Middle Santa Ana River Bacteria TMDL BMP Control Strategy and Prioritization Plan

February 28, 2010

CDM

ON BEHALF OF

Santa Ana Watershed Project Authority

San Bernardino County Stormwater Program

County of Riverside

Cities of Chino Hills, Upland, Montclair, Ontario, Rancho Cucamonga, Rialto, Chino, Fontana, Norco, Corona, Riverside, Pomona, and Claremont

Agricultural Operators

Table of Contents

Figures

Tables

Section 1
Introduction

Various waterbodies in the Middle Santa Ana River (MSAR) watershed are listed on the state 303(d) list of impaired waters due to high levels of fecal indicator bacteria (FIB). The MSAR Bacterial Indicator TMDL ("MSAR Bacteria TMDL) was adopted by the Santa Ana Regional Water Quality Control Board (RWQCB) and approved by the State Water Resources Control Board (SWRCB) to address these impairments (RWQCB 2005). EPA Region 9 approved the MSAR Bacteria TMDL on May 16, 2007 making the TMDL effective.

Implementation of this TMDL includes requirements for the implementation of a watershed-wide compliance monitoring program, evaluation of urban sources of bacterial indicators, and the implementation of water quality control strategies to reduce FIB concentrations in dry and wet weather discharges in the Municipal Separate Storm Sewer System (MS4) managed by San Bernardino and Riverside Counties (Figure 1-1). Agricultural dischargers have additional responsibilities under the TMDL (Figure 1-1).

To date, the responsible parties have implemented a watershed-wide compliance program. In addition, the MS4 dischargers have implemented an evaluation of urban sources of FIB and collected site-specific BMP data. Agricultural dischargers have implemented an evaluation of agricultural sources of FIB. This report summarizes these activities and uses the data collected to date to formulate a BMP Control Strategy and Prioritization Plan (CSPP). The recommendations of this effort will support ongoing efforts to comply with requirements in recently issued MS4 permits for Riverside and San Bernardino Counties.

1.1 Middle Santa Ana River Watershed

1.1.1 General Description

The Santa Ana River watershed, located in southern California, is approximately 2800 square miles in size. Surface water flows begin in the San Bernardino and San Gabriel Mountains and flow in a generally northwest to southwest direction to the Pacific Ocean. The MSAR watershed is 488 square miles in size and located generally in the north central portion of the Santa Ana River watershed. The watershed includes the southwestern part of San Bernardino County, the northwestern part of Riverside County, and a small portion of Los Angeles County (Figure 1-1).

Lying within an arid region, limited natural perennial surface water is present in the watershed. Flows derived from mountain areas (snowmelt or storm runoff) are mostly captured by dams or percolated in recharge basins. In the transition zone from mountains to lower lying valley areas, the sources of surface water flows vary, e.g., dry weather urban runoff, such as occurs from irrigation, stormwater runoff during rain events, highly treated wastewater effluent, or rising groundwater.

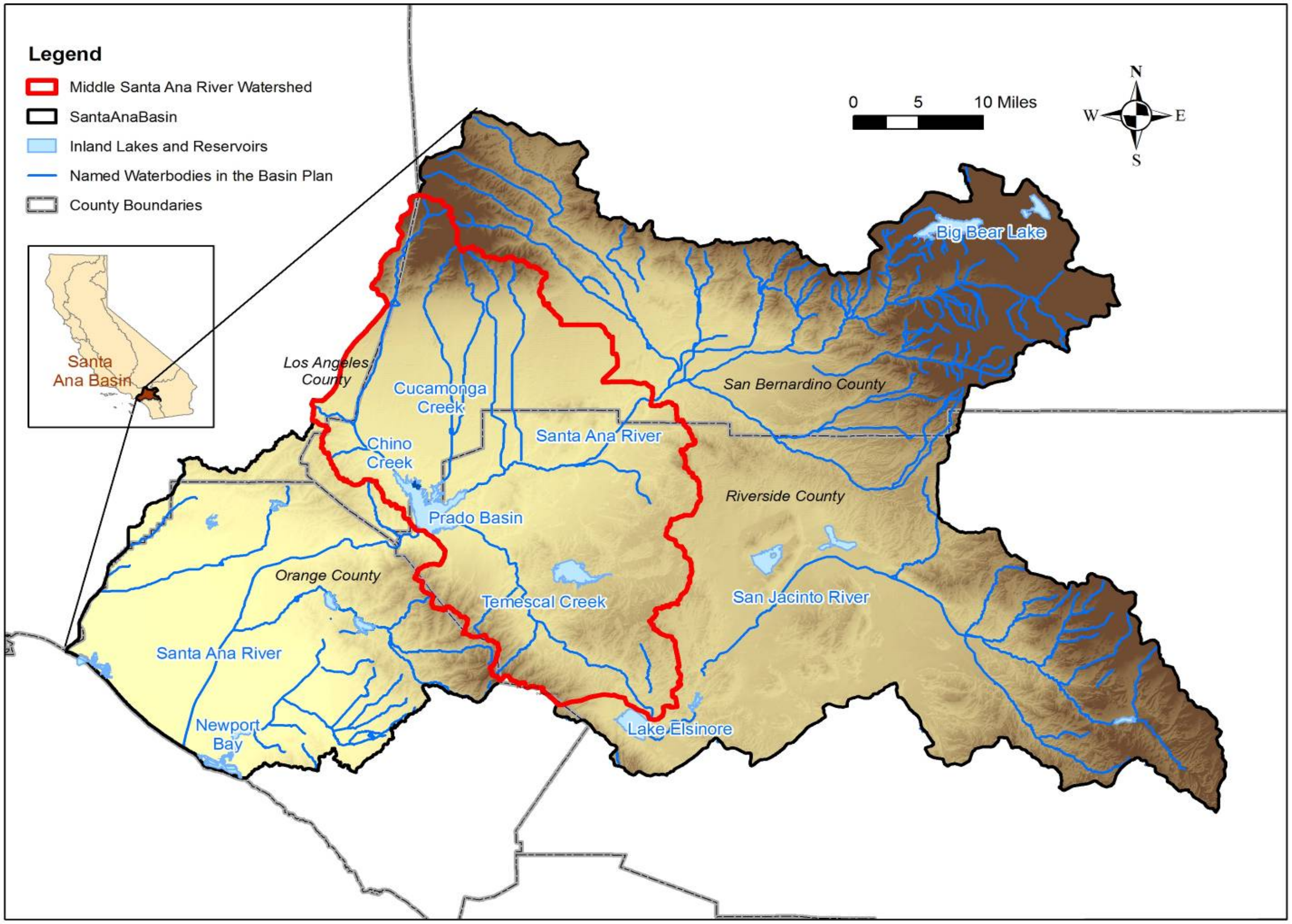

Figure 1-1. Location of the Middle Santa Ana River watershed (red outline) within the Santa Ana River watershed in southern California

The largest order waterbody in the MSAR watershed is Reach 3 of the Santa Ana River which flows from La Cadena to the Prado Basin, where Prado Dam controls flows from the middle to the lower part of the Santa Ana River watershed. A number of major tributaries to the MSAR exist, many of which have been modified for flood control purposes.

Three major geographic areas comprise the MSAR watershed (RWQCB 2005) (Figure 1-2):

- Chino Basin (San Bernardino County, Los Angeles County, and Riverside Counties) – Surface drainage in this area, which is directed to Chino Creek and Mill-Cucamonga Creek, flows generally southward, from the San Gabriel Mountains toward the Santa Ana River and the Prado Flood Control Basin.

- Riverside Watershed (Riverside County) – Surface drainage in this area is generally northwestward or southwestward from the incorporated and unincorporated areas of Riverside County to Reach 3 of the Santa Ana River.

- Temescal Canyon Watershed (Riverside County) – Surface drainage in this area is generally northwest to Temescal Creek.

Based on 2000 census data, the population of the watershed is approximately 1.4 million people. Much of the lowland areas are highly developed; however, a portion of the watershed remains largely agricultural - the area formerly known as the Chino Dairy Preserve. This area is located in the south central part of the Chino Basin subwatershed. At the time of TMDL development the area contained approximately 300,000 cows (RWQCB 2005). As of January 2009, this number was down to about 138,500 (email communication, Ed Kashak [RWQCB] to Pat Boldt, December 8, 2009). In recent years, the cities of Ontario, Chino, and Chino Hills annexed the San Bernardino County portions of this area. The remaining portion of the former preserve, which is in Riverside County, remains unincorporated (RWQCB 2005).

1.1.2 Physical Description

The following sections summarize the regional hydrology, annual precipitation and temperature, and sources of information for previously reported bacterial indicator concentrations in the study area.

Regional Hydrology

The Santa Ana River watershed experiences a Mediterranean type climate with hot, dry summers, and cooler, wetter winters. Average annual precipitation varies and ranges from 12 inches per year in the lower watershed along the Pacific coast to 18 inches per year in the inland valleys. In the mountains of the northern and eastern parts of the watershed annual precipitation may reach 40 inches per year. Most

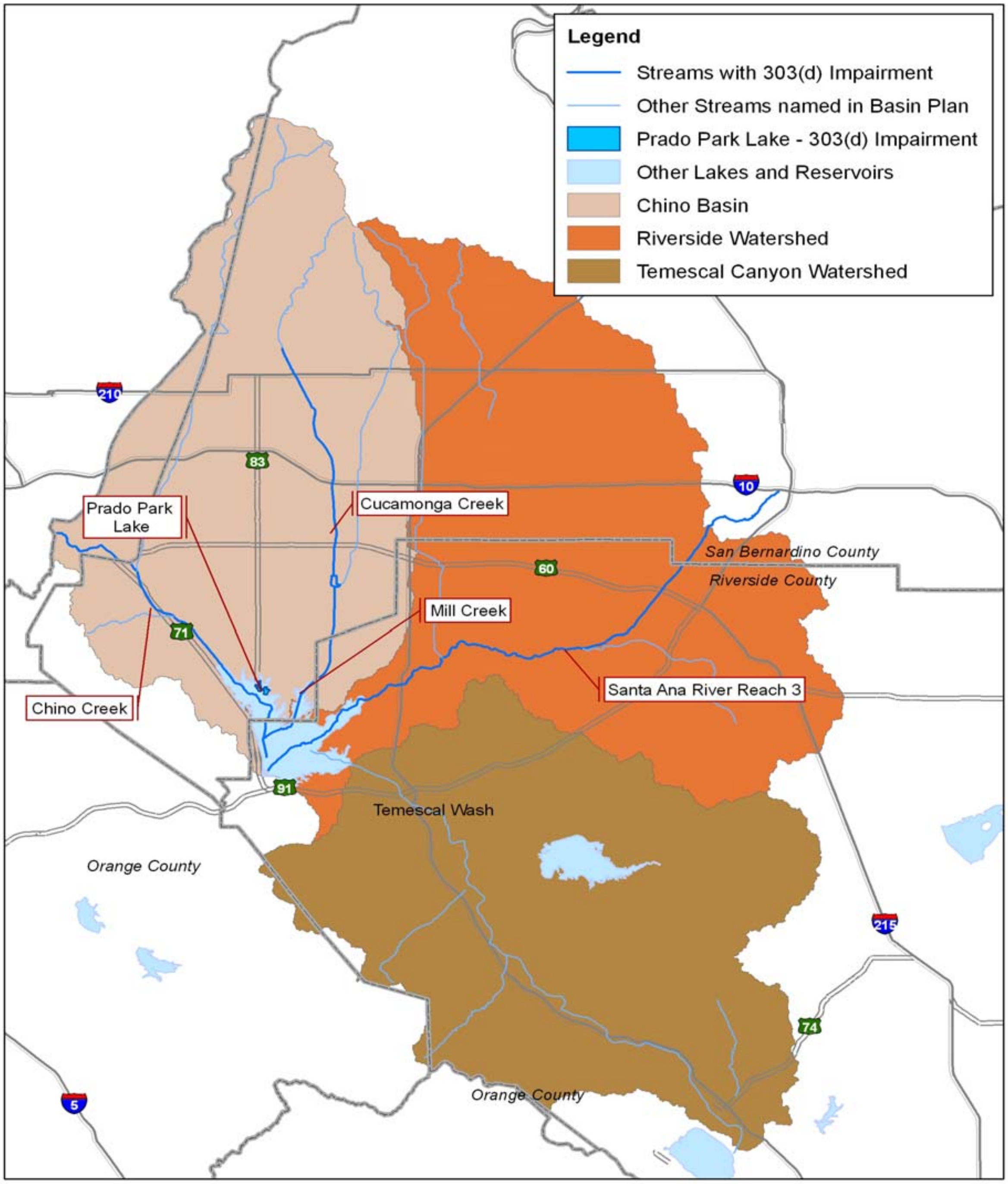

Figure 1-2. Major geographic areas of the Middle Santa Ana River watershed

precipitation falls between November and March and may include variable amounts of snow in the higher mountains (SAWPA 2005).

On average, instream flows are typically low; however, periods of significant precipitation or localized intense rain events can result in rapid increases in surface flows by 1 to 2 orders of magnitude. Following such an event, streams tend to return to baseflow conditions quickly (SAWPA 2005, 2009a). Instream flows in the watershed are influenced by the following (Figure 1-3):

- Dams capture wet weather flows in some subwatersheds resulting in attenuated flows in downstream waters. For example, the Chino Creek subwatershed receives releases from San Antonio Dam via its San Antonio Channel tributary.

- The effort to recharge groundwater by facilitating infiltration of surface water runoff reduces runoff in receiving waters by diversion and spreading of runoff in basins with high infiltration capacity.

- The importation of water to the watershed increases surface flows in certain areas, e.g., importation of water to Chino Creek.

A number of publicly owned treatment works discharge highly treated effluent to MSAR waterbodies, e.g., a significant portion of the flow along segments of Reach 3 of the Santa Ana River is comprised mostly of treated effluent.

Precipitation

Table 1-1 summarizes the precipitation statistics for a rainfall gauge located within the study area (Riverside Fire Station #3). The long-term 30-year average annual precipitation at this location is 10.06 inches/year.

Table 1-1. Average annual precipitation in the study area as measured at Riverside Fire Station #3

Measurement	Precipitation (inches)
Average Annual Precipitation	10.06
Maximum Recorded Annual Precipitation	22.72
Minimum Recorded Annual Precipitation	1.07

Water Quality

Bacterial indicator water quality data have been collected for many years in the MSAR watershed. SAWPA (2009a) references and summarizes the findings from MSAR watershed studies conducted prior to 2007. SAWPA 2009a, 2009b, 2009c and 2009d report bacterial indicator data collected since 2007.

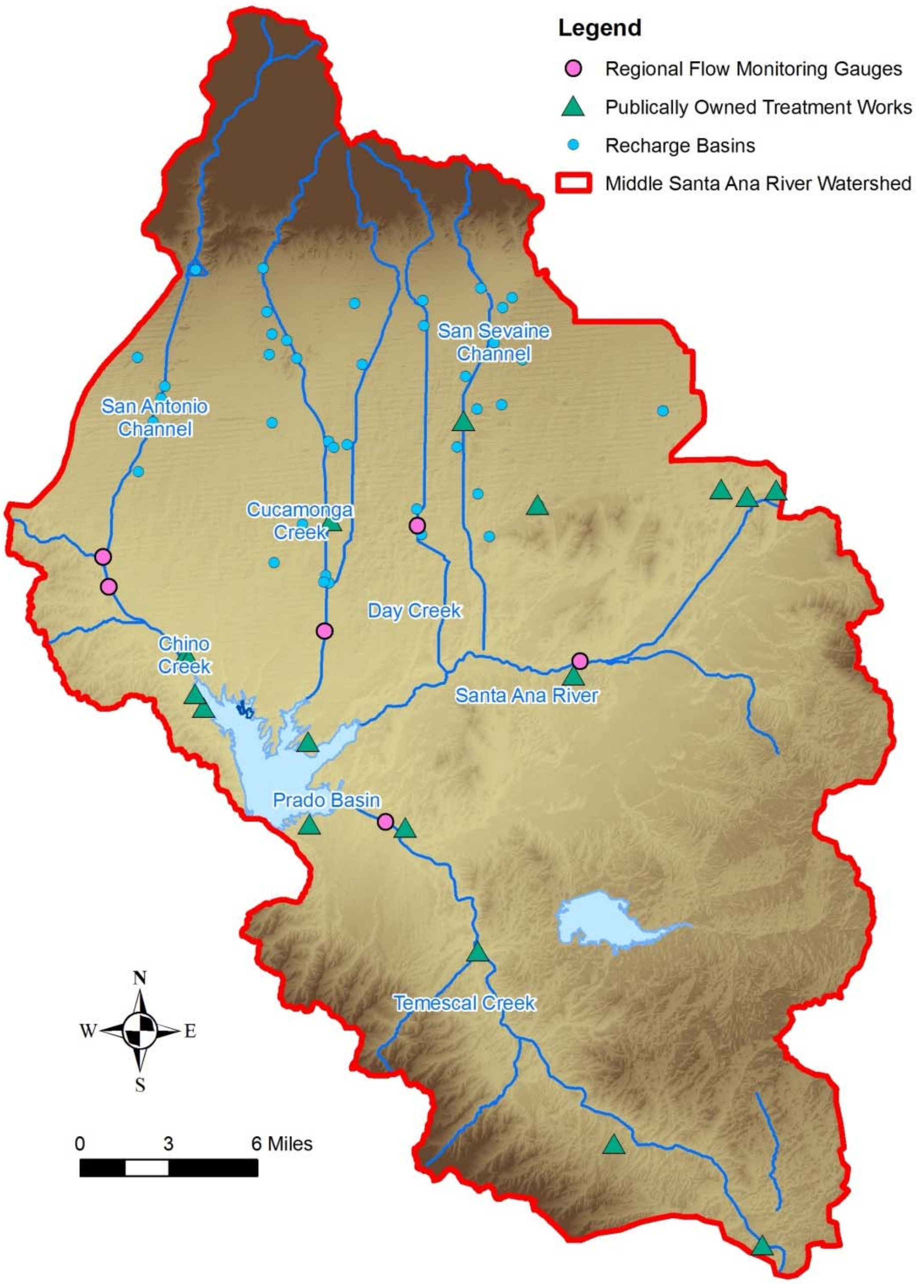

Figure 1-3. Location of recharge basins and publicly owned treatment works that influence instream flows in Middle Santa Ana River waterbodies

1.2 Regulatory Background

The Santa Ana Regional Water Quality Control Plan (Basin Plan) designates beneficial uses for surface waters in the Santa Ana River watershed (RWQCB 1995) (see Table 3-1 of the Basin Plan). The beneficial uses applicable to waterbodies in the MSAR watershed include Water Contact Recreation (REC-1), which is defined in the Basin Plan as follows:

> "waters are used for recreational activities involving body contact with water where ingestion of water is reasonably possible. These uses may include, but are not limited to, swimming, wading, water-skiing, skin and scuba diving, surfing, whitewater activities, fishing, and use of natural hot springs" (Basin Plan, page 3-2).

The Basin Plan (Chapter 4) specifies fecal coliform as a bacterial indicator for pathogens ("bacterial indicator"). Fecal coliform present at concentrations above certain thresholds are believed to be an indicator of the presence of fecal pollution and harmful pathogens, thus increasing the risk of gastroenteritis in bathers exposed to the elevated levels. The Basin Plan currently specifies the following water quality objectives for fecal coliform:

> ***REC-1*** *- Fecal coliform: log mean less than 200 organisms/100 mL based on five or more samples/30-day period, and not more than 10 percent of the samples exceed 400 organisms/ 100 mL for any 30-day period.*

EPA published new bacteria guidance in 1986 (EPA 1986). This guidance advised that for freshwaters *E. coli* is a better bacterial indicator than fecal coliform. Epidemiological studies found that the positive correlation between *E. coli* concentrations and the frequency of gastroenteritis was better than the correlation between fecal coliform concentrations and gastroenteritis.

The RWQCB is currently considering replacing the REC-1 bacteria water quality objectives for fecal coliform with *E. coli* objectives. This evaluation is occurring through the work of the Stormwater Quality Standards Task Force (SWQSTF). The SWQSTF is comprised of representatives from various stakeholder interests, including the Santa Ana Watershed Protection Authority; the counties and cities of Orange, Riverside, and San Bernardino; Orange County Coastkeeper; Inland Empire Waterkeeper; the RWQCB; and EPA Region 9. The SWQSTF plans to recommend Basin Plan amendments for adoption in 2010.

In 1994 and 1998, because of exceedances of the fecal coliform objective established to protect the REC-1 use, the RWQCB added various waterbodies in the MSAR watershed to the state 303(d) list of impaired waters. The MSAR Watershed TMDL Task Force ("TMDL Task Force"), which includes representation by many key watershed stakeholders, was subsequently formed to address bacterial indicator impairments in the following waterbodies:

- Santa Ana River, Reach 3 – Prado Dam to Mission Boulevard
- Chino Creek, Reach 1 – Santa Ana River confluence to beginning of hard lined channel south of Los Serranos Road
- Chino Creek, Reach 2 – Beginning of hard lined channel south of Los Serranos Road to confluence with San Antonio Creek
- Mill Creek (Prado Area) – Natural stream from Cucamonga Creek Reach 1 to Prado Basin
- Cucamonga Creek, Reach 1 – Confluence with Mill Creek to 23rd Street in City of Upland
- Prado Park Lake

The 2005 RWQCB-adopted TMDL for these waters established compliance targets or wasteload allocations (WLAs) for both fecal coliform and *E. coli*:

- Fecal coliform: 5-sample/30-day Logarithmic Mean less than 180 organisms/ 100 mL and not more than 10 percent of the samples exceed 360 organisms/100 mL for any 30-day period.
- *E. coli*: 5-sample/30-day Logarithmic Mean less than 113 organisms/100 mL and not more than 10 percent of the samples exceed 212 organisms/100 mL for any 30-day period.

To focus TMDL implementation efforts, the MSAR Watershed TMDL Task Force ("Task Force") was established. This Task Force, which meets regularly to coordinate water quality management activities, includes representation by key watershed stakeholders, including urban stormwater dischargers, agricultural operators, and the RWQCB.

1.3 TMDL Implementation Requirements

The MSAR Bacteria TMDL addresses bacterial indicator impairments by establishing requirements for urban and agricultural discharges (RWQCB 2005) (Figure 1-4):

- Urban and agricultural dischargers shall develop a Watershed-wide Compliance Monitoring Program by November 30, 2007. A RWQCB-approved program was implemented in 2007 and continues to collect data on a regular basis (see Section 2).
- Permitted MS4 dischargers shall develop an Urban Source Evaluation Plan (USEP) by November 30, 2007 and implement it following RWQCB approval. Key TMDL sections addressing USEP requirements include:

- *Section 4.1* - The purpose of the USEP is to identify specific activities, operations, and processes in urban areas that contribute bacterial indicators to MSAR waterbodies (RWQCB 2005). The Plan should also include a proposed schedule for the activities identified and include contingency provisions as needed to reflect any uncertainty in the proposed activities or schedule.

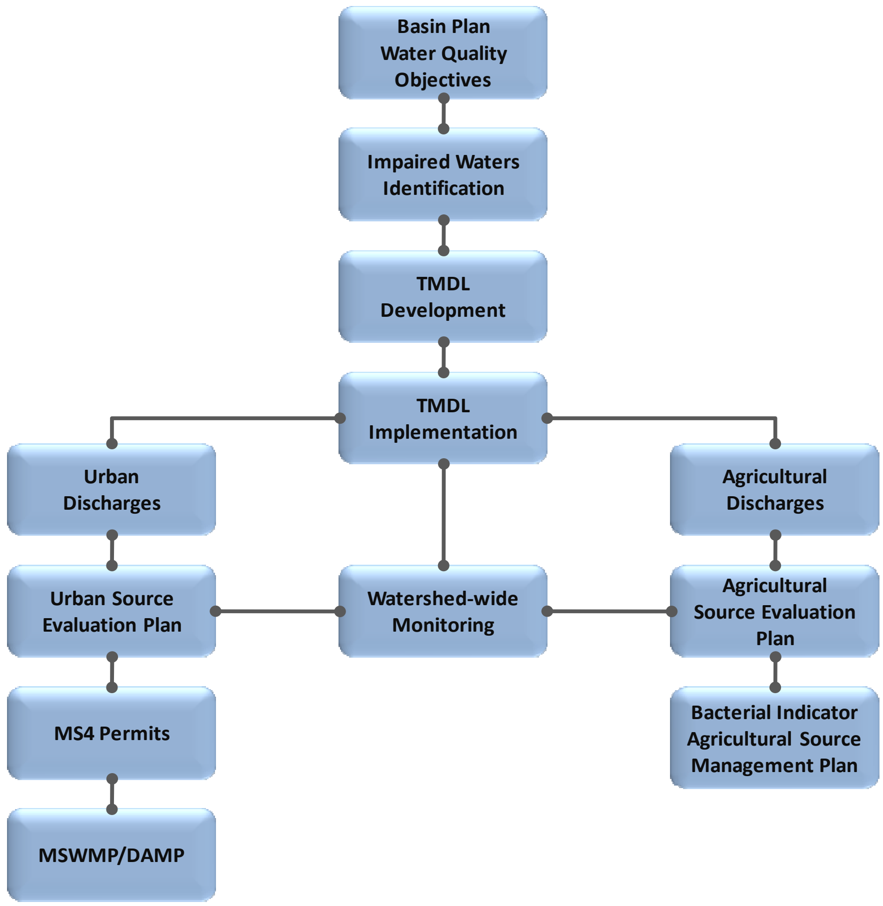

Figure 1-4. Outline of the TMDL development process for the MSAR Bacterial Indicator TMDL and TMDL implementation requirements applicable to urban and agricultural dischargers.

- *Sections 4.2, 4.3, 4.4, and 4.5* -The findings from the USEP activities will be used by the San Bernardino and Riverside County MS4 permit programs to mitigate urban sources of bacterial indicators to the extent practicable. The findings may also be used by the RWQCB to require revisions to the San Bernardino County Municipal Stormwater Management Program (MSWMP) and Riverside County Drainage Area Management Plan (DAMP). Wherever USEP activities identify bacterial indicator sources that are not covered by the San Bernardino and Riverside County MS4 permits, the RWQCB will be responsible for implementing follow-up actions.

The USEP was developed and approved by the RWQCB[1]. The urban source monitoring program incorporated into the USEP was implemented during 2007-2008.

- Agricultural dischargers shall develop an Agricultural Source Evaluation Plan (AgSEP) by November 30, 2007 and implement it with RWQCB approval. Agricultural dischargers are also required to develop a Bacterial Indicator Agricultural Source Management Plan (BASMP) at a later date. The purpose of the AgSEP is to identify specific activities, operations, and processes in agricultural areas that contribute bacterial indicators to MSAR watershed waterbodies (RWQCB 2005). The plan includes a proposed schedule for the steps identified and includes contingency provisions as needed to reflect any uncertainty in the proposed steps or schedule. The AgSEP was developed and approved by the RWQCB[2]. The monitoring program incorporated into the AgSEP was implemented during 2008-2009.

1.4 MS4 NPDES Permit Requirements

The RWQCB adopted new MS4 permits for Riverside and San Bernardino Counties on January 29, 2010. These permits incorporate requirements for compliance with MSAR Bacteria TMDL numeric targets. Each permit describes the requirements associated with implementation of the MSAR Bacteria TMDL, including, but not limited to (RWQCB 2010a, b):

- Submit comprehensive reports every three years that summarize progress towards meeting TMDL WLAs;
- Prepare a draft Comprehensive Bacteria Reduction Plan (CBRP) to describe how compliance will be achieved for flows during the dry season (by December 31, 2010); and
- Revise the DAMP for Riverside County and MSWMP for San Bernardino County as required by the TMDL.

1.5 Proposition 40 State Grant

In anticipation of EPA approval of the TMDL, the Santa Ana Watershed Project Authority (SAWPA), in cooperation with the San Bernardino County Flood Control District (SBCFCD), Riverside County Flood and Water Conservation District

[1] See http://www.waterboards.ca.gov/santaana/water_issues/programs/tmdl/msar_tmdl.shtml to review the RWQCB-approved USEP (SAWPA 2008c).
[2] See http://www.waterboards.ca.gov/santaana/water_issues/programs/tmdl/msar_tmdl.shtml to review the RWQCB-approved AgSEP.

(RCFWCD), and Orange County Water District (OCWD) submitted a Proposition 40 grant proposal to the SWRCB to support the implementation of TMDL requirements. This grant proposal, Middle Santa Ana River Pathogen TMDL-BMP Implementation (Grant Project), included tasks to initiate the watershed-wide compliance monitoring, characterize urban FIB sources, implement a BMP pilot study, and develop a BMP CSPP for dry weather discharges from the MS4. The state approved the grant proposal in fall 2006 and the Grant Project was initiated in early 2007.

1.6 Report Purpose

Per the scope of work associated with the Grant Project, the purpose of the BMP CSPP is to provide the following:

- Based on results from the various monitoring and BMP study activities, develop a plan to reduce the concentration of indicator pathogens in Chino Creek, Mill-Cucamonga Creek, Prado Park Lakes and Reach 3 of the Santa Ana River during dry weather flows. The BMP CSPP should include:
  - A comparison of relative effectiveness for various BMP strategies (measured as both "percent reduction" and by the ability to meet relevant water quality objectives).
  - A comparison of costs for various BMP strategies (construction cost, maintenance cost, operating cost, etc.)
  - A comparison of compliance efficiency for various BMP strategies (measured as cost-per-acre or cost-per-flow volume).
  - A list of subwatersheds that contribute disproportionately to the total load of pathogen indicator bacteria in the receiving water and recommendations as to which (if any) BMPs would be most cost-effective at reducing such loads under dry weather conditions.
- Prepare a report recommending additional water quality studies or BMP evaluations that should be initiated in order to meet the goals identified in the MSAR Bacteria TMDL or other pathogen-related TMDLs that may be pending in Riverside or San Bernardino County.

In addition to the above, this report also provides the following:

- As required by the TMDL and the MS4 permits for Riverside and San Bernardino Counties - A comprehensive report that summarizes the data collected for the preceding three year period (2007-2009) and evaluates progress towards achieving the urban wasteload allocations described in Section 1.2 above (see Section 2);
- Results of the BMP Pilot Study conducted under the Grant Project (see Section 3);

- Strategies for reducing FIB concentrations in each of the major subwatersheds of the MSAR watershed so that the TMDL targets are met at the watershed-wide compliance sites during dry weather (see Sections 4 & 5); and

- Foundation for the development of the draft CBRP for dry weather that is required for submittal to the RWQCB by December 31, 2010 (see Sections 4 & 5).

Section 2
Water Quality Summary (2007-2009)

2.1 Introduction

Various waterbodies in the Middle Santa Ana River (MSAR) watershed are listed on the state 303(d) list of impaired waters due to high levels of fecal indicator bacteria (FIB). The MSAR Bacterial Indicator TMDL ("MSAR Bacteria TMDL") was adopted by the Santa Ana Regional Water Quality Control Board (RWQCB) and approved by the State Water Resources Control Board to address these impairments (RWQCB 2005). EPA Region 9 approved the MSAR Bacteria TMDL on May 16, 2007 making the TMDL effective.

The MSAR Bacteria TMDL requires implementation of a watershed-wide compliance monitoring program for bacterial indicators. This program was initiated in July 2007. The TMDL requires that periodic monitoring reports be submitted to the RWQCB. The first report covered both the dry and wet seasons of 2007-2008. Subsequently, biannual (December – dry season report; May – wet season report) have been submitted to the RWQCB (December 2008, May 2009, and December 2009). Biannual reports will continue to be submitted in the future.

In addition to these regular reporting requirements, the TMDL requires preparation of a water quality assessment every three years that summarizes the data collected for the preceding three year period and evaluates progress towards achieving the wasteload and load allocations. This requirement is also included in the San Bernardino County and Riverside County Municipal Separate Storm Sewer System (MS4) permits (Section V.D.1.iii and Section VI.D.1.a.iii, respectively, permit adopted by RWQCB on January 29, 2010).

This section provides the first three year water quality assessment for the MSAR Bacteria TMDL – fulfilling both TMDL and MS4 permit reporting requirements. It summarizes the results of watershed-wide compliance sampling conducted from 2007 to 2009. This assessment also summarizes wet weather FIB concentrations observed at monitoring locations established by agricultural dischargers.

2.2 MSAR Bacteria TMDL Requirements

In 1994 and 1998, because of exceedances of the fecal coliform objective established to protect the REC-1 use, the RWQCB added the following waterbodies in the MSAR watershed to the state 303(d) list of impaired waters:

- Santa Ana River, Reach 3 – Prado Dam to Mission Boulevard
- Chino Creek, Reach 1 – Santa Ana River confluence to beginning of hard lined channel south of Los Serranos Road

- Chino Creek, Reach 2 – Beginning of hard lined channel south of Los Serranos Road to confluence with San Antonio Creek

- Mill Creek (Prado Area) – Natural stream from Cucamonga Creek Reach 1 to Prado Basin

- Cucamonga Creek, Reach 1 – Confluence with Mill Creek to 23rd Street in City of Upland

- Prado Park Lake

The 2005 RWQCB-adopted TMDL for these waters established compliance targets or wasteload allocations (WLA) and load allocations (LA) for both fecal coliform and *E. coli*. The WLAs apply to urban runoff including stormwater runoff and dischargers from Concentrated Animal Feeding Operations (CAFOs); the LAs apply to agricultural runoff discharges and natural sources. Regardless of the allocation (WLA or LA), the FIB numeric targets are the same:

- Fecal coliform: 5-sample/30-day logarithmic mean less than 180 organisms/100 mL and not more than 10% of the samples exceed 360 organisms/100 mL for any 30-day period.

- *E. coli*: 5-sample/30-day logarithmic mean less than 113 organisms/100 mL and not more than 10% of the samples exceed 212 organisms/100 mL for any 30-day period.

2.3 Watershed-Wide Compliance Monitoring Program

The MSAR Bacterial Indicator TMDL requires urban and agricultural dischargers to implement a watershed-wide bacterial indicator monitoring program by November 2007 (RWQCB 2005). The dischargers worked collaboratively through the MSAR Watershed TMDL Task Force[1] ("Task Force") to develop this program and prepare a Monitoring Plan (SAWPA 2008a) and Quality Assurance Project Plan (QAPP) (SAWPA 2008b)[2]. The TMDL Task Force implemented the monitoring program in July 2007 following RWQCB approval of program documents.

SAWPA (2009a) summarizes the findings from the 2007 dry season and 2007-08 wet season monitoring. SAWPA (2009b) and SAWPA (2009c) summarize the findings from the 2008 dry and 2008-2009 wet seasons, respectively. SAWPA (2009d) summarizes the results from the 2009 dry season.

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[1] This Task Force includes representation by key watershed stakeholders, including stormwater programs for Riverside and San Bernardino Counties, agricultural operators, RWQCB, and SAWPA.
[2] The Middle Santa Ana River Monitoring Plan and Quality Assurance Project Plan are available at http://www.waterboards.ca.gov/santaana/water_issues/programs/tmdl/msar_tmdl.shtml

2.3.1 Watershed-Wide Compliance Monitoring Sites

The TMDL Task Force established five watershed-wide compliance monitoring sites in the MSAR watershed. Table 2-1 and Figure 2-1 identify the locations sampled from 2007 to 2009 [3]. Attachment A of the Monitoring Plan (see footnote 2) provides additional information about each sample location.

Table 2-1. Watershed-wide compliance monitoring program sample locations

Waterbody	Sample Location	Site Code
Icehouse Canyon	Near Icehouse Canyon Trailhead Parking Lot	WW-C1
Prado Lake	Prado Lake Outlet	WW-C3
Chino Creek	Central Avenue	WW-C7
Mill-Cucamonga Creek	Chino-Corona Road	WW-M5
Santa Ana River	MWD Crossing	WW-S1
Santa Ana River	Pedley Avenue	WW-S4

[3] Prior to the 2009 dry season, Icehouse Canyon was included as watershed-wide compliance monitoring site. However, with RWQCB approval the Task Force removed this site from the sampling program prior to the start of the 2009 dry season monitoring program.

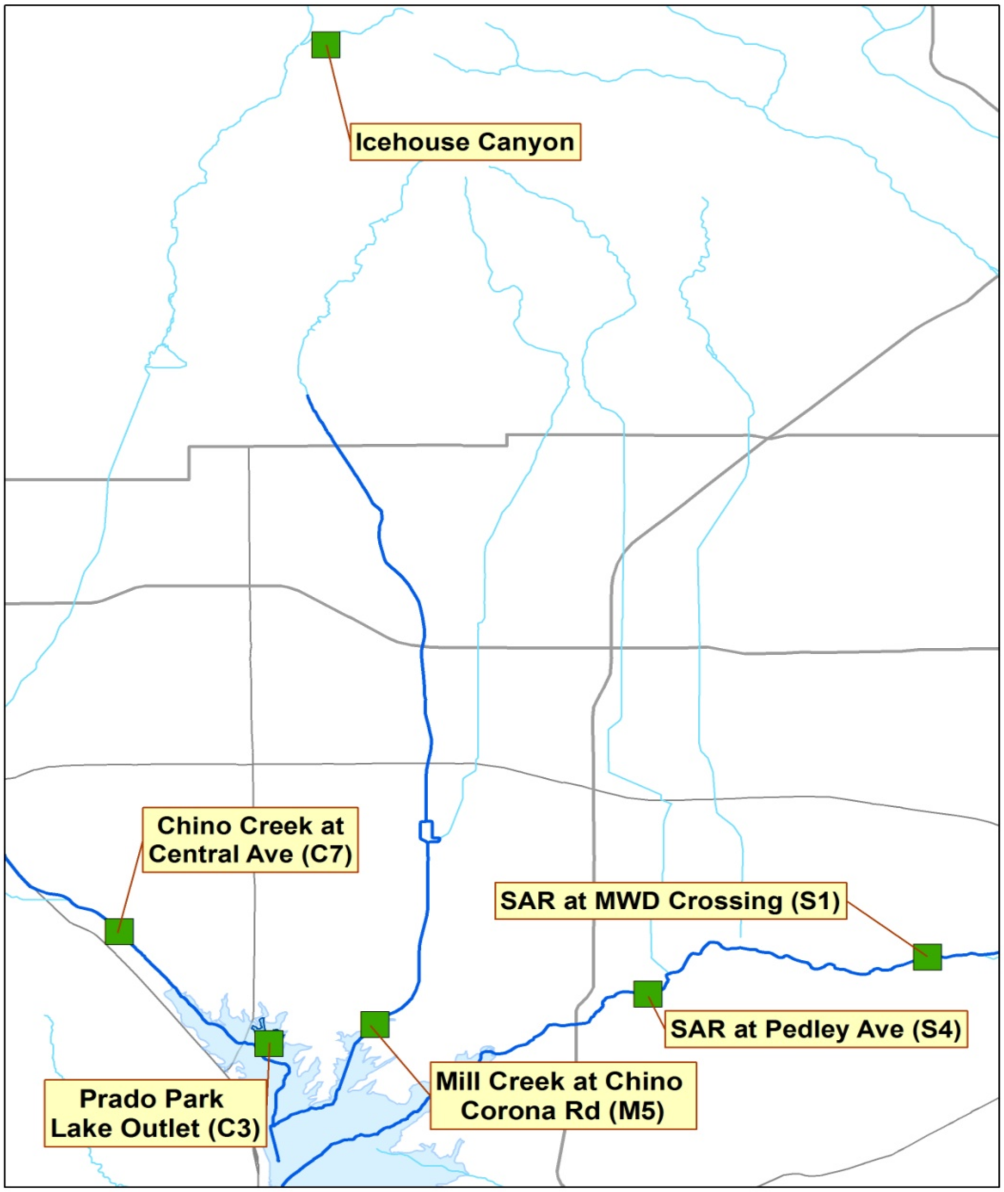

Figure 2-1. Location of watershed-wide compliance monitoring program sample locations in the Middle Santa Ana River watershed

2.3.2 Sampling Methods

The RWQCB-approved Monitoring Plan and QAPP (SAWPA 2008a, b) provide detailed information regarding the collection and analysis of field data and water quality samples. The following sections provide a summary of these methods.

Water Quality Measurements

At each sample site water quality measurements include the collection of field parameter data and water samples for laboratory analysis:

- *Field Measurements*: Flow, temperature, conductivity, pH, dissolved oxygen, and turbidity.

- *Laboratory Analysis*: Fecal coliform, *E. coli*, and total suspended solids (TSS).

Sample Frequency

The Monitoring Plan established sample collection dates for each year of the monitoring program. These are summarized as follows:

- *2007 Dry Season* - Weekly samples were collected over a 15 week period from July 9, 2007 to the week ending October 14, 2007. Table 2-2 summarizes the results of this effort.

Table 2-2. Summary of water sample collection activity during 2007 dry season

Sample Month	Planned	Collected	Site Dry	Samples Missed (Cause)
July	24	20	4[1]	0
August	24	20	4[1]	0
September	24	20	4[1]	0
October	18	15	3[1]	0

[1] Icehouse Canyon was dry – no sample collected

- *2008 Dry Season* – Sampling began as scheduled the week of May 13th. However, laboratory contract problems, which prevented the laboratory from accepting samples for analysis, resulted in the suspension of sampling for a six week period from the week of July 20, 2008 through the end of August 2008. Once the contract issues were resolved, weekly sample collection resumed the week of September 1, 2008. To ensure the collection of 20 warm, dry season samples in 2008, the TMDL Task Force agreed to extend the sample period into the first week of November 2008. Table 2-3 summarizes the results of the 2008 dry season sampling effort.

- *2009 Dry Season* - Weekly samples were collected over a 20 week period from the week ending May 30, 2009 to the week ending October 10, 2009. Table 2-4 summarizes the results of this sampling effort.

Table 2-3. Summary of water sample collection activity during 2008 dry season

Sample Month	Planned	Collected	Site Dry	Samples Missed (Cause)
May	18	17	0	1 (road closure in Icehouse Canyon due to fire)
June	24	24	0	0
July[1]	18	18	0	0
August[2]	0	0	0	0
September	27	27	0	0
October	27	27	0	0
November	6	6	0	0

[1] Sample program suspended for six weeks during months of July and August (see text for discussion)

Table 2-4. Summary of water sample collection activity during 2009 dry season

Sample Month	Planned	Collected	Samples Missed
May	5	5	0
June	25	25	0
July	20	20	0
August	20	20	0
September	25	25	0
October	5	5	0

- *2007-2008 Wet Season* - Weekly samples were collected over a 10 week period from the week ending December 22, 2007 to the week ending February 23, 2008. In addition, one storm event was sampled. Storm event sampling includes: (1) collection of a sample on the day of the storm event; (2) collection of additional samples at 48, 72 and 96 hours after the onset if the storm event. During this wet season a storm event was sampled on December 7, 2007. Additional samples were collected 48, 72 and 96 hours after the storm event on December 9th, 10th and 11th, respectively. Table 2-5 summarizes the results of the 2007-2008 wet season sampling effort.

- *2008-2009 Wet Season* - Weekly samples collected over an 11 week period from the week ending December 13, 2008 to the week ending February 21, 2009. During the 2008-2009 sampling period, a storm event was sampled on December 15th, 2008. Additional samples were collected 48, 72 and 96 hours after the storm event on December 17th, 18th and 19th, respectively. Table 2-6 summarizes the results of the 2008-2009 wet season sampling effort.

Sample Collection

San Bernardino County Flood Control District staff collected the field measurements and water quality samples. CDM coordinated the activities of the sample team and the submittal of samples to the laboratory for analysis.

Table 2-5. Summary of water sample collection activity during 2007-2008 wet season

Sample Month	Planned	Collected	Site Dry	Samples Missed (Cause)
Weekly Sampling				
December	12	10	2[2]	0
January	30	25	5[2]	0
February	18	15	3[2]	0
Storm Event Sampling				
December 7 - 11	24	20	4[2]	0

[1] Wet weather event occurred on December 7th
[2] Icehouse Canyon was dry – no sample collected

Table 2-6. Summary of water sample collection activity during 2008-2009 wet season

Sample Month	Planned	Collected	Site Dry	Samples Missed (Cause)
Weekly Sampling				
December	24	24[1]	0	0
January	24	24	0	0
February	18	18	0	0
Storm Event Sampling				
December 15 -19	24	24	0	0

[1] Collection of weekly samples planned for week of December 15 coincided with collection of samples during the first day of a storm event. Accordingly, the first day storm event sample represented the regular weekly sampling event.

Sample Handling

Sample collection and laboratory delivery followed approved chain of custody procedures, holding time requirements, and required storage procedures for each water quality analysis. The Orange County Health Care Agency Water Quality Laboratory conducted all analyses for fecal coliform, *E. coli*, and TSS.

2.3.3 Data Management

The following sections describe data handling and analysis methods. Additional details are provided in the Monitoring Plan and QAPP (see footnote 2).

Data Handling

CDM and SAWPA maintain a file of all laboratory and field data records (e.g., data sheets, chain of custody forms) as required by the QAPP. CDM entered all field measurements and laboratory analysis results into a project database that is compatible with guidelines and formats established by the California Surface Water Ambient Monitoring Program. CDM periodically submits to SAWPA updates of this for incorporation into the Santa Ana Watershed Data Management System (SAWDMS), which SAWPA manages. Prior to a data submittal to SAWPA, CDM completes a quality assurance/quality control review of the data.

Data Analysis

Data analysis relied primarily on the use of descriptive statistics and comparisons to water quality objectives or TMDL allocations. For any statistical analyses, the bacterial indicator data were assumed to be log-normally distributed as was observed in previous studies (SAWPA 2009a). Accordingly, prior to conducting statistical analyses, the bacterial indicator data were log transformed.

2.4 Compliance with Wasteload Allocations

The TMDL contains WLAs for urban discharges and CAFOs. The watershed-wide compliance monitoring program samples five locations on a regular basis. These sites evaluate compliance with WLAs. Source specific monitoring, i.e., urban discharge vs. CAFO discharge does not occur at this time. The following sections summarize the FIB concentrations observed at the watershed-wide compliance sites during the last three years.

2.4.1 Bacterial Indicator Concentrations

The following tables summarize the observed FIB concentrations at each watershed-wide compliance site during the dry and wet season sample periods from 2007-2009:

- Table 2-7 summarizes observations for both dry and wet seasons from summer 2007 to spring 2008.
- Table 2-8 summarizes the observations during the dry season of 2008.
- Table 2-9 summarizes the observations during the wet season of 2008-2009.
- Table 2-10 summarizes the observations during the dry season of 2009.

Tables 2-11 and 2-12 summarize the geometric mean, median, and coefficient of variation of the fecal coliform data for samples collected during each dry and wet weather season. Data from Icehouse Canyon was not included because the site was either often dry or the results were below laboratory detection.

Tables 2-13 and 2-14 summarize the geometric mean, median, and coefficient of variation of the *E. coli* data for samples collected during each dry and wet weather season. Data from Icehouse Canyon was not included because the site was either often dry or the results were below laboratory detection.

Figures 2-2 to 2-6 illustrate the trend in single sample and geometric mean results for fecal coliform for the 2007-2009 period for all sites except Icehouse Canyon. Figures 2-7 to 2-11 illustrate the same for *E. coli*.

Figure 2-12 illustrates the variability of bacterial indicator concentrations observed during the 2007-2009 period for both dry and wet seasons. Superimposed on this figure are the individual wet weather event sample results. These sample results tend to be higher than the median FIB concentrations.

Table 2-7. Fecal coliform and *E. coli* (cfu/100 mL) concentrations observed at watershed-wide compliance sites during 2007-2008

Sample Week	Fecal coliform						*E. coli*					
	Icehouse Canyon (WW-C1)	Prado Park Lake (WW-C3)	Chino Creek (WW-C7)	Mill Creek (WW-M5)	Santa Ana River @ MWD Crossing (WW-S1)	Santa Ana River @ Pedley Avenue (WW-S4)	Icehouse Canyon (WW-C1)	Prado Park Lake (WW-C3)	Chino Creek (WW-C7)	Mill Creek (WW-M5)	Santa Ana River @ MWD Crossing (WW-S1)	Santa Ana River @ Pedley Avenue (WW-S4)
2007 Dry Season												
7/8/07	NS[1]	30	5,200	5,200	170	150	NS[1]	30	1,210	2,000	30	40
7/15/07	NS[1]	9	3,000	2,600	270	220	NS[1]	< 9	810	> 1,000	290	60
7/22/07	NS[1]	60	5,900	> 9,000	220	2,300	NS[1]	60	> 2,700	> 5,700	99	150
7/29/07	NS[1]	> 340	2,000	> 1,600	700	> 240	NS[1]	230	560	1,170	70	140
8/5/07	NS[1]	210	1,500	2,700	210	550	NS[1]	110	940	> 1,150	140	110
8/12/07	NS[1]	300	2,400	2,200	420	560	NS[1]	170	420	720	280	140
8/19/07	NS[1]	440	1,100	2,800	3,100	1,100	NS[1]	440	> 1,030	> 750	> 490	150
8/26/07	NS[1]	99	> 2,400	> 1,300	> 900	1,110	NS[1]	30	770	780	220	280
9/2/07	NS[1]	140	1,800	> 1,500	2,600	18,000	NS[1]	150	870	550	960	2,800
9/9/07	NS[1]	50	> 720	> 2,300	1,800	2,200	NS[1]	30	> 720	> 1,150	170	180
9/16/07	NS[1]	820	1,100	> 1,500	310	510	NS[1]	990	> 330	> 760	170	170
9/23/07	NS[1]	40	6,000	4,200	4,900	3,400	NS[1]	50	> 800	> 700	> 380	> 310
9/30/07	NS[1]	200	510	1,700	600	430	NS[1]	140	320	730	200	140
10/7/07	NS[1]	140	440	480	280	220	NS[1]	180	260	500	220	200
10/14/07	NS[1]	70	> 700	2,400	110	470	NS[1]	40	440	910	360	480
2007-08 Wet Season												
12/16/07	NS[1]	380	80	730	2,200	2,600	NS[1]	260	120	1,500	3,800	4,600
12/23/07	NS[1]	210	320	170	120	80	NS[1]	170	240	150	120	130
12/30/07	NS[1]	180	230	180	40	60	NS[1]	200	210	200	130	70
1/6/08	NS[1]	80	310	480	160	520	NS[1]	120	220	360	140	490
1/13/08	NS[1]	80	200	180	50	80	NS[1]	110	260	100	40	70
1/20/08	NS[1]	50	4,100	230	40	9	NS[1]	60	2,100	200	30	50
1/27/0/	NS[1]	520	210	340	180	390	NS[1]	470	260	360	190	260
2/3/08	NS[1]	280	70	160	120	90	NS[1]	250	110	50	40	30
2/10/08	NS[1]	130	130	70	40	40	NS[1]	90	50	110	40	80
2/17/08	NS[1]	60	150	7,700	60	140	NS[1]	80	150	5,200	40	80

Table 2-7. Fecal coliform and *E. coli* (cfu/100 mL) concentrations observed at watershed-wide compliance sites during 2007-2008

Sample Week	Fecal coliform						*E. coli*					
	Icehouse Canyon (WW-C1)	Prado Park Lake (WW-C3)	Chino Creek (WW-C7)	Mill Creek (WW-M5)	Santa Ana River @ MWD Crossing (WW-S1)	Santa Ana River @ Pedley Avenue (WW-S4)	Icehouse Canyon (WW-C1)	Prado Park Lake (WW-C3)	Chino Creek (WW-C7)	Mill Creek (WW-M5)	Santa Ana River @ MWD Crossing (WW-S1)	Santa Ana River @ Pedley Avenue (WW-S4)
Wet Weather Event												
12/7/07	NS[1]	260	10,000	22,000	43,000	9,000	NS[1]	160	5,100	> 5,000	22,000	7,200
12/9/07	NS[1]	130	3,100	790	420	2,000	NS[1]	90	2,200	520	310	780
12/10/07	NS[1]	90	230	200	190	190	NS[1]	120	200	130	110	120
12/11/07	NS[1]	99	240		210	190	NS[1]	90	230	120	120	170

[1] – No sample, site dry

Table 2-8. Fecal coliform and *E. coli* concentrations (cfu/100 ml) observed at watershed-wide compliance sites during the 2008 dry season

Sample Date (Week of)	Icehouse Canyon (WW-C1)	Prado Park Lake Outlet (WW-C3)	Chino Creek @ Central Avenue (WW-C7)	Mill Creek @ Chino-Corona Rd (WW-M5)	SAR @ MWD Crossing (WW-S1)	SAR @ Pedley Avenue (WW-S4)
Fecal coliform						
May 13	No Sample (Dry)	99	280	1,000	340	180
May 20	< 9	60	200	540	110	40
May 27	< 9	60	590	3,500	500	690
June 3	< 9	90	470	3,000	820	670
June 10	< 9	30	3,200	1,140	390	380
June 17	< 9	40	1,000	1,400	90	280
June 24	< 9	> 400	2,700	1,400	580	3,900
July 1	< 9	490	580	1,300	340	240
July 8	< 9	420	560	5,900	380	210
July 15	< 9	70	9,600	> 3,400	230	190
September 2	< 9	290	8,100	1,600	350	2,300
September 9	30	170	2,400	590	280	320
September 16	40	> 500	3,800	380	190	210
September 23	20	230	850	2,800	50	140
September 30	< 9	260	560	490	220	60
October 7	< 9	200	380	40	130	110
October 14	< 9	200	210	18,000	150	70
October 21	< 9	160	920	1,700	70	90
October 28	< 9	110	230	420	140	160
November 4	< 9	180	36,000	3,800	2,700	5,600
E. coli						
May 13	No Sample (Dry)	100	350	1,260	470	110
May 20	< 9	40	210	590	160	90
May 27	< 9	80	320	700	270	200
June 3	< 9	20	500	1,180	> 160	> 200

Table 2-8. Fecal coliform and *E. coli* concentrations (cfu/100 ml) observed at watershed-wide compliance sites during the 2008 dry season

Sample Date (Week of)	Icehouse Canyon (WW-C1)	Prado Park Lake Outlet (WW-C3)	Chino Creek @ Central Avenue (WW-C7)	Mill Creek @ Chino-Corona Rd (WW-M5)	SAR @ MWD Crossing (WW-S1)	SAR @ Pedley Avenue (WW-S4)
June 10	< 9	70	610	1,030	150	370
June 17	< 9	90	310	1,240	110	310
June 24	< 9	340	440	810	180	170
July 1	< 9	670	480	620	180	140
July 8	< 9	360	310	8,700	200	130
July 15	< 9	140	1,610	1,100	40	70
September 2	< 9	160	850	790	180	690
September 9	40	50	1,000	540	140	190
September 16	30	350	1,130	730	130	90
September 23	30	230	710	2,100	80	40
September 30	< 9	240	620	720	150	90
October 7	< 9	240	320	140	60	150
October 14	< 9	220	260	2,800	120	90
October 21	< 9	50	210	420	90	140
October 28	< 9	40	230	340	200	320
November 4	< 9	99	33,000	440	340	620

Table 2-9. Fecal coliform and *E. coli* concentrations (cfu/100 mL) observed at watershed-wide compliance sites during the 2008-2009 wet season

Bacterial Indicator	Sample Date (Week of)	Icehouse Canyon Creek (WW-C1)	Prado Park Lake Outlet (WW-C3)	Chino Creek @ Central Avenue (WW-C7)	Mill Creek @ Chino-Corona Rd (WW-M5)	SAR @ MWD Crossing (WW-S1)	SAR @ Pedley Avenue (WW-S4)
Fecal coliform	**Regular Sample Events**						
	December 8	< 9	410	5,800	900	170	150
	December 15[1]	< 90	1,700	4,300	4,800	2,400	4,200
	December 22	< 9	40	410	200	210	320
	December 29	< 9	60	160	180	99	99
	January 5	< 9	40	190	530	20	40
	January 12	< 9	120	190	380	30	70
	January 19	< 9	99	640	850	20	50
	January 26	< 9	220	350	380	80	99
	February 2	9	40	220	390	40	50
	February 9	< 9	2,100	220	280	70	80
	February 16	< 9	10,500	4,800	450	330	330
	Storm Event Samples						
	December 15[1]	< 90	1,700	4,300	4,800	2,400	4,200
	December 17	20	480	10,300	1,700	3,700	4,700
	December 18	< 9	400	3,100	5,900	3,800	3,900
	December 19	< 9	40	290	140	650	1,300
E. coli	**Regular Sample Events**						
	December 8	< 9	510	12,900	970	90	260
	December 15[1]	< 90	2,000	5,700	7,200	1,700	3,800
	December 22	< 9	80	2,100	210	210	340
	December 29	< 9	100	210	270	60	60
	January 5	< 9	110	30	640	30	9
	January 12	< 9	90	150	390	40	40
	January 19	< 9	120	510	660	< 9	120
	January 26	< 9	310	320	390	110	120
	February 2	9	40	160	580	20	80

Table 2-9. Fecal coliform and *E. coli* concentrations (cfu/100 mL) observed at watershed-wide compliance sites during the 2008-2009 wet season

Bacterial Indicator	Sample Date (Week of)	Icehouse Canyon Creek (WW-C1)	Prado Park Lake Outlet (WW-C3)	Chino Creek @ Central Avenue (WW-C7)	Mill Creek @ Chino-Corona Rd (WW-M5)	SAR @ MWD Crossing (WW-S1)	SAR @ Pedley Avenue (WW-S4)
E. coli	February 9	< 9	2,700	280	380	60	70
	February 16	< 9	15,000	6,200	500	220	340
	Storm Event Samples						
	December 15[1]	< 90	2,000	5,700	7,200	1,700	3,800
	December 17	9	290	7,600	1,400	1,400	2,500
	December 18	< 9	600	2,500	4,200	3,400	4,600
	December 19	< 9	260	390	590	880	2,400

[1] First storm event sample coincided with regular weekly sample date and represent the same sample

Table 2-10. Fecal coliform and *E. coli* concentrations (cfu/100 mL) observed at watershed-wide compliance sites during the 2009 dry season

Sample Week	Prado Park Lake Outlet (WW-C3)	Chino Creek @ Central Avenue (WW-C7)	Mill-Cucamonga Creek @ Chino-Corona Rd (WW-M5)	SAR @ MWD Crossing (WW-S1)	SAR @ Pedley Avenue (WW-S4)
Fecal coliform					
May 25	120	210	150	120	99
June 1	40	70	210	80	50
June 8	140	220	540	40	140
June 15	140	170	480	140	90
June 22	20	220	290	99	120
June 29	90	280	350	80	99
July 6	40	1,100	300	140	120
July 13	< 9	1,600	>= 220	120	160
July 20	40	250	280	150	170
July 27	80	320	1,500	160	220
August 3	70	280	280	120	220
August 10	99	>= 520	>= 560	170	140
August 17	250	200	270	130	140
August 24	200	>= 230	4300	140	90
August 31	>= 180	2200	500	240	460
September 7	120	>= 240	>= 450	99	230
September 14	>= 110	1000	3000	150	180
September 21	>= 790	>= 460	>= 840	110	90
September 28	150	250	850	180	220
October 5	80	210	580	70	200
E. coli					
May 25	180	180	320	100	140
June 1	80	40	490	40	40
June 8	90	230	620	80	110
June 15	90	140	830	140	100

Table 2-10. Fecal coliform and *E. coli* concentrations (cfu/100 mL) observed at watershed-wide compliance sites during the 2009 dry season

Sample Week	Prado Park Lake Outlet (WW-C3)	Chino Creek @ Central Avenue (WW-C7)	Mill-Cucamonga Creek @ Chino-Corona Rd (WW-M5)	SAR @ MWD Crossing (WW-S1)	SAR @ Pedley Avenue (WW-S4)
June 22	50	80	330	140	130
June 29	50	130	410	90	99
July 6	40	190	570	60	140
July 13	9	270	370	140	70
July 20	9	160	520	80	130
July 27	40	280	2,300	140	90
August 3	50	210	540	140	120
August 10	9	350	982	110	140
August 17	50	230	620	120	130
August 24	80	>= 410	4,600	320	>= 240
August 31	>= 50	740	1,350	>= 220	>= 210
September 7	110	370	950	180	210
September 14	>= 50	360	2,900	220	150
September 21	>= 730	220	700	210	120
September 28	40	140	690	110	140
October 5	30	110	620	100	110

Table 2-11. Summary of fecal coliform concentrations (cfu/100 mL) and data variability by sample location during the 2007, 2008 and 2009 dry seasons (2007-2008 data from Icehouse Canyon were not included because the site was often dry or values were below detection)

Site	2009				2008				2007			
	N	Geometric Mean	Median	Coefficient of Variation[1]	N	Geometric Mean	Median	Coefficient of Variation[1]	N	Geometric Mean	Median	Coefficient of Variation[1]
Prado Park Lake	20	91	105	0.21	20	152	175	0.17	15	114	140	0.25
Chino Creek	20	339	250	0.14	20	1,116	720	0.20	15	1,678	1,800	0.11
Mill-Cucamonga Creek	20	505	405	0.14	20	1,334	1,400	0.18	15	2,240	2,300	0.09
SAR @ MWD Crossing	20	119	125	0.08	20	232	225	0.18	15	572	420	0.18
SAR @ Pedley Ave.	20	144	140	0.10	20	306	225	0.22	15	773	550	0.19

[1] - Coefficient of variation was calculated using natural log-transformed data

Table 2-12. Summary of *E. coli* concentrations (cfu/100 mL) and data variability by sample location during the 2007, 2008, and 2009 dry seasons (2007-2008 data from Icehouse Canyon were not included because the site was often dry or values were below detection)

Site	2009				2008				2007			
	N	Geometric Mean	Median	Coefficient of Variation[1]	N	Geometric Mean	Median	Coefficient of Variation[1]	N	Geometric Mean	Median	Coefficient of Variation[1]
Prado Park Lake	20	51	50	0.26	20	124	120	0.19	15	90	110	0.27
Chino Creek	20	202	215	0.12	20	570	460	0.18	15	676	770	0.09
Mill-Cucamonga Creek	20	764	620	0.11	20	855	760	0.13	15	979	780	0.09
SAR @ MWD Crossing	20	123	130	0.08	20	148	155	0.14	15	204	220	0.18
SAR @ Pedley Ave.	20	123	130	0.10	20	162	145	0.11	15	187	150	0.19

[1] - Coefficient of variation was calculated using natural log-transformed data

Table 2-13. Summary of fecal coliform concentrations (cfu/100 mL) and data variability by sample location during the 2007-2008 and 2008-2009 wet seasons (2007-2008 data from Icehouse Canyon were not included because the site was often dry or values were below detection)

Site	2008-2009				2007-2008			
	N	Geometric Mean	Median	Coefficient of Variation[1]	N	Geometric Mean	Median	Coefficient of Variation[1]
Prado Park Lake	14	230	170	0.32	14	144	130	0.14
Chino Creek	14	776	380	0.23	14	365	230	0.26
Mill Creek	14	595	420	0.18	14	431	215	0.26
SAR @ MWD Crossing	14	188	135	0.35	14	196	140	0.36
SAR @ Pedley Ave.	14	266	125	0.32	14	219	165	0.34

[1] - Coefficient of variation was calculated using natural log-transformed data

Table 2-14. Summary of *E. coli* concentrations (cfu/100 mL) and data variability by sample location during the 2007-2008 and 2008-2009 wet seasons (2007-2008 data from Icehouse Canyon were not included because the site was often dry or values were below detection)

Site	2008-2009				2007-2008			
	N	Geometric Mean	Median	Coefficient of Variation[1]	N	Geometric Mean	Median	Coefficient of Variation[1]
Prado Park Lake	14	335	275	0.28	14	138	120	0.11
Chino Creek	14	806	450	0.27	14	311	225	0.23
Mill Creek	14	718	585	0.15	14	323	200	0.25
SAR @ MWD Crossing	14	148	100	0.35	14	165	120	0.36
SAR @ Pedley Ave.	14	257	190	0.32	14	214	125	0.34

[1] - Coefficient of variation was calculated using natural log-transformed data

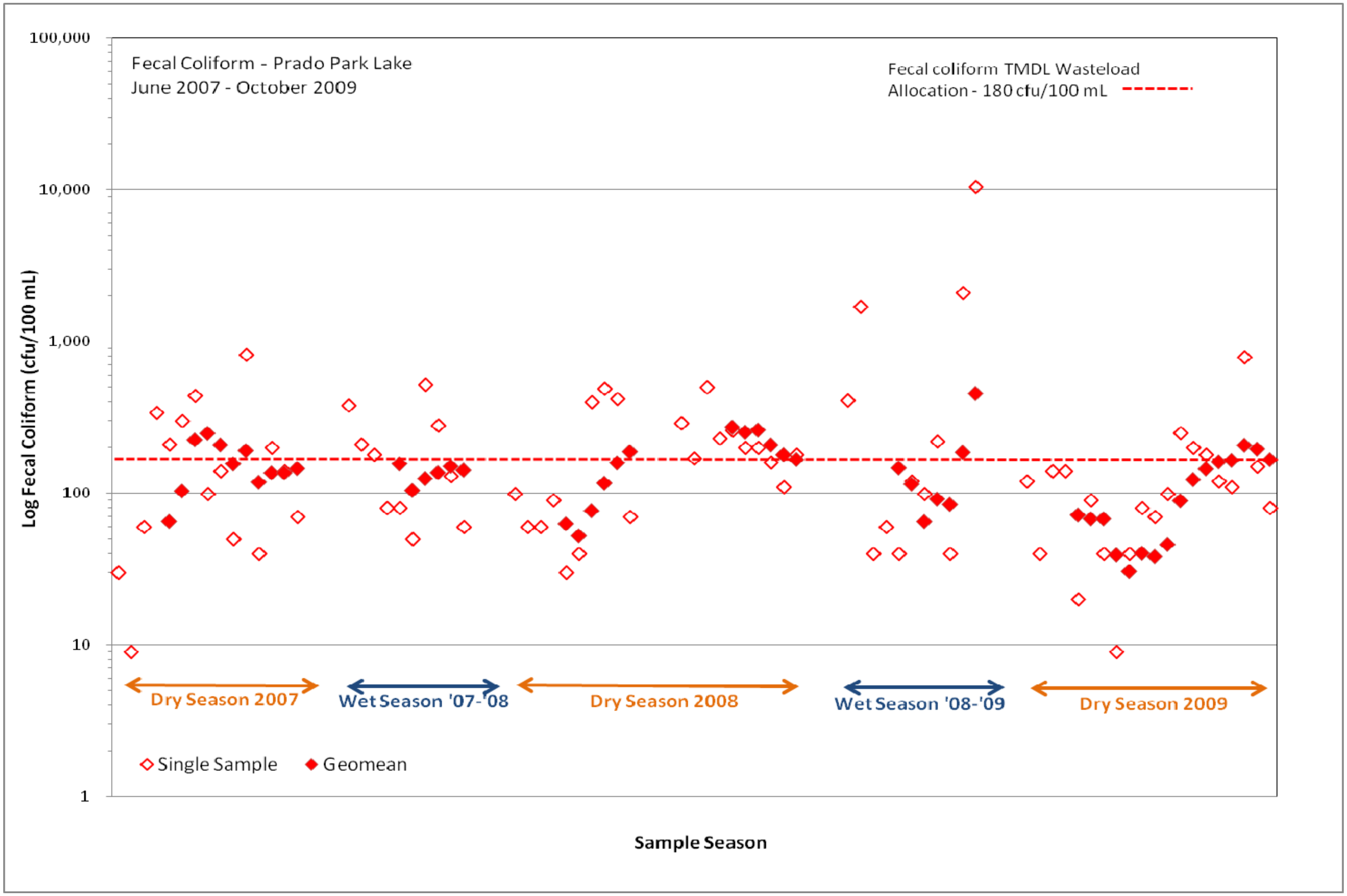

Figure 2-2. Time series plot of fecal coliform single sample results and geometric means for samples collected from Prado Park Lake (2007-2009). Geometric mean was calculated only if five samples were collected during the previous five weeks.

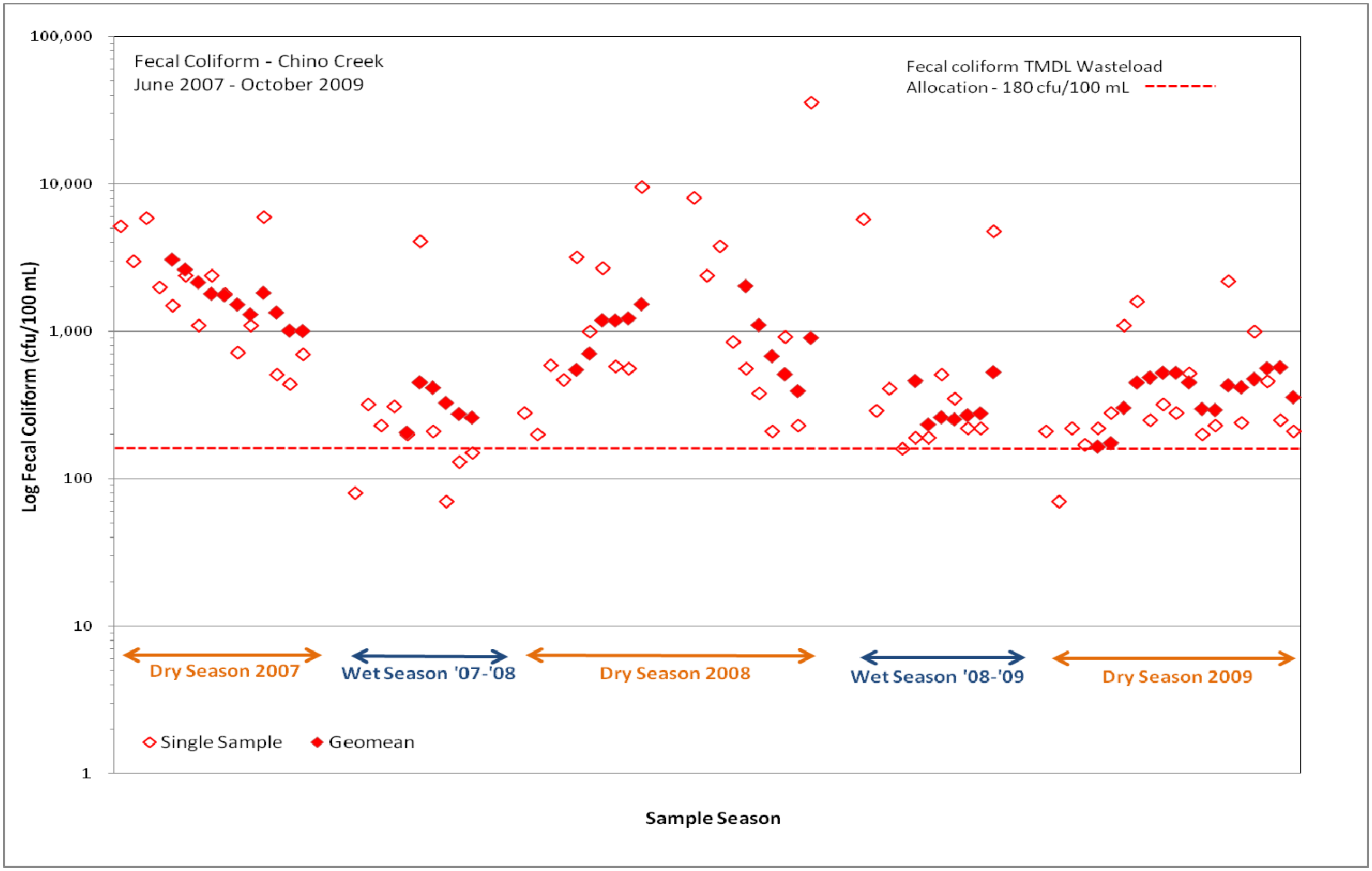

Figure 2-3. Time series plot of fecal coliform single sample results and geometric means for samples collected from Chino Creek (2007-2009). Geometric mean was calculated only if five samples were collected during the previous five weeks.

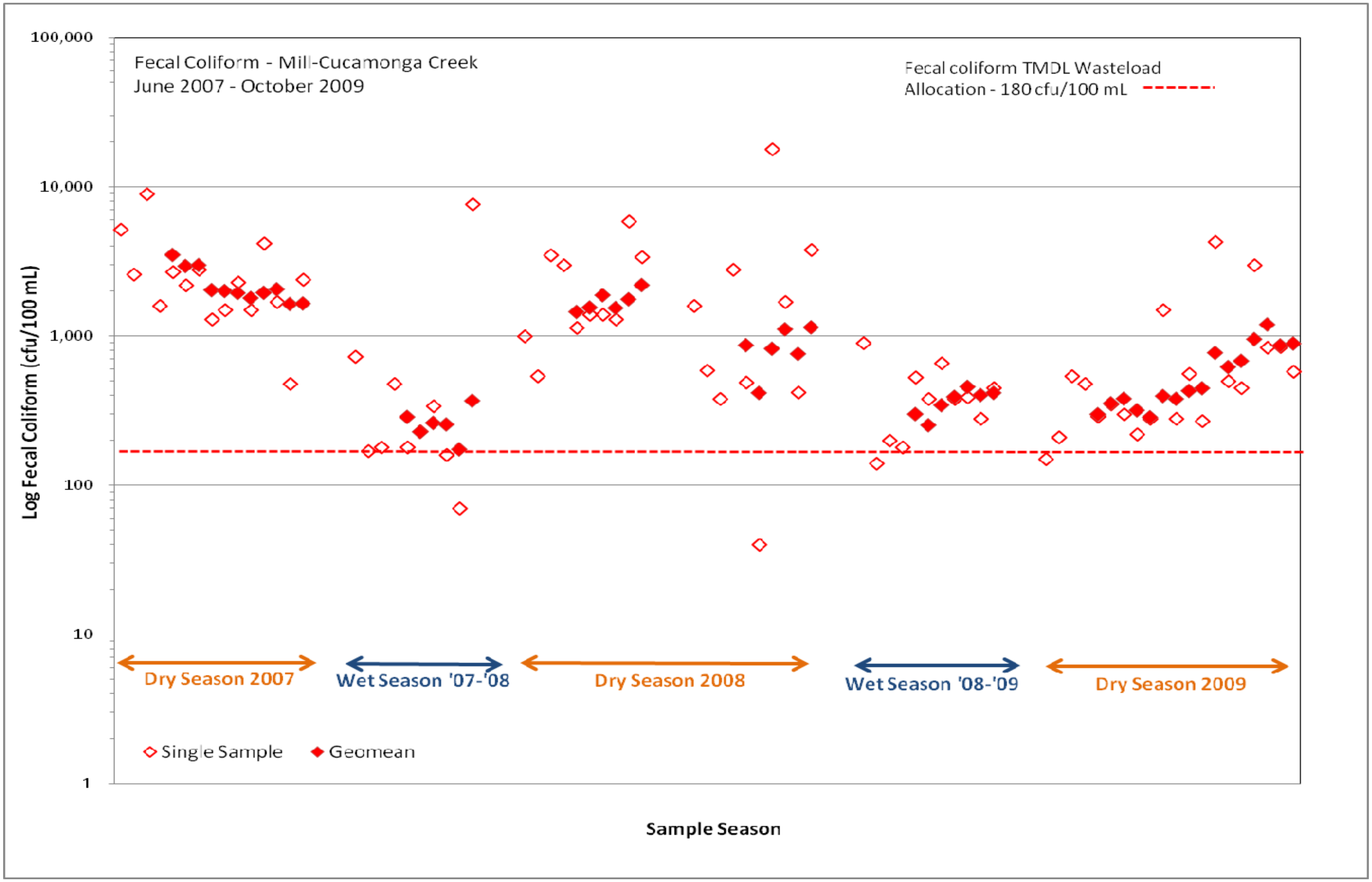

Figure 2-4. Time series plot of fecal coliform single sample results and geometric means for samples collected from Mill-Cucamonga Creek (2007-2009). Geometric mean was calculated only if five samples were collected during the previous five weeks.

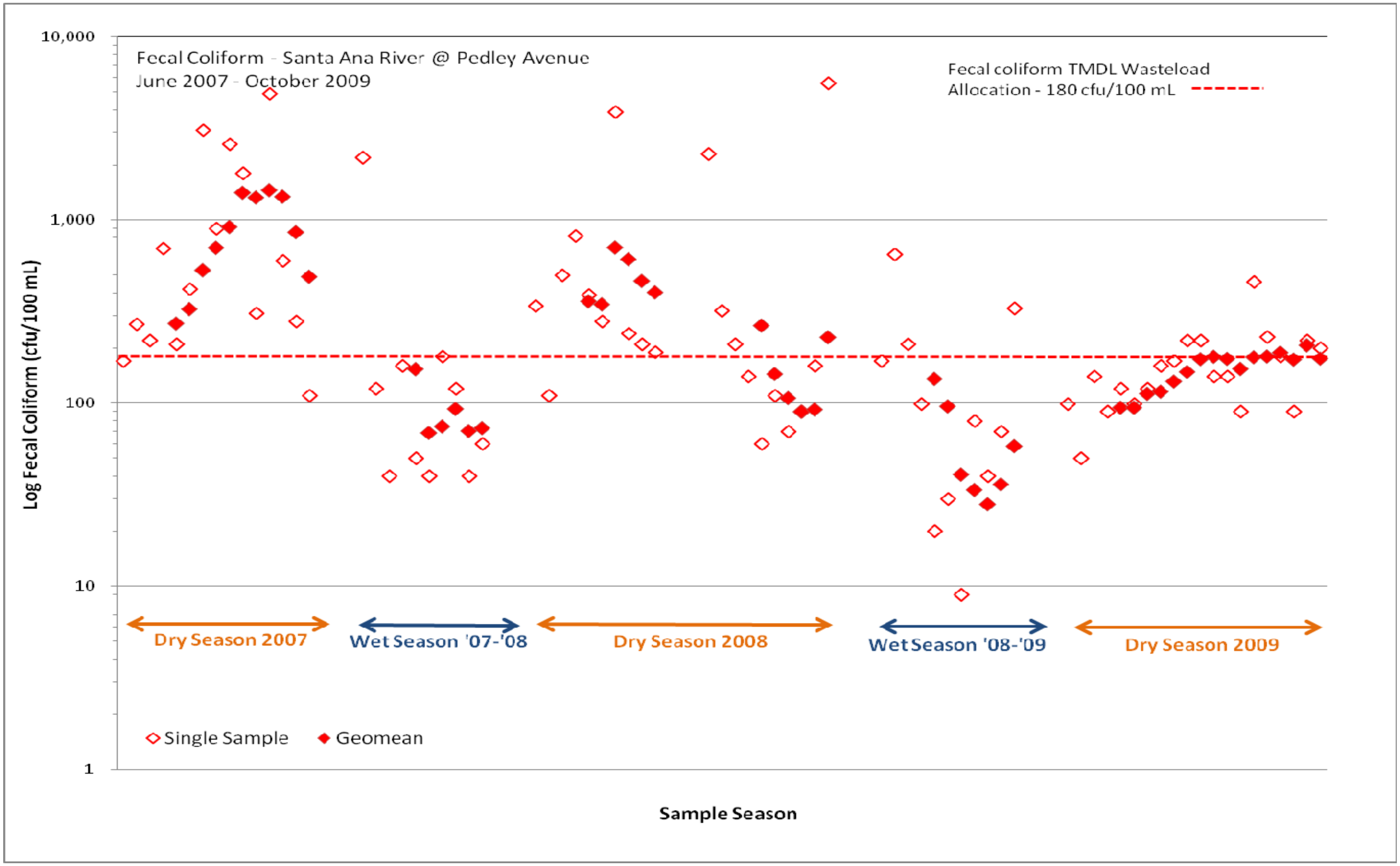

Figure 2-5. Time series plot of fecal coliform single sample results and geometric means for samples collected from Santa Ana River @ Pedley Avenue (2007-2009). Geometric mean was calculated only if five samples were collected during the previous five weeks.

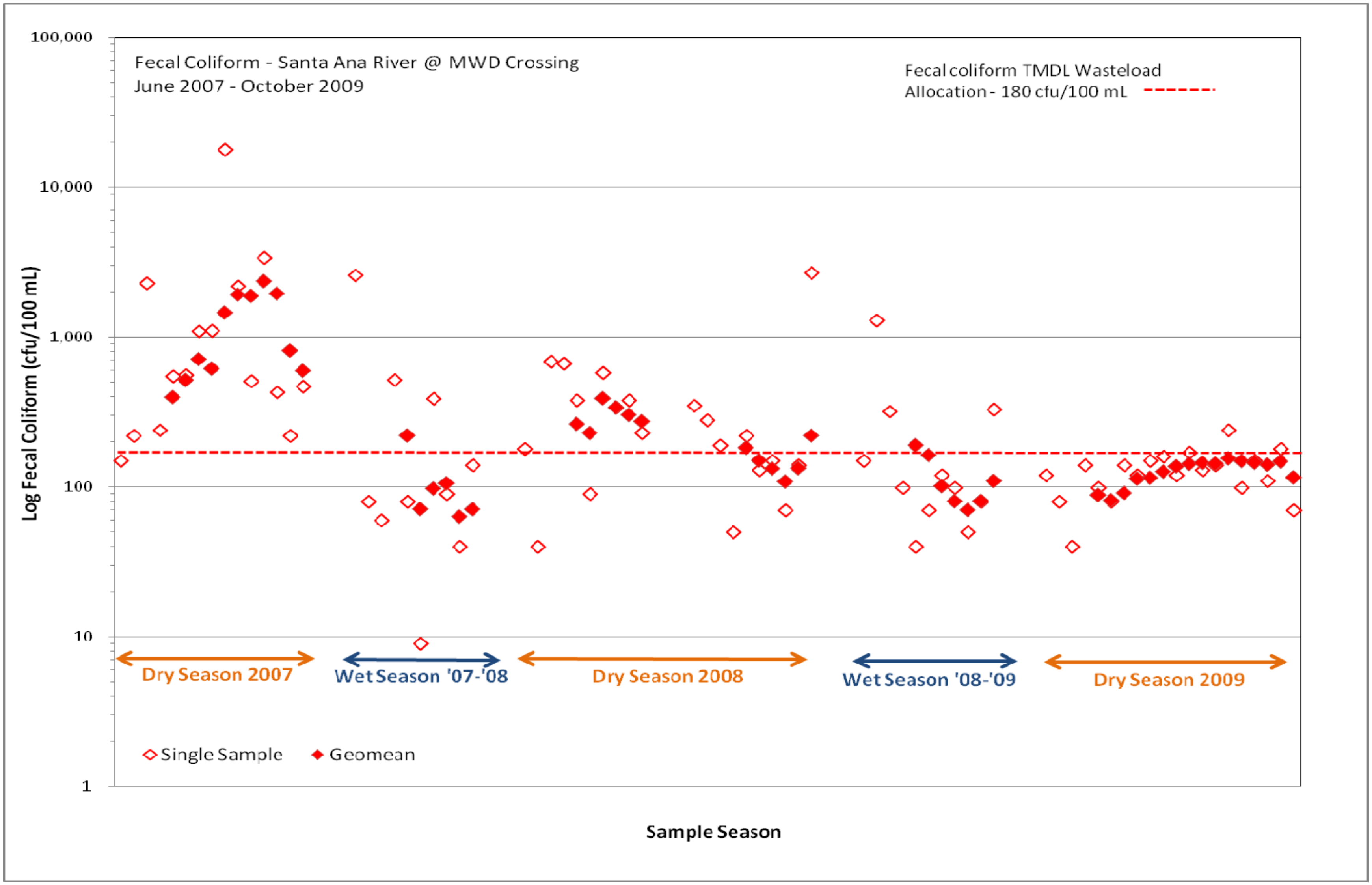

Figure 2-6. Time series plot of fecal coliform single sample results and geometric means for samples collected from Santa Ana River @ MWD Crossing (2007-2009). Geometric mean was calculated only if five samples were collected during the previous five weeks.

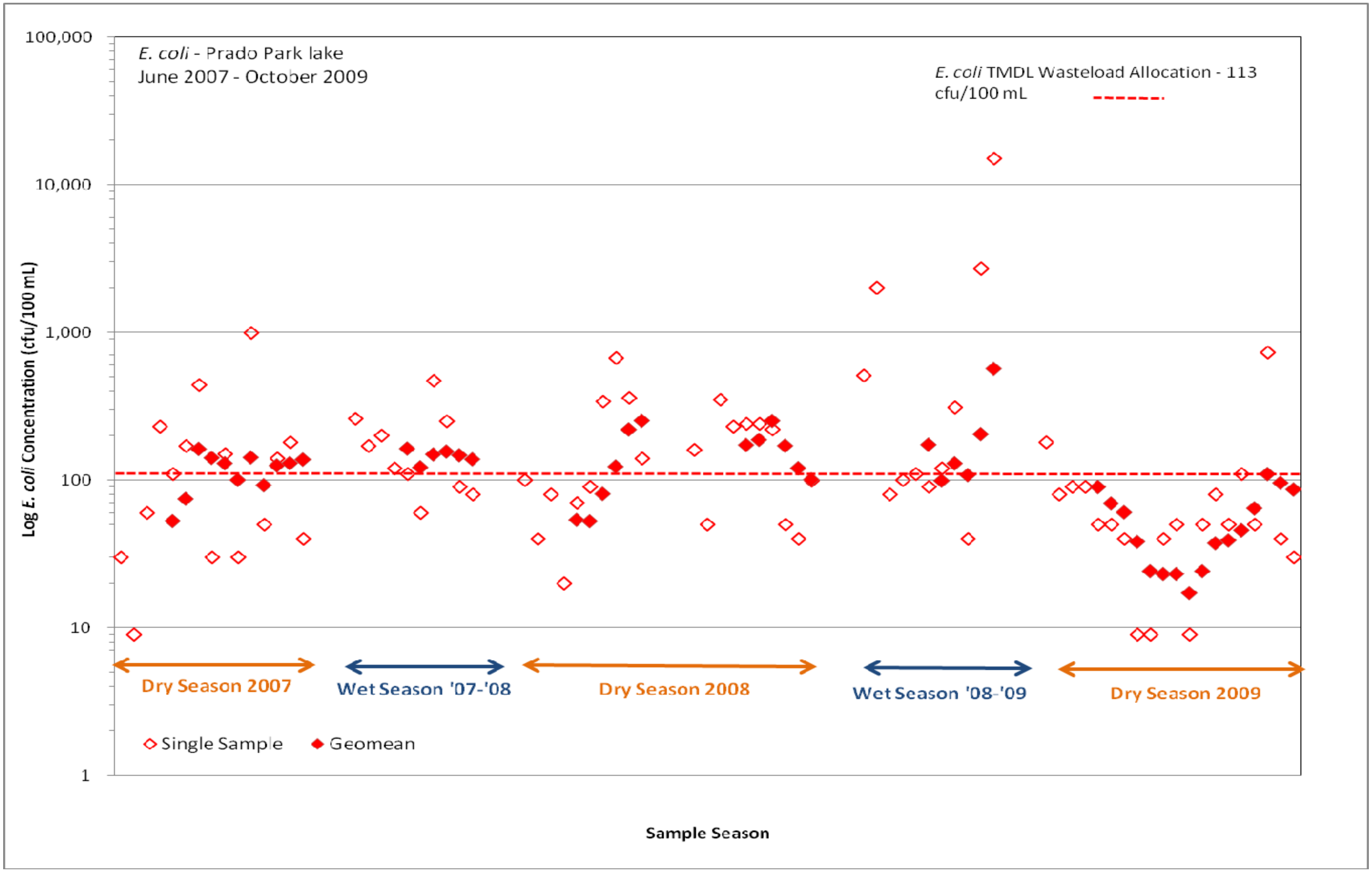

Figure 2-7. Time series plot of *E. coli* single sample results and geometric means for samples collected from Prado Park Lake (2007-2009). Geometric mean was calculated only if five samples were collected during the previous five weeks.

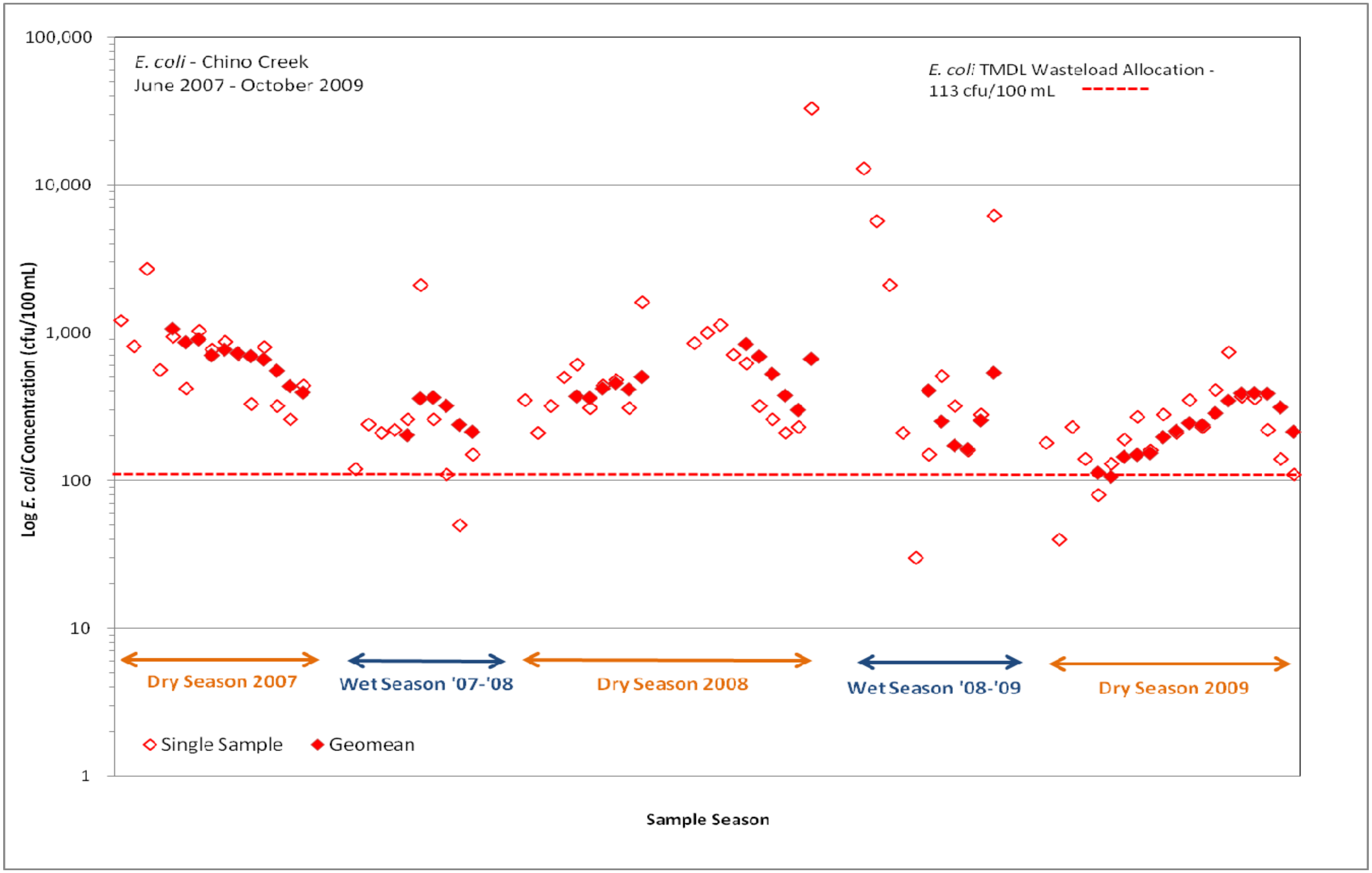

Figure 2-8. Time series plot of *E. coli* single sample results and geometric means for samples collected from Chino Creek (2007-2009). Geometric mean was calculated only if five samples were collected during the previous five weeks.

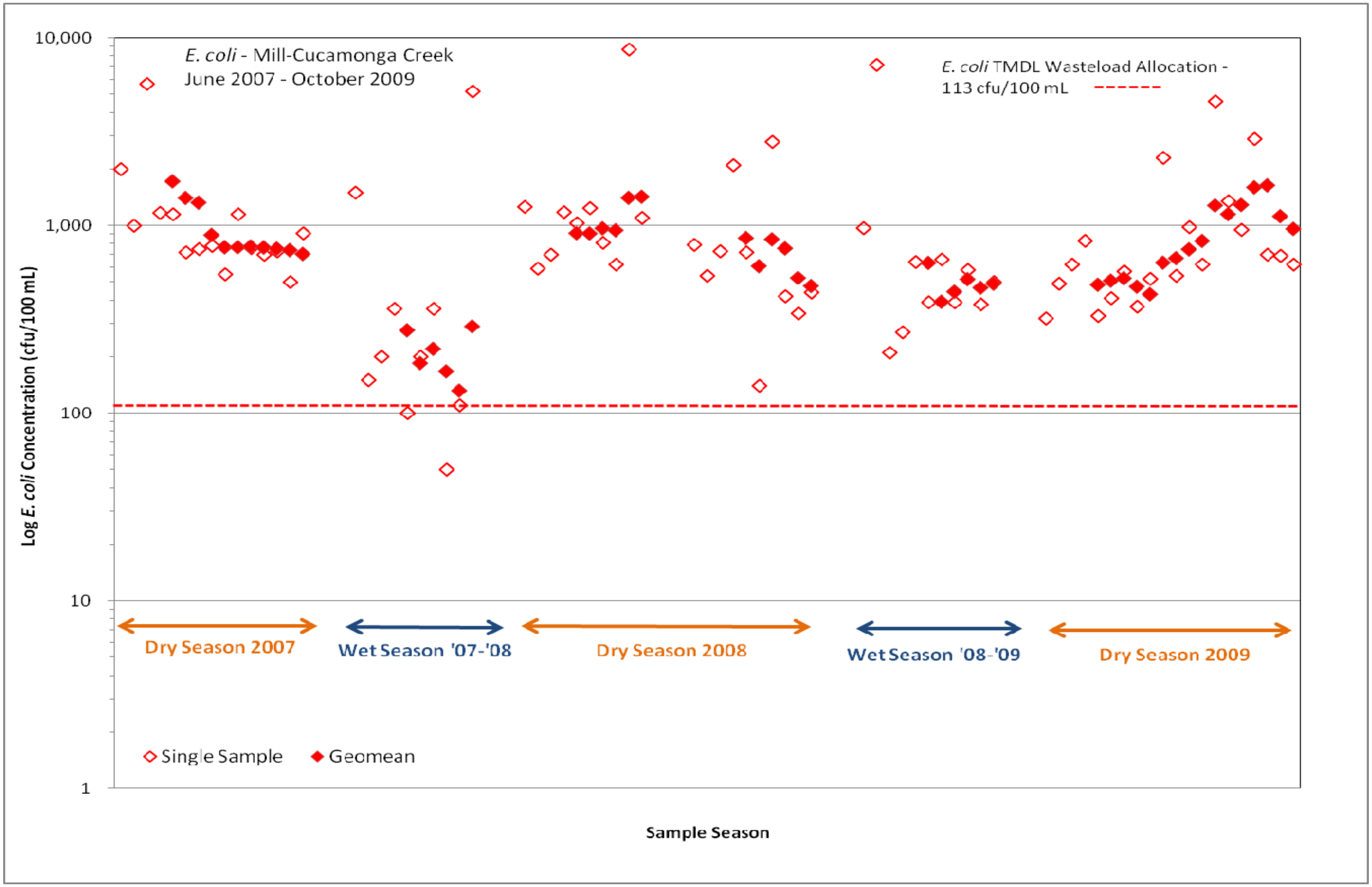

Figure 2-9. Time series plot of *E. coli* single sample results and geometric means for samples collected from Mill-Cucamonga Creek (2007-2009). Geometric mean was calculated only if five samples were collected during the previous five weeks.

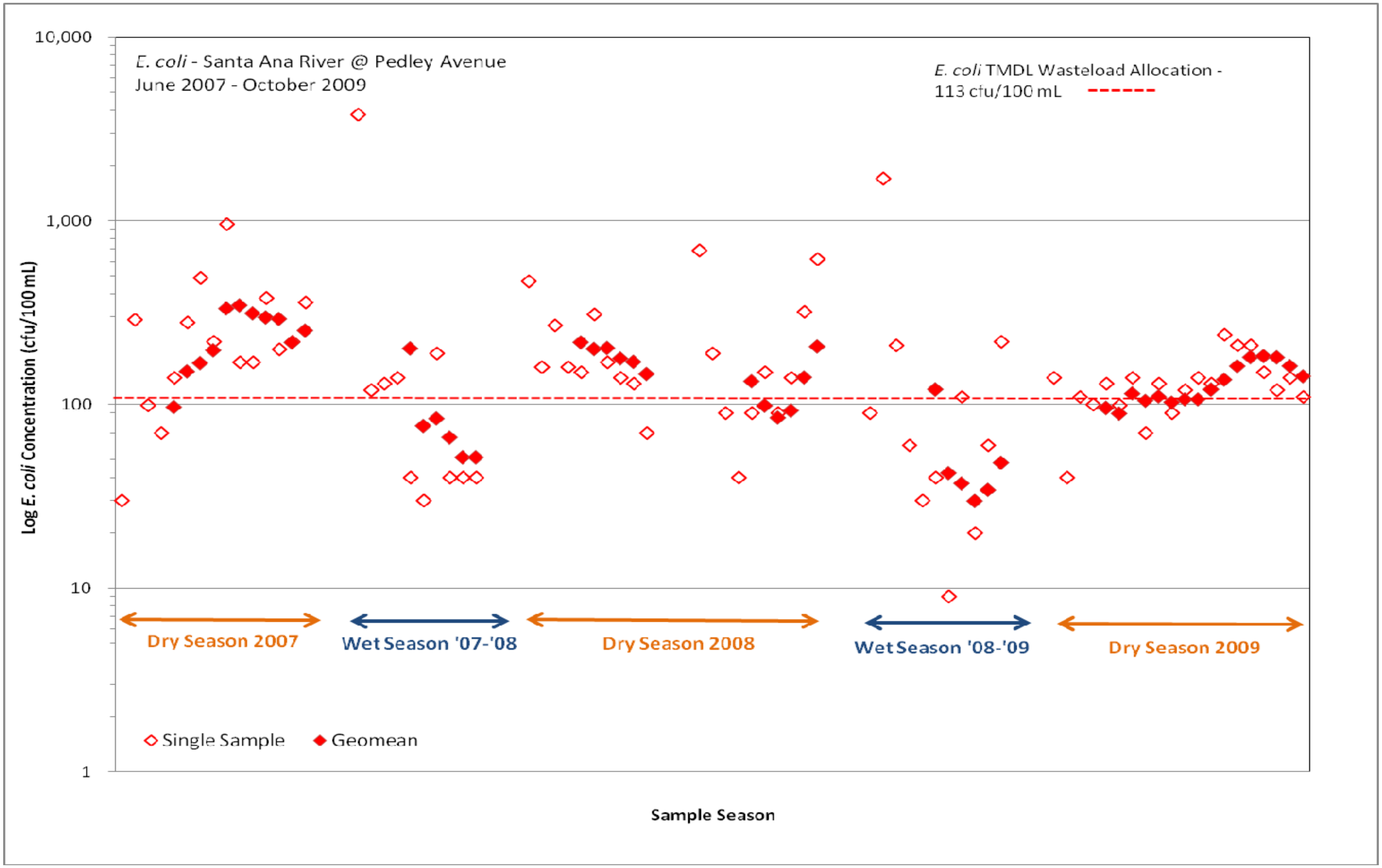

Figure 2-10. Time series plot of *E. coli* single sample results and geometric means for samples collected from Santa Ana River @ Pedley Avenue (2007-2009). Geometric mean was calculated only if five samples were collected during the previous five weeks.

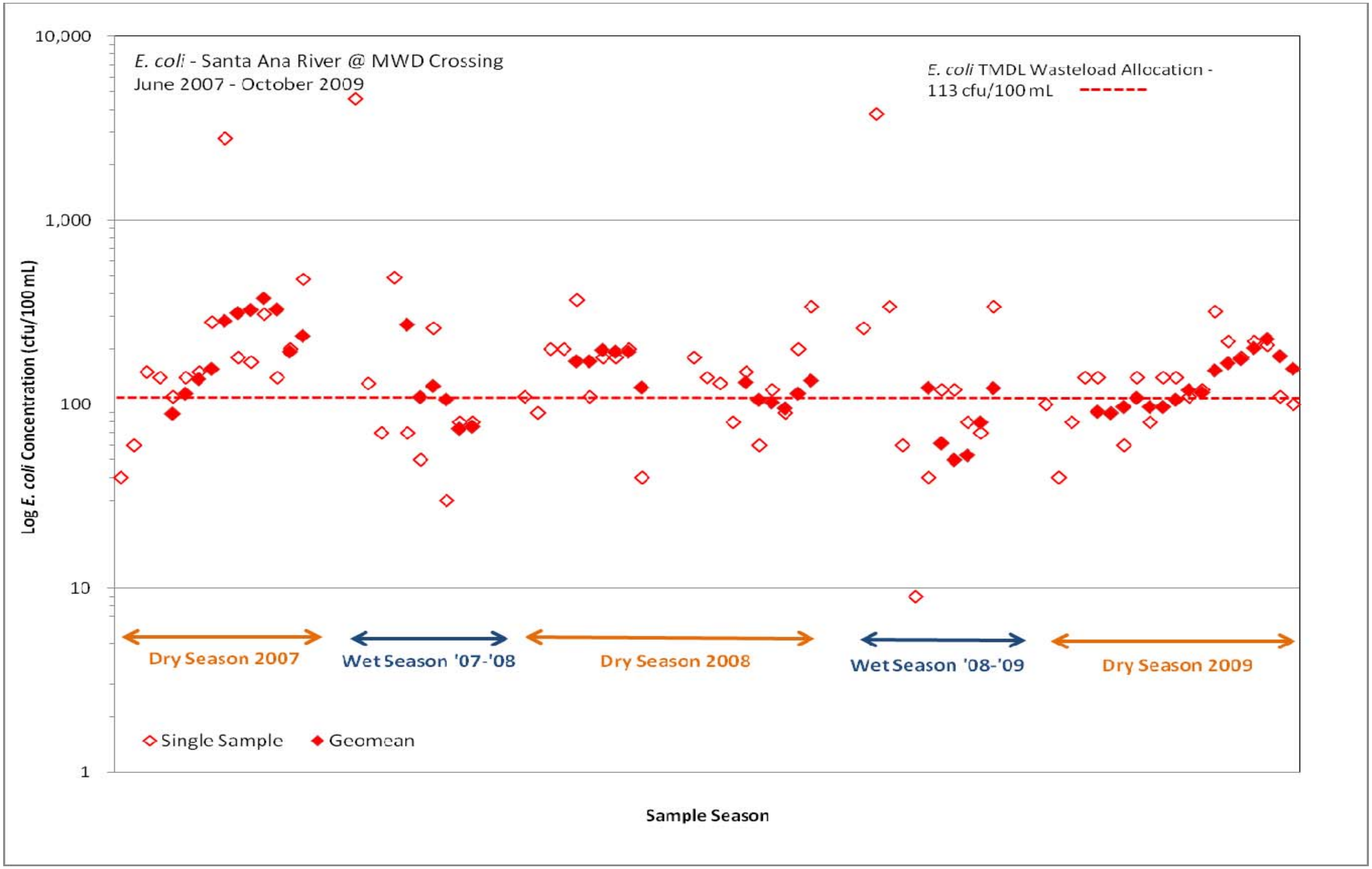

Figure 2-11. Time series plot of *E. coli* single sample results and geometric means for samples collected from Santa Ana River @ MWD Crossing (2007-2009). Geometric mean was calculated only if five samples were collected during the previous five weeks.

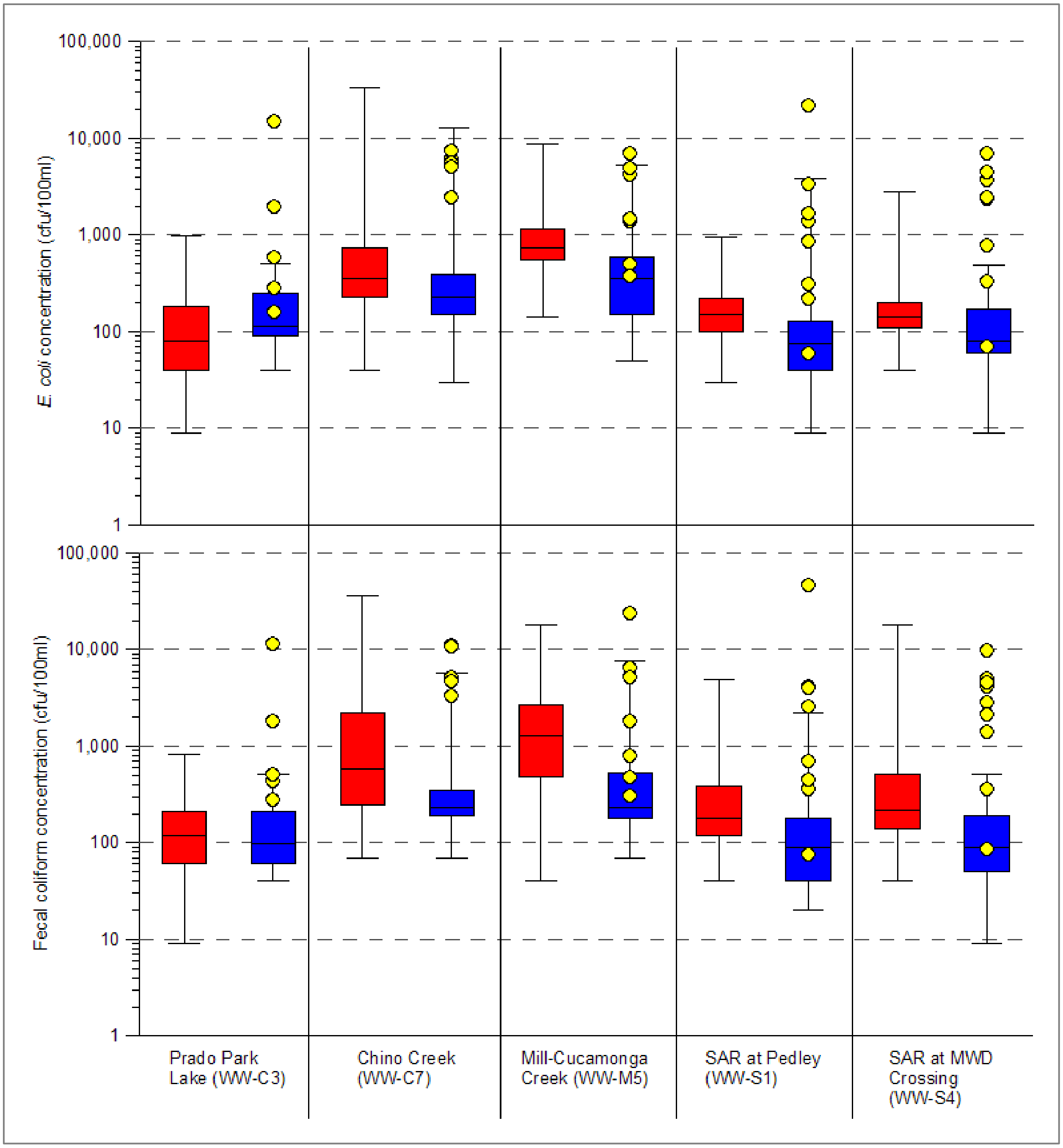

Figure 2-12. Box-whisker plots of bacteria indicator concentrations from 2007-2009 during dry weather in the dry season (red) and wet season (blue), and wet weather events (yellow points).

In general, the observed overall dry season geometric mean FIB concentrations at each watershed-wide compliance site have declined over the period from 2007-2009 (Figures 2-13 and 2-14). Concentrations at Prado Park Lake have been below the fecal coliform WLA throughout the period; with the exception of 2008, *E. coli* concentrations have also been below the WLA. In 2009, the dry season geometric mean observed for fecal coliform was below the WLAs at both Santa Ana River sites; *E. coli* met the water quality objective, but was above the WLA. Although a general decline in geometric means occurred at the Chino Creek and Mill-Cucamonga Creek sites, bacterial indicator concentrations remain well above the WLAs.

Figures 2-15 and 2-16 illustrate the wet season geometric mean for fecal coliform and *E. coli*, respectively. The geometric mean calculations include the storm event data collected during each wet season. In general, the observed wet season geometric mean FIB concentrations at each watershed-wide compliance site were greater in 2008-2009 than in 2007-2008. This difference is influenced to some degree by the concentrations observed during the storm event. With the exception of Prado Park Lake (which met the WLA for fecal coliform in 2007-2008), no site met the WLA for either fecal coliform or *E. coli* for either wet season period.

2.4.2 Compliance Frequency

Tables 2-15 and 2-16 summarize the frequency of compliance with single sample and geometric mean Basin Plan water quality objectives for fecal coliform (single sample maximum: 400 cfu/mL; geometric mean: 200 cfu/mL) and proposed water quality objectives for *E. coli* (single sample maximum: 235 cfu/mL; geometric mean: 126 cfu/mL) during the dry seasons of 2007, 2008 and 2009. In general, the frequency of compliance with single sample criteria has improved during the dry season between 2007 and 2009. Improvements in compliance with geometric criteria have been observed at Prado Park Lake and both Santa Ana River sites. However, this is not the case at the Chino Creek and Mill-Cucamonga Creek sites.

Tables 2-17 and 2-18 summarize the frequency of compliance with single sample and geometric mean Basin Plan water quality objectives for fecal coliform (single sample maximum: 400 cfu/mL; geometric mean: 200 cfu/mL) and proposed water quality objectives for *E. coli* (single sample maximum: 235 cfu/mL; geometric mean: 126 cfu/mL) during the wet seasons of 2007-2008 and 2008-2009. For the single sample data, the compliance frequency was calculated separately for dry and wet weather samples. Compliance with fecal coliform objectives was generally better during the 2008-2009 season than the 2007-2008 season – even during wet weather. Differences occurred between sample seasons with regards to compliance with proposed *E. coli* objectives; however, no particular trend was evident.

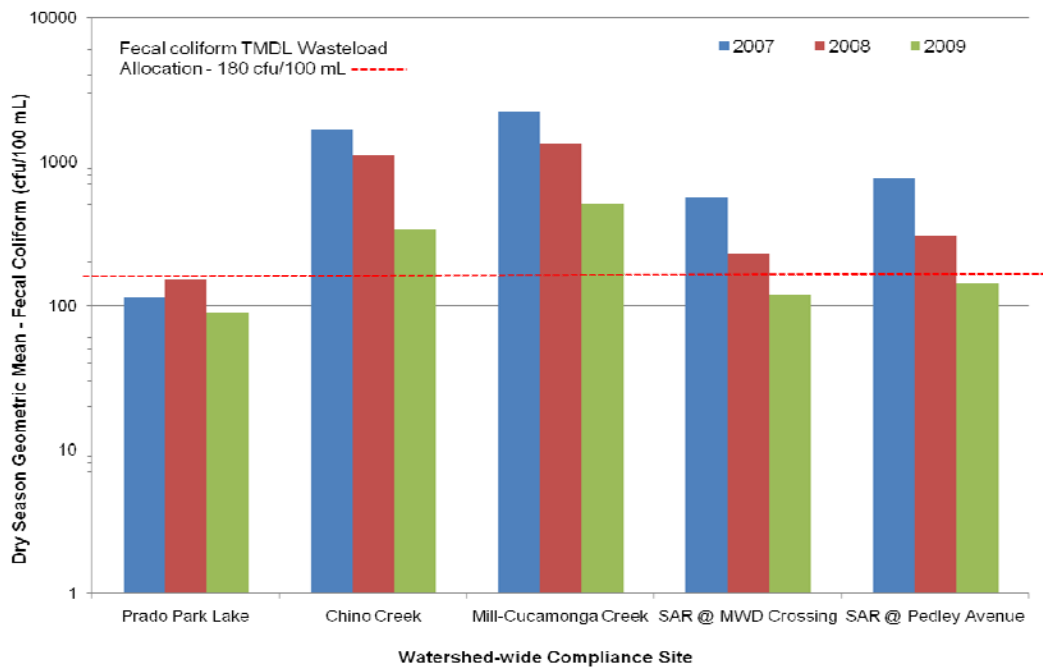

Figure 2-13. Change in dry season fecal coliform geometric means for 2007-2009.

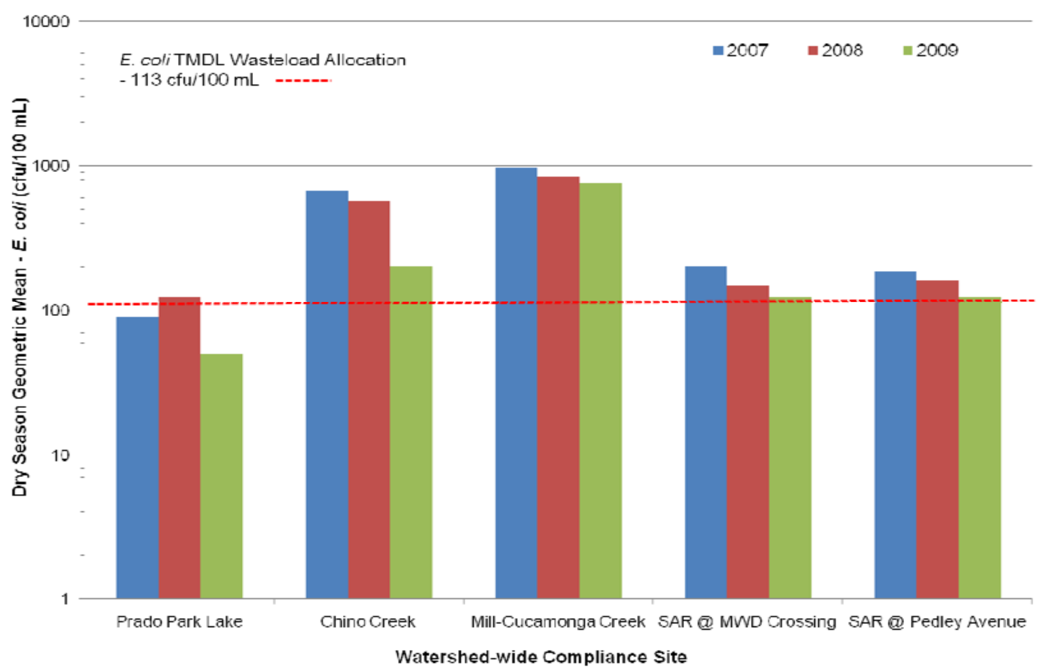

Figure 2-14. Change in dry season *E. coli* geometric means for 2007-2009.

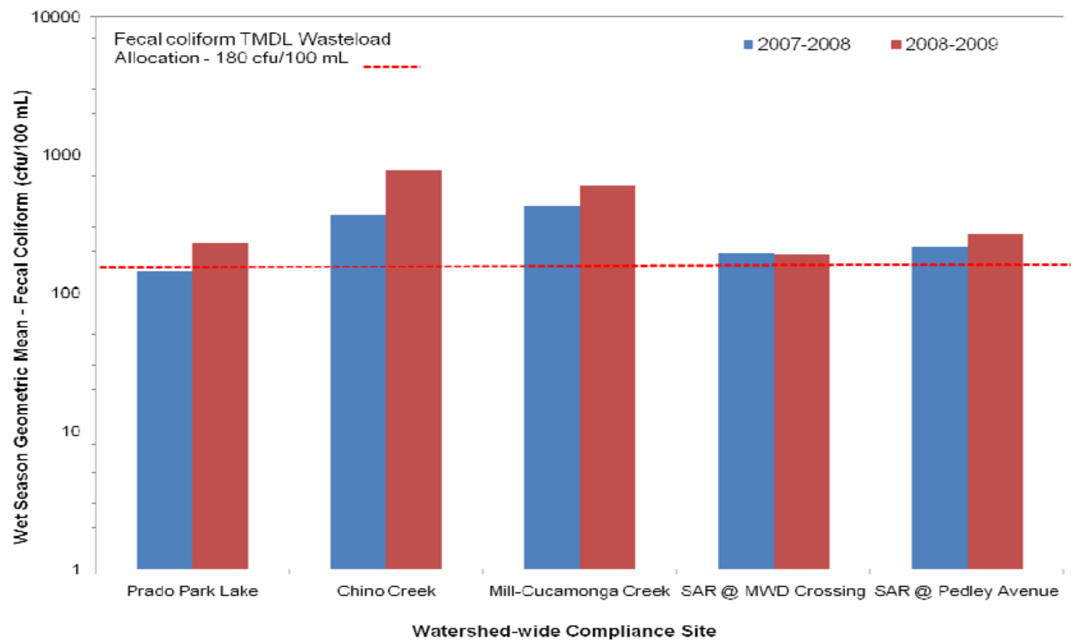

Figure 2-15. Change in wet season fecal coliform geometric means for 2007-2009.

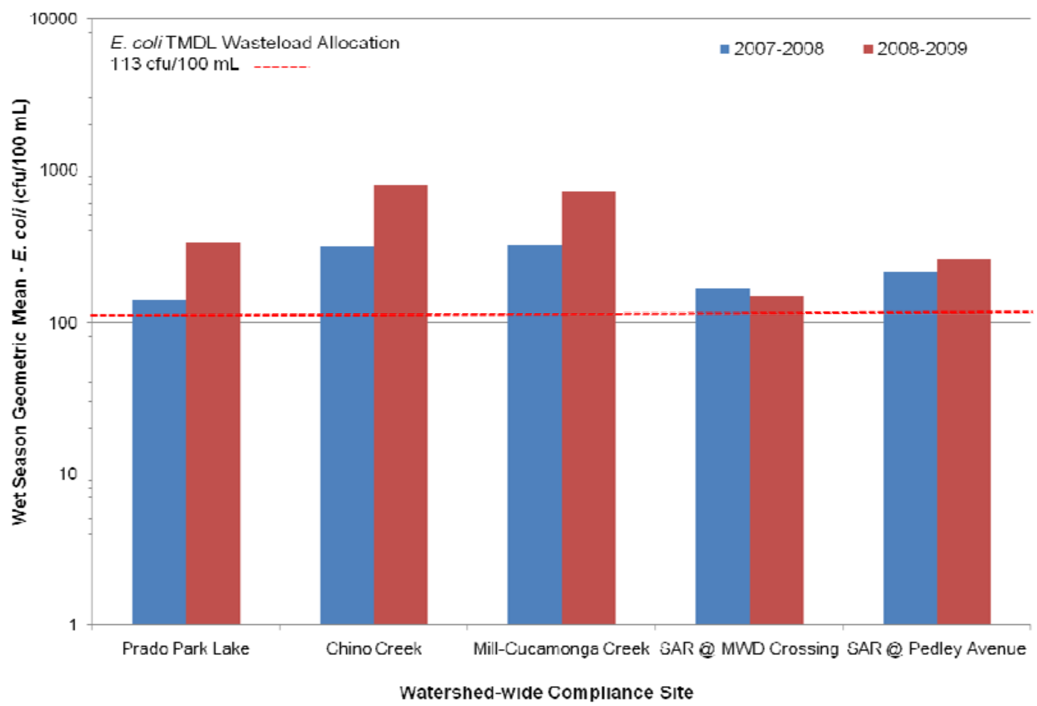

Figure 2-16. Change in wet season *E. coli* geometric means for 2007-2009.

Table 2-15. Compliance frequency for fecal coliform during the 2007, 2008, and 2009 dry seasons (as compared to existing Basin Plan objectives for fecal coliform)

Site	Single Sample Criterion Exceedance Frequency (%)			Geometric Mean Criterion Exceedance Frequency (%)		
	2007	2008	2009	2007	2008	2009
Prado Park Lake	13%	15%	5%	27%	33%	6%
Chino Creek	100%	75%	35%	100%	100%	88%
Mill-Cucamonga Creek	100%	90%	55%	100%	100%	100%
SAR @ MWD Crossing	53%	20%	5%	82%	58%	6%
SAR @ Pedley Ave.	73%	25%	0%	91%	67%	0%

Table 2-16. Compliance frequency for *E. coli* during the 2007, 2008, and 2009 dry seasons (as compared to proposed Basin Plan objectives for *E. coli*)

Site	Single Sample Criterion Exceedance Frequency (%)			Geometric Mean Criterion Exceedance Frequency (%)		
	2007	2008	2009	2007	2008	2009
Prado Park Lake	20%	30%	5%	64%	50%	0%
Chino Creek	100%	85%	35%	100%	100%	88%
Mill-Cucamonga Creek	100%	95%	100%	100%	100%	100%
SAR @ MWD Crossing	40%	15%	5%	91%	58%	44%
SAR @ Pedley Ave.	27%	25%	5%	82%	75%	44%

Table 2-17. Compliance frequency for fecal coliform during the 2007-08 and 2008-2009 wet seasons

Site	Single Sample Criterion Exceedance Frequency (%)				Geometric Mean Criterion Exceedance Frequency (%)	
	2007-2008		2008-2009		2007-2008	2008-2009
	Dry Weather	Wet Weather	Dry Weather	Wet Weather		
Prado Park Lake	21%	100%	20%	75%	10%	30%
Chino Creek	73%	100%	30%	100%	93%	100%
Mill Creek	75%	100%	33%	80%	97%	100%
SAR @ MWD Crossing	50%	100%	0%	67%	70%	40%
SAR @ Pedley Ave.	55%	100%	0%	67%	73%	40%

Table 2-18. Compliance frequency for *E. coli* during the 2007-08 and 2008-2009 wet seasons

Site	Single Sample Criterion Exceedance Frequency (%) *				Geometric Mean Criterion Exceedance Frequency (%)	
	2007-2008		2008-2009		2007-2008	2008-2009
	Dry Weather	Wet Weather	Dry Weather	Wet Weather		
Prado Park Lake	15%	0%	40%	100%	53%	70%
Chino Creek	73%	100%	60%	100%	100%	100%
Mill Creek	75%	100%	89%	100%	100%	100%
SAR @ MWD Crossing	28%	100%	0%	67%	73%	40%
SAR @ Pedley Ave.	23%	100%	25%	83%	63%	40%

2.5 Compliance with Load Allocations

The TMDL contains load allocations (LA) for agricultural runoff discharges and natural sources. These LAs are the same as the WLAs that have been established for urban dischargers and CAFOs. Section 1.2 summarizes these allocations.

As noted previously, the watershed-wide compliance monitoring program samples five locations on a regular basis, which includes natural sources during dry and wet weather and agricultural discharges during runoff events. Monitoring specific to agriculture discharges has also occurred during wet weather. Monitoring that targets natural sources has not occurred during the past three years. The following sections provide information on FIB concentrations observed during agricultural discharge monitoring.

2.5.1 Agricultural Source Monitoring Program

Agricultural dischargers implemented a source evaluation program in 2008. This program included wet weather sampling at selected sites in the MSAR watershed where agricultural activity occurs. Sampling occurred during two separate storm events at four sites (Table 2-19, Figure 2-17). During a storm event, two samples are collected from each site 30 minutes apart. Sampling methods are consistent with the watershed-wide compliance monitoring program. Specific details are provided in the MSAR Monitoring Plan (SAWPA 2008a) and associated Quality Assurance Project Plan (SAWPA 2008b).

2.5.2 Bacterial Indicator Concentrations

Table 2-20 summarizes wet weather monitoring results for the two storm events sampled in 2009. Concentrations of FIB exceeded the LAs established for agriculture discharges at all four sample sites during both storm events. Limited sampling data from these sites prevents making any evaluation of trends at these locations.

Table 2-19. Agriculture discharge monitoring site locations

Site Description	Latitude	Longitude
Grove Avenue Channel at Merrill Avenue (AG-G2)	33 58.986	-117 37.685
Eucalyptus Avenue at Walker Avenue (AG-G1)	33 59.425	-117 37.163
Euclid Avenue Channel at Pine Avenue (AG-E2)	33 57.220	-117 38.926
Eucalyptus Avenue at Cleveland Avenue (*Backup to Walker Avenue, depending on flow conditions)* (AG-CL1)	33 59.405	-117 34.031
Cypress Channel at Kimball Avenue (AG-CYP1)	33.96888	-117.66043

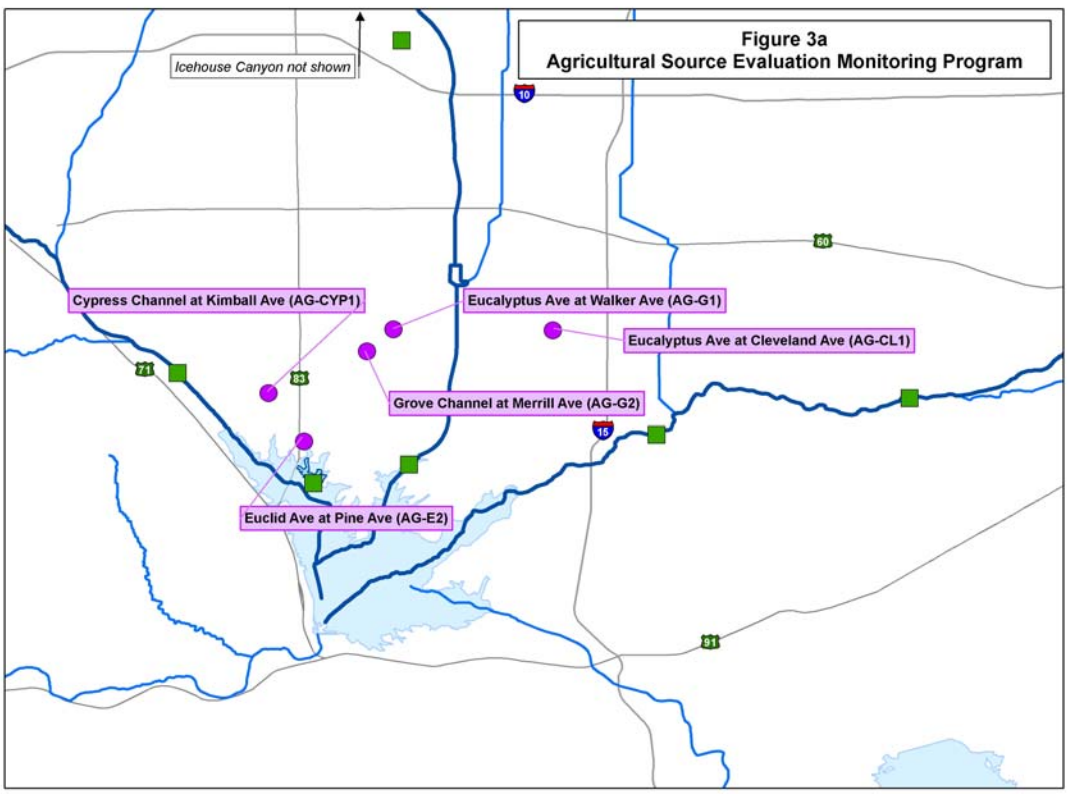

Figure 2-17. Location of agriculture discharge monitoring sites in relation to the watershed-wide compliance monitoring sites (originally Figure 3a in the Monitoring Plan, see SAWPA 2008a).

Table 2-20. FIB concentrations observed at agriculture discharge sites during two storm events sampled in 2009. Each site is sampled twice, 30 minutes apart, during each storm event.

FIB	Event	Cypress Channel at Kimball Ave (CYP1)		Grove Ave. Channel at Merrill Ave. (G2)		Euclid Ave. Channel at Pine Ave. (E2)		Eucalyptus Ave. at Walker Ave. (G1)[1]		Eucalyptus Ave. at Cleveland Ave. (CL-1)[1]	
		1	**2**	**1**	**2**	**1**	**2**	**1**	**2**	**1**	**2**
E. coli	**Storm 1 (2/16/09)**	17,000	24,000	>= 160,000	>= 160,000	3,000	5,000	>= 160,000	>= 160,000	No Sample	No Sample
	Storm 2 (12/12/09)	130,000	30,000	80,000	170,000	4,000	4,000	No Sample	No Sample	7,000	2,000
Fecal coliform	**Storm 1 (2/16/09)**	17,000	24,000	>= 160,000	>= 160,000	3,000	13,000	>= 160,000	>= 160,000	No Sample	No Sample
	Storm 2 (12/12/09)	240,000	130,000	130,000	210,000	4,000	8,000	No Sample	No Sample	7,000	2,000

[1] – CL-1 sample location was established as a back-up location if little or no flow occurred at G1. During Storm 1 site G1 was sampled; during Storm 2 site CL-1 was sampled instead.

Section 3
Best Management Practices Evaluation

BMPs are used to reduce pollutants discharged to receiving waters from the MS4 to the maximum extent practical. BMP selection is based on a variety of factors including effectiveness and cost. The use of BMPs to control bacterial indicators is particularly challenging because of the ubiquitous nature of bacteria. The purpose of this section is to summarize current information on BMPs for control of bacteria sources. This section includes the BMP effectiveness information developed as part of the Grant Project.

3.1 BMP Effectiveness

Treatment control BMPs types such as infiltration basins, extended detention basins, media filters, and vegetated swales are widely implemented BMPs whose aim is to reduce pollutant concentrations and loadings in urban runoff. Targeted pollutants of concern often include sediment, nutrients, metals, and oil and grease, and, therefore, treatment BMP performance data for these targeted pollutants has been more widely researched.

BMP effectiveness for reducing bacteria in urban runoff has not been as widely evaluated as other pollutants. In fact, the existing Water Quality Management Plan (WQMP) Guidance documents for the Riverside and San Bernardino County MS4 permit programs describe the effectiveness of many structural BMPs recommended for bacteria removal as "unknown." These BMPs include biofilters, detention basins, wet ponds, wetlands, and manufactured proprietary devices.

Sources of BMP effectiveness information include the International BMP Database, California Stormwater Quality Agencies, and work completed by the Stormwater Quality Standards Task Force. In addition, the Grant Project developed BMP effectiveness information local to the MSAR watershed. The following sections summarize information from these various sources.

3.1.1 BMP Pilot Study

The Proposition 40 State Grant project included a BMP Pilot Study to evaluate selected BMPs for their effectiveness in removing or reducing bacteria in urban runoff. The monitoring program is described more fully in the Middle Santa Ana River Monitoring Plan[8] and Quality Assurance Project Plan[9]. With support from MSAR Task Force members, a prospective list of existing operational BMPs located within the Counties of Riverside and San Bernardino was compiled. To gather

[8] Middle Santa Ana River Monitoring Plan, SAWPA 2008a. See the Santa Ana Regional Water Quality Control Board: http://www.waterboards.ca.gov/santaana/water_issues/programs/tmdl/msar_tmdl.shtml
[9] Quality Assurance Project Plan for the Middle Santa Ana River Pathogen TMDL – BMP Implementation Project, SAWPA 2008b. See the Santa Ana Regional Water Quality Control Board: http://www.waterboards.ca.gov/santaana/water_issues/programs/tmdl/msar_tmdl.shtml

information on proprietary BMPs, two manufacturers of proprietary stormwater BMP products participated in the pilot study by providing in-kind services for installation and/or maintenance of their installed BMPs:

- Kristar Enterprises ("Kristar") provided in-kind services by installing and maintaining two demonstration media filter-type pilot BMPs: Up-Flo Filter and Perk Filter.

- CONTECH, manufacturer of a below ground media filter vault stormwater BMP, participated by identifying an existing StormFilter BMP located within the City of Ontario.

Selection of BMP Locations

BMP monitoring locations were selected in collaboration with the cities of Canyon Lake, Corona, Fontana, Moreno Valley, Riverside, San Bernardino, and the Flood Control Districts of the counties of Riverside and San Bernardino. In order to prioritize BMP locations for the Pilot Study, screening criteria was established. These criteria included:

- BMP type - Selecting BMPs for which bacteria performance data is lacking

- Siting feasibility - Identifying locations where proprietary BMPs could be installed and monitored for dry weather and wet weather flows

- Sample access conditions - Identifying existing BMP sites with relatively easy access for safe sampling under dry weather and wet weather flow conditions.

- Right-of-way access – A BMP site was selected only if the Owner provided written approval to monitor or install the BMP within their right-of-way.

Applying the above selection criteria, five sites were selected for this study. Table 3-1 summarizes the BMP Pilot Study site locations and characteristics for monitoring. Figure 3-1 depicts the location of the BMP Pilot locations.

Description of Pilot BMPs

The following sections provide a brief description of the BMP located at each pilot study site.

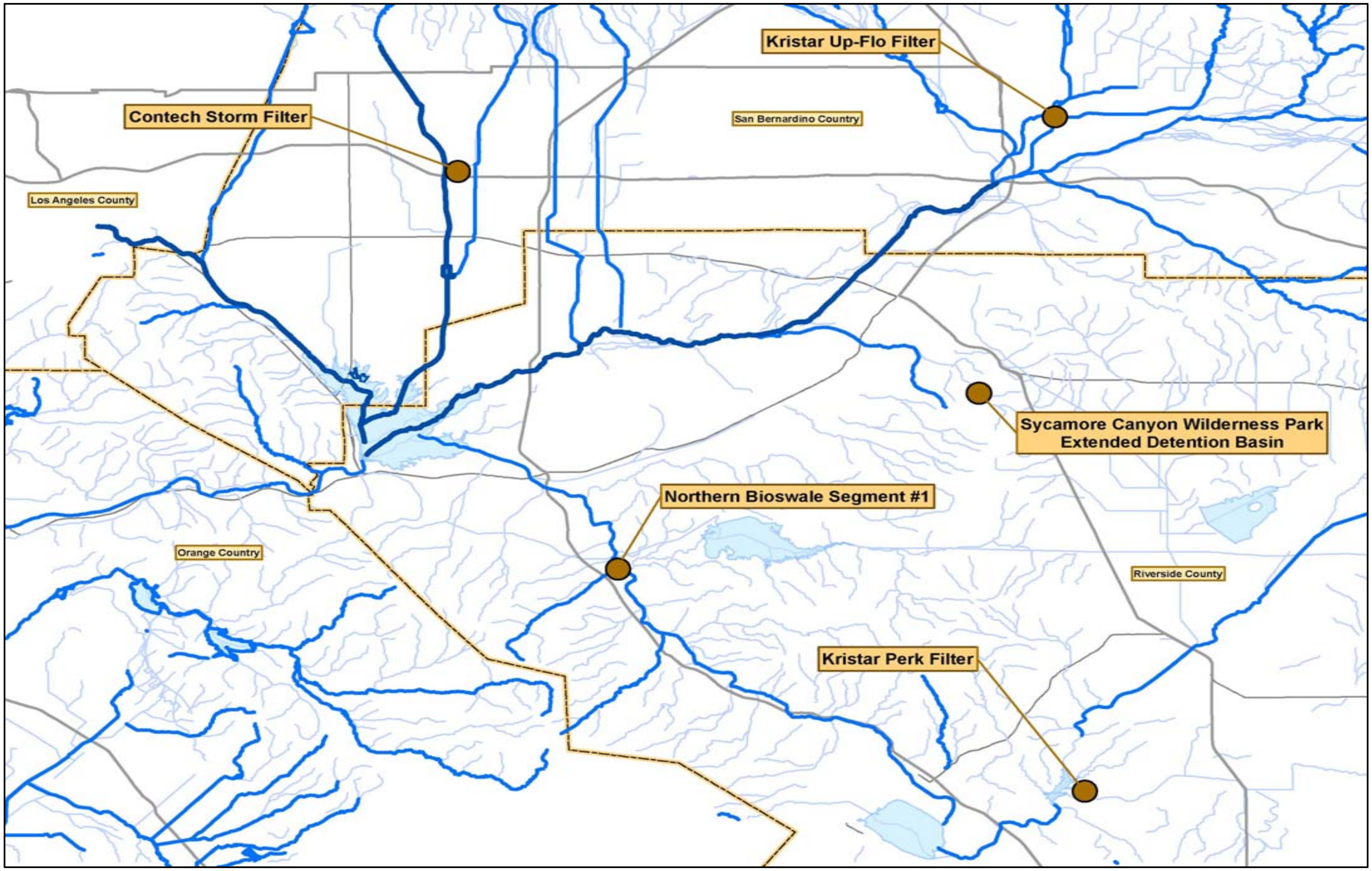

Figure 3-1
BMP Pilot Study Monitoring Locations

Table 3-1. BMP Pilot Study characteristics

BMP Type	Site Name	Wet Weather Sampling	Dry Weather Sampling
Bioswale	Northern Bioswale Segment #1, City of Corona (BMP-BIO1)	X	X
Extended Detention Basin	Sycamore Canyon Wilderness Park, City of Riverside (BMP-EDB1)	X	X
Proprietary Device - Media Filter	Kristar Perk Filter, City of San Bernardino (BMP-PF1)	X	X[1]
	Kristar Up-Flo Filter, City of Canyon Lake (BMP-UF1)	X	X
	CONTECH StormFilter (BMP-SF1)	X	

[1] No observed dry weather flows on sample dates

Northern Bioswale Segment #1, City of Corona
The Northern Bioswale Segment No. 1 was constructed as part of the Dos Lagos commercial and residential development in the City of Corona. It is located south of Cajalco Road and east of Temescal Canyon Road. Dos Lagos Golf Course operates the golf course adjacent to the bioswale. The bioswale is approximately 2.21 acres in size and contains mature cattail, native grasses, and cottonwood. A headwall is located at the most western portion of the bioswale. Runoff enters the bioswale from a drainage pipe that runs under Temescal Canyon Road. Approximately two acres of the golf course also contributes runoff to the bioswale. Flows discharging from Northern Bioswale Segment No. 1 flow into the Northern Bioswale Segment No. 2 (0.26 acres) which then discharges to Bedford Wash, a tributary of Temescal Wash. Northern Bioswale Segment No. 2 is a relatively small-sized bioswale and was not part of the study.

Sycamore Canyon Wilderness Park Extended Detention Basin, City of Riverside
The extended detention basin is located in Sycamore Canyon Wilderness Park, a City of Riverside park. The park is located west of an industrial and commercial area in the southeast portion of the City. The extended detention basin receives drainage from approximately 620 acres of predominantly commercial and industrial land use. Approximately half of the 620 acre drainage area is developed; the remaining portion is yet to be developed. An expansive Ralphs food distribution facility and adjoining parking lot, located adjacent (east) to the detention basin, contributes to the runoff flowing into the extended detention basin.

The detention basin has been operational for approximately 14 years and has mature vegetative growth including large trees within the basin. During a site visit, steady continual dry weather flow was observed entering the inlet to the extended detention basin. A steady discharge was also observed flowing into the outlet riser structure of the detention basin. Effluent from the detention basin continues downstream via surface flows within the Sycamore Canyon Wilderness Park and eventually flows into Canyon Crest Country Golf Club.

The influent location is an approximate 18-inch pipe that conveys runoff to the extended detention basin. The effluent sampling location is an outfall pipe (8-inch) emerging from under a constructed spillway and is located downstream of the outflow riser structure.

Proprietary Up-Flo Filter, City of Canyon Lake
The City of Canyon Lake and Canyon Lake Property Owners Association (POA) jointly participated in the Pilot Study by agreeing to provide full access for retrofit of an existing drain inlet within the City right-of-way. An Up-Flo Filter BMP was installed by Kristar in a drain inlet located on Canyon Lake Drive North near Outrigger Drive. The Up-Flo Filter is a modular system that is scaled to the existing size of the drain inlet. Influent is directed through the filter media via an upward flow path with a unique drain down design. The Up-Flo Filter is designed to target a wide range of pollutants including floatable trash, gross debris, fine sediments, nutrients, metals, oils and grease, and organics. At the time of the study initiation, Kristar had no available performance data for use of the Up-Flo Filter for treating bacteria.

The drain inlet receives intermittent dry weather flows from rising groundwater located upstream of the drain inlets. The high groundwater levels, which the City has indicated are natural springs and the primary source of dry weather runoff, create surface ponds on residential properties. Other sources of flows are from runoff associated with residential irrigation. With these identified dry weather sources, this site provided opportunity for sampling of smaller dry weather flows to the BMPs.

Proprietary Kristar Perk Filter, City of San Bernardino
Perk Filter is a proprietary media filter device that can be retrofitted into an existing drain. The City of San Bernardino collaborated with the Task Force and Kristar to install a Perk Filter in a drain inlet located near 655 East Third Street within the City of San Bernardino.

The Perk (percolation) media filters are installed inside the catch basin. The design of the Perk Filter allows water to percolate through the filter media. As water flows into the catch basin, solids settle out while pollutants such as oils and greases are filtered through the filter medium. High stormwater flows in excess of the filter's capability are directed through a "high flow" bypass. At the time of the study initiation, Kristar had no available performance data for use of the Perk Filter for treating bacteria.

Proprietary CONTECH StormFilter
CONTECH identified an existing StormFilter BMP for study participation. The StormFilter BMP was installed in 2005 in a parking lot adjacent to three newly constructed commercial office buildings at 2850 E. Inland Empire Boulevard in the City of Ontario. The unit receives runoff from approximately 1.15 acres. The

StormFilter unit is a 6 x 8 foot precast vault with five Perlite media cartridges. The Perlite media consists of a naturally occurring puffed volcanic ash, which is designed specifically to remove suspended solids and oil & grease. Sampling at this site was conducted only during wet weather conditions. Few research data are available regarding the ability of the StormFilter unit to remove bacteria.

The owners of the commercial property agreed to participate in the monitoring program and signed access agreements. CONTECH also initiated a separate maintenance contract with the owners of the property to maintain the StormFilter for the duration of the monitoring project.

Methods

The RWQCB-approved Monitoring Plan and Quality Assurance Project Plan provide detailed information regarding the collection and analysis of field data and water quality samples. The following sections provide a summary of these methods. At each sample site water quality measurements include the collection of field parameter data and water samples for laboratory analysis:

- *Field Analysis*: Temperature, conductivity, pH, dissolved oxygen, and turbidity
- *Laboratory Water Quality Analysis*: Fecal coliform, *E. coli*, and total suspended solids
- *Flow*: During each sample event, if conditions were safe, flow was measured.

Data Collection

For the BMP Pilot Study a sampling protocol was established to collect a series of influent and effluent samples for each BMP. Samples were not composited but rather analyzed as discrete samples. Table 3-2 summarizes the sampling collection effort at the five BMP Pilot Study locations under dry and wet weather sample conditions.

As described in the Monitoring Plan, each BMP was evaluated to account for a transit or lag time of water through the BMP. The number of influent and effluent samples that could be collected was constrained by the 6 hour laboratory holding time for bacterial indicator. Following is a discussion of the influent and effluent sample collection protocols.

- *Influent Sampling*: Six grab samples were collected at the influent sampling point for each BMP site, with exception of the Contech StormFilter (Ontario) site. For the StormFilter site, <u>ten</u> grab samples were collected at the influent sampling point.

  After the first sample was collected, each of the successive influent samples were collected after <u>10 minutes</u> of time elapsed. For the Contech StormFilter site, samples were collected after <u>6 minutes</u> of elapsed time due holding time constraints.

Table 3-2. Summary of number of water sample collected for BMP Pilot Study during dry and wet weather conditions

Sample Date	Bioswale		Extended Detention Basin		Up-Flo		Perk Filter		StormFilter	
	Influent	Effluent	Influent	Effluent	Influent	Effluent	Influent	Effluent	Influent	Effluent
Dry Weather										
5/12/08	6	6	6	6	NA[1]	NA[1]				
5/29/08	6	6	6	6	NA[1]	NA[1]				
6/16/08	6	6	6	6	NA[1]	NA[1]				
10/2/08					6	6	NA[1]	NA[1]		
10/9/08					6	6	NA[1]	NA[1]		
10/23/08					5[4]	5[4]	NA[1]	NA[1]		
Wet Weather										
11/26/08	6	6	NA	NA	NA[3]	NA[3]				
12/15/08	NA[2]	NA[2]	6	6	NA[3]	NA[3]	3[4]	3[4]	10	10
2/16/09	6	6	6	6	6	6	6	6	7[5]	7[5]

[1] No observed dry weather flows on sample dates

[2] No samples collected due to sample holding time constraints and delivery of other site samples to lab

[3] No flow during time of wet weather sample event

[4] Insufficient flow to collect complete set of planned influent (6) and effluent (6) samples

[5] Insufficient flow to collect complete set of planned influent (10) and effluent (10) samples

- *Effluent Sampling*: Six grab samples were collected at the effluent sampling point for each BMP site, with exception of the Contech StormFilter (Ontario) site. For the StormFilter site, ten grab samples were collected at the effluent sampling point.

  After the first sample was collected, each of the successive effluent samples were collected after 10 minutes of time had elapsed. For the Contech StormFilter site, samples were collected after 6 minutes of elapsed time.

  With the exception of Extended Detention Basin at Sycamore Canyon Wilderness Park, the timing of the collection of the first and subsequent effluent samples was generally based on a transit or "lag" time unique to the site. That is, influent water would have an expected lag time during which the BMP "treats" the influent. The paired influent and effluent sample results provided a comparison showing water quality before and after BMP treatment.

Sample Results

Tables 3-3 through 3-18 summarize the fecal coliform and *E. coli* concentrations observed for each of the Pilot Study BMPs during dry and wet weather conditions. For each sample event, the results from each series of influent and effluent samples are shown. The tables compare the geometric mean of samples before and after BMP treatment.

Of all pilot BMPs evaluated, only the bioswale showed consistent high percent removal during dry weather monitoring for three separate sample events. Percent removal for both fecal coliform and *E. coli* concentrations between influent and effluent was consistently over 90%. However, for wet weather, the bioswale did not show effectiveness in reducing bacteria. Although the bioswale showed positive results for percent removal for fecal coliform and *E. coli*, when compared to the fecal coliform Basin Plan objectives and proposed *E. coli* objectives, the effluent geomean concentrations were still well above concentrations needed to comply with objectives.

Figure 3-2 summarizes influent and effluent *E. coli* and fecal coliform concentrations for dry weather, respectively, for the bioswale, extended detention basin, and Up-Flo Filter using a Box and Whisker box plot (dry weather flow data were not available for the Perk Filter and StormFilter locations). The substantial breadth of the "whiskers" for the Extended Detention Basin and Up-Flo Filter box plots is indicative of the high variability of bacterial indicator concentrations observed.

Table 3-3. Summary of results for fecal coliform concentrations (cfu/100 ml) for Bioswale during dry weather sampling

Bioswale (Dry Weather, 5/12/08)				
Influent		Effluent		% Removal
Time	Fecal coliform (cfu/100 mL)	Time	Fecal coliform (cfu/100 mL)	
8:45	10000	9:25	360	96
8:55	10,000	9:35	300	97
9:05	11,400	9:45	530	95
9:15	9,200	9:55	420	95
9:25	8,300	10:05	340	96
9:35	9,700	10:15	210	98
Geomean	**9,722**		**346**	**96**

Bioswale (Dry Weather, 5/29/08)				
Influent		Effluent		% Removal
Time	Fecal coliform (cfu/100 mL)	Time	Fecal coliform (cfu/100 mL)	
8:25	46000	9:05	1300	97
8:35	63000	9:15	1400	98
8:45	53000	9:25	1000	98
8:55	41000	9:35	1100	97
9:05	33,000	9:45	1,400	96
9:15	30,000	9:55	980	97
Geomean	**42,901**		**1,183**	**97**

Bioswale (Dry Weather, 6/16/08)				
Influent		Effluent		% Removal
Time	Fecal coliform (cfu/100 mL)	Time	Fecal coliform (cfu/100 mL)	
8:35	20,000	9:15	840	96
8:45	22,000	9:25	780	96
8:55	9,400	9:35	940	90
9:05	7,300	9:45	790	89
9:15	5,800	9:55	720	88
9:25	7,100	10:05	520	93
Geomean	**10,370**		**753**	**93**

Table 3-4. Summary of Results for *E. coli* concentrations (cfu/100 ml) at Bioswale during dry weather

Bioswale (Dry Weather, 5/12/08)				
Influent		**Effluent**		**% Removal**
Time	**E. coli (cfu/100 mL)**	**Time**	**E. coli (cfu/100 mL)**	
8:45	13,800	9:25	540	96
8:55	20,000	9:35	410	98
9:05	24,000	9:45	520	98
9:15	28,000	9:55	520	98
9:25	12,500	10:05	550	96
9:35	11,500	10:15	460	96
Geomean	**17,284**		**497**	**97**

Bioswale (Dry Weather, 5/29/08)				
Influent		**Effluent**		**% Removal**
Time	**E. coli (cfu/100 mL)**	**Time**	**E. coli (cfu/100 mL)**	
8:25	69,000	9:05	1,090	98
8:35	56,000	9:15	1,190	98
8:45	49,000	9:25	1,000	98
8:55	48,000	9:35	940	98
9:05	50,000	9:45	860	98
9:15	26,000	9:55	1,100	96
Geomean	**47,724**		**1,024**	**98**

Bioswale (Dry Weather, 6/16/08)				
Influent		**Effluent**		**% Removal**
Time	**E. coli (cfu/100 mL)**	**Time**	**E. coli (cfu/100 mL)**	
8:35	25000	9:15	720	97
8:45	22000	9:25	850	96
8:55	7800	9:35	1000	87
9:05	7,600	9:45	610	92
9:15	6,400	9:55	640	90
9:25	7,100	10:05	610	91
Geomean	**10,677**		**725**	**93**

Table 3-5. Summary of Results for fecal coliform concentrations (cfu/100 ml) at Bioswale during wet weather

Bioswale (Wet Weather, 11/26/08)				
Influent		Effluent		% Removal
Time	Fecal coliform (cfu/100 mL)	Time	Fecal coliform (cfu/100 mL)	
3:35	30,000	3:47	27,000	10
3:45	21,000	3:57	27,000	-29
3:55	34,000	4:07	26,000	24
4:05	21,000	4:17	20,000	5
4:15	24,000	4:27	46,000	-92
4:25	26,000	4:37	31,000	-19
Geomean	**25,588**		**28,541**	**-12**

Bioswale (Wet Weather, 2/16/09)				
Influent		Effluent		% Removal
Time	Fecal coliform (cfu/100 mL)	Time	Fecal coliform (cfu/100 mL)	
13:20	840	13:35	500	40
13:25	1,300	13:40	1,200	8
13:30	730	13:45	280	62
13:35	410	13:50	480	-17
13:40	410	13:55	310	24
13:45	390	14:00	2,200	-464
Geomean	**611**		**617**	**-1**

Table 3-6. Summary of Results for *E. coli* concentrations (cfu/100 mL) at Bioswale during wet weather

Bioswale (Wet Weather, 11/26/08)				
Influent		**Effluent**		**% Removal**
Time	**E. coli (cfu/100 mL)**	**Time**	**E. coli (cfu/100 mL)**	
3:35	8,800	3:47	8,700	1
3:45	6,800	3:57	6,700	1
3:55	12,500	4:07	9,700	22
4:05	9,000	4:17	8,800	2
4:15	5,800	4:27	8,000	-38
4:25	5,200	4:37	9,100	-75
Geomean	**7,666**		**8,443**	**-10**

Bioswale (Wet Weather, 2/16/09)				
Influent		**Effluent**		**% Removal**
Time	**E. coli (cfu/100 mL)**	**Time**	**E. coli (cfu/100 mL)**	
13:20	1,220	13:35	1,410	-16
13:25	930	13:40	1,320	-42
13:30	920	13:45	610	34
13:35	630	13:50	720	-14
13:40	560	13:55	580	-4
13:45	620	14:00	2,100	-239
Geomean	**782**		**999**	**-28**

Table 3-7. Summary of results for fecal coliform concentrations (cfu/100 ml) for Extended Detention Basin during dry weather sampling

Extended Detention Basin (Dry Weather, 5/12/08)				
Influent		Effluent		% Removal
Time	Fecal coliform (cfu/100 mL)	Time	Fecal coliform (cfu/100 mL)	
10:30	550	10:40	310	44
10:40	430	10:50	600	-40
10:50	560	11:00	460	18
11:00	380	11:10	320	16
11:10	410	11:20	520	-27
11:20	350	11:30	570	-63
Geomean	**440**		**448**	**-2**

Extended Detention Basin (Dry Weather, 5/29/08)				
Influent		Effluent		% Removal
Time	Fecal coliform (cfu/100 mL)	Time	Fecal coliform (cfu/100 mL)	
9:50	650	10:00	60	91
10:00	390	10;10	120	69
10:10	350	10:20	100	71
10:20	1300	10:30	130	90
10:30	350	10:40	110	69
10:40	210	10:50	110	48
Geomean	**452**		**102**	**77**

Extended Detention Basin (Dry Weather, 6/16/08)				
Influent		Effluent		% Removal
Time	Fecal coliform (cfu/100 mL)	Time	Fecal coliform (cfu/100 mL)	
10:00	4,100	10:10	8,500	-107
10:10	3,400	10:20	21,000	-518
10:20	3,900	10:30	7,800	-100
10:30	6,700	10:40	8,700	-30
10:40	4,600	10:50	7,400	-61
10:45	4,400	11:00	5,200	-18
Geomean	**4,412**		**8,805**	**-100**

Table 3-8. Summary of results for *E. coli* concentrations (cfu/100 ml) for Extended Detention Basin during dry weather sampling

Extended Detention Basin (Dry Weather, 5/12/08)				
Influent		Effluent		% Removal
Time	E. coli (cfu/100 mL)	Time	E. coli (cfu/100 mL)	
10:30	360	10:40	380	-6
10:40	290	10:50	320	-10
10:50	410	11:00	360	12
11:00	320	11:10	200	38
11:10	410	11:20	420	-2
11:20	200	11:30	420	-110
Geomean	**322**		**340**	**-6**

Extended Detention Basin (Dry Weather, 5/29/08)				
Influent		Effluent		% Removal
Time	E. coli (cfu/100 mL)	Time	E. coli (cfu/100 mL)	
9:50	350	10:00	120	66
10:00	290	10;10	80	72
10:10	350	10:20	40	89
10:20	300	10:30	30	90
10:30	260	10:40	70	73
10:40	280	10:50	70	75
Geomean	**303**		**62**	**80**

Extended Detention Basin (Dry Weather, 6/16/08)				
Influent		Effluent		% Removal
Time	E. coli (cfu/100 mL)	Time	E. coli (cfu/100 mL)	
10:00	1,800	10:10	6,900	-283
10:10	2,400	10:20	8,500	-254
10:20	2,500	10:30	7,500	-200
10:30	3,100	10:40	7,400	-139
10:40	1,120	10:50	4,400	-293
10:45	1,000	11:00	5,100	-410
Geomean	**1,830**		**6,465**	**-253**

Table 3-9. Summary of results for fecal coliform concentrations (cfu/100 ml) for Extended Detention Basin during wet weather sampling

Extended Detention Basin (Wet Weather, 12/15/08)				
Influent		Effluent		% Removal
Time	Fecal coliform (cfu/100 mL)	Time	Fecal coliform (cfu/100 mL)	
10:30	1,400	10:35	1,600	-14
10:40	1,400	10:45	1,400	0
10:50	1,200	10:55	900	25
11:00	1,700	11:00	1,800	-6
11:10	1,200	11:05	1,400	-17
11:20	1,400	11:15	1,600	-14
Geomean	**1,374**		**1,418**	**-3**

Extended Detention Basin (Wet Weather, 2/16/09)				
Influent		Effluent		% Removal
Time	Fecal coliform (cfu/100 mL)	Time	Fecal coliform (cfu/100 mL)	
8:45	280	8:50	90	68
8:55	120	9:00	250	-108
9:05	130	9:10	100	23
9:15	140	9:20	1,190	-750
9:25	110	9:30	110	0
9:35	20	9:40	80	-300
Geomean	**105**		**169**	**-61**

Table 3-10. Summary of results for *E. coli* concentrations (cfu/100 ml) for Extended Detention Basin during wet weather sampling

Extended Detention Basin (Wet Weather, 12/15/2008)				
Influent		**Effluent**		**% Removal**
Time	**E. coli (cfu/100 mL)**	**Time**	**E. coli (cfu/100 mL)**	
10:30	600	10:35	500	17
10:40	500	10:45	400	20
10:50	400	10:55	400	0
11:00	700	11:00	500	29
11:10	300	11:05	700	-133
11:20	400	11:15	400	0
Geomean	**465**		**473**	**-2**

Extended Detention Basin (Wet Weather, 2/16/09)				
Influent		**Effluent**		**% Removal**
Time	**E. coli (cfu/100 mL)**	**Time**	**E. coli (cfu/100 mL)**	
8:45	240	8:50	99	59
8:55	50	9:00	280	-460
9:05	30	9:10	50	-67
9:15	30	9:20	70	-133
9:25	30	9:30	50	-67
9:35	40	9:40	99	-148
Geomean	**48**		**88**	**-83**

Table 3-11. Summary of results for fecal coliform concentrations (cfu/100 ml) for Up-Flo Filter during dry weather sampling

Up-Flo Filter - Canyon Lake (Dry Weather, 10/2/08)				
Influent		Effluent		% Removal
Time	Fecal coliform (cfu/100 mL)	Time	Fecal coliform (cfu/100 mL)	
5:50	21,000	6:30	7,200	66
6:00	3,700	6:40	12,000	-224
6:10	9,000	6:50	30,000	-233
6:20	3,000	7:00	16,000	-433
6:30	12,000	7:10	12,000	0
6:40	82,000	7:20	17,000	79
Geomean	**11284**		**14275**	**-27**

Up-Flo Filter - Canyon Lake (Dry Weather, 10/9/08)				
Influent		Effluent		% Removal
Time	Fecal coliform (cfu/100 mL)	Time	Fecal coliform (cfu/100 mL)	
6:00	11,000	6:01	4,900	56
6:10	14,000	6:11	7,500	46
6:20	3,800	6:21	5,600	-47
6:30	20,000	6:31	4,200	79
6:40	68,000	6:41	8,800	87
6:50	59,000	6:51	21,000	64
Geomean	**18,994**		**7,366**	**61**

Up-Flo Filter - Canyon Lake (Dry Weather 10/23/08)				
Influent		Effluent		% Removal
Time	Fecal coliform (cfu/100 mL)	Time	Fecal coliform (cfu/100 mL)	
6:18	24,000	6:24	20,000	17
6:28	5,800	6:34	6,800	-17
6:36	9,000	6:42	5,400	40
6:38	8,100	6:44	13,000	-61
6:48	15,000	6:54	21,000	-40
Geomean	**10,877**		**11,493**	**-6**

Table 3-12. Summary of results for *E. coli* concentrations (cfu/100 ml) for Up-Flo Filter during dry weather sampling

Up-Flo Filter - Canyon Lake (Dry Weather, 10/2/08)				
Influent		Effluent		% Removal
Time	E. coli (cfu/100 mL)	Time	E. coli (cfu/100 mL)	
5:50	2,500	6:30	230	90
6:00	370	6:40	1,000	-170
6:10	230	6:50	1,500	-552
6:20	99	7:00	2,100	-2,021
6:30	3,300	7:10	2,100	36
6:40	18,000	7:20	2,100	88
Geomean	**1,038**		**1,214**	**-17**

Up-Flo Filter - Canyon Lake (Dry Weather, 10/9/08)				
Influent		Effluent		% Removal
Time	E. coli (cfu/100 mL)	Time	E. coli (cfu/100 mL)	
6:00	280	6:01	280	0.0
6:10	200	6:11	210	-5.0
6:20	60	6:21	2,300	-3,733
6:30	32,000	6:31	5,700	82.2
6:40	29,000	6:41	7,200	75.2
6:50	32,000	6:51	7,200	77.5
Geomean	**2,154**		**1,849**	**14**

Up-Flo Filter - Canyon Lake (Dry Weather, 10/23/08)				
Influent		Effluent		% Removal
Time	E. coli (cfu/100 mL)	Time	E. coli (cfu/100 mL)	
6:18	260	6:24	530	-103
6:28	660	6:34	580	12
6:36	350	6:42	540	-54
6:38	650	6:44	600	8
6:48	380	6:54	590	-55
Geomean	**431**		**567**	**-32**

Table 3-13. Summary of results for fecal coliform concentrations (cfu/100 ml) for Up-Flo Filter during wet weather sampling

Up-Flo Filter - Canyon Lake (Wet Weather, 2/16/09)				
Influent		**Effluent**		**% Removal**
Time	**Fecal coliform (cfu/100 mL)**	**Time**	**Fecal coliform (cfu/100 mL)**	
11:40	1,600	11:42	380	7
11:50	370	11:52	320	14
12:00	410	12:02	2,600	-534
12:10	3,200	12:12	510	84
12:20	340	12:22	2,700	-694
12:30	1,600	12:32	2,000	-25
Geomean	**866**		**977**	**-13**

Table 3-14. Summary of results for *E. coli* concentrations (cfu/100 ml) for Up-Flo Filter during wet weather sampling

Up-Flo Filter - Canyon Lake (Wet Weather, 2/16/09)				
Influent		**Effluent**		**% Removal**
Time	**E. coli (cfu/100 mL)**	**Time**	**E. coli (cfu/100 mL)**	
11:40	860	11:42	570	34
11:50	780	11:52	300	62
12:00	620	12:02	440	29
12:10	490	12:12	340	31
12:20	280	12:22	1,060	-279
12:30	370	12:32	630	-70
Geomean	**526**		**507**	**4.5**

Table 3-15. Summary of results for fecal coliform concentrations (cfu/100 ml) for Perk Filter during wet weather sampling

Perk Flo - City of San Bernardino (Wet Weather, 12/15/08)				
Influent		Effluent		% Removal
Time	Fecal coliform (cfu/100 mL)	Time	Fecal coliform (cfu/100 mL)	
8:00	5,800	8:01	4,200	28
8:10	4,800	8:11	4,400	8.3
8:20	4,100	8:21	3,900	4.9
Geomean	**4,851**		**4,162**	**14**

Perk Flo - City of San Bernardino (Wet Weather, 2/16/09)				
Influent		Effluent		% Removal
Time	Fecal coliform (cfu/100 mL)	Time	Fecal coliform (cfu/100 mL)	
7:20	500	7:21	310	38
7:30	380	7:31	160	58
7:40	180	7:41	170	5.6
7:50	190	7:51	270	-42
8:00	280	8:01	260	7.1
8:10	210	8:11	240	-14
Geomean	**269**		**228**	**15**

Table 3-16. Summary of results for *E. coli* concentrations (cfu/100 ml) for Perk Filter during wet weather sampling

Perk Flo - City of San Bernardino (Wet Weather, 12/15/08)				
Influent		Effluent		% Removal
Time	E. coli (cfu/100 mL)	Time	E. coli (cfu/100 mL)	
8:00	600	8:01	90	85
8:10	200	8:11	500	-150
8:20	500	8:21	600	-20
Geomean	**391**		**300**	**23**

Perk Flo - City of San Bernardino (Wet Weather, 2/16/09)				
Influent		Effluent		% Removal
Time	E. coli (cfu/100 mL)	Time	E. coli (cfu/100 mL)	
7:20	330	7:21	250	24
7:30	290	7:31	130	55
7:40	130	7:41	180	-39
7:50	80	7:51	140	-75
8:00	220	8:01	210	4.5
8:10	160	8:11	200	-25
Geomean	**181**		**180**	**0.3**

Table 3-17. Summary of results for fecal coliform concentrations (cfu/100 ml) for StormFilter during wet weather sampling

StormFilter (Wet Weather, 12/15/08)				
Influent		**Effluent**		**% Removal**
Time	**Fecal coliform (cfu/100 mL)**	**Time**	**Fecal coliform (cfu/100 mL)**	
4:36	1,600	4:50	1,100	31
4:42	900	4:56	1,400	-56
4:48	1,300	5:02	800	39
4:54	600	5:08	1,100	-83
5:00	400	5:14	1,300	-225
5:06	400	5:20	700	-75
5:12	700	5:26	990	-41
5:18	800	5:32	500	38
5:24	500	5:38	500	0
5:30	700	5:46	400	43
Geomean	**716**		**810**	**-13**

StormFilter (Wet Weather, 2/16/09)				
Influent		**Effluent**		**% Removal**
Time	**Fecal coliform (cfu/100 mL)**	**Time**	**Fecal coliform (cfu/100 mL)**	
5:42	40	5:44	20	50
5:48	40	5:50	99	-148
5:56	30	5:56	50	-67
6:00	20	6:02	40	-100
6:06	70	6:08	60	14
6:12	40	6:14	60	-50
6:18	40	6:20	40	0
Geomean	**38**		**48**	**-27**

Table 3-18. Summary of results for *E. coli* concentrations (cfu/100 ml) for StormFilter during wet weather sampling

StormFilter (Wet Weather, 12/15/08)*			
Influent		Effluent	
Time	E. coli (cfu/100 mL)	Time	E. coli (cfu/100 mL)
4:36	< 90	4:50	< 90
4:42	< 90	4:56	< 90
4:48	< 90	5:02	< 90
4:54	< 90	5:08	< 90
5:00	< 90	5:14	< 90
5:06	< 90	5:20	< 90
5:12	< 90	5:26	< 90
5:18	< 90	5:32	< 90
5:24	< 90	5:38	< 90
5:30	< 90	5:46	< 90

StormFilter (Wet Weather, 2/16/09)*			
Influent		Effluent	
Time	E. coli (cfu/100 mL)	Time	E. coli (cfu/100 mL)
5:42	9	5:44	9
5:48	9	5:50	20
5:56	9	5:56	60
6:00	9	6:02	9
6:06	9	6:08	9
6:12	9	6:14	9
6:18	9	6:20	9

* - % Removal; geomean not calculated for this site

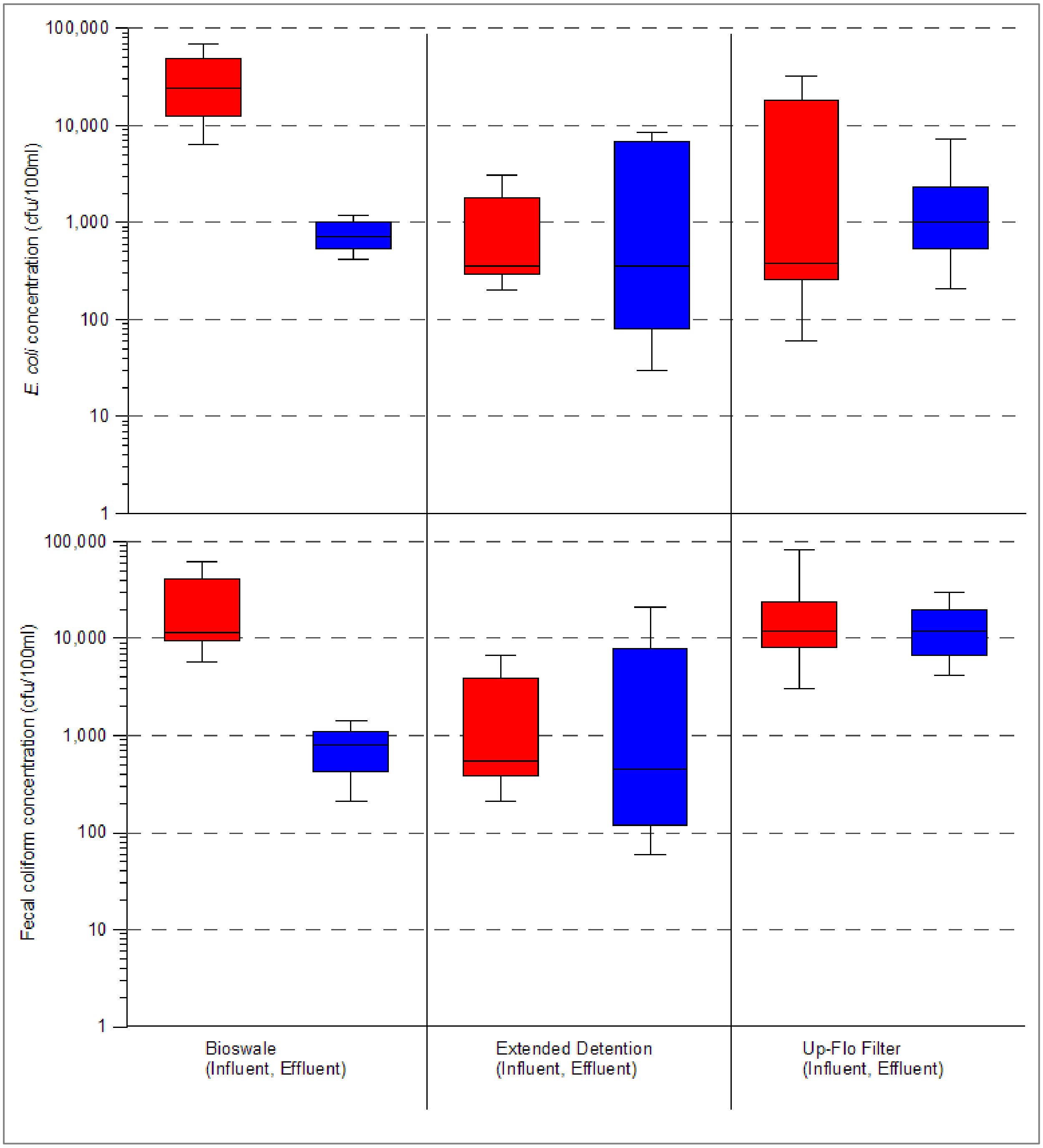

Figure 3-2. Influent (Red) and effluent (Blue) bacterial indicator concentrations in Pilot Study BMPs during dry weather conditions

Summary of Findings

The BMP Pilot Study examined five different BMPs for their bacterial removal effectiveness. The Northern Bioswale Segment #1 was the only BMP to show consistently high bacteria removal (>90%). When comparing the calculated geometric mean concentrations for influent and effluent samples, positive percent removal was observed (97%, 98%, and 93%, respectively) for each of three separate dry weather monitoring events conducted in May through June 2008. However, under wet weather conditions, the Bioswale performed poorly with negative percent removal. This was likely a function of the water moving through too quickly for any treatment benefit to occur.

Three different proprietary BMPs were evaluated in this Pilot Study. For the Kristar Up-Flo Filter, no consistent positive percent removal was observed under dry weather sampling conditions. No sample data was available for the Perk Filter and StormFilter due to lack of dry weather flows. For wet weather conditions, the Perk Filter, Up-Flo Filter, and StormFilter showed no consistent ability to remove bacteria.

For the Kristar Up-Flo and Perk Filters, maintenance of these retrofitted devices was found to be critical for proper operation under wet weather conditions. Since both of these BMPs were retrofitted into existing catch basins, the intensity of storm events and debris loading from generated runoff presented challenges and caused some stormwater to backup around the drain inlet.

3.1.2 BMP International Database

The International BMP Database project is a collection of data from various studies analyzing a range of BMPs and their pollutant removal performance. The project was started in 1996 as a cooperative agreement between the American Society of Civil Engineers (ASCE) and the EPA, and includes support and funding from additional partners including Water Environment Research Foundation (WERF), ASCE Environmental and Water Resources Institute (EWRI), Federal Highway Administration (FHWA) and the American Public Works Association (APWA).

The database includes approximately 600 pairs of influent and effluent bacteria data for over 340 BMPs from studies specifically monitoring for bacteria. From the data, BMP pollutant removal performance can be evaluated and compared between the various BMPs. BMPs used in the analysis include:

- Detention basins
- Retention ponds
- Sand filters
- Porous landscape detention (bioretention cells)
- Wetlands

- Grass swales

Of the 600 paired BMP influent and effluent samples, 100 events were monitored for *E. coli* at 12 sites in Oregon; and 500 events monitored fecal coliform from 61 sites in California, Florida, Virginia, Ontario, New York, Texas, Georgia, North Carolina, and Oregon. The majority of data were collected from grab samples due to six-hour maximum holding time limitations for bacteria analysis. Data are presented as either single pair grab samples of the influent and effluent, arithmetic averages of several grab samples, or flow-weighted averages.

Overall results show significant variability for each BMP in terms of pollutant removal. For all BMP types, there was no consistent reduction in bacteria below water contact recreation objectives. This was attributed to the high bacteria concentrations of the influent urban stormwater, which is often two orders of magnitude higher than the required recreation objectives.

While structural BMPs have not been observed to reduce bacteria to levels below acceptable recreational limits, the majority of BMPs were able to reduce bacteria to more manageable levels. Of the sampled structural BMPs, retention ponds and media filters (inclusive of bioretention cells) had the best performance in bacteria removal. This was attributed to the filtration treatment process of these BMPs.

Grass swales and detention pond BMPs were determined to be the least effective at reducing bacteria levels, and may actually increase bacteria levels due to increased appeal for recreational activities in swales and attraction of wildlife and domesticated pets for detention ponds (Note that this finding for grassy swales is quite different from the findings from the bioswales include in the BMP Pilot Study). Wetlands, porous pavement, and manufactured devices were analyzed but conclusions could not be derived due to limited data. All other BMPs had marginal bacteria removal.

3.1.3 California Stormwater Quality Association

The California Stormwater Quality Association (CASQA) Stormwater Best Management Practice Handbook, New Development and Redevelopment (BMP Handbook), provides general description, design and sizing guidance for selecting treatment control BMPs. Published in 2003, this guidance document contains BMP fact sheets for a variety of treatment control BMPs and is descriptive and qualitative in its approach to describing pollutant removal effectiveness with respect to bacteria.

CASQA cautions that in evaluating BMP performance, researchers have often used a variety of methods to describe efficiency and have often not sufficiently documented the methods to allow for recalculation. For the CASQA BMP Handbook, the BMP fact sheets describe removal effectiveness for BMPs in terms of “High,” “Medium,” or “Low”. Table 3-19 shows the removal effectiveness for bacteria for a variety of BMPs. At the time of publication, the BMP Handbook relied heavily on Caltrans BMP pilot research study data, which was one of the most extensive BMP research efforts at the time.

Table 3-19. Bacteria Removal Effectiveness for Treatment Control BMPs

BMP Type	Removal Effectiveness		
	High	Medium	Low
Infiltration Basin	x		
Infiltration Trench	x		
Media Filter		x	
Vegetated Swale			x
Bioretention	x		
Constructed Wetland	x		
Wet Pond	x		
Extended Detention Basin		x	

Source: CASQA BMP Handbook (2003)

3.1.4 Stormwater Quality Standards Task Force

The SWQSTF recently evaluated BMP effectiveness as part of the development of an implementation plan to support revisions to recreational uses and water quality objectives in the Basin Plan[10]. To support this effort, Orange County Public Works conducted a literature review of numerous BMP monitoring studies to evaluate the effectiveness of BMPs specifically for treating bacteria. These BMPs included:

- Wet basin (wet ponds, wet extended detention ponds, stormwater ponds, retention basins)
- Dry basins (dry ponds, extended detention basins or ponds)
- Constructed wetlands (wetland basins, shallow marshes, extended detention wetlands)
- Vegetated swales (grassed channels, dry swales, bio-filters, retention swales)
- Infiltration basins & trenches
- Media filters
- Flow diversions

Bacteria removal effectiveness varied widely for most BMPs due to a variety of factors, including non-standardized study and sampling methodologies, the percentage of storm flow that can be captured by a particular BMP, water residence time, BMP design, and site characteristics. Removal effectiveness is often reported as percent reduction in concentration as opposed to load reduction, which makes comparisons difficult due to dependence on upstream flow concentrations. Most of

[10] Revisions to the recreational uses and water quality objectives in the Santa Ana Region Basin Plan are currently expected to be adopted in 2010.

BMPs have some capacity to reduce bacterial concentrations when properly designed and sited. However, the evaluation found that the only BMPs with 100% or near 100% effectiveness were infiltration basins and low flow diversions (Table 3-20).

Table 3-20. Comparison of bacteria removal efficiencies among BMP types

BMP Type	Percent Removal
Wet Basins	42% to 99%
Dry Basins	<0% to 79%
Constructed Wetlands	78% to 99%
Vegetated Swales	<0% to 99%
Infiltration Basin & Trenches	>99%
Sand Media Filters	<0% to 76%
Flow Diversions	100%

Source: Stormwater Bacteria BMP Fact Sheet, Orange County (CA) Public Works, February 3, 2009

3.2 BMP Implementation Costs

The capital and annual operations and maintenance (O&M) costs associated with common BMP types was evaluated for the SWQSTF. Table 3-21 summarizes these findings. The following sections summarize the findings developed by Orange County staff (Stormwater Bacteria BMP Fact Sheet, Orange County (CA) Public Works, February 3, 2009).

3.2.1 Wet Basin

Construction costs for wet basins, mainly associated with excavation, are \$1.00 - \$12.25/ft^3. Annual maintenance costs varied from 3-5% of construction cost up to \$17,632 per pond, according to a California Department of Transportation (Caltrans) estimate for a retrofit pond. Annual maintenance may cost up to \$10,000 per pond. Fecal coliform removal effectiveness ranges from 0-99%, with the average removal percentage at 70%, although variance of results makes the average unreliable to use for predicting treatment effectiveness.

3.2.2 Dry Basins

Construction costs for dry basins are mostly related to excavation and range from \$0.30-\$1.00/ft^3. Annual maintenance costs range from \$3,100-\$10,000 per basin. Bacterial removal effectiveness vary widely among studies, ranging from 0-97%. While the average percent bacteria removal is 8%, significant variance in results indicates that the average removal is unreliable for predicting treatment facility.

Table 3-21. Comparison of construction and O&M costs by BMP type

BMP Type	Percent Removal	Construction Costs	Annual O & M Costs
Wet Basins	42% to 99%	$1.00-12.25/ft³ Typically <$100,000 per acre	Up to $10,000 per pond
Dry Basins	<0% to 79%	$0.30-1.00/ft³ Typically < $100,000 per acre	$3,100 to $10,000 per pond
Constructed Wetlands	78% to 99%	$0.35-1.30/ft³, or $26,325 – $55,485/acre of wetland	$600 to $1,100 per acre
Vegetated Swales	<0% to 99%	$0.50/ft² (<$35,000 for 3 ft. x 21 ft. x 1,000 ft. swale)	32% of construction costs
Infiltration Basin & Trenches	>99%	$1.25-20.76/ft³ <$110,000 per 1 ac basin	<$3,000 per basin or trench
Sand Media Filters	<0% to 76%	$6,600-18,500 per acre drainage Total $230,000-$485,000 in Southern CA	5% of construction costs
Flow Diversions	100%	$14,400 - $2,071,000 for diversions of up to 0.5 MGD in Orange County	$2,800 to $83,000

Source: Stormwater Bacteria BMP Fact Sheet, Orange County (CA) Public Works, February 3, 2009

3.2.3 Constructed Wetlands

Construction costs for constructed wetlands range from $0.35 - $1.30/ft³, according to the Center for Watershed Protection. USEPA estimates costs at $26,000 to $56,000 per acre of wetland. Maintenance costs range from $600 to $1,100 per acre. In a wetland in Laguna Niguel, *Enterococcus* removal effectiveness ranged from 60-97%. However, statistically different geometric mean concentrations before and after wetland construction were not observed.

3.2.4 Vegetated Swales

Removal effectiveness for vegetated swales ranged from 0-99%, though many studies reported poor removal effectiveness. Moreover, many studies reported higher bacterial concentrations in effluent relative to influent concentrations. The most likely causes of this finding was pet waste in swales or re-growth of bacteria in the swale. The City of Seattle reported 99% of wet season flow was prevented from entering an adjacent creek through use of vegetated swales in a pilot natural drainage project. Though vegetated swales may not reduce bacterial concentrations, total loads may be reduced through runoff capture.

3.2.5 Infiltration Basins & Trenches

Construction costs for infiltration basins and trenches range from $1.25 to $20.76/ft³. Annual maintenance costs are estimated at $3,000 per basin and $2,639 per trench. Basins can remove 100% of bacteria loading if discharges to surface waters are eliminated. However, groundwater contamination is possible in areas with sandy soils and shallow aquifers.

3.2.6 Sand and Organic Media Filters

Construction costs for media filters may range from $6,600-$18,500 for a system serving a drainage area under an acre. Annual maintenance costs are estimated at approximately 5% of construction costs, and include inspection after every storm event due to frequency of clogging. Bacterial removal effectiveness ranges from 0-76%, although influent and effluent concentrations often could not be statistically distinguished. Underground sand filters may even promote bacterial growth due to increased temperatures depending on geographic areas and degree of ultraviolet light.

3.2.7 Diversions

Diversions of dry weather flows have been implemented in Orange County and the City of Los Angeles to completely eliminate dry weather flows to receiving waters to comply with bacteria TMDLs or protect coastal beaches. Costs include initial construction and continuing O&M costs for diversion structures and piping required to convey dry weather discharges to the nearest sanitary sewer line. Additional costs include conveyance and treatment of these discharges. Treatment cost may vary depending on what treatment is selected for the diverted flow and whether additional treatment facilities upgrades are required to handle the additional flows to the wastewater treatment plants. If all the discharge is captured, removal of 100% of bacteria is expected. For Orange County, a diversion of up to 0.5 MGD costs from $14,400 to $2,071,000 with additional $2,800 to $83,000 for annual operation and maintenance.

3.3 BMP Compliance Efficiency

When examining BMPs for bacterial removal effectiveness and the costs to construct, operate, and maintain BMPs, there is a wide range of effectiveness and costs observed from BMP monitoring studies. With this wide range of costs, a cost comparison between BMP types is not readily apparent without annualizing costs with respect to treated flow volume.

This section evaluates four different BMPs often implemented as regional BMP options for bacterial removal and for dry weather runoff on an annual cost per treated flow volume basis. The BMPs evaluated include:

- Bioswale
- Subsurface flow (SSF) wetland
- Dry weather diversion
- Infiltration

Table 3-22 summarizes for each BMP the estimated costs to build, operate, and maintain the BMP by adding the amortized capital costs over a 30 year period with an assumed interest rate of 5% to the annual operation and maintenance costs. These costs include land acquisition, which was assumed to be $1 million per acre. The annualized total cost for capital and O&M was normalized by a treated dry runoff volume of 362 acre-ft/yr (0.5 cfs). The drainage area was assumed to be a hypothetical 1,800 acres. The following sections discuss the estimated cost per acre-ft for each BMP evaluated.

Table 3-22. Summary of cost efficiency of BMP options effective for bacteria removal during dry weather for a hypothetical 1,800 acre MS4 drainage area

BMP Type	Dry Weather Runoff (ac-ft/yr)	Estimated BMP Footprint (acres)	Amortized Capital ($/yr)	Annual O&M ($/yr)	Cost ($/ac-ft)
Bioswale	362	3.0	$197,757	$1,296	**550**
Subsurface Flow (SSF) Wetland	362	2.0	$163,064	$16,985	**497**
Dry Weather Diversion	362	0.1	$156,472	$101,020	**711**
Infiltration	362	1.0	$81,180	$2,200	**230**

3.3.1 Bioswale

To treat 0.5 cfs (362 ac-ft/year), a bioswale of 3.0 acres would provide a residence time of approximately 12 hours, which is comparable to the pilot bioswale project in Corona. No studies have been completed to determine the residence time needed to remove bacteria in bioswales. Traditionally, reduction of sediment related pollutants from wet-weather runoff is the intended function of these BMPs. During wet weather, residence time decreases to less than 30 minutes, resulting in limited bacteria treatment.

Combining land acquisition at $1 million/acre and bioswale costs (assuming a 3 acres facility) to be approximately $0.50/ft^2, the annual capital cost for a bioswale is approximately $198,000. O&M is assumed to be 2% of the construction cost at $1,300 per year. The cost per treated runoff volume is approximately $550/acre-ft.

3.3.2 Subsurface Flow (SSF) Wetland

The capital cost for a SSF wetland is approximately $250,000 per acre of SSF wetland. This value is based on median unit costs provided by Kadlec and Wallace (2009). Operating costs for SSF wetlands are typically low. To treat 0.5 cfs (362 ac-ft/year) of dry weather flow, a SSF wetland would be required to be approximately 2 acres in size. Inland Empire Utilities Agency estimated the annual cost to maintain SSF wetlands within the Chino Creek Wetlands Education Park (~0.4 acres) to be approximately $3,500 per year. Scaling up from this facility, the estimated cost for a potential 2.0-acre subsurface wetland would be approximately $8,500 per year. When capital costs are amortized over 30 years, the annual capital and O&M cost is approximately $180,000. The cost per treated runoff volume is approximately $484 per acre-ft.

3.3.3 Dry Weather Diversions

The City of Los Angeles, Bureau of Sanitation has implemented numerous low flow diversions (LFD) to treat for dry weather runoff to address bacteria in urban runoff. Average dry weather runoff flows per diversion is assumed to be 0.5 cfs (362 ac-ft/yr), generated from a drainage area of 1,800 acres per outfall (Table 3-23).

The capital cost on a per drainage area basis is $1,336. The total O&M cost on a per drainage area basis is $56. When considering each outfall diversion with a drainage area of 1,800 acres, capital cost is over $2.4 million while O&M is over $100,000 per year. Annual capital and O&M is over $250,000. The cost per treated runoff volume is approximately $711 per acre-ft.

Table 3-23 Dry Weather diversion Assumption and Costs[1]

Drainage Area Treated per Outfall (acres)	1,800
Average Dry Weather Flow per Diversion (cfs)	0.5
Total Capital Cost/ Drainage area	$1,336
Total O&M Cost/ Drainage area	$56

[1] Source: CREST LA River Dry Weather Bacteria TMDL Implementation Plan - draft

3.3.4 Infiltration

A 1.0 acre-sized infiltration basin with an assumed 1.0 ft per day infiltration rate can treat 0.5 cfs (362 ac-ft/yr) of runoff. The capital cost for an infiltration basin is approximately $250,000 per acre [11] plus cost of land acquisition at $1 million. For a capital cost of $1.25 million, the amortized capital cost is approximately $82,000 per year. The cost per treated runoff volume is approximately $230 per acre-ft.

3.4 Summary

Overall, this evaluation of BMPs for bacterial removal and compliance efficiency shows that when considering the selection of BMPs, the effectiveness of bacteria removal for diversions, SSF wetlands, and infiltration BMPs is high with removal percentages well above 90%. From a compliance efficiency perspective, infiltration and subsurface wetlands BMP options at $230/ac-ft and $497/ac-ft, respectively, are less costly than diversion ($711/ac-ft). However, for the infiltration BMP option, challenges exist for locating sufficient sized land areas within highly urbanized areas with suitable infiltration rates. Siting a subsurface or constructed wetland in a highly urbanized area also presents similar challenges.

[11] Estimate from Los Angeles River Metals TMDL Implementation Plan (2009) for North Hollywood Park infiltration basin

The BMP option with the highest removal percentage is diversion with 100% removal when dry weather discharges are completely diverted. The ongoing annual maintenance, operation of diversion BMPs is the source of higher costs due to the ongoing conveyance and treatment costs at the sanitary sewer system. Although the cost per flow volume associated with diversion is the highest, only this BMP option provides full bacteria removal.

Section 4
Prioritization Analysis

The MSAR bacteria TMDL established numeric bacterial indicator targets for MSAR waterbodies based on a presumption that all waterbodies should be protected for water contact recreation. However, ongoing work in the region demonstrates that existing and potential recreational use activity varies based on waterbody characteristics.

The implementation of water quality control activities in all waterbodies at all times is not practical and may not be necessary for achieving compliance with TMDL numeric targets. Instead, the nature and extent of TMDL implementation activities should be prioritized in a manner that reduces bacterial indicators to the maximum extent practical while protecting appropriate recreational uses.

The MSAR bacteria TMDL required urban source dischargers to develop and implement (1) a watershed-wide compliance monitoring program to evaluate compliance with TMDL numeric targets; and (2) an Urban Source Evaluation Plan (USEP) to identify specific activities, operations, and processes in urban areas that contribute bacterial indicators to MSAR waterbodies (SAWPA 2008c)[12]. Section 2 describes the watershed-wide compliance monitoring program, including the five locations used by the Regional Board to evaluate TMDL compliance. The following sections describe the urban source monitoring program and how results from this program and the watershed-wide compliance monitoring program are being used to prioritize TMDL implementation activities.

4.1. Urban Source Monitoring Program

The USEP included a 2007-2008 urban source monitoring program to investigate FIB concentrations and the use of source tracking tools to characterize bacteria sources in key portions of the MS4 in San Bernardino and Riverside Counties. The MSAR Task Force used the 2007-2008 USEP data results to prioritize steps for mitigating controllable urban sources of bacteria within the MSAR watershed. In general, the highest priority sites or subwatersheds for additional TMDL implementation activities are those where:

- Magnitude and frequency of bacterial indicator exceedances are high;
- Source tracking analysis indicates presence of human sources of bacteria relatively frequently;
- The site is in an area, or is close to an area, where water contact recreational activities are likely to occur; and

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[12] The USEP was approved by the RWQCB in 2008 and is available at http://www.waterboards.ca.gov/santaana/water_issues/programs/tmdl/msar_tmdl.shtml

- Observed bacterial indicator exceedances and presence of human bacteria sources occur during periods when people are most likely to be present, e.g., during warm months and dry weather periods.

In contrast, the lowest priority sites for urban dischargers would be those where the bacterial indicator exceedance frequency and magnitude is low, human or other urban sources, e.g., dogs, are not present, and the site is not used for water contact recreation, e.g., the site is a concrete-lined, vertical-walled flood control channel.

The following sections summarize the findings from USEP investigations and provide the basis for prioritizing areas for implementation of water quality control activities to comply with dry weather TMDL targets. This information will be used in Section 5 to develop a strategy for compliance with dry weather targets.

Urban Source Monitoring Program

The MSAR Task Force implemented the urban source monitoring program during both dry and wet seasons in 2007 and 2008. Monitoring activities occurred at 13 locations in the MSAR watershed, including all major subwatersheds that drained to waters listed as impaired for bacterial indicators in the MSAR watershed (Figure 4-1). Table 4-1 provides information on the location of each monitoring site.

Table 4-1. Urban Source Evaluation Monitoring Program Sample Locations

MSAR Waterbody	Waterbody Reach[1]	Sample Location	Site Code
Santa Ana River	Reach 3	Santa Ana River (SAR) at La Cadena Drive	US-SAR
		Box Springs Channel at Tequesquite Avenue	US-BXSP
		Sunnyslope Channel near confluence with SAR	US-SNCH
		Anza Drain near confluence with Riverside effluent channel	US-ANZA
		San Sevaine Channel in Riverside near confluence with SAR	US-SSCH
		Day Creek at Lucretia Avenue	US-DAY
		Temescal Wash at Lincoln Avenue	US-TEM
Chino Creek	Reach 1	Cypress Channel at Kimball Avenue	US-CYP
	Reach 2	San Antonio Channel at Walnut Ave	US-SACH
		Carbon Canyon Creek Channel at Pipeline Avenue	US-CCCH
Mill-Cucamonga Creek	Prado Area	Chris Basin Outflow (Lower Deer Creek)	US-CHRIS
		County Line Channel near confluence with Cucamonga Creek	US-CLCH
	Reach 1	Cucamonga Creek at Highway 60 (Above RP1)	US-CUC

[1] Reaches are defined in the Basin Plan.

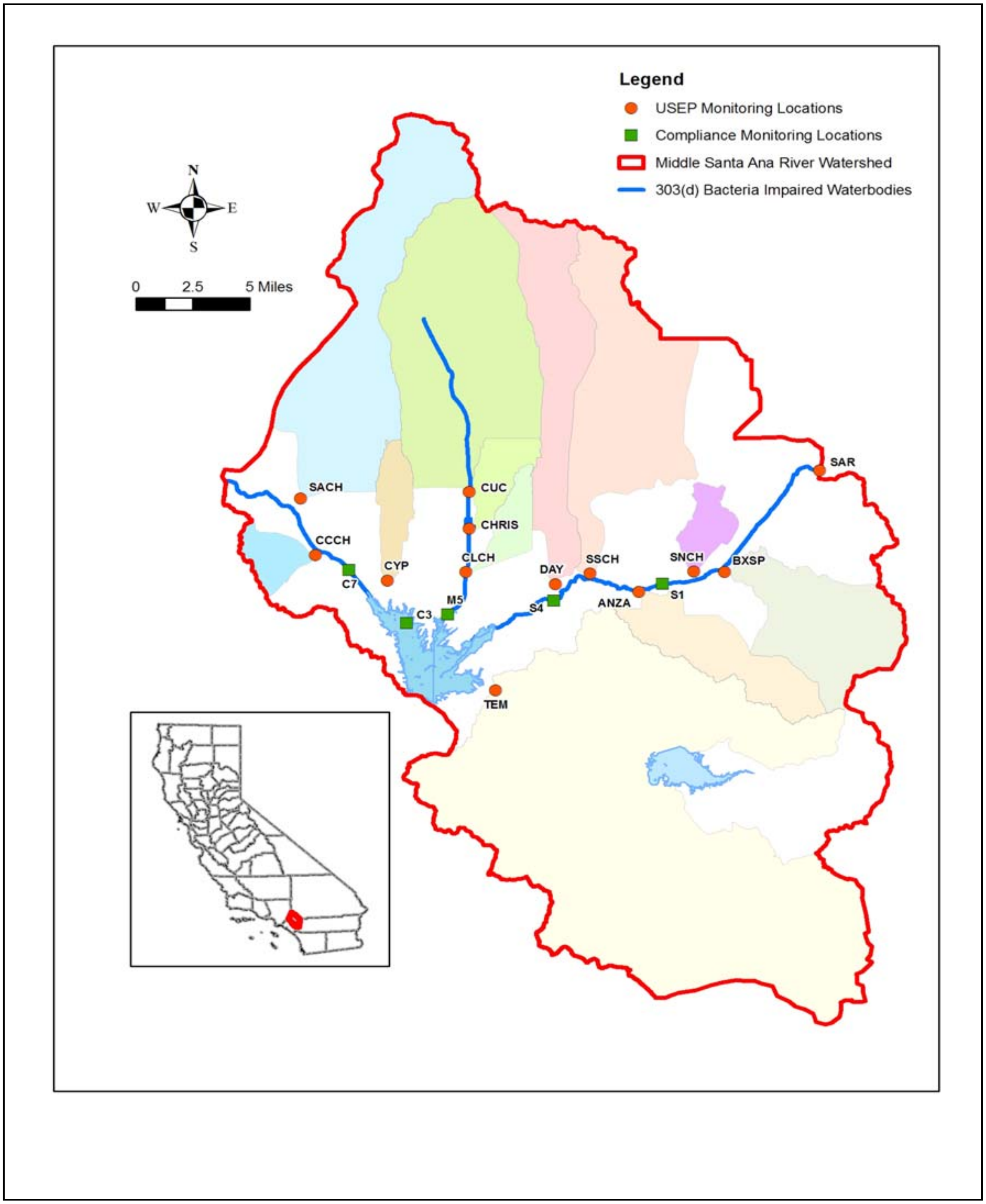


Figure 4-1. Location of urban source monitoring program sites relative to watershed-wide compliance sites.

Sample Methods

Sample teams collected a total of 20 water samples from each site during both wet and dry seasons. Laboratories analyzed each sample for fecal coliform and E. coli concentrations and presence/absence and strength of signal for human, dog and bovine sources of bacteria using accepted microbial source tracking methods. The Monitoring and Quality Assurance Project Plans for this investigation provide additional information regarding sampling and laboratory analysis methods (see footnote in Section 2 for location of current documents).

Monitoring Results Summary

A complete summary of monitoring results may be found in SAWPA (2009a). Compliance with Basin Plan objectives was evaluated using geometric mean and single sample results (Table 4-2). Geometric means were calculated only when at least five sample results were available from the previous five week period. Bacteria indicator concentrations frequently exceeded water quality objectives at most of the sampling locations. Despite this commonality, the range of bacterial indicator concentrations varied significantly among sites (Figure 4-2).

Microbial source tracking analysis detected bacterial contamination originating from human sources at some sites. The detection frequency of human sources indicates that some tributaries to impaired waterbodies could pose a greater risk of contributing harmful pathogens to downstream waters than others (Table 4-3). Of particular concern for human sources were Box Springs Channel and Chris Basin. Several detections of human bacterial sources occurred at each of these sites.

The use of bacterial indicators alone (*E. coli* and fecal coliform) to guide TMDL implementation activities plans may inappropriately focus stormwater management activities on low priority areas, e.g., areas where non-human sources of bacteria dominate. Accordingly, the findings from microbial source tracking analyses provided additional information regarding priority.

4.2 Subwatershed Prioritization

Prioritization of subwatersheds for TMDL implementation activities relied on three general types of information:

- Impairment listing status of waterbodies and their associated subwatershed.
- Monitoring data results from bacterial indicator and microbial source tracking analyses; and
- Risk of exposure to pathogen indicators as a result of recreational activity.

The following sections describe how each of these data types supported the prioritization of subwatersheds.

Table 4-2. Bacterial indicator compliance frequency for fecal coliform and *E. coli* at urban source monitoring program sites

Bacterial Indicator	Site	Single Sample Criterion Exceedance Frequency (%)		Geometric Mean (cfu/100 mL)				Geomean Criterion Exceedance Frequency (%)
		Dry Season	Wet Season	Dry Season 2007 (7/14 – 8/11)	Dry Season 2007 (9/1 – 9/29)	Wet Season 2008 (1/19 – 2/16)	Wet Season 2008 (1/26 – 2/23)	
Fecal coliform	Anza Drain	78	100	577	3,808	261	457	100
	Box Springs Channel	94	100	12,990	23,077	607	858	100
	Carbon Canyon Cr.	32	100	126	257	205	122	50
	Chris Basin	100	100	4,705	1,520	1,758	1,404	100
	County Line Channel	86	n/a[1]	1,476	n/a[2]	n/a[2]	n/a[2]	100
	Cucamonga Cr.	58	100	261	1,624	271	884	100
	Cypress Channel	100	100	11,366	4,949	n/a[2]	n/a[2]	100
	Day Creek	77	100	n/a[2]	n/a[2]	n/a[2]	n/a[2]	n/a[2]
	San Antonio Channel	72	100	n/a[2]	9,026	2,038	1,630	100
	SAR @ La Cadena	60	100	n/a[2]	n/a[2]	n/a[2]	n/a[2]	n/a[2]
	Sunnyslope Channel	63	100	332	776	270	523	100
	San Sevaine Channel	86	100	n/a[2]	n/a[2]	n/a[2]	n/a[2]	n/a[2]
	Temescal Cr.	74	100	5,912	13,232	172	170	50
E. Coli	Anza Drain	56	100	380	638	177	341	100
	Box Springs Channel	83	100	1,149	4,793	655	939	100
	Carbon Canyon Cr.	26	100	44	84	200	177	50
	Chris Basin	89	100	1,758	429	1,530	1,447	100
	County Line Channel	71	n/a[1]	1,194	n/a[2]	n/a[2]	n/a[2]	100
	Cucamonga Cr.	42	100	74	262	176	356	75
	Cypress Channel	100	100	4,745	1,981	n/a[2]	n/a[2]	100
	Day Creek	69	100	n/a[2]	n/a[2]	n/a[2]	n/a[2]	n/a[2]
	San Antonio Channel	67	100	n/a[2]	718	2,085	1,394	100
	SAR @ La Cadena	60	100	n/a[2]	n/a[2]	n/a[2]	n/a[2]	n/a[2]
	Sunnyslope Channel	26	100	165	204	72	207	75
	San Sevaine Channel	79	100	n/a[2]	n/a[2]	n/a[2]	n/a[2]	n/a[2]
	Temescal Cr.	68	100	491	3,127	162	143	100

[1] – Site was dry during wet weather event
[2] – Insufficient data to calculate geomean (see text)

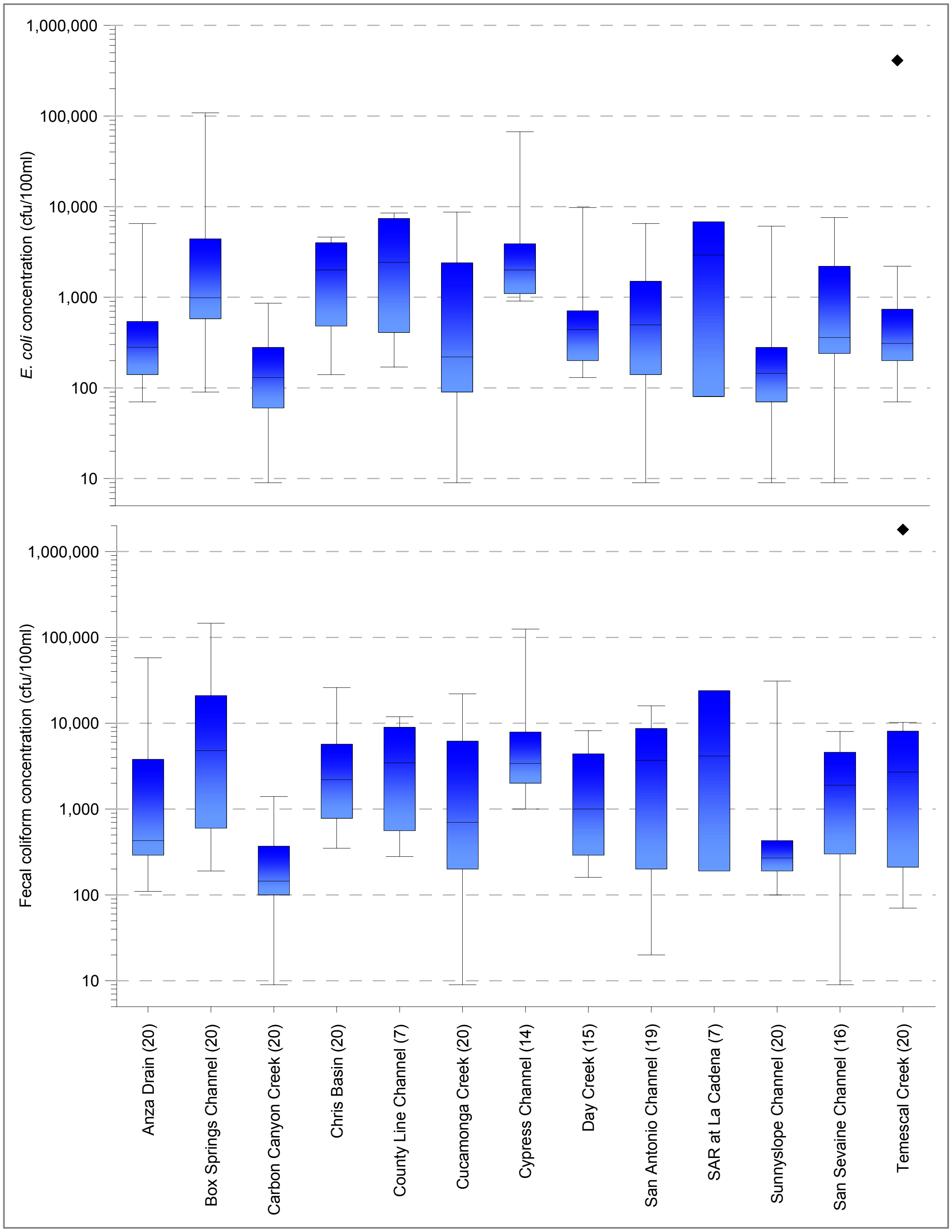


Figure 4-2. Bacterial indicator concentrations at urban source monitoring program sites during dry weather conditions

Table 4-3. Summary of human source bacteria detections at urban source monitoring program sites

Site	N	Number of Detections of Human Sources (N = 20)	Frequency of Detection
Anza Drain	20	1	5%
Box Springs Channel	20	18	90%
Carbon Canyon Creek	20	0	0%
Lower Deer Creek (Chris Basin)	20	5	25%
County Line Channel	7	0	0%
Cucamonga Creek	20	1	5%
Cypress Channel	14	1	7%
Day Creek	15	1	7%
San Antonio Channel	19	3	16%
San Sevaine Channel	7	3	43%
Santa Ana River at La Cadena	20	3	15%
Sunnyslope Channel	16	2	13%
Temescal Creek	20	1	5%

4.2.1 Impairment Status

Currently, five waterbodies are considered impaired because of elevated fecal coliform concentrations: Santa Ana River Reach 3, Chino Creek, Mill Creek (Prado Basin area), Cucamonga Creek Reach 1 and Prado Park Lake (see Section 1 for more complete descriptions). The Regional Board adopted the MSAR Bacteria TMDL to address these impairments. The watershed-wide compliance monitoring program described in Section 2 identified the five RWQCB-approved locations for determining compliance with the TMDL numeric targets for bacterial indicators.

Section 2 summarized the findings from the first three years of watershed-wide compliance sampling. The highest frequency and magnitude of bacterial indicator exceedances occurs at the Mill-Cucamonga Creek and Chino Creek compliance locations. In contrast, the sites with the lowest frequency and magnitude of exceedances are the Prado Park Lake and Santa Ana River sample sites. Based on these results, the priority for TMDL implementation activities is the Mill-Cucamonga and Chino Creek watersheds (Figure 4-3). Figure 4-3 illustrates the areas within the MSAR watershed that drain to each of these compliance points and thus potentially contribute to exceedances of water quality objectives at these locations.

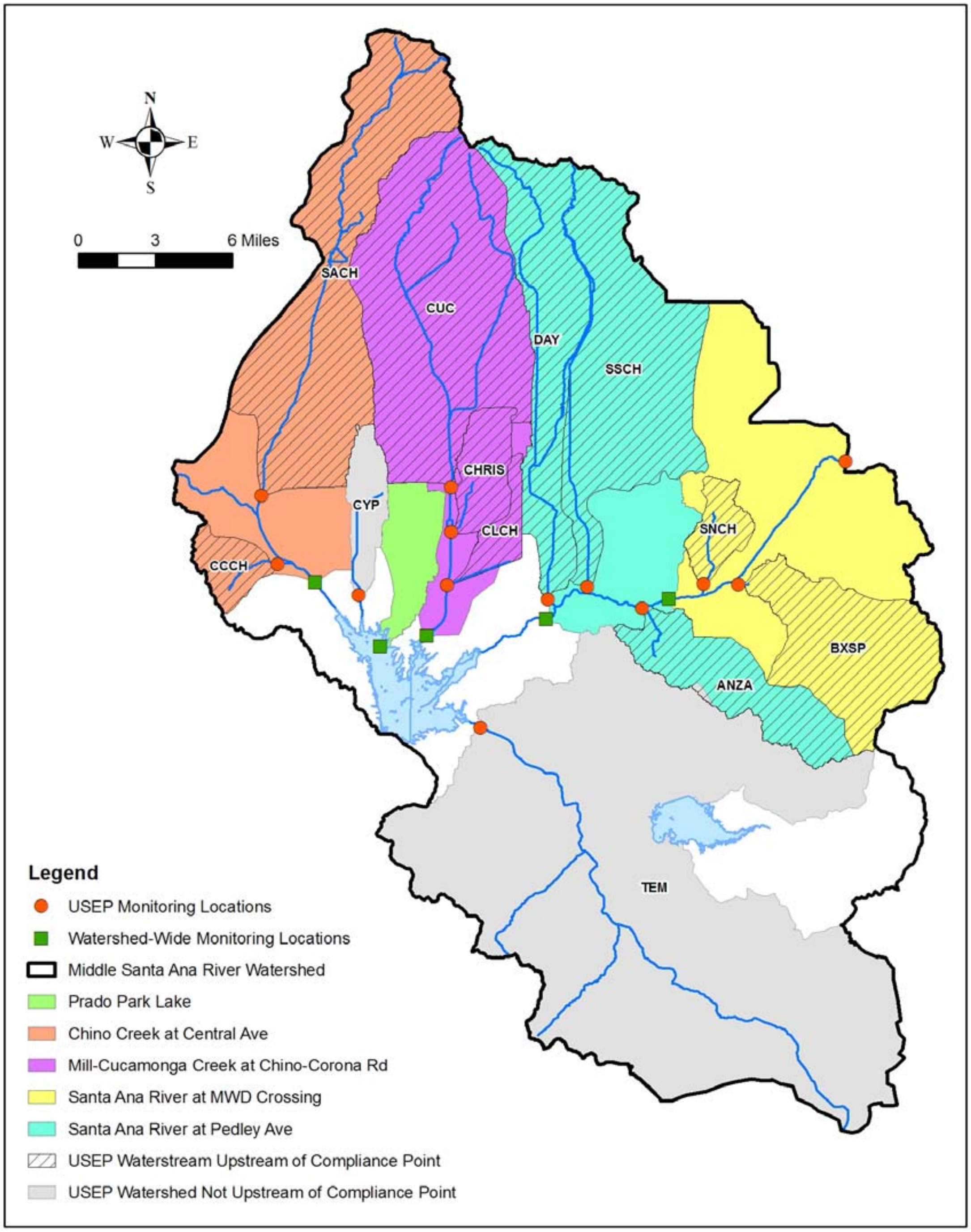


Figure 4-3. Areas of the MSAR watershed draining to each of the watershed-wide compliance locations (note that Temescal Creek (TEM) and Cypress Channel (CYP) do not drain to compliance locations.

4.2.2 Bacterial Indicator and Microbial Source Tracking Results

The urban source monitoring program gathered water quality data on key subwatersheds within each of the watersheds that drain to the TMDL compliance locations. These data were used to compute the relative rank (R) for each of the subwatersheds using the following three criteria;

- Frequency of exceedances of water quality objectives ($F_{non\text{-}compliance}$)
- Magnitude of bacterial indicator concentration ($C_{E.coli}$)
- Number of detections of human source bacteria ($D_{human\text{-}detections}$)

From these ranks, a single normalized index referred to as a Bacterial Prioritization Score (BPS) was calculated using the following equation:

$$BPS = \frac{R_F * R_C * R_D}{MAX_{R_F * R_C * R_D}}$$

Table 4-4 shows the relative ranks and computed BPS for each of the subwatersheds represented by USEP monitoring locations. These BPS values provide a basis for prioritizing TMDL implementation activities within each of the areas draining to watershed-wide compliance points. This analysis shows that highest priority subwatersheds are Box Springs and Lower Deer Creek (Chris Basin) (Figure 4-4). In contrast, subwatersheds that appear to be of low priority include Sunnyslope Channel and Carbon Canyon Creek.

4.2.3 Evaluation of Exposure Risk

The final type of information used to prioritize TMDL implementation activities is an estimation of the risk of exposure by people to pathogen indicators based on waterbody characteristics and the likelihood of water contact recreational activities occurring in the waterbody. For example, where water contact recreation is likely to occur, e.g., a natural waterbody with sufficient flow, the risk of exposure is higher than where such recreation is unlikely, e.g. in a vertical-walled concrete-lined engineered channel.

Table 4-4. Bacteria Prioritization Score (BPS) for major subwatersheds draining to urban source monitoring locations in the MSAR watershed

Site	Relative Rank of Bacterial Indicator Water Quality			Normalized BPS
	Frequency of Single Sample Exceedance (R_F)	Magnitude of Exceedance (R_C)	Proportion of Human Detect (R_D)	
Box Springs Channel	11	13	13	100
Chris Basin Outflow	12	11	11	78
Cypress Channel	13	12	7	59
San Antonio Channel	6	9	10	29
Santa Ana River @ La Cadena	5	8	12	26
San Sevaine Channel	10	4	8	17
Day Creek	8	6	6	15
County Line Channel	9	10	1	5
Cucamonga Creek	3	7	3	3
Anza Drain	4	5	3	3
Temescal Creek	7	2	3	2
Sunnyslope Channel	1	3	9	1
Carbon Canyon Creek	1	1	1	0

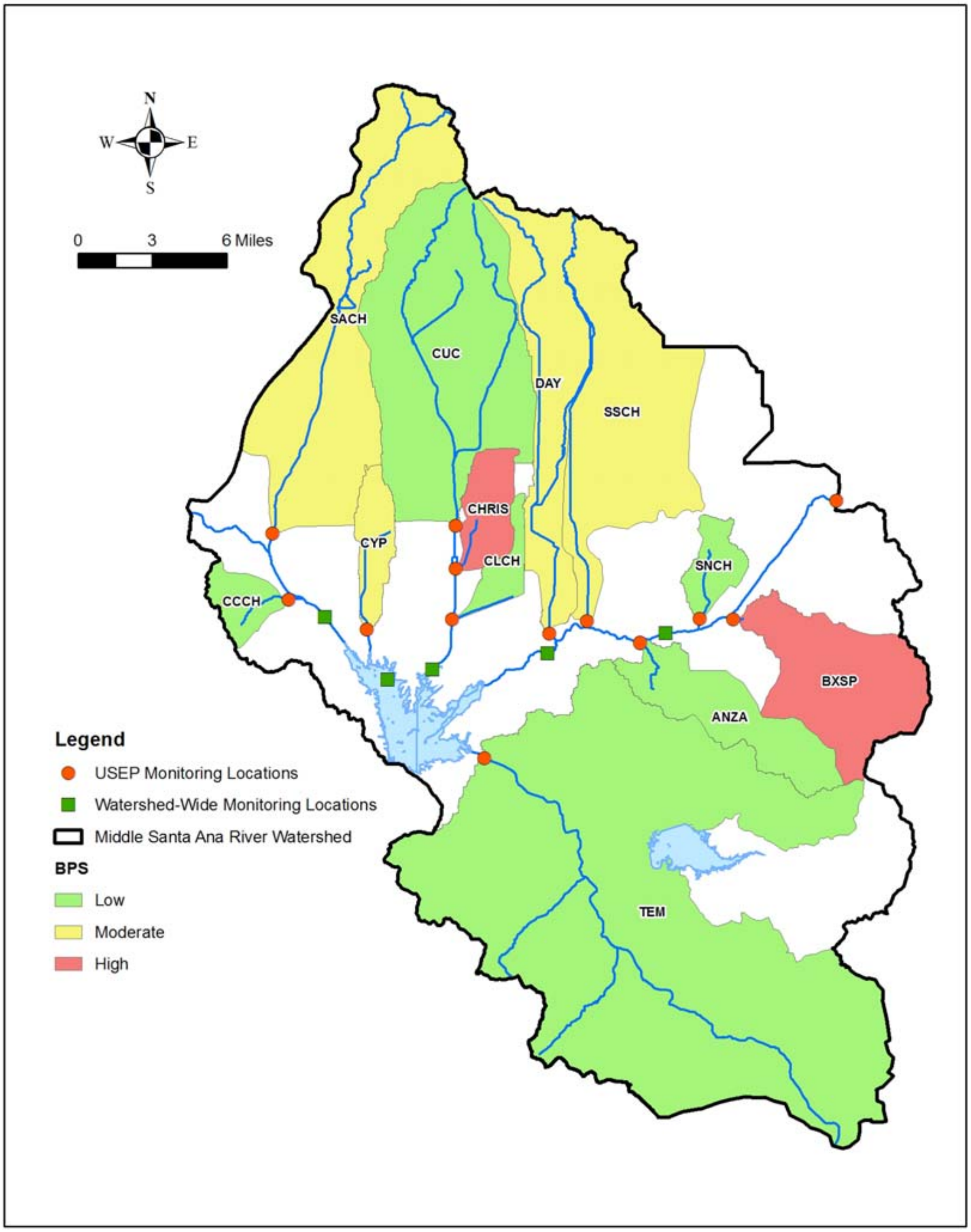


Figure 4-4. Priority urban source monitoring program subwatersheds based on BPS score.

To evaluate exposure risk, data developed by the SWQSTF was evaluated. As previously discussed, the SWQSTF was established in 2003 to evaluate the appropriateness of water contact recreation uses and associated water quality objectives in the Santa Ana River Watershed. As part of this effort, the SWQSTF uses remote camera technology coupled with weekly on-location physical surveys to monitor recreational use in a number waterbodies throughout the watershed. To date, these surveys have collected data from 17 locations with varying characteristics (Table 4-5).

Results from these surveys show that channel characteristics are a strong indicator of existing and potential recreational use activity in the Santa Ana River watershed:

- *Vertical-walled, Concrete-lined Channels* - Based on over 93,000 images collected from all seasons and different areas of the watershed, water contact recreation has not been observed in vertical-walled channels.
- *Trapezoidal-walled, Concrete-lined bottom Channels* - Based on over 35,000 images collected from all seasons and different areas of the watershed, only one contact with water was observed – a person kneeling at the edge of the low flow channel contacted the water on two occasions for a period of less than 30 minutes.
- *Trapezoidal-walled, Natural bottom Channels* – Based on over 113,000 images, only a few images (23) showed some type of contact with the water, but limited to shallow wading, e.g., Chino Creek at Central Avenue where 10 observations occurred.
- *Natural Stream Channels* – A few natural stream channels were surveyed. Three sites were observed using camera technology (Santa Ana Delhi Channel at Newport Bay and Reach 2 of the Santa Ana River at Yorba Linda and Anaheim). Based on over 32,000 images, only two observations of contact with the water were observed and these occurrences were limited to hand/water contact at the Santa Ana Delhi Channel at Newport Bay site.

  Lack of a good location for mounting cameras precluded their use in Reach 3 of the Santa Ana River. However, targeted field visits were conducted during weekends and holidays in the 2007 summer season to assess the frequency of water contact recreation in locations where historical surveys suggested water contact recreation commonly occurs. These surveys showed regular water contact recreational use in certain segments of Reach 3 of the Santa Ana River. Over seven field survey events, 437 individuals were observed contacting the water (Table 4-6).

Table 4-5. Summary of recreational use surveys conducted on a variety of waterbodies in the Santa Ana River watershed

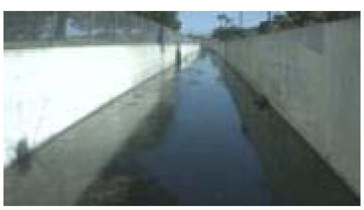
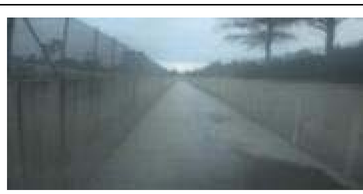
Representative Photo of Site	Summary of Recreational Use Survey
	**Greenville Banning Channel at Adams Avenue Bridge** ■ Concrete lined, vertical walled channel ■ Land use: Residential and open space ■ Period of Survey: 11/17/05 – 1/3/06 ■ Images collected: 2552 ■ Water contact recreational use events: 0
	**Greenville Banning Channel at Pedestrian Bridge** ■ Concrete lined, vertical walled channel ■ Land use: Residential and vacant natural land ■ Period of Survey: 7/7/2005 – 7/27/2005 ■ Images Collected: 45 ■ Water contact recreational use events: 0
	**Santa Ana Delhi Channel at Mesa Ave** ■ Concrete lined, vertical walled channel ■ Land use: Residential / open space and recreation ■ Period of Survey 6/20/2005 – 7/13/2006 ■ Images Collected: 21,284 ■ Water contact recreational use events: 0
	**Cucamonga Creek at RP1** ■ Concrete lined, vertical walled channel ■ Land use: Industrial/commercial and open space/recreation ■ Period of Survey 10/2/2007 – 10/10/2008 ■ Images Collected: 27,122 ■ Water contact recreational use events: 0
	**Anza Channel at John Bryant Park** ■ Concrete lined, vertical walled channel ■ Land use: Residential and open space/ public park ■ Period of Survey 6/6/2008 – 9/29/2009 ■ Images Collected: 20,386 ■ Water contact recreational use events: 2
	**Demens Channel** ■ Concrete lined, vertical walled channel ■ Land use: Residential and open space ■ Period of Survey 2/1/2008 – 2/9/2009 ■ Images Collected: 21,382 ■ Water contact recreational use events: 0

Table 4-5. Summary of recreational use surveys conducted on a variety of waterbodies in the Santa Ana River watershed

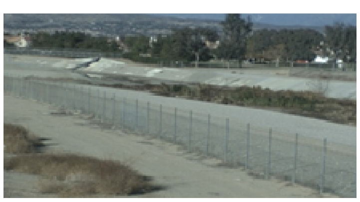
Representative Photo of Site	Summary of Recreational Use Survey
	**Cucamonga Creek at Hellman Ave (Upstream)** ■ Trapezoidal channel, concreted lined wall and bottom ■ Land use: Agriculture ■ Period of Survey 11/1/2005 – 11/1/2006 ■ Images Collected: 2,546 ■ Water contact recreational use events: 0
	**Temescal at Main Street** ■ Trapezoidal channel, concreted lined wall and bottom ■ Land use: Industrial / Commercial ■ Period of Survey 7/26/2005 – 8/4/2005 ■ Images Collected: 513 ■ Water contact recreational use events: 1
	**Temescal at City of Corona WWTP No. 2** ■ Trapezoidal channel, concreted lined wall and bottom ■ Land use: Industrial / Commercial ■ Period of Survey 11/1/2005 – 11/1/2006 ■ Images Collected: 10,653 ■ Water contact recreational use events: 1
	**Santa Ana Delhi Channel at Sunflower Ave** ■ Trapezoidal channel, rip rap side slopes, natural bottom ■ Land use: Commercial/ residential/ school ■ Period of Survey 7/7/2005 – 7/9/2006 ■ Images Collected: 20,978 ■ Water contact recreational use events: 1
	**Cucamonga Creek at Hellman Ave (Downstream)** ■ Trapezoidal channel, rip rap side slopes, natural bottom ■ Land use: Agriculture ■ Period of Survey 7/26/2005 – 11/1/2006 ■ Images Collected: 16,678 ■ Water contact recreational use events: 8
	**Perris Valley Channel at Moreno Valley WRF** ■ Trapezoidal channel / concrete lined side slope and concrete/natural bottom ■ Land use: Industrial/ Residential/school and open space/public park ■ Period of Survey 10/3/2007 – 10/10/2008 ■ Images Collected: 21,962 ■ Water contact recreational use events: 0

Table 4-5. Summary of recreational use surveys conducted on a variety of waterbodies in the Santa Ana River watershed

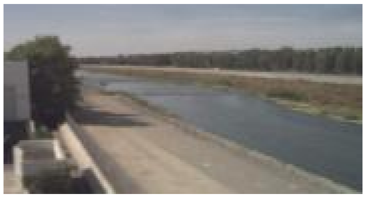
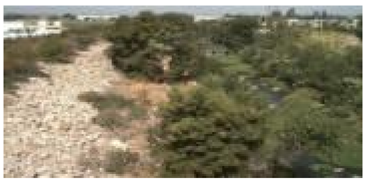
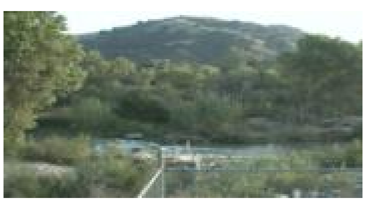
Representative Photo of Site	Summary of Recreational Use Survey
	**SAR at Anaheim** ■ Trapezoidal channel, rip rap side slopes, natural bottom ■ Land use: Industrial/ commercial and open space/public park ■ Period of Survey 10/2/2007 – 10/5/2008 ■ Images Collected: 25,904 ■ Water contact recreational use events: 0
	**Chino Creek at Central Ave** ■ Trapezoidal channel / rip rap slope and bottom ■ Land use: Industrial / commercial ■ Period of Survey 12/19/2007 – 5/23/2009 ■ Images Collected: 23,913 ■ Water contact recreational use events: 10
	**San Diego Creek at Irvine** ■ Trapezoidal channel / natural side slopes and bottom ■ Land use: Residential/commercial/school and open space ■ Period of Survey 6/10/2008 – 9/30/2009 ■ Images Collected: 24,801 ■ Water contact recreational use events: 4
	**Santa Ana Delhi Channel at Newport Bay** ■ Natural Channel ■ Land use: Open space / commercial ■ Period of Survey 6/20/2005 – 6/6/2006 ■ Images Collected: 20,203 ■ Water contact recreational use events: 2
	**SAR at Yorba Linda** ■ Natural Channel ■ Land use: Residential / open space ■ Period of Survey 4/11/2006 – 4/6/2007 ■ Images Collected: 12,645 ■ Water contact recreational use events: 0

Table 4-6. Results of field recreational use surveys from select visits to Middle Santa Ana River Reach 3 in summer of 2007

Date	Swimming		Wading		Fishing		Non-Water	
	Adult	Child	Adult	Child	Adult	Child	Adult	Child
Santa Ana River at Mission Blvd Overpass								
5/26/07	0	0	0	0	0	0	0	0
5/28/07	0	0	0	0	0	0	0	0
6/10/07	1	0	0	0	0	0	0	0
7/4/07	0	0	0	0	0	0	0	0
7/21/07	2	0	0	0	0	3	2	0
9/2/07	0	0	0	0	0	0	0	0
9/3/07	0	0	0	0	0	0	0	0
Subtotal	**3**	**0**	**0**	**0**	**0**	**3**	**2**	**0**
Santa Ana River at Martha Maclean Anza Narrows Park								
5/26/07	0	0	0	0	0	0	0	0
5/28/07	19	34	0	0	0	0	2	0
6/10/07	0	0	3	0	0	0	0	0
7/4/07	35	25	5	0	0	0	15	10
7/21/07	4	12	6	0	0	0	0	0
9/2/07	8	11	3	0	0	0	0	0
9/3/07	0	0	3	5	0	0	2	9
Subtotal	**66**	**82**	**20**	**5**	**0**	**0**	**19**	**19**
Riverside WQCP Effluent Channel at Van Buren								
5/26/07	0	0	0	0	0	0	0	0
5/28/07	11	6	2	0	0	0	10	2
6/10/07	0	8	0	0	0	0	0	0
7/4/07	3	9	0	0	0	0	13	3
7/21/07	2	0	3	1	0	0	0	0
9/2/07	39	36	9	0	10	0	6	1
9/3/07	11	45	7	10	0	0	17	22
Subtotal	**66**	**104**	**21**	**11**	**10**	**0**	**46**	**28**
Santa Ana River at Effluent Channel Confluence								
5/26/07	0	0	0	0	0	0	0	0
5/28/07								
6/10/07	0	8	3	10	1	2	5	10
7/4/07	6	14	2	0	0	0	8	1
7/21/07	0	0	0	0	0	0	0	0
9/2/07	0	0	0	0	0	0	0	0
9/3/07	0	0	0	0	0	0	0	0
Subtotal	**6**	**22**	**5**	**10**	**1**	**2**	**13**	**11**
Total	**141**	**208**	**46**	**26**	**11**	**5**	**80**	**58**

The SWQSTF is using the recreational survey data to support the development of Use Attainability Analyses (UAAs) to assign appropriate recreational uses to surveyed waterbodies. At this time, the SWQSTF is considering three options: (1) waterbody is protected for REC-1 and REC-2 uses; (2) waterbody is protected for only REC-2 use; and (3) waterbody has neither a REC-1 nor a REC-2 use. These options are directly related to risk of exposure from high (REC-1) to low (REC-2 only) or extremely low (neither REC-1 or REC-2).

In addition to developing UAAs, the SWQSTF plans to use the large image dataset as a basis for predicting recreational use activity in unsurveyed waterbodies based on similarities in waterbody characteristics. This approach reduces the need for camera surveys to only those areas where warranted because of unusual site-specific conditions.

While it is the RWQCB's discretion to determine what the appropriate recreational use should be for a waterbody given the existing and potential recreational use activity, the following assumptions regarding risk of exposure were made for planning purposes to prioritize TMDL implementation activities:

- *Vertical-walled, concrete-lined channels* – No exposure risk; No recreational use applies, ambient water quality may not be degraded;
- *Trapezoidal-walled, concrete-lined channels* – Either no recreational beneficial use applies or only REC-2 use applies; ambient water quality may not be degraded;
- *Trapezoidal-walled, earthen-bottomed channels* – only REC 2 use applies; ambient water quality may not be degraded;
- *Natural channels* – both REC-1 and REC-2 apply; water quality objectives apply.

4.3 Prioritization Summary

The results from watershed-wide compliance, urban source monitoring and recreational use survey data provide the means to prioritize TMDL implementation activities and develop a strategy for implementation within each subwatershed. In terms of watersheds draining to the watershed-wide compliance sites, study results clearly identify the highest priority sites as Chino Creek and Mill-Cucamonga Creek. When data from the urban source monitoring program are added to the analysis, Chris Basin (upstream of Mill-Cucamonga Creek site) and Cypress Channel (upstream of Chino Creek site) are two of the highest ranking subwatersheds due to strong indications of bacterial contamination from human sources.

Box Springs was also identified as a high priority subwatershed but it discharges within the watershed draining to the Santa Ana River at Pedley Avenue compliance site, which is a low priority for TMDL implementation activities. Moreover, following the identification of a significant human source signal at the Box Springs site during the urban source monitoring program, follow-up survey work was done by the local jurisdictions which identified a human bacteria source that was subsequently mitigated (SAWPA 2009a). Accordingly, this site is no longer considered a high priority.

The following sections describe how the prioritization analyses have been used to develop a strategy for achieving compliance with MSAR Bacteria TMDL dry weather targets.

Section 5
Dry Weather Compliance Strategy

Section 4 identified the highest priority areas within the MSAR watershed and the highest priority subwatersheds within each of these areas. The purpose of this section is to describe a compliance strategy for the entire MSAR watershed and further develop priorities for TMDL implementation activities by providing a general schedule for implementation.

5.1 Potential Compliance Strategies

Strategies for achieving compliance with dry weather TMDL targets can be divided into four areas[13]:

- UAA development to modify the applicable recreational use
- Conduct channel surveys or implement enhanced tracking methods to gather additional data, e.g., bacterial indicator concentration, microbial source information, outfall locations and associated dry weather flows and presence of homeless camps, etc.
- Conduct controllability assessments to develop regional treatment or outfall-specific control solutions
- No direct action because mitigation of bacterial indicators is not required by the MS4 or mitigation may be accomplished by other means, e.g., non-structural programs

These strategies may be implemented separately or in combination, either in sequence or in parallel. The type of strategy applicable to each waterbody is primarily dependent on the characteristics of the waterbody, e.g., concrete-lined or natural, because these characteristics will likely determine the applicable recreational uses and associated water quality requirements. The following sections further develop the key components of each strategy.

5.1.1 Use Attainability Analyses

All waterbodies in the MSAR Watershed are presumptively classified as REC-1 protected waterbodies unless the Regional Board and EPA approve a UAA, which justifies removal of this use. As described in Section 4, the outcome of a UAA could be removal of REC-1 use or both REC-1 and REC-2 uses. Removal of either of these uses would substantially change the basis for compliance for protection of recreational uses. These changes could greatly reduce the number of locations where

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[13] The Regional Board approved USEP identified potential strategies for evaluating urban sources of bacteria in the MS4. The presentation in this document applies the USEP presented strategies in a more detailed manner, i.e., specific to each subwatershed.

implementation of water quality control activities, e.g., at specific MS4 outfalls, would be necessary for achieving compliance. The SWQSTF is currently developing UAAs for the following waterbodies:

- *Cucamonga Creek* - Hellman Avenue upstream to approximately 750 feet downstream of the confluence of Lower Deer Creek

- *Temescal Creek* – From approximately 100 feet downstream of Cota Street (33°53’29.904”N, 117°34’12.432”) upstream to the Arlington Drain confluence.

- *Temescal Creek* - From the confluence with Arlington Drain (33° 52' 51.204"N, 117° 33' 15.732"W) upstream to approximately 1,400 feet upstream of Magnolia Avenue (33° 52' 1.992"N, 117° 31' 30.108"W).

These UAAs provide a template for all future UAA development in the watershed, which will minimize the need for future camera surveys. As noted in Section 4, camera surveys have been completed in a variety of different types of waterbodies. The existing large dataset provides a basis for predicting recreational use activity in other waterbodies based on similarities in waterbody characteristics. Camera surveys would only be needed in areas where some controversy regarding recreational use activity is expected, e.g. in areas where a channel is within a residential area or near a school and access to the channel is not restricted.

5.1.2 Survey Activities

Within subwatersheds it may be necessary to conduct channel surveys and additional source tracking activities to narrow down where urban sources of bacterial indicators are greatest. Such efforts are intended to provide a means to further prioritize implementation of potential control efforts within the subwatershed. For example, channel surveys may be conducted to better define problem areas prior to implementation of a more costly strategy, e.g., mitigation of a dry weather discharge from outfalls or implementation of a regional treatment solution. Examples of investigative tools include:

- Conduct additional bacterial indicator sampling at selected locations, e.g., above/below outfalls, tributary confluences to better define where elevated bacterial indicator concentrations occur.

- Conduct additional source tracking studies in tributaries or outfalls to better define the source of urban bacterial indicators.

- Determine flow loading from upstream tributaries to evaluate potential for these sources to contribute significant numbers of bacteria.

- Conduct preliminary source reconnaissance to identify locations of:

  - Direct human sources (e.g., leaking sewers or septic systems, homeless camps, diapers, illicit dumping), or presence of treated effluent from a POTW.

- Domesticated animals associated with urban land use, especially areas where domesticated animals are concentrated.

- Wildlife (e.g., birds, rodents, squirrels, rabbits, feral cats and dogs) – identify areas where wildlife are known to congregate, for example, wetland areas.

In addition to channel survey activities it may be appropriate in some instances to implement enhanced tracking methods that can provide additional insight regarding potential bacterial indicator sources. Examples of these activities include:

- Evaluate relative contribution of bacterial indicators by each flow source – Relating bacterial indicator concentrations to flow sources can help narrow down which tributaries or drains contribute the most bacteria to the waterbody. The first step in this assessment is to identify presence or absence of dry weather runoff.

- Human tracer compounds (analgesics, hormones, caffeine, antibiotics, etc.) – This method uses indicators other than bacteria to identify or confirm the presence of human sewage.

5.1.3 Controllability Assessments

In many instances, it may necessary to implement a controllability assessment to identify the best approach for mitigating dry weather sources of bacteria discharged from the MS4. Options may range from outfall-specific controls to regional treatment solutions. Where bacterial indicator sources are present as urban sources, the final step in the investigative process is to determine the controllability of the source. Controllability is largely dependent on the nature of the source, with urban sources likely to be more controllable than non-urban sources, e.g., wildlife. In some instances, it may not be feasible to control the source. For example, where birds are the primary bacteria source, elimination of birds may be difficult. The controllability assessment will consider three alternatives:

- *Prevention (or source control)* – Examples include repair of all sewer leaks, better control of domestic animals, moving homeless camps, stronger enforcement of illicit dumping, etc.

- *Low Flow Diversion* – Construction of diversions to intercept dry weather flows and send the water to a regional treatment facility may be feasible at some outfalls.

- *On-Site or Regional Treatment* – The use of on-site treatment facilities, e.g., bioretention (watersheds <20 acres) and subsurface flow wetlands (watersheds <1,000 acres), is largely dependent on drainage area, facility sizing criteria and land availability. The practicability of these systems will have to be considered on a site-specific and subwatershed specific basis. In many cases, implementation of a regional treatment solution requires successful completion of a UAA for upstream waters.

5.1.4 No Direct Action

In some cases, it may be determined that the best course of action within a waterbody or segment of a waterbody is no direct action by the MS4. Direct means activities such as UAAs, additional surveys/source tracking, or structural BMP implementation are not deemed necessary at this time. This approach would most likely apply in the following situations:

- Waterbody segments which do not receive any discharge from the MS4.
- Results of surveys that indicate that the source is not from MS4 discharges but other sources, e.g., agricultural activity, permitted facilities in violation of permit conditions, unpermitted facilities (where issuance of a permit would result in source mitigation), or homeless encampments that may difficult to mitigate.
- Waterbody segments below practical points for achieving compliance. For example, in several waterbodies that discharge to the MSAR, the segment immediately upstream of the confluence remains mostly natural but for only a short distance upstream of the confluence. From a practicality standpoint, bacteria mitigation activities should occur prior to flows reaching this short natural segment.

In addition, to the above example situations, implementation of this strategy includes reliance on existing non-structural programs and potential implementation of new non-structural programs. Opportunities for implementation of modified or new non-structural programs are briefly described in Section 5.3

5.2 Control Strategy for the MSAR Watershed

Given the compliance strategies described above, a strategy was developed for the MSAR Watershed. This strategy takes into account the findings from other sections, in particular the results of three years of data collection (Section 2) and the prioritization analysis described in Section 4. These data and analyses indicate that the highest priority areas for action are the Chino Creek and Mill-Cucamonga watersheds within the larger MSAR watershed. Lower priority areas are the watersheds associated with the other watershed-wide compliance locations (Santa Ana River at MWD Crossing, Santa Ana River at Pedley Avenue, and Prado Park Lake) and areas that do not drain to any of the five compliance sites, e.g., Temescal Creek.

The following sections provide a brief description of the overall strategy for each of the areas that drain to a watershed-wide compliance location. Associated tables provide waterbody-specific strategies and their priority for implementation within the area. Discussions regarding schedule are provided in Section 5.4.

5.2.1 Chino Creek

The need for TMDL implementation activities is greatest in this watershed and the Mill-Cucamonga Creek watershed. The area encompassed by the Chino Creek watershed-wide compliance site is 90 mi^2 square miles. Chino Creek may be divided into three reaches based on channel characteristics. A portion of this reach was previously characterized for the SWQSTF (Phase 1 Report). In addition to the mainstem Chino Creek which can be subdivided into three segments based on channel characteristics, key tributaries include:

- *San Antonio Channel* – This channel drains a 61 mi^2 subwatershed. It may be divided into two segments – above and below the San Antonio Dam. The urban source monitoring program site on this waterbody indicated relatively high bacterial indicator concentrations as well as occasional indications of the presence of human source bacteria. Accordingly, this subwatershed was given a relatively high BPS score.

- *Carbon Canyon* – drains a relatively small subwatershed (~ 6 mi^2) and discharges to the concrete-lined segment of Chino Creek. Carbon Canyon may be divided into three segments based on channel characteristics. The lower segment includes the English Canyon tributary. Results from the urban source monitoring program showed relatively low bacteria concentrations in water draining to Chino Creek. A survey of this subwatershed was recently completed and showed that the lower segment of this waterbody includes a series of regularly spaced grade control structures, which were designed to reduce flow velocities during wet weather. These structures have caused sedimentation in the channel resulting in ponded water during dry weather and vegetative growth.

- *Cypress Channel* – approximately 8 mi^2 subwatershed that drains to Chino Creek in the Prado Basin area. The subwatershed includes portions of the Cities of Ontario and Chino and the State of California Institute for Men (CIM). A recently completed survey of this reach showed that it is a concrete lined trapezoidal channel from its headwaters to El Prado Golf Course, except for a short (<0.5 mile) unlined segment within the CIM property. The downstream segment of Cypress Creek consists of a small ditch, which flows through the golf course into the Prado Basin. Results from the urban source monitoring program showed relatively high bacteria concentrations in this waterbody, which caused it to receive a high BPS score.

Table 5-1 defines the key waterbodies draining to the Chino Creek watershed-wide compliance site and the prioritized control strategy recommended for each key waterbody segment. Highest priority activities include:

- Completion of UAAs for San Antonio Channel and a portion of Chino Creek;

- Additional study of potential sources of bacterial indicator concentrations in Chino Creek above Central Avenue; and

- Development of controllability assessment for select outfalls or flows reaching the Chino Creek compliance site.

Table 5-1. Control strategy applicable to the watershed draining to Chino Creek watershed-wide compliance site

Subwatershed	Segments	Description	Strategy
Cypress Channel	Headwaters to El Prado Golf Course	5.2 mi concrete-lined channel for entire length, except for 0.5 mi reach on CIM prison property which has an earthen channel	(1) Prepare UAA for concrete-lined portion; (2) Verify human sources continue to be present (as was identified in 2007 - 2008) (a) If human sources still consistently present, implement source control study to identify potential source(s) and mitigate where possible; (1) Conduct monitoring to evaluate Fecal Indicator Bacteria (FIB) concentrations and potential to cause exceedance in Prado Basin; (2) If FIB concentrations expected to contribute to exceedance in Prado Basin, conduct survey to determine if sources of high FIB can be identified and mitigated: (a) If FIB sources are not identified or mitigated, conduct controllability assessment; implement findings as appropriate.
	El Prado Golf Course to Prado Basin	1.2 mi earth lined ditch through El Prado Golf Course	Rely on control of pathogen indicators upstream of this reach
San Antonio Channel	Headwaters to San Antonio Dam	Discharge from headwater area captured by San Antonio Dam	No dry weather flows in area as a result of MS4; no activities required
	Below San Antonio Dam to Chino Creek confluence	9.7 mi concrete-lined reach	(1) Prepare UAA for segment (in conjunction with concrete-lined Chino Cr segment – see above) (2) Conduct monitoring in conjunction with monitoring in concrete-lined Chino Cr. segment to evaluate contribution of FIB from San Antonio Channel to downstream waters. (3) If San Antonio Channel is a significant FIB source, then conduct survey to determine if sources of high FIB can be identified and mitigated: (a) If sources of FIB cannot be identified or mitigated, consider controllability assessment in conjunction with work on concrete-lined Chino Creek segment (see above)
Chino Creek	Headwaters to Hwy 71/Hwy 60 Interchange	2.4 mi underground drainage	No activity in portion that is upstream of MS4 outfalls;
	Hwy 71/Hwy 60 Interchange to Central Avenue	5.6 mi concrete-lined trapezoidal reach; includes San Antonio Channel confluence	Note: Previous SWQSTF work will support UAA (i.e., Phase I, e.g., flow and water quality) (1) Prepare UAA for concrete-lined portion (in conjunction with concrete-lined San Antonio Channel segment – see below) (2) Conduct monitoring to evaluate FIB concentrations and potential to cause exceedance in Chino Cr below Central Avenue; (3) If FIB concentrations expected to contribute to exceedance in downstream segment, conduct survey to determine if sources of high FIB can be identified and mitigated: (a) If FIB sources are not identified or mitigated, conduct controllability assessment; implement findings as appropriate.

Table 5-1. Control strategy applicable to the watershed draining to Chino Creek watershed-wide compliance site

Subwatershed	Segments	Description	Strategy
Chino Creek (ctd)	Central Ave. to Prado Basin	6.5 mi trapezoidal earthen bottom channel	(1) Conduct monitoring of dry weather outfall discharges (if any) and instream flow to evaluate contribution of MS4 to FIB exceedances in the reach. (2) If outfalls contributing to exceedance, then conduct controllability assessment for each outfall; implement findings as appropriate.
Carbon Canyon Cr. (incl. English Canyon)	All segments	Varies from natural, to vertical concrete to trapezoidal with flow control structures	(1) Prior to work in any segment, conduct monitoring to determine if low FIB concentrations typically observed during 2007-2008 in lower segment still exist: (a) If low FIB concentrations exist in all Carbon Canyon segments, then consider no action in this subwatershed at this time or make any activity in this subwatershed the lowest priority in the MSAR watershed (b) If low FIB concentrations exist only in the lower segment (as previously observed), then proceed with additional activities as described below for each segment (2) If finding (1)(b) observed, then consider implementing special research study to evaluate why FIB concentrations decline in lower reach, e.g., determine if the flow control structures play a role in mitigating FIB concentrations
Carbon Canyon Cr. (incl. English Canyon)	Upper - Headwaters to Chino Hills Parkway	0.9 mi reach with natural characteristics	Implementation based on outcome of monitoring survey conducted for all segments (see above) and a finding that low FIB concentrations occur only in the lower segment. (1) Only two MS4 outfalls identified in this reach. No activity in portion that is upstream of the MS4 outfalls; (2) Conduct monitoring of dry weather outfall discharge (if any) and instream flow to evaluate contribution of MS4 to FIB exceedances in the reach. (a) If outfalls contributing to exceedance, then conduct controllability assessment for each outfall; implement findings as appropriate.
	Middle - Chino Hills Parkway to ~1000 ft upstream of English Canyon confluence	0.8 mi vertical concrete-lined reach	Implementation based on outcome of monitoring survey conducted for all segments (see above) and a finding that low FIB concentrations occur only in the lower segment. (1) Prepare UAA for concrete-lined portion; (2) Conduct monitoring to evaluate FIB concentrations and potential to cause exceedance in downstream segment; (3) If FIB concentrations expected to contribute to exceedance in downstream segment, conduct survey to determine if sources of high FIB can be identified and mitigated: (a) If sources of high FIB cannot be identified or mitigated, consider controllability assessment; implement findings of controllability assessment, as needed
	Lower - ~1000 ft upstream of English Canyon confluence to confluence with Chino Creek	0.9 mi trapezoidal channel with concreted rock bottom and grade control structures	If FIB concentrations remain low in this segment, then no activity planned at this time. If FIB concentrations are elevated, then following activities will occur: (1) Conduct monitoring survey (including lower portion of English Canyon) to identify potential sources that contribute to elevated FIB concentrations and determine if they can be mitigated: (a) If FIB sources are not identified or mitigated, consider controllability assessment; implement findings of controllability assessment, as needed

In addition, study is warranted in the Carbon Canyon Creek subwatershed to evaluate how pathogen indicators vary from upstream to downstream and determine if the structure of the lower reach of Carbon Canyon (with rock gabions to mitigate flow velocity) are providing instream treatment. This activity is currently given a low priority in the context of achieving compliance at the Chino Creek compliance site. However, an evaluation of how bacteria concentrations vary in Carbon Canyon Creek and whether the rock gabion structure in lower Carbon Canyon is providing water quality benefits could be very useful if the channel structure in this section can be implemented in other waterbodies. As a consequence, consideration should be given to elevating the priority for this activity.

The lower portion of Chino Creek below Central Avenue is given a low priority because of the emphasis on achieving compliance at the Chino Creek watershed-wide compliance site first. However, two known outfalls in this reach (outfalls located on Fairfield Ranch Road near the Big League Dream Sports Park) should be evaluated during implementation to determine if mitigation activities are necessary.

5.2.2 Mill-Cucamonga Creek

The need for TMDL implementation activities is greatest in this watershed and the Chino Creek watershed. The area encompassed by the Mill-Cucamonga Creek watershed-wide compliance site is 70 mi^2. Flows in this waterbody are greatly influenced by discharges from the Chino Creek RP1 facility, which discharges effluent with bacterial indicator concentrations below 2.2 CFU/100 ml. Effluent from RP1 is discharged to Cucamonga Creek just south of the Highway 60 overpass, between the Lower Deer Creek (Chris Basin) and County Line Channel tributaries. In addition to the mainstem Cucamonga Creek which can be subdivided into four segments based on channel characteristics, key tributaries include:

- *Demens Creek* - This channel drains a 5.7 mi^2 subwatershed. It may be divided into two segments – above and below the detention basins that capture flows from undeveloped canyon areas in the headwaters. No sampling was conducted in this channel under the urban source monitoring program site because of its location upstream of the Chino Creek RP1 facility. It was assumed that any elevated concentrations of bacteria discharged from this subwatershed would be diluted by the RP1 discharge.

- *Upper Deer Creek* - This channel drains a 18 mi^2 subwatershed. It may be divided into two segments – above and below the detention basins that capture flows from undeveloped canyon areas in the headwaters. No sampling was conducted in this channel under the urban source monitoring program site because of its location upstream of the Chino Creek RP1 facility. Similar to Demens Creek, it was assumed that any elevated concentrations of bacteria discharged from this subwatershed would be diluted by the RP1 discharge.

- *Lower Deer Creek* – Creek drains a small subwatershed (~10 mi^2) entirely within the City of Ontario MS4 system. The San Bernardino County Flood Control District owns and operates Chris Basin at the downstream end of Lower Deer Creek just upstream of the Lower Deer Creek's confluence with Cucamonga Creek. As a result of poor infiltration rates within Chris Basin due to soil characteristics, dry weather runoff flows through the basin to Cucamonga Creek. Data from the urban source monitoring program resulted in this subwatershed receiving a high BPS score. A preliminary controllability assessment is under development for this site. At this time, two options for mitigation of dry weather flows have been identified: (1) construction of a subsurface flow wetland within Chris Basin to treat approximately 1 cfs of dry weather runoff; or (2) collaboration with Inland Empire Utilities Agency (IEUA) on a project to capture urban runoff from this part of the Chino basin for routing to other recharge facilities. Additional study regarding these options or others is recommended.

- *County Line Channel* – Concrete lined channel drains a small subwatershed (~6 mi^2). This site received a low BPS rank based as a result of urban source monitoring program sampling. In addition, the sampling program often observed little or no dry weather flow at this site (in 2007-2008), therefore contributions of bacterial indicators to the Cucamonga Creek is likely minor compared to other potential sources.

Table 5-2 defines the key waterbodies draining to the Mill-Cucamonga Creek watershed-wide compliance site and the control strategy recommended for each key waterbody segment. Also provided is the recommended priority for action within the Chino Creek watershed. Highest priority activities include:

- Completion of UAAs for portions of Cucamonga Creek and Lower Deer Creeks; a UAA for the portion of Cucamonga Creek from Hellman Avenue upstream to near the Lower Deer Creek confluence is already in preparation by the SWQSTF.

- Additional study of potential sources of bacterial indicator concentrations in Cucamonga Creek above the Mill-Cucamonga Creek compliance site. This activity is particularly important given the contribution of treated effluent to this reach. FIB concentrations would be expected to be low because of the high volume of treated effluent; however, they are not;

- Implementation of recommendations from preliminary controllability assessment for Lower Deer Creek Basin.

5.2.3 Santa Ana River at MWD Crossing

TMDL implementation activities in this area are a low priority compared to the Chino Creek and Mill-Cucamonga Creek areas of the MSAR watershed. This area (101 mi^2 in Reach 3 watershed) encompasses the upper portion of the MSAR watershed and receives flows from Santa Ana River Reach 4 (typically only during wet weather). Potential sources of elevated bacterial indicators include:

Table 5-2. Control strategy applicable to the watershed draining to Mill-Cucamonga Creek watershed-wide compliance site

Subwatershed	Segments	Description	Strategy
Cucamonga Creek	Headwaters to Cucamonga Canyon Dam	Discharge from undeveloped canyon headwater area captured by Cucamonga Canyon Dam	No dry weather flows in area as a result of MS4; no activities required
	Below Cucamonga Canyon Dam to Hellman Avenue	14 mi concrete-lined reach; includes discharge from RP1 WWTP	(1) Prepare UAA for concrete-lined channel (a portion of this segment already has a UAA in preparation by SWQSTF) (2) Conduct monitoring at strategic locations (e.g., above and below RP1 discharge and each tributary) to identify elevated FIB concentrations (if any) that may contribute to an exceedance at the downstream TMDL compliance location). This is particularly important because of the contribution of treated effluent in this segment. FIB concentrations would be expected to be low, but they are not.
	Hellman Ave. to Chino-Corona Rd	0.25 mi concrete-lined trapezoidal reach	(1) Prepare UAA for concrete-lined channel (2) Conduct monitoring to evaluate FIB concentrations and survey reach to identify potential FIB sources (other than from upstream) that may contribute to exceedance at downstream water quality compliance site. Similar to the previous segment, this is particularly important because of the contribution of treated effluent in this segment. FIB concentrations would be expected to be low, but they are not: (a) If FIB sources are not identified or mitigated, conduct controllability assessment; implement findings of controllability assessment, as needed
	Chino-Corona Rd to Prado Basin	3.4 mi earthen bottom trapezoidal reach	No activity planned for this reach as the focus on other subwatershed activities is to achieve compliance at the upstream Cucamonga Cr water quality compliance site (see previous segment). It is presumed that if compliance is achieved at that site, then compliance in this reach is likely as well. Follow-up monitoring could be conducted to verify this assumption after compliance is achieved at the Cucamonga Cr. Compliance location.
Upper Deer Creek	Headwaters to Detention Basin	Discharge from undeveloped canyon headwater area captured by detention basin	No dry weather flows in area as a result of MS4; no activities required
	Below Detention Basin to Cucamonga Cr. confluence	3.6 mi concrete-lined reach	(1) Prepare UAA for concrete-lined portion; (2) Conduct monitoring to evaluate FIB concentrations and potential to cause exceedance in Cucamonga Cr.; (3) If FIB concentrations expected to contribute to exceedance in Cucamonga Cr, conduct survey to determine if sources of high FIB can be identified and mitigated: (a) If sources of high FIB cannot be identified or mitigated, consider controllability assessment; implement findings of controllability assessment, as needed

Table 5-2. Control strategy applicable to the watershed draining to Mill-Cucamonga Creek watershed-wide compliance site

Subwatershed	Segments	Description	Strategy
Demens Creek	Headwaters to Detention Basin	Discharge from undeveloped canyon headwater area captured by detention basin	No dry weather flows in area as a result of MS4; no activities required
	Below Detention Basin to Cucamonga Cr. confluence	2.2 mi concrete-lined reach	(1) Prepare UAA for concrete-lined portion; (2) Conduct monitoring to evaluate FIB concentrations and potential to cause exceedance in Cucamonga Cr.; (3) If FIB concentrations expected to contribute to exceedance in Cucamonga Cr, conduct survey to determine if sources of high FIB can be identified and mitigated: (a) If sources of high FIB cannot be identified or mitigated, consider controllability assessment; implement findings of controllability assessment, as needed.
Lower Deer Creek (Chris Basin)	Headwaters to Chris Basin at Cucamonga Cr. confluence	2.1 mi concrete-lined reach	(1) Prepare UAA for concrete-lined portion; (2) Verify human sources continue to be present (as was identified in 2007 - 2008) (b) If human sources still consistently present, implement source control study to identify potential source(s) and mitigate where possible; (3) Conduct monitoring to evaluate FIB concentrations and potential to cause exceedance in Cucamonga Cr.; (4) If FIB concentrations expected to contribute to exceedance in Cucamonga Cr, conduct survey to determine if sources of high FIB can be identified and mitigated: (a) If sources of high FIB cannot be identified or mitigated, consider controllability assessment; implement findings of controllability assessment, as needed
County Line Channel	Headwaters to Cucamonga Cr. confluence	2.6 mi concrete-lined reach	(1) Prepare UAA for concrete-lined portion; (2) Conduct monitoring to evaluate FIB concentrations and dry weather flows and potential to cause exceedance in Cucamonga Cr.; (3) If FIB concentrations expected to contribute to exceedance in Cucamonga Cr, conduct survey to determine if sources of high FIB can be identified and mitigated: (a) If sources of high FIB cannot be identified or mitigated, consider controllability assessment; implement findings of controllability assessment, as needed

- *Box Springs* - This subwatershed drains approximately a 31 mi^2 area. It may be divided into two segments – an upstream engineered segment and a short natural segment at the MSAR confluence. This subwatershed received the highest BPS rank because of both high bacteria concentrations and frequent human source signals. Follow-up studies identified a cross-connected sewer line, which has been mitigated. As a result, the priority for TMDL implementation activities in this subwatershed has been lowered.

- *Sunnyslope Channel* - This channel drains an approximately 6 mi^2 area in unincorporated areas of Riverside County. It may be divided into two segments – an upstream engineered segment and a short natural segment at the MSAR confluence. The site received a low BPS ranking. During several field visits over the course of the urban source monitoring program, dry weather flows in Sunnyslope Channel were not hydrologically connected to the Santa Ana River. Just upstream of the confluence, flow seeps into a large sand bar within the Santa Ana River floodplain.

- *MS4 Outfalls Along Santa Ana River* – A number of MS4 outfalls occur along the Santa Ana River in this area. To date, no data have been collected from these outfalls to determine if dry weather flows have the potential to impact water quality in this reach of the river.

Table 5-3 defines the key waterbodies in this area of the MSAR watershed and the control strategy recommended for each identified waterbody segment. Also provided is the recommended priority for action within the watershed. Highest priority activities include;

- Completion of UAA for concrete-lined portion of Box Springs; and

- Additional survey activities in Box Springs to verify that human source bacteria are no longer present in dry weather flows.

5.2.4 Santa Ana River at Pedley Avenue

TMDL implementation activities in this area are a low priority compared to the Chino Creek and Mill-Cucamonga Creek areas of the MSAR watershed. This area (126 mi^2 not including watershed upstream of MWD crossing) generally encompasses the portion of the MSAR watershed upstream of Prado Basin and receives flows from the portion of the MSAR watershed represented by the Santa Ana River at MWD Crossing watershed-wide compliance site. Potential sources of elevated bacterial indicators include:

Table 5-3. Control strategy applicable to the watershed draining to Santa Ana River @ MWD Crossing watershed-wide compliance site

Subwatershed	Segments	Description	Strategy
Box Springs	Headwaters to confluence with MSAR	0.2 mi vertical, concrete-lined channel for entire length except last 0.5 mi prior to confluence with MSAR	(1) Prepare UAA for concrete-lined portion; (2) Verify human source bacteria controlled by previous activities; (a) If human sources still consistently present, implement source control study to identify outfall source; (3) Conduct monitoring to evaluate FIB concentrations and potential to cause exceedance in MSAR; (a) If FIB concentrations are expected to contribute to MSAR exceedance, then conduct controllability assessment; implement findings of controllability assessment, as needed.
Sunnyslope Channel	Headwaters to point where segment transitions from concrete-lined to natural (Rancho Jurupa Park)	3.0 mi reach that is trapezoidal concrete-lined banks	(1) Prepare UAA for concrete-lined portion; (2) Conduct monitoring to evaluate FIB concentrations discharged to downstream natural segment; (3) If FIB concentrations expected to contribute to exceedance in downstream natural segment, conduct survey to determine if sources of high FIB can be identified and mitigated: (a) If sources of high FIB cannot be identified, conduct controllability assessment; implement findings of controllability assessment, as needed.
	Upstream end of natural section (Rancho Jurupa Park) to MSAR confluence	0.4 mi reach with natural banks and bottom; in 2007, section not hydrologically connected to MSAR during dry weather	(1) Verify reach is not hydrologically connected to MSAR during dry weather. If no connection, then no additional action required at this time. (2) If site is hydrologically connected, conduct survey to determine if sources of high FIB can be identified and mitigated: (a) If sources of high FIB cannot be identified, conduct controllability assessment; implement findings of controllability assessment
Outfalls with Direct Discharge to MSAR	N/A	Desktop GIS indicates presence of a number of outfalls with potential directly discharge to MSAR	(1) Conduct survey of channel to evaluate dry weather flow contributions from MS4 (2) Conduct monitoring of dry weather discharges (if any) and instream flow to evaluate contribution of MS4 to FIB exceedances in the reach. (a) For outfalls contributing to exceedance, then conduct surveys to identify potential bacteria sources; mitigate to the extent practicable (b) As needed, conduct controllability assessment for each outfall; implement findings of controllability assessments.

- *Anza Drain* - This subwatershed encompasses an approximately 21 mi^2 area. It may be divided into two segments – an upstream engineered segment and a short natural segment at the MSAR confluence. The natural segment at the confluence receives effluent from the Riverside Wastewater Quality Control Plant (RWQCP) prior to discharging to the MSAR. Surveys conducted by the RWQCP facility and SWQSTF have noted that recreational activity is fairly common in the area.

- *San Sevaine Channel* - This subwatershed drains a relatively large area encompassing approximately 51 mi^2. It may be divided into two segments – a headwaters area that discharges to the San Sevaine Basins upstream of the MS4 and a lengthy engineered segment. This subwatershed received a low BPS ranking as a result of data collected by the urban source monitoring program.

- *Day Creek* – The Day Creek subwatershed encompasses an approximately 51 mi^2 area. It has one major tributary (Etiwanda Channel). The mainstem of Day Creek may be divided into four segments with varying characteristics and the Etiwanda tributary may be divided into two segments, a portion that is upstream of the MS4 and an engineered downstream segment. Data from the urban source monitoring program resulted in a relatively low BPS rank for this subwatershed overall, but a higher BPS ranking than Anza Drain or San Sevaine Channel.

- *MS4 Outfalls Along Santa Ana River* – A number of MS4 outfalls occur along the Santa Ana River in this area. To date, no data have been collected from these outfalls to determine if dry weather flows have the potential to impact water quality in this reach of the river.

Table 5-4 defines the key waterbodies in this area of the MSAR watershed and the control strategy recommended for each identified waterbody segment. Also provided is the recommended priority for action within the watershed. Highest priority activities include completion of UAA for two segments of Day Creek (Note: a UAA for the concrete-lined portion of Etiwanda Channel is given a medium priority; however, this UAA could be completed in conjunction with a portion of Day Creek).

5.2.5 Other Watershed Areas

The above discussion describes the areas of the MSAR watershed that drain to four of the five watershed-wide compliance sites. In addition, these areas, TMDL implementation activities need to be considered for the following:

- *Temescal Creek Watershed* – This subwatershed drains to Prado Basin from an area covering approximately 207 mi^2. This area excludes the portion of the Temescal Creek subwatershed upstream of Lake Elsinore. Discharges from Lake Elsinore do not typically occur during dry weather. Downstream of Lake Elsinore, Temescal Creek can be subdivided into three segments based on channel characteristics. The SWQSTF is currently preparing a UAA for the engineered segment.

Table 5-4. Control strategy applicable to the watershed draining to Santa Ana River @ Pedley Avenue watershed-wide compliance site

Subwatershed	Segments	Description	Strategy
Anza Drain	Headwaters to Arlington Avenue	Vertical-walled, concrete-lined channel	(1) Prepare UAA for concrete-lined portion; (2) Conduct monitoring to evaluate FIB concentrations and potential to cause exceedance in lower portion of Anza Drain and MSAR; (3) If FIB concentrations expected to contribute to exceedance in downstream natural segment, conduct survey to determine if sources of high FIB can be identified and mitigated: (a) If sources of high FIB cannot be identified or mitigated, conduct controllability assessment; implement findings of controllability assessment, as needed
	Arlington Avenue to MSAR confluence	Channel with natural characteristics	Rely on control of pathogen indicators upstream of this reach
San Sevaine Channel	Headwaters to San Sevaine Basins	Discharge from headwater area captured by San Sevaine Basins	No dry weather flows in area as a result of MS4; no activities required
	San Sevaine Basins to MSAR confluence	11 mi concrete-lined reach from San Sevaine Basins to MSAR confluence	(1) Prepare UAA for concrete-lined portion; (2) Conduct monitoring to evaluate FIB concentrations and potential to cause exceedance in MSAR; (3) If FIB concentrations expected to contribute to exceedance in downstream natural segment, conduct survey to determine if sources of high FIB can be identified and mitigated: (a) If sources of high FIB cannot be identified or mitigated, conduct controllability assessment; implement findings of controllability assessment, as needed
Day Creek	Headwaters to Day Creek Basins	Discharge from undeveloped areas captured by Day Creek Basins	No dry weather flows in area as a result of MS4; no activities required
	Day Creek Basins to Limonite Avenue	11 mi concrete-lined reach	(1) Prepare UAA for concrete-lined portion (in conjunction with concrete-lined Etiwanda Channel segment – see below) (2) Conduct monitoring to evaluate FIB concentrations and potential to cause exceedance in MSAR; (3) If FIB concentrations expected to contribute to exceedance in downstream natural segment, conduct survey to determine if sources of high FIB can be identified and mitigated: (a) If sources of high FIB cannot be identified or mitigated, conduct controllability assessment; implement findings of controllability assessment, as needed

Table 5-4. Control strategy applicable to the watershed draining to Santa Ana River @ Pedley Avenue watershed-wide compliance site

Subwatershed	Segments	Description	Strategy
Day Creek (ctd)	Limonite Avenue to Lucretia Avenue	0.6 mi earthen bottom trapezoidal channel	(1) Prepare UAA for concrete-lined portion; (2) Conduct monitoring to evaluate FIB concentrations and potential to cause exceedance in MSAR; (3) If FIB concentrations expected to contribute to exceedance in MSAR, conduct survey to determine if sources of high FIB can be identified and mitigated: (a) If sources of high FIB cannot be identified or mitigated, conduct controllability assessment; implement findings of controllability assessment, as needed
	Lucretia Avenue to MSAR confluence	Natural characteristics	Rely on control of pathogen indicators upstream of this reach
Etiwanda Channel	Headwaters to concrete-lined segment	Discharge from undeveloped areas captured in detention basins	No dry weather flows in area as a result of MS4; no activities required
	Beginning of concrete-lined segment to Day Creek Confluence	8.5 mi concrete-lined for entire length except for short segment between Foothill Boulevard and the Etiwanda Conservation Basins on either side of I-10 Fwy	(1) Prepare UAA for concrete-lined portion (in conjunction with concrete-lined Day Creek segment – see above) (2) Conduct monitoring in conjunction with monitoring in concrete-lined Day Cr. Segment to evaluate contribution of FIB from Etiwanda Channel to downstream waters. (3) If Etiwanda Creek is a significant FIB source, then conduct survey to determined if sources of high FIB can be identified and mitigated: (a) If sources of FIB cannot be identified or mitigated, consider controllability assessment in conjunction with work on concrete-lined Day Creek segment (see above)
Outfalls with Direct Discharge to MSAR	N/A	Desktop GIS indicates presence of a number of outfalls with potential directly discharge to MSAR	(1) Conduct survey of channel to evaluate dry weather flow contributions from MS4 (2) Conduct monitoring of dry weather discharges (if any) and instream flow to evaluate contribution of MS4 to FIB exceedances in the reach. (a) For outfalls contributing to exceedance, then conduct surveys to identify potential bacteria sources; mitigate to the extent practicable (b) As needed, conduct controllability assessment for each outfall; implement findings of controllability assessments.

This subwatershed was given a very low BPS ranking based on the results from the urban source monitoring program. Accordingly, TMDL implementation activities are a low priority as compared to the Chino Creek and Mill-Cucamonga Creek watersheds.

- *Prado Park Lake Watershed* – Prado Park Lake has its own watershed-wide compliance site located at the outfall from the lake to Prado Basin. The watershed encompassing this lake is very small. The source of water to the lake is highly treated effluent from IEUA's RWRP-1 and RWRP-4 plants; dry weather flows into the lake do not occur. This compliance site often meets the water quality objectives during dry weather; accordingly, additional TMDL implementation activities are a low priority for this watershed.

Table 5-5 defines the key waterbodies in this area of the MSAR watershed and the control strategy recommended for each identified segment. The priority for action in these waters is low compared to other areas of the MSAR watershed. Temescal Creek does not drain to any of the compliance sites and Prado Park Lake is already often in compliance with REC-1 objectives and the TMDL WLAs (see Section 2).

5.3 Non-Structural BMP Implementation

Each of the jurisdictions covered by the Riverside County and San Bernardino County MS4 permits implements non-structural BMP programs to reduce pollutants in urban runoff. Existing BMP programs will undergo evaluation to determine if any modifications are needed to better target bacteria. In addition, in the short term new BMPs will be implemented as required by permit or it is determined substantive benefits may be achieved. For example, implementation of water conservation ordinances can result in significant reductions of dry weather flows in urban storm drains. The extent to which existing BMP programs will be modified and new BMPs (including ordinances) implemented to support compliance with TMDL WLAs will occur in the near term as part of MS4 permit implementation.

5.4 Summary of TMDL Implementation Activities

TMDL implementation in the MSAR watershed involves a number of different subwatershed-specific strategies with varying priorities (e.g., see Tables 5-1 to 5-5). A key strategy common throughout the watershed is the development of UAAs to establish appropriate recreational uses. Table 5-6 summarizes the number of waterbody miles where UAAs are anticipated. Figure 5-1 illustrates the portions of each subwatershed where these UAAs would apply. Completion of these UAAs will greatly reduce the area of the MS4 where dry weather mitigation activities are necessary.

In addition, to the completion of UAAs, surveys and controllability assessments are anticipated in a number of areas. Many of these studies are associated with the lower end of segments where UAAs are completed. Where opportunities exist, regional treatment solutions will be considered.

Table 5-5. Bacterial indicator control strategy applicable to other waters in the MSAR watershed

Subwatershed	Segments	Description	Strategy
Prado Park Lake	N/A	During dry weather lake water level maintained by treated effluent	(1) Verify there are no dry weather flows into the lake other than treated effluent (2) Conduct source tracking activities to evaluate presence of human, dog or bovine sources (3) Evaluate potential for discharge from outfall to contribute FIB to Prado Basin waters. (4) Conduct controllability assessment, if needed.
Temescal Creek	Lake Elsinore Spillway to point upstream of Magnolia Ave.	~19 mi reach with natural characteristics; 14 outfalls identified as potential dry weather flow sources	(1) Conduct survey of channel to evaluate dry weather flow contributions from MS4 (2) Conduct monitoring of dry weather discharges (if any) and instream flow to evaluate contribution of MS4 to FIB exceedances in the reach. (a) For outfalls contributing to exceedance, then conduct surveys to identify potential bacteria sources; mitigate to the extent practicable (b) As needed, conduct controllability assessment for each outfall; implement findings of controllability assessments, as needed
	Magnolia Ave. to downstream of Cota Street	~3 mi reach that has trapezoidal and vertical concrete-lined banks	(1) Prepare UAA for concrete-lined portion (Note – UAA currently in preparation by SWQSTF) (2) Conduct monitoring to evaluate FIB concentrations and potential to cause exceedance in downstream reach; (3) If FIB concentrations expected to contribute to exceedance in downstream segment, conduct survey to determine if sources of high FIB can be identified and mitigated: (a) If sources of high FIB cannot be identified or mitigated, conduct controllability assessment; implement findings of controllability assessment, as needed
	Downstream of Cota Street	2.9 mi reach with natural characteristics	Rely on control of pathogen indicators upstream of this reach

Table 5-6. UAA priorities and schedule for completion and adoption by RWQCB

Watershed	MSAR Waterbody	Segment	Priority	No. of Miles	Date (Year End)	Comment
Chino Creek	Chino Creek	Headwaters to Hwy 71/60 Interchange	1	8.0	2011	These UAAs may potentially be combined
		Interchange to Central Ave.	1		2011	
	San Antonio Channel	Below San Antonio Dam to Chino Creek	1	10.4	2011	
	Carbon Canyon	Middle Reach	3	0.9	2014	Low priority because of existing water quality
	Cypress Channel	Headwaters to El Prado Golf Course	2	3.9	2012	Medium priority; site drains to Chino Creek within Prado Basin, below watershed-wide compliance site
Mill-Cucamonga Creek	Cucamonga Creek	Below Dam to Hellman Ave.	1	14.3	2010	UAA in preparation by SWQSTF
		Hellman Ave. to Chino-Corona Rd	2		2012	Complete UAA on portion of Cucamonga Creek not covered by SWQSTF UAA
	Upper Deer Creek	Detention Basin to Cucamonga Creek	3	6.3	2014	Low priority because discharge from creek into Cucamonga Creek mixes with RP1 effluent
	Demens Creek	Detention Basin to Cucamonga Creek	3	2.2	2014	Low priority because discharge from creek into Cucamonga Creek mixes with RP1 effluent
	Lower Deer Creek (Chris Basin)	Headwaters to Cucamonga Creek	1	2.1	2011	High priority based on USEP data and potential need for regional solution
	County Line Channel	Headwaters to Cucamonga Creek	3	2.6	2014	USEP indicated relatively low bacteria and site often dry; likely contributes minimal bacteria
Middle Santa Ana River @ MWD Crossing	Box Springs Channel	Headwaters to MSAR	2	0.2	2013	Medium priority given minimal contribution to MSAR flows
	Sunnyslope Channel	Headwaters to end of concrete-lined section	3	3.0	2014	Low priority because waterbody typically not hydrologically connected to MSAR
Middle Santa Ana River @ Pedley Avenue	Anza Park Drain	Headwaters to Arlington Ave.	2	1.2	2013	Medium priority to support potential regional solution
	San Sevaine Channel	Below San Sevaine Basins to MSAR	2	11.3	2013	Medium priority to support potential regional solution
	Day Creek	Below Basins to Limonite Ave.	2	11.4	2013	May be combined with Etiwanda Channel
		Limonite Ave. to Lucretia Ave.	2		2013	Medium priority to support potential regional solution
	Etiwanda Channel	Below Basins to Day Creek	2	5.2	2013	May be combined with Day Creek Below Basins to Limonite Avenue UAA
Other	Temescal Creek	Upstream of Magnolia Ave. to near Cota St.	1	3.0	2010	Will be completed by SWQSTF

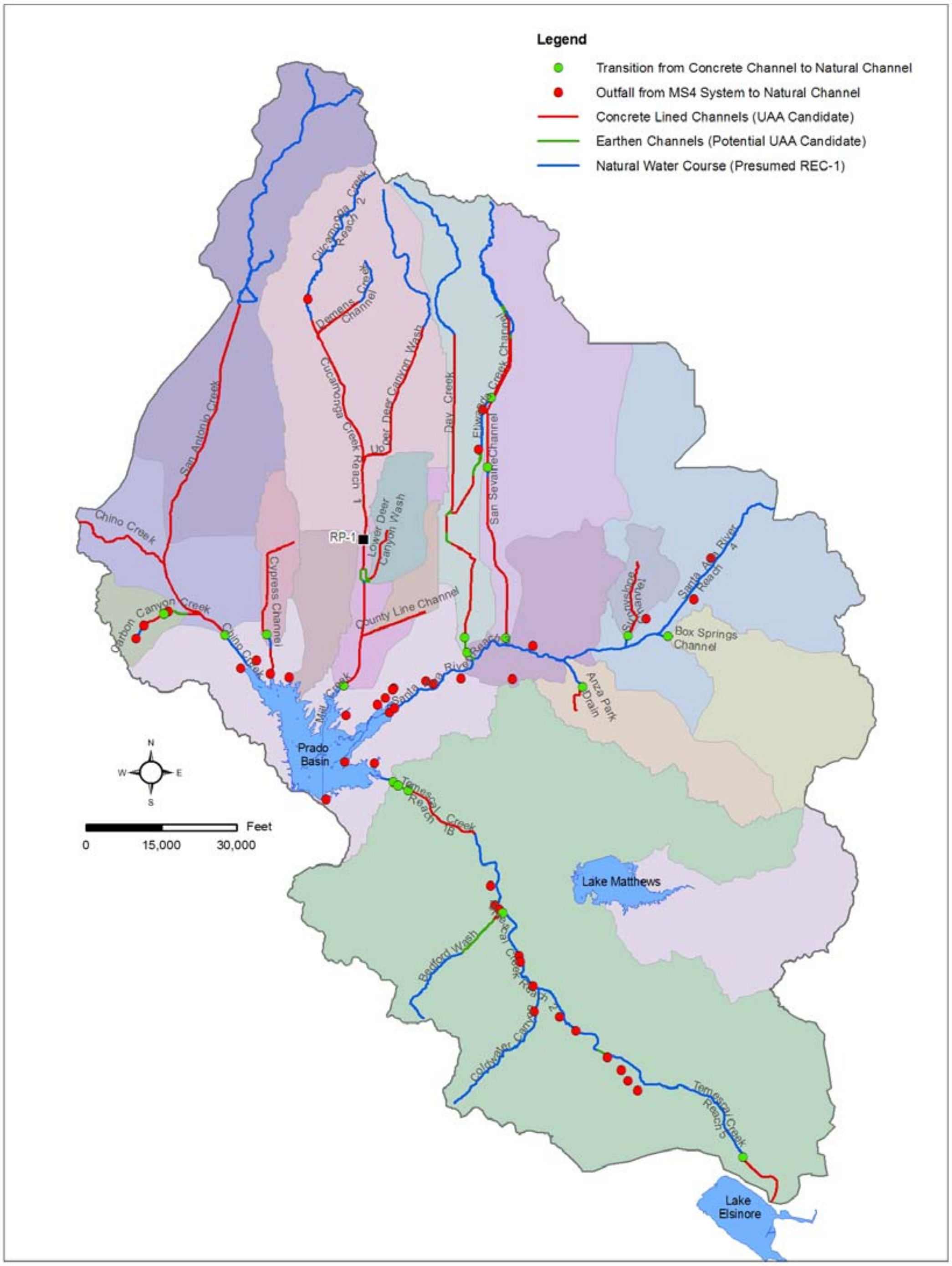

Figure 5-1. Characteristics of key waterbodies in the MSAR watershed including where UAAs are recommended.

Table 5-7 summarizes and prioritizes implementation activities recommended for each waterbody segment based on priority. The basis for UAA priorities and expected completion dates were described above (see Table 5-6). The completion of UAAs is one of the primary keys to success as this will reduce the number of locations where water quality mitigation activities are required.

Survey activities will often be needed prior to conducting a controllability assessment. In many cases, the extent and/or type of mitigation, e.g., regional solution vs. individual outfall controls, will depend on the findings from surveys. Careful, timely implementation of surveys can provide the necessary data to narrow the number of locations where a BMP is necessary. On the other hand, if surveys show that bacteria sources are ubiquitous and not subject to a targeted BMP approach, then regional BMPs can be strategically located below segments where UAAs have been completed.

Table 5-7 includes a recommendation on when a BMP implementation decision is needed in a given waterbody. These are provided as minimum; the earlier a decision can be made, the more quickly BMP implementation can move into design and construction phases. If no date is provided, it is assumed at this time that no BMP implementation will be necessary in the segment, e.g., due to expectations for completion of a downstream UAA.

The specific BMP type planned for any given location has not been determined at this time. However, given the nature of bacteria, the only BMPs that can guarantee compliance are those that capture 100% of the dry weather flow. To achieve this outcome, BMPs would be limited to those that capture and divert dry weather flow to a sanitary sewer or an infiltration basin. In some areas of the watershed, soils provide poor infiltration. Accordingly, capture and diversion to sanitary sewers may be the only certain option.

5.5 Next Steps

The next steps for TMDL implementation are as follows:

- Implement the 2010-2011 activities (see Tables 5-6 and 5-7) as soon as possible given available resources. Where necessary, this effort will need to include the development of sample collection plans which define the minimum data needs to satisfy various elements, e.g., water quality sections of UAAs or making a determination whether a given outfall or waterbody is a significant bacterial indicator source.

- Build on this document to satisfy the MS4 permit requirement to develop a CBRP for dry season flow by December 31, 2010. Elements to develop include refinement of subwatershed strategies, identification of modified or new non-structural BMP programs and potential locations for regional treatment solutions.

Table 5-7. Summary of TMDL implementation activities for key MSAR waterbodies recommended priority

Compliance Site Sub-watershed	Key MSAR Waterbodies	Segment	No Direct Action	UAA Priority			Survey Activity Priority			Controllability Assessment Priority			BMP Implementation Decision
				1	2	3	1	2	3	1	2	3	
Chino Creek	Chino Creek	Headwaters to Hwy 71/60 Interchange	X										
		Interchange to Central Ave.		X			X			X			2012
		Central Ave. to Prado Basin							X			X	2014
	Carbon Canyon Creek	Upper					X					X	
		Middle				X	X					X	
		Lower					X					X	
	San Antonio Creek	Headwaters to San Antonio Dam	X										
		Below San Antonio Dam to Chino Creek		X									
	Cypress Channel	Headwaters to Chino Creek			X		X				X		2013
Mill-Cucamonga Creek	Mill-Cucamonga Creek	Headwaters to Cucamonga Dam	X										
		Below Dam to Hellman Ave.		X[1]	X[2]				X			X	2014
		Hellman Ave. to Chino Corona Rd					X			X			2012
		Chino-Corona Rd to Prado Basin	X										
	Upper Deer Creek	Headwaters to Detention Basin	X										
		Detention Basin to Cucamonga Creek				X			X			X	2014
	Demens Creek	Headwaters to Detention Basin	X										
		Detention Basin to Cucamonga Creek				X			X			X	2014
	Lower Deer Creek (Chris Basin)	Headwaters to Cucamonga Creek		X			X			X			2012
	County Line Channel	Headwaters to Cucamonga Creek				X							

Table 5-7. Summary of TMDL implementation activities for key MSAR waterbodies recommended priority

Compliance Site Sub-watershed	Key MSAR Waterbodies	Segment	No Direct Action	UAA Priority			Survey Activity Priority			Controllability Assessment Priority			BMP Implementation Decision
				1	2	3	1	2	3	1	2	3	
Middle Santa Ana River @ MWD Crossing	Box Springs Channel	Headwaters to MSAR			X		X				X		2013
	Sunnyslope Channel	Headwaters to end of concrete-lined section			X				X			X	2014
		End of concrete-lined section to MSAR							X			X	2014
	MSAR Outfalls	Along MSAR						X			X		2013
Middle Santa Ana River @ Pedley Avenue	Anza Park Drain	Headwaters to Arlington Ave.			X			X			X		2013
		Arlington Ave. to MSAR	X										
	San Sevaine Channel	Headwaters to San Sevaine Basins	X										
		Below San Sevaine Basins to MSAR			X			X					
	Day Creek	Headwaters to Day Cr. Basins	X										
		Below Basins to Limonite Ave.			X			X			X		2013
		Limonite Ave. to Lucretia Ave.			X			X			X		2013
		Lucretia Ave. to MSAR	X										
	Etiwanda Channel	Headwaters to Detention Basins	X										
		Below Basins to Day Creek			X			X				X	2014
	MSAR Outfalls	Along MSAR						X			X		2013
Other Sub-watersheds	Prado Park Lake	N/A							X			X	2014
	Temescal Creek	Below Lake Elsinore to upstream of Magnolia Ave.							X				
		Upstream of Magnolia Ave. to near Cota St.		X[1]					X			X	2014
		Near Cota St. to Prado Basin	X										

[1] UAAs in development by SWQSTF; priority 1 to support completion in a timely manner
[2] UAA needed for remainder of segment not addressed by SWQSTF UAA

Section 6
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