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Nutrient and fecal microbe contamination in Tates Creek, Madison County, Kentucky

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Nutrient and fecal microbe assessment of the water quality of Tates Creek, Madison County, Kentucky

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ABSTRACT

Tates Creek is a significant tributary to the Kentucky River that has shown high levels of microbial and nutrient pollution. We sampled the waters of Tates Creek comprehensively by occupying 25 stations along its 13-mile length, collecting stream water at the confluence of major tributaries from its headwaters to the Kentucky River. Samples were collected four times between May and August 2011 during dry periods as well as immediately after a rainfall event. We measured ammonium (NH_4^+), nitrate (NO_3^-) and phosphate (PO_4^-) concentrations using colorimetry. Microbial samples were measured for total coliform and *Escherichia coli* using IDEXX Colilert-18 media. Background levels of NH_4^+, NO_3^- and PO_4^- are typically ~0.3 mg/L, 5 mg/L, and 1.0 mg/L, respectively. Background levels of nutrient concentrations generally increase during rainfall events, presumably because nutrients are flushed into the stream. Background counts of *E. coli* are typically ~100 cfu/mL but *E. coli* counts reached 1,000 – 2,419 cfu/mL immediately following rain events. A sewage treatment plant exists approximately two miles from the headwaters and noticeably affects water quality. Nutrient concentration, especially NH_4^+ and PO_4^-, are markedly increased at the plant's outflow. These nutrients then decrease steadily in concentration downstream to background levels. In contrast, fecal microbe counts are high upstream from the plant, but fall to near-zero levels at its outflow, and then increase anew downstream. The treatment plant went off line on 19 July 2011 and nutrient levels downstream immediately decreased whereas *E. coli* counts remained high upstream and downstream of the plant. A companion study sampled stream biota before and after the plant shut down into 2012. This allows any changes in stream biota to be recognized and attributed to plant operations.

INTRODUCTION

The nature of water pollution in the United States has changed drastically since the last century. Pollutants then were usually from specific industrial, municipal, or urban sources that could be traced and attributed to their source. Since the enactment and enforcement of the Clean Water Act (1972), the water quality of surface streams, rivers and lakes have become much improved (Robert W. Adler, Jessica C. Landman, Diane M. Cameron (1993). However, much of the nation's water remains contaminated with background levels of various chemical and biotic substances, which cannot be attributed to an unambiguous source although their origins are well known (Clifford S. Russel, Christopher D. Clark). These non-point sources, like significant concentrations of dissolved nutrients and fecal microbes, still negatively impact water quality. Excess levels of nutrients in surface waters lead to significantly increased levels of algae growth that can result in disoxic or anoxic waters (Nicole Silk, Kristine Ciruana 2004), and can impact other freshwater biota and biodiversity (Geoffrey E. Petts, Peter Calow 1996). Animal feces and related biota can present pathological risks to humans while also contributing to elevated nutrient levels.

Tates Creek is a significant tributary to the Kentucky River. Its headwaters are located near downtown Richmond, Madison County, Kentucky and the stream runs approximately thirteen miles northwest to the Valley View ferry located on the Kentucky River. (Fig. 1). The

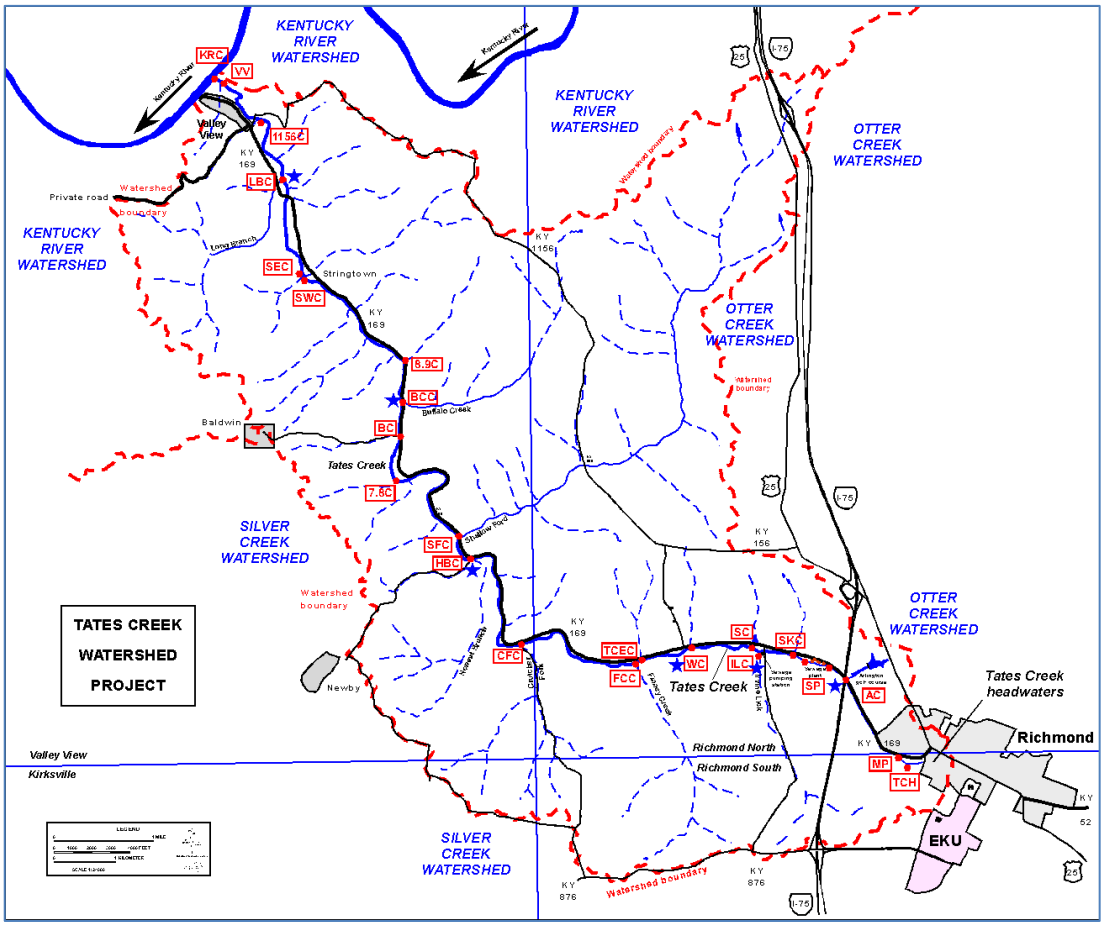

Figure 1. Map of Tates Creek watershed showing sample locations. Sample locations noted by a star are also sites sampled by the Kentucky River Watershed Watch. Base maps are 7.5 minute quadrangle (1:24000) made by the United Stated Geological Survey. Valley View (1952), Kirskville (photorevised 1979), Richmond north (photorevised 1993), and Richmond South (photorevised 1997).

Tates Creek watershed displays various land uses including communities on city sewer and septic, pasture land, a sewage treatment plant, and a golf course. The majority of sample sites upstream of SC are on city sewer, but housing communities downstream from that site are on what are likely aging septic systems that may contribute microbes. Residential areas between STC and VV are suspected of using straight pipes, however none were directly observed while sampling. The golf course, located at sample site AC could potentially contribute various nutrients to Tates Creek in the form of run-off from fertilizing and irrigation practices.

Pastureland as well as some farmland is the primary land use surrounding the entirety of the Tates Creek watershed and several of the residential areas downstream of Station 7.8 contain small family farms that could potentially contribute both nutrients and fecal microbes to the watershed as well. Water levels in Tates are dependent mainly on rainfall but also on the amount of treated water released by the Tates Creek sewage treatment plant. The sewage treatment plant was in operation during all but our final sample date and went offline on July 19, 2011. (Fig. 2)

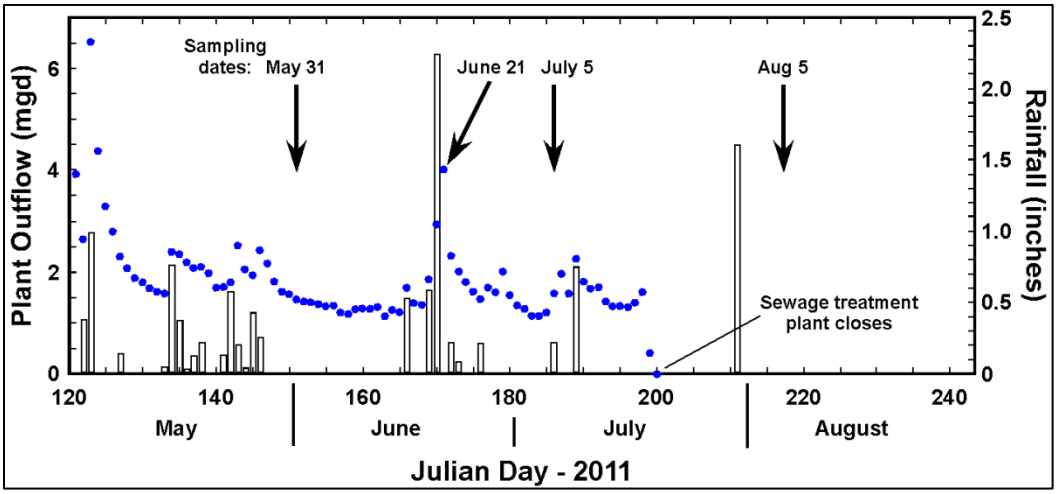

Figure 2. Rainfall amount (columns) as recorded at the Tates Creek sewage plan,t and water outflow from the plant (points).

A comprehensive water quality assessment of Tates Creek has not been conducted; however, the Kentucky River Watershed Watch (KRWW) has occasionally sampled six sites along the creek. In these cases Tates Creek has been identified as a "troubled stream" with high nutrient and fecal microbe counts (Kentucky Division of Water, 2007). The objective of the sampling is to identify possible sources within the watershed that contribute to fecal microbes and the nutrients (phosphate, PO_4^-; ammonium, NH_4^+; nitrate, NO_3^-). Another team working in conjunction with this study is examining the biodiversity of the stream by collecting flora and macroinvertebrates in order to assess the stream's health.

METHODS

Sampling Strategy

Sampling occurred four times during the summer, with approximately two to three weeks between sampling dates (Table 1). One sampling date (June 20) occurred on the day after a major rain event and two were during relatively dry conditions in order to analyze the possible effects of run-off on nutrient and microbe levels. (Fig. 2) Nutrient samples were taken from the mouth of major tributaries at as at upstream and downstream positions within Tates Creek at the tributary entry point. Microbe samples were taken at the tributary mouth and upstream within Tates Creek (Table 1). Sampling sites duplicated those previously tested by the KRWW (Table 1), but increased in number from six to twenty five to cover the entire stream course. At each sampling site, care was taken to cause unnatural levels of turbidity by sampling first at the downstream point. Water was ideally collected in the portions of the stream with higher flow, generally in areas with riffles or cascading water.

Table 1. Sampling dates with general conditions of Tates Creek based on water flow and recent rainfall.

Date	Physical Conditions
May 31st, 2011	Approximately a week after last rainfall. Creek and tributaries have moderate flows.
June 21st, 2011	Day after a significant rainfall with thunderstorms. Creek is at a high flow.
July 5th, 2011	No appreciable rain since last sampling date, June 21st. Creek is shallow and several tributaries are dry.
August 5th, 2011	Several days after last rain fall in dry conditions. Creek is almost dry toward headwaters and several tributaries are dry.

Table 2. List of sample sites along Tates Creek by name and abbreviations with relative locations, land use types, and sampling procedure. Tates Creek road parallels the stream and milage to sample sites are given along with likely contaminants. The number position and number of sample also appears. Sites marked by an asterisk (*) are those shared with those of the Kentucky Rivershed Watch.

Sample Code	Sampling Site	KY 169 Mileage	Effluent Type	Likely Contaminants	Sampling	Number of Samples
MPk-E	Million Park	0.1	urban	N, M	Creek only	1
MPk-W	Million Park	0.1	urban	N, M	Creek only	1
MP	McCready pond	0.3	Residential	N, M	Inflow, outflow	2
KCS	Opposite golf course	1.1	Roadway, golf course	N, M	Creek only	1
AC	Arlington	1.3	Golf course	N	Drainage only	1
I75*	Interstate I-75	1.35	Roadway	N, M	Upstream, down	2
SPU	Sewage plant	1.5	Sewage	N, M	Upstream	1
SPD	Sewage plant	1.8	Sewage	N, M	Downstream	1
SKC	South Keeneland	2.0	Urban, residential	N, M	Drainage only	1
ILC*	Irvine Lick confluence	2.2	Urban, residential	N, M	Inflow, up, down	4
SC	Substation	2.3	Residential septic	N, M	Drainage only	1
WC	Wellington	3.0	Residential septic	N, M	Drainage only	1
TCE*	Tates Creek Estates	3.1	Residential septic	N, M	Drainage only	1
FCC	Finney Creek confluence	3.5	Pasture	N, M	Inflow, up, down	3
CFC	Crutcher Fork confluence	4.9	Pasture, residential	N, M	Inflow, up, down	3
HBC*	Honest Branch confluence	6.2	Pasture	N, M	Inflow, up, down	4
SFC	Shallow Ford confluence	6.4	Pasture	N, M	Inflow, up, down	3
7.8C	Mile 7.8 confluence	7.8	Pasture	N, M	Inflow, up, down	3
BC	Baldwin confluence	8.2	Pasture	N, M	Inflow, up, down	3
BCC*	Buffalo Creek confluence	8.5	Pasture	N, M	Inflow, up, down	3
8.9C	Mile 8.9 confluence	8.9	Pasture	N, M	Inflow, up, down	3
STE	Stringtown east confluence	10.3	Pasture	N, M	Inflow, up, down	3
STW	Stringtown west confluence	10.3+	Pasture	N, M	Inflow only	1
LBC*	Long Branch confluence	11.3	Pasture	N, M	Inflow, up, down	3
1156C	KY 1156 confluence	12.0	Pasture	N, M	Inflow, up, down	2
VV	Valley View	12.5	Residential septic	N, M	Inflow, up, down	1
KRC	Kentucky River confluence	12.6	Pasture	N, M	Inflow, up, down	1
					Total samples	54

KEY: N = nutrients M = microbes up = upstream down = downstream *KRWW location

Sampling Methods

Nutrient sampling was conducted using a 100-mL syringe. The syringe plunger was removed and the syringe was submerged, aperture-end down into the water. The syringe was then turned upright to collect the sample. The syringe was removed from the water and the plunger was replaced. A Millex-HN, 0.45 µm, nylon, 33-mm syringe filter was placed on the syringe to capture any sediment or organic material while filling two, 10-mL test tubes used for ammonium and phosphate analysis, and a 26-mL scintillation vial used for nitrate measurement. The syringe filter was replaced if it became clogged. All samples were acidified with two drops of concentrated sulfuric acid per test tube and four drops per scintillation vial to a pH of <2 for preservation of the sample (Method 4500-NH_3^- A, Method 4500-P, 2005). Nutrient samples were put in a cooler containing ice immediately after collection and were stored in a refrigerator in the lab until analysis.

Microbe sampling was conducted according established protocols (Method 9060A, 2005). Water samples were collected in IDEXX, sterile 120-mL vessels. The vessels were filled with stream water by removing the band-seal and lid, then submerging the entire vessel in to the creek with the aperture end down in order to trap air within the cavity of the vessel and therefore help prevent contamination from surface debris. Once the vessel was completely submerged, it was turned upright to fill with water. The sample was then decanted to the marked 100-mL fill line. The lid was then secured and the vessel was immediately placed in an ice-filled cooler taking care to keep samples out of any melt water.

Laboratory Methods

Phosphate measurements were conducted as outlined by Strickland and Parsons (1968) as modified by Gieskes et al. (1991) using colorimetry (see also Method 4500 P-E, 2005). We made a stock solution of 101.1 mg/L PO_4 (32.9 mg/L P) in double-distilled water. We then diluted this solution to make standards of approximately 0.25, 0.5, 1.0, 2.5 and 5.0 mg/L phosphate. Standards were generally linear between 0 and 2.5 mg/L. Any samples outside the standard range were diluted by half using double distilled water and analyzed again. The samples and standards developed for thirty minutes and then analyzed using a photospectrometer set at 885 nm.

Nitrate values were calculated using the cadmium reduction method (Method 4500-NO_3 E, 2005) utilizing NitraVer packets. We made a NO_3 stock solution of 447.1 mg/L NO_3 (101.0 mg/L N). We then diluted the stock solution using double-distilled water to create standards of about 0.5, 1.0, 2.5, 5.0 and 12.6 mg/L nitrate. The procedure calls adding 1 packet of NitraVer to 20 mL of standard or sample, mixing for two minutes, and developing for at least one minute. Samples and standards were then analyzed using a photospectrometer set to 543 nm.

Ammonium values were calculated using the methods outlined by Solorzano (1960) using colorimetry (Method 4500-NH_3 F, 2005). We prepared a KNO_4 stock solution of 447.1mg/L NH_4^+ (101.0 mg/L N) which we used to create standards of approximately 0.5, 1.0, 2.5, 5.0 and 12.5 mg/L through dilution. Samples and standards were then analyzed using a photospectrometer set to 640 nm.

Microbial rapid assay techniques are based on specific media usage by target microbes that alter media and cause fluorescence (Method 9223, 2005). For coliform bacteria, the growth media ortho-nitrophenyl-β-D-galactopyranoside (ONPG) is used to detect the presence of the

enzyme β-D-galactosidase (Method 9223, 2005). Serial dilutions are the used to statistically estimate microbe counts termed the Most Probable Number (MPN), expressed as the number of colony-forming units per unit volume (Method 9221, 2005). For *E. coli* determinations, 4-methyl-umbelliferyl-β-D-glucuronide (MUG) is used as a substrate to detect the enzyme β -glucuronidase (Method 9223, 2005), using the same statistical method.

We use IDEXX methods that simultaneously assay for total coliform microbes and *E. coli* (IDEXXa, 2011) using Colilert media (IDEXXb, 2011). The media contains ONPG and MUG, and microbial counts are established mirroring serial dilution techniques using their quanti-tray assay method that produces MPN counts (IDEXXc, 2011).

Microbial samples were prepared the same day that they were collected. Individual sample vessels were inspected to double check fill quantities and were decanted if over full. IDEXX Colilert®-18 media then added to each sample and the samples were then gently shaken until the Colilert material was fully dissolved. The sample with dissolved Colilert was then slowly poured in to an IDEXX Quanti-Tray®/2000. The tray was folded shut and placed in a Quanti-Tray 2000 insert and run through a thermal sealer. Sealed trays were incubated at 35°C for 18 hours. After the incubation period, the trays were removed from the incubator and analyzed. The number of large and small wells that changed to a yellowish hue was recorded as positive for fecal coliform. The positive wells were then assessed for most probable number of colonly forming units (cfu) per 100 mL using the IDEXX MPN chart provided with the IDEXX Quanti-Tray 2000s. The trays were then placed under a 6-watt, 365-nm UV light within 5 inches of the sample in a dark environment. The wells that fluoresced were counted as positive for *E. coli* and the MPN cfc/u was calculated through the provided chart. The IDEXX Qunati-Tray/2000 is capable of determining microbe counts between 1 and 2,419 cfu/100 mL. Counts designated as

>2,419 cfu/100 Ml must be diluted to obtain quantitative values. When analyzing wells for *E. coli*, those that fluoresced but did not show positive for fecal coliform were excluded from the count, per the directions provided by IDEXX.

RESULTS

Entry of contaminants in the Tates Creek system is mostly dependent upon rainfall within the watershed. Figure 2 shows the rainfall events and their magnitude as recorded at the Tates Creek sewage plant during the study period. Also shown is the outflow of treated water entering the stream from the plant until the sewage plant was shut down on July 19, 2011. Outflow amounts are also dependent on rainfall as storm water runoff and the sewage stream co-mingle.

Sampling on May 31 occurred several days after some small rainfall. Upstream of the treatment plant, phosphate and nitrate generally occur at their lowest concentrations in the trunk stream (Fig. C1). Phosphate and nitrate concentrations are highest immediately downstream of the sewage treatment plant (SP-d), downstream of adjacent pasture land (upstream Irvine), and at the sewage pumping station at Goggins Lane (ILC-u); ammonium is measurable only at the sampling site downstream of the treatment plant (SP-d). Phosphate and nitrate then decrease steadily downstream within Tates Creek, and contributions from the tributaries are lower than trunk stream levels.

A severe thunderstorm with heavy rainfall passed through the Tates Creek watershed on June 20 and we sampled the day after. Phosphate and ammonium levels are very low upstream of the sewage treatment plant (Fig. C2), and their peak values occur at the 3 sites downstream of the plant (SP-d, upstream Irvine, ILC-u). Peak nitrate values also occur downstream of the treatment plant but are generally high upstream as well. Phosphate and ammonium levels are generally low downstream of the Irvine Lick confluence (ILC) with concentrations in tributary streams being lower that those within Tates Creek. However, nitrate values remain high downstream of the Irvine Lick confluence (ILC). Nutrient levels in the

tributary streams continue to be generally lower than those within the trunk stream with the exception of station 7.8C.

Sampling occurring on July 5 occurred after a period of essentially no rain since the last sampling date, June 21. All nutrients are low upstream of the sewage treatment plant (Fig. C3), with the highest values at the 3 sites downstream of the plant (SP-d, upstream Irvine, ILC-u). Nitrate concentrations are consistently higher downstream of Irvine Lick confluence (ILC) than ammonium or phosphate. The tributary entering Tates Creek from the east at Stringtown (STE) contained ammonium and nitrate values higher than those of Tates Creek. Long Branch (LBC) has ammonium values as high as background values in Tates Creek.

The sampling done on August 5 is the sole sampling foray that occurred after the sewage treatment plant ceased operations and occurred after a gentle rain the day before. All nutrient values are much lower than those measured on other sampling dates, and the strong peak that characteristically occurs immediately downstream of the sewage treatment plant is absent. Nitrate and ammonium concentrations are zero at most sampling stations with ammonium being zero at all stations. Phosphate values are decreased relative to the other sampling dates and tributary levels are consistently lower than those of Tates Creek.

Background levels of nitrogen as ammonium, nitrogen as nitrate, and phosphate are ~0.3, 5, and 1.0 mg/L, respectively. Overall, nutrient levels of the majority of tributaries are at or below background levels. The highest levels of all three nutrients were consistently observed immediately downstream of the sewage treatment plant (SP-d, upstream Irvine, ILC-u) Downstream from the plant, we also observed and abundance of various algae coating the bedrock of the stream bottom in the form of long, wispy tendrils. Peak nutrients levels from these points on Tates Creek gradually decline to background levels downstream

The Tates Creek sewage treatment plant shut down its operations on July 19, 2011 with marked consequences in terms of both nutrient concentrations and fecal microbe counts. Nutrient levels throughout the course of the creek dropped to near zero levels (Gig. 1). On the June 20th sampling date with corresponded with a large rain even the night before, nutrient levels increased overall in tributaries, but sites such as immediately downstream of the sewage treatment plant (SP-d) that peaked well above background levels on dry sampling dates decreased significantly for all nutrients other than ammonium, which increased at after rain events.

Microbe samples collected on May 31 showed counts for total coliform surpassing levels of 2419.6 cfc/100 mL at all sites upstream of the sewage treatment plant (SP-d) (Fig D1). *E. coli* levels were also highest before the sewage treatment plant, and peaked at the areas of the creek where it passes the Arlington golf course under the I-75 interstate (I-75-u and I-75-d) (Figure 1). The run off ditch from the golf course (AC) contains the highest *E. coli* counts of any tributary, surpassing 2419.6 cfc/100 mL. Immediately downstream from the sewage treatment plant (SP-d), total coliform counts drop to near zero levels, but spikes back up to 2419.6 cfc/100 mL for both coliform and *E. coli* at the next site (ILC-U), where the creek passes through active pasture land. Fecal coliform counts remain high downstream from this site, and while most of the tributaries showed counts lower than Tates Creek, several reach counts higher than 2419.6 cfc/100 mL. *E. coli* counts drop down to counts bellow 500 cfc/100 mL past ILC-U with the area where Tates Creek goes under highway 1156 being the only exception at 613.1 cfc/100 mL.

June 21 sampling counts were elevated for virtually every site along the creek. Nearly every site was approached or exceeded 2419.6 cfc/100 mL for fecal coliform. *E. coli* numbers

were generally higher in the trunk stream, where counts often surpassed 2000 cfc/100 mL, but tributaries counts were significantly higher than in the previous samples.

July 5 counts again show fecal coliform numbers surpassing 2419.6 cfc/100 mL for all areas of the trunk stream and the majority of tributaries. The only exceptions were the golf course run off (AC), and run off from residential housing (SC). Counts drop immediately after the sewage plant (SP-d), but not as significantly as on the May 31st sample. *E. coli* counts remain high upstream of the sewage treatment plant, and again drop to near zero levels at the immediate downstream site. They then rise again as they pass through the active cow pasture downstream of the plant (ILC-U). *E. coli* counts are again high from the run off from a residential area on septic (TCE) as well as some tributaries that occupy pasture land (FCC). This sample date corresponds with decreased rainfall and less sewage plant discharge relative to the previous samples.

The August 5th sample date was the only time when samples were collected after the sewage treatment plants went out of operation. Total Coliform counts remained at the 2419.6cfc/100 mL level upstream of the former sewage treatment plant, but does not drop as it did in the previous 3 sample dates at the immediate downstream of the plant (SP-d). Counts remain at this level in all tributaries and the trunk stream until Tates Creek reaches the Kentucky River (KRC). Overall *E. coli* counts are lower than the previous three sample dates, but hot spots do exist. Downstream of the sewage treatment plant (SP-d) has a higher count than previous dates at 920.8 cfc/100 mL. The area downstream of the sewage treatment plant as the stream passes through active pasture land (ILC-u) continues to be at 2419.6cfc/100 mL levels of *E. coli* and the residential areas of (SC) and (TCE) remain at that level. Another tributary that passes through active pasture land (BC) contained counts of 2419.6cfc/100 mL.

Microbial analysis showed high total coliform counts throughout the creek, often exceeding 2419.6 cfc/100 mL with several hotspots of *E. coli*. Elevated counts were observed in samples taken immediately after rain events. Reoccurring hotspots for *E. coli* were observed at areas where the creek or its tributaries pass through cattle pastures, particularly at the cattle field between the sewage treatment plant and the Irvine Lick confluence (ILC-U) the Baldwin Confluence (BC). Consistently low counts of *E. coli* and fecal coliform were observed downstream of the sewage treatment plant (SP-D) in relation to counts immediately upstream (SP-u). After the sewage plant was shut down, an increased count of fecal microbes occurs downstream of the plant (SP-d), and high counts for *E. coli* became more apparent at downstream sources.Increased fecal microbe counts were also observed on sampling dates immediately after rain events.

DISCUSSION

The data collected indicates that the main contributer to nutrient levels in Tates Creek was the sewage treatment plant, as all nutrients observed decreased considerably after the plant's shutt down. After the water discharged from the sewage treatment plant flows downstream, nutrient levels decrease gradually as they are diluted by inflow from tributaries and nutrients are utilized by aquatic biota. Rain events served create run-off from various land uses to increase nutrient levels in tributaries, but at the same time diluted the much higher concentrations contributed to the waterway by the sewage treatment plant.

Microbial data indicates that the sewage treatment plant was contributing enough microbe free water in its discharge to dilute counts down to levels lower than those upstream from the plant. The resuts from this are, however, shortlived as Tates Creek immediately passes through an active cattle pasture once leaving SP-d, at ILC-U-PS. Rainfall resulted in run-off from surrounding land uses causing total coliform and *E. coli* back ground levels in tributaries as well as the creek itself to increase. The three hotspots for *E. coli* observed on August 5th were run off from a small pond that may have been used by cattle at some point (SC), run off from a subdivision on septic (TCE) and a small tributary that runs through land used for various livestock (BC).

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APPENDIX A

Nutrient Data

Table A. Nutrient data for Tates Creek stations organized by sampling data. Concentrations are in milligrams per liter (mg/L; equivalent to parts per million, or ppm).

31-May-11

Sample	[N-NO3] mg/L	[NO3] mg/L	[N-NH4] mg/L	[NH4] mg/L	Total N mg/L	[P-PO4] mg/L	[PO4] mg/L
MPK-E	2.7	12.0	0.0	0.0	2.7	0.0	0.1
MPK-W	1.2	5.3	0.0	0.0	1.2	0.2	0.5
MP-u	1.7	7.6	0.0	0.0	1.7	0.1	0.3
MP-d	1.3	5.7	0.0	0.0	1.3	0.0	0.1
KCS	0.6	2.8	0.0	0.0	0.6	0.0	0.2
I75-u	0.0	0.0	0.0	0.0	0.0	0.0	0.1
AC	0.8	3.5	0.0	0.0	0.8	0.0	0.0
I75-d	0.6	2.7	0.0	0.0	0.6	0.0	0.0
SP-u	0.8	3.3	0.0	0.0	0.8	0.1	0.2
SKC	0.4	1.8	0.0	0.0	0.4	0.1	0.2
SP-d	13.6	51.1	0.0	0.0	13.6	2.2	7.1
IL-u-PS	11.6	43.6	0.2	0.2	11.8	1.6	5.1
ILC-u	10.5	39.5	0.0	0.0	10.5	1.7	5.4
ILC-u-X	-	-	-	-	-	-	-
ILC	0.3	2.2	0.0	0.0	0.3	0.0	0.0
ILC -d	8.1	35.8	0.0	0.0	8.1	1.0	3.3
SC	0.5	2.2	0.0	0.0	0.5	0.1	0.2
WC	0.7	3.1	0.0	0.0	0.7	0.0	0.1
TCE	2.0	9.0	0.0	0.0	2.0	0.1	0.3
FCC-u	8.6	32.7	0.0	0.0	8.6	1.1	3.6
FCC	0.8	3.5	0.0	0.0	0.8	0.0	0.1
FCC-d	6.3	24.4	0.0	0.0	6.3	0.6	1.8
CFC-u	9.1	34.5	0.0	0.0	9.1	1.1	3.4
CFC	1.2	5.4	0.0	0.0	1.2	0.1	0.4
CFC-d	6.3	24.3	0.0	0.0	6.3	0.7	2.3
HBC-u	4.4	19.5	0.0	0.0	4.4	0.6	1.8
HBC-big	-	-	-	-	-	-	-
HBC	1.1	5.0	0.0	0.0	1.1	0.1	0.4
HBC-d	4.4	19.3	0.0	0.0	4.4	0.4	1.4
SFC-u	4.3	18.8	0.0	0.0	4.3	0.6	1.9
SFC	1.3	5.6	0.0	0.0	1.3	0.0	0.1
SFC-d	4.2	18.7	0.0	0.0	4.2	0.5	1.7
7.8C-u	3.6	16.1	0.0	0.0	3.6	0.4	1.1
7.8C	1.6	7.1	0.0	0.0	1.6	0.1	0.2

Sample	[N-NO3] mg/L	[NO3] mg/L	[N-NH4] mg/L	[NH4] mg/L	Total N mg/L	[P-PO4] mg/L	[PO4] mg/L
7.8C-d	3.2	14.0	0.0	0.0	3.2	0.4	1.1
BC-u	3.2	14.1	0.0	0.0	3.2	0.1	0.3
BC	0.9	3.8	0.0	0.0	0.9	0.0	0.1
BC-d	3.0	13.1	0.0	0.0	3.0	0.3	1.0
BCC-u	2.9	12.9	0.0	0.0	2.9	0.3	0.9
BCC	1.0	4.6	0.0	0.0	1.0	0.1	0.4
BCC-d	5.0	22.1	0.0	0.0	5.0	0.3	0.9
8.9C-u	2.5	11.0	0.0	0.0	2.5	0.3	0.9
8.9A	1.0	4.2	0.0	0.0	1.0	0.1	0.4
8.9C	0.7	3.0	0.0	0.0	0.7	0.1	0.4
8.9C-d	2.7	11.9	0.0	0.0	2.7	0.3	1.0
STC-u	2.5	11.3	0.0	0.0	2.5	0.3	0.9
STE-r	1.0	4.6	0.0	0.0	1.0	0.1	0.5
STE	1.1	5.1	0.0	0.0	1.1	0.1	0.4
STW	0.5	2.4	0.0	0.0	0.5	0.1	0.5
STC-d	2.2	9.5	0.0	0.0	2.2	0.2	0.7
LBC-u	1.8	8.0	0.0	0.0	1.8	0.2	0.7
LBC	0.4	1.6	0.0	0.0	0.4	0.1	0.2
LBC-d	1.8	8.1	0.0	0.0	1.8	0.2	0.7
1156	0.1	0.4	0.0	0.0	0.1	0.0	0.2
1156 TC	1.4	6.3	0.0	0.0	1.4	0.1	0.4
VV	1.4	6.3	0.0	0.0	1.4	0.2	0.5
KRC	1.3	5.7	0.0	0.0	1.3	0.2	0.7

21-Jun-11

Sample	[N-NO3] mg/L	[NO3] mg/L	[N-NH4] mg/L	[NH4] mg/L	Total N mg/L	[P-PO4] mg/L	[PO4] mg/L
MPK-E	4.7	20.8	0.0	0.0	4.7	0.1	0.2
MPK-W	3.2	14.3	0.0	0.0	3.2	0.1	0.4
MP-u	3.8	16.8	0.0	0.0	3.8	0.1	0.3
MP-d	2.9	12.9	0.2	0.2	3.1	0.2	0.5
KCS	2.1	9.4	0.1	0.1	2.2	0.1	0.4
I75-u	3.1	13.9	0.0	0.0	3.1	0.1	0.3
AC	3.9	17.3	0.0	0.0	3.9	0.1	0.3
I75-d	3.1	13.7	0.0	0.0	3.1	0.1	0.3
SP-u	2.7	12.1	0.0	0.0	2.7	0.1	0.3
SKC	4.6	20.2	0.0	0.0	4.6	0.1	0.2
SP-d	5.9	26.1	2.0	2.5	7.9	1.0	3.1
IL-u-PS	6.6	29.0	1.4	1.8	8.0	0.8	2.5
ILC-u	6.0	26.6	1.4	1.8	7.4	0.8	2.5
ILC-u-X	-	-	-	-	-	-	-
ILC	1.8	7.8	0.0	0.0	1.8	0.1	0.2
ILC -d	-	-	-	-	-	-	-
SC	1.0	4.3	0.3	0.4	1.3	0.1	0.3
WC	3.2	14.0	0.0	0.0	3.2	0.1	0.4
TCE	4.2	18.8	0.0	0.0	4.2	0.1	0.4
FCC-u	5.7	25.2	0.3	0.4	6.0	0.5	1.6
FCC	1.5	6.5	0.0	0.0	1.5	0.1	0.2
FCC-d	6.6	29.3	0.5	0.6	7.1	0.5	1.6
CFC-u	5.4	24.0	0.3	0.3	5.7	0.5	1.6
CFC	1.2	5.3	0.2	0.2	1.4	0.1	0.4
CFC-d	5.3	23.4	0.3	0.3	5.6	0.5	1.5
HBC-u	5.0	22.1	0.3	0.4	5.3	0.5	1.4
HBC-big	1.0	4.6	0.0	0.0	1.0	0.1	0.3
HBC	1.1	4.9	0.3	0.4	1.4	0.1	0.4
HBC-d	5.2	23.1	0.1	0.1	5.3	0.4	1.4
SFC-u	5.2	23.2	0.3	0.3	5.5	0.5	1.5
SFC	2.5	10.9	0.3	0.3	2.8	0.1	0.3
SFC-d	5.0	22.2	0.3	0.3	5.3	0.4	1.4
	[N-NO3]	**[NO3]**	**[N-NH4]**	**[NH4]**	**Total N**	**[P-PO4]**	**[PO4]**
Sample	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**
7.8C	1.5	6.4	0.7	0.8	2.2	0.1	0.4
7.8C-d	4.2	18.5	0.3	0.3	4.5	0.3	1.0
BC-u	4.1	18.1	0.2	0.2	4.3	0.4	1.2

BC	1.0	4.3	0.0	0.0	1.0	0.1	0.4
BC-d	5.2	23.1	0.3	0.3	5.5	0.4	1.2
BCC-u	4.1	18.2	0.0	0.0	4.1	0.3	1.0
BCC	0.8	3.7	0.0	0.0	0.8	0.3	0.9
BCC-d	5.1	22.6	0.2	0.3	5.3	0.4	1.1
8.9C-u	4.5	20.1	0.2	0.2	4.7	0.4	1.2
8.9A	-	-	-	-	-	-	-
8.9C	1.1	4.7	0.2	0.2	1.3	0.1	0.4
8.9C-d	4.0	17.9	0.0	0.0	4.0	0.3	1.0
STC-u	4.5	20.0	0.0	0.0	4.5	0.4	1.3
STE-r	0.9	4.0	0.0	0.0	0.9	0.1	0.5
STE	2.6	11.6	0.0	0.0	2.6	0.1	0.4
STW	1.0	4.5	0.0	0.0	1.0	0.1	0.4
STC-d	4.0	17.8	0.0	0.0	4.0	0.3	0.9
LBC-u	3.8	16.9	0.2	0.2	4.0	0.3	1.0
LBC	0.2	0.8	0.2	0.2	0.4	0.1	0.4
LBC-d	2.5	11.2	0.1	0.2	2.6	0.2	0.8
1156	-	-	-	-	-	-	-
1156 TC	2.9	13.0	0.0	0.0	2.9	0.3	1.1
VV	0.6	2.8	0.0	0.0	0.6	0.1	0.3
KRC	0.5	2.2	0.0	0.0	0.5	0.0	0.1

5-Jul-11

Sample	[N-NO3] mg/L	[NO3] mg/L	[N-NH4] mg/L	[NH4] mg/L	Total N mg/L	[P] mg/L	[PO4] mg/L
MPK-E	1.8	7.9	0.7	1.0	2.5	0.1	0.3
MPK-W	1.8	7.9	-	-	-	0.2	0.5
MP-u	2.1	9.5	0.9	1.2	3.0	0.2	0.5
MP-d	0.8	3.6	0.6	0.8	1.4	0.1	0.3
KCS	0.7	3.0	0.3	0.4	1.0	0.1	0.3
I75-u	0.4	1.7	0.1	0.1	0.5	0.0	0.1
AC	2.0	8.7	0.3	0.4	2.3	0.0	0.1
I75-d	0.7	3.0	0.4	0.5	1.1	0.0	0.1
SP-u	1.0	4.6	0.3	0.4	1.3	0.1	0.3
SKC	-	-	-	-	-	-	-
SP-d	10.6	47.0	4.6	5.9	15.2	1.0	3.2
IL-u-PS	11.8	52.2	3.4	4.3	15.2	0.8	2.5
ILC-u	12.5	55.4	3.4	4.3	15.9	0.8	2.4
ILC-u-X	-	-	-	-	-	-	-
ILC	1.8	8.0	0.6	0.8	2.4	0.1	0.2
ILC -d	9.4	41.6	4.3	5.5	13.7	0.6	1.9
SC	0.2	1.1	0.2	0.3	0.4	0.0	0.1
WC	0.7	2.9	0.0	0.0	0.7	0.0	0.1
TCE	3.3	14.5	0.7	0.9	4.0	0.2	0.5
FCC-u	8.8	39.0	1.3	1.7	10.1	0.5	1.7
FCC	3.5	15.3	0.0	0.0	3.5	0.1	0.4
FCC-d	7.6	33.6	1.5	1.9	9.1	0.5	1.6
CFC-u	6.3	27.7	1.0	1.3	7.3	0.5	1.6
CFC	0.1	0.7	0.3	0.4	0.4	0.0	0.1
CFC-d	7.3	32.2	1.3	1.7	8.6	0.5	1.6
HBC-u	5.2	23.2	0.3	0.3	5.5	0.3	0.9
HBC-big	0.6	2.6	0.1	0.1	0.7	0.1	0.2
HBC	0.3	1.2	-	-	-	0.1	0.3
HBC-d	5.4	23.8	0.9	1.1	6.3	0.3	1.0
SFC-u	5.9	26.2	0.6	0.8	6.5	-	-
SFC	0.6	2.8	0.2	0.2	0.8	0.1	0.3
SFC-d	5.7	25.1	0.9	1.2	6.6	0.3	1.0
7.8C-u	5.4	23.8	0.8	1.0	6.2	0.4	1.2
7.8C	0.5	2.3	0.0	0.0	0.5	0.1	0.3
BC-u	6.1	27.2	0.6	0.8	6.7	0.3	1.0
BC	0.4	1.7	0.8	1.0	1.2	0.1	0.2
BC-d	6.9	30.5	0.2	0.2	7.1	0.4	1.2

	[N-NO3]	[NO3]	[N-NH4]	[NH4]	Total N	[P]	[PO4]
Sample	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**
BCC	0.3	1.2	0.6	0.8	0.9	0.1	0.4
BCC-d	6.9	30.5	1.0	1.2	7.9	0.5	1.6
8.9C-u	8.1	36.0	0.8	1.1	8.9	0.5	1.6
8.9A	-	-	-	-	-	-	-
8.9C	-	-	-	-	-	-	-
8.9C-d	8.8	38.8	0.6	0.8	9.4	0.5	1.7
STC-u	8.1	36.0	0.2	0.3	8.3	0.5	1.6
STE-r	1.1	4.7	0.3	0.4	1.4	0.1	0.2
STE	5.5	24.5	2.1	2.7	7.6	0.3	0.8
STW	-	-	-	-	-	-	-
STC-d	6.9	30.4	1.1	1.5	8.0	0.5	1.6
LBC-u	10.4	46.1	0.0	0.0	10.4	0.5	1.5
LBC	0.2	1.0	1.1	1.4	1.3	0.0	0.1
LBC-d	11.0	48.6	1.0	1.2	12.0	0.4	1.2
1156	-	-	-	-	-	-	-
1156 TC	8.1	35.9	0.3	0.4	8.4	0.2	0.7
VV	4.0	17.6	0.1	0.1	4.1	0.2	0.6
KRC	0.4	1.7	-	-	-	0.0	0.1

5-Aug-11

Sample	[N-NO3] mg/L	[NO3] mg/L	[N-NH4] mg/L	[NH4] mg/L	Total N mg/L	[P] mg/L	[PO4] mg/L
MPK-E	0.0	0.0	0.0	0.0	0.0	0.0	0.1
MPK-W	0.0	0.0	0.0	0.0	0.0	0.1	0.2
MP-u	0.0	0.0	0.0	0.0	0.0	0.0	0.1
MP-d	0.0	0.0	0.0	0.0	0.0	0.0	0.1
KCS	0.0	0.0	0.0	0.0	0.0	0.1	0.2
I75-u	0.0	0.0	0.0	0.0	0.0	0.1	0.2
AC	0.7	2.9	0.0	0.0	0.7	0.1	0.4
I75-d	0.0	0.0	0.0	0.0	0.0	0.1	0.4
SP-u	0.0	0.0	0.0	0.0	0.0	0.2	0.6
SKC	-	-	-	-	-	0.0	0.1
SP-d	0.0	0.0	0.0	0.0	0.0	0.2	0.5
IL-u-PS	0.0	0.0	0.0	0.0	0.0	0.2	0.7
ILC-u	0.0	0.0	0.0	0.0	0.0	0.3	1.0
ILC-u-X	-	-	-	-	-	-	-
ILC	0.0	0.0	0.0	0.0	0.0	0.1	0.2
ILC -d	0.0	0.0	0.0	0.0	0.0	0.4	1.1
SC	0.0	0.0	0.0	0.0	0.0	0.1	0.2
WC	0.0	0.0	0.0	0.0	0.0	0.1	0.2
TCE	0.0	0.0	0.0	0.0	0.0	0.1	0.4
FCC-u	0.4	1.9	0.0	0.0	0.4	0.6	1.8
FCC	0.0	0.0	0.0	0.0	0.0	0.2	0.5
FCC-d	0.0	0.0	0.0	0.0	0.0	0.5	1.6
CFC-u	0.0	0.0	0.0	0.0	0.0	0.6	1.8
CFC	0.0	0.0	0.0	0.0	0.0	0.2	0.5
CFC-d	0.0	0.0	0.0	0.0	0.0	0.7	2.1
HBC-u	0.0	0.0	0.0	0.0	0.0	0.5	1.7
HBC-big	0.0	0.0	0.0	0.0	0.0	0.1	0.4
HBC	-	-	-	-	-	0.0	0.1
HBC-d	0.0	0.0	0.0	0.0	0.0	0.6	1.9
SFC-u	0.0	0.0	0.0	0.0	0.0	0.6	1.9
SFC	0.0	0.0	0.0	0.0	0.0	0.2	0.5
SFC-d	0.0	0.0	0.0	0.0	0.0	0.2	0.7
7.8C-u	0.7	3.1	0.0	0.0	0.7	0.3	1.0
7.8C	0.0	0.0	0.0	0.0	0.0	0.2	0.5
7.8C-d	0.0	0.0	0.0	0.0	0.0	0.4	1.2
BC-u	0.4	1.9	0.0	0.0	0.4	0.3	1.1
BC	1.0	4.4	0.0	0.0	1.0	0.1	0.3

	[N-NO3]	[NO3]	[N-NH4]	[NH4]	Total N	[P]	[PO4]
Sample	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**
BCC-u	0.0	0.0	0.0	0.0	0.0	0.3	1.0
BCC	0.0	0.2	0.0	0.0	0.0	0.1	0.3
BCC-d	0.3	1.2	0.0	0.0	0.3	0.4	1.2
8.9C-u	0.0	0.0	0.0	0.0	0.0	0.4	1.1
8.9A	-	-	-	-	-	0.0	0.1
8.9C	-	-	-	-	-	0.0	0.1
8.9C-d	0.0	0.0	0.0	0.0	0.0	0.4	1.1
STC-u	0.0	0.0	0.0	0.0	0.0	0.4	1.1
STE-r	0.0	0.0	0.0	0.0	0.0	0.1	0.5
STE	0.0	0.0	0.0	0.0	0.0	0.1	0.5
STW	0.0	0.0	0.0	0.0	0.0	0.2	0.5
STC-d	0.0	0.0	0.0	0.0	0.0	0.4	1.1
LBC-u	0.0	0.0	0.0	0.0	0.0	0.3	1.0
LBC	0.0	0.0	0.0	0.0	0.0	0.0	0.1
LBC-d	0.0	0.0	0.0	0.0	0.0	0.3	1.0
1156	-	-	-	-	-	0.0	0.1
1156 TC	0.0	0.0	0.0	0.0	0.0	0.3	1.0
VV	-	-	-	-	-	0.0	0.1
KRC	0.0	0.0	0.0	0.0	0.0	0.1	0.2

APPENDIX B

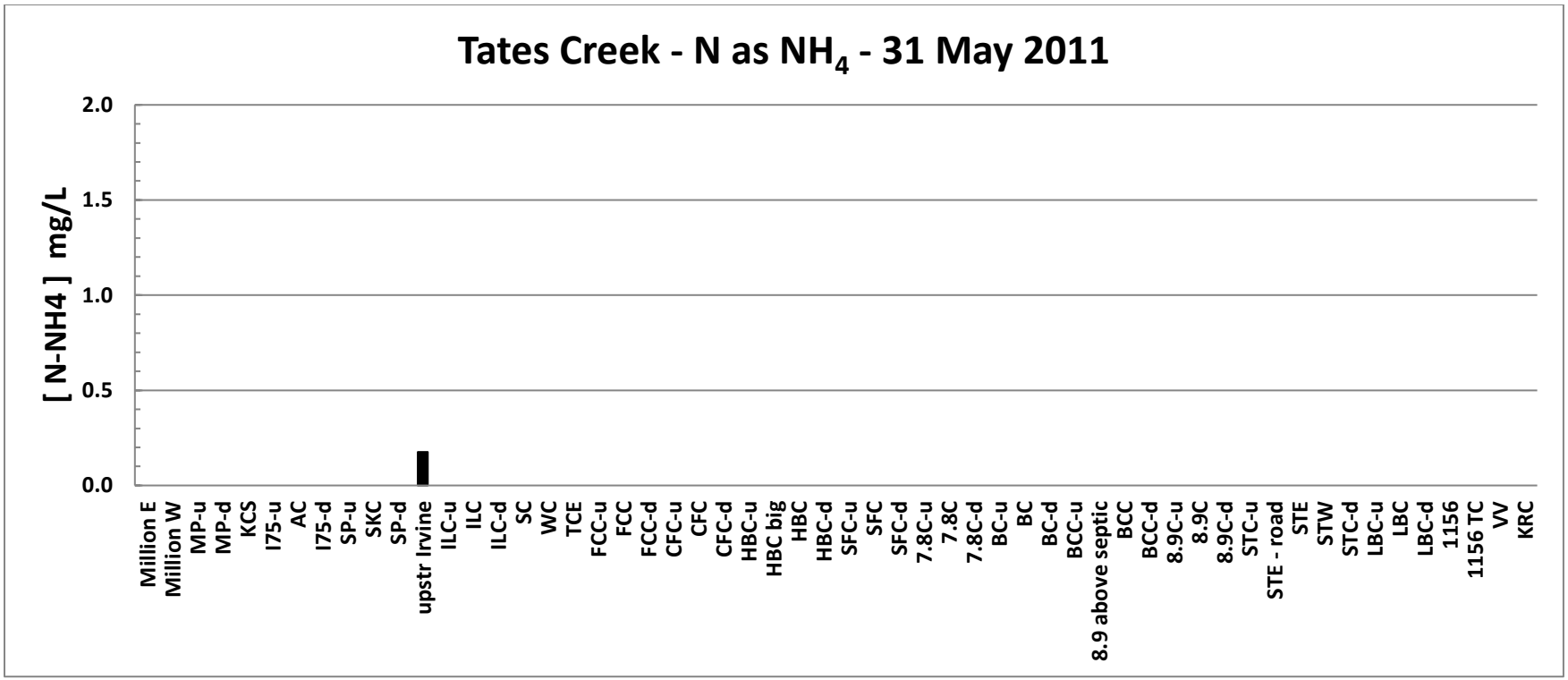
Fecal Microbe Data

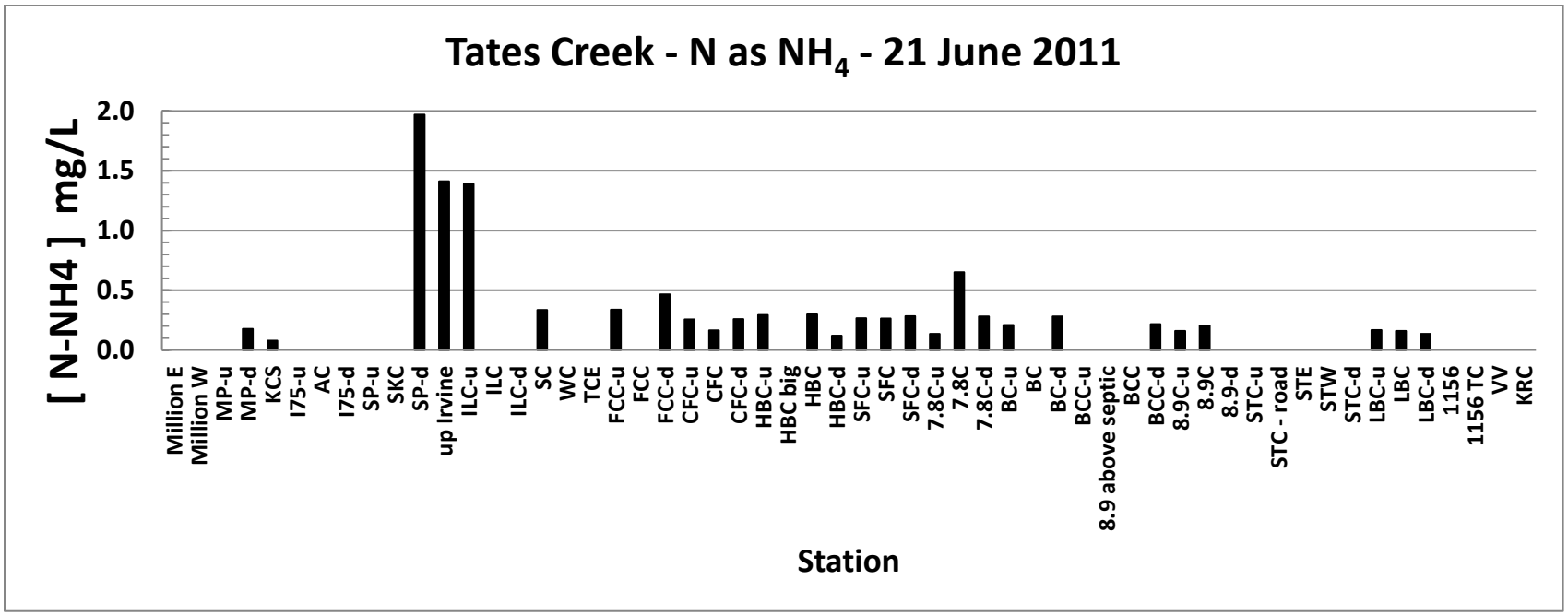
Table A. Microbe count data for Tates Creek stations organized by sampling date. Units are in colony-forming units per 100 milliliters (cfc/100 mL).

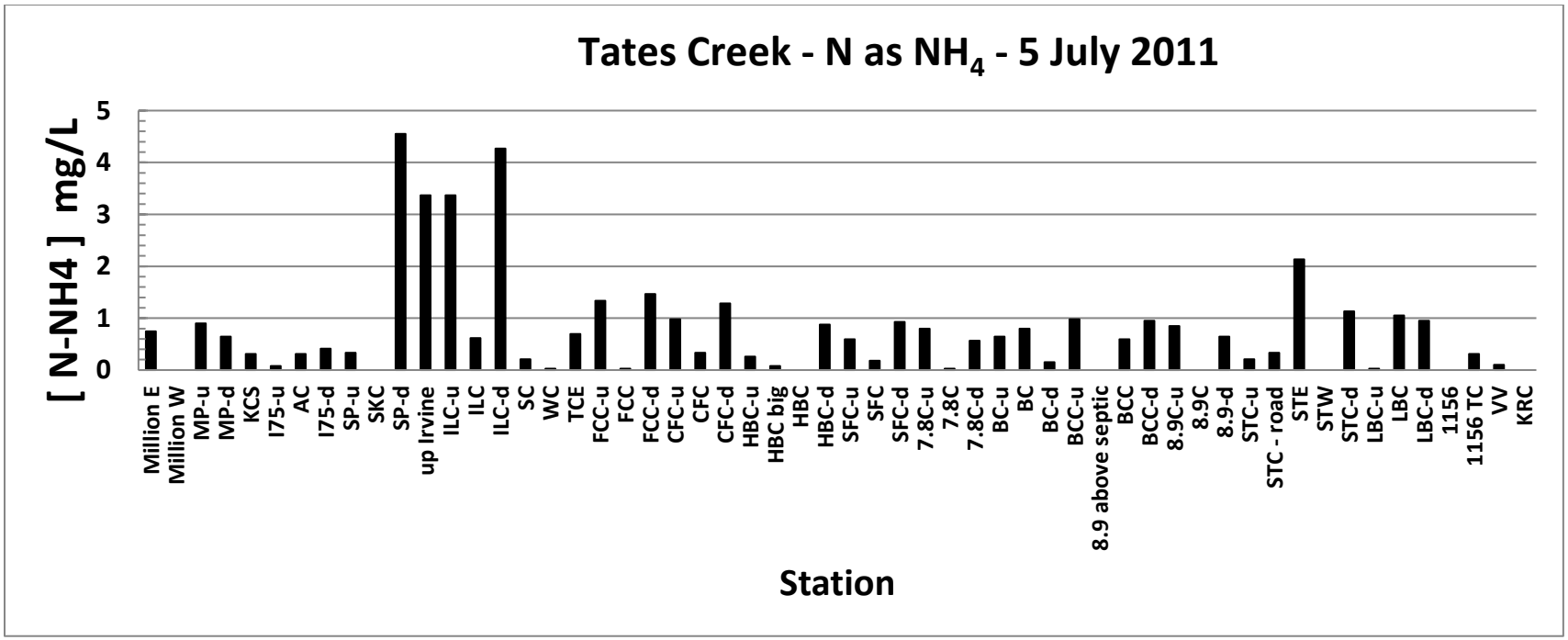
	31-May-11		20-Jun-11		7-Jul-11		5-Aug-11	
Sample	Total Coliform Count (cfc / 100 mL)	*E. coli* Count (cfc / 100 mL)	Total Coliform Count (cfc / 100 mL)	*E. coli* Count (cfc / 100 mL)	Total Coliform Count (cfc / 100 mL)	*E. coli* Count (cfc / 100 mL)	Total Coliform Count (cfc / 100 mL)	*E. coli* Count (cfc / 100 mL)
MPK-E	-	-	>2419.6	1413.6	>2419.6	>2419.6	>2419.6	>2419.6
MPK-W	>2419.6	344.8	>2419.6	1203.5	>2419.6	>2419.6	>2419.6	313
MP-u	>2419.6	727	>2419.6	>2419.6	>2419.6	2419.6	>2419.6	435.2
MP-d	>2419.6	67	>2419.6	148.3	>2419.6	579.4	>2419.6	25.4
KCS	>2419.6	1299.1	>2419.6	1732.9	2419.6	>2419.6	>2419.6	365.4
I75-u	>2419.6	1732.9	>2419.6	2419.6	>2419.6	>2419.6	>2419.6	35.8
AC	>2419.6	>2419.6	>2419.6	1732.9	648.8	35.9	>2419.6	152.9
I75-d	>2419.6	1732.9	-	-	-	-	-	-
SP-u	>2419.6	920.8	1986.3	1732.9	>2419.6	>2419.6	>2419.6	1203.3
SKC	2419.6	396.8	>2419.6	>2419.6	-	-	-	-
SP-d	<1	<1	>2419.6	648.8	1533.1	74.8	>2419.6	920.8
IL-u-PS	>2419.6	2419.6	>2419.6	>2419.6	>2419.6	261.3	>2419.6	2419.6
ILC-u	19.1	11.9	>2419.6	>2419.6	>2419.6	325.5	>2419.6	360.9
ILC-u-X	58.9	50.5	-	-	-	-	-	-
ILC	>2419.6	35	>2419.6	1119.9	>2419.6	1732.9	-	-
ILC -d	156.7	120.5	-	-	-	-	-	-
SC	0	0	>2419.6	791.5	1299.7	214.3	>2419.6	>2419.6
WC	202.2	185.2	>2419.6	>2419.6	>2419.6	547.5		
TCE	870	188.2	>2419.6	>2419.6	>2419.6	>2419.6	>2419.6	>2419.6
FCC-u	483.3	145.5	>2419.6	1732.9	>2419.6	547.5	>2419.6	214.2
FCC	>2419.6	156.5	>2419.6	461.1	>2419.6	>2419.6	>2419.6	727
FCC-d	27.5	17.3	-	-	-	-	-	-
CFC-u	89.7	29.1	>2419.6	648.8	>2419.6	1553.1	>2419.6	185
CFC	>2419.6	435.2	>2419.6	238.2	>2419.6	1553.1	>2419.6	151
CFC-d	7.5	7.5	-	-	-	-	-	-
HBC-u	2419.6	104.3	>2419.6	648.8	>2419.6	2419.6	>2419.6	116
HBC-big	-	-	>2419.6	118.7	>2419.6	1299.7	>2419.6	579.4
HBC	2419.6	238.2	>2419.6	344.8	>2419.6	648.8	-	-
HBC-d	17.5	13.5	-	-	-	-	-	-
SFC-u	>2419.6	40.3	>2419.6	1119.9	2419.6	1299.7	>2419.6	70
SFC	2419.6	166.4	>2419.6	>2419.5	>2419.6	34.1	>2419.6	241.5
SFC-d	>2419.6	48.8	-	-	-	-	-	-
7.8C-u	>2419.6	48.3	>2419.6	1732.9	>2419.6	>2419.6	>2419.6	11.5
7.8C	>2419.6	285.1	>2419.6	980.4	1966.3	143.9	>2419.6	517.2
7.8C-d	>2419.6	35.4	-	-	-	-	-	-
BC-u	>2419.6	48.1	>2419.6	2419.6	>2419.6	1299.7	2419.6	5.1
BC	2419.6	59.5	>2419.6	579.4	>2419.6	42	>2419.6	>2419.6
BC-d	>2419.6	49	-	-	-	-	-	-
BCC-u	>2419.6	67	>2419.6	1986.3	>2419.6	866.4	2419.6	14.4
BCC	>2419.6	72.4	>2419.6	1732.9	>2419.6	231	2419.6	517.2
BCC-d	>2419.6	33.7	-	-	-	-	-	-
8.9C-u	>2419.6	30.7	>2419.6	1986.3	>2419.6	344.8	>2419.6	22.8
8.9A	56.2	29.6	-	-	-	-	-	-
8.9C	2419.6	111.9	2419.5	517.2	-	-	-	-
8.9C-d	>2419.6	37.3	-	-	-	-	-	-
STC-u	8.2	4.1	>2419.6	1732.9	>2419.6	166.4	>2419.6	15.8
STE-r	>2419.6	172.3	-	-	>2419.6	225.4	>2419.6	365.4
STE	31.5	9.4	>2419.6	307.6	>2419.6	1299.7	>2419.6	57.3
STW	980.4	122.3	1986.3	410.6	-	-	-	-
STC-d	>2419.6	50.4	-	-	-	-	-	-
LBC-u	>2419.6	68.7	>2419.6	2919.6	2419.6	290.9	>2419.6	23.8
LBC	1203.3	56.5	1732.9	365.6	>2419.6	155.3	1299.7	77.1
LBC-d	>2419.6	45.2	-	-	-	-	-	-
1156	309.4	67	-	-	-	-	-	-
1156 TC	2419.6	613.1	>2419.6	>2419.5	>2419.6	866.4	>2419.6	130.1
VV	>2419.6	93.5	>2419.6	1203.3	>2419.6	980.4	-	-
KRC	>2419.6	156.5	1553.1	198.9	1986.3	65	1046.2	15.6

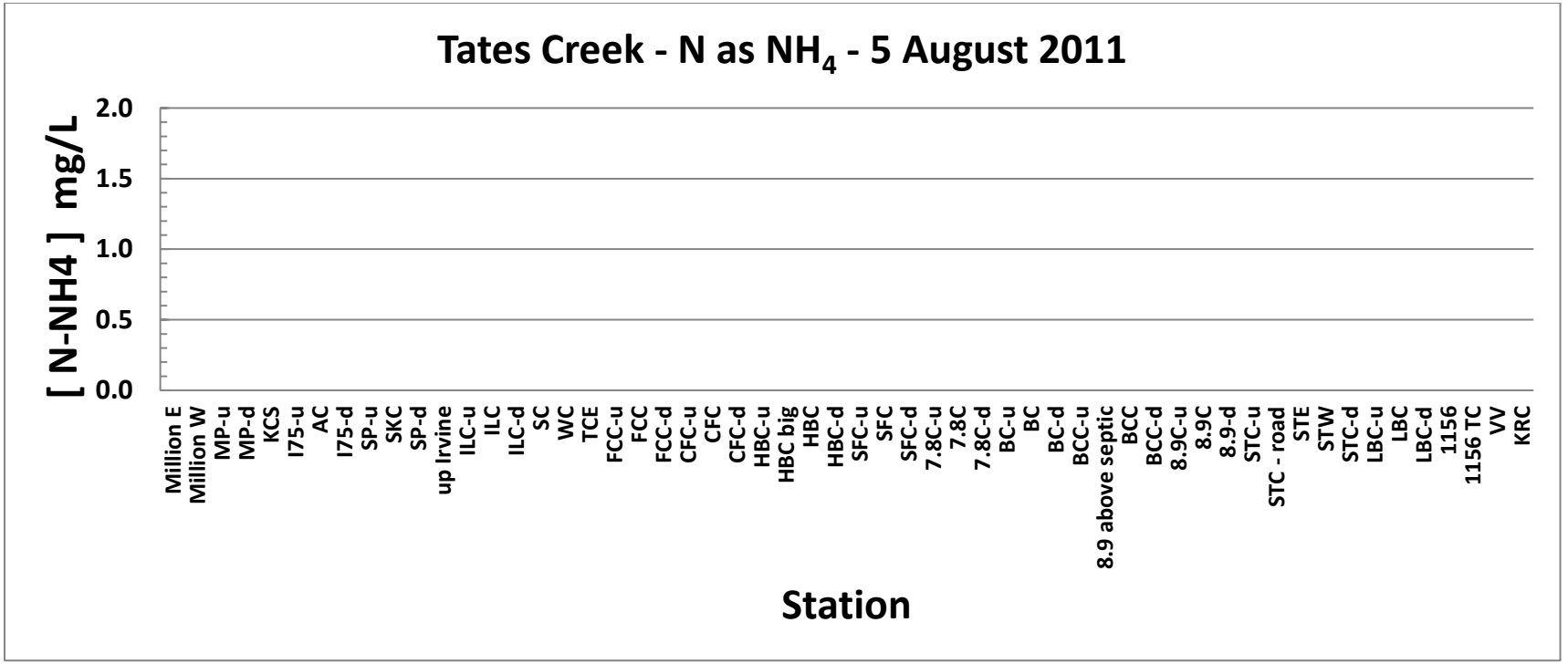
APPENDIX C

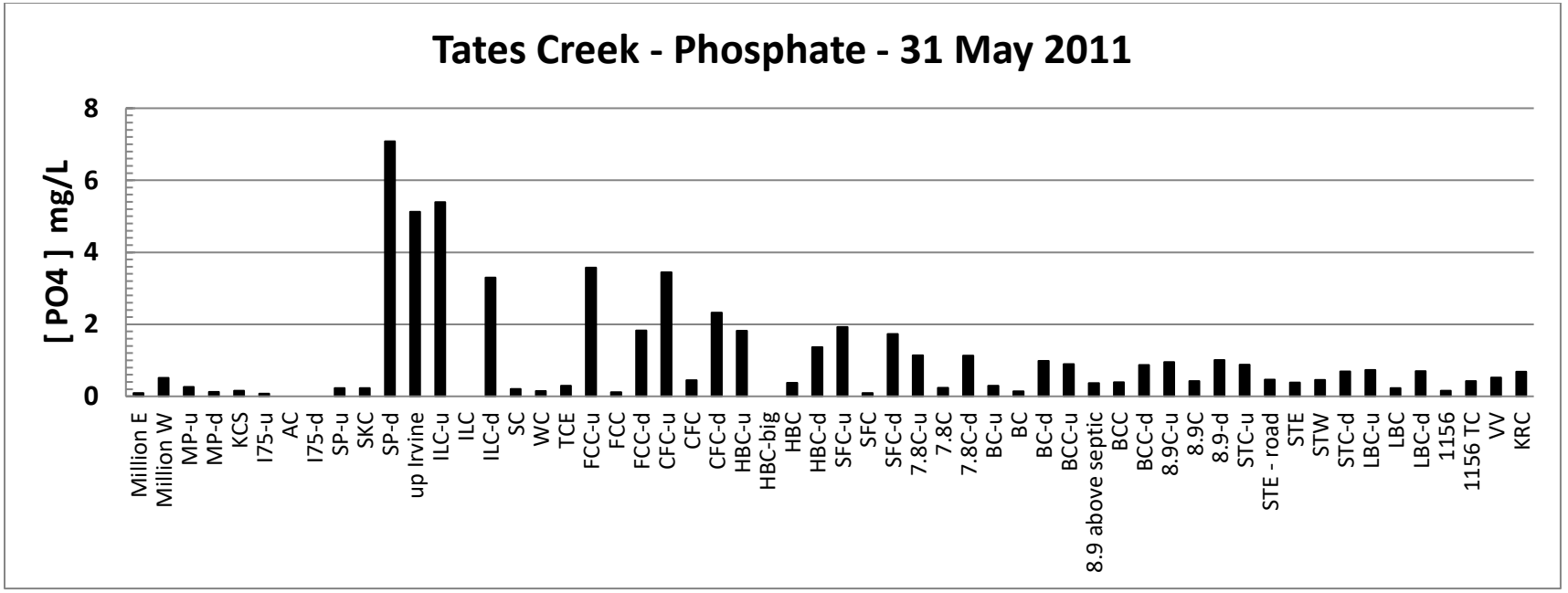
Graphs of ammonium, nitrate, and phosphate concentration and microbe counts

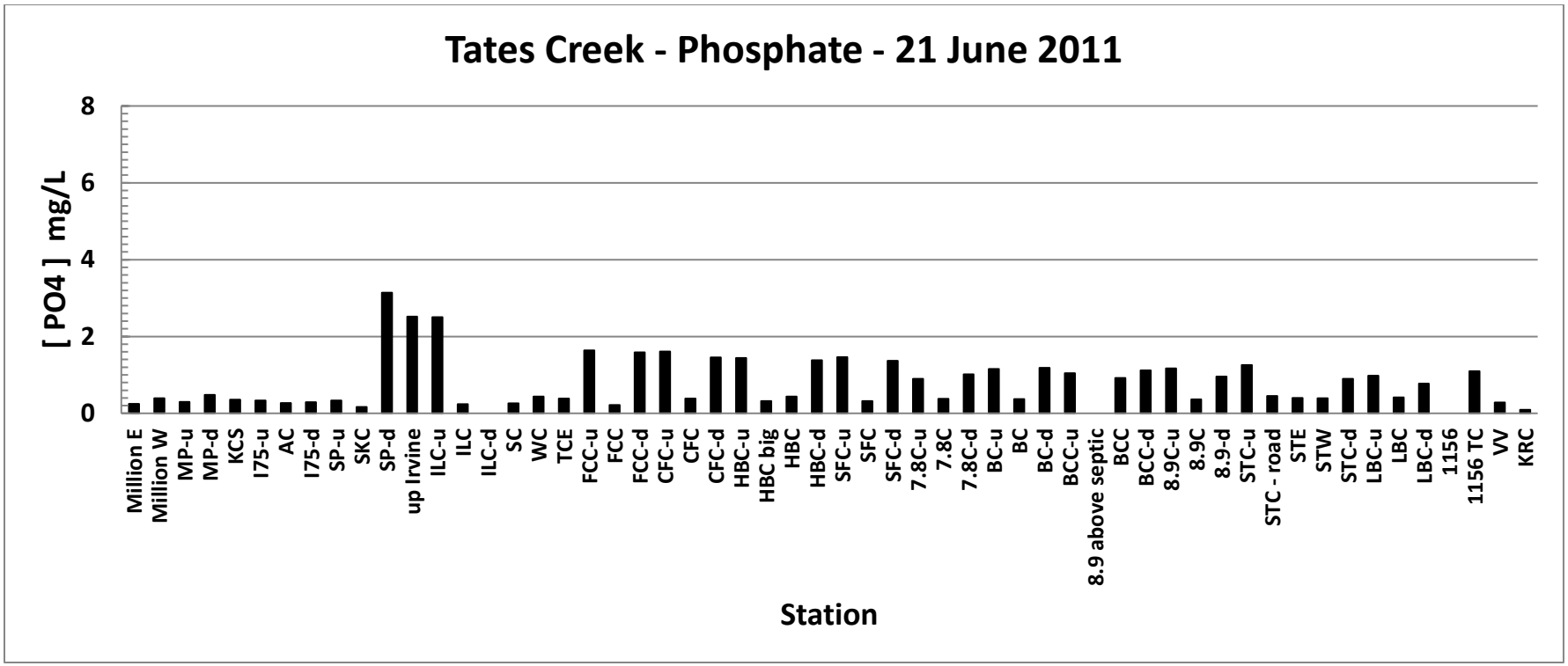

Tates Creek - N as NH4 - 31 May 2011
[N-NH4] mg/L
2.0
1.5
1.0
0.5
0.0
Million E
Million W
MP-u
MP-d
KCS
I75-u
AC
I75-d
SP-u
SKC
SP-d
upstr Irvine
ILC-u
ILC
ILC-d
SC
WC
TCE
FCC-u
FCC
FCC-d
CFC-u
CFC
CFC-d
HBC-u
HBC big
HBC
HBC-d
SFC-u
SFC
SFC-d
7.8C-u
7.8C
7.8C-d
BC-u
BC
BC-d
BCC-u
8.9 above septic
BCC
BCC-d
8.9C-u
8.9C
8.9C-d
STC-u
STE - road
STE
STW
STC-d
LBC-u
LBC
LBC-d
1156
1156 TC
VV
KRC

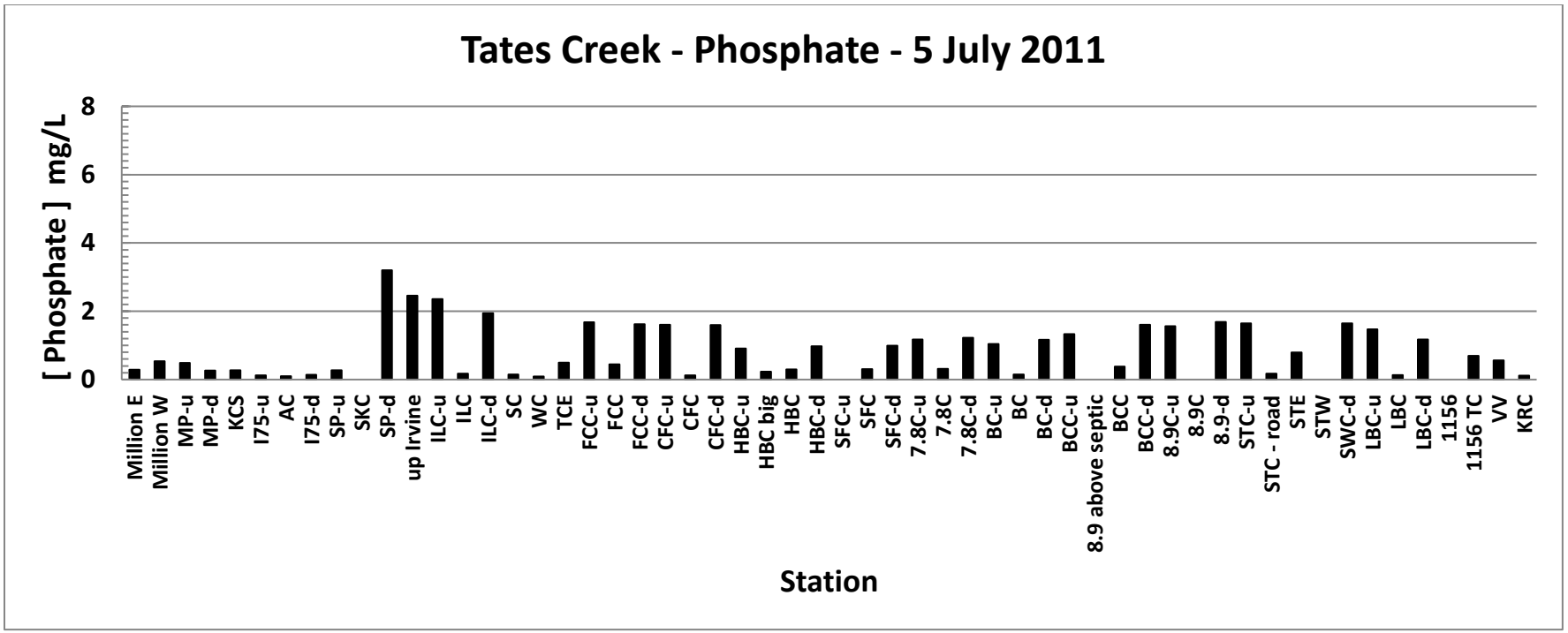

Tates Creek - N as NH4 - 21 June 2011
[N-NH4] mg/L
2.0
1.5
1.0
0.5
0.0
Million E
Million W
MP-u
MP-d
KCS
I75-u
AC
I75-d
SP-u
SKC
SP-d
up Irvine
ILC-u
ILC
ILC-d
SC
WC
TCE
FCC-u
FCC
FCC-d
CFC-u
CFC
CFC-d
HBC-u
HBC big
HBC
HBC-d
SFC-u
SFC
SFC-d
7.8C-u
7.8C
7.8C-d
BC-u
BC
BC-d
BCC-u
8.9 above septic
BCC
BCC-d
8.9C-u
8.9C
8.9-d
STC-u
STC - road
STE
STW
STC-d
LBC-u
LBC
LBC-d
1156
1156 TC
VV
KRC
Station

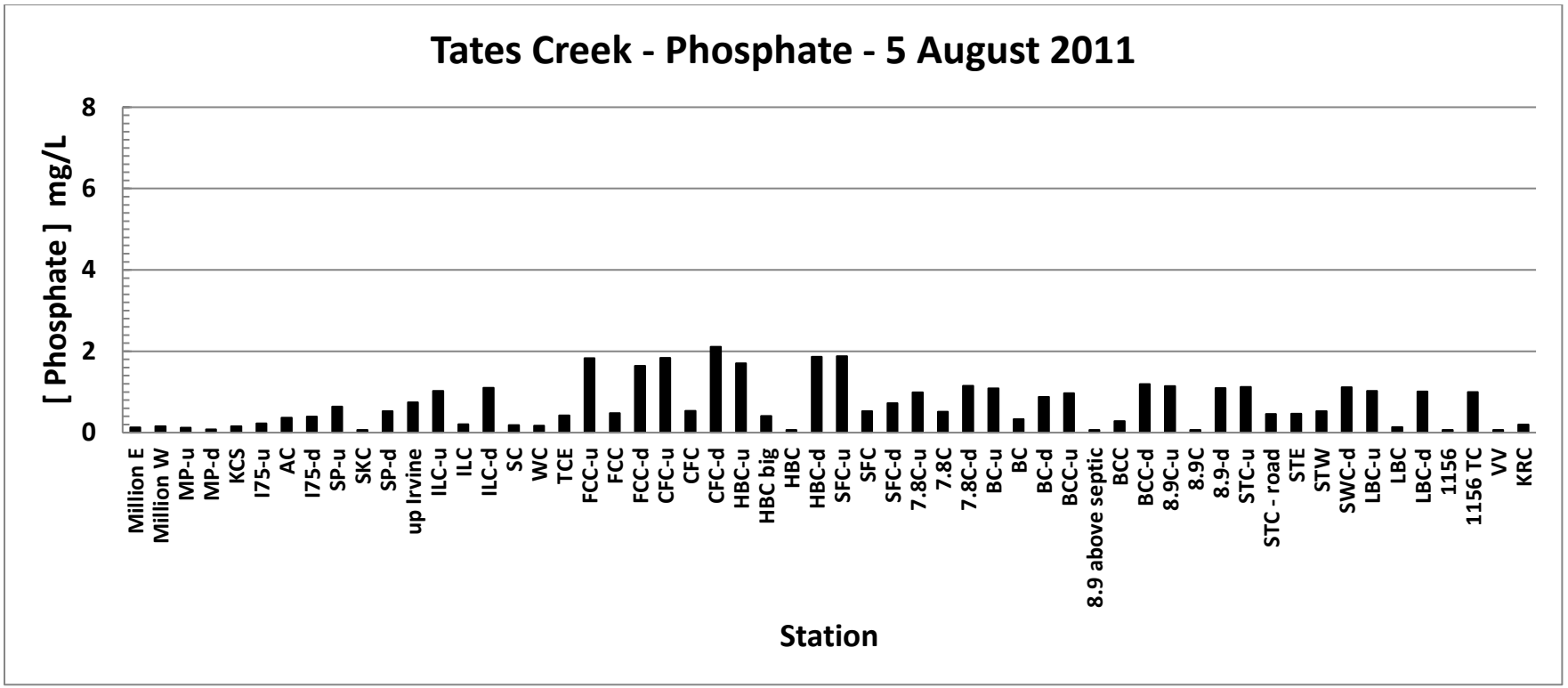

Tates Creek - N as NH4 - 5 July 2011
[N-NH4] mg/L
5
4
3
2
1
0
Million E
Million W
MP-u
MP-d
KCS
I75-u
AC
I75-d
SP-u
SKC
SP-d
up Irvine
ILC-u
ILC
ILC-d
SC
WC
TCE
FCC-u
FCC
FCC-d
CFC-u
CFC
CFC-d
HBC-u
HBC big
HBC
HBC-d
SFC-u
SFC
SFC-d
7.8C-u
7.8C
7.8C-d
BC-u
BC
BC-d
BCC-u
8.9 above septic
BCC
BCC-d
8.9C-u
8.9C
8.9-d
STC-u
STC - road
STE
STW
STC-d
LBC-u
LBC
LBC-d
1156
1156 TC
VV
KRC
Station

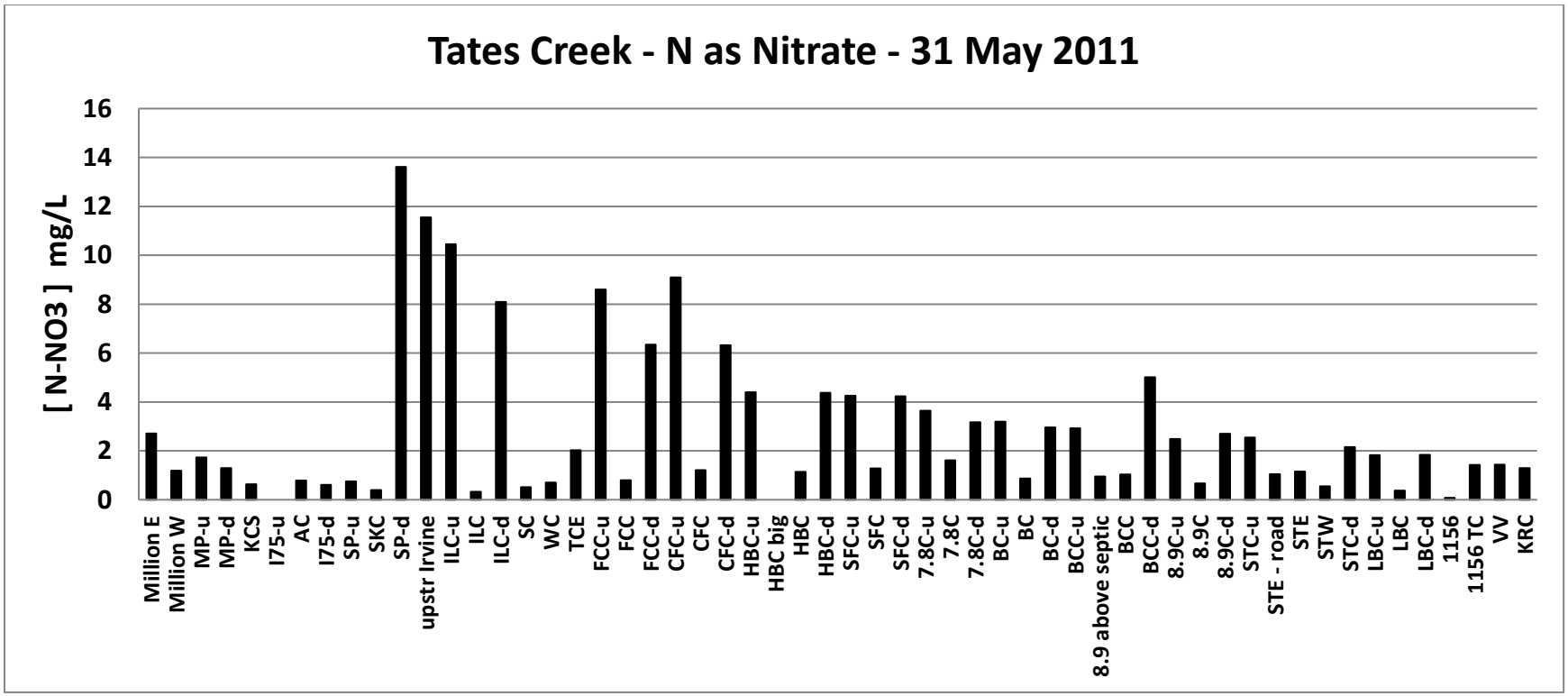

Tates Creek - N as NH4 - 5 August 2011
[N-NH4] mg/L
2.0
1.5
1.0
0.5
0.0
Million E
Million W
MP-u
MP-d
KCS
I75-u
AC
I75-d
SP-u
SKC
SP-d
up Irvine
ILC-u
ILC
ILC-d
SC
WC
TCE
FCC-u
FCC
FCC-d
CFC-u
CFC
CFC-d
HBC-u
HBC big
HBC
HBC-d
SFC-u
SFC
SFC-d
7.8C-u
7.8C
7.8C-d
BC-u
BC
BC-d
BCC-u
8.9 above septic
BCC
BCC-d
8.9C-u
8.9C
8.9-d
STC-u
STC - road
STE
STW
STC-d
LBC-u
LBC
LBC-d
1156
1156 TC
VV
KRC
Station

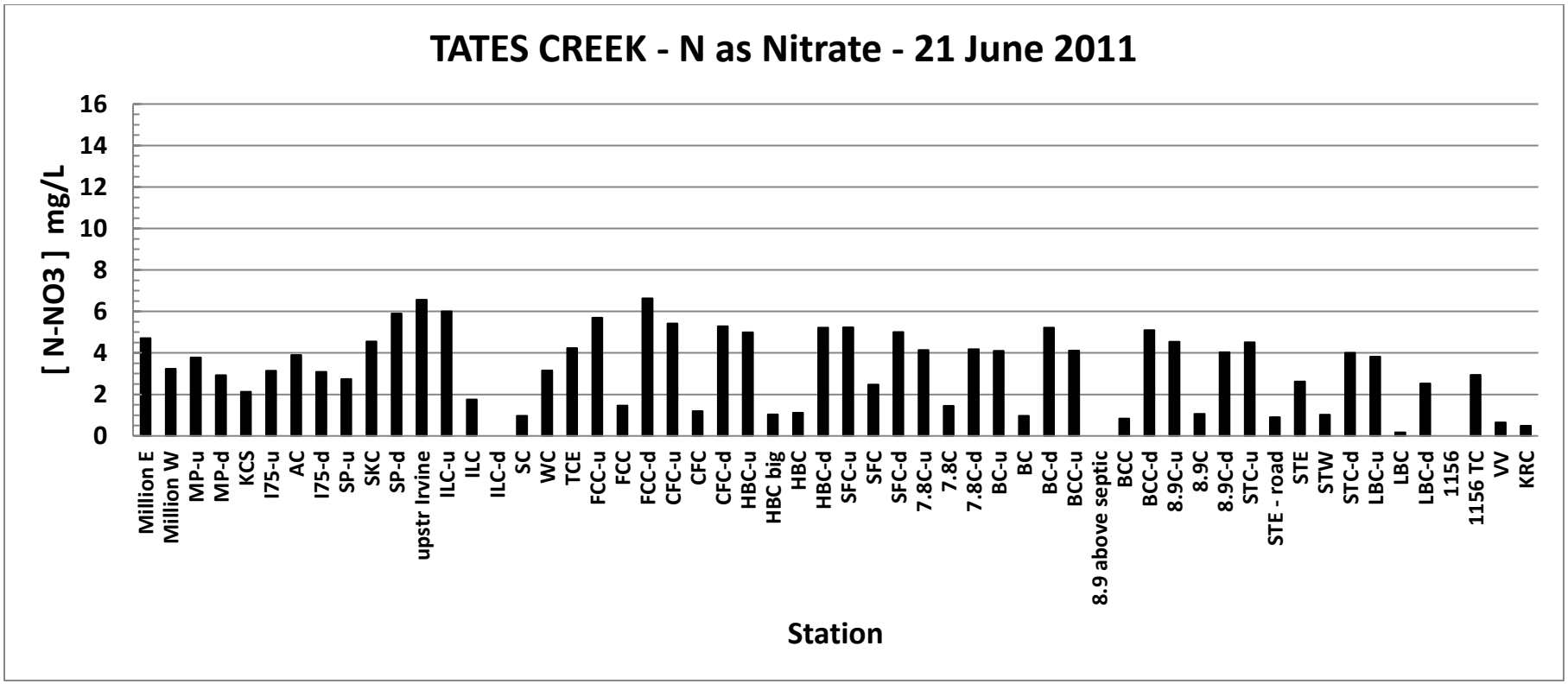

Tates Creek - Phosphate - 31 May 2011
[PO4] mg/L
8
6
4
2
0
Million E
Million W
MP-u
MP-d
KCS
I75-u
AC
I75-d
SP-u
SKC
SP-d
up Irvine
ILC-u
ILC
ILC-d
SC
WC
TCE
FCC-u
FCC
FCC-d
CFC-u
CFC
CFC-d
HBC-u
HBC-big
HBC
HBC-d
SFC-u
SFC
SFC-d
7.8C-u
7.8C
7.8C-d
BC-u
BC
BC-d
BCC-u
8.9 above septic
BCC
BCC-d
8.9C-u
8.9C
8.9-d
STC-u
STE - road
STE
STW
STC-d
LBC-u
LBC
LBC-d
1156
1156 TC
VV
KRC

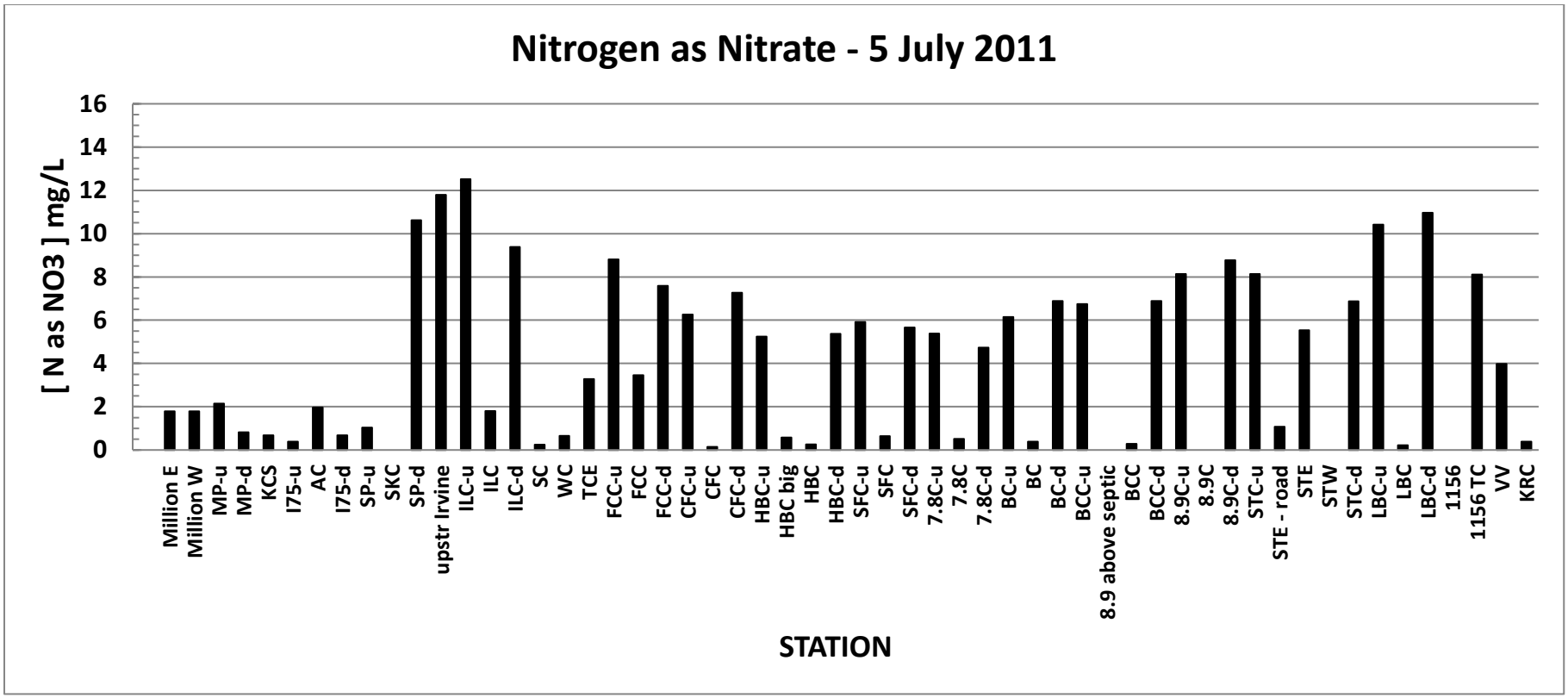

Tates Creek - Phosphate - 21 June 2011
[PO4] mg/L
8
6
4
2
0
Million E
Million W
MP-u
MP-d
KCS
I75-u
AC
I75-d
SP-u
SKC
SP-d
up Irvine
ILC-u
ILC
ILC-d
SC
WC
TCE
FCC-u
FCC
FCC-d
CFC-u
CFC
CFC-d
HBC-u
HBC big
HBC
HBC-d
SFC-u
SFC
SFC-d
7.8C-u
7.8C
7.8C-d
BC-u
BC
BC-d
BCC-u
8.9 above septic
BCC
BCC-d
8.9C-u
8.9C
8.9-d
STC-u
STC - road
STE
STW
STC-d
LBC-u
LBC
LBC-d
1156
1156 TC
VV
KRC
Station

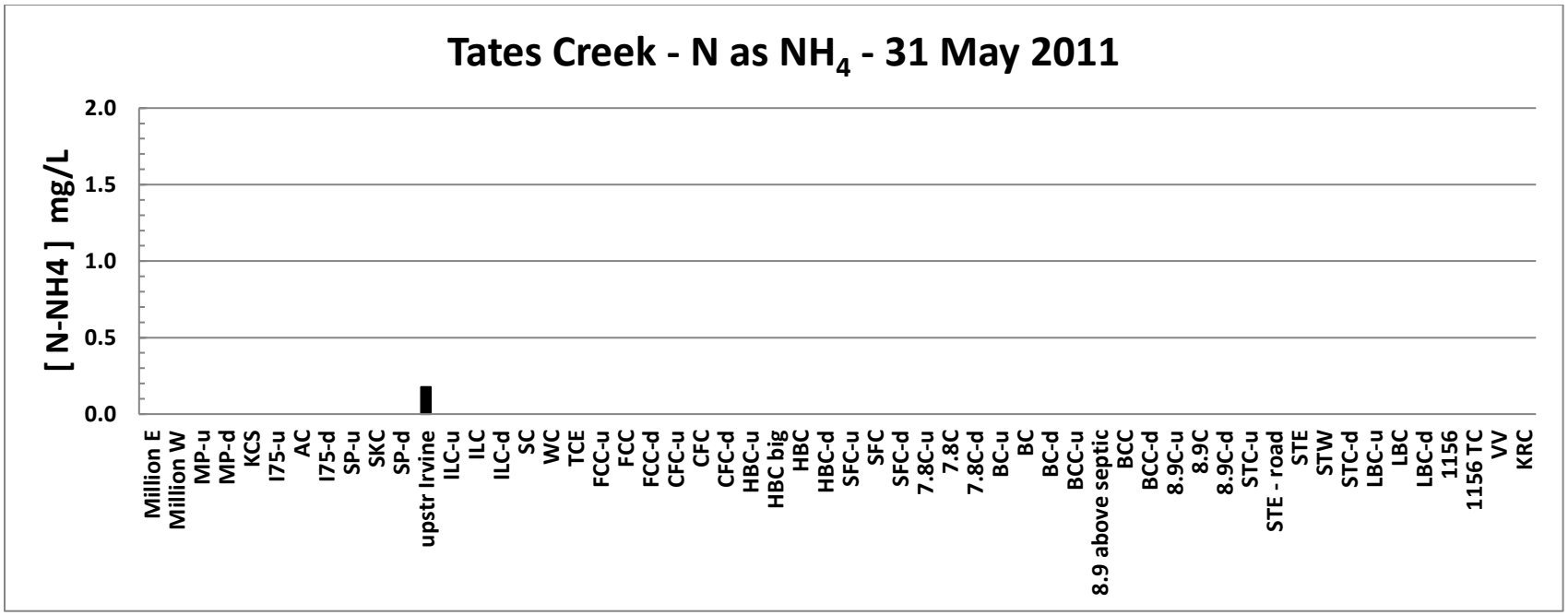

Tates Creek - Phosphate - 5 July 2011
[Phosphate] mg/L
8
6
4
2
0
Million E
Million W
MP-u
MP-d
KCS
I75-u
AC
I75-d
SP-u
SKC
SP-d
up Irvine
ILC-u
ILC
ILC-d
SC
WC
TCE
FCC-u
FCC
FCC-d
CFC-u
CFC
CFC-d
HBC-u
HBC big
HBC
HBC-d
SFC-u
SFC
SFC-d
7.8C-u
7.8C
7.8C-d
BC-u
BC
BC-d
BCC-u
8.9 above septic
BCC
BCC-d
8.9C-u
8.9C
8.9-d
STC-u
STC - road
STE
STW
SWC-d
LBC-u
LBC
LBC-d
1156
1156 TC
VV
KRC
Station

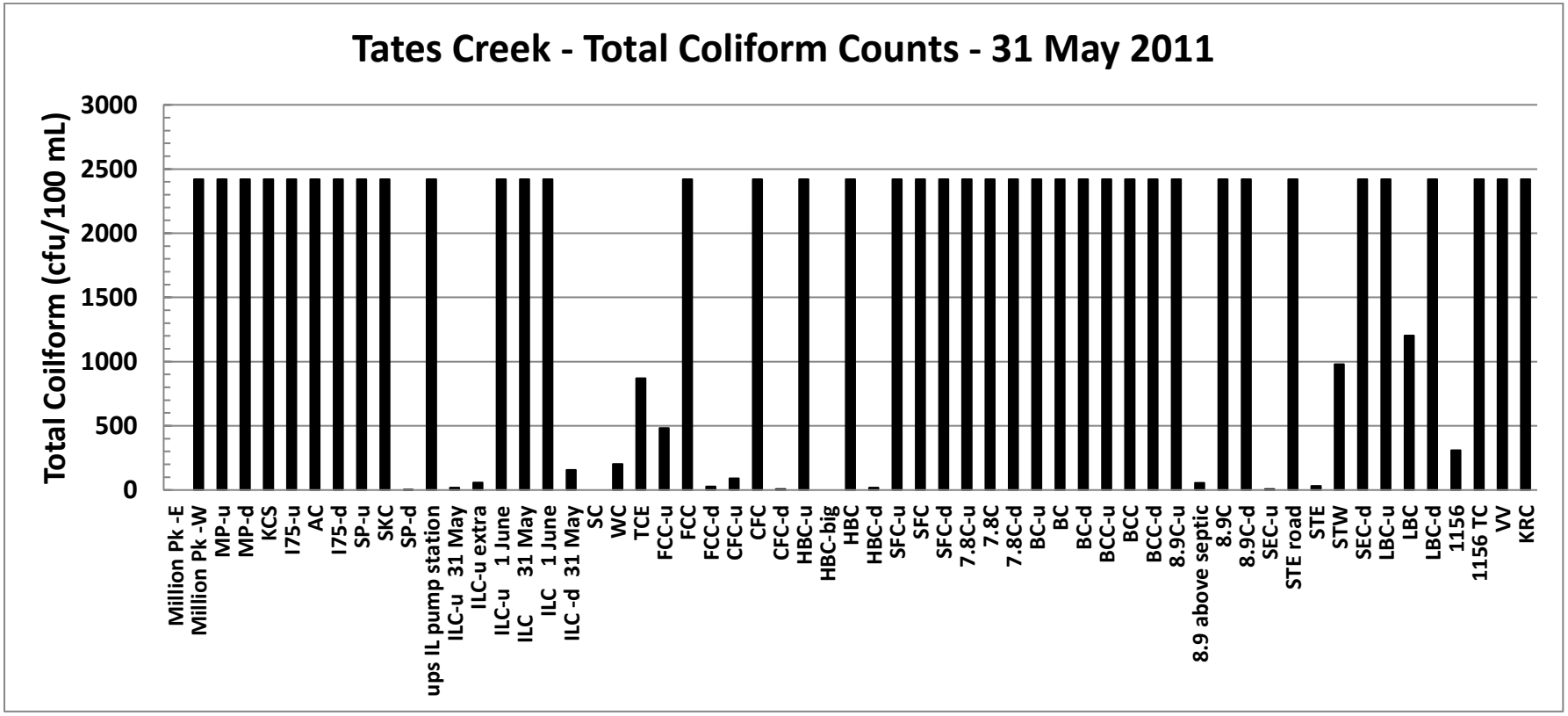

Tates Creek - Phosphate - 5 August 2011
[Phosphate] mg/L
8
6
4
2
0
Million E
Million W
MP-u
MP-d
KCS
I75-u
AC
I75-d
SP-u
SKC
SP-d
up Irvine
ILC-u
ILC
ILC-d
SC
WC
TCE
FCC-u
FCC
FCC-d
CFC-u
CFC
CFC-d
HBC-u
HBC big
HBC
HBC-d
SFC-u
SFC
SFC-d
7.8C-u
7.8C
7.8C-d
BC-u
BC
BC-d
BCC-u
8.9 above septic
BCC
BCC-d
8.9C-u
8.9C
8.9-d
STC-u
STC - road
STE
STW
SWC-d
LBC-u
LBC
LBC-d
1156
1156 TC
VV
KRC
Station

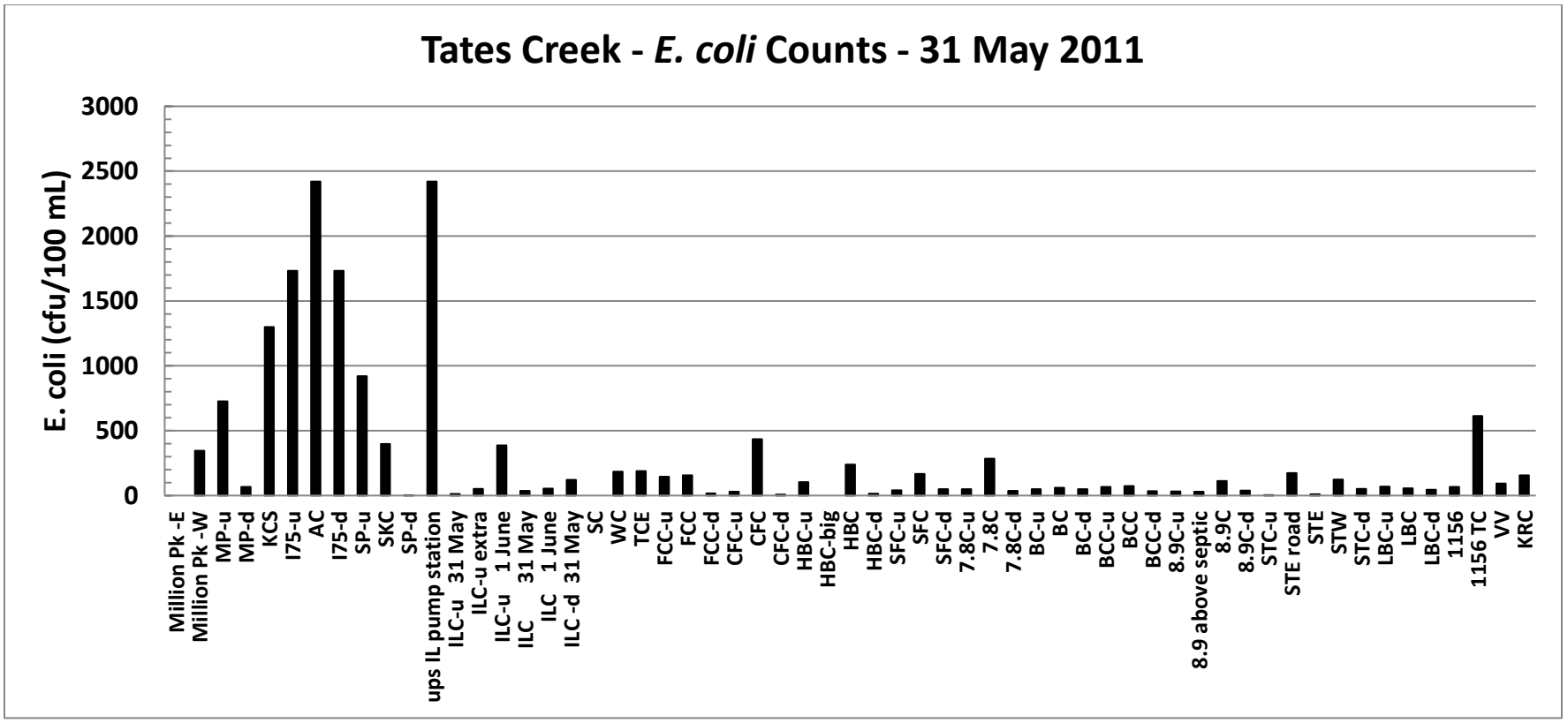

Tates Creek - N as Nitrate - 31 May 2011
[N-NO3] mg/L
16
14
12
10
8
6
4
2
0
Million E
Million W
MP-u
MP-d
KCS
I75-u
AC
I75-d
SP-u
SKC
SP-d
upstr Irvine
ILC-u
ILC
ILC-d
SC
WC
TCE
FCC-u
FCC
FCC-d
CFC-u
CFC
CFC-d
HBC-u
HBC big
HBC
HBC-d
SFC-u
SFC
SFC-d
7.8C-u
7.8C
7.8C-d
BC-u
BC
BC-d
BCC-u
8.9 above septic
BCC
BCC-d
8.9C-u
8.9C
8.9C-d
STC-u
STE - road
STE
STW
STC-d
LBC-u
LBC
LBC-d
1156
1156 TC
VV
KRC

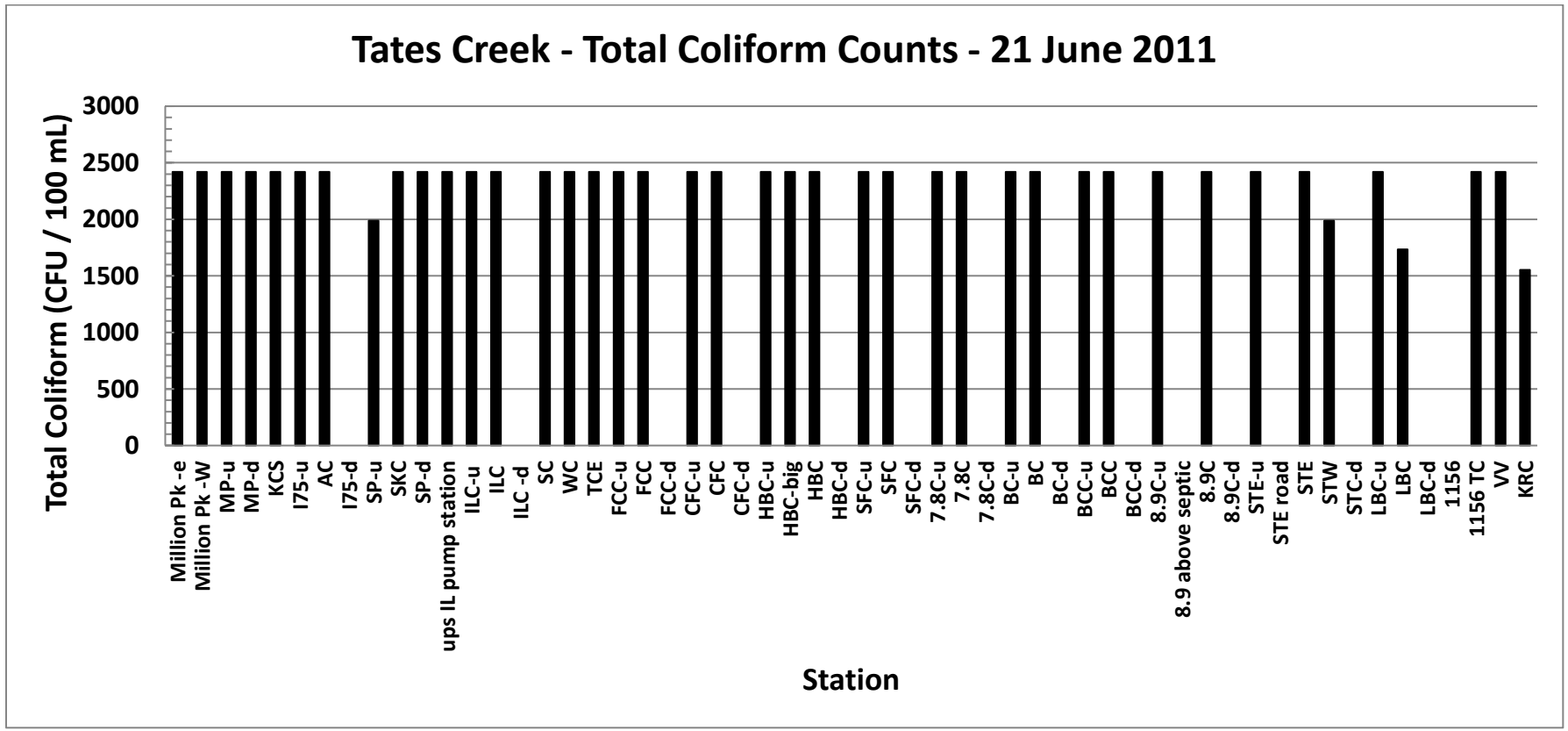

TATES CREEK - N as Nitrate - 21 June 2011
[N-NO3] mg/L
16
14
12
10
8
6
4
2
0
Million E
Million W
MP-u
MP-d
KCS
I75-u
AC
I75-d
SP-u
SKC
SP-d
upstr Irvine
ILC-u
ILC
ILC-d
SC
WC
TCE
FCC-u
FCC
FCC-d
CFC-u
CFC
CFC-d
HBC-u
HBC big
HBC
HBC-d
SFC-u
SFC
SFC-d
7.8C-u
7.8C
7.8C-d
BC-u
BC
BC-d
BCC-u
8.9 above septic
BCC
BCC-d
8.9C-u
8.9C
8.9C-d
STC-u
STE - road
STE
STW
STC-d
LBC-u
LBC
LBC-d
1156
1156 TC
VV
KRC
Station

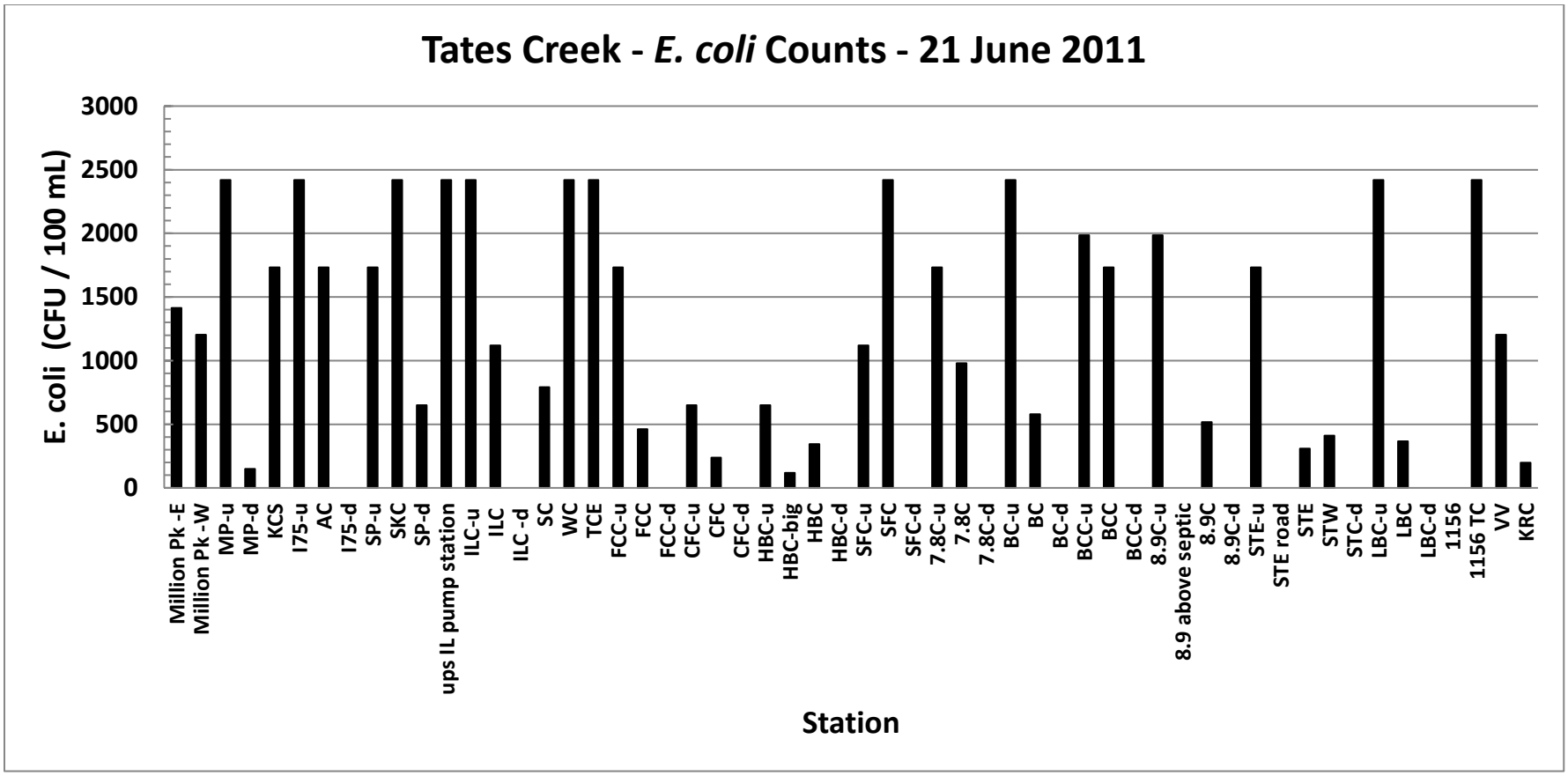

Nitrogen as Nitrate - 5 July 2011
[N as NO3] mg/L
16
14
12
10
8
6
4
2
0
Million E
Million W
MP-u
MP-d
KCS
I75-u
AC
I75-d
SP-u
SKC
SP-d
upstr Irvine
ILC-u
ILC
ILC-d
SC
WC
TCE
FCC-u
FCC
FCC-d
CFC-u
CFC
CFC-d
HBC-u
HBC big
HBC
HBC-d
SFC-u
SFC
SFC-d
7.8C-u
7.8C
7.8C-d
BC-u
BC
BC-d
BCC-u
8.9 above septic
BCC
BCC-d
8.9C-u
8.9C
8.9C-d
STC-u
STE - road
STE
STW
STC-d
LBC-u
LBC
LBC-d
1156
1156 TC
VV
KRC
STATION

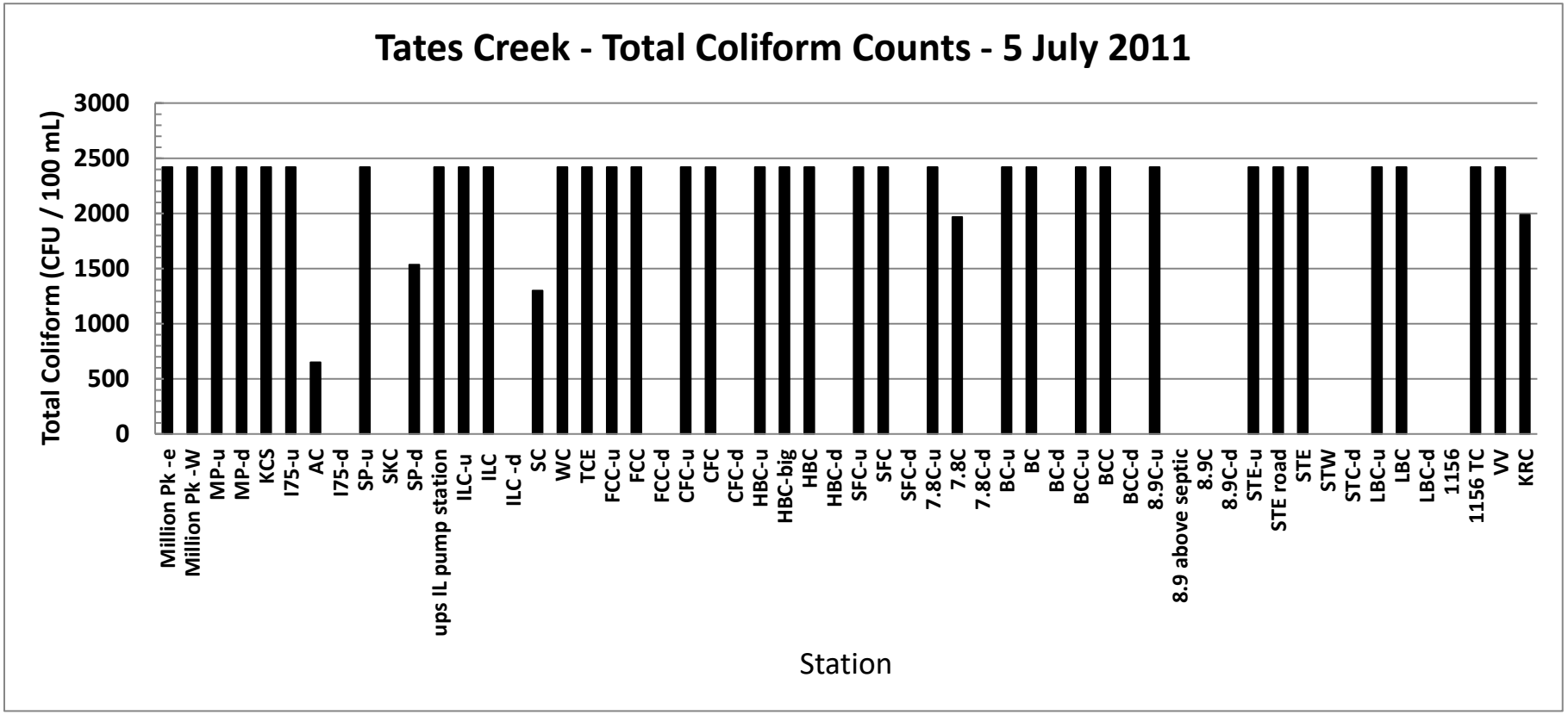

Tates Creek - N as NH4 - 31 May 2011
[N-NH4] mg/L
2.0
1.5
1.0
0.5
0.0
Million E
Million W
MP-u
MP-d
KCS
I75-u
AC
I75-d
SP-u
SKC
SP-d
upstr Irvine
ILC-u
ILC
ILC-d
SC
WC
TCE
FCC-u
FCC
FCC-d
CFC-u
CFC
CFC-d
HBC-u
HBC big
HBC
HBC-d
SFC-u
SFC
SFC-d
7.8C-u
7.8C
7.8C-d
BC-u
BC
BC-d
BCC-u
8.9 above septic
BCC
BCC-d
8.9C-u
8.9C
8.9C-d
STC-u
STE - road
STE
STW
STC-d
LBC-u
LBC
LBC-d
1156
1156 TC
VV
KRC

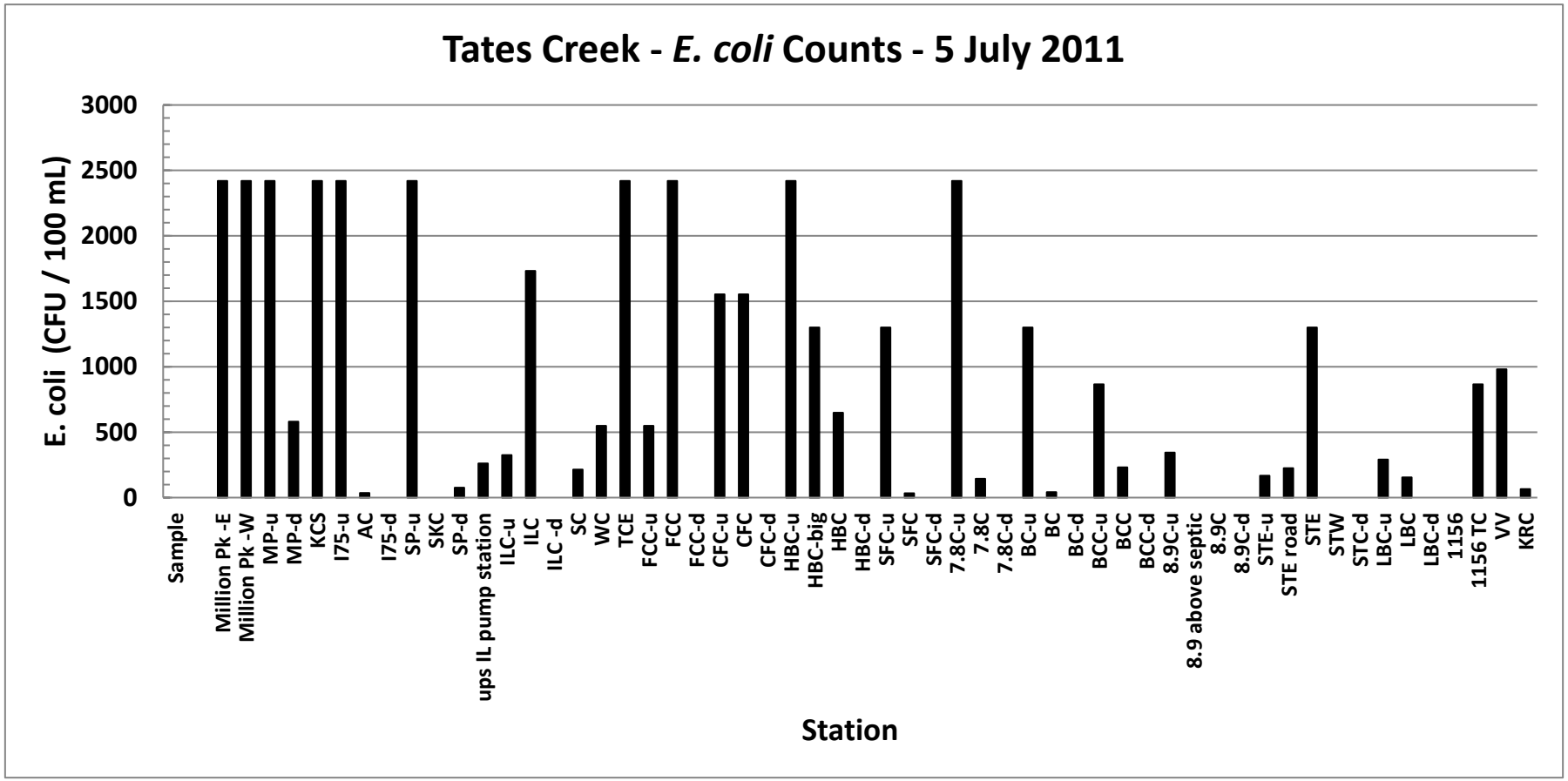

Tates Creek - Total Coliform Counts - 31 May 2011
Total Coilform (cfu/100 mL)
3000
2500
2000
1500
1000
500
0
Million Pk -E
Million Pk -W
MP-u
MP-d
KCS
I75-u
AC
I75-d
SP-u
SKC
SP-d
ups IL pump station
ILC-u 31 May
ILC-u extra
ILC-u 1 June
ILC 31 May
ILC 1 June
ILC-d 31 May
SC
WC
TCE
FCC-u
FCC
FCC-d
CFC-u
CFC
CFC-d
HBC-u
HBC-big
HBC
HBC-d
SFC-u
SFC
SFC-d
7.8C-u
7.8C
7.8C-d
BC-u
BC
BC-d
BCC-u
BCC
BCC-d
8.9C-u
8.9 above septic
8.9C
8.9C-d
SEC-u
STE road
STE
STW
SEC-d
LBC-u
LBC
LBC-d
1156
1156 TC
VV
KRC

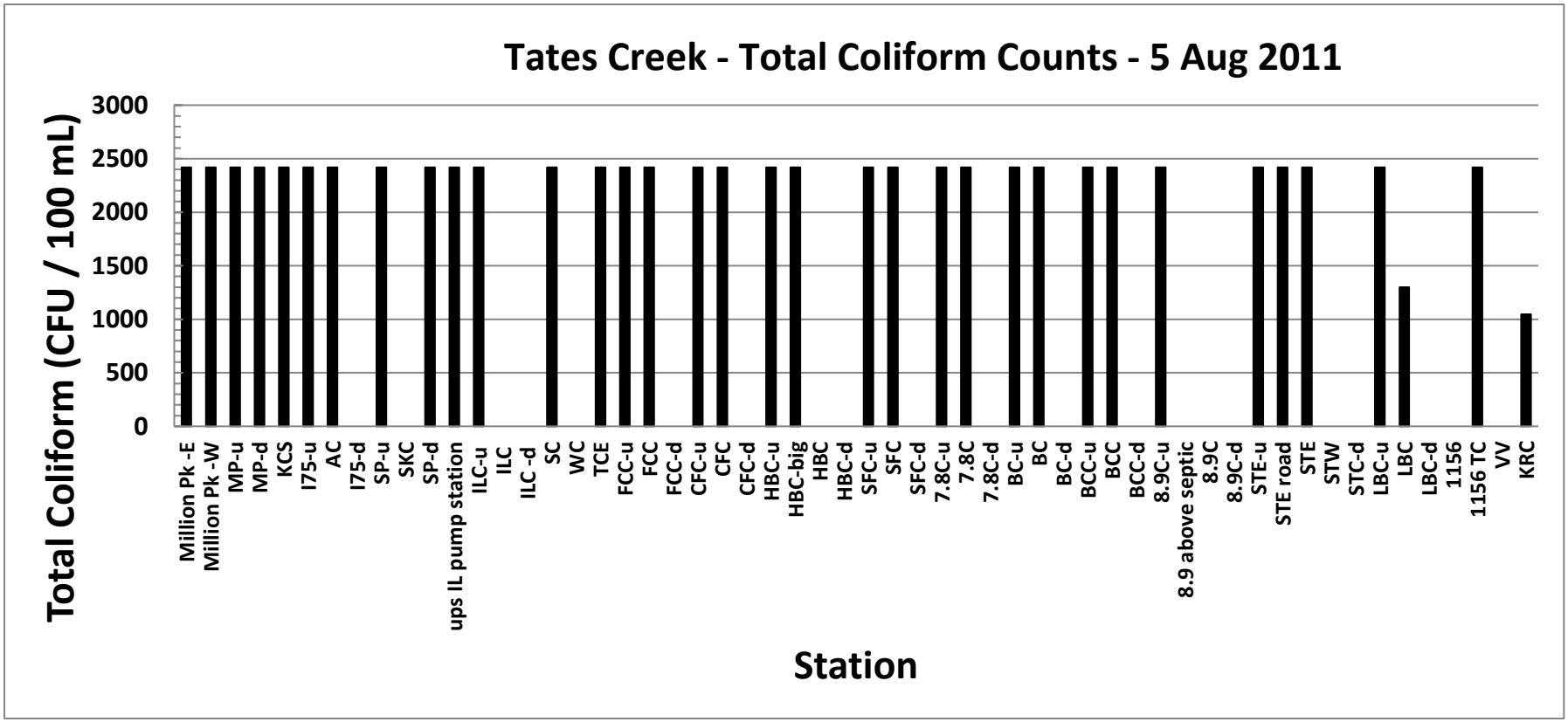

Tates Creek - E. coli Counts - 31 May 2011
E. coli (cfu/100 mL)
3000
2500
2000
1500
1000
500
0
Million Pk -E
Million Pk -W
MP-u
MP-d
KCS
I75-u
AC
I75-d
SP-u
SKC
SP-d
ups IL pump station
ILC-u 31 May
ILC-u extra
ILC-u 1 June
ILC 31 May
ILC 1 June
ILC -d 31 May
SC
WC
TCE
FCC-u
FCC
FCC-d
CFC-u
CFC
CFC-d
HBC-u
HBC-big
HBC
HBC-d
SFC-u
SFC
SFC-d
7.8C-u
7.8C
7.8C-d
BC-u
BC
BC-d
BCC-u
BCC
BCC-d
8.9C-u
8.9 above septic
8.9C
8.9C-d
STC-u
STE road
STE
STW
STC-d
LBC-u
LBC
LBC-d
1156
1156 TC
VV
KRC

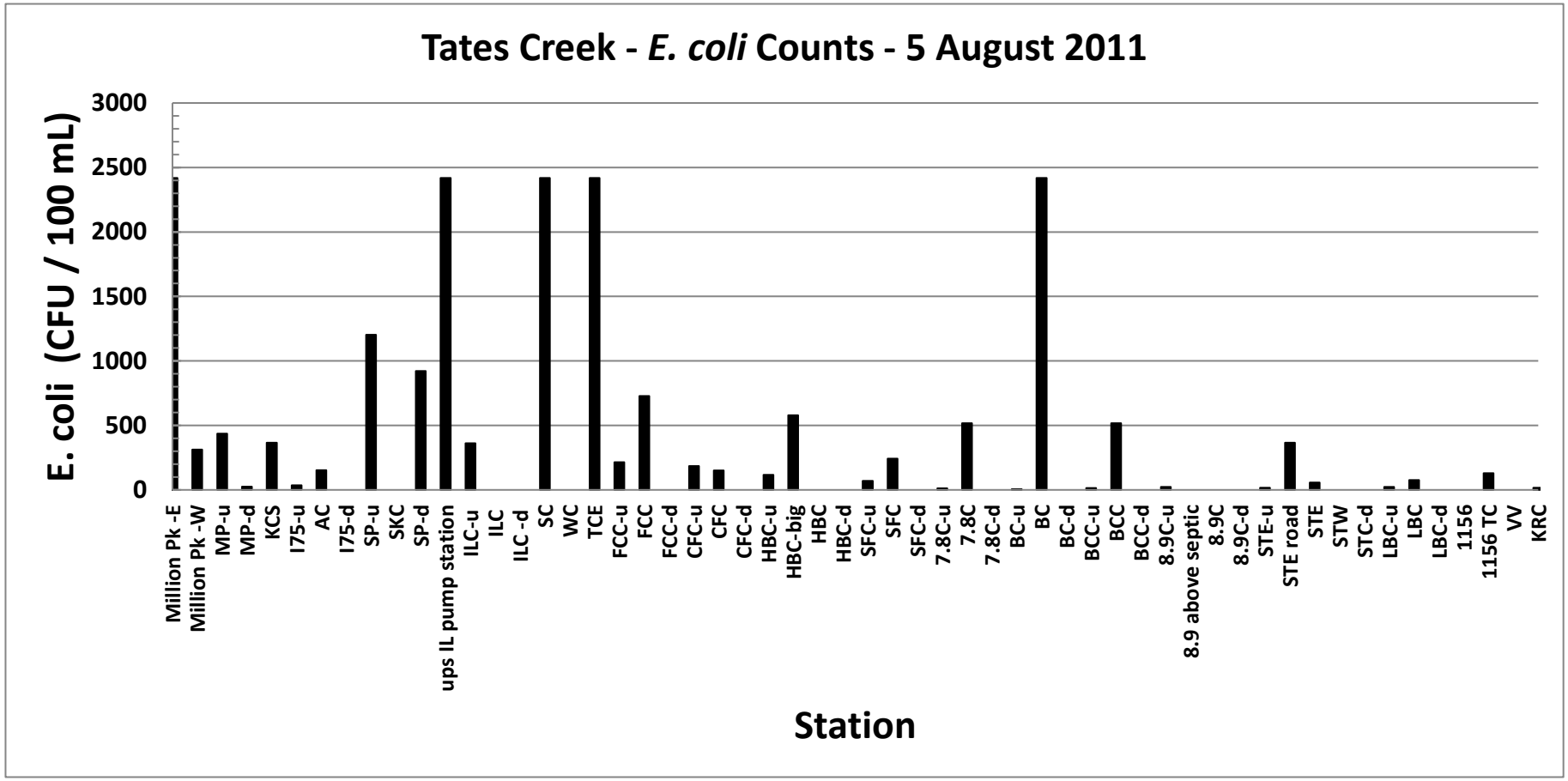

Tates Creek - Total Coliform Counts - 21 June 2011
Total Coliform (CFU / 100 mL)
3000
2500
2000
1500
1000
500
0
Million Pk -e
Million Pk -W
MP-u
MP-d
KCS
I75-u
AC
I75-d
SP-u
SKC
SP-d
ups IL pump station
ILC-u
ILC
ILC -d
SC
WC
TCE
FCC-u
FCC
FCC-d
CFC-u
CFC
CFC-d
HBC-u
HBC-big
HBC
HBC-d
SFC-u
SFC
SFC-d
7.8C-u
7.8C
7.8C-d
BC-u
BC
BC-d
BCC-u
BCC
BCC-d
8.9C-u
8.9 above septic
8.9C
8.9C-d
STE-u
STE road
STE
STW
STC-d
LBC-u
LBC
LBC-d
1156
1156 TC
VV
KRC
Station


Tates Creek - E. coli Counts - 21 June 2011
E. coli (CFU / 100 mL)
3000
2500
2000
1500
1000
500
0
Million Pk -E
Million Pk -W
MP-u
MP-d
KCS
I75-u
AC
I75-d
SP-u
SKC
SP-d
ups IL pump station
ILC-u
ILC
ILC -d
SC
WC
TCE
FCC-u
FCC
FCC-d
CFC-u
CFC
CFC-d
HBC-u
HBC-big
HBC
HBC-d
SFC-u
SFC
SFC-d
7.8C-u
7.8C
7.8C-d
BC-u
BC
BC-d
BCC-u
BCC
BCC-d
8.9C-u
8.9 above septic
8.9C
8.9C-d
STE-u
STE road
STE
STW
STC-d
LBC-u
LBC
LBC-d
1156
1156 TC
VV
KRC
Station


Tates Creek - Total Coliform Counts - 5 July 2011
Total Coliform (CFU / 100 mL)
3000
2500
2000
1500
1000
500
0
Million Pk -e
Million Pk -W
MP-u
MP-d
KCS
I75-u
AC
I75-d
SP-u
SKC
SP-d
ups IL pump station
ILC-u
ILC
ILC -d
SC
WC
TCE
FCC-u
FCC
FCC-d
CFC-u
CFC
CFC-d
HBC-u
HBC-big
HBC
HBC-d
SFC-u
SFC
SFC-d
7.8C-u
7.8C
7.8C-d
BC-u
BC
BC-d
BCC-u
BCC
BCC-d
8.9C-u
8.9 above septic
8.9C
8.9C-d
STE-u
STE road
STE
STW
STC-d
LBC-u
LBC
LBC-d
1156
1156 TC
VV
KRC
Station


Tates Creek - E. coli Counts - 5 July 2011
E. coli (CFU / 100 mL)
3000
2500
2000
1500
1000
500
0
Sample
Million Pk -E
Million Pk -W
MP-u
MP-d
KCS
I75-u
AC
I75-d
SP-u
SKC
SP-d
ups IL pump station
ILC-u
ILC
ILC -d
SC
WC
TCE
FCC-u
FCC
FCC-d
CFC-u
CFC
CFC-d
HBC-u
HBC-big
HBC
HBC-d
SFC-u
SFC
SFC-d
7.8C-u
7.8C
7.8C-d
BC-u
BC
BC-d
BCC-u
BCC
BCC-d
8.9C-u
8.9 above septic
8.9C
8.9C-d
STE-u
STE road
STE
STW
STC-d
LBC-u
LBC
LBC-d
1156
1156 TC
VV
KRC
Station


Tates Creek - Total Coliform Counts - 5 Aug 2011
Total Coliform (CFU / 100 mL)
3000
2500
2000
1500
1000
500
0
Million Pk -E
Million Pk -W
MP-u
MP-d
KCS
I75-u
AC
I75-d
SP-u
SKC
SP-d
ups IL pump station
ILC-u
ILC
ILC -d
SC
WC
TCE
FCC-u
FCC
FCC-d
CFC-u
CFC
CFC-d
HBC-u
HBC-big
HBC
HBC-d
SFC-u
SFC
SFC-d
7.8C-u
7.8C
7.8C-d
BC-u
BC
BC-d
BCC-u
BCC
BCC-d
8.9C-u
8.9 above septic
8.9C
8.9C-d
STE-u
STE road
STE
STW
STC-d
LBC-u
LBC
LBC-d
1156
1156 TC
VV
KRC
Station


Tates Creek - E. coli Counts - 5 August 2011
E. coli (CFU / 100 mL)
3000
2500
2000
1500
1000
500
0
Million Pk -E
Million Pk -W
MP-u
MP-d
KCS
I75-u
AC
I75-d
SP-u
SKC
SP-d
ups IL pump station
ILC-u
ILC
ILC -d
SC
WC
TCE
FCC-u
FCC
FCC-d
CFC-u
CFC
CFC-d
HBC-u
HBC-big
HBC
HBC-d
SFC-u
SFC
SFC-d
7.8C-u
7.8C
7.8C-d
BC-u
BC
BC-d
BCC-u
BCC
BCC-d
8.9C-u
8.9 above septic
8.9C
8.9C-d
STE-u
STE road
STE
STW
STC-d
LBC-u
LBC
LBC-d
1156
1156 TC
VV
KRC
Station