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Fecal microbe contamination in the Otter Creek watershed, Madison County, Kentucky

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Introduction

Anthropogenic activities often harm the water quality of natural freshwater stream systems. In the absence of industrial input freshwater systems in the United States are usually contaminated by excess nutrients, fecal microbes, and excess sediment. Fecal microbes directly degrade the water quality by introducing pathogens. The purpose of this study was to measure the concentration of fecal microbes within the Otter Creek watershed, to examine water quality and determine possible contaminant sources. Livestock contribution occurs through runoff from pastureland. Because of costs, sewage systems typically serve only urban communities, whereas suburban and rural areas rely on septic systems. Leaky or damaged septic systems may release fecal microbes to surface and ground water that could drain into the watershed leading to contaminated waters. The purpose of our study was to determine how these contaminants were entering the watershed and how contaminated the water itself was. For Otter Creek Watershed, we anticipate non-point-source pollution of fecal microbes from pastureland, septic systems, and perhaps the sewage system serving Richmond within the Otter Creek watershed as sources for fecal microbes.

Study Area

Otter Creek is one of the main watersheds of Madison County, Kentucky. It flows into the Kentucky River at Ford, KY right on the Madison/Clark County line (figure 1). The Otter Creek watershed covers 65 square miles of north-central Madison County. About 85% of the land in the Otter Creek watershed is agricultural with the remaining 15% split between residential, commercial and industrial areas. The watershed has three major sub-watersheds. The West fork, East fork, and the central or trunk stream. The central portion of Otter Creek drains Lake Reba and Urban Richmond with Dreaming Creek as a major tributary running through Richmond. The central stream then continues downstream through rural lands. A sewage treatment plant about 6 miles outside of Richmond discharges its effluent in Otter Creek before the trunk stream is joined by the West and East Forks. Both of these major tributaries drain rural land dominate by pasture and containing mostly scattered residences served by septic systems.

The watershed drains mainly rural lands mostly devoted to raising cattle, but a portion also flows through the city of Richmond. Land use dictates contaminants and their sources so that Cattle farming, septic tanks, and sewage lines are possible sources of fecal contamination. Most farmers use the creeks passing through their land as a water source for their cattle and they don't put up fences to keep the cattle out which leads to cattle not only standing in the water but also defecating in the water as well.

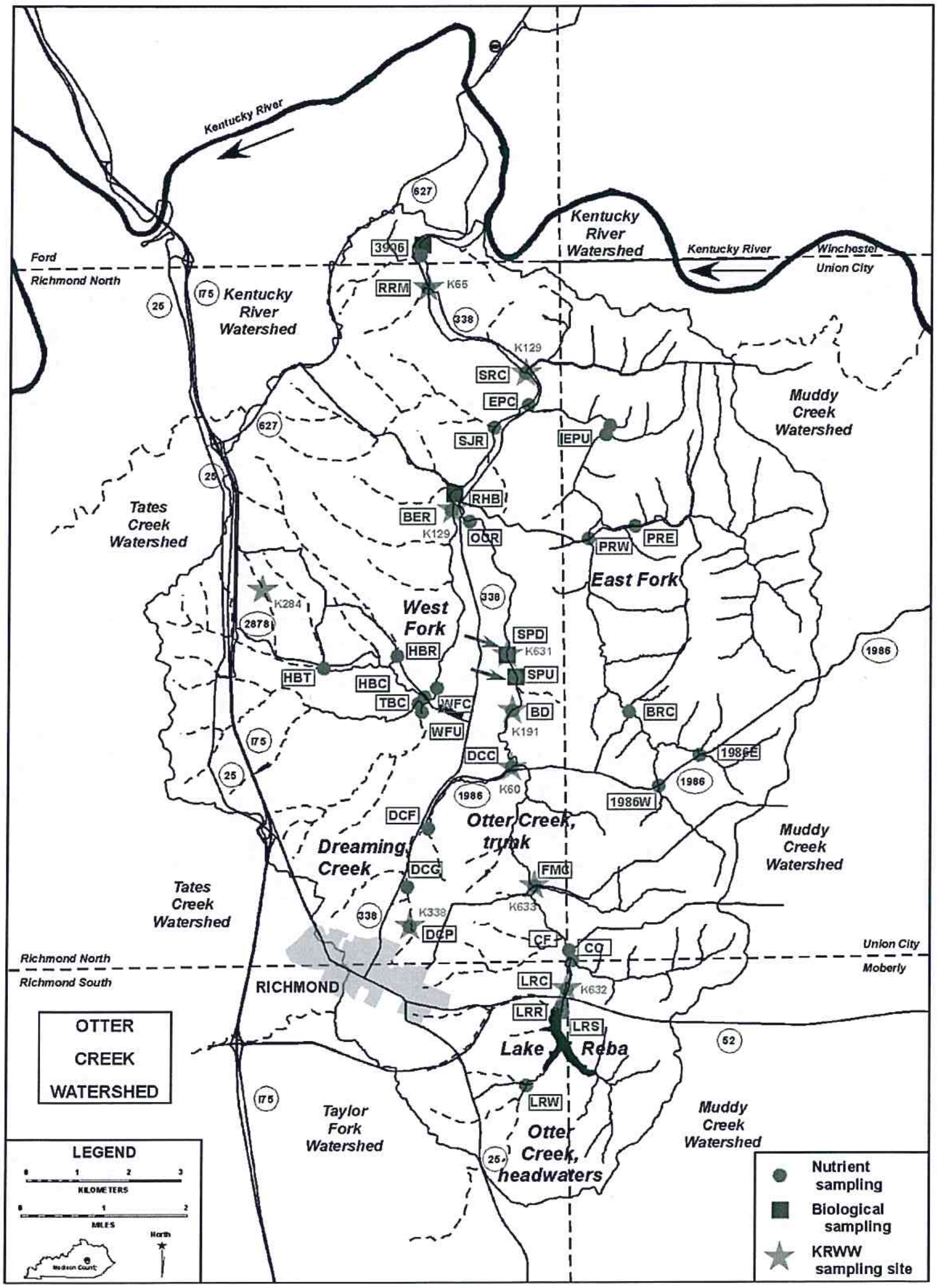

Figure 1. Map of the Otter Creek watershed showing the locations and station codes for sampling sites (also see Table 2). Note locations of biological sampling stations (squares) and those of the Kentucky River Watershed Watch (KRWW, stars) whose stations that were re-occupied by this project.

Table 1. Information regarding sampling sites for this project. Sites are located on Figure 1.Sites marked with asterisk (*) are re-occupied sites of the Kentucky River Watershed watch.

Fork	Sample Code	Sampling Site	Runoff Type	Likely Contaminants	Number of Samples
West	WFU	West Branch upstream of Three Forks road	Fields	Nutrients, microbes	1
	TBC-u	Tribble Branch, upstream West Fork confluence	Fields	Nutrients, microbes	1
	TRC	Tribble Branch, downstream West Fork confluence	Fields	Nutrients, microbes	1
	HBT	Hicks Branch tributary, upstream	Fields	Nutrients, microbes	3
	HBR	Hicks Branch road	Fields	Nutrients, microbes	1
	HBC	Hicks Branch confluence	Fields	Nutrients, microbes	1
	WFC	West Fork confluence, downstream Three Fork Rd	Fields	Nutrients, microbes	1
	BER	Bill Eades Road - upstream confluence	Fields, septic systems	Nutrients, microbes	1
East	1986E	Highway 1986, east	Fields, septic systems	Nutrients, microbes	1
	1986W	Highway 1986, west	Fields, septic systems	Nutrients, microbes	1
	BRC	Brookstown Road, confluence 3 streams	Fields, septic systems	Nutrients, microbes	3
	PRW	Peacock Road, west	Fields, septic systems	Nutrients, microbes	1
	PRE	Peacock Road, east	Fields, septic systems	Nutrients, microbes	1
	EPU	East Prong Road crosses stream	Fields, septic systems	Nutrients, microbes	2
	EPU-trib	Tributary near East Prong Road crossing	Fields, septic systems	Nutrients, microbes	1
	EPC	East Prong confluence	Fields, septic systems	Nutrients, microbes	3
Central	DCP*	Dreaming Creek, former ST plant (K338)	Urban, residential	Nutrients, microbes	1
	DCG	Dreaming Creek - downstream golf course	Recreational	Nutrients	1
	DCF	Dreaming Creek ford - intersection Hwy 388/1986	Urban, residential	Nutrients, microbes	1
	DCC*	Dreaming Creek confluence (K60)	Urban, residential	Nutrients, microbes	3
Central	LRW	West Lake Reba input	Urban, residential	Nutrients, microbes	1
	LRS	Lake Reba Spillway	Recreational	Nutrients, microbes	1
	LRR	Lake Reba spillway - road	Urban, residential	Nutrients, microbes	1
	LRC*	Downstream Lake Reba, Concord (K632)	Residential	Nutrients, microbes	1
	CC	Concord stream	Residential, Hwy	Nutrients, microbes	1
	CF	Concord ford	Residential, Hwy	Nutrients, microbes	1
	FMH*	Four Mile Road/Hunter Road confluence (K633)	Fields	Nutrients, microbes	1
	BD*	Beaver Drive (K191)	Fields, septic systems	Nutrients, microbes	1
	BD-trib	Drainage paralleling Beaver drive	Septic systems	Nutrients, microbes	1
	STP-u	Sewage Treatment plant - upstream	Fields, septic systems	Nutrients, microbes	1
	STP-dis	Sewage Treatment plant - effluent discharge	Plant operations	Nutrients, microbes	1
	STP-d	Sewage Treatment plant - downstream	Plant operations	Nutrients, microbes	1
	OCR*	Otter Creek Road, 388 bridge (K129)	Fields, septic systems	Nutrients, microbes	1
	BER	Bill Eades Road - upstream confluence	Fields, septic systems	Nutrients, microbes	1
	RHB	Ky 3377 crosses Otter Creek	Fields, septic systems	Nutrients, microbes	1
	RHB-trib	Tributary paralleling Lost Fork Road	Fields, septic systems	Nutrients, microbes	1
	SJR	Sam Jones Road, Otter Creek	Fields, septic systems	Nutrients, microbes	1
	SJR-trib	Tributary at bridge, Sam Jones Road	Fields, septic systems	Nutrients, microbes	1
	SRC*	Stony Run confluence (K29)	Fields, septic systems	Nutrients, microbes	3
	RRM*	Railroad crossing on Hwy 338 (K66)	Fields, septic systems	Nutrients, microbes	1
	3906 bridge	Road crossing at 3906	Upland, septic system	Nutrients, microbes	1
	3906C	3906 Redhouse Rd confluence	Upland, septic system	Nutrients, microbes	3
				TOTAL	55
		* Sampling site, Kentucky River Watershed Watch			

≠ 54

METHODS

Field Methods

We sampled at 59 stations, four times (June 19th, June 22nd, July 6th, and July 27th) during the summer 2015 over a variety of rainfall conditions (Table 2, Figure 2) .Sampling sites were positioned to gain a representative sample of the watershed regardless of different land use and terrain and to identify significant sites and sources of fecal microbe contamination. Consequently, we sampled confluences of major tributaries and near suspected contaminant sources. Samples were then placed on ice and processed in laboratory that same day. The sampling dates occurred before (June 19th) and after (June 22nd) a major rainfall event (Fig. 1). Other sampling dates occurred after a rainfall event (July 6th) and after a drier period of weather (July 22nd). We took 100-mL samples with sterile plastic vessels.

Table 2. Sampling conditions for 2015 Field season

Sampling Date	Rainfall History / Stream Conditions
19 June	Mostly dry, trace rain on day before; smaller streams dry
22 June	Rains from tropical storm Bill peaking two days before sampling; all streams flowing
6 July	Rain on July 4, 5; all streams flowing
27 July	Prior week with no rain; ponded water, weak or no flow in smaller streams

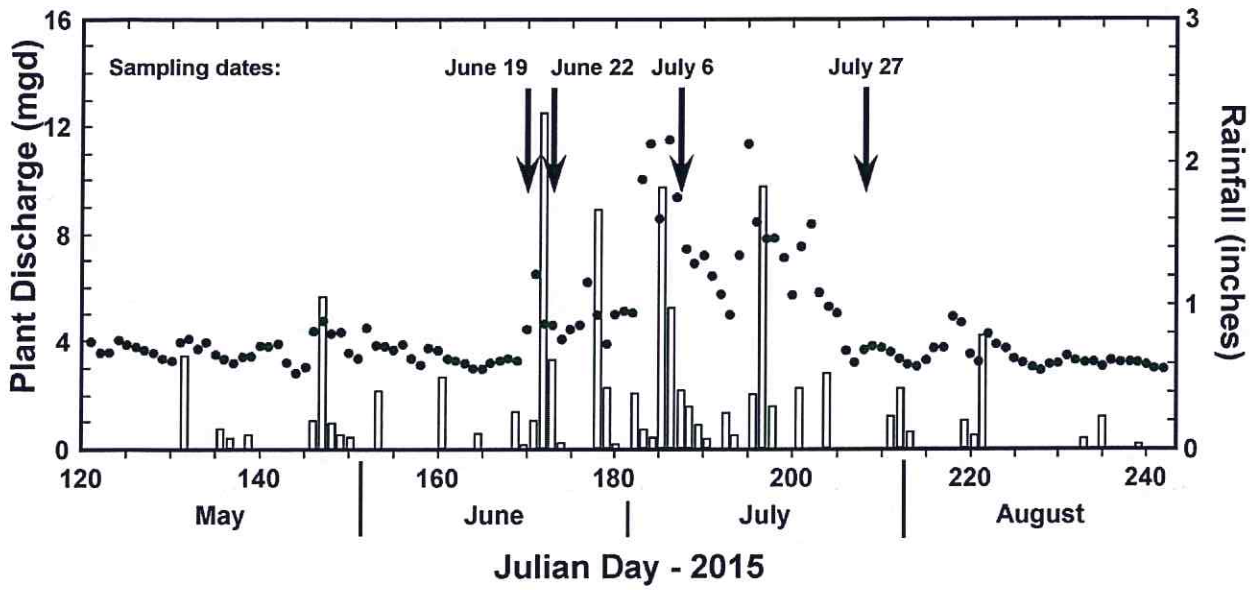

Figure 2. Rainfall amount (columns) and discharge rate (points) at the Otter Creek Sewage Treatment Plant during the 2015 field season. Note that sampling dates are marked with arrows.

Laboratory Methods

We used IDEXX rapid assay methods to measure Total Coliform and *Escherichia coli* concentrations. Samples were spiked with labeled media called Colilert -18 media, poured into IDEXX quanti-trays, and sealed shut, then incubated at 35^{0}C for 18 hours. After incubation we counted Total Coliform and *E. coli*. Maximum count without dilution are 2419. 6 cfu (cfu colony forming units)/100 mL. We discovered that Total Coliform counts are uniformly high (Figure 3) and are therefore specific enough for fecal sources. Therefore, we use *E. coli* counts as a more reliable proxy of fecal contamination.

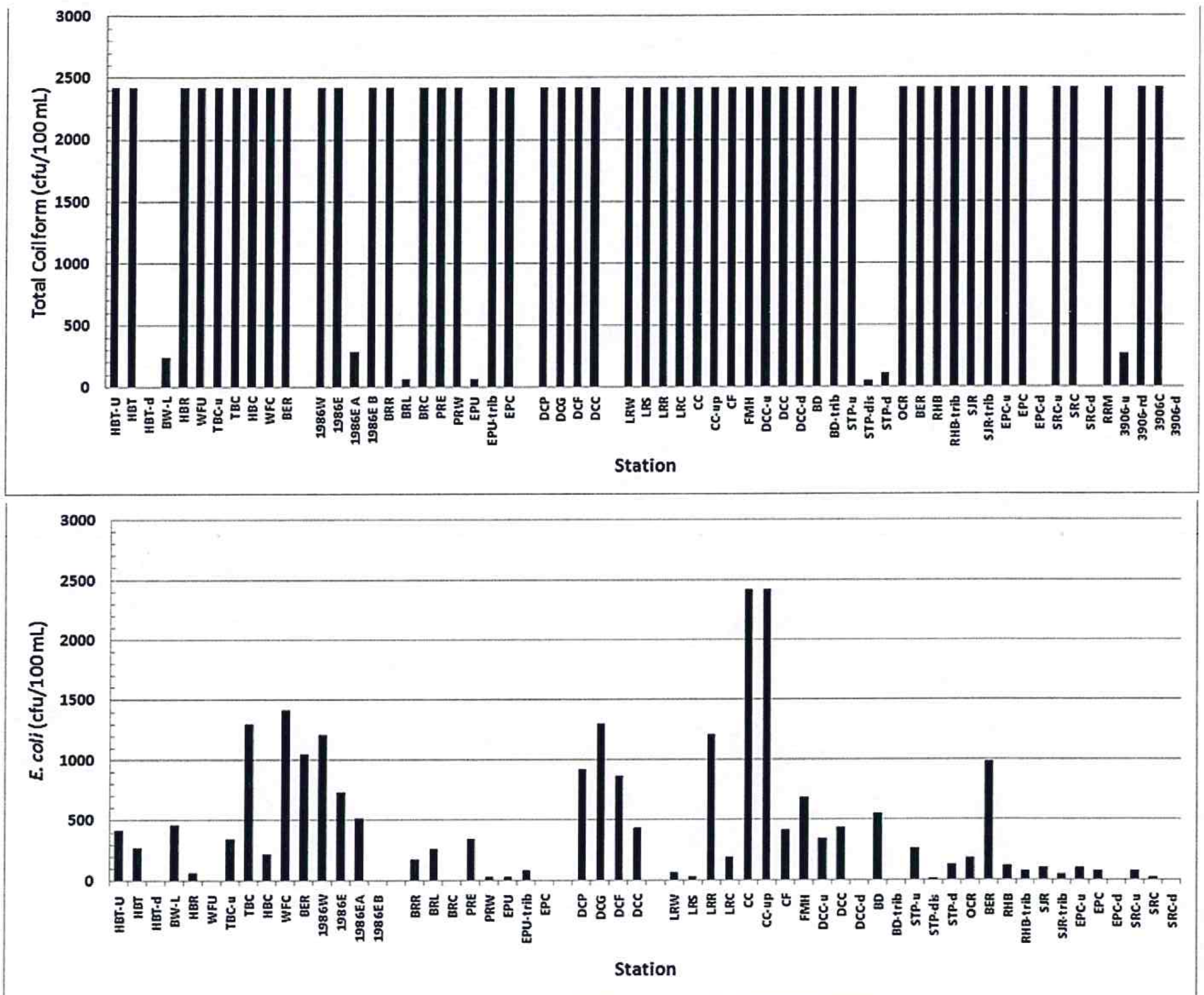

Figure 3. Total Coliform (top) and *E. coli* counts for 6 July 2015. Note the Total Coliform counts are uniformly high in comparison to *E. coli* counts.

not bold

Results

E. coli counts are highly sustainable from station-to-station and from sample date to sample date. The lowest *E. coli* counts occur on 27 July after an extended dry spell as the highest counts occurred on 22 June after a significant rain event. High and low counts occur in all sub-watersheds, but the East Fork, Dreaming Creek, and upper portions of the central trunk show consistently high counts throughout the sampling season. Figure 4 shows *E.coli* counts for all sampling dates. Stations are grouped by sub-watershed (West fork, East fork, Dreaming Creek, Central Otter Creek) from upstream to downstream.

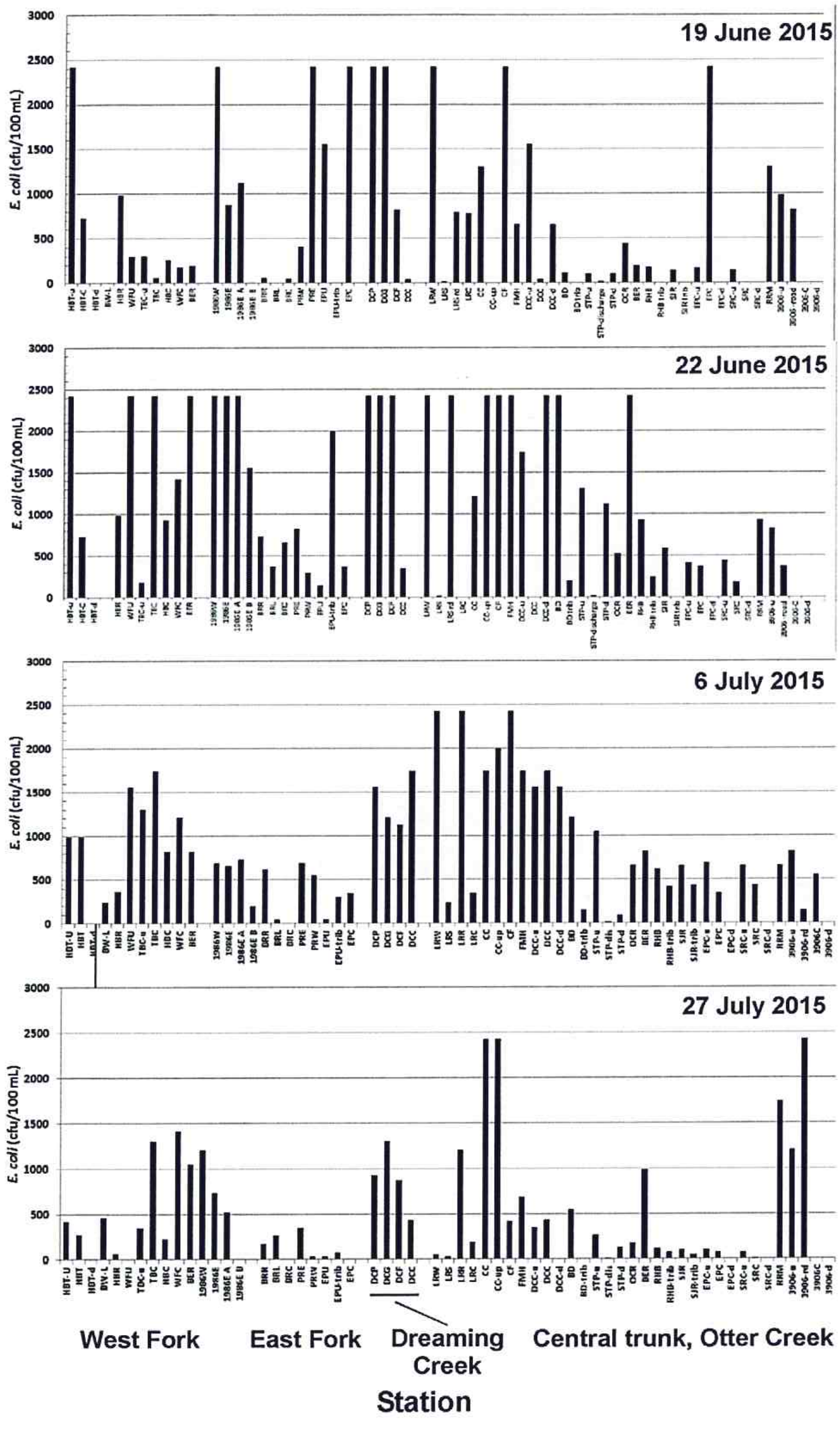

Figure 4. E. coli counts for all sampling dates

Fecal Contaminant Sources

We believe that fecal microbes are a significant contamination source in the Otter Creek watershed. Whether there is a significant amount rainfall or not there were still stations consistently over the threshold. Dreaming Creek had the largest *E. coli* concentrations throughout the entire study. These samples occur upstream of pastureland, so these drain urban Richmond. Because these are upstream of pastureland and drain urban Richmond the most likely fecal source is leaky sewage pipes.

Other areas with high counts are the East and West forks. These areas drain pastureland so the most likely fecal source is cattle. This shows a relationship of rainfall, runoff, and E. coli counts. We Sampled and measured waters before and after a significant rain event (remnants of tropical storm Bill) along with a period of extended amounts of rain and a period of normal weather. We discovered that rain events cause larger *E. coli* counts in the watershed.

Water Quality

The EPA (1986) has categorized water quality in terms of *E. coli* concentration for waters in the United States. The three categories: bathing acceptable (<275 cfu/100mL), recreation only (275-575), and no human contact recommended (>575 cfu/100mL). Over half (54%) of all water samples are severely contaminated with the no human contact designation (Figure 5). Only 23% of samples are acceptable for bathing. We cannot compare the severity of fecal microbe contamination in Otter Creek watershed to other watersheds because of lack of national data set.

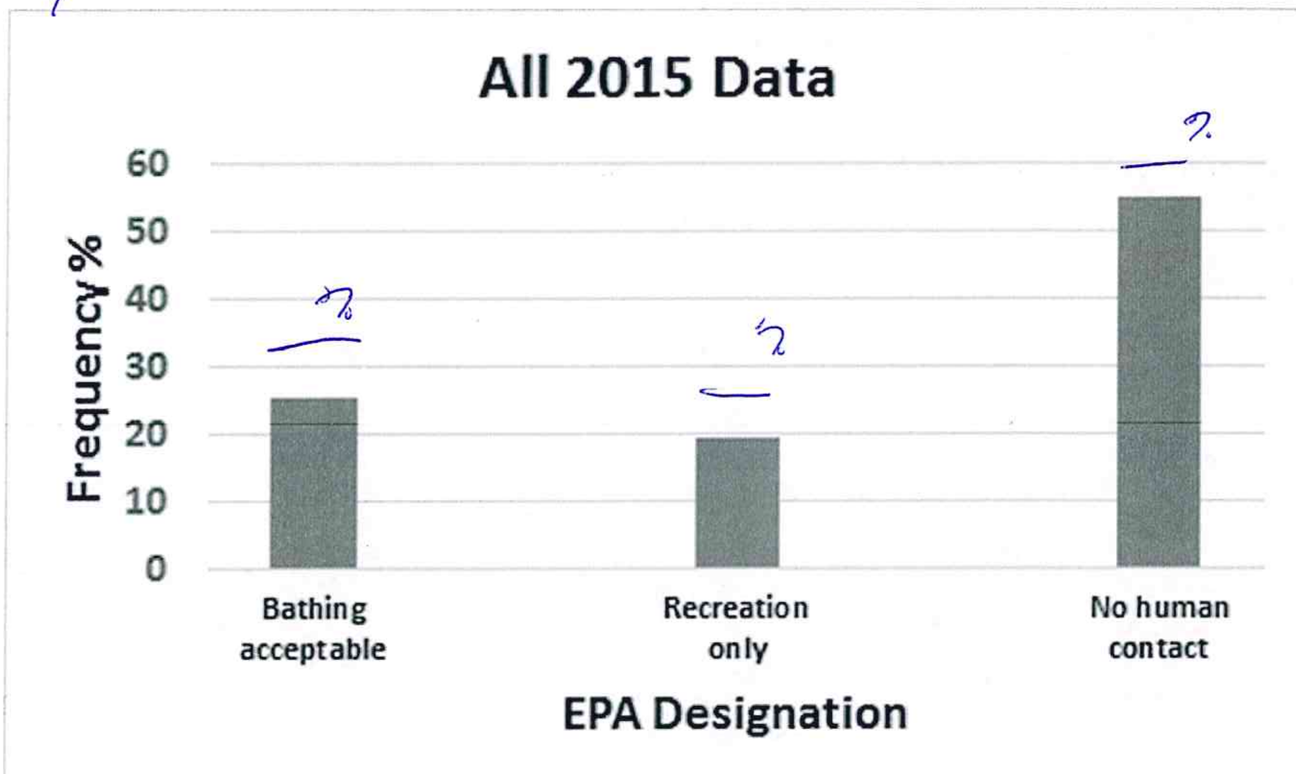

Figure 5. Distribution of water quality according to EPA designation for all water samples during the 2015 field season in the Otter Creek Watershed

centered

References

IDEXX, 2006. Scientific basis of Quanti-Tray/2000. Available from the world-wide web, http://www.idexx.com/water/quantitray/science.jsp.

IDEXX 2010. Summary of ATP Report for *Colilert-18*, Detection and Enumeration of *Fecal Coliforms* in US Wastewater Samples. https://www.idexx.com/resource-library/water/water-reg-article5CV-v2.pdf. Accessed 6/25/2014.

United States Environmental Protection Agency (USEPA), 1986. Ambient water quality criteria for bacteria – 1986. *EPA440/5-84-002*, 18 pp.

Paper B

Course Grade A

Jake,

You didn't make all these corrections from our last draft and did not add a summary. Fig 5 is low resolution low quality. Hence the B.

not bad!

But you did a very good job on the overall independent study and earned a "A" - Congrats! I enjoyed working w/ you. Drew's Senior Thesis will incorporate your microbe work and he will also produce a poster for SE GSA from which you will be a co-author. I invite you to come to Columbia SC [illegible] for the meeting on 31 March and 1 April.