CONATA BASIN WATERSHED PROJECT

South Dakota Water Resources Assistance Program
Division of Financial and Technical Assistance
South Dakota Department of Environment and Natural Resources
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United States Department of Interior-Badlands National Park
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INTRODUCTION

This study was initiated after two public meetings held in 2004 during final preparation of the *Phase I Environmental Assessment of the White River Watershed* final report (RESPEC, 2007). Meetings were held in Kadoka and White River, South Dakota to disseminate findings and take stakeholder comments on the White River watershed assessment project. The document reported fecal coliform bacteria concentrations violated South Dakota water quality standards for limited contact waters and required a total maximum daily load (TMDL) for each impaired reach. The general consensus among stakeholders was that the study did not adequately address and allocate sources of fecal coliform bacteria in the White River. Concerns were expressed that livestock and local ranchers would be assigned large portions of the overall fecal coliform loading to the White River when wildlife, especially prairie dogs, may be a significant source of fecal coliform due to large populations in the middle and upper reaches of the White River in South Dakota. Because of these concerns and concerns expressed by State Senator Jim Lintz of District 30, portions of the Cottonwood Creek watershed assessment project and this study were undertaken to attempt to refine and allocate sources of fecal coliform bacteria in the White River basin. As part of the Cottonwood Creek watershed assessment project monthly and precipitation event fecal coliform and *E. coli* samples were collected and analyzed from May 1 through September 30, 2005, within each proposed segment of the White River (Oglala, Kadoka and Oacoma, South Dakota). *E. coli* bacteria colonies were further processed to extract deoxyribonucleic acid (DNA) for comparison to a known source DNA database. As part of the Conata Basin watershed project, *E. coli* bacteria samples were collected directly from fresh prairie dog fecal pellets and processed for DNA. These samples produced DNA specific markers for prairie dogs and were included into South Dakota's known source DNA database. DNA markers from *E. coli* samples collected in the White River in 2005 were matched with known markers in the DNA database to identify species specific sources of coliform bacteria (*E. coli*) in the White River Basin.

The Conata Basin was selected for study because it was in the White River watershed which was listed in the 2006 Integrated Report (combined 303(d) and 305(b) reports) as impaired by total suspended solids (TSS) and fecal coliform bacteria (SD DENR, 2006). The Conata Basin encompasses approximately 91,799 acres in Pennington County with a primary land use (95%) of agricultural grazing (Figure 1). The major geologic group in the Conata Basin is the White River Group which comprises the Brule, Chadron, Chamberlain and Slim Buttes formations. Streams in the basin drain portions of Badlands National Park. US Forest Service leased grazing allotments and private agricultural lands composed predominantly of grassland pasture with the balance being crop and hay ground (Figure 2). The black-footed ferret (*Mustela nigripes*) was re-introduced into the basin and was the only federally threatened or endangered species listed in and near the Conata Basin (Shannon County). The complete federal and state threatened or endangered list for the entire White River Basin can be referenced in Appendix E of the *Phase I Environmental Assessment of the White River Watershed* final report (RESPEC, 2007). Average annual precipitation in the basin is approximately 16.8 inches of which 66.9 percent usually falls from May through September. Thunderstorms are the main source of precipitation in the growing season and vary greatly in intensity and rainfall amount. Generally, these storms are localized and of short duration occasionally producing heavy rainfall events.

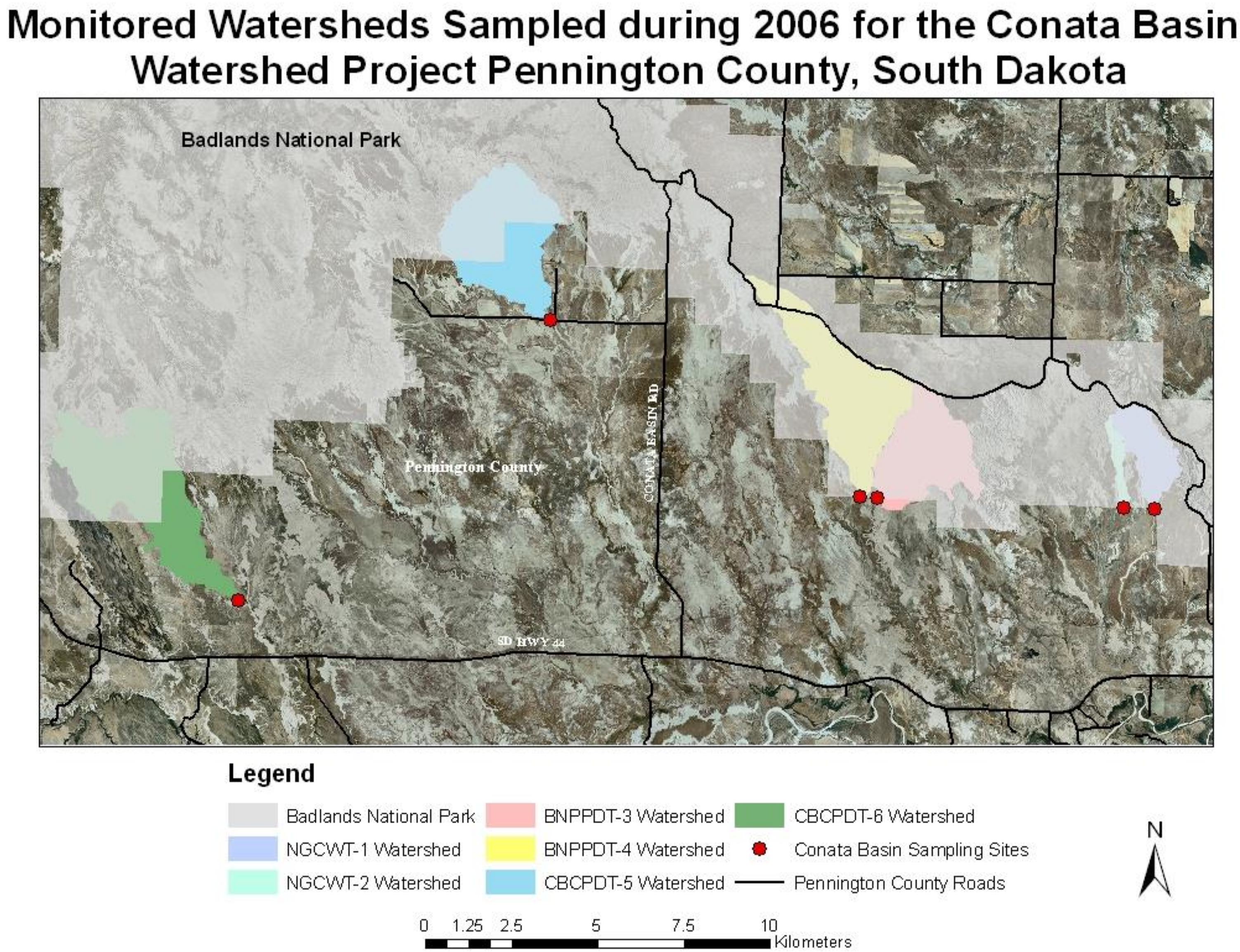

Figure 1. Monitored watersheds sampled during the Conata Basin watershed project in 2006.

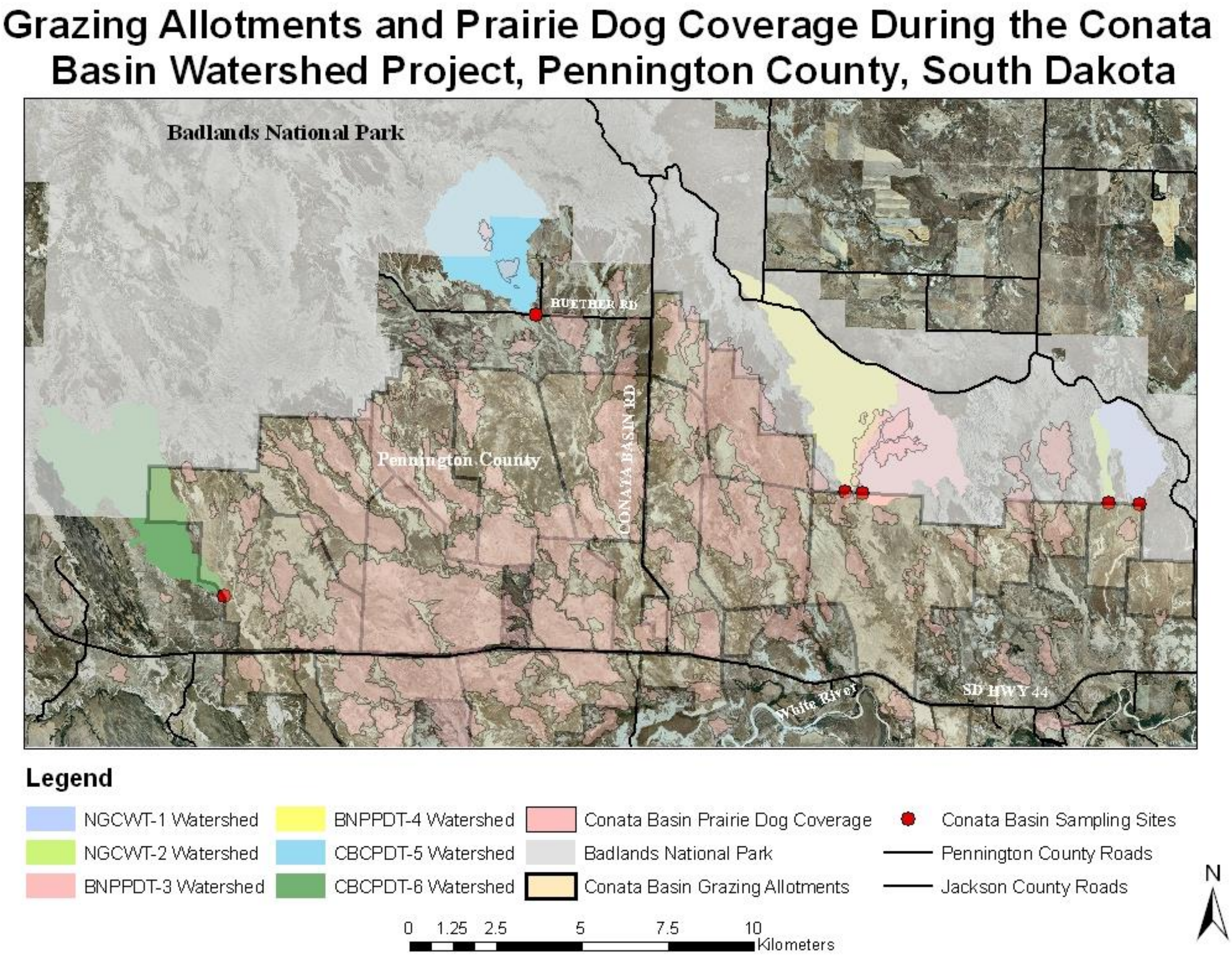

Figure 2. Prairie dog coverage in the Conata Basin during the Conata Basin watershed project, Pennington County, South Dakota in 2006.

All waters of the state are assigned beneficial uses each with associated water quality standards. South Dakota's numeric water quality standards are based on beneficial use categories. Beneficial use classifications are listed in Table 1. All streams in the state are assigned beneficial uses of (9) fish and wildlife propagation, recreation, and stock watering and (10) irrigation water (ARSD § 74:51:03:01).

Table 1. 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.

Tributaries flowing from the Conata Basin into the White River were unnamed and have been assigned the beneficial uses of (9) fish and wildlife propagation, recreation, and stock watering water and (10) irrigation water (Table 1 and Table 2).

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* (ARSD § 74:51:01:12).

Table 2. Assigned beneficial uses for the tributaries in the Conata Basin, Pennington County South Dakota.

Water Body	From	To	Beneficial Uses*	Counties
All Streams	Entire State	Entire State	9, 10	All

*** = See Table 1 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 those beneficial uses and violate water quality standards. Table 3 lists the most stringent water quality parameters for tributaries in the Conata Basin. Six of the eight parameters (total alkalinity, total dissolved solids, nitrates, total petroleum hydrocarbon, oil and grease and sodium adsorption ratio) listed for tributaries in the Conata Basin based on beneficial use classifications were not sampled during this project because they were not considered parameters of concern in these watersheds.

Table 3. The most stringent water quality standards for tributaries in the Conata Basin based on beneficial use classifications.

Water Body	Beneficial Uses	Parameter	Standard Value
Conata Basin	9, 10	Total alkalinity as calcium carbonate [1, 6]	≤ 1313 mg/L
		Total dissolved solids [2, 6]	≤ 4,375 mg/L
		Conductivity at 25° C [3]	≤ 4,375 µS/cm
		Nitrates as N [4, 6]	≤ 88 mg/L
		pH	≥ 6.0 - ≤ 9.5
		Total petroleum hydrocarbon [6]	≤ 1 mg/L
		Oil and grease [6]	≤ 10 mg/L
		Sodium Adsorption Ratio (SAR) [5, 6]	≤ 10 (unit less)

[1] = The daily maximum for total alkalinity as calcium carbonate is ≤ 1,313 mg/L or ≤ 750 mg/L for a 30-day average.
[2] = The daily maximum for total dissolved solids is ≤ 4,375 mg/L or ≤ 2,500 mg/L for a 30-day average.
[3] = The daily maximum for conductivity at 25□ C is ≤ 4,375 µS/cm or ≤ 2,500 µS/cm for a 30-day average.
[4] = The daily maximum for nitrates is ≤ 88 mg/L or 50 mg/L for a 30-day average.
[5] = 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)

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

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

[6] = Parameter not measured during this project.

Paired watershed types in the Conata Basin varied in watershed morphology by area, average slope and percent bare ground (Table 4 and Appendix D, Figures D-1 through D-6). Rainfall patterns, discharge and delivery rate also varied by watershed in the basin (Table 4).

Control watersheds (NGCWT-1 and NGCWT-2) were entirely within Badlands National Park and had no known prairie dog colonies and were only grazed by wildlife (Figure 3 and Figure 4). Prairie dog watersheds (BNPPDT-3 and BNPPDT-4) were also entirely in Badlands National Park and were grazed by prairie dog populations and by wildlife (Figure 5 and Figure 6). Grazed watersheds (CBCPDT-5 and CBCPDT-6) were partially in Badlands National Park, partially in US Forest Service grazing allotments and partially in privately owned land with no known prairie dog populations and were grazed by cattle, horses and wildlife (Figure 7 and Figure 8).

When the project was initially established, available GIS data layers indicated no prairie dog populations within the CBCPDT-5 watershed; however, 2006 Farm Services Agency (FSA) aerial coverage and 2006 SD GF&P unpublished data layers indicated three prairie dog towns within the CBCPDT-5 watershed (Figure 2 and Appendix D, Table D-5). Thus, the CBCPDT-5 watershed was grazed by cattle, horses, prairie dogs and other wildlife during the Conata Basin watershed project in 2006. Data collected from this watershed was still treated as a grazed watershed based on management, land use type, statistical analysis and that the major land use in the watershed was cattle and horse grazing.

Figure 3. View of control watershed NGCWT-1.

Figure 4. View of control watershed NGCWT-2.

Figure 5. View of prairie dog watershed BNPPDT-3.

Figure 6. View of prairie dog watershed BNPPDT-4.

Figure 7. View of grazed watershed CBCPDT-5.

Figure 8. View of grazed watershed CBCPDT-6.

Table 4. Watershed acres, watershed slope, percent bare ground and rainfall statistics for select watersheds in the Conata Basin, Pennington County, South Dakota for 2006.

Site	Watershed Type	Watershed Acres	Average Watershed Slope (m/m)	Percent Bare Ground (%)	Rainfall (inches)	Total Discharge (Acre/ft)
NGCWT-1	Control	769	0.025	78.1	6.68	46.21
NGCWT-2	Control	192	0.027	67.2	5.39	45.40
BNPPDT-3	Prairie Dog	1,764	0.017	54.8	8.38	211.59
BNPPDT-4	Prairie Dog	2,461	0.015	65.1	8.11	356.71
CBCPDT-5	Grazed	2,450	0.029	46.4	7.86	148.36
CBCPDT-6	Grazed	3,089	0.013	42.3	7.19	240.78

Objectives of this study were to document TSS (total suspended solids), volatile total suspended solids, fecal coliform and *E. coli* bacteria loading contributions from selected watersheds in the Conata Basin located in the southeastern corner of Pennington County, South Dakota. Monitored watersheds sampled during this study included control (non-impacted) watersheds, non-grazed/prairie dog only watersheds inside Badlands National Park and cattle/horses only watersheds within the Badlands National Park, US Forest Service grazing allotments and privately owned portions of the Conata Basin (Figure 1 and Figure 2). Other data collected during the project were vegetative cover class transects within each monitored watershed in the basin and prairie dog fecal coliform source tracking samples collected in both the Conata and White River basins. This study should provide adequate background information to help determine sediment loading and pathogen enrichment potentials from watersheds with different land use within the White River geologic group

METHODS

Stage Discharge

Six tributary locations were chosen for collecting hydrologic, sediment and pathogen information from the six different watersheds in the Conata Basin (Figure 1 and Figure 2). Tributary site locations were chosen that would best show watershed managers which sub-watersheds were contributing the largest sediment and coliform loads to the White River. ISCO bubbler flow meters and GLS samplers (Great Little Samplers) were installed at the outlet of each selected watershed in the Conata Basin. In addition to the auto samplers, each site had a battery, sample tubing and screen, bubbler tubing and metered bubbler pipe, protective tubing, a rain gage and a metered staff gage (Figure 9). Data loggers were checked and downloaded at least bi-monthly to update the database and check for mechanical problems.

Monitored watersheds in the Conata Basin consisted of Badlands National Park control (non-impacted) watersheds (NGCWT-1 and NGCWT-2), prairie dog only watersheds (Badlands National Park prairie dog tributary watersheds BNPPDT-3 and BNPPDT-4) and grazed watersheds (privately owned and US Forest Service grazing allotments with cattle and horses grazed tributary watershed CBCPDT-5 and cattle grazed CBCPDT-6). Monitoring site locations in the Conata Basin are shown in Figure 1 and Figure 2.

Instantaneous discharge measurements were collected from the same transect at each station during the project. Discharge measurements were collected at least every time samples were collected. A Marsh-McBirney Model 2000 flow meter was used to collect discharge measurements throughout the project. All discharge data was collected according to South Dakota's *Standard Operating Procedures for Field Samples, Volume I* (SD DENR, 2005).

Stage and discharge measurements were used to develop stage discharge regression curves and equations for each tributary monitoring site and are provided in Appendix A (Figure A-1 through Figure A-6).

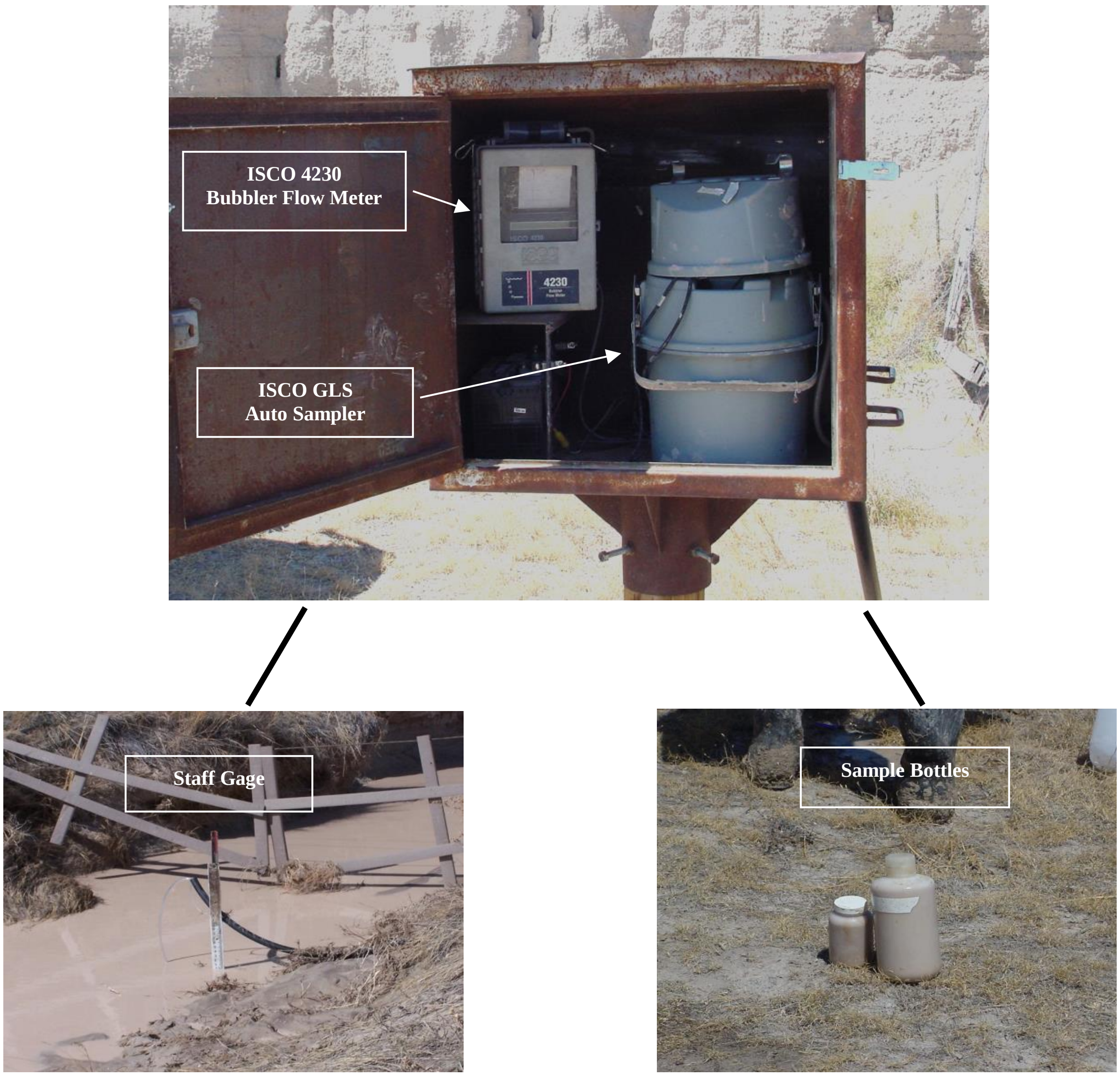

Figure 9. Typical ISCO sampling setup for watersheds in the Conata Basin, Pennington County, South Dakota 2006.

Water Quality Sampling

Samples collected at each tributary site were taken according to South Dakota's *Standard Operating Procedures for Field Samplers*, *Volume I* (SD DENR, 2005). Tributary physical, chemical and biological water quality sample parameters are listed in Table 5. Water temperature, dissolved oxygen, specific conductance and pH data were collected using an YSI® 600 XLS Multi-probe. All other water quality sample parameters were sent to the State Health Laboratory in Pierre for analysis; however, total organic carbon samples were sent by the State Health Laboratory to the Water Resources Institute Laboratory at South Dakota State University in Brookings, South Dakota for analysis.

Table 5. Tributary physical, chemical and biological parameters analyzed in the Conata Basin, Pennington County, South Dakota in 2006.

Physical	Chemical	Biological
Air Temperature	Field pH	Fecal Coliform
Water Temperature	Dissolved Oxygen	*E. coli*
Depth	Total Suspended Solids	
Visual Observations	Volatile Total Suspended Solids	
	Specific Conductance	
	Total Organic Carbon	

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, 1998). 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

Tributary Loading Calculations

The FLUX program was used to develop sediment loadings for all tributary monitoring sites in the Conata Basin. 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. Sample and flow data for this program can be stratified (adjusted) until the coefficient of variation (standard error of 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 6. These methods were used on all tributary monitoring sites to calculate sediment loadings for this project.

Bacterial (fecal coliform) loading was estimated using load duration curves. Since the Conata Basin does not have a beneficial use based standard for fecal coliform, curves were developed using flows specific to each watershed and the fecal coliform standard of the White River (limited contact recreation water, 2,000 cfu/100 ml). *E. coli* bacteria loading could not be estimated because currently South Dakota does not have criteria (standards) for *E. coli* bacteria.

After loadings for all sites were completed, export coefficients were developed for each parameter. Export coefficients were calculated by taking the total sediment load (kilograms) divided by the total area of the sub-watershed (in acres). This calculation results in the determination of the number kilograms of sediment per acre delivered from each sub-watershed (kg/acre). Loading estimates by parameter are listed and discussed in the results section of this report.

Table 6. Stratification, method and coefficient of variation by parameter for FLUX loading analysis in the Conata Basin, Pennington County, South Dakota in 2006.

Site	Parameter	Stratification***	Method	Coefficient of Variation
NGCWT-1	TSS	Date	QwtC	0.372
	VTSS	Date	QwtC	0.321
NGCWT-2	TSS	Date*	QwtC	0.749
	VTSS	Date*	IJC	0.098
BNPPDT-3	TSS	Date**	QwtC	0.550
	VTSS	Date**	QwtC	0.583
BNPPDT-4	TSS	Date	QwtC	0.371
	VTSS	Date	QwtC	0.363
CBCPDT-5	TSS	Date	QwtC	0.538
	VTSS	Date	QwtC	0.617
CBCPDT-6	TSS	Date	IJC	0.017
	VTSS	Flow	QwtC	0.199

*** = Date stratification on NGCWT-2 = Strat. 1 - 03/26 through 05/15, Strat. 2 – 05/15 through 10/17**
**** = Date stratification on BNPPDT-3 = Strat. 1 - 03/26 through 06/01, Strat. 2 – 06/01 through 10/17**
***** = All date stratifications = Strat. 1 - 03/26 through 07/01, Strat. 2 – 07/01 through 10/17, unless indicated.**

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 land use 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.

The input data set for AnnAGNPS Pollutant Loading Model consists of 33 sections of data, which can be supplied by the user in a number of ways. The model utilized digital elevation maps (DEMs) to determine cell and reach geometry, SSURGO soil layers to determine primary soil types with associated NASIS data tables for each soil's property and primary land use based EROS data layers.

Climate/weather data from Rapid City, South Dakota was used to generate simulated weather data for the Conata Basin. Model results are based on one year of climate data for initializing variables prior to 100-year watershed simulation. Simulated precipitation based on climate data ranged from 9.59 to 21.79 inches per year. Mean annual simulated precipitation for watersheds in the Conata Basin was approximately 14.95 inches. Monthly precipitation data for Interior, South Dakota was obtained from South Dakota's Office of Climatology website (http://climate.sdstate.edu/climate_site/climate.htm) with complete data available from 1956 through 2005. Over a 50-year period, annual precipitation ranged from 11.0 to 27.1 inches and averaged 16.8 inches. During that time span 78.6 percent of the annual precipitation fell between April and September.

Table 7. AnnAGNPS sediment model loading by watershed for the Conata Basin, Pennington County, South Dakota using 2000 and 2001 EROS land cover datasets.

Site	Watershed Type	Percent Badlands Formation	Watershed Size (acres)	AnnAGNPS Average Sediment Delivered (kg/0.559 yr)	AnnAGNPS Sediment Rate (kg/acre/0.559 yr)
NGCWT-1	Control	78.1	769	993,645	1,292
NGCWT-2	Control	67.2	192	149,346	778
BNPPDT-3	Prairie dog	54.8	1,764	520,606	295
BNPPDT-4	Prairie dog	65.1	2,461	1,199,530	487
CBCPDT-5	Grazed	46.4	2,450	1,916,850	783
CBCPDT-6	Grazed	42.3	3,089	1,629,720	528
Total	**-**	**-**	**10,725**	**6,409,697**	**598**

AnnAGNPS was used to delineate each watershed, calculate percent bare ground and model TSS loading. VTSS load modeling was estimated by calculating the mean VTSS percentage for each watershed, based on actual water quality data, and applying it to the modeled TSS loading estimated by AnnAGNPS. Modeled TSS and VTSS loading estimates for each watershed are provided in Table 7.

Statistical Analysis

Data was analyzed using StatSoft® statistical software (STATISTICA version 8.0). Shapiro-Wilk's W test was used to test each parameter for normal distribution or normality. Table 8 indicates that most of the data was not normally distributed, thus non-parametric statistical analysis was performed on all project data.

Table 8. Shapiro-Wilk normality analysis results for surface water quality parameters collected in the Conata Basin, Pennington County, South Dakota in 2006.

Parameter	Count	Normality Shapiro-Wilk W	*p*-value
Precipitation	64	0.8458	0.000
Dissolved Oxygen	30	0.9620	0.348
Specific Conductance	50	0.9656	0.152
pH	36	0.8816	0.001
Discharge	60	0.5438	0.000
TSS	64	0.7231	0.000
VTSS	64	0.7837	0.000
TOC	45	0.5730	0.000
Fecal Coliform	60	0.6078	0.000
E. coli	60	0.7299	0.000

Shaded -= Data not normally distributed (*p*-value < 0.05).

The Mann-Whitney U test was used to determine statistical differences among variables within watershed types: control, prairie dog and grazed watersheds (Table 9). Paired analysis for measured values and concentrations showed all data within each watershed type were statistically similar. TSS and VTSS loading data were also similar within watershed type (Table 9). Fecal coliform bacteria loading was analyzed using load duration curves and was not tested for statistical differences. *E. coli* loading was not estimated because laboratory analysis put an upper limit on *E. coli* concentrations restricting (underestimating) loading estimates.

Table 9. Paired (control, prairie dog and grazed) watershed statistics by parameter for watersheds in the Conata Basin, Pennington County, South Dakota in 2006.

	Watershed Type					
	Control Watersheds (Sites 1 and 2)		Prairie Dog Watersheds (Sites 3 and 4)		Cattle/horses Watersheds (Sites 5 and 6)	
Parameter	**Mann-Whitney U**	***p*-value**	**Mann-Whitney U**	***p*-value**	**Mann-Whitney U**	***p*-value**
Precipitation	44.50	0.4996	43.00	0.1724	41.00	0.5185
Dissolved Oxygen	9.00	0.8065	15.00	0.6310	3.00	0.1213
Specific Conductance	17.00	0.2386	43.50	0.9671	25.00	0.5876
pH	12.50	0.2723	10.00	0.1432	7.00	0.2864
Discharge	53.50	0.9717	53.00	0.8880	31.00	0.4239
Concentrations						
TSS	43.00	0.4344	43.50	0.1824	28.00	0.1024
VTSS	50.00	0.7762	39.50	0.1138	28.00	0.1024
TOC	24.00	0.6434	22.00	0.4875	14.00	0.1052
Fecal Coliform	41.50	0.5433	48.50	0.6472	34.00	0.3692
E. coli	40.00	0.4704	49.50	0.6986	25.00	0.1025
Loading						
TSS	16.00	0.4751	13.00	0.2531	22.00	0.4875
VTSS	17.00	0.8728	12.00	0.3367	21.00	0.4179

Kruskal-Wallis ANOVA (multiple comparison non-parametric analysis) was used 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 10. TSS, VTSS concentration data loading data were the only parameters significantly different between monitoring sites.

Table 10 Statistical analysis by site between watersheds in the Conata Basin, Pennington County, South Dakota in 2006.

	Conata Basin					
	Concentration			Loading (monthly)		
Parameter	**Count**	**Kruskal-Wallis H**	***p*-value**	**Count**	**Kruskal-Wallis H**	***p*-value**
Precipitation	64	4.862	0.433	-	-	-
Dissolved Oxygen	30	3.251	0.661	-	-	-
Specific Conductance	50	3.896	0.565	-	-	-
pH	36	5.435	0.365	-	-	-
Discharge	60	2.109	0.834	-	-	-
TSS	64	15.519	0.008	44	4.881	0.430
VTSS	64	14.115	0.015	43	4.632	0.462
TOC	45	5.581	0.345	-	-	-
Fecal Coliform	24	2.982	0.702	-	-	-
E. coli	60	4.417	0.491	-	-	-

Shaded -= significantly different between sampling sites (*p*-value < 0.05).

Only tributary parameters that were significantly different between sampling sites are discussed by parameter when applicable. Significant differences by parameter and watershed using multiple comparison matrix tables are provided in Appendix C, Tables C-1 through Table C-9.

Table 11. Statistical analysis between grouped watersheds by type (control, prairie dog and grazed) for the Conata Basin, Pennington County, South Dakota in 2006.

	Conata Basin					
	Concentration			Loading (monthly)		
Parameter	**Count**	**Kruskal-Wallis H**	***p*-value**	**Count**	**Kruskal-Wallis H**	***p*-value**
TSS	60	6.824	0.0330	48	1.689	0.4297
VTSS	60	6.001	0.0498	48	1.938	0.3794
Fecal Coliform	24	0.7300	0.6942	-	-	-
E. coli	24	1.2007	0.5486	-	-	-

Shaded -= significantly different between watershed types (*p*-value < 0.05).

Concentration and loading data were grouped by watershed type because there were no statistical differences within watershed types (Table 11 and Table 9). Statistical results for concentration data were similar to between monitoring site analysis.

Source Tracking

During this project, fecal samples were collected directly from fresh prairie dog fecal pellets in the Conata Basin and other prairie dog towns throughout the White River Basin to incorporate presumed spatial variability in prairie dog *E. coli* bacteria. Prairie dog *E. coli* bacteria colonies were grown in Petri dishes at 44° Celsius. Known *E. coli* colonies were further analyzed by splicing *E. coli* DNA and performing a pulse-field gel electrophoresis (PFGE) to separate genetic bands (markers) specifically for prairie dogs. Prairie dog markers were included in South Dakota’s known source DNA database.

During this study *E. coli* samples were collected at each sampling site throughout the Conata Basin. Samples were processed and analyzed at State Health Laboratory in Pierre. Samples with *E. coli* colony counts greater than 50 colonies/100ml (colony forming units/100ml, cfu/100ml) were further processed using the following techniques. Five random *E. coli* colonies from the original plate were removed and spliced for PFGE analysis. After processing, the gels were digitally photographed and scanned into a computer for comparison with known species in South Dakota's DNA database (Figure 10). Identification matches were done by computer using pattern recognition software.

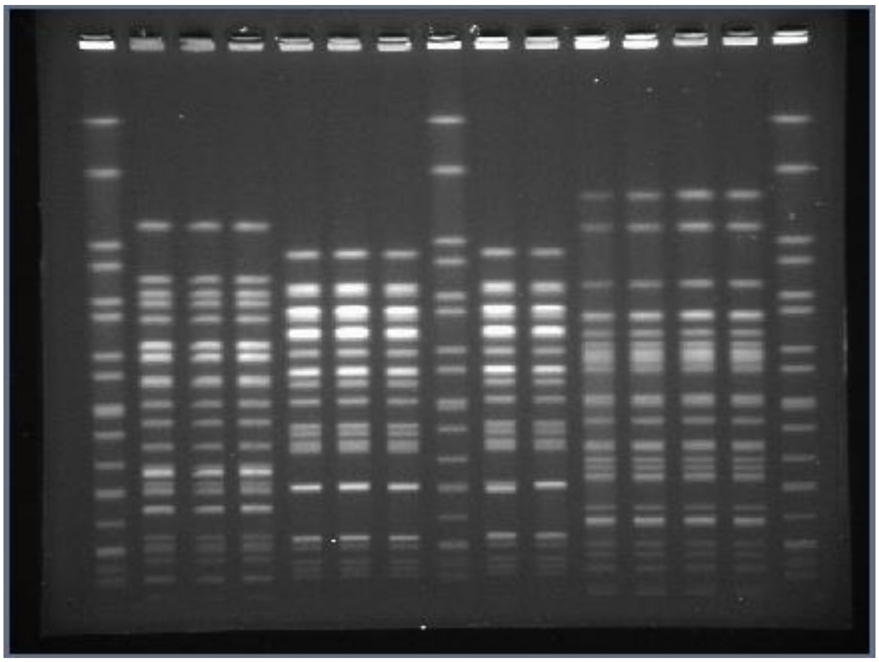

Figure 10. Digital photograph of a PFGE gel of *E. coli* bacteria ready for identification.

Vegetative Analysis

Vegetative cover analysis plot design consisted of three, 30-meter transects in each watershed, using the Daubenmire method (Daubenmire, 1959). Transects were established on both sides of the drainage in each watershed, using as much variety in the terrain as was available: for example, lowlands, sod tables, etc. Within each 30-meter transect, ten random quadrats, using a Daubenmire plot frame, 20 cm x 50 cm inside dimensions, were established and data collected. Percent coverage was then recorded for total cover, litter, bare ground, and for each individual species of grass, forb, *Carex* spp., and shrub. The height of the dominant species in each quadrat was also recorded for rainfall interception if statistical differences were detected between watershed types.

Transects were established in early spring. Painted rebar stakes were placed thirty meters apart and a tape stretched between the stakes (Appendix E, Figure E-1 through Figure E-6). Data was collected in ten randomly placed quadrats in each transect beginning at the zero meter mark. GPS coordinates were recorded at both ends of each transect (zero and thirty meter marks). In areas where cattle and/or horses were grazing, painted plastic lids were fastened to the ground at both ends of each the transect using long stakes. The rebar was very effective for consistent data collection. In transects located in the CBCPDT-5 watershed (private property), rocks and/or debris found in the pasture were used at the zero meter mark, and the boundary fence was used as the thirty meter mark (the stakeholder did not want rebar in his pasture). The plastic lids did not survive the summer for the final measurements; however, the original stakes were located and data was collected on identical transect plots. Only one transect was not repetitive, this was in the pasture on private property, where cattle, horses and/or wildlife interfered with temporary markers.

The first data collection began in early spring from May 12 to 15, 2006, the second was taken from June 26 to July 5, 2006, and the final collection occurred from September 5 through September 8, 2006. During final data collection, due to the condition of the flora and the fact that two of the transects were heavily grazed, percent cover was recorded for total cover, litter, bare ground, total grasses, total forbs, total shrubs and total *Carex* spp.. Species identification was made if apparent, usually without percent cover. During final data collection all stakes, rebar and markings were removed from each transect.

RESULTS

Water Temperature

Water temperature was collected as part of routine sampling during the Conata Basin Watershed Project. However, temperature was not a listed parameter for beneficial use (9) fish and wildlife propagation, recreation and stock watering and (10) irrigation waters for the Conata Basin. Waters from the Conata Basin have the potential to impact the White River which has a temperature standard 32.2^o C. Figure 11 show water temperatures by monitoring site in the Conata Basin in comparison to the temperature standard for the White River. Data indicate that monitored water temperatures in the Conata Basin never exceeded the maximum temperature standard for the White River and was not considered a problem in theses watersheds.

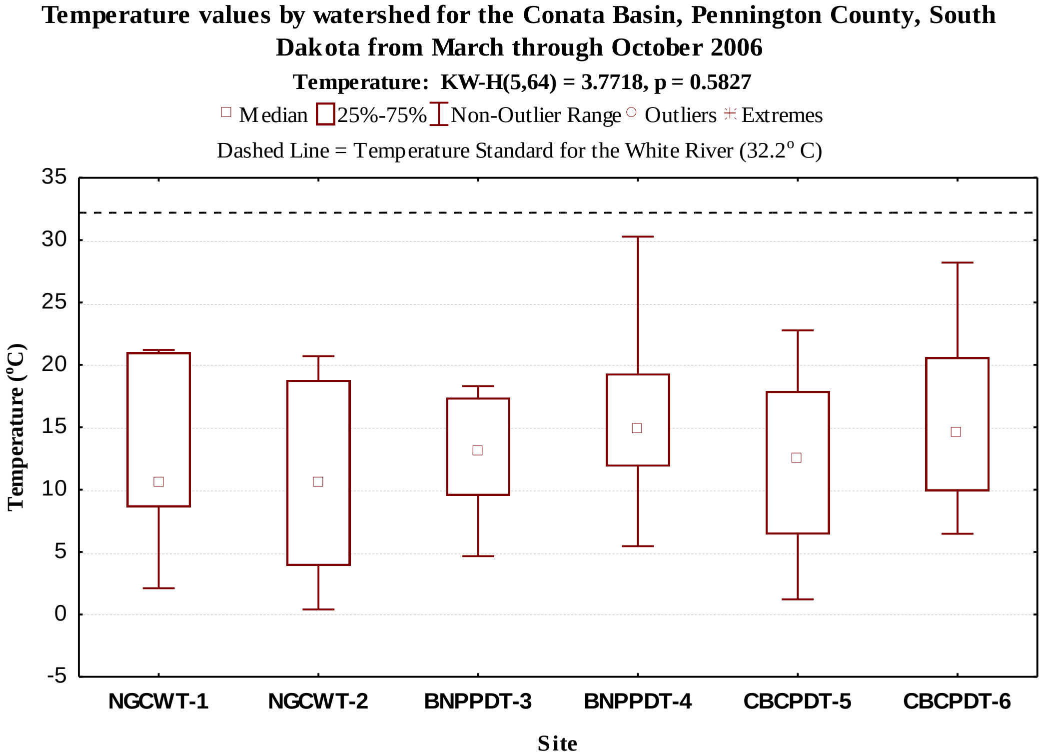

Figure 11. Temperature ranges by watershed for the Conata Basin, Pennington County, South Dakota during 2006.

Precipitation

Precipitation data was collected at each monitoring site in the Conata Basin from March through October 2006. Monitored watersheds in the Conata Basin cover a linear distance (watersheds NGCWT-1 to CBCPDT-6) of approximately 29.3 km or 18.2 miles (Figure 1). Precipitation throughout the study area ranged widely during the study (Figure 12). Rainfall events in the basin ranged from 0.02 inches at BNPPDT-3 and BNPPDT-4 to 1.80 inches at BNPPDT-3. Total precipitation throughout the project ranged from 5.39 inches at NGCWT-2 to 8.38 inches at BNPPDT-3.

Precipitation data indicate rainfall within each watershed type (control, prairie dog and grazed) was similar (Table 9) as was rainfall between monitored watersheds in the Conata Basin (Figure 12 and Table 10).

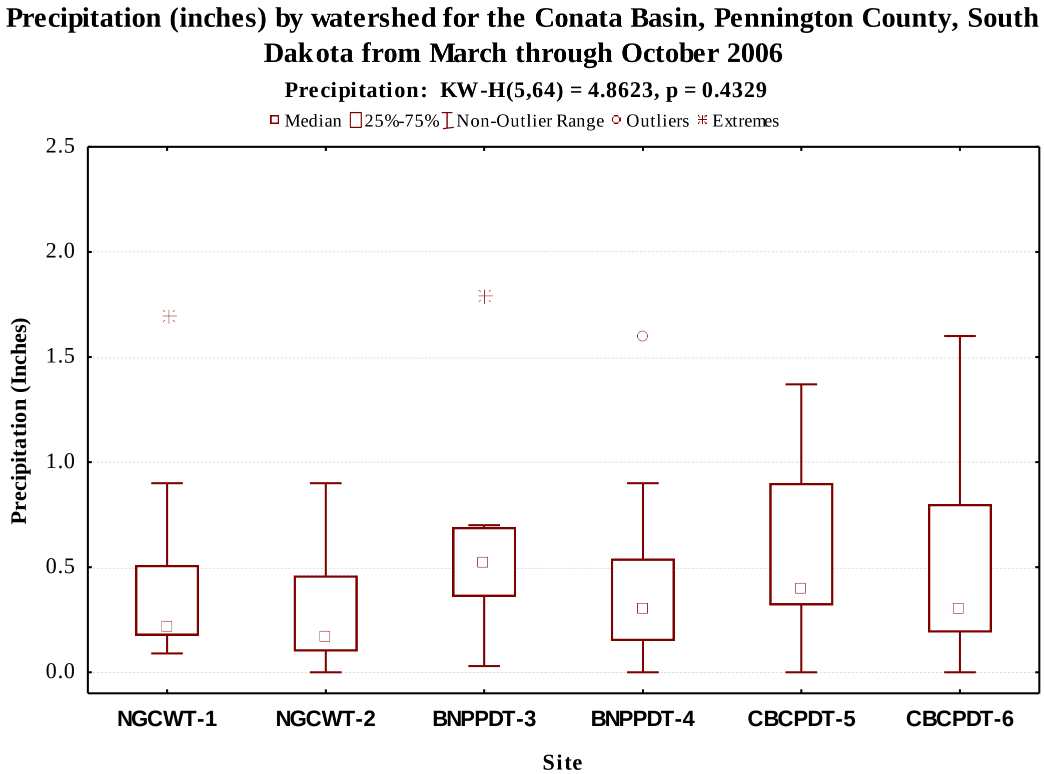

Figure 12. Precipitation ranges by watershed for the Conata Basin, Pennington County, South Dakota during 2006.

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. Generally, dissolved oxygen concentrations are not uniform within or between stream reaches. Upwelling of interstitial waters at the groundwater and stream water mixing zone (hyporheic zone) or lateral 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 median dissolved oxygen concentration in the Conata Basin was 10.3 mg/L and averaged 10.2 mg/L. The maximum dissolved oxygen concentration in monitored watersheds of the Conata Basin was 14.79 mg/L. This sample was collected at site NGCWT-1 on April 7, 2006 (Figure 13 and Appendix B, Table B-1). The minimum dissolved oxygen concentration, 3.09 mg/L, was also at NGCWT-1 on April 6, 2006 (Appendix B, Table B-1).

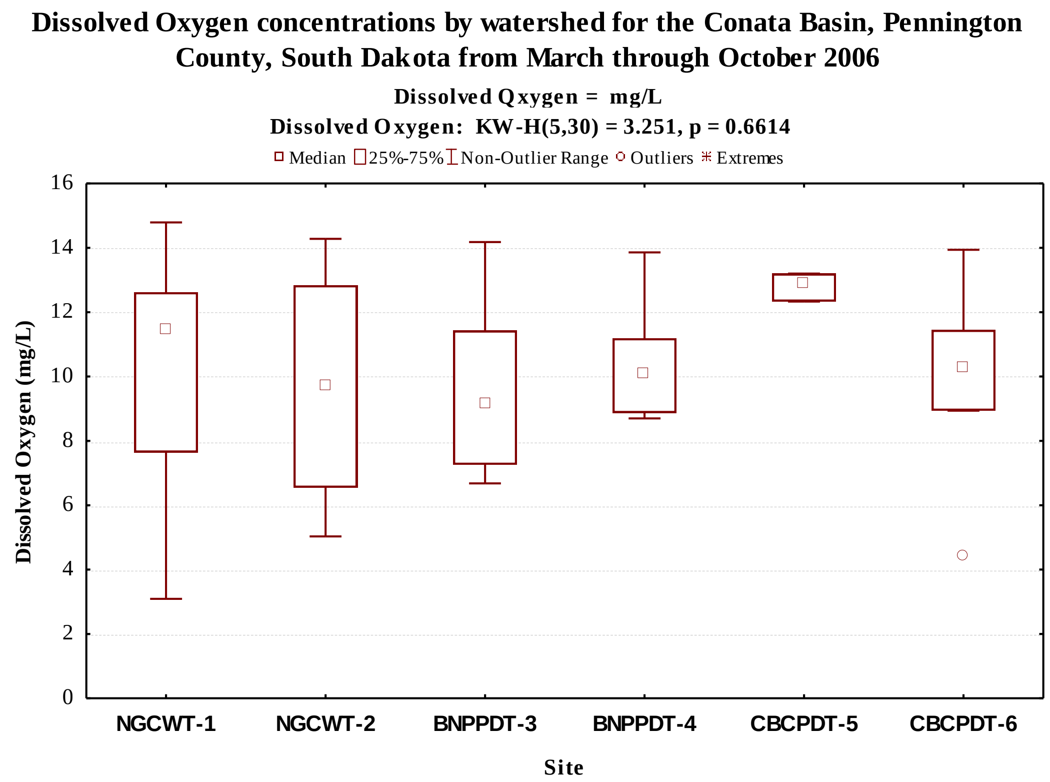

Figure 13. Dissolved oxygen concentrations by watershed for the Conata Basin, Pennington County, South Dakota during 2006.

As mentioned in the introduction, tributaries in the Conata Basin are assigned beneficial use (9) fish and wildlife propagation, recreation, and stock watering water. This beneficial use classification does not have an assigned water quality standard for dissolved oxygen. Water quality data indicated dissolved oxygen concentrations within each watershed type (control, prairie dog and grazed) were similar (Table 9) as were dissolved oxygen concentrations between monitored watersheds in the Conata Basin (Figure 13 and Table 10). Current watershed assessment data indicate dissolved oxygen concentrations were not a problem in monitored tributaries in the Conata Basin.

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).

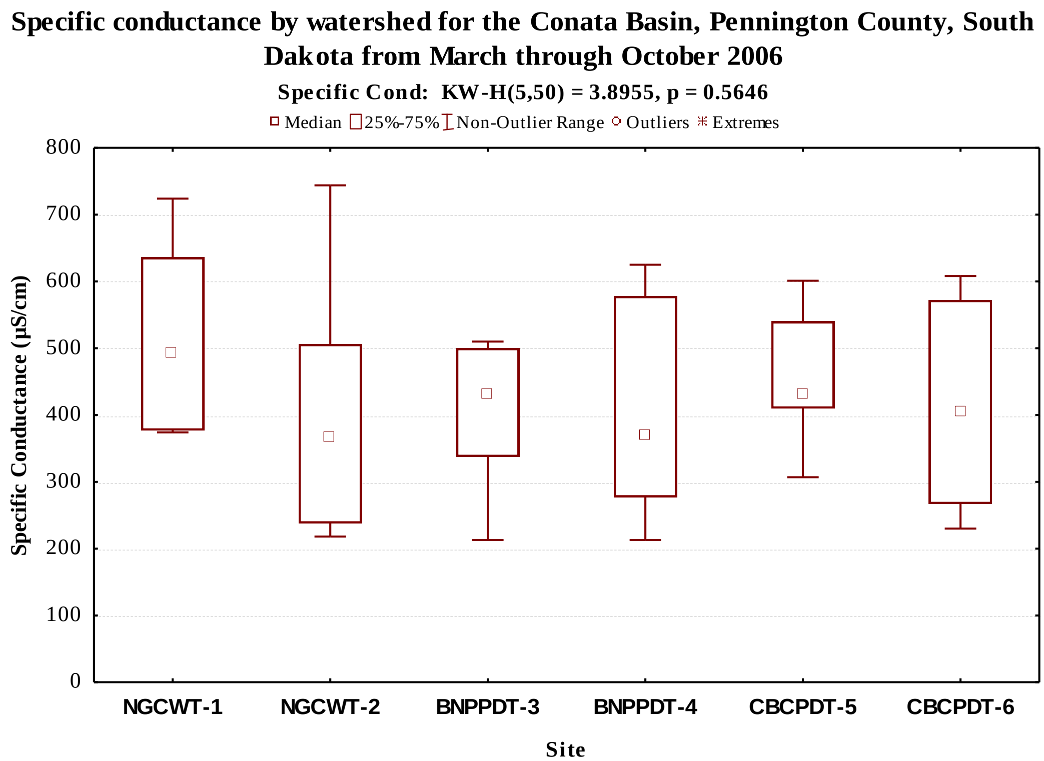

Figure 14. Specific conductance values by watershed for the Conata Basin, Pennington County, South Dakota in 2006.

Specific conductance is conductivity adjusted to temperature (25º C) and is reported in micro-Siemens/centimeter (µS/cm). Surface water quality rules (ARSD, 2004 § 74:51) list specific conductance as conductivity @ 25° C with values in µmhos/cm; for this report, specific conductance will be reported with values in µS/cm (updated units).

The most stringent beneficial use-based water quality standard for specific conductance that applies to fish and wildlife propagation, recreation, stock watering and irrigation waters is 4,375 µS/cm and applies to tributaries in the Conata Basin and White River (Table 3).

The median specific conductance value in the Conata Basin was 419 µS/cm and averaged 436 µS/cm. The maximum specific conductance value in monitored watersheds of the Conata Basin was 744 µS/cm. This sample was collected at NGCWT-2 on August 28, 2006, (Figure 14 and Appendix B, Table B-1). The minimum specific conductance value was 213 µS/cm at BNPPDT-3 on April 6, 2006 (Appendix B, Table B-1). Specific conductance values collected during the project were normally distributed and statistically similar within watershed types (Tables 8 and Table 9). Data indicated specific conductance values were also similar between sampling sites (Figure 14 and Table 10).

Waters that flow out of the Conata Basin impact/load the White River. Continuous long-term water quality data has been collected on the White River near Kadoka, South Dakota by South Dakota Department of Environment and Natural Resources SD DENR since 1968 (WQM 11, DENR 460835). This monitoring site, located downstream from the influence of the Conata

Basin, indicated that specific conductance values at that site were similar to those values collected in the Conata Basin during the study. Long-term data from the White River and from this study show that specific conductance generated in watersheds in the Conata Basin does not significantly impact the White River and should not be considered a parameter of concern.

pH

pH is a measure of hydrogen ion concentration in water, the more free hydrogen ions, (i.e. more acidic) the lower the pH. Lower pH values are normally observed during increased decomposition of organic matter. The most stringent beneficial use-based water quality standard for pH applies to fish and wildlife propagation, recreation, and stock watering waters ranges from $\geq 6.0_{(su)}$ to $\leq 9.5_{(su)}$ within tributaries of the Conata Basin (Table 3).

pH values in the Conata Basin had a median concentration of 8.80 (su) and averaged 8.41 (su). Concentrations ranged from a maximum of 9.47 (su) to a minimum pH of 6.89 (su) (Figure 15 and Appendix B, Table B-1). Most pH concentrations collected in August were above 9.00 (su) at least once at each monitoring site (Figures 15, Figure 16 and Appendix B Table B-1).

Generally throughout this project, pH values were higher in August for all monitored watersheds in the Conata Basin (Figure 15 and Figure 16). During 2006, pH values were similar between monitored watersheds; however, monthly pH values were significantly higher (p=0.000) in August than in April 2006 (Figure 16 and Appendix C, Table C-1).

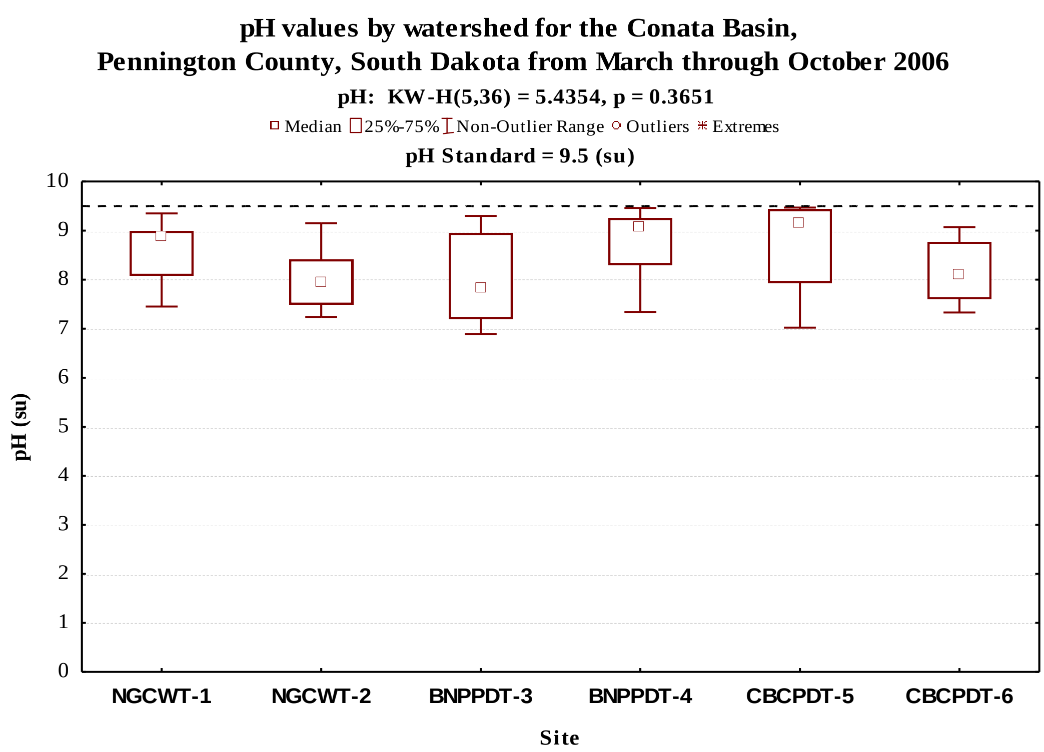

Figure 15. pH values for select watersheds in the Conata Basin, Pennington County, South Dakota during 2006.

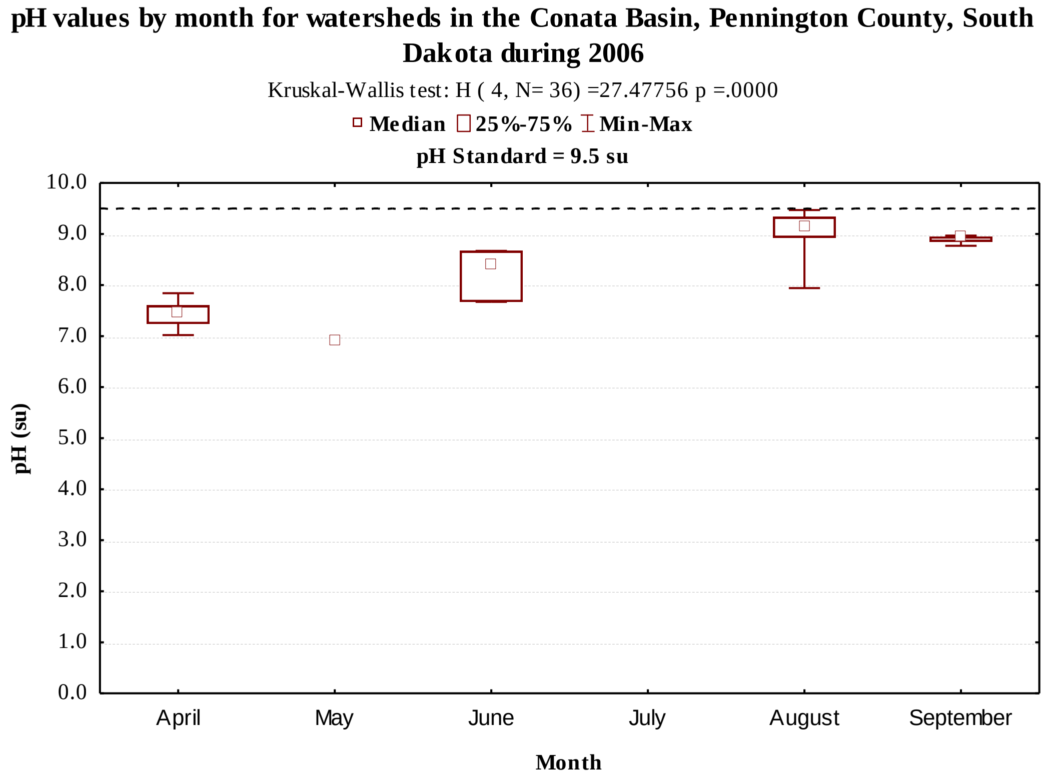

Figure 16. Monthly pH values for the Conata Basin watershed project in 2006.

The White River is the receiving waterbody for waters discharged from the Conata Basin. The White River was assigned the beneficial use of warmwater semi-permanent fish life propagation water. Warmwater semi-permanent fish life propagation waters have a pH standard range from $\geq$ 6.5 $_{(su)}$ through 9.0 $_{(su)}$. Continuous long-term water quality data collected at WQM 11 (DENR 460835) downstream from the influence of the Conata Basin indicate that all pH values were below 9.0 $_{(su)}$. Thus, the pH values above 9.0 $_{(su)}$ observed in the Conata Basin in August did not contribute to water quality standards violations in the White River. Current data suggests that, based on beneficial uses of waters in the Conata Basin, pH values were within South Dakota's Surface Water Quality standards and should not be considered a problem in monitored tributaries of the Conata Basin.

Total Suspended Solids

Total suspended solids (TSS) are the materials that do not pass through a filter, e.g. sediment, organic material and algae. Surface waters from the Conata Basin contribute to the overall load of the White River (receiving waterbody) which is listed in the 2006 South Dakota Integrated Report for Surface Water Quality Assessment (page 134) as impaired for TSS based on the warmwater semi-permanent fish life propagation water standard (ARSD, 2004 § 74:51:01:48, 158 mg/L).

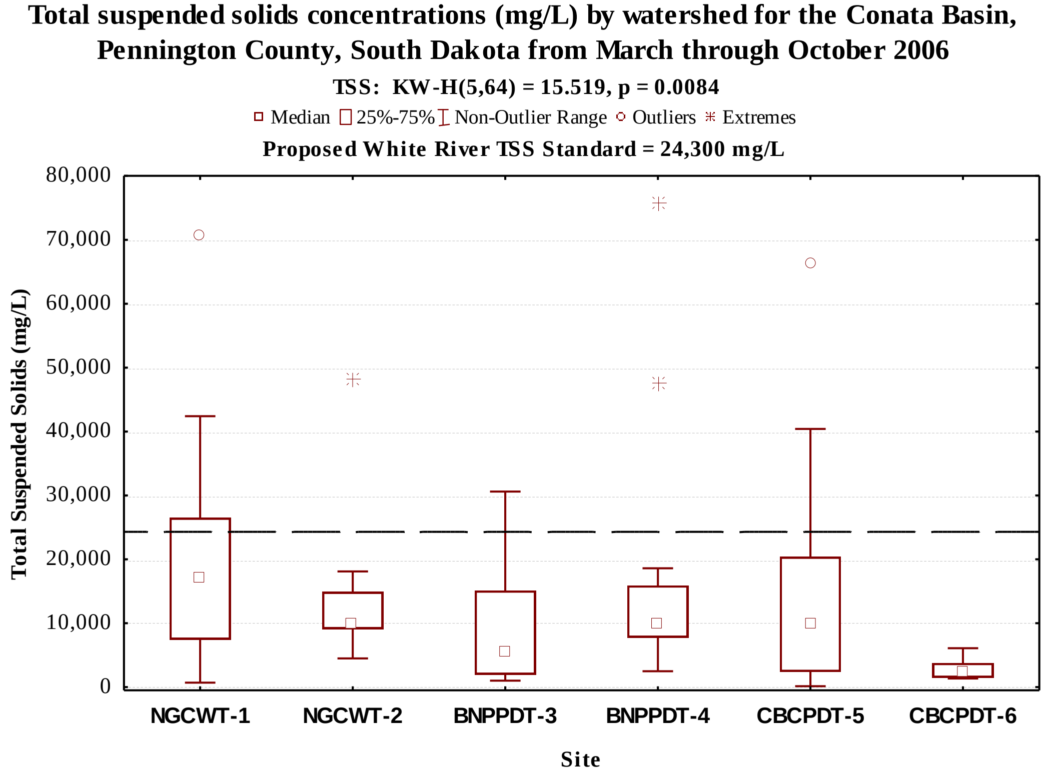

Figure 17. TSS concentrations by site for the Conata Basin, Pennington County, South Dakota during 2006.

The median TSS concentration for samples collected in 2006 was 9,150 mg/L (average 14,116 mg/L). TSS concentrations ranged from a minimum of 144 mg/L collected at site CBCPDT-5 during low flow to a maximum of 76,000 mg/L at BNPPDT-4 during high flows in August (Appendix B, Table B-1). Concentrations collected from CBCPDT-6 (grazed watershed) were significantly lower than NGCWT-1 (control) and BNPPDT-4 (prairie dog) watersheds (Figure 17 and Appendix C, Table C-2).

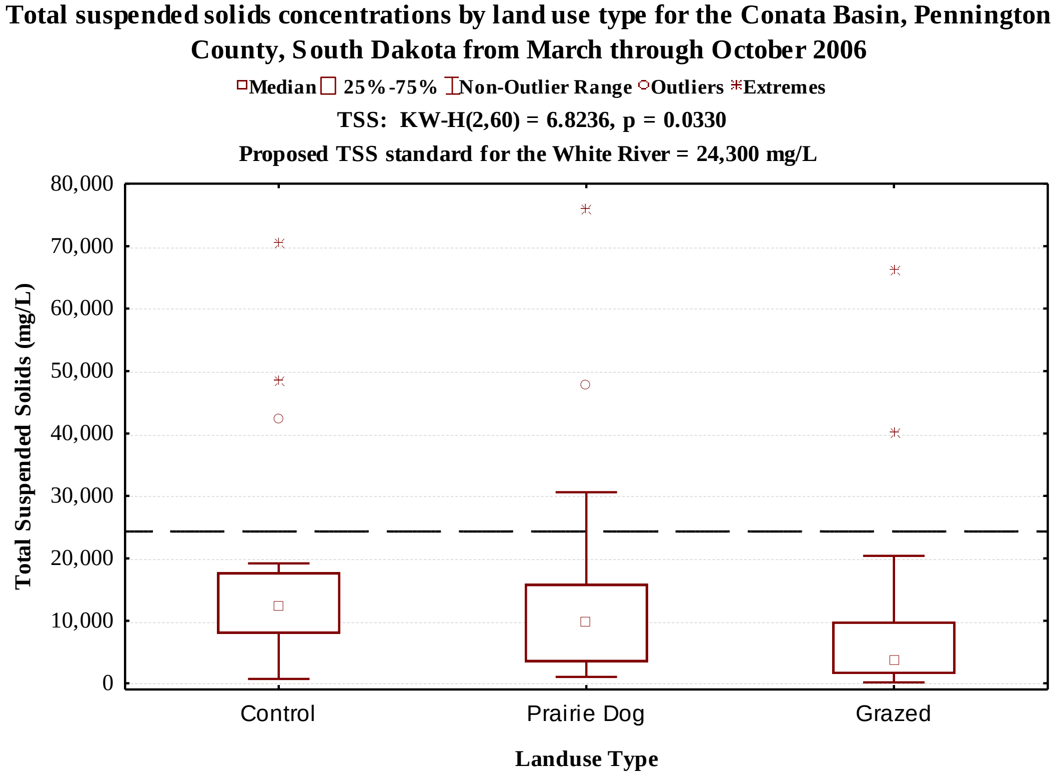

Figure 18. TSS concentrations by landuse type for the Conata Basin, Pennington County, South Dakota from March through October 2006.

TSS concentrations were grouped by land use type (control, prairie dog and grazed) based on within-watershed analysis (Table 9). During the study, grouped data indicated that concentrations in grazed watersheds were significantly lower than control watersheds (p=0.0330, Figure 18 and Appendix C, Table C-8).

As mentioned previously, Conata Basin sediment, bacteria, nutrient concentrations and loading impact the White River. TSS concentrations collected throughout the study were higher than the existing receiving water TSS standard (158 mg/L). Only one sample out of 64 TSS samples was below 158 mg/L (98.4 percent violation rate). During the White River watershed assessment project (RESPEC, 2007), current and historical TSS data was analyzed and indicated that modifications in reach boundaries and site-specific TSS concentration limits should be adopted. Based on the White River study, the proposed TSS standard for reach 7 (Willow Creek to Little White River) in the White River should be changed from 158 mg/L (current standard) to a site-specific standard of 24,300 mg/L based on long-term historical (40+ years) data (RESPEC, 2007). Based on the proposed site-specific receiving water standard, 85.9 percent of the TSS samples (55 samples) collected from the Conata Basin were below the proposed site specific standard, 24,300 mg/L. Sample concentrations above 24,300 mg/L occurred at least once in five of the six monitoring sites (excluding CBCPDT-6) throughout the basin (Figure 17). Most of the TSS concentrations above the proposed White River standard (seven samples out of nine) occurred in August and September during storm events (Figure 19). The remaining two samples were collected in March and April 2006.

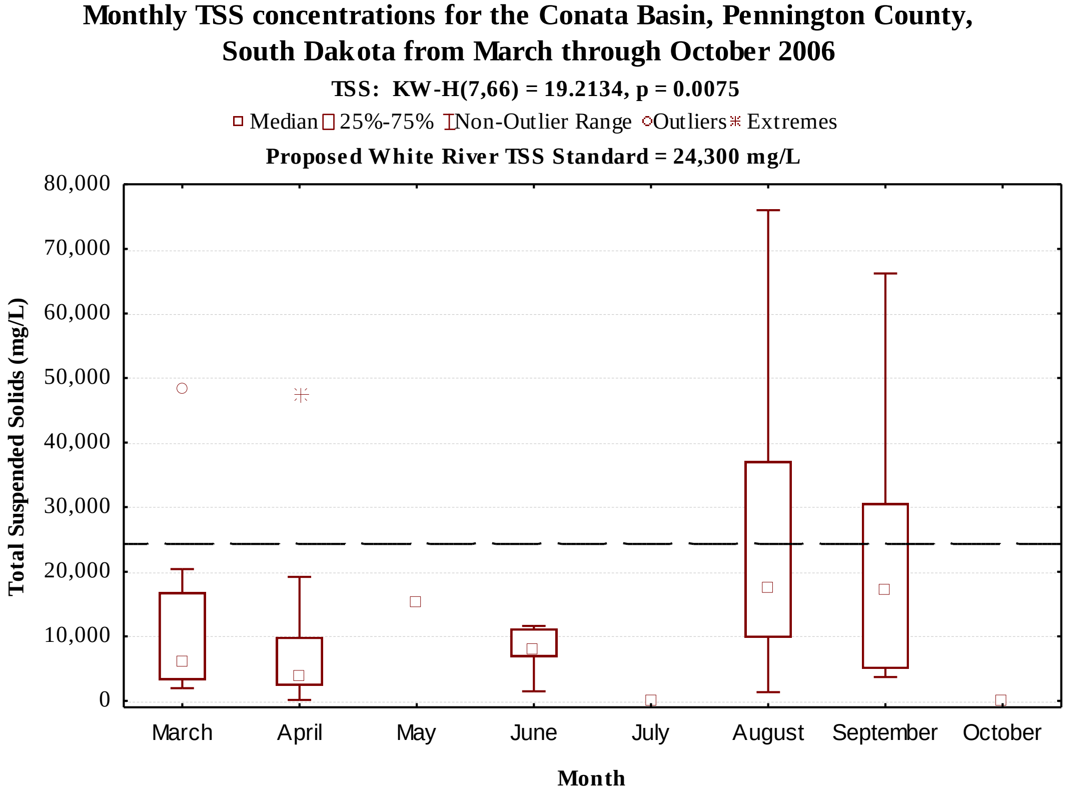

Figure 19. Monthly TSS concentrations from monitored watersheds in the Conata Basin, Pennington County, South Dakota during 2006.

TSS concentrations were significantly different between months with concentrations collected in August 2006 significantly higher than samples collected in April 2006 (Figure 19 and Appendix C, Table C-3).

TSS concentration data collected from watersheds throughout the Conata Basin show concentrations from all watershed types and dates exceed the current water quality standard for the White River (158 mg/L TSS). This suggests that even in watersheds with minimal disturbance within the White River Group formation, TSS concentrations were higher than the current standard. Data collected from watersheds with varying land uses in the Conata Basin support adoption of the proposed site-specific standard for the White River (24,300 mg/L).

Table 12. FLUX modeled TSS loading for watersheds in the Conata Basin, Pennington County, South Dakota in 2006.

Site	Watershed Area (Acres)	Rainfall (Inches)	Percent Bare Ground	FLUX Modeled Load Kg (0.559 yrs)	Load/Inch Rainfall (Kg/Inch)	Load/Acre (Kg/Ac/0.559 yrs)	Load/Acre/Inch (Kg/Ac/Inch)
NGCWT-1	769	6.68	78.1	784,355	117,418	1,020	153
NGCWT-2	192	5.39	67.2	1,056,655	196,040	5,503	1,021
BNPPDT-3	1,764	8.38	54.8	2,627,928	313,595	1,490	178
BNPPDT-4	2,461	8.11	65.1	3,801,919	468,794	1,545	190
CBCPDT-5	2,450	7.86	46.4	2,100,213	267,203	857	109
CBCPDT-6	3,089	7.19	42.3	1,051,270	146,213	340	47
Average	**-**	**7.29**	**59**	**1,903,723**	**251,544**	**1,793**	**283**
Total	**10,725**			**11,422,340**	**-**	**-**	**-**

Table 13. FLUX modeled TSS loading statistics by land use type for the Conata Basin, Pennington County, South Dakota from March through October 2006.

TSS

Landuse Type	Load Median (kg)	Load Average (kg)	Load Total (kg)
Control	12,267	115,063	1,841,010
Prairie Dog	10,797	401,865	6,429,847
Grazed	42,730	196,968	3,151,482
Total			**11,422,340**

TSS loading by watershed during the project (204 days) ranged from 784,355 kg/0.559 yr (865 tons) in control watershed NGCWT-1 to 3,801,919 kg/0.559 yr (4,191 tons) in prairie dog watershed BNPPDT-4 (Table 12). Average loading by watershed for all monitored watersheds in the Conata Basin was 1,903,723 kg/0.559 yr or 2,098 tons. TSS loading per acre was higher in control watershed NGCWT-2; however, this was not considered unusual because of the large White River Group formation on the west side of the tributary (Figure 4). Runoff from this formation drains un-buffered (un-vegetated bare-ground) directly into the tributary approximately 0.12 km upstream from the sampling site (top left edge of Figure 4. Appendix D, Figure D-2 and Appendix E, Figure E-2). Monthly loading between watersheds and land use types were statistically similar (Table 10, Table 11, Figure 20 and Figure 21). Sediment loading per inch of rainfall ranged from 117,418 kg/inch to 468,794 kg/inch of rain. On average, 283 kg of TSS per acre was delivered per inch of rain based on multiple land use types in the Conata Basin (Table 12). Total and average TSS loading by land use type was higher in prairie dog watersheds than in control or grazed watersheds while having the lowest median value during the project (Table 13). TSS loading in watersheds grouped by land use type showed no significant differences (Figure 21).

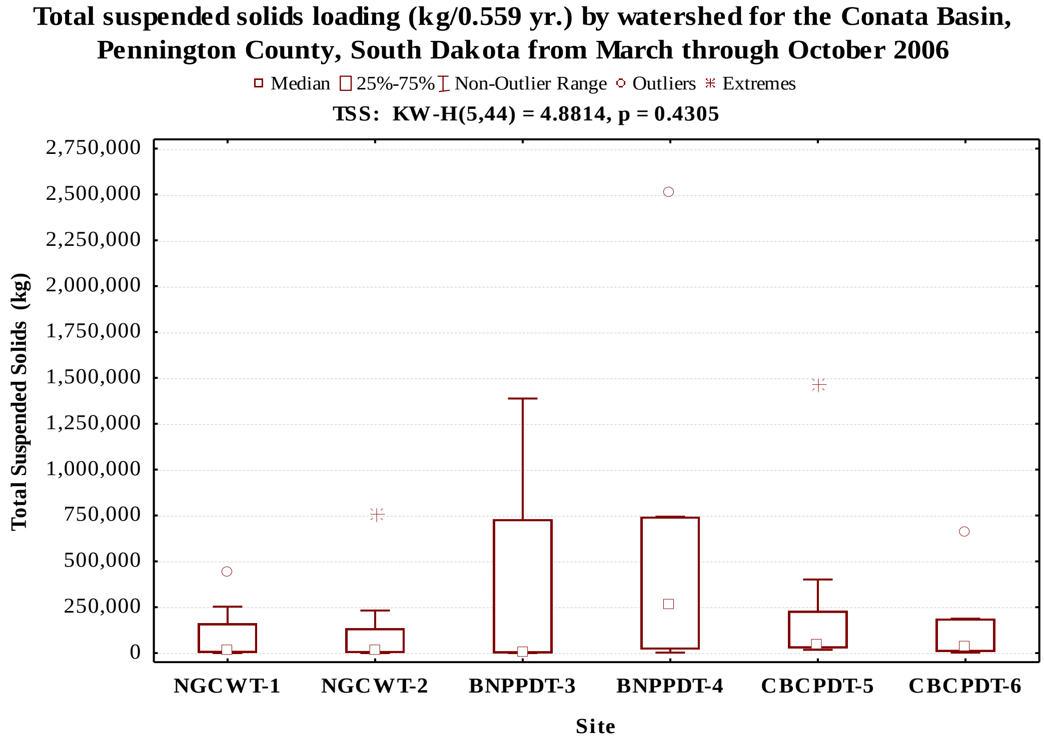

Figure 20 TSS loading by watershed during the Conata Basin watershed project, Pennington County, South Dakota in 2006.

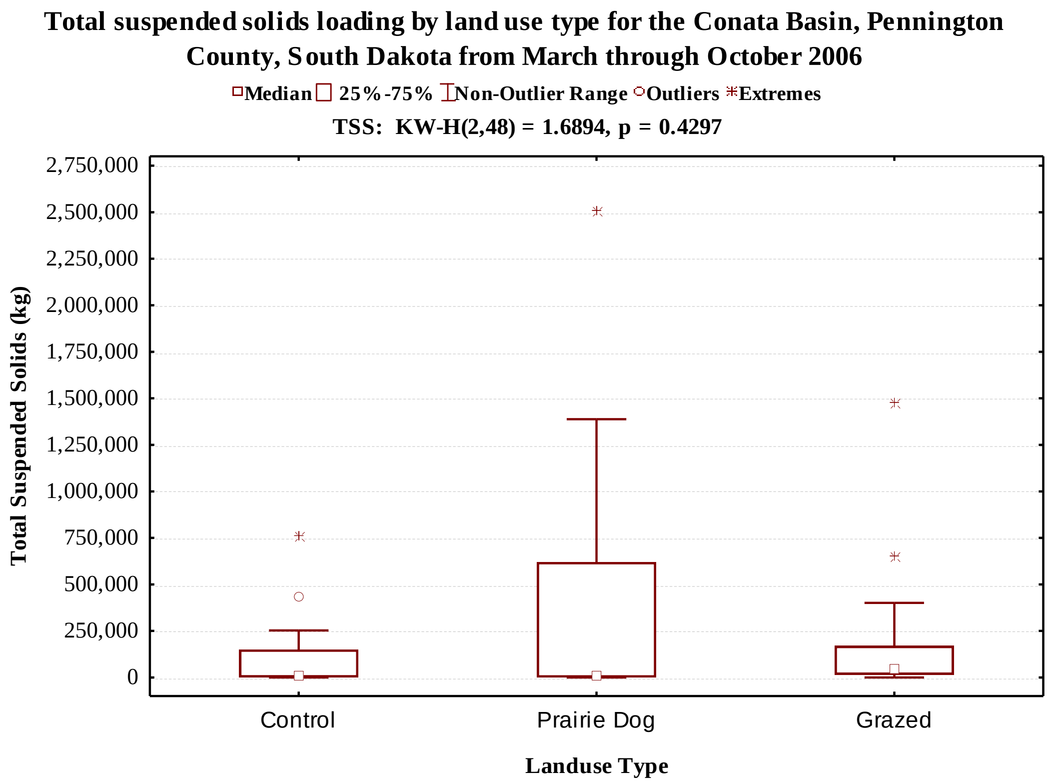

Figure 21 TSS loading by land use type for the Conata Basin, Pennington County, South Dakota from March through October 2006.

Volatile Total Suspended Solids

Volatile total suspended solids (VTSS) are that portion of suspended solids that are organic (organic matter that burns in a 550° C muffle furnace).

The median VTSS concentration during the Conata Basin project was 800 mg/L (average 1,159 mg/L) with a maximum concentration of 6,500 mg/L recorded at BNPPDT-4 on August 8, 2006 during a runoff event. The minimum VTSS concentration of 11 mg/L was collected in April 4, 2006 at CBCPDT-5 (Appendix B, Table B-1). Concentrations collected from CBCPDT-6 (grazed watershed) were significantly lower than VTSS concentrations in the NGCWT-1 (control) watershed (Figure 22 and Appendix C, Table C-4). The organic percentage (VTSS) of total suspended solids (TSS) in the Conata Basin ranged from 2.1 percent to 23.1 percent during the project. These percentages were similar to other watersheds with headwaters originating in White River Group formations. VTSS percentages in Pine Creek (Mellette County) ranged from 1.5 percent to 12.1 percent while Cottonwood Creek also in Mellette County ranged from 4.2 percent to 16.5 percent (Smith, 2006 and unpublished data collected during the Cottonwood Creek watershed assessment project, Smith, 2008).

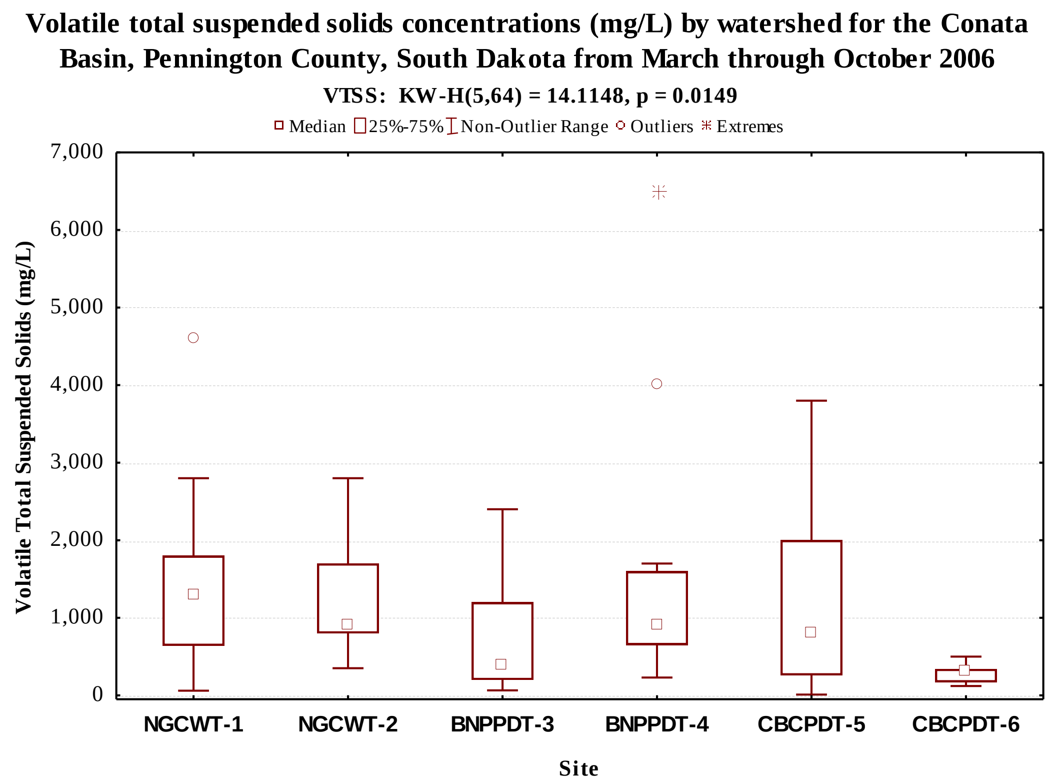

Figure 22. VTSS concentrations by watershed during the Conata Basin watershed project, Pennington County, South Dakota in 2006.

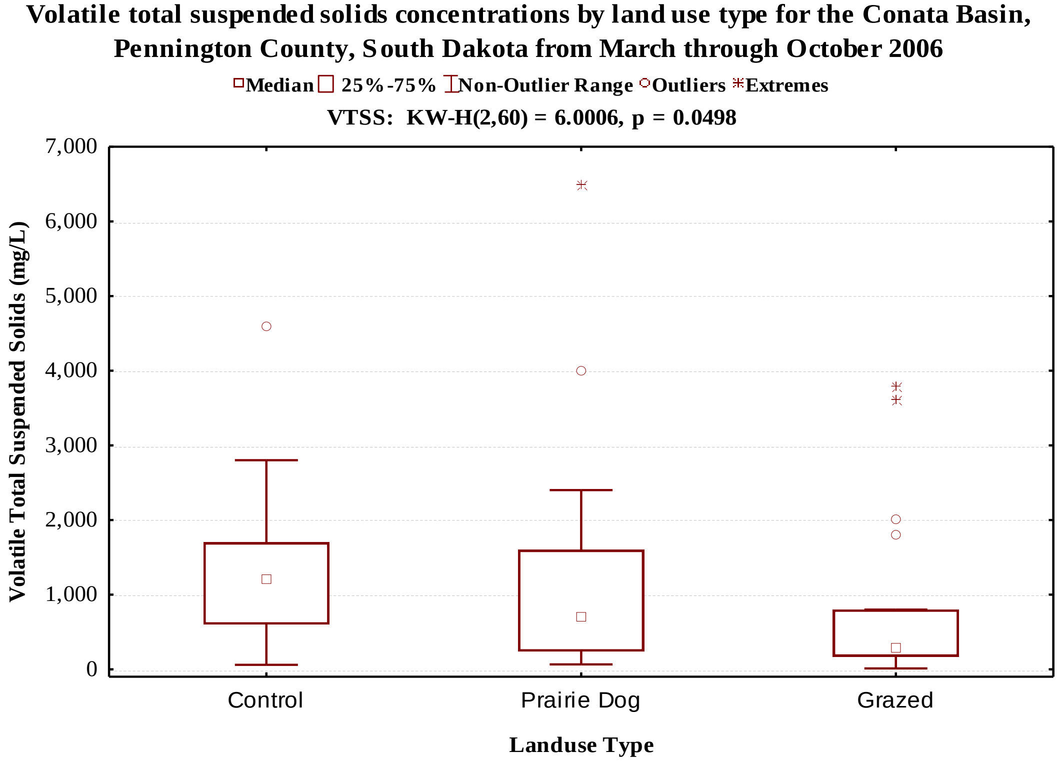

Figure 23 Volatile total suspended solids concentrations by land use type for the Conata Basin, Pennington County, South Dakota from March through October 2006.

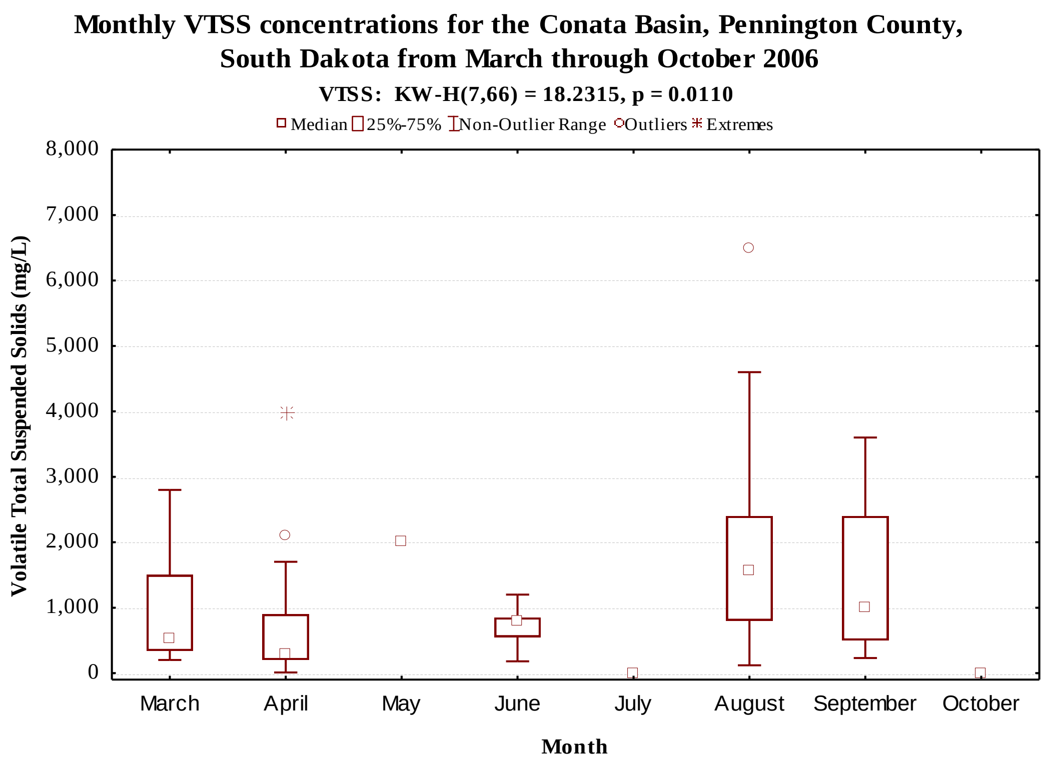

Figure 24. VTSS concentrations by month during the Conata Basin watershed project, Pennington County, South Dakota in 2006.

Similar to TSS, VTSS concentrations were grouped by land use type (control, prairie dog and grazed). Grouped data indicate that VTSS concentrations in grazed watersheds were significantly lower than control watersheds (Figure 23 and Appendix C, Table C-9).

Monthly VTSS concentrations by monitoring site were higher in August and September 2006 (Figure 24). Monthly concentrations were significantly different between months with concentrations collected in April 2006 significantly lower than VTSS concentrations collected in August 2006 (Figure 24 and Appendix C, Table C-5).

VTSS loading by monitoring site ranged from 60,073 kg/0.559 yr (66 tons) in control watershed NGCWT-1 to 342,840 kg/0.559 yr (378 tons) in prairie dog watershed BNPPDT-4 (Table 14). Average loading by watershed for all monitored watersheds in the Conata Basin was 165,734 kg/0.559 yr or 183 tons. Monthly loading within watershed types and between watersheds were statistically similar (Table 10, Table 11 and Figure 25). Similar to TSS, VTSS loading averaged by rainfall (load per inch of rain) was greatest in the BNPPDT-4 watershed (Table 14). Total and average VTSS loading by land use type was higher in prairie dog watersheds than in control or grazed watersheds while having the lowest median value during the project (Table 15). FLUX modeled monthly loadings for VTSS by watershed land use type were similar (Figure 26).

Table 14. FLUX modeled VTSS loading for watersheds in the Conata Basin, Pennington County, South Dakota in 2006.

Site	Watershed Area (Acres)	Rainfall (Inches)	Percent Bare Ground	Percent of TSS (Load)	FLUX Modeled Kg (0.559 yr)	FLUX Load/Inch (Kg/Inch)	FLUX Load/Acre (Kg/Ac/0.559 yr)	FLUX Load/Acre/Inch (Kg/Ac/Inch)
NGCWT-1	769	6.68	78.1	7.7	60,073	8,993	78	12
NGCWT-2	192	5.39	67.2	10.8	113,646	21,085	592	110
BNPPDT-3	1,764	8.38	54.8	7.5	197,039	23,513	112	13
BNPPDT-4	2,461	8.11	65.1	9.0	342,840	42,274	139	17
CBCPDT-5	2,450	7.86	46.4	8.3	174,670	22,223	71	9
CBCPDT-6	3,089	7.19	42.3	10.1	106,133	14,761	34	5
Average	**-**	**7.29**	**59**	**8.7**	**165,734**	**22,141**	**171**	**28**
Total	**10,725**				**994,401**			

Table 15. FLUX modeled VTSS loading by land use type for the Conata Basin, Pennington County, South Dakota from March through October 2006.

VTSS

Landuse Type	Load Median (kg)	Load Average (kg)	Load Total (kg)
Control	1,096	10,857	173,719
Prairie Dog	926	33,742	539,879
Grazed	3,925	17,550	280,803
Total			**994,401**

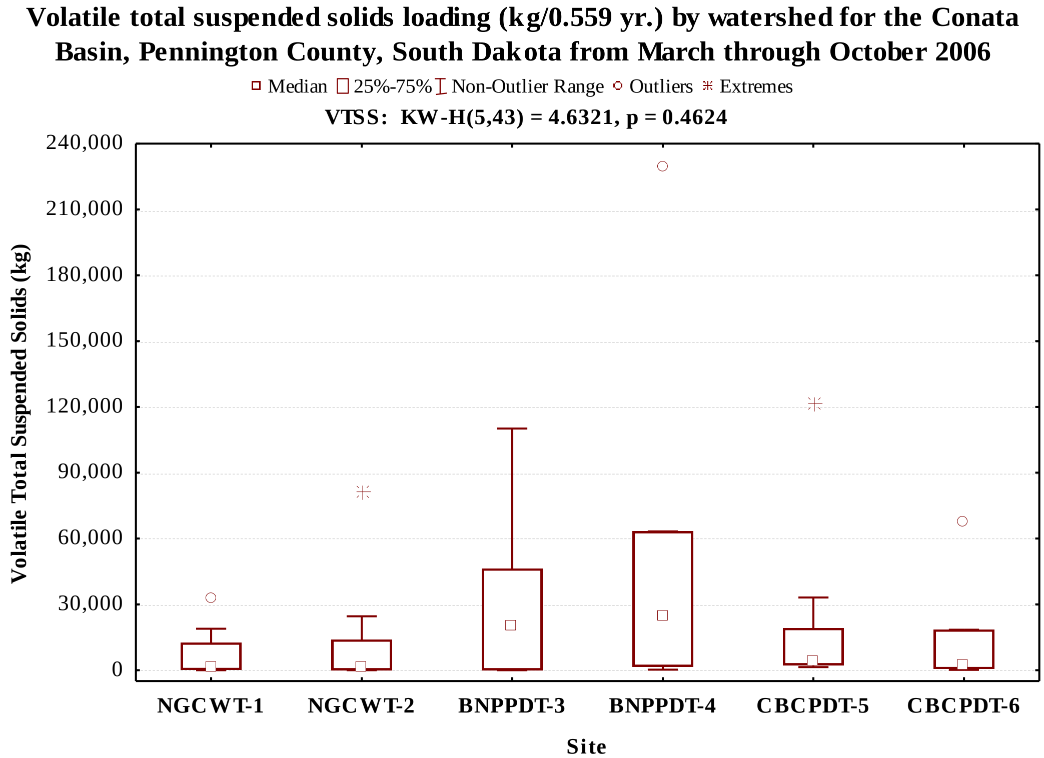

Figure 25 VTSS loading by watershed during the Conata Basin watershed project, Pennington County, South Dakota in 2006.

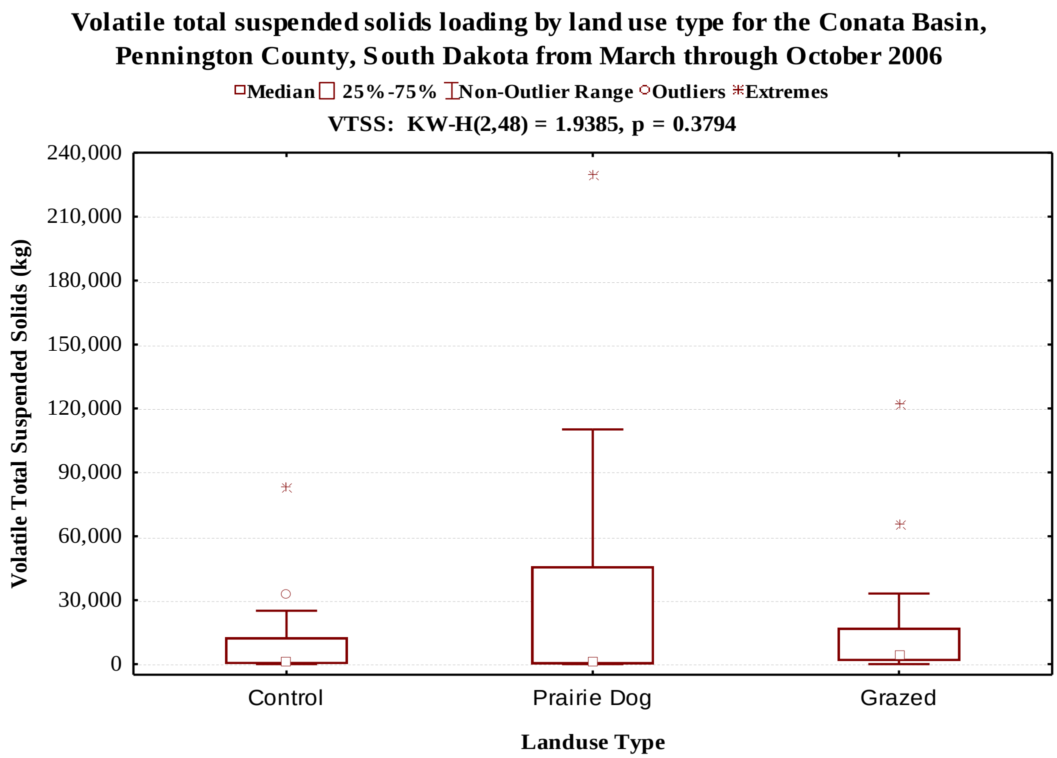

Figure 26 VTSS loading by land use type for the Conata Basin, Pennington County, South Dakota from March through October 2006.

Total Organic Carbon

Total organic carbon (TOC) is a direct expression of total organic content expressed as milligrams of carbon per liter volume (mg C/L). TOC is composed of dissolved organic carbon (DOC), the fraction of TOC that passes through a 0.45 µm filter and particulate organic carbon (POC), the fraction of TOC retained by a 0.45 µm filter. In most natural waters, the inorganic carbon fraction is more abundant than the TOC fraction (APHA, 1998).

TOC samples were collected from late March through mid August 2006 (Figure 27). Table 16 shows the percentage of TOC (mg C/L) in VTSS (mg/L) by watershed in the Conata Basin. Control watershed NGCWT-1 and grazed watershed CBCPDT-5 yielded two samples with organic carbon contributions above twenty percent. TOC concentrations were highest in the NGCWT-1 watershed at 49.7 mg C/L (Figure 27 and Appendix B, Table B-1). 71.7 percent of the TOC samples were at or below two percent of VTSS. The lowest average percentage by watershed was control site NGCWT-2 followed by prairie dog watershed BNPPDT-4 (Table 16).

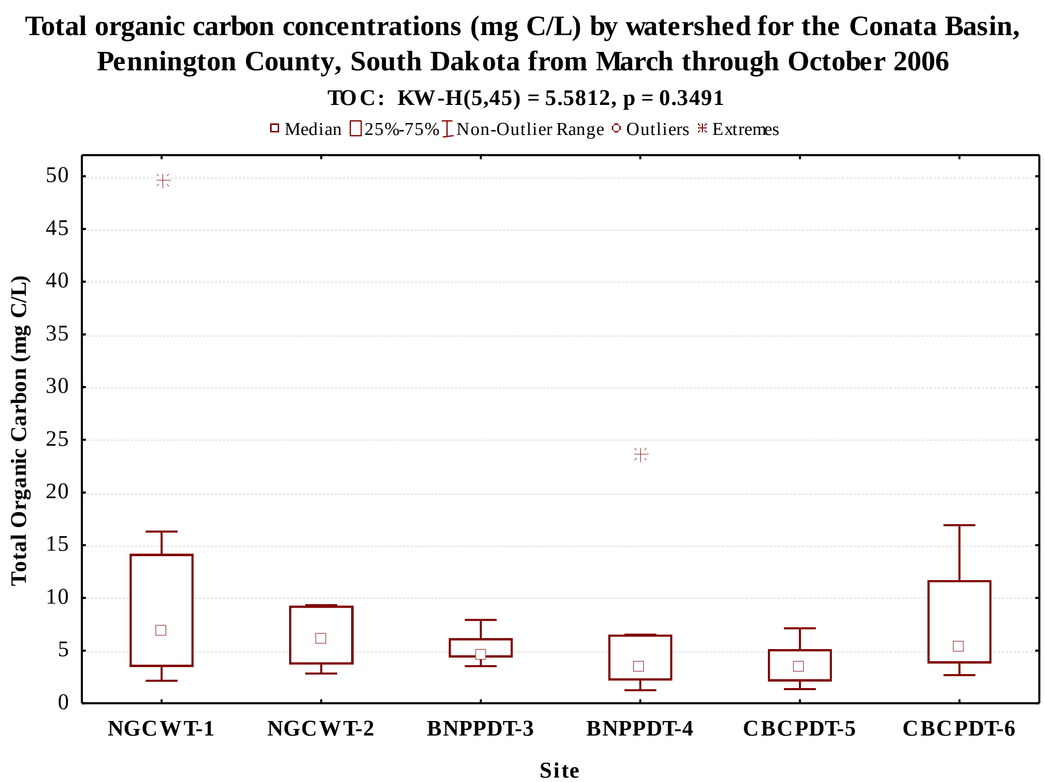

Figure 27. TOC by watershed for the Conata Basin, Pennington County, South Dakota during 2006.

Table 16. Total organic carbon percentage of volatile total suspended solids in samples collected from the Conata Basin, Pennington County, South Dakota in 2006.

	Watershed					
Date	**NGCWT-1**	**NGCWT-2**	**BNPPDT-3**	**BNPPDT-4**	**CBCPDT-5**	**CBCPDT-6**
03/27/2006	2.44%	0.22%	1.76%	0.34%	0.19%	0.67%
03/30/2006	0.24%	0.71%	2.00%	0.45%	19.00%	1.69%
04/06/2006	0.79%	0.55%	4.12%	0.72%	24.31%	3.38%
04/07/2006	0.41%	0.47%	7.20%	2.25%	0.64%	1.90%
04/19/2006	0.29%	0.18%	2.51%	-	1.19%	9.94%
04/25/2006	27.17%	1.00%	0.58%	0.60%	1.34%	2.28%
06/07/2006	1.00%	1.16%	0.40%	0.22%	0.04%	1.68%
08/09/2006	1.08%	-	-	0.02%	-	-
08/18/2006	-	-	1.14%	-	-	8.67%
Watershed Average	**4.18%**	**0.61%**	**2.46%**	**0.66%**	**6.67%**	**3.78%**
Watershed Range						
Maximum	27.17%	1.16%	7.20%	2.25%	24.31%	9.94%
Minimum	0.24%	0.18%	0.40%	0.02%	0.04%	0.67%
Conata Basin						
Average	**3.09%**					
Conata Basin	**Range**					
Maximum	27.17%					
Minimum	0.02%					

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 fecal coliform concentrations within watersheds. 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 and can lessen fecal coliform concentrations although nutrient concentrations remain high. South Dakota water quality standards for fecal coliform are in effect from May 1 through September 30 and apply to limited contact and immersion recreation waters of the State. As mentioned previously, the fecal coliform standard does not apply to waters within the Conata Basin; however, fecal coliform originating in the basin are discharged (load) into the White River. The fecal coliform standard of 2,000 cfu/100ml (cfu = colony forming units applies only to the White River and is shown as a dashed horizontal line for comparison in Conata Basin fecal coliform figures (Figures 28 through 31).

Fecal coliform concentrations by watershed using all dates are shown in Figure 28 and for comparison, fecal concentrations collected during the fecal season (May 1 through September 30) of 2006 (Figure 29). Using all data, most watersheds had median concentrations below the beneficial use-based water quality standard for the White River. Data collected during the fecal season indicate that all median concentration values were above the White River water quality standard. Four of the six watersheds had 25th percentiles above 2,000 cfu/100 ml. Approximately 83.3 percent (20 out of 24 samples) of fecal coliform concentrations collected during the fecal coliform season were above the 2,000 cfu/100ml criterion for the White River.

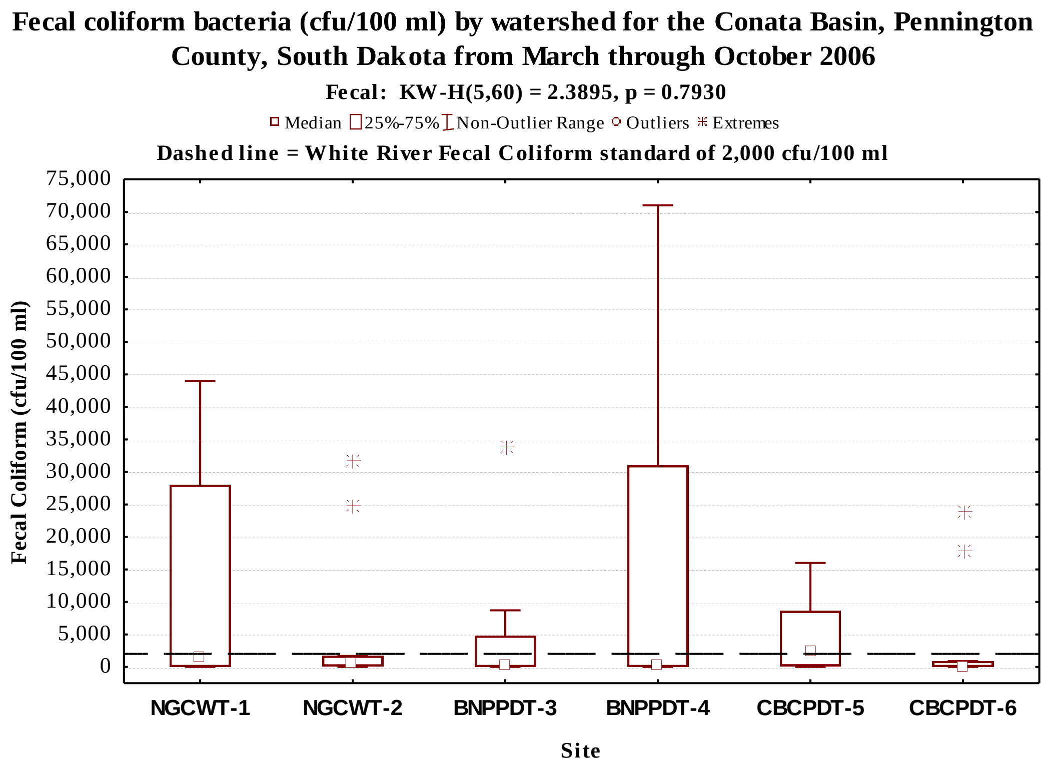

Figure 28 Fecal coliform bacteria by watershed in the Conata Basin, Pennington County, South Dakota for all dates in 2006.

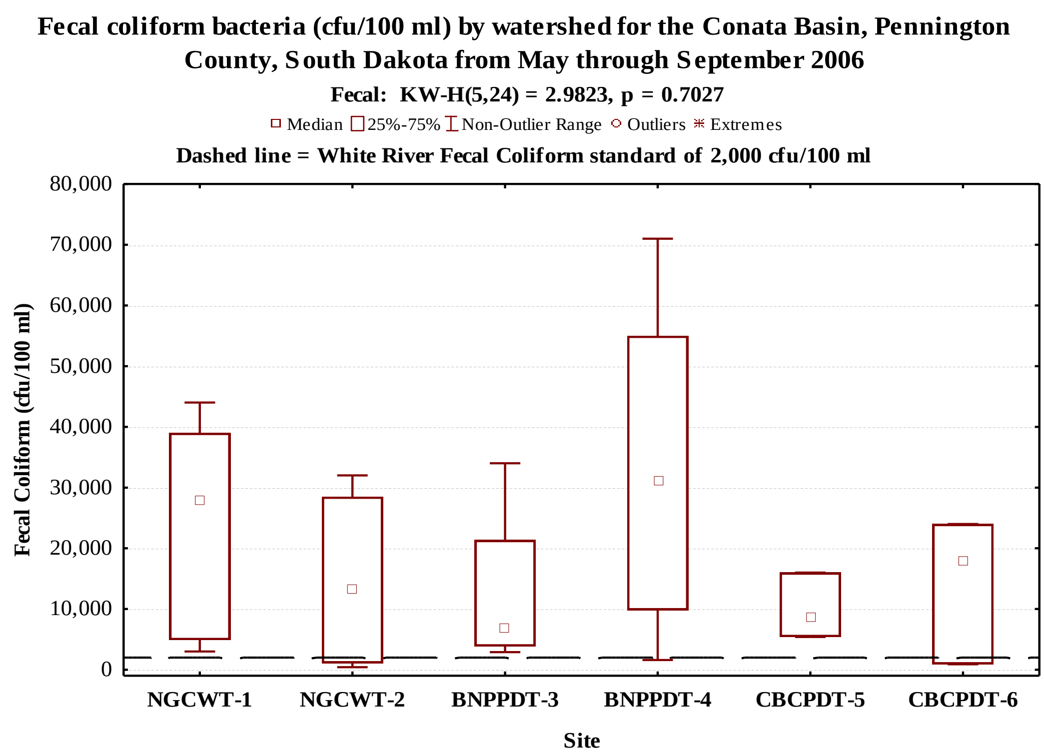

Figure 29. Fecal coliform bacteria concentrations by watershed from May through September 2006 in the Conata Basin, Pennington County, South Dakota.

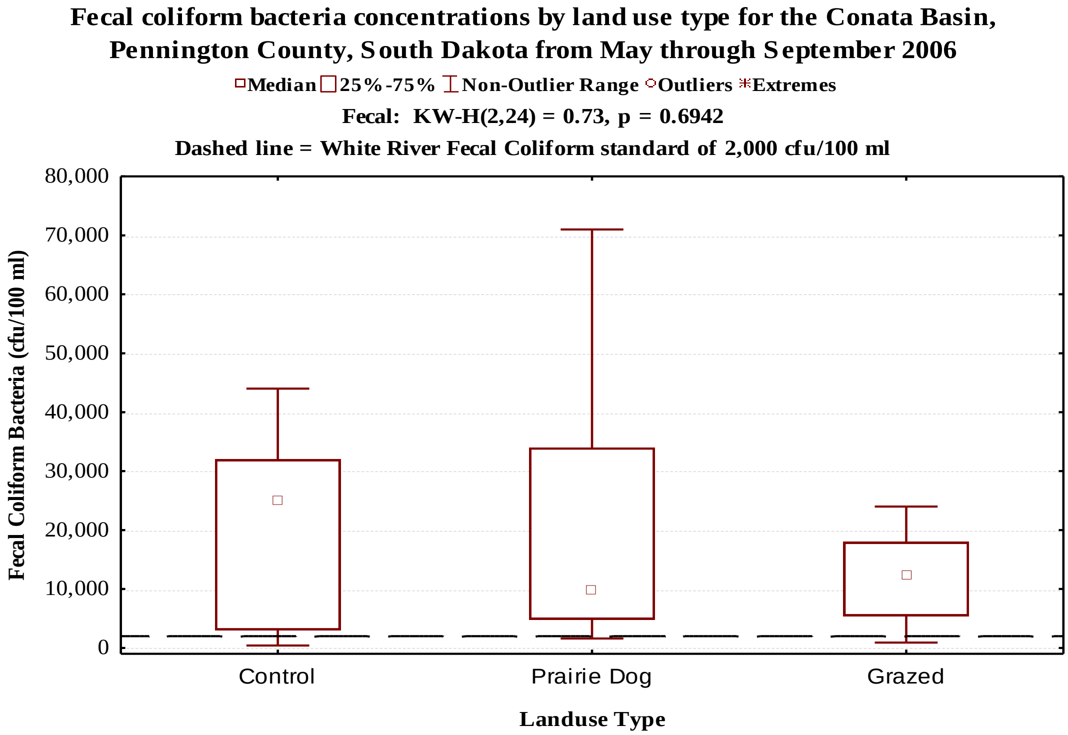

Figure 30 Fecal coliform bacteria concentrations by land use type for the Conata Basin, Pennington County, South Dakota from May through September 2006.

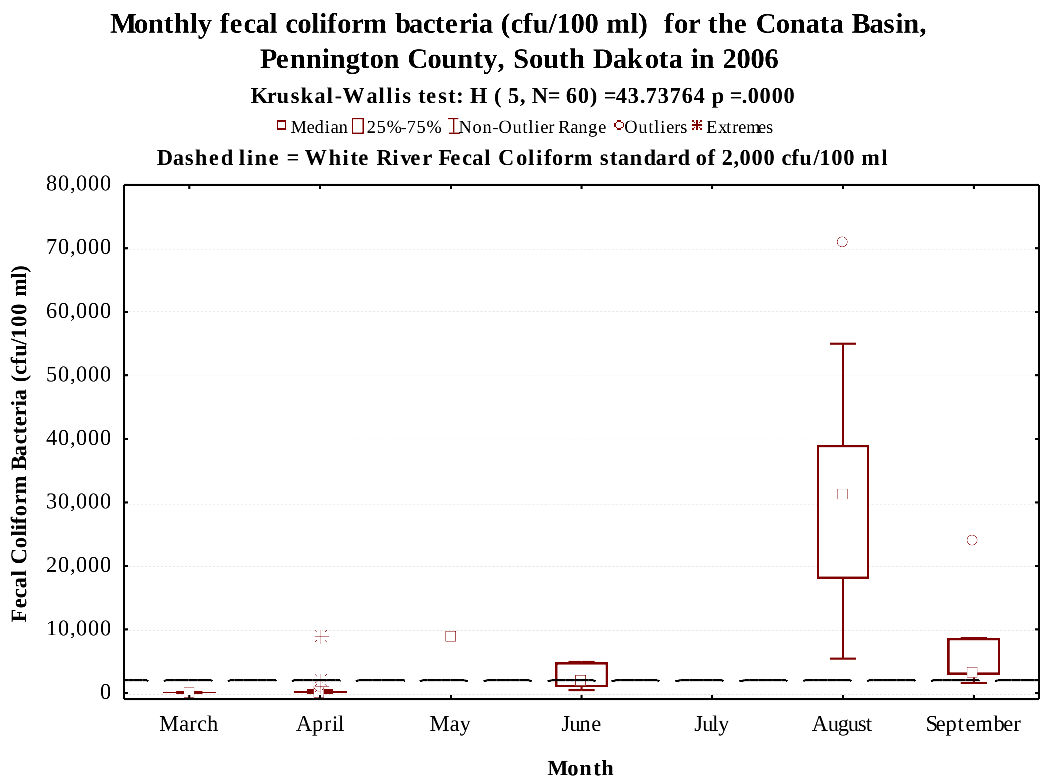

Figure 31. Monthly fecal coliform bacteria concentrations for the Conata Basin, Pennington County, South Dakota in 2006.

Fecal coliform concentrations were grouped by watershed type based on land use. Data show that fecal concentrations between watershed land use types were statistically similar (Figure 30).

Significant differences were detected between monthly fecal coliform concentrations with August and September fecal coliform concentrations significantly higher than March while August concentrations were also significantly higher than April 2006 (Figure 31 and Appendix C, Table C-6). All monthly median fecal coliform concentrations collected from May through September were at or above the receiving water (White River) standard.

Load duration curves were developed for each monitoring site to evaluate fecal coliform loading based on receiving water quality standard (2,000 cfu/100 ml) for fecal coliform (Figure 32 through Figure 37). All flow data collected during the project (March through October, 2006) were used to develop load duration curves for each watershed site in the Conata Basin (fecal coliform standard for the White River applied to Conata Basin flows). Calculated loads based on water quality samples collected during the project were shown as (o) for each site by flow percentage. Flow percentages were arbitrarily broken into high, moderate and low flow régimes based on site specific flow characteristics. Sample loading above the site specific curve represent daily loads greater than the receiving water standard (White River).

Fecal coliform loading from control watershed NGCWT-1 were all above loads based on the receiving water standards, while loading from two of the four samples (50 percent) collected during May through September at NGCWT-2 were above receiving water standards (Figure 32 and Figure 33).

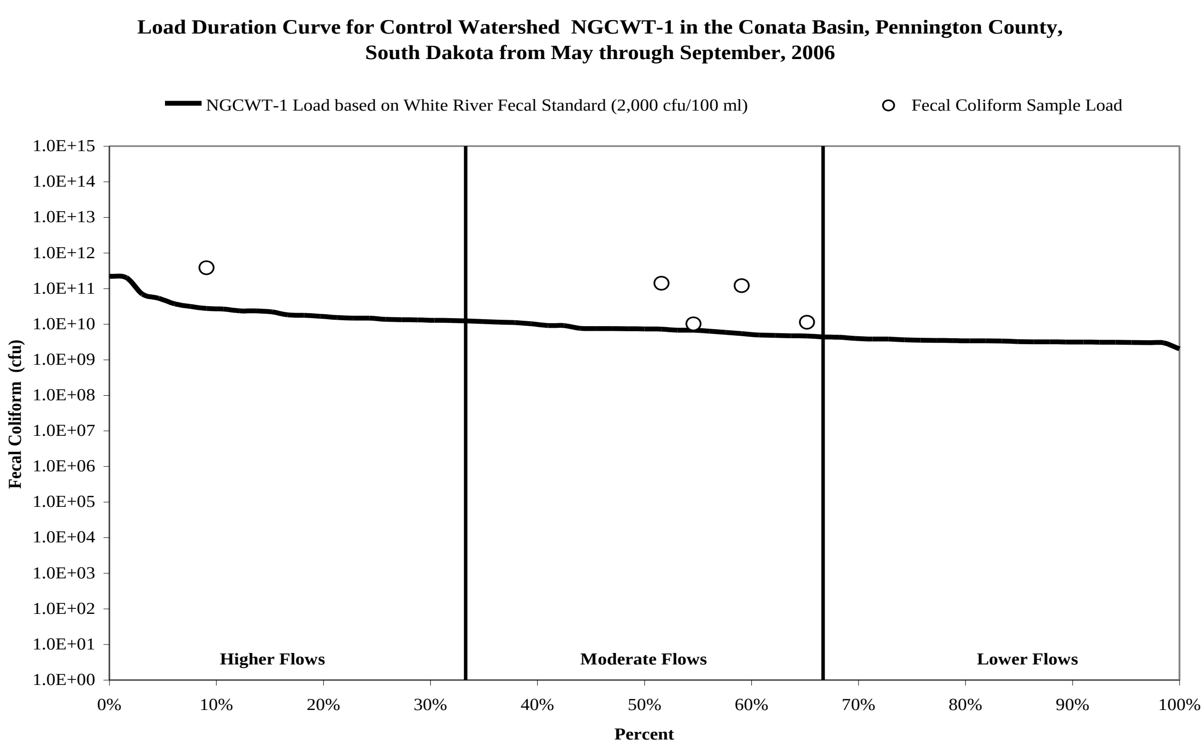

Figure 32. Fecal coliform load duration curve for Control Watershed NGCWT-1 in the Conata Basin, Pennington County, South Dakota in 2006.

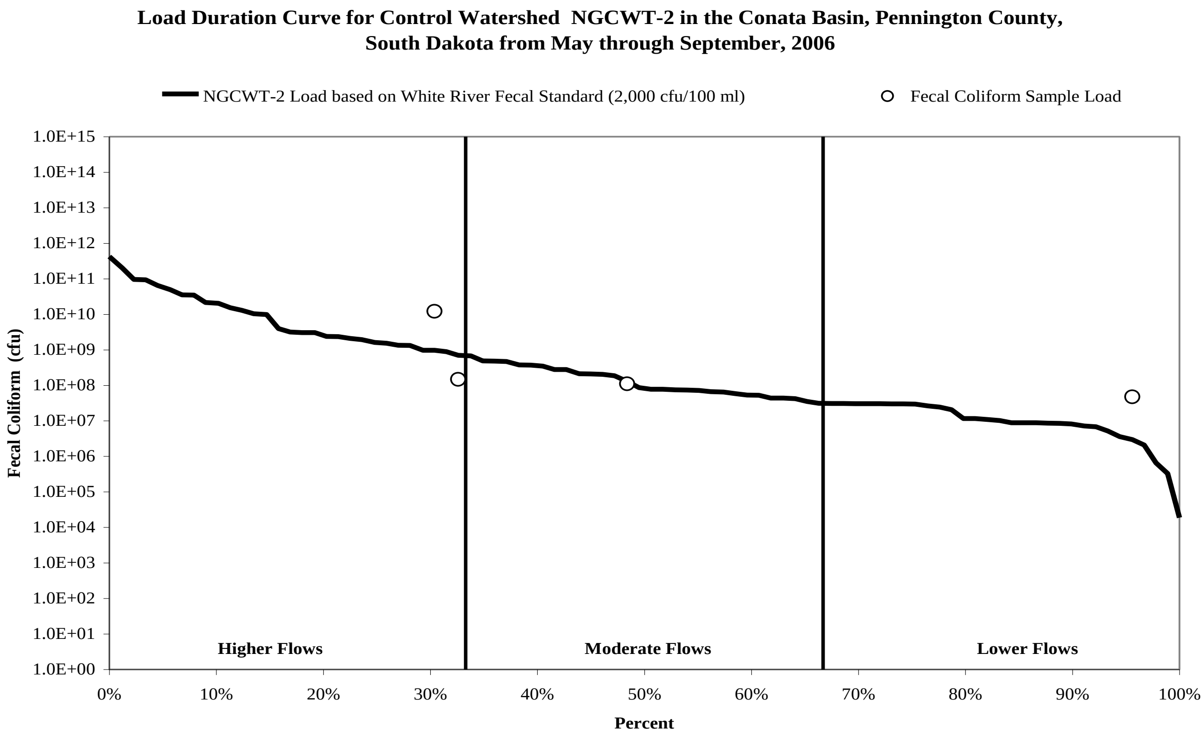

Figure 33. Fecal coliform load duration curve for Control Watershed NGCWT-2 in the Conata Basin, Pennington County, South Dakota in 2006.

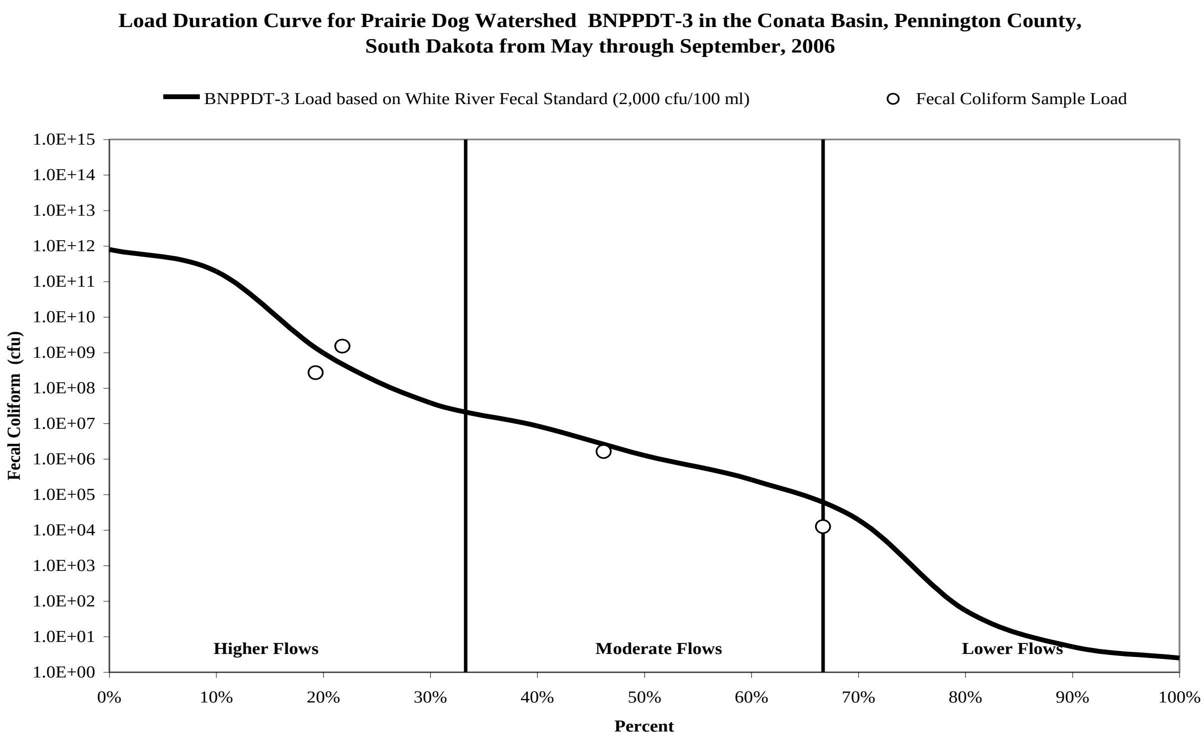

Figure 34. Fecal coliform load duration curve for Prairie Dog Watershed BNPPDT-3 in the Conata Basin, Pennington County, South Dakota in 2006.

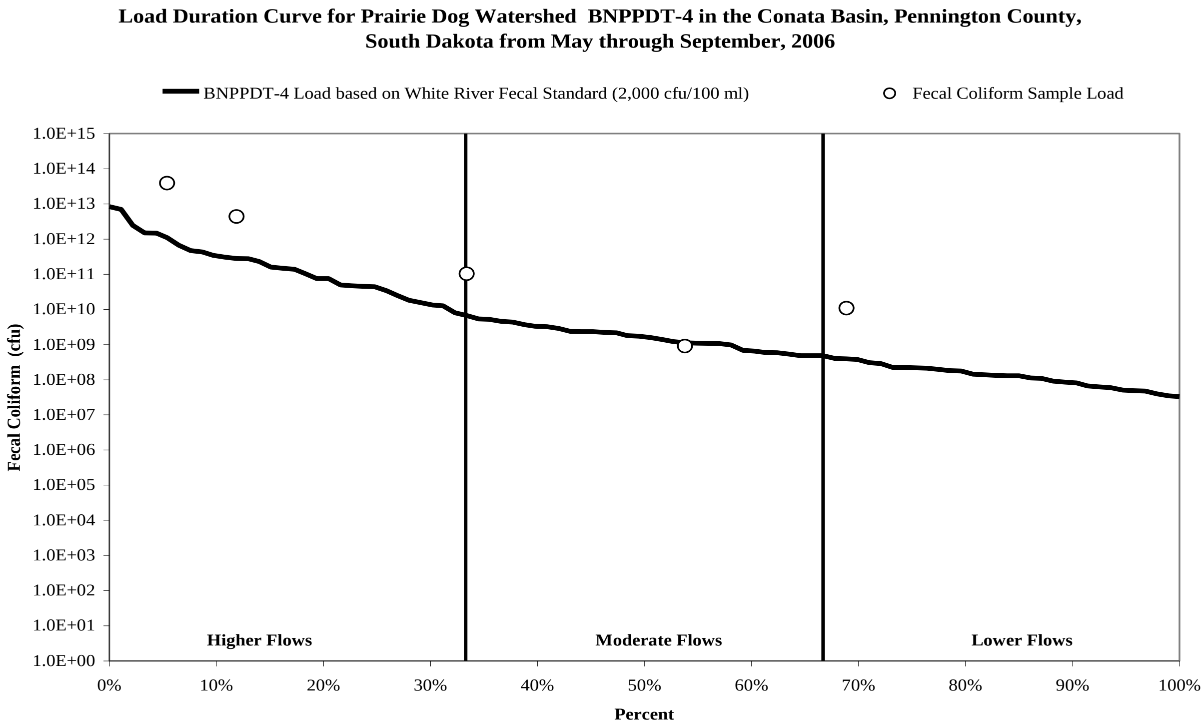

Figure 35. Fecal coliform load duration curve for Prairie Dog Watershed BNPPDT-4 in the Conata Basin, Pennington County, South Dakota in 2006.

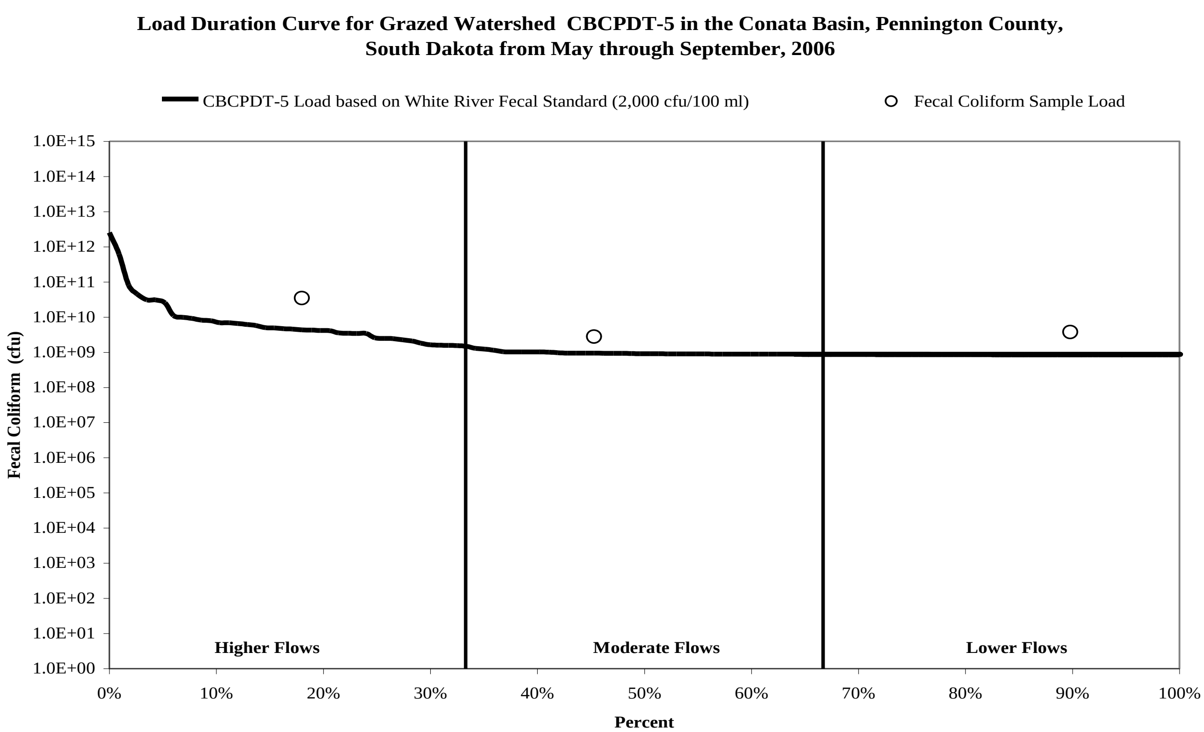

Figure 36. Fecal coliform load duration curve for Grazed Watershed CBCPDT-5 in the Conata Basin, Pennington County, South Dakota in 2006.

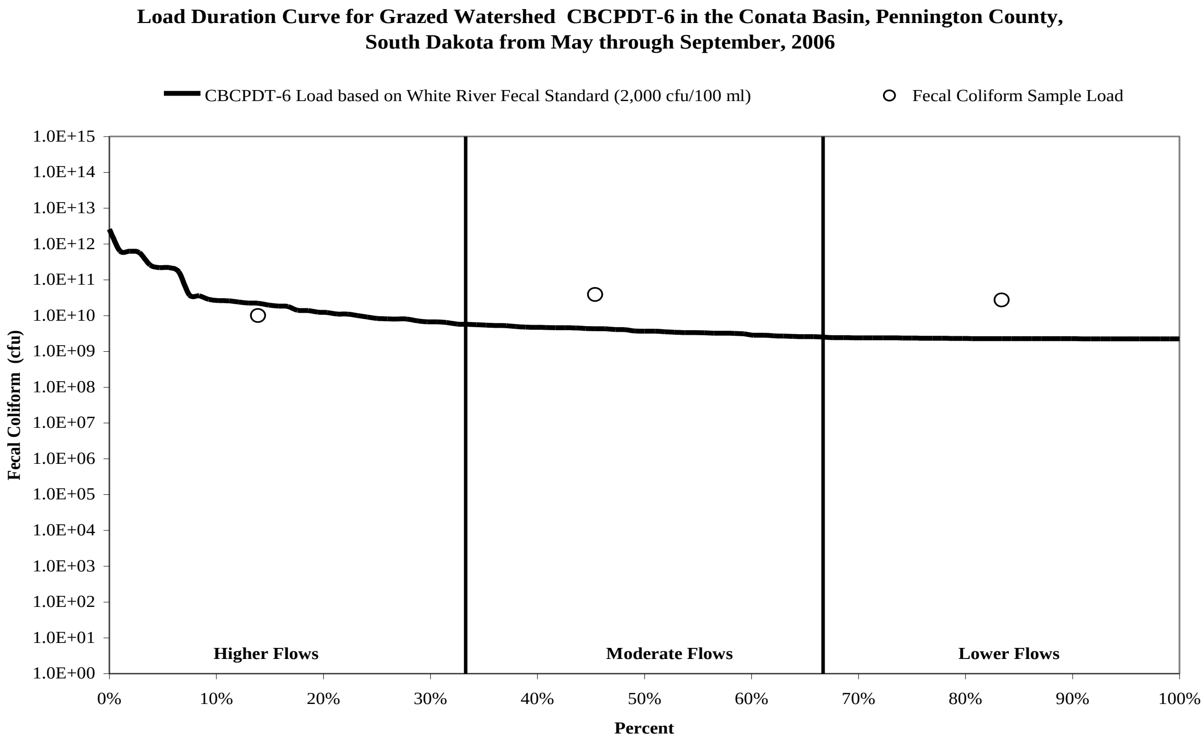

Figure 37. Fecal coliform load duration curve for Grazed Watershed CBCPDT-6 in the Conata Basin, Pennington County, South Dakota in 2006.

Samples collected during May through September from prairie dog watershed BNPPDT-3 exceeded receiving water standard once during higher flows (25 percent), while four out of five samples (80 percent) collected from BNPPDT-4 were higher than the receiving water standard (Figure 34 and Figure 35).

Three samples collected from grazed watershed CBCPDT-5 during May through September 2006 (100 percent) were higher than the White River fecal coliform standard applied to Conata Basin flows (Figure 36). The load duration curve for grazed site CBCPDT-6 was similar to CBCPDT-5 except for sample attainment in the high flow category of CBCPDT-6 (Figure 36 and Figure 37).

E. coli Bacteria

Escherichia coli (*E. coli*) is a species of fecal coliform bacteria that lives in the intestines of humans and other warm-blooded animals and in their waste (fecal matter). The method used for *E. coli* analysis at the South Dakota Public Health Laboratory is APHA 9223 B where a sample is set up in 96 separate wells and incubated at 35° C for 24 hours and then tested for fluorescence using an ultraviolet lamp (APHA, 2005). This procedure yields counts up to a maximum of 2,420 cfu/100 ml. *E. coli* counts collected during this study met or exceeded this maximum 35 percent of the time (21 samples out of 60 total samples). This method biases the data by artificially placing an upper limit threshold of 2,420 cfu/100 ml, reducing concentration data ranges by site. *E. coli* concentration data will be discussed with the knowledge that concentration range estimates will be underestimated.

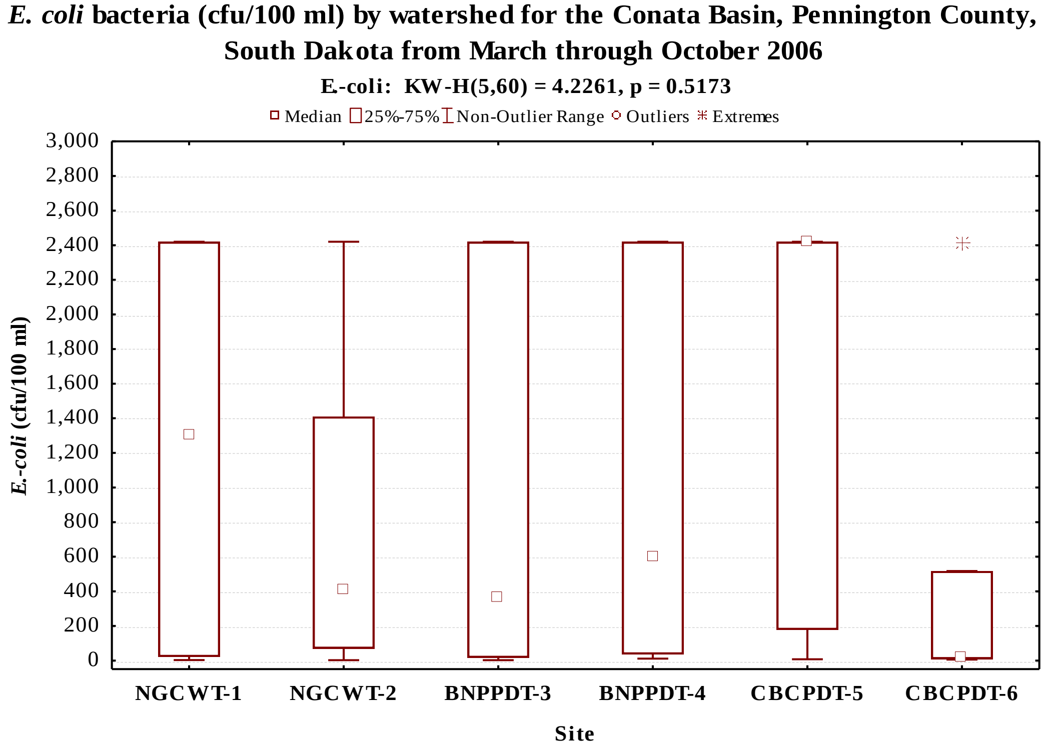

Figure 38. *E. coli* bacteria (cfu/100 ml) by watershed for the Conata Basin, Pennington County, South Dakota from March through October 2006.

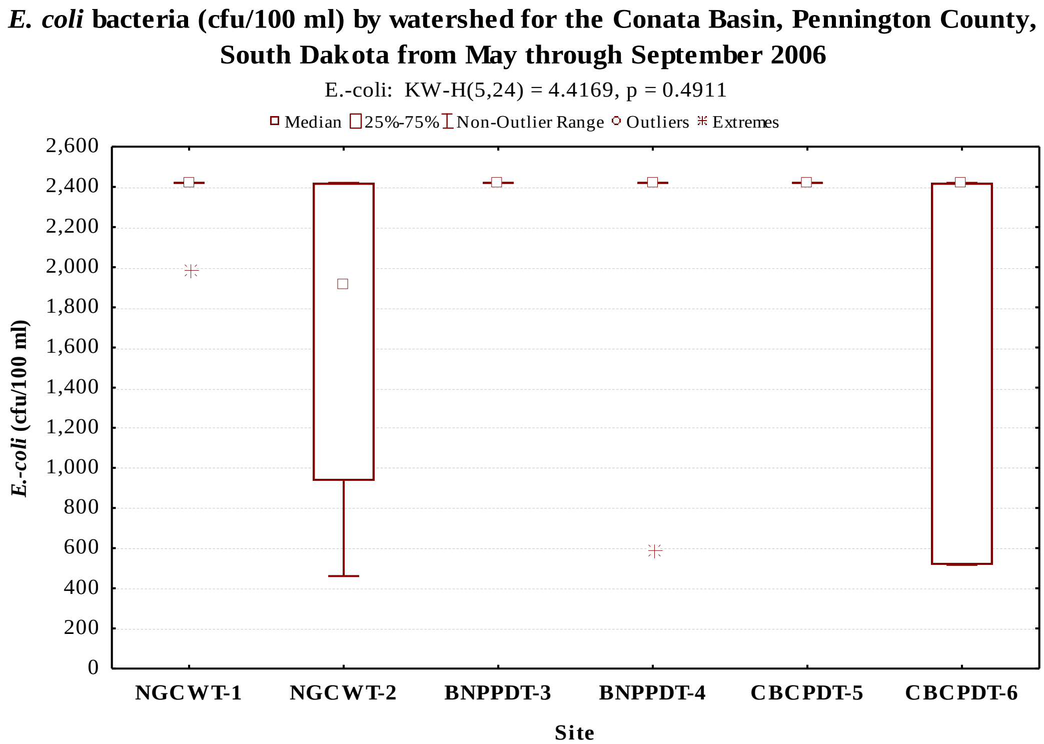

Figure 39. *E. coli* bacteria (cfu/100 ml) by monitored watershed in the Conata Basin, South Dakota from May through September 2006.

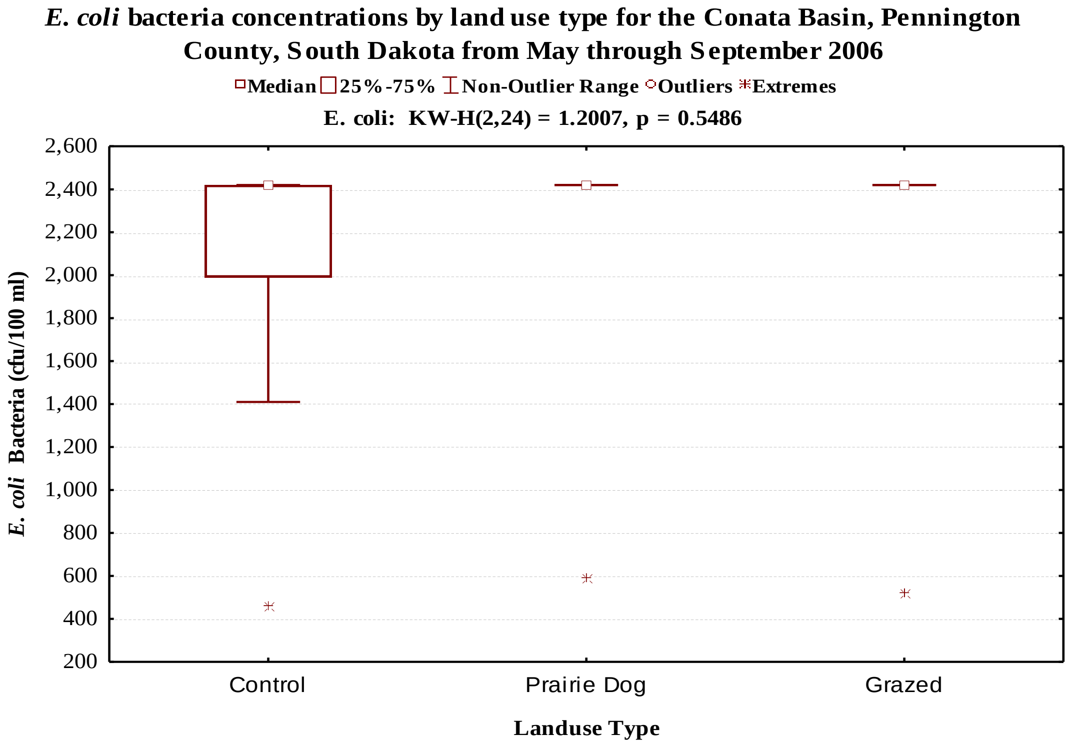

Figure 40. *E. coli* bacteria concentrations by land use type for the Conata Basin, Pennington County, South Dakota from May through September 2006.

During this study, *E. coli* bacteria were sampled as part of routine water quality sampling and source tracking analysis (page 15). All routine water quality and prairie dog fecal pellet samples containing $\geq$ 50 cfu/100 ml *E. coli* counts were further analyzed using PFGE techniques.

Based on all data (March through October), *E. coli* concentrations in cfu/100 ml ranged from less than 10 cfu/100 ml (detection limit) to 2,420 cfu/100 ml, the maximum detection limit based on method (Figure 38 and Appendix B, Table B-1). The maximum *E. coli* concentration (2,420 cfu/100 ml) was recorded at least once in every monitored watershed in the Conata Basin (Figures 38 and Figure 39). *E. coli* bacteria concentrations by monitoring site were statistically similar for all dates and for the *E. coli* season (Figure 38, Figure 39 and Table 10). Figures 38 and Figure 39 indicate that *E. coli* concentrations were higher (based on medians) during the *E. coli* season (May 1 through September 30) than when using all dates (March through October).

E. coli concentration data collected during the *E. coli* season were also grouped by land use type and tested for differences (Figure 40). Data analysis indicated that *E. coli* concentrations between control, prairie dog and grazing land use types were statistically similar with median *E. coli* concentrations in each land use type present at the maximum detection limit (2,420 cfu/100 ml).

Significant differences were detected between monthly concentrations with August and September *E. coli* concentrations significantly higher than March while August concentrations were also significantly higher than April 2006 (Figure 41 and Appendix C, Table C-7).

E. coli loading was not calculated because of the maximum detection limit imposed by the laboratory analysis technique introducing undue error in loading estimations.

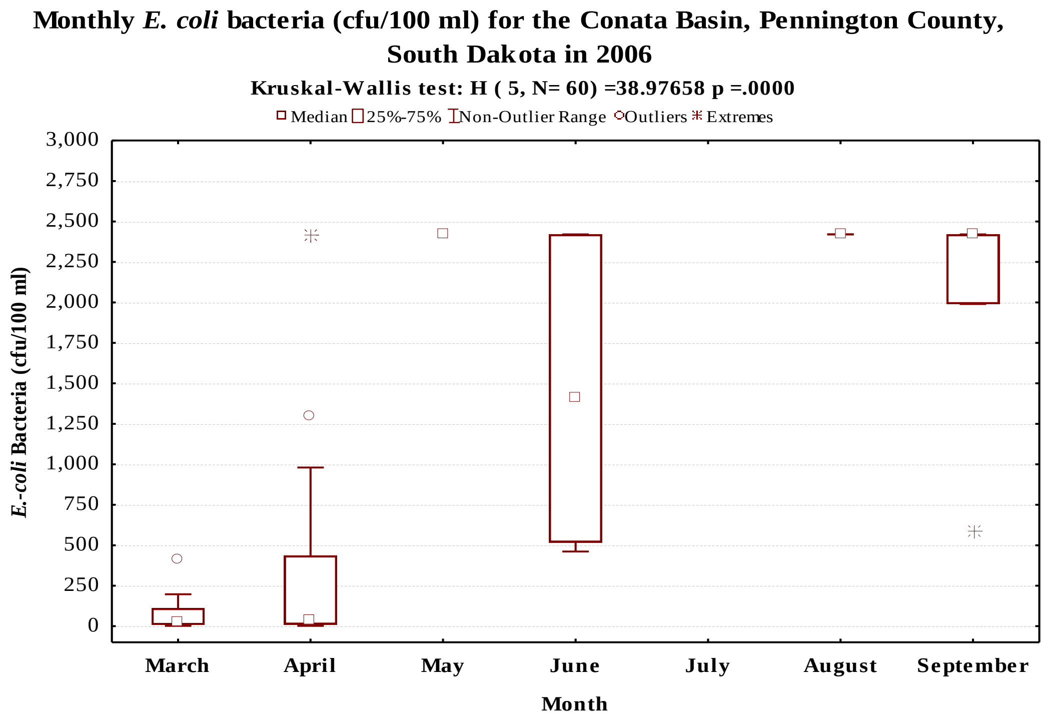

Figure 41. Monthly *E. coli* bacteria concentrations for the Conata Basin, Pennington County, South Dakota in 2006.

Fecal Source Tracking

One of the major objectives of this study was to document fecal coliform loading and attempt to identify fecal coliform contributions from prairie dogs to loadings within watersheds in White River Group to the White River. *E. coli* samples were collected in monitored watersheds in the Conata Basin from March through September 2006. Fresh fecal pellets were also collected from prairie dogs in the Conata Basin and throughout the greater White River Basin for inclusion in South Dakota's known source DNA database. PFGE *E. coli* gels from water quality samples collected during the project were compared to known source sample gels in South Dakota's DNA database to identify possible source organisms. Results provided the animal type, if known, and the percent match to the database. Table 17 provides *E. coli* water quality and PFGE analysis for samples collected in the Conata Basin during the project.

The percentage of *E. coli* samples analyzed by watershed for PFGE were generally between 72.7 percent and 88.9 percent except for grazed watershed CBCPDT-6 where only 30 percent of the samples collected exceeded the minimum threshold for analysis (50 cfu/100 ml). Reduction in *E. coli* counts in the CBCPDT-6 watershed was attributed to wide shallow flows increasing travel time and exposure to sunlight resulting in an increased decay rate. During the project, 11.6 percent (5) of the total PFGE samples (43) sourced positive for prairie dogs while 7.4

percent (2) of the total PFGE samples collected during the fecal season (27) sourced positive for prairie dogs (Table 17).

Table 17. *E. coli* water quality and PFGE analysis for samples collected from monitored watersheds in the Conata Basin, Pennington County, South Dakota in 2006.

Site	Total *E. coli* Samples Collected	Number of *E. coli* Samples Analyzed for PFGE All Dates (> 50 cfu/100ml)	Percent PFGE	Total Prairie Dog Positive (All Dates)	Percent Prairie Dog Positive (All Dates)	Number of *E. coli* Samples Analyzed during the Fecal Season (> 50 cfu/100ml)	Prairie Dog Positive (Fecal Season)	Percent Prairie Dog Positive (Fecal Season)
NGCWT-1	11	9	81.8	1	11.1	6	1	16.7
NGCWT-2	9	7	77.7	1	14.3	4	1	25.0
BNPPDT-3	10	8	80.0	1	12.5	5	0	0.0
BNPPDT-4	11	8	72.7	2	25.0	5	0	0.0
CBCPDT-5	9	8	88.9	0	0.0	4	0	0.0
CBCPDT-6	10	3	30.0	0	0.0	3	0	0.0
Total	**60**	**43**	**71.7**	**5**	**11.6**	**27**	**2**	**7.4**

Control watersheds NGCWT-1 and NGCWT-2 each had one positive prairie dog isolate during the fecal season, both occurring August 28, 2006 (Table 17 and Table 18). In contrast, samples from both prairie dog watersheds BNPPDT-3 and BNPPDT-4 did not record any positive prairie dog isolates during the same time period (Table 17). Prairie dogs were sourced in these watersheds; however, all occurred in April, 2006 before the water quality standard for fecal coliform in the White River was in effect (May 1 through September 30). PFGE *E. coli* samples from grazed watersheds CBCPDT-5 and CBCPDT-6 did not source as prairie dog anytime during the study.

Table 18. Total PFGE and positive prairie dog isolate counts by watershed in the Conata Basin, Pennington County, South Dakota from March through October and May through September, 2006.

Site	Total Number of Isolates	Number of Prairie Dog Isolates	Percent of Prairie Dog Isolates
NGCWT-1	37	1	2.7
NGCWT-2	34	1	2.9
BNPPDT-3	36	3	8.3
BNPPDT-4	38	2	5.3
CBCPDT-5	38	0	0.0
CBCPDT-6	14	0	0.0
Total (March through September)	**197**	**7**	**3.6**
Total (Fecal Season)	**126**	**2**	**1.6**

During the Conata Basin watershed project a total of 197 *E. coli* isolates were analyzed and seven of those sourced as prairie dog (Table 18). 3.6 percent of all PFGE isolates collected during the project were identified as prairie dog and of those only two of the seven prairie dog isolates were recorded in the May through September time frame. Prairie dog isolate percentages (Table 18) were lower than overall sample isolate percentages (Table 17), because there were approximately five *E. coli* isolates collected from each water quality sample with *E. coli* counts greater than 50 cfu/100ml. This was especially evident during the fecal season.

Vegetative Cover

During the Conata Basin watershed project three vegetative transects were set up in each watershed. Each transect had ten random sampling points where Daubenmire quadrats were used to classify vegetative cover by species. Cover would be used if water quality and/or loading data indicated significant differences between watersheds or watershed types.

Fifty-nine plant species were identified in monitored watersheds in the Conata Basin during 2006 (Table 19). Species encountered during the study were typical of other plant communities in the area. Plant species were separated by watershed type (control, prairie dog and grazed) and expressed in frequency of occurrence (percent of total quadrats by watershed type). Frequency of occurrence by watershed type excluding bare ground and litter are presented in Figure 42. Species were considered common if all three watershed types had frequency percentages greater than ten percent. Eight species were considered common among monitored watersheds in the Conata Basin. Common species were *Bouteloua gracilis* (blue grama), *Bromus* ja/te (Brome grass), *Bromus japonicus* (Japanese brome), *Carex* spp. (sedge), forb, *Pascopyrum smithii* (western wheatgrass), Poaceae (grass) and *Sphaeralcea coccinea* (scarlet globemallow). Frequency distributions shown in Figure 42 were only for the 59 identified plant species found in Daubenmire quadrats. Bare ground and litter frequencies and coverage estimates were also recorded for each quadrat during the study. Bare ground and litter frequency of occurrence percentages for control, prairie dog and grazed watersheds were 100 percent (recorded in every quadrat in each watershed). Average coverage of bare ground in control and prairie dog watersheds was approximately 15 percent while grazed watersheds had approximately 38 percent bare ground coverage from May through September 2006 based on vegetative plot data. Litter percent coverage in control and grazed watersheds were approximately 38 percent while prairie dog watersheds had more litter coverage at approximately 63 percent.

Table 19. Species list for monitored watersheds in the Conata Basin, Pennington County, South Dakota in 2006.

Scientific Name	Common Name	New Name
Agropyron cristatum	crested wheatgrass	
Agropyron smithii	western wheatgrass	*Pascopyrum smithii*
Agropyron spp.	wheatgrass	
Agrostemma githago	common corncockle	
Agrostemma spp.	corncockle	
Allium textile	prairie onion	
Ambrosia artemisia folia	ragweed	
Aristida longiseta	red threeawn	
Artemisia cana	silver sagebrush	
Astragalus missouriensis	Missouri milkvetch	
Astragalus racemosus	cream milkvetch	
Astragalus spp.	milkvetch	
Atriplex spp.	saltbush	
Bouteloua curtipendula	sideoats grama	
Bouteloua gracilis	blue grama	
Bromus ja/te	brome grass	
Bromus japonicus	Japanese brome	
Bromus tectorum	cheatgrass, downy brome	
Buchloe dactyloides	buffalo grass	
Carex spp.	sedge	
Cymopterus montanus	mountain springparsley	
Distichlis spicata	saltgrass	
Forb	forb	
Grindelia squarrosa	curlycup gumweed	
Gutierrezia sarothrae	broom snakeweed	
Hedeoma hispida	rough false pennyroyal	
Iva annua	annual marshelder	
Lactuca serriola	prickly lettuce	
Lappula occidentalis	flatspine stickseed	
Lappula spp.	stickseed	
Lesquerella ludoviciana	foothill bladderpod	
Lygodesmia juncea	rush skeletonplant	
Medicago sativa	alfalfa	
Melilotus officinalis	yellow sweetclover	
Melilotus spp.	sweetclover	
Mirabilis linearis	narrowleaf four-o'clock	
Musineon divaricatum	leafy wildparsley	
Musineon spp.	wildparsley	
Musineon tenuifolium	slender wildparsley	
Oenothera caespitosa	white tuffed evening primrose	
Opuntia spp.	prickly pears	
Phlox hoodii	moss phlox	
Plantago patagonica	wooly plantain	
Poa pratensis	Kentucky bluegrass	
Poaceae	grass family	
Psoralea tenuiflora	slimflower scurfypea	
Psoralea spp.	scurfypea genus	
Ratibida columnifera	upright prairie coneflower	
Salsola iberica	Russian thistle	
Salsola kali	prickly saltwort	
Sitanion hystrix	squirreltail grass	
Sonchus spp.	sowthistle	
Sphaeralcea coccinea	scarlet globemallow	
Sporobolus cryptandrus	sand dropseed	
Stipa comata	needle-and-thread grass	
Taraxacum officinale	common dandelion	
Tragopogon dubius	yellow salsify	
Viola nuttallii	Nuttall's violet	
Zigadenus venenosus	meadow deathcamas	
Total Species		**59**

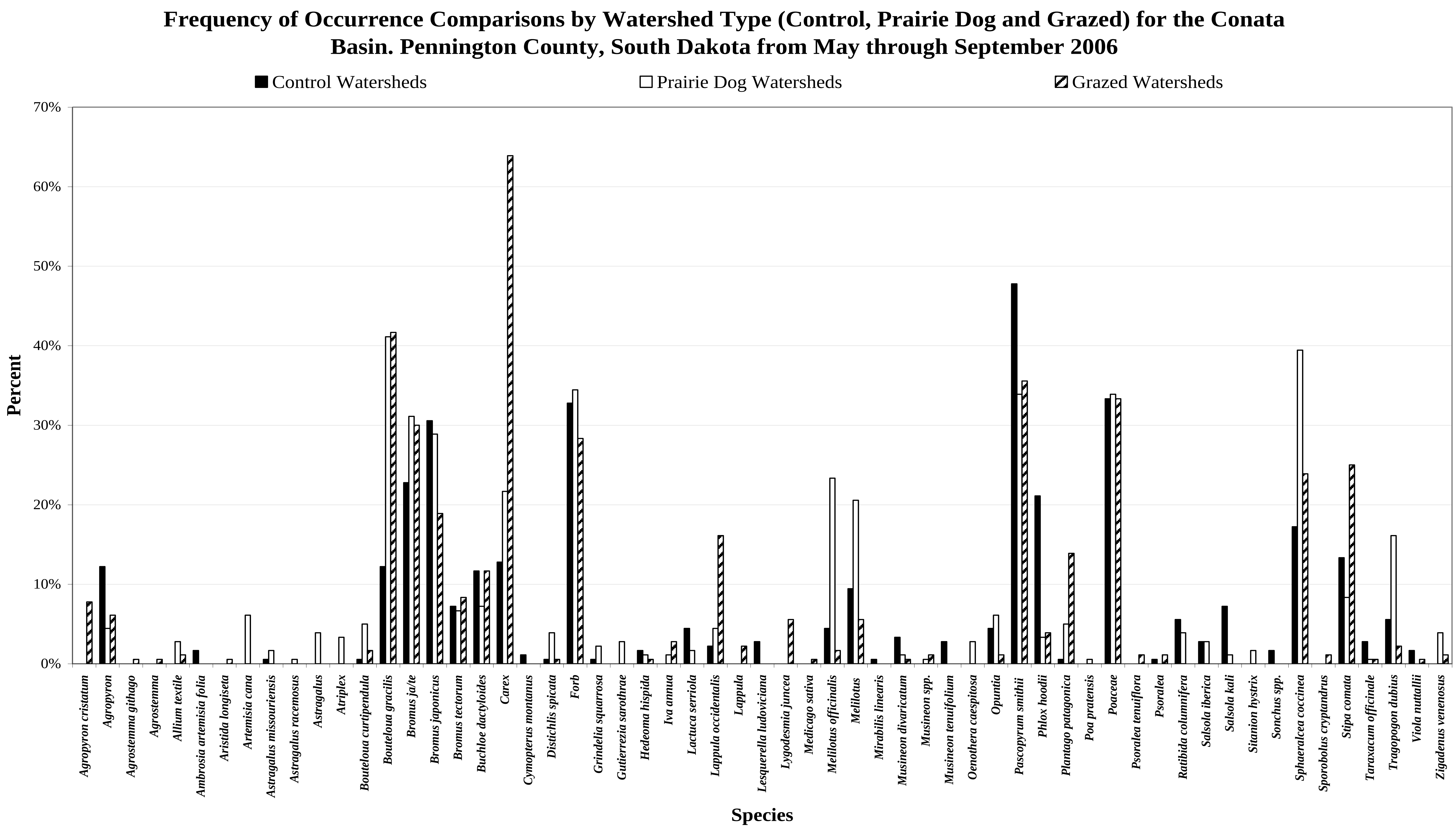

Figure 42. Frequency of occurrence by species and watershed type for vegetative transects in six watersheds in the Conata Basin, Pennington County, South Dakota.

Table 20. Vegetative height by species, quadrats and watershed for the Conata Basin, Pennington County, South Dakota from May through September 2006.

Control Sites

Site	Species	Quadrats	Percent of Total	Height Min (cm)	Range Max (cm)
NGCWT-1	Agropyron smithii	13	14.6%	15.2	30.5
	Agropyron spp.	3	3.4%	20.3	45.7
	Bouteloua gracilis	1	1.1%	6.4	
	Bromus ja/te	11	12.4%	12.7	22.9
	Bromus japonicus	12	13.5%	11.4	35.6
	Bromus spp.	2	2.2%	15.2	20.3
	Bromus tectorum	2	2.2%	30.5	38.1
	Buchloe dactyloides	8	9.0%	5.1	12.7
	Carex spp.	3	3.4%	22.9	25.4
	Melilotus officinalis	1	1.1%	55.9	
	Melilotus spp.	2	2.2%	7.6	30.5
	Musineon divaricatum	1	1.1%	-	
	Opuntia spp.	1	1.1%	20.3	
	Phlox hoodii	4	4.5%	3.8	7.6
	Poaceae	18	20.2%	7.6	16.5
	Salsola kali	1	1.1%	7.6	
	Stipa comata	3	3.4%	30.5	45.7
	Tragopogon dubius	3	3.4%	30.5	
NGCWT-2	Agropyron smithii	25	27.8%	16.5	38.1
	Astragalus missouriensis	1	1.1%	10.2	
	Bouteloua gracilis	2	2.2%	5.1	
	Bromus ja/te	5	5.6%	10.2	25.4
	Bromus japonicus	5	5.6%	10.2	25.4
	Bromus tectorum	1	1.1%	25.4	
	Buchloe dactyloides	5	5.6%	5.1	7.6
	Carex spp	4	4.4%	20.3	30.5
	Melilotus officinalis	1	1.1%	53.3	
	Melilotus spp.	1	1.1%	10.2	
	Phlox hoodii	3	3.3%	5.1	8.9
	Poaceae	24	26.7%	5.1	30.5
	Ratibida Columnifera	1	1.1%	30.5	
	Salsola kali	1	1.1%	10.2	
	Sphaeralcea coccinea	2	2.2%	12.7	15.2
	Stipa comata	9	10.0%	17.8	45.7

Prairie Dog Sites

Site	Species	Quadrats	Percent of Total	Height Min (cm)	Range Max (cm)
BNPPDT-3	Agropyron smithii	1	1.1%	22.9	
	Allium textile	2	2.2%	10.2	
	Astragalus spp.	2	2.2%	2.5	10.2
	Atriplex spp.	2	2.2%	30.5	
	Bouteloua curtipendula	1	1.1%	15.2	
	Bouteloua gracilis	18	20.0%	6.3	12.7
	Bromus ja/te	9	10.0%	5.0	11.4
	Bromus japonicus	10	11.1%	10.2	17.8
	Forb	2	2.2%	5.0	
	Gutierrezia sarothrae	6	6.7%	14.0	22.9
	Melilotus officinalis	2	2.2%	17.8	30.5
	Opuntia spp.	6	6.7%	5.0	15.2
	Poaceae	22	24.4%	5.0	30.5
	Sphaeralcea coccinea	2	2.2%	5.0	15.2
	Stipa comata	1	1.1%	43.2	
	Tragopogon dubius	4	4.4%	15.2	22.9
BNPPDT-4	Agropyron smithii	17	19.1%	12.7	30.5
	Artemesia cana	4	4.5%	20.3	30.5
	Bouteloua gracilis	1	1.1%	7.6	
	Bromus ja/te	2	2.2%	15.2	33.0
	Bromus japonicus	3	3.4%	17.8	20.3
	Bromus tectorum	2	2.2%	27.9	33.0
	Buchloe dactyloides	2	2.2%	5.1	10.2
	Carex spp.	27	30.3%	10.2	40.6
	Meliliotus officinalis	2	2.2%	20.3	58.4
	Melilotus	1	1.1%	14.0	
	Opuntia spp.	2	2.2%	17.8	20.3
	Poaceae	21	23.6%	7.6	55.9
	Sphaeralcea coccinea	2	2.2%	10.2	14.0
	Stipa comata	2	2.2%	30.5	55.9
	Zigadenus venenosus	1	1.1%	20.3	

Grazed Sites

Site	Species	Quadrats	Percent of Total	Height Min (cm)	Range Max (cm)
CBCPDT-5	Agropyron cristatum	2	2.2%	20.3	20.3
	Agropyron smithii	7	7.8%	12.7	25.4
	Agropyron spp.	3	3.3%	7.6	20.3
	Bouteloua gracilis	9	10.0%	2.5	15.2
	Bromus ja/te	3	3.3%	7.6	12.7
	Bromus japonicus	3	3.3%	12.7	17.8
	Buchloe dactyloides	4	4.4%	5.1	10.2
	Carex spp.	14	15.6%	2.5	22.9
	Phlox hoodii	1	1.1%	5.1	
	Poaceae	28	31.1%	5.1	30.5
	Stipa comata	16	17.8%	15.2	48.3
CBCPDT-6	Agropyron smithii	7	7.8%	17.8	30.5
	Bouteloua gracilis	3	3.3%	3.8	6.4
	Bromus ja/te	1	1.1%	15.2	15.2
	Carex spp.	50	55.6%	2.5	25.4
	Lygodesmia juncea	2	2.2%	22.9	25.4
	Poaceae	16	17.8%	3.8	22.9
	Sphaeralcea coccinea	6	6.7%	6.4	11.4
	Stipa comata	3	3.3%	30.5	76.2
	Tragopogon dubius	2	2.2%	25.4	27.9

Height of the tallest species per quadrat was measured to the nearest centimeter each time transect data was collected. Tallest species are shown in Table 20 by quadrat, overall percent of quadrat and height range for vegetation in the Conata Basin in 2006. Height data was then pooled by watershed and height ranges were averaged by species to determine if there was any significant difference between average heights between watersheds irregardless of species (Figure 43). Data show that average rainfall interception height by vegetation was not significantly different between watersheds suggesting that theoretically, rainfall intensity was modified by vegetation similarly in monitored watersheds in the Conata Basin.

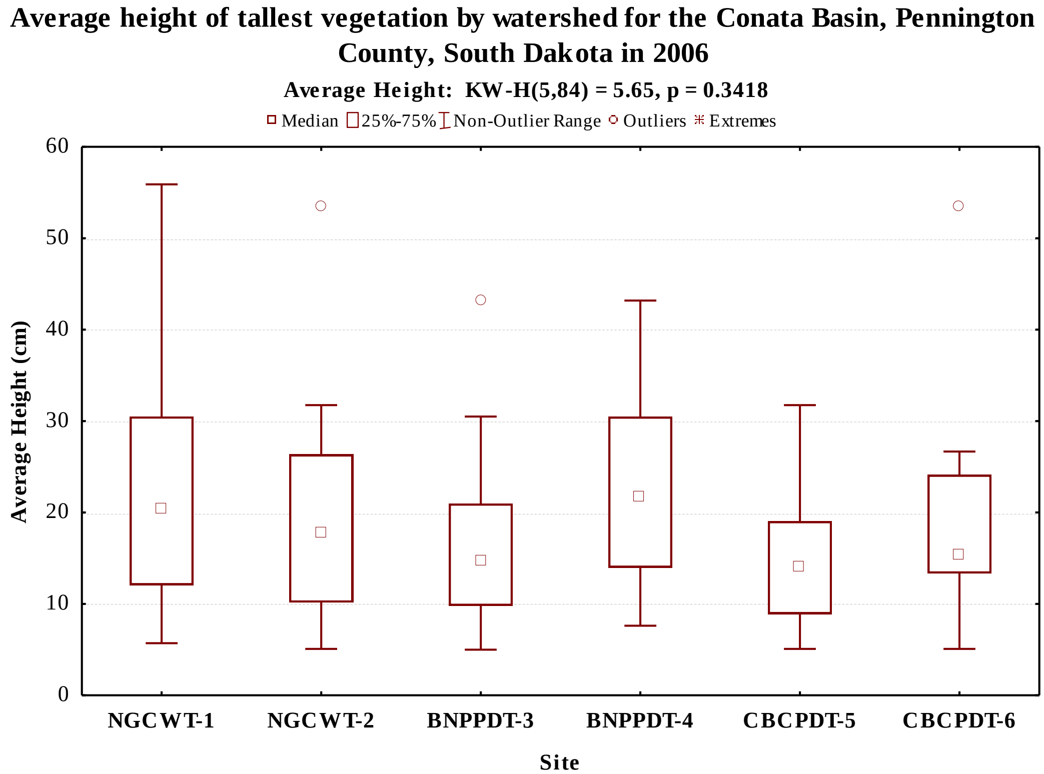

Figure 43. Average height of tallest vegetation by watershed for the Conata Basin, Pennington County, South Dakota in 2006.

DISCUSSION

The amount, intensity and duration of precipitation play a significant role in chemical and biological concentrations and overall loading in a watershed. Average rainfall in the basin from May through September 2006 was 42.4 percent of average (a rainfall deficit of 6.47 inches (16.43 cm)). As a result, concentration and loading data collected during this project may not adequately represent average conditions. However, rainfall totals between watersheds varied as much as 2.72 inches (6.9 cm) during the project. Rainfall patterns and intensities tend to be spatially variable in natural systems which impose variability in measured concentrations and loading within watershed types. Rainfall variability between monitored watersheds throughout the basin was not extreme enough to be statistically significant. Thus, below average rainfall observed during the project may be more representative in terms of averaging concentrations and loading in monitored watersheds across the entire basin on a per inch of rain basis.

Discharge is generally a function of rainfall (amount, duration and intensity) and watershed morphology (vegetation, slope, soils and channel condition). Similar to precipitation, discharge measurements during the project were statistically similar within and between watersheds.

All parameters collected by the YSI multimeter probe (water temperature, dissolved oxygen, pH and specific conductance) were similar both within watershed types and between watersheds in 2006. Dissolved oxygen (DO) is not a listed parameter for beneficial uses in the Conata Basin: (9) fish and wildlife propagation, recreation, and stock watering water and (10) irrigation water. However, waters originating in the basin do impact the White River, listed as a warmwater semi-permanent fish life propagation water with a DO standard of $\geq$ 5.0 mg/L. Two dissolved oxygen samples collected in the Conata Basin were below 5.0 mg/L; however, surface water quality samples collected in the White River in 2006 show the White River is meeting the dissolved oxygen standard. Ninety-four percent of the dissolved oxygen concentrations in the Conata Basin were above the 5.0 mg/L threshold and do not appear to impact DO concentrations in reach 7 of the White River.

Specific conductance (conductivity @ 25° C) values during the project were well below beneficial use-based water quality standards for fish and wildlife propagation, recreation, and stock watering (7,000 µS/cm) and the more stringent beneficial use of irrigation ($\leq$ 4,375 µS/cm). Based on data from this study and long-term monitoring of the White River near Kadoka, South Dakota, specific conductance is not a concern in these watersheds.

Beneficial use-based standard for pH never exceeded the water quality criterion during the study. Values generally increased with respect to water temperature (r^2 = 0.41) and date (r^2 = 0.74). Values ranged from approximately 7.02 in April to 9.47 in August and dropped back down below 9.00 in September. Generally pH is not related to water temperature and was probably coincidental with decreases in hydrogen ion concentrations over time and temperature. This was validated using pH and temperature data from the White River which showed no relationship to water temperature (r^2 = 0.01) and date (r^2 = 0.13). Elevated pH values above 9.00 in August do not appear to impact the overall concentrations in reach 7 of the White River having a pH standard $\leq$ 9.00.

TSS is not a listed parameter for fish and wildlife propagation, recreation, stock watering and irrigation waters; however, TSS loading from the basin contributes to overall TSS loading in the White River. One of the major goals of the project was to document TSS and VTSS contributions from watersheds in the Conata Basin with a variety of land uses to estimate general loading from watersheds within White River Group formations. TSS concentrations exceeded water quality standards for warmwater semi-permanent fish life propagation waters of the White River, currently 158 mg/L. The White River Phase I Watershed Assessment proposed a site specific standards change for reach 7 of the White River based on long-term data from the USGS and SD DENR. The site specific standard proposed for reach 7 of the White River is TSS concentrations $\leq$ 24,300 mg/L. TSS concentrations within the Conata Basin exceeded the proposed standard by 14.1 percent (9 out of 64 samples) and on face value exceed water quality standards for the White River. The median TSS concentration for the tributaries in the Conata Basin was 9,150 mg/L (average 14,116 mg/L) while the long-term median concentration in the White River at Kadoka was lower 1,060 mg/L (average 5,261 mg/L). Thus, TSS concentrations in the Conata Basin were generally higher (median and average) than those in the White River. Reduced concentrations recorded in the White River were attributed to dilution.

Stream morphology within most monitored watersheds in the Conata Basin were incised with little or no access to their floodplain. Streams with access to the floodplain can dissipate hydraulic energy and deposit sediment on the floodplain reducing in-stream sediment concentrations and overall loading. Incised streams tend to be in a down-cutting and widening with bank failures phase (Stage II and Stage III) of stream morphology based on Schumm et al., 1984. In these stages, hydraulic energy in a stream is directed towards the streambed and banks resulting in down cutting and widening of the stream channel. Stage IV channels are in the process of re-establishing floodplains and point bars within the confines of a widened streambed. Generally, these channels tend to be less energetic and closer to reaching hydraulic equilibrium. Estimated Schumm et al. channel evolution stages by monitoring site in the Conata Basin are provided in Table 21.

Table 21. Channel characteristics for monitored watersheds in the Conata Basin, Pennington County, South Dakota in 2006 based on Schumm et al., 1984.

Site	Schumm et al. Channel Evolution Stage	Condition
NGCWT-1	IV	Re-establishing floodplain within streambed
NGCWT-2	II	Down-cutting
BNPPDT-3	III	Widening (bank failures)
BNPPDT-4	III	Widening (bank failures)
CBCPDT-5	III	Widening (bank failures)
CBCPDT-6	IV	Re-establishing floodplain within streambed

Variations in stream morphology in the Conata Basin did not translate into statistically significant variations in TSS loading data during the project. Any variations in sediment loading due to stream morphology may have been masked by the large percentage of bare ground composed of highly erosive badland soils (White River Group) contributing to increased sediment load in each watershed.

TSS was modeled using AnnAGNPS with 2000 and 2001 land cover data to estimate average sediment delivery rates within each monitored watershed. Measured loadings were higher than model predicted loads by AnnAGNPS in four of the six monitored watersheds (NGCWT-2, BNPPDT-3, BNPPDT-4 and CBCPDT-5) and were lower than measured loads in watersheds NGCWT-1 and CBCPDT-6. Generally, AnnAGNPS underestimated the measured sediment load in the Conata Basin by approximately 43.9 percent or 5,012,640 kg/0.559 yr. The AnnAGNPS model estimates sediment contributions from sheet and rill erosion; however, it does not measure/model bed and bank erosion. This may be one reason why sediment loads predicted by AnnAGNPS for NGCWT-2, BNPPDT-3, BNPPDT-4 and CBCPDT-5, all sites with high in-stream sediment contributions (streams down-cutting and widening with bank failures), under-estimated sediment yield based on measured loads.

During the assessment, VTSS averaged 8.1 percent of TSS based on concentration. This percentage was similar to overall percentages from other assessment projects in Ecoregion 43. Generally in South Dakota, Ecoregion 43 comprises the plains west of the Missouri River excluding the Black Hills. Overall VTSS percentages from other assessment projects were 9.3 percent in Medicine Creek watershed in Lyman and Jones Counties and the Little White River watershed in Mellette County; while 11.5 percent of the TSS concentrations in the Cottonwood Creek watershed, Mellette County, were volatile (Smith, 2008, 2006 and 2005). VTSS is not routinely sampled at water quality monitoring (WQM) sites so no comparison could be made with the White River. Intuitively, as the percentage of bare ground in a watershed increases the overall percent of organic matter (VTSS) in water quality samples should decrease. Generally, the correlation coefficient indicated that as the percent of bare ground increased the percentage of organic matter in the sediment decreased ($r = -0.42$) thus the negative value. This indicates that in the Conata Basin, the overall percentage of organic matter does decrease as the percentage of bare ground increases but not consistently or predictably.

Median fecal coliform bacteria concentrations collected from May through September in monitored watersheds in the Conata Basin were above the beneficial use-based standard for the White River, 2,000 cfu/100 ml. In total, 83.3 percent of the fecal coliform samples collected within the basin during the fecal season were above the beneficial use standard for limited contact waters of the White River. Fecal coliform percentage impacting the White River should be lower based on the exponential decay rate for fecal coliform which takes into account flow and distance traveled.

Fecal coliform samples were source tracked during the study, with only two of twenty-seven samples (7.4 percent) collected from May through September positively identified as prairie dog and of those, only two isolates sourced as prairie dog (1.6 percent of 126 isolates). Both positive samples were collected in control watersheds without prairie dog burrows. However, active prairie dog towns were located south of control watershed NGCWT-1 and west of NGCWT-2. During the study, prairie dogs were seen feeding on or clipping vegetation in control watersheds. By October 2006, prairie dogs had begun to colonize (two burrows) the extreme southern portion of control watershed NGCWT-1 (Appendix E, Figure E-1). Other organisms (human, cattle, sheep, horse, etc.) were identified in isolates using the DNA source tracking library. During the study prairie dog fecal samples were collected within Conata Basin and analyzed for *E. coli* and PFGE for inclusion in South Dakota's DNA database. Based on advice from the South Dakota Department of Health – Public Health Laboratory, better and more reliable ribotyping results can be obtained when known samples are collected from watersheds of interest rather than using a general statewide database (SDDH, 2006). Thus, two-thirds of the fecal coliform samples collected from prairie dogs for inclusion in South Dakota's DNA database were collected within the Conata Basin with the remainder collected within the greater White River Basin.

PFGE analysis on White River fecal coliform samples collected in 2005 supported data collected during this study and showed that only six-tenths of one percent (1 out of 174 isolates) of all isolates collected in the White River from 2005 was identified as being from prairie dogs. Data from the Conata Basin and the White River suggest that viable fecal coliform contributions from prairie dogs in the basin were minimal possibly due to reduced *E. coli* viability. This may be due to the minimal moisture content and the small size of prairie dog pellets which promotes rapid desiccation of prairie dog pellets in the arid climate of the Conata and White River Basin. Prairie dogs have adapted to living in arid areas by getting most of the water they need from the vegetation they consume. Another adaptation to conserve moisture in arid climates may be by internally reabsorbing moisture from fecal matter in the distal portion of the colon, resulting in the excretion of relatively dry fecal pellets. Overall, approximately 35 percent of fresh fecal samples were dry and desiccated enough to have little or no viable *E. coli* to source. Another possible reason for the reduced *E. coli* viability may be that most prairie dog burrows usually have a chamber where prairie dogs can defecate safely below ground away from predators. Presumably the pellets in the chamber dry out and desiccate further reducing *E. coli* bacteria viability. Periodically, the chambers are cleaned out and pellets are brought to the surface and distributed around the entrance of the burrow where ultraviolet radiation further reduces what viable *E. coli* remain. A possible reason for this behavior by prairie dogs may be that having fresh pellets around the entrance to the burrow may attract or alert predators that the burrow is currently occupied and a possible food source may be nearby.

To test the viability of fecal pellets around burrows, some fecal pellets were sampled around prairie dog burrows in the Conata Basin. Pellets selection was based on their visual condition, with least desiccated darker pellets selected and sent to the lab for analysis. Results showed that none of the fecal pellet samples had enough viable *E. coli* colonies to analyze further; which supports the theory proposed above.

Fecal coliform loading collected from May through September evaluated using load duration curves based on receiving water beneficial use standard (2,000 cfu/100 ml) and applied to Conata Basin flows indicated loading from most watersheds in the basin were above the current White River water quality standard (71 percent exceedence) throughout all flow zones. Loading exceedence by land use type based on the current receiving water standard was highest in the control watersheds followed grazed and prairie dog watersheds. An exponential decay rate calculation was applied to fecal coliform concentrations to estimate final fecal coliform concentrations entering the White River. Exponential decay rates were calculated using a non-sterile river water coefficient, discharge and distance data to calculate fecal coliform reduction. Decay rate data estimate that the overall fecal coliform exceedence percentage drops from 71 percent to 27 percent by the time fecal coliform loads enter the White River.

Based on concentration, loading and fecal decay rate, fecal coliform originating from monitored watersheds in the Conata Basin does exceed the fecal coliform standard for the White River. However, spatially and hydrologically monitored watersheds in the Conata Basin comprised a small percentage of the total area (0.4 percent) and hydrologic load (1.6 percent) in reach 7 of the White River monitored at Kadoka. Data suggest that fecal coliform generated in the Conata Basin contribute to fecal loading in the White River but not significantly based on scale (area, hydrology and percentage).

Escherichia coli bacteria are one of the many species that make up fecal coliform. Determination of more realistic *E. coli* bacteria concentrations and loading data by site were restricted by the laboratory method used for sample analysis. Due to data limitations, loading analysis using load duration curves were not developed for *E. coli* bacteria. Concentration data indicate that *E. coli* bacteria met or may have exceeded the maximum count (2,420 cfu/100 ml) at least once in every monitored watershed in the Conata Basin.

During the White River watershed assessment, stakeholders expressed concern that following runoff events large piles of prairie dog pellets were seen near culverts and in waterways. One objective of the Conata Basin study was to identify fecal coliform sources in the White River to address stakeholder concerns that fecal coliform from prairie dogs was a major source of the loads that at times violate water quality standards in the White River. Fecal coliform, *E. coli* and source tracking data collected for this study and the White River project suggest that prairie dogs are not a major source of viable fecal coliform contributing to water quality standard violations in the White River.

The percent coverage of vegetative litter in control and grazed watersheds was approximately 38 percent while prairie dog watersheds had more litter coverage at approximately 63 percent. Increased litter in prairie dog towns has been documented in other studies and was attributed to the vegetative clipping activities (non-consumptive) of prairie dogs (Stoltenburg, 2004). Vegetative clipping by prairie dogs is done to improve their view of potential predators.

CONCLUSION

The main goal of this study was to document concentrations and model loading for TSS, VTSS, fecal coliform and *E. coli* in the Conata Basin to determine what impacts White River Group formations (badlands soils) may have on water quality in the White River. Average concentrations and loading results along with total loading from the Conata Basin during the study are provided in Table 22. Sediment and bacteria data collected during this study provided baseline data for estimating soil loss and fecal coliform concentrations in waters originating in White River Group formations.

Table 22 Average concentrations for parameters collected in the Conata Basin, Pennington County and Kadoka, Jackson County, South Dakota in 2006.

Parameter	Average Concentration (Conata Basin) (mg/L)	Average Loading (Conata Basin) (kg)	Average Concentration (White River) (mg/L)
Total Suspended Solids	14,116	1,903,723	9,789
Volatile Total Suspended Solids	1,144	165,734	-****
	(cfu/100 ml)		(cfu/100 ml)
Fecal Coliform Bacteria* **	19,572	-	4,277
E. coli* Bacteria*	2,123	-	-

* = All loads based on data collected over 0.559 yr (204 days).
** = *E. coli* concentrations from May through September were underestimated due to laboratory analysis procedures.
*** = Fecal coliform concentration data from May through September (fecal coliform season)
**** = Volatile total suspended solids are not a routine sample parameter at WQM monitoring sites

Although TSS and fecal coliform standards do not apply to waters in the Conata Basin, comparisons to White River standards were used for reference purposes. TSS concentrations in the basin exceeded the proposed site specific criterion for warmwater semi-permanent fish life propagation standard by 14.1 percent. Fecal coliform concentrations (based on the White River standard) exceeded the criterion for limited contact recreation waters 83.3 percent of the time from May through September. However, WQM data collected from the White River near Kadoka show TSS concentrations were below listing criteria (less than ten percent of the samples exceed the water quality standard over the previous five year period) based on the proposed site-specific standard (24,300 mg/L). Fecal coliform bacteria in the White River at Kadoka exceeded listing criteria based on current water quality standards for limited contact recreation waters 40 percent of the time. Due to the relatively small amount of water that passes through these sub watersheds compared to the White River, there is most likely little impact to the TSS and fecal coliform loading TMDLs being developed for the White River.

One of the major goals of the project was to document TSS and VTSS contributions from watersheds in the Conata Basin with a variety of land uses to estimate general loading from watersheds within White River Group formations. Project data indicate that statistical variability observed in TSS and VTSS concentrations collected during this study did not translate into significant differences in loading rates for either parameter by site or grouped by land use type.

Spatially, monitored watersheds in the Conata Basin comprised four tenths of one percent of the total area of reach 7 of the White River (receiving waterbody for the Conata Basin). Total TSS loading for all monitored watersheds in the Conata Basin comprised six tenths of one percent of the estimated TSS load over (0.559 years) and three tenths of one percent of the estimated average annual load for reach 7 of the White River at Kadoka. For comparison, the overall average TSS loading per acre for monitored watersheds in the Conata Basin (10,725 acres) was 1,065 kg/acre while the overall average loading for reach 7 of the White River (2,552,790 acres) at Kadoka over 0.559 years was 788 kg/acre, 1,410 kg/acre annually. Overall sediment loading during the study was highly variable and numerically higher in prairie dog watersheds but not significantly. Study results suggest that non-impacted (control), prairie dog and grazed watersheds do not appear to significantly increase overall TSS loading to the White River.

The scope of this study did not attempt to monitor sediment runoff in watersheds with multiple stressors; however, watershed CBCPDT-5, initially thought to have only livestock grazing also contained three prairie dog colonies, based on 2006 SD GF&P prairie dog coverage and FSA (Farm Service Agency) flyover GIS layers. Grazed watersheds ownership was comprised of Badlands National Park, private land and a portion of CBCPDT-6 was on US Forest Service grazing allotment land. Although not specifically targeted, TSS loading from the CBCPDT-5 watershed should indicate relative sediment loading from multiple sources (prairie dog colonies and livestock grazing) at least with respect to relative magnitude. As mentioned previously, no significant differences in TSS loading were observed during this study. However, numerically, total TSS loading in the CBCPDT-5 watershed, with multiple stressors, had almost twice as much loading as the livestock grazed only watershed (CBCPDT-6). Grazed watershed CBCPDT-6 had 20.7 percent more watershed area (acres) and received 8.5 percent less precipitation than did CBCPDT-5. Data from CBCPDT-5 suggests that increased grazing pressure with prairie dogs and livestock grazing the same resource may increase total TSS loading. Further studies are needed to elucidate trends.

The other major goal of this study was to allocate and assign sources of fecal coliform in the White River based on stakeholder concerns. Source tracking data collected from May through September during the Conata Basin and White River assessments show that one and six tenths percent of the fecal coliform bacteria sampled from the Conata Basin and six-tenths of one percent of the fecal coliform samples collected from the White River in 2005 originated from prairie dogs. Source tracking results from this assessment and the White River do not appear to support stakeholder concerns that the major source of viable fecal coliform in the White River originates from prairie dogs.

Source tracking results from this study tend to suggest that *E. coli* bacteria from prairie dogs may have limited viability (short-lived) at least under environmental conditions in the White River basin. *E. coli* and PFGE data from prairie dogs appears to be limited, further research is recommended to increase data availability and further develop and refine sediment fecal interactions in highly turbid systems such as the White River. Research is needed to verify the fecal decay coefficient for the unique conditions that make up the Conata Basin and White River watersheds.

REFERENCES CITED

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

APHA. 1998. Standard Methods for the Examination of Water and Wastewater, 21 Edition. United Book Press, Inc., Baltimore. Maryland. 1,185 pp.

APHA. 2005. Standard Methods for the Examination of Water and Wastewater, 21 Edition. United Book Press, Inc., Baltimore. Maryland. 1,362 pp.

ARSD. 74:51. 2004. South Dakota Surface Water Quality Rules. South Dakota Department of Environment and Natural Resources, Pierre, South Dakota. 88 pp.

Daubenmire, R. F. 1959. A canopy-coverage method of vegetational analysis. *Northwest Science* 33:43-66.

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

RESPEC. 2007. Phase I Environmental Assessment of the White River Watershed White River, South Dakota. RESPEC Consulting Services, Rapid City, South Dakota *for* South Dakota Department of Environment and Natural Resources, Pierre South Dakota. 253 pp.

SD DENR. 1998. Non-point Source Quality Assurance Project Plan. South Dakota Department of Environment and Natural Resources, Pierre, South Dakota. 41 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.

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 – Public Health Laboratory.

Schumm, S.A., M.D. Harvey, and C.C. Watson. 1984. Incized 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. 2006. Phase I Watershed Assessment Report for the Little White River, Mellette County, South Dakota. South Dakota Department of Environment and Natural Resources, Pierre, South Dakota. 272 pp.

Smith, R.L. 2008. Phase I Watershed Assessment Report and TMDL Cottonwood Creek, Mellette County, South Dakota. Unpublished data. South Dakota Department of Environment and Natural Resources, Pierre, South Dakota.

Stoltenburg, M.B. 2004. Effects of Prairie Dogs on Plant Community Composition and Vegetation Disappearance in Mixed-Grass Prairie. Masters Thesis. South Dakota State University, Brookings. South Dakota. 87 pp.

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

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

Appendix A

Stage/Discharge Relationships for Watersheds in the Conata Basin in 2006

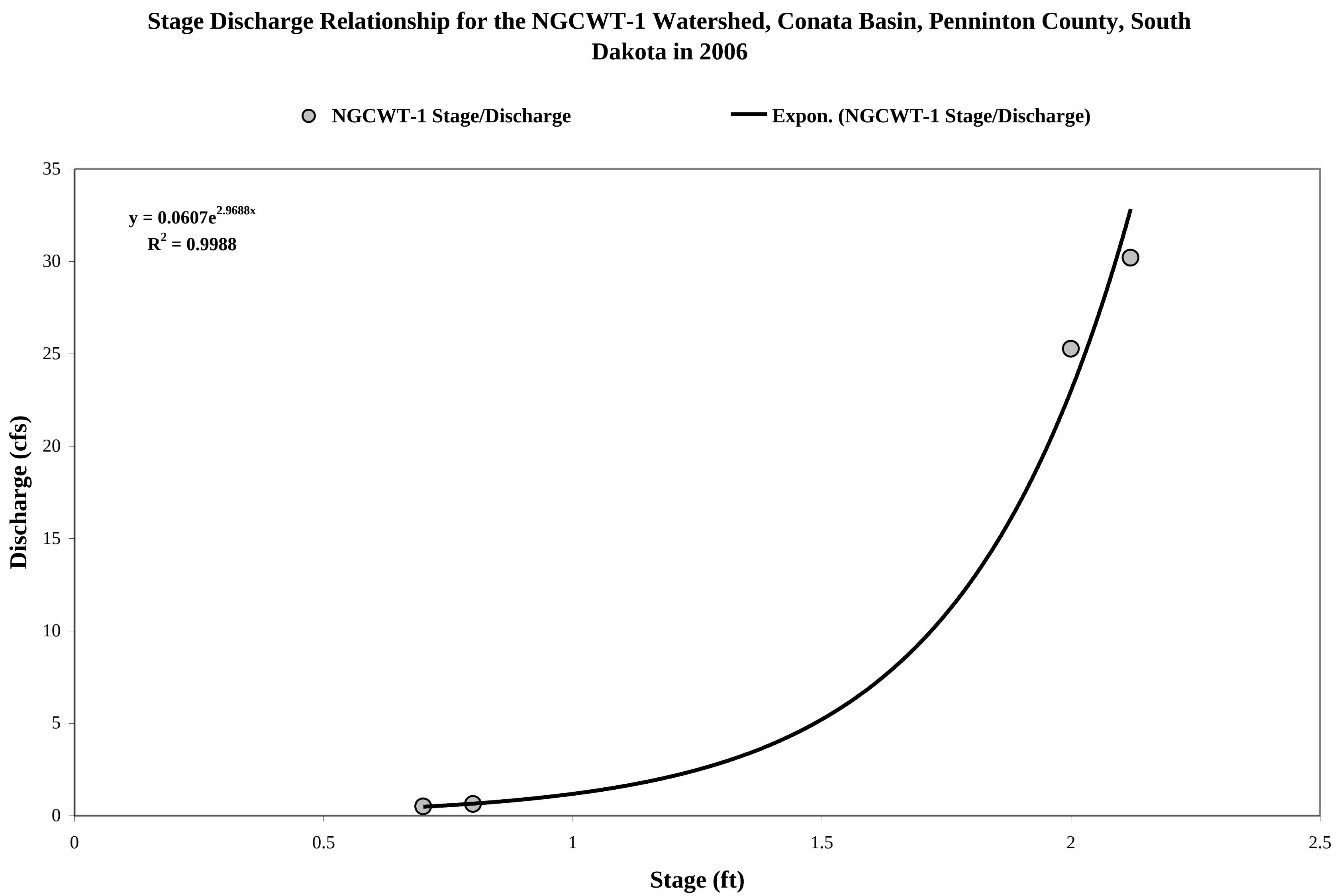

Figure A- 1. Stage/discharge relationship for the NGCWT-1 watershed in the Conata Basin in 2006.

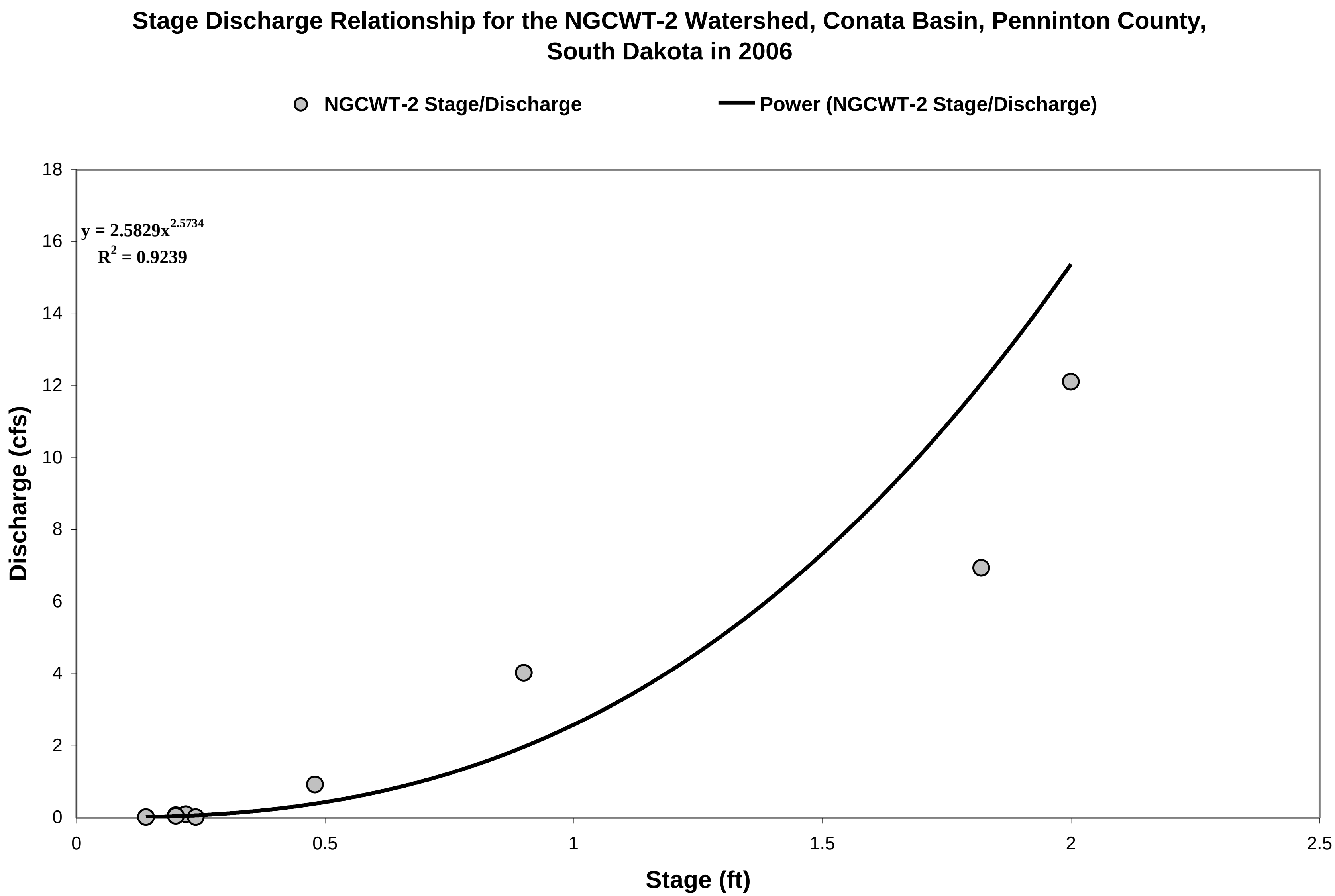

Figure A- 2. Stage/discharge relationship for the NGCWT-2 watershed in the Conata Basin in 2006.

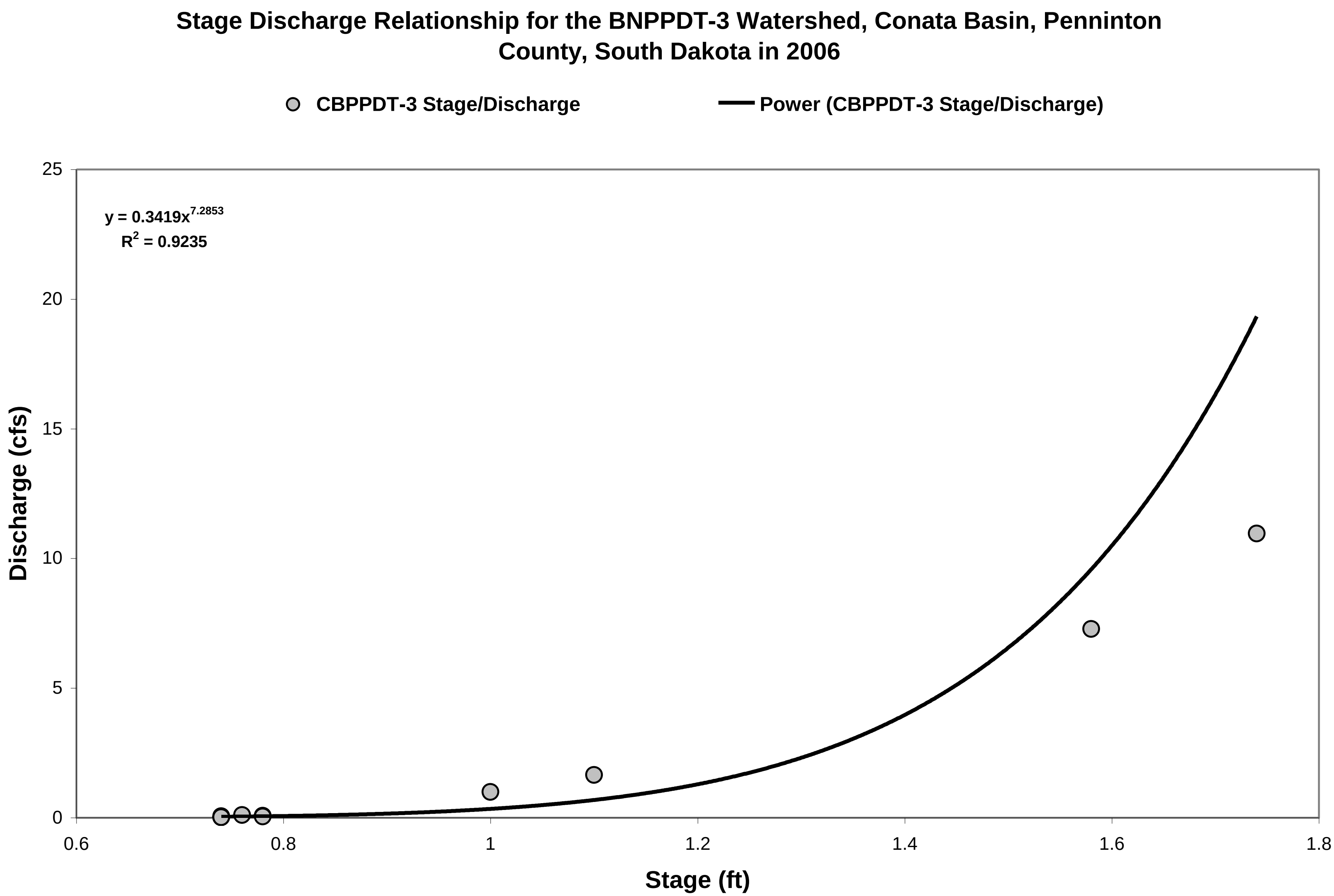

Figure A- 3. Stage/discharge relationship for the BNPPDT-3 watershed in the Conata Basin in 2006.

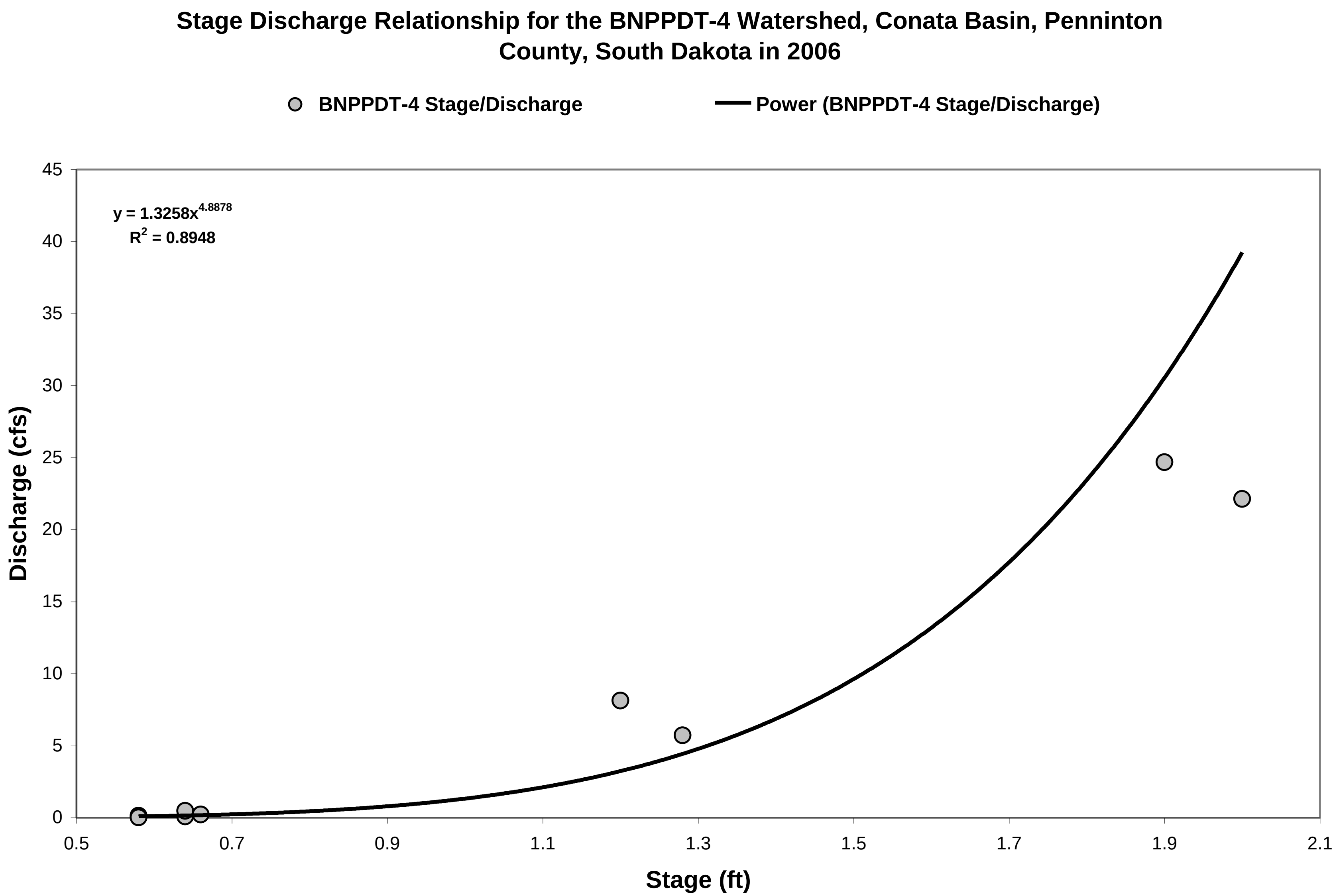

Figure A- 4. Stage/discharge relationship for the BNPPDT-4 watershed in the Conata Basin in 2006.

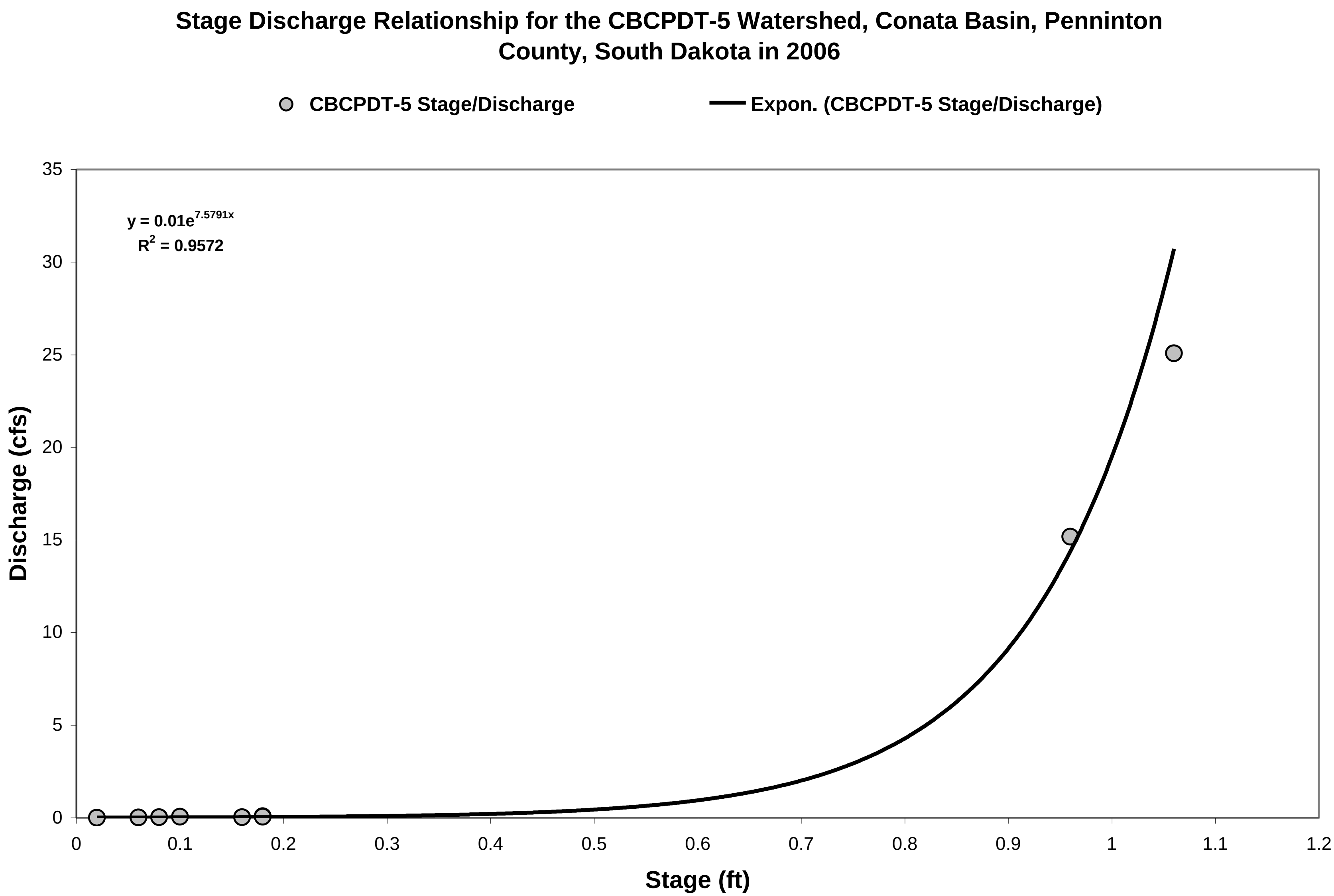

Figure A- 5. Stage/discharge relationship for the CBCPDT-5 watershed in the Conata Basin in 2006.

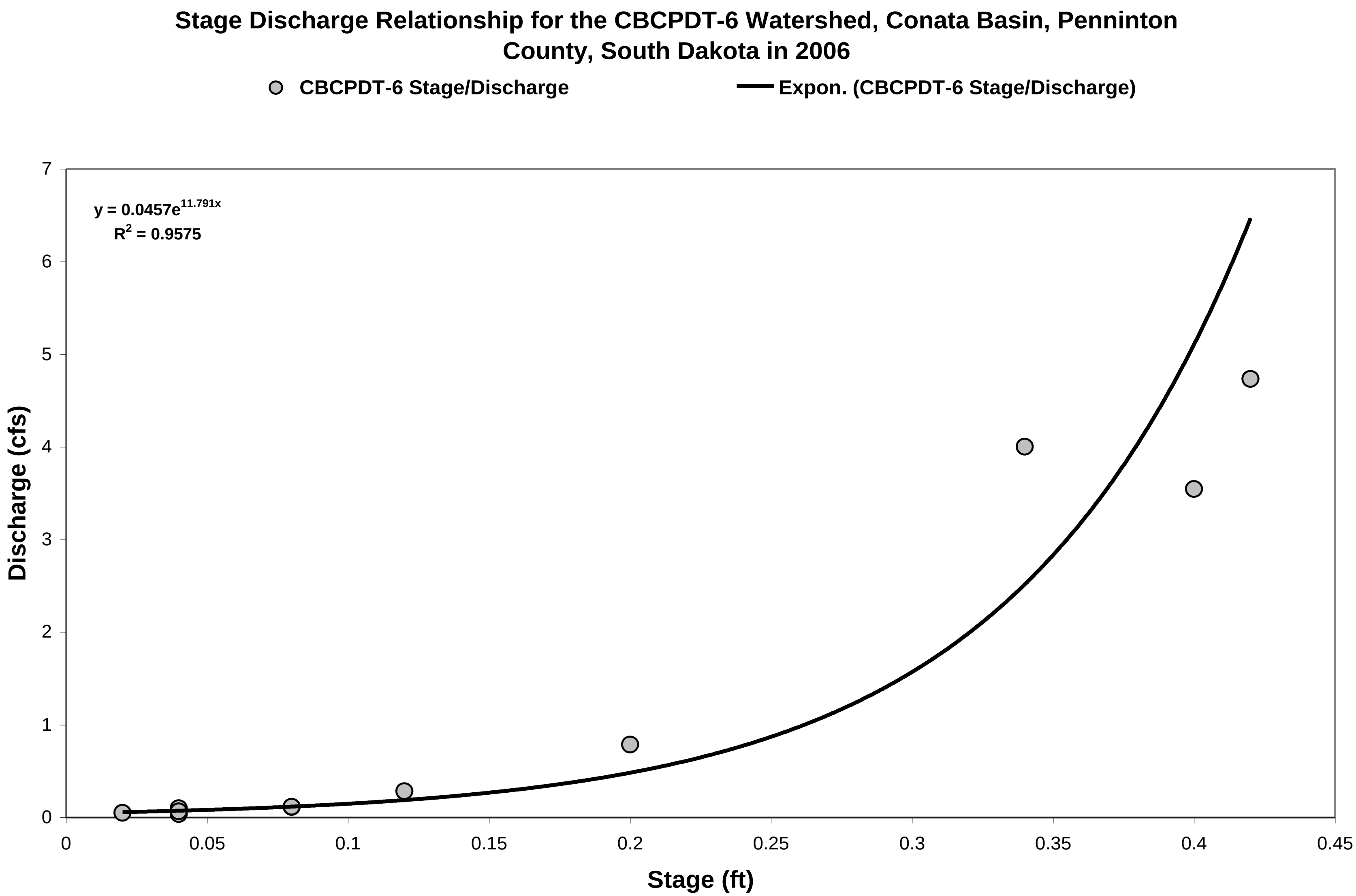

Figure A- 6. Stage/discharge relationship for the CBCPDT-6 watershed in the Conata Basin in 2006.

Appendix B

2006 Water Quality Data for the Conata Basin Watershed Project

Table B-1. Water quality data for the Conata Basin watershed project.

Site	Date	Precipitation (mm)	Air Temperature °C	Water Temperature °C	Wind Speed (mph)	Snow Depth (m)	Width (m)	Discharge (cfs)	Dissolved Oxygen (mg/L)	Dissolved Oxygen Percent (%)	Conductivity (µS/cm)	Specific Conductance (µS/cm)	pH (su)	Total Suspended Solids (mg/L)	Volatile Total Suspended Solids (mg/L)	Total Organic Carbon (mg C/L)	Fecal Coliform Bacteria* (# colonies/100 ml)	E.-coli Bacteria (# colonies/100 ml)
NGCWT-1	03/27/2006	5.1	1.70	2.10		0.1	1.82	4.60	12.62		168			2,830	280	6.83	5	3
NGCWT-1	03/30/2006	5.1	7.20	9.26	30	0.0	1.52	30.19						13,200	1,200	2.85	5	13
NGCWT-1	04/06/2006	2.5	7.20	10.42	8	0.0	0.49	0.01	3.09	29.2		492		3,700	270	2.14	5	21
NGCWT-1	04/07/2006	5.6	4.40	8.26	16	0.0	0.70	0.11	14.79	132.6		485		19,200	1,700	6.89	240	326
NGCWT-1	04/19/2006	17.8	5.00	7.35	30	0.0	1.01	0.50					7.45	16,600	1,400	4.10	1,300	980
NGCWT-1	04/25/2006	8.1	10.00	10.76	2	0.0	0.61	25.27	11.48	109.2		377	7.49	695	60	16.30	880	1,300
NGCWT-1	06/07/2006	5.1	23.50	21.00	16	0.0	0.58	0.01	7.64	83.3	344	374	8.67	11,200	1,200	12.00	4,900	2,420
NGCWT-1	08/18/2006	6.1	20.00	21.00	2	0.0	0.34	0.01				724	8.84	33,800	2,800			
NGCWT-1	08/09/2006	2.3	20.00	21.19	2	0.0	0.64	0.02				375	9.05	42,400	4,600	49.70	44,000	2,420
NGCWT-1	08/22/2006	3.8	17.50	21.17	8	0.0	1.25	0.63				636	9.35	70,500	1,500		39,000	2,420
NGCWT-1	08/28/2006	22.9	17.5	16.16	2	0.0	0.61	0.06				662	8.88	17,400	1,900		28,000	2,420
NGCWT-1	09/24/2006	43.2	9.00	8.95	8	0.0	0.46	0.00				569	8.93	17,200	1,000		3,000	1,990
NGCWT-2	03/27/2006	0.0	3.50	0.40	16	0.2	1.98	6.93			149			48,400	2,800	6.12	140	411
NGCWT-2	03/30/2006	4.3	4.40	10.59	26	0.0	0.99	0.92						4,500	400	2.82	5	2
NGCWT-2	04/07/2006	8.6	-3.90	3.90	26	0.0	0.61	0.06	14.28	114.8		481		14,900	1,700	9.31	110	69
NGCWT-2	04/19/2006	11.7	5.00	3.63	30	0.0	0.53	0.01					7.24	18,100	1,300	6.08	500	411
NGCWT-2	04/25/2006	17.8	5.00	9.18	2	0.0	1.43	4.02	11.39	104.4		238	7.49	9,100	2,100	3.70	20	10
NGCWT-2	06/07/2006	0.0	20.00	19.28	8	0.0	0.40	0.02	8.06	85.7	225	251	8.41	6,800	850	8.51	1,700	1,410
NGCWT-2	06/08/2006	2.5	17.50	18.78	16	0.0	0.34	0.01	5.03	56.9		506		11,600	800	9.25	420	461
NGCWT-2	08/22/2006	3.3	17.50	20.70	2	0.0	0.52	0.04				218	9.15	9,850	350		32,000	2,420
NGCWT-2	08/28/2006	22.9	15.00	15.79	2	0.0	0.30	0.04				744	7.94	9,200	900		25,000	2,420
BNPPDT-3	03/29/2006	9.1	4.44	7.87	2	0.0	2.44	1.65						1,960	200	3.52	10	16
BNPPDT-3	04/03/2006	0.8	7.20	9.64	2	0.0	1.83	0.06						3,080	230	4.61	10	2
BNPPDT-3	04/06/2006	7.1	7.20	10.99	8	0.0	1.83	0.02	8.89	85.1		213		1,460	100	4.12	5	4
BNPPDT-3	04/07/2006	13.7	5.00	9.52	16	0.0	0.30	0.99	14.18	131.3		361		1,020	65	4.68	330	461
BNPPDT-3	04/20/2006	17.8	5.00	4.67	16	0.0	1.56	0.07	11.43	93.7		508	7.20	3,400	240	6.02	250	272
BNPPDT-3	04/25/2006	15.7	5.00	15.60	2	0.0	2.77	10.96	9.40	99.9		314	7.84	10,100	800	4.63	180	194
BNPPDT-3	05/30/2006	12.7	17.50	17.37	2	0.0	0.64	0.08	7.26	75.6	431	510	6.89	15,100	2,000	7.91	8,700	2,420
BNPPDT-3	06/12/2006	12.7	17.50	17.97	2	0.0	1.89	0.02	6.68	74.5		492		7,750	550	6.29	4,800	2,420
BNPPDT-3	08/27/2006	17.5	15.00	18.30	8	0.0	2.71	7.28				412	9.30	18,900	1,200		34,000	2,420
BNPPDT-3	09/24/2006	45.7	12.50	15.31	8	0.0	1.56	0.04				447	8.95	30,600	2,400		2,900	2,420
BNPPDT-4	03/29/2006	7.6	7.20	11.86	2	0.0	3.05	8.13						7,750	650	2.18	10	24
BNPPDT-4	04/03/2006	0.5	8.30	12.25	2	0.0	1.83	0.14	9.96	98.2		247		8,600	650	2.93	10	11
BNPPDT-4	04/06/2006	7.1	4.44	11.00	8	0.0	1.83	0.22	8.87	85.1		213		9,900	900	6.51	310	727
BNPPDT-4	04/07/2006	11.7	8.00	11.85	8	0.0	1.70	0.47	13.86	135.4		419		2,500	280	6.31	310	461
BNPPDT-4	04/10/2006	0.0	15.00	14.90	8	0.0			8.70	91.0		308		3,160	280			
BNPPDT-4	04/20/2006	22.9	5.00	5.47	16	0.0	1.74	0.03	11.19	93.6		578	7.34	47,700	4,000	23.80	5	42
BNPPDT-4	04/25/2006	13.7	7.50	13.02	2	0.0	3.99	24.68	10.26	103.0		342	7.63	15,600	1,600	3.48	50	36
BNPPDT-4	08/18/2006	5.6	20.00	21.05		0.0	1.43	0.01				277	9.19	11,700	1,400			
BNPPDT-4	08/08/2006	3.8	22.50	24.13	8	0.0	3.35	22.12				602	9.32	76,000	6,500	1.24	71,000	2,420
BNPPDT-4	08/09/2006	0.0	30.00	30.28	2	0.0	1.39	0.01			597		8.98	15,900	1,700		55,000	2,420
BNPPDT-4	08/22/2006	8.1	17.50	19.31	2	0.0						368	9.46	9,700	700		9,800	2,420
BNPPDT-4	08/27/2006	18.3	15.00	18.24	8	0.0	2.38	5.72				520	9.15	18,600	1,600		31,000	2,420
BNPPDT-4	09/24/2006	40.6	12.50	16.24	8	0.0	1.33	0.02				625	8.97	3,700	230		1,600	594
CBCPDT-5	03/28/2006	10.2	5.00	10.44	2	0.0	3.96	25.07				307		20,400	1,800	3.36	120	197
CBCPDT-5	04/04/2006	3.6	10.00	1.21	2	0.0	1.80	0.02	12.90	96.7				144	11	2.09	5	24
CBCPDT-5	04/05/2006	0.0	20.00	18.91	2	0.0	0.91	0.01						212	16	3.89	5	7
CBCPDT-5	04/07/2006	17.8	10.00	12.54	8	0.0	1.80	1.32	13.20	131.3		410		9,850	800	5.13	160	178
CBCPDT-5	04/18/2006	8.1	5.00	6.42	30	0.0	0.82	0.08						8,900	600	7.12	9,000	2,420
CBCPDT-5	04/26/2006	29.2	5.00	5.31	8	0.0	1.31	0.05	12.33	103.1		440	7.02	2,400	260	3.49	2,300	2,420
CBCPDT-5	08/08/2006	9.7	22.50	22.77	2	0.0						601	9.40	40,400	3,800	1.35	5,400	2,420
CBCPDT-5	08/27/2006	22.9	17.50	17.89	8	0.0	3.57	15.17				419	9.47	17,600	2,000		16,000	2,420
CBCPDT-5	09/24/2006	34.8	12.50	16.10	8	0.0	1.62	0.02				540	8.85	66,200	3,600		8,600	2,420
CBCPDT-6	03/28/2006	9.7	1.00	7.12	29	0.0	8.84	4.00	11.45	100.3		267		3,600	400	2.67	10	25
CBCPDT-6	04/03/2006	4.8	4.44	6.47	2	0.0	3.05	0.28		97.3		233		2,360	200	3.37	20	17
CBCPDT-6	04/05/2006	0.0	15.60	18.30	2	0.0	0.94	0.04						1,590	125	4.23	5	5
CBCPDT-6	04/07/2006	7.6	10.00	9.89	2	0.0	8.53	4.73	13.94	130.4		414		3,770	300	5.69	40	29
CBCPDT-6	04/10/2006	0.0	10.00	10.71	2	0.0	1.10	0.05	10.51	100.4		608		1,440	170	16.90	5	9
CBCPDT-6	04/20/2006	10.2	5.00	14.55	16	0.0	0.95	0.11	8.94	93.0		347	7.60	6,100	340	7.76	20	9
CBCPDT-6	04/26/2006	6.1	10.00	14.27	8	0.0	5.03	0.79	10.07	104.1		397	7.33	2,420	300	5.03	20	17
CBCPDT-6	06/01/2006	20.3	22.50	28.20	8	0.0	1.10	0.12	4.40	59.8		572	7.67	1,480	180	15.60	900	517
CBCPDT-6	08/18/2006	6.1	20.00	20.61	16	0.0						230	8.52	2,900	300			
CBCPDT-6	08/28/2006	40.6	20.00	21.48	2	0.0	6.95	3.55				587	9.07	1,350	120		18,000	2,420
CBCPDT-6	09/24/2006	36.8	12.50	18.20	16	0.0	2.32	0.08				569	8.77	4,950	500		24,000	2,420

*** Value of 5 = ½ the detection limit for fecal coliform bacteria**

Appendix C

Statistical Tables for the Conata Basin Watershed Project in 2006

Table C-1. Monthly pH values for watershed in the Conata Basin, Pennington County, South Dakota in 2006

Depend.: pH	Multiple Comparisons z' values; pH Independent (grouping) variable: Month Kruskal-Wallis test: H (4, N= 36) =27.47756 p =.0000				
	April R:7.0909	May R:1.0000	June R:14.667	August R:27.250	September R:21.400
April		1.00000	1.00000	0.00001	0.11799
May	1.00000		1.00000	0.15642	0.77131
June	1.00000	1.00000		0.57649	1.00000
August	0.00001	0.15642	0.57649		1.00000
September	0.11799	0.77131	1.00000	1.00000	

Table C-2. TSS concentration (mg/L) comparisons between watersheds for the Conata Basin, Pennington County, South Dakota in 2006.

Depend.: TSS	Multiple Comparisons p values (2-tailed); TSS (Conata Basin) Independent (grouping) variable: Site Kruskal-Wallis test: H (5, N= 64) =15.51895 p =.0084					
	NGCWT-1 R:41.458	NGCWT-2 R:38.500	BNPPDT-3 R:27.650	BNPPDT-4 R:37.769	CBCPDT-5 R:34.056	CBCPDT-6 R:14.727
NGCWT-1		1.00000	1.00000	1.00000	1.00000	0.00874
NGCWT-2	1.00000		1.00000	1.00000	1.00000	0.06752
BNPPDT-3	1.00000	1.00000		1.00000	1.00000	1.00000
BNPPDT-4	1.00000	1.00000	1.00000		1.00000	0.03781
CBCPDT-5	1.00000	1.00000	1.00000	1.00000		0.31364
CBCPDT-6	0.00874	0.06752	1.00000	0.03781	0.31364	

Table C-3. Monthly TSS concentration comparisons collected from the Conata Basin, Pennington County, South Dakota in 2006.

Depend.: TSS	Multiple Comparisons p values (2-tailed); TSS Independent (grouping) variable: Month Kruskal-Wallis test: H (5, N= 60) =13.86720 p =.0165					
	March R:29.938	April R:23.286	May R:41.000	June R:26.900	August R:43.423	September R:39.700
March		1.00000	1.00000	1.00000	1.00000	1.00000
April	1.00000		1.00000	1.00000	0.00886	0.79323
May	1.00000	1.00000		1.00000	1.00000	1.00000
June	1.00000	1.00000	1.00000		1.00000	1.00000
August	1.00000	0.00886	1.00000	1.00000		1.00000
September	1.00000	0.79323	1.00000	1.00000	1.00000	

Table C-4. VTSS concentration (mg/L) comparisons between watersheds for the Conata Basin, Pennington County, South Dakota in 2006.

	Multiple Comparisons p values (2-tailed); VTSS (Conata Basin) Independent (grouping) variable: Site Kruskal-Wallis test: H (5, N= 64) =14.11482 p =.0149					
Depend.: VTSS	NGCWT-1 R:39.417	NGCWT-2 R:40.500	BNPPDT-3 R:26.050	BNPPDT-4 R:38.038	CBCPDT-5 R:34.278	CBCPDT-6 R:16.273
NGCWT-1		1.000000	1.000000	1.000000	1.000000	0.043540
NGCWT-2	1.000000		1.000000	1.000000	1.000000	0.05687
BNPPDT-3	1.000000	1.000000		1.000000	1.000000	1.000000
BNPPDT-4	1.000000	1.000000	1.000000		1.000000	0.06485
CBCPDT-5	1.000000	1.000000	1.000000	1.000000		0.47155
CBCPDT-6	0.043540	0.05687	1.000000	0.06485	0.47155	

Table C-5. Monthly VTSS concentration (mg/L) comparisons for the Conata Basin, Pennington County, South Dakota in 2006.

	Multiple Comparisons p values (2-tailed); VTSS (Conata Basin) Independent (grouping) variable: Month Kruskal-Wallis test: H (5, N= 60) =12.02553 p =.0344					
Depend.: VTSS	March R:30.813	April R:23.679	May R:51.500	June R:28.000	August R:41.885	September R:36.900
March		1.000000	1.000000	1.000000	1.000000	1.000000
April	1.000000		1.000000	1.000000	0.028430	1.000000
May	1.000000	1.000000		1.000000	1.000000	1.000000
June	1.000000	1.000000	1.000000		1.000000	1.000000
August	1.000000	0.028430	1.000000	1.000000		1.000000
September	1.000000	1.000000	1.000000	1.000000	1.000000	

Table C-6. Monthly fecal coliform bacteria concentration (# cfu/100 ml) comparisons for the Conata Basin, Pennington County, South Dakota in 2006.

	Multiple Comparisons p values (2-tailed); Fecal Coliform Bac Independent (grouping) variable: Month Kruskal-Wallis test: H (5, N= 60) =43.73764 p =.0000					
Depend.: Fecal	March R:12.813	April R:20.804	May R:46.000	June R:38.000	August R:53.462	September R:42.800
March		1.000000	1.000000	0.17117	0.00000	0.03893
April	1.000000		1.000000	0.63820	0.000000	0.14220
May	1.000000	1.000000		1.000000	1.000000	1.000000
June	0.17117	0.63820	1.000000		1.000000	1.000000
August	0.00000	0.000000	1.000000	1.000000		1.000000
September	0.03893	0.14220	1.000000	1.000000	1.000000	

Table C-7. Monthly *E. coli* bacteria (cfu/100 ml) comparisons for the Conata Basin, Pennington County, South Dakota in 2006.

Depend.: Ecoli	Multiple Comparisons p values (2-tailed); Ecoli (grouping) variable: Month Kruskal-Wallis test: H (5, N= 60) =38.97658 p =.0000					
	March R:14.375	April R:21.071	May R:50.000	June R:40.400	August R:50.000	September R:44.600
March		1.00000	0.81678	0.13424	0.00008	0.03598
April	1.00000		1.00000	0.33948	0.00001	0.08281
May	0.81678	1.00000		1.00000	1.00000	1.00000
June	0.13424	0.33948	1.00000		1.00000	1.00000
August	0.00008	0.00001	1.00000	1.00000		1.00000
September	0.03598	0.08281	1.00000	1.00000	1.00000	

Table C-8. TSS concentration comparisons by watershed Type collected from the Conata Basin, Pennington County, South Dakota in 2006.

Depend.: TSS	Multiple Comparisons p values (2-tailed); TSS Independent (grouping) variable: type Kruskal-Wallis test: H (2, N= 60) =6.823567 p =.03		
	Control R:36.900	Prairie Dog R:31.690	Grazed R:22.447
Control		1.00000	0.02936
Prairie Dog	1.00000		0.28382
Grazed	0.02936	0.28382	

Table C-9. VTSS concentration comparisons by watershed Type collected from the Conata Basin, Pennington County, South Dakota in 2006.

Depend.: VTSS	Multiple Comparisons p values (2-tailed); VTSS Independent (grouping) variable: type Kruskal-Wallis test: H (2, N= 60) =6.000561 p =.04		
	Control R:36.775	Prairie Dog R:31.190	Grazed R:23.132
Control		0.91827	0.04423
Prairie Dog	0.91827		0.43500
Grazed	0.04423	0.43500	

Appendix D

2006 Arial Coverage for Selected Watersheds in the Conata Basin

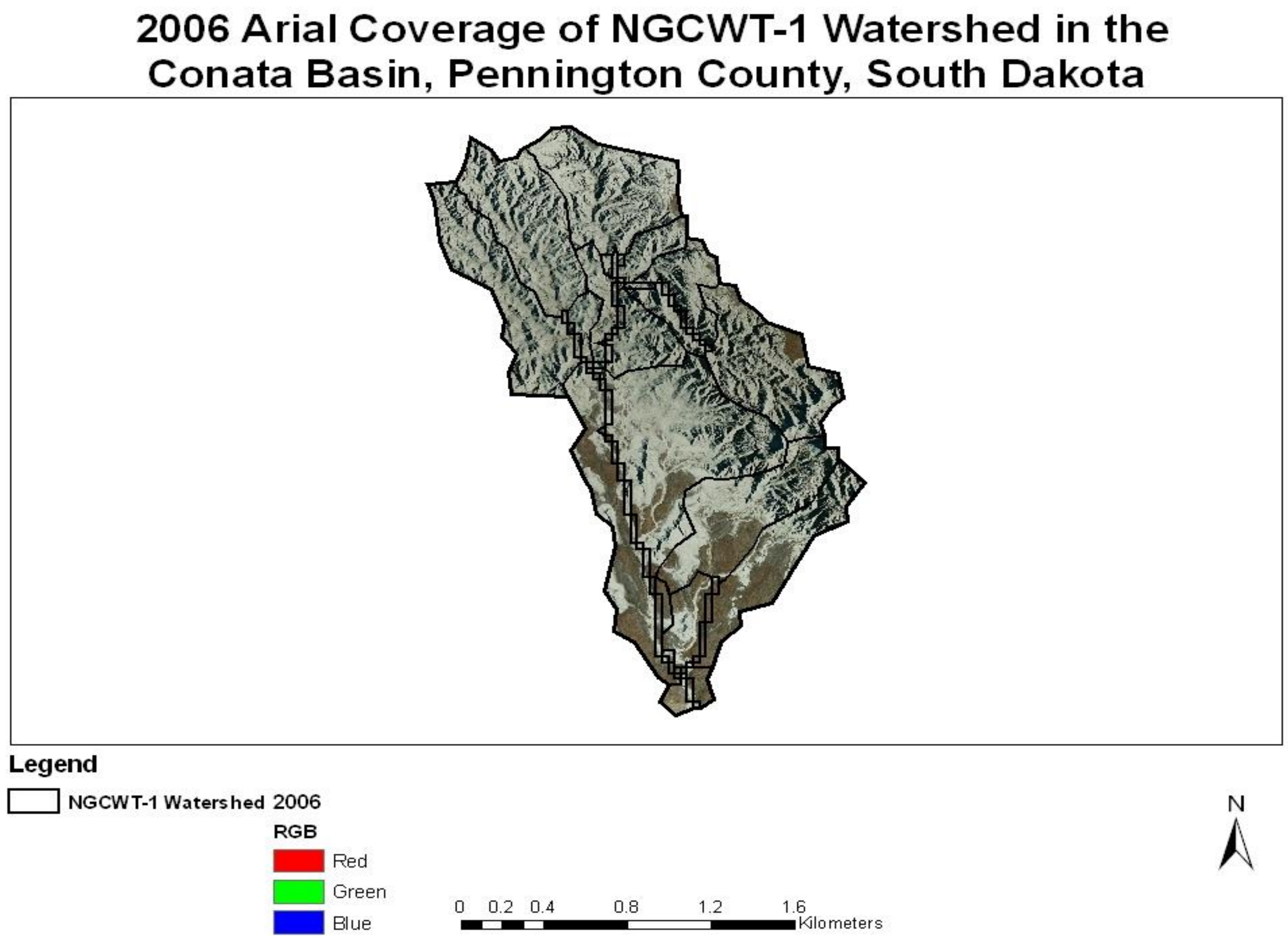

Figure D-1. Arial coverage of control watershed NGCWT-1 in the Conata Basin, Pennington County, South Dakota in 2006.

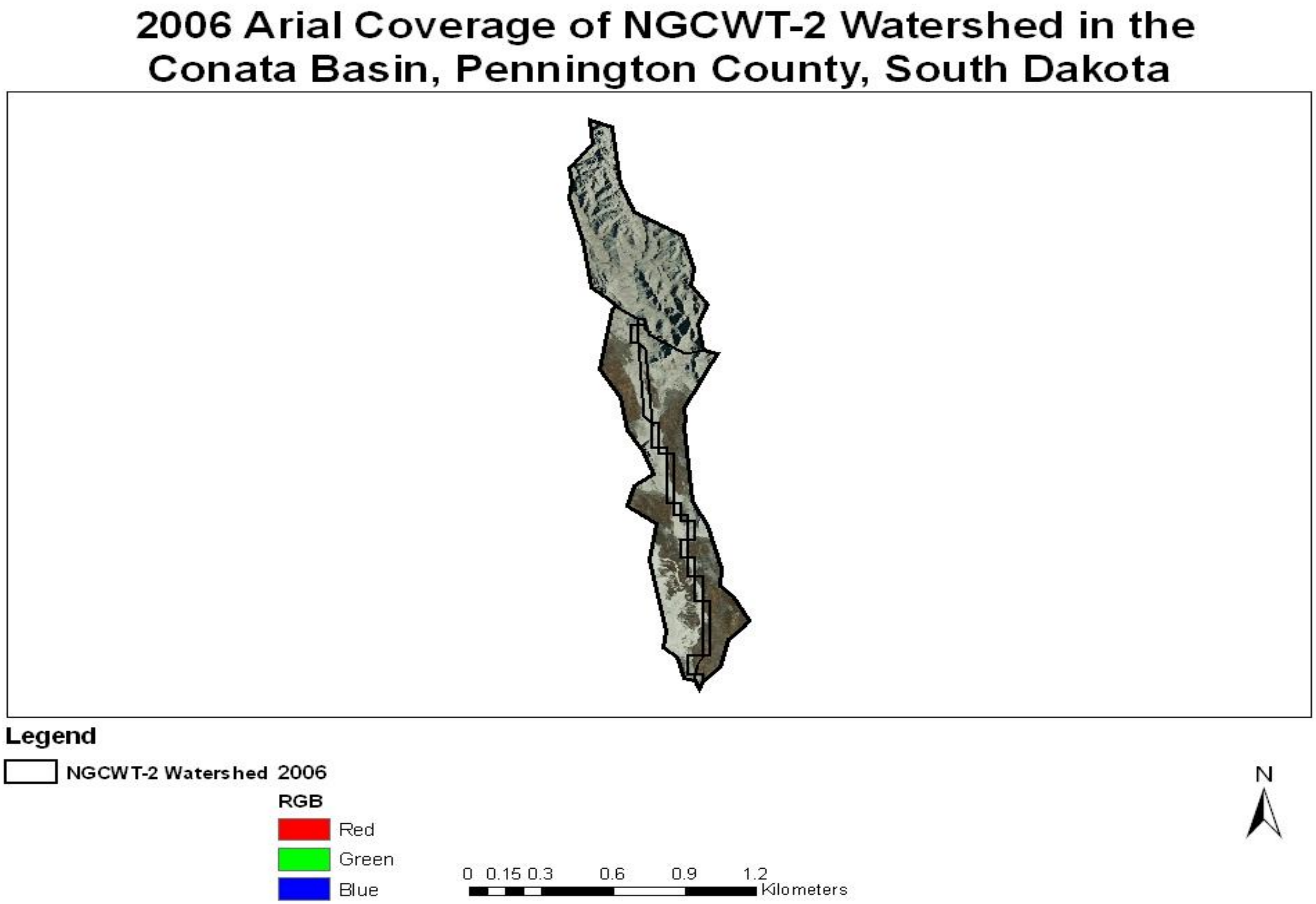

Figure D-2. Arial coverage of control watershed NGCWT-2 in the Conata Basin, Pennington County, South Dakota in 2006.

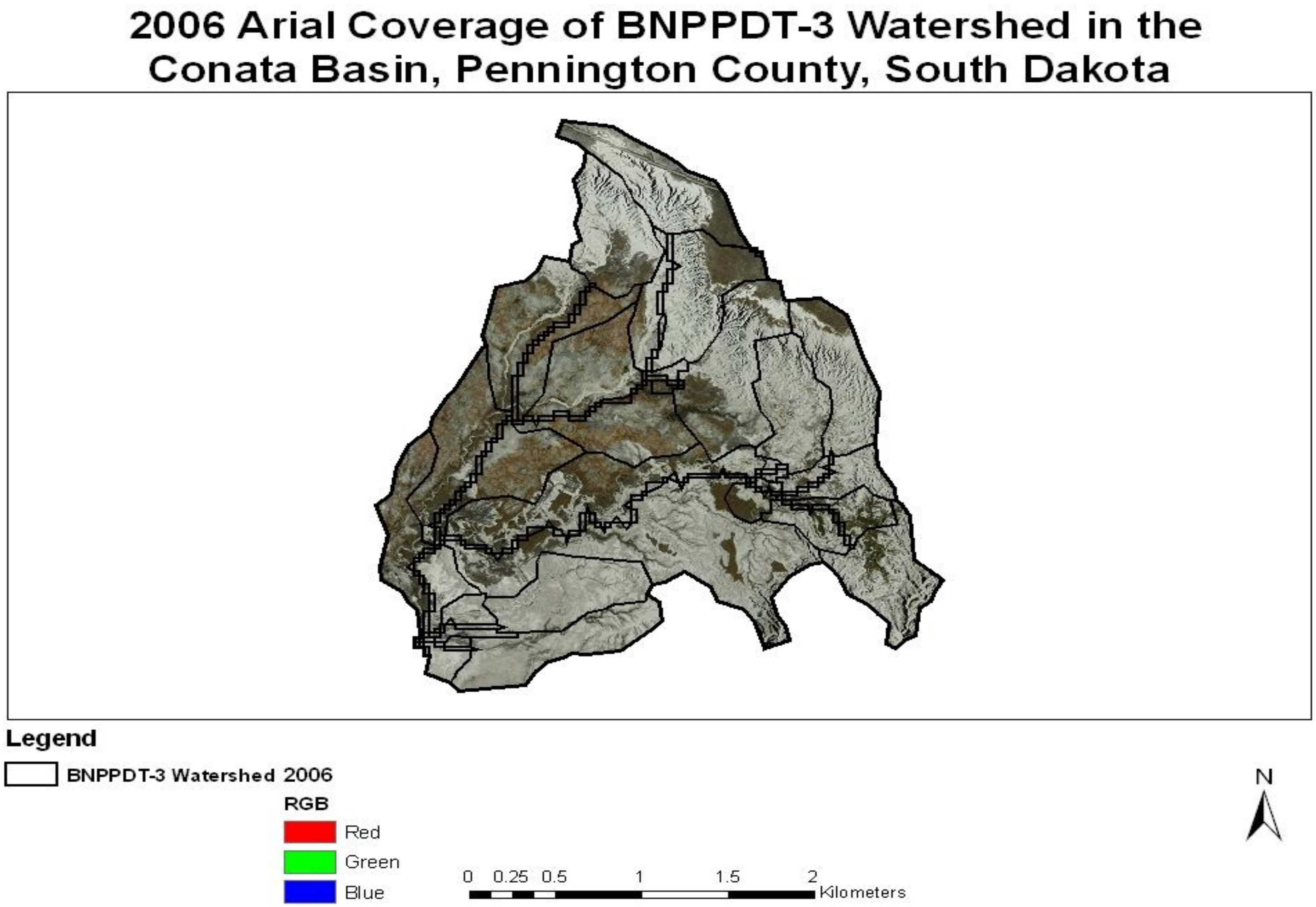

Figure D-3. Arial coverage of control watershed BNPPDT-3 in the Conata Basin, Pennington County, South Dakota in 2006.

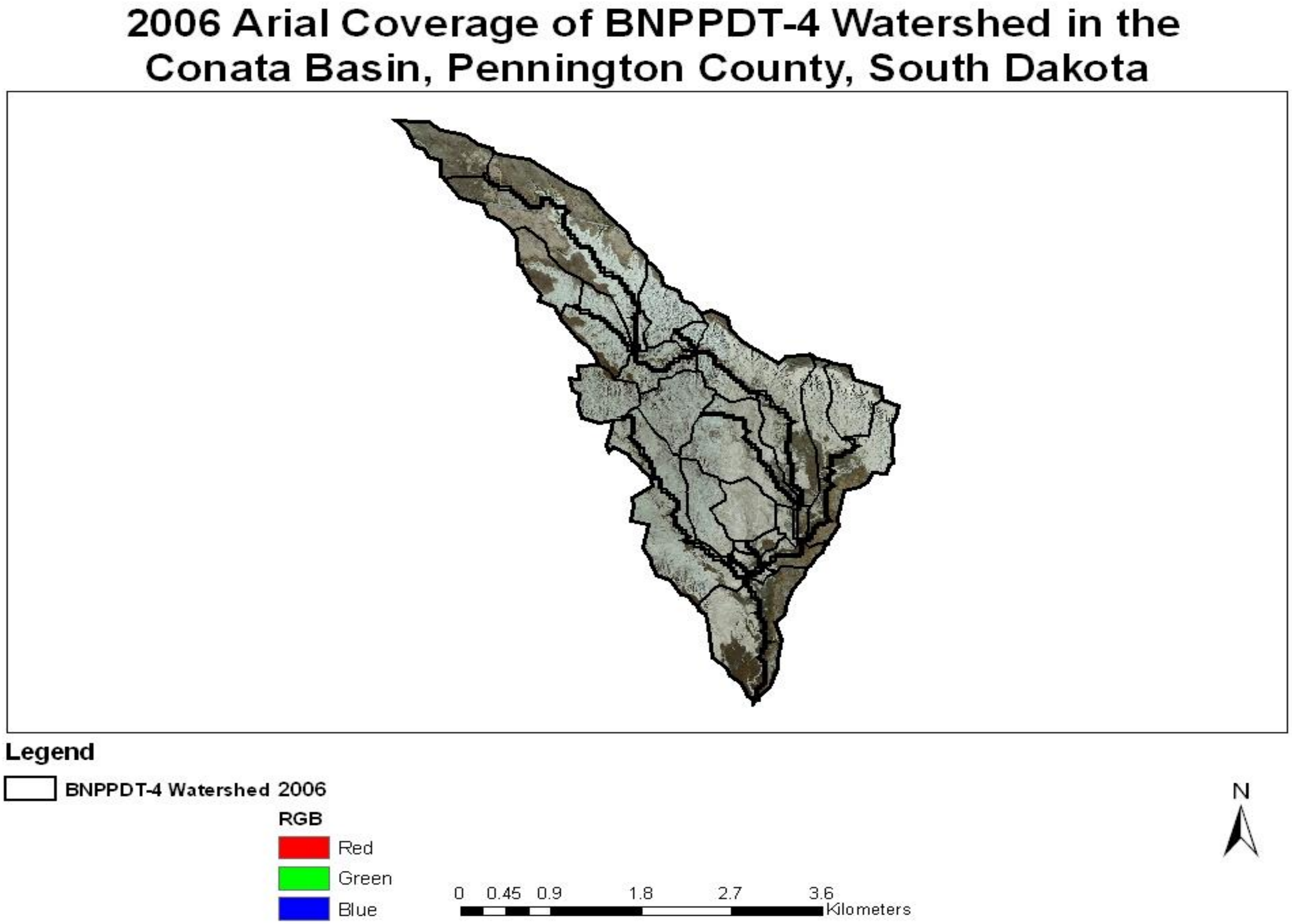

Figure D-4. Arial coverage of control watershed BNPPDT-4 in the Conata Basin, Pennington County, South Dakota in 2006.

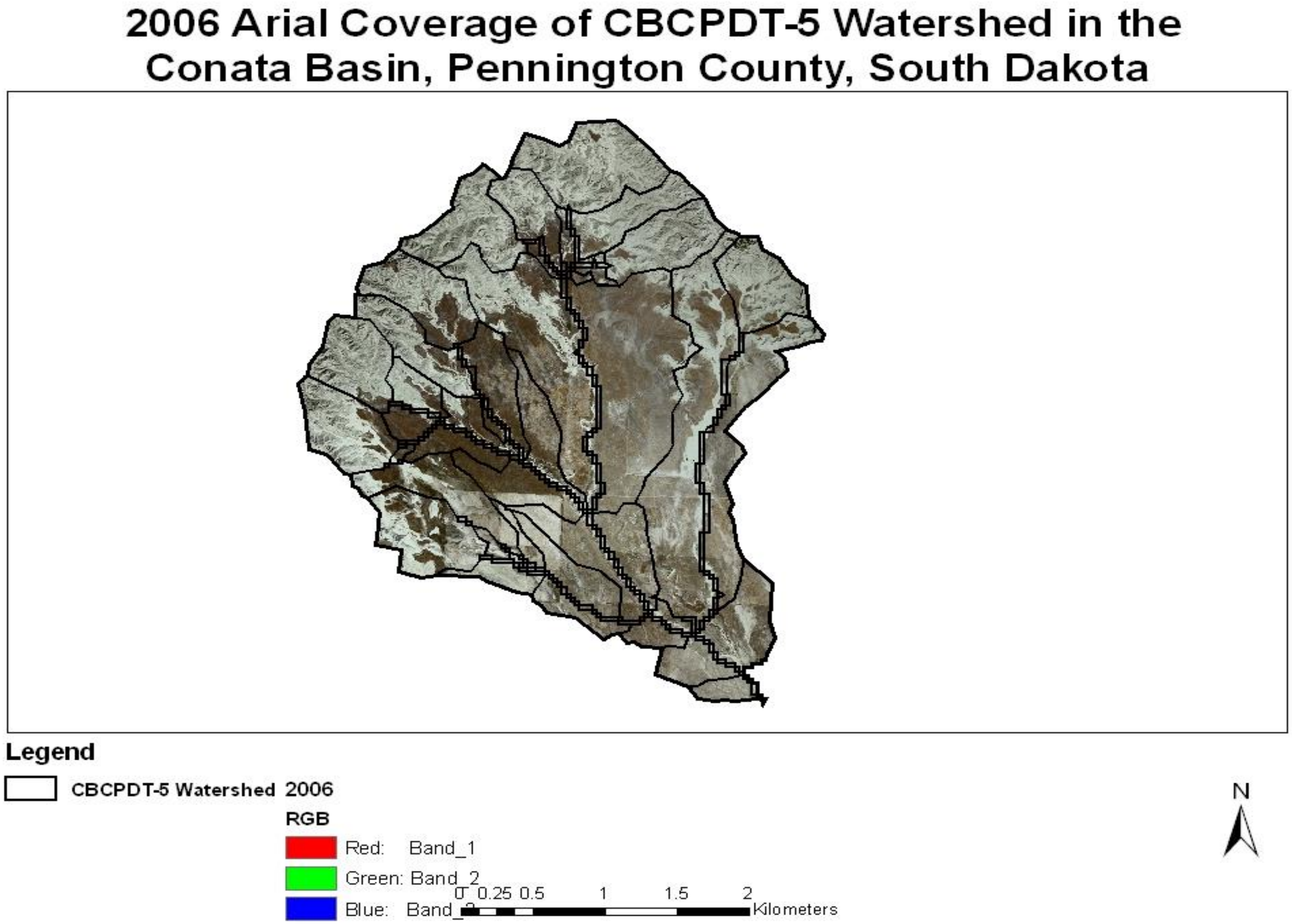

Figure D-5. Arial coverage of control watershed CBCPDT-5 in the Conata Basin, Pennington County, South Dakota in 2006.

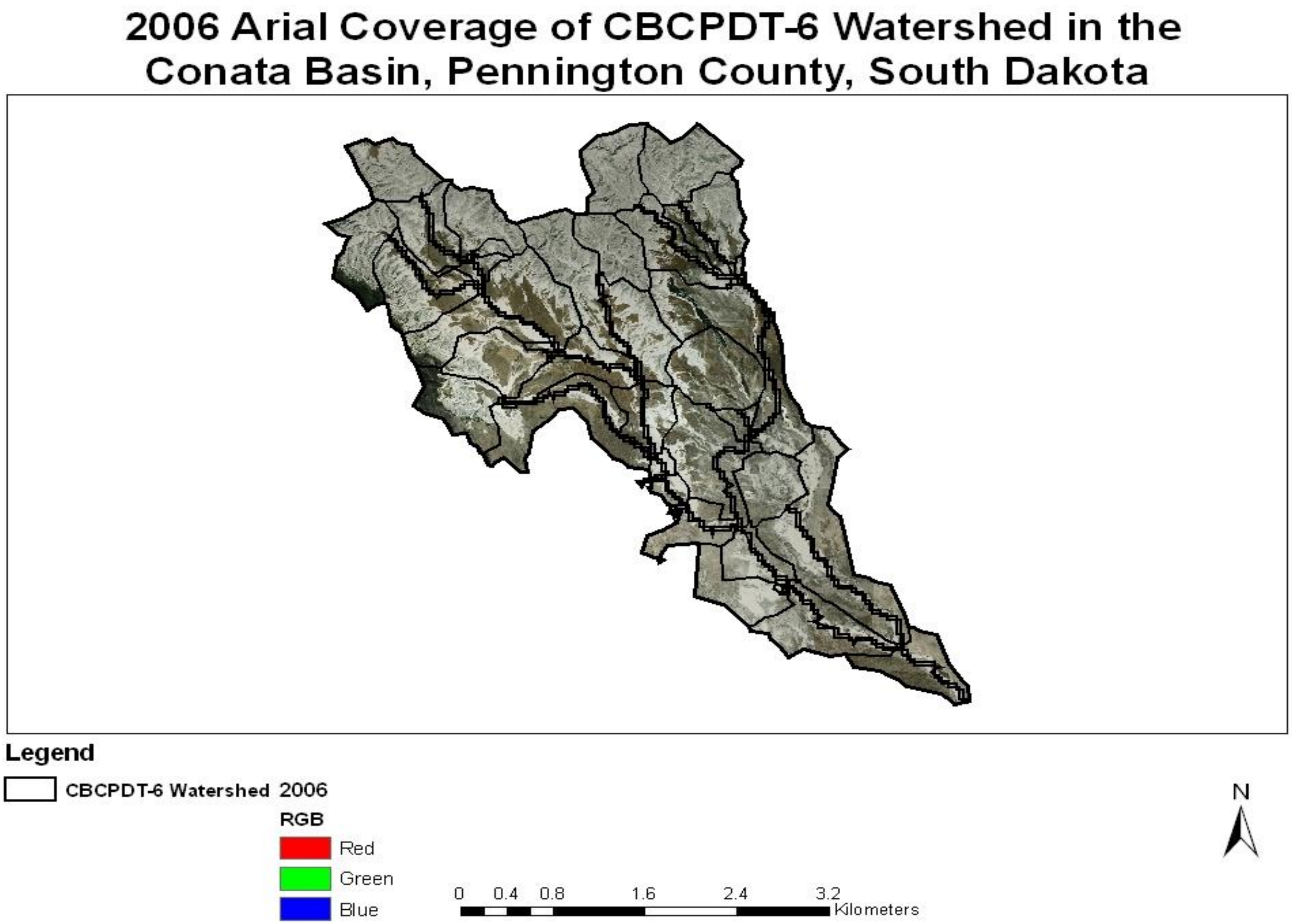

Figure D-6. Arial coverage of control watershed CBCPDT-6 in the Conata Basin, Pennington County, South Dakota in 2006.

Appendix E

2006 Vegetative Transect Locations for Selected Watersheds in the Conata Basin

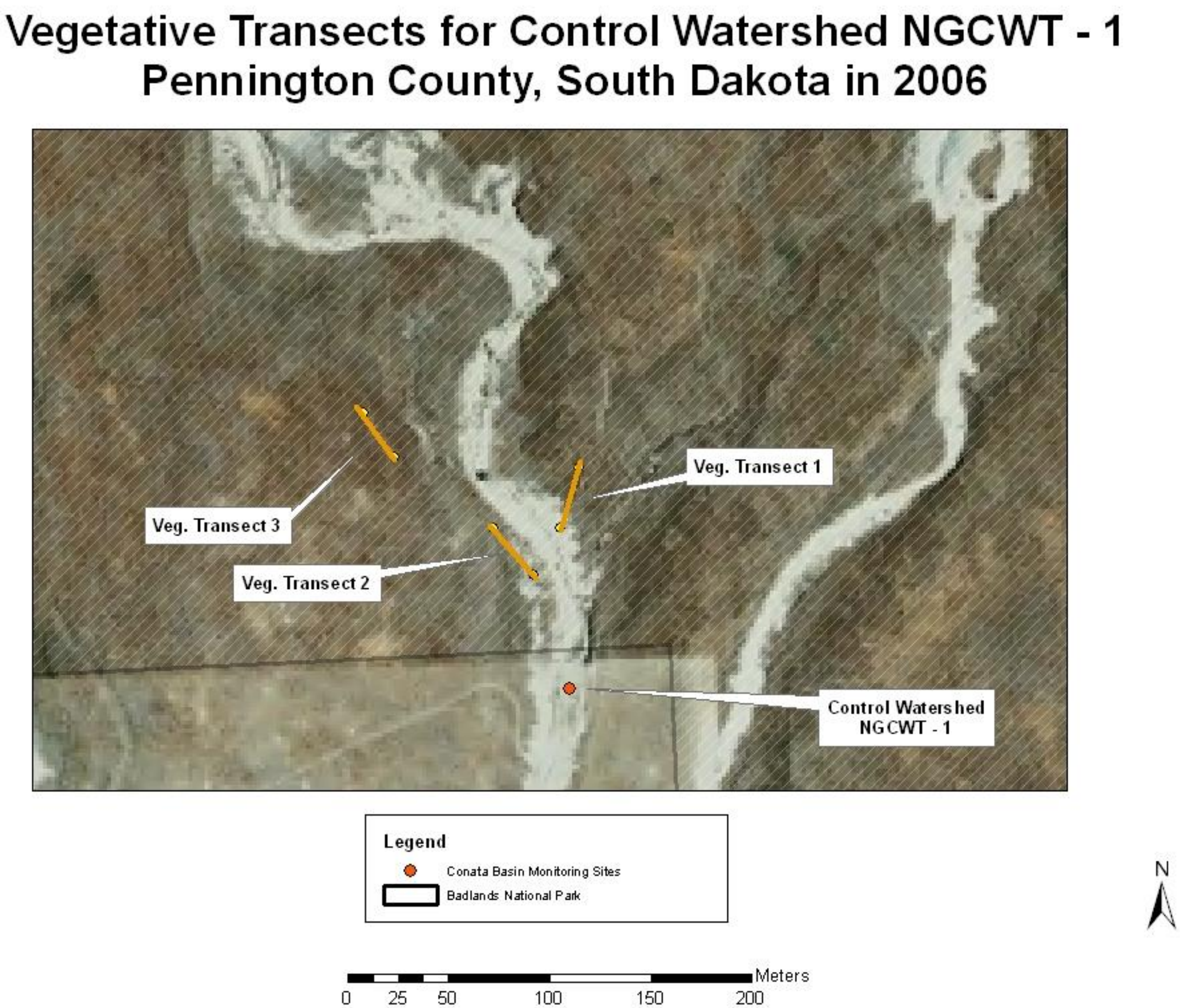

Figure E- 1. 30-meter vegetative transects for NGCWT-1 Pennington County, South Dakota in 2006.

Vegetative Transects for Control Watershed NGCWT - 2 Pennington County, South Dakota in 2006

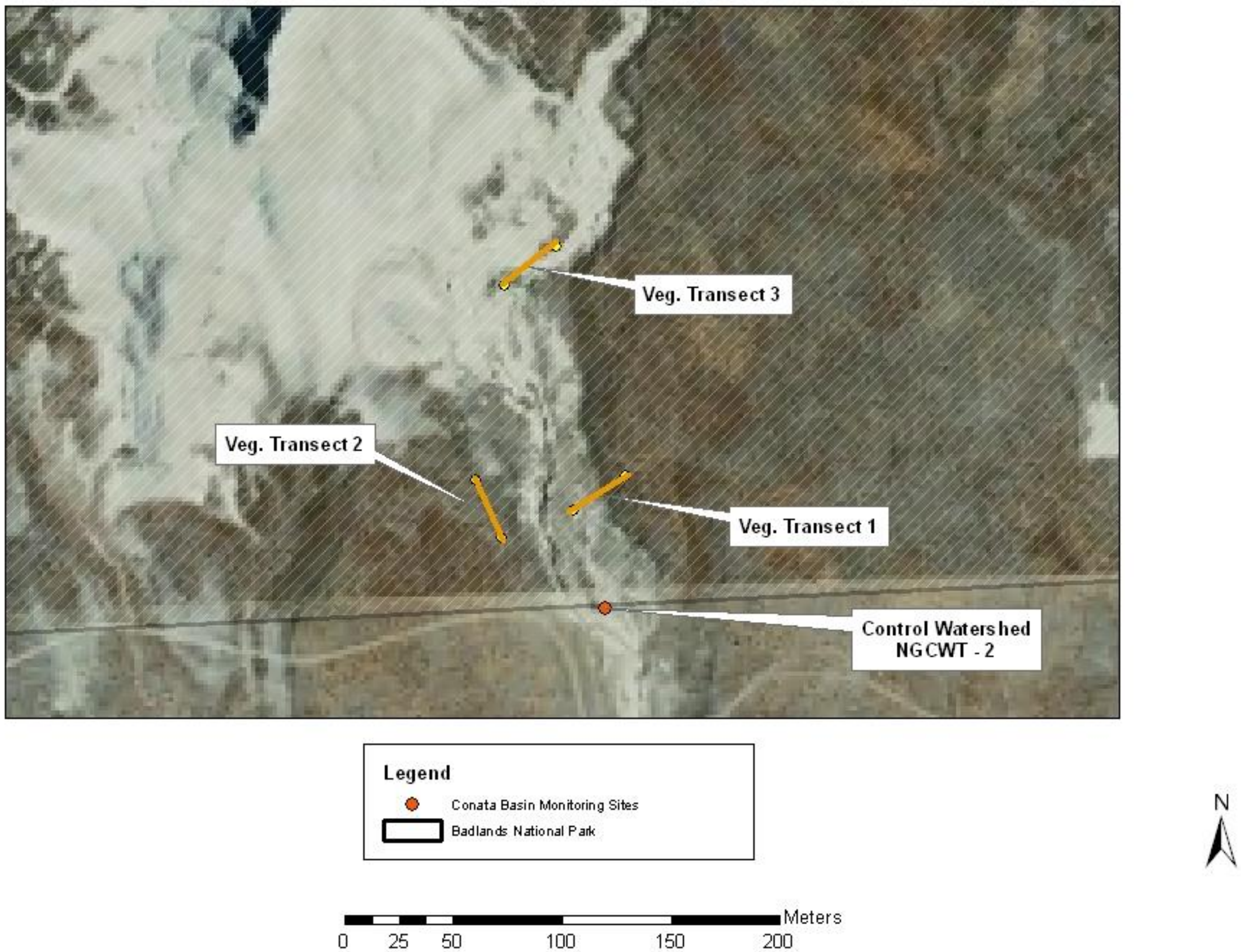

Figure E- 2. 30-meter vegetative transects for NGCWT-2 Pennington County, South Dakota in 2006.

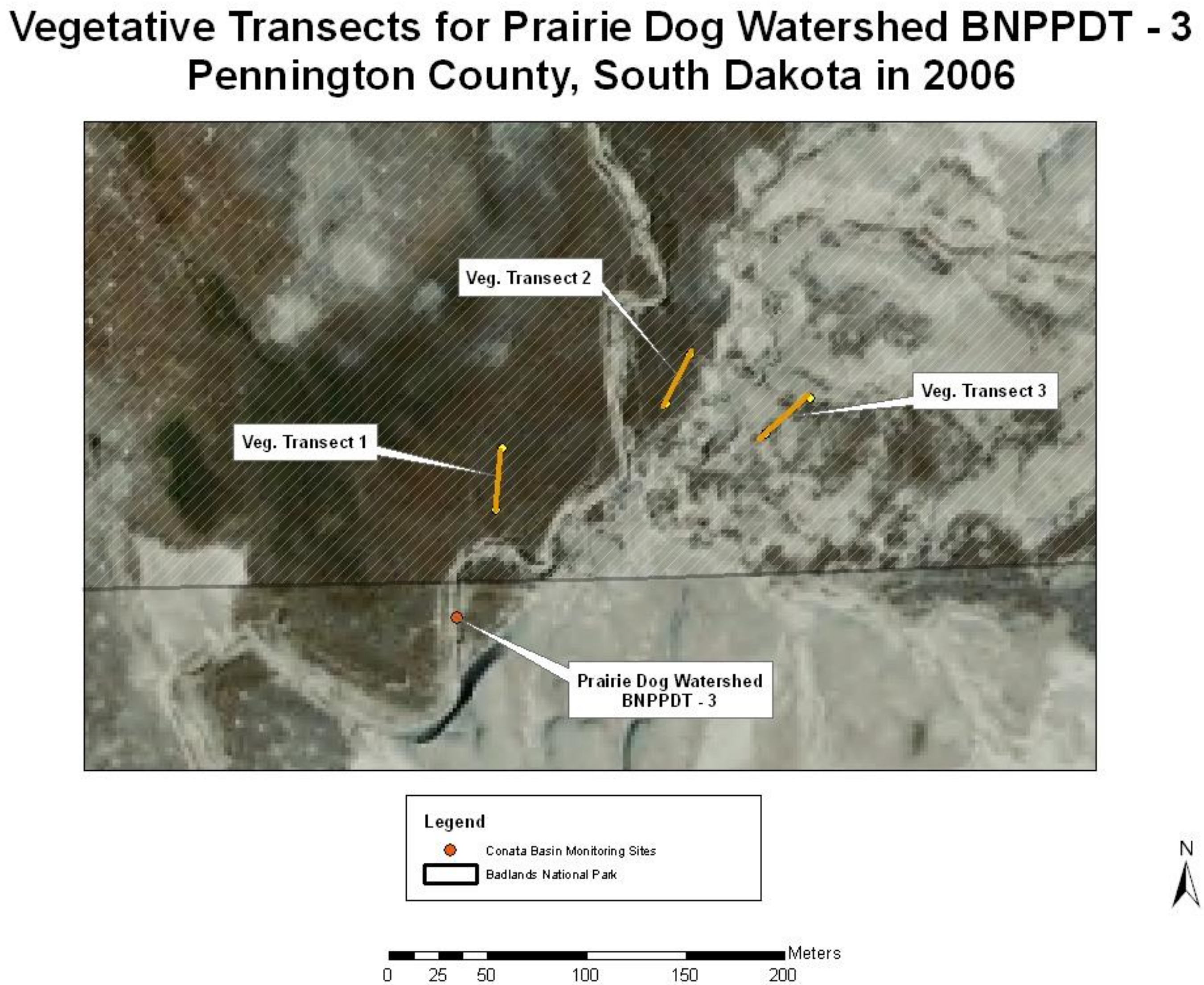

Figure E- 3. 30-meter vegetative transects for BNPPDT-3 Pennington County, South Dakota in 2006.

Vegetative Transects for Prairie Dog Watershed BNPPDT- 4
Pennington County, South Dakota in 2006

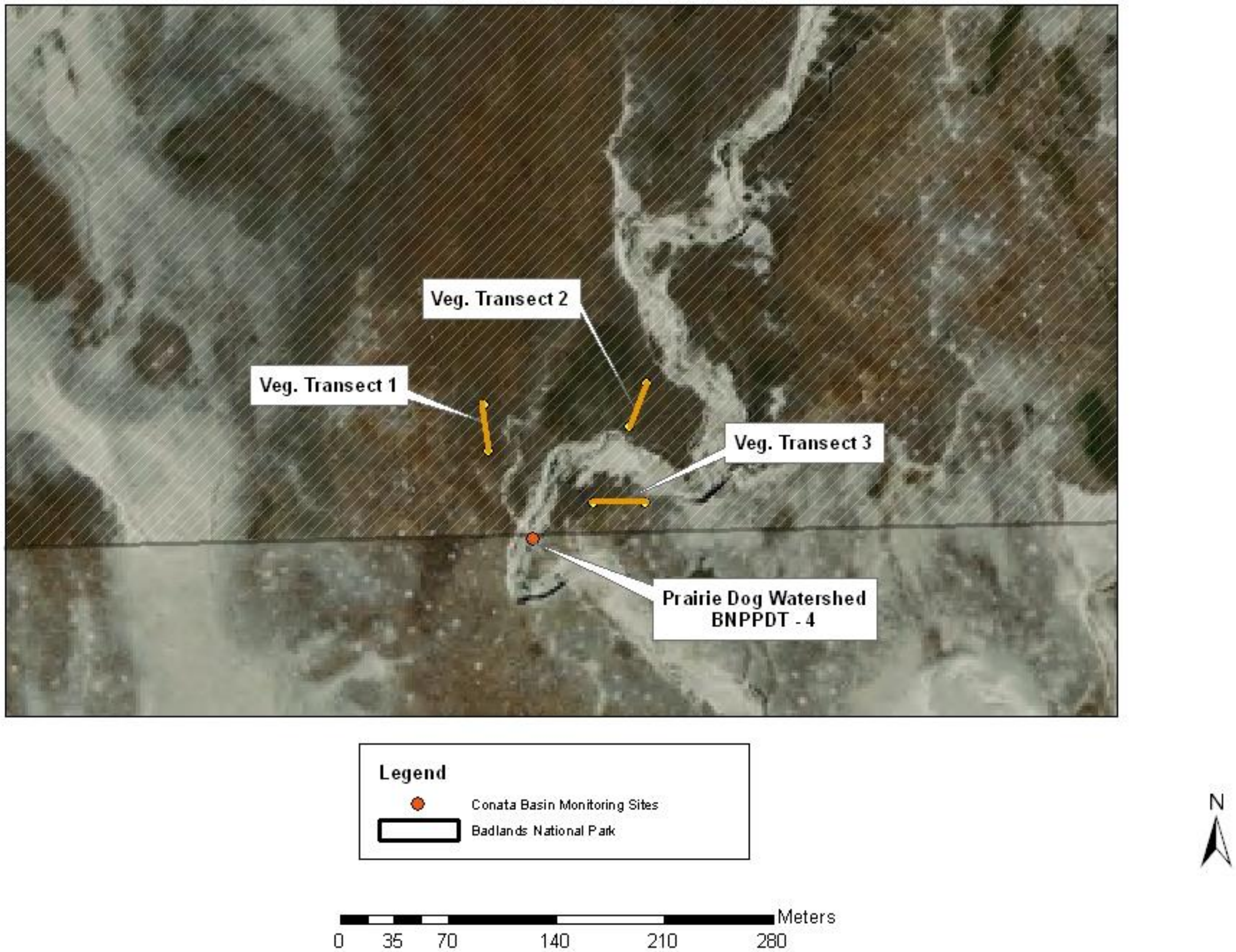

Figure E- 4. 30-meter vegetative transects for BNPPDT-4 Pennington County, South Dakota in 2006.

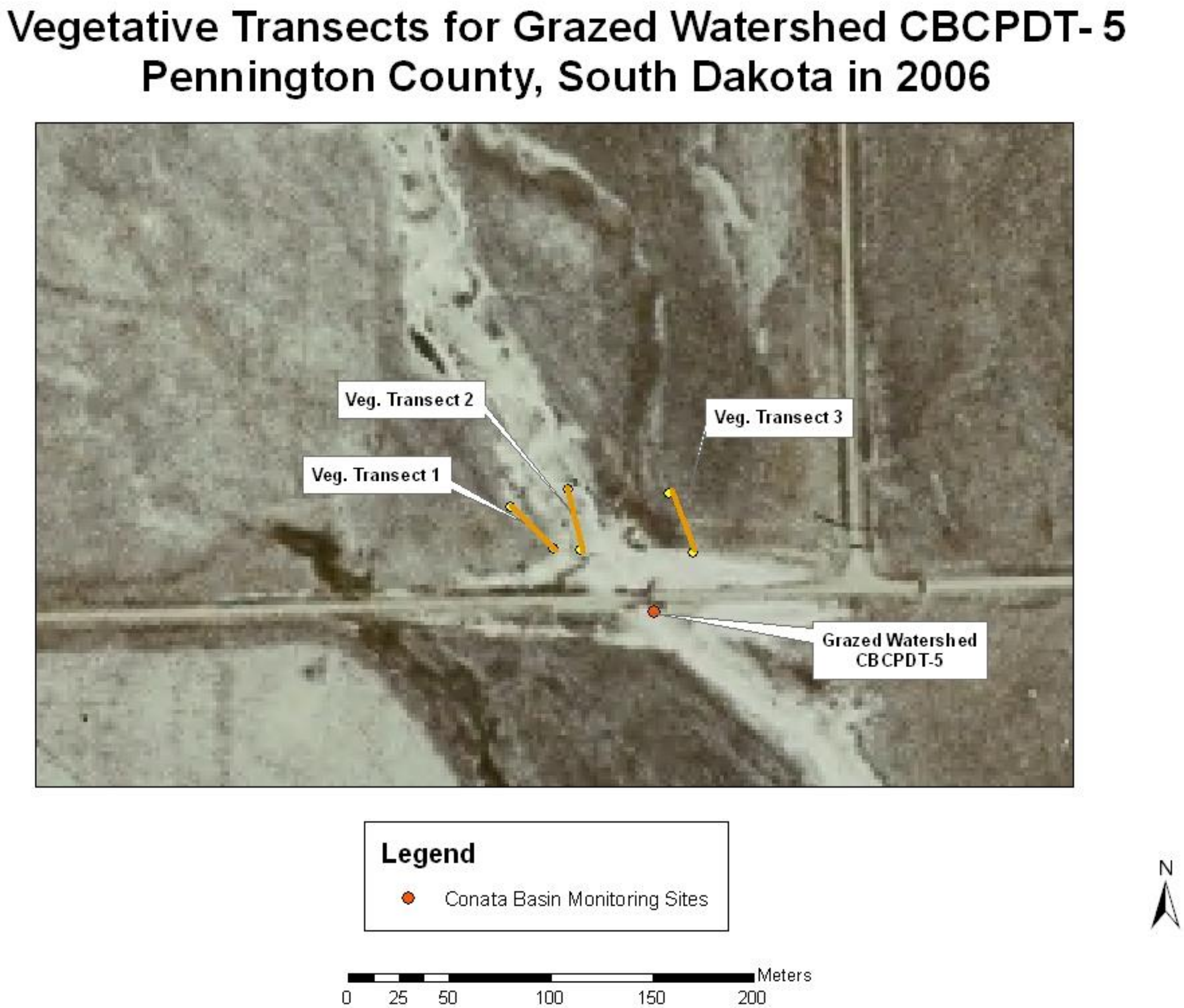

Figure E- 5. 30-meter vegetative transects for CBCPDT-5 Pennington County, South Dakota in 2006.

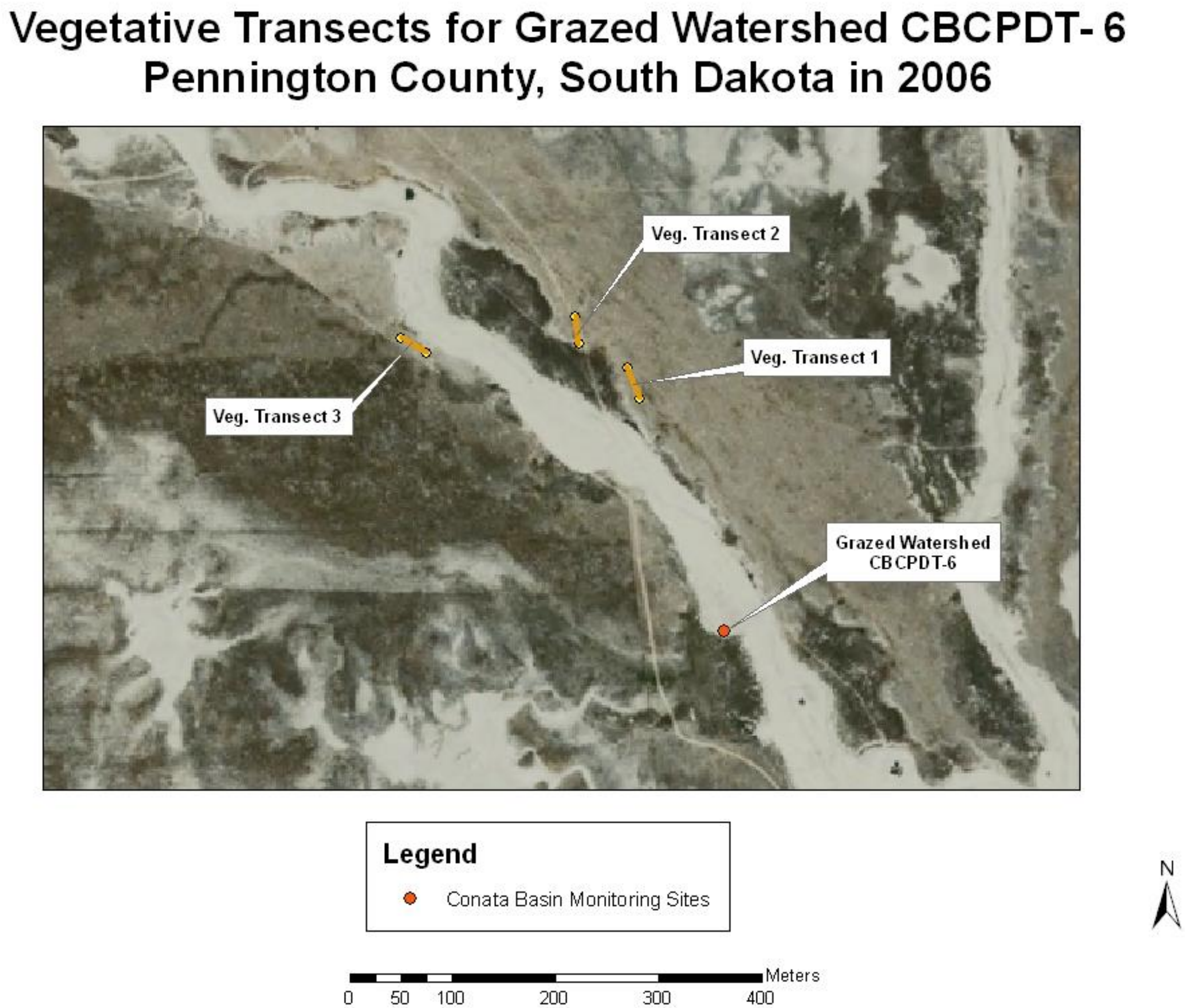

Figure E- 6. 30-meter vegetative transects for CBCPDT-6 Pennington County, South Dakota in 2006.

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