



DRAFT Technical Report

2009

SWAMP Safe-to-Swim Study, June 2009

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SWAMP Safe-to-Swim Study, June 2009

DRAFT November 2009

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CENTRAL VALLEY REGION**

CALIFORNIA ENVIRONMENTAL PROTECTION AGENCY

ACKNOWLEDGEMENTS:

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1.0 EXECUTIVE SUMMARY

On June 29 and June 30, 2009, staff from the Central Valley Regional Water Quality Control Board (Central Valley Water Board) conducted focused water quality sampling to follow-up on the SWAMP Safe-to-Swim study, Labor Day 2008 (Central Valley Water Board, 2009a). The purpose of this study was to monitor and evaluate the ambient water quality of four Sacramento River Basin watersheds reported with elevated levels of *E. coli* during the Labor Day 2008 study. Since *E. coli* is only an indicator of potential pathogens and does not necessarily identify an immediate health concern, the design of this follow-up study was focused on collecting additional data on pathogen indicators (bacteria) and specific water-borne pathogen concentrations to better assess their impact on the beneficial use of recreation and to identify potential contributors by subwatershed.

The study sites were located in the Lower American River Watershed (Sacramento County), the Deer Creek Watershed (Nevada County), the Dry Creek Watershed (Placer County) and the South Yuba River Watershed (Nevada County). Sampling was conducted at the 2008 swimming hole sites and additional sites upstream for *E. coli*, *E. coli* O157:H7, total nitrate-N, total phosphate, total Kjeldahl nitrogen, ammonia-N and ortho-phosphate, specific conductivity, temperature, pH, dissolved oxygen and turbidity. In addition, selected high-use sites were evaluated for *Cryptosporidium*, *Giardia*, and *Salmonella*.

Two stakeholder groups participated with staff from the Central Valley Water Board in the site selection process and field sampling. Two field crews were needed for each of the two days required to sample a total of 17 sites. *E. coli* sample analyses were conducted at Central Valley Water Board's in-house laboratories. Other analyses were contracted to BioVir, Pacific Coast Analytical, or Sierra Foothills Laboratories.

Results show that the Lower American River, Deer Creek and Dry Creek watersheds continued to exhibit elevated *E. coli* levels at one or more sites. None of the sites tested positive for pathogenic *E. coli* O157:H7. There was no clear evidence of a single source of *E. coli* contamination in the Lower American River or the Dry Creek Watershed, where non-point urban sources are abundant. In the Deer Creek Watershed, *E. coli* values were higher upstream of the Labor Day 2008 swimming hole site in an area dominated by cattle grazing.

The Lower American River Watershed and the South Yuba River Watershed had no measurable amounts of *Cryptosporidium*, *Giardia*, or *Salmonella*. The Deer Creek Watershed had a positive value for *Cryptosporidium*, but no measurable amounts of *Giardia* or *Salmonella*. The Dry Creek Watershed had measurable amounts of *Cryptosporidium*, *Giardia*, and *Salmonella* at one or more locations. Nutrient values varied between sites but were generally low or undetectable.

Field measurements also varied between sites, but with the exception of temperature, values most often fell within water quality guidelines. It is not clear whether the nutrient or field constituents had an effect on the occurrence or concentration of *E. coli*, *E. coli* O157:H7, *Cryptosporidium*, *Giardia* or *Salmonella*.

All of the results collected in this study were passed on to the local county public health departments for evaluation. Based on the information collected in this study, future-monitoring efforts in the Central Valley Region should consider:

- Follow-up sampling at other times of the year to develop a more thorough analysis of water quality, especially in the Dry Creek and Deer Creek watersheds where measurable *E. coli*, *Giardia*, *Cryptosporidium* and/or *Salmonella* concentrations were more frequent.
- Continued cooperation and communication with stakeholders and public health departments from these watersheds to help identify potential sources of contamination.
- Continued follow-up and coordination with bacteria source identification efforts like the Central Valley Bacteria Source Identification Study, a pilot effort utilizing coordinated monitoring between the Central Valley Water Board and the University of California at Davis (Central Valley Water Board, 2009b)

Summary data sheets for each watershed are incorporated into this report and are also posted at:

http://www.waterboards.ca.gov/centralvalley/water_issues/water_quality_studies/surface_water_ambient_monitoring/swamp_regionwide_activities/index.shtml.

2.0 INTRODUCTION

On June 29 and June 30, 2009, staff from the Central Valley Regional Water Quality Control Board (Central Valley Water Board) conducted focused water quality sampling to follow-up on the SWAMP Safe-to-Swim study, Labor Day 2008 (Central Valley Water Board, 2009a). The purpose of the 2009 study was to monitor and evaluate the ambient water quality of four Sacramento River Basin watersheds reporting elevated levels of *E. coli* during the Labor Day 2008 study. Since *E. coli* is only an indicator of potential pathogens and does not necessarily identify an immediate health concern, the design of this follow-up study was focused on collecting additional data on pathogen indicators (bacteria) and specific water-borne pathogen concentrations to better assess their impact on the beneficial use of recreation and to identify potential contributors.

The study sites were located in the Lower American River Watershed (Sacramento County), the Deer Creek Watershed (Nevada County), the Dry Creek Watershed (Placer County) and the South Yuba River Watershed (Nevada County). Sampling was conducted at the 2008 swimming hole sites and additional sites upstream for *E. coli*, *E. coli* O157:H7, total nitrate-N, total phosphate, total Kjeldahl nitrogen, ammonia-N and ortho-phosphate, specific conductivity, temperature, pH, dissolved oxygen and turbidity. In addition, some sites were evaluated for *Cryptosporidium*, *Giardia*, and *Salmonella*.

3.0 BACKGROUND

One of the purposes of the Surface Water Ambient Monitoring Program (SWAMP) is to evaluate whether there is any evidence that beneficial uses are not being protected. The Central Valley Regional Water Quality Control Board Basin Plan (Central Valley Water Board, 2007a) identifies contact recreation as a beneficial use throughout the Region. Although the Basin Plan identifies a water quality objective that utilizes fecal coliform (not to exceed 400 MPN/100mL in a single sample), *E. coli* can also be utilized as an indicator for potential pathogens and is a subset of fecal coliform. The U.S. EPA has developed contact recreation guidelines for *E. coli*, and an Amendment to the Central Valley Basin Plan is pending that would change the objective to terms of *E. coli*.

On August 27, August 31, and September 3, 2008, staff from the Central Valley Water Board conducted the SWAMP Safe-to-Swim Study, Labor Day 2008. This study was a region-wide assessment of local swimming holes during a period of anticipated elevated recreation use, e.g. over a holiday weekend (Central Valley Water Board, 2009a). The study consisted of sampling before, during, and after the 2008 Labor Day weekend, using *E. coli* as a pathogen indicator. The Central Valley Water Board field staff worked with 21 cooperating watershed groups in the selection and sampling of sites.

Results showed that 52 out of a total of 57 sites did not exceed the EPA's recommended contact recreation limit for *E. coli* (>235 MPN/100mL) on any of the

three collection dates. Five sites in the Sacramento River Basin exceeded the EPA's recommended limit for *E.coli* on one or more of the collection dates. Four of the 5 sites exhibited the highest *E.coli* concentrations before the Labor Day weekend. Elevated *E. coli* concentrations prior to the highest level of human use indicate that factors other than human recreation likely dominate *E. coli* concentrations. Based on the information collected during the SWAMP Safe-to-Swim 2008 study, a follow-up study was recommended to develop a more thorough analysis of water quality in the impacted watersheds of the Lower American River (Sacramento County), Deer Creek (Nevada County), Dry Creek (Placer County) and South Yuba River (Nevada County).

4.0 MONITORING OVERVIEW

Based on recommendations in the SWAMP Safe-to-Swim Study, Labor Day 2008 report (Central Valley Water Board, 2009a), the design of this follow-up study was focused around two primary questions:

1. What are the pathogen indicator (*E. coli*) and specific waterborne pathogen concentrations at and upstream of the sites with previously elevated levels of *E. coli*?
2. Is there any evidence that beneficial uses of recreation are being impacted, and if so, where are potential contributors located (by subwatershed)?

Watershed organizations from the four Sacramento River Basin watersheds of concern were contacted for input on the selection of sampling sites and parameters during the design phase of this study. These groups were involved in the Safe-to-Swim, Labor Day 2008 study and included the American Basin Council of Watersheds (ABCW), the Friends of Deer Creek (FoDC), and the South Yuba River Citizens League (SYRCL). The FoDC and SYRCL provided staff from the Central Valley Water Board with additional information on possible sample sites and suggested collecting nutrient data for the follow-up study. In addition, both groups were able to assist the staff at the Central Valley Water Board with sample collection.

Grab water samples and field measurements were collected in accordance with the Procedures Manual for the San Joaquin River Water Quality Monitoring Program (Central Valley Water Board, 2007b). Procedures for bacterial sample preparation, collection and analysis were based on the San Joaquin River Basin Bacteria Monitoring Procedures Manual (Central Valley Water Board, 2008). All sample sites were analyzed for *E. coli*, *E. coli* O157:H7 and nutrients (total nitrate-N, total phosphate, total Kjeldahl nitrogen, ammonia-N and ortho-phosphate). In addition, some sites were evaluated for *Cryptosporidium*, *Giardia*, and *Salmonella*. Field measurements included specific conductivity, temperature, pH, dissolved oxygen and turbidity. Photographs were taken at each site during

the sampling event. The original monitoring plan included 19 sample sites. Transportation difficulties and time constraints caused 2 sites in the South Yuba River watershed to be eliminated from the study. Each of the remaining 17 sample sites were sampled once, requiring two field crews from Central Valley Water Board for two days of field work.

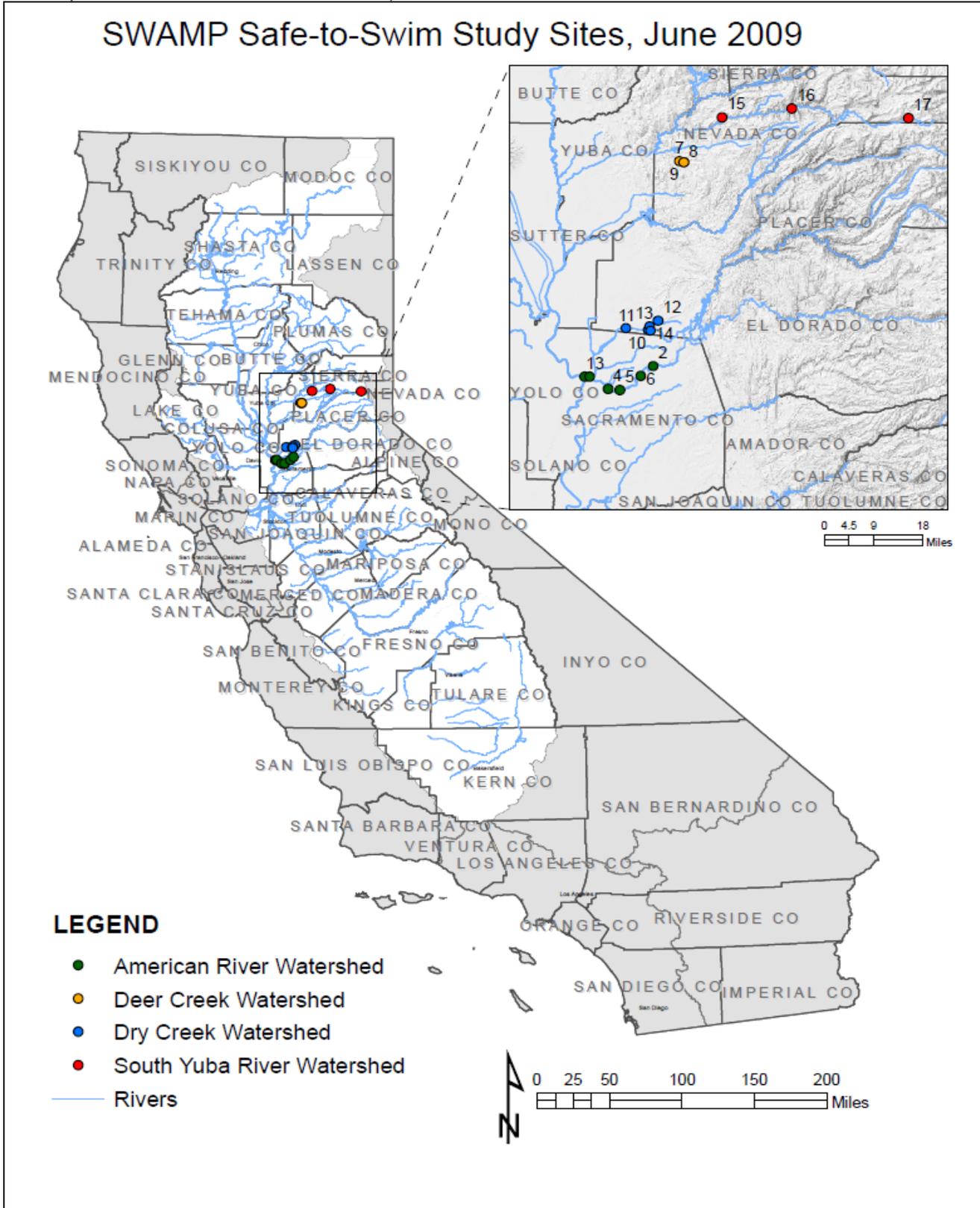
The *E. coli* analyses were conducted in-house by Central Valley Water Board staff. The *E. coli* O157:H7 presence/absence tests were performed by Pacific Coast Analytical (Sylmar, CA). *Cryptosporidium*, *Giardia*, and *Salmonella* analyses were conducted by BioVir (Benicia, CA) and the nutrient scans by Sierra Foothills Laboratory (Jackson, CA).

Table 1 provides a description of each sample location and the parameters measured. Map 1 shows the sample sites for the four Sacramento River Basin watersheds evaluated in this study.

Table 1. Safe-to-Swim Study, June 2009 - Sample Site and Parameter Summary

Number (see Map 1)	Station Number	Site Description	Latitude	Longitude	E. coli	E. coli O157:H7	Crypto/ Giardia	Salmonella	Nutrient Scan
<i>Lower American River Watershed</i>									
1	514SAC007	American River at Discovery Park	38.601706	121.502675	X	X	X	X	X
2	514SAC008	American River at Sunrise Blvd	38.633383	121.270583	X	X	X	X	X
3	514SAC009	American River at North 10th Street	38.600990	121.484310	X	X			X
4	514SAC010	American River at Fair Oaks	38.568060	121.422220	X	X			X
5	514SAC011	American River at Watt Ave. Bridge	38.565800	121.381900	X	X			X
6	514SAC012	American River at Hagan Community Park	38.605320	121.311990	X	X			X
<i>Deer Creek Watershed</i>									
7	516NEV906	Squirrel Creek in Western Gateway Park, Penn Valley	39.204047	121.190609	X	X	X	X	X
8	516NEV907	Clear Creek above confluence with Squirrel Creek	39.200533	121.176367	X	X			X
9	516NEV908	Squirrel Creek above confluence with Clear Creek	39.200883	121.176433	X	X			X
<i>Dry Creek Watershed</i>									
10	531PLA900	Dry Creek/Cirby Confluence	38.733467	121.288483	X	X	X	X	X
11	531PLA901	Dry Creek at Walerga Bridge	38.736935	121.364497	X	X	X	X	X
12	531PLA902	Miners Ravine/Secret Ravine Confluence	38.759750	121.256633	X	X			X
13	531PLA903	Dry Creek at Royer Park	38.743630	121.28368	X	X			X
14	531PLA904	Cirby Creek at Elisa Way near I80	38.730640	121.28123	X	X			X
<i>South Yuba River Watershed</i>									
15	516NEV901	South Yuba River at Purdon Crossing	39.327706	121.04730	X	X	X	X	X
16	516NEV903	South Yuba River below Washington	39.353458	120.808583	X	X			X
17	516NEV910	South Yuba River below Towle Mountain Rd	39.329174	120.40937	X	X			X

Map 1. Sample site locations for the Safe-to-Swim Study, June 2009 (Site numbers correspond to first column of Table 1)



5.0 QUALITY ASSURANCE AND QUALITY CONTROL

Grab water samples and field measurements were collected in accordance with the Procedures Manual for the San Joaquin River Water Quality Monitoring Program (Central Valley Water Board, 2007b). Procedures for bacterial sample preparation, collection and analysis were based on the San Joaquin River Basin Bacteria Monitoring Procedures Manual (Central Valley Water Board, 2008).

Samples collected for *E. coli* were analyzed using the IDEXX[®] Colilert-18 method (Analytical methods 9223B in STANDARD METHODS, EDITION 20). Results using the Colilert method are reported in terms of Most Probable Number (MPN). Analyses were conducted in the Central Valley Regional Water Quality Control Board laboratories. The QA/QC logs for bacteria analysis are found in the Central Valley Water Board laboratory where samples are analyzed.

Samples collected for *E. coli* O157:H7 were analyzed for as a presence/absence test in the laboratories of Pacific Coast Analytical (Sylmar, CA) using the FDA's Standard Method 99D-448,4489.

Samples collected for *Cryptosporidium* and *Giardia* were analyzed in the laboratories of BioVir (Benicia, CA) using the EPA's Standard Method 1623. Although the SWAMP recovery objective for pathogens in water is at a range of 80-120%, values this high are not typical of Standard Method 1623 and the acceptance criteria for the initial mean recovery is 24-100%. BioVir reported a 55% recovery for the analyses conducted for this study.

Samples collected for *Salmonella* were analyzed in the laboratories of BioVir (Benicia, CA) using the EPA's Standard Method 1682, modified for water samples. The modification to Standard Method 1682 for water samples is not USEPA-approved, but has been tested and used for a number of years on different matrices with superior results (R. Danielson, BioVir Laboratory Director, personal communication, 08/26/2009).

Samples collected for nutrient scan analyses were sent to Sierra Foothills Laboratories (Jackson, CA). A standard nutrient scan includes total nitrate-N (EPA 300.0/SM4110B), total phosphate (SM4500-P E), total Kjeldahl nitrogen (SM4500NH3 C), ammonia-N (SM4500NH3C) and ortho-phosphate (SM4500P E).

Field and handling contamination were evaluated by submitting blind travel blanks (phosphate buffered saline) on each run for bacteria monitoring. Travel blank samples traveled through the sampling run, and were processed with the sample set. Blind laboratory blanks (phosphate buffered saline) were also used on each sampling day. All travel and laboratory blank results fell below the analytical detection limits for the elements of concern.

Sample site homogeneity was evaluated by collecting and analyzing replicate bacteria samples at a minimum of 5% frequency of the total project for each constituent. Lab precision and accuracy were evaluated using blind split field samples in addition to internal laboratory controls. Blind split samples, or laboratory duplicates, were collected at a one per 20 samples or per analytical batch, whichever was more frequent. Samples were collected in a container double the normal sample volume and then split into two equal amounts prior to analysis.

SWAMP's measurement quality objective for field and laboratory duplicates is a relative percent difference (RPD) of <25% or not applicable if native concentration of either sample is below the reporting limit. All *E. coli*, *E. coli* O157:H7 and nutrient results complied with the SWAMP quality objective and have been included in this report.

A field duplicate for *Cryptosporidium* and a laboratory duplicate for *Giardia* did not meeting the 25% RPD requirement; however, *Cryptosporidium/Giardia* analyses require a minimum of 10 Liters of water and with the reduced recovery of 55% and the natural variability in oocyst/cyst counts, a RPD of <25% is not always feasible at the lower levels of detection (for example, comparing a sample with 1 oocysts per 11 Liters to another with 2 oocysts per 11 Liters will result in a RPD of 66.7%). Therefore, all reported results have been included within this report, with RPD's noted in the Appendix 1.

Field measurements included temperature, pH, specific conductivity (SC), dissolved oxygen and turbidity and were collected using a Yellow Springs Instruments (YSI) Sonde Model 6920 and YSI Logger Model 650 MDS and the Hach 2100P Turbidimeter (turbidity only).

Table 2 lists the reporting limits, holding times and acceptable recoveries for the parameters monitored. Only data from sample sets whose QA/QC met these specifications (except for the *Cryptosporidium* and *Giardia* as noted above) have been included in this report.

Table 2. Parameters, Acceptable Analytical Recoveries, Reporting Limits, and Holding Times

Group	Parameter	Recovery	Target Reporting Limits	Completeness	Holding Time	Container
<i>Field Analyses</i>						
Standard Field Analyses	pH by meter	+/- 0.2	0.01	95%	on site	in situ
	Specific Conductivity	+/- 0.5% of reading + 0.001 mS/cm	0.001 to 0.1 mS/cm (range dependent)	95%	on site	in situ
	Temp.	+/- 0.15	0.01	95%	on site	in situ
	Dissolved Oxygen	+/- 0.5	0.01	95%	on site	in situ
	Turbidity	+/- 2% of reading or 0.3 NTU, whichever is greater	0.1	95%	on site	in situ
<i>Laboratory Analyses</i>						
Bacterial Analyses	E. coli	95% Confidence Interval	2 MPN/100 mL	95%	24 Hr	Factory sterilized 100 ml plastic
	Total Coliform	95% Confidence Interval	2 MPN/100 mL	95%	24 Hr	Factory sterilized 100 ml plastic
	E. coli O157:H7	80-120%	NA (presence/absence only)	95%	24 Hr	Factory sterilized 100 ml plastic
	Salmonella	80-120%	2.2 MPN/100 mL	95%	24 Hr	Factory sterilized 100 ml plastic
Protozoan Analyses	Cryptosporidium	24-100%	0 oocyst	95%	48 Hr	10 L plastic cubitainer
	Giardia	24-100%	0 cyst	95%	48 Hr	10 L plastic cubitainer
Nutrient Scan mg/L	Nitrogen, Total Nitrate-N	80-120%	<0.050	95%	48 Hr	1 L plastic container
	Nitrogen, Total Kjeldahl	80-120%	<0.50	95%	48 Hr	1 L plastic container
	Nitrogen, Ammonia-N	80-120%	<0.20	95%	48 Hr	1 L plastic container
	Phosphate, Total-P	80-120%	<0.020	95%	48 Hr	1 L plastic container
	Phosphate, Ortho-P	80-120%	<0.010	95%	48 Hr	1 L plastic container

6.0 RESULTS

Water Quality Objectives and Guidelines

Pathogen and Bacteria Indicators

The Central Valley Regional Water Quality Control Board Basin Plan (Central Valley Water Board, 2007a) identifies contact recreation as a beneficial use throughout the Region. Although the Basin Plan identifies a water quality objective that utilizes fecal coliform (not to exceed 400 MPN/100mL in a single sample), *E. coli* can also be utilized as an indicator for potential pathogens and is a subset of fecal coliform.

The United States Environmental Protection Agency (US EPA) has developed contact recreation guidelines for *E. coli*, as described in Table 3 (US EPA, 2003). This study utilized the swimming level of contact at <235 MPN/100mL (designated beach area) as the water quality threshold to indicate a potential concern. An Amendment to the Central Valley Basin Plan is pending that would change the current fecal coliform objective to terms of *E. coli*.

Table 3. U.S. EPA contact recreation guidelines for *E. coli*

Level of Contact	USEPA <i>E. coli</i> Guideline (MPN/100ml)
Designated beach area	<235
Moderate full body contact	<298
Light full body contact	<409
Infrequent full body contact	<574

There are no water quality guidelines in the Sacramento Basin for pathogenic *E. coli* O157:H7, *Cryptosporidium*, *Giardia* or *Salmonella*.

Nutrients

This study included the analyses of total nitrate-N, total phosphate, total Kjeldahl nitrogen, ammonia-N and ortho-phosphate in sample water. Total nitrate-N has a water quality guideline of 10 mg/L as a Primary Maximum Contaminant Level for Drinking Water. Ammonia-N has a US EPA National Ambient Water Quality Criteria of 24.1 mg/L (Salmonids present) or 36.1 mg/L (Salmonids absent) at a pH of 7.0. The USEPA provides a formula for adjusting the water quality criteria for different pH levels (as the pH becomes more acidic, total ammonia-N increases), however all of the ammonia-N results in this study were below detection so no special calculation was needed (US EPA, 1999).

Field Measurements

Although there are no specific objective or guidelines to protect recreation for any of the field parameters (dissolved oxygen, specific conductance, pH, temperature

or turbidity), there are objectives and guidelines to protect aquatic life and drinking water. For Aquatic Life, dissolved oxygen has a Basin Plan Objective of ≥ 7 mg/L, pH an objective of between 6.5 and 8.5, and the temperature of surface water entering the Bay Delta (April through June and September through November 3) an objective of ≤ 20 °C. Specific conductivity has a water quality guideline of ≤ 900 umhos/cm as a Secondary Maximum Contaminant Level for Drinking Water. There are no specific numeric turbidity objectives in the Basin Plan for the watersheds sampled in this study, with the exception of the lower American River which has a Basin Plan Objective of ≤ 10 NTU for the stretch between Folsom Dam and the Sacramento River.

Study results by watershed

Lower American River Watershed

The American River is the second largest tributary to the Sacramento River. The flow in the lower American River is regulated at the Folsom Dam and Reservoir by the U.S. Bureau of Reclamation. One site in the lower watershed, American River at Discovery Park (544SAC007), had elevated *E. coli* concentrations above the EPA guideline (235 MPN/100ml) on two of the three study days in the Safe-to-Swim, Labor Day 2008 study. Discovery Park is a 302-acre park located in downtown Sacramento, where the lower American River meets the Sacramento River. This area is a popular recreational boating area. The next upstream site to the Discovery Park site during the Labor Day 2008 study was the American River at Sunrise Blvd. (544SAC008). On all three days of the 2008 study, the *E. coli* concentrations at Sunrise Blvd. were well below the EPA guideline. Consequently, the six sites chosen for this 2009 study were concentrated on the stretch of the lower American River between Sunrise Blvd. and the confluence of the Sacramento River.

Map 2 shows a map of the American River sites along with photographs of each site on the sample event date. Table 4 on the following page displays the results for each site by constituent. Figure 1 shows a graphical display of the data for *E. coli*, dissolved oxygen, pH, specific conductivity, temperature and turbidity.

Map 2. Study Sites for the Lower American River Watershed

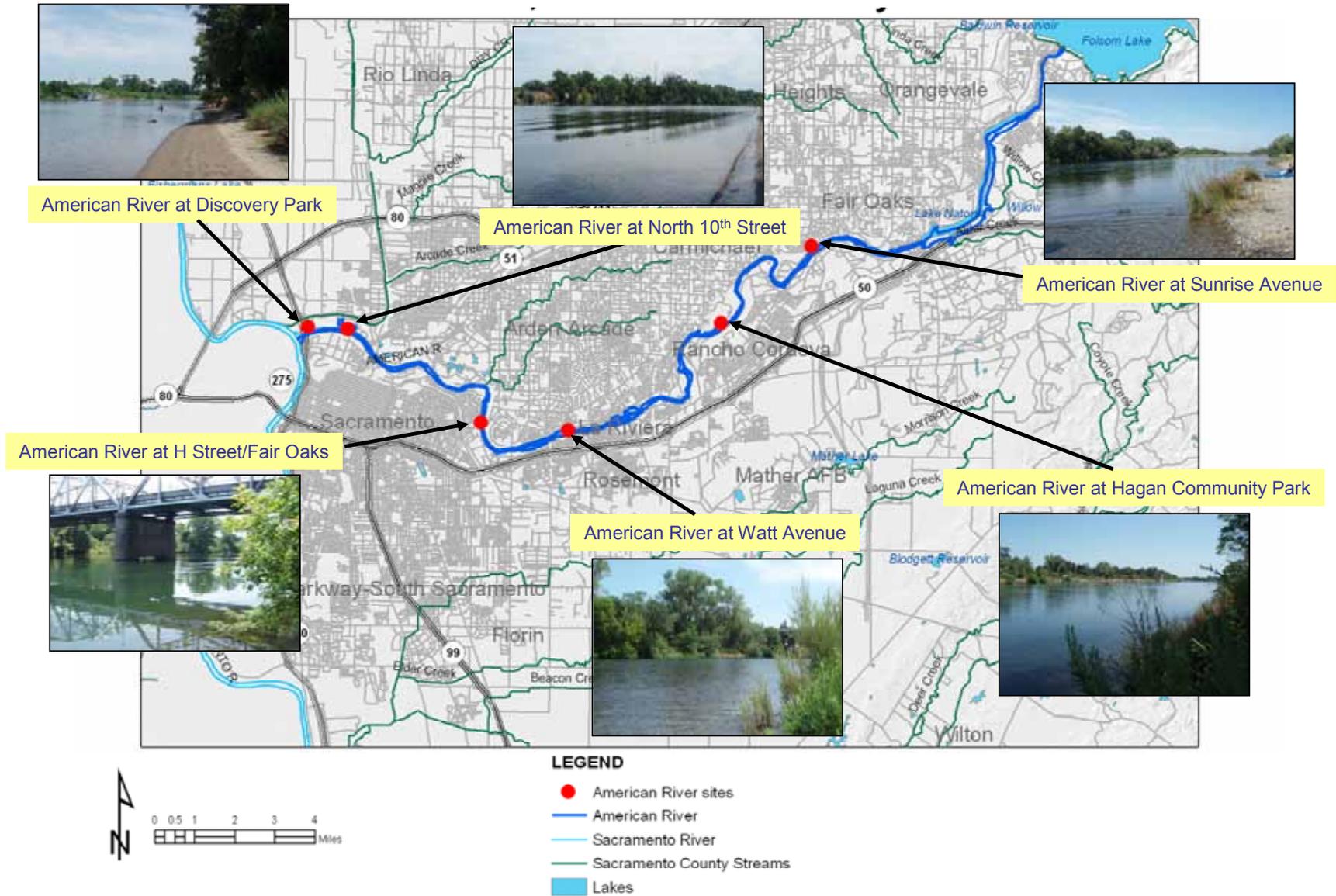


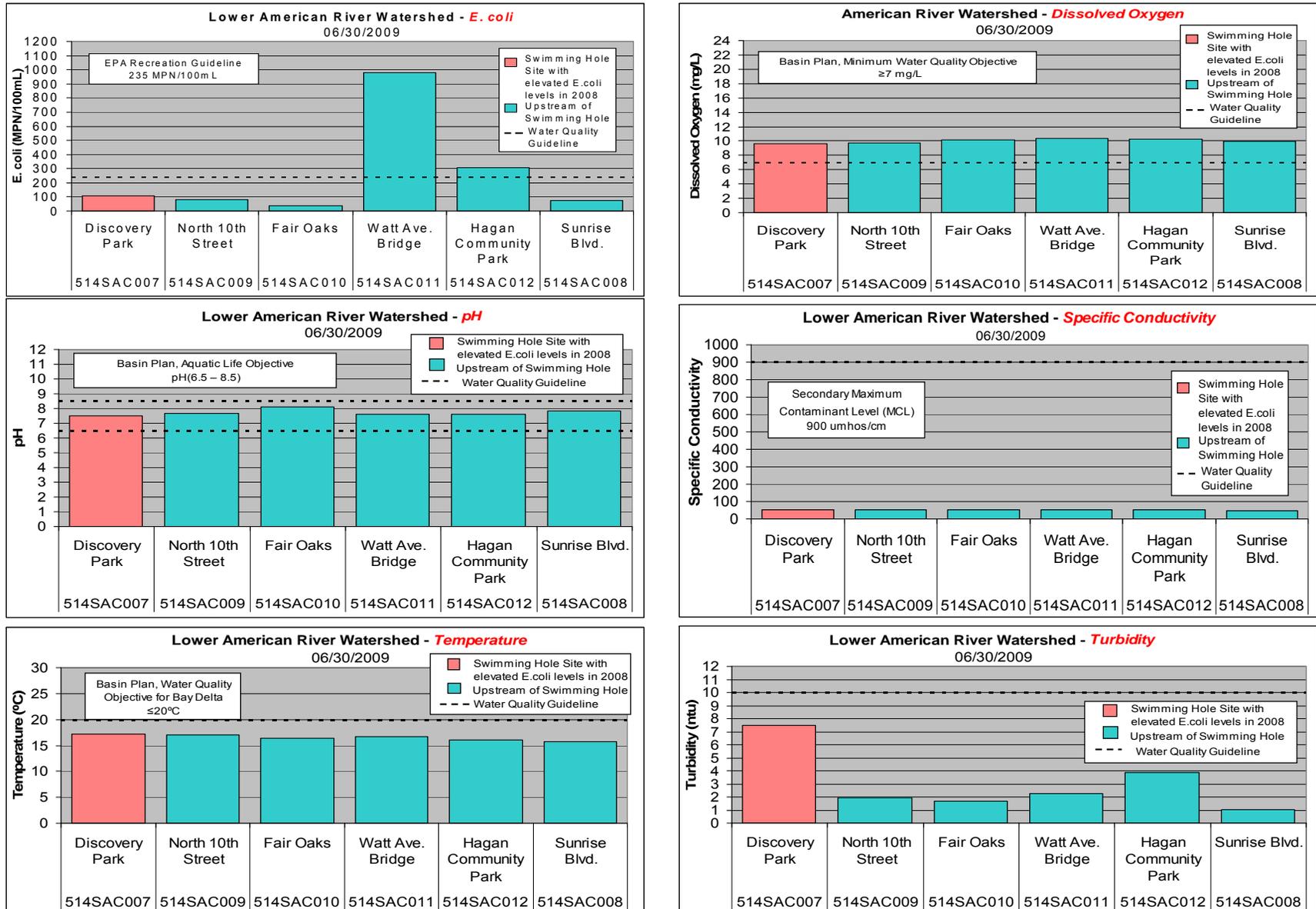
Table 4. Results for the Lower American River Watershed

Constituent	Water Quality Guideline	Lower American River Watershed Sample Sites					
		Discovery Park	North 10th Street	Fair Oaks	Watt Ave. Bridge	Hagan Community Park	Sunrise Blvd.
Total Coliform (MPN/100mL)	NA	>2419.6	>2419.6	>2419.6	>2419.6	>2419.6	1986.3
E. coli (MPN/100 mL)	<235 MPN/100mL (USEPA Contact Recreation Guideline)	110	82	36.4	980.4	307.6	74.9
E. coli O157:H7 (positive/negative)	NA	negative	negative	negative	negative	negative	negative
Cryptosporidium (oocyst/L)	NA	0	No sample taken	No sample taken	No sample taken	No sample taken	0
Giardia (cyst/L)	NA	0	No sample taken	No sample taken	No sample taken	No sample taken	0
Salmonella (MPN/100mL)	NA	<2.2	No sample taken	No sample taken	No sample taken	No sample taken	<2.2
Nitrogen, Total Nitrate-N (mg/L)	≤10 mg/L (Primary Maximum Contaminant Level) ¹	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Nitrogen, Total Kjeldahl (mg/L)	NA	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Nitrogen, Ammonia-N (mg/L)	24.1 mg/L (Salmonids present) or 36.1 mg/L (Salmonids absent) at pH=7 (USEPA National Ambient Water Quality Criteria) ²	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Phosphate, Total-P (mg/L)	NA	0.022	<0.020	<0.020	<0.020	<0.020	<0.020
Phosphate, Ortho-P (mg/L)	NA	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Dissolved Oxygen (mg/L)	≥7 mg/L (Basin Plan Objective) ²	9.58	9.72	10.19	10.39	10.22	9.89
pH	6.5-8.5 (Basin Plan Objective) ²	7.49	7.67	8.1	7.6	7.61	7.85
Specific Conductivity (umhos/cm)	≤900 umhos/cm (Secondary Maximum Contaminant Level) ¹	51	51	52	51	51	49
Temperature (° Celsius)	≤20 °C (Basin Plan Objective for Bay-Delta) ²	17.14	16.98	16.35	16.77	16.01	15.78
Turbidity (ntu)	≤ 10 ntu (Basin Plan Objective for the American River -Folsom Dam to Sacramento River)	7.5	1.96	1.66	2.25	3.88	1.03

Shaded cell = Does not meet Water Quality Guideline

1 - Drinking Water 2- Aquatic Life

Figure 1. Graphical display of *E. coli*, DO, pH, SC, temperature and turbidity for the Lower American River Watershed



Although the Discovery Park site did not have elevated levels of *E. coli*, two other sites had levels above the EPA recreation guideline of 235 MPN/100mL. The American River at Watt Avenue (514SAC011) had the highest value at 980.4 MPN/100mL while the site upstream of Watt Avenue at Hagan Community Park (514SAC012) measured 307.6 MPN/100mL of *E. coli*. All of the sites tested negative for *E. coli* O157:H7. Two sites, Discovery Park and Sunrise Blvd, were tested for *Cryptosporidium*, *Giardia*, and *Salmonella* and neither site had measurable values for these constituents.

Nutrient values at all six lower American River sites were near or at the detection limit. Field measurements met water quality guidelines and there is no indication that any of these parameters had an influence on the higher *E. coli* concentrations at the Watt Avenue and Hagan Community Park sites.

A review of NPDES permits along the American River was conducted to evaluate any potential sources for the higher *E. coli* levels at Watt Avenue and Hagan Community Park. The primary discharges in the area are from groundwater treatment facilities with no human or animal waste component. Because of the time year, storm water discharge also was not a probable contributor to elevated *E. coli* levels. The Sunrise Blvd site did not have elevated levels of *E. coli* so it is unlikely that the *E. coli* was from a source further upstream of our study area. Based on these considerations, there is no evidence of a single source of contamination to this area of the American River and the measured *E. coli* values may be due to urban non-point sources.

Deer Creek Watershed

Deer Creek is located in Nevada County and is a tributary of the Yuba River. During the Labor Day 2008 Study, the local stakeholder group, Friends of Deer Creek (FoDC), selected and sampled one site for this study located in Squirrel Creek, a tributary to Deer Creek, at Western Gateway Park in Penn Valley (516NEV906). Western Gateway Park is a popular recreation spot and includes play structures, hiking trails, baseball fields and a community center. Photos show from the 2008 Labor Day Study show this site to be a heavily used swimming area.

Although none of the normal grab samples at this site during the Labor Day 2008 exceeded the EPA guideline of 235 MPN/100mL for *E. coli*, concentrations for the first two days of the study were above 200 MPN/100mL and a duplicate QA field sample had a value of 260.3 MPN/100mL. In addition to the heavy human recreational use of Squirrel Creek during the holiday period, the Friends of Deer Creek indicated that cattle grazing may also influence the creek's water quality. There is an extensive grazing operation one mile directly upstream of the study site near Clear Creek. Cattle have been seen walking through the creek and using the creek for drinking water (J. Wood, personal communication,

1/27/2009). FoDC tested for *E. coli* at sites upstream of Western Gateway Park during the spring months of 2009 and found levels to be consistently elevated (J. Wood, personal communication, 5/19/2009). The Nevada County Environmental Health Department was contacted by FoDC and an advisory sign was posted for Western Gateway Park prior to the 2009 Memorial Day Weekend holiday.

Three sites were chosen for the Deer Creek Watershed. In addition to the Western Gateway Park swimming hole site, two new sites were sampled at Clear Creek above the confluence with Squirrel Creek (516NEV907) and Squirrel Creek above the confluence with Clear Creek (516NEV908). FoDC was able to assist with sampling and a representative from the Nevada County Environmental Health Department also conferred with the Central Valley Water Board field crew on the day of the study.

Map 3 shows a map of the Deer Creek Watershed sites along with photographs of each site on the sample event date. Table 5 on the following page displays the results for each site by constituent. Figure 2 shows a graphical display of the data for *E. coli*, dissolved oxygen, pH, specific conductivity, temperature and turbidity.

Map 3. Study Sites for the Deer Creek Watershed

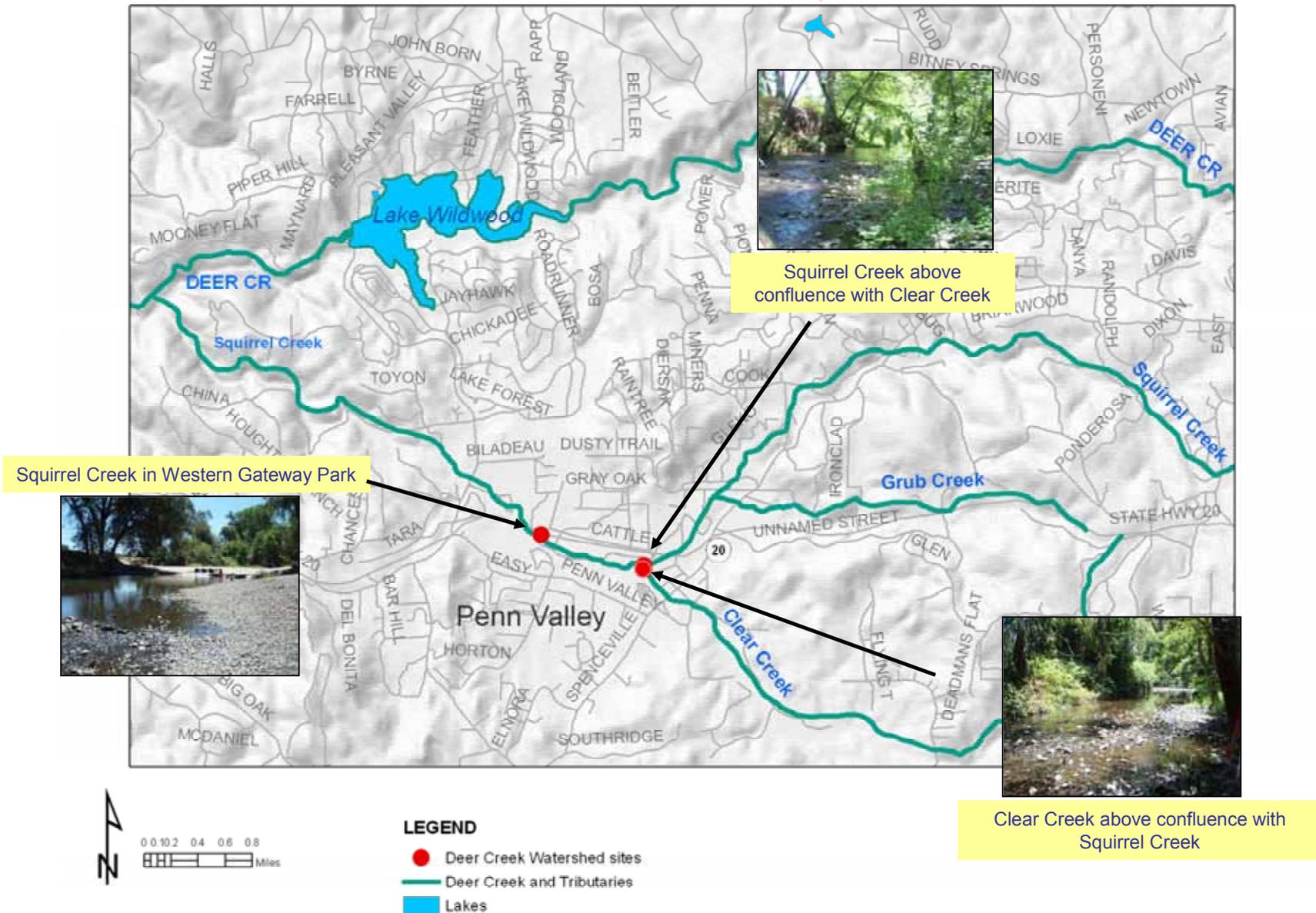
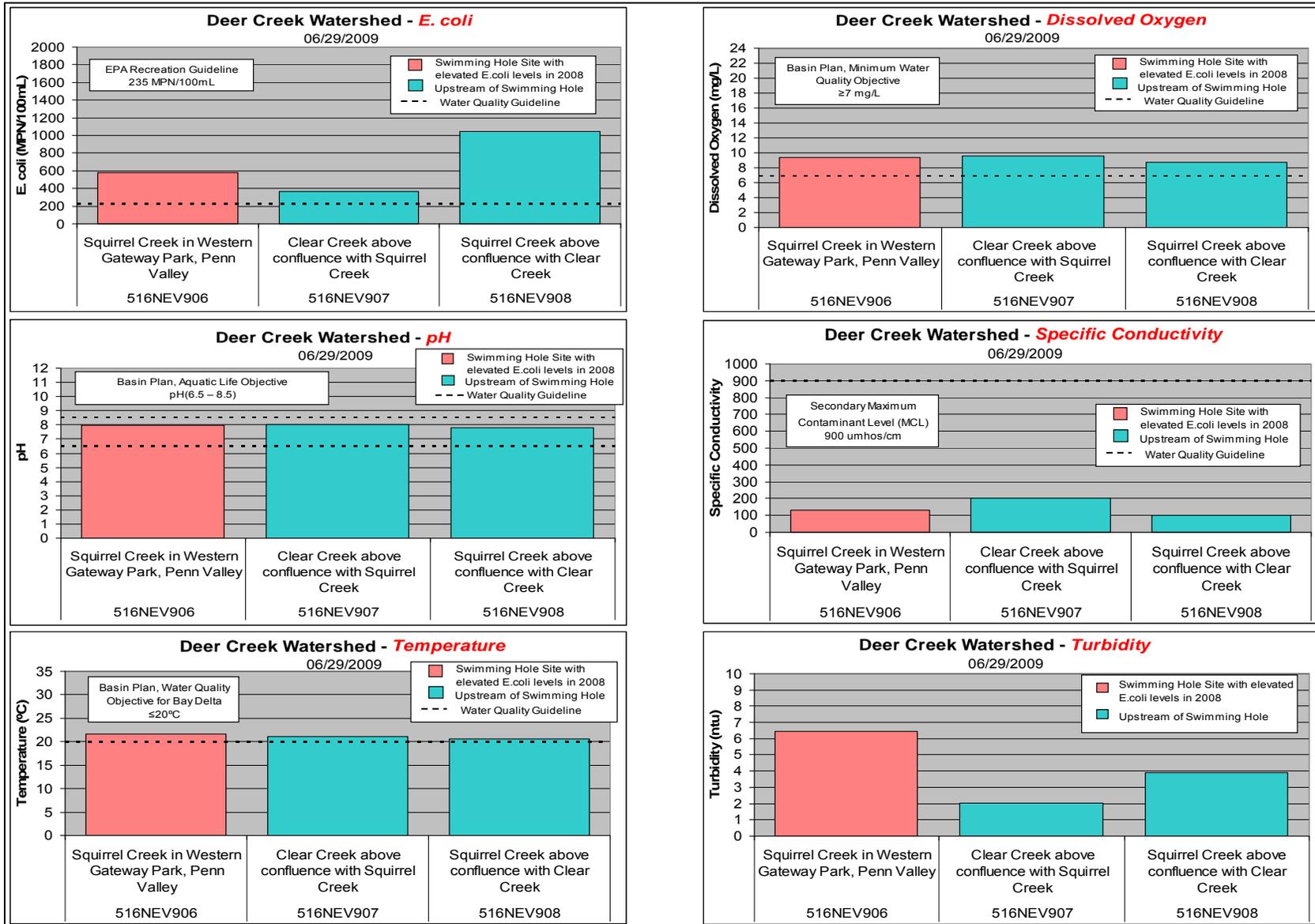


Table 5. Results for the Deer Creek Watershed

Constituent	Water Quality Guideline	Deer Creek Watershed Sample Sites		
		Squirrel Creek in Western Gateway Park, Penn Valley	Clear Creek above confluence with Squirrel Creek	Squirrel Creek above confluence with Clear Creek
Total Coliform (MPN/100mL)	NA	>2419.6	>2419.6	>2419.6
E. coli (MPN/100 mL)	<235 MPN/100mL (USEPA Contact Recreation Guideline)	579.4	365.4	1046.2
E. coli O157:H7 (positive/negative)	NA	negative	negative	negative
Cryptosporidium (oocyst/L)	NA	0.091	No sample taken	No sample taken
Giardia (cyst/L)	NA	0	No sample taken	No sample taken
Salmonella (MPN/100mL)	NA	<2.2	No sample taken	No sample taken
Nitrogen, Total Nitrate-N (mg/L)	≤10 mg/L (Primary Maximum Contaminant Level) ¹	0.19	0.32	0.13
Nitrogen, Total Kjeldahl (mg/L)	NA	<0.50	<0.50	<0.50
Nitrogen, Ammonia-N (mg/L)	24.1 mg/L (Salmonids present) or 36.1 mg/L (Salmonids absent) at pH=7 (USEPA National Ambient Water Quality Criteria) ²	<0.20	<0.20	<0.20
Phosphate, Total-P (mg/L)	NA	0.027	<0.020	0.038
Phosphate, Ortho-P (mg/L)	NA	0.0233	0.0148	0.0325
Dissolved Oxygen (mg/L)	≥7 mg/L (Basin Plan Objective) ²	9.35	9.61	8.7
pH	6.5-8.5 (Basin Plan Objective) ²	7.95	8.03	7.81
Specific Conductivity (umhos/cm)	≤900 umhos/cm (Secondary Maximum Contaminant Level) ¹	132	201	101
Temperature (° Celsius)	≤20 °C (Basin Plan Objective for Bay-Delta) ²	21.62	21.16	20.66
Turbidity (ntu)	NA	6.46	2.03	3.92

Shaded cell = Does not meet Water Quality Guideline 1 - Drinking Water 2- Aquatic Life

Figure 2. Graphical display of *E. coli*, DO, pH, SC, temperature and turbidity for the Deer Creek Watershed



All three Deer Creek Watershed sites had elevated levels of *E. coli* above the EPA recreation guideline of 235 MPN/100 mL. The Squirrel Creek above the Clear Creek confluence (516NEV908) had the highest value at 1046.2 MPN/100 mL while the Clear Creek above the confluence with Squirrel Creek site (516NEV907) measured 365.4 MPN/100mL and the Western Gateway Park site (516NEV906) at 579.4 MPN/100 mL. All of the sites tested negative for *E. coli* O157:H7. The Western Gateway Park site was tested for *Cryptosporidium*, *Giardia*, and *Salmonella* but the only measurable value was 0.091 oocyte/L for *Cryptosporidium*.

Nutrient values at all three Deer Creek Watershed sites were generally low or at the detection limit. Field measurements met water quality guidelines with the exception of temperature, which was slightly above the 20 °Celsius guideline for the surface water entering the Bay Delta (April through June and September through November 3). There is no indication that any of the field parameters had an influence on the elevated *E. coli* concentrations at any of the three sites.

The highest value of *E. coli* was measured upstream of the swimming hole in Western Gateway Park in Squirrel Creek. The value at Western Gateway Park is close to an average between the two upstream sites in Squirrel and Clear Creeks, suggesting that the heavy human recreation at the swimming hole is not a major component to the elevated *E. coli* concentrations. The upstream area is dominated by cattle grazing, the most likely contributor to *E. coli* in this watershed.

Dry Creek Watershed

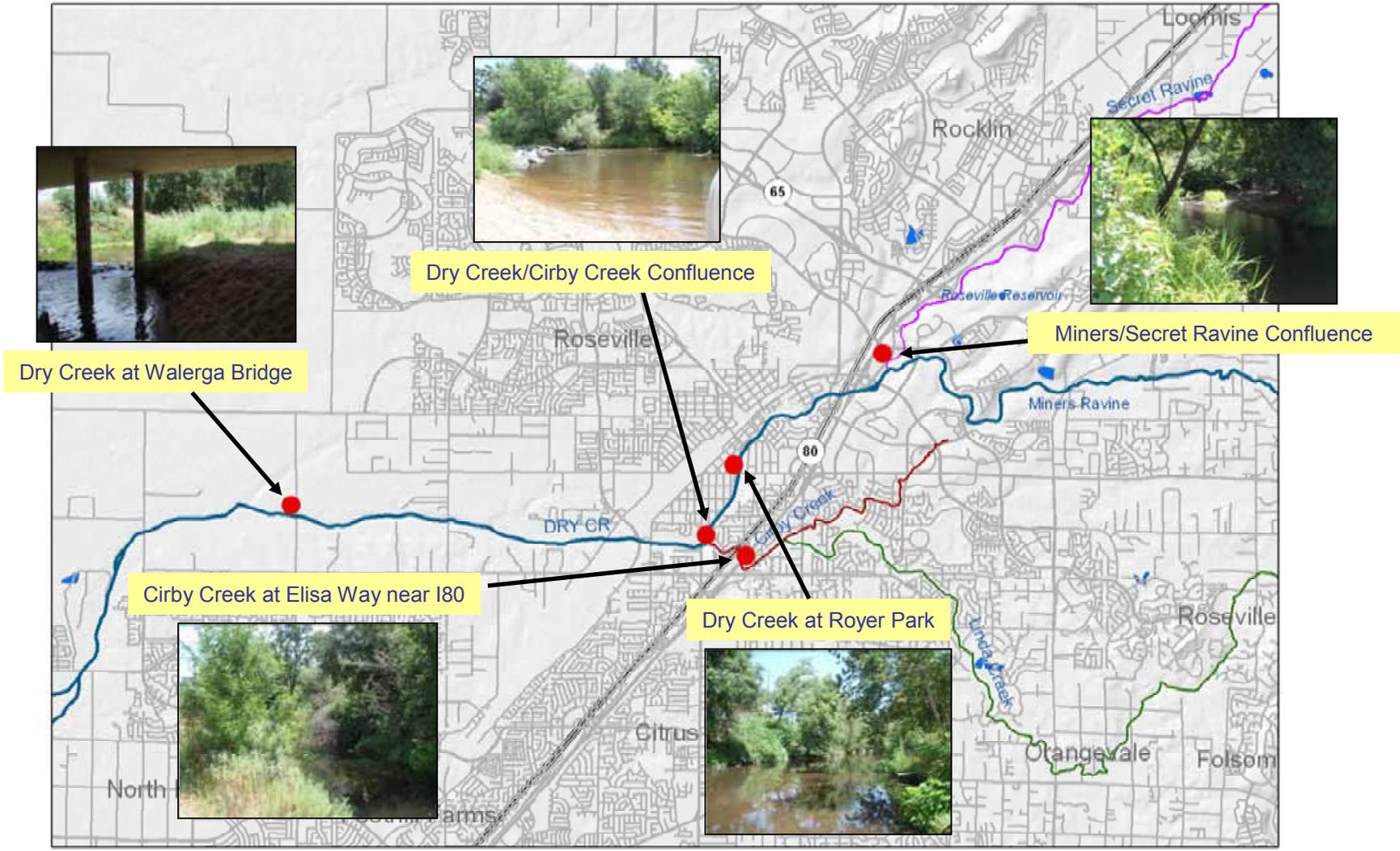
The Dry Creek watershed, located in Placer County, is one of the fastest urbanizing areas of California due to the extensive development of the Roseville region. Loss of riparian vegetation, stream bank erosion and sedimentation of streams are concerns expressed by the American Basin Council of Watersheds (Dry Creek Conservancy, 2007). Much of Dry Creek is also influenced by effluent discharged from Dry Creek Wastewater Treatment Plant (WWTP) in Roseville.

Two Dry Creek sites, the Dry Creek/Cirby Confluence (531PLA900) and Dry Creek at Walerga Bridge (531PLA901), had *E. coli* levels above 235 MPN/100mL during the Safe-to-Swim Study, Labor Day 2008. The highest levels during the 2008 study were at the Dry Creek/Cirby Confluence site which is upstream of the WWTP. The first day of the 2008 study showed an *E. coli* concentration of 2419.6 MPN/100mL, the upper reporting limit of the analytical method and greater than 10 times the US EPA guideline. The *E. coli* level at the Dry Creek at Walerga Bridge site on the same day was 290.9 MPN/100mL, suggestive of a dilution effect from the WWTP which is located between the two sites.

Several tributaries are located upstream of the Dry Creek/Cirby Confluence site including Miners Ravine and Secret Ravine, which feed into Dry Creek, and Linda Creek, which flows into Cirby Creek. Two new sites were chosen for this watershed. The first was upstream of the Dry Creek/Cirby Confluence site along Dry Creek at Royer Park (531PLA903). This area is known to sustain a large portion of Roseville's homeless population. Another site was chosen upstream along Cirby Creek at Elisa Way at Highway I80 (531PLA904). A third new site was originally intended for Linda Creek, however flows were not high enough to support sampling at this time of year. In addition to these two new sites, 3 sites from the original Labor Day 2008 study were re-sampled (Miners Ravine/Secret Ravine Confluence, Dry Creek/Cirby Confluence and Dry Creek at Walerga Bridge).

Map 4 shows a map of the Dry Creek Watershed sites along with photographs of each site on the sample event date. Table 6 on the following page displays the results for each site by constituent. Figure 3 shows a graphical display of the data for *E. coli*, dissolved oxygen, pH, specific conductivity, temperature and turbidity.

Map 4. Study Sites for the Dry Creek Watershed



LEGEND

- Dry Creek Watershed sites
- Dry Creek - Miner's Ravine
- Secret Ravine
- Linda Creek
- Cirby Creek



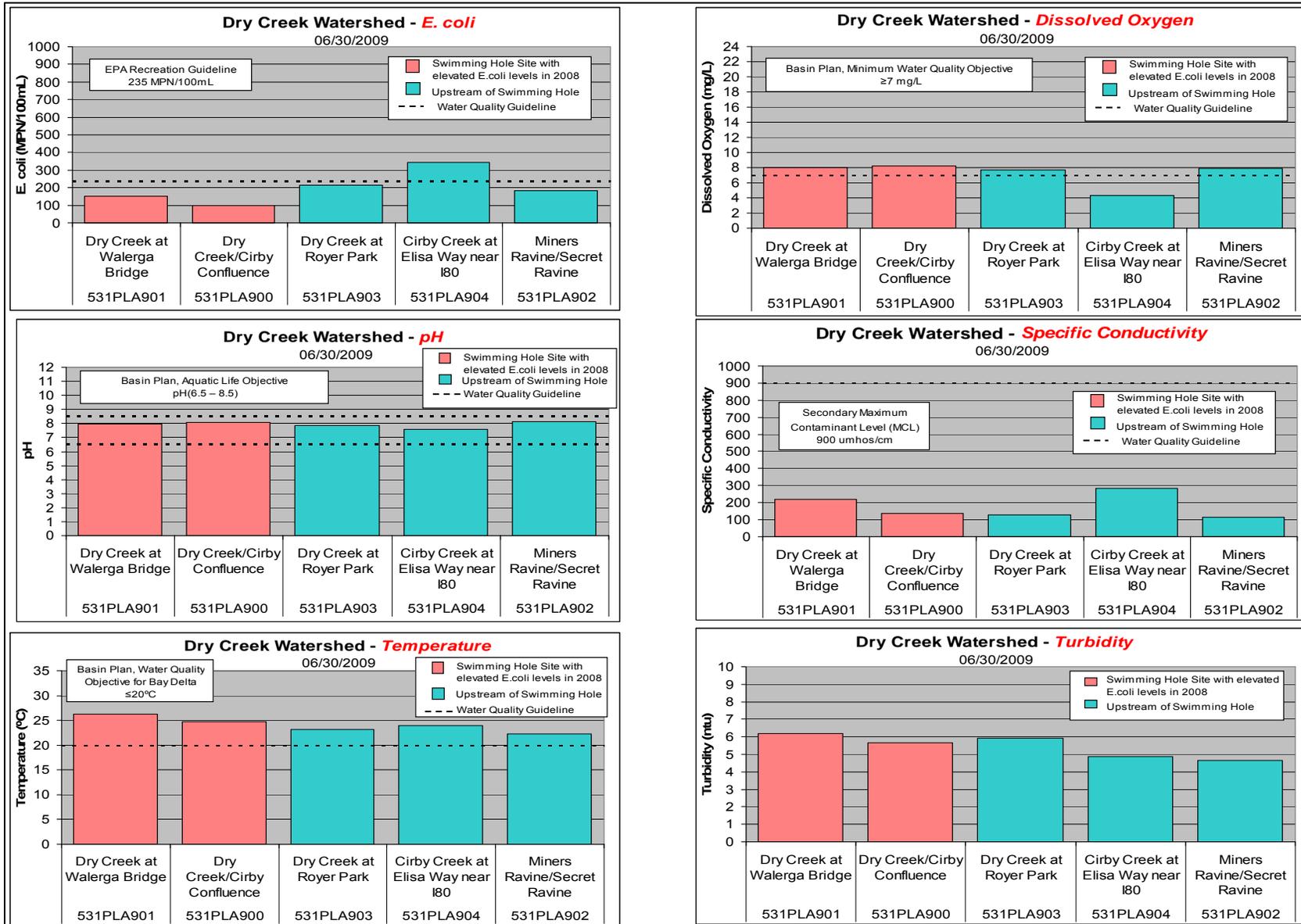
Table 6. Results for the Dry Creek Watershed

Constituent	Water Quality Guideline	Dry Creek Watershed Sample Sites				
		Dry Creek at Walerga Bridge	Dry Creek/Cirby Confluence	Dry Creek at Royer Park	Cirby Creek at Elisa Way near 180	Miners Ravine/Secret Ravine Confluence
Total Coliform (MPN/100mL)	NA	>2419.6	>2419.6	>2419.6	>2419.6	>2419.6
E. coli (MPN/100 mL)	<235 MPN/100mL (USEPA Contact Recreation Guideline)	151.5	98.8	214.3	344.8	185
E. coli O157:H7 (positive/negative)	NA	negative	negative	negative	negative	negative
Cryptosporidium (oocyst/L)	NA	0	0.09	No sample taken	No sample taken	No sample taken
Giardia (cyst/L)	NA	0.444	2	No sample taken	No sample taken	No sample taken
Salmonella (MPN/100mL)	NA	<2.2	5.1	No sample taken	No sample taken	No sample taken
Nitrogen, Total Nitrate-N (mg/L)	≤10 mg/L (Primary Maximum Contaminant Level) ¹	1.4	0.085	0.079	<0.050	0.093
Nitrogen, Total Kjeldahl (mg/L)	NA	0.56	<0.50	<0.50	0.56	<0.50
Nitrogen, Ammonia-N (mg/L)	24.1 mg/L (Salmonids present) or 36.1 mg/L (Salmonids absent) at pH=7 (USEPA National Ambient Water Quality Criteria) ²	<0.20	<0.20	<0.20	<0.20	<0.20
Phosphate, Total-P (mg/L)	NA	0.22	0.12	0.11	0.25	0.064
Phosphate, Ortho-P (mg/L)	NA	0.204	0.093	0.0875	0.223	0.0585
Dissolved Oxygen (mg/L)	≥7 mg/L (Basin Plan Objective) ²	8.04	8.25	7.71	4.3	7.92
pH	6.5-8.5 (Basin Plan Objective) ²	7.95	8.05	7.85	7.57	8.12
Specific Conductivity (umhos/cm)	≤900 umhos/cm (Secondary Maximum Contaminant Level) ¹	217	139	129	284	114
Temperature (° Celsius)	≤20 °C (Basin Plan Objective for Bay-Delta) ²	26.26	24.77	23.17	24.00	22.30
Turbidity (ntu)	NA	6.19	5.67	5.94	4.86	4.67

Shaded cell = Does not meet Water Quality Guideline

1 - Drinking Water 2- Aquatic Life

Figure 3. Graphical display of *E. coli*, DO, pH, SC, temperature and turbidity for the Dry Creek Watershed



Neither of the two sites with elevated levels of *E. coli* in the Labor Day 2008 Study (Dry Creek/Cirby Confluence and Dry Creek at Walerga Bridge) were above the USEPA recreational guideline for *E. coli* in this study. However, the Cirby Creek at Elisa Way site (531PLA904) did have levels above the USEPA guideline with a value of 344.8 MPN/100 mL. Dry Creek at Royer Park was just below the USEPA guideline 214.3 MPN/100 mL. All of the sites tested negative for *E. coli* O157:H7. Two sites, Dry Creek/Cirby Confluence and Dry Creek at Walerga Bridge, were tested for *Cryptosporidium*, *Giardia*, and *Salmonella*. The Dry Creek/Cirby Confluence site had measurable amounts of all three constituents with values of 0.09 oocyst/L, 2.0 cyst/L and 5.1 MPN/100 mL, respectively. The Dry Creek at Walerga Bridge had a measurable amount of only *Giardia* with a value of 0.444 cyst/L.

The nutrient values were more variable for the Dry Creek Watershed sites than the other watersheds. Total phosphate and ortho-phosphate concentrations were higher in this watershed as compared to the others included in this study, with a high at the Cirby Creek at Elisa Way site of 0.25 mg/L and .223 mg/L, respectively. There is no established guideline for phosphorus compounds in water, however to control eutrophication, the USEPA recommends that total phosphorus not exceed 0.1 mg/L in streams that do not discharge directly into lakes and reservoirs (U.S. Environmental Protection Agency, 1986). Total nitrate-N increased at the Dry Creek at Walerga Bridge site, possibly due to the addition of effluent water. The measurement of 1.4 mg/L was still well below the MCL for Drinking water (10 mg/L). With the limited dataset available, it is not clear whether or not the nutrient values had an effect on the *E. coli* concentrations in the Dry Creek Watershed.

Field measurements met water quality guidelines for pH, SC and DO, with the exception of the Cirby Creek at Elisa Way site (531PLA904). The water at this site was low flowing and stagnant in areas. This condition is reflected in the DO value which was measured at 4.3 mg/L, below the minimum level 7.0 mg/L set as a Basin Plan Objective. The temperature in all Dry Creek Watershed locations was above 20°Celsius, the guideline for surface water entering the Bay Delta (April through June and September through November 3). A warm, stagnant waterbody with readily available nutrients, such as the Elisa Way site, provides a favorable environment for the growth of bacteria and it is possible that as flows decrease in Cirby Creek over the dry season, bacteria levels increase and contribute to the elevated levels measured directly downstream at the Dry Creek/Cirby Creek Confluence. *E. coli* values were also higher upstream on Dry Creek at Royer Park where other potential urban and human sources exist.

South Yuba River Watershed

The Yuba River is a major tributary of the Feather River, which is the largest tributary to the Sacramento River. The headwaters of the South Yuba begin along the rim of Donner Summit and flow along and under Interstate 80, and

drain into Spaulding Reservoir. From the Spaulding Reservoir, the river runs another 39 miles through much of Nevada County to the Englebright Reservoir. Six swimming holes were selected and sampled by the South Yuba River Citizen's League (SYRCL) during the Labor Day 2008 Study. One site, South Yuba River at Purdon Crossing (516NEV901), had a concentration of *E. coli* greater than 235 MPN/100-ml on the last day of the study, following the Labor Day weekend.

The site at Purdon Crossing is part of the South Yuba River State Park and is considered an access point to remote areas of the park. It is a popular hiking and fishing area. Unfortunately, there have been issues with illegal camping, drug use and general disrespect of the area as described by a representative of SYRCL (G. Reedy, personal communication, 12/18/2008). Incidence of human waste at this site has also been reported to SYRCL.

SYRCL was contacted by the staff at the Central Valley Water Board for assistance in selecting sites upstream of Purdon Crossing. Originally five sites were selected for this study; three sampled during the Labor Day 2008 Study (Purdon Crossing, Edwards Crossing and below Washington) and two new sites, one along Humbug Creek and one in the headwaters above Spaulding Reservoir at Towle Mountain Road. Due to transportation and time constraints on the day of the study, the Edwards Crossing and Humbug Creek sites were eliminated from this study.

Map 5 shows the remaining three South Yuba River Watershed sites along with photographs of each site on the sample event date. Table 7 on the following page displays the results for each site by constituent. Figure 4 shows a graphical display of the data for *E. coli*, dissolved oxygen, pH, specific conductivity, temperature and turbidity.

Map 5. Study Sites for the South Yuba River Watershed

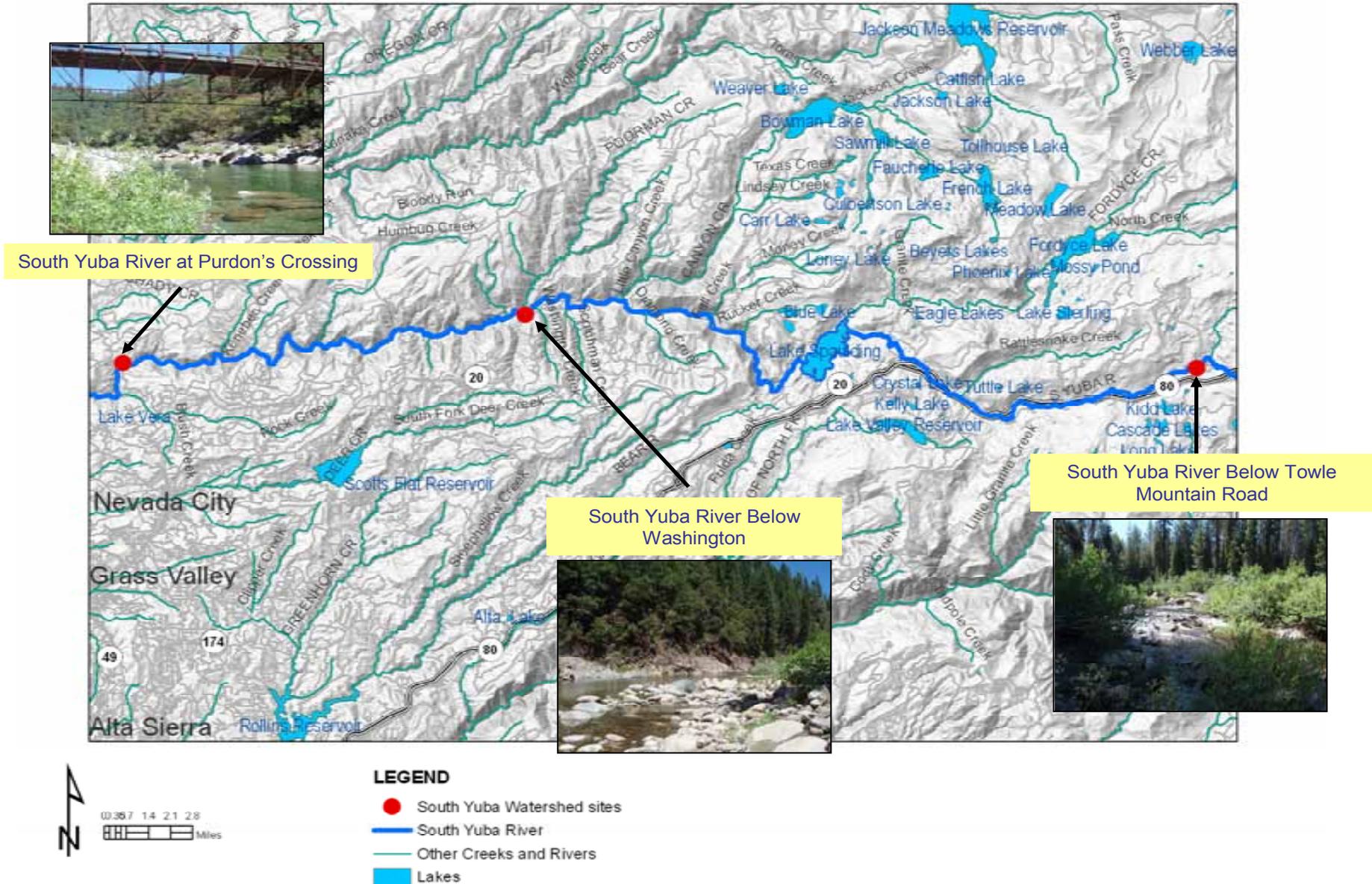
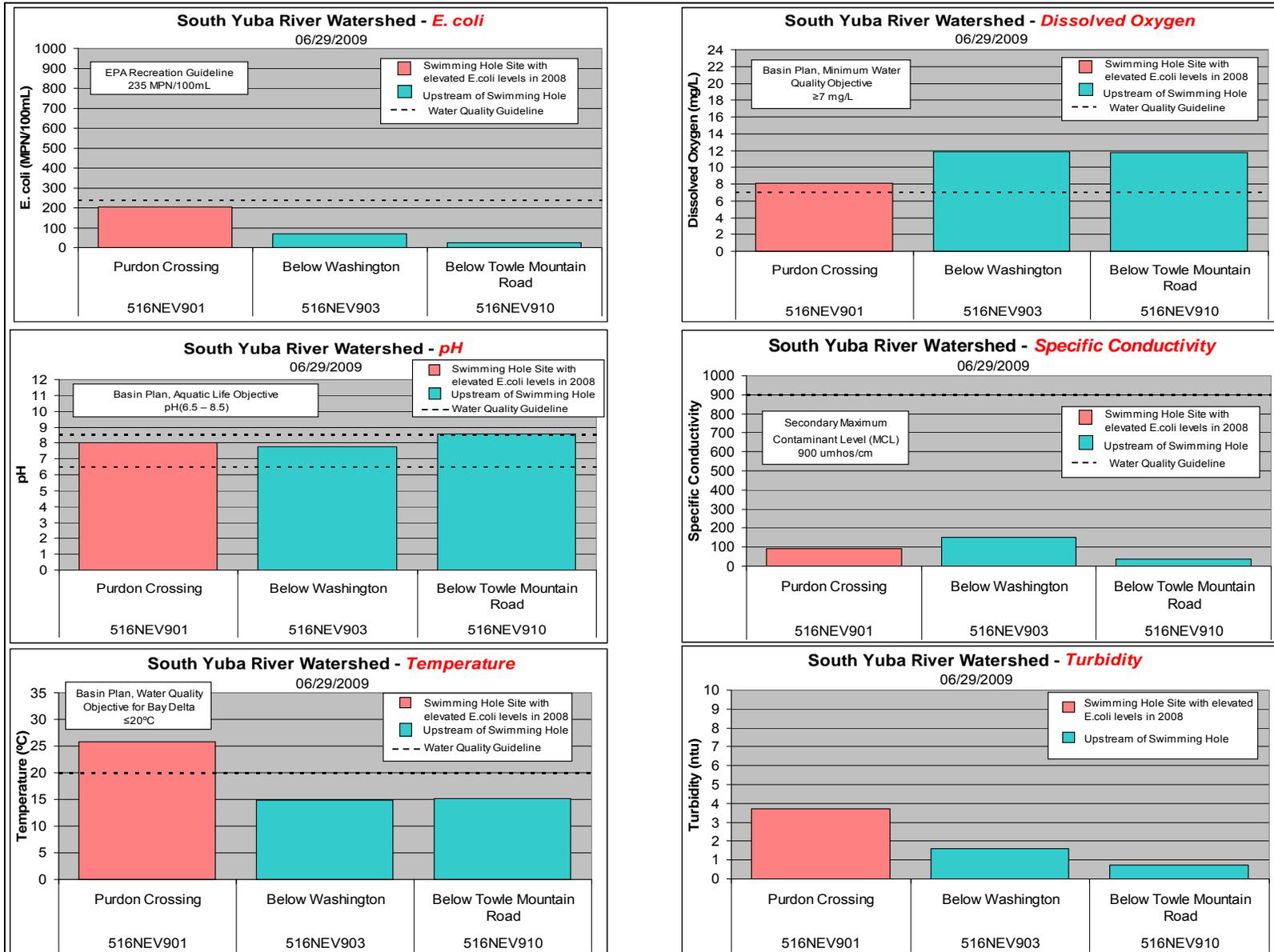


Table 7. Results for the South Yuba River Watershed

Constituent	Water Quality Guideline	South Yuba River Watershed Sample Sites		
		Purdon Crossing	Below Washington	Below Towle Mountain Road
Total Coliform (MPN/100mL)	NA	>2419.6	1413.6	770.1
E. coli (MPN/100 mL)	<235 MPN/100mL (USEPA Contact Recreation Guideline)	204.6	71.2	26.2
E. coli O157:H7 (positive/negative)	NA	negative	negative	negative
Cryptosporidium (oocyst/L)	NA	0	No sample taken	No sample taken
Giardia (cyst/L)	NA	0	No sample taken	No sample taken
Salmonella (MPN/100mL)	NA	<2.2	No sample taken	No sample taken
Nitrogen, Total Nitrate-N (mg/L)	≤10 mg/L (Primary Maximum Contaminant Level) ¹	<0.050	<0.050	<0.050
Nitrogen, Total Kjeldahl (mg/L)	NA	<0.50	<0.50	<0.50
Nitrogen, Ammonia-N (mg/L)	24.1 mg/L (Salmonids present) or 36.1 mg/L (Salmonids absent) at pH=7 (USEPA National Ambient Water Quality Criteria) ²	<0.20	<0.20	<0.20
Phosphate, Total-P (mg/L)	NA	<0.020	0.037	<0.020
Phosphate, Ortho-P (mg/L)	NA	<0.010	0.0293	<0.010
Dissolved Oxygen (mg/L)	≥7 mg/L (Basin Plan Objective) ²	8.09	11.90	11.73
pH	6.5-8.5 (Basin Plan Objective) ²	8.04	7.77	8.55
Specific Conductivity (umhos/cm)	≤900 umhos/cm (Secondary Maximum Contaminant Level) ¹	93	153	36
Temperature (° Celsius)	≤20 °C (Basin Plan Objective for Bay-Delta) ²	25.87	14.86	15.12
Turbidity (ntu)	NA	3.7	1.59	0.75

Shaded cell = Does not meet Water Quality Guideline 1 - Drinking Water 2- Aquatic Life

Figure 4. Graphical display of *E. coli*, DO, pH, SC, temperature and turbidity for the South Yuba River Watershed



None of the three South Yuba River sites had *E. coli* concentrations above the EPA recreation guideline of 235 MPN/100mL. The *E. coli* levels did increase moving downstream with a low of 26.2 MPN at the Towle Mountain Road site to 204.6 MPN/100 mL at the Purdon Crossing site. All three sites tested negative for *E. coli* O157:H7. The South Yuba River at Purdon Crossing site was also tested for *Cryptosporidium*, *Giardia*, and *Salmonella* and no measurable values were detected for these constituents.

Nutrient values at the three South Yuba River sites were near or at the detection limit. Field measurements met water quality guidelines, with the exception of the Towle Mountain Road site which had a pH value of 8.55 and the Purdon Crossing site with a temperature measurement of 25.87 °Celsius. Although the temperature was approximately 10 °Celsius higher at the Purdon Crossing site as compared to the other two sites, similar measurements taken during the Labor Day 2008 study did not show any correlation at this site between temperature and elevated *E. coli* levels (Central Valley Water Board, 2009a).

7.0 SUMMARY AND CONCLUSION

Results show that the Lower American River, Deer Creek and Dry Creek watersheds continued to exhibit elevated *E. coli* levels at one or more sites. None of the sites tested positive for pathogenic *E. coli* O157:H7. There was no clear evidence of a single source of *E. coli* contamination in the Lower American River or the Dry Creek Watershed, where non-point urban sources are abundant. In the Deer Creek Watershed, *E. coli* values were higher upstream of the Labor Day 2008 swimming hole site in an area dominated by cattle grazing.

The Lower American River Watershed and the South Yuba River Watershed had no measurable amounts of *Cryptosporidium*, *Giardia*, or *Salmonella*. The Deer Creek Watershed had a positive value for *Cryptosporidium*, but no measurable amounts of *Giardia* or *Salmonella*. The Dry Creek Watershed had measurable amounts of *Cryptosporidium*, *Giardia*, and *Salmonella* at one or more locations. Nutrient values varied between sites but were generally low or undetectable. Field measurements also varied between sites, but with the exception of temperature, values most often fell within water quality guidelines. It is not clear whether the nutrient or field constituents had an effect on the occurrence or concentration of *E. coli*, *E. coli* O157:H7, *Cryptosporidium*, *Giardia* or *Salmonella*.

All of the results collected in this study were passed on to the local county public health departments for evaluation. Based on the information collected in this study, future-monitoring efforts in the Central Valley Region should consider:

- Follow-up sampling at other times of the year to develop a more thorough analysis of water quality, especially in the Dry Creek and Deer Creek

watersheds where measurable *E. coli*, *Giardia*, *Cryptosporidium* and/or *Salmonella* concentrations were more frequent.

- Continued cooperation and communication with stakeholders and public health departments from these watersheds to help identify potential sources of contamination.
- Continued follow-up and coordination with bacteria source identification efforts like the Central Valley Bacteria Source Identification Study, a pilot effort utilizing coordinated monitoring between the Central Valley Water Board and the University of California at Davis (Central Valley Water Board, 2009b)

8.0 REFERENCES

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APPENDIX 1

Table A1. Quality Assurance duplicate field and laboratory samples with associated Relative Percent Differences (RPD)

Constituent	Sample Type	Site ID	Site Name	Result	Unit	RPD (%)	Notes
<i>Cryptosporidium</i>	Field Duplicate	516NEV906	Squirrel Creek in Western Gateway Park, Penn Valley	0.182	oocyst/L	66.67	2 oocysts in 11 liters as compared to 1 oocyst in 11 liters for normal grab sample
<i>Cryptosporidium</i>	Lab Duplicate	531PLA900	Dry Creek/Cirby Confluence	0	oocyst/L	NA	No RPD because no oocysts were detected
<i>E. coli</i>	Field Duplicate	516NEV906	Squirrel Creek in Western Gateway Park, Penn Valley	579.4	MPN/100mL	0	
<i>E. coli</i>	Lab Duplicate	516NEV901	South Yuba River at Purdon Crossing	179.3	MPN/100mL	13.18	
<i>E. coli</i>	Lab Duplicate	531PLA900	Dry Creek/Cirby Confluence	123.6	MPN/100mL	22.30	
<i>E. coli</i>	Field Duplicate	514SAC007	American River at Discovery Park	111.9	MPN/100mL	1.71	
<i>E. coli</i> O157:H7	Field Duplicate	516NEV906	Squirrel Creek in Western Gateway Park, Penn Valley	Negative	NA	NA	
<i>E. coli</i> O157:H7	Lab Duplicate	516NEV901	South Yuba River at Purdon Crossing	Negative	NA	NA	
<i>E. coli</i> O157:H7	Lab Duplicate	531PLA900	Dry Creek/Cirby Confluence	Negative	NA	NA	
<i>Giardia</i>	Field Duplicate	516NEV906	Squirrel Creek in Western Gateway Park, Penn Valley	0	cyst/L	0	
<i>Giardia</i>	Lab Duplicate	531PLA900	Dry Creek/Cirby Confluence	1.455	cyst/L	31.58	16 cysts in 11 Liters as compared to 22 cysts in 11 Liters for normal grab sample
Nitrogen, Ammonia-N	Field Duplicate	516NEV906	Squirrel Creek in Western Gateway Park, Penn Valley	<0.20	mg/L	0	
Nitrogen, Ammonia-N	Lab Duplicate	516NEV901	South Yuba River at Purdon Crossing	<0.20	mg/L	0	

Table A1. Quality Assurance duplicate field and laboratory samples with associated Relative Percent Differences (RPD)

Constituent	Sample Type	Site ID	Site Name	Result	Unit	RPD (%)	Notes
Nitrogen, Ammonia-N	Lab Duplicate	531PLA900	Dry Creek/Cirby Confluence	<0.20	mg/L	0	
Nitrogen, Total Kjeldahl	Field Duplicate	516NEV906	Squirrel Creek in Western Gateway Park, Penn Valley	<0.50	mg/L	0	
Nitrogen, Total Kjeldahl	Lab Duplicate	516NEV901	South Yuba River at Purdon Crossing	<0.50	mg/L	0	
Nitrogen, Total Kjeldahl	Lab Duplicate	531PLA900	Dry Creek/Cirby Confluence	<0.50	mg/L	0	
Nitrogen, Total Nitrate-N	Field Duplicate	516NEV906	Squirrel Creek in Western Gateway Park, Penn Valley	0.19	mg/L	0	
Nitrogen, Total Nitrate-N	Lab Duplicate	516NEV901	South Yuba River at Purdon Crossing	<0.050	mg/L	0	
Nitrogen, Total Nitrate-N	Lab Duplicate	531PLA900	Dry Creek/Cirby Confluence	0.086	mg/L	1.17	
Phosphate, Ortho-P	Field Duplicate	516NEV906	Squirrel Creek in Western Gateway Park, Penn Valley	0.0235	mg/L	0.85	
Phosphate, Ortho-P	Lab Duplicate	516NEV901	South Yuba River at Purdon Crossing	<0.010	mg/L	0	
Phosphate, Ortho-P	Lab Duplicate	531PLA900	Dry Creek/Cirby Confluence	<0.0932	mg/L	0.21	
Phosphate, Total-P	Field Duplicate	516NEV906	Squirrel Creek in Western Gateway Park, Penn Valley	0.027	mg/L	0	
Phosphate, Total-P	Lab Duplicate	516NEV901	South Yuba River at Purdon Crossing	<0.020	mg/L	0	
Phosphate, Total-P	Lab Duplicate	531PLA900	Dry Creek/Cirby Confluence	0.11	mg/L	8.7	
<i>Salmonella</i>	Field Duplicate	516NEV906	Squirrel Creek in Western Gateway Park, Penn Valley	<2.2	MPN/100mL	0	
<i>Salmonella</i>	Lab	516NEV901	South Yuba River at Purdon	<2.2	MPN/100mL	0	

Table A1. Quality Assurance duplicate field and laboratory samples with associated Relative Percent Differences (RPD)

Constituent	Sample Type	Site ID	Site Name	Result	Unit	RPD (%)	Notes
	Duplicate		Crossing				
<i>Salmonella</i>	Lab Duplicate	516NEV901	South Yuba River at Purdon Crossing	<2.2	MPN/100mL	0	
<i>Salmonella</i>	Lab Duplicate	531PLA900	Dry Creek/Cirby Confluence	<2.2	MPN/100mL	NA	Normal grab sample was at a value of 5.1 MPN/100mL. Since the duplicate is below the detection limit, RPD does not apply
Total Coliform	Field Duplicate	516NEV906	Squirrel Creek in Western Gateway Park, Penn Valley	>2419.6	MPN/100mL	0	
Total Coliform	Lab Duplicate	516NEV901	South Yuba River at Purdon Crossing	>2419.6	MPN/100mL	0	
Total Coliform	Lab Duplicate	531PLA900	Dry Creek/Cirby Confluence	>2419.6	MPN/100mL	0	
Total Coliform	Field Duplicate	514SAC007	American River at Discovery Park	>2419.6	MPN/100mL	0	