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Bacteria monitoring and assessment project at Canyon Lake, California

Natasha Marie Krupnak

BACTERIA MONITORING AND ASSESSMENT PROJECT AT CANYON LAKE, CALIFORNIA

A Project

Presented to the

Faculty of

California State University,

San Bernardino

In Partial Fulfillment

of the Requirements for the Degree

Master of Science

in

Environmental Sciences

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by

Natasha Marie Krupnak

September 2010

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ABSTRACT

A bacterial study at Canyon Lake, California was done during the winter of 2009 (8 consecutive weeks) and the summer of 2009 (18 consecutive weeks) to determine recreational contact water quality. Water samples were collected at six different sites around the lake (4 beach and 2 mid lake) and analyzed for the presence of total coliform and *Escherichia coli (E.coli)* using IDEXX Laboratories Colilert® defined substrate technology and Quanti-Tray®/2000 methodology. *Enterococcus* bacteria were similarly analyzed for 3 samplings (using Enterolert®).

The results were assessed using the United States Environmental Protection Agency (U.S. EPA) water quality criteria of 235 Most Probable Number (MPN)/ 100mL for individual bacteria results and 126 MPN/100mL for the geometric means of all possible 30-day intervals (5 sampling events) for each location. Water quality characteristics (pH, temperature and conductivity) were also measured during each sampling.

The 8 week winter 2009 sampling period showed an increase in pH and a decrease in temperature and conductivity over time. Only one of the individual bacteria samples exceeded the 235MPN/100mL standard (0.007%). Also,

none of the geometric means exceeded the 126MPN/100mL standard.

The 18 week summer 2009 study showed an increase in temperature and conductivity and a lower pH over time. Six individual bacteria samples exceeded the 235MPN/100mL standard (2%). Only one geometric mean exceeded the 126MPN/100mL standard (0.5%). The *Enterococcus* bacteria levels were very low.

These results show that Canyon Lake usually meets the U.S. EPA criteria for *E.coli* in recreational waters during dry weather.

ACKNOWLEDGEMENTS

I would like to thank everyone involved with helping me complete this project. Foremost, I would like to thank Dr. Noblet for giving me this opportunity and advising me throughout this process. I would also like to thank Dr. Stanley, the graduate advisor for Environmental Science, for being such a wonderful listener and advisor also. I would like to thank Dr. Maynard, Chair of the Chemistry Department, for being such a great listener and advisor as well. Additionally, I would like to thank my two committee members, Drs. Phalen and Greer, without whom I would not have gotten through writing this paper. With out the Santa Ana Regional Water Quality Control Board and Sarah Garber (MWH Global, INC.) this project would not have been possible, so I thank them as well. Last but certainly not least, I would like to thank everyone in my family for supporting me through my endeavors, however out of the ordinary they may be.

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CHAPTER ONE

INTRODUCTION

Study Overview

Noblet (2009) states that this study was conducted in response to a cooperative request by the Lake Elsinore and Canyon Lake Total Maximum Daily Load (TMDL) Task Force and the Santa Ana Regional Water Quality Control Board (Hereafter the Regional Board) to characterize and assess the bacterial water quality conditions in Canyon Lake, California. The Lake Elsinore and Canyon Lake TMDL Task Force is comprised of local stakeholders interested in water quality issues within the San Jacinto Watershed. The task force includes representatives from local cities, Riverside County, agriculture and dairy, environmental groups, as well as, the regulatory community. The Lake Elsinore and Canyon Lake TMDL Task Force is a sub-entity of the Santa Ana Watershed Project Authority (SAWPA) at the request of the Regional Board. SAWPA serves as neutral facilitator for the TMDL development process for Lake Elsinore and Canyon Lake, even though these lakes fall within the San Jacinto Watershed.

The laboratory and field work to be performed in this study was contracted to California State University, San Bernardino (CSUSB) through MWH Global Inc., an environmental consulting firm, as the representative of the Lake Elsinore and Canyon Lake TMDL Task Force and the Santa Ana Regional Water Board (*1*). The CSUSB Laboratory Director for this study was Dr. James A. Noblet.

Garber (2009) states that Section 303(d) of the federal Clean Water Act requires that all water bodies in the United States that are impaired in some way with respect to a beneficial use must be listed and described as to the impairment. Canyon Lake is on the most recent (2006) 303(d) list of impaired water bodies for the State of California (*2*). According to the United States Environmental Protection Agency (U.S. EPA) (2003) and its designee in California, the State Water Quality Control Board, Canyon Lake is impaired with pathogens that would render the lake unsuitable for recreational activities such as swimming and water skiing, where there is physical contact with the water. Although there are no enforceable standards for recreational water use, the U.S. EPA has published water quality guidelines for recreational waters, and those guidelines will be adopted by Regional Board.

The Canyon Lake bacterial study intends to provide the data necessary for the Regional Board to assess whether Canyon Lake should be removed from the State of California 303(d) list (*3*).

Problem Statement

The location of this study was Canyon Lake, California. Norton et al.'s (2009) Quality Assurance Project Plan (QAPP) (developed by MWH Global Inc., on behalf of the Regional Board) states that bacterial levels in Canyon Lake have, in the past, exceeded the water quality goals established by the Santa Ana Regional Water Quality Control Plan (Basin Plan). Therefore, the lake was added to the Clean Water Act's 2002 303(d) list of water quality limited segments. It remains included in the most recent version of the California 303(d) list approved by the U.S. EPA in 2006. This Basin Plan presently uses fecal coliform bacteria as an indicator of bacterial pollution in the lake (*3,4*). However, according to the U.S. EPA (2003) and others (Wade et al., 2003) *Escherichia coli* (*E.coli*) is a better measure of the potential presence of pathogens in recreational fresh waters than other indicator bacteria (*3,5*). Garber (2009) states that *E. Coli* will be used as the primary indicator of water quality in this study. If it

can be shown that the bacterial levels in Canyon Lake consistently meet the standards for bacterial pollution suggested by the U.S. EPA and specified in the Basin Plan, then the Santa Ana Regional Board may have justification to remove Canyon Lake from the 303(d) list (*2*).

Coliform Fecal Indicator Bacteria and *E.coli*

Ashbolt et al. (2001) states that traditionally in water quality assessment, fecal indicator organisms that indicate the presence of fecal contamination from warm blooded animals have been used to infer the possible presence of pathogens rather than measuring the pathogenic organisms directly (*6*).

According to Ashbolt et al. (2001), a fecal indicator is defined as "A group of organisms that indicates the prescence of faecal contamination, such as the bacterial groups thermotolerant coliforms or *E.coli*. Hence, they only **infer** that pathogens may be present"(*6*).

Ashbolt et al. (2001) states that the method used for this study was the defined substrate method. It is defined as "Media without harsh selective agents but specific enzyme substrates allow significant improvements in recoveries and identification of target bacteria". This has evolved into the Colilert® technique used in this study (*6*).

According to Ashbolt et al. (2001), coliform bacteria are found in the intestines of most animals. They are "Gram-negative, non spore-forming, oxidase-negative, rod-shaped facultative anaerobic bacteria that ferment lactose to acid and gas in 24 to 48 hours. "*E.coli*, in particular, are thermophilic coliforms that produce indole from tryptophan and are also able to produce β-glucronidase". *E. Coli* has been found to be the most appropriate group of coliforms to indicate the presence of fecal pollution and thus infer the possible presence of pathogens Moreover, rapid and reliable methods for the enumeration of coliforms and specifically *E. Coli* in recreational water samples are readily available (*6*). According to the U.S. EPA (2003) and Basin Plan Bacterial Water Quality Guidelines, the *E.coli* concentrations in recreational waters are to be 126 Most Probable Number (MPN) of bacteria/100mL or less (*3*).

Enterococcus Fecal Indicator Bacteria

According to Ashbolt et al. (2001), Enterococcus bacteria are classified as faecal Streptococci. They have many of the same characteristics as the coliform bacteria mentioned above. One exception is that they are Gram-positive, whereas coliform bacteria are Gram-negative. Enterococcus is most often used as a fecal indicator

organism for salt water applications such as beach monitoring (*6*). However, a few samples were analyzed in this study for comparison purposes.

Canyon Lake, California Background

According to Garber (2009), Canyon Lake is a private gated community of approximately 4,800 homes. Canyon Lake was formed in 1928 when the Canyon Lake Dam was constructed. It was originally called Railroad Canyon reservoir. It has three main sections: the East Bay, central body, and the North area that connects to the San Jacinto River. The lake has an aerial extent of 383 acres, which includes about 14 miles of shoreline. It is fed by a watershed of about 780 square miles in Riverside County. Canyon Lake allows such recreation as swimming, boating, fishing and water sports. Allowance of recreation is with the understanding that bacteria levels do not exceed an established limit. Bacteria levels have exceeded this limit in the past due to body contact recreation. The lake was included in the 2002 Clean Water Act Section 303(d) list of water quality limited segments, due to the violations of the water quality objectives (*2*).

According to Garber (2009), The Santa Ana Regional Board has established a control plan that allows the

advantageous uses of Canyon Lake to be specified. These include "municipal and domestic supply, agricultural supply, groundwater recharge, recreation, warm freshwater habitat and wildlife habitat"(*2*).

Objectives

The objectives of this study were to answer the following questions:

1) Does Canyon Lake, based upon a statistically significant number of samples, consistently meet the U.S. EPA bacterial water quality guidelines for recreational waters during both wet and dry seasons?
2) Can the data generated justify the removal of Canyon Lake from the State of California 303(d) list of impaired water bodies?

Literature Review

A previous study on bacteria levels at Canyon Lake, CA was performed by Davis et al. (2005) from August 2001 to July 2002. They took surface water samples from the lake weekly and analyzed them for *E.coli*, total coliform and Enterococcus concentrations. They found there were seasonal variations in the bacteria concentrations. During the Summer season the *E.coli* concentrations were low. The

E.coli concentrations were continuously below the U.S. EPA standard of 235 MPN/100mL for single sample analyses. Even for the current standard of 126 MPN/100mL for 30-day geometric mean values there was only one sample that exceeded this limit. The total coliform concentrations were consistently high, however the summer sampling session showed a lesser concentration than the winter. Also, the Enterococci concentrations were consistently low. The water temperatures were lower during the winter and higher during the summer (often exceeding 26°C). The pH varied with a mean value of 8.2. The electrical conductivity was consistently low with a mean of 1139µS/cm (7).

CHAPTER TWO

MATERIALS AND METHODS

Sampling

In consultation with staff of the Santa Ana Regional Water Quality Control Board and the Project Manager with MWH Global Inc., a representative of the Lake Elsinore and Canyon Lake TMDL Task Force, a sampling plan was developed. A pre-study field trip was undertaken to Canyon Lake in order to select sampling locations for the study. The field trip was attended by Ms. Sarah Garber, Project Manager with MWH Globlal Inc., Mr William (Bill) Rice of the Regional Board, Dr. James Noblet, laboratory and field supervisor from CSUSB, and Natasha Krupnak, graduate student at CSUSB, designated to perform the majority of the study work. The sampling sites were selected based upon several factors, including frequency of recreational use by residents and guest of Canyon Lake, and ease of access for the sampling crews.

Six different sites were selected around the lake, 4 in the main body of the lake, and two in the East Bay. The sampling sites were: Sierra Beach (CLB1), Midlake Station 1 (CLB2, also known as Station 8 from the ongoing CSUSB Water

Quality Monitoring Study), MidLake Station 2 (CLB3, south of CLB2 and about the same latitutde as Sunset Beach), Sunset Beach (CLB4), Road Runner Beach (CLB5) and Indian Beach (CLB6). For each beach site 3 samples were taken at different locations around the site. The samples were taken at three approximately equally spaced intervals, one from one side of the beach, one in the middle of the beach and one on the other side of the beach. For sites CLB1 (Sierra Beach) and CLB5 (Road Runner Beach) the middle samples were taken at the end of the docks that were in approximately the middle of the Beach. Whereas the two side samples were taken in shallow (e.g., waist deep water) closer to shore. For the Station 8 (CLB2) and MidLake (CLB3) stations only one sample was taken. Each week two duplicate samples were taken randomly to ensure reproducibility of sampling analytical methods. These samples were collected weekly during the winter (8 weeks from January 30th to March 20th) and summer (18 weeks from June 5th to October 2nd) of 2009.

Table 2-1. Geographical Coordinates and Altitudes of Each Sampling Site At Canyon Lake, California

#	Name	Latitude	Longitude	Altitude (feet)	Latitude (degrees)
1	CLB1	N33°41.598'	W117°15.674'	1403	33.69330287
2	CLB2	N33°41.300'	W117°16.136'	1381	33.68832852
3	CLB3	N33°41.193'	W117°16.272'	1381	33.68654527
4	CLB4	N33°41.091'	W117°16.238'	1394	33.68485586
5	CLB5	N33°40.815'	W117°15.470'	1392	33.68025694
6	CLB6	N33°40.753'	W117°15.056'	1394	33.67922452

Source: Garber, S. *Canyon Lake Bacteria Characterization Memorandum*. MWH Global 1343128, 2009.

Figure 2-1. A Map Of Canyon Lake California With The Six Different Sites Highlighted

Source: Garber, S. *Canyon Lake Bacteria Characterization Memorandum*. MWH Global 1343128, 2009.

Figure 2-2. Google Earth Image of Site CLB1 With the Three Sampling Locations Highlighted

Source: Google Earth (2002), http://earth.google.com/, Accessed 2009.

Figure 2-3. Google Earth Image of Site CLB4 With the Three Sampling Locations Highlighted

Source: Google Earth (2002), http://earth.google.com/, Accessed 2009.

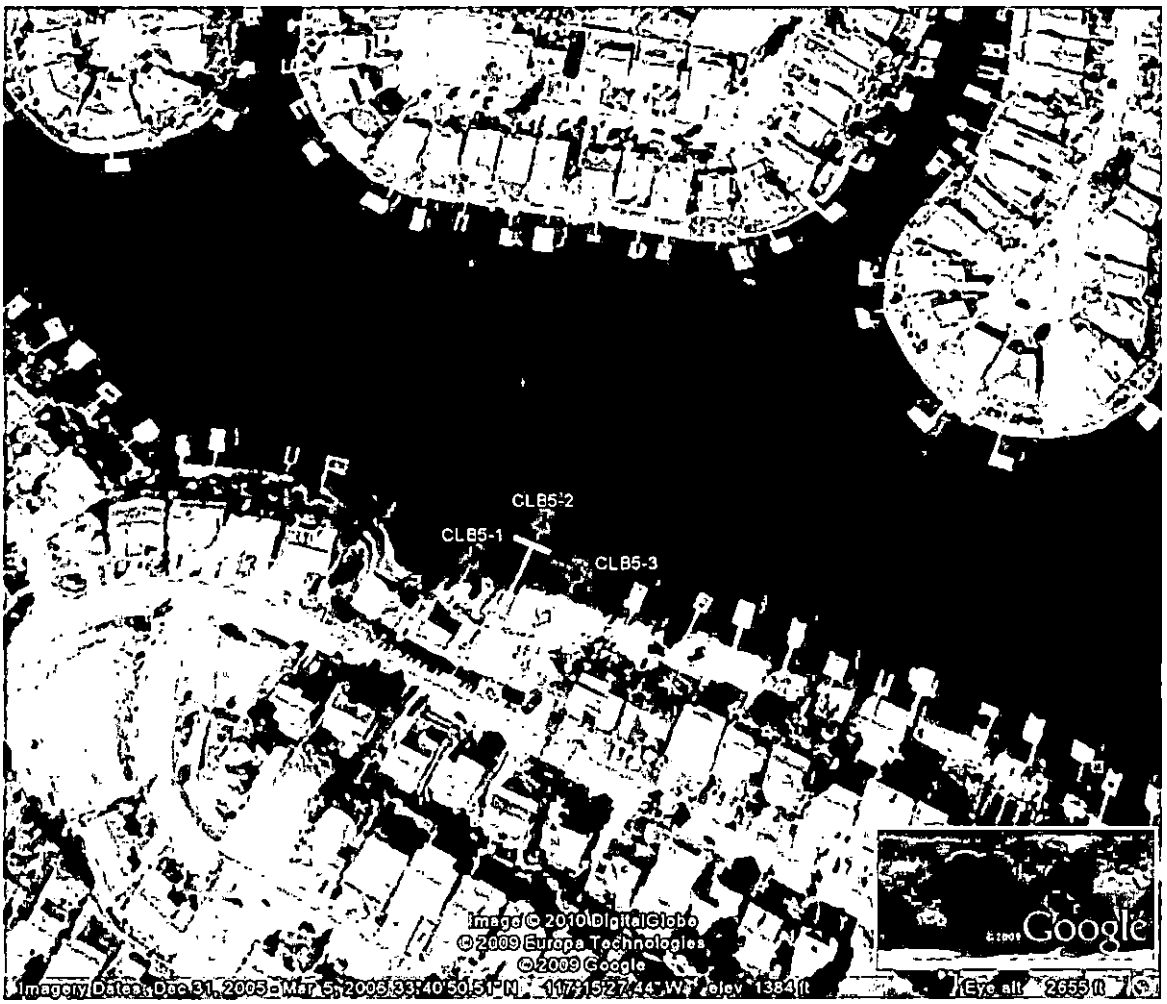

Figure 2-4. Google Earth Image of Site CLB5 With the Three Sampling Locations Highlighted

Source: Google Earth (2002), http://earth.google.com/, Accessed 2009.

Figure 2-5. Google Earth Image of Site CLB6 With the Three Sampling Locations Highlighted

Source: Google Earth (2002), http://earth.google.com/, Accessed 2009.

Quality Assurance Project Plan (QAPP)

Norton et al. (2009) developed a Quality Assurance Project Plan (QAPP) in February 2009. This is to ensure the precision and accuracy of the data (4).

Quality Assurance Project Plan Goals. According to Norton et al (2009), the goals for CSUSB were to: "provide the necessary containers and chain of custody forms for the water samples, conduct field sampling activities to characterize bacterial conditions, provide field sampling personnel and calibrated probe(s), transport the water samples to the CSUSB laboratory within 6 hours, conduct *E.coli* analysis, operate within the quality assurance and control guidelines established the state of California and the U.S. EPA, and to provide all data to the water board" (*4*).

Quality Assurance Project Plan Sampling Methods. There was a sampling method that was followed for grab samples. According to Norton et al. (2009), this was referenced from *Standard Methods For The Examination Of Water And Wastewater* (2005) (Hereafter referred to as Standard Methods or SM 9060A (*4,9*).

At each of the six sites, a 100mL sterile sampling bottle must be opened and dipped into the water. The water

must be at least up to the 100mL mark on the polyethylene plastic bottle. The bottle should be pointed away from the sampler's body, so as to avoid cross contamination. Once this was complete, the lid to the sampling bottle was closed and labeled. The samples must be stored on ice and brought back to the CSUSB laboratory and analyzed no later than 6 hours from the sampling time. Temperature, pH and conductivity were also taken as secondary measurements in order to establish the conditions of the lake water. These were taken with an Ogden probe. Based on Standard Methods (2005) the field methods for these analyses were SM2510B for conductivity, SM4500-H+B for pH and SM2550B for water temperature (*9*).

Quality Assurance Project Plan Laboratory Analysis Methods. The CSUSB laboratory analysis of the Canyon Lake water samples were for *E.coli*. The analytical method followed was referenced from SM9223B. The analysis was achieved by dissolving Colilert® medium (IDEXX Inc.) into each individual 100mL sample of the Canyon Lake water, after shaking to mix well and pouring excess water out of the sample bottle until there was exactly 100 mL of sample (as indicated by a line on the sample bottles). For each new batch of the medium a quality assurance certificate was

provided by IDEXX Laboratories, Inc. Once the Colilert® medium was dissolved, the samples were then poured into IDEXX Quanti Tray® 2000 well trays. Noblet (2009) created a method for ensuring the duplicate samples were homogenized. The duplicate samples were homogenized by first pouring about half (estimated by eye) of one well-mixed (by shaking) sample into a Quanti Tray and then refilling the first sample bottle with the second sample up to the 100 mL line. Then the balance of the duplicate sample was poured into the first Quanti Tray. Then the homogenized sample in the first sample bottled was poured into a second Quanti Tray. Since pre-sterilized bacteria sample bottles with larger than 100 mL volumes are not commercially available, this process allowed for creating two composite samples of exactly 100 mL each using the pre-sterilized 100 mL sample bottles and eliminated the need for sterilizing our own larger sample bottles. A composite sample was needed for evaluating the precision of the analytical method because of the nature of bacteria samples, which can exhibit large differences in bacteria numbers even among samples taken at the same place and time (*1*). These trays were sealed up with the IDEXX Quanti Tray® Sealer and incubated for 24 hours at 35 ± 0.5°C in an air incubator. At 24 hours the

trays were analyzed for the presence of total coliform (the wells in the tray turned a yellow color in the presence of this bacteria) and E.coli (the wells in the tray fluoresced under a blacklight in the presence of this bacteria). The MPN of bacteria was found by using a chart provided by IDEXX laboratories, INC. These results were then recorded and sent to the Santa Ana Regional Water Board. Along with this, chain of custody forms were completed to ensure proper identification and tracking of the samples and data.

Statistical Analysis

Geometric means were calculated for the bacteria data. This formula is $\left[\prod_{i=1}^{n} X_i\right]^{1/n}$, or the nth root of the product of all the sample values. For this study n was equal to 5 samples within a 30-day period, as the geometric mean for every five sampling dates was calculated.

Additional Analysis For Enterococci

Enterococcus bacteria were also analyzed. This was achieved by dissolving Enterolert® medium into each additional individual 100mL sample of the Canyon Lake water. For each new batch of the medium a quality assurance certificate was provided by IDEXX Laboratories, INC. Once the Enterolert® medium was dissolved, the samples were

then poured into IDEXX Quanti Tray® 2000 well trays. Noblet (2009) created a method for ensuring the duplicate samples were homogenized. The duplicate samples were homogenized by first pouring about half (estimated by eye) of one well-mixed (by shaking) sample into a Quanti Tray and then refilling the first sample bottle with the second sample up to the 100 mL line. Then the balance of the duplicate sample was poured into the first Quanti Tray. Then the homogenized sample in the first sample bottled was poured into a second Quanti Tray. Since pre-sterilized bacteria sample bottles with larger than 100 mL volumes are not commercially available, this process allowed for creating two composite samples of exactly 100 mL each using the pre-sterilized 100 mL sample bottles and eliminated the need for sterilizing our own larger sample bottles. A composite sample was needed for evaluating the precision of the analytical method because of the nature of bacteria samples, which can exhibit large differences in bacteria numbers even among samples taken at the same place and time (*1*). These trays were then sealed up with the IDEXX Quanti Tray® Sealer and incubated for 24 hours at 41 ± 0.1 °C in a water bath incubator. At 24 hours the trays were analyzed for the presence of Enterococci(the wells in the tray

fluoresced under a blacklight in the presence of this bacteria). The MPN of bacteria was found using a chart provided by IDEXX laboratories, INC.

Precision Criteria

According to the Standard Methods (2005), the precision of the samples were obtained through a series of steps:

1) The first 15 positive samples must have duplicate analyses run(record as D1 and D2).
2) Then, the logarithm of every result was calculated. 1 was added to every value that was less than 1.
3) The average of the ranges (R) for each pair of log transformed duplicates was calculated as the mean($\overline{R}$).
4) Lastly, 10% of the routine samples were analyzed in duplicates. The duplicates were log transformed and their range calculated. There is found to be excessive laboratory variability if the range is greater than 3.27 $\overline{R}$ (9).

A pre-sampling analysis was done for Canyon Lake on 12/19/08 and 12/23/08 in order to develop the specific precision criteria for this study. The data was obtained

and the procedures from Standard Methods (2005) were followed (Tables 2-2 and 2-3). During the study 2 duplicate samples were taken each week to ensure that the 10% requirement was met (*9*).

Table 2-2. Preliminary Total Coliform (TC) and *E.coli* (EC) Bacteria MPN/100mL Data[a]

	12/19/2006		12/23/2006	
Station	TC	EC	TC	EC
CLB1-1	>2419.6	547.5 (D1)	>24219.6	28.7
CLB1-2				
CLB1-3				
CLB2	>2419.6	275.5	>24219.6	12.1
CLB3				
CLB4-1	>2419.6	152.9	>24219.6	12.1
CLB4-2				
CLB4-3				
CLB5-1	>2419.6	1986.3	579.4	10
CLB5-2				
CLB5-3				
CLB6-1	>2419.6	>2419.6	1986.3	27.1
CLB6-2				
CLB6-3				
Dup1		648.8		
Dup2				
Blank	0	0	0	0

[a]D1 Indicates the Site at Which a Duplicate Sample was Taken.

Table 2-3. Pre-Study Sampling Precision Criteria Data Based on Standard Methods (2005)[a]

Site	TC Rep 1	TC Rep 2	EC Rep 1	EC Rep 2	Log EC1	Log EC2	R_{log} LEC1-LEC2	
Sierra Park Beach 1	>2419.6	>2419.6	4.1	6.3	0.6128	0.7993	0.1866	
Sierra Park Beach 2	>2419.6	>2419.6	3.1	4.1	0.4914	0.6128	0.1214	
Sierra Park Beach 3	>2419.6	>2419.6	3.0	5.2	0.4771	0.7160	0.2389	
Station 8-1	>2419.6	>2419.6	4.1	2.0	0.6128	0.3010	0.3118	
Station 8-2	1986.3	>2419.6	1.0	3.0	0.0000	0.4771	0.4771	
Station 8-3	>2419.6	>2419.6	4.1	2.0	0.6128	0.3010	0.3118	
Sunset Beach 1	>2419.6	>2419.6	4.1	1.0	0.6128	0.0000	0.6128	
Sunset Beach 2	>2419.6	>2419.6	3.0	0.0	0.6021	0.0000	0.6021	
Sunset Beach 3	>2419.6	>2419.6	4.1	6.3	0.6128	0.7993	0.1866	
Road Runner Beach 1	686.7	1553.1	8.6	16.0	0.9345	1.2041	0.2696	
Road Runner Beach 2 (Dock)	501.2	436.6	5.2	4.1	0.7160	0.6128	0.1032	
Road Runner Beach 3	1986.3	1732.9	11.0	19.5	1.0414	1.2900	0.2486	
Indian Beach -1	>2419.6	>2419.6	48.8	47.1	1.6884	1.6730	0.0154	
Indian Beach -2	1119.9	770.1	13.4	10.9	1.1271	1.0374	0.0897	
Indian Beach -3	1299.7	980.4	11.9	11.0	1.0755	1.0414	0.0342	
Small Dock -1	920.8	579.4	21.1	34.1	1.3243	1.5328	0.2085	
(few blocks down						SR_{log} =	4.0181	
Continental way)								
						Ravg =	0.2511	
				Precision Criterion = 3.27Ravg =				0.8212

[a]TC stands for Total Coliform and EC stands for *E.coli*. R stands for the Range of Values. Ravg stands for the Average of the Range.

CHAPTER THREE

DATA AND RESULTS

E.coli Bacteria Data For The Winter 2009 8 Week Sampling Period

Table 3-1 shows that the *E.coli* concentrations were fairly consistent for the winter 8 week sampling period in 2009. The total coliform (TC) bacteria concentrations were consistently above the IDEXX, INC method maximum value of 2420 MPN/ 100 mL throughout the study. High TC values are common in natural waters. Extra time, labor and costs would have been needed to get an accurate measure of TC. Therefore, TC is not used as a criterion here. For *E.Coli*, Only one date (02/27/09) was above the 235 MPN/100mL U.S. EPA single occurrence standard. Sites Clb1-3 and Clb6-1 (near the drainage/ runoff areas) were found to have higher concentrations of *E.coli*.

Figure 3-1 showed that for the 8 weeks during the winter of 2009 the bacteria levels did have an exceedence of the 235 MPN/ 100mL single sample limit (indicated by a horizontal red line). The sampling done on 02/27/09 in particular illustrates this fact.

Table 3-1. *E.coli* Bacteria Data for Winter 2009 8 Week Study[ab]

	1/30/09		2/6/09		2/13/09		2/20/09	
Station	**TC**	**EC**	**TC**	**EC**	**TC**	**EC**	**TC**	**EC**
CLB1-1	>2419.6	8.6	>2419.6	3	>2419.6	5.2	>2419.6	6.3
CLB1-2	>2419.6	10.9	>2419.6	5.2	>2419.6	3.1	>2419.6	1
CLB1-3	>2419.6	10.9	>2419.6	90.9	>2419.6	22.3	>2419.6	6.3(1)
CLB2	>2419.6	3.1 (1)	>200.1	1.0	>2419.6	1.0	>2419.6	4.1(2)
CLB3			>200.1	1.0	>2419.6	1.0	>2419.6	0
CLB4-1	>2419.6	6.3	>2419.6	3	>2419.6	2.0	>2419.6	4.1
CLB4-2	>2419.6	5.2	>2419.6	0	>2419.6	4.1	>2419.6	4.1
CLB4-3	>2419.6	4.1 (2)	>2419.6	0	>2419.6	1.0	>2419.6	1
CLB5-1	>2419.6	7.5	>2419.6	10.8	>2419.6	18.7	>2419.6	29.2
CLB5-2	>2419.6	4.1	>2419.6	149.7**	>2419.6	18.5 (1)	>2419.6	41
CLB5-3	>2419.6	5.2	>2419.6	13.4 (1)	>2419.6	16.0	>2419.6	26.2
CLB6-1	>2419.6	19.9	>2419.6	8.5	>2419.6	13.4	>2419.6	25.6
CLB6-2	>2419.6	21.6	>2419.6	29.5	>2419.6	25.3 (2)	>2419.6	24.6
CLB6-3	>2419.6	24.3	>2419.6	28.8 (2)	>2419.6	21.3	>2419.6	43.2
Dup1	>2419.6	5.2	>2419.6	7.5	>2419.6	24.1	>2419.6	7.4
Dup2	>2419.6	3.1	>2419.6	29.5	>2419.6	18.7	>2419.6	0
Blank	0	0	0	0	0	0	0	0

[a]The numbers in parentheses indicate the sites where duplicate samples were collected. [b]The single site exceeding the 235 MPN limit is marked with an asterisk (*).

Table 3-1. *E.coli* Bacteria Data For Winter 2009 8 Week Study (Continued)[ab]

	2/27/09		3/6/09		3/13/09		3/20/09	
Station	**TC**	**EC**	**TC**	**EC**	**TC**	**EC**	**TC**	**EC**
CLB1-1	>2419.6	69.1	>2419.6	6.3	>2419.6	23.9	>2419.6	97.1
CLB1-2	>2419.6	4.1(1)	>2419.6	3	>2419.6	3	>2419.6	18.1
CLB1-3	>2419.6	63.1	>2419.6	18.7	>2419.6	29.6(1)	>2419.6	10.2
CLB2	>2419.6	5.2	>2419.6	<1	>2419.6	<1(2)	>2419.6	<1(1)
CLB3	>2419.6	6.3(2)	>2419.6	2(1)	>2419.6	<1	>2419.6	<1(2)
CLB4-1	>2419.6	4.1	>2419.6	<1(2)	>2419.6	1	>2419.6	<1
CLB4-2	>2419.6	3.1	>2419.6	1	>2419.6	<1	>2419.6	<1
CLB4-3	>2419.6	3.1	>2419.6	1	>2419.6	2	>2419.6	<1
CLB5-1	>2419.6	5.2	>2419.6	1	>2419.6	1	>2419.6	25
CLB5-2	>2419.6	1	>2419.6	2	>2419.6	2	>2419.6	1
CLB5-3	>2419.6	9.7	>2419.6	2	>2419.6	4.1	>2419.6	12
CLB6-1	>2419.6	*291	>2419.6	38.4	>2419.6	3.1	>2419.6	20.1
CLB6-2	>2419.6	27.5	>2419.6	14.8	>2419.6	1	>2419.6	1
CLB6-3	>2419.6	17.3	>2419.6	6.2	>2419.6	2	>2419.6	1
Dup1	>2419.6	1	>2419.6	1	>2419.6	43.5	>2419.6	<1
Dup2	>2419.6	13.5	>2419.6	<1	>2419.6	1	>2419.6	<1
Blank	0	0	0	0	0	0	0	0

[a]The numbers in parentheses indicate the sites where duplicate samples were collected. [b]The single site exceeding the 235 MPN limit is marked with an asterisk (*).

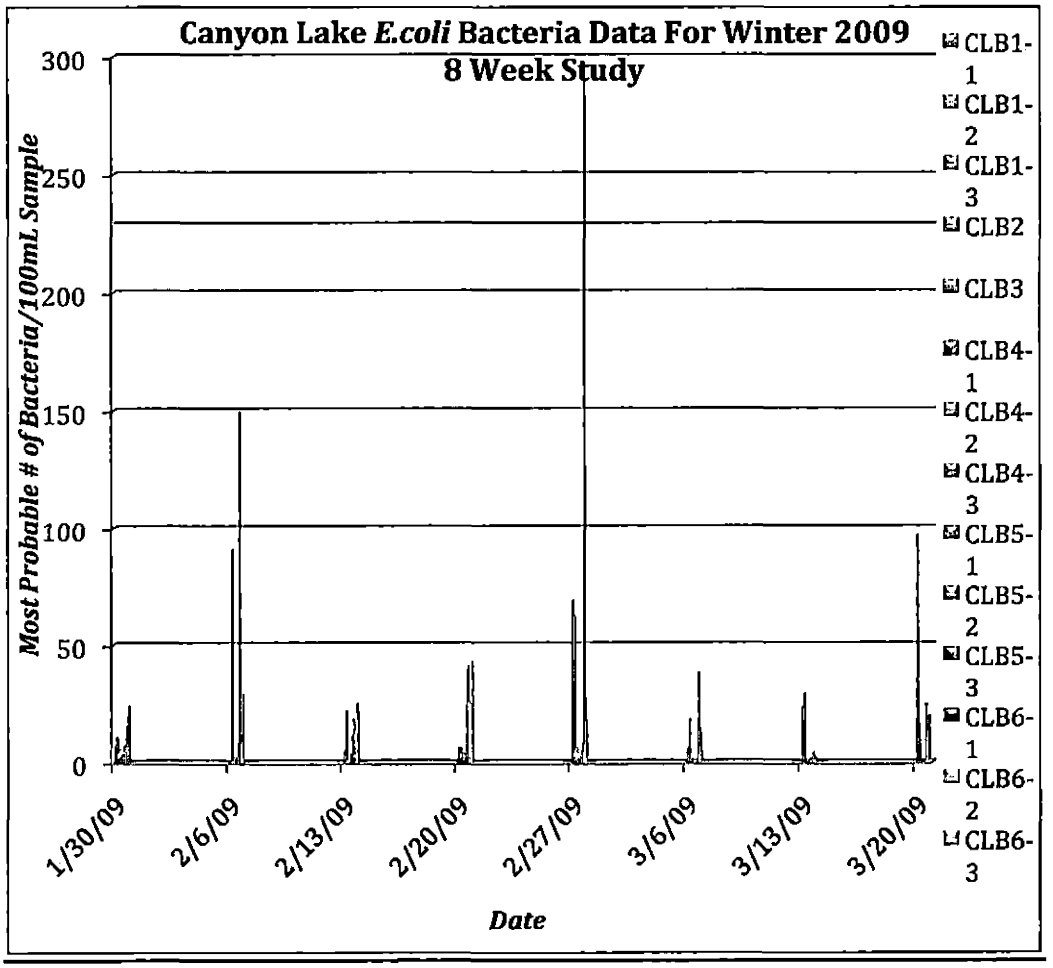

Figure 3-1. Canyon Lake *E.coli* Bacteria Data for the Winter 2009 8 Week Study

Table 3-2 illustrated that the geometric means for the winter of 2009 were all below the 126 MPN per 100mL U.S. EPA 30 day average standard.

Table 3-3 illustrated the weather conditions, locations, conductivity, pH and temperature for the various sampling locations on each date for the 8 weeks of the study during winter 2009. The temperature (°C), pH and conductivity (µS/Cm) measurements were taken to determine if these characteristics had an impact on bacteria levels. There does not appear to be a correlation between them in this study. Any general comments about the atmosphere of Canyon Lake on each sampling date were also recorded. The general trend showed that with rainfall pH increased, and temperature decreased along with conductivity.

Figure 3-2 illustrates the pH trend for the 8 weeks of the study during winter 2009. The figure shows that the pH is variable with time.

Figure 3-3 showed that for the 8 weeks during winter 2009 the temperature tended to start out low and steadily increase over time.

Figure 3-4 illustrated that for the 8 weeks of winter 2009 the conductivity decreased over time.

Table 3-2. 30 Day Geometric Means (Geomean) For Winter 2009 Study

	1/30-2/27	2/6-3/6	2/13-3/13	2/20-3/20
Station	Geomean 1	Geomean 2	Geomean 3	Geomean 4
CLB1-1	9.0	8.4	12.8	22.9
CLB1-2	3.6	2.6	2.3	3.6
CLB1-3	34.4	39.3	29.7	22.9
CLB2	1.7	1.5	1.5	1.5
CLB3	1.0	1.2	1.2	1.2
CLB4-1	3.6	2.5	2.0	1.8
CLB4-2	3.1	2.2	2.2	1.7
CLB4-3	1.3	1.3	1.4	1.4
CLB5-1	11.8	7.9	4.9	5.2
CLB5-2	12.6	10.5	3.6	2.8
CLB5-3	12.1	9.5	8.0	7.6
CLB6-1	27.9	31.8	26.0	28.2
CLB6-2	25.6	23.3	10.0	6.3
CLB6-3	24.9	17.7	11.5	6.2
Min	1.0	1.2	1.2	1.2
Max	34.4	39.3	29.7	28.2

Table 3-3. Environmental Conditions of Canyon Lake, California During The 8 Week Winter 2009 Sampling Period[a]

Date	Weather	Comments	Location	Conductivity µS/cm	pH	Temperature °C
1/30/09	Sunny with Slight Winds	Birds Present at CLB1	CLB1	1159	8.25	11.3
			CLB2	1122	8.22	11.8
			CLB3	1129	8.23	11.8
			CLB4	1117	8.59	12.1
			CLB5	936	7.92	11.8
			CLB6	911	8.02	12.8
2/6/09	Cold and Rainy	Birds Present at CLB1 and CLB5 and Runoff Present at CLB1	CLB1	1146	8.8	13
			CLB2	1118	8.7	12.5
			CLB3	1118	8.58	12.3
			CLB4	1124	8.57	12.3
			CLB5	900	8.85	12.7
			CLB6	791	8.63	13.2

[a]The Unit for conductivity is micro siemens per centimeter (µS/cm). The unit for temperature is degree celsius (°C).

Table 3-3. Environmental Conditions of Canyon Lake, California During The 8 Week Winter 2009 Sampling Period (Continued)[a]

Date	Weather	Comments	Location	Conductivity µS/cm	pH	Temperature °C
2/13/09	Cold and Rainy		CLB1	1034	8.41	12.1
			CLB2	952	8.57	11.9
			CLB3	1009	8.58	11.9
			CLB4	1031	8.56	11.8
			CLB5	896	8.14	11.3
			CLB6	870	8.41	11.1
2/20/09	Cool and Sunny	Birds Present at CLB1, CLB5 and CLB6	CLB1	1040	7.87	11.6
			CLB2	1007	8.25	12.2
			CLB3	1010	8.25	12.1
			CLB4	1002	8.28	12.2
			CLB5	819	7.81	11.6
			CLB6	742	7.57	13

[a]The Unit for conductivity is micro siemens per centimeter (µS/cm). The unit for temperature is degree celsius (°C).

Table 3-3. Environmental Conditions of Canyon Lake, California During The 8 Week Winter 2009 Sampling Period (Continued)[a]

Date	Weather	Comments	Location	Conductivity µS/cm	pH	Temperature °C
2/27/09	Cloudy and Cold	Birds Present at CLB1 and CLB6	CLB1	970	8.64	14.3
			CLB2	901	8.67	14.2
			CLB3	982	8.69	14.2
			CLB4	984	8.71	13.9
			CLB5	811	8.43	14.1
			CLB6	811	8.43	14.1
3/6/09	Sunny and Cold	Birds Present at CLB1 and CLB6	CLB1	973	8.7	14.2
			CLB2	963	8.9	14.6
			CLB3	977	8.91	14.6
			CLB4	991	8.89	14.6
			CLB5	808	9.01	14.3
			CLB6	752	9.02	14.6

[a]The Unit for conductivity is micro siemens per centimeter (µS/cm). The unit for temperature is degree celsius (°C).

Table 3-3. Environmental Conditions of Canyon Lake, California During The 8 Week Winter 2009 Sampling Period (Continued)[a]

Date	Weather	Comments	Location	Conductivity µS/cm	pH	Temperature °C
3/13/09	Sunny and Cool	Birds Present at CLB1	CLB1	992	8.66	14.4
			CLB2	982	9.06	14.9
			CLB3	954	9.07	14.9
			CLB4	985	9.14	15.4
			CLB5	824	9.24	15.7
			CLB6	808	9.05	15.6
3/20/09	Sunny and Cool	Birds Present at CLB1	CLB1	996	9.06	17.1
			CLB2	973	9.13	17.6
			CLB3	974	9.14	17.6
			CLB4	984	9.17	17.6
			CLB5	836	9.41	18.1
			CLB6	842	9.32	18.1

[a]The Unit for conductivity is micro siemens per centimeter (µS/cm). The unit for temperature is degree celsius (°C).

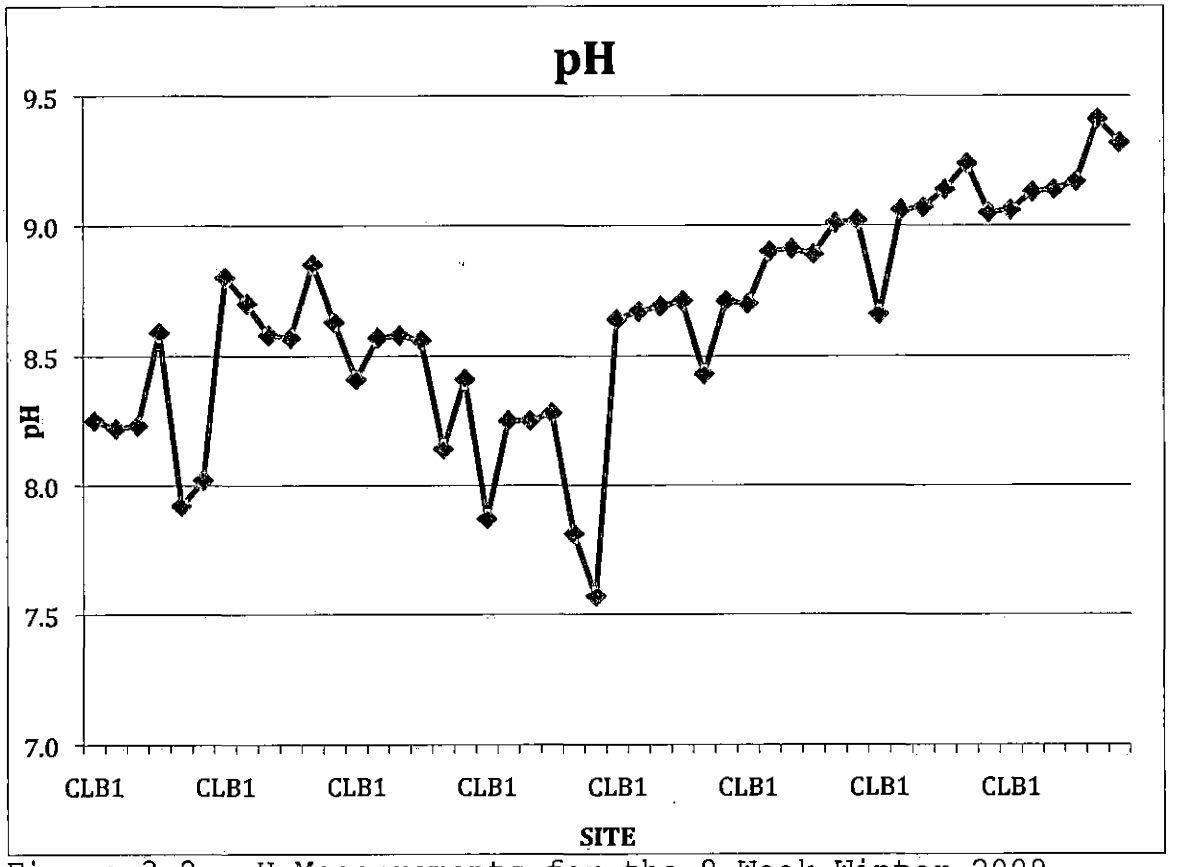

Figure 3-2. pH Measurements for the 8 Week Winter 2009 Sampling Period

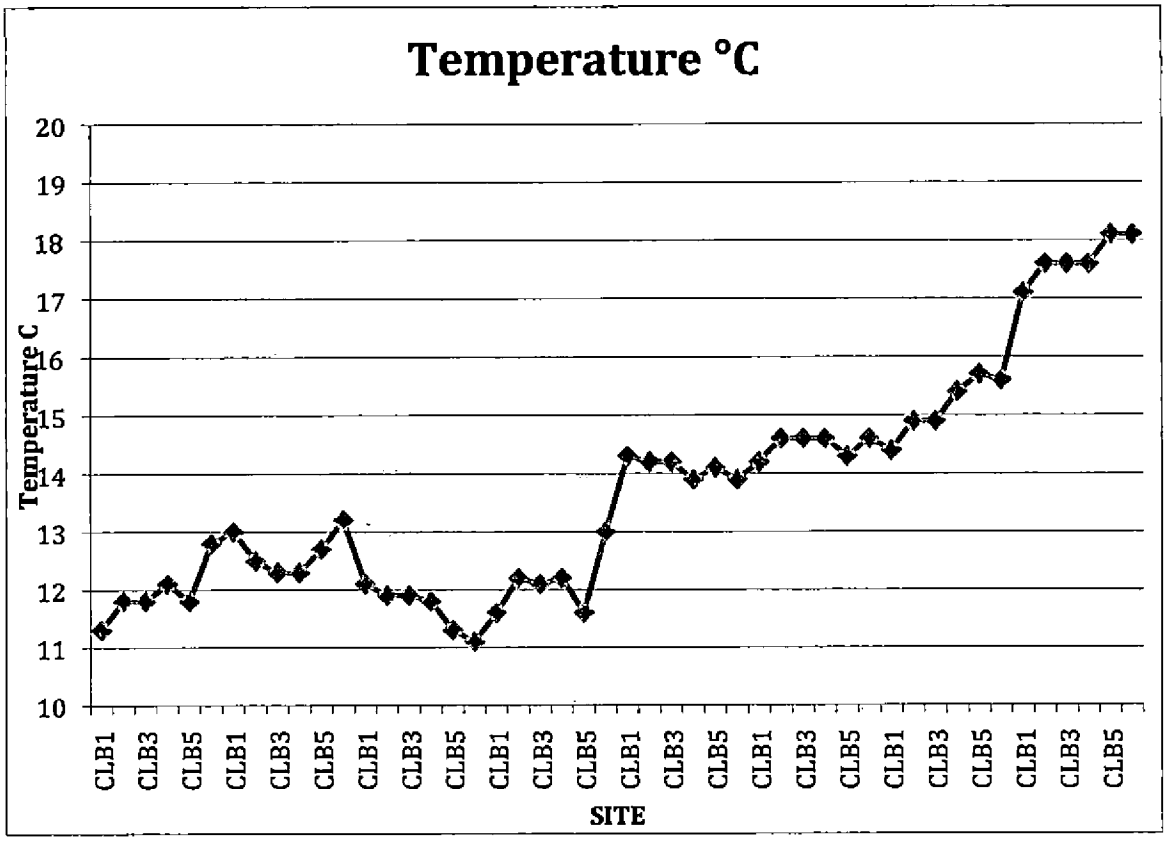

Figure 3-3. Temperature Measurements for the 8 Week Winter 2009 Sampling Period

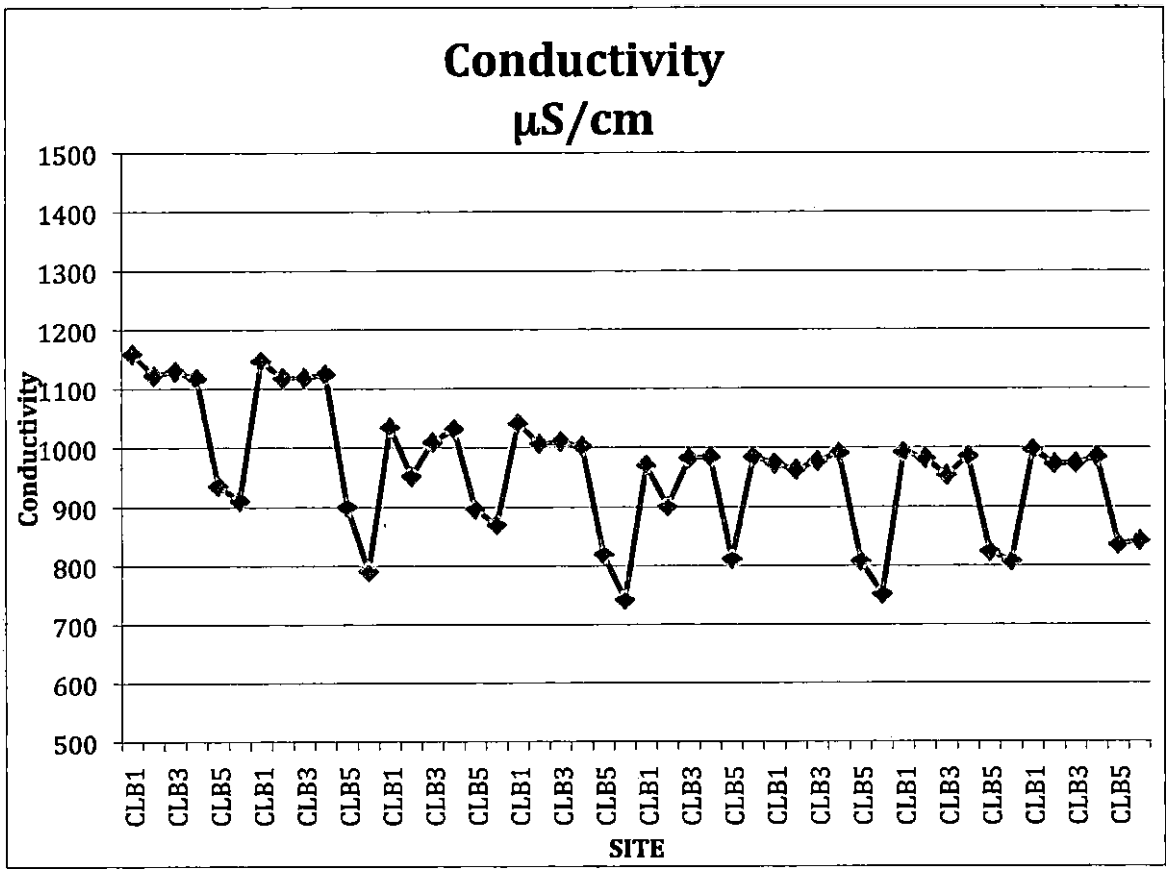

Figure 3-4. Conductivity Measurements for the 8 Week Winter 2009 Sampling Period

E.coli Bacteria Data For The Summer 2009
18 Week Sampling Period

Table 3-4 illustrated that during the summer of 2009 total coliform and *E.coli* bacteria levels at sites Clb1-3 and clb6-1 (near the drainage/ runoff areas) tended to have higher concentrations of *E.coli*.

Figures 3-5 and 3-6 showed that the bacterial levels on 07/03/09, 07/24/09, 08/14/09 and 08/21/09 were higher. Certain sites on these dates exceeded the U.S. EPA standard of 235 MPN/100mL for individual samples (indicated by a horizontal red line).

Table 3-5 illustrated that the geometric means for the summer of 2009 were consistently below the U.S. EPA 126 MPN/ 100mL 30 day average standard. However, geometric mean 8 on 07/24/09 to 08/21/09 was found to have exceeded this.

Table 3-4. *E.coli* Bacteria Data For Summer 2009 18 Week Study[ab]

	6/5/09		6/12/09		6/19/09		6/26/09	
Station	**TC**	**EC**	**TC**	**EC**	**TC**	**EC**	**TC**	**EC**
CLB1-1	>2419.6	<1	>2419.6	3.1	>2419.6	15.5	>2419.6	10.8
CLB1-2	>2419.6	2	>2419.6	1	>2419.6	3.1	>2419.6	12.1
CLB1-3	>2419.6	1	>2419.6	8.4	>2419.6	47.3	>2419.6	13.2 (2)
CLB2	>2419.6	<1	>2419.6	<1	>2419.6	<1	>2419.6	<1 (1)
CLB3	>2419.6	<1	>2419.6	2	>2419.6	2	>2419.6	1
CLB4-1	>2419.6	86.5	>2419.6	57.3	>2419.6	12.1	>2419.6	12.2
CLB4-2	>2419.6	6.3	>2419.6	86.5	>2419.6	33.6	>2419.6	24.1
CLB4-3	>2419.6	7.3	>2419.6	49.6	>2419.6	<1	>2419.6	6.3
CLB5-1	>2419.6	4.1	>2419.6	25.3	>2419.6	9.5	>2419.6	14.8
CLB5-2	>2419.6	<1	>2419.6	8.4	>2419.6	15.6	>2419.6	1
CLB5-3	>2419.6	9.8	>2419.6	49.6	>2419.6	6.3	>2419.6	3.1
CLB6-1	>2419.6	15.8	>2419.6	17.4	>2419.6	5.2	>2419.6	7.4
CLB6-2	>2419.6	4.1	>2419.6	20.1	>2419.6	8.2	>2419.6	67.7
CLB6-3	>2419.6	8.4	>2419.6	8.3	>2419.6	7.3	>2419.6	11
Dup1	>2419.6		>2419.6		>2419.6		>2419.6	<1
Dup2	>2419.6		>2419.6		>2419.6		>2419.6	11
Blank	0	0	0	0	0	0	0	0

[a]The numbers in parentheses indicate the sites where duplicate samples were collected. [b]The sites exceeding the 235 MPN limit are marked with an asterisk (*).

Table 3-4. *E.coli* Bacteria Data For Summer 2009 18 Week Study (Continued)[ab]

	7/3/09		7/10/09		7/17/09		7/24/09	
Station	**TC**	**EC**	**TC**	**EC**	**TC**	**EC**	**TC**	**EC**
CLB1-1	>2419.6	9.8	>2419.6	13.4	>2419.6	1	>2419.6	38.6
CLB1-2	>2419.6	72.3	>2419.6	10.9	>2419.6	3.1	>2419.6	6.3 (1)
CLB1-3	>2419.6	*1299.7	>2419.6	18.3	>2419.6	27.5	>2419.6	9.8
CLB2	547.5	1.0 (1)	613.1	<1 (1)	727	<1	410.6	<1
CLB3	579.4	<1	435.2	<1 (2)	579.4	<1	228.2	<1
CLB4-1	648.8	7.3 (2)	686.7	<1	770.1	<1 (1)	866.4	2
CLB4-2	488.4	1	920.8	<1	1046.2	<1	1732.9	1
CLB4-3	461.1	1	>2419.6	2	209.8	<1	1119.9	<1
CLB5-1	>2419.6	4.1	>2419.6	3.1	>2419.6	11	>2419.6	6.3 (2)
CLB5-2	>2419.6	6.3	1986.3	1	>2419.6	2	>2419.6	14.6
CLB5-3	>2419.6	5.2	>2419.6	1	>2419.6	6.3	>2419.6	*1732.9
CLB6-1	>2419.6	84.2	>2419.6	6.3	>2419.6	9.6	>2419.6	6.1
CLB6-2	>2419.6	19.9	>2419.6	2	>2419.6	16.1 (2)	>2419.6	3
CLB6-3	>2419.6	14.5	>2419.6	1	>2419.6	7.4	>2419.6	49
Dup1	686.7	1	387.3	<1	866.4	<1	>2419.6	10.7
Dup2	727	13	648.8	1	>2419.6	10.9	2419.6	6.3
Blank	0	0	0	0	0	0	0	0

[a]The numbers in parentheses indicate the sites where duplicate samples were collected. [b]The sites exceeding the 235 MPN limit are marked with an asterisk (*).

Table 3-4. *E.coli* Bacteria Data For Summer 2009 18 Week Study (Continued)[ab]

	7/31/09		8/7/09		8/14/09		8/21/09	
Station	**TC**	**EC**	**TC**	**EC**	**TC**	**EC**	**TC**	**EC**
CLB1-1	>2419.6	2	>2419.6	14.6 (1)	>2419.6	2	>2419.6	71.7
CLB1-2	>2419.6	6.1 (1)	>2419.6	<1	>2419.6	18.7	>2419.6	6.3
CLB1-3	>2419.6	32.7	>2419.6	4.1	>2419.6	10.6	>2419.6	*866.4
CLB2	686.7	<1	866.4	<1	1299.7	<1	>2419.6	<1 (1)
CLB3	488.4	<1	727	<1	1119.9	<1	>2419.6	<1
CLB4-1	2419.6	4.1 (2)	2419.6	<1	>2419.6	<1	>2419.6	<1
CLB4-2	1732.9	2	1986.3	1	1413.6	<1	>2419.6	<1
CLB4-3	770.1	3.1	>2419.6	<1	1203.3	2	>2419.6	1
CLB5-1	>2419.6	2	>2419.6	1	>2419.6	35	>2419.6	19.7 (2)
CLB5-2	>2419.6	2	>2419.6	2 (2)	>2419.6	<1	>2419.6	2
CLB5-3	>2419.6	4.1	>2419.6	3	>2419.6	17.5 (1)	>2419.6	3
CLB6-1	>2419.6	51.2	>2419.6	4.1	>2419.6	66.3	>2419.6	9.7
CLB6-2	>2419.6	*307.6	>2419.6	9.5	>2419.6	122.2	>2419.6	16
CLB6-3	>2419.6	*>2419.6	>2419.6	23.5	>2419.6	*727 (2)	>2419.6	29.9
Dup1	>2419.6	4.1	>2419.6	20.1	>2419.6	8.6	1553.1	1
Dup2	1986.3	5.2	2419.6	1	>2419.6	*579.4	>2419.6	16.1
Blank	0	0	0	0	0	0	0	0

[a]The numbers in parentheses indicate the sites where duplicate samples were collected. [b]The sites exceeding the 235 MPN limit are marked with an asterisk (*).

Table 3-4. *E.coli* Bacteria Data For Summer 2009 18 Week Study (Continued)[ab]

	8/28/09		9/4/09		09/11/09		9/18/09	
Station	**TC**	**EC**	**TC**	**EC**	**TC**	**EC**	**TC**	**EC**
CLB1-1	>2419.6	2	>2419.6	13.2	>2419.6	2	>2419.6	39
CLB1-2	>2419.6	2	>2419.6	3	>2419.6	6.3	>2419.6	18.5
CLB1-3	>2419.6	4.1	>2419.6	21.3	>2419.6	5.1 (1)	>2419.6	128.1
CLB2	>2419.6	<1 (1)	>2419.6	<1 (1)	>2419.6	<1	>2419.6	1 (1)
CLB3	1732.9	<1	>2419.6	1	>2419.6	<1	2419.6	<1
CLB4-1	>2419.6	<1	>2419.6	<1	>2419.6	1	1986.3	<1
CLB4-2	>2419.6	<1	>2419.6	<1	>2419.6	4.1 (2)	2419.6	1
CLB4-3	>2419.6	<1	>2419.6	19.7	>2419.6	3.1	1986.3	<1
CLB5-1	>2419.6	1	>2419.6	5.2	>2419.6	6.1	>2419.6	4.1 (2)
CLB5-2	>2419.6	<1	>2419.6	4.1	>2419.6	5.2	>2419.6	<1
CLB5-3	>2419.6	1 (2)	>2419.6	6.2 (2)	>2419.6	8.1	>2419.6	3
CLB6-1	>2419.6	8.4	>2419.6	20.1	>2419.6	54.3	>2419.6	2
CLB6-2	>2419.6	<1	>2419.6	6.3	>2419.6	18.1	>2419.6	17.1
CLB6-3	>2419.6	1	>2419.6	70.5	>2419.6	15.8	>2419.6	7.4
Dup1	>2419.6	<1	>2419.6	<1	>2419.6	6.1	2419.6	<1
Dup2	>2419.6	<1	>2419.6	8.5	>2419.6	1	>2419.6	4.1
Blank	0	0	0	0	0	0	0	0

[a]The numbers in parentheses indicate the sites where duplicate samples were collected. [b]The sites exceeding the 235 MPN limit are marked with an asterisk (*).

Table 3-4. *E.coli* Bacteria Data For Summer 2009 18 Week Study (Continued)[ab]

	9/25/09		10/2/09	
Station	**TC**	**EC**	**TC**	**EC**
CLB1-1	>2419.6	31.6	>2419.6	17.1
CLB1-2	>2419.6	<1	>2419.6	1
CLB1-3	>2419.6	10.9 (1)	>2419.6	2
CLB2	1986.3	1	>2419.6	1
CLB3	1986.3	<1	>2419.6	<1
CLB4-1	770.1	<1	>2419.6	<1
CLB4-2	1119.9	<1	>2419.6	<1
CLB4-3	>2419.6	<1 (2)	>2419.6	2 (1)
CLB5-1	>2419.6	2	>2419.6	23.1
CLB5-2	>2419.6	1	>2419.6	1
CLB5-3	>2419.6	<1	>2419.6	4.1
CLB6-1	>2419.6	3	>2419.6	5.2
CLB6-2	>2419.6	6.1	>2419.6	37.2
CLB6-3	>2419.6	2	>2419.6	24.3 (2)
Dup1	>2419.6	12	>2419.6	2
Dup2	>2419.6	<1	>2419.6	9.5
Blank	0	0	0	0

[a]The numbers in parentheses indicate the sites where duplicate samples were collected. [b]The sites exceeding the 235 MPN limit are marked with an asterisk (*).

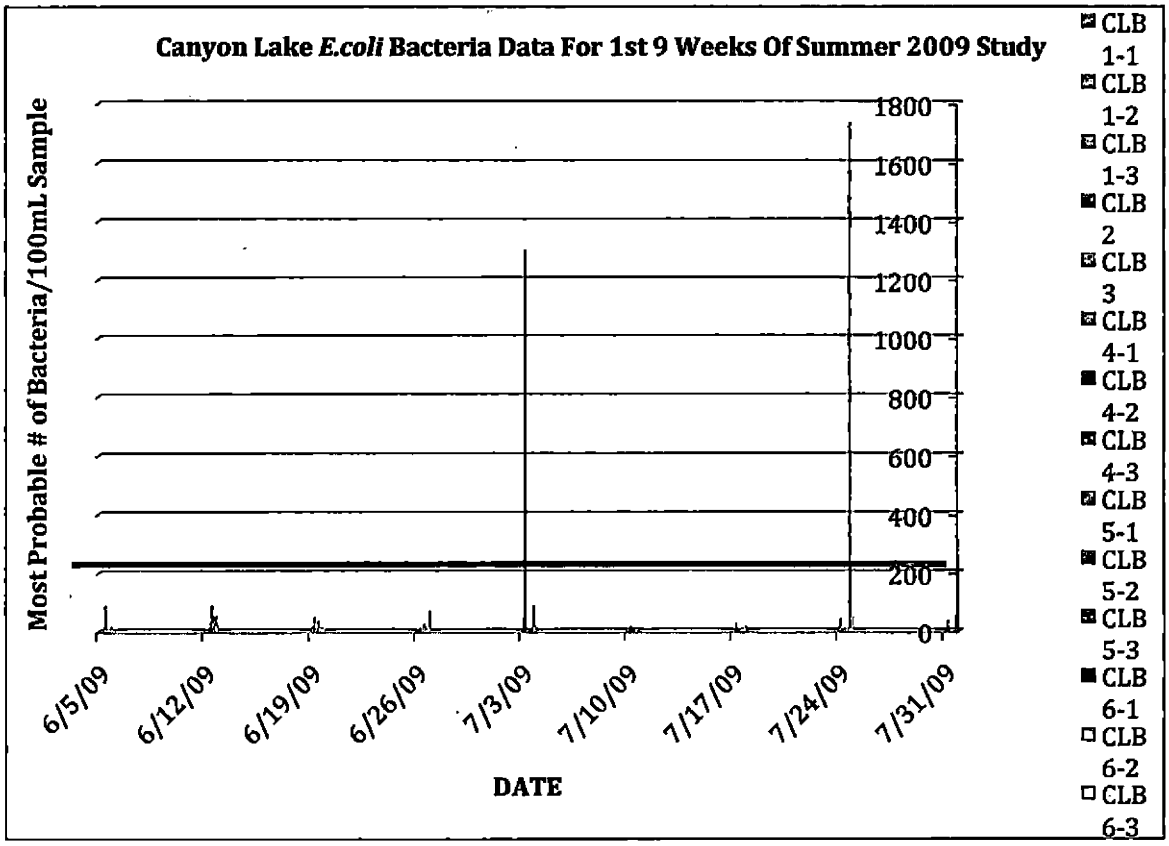

Figure 3-5. Canyon Lake Bacteria Data for the 1st 9 Weeks of the Summer 2009 Study

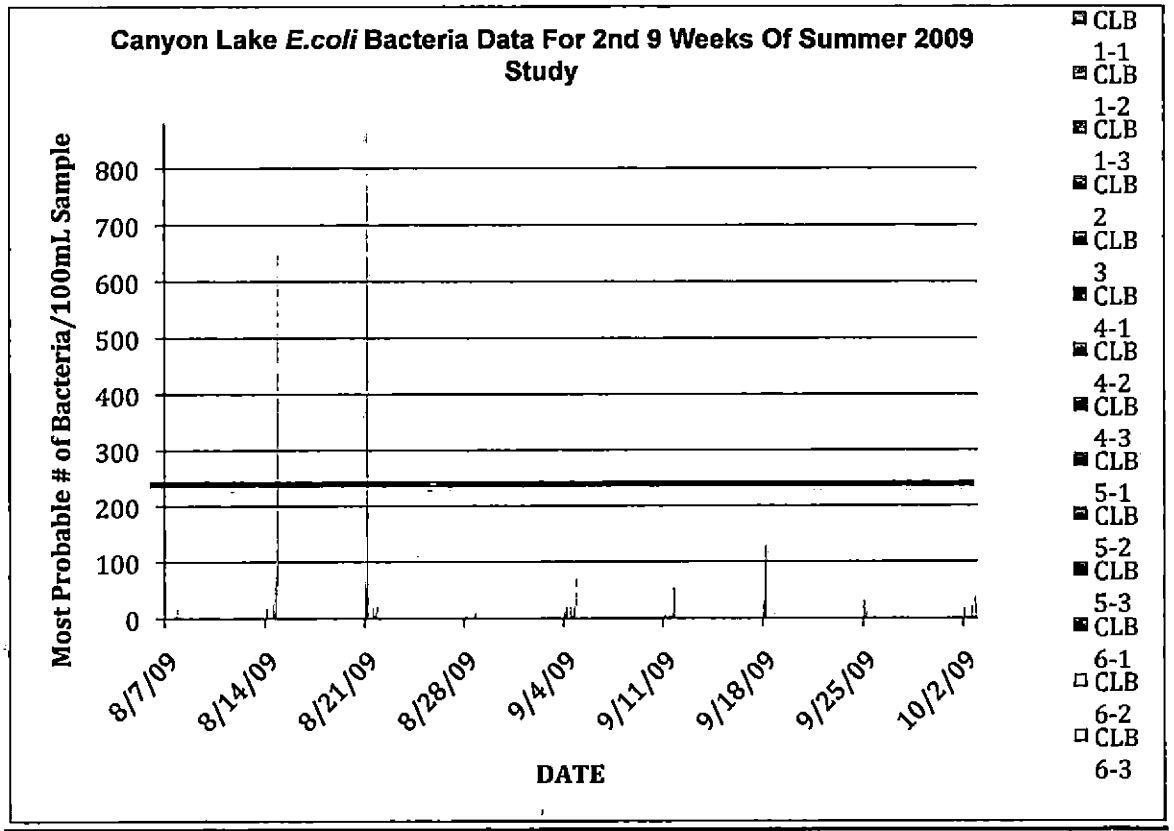

Figure 3-6. Canyon Lake *E.coli* Bacteria Data for the 2nd 9 Weeks of the Summer 2009 Study

Table 3-5. 30 Day Geometric Means (Geomean) For Summer 2009 Study[a]

	6/5-7/3	6/12-7/10	6/19-7/17	6/26-7/24	7/3-7/31	7/10-8/7	7/17-8/14
Station	Geomean 1	Geomean 2	Geomean 3	Geomean 4	Geomean 5	Geomean 6	Geomean 7
CLB1-1	5.5	9.3	7.4	8.9	6.3	6.9	4.7
CLB1-2	9.8	11.3	9.9	4.2	9.9	4.2	4.7
CLB1-3	52.7	38.5	46.2	14.6	46.2	14.6	13.1
CLB2	1.0	1.0	1.0	1.0	1.0	1.0	1.0
CLB3	1.1	1.0	1.0	1.0	1.0	1.0	1.0
CLB4-1	4.0	2.8	2.3	1.5	2.3	1.5	1.5
CLB4-2	3.8	1.9	1.1	1.1	1.1	1.1	1.1
CLB4-3	1.7	1.7	1.4	1.4	1.4	1.4	1.4
CLB5-1	7.2	6.7	4.5	3.4	4.5	3.4	5.5
CLB5-2	2.9	2.8	3.3	2.6	3.3	2.6	2.6
CLB5-3	3.6	11.2	11.8	10.6	11.8	10.6	18.8
CLB6-1	11.4	11.8	17.4	9.5	17.4	9.5	15.2
CLB6-2	12.9	10.5	14.3	12.3	14.3	12.3	28.0
CLB6-3	6.1	9.0	26.4	29.0	26.4	29.0	108.4
Min	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Max	52.7	38.5	46.2	29.0	46.2	29.0	108.4

[a]The highlighted value indicates an exceedence of the 126 MPN/ 100mL standard.

Table 3-5. 30 Day Geometric Means (Geomean) For Summer 2009 Study (Continued)[a]

	7/24-8/21	7/31-8/28	8/7-9/4	8/14-9/11	8/21-9/18	8/28-9/25	9/4-10/2
Station	Geomean 8	Geomean 9	Geomean 10	Geomean 11	Geomean 12	Geomean 13	Geomean 14
CLB1-1	11.0	6.1	8.9	6.0	10.8	9.2	14.1
CLB1-2	5.4	4.3	3.7	5.4	5.4	3.7	3.2
CLB1-3	26.1	21.9	20.1	21.0	34.6	14.4	12.5
CLB2	1.0	1.0	1.0	1.0	1.0	1.0	1.0
CLB3	1.0	1.0	1.0	1.0	1.0	1.0	1.0
CLB4-1	1.5	1.3	1.0	1.0	1.0	1.0	1.0
CLB4-2	1.1	1.1	1.0	1.3	1.3	1.3	1.3
CLB4-3	1.4	1.4	2.1	2.6	2.3	2.3	2.6
CLB5-1	6.1	4.2	5.1	7.4	4.8	3.0	5.7
CLB5-2	2.6	1.5	1.7	2.1	2.1	1.8	1.8
CLB5-3	16.2	3.6	4.0	4.8	3.4	2.7	3.6
CLB6-1	15.2	16.3	13.5	22.6	11.2	8.9	8.1
CLB6-2	28.0	22.5	10.3	11.7	7.9	6.5	13.5
CLB6-3	[redacted]	65.8	32.5	30.0	12.0	7.0	13.2
Min	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Max	[redacted]	65.8	32.5	30.0	34.6	14.4	14.1

[a]The highlighted value indicates an exceedence of the 126 MPN/ 100mL standard.

Table 3-6 showed the weather conditions, locations, conductivity (µS/Cm), pH and temperature (°C) for the various sampling locations on each date for the 18 weeks of the study during summer 2009. The temperature, pH and conductivity measurements were taken to determine if these characteristics had an impact on bacteria levels. There does not appear to be a correlation between them and bacteria levels in this study. Any general comments about the atmosphere of Canyon Lake on each sampling date were also recorded. The general trend was that with less rainfall during the summer the temperature and conductivity rose and the pH decreased.

Figure 3-7 showed that the pH decreased over time for the summer 2009 sampling period.

Figure 3-8 showed that the temperature fluctuated during the summer 2009 sampling period.

Figure 3-9 showed that the conductivity during the 18 week sampling period of summer 2009 increased with time.

Table 3-6. Environmental Conditions For Canyon Lake, California During The 18 Week Summer 2009 Sampling Period[a]

DATE	Weather	Comments	Location	Conductivity µS/Cm	pH	Temperature °C
6/5/09	Sunny, Cloudy and Cool		CLB1	1010	9.19	23.9
			CLB2	1076	9	24
			CLB3	1077	9.07	23.8
			CLB4	1020	9.22	24
			CLB5	1023	9.19	23.8
			CLB6	1028	9.18	24.3
6/12/09	Cool and Cloudy with Slight Sunlight	Birds Present at CLB4 and CLB6	CLB1	1036	9.04	21.6
			CLB2	1038	9.05	21.9
			CLB3	1036	9.13	21.8
			CLB4	1021	9.16	21.9
			CLB5	1036	9	21.8
			CLB6	1053	9.03	22.2

[a]The unit for conductivity is micro siemens per centimeter (µS/cm). The unit for temperature is degree celsius (°C).

Table 3-6. Environmental Conditions For Canyon Lake, California During The 18 Week Summer 2009 Sampling Period (Continued)[a]

DATE	Weather	Comments	Location	Conductivity µS/Cm	pH	Temperature °C
6/19/09	Sunny and Hot	Birds Present at CLB1 and CLB5 and Swimmer Present at CLB1	CLB1	1035	9.19	24.3
			CLB2	1051	9.21	24.4
			CLB3	1015	9.22	24.2
			CLB4	1036	9.19	25.4
			CLB5	1048	9.24	24.5
			CLB6	1062	9.24	25.5
6/26/09	Sunny and Warm		CLB1	1041	9.18	25.6
			CLB2	1039	9.21	25.8
			CLB3	1050	9.21	25.7
			CLB4	1039	9.2	25.8
			CLB5	1054	9.37	25.4
			CLB6	1066	9.33	26.9

[a]The unit for conductivity is micro siemens per centimeter (µS/cm). The unit for temperature is degree celsius (°C).

Table 3-6. Environmental Conditions For Canyon Lake, California During The 18 Week Summer 2009 Sampling Period (Continued)[a]

DATE	Weather	Comments	Location	Conductivity µS/Cm	pH	Temperature °C
7/3/09	Sunny and Clear Skies	Debris and Turbidity at CLB1	CLB1	1046	9.07	27.1
			CLB2	1057	9.17	27.4
			CLB3	1043	9.18	26.7
			CLB4	1072	9.18	27.2
			CLB5	1037	9.17	27.3
			CLB6	1076	9.1	27.8
7/10/09	Sunny and Clear	Birds Present at CLB1	CLB1	1035	8.94	26.8
			CLB2	1094	9.13	25.8
			CLB3	1051	9.06	25.7
			CLB4	1071	9.03	23.6
			CLB5	1056	9.09	26.8
			CLB6	1066	9.09	26.4

[a]The unit for conductivity is micro siemens per centimeter (µS/cm). The unit for temperature is degree celsius (°C).

Table 3-6. Environmental Conditions For Canyon Lake, California During The 18 Week Summer 2009 Sampling Period (Continued)[a]

DATE	Weather	Comments	Location	Conductivity µS/Cm	pH	Temperature °C
7/17/09	Sunny and Cool	Birds and Swimmers Present at CLB1	CLB1	1075	8.95	28.3
			CLB2	1060	9.03	28.4
			CLB3	1063	9.03	28.3
			CLB4	1061	9.05	28.4
			CLB5	1067	9.1	28.5
			CLB6	1085	9.05	28.8
7/24/09	Sunny and Hot	Swimmers Present at CLB4	CLB1	1061	8.94	29.1
			CLB2	1141	8.86	29.3
			CLB3	1085	8.98	29.1
			CLB4	1083	8.99	28.9
			CLB5	1075	9.04	29.6
			CLB6	1140	8.99	29.6

[a]The unit for conductivity is micro siemens per centimeter (µS/cm). The unit for temperature is degree celsius (°C).

Table 3-6. Environmental Conditions For Canyon Lake, California During The 18 Week Summer 2009 Sampling Period (Continued)[a]

DATE	Weather	Comments	Location	Conductivity µS/Cm	pH	Temperature °C
7/31/09	Overcast and Foggy	Birds Present at CLB1 and CLB6 and Swimmers Present at CLB1	CLB1	1065	8.86	28.4
			CLB2	1060	8.98	28.5
			CLB3	1062	8.99	28.5
			CLB4	1065	9	28.4
			CLB5	1061	8.92	28.1
			CLB6	1065	8.84	27.9
8/7/09	Cool and Cloudy	Birds Present at CLB1	CLB1	1081	8.96	27.5
			CLB2	1071	9.01	27.5
			CLB3	1090	9	27.5
			CLB4	1071	9	27.2
			CLB5	1093	8.57	27.2
			CLB6	1094	8.6	27.5

[a]The unit for conductivity is micro siemens per centimeter (µS/cm). The unit for temperature is degree celsius (°C).

Table 3-6. Environmental Conditions For Canyon Lake, California During The 18 Week Summer 2009 Sampling Period (Continued)[a]

DATE	Weather	Comments	Location	Conductivity µS/Cm	pH	Temperature °C
8/14/09	Cloudy and Cool	Birds Present at CLB1 and CLB6 and Swimmers Present at CLB1	CLB1	1060	8.93	27.5
			CLB2	1066	9.02	27.6
			CLB3	1067	9.02	27.7
			CLB4	1071	9.03	27.4
			CLB5	1068	8.65	27.2
			CLB6	1092	8.42	27.3
08/21/09	Cloudy, Cool and Humid	Swimmers Present at CLB2	CLB1	1095	8.88	27.3
			CLB2	1148	8.97	27.3
			CLB3	1077	9.00	27.3
			CLB4	1079	9.00	27.3
			CLB5	1095	8.79	27.0
			CLB6	1104	8.71	27.4

[a]The unit for conductivity is micro siemens per centimeter (µS/cm). The unit for temperature is degree celsius (°C).

Table 3-6. Environmental Conditions For Canyon Lake, California During The 18 Week Summer 2009 Sampling Period (Continued)[a]

DATE	Weather	Comments	Location	Conductivity µS/Cm	pH	Temperature °C
8/28/09	Sunny and Hot	Birds Present at CLB2	CLB1	1092	8.85	27
			CLB2	1093	8.93	27.1
			CLB3	1088	8.95	27
			CLB4	1093	8.92	21.3
			CLB5	1112	8.72	26.6
			CLB6	1117	8.69	28.1
9/4/09	Sunny and Hot		CLB1	1091	8.88	27.9
			CLB2	1086	8.99	28.1
			CLB3	1104	8.96	28
			CLB4	1095	8.95	27.9
			CLB5	1107	8.7	28.4
			CLB6	1136	8.59	28.7

[a]The unit for conductivity is micro siemens per centimeter (µS/cm). The unit for temperature is degree celsius (°C).

Table 3-6. Environmental Conditions For Canyon Lake, California During The 18 Week Summer 2009 Sampling Period (Continued)[a]

DATE	Weather	Comments	Location	Conductivity µS/Cm	pH	Temperature °C
9/11/09	Sunny and Warm	People, Pets and Birds Present at CLB1	CLB1	1074	8.66	26.4
			CLB2	1094	8.77	26.5
			CLB3	1094	8.8	26.5
			CLB4	1098	8.82	26.5
			CLB5	1114	8.62	26.3
			CLB6	1141	8.62	26.6
9/18/09	Sunny and Hot	Birds and People Present at CLB1	CLB1	1093	8.63	25.9
			CLB2	1104	8.79	26
			CLB3	1103	8.85	26.3
			CLB4	1095	8.85	26.2
			CLB5	1155	8.64	25.8
			CLB6	1194	8.74	26.8

[a]The unit for conductivity is micro siemens per centimeter (µS/cm). The unit for temperature is degree celsius (°C).

Table 3-6. Environmental Conditions For Canyon Lake, California During The 18 Week Summer 2009 Sampling Period (Continued)[a]

DATE	Weather	Comments	Location	Conductivity µS/Cm	pH	Temperature °C
9/25/09	Sunny and Warm	Birds Present at CLB1 and Debris Present at CLB4	CLB1	1080	8.66	24.9
			CLB2	1089	8.78	25.6
			CLB3	1095	8.78	25.4
			CLB4	1099	8.77	25.2
			CLB5	1160	8.54	25.2
			CLB6	1186	8.54	25.3
10/2/09	Sunny and Cool	Birds Present at CLB1 and CLB6	CLB1	1166	8.39	23
			CLB2	1113	8.53	23.8
			CLB3	1115	8.58	23.8
			CLB4	1114	8.64	24
			CLB5	1174	8.28	23.4
			CLB6	1202	8.59	23.4

[a]The unit for conductivity is micro siemens per centimeter (µS/cm). The unit for temperature is degree celsius (°C).

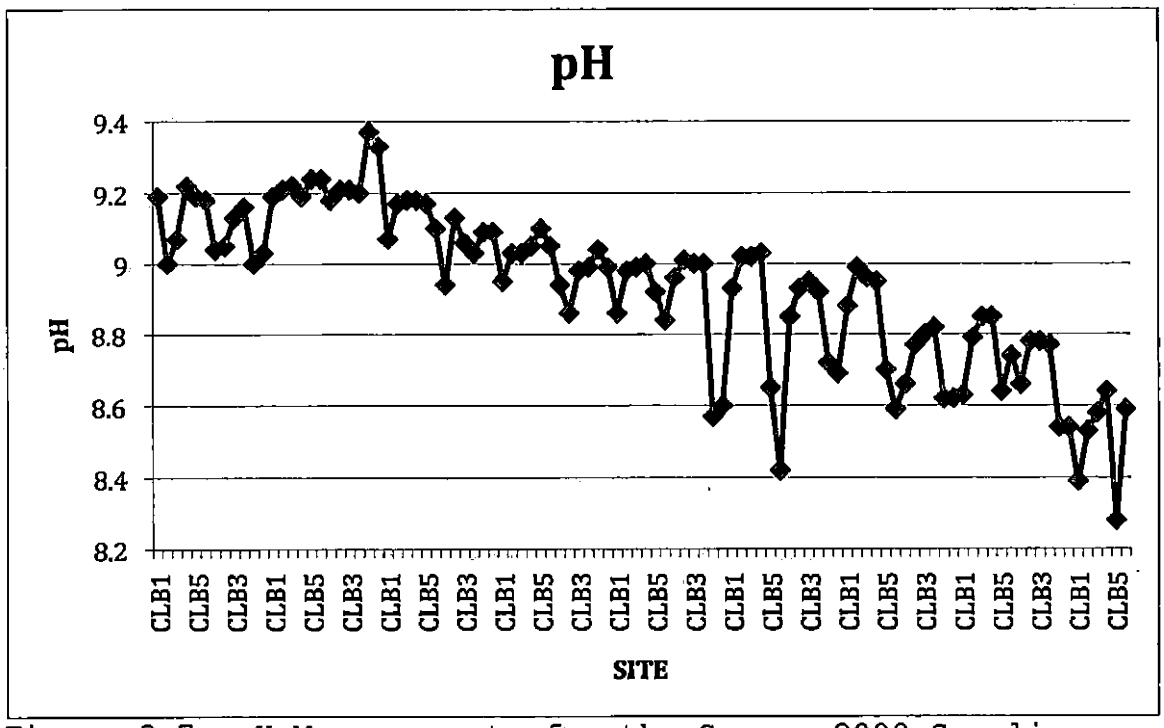

Figure 3-7. pH Measurements for the Summer 2009 Sampling Period

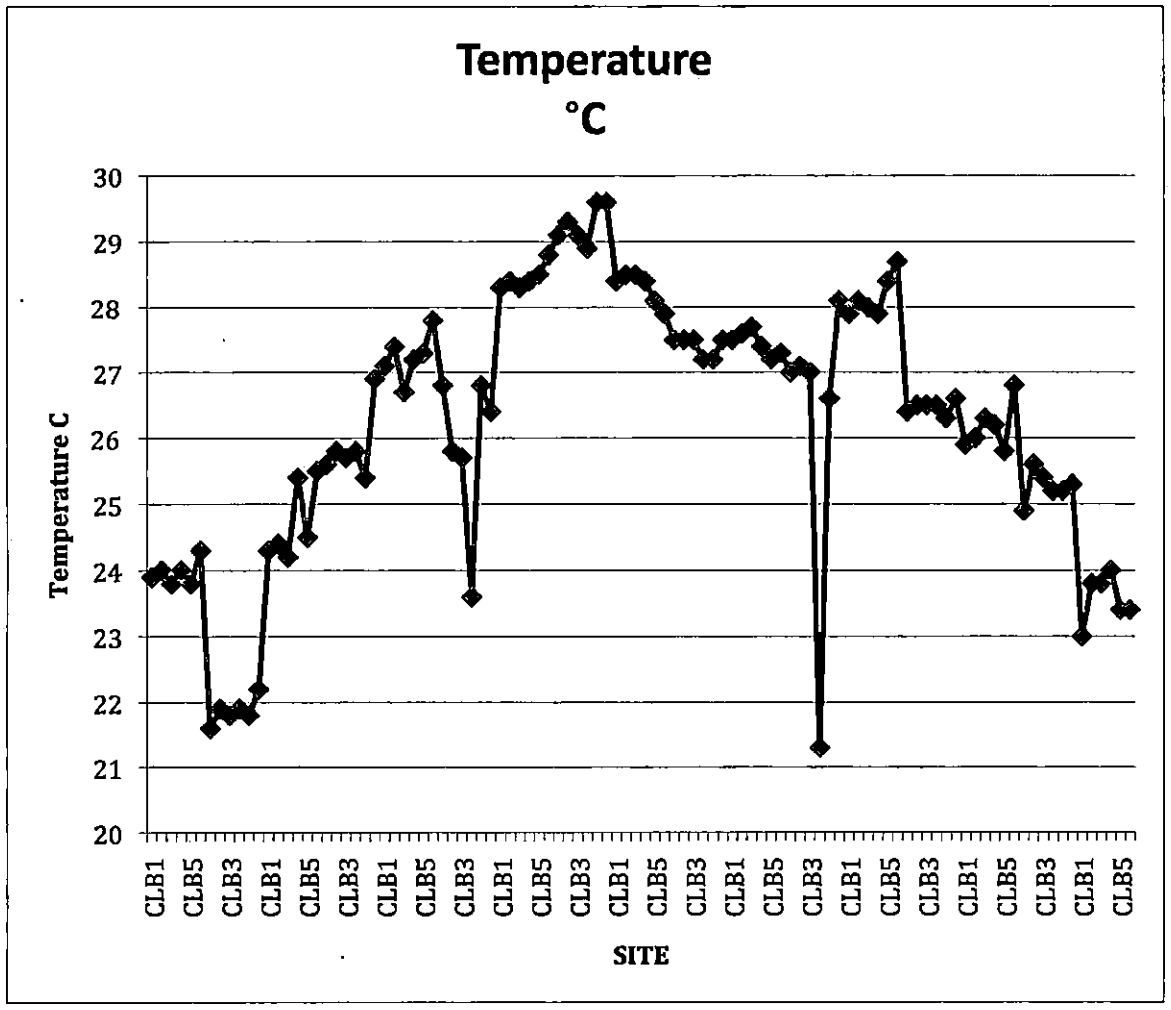

Figure 3-8. Temperature Measurements for the 18 Weeks During the Summer 2009 Sampling Period

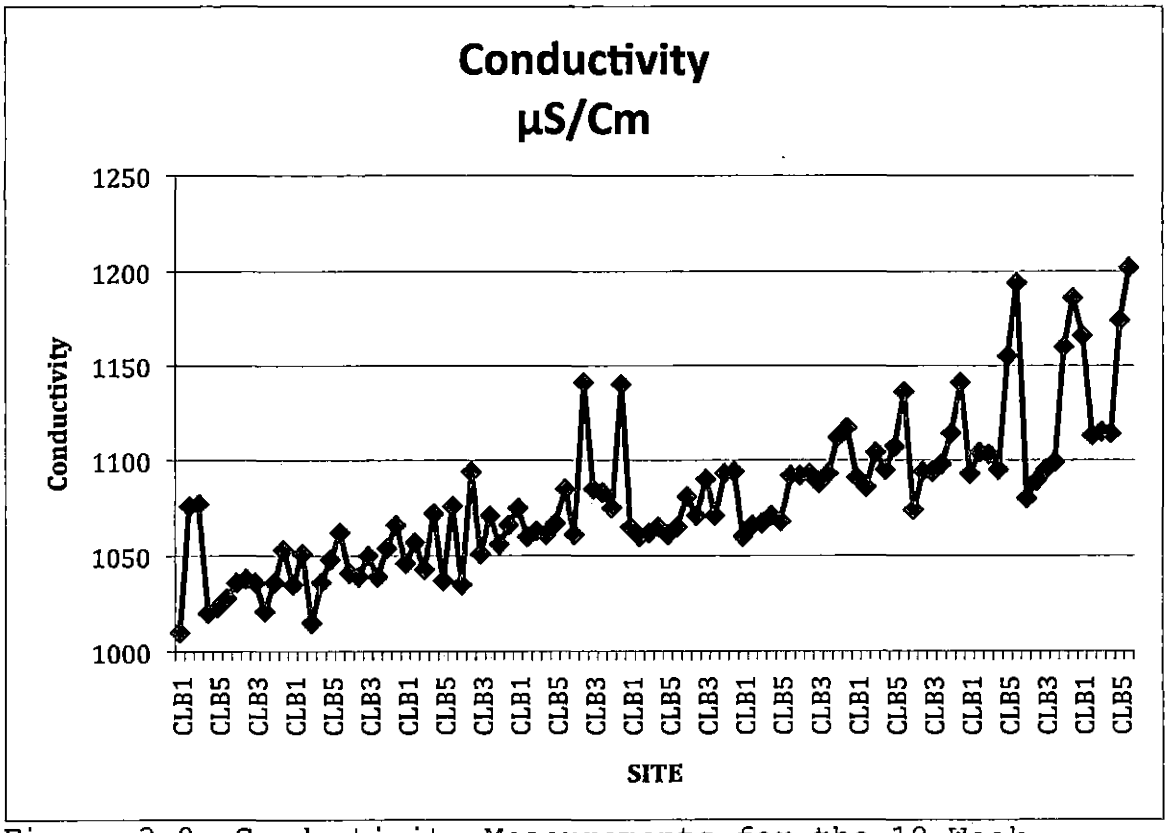

Figure 3-9. Conductivity Measurements for the 18 Week Summer 2009 Sampling Period

Canyon Lake, California Enterococci Bacteria Data

Table 3-7 illustrated that the Enterococci bacteria were consistently low during summer 2009.

Table 3-7. Enterococci Bacteria Data For Selected Dates During Summer 2009

Date	Site	MPN Of Enterococci Per 100mL
06/26/09	CLB1	22.8
	CLB2	<1
	CLB3	<1
	CLB4	4.0
	CLB5	10.8
	CLB6	4.1
07/03/09	CLB1	866.4
	CLB2	<1
	CLB3	1.0
	CLB4	<1
	CLB5	1.0
	CLB6	34.5
07/10/09	CLB1	<1
	CLB2	1.0
	CLB3	2.0
	CLB4	<1
	CLB5	<1
	CLB6	4.1

CHAPTER FOUR

CONCLUSION

Overall Conclusions

This study showed that the bacterial levels for *E. coli* during the summer session (illustrated in Table 3-4 and Figures 3-5 and 3-6) exceeded the U.S. EPA criteria of 235 MPN/ 100mL for single event and 126 MPN/ 100mL for the 30 day average more times than the winter session (illustrated in Table 3-1 and Figure 3-1). The Enterococci data suggested that there was no significant contamination with this bacterium, as the levels were consistently low (as illustrated in Table 3-7). Moreover, the Enterococcus sampling data (on 06/26/09, 07/03/09 and 07/10/09) correlates with the *E.coli* data. On dates that showed a higher concentration for *E.coli,* Enterococcus was also found to be high, and vice versa. Also, throughout this study the geometric means were consistently below the 126 MPN/ 100mL U.S. EPA 30 day average standard (as seen in Tables 3-2 and 3-5). The only exception to this was that the geomean 8 on 07/24/09 to 08/21/09 (Table 3-5) exceeded this standard.

Comparison To Previous Study

The trends found in this study do appear to be in agreement with the previous study by Davis et al. (2005). The water temperatures were consistent with an average of around 26°C during the summer season. The pH was also found to be consistent with a mean of around 8.2. The Conductivity (µS/cm) was found to be around 1,000 µS/cm for this study and 1139µS/cm for the previous study. So dissolved solids concentrations in Canyon Lake appear to have been stable over the past seven years. Also, the bacteria levels did follow a seasonal trend in both studies.

Winter 2009 8 Week Sampling Period Conclusions

During the winter sampling session there was colder weather and increased rainfall. With this came increased bacteria levels. The CLB1 and CLB6 sites (near the open drains) were found to have the highest levels of *E.coli* during this season. This was most likely due to dry weather runoff from surrounding areas and local drains and sewer lines that empty into the lake with the rainwater. Also with increased rainfall came an increase in pH (Figure 3-2); as well as, a decrease in temperature (Figure 3-3) and

conductivity (Figure 3-4). This trend was seen in Table 3-3 also.

Summer 2009 18 Week Sampling Period Conclusions

During the summer sampling session there was warmer weather and almost no rainfall. With this came lower bacteria levels. The CLB1 and CLB6 sites (near the open drains) were found to have the highest levels of *E.coli* during this season. This is most likely due to the runoff from the local drains. Also, with decreased rainfall came an increase in temperature (Figure 3-8) and conductivity (Figure 3-9); as well as, a decrease in pH (Figure 3-7). This trend was illustrated in Table 3-6 also.

Summary Of Data

The results of the 8-week Winter sampling show that only one of the 128 total samples analyzed exceeded the single event criteria of 235 MPN/100mL, and none of the 56 calculated geometric means exceeded the 30-day average criteria of 126 MPN/100mL. The results of the summer sampling show that only 6 of the 288 total samples analyzed (2%) exceeded the 235 MPN/100mL single event criteria, and only one of the 196 calculated geometric means (0.5%) exceeded the 30-day average criteria of 126 MPN/100mL. The results show that Canyon Lake typically meets the U.S. EPA

recommended water quality guidelines for *E.Coli* in recreational waters during dry weather.

Recommendations

As per the Regional Board it is recommended, based on the preceding results that Canyon Lake in California should be removed from the Clean Water Act's 2002 303(d) list of impaired water bodies.

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