

***E. coli* and Total Coliform Sampling of Stevens Arroyo, a Tributary to the San Juan River near Kirtland, New Mexico, 2006**

Abstract

In May of 2005, a sample collected from Stevens Arroyo (a perennial tributary to the San Juan River near Kirtland) where it empties into the San Juan River indicated that, at the time of sampling, it was among seven inflows (of thirty-four tested) with an *E. coli* level greater than ten times that of the nearby San Juan River. This observation led to closer examination of the 6080 acre Stevens Arroyo watershed to confirm that it contains significant sources of *E. coli* to the San Juan River, and to begin identifying the sources. Sampling for *E. coli* coupled with flow estimates in March, May, and June of 2006 indicated that Stevens Arroyo was contributing approximately 13%, 22%, and more than 27% of the *E. coli* load to the San Juan River on the dates sampled. This monitoring effort also documented a noncompliant septic system, riparian grazing or livestock holding, and irrigation return flow from flood-irrigated fields as probable sources.

Methods

Deneb Woods and several other San Juan Watershed Group participants sampled several locations on Stevens Arroyo (a perennial tributary to the San Juan River near Kirtland) for total coliform and *Escherichia coli* bacteria on March 27, May 12, and June 20 2006. In May and June, successively more sites were sampled than were sampled in March, to answer questions that followed earlier data collections. Unless a site was dry, sites sampled on earlier dates were sampled again during the later sampling events. On each date, at least one sample of water assumed to be free of coliform bacteria (tap water, deionized water, or bottled drinking water) was processed for quality control (a blank), and two duplicate samples were collected.

Along with each sample a GPS position was recorded, and observations were made regarding potential sources of fecal coliform bacteria, including the presence or absence of livestock or waterfowl or their droppings, the extent to which the riparian area appeared to be grazed by livestock, and indicators of recent runoff or runoff in progress, from irrigation.

Samples were kept on ice for less than six hours before they were processed using the IDEXX bacteria enumeration system. The system uses a most probable number method to estimate numbers of total coliform bacteria and *E. coli* per 100 mL of sample. The maximum estimate the system can provide (without dilution, when all but one well is positive) is 2419.6 colony forming units per 100 mL. When all wells are positive, the resulting estimate is greater than 2419.6 CFU/100mL, or too numerous to count.

The weather was clear and sunny during all sampling events. The most recent precipitation events that may have affected the study area are indicated by 0.04 inches of precipitation recorded at Fruitland on May 9 or 10, 0.04 inches recorded at Fruitland on March 21 or 22, and 0.02 inches recorded at Farmington on June 9 (with no report available from Fruitland)¹. As such, bacteria sources were characterized in the absence of significant influence from precipitation.

Flow was measured at two sites on May 12 and June 20, and a visual estimate of flow at the

¹ Precipitation data are from precip.fsl.noaa.gov/hourly_precip.html.

lowest site on Stevens Arroyo is available for March 27. Flow in the San Juan River is measured at USGS gage 09365000 (San Juan River at Farmington), which is located downstream of the Animas River but upstream of the diversion for the Farmers Mutual Ditch.

Figures 1-4 indicate locations for samples collected on a high resolution orthophoto made from aerial photography taken in September 2003.

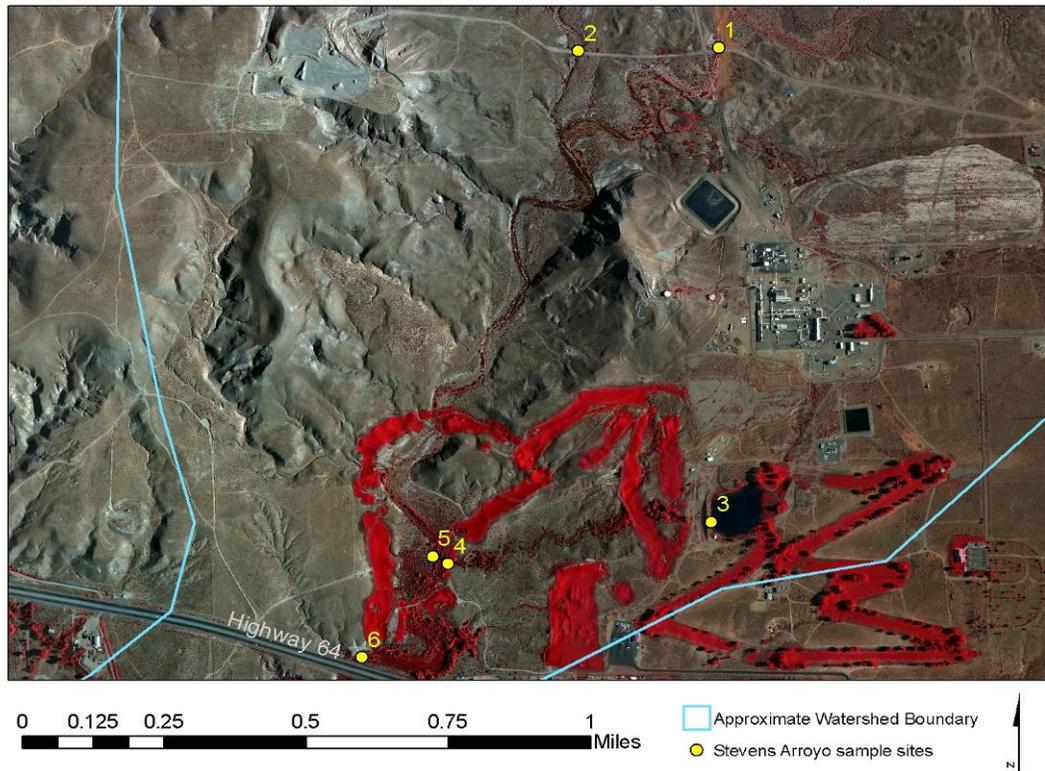


Figure 1: Stevens Arroyo, upper *E. coli* sample sites, 2006.

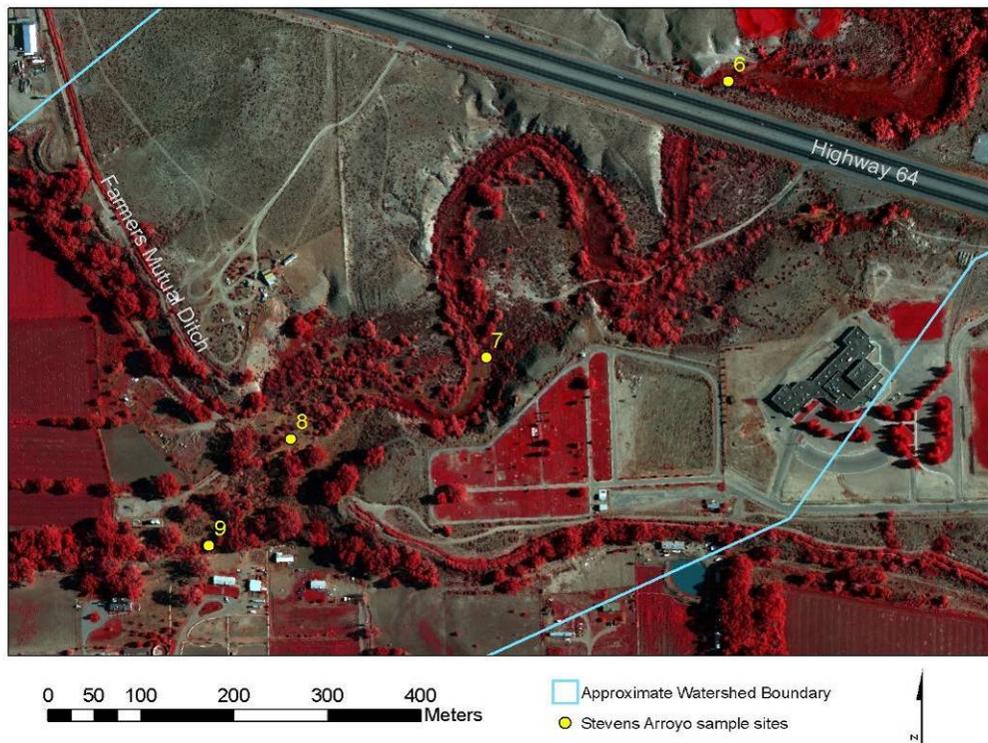


Figure 2: Stevens Arroyo, middle *E. coli* sample sites 6-9, 2006

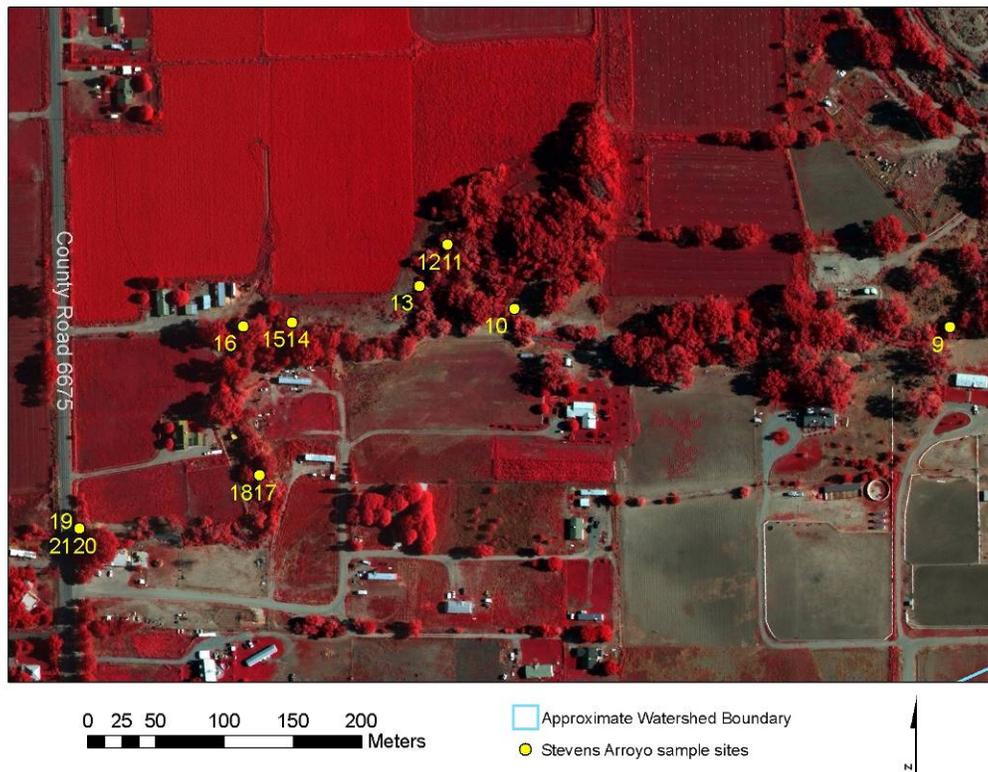


Figure 3: Stevens Arroyo, middle *E. coli* sample sites 9-21, 2006.

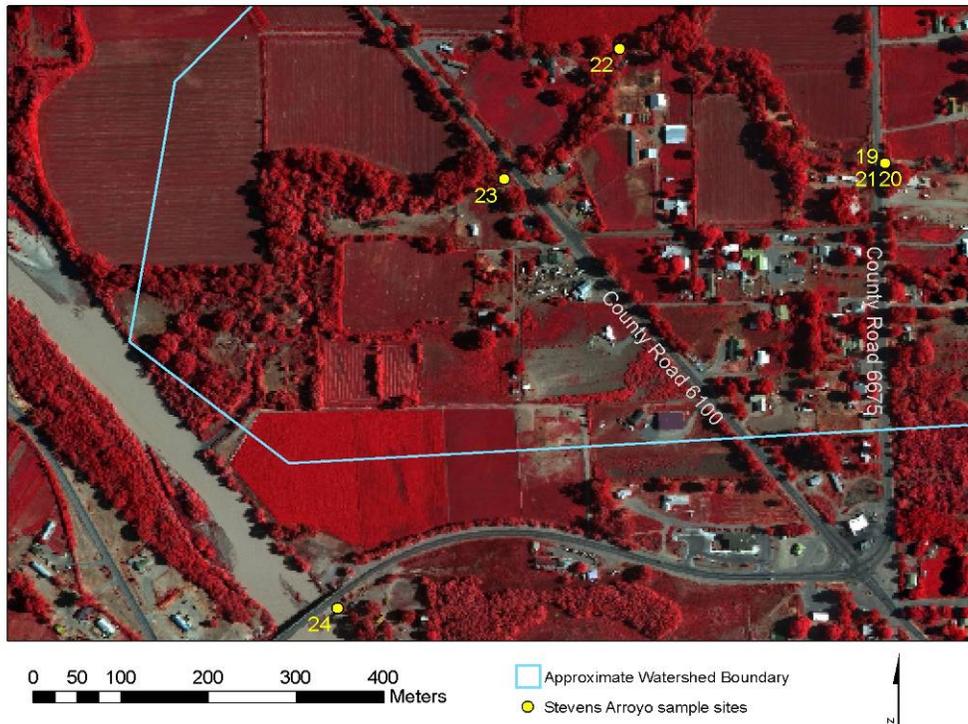


Figure 4: Stevens Arroyo, lower *E. coli* sample sites, 2006.

Results

Total coliform results were generally high, and often too numerous to count. *E. coli* was generally countable, and provides the most useful data for comparisons.

March 27 2006 On March 27, the Farmers Mutual Ditch was not yet running, and thus irrigation return flow can be eliminated as an *E. coli* source on that date. Several of the upper sites had no flow (Table 1), and Site 6 at Highway 64 had a small flow trickling through wetland vegetation probably near the upper end of the stream. Livestock were observed within the riparian area in the vicinity of the Farmers Mutual Ditch (Site 8). The riparian area appeared to be heavily grazed immediately upstream of County Road 6675 (Site 21), although livestock were not observed. Though flow was not measured, the stream seemed to gain flow with distance downstream. Along with that flow, the *E. coli* concentration increased dramatically between the Farmers Mutual Ditch and County Road 6675, then paradoxically decreased between County Road 6675 and CR6100 (Site 23).

That decrease led some members of the San Juan Watershed Group Source Identification Advisory Committee to theorize that the increase in flow between CR6675 and CR6100 was composed of water with a low *E. coli* concentration, and to recommend to BUGS Consulting that flow be measured at both county roads during the next round of sampling. The large increase in *E. coli* between the Farmers Mutual Ditch and County Road 6675 also led to a recommendation of closer inspection of the reach between these sites during the second round of sampling. A recommendation was also made to sample Stevens Arroyo at the upstream boundary of the Hatch property, to bracket the reach between Highway 64 and the Hatch property, where wildlife are thought to be the main potential source of *E. coli*.

Table 1: March 27 sampling locations and results

Site #	Date/Time	Site Description	Total Coliform (CFU/100mL)	<i>E. coli</i> (CFU/100mL)
1	3/27/2006	West Fork Stevens Arroyo above golf course	Dry	Dry
2	3/27/2006	East Fork Stevens Arroyo above golf course	Dry	Dry
3	3/27/06 14:27	Golf course pond	16.8	<1
4	3/27/2006	Golf Course near hole 16 (inflow from east)	Dry	Dry
5	3/27/2006	Stevens Arroyo near hole 16 upstream of inflow from east	Dry	Dry
6	3/27/06 14:53	Stevens Arroyo at Highway 64	>2419.6	3.1
8	3/27/06 15:12	Stevens Arroyo at Hatch property near Farmers Mutual Ditch	313.0	46.4
21	3/27/06 15:36	Stevens Arroyo at CR6675	1986.3	1119.9
21	3/27/06 15:36	Stevens Arroyo at CR6675	1553.1	1203.3
23	3/27/06 16:00	Stevens Arroyo at CR6100	980.4	344.1
23	3/27/06 16:00	Stevens Arroyo at CR6100	1203.3	410.6
24	3/27/06 16:18	San Juan River at Fruitland Bridge	365.4	7.5
NA	3/27/06 16:10	Trip Blank	<1	<1

May 12 2006 On May 12, the Farmers Mutual Ditch was running, and a large portion of the flow in Stevens Arroyo below Farmers Mutual Ditch was composed of water originating from the ditch close to the upper end of its siphon under Stevens Arroyo. *E. coli* increased from a low level at Highway 64 to a very high concentration just above this major input of water (Table 2). The riparian area between Highway 64 (Site 6) and the Hatch property boundary (Site 7) was apparently ungrazed and well vegetated. Livestock were observed within the riparian area on the Hatch property, along with impacts such as trampling and a near-lack of vegetation. There was sufficient vegetation present (sparse Baltic rush, primarily) to indicate that this portion of the riparian area does constitute a grazing resource. The flow at the fence line was very small, and the sample location, being a few feet downstream of the fence, was impacted by grazing and the *E. coli* result may have been influenced by livestock. The ditch water evidently diluted the *E. coli* at site 9, and then livestock in the riparian area and a noncompliant septic system both seemed to raise the *E. coli* level with distance downstream. Portions of the riparian area downstream of the Hatch property (e.g., at Site 10) are used for keeping and watering livestock, but these animals in all likelihood must be fed since understory riparian vegetation is nearly absent.

A pipe discharging a trickle of sewage or sewage effluent directly to Stevens Arroyo was observed on the south bank about 180 meters upstream of CR6675 (Site 18). A dilution series of this septic inflow was prepared, and even the 1:100 dilution produced a result too numerous to count. One irrigation return flow was observed (but not sampled) entering Stevens Arroyo from the north at Site 12, and another (also from the north) was observed (but not sampled) entering Stevens Arroyo just above CR6675 (and above Site 21). No other irrigation return flows were observed entering Stevens Arroyo between the Farmers Mutual Ditch and CR6675 on this date, and the reach was inspected closely enough that probably none were present.

A large increase in both flow (Table 4) and *E. coli* concentration was seen between the two county roads, but no further information about sources between these roads was available. The large increase in *E. coli* loading between the two county roads led to a recommendation that another round of sampling be completed, with closer inspection of the reach between Sites 21 and 23. The large increase seen between Highway 64 and near the upstream boundary of the Hatch property led to a recommendation that the reach between Sites 6 and 7 also be inspected, and samples be collected to characterize potential sources there. The recommendation also included that any inflows observed be characterized by sampling the inflow itself and Stevens Arroyo upstream and downstream of the inflow, and that the sampling conducted at other sites on May 12 be repeated.

Table 2: May 12 sampling locations and results

Site	Date/Time	Site Description	Total Coliform (CFU/100mL)	<i>E. coli</i> (CFU/100mL)
1	5/12/2006	West Fork Stevens Arroyo above golf course	Dry	Dry
2	5/12/2006	East Fork Stevens Arroyo above golf course	Dry	Dry
3	5/12/06 14:19	Golf course pond	>2419.6	6.3
4	5/12/2006	Golf Course near hole 16 (inflow from east)	Dry	Dry
5	5/12/2006	Stevens Arroyo near hole 16 upstream of inflow from east	Dry	Dry
6	5/12/06 13:52	Stevens Arroyo at Highway 64	>2419.6	65.0
7	5/12/06 13:25	Stevens Arroyo at Hatch property 10 feet downstream of fenceline	>2419.6	1203.3
8	5/12/06 13:16	Stevens Arroyo at Hatch property near Farmers Mutual Ditch	>2419.6	>2419.6
9	5/12/06 13:08	Stevens Arroyo downstream of inflow from Farmers Mutual Ditch	1986.3	135.4
9	5/12/06 13:08	Stevens Arroyo downstream of inflow from Farmers Mutual Ditch (duplicate)	1732.9	142.1
10	5/12/06 12:55	Stevens Arroyo at Cline property downstream of sheep	>2419.6	218.7
17	5/12/06 12:24	Stevens Arroyo at Rivas property just upstream of septic system inflow	1011.2	261.3
18	5/12/06 12:29	Inflow from septic system	>2419.6	>2419.6
18	5/12/06 12:29	Inflow from septic system (1:10 dilution)	>2419.6	>2419.6
18	5/12/06 12:29	Inflow from septic system (1:100 dilution)	>2419.6	>2419.6
21	5/12/06 12:03	Stevens Arroyo at CR6675	>2419.6	344.8
21	5/12/06 12:07	Stevens Arroyo at CR6675 (duplicate)	>2419.6	325.5
23	5/12/06 11:31	Stevens Arroyo at CR6100	>2419.6	1046.2
24	5/12/06 15:16	San Juan River at Fruitland Bridge	>2419.6	27.2
NA	5/12/06 13:35	Trip blank	<1	<1

June 20 2006 On June 20, *E. coli* numbers were elevated slightly at Highway 64 (Table 3, Site 6) relative to previous sampling dates, and the flow was very small there. Stevens Arroyo dried up just downstream of Highway 64, and so no samples were collected within the reach between Highway 64 and the Farmers Mutual Ditch. The inflow of ditch water just downstream of the Farmers Mutual Ditch (Site 9) was smaller than it had been on May 12, and the *E. coli* result was lower as well, possibly because there was no input of *E. coli* (or water) from Stevens Arroyo upstream of the ditch. A partially decomposed dead animal, possibly a dog or sheep, was seen in the stream just below Site 9. The *E. coli* level increased quite a bit between Site 9 and Site 10, in an area where sheep and cattle have direct access to the stream. The *E. coli* level decreased between Site 10 and Site 11 (which are only about 72 meters apart) more than can easily be explained by measurement error, and the stream may have gained flow between these two sites from groundwater, which could have diluted the *E. coli*. Just downstream of Site 11, an irrigation return flow (Site 12) was sampled and found to have *E. coli* near the upper measurement limit without dilution, and Stevens Arroyo sampled about 40 meters downstream (Site 13) to permit mixing had a result greater than 2419.6 CFU/100mL.

About 140 meters downstream of Site 13, Stevens Arroyo was sampled again (Site 14), just above a second irrigation return flow from the north that was not flowing on May 12. Here the *E. coli* result was back down to close to 1000 CFU/100mL. The irrigation return flow (Site 15) was found to have an *E. coli* level too high to measure without dilution (greater than 2419.6 CFU/100mL), and downstream of there all sites on Stevens Arroyo were also above this maximum measurable level. A third irrigation return flow entering Stevens Arroyo from the north (Site 20), just upstream of County Road 6675, had a relatively low *E. coli* result. The ditch uphill of its return to Stevens Arroyo was observed to be lined with deep grasses such that the water could not easily be seen flowing within. Four horses were grazing in the irrigated pasture adjacent to this ditch. Flow was measured just below this return flow, and increased almost four-fold between County Roads 6675 and 6100 (Table 4). Stevens Arroyo was inspected at one location between the two county roads where access was granted (Site 22), and no obvious *E. coli* sources were noted. Seepage was noted entering Stevens Arroyo from a cut bank at the edge of a field being irrigated south of the stream, but was insufficiently concentrated to collect a sample.

Table 3: June 20 sampling locations and results

Site	Date/Time	Site Description	Total Coliform (CFU/100mL)	<i>E. coli</i> (CFU/100mL)
1	6/20/2006	West Fork Stevens Arroyo above golf course	Dry	Dry
2	6/20/2006	East Fork Stevens Arroyo above golf course	Dry	Dry
3	6/20/06 15:47	Golf course pond	>2419.6	<1
3	6/20/06 15:47	Golf course pond (duplicate)	>2419.6	<1
4	6/20/2006	Golf Course near hole 16 (inflow from east)	Dry	Dry
5	6/20/2006	Stevens Arroyo near hole 16 upstream of inflow from east	Dry	Dry
6	6/20/06 15:33	Stevens Arroyo at Highway 64	>2419.6	160.7

Site	Date/Time	Site Description	Total Coliform (CFU/100mL)	<i>E. coli</i> (CFU/100mL)
7	6/20/06 14:04	Stevens Arroyo at Hatch property 10 feet downstream of fenceline	Dry	Dry
8	6/20/06 14:15	Stevens Arroyo at Hatch property near Farmers Mutual Ditch	Dry	Dry
9	6/20/06 14:27	Stevens Arroyo downstream of inflow from Farmers Mutual Ditch	>2419.6	81.3
10	6/20/06 14:38	Stevens Arroyo at Cline property downstream of sheep	>2419.6	1413.6
11	6/20/06 14:43	Stevens Arroyo upstream of first irrigation return flow on Cline property	>2419.6	648.8
12	6/20/06 14:43	First irrigation return flow on Cline property	>2419.6	2419.6
13	6/20/06 14:43	Stevens Arroyo downstream of first irrigation return flow on Cline property	>2419.6	>2419.6
14	6/20/06 14:59	Stevens Arroyo upstream of second irrigation return flow on Cline property	>2419.6	980.4
14	6/20/06 14:59	Stevens Arroyo upstream of second irrigation return flow on Cline property (duplicate)	>2419.6	1119.9
15	6/20/06 14:59	Second irrigation return flow on Cline property	>2419.6	>2419.6
16	6/20/06 14:59	Stevens Arroyo downstream of second irrigation return flow on Cline property	>2419.6	>2419.6
17	6/20/06 15:10	Stevens Arroyo at Rivas property just upstream of septic system inflow	>2419.6	>2419.6
19	6/20/06 15:20	Stevens Arroyo just upstream of irrigation return flow on Rivas property	>2419.6	>2419.6
20	6/20/06 15:20	Irrigation return flow on Rivas property	>2419.6	50.4
21	6/20/06 15:20	Stevens Arroyo at CR6675	>2419.6	>2419.6
22	6/20/06 12:54	Stevens Arroyo at Gustin Property	See Text	See Text
23	6/20/06 13:00	Stevens Arroyo at CR6100	>2419.6	>2419.6
24	6/20/06 13:10	San Juan River at Fruitland Bridge	>2419.6	25.0
NA	6/20/06 15:25	Trip Blank	<1	<1
NA	6/20/06 16:27	Lab Blank	<1	<1

The following table lists the available recorded or estimated flows (in cubic feet per second). County Roads 6675 and 6100 are approximately 570 meters apart (following the stream), and flow was considerably greater at CR6100 than at CR6675 on the two dates when flow was measured at both roads.

Table 4: Flow measurements or estimates on three dates of sampling

Date	Location	Type of Measurement	Flow (CFS)
3/27/2006	Stevens Arroyo at County Road 6100	Visual estimate	1.5
3/27/2006	San Juan River at Bisti Bridge	USGS gage 09365000 daily mean	519
5/12/2006	Stevens Arroyo at County Road 6675	Pygmy meter (nine windows)	4.2
5/12/2006	Stevens Arroyo at County Road 6100	Pygmy meter (eight windows)	7.7
5/12/2006	San Juan River at Bisti Bridge	USGS gage 09365000 daily mean	1,060
6/20/2006	Stevens Arroyo at County Road 6675	Pygmy meter (eight windows)	1.4
6/20/2006	Stevens Arroyo at County Road 6100	Pygmy meter (nine windows)	5.3
6/20/2006	San Juan River at Bisti Bridge	USGS gage 09365000 daily mean	1,360

Discussion

The March 27 data alone were not very useful for identifying sources, but the results of this sampling aided selection of additional sampling sites and strategies on May 12 and June 20. Because the March 27 data were collected before the irrigation season, they do indicate with relative certainty that significant sources of *E. coli* unrelated to irrigated agriculture were present at the time of sampling. Although flow was not measured at CR6675 and CR6100 (Sites 21 and 23) on March 27, the decrease in *E. coli* observed between these two sites, coupled with a qualitative observation of increased flow on March 27 (and quantitative observations of increased flow on the other two dates), suggests that the groundwater which the stream gains between these two sites contributes relatively little *E. coli* loading compared to the surface flow entering this reach.

Data from May 12 and June 20, coupled with field observations, strongly suggest that the practice of keeping livestock within the riparian area contributes *E. coli* to Stevens Arroyo. This conclusion is supported by comparing data from Sites 9 and 10 (Table 2 and Table 3), between which livestock were the main potential *E. coli* source observed. The sheep in Figure 5 are the most extreme example observed, but potential livestock sources and heavily grazed riparian areas were observed in other locations as well.



Figure 5: Heavily grazed property and sheep between Sites 8 and 9.

The first site downstream of the septic inflow that was sampled on May 12 (Site 18, Table 2) was at County Road 6675 (Site 21), just downstream of an irrigation return flow that was not sampled on May 12. Therefore, the effect of the septic inflow on Stevens Arroyo cannot be inferred, except that, with an *E. coli* concentration probably greater than 241,960 CFU/100 mL, it undoubtedly increased the concentration and loading of *E. coli* in Stevens Arroyo. The system discovered on May 12 appeared to have not been flowing for some hours or days (as indicated by the presence of cobwebs) on June 20. Staff of the NMED Farmington Field Office, responding to the May 12 observations, found three noncompliant septic systems upstream of County Road 6675 and south of the stream (probably including the one sampled on May 12), which were decommissioned sometime around June 20. The presence of a septic inflow demonstrated that a non-compliant septic system was a source of *E. coli* on that date, and increases the possibility that other non-compliant systems which were not detected may still be present, both in Stevens Arroyo and elsewhere in the San Juan River watershed. That only one system discharging directly to surface water has been found to date on either the main stem San Juan or Animas Rivers during raft trips by watershed group participants, and only one such system was found within the watershed of Stevens Arroyo during this study, suggests that noncompliant septic systems discharging directly to surface waters are not common. Because of the difficulties in recognizing such discharges (the one detected in Stevens Arroyo was obscured by tires and other debris embedded in a steep bank), this conclusion is very tentative. The septic tank survey being conducted by the Cities of Farmington and Bloomfield within the service areas of their water utilities may shed additional light on this issue. However low or high the number of septic systems which discharge directly to surface water, their detection and decommission (or bringing them up to code) are valid priorities.

On June 20 irrigation return flows were significant contributors of *E. coli* to Stevens Arroyo. The inflow sampled at Site 12 on June 20 (Table 3) was flowing but wasn't sampled on May 12. On May 12, this inflow probably had a much lower *E. coli* concentration than on June 20 (when it was sampled), as the concentration at Site 17 (the next site sampled downstream on May 12) was much less elevated on May 12 than on June 20. The irrigation return flow sampled at Site 15 on June 20 had a high *E. coli* result and probably elevated *E. coli* below this point to a level that could not be accurately measured without dilution. The irrigation return at Site 15 was not flowing on May 12. The inflow at Site 20, which was flowing on both May 12 and June 20, probably had little effect on the *E. coli* level in Stevens Arroyo on either date, further demonstrating variability in *E. coli* loading from irrigation return flows.

A likely mechanism of *E. coli* loading from irrigation in the Stevens Arroyo watershed is that most fields in the area serve as winter pasture, and manure from grazing livestock is thus present and potentially bears significant amounts of viable *E. coli*, which may run off to Stevens Arroyo when irrigation water is applied during the growing season. If this is the primary mechanism, then it is puzzling that *E. coli* loading from the irrigation return flow at Site 12 was evidently much lower on May 12, a full five weeks earlier in the growing season than June 20. A possible explanation is that while most fields in the area are planted in hay crops, some irrigated pasture exists which may have livestock present at times during the growing season. Factors contributing to variability in *E. coli* from irrigation return flows probably depend on the specifics of each field, and should be determined with the aid of more specialized observation and assistance from irrigators.



Figure 6: March 6 2006 photo of winter pasture with manure load (right), and cow in adjacent lightly grazed riparian area. The photo location is just west (downstream) of CR6675, on the north side of Stevens Arroyo. Stevens Arroyo flows in the background near the large cottonwoods.



Figure 7: Irrigation return flow at Site 15, observed on June 20.

Another puzzling observation is two reductions in *E. coli* concentrations with distance downstream observed on June 20. There were two pairs of fairly closely spaced sites on Stevens Arroyo where the *E. coli* result at the lower site was much less than the result at the upper site (Table 3). The results at Sites 10 and 11, which are about 80 meters apart, were 1413.6 CFU/100mL (upstream) and 648.8 CFU/100mL (downstream). The downstream sample was collected approximately five minutes after the upstream sample. The results at Sites 13 and 14, which are about 140 meters apart, were >2419.6 CFU/100mL (upstream) and an average of 1050.2 CFU/100mL (downstream). The two downstream samples were collected approximately sixteen minutes after the upstream sample. These apparent reductions in *E. coli* concentration with distance downstream are probably real, since duplicate samples are normally within about 20% of each other. A possible explanation is that flow increased between these pairs of sites, without increases in *E. coli* loading, resulting in dilution of *E. coli*. As an indication of the flow increases with distance that are possible, the flow between county roads 6675 and 6100, which are separated by about 570 meters, increased from approximately 1.4 cubic feet per second to 5.3 cfs on June 20 (nearly four-fold).

Results Relative to Water Quality Standards and Total Maximum Daily Loads

Stevens Arroyo is not specifically mentioned in New Mexico's water quality standards. It seems to be a perennial stream, and thus may be covered under NMAC 20.6.4.99, which assigns to unclassified perennial streams the designated uses of aquatic life, livestock watering, wildlife habitat and secondary contact. Among other water quality criteria that apply to such waters are criteria for *E. coli* intended to protect the designated use of secondary contact, which includes activities such as wading. The criteria read as follows: "the monthly geometric mean of *E. coli*

bacteria shall not exceed 548 CFU/100 mL, no single sample shall exceed 2507 CFU/100 mL”. The single sample criterion may have been exceeded on June 20, but because samples from Stevens Arroyo were not diluted, the maximum measurable concentration was less than this criterion. The monthly geometric mean criterion may have been exceeded, but the stream would need to be sampled on five days within a thirty day period to make this determination.

Perhaps more significantly, Stevens Arroyo appeared to be contributing a significant portion of the *E. coli* loading to the San Juan River on each date of sampling. Table 5 tabulates the loadings observed during this study, in colony forming units per day, for the San Juan River (assuming that flow at the Fruitland Bridge equals that at USGS gage 09365000) and Stevens Arroyo. A visual estimate of flow was used to calculate the loading on March 27. The table also includes the relative loading (as a percent) from Stevens Arroyo to the San Juan River. The latter calculation is for the San Juan River downstream of Stevens Arroyo, and assumes that there were no inputs present between the Fruitland Bridge and Stevens Arroyo.

Table 5: *E. coli* loading of Stevens Arroyo and the San Juan River

Date	Location	Loading of Stevens Arroyo, CFU/day (A)	Loading of San Juan River at Fruitland Bridge, CFU/day (B)	Loading contributed to San Juan River, percent (A/(A+B) x 100)
3/27/2006	Stevens Arroyo at County Road 6100	1.38×10^{10}	9.52×10^{10}	12.7%
5/12/2006	Stevens Arroyo at County Road 6675	3.40×10^{10}	7.05×10^{11}	4.6%
5/12/2006	Stevens Arroyo at County Road 6100	1.96×10^{11}	7.05×10^{11}	21.8%
6/20/2006	Stevens Arroyo at County Road 6675	$>8.27 \times 10^{10}$	8.32×10^{11}	$>9.0\%$
6/20/2006	Stevens Arroyo at County Road 6100	$>3.13 \times 10^{11}$	8.32×10^{11}	$>27.4\%$

The bacteria loading observed in the San Juan River was much lower during this study than in May 2005. On May 12 2005, the San Juan River was flowing at approximately 5780 cfs at USGS gage 09365000, and a sample collected at the Fruitland Bridge had an *E. coli* result of 72.3 CFU/100mL, with a calculated loading near 1.02×10^{13} CFU/day, or about fourteen times the loading observed at the same location on May 12 2006. The maximum loading for the San Juan River from the Hogback upstream to the Animas River that is considered by NMED and the New Mexico Water Quality Control Commission to be protective of designated uses during low flow conditions is 1.43×10^{12} CFU/day. This loading is referred to as the total maximum daily load or TMDL. On June 20 2006, the measured *E. coli* load of Stevens Arroyo at County Road 6100 was more than 20% of the TMDL.

Conclusions

The following conclusions can be drawn.

1. While specific sources of *E. coli* had varying relevance on each date of sampling, the Stevens Arroyo watershed appears to consistently contain significant sources of *E. coli* to the San Juan River.
2. With the exception of two irrigation return flows documented on June 20, and undocumented sources that may have been present on the earlier dates, even conspicuous sources like the heavily grazed reach depicted in Figure 5 and the septic inflow produced, at most, only modest increases in *E. coli* concentrations.
3. The practice of keeping livestock within the riparian area was possibly a significant source of *E. coli* on March 27, and was probably significant on May 12 and June 20.
4. An inflow from a non-compliant septic system was present and flowing into Stevens Arroyo on May 12, and may have been a significant source of *E. coli* on March 27 and May 12. It had probably been decommissioned by June 20, but other septic inflows may be present.
5. Irrigation return flow was not a source of *E. coli* on March 27, may have been a significant source on May 12, and was significant on June 20.

Acknowledgements

We owe special thanks to the Hatch, Cline, Rivas, Gustin, and Copeland families, and to San Juan College and the Kirtland School District, for permitting access to Stevens Arroyo on their property. Their trust has permitted a greater understanding of not only the stream flowing through their property, but also of the San Juan River, and will prove essential to restoring these treasures.