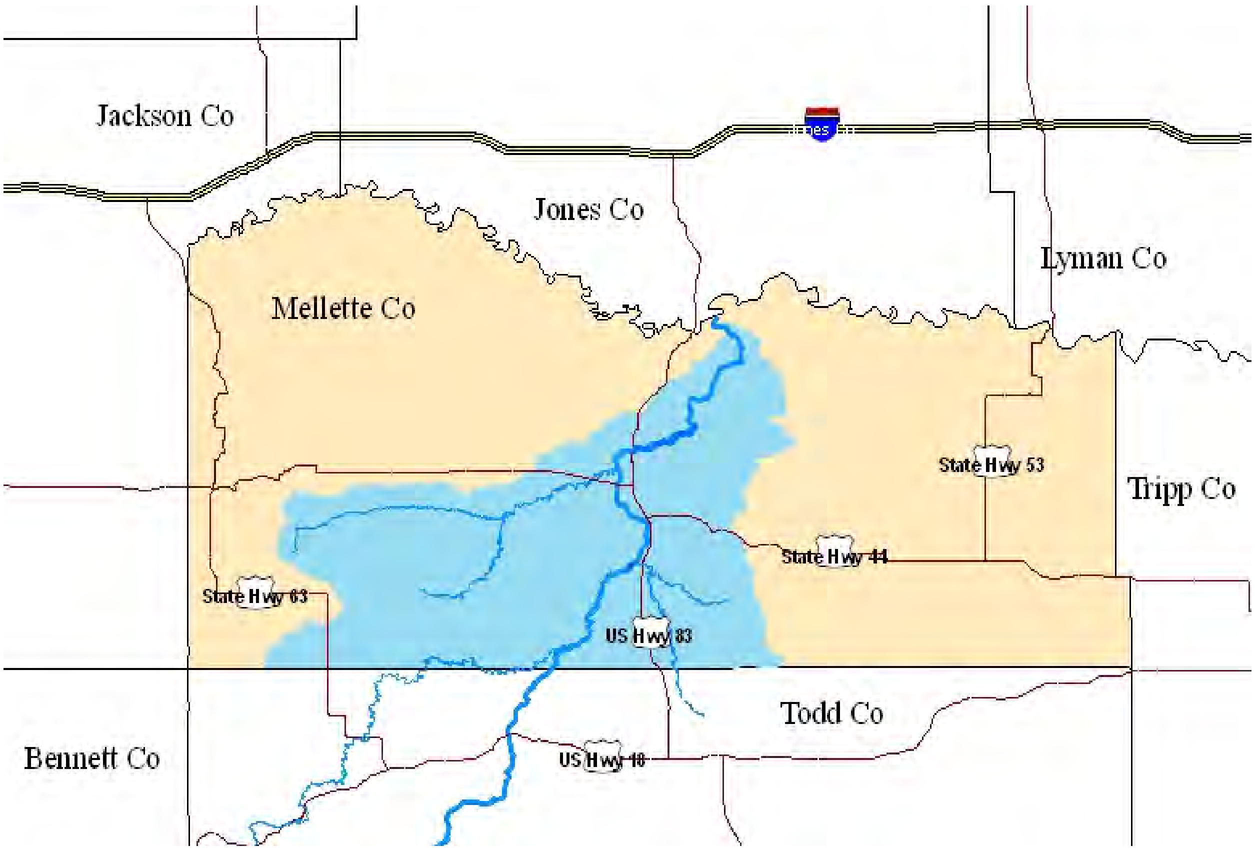
PHASE I
WATERSHED ASSESSMENT FINAL REPORT

LITTLE WHITE RIVER
MELLETTE COUNTY, SOUTH DAKOTA



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

OCTOBER 2006

PHASE I
WATERSHED ASSESSMENT FINAL REPORT

LITTLE WHITE RIVER
MELLETTE COUNTY, SOUTH DAKOTA

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

Prepared By

Robert L. Smith
Environmental Program Scientist

State of South Dakota
M. Michael Rounds, Governor

October, 2006

SECTION 319 NONPOINT SOURCE POLLUTION CONTROL PROGRAM ASSESSMENT/PLANNING PROJECT FINAL REPORT

LITTLE WHITE RIVER WATERSHED ASSESSMENT

by:
Robert L. Smith

Project Sponsor:
Mellette County Conservation District

October 2006

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

EPA Grant # C9998185-02

Executive Summary

Project Title: Little White River Watershed Assessment Project

Project Start Date: September 1, 2003	**Project Completion Date:** May 24, 2005
Funding:	**Total Budget:** $ 84,160
Total EPA Budget:	$ 50,500
Total Expenditures of EPA Funds:	$ 50,449.40
Total Section 319 Match Accrued:	$ 33,686.24
Budget Revisions:	No Revisions
Total Expenditures:	$ 84,135.60

Summary of Accomplishments

Little White River (previously: South Fork of the White River) is located in the Northwestern Great Plains (43) ecoregion (Level III) in central South Dakota has been listed for TSS (Total Suspended Solids) on all 303(d) lists from 1998 through 2006 (SD DENR, 1998, SD DENR, 2002, SD DENR, 2004 and SD DENR, 2006). The Little White River drains a watershed of approximately 426,404 ha (1,053,667 acres) that comprises portions of Cherry and Sheridan Counties, Nebraska and Shannon, Bennett, Todd and Mellette Counties in South Dakota. The study area for this project is the Little White River watershed in Mellette County approximately 98,280 ha (242,855 acres). This portion of the watershed represents approximately 23 percent of the entire Little White River drainage. The Mellette County Conservation District (MCCD) located in the town of White River, South Dakota sponsored and supported this watershed assessment project.

Thirteen tributary locations were chosen for collecting hydrologic, nutrient and sediment information from the Little White River watershed in Mellette County (Figure 3). Tributary site locations were chosen that would best show watershed managers which sub-watersheds were contributing the largest nutrient and sediment loads to the Little White River. OTT Thalimedes data loggers, OTT Nimbus data loggers and ISCO flow meters and GLS samplers (Great Little Samplers) were placed throughout the watershed in Mellette County. Monitoring sites placed in tributaries to the Little White River were Cut Meat Creek (LWR-01), Horse Creek (LWR-02), North Branch of Pine Creek (LWR-3) and Pine Creek (LWR-4). The tributary reference site for biological analysis was South Branch of Pine Creek (LWR-13); however, the site never flowed during the project. Main stem monitoring sites installed along the Little White River were LWR-07 (Todd County line), LWR-08 (Highway 44 Bridge), LWR-05 (Highway 83 Bridge) and LWR-06 (mouth of the Little White River). The mainstem reference site for biological analysis was LWR-12. Prairie dog monitoring sites were LWRPD-09 (above prairie dog town),

LWRPD-10 (below prairie dog town) and LWRPD-11 (no prairie dogs, control site). Prairie dog monitoring sites LWRPD-09 (above prairie dog town) and LWRPD-11 (no prairie dogs, control site) never flowed during the project.

During the assessment, current and long-term data were collected on the parameter of concern, total suspended solids (TSS) in the Little White River. Data indicated total dissolved solids (TDS) violated South Dakota surface water quality standards in the Pine Creek watershed.

Long-term and assessment data indicate TSS concentrations in the Little White River violate current surface water quality standards based on (5) warmwater semi-permanent fish life propagation water beneficial use-based water quality criterion. However, based on long-term trend analysis using USGS, SD DENR WQM and current assessment data, TSS standard violations appear to be relatively constant over the entire flow regime and long-term data suggest a slight decline over time. Ancillary biological data (macroinvertebrate and fisheries) appear to be relatively robust suggesting stability over time. Data support the conclusion that relatively high TSS concentrations that produce surface water quality standard violations in the Little White River do not adversely impact this unique, stable and diverse biological community. Current water quality standards for semi-permanent fish life propagation need to be refined to adequately represent this unique ecosystem. SD DENR suggests the current TSS standard of 158 mg/L needs to be changed to a site specific standard of 2,000 mg/L based on chemical, biological and geological data. After the site specific standard is adopted, a TMDL will not be required and the Little White River can be de-listed in the 2008 Integrated Report as impaired by TSS.

The assessment also revealed TDS concentrations in Pine Creek violate current surface water quality standards based on (9) fish and wildlife propagation, recreation, and stock watering water and (10) irrigation water criteria. Current data from the North Branch of Pine Creek (LWR-03) and ancillary data from other watersheds located in Pierre Shale formations indicate elevated TDS concentrations are naturally occurring and relatively common in western South Dakota, especially during low flow conditions. Given the geologic makeup of the Pine Creek watershed and similar TDS/conductivity violation conditions in Medicine Creek, Cottonwood Creek and in the Freeman Dam watershed; the TDS violations in Pine Creek are from naturally occurring solutes originating from the Pierre shale formations in western South Dakota. Based on data described in this and other assessment reports concerning the Pierre shale formation, SD DENR recommends a modification in surface water quality standards for: fish and wildlife propagation, recreation, and stock watering water and Irrigation waters. It is recommended that (9, 10) waters be amended into the §§ 74:51:01:30 *Flow rates for low quality fishery waters* rule for flows at the 7Q5 or 1 cfs whichever is greater. During low flow conditions, water quality criteria set forth in §§ 74:51:01:52 (fish and wildlife propagation, recreation, and stock watering water) and §§ 74:51:01:53 (irrigation waters) do not apply to the water but all surface water discharge permit limits remain in place. Based on listing criteria set forth in the 2006 Integrated Report (the criterion for support status for streams states that if greater than 10 percent of the samples violate water quality standards, where 20 or more samples are available, or; greater than 25 percent of the samples violate water quality standards, where there are less than 20 samples available, to consider segment water quality-limited) the North Branch of Pine Creek would meet amended water quality standards. After rules changes are adopted, a TMDL will not be required and Pine Creek can be de-listed in the 2008 Integrated Report as impaired by TDS.

All other parameters studied during the assessment met current water quality standards and were not considered a problem in this segment of the Little White River.

Acknowledgements

The cooperation of the following organizations and individuals is gratefully appreciated. The assessment of the Little White River and its watershed could not have been completed without their assistance.

US EPA Non-Point Source Program
Mellette County
South Dakota Conservation Commission
South Dakota Association of Conservation Districts
Mellette County Conservation District
Natural Resource Conservation Service – Mellette County
SD Department of Game, Fish and Parks
SD Department of Environment and Natural Resources – Water Rights Program
SD Department of Environment and Natural Resources – Drinking Water Program
SD Department of Environment and Natural Resources – Water Resources Assistance Program
Rosebud Sioux Tribe

Table of Contents

Table of Contents (continued)

List of Figures

List of Figures (continued)

List of Figures (continued)

List of Figures (continued)

List of Figures (continued)

List of Figures (continued)

List of Figures (continued)

List of Figures (continued)

List of Tables

List of Tables (continued)

List of Tables (continued)

List of Tables (continued)

List of Equations

List of Appendices

Waterbody Type:	Stream
Pollutants:	TSS (Total Suspended Solids)
Designated Uses:	Warmwater semi-permanent fish life propagation, limited contact recreation, wildlife propagation and stock watering and irrigation waters.
Size of Waterbody:	Little White River - (242,855 acres).
Size of Watershed:	Mellette County: 98,279.9 ha (242,855 acres), HUC Code: 10140203. Entire watershed: 426,404 ha (1,053,667 acres)
Water Quality Standards:	Numeric: TSS
Indicators:	Numeric standards exceedances in TSS
Analytical Approach:	Effects of nutrients and sediment loads from the watershed on the Little White River.

1.0 Introduction

Little White River (previously: South Fork of the White River) is located in the Northwestern Great Plains (43) ecoregion (Level III) in central South Dakota has been listed for TSS (Total Suspended Solids) on all 303(d) lists from 1998 through 2006 (SD DENR, 1998, SD DENR, 2002, SD DENR, 2004 and SD DENR, 2006). The Little White River drains a watershed of approximately 426,404 ha (1,053,667 acres) that comprises portions of Cherry and Sheridan Counties, Nebraska and Shannon, Bennett, Todd and Mellette Counties in South Dakota. The study area for this project is the Little White River watershed in Mellette County approximately 98,280 ha (242,855 acres). This portion of the watershed represents approximately 23 percent of the entire Little White River drainage (Figure 1 and Figure 2). The Mellette County Conservation District (MCCD) located in the town of White River, South Dakota sponsored and supported this watershed assessment project.

Water quality monitoring, stream gauging, stream channel and land use analysis were used to document the sources of impairment to the Little White River in Mellette County (from the Todd County line to the White River).

Land use in the watershed is primarily agricultural. Approximately 91.9 percent of the landuse is rangeland and pastureland. The remaining 8.1 percent is cultivated and non-cultivated. Forty-one animal feeding areas/operations are located in the Little White River watershed in Mellette County.

The soil associations found in the Little White River watershed in Mellette County are the Samsil-Lakoma and Opal-Promise-Samsil associations that are moderately to excessively drained clayey soils over shale, on uplands; Imlay-Conata-Badland and Norrest associations that are well to excessively drained loamy silty and clayey soils over siltstone, mudstone and shale on uplands and Tuthill-Manter association well drained loamy soils formed in loamy to sandy material, on uplands. The major soil series in the watershed are Lakoma, Manter, Norrest and Imlay series (USDA 1975).

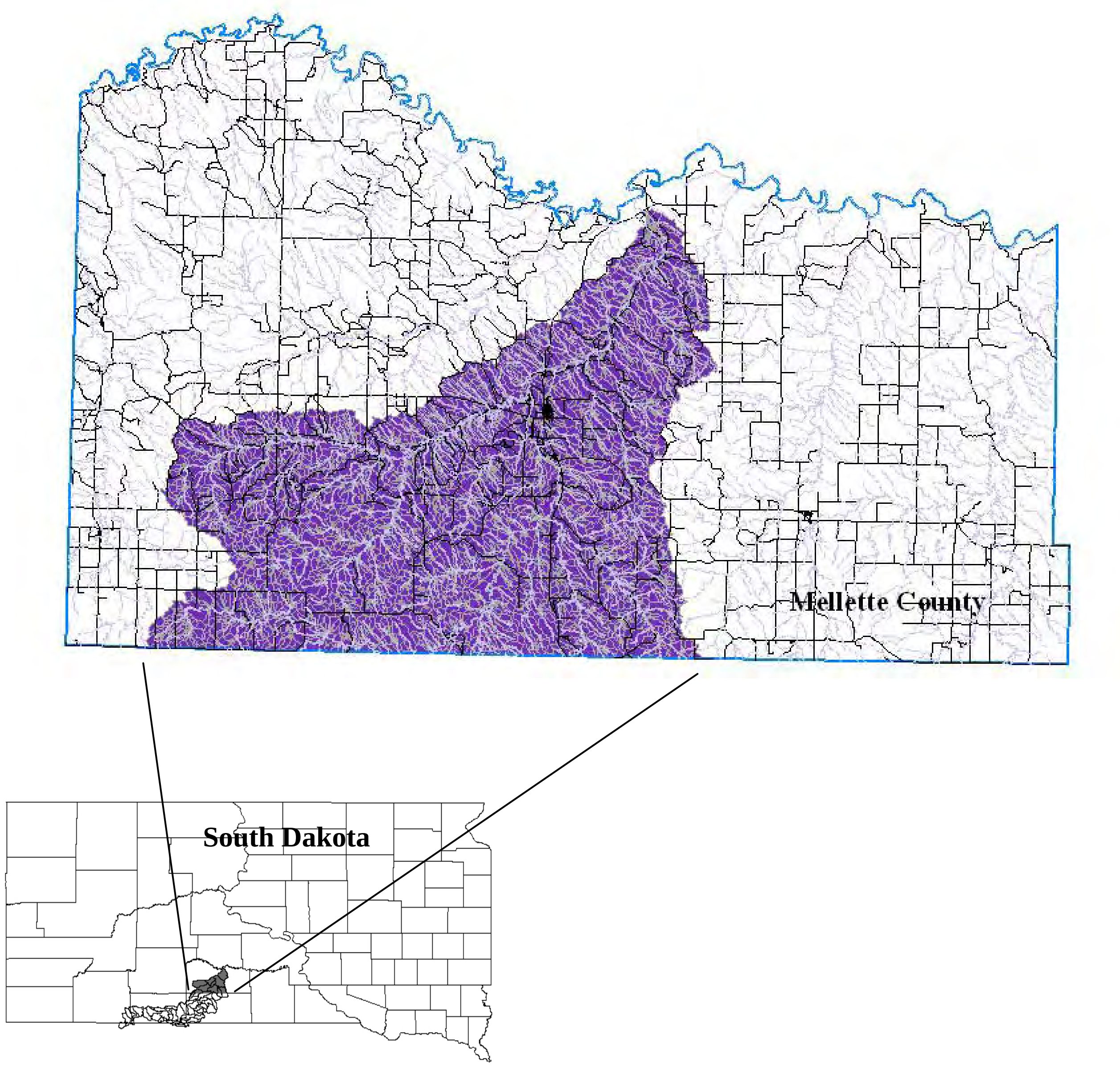


Figure 1. The Little White River watershed and the study area location in the State of South Dakota.

The average annual precipitation in the watershed is 19.1 inches of which 14.3 inches or nearly 75% usually falls during the growing season. During this study (September 2003 through October 2004), 15 inches of rainfall and 31 inches of snow were recorded in Cedar Butte, South Dakota (nearest weather station in Mellette county). Tornadoes and severe thunderstorms strike occasionally. These storms are local and of short duration and occasionally produce heavy rainfall events. The average seasonal snowfall is 33 inches per year (USDA, 1975).

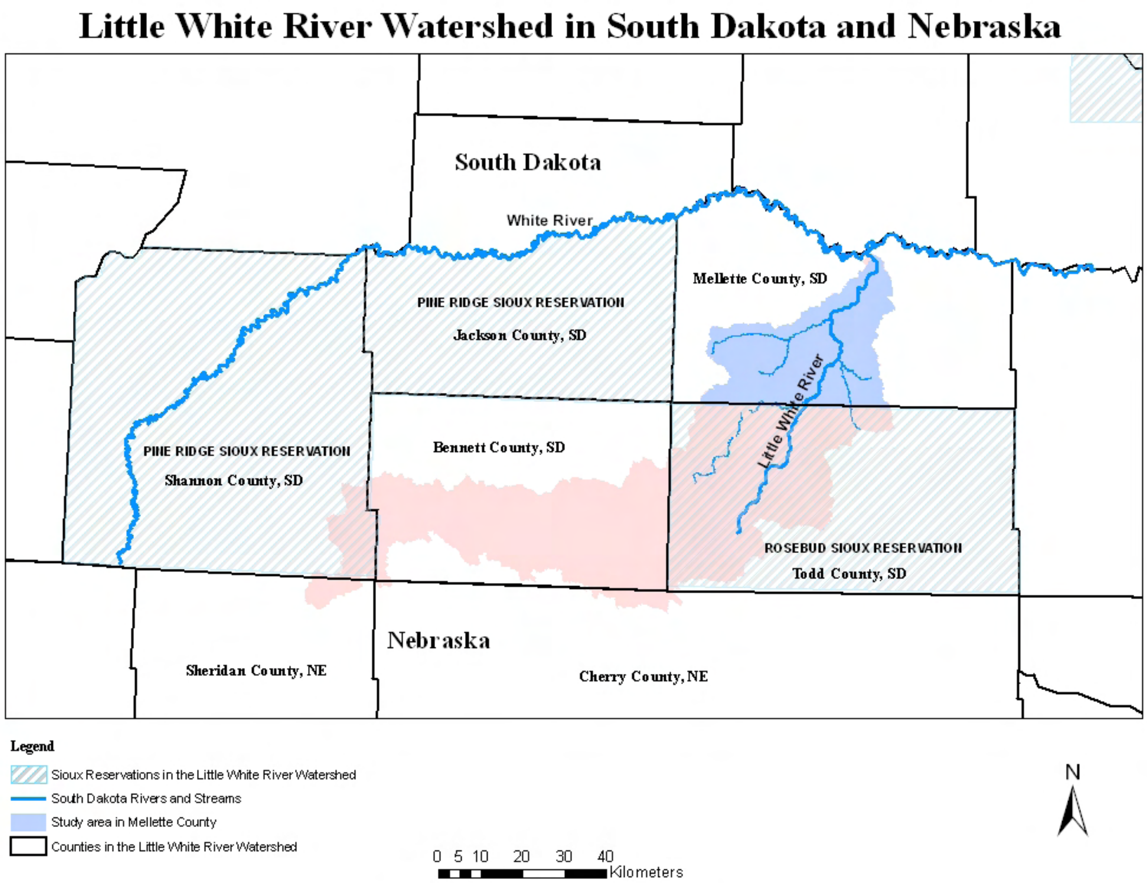


Figure 2. South Dakota and Nebraska Counties and Sioux Reservations in the Little White River Basin.

Land elevation for the Little White River watershed in Mellette County ranges from about 520 m (1,706 feet msl) in the northern sections of the watershed (near mouth of the White River) to about 825 m (2,706 feet msl) near the western boundary of the Pine Creek sub-watershed.

The Little White River watershed in Mellette County is in the Northwestern Great Plains (43) ecoregion (Level III). The remainder of the watershed (southeastern Shannon, Bennett and Todd Counties) lies in the Northwestern Great Plains (43) and Nebraska Sand Hills (44) ecoregions. Level III ecoregions can be further refined to Level IV to elicit more resolution and landscape conditions. The White River watershed in Mellette County is located in three Level IV ecoregion, The River Breaks (43c), the Subhumid Pierre Shale Plains (43f) and the Keya Paha Tablelands (43i), located within the Northwestern Great Plains (43) (Bryce et al., 1998). The remainder of the watershed in Shannon, Bennett and Todd counties is located within the Keya Paha Tablelands (43i) and the Nebraska Sand Hills (44a).

In the 1998 South Dakota Unified Watershed Assessment, the Little White River Hydrologic Unit Code (HUC # 10140203) was scored, categorized and ranked as being a watershed in need of restoration. Some factors involved in the ranking were landuse, treatment needs and point source density; but the ranking was weighted based on the density of TMDL (Total Maximum Daily Load) acres within the HU. The final priority ranking for Little White River was 30 out of a total of 39 HU (watersheds) assessed in this manner (SD DENR, 1998b).

The 1999 South Dakota Nonpoint Source Management Plan schedule is based on the 1998 Section 305(b) report and the related 1998 Section 303(d) list of impaired waters needing TMDL.

Since 1968, South Dakota Department of Environment and Natural Resources (SD DENR) has monitored the Little White River in Mellette County (DENR 460840, WQM 13) as part of its Water Quality Monitoring (WQM) program. Assessment and WQM data will be used as an indication of beneficial use support for the Little White River.

2.0 Project Goals, Objectives and Activities

GOALS:

The goal of the Little White River Assessment Project was to locate and document sources of nonpoint source pollution (primarily excess sediment loading) in the watershed. This project will produce TMDL reports for listed segments of the waterbody and feasible restoration recommendations that may lead to a watershed implementation project.

PROJECT DESCRIPTION:

The Little White River is a major tributary to the White River that eventually dumps into the Missouri River reservoir, Lake Francis Case. The watershed of the Little White River in Mellette County is approximately 242,855 acres and a mixture of cropland and pasture. Little White River was listed on the 1998 303(d) list for violation of total suspended solids standards. The Little White River carries a natural load of colloidal clays and small sands. A major emphasis of this proposal was to document the amount of total suspended solids from natural sources. Through water quality monitoring, stream gauging and land use analysis, the sources of impairment to the river and the watershed were documented.

Objectives and Activities

OBJECTIVE 1: Determine two reference conditions for comparison with the targeted monitoring sites throughout the watershed.

TASK 1 Selecting the reference sites

Before gauging equipment was installed for the watershed project, the local sponsor and project officer found two sites that would be considered least impacted. The sites were representative of the other sample sites to be selected. One site represented tributaries entering the Little White River and the other site represented the main channel itself. Consideration for the sites included land use, river morphology, soil type and other pertinent factors.

OBJECTIVE 2: The annual load of nutrients and sediment to the Little White River were determined. This information was used to help determine the target and goals of the TMDL and was used to verify the results of the land use modeling. The information that was collected at each site is listed in Table 1 and shown in Figure 3.

TASK 2 Installation of gauging equipment

Five monitoring sites were installed which maintained a continuous stage record for the project period, with the exception of winter months after freeze up. There was one USGS gauging station located on the main channel of the Little White River just north of the City of White River. No gauging equipment was needed for this site and the discharge data was acquired from USGS. The tributary sites are listed in Table 1.

Table 1. Tributary Sites:

Site Name	Description
LWR01	Cut Meat Creek just before entering the Little White River
LWR02	Horse Creek just before entering the Little White River
LWR03	North branch of Pine Creek
LWR04	Pine Creek just before entering the Little White River
LWR05	The Little White River just north of White River (USGS gauging site)
LWR06	Little White River just before it enters the White River

TASK 3 Determine the annual water discharge at 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. Discharges were taken at different stages and frequently enough to develop a stage discharge rating curve. Discharge measurements and water level data were used to calculate a hydrologic budget for the stream systems. This information was used with concentrations of sediment and nutrients to calculate loadings from the watershed.

TASK 4 Collect water chemistry samples at selected sites and physical, chemical, and bacterial parameters outlined in Table 2.

Collect water quality samples from 6 tributary monitoring sites and the two reference sites. Samples were collected during spring runoff, storm events, and monthly base flows. Proposed water quality monitoring sites may be found in Figure 3. Samples were collected twice weekly during the first week of spring snowmelt runoff and once a week thereafter until runoff ceased (5). Storm events (4) and base flows (4) were sampled during the project period. Parameters collected at each monitoring site are listed in Table 2. Approximately 13 samples will be collected at each site for an estimated total number of 104 samples.

Table 2. Parameters measured for tributary samples:

PHYSICAL	**CHEMICAL**	**Bacterial**	**BIOLOGICAL**
Air temperature	Total solids	Fecal Coliform	Benthic macroinvertebrates
Water temperature	Total suspended. solids	E. coli	Organic dry ash weight
Discharge	Dissolved oxygen		
Depth	Ammonia		
Visual observations	Nitrate-nitrite		
Water level	Total Kjeldahl nitrogen		
	Total phosphorus		
	Total dissolved phosphorus		
	Volatile suspended solids		
	Chlorophyll *a*		
	Field pH		

TASK 5 Collection of biological samples at all reference and monitoring sites according to the biological parameters found in Table 2.

Benthic macroinvertebrate samples were collected three times during the project at each of the tributary monitoring and reference sites. Composite samples were collected according to the Department's standard operating procedures for benthic macroinvertebrates. Samples were collected using a D-net sampler. All samples were collected during a late summer to fall index period during the project and sent to a private consultant for processing. Periphyton samples were collected at each site during July and August. The samples were collected using the Department's standard operating procedures for periphyton collection. Samples were sent to a private consultant for enumeration and identification. Determination of periphyton chlorophyll *a* and dry ash weight was conducted.

OBJECTIVE 3: Evaluation of agricultural impacts to the water quality of the watershed through the use of the Annualized Agricultural Nonpoint Source (AnnAGNPS) model.

TASK 6 AnnAGNPS model data collection

The Little White River watershed in Mellette County was modeled using the AnnAGNPS model. AnnAGNPS is a comprehensive land use model that estimates sediment and nutrient loss and delivery and evaluates the impacts of livestock feeding areas. The watershed was divided into cells. Each cell will be analyzed after collecting a variety of parameters for each cell with additional information collected for animal feeding operations.

TASK 7 Determine critical areas and attainable TMDL targets and goals.

The model was used to identify critical areas of nonpoint source pollution to the surface waters in the watershed.

OBJECTIVE 4: Assessing the effects of prairie dogs on sediment transport

TASK 8 Locating a prairie dog sampling site.

Local coordinator worked with the conservation district and the NRCS to find suitable sample sites above and below prairie dog towns. The local coordinator found a pasture with similar characteristics with out prairie dogs.

TASK 9 Develop sediment loads above and below prairie dog town for comparison to an area not affected by prairie dogs.

The local coordinator collected discrete discharge samples during runoff events. The local sampler also collected discharge measurements, total suspended solids, and total volatile suspended solids samples during each event. The results of the data were analyzed and included in the final report.

OBJECTIVE 5: QA/QC

TASK 10 QA/QC procedures for data collection.

The collection of all field water quality data was accomplished in accordance with the *Standard Operating Procedures for Field Samplers*, South Dakota Nonpoint Source Program. The number of QA/QC samples is based on a minimum of 10 percent of all samples collected. If the proposed sampling schedule is met, up to 10 blank and 10 replicate QA/QC samples were collected for water chemistry samples. Approximately 2 QA/QC samples were collected for benthic macroinvertebrates, periphyton ID's, chlorophyll *a*, and ash free dry weight. All QA/QC activities were conducted in accordance with the Nonpoint Source Program Quality Assurance Project Plan. The activities involved with QA/QC procedures and the results of QA/QC monitoring will be compiled and reported on in a section of the final project report and in all project reports. All samples were collected using the methods described in the *Standard Operating Procedures for Field Samplers* by the State of South Dakota Water Resources Assistance Program. Range conditions followed NRCS methodologies, stream and habitat assessment followed EMAP methodologies.

OBJECTIVE 6: Public Participation

TASK 11 Public participation and involvement will be provided for and encouraged.

Informational meetings were held on a quarterly basis for the general public and to inform the involved parties of progress on the study. These meetings provided an avenue for input from the residents in the area. A concluding meeting was held while the watershed assessment final draft was in final draft to get any last minute public input and comment into the draft report for DENR and EPA review. News releases were prepared and released to local news media on a quarterly basis. These releases were also provided to local newspapers, radio stations and TV stations.

OBJECTIVE 7: Reporting

TASK 12 Sponsor's reporting duties

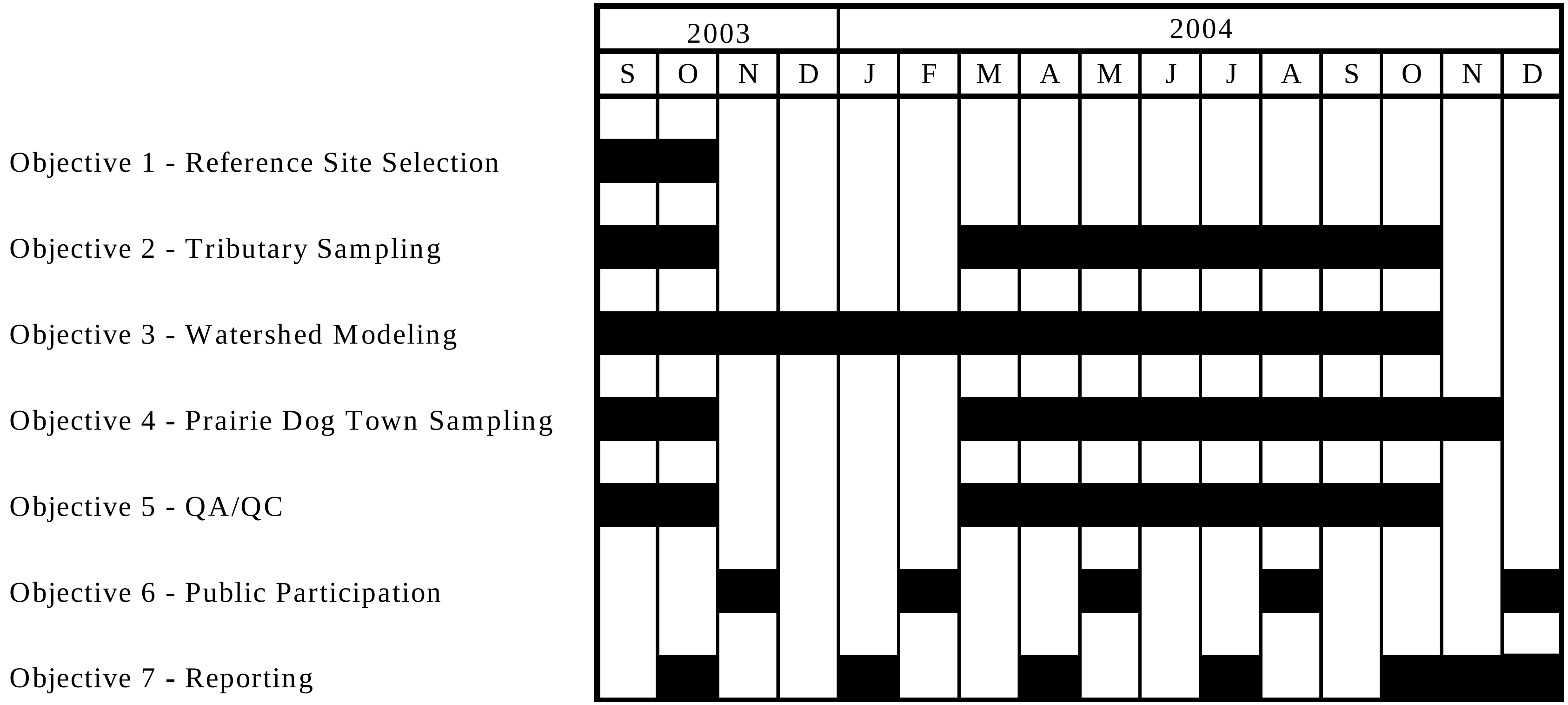
The sponsor submitted no more than monthly requests for payments along with documented work completed since the last voucher. The sponsor fulfilled EPA grant requirements by submitting semi-annual updates and annual reports for input into the GRTS reporting system. Once the field data was collected, an extensive review of the historical and project data was conducted. The data was organized and a final report was submitted to the project officer including all of the data and a financial report of money expended.

TASK 13 Department's reporting duties

The project officer ensured that all semi-annual and annual reports were sent to the GRTS reporting officer. The department was responsible for the final report including hydrologic, sediment and nutrient budgets for the watershed. The final report included the results of the AnnAGNPS modeling of the watershed, which includes cropped, range feedlot and pasture and was used in conjunction with the water quality and hydrologic budget to determine critical areas in the watershed. The feasible management practices were compiled into a list of recommendations for the development of an implementation project to be included in the final project report.

3.3 MILESTONE TABLE - see attached milestone.

Little White River Watershed Assessment Project
Mellette Conservation District
Milestone Chart
2003-2004



3.0 Monitoring Results

Tributary Methods

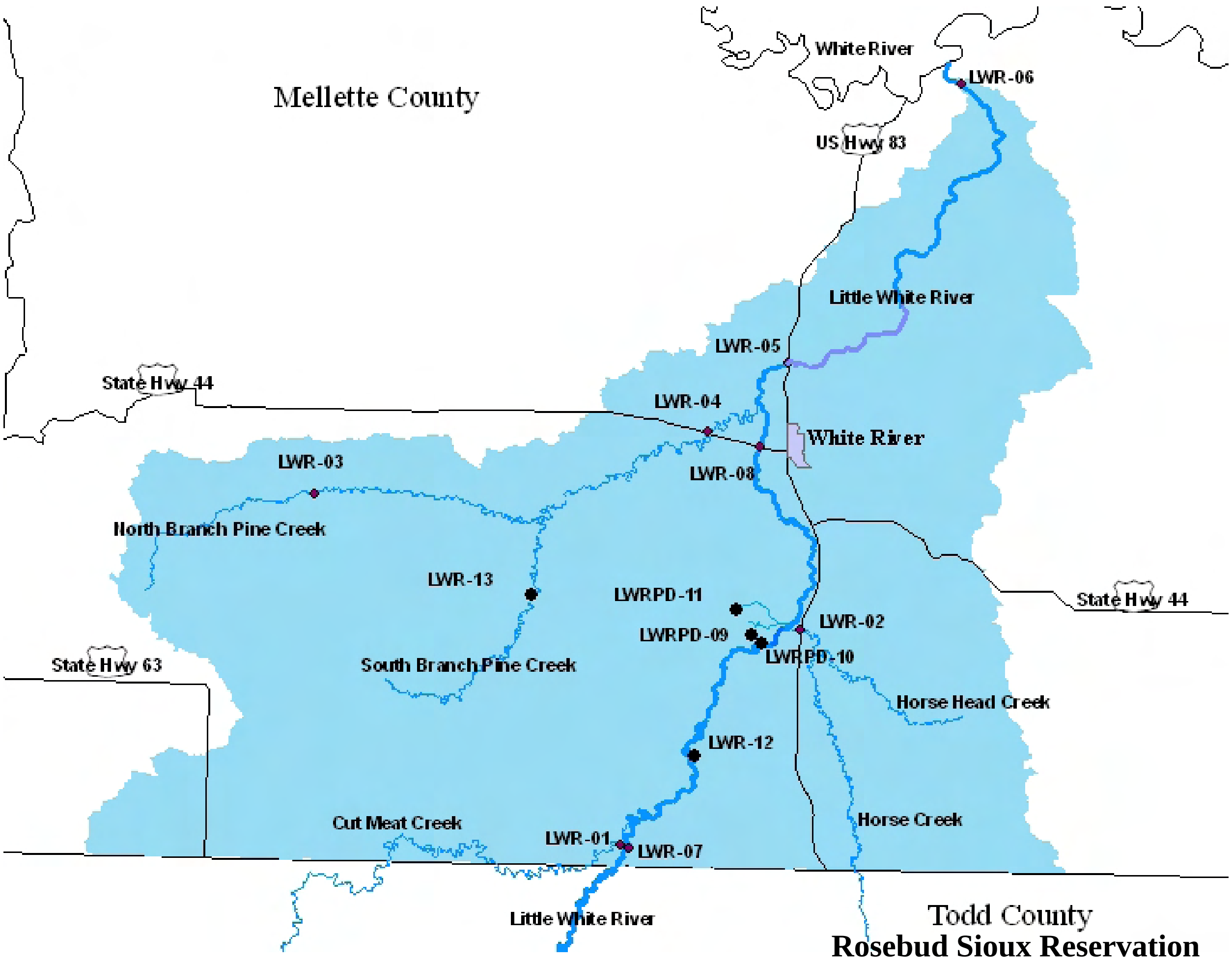


Figure 3. Little White River sampling sites from 2003 through 2004.

Thirteen tributary locations were chosen for collecting hydrologic, nutrient and sediment information from the Little White River watershed in Mellette County (Figure 3). Tributary site locations were chosen that would best show watershed managers which sub-watersheds were contributing the largest nutrient and sediment loads to the Little White River. OTT Thalimedes data loggers, OTT Nimbus data loggers and ISCO flow meters and GLS samplers (Great Little Samplers) were placed throughout the watershed in Mellette County. Monitoring sites placed in tributaries to the Little White River were Cut Meat Creek (LWR-01), Horse Creek (LWR-02), North Branch of Pine Creek (LWR-3) and Pine Creek (LWR-4). The tributary reference site for biological analysis was South Branch of Pine Creek (LWR-13); however, the site never flowed during the project. Mainstem monitoring sites installed along the Little White River were LWR-07 (Todd County line), LWR-08 (Highway 44 Bridge), LWR-05 (Highway 83 Bridge) and

LWR-06 (mouth of the Little White River). The mainstem reference site for biological analysis was LWR-12. Prairie dog monitoring sites were LWRPD-09 (above prairie dog town), LWRPD-10 (below prairie dog town) and LWRPD-11 (no prairie dogs, control site). Prairie dog monitoring sites LWRPD-09 (above prairie dog town) and LWRPD-11 (no prairie dogs, control site) never flowed during the project.

Data loggers were checked and downloaded bi-monthly to update the database and check for mechanical problems. All discharge data was collected according to South Dakota's *Standard Operating Procedures for Field Samples, Volume I* (SD DENR, 2005).

Stage discharge regression graphs and equations for each tributary monitoring site are provided in Appendix A (Figure A-1 through Figure A-7).

Hydrologic Data Collection Methods

Instantaneous discharge measurements were collected for each station during the time each sample was collected. A Marsh-McBirney Model 2000 flow meter was used to collect discharge measurements.

Tributary Water Quality Sampling

Samples collected at each tributary site were taken according to South Dakota's *Standard Operating Procedures for Field Samplers* (SD DENR, 2005). Tributary physical, chemical and biological water quality sample parameters are listed in Table 3. All water samples were sent to the State Health Laboratory in Pierre for analysis.

Table 3. Tributary physical, chemical and biological parameters analyzed in the Little White River, Mellette County, South Dakota in 2003 through 2004.

Physical	Chemical	Biological
Air Temperature	Total Alkalinity	Fecal Coliform
Water Temperature	Field pH	E. coli
Depth	Dissolved Oxygen	Macroinvertebrates
Visual Observations	Total Solids	Chlorophyll-*a*
Transparency Tube Depth	Total Suspended Solids	
Turbidity	Total Dissolved Solids (calculated)	
	Volatile Total Suspended Solids	
	Ammonia	
	Nitrate-Nitrite	
	Total Kjeldahl Nitrogen	
	Total Phosphorus	
	Total Dissolved Phosphorus	
	Conductivity	

Quality Assurance/Quality Control samples were collected for approximately 10 percent of the samples according to South Dakota's EPA-approved *Non-Point Source Quality*

Assurance/Quality Control Plan (SD DENR, 1998c). These documents can be referenced by contacting the South Dakota Department of Environment and Natural Resources at (605) 773-4254 or at http://www.state.sd.us/denr.

Tributary Modeling Methods

Tributary Loading Calculations

The FLUX program was used to develop nutrient and sediment loadings for all tributary monitoring sites in the Little White River watershed. The US Army Corps of Engineers developed the FLUX program for eutrophication (nutrient enrichment) assessment and prediction for reservoirs (Walker, 1999). The FLUX program uses six different calculation techniques (methods) for calculating nutrient and sediment loadings. The sample and flow data for this program can be stratified (adjusted) until the coefficient of variation (standard error of the mean loading divided by the mean loading =CV) for all six methods converge or are all similar. The uncertainty in the estimated loading is reflected by the CV value. The lower the CV value the greater the accuracy (less error) there is in loading estimates. This scenario was applied to each relevant sampling parameter to determine the appropriate method (model) for specific parameters. Methods (models) and CV values for each parameter and sampling site are listed in Table 4. These methods were used on all tributary monitoring sites to calculate nutrient and sediment loadings for this project.

After the loadings for all sites were completed, export coefficients were developed for each of the parameters. Export coefficients are calculated by taking the total nutrient or sediment load (kilograms) and dividing by the total area of the sub-watershed (in acres). This calculation results in the determination of the number of kilograms of sediment and nutrients per acre delivered from each sub-watershed (kg/acre). These values were used to target areas within the watershed with excessive nutrient and sediment loads. These areas will also be used to target recommended BMPs for a projected implementation project.

Table 4. Method and coefficient of variation by parameter for FLUX loading analysis in the Little White River, Mellette County, South Dakota from 2003 through 2004.

	LWR-01		LWR-02		LWR-03		LWR-04		LWR-05		LWR-06		LWR-07		LWR-08	
Parameter	**Method**	**CV[1]**	**Method**	**CV**	**Method**	**CV**	**Method**	**CV**	**Method**	**CV**	**Method**	**CV**	**Method**	**CV**	**Method**	**CV**
Alkalinity	QwtC[2]	0.274	-	-	IJC	0.029	QwtC	0.377	QwtC	0.036	QwtC	0.024	QwtC	0.017	QwtC	0.015
Total Solids	QwtC	0.387	-	-	IJC	0.103	QwtC	0.217	QwtC	0.310	IJC	0.243	IJC	0.114	QwtC	0.094
Total Dissolved Solids	QwtC	0.396	-	-	IJC	0.112	QwtC	0.109	QwtC	0.325	QwtC	0.083	QwtC	0.060	QwtC	0.061
Total Suspended Solids	IJC[3]	0.384	-	-	IJC	0.102	QwtC	0.339	QwtC	0.324	IJC	0.322	IJC	0.198	QwtC	0.221
Volatile Total Suspended Solids	IJC	0.260	-	-	IJC	0.270	QwtC	0.146	QwtC	0.349	IJC	0.294	IJC	0.186	QwtC	0.109
Ammonia	QwtC	0.884	**No flow**		QwtC	0.575	QwtC	0.000	IJC	0.384	IJC	0.606	QwtC	0.184	QwtC	0.000
Nitrate-Nitrite	QwtC	0.629	**during project**		IJC	0.081	QwtC	0.638	QwtC	0.237	QwtC	0.228	IJC	0.154	IJC	0.394
Total Kjeldahl Nitrogen	IJC	0.282	-	-	QwtC	0.647	IJC	0.128	QwtC	0.187	IJC	0.259	IJC	0.182	QwtC	0.217
Inorganic Nitrogen	QwtC	0.670	-	-	QwtC	0.097	QwtC	0.620	IJC	0.222	QwtC	0.208	QwtC	0.155	IJC	0.686
Organic Nitrogen	IJC	0.254	-	-	QwtC	0.685	IJC	0.128	IJC	0.188	IJC	0.254	QwtC	0.220	QwtC	0.166
Total Nitrogen	IJC	0.345	-	-	QwtC	0.525	IJC	0.071	IJC	0.141	IJC	0.220	QwtC	0.153	IJC	0.289
Total Phosphorus	IJC	0.308	-	-	QwtC	0.168	QwtC	0.484	QwtC	0.247	QwtC	0.167	IJC	0.147	QwtC	0.142
Total Dissolved Phosphorus	IJC	0.080	-	-	**No Data**		**No Data**		QwtC	0.206	QwtC	0.259	IJC	0.748	QwtC	0.270
Stratification Scheme	**None**		**None**		**None**		**None**		**None**		**Flow**		**None**		**None**	

[1] = Coefficient of Variation

[2] = Flow weighted concentration method

[3] = International Joint Commission method

Tributary Statistical Analysis

Tributary data was analyzed using StatSoft® statistical software (STATISTICA version 7.1). Kruskal-Wallis ANOVA (multiple comparison non-parametric analysis) was run on tributary concentration and loading data to determine significant differences between tributary monitoring sites. Statistical results for both concentration and loading data for all parameters are provided in Table 5.

Only tributary parameters that were significantly different between sampling sites are discussed by parameter when applicable. Significant differences by parameter, sub-watersheds and season using multiple comparison matrix tables are provided in Appendix B, Tables B-1 through Table B-55.

Table 5. Kruskal-Wallis (H) values, observations and *p* values for tributary concentrations Pine Creek and mainstem Little White River and loading data for mainstem Little White River, Mellette County, South Dakota from 2003 through 2004.

	Concentrations									Loading		
	Pine Creek (Only)			Little White River (Mainstem Only)			Little White River Watershed (Mellette County)			Little White River (Mainstem)		
Parameter	**N**	**Kruskal-Wallis (H)**	**p-value**	**N**	**Kruskal-Wallis (H)**	**p-value**	**N**	**Kruskal-Wallis (H)**	**p-value**	**N**	**Kruskal-Wallis (H)**	**p-value**
Dissolved Oxygen	14	0.040	0.841	61	2.202	0.532	84	3.20	0.783	-	-	-
pH	14	5.444	0.020	62	2.366	0.500	85	13.95	0.030	-	-	-
Transparency Tube Depth	15	1.114	0.291	64	3.785	0.286	88	33.53	0.000	-	-	-
Turbidity (NTU)	12	0.534	0.465	44	1.586	0.663	63	25.72	0.000	-	-	-
Conductivity @ 25° C	14	5.456	0.019	61	2.593	0.459	84	23.47	0.001	-	-	-
Water Temperature	14	0.040	0.841	62	1.352	0.717	85	6.02	0.421	-	-	-
Fecal Coliform Bacteria (all dates)	12	0.260	0.610	56	0.699	0.873	76	25.85	0.000	-	-	-
Fecal Coliform Bacteria (mainstem-May-Sept.)	6	0.086	0.770	31	0.601	0.896	42	15.85	0.014	-	-	-
E. coli Bacteria (all dates)	12	1.091	0.296	56	0.640	0.887	76	21.64	0.001	-	-	-
Alkalinity	15	0.540	0.462	64	5.042	0.169	88	25.66	0.000	60	20.86	0.0001
Total Solids	15	0.015	0.902	64	2.506	0.474	88	37.44	0.000	60	31.89	0.0000
Total Dissolved Solids	15	4.335	0.037	64	4.479	0.214	88	49.99	0.000	60	31.69	0.0000
Total Suspended Solids	15	2.160	0.142	64	2.078	0.556	88	38.20	0.000	60	30.17	0.0000
Volatile Total Suspended Solids	15	0.740	0.390	64	3.027	0.387	88	31.76	0.000	60	32.05	0.0000
Ammonia	15	1.724	0.189	64	2.766	0.429	88	6.02	0.420	60	27.74	0.0000
Nitrate-Nitrite	15	0.000	1.000	64	1.485	0.686	88	14.05	0.029	60	23.55	0.0000
Total Kjeldahl Nitrogen	15	0.455	0.500	64	0.356	0.949	88	9.29	0.158	60	35.25	0.0000
Organic Nitrogen	15	0.735	0.391	64	0.285	0.963	88	8.99	0.174	60	9.14	0.0275
Inorganic Nitrogen	15	0.060	0.806	64	1.120	0.772	88	13.98	0.030	60	35.86	0.0000
Total Nitrogen	15	0.540	0.462	64	0.656	0.883	88	13.75	0.033	60	20.19	0.0002
Total Phosphorus	15	0.060	0.806	64	3.392	0.335	88	28.55	0.000	60	29.92	0.0000
Total Dissolved Phosphorus	3	1.500	0.221	45	2.527	0.470	54	9.52	0.146	60	43.13	0.0000
Total Nitrogen to Total Phosphorus	15	0.060	0.806	64	8.863	0.031	88	19.52	0.003	-	-	-

Shaded = significantly different between sampling sites ($p<0.05$).

Landuse Modeling – Annualized Agricultural Non-Point Source Model, version 3.32a.34 (AnnAGNPS)

In addition to water quality monitoring, information was collected to complete a comprehensive watershed land use model. AnnAGNPS (Annualized Agricultural Non-Point Source) is a landuse model to simulate/model sediment and nutrient loadings from watersheds. AnnAGNPS is a data intensive watershed model that routes sediment and nutrients through a watershed by utilizing land uses and topography. The watershed is broken up into cells of varying sizes based on topography. Each cell is then assigned a primary land use and soil type. Best Management Practices (BMPs) are then simulated by altering the land use in the individual cells and reductions are calculated at the outlet to the watershed.

The input data set for AnnAGNPS Pollutant Loading Model consists of 33 data sets, which can be supplied by the user in a number of ways. This model execution utilized digital elevation maps (DEMs) to determine cell and reach geometry, SSURGO soil layers to determine primary soil types and the associated NASIS data tables for each soils properties, and primary land use based on a 40-acre grid pattern, collected initially with the intention of executing the AGNPS model version 3.65. Impoundment data was obtained using Digital Ortho Quads (DOQs) layers using ArcView Global Information System (GIS)® software.

Climate/weather data from Pierre, South Dakota was used to generate simulated weather data. Model results are based on one year of climate data for initializing variables prior to 25-year watershed simulation. Simulated precipitation based on climate data ranged from 13 to 29 inches per year. Mean annual precipitation for this watershed is approximately 19 inches.

Part of the modeling process includes the assessment of Animal Feeding Operations (AFOs) located in the watershed. This assessment was completed with the assistance of Mellette County Conservation District which provided estimates on the number of animal units and the number of days per year the lot was used. AFO nutrient value loading and rating numbers were calculated using a feedlot program modified by SD DENR. Derived nutrient values for each AFO were used to calculate feedlot/feeding area nutrient and rating values for use in the AnnAGNPS program.

Findings from the AnnAGNPS report can be found throughout the water quality and landuse modeling discussions of this document. Conclusions and recommendations will rely on both water quality and AnnAGNPS data. The complete AnnAGNPS report can be found in Appendix C.

3.1 Tributary Surface Water Chemistry

Tributary Water Quality Standards

South Dakota's numeric water quality standards are based on beneficial use categories. Beneficial use classifications are listed in Table 6. All streams in the state are assigned beneficial uses (category 9) fish and wildlife propagation, recreation and stock watering and (category 10) irrigation (ARSD § 74:51:03:01).

Table 6. South Dakota's beneficial use classifications.

Category	Beneficial Use
1	Domestic water supply waters;
2	Coldwater permanent fish life propagation waters;
3	Coldwater marginal fish life propagation waters;
4	Warmwater permanent fish life propagation waters;
5	Warmwater semi-permanent fish life propagation waters;
6	Warmwater marginal fish life propagation waters;
7	Immersion recreation waters;
8	Limited-contact recreation waters;
9	Fish and wildlife propagation, recreation, and stock watering waters;
10	Irrigation waters; and
11	Commerce and industry waters.

The Little White River in Mellette, Todd and Bennett Counties (S6, T36N, R39W to the mouth of the White River) has been assigned the beneficial uses of (5) Warmwater semi-permanent fish life propagation waters, (8) Limited-contact recreation waters, (9) Fish and wildlife propagation, recreation, and stock watering water and (10) Irrigation water (Table 6).

In addition to physical and chemical standards, South Dakota has developed narrative criteria for the protection of aquatic life uses. *All waters of the state must be free from substances, whether attributable to human-induced point source discharge or nonpoint source activities, in concentration or combinations which will adversely impact the structure and function of indigenous or intentionally introduced aquatic communities* (ASRD § 74:51:01:12).

Table 7. Assigned beneficial uses for Medicine Creek, Lyman County South Dakota.

Water Body	From	To	Beneficial Uses*	Counties
Little White River	S6, T36N, R39W	White River	5, 8	Mellette Todd and Bennett
All Streams	Entire State	Entire State	9, 10	All

*** = See Table 6 above**

Each beneficial use classification has a set of numeric standards uniquely associated with that specific category. Water quality values that exceed those standards, applicable to specific beneficial uses, impair beneficial use and violate water quality standards. Table 8 lists the most stringent water quality parameters for the Little White River. Four of the nine parameters (total petroleum hydrocarbon, oil and grease, un-disassociated hydrogen sulfide and sodium adsorption ratio) listed for the Little White River beneficial use classification were not sampled during this project.

Table 8. The most stringent water quality standards for the Little White River based on beneficial use classifications.

Water Body	Beneficial Uses	Parameter	Standard Value
Little White River	5, 8, 9, 10	Total ammonia nitrogen as N [1]	≤ (calculated value) mg/L
		Dissolved oxygen	≥ 5.0 mg/L
		pH	≥ 6.5 - ≤ 9.0
		Total Suspended Solids [2]	≤ 158 mg/L
		Temperature (°C)	≤ 32.2°C
		Fecal coliform [3]	≤ 2,000 colonies/100mL
		Total alkalinity as calcium carbonate [4]	≤ 1313 mg/L
		Total dissolved solids [5]	≤ 4,375 mg/L
		Conductivity at 25° C [6]	≤ 4,375 µS/cm
		Nitrates as N [7]	≤ 88 mg/L
		Undisassociated hydrogen sulfide [8]	≤ 0.002 mg/L
		Total petroleum hydrocarbon [8]	≤ 1 mg/L
		Sodium Adsorption Ratio (SAR) [8,9]	≤ 10 (unit less)
		Oil and grease [8]	≤ 10 mg/L

[1] = The standard for total ammonia is calculated and dependent on pH and can be equal to or less than the calculated value. The equation used to calculate the total standard is found in Equation 2.
[2] = The daily maximum for total suspended solids is ≤ 158 mg/L or ≤ 90 mg/L for a 30-day average (an average of 3 samples (minimum) taken in separate 24-hour periods).
[3] = The fecal coliform standard is in effect from May 1 to September 30. The ≤ 2,000 colonies/100 ml is for a single sample or ≤ 1,000 colonies/100 ml over a 30-day average (an average of 5 samples (minimum) taken in separate 24-hour periods).
[4] = The daily maximum for total alkalinity as calcium carbonate is ≤ 1,313 mg/L or ≤ 750 mg/L for a 30-day average.
[5] = The daily maximum for total dissolved solids is ≤ 4,375 mg/L or ≤ 2,500 mg/L for a 30-day average.
[6] = The daily maximum for conductivity at 25° C is ≤ 4,375 µS/cm or ≤ 2,500 µS/cm for a 30-day average.
[7] = The daily maximum for nitrates is ≤ 88 mg/L or 50 mg/L for a 30-day average.
[8] = Parameters not measured during this project.
[9] = The sodium absorption ratio is a calculated value that evaluates the sodium hazard of irrigation water based on the Gapon equation and expressed by the mathematical equation:

Equation 1. Sodium adsorption ratio (SAR), (Gapon Equation)

$$\text{SAR} = Na^{+} \Big/ \sqrt{\frac{Ca^{+2} + \text{Mg}^{+2}}{2}}$$

Where Na^{+}, Ca^{+2} and Mg^{+2} are expressed in milliequivalents per liter.

Equation 2. Total ammonia nitrogen as N equation.

$$\textbf{Total ammonia standard=} \left(\left(\frac{0.411}{1 + 10^{7.204 - pH}} \right) + \left(\frac{58.4}{1 + 10^{pH - 7.204}} \right) \right)$$

Where pH is the pH of the water quality sample in standard units.
(Ammonia concentration may not exceed calculated value)

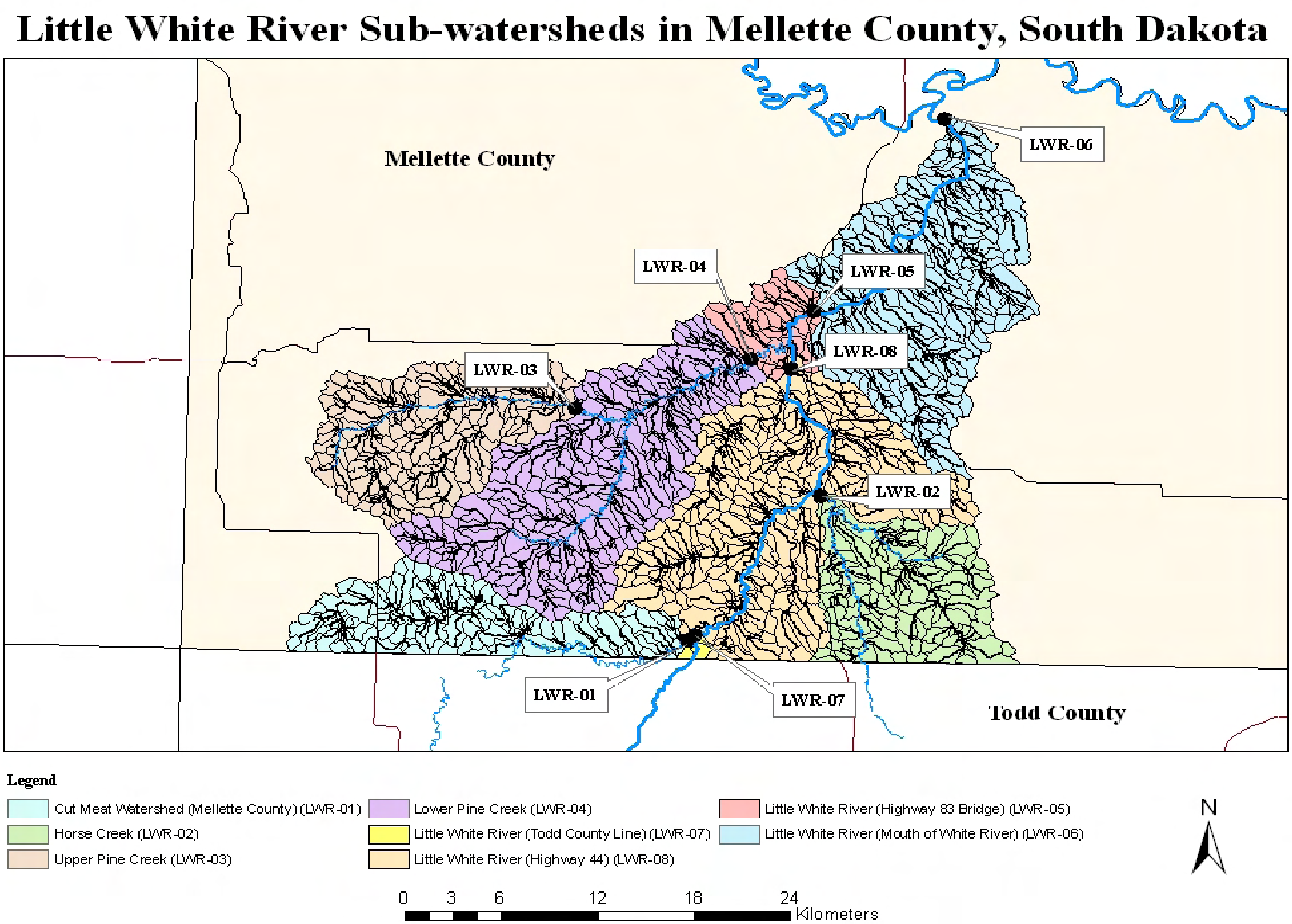


Figure 4. Little White River sub-watersheds by tributary monitoring site, Mellette County, South Dakota 2003 through 2004.

Little White River Water Quality Exceedances

Sixty water quality standards violations in six parameters were observed in assessment data whereas, 32 water quality standards violations in one parameter were observed in Water Quality Monitoring (WQM) data based on assigned beneficial uses for the Little White River from 2001 through 2005 (Table 9 through Table 14). Assigned beneficial uses for the Little White River are as follows: (5) Warmwater semi-permanent fish life propagation water and (8) Limited-contact recreation waters. Assigned beneficial uses for the Cut Meat Creek are as follows: (6) Warmwater marginal fish life propagation water and (8) Limited-contact recreation water. The Little White River, Cut Meat Creek and Pine Creek along with all streams of South Dakota have assigned beneficial uses of (9) Fish and wildlife propagation, recreation, and stock watering water and (10) Irrigation water. Sub-watershed locations are depicted in Figure 4.

Table 9. Long-term pH violations (Assessment (2003 through 2004)) and WQM (2001 through 2005) for the Little White River, Mellette County, South Dakota.

Site/(Stream/River) (Assessment Data)	Date	Flow (CFS)	pH [1] (su)	Sample Total	Violation Total	Percent Violation
LWR-05 / Little White River	8/2/2004	64	9.10			
LWR-06 / Little White River	8/2/2004	49	9.17			
				66	2	3.0
Site (WQM Data)						
WQM-13 (Assessment LWR-05)	-	-	-			
				53	0	0%
Total				**119**	**2**	**1.7%**

[1] = pH standard is ≤ 9.00 su
- = No data

Table 10. Long-term total suspended solids (TSS) concentrations violations ((Assessment (2003 through 2004) and WQM (2001 through 2005)) for the Little White River, Mellette County, South Dakota.

Site/(Stream/River) (Assessment Data)	Date	Flow (CFS)	Total Suspended Solids [1] (mg/L)	Sample Total	Violation Total	Percent Violation
LWR-05 / Little White River	9/24/2003	34	1,260			
LWR-05 / Little White River	11/17/2003	118	2,660			
LWR-05 / Little White River	3/2/2004	246	260			
LWR-05 / Little White River	3/8/2004	174	200			
LWR-05 / Little White River	3/24/2004	161	312			
LWR-05 / Little White River	5/4/2004	158	620			
LWR-05 / Little White River	5/13/2004	136	280			
LWR-05 / Little White River	5/24/2004	211	2,450			
LWR-05 / Little White River	7/21/2004	120	540			
LWR-05 / Little White River	8/15/2004	429	1,980			
LWR-05 / Little White River	8/16/2004	74	3,820			
LWR-05 / Little White River	9/22/2004	100	204			
LWR-05 / Little White River	9/24/2004	187	3,200			
LWR-05 / Little White River	10/27/2004	395	1,200			
LWR-06 / Little White River	11/12/2003	107	222			
LWR-06 / Little White River	3/8/2004	192	696			

Table 10 (continued). Long-term total suspended solids (TSS) concentrations violations ((Assessment (2003 through 2004) and WQM (2001 through 2005)) for the Little White River, Mellette County, South Dakota.

Site/(Stream/River) (Assessment Data)	Date	Flow (CFS)	Total Suspended Solids [1] (mg/L)	Sample Total	Violation Total	Percent Violation
LWR-06 / Little White River	3/24/2004	147	620			
LWR-06 / Little White River	5/4/2004	146	330			
LWR-06 / Little White River	5/13/2004	154	400			
LWR-06 / Little White River	5/24/2004	198	1,030			
LWR-06 / Little White River	6/9/2004	125	420			
LWR-06 / Little White River	7/6/2004	73	370			
LWR-06 / Little White River	8/2/2004	49	176			
LWR-06 / Little White River	8/16/2004	114	4,040			
LWR-06 / Little White River	9/15/2004	86	218			
LWR-06 / Little White River	9/24/2004	108	3,040			
LWR-07 / Little White River	3/2/2004	123	574			
LWR-07 / Little White River	3/24/2004	163	364			
LWR-07 / Little White River	5/4/2004	136	435			
LWR-07 / Little White River	5/12/2004	155	450			
LWR-07 / Little White River	5/13/2004	120	450			
LWR-07 / Little White River	6/9/2004	119	292			
LWR-07 / Little White River	7/6/2004	120	315			
LWR-07 / Little White River	8/2/2004	76	195			
LWR-07 / Little White River	8/15/2004	69	164			
LWR-07 / Little White River	8/16/2004	138	1,250			
LWR-07 / Little White River	9/23/2004	111	388			
LWR-08 / Little White River	11/12/2003	110	230			
LWR-08 / Little White River	8/30/2004	69	176			
LWR-08 / Little White River	9/15/2004	72	176			
LWR-08 / Little White River	9/22/2004	106	210			
LWR-08 / Little White River	9/24/2004	112	450			
				64	**42**	**65.6%**
Site (WQM Data)						
WQM-13 (Assessment LWR-05)	3/19/2001	468	660			
WQM-13 (Assessment LWR-05)	4/16/2001	434	548			
WQM-13 (Assessment LWR-05)	5/21/2001	201	548			
WQM-13 (Assessment LWR-05)	6/18/2001	189	232			
WQM-13 (Assessment LWR-05)	7/9/2001	176	690			
WQM-13 (Assessment LWR-05)	8/13/2001	153	202			
WQM-13 (Assessment LWR-05)	9/17/2001	95	208			
WQM-13 (Assessment LWR-05)	11/19/2001	83	166			
WQM-13 (Assessment LWR-05)	3/18/2002	258	244			
WQM-13 (Assessment LWR-05)	4/1/2002	325	680			
WQM-13 (Assessment LWR-05)	6/17/2002	96	296			
WQM-13 (Assessment LWR-05)	8/12/2002	51	190			
WQM-13 (Assessment LWR-05)	9/23/2002	148	232			
WQM-13 (Assessment LWR-05)	10/15/2002	50	532			
WQM-13 (Assessment LWR-05)	3/18/2003	247	367			
WQM-13 (Assessment LWR-05)	5/20/2003	143	206			
WQM-13 (Assessment LWR-05)	6/17/2003	96	1460			
WQM-13 (Assessment LWR-05)	8/19/2003	53	280			

Table 10 (continued). Long-term total suspended solids (TSS) concentrations violations ((Assessment (2003 through 2004) and WQM (2001 through 2005)) for the Little White River, Mellette County, South Dakota.

Site/(Stream/River) (Assessment Data)	Date	Flow (CFS)	Total Suspended Solids [1] (mg/L)	Sample Total	Violation Total	Percent Violation
WQM-13 (Assessment LWR-05)	9/16/2003	64	214			
WQM-13 (Assessment LWR-05)	10/14/2003	77	860			
WQM-13 (Assessment LWR-05)	11/18/2003	112	212			
WQM-13 (Assessment LWR-05)	3/16/2004	195	220			
WQM-13 (Assessment LWR-05)	4/13/2004	98	2720			
WQM-13 (Assessment LWR-05)	5/18/2004	95	180			
WQM-13 (Assessment LWR-05)	6/22/2004	82	306			
WQM-13 (Assessment LWR-05)	8/17/2004	57	345			
WQM-13 (Assessment LWR-05)	10/12/2004	79	168			
WQM-13 (Assessment LWR-05)	11/16/2004	104	210			
WQM-13 (Assessment LWR-05)	2/15/2005	-	335			
WQM-13 (Assessment LWR-05)	3/14/2005	107	228			
WQM-13 (Assessment LWR-05)	4/12/2005	203	241			
WQM-13 (Assessment LWR-05)	5/17/2005	261	220			
				56	**32**	**57.1%**
Total				**120**	**74**	**61.7%**

[1] = Total suspended solids standard is ≤ 158 mg/L
- = No data

Table 11. Long-term temperature violations ((Assessment (2003 through 2004)) and WQM (2001 through 2005)) for the Little White River, Mellette County, South Dakota.

Site/(Stream/River) (Assessment Data)	Date	Flow (CFS)	Temperature [1] (su)	Sample Total	Violation Total	Percent Violation
LWR-06 / Little White River	7/21/2004	28	33.5			
LWR-06 / Little White River	8/2/2004	49	32.3			
				66	2	3.0%
Site (WQM Data)						
WQM-13 (Assessment LWR-05)	-	-	-			
				53	0	0%
Total				119	2	1.7%

[1] = Temperature standard is ≤ 32.2 °C
- = No data

Table 12. Long-term fecal coliform bacteria (colonies/100 ml) violations from May through September using assessment (2003 through 2004) and WQM (2001 through 2006) data for Cut Meat Creek and the Little White River, Mellette County, South Dakota.

Site/(Stream/River) (Assessment Data)	Date	Flow (CFS)	Fecal Coliform Bacteria [1] (colonies/100 ml)	Sample Total	Violation Total	Percent Violation [2]
LWR-05 / Little White River	5/24/2004	211	7,300			
LWR-05 / Little White River	8/16/2004	74	11,000			
				9	2	22.2%
LWR-06 / Little White River	6/9/2004	125	2,600			
LWR-06 / Little White River	8/16/2004	114	6,600			
				10	2	20.0%
LWR-07 / Little White River	8/16/2004	138	3,600			
LWR-07 / Little White River	9/23/2004	111	2,400			
				11	2	18.2%
LWR-08 / Little White River	-	-	-			
				1	0	0.0%
Site (WQM Data)						
WQM-13 (Assessment LWR-05)	-	-	-	30	0	0%
Little White River Total				61	6	9.8%

Site/(Stream/River) (Assessment Data)	Date	Flow (CFS)	Fecal Coliform Bacteria [1] (colonies/100 ml)	Sample Total	Violation Total	Percent Violation [2]
LWR-01 Cut Meat Creek	5/13/2004	6.45	8,800			
				5	1	20.0%
USGS Site						
# 432358100502600	-	-	-	3	0	0.0%
Cut Meat Creek Total				8	1	12.5%

[1] = Fecal coliform standard is ≤ 2,000 colonies/100 ml
[2] = Criteria for support status for streams is if greater than 10 percent of the samples violate water quality standards where 20 or more samples are available or greater than 25 percent of the samples violate water quality standards where there are less than 20 samples available to consider segment water quality-limited.
- = No data

Table 13. Total dissolved solids (TDS) concentrations violations (Assessment) for Cut Meat Creek, Pine Creek and the Little White River, Mellette County, South Dakota from 2003 through 2004.

Site/(Stream/River) (Assessment Data)	Date	Flow (CFS)	Total Dissolved Solids[1] (mg/L)	Sample Total	Violation Total	Percent Violation
LWR-03 / North Branch Pine Creek	3/29/2004	0.93	7,975			
LWR-03 / North Branch Pine Creek	5/13/2004	0.62	4,953			
LWR-03 / North Branch Pine Creek	5/24/2004	8.04	4,473			
LWR-03 / North Branch Pine Creek	6/11/2004	2.52	5,369			
LWR-03 / North Branch Pine Creek	7/22/2004	0.20	12,805			
LWR-03 / North Branch Pine Creek	9/21/2004	0.48	7,795			
Total				**10**	**6**	**60%**

[1] = Total dissolved solids standard is ≤ 4,375 colonies/100 ml
- = No data

Table 14. Ammonia violations (assessment) for the Little White River, Mellette County, South Dakota from 2003 through 2004.

Site/(Stream/River) (Assessment Data)	Date	Flow (CFS)	Ammonia (mg/L)	Total Ammonia[1] Limit (mg/L)	Sample Total	Violation Total	Percent Violation
LWR-06 / Little White River	8/16/2004	113.6	0.31	0.27			
					64	1	1.6%
Site (WQM Data)							
WQM-13 (Assessment LWR-05)	-	-	-				
					62	0	0%
Total					126	1	0.8%

[1] = Total ammonia standard is calculated using Equation 2, the original sample concentration can not exceed this value

Only assessment data collected from mainstem Little White River sites (Todd County line to the mouth of the White River, LWR-07, LWR-08, LWR-05 and LWR-06) were used to determine water quality standards violations in the Little White River segment (R 5, 2006 Integrated Report, page 134 (SD DENR, 2006)). The WQM site on the Little White River near White River, South Dakota (DENR 460840, WQM 13) was also the location of the USGS gage site and was LWR-05 sampling site during the assessment. Assessment data collected from LWR-01 was used to determine water quality standards violations in the Cut Meat Creek segment; while water quality data collected from LWR-03 and LWR-04 were used to determine water quality standards violations in Pine Creek. Listing criteria for impairment in the South Dakota Integrated Report for the support status for streams states that if greater than 10 percent of the samples violate water quality standards where 20 or more samples are available, or, greater than 25 percent of the samples violate water quality standards, where there are less than 20 samples available, to consider segment water quality-limited (Table 6 and SD DENR, 2006).

Four of the six parameters with water quality standard violations (pH, temperature, fecal coliform and ammonia) based on overall percentage, were below listing criteria outlined above (< 10 percent) and are not considered a problem in the Little White River.

The total suspended solids (TSS) parameter applies to mainstem Little White River and had an overall violation rate of 61.7 percent. Based on assessment, SD DENR WQM and USGS samples, TSS assessment samples were determined to be well within long-term median values and were considered natural for this watershed. Detailed information concerning TSS and the proposed site-specific standards change can be found in the total suspended solids section of this report.

The other parameter, total dissolved solids (TDS) applies to all waters in Mellette County and the state. TDS violations were only observed in the north branch of Pine Creek (LWR-03) with an overall violation rate of 60 percent (Table 13 and Figure 34). Four of the six sample violations occurred during low flow events (< 1 cfs) which were attributed to groundwater recharge during low flow conditions. Most of the Pine Creek watershed is located in the Pierre Shale formation which is known to have regions that contribute high concentrations of dissolved solids via surface water infiltration, seeps and recharge areas along streams and rivers in western South

Dakota. Other watersheds in western South Dakota have high TDS concentrations attributed to the Pierre Shale formation. Medicine Creek in Lyman and Jones Counties, Cottonwood Creek in Mellette County and the Freeman Dam watershed all have TDS violations attributed to naturally occurring solutes originating from the Pierre Shale formation. Detailed information concerning TDS can be found in the total dissolved solids section of this report. Given the geologic makeup of the Pine Creek watershed and similar TDS/conductivity violation conditions in other watersheds discussed above, high TDS concentrations were considered a natural condition in this watershed.

Seasonal Tributary Water Quality

Typically, water quality parameters will vary depending upon season due to changes in temperature, precipitation and agricultural practices. Eighty-eight tributary water quality samples were collected during the Little White River watershed assessment project. These data were separated seasonally: winter (January – March), spring (April – June), summer (July – September) and fall (October – December). Runoff was recorded at three mainstem sites during the summer of 2003 (LWR-08 was flowing, however, the site was not installed or sampled until the fall 2003), four sites in the fall 2003, six sites in the winter of 2004 (LWR-08 was flowing but not sampled), six sites in the spring of 2004 (LWR-08 was flowing but not sampled), seven sites in the summer of 2004 and four mainstem sites in the fall of 2004.

Sediment and nutrient concentrations can change dramatically with changes in water volume. Large hydrologic loads at a site may have small concentrations; however, more runoff usually increases nonpoint source runoff and thus higher loadings of nutrients and sediment may result. Average seasonal tributary concentrations for the Little White River by year and season are provided in Table 15 (summer 2003), Table 16 (fall 2003), Table 17 (winter 2004), Table 18 (spring 2004), Table 19 (summer 2004) and Table 20 (fall 2004).

Tributary Concentrations

Table 15. Average summer tributary concentrations by tributary monitoring site for Cut Meat Creek, Horse Creek[4], Pine Creek and the Little White River, Mellette County, South Dakota for 2003.[1,2,3]

Summer 2003

	Monitoring Site							
	LWR-01	LWR-07	LWR-02	LWR-08	LWR-03	LWR-04	LWR-05	LWR-06
Data	Cut Meat Creek	Little White River (Todd Co. Line)	Horse Creek	Little White River	North Branch Pine Creek	Pine Creek (Mouth)	Little White River	Little White River (Mouth)
Water Temperature (^oC)	-	13.51	-	-	-	-	16.96	18.34
Dissolved Oxygen (mg/L)	-	11.52	-	-	-	-	9.69	9.33
pH (su)	-	7.35	-	-	-	-	7.63	7.87
Conductivity @ 25^o C (µS/cm)	-	266	-	-	-	-	320	360
Fecal Coliform Bacteria (colonies/100 ml)	-	70	-	-	-	-	590	20
E. coli Bacteria (colonies/100 ml)	-	105	-	-	-	-	579	5
Alkalinity (mg/L)	No	141	No	Not	No	No	170	157
Total Solids (mg/L)	Flow	248	Flow	Sampled	Flow	Flow	1,406	317
Total Dissolved Solids (mg/L)	-	219	-	-	-	-	146	264
Total Suspended Solids (mg/L)	-	29	-	-	-	-	1,260	53
Total Volatile Suspended Solids (mg/L)	-	6	-	-	-	-	160	9
Ammonia (mg/L)	-	0.01	-	-	-	-	0.16	0.01
Nitrate-Nitrite (mg/L)	-	0.20	-	-	-	-	0.70	0.05
Total Kjeldahl Nitrogen (mg/L)	-	0.06	-	-	-	-	0.57	0.06
Organic Nitrogen (mg/L)	-	0.05	-	-	-	-	0.41	0.05
Inorganic Nitrogen (mg/L)	-	0.21	-	-	-	-	0.86	0.06
Total Nitrogen (mg/L)	-	0.26	-	-	-	-	1.27	0.11
Total Phosphorus (mg/L)	-	0.081	-	-	-	-	1.140	0.120
Total Dissolved Phosphorus (mg/L)	-	0.047	-	-	-	-	0.052	0.042
Total Nitrogen : Total Phosphorus Ratio (mg/L)	-	3.21	-	-	-	-	1.11	0.92

[1] = **Highlighted are the highest recorded average concentration or value in the Little White River watershed for a given parameter for the summer of 2003.**
[2] = **pH values are the highest seasonal concentration not average.**
[3] = **Four of the eight tributary monitoring sites flowed in the summer of 2003; however no samples were collected on LWR-08 during this sampling period.**
[4] = **Horse Creek never flowed during the project**

Table 16 Average fall tributary concentrations by tributary monitoring site for Cut Meat Creek, Horse Creek[4], Pine Creek and the Little White River, Mellette County, South Dakota for 2003.[1,2,3]

Fall 2003

	Monitoring Site							
	LWR-01	LWR-07	LWR-02	LWR-08	LWR-03	LWR-04	LWR-05	LWR-06
Data	Cut Meat Creek	Little White River (Todd Co. Line)	Horse Creek	Little White River	North Branch Pine Creek	Pine Creek (Mouth)	Little White River	Little White River (Mouth)
Water Temperature (°C)	-	3.99	-	1.19	-	-	5.13	5.23
Dissolved Oxygen (mg/L)	-	12.68	-	11.04	-	-	12.71	12.32
pH (su)	-	7.77	-	7.68	-	-	7.96	7.83
Conductivity @ 25° C (µS/cm)	-	186	-	188	-	-	188	203
Fecal Coliform Bacteria (colonies/100 ml)	-	73	-	170	-	-	295	92
E. coli Bacteria (colonies/100 ml)	-	76	-	122	-	-	140	80
Alkalinity (mg/L)	No	143	No	152	No	No	163	144
Total Solids (mg/L)	Flow	342	Flow	460	Flow	Flow	1,021	400
Total Dissolved Solids (mg/L)	-	244	-	230	-	-	289	249
Total Suspended Solids (mg/L)	-	98	-	230	-	-	732	150
Total Volatile Suspended Solids (mg/L)	-	11	-	24	-	-	71	15
Ammonia (mg/L)	-	0.01	-	0.01	-	-	0.06	0.01
Nitrate-Nitrite (mg/L)	-	0.63	-	0.70	-	-	0.58	0.55
Total Kjeldahl Nitrogen (mg/L)	-	0.39	-	0.52	-	-	0.57	0.38
Organic Nitrogen (mg/L)	-	0.38	-	0.51	-	-	0.51	0.37
Inorganic Nitrogen (mg/L)	-	0.64	-	0.71	-	-	0.63	0.56
Total Nitrogen (mg/L)	-	1.02	-	1.22	-	-	1.14	0.93
Total Phosphorus (mg/L)	-	0.195	-	0.367	-	-	0.605	0.246
Total Dissolved Phosphorus (mg/L)	-	0.097	-	0.105	-	-	0.090	0.076
Total Nitrogen : Total Phosphorus Ratio (mg/L)	-	5.51	-	3.32	-	-	4.04	3.60

[1] = Highlighted are the highest recorded average concentration or value in the Little White River watershed for a given parameter for the fall of 2003.
[2] = pH values are the highest seasonal concentration not average.
[3] = Four of the eight tributary monitoring sites flowed in the fall of 2003.
[4] = Horse Creek never flowed during the project

Table 17. Average winter tributary concentrations by tributary monitoring site for Cut Meat Creek, Horse Creek[4], Pine Creek and the Little White River, Mellette County, South Dakota for 2004.[1,2,3]

Winter 2004

	Monitoring Site							
	LWR-01	LWR-07	LWR-02	LWR-08	LWR-03	LWR-04	LWR-05	LWR-06
Data	Cut Meat Creek	Little White River (Todd Co. Line)	Horse Creek	Little White River	North Branch Pine Creek	Pine Creek (Mouth)	Little White River	Little White River (Mouth)
Water Temperature (°C)	5.24	2.64	-	-	4.95	4.98	4.92	6.76
Dissolved Oxygen (mg/L)	12.77	12.40	-	-	11.99	11.02	12.09	11.52
pH (su)	7.58	7.75	-	-	8.53	7.80	7.98	7.83
Conductivity @ 25° C (µS/cm)	446	256	-	-	285	554	204	237
Fecal Coliform Bacteria (colonies/100 ml)	113	10	-	-	2,467	6,433	31	10
E. coli Bacteria (colonies/100 ml)	150	31	-	-	1,286	2,420	29	17
Alkalinity (mg/L)	205	127	No	Not	163	167	126	133
Total Solids (mg/L)	421	487	Flow	Sampled	6,944	6,285	403	638
Total Dissolved Solids (mg/L)	341	169	-	-	4,261	2,502	202	186
Total Suspended Solids (mg/L)	80	318	-	-	2,683	3,783	201	452
Total Volatile Suspended Solids (mg/L)	6	19	-	-	183	210	14	28
Ammonia (mg/L)	0.01	0.01	-	-	0.04	0.01	0.01	0.01
Nitrate-Nitrite (mg/L)	0.15	0.53	-	-	0.60	0.73	0.50	0.57
Total Kjeldahl Nitrogen (mg/L)	0.80	1.01	-	-	1.42	2.45	0.37	0.21
Organic Nitrogen (mg/L)	0.79	1.00	-	-	1.39	2.44	0.36	0.20
Inorganic Nitrogen (mg/L)	0.16	0.54	-	-	0.64	0.74	0.51	0.58
Total Nitrogen (mg/L)	0.95	1.54	-	-	2.02	3.19	0.87	0.77
Total Phosphorus (mg/L)	0.349	0.331	-	-	2.486	1.536	0.344	0.575
Total Dissolved Phosphorus (mg/L)	0.227	0.129	-	-	0.217	0.112	0.111	0.113
Total Nitrogen : Total Phosphorus Ratio (mg/L)	3.02	5.24	-	-	1.84	2.29	2.87	2.38

[1] = Highlighted are the highest recorded average concentration or value in the Little White River watershed for a given parameter for the winter of 2004.
[2] = pH values are the highest seasonal concentration not average.
[3] = Seven of the eight tributary monitoring sites flowed in the winter of 2004; however no samples were collected on LWR-08 during this sampling period.
[4] = Horse Creek never flowed during the project

Table 18. Average spring tributary concentrations by tributary monitoring site for Cut Meat Creek, Horse Creek[5], Pine Creek and the Little White River, Mellette County, South Dakota for 2004.[1,2,3]

Spring 2004

	Monitoring Site							
	LWR-01	LWR-07	LWR-02	LWR-08	LWR-03	LWR-04	LWR-05	LWR-06
Data	Cut Meat Creek	Little White River (Todd Co. Line)	Horse Creek	Little White River	North Branch Pine Creek	Pine Creek (Mouth)	Little White River	Little White River (Mouth)
Water Temperature (°C)	15.25	16.17	-	-	10.96	15.54	15.11	14.60
Dissolved Oxygen (mg/L)	9.67	9.47	-	-	8.63	6.70	9.62	9.46
pH (su)	8.43	8.65	-	-	8.48	6.92	8.54	8.58
Conductivity @ 25° C (µS/cm)	490	235	-	-	278	428	330	363
Fecal Coliform Bacteria (colonies/100 ml)	2,535	435	-	-	58,700	35,000	2,098	1,305
E. coli Bacteria (colonies/100 ml)	1,168	638	-	-	2,420	2,420	937	1,176
Alkalinity (mg/L)	231	149	No	Not	156	376	163	153
Total Solids (mg/L)	885	595	Flow	Sampled	8,050	18,225	1,248	816
Total Dissolved Solids (mg/L)	471	188	-	-	3,813	2,125	381	271
Total Suspended Solids (mg/L)	415	407	-	-	4,238	16,100	867	545
Total Volatile Suspended Solids (mg/L)	45	60	-	-	408	1,600	136	74
Ammonia (mg/L)	0.01	0.01	-	-	0.07	0.01	0.01	0.01
Nitrate-Nitrite (mg/L)	0.11	0.21	-	-	0.70	0.60	0.18	0.13
Total Kjeldahl Nitrogen (mg/L)	1.03	1.95	-	-	4.11	6.00	1.78	1.72
Organic Nitrogen (mg/L)	1.02	1.94	-	-	4.03	5.99	1.77	1.71
Inorganic Nitrogen (mg/L)	0.12	0.22	-	-	0.77	0.61	0.19	0.14
Total Nitrogen (mg/L)	1.14	2.17	-	-	4.81	6.60	1.95	1.85
Total Phosphorus (mg/L)	0.464	0.511	-	-	3.623	7.990	0.728	0.745
Total Dissolved Phosphorus (mg/L)	0.071	0.080	-	-	*[4]	*[4]	0.062	0.160
Total Nitrogen : Total Phosphorus Ratio (mg/L)	4.27	4.26	-	-	1.54	0.83	3.19	2.52

[1] = Highlighted are the highest recorded average concentration or value in the Little White River watershed for a given parameter for the spring of 2004.
[2] = pH values are the highest seasonal concentration not average.
[3] = Seven of the eight tributary monitoring sites flowed in the spring of 2004; however no samples were collected on LWR-08 during this sampling period.
[4] = Total dissolved phosphorus was not filtered at these sites because of the colloidal nature of the water (plugged filter).
[5] = Horse Creek never flowed during the project

Table 19. Average summer tributary concentrations by tributary monitoring site for Cut Meat Creek, Horse Creek[5], Pine Creek and the Little White River, Mellette County, South Dakota for 2004.[1,2,3]

Summer 2004

	Monitoring Site							
	LWR-01	LWR-07	LWR-02	LWR-08	LWR-03	LWR-04	LWR-05	LWR-06
Data	Cut Meat Creek	Little White River (Todd Co. Line)	Horse Creek	Little White River	North Branch Pine Creek	Pine Creek (Mouth)	Little White River	Little White River (Mouth)
Water Temperature (°C)	16.33	19.26	-	15.95	13.91	10.97	19.25	24.51
Dissolved Oxygen (mg/L)	7.46	8.82	-	10.67	8.06	9.44	9.63	8.32
pH (su)	7.60	8.73	-	8.26	7.90	7.02	9.10	9.17
Conductivity @ 25° C (µS/cm)	249	275	-	280	339	278	258	182
Fecal Coliform Bacteria (colonies/100 ml)	1,800	1,205	-	730	50,500	-	3,018	1,554
E. coli Bacteria (colonies/100 ml)	2,420	1,014	-	1,200	2,420	-	806	795
Alkalinity (mg/L)	108	136	No	140	270	171	142	151
Total Solids (mg/L)	898	538	Flow	442	14,750	9,240	1,886	1,511
Total Dissolved Solids (mg/L)	258	173	-	189	10,300	2,690	462	185
Total Suspended Solids (mg/L)	640	365	-	253	4,450	6,550	1,424	1,326
Total Volatile Suspended Solids (mg/L)	120	48	-	27	284	750	139	150
Ammonia (mg/L)	0.19	0.02	-	0.01	0.01	0.01	0.03	0.06
Nitrate-Nitrite (mg/L)	0.80	0.24	-	0.30	0.40	0.30	0.21	0.15
Total Kjeldahl Nitrogen (mg/L)	2.84	1.95	-	1.06	4.66	4.34	2.71	3.13
Organic Nitrogen (mg/L)	2.65	1.94	-	1.05	4.65	4.33	2.68	3.06
Inorganic Nitrogen (mg/L)	0.99	0.25	-	0.31	0.41	0.31	0.24	0.21
Total Nitrogen (mg/L)	3.64	2.19	-	1.36	5.06	4.64	2.93	3.28
Total Phosphorus (mg/L)	1.600	0.470	-	0.323	4.467	2.580	0.970	0.854
Total Dissolved Phosphorus (mg/L)	*[4]	0.043	-	0.052	*[4]	*[4]	0.025	0.031
Total Nitrogen : Total Phosphorus Ratio (mg/L)	2.28	5.30	-	5.45	5.17	1.80	5.24	5.41

[1] = Highlighted are the highest recorded average concentration or value in the Little White River watershed for a given parameter for the summer of 2004.
[2] = pH values are the highest seasonal concentration not average.
[3] = Seven of the eight tributary monitoring sites flowed in the summer of 2004.
[4] = Total dissolved phosphorus was not filtered at these sites because of the colloidal nature of the water (plugged filter).
[5] = Horse Creek never flowed during the project
[6] = Fecal coliform and E. coli not sampled at this site during the summer 2004.

Table 20. Average fall tributary concentrations by tributary monitoring site for Cut Meat Creek, Horse Creek[5], Pine Creek and the Little White River, Mellette County, South Dakota for 2004.[1,2,3]

Fall 2004

	Monitoring Site							
	LWR-01	LWR-07	LWR-02	LWR-08	LWR-03	LWR-04	LWR-05	LWR-06
Data	Cut Meat Creek	Little White River (Todd Co. Line)	Horse Creek	Little White River	North Branch Pine Creek	Pine Creek (Mouth)	Little White River	Little White River (Mouth)
Water Temperature (^{o}C)	-	8.61	-	8.84	-	-	9.26	8.95
Dissolved Oxygen (mg/L)	-	10.30	-	10.41	-	-	11.05	10.45
pH (su)	-	7.18	-	7.59	-	-	7.88	7.93
Conductivity @ 25^{o} C (µS/cm)	-	304	-	311	-	-	313	328
Fecal Coliform Bacteria (colonies/100 ml)	-	40	-	60	-	-	390	70
E. coli Bacteria (colonies/100 ml)	-	81	-	77	-	-	687	120
Alkalinity (mg/L)	No	140	No	145	No	No	152	146
Total Solids (mg/L)	Flow	308	Flow	361	Flow	Flow	1,357	358
Total Dissolved Solids (mg/L)	-	193	-	227	-	-	157	230
Total Suspended Solids (mg/L)	-	115	-	134	-	-	1,200	128
Total Volatile Suspended Solids (mg/L)	-	13	-	16	-	-	84	16
Ammonia (mg/L)	-	0.01	-	0.01	-	-	0.01	0.01
Nitrate-Nitrite (mg/L)	-	0.70	-	0.60	-	-	0.60	0.50
Total Kjeldahl Nitrogen (mg/L)	-	0.44	-	0.44	-	-	1.51	0.47
Organic Nitrogen (mg/L)	-	0.43	-	0.43	-	-	1.50	0.46
Inorganic Nitrogen (mg/L)	-	0.71	-	0.61	-	-	0.61	0.51
Total Nitrogen (mg/L)	-	1.14	-	1.04	-	-	2.11	0.97
Total Phosphorus (mg/L)	-	0.272	-	0.248	-	-	0.804	0.245
Total Dissolved Phosphorus (mg/L)	-	0.166	-	0.119	-	-	*[4]	0.087
Total Nitrogen : Total Phosphorus Ratio (mg/L)	-	4.19	-	4.19	-	-	2.62	3.96

[1] = Highlighted are the highest recorded average concentration or value in the Little White River watershed for a given parameter for the fall of 2004.
[2] = pH values are the highest seasonal concentration not average.
[3] = Four of the eight tributary monitoring sites flowed in the fall of 2004.
[4] = Total dissolved phosphorus was not filtered at this site.
[5] = Horse Creek never flowed during the project

Two violations in pH have been recorded in the Little White River in the past five years, both during assessment monitoring (Table 9); while no violations were recorded for the WQM sampling site. Seasonally, the highest pH value was recorded in the summer of 2004 at LWR-06 (mouth of the Little White River during low flows). The overall violation percentage rate for pH was 1.7 percent which is below Department listing criteria. Generally, pH does not appear to be a problem in the Little White River.

Similar to pH, the total suspended solids (TSS) standard applies to beneficial use standard (5) warmwater semi-permanent fish life propagation waters (158 mg/L) and only applies to mainstem Little White River. Mainstem Little White River is listed in the 2004 and 2006 Integrated Report (SD DENR, 2004 and SD DENR, 2006) for total suspended solids (TSS). Assessment (42 violations) and WQM data (32 violations) indicate that TSS is a problem in the Little White River with an overall violation rate of 61.7 percent (74 out of 120 samples) based on five years of data (Table 10). Average seasonal concentrations of TSS were greatest during the summer of 2003 (1,260 mg/L, Table 15). The violation rate for TSS at the Todd County line is 65.6 percent (11 violations out of 19 samples) and the TSS violation rate within Mellette County was 57.6 percent (42 violations out of 64 samples).

The temperature standard also applies to beneficial use standard (5) warmwater semi-permanent fish life propagation waters ($\leq$ 32.2 °C) and only applies to mainstem Little White River. Two violations were recorded during the assessment in temperature, while no temperature violations were recorded at the WQM site from 2001 through 2005 in mainstem Little White River (Table 11). Assessment temperature violations occurred during the summer (July and August 2004) near the mouth of the White River (LWR-06). Average seasonal temperatures were also highest at LWR-06 (24.51 °C) during the summer of 2004 (Table 19). Violations were recorded during low flow conditions at LWR-06, a site 54.8 m (180 feet) wide with no mid-channel canopy cover to block sunlight. The overall violation percentage was 1.7 percent and is not considered a problem in the Little White River watershed.

Fecal coliform bacteria originate in waste material from warm-blooded animals and usually indicate the presence of animal or human wastes. The standard applies to the mainstem Little White River from May 1 through September 30 (fecal season) each year. The fecal coliform standard applies to the limited contact recreation waters (8) for the Little White River. Six fecal coliform violations occurred during the assessment, while no WQM fecal coliform violations were recorded from 2001 through 2005. The overall violation rate for mainstem Little White River was 9.8 percent (Table 12). Average fecal coliform concentrations were highest in the spring of 2004 at LWR-05 (2,098 colonies/100 ml) in mainstem Little White River (Table 18). Winter livestock feeding areas in and around mainstem Little White River, cattle having unlimited access to the River and wildlife were the most likely sources of sporadic increased fecal coliform counts. Current data indicate that fecal coliform violations do not exceed surface water quality standards and do not require a TMDL.

Little White River data indicate total dissolved solids (TDS) were high at the North Branch of Pine Creek (LWR-03) sampling site (Table 13). The North Branch of Pine Creek is not currently listed in the 2004 South Dakota Integrated Report as violating TDS standards. Other watersheds in western South Dakota have high TDS concentrations attributed to the Pierre Shale formation. Medicine Creek in Lyman and Jones Counties, Cottonwood Creek in Mellette County and the

Freeman Dam watershed all have TDS violations attributed to naturally occurring solutes originating from the Pierre Shale formation.

The ammonia standard is a calculated value (calculating the total ammonia limit) using pH based on beneficial use category and presence or absence of salmonid fish species or whether early fish life stages are present. The Little White River has the beneficial use of warmwater semi-permanent fish life propagation water with the total ammonia limit calculated using Equation 2. Table 14 indicates a 1.6 percent violation rate (1 violation out of 64 samples) and is not considered a problem in this watershed.

Seasonalized Tributary Hydrologic Loadings

Eight tributary monitoring sites were set up on the Little White River from the Todd County line to the mouth of the White River, South Dakota in the late summer of 2003. All sites were monitored approximately 413 days from September 2003 through November 2004 excluding winter months.

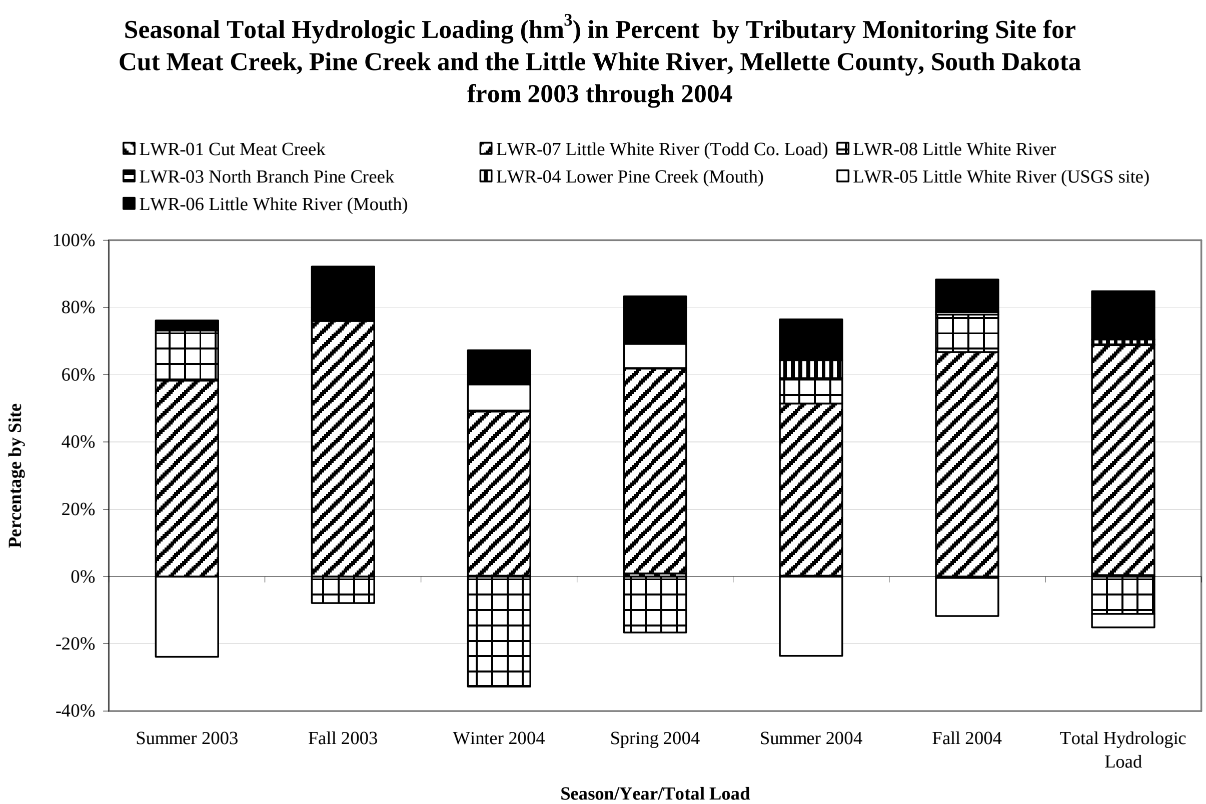


Figure 5. Seasonal hydrologic loading percentage by tributary monitoring site for Cut Meat Creek, Pine Creek and the Little White River, Mellette County, South Dakota from 2003 through 2004.

Table 21. Seasonal hydrologic loading by tributary monitoring site for the Little White River, Mellette County, South Dakota from 2003 through 2004[1].

		Sub-watershed		Seasonal Hydrologic Loading		Export Coefficients	
Location	**Site**	**Acres**	**Season**	**Meters^3**	**Acre-feet**	**Meters^3**	**Acre-feet**
Cut Meat Creek (Near Little White River mouth)	LWR-01	108,769	Summer - 03	0	0.0	0.00	0.000
			Fall - 03	0	0.0	0.00	0.000
			Winter - 04	62,000	50.3	0.57	0.000
			Spring - 04	392,000	317.8	3.60	0.003
			Summer - 04	73,000	59.2	0.67	0.001
			Fall - 04	0	0.0	0.00	0.000
			Sub-watershed Total	**527,000**	**427.2**	**4.85**	**0.004**
Little White River (Todd County Line)	LWR-07	819,479	Summer - 03	2,309,000	1,872	2.82	0.002
			Fall - 03	12,347,000	10,010	15.07	0.012
			Winter - 04	12,905,000	10,462	15.75	0.013
			Spring - 04	26,170,000	21,216	31.93	0.026
			Summer - 04	16,086,000	13,041	19.63	0.016
			Fall - 04	8,387,000	6,799	10.23	0.008
			Sub-watershed Total	**78,204,000**	**63,400**	**95.43**	**0.077**
Horse and Horse Head Creek (Never flowed during the project)	LWR-02	42,965	Summer - 03	0	0.0	0.00	0.000
			Fall - 03	0	0.0	0.00	0.000
			Winter - 04	0	0.0	0.00	0.000
			Spring - 04	0	0.0	0.00	0.000
			Summer - 04	0	0.0	0.00	0.000
			Fall - 04	0	0.0	0.00	0.000
			Sub-watershed Total	**0**	**0.0**	**0.00**	**0.000**
Little White River (Highway 44 Bridge)	LWR-08	56,185	Summer - 03	591,000	479	10.52	0.009
			Fall - 03	-1,279,000	-1,037	-22.76	-0.018
			Winter - 04	-8,611,000	-6,981	-153.26	-0.124
			Spring - 04	-7,155,000	-5,801	-127.35	-0.103
			Summer - 04	2,283,000	1,851	40.63	0.033
			Fall - 04	1,396,000	1,132	24.85	0.020
			Sub-watershed Total	**-12,775,000**	**-10,357**	**-297.34**	**-0.184**

[1] = Periodic negative hydrologic loading at some monitoring sites suggest seasonal reductions in overall water delivery from receiving sub-watersheds.

Table 20 (continued). Seasonal hydrologic loading by tributary monitoring site for the Little White River, Mellette County, South Dakota from 2003 through 2004[1].

		Sub-watershed		Seasonal Hydrologic Loading		Export Coefficients	
Location	**Site**	**Acres**	**Season**	**Meters^3**	**Acre-feet**	**Meters^3**	**Acre-feet**
North Branch Pine Creek	LWR-03	30,319	Summer - 03	0	0	0.00	0.000
			Fall - 03	0	0	0.00	0.000
			Winter - 04	79,000	64	2.61	0.002
			Spring - 04	55,000	45	1.81	0.001
			Summer - 04	84,000	68	2.77	0.002
			Fall - 04	102,000	83	3.36	0.003
			Sub-watershed Total	**320,000**	**259**	**10.55**	**0.009**
Pine Creek (Near Little White River mouth)	LWR-04	49,697	Summer - 03	0	0	0.00	0.000
			Fall - 03	0	0	0.00	0.000
			Winter - 04	-40,000	-32	-0.80	-0.001
			Spring - 04	9,000	7	0.18	0.000
			Summer - 04	1,684,000	1,365	33.89	0.027
			Fall - 04	-51,000	-41	-1.03	-0.001
			Sub-watershed Total	**1,602,000**	**1,299**	**32.24**	**0.026**
Little White River (Highway 38 Bridge, USGS and DENR WQM site)	LWR-05	7,545	Summer - 03	-947,000	-768	-125.51	-0.102
			Fall - 03	78,000	63	10.34	0.008
			Winter - 04	2,059,000	1,669	272.90	0.221
			Spring - 04	3,085,000	2,501	408.88	0.331
			Summer - 04	-7,408,000	-6,006	-981.84	-0.796
			Fall - 04	-1,423,000	-1,154	-188.60	-0.153
			Sub-watershed Total	**-4,556,000**	**-3,694**	**-603.84**	**-0.490**
Little White River (Mouth)	LWR-06	48,218	Summer - 03	116,000	94	2.41	0.002
			Fall - 03	2,545,000	2,063	52.78	0.043
			Winter - 04	2,685,000	2,177	55.68	0.045
			Spring - 04	6,085,000	4,933	126.20	0.102
			Summer - 04	3,803,000	3,083	78.87	0.064
			Fall - 04	1,206,000	978	25.01	0.020
			Sub-watershed Total	**16,440,000**	**13,328**	**340.95**	**0.276**

[1] = Periodic negative hydrologic loading at some monitoring sites suggest seasonal reductions in overall water delivery from receiving sub-watersheds.

Approximately 80.3 million cubic meters (65,091 acre-feet) of water flowed through the Little White River and into the White River during the study (413 days). The overall tributary export coefficient (amount of water delivered per acre) was 76.2 m^3/acre (0.062 acre-foot/acre). Seasonal loading and annual export coefficients for all Little White River watershed monitoring sites are provided in Table 21.

For spatial reference, sub-watershed locations and areas can be compared in Figure 4. The peak hydrologic load for most mainstem Little White River sub-watersheds and Cut Meat Creek (LWR-01, LWR -07, LWR -05 and LWR -06) occurred in the spring of 2004. The other mainstem monitoring site (LWR-08 (Highway 44 Bridge)) and the lower Pine Creek sampling site (LWR-04) had peak flows in the summer of 2004. Peak flows at LWR-03 (North Branch of Pine Creek) were recorded during the fall of 2004 (Table 21).

Hydrologic loading was reduced between LWR-03 and LWR-04 during the winter and fall of 2004 (water originating at LWR-3 did not make it down to LWR-04). Hydrologic reductions were also observed between LWR-7 (Todd County line) and LWR-08 (Highway 44 Bridge) in the fall of 2003 and the winter and spring of 2004 (Table 21).

Tributary Water Quality and Loadings

Dissolved Oxygen

Dissolved oxygen concentrations in most unpolluted streams and rivers remain above 80 percent saturation. Solubility of oxygen generally increases as temperature decreases and decreases with decreasing atmospheric pressure (either by a change in elevation or barometric pressure, Hauer and Hill, 1996). Stream morphology, turbulence, organic loading and flow can also have an effect on oxygen concentrations. Dissolved oxygen concentrations are not uniform within or between stream reaches. Upwelling of interstitial waters at the groundwater and streamwater mixing zone (hyporheic zone) or side flow of groundwater may create patches within a stream reach where dissolved oxygen concentrations are significantly lower than surrounding water (Hauer and Hill, 1996).

During this study, the Little White River had a median dissolved oxygen concentration of 10.3 mg/L and averaged 10.4 mg/L (Appendix D, Table D-1). Overall, there were no significant differences in dissolved oxygen concentrations between Little White River monitoring sites in Mellette County (LWR-01 through LWR-08) or mainstem monitoring sites (Table 5 and Figure 6).

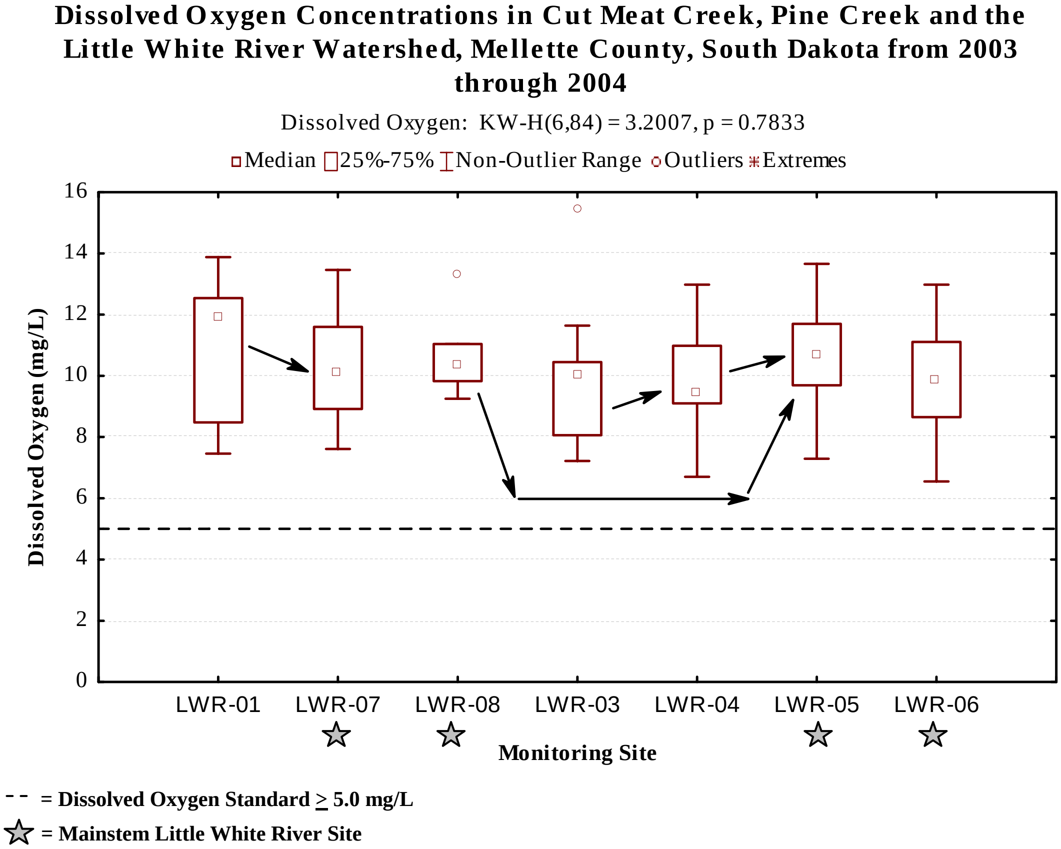


Figure 6. Dissolved oxygen concentrations by tributary monitoring site for Cut Meat Creek, Pine Creek and the Little White River, Mellette County, South Dakota from 2003 through 2004.

Seasonal and daily concentrations of chemicals (biotic and abiotic) in water can also affect dissolved oxygen concentrations. Higher chemical concentrations also increase Biochemical and Sediment Oxygen Demand (BOD and SOD). These processes use oxygen in the system to break down or convert organic and inorganic compounds.

The maximum dissolved oxygen concentration in the Little White River was 15.43 mg/L. This sample was collected at site LWR-03 on March 30, 2004 (Figure 6 and Appendix D, Table D-1). The minimum dissolved oxygen concentration was 6.55 mg/L at LWR-06 on July 21, 2004 (Appendix D, Table D-1). The dissolved oxygen standard only applies to mainstem Little White River sampling sites (LWR-07, LWR-08, LWR-05 and LWR-06). Assessment and WQM data indicate dissolved oxygen concentrations are not a problem in the Little White River.

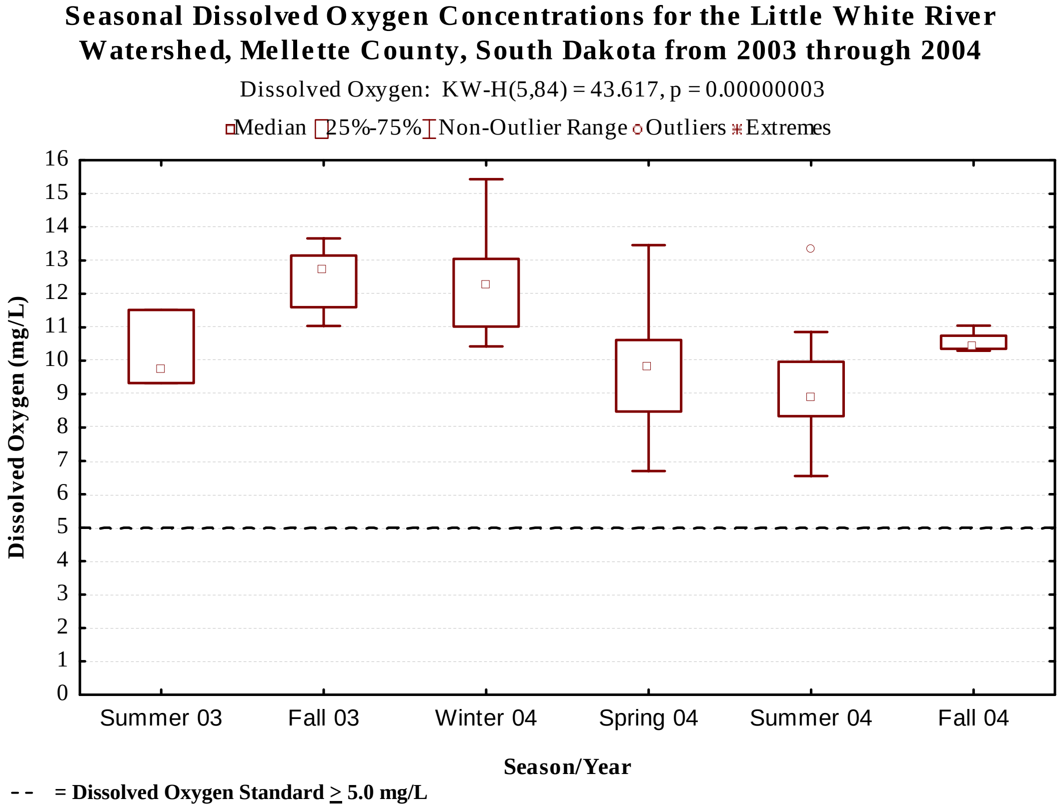


Figure 7. Seasonal comparison of dissolved oxygen by year for Cut Meat Creek, Pine Creek and the Little White River, Mellette County, South Dakota from 2003 through 2004

Seasonal tributary dissolved oxygen concentrations by year indicate the fall 2003 and winter 2004 sample concentrations were significantly higher than spring and summer 2004 sample concentrations (p=0.000) during the project (Figure 7) and was attributed to cool water temperatures during the fall and winter months (Appendix B Table B-36). Cool water can hold higher concentrations of dissolved oxygen than warmer water. Figure 8 shows dissolved oxygen concentrations between mainstem Little White River and tributaries to the Little White River were statistically similar (p= 0.76).

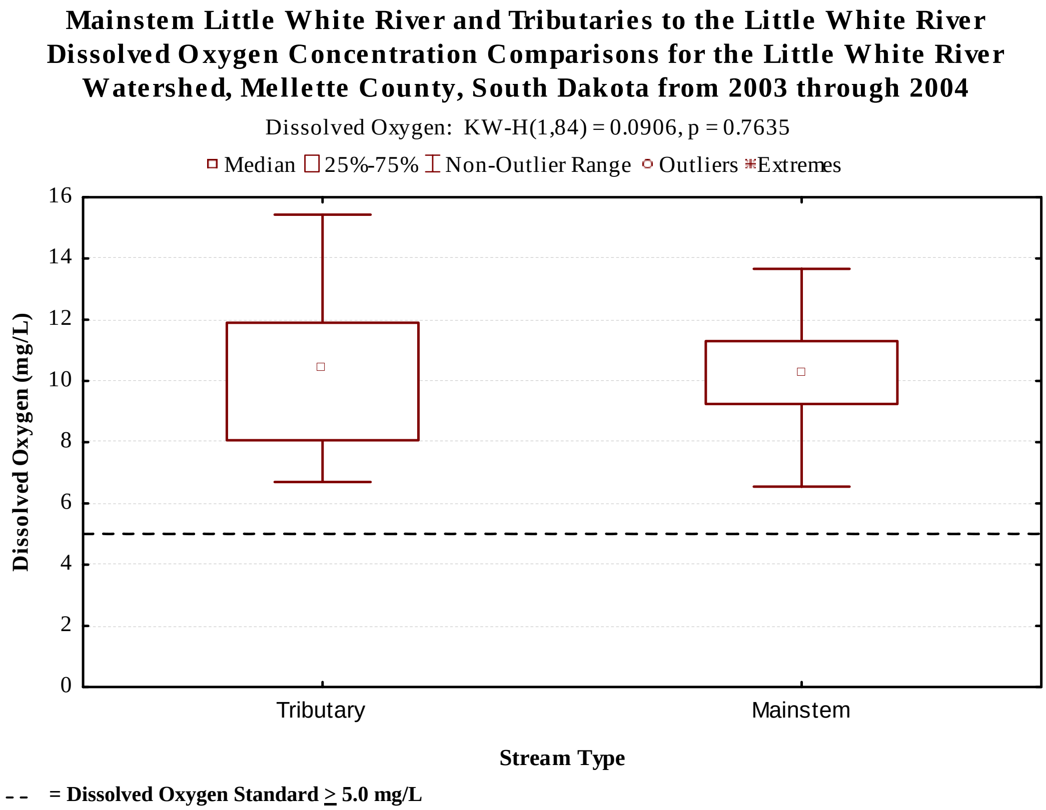


Figure 8. Dissolved oxygen concentration comparison by stream type (Mainstem Little White River and Tributaries to the Little White River) for Cut Meat Creek, Pine Creek and the Little White River, Mellette County, South Dakota from 2003 through 2004.

pH

pH is a measure of hydrogen ion concentration, the more free hydrogen ions, (i.e. more acidic) the lower the pH in water. The pH concentrations in the Little White River were not extreme in any tributary sample. Relatively high alkalinity concentrations in the Little White River appear to buffer dramatic changes in pH. Lower pH values are normally observed during increased decomposition of organic matter.

pH concentrations in the Little White River had a maximum pH of 9.17 su and a minimum pH of 6.73 su (Appendix D, Table D-1). Generally throughout this project, pH concentrations were higher in the spring and summer at LWR-05 (Highway 83 Bridge) and LWR-06 (mouth of the Little White River) than other tributary sampling sites (Figure 9). Overall pH values were significantly different between monitoring sites (p=0.0302) with pH values at LWR-06 (mouth of the Little White River) significantly higher than Lower Pine Creek, LWR-04 (Figure 9 and Appendix B, Table B-3).

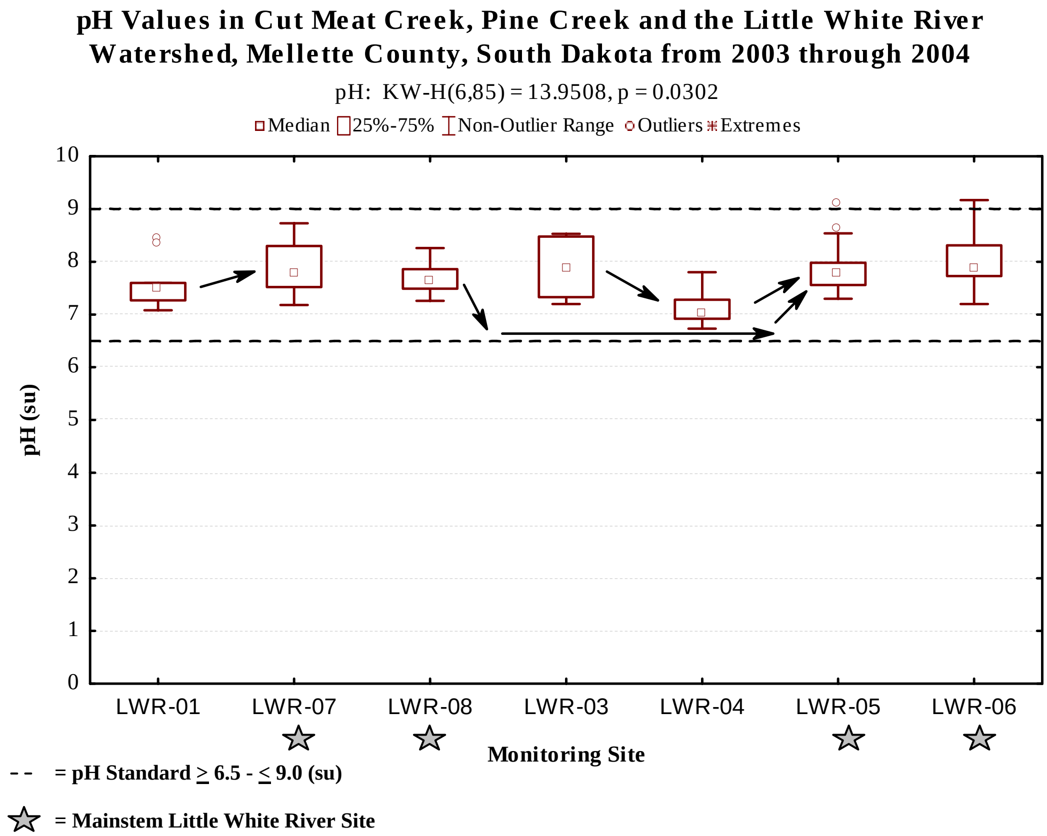


Figure 9. Median, quartile and range for pH concentrations by tributary monitoring site for Cut Meat Creek, Pine Creek and the Little White River, Mellette County, South Dakota from 2003 through 2004.

Seasonal pH values were highest in the summer of 2004 (Table 18, Appendix D, Table D-1 and Figure 10). This may be attributed to stream morphology (increased width), reduced flow and increased algal concentrations based on chlorophyll-*a* values. Increased algal concentrations in lakes have been known to increase pH values (Wetzel, 2001 and Cole, 1988). Two violations in pH have been recorded in the Little White River in the past five years, both during routine assessment monitoring (Table 9); while no violations were recorded during routine WQM monitoring. The overall pH violation rate for the Little White River was 1.7 percent (2 violations/119 observations) well below the 10 percent listing criteria. Overall, seasonal pH values were not significantly different (p=0.1287) throughout the project (Figure 10 and Appendix B Table B-35).

Little White River pH values between mainstem and tributaries to the Little White River were significantly different (p=0.0105) with pH values from mainstem Little White River significantly higher than tributaries to the Little White River and may be due to increased algae in the stream (Figure 11).

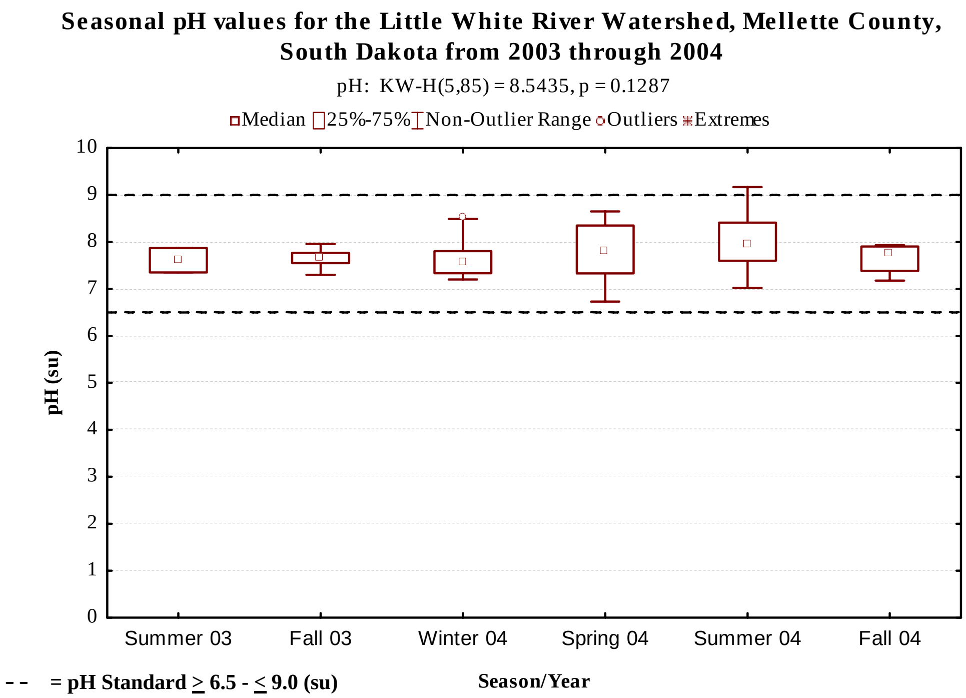


Figure 10. Median, quartile and range for seasonal pH values for the Little White River, Mellette County, South Dakota from 2003 through 2004.

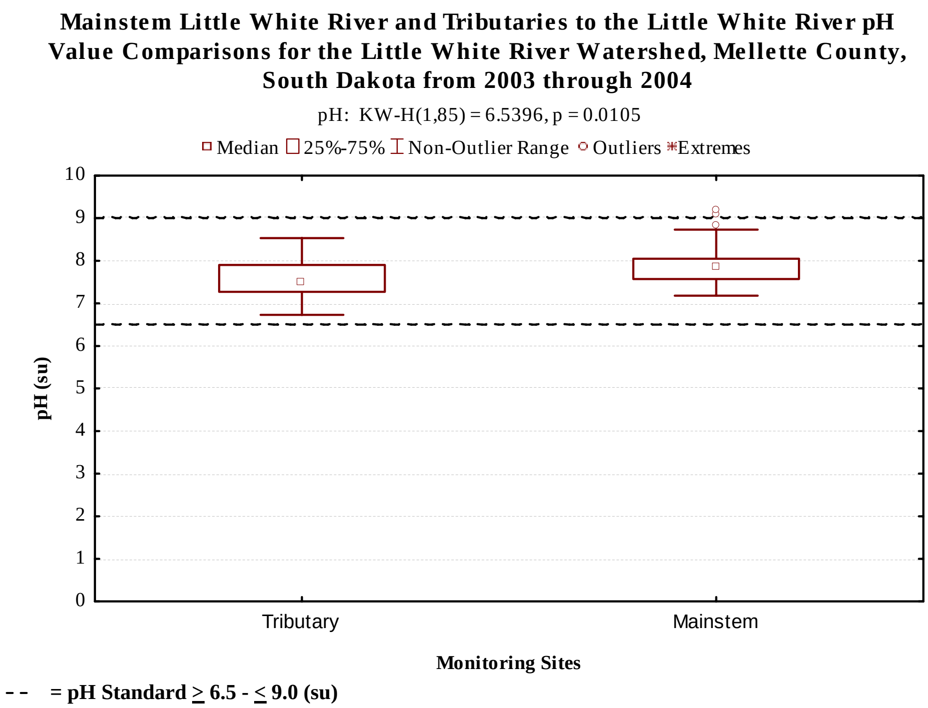


Figure 11. pH value comparison by tributary (mainstem Little White River and tributaries to the Little White River) for the Little White River, Mellette County, South Dakota from 2003 through 2004.

Transparency Tube Depth (Secchi Tube)

A transparency tube also known as Secchi tube is a graduated clear plastic tube approximately 120 cm tall (3.9 feet) and 4.5 cm wide (1.7 inches). This device was used to measure light transparency (in meters) for the Little White River watershed. Transparencies were collected at each sampling site during water quality sampling throughout the project.

The maximum transparency tube depth (deepest) during the project was 0.720 m observed at LWR-05 in August 2004 during base flows while the minimum was 0.007 m recorded at LWR-04 in Lower Pine Creek (Figure 12 and Appendix D, Table D-1). Upper Pine Creek sampling transparency tube depths (LWR-03) were significantly less than Cut Meat Creek (LWR-01) and mainstem Little White River sites LWR-08, LWR-07 and LWR-05. Similarly, Lower Pine Creek transparencies were significantly less than Cut Meat Creek and mainstem Little White River sites LWR-08 and LWR-07.

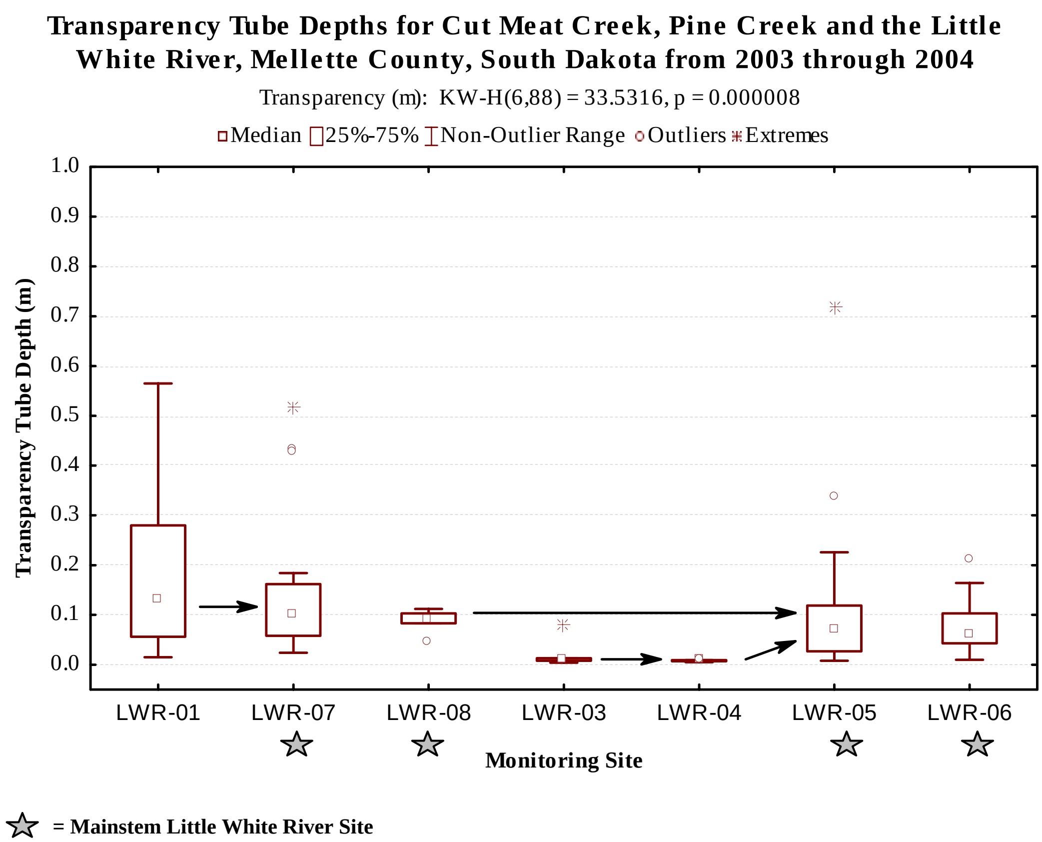


Figure 12. Transparency Tube Depths for Cut Meat Creek, Pine Creek and the Little White River, Mellette County, South Dakota from 2003 through 2004

Seasonal transparencies were highest in the summer of 2004; however, most seasonal transparency depths were statistically similar except samples collected in the fall of 2003 that were significantly higher than spring of 2004 samples. Seasonal transparency tube depths varied the most during the summer of 2003 (Figure 13 and Appendix B Table B-37).

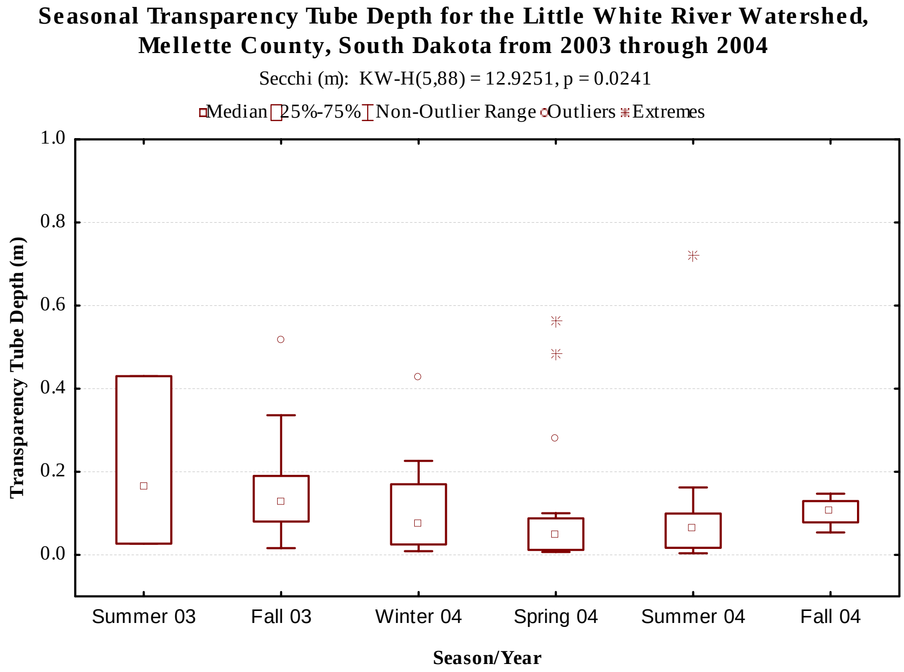


Figure 13. Seasonal Transparency Tube Depth for the Little White River Watershed, Mellette County, South Dakota from 2003 through 2004.

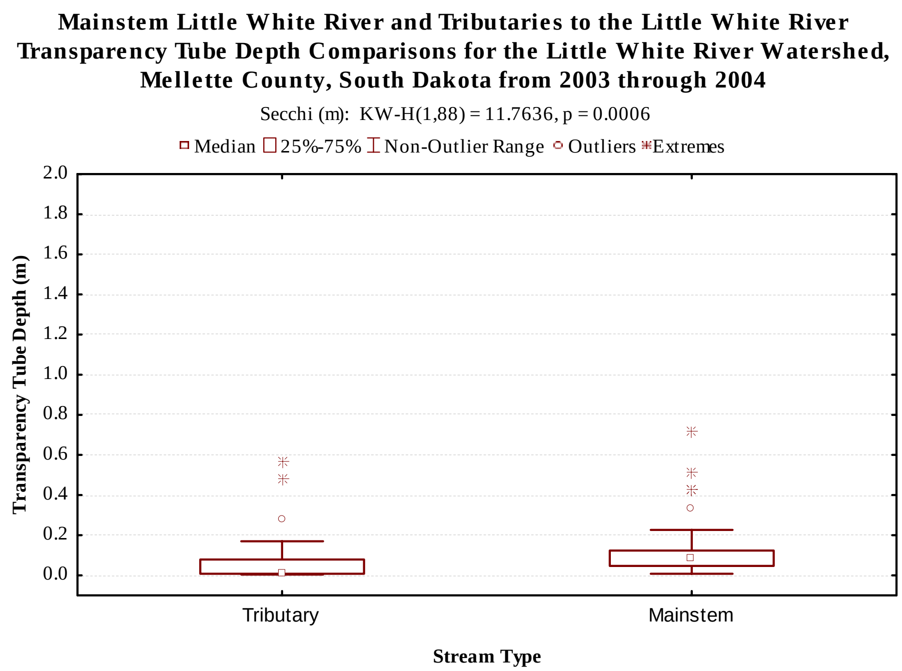


Figure 14. Mainstem Little White River and Tributaries to the Little White River Transparency Tube Depth Comparisons for the Little White River Watershed, Mellette County, South Dakota from 2003 through 2004.

On average, watershed transparency was significantly higher (p=0.0006) in mainstem sampling sites than tributary sites (Figure 14). Pine Creek monitoring sites (LWR-03 and LWR-04) had the greatest influence on lowering median tributary transparency values in the watershed.

As mentioned previously, the Little White River is listed in the 2004 and 2006 Integrated Reports as impaired by (TSS) Total Suspended Solids. Transparency tube samples were collected to develop simple equations for stakeholders to use to monitor relative total suspended solids concentrations at three mainstem monitoring sites (LWR-07 (Todd County Line), LWR-05 (Highway 83 Bridge) and LWR-06 (mouth of the Little White River).

The following site specific equations may be used to estimate TSS concentrations based on transparency tube depth (Equation 3, Equation 4 and Equation 5). The variability explained is the power regression R^2 value expressed as a percentage describing how much of the variability is explained by TSS.

LWR-07 (Todd County Line)

Equation 3. Little White River TSS regression equation for LWR-07.

$$TSS = 11.096*(x)^{-1.2587}$$ **Variability explained: 87.5%**

x = Transparency tube depth in meters

LWR-05 (Highway 83 Bridge)

Equation 4. Little White River TSS regression equation for LWR-05.

$$TSS = 19.498*(x)^{-1.0912}$$ **Variability explained: 76.6%**

x = Transparency tube depth in meters

LWR-06 (mouth of the White River)

Equation 5. Little White River TSS regression equation for LWR-06.

$$TSS= 4.6838*(x)^{-1.4746}$$ **Variability explained: 95.4%**

x = Transparency tube depth in meters

Turbidity

Turbidity is a measure of water clarity and is caused by suspended organic and inorganic matter. Turbidity measurements are expressed in (NTUs) Nephelometric Turbidity Units which are a measure of the intensity of light scattered by suspended material in a sample through a known and adjustable distance of water (Wetzel and Likens, 1991).

The maximum turbidity value during the project was 2,347 NTUs recorded at Pine Creek LWR-03 in May 2004 during event sampling while the minimum 6 NTUs was recorded in the Little White River near the Todd County (LWR-07) in October of 2003 (Figure 15 and Appendix D,

Table D-1). Upper Pine Creek (LWR-03) turbidity values were significantly higher (p=0.0003) than all mainstem Little White River sampling sites LWR-07, LWR-08, LWR-05 and LWR-06 (Figure 15).

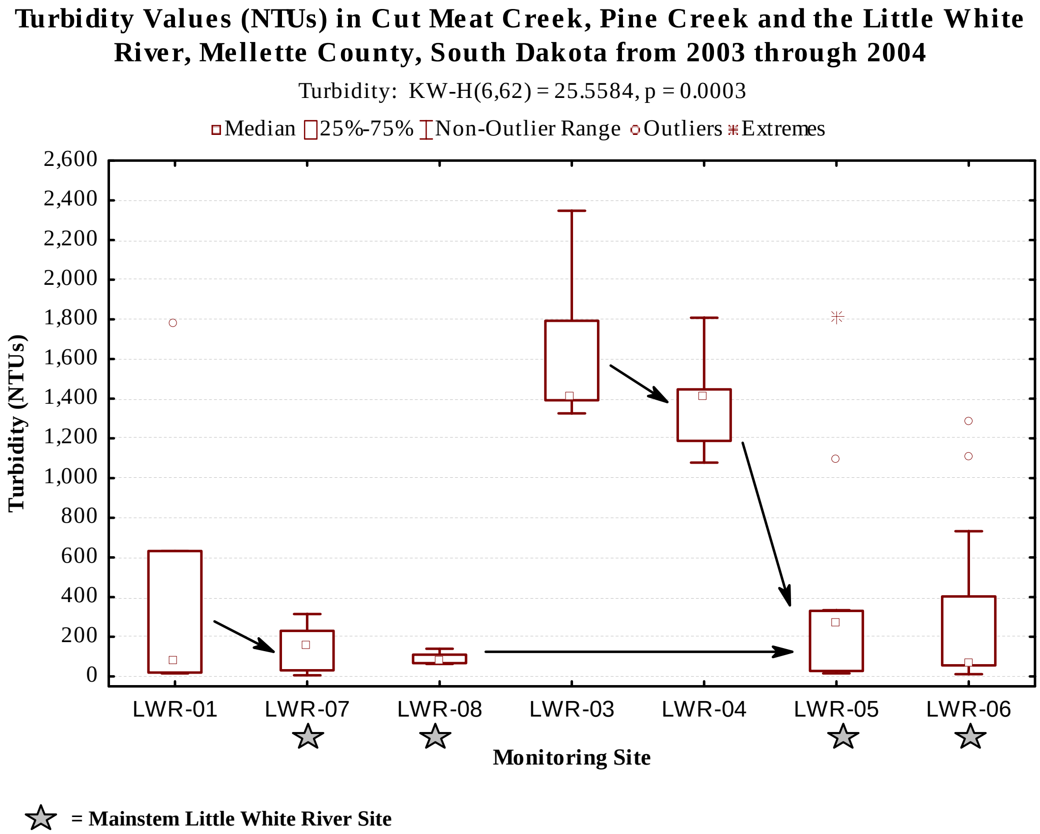


Figure 15. Turbidity Values (NTUs) in Cut Meat Creek, Pine Creek and the Little White River, Mellette County, South Dakota from 2003 through 2004.

Seasonal turbidity values ranged widely during the winter, spring and summer of 2004 in the Mellette County portion of the Little White River watershed (Figure 16). Seasonally, turbidity values were highest in the summer of 2004 in the Little White River. Statistical analysis indicated significant differences between sampling seasons (p=0.0021).

Further analysis using mean separation procedures indicated turbidity values collected in the fall of 2003 which were significantly lower (p=0.0008) than spring 2004 samples (Appendix B Table B-38). On average, watershed transparency was significantly higher (p=0.0001) in mainstem sampling sites than tributary (Cut Meat and Pine Creek) sites (Figure 17).

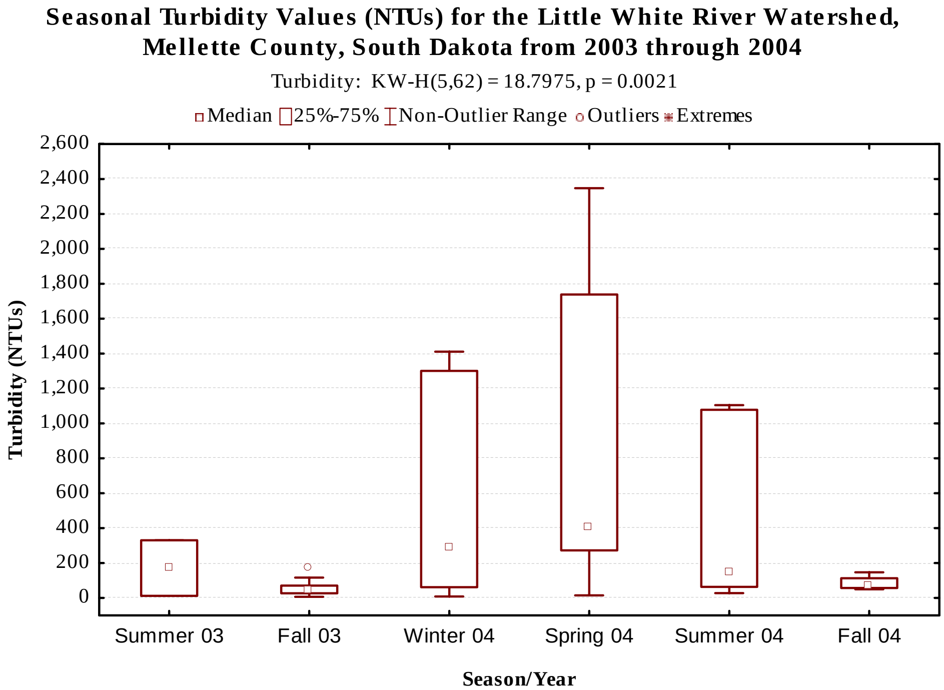


Figure 16. Seasonal Turbidity Values (NTUs) for the Little White River Watershed, Mellette County, South Dakota from 2003 through 2004.

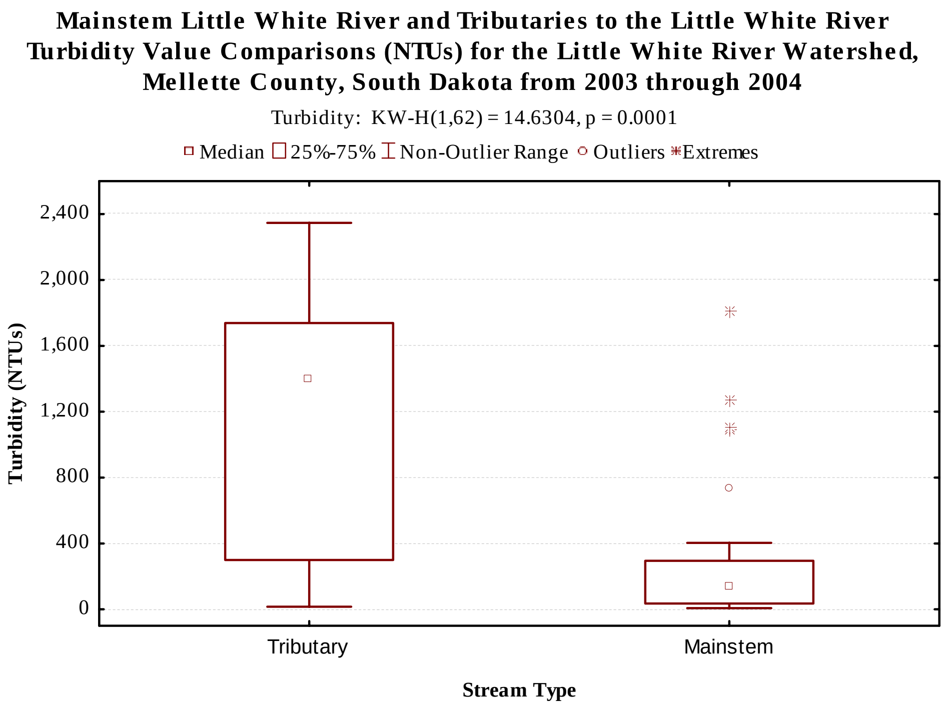


Figure 17. Mainstem Little White River and Tributaries to the Little White River Turbidity Value Comparisons (NTUs) for the Little White River Watershed, Mellette County, South Dakota from 2003 through 2004.

Tributary turbidity and transparency tube depth values were negatively correlated with transparency tube depth (r = -0.70) while mainstem sites were less (r = -0.47). Turbidity explained 81 percent of the variability in transparency tube depth in tributary samples ($r^2 = 0.81$) and turbidity in mainstem sites only explained 59 percent of the variability ($r^2 = 0.59$) in transparency tube depths (Figure 18).

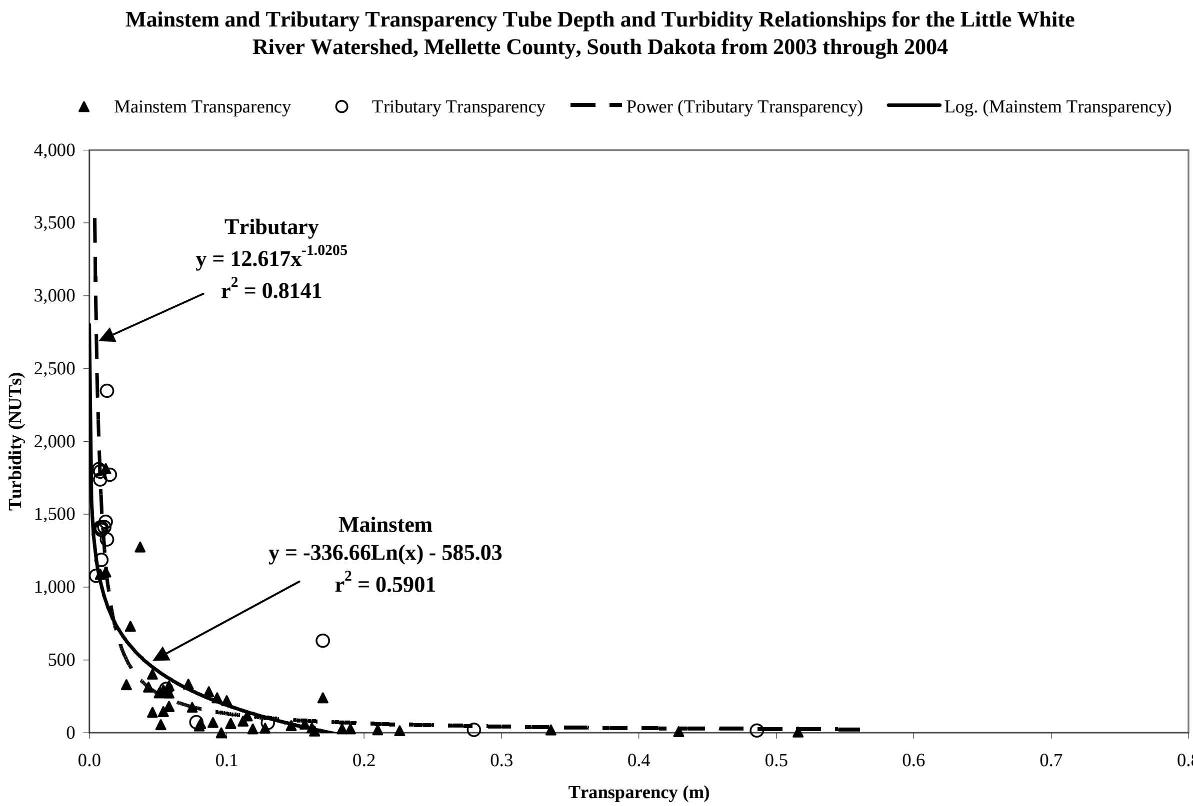


Figure 18. Mainstem and Tributary Transparency Tube Depth and Turbidity Relationships for the Little White River Watershed, Mellette County, South Dakota from 2003 through 2004.

Conductivity @ 25° C (Specific Conductance)

Conductivity is a measure of electrical conductance of water, and an approximate predictor of total dissolved ions. Increased ion concentrations reduce the resistance to electron flow; thus, differences in conductivity result mainly from the concentration of charged ions in solution, and to a lesser degree, ionic composition and temperature (Allan, 1995). The temperature of an electrolyte affects ionic velocities and conductance increases approximately 2 percent per degree Celsius (Wetzel, 2001).

Specific conductance is conductivity adjusted to temperature (25º C) and is reported in micro-Siemens/centimeter (µS/cm). Surface water quality rules (Article 74:51) lists specific conductance as conductivity @ 25° C with values in µmhos/cm; for this report, specific conductance will be referred to as conductivity @ 25° C with values in µS/cm (updated units).

Typically, there is a good relationship between conductivity @ 25° C and total dissolved solids (TDS). Current data indicate that in the Little White River a poor relationship exists (r^2 = 0.0186) between conductivity @ 25° C and total dissolved solids for the mainstem Little White River or approximately two percent of the variability in conductivity is explained by total dissolved solids (Figure 19). The relationship for conductivity @ 25° C and total dissolved solids in tributaries to the Little White River was also extremely poor with an r^2 = 0.1022 (Figure 19).

Long-term (1968 through 2005) Water Quality Monitoring (WQM) site data indicate the conductivity @ 25° C and TDS relationship was also poor with an r^2 = 0.0243 or only 2.43 percent of the variability in conductivity @ 25^o C is explained by TDS (Figure 20). Regression line slopes for the assessment and WQM data collected on the Little White River in Mellette County were similar (Assessment = 5.76 percent and WQM = 1.61 percent). As mentioned above, conductivity and TDS typically have a good relationship; however, the poor relationship observed in the Little White River can be attributed to the high concentrations of White River group soils composed of colloidal materials that interfere (mask) actual conductivity values (SDDH, 2006, personal communication).

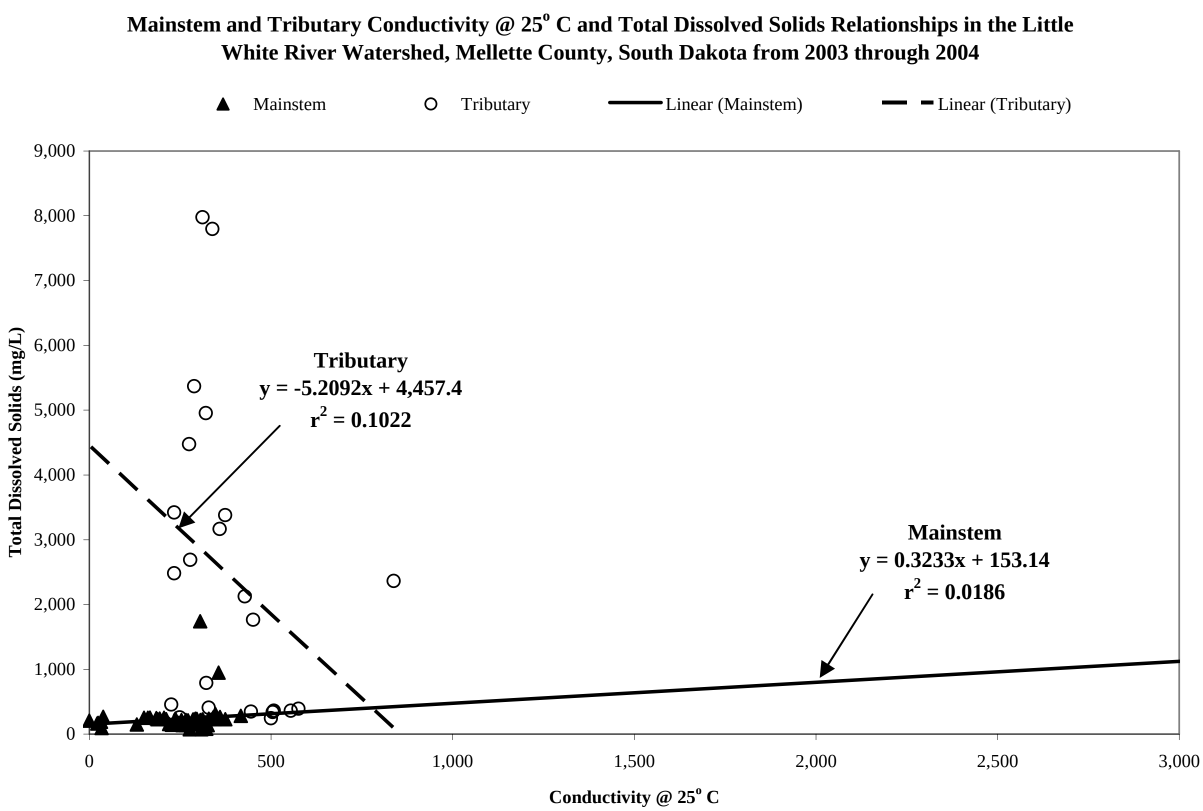


Figure 19. Relationship of total dissolved solids to specific conductance (µS/cm) for the Little White River tributaries and mainstem Little White River, Mellette County, South Dakota from 2000 through 2001.

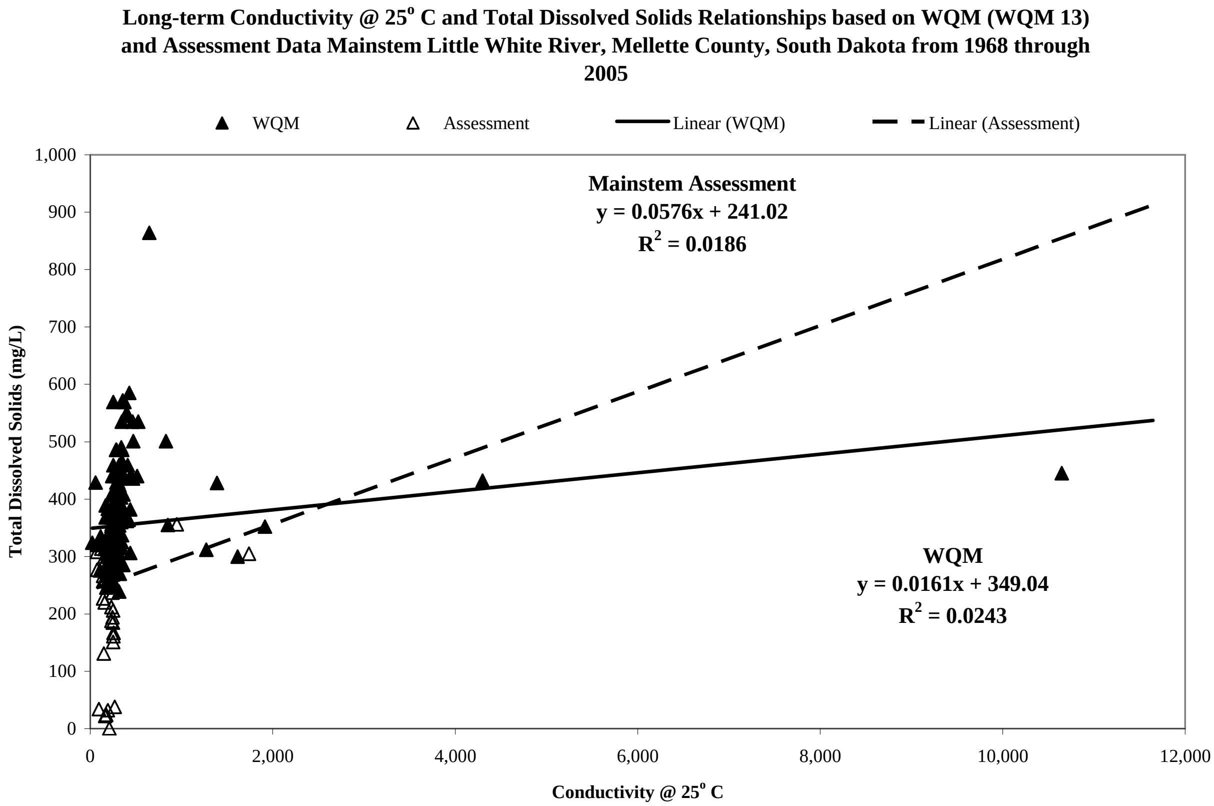


Figure 20. Long-term Conductivity @ 25° C and Total Dissolved Solids Relationships based on WQM (WQM 13) and Assessment Data, Mainstem Little White River, Mellette County, South Dakota from 1968 through 2005.

The relationship between conductivity @ 25° C values by water quality monitoring site can be seen in Figure 21. Conductivity @ 25° C values were significantly different between monitoring sites (p=0.0007). Mean separation procedures show that Conductivity @ 25° C at LWR-01 (Cut Meat Creek, a tributary to the Little White River) was significantly higher than LWR-07 (Little White River at the Todd County line) and LWR-05 (Highway 83 Bridge).

Seasonal conductivity @ 25° C values by year indicate samples collected in the fall of 2003 were significantly lower than samples collected in the winter (p=0.0319) and spring (p=0.0000) of 2004 and appeared to be related to precipitation. Conductivity @ 25° C values recorded in the spring of 2004 were also higher than in samples collected in the summer of 2004 (Figure 22 and Appendix B Table B-39). Little White River conductivity @ 25° C values between mainstem Little White River and tributaries to the Little White River were statistically different (p=0.0002) with tributaries to the Little White River conductivity @ 25° C values significantly higher than mainstem Little White River (Figure 23).

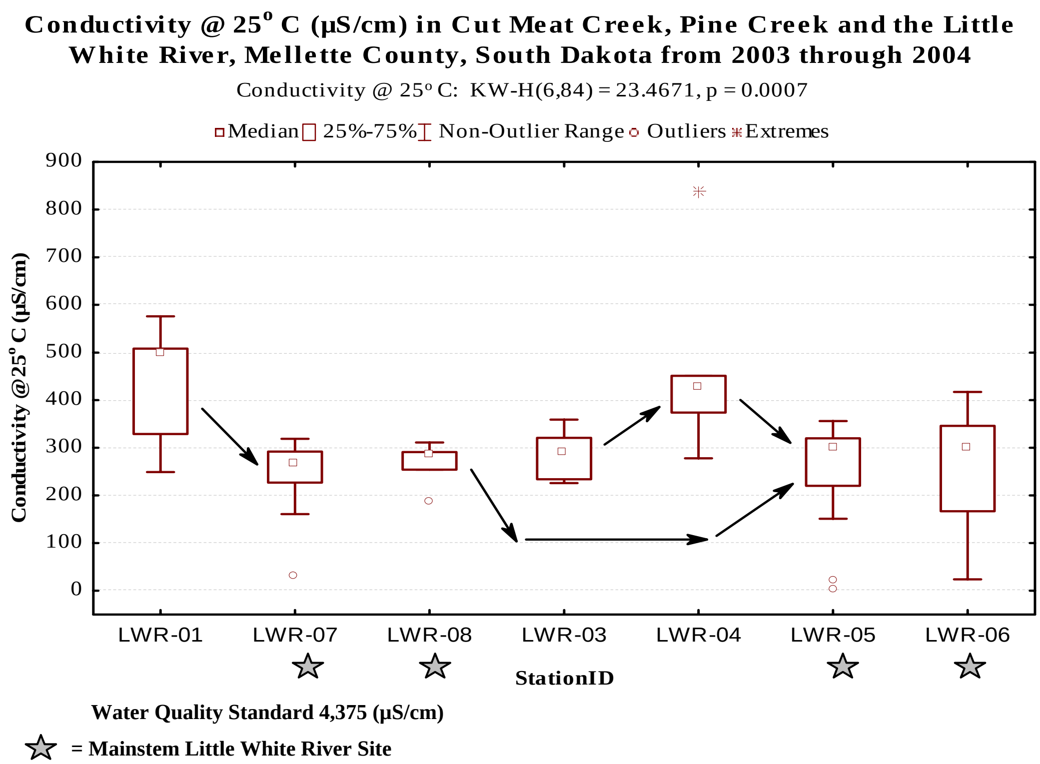


Figure 21. Conductivity @ 25° C values (NTUs) in Cut Meat Creek, Pine Creek and the Little White River, Mellette County, South Dakota from 2003 through 2004.

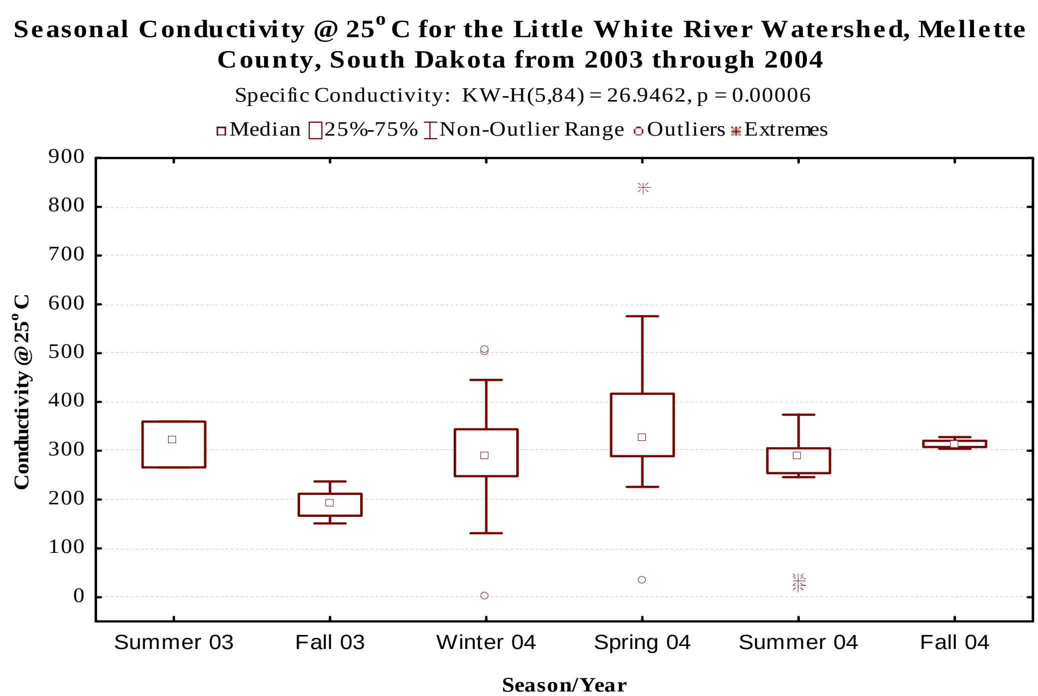


Figure 22. Seasonal comparison of Conductivity @ 25° C for the Little White River Watershed, Mellette County, South Dakota from 2003 through 2004.

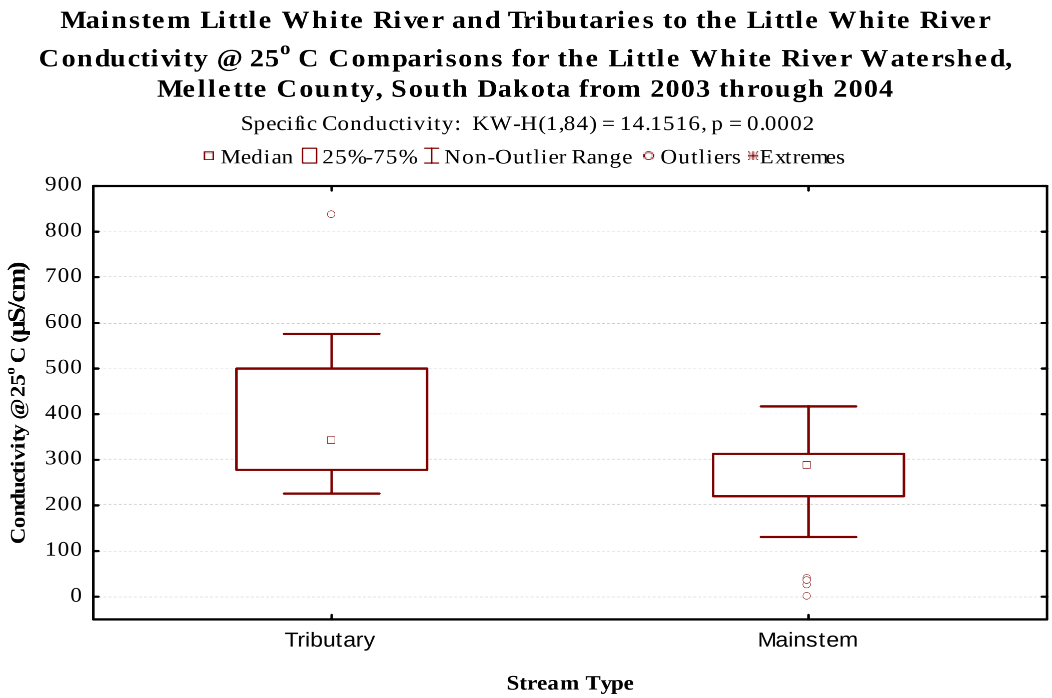


Figure 23. Conductivity @ 25° C value comparison by tributary type (mainstem Little White River and tributaries to the Little White River), Mellette County, South Dakota from 2003 through 2004.

United States Geological Survey (USGS) maintains monitoring site (06450500) on the Little White River below White River, South Dakota from 1950 through the present. Geological Survey conductivity @ 25° C data was collected from December 1950 through August of 2004 with values ranging from 186 to 1,760 (µS/cm). This site was also assessment site LWR-05 and SD DENR WQM site WQM-13. USGS, WQM and assessment data sources indicate that conductivity @ 25° C values were below the assigned beneficial use water quality standard of $\leq$ 4,375 µS/cm.

Total Alkalinity

Alkalinity refers to the quantity of different compounds that shift the pH to the alkaline side of neutral (>7.00 su). These various bicarbonate and carbonate compounds generally originate from dissolution of sedimentary rock (Allan, 1995). Alkalinity in natural environments usually ranges from 20 to 200 mg/L (Lind, 1985).

The median alkalinity in the Little White River was 148.5 mg/L (average, 158.9 mg/L). The minimum alkalinity concentration was 84 mg/L and was collected at site LWR-03 (North Branch of Pine Creek) on May 12, 2004 while the maximum alkalinity sample (376 mg/L) was collected at site LWR-04 (lower Pine Creek) on May 24, 2004 (Figure 24 and Appendix D, Table D-1). Alkalinity concentrations were statistically different (p=0.0003) between sampling sites with LWR-01 significantly higher (p=0.0031) than LWR-07 and LWR-07 significantly lower than LWR-03 (p=0.0499) and LWR-04 (p=0.0169) sites on Pine Creek (Appendix B, Table B-8).

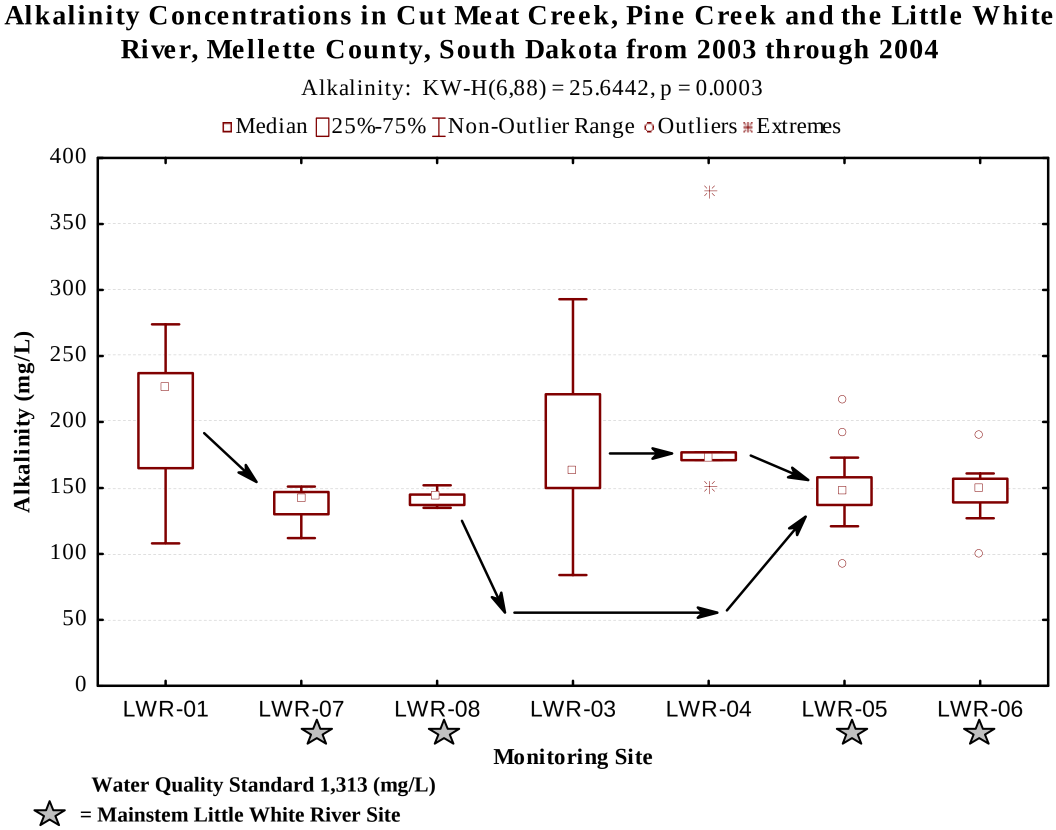


Figure 24. Median, quartile and range for alkalinity concentrations by tributary monitoring site for the Little White River watershed, Mellette County, South Dakota from 2003 through 2004.

Seasonally, Little White River alkalinity concentrations collected in the Little White River watershed in Mellette County were statistically similar between sites (p=0.0942) based on current assessment data (Figure 25). However, alkalinity concentrations in tributaries to the Little White River were significantly higher (p=0.0000) than concentrations in mainstem Little White River (Figure 26).

Total alkalinity loading in the Little White River by site was highest at site LWR-07 with 10,944,036 kg/year which represents13.35 kg/acre (Table 22). Alkalinity loads at the outlet site (LWR-06) of the Little White River was highest in May of 2004. Alkalinity loading between sampling sites was significantly different (Table 5). Appendix B Table B-22 indicated loading from LWR-07 was significantly higher than LWR-01 (Cut Meat Creek), LWR-08 (Little White River Highway 44 Bridge), LWR-03 (North Branch of Pine Creek), LWR-04 (Lower Pine Creek) and LWR-05 (Little White River Highway 44 Bridge). Sub-watershed export coefficients (kilograms/acre) were highest in the LWR-06 (43.18 kg/acre) sub-watershed (Table 22). Tributary alkalinity loading by season was highest in the spring of 2004 for the Little White River sites (Figure 25 and Figure 27).

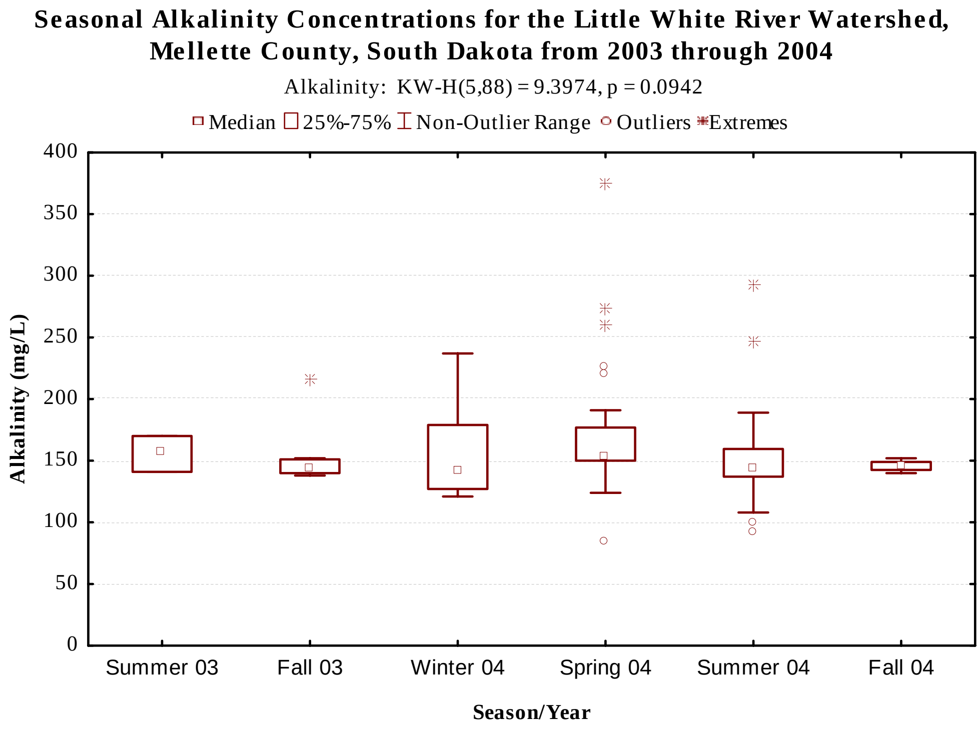


Figure 25. Seasonal comparison of alkalinity concentrations for the Little White River watershed, Mellette County, South Dakota from 2003 through 2004.

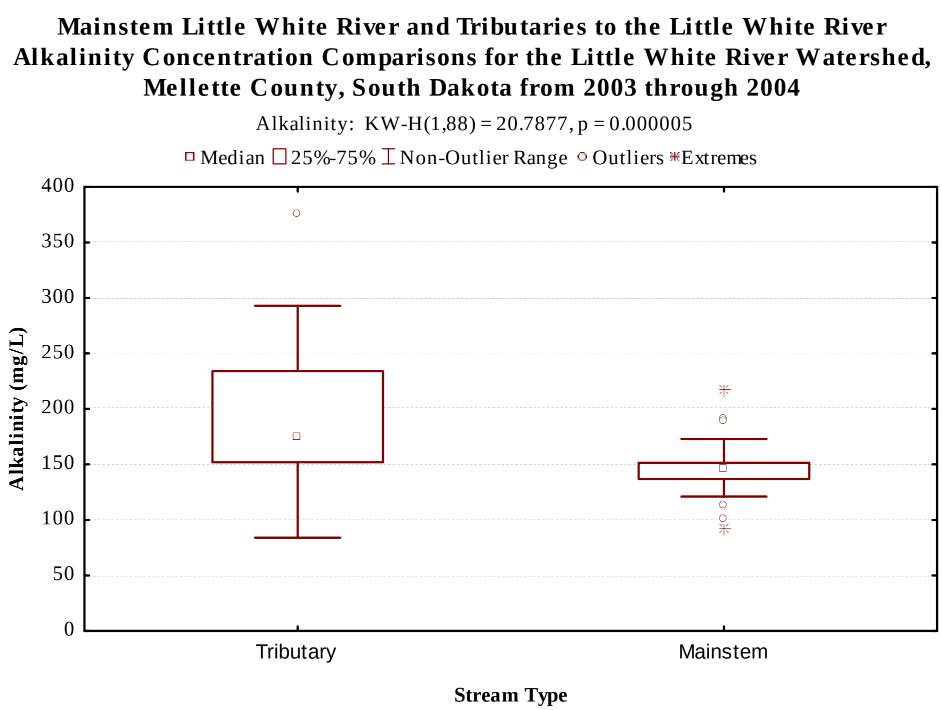


Figure 26. Alkalinity concentration comparison by tributary (mainstem Little White River and tributaries to the Little White River) for the Little White River watershed, Mellette County, South Dakota from 2003 through 2004.

Seasonal load variations in alkalinity loading occurred during the project period (Figure 27). Load reductions were observed between the Todd County line (LWR-07) and the Highway 44 Bridge west of White River, South Dakota (LWR-08) during the fall of 2003, winter and spring of 2004. LWR-08 was in an area in the White River basin where the river is widening before entering the backwater portion of a small hydroelectric dam. This scenario may explain load reductions at this site. LWR-05 is located approximately 4.1 km downstream of the hydroelectric dam which may influence the reduction observed during the summer of 2004 where base flow dominated the flow regime (Figure 27).

Modeled alkalinity loading was significantly different (p=0.0000) between monitoring sites in the Little White River watershed from 2003 through 2004 (Table 5, Figure 28 and Appendix B Table B-22). Alkalinity loading at the Todd County line (LWR-07) was significantly larger than most monitoring sites in Mellette County except the outlet of the Little White River (LWR-06). Assessment and water quality monitoring data indicate that alkalinity was not considered a problem in the Little White River watershed.

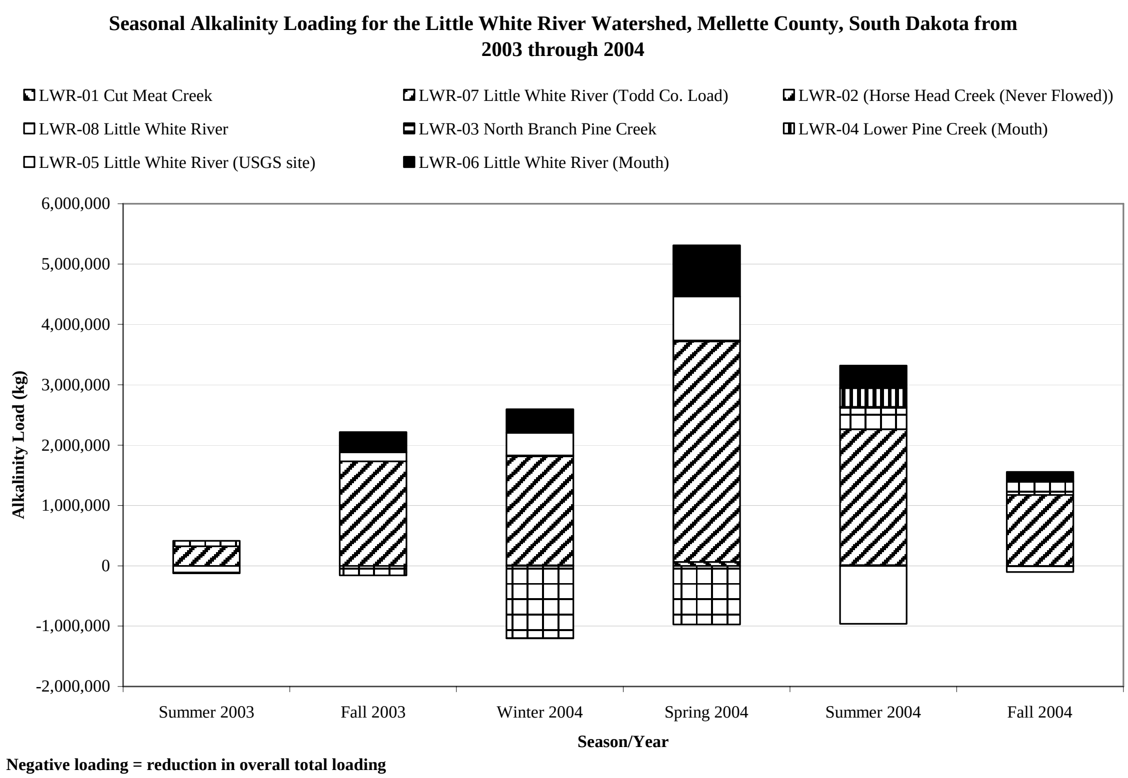


Figure 27. Estimated total alkalinity loads by water quality monitoring site and season in the Little White River, Mellette County, South Dakota in 2000 and 2001.

Table 22. Alkalinity loading per year by site for Cut Meat Creek, Pine Creek and the Little White River, Mellette County, South Dakota from 2003 through 2004.

Alkalinity				
Sub-watershed	**Station**	**Sub-watershed Acreage (Acres)**	**Kilograms by Site (kg)**	**Export Coefficient (kg/acre)**
Cut Meat Creek	LWR-01	108,769	84,424	0.78
Little White River (Todd County Line)	LWR-07	819,479	10,944,027	13.35
Horse Head Creek	LWR-02	42,965	0	0.00
Little White River (Highway 44 Bridge)	LWR-08	56,185	-1,668,934	-29.70
North Branch of Pine Creek	LWR-03	30,319	49,859	1.64
Lower Pine Creek	LWR-04	49,697	305,121	6.14
Little White River (Highway 83 Bridge)	LWR-05	7,545	92,810	12.30
Little White River (mouth of the Little White River)	LWR-06	48,218	2,082,153	43.18
Total alkalinity load to the White River		**1,163,177**	**11,889,460**	**10.22**

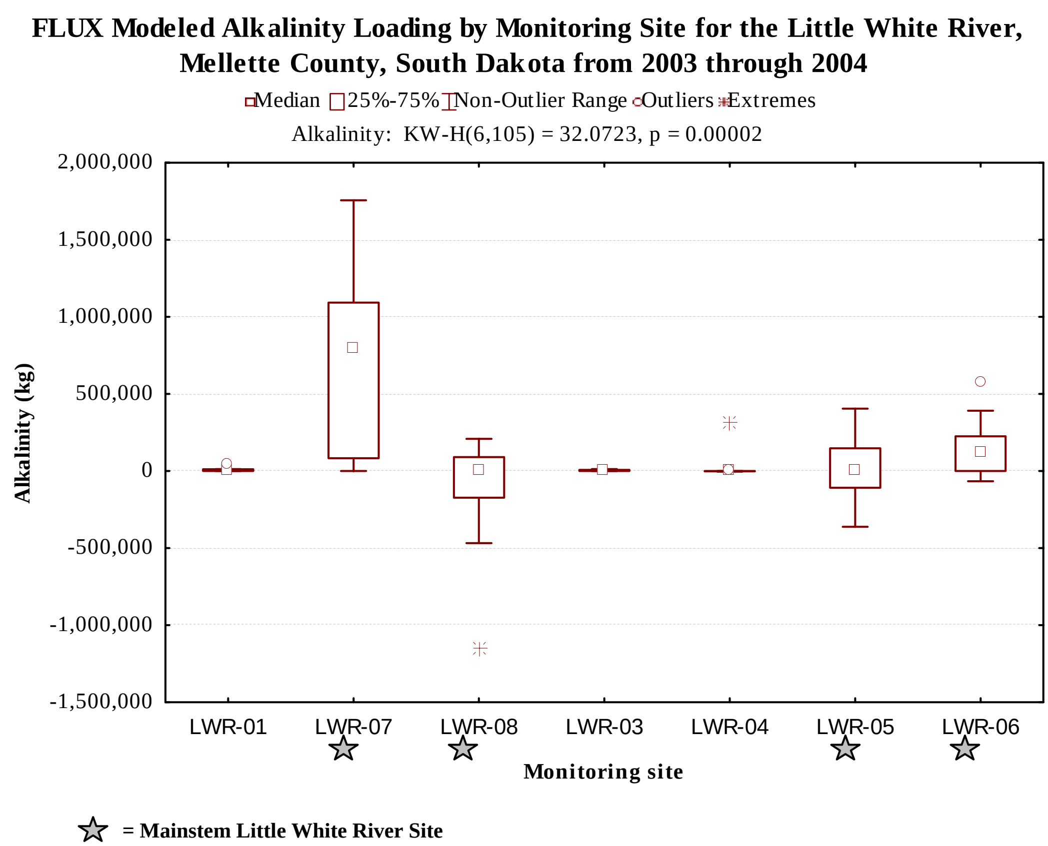


Figure 28. FLUX modeled alkalinity loading by monitoring site for the Little White River, Mellette County, South Dakota from 2003 through 2004.

Solids

Total Solids

Total solids are organic and inorganic materials, suspended and/or dissolved, present in natural water and include materials that pass through a filter.

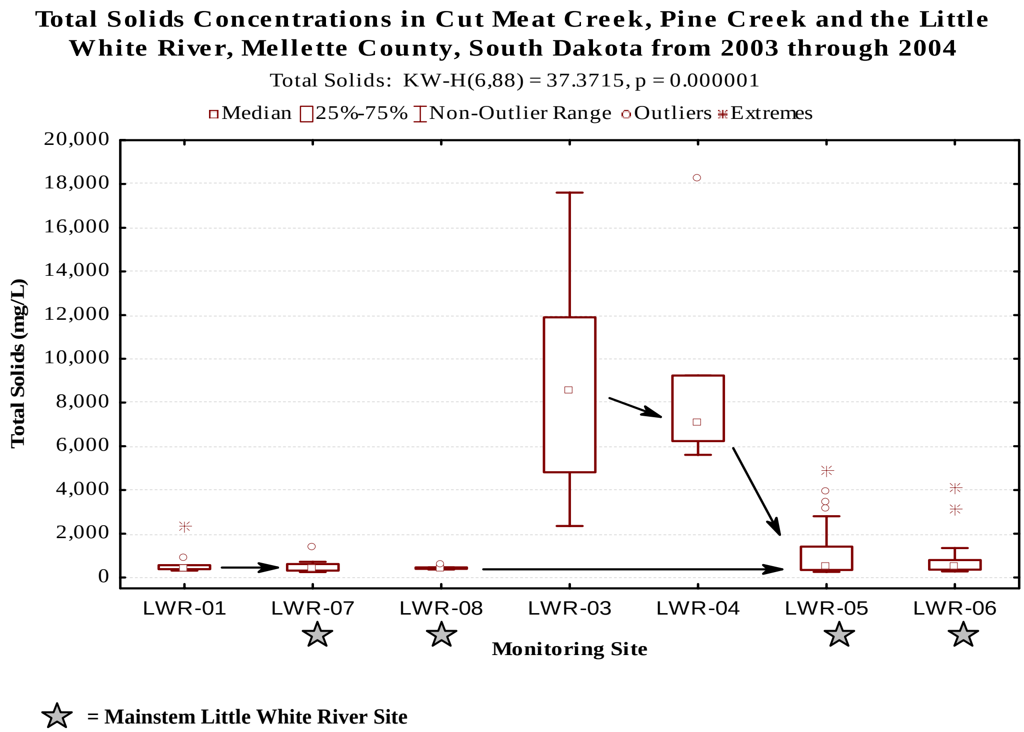


Figure 29. Median, quartile and range of total solids concentrations by tributary monitoring sites in the Little White River watershed, Mellette County, South Dakota from 2003 through 2004.

The median total solids concentrations in the Little White River watershed was 524 mg/L (average 2,233 mg/L) with a maximum of 18,225 mg/L collected in the Pine Creek tributary at LWR-04 on May 22, 2001. The minimum concentration (240 mg/L) collected at Todd County line (LWR-07) on January 19, 2004 (Appendix D, Table D-1 Table D-1, Figure 29 and Figure 30). Overall, total solids concentrations were significantly different (p=0.0000) between monitoring sites (Figure 29). All mainstem Little White River (LWR-07, LWR-08, LWR-05 and LWR-06) and Cut Meat Creek (LWR-01) sampling sites were significantly lower (p=0.000) than Pine Creek sampling sites LWR-03 and LWR-04. A multiple comparison matrix table for total solids is provided in Appendix B, Table B-9 for specific comparisons. Seasonal average concentrations for total solids were highest in the spring of 2004 (Table 18).

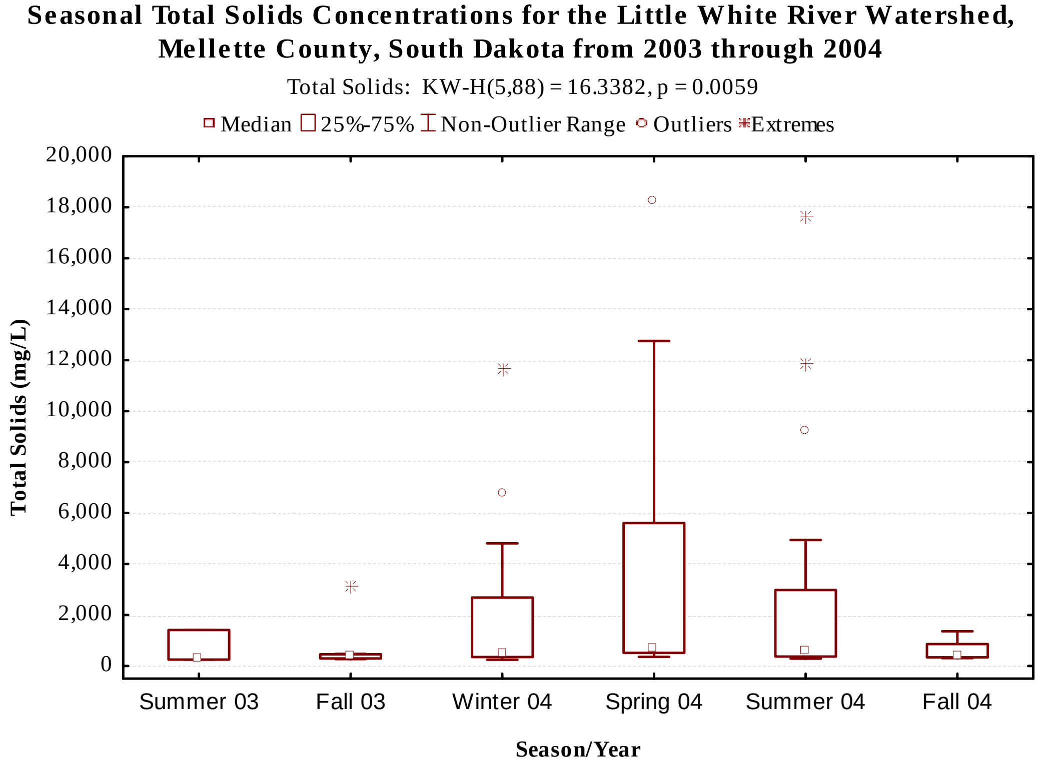


Figure 30. A comparison of total solids concentrations by season in the Little White River watershed, Mellette County, South Dakota from 2003 through 2004.

Seasonally, Little White River total solids concentrations collected in the spring of 2004 were significantly higher (p=0.0059) than concentrations collected in the fall of 2003 (Figure 30). Tributaries to Little White River total solids concentrations (LWR-01, LWR-03 and LWR-04) were significantly higher (p=0.0000) than concentrations in mainstem (LWR-07, LWR-08, LWR-05 and LWR-06) Little White River (Figure 31). Higher total dissolved solids and total suspended solids concentrations in Pine Creek sampling sites influenced the majority of the range in tributary total solids concentrations (Figure 29 and Figure 30 and Figure 31).

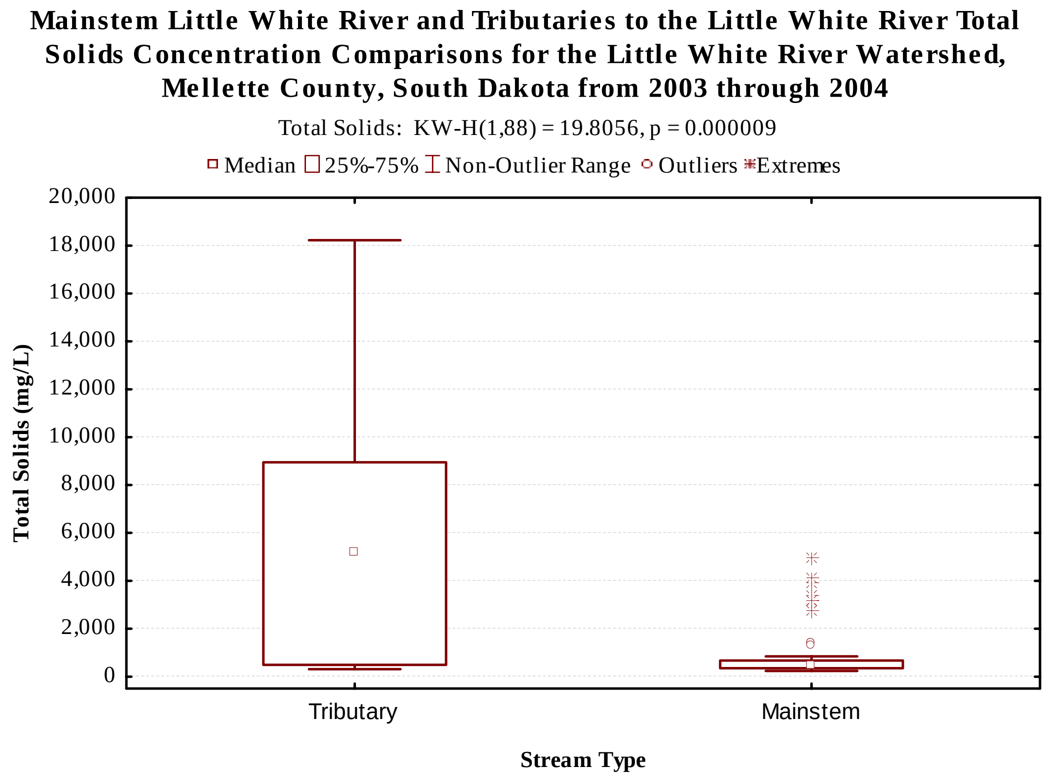


Figure 31. Total solids concentration comparison by tributary (mainstem Little White River and tributaries to the Little White River) for the Little White River watershed, Mellette County, South Dakota from 2003 through 2004.

Table 23. Total solids loading by site for the Little White River and other monitored tributaries, Mellette County, South Dakota from 2003 through 2004.

Total Solids

Sub-watershed	Station	Sub-watershed Acreage (Acres)	Kilograms by Site (kg)	Export Coefficient (kg/acre)
Cut Meat Creek	LWR-01	108,769	573,065	5.27
Little White River (Todd County Line)	LWR-07	819,479	40,746,921	49.72
Horse Head Creek	LWR-02	42,965	0	0.00
Little White River (Highway 44 Bridge)	LWR-08	56,185	-13,437,473	-239.16
North Branch of Pine Creek	LWR-03	30,319	2,364,490	77.99
Lower Pine Creek	LWR-04	49,697	16,164,725	325.27
Little White River (Highway 83 Bridge)	LWR-05	7,545	47,933,932	6,353.07
Little White River (mouth of the Little White River)	LWR-06	48,218	-14,595,532	-302.70
Total solids load to the White River		**1,163,177**	**79,750,128**	**68.56**

Total solids loading by site was highest at site LWR-05 with 47,933,932 kg/year (Table 23). Sub-watershed export coefficients (kilograms/acre) were also highest in the LWR-05 sub-watershed (6,353.07 kg/acre). Total solids loading at LWR-05 was influenced by elevated TSS concentrations from White River Group soils in the upper end of the Pine Creek watershed and higher TDS concentrations from the Pierre Shale formations from LWR-03 through LWR-04 on Pine Creek (Figure 39). Sediment cleanout discharges from the hydroelectric dam 4.1 km (2.5 miles) upstream of LWR-05 may also account for the increased total solids loading at this sampling site (Table 23). Total solids loading at the outlet site on the Little White River (LWR-06), was highest in the spring (May) of 2004 with 14,147,680 kg. Tributary total solids loading by site to the Little White River by season was highest in the summer (September) of 2004 from LWR-04 (Figure 32). Overall total solids loading between sampling sites were significantly different (p=0.0000) between monitoring sites (Figure 32, Figure 33 and Appendix B, Table B-23).

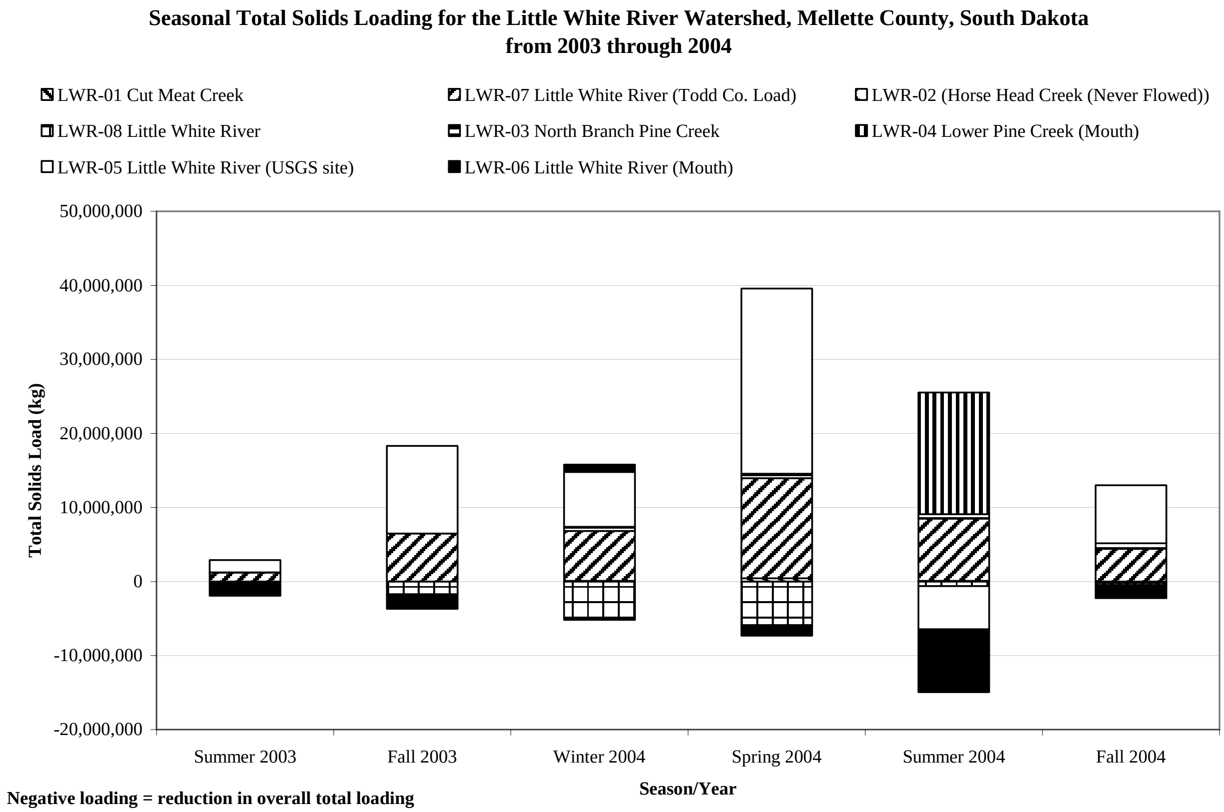


Figure 32. Seasonal total solids loading by tributary monitoring site in the Little White River watershed, Mellette County, South Dakota from 2003 through 2004.

Three sub-watersheds in the Little White River had overall load reductions in total solids during the project period: LWR-08, LWR-05, and LWR-06. Total solids loading at LWR-08 were reduced 93.3 percent of the time followed by the LWR-06 sub-watershed which reduced total solids load 40 percent of the time during the project (Figure 32 and Figure 33). Overall, load reductions in the LWR-06 sub-watershed were greatest and had an overall annual load reduction of -302.70 kg/year (Table 23). Reductions in total solids loading at LWR-05 only occurred in the summer of 2004 during base-flow, with little or no discharge from Pine Creek (Figure 32 and Figure 33).

Modeled total solids loading were significantly different (p=0.0000) between monitoring sites (Figure 33). Loadings at LWR-08, LWR-04 and LWR-06 were significantly lower than LWR-07 while loadings at LWR-06 was significantly lower than LWR-05 (Figure 33 and Appendix B Table B-23).

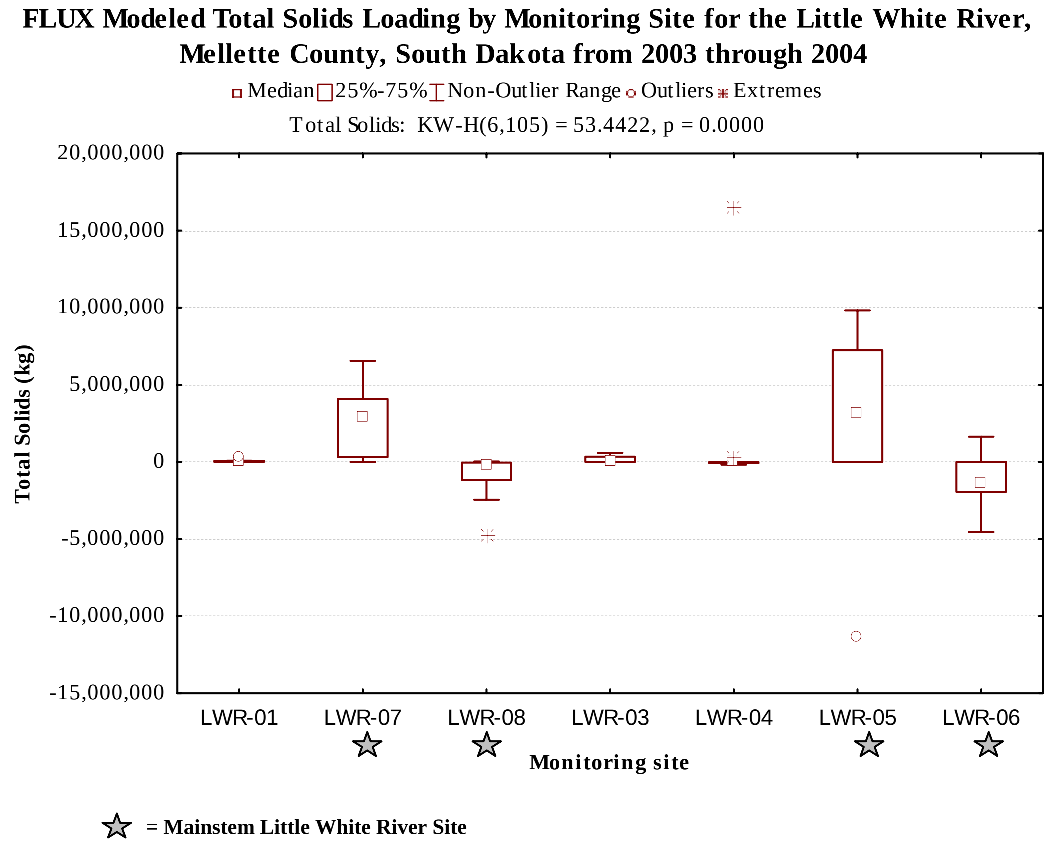


Figure 33. FLUX modeled total solids loading by monitoring site for the Little White River, Mellette County, South Dakota from 2003 through 2004.

Total Dissolved Solids

Total dissolved solids concentrations were calculated by subtracting total suspended solids concentrations from total solids concentrations. During the assessment, several violations were recorded based on current beneficial use-based water quality standards for the North Branch of Pine Creek (Table 13). Pine Creek has been assigned beneficial uses of (9) fish and wildlife propagation, recreation, and stock watering water and (10) irrigation water. Specific water quality standards are attached to each beneficial use and the listing criteria for impairment are based on the 2006 South Dakota Integrated Report for Surface Water Quality Assessment (SD DENR, 2006). Stated criteria are as follows: if greater than 10 percent of the samples violate parameter-specific water quality standards based on a minimum of 20 total samples collected in the past 5 years or, if less than 20 total samples, more than 25 percent of the samples violate parameter-specific water quality standards, the water is considered impaired and should be listed. The North Branch of Pine Creek (LWR-03) had a 60 percent violation rate and should be listed as impaired based on current water quality standards (Table 13); however, current and ancillary data from other watersheds located in Pierre Shale formations indicate elevated TDS concentrations are naturally occurring and relatively common in western South Dakota especially during low flow conditions (Smith, 2005).

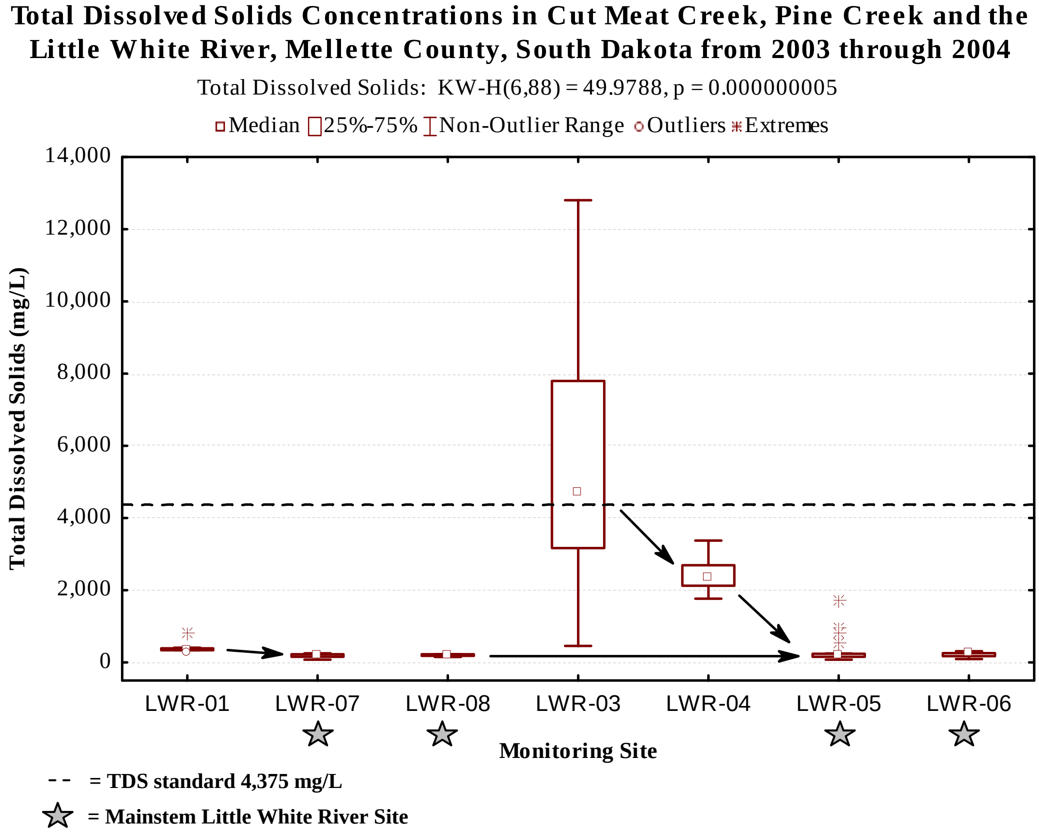


Figure 34. A comparison of total dissolved solids concentrations by tributary monitoring site in the Little White River watershed, Mellette County, South Dakota from 2003 through 2004.

The median total dissolved solids (TDS) concentration was 231.5 mg/L (average 960.8 mg/L) with a maximum concentration of 12,805 mg/L recorded at LWR-03 on July 22, 2004 during low flow (0.20 cfs) conditions (Table 13). The minimum TDS concentration collected in the Little White River during the project was 74 mg/L at LWR-05 on August 16, 2004 with increased flow /discharge (74 cfs). Total dissolved solids concentrations were significantly different (p=0.0000) between monitoring sites (Figure 34). Note that the median concentration at LWR-03 (North Branch of Pine Creek) was above the water quality standard for TDS. Mainstem sampling sites (LWR-07, LWR-08, LWR-05 and LWR-06) were significantly lower (p=0.001) than LWR-03 for all dates data was available (Appendix B, Table B-10). The lower monitoring site on Pine Creek (LWR-04) had TDS concentrations significantly higher than LWR-07, LWR-08 and LWR-05 although concentrations did not violate beneficial use-based water quality standards. Water originating at LWR-03 had approximately two to three day lag-time to reach LWR-04 (Figure 36).

Seasonal average concentrations for total dissolved solids were highest in the summer of 2004 at LWR-03; with water quality violation occurring during groundwater-dominated low flow conditions (Table 16, Table 17 and Table 18). The highest TDS concentration (12,805 mg/L) was recorded in the summer of 2004 at LWR-03 during low flow/discharge conditions (Figure 34, Figure 35 and Table 13). Four of the six TDS violations occurred during low flow conditions (circled events in Figure 36 (<1 cfs)). The other TDS violations, May 24, 2004 and June 11, 2004 occurred during decreasing and increasing flow régimes, respectively (Figure 36 and Table 13). Overall, seasonal TDS concentrations in the Little White River were statistically different; however, not significant enough (p=0.0476) for detecting differences using mean separation procedures (Appendix B, Table B-45).

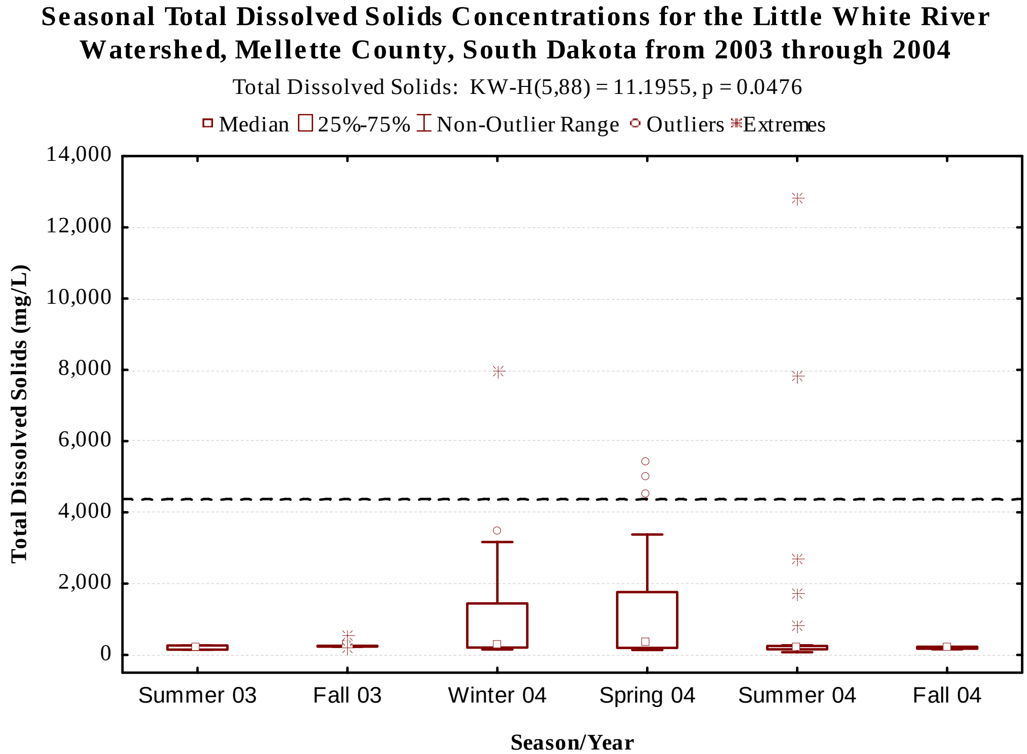


Figure 35. A comparison of total dissolved solids concentrations by season in the Little White River watershed, Mellette County, South Dakota from 2003 through 2004.

Site by site comparison of TDS concentrations indicate TDS concentrations were higher in tributaries to the Little White River (Figure 34). As mentioned previously, TDS and conductivity @ 25^{o} C values were not related in the Little White River using both assessment (Figure 19) and long-term WQM-13 data (Figure 20). High specific conductance (conductivity @ 25^{o} C) values recorded in the North Branch of Pine Creek during low flows/discharge were attributed to groundwater-dominated recharge from Pierre Shale seeps with naturally high concentrations of TDS (Figure 38). Thus, violations in assigned beneficial use water quality standards in the North Branch of Pine Creek for TDS, especially during low flow conditions, should be considered a natural condition in this sub-watershed.

Tributary Little White River TDS concentrations (Cut Meat Creek and Pine Creek) were significantly higher (p=0.0000) than concentrations in mainstem monitoring sites, with TDS concentrations at LWR -03 above assigned beneficial use water quality standards (Figure 37).

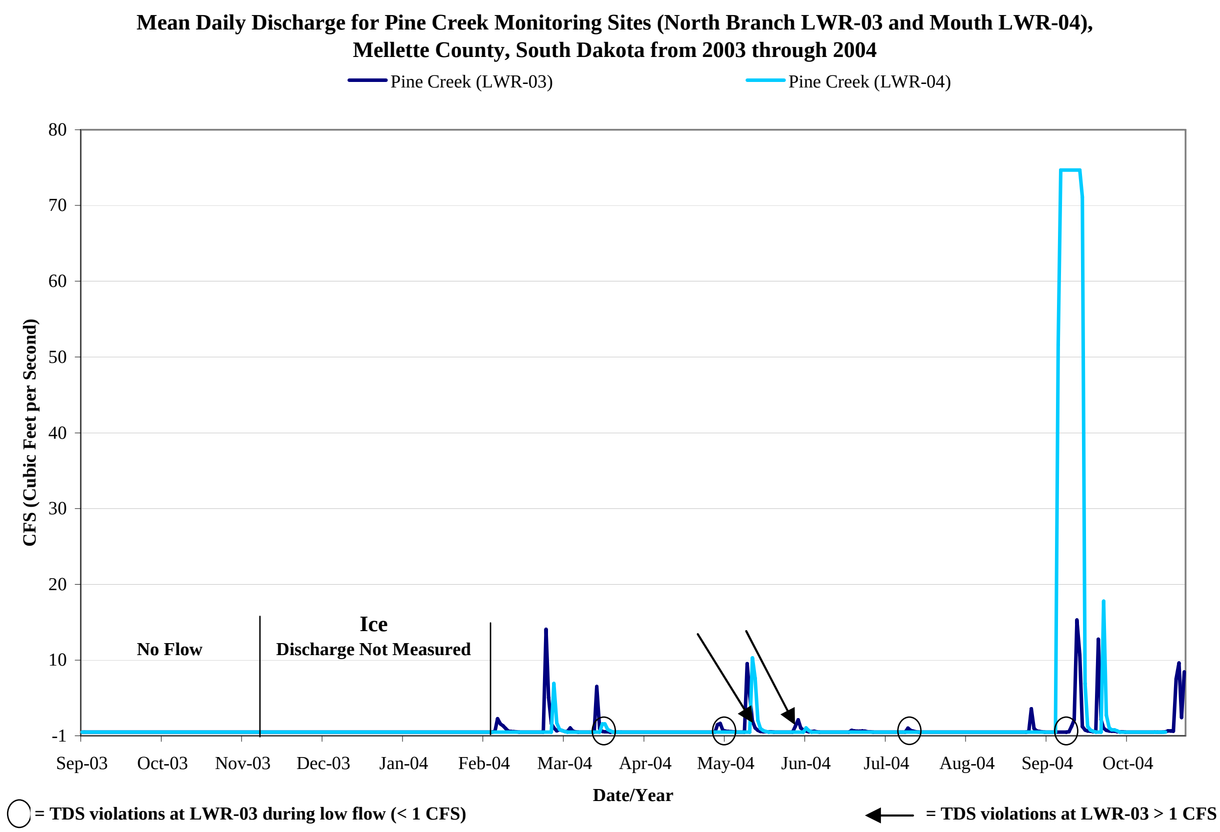


Figure 36. Mean daily discharge by tributary monitoring site on Pine Creek (a tributary of the Little White River), Mellette County, South Dakota from 2003 through 2004.

Table 24. Total dissolved solids loading per year by site for the Little White River and other monitored tributaries, Mellette County, South Dakota from 2003 through 2004.

Total Dissolved Solids

Sub-watershed	Station	Sub-watershed Acreage (Acres)	Kilograms by Site (kg)	Export Coefficient (kg/acre)
Cut Meat Creek	LWR-01	108,769	212,594	1.95
Little White River (Todd County Line)	LWR-07	819,479	14,104,599	17.21
Horse Head Creek	LWR-02	42,965	0	0.00
Little White River (Highway 44 Bridge)	LWR-08	56,185	-1,260,634	-22.44
North Branch of Pine Creek	LWR-03	30,319	1,218,912	40.20
Lower Pine Creek	LWR-04	49,697	3,839,270	77.25
Little White River (Highway 83 Bridge)	LWR-05	7,545	8,551,612	1,133.41
Little White River (mouth of the Little White River)	LWR-06	48,218	-9,386,632	-194.67
Total dissolved solids load to the White River		**1,163,177**	**17,279,720**	**14.86**

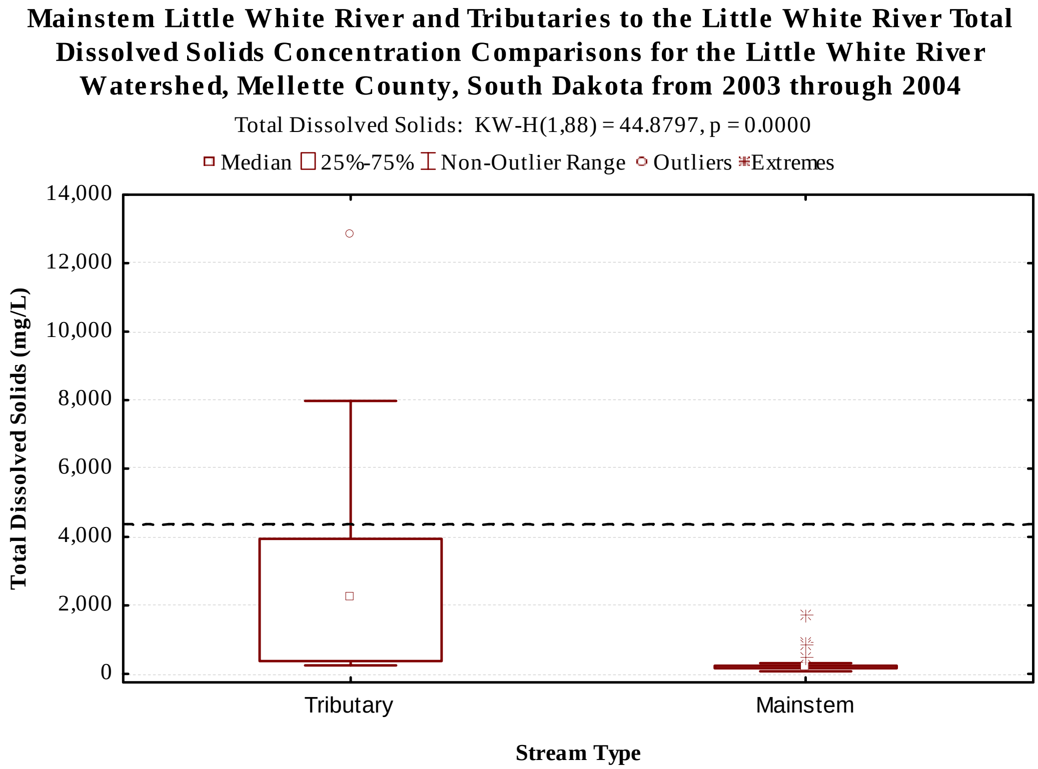


Figure 37. Total dissolved solids concentration comparison by tributary (mainstem Little White River and tributaries to the Little White River) for the Little White River watershed, Mellette County, South Dakota from 2000 through 2001.

Total dissolved solids loading by site was highest at site LWR-07 at the Mellette/Todd County line (14,104,599 kg) comprising 81.6 percent of the total dissolved solids load to the White River (Table 24). Tributary total dissolved solids loading by season was highest in the spring of 2004 for the White River watershed (Figure 38). Overall, total solids loading between sampling sites was significantly different (p=0.0000, Appendix B, Table B-24). Sub-watershed export coefficients (kilograms/acre) were highest in the LWR-05 sub-watershed (1,133.41 kg/acre) and contributed 79.5 percent of the total hydrologic load.

One sub-watershed (LWR-06) in the Little White River had overall load reductions in total dissolved solids during the project period. Load reduction at LWR-06, a mainstem monitoring site located approximately 1.9 km (1.2 miles) upstream of the confluence with the White River, was attributed to morphologic changes in the Little White River between LWR-05 (Highway 83 Bridge) and LWR-06 (mouth of the Little White River). The Little White River at LWR-05 has non-fractured shale bottom with large gravel to cobble sized rock with an average width of 19.2 m (63 feet). Sand and colloidal sediment flow through this section of the Little White River with an average water depth of 0.55 m (1.83 feet) and at a discharge of 2.39 cms (84.3 cfs). LWR-06 is a depositional area composed of shifting sand and colloidal sediment which during low flows becomes a braided channel with an average width of 55.2 m (181 feet). The Little White River near LWR-06 has an average water depth of 0.33 m (1.08 feet) and a discharge of 3.13 cms (110.7 cfs). Assessment and long-term WQM data indicate that TDS does not appear to be a problem in the mainstem of the Little White River.

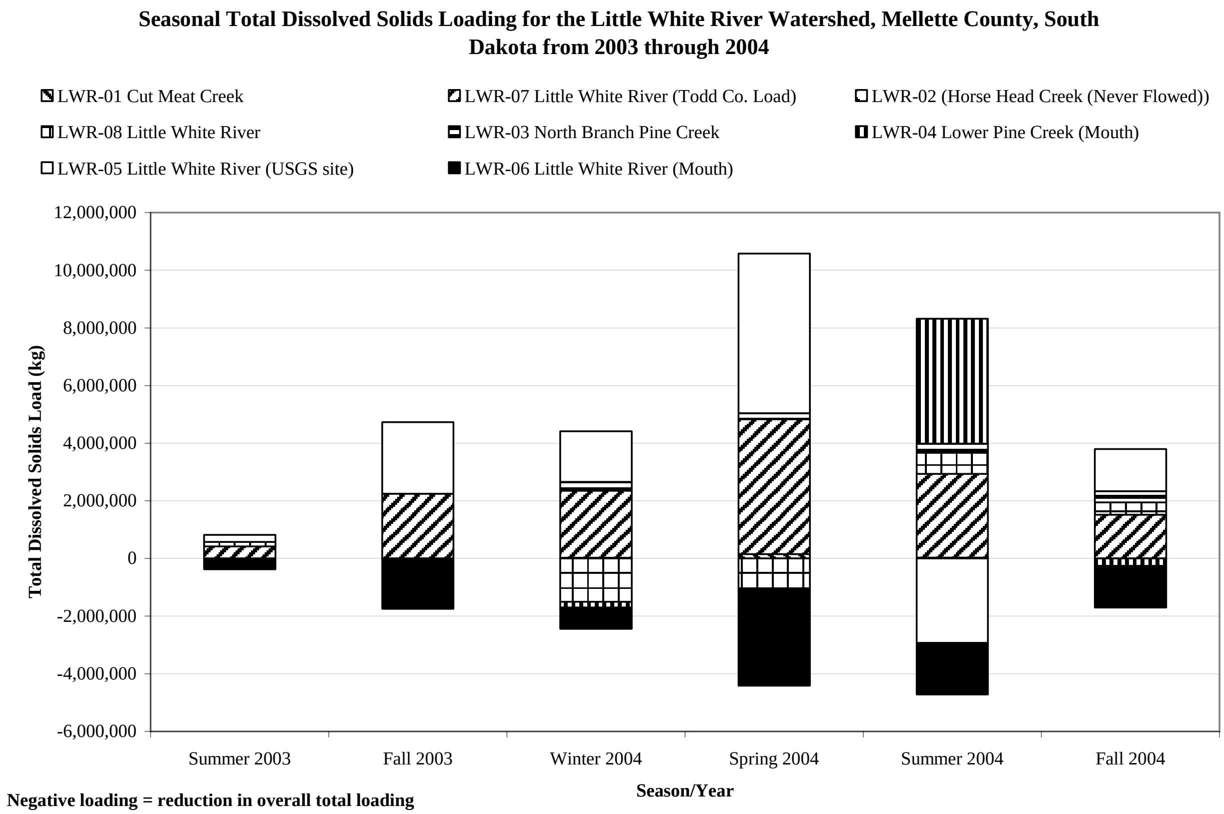


Figure 38. Seasonal total dissolved solids loading by tributary monitoring site the Little White River watershed, Mellette County, South Dakota from 2003 through 2004.

Medicine Creek in Lyman County, South Dakota flows through the Pierre Shale formation and has TDS violations during low flow conditions. During that study, saline seep samples were collected and compared to groundwater well and seep samples collected in the Freeman Dam watershed, also in the Pierre Shale formation (Smith, 2005). Freeman Dam well samples along with Medicine Creek seep samples had very high conductivity values, TDS, nitrate, sulfate, sodium and selenium concentrations. Groundwater seeps with high TDS, nitrate concentrations and specific conductance values were linked to high TDS, nitrate concentrations and specific conductance values in Freeman Dam by way of surface and groundwater runoff concentrating in Freeman Dam. Thus, under certain conditions and locations, natural alkali/saline seeps in Pierre Shale formations can cause high concentrations of TDS, nitrates, sulfate, sodium and selenium concentrations increasing specific conductance values in receiving waters and should be considered a natural condition.

Most TDS violations at LWR-03 in the North Branch of Pine Creek occurred during low flow conditions (four of the 6 sample violations), There was a poor correlation between TDS and specific conductance (conductivity @ 25^{o}C) values (Appendix D, Table D-1, Figure 19 and Figure 20). The poor relationship between TDS and specific conductance in Pine Creek may be explained by the geologic constituents in the watershed.

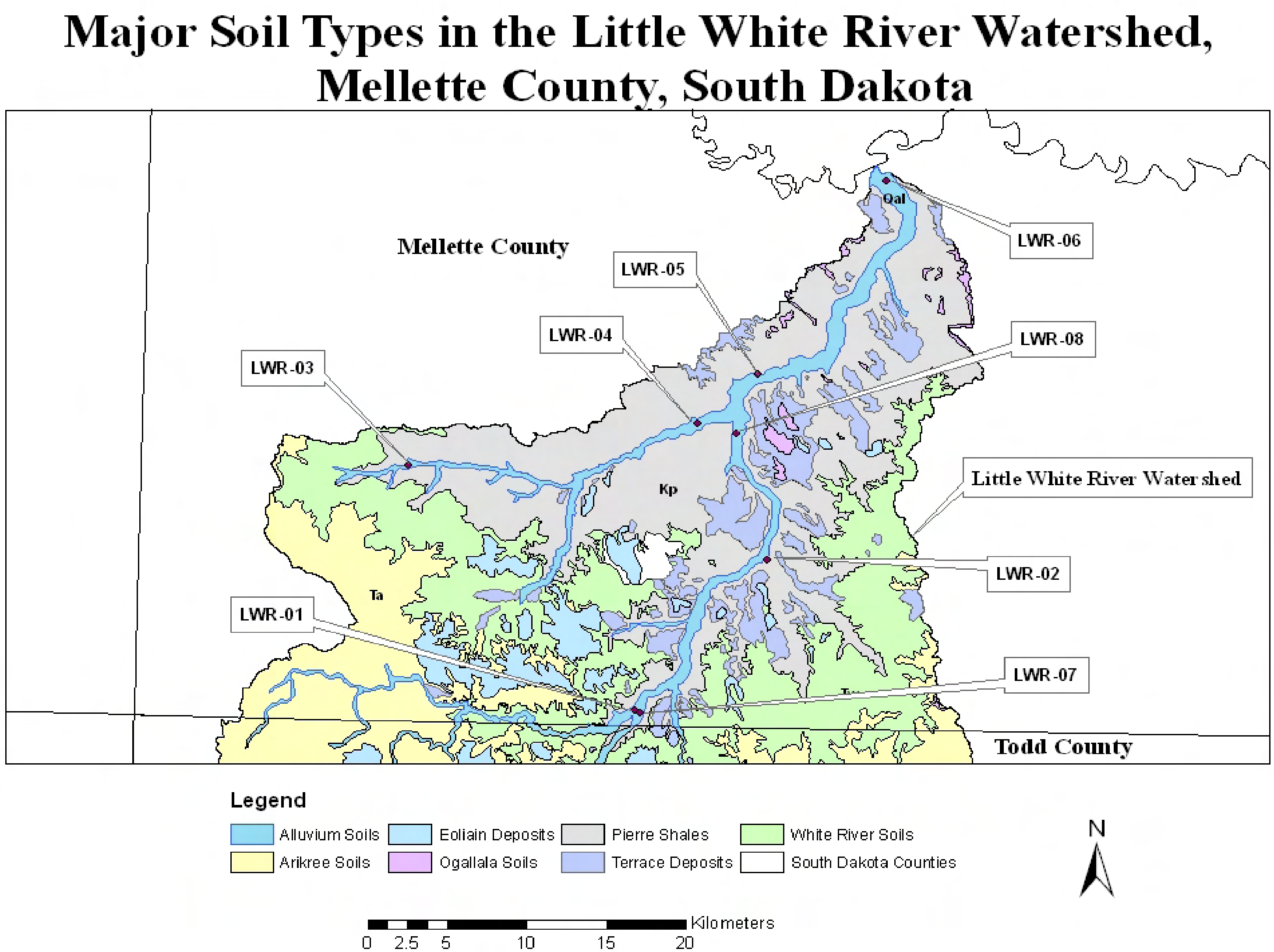


Figure 39. Major soil types in the Little White River watershed, Mellette County, South Dakota.

Little White River monitoring sites LWR-03 and LWR-04 are located in the Pine Creek watershed and are located in the Pierre Shale formation (Figure 39). Most TDS concentrations at both sampling sites were > 1,500 mg/L with six samples collected from LWR-03 exceeding South Dakotas beneficial use-based water quality standards (> 4,375 mg/L). All TDS samples collected in Pine Creek were elevated; however, specific conductance values, which usually correlate well with TDS concentrations were relatively low. This anomaly can be explained by the presence of colloidal White River Group soils. Colloidal soils are known to interfere/mask with specific conductance readings (SDDH, 2006). Pierre Shale makes up 12.1 percent of the Little White River watershed in Mellette County while White River Group soils comprise 9.8 percent of the watershed (Table 25). Pine Creek water originates in the White River Group soils picking up colloidal constituents that flow into fractured areas in the Pierre Shale formations picking up high TDS concentrations and specific conductance, though specific conductance values are altered by the colloidal nature of White River Group soils in the water.

Table 25. Percent and acreage of major soils for the Little White River watershed in Mellette County, South Dakota.

Soil Type	Symbol	Acreage (Acres)	Percent of Mellette County
Arikree Group	Ta	149,735	61.9
Alluvium deposits	Qal	32,656	13.5
Pierre Shale	Kp	29,270	12.1
White River Group	Tw	23,706	9.8
Terrace deposits	Qt	3,387	1.4
Eolian deposits	Qe	1,693	0.7
Ogallala Group	To	726	0.3
Other	-	726	0.3
Total	-	241,899	100.0

Similar to other watersheds in the Pierre Shale formation (Medicine Creek and Freeman Dam) with naturally high concentrations of TDS and specific conductance, Pine Creek exhibits higher frequencies of TDS violations in the upper end of the watershed. TDS concentrations further downstream (LWR-04) were also high but did not violate assigned beneficial use-based water quality standards due to mixing. Conductivity in Pine Creek is most likely higher than observed values but was masked due to interference with colloidal compounds originating in the White River Groups soils upstream of the Pierre Shale formation (Figure 39). Like Medicine Creek and Freeman Dam, Pine Creek has no point sources contributing to the high TDS concentrations observed in Pine Creek. The Cottonwood Creek watershed lies to the north of Pine Creek and flows through the Pierre Shale formation and into the White River is also listed for TDS and conductivity. Preliminary assessment data indicate TDS and conductivity violations occur during low flow conditions (below 1 cfs) and are considered a natural condition given this geologic scenario (Smith, 2007). Water quality violations and high concentrations of TDS at LWR-03 do not affect TDS concentrations at LWR-04 or further downstream in the Little White River (LWR-05 and LWR-06). Given the geologic makeup of the Pine Creek watershed and similar TDS/conductivity violation conditions in Medicine Creek, Cottonwood Creek and in the Freeman Dam watershed, the TDS violations in Pine Creek are from naturally occurring solutes originating from the Pierre Shale formations in western South Dakota.

Based on data described above, SD DENR recommends a change in water quality standards for (9) fish and wildlife propagation, recreation, and stock watering water and (10) irrigation waters. It is recommended that (9, 10) waters be amended into Article 74:51:01:30 *Flow rates for low quality fishery waters* rule for flows at the 7Q5 or 1 cfs which ever is greater. During these conditions, water quality criteria set forth in §§ 74:51:01:52 (fish and wildlife propagation, recreation, and stock watering water) and 74:51:01:53 (irrigation waters) do not apply to the water but all surface water discharge permit limits remain in place. After rule change, four of the six TDS concentrations in the North Branch of Pine Creek would not violate water quality standards; which would then leave two violations out of ten total samples, a 20 percent violation rate. Based on listing criteria set forth in the 2006 Integrated Report (criteria for support status for streams states that if greater than 10 percent of the samples violate water quality standards where 20 or more samples are available or greater than 25 percent of the samples violate water quality standards where there are less than 20 samples available, to consider a segment water quality-limited) the North Branch of Pine Creek would meet water quality standards.

Total Suspended Solids

Total suspended solids (TSS) are the materials that do not pass through a filter, e.g. sediment and algae. The Little White River is listed in the 2004 (page 159) and 2006 (page 134) South Dakota Integrated Report for Surface Water Quality Assessment as impaired for TSS. Violations in the TSS standards were based on warmwater semi-permanent fish life propagation water (Table 8, 158 mg/L). TSS violation percentages for mainstem Little White River are provided in Table 26.

Table 26. Mainstem Little White River TSS violation percentage by water quality monitoring site, Mellette County, South Dakota from 2003 through 2004.

Monitoring Site	Sample Total	Violation Total	Percent
LWR-07	19	11	57.9
LWR-08	6	5	83.3
LWR-05	21	14	66.7
LWR-06	18	12	66.7
Assessment Total	64	42	65.6
Long-term @ LWR-05 (1968 – 2005)	414	241	58.2

Mainstem TSS assessment data (64 samples) indicated a TSS violation rate of 65.6 percent. Long-term monthly WQM and assessment data (414 samples collected from 1968 through 2005) for Little White River was used to determine the overall TSS violation percentage in Mellette County. Based on Table 26, 58.2 percent of all TSS samples collected from mainstem Little White River violated assigned beneficial use-based water quality standards for warmwater semi-permanent fish life propagation waters. One possible reason the violation percentage was higher in assessment samples may be that most samples collected during the assessment were collected during runoff events resulting in event-based TSS concentrations. WQM samples for the Little White River were collected monthly that may or may not have been event-based.

The median total suspended solids (TSS) concentration during the project was 313.5 mg/L (average 1,271.9 mg/L) with a maximum of 16,100 mg/L recorded at LWR-04 on May 24, 2004 at increasing flow/discharge. A minimum concentration of 15 mg/L at LWR-01 was collected on June 9, 2004 during decreasing flow/discharge. Figure 40 shows most Little White River monitoring sites (LWR-07, LWR-08, LWR-05 and LWR-06) exceeded the current 158 mg/L standard. Specific violations in TSS standards from 2001 through 2005 by WQM site and mainstem assessment monitoring sites are provided in Table 10. Site by site comparison of TSS concentrations indicate that median TSS concentrations in mainstem Little White River were below 276 mg/L, while median TSS concentrations in Pine Creek were below 4,650 mg/L (Figure 40). TSS concentrations were significantly different between monitoring sites (Figure 40 and Table 5).

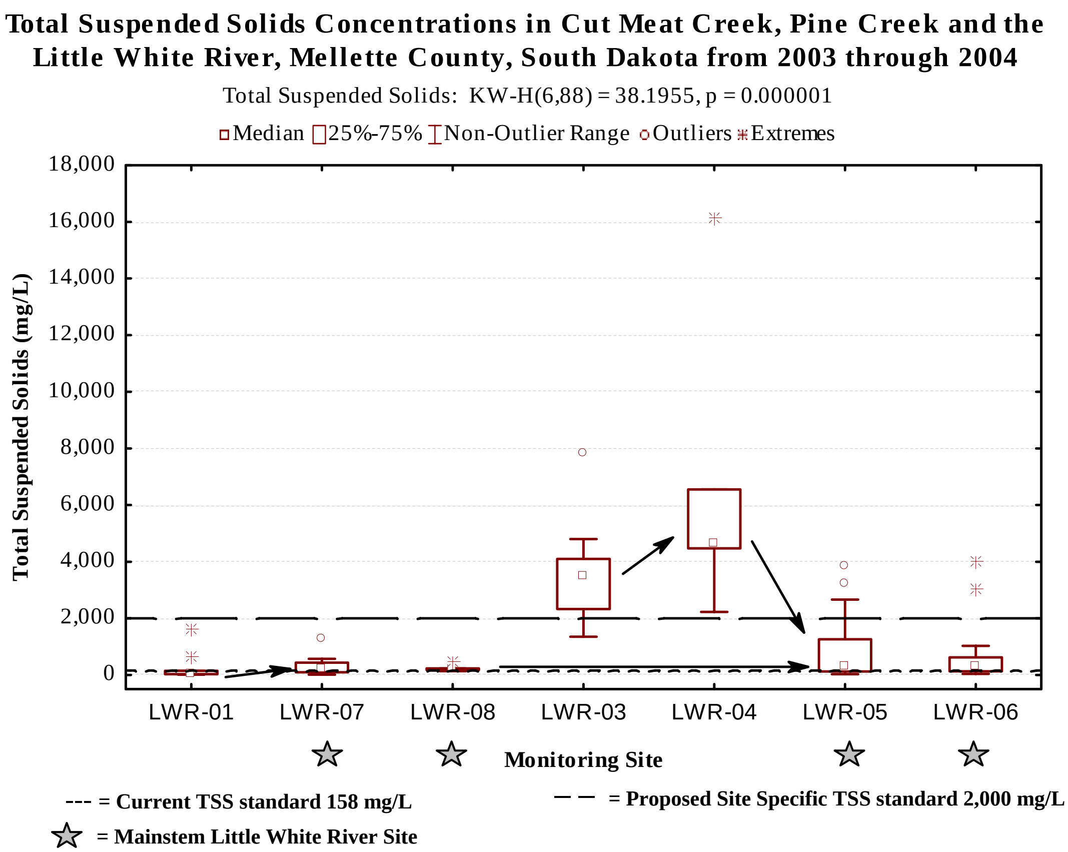


Figure 40. Total suspended solids concentrations by tributary monitoring site in the Little White River watershed, Mellette County, South Dakota from 2003 through 2004.

TSS concentrations were significantly different between seasons with concentrations collected in the spring of 2004 significantly higher than the fall of 2003 (Figure 41, p=0.0182). TSS standards only apply to samples collected on mainstem Little White River monitoring sites (LWR-07, LWR-08, LWR-05 and LWR-06). Therefore, mainstem data was analyzed separately for seasonal variations (Figure 42). Similar to seasonal concentrations collected from all monitoring sites in Mellette County, mainstem concentrations were significantly higher in the spring of 2004 than the fall of 2003, with only a slight change in the significance level or p-value (Figure 42, p=0.0288). Mainstem assessment data was used along with long-term WQM and

USGS data to help determine a site-specific standard for TSS in the Little White River (River segment R-5, 2006 Integrated Report page 134).

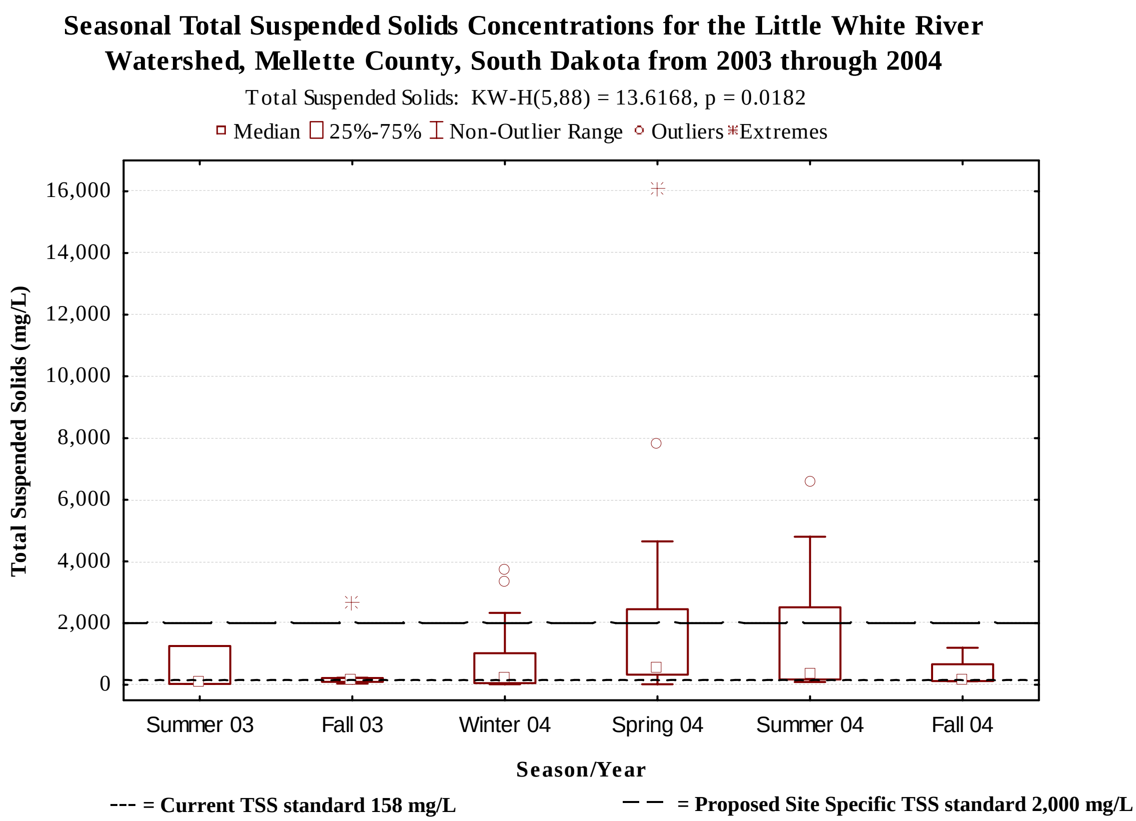
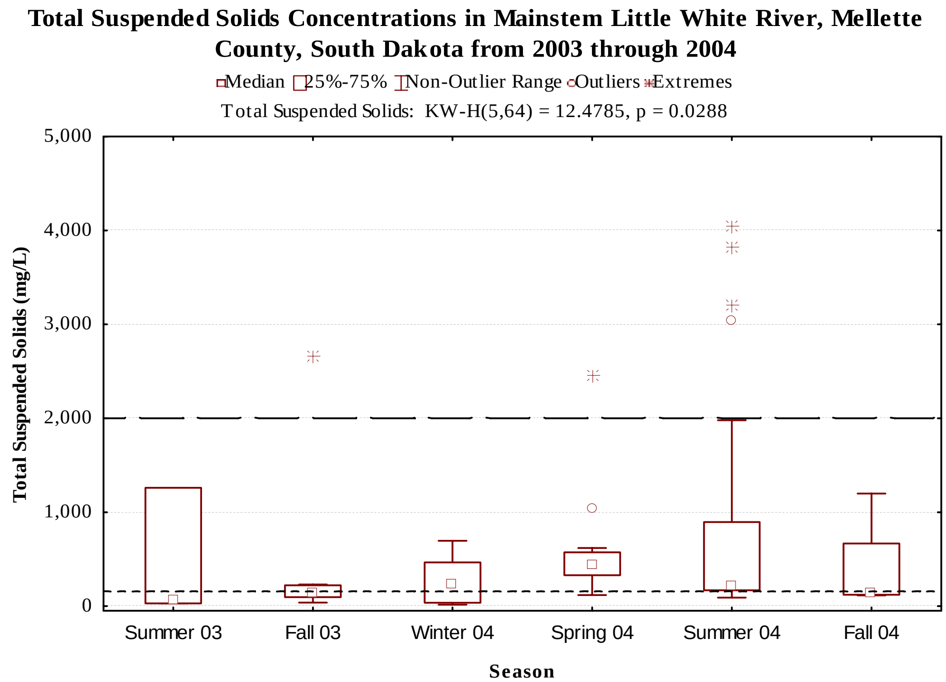


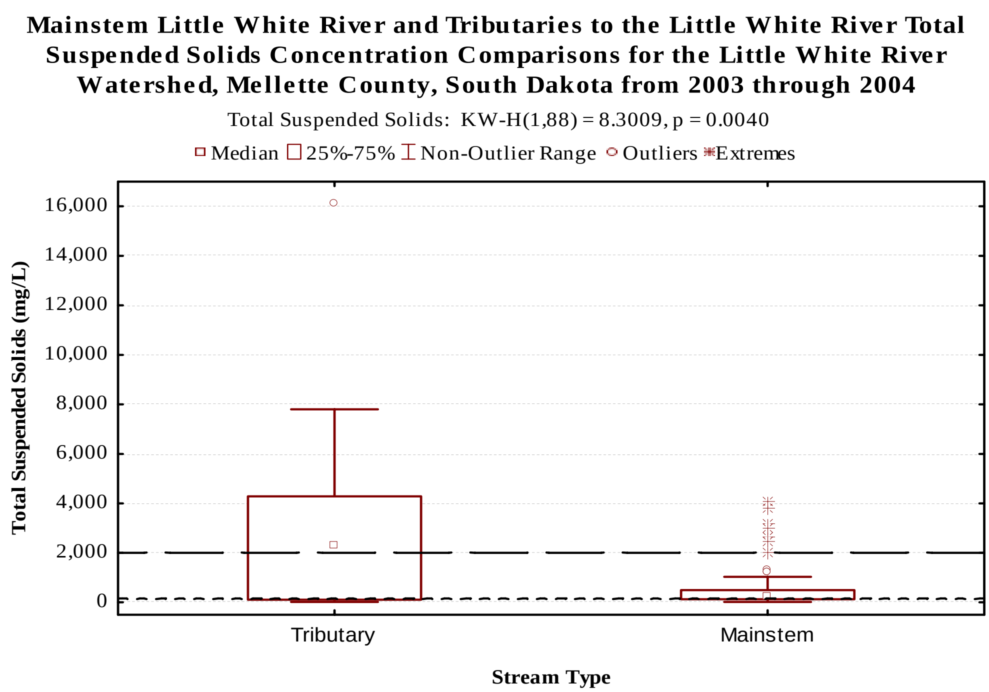
Figure 41. Total suspended solids concentrations by season from Cut Meat Creek, Pine Creek and the Little White River, Mellette County, South Dakota from 2003 through 2004.

TSS concentrations were also tested for differences between tributaries to the Little White River and mainstem Little White River (Figure 43). Data indicate that TSS concentrations from tributaries to the Little White River (Cut Meat Creek (LWR-01) and Pine Creek (LWR-03 and LWR-04)) were significantly higher than samples collected from mainstem Little White River (LWR-07, LWR-08, LWR-05 and LWR-06) monitoring sites (Figure 43, p=0.0040). Figure 39 shows Pine Creek and Cut Meat Creek either originate or flow through White River Group soils which may explain higher TSS concentrations (particulate and colloidal) observed in tributary monitoring sites, especially Pine Creek, during this study. This suggests that relatively high TSS concentrations are common in waterbodies that originate and/or flow through White River Group soils and should be considered naturally occurring.



--- = Current TSS standard 158 mg/L — — = Proposed Site Specific TSS standard 2,000 mg/L

Figure 42. Seasonal total suspended solids concentrations by season in mainstem Little White River, Mellette County, South Dakota from 2003 through 2004.



--- = Current TSS standard 158 mg/L — — = Proposed Site Specific TSS standard 2,000 mg/L

Figure 43. Total suspended solids concentration comparison by tributary (mainstem Little White River and tributaries to the Little White River) for the Little White River watershed, Mellette County, South Dakota from 2003 through 2004.

Table 27 Total suspended solids loading per year by site for the Little White River and other monitored tributaries, Mellette County, South Dakota from 2003 through 2004.

Total Suspended Solids

Sub-watershed	Station	Sub-watershed Acreage (Acres)	Kilograms by Site (kg)	Export Coefficient (kg/acre)
Cut Meat Creek	LWR-01	108,769	373,951	3.44
Little White River (Todd County Line)	LWR-07	819,479	26,652,216	32.52
Horse Head Creek	LWR-02	42,965	0	0.00
Little White River (Highway 44 Bridge)	LWR-08	56,185	-12,213,691	-217.38
North Branch of Pine Creek	LWR-03	30,319	1,145,579	37.78
Lower Pine Creek	LWR-04	49,697	12,325,450	248.01
Little White River (Highway 83 Bridge)	LWR-05	7,545	39,382,326	5,219.66
Little White River (mouth of the Little White River)	LWR-06	48,218	-5,265,146	-109.19
Total suspended solids load to the White River		**1,163,177**	**62,400,684**	**53.65**

Table 27 indicates a TSS load entering the study area (Mellette County) from Bennett and Todd Counties was 26,652,216 kg during the project. In 2002 through 2003, the U.S. Geological Survey conducted a study of the Little White River and selected tributaries in Todd County in cooperation with the Rosebud Sioux Tribe (Williamson, 2005). During that study, USGS personnel collected suspended sediment concentration samples (SSC) expressed in mg/L and compared them to South Dakota water quality standards which use TSS concentrations as the sediment parameter. The TSS standard for the Little White River, warmwater semi-permanent fish life propagation water, is 158 mg/L (Article 74:51:01:48). The South Dakota standard for TSS is a concentration determined by standard methods where 100 ml of a sample is analyzed for suspended materials. Sediment samples collected by USGS for the Todd County study were analyzed for SSC, where the entire sample is analyzed for suspended material. The biggest difference between TSS and SSC methods is that SSC values tend to be larger than TSS values. This is because it is very difficult to keep heavier sediment well mixed within the sample so that a representative sub-sample can be obtained. By analyzing the entire sample, the concentration typically is more representative of concentrations within the stream (Williamson, 2005).

Long-term data from the Todd County study indicated SSC samples collected from 2002 corresponded closely with historical values, indicating that the water quality within the Little White River has not changed substantially over time (Williamson, 2005). Mainstem SSC at USGS monitoring sites in Todd County based on South Dakota water quality standards indicated TSS violation rates ranged from 45 percent to 82 percent. The TSS violation rates collected from mainstem monitoring sites during the current Little White River assessment were well within the range reported by USGS (Table 26).

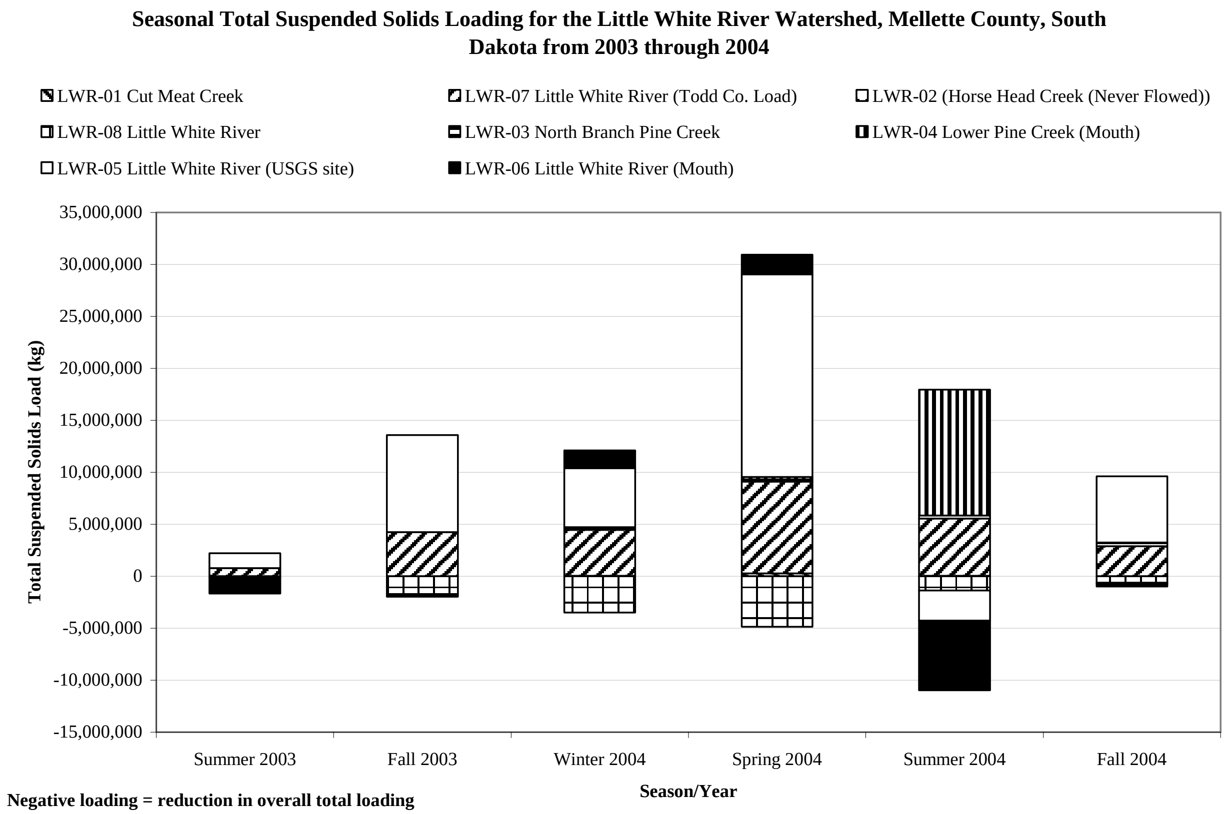


Figure 44. Seasonal total suspended solids concentrations by tributary monitoring site in the Little White River watershed, Mellette County, South Dakota from 2003 through 2004.

Most tributary and mainstem sub-watersheds in Mellette County delivered and contributed to the overall sediment (TSS) load to the White River (positive loading in Table 27). Sub-watershed LWR-05 delivered highest sediment loading during the assessment. This in part is due to the small hydroelectric dam located 4.1 km (2.5 miles) upstream which periodically releases flushing flows to discharge accumulated sediment behind the dam for the purpose of increasing head pressure. During theses releases flows increase dramatically, artificially increasing sediment (TSS) and nutrient loading downstream of the dam.

LWR-5, LWR-06 and LWR-08 were the only sub-watersheds that indicated sub-watershed load reduction potentials for TSS (Table 27 and Figure 44). FLUX modeling detected load reduction in TSS at LWR-05 only during the summer months of 2004 and was attributed to reduced flow during that time of the year (Figure 44). TSS load reductions at LWR-08 were attributed to stream channel widening and reduced velocities due to the ponding effect of the hydroelectric dam 1.3 km (0.81 miles) downstream of this site. Load reduction in the LWR-06 sub-watershed was attributed to morphologic changes in the Little White River between LWR-05 (Highway 83 Bridge) and LWR-06 (mouth of the Little White River). Morphologic change observed in the LWR-06 sub-watershed was due to streambed widening which decreases hydrologic energy, in turn, reducing sediment transport capacity and overall TSS loading.

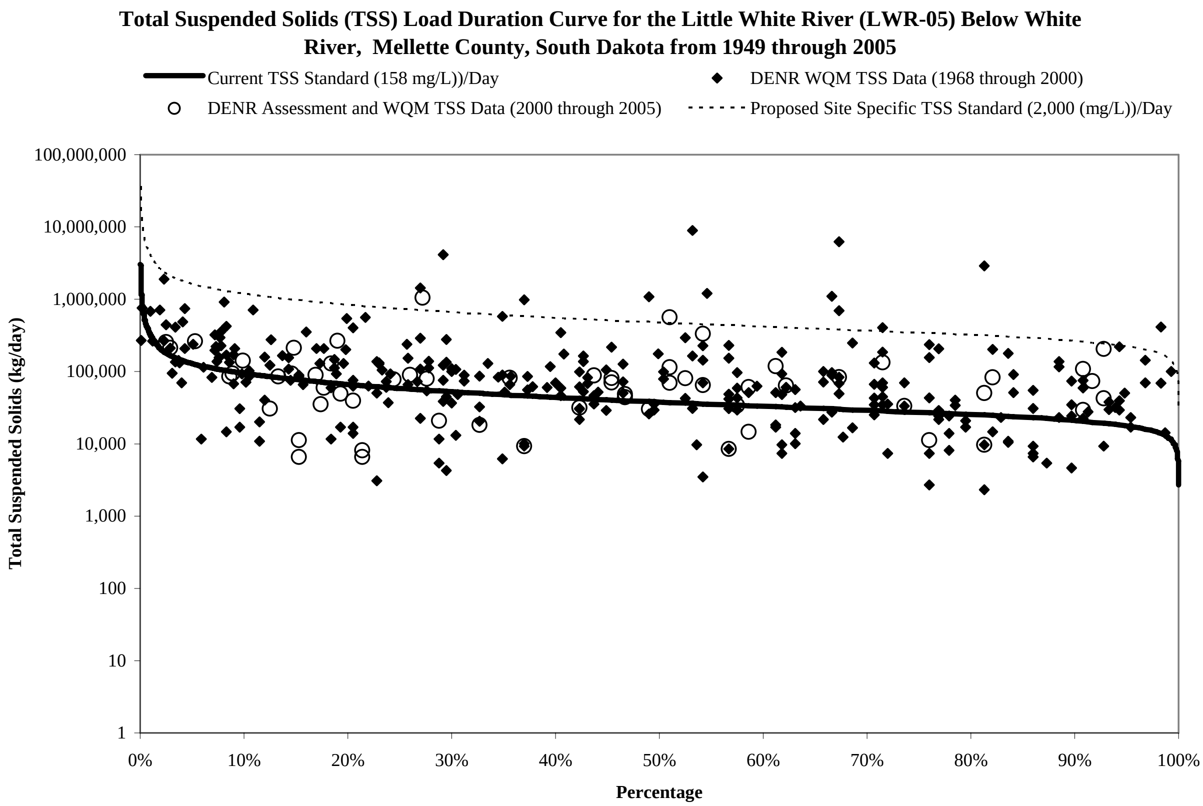


Figure 45. Load duration curve for total suspended solids for the Little White River (LWR-05), Mellette County, South Dakota from 2003 through 2004.

Total suspended solids loading by season was highest in the spring of 2004 for the Little White River (Figure 44). TSS loading in the spring of 2004 was significantly higher than loading during the fall of 2003 (Appendix B, Table B-46). Three sub-watersheds in the Little White River watershed had overall load reductions in TSS during the project period, LWR-05, LWR-06 and LWR-08).

The load duration curve for TSS indicates violations in assigned beneficial use standards for TSS at LWR-05 occurred throughout all (base flow through runoff events) flow regimes (Figure 45). Total maximum daily load based on beneficial use-based water quality standards (158 mg/L) is shown in Figure 45 as the solid black line. Short-term data (2000 through 2005 (hollow circles)) indicate a 56.7 percent violation rate; while the overall long-term violation rate (1968 through 2005 (black diamonds and hollow circles)) is 56.9 percent.

Based on current assessment data, long-term WQM and USGS data, total suspended solids concentrations, although high, were relatively stable and have not changed substantially over time (current assessment and Williamson, 2005). This indicates TSS concentrations exceeding the current water quality standard for the Little White River watershed frequently occur and should be considered a naturally occurring condition in this watershed. Figure 46 substantiates this perception with the long-term trend line having a negative slope (-0.0202) which indicates a slight decrease in TSS concentrations over time. Similar trends in total suspended solids (negative slope) were observed at all long-term water quality monitoring sites in White River (RESPEC, 2005 (Draft Report).

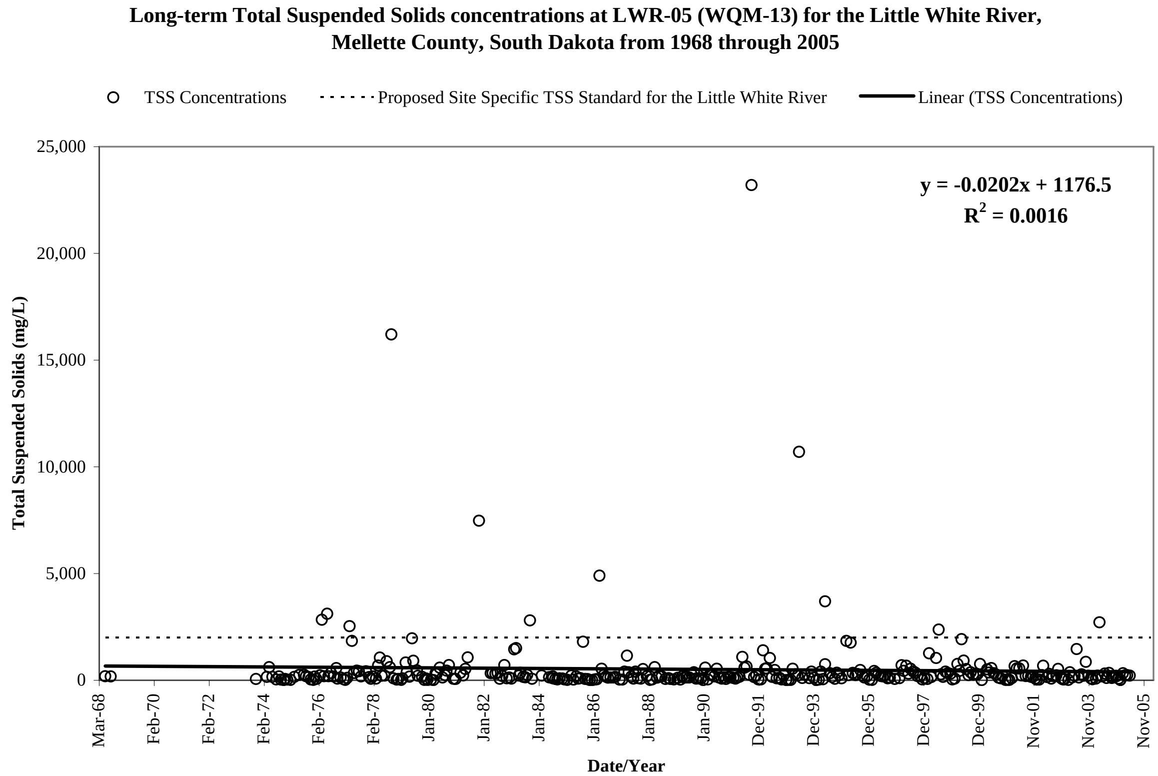


Figure 46. Long-term total suspended solids concentrations at LWR-05 (WQM 13) from the Little White River, Mellette County, South Dakota from 1968 through 2005.

Fisheries survey data indicate the Little White River and the more turbid White River have a diverse fish community with 18 species identified in the Little White River basin and 27 species identified in the White River. Since 1962, 47 total species have been identified in the White River (Baily and Allum, 1962, Bliss and Schainost, 1973, Cunningham et al., 1995, USF&WS, 1997, Fryda, 2001 and Harland, 2003). Benthic macroinvertebrates collected during this study on the Little White River totaled and identified 12 orders comprising 35 families and 108 taxa indicating good biotic diversity. Macroinvertebrate and fisheries data suggest that biological integrity remains relatively good even with large changes in TSS concentrations over time. Apparently, aquatic life in the Little White River has adapted to successfully thrive in waters with highly variable ranges of TSS concentrations (ranging from 6 mg/L to 23,200 mg/L) and turbidity.

The 2004 and 2006 *South Dakota Integrated Report for Surface Water Quality Assessment* (2004 (page 159) and 2006 (page 134)) lists the Little White River as impaired for TSS. Assessment and long-term data (load duration curve for TSS) suggest water quality violations in TSS occurred over the entire flow regime (base to peak flows, Figure 45). TSS violations in the Little White River regularly exceeded the TMDL listing criteria as non-support for TSS standards based on the warmwater semi-permanent fish life propagation water. However, USGS, WQM and assessment TSS data show that TSS concentrations have exceeded South Dakota water quality standards (>158 mg/L) since monitoring began on the Little White River in Mellette and Todd Counties (current assessment and Williamson, 2005). All available data indicate the current total suspended solids standard for TSS on the Little White River (158 mg/L) is not representative or protective of warmwater semi-permanent fish life propagation in the Little White River based on current and long-term geological, chemical and biological data. The TSS standard should be modified to reflect best available data specific to the Little White River and be protective of both human and aquatic life uses. SD DENR recommends the current water-quality based TSS standard for the Little White River (158 mg/L) be changed to a site-specific TSS standard of 2,000 mg/L in the listed segment (R-5). When the site-specific TSS standard is in place, the Little White River will meet South Dakota's beneficial use-based water quality standards and should be de-listed in the upcoming 2008 Integrated Report. This site-specific standards change should not significantly impact the biological community because this community originally developed under these unique conditions and have adapted to changing TSS concentrations.

Volatile Total Suspended Solids

Volatile total suspended solids (VTSS) are that portion of suspended solids that are organic (organic matter that burns in a 500^{o} C muffle furnace).

The median VTSS concentration during the Little White River project was 40.0 mg/L (average 119.4 mg/L) with a maximum concentration of 1,600 mg/L recorded at LWR-04 on May 24 2004 in Pine Creek. Minimum VTSS concentrations of 3.0 mg/L were collected from Cut Meat Creek (LWR-01) on May 24, 2004 and from mainstem Little White River sites LWR-05 and LWR-07 on January 19, 2004 (Appendix D, Table D-1). Site by site comparison of TSS concentrations indicate that median VTSS concentrations in mainstem Little White River were generally below 55 mg/L, except on Pine Creek at LWR-03 and LWR-04 (Figure 47). VTSS concentrations were statistically different between monitoring sites (Figure 47 and Table 5), with LWR-01, LWR-07 and LWR-08 significantly lower than the North Branch of Pine Creek and VTSS concentrations at LWR-01 and LWR-07 significantly lower than lower Pine Creek (Appendix B, Table B-12). The organic percentage (VTSS) of total suspended solids (TSS) in the Little White River watershed ranged from 1.5 percent in the North Branch of Pine Creek to 60 percent in Cut Meat Creek (Appendix D, Table D-1).

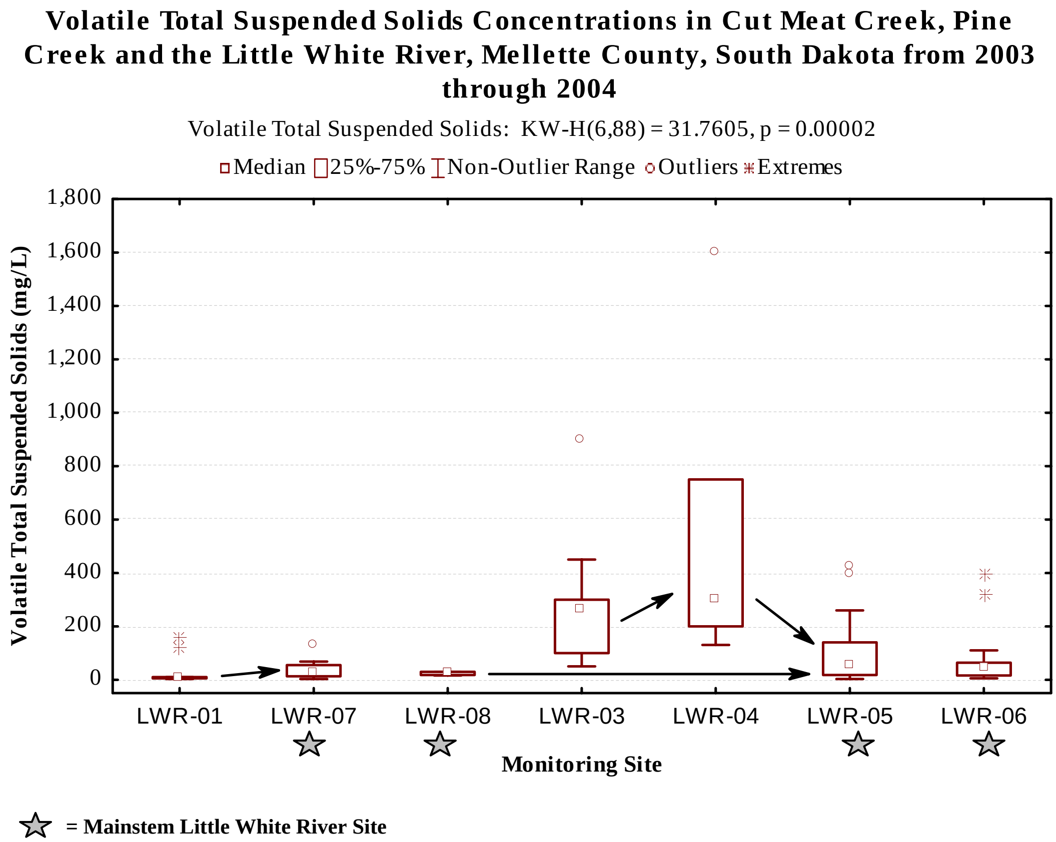


Figure 47. Volatile total suspended solids concentrations by tributary monitoring site in the Little White River watershed, Mellette County, South Dakota from 2003 through 2004.

Seasonally, VTSS concentrations were significantly different between sampling seasons (p=0.0007) with concentrations in the spring of 2004 being significantly higher than fall 2003 and winter 2004 while concentrations collected in summer of 2004 were significantly higher than fall 2003 (Figure 48 and Appendix B, Table B-47). During the Little White River assessment, mainstem Little White River VTSS concentrations were significantly lower (p=0.0158) than concentrations in tributaries to the Little White River (Figure 49).

VTSS loading by site was highest at site LWR-05 comprising 65.5 percent of the total VTSS load to the White River (Table 28). Tributary VTSS loading by season was highest in the spring of 2004 for the Little White River watershed in Mellette County (Figure 48 and Figure 50). Overall volatile total suspended solids loading between sampling sites were significantly different in the Little White River (Appendix B Table B-26). Loading at mainstem monitoring sites LWR-07 and LWR-05 were significantly higher than LWR-08 and LWR-06 (Table 5). Sub-watershed export coefficients (kilograms/acre) in mainstem Little White River were highest in the LWR-05 sub-watershed (594.55 kg/acre) and were highest in tributaries to the Little White River in the lower Pine Creek sub-watershed (LWR-04) at 27.80 kg/acre (Table 28).

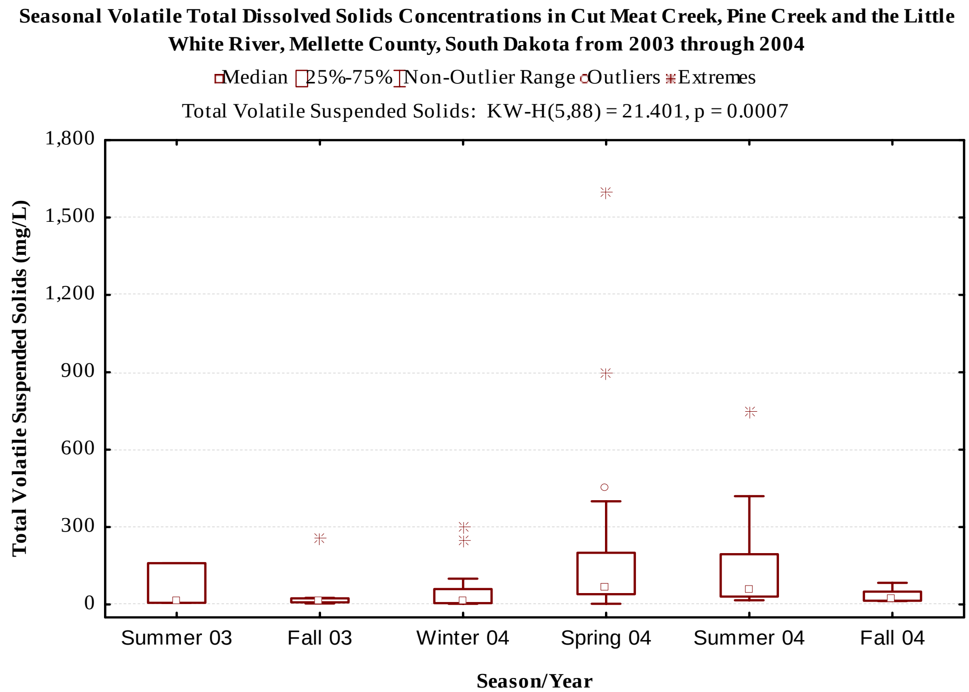


Figure 48. Seasonal volatile total suspended solids concentrations by tributary monitoring site in the Little White River watershed, Mellette County, South Dakota from 2003 through 2004.

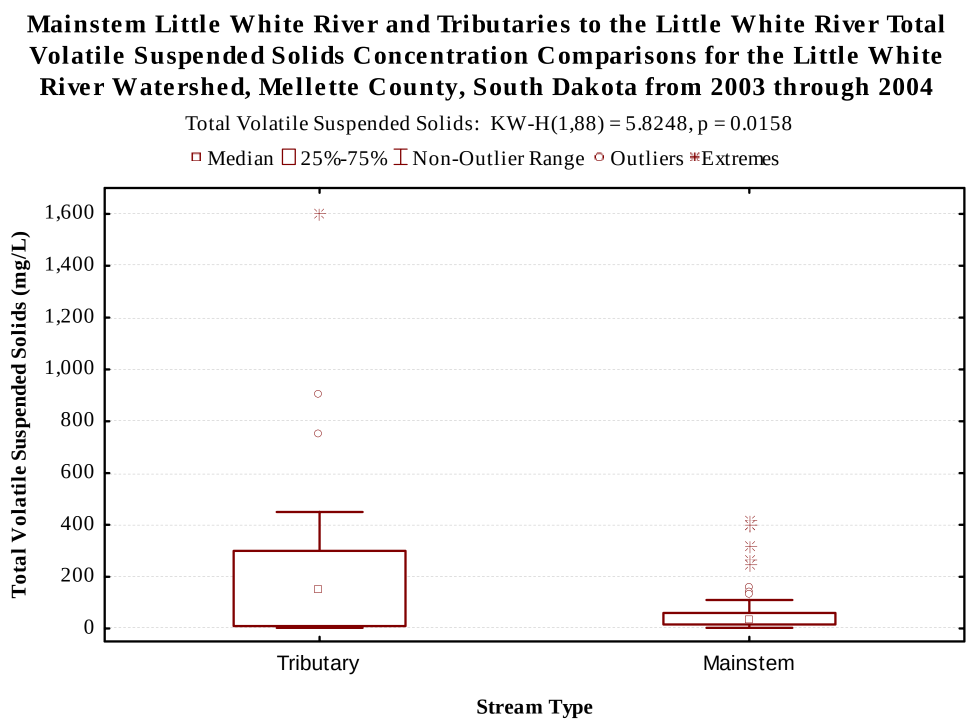


Figure 49. Volatile total suspended solids concentration comparison by tributary (mainstem Little White River and tributaries to the Little White River) for the Little White River watershed, Mellette County, South Dakota from 2003 through 2004.

Table 28. Volatile total suspended solids loading per year by site for the Little White River and other monitored tributaries, Mellette County, South Dakota from 2003 through 2004.

Total Volatile Suspended Solids

Sub-watershed	Station	Sub-watershed Acreage (Acres)	Kilograms by Site (kg)	Export Coefficient (kg/acre)
Cut Meat Creek	LWR-01	108,769	53,164	0.49
Little White River (Todd County Line)	LWR-07	819,479	3,098,841	3.78
Horse Head Creek	LWR-02	42,965	0	0.00
Little White River (Highway 44 Bridge)	LWR-08	56,185	-1,580,777	-28.14
North Branch of Pine Creek	LWR-03	30,319	96,603	3.19
Lower Pine Creek	LWR-04	49,697	1,381,458	27.80
Little White River (Highway 83 Bridge)	LWR-05	7,545	4,485,866	594.55
Little White River (mouth of the Little White River)	LWR-06	48,218	-683,720	-14.18
Total volatile suspended solids load to the White River		**1,163,177**	**6,851,434**	**5.89**

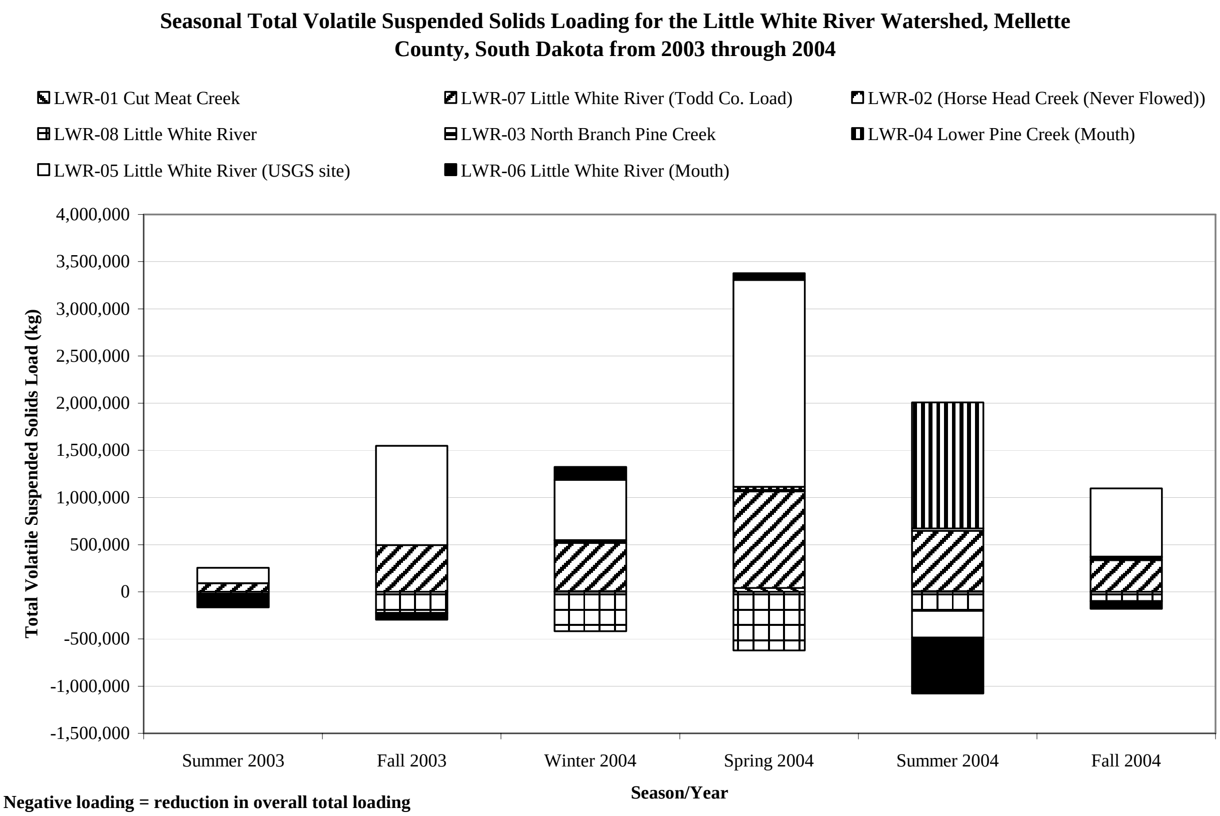


Figure 50. Seasonal volatile total suspended solids loading by tributary monitoring site in the Little White River watershed, Mellette County, South Dakota from 2003 through 2004.

Similar to other solids parameters VTSS showed an overall load reduction in LWR-06 during the project period (Table 28). However, seasonally VTSS loading increased during the winter and spring of 2004 (Figure 50). Based on USGS, WQM and assessment data, VTSS is not a concern in the Little White River watershed.

Ammonia

Ammonia is the nitrogen product of bacterial decomposition of organic matter and is the form of nitrogen most readily available to plants for uptake and growth. Sources of ammonia in the Little White River watershed may come from animal feeding areas, decaying organic matter or bacterial conversion of other nitrogen compounds.

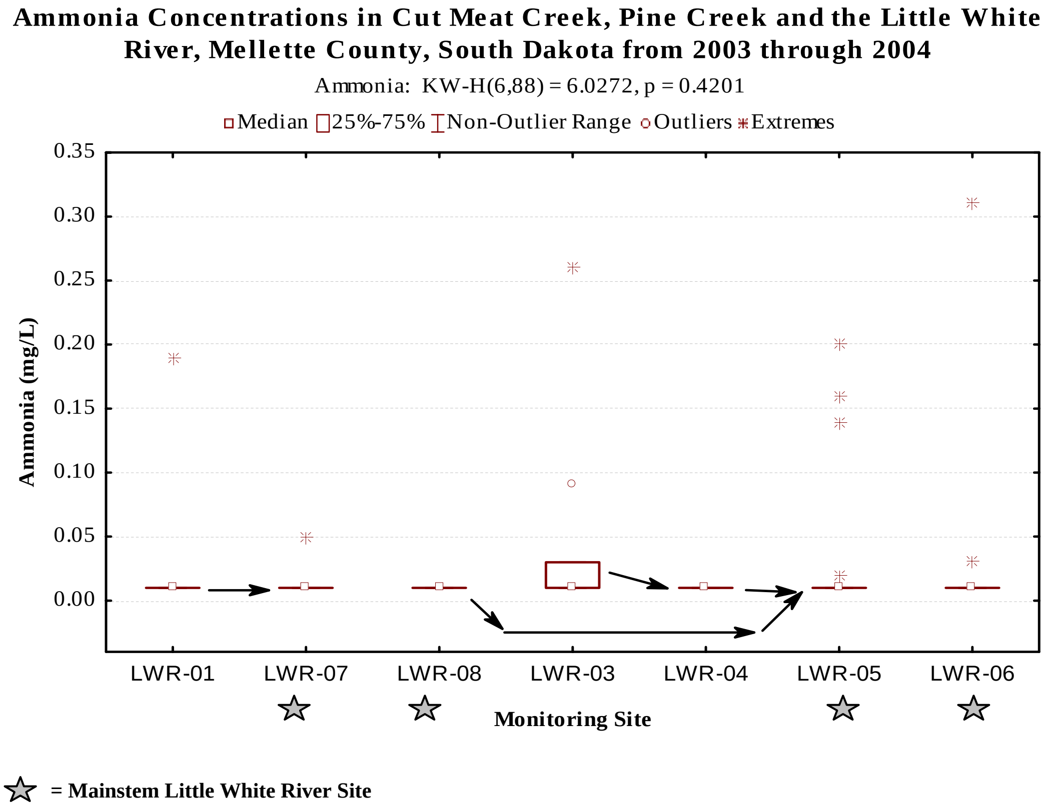


Figure 51. Ammonia concentrations by tributary monitoring site tributary in the Little White River watershed, Mellette County, South Dakota from 2003 through 2004.

Minimum ammonia concentrations (0.01 mg/L, ½ the detection limit) were collected on a variety of dates from all monitoring sites in the Little White River watershed (Appendix D, Table D-1). The median ammonia concentration for the Little White River project was 0.01 mg/L (average 0.026 mg/L) with a maximum concentration of 0.31 mg/L recorded at LWR-06 on August 16, 2004 during a peak runoff event (Figure 51 and Figure 52). Site by site comparison of ammonia concentrations indicate that median ammonia concentrations in the Little White River were generally below 0.02 mg/L (Figure 51), with ammonia concentrations statistically similar (p=0.4201) between monitoring sites (Figure 51 and Table 5).

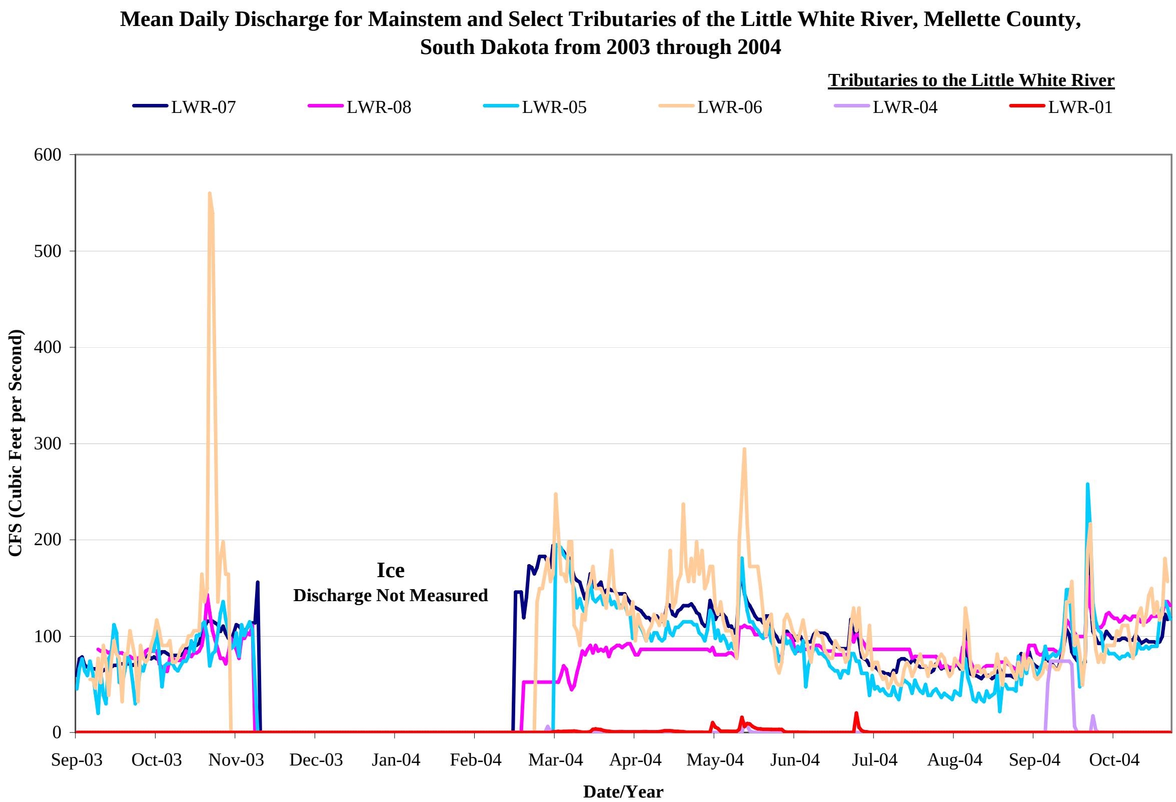


Figure 52. Mean daily discharge for mainstem and select tributaries of the Little White River, Mellette County, South Dakota from 2003 through 2004.

Ammonia concentrations were not significantly different (p=0.3699) between sampling seasons with the highest ammonia concentrations sampled in the summer of 2004 (Figure 53 and Appendix B, Table B-48). Similarly, ammonia concentrations in mainstem Little White River were also statistically similar (p=0.4581) to concentrations in tributaries to the Little White River (Figure 54).

Ammonia loading by site was highest at site LWR-05 (1,026 kg/yr) comprising 45.2 percent of the total ammonia load the White River (Table 29). Sub-watershed export coefficients (kilograms/acre) were also highest in the LWR-05 sub-watershed (0.136 kg/acre) followed by LWR-06 at 0.012 kg/acre (Table 29). Tributary ammonia loading by season was highest in the spring of 2004 in the Little White River watershed. Seasonally, three sub-watersheds in the Little White River watershed (LWR-04, LWR-06 and LWR-08) had overall load reductions in ammonia during the project period (Figure 55). Overall ammonia loading between sampling sites were significantly different (Table 5 and Appendix B, Table B-27).

The ammonia standard is based on the total ammonia limit calculated using Equation 2 (page 19) and pertains to beneficial use category (5) warmwater semi-permanent fish life propagation water. The total ammonia limit is calculated using pH based on beneficial use category and presence or absence of salmonid fish species or whether early fish life stages are present.

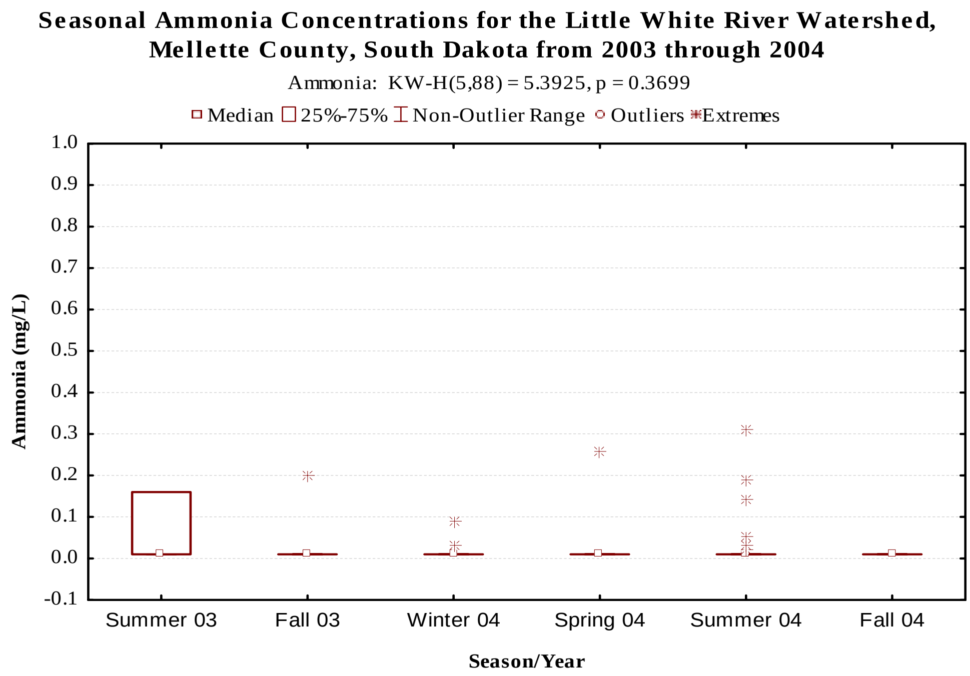


Figure 53. Seasonal ammonia concentrations by tributary monitoring site in the Little White River watershed, Mellette County, South Dakota from 2003 through 2004.

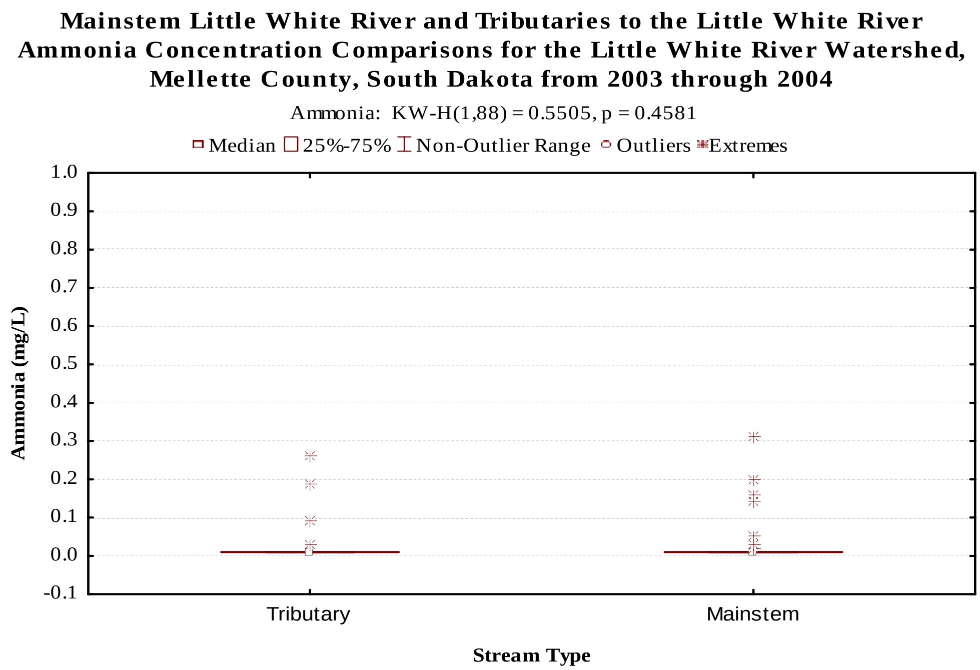


Figure 54. Ammonia concentration comparison by stream type (mainstem Little White River and tributaries to the Little White River), Mellette County, South Dakota from 2003 through 2004.

Table 29. Ammonia loading per year by site for the Little White River watershed and other monitored tributaries, Mellette County, South Dakota from 2003 through 2004.

Ammonia

Sub-watershed	**Station**	**Sub-watershed Acreage (Acres)**	**Kilograms by Site (kg)**	**Export Coefficient (kg/acre)**
Cut Meat Creek	LWR-01	108,769	49	0.000
Little White River (Todd County Line)	LWR-07	819,479	916	0.001
Horse Head Creek	LWR-02	42,965	0	0.000
Little White River (Highway 44 Bridge)	LWR-08	56,185	-349	-0.006
North Branch of Pine Creek	LWR-03	30,319	17	0.001
Lower Pine Creek	LWR-04	49,697	2	0.000
Little White River (Highway 83 Bridge)	LWR-05	7,545	1,026	0.136
Little White River (mouth of the Little White River)	LWR-06	48,218	558	0.012
Total ammonia load to the White River		**1,163,177**	**2,219**	**0.002**

The ammonia standard changed from unionized ammonia to total ammonia effective September 13, 2004 varies because the standard is calculated based on pH of the sample. All ammonia data collected during the assessment (2003 through 2004) and data collected from WQM 13 (2001 through 2006) were analyzed based on the new total ammonia standard. During the current study, data indicated a 1.6 percent violation rate (1 violation out of 64 samples) with no ammonia limit violations observed at WQM 13 (LWR-05). The overall violation rate for the Little White River in Mellette County was 0.8 percent and is not considered a problem in this watershed (Table 14).

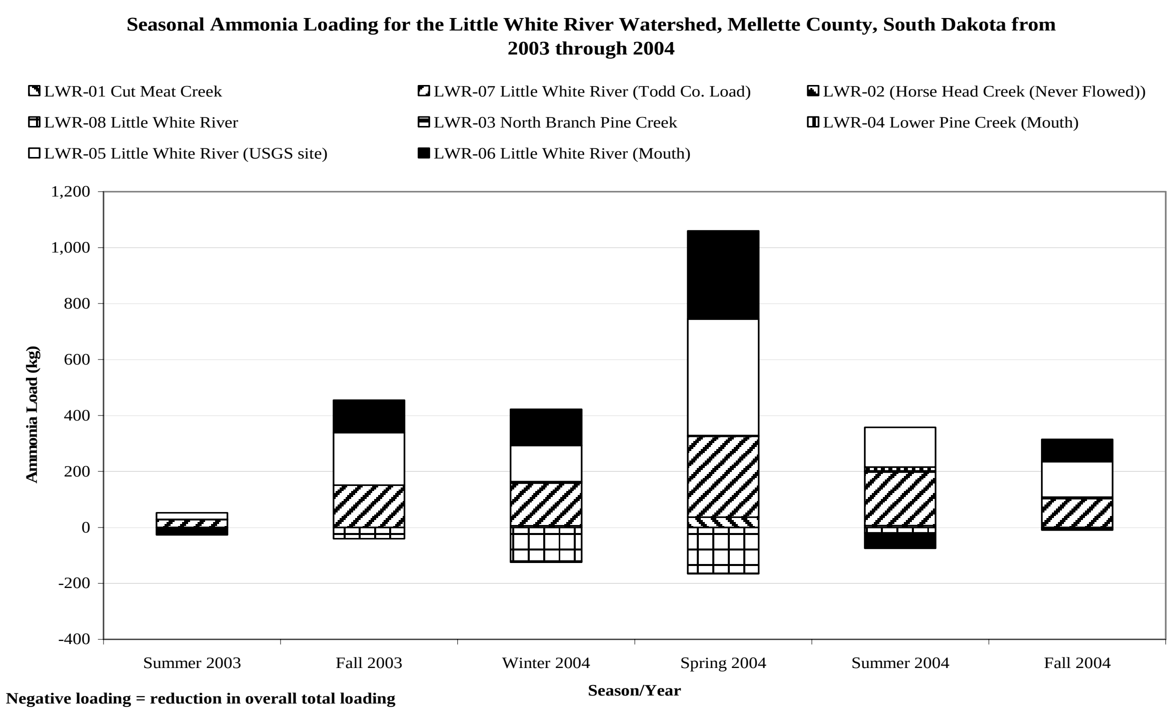


Figure 55. Seasonal ammonia loading by tributary monitoring site by season for the Little White River watershed and other monitored tributaries, Mellette County, South Dakota from 2003 through 2004.

Nitrate-Nitrite

Nitrate and nitrite (NO_3^- and NO_2^-) are inorganic forms of nitrogen easily assimilated by algae and macrophytes. Sources of nitrate and nitrite can be from agricultural practices and direct input from septic tanks, precipitation, groundwater, and from decaying organic matter. Nitrate-nitrite can also be converted from ammonia through de-nitrification by bacteria. This process increases with increasing temperature and decreasing pH.

The median nitrate-nitrite concentration during this project was 0.40 mg/L (average 0.38 mg/L) with a maximum concentration of 1.1 mg/L recorded at LWR-03 on May 15, 2004 during low flow (Figure 56). Minimum nitrate-nitrite concentrations (0.10 mg/L) were collected on a variety of dates from all monitoring sites except LWR-03 and LWR-04 on Pine Creek (Appendix D, Table D-1). Site by site comparison of nitrate and nitrite concentrations indicate that median concentrations in mainstem Little White River (LWR-07, LWR-08 LWR-05 and LWR-06) Cut Meat Creek (LWR-01) and Pine Creek tributary (LWR-03 and LWR-04) were significantly different (Table 5); however, not significant enough (p=0.0291) for detecting differences using mean separation procedures (Appendix B, Table B-14).

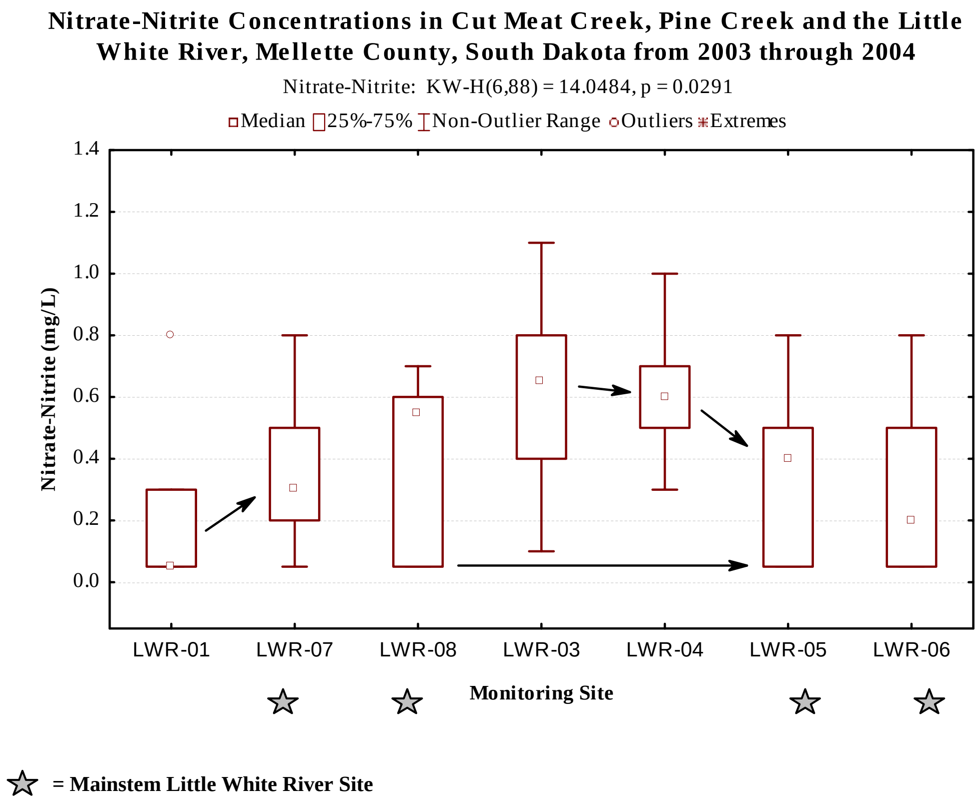


Figure 56. Nitrate-nitrite concentrations by tributary monitoring site in the Little White River watershed, Mellette County, South Dakota from 2003 through 2004.

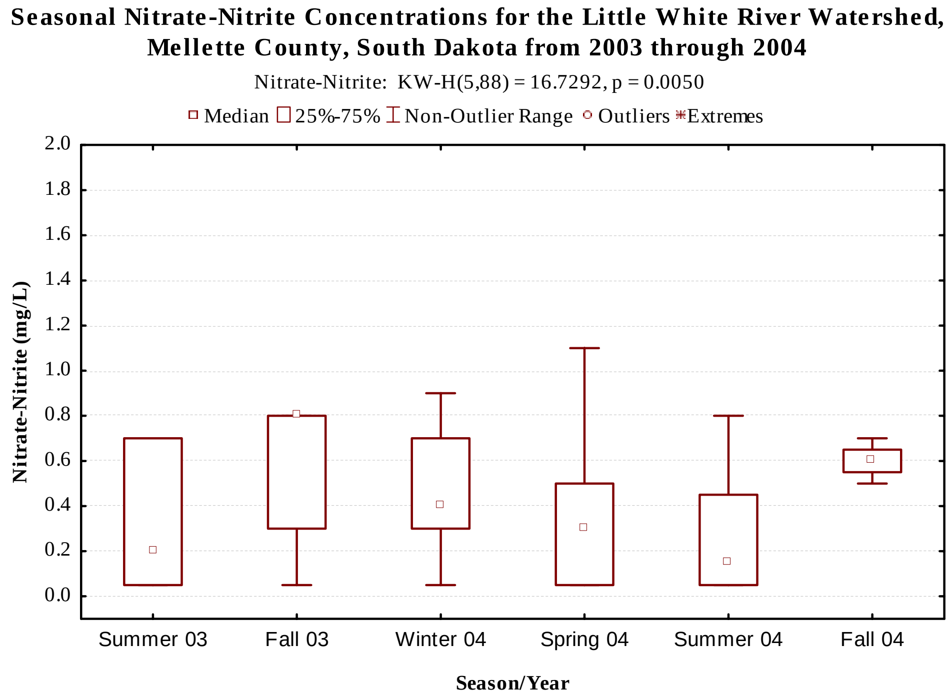


Figure 57. Nitrate-nitrite concentrations by season for the Little White River watershed, Mellette County, South Dakota from 2003 through 2004.

Nitrate-nitrite concentrations were significantly different between sampling seasons (p=0.0050) with concentrations in the fall of 2003 significantly higher than the summer of 2004 (Figure 57 and Appendix B, Table B-49). Sample concentrations collected in mainstem Little White River were statistically similar (p=0.1910) to samples collected in the tributaries to the Little White River (Figure 58). All nitrate-nitrite concentrations collected during the assessment and WQM sample data were well below the beneficial use-based water quality standard for nitrate ($\geq$ 88 mg/L). The maximum nitrate-nitrite concentration recorded in the Little White River watershed Mellette County (1.1 mg/L) was collected in May 2004 in the North Branch of Pine Creek (Appendix D, Table D-1).

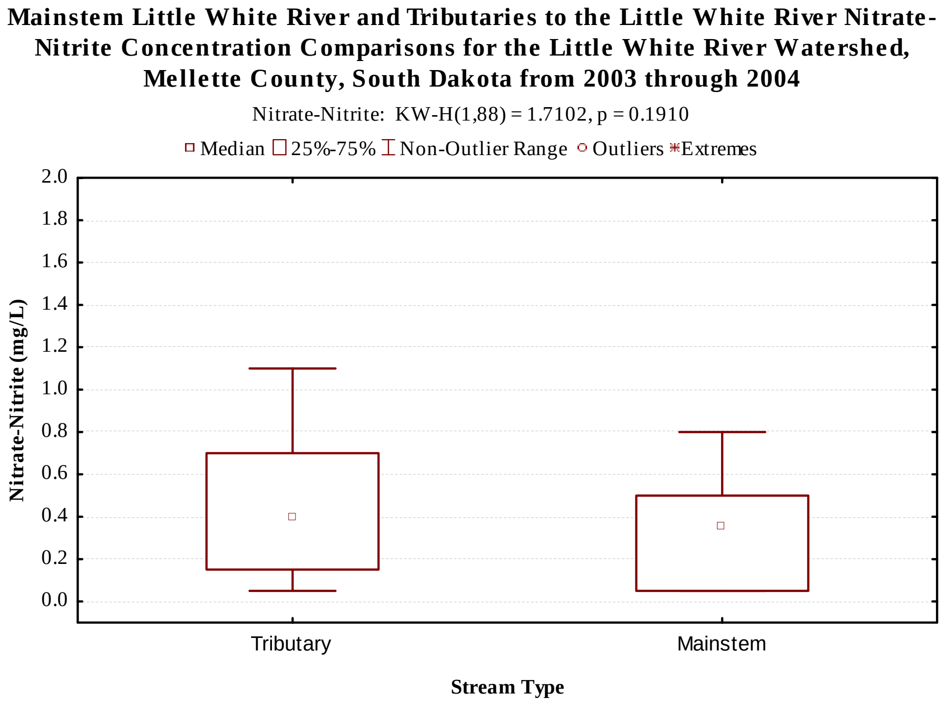


Figure 58. Nitrate-nitrite concentration comparison by tributary type (mainstem Little White River and tributaries to the Little White River) for the Little White River, Mellette County, South Dakota from 2003 through 2004.

Nitrate-nitrite loading by site was highest at site LWR-07 (25,242 kg) followed by LWR-04 (524 kg) in the Little White River (Table 30). Tributary nitrate-nitrite loading by season was highest in the spring of 2004 in the Little White River watershed (Figure 59). Mainstem monitoring sites below the hydroelectric power dam showed an overall load reduction. Load and concentration reduction in monitoring sites below the hydroelectric power dam suggest that nitrate-nitrite concentrations in the pond created by the power dam may be used by algae for growth and reproduction.

Table 30. Nitrate-nitrite loading per year by site for the Little White River watershed, and other monitored tributaries, Mellette County, South Dakota from 2003 through 2004.

Nitrate-Nitrite

Sub-watershed	Station	Sub-watershed Acreage (Acres)	Kilograms by Site (kg)	Export Coefficient (kg/acre)
Cut Meat Creek	LWR-01	108,769	241	0.002
Little White River (Todd County Line)	LWR-07	819,479	25,242	0.031
Horse Head Creek	LWR-02	42,965	0	0.000
Little White River (Highway 44 Bridge)	LWR-08	56,185	-511	-0.009
North Branch of Pine Creek	LWR-03	30,319	137	0.005
Lower Pine Creek	LWR-04	49,697	524	0.011
Little White River (Highway 83 Bridge)	LWR-05	7,545	-3,824	-0.507
Little White River (mouth of the Little White River)	LWR-06	48,218	-2,308	-0.048
Total nitrate-nitrite load to the White River		**1,163,177**	**19,501**	**0.017**

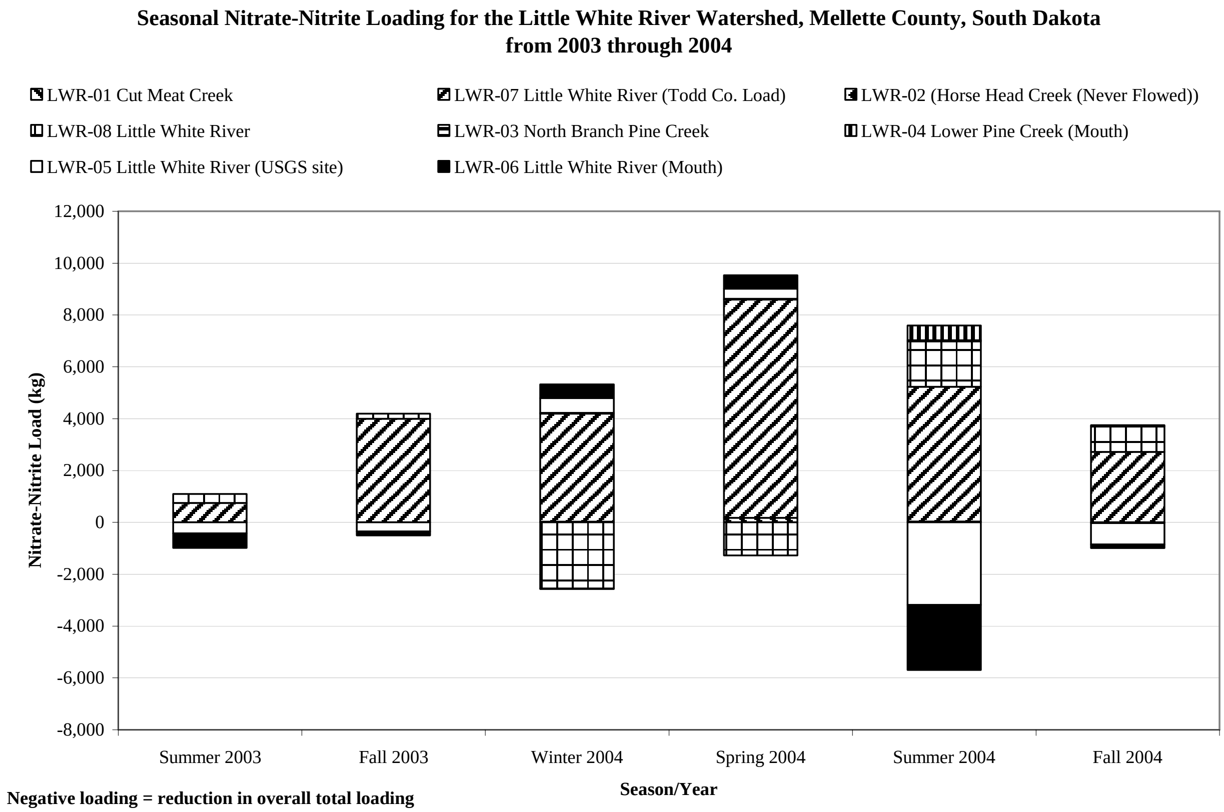


Figure 59. Seasonal nitrate-nitrite loading by tributary monitoring site in the Little White River watershed, Mellette County, South Dakota from 2003 through 2004.

Overall nitrate-nitrite loading between sampling sites was significantly different (p=0.0000) with nitrate-nitrite loading at Todd/Mellette County line significantly higher than most monitoring sites in Mellette County with the exclusion of LWR-3 on Pine Creek (Table 5 and Appendix B, Table B-28). Sub-watershed export coefficients (kilograms/acre) were highest in the LWR-07 sub-watershed (0.031 kg/acre). USGS, WQM and assessment data indicate that nitrate-nitrite is not a concern in the Little White River watershed.

Total Kjeldahl Nitrogen

Total Kjeldahl Nitrogen (TKN) is organic nitrogen including ammonia. Sources of TKN can include live organic matter, release from dead or decaying organic matter, septic systems or agricultural waste.

Median TKN concentration in the Little White River watershed in Mellette County was 1.20 mg/L (average 1.71 mg/L) and had a maximum concentration of 8.3 mg/L recorded at LWR-06 on August 16, 2004 during a peak flow event (Figure 52 and Figure 60). The minimum TKN concentration (0.06 mg/L) was collected from two mainstem monitoring sites (LWR-06 and LWR-07) on September 24, 2003 and two monitoring sites (LWR-03 and LWR-06) on March 10 and March 24, 2004, respectively (Appendix D, Table D-1).

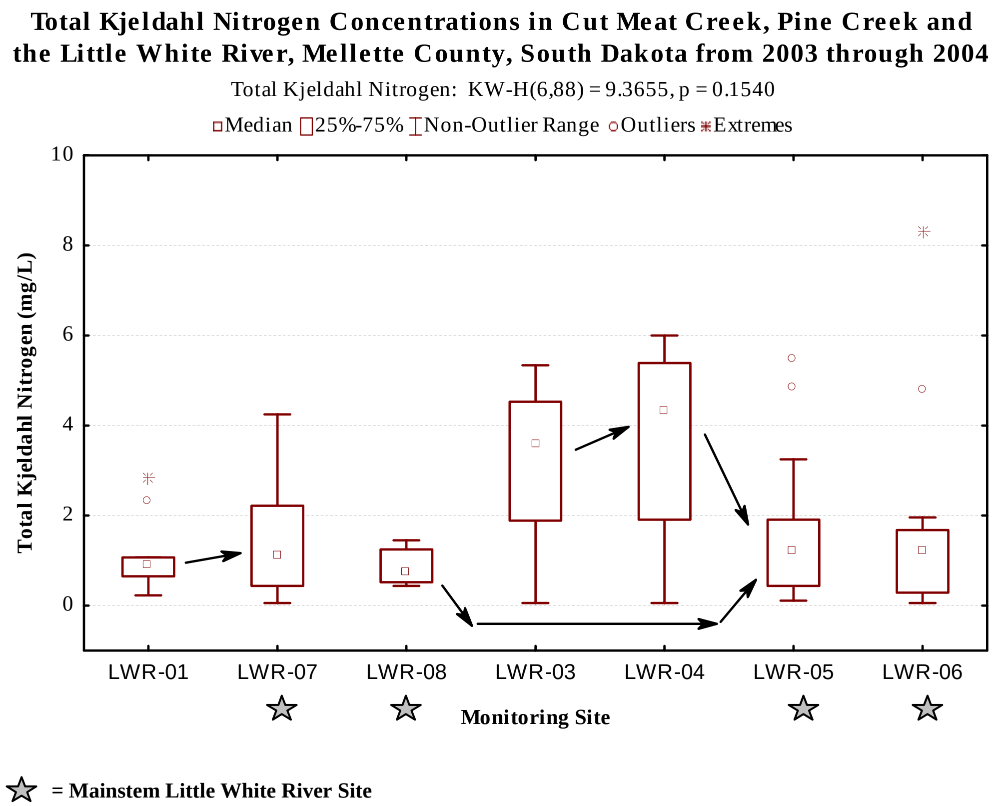


Figure 60. Total Kjeldahl Nitrogen concentrations by tributary monitoring site in the Little White River watershed, Mellette County, South Dakota from 2003 through 2004.

Site by site comparison of TKN concentrations indicate that median concentrations in the mainstem of the Little White River watershed, Mellette County and the Cut Meat Creek tributary generally ranged from one to two milligrams per liter; while median TKN concentrations in Pine Creek were between 3.5 and 4.5 mg/L (Figure 60). However, TKN concentrations were statistically similar (p=0.1540) between monitoring sites (Figure 60 and Table 5).

TKN concentrations were significantly different between sampling seasons (p=0.0000) with concentrations collected in the spring of 2004 and summer of 2004 significantly higher than the fall of 2003 and the winter of 2004; while TKN samples collected in the summer of 2004 were also higher than samples collected in the summer of 2003 (Figure 61). TKN concentrations collected at tributary monitoring sites (Cut Meat and Pine Creeks) were statistically higher (p=0.0366) than concentrations collected from mainstem Little White River (Figure 62).

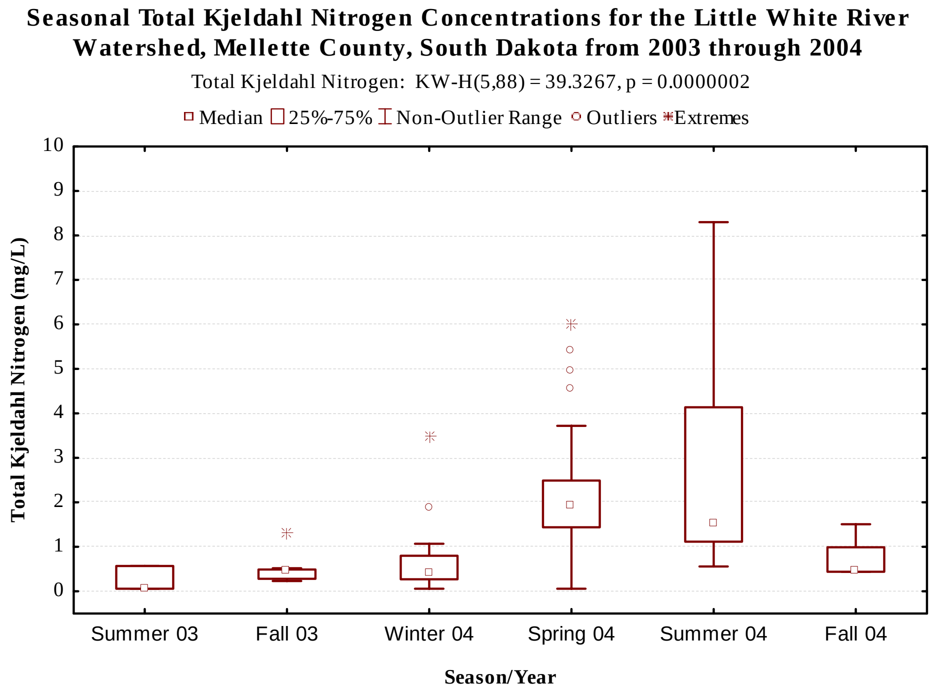


Figure 61. Monthly Total Kjeldahl Nitrogen concentrations by season for the Little White River watershed, Mellette County, South Dakota from 2003 through 2004.

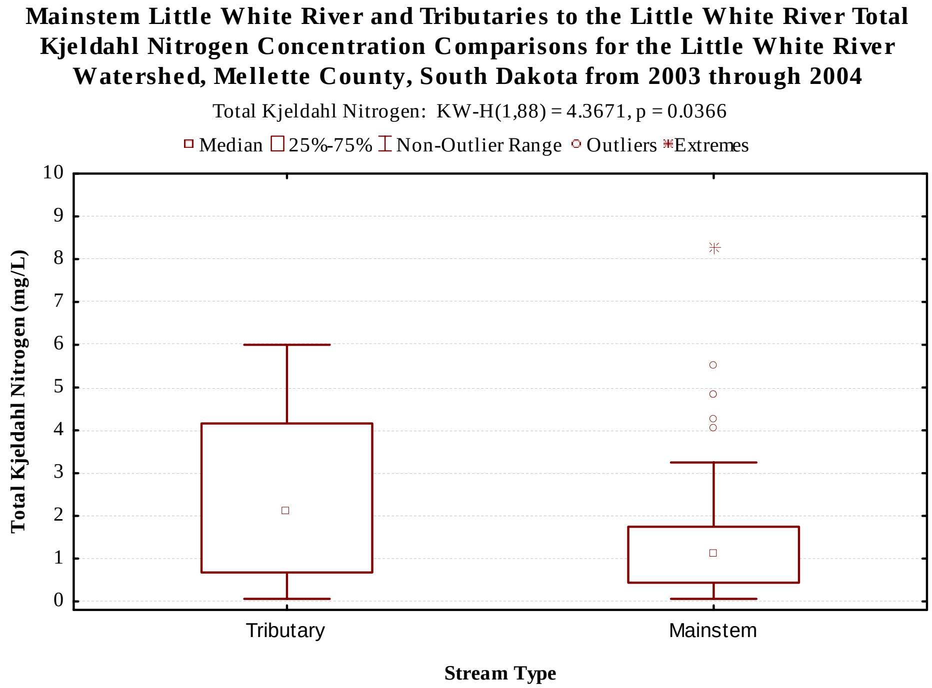


Figure 62. Total Kjeldahl Nitrogen concentration comparison by tributary type (mainstem Little White River and tributaries to the Little White River) for the Little White River, Mellette County, South Dakota from 2003 through 2004.

Table 31. Total Kjeldahl Nitrogen loading per year by site for the Little White River watershed and other monitored tributaries, Mellette County, South Dakota from 2003 through 2004.

Total Kjeldahl Nitrogen

Sub-watershed	Station	Sub-watershed Acreage (Acres)	Kilograms by Site (kg)	Export Coefficient (kg/acre)
Cut Meat Creek	LWR-01	108,769	1,185	0.01
Little White River (Todd County Line)	LWR-07	819,479	114,143	0.14
Horse Head Creek	LWR-02	42,965	0	0.00
Little White River (Highway 44 Bridge)	LWR-08	56,185	-57,419	-1.02
North Branch of Pine Creek	LWR-03	30,319	540	0.02
Lower Pine Creek	LWR-04	49,697	7,689	0.15
Little White River (Highway 83 Bridge)	LWR-05	7,545	35,620	4.72
Little White River (mouth of the Little White River)	LWR-06	48,218	36,828	0.76
Total Kjeldahl Nitrogen load to the White River		**1,163,177**	**138,585**	**0.12**

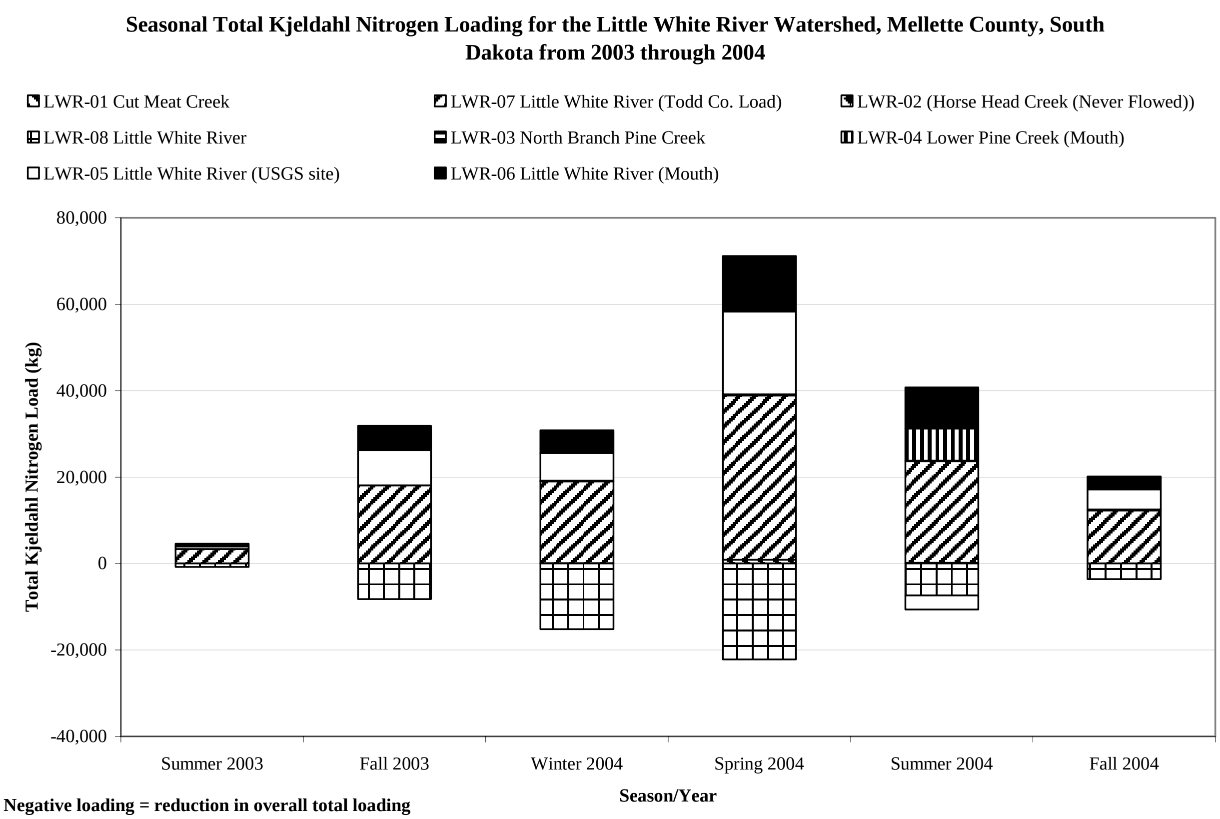


Figure 63. Seasonal Total Kjeldahl Nitrogen loading by tributary monitoring site in the Little White River watershed, Mellette County, South Dakota from 2003 through 2004.

TKN loading by site was highest at LWR-07 (114,143 kg) comprising 82.4 percent of the TKN load in the Little White River (Table 31). Tributary TKN loading by season was highest in the summer of 2004 from LWR-07 located at the Mellette/Todd County line (Figure 63). Overall TKN loading between sampling sites was significantly different (p=0.0000) during the project (Figure 64, Table 5 and Appendix B, Table B-29). Initial loading entering Mellette County (LWR-07) was significantly higher than Cut Meat, Pine Creek and LWR-08 above the hydroelectric dam (Appendix B, Table B-29). Sub-watershed export coefficients (kilograms/acre) were highest in the LWR-05 sub-watershed below the hydroelectric dam (4.72 kg/acre) followed by the LWR-06 sub-watershed (mouth of the Little White River) with 0.76 kg/acre (Table 31).

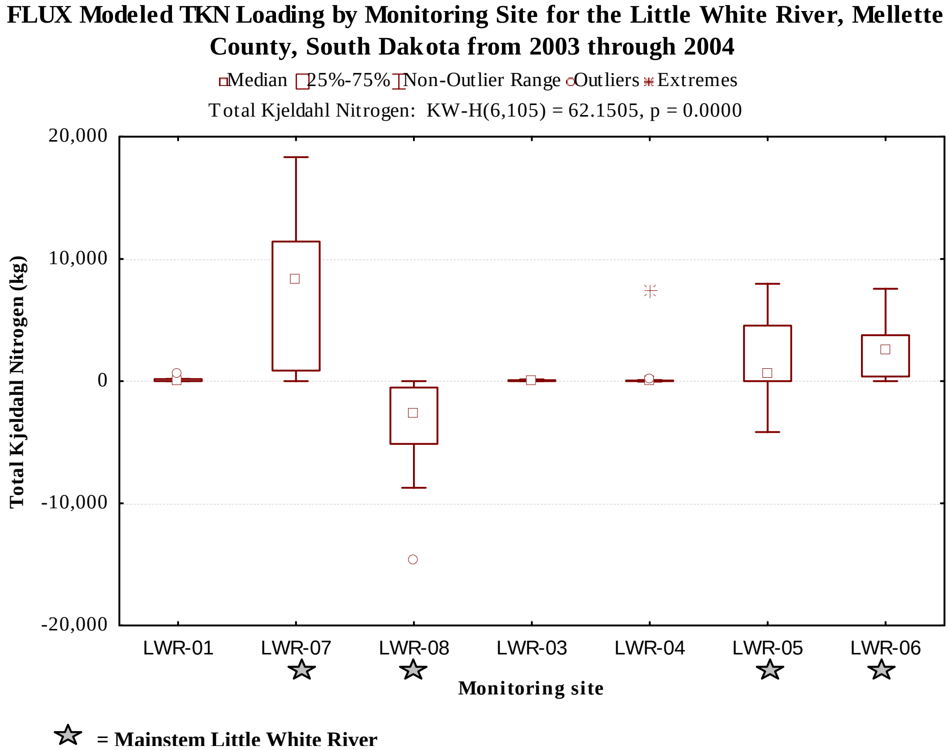


Figure 64 FLUX modeled TKN loading by monitoring site for the Little White River, Mellette County, South Dakota based on 2003 through 2004 hydrology and water quality data.

One sub-watershed in the Little White River (LWR-08) had overall load reductions in TKN during the project period (Table 31, Figure 63 and Figure 64). This was attributed to the hydroelectric dam immediately downstream of the monitoring site. TKN load reductions may have been caused from settling, deposition or biological conversion of TKN into ammonia for plant growth. Loading at all other mainstem monitoring sites on the Little White River had positive loading except at LWR-05 where load reductions were recorded during the summer of 2004 (Figure 63 and Figure 64). Based on USGS, WQM and assessment data, TKN is not a concern in the Little White River watershed.

Organic Nitrogen

Organic nitrogen is calculated using TKN and ammonia (TKN minus ammonia). Organic nitrogen is broken down to more usable ammonia and other forms of inorganic nitrogen by bacteria. Since organic nitrogen is calculated using TKN and ammonia concentrations were relatively low, organic nitrogen graphs and loading tables are similar to those for TKN.

The median organic nitrogen concentration in the Little White River watershed was 1.14 mg/L (average 1.68 mg/L). The maximum concentration of 7.99 mg/L was recorded at LWR-06 on August 16, 2004 during a runoff event (Figure 65). Ammonia concentrations at LWR-06 also violated water quality standards on this date (Table 14). Minimum organic nitrogen concentration (0.03 mg/L) was collected at LWR-03 (North Branch of Pine Creek) on March 10, 2004 (Appendix D, Table D-1). Site by site comparison of organic nitrogen concentrations indicate that median concentrations in mainstem Little White River generally ranged around one milligram per liter (0.70 to 1.18 mg/L), while the Pine Creek tributaries (LWR-03 and LWR-04) hovered around four milligram per liter (3.58 to 4.33 mg/L). Despite increased organic nitrogen concentrations in Pine Creek, overall organic nitrogen concentrations were not significantly different (p=0.1713) between monitoring sites (Figure 65 and Table 5).

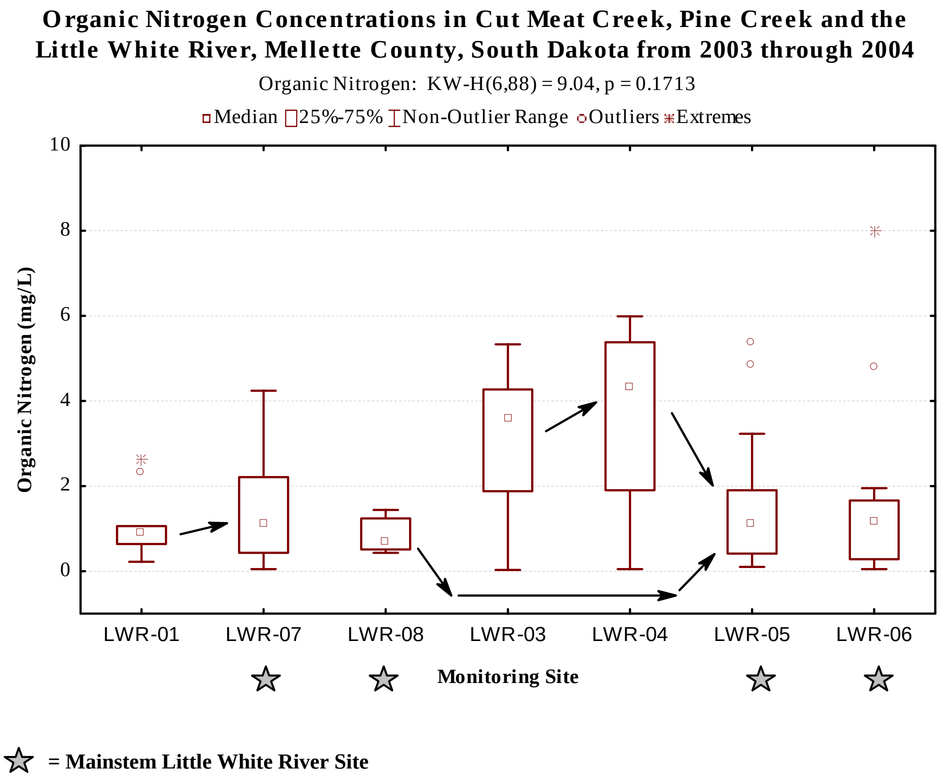


Figure 65. Organic nitrogen concentrations by tributary monitoring site in the Little White River watershed, Mellette County, South Dakota from 2003 through 2004.

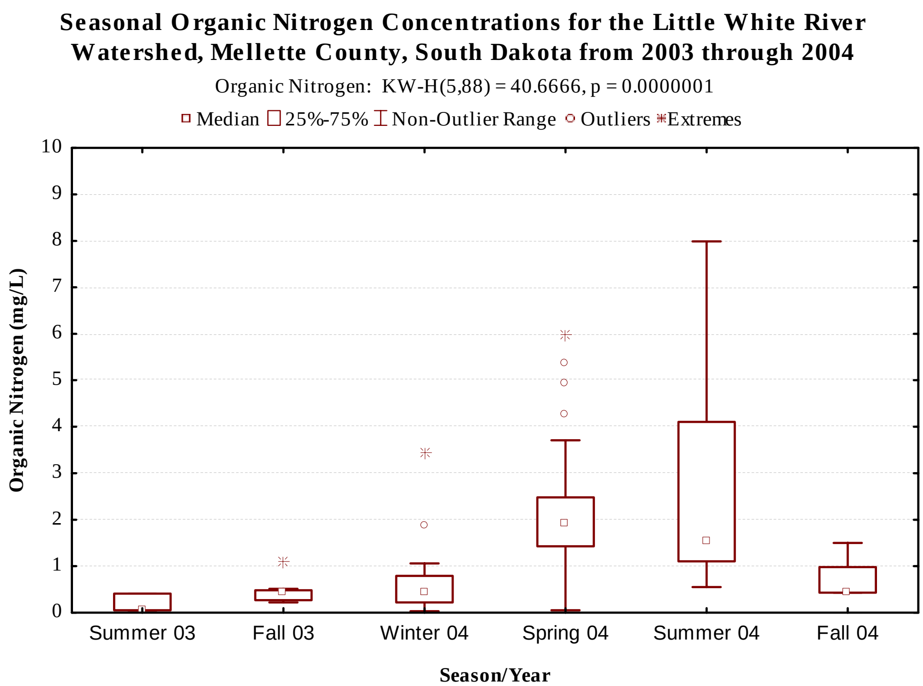


Figure 66. Seasonal organic nitrogen concentrations for the Little White River watershed, Mellette County, South Dakota from 2003 through 2004.

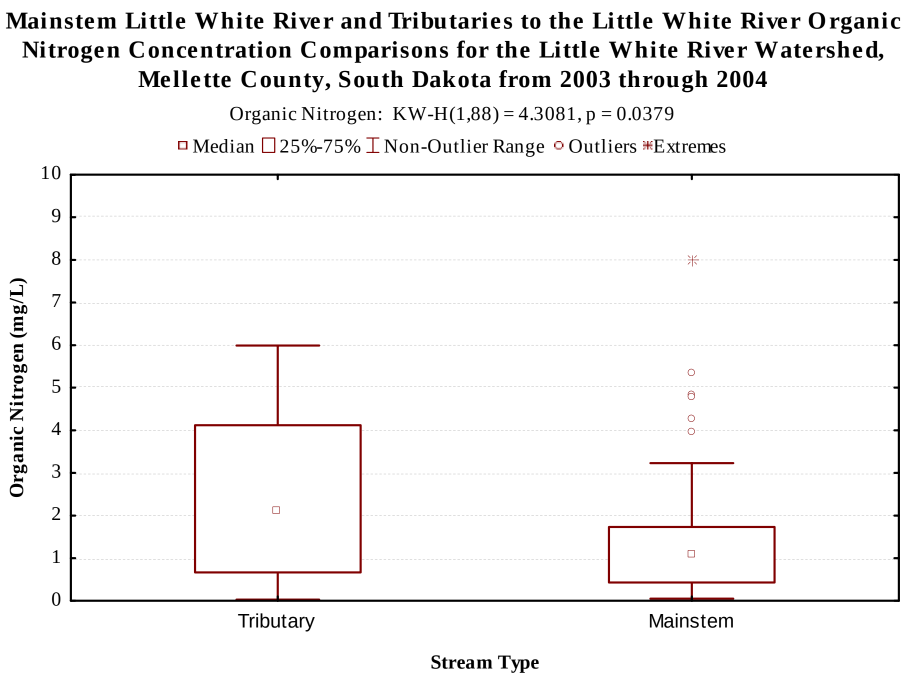


Figure 67. Organic nitrogen concentration comparison by tributary type (mainstem Little White River and tributaries to the Little White River) for the Little White River, Mellette County, South Dakota from 2003 through 2004.

Organic nitrogen concentrations were significantly different between sampling seasons in the Little White River watershed (p=0.0000) with concentrations collected in the spring and summer of 2004 significantly higher than the summer and fall of 2003 and the winter of 2004 (Figure 66 and Appendix B, Table B-51). During this assessment, organic nitrogen concentrations in tributaries to the Little White River were statistically higher (p=0.0379) than concentrations in mainstem Little White River (Figure 67).

Table 32. Organic nitrogen loading per year by site for the Little White River and other monitored tributaries, Mellette County, South Dakota from 2003 through 2004.

Organic Nitrogen

Sub-watershed	Station	Sub-watershed Acreage (Acres)	Kilograms by Site (kg)	Export Coefficient (kg/acre)
Cut Meat Creek	LWR-01	108,769	1,129	0.010
Little White River (Todd County Line)	LWR-07	819,479	57,761	0.070
Horse Head Creek	LWR-02	42,965	0	0.000
Little White River (Highway 44 Bridge)	LWR-08	56,185	23,675	0.421
North Branch of Pine Creek	LWR-03	30,319	523	0.017
Lower Pine Creek	LWR-04	49,697	7,687	0.155
Little White River (Highway 83 Bridge)	LWR-05	7,545	9,267	1.228
Little White River (mouth of the Little White River)	LWR-06	48,218	36,333	0.754
Total organic nitrogen load to the White River		**1,163,177**	**136,374**	**0.117**

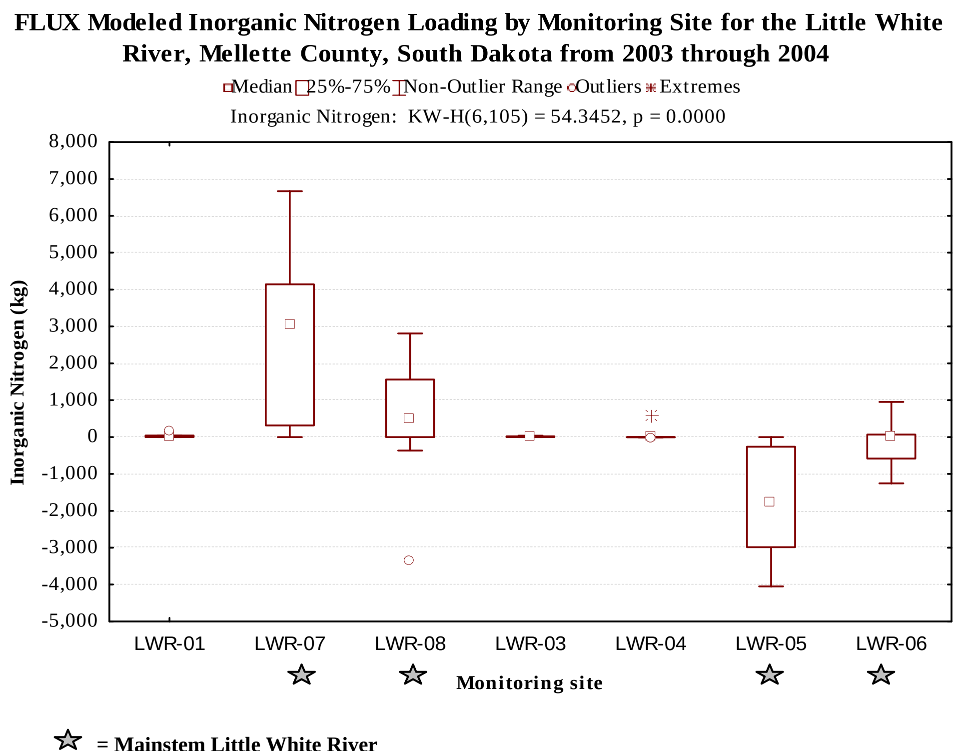


Figure 68. FLUX modeled TKN loading by monitoring site for the Little White River, Mellette County, South Dakota based on 2003 through 2004 hydrology and water quality data.

Organic nitrogen loading by site was highest at site LWR-07 (57,761 kg) comprising 42.4 percent of the organic nitrogen load in the Little White River watershed (Table 32). Overall organic nitrogen loading between sampling sites was significantly different (p=0.0000) between monitoring sites during 2003 and 2004 (Appendix B, Table B-30 and Table 5). Organic nitrogen loading at LWR-07 (Todd/Mellette County line) was significantly higher than Cut Meat Creek and Pine Creek monitoring sites (LWR-01, LWR-03 and LWR-04, respectively); while loadings at LWR-04 were also significantly lower than LWR-06 (Figure 68 and Appendix B, Table B-30). Sub-watershed export coefficients (kilograms/acre) were highest in the LWR-05 sub-watershed below the town of White River, South Dakota (1.23 kg/acre) followed by LWR-06 (0.75 kg/acre) near the mouth of the Little White River (Table 32).

Unlike TKN, loading at LWR-08 (the Little White River above the hydroelectric dam) had overall positive loadings during the project period (Table 32, Figure 64 and Figure 68). Load reductions were observed twice during the project once in the winter of 2004 at LWR-08 and once in the summer of 2004 at LWR-05 (Figure 69). Based on USGS, WQM and assessment data, organic nitrogen is not a concern in the Little White River watershed.

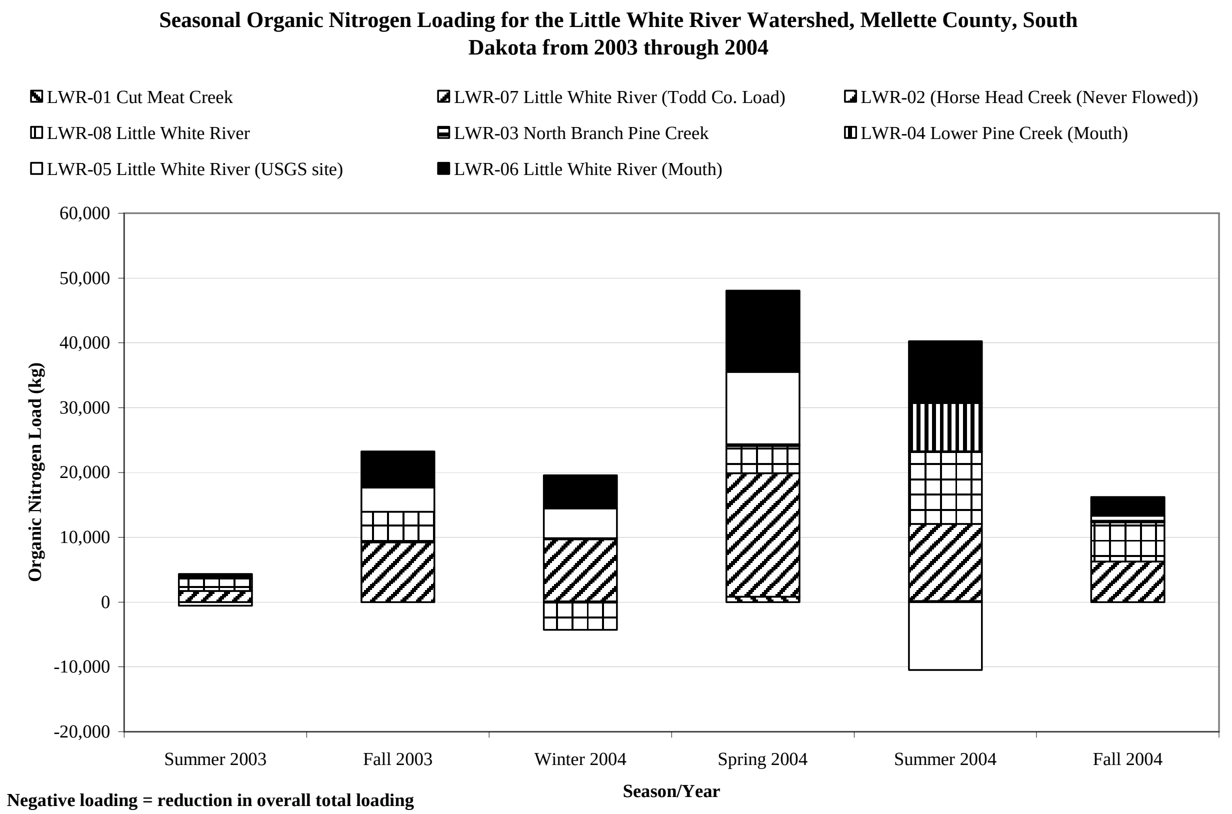


Figure 69. Seasonal organic nitrogen loading by tributary monitoring site in the Little White River watershed, Mellette County, South Dakota from 2003 through 2004.

Inorganic Nitrogen

Inorganic nitrogen is calculated by summing ammonia and nitrate-nitrite concentrations. Inorganic nitrogen is readily assimilated by plants for growth and reproduction.

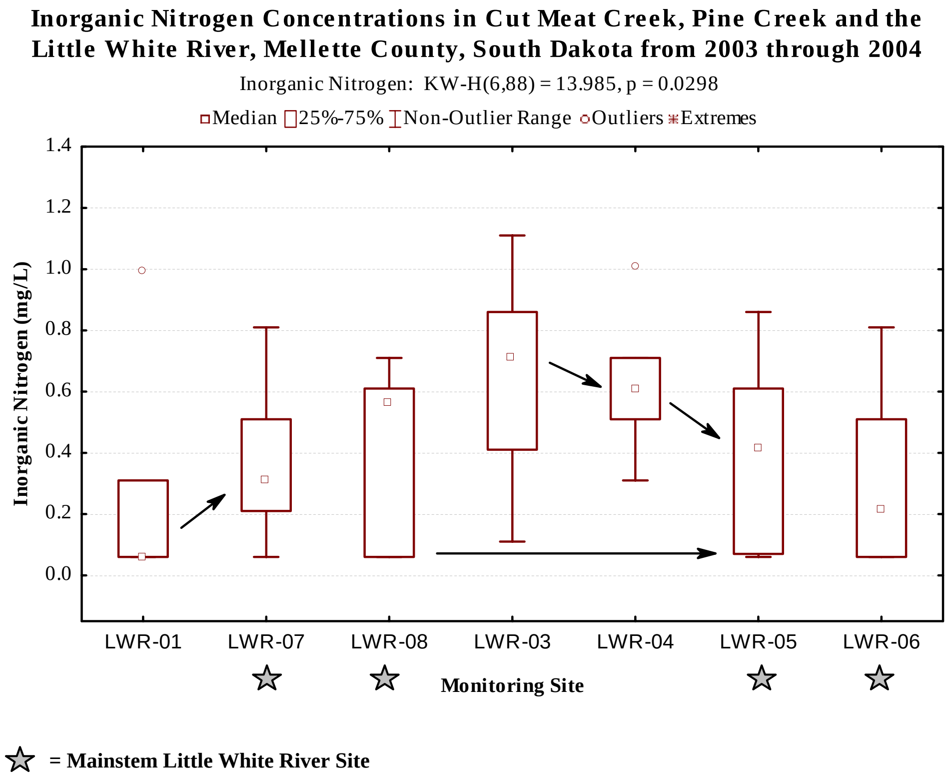


Figure 70. Inorganic nitrogen concentrations by tributary monitoring site in the Little White River watershed, Mellette County, South Dakota from 2003 through 2004.

The median inorganic nitrogen concentration in the Little White River watershed was 0.41 mg/L (average 0.41 mg/L). The maximum concentration of 1.11 mg/L was recorded at LWR-03 (North Branch of Pine Creek) on May 13, 2004 during low flow conditions (Figure 70 and Appendix D, Table D-1). The minimum inorganic nitrogen concentration of 0.06 mg/L was collected from a variety of sampling sites throughout the watershed (LWR-01, LWR-05, LWR-06, LWR-07 and LWR-08) in 2003 and 2004 (Appendix D, Table D-1). Inorganic nitrogen concentrations were significantly different (p=0.0298) between monitoring sites (Figure 70 and Table 5). Site by site comparison of inorganic nitrogen concentrations indicated that median concentrations in Cut Meat Creek (median 0.06 mg/L) were significantly lower (p=0.0487) than inorganic concentrations in the North Branch Pine Creek, LWR-03 (Figure 70 and Appendix B, Table B-17). The inorganic nitrogen graph (Figure 70) was similar to Figure 56 (nitrate-nitrite graph) because nitrate-nitrite make up from 71.4 to 99.1 percent of the inorganic nitrogen total.

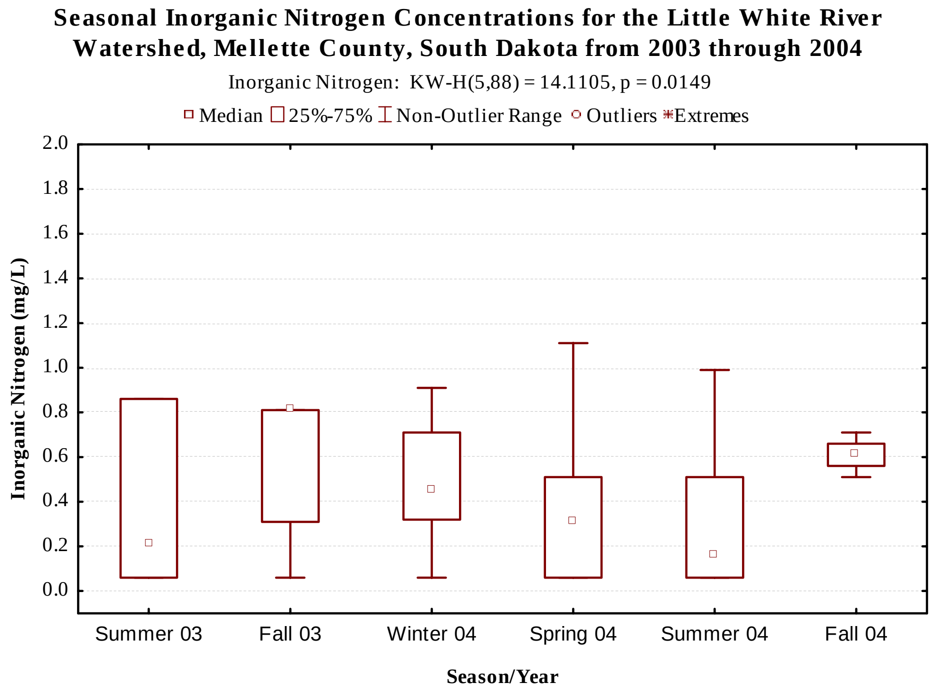


Figure 71. Seasonal inorganic nitrogen concentrations for the Little White River watershed, Mellette County, South Dakota from 2003 through 2004.

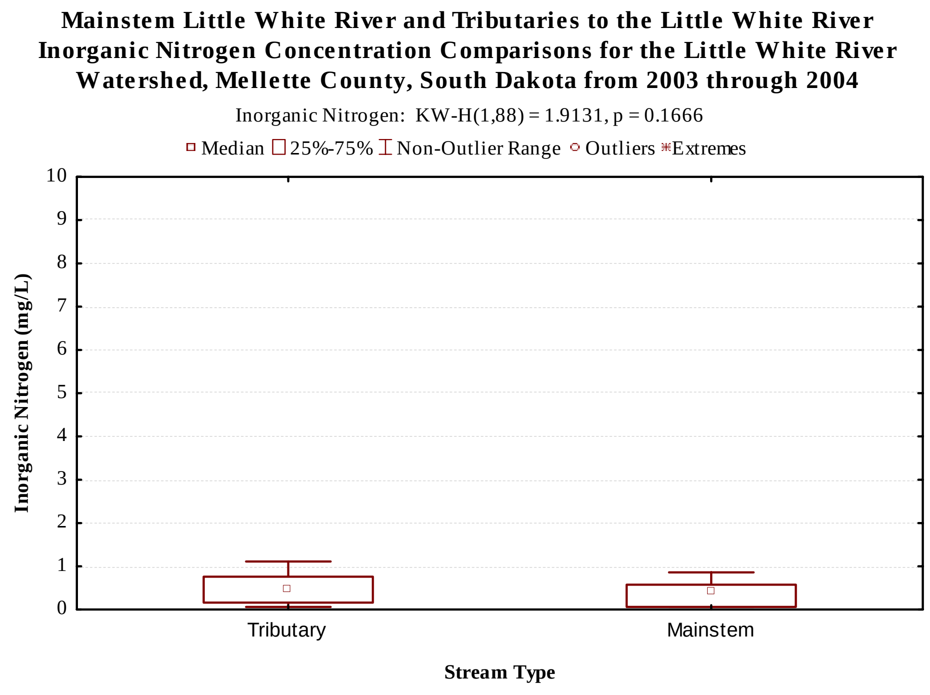


Figure 72. Inorganic nitrogen concentration comparison by tributary type (mainstem Little White River and tributaries to the Little White River) for the Little White River, Mellette County, South Dakota from 2003 through 2004.

Table 33. Inorganic nitrogen loading per year by site for the Little White River and other monitored tributaries, Mellette County, South Dakota from 2003 through 2004.

Inorganic Nitrogen

Sub-watershed	Station	Sub-watershed Acreage (Acres)	Kilograms by Site (kg)	Export Coefficient (kg/acre)
Cut Meat Creek	LWR-01	108,769	289	0.003
Little White River (Todd County Line)	LWR-07	819,479	41,563	0.051
Horse Head Creek	LWR-02	42,965	0	0.000
Little White River (Highway 44 Bridge)	LWR-08	56,185	8,360	0.149
North Branch of Pine Creek	LWR-03	30,319	156	0.005
Lower Pine Creek	LWR-04	49,697	524	0.011
Little White River (Highway 83 Bridge)	LWR-05	7,545	-27,378	-3.629
Little White River (mouth of the Little White River)	LWR-06	48,218	-1,778	-0.037
Total inorganic nitrogen load to the White River		**1,163,177**	**21,737**	**0.019**

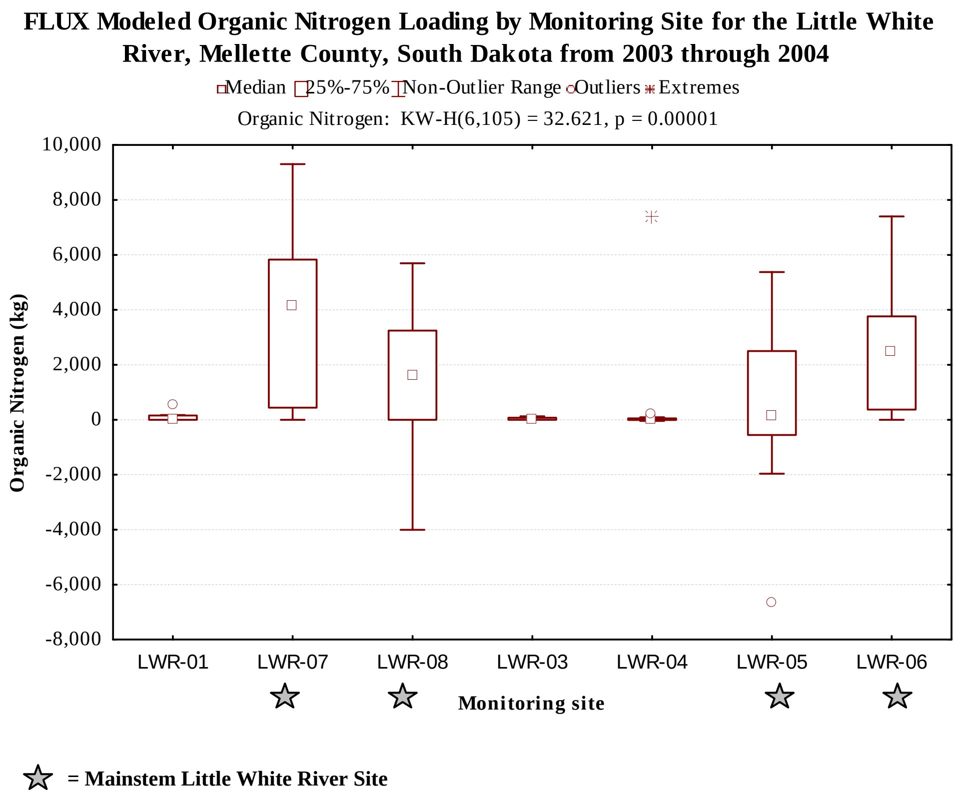


Figure 73. FLUX Modeled inorganic nitrogen loading by monitoring site for the Little White River watershed, Mellette County, South Dakota from 2003 through 2004.

Inorganic nitrogen concentrations in the Little White River were significantly different between sampling seasons (p=0.0149) with concentrations collected in the fall of 2003 significantly higher than the summer of 2004 (Figure 71 and Appendix B, Table B-52). Similar to nitrate-nitrite concentrations, mainstem Little White River inorganic nitrogen concentrations were statistically similar (p=0.1666) to concentrations in upland tributaries to the Little White River (Figure 72).

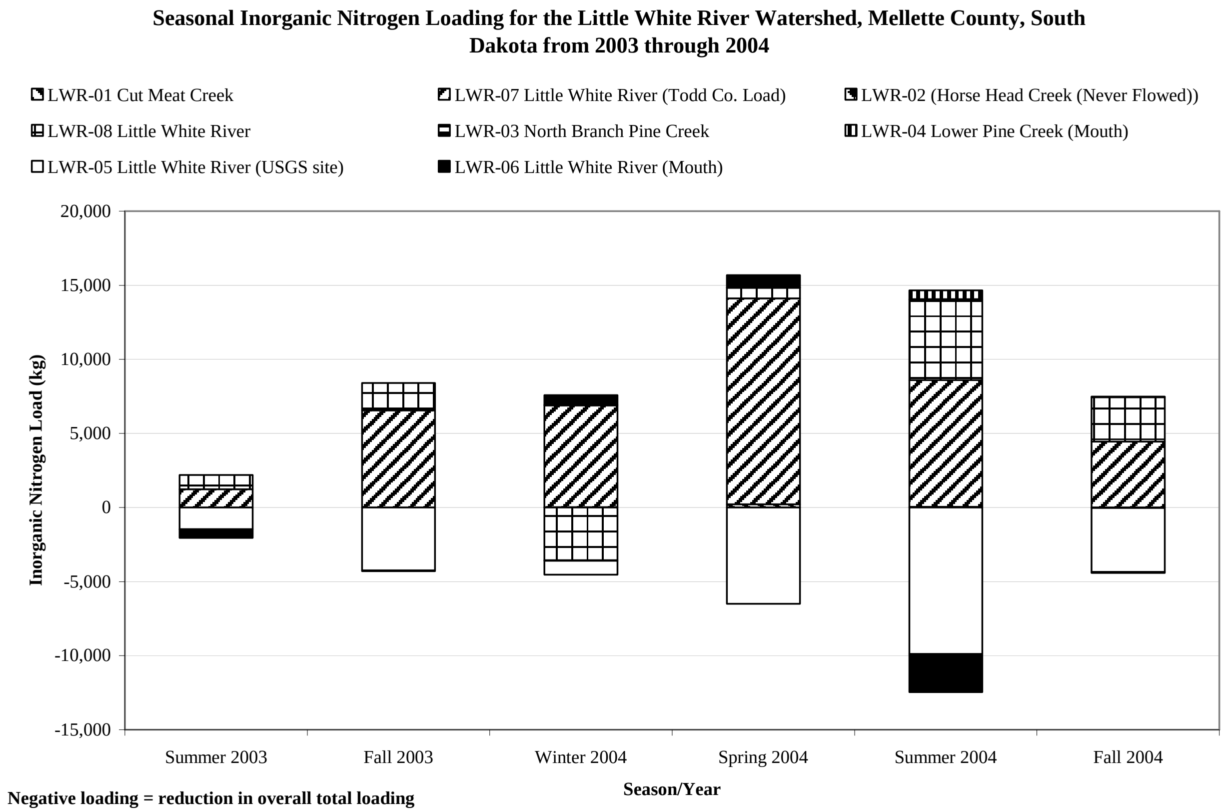


Figure 74. Seasonal inorganic nitrogen loading by tributary monitoring site in the Little White River watershed, Mellette County, South Dakota from 2003 through 2004.

Inorganic nitrogen loading by site was highest at site LWR-07 with 41,563 kg (Table 33). Tributary inorganic nitrogen loading by season was highest in the spring of 2004 in the Little White River watersheds (Figure 74). Overall inorganic nitrogen loading between sampling sites was significantly different (p=0.0000) with concentrations at LWR-07 significantly higher than LWR-01, LWR-04, LWR-05 and LWR-06 (Figure 73 and Appendix B, Table B-31). Loading in sub-watersheds LWR-01, LWR-03 and LWR-08 were significantly higher than the load reduction observed in LWR-05 (Figure 73). Sub-watershed export coefficients (kilograms/acre) were highest in the LWR-08 sub-watershed (0.149 kg/acre) followed by LWR-07 (mainstem Little White River) at 0.051 kg/acre (Table 33).

Similar to nitrate-nitrite loading, three sub-watersheds in the Little White River showed seasonal reductions in overall inorganic nitrogen loading during the project period, LWR-05, LWR-06 and LWR-08 (Figure 73 and Figure 74). All three seasonal load reductions occurred in sub-watersheds on the Little White River. Based on available data (USGS, WQM and assessment data), inorganic nitrogen is not a problem in the Little White River watershed.

Total Nitrogen

Total nitrogen is the sum of nitrate-nitrite and TKN concentrations. Total nitrogen is used mostly in determining the limiting nutrient (nitrogen or phosphorus) for biological growth and will be discussed later in this section of report (page 118).

The median total nitrogen concentration for the project was 1.33 mg/L (average 2.09 mg/L) with a standard deviation of 1.72 mg/L. The maximum total nitrogen concentration observed in the Little White River watershed was 8.50 mg/L at LWR-06 on August 16, 2004 (Figure 75 and Appendix D, Table D-1). The minimum total nitrogen concentration (0.11 mg/L) was recorded at LWR-06 on September 24, 2003. The organic nitrogen fraction (percent of organic nitrogen in total nitrogen (concentrations)) ranged from 8.3 percent to 98.8 percent and averaged 69.7 percent, while the inorganic nitrogen fraction ranged from 1.2 percent to 91.7 percent and averaged 30.3 percent.

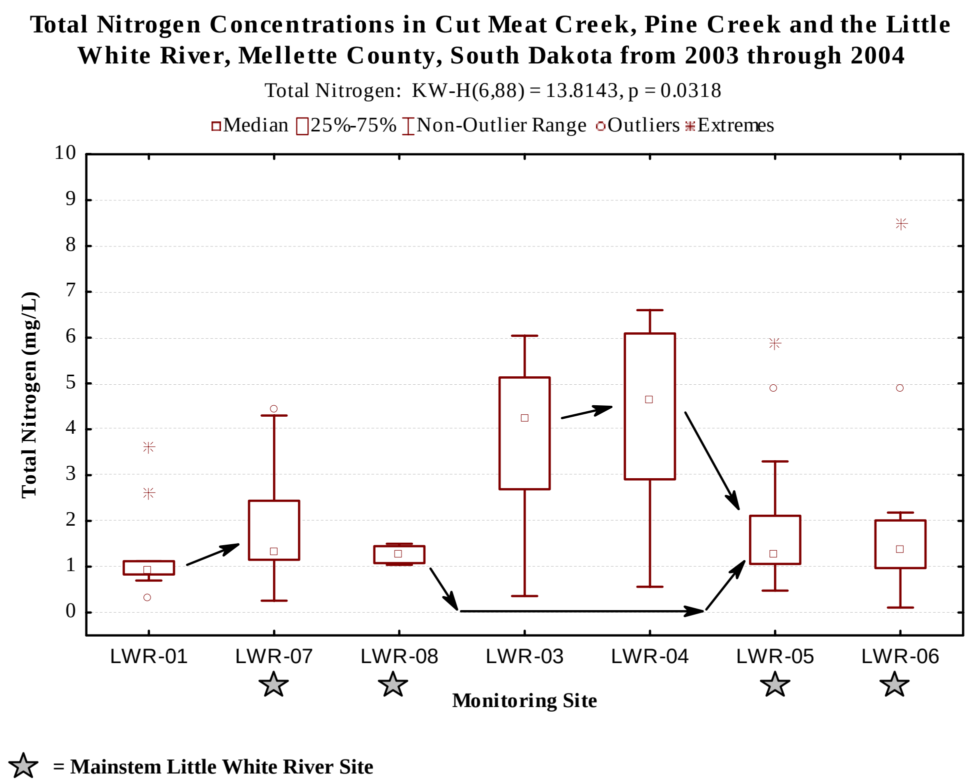


Figure 75. Total nitrogen concentrations by tributary monitoring site in the Little White River watershed, Mellette County, South Dakota from 2003 through 2004.

Total nitrogen concentrations were significantly different between monitoring sites (Figure 75 and Table 5); however, not significant enough (p=0.0318) for detecting differences using mean separation procedures (Appendix B, Table B-18).

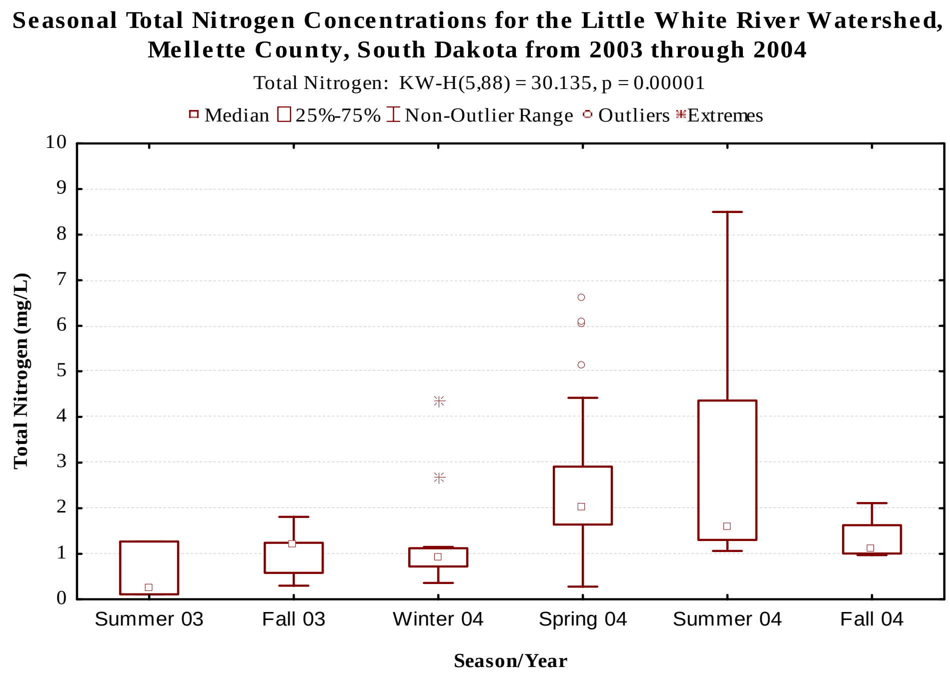


Figure 76. Seasonal total nitrogen concentrations for the Little White River watershed, Mellette County, South Dakota from 2003 through 2004.

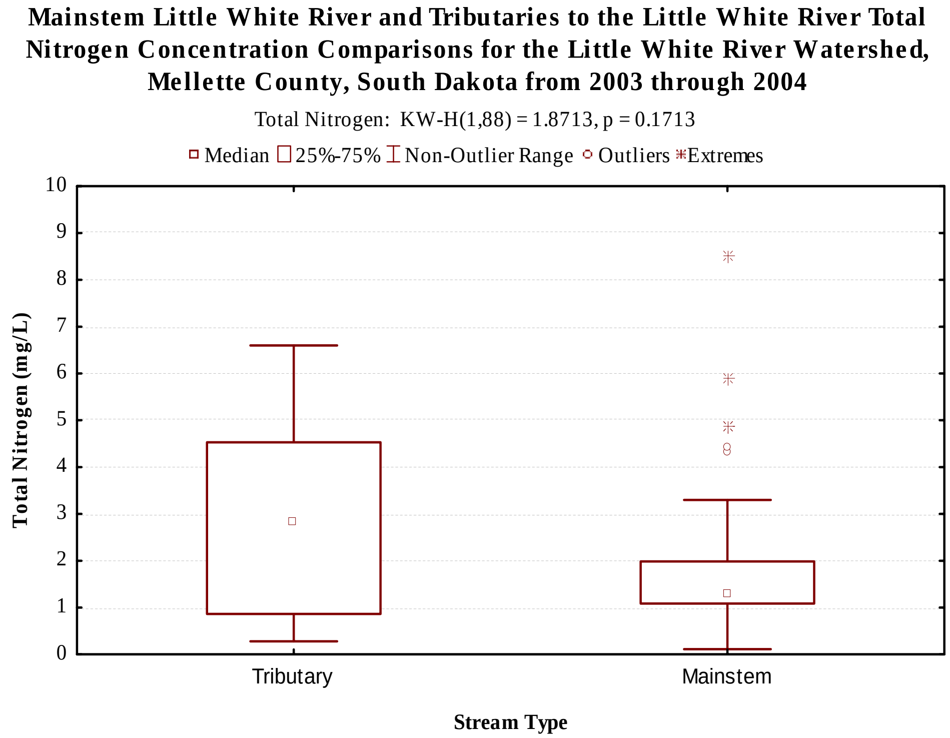


Figure 77. Total nitrogen concentration comparison by tributary type (mainstem Little White River and tributaries to the Little White River) for the Little White River, Mellette County, South Dakota from 2003 through 2004.

Seasonally, average total nitrogen concentrations were higher in the spring of 2004 (Table 18 and Figure 76). Total nitrogen concentrations were significantly different between sampling seasons (p=0.0000) with concentrations collected in the spring of 2004 significantly higher than the winter of 2004 and samples collected during the summer of 2004 were significantly higher than the fall of 2003 and the winter of 2004 (Figure 76 and Appendix B, Table B-53). Mainstem Little White River total nitrogen concentrations were statistically similar (p=0.1713) to tributaries to the Little White River (Figure 77).

Total nitrogen loading by site was highest at site LWR-07 (99,289 kg) comprising 62.8 percent of the total nitrogen load in the Little White River (Table 34). Sub-watershed export coefficients (kilograms/acre) were highest in the LWR-06 sub-watershed (0.72 kg/acre) followed by LWR-08 at 0.56 kg/acre (Table 34).

Table 34. Total nitrogen loading per year by site for the Little White River and other monitored tributaries, Mellette County, South Dakota from 2003 through 2004.

Total Nitrogen

Sub-watershed	**Station**	**Sub-watershed Acreage (Acres)**	**Kilograms by Site (kg)**	**Export Coefficient (kg/acre)**
Cut Meat Creek	LWR-01	108,769	1,453	0.01
Little White River (Todd County Line)	LWR-07	819,479	99,289	0.12
Horse Head Creek	LWR-02	42,965	0	0.00
Little White River (Highway 44 Bridge)	LWR-08	56,185	31,406	0.56
North Branch of Pine Creek	LWR-03	30,319	679	0.02
Lower Pine Creek	LWR-04	49,697	8,167	0.16
Little White River (Highway 83 Bridge)	LWR-05	7,545	-17,473	-2.32
Little White River (mouth of the Little White River)	LWR-06	48,218	34,503	0.72
Total nitrogen load to the White River		**1,163,177**	**158,023**	**0.14**

One sub-watershed in the Little White River had overall load reductions in total nitrogen during the project period, LWR-05. Seasonal load reductions in total nitrogen were recorded at LWR-05 in the summer and fall 2004 and at LWR-08 in the winter of 2004 (Figure 78). Assessment data indicate total nitrogen is not a concern in the Little White River watershed in Mellette County.

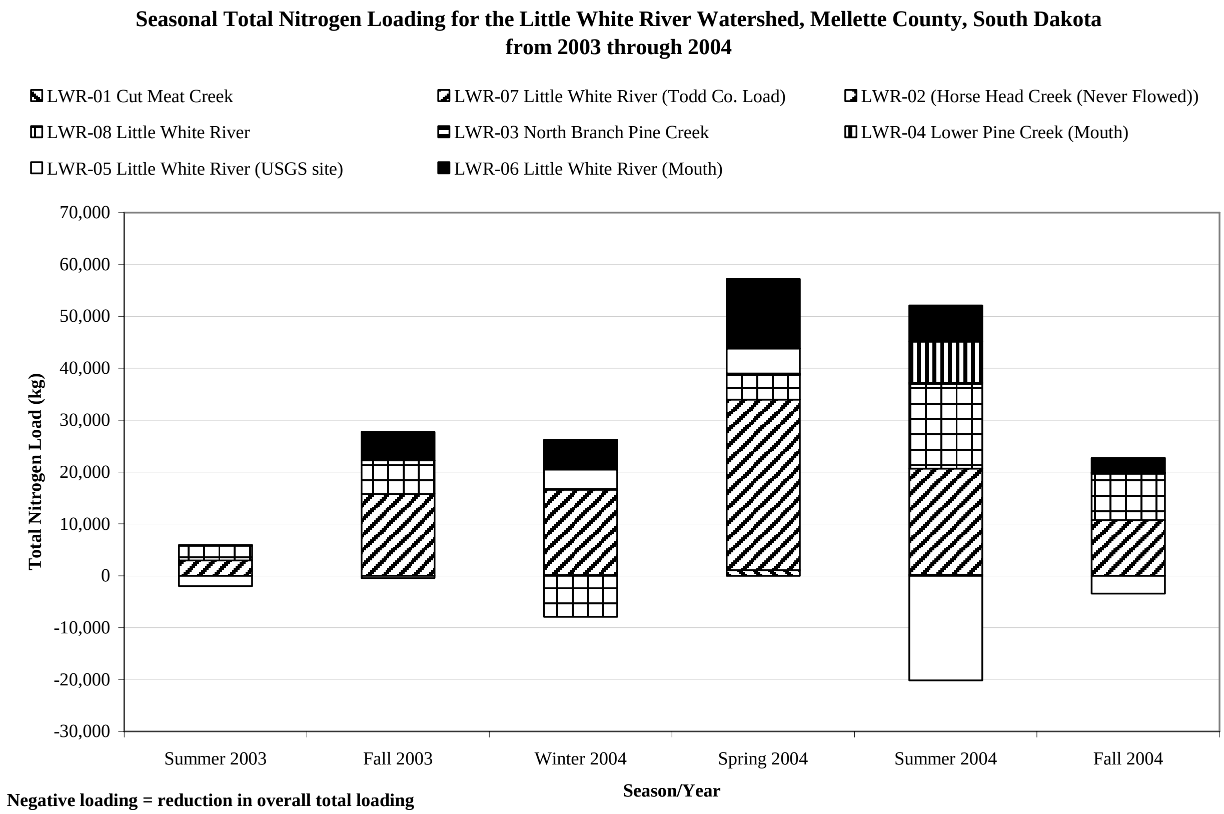


Figure 78. Seasonal total nitrogen loading by tributary monitoring site in the Little White River watershed, Mellette County, South Dakota from 2003 through 2004.

Total Phosphorus

Phosphorus differs from nitrogen in that it is not as water-soluble and will sorb on to sediments and other substrates. Once phosphorus sorbs on to any substrate, it is not readily available for uptake and utilization. Phosphorus sources in the Little White River watershed can be natural from geology and soil, from decaying organic matter, agricultural runoff or waste from septic tanks. Nutrients such as phosphorus and nitrogen tend to accumulate during low flows because they are associated with fine particles whose transport is dependent upon discharge (Allan, 1995). Sampling data from the Little White River confirms this hypothesis with a good relationship (overall r^2 = 0.71, r=0.84) between TSS and total phosphorus (Figure 79). These nutrients are also retained and released on stream banks and floodplains within the watershed. Phosphorus will remain in stream bottom sediments unless released by increased stage (water level), discharge or current. Re-suspending phosphorus and other nutrients associated with sediment into the water column (stream) should show increased concentrations during rain events (increased stage and flow). Reduced flows and discharge may deposit phosphorus and other nutrients associated with sediment on the stream banks and floodplains of the Little White River. Rain events increase flows and re-suspend sediment and phosphorus stored in the floodplain and stream banks. These concentrations combine with event-based concentrations to increase overall nutrient loading, producing peak concentrations of total phosphorus and total nitrogen in the Little White River.

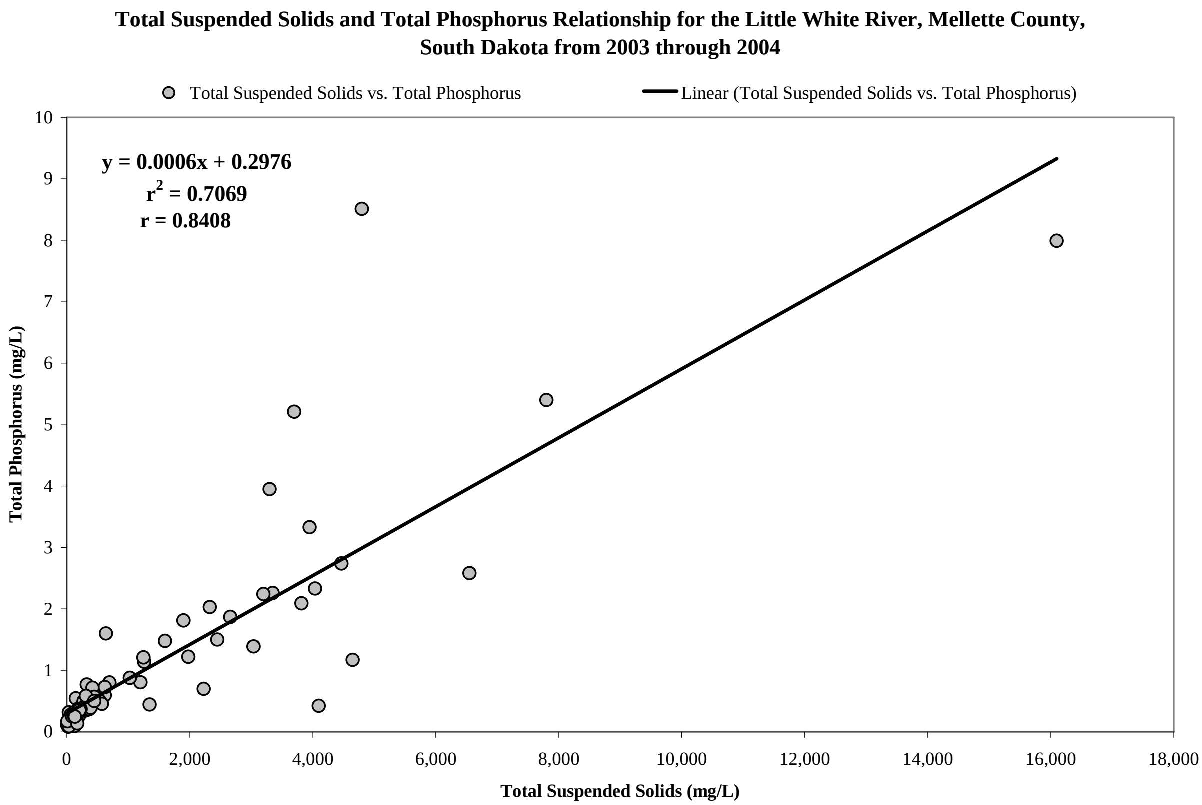


Figure 79. Relationship between total suspended solids and total phosphorus for the Little White River, Mellette County, South Dakota from 2003 through 2004.

Total phosphorus concentrations and loading from Cut Meat Creek, Pine Creek and the Little White River affect concentrations in the White River and effectively in-lake total phosphorus concentrations in Lake Francis Case. Increased in-lake total phosphorus concentrations increase the Trophic State Index (TSI) and eutrophication processes shifting the total nitrogen to total phosphorus ratio from phosphorus-limited (ideal) to nitrogen-limited (excess phosphorus) that may cause algal blooms.

The median total phosphorus concentration for the Little White River was 0.433 mg/L (average 1.01 mg/L) during the project. The maximum concentration of total phosphorus was 8.51 mg/L collected on July 22, 2004 at LWR-03 (North Branch of Pine Creek) and a minimum concentration of 0.081 mg/L at LWR-07 (Mainstem Little White River (Todd/Mellette County line)) on September 24, 2003 (Appendix D, Table D-1). Site by site comparison of total phosphorus concentrations indicated that all median concentrations in mainstem Little White River and Cut Meat Creek were below 0.425 mg/L while median total phosphorus concentrations in Pine Creek sampling sites (LWR-03 and LWR-04) were above 2.50 mg/L (Figure 80).

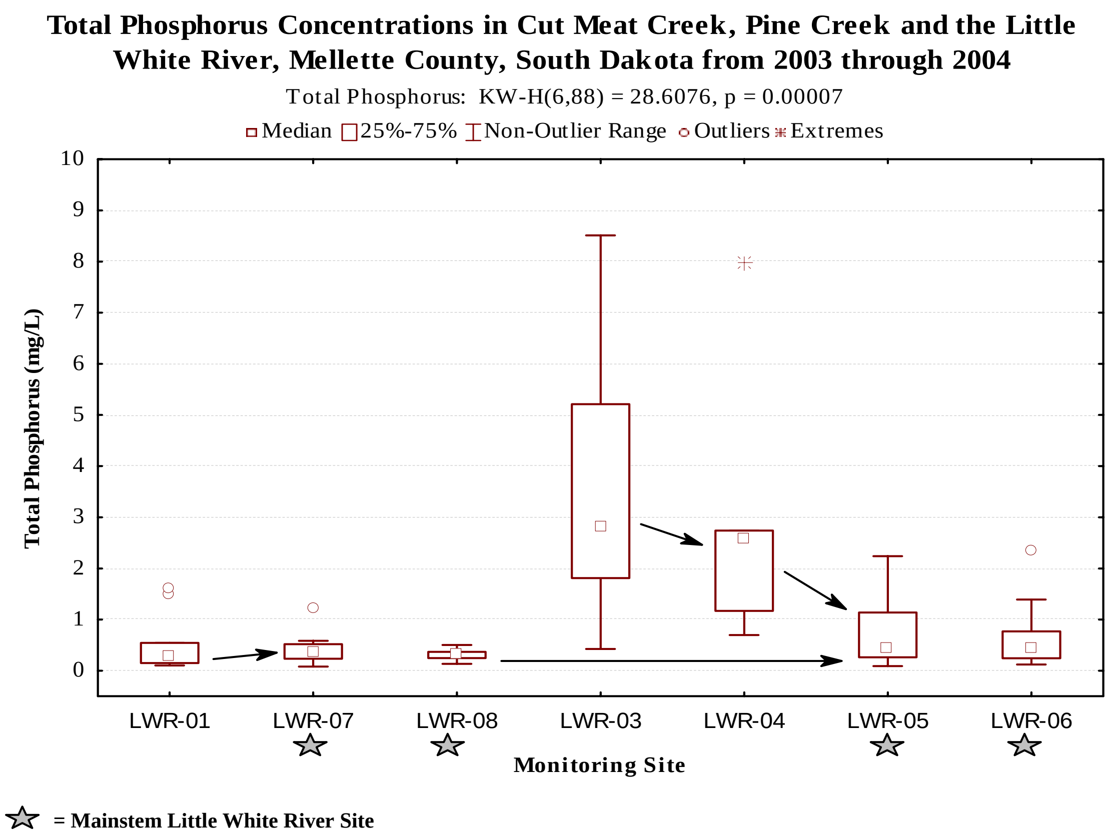


Figure 80. Total phosphorus concentrations by tributary monitoring site in the Little White River watershed, Mellette County, South Dakota from 2003 through 2004.

Total phosphorus concentrations were significantly different between monitoring sites (p=0.0001) with total phosphorus concentrations collected at LWR-03 (North Branch of Pine Creek) significantly higher than most monitoring sites except the lower portion Pine Creek, LWR-04 (Figure 80, Table 5 and Appendix B Table B-19). Lower Pine Creek (LWR-04) total phosphorus concentrations were only statistically higher than LWR-07 (Little White River (Todd/Mellette County line).

Total phosphorus concentrations were significantly different between sampling seasons (p=0.0068) with concentrations collected in the spring of 2004 significantly higher than the fall of 2003 (Figure 81, Appendix B, Table B-54). Mainstem Little White River total phosphorus concentrations were significantly lower (p=0.0011) than concentrations in upland tributaries to the Little White River (Figure 82). This may be due to increased grazing in the upland portions of the watershed draining into tributaries that feed the Little White River. This scenario is supported by water quality data collected from both Pine Creek monitoring sites, with median total phosphorus concentrations in the North Branch of Pine Creek (LWR-03) of 3.35 mg/L (average 3.33) and 3.04 mg/L (average 2.58) in lower Pine Creek LWR-04. Fecal coliform data also point to animal waste as the main source of increased total phosphorus concentrations in Pine Creek with median fecal coliform concentrations in the North Branch of Pine Creek at

35,563 colonies/100 ml (average 23,050) and 13,575 colonies/100 ml in lower Pine Creek LWR-04.

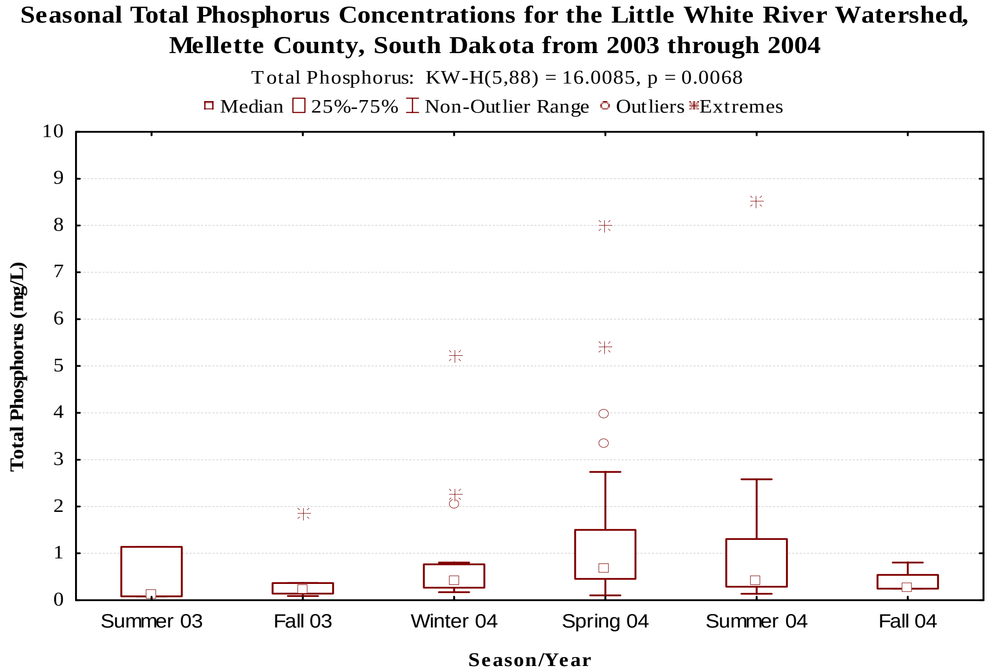


Figure 81. Seasonal median, quartile and range for total phosphorus concentrations for the Little White River watershed, Mellette County, South Dakota from 2003 through 2004.

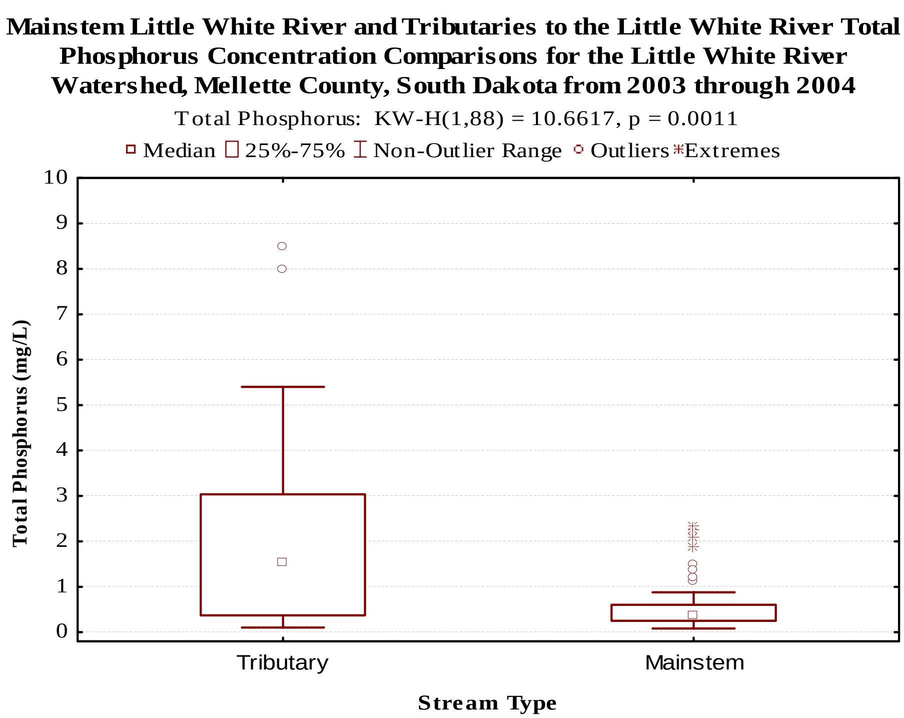


Figure 82. Total phosphorus concentration comparison by tributary type (mainstem Little White River and tributaries to the Little White River) for the Little White River, Mellette County, South Dakota from 2003 through 2004.

Total phosphorus loading by site was highest at site LWR-07 (32,157 kg) comprising 58.8 percent of the total phosphorus load in the Little White River (Table 35). Sub-watershed export coefficients (kilograms/acre) were highest in the LWR-05 sub-watershed (3.29 kg/acre) followed by LWR-06 (0.08 kg/acre) on mainstem Little White River and LWR-04 (lower Pine Creek) at 0.09 kg/acre in tributaries to the Little White River (Table 35). Tributary total phosphorus loading by season was highest in the spring of 2004 for the Little White River watershed (Figure 84). Overall total phosphorus loading between sampling sites was significantly different (p=0.0000) in the Little White River watershed (Figure 83, Table 5 and Appendix B, Table B-33).

Table 35. Total phosphorus per year by site for the Little White River and other monitored tributaries, Mellette County, South Dakota from 2003 through 2004.

Total Phosphorus

Sub-watershed	Station	Sub-watershed Acreage (Acres)	Kilograms by Site (kg)	Export Coefficient (kg/acre)
Cut Meat Creek	LWR-01	108,769	657	0.01
Little White River (Todd County Line)	LWR-07	819,479	32,157	0.04
Horse Head Creek	LWR-02	42,965	0	0.00
Little White River (Highway 44 Bridge)	LWR-08	56,185	-12,180	-0.22
North Branch of Pine Creek	LWR-03	30,319	905	0.03
Lower Pine Creek	LWR-04	49,697	4,567	0.09
Little White River (Highway 83 Bridge)	LWR-05	7,545	24,859	3.29
Little White River (mouth of the Little White River)	LWR-06	48,218	3,735	0.08
Total phosphorus load to the White River		**1,163,177**	**54,698**	**0.05**

Three sub-watersheds in the Little White River showed some load reductions in total phosphorus at least sometime during the project period, LWR-08, LWR-05, and LWR-06 (Figure 83 and Figure 84). Like most parameters, seasonal load reductions occurred at the Highway 44 bridge on mainstem Little White River LWR-08 specifically in the winter and spring of 2004 (Figure 83 and Figure 84). Total phosphorus load reduction was only observed on mainstem monitoring sites (especially at LWR-08 and LWR-06) and was attributed to hydrology (reduced flows). Assessment data indicate that total phosphorus was not a concern in the Little White River watershed.

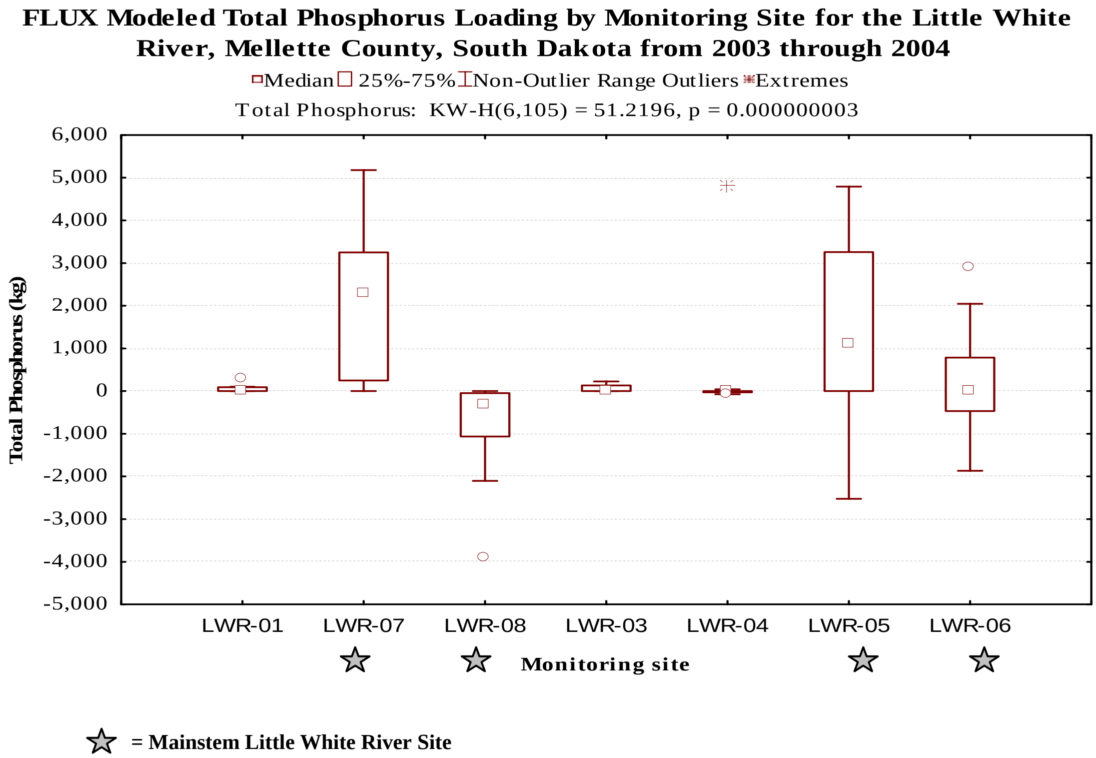


Figure 83. FLUX modeled total phosphorus loading by tributary monitoring site in the Little White River watershed, Mellette County, South Dakota from 2003 through 2004.

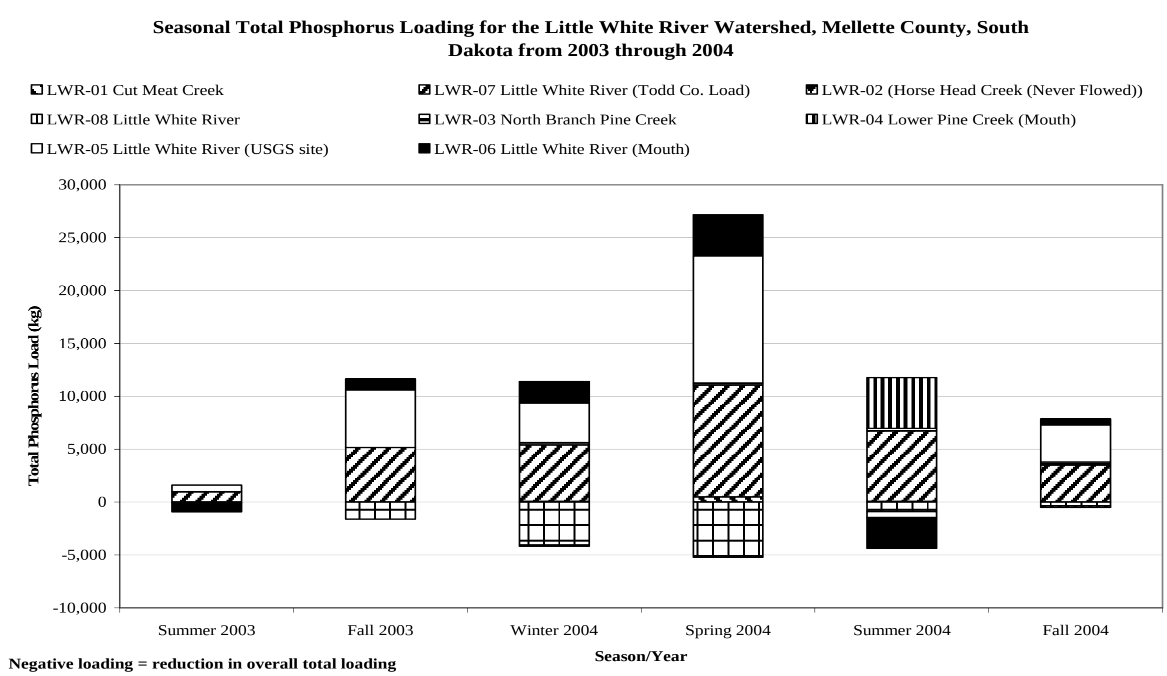


Figure 84. Seasonal total phosphorus loading by tributary monitoring site in the Little White River watershed, Mellette County, South Dakota from 2003 through 2004.

Total Dissolved Phosphorus

Total dissolved phosphorus is the fraction of total phosphorus that is readily available for use by algae. Dissolved phosphorus will sorb on suspended materials (both organic and inorganic) if present in the water column and if not already saturated with phosphorus. Total dissolved phosphorus samples were limited in the Pine Creek monitoring sites (LWR-03 and LWR-04) because high suspended solids concentrations significantly reduced filtering efficiencies.

The median total dissolved phosphorus concentration for the Little White River was 0.100 mg/L (average 0.096 mg/L). The maximum concentration of total dissolved phosphorus was collected on March 12, 2004 at LWR-01 was 0.303 mg/L (mouth of Cut Meat Creek) and a minimum of 0.016 mg/L at LWR-05 (Little White River, Highway 83 bridge) on August 2, 2004 (Appendix D, Table D-1). Total dissolved phosphorus concentrations were not significantly different between monitoring sites (Table 5, Figure 85 and Appendix B, Table B-20). During this study, the percentage of total dissolved phosphorus to total phosphorus ranged from 7.8 percent to 71.2 percent in the spring of 2004 and averaged 11 percent over the project. Seasonally, average total dissolved phosphorus concentrations were elevated in the winter of 2004 with 0.227 mg/L in Cut Meat Creek, LWR-01 (Table 17).

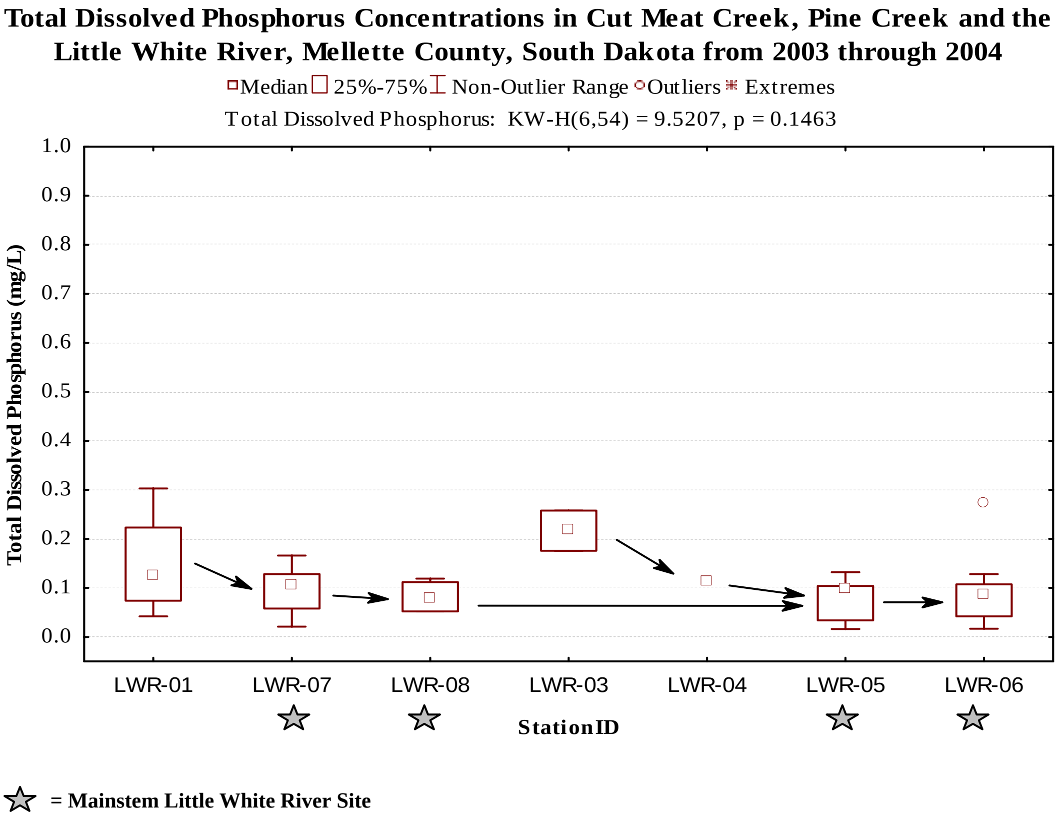


Figure 85. Total dissolved phosphorus concentrations by tributary monitoring site in the Little White River watershed, Mellette County, South Dakota from 2003 through 2004.

Total dissolved phosphorus concentrations were significantly different between sampling seasons (p=0.0000) with concentrations collected in the winter of 2004 significantly higher than the summer of 2004 (Figure 86 and Appendix B, Table B-55).

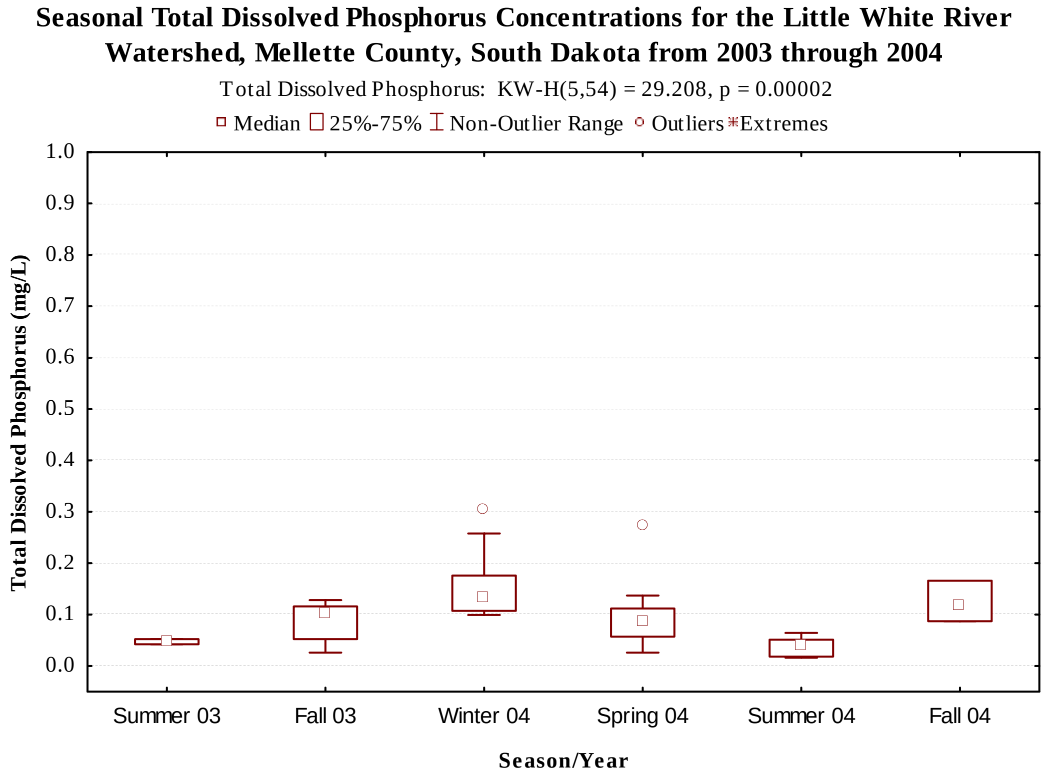


Figure 86. Seasonal total dissolved phosphorus concentrations for the Little White River watershed, Mellette County, South Dakota from 2003 through 2004.

Tributary total dissolved phosphorus concentrations were statistically higher (p=0.0139) than concentrations in mainstem Little White River (Figure 87). Total dissolved phosphorus loading by site was highest at site LWR-07 a modeled load of 27,291 kg (Table 36). Tributary total dissolved phosphorus loading by season was highest in the spring of 2004 for the Little White River watershed in Mellette County (Figure 89). Overall total dissolved phosphorus loading between sampling sites was significantly different (p=0.0000) in the Little White River watershed (Table 5 and Appendix B, Table B-34). Sub-watershed export coefficients (kilograms/acre) were highest in LWR-06 (mouth of the Little White River) at 0.067 kg/acre followed by LWR-07 sub-watershed on mainstem Medicine Creek (0.033 kg/acre) (Table 36). Two sub-watersheds in the Little White River had overall load reductions in total dissolved phosphorus during the project period, LWR-05 and LWR-08 (Figure 88 and Figure 89).

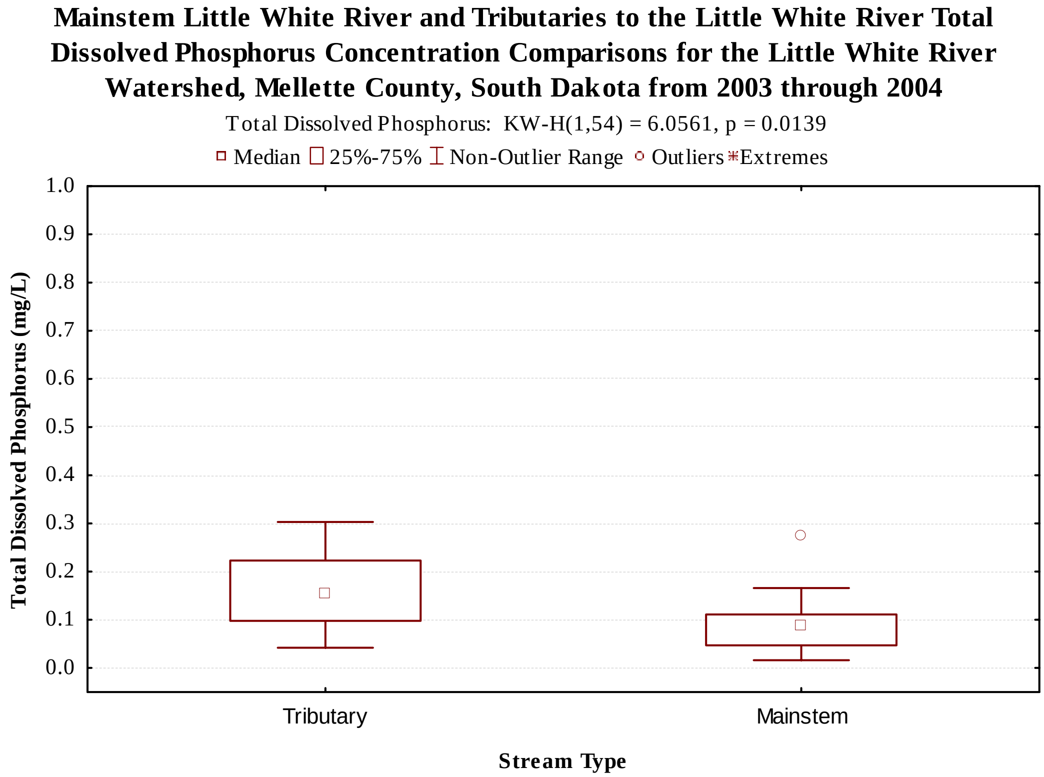


Figure 87. Total dissolved phosphorus concentration comparison by tributary type (mainstem Little White River and tributaries to the Little White River) for the Little White River, Mellette County, South Dakota from 2003 through 2004.

Table 36. Total dissolved phosphorus loading per year by site for the Little White River and other monitored tributaries, Mellette County, South Dakota from 2003 through 2004.

Total Dissolved Phosphorus

Sub-watershed	Station	Sub-watershed Acreage (Acres)	Kilograms by Site (kg)	Export Coefficient (kg/acre)
Cut Meat Creek	LWR-01	108,769	73	0.001
Little White River (Todd County Line)	LWR-07	819,479	27,291	0.033
Horse Head Creek	LWR-02	42,965	0	0.000
Little White River (Highway 44 Bridge)	LWR-08	56,185	-22,192	-0.395
North Branch of Pine Creek [1]	LWR-03	30,319	0	-
Lower Pine Creek [1]	LWR-04	49,697	0	-
Little White River (Highway 83 Bridge)	LWR-05	7,545	-965	-0.128
Little White River (mouth of the Little White River)	LWR-06	48,218	3,238	0.067
Total dissolved phosphorus load to the White River		**1,163,177**	**7,444**	**0.006**

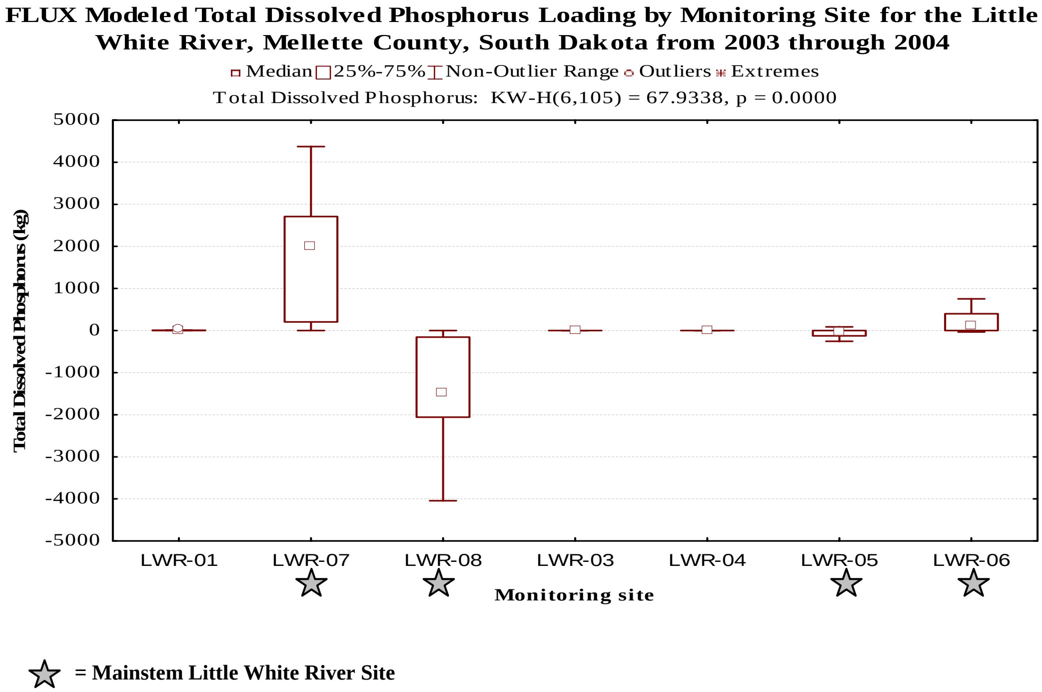


Figure 88. FLUX modeled total dissolved phosphorus loading by monitoring site for the Little White River, Mellette County, South Dakota based on 2003 through 2004 hydrology and water quality data.

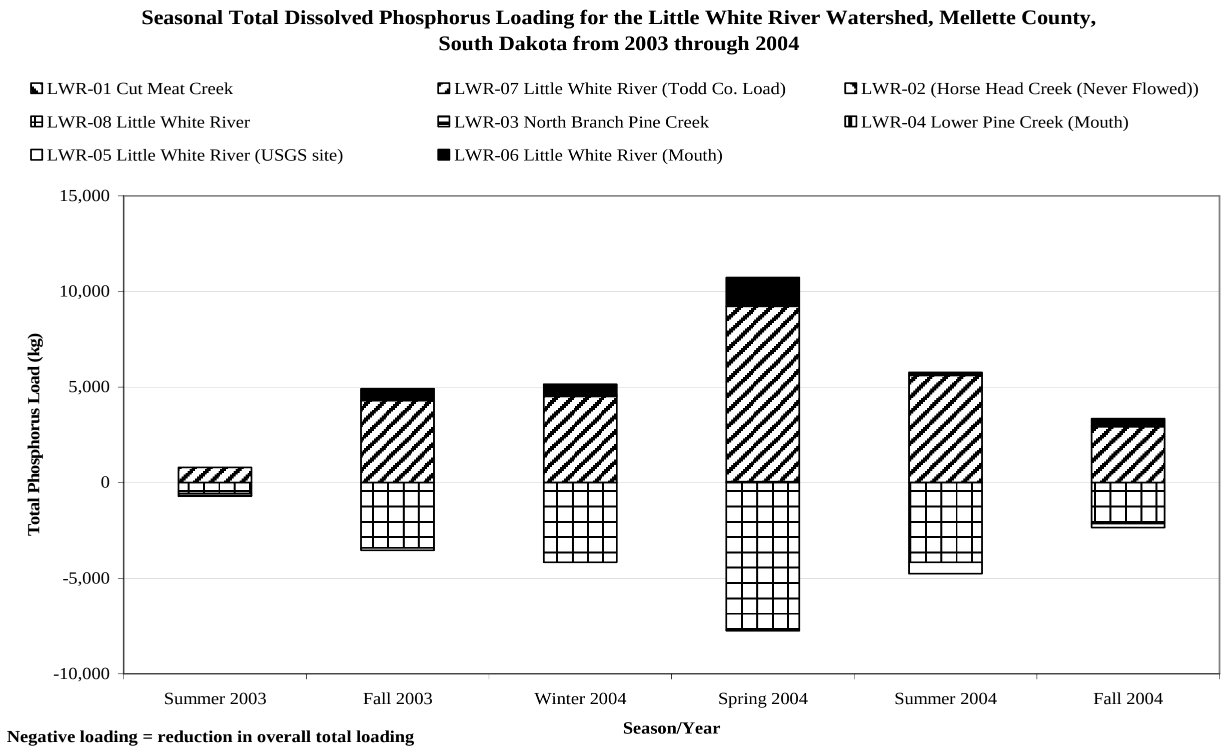


Figure 89. Seasonal total dissolved phosphorus loading by tributary monitoring site in the Little White River watershed, Mellette County, South Dakota from 2003 through 2004.

Fecal Coliform Bacteria

Fecal coliform bacteria are found in the intestinal tract of warm-blooded animals and are used as indicators of waste and the presence of pathogens in a waterbody. Many outside factors can influence the concentration of fecal coliform. Like most bacteria, fecal coliform bacteria are sensitive to ultraviolet light. Sunlight and transport time can affect fecal coliform bacteria in a predictable way that can be calculated, that can lessen fecal coliform concentrations although nutrient concentrations remain high. As a rule, just because fecal bacteria concentrations are low or non-detectable, does not mean animal waste is not present in a waterbody. South Dakota water quality standards for fecal coliform are in effect from May 1 through September 30. The fecal coliform standard of 2,000 colonies/100ml applies only to Cut Meat Creek (Little White River to He Dog Lake) LWR-01 and mainstem Little White River monitoring sites LWR-05, LWR 06, LWR-07 and LWR-08 and is listed as limited contact waters.

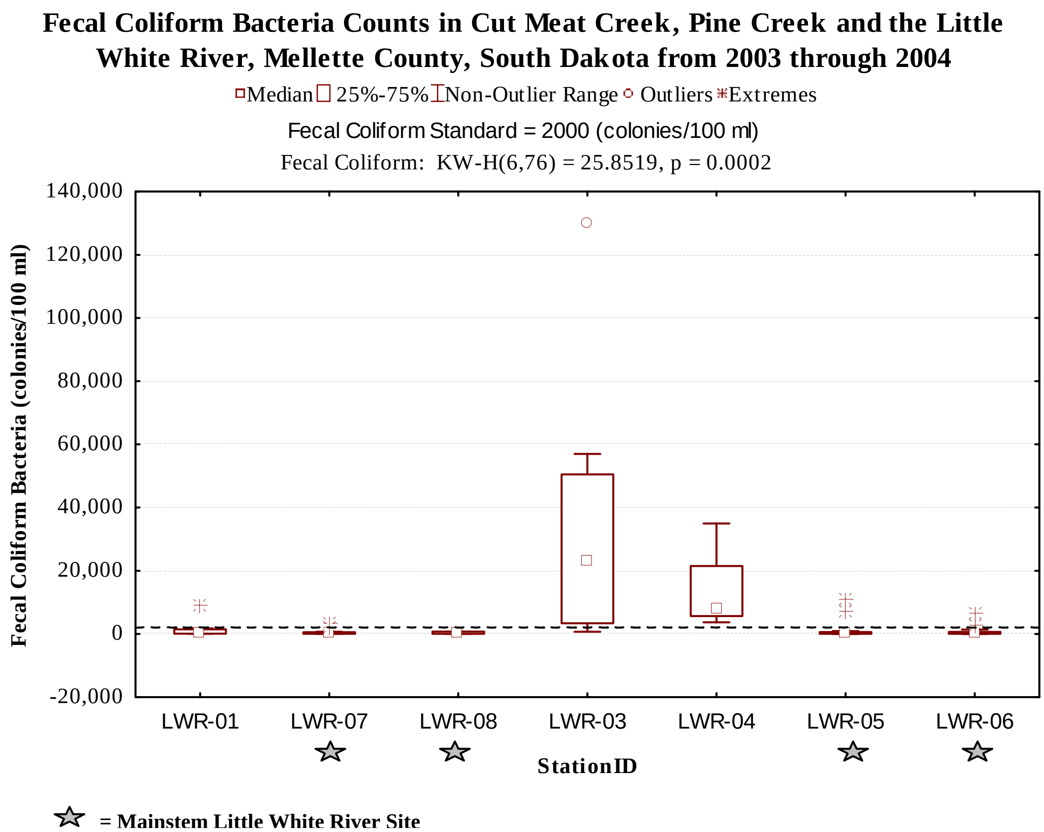


Figure 90. Fecal coliform concentrations (# colonies/100 ml) by mainstem monitoring site on the Little White River, Mellette County, South Dakota for all dates, 2003 through 2004.

The median fecal coliform count for all sites and dates was 280.0 colonies/100ml (average 524 colonies/100ml) with a maximum count of 130,000 colonies/100ml and a minimum count of 5 (½ the detection limit). Overall (using all dates), fecal coliform bacteria counts were significantly different (p=0.0002) between Little White River monitoring sites (Figure 90 and Table 5). Fecal coliform bacteria counts collected from May through September (dates standard applies) on mainstem Little White River were also significantly different (p=0.0145) during the project (Table 5). Descriptive statistics for mainstem Little White River samples collected from May through September were a median count of 250 colonies/100ml (average 1,413 colonies/100ml) with a maximum of 11,000 colonies/100ml and a minimum of 20 colonies/100ml.

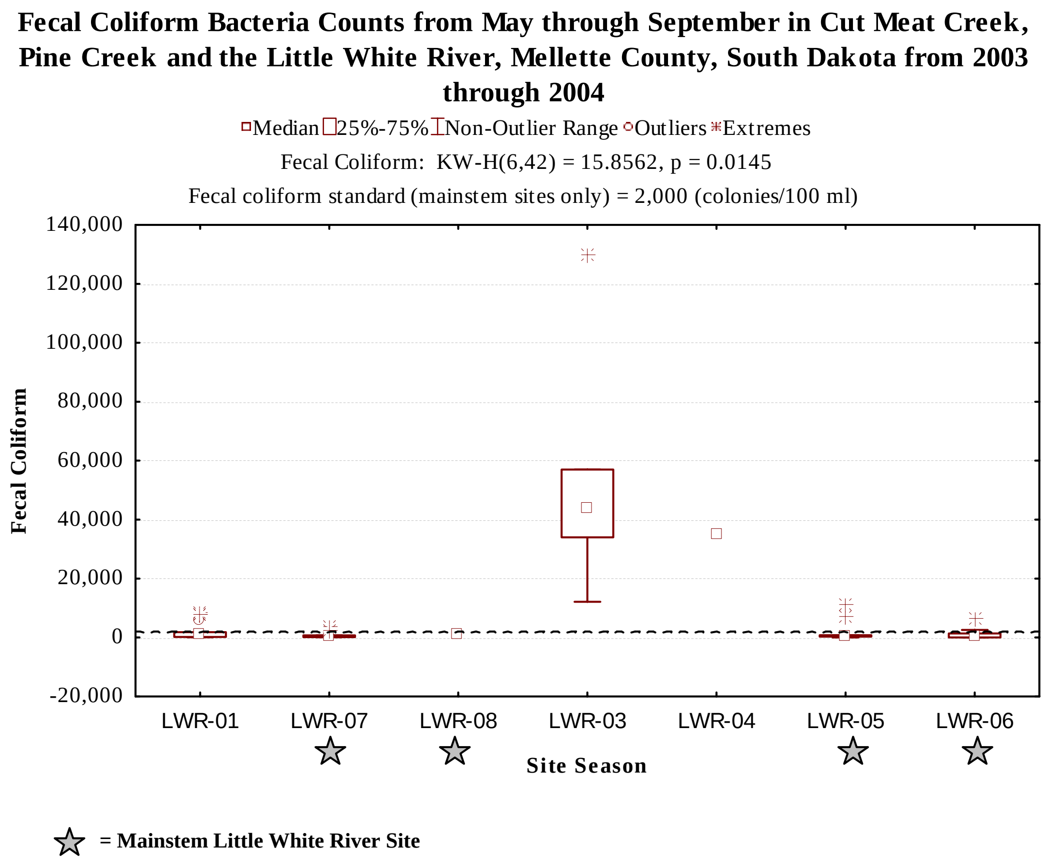


Figure 91. Fecal coliform concentrations (# colonies/100 ml) by mainstem monitoring site on the Little White River, Mellette County, South Dakota from May through September, 2003 through 2004.

Six water quality violations of fecal coliform standards have been documented on mainstem Little White River and one violation documented on Cut Meat Creek since 2001; all violations were detected during the assessment project (Table 12). No violations were detected in WQM (WQM-13) sample data collected from 2001 through 2006. Assessment data indicates three of the six violations occurred in August on the same date at three different monitoring sites (LWR-05, LWR-06 and LWR-07, Table 12) and were sampled from upstream to downstream. Given this sampling routine and flow rates between monitoring sites, water quality samples may have been collected from the same hydrologic plume/event as it continued downstream. Most fecal coliform violations collected during the assessment were collected during event conditions (Table 12). All median and 75th percentile concentrations in samples collected on mainstem monitoring sites from May through September were below water quality standards for fecal coliform bacteria (2,000 colonies/100 ml). Fecal coliform samples collected on Pine Creek (assigned 9, 10 beneficial use-based fecal standard does not apply) were significantly higher than LWR-06 and LWR-07 (Figure 90 and Figure 91). Load duration curves for fecal coliform bacteria were developed for three of the four mainstem monitoring sites based on assessment data for the Little White River to detect flow-related load scenarios (Figure 92, Figure 93 and Figure 94).

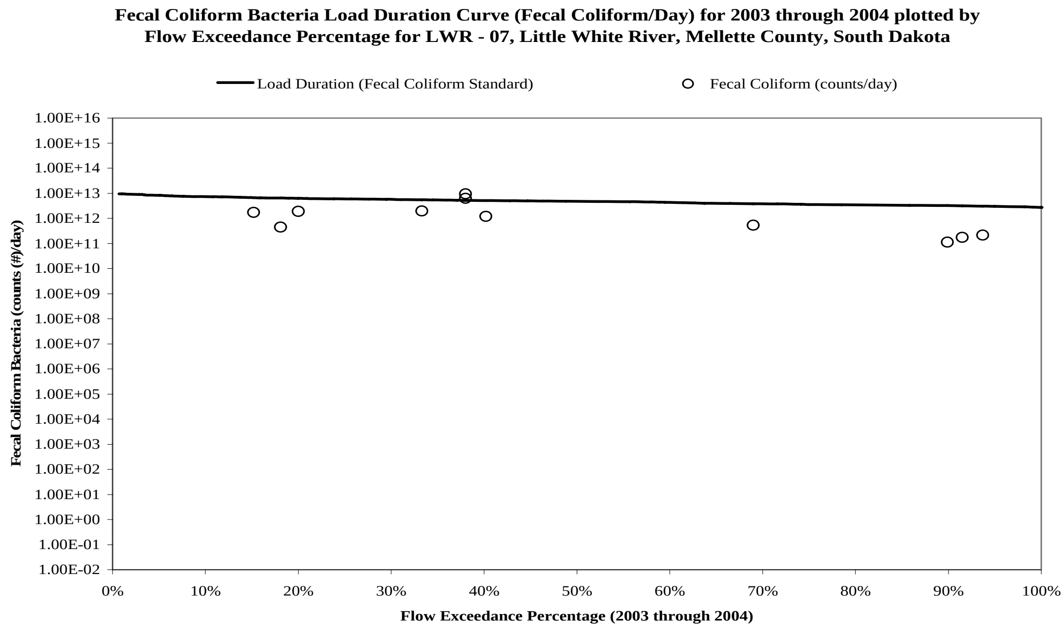


Figure 92. Load duration curve for fecal coliform bacteria in the Little White River at the Todd/ Mellette County line (LWR-07), Mellette County, South Dakota from May through September, 2003 and 2004.

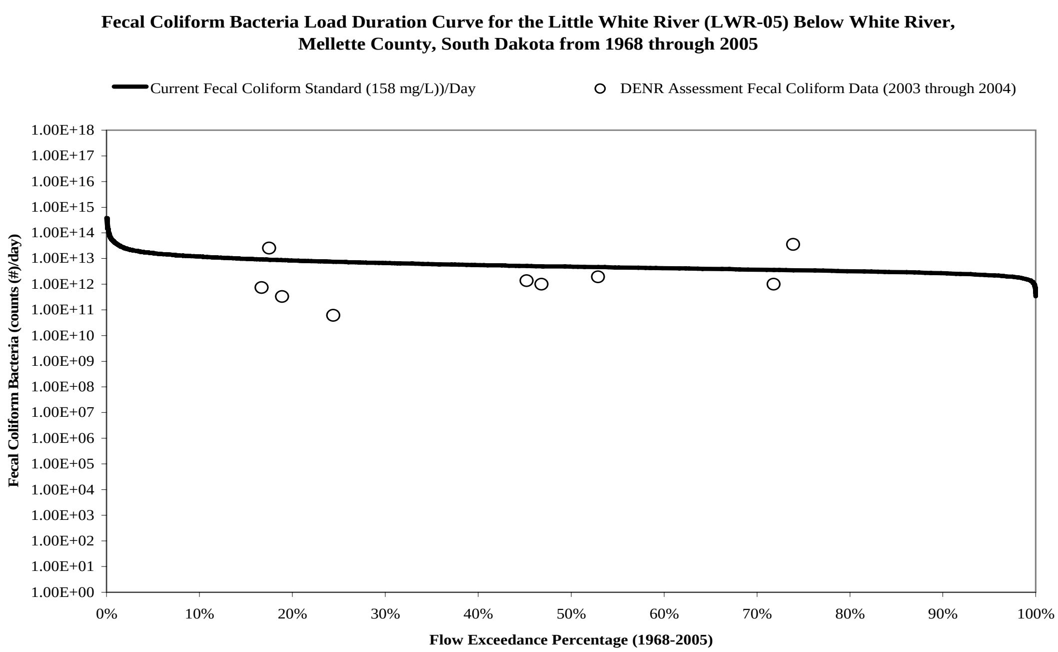


Figure 93. Load duration curve based on assessment data for fecal coliform bacteria in the Little White River at the Highway 83 Bridge (LWR-05), Mellette County, South Dakota from May through September, 1968 and 2004.

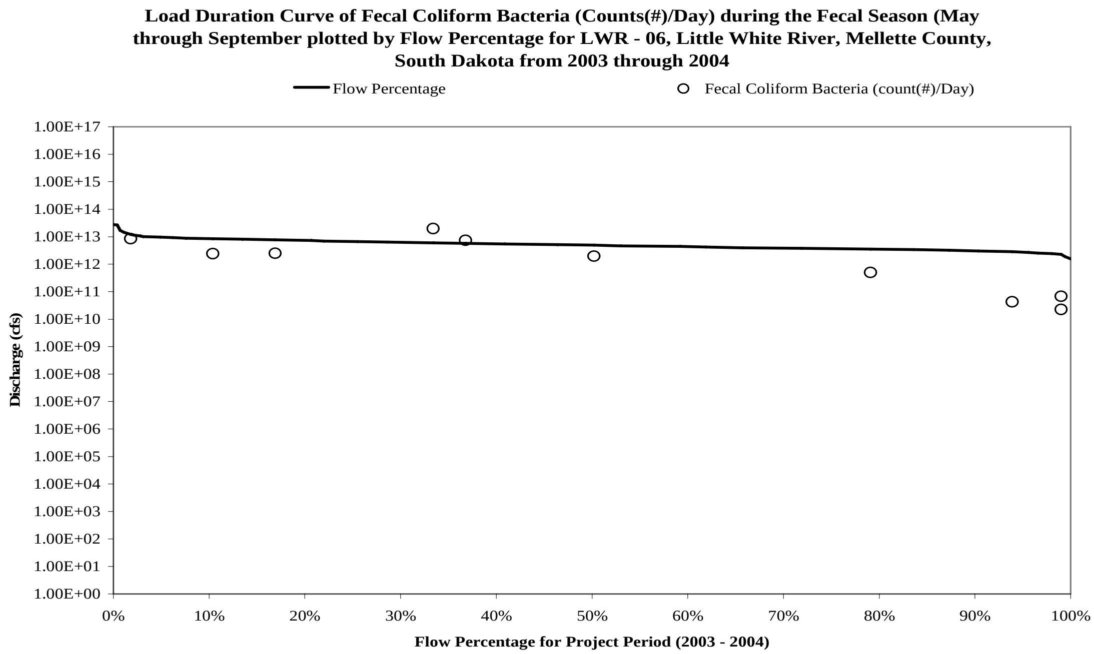


Figure 94. Load duration curve for fecal coliform bacteria in the Little White River at the mouth of the Little White River (LWR-06), Mellette County, South Dakota from May through September, 2003 and 2004.

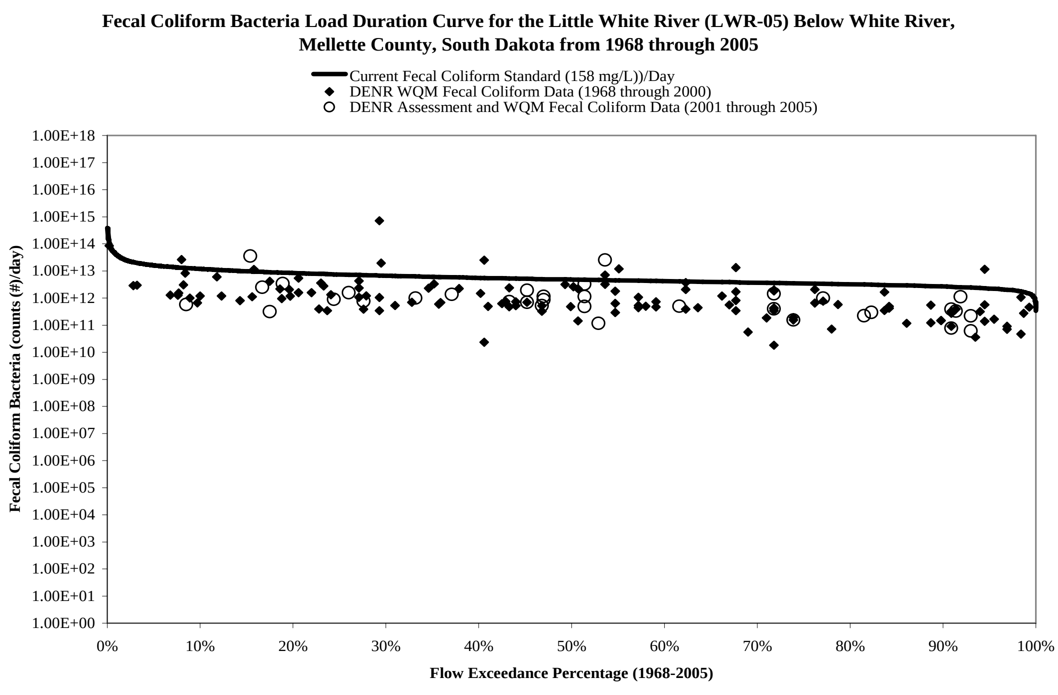


Figure 95. Load duration curve using long-term and recent (five year) data for fecal coliform bacteria in the Little White River at the Highway 83 Bridge (LWR-05), Mellette County, South Dakota from May through September, 1968 through 2005.

LWR-08 (Highway 44 Bridge) only had one fecal coliform sample collected during the project which was below the fecal coliform standard of 2,000 colonies/100 ml (730 colonies/100 ml). Based on assessment and long-term data, fecal coliform does not meet impaired status based on 2006 *Integrated Report* listing criteria for Cut Meat Creek or the mainstem of the Little White River (Table 12 and Figure 95).

Little White River Watershed Total Nitrogen /Total Phosphorus Ratios (Limiting Nutrient)

Nutrients are inorganic materials necessary for life, the supply of which is potentially limiting to biological activity within lotic (stream) and lentic (lake) ecosystems. Lakes that have average concentrations of total phosphorus of 0.01 mg/L or less are considered oligotrophic, while lakes with more than 0.030 mg/L, usually eutrophic (Wetzel, 2001). The conventions of oligotrophic and eutrophic states do not have the same utility for running water that they do for lakes, nor is there evidence for a natural process of eutrophication corresponding to lake succession (Hynes, 1969). Studies from diverse regions of North America (Omernik, 1977, Stockner and Shortreed, 1978 and Pringle and Bowers, 1984) imply that phosphorus limitation is widespread in streams. It is apparent that variations in nutrient concentrations and nitrogen-to-phosphorus ratios have predictable consequences for algae/periphyton community structure and metabolism in running waters (Allan, 1995).

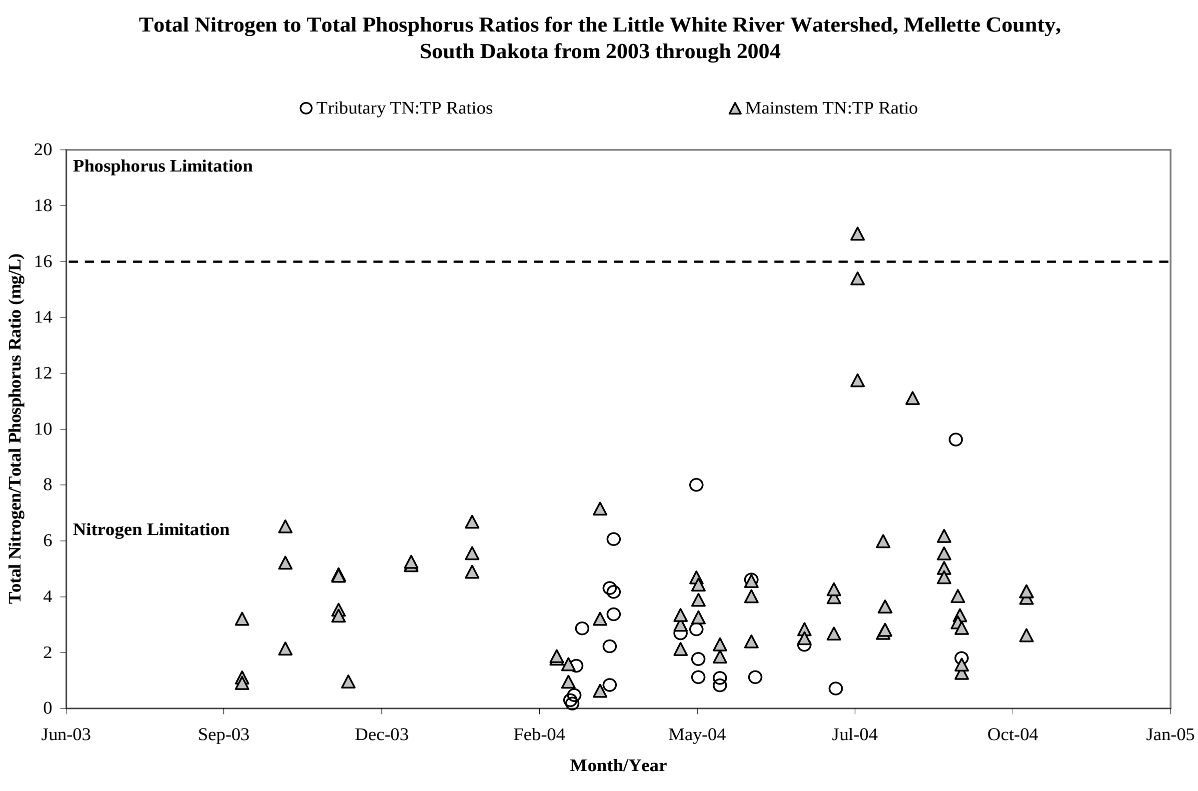


Figure 96. Total nitrogen-to-total phosphorus ratios based on tributary and mainstem concentrations in the Little White River watershed, Mellette County, South Dakota from 2003 and 2004.

Most estimates of the total nitrogen-to-total phosphorus ratio in freshwaters are above 16:1, based on the Redfield ratio (Redfield, et. al., 1963) and numerous bioassay experiments (Allan, 1995). This suggests that nitrogen is in surplus and phosphorus is in limited supply. The Environmental Protection Agency (EPA) has suggested total nitrogen-to-total phosphorus ratios for lakes of 10:1 as being the break for phosphorus limitation (US EPA, 1990). For tributary samples, a total nitrogen-to-total phosphorus ratio of 16:1 was used to determine phosphorus limitation.

Total nitrogen-to-total phosphorus ratios were calculated for all monitoring sites (24 tributaries to the Little White River and 64 mainstem Little White River samples) by date and by sampling site (Figure 96 and Figure 97, respectively). LWR-05 had the highest total nitrogen-to-total phosphorus ratios during the project, 2003 through 2004 (Figure 97). Total nitrogen-to-total phosphorus ratios were statistically different (p=0.0034) between tributary monitoring sites with LWR-07 significantly higher than LWR-03. Both tributaries to the Little White River (upland tributaries) and mainstem Little White River total nitrogen-to-total phosphorus ratios were considered nitrogen-limited based on the 16:1 ratio. The Little White River watershed is located in a semi-arid portion of South Dakota which typically exhibits nitrogen limitation based on Grimm and Fisher (1986). AnnAGNPS also modeled the Little White River watershed in Mellette County as a nitrogen-limited system (Appendix C).

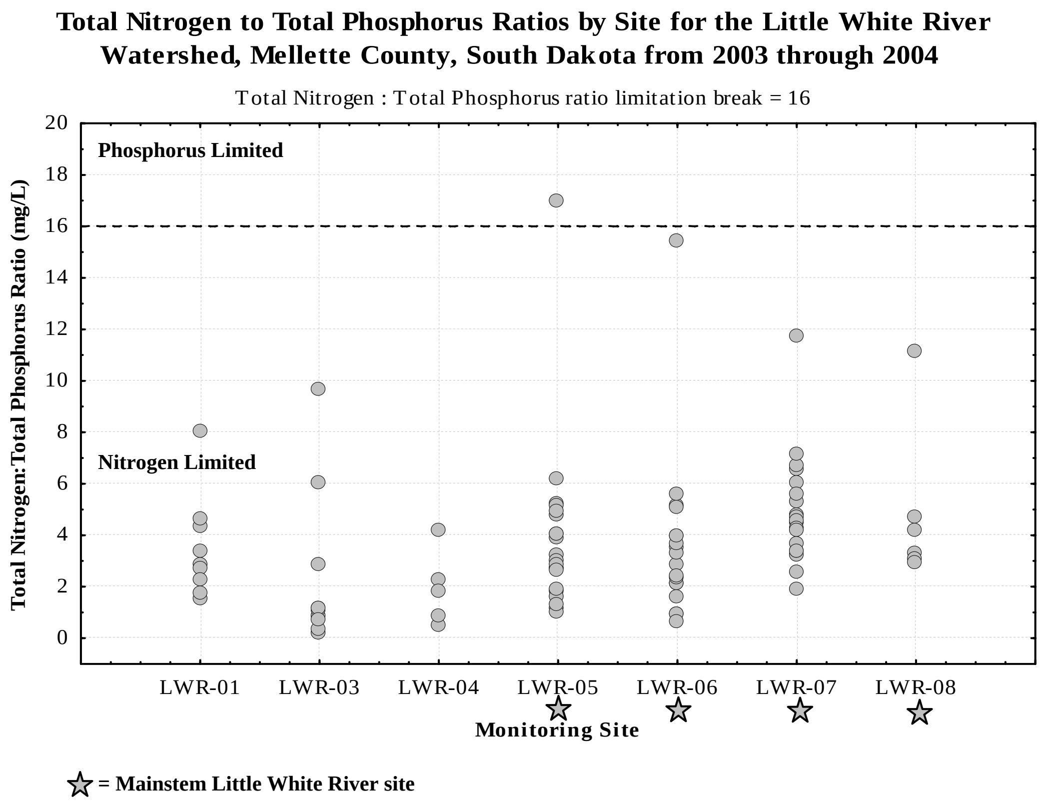


Figure 97. A comparison of total nitrogen to total phosphorus ratios (mg/L) by site for the Little White River watershed, Mellette County, South Dakota from 2003 through 2004.

3.2 Groundwater Monitoring

No groundwater monitoring was done during this assessment

3.3 Biological Monitoring

Benthic Macroinvertebrates

Macroinvertebrate data was collected during the summer of 2004. Two-minute kick nets were used to collect benthic macroinvertebrate samples from eleven transects during the designated index period. Sampling methods followed SD DENR Standard Operating Procedures, Volume II (SD DENR, 2005a). Macroinvertebrates were collected and shipped to a private consultant (Natural Resource Solutions) for identification and enumeration. A standard count of 300 organisms was used in the calculation of 5 commonly calculated macroinvertebrate metrics for each monitoring site (Table 37).

Table 37. Macroinvertebrate metrics calculated on biological data collected from the Little White River, Mellette County, South Dakota in 2004.

Metric Category	Metric	Expected Response to Increasing Disturbance
Richness	Taxa Richness	Decrease
Diversity/Evenness Measures	Hilsenhoff HBI	Increase
Richness	EPT Richness	Decrease
Enumerations	EPT Chironomidae Ratio	Decrease
Functional Group Composition	Scraper to Collector-Filterer Ratio	Decrease

Four mainstem monitoring sites (LWR-07, LWR-12, LWR-05 and LWR-06) were sampled in June, July and August; while only one site (Cut Meat Creek) was sampled in June on tributaries to the Little White River due to lack of flow. During the assessment, 108 species were identified throughout the Little White River basin in Mellette County (Table 38). Ten of these taxa (9.3 percent) were relatively intolerant to organic pollution (HBI tolerance values ranging from zero to two) based on Hilsenhoff Biotic Index (HBI) values (organic pollution tolerance values ranging from zero (intolerant) to ten (tolerant)). The presence of intolerant taxa at all monitoring sites suggests that organic pollution in the watershed is relatively stable over time. Species identified during the assessment were similar to the species identified in the Little White River and its tributaries in a report for Rosebud Sioux Tribe in Todd County (Williamson, 2005). Calculated metrics for assessment data by month are provided in Table 39; while macroinvertebrate sample data collected by site and month are provided in Appendix F.

Table 38. Macroinvertebrate species list for the Little White River watershed, Mellette County, South Dakota from 2004.

Little White River Species List	
Ablabesmyia sp.	*Lestes sp.*
Acari	*Limnodrilus hoffmeisteri*
Acentrella sp.	*Limnodrilus udekemianus*
Ambrysus sp.	*Lopescladius sp.*
Amercaenis ridens	*Macronychus glabratus*
Atherix sp.	*Mayatrichia sp.*
Axarus sp.	*Microcylloepus sp.*
Baetidae	Naididae
Berosus sp.	*Nais behningi*
Brachycentrus sp.	*Nais communis*
Caenis sp.	*Nais pardalis*
Camelobaetidius sp.	*Nais variabilis*
Cardiocladius sp.	*Nanocladius sp.*
Ceratopogonidae	*Nectopsyche sp.*
Ceratopogoninae	*Nectopsyche candida*
Cercobrachys sp.	*Nectopsyche diarina*
Chaetogaster diaphanus	*Neochoroterpes sp.*
Chelifera/Hemerodromia	*Ochrotrichia sp.*
Cheumatopsyche sp.	*Oecetis sp.*
Chironominae	*Ophidonais serpentina*
Chironomus sp.	*Ophiogomphus sp.*
Cladotanytarsus sp.	Orthocladiinae
Coenagrionidae	*Paracloeodes minutus*
Corduliidae	*Paracymus sp.*
Corixidae	*Parakiefferiella sp.*
Cricotopus sp.	*Paratanytarsus sp.*
Cricotopus trifascia	*Paratendipes subequalis*
Cricotopus/Orthocladius	*Peltodytes sp.*
Cryptochironomus sp.	*Pentaneura sp.*
Cryptotendipes sp.	*Perlesta sp.*
Culoptila sp.	*Petrophila sp.*
Dero digitata	*Physella sp.*
Dicrotendipes sp.	Physidae
Dystiscidae	Polymitarcidae
Elmidae	*Polypedilum sp.*
Ephoron sp.	*Procladius sp.*
Fallceon quilleri	*Procloeon sp.*
Gomphidae	*Pseudorthocladius sp.*
Gomphus sp.	*Pseudosmittia sp.*
Harnischia complex	*Rheocricotopus sp.*
Helophorus sp.	*Rheotanytarsus sp.*
Hemerodromia sp.	*Robackia claviger*
Heptagenia sp.	*Saetheria sp.*
Heptageniidae	*Sigara sp.*
Hetaerina sp.	*Simulium sp.*
Homoneuria sp.	*Stempellinella sp.*
Hyalella sp.	*Stenelmis sp.*
Hydropsyche sp.	*Stictochironomus sp.*
Hydropsyche occidentalis	Stratiomyidae
Hydropsychidae	*Tanytarsus sp.*
Hydroptila sp.	*Thienemanniella sp.*
Hydroptilidae	*Thienemannimyia sp.*
Isonychia sp.	*Tricorythodes sp.*
Leptoceridae	Tubificidae
Total Taxa	**108**

Shaded = Intolerant (to organic pollution) taxa identified in the Little White River (HBI tolerance values range from zero to two)

Table 39. Site specific metric values by monitoring site for the Little White River watershed, Mellette County, South Dakota from data collected in 2004.

June-04

	Site				
Metric	**LWR-01**	**LWR-07**	**LWR-12**	**LWR-05**	**LWR-06**
Taxa Richness	39	29	26	23	25
Hilsenhoff HBI	6.21	4.41	4.21	6.14	5.55
EPT Richness	6	16	15	15	10
EPT/Chironomidae	0.40	1.60	1.87	3.00	0.91
Scraper to Collector-Filterer	0.09	0.05	0.19	0.11	0.06

July-04

	Site				
Metric	**LWR-01**	**LWR-07**	**LWR-12**	**LWR-05**	**LWR-06**
Taxa Richness	-	22	22	32	23
Hilsenhoff HBI	-	4.11	4.30	5.37	5.05
EPT Richness	-	12	12	14	9
EPT/Chironomidae	-	1.71	1.70	1.20	0.90
Scraper to Collector-Filterer	-	0.12	0.00	0.21	0.07

August-04

	Site				
Metric	**LWR-01**	**LWR-07**	**LWR-12**	**LWR-05**	**LWR-06**
Taxa Richness	-	23	22	29	25
Hilsenhoff HBI	-	4.19	4.59	4.38	5.62
EPT Richness	-	13	9	16	9
EPT/Chironomidae	-	1.86	0.82	2.29	0.69
Scraper to Collector-Filterer	-	0.06	0.06	0.19	0.17

Table 40. Kruskal-Wallis analysis *p*-values[1] by month for calculated metrics by monitoring site from the Little White River watershed.

Month	**p Values**
June	0.41
July	0.39
August	0.39

[1] = **Significantly different if p-values <0.05**

Table 41. Kruskal-Wallis monthly comparisons by metric for the Little White River watershed.

Metric	**p Value**
Taxa Richness	0.31
Hilsenhoff HBI	0.41
EPT Richness	0.79
EPT/Chironomidae	0.80
Scraper to Collector-Filterer	0.93

Taxa richness ranged from 22 to 32 taxa in mainstem Little White River; while Cut Meat Creek had 39 total taxa. Taxa richness at each site was relatively high indicative of a stable biological community. Hilsenhoff Biotic Index (HBI) values ranged from 4.11 at LWR-07 to 6.21 in Cut Meat Creek (Table 39). HBI values calculated for Mellette County were similar to values reported in the Todd County study conducted by United States Geological Survey (Williamson, 2005). EPT abundance taxa (comprised of Ephemeroptera, Plecoptera and Trichoptera) tend to be more abundant in erosional habitat. Plecopterans are relatively rare within streams in Ecoregion 43; however, during this study one Plecopteran Genus *Perlesta*, was identified at LWR-07 and LWR-05 during the June sampling period which were categorized as erosional. EPT richness ranged from 9 to 16 taxa and was interpreted as relatively high in the plains of western South Dakota. EPT/Chironomidae ratio values were relatively high in erosional and depositional habitat in June and July and were reduced, although not significantly (Table 41), in depositional sites (LWR-12 and LWR-06) by August 2004 (Table 39). Scrapers to collector-filterer ratios were used to evaluate organic pollution based on functional feeding groups. Table 39 indicates relatively low ratios throughout the summer of 2004 with little change between sites and sampling months (Table 40 and Table 41, respectively), suggesting a relatively stable physical and biological community.

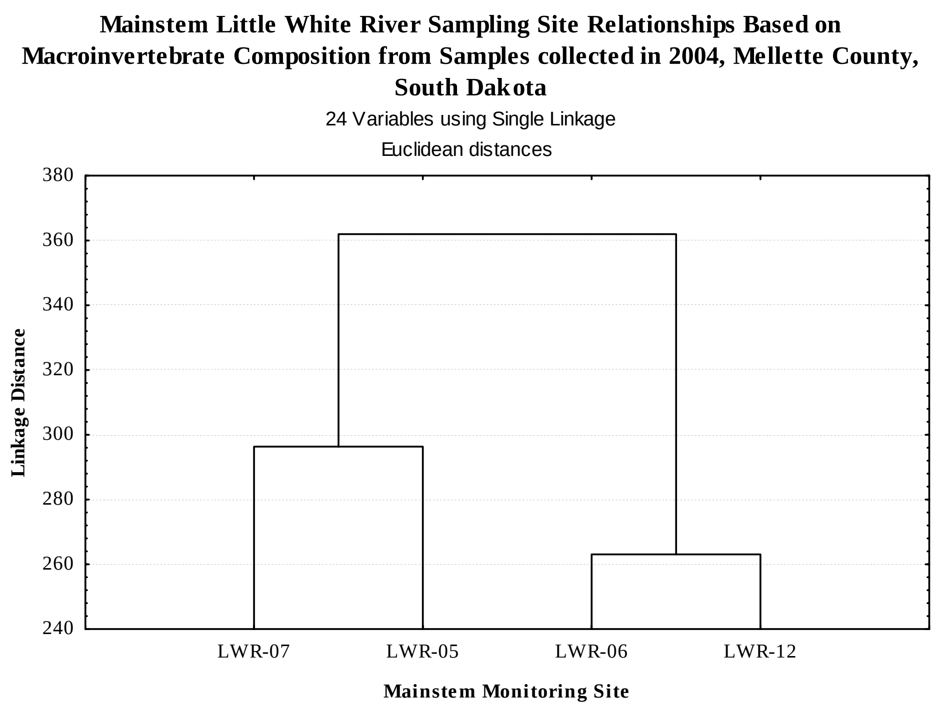


Figure 98. Mainstem Little White River sampling site relationships based on macroinvertebrate composition, Mellette County, South Dakota.

Cluster analysis was used to determine relationships between sites based solely on biology (community structure). Before analysis, taxa which were rarely encountered were removed from the data pool. Clustering was performed based on 24 species (variables) to determine monitoring site relationships based on biology. Results indicate that biologically, communities at LWR-07 (Little White River, Todd/Mellette County line) and LWR-05 (Little White River, Highway 83

Bridge) were similar while LWR-06 (mouth of the Little White River) and LWR-12 (Little White River, 9.6 river kilometers (5.9 river miles) downstream of LWR-07) were biologically similar (Figure 98). These relationships correspond well with general habitat data specific to these sites. Figure 98 indicated that monitoring sites LWR-07 and LWR-05 were related biologically and were also erosional sites with hardpan bedrock and cobble substrate. Similarly monitoring sites LWR-06 and LWR-12 showed a biological relationship and both were depositional habitats with shifting sand substrate.

Data indicate the benthic macroinvertebrate in the Little White River, Mellette County is robust with 108 identified taxa and appears to be relatively stable. Organic enrichment does not appear to be substantially impacting the benthic community based on the ten intolerant taxa populating all five monitoring sites in the basin (Table 38). As mentioned above, calculated metrics and statistical analysis also show a relatively stable benthic community populates the Little White River in Mellette County. The stable benthic community exists in the Little White River despite the fact that the River segment is listed in the 2006 Integrated Report as impaired by violations in the TSS standard (SD DENR, 2006). As previously mentioned in this document, violations in TSS have occurred both spatially and temporally during all flow regimes throughout the period of record indicating a natural condition. Macroinvertebrate data collected during the assessment support SD DENR recommendation that the current water quality based TSS standard for the Little White River (158 mg/L) be changed to a site specific TSS standard of 2,000 mg/L to reflect natural conditions based on available data in the listed segment. When the site specific TSS standard is in place, the Little White River will meet South Dakotas beneficial use based water quality standards and should be de-listed in the upcoming 2008 Integrated Report. This site-specific standards change should not significantly impact the biological community because this community originally developed under these unique conditions and have adapted to changing TSS concentrations.

3.4 Other Monitoring

Fisheries Data

South Dakota Game, Fish and Parks (SD GF&P) have not conducted extensive fishery surveys in the Little White River; however, SD GF&P have funded other studies that surveyed Little White River. Fisheries survey data indicate the Little White River and the more turbid White River have a diverse fish community with 18 species identified in the Little White River basin and 27 species identified in the White River. Since 1962, 47 total species have been identified in the White River (Baily and Allum, 1962, Bliss and Schainost, 1973, Cunningham et al., 1995, USF&WS, 1997, Fryda, 2001 and Harland, 2003). These studies indicate that based on fisheries data, the Little White River and White River basins although turbid, have viable fisheries populations that are not adversely impacted by high TSS concentrations.

Endangered Species

The South Dakota Natural Heritage Database identified two species, the whooping crane and Black-footed ferret, as being endangered in the Little White River watershed in Mellette County. This database contains documented identifications of rare, threatened or endangered species across the state and is listed in Appendix G. The whooping crane (*Grus americana*), a federally-listed endangered species, has been recorded in the Little White River watershed. The latest observation was recorded in Mellette County on April 24, 1993. The State of South Dakota lists the whooping crane as SZN, nonbreeding, no definable occurrences for conservation purposes, a category usually assigned to migrants. The other threatened Federal and State listed species is the black-footed ferret (*Mustela nigripes*) with the latest sighting in 1972. One fish species, the sturgeon chub (*Macrhybopsis gelida*), was last sighted in the Little White River in September 10 1994. Four other species (two plant species and two fish species) are identified but do not have State or Federal listing status. Identified plant species are Dakota buckwheat (*Eriogonum visheri*) and the slimleaf scrufpea (*Psoralea linearfolia*) while listed fish species are the plains minnow (*Hybognathus placitus*) and flathead chub (*Platygobio gracilis*). The US Fish and Wildlife Service list the bald eagle as species that could potentially be found in the area. None of these species were encountered during this study; however, care should be taken when conducting mitigation projects in the Little White River watershed.

Prairie Dog Study

One aspect of this assessment plan was to assess the impact prairie dogs have on sediment transport (Objective 4). Three monitoring sites were set up in the Little White River watershed: one above (upstream) the prairie dog town, one below the prairie dog town and one in a similar sized watershed without prairie dog impacts (Figure 99).

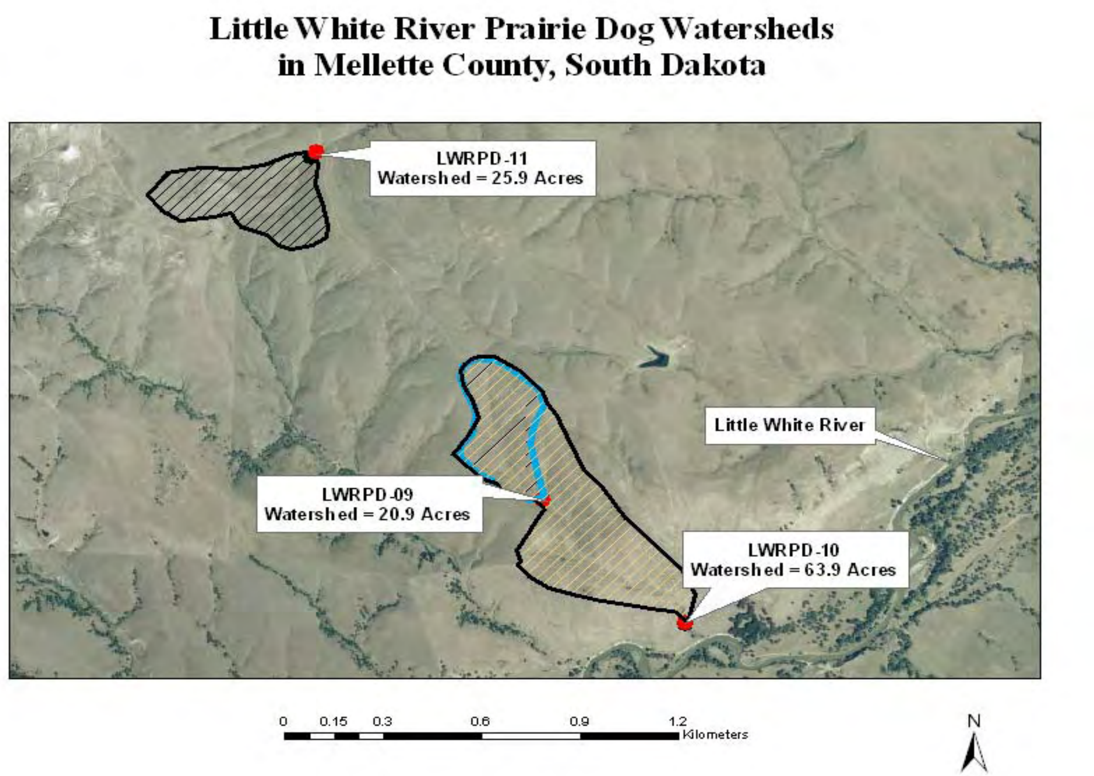


Figure 99. Prairie dog sub-watersheds in the Little White River Watershed, Mellette County, South Dakota from 2003 through 2004.

Table 42. Sample data for LWRPD-10 (downstream of prairie dog town) in the Little White River watershed, Mellette County, South Dakota in 2004.

Site	Date	Total Solids	Total Dissolved Solids	Total Suspended Solids	Volatile Total Suspended Solids	Percent Volatile Total Suspended Solids
LWRPD-10	05/06/04	35,796	996	34,800	3,400	9.8
LWRPD-10	08/13/04	51,946	2,946	49,000	4,330	8.8
LWRPD-10*	08/15/04	78,340	-	79,000	8,000	10.1
LWRPD-10**	09/30/04	-	-	-	-	-

*** = Sample run past holding time (not a valid sample just for reference)**
**** = Samples arrived at the South Dakota Public Health Laboratory after US EPA holding time and were not run**

Sampling site LWRPD-09 was set up directly above (upstream) of the targeted prairie dog town while LWRPD-10 was placed immediately below the influence of the prairie dog town. LWRPD-11 was a control watershed set up in a different drainage without prairie dog influence (Figure 99). Sampling equipment used to collect samples were ISCO 4230 flow meters and ISCO GLS auto samplers set to collect samples based on a preset stage.

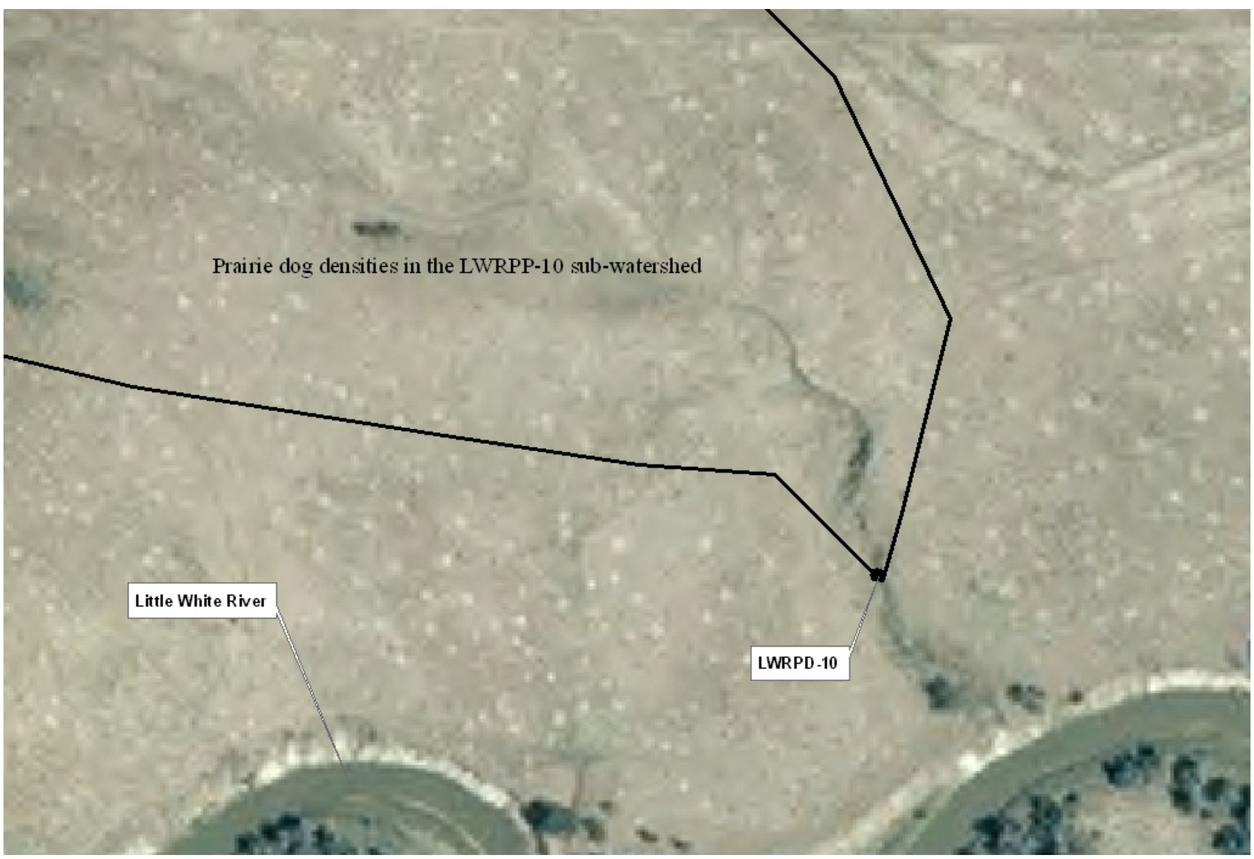


Figure 100. Prairie dog densities within LWRPD-10 sub-watershed (white spots are individual burrows) Mellette County, South Dakota in 2004.

Runoff was only detected at LWRPD-10 downstream of the prairie dog town during the project period (September 2003 through October 2004). Four sizable rain events occurred in the prairie dog watersheds large enough to sample, one in May, two in August and one in September 2004, (Table 42). Due to limited rainfall and the remote location (4.4 kilometers by ATV or four-wheel drive) access was limited during significant rainfall events. This limited the number of samples and discharge measurements at the only site that flowed (LWRPD-10).

As mentioned above, the only sub-watershed that flowed during these events was LWRPD-10, the one influenced by prairie dogs (Table 42 and Figure 100). The other sites, LWRPD09 above the prairie dog town and the control site (LWRPD-11) never flowed during the project period. This indicates sheet and rill runoff and erosion is more prevalent in areas influenced by prairie dogs than in watersheds without prairie dogs. Increased runoff response in areas influenced by prairie dogs appears to be the result of denuded vegetation from prairie dog clipping, foraging and grazing activities. Since there was no flow in the vegetated watersheds (LWRPD-09 and LWRPD-11) suggests that vegetated areas decrease the rain intensity that hits the ground and allow more infiltration and less runoff to occur. The limited sample data collected at LWRPD-10 suggest that even with limited rainfall events areas influenced by prairie dogs have increased runoff potential and higher sediment concentrations compared to any samples collected during the Little White River watershed assessment (Appendix D, Table D-1). However, due to limited number of samples and flow measurements direct comparisons between different landuse cover types could not be made and further study is warranted.

3.5 Quality Assurance Reporting

Seventeen quality assurance and quality control (QA/QC) samples were collected throughout the 2003 and 2004 sampling periods for tributary monitoring sites in the Little White River watershed (8 blank and 9 replicate). Standard chemical analysis was performed on all blank and replicate samples collected. Analyses followed tributary standard routine chemical parameters for analysis and are listed in Table 2.

Replicate samples were compared to the original samples using the industrial statistic (%I). The value given is the absolute difference between the original and the replicate sample expressed as a percent and is provided shown in Equation 6.

Equation 6. Industrial statistic equation.

$$\%I = (A-B) / (A+B)*100$$

Where: %I = Industrial Statistic
(A-B) = Absolute difference
(A+B) = Absolute sum

Blank samples were evaluated by calculating the mean and standard deviation of all blank samples for all tributary sites collected during the study. The criterion for compliance was that the standard deviation of the blank samples is less than the mean of all blank samples collected (Table 43). All blank quality assurance/quality control tributary samples were in compliance with the criterion proposed above with the standard deviation being less than the mean for each chemical parameter.

Nine tributary replicate samples were collected in the Little White River watershed during the project for an overall quality assurance/quality control percentage of 10.2 percent. Seven replicate sample parameters (fecal coliform, E. coli, total suspended solids, volatile total suspended solids, TKN, organic nitrogen, and total dissolved phosphorus) had at least one sample period with industrial statistics (%I) greater than 10 percent (absolute percent). Fecal coliform and *E. coli* colony counts often vary due to variations in sunlight, bacterial growth on incubated media and temperature. Total suspended and volatile total suspended solids concentrations can vary considerably because of variations in sample collection and processing. 12.5 percent (one sample set) violated both total suspended and volatile total suspended solids based on above criteria. Two related parameters, TKN and organic nitrogen, had industrial statistics greater than 10 percent in the sample set collected in March 24, 2004 at LWR-06. One total dissolved phosphorus sample set exceeded criteria. Over all, 89.6 percent of all tributary industrial statistics values were less than 10 percent different (Table 44). Variations in field sampling techniques, preparation and that the samples are replicate and not duplicate may contribute to the variability seen in some sample parameters.

Table 43. Tributary blank quality assurance/quality control samples collected in the Little White River, Mellette County, South Dakota from 2003 through 2004.

Site	Sample Type	Date	Fecal Coliform	E. coli	Alkalinity	Total Solids	Total Dissolved Solids	Total Suspended Solids	Total Volatile Suspended Solids	Ammonia	Nitrate-Nitrite	Total Kjeldahl Nitrogen	Organic Nitrogen	Inorganic Nitrogen	Total Nitrogen	Total Phosphorus	Total Dissolved Phosphorus
LWR07	Blank	10/16/2003	5	0.5	3	4	3.5	0.5	0.5	0.01	0.05	0.06	0.05	0.06	0.11	0.001	0.001
LWR05	Blank	11/12/2003	5	0.5	3	4	3.5	0.5	0.5	0.04	0.05	0.06	0.02	0.09	0.11	0.001	0.004
LWR06	Blank	3/24/2004	5	0.5	3	4	3.5	0.5	0.5	0.03	0.05	0.12	0.09	0.08	0.17	0.005	0.006
LWR01	Blank	3/31/2004	5	0.5	3	4	3.5	0.5	0.5	0.01	0.05	0.12	0.11	0.06	0.17	0.004	0.005
LWR03	Blank	5/24/2004	5	0.5	3	10	9	1	0.5	0.01	0.05	0.12	0.11	0.06	0.17	0.001	0.001
LWR05	Blank	6/9/2004	5	0.5	3	4	3.5	0.5	0.5	0.01	0.05	0.12	0.11	0.06	0.17	0.001	0.001
LWR06	Blank	9/15/2004	5	0.5	3	4	3.5	0.5	0.5	0.01	0.05	0.12	0.11	0.06	0.17	0.004	0.002
LWR08	Blank	9/15/2004	5	0.5	3	4	3.5	0.5	0.5	0.01	0.05	0.12	0.11	0.06	0.17	0.007	0.002
		Mean:	5	0.5	3	5	4.2	0.6	0.5	0.02	0.05	0.11	0.09	0.07	0.16	0.003	0.003
		Standard Deviation:	0	0.0	0	2	1.9	0.2	0.0	0.01	0.00	0.03	0.03	0.01	0.03	0.002	0.002

Table 44. Tributary routine and replicate quality assurance/quality control samples collected in Little White River, Mellette County, South Dakota from 2003 through 2004.

Station	Sample Type	Date	Fecal Coliform	E. coli	Alkalinity	Total Solids	Total Dissolved Solids	Total Suspended Solids	Total Volatile Suspended Solids	Ammonia	Nitrate-Nitrite	Total Kjeldahl Nitrogen	Organic Nitrogen	Inorganic Nitrogen	Total Nitrogen	Total Phosphorus	Total Dissolved Phosphorus
LWR07	Routine	10/16/2003	40	98.8	142	270	231	39	4	0.01	0.30	0.28	0.27	0.31	0.58	0.089	0.052
LWR07	Duplicate	10/16/2003	170	130	142	269	215	54	5	0.01	0.30	0.29	0.28	0.31	0.59	0.1	0.045
		Industrial Statistic (I%)	**61.90%**	**13.64%**	0.00%	0.19%	3.59%	**16.13%**	**11.11%**	0.00%	0.00%	1.75%	1.82%	0.00%	0.85%	5.82%	7.22%
LWR05	Routine	11/12/2003	160	161	149	340	242	98	12	0.01	0.80	0.44	0.43	0.81	1.24	0.258	0.101
LWR05	Duplicate	11/12/2003	180	107	149	348	246	102	12	0.01	0.80	0.47	0.46	0.81	1.27	0.258	0.096
		Industrial Statistic (I%)	5.88%	**20.15%**	0.00%	1.16%	0.82%	2.00%	0.00%	0.00%	0.00%	3.30%	3.37%	0.00%	1.20%	0.00%	2.54%
LWR06	Routine	3/24/2004	10	28.8	145	795	175	620	40	0.01	0.40	0.06	0.05	0.41	0.46	0.726	0.107
LWR06	Duplicate	3/24/2004	40	39.5	144	770	126	644	44	0.01	0.40	1.83	1.82	0.41	2.23	0.718	0.105
		Industrial Statistic (I%)	**60.00%**	**15.67%**	0.35%	1.60%	16.28%	1.90%	4.76%	0.00%	0.00%	**93.65%**	**94.65%**	0.00%	65.80%	0.55%	0.94%
LWR01	Routine	3/31/2004	140	126	237	429	362	67	5	0.01	0.05	0.88	0.87	0.06	0.93	0.276	0.154
LWR01	Duplicate	3/31/2004	140	112	235	432	361	71	6	0.01	0.05	0.90	0.89	0.06	0.95	0.292	0.129
		Industrial Statistic (I%)	0.00%	5.88%	0.42%	0.35%	0.14%	2.90%	9.09%	0.00%	0.00%	1.12%	1.14%	0.00%	1.06%	2.82%	8.83%
LWR03	Routine	5/24/2004	12100	2420	150	8423	4473	3950	450	0.01	0.40	3.23	3.22	0.41	3.63	3.33	*
LWR03	Duplicate	5/24/2004	12000	2420	148	8521	3971	4550	500	0.01	0.40	2.71	2.70	0.41	3.11	3.49	*
		Industrial Statistic (I%)	0.41%	0.00%	0.67%	0.58%	5.95%	7.06%	5.26%	0.00%	0.00%	8.75%	8.78%	0.00%	7.72%	2.35%	-
LWR05	Routine	6/9/2004	280	240	150	357	239	118	30	0.01	0.05	1.22	1.21	0.06	1.27	0.316	0.026
LWR05	Duplicate	6/9/2004	300	488	150	342	226	116	28	0.01	0.05	1.24	1.23	0.06	1.29	0.327	0.027
		Industrial Statistic (I%)	3.45%	**34.07%**	0.00%	2.15%	2.80%	0.85%	3.45%	0.00%	0.00%	0.81%	0.82%	0.00%	0.78%	1.71%	1.89%
LWR07	Routine	7/21/2004	140	133.4	143	365	213	152	30	0.01	0.05	1.18	1.17	0.06	1.23	0.288	0.064
LWR07	Duplicate	7/21/2004	100	115.3	143	362	196	166	36	0.01	0.05	1.30	1.29	0.06	1.35	0.299	0.061
		Industrial Statistic (I%)	**16.67%**	7.28%	0.00%	0.41%	4.16%	4.40%	9.09%	0.00%	0.00%	4.84%	4.88%	0.00%	4.65%	1.87%	2.40%
LWR06	Routine	9/15/2004	280	222	139	436	218	218	36	0.01	0.05	1.60	1.59	0.06	1.65	0.328	0.042
LWR06	Duplicate	9/15/2004	270	77.6	140	430	186	244	40	0.01	0.05	1.47	1.46	0.06	1.52	0.332	0.056
		Industrial Statistic (I%)	1.82%	**48.20%**	0.36%	0.69%	7.92%	5.63%	5.26%	0.00%	0.00%	4.23%	4.26%	0.00%	4.10%	0.61%	**14.29%**
LWR08	Routine	9/15/2004	730	1200	143	372	196	176	28	0.01	0.05	1.37	1.36	0.06	1.42	0.302	0.052
LWR08	Duplicate	9/15/2004	690	770	141	386	200	186	28	0.01	0.05	1.25	1.24	0.06	1.30	0.286	0.051
		Industrial Statistic (I%)	2.82%	**21.83%**	0.70%	1.85%	1.01%	2.76%	0.00%	0.00%	0.00%	4.58%	4.62%	0.00%	4.41%	2.72%	0.97%

*** =Not Sampled at this site**

3.6 Monitoring Summary and Recommendations

Monitoring Summary

Tributary

Little White River (previously: South Fork of the White River) is located in the Northwestern Great Plains (43) ecoregion (Level III) in central South Dakota has been listed for TSS on all 303(d) lists from 1998 through 2006 (SD DENR, 1998, SD DENR, 2002, SD DENR, 2004 and SD DENR, 2006).The Little White River drains a watershed of approximately 426,404 ha (1,053,667 acres) and comprises portions of Cherry and Sheridan Counties, Nebraska and Shannon, Bennett, Todd and Mellette Counties in South Dakota. The study area for this project is the Little White River watershed in Mellette County approximately 98,280 ha (242,855 acres). This portion of the watershed represents approximately 23 percent of the entire Little White River watershed (Figure 101 and Figure 102). The Mellette County Conservation District (MCCD) located in White River, South Dakota sponsored and supported this watershed assessment project.

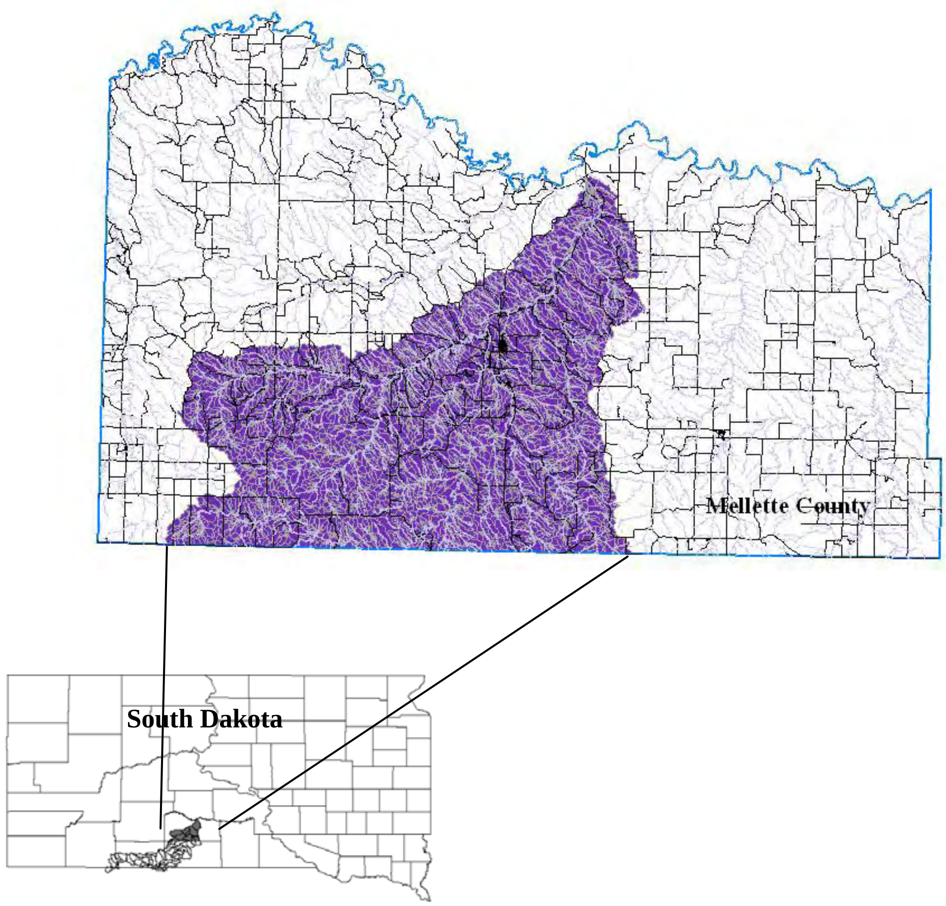


Figure 101. The Little White River watershed and the study area location in the State of South Dakota.

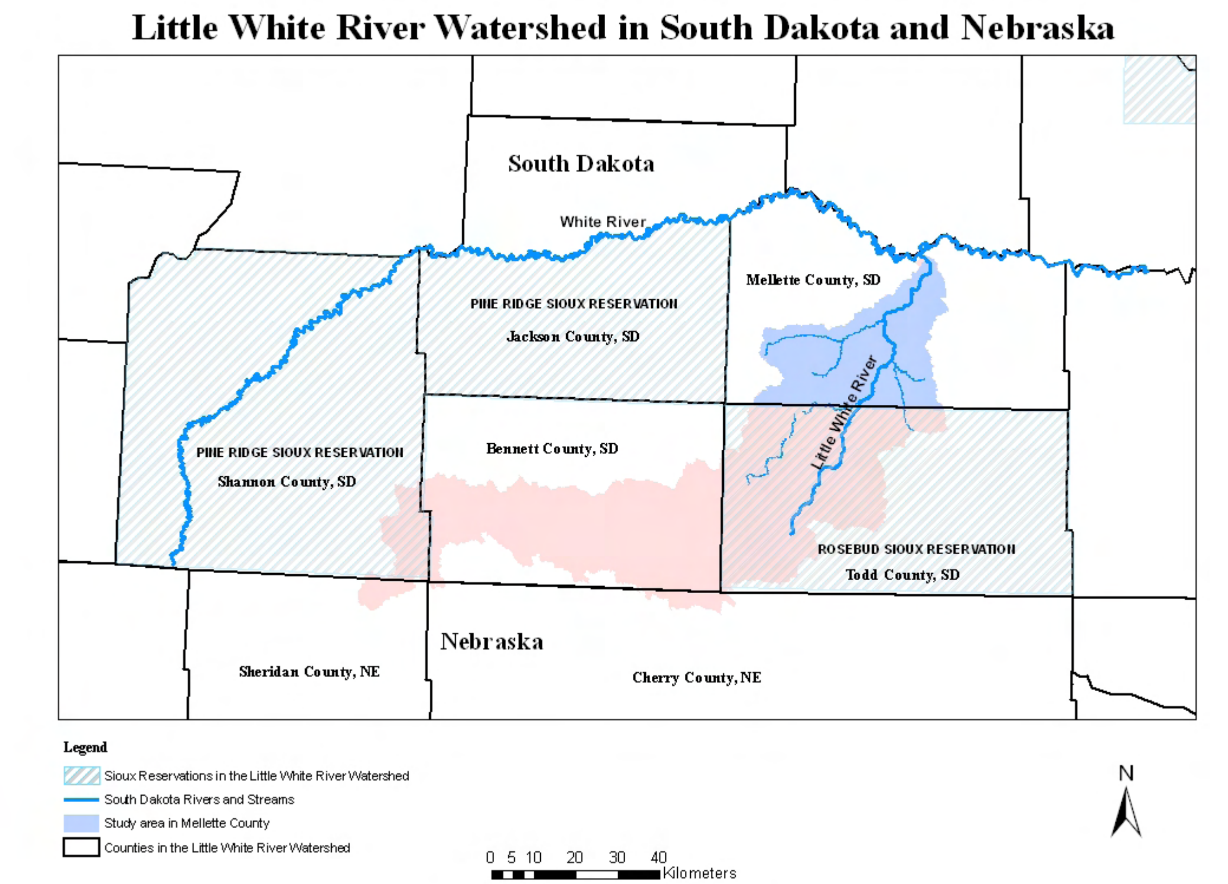


Figure 102. South Dakota and Nebraska Counties and Sioux Reservations in the Little White River Basin.

Only assessment data collected from mainstem Little White River sites (Todd/Mellette County line to the mouth, LWR-07, LWR-08, LWR-05 and LWR-06) were used to determine water quality standards violations in the Little White River stream segment (R5, 2006 Integrated Report, page 134 (SD DENR, 2006)). The WQM site on Little White River North of the town of White River on the Highway 83 Bridge, South Dakota (DENR 460840, WQM 13) was also the location LWR-05 sampling site during the assessment. Assessment data collected from LWR-01 was used to determine water quality standards violations in Cut Meat Creek segment; while water quality data collected from LWR-03 and LWR-04 was used to determine water quality standards violations in Pine Creek. Listing criteria for impairment in the South Dakota Integrated Report for streams are for parameters where greater than 10 percent of the samples violate water quality standards with 20 or more samples available. If less than 20 samples are available, greater than 25 percent of the samples must violate water quality standards for the segment to be considered water quality-limited (impaired).

Assigned beneficial uses for the Little White River are as follows: (5) warmwater semi-permanent fish life propagation water and (8) limited-contact recreation waters. The assigned beneficial uses for the Cut Meat Creek are as follows: (6) warmwater marginal fish life propagation water and (8) limited-contact recreation water. The Little White River, Cut Meat Creek and Pine Creek along with all streams in South Dakota have assigned beneficial uses of (9) fish and wildlife propagation, recreation, and stock watering water and (10) irrigation water.

Sixty water quality standards violations in six different parameters were observed in assessment data. Four of the six parameters (pH, temperature, fecal coliform and ammonia) were below listing criteria described above. The remaining two parameters, TSS, currently listed parameter for the Little White River and TDS, not currently listed for the North Branch of Pine Creek, violated water quality standards and exceeded the listing criterion. Thirty-two violations were observed in TSS data based on assigned beneficial uses for the Little White River, while six water quality violations in TDS were detected in Pine Creek from 2001 through 2005 (Table 9 through Table 14).

Although not listed as impaired in the 2006 Integrated report, the North Branch of Pine Creek (LWR-03) had a 60 percent violation rate and should be listed as impaired based on current water quality standards (Table 13); however, current and ancillary data from other watersheds located in Pierre Shale formations indicate elevated TDS concentrations are naturally occurring and relatively common in western South Dakota especially during low flow conditions (Smith, 2005). Little White River monitoring sites LWR-03 and LWR-04 are located in the Pine Creek watershed and are located in the Pierre Shale formation (Figure 39). Most TDS concentrations at both sampling sites were > 1,500 mg/L with six samples collected from LWR-03 exceeding South Dakota's beneficial use-based water quality standards (> 4,375 mg/L). All TDS samples collected in Pine Creek were elevated; however, specific conductance values, which usually correlate well with TDS concentrations were relatively low. This anomaly can be explained by the presence of colloidal White River Group soils. Colloidal soils are known to influence/mask specific conductance readings (SDDH, 2006). Pierre Shale makes up 12.1 percent of the Little White River watershed in Mellette County and White River Group soils comprise 9.8 percent of the watershed (Table 25). Waters the Pine Creek originate in the White River Group soils picking up colloidal constituents that flow into fractured areas in the Pierre Shale formations picking up high TDS concentrations and specific conductance, though specific conductance values are altered by the colloidal nature of White River Group soils in the water.

Similar to other watersheds in the Pierre Shale formation (Medicine Creek and Freeman Dam) with naturally high concentrations of TDS and specific conductance, Pine Creek exhibits higher frequencies of TDS violations in the upper end of the watershed. TDS concentrations further downstream (LWR-04) were also high but did not violate assigned beneficial use based water quality standards due to mixing and dilution. Conductivity in Pine Creek is most likely higher than observed values but was masked due to interference with colloidal compounds originating in the White River Groups soils upstream of the Pierre Shale formation (Figure 39). Like Medicine Creek and Freeman Dam, Pine Creek has no point sources contributing to the high TDS concentrations observed in Pine Creek. The Cottonwood Creek watershed that lies to the north of Pine Creek and flows through the Pierre Shale formation and into the White River is also listed for TDS and conductivity. Preliminary assessment data indicate TDS and conductivity violations occur during low flow conditions (below 1 cfs) and are considered a natural condition given this geologic scenario (Smith, 2007). Water quality violations and high concentrations of TDS at LWR-03 do not affect TDS concentrations at LWR-04 or further downstream in the Little White River (LWR-05 and LWR-06). Given the geologic makeup of the Pine Creek watershed and similar TDS/conductivity violation conditions in Medicine Creek, Cottonwood Creek and in the Freeman Dam watershed; the TDS violations in Pine Creek are from naturally occurring solutes originating from the Pierre Shale formations in western South Dakota.

Based on data described above, SD DENR recommends a change in water quality standards for (9) Fish and wildlife propagation, recreation, and stock watering water and (10) Irrigation waters. It is recommended that (9, 10) waters be amended into Article 74:51:01:30 *Flow rates for low quality fishery waters* rule for flows at the 7Q5 or 1 cfs which ever is greater. During these conditions, water quality criteria set forth in §§ 74:51:01:52 (Fish and wildlife propagation, recreation, and stock watering water) and §§ 74:51:01:53 (Irrigation waters) do not apply to the water but all surface water discharge permit limits remain in place. After rule change, four of the six TDS concentrations in the North Branch of Pine Creek would not violate water quality standards; which would then leave two violations out of ten total samples (20 percent violation rate). Based on listing criteria set forth in the 2006 Integrated Report (where less than 20 samples are available, greater than 25 percent of the samples must violate water quality standards for the segment to be considered water quality-limited or impaired) the North Branch of Pine Creek would meet water quality standards.

The Little White River is listed in the 2004 and 2006 South Dakota Integrated Report for Surface Water Quality Assessment as impaired for TSS (2004 Integrated Report (page 159) and 2006 Integrated Report (page134)). Violations in the TSS standards were based on the beneficial use of warmwater semi-permanent fish life propagation (Table 8, 158 mg/L). Mainstem TSS assessment data (64 samples) indicated a TSS violation rate of 65.6 percent, a five year WQM violation rate of 57.1 percent and an overall violation rate based on recent data of 61.7 percent (Table 10). Long-term monthly WQM and assessment data (414 samples collected from 1968 through 2005) for Little White River to determine the overall TSS violation percentage in Mellette County. Based on Table 26, 58.2 percent of all TSS samples collected from mainstem Little White River violated assigned beneficial use-based water quality standards for warmwater semi-permanent fish life propagation waters.

Based on current assessment data, long-term WQM and USGS data total suspended solids concentrations, although high, were relatively stable and have not changed substantially over time (current assessment and Williamson, 2005). This indicates TSS concentrations exceeding the current water quality standard for the Little White River watershed frequently occur and should be considered a naturally occurring condition in this watershed. Figure 46 substantiates this perception with the long-term trend line having a negative slope (-0.0202) which indicates a slight decrease in TSS concentrations over time. Similar trends in total suspended solids (negative slope) were observed at all long-term water quality monitoring sites in White River (RESPEC, 2005 (Draft Report).

TSS concentrations from tributaries to the Little White River (Cut Meat Creek (LWR-01) and Pine Creek (LWR-03 and LWR-04)) were significantly higher than samples collected from mainstem Little White River (LWR-07, LWR-08, LWR-05 and LWR-06) monitoring sites

(Figure 43, p=0.0040). Figure 39 shows Pine Creek and Cut Meat Creek either originate or flow through White River Group soils which may explain higher TSS concentrations (particulate and colloidal) observed in tributary monitoring sites, especially Pine Creek, during this study. This suggests that similar to mainstem Little White River, tributaries were also relatively high in TSS concentrations and supports the premise that waterbodies that originate and or flow through White River Group soils are considered naturally occurring based on this and other assessments reports throughout western South Dakota.

The 2004 and 2006 *South Dakota Integrated Report for Surface Water Quality Assessment* (2004 (page 159) and 2006 (page 134)) lists the Little White River as impaired for TSS, assessment and long-term data suggest water quality violations in TSS occurred over the entire (base to peak flows) flow regime (Figure 45). TSS violations in the Little White River regularly exceeded the TMDL listing criteria; as non-support for TSS standards based on the warmwater semi-permanent fish life propagation water. However, USGS, WQM and assessment TSS data show that TSS concentrations have exceeded South Dakota water quality standards (>158 mg/L) since monitoring began on the Little White River in Mellette and Todd Counties (current assessment and Williamson, 2005). All available data indicate the current total suspended solids standard for TSS on the Little White River (158 mg/L) is not representative or protective of warmwater semi-permanent fish life propagation in the Little White River based on current and long-term geological, chemical and biological data. The TSS standard should be modified to reflect natural conditions and best available data specific to the Little White River that is also protective of both human and aquatic life uses. SD DENR recommends the current water quality based TSS standard (158 mg/L) for the listed segment R5 on the Little White River in Mellette County be changed to a site-specific TSS standard of 2,000 mg/L. When the site specific TSS standard is in place, the Little White River will meet South Dakotas beneficial use based water quality standards and should be de-listed in the upcoming 2008 Integrated Report. This site-specific standards change should not significantly impact the biological community because this community originally developed under these unique conditions and have adapted to fluctuating TSS concentrations.

Total phosphorus concentrations were significantly different between sampling seasons (p=0.0068) with concentrations collected in the spring of 2004 significantly higher than the fall of 2003 (Figure 81, Appendix B, Table B-54). Mainstem Little White River total phosphorus concentrations were significantly lower (p=0.0011) than concentrations in upland tributaries to the Little White River (Figure 82). This may be due to increased grazing in the upland portions of the watershed draining into tributaries that feed the Little White River. This scenario is supported by water quality data collected from both Pine Creek monitoring sites, with median total phosphorus concentrations in the North Branch of Pine Creek (LWR-03) of 3.35 mg/L (average 3.33) and 3.04 mg/L (average 2.58) in lower Pine Creek LWR-04. Fecal coliform data also point to animal waste as the main source of increased total phosphorus concentrations in Pine Creek with median fecal coliform concentrations in the North Branch of Pine Creek at 35,563 colonies/100 ml (average 23,050) and 13,575 colonies/100 ml in lower Pine Creek LWR-04. Although not listed, SD DENR suggests that there should be some type of implementation project in the Pine Creek watershed to reduce high phosphorus concentrations and elevated fecal coliform counts coming out of this watershed.

Six water quality violations in fecal coliform standards have been documented on mainstem Little White River and one violation documented on Cut Meat Creek since 2001; all violations were detected during the assessment project (Table 12). No violations were detected in WQM (WQM-13) sample data collected from 2001 through 2006. Assessment data indicates three of the six violations occurred in August on the same date at three different monitoring sites (LWR-05, LWR-06 and LWR-07, Table 12) and were sampled from upstream to downstream. Given this sampling routine and flow rates between monitoring sites, water quality samples may have been collected from the same hydrologic plume/event as it continued downstream. Most fecal coliform violations collected during the assessment were collected during event conditions (Table 12). All median and 75th percentile concentrations in samples collected on mainstem monitoring sites from May through September were below water quality standards for fecal coliform bacteria (2,000 colonies/100 ml). Fecal coliform samples collected on Pine Creek were significantly higher than LWR-06 and LWR-07 (Figure 90 and Figure 91); however, Pine Creek is listed as a (9) fish and wildlife propagation, recreation, and stock watering water and (10) irrigation water, so the fecal coliform standard does not apply. Load duration curves for fecal coliform bacteria were developed for three of the four mainstem monitoring sites based on assessment data for the Little White River to detect flow related load scenarios (Figure 92, Figure 93 and Figure 94). Based on assessment and long-term data, fecal coliform meets beneficial use-based water quality standards for limited contact recreation waters (Table 12 and Figure 95).

Total nitrogen-to-total phosphorus ratios were calculated for all monitoring sites (24 tributaries to the Little White River and 64 mainstem Little White River samples) by date and by sampling site (Figure 96 and Figure 97, respectively). LWR-05 had the highest total nitrogen-to-total phosphorus ratios during the project, 2003 through 2004 (Figure 97). Total nitrogen-to-total phosphorus ratios were statistically different (p=0.0034) between tributary monitoring sites with LWR-07 significantly higher than LWR-03. Both tributaries to the Little White River (upland tributaries) and mainstem Little White River total nitrogen-to-total phosphorus ratios were considered nitrogen-limited based on a 16:1 ratio. The Little White River watershed is located in a semi-arid portion of South Dakota which typically exhibit nitrogen limitation based on Grimm and Fisher (1986). AnnAGNPS also modeled the Little White River watershed in Mellette County as a nitrogen-limited system (Appendix C).

During the assessment, sampling site LWRPD-09 was set up directly above (upstream) the targeted prairie dog town while LWRPD-10 was placed immediately below the influence of the prairie dog town. LWRPD-11 was a control watershed set up in a different drainage without prairie dog influence (Figure 99). The only sub-watershed that flowed during these events was LWRPD-10, the one influenced by prairie dogs (Table 42 and Figure 100). The other sites, LWRPD09 above the prairie dog town and the control site (LWRPD-11) never flowed during the project period. This indicates sheet and rill runoff and erosion may be more prevalent in areas influenced by prairie dogs than in watersheds without prairie dogs. Increased runoff response in areas influenced by prairie dogs may be the result of denuded vegetation from prairie dog clipping, foraging and grazing activities. Since there was no flow in the vegetated watersheds (LWRPD-09 and LWRPD-11) suggests that vegetated areas decrease the rain intensity that hits the ground and allow more infiltration and less runoff to occur. The limited sample data collected at LWRPD-10 suggest that even with limited rainfall events areas influenced by prairie dogs appear to have increased runoff potential and higher sediment concentrations than any samples collected during the Little White River watershed assessment (Appendix D, Table D-1).

Biologically based, the Little White River watershed is generally stable, based on fisheries and benthic macroinvertebrate data. Fisheries survey data indicate the Little White River and the more turbid White River have a diverse fish community with 18 species identified in the Little White River basin and 27 species identified in the White River. Since 1962, 47 total species have been identified in the White River (Baily and Allum, 1962, Bliss and Schainost, 1973, Cunningham et al., 1995, USF&WS, 1997, Fryda, 2001 and Harland, 2003). These studies indicate that based on fisheries data, the Little White River and White River basins although turbid, have viable fisheries populations that are not adversely impacted by high TSS concentrations. Data indicate the benthic macroinvertebrate in the Little White River, Mellette County is robust with 108 identified taxa and appears to be relatively stable. Organic enrichment does not appear to be substantially impacting the benthic community based on the ten intolerant taxa populating all five monitoring sites in the basin (Table 38). As mentioned above, calculated metrics and statistical analysis also show a relatively stable benthic community populates the Little White River in Mellette County. The stable benthic community exists in the Little White River despite the fact that the river segment is listed in the 2006 Integrated Report as impaired by violations in the TSS standard (SD DENR, 2006). As previously mentioned in this document, violations in TSS occur and have occurred both spatially and temporally during all flow regimes throughout the period of record indicating a natural condition. Macroinvertebrate data collected during the assessment support SD DENR recommendation that the current water quality based TSS standard for the Little White River (158 mg/L) be changed to a site-specific TSS standard of 2,000 mg/L to reflect natural conditions in the listed segment. When the site-specific TSS standard is in place, the Little White River will meet South Dakota’s beneficial use-based water quality standards and should be de-listed in the upcoming 2008 Integrated Report. This site-specific standards change should not significantly impact the biological community because this community originally developed under these unique conditions and have adapted to changing TSS concentrations.

Tributary Recommendations

Long-term and assessment data indicate TSS concentrations in the Little White River violate current surface water quality standards based on (5) warmwater semi-permanent fish life propagation water criteria. However, based on long-term trend analysis using USGS, SD DENR WQM and current assessment data, fisheries and benthic macroinvertebrate community structure TSS standard violations appear to be relatively constant showing a slight decline over time. Ancillary biological data (macroinvertebrate and fisheries) appear to be relatively robust suggesting stability over time. Data support the conclusion that relatively high TSS concentrations producing surface water quality standard violations do not adversely impact this unique, stable and diverse biological community. Current water quality standards for semi-permanent fish life propagation need to be refined to adequately represent this unique ecosystem. SD DENR suggests the current TSS standard of 158 mg/L needs to be changed to a site-specific standard of 2,000 mg/L based on chemical, biological and geological data. This change would still be protective, based on available data and §§ 74:51:01:34 antidegradation of waters of the state. As a result, the current impaired listing for the Little White River for TSS in the 2006

Integrated Report should be de-listing in the 2008 Integrated Report based on this assessment. Based on current data, elevated TSS concentrations in this watershed are a natural occurrence and a TMDL was not required.

The assessment also revealed TDS concentrations in Pine Creek violate current surface water quality standards based on (9) Fish and wildlife propagation, recreation, and stock watering water and (10) Irrigation water criteria. Current data from the North Branch of Pine Creek (LWR-03) and ancillary data from other watersheds located in Pierre Shale formations indicate elevated TDS concentrations are naturally occurring and relatively common in western South Dakota, especially during low flow conditions. Given the geologic makeup of the Pine Creek watershed and similar TDS/conductivity violation conditions in Medicine Creek, Cottonwood Creek and in the Freeman Dam watershed; the TDS violations in Pine Creek are from naturally occurring solutes originating from the Pierre Shale formations in western South Dakota. Based on data described in this and other assessment reports in the Pierre Shale formation, SD DENR recommends a modification in surface water quality standards for: Fish and wildlife propagation, recreation, and stock watering water and Irrigation waters. It is recommended that (9, 10) waters be amended into §§ 74:51:01:30 *Flow rates for low quality fishery waters* rule for flows at the 7Q5 or 1 cfs which ever is greater. During these conditions, water quality criteria set forth in §§ 74:51:01:52 (fish and wildlife propagation, recreation, and stock watering water) and §§ 74:51:01:53 (irrigation waters) do not apply to the water but all surface water discharge permit limits remain in place. Based on listing criteria set forth in the 2006 Integrated Report the North Branch of Pine Creek would meet amended water quality standards. As a result Pine Creek listing in the 2008 Integrated Report for TDS will be in the waterbodies to be de-listed based on this assessment. Based on current data, elevated TDS concentrations in this watershed are a natural occurrence and a TMDL was not required.

All other parameters studied during the assessment were meeting current water quality standards and were not considered a problem in this section of the Little White River. However, high total phosphorus concentrations and fecal coliform counts in Pine Creek should be addressed to improve overall water quality in both Pine Creek and the Little White River. Best Management Practices (BMPs) outlined in the AnnAGNPS report should be considered to reduce sediment and fecal coliform concentrations and loading. Any mitigation projects implemented in the Little White River watershed will improve overall water quality in the system

4.0 Public Involvement and Coordination

Public involvement and coordination were the responsibility of Mellette County Conservation District. As local sponsor for the project, they were responsible for issuing press releases and/or news bulletins. The project was discussed at monthly thirteen meetings of the Mellette County Conservation District Board, which is also a public setting where the public is invited to attend. The Mellette County Conservation District was the appropriate lead project sponsor for this project. The Conservation District was important to this project because of its working relationship with the stakeholders within the watershed.

4.1 State Agencies

Because the South Dakota Department of Environment and Natural Resources (SD DENR) is the statewide pollution control agency, it was the appropriate lead state agency for this project. SD DENR is responsible for tracking Section 319 funds and state and local match for federal funding. The Department (SD DENR) is also responsible for coordination and data collection for all assessment and implementation projects throughout the State of South Dakota.

South Dakota Department of Agriculture (SD DOA) provided conservation commission funds for this project.

South Dakota Game, Fish and Parks (SD GF&P) provided current and long-term fisheries data reports and endangered species list (Heritage List) for Little White River watershed. SD GF&P should be contacted and consulted during the planning and implementation phases of this project.

4.2 Federal Agencies

US Department of Agriculture Natural Resources Conservation Service (NRCS) provided office space and technical assistance for the project. NRCS is the contact for local landowners involved with conservation plans and practices. NRCS needs to be involved up front during all phases of the implementation process.

The United States Environmental Protection Agency (US EPA) provided financial assistance for the project. The US EPA provided $50,499.40 of Section 319 funds to cover project costs for the Little White River watershed assessment in which the Little White River watershed in Mellette County was assessed. EPA will also review and approve this assessment.

The United States Fish and Wildlife Service (US FWS) did not provide financial or technical assistance during the assessment project. However, they should be contacted prior to the implementation project regarding their role in the implementation of the TMDLs and the potential impact on any endangered species (consultation process).

The United States Geological Survey (USGS) did not provide financial support during the assessment project. However, they did provide technical assistance USGS gage data and information on the Little White River watershed assessment in Todd County on the Rosebud Indian Reservation. USGS should be contacted prior to the implementation of any project regarding their role in the implementation BMPs and the potential impact on any endangered species (consultation process).

4.3 Local Governments, Industry, Environmental, and Other Groups; Public-at-Large

The Mellette County Conservation District within the Little White River watershed took a leading role in the planning and implementation of this project. This was evident during the assessment phase and becomes more important during the implementation phase when conservation practices need to be coordinated and implemented with local landowners.

4.4 Other Sources of Funds

The Little White River Watershed Assessment project was funded with Section 319, state funds and local funds. Conservation Commission funds along with funds from Mellette County Conservation District were also secured for this project.

Funding Category	Source	Total
EPA Section 319 Funds	US EPA	$50,499.40
State Fee Fund	State	17,000.00
Conservation Commission	State	$9,500.00
Conservation District	Local	$7,160.00
Total Budget		**$84,159.40**

5.0 Aspects of the Project That Did Not Work Well

The Little White River watershed assessment project progressed well and stayed on schedule. Thanks to the local coordinator and the Mellette County Conservation District there were no significant time delays.

6.0 Future Activity Recommendations

The Little White River watershed in Mellette County is an estimated 98,280 ha (242,855 acres) in size. This assessment project revealed two parameters, TSS and TDS, as violating surface water quality standards. The assessment also documented, based on long-term USGS, SD DENR WQM data and biological communities, that TSS concentrations in the Little White River were a natural occurrence for this system and a site-specific water quality standard of 2,000 mg/L be adopted for this stream segment. Furthermore, TDS violations during low flows in Pine Creek, based on geology and other assessed waterbodies in the Pierre Shale formation located in western South Dakota, were also a natural occurrence in this watershed. SD DENR recommends a modification in surface water quality standards to include fish and wildlife propagation, recreation, and stock watering water and irrigation water beneficial use categories be amended into §§ 74:51:01:30 *Flow rates for low quality fishery waters* rule for flows at the 7Q5 or 1 cfs which ever is greater. During these conditions, water quality criteria set forth in §§ 74:51:01:52 (Fish and wildlife propagation, recreation, and stock watering water) and §§ 74:51:01:53 (Irrigation waters) would not apply to the water but all surface water discharge permit limits remain in place. After the site-specific standard for TSS and surface water quality standards are modified for TDS and conductivity to reflect natural conditions in the watershed; requirements for TMDLs will not be needed because the Little White River will meet adjusted water quality standards which reflect natural conditions in this watershed.

Any future work by local land owners, Mellette County Conservation District, Natural Resource Conservation Service, U.S. Fish and Wildlife Service or other entity in the Little White River watershed especially in Pine Creek should be encouraged, based on findings of this assessment. High total phosphorus concentrations and fecal coliform counts in Pine Creek should be addressed to improve overall water quality in both Pine Creek and the Little White River. Best management practices (BMPs) outlined in the AnnAGNPS report should be considered to reduce sediment, phosphorus and fecal coliform concentrations and loading and improve water quality in these watersheds.

References Cited

Allan, J. D. 1995. Stream Ecology Structure and Function of Running Waters. Chapman & Hall Publishers. London. 388pp.

Bailey, R.M., and M.O. Allum. 1962. Fishes of South Dakota. University of Michigan Museaum of Zoology Miscvellaueous Publication 119.

Bliss, Q.P., and S. Schainost. 1973. White River-Hat Creek stream inventory report. Nebraska Game and Parks Comission. Project F-9-R.

Brower, J.E., and Zar, J.H. 1984. Field & Laboratory Methods for General Ecology, 2rd Edition. Wm. C. Brown Publishers, Dubuque, Iowa. 226 pp.

Bryce, S.A., J.M. Omernik, D.E. Pater, M. Ulmer, J. Schaar, J. Freeouf, R. Johnson, P. Kuck, and S.H. Azevedo. 1998. *Ecoregions of North Dakota and South Dakota*. Map. U.S. Environmental Protection Agency, Office of Research and Development, Regional Applied Research Effort (RARE) program.

Canfield, D.E. Jr., K.A. Langland, S.B. Linda, and W.T. Haller. 1985. Relations between water transparency and maximum depth of macrophyte colonization in lakes. Journal of Aquatic Plant Management 23: 25-28.

Carlson, R. E. 1977. A Trophic State Index for Lakes. Limnology and Oceanography. 22:361 - 369.

Cole G.A. 1988. Textbook of Limnology Third Edition. Waveland Press, Inc., Prospect Heights, Illinois. 401 pp.

Crow G.E., and C.B. Hellquist. 2000. Aquatic and Wetland Plants of Northeastern North America, Volume 1. The University of Wisconsin Press, Madison, Wisconsin. 536 pp.

_____. 2000a. Aquatic and Wetland Plants of Northeastern North America, Volume 2. The University of Wisconsin Press, Madison. Wisconsin. 456 pp.

CTIC, 1999. Effectiveness Varies with Width and Age. Conservation Technology Information Center, Partners, Summer 1999. p. 9.

Cunningham, G.R., R.D. Olson, and S.M. Hickey. 1995. Fish surveys of the streams and rivers in south central South Dakota west of the Missouri River. Proceedings of the South Dakota Academy of Science 74:55-64.

Fryda, D.D. 2001. A survey of the fishes and habitat of the White River, South Dakota. M.S. Thesis, South Dakota State University, Brookings.

Grimm, N.B. and S.G. Fisher. 1986. Nitrogen Limitation in a Sonoran Desert stream. *J. N. Am Benthol. Soc*, 5, pp 2-15

Harland, B.C. 2003. Survey of fishes and habitat of western South Dakota streams. M.S. Thesis, South Dakota State University, Brookings.

Hauer, F.R., and W.R. Hill. 1996. Temperature, Light and Oxygen. in Stream Ecology. Academic Press, San Diego. California. pp. 93-106.

Hutchinson, G.E., 1957. A Treatise on Limnology, Volume 2. Wiley, New York, and London. 1115 pp.

Hynes, H.B.N. 1969. The Enrichment of Streams. in Eutrophication: Causes, Consequences, Correctives. National Academy of Sciences, Washington, DC. pp. 188-196.

Koth, R.M. 1981. South Dakota Lakes Survey. South Dakota Department of Environment and Natural Resources. Office of Water Quality. Joe Foss Building, Pierre, South Dakota. 688pp.

Lorenzen, P.M., S.M Kruger, A. Repsys, and L.P Kuck. 2004. Phase I Watershed Assessment Report, Hayes Lake/Frozen Man Creek, Stanley County, South Dakota. Water Resources Assistance Program, South Dakota Department of Environment and Natural Resources, Pierre, South Dakota. 134 pp.

Lind, O. T. 1985. Handbook of Common Methods used in Limnology, 2nd Edition. Kendall/Hunt Publishing Company, Dubuque, Iowa. 199 pp.

MI DEQ. 1999. Pollutants Controlled Calculation and Documentation for Section 319 Watersheds Training Manual, 1999 Revision. Michigan Department of Environmental Quality, Surface Water Quality Division, Nonpoint Source Unit, Lansing, Michigan. 58 pp.

MSP. 1976. Livestock Waste Facilities Handbook. The Midwest Plan Service, Iowa State University, Ames. Iowa. 94 pp.

Odum, E. P. 1959. Fundamentals of Ecology, 2nd Edition. W.B. Saunders Co., Philadelphia, Pennsylvania. 545 pp.

Omernik, J.M. 1977. Nonpoint Source-Stream Nutrient Level Relationship: A Nationwide Study. EPA-600/3-77-105.

Prescott, G.W. 1962. Algae of the Western Great Lakes Area. Wm. C. Brown Publishers. Dubuque, Iowa. 977pp.

Pringle, C.M., and J.A. Bowers, 1984. An in situ substratum fertilization Technique: Diatom Colonization on Nutrient-enriched, sand substrata. Canadian Journal of Fish. Aquat. Sci. 41:1247-1251.

Redfield, A.C., B.H. Ketchum, and F.A. Richards. 1963. The influence of organisms on the composition of sea water, in The Sea, Volume 2, (ed. M.N. Hill), Interscience, New York, New York. pp. 26-77.

Reid, G.K., 1961. Ecology of Inland Waters and Estuaries. Reinhold Publishing Company. 375 pp.

RESPEC. 2005. Phase I Environmental Assessment of the White River Watershed White River, South Dakota. RESPEC Consulting & Services 3824 Jet Drive Rapid City, South Dakota. 181 pp.

Round, F.E. 1965. The Biology of the Algae. Edward Arnold Publishers Ltd. 269pp.

Schumm, S.A., M.D. Harvey, and C.C. Watson. 1984. Incised Channels Morphology, Dynamics and Control. Water Resources Publications. Littleton, Colorado. 197 pp.

Smith, R.L., 2005. Phase I Watershed Assessment Report and TMDL Medicine Creek, Lyman and Jones Counties, South Dakota. South Dakota Department of Environment and Natural Resources, Pierre, South Dakota. 281 pp.

Smith, R.L. 2007. Phase I Watershed Assessment Report and TMDL Cottonwood Creek, Mellette County, South Dakota. Draft Report. South Dakota Department of Environment and Natural Resources, Pierre, South Dakota. .

SD DENR. 1990. Phase I Diagnostic Feasibility Study Final Report. Richmond Lake, Brown County, South Dakota. South Dakota Clean Lakes Program. South Dakota Department of Water and Natural Resources, Pierre, South Dakota. 74pp.

SD DENR. 1998. The 1998 South Dakota 303(d) Waterbody List and Supporting Documentation. South Dakota Department of Environment and Natural Resources, Pierre, South Dakota. 94 pp.

_______. 1998a. The 1998 South Dakota Report to Congress 305(b) Water Quality Assessment. South Dakota Department of Environment and Natural Resources, Pierre, South Dakota. 235 pp.

_______. 1998b. South Dakota Unified Watershed Assessment. South Dakota Department of Environment and Natural Resources, Pierre, South Dakota. 60 pp.

_______. 1998c. Quality Assurance Project Plan. South Dakota Department of Environment and Natural Resources, Pierre, South Dakota. 41 pp.

SD DENR. 2000. Standard Operating Procedures for Field Samplers. South Dakota Department of Environment and Natural Resources, Pierre, South Dakota. 303 pp.

_______. 2000a. Ecoregion Targeting for Impaired Lakes in South Dakota. South Dakota Department of Environment and Natural Resources, Pierre, South Dakota. 94 pp.

_______. 2000b. The 2000 South Dakota Report to Congress 305(b) Water Quality Assessment. South Dakota Department of Environment and Natural Resources, Pierre, South Dakota. 262 pp.

SD DENR. 2002. South Dakota Total Maximum Daily Load Waterbody List with Supporting Documentation. South Dakota Department of Environment and Natural Resources, Pierre, South Dakota. 58 pp.

SD DENR. 2004. The 2004 South Dakota Integrated Report for Surface Water Quality Assessment. South Dakota Department of Environment and Natural Resources, Pierre, South Dakota. 220 pp.

SD DENR. 2005. Standard Operating Procedures for Field Samplers. Volume I. South Dakota Department of Environment and Natural Resources, Pierre, South Dakota. 175 pp.

______. 2005a. Standard Operating Procedures for Field Samplers. Volume II. South Dakota Department of Environment and Natural Resources, Pierre, South Dakota. 123 pp.

SD DENR. 2006. The 2006 South Dakota Integrated Report for Surface Water Quality Assessment. South Dakota Department of Environment and Natural Resources, Pierre, South Dakota. 203 pp.

SDDH. 2006. Personal communications. South Dakota Department of Health State Public Health Laboratory.

Shapiro J., 1973. Blue-green algae: why they become dominant. Science. Vol.179. pp.382-384.

Stockner, J.G., and K. R. S. Shortreed. 1978. Enhancement of autotrophic production by nutrient addition in a coastal rainforest stream on Vancouver Island. Journal of the Fisheries Board of Canada, 35, 28-34.

Stueven E.H., and W.C. Stewart. 1996. 1995 South Dakota Lakes Assessment Final Report. Watershed Protection Program, South Dakota Department of Environment and Natural Resources, Pierre, South Dakota. 760 pp.

Stueven, E.H., and R. Bren. 1999. Phase I Watershed Assessment Final Report, Blue Dog Lake, Day County, South Dakota. South Dakota Department of Environment and Natural Resources, Pierre, South Dakota. 157 pp.

Sweetwater, 2000. Control of Algae with Alum/Sodium Aluminate. SweetwaterTechnology Corporation. http://www.aitkin.com/sweetwater/algae. Aitkin, Minnesota.

Sweet, J. W. 1986. Survey and Ecological Analysis of Oregon and Idaho Phytoplankton. Final Report to EPA, Seattle, WA. 47 pp.

USDA. 1987. Soil Survey of Lyman County. United States Department of Agriculture, Soil Conservation Service. 129 pp.

US EPA. 2001. Protocol for Developing Pathogen TMDLs. First Edition. EPA 841-R-00-002. United States Environmental Protection Agency. Washington, DC. 132 pp.

US EPA. 1990. Clean Lakes Program Guidance Manual. EPA-44/4-90-006. . United States Environmental Protection Agency. Washington, DC. 326 pp.

US F&WS. 1997. Fishes of the Little White River south central South Dakota. U.S. Fish and Wildlife Service, Pierre.

Usinger, R.L. 1968. Aquatic insects of California. University of California Press. Berkeley and Los Angeles, California. 508 pp.

Vollenwieder, R.A. and J. Kerekes. 1980. The Loading Concept as a Basis for Controlling Eutrophication Philosophy and Preliminary Results of the OECD Programme on Eutrophication. Prog. Water Technol. 12:3-38.

Walker, W. W. 1999. Simplified Procedures for Eutrophication Assessment and Prediction: User Manual. United States Army Corps of Engineers. Washington DC. 232 pp.

Welch, B.W., and G.D. Cooke. 1995. Effectiveness and Longevity of Alum Treatments in Lakes. University of Washington, Department of Civil Engineering, Environmental Engineering and Science, Seattle, Washington. 88 pp.

Wetzel, R.G., and G.E. Likens. 1991. Limnological Analysis, 2nd Edition.Springer-Verlag New York, Inc., New York, New York. 391 pp.

Wetzel, R.G. 1983. Limnology 2nd Edition. Saunders College Publishing, Philadelphia, Pennsylvania. 858pp.

Wetzel, R.G. 2001. Limnology Lake and River Ecosystems 3rd Edition. Academic Press, San Diego, California. 1,006 pp.

Williamson, J.E. Water-Quality and Biological Characteristics of the Little White River and Selected Tributaries, Todd County, South Dakota, 2002-2003. U.S. Geological Survey Scientific Investigations Report 2005-5267. 76p.

WWP. 1941. South Dakota Place Names. Workers of the Writers Program of the Work Projects' Administration in the State of South Dakota. University of South Dakota, Vermillion, South Dakota. 689 pp.

Young, R.A., C.A. Onstad, D.D. Bosh, and W.P. Anderson. 1986. AGNPS, Agricultural Nonpoint Source Pollution Model. USDA-ARS Conservation Research Report 35. 89 pp.

Zicker, E.L., K.C. Berger, and A.D. Hasler, 1956. Phosphorus release form bog lake muds. Limnology and Oceanography. 1:296-303.

APPENDIX A

Little White River Tributary Stage Discharge Regression Graphs and Equations from 2003 through 2004

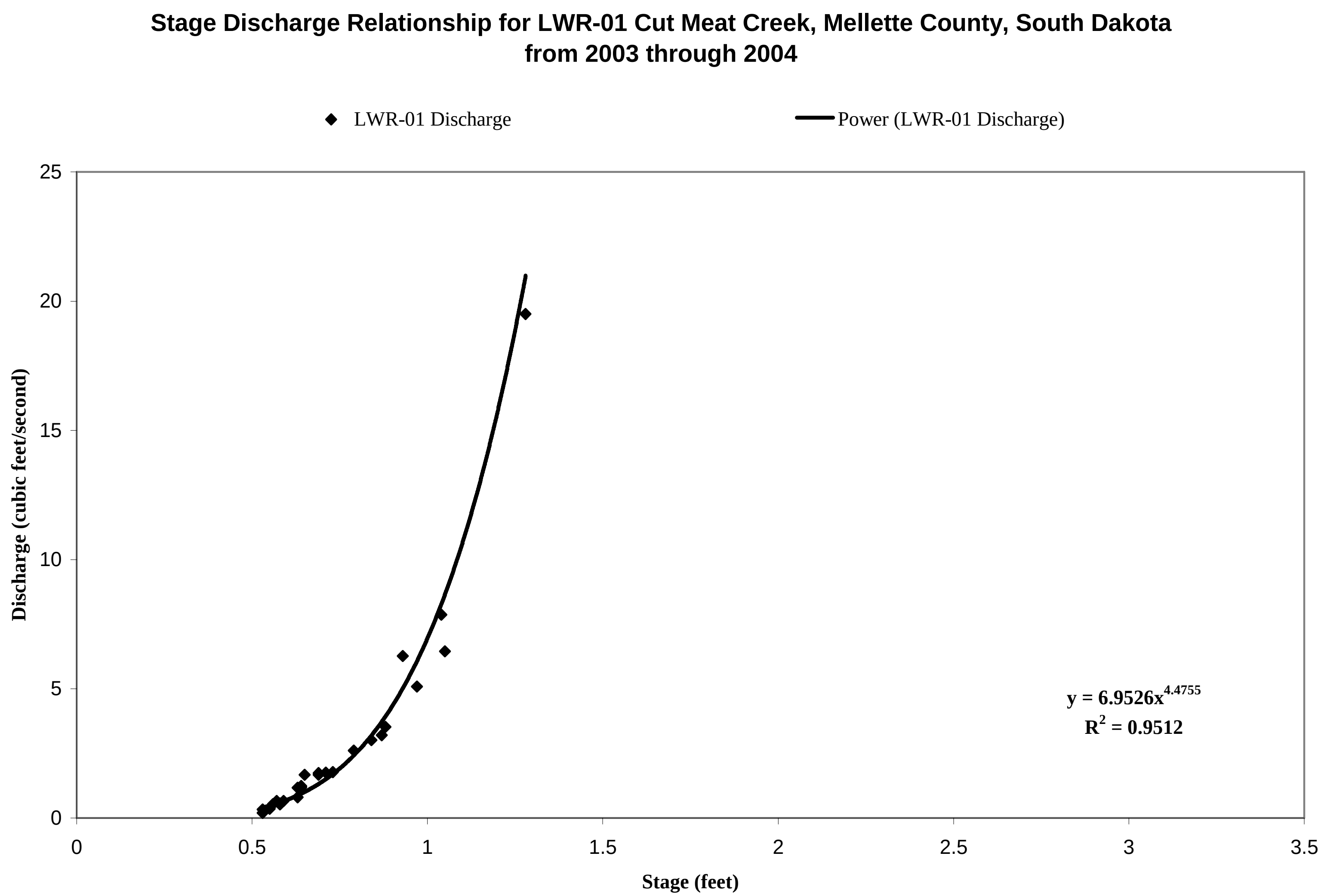


Figure A-1. Stage discharge relationship for LWR-1, Cut Meat Creek, Mellette County, South Dakota from 2003 through 2004.

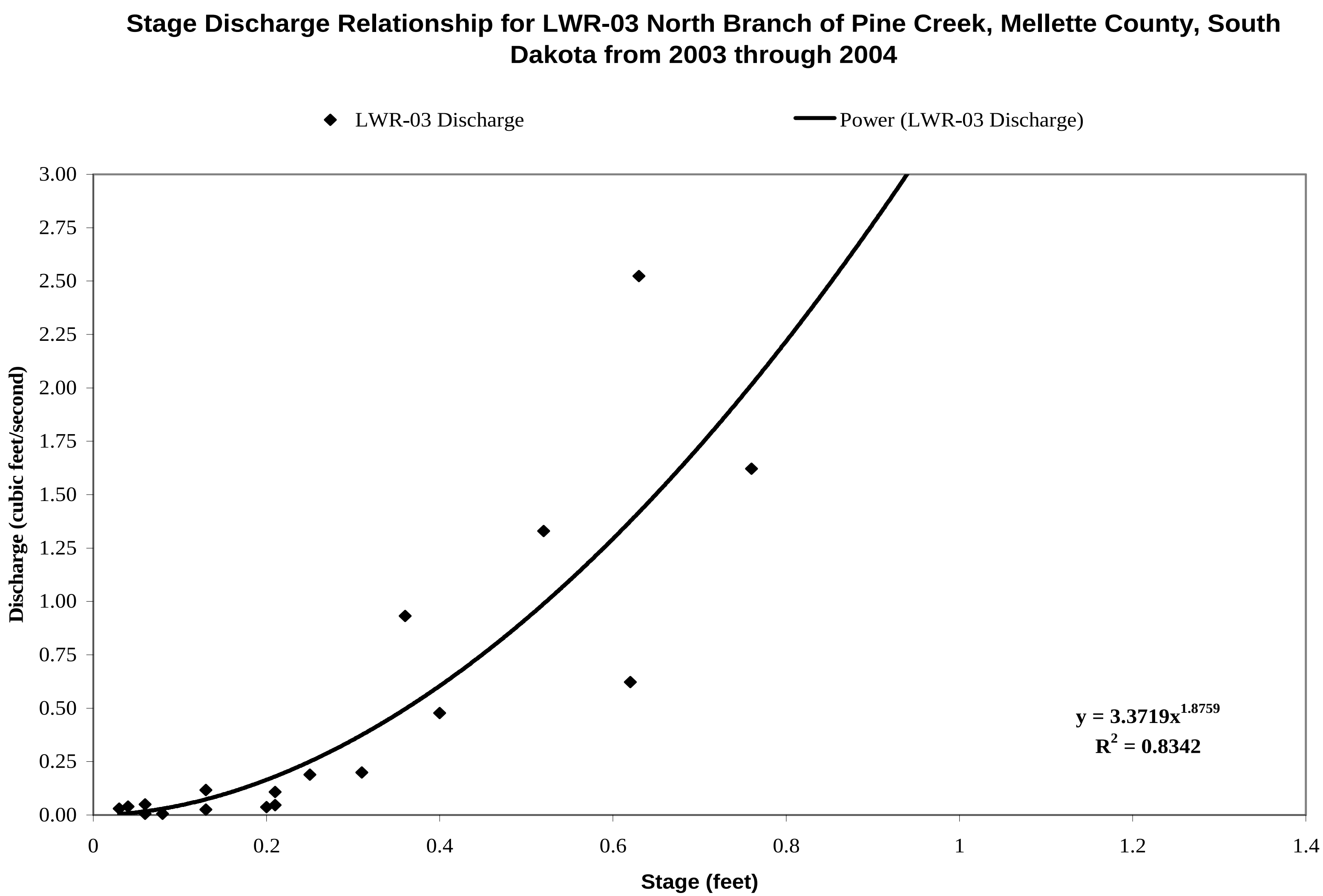


Figure A-2. Stage discharge relationship for LWR-03, North Branch of Pine Creek, Mellette County, South Dakota from 2003 through 2004.

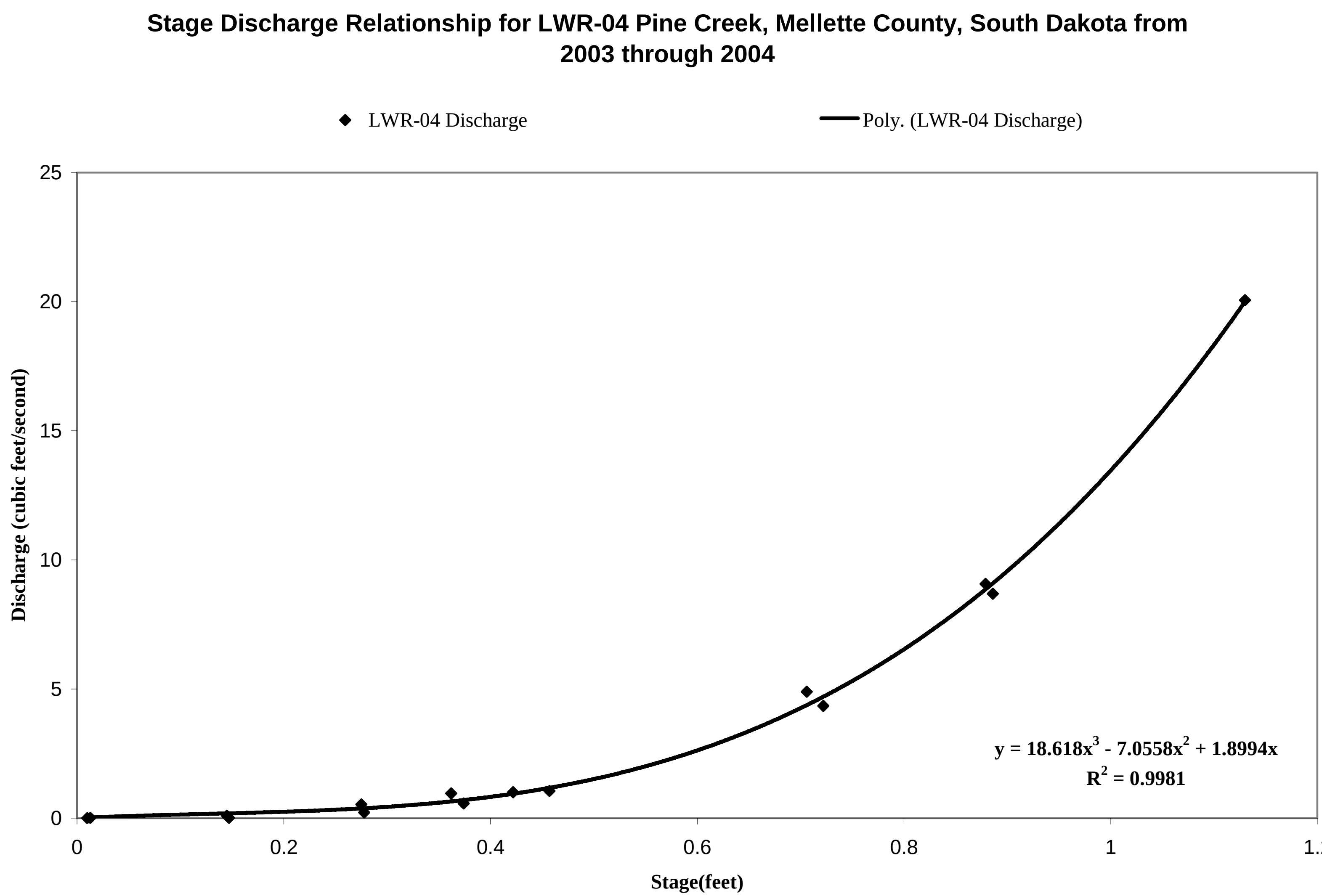


Figure A-3. Stage discharge relationship for LWR-04, Pine Creek, Mellette County, South Dakota from 2003 through 2004.

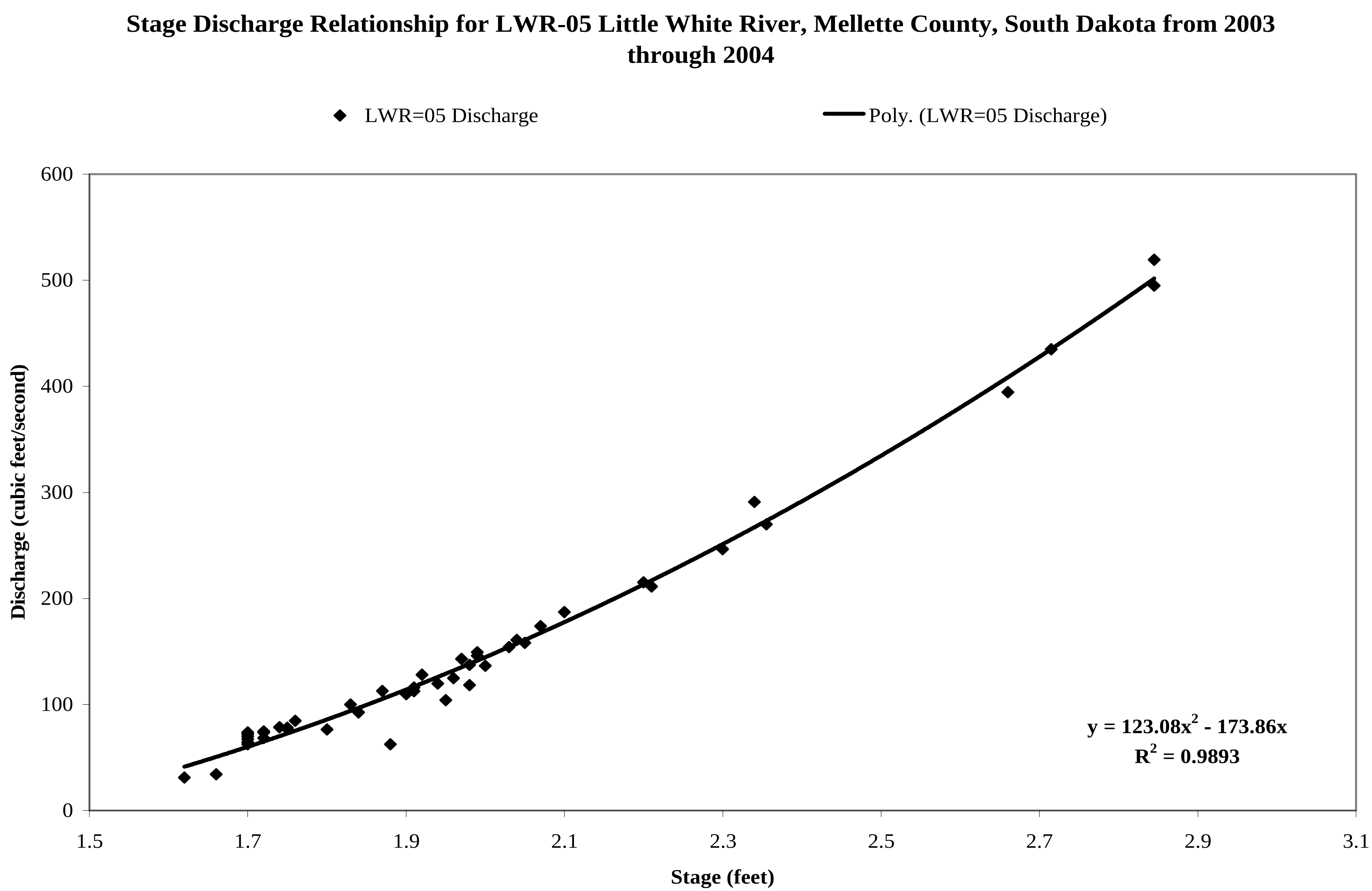


Figure A-4. Stage discharge relationship for LWR-05, Little White River, Mellette County, South Dakota from 2003 through 2004.

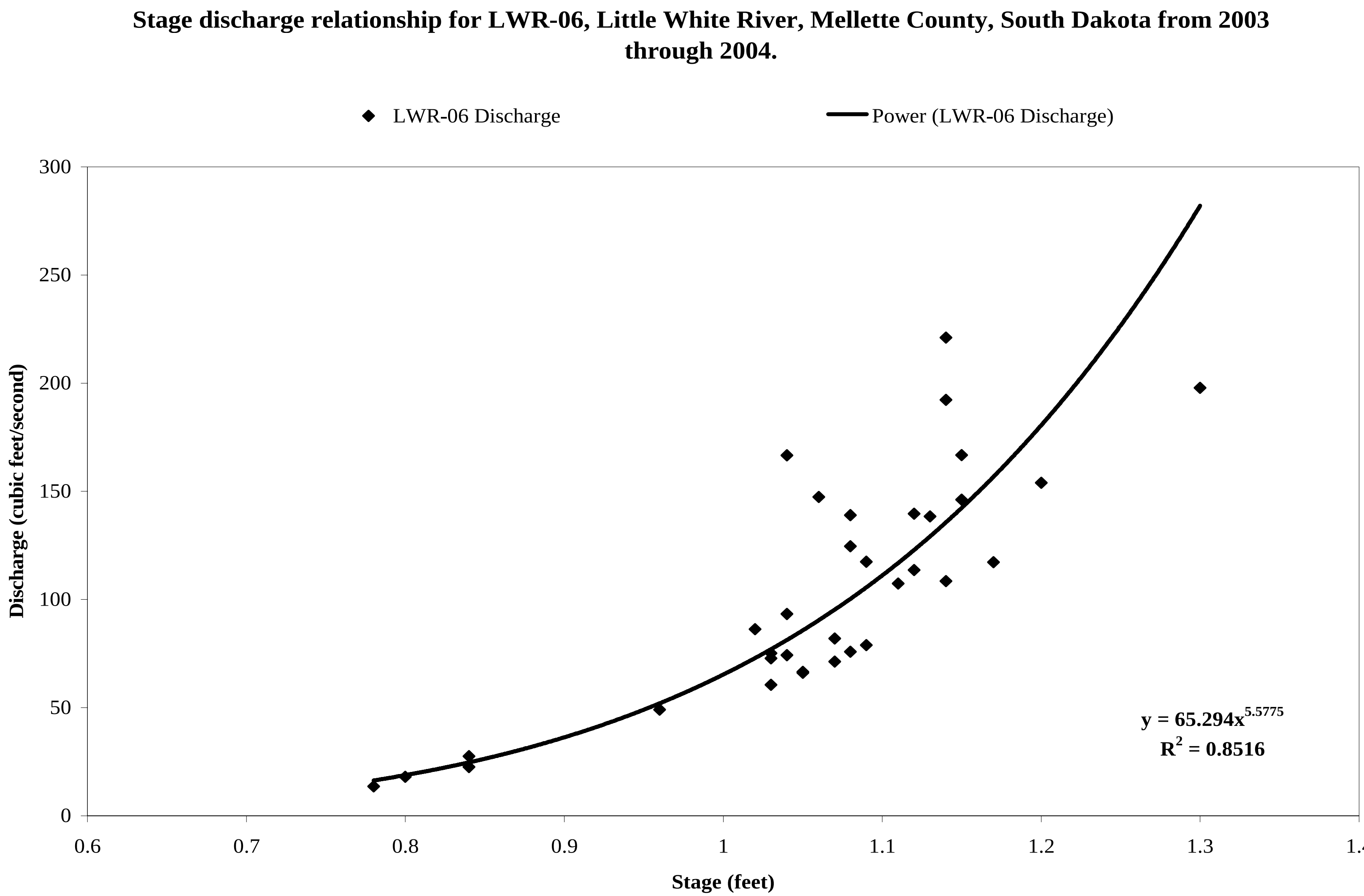


Figure A-5. Stage discharge relationship for LWR-06, Little White River, Mellette County, South Dakota from 2003 through 2004.

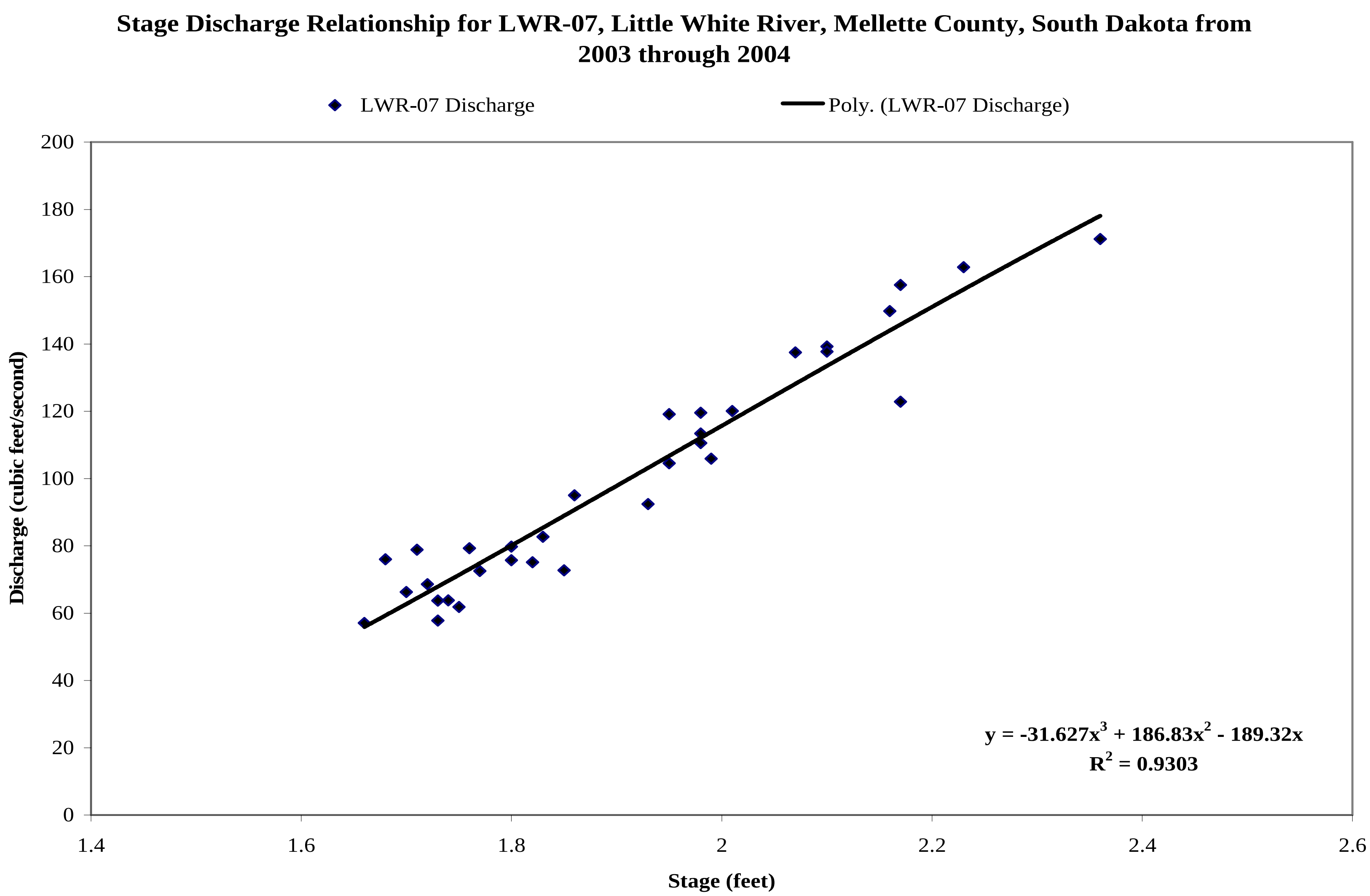


Figure A-6. Stage discharge relationship for LWR-07, Little White River, Mellette County, South Dakota from 2003 through 2004.

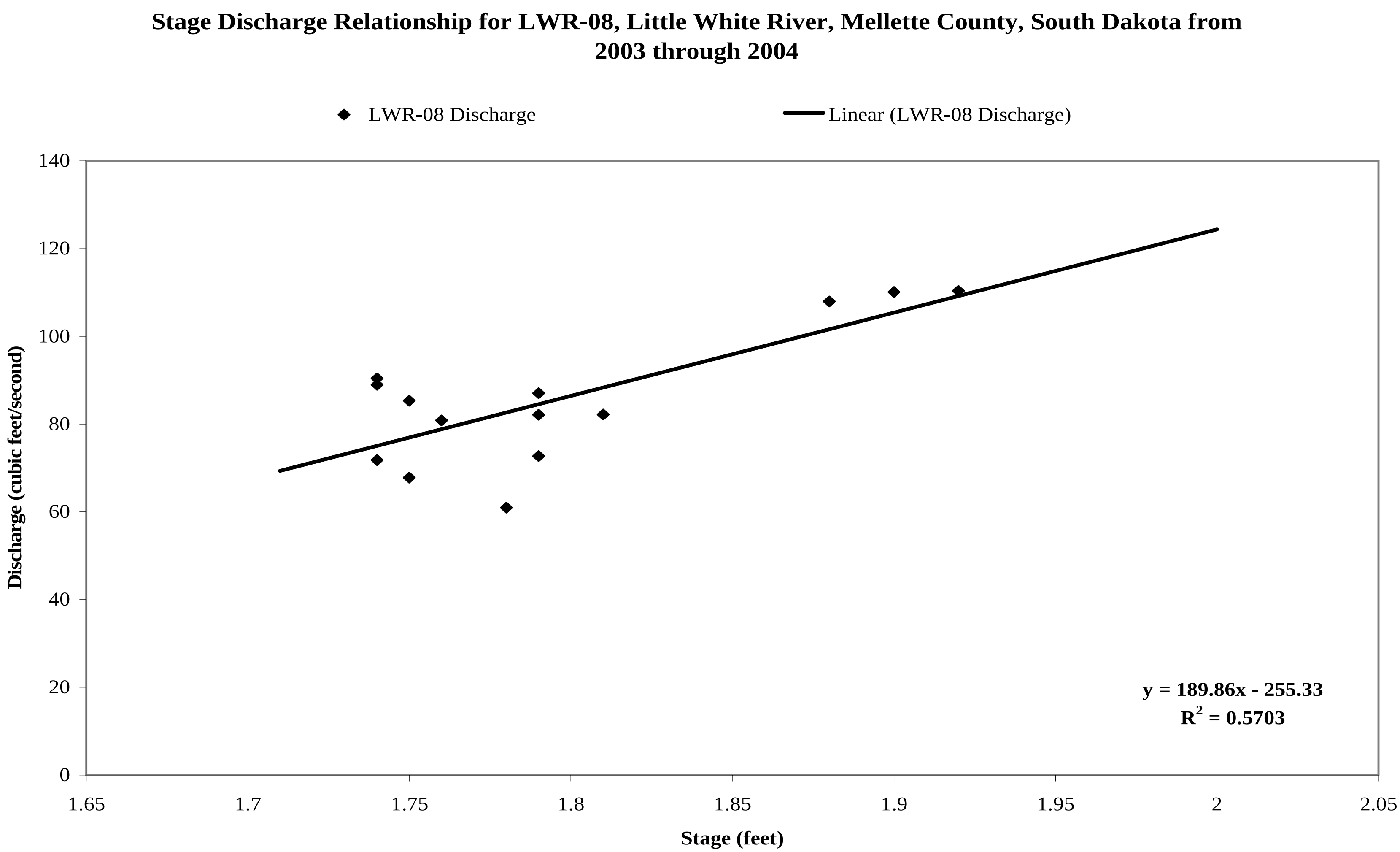


Figure A-7. Stage discharge relationship for MCT-9, Medicine Creek, Lyman and Jones Counties, South Dakota from 2000 through 2001.

APPENDIX B

Multiple Comparison Matrix Tables for Concentrations and Loading for the Little White River, Mellette County from 2003 through 2004

Table B-1. Little White River conductivity @ 25° C (µS/cm) comparisons between sampling sites, highlighted = significantly different.

Depend.: Specific Conductivity	Multiple Comparisons p values (2-tailed); Specific Conductivity (Concentrations) Independent (grouping) variable: StationID Kruskal-Wallis test: H (6, N= 84) =23.46712 p =.0007						
	LWR01 (Cut Meat Creek) R:70.000	LWR07 (Little White River) R:29.806	LWR08 (Little White River) R:34.167	LWR03 (Pine Creek) R:41.889	LWR04 (Pine Creek) R:69.100	LWR05 (Little White River) R:38.816	LWR06 (Little White River) R:41.028
LWR01 (Cut Meat Creek)		0.001140	0.111622	0.304442	1.000000	0.033208	0.076053
LWR07 (Little White River)	0.001140		1.000000	1.000000	0.030229	1.000000	1.000000
LWR08 (Little White River)	0.111622	1.000000		1.000000	0.378550	1.000000	1.000000
LWR03 (Pine Creek)	0.304442	1.000000	1.000000		0.955505	1.000000	1.000000
LWR04 (Pine Creek)	1.000000	0.030229	0.378550	0.955505		0.283661	0.479086
LWR05 (Little White River)	0.033208	1.000000	1.000000	1.000000	0.283661		1.000000
LWR06 (Little White River)	0.076053	1.000000	1.000000	1.000000	0.479086	1.000000	

Table B-2. Little White River dissolved oxygen concentrations (mg/L) comparisons between sampling sites, highlighted = significantly different.

Depend.: Dissolved Oxygen	Multiple Comparisons p values (2-tailed); Dissolved Oxygen (Concentrations) Independent (grouping) variable: StationID Kruskal-Wallis test: H (6, N= 84) =3.200740 p =.7833						
	LWR01 (Cut Meat Creek) R:48.222	LWR07 (Little White River) R:42.750	LWR08 (Little White River) R:47.167	LWR03 (Pine Creek) R:36.778	LWR04 (Pine Creek) R:36.500	LWR05 (Little White River) R:47.500	LWR06 (Little White River) R:37.083
LWR01 (Cut Meat Creek)		1.000000	1.000000	1.000000	1.000000	1.000000	1.000000
LWR07 (Little White River)	1.000000		1.000000	1.000000	1.000000	1.000000	1.000000
LWR08 (Little White River)	1.000000	1.000000		1.000000	1.000000	1.000000	1.000000
LWR03 (Pine Creek)	1.000000	1.000000	1.000000		1.000000	1.000000	1.000000
LWR04 (Pine Creek)	1.000000	1.000000	1.000000	1.000000		1.000000	1.000000
LWR05 (Little White River)	1.000000	1.000000	1.000000	1.000000	1.000000		1.000000
LWR06 (Little White River)	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	

Table B-3. Little White River pH value (su) comparisons between sampling sites, highlighted = significantly different.

Depend.: pH	Multiple Comparisons p values (2-tailed); pH (Concentrations) Independent (grouping) variable: StationID Kruskal-Wallis test: H (6, N= 85) =13.95082 p =.0302						
	LWR01 (Cut Meat Creek) R:29.833	LWR07 (Little White River) R:45.763	LWR08 (Little White River) R:36.000	LWR03 (Pine Creek) R:44.333	LWR04 (Pine Creek) R:12.600	LWR05 (Little White River) R:47.447	LWR06 (Little White River) R:52.083
LWR01 (Cut Meat Creek)		1.000000	1.000000	1.000000	1.000000	1.000000	0.571843
LWR07 (Little White River)	1.000000		1.000000	1.000000	0.157740	1.000000	1.000000
LWR08 (Little White River)	1.000000	1.000000		1.000000	1.000000	1.000000	1.000000
LWR03 (Pine Creek)	1.000000	1.000000	1.000000		0.444380	1.000000	1.000000
LWR04 (Pine Creek)	1.000000	0.157740	1.000000	0.444380		0.104348	0.032625
LWR05 (Little White River)	1.000000	1.000000	1.000000	1.000000	0.104348		1.000000
LWR06 (Little White River)	0.571843	1.000000	1.000000	1.000000	0.032625	1.000000	

Table B-4. Little White River transparency tube depth (m) comparisons between sampling sites, highlighted = significantly different.

Depend.: Secchi (m)	Multiple Comparisons p values (2-tailed); Secchi (m) (Concentrations) Independent (grouping) variable: StationID Kruskal-Wallis test: H (6, N= 88) =33.53157 p =.0000						
	LWR01 (Cut Meat Creek) R:58.389	LWR07 (Little White River) R:57.395	LWR08 (Little White River) R:54.083	LWR03 (Pine Creek) R:13.950	LWR04 (Pine Creek) R:7.4000	LWR05 (Little White River) R:47.690	LWR06 (Little White River) R:44.306
LWR01 (Cut Meat Creek)		1.000000	1.000000	0.003217	0.007264	1.000000	1.000000
LWR07 (Little White River)	1.000000		1.000000	0.000282	0.002075	1.000000	1.000000
LWR08 (Little White River)	1.000000	1.000000		0.049334	0.053482	1.000000	1.000000
LWR03 (Pine Creek)	0.003217	0.000282	0.049334		1.000000	0.012332	0.054384
LWR04 (Pine Creek)	0.007264	0.002075	0.053482	1.000000		0.032088	0.089637
LWR05 (Little White River)	1.000000	1.000000	1.000000	0.012332	0.032088		1.000000
LWR06 (Little White River)	1.000000	1.000000	1.000000	0.054384	0.089637	1.000000	

Table B-5. Little White River turbidity (NTU) value comparisons between sampling sites, highlighted = significantly different.

Depend.: Turbidity	LWR01 (Cut Meat Creek) R:28.286	LWR07 (Little White River) R:22.417	LWR08 (Little White River) R:23.200	LWR03 (Pine Creek) R:56.571	LWR04 (Pine Creek) R:54.000	LWR05 (Little White River) R:29.857	LWR06 (Little White River) R:26.846
Multiple Comparisons p values (2-tailed); Turbidity (Concentrations) Independent (grouping) variable: StationID Kruskal-Wallis test: H (6, N= 63) =25.72068 p =.0003							
LWR01 (Cut Meat Creek)		1.000000	1.000000	0.081703	0.348279	1.000000	1.000000
LWR07 (Little White River)	1.000000		1.000000	0.001876	0.025369	1.000000	1.000000
LWR08 (Little White River)	1.000000	1.000000		0.039395	0.165684	1.000000	1.000000
LWR03 (Pine Creek)	0.081703	0.001876	0.039395		1.000000	0.034486	0.011382
LWR04 (Pine Creek)	0.348279	0.025369	0.165684	1.000000		0.240844	0.102424
LWR05 (Little White River)	1.000000	1.000000	1.000000	0.034486	0.240844		1.000000
LWR06 (Little White River)	1.000000	1.000000	1.000000	0.011382	0.102424	1.000000	

Table B-6. Little White River water temperature (^{o}C) comparisons between sampling sites, highlighted = significantly different.

Depend.: Water Temperature C	LWR01 (Cut Meat Creek) R:40.889	LWR07 (Little White River) R:44.611	LWR08 (Little White River) R:46.000	LWR03 (Pine Creek) R:30.556	LWR04 (Pine Creek) R:29.600	LWR05 (Little White River) R:43.100	LWR06 (Little White River) R:51.278
Multiple Comparisons p values (2-tailed); Water Temperature C (Concentrations) Independent (grouping) variable: StationID Kruskal-Wallis test: H (6, N= 85) =6.018175 p =.4212							
LWR01 (Cut Meat Creek)		1.000000	1.000000	1.000000	1.000000	1.000000	1.000000
LWR07 (Little White River)	1.000000		1.000000	1.000000	1.000000	1.000000	1.000000
LWR08 (Little White River)	1.000000	1.000000		1.000000	1.000000	1.000000	1.000000
LWR03 (Pine Creek)	1.000000	1.000000	1.000000		1.000000	1.000000	0.834276
LWR04 (Pine Creek)	1.000000	1.000000	1.000000	1.000000		1.000000	1.000000
LWR05 (Little White River)	1.000000	1.000000	1.000000	1.000000	1.000000		1.000000
LWR06 (Little White River)	1.000000	1.000000	1.000000	0.834276	1.000000	1.000000	

Table B-7. Little White River fecal coliform bacteria (colonies/100 ml) comparisons between sampling sites, highlighted = significantly different.

Depend.: Fecal Coliform	LWR01 (Cut Meat Creek) R:39.188	LWR07 (Little White River) R:30.583	LWR08 (Little White River) R:35.500	LWR03 (Pine Creek) R:67.375	LWR04 (Pine Creek) R:67.750	LWR05 (Little White River) R:34.889	LWR06 (Little White River) R:30.441
	Multiple Comparisons p values (2-tailed); Fecal Coliform (Concentrations) Independent (grouping) variable: StationID Kruskal-Wallis test: H (6, N= 76) =25.85193 p =.0002						
LWR01 (Cut Meat Creek)		1.000000	1.000000	0.224377	0.728195	1.000000	1.000000
LWR07 (Little White River)	1.000000		1.000000	0.001853	0.048909	1.000000	1.000000
LWR08 (Little White River)	1.000000	1.000000		0.693053	1.000000	1.000000	1.000000
LWR03 (Pine Creek)	0.224377	0.001853	0.693053		1.000000	0.011258	0.002013
LWR04 (Pine Creek)	0.728195	0.048909	1.000000	1.000000		0.149151	0.049657
LWR05 (Little White River)	1.000000	1.000000	1.000000	0.011258	0.149151		1.000000
LWR06 (Little White River)	1.000000	1.000000	1.000000	0.002013	0.049657	1.000000	

Table B-8. Little White River alkalinity concentration (mg/L) comparisons between sampling sites, highlighted = significantly different.

Depend.: Alkalinity	LWR01 (Cut Meat Creek) R:67.667	LWR07 (Little White River) R:28.474	LWR08 (Little White River) R:31.750	LWR03 (Pine Creek) R:58.800	LWR04 (Pine Creek) R:71.500	LWR05 (Little White River) R:40.476	LWR06 (Little White River) R:43.333
	Multiple Comparisons p values (2-tailed); Alkalinity (Concentrations) Independent (grouping) variable: StationID Kruskal-Wallis test: H (6, N= 88) =25.66293 p =.0003						
LWR01 (Cut Meat Creek)		0.003148	0.160486	1.000000	1.000000	0.158618	0.412512
LWR07 (Little White River)	0.003148		1.000000	0.049938	0.016923	1.000000	1.000000
LWR08 (Little White River)	0.160486	1.000000		0.846847	0.213849	1.000000	1.000000
LWR03 (Pine Creek)	1.000000	0.049938	0.846847		1.000000	1.000000	1.000000
LWR04 (Pine Creek)	1.000000	0.016923	0.213849	1.000000		0.308109	0.612919
LWR05 (Little White River)	0.158618	1.000000	1.000000	1.000000	0.308109		1.000000
LWR06 (Little White River)	0.412512	1.000000	1.000000	1.000000	0.612919	1.000000	

Table B-9. Little White River total solids concentration (mg/L) comparisons between sampling sites, highlighted = significantly different.

Depend.: Total Solids	Multiple Comparisons p values (2-tailed); Total Solids (Concentrations) Independent (grouping) variable: StationID Kruskal-Wallis test: H (6, N= 88) =37.44302 p =.0000						
	LWR01 (Cut Meat Creek) R:37.778	LWR07 (Little White River) R:31.211	LWR08 (Little White River) R:33.167	LWR03 (Pine Creek) R:79.900	LWR04 (Pine Creek) R:81.200	LWR05 (Little White River) R:40.000	LWR06 (Little White River) R:41.056
LWR01 (Cut Meat Creek)		1.000000	1.000000	0.006985	0.048498	1.000000	1.000000
LWR07 (Little White River)	1.000000		1.000000	0.000022	0.002079	1.000000	1.000000
LWR08 (Little White River)	1.000000	1.000000		0.008327	0.039959	1.000000	1.000000
LWR03 (Pine Creek)	0.006985	0.000022	0.008327		1.000000	0.001009	0.002429
LWR04 (Pine Creek)	0.048498	0.002079	0.039959	1.000000		0.025026	0.039502
LWR05 (Little White River)	1.000000	1.000000	1.000000	0.001009	0.025026		1.000000
LWR06 (Little White River)	1.000000	1.000000	1.000000	0.002429	0.039502	1.000000	

Table B-10. Little White River total dissolved solids concentration (mg/L) comparisons between sampling sites, highlighted = significantly different.

Depend.: Total Dissolved Solids	Multiple Comparisons p values (2-tailed); Total Dissolved Solids (Little White Data.sta) Independent (grouping) variable: StationID Kruskal-Wallis test: H (6, N= 88) =49.98845 p =.0000						
	LWR01 (Cut Meat Creek) R:63.667	LWR03 (Pine Creek) R:82.200	LWR04 (Pine Creek) R:77.600	LWR05 (Little White River) R:33.167	LWR06 (Little White River) R:40.611	LWR07 (Little White River) R:27.605	LWR08 (Little White River) R:30.167
LWR01 (Cut Meat Creek)		1.000000	1.000000	0.057338	0.568369	0.010207	0.269774
LWR03 (Pine Creek)	1.000000		1.000000	0.000012	0.000770	0.000001	0.001682
LWR04 (Pine Creek)	1.000000	1.000000		0.009948	0.087831	0.002075	0.045526
LWR05 (Little White River)	0.057338	0.000012	0.009948		1.000000	1.000000	1.000000
LWR06 (Little White River)	0.568369	0.000770	0.087831	1.000000		1.000000	1.000000
LWR07 (Little White River)	0.010207	0.000001	0.002075	1.000000	1.000000		1.000000
LWR08 (Little White River)	0.269774	0.001682	0.045526	1.000000	1.000000	1.000000	

Table B-11. Little White River total suspended solids concentration (mg/L) comparisons between sampling sites, highlighted = significantly different.

Depend.: Total Suspended Solids	Multiple Comparisons p values (2-tailed); Total Suspended Solids (Concentrations) Independent (grouping) variable: StationID Kruskal-Wallis test: H (6, N= 88) =38.20494 p =.0000						
	LWR01 (Cut Meat Creek) R:21.611	LWR07 (Little White River) R:34.211	LWR08 (Little White River) R:36.833	LWR03 (Pine Creek) R:77.000	LWR04 (Pine Creek) R:82.200	LWR05 (Little White River) R:44.071	LWR06 (Little White River) R:41.333
LWR01 (Cut Meat Creek)		1.000000	1.000000	0.000050	0.000445	0.574057	1.000000
LWR07 (Little White River)	1.000000		1.000000	0.000380	0.003906	1.000000	1.000000
LWR08 (Little White River)	1.000000	1.000000		0.048922	0.070585	1.000000	1.000000
LWR03 (Pine Creek)	0.000050	0.000380	0.048922		1.000000	0.016684	0.008410
LWR04 (Pine Creek)	0.000445	0.003906	0.070585	1.000000		0.056835	0.032643
LWR05 (Little White River)	0.574057	1.000000	1.000000	0.016684	0.056835		1.000000
LWR06 (Little White River)	1.000000	1.000000	1.000000	0.008410	0.032643	1.000000	

Table B-12. Little White River volatile total suspended solids concentration (mg/L) comparisons between sampling sites, highlighted = significantly different.

Depend.: Total Volatile Suspended Solids	Multiple Comparisons p values (2-tailed); Total Volatile Suspended Solids (Concentrations) Independent (grouping) variable: StationID Kruskal-Wallis test: H (6, N= 88) =31.76050 p =.0000						
	LWR01 (Cut Meat Creek) R:22.778	LWR07 (Little White River) R:34.974	LWR08 (Little White River) R:32.167	LWR03 (Pine Creek) R:72.800	LWR04 (Pine Creek) R:78.500	LWR05 (Little White River) R:45.381	LWR06 (Little White River) R:43.333
LWR01 (Cut Meat Creek)		1.000000	1.000000	0.000426	0.001935	0.553767	1.000000
LWR07 (Little White River)	1.000000		1.000000	0.003165	0.014693	1.000000	1.000000
LWR08 (Little White River)	1.000000	1.000000		0.043468	0.057613	1.000000	1.000000
LWR03 (Pine Creek)	0.000426	0.003165	0.043468		1.000000	0.109525	0.072466
LWR04 (Pine Creek)	0.001935	0.014693	0.057613	1.000000		0.192827	0.135866
LWR05 (Little White River)	0.553767	1.000000	1.000000	0.109525	0.192827		1.000000
LWR06 (Little White River)	1.000000	1.000000	1.000000	0.072466	0.135866	1.000000	

Table B-13. Little White River ammonia concentration (mg/L) comparisons between sampling sites, highlighted = significantly different.

Depend.: Ammonia	Multiple Comparisons p values (2-tailed); Ammonia (Concentrations) Independent (grouping) variable: StationID Kruskal-Wallis test: H (6, N= 88) =6.027247 p =.4201						
	LWR01 (Cut Meat Creek) R:44.111	LWR07 (Little White River) R:41.211	LWR08 (Little White River) R:39.000	LWR03 (Pine Creek) R:52.150	LWR04 (Pine Creek) R:39.000	LWR05 (Little White River) R:47.333	LWR06 (Little White River) R:43.972
LWR01 (Cut Meat Creek)		1.000000	1.000000	1.000000	1.000000	1.000000	1.000000
LWR07 (Little White River)	1.000000		1.000000	1.000000	1.000000	1.000000	1.000000
LWR08 (Little White River)	1.000000	1.000000		1.000000	1.000000	1.000000	1.000000
LWR03 (Pine Creek)	1.000000	1.000000	1.000000		1.000000	1.000000	1.000000
LWR04 (Pine Creek)	1.000000	1.000000	1.000000	1.000000		1.000000	1.000000
LWR05 (Little White River)	1.000000	1.000000	1.000000	1.000000	1.000000		1.000000
LWR06 (Little White River)	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	

Table B-14. Little White River nitrate-nitrite concentration (mg/L) comparisons between sampling sites, highlighted = significantly different.

Depend.: Nitrate-Nitrite	Multiple Comparisons p values (2-tailed); Nitrate-Nitrite (Concentrations) Independent (grouping) variable: StationID Kruskal-Wallis test: H (6, N= 88) =14.04844 p =.0291						
	LWR01 (Cut Meat Creek) R:28.278	LWR07 (Little White River) R:43.684	LWR08 (Little White River) R:48.167	LWR03 (Pine Creek) R:62.800	LWR04 (Pine Creek) R:64.600	LWR05 (Little White River) R:44.238	LWR06 (Little White River) R:36.806
LWR01 (Cut Meat Creek)		1.000000	1.000000	0.068699	0.226871	1.000000	1.000000
LWR07 (Little White River)	1.000000		1.000000	1.000000	1.000000	1.000000	1.000000
LWR08 (Little White River)	1.000000	1.000000		1.000000	1.000000	1.000000	1.000000
LWR03 (Pine Creek)	0.068699	1.000000	1.000000		1.000000	1.000000	0.207579
LWR04 (Pine Creek)	0.226871	1.000000	1.000000	1.000000		1.000000	0.659120
LWR05 (Little White River)	1.000000	1.000000	1.000000	1.000000	1.000000		1.000000
LWR06 (Little White River)	1.000000	1.000000	1.000000	0.207579	0.659120	1.000000	

Table B-15. Little White River Total Kjeldahl Nitrogen concentration (mg/L) comparisons between sampling sites, highlighted = significantly different.

	Multiple Comparisons p values (2-tailed); Total Kjeldahl Nitrogen (Concentrations) Independent (grouping) variable: StationID Kruskal-Wallis test: H (6, N= 88) =9.291864 p =.1578						
Depend.: Total Kjeldahl Nitrogen	LWR01 (Cut Meat Creek) R:39.500	LWR07 (Little White River) R:41.816	LWR08 (Little White River) R:36.167	LWR03 (Pine Creek) R:61.900	LWR04 (Pine Creek) R:63.300	LWR05 (Little White River) R:42.905	LWR06 (Little White River) R:39.583
LWR01 (Cut Meat Creek)		1.000000	1.000000	1.000000	1.000000	1.000000	1.000000
LWR07 (Little White River)	1.000000		1.000000	0.928015	1.000000	1.000000	1.000000
LWR08 (Little White River)	1.000000	1.000000		1.000000	1.000000	1.000000	1.000000
LWR03 (Pine Creek)	1.000000	0.928015	1.000000		1.000000	1.000000	0.562203
LWR04 (Pine Creek)	1.000000	1.000000	1.000000	1.000000		1.000000	1.000000
LWR05 (Little White River)	1.000000	1.000000	1.000000	1.000000	1.000000		1.000000
LWR06 (Little White River)	1.000000	1.000000	1.000000	0.562203	1.000000	1.000000	

Table B-16. Little White River organic nitrogen concentration (mg/L) comparisons between sampling sites, highlighted = significantly different.

	Multiple Comparisons p values (2-tailed); Organic Nitrogen (Concentrations) Independent (grouping) variable: StationID Kruskal-Wallis test: H (6, N= 88) =8.991964 p =.1740						
Depend.: Organic Nitrogen	LWR01 (Cut Meat Creek) R:39.722	LWR07 (Little White River) R:42.158	LWR08 (Little White River) R:36.500	LWR03 (Pine Creek) R:61.300	LWR04 (Pine Creek) R:63.800	LWR05 (Little White River) R:42.357	LWR06 (Little White River) R:39.833
LWR01 (Cut Meat Creek)		1.000000	1.000000	1.000000	1.000000	1.000000	1.000000
LWR07 (Little White River)	1.000000		1.000000	1.000000	1.000000	1.000000	1.000000
LWR08 (Little White River)	1.000000	1.000000		1.000000	1.000000	1.000000	1.000000
LWR03 (Pine Creek)	1.000000	1.000000	1.000000		1.000000	1.000000	0.695783
LWR04 (Pine Creek)	1.000000	1.000000	1.000000	1.000000		1.000000	1.000000
LWR05 (Little White River)	1.000000	1.000000	1.000000	1.000000	1.000000		1.000000
LWR06 (Little White River)	1.000000	1.000000	1.000000	0.695783	1.000000	1.000000	

Table B-17. Little White River inorganic nitrogen concentration (mg/L) comparisons between sampling sites, highlighted = significantly different.

Depend.: Inorganic Nitrogen	Multiple Comparisons p values (2-tailed); Inorganic Nitrogen (Concentrations) Independent (grouping) variable: StationID Kruskal-Wallis test: H (6, N= 88) =13.98500 p =.0298						
	LWR01 (Cut Meat Creek) R:28.444	LWR07 (Little White River) R:42.500	LWR08 (Little White River) R:45.000	LWR03 (Pine Creek) R:64.200	LWR04 (Pine Creek) R:63.200	LWR05 (Little White River) R:45.238	LWR06 (Little White River) R:37.472
LWR01 (Cut Meat Creek)		1.000000	1.000000	0.048687	0.309244	1.000000	1.000000
LWR07 (Little White River)	1.000000		1.000000	0.623553	1.000000	1.000000	1.000000
LWR08 (Little White River)	1.000000	1.000000		1.000000	1.000000	1.000000	1.000000
LWR03 (Pine Creek)	0.048687	0.623553	1.000000		1.000000	1.000000	0.167728
LWR04 (Pine Creek)	0.309244	1.000000	1.000000	1.000000		1.000000	0.973533
LWR05 (Little White River)	1.000000	1.000000	1.000000	1.000000	1.000000		1.000000
LWR06 (Little White River)	1.000000	1.000000	1.000000	0.167728	0.973533	1.000000	

Table B-18. Little White River total nitrogen concentration (mg/L) comparisons between sampling sites, highlighted = significantly different.

Depend.: Total Nitrogen	Multiple Comparisons p values (2-tailed); Total Nitrogen (Concentrations) Independent (grouping) variable: StationID Kruskal-Wallis test: H (6, N= 88) =13.75042 p =.0326						
	LWR01 (Cut Meat Creek) R:27.833	LWR07 (Little White River) R:43.658	LWR08 (Little White River) R:38.000	LWR03 (Pine Creek) R:63.350	LWR04 (Pine Creek) R:66.000	LWR05 (Little White River) R:43.857	LWR06 (Little White River) R:40.194
LWR01 (Cut Meat Creek)		1.000000	1.000000	0.052086	0.155332	1.000000	1.000000
LWR07 (Little White River)	1.000000		1.000000	1.000000	1.000000	1.000000	1.000000
LWR08 (Little White River)	1.000000	1.000000		1.000000	1.000000	1.000000	1.000000
LWR03 (Pine Creek)	0.052086	1.000000	1.000000		1.000000	0.987920	0.452692
LWR04 (Pine Creek)	0.155332	1.000000	1.000000	1.000000		1.000000	0.959742
LWR05 (Little White River)	1.000000	1.000000	1.000000	0.987920	1.000000		1.000000
LWR06 (Little White River)	1.000000	1.000000	1.000000	0.452692	0.959742	1.000000	

Table B-19. Little White River total phosphorus concentration (mg/L) comparisons between sampling sites, highlighted = significantly different.

Depend.: Total Phosphorus	Multiple Comparisons p values (2-tailed); Total Phosphorus (Concentrations) Independent (grouping) variable: StationID Kruskal-Wallis test: H (6, N= 88) =28.55414 p =.0001						
	LWR01 (Cut Meat Creek) R:32.833	LWR07 (Little White River) R:33.342	LWR08 (Little White River) R:30.250	LWR03 (Pine Creek) R:74.500	LWR04 (Pine Creek) R:75.200	LWR05 (Little White River) R:44.214	LWR06 (Little White River) R:42.000
LWR01 (Cut Meat Creek)		1.000000	1.000000	0.008100	0.061894	1.000000	1.000000
LWR07 (Little White River)	1.000000		1.000000	0.000783	0.023415	1.000000	1.000000
LWR08 (Little White River)	1.000000	1.000000		0.016718	0.076955	1.000000	1.000000
LWR03 (Pine Creek)	0.008100	0.000783	0.016718		1.000000	0.042679	0.026410
LWR04 (Pine Creek)	0.061894	0.023415	0.076955	1.000000		0.310674	0.213142
LWR05 (Little White River)	1.000000	1.000000	1.000000	0.042679	0.310674		1.000000
LWR06 (Little White River)	1.000000	1.000000	1.000000	0.026410	0.213142	1.000000	

Table B-20. Little White River total dissolved phosphorus concentration (mg/L) comparisons between sampling sites, highlighted = significantly different.

Depend.: Total Dissolved Phosphorus	Multiple Comparisons p values (2-tailed); Total Dissolved Phosphorus (Concentrations) Independent (grouping) variable: StationID Kruskal-Wallis test: H (6, N= 54) =9.520657 p =.1463						
	LWR01 (Cut Meat Creek) R:35.500	LWR07 (Little White River) R:29.923	LWR08 (Little White River) R:26.875	LWR03 (Pine Creek) R:51.000	LWR04 (Pine Creek) R:38.500	LWR05 (Little White River) R:21.967	LWR06 (Little White River) R:23.500
LWR01 (Cut Meat Creek)		1.000000	1.000000	1.000000	1.000000	1.000000	1.000000
LWR07 (Little White River)	1.000000		1.000000	1.000000	1.000000	1.000000	1.000000
LWR08 (Little White River)	1.000000	1.000000		1.000000	1.000000	1.000000	1.000000
LWR03 (Pine Creek)	1.000000	1.000000	1.000000		1.000000	0.298687	0.448787
LWR04 (Pine Creek)	1.000000	1.000000	1.000000	1.000000		1.000000	1.000000
LWR05 (Little White River)	1.000000	1.000000	1.000000	0.298687	1.000000		1.000000
LWR06 (Little White River)	1.000000	1.000000	1.000000	0.448787	1.000000	1.000000	

Table B-21. Little White River total nitrogen to total phosphorus ratio (mg/L) comparisons between sampling sites, highlighted = significantly different.

Depend.: TNTP	Multiple Comparisons p values (2-tailed); TNTP (Concentrations) Independent (grouping) variable: StationID Kruskal-Wallis test: H (6, N= 88) =19.51598 p =.0034						
	LWR01 (Cut Meat Creek) R:43.222	LWR07 (Little White River) R:61.579	LWR08 (Little White River) R:55.833	LWR03 (Pine Creek) R:25.100	LWR04 (Pine Creek) R:22.600	LWR05 (Little White River) R:43.952	LWR06 (Little White River) R:40.833
LWR01 (Cut Meat Creek)		1.000000	1.000000	1.000000	1.000000	1.000000	1.000000
LWR07 (Little White River)	1.000000		1.000000	0.005403	0.050417	0.615799	0.284660
LWR08 (Little White River)	1.000000	1.000000		0.416384	0.665509	1.000000	1.000000
LWR03 (Pine Creek)	1.000000	0.005403	0.416384		1.000000	1.000000	1.000000
LWR04 (Pine Creek)	1.000000	0.050417	0.665509	1.000000		1.000000	1.000000
LWR05 (Little White River)	1.000000	0.615799	1.000000	1.000000	1.000000		1.000000
LWR06 (Little White River)	1.000000	0.284660	1.000000	1.000000	1.000000	1.000000	

Table B-22. Little White River alkalinity load comparisons (kg) between sampling sites, highlighted = significantly different.

Depend.: Alkalinity	Multiple Comparisons p values (2-tailed); Alkalinity (Loading) Independent (grouping) variable: Site Kruskal-Wallis test: H (6, N= 105) =32.07229 p =.0000						
	LWR-01 (Cut Meat Creek) R:46.333	LWR-07 (Little White River) R:87.733	LWR-08 (Little White River) R:42.400	LWR-03 (Pine Creek) R:50.400	LWR-04 (Pine Creek) R:34.267	LWR-05 (Little White River) R:44.967	LWR-06 (Little White River) R:64.900
LWR-01 (Cut Meat Creek)		0.004137	1.000000	1.000000	1.000000	1.000000	1.000000
LWR-07 (Little White River)	0.004137		0.000960	0.016538	0.000032	0.002524	0.841004
LWR-08 (Little White River)	1.000000	0.000960		1.000000	1.000000	1.000000	0.903928
LWR-03 (Pine Creek)	1.000000	0.016538	1.000000		1.000000	1.000000	1.000000
LWR-04 (Pine Creek)	1.000000	0.000032	1.000000	1.000000		1.000000	0.123382
LWR-05 (Little White River)	1.000000	0.002524	1.000000	1.000000	1.000000		1.000000
LWR-06 (Little White River)	1.000000	0.841004	0.903928	1.000000	0.123382	1.000000	

Table B-23. Little White River total solids load comparisons (kg) between sampling sites, highlighted = significantly different.

Depend.: Total Solids	Multiple Comparisons p values (2-tailed); Total Solids (Loading) Independent (grouping) variable: Site Kruskal-Wallis test: H (6, N= 105) =53.44223 p =.0000						
	LWR-01 (Cut Meat Creek) R:53.000	LWR-07 (Little White River) R:83.000	LWR-08 (Little White River) R:21.600	LWR-03 (Pine Creek) R:61.000	LWR-04 (Pine Creek) R:43.133	LWR-05 (Little White River) R:78.700	LWR-06 (Little White River) R:30.567
LWR-01 (Cut Meat Creek)		0.146619	0.099724	1.000000	1.000000	0.437448	0.916979
LWR-07 (Little White River)	0.146619		0.000001	1.000000	0.007080	1.000000	0.000051
LWR-08 (Little White River)	0.099724	0.000001		0.008308	1.000000	0.000006	1.000000
LWR-03 (Pine Creek)	1.000000	1.000000	0.008308		1.000000	1.000000	0.130334
LWR-04 (Pine Creek)	1.000000	0.007080	1.000000	1.000000		0.029032	1.000000
LWR-05 (Little White River)	0.437448	1.000000	0.000006	1.000000	0.029032		0.000316
LWR-06 (Little White River)	0.916979	0.000051	1.000000	0.130334	1.000000	0.000316	

Table B-24. Little White River total dissolved solids load comparisons (kg) between sampling sites, highlighted = significantly different.

Depend.: Total Dissolved Solids	Multiple Comparisons p values (2-tailed); Total Dissolved Solids (Loading) Independent (grouping) variable: Site Kruskal-Wallis test: H (6, N= 105) =52.51043 p =.0000						
	LWR-01 (Cut Meat Creek) R:50.267	LWR-07 (Little White River) R:83.933	LWR-08 (Little White River) R:47.067	LWR-03 (Pine Creek) R:60.267	LWR-04 (Pine Creek) R:38.000	LWR-05 (Little White River) R:75.500	LWR-06 (Little White River) R:15.967
LWR-01 (Cut Meat Creek)		0.051795	1.000000	1.000000	1.000000	0.488543	0.042835
LWR-07 (Little White River)	0.051795		0.019232	0.699745	0.000760	1.000000	0.000000
LWR-08 (Little White River)	1.000000	0.019232		1.000000	1.000000	0.221826	0.108443
LWR-03 (Pine Creek)	1.000000	0.699745	1.000000		0.950305	1.000000	0.001425
LWR-04 (Pine Creek)	1.000000	0.000760	1.000000	0.950305		0.015663	0.998671
LWR-05 (Little White River)	0.488543	1.000000	0.221826	1.000000	0.015663		0.000002
LWR-06 (Little White River)	0.042835	0.000000	0.108443	0.001425	0.998671	0.000002	

Table B-25. Little White River total suspended solids load comparisons (kg) between sampling sites, highlighted = significantly different.

Depend.: Total Suspended Solids	Multiple Comparisons p values (2-tailed); Total Suspended Solids (Loading) Independent (grouping) variable: Site Kruskal-Wallis test: H (6, N= 105) =50.65009 p =.0000						
	LWR-01 (Cut Meat Creek) R:50.333	LWR-07 (Little White River) R:81.267	LWR-08 (Little White River) R:16.733	LWR-03 (Pine Creek) R:58.067	LWR-04 (Pine Creek) R:47.667	LWR-05 (Little White River) R:78.567	LWR-06 (Little White River) R:38.367
LWR-01 (Cut Meat Creek)		0.113580	0.052832	1.000000	1.000000	0.233561	1.000000
LWR-07 (Little White River)	0.113580		0.000000	0.776119	0.052832	1.000000	0.002403
LWR-08 (Little White River)	0.052832	0.000000		0.004236	0.113580	0.000001	1.000000
LWR-03 (Pine Creek)	1.000000	0.776119	0.004236		1.000000	1.000000	1.000000
LWR-04 (Pine Creek)	1.000000	0.052832	0.113580	1.000000		0.114633	1.000000
LWR-05 (Little White River)	0.233561	1.000000	0.000001	1.000000	0.114633		0.006309
LWR-06 (Little White River)	1.000000	0.002403	1.000000	1.000000	1.000000	0.006309	

Table B-26. Little White River volatile total suspended solids load comparisons (kg) between sampling sites, highlighted = significantly different.

Depend.: Volatile Total Suspended Solids	Multiple Comparisons p values (2-tailed); Volatile Total Suspended Solids (Loading) Independent (grouping) variable: Site Kruskal-Wallis test: H (6, N= 105) =52.81075 p =.0000						
	LWR-01 (Cut Meat Creek) R:51.267	LWR-07 (Little White River) R:81.867	LWR-08 (Little White River) R:16.733	LWR-03 (Pine Creek) R:57.533	LWR-04 (Pine Creek) R:49.333	LWR-05 (Little White River) R:78.967	LWR-06 (Little White River) R:35.300
LWR-01 (Cut Meat Creek)		0.124517	0.039910	1.000000	1.000000	0.267594	1.000000
LWR-07 (Little White River)	0.124517		0.000000	0.601846	0.072216	1.000000	0.000592
LWR-08 (Little White River)	0.039910	0.000000		0.005116	0.070837	0.000000	1.000000
LWR-03 (Pine Creek)	1.000000	0.601846	0.005116		1.000000	1.000000	0.957091
LWR-04 (Pine Creek)	1.000000	0.072216	0.070837	1.000000		0.161802	1.000000
LWR-05 (Little White River)	0.267594	1.000000	0.000000	1.000000	0.161802		0.001809
LWR-06 (Little White River)	1.000000	0.000592	1.000000	0.957091	1.000000	0.001809	

Table B-27. Little White River ammonia load comparisons (kg) between sampling sites, highlighted = significantly different.

Depend.: Ammonia	Multiple Comparisons p values (2-tailed); Ammonia (Loading) Independent (grouping) variable: Site Kruskal-Wallis test: H (6, N= 105) =56.31299 p =.0000						
	LWR-01 (Cut Meat Creek) R:50.000	LWR-07 (Little White River) R:80.200	LWR-08 (Little White River) R:16.267	LWR-03 (Pine Creek) R:51.300	LWR-04 (Pine Creek) R:31.900	LWR-05 (Little White River) R:80.500	LWR-06 (Little White River) R:60.833
LWR-01 (Cut Meat Creek)		0.138888	0.050777	1.000000	1.000000	0.127978	1.000000
LWR-07 (Little White River)	0.138888		0.000000	0.196460	0.000295	1.000000	1.000000
LWR-08 (Little White River)	0.050777	0.000000		0.034249	1.000000	0.000000	0.001288
LWR-03 (Pine Creek)	1.000000	0.196460	0.034249		1.000000	0.181552	1.000000
LWR-04 (Pine Creek)	1.000000	0.000295	1.000000	1.000000		0.000261	0.194751
LWR-05 (Little White River)	0.127978	1.000000	0.000000	0.181552	0.000261		1.000000
LWR-06 (Little White River)	1.000000	1.000000	0.001288	1.000000	0.194751	1.000000	

Table B-28. Little White River nitrate-nitrite load comparisons (kg) between sampling sites, highlighted = significantly different.

Depend.: Nitrate-Nitrite	Multiple Comparisons p values (2-tailed); Nitrate-Nitrite (Loading) Independent (grouping) variable: Site Kruskal-Wallis test: H (6, N= 105) =34.06953 p =.0000						
	LWR-01 (Cut Meat Creek) R:54.033	LWR-07 (Little White River) R:89.800	LWR-08 (Little White River) R:55.400	LWR-03 (Pine Creek) R:56.833	LWR-04 (Pine Creek) R:41.600	LWR-05 (Little White River) R:35.667	LWR-06 (Little White River) R:37.667
LWR-01 (Cut Meat Creek)		0.027273	1.000000	1.000000	1.000000	1.000000	1.000000
LWR-07 (Little White River)	0.027273		0.041558	0.063671	0.000307	0.000024	0.000058
LWR-08 (Little White River)	1.000000	0.041558		1.000000	1.000000	1.000000	1.000000
LWR-03 (Pine Creek)	1.000000	0.063671	1.000000		1.000000	1.000000	1.000000
LWR-04 (Pine Creek)	1.000000	0.000307	1.000000	1.000000		1.000000	1.000000
LWR-05 (Little White River)	1.000000	0.000024	1.000000	1.000000	1.000000		1.000000
LWR-06 (Little White River)	1.000000	0.000058	1.000000	1.000000	1.000000	1.000000	

Table B-29. Little White River Total Kjeldahl Nitrogen load comparisons (kg) between sampling sites, highlighted = significantly different.

Depend.: Total Kjeldahl Nitrogen	LWR-01 (Cut Meat Creek) R:45.000	LWR-07 (Little White River) R:86.733	LWR-08 (Little White River) R:11.200	LWR-03 (Pine Creek) R:47.800	LWR-04 (Pine Creek) R:40.133	LWR-05 (Little White River) R:67.833	LWR-06 (Little White River) R:72.300
Multiple Comparisons p values (2-tailed); Total Kjeldahl Nitrogen (Loading) Independent (grouping) variable: Site Kruskal-Wallis test: H (6, N= 105) =62.15046 p =.0000							
LWR-01 (Cut Meat Creek)		0.003672	0.049778	1.000000	1.000000	0.841004	0.295928
LWR-07 (Little White River)	0.003672		0.000000	0.009733	0.000585	1.000000	1.000000
LWR-08 (Little White River)	0.049778	0.000000		0.020950	0.194751	0.000007	0.000001
LWR-03 (Pine Creek)	1.000000	0.009733	0.020950		1.000000	1.000000	0.579300
LWR-04 (Pine Creek)	1.000000	0.000585	0.194751	1.000000		0.267594	0.080249
LWR-05 (Little White River)	0.841004	1.000000	0.000007	1.000000	0.267594		1.000000
LWR-06 (Little White River)	0.295928	1.000000	0.000001	0.579300	0.080249	1.000000	

Table B-30. Little White River organic nitrogen load comparisons (kg) between sampling sites, highlighted = significantly different.

Depend.: Organic Nitrogen	LWR-01 (Cut Meat Creek) R:37.333	LWR-07 (Little White River) R:80.467	LWR-08 (Little White River) R:61.733	LWR-03 (Pine Creek) R:39.933	LWR-04 (Pine Creek) R:33.400	LWR-05 (Little White River) R:47.767	LWR-06 (Little White River) R:70.367
Multiple Comparisons p values (2-tailed); Organic Nitrogen (Loading) Independent (grouping) variable: Site Kruskal-Wallis test: H (6, N= 105) =32.62100 p =.0000							
LWR-01 (Cut Meat Creek)		0.002205	0.592739	1.000000	1.000000	1.000000	0.062441
LWR-07 (Little White River)	0.002205		1.000000	0.005617	0.000486	0.068813	1.000000
LWR-08 (Little White River)	0.592739	1.000000		1.000000	0.227627	1.000000	1.000000
LWR-03 (Pine Creek)	1.000000	0.005617	1.000000		1.000000	1.000000	0.130334
LWR-04 (Pine Creek)	1.000000	0.000486	0.227627	1.000000		1.000000	0.018623
LWR-05 (Little White River)	1.000000	0.068813	1.000000	1.000000	1.000000		0.884646
LWR-06 (Little White River)	0.062441	1.000000	1.000000	0.130334	0.018623	0.884646	

Table B-31. Little White River inorganic nitrogen load comparisons (kg) between sampling sites, highlighted = significantly different.

Depend.: Inorganic Nitrogen	Multiple Comparisons p values (2-tailed); Inorganic Nitrogen (Loading) Independent (grouping) variable: Site Kruskal-Wallis test: H (6, N= 105) =54.34523 p =.0000						
	LWR-01 (Cut Meat Creek) R:55.467	LWR-07 (Little White River) R:89.933	LWR-08 (Little White River) R:67.867	LWR-03 (Pine Creek) R:57.600	LWR-04 (Pine Creek) R:40.400	LWR-05 (Little White River) R:15.467	LWR-06 (Little White River) R:44.267
LWR-01 (Cut Meat Creek)		0.040726	1.000000	1.000000	1.000000	0.006762	1.000000
LWR-07 (Little White River)	0.040726		0.991638	0.076502	0.000177	0.000000	0.000844
LWR-08 (Little White River)	1.000000	0.991638		1.000000	0.283816	0.000052	0.710245
LWR-03 (Pine Creek)	1.000000	0.076502	1.000000		1.000000	0.003179	1.000000
LWR-04 (Pine Creek)	1.000000	0.000177	0.283816	1.000000		0.524060	1.000000
LWR-05 (Little White River)	0.006762	0.000000	0.000052	0.003179	0.524060		0.201667
LWR-06 (Little White River)	1.000000	0.000844	0.710245	1.000000	1.000000	0.201667	

Table B-32. Little White River total nitrogen load comparisons (kg) between sampling sites, highlighted = significantly different.

Depend.: Total Nitrogen	Multiple Comparisons p values (2-tailed); Total Nitrogen (Loading) Independent (grouping) variable: Site Kruskal-Wallis test: H (6, N= 105) =36.91694 p =.0000						
	LWR-01 (Cut Meat Creek) R:42.800	LWR-07 (Little White River) R:84.933	LWR-08 (Little White River) R:64.867	LWR-03 (Pine Creek) R:45.267	LWR-04 (Pine Creek) R:37.333	LWR-05 (Little White River) R:30.633	LWR-06 (Little White River) R:65.167
LWR-01 (Cut Meat Creek)		0.003179	0.991638	1.000000	1.000000	1.000000	0.930189
LWR-07 (Little White River)	0.003179		1.000000	0.007584	0.000392	0.000022	1.000000
LWR-08 (Little White River)	0.991638	1.000000		1.000000	0.279095	0.043707	1.000000
LWR-03 (Pine Creek)	1.000000	0.007584	1.000000		1.000000	1.000000	1.000000
LWR-04 (Pine Creek)	1.000000	0.000392	0.279095	1.000000		1.000000	0.258698
LWR-05 (Little White River)	1.000000	0.000022	0.043707	1.000000	1.000000		0.039910
LWR-06 (Little White River)	0.930189	1.000000	1.000000	1.000000	0.258698	0.039910	

Table B-33. Little White River total phosphorus load comparisons (kg) between sampling sites, highlighted = significantly different.

Depend.: Total Phosphorus	Multiple Comparisons p values (2-tailed); Total Phosphorus (Loading) Independent (grouping) variable: Site Kruskal-Wallis test: H (6, N= 105) =51.21958 p =.0000						
	LWR-01 (Cut Meat Creek) R:50.600	LWR-07 (Little White River) R:83.800	LWR-08 (Little White River) R:15.133	LWR-03 (Pine Creek) R:56.333	LWR-04 (Pine Creek) R:40.267	LWR-05 (Little White River) R:75.433	LWR-06 (Little White River) R:49.433
LWR-01 (Cut Meat Creek)		0.059461	0.029951	1.000000	1.000000	0.536386	1.000000
LWR-07 (Little White River)	0.059461		0.000000	0.283816	0.001901	1.000000	0.041980
LWR-08 (Little White River)	0.029951	0.000000		0.004442	0.500142	0.000001	0.042835
LWR-03 (Pine Creek)	1.000000	0.283816	0.004442		1.000000	1.000000	1.000000
LWR-04 (Pine Creek)	1.000000	0.001901	0.500142	1.000000		0.032869	1.000000
LWR-05 (Little White River)	0.536386	1.000000	0.000001	1.000000	0.032869		0.407117
LWR-06 (Little White River)	1.000000	0.041980	0.042835	1.000000	1.000000	0.407117	

Table B-34. Little White River total dissolved phosphorus load comparisons (kg) between sampling sites, highlighted = significantly different.

Depend.: Total Dissolved Phosphorus	Multiple Comparisons p values (2-tailed); Total Dissolved Phosphorus (Loading) Independent (grouping) variable: Site Kruskal-Wallis test: H (6, N= 105) =67.93381 p =.0000						
	LWR-01 (Cut Meat Creek) R:58.733	LWR-07 (Little White River) R:91.467	LWR-08 (Little White River) R:13.133	LWR-03 (Pine Creek) R:49.500	LWR-04 (Pine Creek) R:49.500	LWR-05 (Little White River) R:36.767	LWR-06 (Little White River) R:71.900
LWR-01 (Cut Meat Creek)		0.068150	0.000866	1.000000	1.000000	1.000000	1.000000
LWR-07 (Little White River)	0.068150		0.000000	0.003376	0.003376	0.000018	1.000000
LWR-08 (Little White River)	0.000866	0.000000		0.022567	0.022567	0.704978	0.000003
LWR-03 (Pine Creek)	1.000000	0.003376	0.022567		1.000000	1.000000	0.923564
LWR-04 (Pine Creek)	1.000000	0.003376	0.022567	1.000000		1.000000	0.923564
LWR-05 (Little White River)	1.000000	0.000018	0.704978	1.000000	1.000000		0.033209
LWR-06 (Little White River)	1.000000	1.000000	0.000003	0.923564	0.923564	0.033209	

Table B-35. Little White River pH value comparisons between sampling seasons, highlighted = significantly different.

Depend.: pH	Summer 03 R:34.833	Fall 03 R:34.900	Winter 04 R:33.594	Spring 04 R:43.423	Summer 04 R:53.346	Fall 04 R:37.000
	Multiple Comparisons p values (2-tailed); pH (Little White Data.sta) Independent (grouping) variable: Season Kruskal-Wallis test: H (5, N= 85) =8.543486 p =.1287					
Summer 03		1.000000	1.000000	1.000000	1.000000	1.000000
Fall 03	1.000000		1.000000	1.000000	0.668843	1.000000
Winter 04	1.000000	1.000000		1.000000	0.176691	1.000000
Spring 04	1.000000	1.000000	1.000000		1.000000	1.000000
Summer 04	1.000000	0.668843	0.176691	1.000000		1.000000
Fall 04	1.000000	1.000000	1.000000	1.000000	1.000000	

Table B-36. Little White River dissolved oxygen concentration comparisons between sampling seasons, highlighted = significantly different.

Depend.: Dissolved Oxygen	Summer 03 R:39.000	Fall 03 R:69.700	Winter 04 R:66.063	Spring 04 R:33.423	Summer 04 R:25.380	Fall 04 R:48.875
	Multiple Comparisons p values (2-tailed); Dissolved Oxygen (Little White Data.sta) Independent (grouping) variable: Season Kruskal-Wallis test: H (5, N= 84) =43.61702 p =.0000					
Summer 03		0.838304	1.000000	1.000000	1.000000	1.000000
Fall 03	0.838304		1.000000	0.000963	0.000018	1.000000
Winter 04	1.000000	1.000000		0.000381	0.000003	1.000000
Spring 04	1.000000	0.000963	0.000381		1.000000	1.000000
Summer 04	1.000000	0.000018	0.000003	1.000000		1.000000
Fall 04	1.000000	1.000000	1.000000	1.000000	1.000000	

Table B-37. Little White River transparency tube depth comparisons between sampling seasons, highlighted = significantly different.

Depend.: Secchi (m)	Summer 03 R:61.000	Fall 03 R:63.909	Winter 04 R:47.531	Spring 04 R:36.173	Summer 04 R:39.179	Fall 04 R:58.000
	Multiple Comparisons p values (2-tailed); Secchi (m) (Little White Data.sta) Independent (grouping) variable: Season Kruskal-Wallis test: H (5, N= 88) =12.92508 p =.0241					
Summer 03		1.000000	1.000000	1.000000	1.000000	1.000000
Fall 03	1.000000		1.000000	0.038114	0.097809	1.000000
Winter 04	1.000000	1.000000		1.000000	1.000000	1.000000
Spring 04	1.000000	0.038114	1.000000		1.000000	1.000000
Summer 04	1.000000	0.097809	1.000000	1.000000		1.000000
Fall 04	1.000000	1.000000	1.000000	1.000000	1.000000	

Table B-38. Little White River turbidity value comparisons between sampling seasons, highlighted = significantly different.

Depend.: Turbidity	Multiple Comparisons p values (2-tailed); Turbidity (Little White Data.sta) Independent (grouping) variable: Season Kruskal-Wallis test: H (5, N= 62) =18.79746 p =.0021					
	Summer 03 R:22.000	Fall 03 R:14.500	Winter 04 R:32.969	Spring 04 R:42.500	Summer 04 R:28.667	Fall 04 R:21.500
Summer 03		1.000000	1.000000	1.000000	1.000000	1.000000
Fall 03	1.000000		0.166552	0.000804	1.000000	1.000000
Winter 04	1.000000	0.166552		1.000000	1.000000	1.000000
Spring 04	1.000000	0.000804	1.000000		0.814348	0.493130
Summer 04	1.000000	1.000000	1.000000	0.814348		1.000000
Fall 04	1.000000	1.000000	1.000000	0.493130	1.000000	

Table B-39. Little White River conductivity @ 25° C comparisons between sampling seasons, highlighted = significantly different.

Depend.: Specific Conductivity	Multiple Comparisons p values (2-tailed); Specific Conductivity (Little White Data.sta) Independent (grouping) variable: Season Kruskal-Wallis test: H (5, N= 84) =26.94622 p =.0001					
	Summer 03 R:52.833	Fall 03 R:12.900	Winter 04 R:42.500	Spring 04 R:56.942	Summer 04 R:36.220	Fall 04 R:54.125
Summer 03		0.193268	1.000000	1.000000	1.000000	1.000000
Fall 03	0.193268		0.039151	0.000018	0.159241	0.064206
Winter 04	1.000000	0.039151		0.936144	1.000000	1.000000
Spring 04	1.000000	0.000018	0.936144		0.036338	1.000000
Summer 04	1.000000	0.159241	1.000000	0.036338		1.000000
Fall 04	1.000000	0.064206	1.000000	1.000000	1.000000	

Table B-40. Little White River water temperature °C comparisons between sampling seasons, highlighted = significantly different.

Depend.: Water Temperature C	Multiple Comparisons p values (2-tailed); Water Temperature C (Little White Data.sta) Independent (grouping) variable: Season Kruskal-Wallis test: H (5, N= 85) =51.89202 p =.0000					
	Summer 03 R:61.333	Fall 03 R:17.864	Winter 04 R:19.063	Spring 04 R:46.173	Summer 04 R:66.160	Fall 04 R:28.750
Summer 03		0.102756	0.097280	1.000000	1.000000	1.000000
Fall 03	0.102756		1.000000	0.021420	0.000001	1.000000
Winter 04	0.097280	1.000000		0.008195	0.000000	1.000000
Spring 04	1.000000	0.021420	0.008195		0.057601	1.000000
Summer 04	1.000000	0.000001	0.000000	0.057601		0.073251
Fall 04	1.000000	1.000000	1.000000	1.000000	0.073251	

Table B-41. Little White River fecal coliform bacteria concentration comparisons between sampling seasons, highlighted = significantly different.

Depend.: Fecal Coliform	Multiple Comparisons p values (2-tailed); Fecal Coliform (Little White Data.sta) Independent (grouping) variable: Season Kruskal-Wallis test: H (5, N= 76) =23.41790 p =.0003					
	Summer 03 R:27.000	Fall 03 R:25.364	Winter 04 R:22.536	Spring 04 R:50.180	Summer 04 R:47.132	Fall 04 R:25.125
Summer 03		1.000000	1.000000	1.000000	1.000000	1.000000
Fall 03	1.000000		1.000000	0.028452	0.139117	1.000000
Winter 04	1.000000	1.000000		0.002651	0.023490	1.000000
Spring 04	1.000000	0.028452	0.002651		1.000000	0.526957
Summer 04	1.000000	0.139117	0.023490	1.000000		1.000000
Fall 04	1.000000	1.000000	1.000000	0.526957	1.000000	

Table B-42. Little White River E. coli bacteria concentration comparisons between sampling seasons, highlighted = significantly different.

Depend.: E. coli	Multiple Comparisons p values (2-tailed); E. coli (Little White Data.sta) Independent (grouping) variable: Season Kruskal-Wallis test: H (5, N= 76) =22.91913 p =.0003					
	Summer 03 R:26.333	Fall 03 R:24.500	Winter 04 R:23.107	Spring 04 R:51.100	Summer 04 R:45.132	Fall 04 R:29.750
Summer 03		1.000000	1.000000	0.996444	1.000000	1.000000
Fall 03	1.000000		1.000000	0.013066	0.204978	1.000000
Winter 04	1.000000	1.000000		0.002193	0.069480	1.000000
Spring 04	0.996444	0.013066	0.002193		1.000000	1.000000
Summer 04	1.000000	0.204978	0.069480	1.000000		1.000000
Fall 04	1.000000	1.000000	1.000000	1.000000	1.000000	

Table B-43. Little White River alkalinity concentration comparisons between sampling seasons, highlighted = significantly different.

Depend.: Alkalinity	Multiple Comparisons p values (2-tailed); Alkalinity (Little White Data.sta) Independent (grouping) variable: Season Kruskal-Wallis test: H (5, N= 88) =9.397421 p =.0942					
	Summer 03 R:53.500	Fall 03 R:40.227	Winter 04 R:38.125	Spring 04 R:56.673	Summer 04 R:38.357	Fall 04 R:38.875
Summer 03		1.000000	1.000000	1.000000	1.000000	1.000000
Fall 03	1.000000		1.000000	1.000000	1.000000	1.000000
Winter 04	1.000000	1.000000		0.334743	1.000000	1.000000
Spring 04	1.000000	1.000000	0.334743		0.127175	1.000000
Summer 04	1.000000	1.000000	1.000000	0.127175		1.000000
Fall 04	1.000000	1.000000	1.000000	1.000000	1.000000	

Table B-44. Little White River total solids concentration comparisons between sampling seasons, highlighted = significantly different.

Depend.: Total Solids	Multiple Comparisons p values (2-tailed); Total Solids (Little White Data.sta) Independent (grouping) variable: Season Kruskal-Wallis test: H (5, N= 88) =16.33817 p =.0059					
	Summer 03 R:26.667	Fall 03 R:25.091	Winter 04 R:42.375	Spring 04 R:57.731	Summer 04 R:45.143	Fall 04 R:29.250
Summer 03		1.000000	1.000000	0.692008	1.000000	1.000000
Fall 03	1.000000		1.000000	0.005733	0.411035	1.000000
Winter 04	1.000000	1.000000		0.878003	1.000000	1.000000
Spring 04	0.692008	0.005733	0.878003		1.000000	0.568842
Summer 04	1.000000	0.411035	1.000000	1.000000		1.000000
Fall 04	1.000000	1.000000	1.000000	0.568842	1.000000	

Table B-45. Little White River total dissolved solids concentration comparisons between sampling seasons, highlighted = significantly different.

Depend.: Total Dissolved Solids	Multiple Comparisons p values (2-tailed); Total Dissolved Solids (Little White Data.sta) Independent (grouping) variable: Season Kruskal-Wallis test: H (5, N= 88) =11.19554 p =.0476					
	Summer 03 R:35.167	Fall 03 R:49.091	Winter 04 R:50.719	Spring 04 R:53.596	Summer 04 R:33.643	Fall 04 R:30.875
Summer 03		1.000000	1.000000	1.000000	1.000000	1.000000
Fall 03	1.000000		1.000000	1.000000	1.000000	1.000000
Winter 04	1.000000	1.000000		1.000000	0.494116	1.000000
Spring 04	1.000000	1.000000	1.000000		0.062015	1.000000
Summer 04	1.000000	1.000000	0.494116	0.062015		1.000000
Fall 04	1.000000	1.000000	1.000000	1.000000	1.000000	

Table B-46. Little White River total suspended solids concentration comparisons between sampling seasons, highlighted = significantly different.

Depend.: Total Suspended Solids	Multiple Comparisons p values (2-tailed); Total Suspended Solids (Little White Data.sta) Independent (grouping) variable: Season Kruskal-Wallis test: H (5, N= 88) =13.61676 p =.0182					
	Summer 03 R:27.000	Fall 03 R:26.818	Winter 04 R:37.969	Spring 04 R:54.654	Summer 04 R:49.268	Fall 04 R:33.000
Summer 03		1.000000	1.000000	1.000000	1.000000	1.000000
Fall 03	1.000000		1.000000	0.036772	0.202958	1.000000
Winter 04	1.000000	1.000000		0.597546	1.000000	1.000000
Spring 04	1.000000	0.036772	0.597546		1.000000	1.000000
Summer 04	1.000000	0.202958	1.000000	1.000000		1.000000
Fall 04	1.000000	1.000000	1.000000	1.000000	1.000000	

Table B-47. Little White River total volatile suspended solids concentration comparisons between sampling seasons, highlighted = significantly different.

Depend.: Total Volatile Suspended Solid	Multiple Comparisons p values (2-tailed); Total Volatile Suspended Solids (Little White Data Independent (grouping) variable: Season Kruskal-Wallis test: H (5, N= 88) =21.40099 p =.0007					
	Summer 03 R:32.000	Fall 03 R:23.864	Winter 04 R:30.844	Spring 04 R:55.462	Summer 04 R:53.250	Fall 04 R:32.750
Summer 03		1.000000	1.000000	1.000000	1.000000	1.000000
Fall 03	1.000000		1.000000	0.008768	0.018405	1.000000
Winter 04	1.000000	1.000000		0.036360	0.076994	1.000000
Spring 04	1.000000	0.008768	0.036360		1.000000	1.000000
Summer 04	1.000000	0.018405	0.076994	1.000000		1.000000
Fall 04	1.000000	1.000000	1.000000	1.000000	1.000000	

Table B-48. Little White River ammonia concentration comparisons between sampling seasons, highlighted = significantly different.

Depend.: Ammonia	Multiple Comparisons p values (2-tailed); Ammonia (Little White Data.sta) Independent (grouping) variable: Season Kruskal-Wallis test: H (5, N= 88) =5.392527 p =.3699					
	Summer 03 R:54.000	Fall 03 R:43.273	Winter 04 R:44.219	Spring 04 R:40.846	Summer 04 R:48.304	Fall 04 R:39.000
Summer 03		1.000000	1.000000	1.000000	1.000000	1.000000
Fall 03	1.000000		1.000000	1.000000	1.000000	1.000000
Winter 04	1.000000	1.000000		1.000000	1.000000	1.000000
Spring 04	1.000000	1.000000	1.000000		1.000000	1.000000
Summer 04	1.000000	1.000000	1.000000	1.000000		1.000000
Fall 04	1.000000	1.000000	1.000000	1.000000	1.000000	

Table B-49. Little White River nitrate-nitrite concentration comparisons between sampling seasons, highlighted = significantly different.

Depend.: Nitrate-Nitrite	Multiple Comparisons p values (2-tailed); Nitrate-Nitrite (Little White Data.sta) Independent (grouping) variable: Season Kruskal-Wallis test: H (5, N= 88) =16.72924 p =.0050					
	Summer 03 R:38.667	Fall 03 R:63.591	Winter 04 R:52.406	Spring 04 R:40.635	Summer 04 R:33.661	Fall 04 R:65.750
Summer 03		1.000000	1.000000	1.000000	1.000000	1.000000
Fall 03	1.000000		1.000000	0.187205	0.014903	1.000000
Winter 04	1.000000	1.000000		1.000000	0.288219	1.000000
Spring 04	1.000000	0.187205	1.000000		1.000000	1.000000
Summer 04	1.000000	0.014903	0.288219	1.000000		0.281681
Fall 04	1.000000	1.000000	1.000000	1.000000	0.281681	

Table B-50. Little White River total Kjeldahl nitrogen concentration comparisons between sampling seasons, highlighted = significantly different.

Depend.: Total Kjeldahl Nitrogen	Summer 03 R:12.000	Fall 03 R:20.545	Winter 04 R:25.594	Spring 04 R:57.058	Summer 04 R:58.571	Fall 04 R:30.250
	Multiple Comparisons p values (2-tailed); Total Kjeldahl Nitrogen (Little White Data.sta) Independent (grouping) variable: Season Kruskal-Wallis test: H (5, N= 88) =39.32672 p =.0000					
Summer 03		1.000000	1.000000	0.057331	0.040395	1.000000
Fall 03	1.000000		1.000000	0.001062	0.000432	1.000000
Winter 04	1.000000	1.000000		0.001592	0.000571	1.000000
Spring 04	0.057331	0.001062	0.001592		1.000000	0.760956
Summer 04	0.040395	0.000432	0.000571	1.000000		0.571225
Fall 04	1.000000	1.000000	1.000000	0.760956	0.571225	

Table B-51. Little White River organic nitrogen concentration comparisons between sampling seasons, highlighted = significantly different.

Depend.: Organic Nitrogen	Summer 03 R:8.6667	Fall 03 R:20.636	Winter 04 R:25.438	Spring 04 R:57.192	Summer 04 R:58.750	Fall 04 R:31.000
	Multiple Comparisons p values (2-tailed); Organic Nitrogen (Little White Data.sta) Independent (grouping) variable: Season Kruskal-Wallis test: H (5, N= 88) =40.66661 p =.0000					
Summer 03		1.000000	1.000000	0.027581	0.018761	1.000000
Fall 03	1.000000		1.000000	0.001041	0.000414	1.000000
Winter 04	1.000000	1.000000		0.001374	0.000476	1.000000
Spring 04	0.027581	0.001041	0.001374		1.000000	0.844117
Summer 04	0.018761	0.000414	0.000476	1.000000		0.632109
Fall 04	1.000000	1.000000	1.000000	0.844117	0.632109	

Table B-52. Little White River inorganic nitrogen concentration comparisons between sampling seasons, highlighted = significantly different.

Depend.: Inorganic Nitrogen	Summer 03 R:42.167	Fall 03 R:62.682	Winter 04 R:51.281	Spring 04 R:40.404	Summer 04 R:34.750	Fall 04 R:64.000
	Multiple Comparisons p values (2-tailed); Inorganic Nitrogen (Little White Data.sta) Independent (grouping) variable: Season Kruskal-Wallis test: H (5, N= 88) =14.11051 p =.0149					
Summer 03		1.000000	1.000000	1.000000	1.000000	1.000000
Fall 03	1.000000		1.000000	0.229978	0.031838	1.000000
Winter 04	1.000000	1.000000		1.000000	0.584165	1.000000
Spring 04	1.000000	0.229978	1.000000		1.000000	1.000000
Summer 04	1.000000	0.031838	0.584165	1.000000		0.482934
Fall 04	1.000000	1.000000	1.000000	1.000000	0.482934	

Table B-53. Little White River total nitrogen concentration comparisons between sampling seasons, highlighted = significantly different.

Depend.: Total Nitrogen	Multiple Comparisons p values (2-tailed); Total Nitrogen (Little White Data.sta) Independent (grouping) variable: Season Kruskal-Wallis test: H (5, N= 88) =30.13505 p =.0000					
	Summer 03 R:14.500	Fall 03 R:29.273	Winter 04 R:24.156	Spring 04 R:55.077	Summer 04 R:57.054	Fall 04 R:33.625
Summer 03		1.000000	1.000000	0.137874	0.091632	1.000000
Fall 03	1.000000		1.000000	0.074731	0.033655	1.000000
Winter 04	1.000000	1.000000		0.002092	0.000596	1.000000
Spring 04	0.137874	0.074731	0.002092		1.000000	1.000000
Summer 04	0.091632	0.033655	0.000596	1.000000		1.000000
Fall 04	1.000000	1.000000	1.000000	1.000000	1.000000	

Table B-54. Little White River total phosphorus concentration comparisons between sampling seasons, highlighted = significantly different.

Depend.: Total Phosphorus	Multiple Comparisons p values (2-tailed); Total Phosphorus (Little White Data.sta) Independent (grouping) variable: Season Kruskal-Wallis test: H (5, N= 88) =16.00854 p =.0068					
	Summer 03 R:24.167	Fall 03 R:23.364	Winter 04 R:43.750	Spring 04 R:56.096	Summer 04 R:46.500	Fall 04 R:31.500
Summer 03		1.000000	1.000000	0.605876	1.000000	1.000000
Fall 03	1.000000		0.624205	0.005517	0.163904	1.000000
Winter 04	1.000000	0.624205		1.000000	1.000000	1.000000
Spring 04	0.605876	0.005517	1.000000		1.000000	1.000000
Summer 04	1.000000	0.163904	1.000000	1.000000		1.000000
Fall 04	1.000000	1.000000	1.000000	1.000000	1.000000	

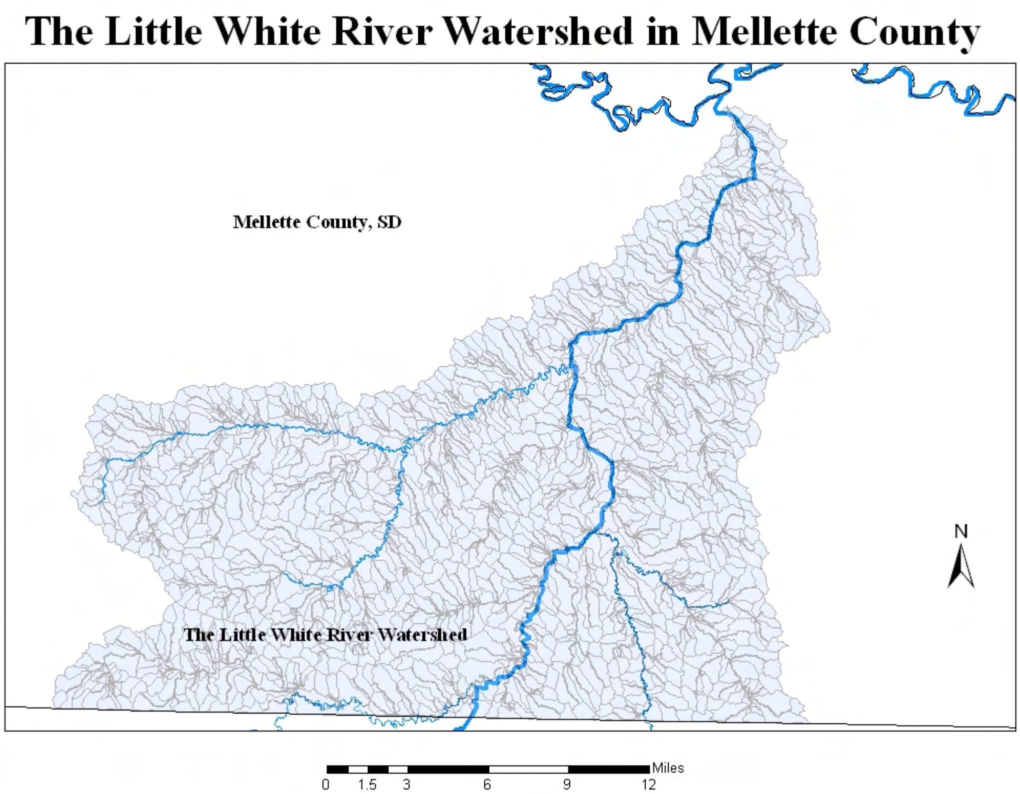
Table B-55. Little White River total dissolved phosphorus concentration comparisons between sampling seasons, highlighted = significantly different.

Depend.: Total Dissolved Phosphoru	Multiple Comparisons p values (2-tailed); Total Dissolved Phosphorus (Little White Data Independent (grouping) variable: Season Kruskal-Wallis test: H (5, N= 54) =29.20801 p =.0000					
	Summer 03 R:13.667	Fall 03 R:27.864	Winter 04 R:42.462	Spring 04 R:27.107	Summer 04 R:9.1000	Fall 04 R:38.333
Summer 03		1.00000(	0.06403ı	1.00000(	1.00000(	0.82230ŧ
Fall 03	1.00000(		0.35270ı	1.00000(	0.09508ϵ	1.00000(
Winter 04	0.06403ı	0.35270ı		0.16917ŧ	0.00000ı	1.00000(
Spring 04	1.00000(	1.00000(	0.16917ŧ		0.08551ı	1.00000(
Summer 04	1.00000(	0.09508ϵ	0.00000ı	0.08551ı		0.07141(
Fall 04	0.82230ŧ	1.00000(	1.00000(	1.00000(	0.07141(	

APPENDIX C

Little White River Watershed In Mellette County Annual Agricultural Non-Point Source Pollution Model (AnnAGNPS) Final Report

ANNUALIZED AGRICULTURAL NON-POINT SOURCE (AnnAGNPS) ANALYSIS OF THE LITTLE WHITE RIVER WATERSHED IN MELLETTE COUNTY, SOUTH DAKOTA



Prepared by:
Robert L. Smith
Environmental Program Scientist

And

Kara Krogman
Project Coordinator

SOUTH DAKOTA DEPARTMENT OF ENVIRONMENT AND NATURAL RESOURCES
DIVISION OF FINANCIAL AND TECHNICAL ASSISTANCE
WATER RESOURCES ASSISTANCE PROGRAM

OCTOBER, 2006

Table of Contents

List of Figures

List of Tables

INTRODUCTION

Water quality is a major concern, especially in the agricultural states of the Midwestern United States. Several common water quality problems have been noted in lakes and reservoirs of the Central Plains. There have been reports of elevated plant nutrient levels, with concurrent elevations in plant biomass (Smith, 1998). Suspended solids and siltation have increased, and increases in these factors reduce light penetration, aesthetics, lake depth and volume, leading to alteration of aquatic habitats (deNoyelles et al., 1999). Water quality assessments have shown elevated levels of pesticides and other toxic chemicals (Scribner et al., 1996). Further, local and state regulatory agencies have fielded complaints regarding objectionable taste and odor conditions (e.g., KDHE, 1999). All these problems contribute to or are symptomatic of water quality degradation. However, excess nutrients and siltation, both of which result from intensive agricultural activities, are the water quality factors that contribute most to eutrophication (Carpenter et al., 1998). Eutrophication is itself a serious and widespread problem in the Midwest. According to the National Water Quality Report to Congress, 50 percent of assessed U.S. lakes and a higher percentage of reservoirs in the agriculturally dominated Midwest were considered eutrophic (USEPA, 2000).

A vital key to the development of a lake/reservoir management strategy is to identify nutrient loading that describes associated eutrophic conditions in lakes and reservoirs. Annualized Agricultural Nonpoint Source (AnnAGNPS 3.32.a. 34) is a batch-process, continuous-simulation, watershed-scale model designed for agriculturally dominated watersheds, which was developed jointly by U.S. Department of Agriculture's Agricultural Research Service and Natural Resource Conservation Service (Bosch et al., 1998; Cronshey and Theurer, 1998; Geter and Theurer, 1998; Theurer and Cronshey, 1998; Johnson et al., 2000).

AnnAGNPS requires more than 400 parameters in 34 data categories, including land use, topography, hydrology, soils, feedlot operation, field management, and climate. AnnAGNPS uses up-to-date technologies that expand the original modeling capabilities of AGNPS. For example, soil loss from each field is predicted based on the Revised Universal Soil Loss Equation (RUSLE) (Renard et al, 1997) and the sediment yield leaving each field is based on the Hydrogeomorphic Universal Soil Loss Equation (HUSLE) (Theurer and Clarke, 1991).

AnnAGNPS is an effective tool for watershed assessment. However, the complexity of modeling procedures and massive data preparation render its application tedious and time consuming. Therefore, automation of the preparation and processing of repetitive data is required. ArcView® Spatial AnnAGNPS interface is a user-friendly tool developed to assist decision-makers to conduct easier, effective watershed assessments. The Spatial AnnAGNPS interface not only assists users to extract the required soil data from the National Soil Survey Geographic Database (SSURGO) but also helps users organize input files, run the model, and visualize modeling results.

AnnAGNPS is a data-intensive watershed model that routes sediment and nutrients through a watershed by utilizing land uses and topography. The watershed is broken up into cells of varying sizes based on topography. Each cell is then assigned a primary land use and soil type.

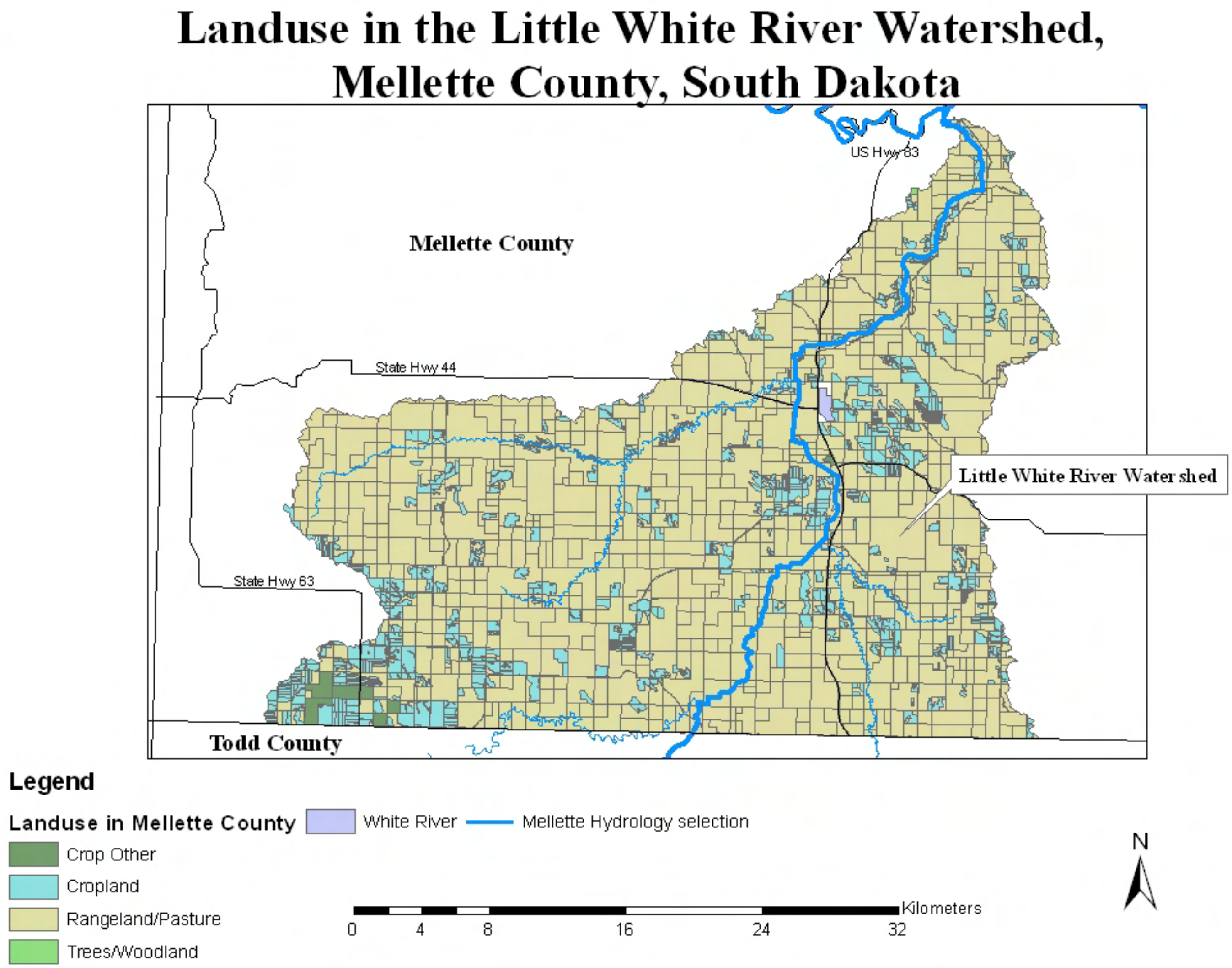


Figure C-1. Landuse in the Little White River watershed, Mellette County, South Dakota from 2003 through 2004.

Best Management Practices (BMPs) are then simulated by altering the land use in individual cells with reductions in sediment and nutrient yields calculated at the outlet to the watershed.

METHODS

The Little White River watershed in Mellette County (Figure C-1) was modeled and analyzed using AnnAGNPS modeling program. ArcView® data layers for AnnAGNPS were acquired from various governmental agencies. Digital Elevation Model layers (DEMs) were downloaded from a United States Geological Survey website, soil layers were downloaded from a United States Department of Agricultural, Natural Resource Conservation Service (USDA-NRCS) website and digital NASIS (National Soil Information System) data were obtained from the NRCS office in Huron, South Dakota. AnnAGNPS field and feedlot data for the Little White River watershed analysis was collected/performed by personnel from the Mellette County Conservation District from 2003 through 2004. Field history, planting and crop rotation data was obtained from the Farm Service Agency in White River, Mellette County Conservation District and land owners. Tillage, fertilization and feedlot data for the Little White River watershed was acquired through stakeholder surveys, personal contact and by phones. Planting dates for specific crops and tillage practices were acquired for this region using RUSLE data provided by NRCS and were modified by the Mellette County Conservation District. All AnnAGNPS data modification and entry was preformed by the local project coordinator under guidance by South Dakota Department of Environment and Natural Resources (SD DENR) Water Resources Assistance Program (WRAP).

Part of the modeling process includes the assessment of Animal Feeding Operations (AFOs) located in the watershed. This assessment was completed with the assistance of the Mellette County Conservation District which provided estimates on the number of animal units and duration of use in the Little White River Watershed. Forty-one AFOs were identified in the Little White River Watershed and are listed in Attachment A.

Climate/weather data from Pierre, South Dakota was used to generate simulated weather data. Model results are based on one year of climate data for initializing variables prior to 25-year watershed simulation. Simulated precipitation based on climate data ranged from 13 to 26 inches per year. Mean annual precipitation for this watershed is approximately 17 inches.

Impoundment data was obtained from ArcView® Digital Ortho Quad layers (DOQs). DOQs were used to identify and quantify impoundments greater than 10 acres. Average depths were estimated based on best professional judgment using known waterbodies of similar size. Coefficients were calculated based on surface area and depth, with an equation based on impoundment morphology.

Initial critical cells for sediment, nitrogen and phosphorus were determined using simulated cell specific runoff values (kg/acre), with threshold runoff values greater than one and two standard deviations above the mean. Sediment, nitrogen and phosphorus cells were analyzed and prioritized independently based on statistical characteristics. Cellular loading greater than two standard deviations above the mean for each category (sediment, nitrogen and phosphorus) received a priority ranking of one (1), loading cells greater than one but less than two standard deviation above the mean received a priority ranking of two (2) and cellular loading between one standard deviation and the mean received a priority three (3) ranking.

The Little White River was identified in the 2004 and 2006 Integrated Report (SD DENR, 2004 and SD DENR, 2006) as having increased loading and assigned beneficial use water quality standards violations for TSS (Total Suspended Solids). Modeled reductions were based on sediment critical cells only, as sediment is the main component of concern.

The existing field conditions, three-year crop rotation and fertilizer applications were modeled through AnnAGNPS to obtain initial (current) loading values at the outlet of each cell and the watershed (sediment (tons/acre/year); nitrogen and phosphorus (pounds/acre/year)). Specific AnnAGNPS parameters would then be manipulated (conventional tillage converted to no-tillage, low phosphorus fertilization application converted to no fertilization applications, etc.) to represent specific BMPs applied to the watershed. The AnnAGNPS model was re-run with manipulated values, the modified loading values were compared to the initial values to estimate/calculate sediment and nutrient reduction percentages. All reduction percentages were developed and calculated using AnnAGNPS modeled load reductions based on best available landuse (modified EROS and FSA coverage) data.

RESULTS AND DISCUSSION

Critical Cells

Priority critical cells for sediment, nitrogen and phosphorus for the Little White River watershed based on AnnAGNPS modeling are shown spatially in Figure C-2 (sediment), Figure C-3 (nitrogen) and Figure C-4 (phosphorus). AnnAGNPS model identified approximately 26,376 acres of critical areas for sediment, or 10.9 percent of the entire Little White River watershed, based on the above criteria (Table C-1). The Little White River watershed has been identified as having increased TSS concentrations/loading violating assigned beneficial use based water quality standards (SD DENR, 2002, SD DENR, 2004 and SD DENR, 2006).

Table C-1. Critical cell acreage by priority ranking[1] for the Little White River watershed, Mellette County, South Dakota from 2003 through 2004.

	Sediment		Nitrogen		Phosphorus	
Priority Ranking	**Acres**	**Percentage of the watershed**	**Acres**	**Percentage of the watershed**	**Acres**	**Percentage of the watershed**
1	2,923	1.2	3,831	1.6	1,116	0.5
2	1,053	0.4	2,653	1.1	41,861	17.3
3	22,400	9.2	9,485	3.9	50,943	21.0
Total	26,376	10.9	15,969	6.6	93,920	38.7
Total Watershed Acres in Mellette County						**242,855**

[1] = Priority ranking excluding barren cells (White River group soils (badlands formation))

Spatially, sediment and nitrogen critical cells were generally within the Cut Meat Creek and Pine Creek drainages (Figure C-2 and Figure C-3), while phosphorus critical cells were mainly distributed throughout the lower portions of the Little White River watershed in Mellette County (Figure C-4). The parameter of concern for the Little White River was sediment and was used to determine percent reductions by BMP for sediment, nitrogen and phosphorus. Table C-1 indicates sediment critical cell acreages were relatively low compared to nutrient parameters; however, since the majority of the watershed is composed of range and pastureland increased nutrients, especially phosphorus, were expected. AnnAGNPS generally modeled the Little White River watershed in Mellette County as a nitrogen-limited system which was similar to actual water quality monitoring conducted during the watershed assessment (Assessment Report, pages 118 and 119). Thus, BMPs will be manipulated in priority one and priority two sediment critical cells to model/estimate sediment, nitrogen and phosphorus reductions. All priority cells should be field verified and refined prior to BMP implementation.

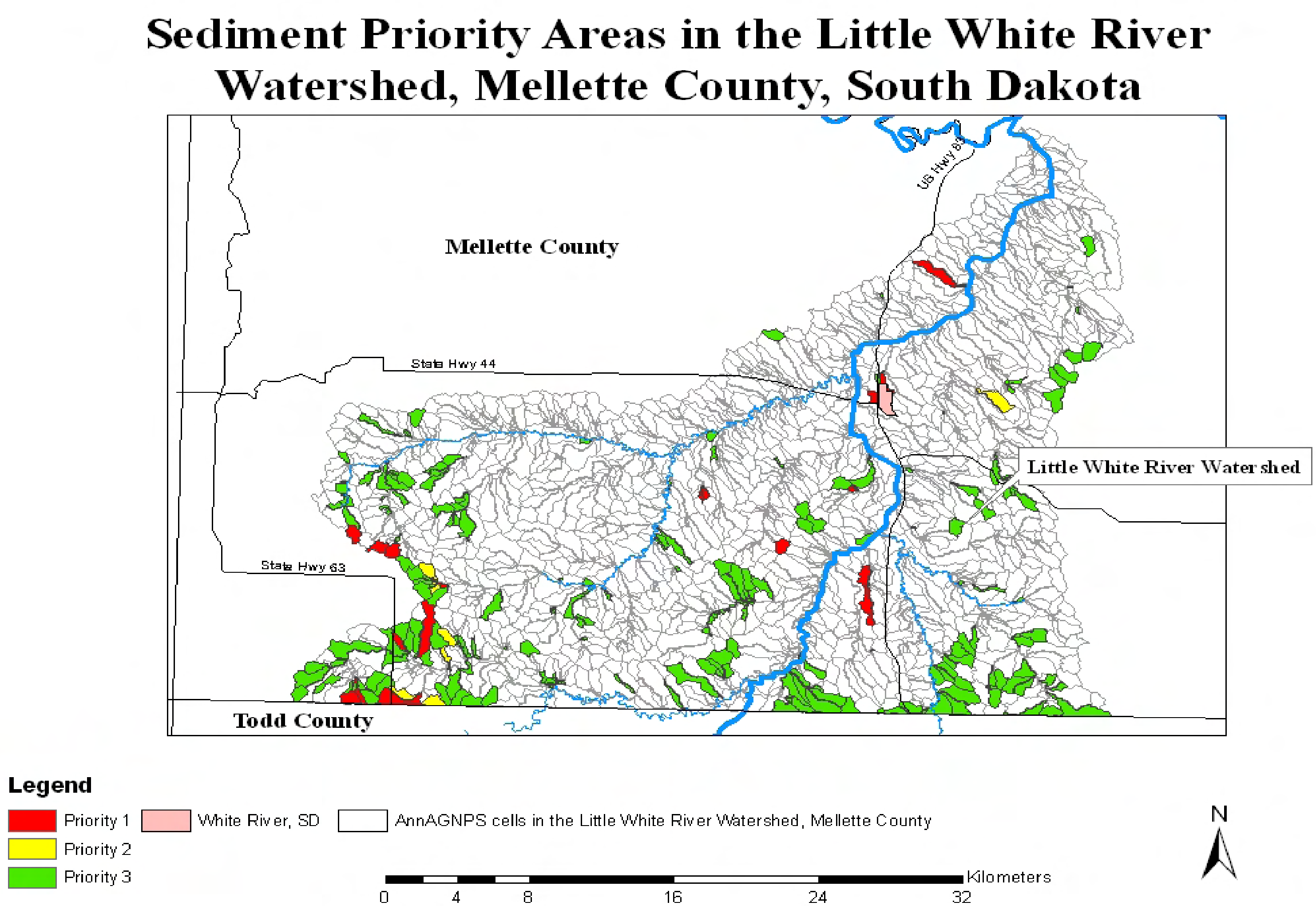


Figure C-2. AnnAGNPS Little White River critical sediment cells by priority ranking based on data from 2003 through 2004.

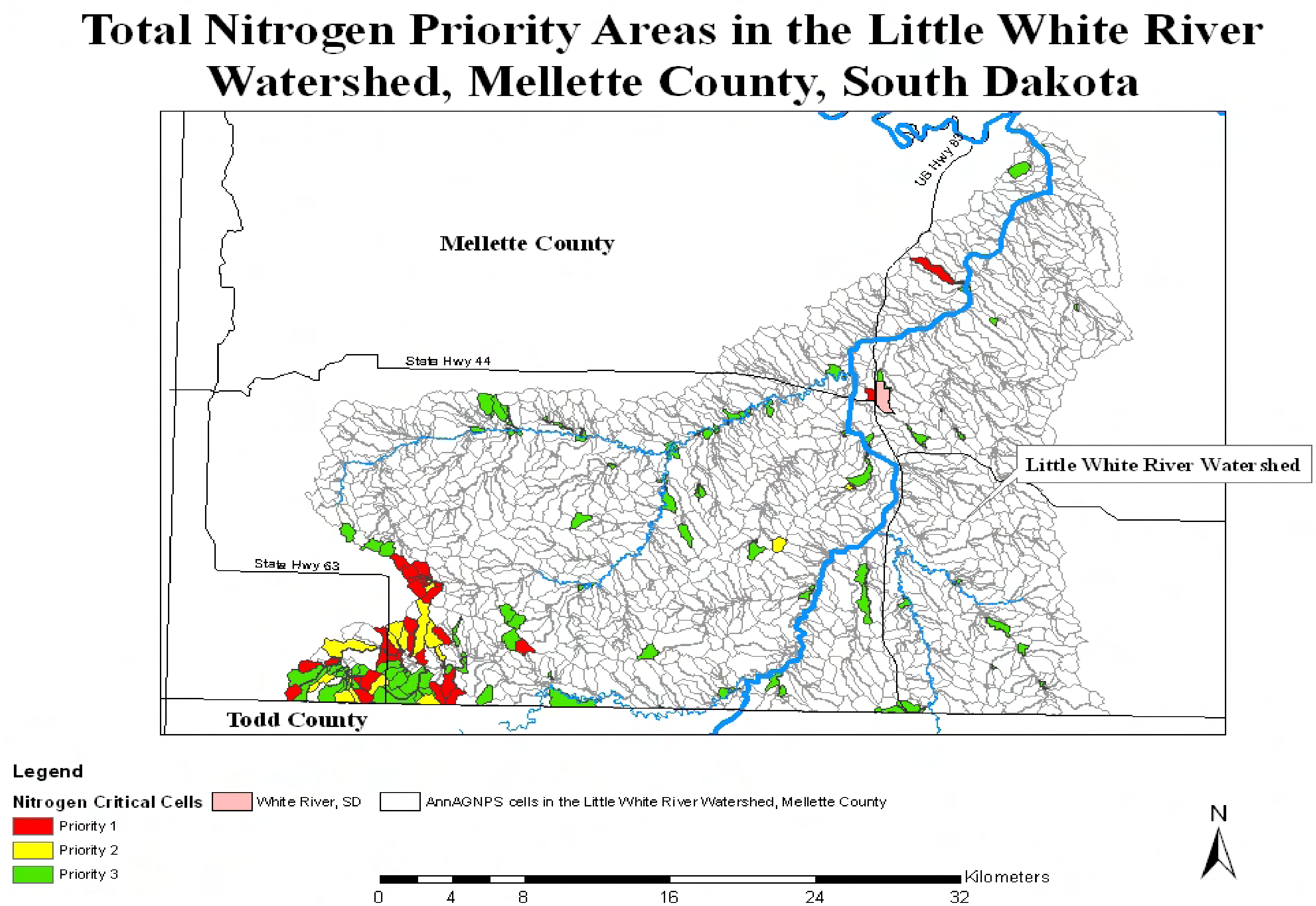


Figure C-3. AnnAGNPS Little White River critical nitrogen cells by priority ranking based on data from 2003 through 2004.

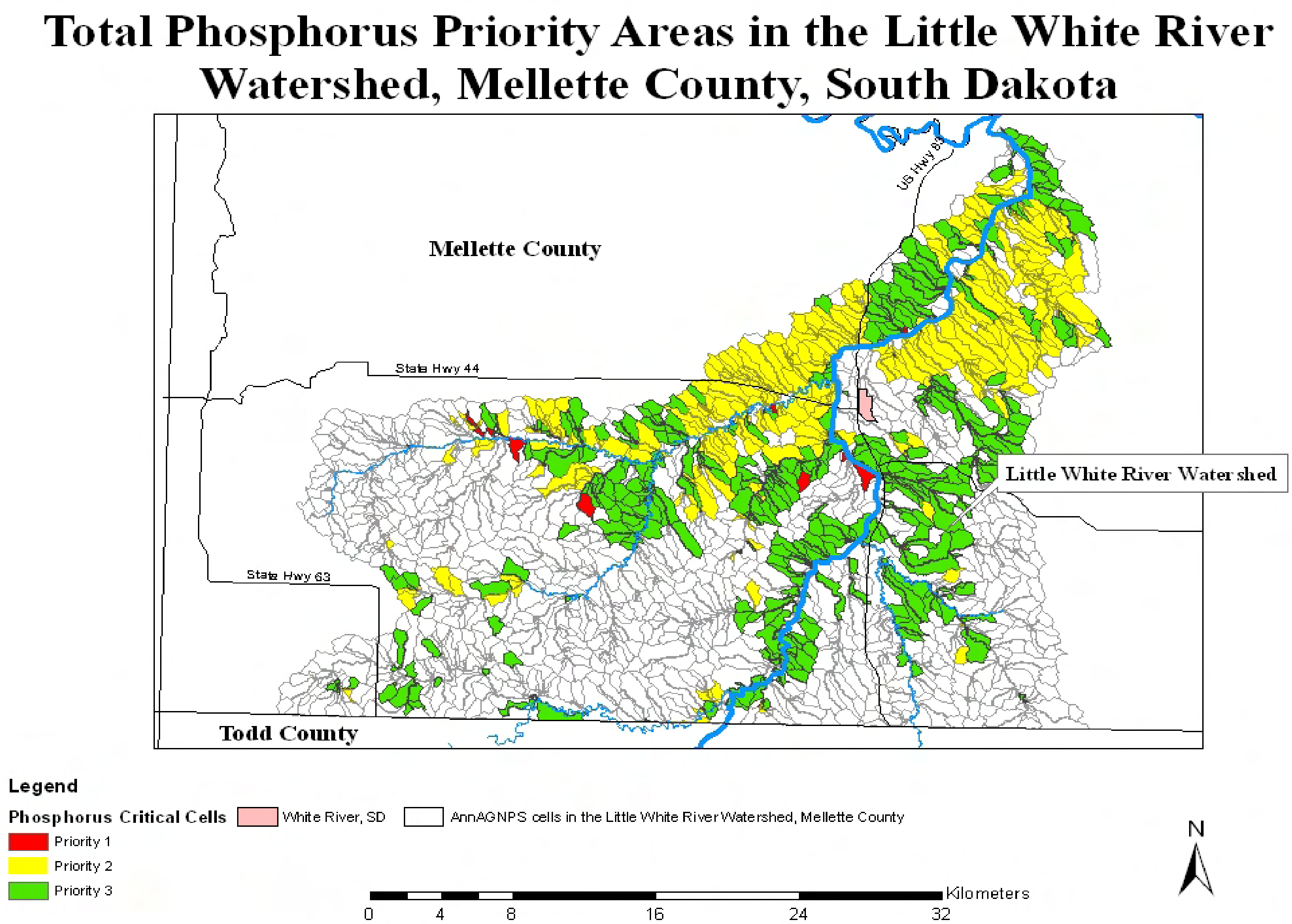


Figure C-4. Little White River critical phosphorus cells by priority ranking based on data from 2003 through 2004.

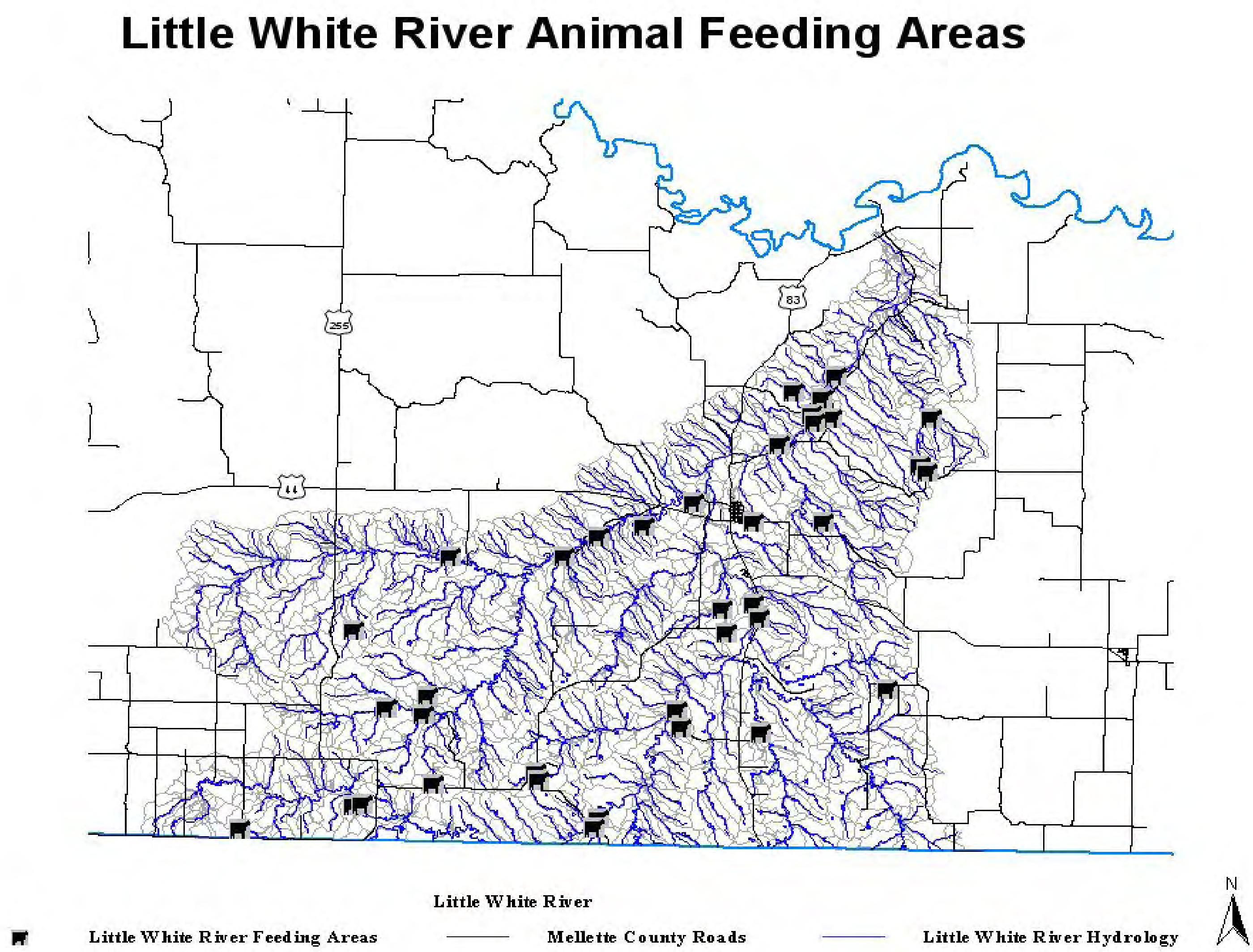


Figure C-5. AnnAGNPS Little White River feeding area locations based on data from 2003 through 2004.

AnnAGNPS Load Reduction Estimates

The Little White River watershed is identified as transporting considerable total suspended solids loading resulting violations in assigned beneficial use based water quality standards (SD DENR, 2002 SD DENR, 2004 and SD DENR, 2006). Existing conditions for the years 2003 through 2004, including row crop, pasture, fertilizer application rates, buffers, feedlots and tillage practices were modeled using AnnAGNPS in 2005. Initial conditions were modeled and loads were estimated at the outlet cell of the watershed (Table C-2). To model the best possible condition the watershed could attain, all land use in the watershed was converted to all grass including badlands (White River Group soils which are barren and can not support vegetation). Data indicate under ideal conditions, annual sediment would be dramatically reduced while nutrients parameters would be much less reduced. AnnAGNPS estimated reductions by converting current field conditions to an all grass condition would result in an estimated sediment reduction of 87.8 percent. However, by modeling badlands soils as barren; which are unable to sustain vegetation, the corrected (best possible) percent reduction was adjusted (9.8 percent load reduction in the average annual sediment load) to better represent best possible conditions in the watershed. Based on this scenario the corrected reduction percentage for the Little White River indicate sediment originating from sheet, rill and gully erosion is somewhat limited (modeled 9.8 percent). Thus the Little White River appears to transport high sediment load entering Mellette County from Todd County and deposits it into the White River. This scenario (converting the entire watershed to grass) is not realistic based on geological, logistical, technical and/or financial constraints.

Table C-2 Modeled initial condition and best possible condition for the Little White River watershed, Mellette County, South Dakota based on AnnAGNPS data from 2003 through 2004[1].

Best Management Practice	Sediment (tons/acre/year)	Nitrogen (lbs/acre/year)	Phosphorus (lbs/acre/year)
Initial Condition	0.041	0.085	2.587
Entire Watershed All Grass (Including Badlands)	0.005	0.057	2.367
Percent Reduction	**87.8**	**32.9**	**8.5**
Badlands Background Load (modeled (best possible))	0.037	0.077	2.590
Corrected Percent Reduction (adjusted for badlands)	**9.8**	**9.4**	**-0.1**

[1] = Load reduction calculated at the outlet of the watershed.

AnnAGNPS was used to predict/estimate nutrient load reductions with reduced fertilizer application rates (based on average 2003 through 2004 field application rates). Fertilizer reduction modeling was done by reducing nitrogen and phosphorus fertilizer application rates one level (rate change from high to moderate, moderate to low or low to no fertilizer application) in all priority one and priority two critical sediment cells (parameter of concern) in the Little White River watershed. Priority one and two sediment critical cells are listed in Attachment B Table C-B-1. Application rates varied in the type and amount of fertilizer applied throughout the watershed. Nitrogen and phosphorus in combination, nitrogen only or phosphorus only may be applied depending upon field, crop and/or tillage practice. Phosphorus applications rates also varied from high to low in pounds/acre. AnnAGNPS modeling indicated reducing fertilizer application rates one level in sediment priority one and priority two critical cells one level; overall estimated sediment reductions were non-existent. Nitrogen exhibited the highest nutrient reduction percentage at 4.7 percent while phosphorus loading was reduced by only 0.3 percent (Table C-3). The modest reduction in phosphorus was not unexpected due to the high percentage (91.9 percent) of range and pastureland in the watershed which generally have increased phosphorus loading.

Table C-3. Modeled initial condition and fertilizer reduction for the Little White River watershed, Mellette County, South Dakota based on AnnAGNPS data from 2000 through 2004[1].

Best Management Practice	Sediment (tons/acre/year)	Nitrogen (lbs/acre/year)	Phosphorus (lbs/acre/year)
Initial Condition	0.041	0.085	2.587
Fertilizer Reduction[2]	0.041	0.081	2.580
Percent Reduction	**0.0**	**4.7**	**0.3**

[1] = Load reduction calculated at the outlet of the watershed.
[2] = Reduced phosphorus fertilizer application rates one level in all priority-one and priority two critical sediment cells

AnnAGNPS was again used to predict/estimate phosphorus load reduction based on grazing management. Field data on pastures in the Little White River watershed indicated pasture locations but did not delineate specific grass conditions by pasture. The district manager for the Mellette County Conservation District (MCCD) indicated that the majority of the pasture in this watershed was in reasonably good condition. Based on this, the rating of the existing condition used in the model for all pastures was “fair”. Reductions were modeled by switching all existing pasture from fair (grass two to four inches in height) to “good” (grass four to six inches in height).

Table C-4. Modeled initial condition and grazing management improvements for the Little White River watershed, Mellette County, South Dakota based on AnnAGNPS data from 2000 through 2004[1].

Best Management Practice	Sediment (tons/acre/year)	Nitrogen (lbs/acre/year)	Phosphorus (lbs/acre/year)
Initial Condition	0.041	0.085	2.587
Grazing Management[2]	0.041	0.084	2.584
Percent Reduction	**0.0**	**1.2**	**0.1**

[1] = Load reduction calculated at the outlet of the watershed.
[2] = Modeled all pastures from poor or fair condition (grass two to four inches high) to good condition (grass four to six inches high).

Sediment, nitrogen and phosphorus reductions based on grazing management improvements on all current pastures in the Little White River watershed indicated no overall reduction in sediment and minimal reductions in nitrogen and phosphorus loading at the outlet of the watershed (Table C-4). Modeling results suggest grazing management the Little White River watershed would have relatively no effect on overall sediment loading (parameter of concern) to the White River; however, grazing improvement should have localized impacts on sheet and rill erosion within the watershed.

Tillage practices were modified (converted from tillage to no tillage) in all cropped priority-one and priority two critical sediment cells (30 critical cells comprising approximately 3,976 acres or 1.6 percent of the Little White River watershed) to estimate reductions. AnnAGNPS predicted a 2.4 percent reduction in overall delivered sediment by converting cropped sediment critical cells with tillage to no tillage (Table C-5). Tillage BMPs showed the greatest overall reduction (2.4 percent) in sediment loading followed by buffer strips.

Table C-5. Modeled initial condition and conservation tillage for the Little White River watershed, Mellette County, South Dakota based on AnnAGNPS data from 2000 through 2004[1].

Best Management Practice	Sediment (tons/acre/year)	Nitrogen (lbs/acre/year)	Phosphorus (lbs/acre/year)
Initial Condition	0.041	0.085	2.587
Conservation Tillage Reduction[2]	0.040	0.083	2.585
Percent Reduction	**2.4**	**2.4**	**0.08**

[1] = Load reduction calculated at the outlet of the watershed.
[2] = Modeled cropped priority-one and priority two sediment critical cells that are currently tilled to no tillage.

AnnAGNPS was also used to predict/estimate sediment and nutrient load reduction based on buffer management. Sediment priority-one and priority two critical cells for The Little White River were converted from current crops to all grass and modeled using AnnAGNPS. Parameter specific delivered reduction results were further reduced by 50 percent for a more conservative sediment, nitrogen and phosphorus load reductions (better simulates typical buffer reduction). AnnAGNPS predicted reductions were 2.4 percent for sediment and nitrogen loading and a slight decrease (0.08 percent) in phosphorus by applying buffer strips to sediment priority-one and priority two critical cells (Table C-6).

Table C-6. Modeled initial condition and buffer strips for the Little White River watershed, Mellette County, South Dakota based on AnnAGNPS data from 2000 through 2004[1].

Best Management Practice	Sediment (tons/acre/year)	Nitrogen (lbs/acre/year)	Phosphorus (lbs/acre/year)
Initial Condition	0.041	0.085	2.587
Buffer Strips[2]	0.0405	0.084	2.586
Percent Reduction	**1.2**	**1.2**	**0.04**

[1] = Load reduction calculated at the outlet of the watershed.
[2] = Modeled by converting all priority-one and two sediment critical cells to grass and reducing delivered output one-half to better represent buffers.

Forty-one animal feeding areas were identified in the Little White River drainage. Figure C- 5 depicts locations of animal feeding areas in the watershed.

Table C-7. Modeled initial condition and feedlot reductions for the Little White River watershed, Mellette County, South Dakota based on AnnAGNPS data from 2000 through 2004[1].

Best Management Practice	Sediment (tons/acre/year)	Nitrogen (lbs/acre/year)	Phosphorus (lbs/acre/year)
Initial Condition	0.041	0.085	2.587
Feedlots[2]	0.041	0.085	2.587
Percent Reduction	**0.0**	**0.0**	**0.0**

[1] = Load reduction calculated at the outlet of the watershed.
[2] = Modeled by removing one feedlot in the Little White River watershed rating over sixty.

Feedlot reduction modeling was performed to estimate sediment and nutrient reductions by removing one feeding area that rated sixty and over in the Little White River watershed (Attachment A). Feedlot rating consisted of entering feedlot parameters into a SD DENR feedlot program which calculates COD, nitrogen and phosphorus values and rating numbers for AnnAGNPS data entry. Estimated sediment and nutrient load reductions for feedlots were modeled by removing all feedlots rating at or above 60. One feedlot was removed and modeled by AnnAGNPS with no average overall load reductions in sediment, nitrogen or phosphorus at the outlet of The Little White River (Table C-7). Table C-7 indicates that estimated AnnAGNPS average annual sediment in tons/acre/year and nutrients lbs/acre/year load reductions may average out or mask cell specific load reductions in the Little White River watershed.

CONCLUSION

Modeled BMP reductions were: fertilizer, grazing management, conservation tillage, buffer strips and feedlots. The combination of increased implementation of fertilizer, grazing management, conservation tillage, buffer strips and feedlots will result in estimated annual load reductions in sediment nitrogen and phosphorus (Table C-8).

Table C-8 AnnAGNPS modeled overall BMP reduction percentages for the Little White River watershed, Mellette County, South Dakota based on AnnAGNPS data from 2000 through 2004.

Best Management Practice	Sediment Reduction (tons/acre/yr)	Nitrogen Reduction (lbs/acre/yr)	Phosphorus Reduction (lbs/acre/yr)
Fertilizer Reduction	0.000	0.004	0.007
Grazing Management Reduction	0.000	0.001	0.003
Conservation Tillage Reduction	0.001	0.002	0.002
Buffer Strips Reduction	0.0005	0.001	0.001
Feedlot Reductions	0.000	0.000	0.000
Estimated Overall Reduction	**0.0015**	**0.008**	**0.013**

Installing these practices on priority-one and priority two sediment critical cells the Little White River will reduce the amount of sediment, nitrogen and phosphorus entering The Little White River on a per acre basis annually. Grazing management and conservation tillage had the greatest impact on overall sediment reductions while fertilizer, grazing management reductions had the greatest impact on nitrogen and phosphorus loading (Table C-8).

It is recommended that efforts to reduce sediment and nutrients be targeted to the installation of appropriate BMPs that include but are not limited to grazing management, conservation tillage on cropland, fertilizer reduction, buffer/filter strips and feedlot agricultural waste systems. BMPs should also be implemented/installed in sediment, nitrogen and phosphorus priority-one and two critical cells in the Little White River watershed. This should reduce sediment and nutrient loading throughout the watershed and reduce violations in total suspended solids.

The implementation of appropriate BMPs in field verified critical cells in priority-one and two sub-watersheds should produce the most cost-effective treatment plan for reducing sediment and nutrient yields from the Little White River watershed.

REFERENCES

Bosch, D.D., R.L. Bingner, F.G. Theurer, G. Felton, and I. Chaubey, 1998. Evaluation of the AnnAGNPS water quality model. ASAE Paper No. 98–2195, St Joseph, Michigan, 12 pp.

Carpenter, S.R., N.F. Caraco, D.L. Correll, R.W. Howarth, A.N. Sharpley, and V.H. Smith. 1998. Non-point pollution of surface waters with phosphorus and nitrogen. Ecological Applications 8: 559-568.

Cronshey, R.G. and F.G. Theurer, 1998. AnnAGNPS-Non Point Pollutant Loading Model. *In*: Proceedings of the First Federal Interagency Hydrologic Modeling Conference. 19-23 April 1998, Las Vegas, NV.

deNoyelles, F., S.H. Wang, J.O. Meyer, D.G. Huggins, J.T. Lennon, W.S. Kolln, and S.J. Randtke. 1999. Water quality issues in reservoirs: some considerations from a study of a large reservoir in Kansas. 49th Annual Conference of Environmental Engineering. Department of Civil and Environmental Engineering and Division of Continuing Education, The University of Kansas. Lawrence, KS. 83-119.

Geter, F. and F. G. Theurer, 1998. AnnAGNPS-RUSLE sheet and rill erosion. *In*: Proceedings of the First Federal Interagency Hydrologic Modeling Conference. 19-23 April 1998, Las Vegas, NV.

Johnson, G.L., C.Daly, G.H. Taylor and C.L. Hanson, 2000. Spatial variability and interpolation of stochastic weather simulation model parameters. J. Appl. Meteor., 39, 778-796.

Kansas. 2003. GIS interface for AnnAGNPS user's manual (draft). Central Plains Center for Bioassessment, Kansas Biological Survey and Kansas Geological Survey, University of Kansas. Lawrence, KS. 60 pp.

Kansas Department of Health and Environment (KDHE). 1999. Lake and reservoir monitoring program report. Division of Environment, Bureau of Environmental Field Services, KDHE. 60 pp.

Renard, K.G., G.R. Foster, G.A. Weesies, D.K. McCool, and D.C. Yoder, 1997. Predicting soil erosion by water: A Guide to conservation planning with the Revised Universal Soil Loss Equation (RUSLE). U.S. Department of Agriculture. Agriculture Handbook No 703.

Scribner, E.A., D.A. Goolsby, E.E. Thurman, M.T. Meyer and W.A. Battaglin. 1996. Concentrations of selected herbicides, herbicide metabolites and nutrients in outflow from selected Midwestern reservoirs, April 1992 through September 1993. U.S. Geological Survey Open-File Report 96-393. 128 pp.

Smith, V.H. 1998. Cultural eutrophication of inland, estuarine, and coastal waters. *In* Successes, Limitations, and Frontiers in Ecosystem Science. M.L. Pace and P.M. Goffman, editors. Springer-Verlag, New York. 7-49.

SD DENR. 1998. The 1998 South Dakota 303(d) Waterbody List and Supporting Documentation. South Dakota Department of Environment and Natural Resources, Pierre, South Dakota. 94 pp.

SD DENR. 2002. South Dakota Total Maximum Daily Load Waterbody List with Supporting Documentation. South Dakota Department of Environment and Natural Resources, Pierre, South Dakota. 58 pp.

SD DENR. 2004. The 2004 South Dakota Integrated Report for Surface Water Quality Assessment. South Dakota Department of Environment and Natural Resources, Pierre, South Dakota. 220 pp.

SD DENR. 2006. The 2006 South Dakota Integrated Report for Surface Water Quality Assessment. South Dakota Department of Environment and Natural Resources, Pierre, South Dakota. 203 pp.

Theurer, F. G. and C.D. Clarke, 1991. Wash load component for sediment yield modeling. *In*: Proceedings of the Fifth Federal Interagency Sedimentation Conference. 18-21 March 1991, Las Vegas, Nevada. p 7-1 to 7-8.

Theurer, F. G. and R. G. Cronshey, 1998. AnnAGNPS-reach routing processes. *In*: Proceedings of the First Federal Interagency Hydrologic Modeling Conference. 19-23 April 1998, Las Vegas, NV.

U.S. Environmental Protection Agency. 2000. National Water Quality Inventory: 1998 Report to Congress. EPA841-R-00-001. Office of Water. Washington, D.C.

ATTACHMENT A

Feedlot Rating Datasheets

AnnAGNPS Feeding Area Data

Lot ID 2 **P Load Pounds:** 72
Lot Area in Acres 1.4 **Upslope Area:** 5.2 **Duration:** 150 **Rating #:** 20

Feedlot Initial N	8	**Delta N**	0.043	**Feedlot Max N**	36	**Pack N**	100
Feedlot Initial P	3	**Delta P**	0.016	**Feedlot Max P**	11	**Pack P**	100
Feedlot Initial C	179	**Delta C**	1.000	**Feedlot Max C**	568	**Pack C**	100

Lot ID 3 **P Load Pounds:** 133
Lot Area in Acres 4.4 **Upslope Area:** 0.0 **Duration:** 36 **Rating #:** 24

Feedlot Initial N	13	**Delta N**	0.000	**Feedlot Max N**	100	**Pack N**	100
Feedlot Initial P	10	**Delta P**	0.000	**Feedlot Max P**	30	**Pack P**	100
Feedlot Initial C	225	**Delta C**	0.000	**Feedlot Max C**	1964	**Pack C**	100

Lot ID 4 **P Load Pounds:** 27
Lot Area in Acres 3.3 **Upslope Area:** 1.8 **Duration:** 45 **Rating #:** 3

Feedlot Initial N	3	**Delta N**	0.018	**Feedlot Max N**	18	**Pack N**	100
Feedlot Initial P	1	**Delta P**	0.007	**Feedlot Max P**	5	**Pack P**	100
Feedlot Initial C	76	**Delta C**	0.424	**Feedlot Max C**	276	**Pack C**	100

Lot ID 5 **P Load Pounds:** 266
Lot Area in Acres 6.0 **Upslope Area:** 58.2 **Duration:** 150 **Rating #:** 67

Feedlot Initial N	11	**Delta N**	0.060	**Feedlot Max N**	14	**Pack N**	100
Feedlot Initial P	5	**Delta P**	0.023	**Feedlot Max P**	4	**Pack P**	100
Feedlot Initial C	250	**Delta C**	1.400	**Feedlot Max C**	215	**Pack C**	100

Lot ID 6 **P Load Pounds:** 7
Lot Area in Acres 3.6 **Upslope Area:** 0.0 **Duration:** 180 **Rating #:** 3

Feedlot Initial N	1	**Delta N**	0.005	**Feedlot Max N**	6	**Pack N**	100
Feedlot Initial P	0	**Delta P**	0.002	**Feedlot Max P**	2	**Pack P**	100
Feedlot Initial C	21	**Delta C**	0.117	**Feedlot Max C**	94	**Pack C**	100

Lot ID 7 **P Load Pounds:** 98
Lot Area in Acres 4.3 **Upslope Area:** 5.5 **Duration:** 63 **Rating #:** 29

Feedlot Initial N	7	**Delta N**	0.000	**Feedlot Max N**	33	**Pack N**	100
Feedlot Initial P	5	**Delta P**	0.000	**Feedlot Max P**	10	**Pack P**	100
Feedlot Initial C	115	**Delta C**	0.000	**Feedlot Max C**	645	**Pack C**	100

AnnAGNPS Feeding Area Data

Lot ID 8 **P Load Pounds:** 108
Lot Area in Acres 1.9 **Upslope Area:** 20.4 **Duration:** 75 **Rating #:** 43

Feedlot Initial N	13	**Delta N**	0.076	**Feedlot Max N**	16	**Pack N**	100
Feedlot Initial P	6	**Delta P**	0.029	**Feedlot Max P**	5	**Pack P**	100
Feedlot Initial C	316	**Delta C**	1.768	**Feedlot Max C**	250	**Pack C**	100

Lot ID 9 **P Load Pounds:** 35
Lot Area in Acres 5.4 **Upslope Area:** 0.0 **Duration:** 180 **Rating #:** 25

Feedlot Initial N	3	**Delta N**	0.018	**Feedlot Max N**	21	**Pack N**	100
Feedlot Initial P	1	**Delta P**	0.007	**Feedlot Max P**	6	**Pack P**	100
Feedlot Initial C	74	**Delta C**	0.415	**Feedlot Max C**	333	**Pack C**	100

Lot ID 10 **P Load Pounds:** 53
Lot Area in Acres 6.1 **Upslope Area:** 16.1 **Duration:** 153 **Rating #:** 33

Feedlot Initial N	3	**Delta N**	0.014	**Feedlot Max N**	8	**Pack N**	100
Feedlot Initial P	1	**Delta P**	0.005	**Feedlot Max P**	2	**Pack P**	100
Feedlot Initial C	59	**Delta C**	0.330	**Feedlot Max C**	124	**Pack C**	100

Lot ID 11 **P Load Pounds:** 37
Lot Area in Acres 2.4 **Upslope Area:** 0.2 **Duration:** 36 **Rating #:** 4

Feedlot Initial N	7	**Delta N**	0.040	**Feedlot Max N**	46	**Pack N**	100
Feedlot Initial P	3	**Delta P**	0.015	**Feedlot Max P**	14	**Pack P**	100
Feedlot Initial C	167	**Delta C**	0.933	**Feedlot Max C**	719	**Pack C**	100

Lot ID 12 **P Load Pounds:** 93
Lot Area in Acres 4.1 **Upslope Area:** 0.9 **Duration:** 60 **Rating #:** 26

Feedlot Initial N	9	**Delta N**	0.000	**Feedlot Max N**	61	**Pack N**	100
Feedlot Initial P	7	**Delta P**	0.000	**Feedlot Max P**	19	**Pack P**	100
Feedlot Initial C	151	**Delta C**	0.000	**Feedlot Max C**	1202	**Pack C**	100

Lot ID 13 **P Load Pounds:** 70
Lot Area in Acres 1.1 **Upslope Area:** 0.9 **Duration:** 30 **Rating #:** 7

Feedlot Initial N	16	**Delta N**	0.000	**Feedlot Max N**	114	**Pack N**	100
Feedlot Initial P	12	**Delta P**	0.000	**Feedlot Max P**	35	**Pack P**	100
Feedlot Initial C	282	**Delta C**	0.000	**Feedlot Max C**	2245	**Pack C**	100

AnnAGNPS Feeding Area Data

Lot ID 14 **P Load Pounds:** 46
Lot Area in Acres 3.0 **Upslope Area:** 0.3 **Duration:** 165 **Rating #:** 27

Feedlot Initial N	7	**Delta N**	0.040	**Feedlot Max N**	46	**Pack N**	100
Feedlot Initial P	3	**Delta P**	0.015	**Feedlot Max P**	14	**Pack P**	100
Feedlot Initial C	167	**Delta C**	0.933	**Feedlot Max C**	719	**Pack C**	100

Lot ID 15 **P Load Pounds:** 43
Lot Area in Acres 6.6 **Upslope Area:** 0.0 **Duration:** 72 **Rating #:** 16

Feedlot Initial N	3	**Delta N**	0.018	**Feedlot Max N**	22	**Pack N**	100
Feedlot Initial P	1	**Delta P**	0.007	**Feedlot Max P**	7	**Pack P**	100
Feedlot Initial C	76	**Delta C**	0.424	**Feedlot Max C**	341	**Pack C**	100

Lot ID 16 **P Load Pounds:** 2
Lot Area in Acres 5.2 **Upslope Area:** 0.0 **Duration:** 328 **Rating #:** 0

Feedlot Initial N	0	**Delta N**	0.000	**Feedlot Max N**	1	**Pack N**	100
Feedlot Initial P	0	**Delta P**	0.000	**Feedlot Max P**	0	**Pack P**	100
Feedlot Initial C	12	**Delta C**	0.000	**Feedlot Max C**	22	**Pack C**	100

Lot ID 17 **P Load Pounds:** 4
Lot Area in Acres 6.7 **Upslope Area:** 0.0 **Duration:** 328 **Rating #:** 3

Feedlot Initial N	0	**Delta N**	0.000	**Feedlot Max N**	2	**Pack N**	100
Feedlot Initial P	0	**Delta P**	0.000	**Feedlot Max P**	1	**Pack P**	100
Feedlot Initial C	15	**Delta C**	0.000	**Feedlot Max C**	28	**Pack C**	100

Lot ID 18 **P Load Pounds:** 24
Lot Area in Acres 1.3 **Upslope Area:** 1.7 **Duration:** 45 **Rating #:** 5

Feedlot Initial N	6	**Delta N**	0.000	**Feedlot Max N**	27	**Pack N**	100
Feedlot Initial P	4	**Delta P**	0.000	**Feedlot Max P**	8	**Pack P**	100
Feedlot Initial C	95	**Delta C**	0.000	**Feedlot Max C**	529	**Pack C**	100

Lot ID 19 **P Load Pounds:** 26
Lot Area in Acres 0.3 **Upslope Area:** 0.0 **Duration:** 150 **Rating #:** 26

Feedlot Initial N	41	**Delta N**	0.000	**Feedlot Max N**	280	**Pack N**	100
Feedlot Initial P	17	**Delta P**	0.000	**Feedlot Max P**	85	**Pack P**	100
Feedlot Initial C	960	**Delta C**	0.000	**Feedlot Max C**	4500	**Pack C**	100

AnnAGNPS Feeding Area Data

Lot ID 20 **P Load Pounds:** 15
Lot Area in Acres 4.2 **Upslope Area:** 0.0 **Duration:** 180 **Rating #:** 14

Feedlot Initial N	2	**Delta N**	0.010	**Feedlot Max N**	12	**Pack N**	100
Feedlot Initial P	1	**Delta P**	0.004	**Feedlot Max P**	4	**Pack P**	100
Feedlot Initial C	42	**Delta C**	0.233	**Feedlot Max C**	188	**Pack C**	100

Lot ID 21 **P Load Pounds:** 167
Lot Area in Acres 6.6 **Upslope Area:** 0.0 **Duration:** 22 **Rating #:** 21

Feedlot Initial N	11	**Delta N**	0.000	**Feedlot Max N**	83	**Pack N**	100
Feedlot Initial P	8	**Delta P**	0.000	**Feedlot Max P**	25	**Pack P**	100
Feedlot Initial C	188	**Delta C**	0.000	**Feedlot Max C**	1636	**Pack C**	100

Lot ID 22 **P Load Pounds:** 51
Lot Area in Acres 2.1 **Upslope Area:** 5.6 **Duration:** 165 **Rating #:** 32

Feedlot Initial N	7	**Delta N**	0.040	**Feedlot Max N**	22	**Pack N**	100
Feedlot Initial P	3	**Delta P**	0.015	**Feedlot Max P**	7	**Pack P**	100
Feedlot Initial C	167	**Delta C**	0.933	**Feedlot Max C**	347	**Pack C**	100

Lot ID 23 **P Load Pounds:** 43
Lot Area in Acres 3.5 **Upslope Area:** 2.0 **Duration:** 60 **Rating #:** 12

Feedlot Initial N	4	**Delta N**	0.000	**Feedlot Max N**	26	**Pack N**	100
Feedlot Initial P	3	**Delta P**	0.000	**Feedlot Max P**	8	**Pack P**	100
Feedlot Initial C	62	**Delta C**	0.000	**Feedlot Max C**	508	**Pack C**	100

Lot ID 24 **P Load Pounds:** 33
Lot Area in Acres 0.8 **Upslope Area:** 0.0 **Duration:** 30 **Rating #:** 0

Feedlot Initial N	20	**Delta N**	0.115	**Feedlot Max N**	137	**Pack N**	100
Feedlot Initial P	9	**Delta P**	0.044	**Feedlot Max P**	42	**Pack P**	100
Feedlot Initial C	481	**Delta C**	2.692	**Feedlot Max C**	2163	**Pack C**	100

Lot ID 25 **P Load Pounds:** 56
Lot Area in Acres 0.7 **Upslope Area:** 2.0 **Duration:** 45 **Rating #:** 15

Feedlot Initial N	23	**Delta N**	0.129	**Feedlot Max N**	68	**Pack N**	100
Feedlot Initial P	10	**Delta P**	0.049	**Feedlot Max P**	21	**Pack P**	100
Feedlot Initial C	536	**Delta C**	3.000	**Feedlot Max C**	1074	**Pack C**	100

AnnAGNPS Feeding Area Data

Lot ID	26					**P Load Pounds:**	4		
Lot Area in Acres	16.2	**Upslope Area:**	0.0	**Duration:**	365	**Rating #:**	4		
Feedlot Initial N	0	**Delta N**	0.000	**Feedlot Max N**	1	**Pack N**	100		
Feedlot Initial P	0	**Delta P**	0.000	**Feedlot Max P**	0	**Pack P**	100		
Feedlot Initial C	6	**Delta C**	0.000	**Feedlot Max C**	12	**Pack C**	100		

Lot ID	27					**P Load Pounds:**	15
Lot Area in Acres	0.9	**Upslope Area:**	0.0	**Duration:**	120	**Rating #:**	8
Feedlot Initial N	9	**Delta N**	0.049	**Feedlot Max N**	58	**Pack N**	100
Feedlot Initial P	4	**Delta P**	0.019	**Feedlot Max P**	18	**Pack P**	100
Feedlot Initial C	203	**Delta C**	1.140	**Feedlot Max C**	916	**Pack C**	100

Lot ID	28					**P Load Pounds:**	87
Lot Area in Acres	3.0	**Upslope Area:**	0.0	**Duration:**	200	**Rating #:**	38
Feedlot Initial N	14	**Delta N**	0.080	**Feedlot Max N**	95	**Pack N**	100
Feedlot Initial P	6	**Delta P**	0.031	**Feedlot Max P**	29	**Pack P**	100
Feedlot Initial C	333	**Delta C**	1.867	**Feedlot Max C**	1500	**Pack C**	100

Lot ID	29					**P Load Pounds:**	49
Lot Area in Acres	2.8	**Upslope Area:**	0.4	**Duration:**	180	**Rating #:**	27
Feedlot Initial N	8	**Delta N**	0.043	**Feedlot Max N**	50	**Pack N**	100
Feedlot Initial P	3	**Delta P**	0.016	**Feedlot Max P**	15	**Pack P**	100
Feedlot Initial C	179	**Delta C**	1.000	**Feedlot Max C**	791	**Pack C**	100

Lot ID	30					**P Load Pounds:**	137
Lot Area in Acres	1.6	**Upslope Area:**	0.0	**Duration:**	18	**Rating #:**	50
Feedlot Initial N	41	**Delta N**	0.000	**Feedlot Max N**	280	**Pack N**	100
Feedlot Initial P	17	**Delta P**	0.000	**Feedlot Max P**	85	**Pack P**	100
Feedlot Initial C	960	**Delta C**	0.000	**Feedlot Max C**	4493	**Pack C**	100

Lot ID	31					**P Load Pounds:**	10
Lot Area in Acres	0.7	**Upslope Area:**	0.0	**Duration:**	45	**Rating #:**	0
Feedlot Initial N	6	**Delta N**	0.000	**Feedlot Max N**	45	**Pack N**	100
Feedlot Initial P	4	**Delta P**	0.000	**Feedlot Max P**	14	**Pack P**	100
Feedlot Initial C	102	**Delta C**	0.000	**Feedlot Max C**	888	**Pack C**	100

AnnAGNPS Feeding Area Data

Lot ID 32 **P Load Pounds:** 22
Lot Area in Acres 0.6 **Upslope Area:** 0.0 **Duration:** 108 **Rating #:** 11

Feedlot Initial N	17	**Delta N**	0.098	**Feedlot Max N**	117	**Pack N**	100
Feedlot Initial P	7	**Delta P**	0.038	**Feedlot Max P**	36	**Pack P**	100
Feedlot Initial C	410	**Delta C**	2.295	**Feedlot Max C**	1844	**Pack C**	100

Lot ID 33 **P Load Pounds:** 125
Lot Area in Acres 13.5 **Upslope Area:** 0.0 **Duration:** 48 **Rating #:** 29

Feedlot Initial N	4	**Delta N**	0.000	**Feedlot Max N**	30	**Pack N**	100
Feedlot Initial P	3	**Delta P**	0.000	**Feedlot Max P**	9	**Pack P**	100
Feedlot Initial C	69	**Delta C**	0.000	**Feedlot Max C**	600	**Pack C**	100

Lot ID 34 **P Load Pounds:** 139
Lot Area in Acres 4.3 **Upslope Area:** 6.4 **Duration:** 90 **Rating #:** 26

Feedlot Initial N	7	**Delta N**	0.042	**Feedlot Max N**	43	**Pack N**	100
Feedlot Initial P	3	**Delta P**	0.016	**Feedlot Max P**	13	**Pack P**	100
Feedlot Initial C	174	**Delta C**	0.977	**Feedlot Max C**	673	**Pack C**	100

Lot ID 35 **P Load Pounds:** 751
Lot Area in Acres 8.2 **Upslope Area:** 30.8 **Duration:** 14 **Rating #:** 42

Feedlot Initial N	22	**Delta N**	0.000	**Feedlot Max N**	63	**Pack N**	100
Feedlot Initial P	17	**Delta P**	0.000	**Feedlot Max P**	19	**Pack P**	100
Feedlot Initial C	378	**Delta C**	0.000	**Feedlot Max C**	1249	**Pack C**	100

Lot ID 36 **P Load Pounds:** 108
Lot Area in Acres 2.6 **Upslope Area:** 0.0 **Duration:** 45 **Rating #:** 24

Feedlot Initial N	18	**Delta N**	0.000	**Feedlot Max N**	137	**Pack N**	100
Feedlot Initial P	14	**Delta P**	0.000	**Feedlot Max P**	42	**Pack P**	100
Feedlot Initial C	310	**Delta C**	0.000	**Feedlot Max C**	2700	**Pack C**	100

Lot ID 37 **P Load Pounds:** 268
Lot Area in Acres 4.1 **Upslope Area:** 40.0 **Duration:** 60 **Rating #:** 26

Feedlot Initial N	6	**Delta N**	0.035	**Feedlot Max N**	20	**Pack N**	100
Feedlot Initial P	3	**Delta P**	0.013	**Feedlot Max P**	6	**Pack P**	100
Feedlot Initial C	146	**Delta C**	0.820	**Feedlot Max C**	315	**Pack C**	100

AnnAGNPS Feeding Area Data

Lot ID	38					**P Load Pounds:**	98
Lot Area in Acres	3.7	**Upslope Area:**	18.1	**Duration:**	54	**Rating #:**	31
Feedlot Initial N	7	**Delta N**	0.039	**Feedlot Max N**	15	**Pack N**	100
Feedlot Initial P	3	**Delta P**	0.015	**Feedlot Max P**	4	**Pack P**	100
Feedlot Initial C	162	**Delta C**	0.908	**Feedlot Max C**	233	**Pack C**	100

Lot ID	39					**P Load Pounds:**	155
Lot Area in Acres	4.6	**Upslope Area:**	11.6	**Duration:**	90	**Rating #:**	26
Feedlot Initial N	6	**Delta N**	0.034	**Feedlot Max N**	31	**Pack N**	100
Feedlot Initial P	3	**Delta P**	0.013	**Feedlot Max P**	10	**Pack P**	100
Feedlot Initial C	141	**Delta C**	0.791	**Feedlot Max C**	496	**Pack C**	100

Lot ID	41					**P Load Pounds:**	92
Lot Area in Acres	1.8	**Upslope Area:**	0.0	**Duration:**	24	**Rating #:**	13
Feedlot Initial N	22	**Delta N**	0.000	**Feedlot Max N**	168	**Pack N**	100
Feedlot Initial P	17	**Delta P**	0.000	**Feedlot Max P**	51	**Pack P**	100
Feedlot Initial C	379	**Delta C**	0.000	**Feedlot Max C**	3300	**Pack C**	100

Lot ID	42					**P Load Pounds:**	73
Lot Area in Acres	0.9	**Upslope Area:**	57.9	**Duration:**	30	**Rating #:**	49
Feedlot Initial N	18	**Delta N**	0.102	**Feedlot Max N**	4	**Pack N**	100
Feedlot Initial P	8	**Delta P**	0.039	**Feedlot Max P**	1	**Pack P**	100
Feedlot Initial C	426	**Delta C**	2.386	**Feedlot Max C**	65	**Pack C**	100

Lot ID	43					**P Load Pounds:**	82
Lot Area in Acres	4.6	**Upslope Area:**	6.7	**Duration:**	45	**Rating #:**	10
Feedlot Initial N	4	**Delta N**	0.023	**Feedlot Max N**	24	**Pack N**	100
Feedlot Initial P	2	**Delta P**	0.009	**Feedlot Max P**	7	**Pack P**	100
Feedlot Initial C	98	**Delta C**	0.548	**Feedlot Max C**	379	**Pack C**	100

ATTACHMENT B

Critical cells by priority ranking for sediment, nitrogen and phosphorus in the Little White River watershed, Mellette County, South Dakota

Table C-B-1. Critical cells by priority ranking for sediment, nitrogen and phosphorus in the Little White River watershed, Mellette County, South Dakota based on 2003 through 2004 data.

Sediment				Total Nitrogen				Total Phosphorus			
Priority	Cell	Acres	Sediment	Priority	Cell	Acres	Nitrogen	Priority	Cell	Acres	Phosphorus
1	8,052	318.91	1.263	1	3691	153.45	8.917	1	1,293	14.90	7.142
1	1,451	148.56	0.900	1	3623	46.04	7.642	1	4,563	17.35	7.059
1	3,732	104.53	0.551	1	3683	64.49	5.291	1	4,982	34.25	7.038
1	4,791	149.45	0.423	1	6033	15.57	1.774	1	1,573	271.99	7.026
1	5,293	49.15	0.414	1	3503	104.97	1.683	1	1,543	61.16	7.016
1	4,532	31.36	0.394	1	7061	148.34	1.667	1	4,611	151.90	6.380
1	7,081	154.56	0.343	1	8052	318.91	1.643	1	7,423	54.93	6.206
1	4,533	10.23	0.303	1	6052	66.94	1.604	1	7,412	45.59	5.973
1	7,091	149.23	0.292	1	6031	184.14	1.586	1	7,442	34.47	5.961
1	3,492	344.93	0.275	1	6063	10.90	1.394	1	6,532	195.26	5.896
1	723	18.68	0.231	1	6013	154.79	1.366	1	6,382	234.40	5.873
1	1,262	2.45	0.224	1	6051	153.01	1.155	2	7,432	8.01	5.655
1	1,382	109.64	0.211	1	3631	152.56	1.153	2	7,402	33.14	5.637
1	2,733	156.57	0.177	1	6053	24.46	1.150	2	7,422	69.83	5.619
1	7,191	159.68	0.167	1	6061	150.34	1.127	2	7,453	207.05	5.605
1	3,651	175.47	0.164	1	1451	148.56	1.083	2	4,832	17.79	5.570
1	5,302	34.03	0.162	1	3562	182.36	1.070	2	5,912	66.27	5.501
1	3,633	77.62	0.135	1	3901	159.90	1.042	2	6,063	10.90	5.493
1	3,743	455.02	0.125	1	3742	253.08	1.027	2	8,112	32.02	5.352
1	6,022	29.36	0.119	1	3421	150.56	0.931	2	5,291	150.56	5.289
1	8,022	4.45	0.119	1	3423	238.85	0.915	2	4,792	73.39	5.287
1	2,753	233.29	0.099	1	3771	149.67	0.912	2	232	32.25	5.263
1	6,062	6.23	0.099	1	3701	155.45	0.910	2	6,082	104.97	5.220
2	6,042	7.56	0.093	1	3563	234.40	0.844	2	262	64.05	5.198
2	3,771	149.67	0.089	1	3451	155.01	0.841	2	792	259.53	5.197
2	3,493	147.89	0.075	1	3621	211.50	0.799	2	592	235.52	5.191
2	6,063	10.90	0.070	1	3533	13.34	0.725	2	282	84.06	5.188
2	1,012	301.57	0.067	1	6022	29.36	0.721	2	202	94.96	5.185
2	3,753	83.62	0.067	2	6042	7.56	0.695	2	3,623	46.04	5.185
2	3,481	154.12	0.064	2	6032	47.37	0.683	2	203	54.93	5.183
2	6,061	150.34	0.063	2	3731	166.35	0.675	2	173	11.56	5.182
2	6,032	47.37	0.061	2	3733	153.67	0.674	2	233	23.57	5.180
3	6,033	15.57	0.050	2	3481	154.12	0.668	2	943	66.27	5.176
3	3,491	170.80	0.049	2	3753	83.62	0.663	2	972	79.84	5.175
3	3,631	152.56	0.048	2	3491	170.80	0.644	2	8,121	159.01	5.170
3	1,383	101.19	0.045	2	3751	229.73	0.643	2	4,922	224.17	5.167
3	6,053	24.46	0.045	2	3732	104.53	0.582	2	823	5.78	5.165
3	3,691	153.45	0.034	2	3743	455.02	0.577	2	303	2.00	5.162
3	3,901	159.90	0.034	2	4532	31.36	0.554	2	983	342.71	5.160
3	4,473	224.84	0.030	2	3702	3.34	0.543	2	1,322	47.15	5.160
3	6,013	154.79	0.025	2	6062	6.23	0.531	2	7,862	6.45	5.160
3	3,421	150.56	0.023	2	3633	77.62	0.481	2	283	22.91	5.154
3	3,451	155.01	0.023	2	3573	463.47	0.477	2	7,913	10.23	5.153
3	3,503	104.97	0.023	2	4791	149.45	0.475	2	8,092	137.66	5.153
3	6,052	66.94	0.023	2	4533	10.23	0.452	2	292	136.99	5.151

Table C-B-1 (continued). Critical cells by priority ranking for sediment, nitrogen and phosphorus in the Little White River watershed, Mellette County, South Dakota based on 2003 through 2004 data.

Sediment				Total Nitrogen				Total Phosphorus			
Priority	Cell	Acres	Sediment	Priority	Cell	Acres	Nitrogen	Priority	Cell	Acres	Phosphorus
3	3,731	166.35	0.021	2	3712	7.12	0.414	2	183	171.24	5.148
3	3,653	37.14	0.020	2	3651	175.47	0.409	2	4,962	28.02	5.147
3	3,733	153.67	0.020	2	3671	156.12	0.385	2	7,722	21.35	5.147
3	7,213	6.00	0.019	3	3341	167.69	0.365	2	7,852	151.67	5.147
3	3,621	211.50	0.017	3	7452	76.28	0.365	2	352	37.14	5.146
3	3,712	7.12	0.017	3	7433	17.79	0.360	2	412	11.79	5.146
3	3,742	253.08	0.017	3	3472	178.80	0.353	2	8,093	102.30	5.146
3	4,213	2.22	0.017	3	3482	77.84	0.350	2	7,932	16.68	5.145
3	3,172	9.12	0.016	3	5293	49.15	0.343	2	302	17.79	5.144
3	6,031	184.14	0.016	3	3483	48.70	0.341	2	812	332.03	5.142
3	7,801	153.01	0.016	3	3642	22.68	0.334	2	7,883	1.33	5.142
3	2,032	19.57	0.015	3	3643	19.57	0.333	2	363	44.70	5.140
3	3,701	155.45	0.015	3	3492	344.93	0.332	2	7,912	19.13	5.140
3	3,713	5.56	0.015	3	3443	1.33	0.327	2	312	34.47	5.137
3	3,751	229.73	0.015	3	3432	48.26	0.319	2	333	6.89	5.137
3	4,153	46.93	0.014	3	3693	336.70	0.304	2	843	33.58	5.136
3	4,183	13.57	0.014	3	2733	156.57	0.297	2	7,933	56.27	5.136
3	7,061	148.34	0.013	3	7441	166.13	0.295	2	7,863	6.00	5.135
3	3,323	36.70	0.012	3	3713	5.56	0.269	2	563	95.18	5.134
3	3,341	167.69	0.012	3	3632	59.38	0.261	2	332	29.80	5.133
3	3,671	156.12	0.012	3	7081	154.56	0.247	2	372	18.68	5.133
3	6,051	153.01	0.012	3	723	18.68	0.246	2	653	23.13	5.133
3	1,133	9.34	0.011	3	3653	37.14	0.245	2	5,123	85.18	5.133
3	3,131	149.45	0.011	3	3652	32.69	0.240	2	782	433.22	5.132
3	3,423	238.85	0.011	3	1382	109.64	0.228	2	4,583	116.53	5.132
3	3,562	182.36	0.011	3	7091	149.23	0.227	2	4,902	19.13	5.132
3	3,683	64.49	0.011	3	1262	2.45	0.177	2	7,732	41.59	5.132
3	5,473	27.58	0.011	3	3233	72.95	0.159	2	7,693	19.13	5.131
3	453	16.01	0.010	3	7191	159.68	0.158	2	182	158.12	5.129
3	2,353	204.16	0.010	3	2753	233.29	0.128	2	4,893	238.85	5.129
3	2,543	72.50	0.010	3	8022	4.45	0.128	2	7,902	136.99	5.129
3	2,593	228.40	0.010	3	3223	15.35	0.122	2	353	37.36	5.128
3	3,133	333.37	0.010	3	5302	34.03	0.120	2	5,073	67.61	5.128
3	3,162	16.01	0.010	3	3292	445.68	0.119	2	382	31.80	5.126
3	3,652	32.69	0.010	3	8151	199.26	0.116	2	852	112.31	5.126
3	3,933	7.12	0.010	3	2013	4.00	0.111	2	7,721	150.34	5.126
3	4,063	82.06	0.010	3	7462	2.67	0.104	2	7,833	69.16	5.126
3	4,162	10.23	0.010	3	6251	149.00	0.100	2	323	20.02	5.124
3	4,193	2.00	0.010	3	2032	19.57	0.097	2	1,313	29.13	5.124
3	4,352	32.91	0.010	3	3493	147.89	0.096	2	7,983	18.01	5.124
3	6,953	29.58	0.010	3	4812	6.00	0.095	2	263	188.15	5.122
3	1,101	155.23	0.009	3	4813	1.78	0.094	2	743	122.98	5.122
3	1,153	185.03	0.009	3	3473	254.86	0.092	2	751	150.12	5.122
3	2,371	153.23	0.009	3	1243	31.14	0.090	2	5,103	95.18	5.121
3	2,403	1.33	0.009	3	3521	185.03	0.090	2	4,901	151.45	5.120

Table C-B-1 (continued). Critical cells by priority ranking for sediment, nitrogen and phosphorus in the Little White River watershed, Mellette County, South Dakota based on 2003 through 2004 data.

Sediment				Total Nitrogen				Total Phosphorus			
Priority	Cell	Acres	Sediment	Priority	Cell	Acres	Nitrogen	Priority	Cell	Acres	Phosphorus
3	2,562	135.22	0.009	3	3603	53.37	0.088	2	813	442.79	5.119
3	2,612	151.90	0.009	3	3622	75.84	0.088	2	853	221.06	5.119
3	3,161	150.78	0.009	3	453	16.01	0.086	2	7,982	11.12	5.119
3	3,163	17.79	0.009	3	4912	26.91	0.086	2	8,103	181.70	5.119
3	3,632	59.38	0.009	3	5391	148.56	0.084	2	8,111	153.23	5.119
3	4,142	16.01	0.009	3	763	31.14	0.083	2	373	6.45	5.118
3	4,163	5.56	0.009	3	5042	82.29	0.083	2	833	12.90	5.118
3	4,222	11.12	0.009	3	5113	76.28	0.083	2	4,932	231.29	5.118
3	4,362	185.92	0.009	3	6492	39.81	0.083	2	7,812	52.71	5.118
3	5,773	36.25	0.009	3	4271	162.79	0.082	2	403	184.59	5.117
3	6,673	47.37	0.009	3	4811	159.23	0.082	2	5,143	91.85	5.117
3	7,082	5.34	0.009	3	5132	5.56	0.082	2	362	72.72	5.116
3	7,182	48.70	0.009	3	3412	74.72	0.081	2	753	14.01	5.115
3	7,183	35.81	0.009	3	4473	224.84	0.081	2	4,963	21.79	5.115
3	171	152.78	0.008	3	4933	132.32	0.081	2	6,033	15.57	5.115
3	681	149.00	0.008	3	5082	27.13	0.081	2	383	43.37	5.114
3	1,123	163.24	0.008	3	5093	30.47	0.081	2	7,713	351.60	5.113
3	1,132	19.57	0.008	3	5232	10.45	0.081	2	7,743	55.38	5.112
3	2,253	189.70	0.008	3	2612	151.90	0.080	2	293	120.09	5.111
3	2,352	152.12	0.008	3	3403	17.12	0.080	2	422	80.28	5.111
3	2,382	85.84	0.008	3	5162	16.23	0.080	2	832	37.81	5.111
3	2,393	5.78	0.008	3	7632	4.67	0.080	2	5,002	4.67	5.111
3	2,563	92.07	0.008	3	3523	6.00	0.079	2	342	70.05	5.108
3	2,613	156.79	0.008	3	3783	38.92	0.079	2	1,321	150.78	5.108
3	3,053	147.00	0.008	3	3871	215.28	0.079	2	5,142	112.53	5.108
3	3,112	108.97	0.008	3	6542	19.35	0.079	2	5,063	146.11	5.107
3	3,113	151.23	0.008	3	2613	156.79	0.078	2	7,803	371.18	5.107
3	3,412	74.72	0.008	3	3402	22.46	0.078	2	573	70.05	5.106
3	3,442	8.23	0.008	3	3522	25.58	0.078	2	7,881	151.01	5.106
3	3,883	45.15	0.008	3	3923	17.57	0.078	2	7,923	246.41	5.106
3	3,953	10.45	0.008	3	7552	7.56	0.078	2	663	172.80	5.105
3	4,232	17.79	0.008	3	3442	8.23	0.077	2	762	4.23	5.105
3	4,242	40.03	0.008	3	3531	150.12	0.077	2	963	202.82	5.105
3	4,342	185.70	0.008	3	3532	144.56	0.077	2	7,993	24.91	5.105
3	4,353	51.37	0.008	3	6722	37.14	0.077	2	7,903	168.80	5.104
3	4,421	155.23	0.008	3	3612	67.83	0.076	2	343	22.46	5.103
3	5,853	11.34	0.008	3	3662	272.43	0.076	2	822	17.57	5.103
3	6,672	56.27	0.008	3	3672	25.35	0.076	2	7,893	49.15	5.103
3	6,842	78.51	0.008	3	3673	62.94	0.076	2	463	199.04	5.102
3	7,003	19.79	0.008	3	3682	37.81	0.076	2	5,062	43.37	5.102
3	7,203	58.93	0.008	3	3803	42.48	0.076	2	7,992	12.23	5.102
3	7,341	152.34	0.008	3	5871	149.45	0.076	2	322	41.59	5.101
3	441	232.40	0.007	3	6043	3.56	0.075	2	7,873	114.53	5.101
3	691	197.26	0.007	3	6493	23.80	0.075	2	413	13.79	5.100
3	701	149.45	0.007	3	6773	49.82	0.075	2	7,823	58.04	5.100
3	901	263.76	0.007	3	3692	230.18	0.074	2	7,853	42.70	5.100
3	1,081	153.23	0.007	3	6863	0.22	0.074	2	341	153.90	5.099

Table C-B-1 (continued). Critical cells by priority ranking for sediment, nitrogen and phosphorus in the Little White River watershed, Mellette County, South Dakota based on 2003 through 2004 data.

Sediment				Total Nitrogen				Total Phosphorus			
Priority	**Cell**	**Acres**	**Sediment**	**Priority**	**Cell**	**Acres**	**Nitrogen**	**Priority**	**Cell**	**Acres**	**Phosphorus**
3	1,162	36.25	0.007	3	52	11.79	0.073	2	7,752	96.74	5.098
3	1,163	59.82	0.007	3	1492	112.53	0.073	2	473	4.67	5.097
3	1,643	123.43	0.007	3	1503	10.90	0.073	2	783	584.90	5.097
3	1,801	164.57	0.007	3	3262	15.79	0.073	2	4,903	13.34	5.097
3	2,213	228.18	0.007	3	5412	25.35	0.073	2	5,342	19.79	5.097
3	2,222	133.66	0.007	3	5921	155.23	0.073	2	7,891	198.38	5.097
3	2,283	67.39	0.007	3	7553	7.78	0.073	2	7,832	37.14	5.096
3	2,303	433.22	0.007	3	53	3.78	0.072	2	4,943	293.12	5.095
3	2,392	18.90	0.007	3	6342	27.35	0.072	2	5,023	97.85	5.095
3	2,542	184.14	0.007	3	5222	80.06	0.071	2	7,723	39.81	5.095
3	2,863	4.23	0.007	3	733	51.37	0.069	2	5,333	5.78	5.094
3	3,171	172.36	0.007	3	1542	54.71	0.069	2	7,733	52.71	5.094
3	3,322	12.68	0.007	3	2372	14.23	0.069	2	7,973	125.21	5.094
3	3,361	170.58	0.007	3	3143	108.08	0.069	2	253	285.11	5.093
3	3,403	17.12	0.007	3	4572	15.57	0.069	2	1,333	181.25	5.093
3	3,573	463.47	0.007	3	5352	83.18	0.068	2	153	139.44	5.092
3	3,813	51.37	0.007	3	7482	27.80	0.068	2	761	148.34	5.092
3	3,852	7.56	0.007	3	5163	10.23	0.067	2	5,112	63.16	5.092
3	3,923	17.57	0.007	3	5313	1.78	0.067	2	7,762	57.38	5.092
3	4,032	452.13	0.007	3	5353	56.93	0.067	2	7,772	23.80	5.092
3	4,081	155.68	0.007	3	5442	2.45	0.067	2	6,293	210.83	5.090
3	4,143	18.46	0.007	3	7431	213.50	0.067	2	7,682	45.59	5.090
3	4,202	26.91	0.007	3	7493	16.01	0.067	2	7,702	11.56	5.090
3	4,253	30.69	0.007	3	2473	57.38	0.066	2	4,923	80.73	5.089
3	4,263	1.56	0.007	3	2963	18.90	0.066	2	7,901	193.04	5.089
3	4,341	163.01	0.007	3	2973	57.16	0.066	2	4,972	25.58	5.088
3	4,411	152.56	0.007	3	3152	61.83	0.066	2	7,931	149.89	5.088
3	5,412	25.35	0.007	3	5402	24.91	0.066	2	482	112.53	5.087
3	5,472	80.51	0.007	3	5422	195.04	0.066	2	662	117.42	5.086
3	5,772	71.39	0.007	3	7472	17.79	0.066	2	393	22.68	5.085
3	6,043	3.56	0.007	3	2202	166.35	0.065	2	933	27.13	5.085
3	6,113	8.01	0.007	3	2273	16.23	0.065	2	392	52.04	5.084
3	6,492	39.81	0.007	3	2232	75.17	0.064	2	442	85.62	5.084
3	6,623	59.38	0.007	3	2292	7.78	0.064	2	882	227.51	5.084
3	6,712	54.71	0.007	3	2773	0.44	0.064	2	7,673	138.11	5.084
3	6,952	25.80	0.007	3	2782	2.00	0.064	2	883	34.47	5.083
3	7,122	13.79	0.007	3	5312	2.00	0.064	2	5,072	196.60	5.083
3	7,173	86.51	0.007	3	5732	18.46	0.064	2	7,692	59.60	5.083
3	7,223	4.45	0.007	3	5832	22.68	0.064	2	682	8.90	5.082
3	7,253	60.71	0.007	3	6543	3.11	0.064	2	7,872	202.16	5.082
3	7,303	15.12	0.007	-	-	-	-	2	7,882	5.34	5.081
3	8,002	11.34	0.007	-	-	-	-	2	831	156.79	5.080
3	373	6.45	0.006	-	-	-	-	2	1,532	166.80	5.079
3	862	13.79	0.006	-	-	-	-	2	7,683	65.38	5.079
3	872	49.59	0.006	-	-	-	-	2	7,783	59.38	5.079
3	923	25.58	0.006	-	-	-	-	2	7,892	38.25	5.079
3	1,603	20.68	0.006	-	-	-	-	2	672	194.15	5.078

Table C-B-1 (continued). Critical cells by priority ranking for sediment, nitrogen and phosphorus in the Little White River watershed, Mellette County, South Dakota based on 2003 through 2004 data.

Sediment				Total Nitrogen				Total Phosphorus			
Priority	**Cell**	**Acres**	**Sediment**	**Priority**	**Cell**	**Acres**	**Nitrogen**	**Priority**	**Cell**	**Acres**	**Phosphorus**
3	1,671	163.24	0.006	-	-	-	-	2	3,243	34.03	5.078
3	1,773	6.45	0.006	-	-	-	-	2	7,763	42.70	5.077
3	2,063	78.51	0.006	-	-	-	-	2	313	125.87	5.076
3	2,102	34.47	0.006	-	-	-	-	2	583	282.89	5.075
3	2,272	91.40	0.006	-	-	-	-	2	472	10.01	5.073
3	2,321	157.68	0.006	-	-	-	-	2	4,043	36.25	5.073
3	2,332	173.69	0.006	-	-	-	-	2	7,991	148.56	5.073
3	2,391	163.46	0.006	-	-	-	-	2	8,073	284.44	5.073
3	2,431	158.12	0.006	-	-	-	-	2	7,703	92.07	5.072
3	2,432	105.19	0.006	-	-	-	-	2	7,753	42.70	5.072
3	2,531	159.68	0.006	-	-	-	-	2	4,952	293.56	5.071
3	2,561	153.45	0.006	-	-	-	-	2	7,781	149.89	5.071
3	2,572	157.90	0.006	-	-	-	-	2	4,623	454.80	5.070
3	2,592	371.62	0.006	-	-	-	-	2	7,773	74.50	5.069
3	2,602	281.77	0.006	-	-	-	-	2	5,153	104.30	5.067
3	2,703	102.08	0.006	-	-	-	-	2	7,813	120.54	5.067
3	3,123	29.58	0.006	-	-	-	-	2	7,831	148.78	5.066
3	3,132	270.43	0.006	-	-	-	-	2	5,152	185.03	5.065
3	3,142	257.31	0.006	-	-	-	-	2	371	156.79	5.064
3	3,312	11.56	0.006	-	-	-	-	2	932	15.12	5.064
3	3,393	16.01	0.006	-	-	-	-	2	7,592	22.24	5.064
3	3,563	234.40	0.006	-	-	-	-	2	281	156.34	5.063
3	3,693	336.70	0.006	-	-	-	-	2	301	149.00	5.063
3	3,763	32.91	0.006	-	-	-	-	2	4,693	19.13	5.063
3	3,782	30.47	0.006	-	-	-	-	2	5,052	27.80	5.063
3	3,783	38.92	0.006	-	-	-	-	2	7,742	101.63	5.063
3	3,913	2.67	0.006	-	-	-	-	2	5,122	55.82	5.061
3	3,922	8.45	0.006	-	-	-	-	2	7,603	314.91	5.061
3	3,992	70.28	0.006	-	-	-	-	2	683	1.78	5.060
3	4,012	114.09	0.006	-	-	-	-	2	6,313	53.15	5.060
3	4,051	159.68	0.006	-	-	-	-	2	7,672	218.39	5.059
3	4,053	31.58	0.006	-	-	-	-	2	331	168.80	5.056
3	4,061	237.29	0.006	-	-	-	-	2	702	270.21	5.056
3	4,062	83.40	0.006	-	-	-	-	2	8,001	152.78	5.056
3	4,173	17.79	0.006	-	-	-	-	2	7,691	184.14	5.054
3	4,343	269.32	0.006	-	-	-	-	2	481	151.90	5.051
3	4,351	149.00	0.006	-	-	-	-	2	7,793	252.64	5.051
3	4,531	154.79	0.006	-	-	-	-	2	7,602	92.74	5.050
3	4,701	158.12	0.006	-	-	-	-	2	673	106.75	5.049
3	4,873	24.02	0.006	-	-	-	-	2	7,861	217.28	5.049
3	5,193	50.71	0.006	-	-	-	-	2	5,071	149.23	5.048
3	5,222	80.06	0.006	-	-	-	-	2	471	160.12	5.047
3	5,453	177.25	0.006	-	-	-	-	2	5,213	62.49	5.047
3	5,502	17.35	0.006	-	-	-	-	2	7,792	82.29	5.047
3	5,703	29.13	0.006	-	-	-	-	2	703	350.27	5.046
3	5,743	33.58	0.006	-	-	-	-	2	693	46.26	5.045
3	5,763	135.44	0.006	-	-	-	-	2	7,782	33.80	5.045

Table C-B-1 (continued). Critical cells by priority ranking for sediment, nitrogen and phosphorus in the Little White River watershed, Mellette County, South Dakota based on 2003 through 2004 data.

Sediment				Total Nitrogen				Total Phosphorus			
Priority	**Cell**	**Acres**	**Sediment**	**Priority**	**Cell**	**Acres**	**Nitrogen**	**Priority**	**Cell**	**Acres**	**Phosphorus**
3	5,793	11.34	0.006	-	-	-	-	2	6,453	61.83	5.044
3	5,833	42.92	0.006	-	-	-	-	2	7,851	184.14	5.044
3	5,882	12.68	0.006	-	-	-	-	2	7,791	151.01	5.041
3	5,943	214.83	0.006	-	-	-	-	2	8,123	42.03	5.041
3	6,633	243.08	0.006	-	-	-	-	2	123	143.67	5.040
3	6,643	2.00	0.006	-	-	-	-	2	7,822	221.50	5.037
3	6,663	67.16	0.006	-	-	-	-	2	7,711	157.68	5.036
3	6,683	158.57	0.006	-	-	-	-	2	7,593	19.57	5.035
3	6,823	117.20	0.006	-	-	-	-	2	161	165.46	5.031
3	6,833	155.01	0.006	-	-	-	-	2	7,503	2.00	5.031
3	6,843	91.40	0.006	-	-	-	-	2	7,542	25.13	5.031
3	6,943	26.69	0.006	-	-	-	-	2	7,543	45.59	5.031
3	6,951	157.01	0.006	-	-	-	-	2	7,821	180.14	5.030
3	6,962	174.80	0.006	-	-	-	-	2	7,771	153.45	5.028
3	6,963	138.11	0.006	-	-	-	-	2	4,071	149.00	5.026
3	6,973	70.50	0.006	-	-	-	-	2	252	338.71	5.019
3	7,072	20.46	0.006	-	-	-	-	2	7,712	179.92	5.017
3	7,113	16.23	0.006	-	-	-	-	2	881	151.45	5.014
3	7,143	96.07	0.006	-	-	-	-	2	4,722	24.24	5.006
3	7,193	138.55	0.006	-	-	-	-	2	2,421	158.34	5.005
3	7,313	134.99	0.006	-	-	-	-	2	4,713	74.72	5.003
3	7,332	17.35	0.006	-	-	-	-	2	7,492	50.71	5.000
-	-	-	-	-	-	-	-	2	133	53.37	4.998
-	-	-	-	-	-	-	-	2	4,042	89.85	4.998
-	-	-	-	-	-	-	-	2	6,402	222.17	4.998
-	-	-	-	-	-	-	-	2	523	100.52	4.996
-	-	-	-	-	-	-	-	2	273	175.69	4.995
-	-	-	-	-	-	-	-	2	6,403	426.11	4.992
-	-	-	-	-	-	-	-	2	7,533	58.93	4.989
-	-	-	-	-	-	-	-	2	7,761	149.45	4.988
-	-	-	-	-	-	-	-	2	942	125.21	4.984
-	-	-	-	-	-	-	-	2	7,843	33.80	4.981
-	-	-	-	-	-	-	-	2	1,393	50.93	4.979
-	-	-	-	-	-	-	-	2	7,532	90.51	4.978
-	-	-	-	-	-	-	-	2	803	4.23	4.972
-	-	-	-	-	-	-	-	2	8,113	99.63	4.971
-	-	-	-	-	-	-	-	2	4,363	201.49	4.969
-	-	-	-	-	-	-	-	2	7,571	151.23	4.966
-	-	-	-	-	-	-	-	2	1,423	31.14	4.963
-	-	-	-	-	-	-	-	2	201	151.67	4.957
-	-	-	-	-	-	-	-	2	1,413	54.49	4.957
-	-	-	-	-	-	-	-	2	692	159.90	4.955
-	-	-	-	-	-	-	-	2	8,072	158.12	4.953
-	-	-	-	-	-	-	-	2	4,573	24.69	4.947
-	-	-	-	-	-	-	-	2	8,091	159.01	4.942
-	-	-	-	-	-	-	-	2	623	189.70	4.941
-	-	-	-	-	-	-	-	2	562	163.46	4.940

Table C-B-1 (continued). Critical cells by priority ranking for sediment, nitrogen and phosphorus in the Little White River watershed, Mellette County, South Dakota based on 2003 through 2004 data.

Sediment				Total Nitrogen				Total Phosphorus			
Priority	**Cell**	**Acres**	**Sediment**	**Priority**	**Cell**	**Acres**	**Nitrogen**	**Priority**	**Cell**	**Acres**	**Phosphorus**
-	-	-	-	-	-	-	-	2	8,102	159.01	4.939
-	-	-	-	-	-	-	-	2	4,961	251.53	4.936
-	-	-	-	-	-	-	-	2	1,312	42.03	4.935
-	-	-	-	-	-	-	-	2	7,541	149.00	4.935
-	-	-	-	-	-	-	-	2	1,352	105.41	4.934
-	-	-	-	-	-	-	-	2	982	348.05	4.932
-	-	-	-	-	-	-	-	2	1,463	92.52	4.929
-	-	-	-	-	-	-	-	2	5,172	38.03	4.928
-	-	-	-	-	-	-	-	2	642	504.39	4.927
-	-	-	-	-	-	-	-	2	231	173.47	4.926
-	-	-	-	-	-	-	-	2	1,403	13.57	4.922
-	-	-	-	-	-	-	-	2	5,001	152.78	4.921
-	-	-	-	-	-	-	-	2	742	328.92	4.920
-	-	-	-	-	-	-	-	2	1,023	55.82	4.919
-	-	-	-	-	-	-	-	2	5,223	131.88	4.918
-	-	-	-	-	-	-	-	2	5,083	263.98	4.917
-	-	-	-	-	-	-	-	2	163	444.79	4.916
-	-	-	-	-	-	-	-	2	601	148.56	4.914
-	-	-	-	-	-	-	-	2	863	5.12	4.914
-	-	-	-	-	-	-	-	2	651	153.90	4.913
-	-	-	-	-	-	-	-	2	1,813	4.45	4.913
-	-	-	-	-	-	-	-	2	4,942	182.36	4.909
-	-	-	-	-	-	-	-	2	5,151	157.01	4.905
-	-	-	-	-	-	-	-	2	752	36.03	4.904
-	-	-	-	-	-	-	-	2	772	96.74	4.899
-	-	-	-	-	-	-	-	2	4,983	64.72	4.899
-	-	-	-	-	-	-	-	2	5,033	96.96	4.893
-	-	-	-	-	-	-	-	2	4,921	149.00	4.892
-	-	-	-	-	-	-	-	2	5,133	36.92	4.890
-	-	-	-	-	-	-	-	2	7,463	8.23	4.887
-	-	-	-	-	-	-	-	2	6,433	322.69	4.884
-	-	-	-	-	-	-	-	2	402	577.33	4.882
-	-	-	-	-	-	-	-	2	2,163	4.67	4.880
-	-	-	-	-	-	-	-	2	8,003	69.16	4.880
-	-	-	-	-	-	-	-	2	1,481	153.23	4.874
-	-	-	-	-	-	-	-	2	4,852	28.02	4.872
-	-	-	-	-	-	-	-	2	652	54.93	4.871
-	-	-	-	-	-	-	-	2	4,763	27.35	4.871
-	-	-	-	-	-	-	-	2	4,853	20.91	4.871
-	-	-	-	-	-	-	-	2	6,343	52.48	4.871
-	-	-	-	-	-	-	-	2	433	79.62	4.868
-	-	-	-	-	-	-	-	2	5,212	19.35	4.861
-	-	-	-	-	-	-	-	2	452	12.68	4.860
-	-	-	-	-	-	-	-	2	5,211	152.34	4.855
-	-	-	-	-	-	-	-	2	572	106.08	4.854
-	-	-	-	-	-	-	-	2	7,473	17.79	4.854
-	-	-	-	-	-	-	-	2	1,681	149.23	4.853

Table C-B-1 (continued). Critical cells by priority ranking for sediment, nitrogen and phosphorus in the Little White River watershed, Mellette County, South Dakota based on 2003 through 2004 data.

Sediment				Total Nitrogen				Total Phosphorus			
Priority	Cell	Acres	Sediment	Priority	Cell	Acres	Nitrogen	Priority	Cell	Acres	Phosphorus
-	-	-	-	-	-	-	-	2	3,153	31.58	4.853
-	-	-	-	-	-	-	-	2	7,802	615.14	4.853
-	-	-	-	-	-	-	-	2	5,121	148.78	4.845
-	-	-	-	-	-	-	-	2	492	99.85	4.837
-	-	-	-	-	-	-	-	2	1,332	187.48	4.837
-	-	-	-	-	-	-	-	2	6,512	204.60	4.832
-	-	-	-	-	-	-	-	2	3,252	90.74	4.830
-	-	-	-	-	-	-	-	2	1,991	161.46	4.828
-	-	-	-	-	-	-	-	2	921	148.34	4.827
-	-	-	-	-	-	-	-	2	6,373	76.50	4.822
-	-	-	-	-	-	-	-	2	7,922	196.60	4.817
-	-	-	-	-	-	-	-	2	462	157.01	4.815
-	-	-	-	-	-	-	-	2	582	199.26	4.813
-	-	-	-	-	-	-	-	2	6,353	33.80	4.812
-	-	-	-	-	-	-	-	2	962	387.19	4.808
-	-	-	-	-	-	-	-	2	842	147.45	4.806
-	-	-	-	-	-	-	-	2	1,002	14.90	4.802
-	-	-	-	-	-	-	-	2	7,972	210.16	4.802
-	-	-	-	-	-	-	-	2	781	162.79	4.793
-	-	-	-	-	-	-	-	2	4,892	195.48	4.792
-	-	-	-	-	-	-	-	2	873	20.68	4.786
-	-	-	-	-	-	-	-	2	5,022	64.27	4.778
-	-	-	-	-	-	-	-	2	5,332	12.01	4.765
-	-	-	-	-	-	-	-	2	7,502	5.34	4.756
-	-	-	-	-	-	-	-	2	6,493	23.80	4.719
-	-	-	-	-	-	-	-	2	5,252	398.97	4.709
-	-	-	-	-	-	-	-	2	1,503	10.90	4.708
-	-	-	-	-	-	-	-	2	5,202	287.11	4.707
-	-	-	-	-	-	-	-	2	1,492	112.53	4.705
-	-	-	-	-	-	-	-	2	7,553	7.78	4.686
-	-	-	-	-	-	-	-	2	6,443	196.15	4.679
-	-	-	-	-	-	-	-	2	5,303	53.60	4.660
-	-	-	-	-	-	-	-	2	1,652	3.34	4.592
-	-	-	-	-	-	-	-	2	6,052	66.94	4.581
-	-	-	-	-	-	-	-	2	6,031	184.14	4.576
-	-	-	-	-	-	-	-	2	6,743	123.21	4.532
-	-	-	-	-	-	-	-	2	6,473	102.75	4.504
-	-	-	-	-	-	-	-	2	7,521	149.23	4.489
-	-	-	-	-	-	-	-	2	7,531	192.37	4.489
-	-	-	-	-	-	-	-	2	3,443	1.33	4.466
-	-	-	-	-	-	-	-	2	7,433	17.79	4.416
-	-	-	-	-	-	-	-	2	5,932	159.46	4.385
-	-	-	-	-	-	-	-	2	6,073	261.09	4.364
-	-	-	-	-	-	-	-	2	5,292	55.82	4.363
-	-	-	-	-	-	-	-	2	5,993	181.47	4.355
-	-	-	-	-	-	-	-	2	7,042	46.70	4.353
-	-	-	-	-	-	-	-	2	6,762	37.14	4.304

Table C-B-1 (continued). Critical cells by priority ranking for sediment, nitrogen and phosphorus in the Little White River watershed, Mellette County, South Dakota based on 2003 through 2004 data.

Sediment				Total Nitrogen				Total Phosphorus			
Priority	Cell	Acres	Sediment	Priority	Cell	Acres	Nitrogen	Priority	Cell	Acres	Phosphorus
-	-	-	-	-	-	-	-	2	6,752	78.06	4.299
-	-	-	-	-	-	-	-	2	6,803	112.09	4.248
-	-	-	-	-	-	-	-	2	5,913	60.94	4.217
-	-	-	-	-	-	-	-	2	3,223	15.35	4.186
-	-	-	-	-	-	-	-	3	4,652	10.67	4.181
-	-	-	-	-	-	-	-	3	6,083	277.33	4.176
-	-	-	-	-	-	-	-	3	5,933	364.73	4.160
-	-	-	-	-	-	-	-	3	7,842	33.80	4.036
-	-	-	-	-	-	-	-	3	6,013	154.79	4.018
-	-	-	-	-	-	-	-	3	952	2.45	4.015
-	-	-	-	-	-	-	-	3	712	92.52	3.927
-	-	-	-	-	-	-	-	3	603	40.70	3.920
-	-	-	-	-	-	-	-	3	132	99.41	3.896
-	-	-	-	-	-	-	-	3	6,053	24.46	3.888
-	-	-	-	-	-	-	-	3	7,061	148.34	3.866
-	-	-	-	-	-	-	-	3	1,323	4.89	3.859
-	-	-	-	-	-	-	-	3	643	280.44	3.854
-	-	-	-	-	-	-	-	3	1,553	102.30	3.841
-	-	-	-	-	-	-	-	3	7,941	223.95	3.840
-	-	-	-	-	-	-	-	3	423	83.84	3.837
-	-	-	-	-	-	-	-	3	141	156.34	3.833
-	-	-	-	-	-	-	-	3	8,081	195.93	3.833
-	-	-	-	-	-	-	-	3	32	113.64	3.810
-	-	-	-	-	-	-	-	3	992	182.14	3.809
-	-	-	-	-	-	-	-	3	1,192	161.68	3.806
-	-	-	-	-	-	-	-	3	8,133	30.69	3.806
-	-	-	-	-	-	-	-	3	1,032	326.47	3.805
-	-	-	-	-	-	-	-	3	62	195.26	3.802
-	-	-	-	-	-	-	-	3	5,003	5.78	3.802
-	-	-	-	-	-	-	-	3	73	23.35	3.798
-	-	-	-	-	-	-	-	3	8,143	8.90	3.798
-	-	-	-	-	-	-	-	3	513	128.54	3.797
-	-	-	-	-	-	-	-	3	92	165.24	3.794
-	-	-	-	-	-	-	-	3	552	33.14	3.794
-	-	-	-	-	-	-	-	3	1,182	10.23	3.793
-	-	-	-	-	-	-	-	3	8,153	10.01	3.792
-	-	-	-	-	-	-	-	3	72	123.43	3.791
-	-	-	-	-	-	-	-	3	102	11.56	3.789
-	-	-	-	-	-	-	-	3	4,422	105.86	3.789
-	-	-	-	-	-	-	-	3	1,672	173.24	3.787
-	-	-	-	-	-	-	-	3	1,501	175.25	3.786
-	-	-	-	-	-	-	-	3	43	48.70	3.785
-	-	-	-	-	-	-	-	3	192	94.30	3.785
-	-	-	-	-	-	-	-	3	483	146.78	3.785
-	-	-	-	-	-	-	-	3	512	205.94	3.784
-	-	-	-	-	-	-	-	3	122	223.06	3.781
-	-	-	-	-	-	-	-	3	1,082	84.95	3.778

Table C-B-1 (continued). Critical cells by priority ranking for sediment, nitrogen and phosphorus in the Little White River watershed, Mellette County, South Dakota based on 2003 through 2004 data.

Sediment				Total Nitrogen				Total Phosphorus			
Priority	Cell	Acres	Sediment	Priority	Cell	Acres	Nitrogen	Priority	Cell	Acres	Phosphorus
-	-	-	-	-	-	-	-	3	243	171.69	3.777
-	-	-	-	-	-	-	-	3	143	1.56	3.772
-	-	-	-	-	-	-	-	3	6,442	179.25	3.771
-	-	-	-	-	-	-	-	3	892	13.57	3.766
-	-	-	-	-	-	-	-	3	113	67.83	3.765
-	-	-	-	-	-	-	-	3	543	37.58	3.760
-	-	-	-	-	-	-	-	3	443	121.87	3.759
-	-	-	-	-	-	-	-	3	6,301	170.35	3.755
-	-	-	-	-	-	-	-	3	6,352	48.26	3.752
-	-	-	-	-	-	-	-	3	581	149.00	3.751
-	-	-	-	-	-	-	-	3	212	36.03	3.748
-	-	-	-	-	-	-	-	3	1,122	168.13	3.747
-	-	-	-	-	-	-	-	3	2,803	5.12	3.747
-	-	-	-	-	-	-	-	3	7,921	174.80	3.746
-	-	-	-	-	-	-	-	3	3,042	60.94	3.744
-	-	-	-	-	-	-	-	3	841	159.23	3.742
-	-	-	-	-	-	-	-	3	4,462	1.11	3.740
-	-	-	-	-	-	-	-	3	8,011	151.01	3.740
-	-	-	-	-	-	-	-	3	8,083	106.30	3.740
-	-	-	-	-	-	-	-	3	1,692	22.91	3.739
-	-	-	-	-	-	-	-	3	4,871	149.00	3.738
-	-	-	-	-	-	-	-	3	7,962	137.22	3.737
-	-	-	-	-	-	-	-	3	142	5.78	3.736
-	-	-	-	-	-	-	-	3	22	117.87	3.734
-	-	-	-	-	-	-	-	3	112	97.85	3.734
-	-	-	-	-	-	-	-	3	1,533	212.61	3.734
-	-	-	-	-	-	-	-	3	3,103	31.14	3.734
-	-	-	-	-	-	-	-	3	4,512	92.96	3.734
-	-	-	-	-	-	-	-	3	7,661	171.47	3.734
-	-	-	-	-	-	-	-	3	1,662	35.14	3.733
-	-	-	-	-	-	-	-	3	3,052	203.27	3.731
-	-	-	-	-	-	-	-	3	4,992	73.83	3.731
-	-	-	-	-	-	-	-	3	5,253	107.86	3.731
-	-	-	-	-	-	-	-	3	1,171	184.59	3.728
-	-	-	-	-	-	-	-	3	8,062	246.63	3.727
-	-	-	-	-	-	-	-	3	6,462	517.51	3.726
-	-	-	-	-	-	-	-	3	7,953	68.27	3.724
-	-	-	-	-	-	-	-	3	1,592	3.11	3.721
-	-	-	-	-	-	-	-	3	4,553	4.45	3.721
-	-	-	-	-	-	-	-	3	3,102	25.58	3.720
-	-	-	-	-	-	-	-	3	8,053	187.26	3.719
-	-	-	-	-	-	-	-	3	2,812	12.01	3.718
-	-	-	-	-	-	-	-	3	1,043	264.65	3.717
-	-	-	-	-	-	-	-	3	4,913	54.93	3.717
-	-	-	-	-	-	-	-	3	6,271	155.01	3.717
-	-	-	-	-	-	-	-	3	6,522	102.08	3.715
-	-	-	-	-	-	-	-	3	8,063	233.07	3.713

Table C-B-1 (continued). Critical cells by priority ranking for sediment, nitrogen and phosphorus in the Little White River watershed, Mellette County, South Dakota based on 2003 through 2004 data.

Sediment				Total Nitrogen				Total Phosphorus			
Priority	Cell	Acres	Sediment	Priority	Cell	Acres	Nitrogen	Priority	Cell	Acres	Phosphorus
-	-	-	-	-	-	-	-	3	1,062	133.66	3.712
-	-	-	-	-	-	-	-	3	1,802	229.29	3.712
-	-	-	-	-	-	-	-	3	2,552	106.75	3.710
-	-	-	-	-	-	-	-	3	451	235.52	3.707
-	-	-	-	-	-	-	-	3	6,362	72.72	3.706
-	-	-	-	-	-	-	-	3	7,952	77.62	3.705
-	-	-	-	-	-	-	-	3	8,043	264.65	3.705
-	-	-	-	-	-	-	-	3	713	108.75	3.703
-	-	-	-	-	-	-	-	3	4,432	14.90	3.703
-	-	-	-	-	-	-	-	3	8,021	151.45	3.703
-	-	-	-	-	-	-	-	3	8,142	25.35	3.703
-	-	-	-	-	-	-	-	3	213	3.56	3.702
-	-	-	-	-	-	-	-	3	222	122.09	3.702
-	-	-	-	-	-	-	-	3	1,583	8.01	3.702
-	-	-	-	-	-	-	-	3	3,021	234.63	3.702
-	-	-	-	-	-	-	-	3	7,943	22.24	3.702
-	-	-	-	-	-	-	-	3	1,773	6.45	3.701
-	-	-	-	-	-	-	-	3	6,272	16.46	3.701
-	-	-	-	-	-	-	-	3	8,082	201.71	3.701
-	-	-	-	-	-	-	-	3	1,103	161.24	3.700
-	-	-	-	-	-	-	-	3	2,953	84.06	3.699
-	-	-	-	-	-	-	-	3	4,633	17.79	3.699
-	-	-	-	-	-	-	-	3	8,012	46.26	3.698
-	-	-	-	-	-	-	-	3	1,343	22.91	3.696
-	-	-	-	-	-	-	-	3	7,452	76.28	3.696
-	-	-	-	-	-	-	-	3	8,023	156.12	3.695
-	-	-	-	-	-	-	-	3	1,742	42.92	3.694
-	-	-	-	-	-	-	-	3	4,412	223.95	3.694
-	-	-	-	-	-	-	-	3	5,282	157.01	3.694
-	-	-	-	-	-	-	-	3	1,433	54.26	3.693
-	-	-	-	-	-	-	-	3	1,593	2.89	3.693
-	-	-	-	-	-	-	-	3	5,053	31.36	3.693
-	-	-	-	-	-	-	-	3	8,013	115.42	3.693
-	-	-	-	-	-	-	-	3	4,662	23.13	3.691
-	-	-	-	-	-	-	-	3	6,281	150.12	3.691
-	-	-	-	-	-	-	-	3	8,152	4.67	3.689
-	-	-	-	-	-	-	-	3	1,702	39.81	3.687
-	-	-	-	-	-	-	-	3	3,001	149.23	3.687
-	-	-	-	-	-	-	-	3	4,092	106.97	3.687
-	-	-	-	-	-	-	-	3	1,303	151.45	3.686
-	-	-	-	-	-	-	-	3	5,233	27.58	3.686
-	-	-	-	-	-	-	-	3	5,373	182.14	3.686
-	-	-	-	-	-	-	-	3	4,642	31.58	3.685
-	-	-	-	-	-	-	-	3	5,192	28.47	3.685
-	-	-	-	-	-	-	-	3	401	170.80	3.683
-	-	-	-	-	-	-	-	3	5,182	150.78	3.683
-	-	-	-	-	-	-	-	3	8,032	221.06	3.682

Table C-B-1 (continued). Critical cells by priority ranking for sediment, nitrogen and phosphorus in the Little White River watershed, Mellette County, South Dakota based on 2003 through 2004 data.

Sediment				Total Nitrogen				Total Phosphorus			
Priority	Cell	Acres	Sediment	Priority	Cell	Acres	Nitrogen	Priority	Cell	Acres	Phosphorus
-	-	-	-	-	-	-	-	3	4,663	21.57	3.681
-	-	-	-	-	-	-	-	3	2,783	2.67	3.680
-	-	-	-	-	-	-	-	3	4,582	107.64	3.680
-	-	-	-	-	-	-	-	3	4,562	36.03	3.679
-	-	-	-	-	-	-	-	3	4,622	168.57	3.678
-	-	-	-	-	-	-	-	3	7,441	166.13	3.678
-	-	-	-	-	-	-	-	3	5,183	29.36	3.677
-	-	-	-	-	-	-	-	3	1,602	17.35	3.676
-	-	-	-	-	-	-	-	3	5,173	37.36	3.675
-	-	-	-	-	-	-	-	3	993	67.61	3.673
-	-	-	-	-	-	-	-	3	7,963	145.45	3.672
-	-	-	-	-	-	-	-	3	4,673	11.34	3.671
-	-	-	-	-	-	-	-	3	4,402	61.60	3.670
-	-	-	-	-	-	-	-	3	1,572	328.48	3.667
-	-	-	-	-	-	-	-	3	4,393	73.39	3.667
-	-	-	-	-	-	-	-	3	1,102	69.61	3.666
-	-	-	-	-	-	-	-	3	6,283	22.91	3.666
-	-	-	-	-	-	-	-	3	1,222	58.04	3.665
-	-	-	-	-	-	-	-	3	7,643	221.95	3.664
-	-	-	-	-	-	-	-	3	4,752	20.68	3.662
-	-	-	-	-	-	-	-	3	1,953	285.55	3.661
-	-	-	-	-	-	-	-	3	7,631	148.78	3.661
-	-	-	-	-	-	-	-	3	8,042	495.94	3.661
-	-	-	-	-	-	-	-	3	4,643	40.03	3.660
-	-	-	-	-	-	-	-	3	1,022	23.13	3.658
-	-	-	-	-	-	-	-	3	4,442	8.90	3.658
-	-	-	-	-	-	-	-	3	7,583	8.67	3.658
-	-	-	-	-	-	-	-	3	4,103	191.48	3.656
-	-	-	-	-	-	-	-	3	4,632	217.28	3.656
-	-	-	-	-	-	-	-	3	4,672	12.01	3.656
-	-	-	-	-	-	-	-	3	42	176.80	3.655
-	-	-	-	-	-	-	-	3	4,603	151.01	3.655
-	-	-	-	-	-	-	-	3	71	175.91	3.654
-	-	-	-	-	-	-	-	3	4,602	97.63	3.654
-	-	-	-	-	-	-	-	3	4,613	70.28	3.653
-	-	-	-	-	-	-	-	3	1,213	40.48	3.652
-	-	-	-	-	-	-	-	3	1,453	11.56	3.652
-	-	-	-	-	-	-	-	3	4,093	39.81	3.652
-	-	-	-	-	-	-	-	3	4,443	5.56	3.652
-	-	-	-	-	-	-	-	3	1,033	328.25	3.651
-	-	-	-	-	-	-	-	3	4,593	88.07	3.651
-	-	-	-	-	-	-	-	3	4,682	40.25	3.651
-	-	-	-	-	-	-	-	3	4,883	61.83	3.650
-	-	-	-	-	-	-	-	3	7,701	148.56	3.650
-	-	-	-	-	-	-	-	3	4,102	178.58	3.649
-	-	-	-	-	-	-	-	3	1,603	20.68	3.648
-	-	-	-	-	-	-	-	3	2,763	142.78	3.648

Table C-B-1 (continued). Critical cells by priority ranking for sediment, nitrogen and phosphorus in the Little White River watershed, Mellette County, South Dakota based on 2003 through 2004 data.

Sediment				Total Nitrogen				Total Phosphorus			
Priority	Cell	Acres	Sediment	Priority	Cell	Acres	Nitrogen	Priority	Cell	Acres	Phosphorus
-	-	-	-	-	-	-	-	3	6,292	175.25	3.648
-	-	-	-	-	-	-	-	3	7,642	90.51	3.648
-	-	-	-	-	-	-	-	3	1,703	80.95	3.647
-	-	-	-	-	-	-	-	3	2,793	134.99	3.647
-	-	-	-	-	-	-	-	3	5,433	116.98	3.647
-	-	-	-	-	-	-	-	3	8,033	325.14	3.647
-	-	-	-	-	-	-	-	3	4,433	13.34	3.646
-	-	-	-	-	-	-	-	3	5,483	67.61	3.644
-	-	-	-	-	-	-	-	3	5,463	80.06	3.642
-	-	-	-	-	-	-	-	3	1,812	14.90	3.641
-	-	-	-	-	-	-	-	3	4,403	31.36	3.640
-	-	-	-	-	-	-	-	3	1,633	52.71	3.639
-	-	-	-	-	-	-	-	3	1,792	7.78	3.639
-	-	-	-	-	-	-	-	3	4,712	33.58	3.639
-	-	-	-	-	-	-	-	3	4,753	15.35	3.639
-	-	-	-	-	-	-	-	3	4,733	360.72	3.638
-	-	-	-	-	-	-	-	3	7,563	40.92	3.638
-	-	-	-	-	-	-	-	3	1,591	162.13	3.636
-	-	-	-	-	-	-	-	3	4,641	150.34	3.635
-	-	-	-	-	-	-	-	3	1,582	160.12	3.634
-	-	-	-	-	-	-	-	3	4,392	127.88	3.634
-	-	-	-	-	-	-	-	3	4,732	149.23	3.634
-	-	-	-	-	-	-	-	3	1,983	347.60	3.633
-	-	-	-	-	-	-	-	3	2,952	39.81	3.633
-	-	-	-	-	-	-	-	3	3,472	178.80	3.633
-	-	-	-	-	-	-	-	3	5,092	57.16	3.633
-	-	-	-	-	-	-	-	3	5,372	305.12	3.633
-	-	-	-	-	-	-	-	3	7,591	151.67	3.633
-	-	-	-	-	-	-	-	3	3,483	48.70	3.631
-	-	-	-	-	-	-	-	3	5,181	148.78	3.631
-	-	-	-	-	-	-	-	3	6,322	251.97	3.631
-	-	-	-	-	-	-	-	3	4,133	140.55	3.630
-	-	-	-	-	-	-	-	3	2,712	111.20	3.629
-	-	-	-	-	-	-	-	3	4,702	198.82	3.629
-	-	-	-	-	-	-	-	3	6,452	48.70	3.629
-	-	-	-	-	-	-	-	3	1,483	144.11	3.627
-	-	-	-	-	-	-	-	3	3,482	77.84	3.627
-	-	-	-	-	-	-	-	3	5,462	33.58	3.626
-	-	-	-	-	-	-	-	3	1,793	4.23	3.625
-	-	-	-	-	-	-	-	3	3,012	219.73	3.625
-	-	-	-	-	-	-	-	3	4,862	97.41	3.624
-	-	-	-	-	-	-	-	3	3,233	72.95	3.622
-	-	-	-	-	-	-	-	3	1,653	1.11	3.620
-	-	-	-	-	-	-	-	3	3,642	22.68	3.620
-	-	-	-	-	-	-	-	3	4,863	145.67	3.617
-	-	-	-	-	-	-	-	3	7,551	150.78	3.616
-	-	-	-	-	-	-	-	3	1,682	126.32	3.615

Table C-B-1 (continued). Critical cells by priority ranking for sediment, nitrogen and phosphorus in the Little White River watershed, Mellette County, South Dakota based on 2003 through 2004 data.

Sediment				Total Nitrogen				Total Phosphorus			
Priority	Cell	Acres	Sediment	Priority	Cell	Acres	Nitrogen	Priority	Cell	Acres	Phosphorus
-	-	-	-	-	-	-	-	3	1,701	152.12	3.615
-	-	-	-	-	-	-	-	3	7,623	253.75	3.615
-	-	-	-	-	-	-	-	3	1,613	92.96	3.614
-	-	-	-	-	-	-	-	3	912	129.66	3.613
-	-	-	-	-	-	-	-	3	3,643	19.57	3.613
-	-	-	-	-	-	-	-	3	1,623	75.84	3.612
-	-	-	-	-	-	-	-	3	1,632	64.27	3.612
-	-	-	-	-	-	-	-	3	5,482	11.79	3.612
-	-	-	-	-	-	-	-	3	1,782	44.70	3.611
-	-	-	-	-	-	-	-	3	6,263	140.33	3.610
-	-	-	-	-	-	-	-	3	1,072	118.76	3.607
-	-	-	-	-	-	-	-	3	4,743	26.91	3.607
-	-	-	-	-	-	-	-	3	6,262	161.01	3.607
-	-	-	-	-	-	-	-	3	6,372	50.04	3.605
-	-	-	-	-	-	-	-	3	4,742	114.98	3.604
-	-	-	-	-	-	-	-	3	6,213	296.01	3.604
-	-	-	-	-	-	-	-	3	7,523	32.25	3.604
-	-	-	-	-	-	-	-	3	4,413	104.97	3.603
-	-	-	-	-	-	-	-	3	1,622	134.55	3.602
-	-	-	-	-	-	-	-	3	2,482	94.07	3.602
-	-	-	-	-	-	-	-	3	2,692	14.01	3.602
-	-	-	-	-	-	-	-	3	8,031	173.02	3.601
-	-	-	-	-	-	-	-	3	3,192	411.87	3.599
-	-	-	-	-	-	-	-	3	4,661	148.34	3.599
-	-	-	-	-	-	-	-	3	4,703	106.97	3.599
-	-	-	-	-	-	-	-	3	5,423	150.56	3.599
-	-	-	-	-	-	-	-	3	7,573	290.45	3.599
-	-	-	-	-	-	-	-	3	7,653	111.20	3.598
-	-	-	-	-	-	-	-	3	8,061	243.97	3.598
-	-	-	-	-	-	-	-	3	1,551	148.56	3.596
-	-	-	-	-	-	-	-	3	4,453	237.74	3.596
-	-	-	-	-	-	-	-	3	3,073	33.36	3.595
-	-	-	-	-	-	-	-	3	1,642	401.42	3.593
-	-	-	-	-	-	-	-	3	3,022	49.15	3.593
-	-	-	-	-	-	-	-	3	4,423	208.83	3.593
-	-	-	-	-	-	-	-	3	3,003	63.16	3.592
-	-	-	-	-	-	-	-	3	1,823	555.98	3.591
-	-	-	-	-	-	-	-	3	2,822	384.30	3.590
-	-	-	-	-	-	-	-	3	6,212	171.69	3.589
-	-	-	-	-	-	-	-	3	1,803	128.54	3.588
-	-	-	-	-	-	-	-	3	2,453	268.65	3.588
-	-	-	-	-	-	-	-	3	1,083	142.11	3.586
-	-	-	-	-	-	-	-	3	1,972	26.69	3.585
-	-	-	-	-	-	-	-	3	2,972	139.00	3.585
-	-	-	-	-	-	-	-	3	3,023	19.79	3.584
-	-	-	-	-	-	-	-	3	4,372	21.13	3.584
-	-	-	-	-	-	-	-	3	4,452	184.14	3.583

Table C-B-1 (continued). Critical cells by priority ranking for sediment, nitrogen and phosphorus in the Little White River watershed, Mellette County, South Dakota based on 2003 through 2004 data.

Sediment				Total Nitrogen				Total Phosphorus			
Priority	**Cell**	**Acres**	**Sediment**	**Priority**	**Cell**	**Acres**	**Nitrogen**	**Priority**	**Cell**	**Acres**	**Phosphorus**
-	-	-	-	-	-	-	-	3	5,413	58.93	3.582
-	-	-	-	-	-	-	-	3	2,033	6.67	3.581
-	-	-	-	-	-	-	-	3	4,441	152.78	3.581
-	-	-	-	-	-	-	-	3	5,382	411.87	3.581
-	-	-	-	-	-	-	-	3	2,043	30.47	3.579
-	-	-	-	-	-	-	-	3	2,493	50.71	3.579
-	-	-	-	-	-	-	-	3	6,261	159.23	3.579
-	-	-	-	-	-	-	-	3	6,333	71.17	3.579
-	-	-	-	-	-	-	-	3	1,683	85.18	3.578
-	-	-	-	-	-	-	-	3	2,693	60.71	3.578
-	-	-	-	-	-	-	-	3	3,232	76.50	3.578
-	-	-	-	-	-	-	-	3	1,942	24.02	3.577
-	-	-	-	-	-	-	-	3	2,073	215.72	3.577
-	-	-	-	-	-	-	-	3	3,032	131.21	3.577
-	-	-	-	-	-	-	-	3	6,463	239.30	3.577
-	-	-	-	-	-	-	-	3	4,401	154.12	3.574
-	-	-	-	-	-	-	-	3	2,943	93.63	3.573
-	-	-	-	-	-	-	-	3	913	49.37	3.571
-	-	-	-	-	-	-	-	3	1,612	155.23	3.566
-	-	-	-	-	-	-	-	3	1,663	99.85	3.566
-	-	-	-	-	-	-	-	3	6,332	192.15	3.565
-	-	-	-	-	-	-	-	3	1,172	15.79	3.564
-	-	-	-	-	-	-	-	3	2,502	151.45	3.564
-	-	-	-	-	-	-	-	3	2,023	80.73	3.562
-	-	-	-	-	-	-	-	3	1,053	24.69	3.561
-	-	-	-	-	-	-	-	3	911	185.70	3.560
-	-	-	-	-	-	-	-	3	1,621	186.14	3.560
-	-	-	-	-	-	-	-	3	1,822	561.10	3.559
-	-	-	-	-	-	-	-	3	6,363	95.63	3.558
-	-	-	-	-	-	-	-	3	3,202	126.32	3.557
-	-	-	-	-	-	-	-	3	2,051	152.12	3.555
-	-	-	-	-	-	-	-	3	2,083	129.43	3.554
-	-	-	-	-	-	-	-	3	1,063	217.72	3.553
-	-	-	-	-	-	-	-	3	172	28.24	3.552
-	-	-	-	-	-	-	-	3	3,002	126.10	3.551
-	-	-	-	-	-	-	-	3	3,033	24.91	3.551
-	-	-	-	-	-	-	-	3	2,443	112.31	3.549
-	-	-	-	-	-	-	-	3	2,732	62.05	3.549
-	-	-	-	-	-	-	-	3	6,273	22.46	3.547
-	-	-	-	-	-	-	-	3	4,451	188.59	3.543
-	-	-	-	-	-	-	-	3	1,183	6.89	3.541
-	-	-	-	-	-	-	-	3	2,003	31.58	3.539
-	-	-	-	-	-	-	-	3	152	484.15	3.538
-	-	-	-	-	-	-	-	3	2,472	183.03	3.537
-	-	-	-	-	-	-	-	3	1,051	190.37	3.536
-	-	-	-	-	-	-	-	3	1,523	175.25	3.536
-	-	-	-	-	-	-	-	3	1,943	11.79	3.536

Table C-B-1 (continued). Critical cells by priority ranking for sediment, nitrogen and phosphorus in the Little White River watershed, Mellette County, South Dakota based on 2003 through 2004 data.

Sediment				Total Nitrogen				Total Phosphorus			
Priority	Cell	Acres	Sediment	Priority	Cell	Acres	Nitrogen	Priority	Cell	Acres	Phosphorus
-	-	-	-	-	-	-	-	3	1,952	254.20	3.536
-	-	-	-	-	-	-	-	3	2,152	28.02	3.536
-	-	-	-	-	-	-	-	3	3,072	85.40	3.534
-	-	-	-	-	-	-	-	3	1,673	526.85	3.532
-	-	-	-	-	-	-	-	3	1,193	34.69	3.527
-	-	-	-	-	-	-	-	3	4,592	126.54	3.527
-	-	-	-	-	-	-	-	3	2,981	243.08	3.524
-	-	-	-	-	-	-	-	3	5,102	28.02	3.520
-	-	-	-	-	-	-	-	3	1,721	154.56	3.518
-	-	-	-	-	-	-	-	3	2,452	459.02	3.514
-	-	-	-	-	-	-	-	3	5,403	27.58	3.513
-	-	-	-	-	-	-	-	3	4,112	6.23	3.512
-	-	-	-	-	-	-	-	3	181	160.79	3.503
-	-	-	-	-	-	-	-	3	2,492	155.90	3.502
-	-	-	-	-	-	-	-	3	2,442	118.09	3.500
-	-	-	-	-	-	-	-	3	6,331	154.34	3.500
-	-	-	-	-	-	-	-	3	1,093	18.90	3.496
-	-	-	-	-	-	-	-	3	1,212	27.13	3.488
-	-	-	-	-	-	-	-	3	4,612	47.37	3.487
-	-	-	-	-	-	-	-	3	1,552	201.93	3.486
-	-	-	-	-	-	-	-	3	931	161.46	3.479
-	-	-	-	-	-	-	-	3	7,633	98.52	3.476
-	-	-	-	-	-	-	-	3	4,132	199.93	3.475
-	-	-	-	-	-	-	-	3	5,242	253.53	3.475
-	-	-	-	-	-	-	-	3	5,051	150.78	3.473
-	-	-	-	-	-	-	-	3	7,562	53.15	3.473
-	-	-	-	-	-	-	-	3	1,283	28.02	3.470
-	-	-	-	-	-	-	-	3	7,612	82.95	3.470
-	-	-	-	-	-	-	-	3	4,882	25.80	3.468
-	-	-	-	-	-	-	-	3	1,723	56.04	3.464
-	-	-	-	-	-	-	-	3	4,723	18.46	3.464
-	-	-	-	-	-	-	-	3	7,572	75.39	3.464
-	-	-	-	-	-	-	-	3	1,113	3.11	3.461
-	-	-	-	-	-	-	-	3	2,993	171.69	3.459
-	-	-	-	-	-	-	-	3	4,933	132.32	3.457
-	-	-	-	-	-	-	-	3	1,741	149.89	3.453
-	-	-	-	-	-	-	-	3	5,363	92.96	3.453
-	-	-	-	-	-	-	-	3	7,582	10.67	3.453
-	-	-	-	-	-	-	-	3	3,013	324.47	3.451
-	-	-	-	-	-	-	-	3	4,653	24.24	3.450
-	-	-	-	-	-	-	-	3	6,282	7.12	3.449
-	-	-	-	-	-	-	-	3	1,042	273.32	3.448
-	-	-	-	-	-	-	-	3	4,122	88.74	3.443
-	-	-	-	-	-	-	-	3	1,173	68.05	3.442
-	-	-	-	-	-	-	-	3	4,692	44.70	3.440
-	-	-	-	-	-	-	-	3	2,203	402.53	3.437
-	-	-	-	-	-	-	-	3	7,671	185.03	3.435

Table C-B-1 (continued). Critical cells by priority ranking for sediment, nitrogen and phosphorus in the Little White River watershed, Mellette County, South Dakota based on 2003 through 2004 data.

Sediment				Total Nitrogen				Total Phosphorus			
Priority	Cell	Acres	Sediment	Priority	Cell	Acres	Nitrogen	Priority	Cell	Acres	Phosphorus
-	-	-	-	-	-	-	-	3	1,763	83.84	3.432
-	-	-	-	-	-	-	-	3	7,662	49.59	3.429
-	-	-	-	-	-	-	-	3	1,832	340.49	3.416
-	-	-	-	-	-	-	-	3	5,432	283.55	3.413
-	-	-	-	-	-	-	-	3	7,483	38.03	3.409
-	-	-	-	-	-	-	-	3	3,432	48.26	3.408
-	-	-	-	-	-	-	-	3	7,622	113.87	3.407
-	-	-	-	-	-	-	-	3	6,061	150.34	3.397
-	-	-	-	-	-	-	-	3	4,721	168.13	3.395
-	-	-	-	-	-	-	-	3	4,861	157.68	3.392
-	-	-	-	-	-	-	-	3	3,322	12.68	3.386
-	-	-	-	-	-	-	-	3	2,513	121.20	3.384
-	-	-	-	-	-	-	-	3	7,652	151.23	3.384
-	-	-	-	-	-	-	-	3	4,391	151.90	3.334
-	-	-	-	-	-	-	-	3	3,262	15.79	3.317
-	-	-	-	-	-	-	-	3	1,273	5.78	3.312
-	-	-	-	-	-	-	-	3	3,313	4.67	3.310
-	-	-	-	-	-	-	-	3	5,712	0.44	3.302
-	-	-	-	-	-	-	-	3	5,412	25.35	3.293
-	-	-	-	-	-	-	-	3	5,442	2.45	3.292
-	-	-	-	-	-	-	-	3	6,312	81.17	3.281
-	-	-	-	-	-	-	-	3	7,482	27.80	3.278
-	-	-	-	-	-	-	-	3	7,472	17.79	3.277
-	-	-	-	-	-	-	-	3	3,143	108.08	3.275
-	-	-	-	-	-	-	-	3	7,493	16.01	3.270
-	-	-	-	-	-	-	-	3	6,893	5.12	3.260
-	-	-	-	-	-	-	-	3	5,732	18.46	3.246
-	-	-	-	-	-	-	-	3	2,273	16.23	3.238
-	-	-	-	-	-	-	-	3	2,292	7.78	3.238
-	-	-	-	-	-	-	-	3	6,051	153.01	3.224
-	-	-	-	-	-	-	-	3	3,373	29.13	3.183
-	-	-	-	-	-	-	-	3	8,052	318.91	3.165
-	-	-	-	-	-	-	-	3	4,793	18.90	3.141
-	-	-	-	-	-	-	-	3	6,342	27.35	3.124
-	-	-	-	-	-	-	-	3	3,503	104.97	3.063
-	-	-	-	-	-	-	-	3	4,572	15.57	3.044
-	-	-	-	-	-	-	-	3	5,313	1.78	3.032
-	-	-	-	-	-	-	-	3	5,353	56.93	3.028
-	-	-	-	-	-	-	-	3	602	43.37	3.025
-	-	-	-	-	-	-	-	3	5,352	83.18	3.021
-	-	-	-	-	-	-	-	3	2,182	3.78	3.016
-	-	-	-	-	-	-	-	3	171	152.78	3.004
-	-	-	-	-	-	-	-	3	3,152	61.83	3.004
-	-	-	-	-	-	-	-	3	2,342	3.56	2.998
-	-	-	-	-	-	-	-	3	5,422	195.04	2.998
-	-	-	-	-	-	-	-	3	3,292	445.68	2.988
-	-	-	-	-	-	-	-	3	6,251	149.00	2.988

Table C-B-1 (continued). Critical cells by priority ranking for sediment, nitrogen and phosphorus in the Little White River watershed, Mellette County, South Dakota based on 2003 through 2004 data.

Sediment				Total Nitrogen				Total Phosphorus			
Priority	Cell	Acres	Sediment	Priority	Cell	Acres	Nitrogen	Priority	Cell	Acres	Phosphorus
-	-	-	-	-	-	-	-	3	5,832	22.68	2.986
-	-	-	-	-	-	-	-	3	3,901	159.90	2.977
-	-	-	-	-	-	-	-	3	3,742	253.08	2.976
-	-	-	-	-	-	-	-	3	2,202	166.35	2.967
-	-	-	-	-	-	-	-	3	3,771	149.67	2.958
-	-	-	-	-	-	-	-	3	3,963	0.22	2.874
-	-	-	-	-	-	-	-	3	8,151	199.26	2.873
-	-	-	-	-	-	-	-	3	3,303	178.80	2.869
-	-	-	-	-	-	-	-	3	5,402	24.91	2.822
-	-	-	-	-	-	-	-	3	1,502	6.67	2.816
-	-	-	-	-	-	-	-	3	2,162	1.33	2.801
-	-	-	-	-	-	-	-	3	3,182	8.90	2.799
-	-	-	-	-	-	-	-	3	2,013	4.00	2.789
-	-	-	-	-	-	-	-	3	1,513	238.41	2.781
-	-	-	-	-	-	-	-	3	2,742	100.30	2.757
-	-	-	-	-	-	-	-	3	4,812	6.00	2.738
-	-	-	-	-	-	-	-	3	4,813	1.78	2.733
-	-	-	-	-	-	-	-	3	3,473	254.86	2.727
-	-	-	-	-	-	-	-	3	3,603	53.37	2.722
-	-	-	-	-	-	-	-	3	5,921	155.23	2.720
-	-	-	-	-	-	-	-	3	3,521	185.03	2.715
-	-	-	-	-	-	-	-	3	3,622	75.84	2.701
-	-	-	-	-	-	-	-	3	7,462	2.67	2.700
-	-	-	-	-	-	-	-	3	3,552	23.57	2.665
-	-	-	-	-	-	-	-	3	3,523	6.00	2.579

APPENDIX D

Little White River Chemical Data for 2003 through 2004

Table D-1. Chemical data for the Little White River, Mellette County, South Dakota from 2003 through 2004.

Station	Date	pH (su)	Dissolved Oxygen (mg/L)	Transparency Tube Depth (m)	Turbidity (NTUs)	Conductivity (@ 25o C)	Water Temperature (^{o}C)	Fecal Coliform (#/100 ml)	E. coli (#/100 ml)	Alkalinity (mg/L)	Total Solids (mg/L)	Total Dissolved Solids (mg/L)
LWR01	3/12/2004	7.27	13.88	0.056	300	329	1.48			148	557	407
LWR01	3/15/2004	7.50	12.76	0.170	632	445	1.40	10	38	203	384	348
LWR01	3/29/2004	7.27	11.90	0.078	73	500	9.29	190	285	231	314	246
LWR01	3/31/2004	7.58	12.54	0.130	68	508	8.78	140	126	237	429	362
LWR01	5/4/2004	8.43	11.88	0.486	16	576	19.77	70	88	274	408	392
LWR01	5/12/2004	8.35	10.84	0.280	19	505	13.36	1,100	1,990	225	367	339
LWR01	5/13/2004	7.46	8.48	0.015	1,771	322	12.30	8,800	2,420	165	2,389	789
LWR01	6/9/2004	7.08	7.46	0.565		555	15.55	170	172	260	377	362
LWR01	7/6/2004	7.60	7.46	0.022		249	16.33	1,800	2,420	108	898	258
LWR03	3/10/2004	8.49	10.45	0.013	1,327	234	3.90	5,600	2,420	138	4,812	2,482
LWR03	3/9/2004	8.53	10.43	0.009	1,409	234	5.96			155	6,771	3,421
LWR03	3/29/2004	7.20	11.64	0.009	1,392	312	4.99	1,100	1,050	206	11,675	7,975
LWR03	3/31/2004	7.60	15.43	0.011	1,411	359	4.94	700	387	153	4,517	3,167
LWR03	5/12/2004	7.85	9.81	0.013	2,347	226	9.00	130,000	2,420	84	2,356	456
LWR03	5/13/2004	7.32	9.98	0.008	1,739	321	6.28	34,000	2,420	221	12,753	4,953
LWR03	5/24/2004	7.33	7.50	0.008	1,793	275	12.72	12,100	2,420	150	8,423	4,473
LWR03	6/11/2004	8.48	7.22	0.080		289	15.84			170	8,669	5,369
LWR03	7/22/2004			0.004				57,000	2,420	293	17,605	12,805
LWR03	9/21/2004	7.90	8.06	0.008		339	13.91	44,000	2,420	246	11,895	7,795
LWR04	3/11/2004	7.80	12.98	0.009	1,187	838	0.43	7,600	2,420	177	7,012	2,362
LWR04	3/29/2004	6.73	10.98	0.008	1,409	451	6.41	8,000	2,420	151	6,235	1,765
LWR04	3/31/2004	7.28	9.10	0.012	1,447	374	8.11	3,700	2,420	172	5,608	3,378
LWR04	5/24/2004	6.92	6.70	0.007	1,809	428	15.54	35,000	2,420	376	18,225	2,125
LWR04	9/24/2004	7.02	9.44	0.005	1,078	278	10.97			171	9,240	2,690
LWR05	9/24/2003	7.63	9.69	0.027	331	320	16.96	590	579	170	1,406	146
LWR05	10/16/2003	7.96	12.76	0.336	20	220	9.94	100	102	144	287	158
LWR05	11/12/2003	7.57	11.70	0.080	47	194	4.01	160	161	149	340	242
LWR05	11/17/2003			0.016			6.60	900	250	217	3,166	506
LWR05	12/19/2003	7.30	13.66	0.190	27	151	-0.04	20	49	140	290	250
LWR05	1/19/2004	7.53	12.99	0.226	15	288	-0.06	20	28	126	255	224

Table D-1 (continued). Chemical data for the Little White River, Mellette County, South Dakota from 2003 through 2004.

Station	Date	Total Suspended Solids (mg/L)	Total Volatile Suspended Solids (mg/L)	Ammonia (mg/L)	Nitrate-Nitrite (mg/L)	Total Kjeldahl Nitrogen (mg/L)	Organic Nitrogen (mg/L)	Inorganic Nitrogen (mg/L)	Total Nitrogen (mg/L)	Total Phosphorus (mg/L)	Total Dissolved Phosphorus (mg/L)	Total Nitrogen : Total Phosphorus Ratio (mg/L)
LWR01	3/12/2004	150	10	0.01	0.30	0.53	0.52	0.31	0.83	0.544	0.303	1.53
LWR01	3/15/2004	36	4	0.01	0.20	0.70	0.69	0.21	0.90	0.314	0.223	2.87
LWR01	3/29/2004	68	6	0.01	0.05	1.07	1.06	0.06	1.12	0.260		4.31
LWR01	3/31/2004	67	5	0.01	0.05	0.88	0.87	0.06	0.93	0.276	0.154	3.37
LWR01	5/4/2004	16	3	0.01	0.05	0.23	0.22	0.06	0.28	0.104	0.074	2.69
LWR01	5/12/2004	28	7	0.01	0.05	0.91	0.90	0.06	0.96	0.120	0.042	8.00
LWR01	5/13/2004	1,600	160	0.01	0.30	2.32	2.31	0.31	2.62	1.480		1.77
LWR01	6/9/2004	15	9	0.01	0.05	0.65	0.64	0.06	0.70	0.152	0.098	4.61
LWR01	7/6/2004	640	120	0.19	0.80	2.84	2.65	0.99	3.64	1.600		2.28
LWR03	3/10/2004	2,330	100	0.03	0.30	0.06	0.03	0.33	0.36	2.030	0.176	0.18
LWR03	3/9/2004	3,350	250	0.09	0.40	0.27	0.18	0.49	0.67	2.260	0.258	0.30
LWR03	3/29/2004	3,700	300	0.01	0.90	3.47	3.46	0.91	4.37	5.210		0.84
LWR03	3/31/2004	1,350	80	0.01	0.80	1.89	1.88	0.81	2.69	0.444		6.06
LWR03	5/12/2004	1,900	230	0.26	0.60	4.53	4.27	0.86	5.13	1.810		2.83
LWR03	5/13/2004	7,800	900	0.01	1.10	4.94	4.93	1.11	6.04	5.400		1.12
LWR03	5/24/2004	3,950	450	0.01	0.40	3.23	3.22	0.41	3.63	3.330		1.09
LWR03	6/11/2004	3,300	50	0.01	0.70	3.72	3.71	0.71	4.42	3.950		1.12
LWR03	7/22/2004	4,800	267	0.01	0.70	5.34	5.33	0.71	6.04	8.510		0.71
LWR03	9/21/2004	4,100	300	0.01	0.10	3.98	3.97	0.11	4.08	0.424		9.62
LWR04	3/11/2004	4,650	300	0.01	0.50	0.06	0.05	0.51	0.56	1.170	0.112	0.48
LWR04	3/29/2004	4,470	200	0.01	0.70	5.39	5.38	0.71	6.09	2.740		2.22
LWR04	3/31/2004	2,230	130	0.01	1.00	1.91	1.90	1.01	2.91	0.698		4.17
LWR04	5/24/2004	16,100	1,600	0.01	0.60	6.00	5.99	0.61	6.60	7.990		0.83
LWR04	9/24/2004	6,550	750	0.01	0.30	4.34	4.33	0.31	4.64	2.580		1.80
LWR05	9/24/2003	1,260	160	0.16	0.70	0.57	0.41	0.86	1.27	1.140	0.052	1.11
LWR05	10/16/2003	129	8	0.01	0.20	0.28	0.27	0.21	0.48	0.092	0.034	5.22
LWR05	11/12/2003	98	12	0.01	0.80	0.44	0.43	0.81	1.24	0.258	0.101	4.81
LWR05	11/17/2003	2,660	260	0.20	0.50	1.31	1.11	0.70	1.81	1.870	0.102	0.97
LWR05	12/19/2003	40	5	0.01	0.80	0.23	0.22	0.81	1.03	0.200	0.123	5.15
LWR05	1/19/2004	31	3	0.01	0.70	0.27	0.26	0.71	0.97	0.198	0.132	4.90

Table D-1 (continued). Chemical data for the Little White River, Mellette County, South Dakota from 2003 through 2004.

Station	Date	pH (su)	Dissolved Oxygen (mg/L)	Transparency Tube Depth (m)	Turbidity (NTUs)	Conductivity (@ 25o C)	Water Temperature (°C)	Fecal Coliform (#/100 ml)	E. coli (#/100 ml)	Alkalinity (mg/L)	Total Solids (mg/L)	Total Dissolved Solids (mg/L)
LWR05	3/2/2004	7.78	13.23	0.087	282	262	0.35	40	36	124	431	171
LWR05	3/8/2004	7.98	11.21	0.170	240	265	8.12	5	1	121	405	205
LWR05	3/24/2004	7.56	10.93	0.072	334	0.3	11.26	60	51	134	521	209
LWR05	5/4/2004	8.54	10.02	0.058	324	326	16.85	470	461	158	759	139
LWR05	5/13/2004	7.69	10.66	0.054	294	308	9.66	320	378	152	476	196
LWR05	5/24/2004	7.78	8.31	0.012	1,813	356	16.39	7,300	2,420	191	3,399	949
LWR05	6/9/2004	7.98	9.49	0.090		329	17.52	300	488	150	357	239
LWR05	7/21/2004	8.63	7.29	0.071		322	26.98	260	211	146	622	82
LWR05	8/2/2004	9.10	10.15	0.720		22	29.11	50	20	92	288	163
LWR05	8/15/2004			0.025						160	2,796	816
LWR05	8/16/2004	7.52	10.86	0.010		308	13.89	11,000	2,420	173	3,894	74
LWR05	9/15/2004	8.40	10.18	0.119	28	291	18.62	760	574	137	301	201
LWR05	9/22/2004	7.92	9.97	0.113		300	13.00			137	359	155
LWR05	9/24/2004	7.39	9.35	0.008	1,088	305	13.87			148	4,940	1,740
LWR05	10/27/2004	7.88	11.05	0.054	147	313	9.26	390	687	152	1,357	157
LWR06	7/6/2004	8.41	8.43	0.043		374	22.01	800	1,300	161	601	231
LWR06	9/24/2003	7.87	9.33	0.164	12	360	18.34	20	5	157	317	264
LWR06	10/16/2003	7.83	12.67	0.157	58	237	11.06	160	105	144	375	243
LWR06	11/12/2003	7.55	11.30	0.075	176	206	4.67	110	104	151	472	250
LWR06	12/19/2003	7.65	12.98	0.128	31	167	-0.04	5	30	138	352	255
LWR06	1/19/2004	7.37	12.83	0.210	21	296	-0.40	10	23	128	275	234
LWR06	3/8/2004	7.83	10.63	0.037	1,275	131	10.23	10	1	127	845	149
LWR06	3/24/2004	7.73	11.11	0.052	56	283	10.45	10	29	145	795	175
LWR06	5/4/2004	8.58	10.44	0.058	273	341	13.90	650	461	157	587	257
LWR06	5/13/2004	8.03	10.28	0.046	403	346	9.94	570	411	154	632	232
LWR06	5/24/2004	7.20	8.65	0.030	732	347	15.38	1,400	1,410	149	1,343	313
LWR06	6/9/2004	7.82	8.48	0.044		417	19.16	2,600	2,420	151	703	283
LWR06	7/21/2004	8.82	6.55	0.089		38	33.47	60	27	155	382	268
LWR06	8/2/2004	9.17	8.86	0.066		24	32.32	30	5	100	350	174
LWR06	8/16/2004	7.97	8.90	0.010		34	18.71	6,600	2,420	189	4,135	95

Table D-1 (continued). Chemical data for the Little White River, Mellette County, South Dakota from 2003 through 2004.

Station	Date	Total Suspended Solids (mg/L)	Total Volatile Suspended Solids (mg/L)	Ammonia (mg/L)	Nitrate-Nitrite (mg/L)	Total Kjeldahl Nitrogen (mg/L)	Organic Nitrogen (mg/L)	Inorganic Nitrogen (mg/L)	Total Nitrogen (mg/L)	Total Phosphorus (mg/L)	Total Dissolved Phosphorus (mg/L)	Total Nitrogen : Total Phosphorus Ratio (mg/L)
LWR05	3/2/2004	260	24	0.01	0.40	0.39	0.38	0.41	0.79	0.443	0.099	1.78
LWR05	3/8/2004	200	8	0.01	0.50	0.11	0.10	0.51	0.61	0.384	0.103	1.59
LWR05	3/24/2004	312	20	0.01	0.40	0.72	0.71	0.41	1.12	0.349	0.108	3.21
LWR05	5/4/2004	620	55	0.01	0.30	1.48	1.47	0.31	1.78	0.593	0.104	3.00
LWR05	5/13/2004	280	60	0.01	0.05	1.91	1.90	0.06	1.96	0.504	0.057	3.89
LWR05	5/24/2004	2,450	400	0.01	0.30	2.49	2.48	0.31	2.79	1.500		1.86
LWR05	6/9/2004	118	30	0.01	0.05	1.22	1.21	0.06	1.27	0.316	0.026	4.02
LWR05	7/21/2004	540	56	0.01	0.05	1.30	1.29	0.06	1.35	0.503	0.041	2.68
LWR05	8/2/2004	125	60	0.01	0.05	4.83	4.82	0.06	4.88	0.287	0.016	17.00
LWR05	8/15/2004	1,980	140	0.02	0.05	3.25	3.23	0.07	3.30	1.220		2.70
LWR05	8/16/2004	3,820	420	0.14	0.40	5.49	5.35	0.54	5.89	2.090		2.82
LWR05	9/15/2004	100	26	0.01	0.05	1.10	1.09	0.06	1.15	0.186	0.018	6.18
LWR05	9/22/2004	204	18	0.01	0.50	0.56	0.55	0.51	1.06	0.263		4.03
LWR05	9/24/2004	3,200	250	0.01	0.40	2.46	2.45	0.41	2.86	2.240		1.28
LWR05	10/27/2004	1,200	84	0.01	0.60	1.51	1.50	0.61	2.11	0.804		2.62
LWR06	7/6/2004	370	55	0.01	0.05	1.33	1.32	0.06	1.38	0.486		2.84
LWR06	9/24/2003	53	9	0.01	0.05	0.06	0.05	0.06	0.11	0.120	0.042	0.92
LWR06	10/16/2003	132	10	0.01	0.05	0.25	0.24	0.06	0.30	0.140	0.026	2.14
LWR06	11/12/2003	222	26	0.01	0.80	0.49	0.48	0.81	1.29	0.365	0.085	3.53
LWR06	12/19/2003	97	8	0.01	0.80	0.39	0.38	0.81	1.19	0.232	0.116	5.13
LWR06	1/19/2004	41	5	0.01	0.80	0.29	0.28	0.81	1.09	0.196	0.128	5.56
LWR06	3/8/2004	696	40	0.01	0.50	0.27	0.26	0.51	0.77	0.803	0.105	0.96
LWR06	3/24/2004	620	40	0.01	0.40	0.06	0.05	0.41	0.46	0.726	0.107	0.63
LWR06	5/4/2004	330	40	0.01	0.20	1.44	1.43	0.21	1.64	0.770	0.272	2.13
LWR06	5/13/2004	400	80	0.01	0.05	1.96	1.95	0.06	2.01	0.616	0.048	3.26
LWR06	5/24/2004	1,030	110	0.01	0.20	1.81	1.80	0.21	2.01	0.876		2.29
LWR06	6/9/2004	420	64	0.01	0.05	1.67	1.66	0.06	1.72	0.716		2.40
LWR06	7/21/2004	114	30	0.01	0.05	1.05	1.04	0.06	1.10	0.276	0.035	3.99
LWR06	8/2/2004	176	56	0.01	0.05	4.80	4.79	0.06	4.85	0.315	0.017	15.40
LWR06	8/16/2004	4,040	400	0.31	0.20	8.30	7.99	0.51	8.50	2.330		3.65

Table D-1 (continued). Chemical data for the Little White River, Mellette County, South Dakota from 2003 through 2004.

Station	Date	pH (su)	Dissolved Oxygen (mg/L)	Transparency Tube Depth (m)	Turbidity (NTUs)	Conductivity (@ 25o C)	Water Temperature (^{o}C)	Fecal Coliform (#/100 ml)	E. coli (#/100 ml)	Alkalinity (mg/L)	Total Solids (mg/L)	Total Dissolved Solids (mg/L)
LWR06	9/15/2004	8.31	8.86	0.081	64	306	20.85	280	222	139	436	218
LWR06	9/24/2004	7.83	8.34	0.012	1,105	314	19.67			159	3,162	122
LWR06	10/27/2004	7.93	10.45	0.103	65	328	8.95	70	120	146	358	230
LWR07	9/24/2003	7.35	11.52	0.430		266	13.51	70	105	141	248	219
LWR07	10/16/2003	7.77	13.15	0.516	6	212	8.98	40	99	142	270	231
LWR07	11/12/2003	7.66	11.60	0.115	117	185	3.00	140	99	149	406	248
LWR07	12/19/2003	7.52	13.29	0.184	27	161	-0.01	40	32	138	349	252
LWR07	1/19/2004	7.30	13.11	0.429	8	285	-0.70	10	16	127	240	225
LWR07	3/2/2004	7.75	13.46	0.093	240	257	0.30	10	55	124	714	140
LWR07	3/24/2004	7.63	10.62	0.100	220	227	8.32	10	22	130	506	142
LWR07	5/4/2004	8.50	9.78	0.051	275	319	19.37	140	190	151	614	179
LWR07	5/12/2004	8.65	9.81	0.058	180	274	15.43	520	770	146	612	162
LWR07	5/13/2004	8.05	9.36	0.043	315	32	13.80	610	727	150	642	192
LWR07	6/9/2004	7.71	8.92	0.088		313	16.09	470	866	147	510	218
LWR07	7/6/2004	8.30	8.36	0.048		292	18.23	700	816	140	553	238
LWR07	7/21/2004	8.73	7.61	0.104		272	24.26	140	133	143	365	213
LWR07	8/2/2004	8.71	8.76	0.074		246	24.74	110	34	112	370	175
LWR07	8/16/2004	7.95	8.08	0.024		277	21.30	3,600	2,420	148	1,326	76
LWR07	8/15/2004	7.85		0.150						146	319	155
LWR07	9/15/2004	7.85	10.23	0.162	35	295	15.62	280	260	139	307	216
LWR07	9/23/2004	7.22	9.88	0.058	182	266	11.38	2,400	2,420	127	528	140
LWR07	10/27/2004	7.18	10.30	0.147	50	304	8.61	40	81	140	308	193
LWR08	11/12/2003	7.68	11.04	0.090	71	188	1.19	170	122	152	460	230
LWR08	8/30/2004	7.86	13.32	0.083		254	16.84			145	395	219
LWR08	9/15/2004	8.26	10.29	0.103	63	291	17.74	730	1,200	143	372	196
LWR08	9/22/2004	7.49	9.83	0.096		286	13.22			137	400	190
LWR08	9/24/2004	7.26	9.25	0.046	140	288	16.01			135	599	149
LWR08	10/27/2004	7.59	10.41	0.112	80	311	8.84	60	77	145	361	227

Table D-1 (continued). Chemical data for the Little White River, Mellette County, South Dakota from 2003 through 2004.

Station	Date	Total Suspended Solids (mg/L)	Total Volatile Suspended Solids (mg/L)	Ammonia (mg/L)	Nitrate-Nitrite (mg/L)	Total Kjeldahl Nitrogen (mg/L)	Organic Nitrogen (mg/L)	Inorganic Nitrogen (mg/L)	Total Nitrogen (mg/L)	Total Phosphorus (mg/L)	Total Dissolved Phosphorus (mg/L)	Total Nitrogen : Total Phosphorus Ratio (mg/L)
LWR06	9/15/2004	218	36	0.01	0.05	1.60	1.59	0.06	1.65	0.328	0.042	5.03
LWR06	9/24/2004	3,040	320	0.03	0.50	1.68	1.65	0.53	2.18	1.390		1.57
LWR06	10/27/2004	128	16	0.01	0.50	0.47	0.46	0.51	0.97	0.245	0.087	3.96
LWR07	9/24/2003	29	6	0.01	0.20	0.06	0.05	0.21	0.26	0.081	0.047	3.21
LWR07	10/16/2003	39	4	0.01	0.30	0.28	0.27	0.31	0.58	0.089	0.052	6.52
LWR07	11/12/2003	158	20	0.01	0.80	0.44	0.43	0.81	1.24	0.261	0.111	4.75
LWR07	12/19/2003	97	9	0.01	0.80	0.44	0.43	0.81	1.24	0.236	0.128	5.25
LWR07	1/19/2004	15	3	0.01	0.70	0.45	0.44	0.71	1.15	0.172	0.146	6.69
LWR07	3/2/2004	574	38	0.01	0.50	0.35	0.34	0.51	0.85	0.454	0.104	1.87
LWR07	3/24/2004	364	16	0.01	0.40	2.22	2.21	0.41	2.62	0.366	0.137	7.16
LWR07	5/4/2004	435	50	0.01	0.30	1.52	1.51	0.31	1.82	0.544	0.112	3.35
LWR07	5/12/2004	450	55	0.01	0.20	2.24	2.23	0.21	2.44	0.520	0.069	4.69
LWR07	5/13/2004	450	65	0.01	0.30	2.23	2.22	0.31	2.53	0.570		4.44
LWR07	6/9/2004	292	68	0.01	0.05	1.82	1.81	0.06	1.87	0.410	0.058	4.56
LWR07	7/6/2004	315	50	0.01	0.20	1.27	1.26	0.21	1.47	0.584		2.52
LWR07	7/21/2004	152	30	0.01	0.05	1.18	1.17	0.06	1.23	0.288	0.064	4.27
LWR07	8/2/2004	195	55	0.01	0.05	4.25	4.24	0.06	4.30	0.366	0.021	11.75
LWR07	8/16/2004	1,250	130	0.05	0.40	4.02	3.97	0.45	4.42	1.210		3.65
LWR07	8/15/2004	164	18	0.01	0.05	1.13	1.12	0.06	1.18	0.197		5.99
LWR07	9/15/2004	91	16	0.01	0.40	1.00	0.99	0.41	1.40	0.252		5.56
LWR07	9/23/2004	388	36	0.01	0.50	0.81	0.80	0.51	1.31	0.392		3.34
LWR07	10/27/2004	115	13	0.01	0.70	0.44	0.43	0.71	1.14	0.272	0.166	4.19
LWR08	11/12/2003	230	24	0.01	0.70	0.52	0.51	0.71	1.22	0.367	0.105	3.32
LWR08	8/30/2004	176	30	0.01	0.05	1.45	1.44	0.06	1.50	0.135	0.052	11.11
LWR08	9/15/2004	176	28	0.01	0.05	1.37	1.36	0.06	1.42	0.302	0.052	4.70
LWR08	9/22/2004	210	18	0.01	0.50	0.58	0.57	0.51	1.08	0.350		3.09
LWR08	9/24/2004	450	30	0.01	0.60	0.85	0.84	0.61	1.45	0.503		2.88
LWR08	10/27/2004	134	16	0.01	0.60	0.44	0.43	0.61	1.04	0.248	0.119	4.19

APPENDIX E

Transparency Tube Depth and Total Suspended Solids Regression Relationships in Mainstem Little White River, Mellette County, South Dakota from 2003 through 2004

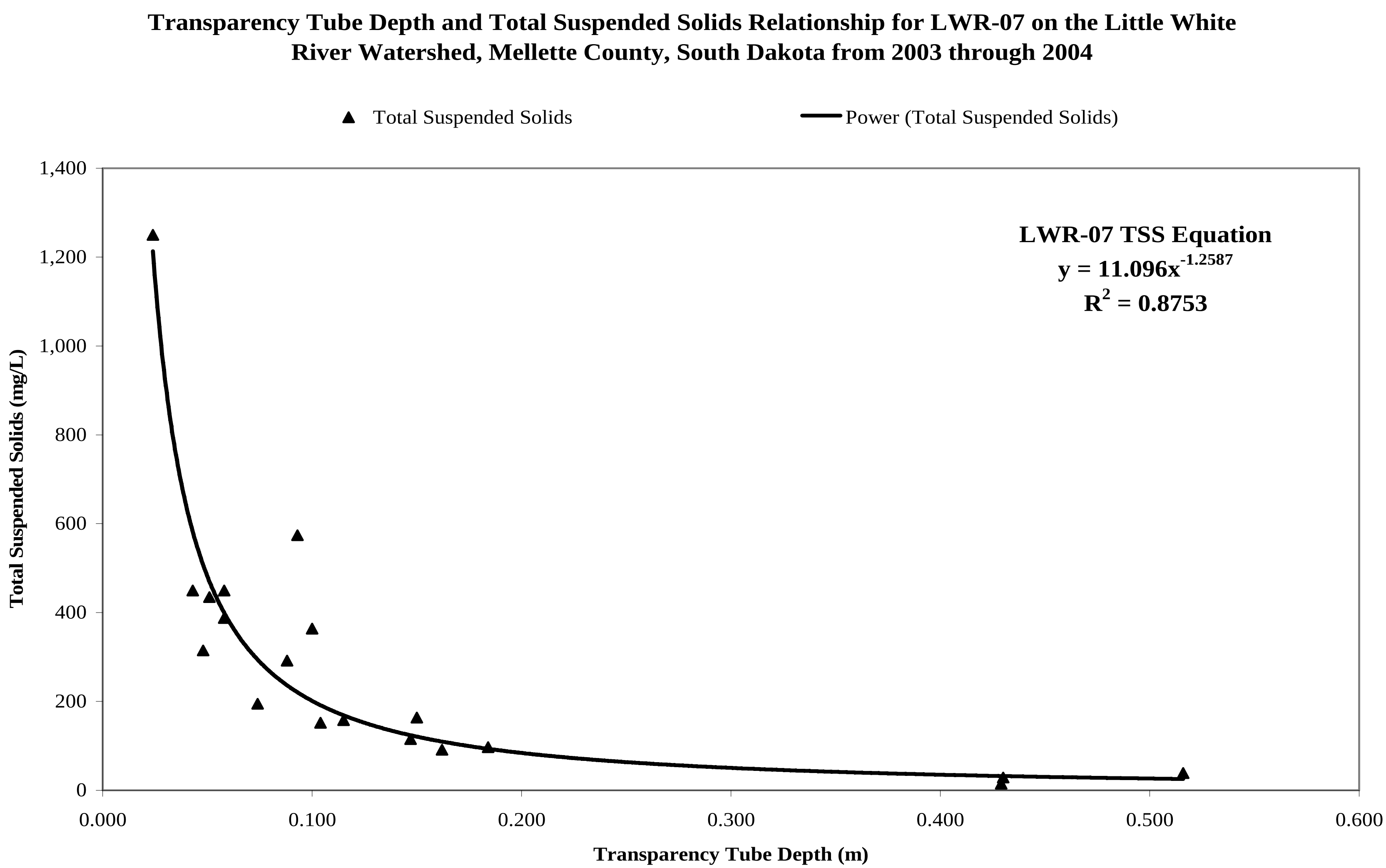


Figure E-1. Transparency Tube Depth and Total Suspended Solids Relationship for LWR-07 (Todd County Line) on the Little White River Watershed, Mellette County, South Dakota from 2003 through 2004.

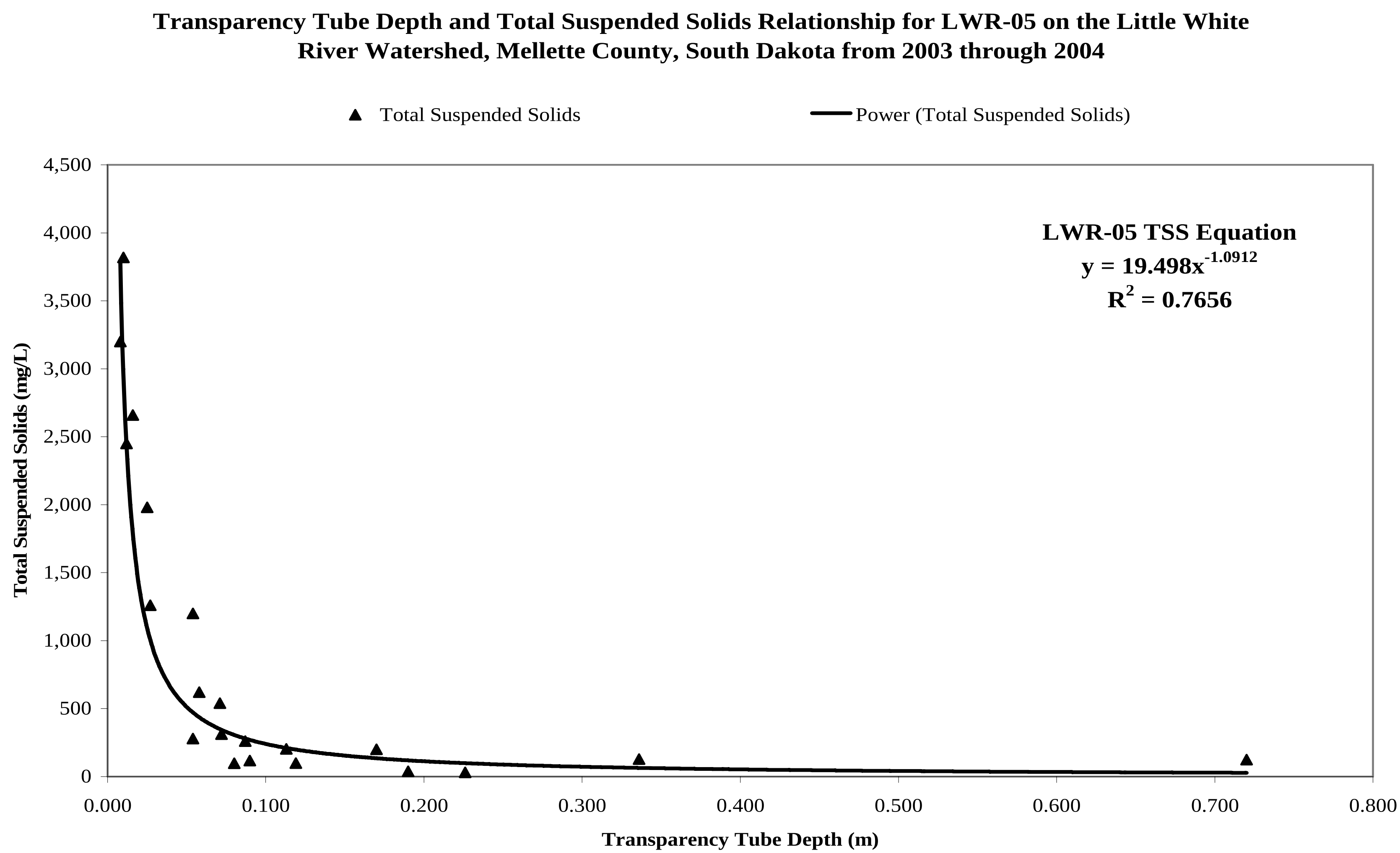


Figure E-2. Transparency Tube Depth and Total Suspended Solids Relationship for LWR-05 (Highway 83 Bridge) on the Little White River Watershed, Mellette County, South Dakota from 2003 through 2004.

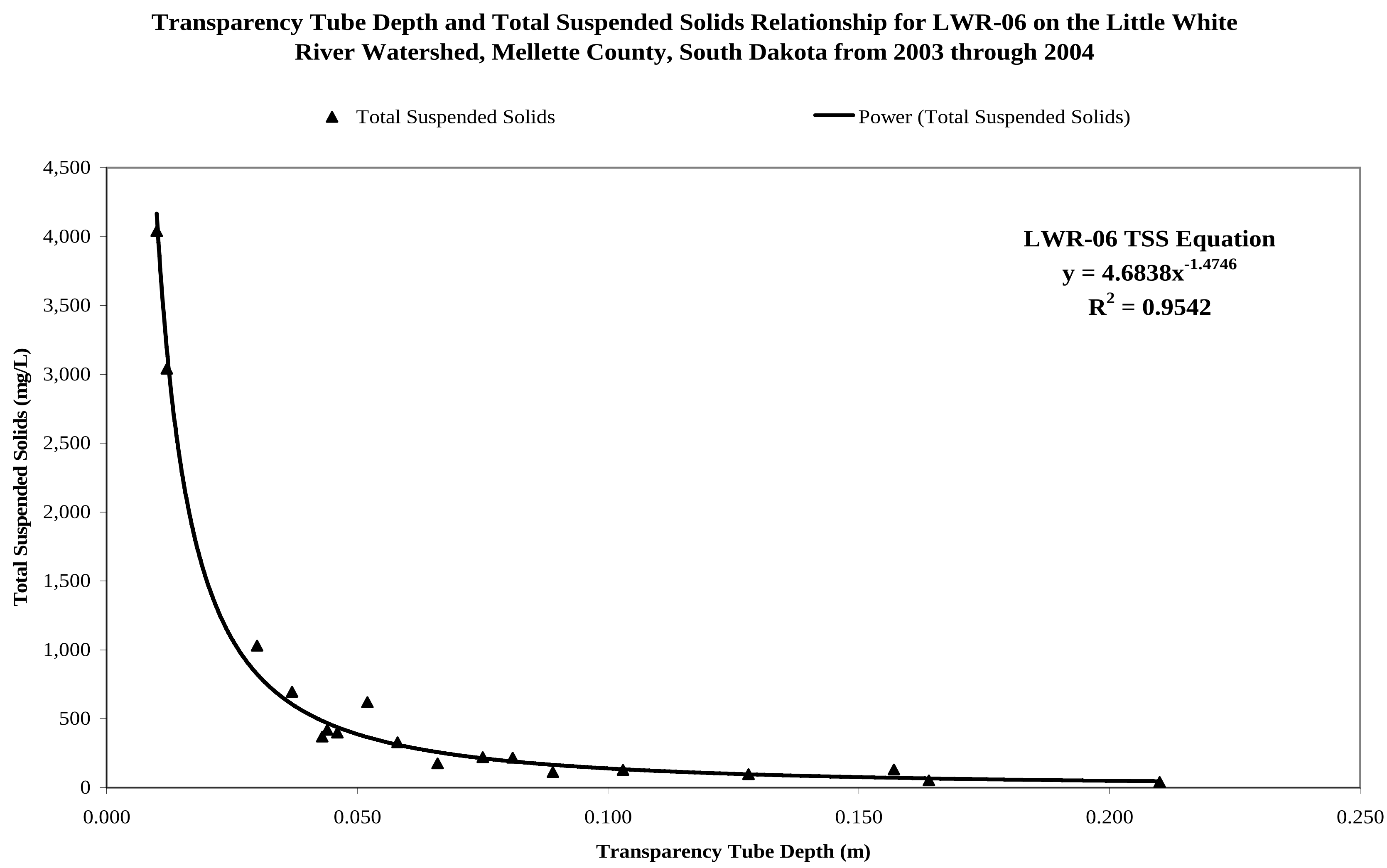


Figure E-3. Transparency Tube Depth and Total Suspended Solids Relationship for LWR-05 (mouth of the Little White River) on the Little White River Watershed, Mellette County, South Dakota from 2003 through 2004.

APPENDIX F

Macroinvertebrates Collected in 2004 for the Little White River Watershed by Site and month, Mellette County, South Dakota

Table F-1. Macroinvertebrates collected in 2004 for the Little White River watershed by month, Mellette County, South Dakota.

Little White River, June 2004

Taxa	LWR-01	LWR-05	LWR-06	LWR-07	LWR-12
Ablabesmyia	5				
Acentrella	1	157	16	123	16
Amercaenis ridens	1	4		5	1
Atherix				2	
Baetidae			1	2	5
Berosus	1				
Brachycentrus					1
Caenis	1		7		4
Camelobaetidius		25		5	7
Cardiocladius		1		14	2
Ceratopogonidae			4		
Ceratopogoninae	7			1	4
Cercobrachys			1		
Chaetogaster diaphanus	2				
Chelifera/Hemerodromia		2			
Cheumatopsyche		3		2	
Chironomus			1		
Cladotanytarsus		4		11	
Coenagrionidae	6				
Corduliidae	2				
Corixidae	24				
Cricotopus	8			1	
Cricotopus trifascia	2	2			
Cricotopus/Orthocladius	25				
Cryptochironomus			2		
Cryptotendipes	2				
Dicrotendipes	15				
Dytiscidae	9				
Ephoron			1		
Fallceon quilleri		15	8	28	22
Gomphidae			2	1	1
Gomphus			2		
Harnischia complex			7	1	4
Helophorus	1				
Hemerodromia				1	
Heptageniidae	2	3			1
Homoneuria		1	14	1	2
Hyalella	1				
Hydropsyche occidentalis		4		25	2
Hydropsychidae		8		15	
Hydroptila		1			
Isonychia		19	1	1	2
Leptoceridae		1			
Lestes	1				
Limnodrilus udekemianus	1				
Lopescladius			1		2
Mayatrichia				3	1
Microcylloepus					1
Naididae	257	1			
Nais behningi				1	
Nais communis	185				
Nais pardalis	19				
Nais variabilis		1			
Nanocladius	7		2		1
Nectopsyche					1
Nectopsyche candida				3	
Nectopsyche diarina				2	
Ochrotrichia				2	
Ophidonais serpentina	1				
Paracloeodes minutus			2		1
Paracymus			1		
Parakiefferiella	1				
Paratanytarsus	35				
Paratendipes subequalis			5		
Peltodytes	22				
Pentaneura	1				
Perlesta	5	1		1	
Physella	4				
Polymitarcidae		2			
Polypedilum			6		1
Procladius	74			1	
Procloeon	5				
Rheotanytarsus		1	2	2	1
Sigara	3				
Simulium		164	1	48	10
Stempellinella			3	1	
Stictochironomus	4				
Tanytarsus	91				
Thienemanniella	2				
Thienemannimyia			1		1
Tricorythodes		3	1	10	4
Tubificidae	17				

Table F-1 (continued). Macroinvertebrates collected in 2004 for the Little White River watershed by month, Mellette County, South Dakota.

Little White River, July 2004

Taxa	LWR-05	LWR-06	LWR-07	LWR-12
Acentrella			48	27
Ambrysus	2			
Amercaenis ridens	8	283	22	32
Atherix	2		3	1
Baetidae	1	2		5
Caenis	1	9		
Camelobaetidius			11	10
Cardiocladius	4			
Ceratopogoninae	5	1		
Cercobrachys		2		
Cheumatopsyche	7		5	1
Chironominae		1		
Cladotanytarsus	1		3	1
Cricotopus	6			
Cricotopus/Orthocladius	5		1	
Cryptochironomus	1			
Dero digitata	7			
Elmidae				1
Ephoron	1			
Fallceon quilleri	1	17	4	
Gomphidae			2	2
Hemerodromia	1	1		
Hetaerina		2		
Homoneuria		1	3	17
Hydropsyche	2			
Hydropsyche occidentalis	13		94	8
Hydropsychidae	5		80	8
Hydroptilidae	1			1
Isonychia		3		
Leptoceridae	1		1	1
Macronychus glabratus		1		
Mayatrichia	1		5	
Nanocladius		1		2
Nectopsyche	1	2		
Ochrotrichia			2	
Oecetis				1
Paracloeodes minutus	11			
Pentaneura		1		
Petrophila	4			
Polypedilum	2	2	1	9
Rheocricotopus				1
Rheotanytarsus	11	21	2	9
Robackia claviger			1	7
Simulium	220	12	133	20
Stenelmis	4	1	1	
Stictochironomus	1	1		
Thienemanniella		1	1	
Thienemannimyia	17	2		
Tricorythodes		4	14	2
Tubificidae	28			

Table F-1 (continued). Macroinvertebrates collected in 2004 for the Little White River watershed by month, Mellette County, South Dakota.

Little White River, August 2004

CharacteristicName	LWR-05	LWR-06	LWR-07	LWR-12
Acari	3	1		
Acentrella	40		62	10
Ambrysus		1	2	
Amercaenis ridens	45	6	2	
Atherix	2		5	
Baetidae	5		11	7
Caenis	10	7	3	2
Camelobaetidius	14		10	4
Ceratopogonidae		12		3
Ceratopogoninae		3		1
Cercobrachys	1	4		
Cheumatopsyche	21		2	1
Chironominae		4		2
Cladotanytarsus	4		17	
Corixidae	1			
Cryptochironomus	3	2		
Fallceon quilleri	21	8	8	5
Harnischia complex		1		
Hemerodromia	9	1		
Hydropsyche	12		6	4
Hydropsyche occidentalis	26		75	
Hydropsychidae	11		60	5
Isonychia		2		
Leptoceridae			1	
Macronychus glabratus				1
Mayatrichia	6	1	49	1
Microcylloepus			4	
Nectopsyche	2	1		
Nectopsyche candida	1			
Neochoroterpes	1			
Ochrotrichia			1	
Oecetis		1		
Ophiogomphus	1			
Paracloeodes minutus		4		
Pentaneura		1	2	2
Physidae	1			
Polypedilum	12	5	4	5
Rheocricotopus			2	1
Rheotanytarsus	3	4	9	2
Robackia claviger				2
Simulium	81	11	71	17
Stempellinella		4		4
Stenelmis	1			
Stictochironomus		3		
Tanytarsus		5	1	1
Thienemannimyia	5	3		2
Tricorythodes	1			

APPENDIX G

Rare, Threatened or Endangered Species Documented in the Little White River Watershed in Mellette County, South Dakota as of 2004

Key to Codes Used in Natural Heritage Database Reports

FEDERAL STATUS	LE = Listed endangered LT = Listed threatened LELT = Listed endangered in part of range, threatened in part of range PE = Proposed endangered PT = Proposed threatened C = Candidate for federal listing, information indicates that listing is justified.
STATE STATUS	SE = State Endangered ST = State Threatened

An endangered species is a species in danger of extinction throughout all or a significant portion of its range. (applied range wide for federal status and statewide for state status)

A threatened species is a species likely to become endangered in the foreseeable future.

Global Rank	State Rank	Definition (applied rangewide for global rank and statewide for state rank)
G1	S1	Critically imperiled because of extreme rarity (5 or fewer occurrences or very few remaining individuals or acres) or because of some factor(s) making it especially vulnerable to extinction.
G2	S2	Imperiled because of rarity (6 to 20 occurrences or few remaining individuals or acres) or because of some factor(s) making it very vulnerable to extinction throughout its range.
G3	S3	Either very rare and local throughout its range, or found locally (even abundantly at some of its locations) in a restricted range, or vulnerable to extinction throughout its range because of other factors; in the range of 21 of 100 occurrences.
G4	S4	Apparently secure, though it may be quite rare in parts of its range, especially at the periphery. Cause for long term concern.
G5	S5	Demonstrably secure, though it may be quite rare in parts of its range, especially at the periphery.
GU	SU	Possibly in peril, but status uncertain, more information needed.
GH	SH	Historically known, may be rediscovered.
GX	SX	Believed extinct, historical records only.
G?	S?	Not yet ranked
_?	_?	Inexact rank
_T		Rank of subspecies or variety
_Q		Taxonomic status is questionable, rank may change with taxonomy
	SZ	No definable occurrences for conservation purposes, usually assigned to migrants
	SP	Potential exists for occurrence in the state, but no occurrences
	SR	Element reported for the state but no persuasive documentation
	SA	Accidental or casual

Bird species may have two state ranks, one for breeding (S#B) and one for nonbreeding seasons (S#N). Example: Ferruginous Hawk (S3B, SZN) indicates an S3 rank in breeding season and SZ in nonbreeding season.

Rare, Threatened or Endangered Species Documented in the Little White River Watershed in Mellette County HUC: 10140203
South Dakota Natural Heritage Database
06/30/2004

Type	Species Name	Common Name	County	State Listing	Federal ESA Listing	Township Range	Section	Last Observation
Mammal								
	Mustela nigripes	Black-footed ferret	Mellette	SE	LE	042N030W		1967-09-05
	Mustela nigripes	Black-footed ferret	Mellette	SE	LE	040N031W	35	1966-04-24
	Mustela nigripes	Black-footed ferret	Mellette	SE	LE	040N031W	17	1972
	Mustela nigripes	Black-footed ferret	Mellette	SE	LE	042N032W	33	
	Mustela nigripes	Black-footed ferret	Mellette	SE	LE	041N030W	07	1970
	Mustela nigripes	Black-footed ferret	Mellette	SE	LE	041N030W	16	1968
	Mustela nigripes	Black-footed ferret	Mellette	SE	LE	041N031W	07	
	Mustela nigripes	Black-footed ferret	Mellette	SE	LE	041N031W	10	1969
	Mustela nigripes	Black-footed ferret	Mellette	SE	LE	041N029W	03	1967-08-02
	Mustela nigripes	Black-footed ferret	Mellette	SE	LE	040N031W	23	1966-04-24
Plant								
	Eriogonum visheri	Dakota buckwheat	Mellette			041N028W	21	1986-08-11
	Psoralea linearifolia	Slimleaf scurfpea	Mellette			041N029W	03	1924-07-11
	Psoralea linearifolia	Slimleaf scurfpea	Mellette			042N030W	26	1971-07-13
Fish								
	Hybognathus placitus	Plains minnow	Mellette			042N029W	34	1994-09-10
	Hybognathus placitus	Plains minnow	Mellette			043N028W	9	1994-09-10
	Platygobio gracilis	Flathead chub	Mellette			042N029W	23	1994-09-10
	Platygobio gracilis	Flathead chub	Mellette			043N028W	9	1994-09-10
	Platygobio gracilis	Flathead chub	Mellette			042N029W	34	1994-09-10
	Macrhybopsis gelida	Sturgeon chub	Mellette	ST		042N029W	23	1994-09-10
Bird								
	Grus americana	Whooping crane	Mellette	SE	LE	041N030W	02	1993-04-24

APPENDIX H

Public Comments and Responses to Little White River Watershed Assessment Report

50 copies of this document were printed by the Department of Environment and Natural Resources at a cost of $7.37 per copy