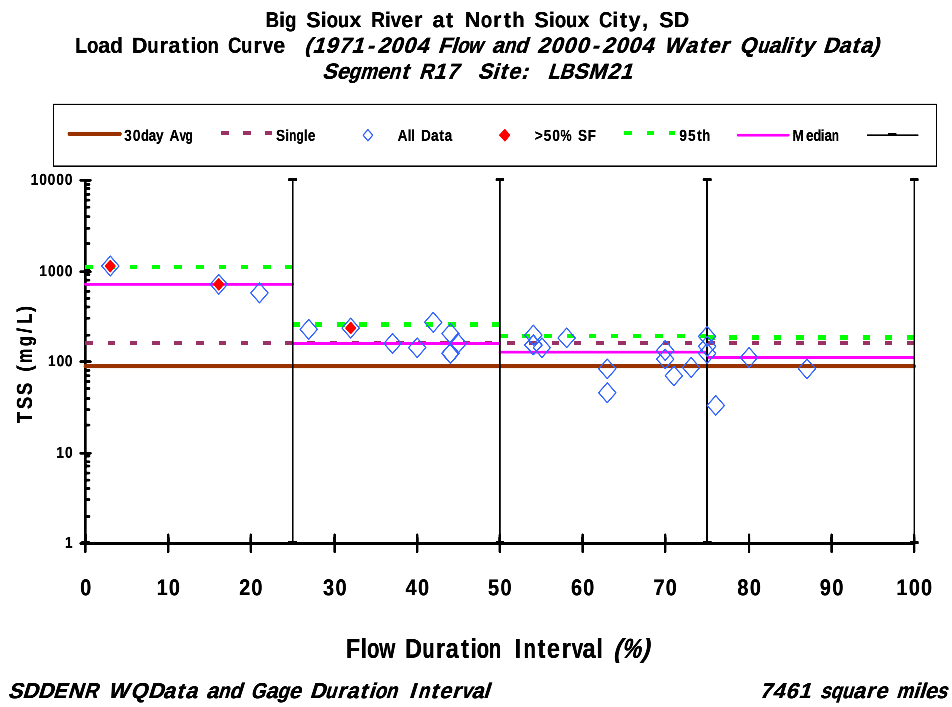

Big Sioux River at Akron, IA
Load Duration Curve (1971-2004 Flow and 2000-2004 Water Quality Data)
Segment R16 Site: LBSM17
Target
All Data
>50% SF
95th
Median
TMDL
WLA
High Flow
Moist
Mid
Dry
TSS (tons/day)
1000000
100000
10000
1000
100
10
1
0.1
0.01
0
10
20
30
40
50
60
70
80
90
100
Flow Duration Interval (%)
SDDENR WQData and USGS Gage Duration Interval
6937 square miles

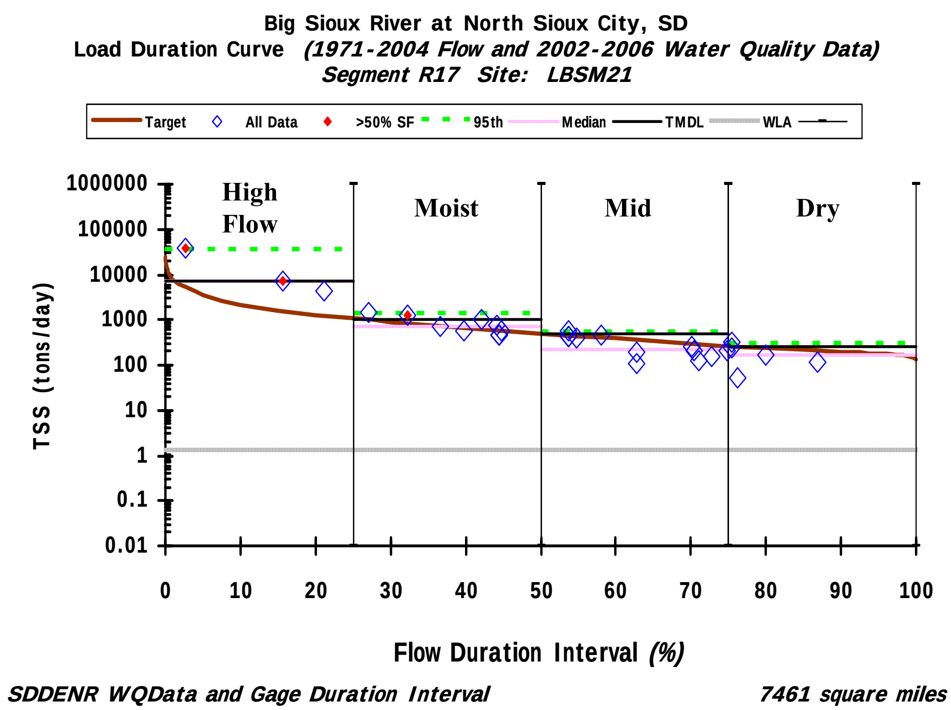

Big Sioux River at Richland, SD
Load Duration Curve (1971-2004 Flow and 2000-2004 Water Quality Data)
Segment R17 Site: LBSM19 and WQM460832
Geo.Mean
Single
All Data
>50% SF
90th
Median
High Flow
Moist
Mid
Dry
TSS (mg/L)
10000
1000
100
10
1
0
10
20
30
40
50
60
70
80
90
100
Flow Duration Interval (%)
SDDENR WQData and Gage Duration Interval
6980 square miles


Big Sioux River at Richland, SD
Load Duration Curve (1971-2004 Flow and 2000-2004 Water Quality Data)
Site: LBSM19 and WQM460832
Target
All Data
May1-Sep30
>50% SF
90th
60th
Median
TSS (tons/day)
1000000
100000
10000
1000
100
10
1
0.1
0.01
0
10
20
30
40
50
60
70
80
90
100
Flow Duration Interval (%)
SDDENR WQData and Gage Duration Interval
6937 square miles


Big Sioux River near Broken Kettle Creek
Load Duration Curve (1971-2004 Flow and 2000-2004 Water Quality Data)
Site: LBSM20
Geo.Mean
Single
All Data
May-Sep
>50% SF
90th
60th
Median
TSS (mg/L)
Flow Duration Interval (%)
SDDENR WQData and Gage Duration Interval
7426 square miles


Big Sioux River near Broken Kettle Creek
Load Duration Curve (1971-2004 Flow and 2000-2004 Water Quality Data)
Site: LBSM20
Target
All Data
May1-Sep30
>50% SF
90th
60th
Median
TSS (tons/day)
Flow Duration Interval (%)
SDDENR WQData and Gage Duration Interval
7426 square miles


Big Sioux River at North Sioux City, SD
Load Duration Curve (1971-2004 Flow and 2000-2004 Water Quality Data)
Segment R17 Site: LBSM21
30day Avg
Single
All Data
>50% SF
95th
Median
10000
1000
100
10
1
TSS (mg/L)
0
10
20
30
40
50
60
70
80
90
100
Flow Duration Interval (%)
SDDENR WQData and Gage Duration Interval
7461 square miles


Big Sioux River at North Sioux City, SD
Load Duration Curve (1971-2004 Flow and 2002-2006 Water Quality Data)
Segment R17 Site: LBSM21
Target
All Data
>50% SF
95th
Median
TMDL
WLA
High Flow
Moist
Mid
Dry
1000000
100000
10000
1000
100
10
1
0.1
0.01
TSS (tons/day)
0
10
20
30
40
50
60
70
80
90
100
Flow Duration Interval (%)
SDDENR WQData and Gage Duration Interval
7461 square miles

17.0 APPENDIX B: Load Allocation and Reduction Tables

Station ID:	LBSM08			
Station name:	Big Sioux River at Fairview, SD			
	Flow Zone (expressed as tons/day)			
TMDL Component	High 0-25% Flow	Moist 25-50% Flow	Mid 50-75% Flow	Dry 75-100% Flow
	1,234 - 35,278 cfs	439 - 1,233 cfs	188 - 438 cfs	0.2 - 187 cfs
95th Percentile Flow Pe	11,141.2	1,157.0	426.2	180.9
LA	4,124.5	384.1	138.7	56.1
WLA	0	0	0	0
MOS	610.7	107.7	42.4	20.8
TMDL	**4,735.2**	**491.8**	**181.1**	**76.9**
Existing Condition				
95th Percentile Load	2,569.4	1,328.0	166.1	65.6
Load Reduction	**-84%**	**63%**	**-9%**	**-17%**
Number of Values	4	5	13	10
* Current Load or existing condition is the 95th percentile of observed TSS loads for each flow zone.				
Runoff with 95th Percentile Flow/Area				
mm/day	2.20	0.23	0.08	0.04
cfs/sqmile	2.33	0.24	0.09	0.04

Station ID:	LBSM09			
Station name:	Big Sioux River at Hudson, SD			
	Flow Zone (expressed as tons/day)			
TMDL Component	High 0-25% Flow	Moist 25-50% Flow	Mid 50-75% Flow	Dry 75-100% Flow
	1,328 - 36,822 cfs	477 - 1,327 cfs	206 - 476 cfs	0.2 - 205 cfs
95th Percentile Flow Pe	11,750.5	1,245.6	463.0	198.1
LA	4,345.7	413.8	150.9	61.5
WLA	0	0	0	0
MOS	648.6	115.6	45.9	22.7
TMDL	**4,994.2**	**529.4**	**196.8**	**84.2**
Existing Condition				
95th Percentile Load	4,812.7	663.4	192.8	74.5
Load Reduction	**-4%**	**20%**	**-2%**	**-13%**
Number of Values	14	22	30	24
* Current Load or existing condition is the 95th percentile of observed TSS loads for each flow zone.				
Runoff with 95th Percentile Flow/Area				
mm/day	2.26	0.24	0.09	0.04
cfs/sqmile	2.39	0.25	0.09	0.04

Station ID:	LBSM13			
Station name:	Big Sioux River @ Hawarden, IA			
	Flow Zone (expressed as tons/day)			
TMDL Component	High 0-25% Flow	Moist 25-50% Flow	Mid 50-75% Flow	Dry 75-100% Flow
	1,697 - 46,772 cfs	634 - 1,696 cfs	208 - 633 cfs	0.2 - 207 cfs
95th Percentile Flow Pe	13,201.7	1,632.5	618.5	198.1
LA	4,997.8	532.7	175.6	35.0
WLA	0.00	0.00	0.00	0.00
MOS	613.2	161.2	87.3	49.1
TMDL	**5,611.0**	**693.8**	**262.9**	**84.2**
Existing Condition				
95th Percentile Load	5,503.4	4,560.2	199.3	78.7
Load Reduction	**-2%**	**85%**	**-32%**	**-7%**
Number of Values	16	25	33	17
* Current Load or existing condition is the 95th percentile of observed TSS loads for each flow zone.				
Runoff with 95th Percentile Flow/Area				
mm/day	1.89	0.23	0.09	0.03
cfs/sqmile	2.00	0.25	0.09	0.03

Station ID:	LBSM17			
Station name:	USGS Gaging Station, Akron, IA			
	Flow Zone (expressed as tons/day)			
TMDL Component	High 0-25% Flow	Moist 25-50% Flow	Mid 50-75% Flow	Dry 75-100% Flow
	1,860 - 50,600 cfs	710 - 1,859 cfs	250 - 709 cfs	4 - 249 cfs
95th Percentile Flow Per Zone	14,300.0	1,790.0	693.6	239.0
LA	5,414.2	586.0	199.9	39.0
WLA	0.531	0.531	0.531	0.531
MOS	663.0	174.3	94.4	62.1
TMDL	**6,077.8**	**760.8**	**294.8**	**101.6**
Existing Condition				
95th Percentile Load	6,756.3	1,518.2	249.8	101.4
Load Reduction	**10%**	**50%**	**-18%**	**0%**
Number of Values	5	12	9	5
* Current Load or existing condition is the 95th percentile of observed TSS loads for each flow zone.				
Runoff with 95th Percentile Flow/Area				
mm/day	1.95	0.24	0.09	0.03
cfs/sqmile	2.06	0.26	0.10	0.03

Station ID:	LBSM19			
Station name:	Big Sioux River Near Richland, SD			
	Flow Zone (expressed as tons/day)			
TMDL Component	High 0-25% Flow	Moist 25-50% Flow	Mid 50-75% Flow	Dry 75-100% Flow
	1,864 - 50,421 cfs	718 - 1,862 cfs	260 - 717 cfs	14 - 259 cfs
95th Percentile Flow Per Zone	14,257.0	1,793.8	702.3	248.6
LA	5,397.5	587.4	203.1	42.4
WLA	1.4	1.4	1.4	1.4
MOS	660.6	173.6	94.0	61.8
TMDL	**6,059.5**	**762.4**	**298.5**	**105.7**
Existing Condition				
95th Percentile Load	9,225.3	1,158.3	231.2	93.7
Load Reduction	**34%**	**34%**	**-29%**	**-13%**
Number of Values	14	24	31	17
* Current Load or existing condition is the 95th percentile of observed TSS loads for each flow zone.				
Runoff with 95th Percentile Flow/Area				
mm/day	1.93	0.24	0.10	0.03
cfs/sqmile	2.04	0.26	0.10	0.04

Station ID:	LBSM20			
Station name:	Lower Big Sioux near Broken Kettle Creek (Iowa Side)			
	Flow Zone (expressed as tons/day)			
TMDL Component	High 0-25% Flow	Moist 25-50% Flow	Mid 50-75% Flow	Dry 75-100% Flow
	2,479 - 59,753 cfs	1,128 - 2,478 c	587 - 1,127 cfs	298 - 586 cfs
95th Percentile Flow Per Zone	17,097.4	2,397.0	1,108.6	574.5
LA	6,486.2	812.6	358.9	169.8
WLA	1.4	1.4	1.4	1.4
MOS	779.1	204.8	110.9	72.9
TMDL*	**7,266.7**	**1,018.8**	**471.2**	**244.2**
*based on 158 mg/L daily max				
Existing Condition				
95th Percentile Load	23,257.6	2,555.6	2,653.8	221.6
Load Reduction	**69%**	**60%**	**82%**	**-10%**
Number of Values	7	9	12	5
* Current Load or existing condition is the 95th percentile of observed TSS loads for each flow zone.				
Runoff with 95th Percentile Flow/Area				
mm/day	2.17	0.30	0.14	0.07
cfs/sqmile	2.30	0.32	0.15	0.08

Station ID:	**LBSM21**			
Station name:	**Big Sioux River at North Sioux City, SD**			
	Flow Zone (expressed as tons/day)			
TMDL Component	High 0-25% Flow	Moist 25-50% Flow	Mid 50-75% Flow	Dry 75-100% Flow
	2,492 - 53,393 cfs	,149 - 2,491 c	612 - 1,148 cfs	325 - 611cfs
95th Percentile Flow Per Zone	17,014.6	2,409.8	1,129.8	599.1
LA	6,456.1	819.4	368.6	180.8
WLA	1.4	1.4	1.4	1.4
MOS	774.1	203.4	110.2	72.4
TMDL*	**7,231.6**	**1,024.2**	**480.2**	**254.6**
*based on 158 mg/L daily max				
Existing Condition				
95th Percentile Load	34,754.1	1,345.5	515.6	300.4
Load Reduction	79%	24%	7%	15%
Number of Values	3	9	12	5
* Current Load or existing condition is the 95th percentile of observed TSS loads for each flow zone.				
Runoff with 95th Percentile Flow/Area				
mm/day	2.15	0.31	0.14	0.08
cfs/sqmile	2.28	0.32	0.15	0.08

18.0 APPENDIX C: Monitoring Sites

See Figures 1, 6, 7, and 8 for maps showing locations of monitoring sites.

Site	Site Description	Latitude	Longitude
460117*	WQM 117 - Big Sioux River Near Sioux Falls WWTF	43.608889	-96.630833
IA01	Little Rock @ Minn/IA Border	43.498019	-95.849159
IA02	Rock River below Rock Rapids, IA	43.400264	-96.148587
IA03	Rock River @ Minn/IA Border	43.498379	-96.18418
IA04	Mud Creek near Minn/IA Border	43.489246	-96.348818
IA05	Mud Creek near Doon, IA	43.284525	-96.257957
IA06	Little Rock River near Doon, IA	43.262559	-96.235777
IA07	Rock River @ Rock Valley, IA (USGS #06483500)	43.21477	-96.291681
IA08	Six Mile Creek (IA)	42.923916	-96.515242
IA09	Indian Creek (IA)	42.889025	-96.516788
IA10	Westfield Creek near Westfield, IA	42.759774	-96.606362
IA11	Broken Kettle Creek near Jefferson, SD	42.625923	-96.513847
IA12*	Mouth of Rock River north of Hawarden, IA (STORETID-0840001)	43.081991	-96.444804
LBSM01*	Big Sioux Rec Area Near Brandon, SD (WQM-31)	43.572653	-96.599963
LBSM03	Big Sioux @ Klondike Dam north of Canton, SD	43.390068	-96.522278
LBSM05*	Big Sioux at Canton, SD (Hiway18) (WQM-65)	43.281454	-96.578248
LBSM08	Big Sioux at Fairview, SD	43.223957	-96.484988
LBSM09*	Big Sioux at Hudson, SD (WQM-66)	43.132857	-96.442806
LBSM13*	Big Sioux at Hawarden, IA (WQM-67)	42.99816	-96.500071
LBSM17	USGS Gaging Station (#06485500) at Akron, IA	42.839198	-96.561918
LBSM19*	Big Sioux at Richland, SD (WQM-32)	42.755252	-96.619593
LBSM20	Big Sioux near Jefferson, SD	42.624974	-96.517003
LBSM21	Big Sioux north Edge of Sioux City	42.556159	-96.47908
LBST02	Lake Alvin Outlet	43.440565	-96.608594
LBST04	Beaver Creek 1mile upstream of Canton, SD	43.316771	-96.608557
LBST06	Beaver Creek 1mile below Canton, SD	43.278968	-96.588102
LBST07	Little Beaver Creek 2 miles South of Canton, SD	43.266985	-96.588966
LBST10	Patte Creek Outlet near Hudson, SD	43.111496	-96.479833
LBST11	Finnie Creek north Alcester, SD	43.054162	-96.50853
LBST12	Green Creek west of Hawarden, IA	43.000708	-96.518491
LBST14	West Brule Creek west of Alcester, SD	43.025997	-96.730325
LBST15	East Brule Creek west of Alcester, SD	43.011363	-96.693501
LBST16	Union Creek Outlet (SD) near Akron, IA	42.837568	-96.586291
LBST18	Brule Creek Outlet near Richland, SD	42.743718	-96.650132

* - Ambient Water Quality Monitoring Station since 1974.

19.0 APPENDIX D: Quality Assurance / Quality Control Samples

Blank Table

StationID	Date	Time	ActivityClass	Fecal_Coliform	E_Coli	Alk	TSS	TSS	VTSS	NH3	Nox	TKN	TP	TDP
LBSM01	9/10/03	12:05:00 PM	BLANK	<10	<1									
LBSM01	9/11/03	11:00:00 AM	BLANK	<10	<1									
LBSM01	9/25/03	2:00:00 PM	BLANK	<10	<1	<6	<7	<1	<1	<0.02	<0.1	<0.11	0.004	<0.002
LBST02	9/10/03	6:30:00 PM	BLANK	<10	<1	<6	<7	<1	<1	<0.02	<0.1	<0.11	<0.002	0.005
LBSM05	8/6/03	10:00:00 AM	BLANK	<10	<1									
LBSM05	8/5/03	9:00:00 AM	BLANK			<6	7	<1	<1	<0.02	<0.1	<0.11	<0.002	0.003
LBST07	9/23/03	8:00:00 AM	BLANK	<10	<1	<6	<7	<1	<1	<0.02	<0.1	<0.11	0.003	0.003
LBSM13	7/30/03	12:00:00 PM	BLANK	<10	<1	<6	10	<1	<1	<0.02	<0.1	<0.11	<0.002	0.002
LBSM13	8/19/03	9:00:00 AM	BLANK	<10	<1	<6	<7	<1	<1	<0.02	<0.1	<0.11	<0.002	<0.002
LBSM01	9/10/03	1:25:00 PM	BLANK			<6	<7	1	<1	<0.02	<0.1	<0.11	0.004	0.006
LBSM03	10/16/03	12:30:00 PM	BLANK	<10	<1	<6	<7	<1	<1	<0.02	<0.1	<0.11	<0.002	<0.002
LBST14	5/20/03	10:00:00 AM	BLANK	<10	<1	<6	115	<1	<1	<0.02	<0.1	<0.11	0.003	0.009
LBST04	10/23/03	3:00:00 PM	BLANK	<10	<1	<6	<7	<1	<1	<0.02	<0.1	<0.11	0.002	0.004
LBST11	7/8/03	1:00:00 PM	BLANK	<10	<1	<6	<7	<1	<1	<0.02	<0.1	<0.11	<0.002	<0.002
LBSM01	5/24/04	12:25:00 PM	BLANK	<10	1	6	13	1	1	0.02	0.1	0.23	0.002	0.002
LBSM01	6/24/03	12:15:00 PM	BLANK			<6	38	<1	<1	<0.02	<0.1	<0.11	0.003	0.007
LBSM19	10/9/02	10:00:00 AM	BLANK	<10	<1	<6	<7	<1	<1	<0.02	<0.1	<0.32	<0.002	0.002
LBSM05	7/11/02	6:00:00 PM	BLANK	<1.0										
LBSM09	5/29/02	4:00:00 PM	BLANK	<10	<1	<6	<6	<1	<1	<0.02	0.1	<0.32	0.002	0.005
LBST07	6/25/02	7:30:00 AM	BLANK	<10	<1	<6	<7	<1	<1	<0.02	<0.1	<0.32	<0.002	0.003
LBST12	4/17/02	4:00:00 PM	BLANK	<2	<1	<6	<6	<1	<1	<0.02	<0.1	<0.32	<0.002	0.005
LBST06	8/15/02	11:30:00 AM	BLANK	<10	<1	<6	<7	<1	<1	<0.02	<0.1	<0.32	<0.002	0.003
LBST04	9/9/02	10:00:00 AM	BLANK	<10	<1	<6	<7	<1	<1	<0.02	<0.1	<0.32	<0.002	0.003
LBST18	8/20/02	9:30:00 AM	BLANK	60	<1	<6	<7	<1	<1	<0.02	<0.1	<0.32	<0.002	0.004
LBST18	4/9/03	6:00:00 PM	BLANK	<2	<1	<6	<7	<1	<1	<0.02	<0.1	<0.11	<0.002	<0.002
LBST16	9/23/02	11:15:00 AM	BLANK	<10	<1	<6	<7	<1	<1	<0.02	<0.1	<0.32	0.002	0.003
LBSM01	9/2/03	1:25:00 PM	BLANK			<7	<7	<1	<1	<0.02	<0.1	<0.11	0.003	0.005
LBSM20	12/10/02	10:00:00 AM	BLANK	<10	<1	<6	<7	<1	<1	<0.02	<0.1	<0.32	0.003	0.003
LBST04	3/26/03	1:00:00 PM	BLANK	<10	1	6	7	1	1	0.02	0.1	0.11	0.002	0.003

StationID	Date	Time	ActivityClass	Fecal_Coliform	E_Coli	Alk	TSS	TSS	VTSS	NH3	Nox	TKN	TP	TDP
LBST11	4/1/03	11:00:00 AM	BLANK	<2	<1	<6	<7	<1	<1	<0.02	<0.1	<0.11	<0.002	<0.002
LBST11	4/30/03	11:00:00 AM	BLANK	<10	<1	<6	9	<1	<1	<0.02	<0.1	<0.11	0.008	0.012
LBSM01	9/2/03	1:25:00 PM	BLANK	<10	<1									
LBST16	3/25/03	2:00:00 PM	BLANK	<2	<1	<6	48	<1	<1	<0.02	<0.1	<0.11	>0.002	0.002
LBST02	4/4/04	9:30:00 AM	BLANK	10	1	6	7	1	1	0.02	0.1	0.23	0.002	0.004
LBSM19	8/6/02	12:00:00 PM	BLANK	<10	<1	<6	<7	<1	<1	<0.02	<0.1	<0.32	0.005	0.009

Duplicate Sampling Data:

StationID	ActivityID	StartDate	StartTime	ActivityClass	ALK	TS	TDS	TSS	VTSS	NH3	NO3	TKN	TP	TDP	Fecal	Ecoli
LBSM01	E03EC002403	4/21/2003	2:05:00 PM	DUPLICATE	252	862	730	132	24	0.02	2	1.58	0.562	0.264		
LBSM01	E03EC002402	4/21/03	2:15:00 PM	INTEGRATED FLOW	253	856	700	156	24	0.07	2	1.31	0.555	0.262		
				Percent Difference	**0.20%**	**0.35%**	**2.10%**	**8.33%**	**0.00%**	**55.56%**	**0.00%**	**9.34%**	**0.63%**	**0.38%**		
LBSM01	E03EC007000	9/2/2003	1:40:00 PM	DUPLICATE	152	962	941	21	9	0.02	15.9	1.11	3.04	2.81		13.2
LBSM01	E03EC007004	9/2/03	1:30:00 PM	INTEGRATED FLOW	150	973	953	20	7	0.02	15.7	1.3	2.95	2.74	50	15.6
				Percent Difference	**0.66%**	**0.57%**	**0.63%**	**2.44%**	**12.50%**	**0.00%**	**0.63%**	**7.88%**	**1.50%**	**1.26%**		**8.33%**
LBSM01	E03EC007249	9/10/2003	1:40:00 PM	DUPLICATE	97	605	157	448	60	0.37	1.1	0.74	1.03	0.292	39000	
LBSM01	E03EC007246	9/10/03	1:30:00 PM	INTEGRATED FLOW	96	614	150	464	52	0.36	1.2	0.79	1.02	0.292	35000	
				Percent Difference	**0.52%**	**0.74%**	**2.28%**	**1.75%**	**7.14%**	**1.37%**	**4.35%**	**3.27%**	**0.49%**	**0.00%**	**5.41%**	
LBSM01	E03EC007585	9/23/2003	8:00:00 AM	DUPLICATE	176	830	812	18	10	0.02	10.9	1.2	1.79	1.62	110	44.1
LBSM01	E03EC007584	9/23/03	8:00:00 AM	INTEGRATED FLOW	177	829	808	21	12	0.02	11.1	1.81	1.8	1.62	130	56.5
				Percent Difference	**0.28%**	**0.06%**	**0.25%**	**7.69%**	**9.09%**	**0.00%**	**0.91%**	**20.27%**	**0.28%**	**0.00%**	**8.33%**	**12.33%**
LBSM01	E03EC009364	12/1/2003	4:15:00 PM	DUPLICATE	197	1132	1115	17	7	0.02	15.2	1.02	2.5	2.1	60	166
LBSM01	E03EC009362	12/1/03	4:05:00 PM	INTEGRATED FLOW	195	803	783	20	5	0.02	15.5	0.96	2.48	2.5	50	148
				Percent Difference	**0.51%**	**17.00%**	**17.49%**	**8.11%**	**16.67%**	**0.00%**	**0.98%**	**3.03%**	**0.40%**	**8.70%**	**9.09%**	**5.73%**
LBSM03	E02EC009126	12/10/2002	8:00:00 AM	DUPLICATE	289	811	793	18	7	0.02	6.9	1.38	0.814	0.528	20	15
LBSM03	E02EC009127	12/10/02	8:00:00 AM	GRAB	289	832	812	20	7	0.02	6.9	1.43	0.821	0.517	70	33
				Percent Difference	**0.00%**	**1.28%**	**1.18%**	**5.26%**	**0.00%**	**0.00%**	**0.00%**	**1.78%**	**0.43%**	**1.05%**	**55.56%**	**37.50%**
LBSM03	E03EC008243	10/16/2003	12:00:00 PM	DUPLICATE	202	735	682	53	20	0.02	6.5	2.18	1.15	0.623		9.6
LBSM03	E03EC008244	10/16/03	12:00:00 PM	INTEGRATED	203	732	684	48	20	0.02	6.5	1.88	1.18	0.622		17.3

				FLOW												
				Percent Difference	**0.25%**	**0.20%**	**0.15%**	**4.95%**	**0.00%**	**0.00%**	**0.00%**	**7.39%**	**1.29%**	**0.08%**		**28.62%**
LBSM03	E04EC003635	6/14/2004	12:15:00 PM	DUPLICATE	249	790	624	166	22	0.02	2.5	1.95	0.48	0.189	1700	921
LBSM03	E04EC003634	6/14/04	12:00:00 PM	INTEGRATED FLOW	249	769	605	164	18	0.02	2.5	1.91	0.461	0.195	1300	1990
				Percent Difference	**0.00%**	**1.35%**	**1.55%**	**0.61%**	**10.00%**	**0.00%**	**0.00%**	**1.04%**	**2.02%**	**1.56%**	**13.33%**	**36.72%**
LBSM05	E02EC007031	9/24/2002	6:00:00 PM	DUPLICATE	187	729	649	80	42	0.02	3.6	2.83	0.838			4.1
LBSM05	E02EC007030	9/24/02	3:00:00 PM	INTEGRATED FLOW	210	738	656	82	44	0.02	3.6	2.65	0.831		40	2
				Percent Difference	**5.79%**	**0.61%**	**0.54%**	**1.23%**	**2.33%**	**0.00%**	**0.00%**	**3.28%**	**0.42%**		**100.00%**	**34.43%**
LBSM05	E03EC006135	8/5/2003	9:00:00 AM	DUPLICATE	122	690	604	86	36	0.02	2.2	1.76	0.37	0.031		
LBSM05	E03EC006031	8/5/03	9:00:00 AM	INTEGRATED FLOW	120	697	626	71	24	0.02	2.2	1.62	0.372	0.028	800	55.5
				Percent Difference	**0.83%**	**0.50%**	**1.79%**	**9.55%**	**20.00%**	**0.00%**	**0.00%**	**4.14%**	**0.27%**	**5.08%**	**100.00%**	**100.00%**
LBSM08	E04EC002600	5/11/2004	8:00:00 PM	DUPLICATE	125	758	626	132	34	0.02	1.1	3.13	0.399	0.017		7.4
LBSM08	E04EC002599	5/11/04	8:00:00 PM	INTEGRATED FLOW	119	750	620	130	38	0.02	1.1	3.21	0.406	0.017	10	11.9
				Percent Difference	**2.46%**	**0.53%**	**0.48%**	**0.76%**	**5.56%**	**0.00%**	**0.00%**	**1.26%**	**0.87%**	**0.00%**	**100.00%**	**23.32%**
LBSM09	E02EC005820	8/22/2002	8:30:00 AM	DUPLICATE	368	1255	-55	1310	200	0.22	2.3	0.88	2.06	0.196	20000	
LBSM09	E02EC005819	8/22/02	8:30:00 AM	INTEGRATED FLOW	312	1428	476	952	136	0.31	2.6	1.32	1.92	0.209	21000	
				Percent Difference	**8.24%**	**6.45%**	**126.13%**	**15.83%**	**19.05%**	**16.98%**	**6.12%**	**20.00%**	**3.52%**	**3.21%**	**2.44%**	
LBSM09	E03EC006550	8/19/2003	11:30:00 AM	DUPLICATE	105	821	727	94	36	0.02	0.7	1.98	0.255	0.017	20	
LBSM09	E03Ec006549	8/19/03	11:30:00 AM	INTEGRATED FLOW	107	809	719	90	38	0.02	0.7	1.9	0.332	0.015	10	2
				Percent Difference	**0.94%**	**0.74%**	**0.55%**	**2.17%**	**2.70%**	**0.00%**	**0.00%**	**2.06%**	**13.12%**	**6.25%**	**33.33%**	**100.00%**
LBSM13	E03EC005075	7/8/2003	5:00:00 PM	DUPLICATE	157	1575	325	1250	170	0.14	2.2	1.29	1.97	0.179	160000	
LBSM13	E03EC005074	7/8/03	5:00:00 PM	INTEGRATED FLOW	151	1485	325	1160	200	0.09	2.1	1.07	1.83	0.177	31000	
				Percent Difference	**1.95%**	**2.94%**	**0.00%**	**3.73%**	**8.11%**	**21.74%**	**2.33%**	**9.32%**	**3.68%**	**0.56%**	**67.54%**	
LBSM13	E04EC004117	6/28/2004	8:15:00 AM	DUPLICATE	203	799	659	140	20	0.02	5.7	1.56	0.297	0.072	180	131
LBSM13	E04EC004118	6/28/04	8:00:00 AM	INTEGRATED FLOW	255	774	632	142	20	0.02	5.7	1.55	0.306	0.015	130	133
				Percent Difference	**11.35%**	**1.59%**	**2.09%**	**0.71%**	**0.00%**	**0.00%**	**0.00%**	**0.32%**	**1.49%**	**65.52%**	**16.13%**	**0.76%**
LBSM17	E02EC003917	6/27/2002	1:00:00 PM	DUPLICATE	225	801	587	214	36	0.02	3.5	0.91	0.46	0.051	370	275
LBSM17	E02EC003921	6/27/02	1:00:00 PM	INTEGRATED FLOW	217	774	554	220	44	0.02	3.5	1.88	0.463	0.042	500	416
				Percent Difference	**1.81%**	**1.71%**	**2.89%**	**1.38%**	**10.00%**	**0.00%**	**0.00%**	**34.77%**	**0.33%**	**9.68%**	**14.94%**	**20.41%**
LBSM20	E04EC001734	4/7/2004	10:30:00 AM	DUPLICATE	242	795	627	168	26	0.02	4.1	1.68	0.374	0.05	40	44.1

LBSM20	E04EC001733	4/7/04	10:00:00 AM	INTEGRATED FLOW	237	790	624	166	22	0.02	4	1.61	0.362	0.05	40	62.4
				Percent Difference	**1.04%**	**0.32%**	**0.24%**	**0.60%**	**8.33%**	**0.00%**	**1.23%**	**2.13%**	**1.63%**	**0.00%**	**0.00%**	**17.18%**
LBSM21	E02EC007661	10/8/2002	2:00:00 PM	DUPLICATE	219	781	655	126	36	0.02	2.3	2.13	0.678	0.138	540	548
LBSM21	E02EC007662	10/8/02	2:00:00 PM	INTEGRATED FLOW	220	778	652	126	38	0.02	2.3	2.12	0.677	0.136	560	727
				Percent Difference	**0.23%**	**0.19%**	**0.23%**	**0.00%**	**2.70%**	**0.00%**	**0.00%**	**0.24%**	**0.07%**	**0.73%**	**1.82%**	**14.04%**
LBST02	E02EC004604	7/18/2002	10:00:00 AM	DUPLICATE	99	1357	1283	74	30	0.23	0.1	1.51	0.195	0.026	100	18.9
LBST02	E02EC004603	7/18/02	10:00:00 AM	GRAB	97	1361	1308	53	16	0.23	0.1	1.3	0.199	0.024	400	11.6
				Percent Difference	**1.02%**	**0.15%**	**0.96%**	**16.54%**	**30.43%**	**0.00%**	**0.00%**	**7.47%**	**1.02%**	**4.00%**	**60.00%**	**23.93%**
LBST02	E02EC007870	10/14/2002	2:30:00 PM	DUPLICATE	137	1133	1112	21	10	0.02	0.1	1.05	0.271	0.142		
LBST02	E02EC007869	10/14/02	2:30:00 PM	GRAB	136	1138	1115	23	9	0.02	0.1	1.15	0.271	0.138		
				Percent Difference	**0.37%**	**0.22%**	**0.13%**	**4.55%**	**5.26%**	**0.00%**	**0.00%**	**4.55%**	**0.00%**	**1.43%**		
LBST02	E04EC001617	4/4/2004	9:15:00 AM	DUPLICATE	162	1191	1165	26	11	0.02	0.9	1.79	0.204	0.076	10	5.2
LBST02	E04EC001615	4/4/04	9:00:00 AM	GRAB	162	1188	1163	25	12	0.02	0.9	1.79	0.21	0.078	10	1
				Percent Difference	**0.00%**	**0.13%**	**0.09%**	**1.96%**	**4.35%**	**0.00%**	**0.00%**	**0.00%**	**1.45%**	**1.30%**	**0.00%**	**67.74%**
LBST02	E04EC003346	6/4/2004	11:30:00 AM	DUPLICATE	103	591	570	21	6	0.24	4.5	1.6	0.238	0.164	180	157
LBST02	E04EC003348	6/4/04	11:00:00 AM	GRAB	103	602	578	24	7	0.24	4.5	1.74	0.231	0.162	130	138
				Percent Difference	**0.00%**	**0.92%**	**0.70%**	**6.67%**	**7.69%**	**0.00%**	**0.00%**	**4.19%**	**1.49%**	**0.61%**	**16.13%**	**6.44%**
LBST02	E04EC004167	6/29/2004	7:15:00 PM	DUPLICATE	135	805	705	100	21	0.02	1.9	1.2	0.104	0.007	20	11.8
LBST02	E03E004167	6/29/04	7:15:00 PM	GRAB	135	805	705	100	21	0.02	1.9	1.2	0.104	0.007	20	11.8
				Percent Difference	**0.00%**	**0.00%**	**0.00%**	**0.00%**	**0.00%**	**0.00%**	**0.00%**	**0.00%**	**0.00%**	**0.00%**	**0.00%**	**0.00%**
LBST06	E03EC001555	3/26/2003	12:00:00 PM	DUPLICATE	283	2089	2081	8	1	0.02	0.1	0.41	0.07	0.03	2	3.1
LBST06	E03EC001556	3/26/03	12:00:00 PM	GRAB	285	2087	2080	7	2	0.02	0.2	0.37	0.066	0.03	2	2
				Percent Difference	**0.35%**	**0.05%**	**0.02%**	**6.67%**	**33.33%**	**0.00%**	**33.33%**	**5.13%**	**2.94%**	**0.00%**	**0.00%**	**21.57%**
LBST07	E02EC002296	5/3/2002	8:30:00 AM	DUPLICATE	323	2043	2038	5	1	0.02	2	0.32	0.023	0.014		
LBST07	E02EC002295	5/3/02	8:30:00 AM	GRAB	324	2042	2036	6	1	0.02	2	0.32	0.024	0.015		
				Percent Difference	**0.15%**	**0.02%**	**0.05%**	**9.09%**	**0.00%**	**0.00%**	**0.00%**	**0.00%**	**2.13%**	**3.45%**		
LBST07	E02EC002874	5/30/2002	9:30:00 AM	DUPLICATE	323	2080	2064	16	4	0.02	1.9	0.32	0.066	0.049	120	291
LBST07	E02EC002873	5/30/02	9:30:00 AM	GRAB	322	2084	2069	15	4	0.02	1.9	0.32	0.081	0.044	120	135
				Percent Difference	**0.16%**	**0.10%**	**0.12%**	**3.23%**	**0.00%**	**0.00%**	**0.00%**	**0.00%**	**10.20%**	**5.38%**	**0.00%**	**36.62%**
LBST07	E02EC005504	8/15/2002	12:30:00 PM	DUPLICATE	299	2061	2052	9	3	0.02	2.1	0.33	0.056	0.048	450	770
LBST07	E02EC005505	8/15/02	12:30:00 PM	GRAB	296	2058	2049	9	5	0.02	2.1	0.32	0.055		480	1050
				Percent Difference	**0.50%**	**0.07%**	**0.07%**	**0.00%**	**25.00%**	**0.00%**	**0.00%**	**1.54%**	**0.90%**	**100.00%**	**3.23%**	**15.38%**

LBST07	E03EC001974	4/10/2003	9:00:00 AM	DUPLICATE	335	1074	1067	7	1	0.02	1.7	0.45	0.033	0.018	14	18.3
LBST07	E03EC001975	4/10/2003	9:00:00 AM	GRAB	331	2079	2073	6	1	0.02	1.7	0.45	0.033	0.018	6	18.3
				Percent Difference	**0.60%**	**31.87%**	**32.04%**	**7.69%**	**0.00%**	**0.00%**	**0.00%**	**0.00%**	**0.00%**	**0.00%**	**40.00%**	**0.00%**
LBST07	E03EC005949	7/29/2003	11:00:00 AM	DUPLICATE	295	2032	2020	12	9	0.02	2.6	0.45	0.039	0.027		
LBST07	E03EC005945	7/29/03	11:00:00 AM	GRAB	305	2032	2016	16	8	0.02	2.6	0.41	0.04	0.024		
				Percent Difference	**1.67%**	**0.00%**	**0.10%**	**14.29%**	**5.88%**	**0.00%**	**0.00%**	**4.65%**	**1.27%**	**5.88%**		
LBST07	E04EC002337	5/3/2004	4:30:00 PM	DUPLICATE	324	2044	2037	7	2	0.02	2.6	0.23	0.029	0.02	60	27.8
LBST07	E04EC002338	5/3/04	12:00:00 PM	GRAB	330	2054	2048	6	2	0.02	2.6	0.23	0.029	0.021	10	19.7
				Percent Difference	**0.92%**	**0.24%**	**0.27%**	**7.69%**	**0.00%**	**0.00%**	**0.00%**	**0.00%**	**0.00%**	**2.44%**	**71.43%**	**17.05%**
LBST10	E03EC003313	5/21/2003	11:00:00 AM	DUPLICATE	329	810	761	49	7	0.02	1.7	0.19	0.068	0.029	80	98.5
LBST10	E03EC003309	5/21/03	11:00:00 AM	GRAB	325	803	749	54	9	0.02	1.7	0.35	0.14	0.031	50	147
				Percent Difference	**0.61%**	**0.43%**	**0.79%**	**4.85%**	**12.50%**	**0.00%**	**0.00%**	**29.63%**	**34.62%**	**3.33%**	**23.08%**	**19.76%**
LBST10	E03EC008307	10/20/2003	10:15:00 AM	DUPLICATE	317	812	802	10	2	0.02	1.5	0.18	0.044	0.016	90	88.4
LBST10	E03EC008302	10/20/03	10:15:00 AM	GRAB	321	807	797	10	2	0.02	1.5	0.14	0.045	0.033	70	118
				Percent Difference	**0.63%**	**0.31%**	**0.31%**	**0.00%**	**0.00%**	**0.00%**	**0.00%**	**12.50%**	**1.12%**	**34.69%**	**12.50%**	**14.34%**
LBST11	E02EC001987	4/18/2002	8:45:00 AM	DUPLICATE	320	897	882	15	4	0.02	1.2	0.32	0.226	0.168	100	48
LBST11	E02EC001986	4/18/02	8:45:00 AM	GRAB	318	889	870	19	4	0.02	1.1	0.32	0.225	0.166	50	37.3
				Percent Difference	**0.31%**	**0.45%**	**0.68%**	**11.76%**	**0.00%**	**0.00%**	**4.35%**	**0.00%**	**0.22%**	**0.60%**	**33.33%**	**12.54%**
LBST11	E03EC007589	9/23/2003	9:35:00 AM	DUPLICATE	335	942	915	27	8	0.02	1.5	0.11	0.563	0.449	6900	
LBST11	E03EC007588	9/23/03	9:35:00 AM	GRAB	334	951	919	32	8	0.02	1.5	0.24	0.56	0.446	6800	
				Percent Difference	**0.15%**	**0.48%**	**0.22%**	**8.47%**	**0.00%**	**0.00%**	**0.00%**	**37.14%**	**0.27%**	**0.34%**	**0.73%**	
LBST12	E03EC001606	4/1/2003	8:00:00 AM	DUPLICATE	350	1001	994	7	2	0.02	3.5	0.49	0.094	0.071	6	19.7
LBST12	E03EC001604	4/1/03	10:00:00 AM	GRAB	346	996	989	7	3	0.02	3.4	0.47	0.098	0.074	8	26.2
				Percent Difference	**0.57%**	**0.25%**	**0.25%**	**0.00%**	**20.00%**	**0.00%**	**1.45%**	**2.08%**	**2.08%**	**2.07%**	**14.29%**	**14.16%**
LBST12	E03EC002592	4/30/2003	10:00:00 AM	DUPLICATE	308	903	830	73	14	0.19	2.7	2.3	0.395	0.207	70000	
LBST12	E03EC002591	4/30/03	10:00:00 AM	GRAB	308	885	807	78	11	0.18	2.7	2.28	0.37	0.184	81000	
				Percent Difference	**0.00%**	**1.01%**	**1.41%**	**3.31%**	**12.00%**	**2.70%**	**0.00%**	**0.44%**	**3.27%**	**5.88%**	**7.28%**	
LBST12	E03EC004083	6/11/2003	12:00:00 PM	DUPLICATE	370	1000	983	17	5	0.02	4.4	0.66	0.203	0.169	3200	411
LBST12	E03EC004082	6/11/03	12:00:00 PM	GRAB	373	1008	989	19	7	0.02	4.4	0.68	0.206	0.176	200	387
				Percent Difference	**0.40%**	**0.40%**	**0.30%**	**5.56%**	**16.67%**	**0.00%**	**0.00%**	**1.49%**	**0.73%**	**2.03%**	**88.24%**	**3.01%**
LBST12	E04EC003801	6/16/2004	8:15:00 PM	DUPLICATE	248	1358	578	780	150	0.21	5.4	3.44	1.31	0.177	21000	

LBST12	E04EC003802	6/16/04	8:00:00 PM	GRAB	248	1370	590	780	120	0.2	5.5	3.62	1.38	0.18	32000	2420
				Percent Difference	**0.00%**	**0.44%**	**1.03%**	**0.00%**	**11.11%**	**2.44%**	**0.92%**	**2.55%**	**2.60%**	**0.84%**	**20.75%**	**100.00%**
LBST14	E02EC004002	7/2/2002	8:30:00 AM	DUPLICATE	354	465	439	26	6	0.02	0.9	0.32	0.076	0.033	770	1120
LBST14	E02EC004001	7/2/02	8:30:00 AM	GRAB	356	1458	1433	25	5	0.02	0.8	0.32	0.074	0.031	870	1410
				Percent Difference	**0.28%**	**51.64%**	**53.10%**	**1.96%**	**9.09%**	**0.00%**	**5.88%**	**0.00%**	**1.33%**	**3.13%**	**6.10%**	**11.46%**
LBST14	E03EC003219	5/20/2003	10:30:00 AM	DUPLICATE	344	978	954	24	1	0.02	4.3	0.12	0.083	0.03	110	130
LBST14	E03EC003218	5/20/03	10:00:00 AM	GRAB	344	977	951	26	1	0.02	4.3	0.18	0.079	0.029	220	228
				Percent Difference	**0.00%**	**0.05%**	**0.16%**	**4.00%**	**0.00%**	**0.00%**	**0.00%**	**20.00%**	**2.47%**	**1.69%**	**33.33%**	**27.37%**
LBST15	E03EC002100	4/15/2003	11:00:00 AM	DUPLICATE	353	880	745	135	15	0.15	3.5	0.37	0.336	0.117	610	328
LBST15	E03EC002099	4/15/03	11:00:00 AM	GRAB	351	876	754	122	16	0.14	3.4	0.44	0.323	0.113	600	313
				Percent Difference	**0.28%**	**0.23%**	**0.60%**	**5.06%**	**3.23%**	**3.45%**	**1.45%**	**8.64%**	**1.97%**	**1.74%**	**0.83%**	**2.34%**
LBST15	E03EC002154	4/16/2003	12:00:00 PM	DUPLICATE	332	846	736	110	13	0.12	2.6	0.61	0.288	0.116	410	1046
LBST15	E03EC002153	4/16/03	12:00:00 PM	GRAB	337	849	738	111	16	0.13	2.7	0.83	0.309	0.105	600	866
				Percent Difference	**0.75%**	**0.18%**	**0.14%**	**0.45%**	**10.34%**	**4.00%**	**1.89%**	**15.28%**	**3.52%**	**4.98%**	**18.81%**	**9.41%**
LBST15	E03EC004718	6/26/2003	10:00:00 AM	DUPLICATE	279	735	693	42	9	0.02	7	1.7	0.414	0.332	7800	
LBST15	E03EC004717	6/26/03	10:00:00 AM	GRAB	277	744	704	40	10	0.02	7	1.53	0.407	0.33	9700	
				Percent Difference	**0.36%**	**0.61%**	**0.79%**	**2.44%**	**5.26%**	**0.00%**	**0.00%**	**5.26%**	**0.85%**	**0.30%**	**10.86%**	
LBST16	E02EC005624	8/20/2002	11:30:00 AM	DUPLICATE	358	692	637	55	9	0.02	4.5	0.52	0.34	0.223	11000	
LBST16	E02EC005623	8/20/02	11:30:00 AM	GRAB	356	689	633	56	10	0.02	4.5	0.59	0.332	0.233	12000	
				Percent Difference	**0.28%**	**0.22%**	**0.31%**	**0.90%**	**5.26%**	**0.00%**	**0.00%**	**6.31%**	**1.19%**	**2.19%**	**4.35%**	
LBST18	E02EC006940	9/23/2002	8:30:00 AM	DUPLICATE	221	755	738	17	5	0.02	0.2	0.32	0.061	0.022	210	82.6
LBST18	E02EC006939	9/23/02	8:30:00 AM	GRAB	220	750	730	20	5	0.02	0.2	0.32	0.062	0.023	130	79.5
				Percent Difference	**0.23%**	**0.33%**	**0.54%**	**8.11%**	**0.00%**	**0.00%**	**0.00%**	**0.00%**	**0.81%**	**2.22%**	**23.53%**	**1.91%**
LBST18	E03EC001505	3/25/2003	3:00:00 PM	DUPLICATE	328	827	786	41	7	0.03	2	0.76	0.171	0.094	2	1
LBST18	E03EC001504	3/25/03	3:00:00 PM	GRAB	334	821	780	41	8	0.02	2	0.69	0.161	0.094		4.1
				Percent Difference	**0.91%**	**0.36%**	**0.38%**	**0.00%**	**6.67%**	**20.00%**	**0.00%**	**4.83%**	**3.01%**	**0.00%**	**100.00%**	**60.78%**
LBST18	E03EC006937	9/1/2003	3:15:00 PM	DUPLICATE	216	817	784	33	9	0.02	0.1	0.27	0.079	0.03		
LBST18	E03EC006936	9/1/03	3:00:00 PM	GRAB	220	824	788	36	6	0.02	0.1	0.36	0.084	0.03		
				Percent Difference	**0.92%**	**0.43%**	**0.25%**	**4.35%**	**20.00%**	**0.00%**	**0.00%**	**14.29%**	**3.07%**	**0.00%**		
LBST18	E03WB012225	9/2/2003	7:15:00 AM	DUPLICATE											330	32
LBST18	E03WB012224	9/2/03	7:15:00 AM	GRAB											300	31.2

				Percent Difference											**4.76%**	**1.27%**
LBST18	E03EC007193	9/10/2003	8:00:00 AM	DUPLICATE	199	901	589	312	40	0.02	0.4	0.56	0.459	0.061	5800	2420
LBST18	E03EC007192	9/10/03	8:00:00 AM	GRAB	192	897	613	284	28	0.02	0.4	0.47	0.461	0.062	6000	
				Percent Difference	**1.79%**	**0.22%**	**2.00%**	**4.70%**	**17.65%**	**0.00%**	**0.00%**	**8.74%**	**0.22%**	**0.81%**	**1.69%**	**100.00%**
LBST18	E04EC005816	8/17/2004	4:45:00 PM	DUPLICATE	230	764	720	44	5	0.02	1.6	0.32	0.093	0.03	290	95.8
LBST18	E04EC005815	8/17/04	4:30:00 PM	INTEGRATED FLOW	232	757	713	44	5	0.02	1.6	0.28	0.09	0.028	110	74.8
				Percent Difference	**0.43%**	**0.46%**	**0.49%**	**0.00%**	**0.00%**	**0.00%**	**0.00%**	**6.67%**	**1.64%**	**3.45%**	**45.00%**	**12.31%**

20.0 APPENDIX E: Stage/Discharge Calculations and Graphs for all Sites.

Because of the large volume of information, this data is available upon request from the SD Department of Environment and Natural Resources.

21.0 APPENDIX F: Sediment Loading output with Discharge and TSS information from Each monitoring Sites.

Because of the large volume of information, this data is available upon request from the SD Department of Environment and Natural Resources.

22.0 APPENDIX G: Mass Balance Calculations and Supplementary Loading Information

Because of the large volume of information, this data is available upon request from the SD Department of Environment and Natural Resources.

23.0 APPENDIX H: FLUX Loading Setup for Lower Big Sioux River Mainstem Sites.

```
 Site LBSM01 Lower Big Sioux            VAR=TSS       METHOD= 2 Q WTD C
 COMPARISON OF SAMPLED AND TOTAL FLOW DISTRIBUTIONS
 STR       NQ  NC  NE  VOL%   TOTAL FLOW SAMPLED FLOW   C/Q SLOPE SIGNIF
  1       462  26  21  10.3       66.365       60.423        .789   .001
  2       507  34  27  44.7      263.465      276.312        .768   .010
  3       126  11   9  45.1     1069.176      914.726        .026   .971
***      1095  71  57 100.0      273.017      296.163

 FLOW STATISTICS
 FLOW DURATION =    1095.0 DAYS  =  2.998 YEARS
 MEAN FLOW RATE =   273.017 HM3/YR
 TOTAL FLOW VOLUME =     818.49 HM3
 FLOW DATE RANGE   = 20011001 TO 20040929
 SAMPLE DATE RANGE = 20011017 TO 20040901

 METHOD         MASS (KG)   FLUX (KG/YR)  FLUX VARIANCE CONC (PPB)      CV
 1 AV LOAD    112928400.0     37668570.0      .4848E+14  137971.50    .185
 2 Q WTD C    123910900.0     41331910.0      .5014E+14  151389.50    .171
 3 IJC        124046500.0     41377140.0      .4781E+14  151555.20    .167
 4 REG-1      123273500.0     41119320.0      .6751E+14  150610.90    .200
 5 REG-2      122302000.0     40795270.0      .9509E+14  149424.00    .239
 6 REG-3      127671700.0     42586370.0      .8903E+14  155984.30    .222
```

```
Site LBSM03 Lower Big Sioux            VAR=TSS       METHOD= 2 Q WTD C
 COMPARISON OF SAMPLED AND TOTAL FLOW DISTRIBUTIONS
 STR       NQ  NC  NE  VOL%   TOTAL FLOW SAMPLED FLOW   C/Q SLOPE SIGNIF
  1       781  19  16  34.3      187.177      156.359        .073   .815
  2       314   9   7  65.7      893.363      936.363        .348   .395
***      1095  28  23 100.0      389.681      407.074

 FLOW STATISTICS
 FLOW DURATION =    1095.0 DAYS  =  2.998 YEARS
 MEAN FLOW RATE =   389.681 HM3/YR
 TOTAL FLOW VOLUME =    1168.24 HM3
 FLOW DATE RANGE   = 20011001 TO 20040929
 SAMPLE DATE RANGE = 20020910 TO 20040628

 METHOD         MASS (KG)   FLUX (KG/YR)  FLUX VARIANCE CONC (PPB)      CV
 1 AV LOAD    156122400.0     52076460.0      .1105E+15  133638.60    .202
 2 Q WTD C    154290300.0     51465320.0      .1965E+14  132070.30    .086
 3 IJC        155067200.0     51724480.0      .1941E+14  132735.30    .085
 4 REG-1      152560600.0     50888380.0      .3732E+14  130589.70    .120
 5 REG-2      168794800.0     56303490.0      .7007E+14  144486.00    .149
 6 REG-3      158633100.0     52913910.0      .4799E+14  135787.60    .131
```

```
Site LBSM05 Lower Big Sioux           VAR=TSS       METHOD= 2 Q WTD C
 COMPARISON OF SAMPLED AND TOTAL FLOW DISTRIBUTIONS
 STR       NQ  NC  NE  VOL%   TOTAL FLOW SAMPLED FLOW   C/Q SLOPE SIGNIF
  1       781  47  44  35.9      207.560      203.785        .636   .094
  2       314  20  19  64.1      923.351      829.605        .493   .134
***      1095  67  63 100.0      412.819      390.597

 FLOW STATISTICS
 FLOW DURATION =    1095.0 DAYS  =  2.998 YEARS
 MEAN FLOW RATE =   412.819 HM3/YR
 TOTAL FLOW VOLUME =    1237.61 HM3
 FLOW DATE RANGE   = 20011001 TO 20040929
 SAMPLE DATE RANGE = 20011016 TO 20040901

Site LBSM01 Lower Big Sioux           VAR=TSS       METHOD= 2 Q WTD C
 1 AV LOAD    150330900.0     50144640.0      .4573E+14  121468.90    .135
 2 Q WTD C    163828100.0     54646760.0      .2283E+14  132374.80    .087
 3 IJC        164368400.0     54827010.0      .2322E+14  132811.40    .088
 4 REG-1      171102600.0     57073260.0      .2690E+14  138252.60    .091
 5 REG-2      194334800.0     64822650.0      .9052E+14  157024.50    .147
 6 REG-3      192658900.0     64263640.0      .3518E+14  155670.40    .092
```

```
Site LBSM08 Lower Big Sioux           VAR=TSS       METHOD= 2 Q WTD C
 COMPARISON OF SAMPLED AND TOTAL FLOW DISTRIBUTIONS
 STR       NQ  NC  NE  VOL%   TOTAL FLOW SAMPLED FLOW   C/Q SLOPE SIGNIF
  1       781  24  20  36.3      238.332      213.016        .644   .009
  2       314   8   8  63.7     1040.923     1067.116        .085   .890
***      1095  32  28 100.0      468.482      426.541

 FLOW STATISTICS
 FLOW DURATION =    1095.0 DAYS  =  2.998 YEARS
 MEAN FLOW RATE =   468.482 HM3/YR
 TOTAL FLOW VOLUME =    1404.48 HM3
 FLOW DATE RANGE   = 20011001 TO 20040929
 SAMPLE DATE RANGE = 20020619 TO 20040628

 METHOD         MASS (KG)   FLUX (KG/YR)  FLUX VARIANCE CONC (PPB)      CV
 1 AV LOAD    370521800.0    123591900.0      .8061E+15  263813.70    .230
 2 Q WTD C    369782500.0    123345300.0      .4196E+15  263287.30    .166
 3 IJC        370784700.0    123679600.0      .4213E+15  264000.90    .166
 4 REG-1      374030300.0    124762200.0      .6554E+15  266311.80    .205
 5 REG-2      382133700.0    127465200.0      .5183E+15  272081.40    .179
 6 REG-3      422517500.0    140935600.0      .1314E+16  300834.90    .257
```

```
Site LBSM09 Lower Big Sioux            VAR=TSS       METHOD= 2 Q WTD C
 COMPARISON OF SAMPLED AND TOTAL FLOW DISTRIBUTIONS
 STR       NQ  NC  NE  VOL%   TOTAL FLOW SAMPLED FLOW   C/Q SLOPE SIGNIF
  1       780  47  43  36.5      259.433      249.643        .496   .237
  2       315  21  18  63.5     1116.435     1108.819       1.058   .006
***      1095  68  61 100.0      505.968      514.977

 FLOW STATISTICS
 FLOW DURATION =    1095.0 DAYS  =  2.998 YEARS
 MEAN FLOW RATE =   505.968 HM3/YR
 TOTAL FLOW VOLUME =    1516.86 HM3
 FLOW DATE RANGE   = 20011001 TO 20040929
 SAMPLE DATE RANGE = 20011016 TO 20040901

 METHOD         MASS (KG)   FLUX (KG/YR)  FLUX VARIANCE CONC (PPB)      CV
 1 AV LOAD    375691300.0    125316200.0      .1753E+16  247676.30    .334
 2 Q WTD C    379987400.0    126749200.0      .1424E+16  250508.50    .298
 3 IJC        382180100.0    127480600.0      .1439E+16  251954.10    .298
 4 REG-1      383409900.0    127890800.0      .1487E+16  252764.80    .302
 5 REG-2      524043900.0    174800900.0      .4679E+16  345478.50    .391
 6 REG-3      400387200.0    133553800.0      .1107E+16  263957.30    .249
```

```
Site LBSM13 Lower Big Sioux            VAR=TSS       METHOD= 2 Q WTD C
 COMPARISON OF SAMPLED AND TOTAL FLOW DISTRIBUTIONS
 STR       NQ  NC  NE  VOL%   TOTAL FLOW SAMPLED FLOW   C/Q SLOPE SIGNIF
  1       737  43  42  31.3      369.940      360.168        .393   .248
  2       358  26  24  68.7     1671.172     1726.898        .539   .093
***      1095  69  66 100.0      795.366      875.168

 FLOW STATISTICS
 FLOW DURATION =    1095.0 DAYS  =  2.998 YEARS
 MEAN FLOW RATE =   795.366 HM3/YR
 TOTAL FLOW VOLUME =    2384.46 HM3
 FLOW DATE RANGE   = 20011001 TO 20040929
 SAMPLE DATE RANGE = 20011016 TO 20040901

 METHOD         MASS (KG)   FLUX (KG/YR)  FLUX VARIANCE CONC (PPB)      CV
 1 AV LOAD    635072400.0    211835800.0      .3415E+16  266337.60    .276
 2 Q WTD C    618773400.0    206399100.0      .1618E+16  259502.10    .195
 3 IJC        625247900.0    208558700.0      .1582E+16  262217.40    .191
 4 REG-1      609967700.0    203461900.0      .1372E+16  255809.20    .182
 5 REG-2      548713300.0    183029700.0      .3201E+16  230120.20    .309
 6 REG-3      657381600.0    219277300.0      .2435E+16  275693.70    .225
```

```
Site LBSM17 Lower Big Sioux            VAR=TSS       METHOD= 2 Q WTD C
 COMPARISON OF SAMPLED AND TOTAL FLOW DISTRIBUTIONS
 STR       NQ  NC  NE  VOL%   TOTAL FLOW SAMPLED FLOW   C/Q SLOPE SIGNIF
  1       737  20  16  32.2      422.189      454.625        .501   .006
  2       358  11  11  67.8     1829.229     2322.808        .090   .748
***      1095  31  27 100.0      882.207     1117.529

 FLOW STATISTICS
 FLOW DURATION =    1095.0 DAYS  =  2.998 YEARS
 MEAN FLOW RATE =   882.207 HM3/YR
 TOTAL FLOW VOLUME =    2644.81 HM3
 FLOW DATE RANGE   = 20011001 TO 20040929
 SAMPLE DATE RANGE = 20020627 TO 20040629

 METHOD         MASS (KG)   FLUX (KG/YR)  FLUX VARIANCE CONC (PPB)      CV
 1 AV LOAD    923279900.0    307970800.0      .5027E+16  349091.20    .230
 2 Q WTD C    750561700.0    250358600.0      .8224E+15  283786.60    .115
 3 IJC        741977200.0    247495200.0      .8755E+15  280540.80    .120
 4 REG-1      732333600.0    244278400.0      .1673E+16  276894.60    .167
 5 REG-2      707691700.0    236058800.0      .3172E+16  267577.50    .239
 6 REG-3      800546100.0    267031500.0      .2334E+16  302685.60    .181
```

```
Site LBSM19 Lower Big Sioux            VAR=TSS       METHOD= 2 Q WTD C
 COMPARISON OF SAMPLED AND TOTAL FLOW DISTRIBUTIONS
 STR       NQ  NC  NE  VOL%   TOTAL FLOW SAMPLED FLOW   C/Q SLOPE SIGNIF
  1       737  42  37  32.6      430.012      421.892        .396   .278
  2       358  23  23  67.4     1831.789     1801.343        .745   .007
***      1095  65  60 100.0      888.310      910.005

 FLOW STATISTICS
 FLOW DURATION =    1095.0 DAYS  =  2.998 YEARS
 MEAN FLOW RATE =   888.310 HM3/YR
 TOTAL FLOW VOLUME =    2663.11 HM3
 FLOW DATE RANGE   = 20011001 TO 20040929
 SAMPLE DATE RANGE = 20011016 TO 20040901

 METHOD         MASS (KG)   FLUX (KG/YR)  FLUX VARIANCE CONC (PPB)      CV
 1 AV LOAD    766118500.0    255547800.0      .6674E+16  287678.70    .320
 2 Q WTD C    779272700.0    259935500.0      .3434E+16  292618.10    .225
 3 IJC        798985200.0    266510800.0      .4116E+16  300020.10    .241
 4 REG-1      788621100.0    263053700.0      .1908E+16  296128.40    .166
 5 REG-2      734418600.0    244973900.0      .3254E+15  275775.30    .074
 6 REG-3      790543000.0    263694800.0      .7410E+15  296850.10    .103
```

Site LBSM20 Lower Big Sioux VAR=TSS METHOD= 2 Q WTD C

COMPARISON OF SAMPLED AND TOTAL FLOW DISTRIBUTIONS

STR	NQ	NC	NE	VOL%	TOTAL FLOW	SAMPLED FLOW	C/Q SLOPE	SIGNIF
1	301	9	8	11.0	518.477	521.703	1.251	.532
2	698	17	15	62.9	1281.413	1151.802	.357	.591
3	96	7	6	26.2	3875.252	3915.541	.513	.205
***	1095	33	29	100.0	1299.098	1566.204		

FLOW STATISTICS
FLOW DURATION = 1095.0 DAYS = 2.998 YEARS
MEAN FLOW RATE = 1299.098 HM3/YR
TOTAL FLOW VOLUME = 3894.63 HM3
FLOW DATE RANGE = 20011001 TO 20040929
SAMPLE DATE RANGE = 20020626 TO 20040819

METHOD	MASS (KG)	FLUX (KG/YR)	FLUX VARIANCE	CONC (PPB)	CV
1 AV LOAD	1586980000.0	529355700.0	.1360E+17	407479.50	.220
2 Q WTD C	1655702000.0	552278800.0	.6333E+16	425124.90	.144
3 IJC	1676596000.0	559248100.0	.7081E+16	430489.60	.150
4 REG-1	1680737000.0	560629400.0	.9165E+16	431552.90	.171
5 REG-2	1659402000.0	553512800.0	.8619E+16	426074.80	.168
6 REG-3	1755702000.0	585634900.0	.1222E+17	450801.20	.189

Site LBSM21 Lower Big Sioux VAR=TSS METHOD= 2 Q WTD C

COMPARISON OF SAMPLED AND TOTAL FLOW DISTRIBUTIONS

STR	NQ	NC	NE	VOL%	TOTAL FLOW	SAMPLED FLOW	C/Q SLOPE	SIGNIF
1	1095	29	26	100.0	1316.004	1424.150	.840	.000
***	1095	29	26	100.0	1316.004	1424.150		

FLOW STATISTICS
FLOW DURATION = 1095.0 DAYS = 2.998 YEARS
MEAN FLOW RATE = 1316.004 HM3/YR
TOTAL FLOW VOLUME = 3945.31 HM3
FLOW DATE RANGE = 20011001 TO 20040929

SAMPLE DATE RANGE = 20020711 TO 20040630

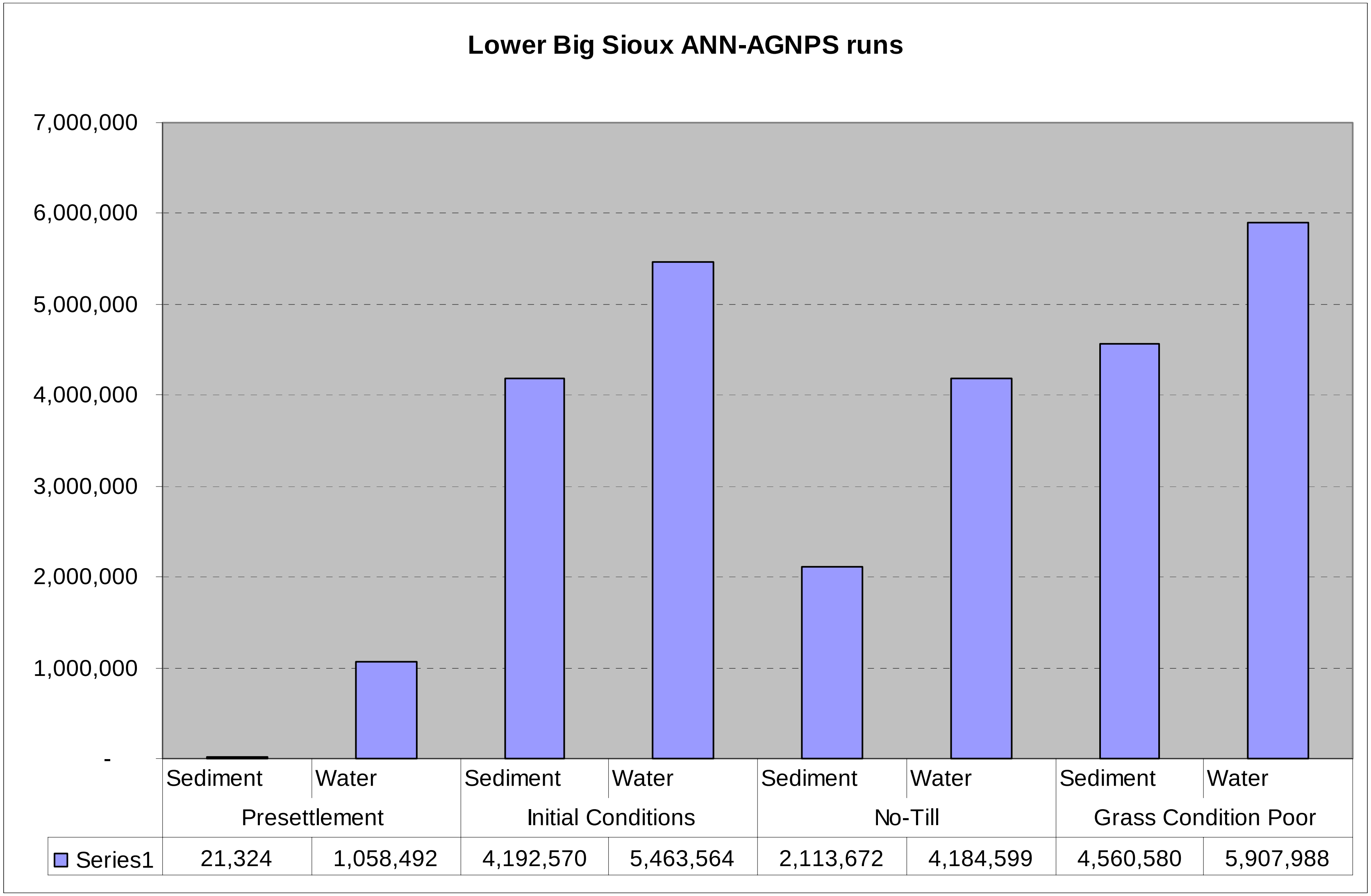
METHOD	MASS (KG)	FLUX (KG/YR)	FLUX VARIANCE	CONC (PPB)	CV
1 AV LOAD	2113416000.0	704954400.0	.1893E+18	535677.90	.617
2 Q WTD C	1952929000.0	651422300.0	.9665E+17	495000.20	.477
3 IJC	2115978000.0	705809200.0	.1282E+18	536327.40	.507
4 REG-1	1827518000.0	609589800.0	.4394E+17	463212.70	.344
5 REG-2	1128719000.0	376497200.0	.9209E+16	286091.20	.255
6 REG-3	1306559000.0	435818100.0	.2575E+16	331167.70	.116

24.0 APPENDIX I: Annualized AGNPS Modeling and Rapid Geomorphic (RGA) Field Sampling Results

Watershed	SD Segment 17 (Sites 17 to 21)					SD Segment 16 (Sites 13 to 17)		
	Big Ditch Creek	Brule	Broken Kettle	Union	Westfield	Sixmile	Green Creek	Indian
Max Erosion ton/acre/year	2.783	18.604	3.112	3.056	3.091	1.898	2.691	2.684
Subwatershed 10th %tile erosion rate	0.004	0.018	0.023	0.0025	0.1575	0.086	0.0191	0.117
Subwatershed 25th %tile erosion rate	0.014	0.12175	0.06325	0.2415	0.424	0.179	0.3155	0.25575
Subwatershed 50th %tile erosion rate	0.032	0.395	0.357	0.535	0.6695	0.302	0.6015	0.44
Subwatershed 75th %tile erosion rate	0.06475	0.714	0.671	0.86625	1.017	0.459	0.8835	0.60425
Subwatershed 90th %tile erosion rate	0.183	1.098	1.0654	1.2225	1.3527	0.6866	1.1692	0.8736
Acres exceeding Subwatershed 90th %tile	2175	12833.01	6551.1	2749.89	1437.32	6736.38	1377.28	4323.56
% of Acres exceeding Subwatershed 90th %tile	10%	9%	11%	12%	8%	10%	13%	11%
Subwatershed average erosion rate ton/acre/year	0.08	0.54	0.469	0.674	0.759	0.385	0.716	0.497
Total Acres in subwatershed	22521	138764	62325	23280	17713	68925	10822	40550
Load from cells exceeding 90th %tile tons/year	907	20919	9172	4519	2396	6809	2178	4697
% of total load from cells exceeding 90th %tile	50%	28%	31%	29%	18%	26%	28%	23%
Subwatershed total erosion load tons/year	1802	74933	29231	15691	13444	26536	7748	20153
Basinwide 10th %tile erosion rate	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
Basinwide 25th %tile erosion rate	0.057	0.057	0.057	0.057	0.057	0.057	0.057	0.057
Basinwide 50th %tile erosion rate	0.156	0.156	0.156	0.156	0.156	0.156	0.156	0.156
Basinwide 75th %tile erosion rate	0.298	0.298	0.298	0.298	0.298	0.298	0.298	0.298
Basinwide 90th %tile erosion rate	0.530	0.530	0.530	0.530	0.530	0.530	0.530	0.530
% of Subwatershed Load Exceeding Basin 10th %tile	100%	100%	100%	100%	100%	100%	100%	100%
% of Subwatershed Load Exceeding Basin 25th %tile	79%	100%	99%	100%	100%	100%	100%	100%
% of Subwatershed Load Exceeding Basin 50th %tile	57%	98%	97%	100%	100%	97%	99%	99%
% of Subwatershed Load Exceeding Basin 75th %tile	32%	93%	92%	97%	99%	79%	98%	91%
% of Subwatershed Load Exceeding Basin 90th %tile	26%	74%	71%	83%	87%	43%	85%	56%
Load from cells exceeding Basin 10th %tile tons/year	1797	74987	29209	15697	13438	26568	7746	20167
Load from cells exceeding Basin 25th %tile tons/year	1421	74681	28807	15684	13414	26538	7727	20151
Load from cells exceeding Basin 50th %tile tons/year	1024	73163	28477	15618	13396	25733	7708	20018
Load from cells exceeding Basin 75th %tile tons/year	585	69674	26846	15152	13260	20996	7615	18242
Load from cells exceeding Basin 90th %tile tons/year	466	55382	20895	13026	11719	11525	6581	11297
% of Subwatershed Acres Exceeding Basin 10th %tile	91%	96%	94%	92%	98%	98%	96%	99%
% of Subwatershed Acres Exceeding Basin 25th %tile	32%	88%	77%	89%	92%	96%	89%	98%
% of Subwatershed Acres Exceeding Basin 50th %tile	13%	77%	70%	87%	92%	86%	88%	95%
% of Subwatershed Acres Exceeding Basin 75th %tile	4%	66%	59%	79%	88%	57%	84%	76%
% of Subwatershed Acres Exceeding Basin 90th %tile	2%	42%	36%	57%	69%	21%	62%	36%
Acres from cells exceeding Basin 10th %tile tons/year	20482	132543	58558	21421	17338	67237	10429	40298
Acres from cells exceeding Basin 25th %tile tons/year	7097	121703	48120	20832	16376	66379	9652	39597
Acres from cells exceeding Basin 50th %tile tons/year	2858	107502	43632	20313	16252	59518	9491	38328
Acres from cells exceeding Basin 75th %tile tons/year	797	92136	36870	18372	15668	39067	9094	30785
Acres from cells exceeding Basin 90th %tile tons/year	502	58059	22399	13233	12156	14710	6718	14481

	SD Segment 15 (Sites 8 to 13)									
Watershed	Dry Creek	Finnie	Pattee	Central Rock	East Rock	Lower Rock	North Central Rock	Southeast Rock	Uppper Rock	West Rock
Max Erosion ton/acre/year	2.332	3.589	2.097	2.584	0.877	2.977	2.753	1.007	5.282	2.179
Subwatershed 10th %tile erosion rate	0.0768	0.1397	0.0167	0.003	0.003	0.0113	0.003	0.029	0.005	0.004
Subwatershed 25th %tile erosion rate	0.151	0.44925	0.0855	0.055	0.058	0.111	0.04225	0.065	0.019	0.105
Subwatershed 50th %tile erosion rate	0.268	0.789	0.3475	0.142	0.124	0.253	0.129	0.119	0.121	0.2015
Subwatershed 75th %tile erosion rate	0.423	1.02125	0.56	0.222	0.192	0.39625	0.213	0.19	0.22525	0.315
Subwatershed 90th %tile erosion rate	0.5776	1.227	0.8136	0.298	0.272	0.5617	0.306	0.276	0.3285	0.46
Acres exceeding Subwatershed 90th %tile	3703.52	597.35	2932.69	12998.33	12855.09	13399.21	15692.15	12119.11	17008.59	17419.09
% of Acres exceeding Subwatershed 90th %tile	12%	8%	11%	7%	10%	9%	9%	9%	11%	10%
Subwatershed average erosion rate ton/acre/year	0.339	0.91	0.417	0.157	0.145	0.3	0.161	0.142	0.171	0.242
Total Acres in subwatershed	31876	7418	25952	176890	130673	141693	174963	134806	149455	174996
Load from cells exceeding 90th %tile tons/year	2989	1555	3320	4961	4828	10475	6656	4460	8157	10835
% of total load from cells exceeding 90th %tile	28%	23%	31%	18%	25%	25%	24%	23%	32%	26%
Subwatershed total erosion load tons/year	10806	6750	10822	27772	18948	42508	28169	19142	25557	42349
Basinwide 10th %tile erosion rate	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
Basinwide 25th %tile erosion rate	0.057	0.057	0.057	0.057	0.057	0.057	0.057	0.057	0.057	0.057
Basinwide 50th %tile erosion rate	0.156	0.156	0.156	0.156	0.156	0.156	0.156	0.156	0.156	0.156
Basinwide 75th %tile erosion rate	0.298	0.298	0.298	0.298	0.298	0.298	0.298	0.298	0.298	0.298
Basinwide 90th %tile erosion rate	0.530	0.530	0.530	0.530	0.530	0.530	0.530	0.530	0.530	0.530
% of Subwatershed Load Exceeding Basin 10th %tile	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
% of Subwatershed Load Exceeding Basin 25th %tile	100%	100%	99%	98%	97%	99%	98%	97%	97%	100%
% of Subwatershed Load Exceeding Basin 50th %tile	94%	100%	97%	76%	65%	94%	73%	60%	80%	89%
% of Subwatershed Load Exceeding Basin 75th %tile	74%	98%	89%	18%	21%	71%	26%	20%	37%	54%
% of Subwatershed Load Exceeding Basin 90th %tile	34%	92%	59%	3%	4%	29%	6%	2%	10%	17%
Load from cells exceeding Basin 10th %tile tons/year	10812	6754	10818	27865	18956	42429	28084	19188	25457	42425
Load from cells exceeding Basin 25th %tile tons/year	10781	6753	10717	27285	18403	42168	27523	18540	24806	42186
Load from cells exceeding Basin 50th %tile tons/year	10185	6726	10473	20991	12280	39938	20587	11455	20403	37872
Load from cells exceeding Basin 75th %tile tons/year	8036	6627	9593	4961	3939	30377	7193	3781	9463	23076
Load from cells exceeding Basin 90th %tile tons/year	3658	6213	6368	699	834	12246	1813	437	2621	7102
% of Subwatershed Acres Exceeding Basin 10th %tile	98%	100%	98%	92%	92%	94%	94%	96%	94%	92%
% of Subwatershed Acres Exceeding Basin 25th %tile	96%	100%	83%	82%	81%	88%	81%	84%	74%	88%
% of Subwatershed Acres Exceeding Basin 50th %tile	80%	96%	74%	50%	39%	74%	45%	34%	47%	67%
% of Subwatershed Acres Exceeding Basin 75th %tile	50%	91%	59%	7%	7%	44%	10%	7%	14%	29%
% of Subwatershed Acres Exceeding Basin 90th %tile	15%	78%	29%	0%	1%	12%	1%	1%	2%	6%
Acres from cells exceeding Basin 10th %tile tons/year	31329	7417	25392	162556	120223	133073	163608	128859	140846	161428
Acres from cells exceeding Basin 25th %tile tons/year	30561	7408	21509	145853	106266	125204	142404	113030	111075	154756
Acres from cells exceeding Basin 50th %tile tons/year	25353	7122	19207	87745	50436	104904	79422	46384	70918	116932
Acres from cells exceeding Basin 75th %tile tons/year	15821	6730	15252	12998	9758	62927	17467	9732	21185	50515
Acres from cells exceeding Basin 90th %tile tons/year	4903	5817	7585	727	1282	16645	2199	700	3279	9798

Watershed	SD Segment 14 (Sites 3 to 8) BigBeaver	Unnamed Upstream of Beaver SD	Little Beaver	Klondike	SD Segment 13 (Sites 1 to 3) Beaver Mn	Blood Run	Nine Mile	Lower Split Rock	Upper Split Rock
Max Erosion ton/acre/year	3.2	0.604	2.076	2.719	2.918	4.152	1.317	7.592	1.715
Subwatershed 10th %tile erosion rate	0.006	0.0066	0.0063	0.021	0.005	0.0037	0.002	0.004	0.003
Subwatershed 25th %tile erosion rate	0.024	0.024	0.04125	0.143	0.095	0.11325	0.015	0.0405	0.048
Subwatershed 50th %tile erosion rate	0.052	0.044	0.101	0.264	0.227	0.224	0.042	0.121	0.092
Subwatershed 75th %tile erosion rate	0.094	0.067	0.166	0.38	0.362	0.36075	0.078	0.2335	0.151
Subwatershed 90th %tile erosion rate	0.167	0.117	0.3819	0.582	0.5198	0.5194	0.1378	0.432	0.216
Acres exceeding Subwatershed 90th %tile	7393.76	1342.6	531.29	2381.62	10171.19	2231.94	3301.01	17071.84	13200.39
% of Acres exceeding Subwatershed 90th %tile	9%	13%	7%	10%	11%	11%	10%	10%	10%
Subwatershed average erosion rate ton/acre/year	0.077	0.068	0.143	0.319	0.28	0.277	0.065	0.193	0.114
Total Acres in subwatershed	81263	10015	7330	23682	96766	20130	31964	164192	137460
Load from cells exceeding 90th %tile tons/year	1917	288	303	2223	6860	1781	792	11428	4030
% of total load from cells exceeding 90th %tile	31%	42%	29%	29%	25%	32%	38%	36%	26%
Subwatershed total erosion load tons/year	6257	681	1048	7555	27095	5576	2078	31689	15670
Basinwide 10th %tile erosion rate	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
Basinwide 25th %tile erosion rate	0.057	0.057	0.057	0.057	0.057	0.057	0.057	0.057	0.057
Basinwide 50th %tile erosion rate	0.156	0.156	0.156	0.156	0.156	0.156	0.156	0.156	0.156
Basinwide 75th %tile erosion rate	0.298	0.298	0.298	0.298	0.298	0.298	0.298	0.298	0.298
Basinwide 90th %tile erosion rate	0.530	0.530	0.530	0.530	0.530	0.530	0.530	0.530	0.530
% of Subwatershed Load Exceeding Basin 10th %tile	100%	99%	100%	100%	100%	100%	99%	100%	100%
% of Subwatershed Load Exceeding Basin 25th %tile	81%	67%	97%	99%	99%	99%	75%	98%	96%
% of Subwatershed Load Exceeding Basin 50th %tile	35%	27%	65%	93%	93%	94%	32%	81%	47%
% of Subwatershed Load Exceeding Basin 75th %tile	10%	17%	37%	70%	66%	67%	9%	52%	11%
% of Subwatershed Load Exceeding Basin 90th %tile	2%	11%	17%	35%	24%	31%	7%	27%	4%
Load from cells exceeding Basin 10th %tile tons/year	6259	677	1046	7545	27052	5575	2059	31707	15683
Load from cells exceeding Basin 25th %tile tons/year	5094	457	1020	7515	26929	5541	1563	31151	14980
Load from cells exceeding Basin 50th %tile tons/year	2189	181	677	7049	25323	5252	659	25726	7436
Load from cells exceeding Basin 75th %tile tons/year	618	116	392	5287	18003	3747	189	16355	1678
Load from cells exceeding Basin 90th %tile tons/year	114	78	174	2637	6410	1720	143	8574	624
% of Subwatershed Acres Exceeding Basin 10th %tile	94%	95%	94%	97%	95%	88%	89%	91%	91%
% of Subwatershed Acres Exceeding Basin 25th %tile	50%	36%	79%	91%	87%	80%	39%	77%	77%
% of Subwatershed Acres Exceeding Basin 50th %tile	11%	6%	31%	75%	73%	69%	8%	45%	23%
% of Subwatershed Acres Exceeding Basin 75th %tile	2%	2%	11%	42%	40%	36%	1%	19%	3%
% of Subwatershed Acres Exceeding Basin 90th %tile	0%	1%	3%	13%	10%	11%	1%	7%	1%
Acres from cells exceeding Basin 10th %tile tons/year	76633	9507	6876	23043	92139	17781	28506	149564	124431
Acres from cells exceeding Basin 25th %tile tons/year	40235	3571	5781	21586	84208	16154	12613	127087	105765
Acres from cells exceeding Basin 50th %tile tons/year	9060	554	2255	17644	70677	13868	2422	74557	31923
Acres from cells exceeding Basin 75th %tile tons/year	1483	217	821	10036	38782	7225	291	30951	3825
Acres from cells exceeding Basin 90th %tile tons/year	152	130	213	3120	9318	2116	179	11035	834


Lower Big Sioux ANN-AGNPS runs
7,000,000
6,000,000
5,000,000
4,000,000
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-
Sediment
Water
Sediment
Water
Sediment
Water
Sediment
Water
Presettlement
Initial Conditions
No-Till
Grass Condition Poor
Series1
21,324
1,058,492
4,192,570
5,463,564
2,113,672
4,184,599
4,560,580
5,907,988

IDCode from RGA Database	779	780	781	783	784	785	769	786
Date	26-Jun-07	26-Jun-07	26-Jun-07	26-Jun-07	26-Jun-07	26-Jun-07	26-Jun-07	26-Jun-07
Evaluators	SB, AW	SB, AW	SB, AW	SB, AW	SB, AW	SB, AW	SB, AW	SB, AW
Flow (CFS)	2500		2500	2500	2500		2500	2500
Station	LBSM13	BROKEN KETTLE CREEK	BIG SIOUX RIVER	LBSM19	LBSM17	LBST18	LBSM20	LBSM21
Waterbody	Big Sioux	Broken Kettle	Big Sioux	Big Sioux	Big Sioux	Brule Creek	Big Sioux	Big Sioux
Northing		7043121	707194	693820	699175		103836	
Easting		4723621	4714406	4737081	4745739		4722310	
Pattern	Meandering	Straight	Meandering	Straight	Meandering	Straight	Straight	Meandering
PrimaryBedMaterial	3	4	0	3	4	4	4	4
Bed/BankProtection	2	1	2	1	1	1	1	3
DegreeofIncision	2	3	3	2	1	4	2	2
Degree of Constriction	0	0	0	0	0	0	0	0
Inside/Left Bank Erosion	1	0	0	1	0	0	2	0
Outside/Right Bank Erosion	1	0	2	2	2	0	1	0
Inside/Left Streambank instability	0	0	0	0	0	0	1.5	0
Outside/Right Streambank Instability	0.5	0	1.5	0.5	1	0	1	0
Inside/ Left Established Riparian Woody Veg	2	0	0	2	2	1	2	0.5
Outside/ Right Established Riparian Woody Veg	2	0	1.5	2	1.5	1	2	0.5
Inside/ Left Occurence of Bank Accretion	2	2	2	2	1.5	1.5	2	2
Outside/ Right Occurence of Bank Accretion	1.5	2	2	2	2	1.5	2	2
Stage	3	1.5	3	3	3	4	3	2
Final Score	20	13.5	17	20.5	19	18	23.5	16

RGA Table Continued with Notes								
Station	LBSM13	BROKEN KETTLE CREEK	BIG SIOUX RIVER	LBSM19	LBSM17	LBST18	LBSM20	LBSM21
Notes	Big Sioux River at Hawarden. Seems like a stable site. Could be stage I or stage VI, but small amount of mass wasting on right bank put it into stage V.	No mass wasting, but incised. RGA taken upstream of Broken Kettle confluence with Big Sioux at station BSM20. Relatively high flow with turbid water.	Big Sioux below BSM20 and above BSM21. Reach about 50% amored on left bank by sedimentry rock. Rapids observed.	Big Sioux River near Richland. 100' of rip rap on right bank under bridge. Good woody vegetation on terrace, but none between top of bank and water edge. Some central deposition evidenced be woody debris.	Big Sioux River near Akron.	Brule Creek above confluence with Big Sioux just downstream of Richland site. Less than 10% fluvial erosion on both banks.	Question:Could it be stage IV with incision and mass wasting. Big Sioux River at Broken Kettle. Two layers of bank material: brown silty sand top 8' and yellow clay from 8' to water edge. Confluence of Broken Kettle Creek is about 400' above the bridge w	Big Sioux River at North Sioux City. Constructed channel with rip rap and levees on both sides.
Structure Type	Bridge	Bridge	None	Bridge	Bridge	Bridge	Bridge	Bridge
Structure Size	70	40	0	70	70	40	70	100
Stream Width	250	30	250	250	225	20	265	200
Length Assessed	2000	500	2000	1750	1200	160	2000	1000
Assessment From Structure	Both	Both	Both	Both	Both	Both	Both	Above
Bank Erosion	2	0	2	3	2	0	3	0
Streambank Instability	0.5	0	1.5	0.5	1	0	2.5	0
Woody Veg	4	0	1.5	4	3.5	2	4	1
Bank Accretion	3.5	4	4	4	3.5	3	4	4

25.0 APPENDIX J: Public Notice Comments including EPA and Response to Comments

EPA REGION VIII TMDL REVIEW

TMDL Document Info:

Document Name:	**Total Suspended Solids Total Maximum Daily Load (TMDL) for Three Segments of the Lower Big Sioux River, South Dakota and Iowa**
Submitted by:	**Cheryl Saunders, SD DENR**
Date Received:	**October 1, 2009**
Review Date:	**October 26, 2009**
Reviewer:	**Vern Berry, EPA**
Rough Draft / Public Notice / Final?	**Public Notice Draft**
Notes:	

Reviewers Final Recommendation(s) to EPA Administrator (used for final review only):

☐ Approve
☐ Partial Approval
☐ Disapprove
☐ Insufficient Information

Approval Notes to Administrator:

This document provides a standard format for EPA Region 8 to provide comments to state TMDL programs on TMDL documents submitted to EPA for either formal or informal review. All TMDL documents are evaluated against the minimum submission requirements and TMDL elements identified in the following 8 sections:

1. Problem Description
   a. TMDL Document Submittal Letter
   b. Identification of the Waterbody, Impairments, and Study Boundaries
   c. Water Quality Standards
2. Water Quality Target
3. Pollutant Source Analysis
4. TMDL Technical Analysis
   a. Data Set Description
   b. Waste Load Allocations (WLA)
   c. Load Allocations (LA)
   d. Margin of Safety (MOS)
   e. Seasonality and variations in assimilative capacity
5. Public Participation
6. Monitoring Strategy
7. Restoration Strategy
8. Daily Loading Expression

Under Section 303(d) of the Clean Water Act, waterbodies that are not attaining one or more water quality standard (WQS) are considered “impaired.” When the cause of the impairment is determined to be a pollutant, a TMDL analysis is required to assess the appropriate maximum allowable pollutant loading rate. A TMDL document consists of a technical analysis conducted to: (1) assess the maximum pollutant loading rate that a waterbody is able to assimilate while maintaining water quality standards; and (2) allocate that assimilative capacity among the known sources of that pollutant**.** A well written TMDL document will describe a path forward that may be used by those who implement the TMDL recommendations to attain and maintain WQS.

Each of the following eight sections describes the factors that EPA Region 8 staff considers when reviewing TMDL documents. Also included in each section is a list of EPA's minimum submission requirements relative to that section, a brief summary of the EPA reviewer's findings, and the reviewer's comments and/or suggestions. Use of the verb "must" in the minimum submission requirements denotes information that is required to be submitted because it relates to elements of the TMDL required by the CWA and by regulation. Use of the term "should" below denotes information that is generally necessary for EPA to determine if a submitted TMDL is approvable.

This review template is intended to ensure compliance with the Clean Water Act and that the reviewed documents are technically sound and the conclusions are technically defensible.

1. Problem Description

A TMDL document needs to provide a clear explanation of the problem it is intended to address. Included in that description should be a definitive portrayal of the physical boundaries to which the TMDL applies, as well as a clear description of the impairments that the TMDL intends to address and the associated pollutant(s) causing those impairments. While the existence of one or more impairment and stressor may be known, it is important that a comprehensive evaluation of the water quality be conducted prior to development of the TMDL to ensure that all water quality problems and associated stressors are identified. Typically, this step is conducted prior to the 303(d) listing of a waterbody through the monitoring and assessment program. The designated uses and water quality criteria for the waterbody should be examined against available data to provide an evaluation of the water quality relative to all applicable water quality standards. If, as part of this exercise, additional WQS problems are discovered and additional stressor pollutants are identified, consideration should be given to concurrently evaluating TMDLs for those additional pollutants. If it is determined that insufficient data is available to make such an evaluation, this should be noted in the TMDL document.

1.1 TMDL Document Submittal Letter

When a TMDL document is submitted to EPA requesting formal comments or a final review and approval, the submittal package should include a letter identifying the document being submitted and the purpose of the submission.

Minimum Submission Requirements.

☒ A TMDL submittal letter should be included with each TMDL document submitted to EPA requesting a formal review.

☒ The submittal letter should specify whether the TMDL document is being submitted for initial review and comments, public review and comments, or final review and approval.

☐ Each TMDL document submitted to EPA for final review and approval should be accompanied by a submittal letter that explicitly states that the submittal is a final TMDL submitted under Section 303(d) of the Clean Water Act for EPA review and approval. This clearly establishes the State's/Tribe's intent to submit, and EPA's duty to review, the TMDL under the statute**.** The submittal letter should contain such identifying information as the name and location of the waterbody and the pollutant(s) of concern, which matches similar identifying information in the TMDL document for which a review is being requested.

Recommendation:
☒ Approve ☐ Partial Approval ☐ Disapprove ☐ Insufficient Information

SUMMARY: The public notice draft Lower Big Sioux River total suspended solids (TSS) TMDLs were submitted to EPA for review during the public notice period via an email from Cheryl Saunders, SD DENR on 10/01/2009. The email included the draft TMDL document and a public notice announcement requesting review and comment.

COMMENTS: None.

1.2 Identification of the Waterbody, Impairments, and Study Boundaries

The TMDL document should provide an unambiguous description of the waterbody to which the TMDL is intended to apply and the impairments the TMDL is intended to address. The document should also clearly delineate the physical boundaries of the waterbody and the geographical extent of the watershed area studied. Any additional information needed to tie the TMDL document back to a current 303(d) listing should also be included.

Minimum Submission Requirements:

☒ The TMDL document should clearly identify the pollutant and waterbody segment(s) for which the TMDL is being established. If the TMDL document is submitted to fulfill a TMDL development requirement for a waterbody on the state's current EPA approved 303(d) list, the TMDL document submittal should clearly identify the waterbody and associated impairment(s) as they appear on the State's/Tribe's current EPA approved 303(d) list, including a full waterbody description, assessment unit/waterbody ID, and the priority ranking of the waterbody. This information is necessary to ensure that the administrative record and the national TMDL tracking database properly link the TMDL document to the 303(d) listed waterbody and impairment(s).

☒ One or more maps should be included in the TMDL document showing the general location of the waterbody and, to the maximum extent practical, any other features necessary and/or relevant to the understanding of the TMDL analysis, including but not limited to: watershed boundaries, locations of major pollutant sources, major tributaries included in the analysis, location of sampling points, location of discharge gauges, land use patterns, and the location of nearby waterbodies used to provide surrogate information or reference conditions. Clear and concise descriptions of all key features and their relationship to the waterbody and water quality data should be provided for all key and/or relevant features not represented on the map

☐ If information is available, the waterbody segment to which the TMDL applies should be identified/geo-referenced using the National Hydrography Dataset (NHD). If the boundaries of the TMDL do not correspond to the Waterbody ID(s) (WBID), Entity_ID information or reach code (RCH_Code) information should be provided. If NHD data is not available for the waterbody, an alternative geographical referencing system that unambiguously identifies the physical boundaries to which the TMDL applies may be substituted.

Recommendation:
☒ Approve ☐ Partial Approval ☐ Disapprove ☐ Insufficient Information

SUMMARY: The Lower Big Sioux River is located southeastern South Dakota and forms a border between South Dakota and Iowa. The Lower Big Sioux River watershed (HUC 10170203) is part of the larger Missouri River basin. Lower Big Sioux River has a total drainage area of approximately 661,418 acres in South Dakota and approximately 919,040 acres in Iowa. This TMDL document covers three (3) listed segments of Lower Big Sioux River including: 1) Big Sioux River from near Fairview to near Alcester, SD (20.0 miles, SD-BS-R-BIG_SIOUX_15); 2) Big Sioux River from near Alcester, SD to Indian Creek (16.6 miles, SD-BS-R-BIG_SIOUX_16); and 3) Big Sioux River from Indian Creek to the mouth (59.9 miles, SD-BS-R-BIG_SIOUX_17). All three segments are listed as high priority for TMDL development.

The designated uses for Lower Big Sioux River segments include warmwater semi-permanent fish life propagation waters, immersion recreation waters, irrigation, fish and wildlife propagation, recreation, and stock watering. These segments were listed in 2008 for fecal coliform bacteria which is impairing the immersion recreational uses, and for total suspended solids (TSS) which is impairing the warmwater fish propagation uses. The fecal coliform impairment in these segments have been addressed by SDDENR in a separate TMDL document.

COMMENTS: None.

1.3 Water Quality Standards

TMDL documents should provide a complete description of the water quality standards for the waterbodies addressed, including a listing of the designated uses and an indication of whether the uses are being met, not being met, or not assessed. If a designated use was not assessed as part of the TMDL analysis (or not otherwise recently assessed), the documents should provide a reason for the lack of assessment (e.g., sufficient data was not available at this time to assess whether or not this designated use was being met).

Water quality criteria (WQC) are established as a component of water quality standard at levels considered necessary to protect the designated uses assigned to that waterbody. WQC identify quantifiable targets and/or qualitative water quality goals which, if attained and maintained, are intended to ensure that the designated uses for the waterbody are protected. TMDLs result in maintaining and attaining water quality standards by determining the appropriate maximum pollutant loading rate to meet water quality criteria, either directly, or through a surrogate measurable target. The TMDL document should include a description of all applicable water quality criteria for the impaired designated uses and address whether or not the criteria are being attained, not attained, or not evaluated as part of the analysis. If the criteria were not evaluated as part of the analysis, a reason should be cited (e.g. insufficient data were available to determine if this water quality criterion is being attained).

Minimum Submission Requirements:

- ☒ The TMDL must include a description of the applicable State/Tribal water quality standard, including the designated use(s) of the waterbody, the applicable numeric or narrative water quality criterion, and the anti-degradation policy. (40 C.F.R. §130.7(c)(1)).
- ☒ The purpose of a TMDL analysis is to determine the assimilative capacity of the waterbody that corresponds to the existing water quality standards for that waterbody, and to allocate that assimilative capacity between the significant sources. Therefore, <u>all TMDL documents must be written to meet the existing water quality standards</u> for that waterbody (CWA §303(d)(1)(C)).

  Note: In some circumstances, the load reductions determined to be necessary by the TMDL analysis may prove to be infeasible and may possibly indicate that the existing water quality standards and/or assessment methodologies may be erroneous. However, the TMDL must still be determined based on existing water quality standards. Adjustments to water quality standards and/or assessment methodologies may be evaluated separately, from the TMDL.
- ☐ The TMDL document should describe the relationship between the pollutant of concern and the water quality standard the pollutant load is intended to meet. This information is necessary for EPA to evaluate whether or not attainment of the prescribed pollutant loadings will result in attainment of the water quality standard in question.
- ☐ If a standard includes multiple criteria for the pollutant of concern, the document should demonstrate that the TMDL value will result in attainment of all related criteria for the pollutant. For example, both acute and chronic values (if present in the WQS) should be addressed in the document, including consideration of magnitude, frequency and duration requirements.

Recommendation:
☐ Approve ☒ Partial Approval ☐ Disapprove ☐ Insufficient Information

SUMMARY: The Lower Big Sioux River segments addressed by these TMDLs are impaired based on the total suspended solids (TSS) concentrations for warmwater semi permanent fish life propagation. South Dakota has applicable numeric standards for TSS that may be applied to these river segments. The numeric standards being implemented in these TMDLs are: a daily maximum value of TSS of 158 mg/L in any one sample, or an arithmetic mean of 90 mg/L over a 30 day period. Discussion of additional applicable water quality standards for Lower Big Sioux River can be found on pages 13 - 15 of the TMDL document.

COMMENTS: As a multijurisdictional TMDL that addresses pollutant loadings from two states (SD and IA), there should be recognition and discussion of the WQS on both sides of the border. The water quality standards section should include a listing or discussion of the IA standards including any narrative or numeric standards that relate to sediment.

Page 13 mentions that the most stringent standard is used in a TMDL when multiple criteria exist for a particular parameter. It goes on to say that the daily maximum TSS standard was used as the target for these TMDLs. It's not clear why the acute criterion for TSS (158 mg/L) is considered more stringent that the chronic criterion for TSS (90 mg/L). It is also not clear how using the daily maximum standard as the TMDL target will ensure that the 30-day average standard will be met. Further, the document (see Section 8.0 TMDL Allocations) seems to imply that the chronic, 30-day average standard is not applicable to these stream segments because too few samples were collected. We differ with these interpretations of the standards.

Numerically, the chronic TSS criterion is the most stringent applicable criterion. Also, the applicability of the chronic criterion is independent of the specific number of field samples taken prior to development of the TMDL. If too few samples were collected, then DENR may not be able to make a statistically reliable determination of whether the criterion was met during those periods, but the chronic criterion would still apply. For the Lower Big Sioux River segments, both the chronic and acute criteria are applicable, independent of whether sufficient sampling occurred to make a determination as to whether the chronic criterion was met.

When there is a reference to "the TSS criterion" in the text or tables it should be accompanied by a reference to the "acute" or "chronic" criterion. Specifically, the text at the bottom of page 13 and the title of Table 3 lack this distinction.

SDDENR RESPONSE: To address the comment regarding the need for a discussion of the water quality standards on both sides of the state border, another section detailing the Iowa beneficial uses and associated water quality standards was added (Section 4.2, pg 13). The Iowa DNR provided this information and emphasized the fact that they do not have any numerical "sediment" or "turbidity" type standard in place. The following language was added to the TMDL "A Chapter 61 of the IAC does not contain specific WQ standards, narrative or numeric, that directly apply to sedimentation or ambient turbidity. The narrative standards in Chapter 61 (http://www.iowadnr.gov/water/standards/files/chapter61.pdf) apply to all Iowa surface waters and do not exist specifically for streams and rivers. The only turbidity-related standard is included in the narrative standards under Section 61.3(2), General Water Quality Criteria:

"f. The turbidity of the receiving water shall not be increased by more than 25 Nephelometric turbidity units by any point source discharge.""

SD DENR recognizes that both the acute and the chronic criteria within SD Surface Water Quality Standards are applicable to the three impaired segments reach of the Lower Big Sioux River. However, SD DENR was not able to determine compliance with the 30-day average chronic criterion based on sample data alone, as indicated by the statement in the Load Allocation sections for each segment , "In many instances, only one or two samples were collected during any 30-day period, so the average criterion was applied to each flowzone. Although the daily maximum criteria are exceeded, to be conservative it was decided to use the average criterion to develop the loading capacity of the stream in order to ensure that the most stringent water quality standards are met. Additional data is needed to accurately assess compliance with the 30-day average criterion." To address EPA's concern regarding compliance with all applicable criteria, the TMDL was revised and is now based on the chronic criterion to ensure that all applicable criteria are met.

Any reference to "the TSS criterion" in the text or tables is now accompanied by a reference to the "acute" or "chronic" criterion.

2. Water Quality Targets

TMDL analyses establish numeric targets that are used to determine whether water quality standards are being achieved. Quantified water quality targets or endpoints should be provided to evaluate each listed pollutant/water body combination addressed by the TMDL, and should 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 water quality target. For pollutants with narrative standards, the narrative standard should 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 a variety of targets representing water column sediment such as TSS, embeddeness, stream morphology, up-slope conditions and a measure of biota).

Minimum Submission Requirements:

☒ The TMDL should identify a numeric water quality target(s) for each waterbody pollutant combination. The TMDL target is a quantitative value used to measure whether or not the applicable water quality standard is attained.

Generally, the pollutant of concern and the numeric water quality target are, respectively, the chemical causing the impairment and the numeric criteria for that chemical (e.g., chromium) contained in the water quality standard. Occasionally, the pollutant of concern is different from the parameter that is the subject of the numeric water quality target (e.g., when the pollutant of concern is phosphorus and the numeric water quality target is expressed as a numerical dissolved oxygen criterion). In such cases, the TMDL should explain the linkage between the pollutant(s) of concern, and express the quantitative relationship between the TMDL target and pollutant of concern. In all cases, TMDL targets must represent the attainment of current water quality standards.

☐ When a numeric TMDL target is established to ensure the attainment of a narrative water quality criterion, the numeric target, the methodology used to determine the numeric target, and the link between the pollutant of concern and the narrative water quality criterion should all be described in the TMDL document. Any additional information supporting the numeric target and linkage should also be included in the document.

Recommendation:
☐ Approve ☒ Partial Approval ☐ Disapprove ☐ Insufficient Information

SUMMARY: The numeric TMDL target established for the three segments of the Lower Big Sioux River is based on the daily maximum water quality standard for TSS for the warmwater semi permanent fish life propagation beneficial use. The TMDL target for all three segments is the TSS daily maximum value of $\leq$ 158 mg/L in any one sample.

COMMENTS: As mentioned in the comments above, the chronic TSS criterion is also applicable to these stream segments. The TMDL reductions that are detailed in the document may also be protective of the chronic criterion if averaged over a 30-day period, but the information needed to demonstrate that the chronic criterion will be met does not seem to be included in the document. Using the current data set, is there some way to demonstrate that the proposed reductions needed to meet the daily maximum target could reasonably meet the 30-day average value too? If not, could the document be revised as a phased TMDL to include an additional, chronic target, and a commitment to collect the data necessary to evaluate the reductions necessary to meet the chronic standard?

SDDENR RESPONSE: As described above, the TMDL is now based on the chronic (i.e. 30-day average) criterion, rather than the acute (i.e. daily maximum) criterion to ensure compliance with all applicable TSS standards. The reductions for each segment are now based on reaching the chronic (30-day average target).

3. Pollutant Source Analysis

A TMDL analysis is conducted when a pollutant load is known or suspected to be exceeding the loading capacity of the waterbody. Logically then, a TMDL analysis should consider all sources of the pollutant of concern in some manner. The detail provided in the source assessment step drives the rigor of the pollutant load allocation. In other words, it is only possible to specifically allocate quantifiable loads or load reductions to each significant source (or source category) when the relative load contribution from each source has been estimated. Therefore, the pollutant load from each significant source (or source category) should be identified and quantified to the maximum practical extent. This may 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 may be appropriate. The approach should be clearly defined in the document.

Minimum Submission Requirements:

- ☒ The TMDL should include an identification of all potentially significant point and nonpoint sources of the pollutant of concern, including the geographical location of the source(s) and the quantity of the loading, e.g., lbs/per day. This information is necessary for EPA to evaluate the WLA, LA and MOS components of the TMDL.
- ☒ The level of detail provided in the source assessment should be commensurate with the nature of the watershed and the nature of the pollutant being studied. Where it is possible to separate natural background from nonpoint sources, the TMDL should include a description of both the natural background loads and the nonpoint source loads.
- ☒ Natural background loads should not be assumed to be the difference between the sum of known and quantified anthropogenic sources and the existing *in situ* loads (e.g. measured in stream) unless it can be demonstrated that all significant anthropogenic sources of the pollutant of concern have been identified, characterized, and properly quantified.
- ☒ The sampling data relied upon to discover, characterize, and quantify the pollutant sources should be included in the document (e.g. a data appendix) along with a description of how the data were analyzed to characterize and quantify the pollutant sources. A discussion of the known deficiencies and/or gaps in the data set and their potential implications should also be included.

Recommendation:
☒ Approve ☐ Partial Approval ☐ Disapprove ☐ Insufficient Information

SUMMARY: The TMDL document includes a discussion of the landuses in the Lower Big Sioux River watershed. Much of the watershed was originally dominated by tallgrass prairie, but it has since been converted to intensive row crop agriculture. The cropland is dominated by corn, soybeans and other feed grains that are interspersed with pastureland. Table 2 shows the significant percentages of the 15-land use categories taken from the 2001 National Land Cover Data set (NLCD, 2001) used for the Lower Big Sioux River and the Rock River drainage areas in Iowa, respectively. The Table lists both the total acreage and the percent land uses.

Table 2. Landuse for three segments of the Lower Big Sioux River.

NLCD Code	2001 National Land Cover Data Set Landuse Category	Segment R15		Segment R16		Segment R17	
		Iowa*	SD	Iowa	SD	Iowa	SD
11	Open Water	0.29%	0.97%	0.33%	0.88%	1.11%	0.32%
21	Developed, Open Space	5.37%	5.20%	5.63%	3.84%	5.20%	5.43%
22	Developed, Low Intensity	0.78%	0.25%	0.69%	0.11%	0.87%	0.60%
23	Developed, Medium Intensity	0.27%	0.06%	0.32%	0.03%	0.22%	0.32%
24	Developed, High Intensity	0.05%	0.01%	0.08%	0.00%	0.05%	0.07%
31	Barren Land, Rock, Sand, Clay	0.08%	0.01%	0.06%	0.00%	0.05%	0.03%
41	Deciduous Forest	0.71%	3.13%	0.75%	2.82%	8.53%	1.42%
42	Evergreen Forest	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
43	Mixed Forest	0.14%	0.01%	0.13%	0.05%	0.27%	0.08%
52	Shrub, Scrub	0.07%	0.00%	0.03%	0.00%	0.11%	0.00%
71	Grassland, Herbaceous	5.30%	4.31%	4.44%	8.93%	27.89%	3.19%
81	Pasture, Hay	3.24%	11.41%	1.75%	16.30%	2.19%	9.07%
82	Cultivated Crops	82.48%	72.95%	84.26%	62.99%	50.97%	78.19%
90	Woody Wetlands	0.03%	0.16%	0.12%	0.90%	0.44%	0.17%
95	Emergent Herbaceous Wetlands	1.20%	1.52%	1.42%	3.14%	2.09%	1.11%
	Total Acres per Segment per State	1,094,943	47,625	26,928	158,195	117,106	239,797
	Total Hectares per Segment per State	443,124	19,274	10,898	64,022	47,393	97,046

* includes Minnesota portion of the Rock River

The TMDL document identifies the main sediment sources as: overland runoff from nearby croplands and feedlots, inflow from tributaries and streambank erosion. There are also three point sources located directly on the river, and there are several other National Pollution Discharge Elimination System (NPDES) permittees within both Iowa and SD, but they drain into tributaries of the Big Sioux River. For Iowa, many of the NPDES permittees are either zero discharge facilities or are located a long distance away from the Big Sioux River. They provide an insignificant contribution of sediment relative to nonpoint sources.

The City of Hudson, SD (NPDES permit number SDG822471) is located approximately in the middle of Segment R15. Although Hudson is a NPDES permitted facility it does not discharge and, therefore, will not be included as part of the waste load allocation for Segment R15.

Hawarden, IA (NPDES permit number 8434001; IA0021083) is a municipal activated sludge wastewater treatment facility (WWTF) located in Segment R16. The Hawarden WWTF outfall discharges directly to the Big Sioux River. A wasteload allocation (WLA) provided by the Iowa Department of Natural Resources (IDNR) was calculated for this facility and is included in the TMDL for Segment R16. However, the TSS contribution from this facility to the Big Sioux River is insignificant (<1.0%).

Akron, IA (NPDES permit number 7509001; IA0035211) is a three-cell waste stabilization lagoon system that has a controlled discharge to Segment R17 of the Big Sioux River. A WLA provided by IDNR was calculated for this facility and is included in the TSS TMDL for Segment R17. However, the TSS contribution from this facility to the Big Sioux River is insignificant (<1.0%).

4. TMDL Technical Analysis

TMDL determinations should be supported by a robust data set and an appropriate level of technical analysis**.** This 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.

A TMDL analysis determines the maximum pollutant loading rate that may be allowed to a waterbody without violating water quality standards. The TMDL analysis should demonstrate an understanding of the relationship between the rate of pollutant loading into the waterbody and the resultant water quality impacts. This stressor → response relationship between the pollutant and impairment and between the selected targets, sources, TMDLs, and load allocations needs to be clearly articulated and supported by an appropriate level of technical analysis. Every effort should be made to be as detailed as possible, and to base all conclusions on the best available scientific principles.

The pollutant loading allocation is at the heart of the TMDL analysis. TMDLs apportion responsibility for taking actions by allocating 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 division of responsibility.

The pollutant loading allocation that will result in achievement of the water quality target is expressed in the form of the standard TMDL equation:

$$TMDL = \sum LAs + \sum WLAs + MOS$$

Where:

TMDL = Total Pollutant Loading Capacity of the waterbody

LAs = Pollutant Load Allocations

WLAs = Pollutant Wasteload Allocations

MOS = The portion of the Load Capacity allocated to the Margin of safety.

Minimum Submission Requirements:

- ☒ A TMDL must identify the loading capacity of a waterbody for the applicable pollutant, taking into consideration temporal variations in that capacity. EPA regulations define loading capacity as the greatest amount of a pollutant that a water can receive without violating water quality standards (40 C.F.R. §130.2(f)).
- ☒ The total loading capacity of the waterbody should be clearly demonstrated to equate back to the pollutant load allocations through a balanced TMDL equation. In instances where numerous LA, WLA and seasonal TMDL capacities make expression in the form of an equation cumbersome, a table may be substituted as long as it is clear that the total TMDL capacity equates to the sum of the allocations.

☒ The TMDL document should describe the methodology and technical analysis used to establish and quantify the cause-and-effect relationship between the numeric target and the identified pollutant sources. In many instances, this method will be a water quality model.

☒ It is necessary for EPA staff to be aware of any assumptions used in the technical analysis to understand and evaluate the methodology used to derive the TMDL value and associated loading allocations. Therefore, the TMDL document should contain a description of any important assumptions (including the basis for those assumptions) made in developing the TMDL, including but not limited to:

(1) the spatial extent of the watershed in which the impaired waterbody is located and the spatial extent of the TMDL technical analysis;
(2) the distribution of land use in the watershed (e.g., urban, forested, agriculture);
(3) a presentation of relevant information affecting the characterization of the pollutant of concern and its allocation to sources such as population characteristics, wildlife resources, industrial activities etc…;
(4) present and future growth trends, if taken into consideration in determining the TMDL and preparing the TMDL document (e.g., the TMDL could include the design capacity of an existing or planned wastewater treatment facility);
(5) an explanation and analytical basis for expressing the TMDL through surrogate measures, if applicable. Surrogate measures are parameters such as percent fines and turbidity for sediment impairments; chlorophyll *a* and phosphorus loadings for excess algae; length of riparian buffer; or number of acres of best management practices.

☒ The TMDL document should contain documentation supporting the TMDL analysis, including an inventory of the data set used, a description of the methodology used to analyze the data, a discussion of strengths and weaknesses in the analytical process, and the results from any water quality modeling used. This information is necessary for EPA to review the loading capacity determination, and the associated load, wasteload, and margin of safety allocations.

☒ TMDLs must take critical conditions (e.g., steam flow, loading, and water quality parameters, seasonality, etc…) into account as part of the analysis of loading capacity (40 C.F.R. §130.7(c)(1)). TMDLs should define applicable critical conditions and describe the approach used to determine both point and nonpoint source loadings under such critical conditions. In particular, the document should discuss the approach used to compute and allocate nonpoint source loadings, e.g., meteorological conditions and land use distribution.

☐ Where both nonpoint sources and NPDES permitted point sources are included in the TMDL loading allocation, and attainment of the TMDL target depends on reductions in the nonpoint source loads, the TMDL document must include a demonstration that nonpoint source loading reductions needed to implement the load allocations are actually practicable [40 CFR 130.2(i) and 122.44(d)].

Recommendation:
☐ Approve ☒ Partial Approval ☐ Disapprove ☐ Insufficient Information

SUMMARY: The technical analysis should 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 Lower Big Sioux River TMDL describes how the TSS loads were derived in order to meet the applicable water quality standards for the three 303(d) impaired stream segments.

A combination of FLUX and AnnAGNPS models along with load duration curves were used as part of the technical analysis for the Lower Big Sioux River TSS TMDLs. FLUX is a statistical modeling program that allows estimation of tributary mass discharges (loadings) from sample concentration data and daily flow records. Sediment and nutrient impacts on the surface water quality of the Lower Big Sioux Watershed were also evaluated through the use of the Annualized Agricultural Nonpoint Source (AnnAGNPS), a watershed runoff model. However, AnnAGNPS does not address channel stability or channel erosion, so a number of rapid geomorphic assessments (RGAs) were conducted at all mainstem sites and SD tributary sites during the course of the project. Scores from the RGAs help determine whether the channel is stable or unstable.

The TMDL loads and loading capacities were derived using the load duration curve (LDC) approach that results in a flow-variable target that considers the entire flow regime. The LDC is a dynamic expression of the allowable load for any given day. To aid in the interpretation of the TMDL, the LDC flow intervals were grouped into four flow zones. Once the loading capacity was derived for each flow zone then the load allocations were calculated by subtracting the WLA and MOS. The following tables from the TMDL document show the calculated loads for each flow regime for all three segments.

Table 10. Segment R15 – TSS Total Maximum Daily Load (TMDL) allocations by flow zone (Site LBSM13).

TMDL Component	Flow Zone (expressed as tons/day)			
	High 0-25% Flow	Moist 25-50% Flow	Mid 50-75% Flow	Dry 75-100% Flow
	1,697 - 46,772 cfs	634 - 1,696 cfs	208 - 633 cfs	0.2 - 207 cfs
95th Percentile Flow Per Zone	13,201.7	1,632.5	618.5	198.1
LA	4,997.3	532.1	175.1	34.5
WLA	0	0	0	0
MOS	613.2	161.2	87.3	49.1
TMDL	**5,611.0**	**693.8**	**262.9**	**84.2**

Table 11. Segment R16 – TSS Total Maximum Daily Load (TMDL) allocations by flow zone (Site LBSM17).

TMDL Component	Flow Zone (expressed as tons/day)			
	High 0-25% Flow	Moist 25-50% Flow	Mid 50-75% Flow	Dry 75-100% Flow
	1,860 - 50,600 cfs	710 - 1,859 cfs	250 - 709 cfs	4 - 249 cfs
95th Percentile Flow Per Zone	14,300.0	1,790.0	693.6	239.0
LA	5,414.2	586.0	199.9	39.0
WLA	0.531	0.531	0.531	0.531
MOS	663.0	174.3	94.4	62.1
TMDL	**6,077.8**	**760.8**	**294.8**	**101.6**

Table 13. Segment R17 – TSS Total Maximum Daily Load (TMDL) allocations by flow zone (Site LBSM21).

TMDL Component	Flow Zone (expressed as tons/day)			
	High 0-25% Flow	Moist 25-50% Flow	Mid 50-75% Flow	Dry 75-100% Flow
	2,492 - 53,393 cfs	1,149 - 2,491 cfs	612 - 1,148 cfs	325 - 611cfs
95th Percentile Flow Per Zone	17,014.6	2,409.8	1,129.8	599.1
LA	6,456.1	819.4	368.6	180.8
WLA	1.431	1.431	1.431	1.431
MOS	774.1	203.4	110.2	72.4
TMDL	**7,231.6**	**1,024.2**	**480.2**	**254.6**

COMMENTS: The technical analysis section should include the calculations and description of how the proposed loading capacity will be protective of both the acute and chronic WQS for TSS.

SDDENR RESPONSE: The following language was changed to Section 4.3 Water Quality Targets "Total suspended solids water quality criteria for the warmwater semipermanent fishery beneficial use requires that 1) no sample exceeds the daily maximum of 158 mg/L and 2) the arithmetic mean of a minimum of three (3) consecutive grab or composite samples taken on separate weeks in a 30-day period must not exceed 90 mg/L. Both criterion are applicable year round (ARSD 74:51:01:42). The appropriate target for the sediment TMDL for Segment R15, R16, and R17 of the Big Sioux River will be based on the 30-day average chronic criteria for total suspend solids.

During this study, each site shown in Table 6 (pg 18) exhibited several samples that exceeded the TSS daily maximum criterion (158 mg/L). Total Suspended Solids was listed as the cause of impairment for all three reaches in the SD 2008 Impaired Waterbodies List. Table 5 shows significant differences in violations rates between flowzones. There is a significant relationship between high flows (storm events) and high concentrations of TSS.

The numeric TMDL targets established herein for Segments R15, R16, and R17 warmwater semipermanent fish life propagation is based on South Dakota's 30-day average TSS criterion for the fishery use."

SDDENR RESPONSE cont: In addition the following language was changed in the Load Allocation section for each TMDL:

"The 30-day average criterion (90 mg/L) was used for the calculation of the LC, rather than the daily maximum criterion (158 mg/L) because the chronic criterion is considered more protective. The 30-day average, as defined in ARSD § 74:51:01:01, is the arithmetic mean of a minimum of three consecutive grab or composite samples taken on separate weeks in a 30-day period. The 30-day average TSS criteria (ARSD § 74:51:01:48) applies at all times but compliance can only be determined when a minimum of three samples are obtained during separate weeks for any 30-day period. In many instances, only one or two samples were collected during any 30-day period, so the average criterion was applied to each flowzone in Figure X. Although the daily maximum criteria are exceeded, to be conservative it was decided to use the average criterion to develop the loading capacity of the stream in order to ensure that the most stringent water quality standards are met. Additional data is needed to accurately assess compliance with the 30-day average criterion. The loading capacities and reductions derived from the available data are estimates (i.e., the calculated loading capacities and reductions may be higher or lower if/when a more extensive data set is collected to fully assess compliance with the chronic standard). For each of the four flow zones, the 50th percentile (median) of the range of LCs within a zone was set as the flow zone goal. TSS loads experienced during the largest stream flows (e.g. top 5 percent) cannot be feasibly controlled by practical management practices. Setting the flow zone goal at the 50th percentile while using the average (90 mg/L) criterion within each flowzone will protect the warmwater semipermanent fish life propagation beneficial use and allow for the natural variability of the system (Figure X)."

4.1 Data Set Description

TMDL documents should include a thorough description and summary of all available water quality data that are relevant to the water quality assessment and TMDL analysis. An inventory of the data used for the TMDL analysis should be provided to document, for the record, the data used in decision making. This also provides the reader with the opportunity to independently review the data. The TMDL analysis should make use of all readily available data for the waterbody under analysis unless the TMDL writer determines that the data are not relevant or appropriate. For relevant data that were known but rejected, an explanation of why the data were not utilized should be provided (e.g., samples exceeded holding times, data collected prior to a specific date were not considered timely, etc…).

Minimum Submission Requirements:

☒ TMDL documents should include a thorough description and summary of all available water quality data that are relevant to the water quality assessment and TMDL analysis such that the water quality impairments are clearly defined and linked to the impaired beneficial uses and appropriate water quality criteria.

☒ The TMDL document submitted should be accompanied by the data set utilized during the TMDL analysis. If possible, it is preferred that the data set be provided in an electronic format and referenced in the document. If electronic submission of the data is not possible, the data set may be included as an appendix to the document.

Recommendation:
☒ Approve ☐ Partial Approval ☐ Disapprove ☐ Insufficient Information

SUMMARY: The Lower Big Sioux River TMDL data description and summary are included mainly in the Data Collection Method section of the document and are plotted on the load duration curves for all of the mainstem sites (see Appendix A). Sampling was conducted on a temporal basis over the period from January 2002 to August 2004 and included 1541 total samples for TSS and flow (combined). The data set also includes 30 years of flow record on the Lower Big Sioux River.

COMMENTS: None.

4.2 Waste Load Allocations (WLA):

Waste Load Allocations represent point source pollutant loads to the waterbody. Point source loads are typically better understood and more easily monitored and quantified than nonpoint source loads. Whenever practical, each point source should be given a separate waste load allocation. All NPDES permitted dischargers that discharge the pollutant under analysis directly to the waterbody should be identified and given separate waste load allocations. The finalized WLAs are required to be incorporated into future NPDES permit renewals.

Minimum Submission Requirements:

☒ EPA regulations require that a TMDL include WLAs for all significant and/or NPDES permitted point sources of the pollutant. TMDLs must identify the portion of the loading capacity allocated to individual existing and/or future point source(s) (40 C.F.R. §130.2(h), 40 C.F.R. §130.2(i)). In some cases, WLAs may cover more than one discharger, e.g., if the source is contained within a general permit. If no allocations are to be made to point sources, then the TMDL should include a value of zero for the WLA.

☒ All NPDES permitted dischargers given WLA as part of the TMDL should be identified in the TMDL, including the specific NPDES permit numbers, their geographical locations, and their associated waste load allocations.

Recommendation:
☒ Approve ☐ Partial Approval ☐ Disapprove ☐ Insufficient Information

SUMMARY: The Lower Big Sioux River TMDL document mentions three point sources located directly on the river, and several other NPDES permittees within both Iowa and SD that drain into tributaries of the Big Sioux River. The two point sources that discharge directly to the Big Sioux River (i.e., Akron, Hawarden) both provide an insignificant contribution of sediment relative to nonpoint sources.

COMMENTS: None.

4.3 Load Allocations (LA):

Load allocations include the nonpoint source, natural, and background loads. These types of loads are typically more difficult to quantify than point source loads, and may include a significant degree of uncertainty. Often it is necessary to group these loads into larger categories and estimate the loading rates based on limited monitoring data and/or modeling results. The background load represents a composite of all upstream pollutant loads into the waterbody. In addition to the upstream nonpoint and upstream natural load, the background load often includes upstream point source loads that are not given specific waste load allocations in this particular TMDL analysis. In instances where nonpoint source loading rates are particularly difficult to quantify, a performance-based allocation approach, in which a detailed monitoring plan and adaptive management strategy are employed for the application of BMPs, may be appropriate.

Minimum Submission Requirements:

☒ EPA regulations require that TMDL expressions include LAs which identify the portion of the loading capacity attributed to nonpoint sources and to natural background. Load allocations may range from reasonably accurate estimates to gross allotments (40 C.F.R. §130.2(g)). Load allocations may be included for both existing and future nonpoint source loads. Where possible, load allocations should be described separately for natural background and nonpoint sources.

☒ Load allocations assigned to natural background loads should not be assumed to be the difference between the sum of known and quantified anthropogenic sources and the existing *in situ* loads (e.g., measured in stream) unless it can be demonstrated that all significant anthropogenic sources of the pollutant of concern have been identified and given proper load or waste load allocations.

Recommendation:
☐ Approve ☒ Partial Approval ☐ Disapprove ☐ Insufficient Information

SUMMARY: The Load Allocations section for each of the three segments explains how the loading capacity and load allocation for each segment was derived. Since the majority of the landuse in the watershed is nonpoint sources, the majority of the loading capacity has been allocated to the nonpoint sources in the form of load allocations. Tables 10, 12 and 15 show the load allocations for each of the four flow regimes for each segment. Since these TMDLs are multijurisdictional, the load allocations for each state are based on the source contributions (in percent) from each 12 digit HUC watershed (see Tables 7, 8 and 9).

COMMENTS: As mentioned in comments above, we disagree with the statement in the Load Allocation section for each segment that implies that the 30-day average TSS criterion is not applicable to these TMDLs. We recommend either: averaging whatever monthly data is available (even if it's across different years), using the FLUX model to derive estimated monthly sediment loads (page 18 says it was used to develop estimated daily loads), or averaging the data within each flow zone. Using one of these methods, the data could be compared to the 30-day average criterion to determine the necessary load reductions. The more stringent loads (or load reductions) for each zone (i.e., based on those needed to meet the acute or chronic WQS) should be chosen for the TMDL for each segment.

SDDENR RESPONSE: Each TMDL was changed to reflect the use of the 30-day average target resulting in more stringent load reductions for each zone. See Sections 8.1, 8.2, 8.3 for the resulting changes.

4.4 Margin of Safety (MOS):

Natural systems are inherently complex. Any mathematical relationship used to quantify the stressor → response relationship between pollutant loading rates and the resultant water quality impacts, no matter how rigorous, will include some level of uncertainty and error. To compensate for this uncertainty and ensure water quality standards will be attained, a margin of safety is required as a component of each TMDL. The MOS may take the form of a explicit load allocation (e.g., 10 lbs/day), or may be implicitly built into the TMDL analysis through the use of conservative assumptions and values for the various factors that determine the TMDL pollutant load → water quality effect relationship. Whether explicit or implicit, the MOS should be supported by an appropriate level of discussion that addresses the level of uncertainty in the various components of the TMDL technical analysis, the assumptions used in that analysis, and the relative effect of those assumptions on the final TMDL. The discussion should demonstrate that the MOS used is sufficient to ensure that the water quality standards would be attained if the TMDL pollutant loading rates are met. 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).

Minimum Submission Requirements:

☒ TMDLs must include a margin of safety (MOS) to account for any lack of knowledge concerning the relationship between load and wasteload allocations and water quality (CWA §303(d)(1)(C), 40 C.F.R. §130.7(c)(1)). EPA's 1991 TMDL Guidance explains that the MOS may be implicit (i.e., incorporated into the TMDL through conservative assumptions in the analysis) or explicit (i.e., expressed in the TMDL as loadings set aside for the MOS).

- ☐ If the MOS is implicit, the conservative assumptions in the analysis that account for the MOS should be identified and described. The document should discuss why the assumptions are considered conservative and the effect of the assumption on the final TMDL value determined.
- ☒ If the MOS is explicit, the loading set aside for the MOS should be identified. The document should discuss how the explicit MOS chosen is related to the uncertainty and/or potential error in the linkage analysis between the WQS, the TMDL target, and the TMDL loading rate.
- ☐ If, rather than an explicit or implicit MOS, the TMDL relies upon a phased approach to deal with large and/or unquantifiable uncertainties in the linkage analysis, the document should include a description of the planned phases for the TMDL as well as a monitoring plan and adaptive management strategy.

Recommendation:
☒ Approve ☐ Partial Approval ☐ Disapprove ☐ Insufficient Information

SUMMARY: The Lower Big Sioux River TMDLs include an explicit MOS for each segment that was derived by calculating the difference between the loading capacity at the mid-point of each of the four flow zones and the loading capacity at the minimum flow in each zone. The explicit MOS values are included in Tables 10, 12 and 15 of the TMDL.

COMMENTS: None.

SDDENR RESPONSE: Due to the changes in the target a change was required in the MOS methodology as well. An explicit 10% MOS was used rather than the previous method. See Section 9.0 of the TMDL document for the resulting changes.

4.5 Seasonality and variations in assimilative capacity:

The TMDL relationship is a factor of both the loading rate of the pollutant to the waterbody and the amount of pollutant the waterbody can assimilate and still attain water quality standards. Water quality standards often vary based on seasonal considerations. Therefore, it is appropriate that the TMDL analysis consider seasonal variations, such as critical flow periods (high flow, low flow), when establishing TMDLs, targets, and allocations.

Minimum Submission Requirements:

☒ The statute and regulations require that a TMDL be established with consideration of seasonal variations. The TMDL must describe the method chosen for including seasonal variability as a factor. (CWA §303(d)(1)(C), 40 C.F.R. §130.7(c)(1)).

Recommendation:
☒ Approve ☐ Partial Approval ☐ Disapprove ☐ Insufficient Information

SUMMARY: By using the load duration curve approach to develop the TMDL allocations seasonal variability in TSS loads are taken into account. Highest steam flows typically occur during late spring, and the lowest stream flows occur during the winter months.

COMMENTS: None.

5. Public Participation

EPA regulations require that the establishment of TMDLs be conducted in a process open to the public, and that the public be afforded an opportunity to participate. To meaningfully participate in the TMDL process it is necessary that stakeholders, including members of the general public, be able to understand the problem and the proposed solution. TMDL documents should include language that explains the issues to the general public in understandable terms, as well as provides additional detailed technical information for the scientific community. Notifications or solicitations for comments regarding the TMDL should be made available to the general public, widely circulated, and 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 approval, a copy of the comments received by the state and the state responses to those comments should be included with the document.

Minimum Submission Requirements:
☒ The TMDL must include a description of the public participation process used during the development of the TMDL (40 C.F.R. §130.7(c)(1)(ii)).

☐ TMDLs submitted to EPA for review and approval should include a summary of significant comments and the State's/Tribe's responses to those comments.

Recommendation:
☒ Approve ☐ Partial Approval ☐ Disapprove ☐ Insufficient Information

SUMMARY: The State's submittal includes a summary of the public participation process that has occurred which describes the ways the public has been given an opportunity to be involved in the TMDL development process so far. In particular, the State has encouraged participation through public meetings in the watershed, and a website was developed and maintained throughout the project. The TMDL has been available for a 30-day public notice period prior to finalization.

COMMENTS: None.

6. Monitoring Strategy

TMDLs may have significant uncertainty associated with the 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 document to articulate the means by which the TMDL will be evaluated in the field, and to provide for future supplemental data that will address any uncertainties that may exist when the document is prepared.

Minimum Submission Requirements:

☒ When a TMDL involves both NPDES permitted point source(s) and nonpoint source(s) allocations, and attainment of the TMDL target depends on reductions in the nonpoint source loads, the TMDL document should include a monitoring plan that describes the additional data to be collected to determine if the load reductions provided for in the TMDL are occurring.

☒ Under certain circumstances, a phased TMDL approach may be utilized when limited existing data are relied upon to develop a TMDL, and the State believes that the use of additional data or data based on better analytical techniques would likely increase the accuracy of the TMDL load calculation and merit development of a second phase TMDL. EPA recommends that a phased TMDL document or its implementation plan include a monitoring plan and a scheduled timeframe for revision of the TMDL. These elements would not be an intrinsic part of the TMDL and would not be approved by EPA, but may be necessary to support a rationale for approving the TMDL. http://www.epa.gov/owow/tmdl/tmdl_clarification_letter.pdf

Recommendation:
☒ Approve ☐ Partial Approval ☐ Disapprove ☐ Insufficient Information

SUMMARY: The Lower Big Sioux River should continue to be monitored as part of DENR's ambient water quality monitoring at stations within the three impaired segments addressed by this TMDL document. Post-implementation monitoring will be necessary to assure the TMDL has been reached and maintenance of the beneficial use occurs.

COMMENTS: None.

7. Restoration Strategy

The overall purpose of the TMDL analysis is to determine what actions are necessary to ensure that the pollutant load in a waterbody does not result in water quality impairment. Adding additional detail regarding the proposed approach for the restoration of water quality <u>is not</u> currently a regulatory requirement, but is considered a value added component of a TMDL document. During the TMDL analytical process, information is often gained that may serve to point restoration efforts in the right direction and help ensure that resources are spent in the most efficient manner possible. For example, watershed models used to analyze the linkage between the pollutant loading rates and resultant water quality impacts might also be used to conduct "what if" scenarios to help direct BMP installations to locations that provide the greatest pollutant reductions. Once a TMDL has been written and approved, it is often the responsibility of other water quality programs to see that it is implemented. The level of quality and detail provided in the restoration strategy will greatly influence the future success in achieving the needed pollutant load reductions.

Minimum Submission Requirements:

☒ EPA is not required to and does not approve TMDL implementation plans. However, in cases where a WLA is dependent upon the achievement of a LA, "reasonable assurance" is required to demonstrate the necessary LA called for in the document is practicable). A discussion of the BMPs (or other load reduction measures) that are to be relied upon to achieve the LA(s), and programs and funding sources that will be relied upon to implement the load reductions called for in the document, may be included in the implementation/restoration section of the TMDL document to support a demonstration of "reasonable assurance".

Recommendation:
☒ Approve ☐ Partial Approval ☐ Disapprove ☐ Insufficient Information

SUMMARY: The Implementation section of the TMDL document says that an implementation project has already been developed to address the Lower Big Sioux River pathogen impairments. The next round of Section 319 project funding, an expansion project will be proposed to address the TSS impairment sources detailed in the TMDL document. Since the point sources in the Lower Big Sioux River watershed are insignificant contributors of TSS, and the WLAs for those point sources are included in the load allotments for Iowa, there is no need to include a discussion of reasonable assurance in this TMDL document.

COMMENTS: None.

8. Daily Loading Expression

The goal of a TMDL analysis is to determine what actions are necessary to attain and maintain WQS. The appropriate averaging period that corresponds to this goal will vary depending on the pollutant and the nature of the waterbody under analysis. When selecting an appropriate averaging period for a TMDL analysis, primary concern should be given to the nature of the pollutant in question and the achievement of the underlying WQS. However, recent federal appeals court decisions have pointed out that the title TMDL implies a "daily" loading rate. While the most appropriate averaging period to be used for developing a TMDL analysis may vary according to the pollutant, a daily loading rate can provide a more practical indication of whether or not the overall needed load reductions are being achieved. When limited monitoring resources are available, a daily loading target that takes into account the natural variability of the system can serve as a useful indicator for whether or not the overall load reductions are likely to be met. Therefore, a daily expression of the required pollutant loading rate is a required element in all TMDLs, in addition to any other load averaging periods that may have been used to conduct the TMDL analysis. The level of effort spent to develop the daily load indicator should be based on the overall utility it can provide as an indicator for the total load reductions needed.

Minimum Submission Requirements:

☒ The document should include an expression of the TMDL in terms of a daily load. However, the TMDL may also be expressed in temporal terms other than daily (e.g., an annual or monthly load). If the document expresses the TMDL in additional "non-daily" terms the document should explain why it is appropriate or advantageous to express the TMDL in the additional unit of measurement chosen.

Recommendation:
☒ Approve ☐ Partial Approval ☐ Disapprove ☐ Insufficient Information

SUMMARY: The Lower Big Sioux River TSS TMDLs include daily loads expressed as tons per day. The daily TMDL loads are included in the TMDL Allocations sections of the TMDL document.

COMMENTS: None.

26.0 APPENDIX K:

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 8
1595 Wynkoop Street
DENVER, CO 80202-1129
Phone 800-227-8917
http://www.epa.gov/region08
FEB 01 2010

RECEIVED

FEB 04 2010

DEPT. OF ENVIRONMENT AND NATURAL RESOURCES, WASTE MANAGEMENT

Ref: 8EPR-EP

Steven M. Pirner
Secretary
South Dakota Department of Environment & Natural Resources
Joe Foss Building
523 East Capitol
Pierre, SD 57501-3181

Re: TMDL Approvals
Big Sioux River, 3 lower segments; SD-BS-R-BIG_SIOUX_15; SD-BS-R-BIG_SIOUX_16; SD-BS-R-BIG_SIOUX_17

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.

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 he may be reached at 303-312-6234.

Sincerely,

Eddie A. Sierra

Eddie A. Sierra
Acting Assistant Regional Administrator
Office of Ecosystems Protection
and Remediation

Enclosures

ENCLOSURE 1: APPROVED TMDLs

Total Suspended Solids Total Maximum Daily Load (TMDL) for Three Segments of the Lower Big Sioux River, South Dakota and Iowa, SD DENR, Sept 2009

Submitted: 1/5/2010

3 Pollutant TMDLs completed.

3 Causes addressed from the 2008 303(d) list.

Determinations that no pollutant TMDL needed.

Segment: Big Sioux River - Fairview to near Alcester

303(d) ID: SD-BS-R-BIG SIOUX 15

Parameter/Pollutant (303(d) list cause): TOTAL SUSPENDED SOLIDS - 518

Water Quality Targets: 30-day average < = 90 mg/L, and daily maximum < = 158 mg/L.

Allocation*	Value	Units	Permits
WLA	0	TONS/DAY	
LA	222.7	TONS/DAY	
MOS	24.7	TONS/DAY	
TMDL	247.4	TONS/DAY	

Notes: Loads shown represent the loads during the moist flow regime as defined by the load duration curve for the lower Big Sioux River (see Table 11 of the TMDL). The moist range flows are when the largest differences occur between the existing loads and the target loads, therefore the greatest load reductions are needed to meet the water quality standards.

ENCLOSURE 1: APPROVED TMDLs

Date Submitted: 1/5/2010

Segment: **Big Sioux River - Indian Creek to mouth**

303(d) ID: SD-BS-R-BIG SIOUX 17

Parameter/Pollutant (303(d) list cause): TOTAL SUSPENDED SOLIDS - 518

Water Quality Targets: 30-day average <= 90 mg/L, and daily maximum <= 158 mg/L.

Allocation*	Value	Units	Permits
LA	357.2	TONS/DAY	
MOS	39.7	TONS/DAY	
TMDL	396.9	TONS/DAY	
WLA	negligible		

Notes: Loads shown represent the loads during the moist flow regime as defined by the load duration curve for the lower Big Sioux River (see Table 16 of the TMDL). The moist range flows are when significant differences occur between the existing loads and the target loads, and represent the flow regime that is most likely to be targeted for BMP implementation. The City of Akron, IA has a wastewater treatment facility that discharges to this stream segment. The TSS load from this facility is < 1.0 percent of the total load in this segment and is considered insignificant. The WLA is included in the gross load allotment for Iowa.

ENCLOSURE 1: APPROVED TMDLs

Date Submitted: 1/5/2010

Segment: **Big Sioux River - Near Alcester to Indian Creek**

303(d) ID: SD-BS-R-BIG SIOUX 16

Parameter/Pollutant (303(d) list cause): TOTAL SUSPENDED SOLIDS - 518

Water Quality Targets: 30-day average < = 90 mg/L, and daily maximum < = 158 mg/L.

Allocation*	Value	Units	Permits
LA	246.2	TONS/DAY	
MOS	27.4	TONS/DAY	
TMDL	273.6	TONS/DAY	
WLA	negligible		

Notes: Loads shown represent the loads during the moist flow regime as defined by the load duration curve for the lower Big Sioux River (see Table 13 of the TMDL). The moist range flows are when significant differences occur between the existing loads and the target loads, and represent the flow regime that is most likely to be targeted for BMP implementation. The City of Hawarden, IA has a wastewater treatment facility that discharges to this stream segment. The TSS load from this facility is < 1.0 percent of the total load in this segment and is considered insignificant. The WLA is included in the gross load allotment for Iowa.

* LA = Load Allocation, WLA = Wasteload Allocation, MOS = Margin of Safety, TMDL = sum(WLAs) + sum(LAs) + MOS

ENCLOSURE 2

EPA REGION VIII TMDL REVIEW

TMDL Document Info:

Document Name:	**Total Suspended Solids Total Maximum Daily Load (TMDL) for Three Segments of the Lower Big Sioux River, South Dakota and Iowa**
Submitted by:	**Cheryl Saunders, SD DENR**
Date Received:	**January 5, 2010**
Review Date:	**January 12, 2010**
Reviewer:	**Vern Berry, EPA**
Rough Draft / Public Notice / Final?	**Final**
Notes:	

Reviewers Final Recommendation(s) to EPA Administrator (used for final review only):

☒ Approve
☐ Partial Approval
☐ Disapprove
☐ Insufficient Information

Approval Notes to Administrator:

This document provides a standard format for EPA Region 8 to provide comments to state TMDL programs on TMDL documents submitted to EPA for either formal or informal review. All TMDL documents are evaluated against the minimum submission requirements and TMDL elements identified in the following 8 sections:

1. Problem Description
   1.1. TMDL Document Submittal Letter
   1.2. Identification of the Waterbody, Impairments, and Study Boundaries
   1.3. Water Quality Standards
2. Water Quality Target
3. Pollutant Source Analysis
4. TMDL Technical Analysis
   4.1. Data Set Description
   4.2. Waste Load Allocations (WLA)
   4.3. Load Allocations (LA)
   4.4. Margin of Safety (MOS)
   4.5. Seasonality and variations in assimilative capacity
5. Public Participation
6. Monitoring Strategy
7. Restoration Strategy
8. Daily Loading Expression

Under Section 303(d) of the Clean Water Act, waterbodies that are not attaining one or more water quality standard (WQS) are considered "impaired." When the cause of the impairment is determined to be a pollutant, a TMDL analysis is required to assess the appropriate maximum allowable pollutant loading rate.

A TMDL document consists of a technical analysis conducted to: (1) assess the maximum pollutant loading rate that a waterbody is able to assimilate while maintaining water quality standards; and (2) allocate that assimilative capacity among the known sources of that pollutant. A well written TMDL document will describe a path forward that may be used by those who implement the TMDL recommendations to attain and maintain WQS.

Each of the following eight sections describes the factors that EPA Region 8 staff considers when reviewing TMDL documents. Also included in each section is a list of EPA's minimum submission requirements relative to that section, a brief summary of the EPA reviewer's findings, and the reviewer's comments and/or suggestions. Use of the verb "must" in the minimum submission requirements denotes information that is required to be submitted because it relates to elements of the TMDL required by the CWA and by regulation. Use of the term "should" below denotes information that is generally necessary for EPA to determine if a submitted TMDL is approvable.

This review template is intended to ensure compliance with the Clean Water Act and that the reviewed documents are technically sound and the conclusions are technically defensible.

1. Problem Description

A TMDL document needs to provide a clear explanation of the problem it is intended to address. Included in that description should be a definitive portrayal of the physical boundaries to which the TMDL applies, as well as a clear description of the impairments that the TMDL intends to address and the associated pollutant(s) causing those impairments. While the existence of one or more impairment and stressor may be known, it is important that a comprehensive evaluation of the water quality be conducted prior to development of the TMDL to ensure that all water quality problems and associated stressors are identified. Typically, this step is conducted prior to the 303(d) listing of a waterbody through the monitoring and assessment program. The designated uses and water quality criteria for the waterbody should be examined against available data to provide an evaluation of the water quality relative to all applicable water quality standards. If, as part of this exercise, additional WQS problems are discovered and additional stressor pollutants are identified, consideration should be given to concurrently evaluating TMDLs for those additional pollutants. If it is determined that insufficient data is available to make such an evaluation, this should be noted in the TMDL document.

1.1 TMDL Document Submittal Letter

When a TMDL document is submitted to EPA requesting formal comments or a final review and approval, the submittal package should include a letter identifying the document being submitted and the purpose of the submission.

Minimum Submission Requirements.

☒ A TMDL submittal letter should be included with each TMDL document submitted to EPA requesting a formal review.

☒ The submittal letter should specify whether the TMDL document is being submitted for initial review and comments, public review and comments, or final review and approval.

☒ Each TMDL document submitted to EPA for final review and approval should be accompanied by a submittal letter that explicitly states that the submittal is a final TMDL submitted under Section 303(d) of the Clean Water Act for EPA review and approval. This clearly establishes the State's/Tribe's intent to submit, and EPA's duty to review, the TMDL under the statute. The submittal letter should contain such identifying information as the name and location of the waterbody and the pollutant(s) of concern, which matches similar identifying information in the TMDL document for which a review is being requested.

Recommendation:
☒ Approve ☐ Partial Approval ☐ Disapprove ☐ Insufficient Information

SUMMARY: The final Lower Big Sioux River total suspended solids (TSS) TMDLs were submitted to EPA via an email from Cheryl Saunders, SD DENR on January 5, 2010. The email included the final TMDL document and a letter requesting EPA review and approval of the TMDLs.

COMMENTS: None.

1.2 Identification of the Waterbody, Impairments, and Study Boundaries

The TMDL document should provide an unambiguous description of the waterbody to which the TMDL is intended to apply and the impairments the TMDL is intended to address. The document should also clearly delineate the physical boundaries of the waterbody and the geographical extent of the watershed area studied. Any additional information needed to tie the TMDL document back to a current 303(d) listing should also be included.

Minimum Submission Requirements:

☒ The TMDL document should clearly identify the pollutant and waterbody segment(s) for which the TMDL is being established. If the TMDL document is submitted to fulfill a TMDL development requirement for a waterbody on the state's current EPA approved 303(d) list, the TMDL document submittal should clearly identify the waterbody and associated impairment(s) as they appear on the State's/Tribe's current EPA approved 303(d) list, including a full waterbody description, assessment unit/waterbody ID, and the priority ranking of the waterbody. This information is necessary to ensure that the administrative record and the national TMDL tracking database properly link the TMDL document to the 303(d) listed waterbody and impairment(s).

☒ One or more maps should be included in the TMDL document showing the general location of the waterbody and, to the maximum extent practical, any other features necessary and/or relevant to the understanding of the TMDL analysis, including but not limited to: watershed boundaries, locations of major pollutant sources, major tributaries included in the analysis, location of sampling points, location of discharge gauges, land use patterns, and the location of nearby waterbodies used to provide surrogate information or reference conditions. Clear and concise descriptions of all key features and their relationship to the waterbody and water quality data should be provided for all key and/or relevant features not represented on the map

☐ If information is available, the waterbody segment to which the TMDL applies should be identified/geo-referenced using the National Hydrography Dataset (NHD). If the boundaries of the TMDL do not correspond to the Waterbody ID(s) (WBID), Entity_ID information or reach code (RCH_Code) information should be provided. If NHD data is not available for the waterbody, an alternative geographical referencing system that unambiguously identifies the physical boundaries to which the TMDL applies may be substituted.

Recommendation:
☒ Approve ☐ Partial Approval ☐ Disapprove ☐ Insufficient Information

SUMMARY: The Lower Big Sioux River is located southeastern South Dakota and forms a border between South Dakota and Iowa. The Lower Big Sioux River watershed (HUC 10170203) is part of the larger Missouri River basin. Lower Big Sioux River has a total drainage area of approximately 661,418 acres in South Dakota and approximately 919,040 acres in Iowa. This TMDL document covers three (3) listed segments of Lower Big Sioux River including: 1) Big Sioux River from near Fairview to near Alcester, SD (20.0 miles, SD-BS-R-BIG_SIOUX_15); 2) Big Sioux River from near Alcester, SD to Indian Creek (16.6 miles, SD-BS-R-BIG_SIOUX_16); and 3) Big Sioux River from Indian Creek to the mouth (59.9 miles, SD-BS-R-BIG_SIOUX_17). All three segments are listed as high priority for TMDL development.

The South Dakota designated uses for the Lower Big Sioux River segments include warmwater semi-permanent fish life propagation waters, immersion recreation waters, irrigation, fish and wildlife propagation, recreation, and stock watering. The Iowa designated uses for these segments include primary contact recreation, warm water, type 1 aquatic life and human health. These segments were listed by SD DENR in 2008 for fecal coliform bacteria which is impairing the immersion recreational uses, and for total suspended solids (TSS) which is impairing the warmwater fish propagation uses. Iowa has not listed these segments as impaired by sediment. This approval applies only to the SD TSS impairments, the fecal coliform impairments in these segments have been addressed by both IA and SD in a separate TMDL document.

COMMENTS: None.

1.3 Water Quality Standards

TMDL documents should provide a complete description of the water quality standards for the waterbodies addressed, including a listing of the designated uses and an indication of whether the uses are being met, not being met, or not assessed. If a designated use was not assessed as part of the TMDL analysis (or not otherwise recently assessed), the documents should provide a reason for the lack of assessment (e.g., sufficient data was not available at this time to assess whether or not this designated use was being met).

Water quality criteria (WQC) are established as a component of water quality standard at levels considered necessary to protect the designated uses assigned to that waterbody. WQC identify quantifiable targets and/or qualitative water quality goals which, if attained and maintained, are intended to ensure that the designated uses for the waterbody are protected. TMDLs result in maintaining and attaining water quality standards by determining the appropriate maximum pollutant loading rate to meet water quality criteria, either directly, or through a surrogate measurable target. The TMDL document should include a description of all applicable water quality criteria for the impaired designated uses and address whether or not the criteria are being attained, not attained, or not evaluated as part of the analysis. If the criteria were not evaluated as part of the analysis, a reason should be cited (e.g. insufficient data were available to determine if this water quality criterion is being attained).

Minimum Submission Requirements:

- ☒ The TMDL must include a description of the applicable State/Tribal water quality standard, including the designated use(s) of the waterbody, the applicable numeric or narrative water quality criterion, and the anti-degradation policy. (40 C.F.R. §130.7(c)(1)).
- ☒ The purpose of a TMDL analysis is to determine the assimilative capacity of the waterbody that corresponds to the existing water quality standards for that waterbody, and to allocate that assimilative capacity between the significant sources. Therefore, all TMDL documents must be written to meet the existing water quality standards for that waterbody (CWA §303(d)(1)(C)).

  Note: In some circumstances, the load reductions determined to be necessary by the TMDL analysis may prove to be infeasible and may possibly indicate that the existing water quality standards and/or assessment methodologies may be erroneous. However, the TMDL must still be determined based on existing water quality standards. Adjustments to water quality standards and/or assessment methodologies may be evaluated separately, from the TMDL.
- ☒ The TMDL document should describe the relationship between the pollutant of concern and the water quality standard the pollutant load is intended to meet. This information is necessary for EPA to evaluate whether or not attainment of the prescribed pollutant loadings will result in attainment of the water quality standard in question.
- ☒ If a standard includes multiple criteria for the pollutant of concern, the document should demonstrate that the TMDL value will result in attainment of all related criteria for the pollutant. For example, both acute and chronic

values (if present in the WQS) should be addressed in the document, including consideration of magnitude, frequency and duration requirements.

Recommendation:
☒ Approve ☐ Partial Approval ☐ Disapprove ☐ Insufficient Information

SUMMARY: The Lower Big Sioux River segments addressed by these TMDLs are impaired based on SD DENR's water quality standards for total suspended solids (TSS) designed to protect the warmwater semi permanent fish life propagation designated use. Iowa has narrative standards that may indirectly be applicable to sediment impairments. South Dakota has applicable numeric standards for TSS that may be applied to these river segments. The numeric standards being implemented in these TMDLs are: a daily maximum value of TSS of 158 mg/L in any one sample, or an arithmetic mean of 90 mg/L over a 30 day period. South Dakota's numeric standards are more stringent than Iowa's narrative standards; therefore South Dakota's standards are more protective. Discussion of additional applicable water quality standards for Lower Big Sioux River can be found on pages 13 - 15 of the TMDL document.

COMMENTS: None.

2. Water Quality Targets

TMDL analyses establish numeric targets that are used to determine whether water quality standards are being achieved. Quantified water quality targets or endpoints should be provided to evaluate each listed pollutant/water body combination addressed by the TMDL, and should 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 water quality target. For pollutants with narrative standards, the narrative standard should 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 a variety of targets representing water column sediment such as TSS, embeddeness, stream morphology, up-slope conditions and a measure of biota).

Minimum Submission Requirements:

☒ The TMDL should identify a numeric water quality target(s) for each waterbody pollutant combination. The TMDL target is a quantitative value used to measure whether or not the applicable water quality standard is attained.

Generally, the pollutant of concern and the numeric water quality target are, respectively, the chemical causing the impairment and the numeric criteria for that chemical (e.g., chromium) contained in the water quality standard. Occasionally, the pollutant of concern is different from the parameter that is the subject of the numeric water quality target (e.g., when the pollutant of concern is phosphorus and the numeric water quality target is expressed as a numerical dissolved oxygen criterion). In such cases, the TMDL should explain the linkage between the pollutant(s) of concern, and express the quantitative relationship between the TMDL target and pollutant of concern. In all cases, TMDL targets must represent the attainment of current water quality standards.

☐ When a numeric TMDL target is established to ensure the attainment of a narrative water quality criterion, the numeric target, the methodology used to determine the numeric target, and the link between the pollutant of concern and the narrative water quality criterion should all be described in the TMDL document. Any additional information supporting the numeric target and linkage should also be included in the document.

Recommendation:
☒ Approve ☐ Partial Approval ☐ Disapprove ☐ Insufficient Information

SUMMARY: The numeric TMDL targets established for the three segments of the Lower Big Sioux River are based on the 30-day average chronic criteria water quality standard for TSS for the warmwater semi permanent fish life propagation beneficial use. The TMDL targets for all three segments are the TSS 30-day average value of ≤ 90 mg/L, and the daily maximum value of ≤ 158 mg/L.

COMMENTS: None.

3. Pollutant Source Analysis

A TMDL analysis is conducted when a pollutant load is known or suspected to be exceeding the loading capacity of the waterbody. Logically then, a TMDL analysis should consider all sources of the pollutant of concern in some manner. The detail provided in the source assessment step drives the rigor of the pollutant load allocation. In other words, it is only possible to specifically allocate quantifiable loads or load reductions to each significant source (or source category) when the relative load contribution from each source has been estimated. Therefore, the pollutant load from each significant source (or source category) should be identified and quantified to the maximum practical extent. This may 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 may be appropriate. The approach should be clearly defined in the document.

Minimum Submission Requirements:

☒ The TMDL should include an identification of all potentially significant point and nonpoint sources of the pollutant of concern, including the geographical location of the source(s) and the quantity of the loading, e.g., lbs/per day. This information is necessary for EPA to evaluate the WLA, LA and MOS components of the TMDL.

☒ The level of detail provided in the source assessment should be commensurate with the nature of the watershed and the nature of the pollutant being studied. Where it is possible to separate natural background from nonpoint sources, the TMDL should include a description of both the natural background loads and the nonpoint source loads.

☒ Natural background loads should not be assumed to be the difference between the sum of known and quantified anthropogenic sources and the existing *in situ* loads (e.g. measured in stream) unless it can be demonstrated that all significant anthropogenic sources of the pollutant of concern have been identified, characterized, and properly quantified.

☒ The sampling data relied upon to discover, characterize, and quantify the pollutant sources should be included in the document (e.g. a data appendix) along with a description of how the data were analyzed to characterize and quantify the pollutant sources. A discussion of the known deficiencies and/or gaps in the data set and their potential implications should also be included.

Recommendation:
☒ Approve ☐ Partial Approval ☐ Disapprove ☐ Insufficient Information

SUMMARY: The TMDL document includes a discussion of the landuses in the Lower Big Sioux River watershed. Much of the watershed was originally dominated by tallgrass prairie, but it has since been converted to intensive row crop agriculture. The cropland is dominated by corn, soybeans and other feed grains that are interspersed with pastureland. Table 2 shows the significant percentages of the 15-land use categories taken from the 2001 National Land Cover Data set (NLCD, 2001) used for the Lower Big Sioux River and the Rock River drainage areas in Iowa, respectively. The Table lists both the total acreage and the percent land uses.

Table 2. Landuse for three segments of the Lower Big Sioux River.

NLCD Code	2001 National Land Cover Data Set Landuse Category	Segment R15		Segment R16		Segment R17	
		Iowa*	SD	Iowa	SD	Iowa	SD
11	Open Water	0.29%	0.97%	0.33%	0.88%	1.11%	0.32%
21	Developed, Open Space	5.37%	5.20%	5.63%	3.84%	5.20%	5.43%
22	Developed, Low Intensity	0.78%	0.25%	0.69%	0.11%	0.87%	0.60%
23	Developed, Medium Intensity	0.27%	0.06%	0.32%	0.03%	0.22%	0.32%
24	Developed, High Intensity	0.05%	0.01%	0.08%	0.00%	0.05%	0.07%
31	Barren Land, Rock, Sand, Clay	0.08%	0.01%	0.06%	0.00%	0.05%	0.03%
41	Deciduous Forest	0.71%	3.13%	0.75%	2.82%	8.53%	1.42%
42	Evergreen Forest	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
43	Mixed Forest	0.14%	0.01%	0.13%	0.05%	0.27%	0.08%
52	Shrub, Scrub	0.07%	0.00%	0.03%	0.00%	0.11%	0.00%
71	Grassland, Herbaceous	5.30%	4.31%	4.44%	8.93%	27.89%	3.19%
81	Pasture, Hay	3.24%	11.41%	1.75%	16.30%	2.19%	9.07%
82	Cultivated Crops	82.48%	72.95%	84.26%	62.99%	50.97%	78.19%
90	Woody Wetlands	0.03%	0.16%	0.12%	0.90%	0.44%	0.17%
95	Emergent Herbaceous Wetlands	1.20%	1.52%	1.42%	3.14%	2.09%	1.11%
Total Acres per Segment per State		1,094,943	47,625	26,928	158,195	117,106	239,797
Total Hectares per Segment per State		443,124	19,274	10,898	64,022	47,393	97,046

* includes Minnesota portion of the Rock River

The TMDL document identifies the main sediment sources as: overland runoff from nearby croplands and feedlots, inflow from tributaries and streambank erosion. There are also three point sources located directly on the river, and there are several other National Pollution Discharge Elimination System (NPDES) permittees within both Iowa and SD, but they drain into tributaries of the Big Sioux River. For Iowa, many of the NPDES permittees are either zero discharge facilities or are located a long distance away from the Big Sioux River. They provide an insignificant contribution of sediment relative to nonpoint sources.

The City of Hudson, SD (NPDES permit number SDG822471) is located approximately in the middle of Segment R15. Although Hudson is a NPDES permitted facility it does not discharge and, therefore, will not be included as part of the waste load allocation for Segment R15.

Hawarden, IA (NPDES permit number 8434001; IA0021083) is a municipal activated sludge wastewater treatment facility (WWTF) located in Segment R16. The Hawarden WWTF outfall discharges directly to the Big Sioux River. A wasteload allocation (WLA) provided by the Iowa Department of Natural Resources (IDNR) was calculated for this facility. However, the TSS contribution from this facility to the Big Sioux River was determined to be insignificant (<1.0%).

Akron, IA (NPDES permit number 7509001; IA0035211) is a three-cell waste stabilization lagoon system that has a controlled discharge to Segment R17 of the Big Sioux River. A WLA provided by IDNR was calculated for this facility. However, the TSS contribution from this facility to the Big Sioux River was determined to be insignificant (<1.0%).

COMMENTS: None.

4. TMDL Technical Analysis

TMDL determinations should be supported by a robust data set and an appropriate level of technical analysis. This 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.

A TMDL analysis determines the maximum pollutant loading rate that may be allowed to a waterbody without violating water quality standards. The TMDL analysis should demonstrate an understanding of the relationship between the rate of pollutant loading into the waterbody and the resultant water quality impacts. This stressor → response relationship between the pollutant and impairment and between the selected targets, sources, TMDLs, and load allocations needs to be clearly articulated and supported by an appropriate level of technical analysis. Every effort should be made to be as detailed as possible, and to base all conclusions on the best available scientific principles.

The pollutant loading allocation is at the heart of the TMDL analysis. TMDLs apportion responsibility for taking actions by allocating 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 division of responsibility.

The pollutant loading allocation that will result in achievement of the water quality target is expressed in the form of the standard TMDL equation:

$$TMDL = \sum LAs + \sum WLAs + MOS$$

Where:

TMDL = Total Pollutant Loading Capacity of the waterbody

LAs = Pollutant Load Allocations

WLAs = Pollutant Wasteload Allocations

MOS = The portion of the Load Capacity allocated to the Margin of safety.

Minimum Submission Requirements:

☒ A TMDL must identify the loading capacity of a waterbody for the applicable pollutant, taking into consideration temporal variations in that capacity. EPA regulations define loading capacity as the greatest amount of a pollutant that a water can receive without violating water quality standards (40 C.F.R. §130.2(f)).

☒ The total loading capacity of the waterbody should be clearly demonstrated to equate back to the pollutant load allocations through a balanced TMDL equation. In instances where numerous LA, WLA and seasonal TMDL capacities make expression in the form of an equation cumbersome, a table may be substituted as long as it is clear that the total TMDL capacity equates to the sum of the allocations.

☒ The TMDL document should describe the methodology and technical analysis used to establish and quantify the cause-and-effect relationship between the numeric target and the identified pollutant sources. In many instances, this method will be a water quality model.

☒ It is necessary for EPA staff to be aware of any assumptions used in the technical analysis to understand and evaluate the methodology used to derive the TMDL value and associated loading allocations. Therefore, the TMDL document should contain a description of any important assumptions (including the basis for those assumptions) made in developing the TMDL, including but not limited to:

(1) the spatial extent of the watershed in which the impaired waterbody is located and the spatial extent of the TMDL technical analysis;

(2) the distribution of land use in the watershed (e.g., urban, forested, agriculture);
(3) a presentation of relevant information affecting the characterization of the pollutant of concern and its allocation to sources such as population characteristics, wildlife resources, industrial activities etc…;
(4) present and future growth trends, if taken into consideration in determining the TMDL and preparing the TMDL document (e.g., the TMDL could include the design capacity of an existing or planned wastewater treatment facility);
(5) an explanation and analytical basis for expressing the TMDL through surrogate measures, if applicable. Surrogate measures are parameters such as percent fines and turbidity for sediment impairments; chlorophyll *a* and phosphorus loadings for excess algae; length of riparian buffer; or number of acres of best management practices.

☒ The TMDL document should contain documentation supporting the TMDL analysis, including an inventory of the data set used, a description of the methodology used to analyze the data, a discussion of strengths and weaknesses in the analytical process, and the results from any water quality modeling used. This information is necessary for EPA to review the loading capacity determination, and the associated load, wasteload, and margin of safety allocations.

☒ TMDLs must take critical conditions (e.g., steam flow, loading, and water quality parameters, seasonality, etc…) into account as part of the analysis of loading capacity (40 C.F.R. §130.7(c)(1)). TMDLs should define applicable critical conditions and describe the approach used to determine both point and nonpoint source loadings under such critical conditions. In particular, the document should discuss the approach used to compute and allocate nonpoint source loadings, e.g., meteorological conditions and land use distribution.

☐ Where both nonpoint sources and NPDES permitted point sources are included in the TMDL loading allocation, and attainment of the TMDL target depends on reductions in the nonpoint source loads, the TMDL document must include a demonstration that nonpoint source loading reductions needed to implement the load allocations are actually practicable [40 CFR 130.2(i) and 122.44(d)].

Recommendation:
☒ Approve ☐ Partial Approval ☐ Disapprove ☐ Insufficient Information

SUMMARY: The technical analysis should 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 Lower Big Sioux River TMDL describes how the TSS loads were derived in order to meet the applicable water quality standards for the three 303(d) impaired stream segments.

A combination of FLUX and AnnAGNPS models along with load duration curves were used as part of the technical analysis for the Lower Big Sioux River TSS TMDLs. FLUX is a statistical modeling program that allows estimation of tributary mass discharges (loadings) from sample concentration data and daily flow records. Sediment and nutrient impacts on the surface water quality of the Lower Big Sioux Watershed were also evaluated through the use of the Annualized Agricultural Nonpoint Source (AnnAGNPS), a watershed runoff model. However, AnnAGNPS does not address channel stability or channel erosion, so a number of rapid geomorphic assessments (RGAs) were conducted at all mainstem sites and SD tributary sites during the course of the project. Scores from the RGAs help determine whether the channel is stable or unstable.

The TMDL loads and loading capacities were derived using the load duration curve (LDC) approach that results in a flow-variable target that considers the entire flow regime. The LDC is a dynamic expression of the allowable load for any given day. To aid in the interpretation of the TMDL, the LDC flow intervals were grouped into four flow zones. Once the loading capacity was derived for each flow zone then the load allocations were calculated by subtracting the WLA and MOS. The following tables from the final TMDL document show the calculated loads for each flow regime for all three segments. Separate tables (i.e., see Table 12, 15 and 18) in the TMDL document show the load estimated load reductions needed in each 12-digit HUC for all Iowa and South Dakota sub-watersheds draining into the affected Big Sioux River segments.

Table 11. Segment R15 – TSS Total Maximum Daily Load (TMDL) allocations by flow zone (Site LBSM13).

TMDL Component	Flow Zone (expressed as tons/day)			
	High 0-25% Flow	Moist 25-50% Flow	Mid 50-75% Flow	Dry 75-100% Flow
	1,697 – 46,772 cfs	634 - 1,696 cfs	208 - 633 cfs	0.2 - 207 cfs
50th Percentile Flow Per Zone	3,139.9	1,022.1	417.3	115.8
LA	684.1	222.7	90.9	25.2
WLA*	negligible	negligible	negligible	negligible
MOS (10% Explicit)	76.0	24.7	10.1	2.8
TMDL	**760.2**	**247.4**	**101.0**	**28.0**
*WLA inputs are negligible for this segment.				

Table 13. Segment R16 – TSS Total Maximum Daily Load (TMDL) allocations by flow zone (Site LBSM17).

TMDL Component	Flow Zone (expressed as tons/day)			
	High 0-25% Flow	Moist 25-50% Flow	Mid 50-75% Flow	Dry 75-100% Flow
	1,860 - 50,600 cfs	710 - 1,859 cfs	250 - 709 cfs	4 - 249 cfs
50th Percentile Flow Per Zone	3,420.0	1,130.0	476.0	150.0
LA	745.1838	246.2	103.7	32.7
WLA*	negligible	negligible	negligible	negligible
MOS (10% Explicit)	82.8	27.4	11.5	3.6
TMDL	**828.0**	**273.6**	**115.2**	**36.3**
* WLA inputs are negligible for this segment.				

Table 16. Segment R17 – TSS Total Maximum Daily Load (TMDL) allocations by flow zone (Site LBSM21).

TMDL Component	Flow Zone (expressed as tons/day)			
	High 0-25% Flow	Moist 25-50% Flow	Mid 50-75% Flow	Dry 75-100% Flow
	2,492 - 53,393 cfs	1,149 - 2,491 cfs	612 - 1,148 cfs	325 - 611cfs
(50th) Average flow per flowzone	4,312.8	1,627.6	871.1	495.2
LA	939.7	357.2	190.8	107.9
WLA	negligible	negligible	negligible	negligible
MOS	104.4	39.7	21.2	12.0
TMDL	**1,044.1**	**396.9**	**212.0**	**119.9**
* WLA inputs are negligible for this segment.				

COMMENTS: None.

4.1 Data Set Description

TMDL documents should include a thorough description and summary of all available water quality data that are relevant to the water quality assessment and TMDL analysis. An inventory of the data used for the TMDL analysis should be provided to document, for the record, the data used in decision making. This also provides the reader with the opportunity to independently review the data. The TMDL analysis should make use of all readily available data for the waterbody under analysis unless the TMDL writer determines that the data are not relevant or appropriate. For relevant data that were known but rejected, an explanation of why the data were not utilized should be provided (e.g., samples exceeded holding times, data collected prior to a specific date were not considered timely, etc...).

Minimum Submission Requirements:

☒ TMDL documents should include a thorough description and summary of all available water quality data that are relevant to the water quality assessment and TMDL analysis such that the water quality impairments are clearly defined and linked to the impaired beneficial uses and appropriate water quality criteria.

☒ The TMDL document submitted should be accompanied by the data set utilized during the TMDL analysis. If possible, it is preferred that the data set be provided in an electronic format and referenced in the document. If electronic submission of the data is not possible, the data set may be included as an appendix to the document.

Recommendation:
☒ Approve ☐ Partial Approval ☐ Disapprove ☐ Insufficient Information

SUMMARY: The Lower Big Sioux River TMDL data description and summary are included mainly in the Data Collection Method section of the document and are plotted on the load duration curves for all of the mainstem sites (see Appendix A). Sampling was conducted on a temporal basis over the period from January 2002 to August 2004 and included 1541 total samples for TSS and flow (combined). The data set also includes 30 years of flow record on the Lower Big Sioux River.

COMMENTS: None.

4.2 Waste Load Allocations (WLA):

Waste Load Allocations represent point source pollutant loads to the waterbody. Point source loads are typically better understood and more easily monitored and quantified than nonpoint source loads. Whenever practical, each point source should be given a separate waste load allocation. All NPDES permitted dischargers that discharge the pollutant under analysis directly to the waterbody should be identified and given separate waste load allocations. The finalized WLAs are required to be incorporated into future NPDES permit renewals.

Minimum Submission Requirements:

☒ EPA regulations require that a TMDL include WLAs for all significant and/or NPDES permitted point sources of the pollutant. TMDLs must identify the portion of the loading capacity allocated to individual existing and/or future point source(s) (40 C.F.R. §130.2(h), 40 C.F.R. §130.2(i)). In some cases, WLAs may cover more than one discharger, e.g., if the source is contained within a general permit. If no allocations are to be made to point sources, then the TMDL should include a value of zero for the WLA.

☒ All NPDES permitted dischargers given WLA as part of the TMDL should be identified in the TMDL, including the specific NPDES permit numbers, their geographical locations, and their associated waste load allocations.

Recommendation:
☒ Approve ☐ Partial Approval ☐ Disapprove ☐ Insufficient Information

SUMMARY: The Lower Big Sioux River TMDL document mentions three point sources located directly on the river, and several other NPDES permittees within both Iowa and SD that drain into tributaries of the Big Sioux River. The two point sources that discharge directly to the Big Sioux River (i.e., Akron, Hawarden) both provide an insignificant contribution of sediment relative to nonpoint sources.

COMMENTS: None.

4.3 Load Allocations (LA):

Load allocations include the nonpoint source, natural, and background loads. These types of loads are typically more difficult to quantify than point source loads, and may include a significant degree of uncertainty. Often it is necessary to group these loads into larger categories and estimate the loading rates based on limited monitoring data and/or modeling results. The background load represents a composite of all upstream pollutant loads into the waterbody. In addition to the upstream nonpoint and upstream natural load, the background load often includes upstream point source loads that are not given specific waste load allocations in this particular TMDL analysis. In instances where nonpoint source loading rates are particularly difficult to quantify, a performance-based allocation approach, in which a detailed monitoring plan and adaptive management strategy are employed for the application of BMPs, may be appropriate.

Minimum Submission Requirements:

- ☒ EPA regulations require that TMDL expressions include LAs which identify the portion of the loading capacity attributed to nonpoint sources and to natural background. Load allocations may range from reasonably accurate estimates to gross allotments (40 C.F.R. §130.2(g)). Load allocations may be included for both existing and future nonpoint source loads. Where possible, load allocations should be described separately for natural background and nonpoint sources.
- ☒ Load allocations assigned to natural background loads should not be assumed to be the difference between the sum of known and quantified anthropogenic sources and the existing *in situ* loads (e.g., measured in stream) unless it can be demonstrated that all significant anthropogenic sources of the pollutant of concern have been identified and given proper load or waste load allocations.

Recommendation:
☒ Approve ☐ Partial Approval ☐ Disapprove ☐ Insufficient Information

SUMMARY: The Load Allocations section for each of the three segments explains how the loading capacity and load allocation for each segment was derived. Since the majority of the landuse in the watershed is nonpoint sources, the majority of the loading capacity has been allocated to the nonpoint sources in the form of load allocations. Tables 11, 13 and 16 show the load allocations for each of the four flow regimes for each segment. Since these TMDLs are multijurisdictional, the load allocations for each state are based on the source contributions (in percent) from each 12 digit HUC watershed (see Tables 8, 9 and 10).

COMMENTS: None.

4.4 Margin of Safety (MOS):

Natural systems are inherently complex. Any mathematical relationship used to quantify the stressor → response relationship between pollutant loading rates and the resultant water quality impacts, no matter how rigorous, will include some level of uncertainty and error. To compensate for this uncertainty and ensure water quality standards will be attained, a margin of safety is required as a component of each TMDL. The

MOS may take the form of a explicit load allocation (e.g., 10 lbs/day), or may be implicitly built into the TMDL analysis through the use of conservative assumptions and values for the various factors that determine the TMDL pollutant load → water quality effect relationship. Whether explicit or implicit, the MOS should be supported by an appropriate level of discussion that addresses the level of uncertainty in the various components of the TMDL technical analysis, the assumptions used in that analysis, and the relative effect of those assumptions on the final TMDL. The discussion should demonstrate that the MOS used is sufficient to ensure that the water quality standards would be attained if the TMDL pollutant loading rates are met. 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).

Minimum Submission Requirements:

☒ TMDLs must include a margin of safety (MOS) to account for any lack of knowledge concerning the relationship between load and wasteload allocations and water quality (CWA §303(d)(1)(C), 40 C.F.R. §130.7(c)(1)). EPA's 1991 TMDL Guidance explains that the MOS may be implicit (i.e., incorporated into the TMDL through conservative assumptions in the analysis) or explicit (i.e., expressed in the TMDL as loadings set aside for the MOS).

- ☐ If the MOS is implicit, the conservative assumptions in the analysis that account for the MOS should be identified and described. The document should discuss why the assumptions are considered conservative and the effect of the assumption on the final TMDL value determined.
- ☒ If the MOS is explicit, the loading set aside for the MOS should be identified. The document should discuss how the explicit MOS chosen is related to the uncertainty and/or potential error in the linkage analysis between the WQS, the TMDL target, and the TMDL loading rate.
- ☐ If, rather than an explicit or implicit MOS, the TMDL relies upon a phased approach to deal with large and/or unquantifiable uncertainties in the linkage analysis, the document should include a description of the planned phases for the TMDL as well as a monitoring plan and adaptive management strategy.

Recommendation:
☒ Approve ☐ Partial Approval ☐ Disapprove ☐ Insufficient Information

SUMMARY: The Lower Big Sioux River TMDLs include an explicit MOS for each segment. A ten percent explicit MOS was calculated within the duration curve framework to account for uncertainty (e.g., loads from tributary streams, effectiveness of controls, etc.). This 10% explicit MOS was calculated from the TMDL within each flow zone and reserved as unallocated assimilative capacity. The remaining assimilative capacity was attributed nonpoint sources (LA) or point sources (WLA). The explicit MOS values are included in Tables 11, 13 and 16 of the TMDL.

COMMENTS: None.

4.5 Seasonality and variations in assimilative capacity:

The TMDL relationship is a factor of both the loading rate of the pollutant to the waterbody and the amount of pollutant the waterbody can assimilate and still attain water quality standards. Water quality standards often vary based on seasonal considerations. Therefore, it is appropriate that the TMDL analysis consider seasonal variations, such as critical flow periods (high flow, low flow), when establishing TMDLs, targets, and allocations.

Minimum Submission Requirements:

☒ The statute and regulations require that a TMDL be established with consideration of seasonal variations. The TMDL must describe the method chosen for including seasonal variability as a factor. (CWA §303(d)(1)(C), 40 C.F.R. §130.7(c)(1)).

Recommendation:
☒ Approve ☐ Partial Approval ☐ Disapprove ☐ Insufficient Information

SUMMARY: By using the load duration curve approach to develop the TMDL allocations seasonal variability in TSS loads are taken into account. Highest steam flows typically occur during late spring, and the lowest stream flows occur during the winter months.

COMMENTS: None.

5. Public Participation

EPA regulations require that the establishment of TMDLs be conducted in a process open to the public, and that the public be afforded an opportunity to participate. To meaningfully participate in the TMDL process it is necessary that stakeholders, including members of the general public, be able to understand the problem and the proposed solution. TMDL documents should include language that explains the issues to the general public in understandable terms, as well as provides additional detailed technical information for the scientific community. Notifications or solicitations for comments regarding the TMDL should be made available to the general public, widely circulated, and 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 approval, a copy of the comments received by the state and the state responses to those comments should be included with the document.

Minimum Submission Requirements:
☒ The TMDL must include a description of the public participation process used during the development of the TMDL (40 C.F.R. §130.7(c)(1)(ii)).

☒ TMDLs submitted to EPA for review and approval should include a summary of significant comments and the State's/Tribe's responses to those comments.

Recommendation:
☒ Approve ☐ Partial Approval ☐ Disapprove ☐ Insufficient Information

SUMMARY: The State's submittal includes a summary of the public participation process that has occurred which describes the ways the public has been given an opportunity to be involved in the TMDL development process so far. In particular, the State has encouraged participation through public meetings in the watershed, and a website was developed and maintained throughout the project. The TMDL has been available for a 30-day public notice period prior to finalization.

COMMENTS: None.

6. Monitoring Strategy

TMDLs may have significant uncertainty associated with the 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 document to articulate the means by which the TMDL will be evaluated in the field, and to provide for future supplemental data that will address any uncertainties that may exist when the document is prepared.

Minimum Submission Requirements:

☒ When a TMDL involves both NPDES permitted point source(s) and nonpoint source(s) allocations, and attainment of the TMDL target depends on reductions in the nonpoint source loads, the TMDL document should include a monitoring plan that describes the additional data to be collected to determine if the load reductions provided for in the TMDL are occurring.

☒ Under certain circumstances, a phased TMDL approach may be utilized when limited existing data are relied upon to develop a TMDL, and the State believes that the use of additional data or data based on better analytical techniques would likely increase the accuracy of the TMDL load calculation and merit development of a second phase TMDL. EPA recommends that a phased TMDL document or its implementation plan include a monitoring plan and a scheduled timeframe for revision of the TMDL. These elements would not be an intrinsic part of the TMDL and would not be approved by EPA, but may be necessary to support a rationale for approving the TMDL. http://www.epa.gov/owow/tmdl/tmdl_clarification_letter.pdf

Recommendation:
☒ Approve ☐ Partial Approval ☐ Disapprove ☐ Insufficient Information

SUMMARY: The Lower Big Sioux River should continue to be monitored as part of DENR's ambient water quality monitoring at stations within the three impaired segments addressed by this TMDL document. Post-implementation monitoring will be necessary to assure the TMDL has been reached and maintenance of the beneficial use occurs.

COMMENTS: None.

7. Restoration Strategy

The overall purpose of the TMDL analysis is to determine what actions are necessary to ensure that the pollutant load in a waterbody does not result in water quality impairment. 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. During the TMDL analytical process, information is often gained that may serve to point restoration efforts in the right direction and help ensure that resources are spent in the most efficient manner possible. For example, watershed models used to analyze the linkage between the pollutant loading rates and resultant water quality impacts might also be used to conduct "what if" scenarios to help direct BMP installations to locations that provide the greatest pollutant reductions. Once a TMDL has been written and approved, it is often the responsibility of other water quality programs to see that it is implemented. The level of quality and detail provided in the restoration strategy will greatly influence the future success in achieving the needed pollutant load reductions.

Minimum Submission Requirements:

☒ EPA is not required to and does not approve TMDL implementation plans. However, in cases where a WLA is dependent upon the achievement of a LA, "reasonable assurance" is required to demonstrate the necessary LA called for in the document is practicable). A discussion of the BMPs (or other load reduction measures) that are to be relied upon to achieve the LA(s), and programs and funding sources that will be relied upon to implement the load reductions called for in the document, may be included in the implementation/restoration section of the TMDL document to support a demonstration of "reasonable assurance".

Recommendation:

☒ Approve ☐ Partial Approval ☐ Disapprove ☐ Insufficient Information

SUMMARY: The Implementation section of the TMDL document says that an implementation project has already been developed to address the Lower Big Sioux River pathogen impairments. The next round of Section 319 project funding, an expansion project will be proposed to address the TSS impairment sources detailed in the TMDL document. Since the point sources in the Lower Big Sioux River watershed are insignificant contributors of TSS, and the WLAs for those point sources are included in the load allotments for Iowa, there is no need to include a discussion of reasonable assurance in this TMDL document.

COMMENTS: None.

8. Daily Loading Expression

The goal of a TMDL analysis is to determine what actions are necessary to attain and maintain WQS. The appropriate averaging period that corresponds to this goal will vary depending on the pollutant and the nature of the waterbody under analysis. When selecting an appropriate averaging period for a TMDL analysis, primary concern should be given to the nature of the pollutant in question and the achievement of the underlying WQS. However, recent federal appeals court decisions have pointed out that the title TMDL implies a "daily" loading rate. While the most appropriate averaging period to be used for developing a TMDL analysis may vary according to the pollutant, a daily loading rate can provide a more practical indication of whether or not the overall needed load reductions are being achieved. When limited monitoring resources are available, a daily loading target that takes into account the natural variability of the system can serve as a useful indicator for whether or not the overall load reductions are likely to be met. Therefore, a daily expression of the required pollutant loading rate is a required element in all TMDLs, in addition to any other load averaging periods that may have been used to conduct the TMDL analysis. The level of effort spent to develop the daily load indicator should be based on the overall utility it can provide as an indicator for the total load reductions needed.

Minimum Submission Requirements:

☒ The document should include an expression of the TMDL in terms of a daily load. However, the TMDL may also be expressed in temporal terms other than daily (e.g., an annual or monthly load). If the document expresses the TMDL in additional "non-daily" terms the document should explain why it is appropriate or advantageous to express the TMDL in the additional unit of measurement chosen.

Recommendation:
☒ Approve ☐ Partial Approval ☐ Disapprove ☐ Insufficient Information

SUMMARY: The Lower Big Sioux River TSS TMDLs include daily loads expressed as tons per day. The daily TMDL loads are included in the TMDL Allocations sections of the TMDL document.

COMMENTS: None.