Fecal Coliform Bacteria Total Maximum Daily Load (TMDL) for Spring Creek, Pennington County, South Dakota

South Dakota Department of
Environment and Natural Resources

Protecting South Dakota's Tomorrow ... Today

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Total Maximum Daily Load Summary

Waterbody Type:	Stream
303(d) Listing Parameter:	Fecal coliform bacteria
Designated Uses:	Coldwater permanent fish life propagation waters, immersion recreation waters, limited-contact recreation waters, fish and wildlife propagation, recreation, and stock watering
Size of Impaired Waterbody:	Approximately 50 km in length
Size of Watershed:	32,893 hectares
Indicator(s):	Concentration of fecal coliform bacteria
Analytical Approach:	BASINS and HSPF hydrologic modeling
Location:	Hydrologic Unit Codes (12-digit HUC): 101201090901, 101201090902, 101201090903 and 101201090904
Goal:	Meet applicable water quality standards for fecal coliform bacteria
Target (Water Quality Standards):	Maximum daily concentration of ≤ 400 CFU/100mL and a geometric mean of 5 samples over a 30 day period ≤ 200 CFU/100mL. These criteria apply from May through September.
Reach Number:	SD-CH-R-Spring_01

Objective

The intent of this document is to clearly identify the components of the TMDL, support adequate public participation, and facilitate the US Environmental Protection Agency (US EPA) review. The TMDL was developed in accordance with Section 303(d) of the federal Clean Water Act and guidance developed by US EPA. This TMDL document addresses the fecal coliform bacteria impairment of Spring Creek from the headwaters to Sheridan Lake (SD-CH-R-Spring_01), which was assigned to priority category 1 (high-priority) in the 2008 impaired waterbodies list.

Watershed Characteristics

Spring Creek is a small perennial mountain stream located in Pennington and Custer Counties in the Black Hills of South Dakota. Spring Creek is a tributary of the Cheyenne River, which flows into the Missouri River. The drainage area of Spring Creek is approximately 425 square miles (1,100 square kilometers) at the confluence with the Cheyenne River.

The impaired (303(d) listed) segment of Spring Creek has a length of 31 miles and flows through Mitchell Lake, which has a surface area of 10 acres (4 hectares). The 303(d) listed segment ends where Spring Creek empties into Sheridan Lake, approximately four miles downstream of Mitchell Lake. (SD DENR, 2002a). The drainage area of the 303(d) listed segment is approximately 126 square miles (327 square kilometers) (Figure 1).

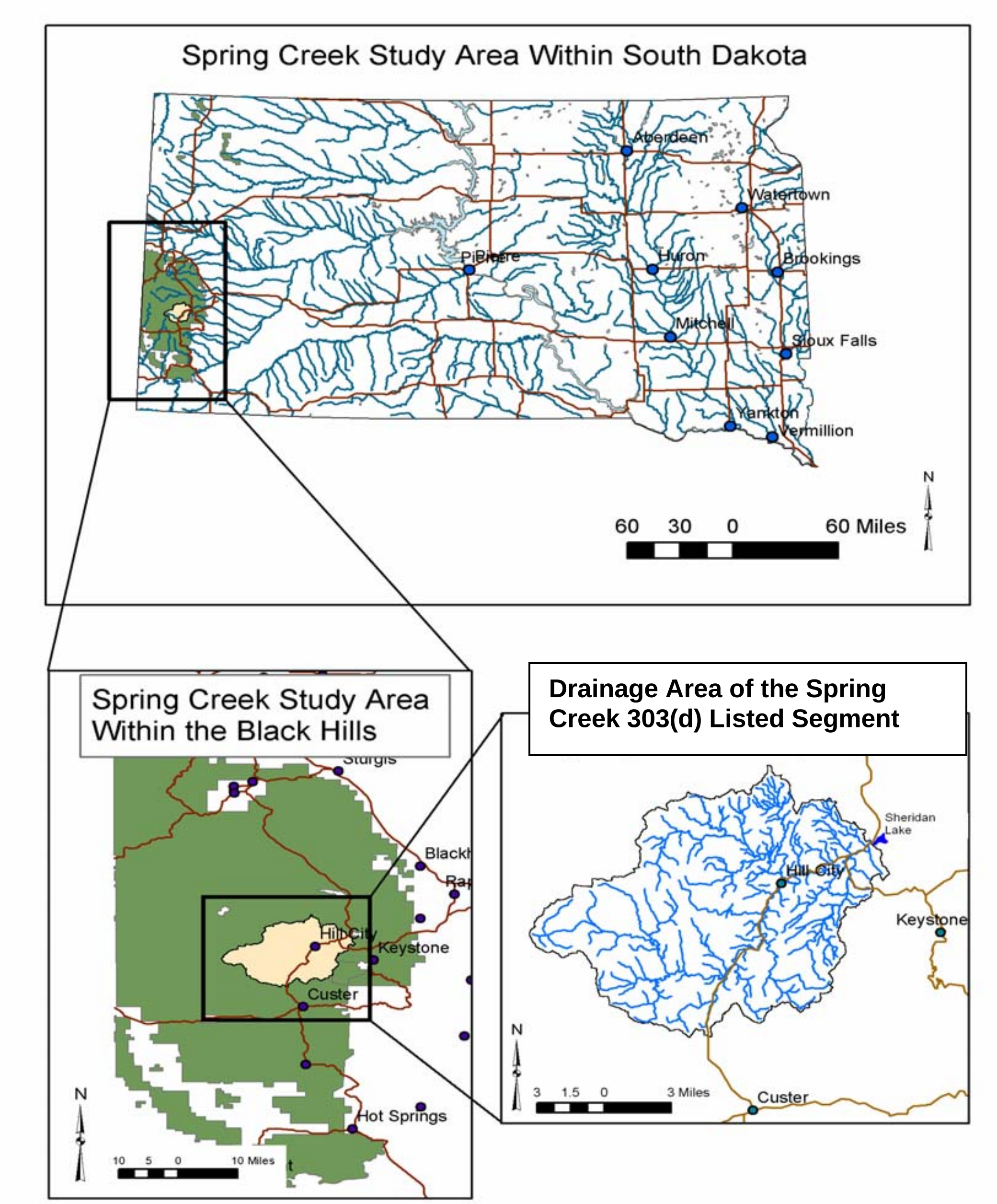

Figure 1. Location of the Spring Creek watershed within the Black Hills of South Dakota.

Metamorphic slates and schists along with granite rock underlie a large portion of the basin. Those form the Central Crystalline Area of the Black Hills (USDA, 1990) that covers the majority of the study area.

The watershed's major soil types are Pactola, Buska, Mocmont, and Stovho. The Pactola series of soils, which cover most of the basin, were formed by the weathering of materials in steeply tilted metamorphic rock. The Buska series descends from micaceous schist while the Mocmont formed from material weathered from granite. Those two series generally occur in the upper reaches of the basin in the Harney Peak area. The Stovho series formed from the weathering of limestone and calcareous sandstone and is found in the upper reaches of the basin in the area underlain by the Madison Limestone formation (USDA, 1990).

Digital Elevation Models of the area show the average slope to be approximately 20 percent. Much of the land is located within the Black Hills National Forest and is predominantly forested with ponderosa pine. Other cover includes grasslands and hardwoods (Klassen, 1997).

According to National Weather Service records, average annual precipitation at Hill City is 20.4 inches with over 70 percent occurring during the months of April through August and over 50 percent occurring during the months of May through July.

Watershed landuse is predominantly evergreen forest (83%) and herbaceous rangeland (17%).

Problem Identification

Spring Creek was listed in 1998 as impaired due to exceedence of fecal coliform criteria. It was not listed in 2002 or 2004, but was listed in 2006 and 2008. In 1969, a water quality study of the Spring Creek area was completed to evaluate existing and potential pollution problems (SDDH, 1969). The study found the primary pollution sources in the Spring Creek basin to be cattle grazing, road construction, timbering and municipal, residential and commercial wastewater. Silt and bacteria were found to be the major pollutants in the watershed.

Since 1976, the U.S. Forest Service and the South Dakota Department of Environment and Natural Resources (SD DENR) have collected fecal coliform bacteria samples at various locations along Spring Creek. Water quality monitoring over the period May 2002 to July 2003 showed that approximately 17 percent of samples collected on Spring Creek exceeded fecal coliform bacteria criteria. Across all sites, maximum concentrations ranged from 2,000 colony-forming units per 100 mL (CFU/100mL) up to >20,000 CFU/100mL (too numerous to count). Most of the samples that exceeded criteria were collected during runoff events.

Description of Applicable Water Quality Standards & Numeric Water Quality Targets

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

Spring Creek has been assigned the following beneficial uses: coldwater permanent fish life propagation (above Sheridan Lake), coldwater marginal fish life propagation (below Sheridan

Lake), immersion recreation, limited contact recreation, fish and wildlife propagation, recreation and stock watering, and irrigation. Table 1 lists the criteria that must be met to support the specified beneficial uses. When multiple criteria exist for a particular parameter, the most stringent criterion is used.

Individual parameters, determine the support of these beneficial uses. South Dakota has narrative standards that may be applied to the undesired eutrophication of lakes and streams. Administrative Rules of South Dakota (ARSD) Article 74:51 contains language that prohibits the presence of materials causing pollutants to form, visible pollutants, taste and odor producing materials, and nuisance aquatic life. Reduction of nutrients in Spring Creek, specifically phosphorus, has been addressed in the TMDL developed for Sheridan Lake.

The numeric TMDL target established for Spring Creek is based on the current daily maximum criteria for fecal coliform bacteria. Water quality criteria for the immersion recreation beneficial use requires that 1) no sample exceeds 400 CFU/100 mL and 2) during a 30-day period, the geometric mean of a minimum of 5 samples collected during separate 24-hour periods must not exceed 200 CFU/100 mL. This criteria is applicable from May 1 through September 30 (SD DENR, 2002b).

Of all the assessed parameters for which surface water quality criteria are established (Table 1), fecal coliform, water temperature and total suspended solids (TSS) exceeded criteria for the coldwater permanent fish life propagation beneficial use on Spring Creek. Eleven percent of the temperature measurements on Spring Creek above Sheridan Lake failed to meet required standards. Revisions to water temperature criteria are being considered, so the temperature impairment will be addressed in a future document.

During this study, ten samples collected from several sites within the assessed stream segment exceeded the TSS criterion. However, TSS was not included as a cause of impairment for this reach in the 2008 Impaired Waterbodies List because no exceedences of the TSS criterion were observed during the period of record considered for the 2008 report (October 1, 2002, to September 30, 2007).

Table 1. State surface water quality standards for Spring Creek, Pennington County, South Dakota.

Parameter	**Criteria**	**Unit of Measure**	**Special Conditions**
Total alkalinity as calcium carbonate	≤ 750	mg/L	30-day average
	≤ 1313	mg/L	daily maximum
Chlorides (cold water permanent)	≤ 100	mg/L	30-day average
	≤ 175	mg/L	daily maximum
Dissolved oxygen (cold water permanent)	≥ 6.0	mg/L	
	≥ 7.0		in spawning areas during the spawning season
Total ammonia nitrogen as N (cold water permanent)	Equal to or less than the result from Equation 3 in Appendix A	mg/L	30-day average
	Equal to or less than the result from Equation 1 in Appendix A	mg/L	daily maximum
Fecal coliform (May 1 – September 30) (immersion recreation)	≤ 200	/100 mL	geometric mean based on a minimum of 5 samples obtained during separate 24-hour periods for any 30-day period
	≤ 400		in any one sample
Conductivity at 25°C	≤ 2,500	micromhos/cm	30-day average
	≤ 4,375	micromhos/cm	daily maximum
pH (cold water permanent)	≥ 6.6 and ≤ 8.6	standard units	
Nitrates as N	≤ 88	mg/L	daily maximum
	≤ 50	mg/L	30-day average
Total dissolved solids	≤ 2,500	mg/L	30-day average
	≤ 4,375	mg/L	daily maximum
	≤ 158	mg/L	daily maximum
Total Suspended Solids (cold water permanent)	≤ 30	mg/L	30-day average
	≤ 53	mg/L	daily maximum
Temperature (cold water permanent)	≤ 65	°F	see § 74:51:01:31
Undisassociated hydrogen sulfide	≤ 0.002	mg/L	
Total petroleum hydrocarbon	≤ 10	mg/L	see § 74:51:01:10
Oil and grease	≤ 10	mg/L	see § 74:51:01:10
Sodium adsorption ratio	≤ 10		

Pollutant Assessment

Point Sources

The City of Hill City is located approximately in the middle of the study area between monitoring sites SCT4 and SCT6. The past municipal sewage treatment system includes three lagoons, which were constructed in 1972 (USEPA, 1976). The lagoons were located at the downstream end of Hill City adjacent to Spring Creek. Based on a hydrologic balance approximately 5.07 million cubic feet (143,000 cubic meters) of water per year seep from the lagoons (McLaughlin Water Engineers Inc, 2000). Fecal coliform sampling completed during the water quality monitoring program for this study did not show a significant change in bacteria concentrations downstream from the lagoons compared to upstream.

Hill City has recently constructed a new wastewater treatment facility that discharges to Spring Creek. The facility is located at the previous treatment sites (adjacent to the lagoons). The treatment process will include disinfection, and a discharge permit will limit the fecal coliform concentration of the effluent.

Nonpoint Sources

Based on review of available information and communication with local land owners and representatives from Hill City, the primary nonpoint sources of fecal coliform within the Spring Creek watershed include urban and agricultural runoff, as well as wildlife and human sources. Using the best available information, loadings were estimated from each of these sources based on the number of units (e.g. numbers of animals, failing septic systems, etc.) representative of each source.

Urban

Two percent of the study area is characterized as impervious area. Most of the impervious area is located in Hill City (Spring Creek), the Rafter J Campground (Spring Creek), and the KOA campground (Palmer Gulch Creek). Residential areas located along Spring Creek downstream of Hill City also contribute surface runoff. Water quality samples taken during storm events show a 30% increase in fecal coliform bacteria levels in Spring Creek between locations upstream and downstream of Hill City. This indicates that urban runoff from Hill City has a major impact on the water quality of Spring Creek.

Agriculture

Manure from livestock is a potential source of fecal coliform to the stream. Livestock in the basin are mainly beef cattle with horses being the next abundant animals in the study area. The KOA campground located along Palmer Gulch Creek near sampling site PCT2 has a significant horse population that is used for trail rides. The horses at the campsite may contribute to the high fecal coliform concentrations in Palmer Gulch. The other livestock in the basin include hogs, dairy cattle, chickens, and sheep. Numbers of animals on private land were estimated through personal communication with landowners in the watershed.

Beef cattle in the basin are grazed on private land and on Black Hills National Forest (BHNF) land during the summer months. Cattle kept on BHNF land remain in the basin from June through October on grazing allotments. Allotments within the basin include Palmer Gulch, Tigerville, Newton Fork, Murphy, Medicine Mountain, Spring Creek, Hill City, and Gordon Points. Approximately 1,080 cow/calf pairs are allowed on these allotments from June to October. The actual number of cattle that graze these allotments is generally less than the allowable number. Allotments cover more than 75 percent of the study area.

Human

The studied drainage area contains an estimated 662 septic systems that are mostly located near Spring Creek and its tributaries (SD DENR, unpublished data). The high density of septic systems near drainages in the study area provides a potential source of fecal coliform to Spring Creek. Limited information is available on the age and condition of these systems.

Natural background/wildlife

Wildlife within the watershed is a natural source of fecal coliform bacteria in the study area. County wildlife assessments provided the best available estimate of wildlife population densities. The wildlife assessment for Pennington County was obtained from the South Dakota Department of Game, Fish and Parks.

Bacterial Ribotyping Analysis

Bacteria samples were collected and analyzed to help define the source of fecal coliform within the basin. During the initial sampling period one set of ribotyping samples were taken at SCT1A, SCT4, SCT6, and PCT1. The first ribotyping sample was collected on September 3, 2002, during one storm event. Approximately 35 percent of the fecal coliform bacteria in Spring Creek were from human sources and 65 percent animal.

Supplemental sampling was completed from May through August of 2004 at SCT1A, SCT4, SCT5, SCT6, and PCT1 and consisted of a combination of event and non-event samples (Appendix B). A total of 19 samples with five isolates from each sample were analyzed. The results of this source tracking assessment indicate the following sources and relative percent contributions: agricultural livestock (47.0 percent), domestic animals (12.5 percent), human (13.1 percent), wildlife (7.7 percent), and unknown (19.8 percent).

The results of ribotyping samples indicate, in general, two primary sources: agricultural livestock and a combination of human and domestic animals. Urban sources of fecal coliform bacteria in the watershed include humans and domestic animals. See appendices A and E for more information on bacterial source tracking results.

Linkage Analyses

Load Duration Curve Analysis

The TMDL was developed using the Load Duration Curve (LDC) approach that results in a flow-variable target that considers the entire flow regime. In Spring Creek, fecal coliform concentrations are positively related to stream flow. Thus, the LDC approach was deemed an appropriate method for setting a flow-variable fecal coliform bacteria TMDL for Spring Creek.

The LDC is a dynamic expression of the allowable load for any given day. To aid in interpretation and implementation of the TMDL, the LDC flow intervals were grouped into five flow zones representing high flows (0–10 percent), moist conditions (10–40 percent), mid-range flows (40–60 percent), dry conditions (60–90 percent), and low flows (90–100 percent) according to EPA's *An Approach for Using Load Duration Curves in the Development of TMDLs* (USEPA, 2006).

Instantaneous loads were calculated by multiplying the fecal coliform sample concentrations from SD DENR ambient water quality data (site number 460654), the USGS daily average flow (gage number 06406920) on the date of the sample, and a units conversion factor. The SD DENR water quality monitoring site and USGS flow gaging station are co-located near the inlet of Sheridan Lake (shown as site SCT1 on the map in Appendex B).

When the instantaneous loads are plotted on the LDC, characteristics of the water quality impairment are shown. Instantaneous loads that plot above the curve are exceeding the TMDL, while those below the curve are in compliance. As the plot shows, fecal coliform samples collected from Spring Creek exceed the daily maximum criterion mostly during high to mid-range flow conditions. Only one sample exceeded the daily maximum criteria during low flow conditions (Figure 2). Loads exceeding the criteria in the low flow zone typically indicate point source load contributions, while those further left on the plot generally reflect potential nonpoint source contributions (USEPA, 2006).

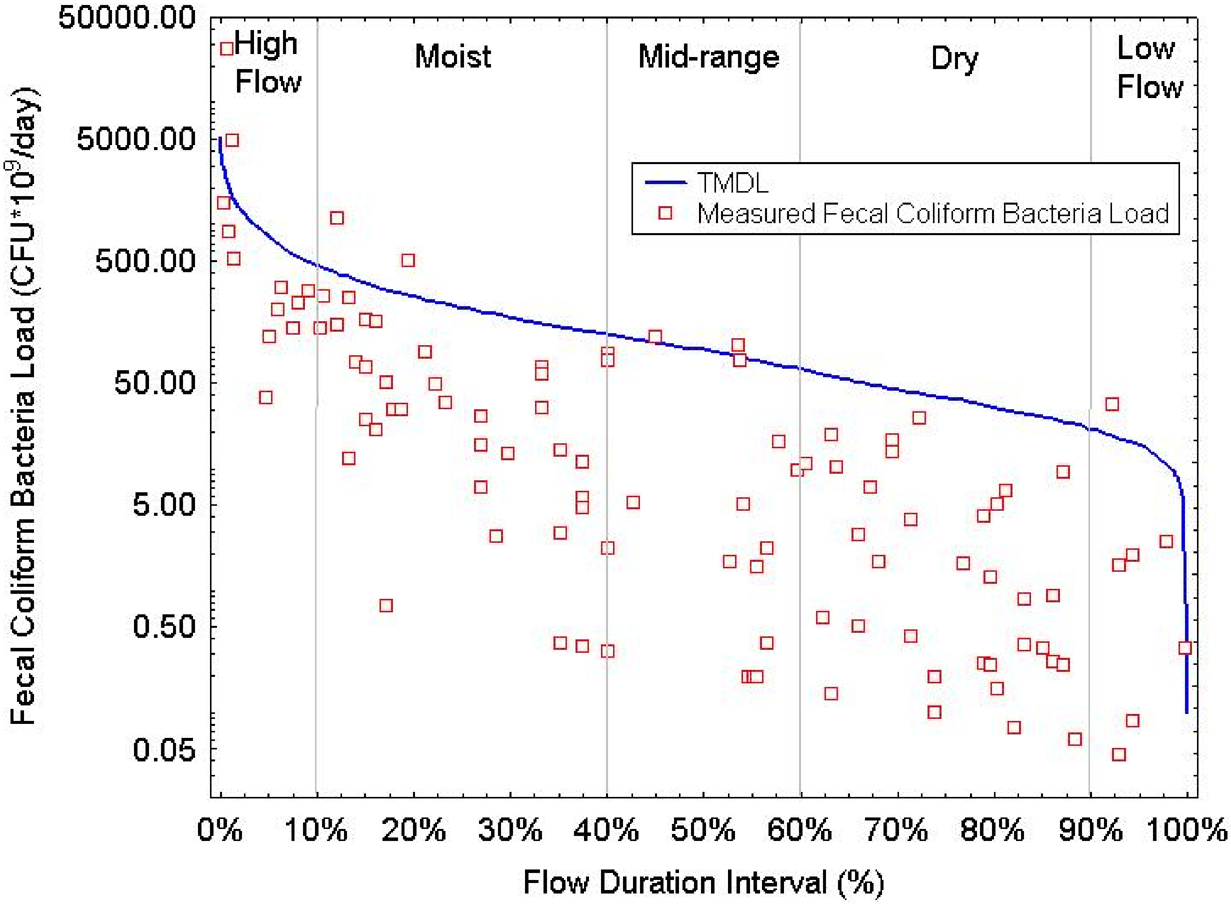

Figure 2. Load duration curve representing allowable daily fecal coliform loads based on the daily maximum fecal coliform criteria (≤ 400 mg/L) and observed stream flow for a period of record of 10/1/90 to 9/30/04. Measured fecal coliform loads for the same time period are also displayed.

Source Assessment Modeling Results

The Better Assessment Science Integrating Point and Nonpoint Sources (BASINS) model Version 3.0, along with Hydrologic Simulation Program Fortran (HSPF) were used to determine the contribution of fecal coliform bacteria from identified sources and evaluate the implementation of Best Management Practices (BMPs) to control these sources. The Spring Creek watershed was represented using four sub-basins in the model to represent the upper and lower Spring Creek and key tributaries (Palmer and Newton Fork Creeks). The nonpoint sources in the study area are modeled in HSPF by estimating per acre fecal coliform accumulation rates and maximum fecal coliform storage rates for each source. The buildup and wash-off of fecal coliform is simulated based on these rates and precipitation. The values for the accumulation and storage rates were calculated using the Bacterial Indicator Tool (USEPA, 2000b). Human sources (failing septic systems, leaking sanitary sewer lines, and leaking lagoons) and livestock in streams are nonpoint sources that are modeled as point sources because the coliform that they produce can not be adequately represented by buildup and accumulation rates. The Bacterial

Indicator Tool (BIT) calculates a flow rate and a fecal coliform count per hour that are used in the simulation model to represent cattle in streams and human sources.

Hydrologic calibration of the model was completed for the time period from January 1, 1991 through January 1, 1998. Model calibration resulted in a difference of 9 percent between measured and simulated volumes over the calibration period. The calibrated hydrologic model was then validated by simulating the time period January 1, 1998 through January 1, 2003. The hydrologic model predicted the validation period runoff volumes to within 4 percent.

To calibrate the fecal coliform model, the average daily flow from the outlet of the study area from May 1 to September 30 of each year was multiplied by the geometric mean of the fecal coliform samples (CFU/100 mL) for that season. The average of these results was calculated to determine an average seasonal fecal coliform loading. The parameters affecting fecal coliform concentration were calibrated using an iterative process to minimize the percent error between the observed and simulated average fecal coliform loading per season. The difference in the percent of samples exceeding the daily maximum water quality standard between simulated and observed data was also minimized. The resulting difference in simulated versus observed average seasonal loading was 7.2 percent.

Model calibration was adequate to evaluate fecal coliform source contributions, load reductions and implementation of BMPs. The resulting fecal coliform bacteria loading sources for the calibrated model are given in Table 2.

Table 2. Fecal coliform bacteria non-point sources based on HSPF model results.

Non-point Sources of Fecal Coliform Bacteria	Percent Load Contribution
Livestock in Streams	37.9%
Fecal Coliform Washoff (agricultural land)	25.6%
Human Sources (e.g. failing septic systems)	14.8%
Urban Runoff	13.7%
Background (Wildlife)	7.9%

TMDL Allocations

The LDC (Figure 2) represents the dynamic expression of the fecal coliform bacteria TMDL for Spring Creek, resulting in a unique maximum daily load that corresponds to a measured average daily flow. To aid in the implementation of the TMDL and estimation of needed bacteria load reductions, Table 3 presents a combination of allocations for each of five flow zones. Methods used to calculate the TMDL components are discussed below. This TMDL is in effect from May 1 through September 30, as the fecal coliform criteria are applicable only during this period.

Table 3. Total Maximum Daily Load (TMDL) allocations by flow zone.

TMDL Component	Flow Zone (expressed as CFU*10^9/day)				
	High	Moist	Mid-range	Dry	Low
	48-525 cfs	14-47 cfs	6.8-13 cfs	2.2-6.7 cfs	0-2.1 cfs
LA	2443.07	328.99	94.09	40.26	1.11
WLA	3.78	3.78	3.78	3.78	3.78
MOS	362.13	88.09	29.36	16.64	15.66
TMDL	2808.98	420.86	127.24	60.68	20.55
Current Load*	27575.98	502.09	118.43	18.45	33.01
Load Reduction	90%	16%	0%	0%	38%

*** Current load is the 95th percentile of observed fecal coliform bacteria loads for each flow zone.**

Load Allocation (LA)

To develop the fecal coliform bacteria load allocation (LA), the loading capacity (LC) was first determined. The LC for Spring Creek was calculated by multiplying the daily maximum fecal coliform bacteria criterion by the daily average flow measured at USGS gaging station 06406920 near the inlet of Sheridan Lake.

The daily maximum criterion (400 CFU/100ml) was used, rather than the geometric mean criterion (200 CFU/100ml), because observed fecal coliform loads do not appear to exceed the geometric mean criterion. The geometric mean, as defined in ARSD § 74:51:01:01, is the n^{th} root of a product of n factors. The geometric mean fecal coliform criteria (ARSD § 74:51:01:50) applies only under special conditions, where a minimum of five samples are obtained during separate 24-hour periods for any 30-day period, and the calculated geometric mean may not exceed the criterion in more than 20% of the samples collected in this same 30-day period. Since only one or two samples were collected during any 30-day period, the geometric mean criterion does not apply. However, a geometric mean concentration was calculated using all the samples within each flow zone to assess whether or not the geometric mean criterion would be exceeded within a flow zone if a sufficient number of samples are taken. Table 4 shows that geometric mean values for all flow zones are below the criterion of 200 CFU/100ml.

Table 4. Geometric mean of samples by flow zone. The geometric mean criterion (≤ 200 CFU/100 ml) applies under special conditions described in ARSD § 74:51:01:50.

	Flow Zone				
	High	Moist	Mid	Dry	Low
Number of samples (n)	**12**	**35**	**18**	**33**	**7**
Geometric Mean Concentration, CFU/100ml	**187**	**45**	**19**	**13**	**30**

Since the daily maximum criteria are exceeded, it was decided to use the daily maximum criterion to develop the loading capacity of the stream in order to ensure that the most stringent water quality standards are met. For each of the five flow zones, the 95th percentile of the range of LCs within a zone was set as the flow zone goal. Bacteria loads experienced during the largest stream flows (e.g. top 5 percent) can not be feasibly controlled by practical management practices. Setting the flow zone goal at the 95th percentile of the range of LCs will protect the immersion recreation beneficial use and allow for the natural variability of the system (Figure 3).

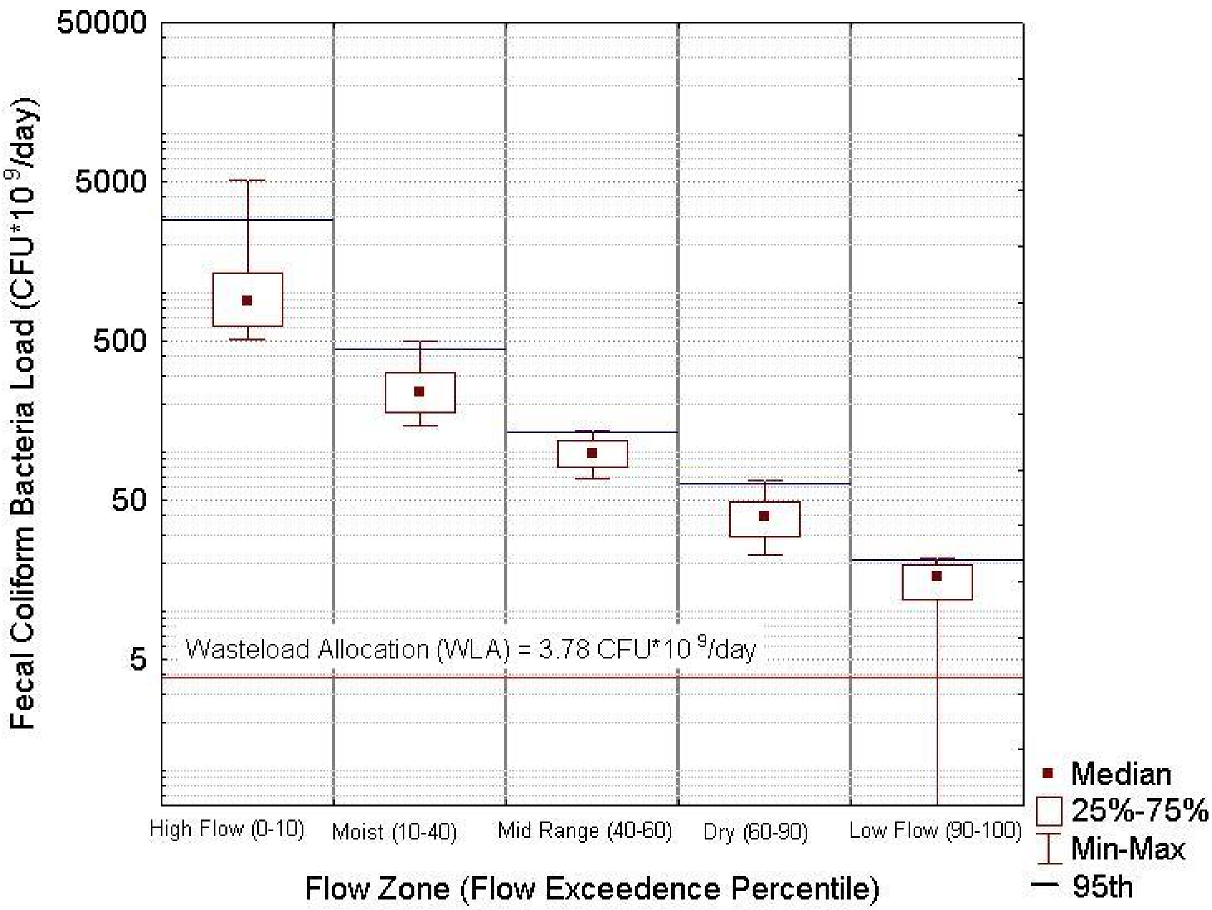

Figure 3. Boxplot showing median, 25th and 75th percentiles, and range of maximum daily loads for each flow zone. The horizontal line drawn at the 95th percentile represents the flow zone TMDL goal. The wasteload allocation (point source) is also shown at 3.78 CFU*10^{9}/day.

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

Waste Load Allocation (WLA)

Hill City has a mechanical wastewater treatment facility (WWTF) that discharges directly into Spring Creek. The wastewater treatment system discharge characteristics are based on historical flow rates and population estimates (McLaughlin Water Engineers 2000). The waste load allocation for the Hill City wastewater treatment facility is based on the design peak day flow (Table 3) (McLaughlin Rincon 2003). The ultimate build-out condition is used for the waste load allocation to avoid revising the allocation at the time of future expansion. A waste load of 3.78E+09 per day was allocated to Hill City's proposed WWTF. The WLA for the treatment facility will be implemented through a South Dakota Surface Water Discharge permit (permit number: SD0020885) and is given in Table 3. The WLA is constant across all flow conditions and ensures that water quality standards will be attained.

Table 5. Discharge characteristics of Hill City's wastewater treatment facility.

Peak Day Flow	Average Conc. (CFU/100mL)	Discharge Rate (MGD)	Estimated Load (CFU/day)
Initial	200	0.25	1.90E+09
Ultimate	200	0.50	3.78E+09

Margin of Safety (MOS)

An explicit MOS identified using a duration curve framework is basically unallocated assimilative capacity intended to account for uncertainty (e.g., loads from tributary streams, effectiveness of controls, etc). An explicit MOS was calculated as the difference between the loading capacity at the mid-point of each of the five flow zones and the loading capacity at the minimum flow in each zone. A substantial MOS is provided using this method, because the loading capacity is typically much less at the minimum flow of a zone as compared to the mid-point.

Because the allocations are a direct function of flow, accounting for potential flow variability is an appropriate way to address the MOS. As new information becomes available and the TMDL is revisited, this unallocated capacity may be attributed to nonpoint sources and added to the load allocation, or the unallocated capacity may be attributed to point sources and become part of the waste load allocation.

Seasonal Variation

Stream flows in Spring Creek (USGS gage 06406920, Spring Creek above Sheridan Lake near Keystone, SD) displayed seasonal variation for the period of record (10/1/90 to 9/30/04). Highest stream flows typically occur during late spring with highest monthly average stream flow reported in June (72 cfs), and lowest stream flows occur during the winter months with lowest monthly average stream flow reported in January (11 cfs). Fecal coliform concentrations also displayed seasonal variation, and were positively correlated with stream flow. By using the LDC approach to develop the TMDL allocations, seasonal variability in fecal coliform loads is taken into account.

In addition, the TMDL is seasonal, as it is effective only during the period of May 1 through September 30. Since the fecal coliform criteria are in effect from May 1 through September 30, the TMDL is also applicable only during this time period.

Critical Conditions

Critical conditions occur within the basin during the summer. Typically, greatest numbers of livestock and tourist activities (i.e. trail rides, camping, etc.) are highest in the basin during the summer months. Combined with the peak in bacteria sources, high-intensity rainstorm events are common during the summer and produce a significant amount of fecal coliform load due to bacterial wash-off from the watershed.

Follow-Up Monitoring

During and after the implementation of management practices, monitoring will be necessary to assure attainment of the TMDL. Stream water quality monitoring will be accomplished through SD DENR's ambient water quality monitoring station at the Spring Creek inlet to Sheridan Lake (STORET ID: 460654). This station is sampled on a monthly basis.

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

Public Participation

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

1. Presentations to local groups on the findings of the assessment.
2. 30-day public notice period for public review and comment.

The findings from these public meetings and comments have been taken into consideration in development of the Spring Creek TMDL.

Implementation

Several types of BMPs should be considered in the development of a water quality management implementation plan for watershed draining the impaired segment of Spring Creek. The results of the HSPF model indicate that more than half (63.5%) of the bacteria load originates from livestock and other agricultural land uses. The remaining load originates from urban runoff (13.7%) and other human sources (14.8%), including failing septic systems and leaking sanitary sewer systems. While several types of control measures are available for reducing fecal coliform bacteria loads, the practicable control measures listed and discussed below are recommended to address these identified sources. Based on water quality monitoring, bacterial source tracking and HSPF model results, the recommended control measures are expected to achieve the required load reductions and attain the TMDL goal.

- Livestock access to streams should be reduced, and livestock should be provided sources of water away from streams.
- Unstable stream banks should be protected by enhancing the riparian vegetation that provides erosion control and filters runoff of pollutants into the stream.
- Filter strips should be installed along the stream bordering cropland and pastureland.
- Animal confinement facilities should implement proper animal waste management systems.
- A sanitary sewer inspection program should be implemented to repair or replace failing septic systems.
- A litter control program (which would include cleanup and control of domestic animal wastes) should be implemented in Hill City
- Stormwater BMPs should be implemented in impervious areas, including detention, retention and infiltration.

Palmer Gulch Creek and Spring Creek through Hill City (from Mitchell Lake to immediately upstream of Hill City) are two reaches with the greatest number of fecal coliform bacteria samples exceeding criteria. Since the exceedance levels are higher for these two reaches, higher levels of BMP implementation are recommended. In a report analyzing the phosphorus from the study area that is reaching Sheridan Lake (Swanson, 2004), more BMP implementation is also recommended for these reaches to improve the water quality in the lake.

In Palmer Gulch, off-stream livestock watering is recommended for the entire basin. This would reduce the bacteria originating from livestock watering in the stream. Horse trails should be moved away from stream banks to allow for an appropriate riparian buffer zone to be maintained.

In Hill City, detention ponds, grass swales, and filter systems located within the storm sewer are recommended to treat stormwater runoff. Implementation of these BMPs should reduce the fecal coliform concentrations in these reaches to levels that will support assigned beneficial uses.

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

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APPENDIX A: Results of Fecal Coliform Bacteria Source Tracking Using Pulse-field Gel Electrophoresis (PFGE)

Introduction

Water samples were collected from five locations in Spring and Palmer Creeks (PCT1, SCT1A, SCT4, SCT5, and SCT6; see Figure 1) roughly twice per month from May through August 2003 in order to determine the source of the bacterial contamination. Samples were analyzed with a bacterial source tracking technique known as pulsed-field gel electrophoresis (PFGE), which uses DNA to identify sources of fecal bacteria. A total of 47 stream samples were collected. From each sample, laboratory staff attempted to isolate five *E. coli* bacteria cells to test using the PFGE technique. A total of 235 bacterial cultures were attempted, but only 195 *E. coli* isolates were successfully cultured.

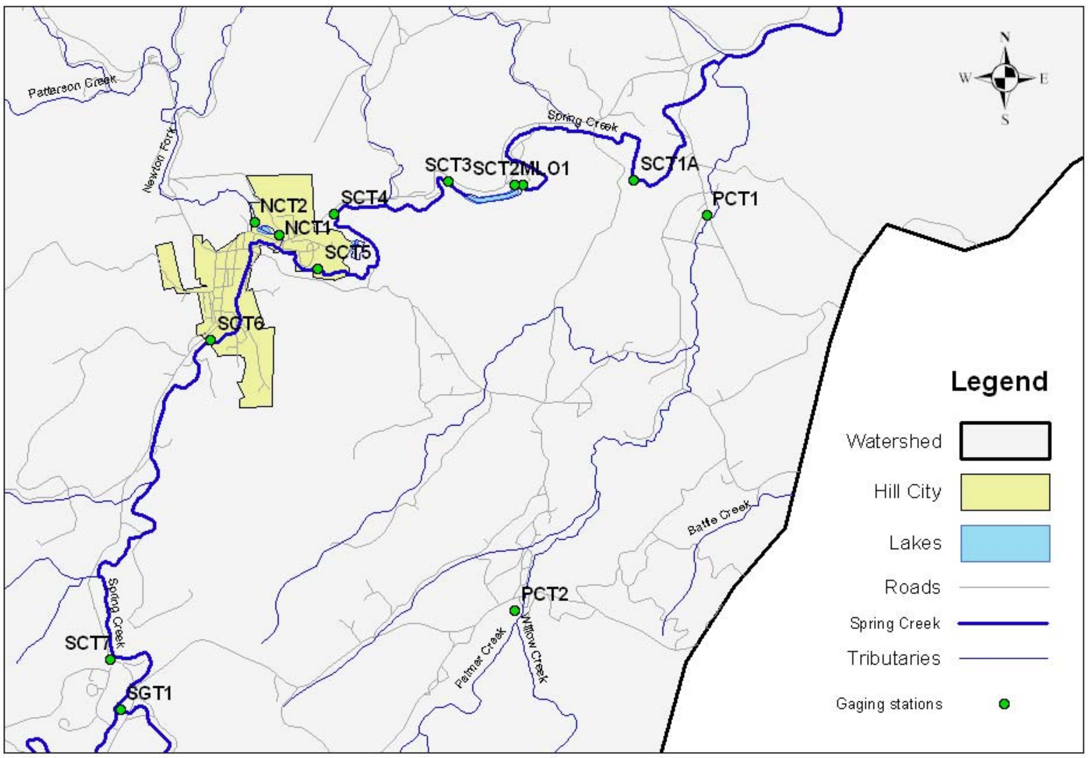


Figure 1. Map of water quality sampling sites near Hill City showing the location of bacterial source tracking sites (PCT1, SCT1A, SCT4, SCT5, and SCT6).

Results

Of the 195 isolates that were tested, approximately 23% were unidentifiable. Among the isolates for which the source could be identified, dog and pig were the major animal sources (13.3% each). Sheep and beef cow were also significant sources. Other identified animal sources include turkey, horse, dairy cow, chicken, and cat (Figure 2). Approximately 12.8% of the isolates were identified as human.

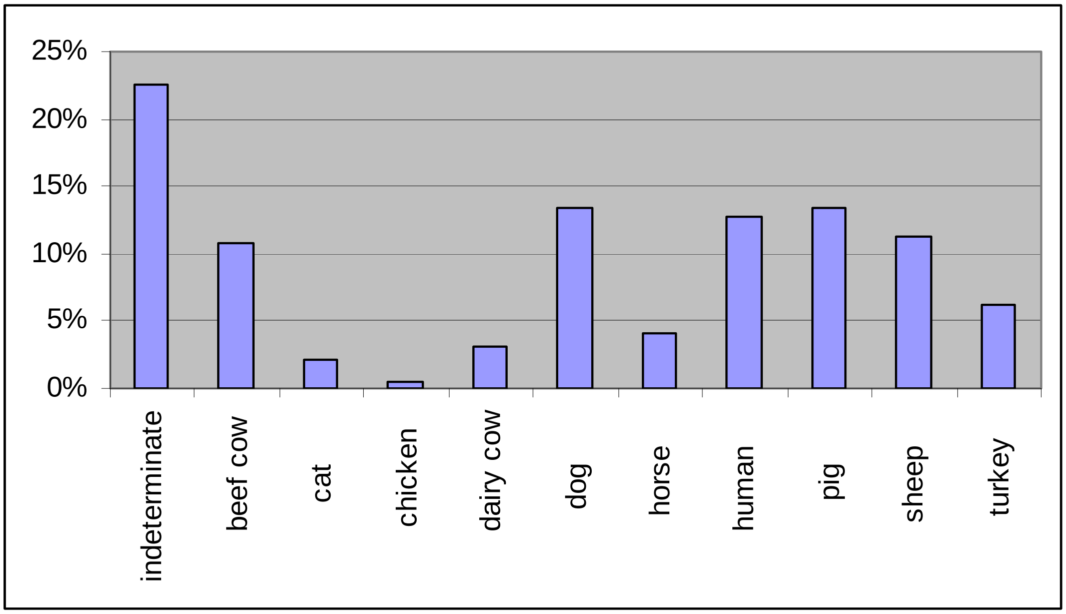


Figure 2. Percent of isolates by source.

Despite unequal sample sizes, comparisons were made between the two sampled streams. Palmer Creek showed higher numbers of beef cow, dairy cow, pig, horse, and cat sources, while Spring Creek had higher numbers of turkey, sheep, dog, and human sources. Chickens were not identified as a source in Palmer Creek. The number of isolates identified as originating from pigs and cows in Palmer Creek were significantly greater than the number identified in Spring Creek. The number of isolates identified as originating from dogs in Spring Creek was significantly greater than the number identified in Palmer Creek (Figure 3).

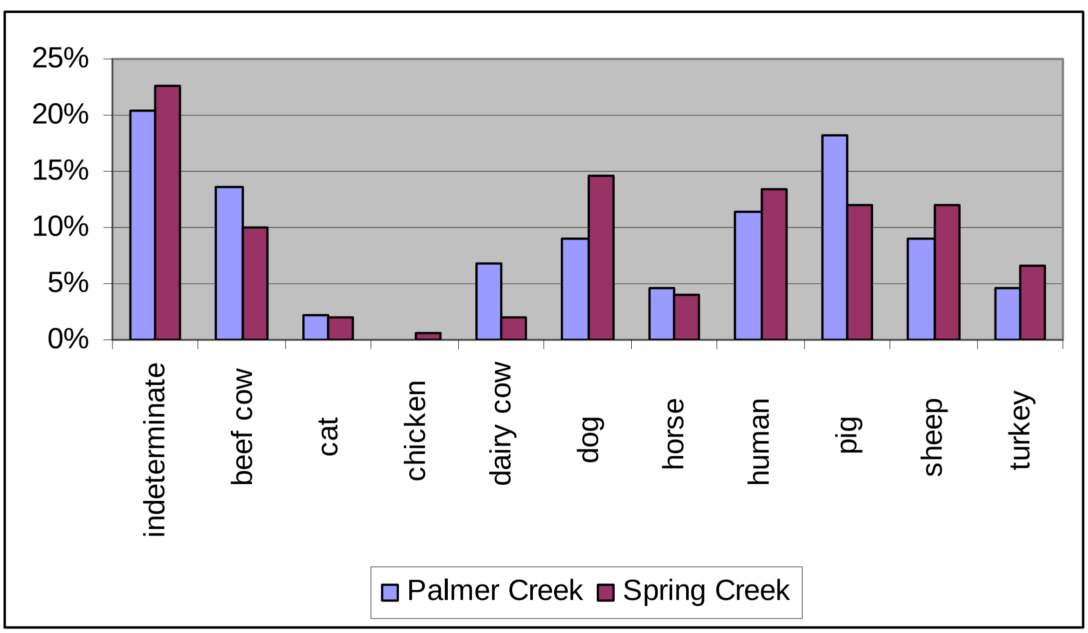


Figure 3. Percent of isolates by source and stream.

As expected, bacteria source results were highly variably, both spatially and temporally. Still, some trends were apparent. Among the Spring Creek sites, the percent of isolates from human sources appear to increase in a downstream direction from less than 10% at site SCT6 to 20% at site SCT1A. Likewise, the turkey source increased in a downstream direction in Spring Creek (Figure 5). Among all sites, the percent of isolates from animal sources was greatest at site SCT-5, which is located immediately downstream of the Hill City wastewater lagoons (Figure 4). The predominant animal source in Spring Creek is dog, while the predominant animal source in Palmer Creek is pig (Figures 5 and 6).

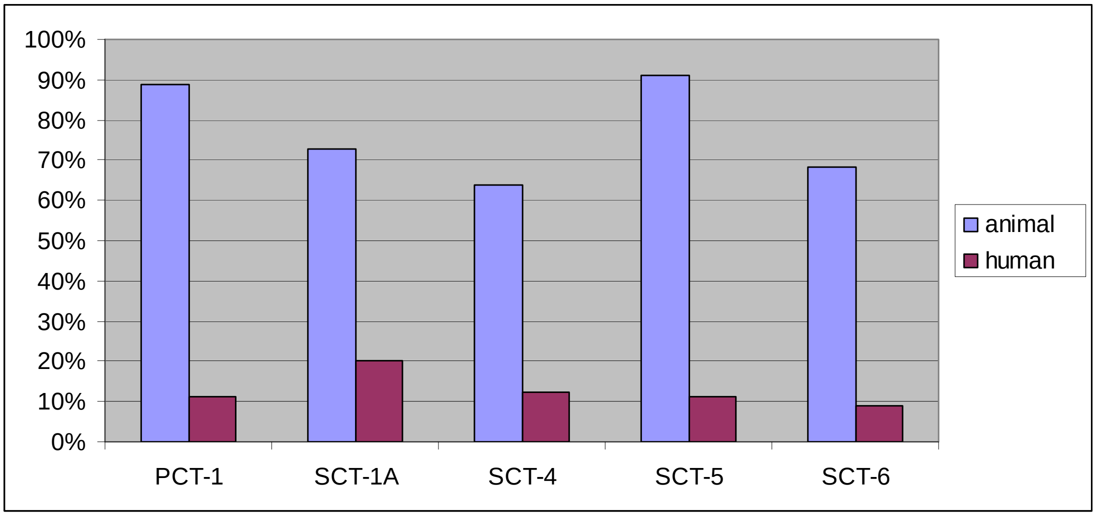


Figure 4. Percent of isolates by site and source (human vs. animal).

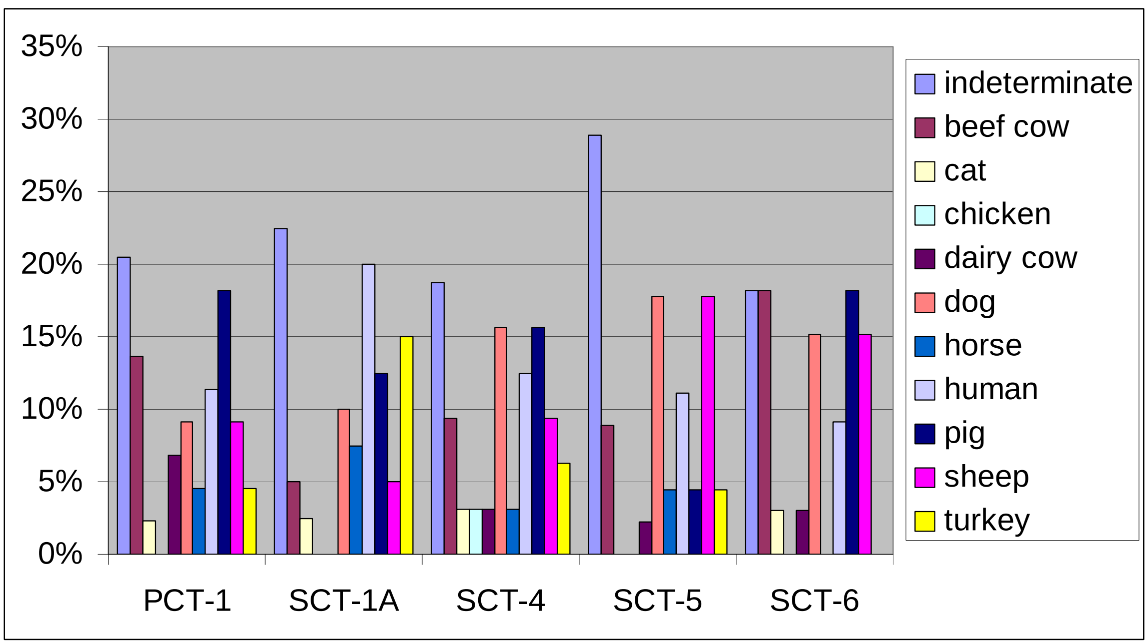


Figure 5. Percent of isolates by site and all identified sources.

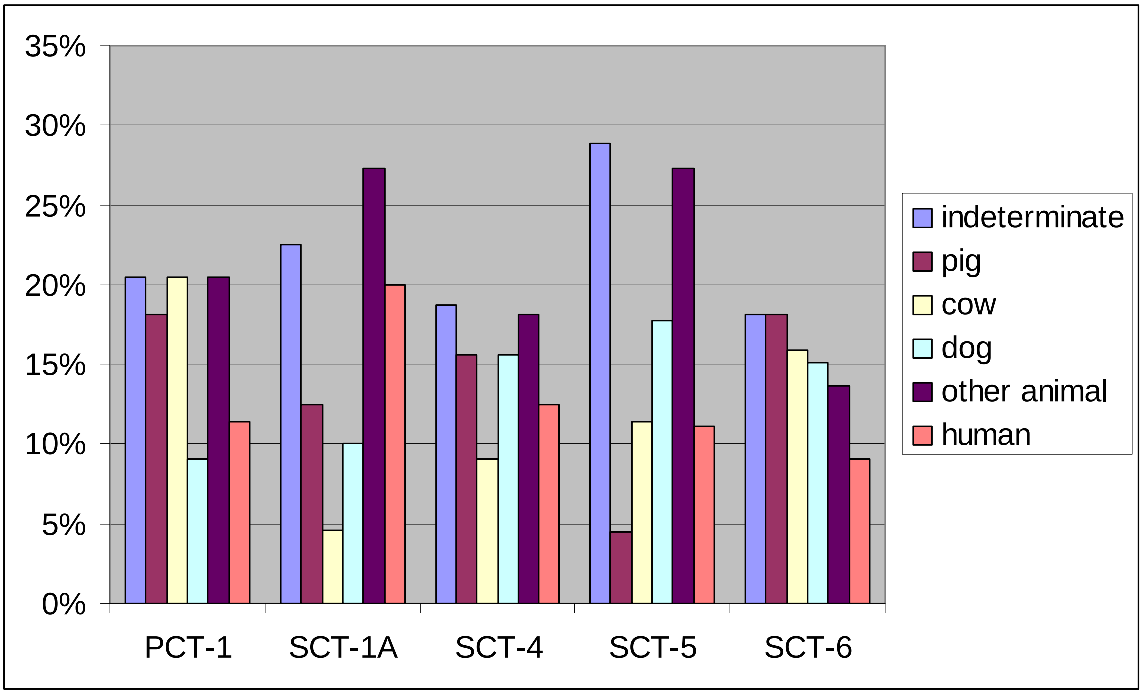


Figure 6. Percent of isolates by site and major sources (indeterminate, pig, cow, dog, other animal, or human).

Discussion

Bacteria source tracking results indicated that the largest sources of *E. coli* in the study area were livestock (i.e. beef cattle, sheep, and pigs), dogs, and humans. Other livestock sources, primarily horses and dairy cattle, were observed less frequently.

Surprisingly, *E. coli* from pigs was detected more frequently than from any other livestock animal. While pigs may be present in the study area, the predominant livestock animal is thought to be beef cattle. The Pennington County Conservation District may have information regarding livestock abundances that could be used to verify the anomalously high pig *E. coli* counts.

Dogs were identified as one of the most prevalent sources of *E. coli* in samples collected from Spring Creek. Highest numbers of dog *E. coli* were observed within Hill City at site SCT5, which then decreased downstream. Dog traffic on the Michelson Trail within Hill City could be contributing to this impairment.

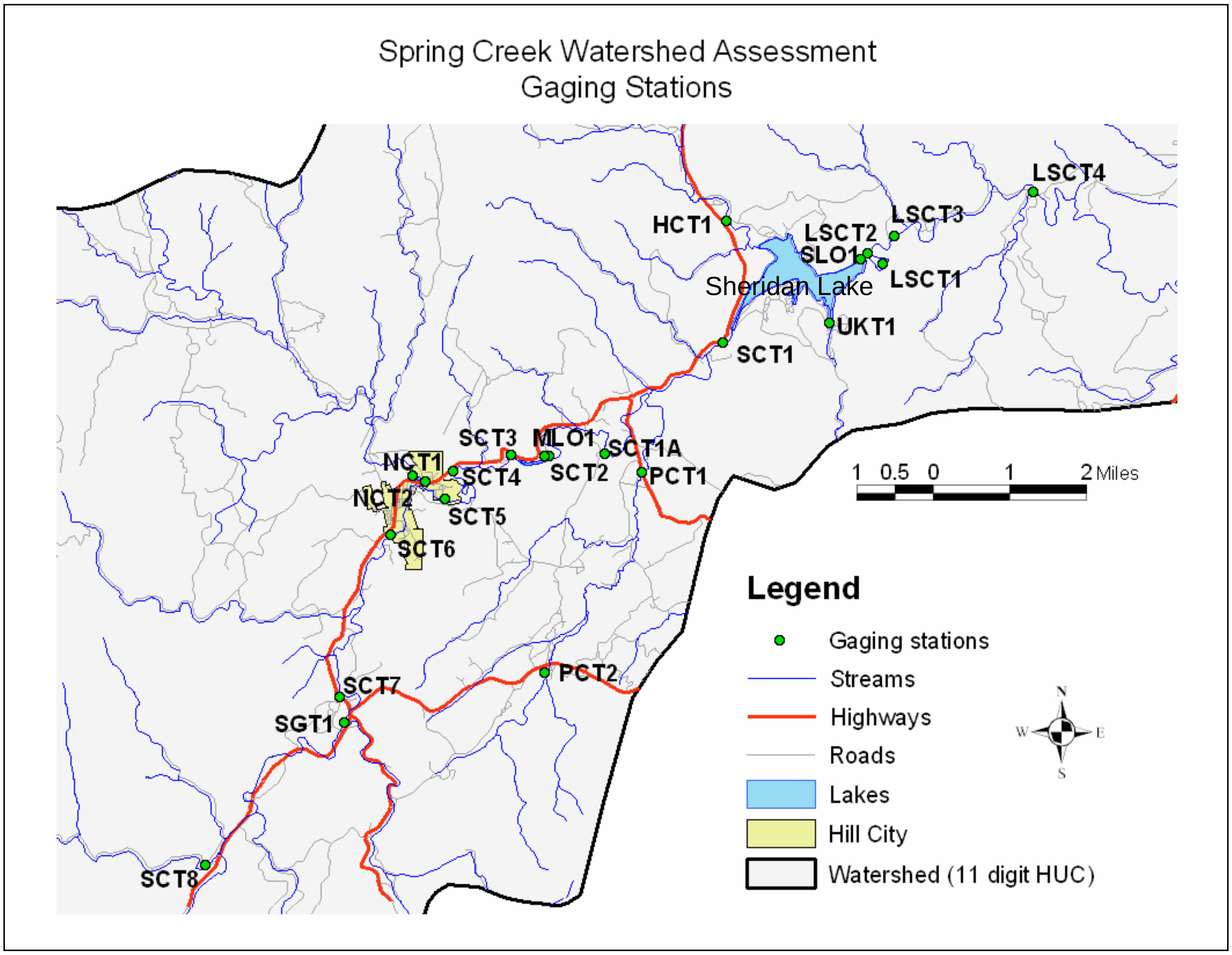
Overall, human sources of *E. coli* were observed much less frequently than livestock or other animal sources. The amount of human *E. coli* was somewhat greater in Spring Creek samples than Palmer Creek samples. However, a slight increase in human *E. coli* was observed in Spring Creek through Hill City.

The source of a large number of isolates was unidentifiable. This is attributed, in part, to the size of the reference DNA database used by the laboratory to identify known sources. If the reference database is increased, the ability to identify sources should increase. In addition, samples gathered to represent the human source were collected from a wastewater lagoon. Choosing to sample lagoons as a known human source may have introduced error in the identification of human sources, as other sources of *E. coli* could also be present in the lagoons.

APPENDIX B: Monitoring Sites

Monitoring Sites

Site ID	LATITUDE	LONGITUDE
HCT1	43.984341287	-103.486770313
LSCT1	43.975500443	-103.445516650
LSCT2	43.977732148	-103.449678365
LSCT3	43.980858924	-103.442483153
LSCT4	43.988826586	-103.405735612
MLO1	43.940102530	-103.535803348
NCT1	43.935672254	-103.567852299
NCT2	43.936339995	-103.571503849
PCT1	43.936796369	-103.510369579
PCT2	43.899002181	-103.536674459
SCT1	43.961278532	-103.488178731
SCT1A	43.940331873	-103.520003651
SCT2	43.940169386	-103.534559105
SCT3	43.940565177	-103.544615313
SCT4	43.937855056	-103.560697538
SCT5	43.932411774	-103.562228939
SCT6	43.925647246	-103.576986129
SCT7	43.894936486	-103.590928884
SCT8	43.863385199	-103.627033042
SGT1	43.890131692	-103.589646634
SLO1	43.976456636	-103.451328314
UKT1	43.964505569	-103.460021994


Spring Creek Watershed Assessment
Gaging Stations
LSCT4
HCT1
LSCT3
LSCT2
SLO1
Sheridan Lake
LSCT1
UKT1
SCT1
SCT3
MLO1
SCT1A
NCT1
SCT4
SCT2
PCT1
NCT2
SCT5
SCT6
1 0.5 0 1 2 Miles
Legend
Gaging stations
Streams
Highways
Roads
Lakes
Hill City
Watershed (11 digit HUC)
SCT7
PCT2
SGT1
SCT8
N
W
E
S

APPENDIX C: Quality Assurance / Quality Control Samples

Site ID	Date	QA/QC	Fecal Col	Tot. Sol.	TSS	Ammonia	TKN	Nitrate	Total_P
		Blank/Dup	(CFU/100mL)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)
SCT04	05/28/2002	Field Blank	ND	ND	ND	ND	ND	ND	0.007
PCT01	05/30/2002	Field Blank	ND	ND	ND	ND	ND	ND	0.006
SGT01	06/13/2002	Field Blank	ND	ND	ND	ND	ND	ND	0.011
PCT02	07/08/2002	Field Blank	ND	ND	ND	ND	ND	ND	0.008
School	08/06/2002	Blank	0	ND	ND	ND	ND	ND	0.009
SCT07	08/12/2002	Field Blank	ND	ND	ND	ND	ND	ND	ND
SCT5	08/12/2002	Field Blank	ND	ND	ND	ND	ND	ND	ND
SCT01	08/21/2002	Field Blank	ND	ND	ND	ND	ND	ND	ND
SGT01	08/21/2002	Field Blank	ND	ND	ND	ND	ND	ND	0.016
SCT07	09/09/2002	Field Blank	ND	6	ND	ND	ND	ND	0.017
NCT01	10/07/2002	Field Blank	ND	ND	ND	ND	ND	ND	0.014
SCT03	11/04/2002	Field Blank	ND	ND	ND	ND	ND	ND	0.015
SCT02	11/04/2002	Field Blank	ND	ND	ND	ND	ND	ND	0.015
SCT6	01/16/2003	Field Blank	ND	ND	ND	ND	ND	ND	0.008
SCT08	03/20/2003	Field Blank	ND	6	ND	ND	ND	ND	0.020
SGT01	03/20/2003	Field Blank	ND	ND	ND	ND	ND	ND	0.020
PCT01	03/20/2003	Field Blank	ND	ND	ND	ND	ND	ND	0.020
SGT01	05/20/2003	Field Blank	ND	8	ND	ND	ND	ND	ND

Site ID	Date	QA/QC	Fecal Col	Tot. Sol.	TSS	Ammonia	TKN	Nitrate	Total_P
		Blank/Dup	(CFU/100mL)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)
SCT02	05/07/2002	Duplicate	1	200	8	ND	ND	ND	0.026
			6	210	2.5	ND	0.6	ND	0.030
			71.4%	**2.4%**	**52.4%**	**0.0%**	**0.0%**	**0.0%**	**7.1%**
SCT5	05/28/2002	Duplicate	2	190	29	ND	ND	ND	0.060
			5	180	23	ND	ND	ND	0.050
			42.9%	**2.7%**	**11.5%**	**0.0%**	**0.0%**	**0.0%**	**9.1%**
PCT02	05/30/2002	Duplicate	90	58	5	ND	ND	ND	0.057
			28	56	5	ND	ND	ND	0.056
			52.5%	**1.8%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.9%**
NCT01	06/13/2002	Duplicate	4	150	2.5	ND	ND	ND	0.021
			1	130	7	ND	ND	ND	0.021
			60.0%	**7.1%**	**47.4%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**
SCT04	06/13/2002	Duplicate	4	210	2.5	0.07	ND	ND	0.029
			2	200	5	5	ND	ND	0.025
			33.3%	**2.4%**	**33.3%**	**97.2%**	**0.0%**	**0.0%**	**7.4%**
NCT02	07/08/2002	Duplicate	1	140	6	ND	ND	0.08	0.024
			6	110	2.5	ND	ND	0.08	0.026
			71.4%	**12.0%**	**41.2%**	**0.0%**	**0.0%**	**0.0%**	**4.0%**
SCT07	07/08/2002	Duplicate	110	200	2.5	ND	ND	ND	0.038
			96	200	7	ND	ND	ND	0.040
			6.8%	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**2.6%**
SGT01	08/05/2002	Duplicate	>=2000	110	22	ND	0.5	0.05	0.230
			>=1000	110	16	ND	0.5	0.05	0.210
			*	**0.0%**	**15.8%**	**0.0%**	**0.0%**	**0.0%**	**4.5%**
NCT02	08/12/2002	Duplicate	25	130	ND	ND	ND	0.07	0.029
			15	130	ND	ND	ND	0.09	0.025
			25.0%	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**12.5%**	**7.4%**

* undetermined

Site ID	Date	QA/QC	Fecal Col	Tot. Sol.	TSS	Ammonia	TKN	Nitrate	Total_P
		Blank/Dup	(CFU/100mL)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)
SGT01	08/12/2002	Duplicate	15	100	ND	ND	ND	ND	0.087
			3	48	ND	ND	ND	ND	0.088
			66.7%	**35.1%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.6%**
SCT08	09/09/2002	Duplicate	540	220	29	ND	0.7	0.05	0.120
			440	220	32	ND	0.6	0.05	0.12
			10.2%	**0.0%**	**4.9%**	**0.0%**	**7.7%**	**0.0%**	**0.0%**
PCT02	09/09/2002	Duplicate	>=4000	100	18	ND	0.7	0.025	0.290
			>=4000	100	15	ND	0.8	0.06	0.28
			0.0%	**0.0%**	**9.1%**	**0.0%**	**6.7%**	**41.2%**	1.8%
PCT01	09/09/2002	Duplicate	540	880	370	0.39	8.6	2.8	2.5
			>=6700	880	300	0.37	9.7	2.8	2.80
			*	**0.0%**	**10.4%**	**2.6%**	**6.0%**	**0.0%**	**5.7%**
SGT01	10/07/2002	Duplicate	3	120	ND	ND	ND	ND	0.078
			15	120	ND	ND	ND	ND	0.076
			66.7%	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**1.3%**
SCT04	10/07/2002	Duplicate	18	230	ND	0.12	0.5	0.1	0.040
			4	230	ND	0.12	0.25	0.1	0.046
			63.6%	**0.0%**	**0.0%**	**0.0%**	**33.3%**	**0.0%**	**7.0%**
SCT5	11/04/2002	Duplicate	ND	230	ND	ND	ND	0.11	0.016
			ND	230	ND	ND	ND	0.11	0.016
			0.0%	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**
SCT01	11/04/2002	Duplicate	4	260	5	ND	ND	0.12	0.017
			4	260	5	ND	ND	0.12	0.018
			0.0%	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**2.9%**
NCT01	01/16/2003	Duplicate	ND	160	2.5	ND	0.68	ND	0.037
			ND	150	5	ND	0.68	ND	0.040
			0.0%	**3.2%**	**33.3%**	**0.0%**	**0.0%**	**0.0%**	**3.9%**
HCT01	01/28/2003	Duplicate	4	170	ND	ND	ND	0.29	0.040
			10	160	ND	ND	ND	0.29	0.038
			42.9%	**3.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**2.6%**
SCT6	03/20/2003	Duplicate	1	280	55	0.06	0.82	0.23	0.130
			50	260	48	0.06	0.85	0.23	0.14
			96.1%	**3.7%**	**6.8%**	**0.0%**	**1.8%**	**0.0%**	**3.7%**
SCT04	03/20/2003	Duplicate	ND	260	17	0.09	0.7	0.28	0.070
			ND	280	16	0.1	0.65	0.28	0.082
			0.0%	**3.7%**	**3.0%**	**5.3%**	**3.7%**	**0.0%**	**7.9%**
SCT01	03/20/2003	Duplicate	10	290	34	0.18	1.2	0.34	0.180
			8	260	22	0.19	1.2	0.32	0.16
			11.1%	**5.5%**	**21.4%**	**2.7%**	**0.0%**	**3.0%**	**5.9%**
SCT03	05/20/2003	Duplicate	2	210	10	ND	ND	ND	0.024
			2	190	11	ND	ND	ND	0.026
Average			0.0%	**5.0%**	**4.8%**	**0.0%**	**0.0%**	**0.0%**	**4.0%**
			33.6%	4.2%	12.6%	5.7%	1.0%	0.2%	3.9%
* undetermined									

APPENDIX D: Bacteria Sample Data

Site ID	Sample Date	Sample Time	Fecal Coliform Bacteria Concentration (CFU/100ml)	*E. coli* Concentration (CFU/100ml)
HCT01	5/7/2002	12:25:00 PM	52	60
HCT01	6/13/2002	3:25:00 PM	4	1
HCT01	7/8/2002	3:45:00 PM	66	30
HCT01	5/29/2002	10:52:00 AM	2	5
HCT01	8/12/2002	12:55:00 PM	200	5
HCT01	8/5/2002	11:00:00 PM	1000	30
HCT01	9/9/2002	1:45:00 PM	290	5
HCT01	10/7/2002	1:05:00 PM	1	3
HCT01	11/4/2002	1:00:00 PM	26	1
HCT01	1/28/2003	12:50:00 PM	10	2
HCT01	3/16/2003	1:45:00 PM	1	5
HCT01	3/20/2003	3:00:00 PM	1	5
HCT01	5/20/2003	12:35:00 PM	2	2
LSCT01	5/13/2002	2:45:00 PM	1	1
LSCT01	5/29/2002	9:40:00 AM	6	5
LSCT01	6/18/2002	12:05:00 PM	6	1
LSCT01	7/8/2002	4:43:00 PM	34	20
LSCT01	8/12/2002	1:35:00 PM	3	5
LSCT01	9/9/2002	2:35:00 PM	10	10
LSCT01	10/7/2002	1:50:00 PM	1	3
LSCT01	11/4/2002	2:05:00 PM	1	1
LSCT01	6/18/2002	12:05:00 PM	1	1
LSCT01	1/28/2003	11:45:00 AM	4	1
LSCT01	3/16/2003	2:20:00 PM	1	1
LSCT01	3/20/2003	1:35:00 PM	2	5
LSCT01	5/20/2003	1:10:00 PM	1	1
LSCT02	5/13/2002	3:05:00 PM	1	1
LSCT02	5/29/2002	10:07:00 AM	52	5
LSCT02	6/18/2002	11:38:00 AM	1	1
LSCT02	7/8/2002	4:21:00 PM	22	10
LSCT02	8/12/2002	2:00:00 PM	30	5
LSCT02	9/9/2002	2:20:00 PM	100	10
LSCT02	10/7/2002	2:10:00 PM	1	3
LSCT02	11/4/2002	2:20:00 PM	1	2
LSCT02	1/28/2003	12:10:00 PM	2	1
LSCT02	3/16/2003	2:40:00 PM	1	1
LSCT02	3/20/2003	3:50:00 PM	1	5
LSCT02	5/20/2003	1:20:00 PM	1	1
LSCT03	5/13/2002	3:35:00 PM	1	1
LSCT03	5/29/2002	9:00:00 AM	52	5
LSCT03	6/13/2002	3:55:00 PM	2.5	2.5
LSCT03	7/8/2002	5:23:00 PM	8	10

Site ID	Sample Date	Sample Time	Fecal Coliform Bacteria Concentration (CFU/100ml)	*E. coli* Concentration (CFU/100ml)
LSCT03	8/12/2002	2:30:00 PM	280	5
LSCT03	9/9/2002	3:05:00 PM	180	15
LSCT03	10/7/2002	2:30:00 PM	4	3
LSCT03	11/4/2002		4	1
LSCT03	1/28/2003	11:00:00 AM	4	1
LSCT04	5/13/2002	4:05:00 PM	1	1
LSCT04	5/29/2002	8:40:00 AM	4	10
LSCT04	6/13/2002	4:15:00 PM	4	1
LSCT04	7/8/2002	5:40:00 PM	66	66
LSCT04	8/12/2002	2:45:00 PM	20	5
LSCT04	9/9/2002	3:35:00 PM	1200	10
LSCT04	10/7/2002	2:40:00 PM	16	3
LSCT04	11/4/2002	2:50:00 PM	4	1
LSCT04	5/13/2002	4:05:00 PM	1	1
LSCT04	7/8/2002	5:40:00 PM	66	20
LSCT04	8/12/2002	2:45:00 PM	15	5
LSCT04	10/7/2002	2:40:00 PM	1	1
LSCT04	1/28/2003	10:35:00 AM	4	1
LSCT04	3/16/2003	3:10:00 PM	2	2
LSCT04	5/20/2003	1:50:00 PM	1	1
LSCT04	3/16/2003	3:10:00 PM	1	1
NCT01	5/13/2002	10:50:00 AM	1	1
NCT01	5/28/2002	3:50:00 PM	4	5
NCT01	6/13/2002	12:45:00 PM	1	1
NCT01	7/8/2002	1:17:00 PM	10	0
NCT01	8/12/2002	10:20:00 AM	10	15
NCT01	9/9/2002	11:40:00 AM	100	50
NCT01	10/7/2002	11:05:00 AM	5	10
NCT01	11/4/2002	10:30:00 AM	1	1
NCT01	6/13/2002	12:45:00 PM	4	1
NCT01	10/7/2002	11:05:00 AM	1	1
NCT01	1/16/2003	1:15:00 PM	1	5
NCT01	3/16/2003	10:50:00 AM	2	1
NCT01	3/20/2003	12:35:00 PM	9	5
NCT01	5/20/2003	10:25:00 AM	32	1
NCT02	5/13/2002	11:15:00 AM	1	50
NCT02	5/28/2002	3:30:00 PM	72	40
NCT02	6/13/2002	12:30:00 PM	12	1
NCT02	7/8/2002	12:51:00 PM	6	5
NCT02	8/12/2002	10:35:00 AM	15	5
NCT02	9/9/2002	11:25:00 AM	1000	0
NCT02	10/7/2002	10:50:00 AM	1	3
NCT02	11/4/2002	10:20:00 AM	1	1
NCT02	7/8/2002	12:51:00 PM	1	5

Site ID	Sample Date	Sample Time	Fecal Coliform Bacteria Concentration (CFU/100ml)	*E. coli* Concentration (CFU/100ml)
NCT02	8/12/2002	10:35:00 AM	25	30
NCT02	5/20/2003	3:15:00 PM	4	1
PCT01	5/7/2002	11:45:00 AM	140	50
PCT01	5/30/2002	4:10:00 PM	400	310
PCT01	6/13/2002	10:35:00 AM	280	300
PCT01	7/8/2002	10:05:00 AM	400	5
PCT01	8/12/2002	8:25:00 AM	640	10
PCT01	8/5/2002	9:10:00 PM	20000	100
PCT01	9/9/2002	12:33:00 AM	6700	300
PCT01	10/7/2002	9:10:00 AM	130	5
PCT01	11/4/2002	8:45:00 AM	48	1
PCT01	5/30/2002	4:10:00 PM	1	5
PCT01	9/9/2002	12:33:00 AM	540	300
PCT01	1/16/2003	10:10:00 AM	4	1
PCT01	3/16/2003	8:40:00 AM	240	5
PCT01	3/20/2003	10:30:00 AM	97	45
PCT01	5/20/2003	8:25:00 AM	74	10
PCT01	3/20/2003	10:30:00 AM	1	1
PCT01	6/13/2003	11:30:00 AM	2400	36
PCT01	6/13/2003	11:30:00 AM	2200	48
PCT01	8/8/2003	9:30:00 AM	16000	91000
PCT01	8/8/2003	9:30:00 AM	19	2
PCT02	5/30/2002	11:00:00 AM	28	20
PCT02	7/8/2002	10:35:00 AM	1300	40
PCT02	9/9/2002	9:40:00 AM	4000	50
PCT02	5/30/2002	11:00:00 AM	90	80
PCT02	7/8/2002	10:35:00 AM	1	1
PCT02	9/9/2002	9:40:00 AM	4000	100
PCT02	1/16/2003	10:45:00 AM	1	5
PCT02	5/20/2003	9:00:00 AM	4	2
SCT01	5/7/2002	1:55:00 PM	2	1
SCT01	5/29/2002	10:52:00 AM	6	5
SCT01	5/29/2002	11:51:00 AM	12	5
SCT01	6/13/2002	2:40:00 PM	20	10
SCT01	7/8/2002	3:58:00 PM	54	10
SCT01	8/12/2002	12:10:00 PM	130	3
SCT01	9/9/2002	1:05:00 PM	6700	50
SCT01	10/7/2002	12:25:00 PM	10	3
SCT01	11/4/2002	12:05:00 PM	4	1
SCT01	8/21/2002	7:20:00 PM	1	1
SCT01	11/4/2002	12:05:00 PM	4	1
SCT01	1/16/2003	3:05:00 PM	100	5
SCT01	3/16/2003	12:45:00 PM	5	5
SCT01	3/20/2003	2:20:00 PM	8	5

Site ID	Sample Date	Sample Time	Fecal Coliform Bacteria Concentration (CFU/100ml)	*E. coli* Concentration (CFU/100ml)
SCT01	5/20/2003	12:05:00 PM	1	1
SCT01	3/20/2003	2:20:00 PM	10	5
SCT01	8/8/2003	8:30:00 AM	16000	11000
SCT01	5/7/2002	3:20:00 PM	6	1
SCT02	5/28/2002	1:00:00 PM	8	20
SCT02	6/13/2002	2:20:00 PM	1	1
SCT02	7/8/2002	2:25:00 PM	18	10
SCT02	9/9/2002	12:30:00 PM	45	10
SCT02	8/12/2002	11:50:00 AM	20	10
SCT02	10/7/2002	12:10:00 PM	3	5
SCT02	11/4/2002	11:40:00 AM	1	1
SCT02	5/7/2002	3:20:00 PM	1	1
SCT02	11/4/2002	11:40:00 AM	1	1
SCT02	1/16/2003	2:25:00 PM	10	10
SCT02	3/16/2003	12:00:00 PM	2	5
SCT02	3/20/2003	1:45:00 PM	3	5
SCT02	5/20/2003	11:30:00 AM	2	1
SCT03	5/7/2002	3:50:00 PM	1	1
SCT03	5/28/2002	2:00:00 PM	2	5
SCT03	6/13/2002	2:00:00 PM	6	2
SCT03	7/8/2002	2:11:00 PM	40	5
SCT03	8/12/2002	11:30:00 AM	30	5
SCT03	9/9/2002	12:15:00 PM	2500	100
SCT03	10/7/2002	11:55:00 AM	3	3
SCT03	11/4/2002	11:20:00 AM	2	1
SCT03	11/4/2002	11:20:00 AM	1	1
SCT03	1/16/2003	2:10:00 PM	1	1
SCT03	3/16/2003	11:40:00 AM	2	5
SCT03	3/20/2003	1:30:00 PM	1	5
SCT03	5/20/2003	11:25:00 AM	2	1
SCT03	5/20/2003	11:25:00 AM	2	1
SCT04	5/13/2002	9:35:00 AM	1	1
SCT04	5/28/2002		10	50
SCT04	6/13/2002	1:40:00 PM	2	
SCT04	7/8/2002	1:49:00 PM	46	70
SCT04	8/12/2002	11:20:00 AM	65	5
SCT04	8/5/2002	9:45:00 PM		200
SCT04	9/9/2002	12:00:00 PM	1600	50
SCT04	8/22/2002	11:54:00 AM	2800	100
SCT04	10/7/2002	11:35:00 AM	4	3
SCT04	11/4/2002	11:05:00 AM	1	1
SCT04	5/28/2002		1	1
SCT04	6/13/2002	1:40:00 PM	4	1
SCT04	10/7/2002	11:35:00 AM	18	5

Site ID	Sample Date	Sample Time	Fecal Coliform Bacteria Concentration (CFU/100ml)	*E. coli* Concentration (CFU/100ml)
SCT04	1/16/2003	1:50:00 PM	1	3
SCT04	3/16/2003	11:25:00 AM	2	5
SCT04	3/20/2003	1:10:00 PM	2	5
SCT04	5/20/2003	11:10:00 AM	2	1
SCT04	3/20/2003	1:10:00 PM	1	5
SCT04	6/13/2003	10:30:00 AM	46	4
SCT04	8/8/2003	8:50:00 AM	9000	820
SCT05	5/13/2002	10:15:00 AM	1	1
SCT05	5/28/2002	3:10:00 PM	5	5
SCT05	6/13/2002	1:20:00 PM	12	2
SCT05	7/8/2002	1:31:00 PM	120	30
SCT05	8/12/2002	10:55:00 AM	40	5
SCT05	9/9/2002	11:50:00 AM	2000	50
SCT05	10/7/2002	11:20:00 AM	1	3
SCT05	11/4/2002	10:45:00 AM	1	1
SCT05	5/28/2002	3:10:00 PM	2	10
SCT05	8/12/2002	10:55:00 AM	1	1
SCT05	11/4/2002	10:45:00 AM	1	1
SCT05	1/16/2003	1:40:00 PM	60	32
SCT05	3/16/2003	11:00:00 AM	10	1
SCT05	3/20/2003	12:55:00 PM	5	10
SCT05	5/20/2003	10:55:00 AM	6	1
SCT06	5/13/2002	12:05:00 PM	4	10
SCT06	5/29/2002	12:45:00 PM	1	5
SCT06	6/13/2002	12:15:00 PM	20	2
SCT06	7/8/2002	12:21:00 PM	94	60
SCT06	8/12/2002	10:05:00 AM	20	5
SCT06	8/5/2002	9:54:00 PM	3000	50
SCT06	9/9/2002	11:10:00 AM	1800	50
SCT06	8/22/2002	12:00:00 PM	940	20
SCT06	10/7/2002	10:35:00 AM	1	3
SCT06	11/4/2002	10:05:00 AM	1	1
SCT06	1/16/2003	12:35:00 PM	10	1
SCT06	3/16/2003	10:30:00 AM	5	5
SCT06	3/20/2003	12:15:00 PM	50	10
SCT06	5/20/2003	10:00:00 AM	1	1
SCT06	3/20/2003	12:15:00 PM	1	5
SCT06	6/12/2003	9:35:00 PM	30	18
SCT06	8/8/2003	9:05:00 AM	9000	3200
SCT07	5/13/2002	12:25:00 PM	6	1
SCT07	5/29/2002	1:00:00 PM	1	5
SCT07	6/13/2002	12:00:00 PM	1	1
SCT07	7/8/2002	11:51:00 AM	96	5
SCT07	8/12/2002	9:35:00 AM	35	5

Site ID	Sample Date	Sample Time	Fecal Coliform Bacteria Concentration (CFU/100ml)	*E. coli* Concentration (CFU/100ml)
SCT07	8/5/2002	10:10:00 PM	1000	5
SCT07	9/9/2002	10:50:00 AM	2000	50
SCT07	10/7/2002	10:20:00 AM	10	3
SCT07	11/4/2002	9:50:00 AM	1	1
SCT07	7/8/2002	11:51:00 AM	110	5
SCT07	8/12/2002	9:35:00 AM	1	1
SCT07	9/9/2002	10:50:00 AM	1	1
SCT07	1/16/2003	12:10:00 PM	1	1
SCT07	3/16/2003	10:05:00 AM	2	5
SCT07	3/20/2003	12:00:00 PM	2	5
SCT07	5/20/2003	9:50:00 AM	4	1
SCT08	5/13/2002	1:30:00 AM	1	1
SCT08	5/29/2002	1:45:00 PM	1	5
SCT08	6/13/2002	11:00:00 AM	1	1
SCT08	7/8/2002	11:11:00 AM	36	5
SCT08	8/12/2002	9:00:00 AM	40	50
SCT08	9/9/2002	10:10:00 AM	440	50
SCT08	10/7/2002	9:40:00 AM	12	3
SCT08	11/4/2002	9:15:00 AM	8	1
SCT08	9/9/2002	10:10:00 AM	540	50
SGT01	1/16/2003	11:10:00 AM	1	1
SCT08	3/16/2003	9:30:00 AM	13	5
SCT08	3/20/2003	11:25:00 AM	1	5
SCT08	5/20/2003	9:15:00 AM	12	1
SCT08	3/20/2003	11:25:00 AM	1	1
SCT1A	5/7/2002	2:30:00 PM	20	10
SCT1A	5/29/2002	12:21:00 PM		
SCT1A	8/5/2002	9:32:00 PM	20000	100
SCT1A	9/9/2002	12:45:00 PM	300	50
SCT01A	1/16/2003	2:50:00 PM	2	1
SCT1A	3/16/2003	12:15:00 PM	5	5
SCT1A	3/20/2003	1:55:00 PM	390	350
SCT1A	5/20/2003	11:45:00 AM	2	1
SCT1A	6/12/2002	8:50:00 PM	1600	40
SCT1A	8/7/2003	6:25:00 PM	16000	12000
SGT01	5/13/2002	1:05:00 AM	1	1
SGT01	5/29/2002	1:20:00 PM	1	5
SGT01	6/13/2002	11:40:00 AM	2	1
SGT01	7/8/2002	11:31:00 AM	24	5
SGT01	8/12/2002	9:15:00 AM	3	5
SGT01	8/5/2002	10:20:00 PM	1000	5
SGT01	9/9/2002	10:30:00 AM	2400	50
SGT01	10/7/2002	10:00:00 AM	15	5
SGT01	11/4/2002	9:35:00 AM	1	1

Site ID	Sample Date	Sample Time	Fecal Coliform Bacteria Concentration (CFU/100ml)	*E. coli* Concentration (CFU/100ml)
SGT01	6/13/2002	11:40:00 AM	1	1
SGT01	8/12/2002	9:15:00 AM	15	5
SGT01	8/5/2002	10:20:00 PM	2000	50
SGT01	9/9/2002	10:30:00 AM	1	1
SGT01	10/7/2002	10:00:00 AM	3	5
SCT08	1/16/2003	11:50:00 AM	1	2
SGT01	3/16/2003	9:50:00 AM	1	1
SGT01	3/20/2003	11:45:00 AM	1	5
SGT01	5/20/2003	9:35:00 AM	1	1
SGT01	3/20/2003	11:45:00 AM	1	1
SCT01	5/20/2003	9:35:00 AM	1	1
UKT01	5/7/2002	1:16:00 PM	1	1
UKT01	5/29/2002	11:24:00 AM	45	40
UKT01	6/13/2002	3:00:00 PM	1	50
UKT01	7/8/2002	3:21:00 PM	40	20
UKT01	8/12/2002	12:30:00 PM	1	50
UKT01	9/9/2002	1:25:00 PM	2000	50
UKT01	10/7/2002	12:55:00 PM	5	5
UKT01	11/4/2002	12:40:00 PM	3	5
UKT01	1/16/2003	3:30:00 PM	1	5
UKT01	3/16/2003	1:15:00 PM	5	5
UKT01	3/20/2003	2:40:00 PM	1	15
UKT01	5/20/2003	12:15:00 PM	15	8

APPENDIX E: Supplemental Source Tracking Analysis

Supplemental Sampling Background

Supplemental sampling was conducted from May through August of 2004 at SCT1A, SCT4, SCT5, SCT6, and PCT1 (see Figure 3 pg 10 Appendix A). Nineteen samples were taken at each location. The objective of the supplemental sampling was to better define the source of coliform bacteria in the watershed. Ribo typing analysis was done on a minimum of five isolates from each sample. The results are summarized here and briefly discussed with respect to the watershed assessment.

Categorizing the sample sources was done using both the statewide library and ECO 17 categories. The individual results are summarized in Table D1 and Figures D1 and D2, giving the percent of samples that occurred within specified animal categories. ‘Unknown’ makes up 22.6 and 17.1 percent of the analysis in each classification, statewide and ECO 17, respectively. Because there is limited identification of wildlife it may be reasonable to associate a significant portion of the unknown to wildlife. Both classifications have similar percentages of human, 12.8 and 13.3 percent, statewide and ECO 17, respectively.

Table D2 and Figure D3 present the data aggregated into five general categories. There is general agreement between the two classifications for the general groupings with livestock being the highest at 43.1 and 50.8 percent, statewide and ECO 17 respectively. The human and domestic combined make up 19.0 and 32.2 percent, statewide and ECO 17, respectively.

The original analysis identified a needed reduction in fecal coliform loading of approximately 26 to 28 percent. With livestock and human plus domestic animals making up a majority of the sources, the required reduction can be achieved by focusing on riparian zone management and stormwater management. The data clearly indicate most exceedences are associated with runoff events. A third BMP category would be development and implementation of a septic tank management system. To account for uncertainty, these practices should be implemented along a minimum of 30 percent of the riparian zone in the most highly impacted reaches. For current conditions and long-term management a stormwater management plan should be developed and implemented for the entire watershed with emphasis on the Hill City area and the Palmer Creek watershed.

Table D1. Summary of ribo typing results for two classification approaches for both the statewide and Ecoregion 17 classifications.

Statewide Analysis			Eco 17 Specific		
Category	**Count**	**Percent**	**Category**	**Count**	**Percent**
Beef cow	21	10.8%	Bovine	44	18.3%
Pig	26	13.3%	Canine	26	10.8%
Sheep	22	11.3%	Equine	32	13.3%
Dairy cow	6	3.1%	Feline	19	7.9%
Horse	8	4.1%	Human	32	13.3%
Chicken	1	0.5%	Ovine	22	9.2%
Turkey	12	6.2%	Porcine	24	10.0%
Dog	26	13.3%	Unknown	41	17.1%
Cat	4	2.1%			
Human	25	12.8%			
Unknown	44	22.6%			

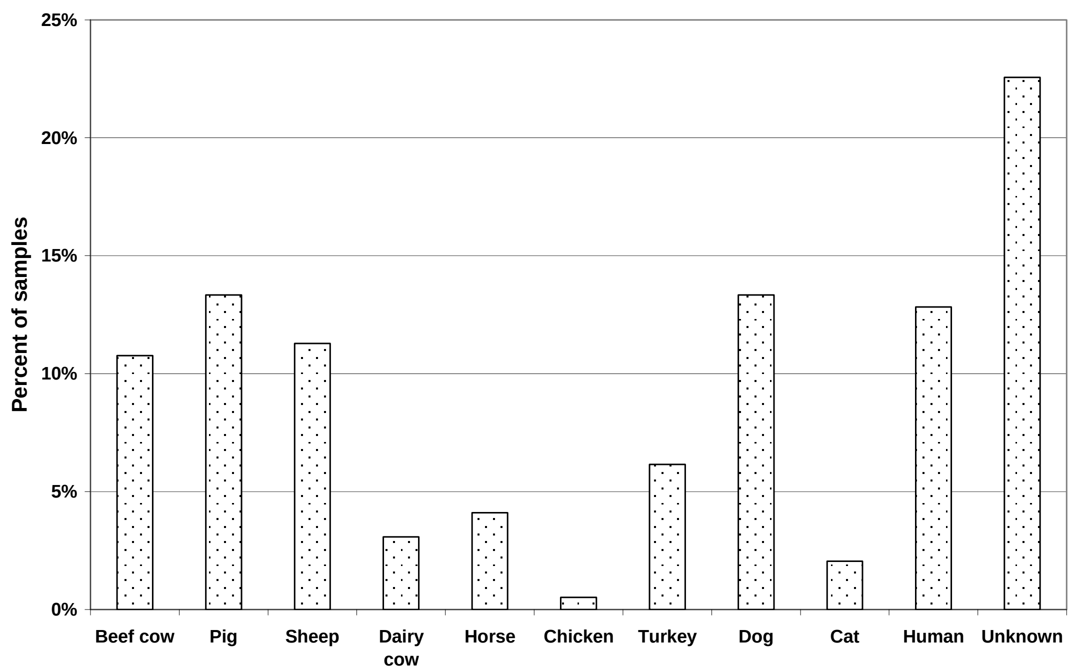


Figure D1. Percent of ribo-typing results in specified categories based on the statewide library.

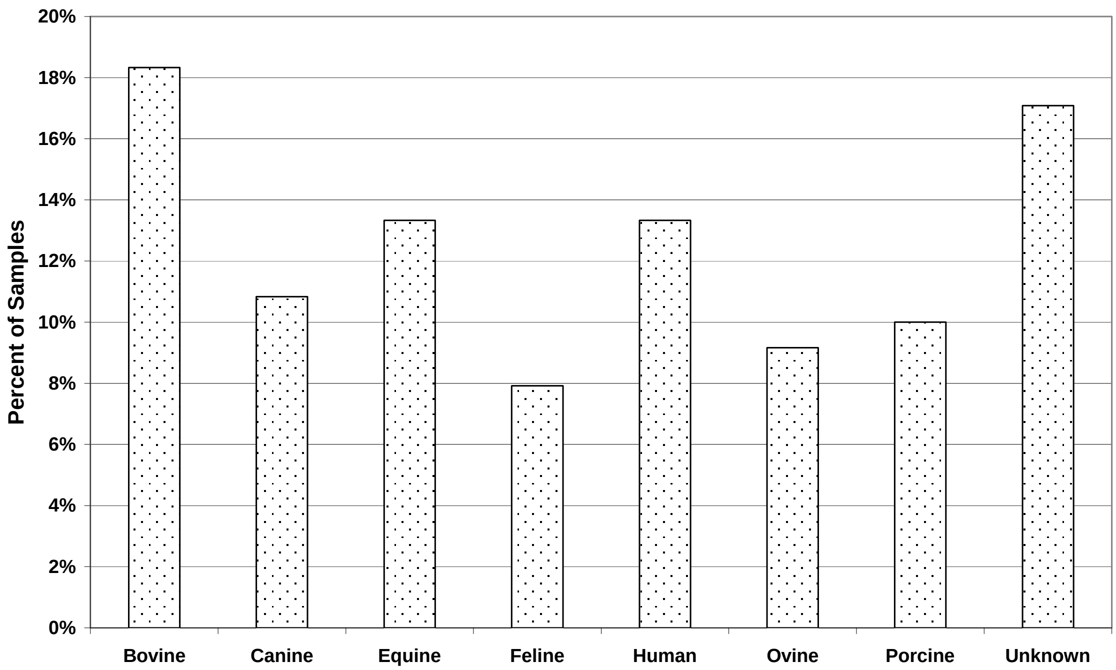


Figure D2. Percent of ribo-typing results in specified categories based on the Ecoregion 17 classification.

Table D2. Summary of ribo typing results for generalized groups for both the statewide and Eco 17 classifications.

Statewide Analysis			Eco 17 Specific		
Category	Count	Percent	Category	Count	Percent
Livestock	84	43.1%	Livestock	122	50.8%
Domestic	12	6.2%	Domestic	45	18.8%
Wildlife	30	15.4%	Wildlife	NA	
Human	25	12.8%	Human	32	13.3%
Unknown	44	22.6%	Unknown	41	17.1%

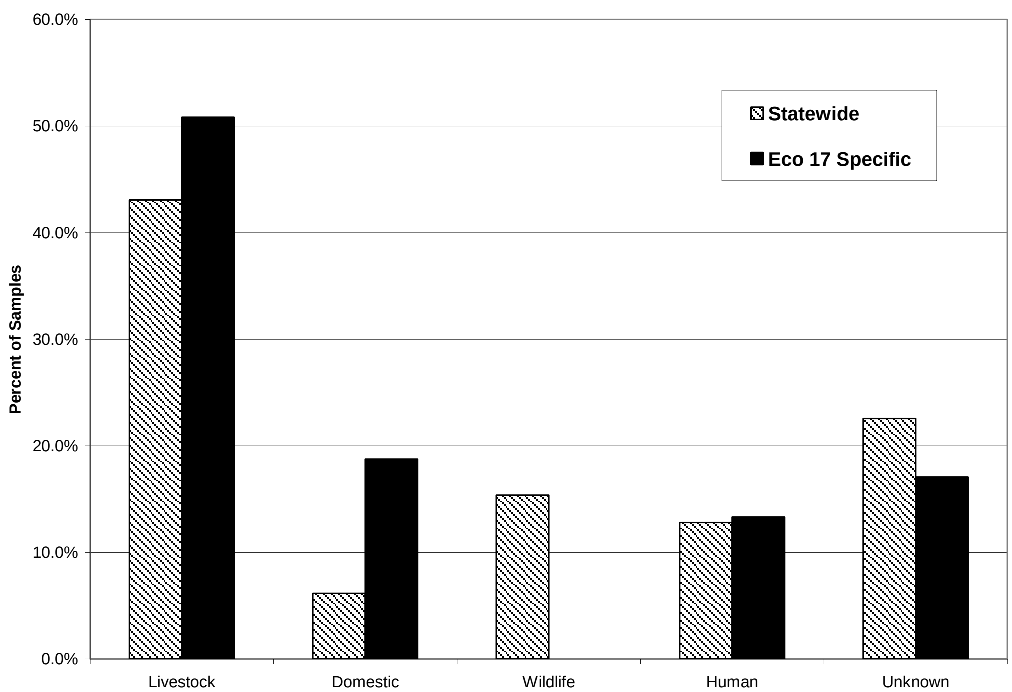


Figure D3. Summary of ribo typing results for generalized groups for both the statewide and Ecoregion 17 classifications.

APPENDIX F: Response to Comments

No comments were received from the general public during the initial 30-day public comment period. However, during the public comment period, the TMDL was reviewed by the U.S. Environmental Protection Agency (EPA) Region 8. Responses to comments received from EPA are provided below.

EPA Comment – *Water Quality Impairment Status* – It's still difficult to differentiate the Spring Creek "study area" from the 303(d) listed segment. Does the study area cover the entire listed segment? It would be helpful to show the listed segment on the study area map. The length of the Spring Creek study area is 31 miles, what is the length of the listed segment? We understand that the assessment needs to include a watershed area larger than the listed segment, however, in general the focus of the TMDL should be on the listed segment rather than the study area. It would also be helpful to show the location of the USGS gage (06406920) where the flow data was taken to derive the flow duration curve, and the location of the bacterial monitoring sites. Perhaps the map in Appendix B is intended to show the monitoring sites, but the map appears to only cover a portion of the listed segment and has very little descriptive information. Which gage is the USGS gage? Is the lake shown on the map Lake Mitchell or Sheridan Lake?

The 303(d) priority ranking of the listed waterbody needs to be mentioned in the TMDL document (in the Summary and/or Objective section of the document).

DENR Response – The study area includes the entire listed stream segment (Spring Creek from the headwaters to Sheridan Lake). The listed stream segment is approximately 31 miles in length. The second paragraph of the Watershed Characteristics Section on page 2 was revised as follows: "The impaired (303(d) listed) segment of Spring Creek has a length of 31 miles and flows through Mitchell Lake, which has a surface area of 10 acres (4 hectares). The 303(d) listed segment ends where Spring Creek empties into Sheridan Lake, approximately four miles downstream of Mitchell Lake. (SD DENR, 2002a). The drainage area of the 303(d) listed segment is approximately 126 square miles (327 square kilometers)." The listed segment drainage area is shown in Figure 1, and the title of the map inset in Figure 1 showing the 303(d) listed segment drainage area was changed to "Drainage area of the 303(d) Listed Segment."

To better explain the location of the monitoring sites used to develop the TMDL, the third paragraph of the Linkage Analysis section on page 9 was revised as follows: "Instantaneous loads were calculated by multiplying the fecal coliform sample concentrations from SD DENR ambient water quality data (site number 460654), the USGS daily average flow (gage number 06406920) on the date of the sample, and a units conversion factor. The SD DENR water quality monitoring site and USGS flow gaging station are co-located near the inlet of Sheridan Lake (shown as site SCT1 on the map in Appendex B)."

Sheridan Lake was labeled on the map in Appendix B.

The 303(d) priority ranking of the listed waterbody (category 1 or high priority) was added to the Objective Section on page 2.

EPA Comment – *TMDL Technical Analysis –* As mentioned above in the minimum submission requirements, the TMDL needs to include language that the nonpoint source loads reductions are reasonably achievable. When a TMDL is developed for waters impaired by both point and nonpoint sources, and the WLA is based on an assumption that nonpoint source load reductions will occur, EPA's 1991 TMDL Guidance states that the TMDL should provide reasonable assurances that nonpoint source control measures will achieve expected load reductions in order for the TMDL to be approvable. We recommend adding a few sentences to the LA section or the Implementation section that explains that the proposed nonpoint source controls can be reasonably expected to achieve the necessary load reductions to meet the water quality standards.

DENR Response – The Implementation Section on page 16 was revised to explain that, based on water quality monitoring, bacterial source tracking and HSPF model results, the proposed nonpoint source controls are expected to address the identified sources and achieve the load reductions required to meet the applicable water quality standards.

EPA Comment – *Waste Load Allocations (WLA) –* Please provide the SDSWDP (NPDES) permit number for the Hill City WWTF WLA. It would also be helpful to include a geographical description of the location of the facility or show the location on one of the maps included in the TMDL.

DENR Response – The SDSWDP (NPDES) permit number for the Hill City WWTF is SD0020885. This information was added to the WLA section of the TMDL on page 14.

EPA Comment – *Restoration Strategy –* As mentioned above in the Technical Analysis comments, reasonable assurance language should be added to the TMDL document.

DENR Response – See above response to comments on the Technical Analysis Section.

EPA Comment – *Daily Loading Expression –* The daily loading expressions shown in Figure 2, Table 3, Table 4 and Figure 3 are in scientific notation (i.e., $x*10^n$). However, they all appear to be to 10 to the **negative** ninth power (10^{-9}). We believe that it is intended to be 10 to the **positive** ninth power, and should be expressed as 10^9, or otherwise expressed as x.xxE+09 (e.g., 3.78E+09 CFU/day).

DENR Response – The daily loading units were corrected to show a positive exponent.