Bacteria Contamination of Surface Waters Due to Livestock Grazing in the Stanislaus National Forest, California

(Second Year of Study)

Lindsey Myers, staff biologist
Central Sierra Environmental Resource Center
P.O. Box 396, Twain Harte, CA 95383
Brenda Whited, M.S.

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Abstract

Surface waters were tested for pathogenic bacteria indicators (i.e., *E. coli*, total coliform bacteria, and fecal coliform bacteria) within commercial cattle grazing allotments in the Stanislaus National Forest. Water samples were collected from two-control/ungrazed stream sites, at four grazed stream sites before cattle grazing began and during the period when livestock were present, and at two sites only after cattle were present. Fecal coliform concentrations were compared to regulatory water quality standards adopted by the State of California. Results showed that individual and average concentrations of fecal coliform bacteria in surface waters were below regulatory thresholds at the control/ungrazed sites and at the grazed sites before cattle arrived. Shortly after cattle were released to graze, fecal coliform concentrations were much higher, and in places exceeded state standards. The increase in mean concentration of fecal coliform at each grazed site was signicant ($p < 0.05$), but there was no significant difference at the control site. Total coliform bacteria and *E. coli* concentrations showed the same pattern. The violations of state water quality standards persisted throughout the summer grazing period, with100 documented violations of state water quality standards in 2010.

Key words: water, Stanislaus National Forest, cattle, livestock grazing, bacteria

Introduction

The Stanislaus National Forest ("Stanislaus NF") is located in the Sierra Nevada of California, just north of Yosemite National Park. The Stanislaus NF is popular for outdoor recreation.[1] The Tuolumne and Stanislaus River watersheds provides about three million acre-feet of water storage for recreation, agriculture, domestic supply, and other uses.[2,3] The Mokelumne River watershed provides close to a million acre-feet of water storage for similar uses.[4] The U.S. Forest Service issues permits allowing commercial livestock grazing on most of the public lands in the Stanislaus NF. In recent years, there has been concern about the effects of livestock grazing on watersheds, wildlife, recreation, and other resources.[4,5] Previous studies have documented water quality degradation in the Sierra Nevada, including the Stanislaus NF, linked to domestic livestock such as cattle and pack animals.[5,6] The current study was undertaken to analyze water quality in representative areas exposed to cattle grazing and to compare sampling results with pertinent water quality standards established by the State of California.

Methods

Field Site Selection

Six water sampling sites were selected in areas frequented by commercial cattle grazing within the Stanislaus NF. The sites are typical of grazed areas throughout the forest. The sites are also open for and used to varying degrees by the public for recreational and other purposes. Recent Forest Service environmental documentation states that grazing within each livestock allotment including the six sites is required to comply with certain "best management practices" ("BMPs") and other provisions in grazing permits to ensure compliance with water quality standards. The California Regional Water Quality Board, Central Valley Region designated "water contact recreation" as among the beneficial uses of streams within the national forest. Two control sites that were not subject to cattle grazing (the "ungrazed" sites) were also tested. The sites are described below. Table 1 provides location (i.e., latitude, longitude) coordinates for each site, using datum NAD 83. A vicinity map and maps of each sample location are included in appendix 6.

Rose Creek – sample site: 1,145 meters (3,756 feet) elevation
Samples were collected from Rose Creek in an area accessed by Forest Service Road 3N59Y, which spurs off road 4N16 (which is within the Rushing Range Allotment). Rose Creek is entirely within the Stanislaus River watershed and flows into the Lower Middle Fork of the Stanislaus River. Three "before" water samples were collected between May 4, 2010 and May 7, 2010. The cattle were first observed in the sample area on May 12, 2010 (which was three days earlier than expected based on allotment management scheduling). Sixteen "after livestock arrival" water samples were collected between May 12, 2010 and August 13, 2010.

Jawbone Creek (JC) – sample site: 1,733 meters (5,687 feet) elevation
Samples were collected from Jawbone Creek above Jawbone Falls, where the flows adjacent to Jawbone Meadow (which is within the Rosasco Range Allotment). Jawbone Creek is entirely within the Tuolumne River watershed and flows directly into the Tuolumne River. Six "before" grazing water samples were collected between June 16, 2010 and July 7, 2010. Grazing was first observed along the Creek July 21, 2010. Six "after livestock arrival" grazing water samples were collected between July 21, 2010 and August 18, 2010.

Boggy Meadow 1 & 2 (Bog 1 & Bog 2)
Bog 1 sample site: 1,694 meters (5,558 feet) elevation
Bog 2 sample site: 1,695 meters (5,561 feet) elevation
Two samples were collected from an unnamed tributary stream of Jawbone Creek where it flows out of Boggy Meadow (which is within the Rosasco Range Allotment). As mentioned earlier, Jawbone Creek is entirely within the Tuolumne River watershed and flows directly into the Tuolumne River. Boggy Meadow is used as a gathering area for cattle at the end of the permitted grazing season in October. Boggy Meadow is fenced to exclude cattle for most of the summer; it was fenced during the time period when samples were collected from the unnamed tributary of Jawbone Creek that flows from the meadow. Two samples were collected from this stream to provide a "before vs. after livestock arrival" comparison. The first sample was collected 100 feet downstream/outside of the Meadow fence (where the livestock have unrestricted access to the

stream); the second sample was collected 4 feet inside the fence (where livestock did not have access to the stream or Meadow while these samples were collected). After the winter snowpack receded from this area, there was no flowing water entering Boggy Meadow. The stream flowing from Boggy Meadow is spring-fed, discharging from within the fenced meadow. Eight "inside fence/before" and "outside fence/after" grazing water samples were collected between June 8, 2010 and August 18 2010.

<u>Lower Wolfin Meadow</u> (LWM) – sample site: 1,479 meters (4,854 feet) elevation
Samples were collected from an unnamed tributary of Reed Creek where the stream flows through Lower Wolfin Meadow (which is within the Jawbone Range Allotment). Reed Creek is entirely within the Tuolumne River watershed and flows into the Tuolumne River via the Clavey River. Eight "before" water samples were collected between May 24, 2010 and June 24, 2010. Grazing was first observed in the upper meadow on June 29, 2010. Eight "after livestock arrival" water samples were collected between June 29, 2010 and August 18, 2010.

<u>Bull Meadow Creek</u> (BM) – sample site: 1,145 meters (3,757 feet) elevation
The samples were collected from Bull Meadow Creek a short distance below Bull Meadow (which is within the Jawbone Range Allotment). Bull Meadow Creek is entirely within the Tuolumne River watershed and flows into the Tuolumne River via the Clavey River. Cows were already present at the time of the first visit to this site. Accordingly, no "before" grazing samples were collected at this site. Seven "after cattle arrival" samples were collected between June 16, 2010 and July 21, 2010.

<u>Sheep Meadow</u> (SM2 & SM3)
SM2 sample site: 2,634 meters (8,642 feet) elevation
SM3 sample site: 2,640 meters (8660 feet) elevation
Two samples were collected from an unnamed tributary of Elbow Creek below Sheep Meadow, which is within the Mokelumne Wilderness (which is within the Highland Lakes Range Allotment). The unnamed tributary is entirely within the North Fork Mokelumne River watershed and flows into the North Fork Mokelumne River via Elbow Creek. The unnamed tributary of Elbow Creek has several confluences with tributaries and seeps that drain into the stream from Sheep Meadow. The two sample sites are located 80 feet apart on the main stream below separate confluences with water flowing from Sheep Meadow. Residual moisture from scattered snow patches may have also been contributing to the stream. Cows were already present at the time of the first visit to this site. Accordingly, no "before" grazing samples were collected at this site. Six "after cattle arrival" samples were collected at both SM2 and SM3 between August 2, 2010 and August 23, 2010.

<u>Bourland Creek (control site, not grazed)</u> – sample site: 2,225 meters (7,299 feet) elevation
Samples were collected below Bourland Meadow from Bourland Creek. Bourland Meadow lies within a designated research natural area (RNA). While instances of livestock grazing trespass into the RNA have been documented by CSERC in past years, no livestock grazing is lawfully authorized within the Bourland Meadow area. No observed grazing use occurred within the RNA or within Bourland Meadow during the duration of this project in 2010. Bourland Creek is entirely within the Tuolumne River watershed and flows into the Tuolumne River via the Clavey River. Five water quality samples were taken between July 29, 2009 and August 18, 2009

(covering the same general time period when the "after cattle arrival" grazing samples were taken at JC, Bog 1 & 2, BM, LWM, RC, and SM 2 &3).

Cottonwood Meadow (control site, not grazed in 2010) – sample site: 1,643 meters (5,390 feet) elevation
Samples were collected below Cottonwood Meadow from a tributary of Cottonwood Creek (which is within the Jawbone Range Allotment). Cottonwood Creek is entirely within the Tuolumne River watershed and flows into the Tuolumne River via Cherry Creek.

Table 1. List of water sample sites (lat/long datum NAD 83).

Site name	county	latitude	longitude
Bog 1 (outside fence/after cows)	Tuolumne	37.89369444	-120.05788889
Bog 2 (inside fence/before cows)	Tuolumne	37.98830556	-119.96372222
JC	Tuolumne	38.00974167	-119.96610278
LWM	Tuolumne	38.00691667	-119.02586111
BM	Tuolumne	37.89369444	-120.05788889
CM (Control site)	Tuolumne	37.98658611	-119.93808889
RC	Tuolumne	38.14194962	-120.19911384
SM2	Alpine	38.56216667	-119.85891667
SM3	Alpine	38.56238889	-119.85883333
BoM (Control site)	Tuolumne	38.10920712	-119.91242115

Field Water Collection

A Quality Assurance Project Plan (QAPP) was prepared for this water-monitoring project and all procedures specified in the QAPP were followed (see Appendix 4).[7]

Water samples that were collected for bacteriological testing were collected while wearing sterile gloves and collected in sample bottles sterilized and provided by AquaLab Water Analysis (which has ELAP certification). The bacteriological samples were collected before any other work was performed at the site. The sterilized Nalgene bottles hold 125mL of liquid. They were filled to 100 mL with sample water taken directly from flowing water approximately 0.1 m below the surface.

The sample containers were marked with a unique 3-digit identifying number with an indelible marker so that the markings would not "run" or otherwise become illegible when collecting the sample. The collection date, time and samplers' names were recorded on the field datasheets (QAPP Appendix B),[7] which are retained at the CSERC office; they are also recorded on the Chain-of-Custody (QAPP Appendix C)[7] form that was transmitted to AquaLab along with each sample. No sampling bottles were contaminated during sampling or transit.

All water samples collected for bacteriological analyses were delivered to AquaLab within six hours from the time the samples were collected. The sample bottles were placed in Zip-loc plastic bags (to avoid any potential contamination from the ice water) on ice in a cooler until delivered into the custody of AquaLab.

While collecting the water samples, the relative flow of the stream being sampled was recorded on a field datasheet along with other observations about the sample area (see Appendix 2).

Laboratory Analyses

Water samples were delivered at Twain Harte, CA, to AquaLab, a State-certified analytical laboratory. All water samples were tested for *E. coli,* total coliform, and fecal coliform bacteria within the 6-hour holding time specified in the QAPP, using Multiple Tube Fermentation (Most Probable Number/100 mL). The detection limit using this method of analysis is two fecal coliform organisms/100 mL of water. The detection maximum using this method of analysis is 1,600 fecal coliform organism/100 mL of water.

A copy of AquaLab's Quality Assurance SOP for Multiple Tube Fermentation is on file at the CSERC office and included in appendix 5. The analytical methods utilized by this laboratory are specified in *Standard Methods For the Examination of Water and Wastewater* (19^{th} Edition).

Data Analysis

The bacteria results were compared to the relevant water quality standards contained in the Central Valley Regional Water Quality Control Board's *Water Quality Control Plan for the Sacramento and San Joaquin River Basins* ("Basin Plan")[8]. Water contact recreation is a designated beneficial use of the receiving waters included in this study. To protect that beneficial use, the Basin Plan specifies (in part) the following numeric objectives (i.e., standards):

> *In waters designated for contact recreation (REC-1), the fecal coliform concentration based on a minimum of not less than five samples for any 30-day period shall not exceed a geometric mean of 200/100 ml, nor shall more than ten percent of the total number of samples taken during any 30-day period exceed 400/100 ml. (Basin Plan at III-3)*

Data were compiled whenever five or more samples were collected within a 30-day period, and results were judged as a "Type 1 Violation" whenever the geometric mean of five samples collected over a 30-day period exceeded 200 fecal coliform colonies per 100 ml of water. Results were judged as a "Type 2 Violation" whenever more than ten percent of the samples collected over a 30-day period exceeded 400 fecal coliform colonies per 100 ml of water. In effect, a Type 2 Violation exists for this study any time there are at least five samples during a 30-day period for which any single sample exceeded 400 fecal coliform colonies per 100 ml of water.

For this study, reporting periods were tabulated only when five or more samples were collected within a 30-day period. This conservative method of data analysis documented 100 violations of the above state water quality standards for fecal coliform bacteria. A more comprehensive analysis (i.e., tabulating all possible 30-day periods by re-starting the 30-day calendar each day) would likely produce additional violations.

Results

Comparison to State Standards

Below are tables that provide results for each of the 100 documented violations of state water quality standards.

Violation #1 (Type 1 Violation) — Site: BM
Sampling period: June 16, 2010 – July 29, 2010

Date	FC / 100ml
6/16/10	>1600
6/18/10	500
6/22/10	>1600
6/24/10	900
6/24/10	900
6/29/10	>1600
Geo Mean	**1088**

Violation #2 (Type 1 Violation) — Site: BM
Sampling period: June 16, 2010 – July 7, 2010

Date	FC / 100ml
6/16/10	>1600
6/18/10	500
6/22/10	>1600
6/24/10	900
6/24/10	900
6/29/10	>1600
7/7/10	1600
7/7/10	1600
Geo Mean	**1198**

Violation #3 (Type 1 Violation) — Site: BM
Sampling period: June 18, 2010 – July 7, 2010

Date	FC / 100ml
6/18/10	500
6/22/10	>1600
6/24/10	900
6/24/10	900
6/29/10	>1600
7/7/10	1600
7/7/10	1600
Geo Mean	**1150**

Violation #4 (Type 1 Violation) — Site: BM
Sampling period: June 22, 2010 – July 21, 2010

Date	FC / 100ml
6/22/10	>1600
6/24/10	900
6/24/10	900
6/29/10	>1600
7/7/10	1600
7/7/10	1600
7/21/10	500
Geo Mean	**1150**

Violation #5 (*Type 2 Violation) — Site: BM
Sampling period: June 16, 2010 – June 29,2010

Date	FC / 100ml
6/16/10*	>1600
6/18/10	500
6/22/10	>1600
6/24/10	900
6/24/10	900
6/29/10	>1600

Violation #6 (*Type 2 Violation) — Site: BM
Sampling period: June 16, 2010 – June 29,2010

Date	FC / 100ml
6/16/10	>1600
6/18/10*	500
6/22/10	>1600
6/24/10	900
6/24/10	900
6/29/10	>1600

Violation #7 (*Type 2 Violation) — Site: BM
Sampling period: June 16, 2010 – June 29,2010

Date	FC / 100ml
6/16/10	>1600
6/18/10	500
6/22/10*	>1600
6/24/10	900
6/24/10	900
6/29/10	>1600

Violation #8 (*Type 2 Violation) — Site: BM
Sampling period: June 16, 2010 – June 29,2010

Date	FC / 100ml
6/16/10	>1600
6/18/10	500
6/22/10	>1600
6/24/10*	900
6/24/10*	900
6/29/10	>1600

Violation #9 (*Type 2 Violation) — Site: BM
Sampling period: June 16, 2010 – June 29,2010

Date	FC / 100ml
6/16/10	>1600
6/18/10	500
6/22/10	>1600
6/24/10	900
6/24/10	900
6/29/10*	>1600

Violation #10 (*Type 2 Violation) — Site: BM
Sampling period: June 16, 2010 – July 7, 2010

Date	FC / 100ml
6/16/10	>1600
6/18/10	500
6/22/10	>1600
6/24/10	900
6/24/10	900
6/29/10	>1600
7/7/10*	1600
7/7/10*	1600

Violation #11 (*Type 1 Violation) — Site: BM
Sampling period: June 18, 2010 – July 7, 2010

Date	FC / 100ml
6/18/10*	500
6/22/10	>1600
6/24/10	900
6/24/10	900
6/29/10	>1600
7/7/10	1600
7/7/10	1600

Violation #12 (*Type 1 Violation) — Site: BM
Sampling period: June 18, 2010 – July 7, 2010

Date	FC / 100ml
6/18/10	500
6/22/10*	>1600
6/24/10	900
6/24/10	900
6/29/10	>1600
7/7/10	1600
7/7/10	1600

Violation #13 (*Type 1 Violation) — Site: BM
Sampling period: June 18, 2010 – July 7, 2010

Date	FC / 100ml
6/18/10	500
6/22/10	>1600
6/24/10*	900
6/24/10*	900
6/29/10	>1600
7/7/10	1600
7/7/10	1600

Violation #14 (*Type 1 Violation) — Site: BM
Sampling period: June 18, 2010 – July 7, 2010

Date	FC / 100ml
6/18/10	500
6/22/10	>1600
6/24/10	900
6/24/10	900
6/29/10*	>1600
7/7/10	1600
7/7/10	1600

Violation #15 (*Type 1 Violation) — Site: BM
Sampling period: June 18, 2010 – July 7, 2010

Date	FC / 100ml
6/18/10	500
6/22/10	>1600
6/24/10	900
6/24/10	900
6/29/10	>1600
7/7/10*	1600
7/7/10*	1600

Violation #16 (*Type 2 Violation) — Site: BM
Sampling period: June 22, 2010 – July 21, 2010

Date	FC / 100ml
6/22/10*	>1600
6/24/10	900
6/24/10	900
6/29/10	>1600
7/7/10	1600
7/7/10	1600
7/21/10	500

Violation #17 (*Type 2 Violation) — Site: BM
Sampling period: June 22, 2010 – July 21, 2010

Date	FC / 100ml
6/22/10	>1600
6/24/10*	900
6/24/10*	900
6/29/10	>1600
7/7/10	1600
7/7/10	1600
7/21/10	500

Violation #18 (*Type 2 Violation) — Site: BM
Sampling period: June 22, 2010 – July 21, 2010

Date	FC / 100ml
6/22/10	>1600
6/24/10	900
6/24/10	900
6/29/10*	>1600
7/7/10	1600
7/7/10	1600
7/21/10	500

Violation #19 (*Type 2 Violation) — Site: BM
Sampling period: June 22, 2010 – July 21, 2010

Date	FC / 100ml
6/22/10	>1600
6/24/10	900
6/24/10	900
6/29/10	>1600
7/7/10*	1600
7/7/10*	1600
7/21/10	500

Violation #20 (*Type 2 Violation) — Site: BM
Sampling period: June 22, 2010 – July 21, 2010

Date	FC / 100ml
6/22/10	>1600
6/24/10	900
6/24/10	900
6/29/10	>1600
7/7/10	1600
7/7/10	1600
7/21/10*	500

Violation #21 (Type 1 Violation) — Site: RC
Sampling period: June 23, 2010 – July 19, 2010

Date	FC / 100ml
6/23/10	240
6/23/10	240
6/25/10	220
6/30/10	80
7/6/10	>1600
7/12/10	22
7/19/10	900
7/19/10	1600
Geo Mean	**291**

Violation #22 (Type 1 Violation) — Site: RC
Sampling period: June 30, 2010 – July 26, 2010

Date	FC / 100ml
6/30/10	80
7/6/10	>1600
7/12/10	22
7/19/10	900
7/19/10	1600
7/26/10	>1600
Geo Mean	**432**

Violation #23 (Type 1 Violation) — Site: RC
Sampling period: June 30, 2010 – July 29, 2010

Date	FC / 100ml
6/30/10	80
7/6/10	>1600
7/12/10	22
7/19/10	900
7/19/10	1600
7/26/10	>1600
7/29/10	280
Geo Mean	**406**

Violation #24 (Type 1 Violation) — Site: RC
Sampling period: July 12, 2010 – August 5, 2010

Date	FC / 100ml
7/12/10	22
7/19/10	900
7/19/10	1600
7/26/10	>1600
7/29/10	280
8/5/10	1600
8/5/10	900
Geo Mean	**574**

Violation #25 (Type 1 Violation) — Site: RC
Sampling period: July 19, 2010 – August 13, 2010

Date	FC / 100ml
7/19/10	900
7/19/10	1600
7/26/10	>1600
7/29/10	280
8/5/10	1600
8/5/10	900
8/13/10	900
Geo Mean	**975**

Violation #26 (*Type 2 Violation) — Site: RC
Sampling period: June 23, 2010 – July 19, 2010

Date	FC / 100ml
6/23/10	240
6/23/10	240
6/25/10	220
6/30/10	80
7/6/10*	>1600
7/12/10	22
7/19/10	900
7/19/10	1600

Violation #27 (*Type 2 Violation) — Site: RC
Sampling period: June 23, 2010 – July 19, 2010

Date	FC / 100ml
6/23/10	240
6/23/10	240
6/25/10	220
6/30/10	80
7/6/10	>1600
7/12/10	22
7/19/10*	900
7/19/10	1600

Violation #28 (*Type 2 Violation) — Site: RC
Sampling period: June 23, 2010 – July 19, 2010

Date	FC / 100ml
6/23/10	240
6/23/10	240
6/25/10	220
6/30/10	80
7/6/10	>1600
7/12/10	22
7/19/10	900
7/19/10*	1600

Violation #29 (*Type 2 Violation) — Site: RC
Sampling period: June 30, 2010 – July 26, 2010

Date	FC / 100ml
6/30/10	80
7/6/10*	>1600
7/12/10	22
7/19/10	900
7/19/10	1600
7/26/10	>1600

Violation #30 (*Type 2 Violation) — Site: RC
Sampling period: June 30, 2010 – July 26, 2010

Date	FC / 100ml
6/30/10	80
7/6/10	>1600
7/12/10	22
7/19/10*	900
7/19/10	1600
7/26/10	>1600

Violation #31 (*Type 2 Violation) — Site: RC
Sampling period: June 30, 2010 – July 26, 2010

Date	FC / 100ml
6/30/10	80
7/6/10	>1600
7/12/10	22
7/19/10	900
7/19/10*	1600
7/26/10	>1600

Violation #32 (*Type 2 Violation) — Site: RC
Sampling period: June 30, 2010 – July 26, 2010

Date	FC / 100ml
6/30/10	80
7/6/10	>1600
7/12/10	22
7/19/10	900
7/19/10	1600
7/26/10*	>1600

Violation #33 (*Type 2 Violation) — Site: RC
Sampling period: June 30, 2010 – July 29, 2010

Date	FC / 100ml
6/30/10	80
7/6/10*	>1600
7/12/10	22
7/19/10	900
7/19/10	1600
7/26/10	>1600
7/29/10	280

Violation #34 (*Type 2 Violation) — Site: RC
Sampling period: June 30, 2010 – July 29, 2010

Date	FC / 100ml
6/30/10	80
7/6/10	>1600
7/12/10	22
7/19/10*	900
7/19/10	1600
7/26/10	>1600
7/29/10	280

Violation #35 (*Type 2 Violation) — Site: RC
Sampling period: June 30, 2010 – July 29, 2010

Date	FC / 100ml
6/30/10	80
7/6/10	>1600
7/12/10	22
7/19/10	900
7/19/10*	1600
7/26/10	>1600
7/29/10	280

Violation #36 (*Type 2 Violation) — Site: RC
Sampling period: June 30, 2010 – July 29, 2010

Date	FC / 100ml
6/30/10	80
7/6/10	>1600
7/12/10	22
7/19/10	900
7/19/10	1600
7/26/10*	>1600
7/29/10	280

Violation #37 (*Type 2 Violation) — Site: RC
Sampling period: July 12, 2010 – August 5, 2010

Date	FC / 100ml
7/12/10	22
7/19/10*	900
7/19/10	1600
7/26/10	>1600
7/29/10	280
8/5/10	1600
8/5/10	900

Violation #38 (*Type 2 Violation) — Site: RC
Sampling period: July 12, 2010 – August 5, 2010

Date	FC / 100ml
7/12/10	22
7/19/10	900
7/19/10*	1600
7/26/10	>1600
7/29/10	280
8/5/10	1600
8/5/10	900

Violation #39 (*Type 2 Violation) — Site: RC
Sampling period: July 12, 2010 – August 5, 2010

Date	FC / 100ml
7/12/10	22
7/19/10	900
7/19/10	1600
7/26/10*	>1600
7/29/10	280
8/5/10	1600
8/5/10	900

Violation #40 (*Type 2 Violation) — Site: RC
Sampling period: July 12, 2010 – August 5, 2010

Date	FC / 100ml
7/12/10	22
7/19/10	900
7/19/10	1600
7/26/10	>1600
7/29/10	280
8/5/10*	1600
8/5/10*	900

Violation #41 (*Type 2 Violation) — Site: RC
Sampling period: July 19, 2010 – August 13, 2010

Date	FC / 100ml
7/19/10*	900
7/19/10	1600
7/26/10	>1600
7/29/10	280
8/5/10	1600
8/5/10	900
8/13/10	900

Violation #42 (*Type 2 Violation) — Site: RC
Sampling period: July 19, 2010 – August 13, 2010

Date	FC / 100ml
7/19/10	900
7/19/10*	1600
7/26/10	>1600
7/29/10	280
8/5/10	1600
8/5/10	900
8/13/10	900

Violation #43 (*Type 2 Violation) — Site: RC
Sampling period: July 19, 2010 – August 13, 2010

Date	FC / 100ml
7/19/10	900
7/19/10	1600
7/26/10*	>1600
7/29/10	280
8/5/10	1600
8/5/10	900
8/13/10	900

Violation #44 (*Type 2 Violation) — Site: RC
Sampling period: July 19, 2010 – August 13, 2010

Date	FC / 100ml
7/19/10	900
7/19/10	1600
7/26/10	>1600
7/29/10	280
8/5/10*	1600
8/5/10*	900
8/13/10	900

Violation #45 (*Type 2 Violation) — Site: RC
Sampling period: July 19, 2010 – August 13, 2010

Date	FC / 100ml
7/19/10	900
7/19/10	1600
7/26/10	>1600
7/29/10	280
8/5/10	1600
8/5/10	900
8/13/10*	900

Violation #46 (Type 1 Violation) — Site: JC
Sampling period: July 21, 2010 – August 10, 2010

Date	FC / 100ml
7/21/10	50
7/28/10	300
8/4/10	110
8/5/10	>1600
8/10/10	240
Geo Mean	**229**

Violation #47 (Type 1 Violation) — Site: JC
Sampling period: July 21, 2010 – August 18, 2010

Date	FC / 100ml
7/21/10	50
7/28/10	300
8/4/10	110
8/5/10	>1600
8/10/10	240
8/18/10	240
Geo Mean	**231**

Violation #48 (Type 1 Violation) — Site: JC
Sampling period: July 28, 2010 – August 23, 2010

Date	FC / 100ml
7/28/10	300
8/4/10	110
8/5/10	>1600
8/10/10	240
8/18/10	240
8/23/10	130
Geo Mean	**271**

Violation #49 (Type 1 Violation) — Site: JC
Sampling period: August 4, 2010 – August 23, 2010

Date	FC / 100ml
8/4/10	110
8/5/10	>1600
8/10/10	240
8/18/10	240
8/23/10	130
Geo Mean	**265**

Violation #50 (*Type 2 Violation) — Site: JC
Sampling period: July 21, 2010 – August 10, 2010

Date	FC / 100ml
7/21/10	50
7/28/10	300
8/4/10	110
8/5/10*	>1600
8/10/10	240

Violation #51 (*Type 2 Violation) — Site: JC
30-day period: July 21, 2010 – August 18, 2010

Date	FC / 100ml
7/21/10	50
7/28/10	300
8/4/10	110
8/5/10*	>1600
8/10/10	240
8/18/10	240

Violation #52 (*Type 2 Violation) — Site: JC
Sampling period: July 28, 2010 – August 23, 2010

Date	FC / 100ml
7/28/10	300
8/4/10	110
8/5/10*	>1600
8/10/10	240
8/18/10	240
8/23/10	130

Violation #53 (*Type 2 Violation) — Site: JC
Sampling period: August 4, 2010 – August 23, 2010

Date	FC / 100ml
8/4/10	110
8/5/10*	>1600
8/10/10	240
8/18/10	240
8/23/10	130

Violation #54 (Type 1 Violation) — Site: Bog 1
Sampling period: July 8, 2010 – August 5, 2010

Date	FC / 100ml
7/8/10	50
7/15/10	220
7/21/10	70
7/28/10	500
8/4/10	220
8/5/10	900
Geo Mean	**205**

Violation #55 (Type 1 Violation) — Site: Bog 1
Sampling period: July 15, 2010 – August 5, 2010

Date	FC / 100ml
7/15/10	220
7/21/10	70
7/28/10	500
8/4/10	220
8/5/10	900
Geo Mean	**273**

Violation #56 (Type 1 Violation) — Site: Bog 1
Sampling period: July 15, 2010 – August 10, 2010

Date	FC / 100ml
7/15/10	220
7/21/10	70
7/28/10	500
8/4/10	220
8/5/10	900
8/10/10	>1600
8/10/10	>1600
Geo Mean	**453**

Violation #57 (Type 1 Violation) — Site: Bog 1
Sampling period: July 21, 2010 – August 10, 2010

Date	FC / 100ml
7/21/10	70
7/28/10	500
8/4/10	220
8/5/10	900
8/10/10	>1600
8/10/10	>1600
Geo Mean	**511**

Violation #58 (Type 1 Violation) — Site: Bog 1
Sampling period: July 21, 2010 – August 18, 2010

Date	FC / 100ml
7/21/10	70
7/28/10	500
8/4/10	220
8/5/10	900
8/10/10	>1600
8/10/10	>1600
8/18/10	>1600
Geo Mean	**860**

Violation #59 (Type 1 Violation) — Site: Bog 1
Sampling period: July 28, 2010 – August 18, 2010

Date	FC / 100ml
7/28/10	500
8/4/10	220
8/5/10	900
8/10/10	>1600
8/10/10	>1600
8/18/10	>1600
Geo Mean	**940**

Violation #60 (Type 1 Violation) — Site: Bog 1
Sampling period: July 28, 2010 – August 23, 2010

Date	FC / 100ml
7/28/10	500
8/4/10	220
8/5/10	900
8/10/10	>1600
8/10/10	>1600
8/18/10	>1600
8/23/10	1600
Geo Mean	**940**

Violation #61 (Type 1 Violation) — Site: Bog 1
Sampling period: Aug 4, 2010 – August 23, 2010

Date	FC / 100ml
8/4/10	220
8/5/10	900
8/10/10	>1600
8/10/10	>1600
8/18/10	>1600
8/23/10	1600
Geo Mean	**1044**

Violation #62 (*Type 2 Violation) — Site: Bog 1
Sampling period: July 8, 2010 – August 5, 2010

Date	FC / 100ml
7/8/10	50
7/15/10	220
7/21/10	70
7/28/10*	500
8/4/10	220
8/5/10	900

Violation #63 (*Type 2 Violation) — Site: Bog 1
Sampling period: July 8, 2010 – August 5, 2010

Date	FC / 100ml
7/8/10	50
7/15/10	220
7/21/10	70
7/28/10	500
8/4/10	220
8/5/10*	900

Violation #64 (*Type 2 Violation) — Site: Bog 1
Sampling period: July 15, 2010 – August 5, 2010

Date	FC / 100ml
7/15/10	220
7/21/10	70
7/28/10*	500
8/4/10	220
8/5/10	900

Violation #65 (*Type 2 Violation) — Site: Bog 1
Sampling period: July 28, 2010 – August 18, 2010

Date	FC / 100ml
7/28/10*	500
8/4/10	220
8/5/10	900
8/10/10	>1600
8/10/10	>1600
8/18/10	>1600

Violation #66 (*Type 2 Violation) — Site: Bog 1
Sampling period: July 28, 2010 – August 18, 2010

Date	FC / 100ml
7/28/10	500
8/4/10	220
8/5/10*	900
8/10/10	>1600
8/10/10	>1600
8/18/10	>1600

Violation #67 (*Type 2 Violation) — Site: Bog 1
Sampling period: July 28, 2010 – August 18, 2010

Date	FC / 100ml
7/28/10	500
8/4/10	220
8/5/10	900
8/10/10*	>1600
8/10/10*	>1600
8/18/10	>1600

Violation #68 (*Type 2 Violation) — Site: Bog 1
Sampling period: July 28, 2010 – August 18, 2010

Date	FC / 100ml
7/28/10	500
8/4/10	220
8/5/10	900
8/10/10	>1600
8/10/10	>1600
8/18/10*	>1600

Violation #69 (*Type 2 Violation) — Site: Bog 1
Sampling period: July 15, 2010 – August 5, 2010

Date	FC / 100ml
7/15/10	220
7/21/10	70
7/28/10	500
8/4/10	220
8/5/10*	900

Violation #70 (*Type 2 Violation) — Site: Bog 1
Sampling period: July 15, 2010 – August 10, 2010

Date	FC / 100ml
7/15/10	220
7/21/10	70
7/28/10*	500
8/4/10	220
8/5/10	900
8/10/10	>1600
8/10/10	>1600

Violation #71 (*Type 2 Violation) — Site: Bog 1
Sampling period: July 15, 2010 – August 10, 2010

Date	FC / 100ml
7/15/10	220
7/21/10	70
7/28/10	500
8/4/10	220
8/5/10*	900
8/10/10	>1600
8/10/10	>1600

Violation #72 (*Type 2 Violation) — Site: Bog 1
Sampling period: July 15, 2010 – August 10, 2010

Date	FC / 100ml
7/15/10	220
7/21/10	70
7/28/10	500
8/4/10	220
8/5/10	900
8/10/10*	>1600
8/10/10*	>1600

Violation #73 (*Type 2 Violation) — Site: Bog 1
Sampling period: July 21, 2010 – August 10, 2010

Date	FC / 100ml
7/21/10	70
7/28/10*	500
8/4/10	220
8/5/10	900
8/10/10	>1600
8/10/10	>1600

Violation #74 (*Type 2 Violation) — Site: Bog 1
Sampling period: July 21, 2010 – August 10, 2010

Date	FC / 100ml
7/21/10	70
7/28/10	500
8/4/10	220
8/5/10*	900
8/10/10	>1600
8/10/10	>1600

Violation #75 (*Type 2 Violation) — Site: Bog 1
Sampling period: July 21, 2010 – August 10, 2010

Date	FC / 100ml
7/21/10	70
7/28/10	500
8/4/10	220
8/5/10	900
8/10/10*	>1600
8/10/10*	>1600

Violation #76 (*Type 2 Violation) — Site: Bog 1
Sampling period: July 21, 2010 – August 18, 2010

Date	FC / 100ml
7/21/10	70
7/28/10*	500
8/4/10	220
8/5/10	900
8/10/10	>1600
8/10/10	>1600
8/18/10	>1600

Violation #77 (*Type 2 Violation) — Site: Bog 1
Sampling period: July 21, 2010 – August 18, 2010

Date	FC / 100ml
7/21/10	70
7/28/10	500
8/4/10	220
8/5/10*	900
8/10/10	>1600
8/10/10	>1600
8/18/10	>1600

Violation #78 (*Type 2 Violation) — Site: Bog 1
Sampling period: July 21, 2010 – August 18, 2010

Date	FC / 100ml
7/21/10	70
7/28/10	500
8/4/10	220
8/5/10	900
8/10/10*	>1600
8/10/10*	>1600
8/18/10	>1600

Violation #79 (*Type 2 Violation) — Site: Bog 1
Sampling period: July 21, 2010 – August 18, 2010

Date	FC / 100ml
7/21/10	70
7/28/10	500
8/4/10	220
8/5/10	900
8/10/10	>1600
8/10/10	>1600
8/18/10*	>1600

Violation #80 (*Type 2 Violation) — Site: Bog 1
Sampling period: July 28, 2010 – August 23, 2010

Date	FC / 100ml
7/28/10*	500
8/4/10	220
8/5/10	900
8/10/10	>1600
8/10/10	>1600
8/18/10	>1600
8/23/10	1600

Violation #81 (*Type 2 Violation) — Site: Bog 1
Sampling period: July 28, 2010 – August 23, 2010

Date	FC / 100ml
7/28/10	500
8/4/10	220
8/5/10*	900
8/10/10	>1600
8/10/10	>1600
8/18/10	>1600
8/23/10	1600

Violation #82 (*Type 2 Violation) — Site: Bog 1
Sampling period: July 28, 2010 – August 23, 2010

Date	FC / 100ml
7/28/10	500
8/4/10	220
8/5/10	900
8/10/10*	>1600
8/10/10*	>1600
8/18/10	>1600
8/23/10	1600

Violation #83 (*Type 2 Violation) — Site: Bog 1
Sampling period: July 28, 2010 – August 23, 2010

Date	FC / 100ml
7/28/10	500
8/4/10	220
8/5/10	900
8/10/10	>1600
8/10/10	>1600
8/18/10*	>1600
8/23/10	1600

Violation #84 (*Type 2 Violation) — Site: Bog 1
Sampling period: July 28, 2010 – August 23, 2010

Date	FC / 100ml
7/28/10	500
8/4/10	220
8/5/10	900
8/10/10	>1600
8/10/10	>1600
8/18/10	>1600
8/23/10*	1600

Violation #85 (*Type 2 Violation) — Site: Bog 1
Sampling period: Aug 4, 2010 – August 23, 2010

Date	FC / 100ml
8/4/10	220
8/5/10*	900
8/10/10	>1600
8/10/10	>1600
8/18/10	>1600
8/23/10	1600

Violation #86 (*Type 2 Violation) — Site: Bog 1
Sampling period: Aug 4, 2010 – August 23, 2010

Date	FC / 100ml
8/4/10	220
8/5/10	900
8/10/10*	>1600
8/10/10*	>1600
8/18/10	>1600
8/23/10	1600

Violation #87 (*Type 2 Violation) — Site: Bog 1
Sampling period: Aug 4, 2010 – August 23, 2010

Date	FC / 100ml
8/4/10	220
8/5/10	900
8/10/10	>1600
8/10/10	>1600
8/18/10*	>1600
8/23/10	1600

Violation #88 (*Type 2 Violation) — Site: Bog 1
Sampling period: Aug 4, 2010 – August 23, 2010

Date	FC / 100ml
8/4/10	220
8/5/10	900
8/10/10	>1600
8/10/10	>1600
8/18/10	>1600
8/23/10*	1600

Violation #89 (*Type 2 Violation) — Site: SM2
Sampling period: August 2, 2010 – August 20, 2010

Date	FC / 100ml
8/2/10	50
8/6/10*	1600
8/11/10	900
8/19/10	170
8/20/10	70

Violation #90 (*Type 2 Violation) — Site: SM2
Sampling period: August 2, 2010 – August 20, 2010

Date	FC / 100ml
8/2/10	50
8/6/10	1600
8/11/10*	900
8/19/10	170
8/20/10	70

Violation #91 (*Type 2 Violation) — Site: SM2
Sampling period: August 2, 2010 – August 23, 2010

Date	FC / 100ml
8/2/10	50
8/6/10*	1600
8/11/10	900
8/19/10	170
8/20/10	70
8/23/10	170

Violation #92 (*Type 2 Violation) — Site: SM2
Sampling period: August 2, 2010 – August 23, 2010

Date	FC / 100ml
8/2/10	50
8/6/10	1600
8/11/10*	900
8/19/10	170
8/20/10	70
8/23/10	170

Violation #93 (*Type 2 Violation) — Site: SM2
Sampling period: August 6, 2010 – August 23, 2010

Date	FC / 100ml
8/6/10*	1600
8/11/10	900
8/19/10	170
8/20/10	70
8/23/10	170

Violation #94 (*Type 2 Violation) — Site: SM2
Sampling period: August 6, 2010 – August 23, 2010

Date	FC / 100ml
8/6/10	1600
8/11/10*	900
8/19/10	170
8/20/10	70
8/23/10	170

Violation #95 (*Type 2 Violation) — Site: SM3
Sampling period: August 2, 2010 – August 20, 2010

Date	FC / 100ml
8/2/10	170
8/6/10*	900
8/11/10	>1600
8/19/10	17
8/19/10	34
8/20/10	300

Violation #96 (*Type 2 Violation) — Site: SM3
Sampling period: August 2, 2010 – August 20, 2010

Date	FC / 100ml
8/2/10	170
8/6/10	900
8/11/10*	>1600
8/19/10	17
8/19/10	34
8/20/10	300

Violation #97 (*Type 2 Violation) — Site: SM3
Sampling period: August 2, 2010 – August 23, 2010

Date	FC / 100ml
8/2/10	170
8/6/10*	900
8/11/10	>1600
8/19/10	17
8/19/10	34
8/20/10	300
8/23/10	130

Violation #98 (*Type 2 Violation) — Site: SM3
Sampling period: August 2, 2010 – August 23, 2010

Date	FC / 100ml
8/2/10	170
8/6/10	900
8/11/10*	>1600
8/19/10	17
8/19/10	34
8/20/10	300
8/23/10	130

Violation #99 (*Type 2 Violation) — Site: SM3
Sampling period: August 6, 2010 – August 23, 2010

Date	FC / 100ml
8/6/10*	900
8/11/10	>1600
8/19/10	17
8/19/10	34
8/20/10	300
8/23/10	130

Violation #100* (Type 2 Violation) — Site: SM3
Sampling period: August 6, 2010 – August 23, 2010

Date	FC / 100ml
8/6/10	900
8/11/10*	>1600
8/19/10	17
8/19/10	34
8/20/10	300
8/23/10	130

Table 2. Summary of Violations by site

Site ID	Violations
BM	20
RC	25
JC	8
Bog1 (outside fence)	35
Bog2 (inside fence/control)	0
SM2	6
SM3	6
LWM	0
BoM (Control)	0
CM (Control)	0
Total	**100**

<u>Comparison of Data From Control Stream to Livestock Presence Steams</u>

There was a rapid rise in the fecal coliform concentration immediately after commencement of cattle grazing at all four main sample sites (i.e., where samples were collected "before" grazing and "after livestock arrival" during the period when grazing was taking place in the sample vicinity).

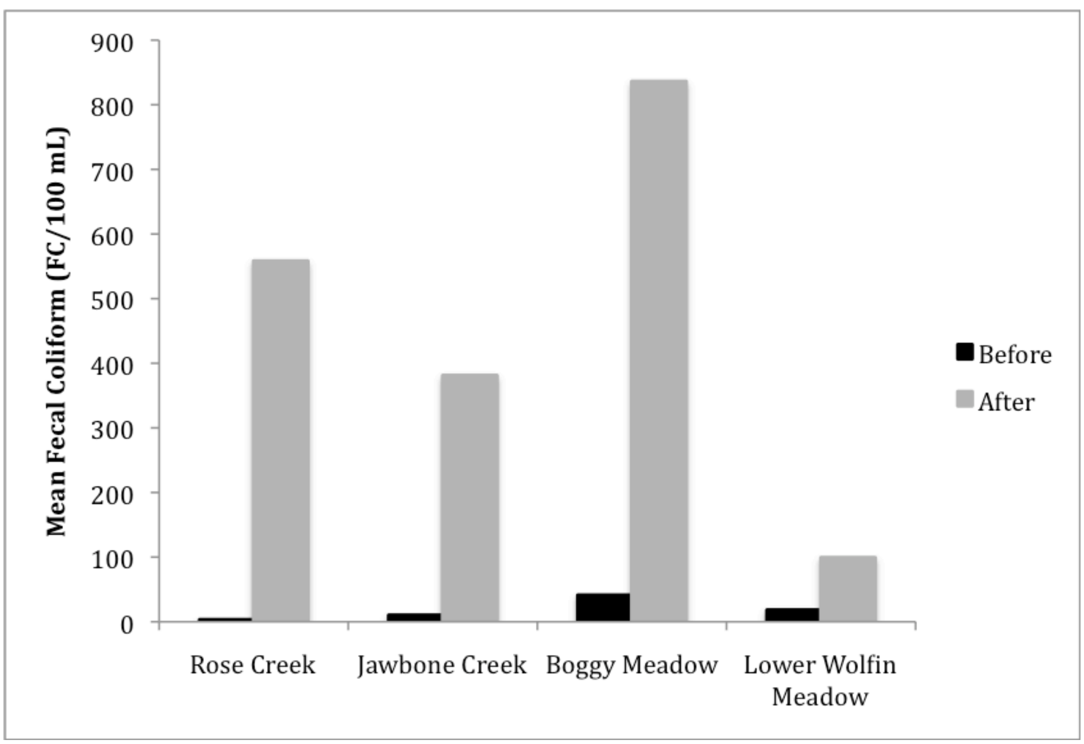
At Rose Creek, the mean (average) fecal coliform count prior to livestock presence was 3, whereas after cows arrived the mean (average) was 558 with seven samples of 900 or higher.

At Jawbone Creek, the mean (average) fecal coliform count prior to livestock presence was 4, whereas after cows arrived the mean (average) was 381 with one sample of >1600.

At Boggy Meadow, (sample sites on the same stream 100' apart) the mean (average) fecal coliform count inside the fence/before livestock was 41, whereas the downstream/outside fence/after livestock presence the mean (average was 836 with five samples of 500 or higher.

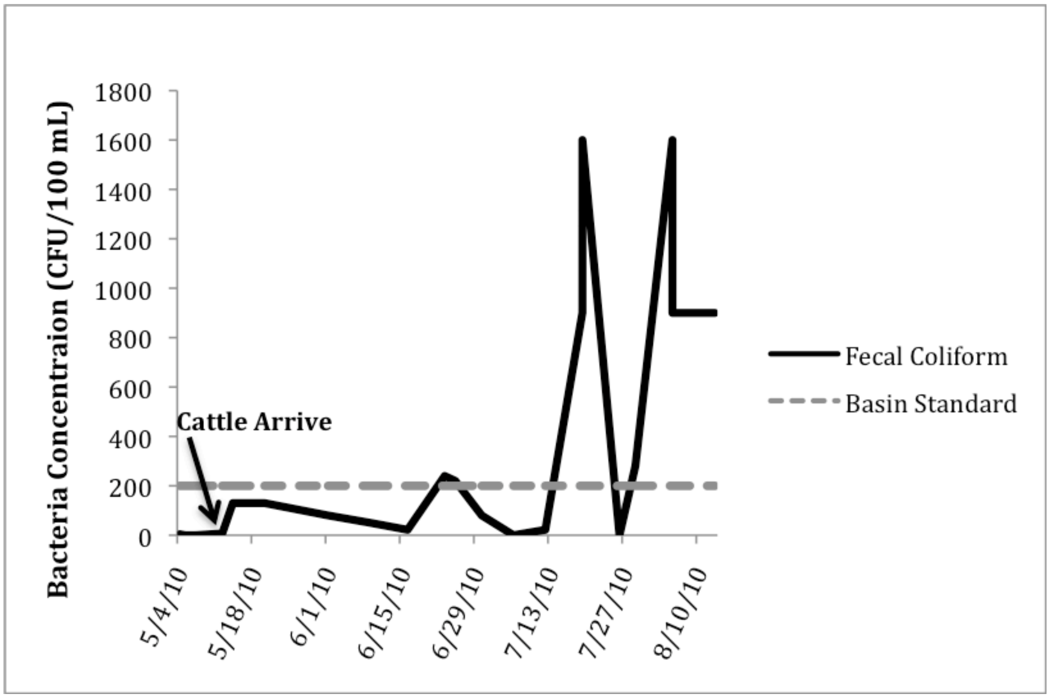
At Lower Wolfin Meadow, the mean (average) fecal coliform count prior to livestock presence was 18, whereas after cows arrived the mean (average) was 99 with two samples over 200.

Figure 1. Graph depicts the results for mean fecal coliform concentration (for the four sites discussed above) "before grazing" and "after livestock arrival" at each site:



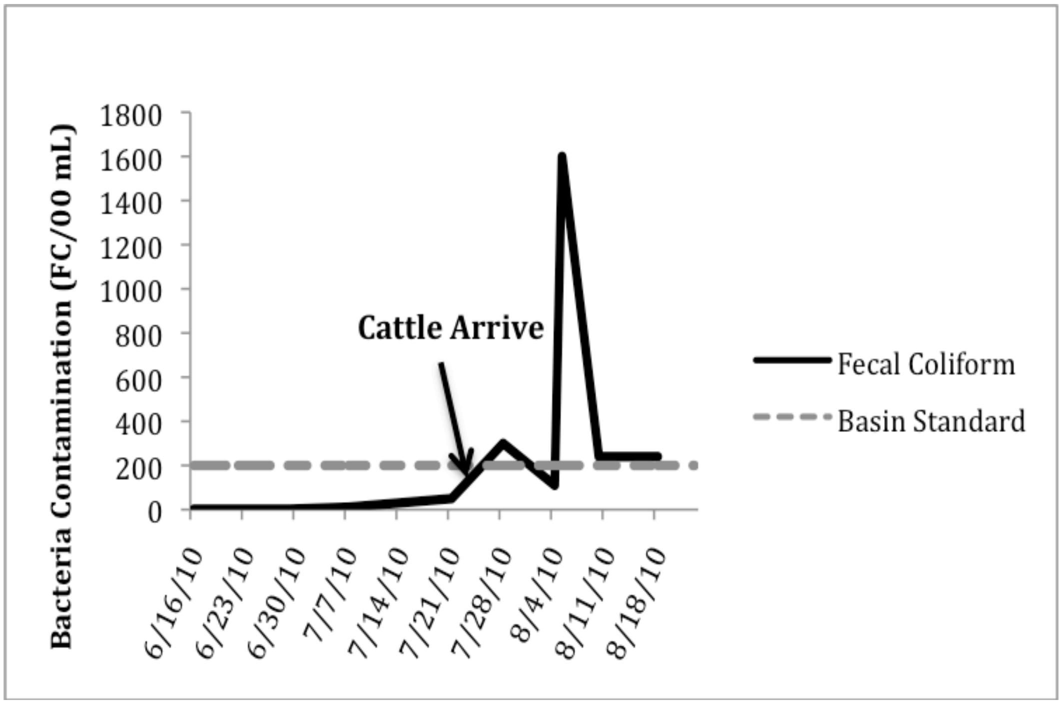
Note: The bar charts above shows the mean (average) fecal coliform concentrations "before" (control) and "after" the commencement of grazing.

Figure 2. Rose Creek – "before" vs. "after" livestock arrival



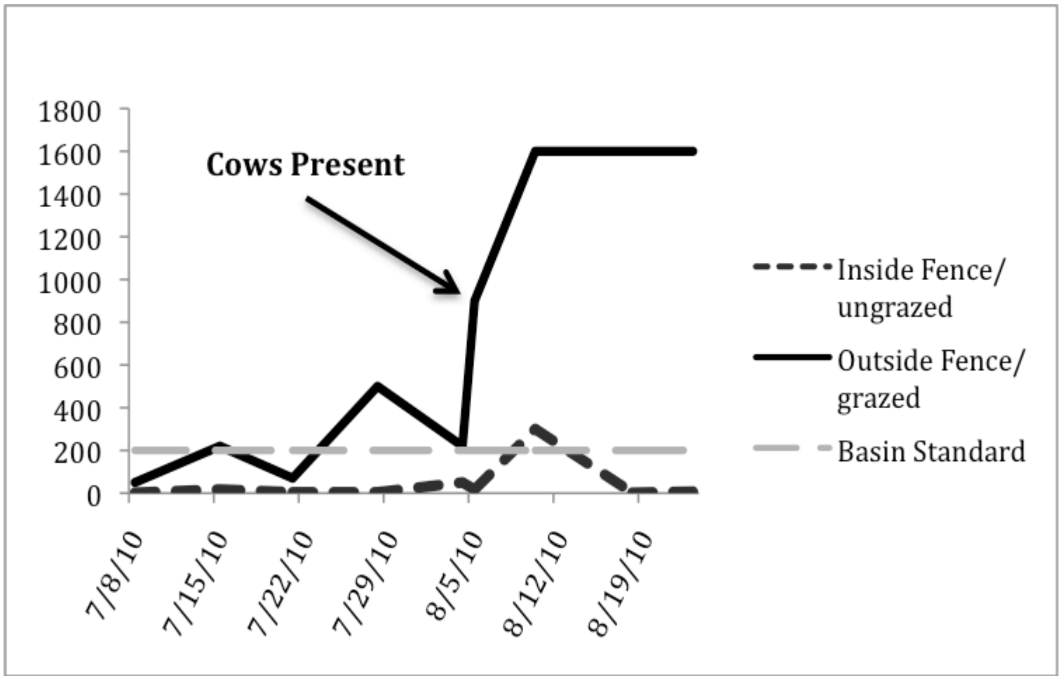
Note: The Rose Creek sample site had the highest amount of discharge of all waters sampled. The discharge at Rose Creek was noted to diminish relative to the first sample taken (see Appendix 1). Cows were often observed near Rose Creek. The higher fecal coliform sample results may reflect periods when the livestock were spending time near the creek or within the many seeps that drain into the Rose Creek. Conversely, the lower fecal coliform results may reflect periods when the livestock were not spending time near the creek.

Figure 3. Jawbone Creek – "before" vs. "after" livestock arrival



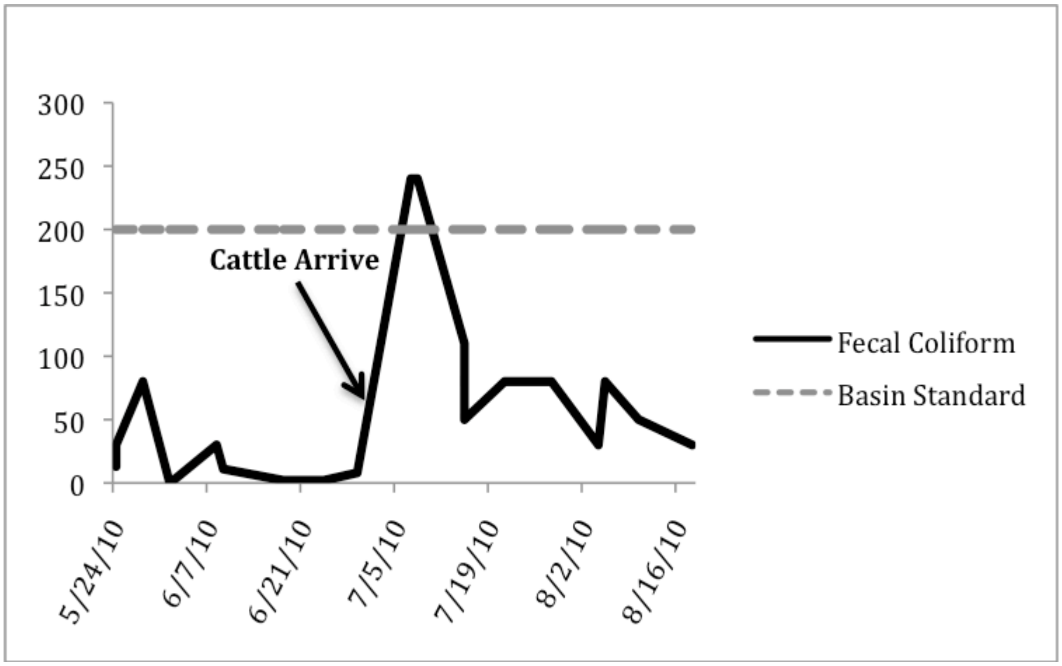
Note: Jawbone Creek had the next highest amount of discharge after Rose Creek. The discharge at Rose Creek was noted to diminish relative to the first sample taken (see Appendix 1). Cows were occasionally observed near Jawbone Creek or in the general area of the sample site. The highest fecal coliform level (>1600 FC/100 mL) was detected on August 5, 2010 after cattle had been observed near the creek for two consecutive days.

Figure 4. Boggy Meadow - "before" vs. "after" livestock arrival



Note: The stream flowing out of Boggy Meadow (unnamed tributary of Jawbone Creek) had the next highest amount of discharge after Jawbone Creek. The discharge from this spring-fed stream was very stable with only a slight visible reduction in the amount of flow noted while collecting the last sample from this site on August 23, 2010. Cows were never visibly observed near this stream but fresh disturbance along the stream was often noted. Nine samples were collected from the "outside fence/after livestock presence" sample site along with nine samples collected from the " inside fence/before cattle presence" sample site. High levels of fecal coliform above state standards for bacteria were regularly detected at the "outside fence/ after livestock presence" sample site. Except for one sample on August 13, 2010 the "inside fence/before livestock presence" fecal coliform levels were consistently low and well below state standards for bacteria. CSERC staff decided to walk through Boggy Meadow after we received the unusual data back for the August 13, 2010 "inside fence/before cattle presence" sample. It appeared that a number of deer had been using the meadow to browse and bed-down at night (there was a large area [~10-15' diameter] where the vegetation had been flattened to the ground). It is possible that the deer may have contributed to this unusual data.

Figure 5. Lower Wolfin Meadow – "before" vs. "after" livestock arrival



Note: The LWM samples were taken from spring/seep-fed water as it passed through Lower Wolfin Meadow. The relative flow was noted to diminish throughout the duration of the study (see Appendix 1). CSERC staff only observed cattle near the stream on one occasion (7/7/10), when there was a corresponding spike in the fecal coliform concentration for that sample.

Cows Present/No "before grazing" data:

Bull Meadow Creek Sample Site

At the Bull Meadow Creek site, water sampling on seven days of the summer grazing season revealed consistent violations of water quality standards. The geometric mean of eight water samples (two samples were duplicates) for fecal coliform bacteria was 1198 (the mean/average = 1200), the highest level of contamination detected by this study. All samples collected were 500 or higher with four samples with level of 1600 or greater. Cows were already present in the area at the time of the first visit. Therefore, the Bull Meadow Creek site is not included in Figure 1 because no samples were collected at this site prior to the onset of grazing. For a comparison to an ungrazed site, Figure 6 compares the results of the mean (average) fecal coliform concentration of this site to the mean (average) fecal coliform concentrations of the two ungrazed control sites.

Sheep Meaddow Sample Sites

At the Sheep Meadow sites, water sampling on six days of the summer grazing season revealed violations of water quality standards. The mean (average) fecal coliform concentration at SM2 was 493, with two samples of 900 or higher. The mean (average) fecal coliform concentration at SM3 was 450, with two samples of 900 or higher. The combined average for SM2 and SM3 = 470. Cows were already present in the area at the time of first visit. Therefore, the Sheep Meadow sites are not included in Figure 1 because no samples were collected at this site prior to the onset of grazing. For a comparison to an ungrazed site, Figure 6 compares the results to the mean (average) fecal coliform concentration of this site to the mean (average) fecal coliform concentrations of the two ungrazed control sites.

Ungrazed Control Sites:

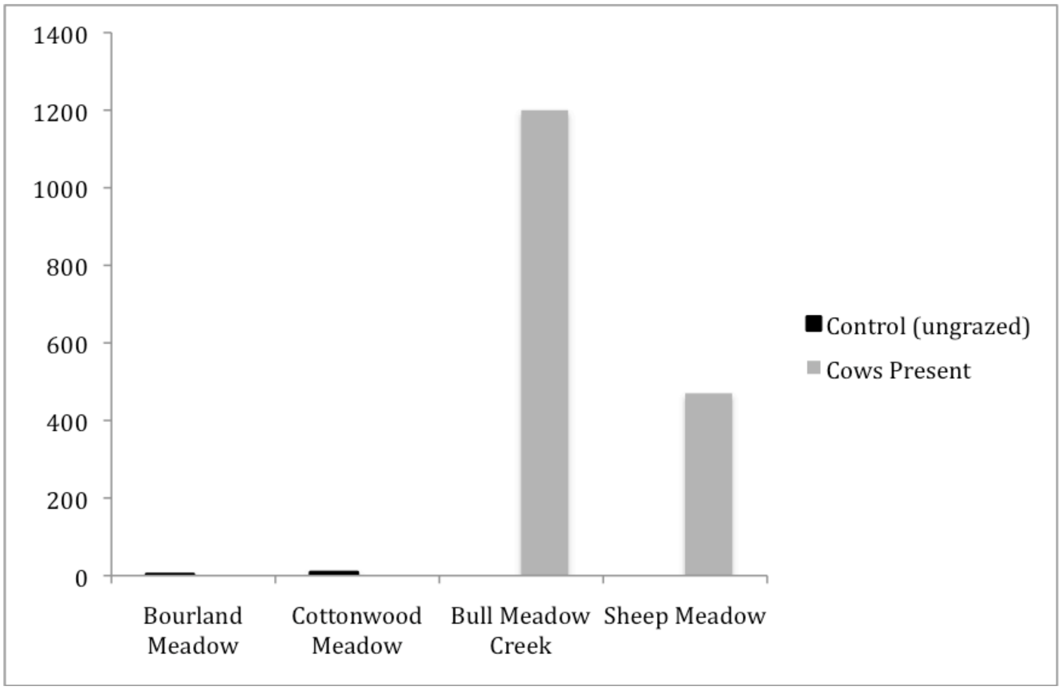
Bourland Meadow

In comparison to the significant increase in fecal coliform concentrations quantified at the streams with grazing once livestock were present, the fecal coliform concentrations at Bourland Creek (one of the ungrazed/control sites) remained consistently low and within standard limits throughout the same time period that the grazed samples were being collected. Six water samples collected from Bourland Creek produced results ranging from <2 to a high of 8. The geometric mean of fecal coliform results from Bourland Creek was 3 (the mean/average = 3). As noted previously, Bourland Meadow is managed as a Research Natural Area that does not have any permitted livestock grazing. Otherwise, the stream at Bourland Meadow experienced the same weather conditions, exposure to wildlife use, dispersed recreation, and other environmental influences as the sample streams that experienced violations of water quality standards. Bourland Creek was utilized as ungrazed/control stream both in 2009 and in 2010. The use of Bourland Creek for the second year was done to validate whether or not the low contamination levels of 2009 were or were not representative of the water quality in that stream. The results from 2010 testing validated that water quality in Bourland Creek, an ungrazed/control stream, consistently stayed below state thresholds for bacteria.

Cottonwood Meadow

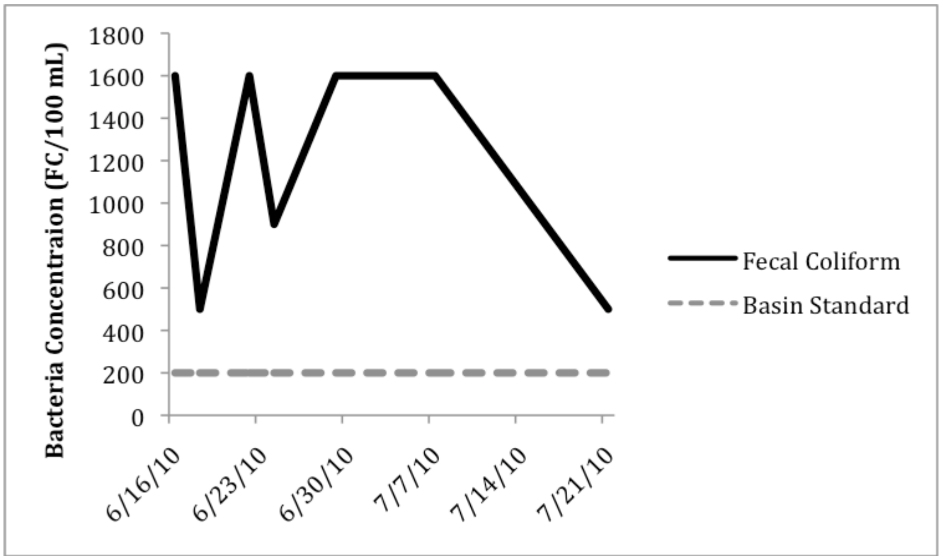
Cottonwood Meadow (the second control site), in comparison to Bourland Meadow that does not have any permitted livestock grazing, is used as a gathering meadow at the end of the summer for the Jawbone Range Allotment. In previous years the area below the meadow where the stream is flowing (and where the sample site was located) was normally not fenced and was therefore grazed by livestock earlier in the season than Cottonwood Meadow. This year, however, the fence was extended to include the stream segment below Cottonwood Meadow (which turned this site into a control instead of a study site). Seven water samples were collected from this ungrazed section of stream, producing results ranging from <2 to a high of 23 FC/100 mL. The geometric mean of fecal coliform results from the Cottonwood Meadow stream was 6 (the mean/average = 8).

Figure 6. Depicts the mean fecal coliform concentration for the two "control sites" and the two "cows present when sampling was initiated" sites



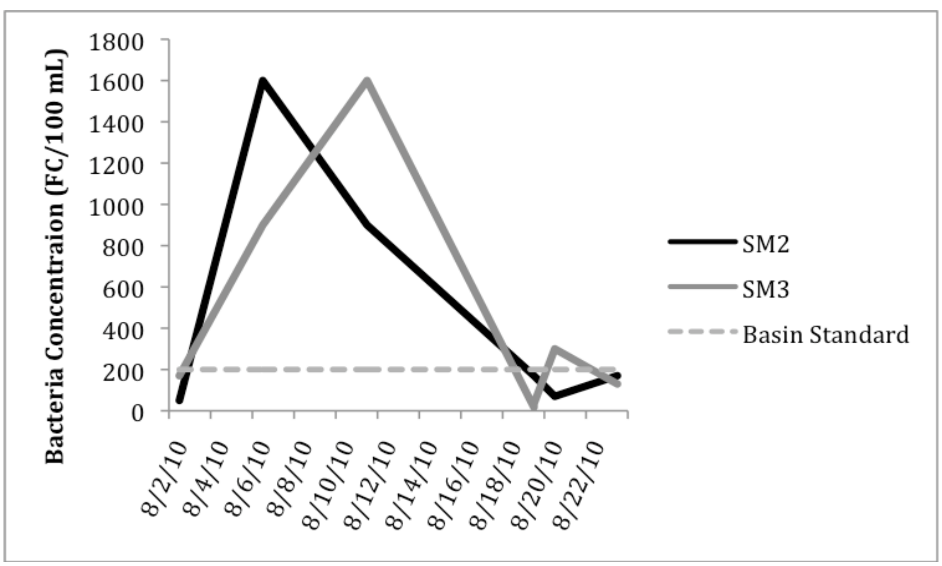
Note: The bar chart above shows the mean (average) fecal coliform concentrations at the two-control/ungrazed samples sites and at the two "cattle present upon first visit" sample sites.

Figure 7. Bull Meadow Creek – Cattle Present



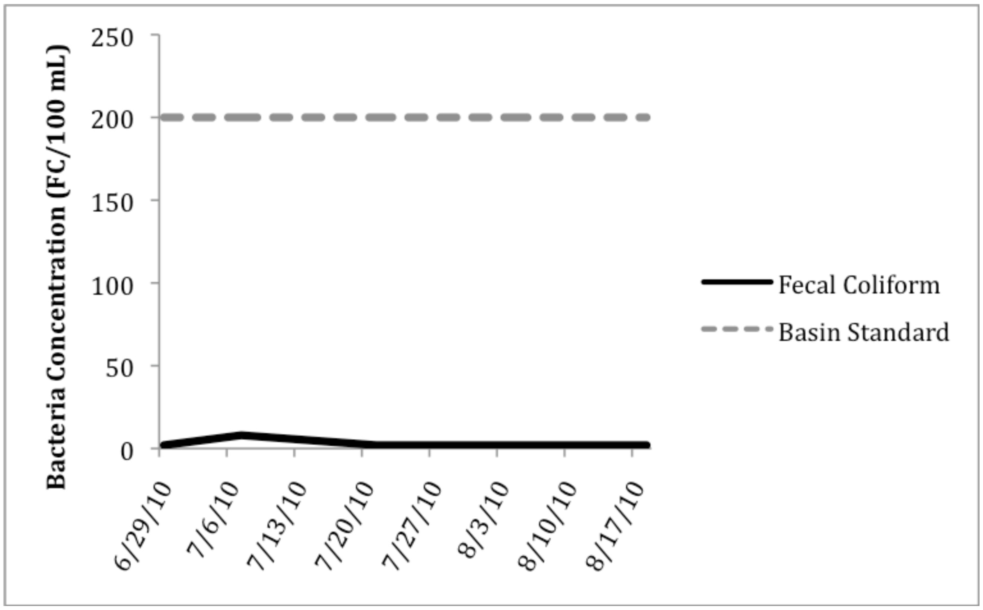
Note: The BM samples were taken from stream and spring/seep-fed water within the creek where the relative flow diminished gradually (see Appendix 1). Cows were already present at the time of the first visit. Accordingly, no "before" grazing samples were collected at this site. Cows and/or fresh disturbance along the creek were often observed along the creek. Accordingly, this site consistently had high fecal coliform results.

Figure 8. Sheep Meadow – Cattle Present



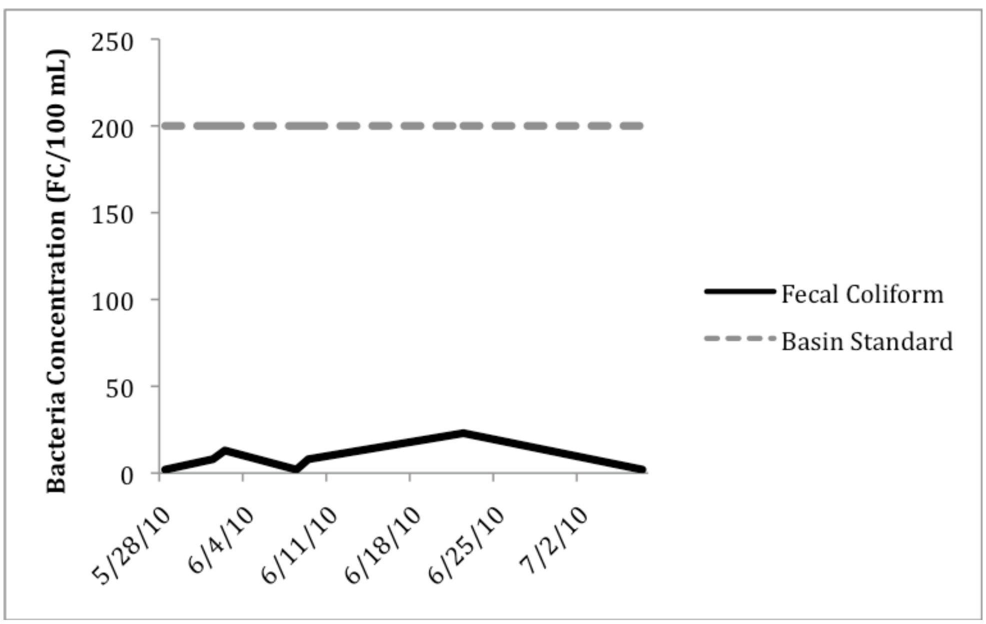
Note: The SM2 and SM3 samples were taken from spring/seep-fed water within the creek where the relative flow diminished very gradually (see Appendix 1). Cows were already present at the time of the first visit. Accordingly, no "before" grazing samples were collected at this site. Cows were often observed in the upper portion of Sheep Meadow above the wetter/fenced portion of the meadow. The higher fecal coliform results may reflect when the cattle had more recently grazed near the streams.

Figure 9. Bourland Meadow – Control Site (not grazed)



Note: The Bourland Meadow samples were taken from the headwaters of Bourland Creek, which is fed by seeps and springs. The relative flow at this sample site was observed to diminish throughout the duration of this study (see Appendix 1).

Figure 10. Cottonwood Meadow – Control Site (Fenced to exclude cattle and then used as a gathering area at the end of the summer. Not grazed while these samples were collected)



Note: The Cottonwood Meadow samples were taken from a tributary stream of Cottonwood Creek, which is fed by water emanating from the meadow. The relative flow at this sample site was also observed to diminish throughout the time this site was sampled (see Appendix 1).

Weather

The weather was mostly stable throughout the sampling period of this study. Winter snows had melted prior to sample collections (except at Sheep Meadow, where a very few scattered patches were present in the area at the beginning of sampling). The weather was generally dry for most of this study, especially during the time when the "after livestock presence" samples were being collected. However, there were several days during the time when "after livestock presence" samples were being collected where there may have been precipitation at some or all of the sample sites (those dates are: July 8, August 8, and 25). Also, there were seven days in May when there may have been precipitation at all or some the sample sites (those dates are: May 10, 11, 14,1 9, 25, 26, 27). However, the only site where "after livestock presence" samples were being collected in May was at Rose Creek (samples were collected at this site for another two and half months after the summer weather became was more stable at this site). With the exception of those few scattered storm events, the substantial increases in bacteria concentrations documented in surface waters after the arrival of livestock could not have been caused by inputs from overland or storm runoff.

Statistical Analyses

The statistical analysis of fecal coliform concentrations "before grazing" and "after livestock arrival/the onset of grazing" is summarized in Table 3 by site. The statistical analysis of fecal coliform concentrations for all "before grazing" samples (including the control data) and all "after livestock arrival" samples (including the sites that do not have before livestock data) is summarized in Table 4. T-tests show that the mean concentration of fecal coliform bacteria was significantly higher ($p < 0.05$) at all sites after the onset of grazing.

In all cases, the mean concentration of fecal coliform bacteria after the onset of grazing were one or two orders of magnitude higher than before grazing. These t-tests demonstrate that these differences were statistically significant, and therefore unlikely to have occurred due to random chance.

Table 3. Summary of statistics by site

Site name	Cows	n	Mean	Std dev	*p*
Bog 2 (inside fence)	Before	10	41	92	
Bog 1 (outside fence)	After arrival	10	836	700	<.0001
Jawbone Creek	Before	6	4	4	
Jawbone Creek	After arrival	7	381	544	<.0001
Rose Creek	Before	3	3	1	
Rose Creek	After arrival	19	558	626	0.0002
Lower Wolfin Meadow	Before	10	18	24	
Lower Wolfin Meadow	After arrival	10	99	78	0.0002
Bourland Creek (control)	Before	6	3	2	
Cottonwood Creek (control)	Before	7	8	8	
Bull Meadow Creek	After arrival	9	1200	495	
Sheep Meadow (SM2)	After arrival	6	493	628	
Sheep Meadow (SM3)	After arrival	7	450	490	

Legend: “cows” = grazing status (i.e., results from before vs. after presence of cows); “n” = the number of samples; “std dev” = standard deviation.

Table 4. Summary of statistics “before” vs. “after livestock arrival” (data from all sample sites)

Cow Presence	n	Mean	Std dev	p
Before (including control sites)	42	16	47	
After livestock	68	563	613	<.0001

Legend: “Cow Presence” = grazing status (i.e., results from before vs. after presence of cows); “n” = the number of samples; “std dev” = standard deviation.

Conclusion

The results presented here document 100 individual violations of California's regulatory water quality standards for bacteria within range allotments where water sampling was performed during the 2010 summer/fall season.

The 100 individual violations, combined with CSERC's previous study done during the 2010 - grazing season, provide repeated evidence of the failure of Best Management Practices (BMPs) to comply with state water quality standards. This study documents that BMPs as currently applied by the Stanislaus NF are not resulting in water quality in livestock-affected streams that meets state water quality standards. This study also documents that significant pollution of surface waters is resulting from cattle grazing as currently regulated and permitted on National Forest System lands.

Further, the levels and methods of livestock grazing in the sampled areas are not unlike practices throughout the Stanislaus NF and other public lands where livestock grazing occurs in the Sierra Nevada. These findings confirm earlier studies[5,6] indicating that widespread pollution of surface waters is occurring due to livestock presence on National Forest System lands in the Sierra Nevada, and demonstrate the need for consideration of: (1) appropriate changes in permitted livestock grazing activities in order to eliminate or reduce contamination of surface waters, (2) increased water quality monitoring of high use livestock sites where prolonged or concentrated presence of cattle increases the potential for violations of water quality standards, and (3) removal of livestock in areas where current livestock management techniques such as fencing and herding have not assured compliance with water quality standards.

This is the second year where "before cows" and "cows present" water sampling has detected high levels of fecal coliform, total coliform, and *E. coli* in national forest areas used by varying numbers of recreational visitors. One obvious consideration for reducing the risk of exposing recreational visitors (swimmers, waters, campers, backpackers) to pathogens or indicators of pathogens in national forest water is to evaluate where the areas with the highest levels of backcountry recreational use occur within each national forest. Keeping livestock out of those high-use recreational areas would appear to be one effective strategy to avoid exposure in those specific areas to water that fails to meet State standards for public health.

References

1. *See:* http://www.fs.fed.us/r5/stanislaus/visitor/

2. *S*ee: http://www.fws.gov/stockton/afrp/ws_stats.cfm?code=TUOLR

3. *See:* http://www.fws.gov/stockton/afrp/ws_stats.cfm?code=STANR

4. *See:* http://www.fws.gov/stockton/afrp/ws_stats.cfm?code=MOKER

5. *See:* http://www.cserc.org/main/news/news_briefs/2009-5.html

6. Derlet, R.W., K.A. Ger, J.R. Richards, and J.R. Carlson. 2008. Risk Factors for Coliform Bacteria in Backcountry Lakes and Streams in the Sierra Nevada Mountains: A 5-Year Study. *Wilderness and Environmental Medicine*, 19:82-90

7. Derlet, R.W., Goldman, C.R., Connor, M.J. 2010 Reducing the impact of summer cattle grazing on water quality in the Sierra Nevada Mountains of California: a proposal. *Journal of Water and Health*, 08.2

8. Myers, L. 2010. *Surface Water Ambient Monitoring Project in the Stanislaus National Forest Quality Assurance Project Plan (QAPP)*. Central Sierra Environmental Resource Center (CSERC). Twain Harte, CA. August 2010.

9. State of California. 2007. *Water Quality Control Plan for the Sacramento and San Joaquin River Basins*. California Regional Water Quality Control Board, Central Valley Region, Sacramento, CA. October 2007. Available at: http://www.waterboards.ca.gov/centralvalley/water_issues/basin_plans/sacsjr.pdf

Appendices

1. Bacteria/NTU/Relative Flow Data Results (in table format)
    1. Rose Creek (RC)
    2. Lower Wolfin Meadow (LWM)
    3. Cottonwood Meadow (CM)
    4. Jawbone Creek (JC)
    5. Bull Meadow (BM)
    6. Bourland Meadow (BoM)
    7. Boggy Meadow (Bog 1&2)
    8. Shee Meadow (SM 2&3)

2. Field datasheets

3. Copies of Bacteria Results from Laboratory/Chain-of-Custody forms

4. Quality Assurance Project Plan

5. AquaLab's Multiple Tube Fermentation QA SOP

6. Maps
    1. Vicinity Area Map within California
    2. Vicinity Area Map of the Stanislaus NF
    3. JC – Google Earth image
    4. Bog 1&2 – Google Earth image
    5. BM – Google Earth image
    6. RC – Google Earth image
    7. SM 2&3 – Google Earth image
    8. BoM – Google Earth image
    9. CM – Google Earth image

Appendix 1. Summary (in table format) of total coliform, fecal coliform, E.coli, turbidity, relative flow for each site sampled, and observations about cattle presence.
Appendix 2. Field datasheets for each sample taken for this study, datasheets include: observations about the weather and stream, water temperature, time the bacteria sample was collected, any unusual observations.
Appendix 3. Copy of the Chain of Custody forms that went with the water samples to AquaLab. The results for total coliform, fecal coliform, E. coli, and turbidity were recorded on this form by lab personnel.
Appendix 4. Copy of CSERC's Quality Assurance Project Plan for this study, includes project description, problem statement, sampling process design, quality control, etcetera.
Appendix 5. Copy of AquaLab's Quality Assurance Plan for Multiple Tube Fermentation.
Appendix 6. Contains a vicinity map, and maps for each sample site.