Middle Santa Ana River Bacterial Indicator TMDLs: 2023 Triennial Report

Submitted to:

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February 11, 2023

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Acronyms

Acronym	Definition
AgSEP	Bacterial Indicator Agricultural Source Evaluation Plan
Basin Plan	Water Quality Control Plan for the Santa Ana River Basin
BASMP	Bacterial Indicator Agricultural Source Management Plan
BDL	Below Detection Limit
BMP	Best Management Practice
BXSP	Box Springs Channel
CAFO	Concentrated Animal Feeding Operation
CBRP	Comprehensive Bacteria Reduction Plan
CBW	Chino Basin Watermaster
CC WRP	Carbon Canyon Water Reclamation Plant
cfs	Cubic feet per second
cfu	Colony Forming Units
CIMP	Coordinated Integrated Monitoring Program
DAMP	Drainage Area Management Plan
DOC	Dissolved Organic Carbon
DWF	Dry Weather Flow
E. coli	*Escherichia coli*
ESGV	East San Gabriel Valley
ESGVWMP	East San Gabriel Valley Watershed Management Program
FBRP	Facility Bacteria Reduction Plan
gal/ac/day	gallons per acre per day
gc	Gene Copies
IEUA	Inland Empire Utilities Agency
LA	Load Allocation
lbs	Pounds
Los Angeles Water Board	Los Angeles Regional Water Quality Control Board
LSD	Log Standard Deviation
MBB	Mission Boulevard Bridge
MCSD	Magnolia Center Storm Drain
MCW	Mill Creek Wetland
mL	milliliter
MPC	Milk Producers Council
MPN	Most Probable Number
MS4	Municipal Separate Storm Sewer System
MSAR	Middle Santa Ana River
MSB	Market Street Bridge
MST	Microbial Source Tracking
MSWMP	Municipal Storm Water Management Plan
NA	Not Applicable

Acronym	Definition
ND	Non-detect
NM	Not Measured
NPDES	National Pollutant Discharge Elimination System
n	Number
O&M	Operation and Maintenance
PHNX	Phoenix Storm Drain
POTW	Publicly-owned Treatment Works
QAPP	Quality Assurance Project Plan
QMRA	Quantitative Microbial Risk Assessment
qPCR	Quantitative Polymerase Chain Reaction
RAA	Reasonable Assurance Analysis
RBMP	Regional Bacteria Monitoring Program
RCFC&WCD or District	Riverside County Flood Control & Water Conservation District
REC1	Water Contact Recreation
REC2	Non-contact Water Recreation
RIX	Rapid Infiltration and Extraction Facility
RTA	Rapid Trash Assessment
Santa Ana Water Board	Santa Ana Regional Water Quality Control Board
San Francisco Bay Board	San Francisco Bay Regional Water Quality Control Board
SAWPA	Santa Ana Watershed Project Authority
SBCFCD	San Bernardino County Flood Control District
SNCH	Sunnyslope Channel
State Water Board	State Water Resources Control Board
SWQDv	Storm Water Quality Design Volume
T1	Tier 1
T2	Tier 2
Task Force	MSAR Watershed TMDL Task Force
TMDL	Total Maximum Daily Load
TSS	Total Suspended Solids
UC Riverside	University of California Riverside
USEP	Urban Source Evaluation Plan
USEPA	United States Environmental Protection Agency
USGS	United State Geological Survey
VBB	Van Buren Bridge
WDR	Waste Discharge Requirements
WLA	Wasteload Allocation
WQBEL	Water Quality Based Effluent Limitation
WQCP	Water Quality Control Plant
WQMP	Water Quality Management Plan
WWTP	Wastewater Treatment Plant

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Executive Summary

Background

On August 26, 2005, the Santa Ana Regional Water Quality Control Board (Santa Ana Water Board) adopted Middle Santa Ana River (MSAR) Bacterial Indicator Total Maximum Daily Loads (TMDL) ("MSAR TMDL") for Reach 3 of the Santa Ana River, Mill Creek (in the Prado area), Reach 1 of Cucamonga Creek, Reaches 1 and 2 of Chino Creek, and the Prado Park Lakes. The adopted TMDLs became effective on May 16, 2007, following approval by the United States Environmental Protection Agency. Soon after the approval of the MSAR TMDLs in May 2005, the MSAR Watershed TMDL Task Force ("Task Force") was established in January 2006. This Task Force, administered by the Santa Ana Water Project Authority (SAWPA), is a stakeholder-led effort to collaboratively implement the MSAR TMDLs.

Task 3 of the Phase 1 TMDL Implementation Plan requires preparation of a Triennial Report every three years. Since the TMDLs became effective, four Triennial Reports have been submitted: 2010, 2013, 2016 and 2020. The purpose of this fifth Triennial Report is to assess the data collected for the preceding three year period (2020-2022) and evaluate progress towards achieving the wasteload allocations (WLA) and load allocations (LA) in the MSAR TMDLs. This evaluation of progress includes an update on work being carried out by urban dischargers and agricultural operators in the watershed to reduce or eliminate sources of *Escherichia coli* (*E. coli*) in the watershed.

Watershed-wide Monitoring Program

The TMDLs require implementation of a watershed-wide monitoring program that will provide data needed to review and update the TMDLs and evaluate compliance with the TMDL WLAs and LAs. The MSAR Task Force began implementation of this monitoring program in 2007. In 2016, the watershed-wide monitoring activities specific to the TMDLs were incorporated into a new Regional Bacteria Monitoring Program (RBMP), which is implemented through SAWPA's Regional Water Quality Monitoring Task Force.

The RBMP regularly samples five TMDL watershed-wide compliance monitoring sites. These sites which have been sampled since 2007 include: Mill-Cucamonga Creek; Chino Creek at Central Avenue; Prado Park Lake; Santa Ana River Reach 3 at MWD Crossing; and Santa Ana River Reach 3 at Pedley Avenue. In 2021 an additional monitoring site was added: Santa Ana River Reach 3 at Mission Avenue (upper portion of Reach 3). The monitoring program collects field measurements (including flow) and bacterial indicator data during dry weather conditions, collecting 25 samples/year from each watershed-wide monitoring site. In addition, the program samples one wet weather event each year at each of the compliance sites.

This Triennial Report summarizes the long-term patterns observed for *E. coli* geometric means over the entire period of record from 2007-2022. In addition, the report summarizes the frequency of compliance with WLAs/LAs (geometric mean and single sample values) under dry weather conditions for the most recent reporting period, 2020-2022. As has been observed during other reporting periods, exceedances of the dry summer condition WLAs/LAs at the TMDL compliance monitoring sites occur fairly frequently. However, as has been shown in previous Triennial Reports, after accounting for known sources of bacteria and dry weather flow, there is a significant reservoir of unaccounted for *E. coli* bacteria, at least in the Santa Ana River Reach 3 portion of the watershed. The specific source(s) of these bacteria remains unclear and further investigation of these sources of bacteria may be warranted.

TMDL Implementation Activities

TMDL implementation activities are regularly carried out by entities with applicable WLAs and LAs. In addition, the MSAR Task Force or SAWPA implement watershed-wide studies in the MSAR watershed that provide information that supports TMDL implementation. This report provides a summary of the primary TMDL-related activities that have occurred during the reporting period. Key activities include:

- *SAWPA Homeless Encampment Studies* - SAWPA implemented studies to evaluate potential impacts of homeless encampment activity on water quality and riparian habitat in the upper Santa Ana River watershed, which includes the MSAR watershed. While the study documented significant trash impacts from homeless encampments, no obvious water quality impacts were observed during dry weather conditions.

- *MSAR Task Force Pig Marker Study* – MSAR Task Force implemented a special study to evaluate feral pigs as a potential source of *E. coli* in the MSAR watershed. Data results to date provide consistent evidence that fecal matter from feral pigs, an uncontrollable source, contributes to the observed water quality conditions in the Santa Ana River. However, data results to date also indicate that feral pigs alone likely do not account for all instream sources of *E. coli* observed in the watershed.

- *Riverside County Municipal Separate Storm Sewer System (MS4) Program* – Report provides findings from projects implemented by the City of Riverside and Riverside County Flood Control & Water Conservation District: (a) long-term Tier 2 source investigation in the Magnolia Center Storm Drain subwatershed which has been shown to have high levels of *E. coli*; and (b) recently completed Phoenix Storm Drain Diversion Project, which is the first stormwater diversion to sewer project in Riverside County and thus serves as a pilot for future urban runoff diversion projects.

- *San Bernardino County MS4 Program* – The Triennial Report provides a detailed analysis of findings from TMDL-related studies: (a) six years of Tier 2 source investigation work in the Cucamonga Creek subwatershed, which shows a significant instream, but unknown, source of *E. coli* in the subwatershed; (b) pre- and post-construction bacteria data collection activities associated with the recently completed Chris Basin Retrofit regional treatment project, including the observation that *E. coli* concentrations are one to two orders of magnitude lower in the afternoon than in the morning; and (c) demonstration that the Mill Creek Wetlands regional treatment project removes more than 95 percent of the *E. coli* load in dry weather flows diverted through the wetlands.

- *City of Claremont and City of Pomona* – Updates on ongoing TMDL-related activities (best management practice (BMP) implementation and stormwater capture projects) are reported for these MS4 Permittees in the portion of the MSAR watershed that is located in Los Angeles County.

- *University of California Riverside* – The Triennial Report summarizes TMDL implementation activities conducted by this Small MS4. These activities include: (a) participation in the TMDL monitoring program; and (b) preparation and implementation of the University's Facility Bacteria Reduction Plan (FBRP) that addresses dry summer condition WLAs applicable to all lands within the jurisdiction of the university.

- *Concentrated Animal Feed Operations (CAFO)* – The report documents the continued decline in the number of dairies in the MSAR watershed. These dairies, which through their representatives participate in the MSAR Task Force, are subject to the TMDL requirements incorporated in the current General Order that permits the operation of dairies.

- *Non-CAFO Agricultural Operators* – Similar to dairies, the acreage of land used for irrigated agriculture or dry land farming continues to decline in the watershed. With the exception of the agricultural facilities located in the Arlington Greenbelt area (other than Altman Plants), all other agriculture facilities in the watershed continue through their representatives to participate in the MSAR Task Force and implement the BMPs established in their respective bacteria management plans (i.e., Chino Basin Watermaster/Milk Producers Council's Bacterial Indicator Agricultural Source Management Plan and University of California Riverside's FBRP).

Bacterial Indicator Source Analysis

This 2023 Triennial Report updates previous bacteria source contribution analyses prepared for the MSAR watershed. The latest analysis incorporates dry weather flow and bacterial indicator data collected during the 2020-2022 dry seasons. These new data were primarily acquired through implementation of MS4 Permittee-directed Tier 2 source evaluations as part of Comprehensive Bacteria Reduction Plan (CBRP) implementation. In addition, data collected from the new dry weather monitoring site at the Santa Ana River Mission

Boulevard Bridge provided an important source of additional information for the updated analysis for Santa Ana River Reach 3.

In Mill-Cucamonga Creek and Santa Ana River Reach 3, tertiary treated effluent from wastewater treatment facilities comprises the majority of dry weather flow under dry weather conditions. This effluent, which is essentially free of any fecal bacteria, provides water that dilutes inputs from MS4 outfalls to these waterbodies. The volume of discharged effluent has declined significantly since the TMDLs became effective. This decline is due to increased water conservation and reuse of treated effluent. Since the last source contribution analysis was completed in 2020, the volume of discharged effluent has remained generally unchanged.

Updated source contribution analysis results are provided for each of the three key subwatersheds: Santa Ana River Reach 3, Cucamonga Creek and Chino Creek. Key findings for each subwatershed include:

- *Santa Ana River Reach 3* - The majority of *E. coli* load observed in Reach 3 of the Santa Ana River has been demonstrated to come from in-stream sources upstream of Mission Boulevard in Santa Ana Reach 4.
- *Cucamonga Creek* - In-stream sources of *E. coli* have been found to also be important contributors to the bacteria load in this subwatershed (~28%).
- *Chino Creek* - For the first time, *E. coli* loads from Tier 1 MS4 outfalls to Chino Creek were found to have exceeded the load reduction target set in the CBRP; overall the MS4 load from outfalls to Chino Creek has been reduced by approximately 92% since 2007. Additional study over time will determine if this finding is consistent from year to year.

TMDL Implementation – Recommended Next Steps

This report recommends the following additional studies and activities as next steps: :

- Collect data to update the last Tier 1 source evaluation conducted in 2019. These Tier 1 evaluations have historically been conducted about every 5-7 years; therefore, it is recommended that the next source evaluation be conducted in 2024-2025 to provide data to support the next Triennial Report due in 2026.
- Conduct studies to identify and quantify instream sources of *E. coli*, especially in Santa Ana River Reaches 3 and 4 and Cucamonga Creek. Studies should be comprehensive so that multiple potential sources of bacteria are evaluated at the same time.
- Conduct additional studies on the effectiveness of Chris Basin as a regional treatment facility, with consideration of the dynamics of the diurnal differences in *E. coli* concentrations.

- Increase collection of wet weather data to support the next phase of TMDL implementation that will focus on compliance with wet winter condition WLAs/LAs.
- Consider development of site-specific objectives for the MSAR watershed, in particular for Santa Ana River Reach 3 based on the findings from multiple studies conducted over the past 15 years.
- Continue to move forward with proposed limited revisions to the MSAR TMDLs to provide opportunity to conduct needed additional assessments of bacteria conditions during wet weather conditions and determine the best approach to meet the wet winter condition WLAs and LAs.

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1. Introduction

1.1 Regulatory Background

On August 26, 2005, the Santa Ana Regional Water Quality Control Board (Santa Ana Water Board) adopted Middle Santa Ana River (MSAR) Bacterial Indicator Total Maximum Daily Loads (TMDL) ("MSAR TMDL") for Reach 3 of the Santa Ana River, Mill Creek (in the Prado area), Reach 1 of Cucamonga Creek, Reaches 1 and 2 of Chino Creek, and the Prado Park Lakes (Santa Ana Water Board 2005b; Resolution No. R8-2005-0001). The adopted TMDLs were approved by the State Water Resources Control Board (State Water Board) on May 15, 2006 (State Water Board 2006; Resolution No 2006-030) and by the United States Environmental Protection Agency (USEPA) Region 9 on May 16, 2007.

The MSAR TMDLs established fecal coliform and *Escherichia coli* (*E. coli*) wasteload allocations (WLA) for urban Municipal Separate Storm Sewer System (MS4) and Confined Animal Feeding Operation (CAFO) discharges and load allocations (LAs) for agricultural and natural sources:

- Fecal coliform: 5-sample/30-day logarithmic mean (or geometric mean) less than 180 organisms/100 mL and not more than 10 percent of the samples exceed 360 organisms/100 milliliters (mL) for any 30-day period.[1]
- *E. coli*: 5-sample/30-day logarithmic mean (or geometric 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.

The TMDLs establish different season-based compliance dates for these WLAs and LAs as follows:

- Dry Summer Conditions (April 1 through October 31) – WLAs/LAs should be complied with as soon as possible, but no later than December 31, 2015; and
- Wet Winter Conditions (November 1 through March 31) – WLAs/LAs should be complied with as soon as possible, but no later than December 31, 2025.

The TMDLs identify the following entities responsible for compliance with WLAs and LAs in the MSAR watershed: Counties of Riverside and San Bernardino, Cities of Ontario, Chino, Chino Hills, Montclair, Rancho Cucamonga, Upland, Rialto, Fontana, Corona, Norco,

[1] The WLAs and LAs for fecal coliform are no longer applicable following USEPA's 2015 approval of the 2012-adopted Basin Plan amendment to revise bacterial indicator objectives in the Santa Ana Region for inland freshwaters (Resolution No. R8-2012-0001). See discussion on next page.

Riverside, Claremont and Pomona, Agricultural Operators (including both CAFOs and irrigated and dry-land farming) and the United States Forest Service.

Since TMDL adoption, a portion of the Riverside County area has become the newly incorporated Cities of Eastvale and Jurupa Valley. In addition, the State Water Board identified four additional entities responsible for compliance with WLAs through adoption of the General Permit for Waste Discharge Requirements (WDR) for Storm Water Discharges from Small MS4s (State Water Board 2017; Resolution No. 2013-0001-DWQ, as amended in 2017): University of California Riverside (UC Riverside), California Institute for Men (Chino, CA); California Institute for Women (Chino CA); and California Rehabilitation Center (Norco, CA).

In 2012, the Santa Ana Water Board adopted changes to the recreation water quality standards in the Water Quality Control Plan for the Santa Ana River Basin (Basin Plan), based on the work and recommendations of the Stormwater Quality Standards Task Force (Santa Ana Water Board 2012c; Resolution No. R8-2012-0001). That Basin Plan amendment was subsequently approved by the State Water Board on January 21, 2014 (State Water Board 2014; Resolution No. 2014-0005) and by USEPA on April 8, 2015. This Basin Plan amendment included several key elements that are relevant to the MSAR TMDLs:

- Revised bacteria quality objectives applicable to freshwaters (e.g., fecal coliform water quality objectives were replaced by *E. coli* objectives).
- Changes to the recreational use designations for specific freshwaters, including removal of the Water Contact Recreation (REC1) beneficial use from Cucamonga Creek Reach 1 through an approved Use Attainability Analysis.
- Specific implementation strategies pertaining to the revised standards for freshwaters including:
  - Intended application of Single Sample Maximum values in freshwaters with a REC1 beneficial use;
  - Antidegradation targets for freshwaters with a Non-contact Water Recreation (REC2) only beneficial use, including Cucamonga Creek Reach 1;
  - Controllable and uncontrollable sources of bacteria; and
  - High flow suspension of recreation standards under specified conditions.

In 2018, the State Water Board amended the Water Quality Control Plan for Inland Surface Waters to establish new statewide water quality standards for pathogen indicator bacteria (State Water Board 2018; Resolution No. 2018-0038, August 7, 2018). Both the 2012 Santa Ana Water Board Basin Plan amendment and 2018-adopted State Water Board statewide bacteria water quality standards provisions have the potential to impact the underlying basis for the 2005-adopted MSAR TMDLs. However, until the MSAR TMDLs are revised to incorporate these statewide requirements, the requirements established in the existing MSAR TMDLs continue to apply.

1.2 MSAR TMDL Task Force

The MSAR Watershed TMDL Task Force ("Task Force") is a multi-agency[2] collaborative effort organized by the Santa Ana Water Project Authority (SAWPA).[3] Formed in January 2006 after Santa Ana Water Board adoption of the MSAR TMDLs in May 2005, the Task Force coordinates water quality improvement activities designed to support compliance with the MSAR TMDLs. Specifically, the Task Force:

- Serves as a forum for Task Force participants to report to the Santa Ana Water Board regarding progress being made towards compliance with WLAs and LAs;
- Collectively implements watershed-wide monitoring efforts, as required by the MSAR TMDLs;
- Supports activities designed to manage or eliminate sources of bacterial indicators in local waterbodies, including coordinating as appropriate activities included in the Comprehensive Bacteria Reduction Plans (CBRPs) prepared by various MS4 Programs in the MSAR watershed.

SAWPA, through its administrative role in supporting the MSAR Task Force, actively maintains a Task Force website where the work of the Task Force is documented: https://sawpa.org/task-forces/middle-santa-ana-river-watershed-tmdl-task-force/.

1.3 TMDL Implementation Requirements

This section summarizes the implementation requirements established in the adopted TMDLs and subsequent requirements established through discharge permits.

1.3.1 MSAR TMDL Implementation Plan

Table 5-9y in MSAR TMDL Resolution No. R8-2005-0001 (Santa Ana Water Board 2005b) (Basin Plan Table 6-1y, Santa Ana Water Board 2019) summarizes the Phase 1 TMDL Implementation Plan, identifying six tasks and the entities responsible for implementation. **Table 1-1** summarizes these Phase 1 tasks. The TMDL Implementation Plan section of the

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[2] Current Task Force members include San Bernardino County Flood Control District (representing County of San Bernardino and Cities of Ontario, Chino, Chino Hills, Montclair, Rancho Cucamonga, Upland, Rialto, and Fontana); County of Riverside; Cities of Claremont, Corona, Eastvale, Jurupa Valley, Norco, Pomona and Riverside; and Agricultural Operators (represented by the Chino Basin Watermaster/Milk Producers Council) and University of California Riverside.

[3] SAWPA is a Joint Powers Authority of five member agencies that supports water resources planning: Eastern Municipal Water District, Inland Empire Utilities Agency, Orange County Water District, San Bernardino Valley Municipal Water District, and Western Municipal Water District.

adopted resolution provides detailed descriptions of the requirements and schedules associated with each of these tasks/subtasks.

Table 1-1. MSAR Watershed Phase 1 TMDL Implementation Plan (excerpted from Table 5-9y in the adopting resolution or Table 6-1y in the Basin Plan)

Task/Subtasks		Responsible Entity
1 – Revise Existing Waste Discharge Requirements		Santa Ana Water Board staff
2 - Identify Agricultural Operators		Santa Ana Water Board staff
3 – Watershed-wide Bacterial Indicator Monitoring Program	• Seasonal Reports (May 31; December 31) • Triennial Reports	Urban and Agricultural Dischargers
4 – Urban Discharges	• 4.1 - Develop and Implement Bacterial Indicator Urban Source Evaluation Plan (USEP) • Dependent on findings from Task 4.1 implement the following: – 4.2 - San Bernardino County MS4: Revise Municipal Storm Water Management Program (MSWMP) – 4.3 - Riverside County MS4: Revise Drainage Area Management Plan (DAMP) – 4.4 - San Bernardino County MS4: Revise Water Quality Management Plan (WQMP) – 4.5 Riverside County MS4: Revise WQMP	Urban Dischargers (cities and unincorporated communities)
5 - Agricultural Dischargers	• 5.1 Develop and Implement Bacterial Indicator Agricultural Source Evaluation Plan (AgSEP); • 5.2 - Dependent on Task 5.1 results, Develop and Implement Bacterial Indicator Agricultural Source Management Plan (BASMP)	Agricultural Operators (includes CAFOs and irrigated and dry land farming)
6 – Review of TMDL/WLAs/LAs		Santa Ana Water Board

1.3.2 Additional Implementation Requirements

1.3.2.1 Urban Dischargers

When the MSAR TMDLs were adopted in 2005, the San Bernardino and Riverside County MS4s were authorized to discharge urban runoff under MS4 Permits R8-2002-0012 and R8-2002-0011, respectively (Santa Ana Water Board 2002a, 2002b. Accordingly, the Phase 1 TMDL Implementation Plan tasks applicable to urban discharges and summarized in Table 1-1 above were based on the requirements of these MS4 Permits.

In 2010, the Santa Ana Water Board adopted new MS4 Permits for the portions of Riverside and San Bernardino Counties within the Santa Ana River watershed (Santa Ana Water Board 2010a, 2010b; Order Nos. R8-2010-0033 and R8-2010-0036, respectively). These 2010 MS4 Permits significantly updated the MSAR TMDL requirements applicable to MS4s within the

MSAR watershed in Riverside and San Bernardino Counties. Specifically, the 2010 Permits required development of CBRPs designed to achieve compliance with the urban WLAs for the dry season (April 1 through October 31). Similarly, when the Los Angeles Regional Water Quality Control Board (Los Angeles Water Board) adopted a new MS4 Permit in 2012, it required the Cities of Claremont and Pomona to submit CBRPs to the Santa Ana Water Board for the portions of their cities located within the MSAR watershed (Los Angeles Water Board 2012; Order No. R4-2012-0175).

The Santa Ana Water Board approved CBRPs submitted by Riverside and San Bernardino County MS4 Programs on February 10, 2012 (Santa Ana Water Board 2012a, 2012b; Resolution Nos. R8-2012- 0015 and R8-2012-0016, respectively) (Riverside County MS4 Program 2011; San Bernardino County Flood Control District [SBCFCD] 2011). The Santa Ana Water Board also approved CBRPs for the Cities of Claremont and Pomona on March 14, 2014 (Santa Ana Water Board 2014a, 2014b; Resolution Nos. R8-2014-0030 and R8-2014-0031, respectively) (City of Claremont 2014; City of Pomona 2014). All of the Santa Ana Water Board Resolutions approving CBRPs state that the approved CBRP "will serve as the final Water Quality Based Effluent Limitations (WQBEL) for bacterial indicators during the dry season (annually April 1 through October 31)."

As noted above, the State Water Board amended the MS4 Permit applicable to Phase II Small MS4s to include MSAR TMDL implementation requirements for four Small MS4s in the MSAR watershed (State Water Board 2017). In accordance with these requirements, UC Riverside is a participant in the TMDL monitoring program and recently submitted its Facility Bacteria Reduction Plan (FBRP) to the Santa Ana Water Board (September 26, 2022). Similar to a CBRP, the FBRP is designed to achieve compliance with the urban WLAs applicable to the dry season (see discussion of FBRP in Section 3.2.2.1).

1.3.2.2 Agricultural Operators

The "agricultural operator" group includes CAFOs with applicable WLAs and irrigated and dry land farming activities with applicable LAs. At the time of TMDL adoption, CAFOs were permitted under General Order 99-11 (Santa Ana Water Board 1999). This permit has since been superseded by the following General Orders: R8-2007-0001, 2013-0001 and 2018-0001 (Santa Ana Water Board 2007, 2013 and 2018c, respectively). Each of these Orders has included TMDL implementation requirements consistent with the TMDLs Implementation Plan (e.g., see Table 1-1). Farming activities within the MSAR watershed are not currently regulated under any Order.

1.3.3 TMDL Implementation Overview

Implementation of many MSAR TMDL activities occurs through the collaborative work of the MSAR Task Force, especially the TMDL's watershed-wide monitoring requirements and various studies to understand sources of bacterial indicators. Soon after the TMDLs became effective, much of the early work was supported by the Middle Santa Ana River Pathogen TMDL BMP Implementation Proposition 40 grant project administered by SAWPA on behalf of the Task Force and funding partners Riverside County Flood Control & Water Conservation District (RCFC&WCD or District) and SBCFCD. In addition, implementation of TMDL activities occurs locally through implementation of: (a) CBRPs by the urban MS4 Permittees; (b) UC Riverside's FBRP; (c) BASMP prepared by the agricultural community; and (d) compliance with CAFO General Order requirements.

Appendix A provides a figure that summarizes key activities that have occurred over time through implementation of the MSAR TMDLs, from adoption in 2005 through 2022 (**Figure A-1**). This figure provides a timeline of activities categorized as follows:

- Key regulatory dates/events
- TMDL Triennial Reports
- Proposition 40 grant project deliverables
- Monitoring programs
- USEP and AgSEP
- Tier 1 prioritization (through USEP and CBRP implementation)
- Task Force-coordinated source evaluation studies
- MS4 Permittee directed CBRP activities
- MS4 Program Best Management Practice (BMP) projects

Deliverables resulting from implementation of the Proposition 40 grant project may be found here: https://sawpa.org/task-forces/middle-santa-ana-river-watershed-tmdl-task-force/#resourcesb8a6-4b67. These deliverables initiated the required TMDL watershed-wide monitoring program and provided the initial data that resulted in the first prioritization of Tier 1 sites for subsequent source evaluation activities.

Appendix B provides a brief summary of key studies completed through implementation of the USEP (SAWPA 2007a), AgSEP (SAWPA 2007b) and CBRPs. Outcomes from these various activities have resulted in periodic revisions to the prioritization of Tier 1 sites for subsequent source evaluation studies in the MSAR watershed.

As noted above, the TMDL requires the preparation of Triennial Reports every three years. The findings from the assessment completed for each of these reports has been important to guide future TMDL implementation activities. Section 1.4 below summarizes key findings from the previously submitted Triennial Reports.

1.4 TMDL Triennial Reports

TMDL Task 3 requires preparation of a Triennial Report that assesses the data collected for the preceding three-year period and evaluates progress towards achieving the WLAs and LAs in the MSAR TMDLs. Four Triennial Reports have been prepared to date:

- *2007-2009 Triennial Report* (SAWPA 2010a) - Submitted to the Santa Ana Water Board in 2010, this report provided a water quality and TMDL compliance assessment based on data collected from the 2007 effective date of the TMDLs through 2009. The report included findings from the first watershed-wide assessment conducted at multiple sites in the MSAR watershed (reported in SAWPA 2009, see Section 2.1.4.1) and wet weather findings from storm event sampling of agricultural runoff (as required by the AgSEP). The complete report is available at: https://www.sawpa.org/wp-content/uploads/2018/04/2010_Triennial-Report.pdf.

- *2010 -2012 Triennial Report* (SAWPA 2013) – The second Triennial Report not only evaluated the status of compliance with WLAs and LAs as required by the TMDLs but also provided the results from source evaluation studies conducted as part of the implementation of the Riverside and San Bernardino County MS4 Program CBRPs. **Appendix C** provides a summary of the key findings from this assessment (complete report is available at: https://www.sawpa.org/wp-content/uploads/2018/04/2013-Triennial-Report_Tier-1-Source-Evaluation-Final.pdf).

- *2013-2015 Triennial Report* (SAWPA 2017) -This Triennial Report provided an update on the status of compliance with the TMDLs and also summarized findings from a number of Tier 1 and Tier 2 source evaluation studies conducted in the watershed by the Task Force and MS4 Permittees. The complete report is available at https://www.sawpa.org/wp-content/uploads/2018/04/2016_Triennial-Report-June-2017.pdf); a summary of the key findings are provided in **Appendix C**.

- *2016-2019 Triennial Report* (SAWPA 2020a) – In addition to providing an updated assessment of compliance with the TMDL WLAs and LAs, the fourth Triennial Report included the findings of a synoptic study conducted in the MSAR watershed to provide updated information on the status of dry weather flow (DWF) and bacterial indicators within each MSAR subwatershed. **Appendix C** provides a summary of the key findings from that report which is available here: https://sawpa.org/wp-content/uploads/2020/05/Final-Synoptic-Study-Report_021020_BabcockLabQAQC-Report-Appended_051920.pdf.

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2. Watershed-wide Monitoring Program

2.1 Program Overview

Task 3 in the Phase 1 TMDL Implementation Plan (Santa Ana Water Board 2005b) required responsible entities with assigned WLAs and LAs to submit a proposed watershed-wide monitoring program that,

> *"…will provide data necessary to review and update the TMDLs," and collect and analyze data that "shall address, at a minimum, determination of compliance with the TMDLs, WLAs and LAs."*

When developing the monitoring program, the MSAR TMDLs further stated the following regarding selection of monitoring sites and collection of water quality data:

> *"At a minimum, the stations specified in Tables 5-9z and 5-9aa and shown in Figure 5-6, at the frequency specified in Tables 5-9z and 5-9aa, shall be considered for inclusion in the proposed monitoring plan. If one or more of these monitoring stations are not included, the rationale shall be provided and proposed alternative monitoring locations shall be identified in the proposed monitoring plan."*

When the MSAR Task Force developed the watershed-wide monitoring program, two key factors were used to select watershed sites: (a) sites should be located on waterbodies that are impaired and thus incorporated into the TMDLs; and (b) sites should be located in reaches of the impaired waterbodies where REC1 activity is likely to occur, i.e., there is an increased risk from exposure to pathogens (SAWPA 2008a).

Using the impaired waters list, recreational use data that had already been developed by the SAWPA Stormwater Quality Standards Task Force, and recommendations from Santa Ana Water Board staff participating in the MSAR Task Force, six sites were selected for inclusion in the initial MSAR TMDL watershed-wide monitoring program:

- Icehouse Canyon Creek;
- Chino Creek at Central Avenue;
- Santa Ana River at Pedley Avenue;
- Santa Ana River at MWD Crossing;
- Prado Park Lake at Lake Outlet; and
- Mill Creek at Chino-Corona Road.

All six of these sites were either already recommended monitoring locations in the MSAR TMDLs or were located very close to recommended sites. As required, the approved TMDL monitoring program's Monitoring Plan and supporting Quality Assurance Project Plan (QAPP) provided the rationale for not including other sites recommended for consideration by the TMDLs (see Section 2.2, SAWPA 2008a; SAWPA 2008b).

The Santa Ana Water Board formally approved the watershed-wide monitoring program Monitoring Plan and QAPP in April 2008 (Santa Ana Water Board 2008; Resolution No. R8-2008-0044). The watershed-wide monitoring program's Monitoring Plan and QAPP were routinely updated as the TMDL monitoring program evolved based on knowledge gained during implementation. With the concurrence of the MSAR Task Force and Santa Ana Water Board, monitoring at Icehouse Canyon Creek was discontinued after the 2008-2009 wet season.[4]

As noted in Section 1.1, the Santa Ana Water Board adopted a Basin Plan amendment to revise recreation water quality standards on June 15, 2012 (Santa Ana Water Board 2012c). The Basin Plan amendment required establishment of a comprehensive Regional Bacteria Monitoring Program (RBMP) for implementation throughout the Santa Ana Region to support implementation of the revised recreation standards. To facilitate efficient use of resources and coordinate data collection in the watershed, the existing MSAR TMDL watershed-wide monitoring program was incorporated into the RBMP. The Santa Ana Water Board approved the original RBMP Monitoring Plan and QAPP on March 11, 2016 (Santa Ana Water Board 2016; Resolution No. R8-2016-0022). The Monitoring Plan and QAPP are routinely updated; SAWPA (2022a, b) provides the most recent program updates.

Prior to the establishment of the RBMP, the MSAR Task Force prepared two monitoring reports each year as required by the TMDL Implementation Plan (Task 3): Dry Season Report (December 31) and Wet Season Report (May 31). When the MSAR TMDL monitoring program was incorporated into the RMBP this biannual reporting requirement was modified into a single annual watershed report to be submitted by June 30 each year. The first RBMP annual report was submitted in June 2017 and included water quality monitoring results during the 2016 dry season and 2016-2017 wet season. The most recent annual report (SAWPA 2022d), previous reports, and access to the online data viewer are available at SAWPA: https://sawpa.org/task-forces/regional-water-quality-monitoring-task-force/#geographic-setting.

2.2 Water Quality Monitoring Program

Sampling began at the TMDL watershed-wide monitoring sites in fall 2007. This section provides an overview of the current program and focuses on the past three years of data

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[4] From 2007 to 2009, *E. coli* results from the Icehouse Canyon site were below the water quality objective and often below laboratory detection (< 9 cfu/100 mL). Given the resources required to sample this site (especially time required to sample due to access), it was agreed that continued sampling at this location was unnecessary.

collection (2020-2022), especially data collected under dry weather conditions. Previous data may be reviewed at the monitoring program's data dashboard: https://sawpa.cdmsmith.com/.

2.2.1 Watershed-wide Compliance Monitoring Sites

Sample collection regularly occurs at the following five locations (**Table 2-1**): Chino Creek at Central Avenue (WW-C7), Mill-Cucamonga Creek (WW-M6), Santa Ana River at MWD Crossing (WW-S1), Santa Ana River at Pedley Avenue (WW-S4) and Prado Park Lake (WW-C3) (**Figure 2-1**). The MSAR Task Force added the WW-MISSION monitoring site in 2020 to characterize bacterial indicators flowing from Santa Ana River Reach 4 into Reach 3 during dry weather conditions. The Task Force recognized the need for additional data collection based on findings from the 2019 Synoptic Study that found that (a) the DWF at the WW-MISSION site does not include any flow from an MS4; and (b) the majority of *E. coli* load observed in Santa Ana River Reach 3 results from in-stream bacteria sources (SAWPA 2020a). SAWPA (2022a; see Attachment A) provides additional information about each of these monitoring locations.

Table 2-1. MSAR TMDLs Watershed-wide Monitoring Sites (see Figure 2-1)

Site ID	Site Description	Type	County	Latitude	Longitude
WW-M6	Mill-Cucamonga Creek below Wetlands	Compliance	San Bernardino	33.9268	-117.6250
WW-C7	Chino Creek at Central Avenue	Compliance	San Bernardino	33.9737	-117.6889
WW-C3	Prado Park Lake	Compliance	San Bernardino	33.9400	-117.6473
WW-S1	Santa Ana River Reach 3 at MWD Crossing	Compliance	Riverside	33.9681	-117.4479
WW-S4	Santa Ana River Reach 3 at Pedley Avenue	Compliance	Riverside	33.9552	-117.5327
WW-MISSION	Santa Ana River Reach 3 at Mission Avenue	Non-MS4 Boundary Inflow	Riverside	33.9906	-117.3951

2.2.2 Water Quality Sampling Program

The RMBP Monitoring Plan and QAPP (SAWPA 2022a, b) provide detailed information regarding the collection and analysis of field data and water quality samples. The Monitoring Plan establishes seasonal sample collection dates for dry weather events for each year of the monitoring program. Dry weather condition samples are collected during two periods: (a) weekly over 20 consecutive weeks, generally from May to September during the TMDL-defined dry season (April 1 - October 31); and (b) weekly over 5 consecutive weeks generally from late October through early December during the TMDL-defined wet season (November 1 – March 31). In addition, one multi-sample wet weather event is monitored each year.

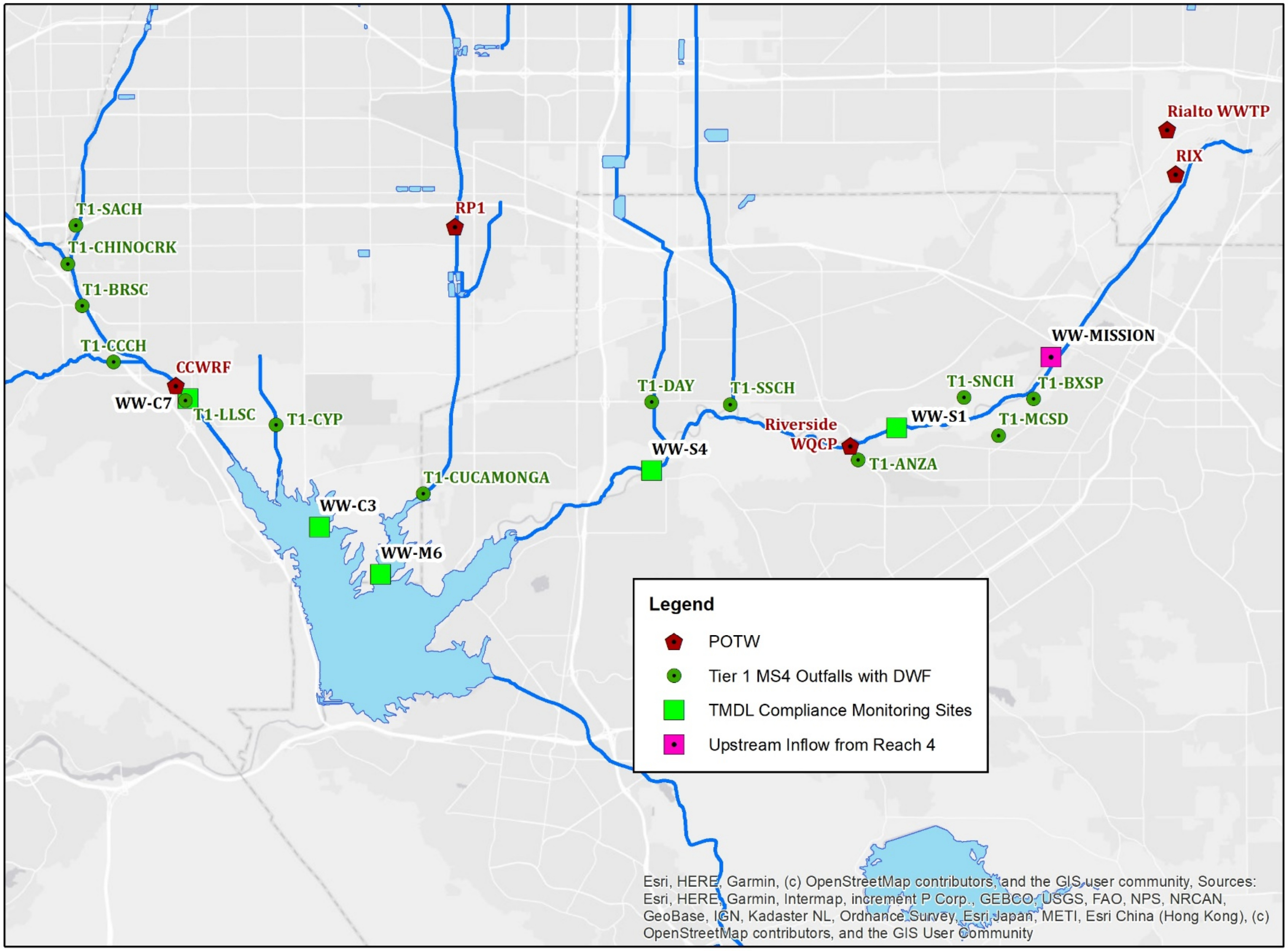

Figure 2-1. Location of TMDL Compliance Monitoring Sites, Tier 1 Sites and POTWs in the MSAR Watershed

During each sample event, the sample team gathers field measurements (flow, temperature, electrical conductivity, pH, dissolved oxygen, and turbidity) and collects water samples for laboratory analysis of *E. coli* and total suspended solids (TSS). **Table 2-2** summarizes data collection efforts for the dry and wet seasons for the past three-year period (2020-2022); all planned samples were collected. The dry weather data are used to assess compliance with the dry summer condition TMDL targets, assess the role of in-stream sources, and provide the basis for comparing the downstream *E. coli* load to measurements from upstream sources to support this report's source contribution analysis (Section 4).

Table 2-2. Summary of Water Sample Collection Activity during 2020-2022 Period

Type	Planned Sample Days (2020-2022)	Sites	Collected Samples (2020 – 2022)[1]
Dry weather, warm season	60	6	360
Dry weather, cool season	15	6	90
Wet weather, wet season[2]	12	5	60

[1] Includes wet event in 2019-2020 wet season on March 10, 2020, does not include wet event in 2022-2023 wet season.

[2] Includes samples collected "post-storm" as part of the targeted weather event (see text).

As noted above, a single wet weather event is sampled each year. Each event involves the collection of four grab samples: (a) the first sample is collected during active wet weather; and (b) three follow-up samples are collected at approximately 24, 48, and 72 hours after collection of the first sample.[5] The scheduling of sample collection at uniform time intervals after the initial sample is collected has the potential to result in the collection of some follow-up samples during wet weather, especially during longer duration storms or when multiple rain events occur within the 96-hour sampling event.

To determine whether a sample was collected during wet weather or post-storm, flow data have been evaluated. Specifically, United State Geological Survey (USGS) gauge data at 15-minute intervals were used to estimate the time that passed from when flow returned to a pre-wet weather event flow condition to when a post-storm sample was collected. This hydrograph analysis using best professional judgement was conducted for all storm events sampled by the MSAR Task Force since 2007 to determine which follow-up samples were collected during active wet weather or post-storm, that is whether flow had returned to pre-wet weather event conditions. Based on this analysis, the amount of time that passed from when flow returned to pre-event conditions to the time of collection of a post-storm sample has been estimated for all wet weather events sampled.

[5] Note: The timing of the follow-up samples was changed in the 2021 update to the Monitoring Plan and QAPP. Prior to 2021, collection of post-storm samples occurred at 48, 72, and 96 hours after collection of the first sample.

Table 2-3 provides a summary of the classifications of all wet weather event samples (15 wet weather events from 2007-2022) - either collected during active wet weather or collected post-storm – for monitoring locations on Chino Creek, Mill-Cucamonga Creek and Santa Ana River Reach 3. For samples collected post-storm, Table 2-3 also reports the estimated time that had passed since flow had returned to pre-wet weather conditions. Specifically, the values in the "Post-storm Samples" columns show the time in hours for each sample collected since active wet weather ceased and flow returned to pre-event levels (sample collection times are listed in chronological order). For example, in the first row a wet weather event was sampled on 12/7/2007 (see Table 2-3). In Chino Creek, based on the hydrologic analysis, two of four samples collected during the event were collected during active wet weather (12/7/2007 and 48 hours later on 12/9/2007). Flow conditions in Chino Creek returned to pre-wet weather event levels one hour before the third wet weather event sample was collected. A fourth event sample was collected 24 hours after the return to pre-event runoff.

Table 2-3. Wet Event Samples Classified as Either Active Wet Weather or Post-Storm in the MSAR Watershed (see text) (NA = not applicable)

Event (Date of Collection of First Sample)	Chino Creek		Mill-Cucamonga Creek		Santa Ana River[1]	
	Wet Samples	Post-storm Samples (Hours since active wet weather)	Wet Samples	Post-storm Samples (Hours since active wet weather)	Wet Samples	Post-storm Samples (Hours since active wet weather)
12/7/2007	2	1,24	1	36,60,84	2	13, 37
12/15/2008	2	3,27	2	20,19	3	4
10/14/2009	1	46,69,93	2	8,12	1	20,43,67
11/20/2010	1	23,48,10	1	8,33,8	2	7,31
12/12/2011	1	43,67,18	1	32,56,12	1	24,47,72
12/13/2012	1	4,28,53	1	5,29,53	1	14,38,62
2/28/2014	1	10,20,40	1	1,25,49	1	6,30,54
12/2/2014	1	2,11,35	2	17,41	3	9
3/6/2016	1	5,29,54	1	8,17,41	2	19,44
12/15/2016	1	5,29,53	2	15,39	3	24
2/27/2018	1	24,47,5	4	NA	2	42,66
2/1/2019	4	NA	4	NA	4	NA
3/10/2020	3	14	3	48	3	10
1/25/2021	3	7	2	9,33	2	10,6
3/29/2022	1	13,37,60	1	21,44,68	2	21,44

[1] Analysis based on USGS flow gauge data at MWD Crossing and assumed to represent conditions at both the WW-S1 and WW-S4 sites

The hydrologic analysis found that in some cases, additional wet weather runoff occurred between the time the third and fourth samples were collected. In these cases, the hours shown for the fourth sample are less than the hours shown for the third sample (e.g., see the Chino Creek and Mill-Cucamonga Creek Results for the 11/20/2010 wet weather event). The analysis also found that duration of wet weather events can vary somewhat (e.g., note that for the wet weather sample event that began on 2/1/2019, flow at all sites did not return to pre-wet weather conditions during the entire wet weather sample event). This type of information is of critical importance when evaluating compliance with wet weather condition TMDL WLAs and LAs.

2.3 Summary of Bacteriological Conditions

2.3.1 Dry Weather Bacteria

To illustrate long-term trends, **Figure 2-2** depicts the dry weather *E. coli* geomean for warm and cool seasons, for each of the watershed-wide TMDL compliance monitoring sites, for each year of sampling, from 2007 through 2022. **Appendix D** provides additional plots of single sample and rolling geometric mean results for the most recent period, 2020-2022. Key findings for each of the impaired waters include:

- *Chino Creek* – Week to week variability of 2-3 orders of magnitude suggests an intermittent bacterial indicator source(s) of concern. In addition, there may be an intermittent environmental condition that causes significant variability rates of in-stream decay. To better understand these patterns, SBCFCD conducted 12 synoptic Tier 1 source evaluations at all MS4 outfalls to Chino Creek in 2021-2022 (see Section 4.3.3).

- *Mill-Cucamonga Creek* - Warm season *E. coli* concentrations decreased in the mid-2010s and have remained at low levels since then. This pattern may potentially be attributed to benefits obtained from construction of two key regional treatment facilities in the Cucamonga Creek subwatershed: Chris Basin retrofit completed in 2021 (see Section 3.2.1.2.2) and Mill Creek Wetlands (MCW) completed in 2015 (see Section 3.2.1.2.3).

- *Santa Ana River Reach 3 (MWD Crossing and Pedley Avenue)* – Rising *E. coli* loads within Reach 4 are likely causing a rise in *E. coli* concentrations at the downstream TMDL compliance monitoring locations in Reach 3 (see Section 4.3.1). Quantification of this load has been possible through the inclusion of the watershed-wide monitoring site at Mission Avenue (WW-MISSION).

Figure 2-2. Seasonal Geomean *E. coli* Concentration (Most Probable Number [MPN]/100 mL) for all Samples Collected at each Site during Dry Weather Warm (left panel in red; n = 20) and Cool Seasons (right panel in blue; n = 11 before 2016, n = 5 after 2016); applicable WLA/LA = 113 *E. coli*/100 mL

- *Prado Park Lake* – Since completion of the Prado Park Lake pipeline reconstruction project[6] in 2017, *E. coli* concentrations during the warm season remain below TMDL numeric targets most of the time. Elevated *E. coli* concentrations are limited to the cool season. Further study is needed to understand the sources that may cause non-compliance during the cool season. Preliminary hypotheses to potentially assess include increased bird activity or prolonged impacts from wet weather inflow to the lake.

2.3.2 Wet Weather Bacteria

As shown in Table 2-3, four grab samples over a 4- or 5-day period comprising a single wet event were parsed into two categories for all sampled wet weather events from 2007 through 2022: (a) active wet weather; or (b) post-storm. *E. coli* concentrations have significantly higher geometric mean concentrations when collected during active wet weather versus being collected under post-storm conditions (**Figure 2-3**). When considering the elevated flow during active wet weather, an even greater difference in fecal bacteria load is expected when compared to post-storm conditions.

Most of the sampled storm events in impaired waters exceed the 0.5 inches of rainfall threshold to trigger a temporary high flow suspension of recreational use and as such would not be subject to treatment. The Basin Plan states that termination of the temporary high flow suspension occurs 24 hours after the end of the storm event.

A more focused analysis of the full set of post-storm samples shows that *E. coli* concentrations decline most sharply within the first 24 hours following a return to a pre-event flow condition for all the impaired waters (**Figure 2-4**). Thus, it is possible that controls implemented to address dry weather *E. coli* loads may also provide significant protection to potential swimmers 24 hours post-storm.

2.4 Compliance with Wasteload Allocations

Tables 2-4 and 2-5 summarize the frequency of compliance with geometric mean and single sample WLAs for *E. coli* (geometric mean maximum: 113 MPN/100 mL; single sample maximum: 212 MPN/100 mL) during dry weather in the 2020, 2021 and 2022 warm seasons and 2019-2020, 2020-2021 and 2021-2022 cool seasons.

[6] A pipeline that carries stormwater under Prado Park Lake was replaced in 2017; this project restored the original MS4 conveyance that ensured that stormwater properly bypasses the lake. During the construction project, the lake was dry.

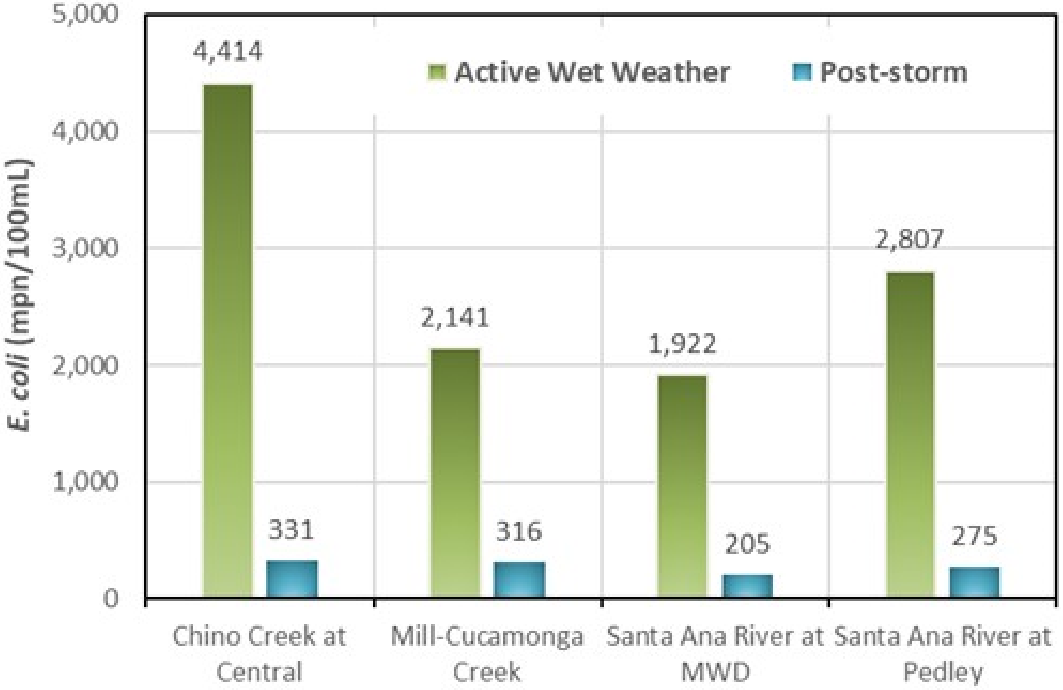

Figure 2-3. Geomean of *E. coli* Concentrations (MPN/100 mL) for Grab Samples during Active Wet Weather and Post-Storm Events (15 storm events 2007-2022)

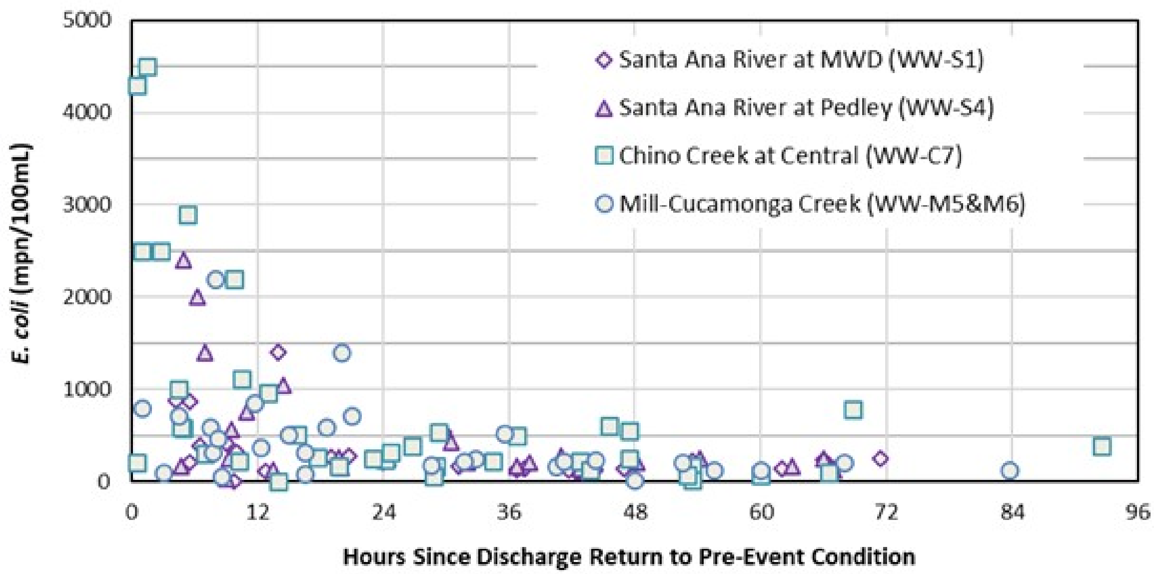

Figure 2-4. *E. coli* Concentrations for All Post-storm Samples Based on the Time Since the Return of Pre-Wet Weather Event Flow Conditions (2007-2022)

Table 2-4. Frequency of Exceedance of WLAs/LAs for *E. coli* during the 2020, 2021 and 2022 Warm Seasons, Dry Weather Conditions Only

Site	Geometric Mean Criterion Exceedance Frequency (%)			Single Sample Value Exceedance Frequency (%)		
	2020	2021	2022	2020	2021	2022
Prado Park Lake	0%	20%	19%	0%	10%	30%
Chino Creek	80%	80%	63%	70%	60%	40%
Mill-Cucamonga Creek	100%	100%	100%	40%	45%	25%
Santa Ana River @ MWD Crossing	100%	100%	100%	40%	85%	95%
Santa Ana River @ Pedley Ave.	87%	73%	50%	35%	50%	30%

Table 2-5. Compliance with WLAs/LAs for *E. coli* during the 2019-2020, 2020-2021 and 2021-2022 Cool Seasons, Dry Weather Conditions Only (Note: Only one geometric mean can be calculated from the five-sample cool season data set – table provides that value)

Site	Geometric Mean Value (Compliance Status)			Single Sample Value Exceedance Frequency (%)		
	2019-2020	2020-2021	2021-2022	2019-2020	2020-2021	2021-2022
Prado Park Lake	355 (Exceeds)	253 (Exceeds)	79 (Complies)	80%	60%	0%
Chino Creek	288 (Exceeds)	792 (Exceeds)	79 (Complies)	80%	80%	17%
Mill-Cucamonga Creek	110 (Complies)	189 (Exceeds)	195 (Exceeds)	80%	40%	50%
Santa Ana River @ MWD Crossing	125 (Exceeds)	200 (Exceeds)	157 (Exceeds)	0%	80%	50%
Santa Ana River @ Pedley Ave.	356 (Exceeds)	223 (Exceeds)	288 (Exceeds)	0%	40%	50%

2.5 Compliance with Load Allocations

2.5.1 Agricultural Dischargers

The MSAR TMDLs contain LAs for discharges from agricultural runoff (see Table 5-9y in the TMDLs or Table 6-1x in the Basin Plan). The TMDL LAs applicable to these sources are the same as the WLAs applicable to discharges of urban runoff including stormwater and CAFOs. The TMDL watershed-wide compliance monitoring program is intended to evaluate compliance with both WLAs and LAs; Section 2.4 above summarizes the status of compliance with these allocations and will not be repeated here.

2.5.2 Natural Sources

The LAs applicable to natural sources of bacterial indicators are also the same as the WLAs (see Table 5-9y in the TMDLs or Table 6-1x in the Basin Plan); and, as noted above, the watershed-wide compliance monitoring program evaluates compliance with all MSAR TMDL WLAs and LAs.

While Section 2.4 above provides the findings from the watershed-wide monitoring compliance program, the MSAR Task Force has periodically assessed contributions from non-urban/agricultural sources of bacteria that may be natural. These previous assessments have suggested that a significant source(s) of unaccounted for bacteria are present in the impaired waters. The following sections summarize these previous findings as well as findings from the most recent analysis completed for this report. The Bacterial Indicator Source Analysis presented in Section 4 below further evaluates the importance of these findings within the context of compliance with the MSAR TMDLs WLAs and LAs.

2.5.2.1 Unaccounted Sources of Bacteria - Previous Findings (2007-2019)

The technical report supporting the adoption of the MSAR TMDLs concluded: (a) open space and wilderness areas were not significant sources of bacterial indicators under the dry weather conditions investigated; and (b) it was unknown if there was survival and reproduction of bacterial indicators in the sediments of the impaired waterbodies and that this lack of information needed to be investigated (Santa Ana Water Board 2005a).

The MSAR Task Force and MS4 Programs have conducted numerous studies since TMDL adoption that have included a bacteria mass balance analysis for the MSAR watershed. These analyses repeatedly suggest that there is a significant pool of "unaccounted for" bacteria in the watershed, i.e., the source is not DWF from urban or agricultural sources. In particular:

- Using data from 2007-2009 (SAWPA 2009), Riverside and San Bernardino County prepared CBRPs that included a bacterial load analysis that demonstrated the potential for "unaccounted for" bacteria in the impaired waters. Potentially of more significance, the CBRP analysis demonstrated that even if upstream MS4s achieved all their targeted load reductions, the receiving waters would still not achieve the *E. coli* WLAs in the MSAR TMDLs (e.g., RCFC&WCD 2011; SBCFCD 2011).
- The 2013 Triennial Report, which updated the bacteria load analysis using a much larger data set, found (SAWPA 2013):

  "Recent analyses of bacterial indicator data from selected watershed-wide compliance sites coupled with an updated compliance analysis from recent Tier 1 source evaluation activities suggest that natural or uncontrollable sources of bacterial indicators may be important contributors to bacterial indicator concentrations at the watershed-wide compliance sites." (Section 4.1, pg. 4-1)

- Similarly, the 2016 Triennial Report observed (SAWPA 2017):

  "[b]y process of elimination, the Uncontrollable Bacteria Sources Study suggested that the majority of E. coli in the impaired waters may be from releases from naturalized colonies in channel bottom sediment and biofilms. Fecal bacteria from a specific host released to the environment can settle to channel bottom and survive within sediments or biofilms for weeks or months over a wide range of temperature and moisture conditions. Growth of these initially deposited fecal bacteria within channel bottom sediments and biofilms results in colonies, where the majority of the population may be considered naturalized, reproducing outside of a specific organism. The BPA [Basin Plan amendment] determined that bacteria regrowth within sediment and biofilm is an uncontrollable source of fecal bacteria. As noted in Section 3.3, additional study would be necessary to better understand the potential for naturalized bacteria colonies to contribute to bacteria concentrations in overlying waters and the transport process by which bacteria is released." (Section 5, pgs. 5-1 – 5-2)

- Most recently, the 2020 MSAR Synoptic Study/Triennial Report made the following findings (SAWPA 2020a):

  "[c]onsistent with the many iterations of the source contribution analyses completed over a number of years, studies have shown that sources of fecal bacteria exist in the MSAR watershed that cannot be attributed solely to MS4 discharges. Historically, the basis for quantifying non-MS4 sources has involved a process of elimination, subtracting measured inflows from the MS4 from measured loads within the receiving waters." (Section 3.1.5, page 3-26)

  "Unidentified non-point sources now account for the majority (77%) of the total bacteria load in the Santa Ana River. As has been demonstrated, based on source analyses completed in 2007, 2012, and now 2019, the Santa Ana River would be in compliance with the TMDL targets and the state's new water quality standards for pathogen indicator bacteria were it not for the excessive loads from these unknown non-point sources which are not conveyed through the MS4." (Section 4.1, page 4-2)

  "Sampling data from Reach 4 of the Santa Ana River shows that bacteria loads from unknown non-point sources contribute about 300 billion MPN/day, which is enough to consume nearly 100% of the total allowable load for E. coli bacteria in the receiving water." (Section 4.1, page 4-2)

Collectively, these various studies demonstrated with increased certainty the significance of "unaccounted for" or potentially "uncontrollable" sources of bacteria in the MSAR watershed.

2.5.2.2 Unaccounted for Sources of Bacteria - 2020-2022 Assessment

DWF in Santa Ana River Reach 3 is almost entirely comprised of tertiary treated effluent from publicly owned treatment works (POTW) located in upstream Reach 4. In this upstream reach, a distinctive condition exists. Above the wastewater facilities, Santa Ana River Reach 4 is generally dry during dry weather conditions. Flow begins in Reach 4 downstream of the Rialto Channel (which discharges treated effluent from the Rialto Wastewater Treatment Plant [WWTP] to the Santa Ana River) and the City of Colton and San Bernardino Rapid Infiltration and Extraction (RIX) facility. Downstream of the RIX facility the flow typically increases to a rate of over 50 cubic feet per second (cfs).

Thorough, regular field observations over the past 15 years have investigated MS4 outfalls along the mainstem of Reaches 3 and 4 of the Santa Ana River and identified no hydrologically connected inflows from MS4s to the river upstream from Box Springs Channel (BXSP) to the dry condition near the Rialto WWTP discharge (distance of 5.7 miles). Barry (2017) showed that this portion of the Santa Ana River is a losing stream (i.e., flow seeps through channel bottom to underlying unsaturated zone) and would be completely dry in its natural condition without the addition of POTW effluent. The existence of this subsurface condition would also make it implausible that a localized source of groundwater contamination (e.g., failing septic systems or leaking sewer pipeline) would contribute to DWF in the mainstem of the Santa Ana River. Thus, 100 percent of the DWF volume at the boundary or transition between Reach 4 to Reach 3 should be attributed to POTW effluent.

Water quality sampling at the Rialto WWTP and RIX has shown consistently no detection of *E. coli* in treated effluent discharged to the Santa Ana River. Thus, any *E. coli* measured within the Santa Ana River below these POTWs is attributed to in-stream sources. Previous Triennial Reports identified a large, unaccounted for load of *E. coli* and hypothesized an in-stream source (Section 2.5.2.1). Routine dry weather sampling at the Mission Boulevard Bridge (WW-MISSION) was incorporated into the TMDL watershed-wide monitoring program (through the RBMP) to better understand bacteria conditions before flow reaches Santa Ana River Reach 3.

Results from 2020-2022 show that *E. coli* concentrations at WW-MISSION exceed the concentration-based LA in 36 of 42 (86%) rolling geomeans in 2020-2022 period (**Figure 2-5**). Considering that DWF from Reach 4 represents the majority of flow volume at downstream TMDL compliance monitoring sites in Reach 3 (WW-S1 and WW-S4), understanding the nature and potential controllability of instream sources of bacteria is critically important in TMDL implementation (Section 4.3.1). This is because existing data strongly suggest that a compliance strategy that focuses only on elimination of all MS4 DWF and associated bacteria load to Santa Ana River Reach 3 would not result in attainment of water quality objectives.

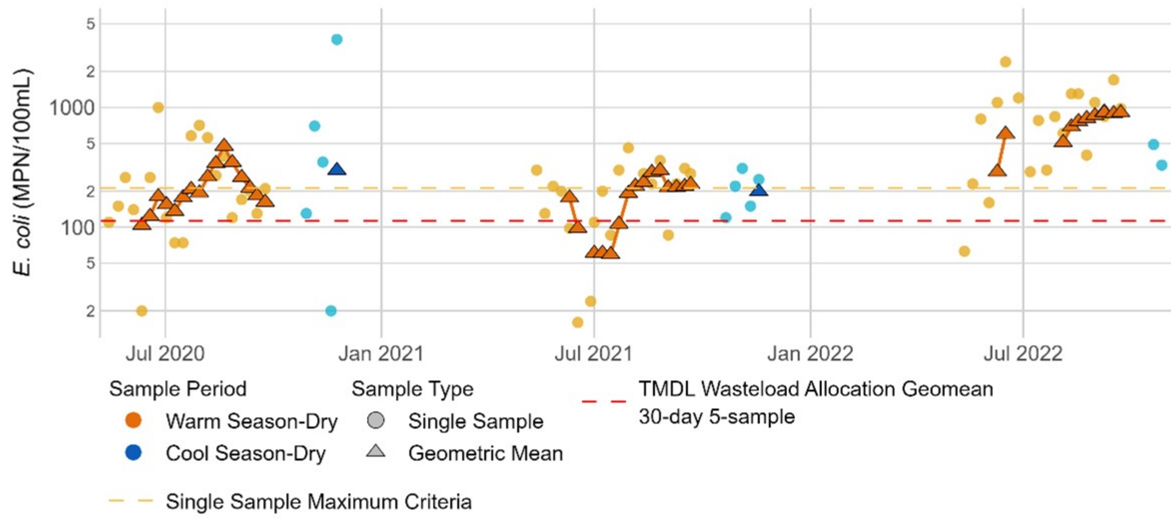

Figure 2-5. Grab Sample and Calculated Rolling Geomeans of *E. coli* Concentration in Santa Ana River Reach 3 at Mission Boulevard Bridge, WW-MISSION (2020-2022)

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3. TMDL Implementation Activities

TMDL implementation activities are regularly carried out by entities with applicable WLAs and LAs, both urban dischargers and agricultural operators. In addition, the MSAR Task Force or SAWPA may authorize additional watershed-wide studies in the MSAR watershed. This section summarizes recently completed or ongoing TMDL implementation activities in the MSAR watershed.

3.1 Watershed-wide Projects

During the 2020-2022 period covered by this report, SAWPA has implemented studies to evaluate potential impacts of homeless encampment activity in the upper Santa Ana River watershed including the MSAR watershed. Findings from this effort resulted in the initiation of follow-up bacteria source analysis in the MSAR watershed. The following sections summarize the findings from work completed to date.

3.1.1 Homeless Encampment Study

SAWPA and its member agencies commissioned a study in 2019 to develop an understanding of homeless encampment activity and potential impacts of this activity on water quality and habitat in the upper Santa Ana River watershed ("Homeless Study"). This study, which included no field data collection, included the following activities:

- Develop a better understanding of potential impacts of homeless encampments on water quality and riparian and aquatic habitat based on an assessment of existing information.
- Identify areas in the upper Santa Ana River watershed where encampments are concentrated.
- Based on the findings from the above activities, prepare a Preliminary Water Quality Monitoring Program for potential implementation by SAWPA. The purpose of the monitoring program would be to gather data from areas within the upper Santa Ana River watershed, where homeless encampments are typically present, to evaluate potential impacts to water quality and aquatic and riparian habitats.

The Homeless Study identified five areas in the upper Santa Ana River riparian channel where homeless encampments were concentrated: Van Buren Bridge upstream to Anza Drain; along the Tequesquite Landfill; above and below the Mission Boulevard Bridge crossing; upstream of the 60 freeway bridge (near the Market Street Bridge); and between the Interstate-215 bridge and Tippecanoe Road (SAWPA 2020b; https://sawpa.org/owow/dci-program/services/owow-dci-assessment-of-homelessness-and-water-quality/).

The five areas identified in the study had two things in common – they were located in areas where the river is flowing during dry weather conditions and there is vegetative cover, including overhead cover in more densely vegetated areas, e.g., in Santa Ana River Reach 3. The Preliminary Water Quality Monitoring Program recommended future monitoring activities focus on three of the five locations: Market Street Bridge crossing (MSB); Mission Boulevard Bridge (MBB) crossing and upstream of the Van Buren Boulevard (VBB) Bridge (**Figure 3-1**).

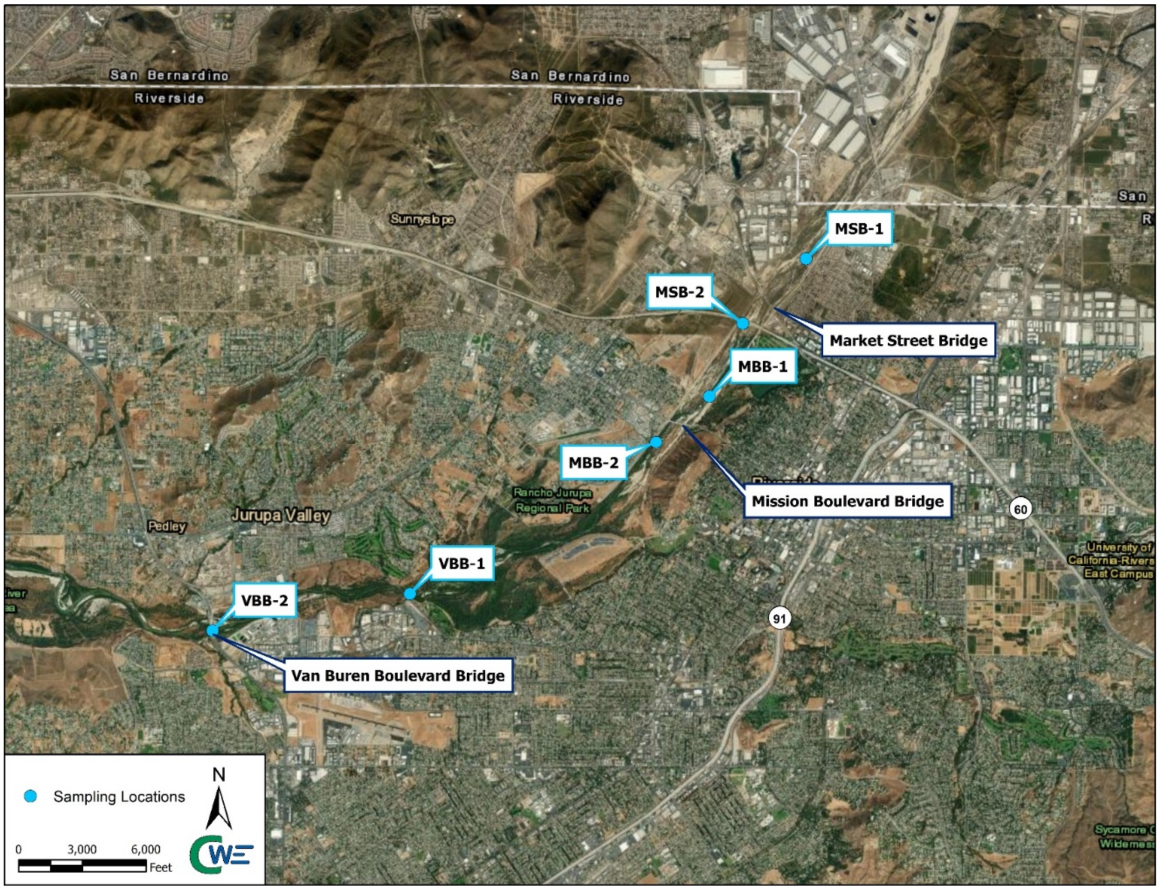

Figure 3-1. Santa Ana River Monitoring Sites for the Study to Evaluate Impacts from Homeless Encampments on Water Quality (MSB = Market Street Bridge; MBB = Mission Boulevard Bridge; VBB = Van Buren Boulevard Bridge) (1= upstream site; 2 = downstream site) (see Figure 2-2 in SAWPA 2022c)

Following completion of the 2020 Homeless Study (SAWPA 2020b), SAWPA in partnership with the RCFC&WCD and SBCFCD authorized the implementation of a study to evaluate potential impacts from three areas of concentrated homeless encampments in the Santa Ana River riparian channel on water quality during dry weather conditions. Data collection included (a) preliminary site visits to finalize selection of upstream and downstream monitoring sites around areas with concentrated homeless encampments and estimate the population of homeless individuals within each monitored area; and (b) completion of four dry weather condition monitoring events. The four events included field measurements, collection of water quality samples to evaluate bacterial indicators and presence of human sources of bacteria, and Rapid Trash Assessments (RTA) (San Francisco Bay Regional Water Quality Control Board [San Francisco Bay Board] 2004). Two events also included collection of water quality samples to evaluate presence of dog and pig sources of bacteria.

SAWPA (2022c) provides the complete findings from the study including information on locations of homeless encampments, water quality results, trash assessments data and photographs from each monitoring site (https://sawpa.org/task-forces/regional-water-quality-monitoring-task-force/#geographic-setting). Following is a summary of key findings.

3.1.1.1 Rapid Trash Assessments

The RTA Worksheet assessment of a site results in a total score that ranges from 0 to 120 and categorization of the site into one of the following four categories: (a) Poor – 0 to 30; (b) Marginal – 31 to 60; (c) Suboptimal – 61 to 90; and (d) Optimal – 91 to 120 (San Francisco Bay Board 2004). All monitoring sites had relatively high levels of trash; monitoring sites located directly downstream of each area of concentrated homeless encampments tended to have higher levels of trash (**Table 3-1**). The monitoring team collected 492.3 pounds of trash over the four dry weather events (Table 3-1). The amount of trash picked up during the January sampling event was lower than the other three dry weather events due to several storms that occurred from mid to late December, causing a lot of the trash to be transported downstream.

Given the amount of trash collected at the monitoring sites, the data strongly suggest that a significant amount of the trash deposited in the Santa Ana Riverbed is a direct result of homeless encampment activities. Moreover, given the consistency of the weight of trash observed from one event to the next, trash is being redeposited over time at a significant rate. **Figure 3-2** summarizes the types of trash typically observed over all sites. Many toxic items, such as chemical containers, spray paint cans, batteries, and cigarette butts were observed in the river bottom. Likewise, biohazardous waste (including human waste/diapers, pet waste and syringes/pipettes) were observed at least once per each monitoring event day.

3.1.1.2 Bacteria-related Water Quality Concentrations

Bacteria concentrations were typically greater downstream of areas of concentrated homeless encampments, but that location-specific trend occurred within the broader Santa Ana River Reach 3 trend of increasing *E. coli* concentrations from the most upstream site (MSB-1) to the most downstream site (VBB-1) (**Figure 3-3**) (similar to upstream/downstream longitudinal trends observed in other studies, e.g., see previous Triennial Reports, e.g., SAWPA 2020a). It was unknown whether this larger trend was related to homeless encampment activity or was it caused by the presence of other sources of bacteria.

Table 3-1. Rapid Trash Assessment Results - Weight (pounds, lbs) and Site Score (see SAWPA 2022c)

Site ID[1]	9/21/2021		10/21/2021		11/18/2021		1/6/2022	
	lbs	Site Score	lbs	Site Score	lbs	Site Score	lbs	Site Score
MSB-1	9.7	70/Suboptimal	6.5	84/Suboptimal	3.9	84/Suboptimal	5.0	75/Suboptimal
MSB-2	16.5	26/Poor	10.5	29/Poor	33.2	28/Poor	15.2	60/Suboptimal
MBB-1	27.9	54/Marginal	37.5	45/Marginal	24.2	53/Marginal	9.0	53/Marginal
MBB-2	35.4	44/Marginal	46.8	39/Marginal	33.7	40/Marginal	8.1[2]	41/Marginal[2]
VBB-1	13.4	44/Marginal	13.0	45/Marginal	3.3	71/Suboptimal	26.8	61/Suboptimal
VBB-2	25.7	37/Marginal	36.5	44/Marginal	40.6	34/Marginal	9.9	53/Marginal
Total	**128.6**	--	**150.8**	--	**138.9**	--	**74.0**	--

[1] #1 = Monitoring site upstream of the homeless encampment area; #2 = monitoring site downstream of the area

[2] On this sample date, the RTA at MBB-2 concluded after eight minutes due to safety concerns by field personnel. A complete RTA takes 15 minutes; therefore, the total pounds of trash at this site is likely about two times higher.

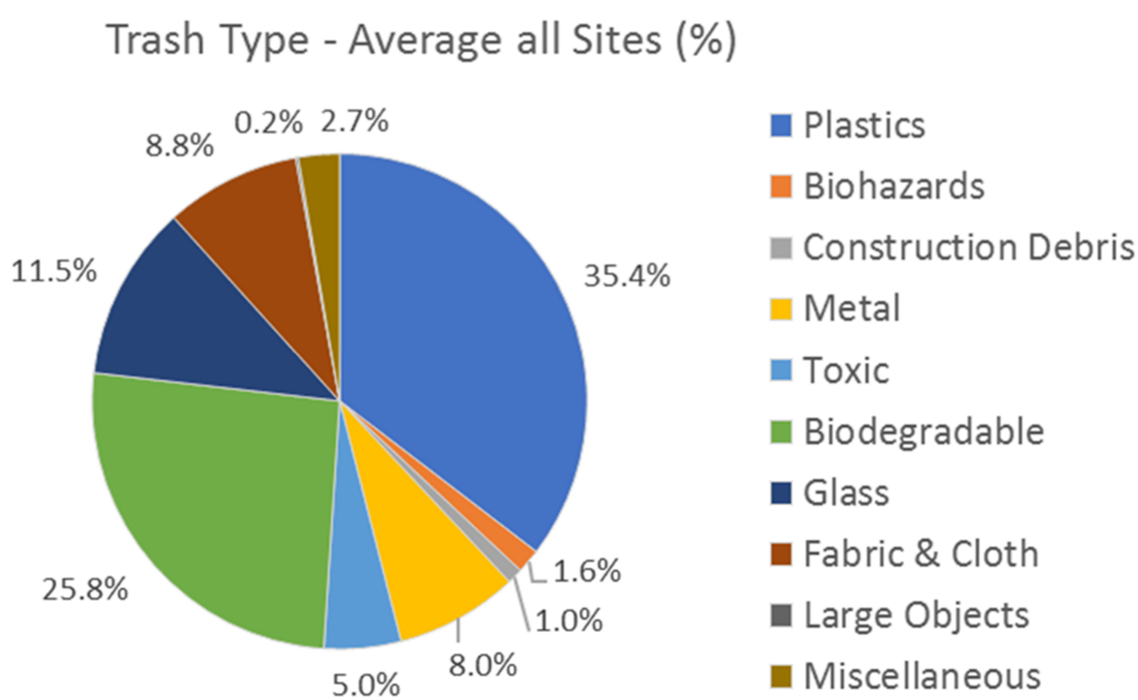

Figure 3-2. Summary of the Average Trash Type Observed at All Sites during the Homeless Encampment Water Quality Study (SAWPA 2022c)

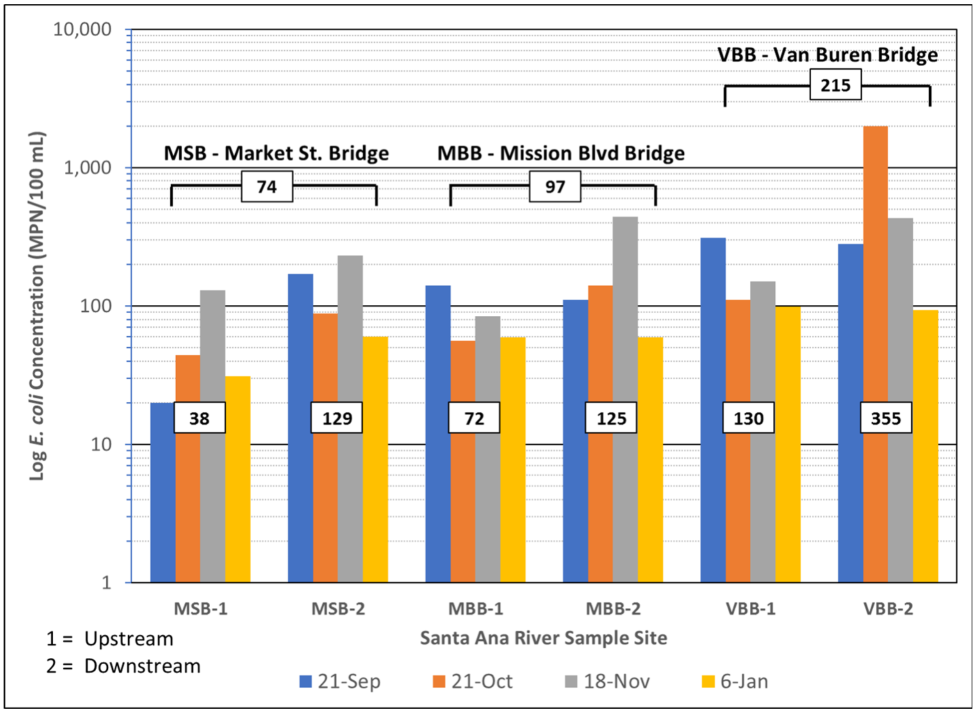

Figure 3-3. *E. coli* Concentrations at Homeless Study Monitoring Sites during Each Dry Weather Event (Bars = monitoring event-specific *E. coli* results; black numbers = median *E. coli* results by monitoring site or monitoring location) (from SAWPA 2022c)

Analyses of bacteria human source marker HF183 suggested that human fecal matter was not an important contributor to increased *E. coli* concentrations from upstream to downstream under dry weather conditions. In addition, the limited water quality analyses conducted to evaluate dogs and pigs as bacteria sources found, (a) dog fecal matter was not an important source of *E. coli*; and (b) pig sources of *E. coli* were important contributors to *E. coli* concentrations at the downstream MBB monitoring site (MBB-2) and at both VBB monitoring sites (VBB-1 and VBB-2). This key finding led to the collection of water quality samples under the RBMP to further evaluate pigs as an important source of *E. coli* in the upper Santa Ana River watershed (See Section 3.1.2 for a summer of findings from this analysis).

3.1.2 Pig Marker Analysis

In 2021, following the completion of two monitoring events for the Homeless Encampment Study (see Section 3.1.1 above), water quality data results consistently indicated only a limited presence of human sources of bacteria Santa Ana River Reach 3, but the concentration of *E. coli* bacteria was steadily increasing from upstream to downstream. Following a discussion with local stakeholders regarding other potential sources of bacteria in the river, two additional bacteria source assays were added to the study:

- *Dogs (DG37 assay)* – Dogs were frequently observed around homeless camps by the monitoring team.

- *Feral pigs (Pig2Bac assay)* – It is well known by local stakeholders that a population of feral pigs resides within the Santa Ana River riparian corridor; accordingly, they may be an important source of fecal bacteria in the impaired waters.[7] Recently, California Department of Fish and Wildlife staff indicated that a significant number of pigs are in the riparian corridor in an area that generally spans from the Riverside Drive Bridge crossing to Prado Basin. These non-native pigs are considered to have a negative impact on the native riparian habitat (Rick Whetsel, personal communication with California Department of Fish and Wildlife staff, September 13, 2022).

Results from two sample events of the Homeless Encampment Study that included the dog and pig assays showed high concentrations of the Pig2Bac marker in all samples collected from downstream of the Mission Boulevard Bridge and at sites upstream and downstream sites Van Buren Bridge. Given the small sample size (n = 12), the MSAR Task Force approved collection of additional samples for Quantitative Polymerase Chain Reaction (qPCR) analysis of the Pig2Bac *Bacteroides* marker concurrent with routine RBMP monitoring at selected TMDL monitoring sites. Samples were collected every other week over the 2022 dry season from the following Santa Ana River sites: WW-MISSION, WW-S1 and WW-S4; and the Mill-Cucamonga Creek site: WW-M6 (see Figure 2-1). Samples were sent to a Weston Solutions Laboratory for qPCR analysis of the Pig2Bac marker (samples have been archived at the laboratory and may be used for additional assays if requested by the Task Force). **Table 3-2** summarizes the results from the Pig2Bac analysis of water samples. The study found that the concentration of *Bacteroides* from feral pigs varies significantly from site to site. Specifically,

- No detections of the Pig2Bac marker were observed at the Mill-Cucamonga Creek (WW-M6) TMDL compliance site.
- Consistent detections (ranging from 295 – 5,322 gene copies (gc)/100 mL) were observed at the Santa Ana River MWD Crossing (WW-S1) and Pedley Avenue (WW-S4) sites, indicating that feral pigs may be a potentially important source of *E. coli* at these sites.
- At the WW-MISSION site, shown to generate the majority of dry weather *E. coli* load to Santa Ana River Reach 3 from an unknown in-stream source (Section 4.3.1), the Pig2Bac marker was only detected in one of 10 samples. The one detection occurred during the final week of sampling after a construction project along the levee in the vicinity of Mission Avenue was initiated. Meanwhile, *E. coli* concentrations were elevated relative to downstream sites in all 10 samples, showing that fresh fecal deposits from feral pigs was not an important source during 2022 contributing to the *E. coli* fecal bacteria load that enters Reach 3 of the Santa Ana River at this location.

[7] Orange County Register (January 14, 2022; updated January 19, 2022) noted that in the 1990s it was estimated that the population of feral pigs likely ranged from 300-400 animals and even at that time pigs have been observed for decades in parts of Riverside County. https://www.ocregister.com/2022/01/14/wild-hungry-pigs-still-rampaging-around-santa-ana-river/

Table 3-2. ***E. coli*** **Concentration (MPN/100 mL) and Pig2Bac Assay (gc/100 mL) Results from MSAR Watershed Sites, May through September 2022 (ND = Non-Detect)**

Sample Date	WW-M6		WW-S4		WW-S1		WW-MISSION	
	E. coli	Pig2Bac	*E. coli*	Pig2Bac	*E. coli*	Pig2Bac	*E. coli*	Pig2Bac
5/12/2022	110	ND	140	795	460	1,072	63	ND
5/26/2022	230	ND	200	438	680	7,629	800	ND
6/9/2022	74	ND	880	1,599	350	3,057	1,100	ND
6/27/2022	86	ND	190	1,161	310	4,099	190	ND
6/30/2022	98	ND	210	962	440	1,843	1,400	ND
7/14/2022	63	ND	340	2,042	280	1,044	780	ND
7/28/2022	41	ND	150	1,692	410	1,364	840	ND
8/11/2022	140	ND	230	1,802	460	2,728	1,300	ND
8/25/2022	180	ND	85	295	270	5,322	1,100	ND
9/8/2022	200	ND	230	1,470	1,100	BDL	840	1,947

3.2 Urban Discharger Activities

3.2.1 CBRP Implementation

All MS4s permitted under the Phase 1 municipal stormwater program are implementing CBRPs to address urban sources of bacteria under dry weather conditions. Per the approving Santa Ana Water Board resolutions, each of the approved CBRPs serves as the final WQBEL for bacterial indicators during the dry season (annually April 1 through October 31) (Santa Ana Water Board 2012a, b; 2014a, b).[8] CBRPs include BMPs to reduce or eliminate bacteria sources in the MS4. Efforts to implement these BMPs are described in the MS4 Permit Annual Reports prepared by each MS4 Program. In addition to the implementation of non-structural BMPs that target bacteria sources (e.g., street sweeping, pet waste programs, etc.), MS4 Programs are also conducting studies to identify bacteria sources or implementing structural BMP projects designed to reduce the discharge of bacteria to impaired waters. The sections below highlight key activities carried out by Phase 1 MS4 Programs during the 2020-2022 period to support compliance with bacterial indicator WLAs.

[8] The Santa Ana Water Board audited the Riverside and San Bernardino County MS4 Program CBRPs between February 13 and May 29, 2018. The audit reports found that these MS4 Programs were in compliance with their respective CBRPs (Santa Ana Water Board 2018a, b).

3.2.1.1 Riverside County MS4 Program

The following sections describe key CBRP implementation activities within Riverside County, including a long-term Tier 2 source investigation occurring in the Magnolia Center Storm Drains subwatershed and construction of the Phoenix Storm Drain Diversion Project.

3.2.1.1.1 Magnolia Center Storm Drain Tier 2 Investigation

The 2019 Tier 1 Synoptic Study gathered data that supported an update to the prioritization of MS4 outfalls for bacteria mitigation work in the MSAR watershed (SAWPA 2020a). Magnolia Center Storm Drain (T1-MCSD) was ranked as the highest priority outfall for Tier 2 follow-up studies to identify sources of bacteria in the subwatershed draining to this Tier 1 outfall. The City of Riverside in collaboration with RCFC&WCD has a Tier 2 source investigation using a bottom-up subwatershed sampling strategy incorporating field measured parameters, collection of *E. coli* data and analysis for presence of HF183 human marker. Samples were collected in 2020 from selected storm sewer junctions downstream of eight large, delineated subareas (A-H) as well as two inflows and an outflow from the Mary Street Detention Basin in the upper part of the subwatershed (**Figure 3-4**).

Table 3-3 provides summary results from the five weekly sampling events in July 2020. Based on the results, it was possible to narrow down the area of concern from the entire T1-MCSD subwatershed of 7,049 acres to a focused area of 1,121 acres (see red-lined area in Figure 3-4). The study also found that the Mary Street Detention Basin does not infiltrate most incoming DWF (losses within basin were ~25 percent), but removes over 95 percent of the influent *E. coli* bacteria load, returning about 0.3 cfs of flow back to the MCSD storm drain system at low bacteria concentrations. Additional details of the 2020 Tier 2 sampling program are available from the City and District.[9]

In 2021, the Tier 2 source evaluation study focused its sampling efforts on the smaller area identified in the 2020 sampling effort (see inset area in Figure 3-4). Samples were collected from five sites in May 2021 all within the vicinity of the Riverside Plaza. Figure 3-4 provides the weekly sample results from each sample location. The City is using the findings from this study to support its ongoing effort to identify and mitigate sources of bacteria, including conducting windshield surveys and outreach to businesses and coordinating with a team of local officials to manage potential impacts from the local homeless population.

[9] More information may be obtained from this stakeholder 2021 PowerPoint presentation to the MSAR Task Force: https://sawpa.org/wp-content/uploads/2021/02/MSAR-Task-Force_Magnolia_SAWPAFinal-Read-Only.pdf

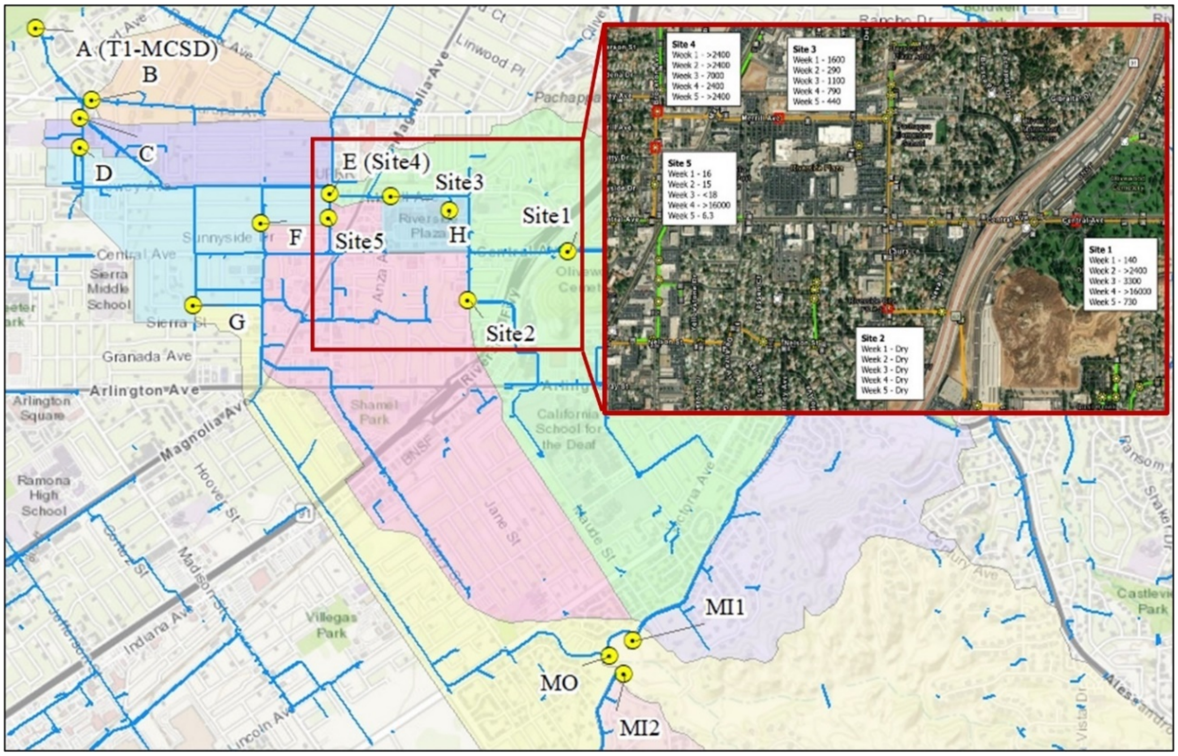

Figure 3-4. Magnolia Center Storm Drain Tier 2 Source Investigation Sampling Sites; Sites A-H, MI1, MI2 and MO represent 2020 sample locations (see Table 3-3 for 2020 results); Sites 1-5 represent the 2021 sample locations within focus area identified from the 2020 data results

Table 3-3. Summary of *E. coli* and *Bacteroides* (HF183) Sample Results at Tier 2 2020 Sample Locations in Magnolia Center Storm Drain Subwatershed

Site Description	Site ID	Average Flow (cfs)	*E. coli* Geomean (MPN/100 mL)	*E. coli* Load (Billion MPN/Day)	Average HF183 Concentration (gc/100 mL)
A. Magnolia Center Storm Drain (T1-MCSD)	364a	1.05	2,269	58	5,884
B. Jurupa Avenue near Grapevine Way	364b	0.06	1,656	2	1,495
C. Correll St. near Jurupa Avenue	364c	0.47	2,224	25	5,816
D. Correll St. near Arborwood Lane	364d	0.07	3,609	6	280
E. Brockton Avenue near Merrill Avenue	364e	0.46	2,565	29	14,678
F. Palm Avenue near Beatty Drive	364f	0.18	72	0.3	264
G. Arch Way near Orange Vista Way	364g	0.51	2,895	36	400
H. Riverside Plaza	364h	0.12	12,200	34	401
Mary St. Inlet 1	MI1	0.09	443	1	324
Mary St. Inlet 2	MI2	0.29	2,023	14	323
Mary St. Outlet	MO	0.28	43	0.3	299

3.2.1.1.2 Phoenix Storm Drain Diversion

The Phoenix Avenue Storm Drain DWF diversion project was completed in July 2021. This project is the first stormwater-diversion-to-sewer project in Riverside County and will serve as a pilot project for additional future diversions to comply with MSAR TMDL WLAs. This project, led by the City of Riverside working in collaboration with the District, was implemented with the goal of minimizing bacteria levels in the MSAR. Studies found significantly elevated concentrations of *E. coli* bacteria at the Phoenix Avenue Storm Drain outfall to the Santa Ana River Reach 3; accordingly, it was identified as a high priority for a DWF mitigation project. The constructed diversion project prevents bacterial indicators in dry weather urban runoff that drains from a 578-acre residential area from discharging to the Santa Ana River near Martha Mclean Anza Narrows Regional Park. The project now diverts up to 1 cfs of DWF into a nearby sewer line. The District continues to work with various water districts and treatment facilities to address urban runoff discharges from MS4 outfalls that may be addressed with a similar storm drain to sewer diversion project.

3.2.1.2 San Bernardino County

The following sections describe key CBRP implementation activities within San Bernardino County, including Tier 2 source investigations in the Cucamonga Creek subwatershed and constructed regional treatment facilities: Chris Basin and MCW.

3.2.1.2.1 Tier 2 Source Investigation in Cucamonga Creek Subwatershed

For six years, SBCFCD has collected weekly fecal bacteria samples over a 10 consecutive week period under dry weather conditions from the Cucamonga Creek subwatershed. Samples are collected at various sites to evaluate bacteria source loads and guide implementation of the CBRP. A single Tier 1 site (T1-CUCAMONGA) is located at the Hellman Road crossing upstream of the WW-M6 TMDL compliance monitoring site on Mill-Cucamonga Creek. **Figure 3-5** illustrates the location of Tier 2 sample sites upstream of the Tier 1 site. In addition, samples have been collected at key locations within the Cucamonga Creek subwatershed to assess bacteria removal resulting from downstream regional BMPs (Chris Basin and MCW) and the potential importance of inputs from two small drains in the City of Eastvale (Lines A and B). **Table 3-4** summarizes key bacteria data sources illustrated in Figure 3-5 and other data sources used to support the analysis.

Summary of Dry Weather Flow Conditions

The dry weather hydrologic condition of the investigated segment of Cucamonga Creek is distinctive in that it is typically an effluent-dominated waterbody with extreme temporal variability in flow rate. This variability is caused by: (1) variable recycled water demand from Regional Water Recycling Plan No. 1 (RP-1) within the Inland Empire Utilities Agency (IEUA) system; and (2) regular operation and maintenance (O&M) activities requiring dewatering and/or temporary closure of diversions to the upstream Turner Recharge Basins

(Figure 3-5). Overall, the observed fluctuations in flow rates exceed those expected from diurnal fluctuations resulting from typical indoor water use patterns.

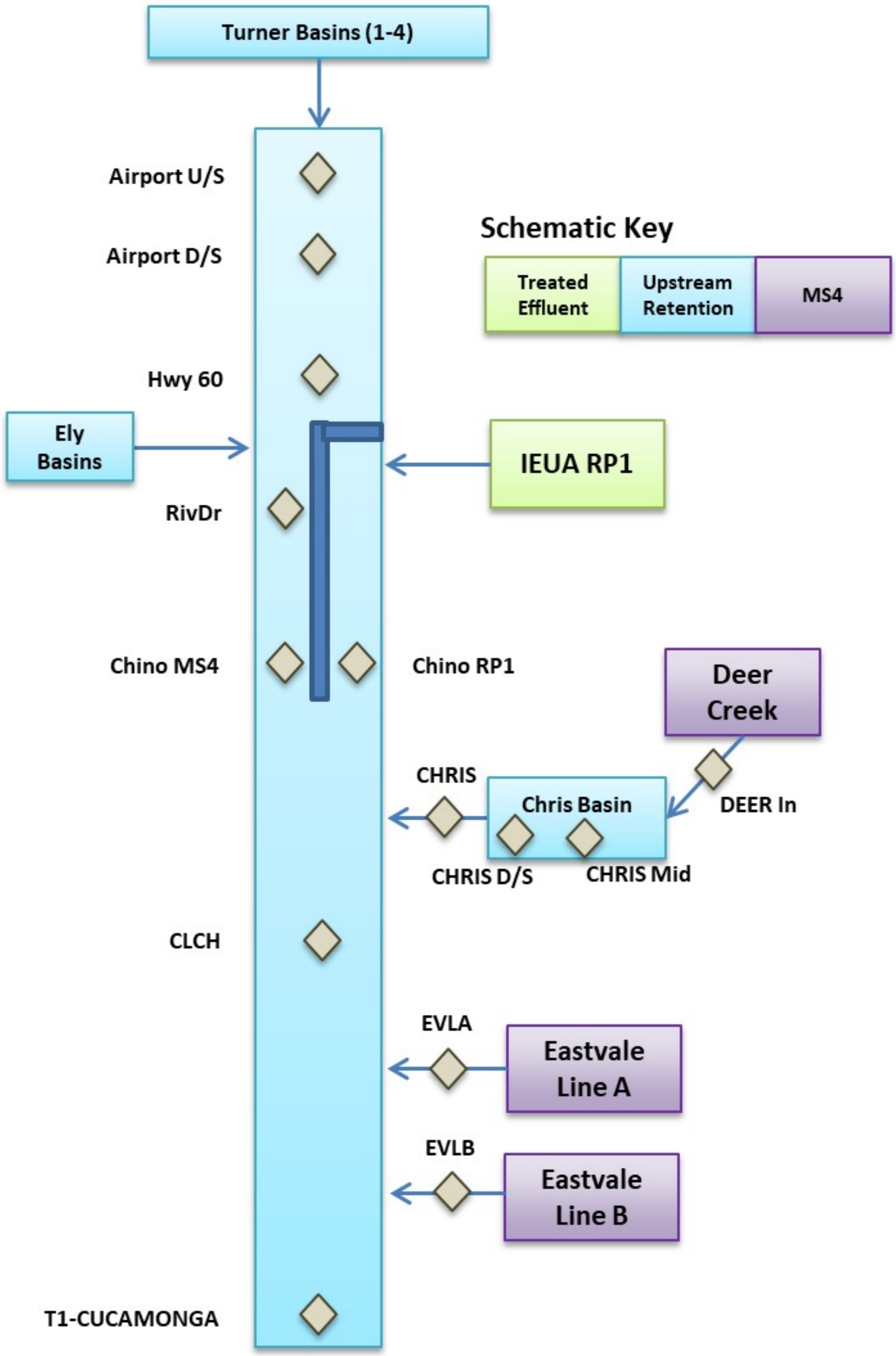

Figure 3-5. Tier 2 Sampling Locations in Cucamonga Creek Subwatershed (see Table 3-4 for additional information)

Table 3-4. Summary of Data Sources (2017-2022) Used to Support Tier 2 Source Investigation in the Cucamonga Creek Subwatershed

Data Type	Source	Locations (See Figures 3-5 and 4-8)
E. coli Concentration and Flow Measurement	SBCFCD 10-week Studies[1]	Airport U/S, Airport D/S, Hwy 60, RivDr Chino MS4, Chino RP-1, DEER In, CHRIS Mid, CHRIS D/S, CHRIS, CLCH, T1-CUCAMONGA[1], BASEFLOW, MCW IN, MCW OUT
	RBMP	P4-SBC1[2], WW-M6[3]
	RCFC&WCD	EVLA, EVLB
RP-1 Flow	IEUA	RP-1
Recharge Basins	IEUA	Turner 1-4 and Ely Basins
In-stream Flow	USGS	Cucamonga Creek at Merrill Ave (Station# 11073495)

[1] BASEFLOW, MCW IN AND MCW OUT sites are downstream of T1-CUCAMONGA (see Figure 4-8)

[2] Co-located sites, upstream side of Hellman Avenue Bridge: T1-CUCAMONGA, HELLMAN, and P4-SBC1

[3] TMDL compliance monitoring site downstream of T1-CUCAMONGA in Mill-Cucamonga Creek (see Figure 4-8)

Figure 3-6 shows the reported daily effluent discharged from RP-1 to Cucamonga Creek. This discharge ranged from 0 to 18 cfs on dates when Tier 2 bacteria source evaluation sampling was being conducted. Thus, flow in Cucamonga Creek is usually effluent-dominated, while at times the flow is comprised predominantly of urban dry weather runoff from MS4s. These sources of flow have very different expected bacteria concentrations, especially given that the tertiary treated RP-1 effluent is disinfected prior to discharge to Cucamonga Creek.

Regular O&M activities at IEUA's Turner Basins occurred concurrent to Tier 2 source investigations during all 10 sampling weeks in 2020 and part of 2021. These O&M activities resulted in periods of flow bypass or dewatering which significantly increased the measured rate of DWF at the Airport Upstream (Airport U/S) Tier 2 sampling location (Figure 3-5). Measured DWF averaged 4.1 cfs during periods when the Turner Basins were offline or actively dewatering; in contrast, the DWF rate averaged 0.5 cfs during periods when the Turner Basins completely captured all dry weather runoff.

In addition to the known sources of DWF variability associated with RP-1 and Turner Basins, there are other potential causes of temporal variability in DWF within Cucamonga Creek that could impact flow in Cucamonga Creek. These include flows contributed by well blow-offs, releases from other downstream recharge basins (e.g., Ely Basins) or runoff from fire-fighting-related activities.

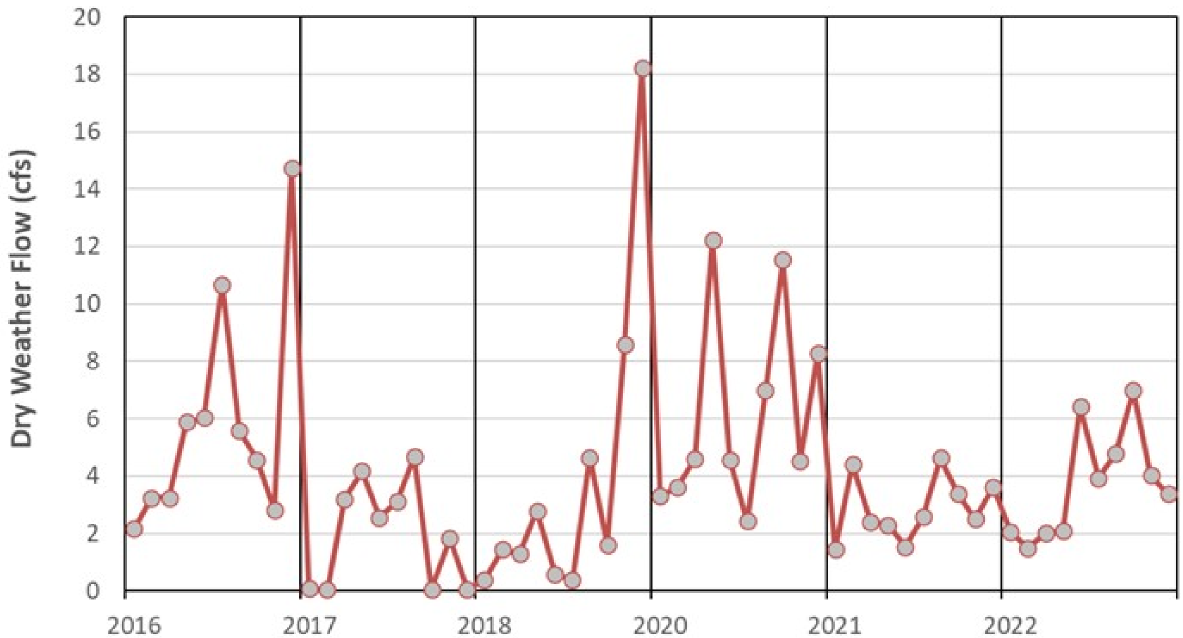

Figure 3-6. Daily Effluent Flow (cfs) from RP-1 to Cucamonga Creek on Dates Concurrent with Tier 2 Source Investigation Sampling

Given these sources of DWF variability, a large dataset is needed to characterize the wide range of flow and bacteria conditions that can occur with different operational and environmental factors. SBCFCD's long-term Tier 2 dataset from this watershed now includes 50 sample dates from over six dry season periods (2017-2022). Findings from this comprehensive dataset are summarized in the following sections.

Summary of Bacteria Loads during Dry Weather Conditions

Table 3-5 presents summary bacterial indicator statistics from the six years of data collection. Sites listed in the table (rows) are ordered from upstream to downstream. Results from the downstream TMDL compliance monitoring site on Mill-Cucamonga Creek (WW-M6) are from sampling performed during the same 10-week periods when SBCFCD was also conducting its Tier 2 source investigations, though not necessarily on the same sampling dates.

Given the factors described above that result in significant sub-hourly temporal variability in DWF rate, it is nearly impossible to collect bacterial indicator data in such a way as to achieve a water balance over the course of a synoptic sampling event. Thus, evaluations of specific source areas were completed using summary statistical metrics, specifically the median and range of the 25th to 75th percentiles of bacterial load.

Table 3-5. Summary of *E. coli* Sample Results in Cucamonga Creek Subwatershed, Tier 2 Source Investigations (2017-2022) (see Figures 3-5 and 4-8 for site locations)

Site	No. of Samples (Period)[1]	*E. coli* Geomean (MPN/100 mL)	Median Flow (cfs)	Median *E. coli* Load (MPN/Day)
Airport U/S	50 (2017-2022)	33	0.2	0.2
Airport D/S	50 (2017-2022)	454	0.2	2.3
Hwy 60	50 (2017-2022)	45	0.6	1.1
RivDr	50 (2017-2022)	207	3.3	26.1
Chino MS4[2]	50 (2017-2022)	310	3.0	38.2
Chino RP-1[2]	50 (2017-2022)	45	0.8	1.2
DEER In	70 (2017-2022)	108	0.5	7.6
CHRIS Mid[3]	40 (2020, 2022)	216	0.8	8.5
CHRIS D/S[3]	40 (2020, 2022)	439	0.6	4.0
CHRIS	50 (2017-2022)	996	1.0	32.1
CLCH	50 (2017-2022)	257	7.7	91.7
EVLA[4]	10 (2020)	2,068	0.05	3.0
EVLB[4]	7 (2020)	3,526	0.01	0.2
T1-CUCAMONGA[5]	50 (2017-2022)	434	6.6	102.1
BASEFLOW	50 (2017-2022)	478	5.5	66.4
MCW IN	50 (2017-2022)	632	2.5	37.3
MCW OUT	50 (2017-2022)	80	0.7	1.1
WW-M6[6]	55 (2017-2022)	200	6.5	38.8

[1] Summary data is based on sampling during dry season only

[2] Curb separating MS4 flow from RP-1 effluent terminates at Chino Avenue; samples are collected prior to the two sources of flow mixing

[3] Includes samples collected during second round in afternoon on synoptic sampling event days, no other Tier 2 sites were sampled in afternoons (e.g., CHRIS outfall to Cucamonga Creek based on samples only collected in morning hours only)

[4] Samples collected from MS4 outfall; not within mainstem of Cucamonga Creek. Three sampling events were dry at EVLB in the 2020 dry season Tier 2 investigation by RCFC&WCD

[5] Also known as HELLMAN or P4-SBC1

[6] Sampling dates are from the same 10-week period as the Tier 2 source investigation dates but are not necessarily on the same sampling date as those collected for the Tier 2 study

Figure 3-7 plots the results for each mainstem Cucamonga Creek sampling site along a longitudinal profile (x-axis provides the distance upstream of the TMDL compliance monitoring site, WW-M6). The longitudinal profile portrays changes to the load of bacteria within the channel as flows come into the creek from upstream of Ontario Airport (just downstream of the Turner Basin dry weather diversion) to the downstream TMDL compliance monitoring site. Generally, the *E. coli* load rises as new bacteria sources come into the creek that exceed bacteria losses from natural decay. While a significant reduction of *E. coli* load (~60 billion MPN/day) between T1-CUCAMONGA and the TMDL compliance monitoring site at WW-M6 is shown in the figure, the cause of the apparent reduction is unclear and could be due to differences in sampling dates for the Tier 2 and RMBP programs or represent removal of bacteria within the Mill Creek Wetlands (see Section 3.2.1.2.3).

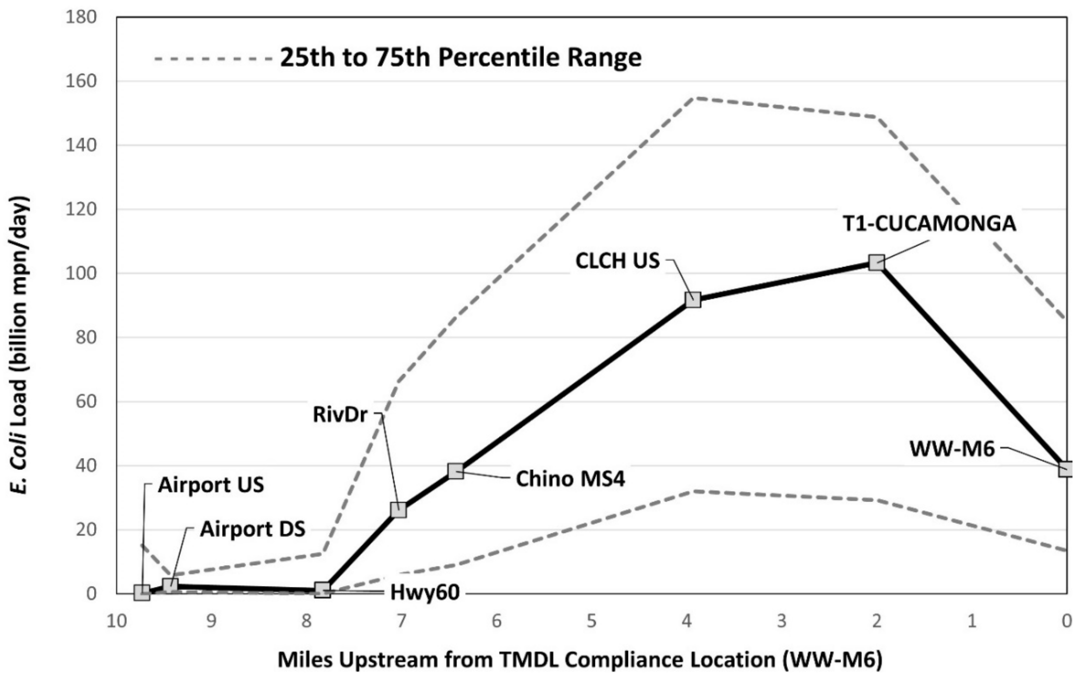

Figure 3-7. Longitudinal Profile of Dry Weather *E. coli* Load within Cucamonga Creek (n = 50; 2017-2022, see Figures 3-5 and 4-8 for site locations)

Potential Sources of Bacteria in Subwatershed

The data collected were used to evaluate a hypothesis about a potential source of *E. coli* in Cucamonga Creek: are naturalized bacteria scoured due to changes in flow from RP-1a notable source of bacteria in the downstream, main stem channel? Discharge of RP-1 treated effluent could facilitate colonization of *E. coli* on the channel bottom by providing a consistently wet habitat and a source of food. When the effluent discharge rate increases (as it can on an hourly basis), naturalized *E. coli* are scoured from the channel bottom and transported downstream. This hypothesis was evaluated by comparing sample results from Tier 2 site, Chino RP-1 with downstream data results. The Chino RP-1 site, located about 1 mile downstream of the POTW effluent discharge location, represents bacteria loading from only this source of flow. Analysis shows that any *E. coli* loads mobilized by scouring at Chino RP-1 represent about 1 percent of the total *E. coli* load measured at the downstream locations CLCH and Tier 1 site (T1-CUCAMONGA). Furthermore, given the relatively low *E. coli* concentrations at Chino RP-1 (geomean of 45 MPN/100 mL), the discharge of treated effluent has a dilution effect and likely improves downstream water quality.

Based on this analysis, a hypothesized source of scoured naturalized bacteria was not observed, i.e., naturalized bacteria from the RP-1 side of the divided channel were not an important source of bacteria at CLCH or T1-CUCMONGA. Moreover, concentrations of dissolved organic carbon (DOC) at Chino RP-1 (average 5.8 mg/L, range 4.7 – 7.5 mg/L), a potential source of food for bacteria, are typically below the estimated threshold to cause a shift from a condition of bacteria decay to bacteria colonization. Surbeck et al. (2010) has reported that this shift may occur when DOC is greater than 7 mg/L.

Loading analyses were also performed to compare all upstream sources of bacteria with the bacteria load measured at the downstream Tier 1 site (T1-CUCAMONGA) to assess whether there is a condition of net bacteria decay or growth within Cucamonga Creek. As illustrated by Figure 3-7, a significant rise in the median *E. coli* load was observed from 38 to 103 billion MPN/day over the 4.5 mile segment of Cucamonga Creek from Chino Avenue (Chino MS4) downstream to Hellman Avenue (T1-CUCAMONGA). Sources of bacteria include urban runoff from key MS4 tributaries (Chino MS4, CHRIS, EVLA, EVLB) and RP-1 effluent (however, as discussed above RP-1 does not appear to be an important source). If more bacteria load is measured downstream than can be accounted for from all the inflow sources, then an in-stream bacteria source may be important and should be investigated. Water quality controls that can effectively reduce this source of loading could have profound benefits to water quality at the Tier 1 site and further downstream within Mill-Cucamonga Creek.

Using the available data collected from 2017-2022, the loading analysis shows that measured inflows do not account for all of the measured bacteria load downstream. **Figure 3-8** shows that 28.5 billion MPN/day of the measured load (~28%) are due to unmeasured sources, some of which could be attributed to instream sources, indicating the potential importance of instream sources in this subwatershed. Potential instream sources include:

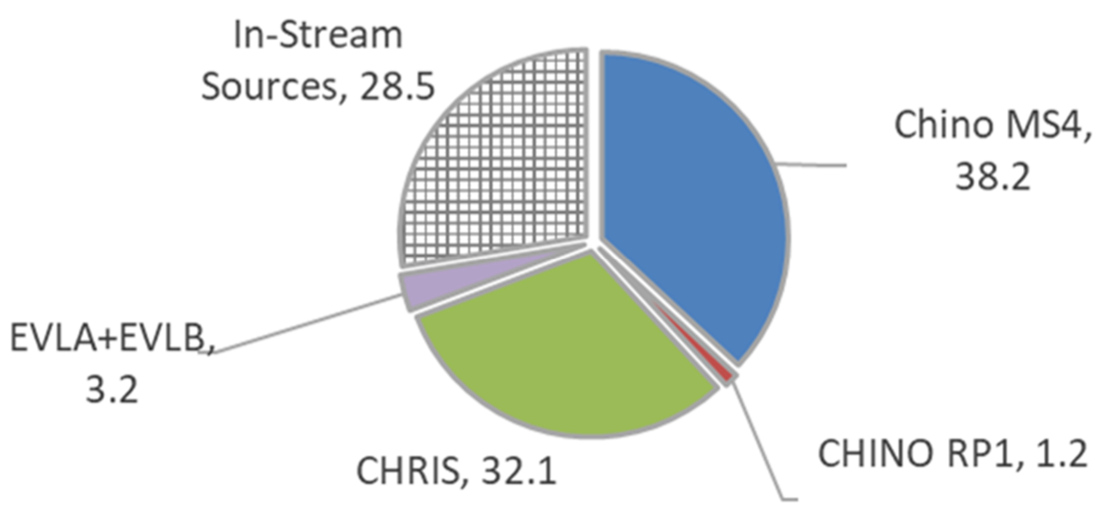

Figure 3-8. Estimated Dry Weather *E. coli* Loads (billion MPN/day) from Potential Sources Upstream of the Tier 1 Site T1-CUCAMONGA

- *Regrowth* – Surbeck et al. (2010) conducted 18 laboratory microcosm experiments on surface runoff and storm drain flow from a similar area on Cucamonga Creek and observed a more frequent condition of net *E. coli* regrowth than a condition of *E. coli* decay. The research estimated an average growth rate for *E. coli* in the microcosms of 0.3 hr^{-1} where net growth was observed. This growth rate was used to approximate whether the estimated in-stream load of *E. coli* of 28.5 billion MPN/day (estimated by mass balance from 2017-2022 data) could be attributed to regrowth within the 4.5-mile segment of Cucamonga Creek during dry weather. Based on DWF velocity observations, the time of travel within this segment of Cucamonga Creek is estimated to be ~3-5 hours. Given this residence time, it is possible that regrowth could explain at least some of the estimated in-stream load of 28.5 billion MPN/day.

- *Wildlife* - The 2015 Uncontrollable Bacteria Sources Study (RCFC&WCD 2016) included a series of special studies investigating different in-stream sources of fecal bacteria. *Bacteroides* markers associated with birds were the most frequently detected wildlife source across several studies. A large population of nesting swallows was observed underneath the Schleisman Avenue Bridge over Cucamonga Creek. Samples were collected upstream and downstream of this bridge and analyzed for *E. coli* and *Bacteroides* markers for birds (presence/absence). While no difference was observed between the upstream/downstream sites around the bridge, bird fecal matter was detected in 70 percent of all samples (9 of 10 upstream and 5 of 10 downstream), indicating the potential for birds to be a source of fecal contamination in local waters. Additional study would be needed to determine their overall contribution. Newer Microbial Source Tracking (MST) methods are now available and could be employed to further evaluate this potential source – not just in Cucamonga Creek but other waterbodies as well.

3.2.1.2.2 Chris Basin Water Quality Retrofit

Chris Basin is a large flood control facility that captures all runoff from the Lower Deer Creek subwatershed during dry and wet weather conditions. The underlying soils have low permeability, thus captured flows are detained and discharged to Cucamonga Creek. During dry weather conditions, urban runoff travels through Chris Basin within a naturally carved low-flow channel that cuts across the center of the basin from Deer Creek inflow to the outflow to Cucamonga Creek.

SAWPA (2009) identified the outfall from Chris Basin to Cucamonga Creek as a high priority Tier 1 site for subsequent investigation. Subsequently, a concept to construct a wetland treatment system within the bottom of Chris Basin to enhance bacteria removal during dry weather was developed (SAWPA 2010b). This option was determined to be infeasible due to the need to provide capacity during extended periods of wet weather inundation when the basin is used for flood control. Working with the appropriate agencies, including the Santa Ana Water Board and California Fish and Wildlife, a project was developed to reconstruct the bottom of Chris Basin to create a longer meandering low-flow channel to increase the hydraulic residence time to increase the potential for bacteria removal by ultraviolet radiation. The planned project was completed in 2022.

SBCFCD conducted monitoring of fecal bacteria in Chris Basin influent and effluent prior to construction (2020-21) and following construction (2022) as part of its ongoing Tier 2 source investigations. Three sampling sites were selected upstream from the outfall of Chris Basin to Cucamonga Creek (T2-CHRIS): inflow from Deer Creek to Chris Basin (DEER In); a mid-basin location (CHRIS Mid); and a sample at the outflow structure (CHRIS D/S) (**Figure 3-9**).

Data collected during both pre- and post- project construction monitoring showed a rise in *E. coli* loads from the Deer Creek inflow to the outflow to Cucamonga Creek in the majority of paired samples, i.e., median *E. coli* loads measured below Chris Basin were significantly greater than *E. coli* loads entering Chris Basin (**Figure 3-10**). Thus, based on the first year results from post-construction sampling, the effort to increase hydraulic residence time, potentially to reduce fecal bacteria, has not resulted in a reduction in *E. coli* load from Chris Basin. Additional study may be warranted to assess the specific source of fecal bacteria within Chris Basin and how project effectiveness could be improved.

An interesting finding came from SBCFCD's vision to increase understanding of bacterial dynamics by collecting samples not only in the morning as routinely done, but also in the afternoon. Accordingly, in 2020 and 2022, a second round of samples from the Chris Basin Tier 2 sites was collected in the afternoon to assess potential changes in *E. coli* loads over the course of a day. Results showed (a) a significantly reduced load of *E. coli* entering Chris Basin the Lower Deer Creek subwatershed in the afternoon relative to the morning; and (b) the observed increased load of bacteria coming from within Chris Basin was also reduced in the afternoon (Figure 3-10). Given these findings, the MSAR Task Force could consider shifting sampling schedules to assess whether a similar diurnal variability in *E. coli* loads occurs at other Tier 1 MS4 sites across the MSAR watershed. Such a finding could greatly affect the evaluation of compliance with TMDL targets in other areas of the watershed.

3.2.1.2.3 Mill Creek Wetlands

MCW is a seven cell, 52-acre, surface wetland complex that treats a portion of dry and wet weather runoff from Cucamonga Creek. A diversion structure in the west bank sidewall of Mill-Cucamonga Creek captures a portion of the total flow, while the undiverted flow remains within the mainstem of Mill-Cucamonga Creek to support riparian habitat (**Figure 3-11**). Tier 2 sampling sites are located at the inflow and outflow from the MCW as well as upstream and downstream of the diversion.

Figure 3-9. Changes to the Low-Flow Channel Configuration in Chris Basin (Pre- and Post-Construction) and Tier 2 Sampling Locations (2020-2022)

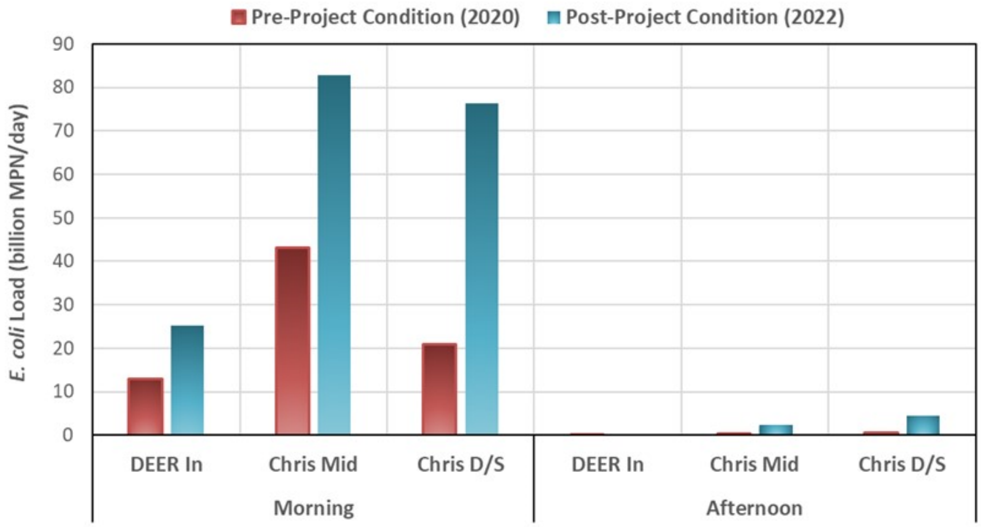

Figure 3-10. Median *E. coli* Load Measured at Inflow, Middle, and Outflow Structure in Chris Basin Based on Samples Collected in the Morning (left) and Afternoon (right) for Pre-Project (red) and Post-Project (blue) Conditions (2020-2022; see Figure 3-5 for site locations)

Figure 3-11. Sampling Locations to Assess Effectiveness of the Mill Creek Wetlands

Monitoring of the influent and effluent flows and bacterial loads demonstrated an over 95 percent reduction in *E. coli* load within MCW (**Table 3-6**). Some of the achieved *E. coli* load reduction is associated with volume mitigation from losses associated with infiltration or evapotranspiration. A reduction in the concentration in the outflows to levels below the TMDL WLAs were consistently observed. This return of treated effluent with lower *E. coli* concentration helps to reduce concentrations within Mill-Cucamonga Creek at the compliance monitoring location, and has resulted in improved water quality at WW-M6 in recent years (e.g., see Figure 2-2). Further reductions toward the concentration based WLA could be achieved by maximizing the amount of DWF that can be diverted and treated in the wetlands.[10]

Table 3-6. Estimate of Reduction in *E. coli* Load Resulting from Implementation of the Mill Creek Wetlands BMP, 2017-2022 (n = 50)

Mill Creek Wetlands	Median Flow (cfs)	*E. coli* Geomean Concentration (MPN/100 mL)	*E. coli* Load (Billion MPN/Day)
Influent	2.5	632	38.5
Effluent	0.7	80	1.4
Median Removal (%) in MCW	71%	88%	96%

3.2.1.3 City of Claremont

The City of Claremont continues to enforce and implement the stormwater control measures specified in the Los Angeles Regional Phase I MS4 National Pollutant Discharge Elimination System (NPDES) Permit, Order No. R4-2021-0105, which acknowledges the 2013 MSAR Bacterial TMDL agreement between the Los Angeles and the Santa Ana Regional Water Quality Control Boards. As such, the City will continue to implement the programs and BMPs in its CBRP, in addition to the structural and non-structural BMPs identified in the East San Gabriel Valley Watershed Management Program (ESGVWMP). On June 30, 2020, the ESGVWMP group submitted its revised Watershed Management Plan and Reasonable Assurance Analysis (RAA) to the Los Angeles Regional Water Quality Control Board and is awaiting final approval of the documents. The revised ESGVWMP identifies a number of regional projects and BMPs that will have a positive impact on both the East San Gabriel Valley (ESGV) and MSAR portions of the City.

[10] An existing streambed alteration permit specifies that 15 cfs of flow must be maintained within the mainstem of Mill-Cucamonga Creek, however the streambed agreement predates IEUA's recycled water system as well as capture of dry weather runoff in the Turner Basins, and involved an empirical analysis based on higher downstream flows during dry weather than are typically observed in modern conditions (average DWF during Tier 2 sampling periods at T1-CUCAMONGA in 2017-2022 was 9 cfs).

The City continues to observe site T2-CLARM, as part of our ongoing coordinated monitoring efforts for the MSAR and ESGV monitoring programs. The stormwater control measures identified in the revised ESGVWMP and the monitoring performed in accordance with our Coordinated Integrated Monitoring Program (CIMP) will result in water-quality improvements in both the ESGV and MSAR portions of the City of Claremont.

3.2.1.4 City of Pomona

The City of Pomona is the lead agency in the ESGV watershed for implementing the CIMP. This program is implemented to assess the City's compliance with water quality requirements and measure/improve the effectiveness of implementation of the NPDES Permit, Watershed Management Plan and CIMP programs. This included monitoring outfalls, reporting, and assists with adaptive management of the programs.

The City of Pomona is in its design phase in implementing the Pedley Spreading Grounds project which would increase infiltration for water quality and supply. This project will assist Claremont by diverting flows from the north neighborhood above baseline from a pipe formerly plugged by cement, enhancing groundwater recharge. Several outreach meetings have occurred in providing information to the public as well as receiving feedback.

The City has installed trash capture devices to fulfill the Statewide Trash Provisions Track 1 requirements in over 200 of our priority land use catch basins. These devices are maintained by a small crew who regularly inspect and clean the catch basins selected by priority.

The Fairplex storm water capture project is still in planning and the City is anticipating it will go for bid and award for design. This project will divert storm water from Thompson Creek and Los Angeles County Flood Control District flowing into an infiltration system. This system will consist of diversions, conveyance pipes, pretreatment, and solids removal that shall serve a full capture system to remove debris from the diverted flows.

The City of Pomona continues to contract with CASC for inspections on new development/ redevelopment as well as affirming good stormwater practices conducted from our commercial and industrial sites. A recently completed project is The Myrtle Apartments, which is located in the Chino Creek subwatershed. The project was completed in May 2022 and acts as on-site retention with a drainage area of 1.99 acres and a Storm Water Quality Design Volume (SWQDv) of 0.13.

3.2.2 Small MS4s

3.2.2.1 University of California Riverside

The Phase II Small MS4 Permit requires UC Riverside to either participate in an existing TMDL monitoring program or implement its own monitoring program that is adequate to determine attainment with the dry and wet season WLAs. UC Riverside fulfills this monitoring requirement through its participation in the MSAR Task Force. The MS4 Permit also requires UC Riverside to either develop an FBRP or participate in an existing MSAR watershed-based bacterial reduction plan, e.g., CBRP. Accordingly, UC Riverside submitted its FBRP to the Santa Ana Water Board on September 26, 2022.

The submitted FBRP, which describes how the UC Riverside campus, including all agricultural areas on the west side of the campus, is complying with the dry season WLAs in the MSAR TMDLs, was required to address six specific elements (State Water Board 2017, see Attachment G). These six elements and how they were addressed in the FBRP are described as follows:

1. *The specific BMPs implemented to reduce the concentration of indicator bacteria from the facility and the water quality improvements expected to result from these BMPs.*

   The FBRP includes a characterization of the campus' DWF hydrology that demonstrates that the UC Riverside campus contributes no indicator bacteria that affects downstream water quality during dry weather conditions. In addition, the FBRP describes the existing campus dry weather urban runoff management program, identifies potential campus sources of DWF and the BMPs being implemented to reduce or eliminate these sources, e.g., through implementation of good housekeeping and pollution prevention practices, sanitary sewer overflow program and restrictions on outdoor washing activities. In addition, the FBRP describes how UC Riverside actively manages trash and transient encampment activity to minimize these potential sources of indicator bacteria not just during dry conditions but wet weather conditions as well.

2. *Any specific regional treatment facilities and the locations where such facilities will be built to reduce the concentration of indicator bacteria discharged from the facility and the expected water quality improvements to result when complete.*

   The FBRP does not propose development of any specific regional treatment facilities to reduce concentrations of indicator bacteria during dry season or dry weather conditions. However, for wet weather, UC Riverside's long-range planning goals and objectives for stormwater management include the transition of campus lands to manage stormwater in a manner that replicates natural drainage patterns, promotes infiltration, and allows plants and soil to remove pollutants from stormwater runoff. These features also serve to capture any dry season urban runoff if it occurs. There are currently several relatively large green infrastructure basins in campus arroyo drainage areas providing retention and infiltration capacity that may be improved in the future to (a) manage DWF onsite within the Gage Detention Basin to accommodate up to 8,670 cubic feet/day demand, and (b) meet design requirements for Certified Multi-Benefit Trash Treatment Systems. In addition to other environmental benefits, these systems remove pollutants such as trash and bacteria from stormwater runoff. Future improvements to green infrastructure basins are expected to result in significant water quality improvements during wet weather conditions.

3. *The technical documentation used to conclude that the FBRP, once fully implemented, is expected to achieve attainment of either the dry season or wet season urban WLA for indicator bacteria by the specified attainment date.*

   The FBRP characterized DWF hydrology within the UC Riverside jurisdictional area relative to its place in the MSAR watershed. The FBRP concludes that the UC Riverside campus is currently in compliance with the dry weather WLA established in the MSAR TMDLs and is not contributing bacteria to impaired Reach 3 of the Santa Ana River. This finding is based on UC Riverside's analysis of sources of DWF, campus green infrastructure retention and infiltration capacity and the connectivity of its drainage system to downstream impaired waters during dry weather conditions. Specifically, DWF entering the campus storm drain system is retained and infiltrated within campus green infrastructure areas. Any significant DWFs, e.g., such as might occur from a potable water main break, would either be contained in the University Wash MS4 system, or if any water were to leave the UC Riverside campus, it would either infiltrate within a section of dry channel in the Box Springs Channel MS4 system or it would be captured in Lake Evans.

4. *A detailed schedule for implementing the FBRP. The schedule must identify measurable and verifiable milestones to assess satisfactory progress toward meeting the dry and wet season WLAs.*

   Compliance with the WLAs will continue through implementation of UC Riverside's urban runoff management program under its MS4 Permit. The FBRP summarizes the specific urban runoff management practices being implemented within the UC Riverside Phase II Small MS4 jurisdiction to reduce or eliminate dry weather runoff. This plan also describes the long-range policies, goals and objectives for future land use related to water conservation and stormwater management that will ensure continued compliance with the dry season WLA.

5. *The specific metric(s) that will be established to demonstrate the effectiveness of the FBRP.*

   Through its MS4 Annual Report, UC Riverside will provide a summary of its annual BMP activities and any specific actions taken to reduce or eliminate sources of dry weather urban runoff from its jurisdiction. This summary will be reported in the TMDL Implementation Status Report and will include metrics described in Section 4 of the FBRP.

6. *Detailed descriptions of any additional BMPs planned, and the time required to implement those BMPs, in the event that data from the watershed-wide water quality monitoring program indicate that water quality objectives for indicator bacteria are still being exceeded after the FBRP is fully implemented.*

As noted above, the FBRP's characterization of campus DWF hydrology demonstrated that there is no expectation that UC Riverside will contribute indicator bacteria to downstream impaired waters during dry weather conditions. Thus, any observed exceedances of water quality objectives for indicator bacteria observed in Santa Ana Reach 3 through the TMDL watershed-wide water monitoring program would not be caused by dry weather urban runoff from lands within UC Riverside's jurisdiction. Therefore, the FBRP did not document any additional planned BMPs.

3.2.2.2 Other Small MS4s

The Small MS4 General Permit (State Water Board 2017, Attachment G) includes MSAR TMDL implementation requirements for three additional facilities: California Institute for Men (Chino, CA); California Institute for Women (Chino, CA); and California Rehabilitation Center (Norco, CA). These entities are not participants of the MSAR Task Force; no information is available on TMDL implementation activities being carried out by these facilities to comply with the Small MS4 Permit TMDL requirements.

3.3 Agriculture Dischargers

The following sections summarize the status of implementation of TMDL requirements as established by the MSAR TMDLs (Santa Ana Water Board 2005b) and as required by other regulatory actions, e.g., General Orders.

3.3.1 CAFOs

The number of CAFOs has been declining steadily since the adoption of the TMDLs in 2005 (**Table 3-7**). When the TMDLs were adopted the TMDL Staff Report stated that Chino Dairy Preserve in the MSAR watershed had more than 300,000 animal units (Santa Ana Water Board 2005a), down from the 320,000 reported in the 1999 CAFO General Order (Santa Ana Water Board 1999; also, see Table 3-7). As of 2021 the number of animal units had declined to approximately 54,000, a reduction of more than 80%. The number of dairies is expected to continue to decline in the future (Pat Boldt, personal communication, November 2022).

The TMDLs assign WLAs to CAFOs that are the same as the WLAs assigned to urban dischargers (see Section 1.1) (Table 5-9x in Santa Ana Water Board 2005b). TMDL Table 5-9y established TMDL implementation requirements applicable to "Agricultural Operators," including CAFOs (Santa Ana Water Board 2005b). Represented by the Milk Producers Council (MPC) and Chino Basin Watermaster (CBW), CAFOs have completed the following TMDL implementation requirements:

- *Task 3: Watershed-wide Bacterial Indicator Monitoring Program* – CAFOs have complied with the requirement to implement a monitoring program and prepare triennial assessment reports through their participation on the MSAR Task Force.

Table 3-7. Changes in Number of Dairies and Animal Units in Chino Basin Area of the Santa Ana Region, 1999 – 2021 (NA = Not Available)

Year	Dairies	Animal Units	Source
1999	297	320,000	Santa Ana Water Board 1999; Order 99-11
2005	NA	300,000	TMDL Staff Report (Santa Ana Water Board 2005a)
2007	137	185,000	Santa Ana Water Board 2007; General Order (R8-2007-0001)
2010	116	135,560	Personal communication, Pat Boldt (November 2022)
2013	99	116,000	Santa Ana Water Board 2013; General Order R8-2013-0001
2018	84	78,000	Santa Ana Water Board 2018c; General Order R8-2018-0001
2020	68	67,946	Personal communication, Pat Boldt (November 2022)
2021	56	54,117	Personal communication, Pat Boldt (November 2022)

- *Task 5.1: Develop and Implement Bacterial Indicator Agricultural Source Evaluation Plan* – CAFOs, along with other agricultural stakeholders, submitted an AgSEP to the Santa Ana Water Board on November 28, 2007 (SAWPA 2007b); it was subsequently approved on April 18, 2008 (Resolution No. R8-2008-0044). The AgSEP included a wet weather monitoring program for implementation during the wet season of 2009-2010. The findings from this monitoring activity were reported in the 2010 TMDL Triennial Report (SAWPA 2010a).

- *Task 5.2: Develop and Implement Bacterial Indicator Agricultural Source Management Plan* - The 2013 CAFO General Order (Santa Ana Water Board 2013; R8-2013-0001, II.B.2.a.iii.d) stated:

  "Based on the annual evaluation of the monitoring results and the source evaluation report, the Dischargers in the Middle Santa Ana River Watershed shall develop and submit for approval by the Regional Board or Executive Officer an Agricultural Bacterial Source Management Plan by December 31, 2014."

  Consistent with the TMDL Implementation Plan, the BASMP was required to include, at a minimum, the following:

  (1) Description of tasks for completing a detailed evaluation of bacterial indicator sources and discharge pathways associated with CAFO operations;

  (2) Specific steps that the Dischargers have taken or will take to achieve compliance with the CAFO wet weather wasteload allocations by December 31, 2025;

(3) Description of specific ' best management practices that have been implemented or will be implemented to reduce the discharge of wastes containing bacteria associated with CAFO operations to surface waters;

(4) Description of any improvements needed to the design, construction, operation and maintenance of waste containment facilities at CAFOs to minimize accidental discharge of wastes from waste containment facilities;

(5) Description of any additional good housekeeping practices needed at CAFO facilities to minimize the discharge of any runoff, including precipitation, from the production areas to surface waters;

(6) Description of specific metrics that will be used to demonstrate the effectiveness of the Plan and acceptable progress toward meeting the CAFO wasteload allocations for bacterial indicators by December 31, 2025; and

(7) Schedule for completing the tasks described in the Plan.

The final BASMP was submitted to the Santa Ana Water Board in December 2014 (CBW Agricultural Pool 2014). This document was prepared on behalf of all agricultural operators in the MSAR watershed except "citrus growers and nurseries in the Arlington Greenbelt Area, with the exception of Altman Plants" (CBW Agricultural Pool 2014, see section prior to the table of contents). Per the BASMP, the agricultural operators not covered by the BASMP would comply with TMDL requirements separately from the other agricultural operators in the watershed.

For CAFOs, compliance with the dry weather condition WLAs is accomplished through implementation of the prohibition against discharge of any DWF from a permitted facility (see BASMP Section 2.3.1; CBW Agricultural Pool 2014). Per the current CAFO General Order these discharge prohibitions are found in Section II.A (Santa Ana Water Board 2018c; R8-2018-0001).

For wet weather conditions, the Section II.B.1 of the CAFO General Order establishes Technology-based Effluent Limitations that limit the discharge of stormwater from dairy facilities. In particular, CAFO General Order requires that discharges of waste in stormwater runoff from production areas (as defined in Attachment G of the Order) and in process wastewater are authorized only under the following conditions (II.B.1.b): Containment structures have been designed, constructed, operated and maintained to contain all manure, litter, process wastewater, and the runoff and the direct precipitation from all rainfall events up to and including a 25-year, 24-hour rainfall event from the production area.

3.3.2 Non-CAFOs

The TMDL LAs apply to non-CAFO agricultural land uses including both irrigated and dry land farming. These LAs are the same as the WLAs applicable to urban dischargers and CAFOs (see Section 1.1) (Table 5-9x in Santa Ana Water Board 2005b). The TMDL implementation tasks applicable to CAFOs (Tasks 3, 5.1 and 5.2) are also applicable to these agricultural operators (see Section 3.3.1 for a description of these tasks).

The BASMP provided an analysis of non-CAFO agricultural land use in the MSAR watershed, in particular in relation to the potential discharge of DWF to receiving waters (CBW Agricultural Pool 2014). Based on 2012 land use data, the analysis found that the total effective acreage[11] of non-CAFO agricultural land use in the MSAR watershed was approximately 9,200 acres or just 1.9 percent of the total MSAR watershed (746 square miles).

Non-CAFO land use is declining in the MSAR watershed. While the total reduction in this land use between the time of TMDL adoption, 2005, and 2022 is difficult to estimate, it is known that just between years 2010 and 2018 the acreage decreased 19% (Pat Boldt, personal communication, November 2022). Of the remaining effective acreage of non-CAFO agricultural land use in the MSAR watershed, about half is located within the IEUA management boundary and half is located outside. Areas within the IEUA boundary are more likely to continue to transition to urban land uses in the future because much of this acreage is owned by developers and only being leased for agricultural use.

Because the area of non-CAFO agricultural land use is small, any contributions of bacterial indicators during dry weather conditions is likely to be limited. However, the potential does exist. In 2017 the MSAR Task Force conducted a preliminary bacteria and flow source investigation in the Arlington Area of Riverside County. This study found that grove irrigation from agricultural land uses in the Arlington Greenbelt area was contributing a part of the flow and bacteria to the MS4 (SAWPA 2018; also see Appendix B.6).

Non-CAFO agricultural operators in coordination with dairy industry representatives (MPC and CBW) completed the relevant required Phase 1 TMDL implementation tasks in a timely manner (Task 5.1 – AgSEP; Task 5.2 - BASMP; see Section 3.3.1 for more information about the purpose/content of these TMDL deliverables). As noted above, the BASMP was prepared on behalf of all agricultural operators in the MSAR watershed except “citrus growers and nurseries in the Arlington Greenbelt Area, with the exception of Altman Plants” (CBW Agricultural Pool 2014). Also as noted in the BASMP, the agricultural operators not covered by the BASMP would comply with TMDL requirements separately from the other agricultural operators in the watershed.

[11] Areas of MSAR watershed that are not hydrologically disconnected from a downstream receiving water. Hydrologically-disconnected areas are drainage areas that do not typically cause or contribute to flow to a downstream TMDL watershed-wide compliance monitoring location. DWF may be hydrologically disconnected from receiving waters because of constructed regional retention facilities or through losses in earthen channel bottoms, where the recharge capacity of the underlying soils exceeds dry weather runoff generated in the upstream drainage area.

4. Bacterial Indicator Source Analysis

The MSAR TMDL Task Force regularly updates the source contribution analysis for each of the impaired waters: Santa Ana River Reach 3, Mill-Cucamonga Creek and Chino Creek. The objective of the source contribution analysis is to compare measured bacteria loads from known sources of flow to impaired water (e.g., Tier 1 MS4 outfalls and POTW effluent) with downstream measured loads at the TMDL compliance monitoring sites.

4.1 Summary of Previous Studies

4.1.1 Tier 1 Prioritization and Tier 2 Source Investigations

Through CBRP implementation, MS4s collect DWF and bacterial indicator data from sites that discharge directly to an impaired water (Tier 1 sites). Comprehensive data collection activities at Tier 1 locations over periods of consecutive weeks was previously conducted under dry weather conditions in 2007-2008, 2012 and 2019. Subsequently, the MSAR Task Force used these data to estimate bacteria loads and in conjunction with microbial source data (presence of human marker, *Bacteroides*) and potential for exposure to recreators, Tier 1 subwatersheds were prioritized for follow-up Tier 2 source investigations. SAWPA 2009, SAWPA 2014 and SAWPA 2020a document the resulting prioritized sites. **Table 4-1** illustrates how site prioritization has changed over time.

Table 4-1. Summary of High Priority Tier 1 Sites for Subsequent Tier 2 Studies

Tier 1 Dataset	Report	Highest Priority Tier 1 Sites for Tier 2 Investigation
2007-2008	SAWPA 2009 (see Figure 5-30 in report)	• Box Springs Channel (BXSP) • Chris Basin • Cypress Channel
2012	SAWPA 2013 (see Figure 3-8 in report)	• Eastvale Line D (EVLD) • Eastvale Line E (EVLE) • Cypress Channel • Eastvale Line B (EVLB) • Anza Drain • Cucamonga Creek at Airport Dr. • Lower Deer Creek (Chris Basin) • San Sevaine Channel • Eastvale Line A (EVLA) • Chino Creek (Pomona MS4) • Boys Republic South Channel
2019[1]	SAWPA 2020a (see Figure 3-32 in report)	• Magnolia Center Storm Drain • Sunnyslope Channel • Anza Drain

[1] Sites with outfalls downstream of TMDL compliance monitoring sites (EVLD, EVLE, and Cypress Channel) and upstream of Cucamonga Creek at Hellman Avenue (T1-CUCAMONGA) were not included in the 2019 Synoptic Study.

The MSAR Task Force completed the first Tier 1 MS4 outfall source investigation in 2007-2008. SAWPA (2009) reports the findings from this data collection effort, which were used to establish the first set of high priority sites for subsequent investigation under the USEP (SAWPA 2007a). Twenty site visits were made to each of 13 sites during dry weather conditions. Flow measurements and water quality samples (for analysis of fecal indicators and human, bovine and dog markers) were collected when DWF was present. The results were used to approximate a load reduction needed from urban runoff sources to result in compliance with the TMDL WLAs. The load reduction target was translated into a target DWF reduction from each MSAR subwatershed. These findings were incorporated into CBRPs as a compliance metric (RCFC&WCD 2011; SBCFCD 2011).[12] Subsequent Tier 2 investigations led to the detection and elimination of human waste sources in Box Springs Channel (storm/sanitary sewer cross connection) and studies of Chris Basin and Cypress Channel (SAWPA 2010b, c and 2011; see Appendix B.2).

In 2012, the MSAR Task Force in coordination with the CBRP inspection programs being implemented by the MS4 Programs implemented a comprehensive Tier 1 source evaluation program that included DWF measurements and water quality sample collection from 34 MS4 outfalls to impaired waterbodies over ten consecutive weeks. Tier 1 source evaluations were conducted during the dry season at sites in San Bernardino, Riverside and Los Angeles County MS4 sites. The large number of sites visited represented all MS4 drainages to downstream impaired waterbodies in the MSAR watershed. The results updated the prior source contribution analysis included in the CBRPs and prioritization of subwatershed for subsequent Tier 2 source evaluations (SAWPA 2013; also see Table 4-1).

The third iteration of bacterial source data collection was conducted over a six-week period from July to September 2019. This study sampled all known Tier 1 sites with DWF upstream of TMDL compliance monitoring sites.[13] The results were once again used to refine the prioritization of drainage areas for subsequent Tier 2 source investigations (Table 4-1). SAWPA (2020a) provides the findings from the bacterial source contribution analysis. Follow-up Tier 2 source investigations in the MSAR watershed are discussed in Section 3 of this report.

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[12] For example, see Table 3-4 *in* https://www.sawpa.org/wp-content/uploads/2018/04/2011_CBRP_Riverside-County-MS4-Program.pdf *and* https://www.sawpa.org/wp-content/uploads/2018/04/2011_CBRP_San-Bernardino-County-MS4-Program.pdf

[13] Sites with outfalls downstream of TMDL compliance monitoring sites (EVLD, EVLE, CYP) were not included in the 2019 Synoptic Study. Sites that were categorized as Tier 1 in 2012 discharging to the concrete lined segment of Cucamonga Creek were reclassified as Tier 2, and thereby not included in the 2019 Synoptic Study. More rigorous Tier 2 sampling occurred at these outfalls to Cucamonga Creek in 2017-2022 as described in Section 3.2.1.2.1 above.

4.1.2 Review of Microbial Source Tracking Study Findings

MST studies since 2007 have investigated potential sources of bacteria loads within the watershed (**Table 4-2**). Based on the pooled dataset of samples collected within impaired waters (2007-2022), most samples analyzed for human, dog, cattle (or rumen) and horse *Bacteroides* markers have been found to be non-detect or amplified below detection limit (BDL) (e.g., RCFC&WCD 2016). In contrast, detections of bacterial source markers for feral pigs in Reach 3 of the Santa Ana River and birds in all impaired waters have been observed (Table 4-2) (e.g., 2022 Pig Marker Sampling).

For the few human detections involving qPCR, concentrations of HF183 were low (< 100 gc/100 mL) relative to a recent study that estimates a threshold of 525 gc/100mL is correlated to a risk of gastrointestinal illness of 32/1000 for swimmers (Boehm and Soller 2020). Thus, illness risk posed to swimmers in Reach 3 of the Santa Ana River during dry weather conditions may be considered as meeting thresholds used in USEPA recreational water quality criteria.[14] Gedalanga et. al. (2019) collected data on HF183 marker during wet weather within Reach 3 of the SAR in the 2018-2019 wet season. Frequent human detections at concentrations ranging up to 10,000 gc/100 mL were found at multiple sites along the Santa Ana River during wet weather. Thus, wet weather watershed runoff brings new sources of human associated fecal contamination to the receiving waters that are not present during dry weather and could result in a condition that poses greater risk to downstream swimmers. Further study will be needed understand sources of human associated fecal contamination that come from the larger watershed during wet weather.

Table 4-2 also summarizes MST studies conducted at Tier 1 sites (MS4 outfalls) and Tier 2 sites (locations upstream of outfalls in MS4 drainage systems). Over 650 samples from MS4s tributary to impaired waters have been analyzed for human sources since 2007. These data have been integral to the prioritization of subwatersheds for more rigorous source investigation work. In addition to human sources, other host organisms have been analyzed at various times in DWF including dog, bird, cow, horse, chicken, and other ruminates.

4.2 New Data to Support 2023 Source Contribution Analysis

For this 2023 Triennial Report, the previous bacteria source contribution analysis (SAWPA 2020a) has been updated to account for additional DWF and bacteria indicator data collected during the 2020-2022 dry seasons. New source contribution data were primarily acquired through implementation of Tier 2 source evaluations implemented by MS4 Permittees as part of CBRP implementation. In addition, routine dry weather monitoring at the Santa Ana River Mission Boulevard site (WW-MISSION) provided an important source of new information for the updated source contribution analysis applicable to Santa Ana River Reach 3.

[14] Various documents developed by USEPA: https://www.epa.gov/wqc/recreational-water-quality-criteria-and-methods

Table 4-2. Summary of Findings from Historical MST Analyses Conducted in the MSAR Watershed, 2007-2022

<table>
<tr><th>Study (Reference)</th><th>Period of Data Collection</th><th>Host Species</th><th>Method</th><th>No. of Sites</th><th>No./Type of Events</th><th>Key Findings</th></tr>
<tr><td>2022 Pig Marker Sampling (this report)</td><td>May – September 2022</td><td>Pig</td><td>qPCR</td><td>4</td><td>10 Dry</td><td>• Detection in 9 of 10 samples at WW-S1, WW-S4; detections range from 300 to 5300 gc/100 mL
• All non-detect at WW-M6
• 1 detection of WW-MISSION</td></tr>
<tr><td rowspan="3">Homeless Encampment Study (SAWPA 2022c)</td><td rowspan="3">September – January, 2021-2022</td><td>Human</td><td>qPCR</td><td>6</td><td>4 Dry</td><td>• 6 of 24 samples with amplification below detection (< 100 gc/100 mL)
• Field observation of human feces on ground within riparian area</td></tr>
<tr><td>Pig</td><td>qPCR</td><td>6</td><td>2 Dry</td><td>• Persistent detections downstream of Mission Boulevard Bridge and upstream downstream of Van Buren Bridge sites; detections range from 100 to 27,000 gc/100 mL
• All samples non-detect at Market Street Bridge site</td></tr>
<tr><td>Dog</td><td>qPCR</td><td>6</td><td>2 Dry</td><td>• 1 of 12 samples with amplification below detection (< 100 gc/100 mL)</td></tr>
<tr><td>Magnolia Center Storm Drain Tier 2 Investigation (this report)</td><td>2020</td><td>Human</td><td>qPCR</td><td>11</td><td>5 Dry</td><td>• 27 of 50 samples detected above 100 gc/100 mL
• Results facilitated focus Tier 2 follow-up via a bottom-up investigative strategy</td></tr>
<tr><td>Synoptic Study (SAWPA 2020a)</td><td>July – September, 2019</td><td>Human</td><td>qPCR</td><td>23</td><td>6 Dry</td><td>• Amplification below detection in 22 of 42 samples from 7 sites within impaired waters, one sample at WW-MISSION above detection at 100 gc/100 mL
• Of the 85 samples in the synoptic study (collected from 16 Tier 1 or Tier 2 sites):
  – Amplification below detection observed in 17 of 85 samples
  – Detection with quantification above 10 gc/100 mL in 8 of 85 samples. These 8 samples included:
    o 6 of 6 samples collected at T1-MCSD
    o 2 of 6 samples collected at T1-BXSP
  – Quantification above 525 gc/100 mL[1] in 2 of 85 samples – both collected at T1-MCSD
• No correlation to E. coli concentration for samples within impaired waters
• Significantly higher E. coli concentration in Tier 1 or 2 samples with presence of human marker than without</td></tr>
<tr><td>University California Fullerton Study (Gedalanga et al. 2019)</td><td>2018-2019</td><td>Human</td><td>qPCR</td><td>5</td><td>3 Dry; 2 Wet</td><td>• Frequent detection
• Range 100 to 10,000 gc/100 mL</td></tr>
</table>

Table 4-2. Summary of Findings from Historical MST Analyses Conducted in the MSAR Watershed, 2007-2022

Study (Reference)	Period of Data Collection	Host Species	Method	No. of Sites	No./Type of Events	Key Findings
Transient Encampment Cleanup at Market St (RCFC&WCD 2016)	2015	Human	PCR	2	3 Dry	All non-detect
		Dog	PCR	2	3 Dry	Detected in 2 of 6 samples; detections occurred in samples with < 10 MPN/100 mL *E. coli*
Uncontrollable Source Study (RCFC&WCD 2016)	2015	Human	PCR	6	13 Dry	All results non-detect
		Bird	PCR	16	8 Dry	• Detection in 24 of 40 samples from focused bird study • Detection in 12 of 24 samples collected from within SAR Reach 4 downstream from RIX discharge (non-MS4 segment) • No correlation to *E. coli* in either bird or natural focus studies
		Dog	PCR	6	7 Dry	Detected in only 1 of 60 samples
		Rumen	PCR	4	3 Dry	All non-detect
		Horse	PCR	6	2 Dry	All non-detect
Tier 2 Source Assessment (SAWPA 2014)	2013	Human	PCR	53	20 Dry	Detected in 6 of 135 samples from within MS4 systems of various cities (Eastvale, Riverside, Jurupa Valley, Chino, Chino Hills, Ontario, Fontana, Pomona, Claremont)
		Dog	PCR	11	3 Dry	Detected in 8 of 18 samples from Chino and Chino Hills MS4
		Cow, bird, horse, chicken, rumen	PCR	3	1 Dry	Fontana MS4 samples; all non-detect
Tier 1 Source Evaluation (SAWPA 2013)	2012	Human	PCR	34	10 Dry	• 41 of 196 samples at MS4 outfalls with presence of human *Bacteroides*, results used to support prioritization of Tier 1 sites • Significantly higher *E. coli* concentration in Tier 1 MS4 outfall samples with presence of human marker than without
Bacterial Indicator TMDL Analysis (SAWPA 2009)	2007-2008	Human	PCR	13	217 Dry	• 39 of 217 samples at MS4 outfalls with presence of human *Bacteroides*, no correlation to *E. coli* concentration • Results used to support first prioritization of sites in CBRP
		Dog	PCR	13	217 Dry	Detection in 73 of 217 samples, no correlation to *E. coli* concentration
		Rumen	PCR	13	217 Dry	Detection in 45 of 217 samples, no correlation to *E. coli* concentration

[1] Estimated concentration of HF183 gene/copies per 100 mL that may relate to 32 per 1000 risk of illness for swimmers - based on laboratory studies of samples spiked with raw sewage of unknown age (Boehm and Soller 2020)

4.3 New Data to Support 2023 Source Contribution Analysis

For this 2023 Triennial Report, the previous bacteria source contribution analysis (SAWPA 2020a) has been updated to account for additional DWF and bacteria indicator data collected during the 2020-2022 dry seasons. New source contribution data were primarily acquired through implementation of Tier 2 source evaluations implemented by MS4 Permittees as part of CBRP implementation. In addition, routine dry weather monitoring at the Santa Ana River Mission Boulevard site (WW-MISSION) provided an important source of new information for the updated source contribution analysis applicable to Santa Ana River Reach 3.

The main sources of DWF in the MSAR watershed include the discharge of POTW treated effluent and outflow from MS4 drainage systems. For Santa Ana River Reach 3 and Mill-Cucamonga Creek, tertiary treated POTW effluent comprises the majority of DWF. This effluent, which is essentially free of any fecal bacteria, provides water that dilute inputs from MS4 outfalls in these waterbodies. In comparison, recent changes to operation by IEUA have resulted in almost the complete elimination of POTW effluent discharge to Chino Creek. Changes in IEUA operations have also resulted in considerable temporal variability in discharges of treated effluent to Cucamonga Creek during the dry season. Although these operational changes have reduced the degree of dilution from treated effluent that has occurred in the past, the changes may also be increasing the residence time and natural decay of bacteria within the channel.

The following sections present the updated source contribution analysis based on data collected through 2022. Where possible, bacterial indicator and DWF flow data have been updated from previous Triennial Reports.

4.3.1 Bacteria at MS4 Outfalls

Although the MSAR Task Force did not conduct a comprehensive synoptic study at Tier 1 outfalls during the 2020-2022 reporting period, individual MS4 Permittees collected samples from selected Tier 1 outfalls as part of implementation of Tier 2 source evaluations within high priority subwatersheds. In total, 137 samples were collected from Tier 1 sites from 2020-2022. These data were used to update estimated DWF and bacterial indicator concentrations for Tier 1 outfalls in the source contribution analysis. **Table 4-3** provides a summary of the *E. coli* data results observed at each Tier 1 site.

4.3.2 Dry Weather Flow within MS4

Within the MSAR watershed, there are many MS4 drainage areas that do not typically contribute any DWF (and thus no bacterial indicators) to a downstream impaired waterbody. In these drainages, DWF is hydrologically disconnected from the downstream receiving waterbody either because the flow is captured and purposefully recharged to groundwater in constructed regional retention facilities or because the DWF is lost to groundwater through the earthen channel bottom. In these channels, the recharge capacity of the underlying soils exceeds the dry weather runoff generated from upstream drainage areas. **Figure 4-1** illustrates hydrologically disconnected areas within the MSAR watershed (see hashed areas).

Table 4-3. Geometric Mean of *E. coli* Concentrations (colony forming units [cfu]/100 mL) in Samples from Tier 1 Sites in 2020-2022 Period

MSAR Subwatershed	Site ID	Description[1]	Geomean *E. coli* (cfu/100 mL)	Number of Samples
Chino Creek	T1-BRSC	Boys Republic South Channel	971	12
	T1-CCCH	Carbon Canyon Creek Channel	105	12
	T1-CHINOCRK	Chino Creek u/s from San Antonio Channel	405	12
	T1-SACH	San Antonio Channel	187	12
	T1-LLSC	Lower Los Serranos Channel	2,181	3
Mill-Cucamonga Creek	T1-CUCAMONGA	Transition from REC2-only Reach to Impaired Water	551	51
	T1-MCW[2]	Mill Creek Wetland Outflow	54	30
Santa Ana River	T1-MCSD	Magnolia Center Storm Drain	4,578	8

[1] Map showing these Tier 1 sites and MS4 drainage areas is provided in Figure 2-1

[2] Mill Creek Wetland outflow of treated runoff back to Mill-Cucamonga Creek

To verify that the DWF from MS4s is hydrologically disconnected, MS4 Permittees have actively conducted field observations at key control points, collecting over 5,000 photos over many years, as part of the CBRP Tier 2 source evaluation program. Results from these inspection activities have shown consistent hydrologic disconnectivity during dry weather conditions (as reported by Permittees as part of annual MS4 Program reports). Field observations support the finding that areas hydrologically disconnected areas meet the dry weather TMDL WLAs.

The 2019 Synoptic Survey demonstrated that measured DWF rates from all MS4 outfalls were reduced beyond the target reductions that the CBRPs estimated would be sufficient to meet TMDL numeric targets (SAWPA 2020a; e.g., see Figure 3-6). Despite meeting the targeted DWF reductions, *E. coli* concentrations at the downstream TMDL watershed-wide compliance monitoring sites remained above the TMDLs numeric targets. This observation has previously been attributed to (a) regional declines in rates of POTW effluent discharged in the watershed and the associated dilution effects (e.g., see Figure 3-3 in SAWPA 2020a); and (2) unaccounted in-stream sources of bacteria.

New field measurements of DWF collected from prioritized Tier 1 MS4 outfalls in 2020-2022 are summarized in **Table 4-4**. These flow rates are used to update source contribution analysis in the 2023 Triennial Review. Increases in DWF rates were observed at some sites compared to what was observed during the 2019 Synoptic Study (SAWPA 2020a). Despite these increased flows, the targeted reductions in DWF to each impaired waterbody, estimated in the CBRPs, continue to be achieved (e.g., RCFC&WCD 2011).

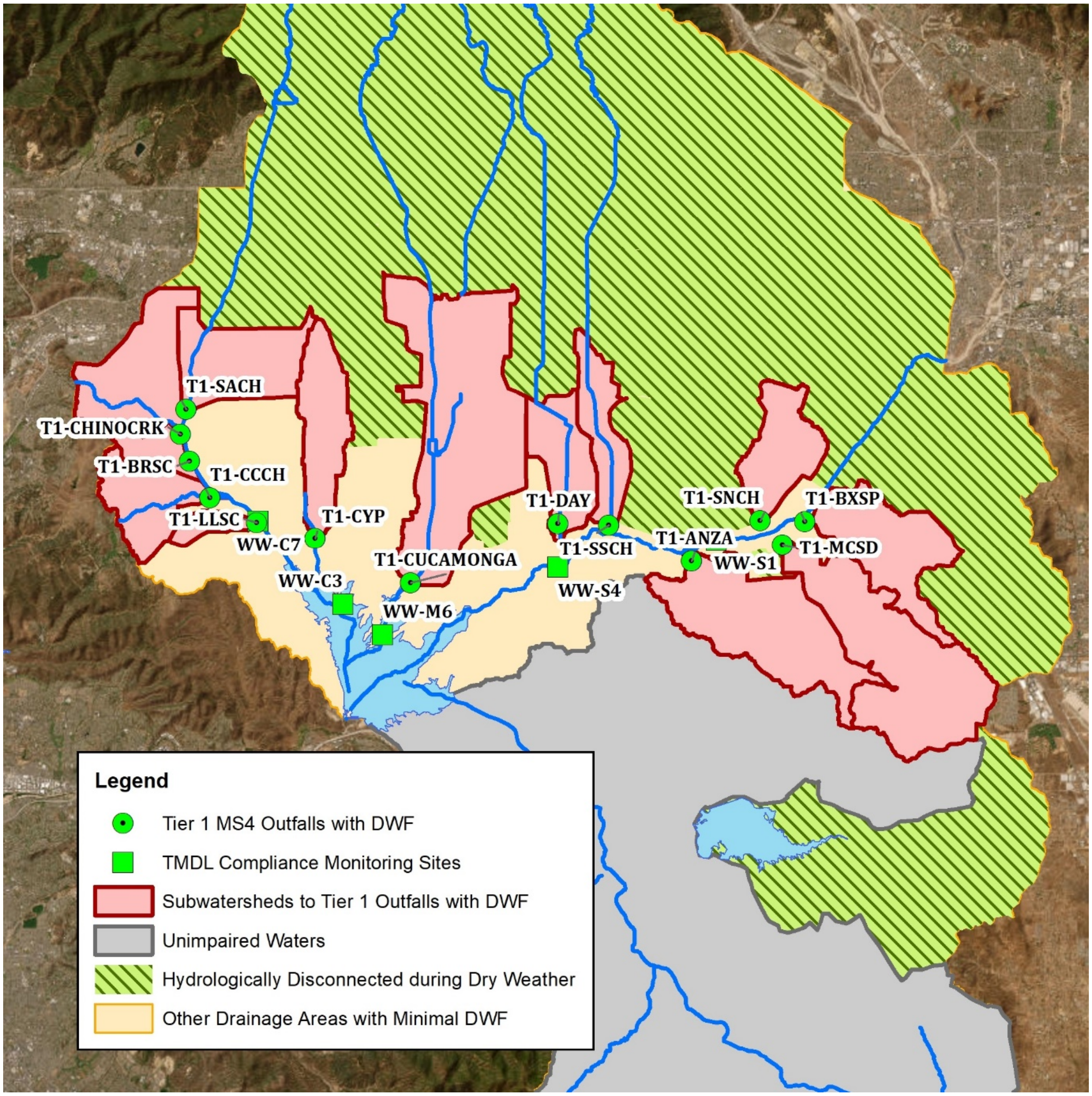

Figure 4-1. Map of MS4 Drainage Areas Determined to be Hydrologically Disconnected during Dry Weather Conditions (based on observations over multiple years of implementation)

Table 4-4. Dry Weather Flow Rate Measurements from Tier 1 Sites in 2020-2022 Compared with 2017-2019

MSAR Subwatershed	Site ID	Description[1]	2020-22 Average DWF (cfs)	2017-19 Average DWF (cfs)
Chino Creek	T1-BRSC	Boys Republic South Channel	0.14	0.13
	T1-CCCH	Carbon Canyon Creek Channel	0.81	0.46
	T1-CHINOCRK	Chino Creek u/s from San Antonio Channel	0.55	0.53
	T1-SACH	San Antonio Channel	0.21	0.01
	T1-LLSC	Lower Los Serranos Channel	0.08	0.003
Mill-Cucamonga Creek	T1-CUCAMONGA	Transition from REC2-only to Impaired Water	9.68	8.53
	T1-MCW[2]	Mill Creek Wetland Outflow	0.79	1.36
Santa Ana River	T1-MCSD	Magnolia Center Storm Drain	0.99	0.33

[1] Map showing these Tier 1 sites and MS4 drainage areas is provided in Figure 2-1

[2] Mill Creek Wetland outflow of treated runoff back to Mill-Cucamonga Creek

4.3.3 POTW Effluent

Highly treated effluent from POTWs is key water resource, especially in arid regions. Reuse of POTW effluent serves to reduce the need to pump water from underlying groundwater basins and limit demand for imported water sources that are typically more energy intensive and less reliable than local supplies. **Figure 4-2** shows that all POTWs in the MSAR watershed have reduced discharges to the impaired waterbodies over the past 12 years as a result of increasing reuse and increased water conservation.[15] Moreover, IEUA and the City of Rialto plan to increase recycled water use in the future, thus average annual discharges to the impaired waters may continue to decline.

One outcome of increased reuse of POTW effluent is a reduction in the discharge of bacteria free water to downstream impaired waterbodies in the MSAR watershed. As a result, there is less dilution of DWF inputs from MS4 outfalls, thus changing the estimated blend of POTW and MS4 water inputs.

[15] POTW data provided by: (a) Riverside Water Quality Control Plant (WQCP), email from Bobby Gustafson on November 3, 2022; IEUA RP-1 and Carbon Canyon Water Reclamation Plant, email from Scott Lening on November 3, 2022; San Bernardino Municipal Water District RIX Facility, email from Marissa Flores on November 1, 2022.

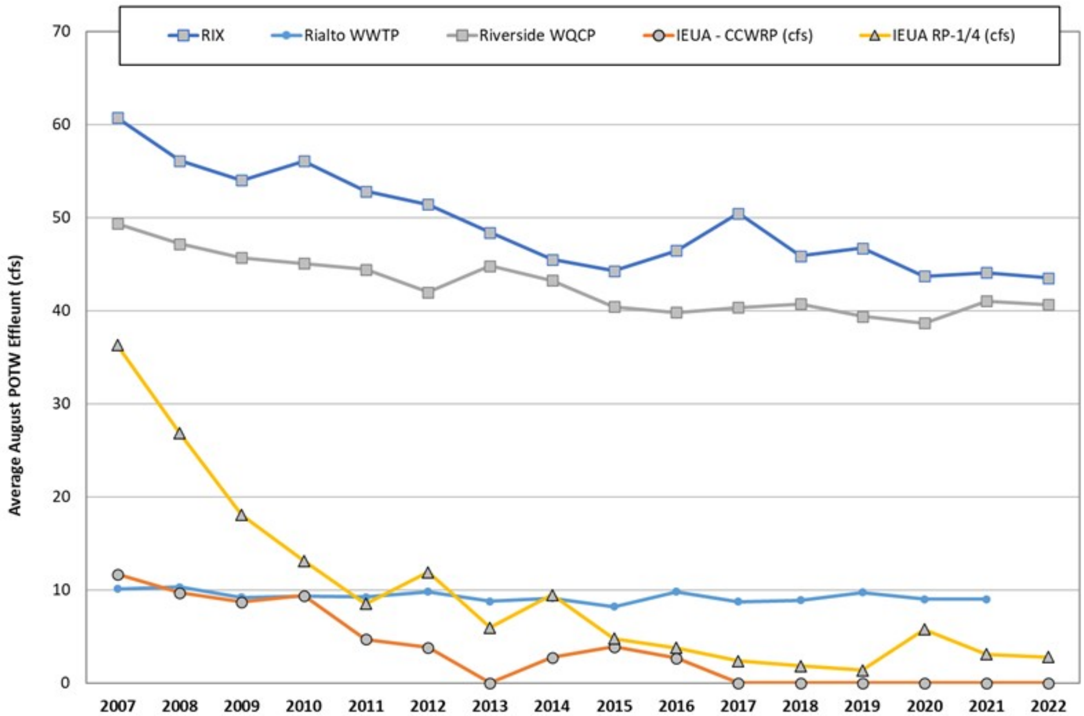

Figure 4-2. Average Daily POTW Effluent in August/September Discharged to Impaired Waters from 2007-2022

In addition to long-term trends that show a gradual decline in discharge of tertiary treated effluent to impaired waters, reviews of discharge records provided by POTWs show a persistent condition of very large daily fluctuations in effluent discharge rates. For example, hourly fluctuations of greater than 90 percent occur in the discharge of treated effluent from IEUA plants to Mill-Cucamonga and Chino Creeks (see Section 3.2.1.2.1). These fluctuations are the result of varying deliveries to the extensive reuse system in this part of the MSAR watershed. During periods with higher demand or as storage reservoirs are drawn down and need to be refilled, effluent is sent to the reuse system and not discharged to the creeks (personal communication with Andy Campbell, IEUA Deputy Manager of Planning and Environmental Resources, December 30, 2015). Given the temporal variability on the order of several hours, a synoptic snapshot of a constant dry weather bacteria condition for Mill-Cucamonga and Chino Creeks is infeasible without coordination with the POTWs in advance of a sampling event. Instead, a large dataset has been amassed to effectively characterize the central tendency and range of bacteria load that can occur at the Tier 1 site and within the Mill Creek Wetlands. SBCFCD's long-term Tier 2 dataset from the Cucamonga Creek subwatershed now includes 50 sample dates from over six dry season periods (2017-2022).

4.3.4 Channel Bottom Seepage in the Santa Ana River

Channel bottom seepage within Santa Ana River Reach 4 reduces the volume of POTW effluent that arrives at the transition from Reach 4 to Reach 3 at Mission Boulevard. Seepage losses were approximated by comparing daily metered POTW discharges and average of field measured MS4 inflows at Tier 1 sites (T1-MCSD + T1-BXSP + T1-PHNX + T1-SNCH = 1.6 cfs) with downstream flow records (USGS Station #11066460). **Figure 4-3** shows that percent of losses of POTW effluent have increased in recent years based on declining flow measured in the Santa Ana River at MWD Crossing relative to upstream inflows. Only losses from the Santa Ana River upstream of MWD Crossing are accounted for by this method.

The 2020 source contribution analysis included in the 2020 Triennial Report neglected to account for seepage losses of POTW effluent and associated load within Reach 4 upstream of Mission Avenue (SAWPA 2020a). Thus, the load of bacteria assigned to upstream inflows from Reach 4 to Reach 3 (at Mission Boulevard) may have been overestimated previously. For this analysis, an alternative method was used to estimate DWF in the Santa Ana River at Mission Boulevard Bridge. Specifically, the volume of runoff at Mission Boulevard was estimated as the daily measured flow at the USGS Santa Ana River at MWD Crossing gauge minus the sum of typical DWF contributions from MS4s, estimated above at 1.6 cfs.[16]

4.4 Results of Source Contribution Analysis Update

Consistent with previous source contribution analyses, the updated analysis is presented on an impaired waterbody-specific basis. Updated analyses are presented for the following three impaired waters: Santa Ana River Reach 3, Mill-Cucamonga Creek and Chino Creek.

4.4.1 Santa Ana River Reach 3

Tertiary treated POTW effluent is discharged (~44 cfs from RIX and 9 cfs from Rialto WWTP) into Reach 4 of the Santa Ana River. Upstream of these discharges the Santa Ana River is dry. This effluent travels approximately 5 miles down the Santa Ana River riverbed with no additional inflows from MS4s during dry weather conditions.

As part of the 2019 Synoptic Study, *E. coli* loads were measured at the Mission Boulevard Bridge (WW-MISSION) weekly over a six-week period (SAWPA 2020a). When compared with measured *E. coli* loads at the MS4 outfalls taken on the same day, the upstream non-MS4 *E. coli* load was determined to account for about 77 percent of the downstream mass at the Santa Ana River MWD Crossing (WW-S1) compliance monitoring site. This finding provided additional evidence of the potentially significant in-stream bacterial load, previously referred to as "unaccounted for" bacteria.

[16] Based on measured flow in July 2020 from T1-MCSD and from July 2019 from T1-BXSP, T1-SNCH, and T1-PHNX

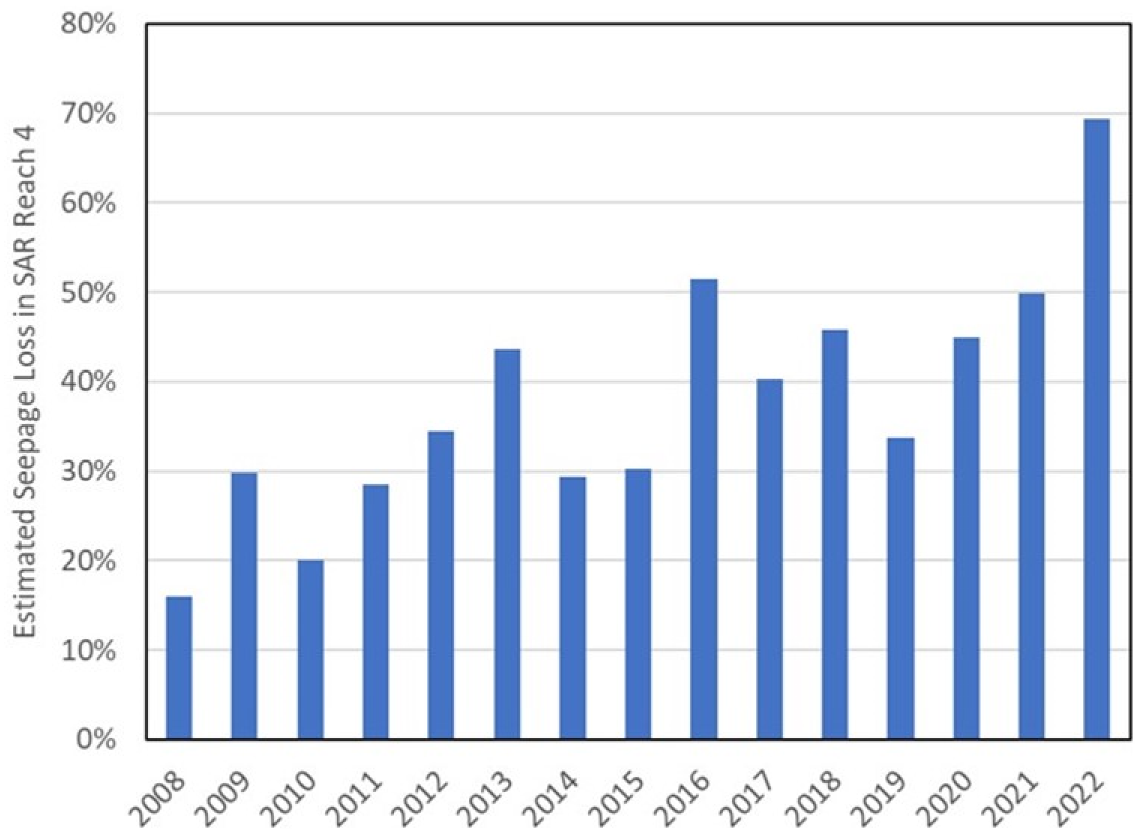

Figure 4-3. Estimated Seepage Loss in Santa Ana River Reach 4 (see text for basis of estimate)

Following the 2019 Synoptic Study, the MSAR Task Force coordinated with the RBMP to include sampling at WW-MISSION as part of the routine dry weather sampling for the TMDL watershed-wide monitoring program. In addition, in July 2020 weekly samples were collected at both WW-MISSION and T1-MCSD site to help assess the relative contribution of the MCSD subwatershed.

Assuming other Tier 1 MS4 outfall bacteria loads were unchanged from what was observed during the 2019 Synoptic Study (SAWPA 2020a), **Figure 4-4** illustrates the relative sources of *E. coli* loading upstream of the Santa Ana River at MWD Crossing watershed-wide compliance site.[17] Overall, the relative contributions of the *E. coli* load during the 2020 sampling event were similar to the loads observed during the 2019 Synoptic Study with the upstream bacterial load from non-MS4 sources accounting for 63 percent of the total bacterial load, followed by 34 percent from the MCSD MS4 outfall. Given the observations at the MCSD outfall, the City of Riverside and RCFC&WCD implemented a Tier 2 source investigation in MCSD MS4 drainage area during the 2020-22 period (see Section 3.2.1.1.1 above). In addition, research into potential sources of elevated *E. coli* in Santa Ana River

[17] The Phoenix Storm Drain Diversion project that diverts DWF to the Riverside WQCP came online in 2021. Future Tier 1 investigations will verify the presence of dry conditions downstream of the diversion facility.

Reach 4 (upstream of any MS4 inflows) was advanced through two key special studies: (a) potential impacts from homeless encampment activity (see Section 3.1.1) and (b) impacts from feral pigs in the watershed (see Section 3.1.2).

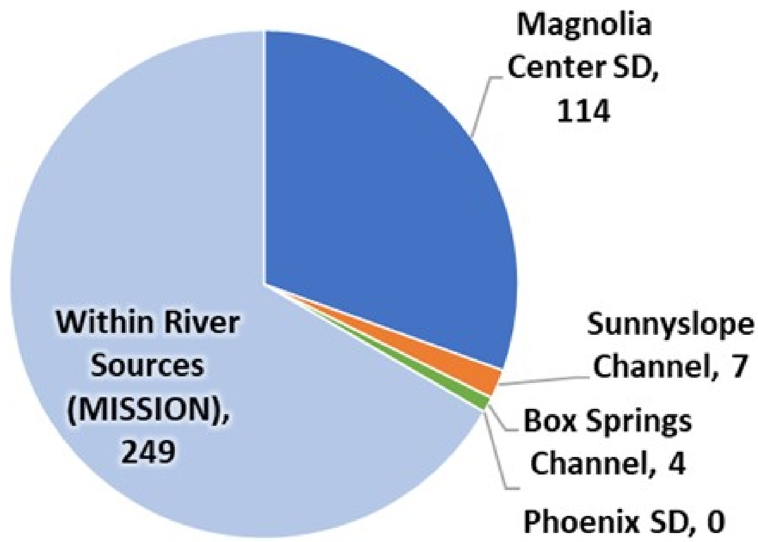

Figure 4-4. Relative Contribution to Median *E. coli* Load (billion MPN/day) to Santa Ana River Reach 3, Upstream of the Santa Ana River at MWD Crossing TMDL Compliance Monitoring Site (WW-S1) from Tier 1 MS4 Sites (Medians calculated from (a) July 2020 samples collected at WW-MISSION and T1-MCSD; and (b) 2019 data collected at the other Tier 1 MS4 sites)

Dry weather sampling results from the Mission Boulevard Bridge site (2020-2022) have greatly increased understanding of ambient bacterial loads present in the Santa Ana River upstream of any MS4 source. **Figure 4-5** illustrates the estimated bacterial load at the WW-MISSION site (line) compared to the measured load at the Santa Ana River at MWD Crossing site (shaded area). This analysis shows that most of the time the *E. coli* load from in-stream sources upstream of Mission Boulevard Bridge comprises the majority of total load at the TMDL watershed-wide compliance site. Moreover, in 2022, loads measured at the Mission Boulevard Bridge site were greater than loads measured at the downstream compliance site without accounting for any contributions from MS4 inflows, indicating that natural decay processes cause a net loss of *E. coli* within Reach 3 of the Santa Ana River. This finding suggests that the in-stream sources that cause an increase in load during dry weather conditions may be limited to the flowing segment of the Santa Ana River Reach 4 upstream of any MS4 inflows.

Figure 4-6 provides an updated schematic of sources of DWF and *E. coli* in Santa Ana River Reach 3 (see other Triennial Reports for previously developed schematics). Key areas updated include: (noted in red within the diagram):

- New flow and *E. coli* concentrations measurement data from the Tier 1 MS4 outfall as part of Tier 2 source evaluation and RCFC&WCD core NPDES MS4 monitoring at Magnolia Center Storm Drain (n=8).
- New bacteria concentrations from routine monitoring at the WW-MISSION station (n=55).
- Refinement of the upstream boundary flow rate to account for channel bottom seepage (see Section 4.2.4 above).

The most important finding from this updated source contribution analysis is the refinement to the expected downstream *E. coli* concentration when the upstream bacteria load based on the 2020-2022 data from WW-MISSION is incorporated. By accounting for the upstream boundary inflow at the WW-MISSION site, the flow weighted average *E. coli* concentration of all inflows to the Santa Ana River Reach 3 at MWD Crossing site would be approximately 380 MPN/100 mL (see Figure 4-6), which is within the range of measured *E. coli* at this TMDL compliance monitoring site (see Section 2.3). Thus, the previously unaccounted for bacteria load within Reach 3 of the Santa Ana River has been effectively quantified as coming from DWF and bacteria sources outside of flow/sources contributed by urban runoff from MS4s.

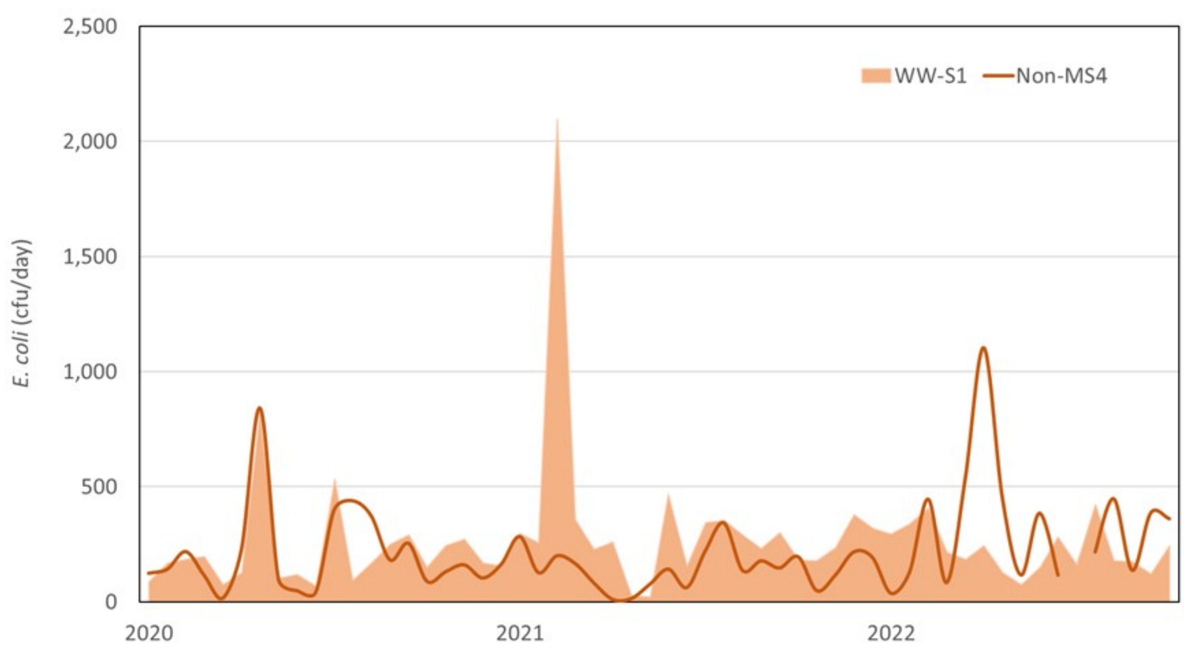

Figure 4-5. Relative Comparison of *E. coli* Load (billion MPN/day) at Mission Boulevard Bridge in Santa Ana River Reach 4 (line) to *E. coli* Load Observed at Santa Ana River Reach 3 at MWD Crossing (shaded area)

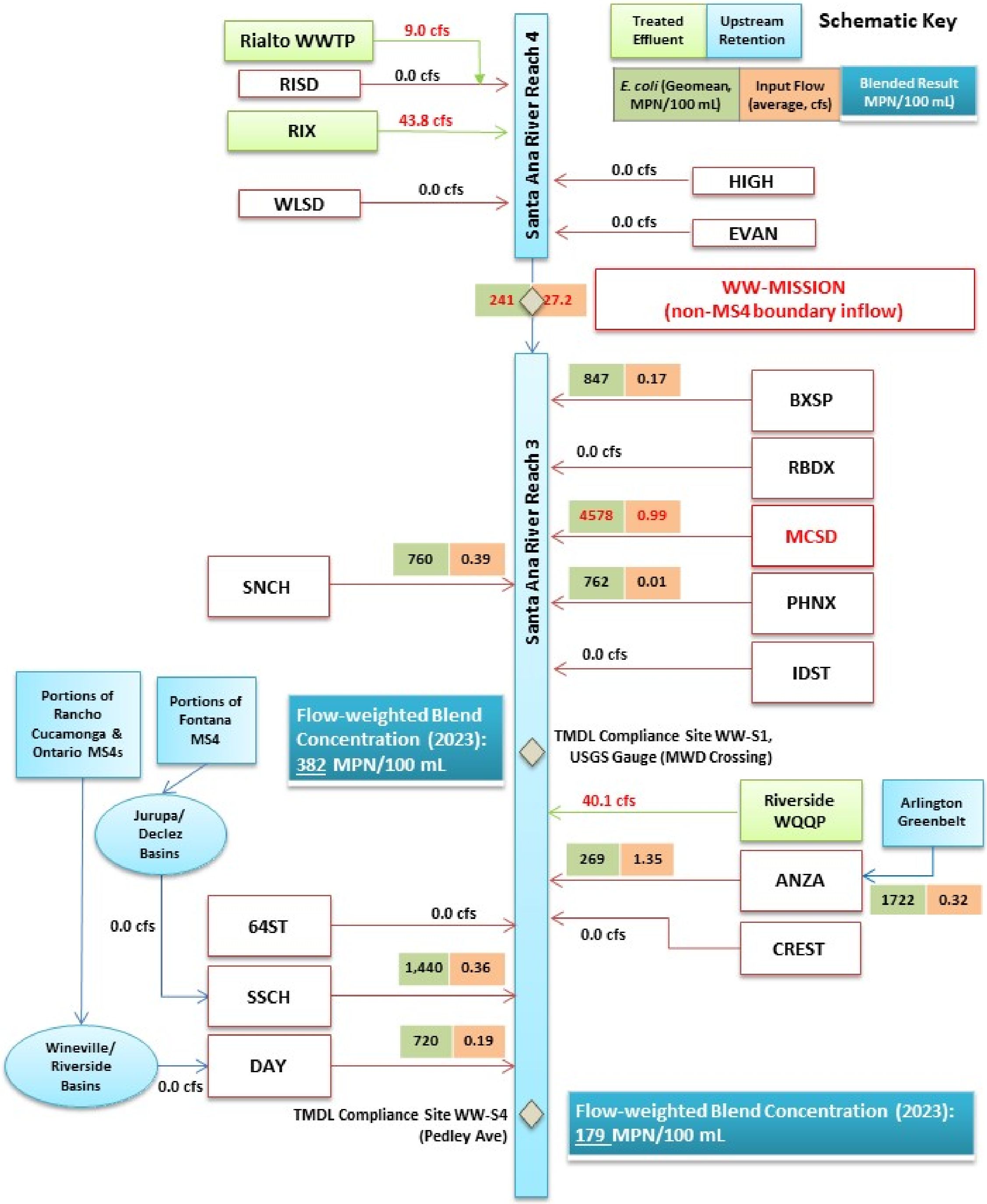

Figure 4-6. Santa Ana River Reach 3 Schematic - Known *E. coli* Concentrations, DWF from MS4 Inflows and POTW Effluent Discharges to Reach 3 in Relation to Downstream TMDL Compliance Monitoring Sites (Items in red indicate new data collected in the 2020-22 period, all other inputs based on 2019 Synoptic Study results or recent field observations of no flow during dry weather)

4.4.2 Mill-Cucamonga Creek

When the Cucamonga Creek Reach 1 bacterial indicator TMDL was adopted in 2005 the Basin Plan assigned both REC1 and REC2 uses to the waterbody. The 2012 Basin Plan amendment that revised recreational water quality standards in freshwaters in the Santa Ana Region included the removal of the REC1 use from Cucamonga Creek Reach 1.[18] Accordingly, only a REC2 use now applies to Cucamonga Creek Reach 1 and compliance is based on approved antidegradation criteria. Routine monitoring by the RBMP finds that these criteria are routinely met at the REC2 compliance site (Cucamonga Creek at Hellman Avenue). Because the REC1 use no longer applies above this site, the Hellman Avenue site is also now considered a Tier 1 site under the CBRP and all upstream MS4 outfalls tributary to the subwatershed are considered Tier 2 sites. Section 3.2.1.2.1 presents findings from ongoing Tier 2 source investigation in this subwatershed.

Source contribution analysis for the Mill-Cucamonga Creek compliance site (WW-M6) considers (a) bacterial loading assessment from the single Tier 1 site (T1-CUCAMONGA); and (b) accounting for the diversion, treatment, and discharge of bacteria load from the MCW control measure located upstream of the compliance site (see Section 3.2.1.2.3). Implementation of the SBCFCD 10-week sampling program over multiple years has resulted in a large dataset to evaluate DWF and *E. coli* load at the T1-CUCAMONGA site (**Figure 4-7**), diversions to and effluent discharged from the MCW and other key Tier 2 MS4 sites tributary to Cucamonga Creek Reach 1.

Figure 4-8 illustrates the two sources of flow and bacteria loads to the Mill-Cucamonga Creek TMDL compliance monitoring site (WW-M6): (1) Tier 1 flow at where it transitions from Cucamonga Creek Reach 1 (REC2 only) (T1-CUCAMONGA) to Mill-Cucamonga Creek below Hellman Avenue; (2) return of flow diverted and treated in the MCW. The schematic reports DWF rates and bacteria concentrations in water diverted to the MCW. The source contribution analysis suggests that bacteria concentrations at the downstream WW-M6 compliance site are reduced as a result of bacteria reduction occurring in the MCW prior to the MCW flow being discharged back to Mill-Cucamonga Creek.

Figure 4-8 estimates that the flow-weighted blended *E. coli* concentration below the MCW would be 346 MPN/100 mL. However, from 2020-2022 the observed dry season *E. coli* geomean was 128 MPN/100 mL. The difference between the expected and observed *E. coli* concentrations suggests that even greater reductions in bacteria concentrations are occurring within Mill-Cucamonga Creek than can be attributed to MCW return flows. The reduced downstream concentration at WW-M6 potentially may be attributed to the following:

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[18] Removal of the REC1 use was supported by an approved Use Attainability Analysis (see USEPA letters to Santa Ana Water Board, April 8 and August 3, 2015)

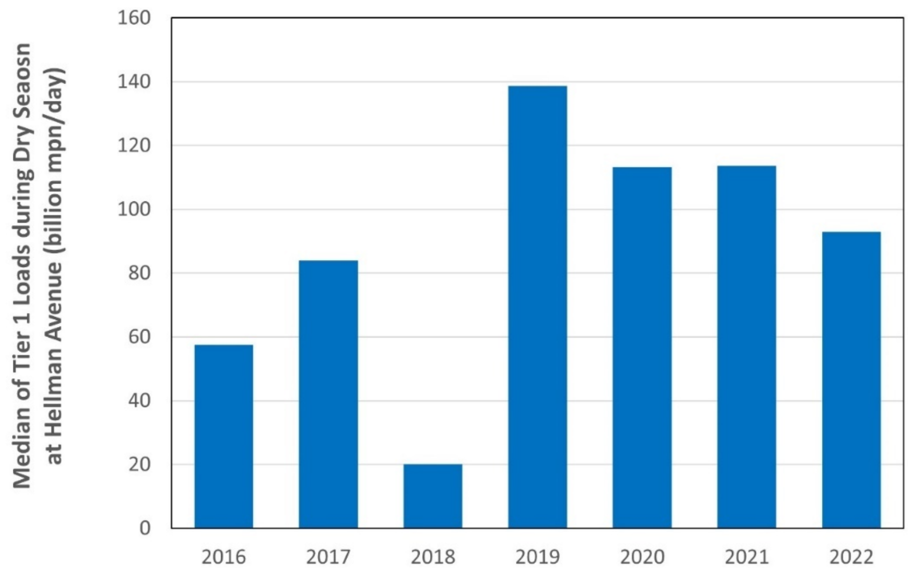

Figure 4-7. Median *E. coli* Load (billion MPN/day) during Tier 1 Source Evaluations at Cucamonga Creek at Hellman Avenue (T1-CUCAMONGA), July through September from 2016-2022 (Sources: SBCFCD 10-week studies in 2016-2018 and 2020-2022; MSAR TMDL Task Force 2019 Synoptic Study)

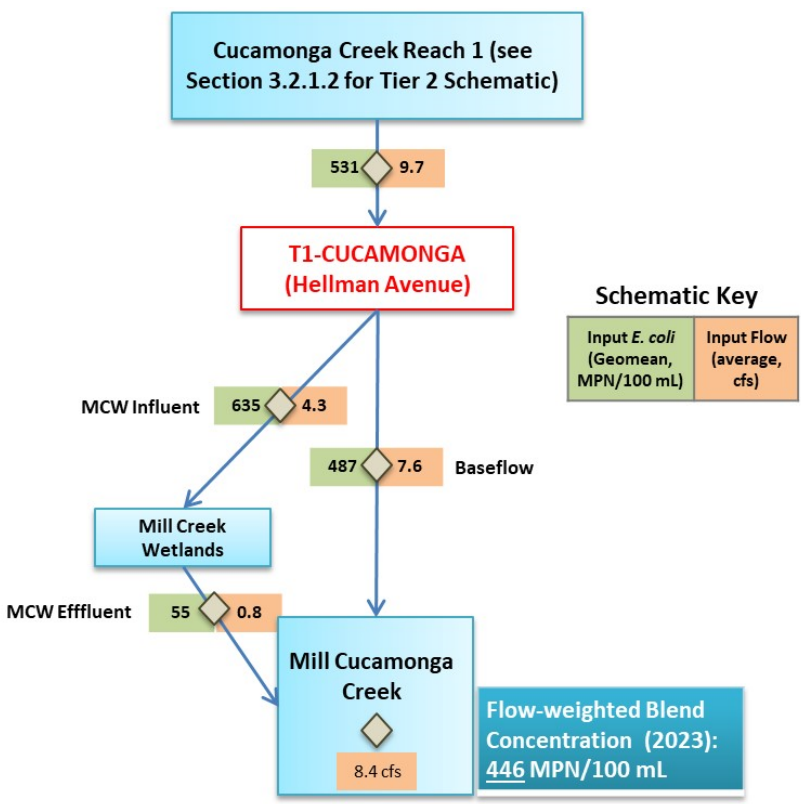

Figure 4-8. Mill-Cucamonga Creek Schematic - Known *E. coli* Concentrations and DWF at Sites in Area of Mill-Cucamonga Creek TMDL Compliance Site (Estimated downstream blended concentration takes into account reductions in bacteria within the Mill Creek Wetlands)

- Natural decay within the open channel segment of Mill-Cucamonga Creek – The reduced load from ~100 billion MPN/day at the T1-CUCAMONGA site to ~25 billion MPN/day at WW-M6 can only be partially attributed to the approximately 50 billion MPN/day removal occurring within the MCW (see Table 3-6 above). Other in-stream losses may be occurring within the open channel.
- Rising groundwater within the natural segment of Mill-Cucamonga Creek – On average, flow measured at the downstream TMDL compliance monitoring site WW-M6 over the same time period in the 2020-2022 dry season (average of 7.9 cfs at WW-M6) is greater than the sum of inflows (6.2 cfs). This difference may indicate the presence of some rising groundwater that would provide additional dilution to surface flows in Mill-Cucamonga Creek.

4.4.3 Chino Creek

Over six consecutive weeks in both the 2021 and 2022 dry seasons, SBCFCD conducted comprehensive Tier 1 source evaluations within the Chino Creek subwatershed. Flow measurements, field parameters and laboratory analysis for *E. coli* and nutrients were completed at five Tier 1 locations, accounting DWF inputs to Chino Creek upstream from the TMDL compliance monitoring site at Central Avenue (WW-C7). These data were used to compute daily *E. coli* loads for 12 comprehensive dry weather Tier 1 source evaluation events (n = 6 in 2021; n = 6 in 2022). Results were compared with historical Tier 1 source evaluation data to assess progress towards meeting Chino Creek load reduction targets established in the CBRP (**Table 4-5**). Median *E. coli* load for each year of Tier 1 source evaluation show a decline over time as a result of ongoing source identification and elimination and outdoor water conservation, most notable involving measurements in the 2022 dry season. Compared to 2007, the measured *E. coli* loads from Tier 1 MS4 outfalls to Chino Creek in 2022 had been reduced by 49 billion MPN/day (53 billion MPN/day to 3.6 billion MPN/day), exceeding the 37 billion MPN/day target set in the CBRP (SBCFCD 2011; see Table 3-3 in the CBRP). Ongoing Tier 1 source evaluation is needed to provide more data to support this finding in future years.

Figure 4-9 provides a schematic of the Chino Creek subwatershed, including sources of flow (e.g., POTWs and Tier 1 sites) and flow diversions. The flows and bacteria concentrations on the figure are based on the 12 comprehensive dry weather Tier 1 source evaluation events (n = 6 in 2021; n = 6 in 2022).

DWF from most of the Chino Creek subwatershed does not reach the downstream compliance site at Central Avenue (WW-C7) because of diversions. For example, DWF in San Antonio Channel, the largest tributary to Chino Creek, is diverted into a series of retention basins that span from San Antonio Dam in the upper part of the subwatershed to Brooks Basin in the City of Montclair. Downstream of the diversion to Brooks Basin, there are five MS4 outfalls to Chino Creek that comprise nearly all the DWF measured at the compliance site at Central Avenue (see Figure 4-9).

Table 4-5. Median Dry Weather *E. coli* Load (billion MPN/day) from Comprehensive Tier 1 Evaluations (NM = Not Measured)

Site ID	Description[1]	2007	2012	2019	2021	2022
T1-BRSC	Boys Republic South Channel	NM	6.9	4.8	14.1	0.8
T1-CCCH	Carbon Canyon Creek Channel	22	7.5	0.7	1.9	1.2
T1-CHINOCRK	Chino Creek u/s from San Antonio Channel	NM	22.2	14.3	11.4	1.0
T1-SACH	San Antonio Channel	7	0.1	0.1	2.5	0.6
T1-LLSC	Lower Los Serranos Channel	NM	0.001	0.1	Dry	Dry
Total MS4 Inflows (billion MPN/day)		**53.0[1]**	**36.7**	**20.0**	**29.8**	**3.6**

[1] To support the compliance analysis in the CBRP, an approximated DWF of 100 gallons/acre/day (gal/acre/day) and *E. coli* concentration of 600 MPN/100 mL was assumed for unmeasured Tier 1 outfalls to Chino Creek resulting in a loading of 24 billion MPN/day in Chino Creek subwatershed

During the comprehensive Tier 1 source evaluations in the 2021 and 2022 dry seasons, IEUA's Carbon Canyon Water Reclamation Plant (CC WRP), the only source of treated effluent to Chino Creek, discharged no effluent to Chino Creek. Consequently, the source evaluation analysis for the Chino Creek subwatershed involves computation of a flow-weighted concentration for the five Tier 1 MS4 outfalls with DWF. The estimated blended *E. coli* concentration of 306 MPN/100 mL is greater than the concentration of *E. coli* at the downstream watershed-wide compliance monitoring site over the same time periods in 2021 and 2022 dry seasons at Central Avenue WW-C7 (*E. coli* geomean of 40 MPN/100 mL). This finding suggests that in-stream processes yield a net decay in fecal bacteria between upstream sources and the impaired portion of Chino Creek.

Figure 4-10 shows that significant week to week variability exists in the relative *E. coli* load to Chino Creek between each of the Tier 1 MS4 outfalls. DWF from Pomona's MS4 (T1-CHINOCRK: ~6,000 acres), Boys Republic South Channel (T1-BRSC: ~1,200 acres), and Carbon Canyon Creek Channel (T1-CCCH: ~3,900 acres) have each accounted for the majority of *E. coli* loads during at least one comprehensive Tier 1 source evaluation event in 2021-2022. Thus, future *E. coli* mitigation activities may need to address multiple drainages within the Chino Creek subwatershed to effectively meet the MS4 WLA.

Figure 4-11 illustrates the estimated relative median *E. coli* loading from each of the Chino Creek subwatersheds that drain to the WW-C7 compliance site based on the 2021-2022 data. The hatched slice of the pie chart in Figure 4-11 represents loss of upstream bacteria load from MS4s based on measurements at WW-C7 downstream.

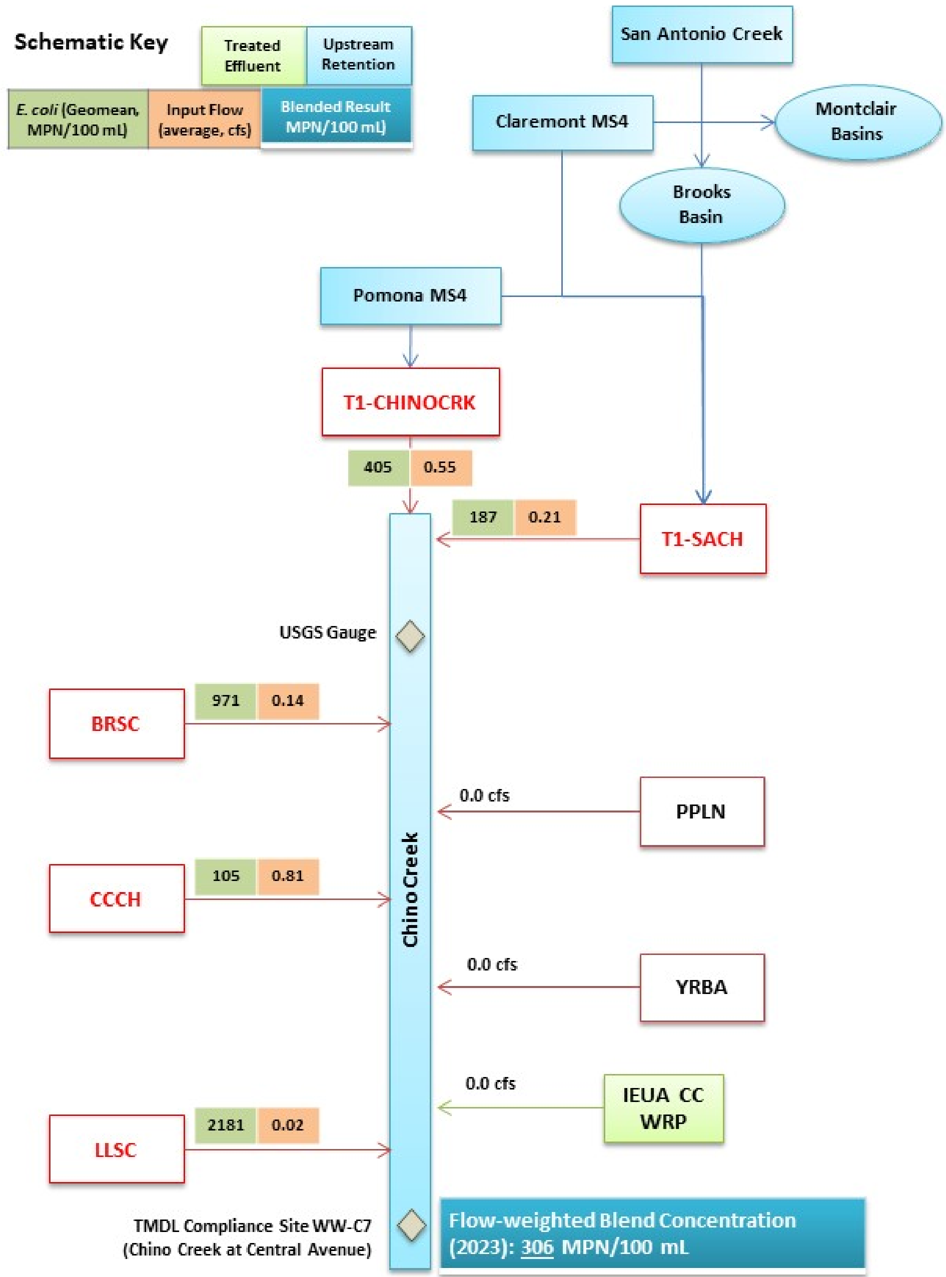

Figure 4-9. Chino Creek Schematic - Known *E. coli* Concentrations, DWF from MS4 Inflows and Location of Potential POTW Effluent Discharge to Chino Creek in Relation to the Downstream TMDL Compliance Monitoring Site (WW-C7)

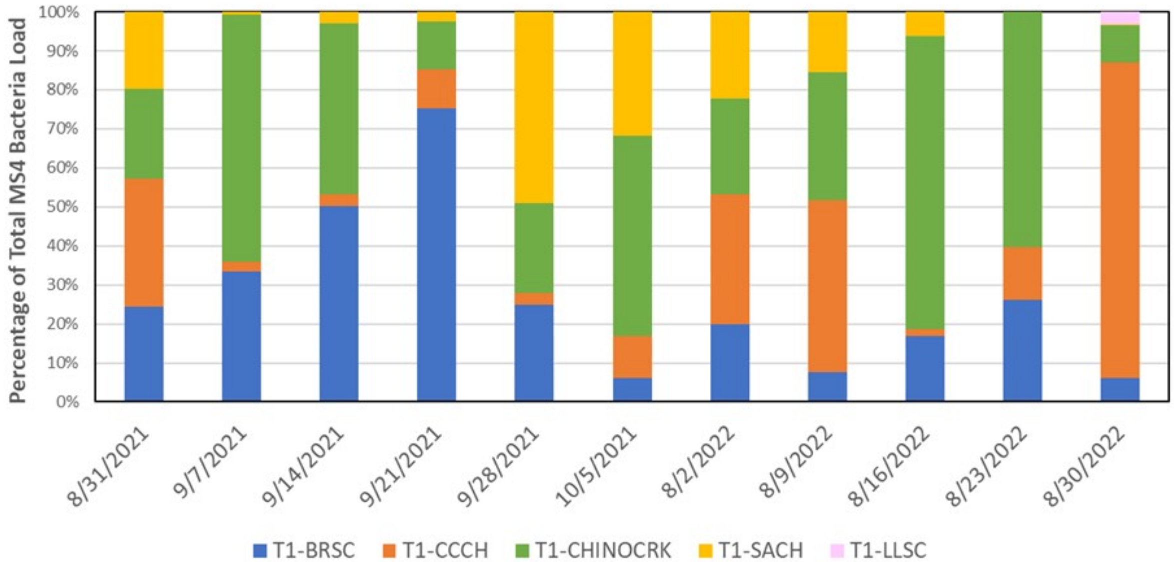

Figure 4-10. Relative Contribution of *E. coli* Loading from Tier 1 Subwatersheds to the Total MS4 *E. coli* Load to the Chino Creek at Central Avenue TMDL Compliance Site (WW-C7)

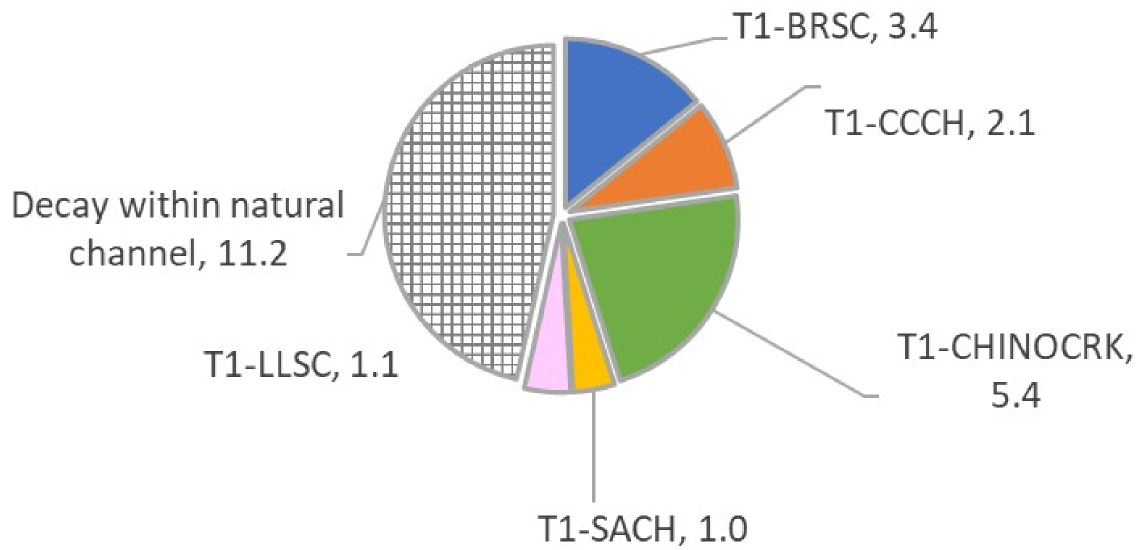

Figure 4-11. *E. coli* Loads (billion MPN/day) from Chino Creek Subwatersheds Upstream of Central Avenue TMDL Compliance Site (2021-2022)

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5. TMDL Implementation - Next Steps

This report highlights results from the watershed-wide TMDL compliance monitoring program and findings from an extensive series of Tier 1 studies, Tier 2 source investigations, special studies and targeted monitoring to evaluate the effectiveness of regional treatment projects. As demonstrated by studies conducted in the Chino Creek and Mill-Cucamonga Creek subwatersheds, substantial progress has been made towards meeting the TMDLs WLAs and LAs applicable to dry summer conditions. Given the findings from these various efforts and other TMDL compliance considerations relevant to the wet winter condition, the following sections identify recommended next steps for TMDL implementation.

5.1 Additional Studies

Recommendations for additional studies to be implemented to support MSAR TMDLs implementation include:

- *Updated Comprehensive Tier 1 Source Evaluation* – Tier 1 source evaluations that include a comprehensive synoptic sampling and analysis of DWF and *E. coli* at MS4 outfalls to impaired waters have been conducted by the MSAR Task Force about once every 5-7 years (2007, 2012 and 2019). In addition, since 2017 SBCFCD has collected data annually at Tier 1 sites that outfall to Chino Creek and Mill-Cucamonga Creek. These data have provided an important update on status of bacteria loads to impaired waters for this Triennial Report. No similar comprehensive data collection to assess bacteria loads to Santa Ana River Reach 3 has been obtained since 2019. Given this need and considering the findings in this report, it is recommended that:
  - MSAR Task Force will consider implementing its next comprehensive Tier 1 source evaluation study in the 2024-2025 time frame, or about 5 years since the last effort was completed in 2019. This study will not only provide an up to date data set to support preparation of the next Triennial Report (due in 2026), but it will provide an opportunity to update information on the hydrologic connectivity of Tier 1 sites to downstream impaired waters during dry summer conditions.
  - Future Tier 1 source evaluation studies consider an evaluation of other factors that may influence bacteria loading estimates, e.g., (a) coordinate sample collection with operations at recharge basins and POTWs; and (b) gather data to allow an evaluation of potential diurnal differences in bacteria concentrations.
  - Future Tier 1 source evaluation studies also include at the same time sample collection at the compliance sampling locations.
- *Identification of In-stream Sources of Bacteria Loads* - The findings presented in this report have shown that in-stream sources of *E. coli* are a significant contributor to *E. coli*

loads in downstream impaired waters. Understanding the origin of these sources is critical to compliance with the TMDL targets applicable under dry summer conditions. Specifically:

- Based on studies conducted over many years, it has been shown that even if upstream MS4s achieved all of their WLAs applicable to urban runoff, the downstream impaired receiving waters would still not achieve the *E. coli* targets in the MSAR TMDLs (see findings provided in Section 2.5.2). In particular, the majority of *E. coli* load observed within Reach 3 of the Santa Ana River has been demonstrated to come from in-stream sources upstream of Mission Boulevard in Santa Ana Reach 4. It is plausible, that a program that successfully identifies and eliminates the predominant source(s) of these *E. coli* (if controllable) could have enough of an impact to bring Santa Ana River Reach 3 into attainment with water quality objectives.

  Based on studies conducted over several years, it is unlikely that sources of *E. coli* derived from humans (including homeless encampments), feral pigs, dogs or horses can explain all observed *E. coli* loads where Santa Ana River 4 transitions to Reach 3. However, to date analyses of different potential warm-blooded sources have been conducted independently rather than jointly, e.g., through implementation of one comprehensive study. Given the importance of understanding the source(s) of *E. coli* bacteria, it is recommended that the Task Force continue to implement special studies in the Santa Ana River segment upstream of Mission Boulevard Bridge. In particular, implement a comprehensive study that looks at multiple potential bacteria sources in water and sediment.[19] Any planned studies should maximize use of historical and ongoing data collection from Reach 4 of the Santa Ana River collected at the confluence of High Grove Channel (MS4 permit compliance monitoring conducted by RCFC&WCD) as well as at Riverside Drive bridge crossing (RMBP Priority 3 station).

- Mass balance analysis completed for Cucamonga Creek found that in-stream sources of *E. coli* are important contributors of the bacteria load to the downstream impaired waterbody. Similar to Santa Ana River Reach 3, it is recommended that the Task Force implement special studies to identify this source(s).

• *Additional Chris Basin Study* - SBCFCD completed a regional treatment project in Chris Basin to reroute the DWF path to increase hydraulic residence time to enhance opportunity for natural *E. coli* decay in DWF from upstream Deer Creek prior to discharge to Cucamonga Creek. After the first year of operation, anticipated load

[19] Future studies may need to consider potential impacts from the ongoing Santa Ana River Levee Rehabilitation Project, especially if samples are collected from areas where the low flow channel has been diverted and if sample collection includes river sediments taken from within areas where the riverbed has been disturbed. The levee project, which began in 2022, includes construction of three diversion projects to realign the low flow channel in three specific segments of Santa Ana River Reach 3. To date, two of three diversion channels (southern and central) have been constructed; the northern diversion channel is expected to be constructed in the latter part of 2023. The entire rehabilitation project is expected to be completed in 2025.

reductions have not been observed; however, as was also noted a significant diurnal difference in *E. coli* concentrations was observed. Additional study is recommended to understand bacteria dynamics around this facility. In addition, the finding of diurnal differences in bacteria concentrations should be considered in the design of other studies in the MSAR watershed, including the recommended comprehensive Tier 1 source evaluation study (see above).

- *Wet Weather Data Collection* – Given the upcoming compliance deadline to comply with the wet winter condition TMDL WLAs and LAs, it is important for the MSAR Task Force to increase efforts to collect wet weather data to support future planning efforts. Data collection will also be necessary to support the next phase of TMDL implementation (see Section 5.2 below). Key considerations include:
  - Wet weather sampling would be particularly valuable at the key MS4 Tier 1 sites that flow into Chino Creek, Mill-Cucamonga Creek and Santa Ana River Reach 3, especially during small storms that do not exceed thresholds for implementation of a high flow suspension. These data will support understanding of how to apply the high flow suspension in the watershed.
  - Given that there are more than 30 MS4 outfalls that can contribute urban runoff to impaired waters in the MSAR watershed it must be recognized that it will be difficult (if not infeasible) to collect data from all potential sites during a single synoptic wet weather event (as is possible for dry weather condition studies). In addition, given the flashiness of storm event runoff and varying fecal bacteria washoff at different points along a storm hydrograph, wet weather sampling will have to focus on a subset of sites for data collection during any single storm event. Careful consideration will need to be given regarding how to collect the best data to evaluate wet weather impacts.
- *Consideration of Site-specific Objectives* - Multiple studies over the past 15 years have shown that the majority *E. coli* in Reach 3 of the Santa Ana River are not associated with human and other more pathogenic host organisms. This condition makes Reach 3 of the Santa Ana River and possibly other waterbodies as potential candidates for development of a site-specific objective for water contact recreation based on illness risk. Such an approach involving application of quantitative microbial risk assessment (QMRA) was a key topic at the recent 2022 California Bacteria Summit (State Water Board and California Stormwater Quality Association 2022). The Task Force could evaluate the costs and potential benefits of conducting QMRA analyses within the MSAR watershed to support a future site-specific objective applicable under dry conditions.

5.2 Limited Revisions to MSAR TMDLs

Section 5.1 above summarizes key recommendations for: (a) additional studies to support continued implementation of the TMDLs to comply with WLAs and LAs applicable to dry summer conditions in the MSAR watershed; and (b) increasing the collection of wet weather event data. The recommendation to increase wet weather data collection is particularly important given that the MSAR TMDLs include WLAs and LAs applicable to the Wet Winter Condition (November 1 through March 31) (see Section 1.1). These WLAs/LAs are to be achieved as soon as possible but not later than December 31, 2025.

Given the upcoming 2025 wet winter condition compliance date, the MSAR Task Force in collaboration with the Santa Ana Water Board recently began the process to make limited revisions to the MSAR TMDLs, primarily to identify tasks that focus on wet-weather based assessments that will support efforts to understand how to comply with the wet weather condition WLAs and LAs. The planned revisions would identify the specific tasks, purpose of the tasks and the schedule for implementation. To support this effort, the MSAR Task Force is currently working with the Santa Ana Water Board staff to develop the Technical Report and Substitute Environmental Document to support the Basin Plan amendment to make the proposed limited revisions to the TMDLs.

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Appendix A: Timeline of Key TMDL Implementation Activities

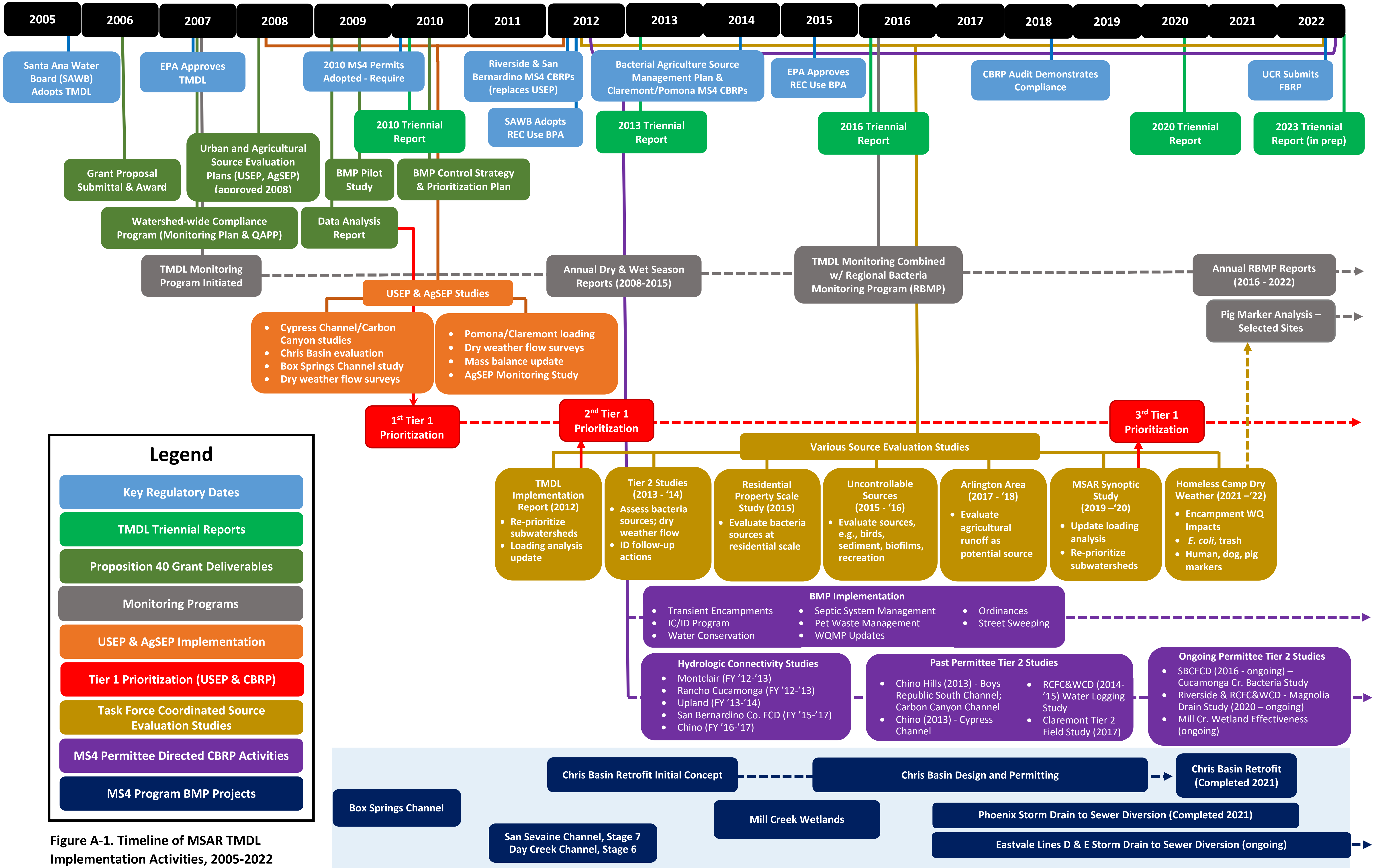

Figure A-1. Timeline of MSAR TMDL Implementation Activities, 2005-2022

Appendix B: Previous MSAR Special Studies

Since the TMDLs became effective in 2007 numerous bacterial indicator-related special studies have been implemented in the watershed either collectively by the MSAR Task Force or by specific MS4 Permittees. The outcome of this extensive work, which has primarily focused on understanding bacterial indicator dynamics under dry weather conditions, provides the foundation for ongoing TMDL implementation activities in particular as related to compliance with the dry summer condition TMDLs. While these studies occurred outside the time frame of this 2023 Triennial Report, brief summaries of the findings from these earlier studies (with links to the study reports, where available) are provided here to provide a complete record.

B.1 MSAR Bacterial Indicator TMDL Data Analysis Report (2007-2008)

The first comprehensive analysis of bacterial indicators, bacteria sources and DWF sources in the MS4 within the MSAR watershed was conducted by the Task Force in 2007-2008. Sample locations included both the watershed-wide compliance sites and a number of Tier 1 sites (defined as sites where urban sources of DWF may directly discharge to a downstream impaired water). A key outcome of this report was a list of prioritized waterbodies for implementation of subsequent source evaluation studies. The findings are provided in the MSAR Bacterial Indicator TMDL Data Analysis Report (SAWPA 2009; https://www.sawpa.org/wp-content/uploads/2018/04/2009_Final-Data-Analysis-Report_033109.pdf.)

B.2 Urban Source Evaluation Studies (2009-2011)

As noted above, SAWPA (2009) identified priorities for additional mostly site-specific studies to evaluate urban sources of bacterial indicators. Findings from these early Task Force studies were documented in a series of technical memoranda, which are summarized below:

- *Final Technical Memorandum – Dry Weather Runoff Controllability Assessment for Lower Deer Creek Subwatershed (Chris Basin) Special Study* (SAWPA 2010b): Data collected in 2007 and 2008 resulted in the Lower Deer Creek subwatershed in the Cucamonga Creek watershed receiving a high priority ranking for subsequent bacteria mitigation work. This controllability assessment evaluated two potential options to control dry weather runoff from Chris Basin before it was discharged into mainstem Cucamonga Creek. The complete technical memorandum may be reviewed here: https://www.sawpa.org/wp-content/uploads/2018/04/2010_Chris-Basin-Final-TM.pdf.
- *Final Technical Memorandum – Source Evaluation Activities in Carbon Canyon Creek and Cypress Channel* (SAWPA 2010c): Data collected in 2007 and 2008 resulted in a high priority ranking for Cypress Channel for subsequent source evaluation activities (SAWPA 2009). In contrast, SAWPA (2009) established a very low priority ranking for

Carbon Canyon Creek because of low bacteria concentrations as compared to other subwatersheds. The Task Force implemented source evaluation studies in each of these subwatersheds in 2009-2010 to better understand the basis for these findings. The resulting technical memorandum noted the following (complete technical memorandum may be reviewed here: https://www.sawpa.org/wp-content/uploads/2018/04/2010_Cypress_CarbonCyn_TM.pdf):

- *Cypress Channel* – potential sources of bacterial indicators to this waterbody were identified during a field study, resulting in recommendations for follow-up actions for both MS4 Permittees and Santa Ana Water Board staff.
- *Carbon Canyon Creek* - field study identified the presence of flow dissipation structures in the segment upstream of the Tier 1 sample location. These structures greatly reduced flow rates. It was hypothesized that these structures provide increased opportunity for natural reduction of bacteria via filtering processes through the structures and increased exposure to sunlight. It was concluded that the flow dissipation structures could be a potential BMP for use in other channels, where structurally appropriate.

■ *Final Submittal - Source Evaluation Project Activities for Middle Santa Ana River, TMDL Program Support, 2010-2011* (SAWPA 2011): The Task Force identified five source evaluation activities for implementation in 2010-2011. The findings from these five activities were summarized in the following series of technical memoranda (https://www.sawpa.org/wp-content/uploads/2018/04/2011_Source-Evaluation-Project-Activities.pdf):

- *Box Springs Channel Follow-up Study* - The Box Springs Channel (T1-BXSP) site was originally sampled in 2007- 2008. During that sample period, human source bacteria were regularly detected, and high bacterial indicator concentrations were present. Following a local investigation in 2008, a sanitary/storm sewer cross connection was identified and corrected. The purpose of this study was to conduct follow-up sampling to evaluate current bacterial indicator levels and verify that human source bacteria were no longer present. The follow-up study confirmed human source bacteria were no longer present.
- *Preliminary Characterization of Bacteria Loading from MS4 in Pomona and Claremont* –The purpose of this task was to gather dry weather condition bacterial indicator data during the dry season to provide a preliminary characterization of potential bacteria loading and presence/absence of human sources of bacteria from the portion of the MSAR watershed located within the jurisdictions of the Cities of Pomona and Claremont (this portion of the MSAR watershed was not included in the original 2007-2008 data collection activity, as reported in SAWPA 2009).
- *Survey of DWF from MS4 Outfalls to Major Tributaries* - The purpose of this source evaluation study was to gain additional information regarding the variability of DWFs in stormwater channels/outfalls in the MSAR watershed. The information gained

from this effort, combined with other available DWF data, supported characterizations of typical DWFs in the area and facilitated compliance analyses to provide input to the development of the CBRPs.

- *Calculate Mass Balance for Dry Weather Conditions* – The purpose of this activity was to quantify, to the extent possible, the mass balance of bacterial indicators under dry weather conditions based on known dry weather hydrology, source of flow, and available bacteria concentration data. The resulting mass balance characterizations supported development of the compliance analysis contained within the CBRPs.
- *Calculate Site-specific Log Standard Deviation at Monitoring Sites* – The USEPA uses a default log standard deviation (LSD) of 0.4 for *E. coli* when calculating single sample maximum criteria. A site-specific LSD may be substituted for the default value where such data exist, which would result in different single sample maximum criteria. The potential to use site-specific LSDs to establish site-specific single sample criteria had been incorporated into the Basin Plan amendment under development by the Stormwater Quality Standards Task Force at that time. The purpose of this task was to calculate LSD values for MSAR watershed sample sites.

B.3 Tier 2 Source Evaluation Assessment

Based on the Tier 1 prioritization analysis developed as part of the 2013 MSAR Triennial Report, the MS4 Permittees in Riverside and San Bernardino Counties implemented Tier 2 (sample locations that are tributary to a downstream Tier 1 site) source evaluation studies within the drainage areas of the highest priority Tier 1 sites. These evaluations focused on identifying sources of bacteria within the stormwater networks of the MS4 facilities draining to these Tier 1 sites. The findings facilitated efforts within each MS4 Program to implement projects to manage sources of DWF and bacteria within the MS4 (SAWPA 2014; https://www.sawpa.org/wp-content/uploads/2018/04/2014_Tier-2-_2013-Evaluation_Final.pdf).

B.4 Uncontrollable Bacteria Sources Study

Implemented by the Riverside County MS4 Program, the Uncontrollable Bacteria Sources Study evaluated the potential importance of various non-MS4 sources of bacteria in the MSAR watershed (RCFC&WCD 2016; https://www.sawpa.org/wp-content/uploads/2018/04/2016_Uncontrollable-Bacteria-Sources-Final-Report.pdf). By process of elimination, the study's findings suggested that the majority of *E. coli* in the impaired waters may be the result of releases from naturalized colonies in channel bottom sediment and biofilms. Fecal bacteria from a specific host released to the environment can settle to the channel bottom and survive within sediments or biofilms for weeks or months over a wide range of temperature and moisture conditions. Growth of these initially deposited fecal bacteria within channel bottom sediments and biofilms results in colonies, where the majority of the population may be considered naturalized, reproducing outside of a specific organism. The Basin Plan categorizes bacteria regrowth within sediment and biofilm as an uncontrollable source of fecal bacteria (Santa Ana Water Board 2019). The report concluded that additional study would be necessary to better understand the potential for naturalized bacteria colonies to contribute to bacteria concentrations in overlying waters and the transport process by which bacteria is released.

B.5 Residential Property Scale Bacteria Study

Implemented by the San Bernardino County MS4 Program, the Residential Property Scale Bacteria Water Quality Study was able to demonstrate support for the hypothesis that extreme variability in concentrations at MS4 outfalls is linked to the quantity and quality of irrigation excess runoff from individual properties (CDM Smith 2015; https://www.sawpa.org/wp-content/uploads/2018/04/2015_Residential-Property-Scale-Bacteria-Study-Interim-Data-Analysis.pdf). Unlike rainfall driven runoff, where rain is spread across the entire watershed, the primary source of DWF in an urban catchment at any given point in time is outdoor water use by a single or small group of properties. The statistically randomized study found that irrigation excess from a majority of properties ($n = 80$) would be expected to meet WLAs in the TMDLs. The reason for very high bacteria concentrations at some sites may be partially due to the sampling method, whereby samples collected from a wetted street gutter had significantly greater bacteria concentrations than those collected from the edge of the lawn.

B.6 Arlington Study

The MSAR Task Force conducted a preliminary bacteria and flow source investigation in the Arlington Area of Riverside County in 2017 (SAWPA 2018; https://www.sawpa.org/wp-content/uploads/2018/04/FinalDeliverable_2018.pdf). The investigation sought to answer the following study questions: (a) What is the status of DWF leaving the Monroe Retention Basin; (b) What are the predominant sources of DWF in the Arlington Area; (c) What are the magnitude and sources of *E. coli* in observed DWF; and (d) Are the observed *E. coli* from human sources?

This study confirmed that DWF from the MS4 is continuous both into and out of the Monroe Retention Basin, which is hydrologically connected to the Anza Drain Tier 1 Site. This study also confirmed that grove irrigation from agricultural land uses is contributing flow and bacteria to the MS4 in the Arlington Area, though grove irrigation is not the sole contributor. Controlling or reducing flows both in upstream agricultural land uses and downstream urban land uses would help reduce bacteria loads to/from the Monroe Retention Basin. Human source marker HF183 was quantifiable in only two of 21 samples analyzed. Human source bacteria were not detected in DWFs originating from agriculture land uses. The two samples where the human source marker was quantifiable were from mixed land use monitoring locations. Where detected, the concentrations were low and not persistent.

B.7 City of Claremont Tier 2 Field Study

The City of Claremont has the potential to contribute DWF to the Chino Creek subwatershed from only a very small area. This area, 397 acres, can potentially contribute DWF via an underground storm drain which is connected to the City of Pomona's MS4 (City of Claremont 2017). This underground storm drain eventually discharges to San Antonio Creek about two miles upstream of its confluence with Chino Creek (four miles upstream of the Chino Creek at Central Avenue watershed-wide compliance site (WW-C7)). The remainder of DWFs from the City of Claremont is captured in retention basins.

The City of Claremont conducted a Tier 2 study in 2013 to characterize DWFs that have the potential to leave the City and enter the City of Pomona MS4 (City of Claremont 2017). Field surveys were conducted for eight weeks in the summer of 2013. No flow was recorded on six of eight site visits; in the other two visits, the estimated flow averaged less than 0.0018 cubic feet/second (cfs; ≈ 0.8 gallons/minute). Based on these DWF results, the total dry weather discharge found to emanate from the City is less than 2.8 gal/ac/day. Based on these findings, it was determined that "*dry weather flow from the City of Claremont is minimal and does not influence downstream concentrations*" and per the City's CBRP, "*targeted E. coli reduction needed from the City of Claremont MS4 contribution was estimated to be negligible.*"

The City of Claremont (2017) also reported reductions in DWF from ongoing coordination with the Golden State Water Company to improve outdoor water use efficiency (consistent with CBRP requirements to implement water conservation practices) and reduce DWF from areas that may potentially drain to Chino Creek. These efforts have been successful. Long-term monitoring data showed that the median annual flow measured by the USGS gauge in San Antonio Creek (#11073300) had declined by 75% over the last 15 years - from 0.75 cfs in 2002 to less than 0.2 cfs in 2016-17 (City of Claremont 2017). The City of Claremont contributes less than one-half of 1% of the total DWF measured at this stream gauge.

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Appendix C: Triennial Report Key Findings

The 2013, 2016 and 2020 Triennial Reports included a number of important findings that have guided subsequent actions to support TMDL compliance in the MSAR watershed. Summaries of the key findings from each of these reports is provided below.

C.1 2013 Triennial Report

The second Triennial Report (*Middle Santa Ana River Bacterial Indicator TMDL Implementation Report*; SAWPA 2013) not only evaluated the status of compliance with urban WLAs and LAs as required by the TMDLs but also provided the results from source evaluation studies conducted as part of the implementation of the Riverside and San Bernardino County MS4 Program CBRPs. The complete report is available at: https://www.sawpa.org/wp-content/uploads/2018/04/2013-Triennial-Report_Tier-1-Source-Evaluation-Final.pdf. Key findings from this 2013 report include:

Status of Compliance - Dry Weather Conditions

- Bacterial indicator concentrations and frequency of exceedances remained generally constant at all watershed-wide compliance sites during the six years sampling had occurred to date. No stations reported a marked increase or decrease in concentration from 2007 to 2012.
- During each year of dry season sampling, the highest bacterial indicator concentrations were observed at the Mill-Cucamonga Creek and Chino Creek sites.
- With the exception of 2009, for the period from 2007 through 2012 Prado Park Lake generally remained below the *E. coli* WLA (on an annual basis) during the dry season.
- Analyses of bacterial indicator data suggested that natural or uncontrollable sources[20] of bacterial indicators may be important contributors to bacterial indicator concentrations at the watershed-wide compliance sites.
- Seasonal increases in bacterial indicators were regularly observed at the watershed-wide compliance monitoring sites. Understanding the cause of these increases may provide information regarding controllable and uncontrollable sources of bacterial indicators in the watershed.

Tier 1 Source Evaluation Data Analysis Activities

- DWF rates from MS4 outfalls were low in most places where there were no known sources of rising groundwater.

[20] The Basin Plan defines "uncontrollable sources" as: wildlife activity and waste; bacterial regrowth within sediment or biofilm; resuspension from disturbed sediment; concentrations (flocks) of semi-wild waterfowl; shedding during swimming (Santa Ana Water Board 2019).

- Bacterial water quality observed in DWFs from MS4 outfalls was highly variable across the MSAR watershed.
- *E. coli* concentrations in samples that also had a detection of the *Bacteroides* human marker were higher than in samples with no *Bacteroides* human marker detection.
- Data results provided the basis for prioritizing MS4 subwatersheds for subsequent CBRP compliance activities within the MSAR watershed.
- In some weeks, a close correlation existed between the estimated *E. coli* concentration expected from blended MS4 outfall flows, and POTW discharges. However, in a number of cases, the observed *E. coli* concentrations were substantially higher than expected suggesting that additional sources of *E. coli* had not yet been accounted for.
- Data analysis identified the key MS4 outfalls within each impaired waterbody (based on DWFs and *E. coli* concentrations) where subsequent source evaluation work could provide the most benefit with regards to meeting bacterial indicator water quality objectives at watershed-wide compliance sites.

C.2 2016 Triennial Report

The third Triennial Report (*Middle Santa Ana River Bacterial Indicator TMDL Implementation Final Report*) provided an update on the status of compliance with the TMDLs and also summarized findings from other studies completed in the watershed (SAWPA 2017). Below is a summary of the findings from that report (https://www.sawpa.org/wp-content/uploads/2018/04/2016_Triennial-Report-June-2017.pdf):

- The Permittees fulfilled the requirements established in the four base CBRP elements through: (1) revision and enforcement of city water conservation and stormwater ordinances; (2) deployment of a range of water quality BMPs to reduce DWF (e.g., through implementation of water conservation BMPs) or control sources of fecal bacteria within the MSAR watershed; (3) implementation of a source evaluation program and set of supplementary studies; and (4) completion of regional BMPs to provide additional treatment of DWFs.
- Prado Park Lake had bacteria concentrations that were consistently close to water quality objectives. In the 2015 dry season a significant reduction was observed (geometric mean of *E. coli* of 40 cfu/100 mL; see Figures 2-5 and 2-6), which might have been attributable to a revision in the way IEUA delivers treated effluent to the lake. Thus, there is reason to believe lower bacteria levels may continue in the future, which would support delisting this waterbody and removing it from the list of impaired waters in the future.
- Updates to the source contribution analysis for MS4 and POTW inputs to each of the impaired waters showed that the expected bacteria concentration at four of five of the watershed-wide compliance monitoring sites was below water quality objectives (only Mill-Cucamonga had estimated MS4+POTW blend concentrations over the water quality

objective). However, monitoring data showed that exceedances of the water quality objectives continued to occur at varying frequencies at all of the sites.

- Since the TMDLs were adopted, there has been a continuous decline in POTW effluent discharges to each of the impaired waterbodies caused by indoor water conservation measures and increasing reuse of wastewater, such as in the IEUA service area. Per the source contribution analysis, this would naturally result in an increase in the estimated flow-weighted average concentration that may be expected at the downstream compliance monitoring sites. No such rise in fecal bacteria has been observed at any of the watershed-wide compliance monitoring sites.

C.3 2020 Triennial Report

The fourth Triennial Report (Middle Santa Ana River Bacteria Synoptic Study and TMDL Triennial Report) included the findings of a synoptic study designed to provide updated information on key sources of DWF in the MSAR watershed and data to update the priority for source evaluation activities at Tier 1 sites. Below is a summary of the key findings and recommendations for next steps by the Task Force and responsible parties from the report (SAWPA 2020a).

C.3.1 Key Findings

Taking into account the body of research related to TMDL implementation that had been completed to date in the MSAR watershed, the study report incorporated the following key findings.

- The MS4 Programs met the CBRP goals to significantly reduce DWF to the waterbodies named in the TMDLs, e.g.:
  - The MS4 Programs have hydrologically-disconnected the majority (66%) of the upper MSAR watershed during dry weather conditions through infiltration in unlined flood control channels, retention basins, and other flow diversion projects. These areas no longer cause or contribute to exceedances of the water quality objectives for pathogen indicator bacteria (evaluated as concentrations of *E. coli*) in the downstream receiving waters during dry weather conditions.
  - Long-term monitoring data shows DWFs from MS4 conveyance facilities are substantially lower continuing a downward trend that has been observed since 2007 (the first year of TMDL implementation).
  - The City of Claremont has effectively eliminated dry weather runoff from its jurisdiction and is no longer causing or contributing to downstream exceedances.
- With the exception of the Chino Creek subwatershed, the MS4 Programs also met the bacteria load reduction goals established in the CBRPs as necessary to assure compliance with the bacteria concentration targets established by the TMDLs (in fact, bacterial loads were reduced from MS4 inflows to the Santa Ana River much more than was required by

the CBRP). For Chino Creek, the MS4 Programs have achieved approximately 80% of the estimated bacteria load reduction needed to assure compliance with the bacteria concentration targets established by the TMDL.

- At Prado Park Lake a major engineering project has been completed that repaired and restored the MS4 conveyance system so that it properly bypasses the lake. Data from the watershed-wide compliance site at Prado Park Lake shows that water quality at this site often meets the TMDL *E. coli* targets. When sufficient data have been collected to demonstrate consistent long-term compliance, this site should be considered for de-listing. If not delisted when the MSAR TMDLs are revised, no dry weather WLA should be assigned to the MS4s for this waterbody, because no DWF is discharged to this waterbody from an MS4.
- Unidentified non-point sources now account for the majority (77%) of the total bacteria load in the Santa Ana River. As has been demonstrated, based on source analyses completed in 2007, 2012, and now 2019, the Santa Ana River would be in compliance with the TMDL targets and the state's new water quality standards for pathogen indicator bacteria were it not for the excessive loads from these unknown non-point sources which are not conveyed through the MS4.
- Sampling data from Reach 4 of the Santa Ana River shows that bacteria loads from unknown non-point sources contribute about 300 billion MPN/day, which is enough to consume nearly 100% of the total allowable load for *E. coli* bacteria in the receiving water.
- Examples of de minimis discharges within the MS4 network continue to be evident in the watershed. During just the six-week study we observed DWF volume anomalies at two locations (San Antonio Channel and Anza Drain).
- Quantification of the load of HF183 gc in the MS4 provides insight into the extent of human fecal contamination from MS4 sources. The maximum measured load of HF183 from a Tier 1 MS4 site (8,282 gc/day in Week 3 from T1-MCSD) may be associated with approximately 1.5 grams/day of human feces based on pooled data from multiple studies translating gene copies of HF183 to mass of human feces (Ahmed et al. 2016). Thus, a small amount of human feces contamination can cause HF183 amplification downstream and contribute to a sharp rise in fecal bacteria concentrations at MS4 outfalls. This finding is important because it shows that source tracking and elimination of isolated cases of human feces contamination can be highly effective in improving water quality at MS4 outfalls in the MSAR watershed. Evidence of this has been reported following prior Tier 2 investigations conducted by MS4 Permittees.
- The maximum load of HF183 from within the mainstem of the Santa Ana River (69,727 gc/day in week 3 from MISSION) is eight times greater than the maximum load of HF183 measured at any of the Tier 1 MS4 outfalls. This much larger human fecal load at the MISSION site was demonstrated to be entirely associated with a source that does not originate from within MS4 drainages, nor could it be attributed to non-viable genetic

material from POTW effluent. This finding is important because efforts to mitigate sources of *E. coli* bacteria within MS4 jurisdictions alone will not be enough to attain the *E. coli* water quality objectives at downstream watershed-wide compliance sites.

- There appears to be lower (less frequent and smaller magnitude) human signal present in 2019 compared to the previous Synoptic Study performed in 2012. This indicates that recent efforts to regulate septic systems and better maintain sewer collection systems have been effective. The relative absence of significant human signal strongly suggests that the *E. coli* observed in the receiving waters is more likely coming from natural background sources (sediment, biofilms, wildlife) than from homeless encampments, water recreation activities, or other controllable anthropogenic sources.

C.3.2 Recommendations

The 2020 Triennial Report/Synoptic Study also included the following recommendations for consideration by the Task Force:

- *Special Studies* – The Task Force should consider the implementation of the following special studies to gather data to support the upcoming TMDL revision:
  - *Releases from Naturalized E. coli in Santa Ana River Bottom* – This special study would be designed to collect site-specific data to assess the extent to which naturalized *E. coli* exists in the bottom sediments or biofilms of the Santa Ana River. This study would include collection of surface sediment and/or biofilm samples for enumeration of attached *E. coli* at multiple sites within the Santa Ana River during different seasons. Also, the study design should include collection of data that may facilitate quantification of key factors influencing colony formation and growth (e.g., nutrients, dissolved organic carbon, and temperature), as well as provide information regarding processes that drive the release of *E. coli* colonies to the overlying water.
  - *Mill Creek Wetlands Special Study* – The purpose of this special study would be to evaluate the performance of MCW. Based on available data, it is currently difficult to fully quantify the water quality benefits of this wetlands. Findings from this study can also support development of future agreements regarding operation of the facility.
- *Tier 2 Source Investigations* – MS4 Programs should initiate Tier 2 source investigations as described below for each subwatershed:
  - *Santa Ana River Reach 3 Subwatersheds* – Three sites received a high priority ranking in the areas draining to the Santa Ana River watershed-wide compliance sites: Magnolia Center Storm Drain [T1-MCSD], Sunnyslope Channel [T1-SNCH] and ANZA Drain [T1-ANZA]. Of these three sites, it is recommended that a Tier 2 investigation be initiated as soon as possible within Magnolia Center Storm Drain drainage area given the persistent presence of the human marker HF183 (Note: The RCFC&WCD and City of Riverside initiated a Tier 2 investigation in this

subwatershed soon after these findings were obtained – see Section 3.2.1.1.1 of this Triennial Report for an update on this effort).

  - *Cucamonga Creek Subwatershed* - For Cucamonga Creek, it is assumed that the Chris Basin Project will address a majority of the bacteria load reaching the Tier 1 CUCAMONGA site. However, it is recommended that a Tier 2 investigation be initiated by the Cities of Ontario and Eastvale in coordination with the implementation of the Chris Basin Project to verify expected bacterial load reductions following completion of that project. Implementation of these studies could also provide additional information from sites not sampled during the Synoptic Study (Eastvale Lines A and B) that may be needed to support the planned TMDL revision for this subwatershed.
  - *Chino Creek Subwatershed* - Consistent with CBRP implementation, additional Tier 2 investigations are recommended within individual subwatersheds to further identify sources of bacteria and DWF in the MS4 and options to mitigate those sources.

- *Water Quality Monitoring Program Enhancements* – Addition of the Santa Ana River WW-MISSION site to the RBMP as part of the TMDL compliance monitoring program. Regular sample collection from this location will provide data to support the upcoming revision of the TMDLs by providing information on bacteria loads in the river that are not derived from an MS4 source.
- *Preparation for TMDL Revision* – The Task Force should begin work on a strategy for revision of the TMDLs, including developing the approach to revise the WLAs and LAs, identifying the components that should be revised, e.g., dry/wet seasons vs. weather, identifying any additional data needs to effectively revise the TMDL, and an approach for addressing the wet weather component of the TMDL given the allowable high flow suspension in the Basin Plan.
- *Preparation for Potential Basin Plan Revision* – In addition to developing a strategy for revisions of the TMDLs, the Task Force should also begin work on a strategy for a potential Basin Plan revision, if determined necessary. The Basin Plan revision strategy may include consideration of unidentified nonpoint sources, dry/wet seasons versus dry and wet weather, and implementation of the State Board's Inland Surface Waters Plan.

Appendix D: Bacterial Indicator Data – Watershed Wide Monitoring Sites

This appendix provides time series plots of the results of bacterial indicator data collection at the Santa Ana River Mission Boulevard Bridge and five TMDL watershed-wide monitoring sites from Spring 2020 through Fall 2022 (**Figure D1** through **Figure D-6**; see Table 2-1 and Figure 2-1 for location information). Plots provide both the single sample and rolling geometric mean (based on five previous samples) results.

Mission Boulevard Bridge (WW-MISSION)

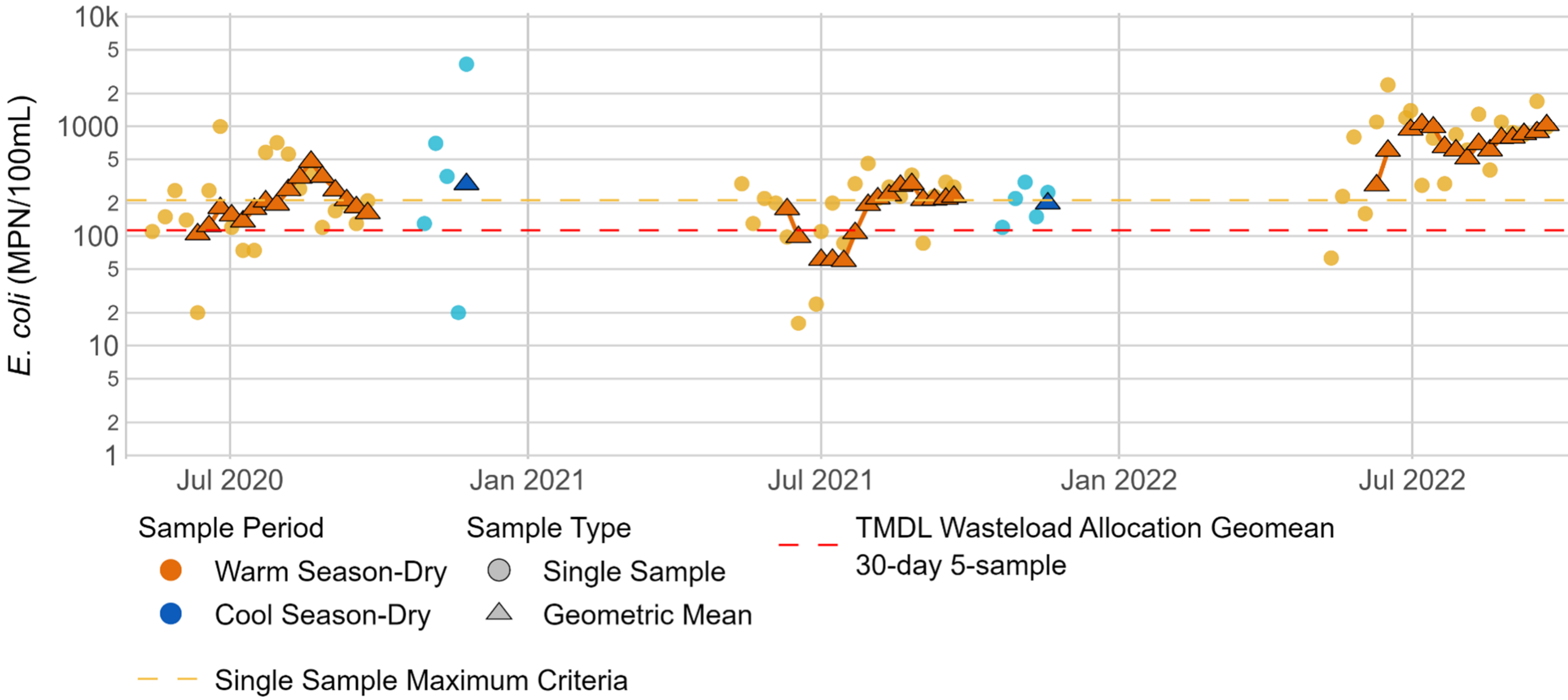

Figure D-1. Single Sample and Rolling Geometric Mean Results for *E. coli* at the Santa Ana River at Mission Boulevard Bridge Site (WW-MISSION) (Spring 2020 – Fall 2022)

Santa Ana River at MWD Crossing (WW-S1)

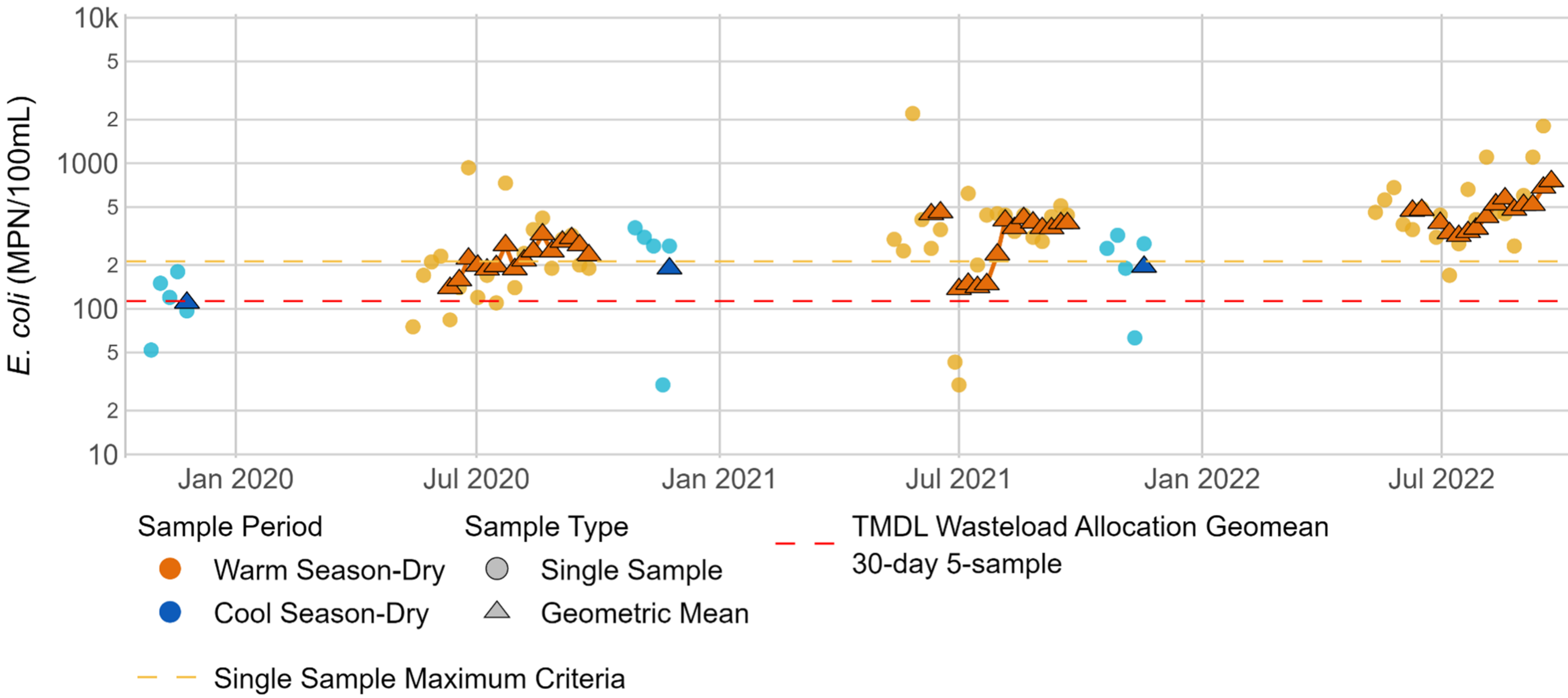

Figure D-2. Single Sample and Rolling Geometric Mean Results for *E. coli* at the Santa Ana River at MWD Crossing Site (WW-S1) (Spring 2020 – Fall 2022)

Santa Ana River at Pedley Avenue (WW-S4)

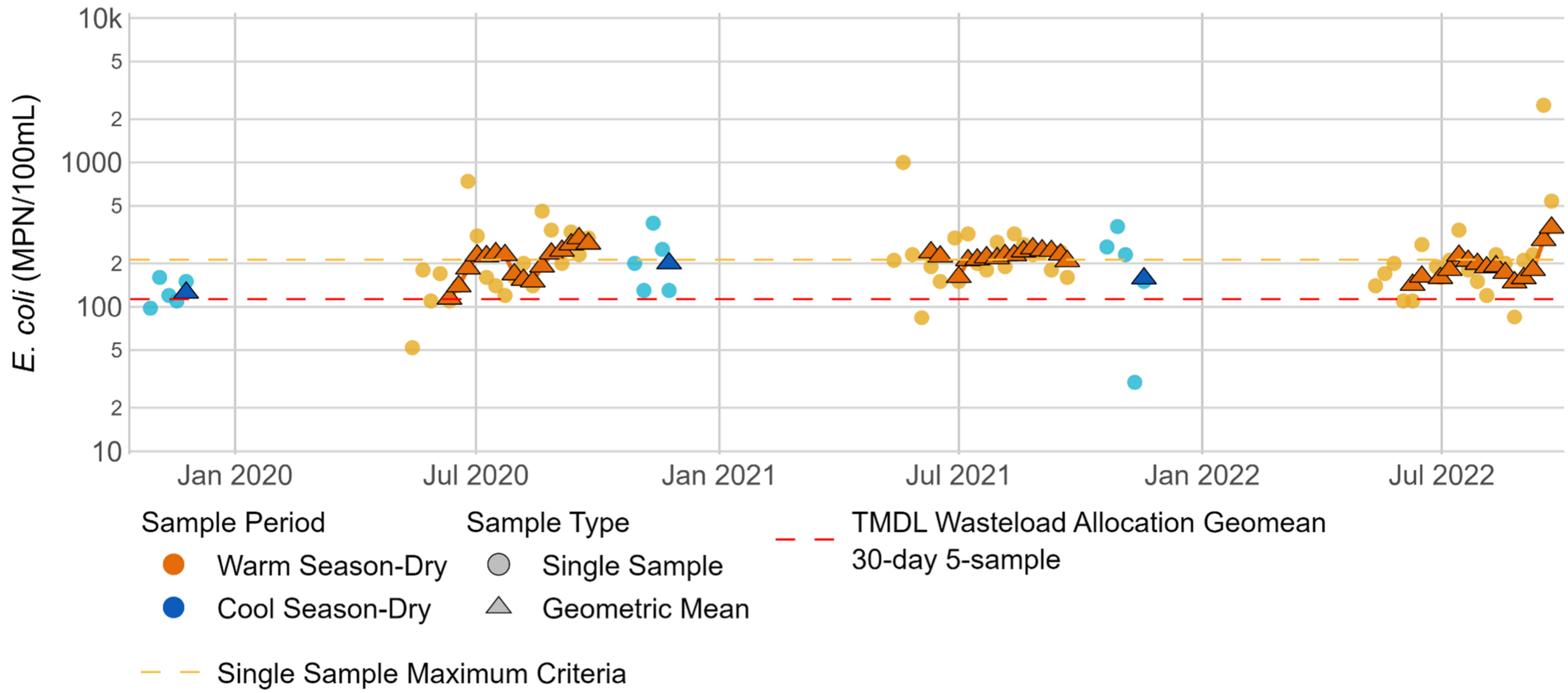

Figure D-3. Single Sample and Rolling Geometric Mean Results for *E. coli* at the Santa Ana River at Pedley Avenue Site (WW-S4) (Spring 2020 – Fall 2022)

Mill-Cucamonga Creek (WW-M6)

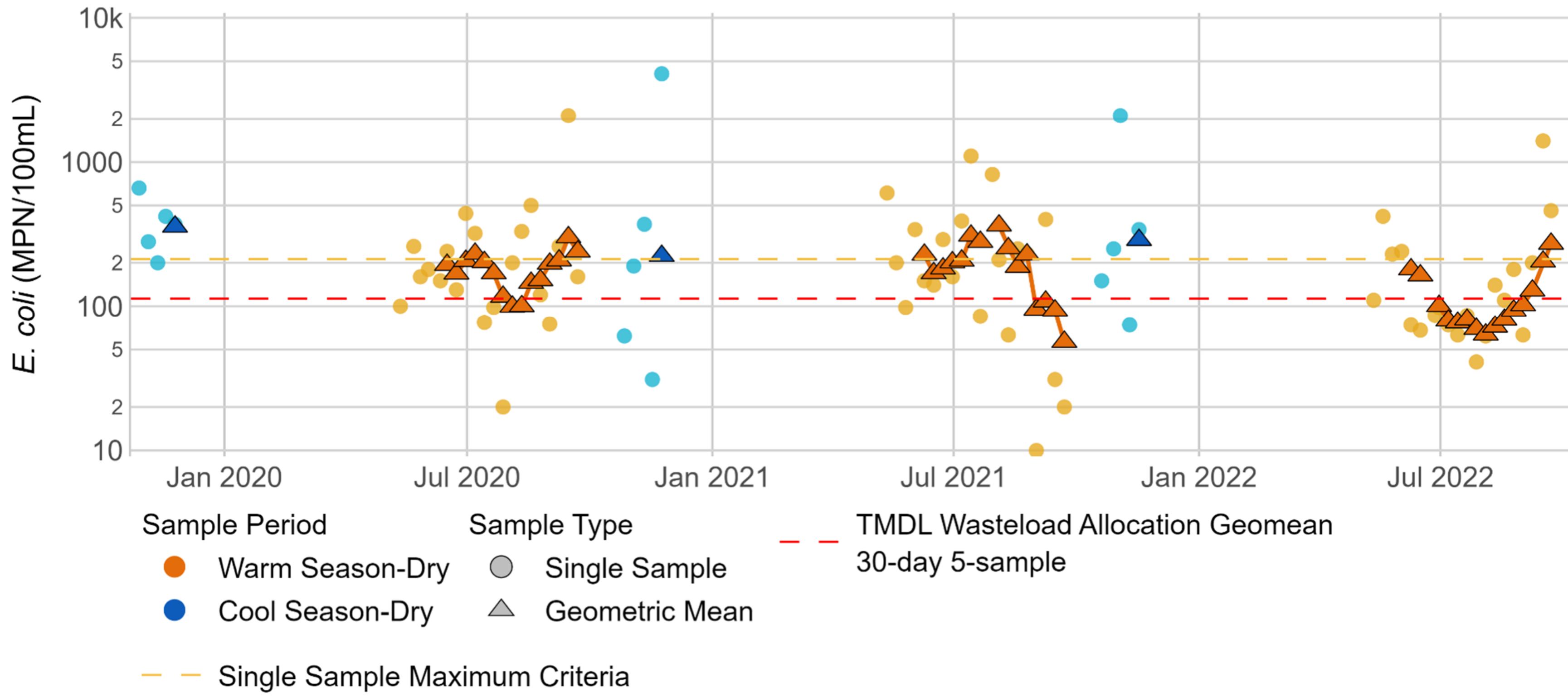

Figure D-4. Single Sample and Rolling Geometric Mean Results for *E. coli* at the Mill-Cucamonga Creek Site (WW-M6) (Spring 2020 – Fall 2022)

Chino Creek at Central Ave (WW-C7)

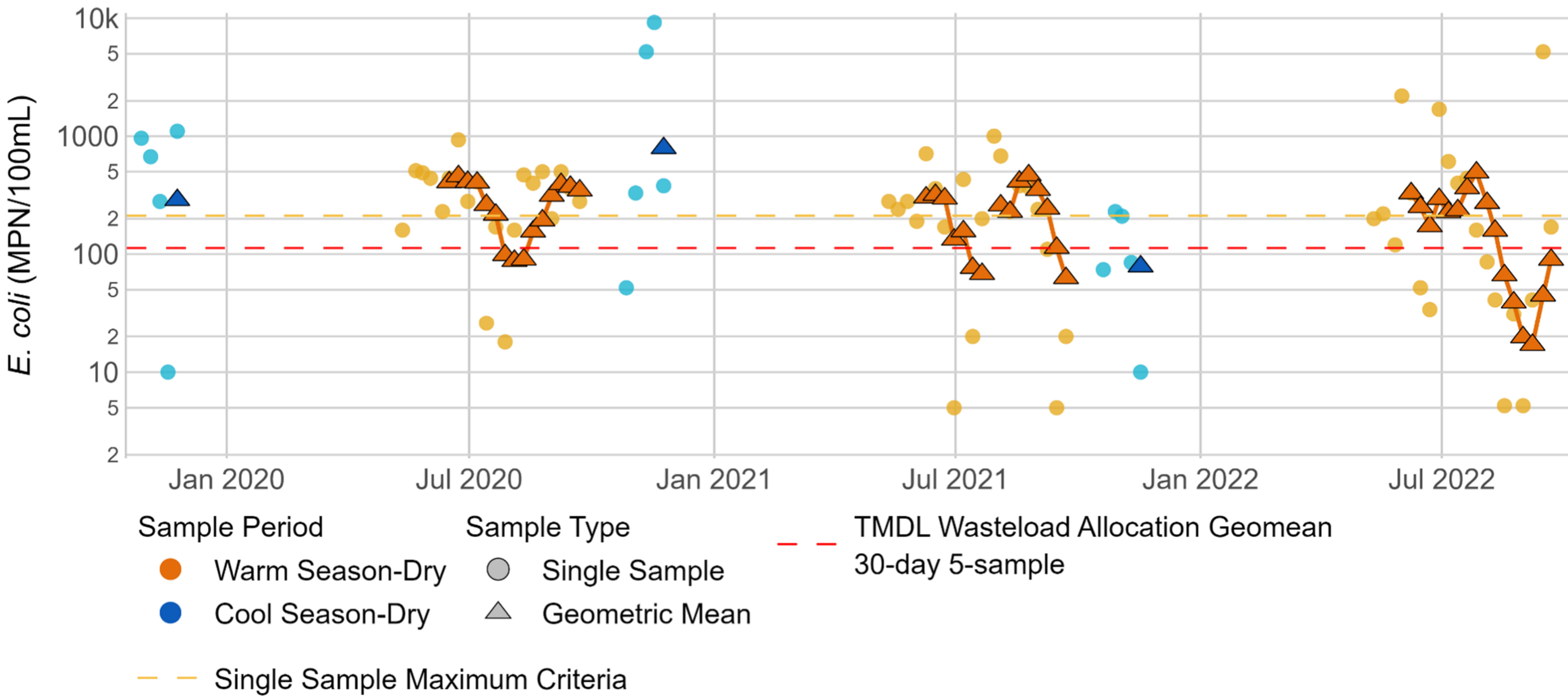

Figure D-5. Single Sample and Rolling Geometric Mean Results for *E. coli* at the Chino Creek at Central Avenue Site (WW-C7) (Spring 2020 – Fall 2022)

Prado Park Lake (WW-C3)

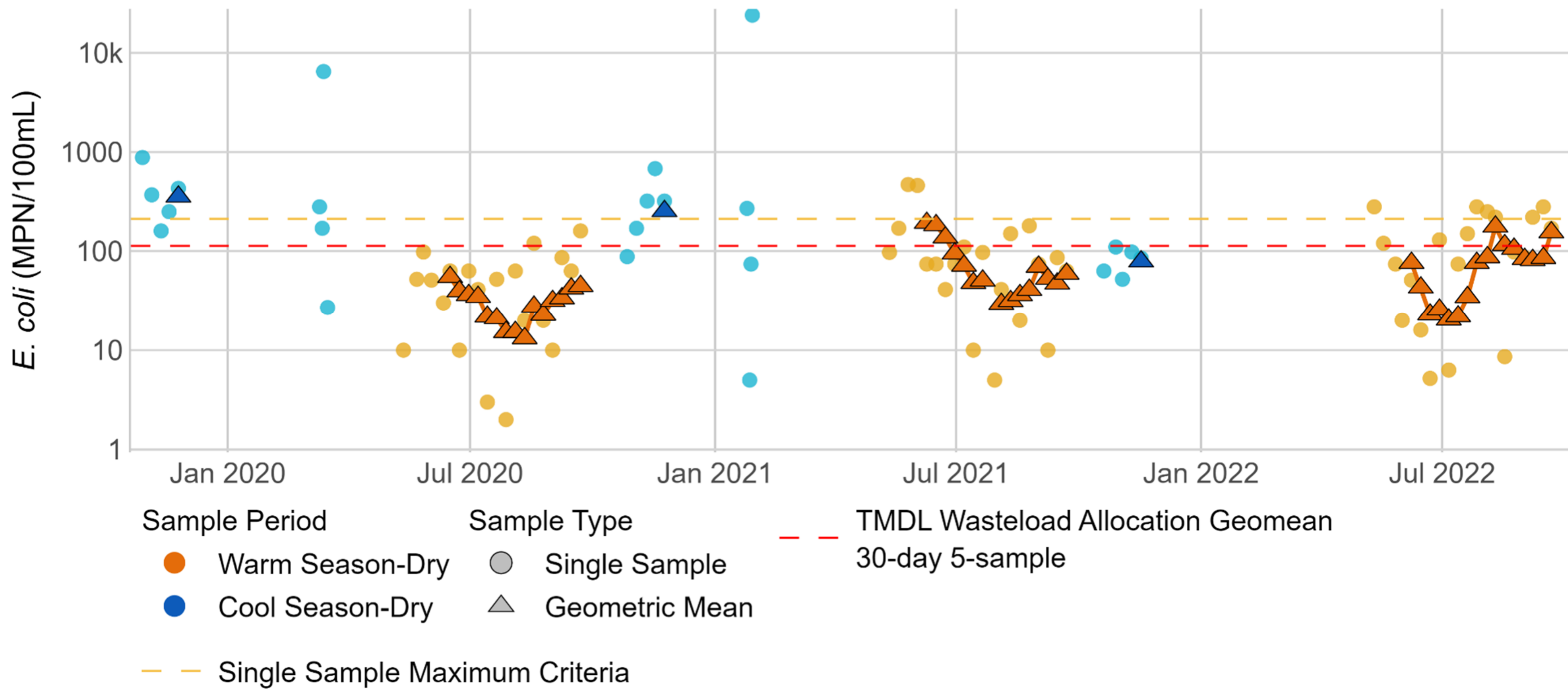

Figure D-6. Single Sample and Rolling Geometric Mean Results for *E. coli* at the Prado Park Lake Site (WW-C3) (Spring 2020 – Fall 2022)