Attachment C: Revised RAA

CONTENTS

1.0 MODELING SYSTEM USED FOR RAA

1.1 LSPC

The Loading Simulation Program in C++ (LSPC) was the watershed model selected to evaluate baseline hydrology and pollutant loading conditions. LSPC simulates hydrology, sediment, and pollutant generation, transformation, and transport on land, as well as fate and transport within streams (Shen et al., 2004; USEPA, 2003; Tetra Tech and USEPA, 2002). The WMMS model, which includes LSPC, was updated to improve local, more current, conditions based on recent monitoring data for the area of interest. The LSPC watershed modeling system includes Hydrologic Simulation Program FORTRAN (HSPF) algorithms and additionally integrates a geographical information system (GIS), comprehensive data storage and management capabilities, and a data analysis/post-processing system into a convenient Windows interface. The algorithms of LSPC are identical to a subset of those in the HSPF model, with some additions. LSPC is freely distributed by the U.S. Environmental Protection Agency (EPA) Office of Research and Development in Athens, Georgia, and is a component of EPA's National Total Maximum Daily Load (TMDL) Toolbox (www.epa.gov/athens/wwqtsc/index.html).

1.2 SUSTAIN

The System for Urban Stormwater Treatment and Analysis Integration (SUSTAIN) was the model selected to evaluate and select regional BMP designs to meet water quality objectives. SUSTAIN was developed by the USEPA to support selection of BMPs in urban watersheds (USEPA, 2009; www.epa.gov/water-research/system-urban-stormwater-treatment-and-analysis-integration-sustain). The performance of stormwater control measures is simulated with a process-based continuous simulation BMP module, which routes flow and pollutant transport through identified structural BMPs. To optimize the selection and placement of BMPs, SUSTAIN iteratively runs different combinations of BMP properties, varied within a specified range, to generate a cost-effectiveness curve. The recommended BMP sizes and diversion rates to BMPs are based on the most cost-effective scenario.

2.0 BASELINE CRITICAL CONDITIONS AND REQUIRED POLLUTANT REDUCTION

2.1 WATERSHED MODEL DEVELOPMENT AND CALIBRATION

The LA County WASOP watershed model was calibrated for all of LA County, based on monitoring data from 1990 through 2006. Updates to the County WASOP watershed model used a tailored approach, with more recent, localized monitoring data, where the Los Angeles River (LAR) and San Gabriel River (SGR) watersheds were calibrated separately. The objective of the LSPC model development was to achieve the best model fit possible and due to the highly managed conditions in the upper reaches of the watersheds. While soil type and slope are already reflected in the hydrologic response unit (HRU) definitions at the land use level, the calibration effort focused on parameter adjustments that best captured the site-specific conditions in the respective watersheds. The LAR and SGR watersheds were calibrated separately, based on 15 flow stations and 1 water quality station in LAR and 11 flow stations and 1 water quality station in SGR (Figure 2-1). The area of calibration focused on the drainage area to the most downstream monitoring station in each watershed, which was the water quality station for both. The EWMP boundary contains the participating jurisdictions in the Rio Hondo/San Gabriel River Water

Quality Group[1]. While the City of Azusa was a member of this Water Quality Group during development of the 2016 EWMP, they are not included as a member agency participating in this Revised Enhanced Watershed Management Program (rEWMP) update, which supersedes the 2016 EWMP.

The calibration process prioritizes representing the general trends of observed conditions over any single event without supporting causal data that can be incorporated into the watershed model. Therefore, it is acknowledged that some observed data points are not as well represented as others. The quality of the model is limited by the available data and therefore should continue to be assessed and potentially updated as part of the adaptive management process, with additional data from the watershed. The watershed model drives the numeric targets and expected effectiveness of control measures within the rEWMP, and thus it is a foundational piece to the success of the program. Additional data, as well as advances in the scientific understanding of processes influencing water quality within the watershed, will improve the accuracy of the model, and will provide greater certainty that the goals as outlined in the rEWMP will be achieved through implementation of the proposed control measures. Such improvements to the model will be incorporated as part of the adaptive management process.

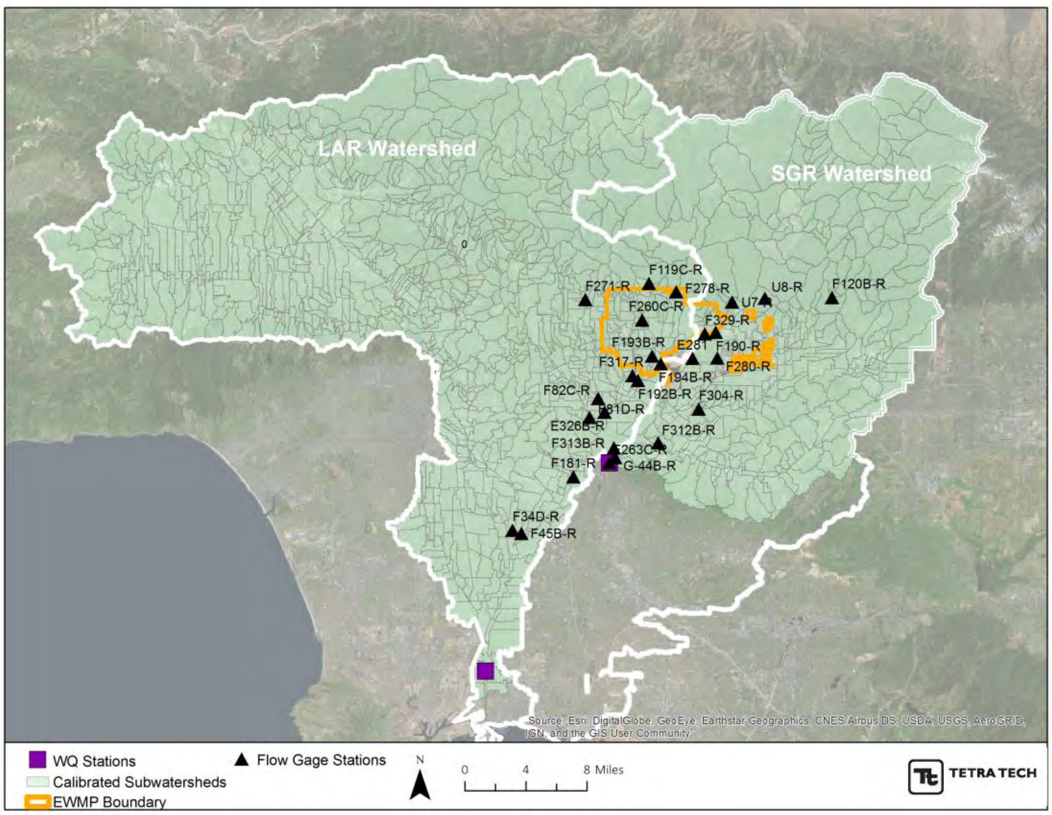

Figure 2-1. Monitoring Stations for Recalibration Effort.

[1] The City of Duarte wished to cooperate with adjoining cities to contribute towards regionally responsible stormwater treatment programs and to remain compliant with the 2012 Permit, but without jeopardizing its legal claims in *The Cities of Duarte and Huntington Park v. State Water Resources Control Board, et al., Los Angeles Superior Court Case 16 No. BS156303.* As such, Duarte must continue to reserve all of its rights and claims, as stated in its lawsuit, until final resolution of the case.

2.1.1 Hydrology Model Calibration

The calibration period was 10/1/1990 through 4/30/2012 based on the available monitoring data, obtained from LA County. Flow monitoring stations along the main stem were prioritized, and the calibration process first focused on the most upstream stations and then worked downstream. The following subsection focuses on the prioritized monitoring stations, though all available monitoring data was referenced in the calibration process. Hydrologic calibration followed the standard operating procedures for the model described in USEPA (2000), Donigian et al. (1984) and Lumb et al. (1994). An iterative approach was used to refine parameters from the WMMS set up influencing the water balance of the modeled system. Daily, monthly, seasonal, and total modeled flow volumes were compared to observed data, and error statistics were calculated for the percent difference, along with the Nash-Sutcliffe coefficient of model fit efficiency (NSE) for daily average flows. Unlike relative error on volumes, NSE (Nash and Sutcliffe 1970) is a measure of the ability of the model to explain the variance in the observed data. Values may vary from -∞ to 1.0. A value of NSE = 1.0 indicates a perfect fit between modeled and observed data, while values equal to or less than 0 indicate the model's predictions of temporal variability in observed flows are no better than using the average of observed data. The accuracy of a model increases as the value approaches 1.0 and an NSE of 0.75 or greater on monthly flows constitutes a good modeling fit for watershed applications. The baseline adjustment coefficient (Garrick et al. 1978), which is also presented, is a modified version of the NSE, but can be interpreted similarly.

The percent volume errors were then compared to recommended tolerance targets from Donigian et al. (1984) and Lumb et al. (1994). Targets are show in Table 2-1 and represent long term averages for relative error. In general, meeting these targets indicates that a model calibration can be rated as "very good". In contrast, failure to achieve these targets does not indicate that the model is unusable, but rather indicates a need to consider the impacts of model uncertainty on decisions. Values for hydrologic parameters were set in accordance with the ranges recommended in USEPA (2000) and adjusted during calibration.

Model results were also visually compared to observed data using time series plots, and additional graphical and tabular monthly comparisons were performed. Less credence was placed in the seasonal summer and storm event summer statistics since runoff volumes are low (or non-existent) during the dry seasons, and storms are rare.

Table 2-1. Criteria for the Hydrology Calibration

Category	Recommended Criteria (%)
Error in total volume:	±10
Error in 50% lowest flows:	±10
Error in 10% highest flows:	±15
Seasonal volume error - Summer:	±30
Seasonal volume error - Fall:	±30
Seasonal volume error - Winter:	±30
Seasonal volume error - Spring:	±30

Category	Recommended Criteria (%)
Error in storm volumes:	±20
Error in summer storm volumes:	±50
Nash-Sutcliffe efficiency statistic (NSE):	>0.75

Modified from Lumb et al., 1994 and Donigian et al., 1984

2.1.1.1 Model Calibration Locations

The HRU distribution for prioritized locations summed across soil and slope categorization are given in Figure 2-2 through Figure 2-7.

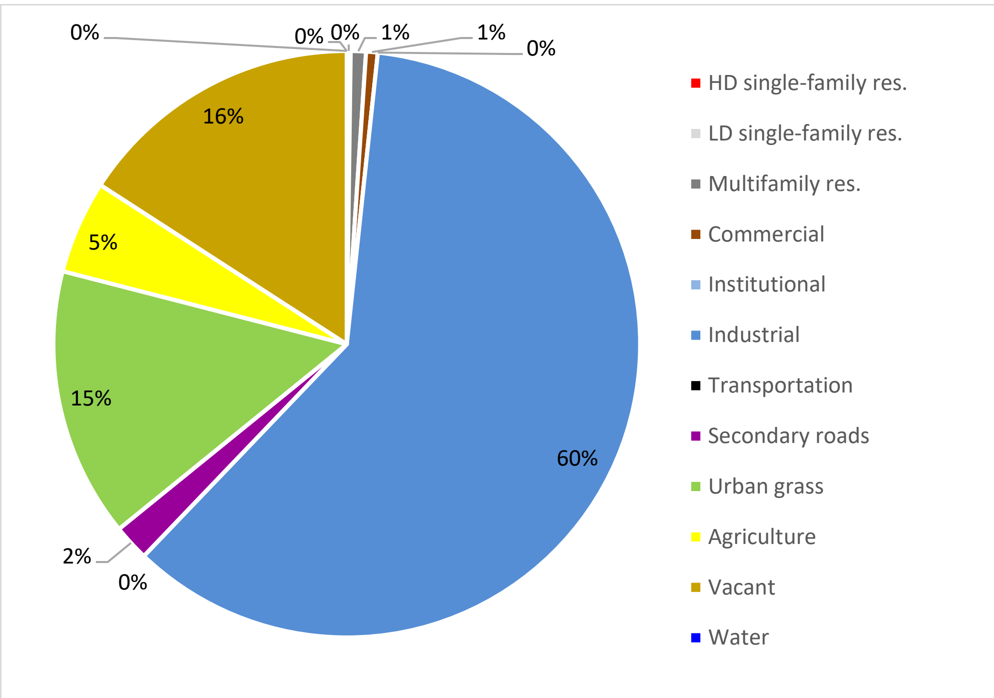

Figure 2-2. HRU Distribution at Flow Gage E326

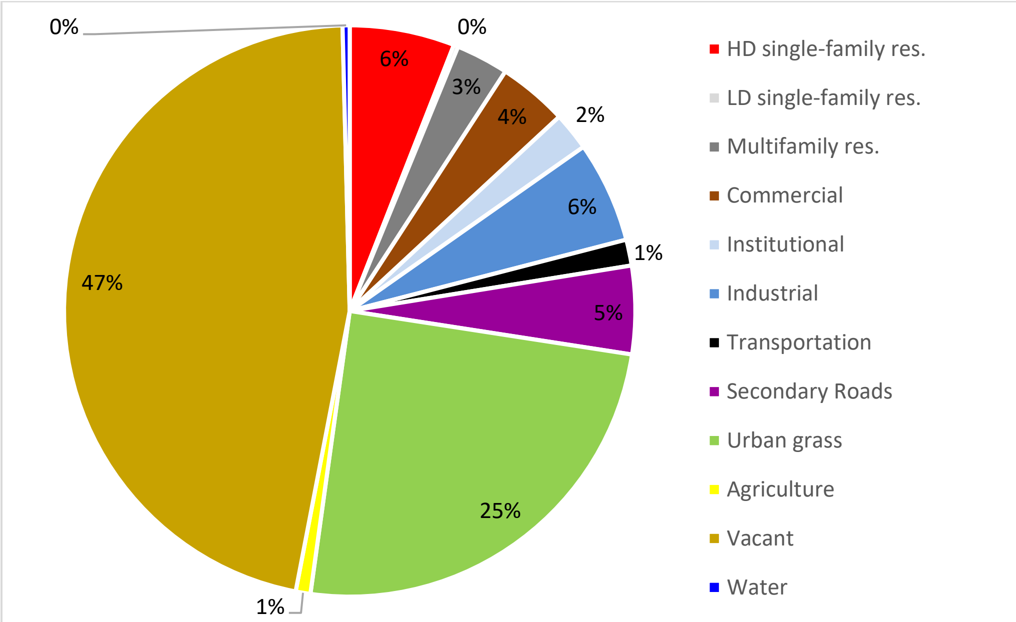

Figure 2-3. HRU Distribution at Flow Gage F194.

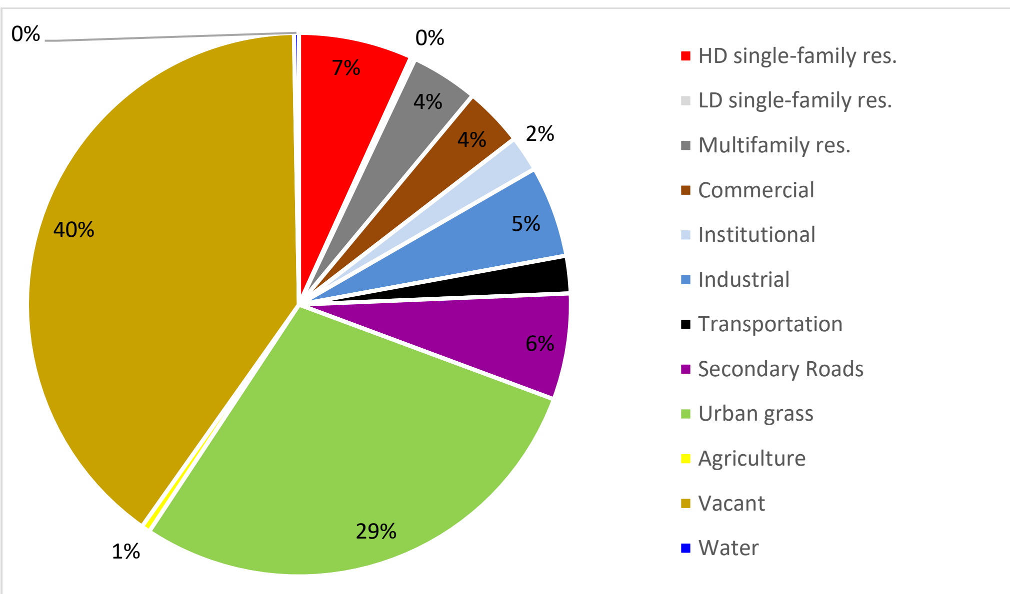

Figure 2-4. HRU Distribution at Flow Gage F319

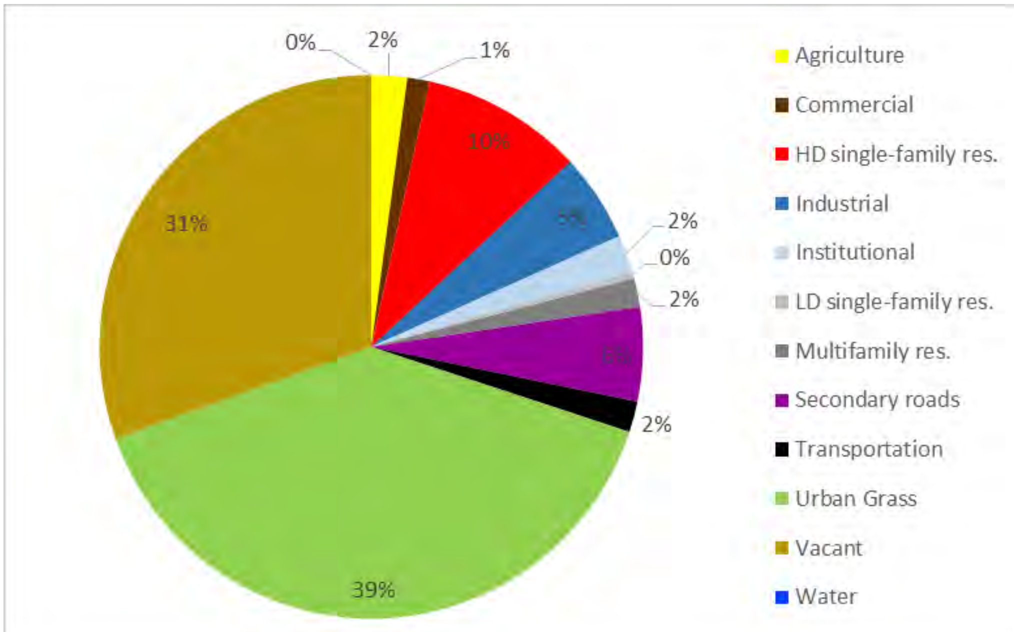

Figure 2-5. HRU Distribution at Flow Gage F329-R.

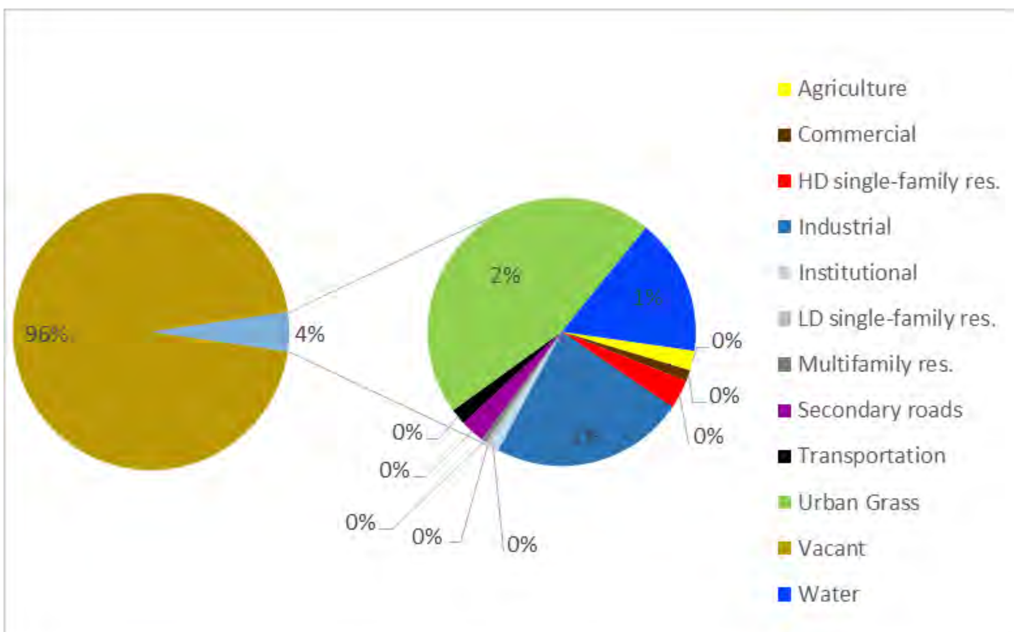

Figure 2-6. HRU Distribution at Flow Gage E281.

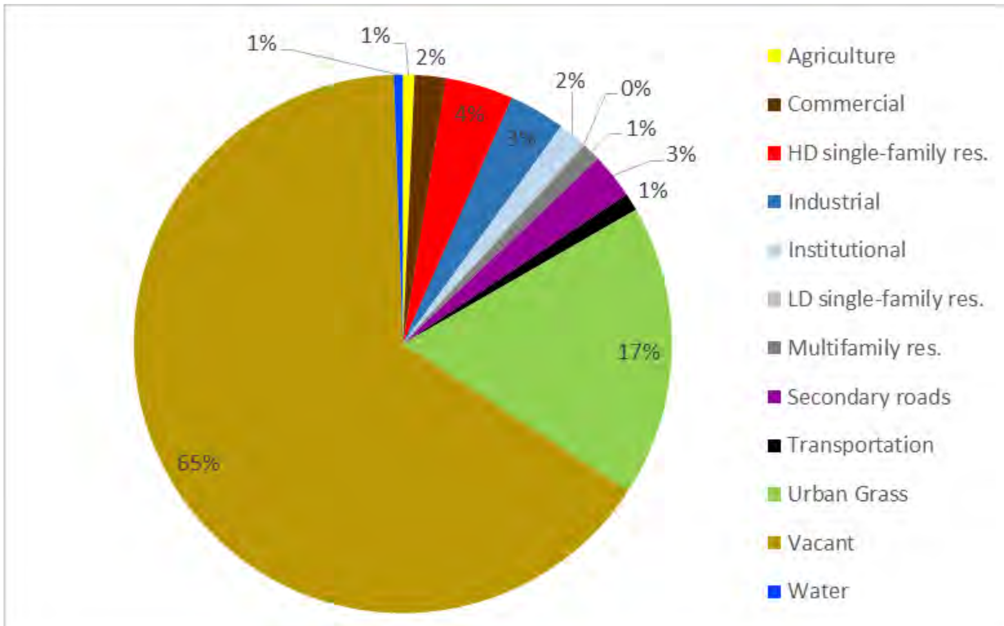

Figure 2-7. HRU Distribution at Flow Gage F263-R.

A review of the available stream monitoring data yielded the following observations:

<u>Rio Hondo</u>

- E326 is a flow monitoring gage located on the Rio Hondo below the confluence with Arcadia Wash. The land use distribution is predominantly Industrial (60%). Larger pervious areas include Vacant (15%), Urban Grass (15%) and Agriculture (5%). Low base flows are observed at this location, with peak flows associated with rainfall events. The largest flow event occurs in January 2005, following a string on rainfall over the previous 14 days. These high flow events appear to primarily be influenced by surface runoff from the impervious areas in the watershed.

- F194 is a flow monitoring gage located on Sawpit Wash above Peck Road Park Lake. A significant portion of the land use distribution is Vacant (47%). The next largest landuse classification is Urban Grass (25%). Impervious areas account for a smaller portion of the area, the largest being High-density Single-family Residential and Industrial at 6% each. Stream flows appear to primarily respond to rainfall runoff, however a small number of events (one large and 3-4 smaller events) in 2003 occur without the initiation of rainfall. Given the large pervious area at this location we expect greater influence of subsurface flows, however events such as this are likely due to manually/controlled releases, for which we do not have the appropriate information to represent in the model. The seasonal summer volume error and summer storm volume error are significantly impacted by these events, which are expected to be low during the dry season, thus indicating model under prediction. However, 2003 is the only year for which this observation is made, thus we do not expect this to be a reoccurring condition.

- F319 is a flow monitoring gage located on the Los Angeles River below Wardlow River Road and is co-located with an available water quality data monitoring dataset. The land use distribution is predominantly Vacant (40%), with additional pervious area classified as Urban Grass (29%). High-density Single-family Residential (7%), Secondary Roads (6%) and Industrial (5%) are the larger impervious areas identified. A sustained, consistent base flow is observed at this location, with peak flows primarily in response to rainfall. Flow rates are significantly higher at this location, further downstream the Los Angeles River, with a large drainage area.

San Gabriel

- F329-R is a flow monitoring gage located on Bradbury channel, an unmanaged watershed located upstream of the Santa Fe Dam. The land use distribution is predominantly Vacant (31%) and Urban Grass (39%) with the largest impervious areas identified as High-density Single-family Residential (10%), Secondary Roads (6%), and Industrial (5%). Stream flow in the channel shows a rainfall runoff response where rainfall events are associated with peak flows that appear to be primarily surface run off exhibiting quick recession with little or no base flow or inter flow. This indicates that the impervious cover in the watershed is the dominant factor affecting hydrologic response.
- E281 is a flow monitoring gage located on the San Gabriel River below the Santa Fe Dam and has been selected as a project compliance location. The land use distribution for this location is almost entirely Vacant (96%), with the remaining area made up of Urban Grass (2%), Water (1%), and Industrial (1%). This location is highly managed with flow being driven by dam releases, which are intermittent and generally below 100 cfs. There are two major rainfall events in the winter of 2005 that showed recorded flows of 14,586 and 10,317 cfs on January 10th and February 21st, respectively. Matching hydrologic response at this location is highly dependent on the proper representation of the Santa Fe Dam.
- F263C-R is a flow monitoring gage located on the San Gabriel River below the Whittier Narrows Dam and is co-located with an available water quality data monitoring dataset. The land use distribution is predominantly Vacant (65%) and Urban Grass (17%) with the largest impervious areas identified as High-density Single-family Residential (4%), Secondary Roads (3%), and Industrial (3%). This location is highly managed with flow being driven by dam releases, which are more frequent and greater than the Santa Fe Dam, typically between 100 and 1000 cfs. Similar to what is observed at gage E281, there are two major rainfall events in the winter of 2005. The events at this downstream location result in significantly smaller flows, however, with stream flow measured at 4,820 and 5,803 cfs on January 14th and February 21st, respectively. That there is a greater contributing watershed area, but smaller flows for the two peak events indicates that the operation of the Whittier Narrows Dam is the dominant factor in hydrologic response at this location. The reservoir is attenuating peak flows to a significant degree by allowing reservoir storage to infiltrate and evaporate, while also maintaining greater and more frequent intermediate flows.

Reservoir Representation

The representation of reservoirs and spreading grounds in the study watersheds was first configured in the WASOP model as detailed in the Los Angeles County Watershed Model Configuration and Calibration Report (Tetra Tech 2010a). Both watersheds have uninhabited mountains in the headwaters, with a number of dams at the edge of the mountains. The user-specified FTables developed in the original WMMS to represent these dams were found to be inaccurate based on more recent monitoring data. An iterative approach was again used to adjust these FTables to improve the simulation relative to the observed flows. For the LAR watershed model adjustments were made to FTables to improve representation of Eaton Wash Dam, Santa Anita Dam, and Sawpit Wash Dam.

The Whittier Narrows Dam on the San Gabriel River was represented to better calibrate the hydrology at the F263 location. The Whittier Narrows Dam is operated by the Army Corps of Engineers Los Angeles District, which provides the following description of the San Gabriel River side of the dam.

Whittier Narrows Dam provides water conservation storage and is also the central element of the Los Angeles County Drainage Area (LACDA) flood control system. The purpose of the project is to collect runoff from the uncontrolled drainage areas upstream along with releases into the San Gabriel River from Santa Fe Dam. If the inflow to the reservoir exceeds the groundwater recharge capacity of the spreading grounds along the Rio Hondo or the bed of the San Gabriel River downstream, this water is stored temporarily in a water conservation pool. The San Gabriel outlet has nine large gates installed on top of a spillway with one gate is normally open about 0.5 feet (0.15 meters) with the remaining gates closed. The reservoir is normally empty and a "crossover weir" within the reservoir keeps the flows from the Rio Hondo and the San Gabriel River separated. If the water conservation pool on either side of the reservoir is exceeded, discharges on the San Gabriel side can be increased to approximately 5000 cfs (142 cms). The San Gabriel outlet has automatic spillway gates. When the pool in the reservoir exceeds flood control storage these gates will begin to open automatically.

The design specifications given for the San Gabriel side Flood Control pool are shown in Table 2-2. These design elements were used to develop an F-table for a trapezoidal representation of the reservoir that included losses representing spreading ground infiltration and overflows of the crossover weir. In addition, two stages of discharge were represented, one at the Water Conservation Pool Depth and a one at the Flood Control Pool Depth to achieve a better model fit.

Table 2-2. San Gabriel River Whittier Narrows Dam Design Specifications

Design Component	Unit	Value
Depth (to top) of Spillway Gate	ft	29
Water Conservation Pool Depth	ft	13.5
Flood Control Pool Depth	ft	28.5
Total Height	ft	39
Water Conservation Pool Area	ac	71
Water Conservation Pool Volume	ac-ft	387
Spillway Gate Dimensions	ft	50 x 29

Santa Fe Flood Control Basin Diversion

The LA River watershed in the original WMMS was notably missing a diversion from the Santa Fe Flood Control Basin. The major inflows to Peck Road Park Lake include Sawpit Wash, Santa Anita Wash, and this diversion from the Santa Fe Flood Control Basin. Flow data was obtained for this diversion from the stream gage in the Santa Fe Diversion Channel and added as a point source to the subbasin containing Peck Road Park Lake in the recalibrated model. From 1991 – 2012 the average volume of water diverted to Peck Road Park Lake from the Santa Fe Diversion was 9,756 acre-ft/yr. This has a considerable influence on the hydrology and water quality in the downstream watershed.

2.1.1.2 Hydrology Results

The model calibration covered the period of record for each monitoring location as shown in Table 2-3 and Table 2-4. The entire modeling time period was selected for calibration as a means of ensuring that the models captured the range of hydrologic conditions in watersheds where wet, dry, and average years are all properly represented.

Table 2-3. Los Angeles River Flow Monitoring Locations

Station ID	Station Description	Data Record	Record Count
E326	Rio Hondo below Garvey	10/1/2001 – 4/30/2012	4,865
F194	Sawpit Wash below Live Oak Avenue	10/1/2000 – 4/30/2004	1,308
F319	Los Angeles River below Wardlow	5/1/2001 – 4/30/2012	4,018

Table 2-4. San Gabriel River Flow Monitoring Locations

Station ID	Station Description	Data Record	Record Count
F329-R	Bradbury Channel Below Central Avenue	10/1/2001–4/30/2012	3,865
E281	San Gabriel River below Santa Fe Dam	12/1/1999–4/30/2012	4,484
F263C-R	San Gabriel River below S. G. River Parkway	10/1/1996–4/30/2012	5,508

An initial review of model simulated hydrology performance showed a need to reduce low flows, increase storm flows, and improve total volume errors. Model parameters adjusted to achieve those performance areas for the SGR watershed included the baseflow evapotranspiration coefficient (BASETP), interflow (INTFW), and upper zone nominal storage (UZSN). The key parameters adjusted for the LAR watershed included those that influence the deep storage (DEEPFR), lower and upper zone storage (LZSN and UZSN), infiltration (INFILT), interflow (INTFW), evaporation (BASETP, and LZETP), and irrigation demand (Irrigation Constant ET Coefficient). After parameter adjustment, an overall assessment of the hydrology calibration was done to give a focused overview of its performance. This assessment used the quantitative metrics presented in Table 2-5 applied to critical hydrologic measures for the Los Angeles County watershed models for the model calibration time period. Those critical measures include: total volume, error in the 10 percent highest flows, and the Nash-Sutcliffe efficiency statistic (NSE). Together these metrics are indicators for the overall water budget, critical wet-periods, and overall monthly fit of the model to observed conditions, respectively. Calibration summaries of the watershed hydrology include, critical hydrology calibration metrics (Table 2-5) and time series and regression plots comparing modeled and observed average monthly flows for the calibration time period are shown in Figure 2-8 through Figure 2-13.

For the model calibration time period all measures at station E326 are within the target criteria, with the exception of the 50% lowest flow volumes. At station F194 the total volume falls just outside the target criteria and a number of the other statistics fall outside the recommended criteria as well. Overall summer volumes are under-predicted, while winter and spring volumes are over-predicted by the model. However, the 10% highest flows volumes and storm volumes fall within the target criteria and there is a reasonable NSE. At station F319 the total volume falls just above the target criteria, whereas the 10% highest flows is further outside the criteria. However, the error in storm volumes is lower and within the criteria, at 15.29 percent error. The error in 10% highest flows could not be further improved without sacrificing the reasonable NSE value at this station. For the San Gabriel River watershed stations, all critical metrics are met except for the NSE at F329-R and F263C-R. All sites show a generally good agreement for both the total volume and error in the 10 percent highest flows metric, where both measures are met for all locations. The model also captures peak stormflows well, with the only notable miss being for storm events in February 2005 at F329-R.

Table 2-5. Overall Calibration Assessment for Critical Hydrology Metrics (Calibration Time Period)

Station ID	Station Description	Error in total volume	Error in 10% highest flows	NSE
E326	Rio Hondo below Garvey	4.97	-11.11	0.723
F194	Sawpit Wash below Live Oak Avenue	13.71	3.76	0.626
F319	Los Angeles River below Wardlow	11.33	32.90	0.729
F329-R	Bradbury Channel Below Central Avenue	-0.87	1.57	0.587
E281	San Gabriel River below Santa Fe Dam	-9.45	-8.09	0.790
F263C-R	San Gabriel River below S. G. River Parkway	-0.83	1.28	0.548

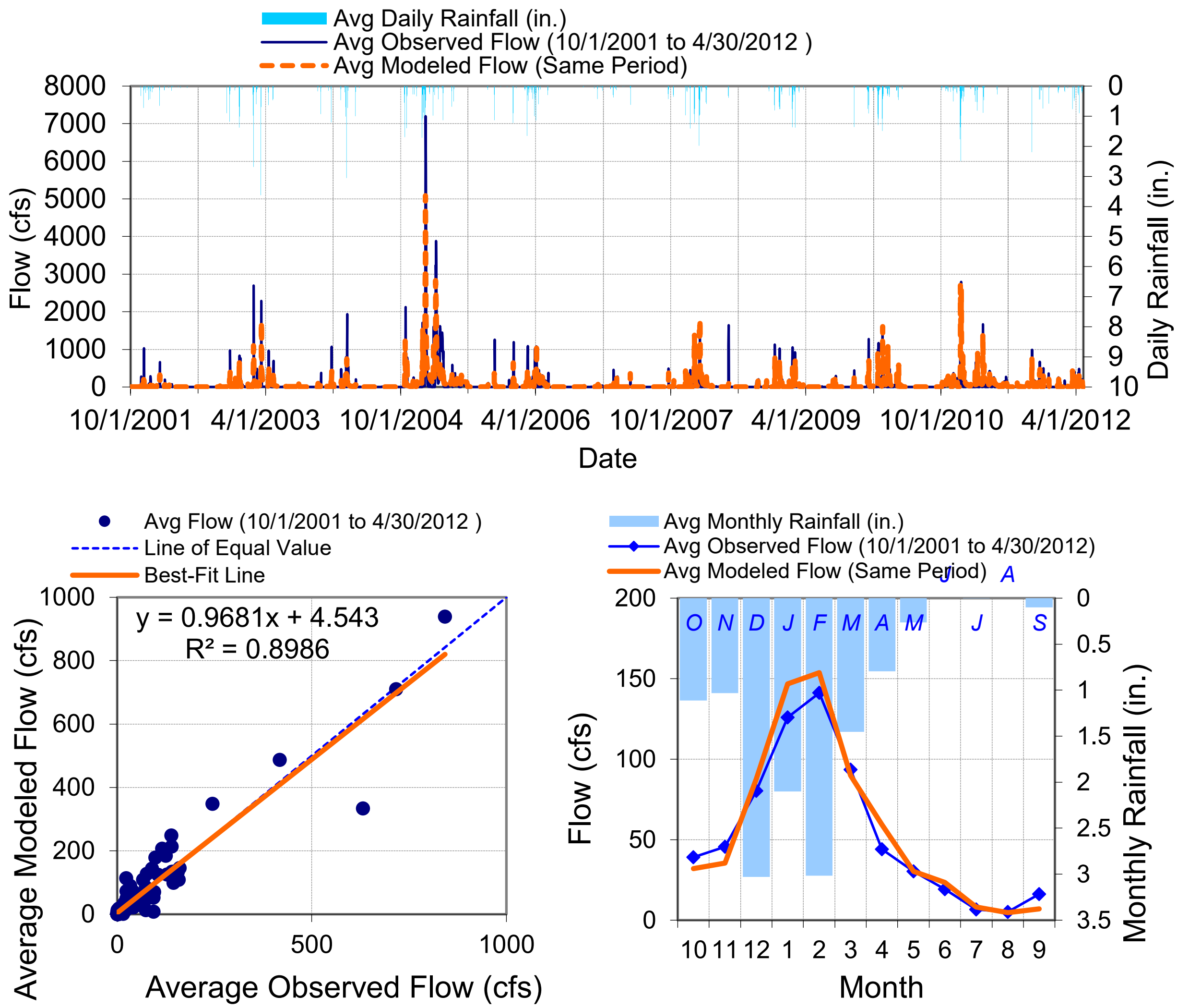

Figure 2-8. Daily Flow: Outlet 6137 vs E326 Rio Hondo below Garvey.

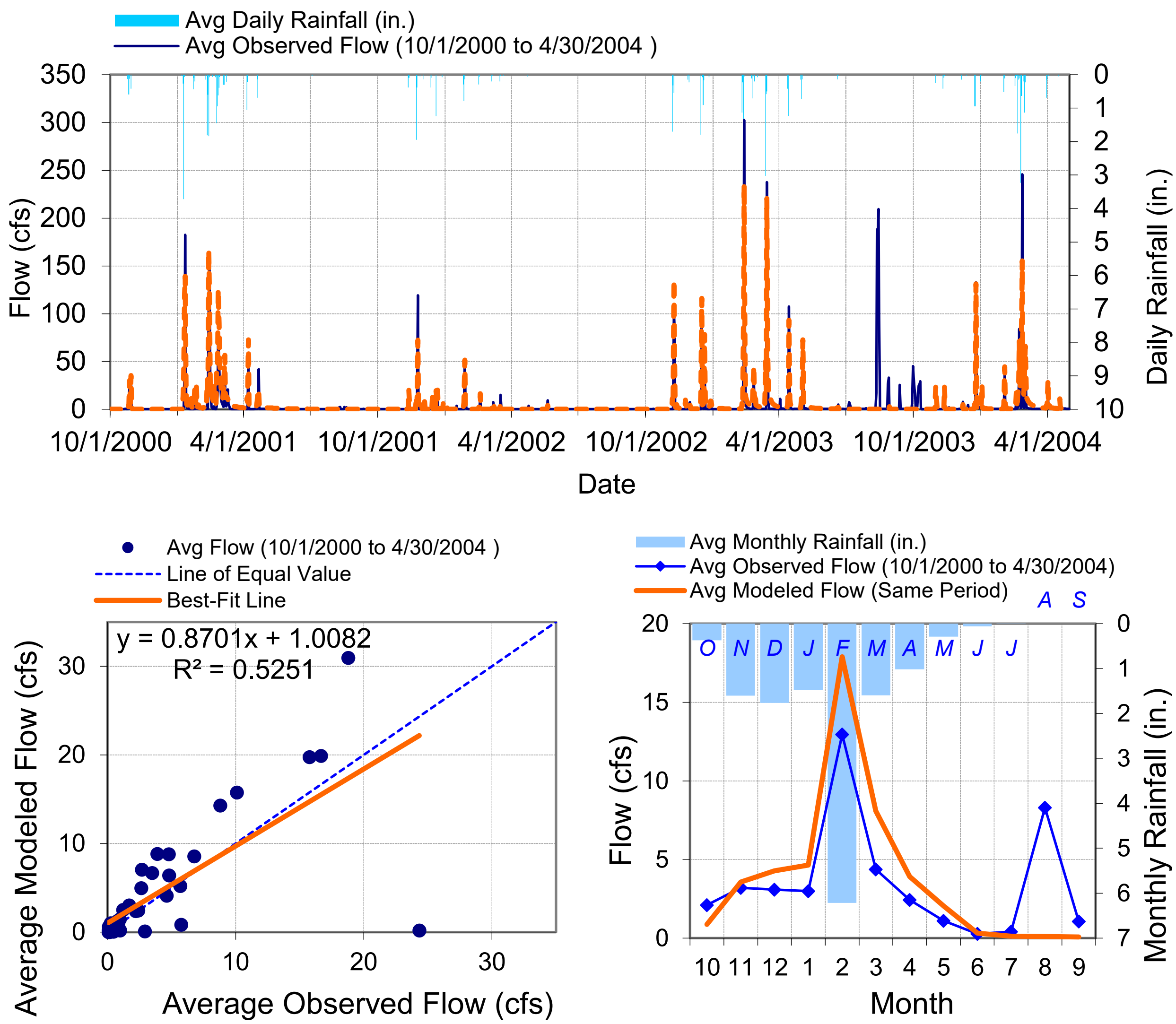

Figure 2-9. Daily Flow: Outlet 6302 vs F194 Sawpit Wash below Live Oak Avenue.

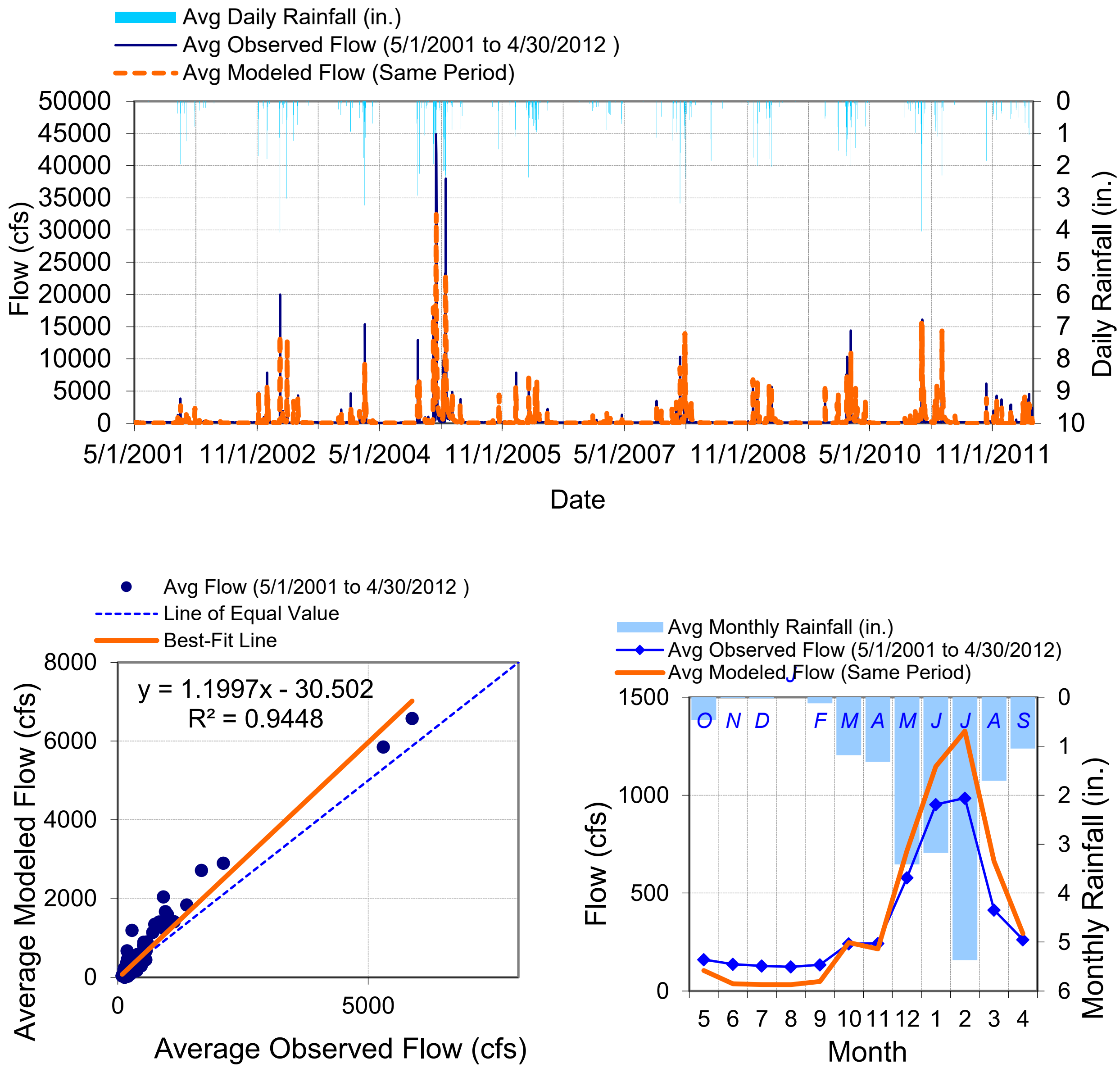

Figure 2-10. Daily Flow: Outlet 6006 vs F319 Los Angeles River below Wardlow.

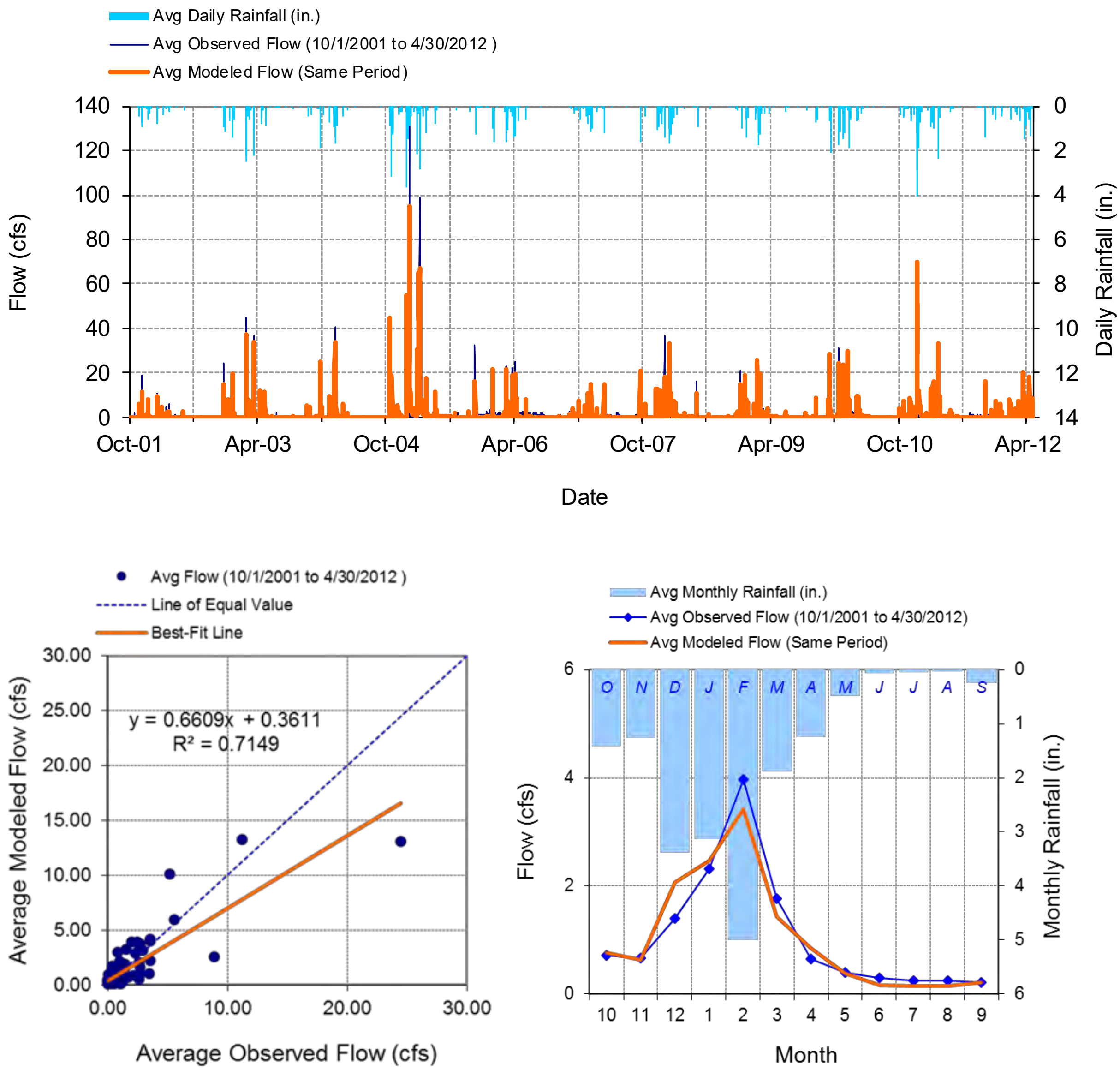

Figure 2-11. Mean Daily Flow: Outlet 5250 vs F329-R Bradbury Channel below Central Avenue.

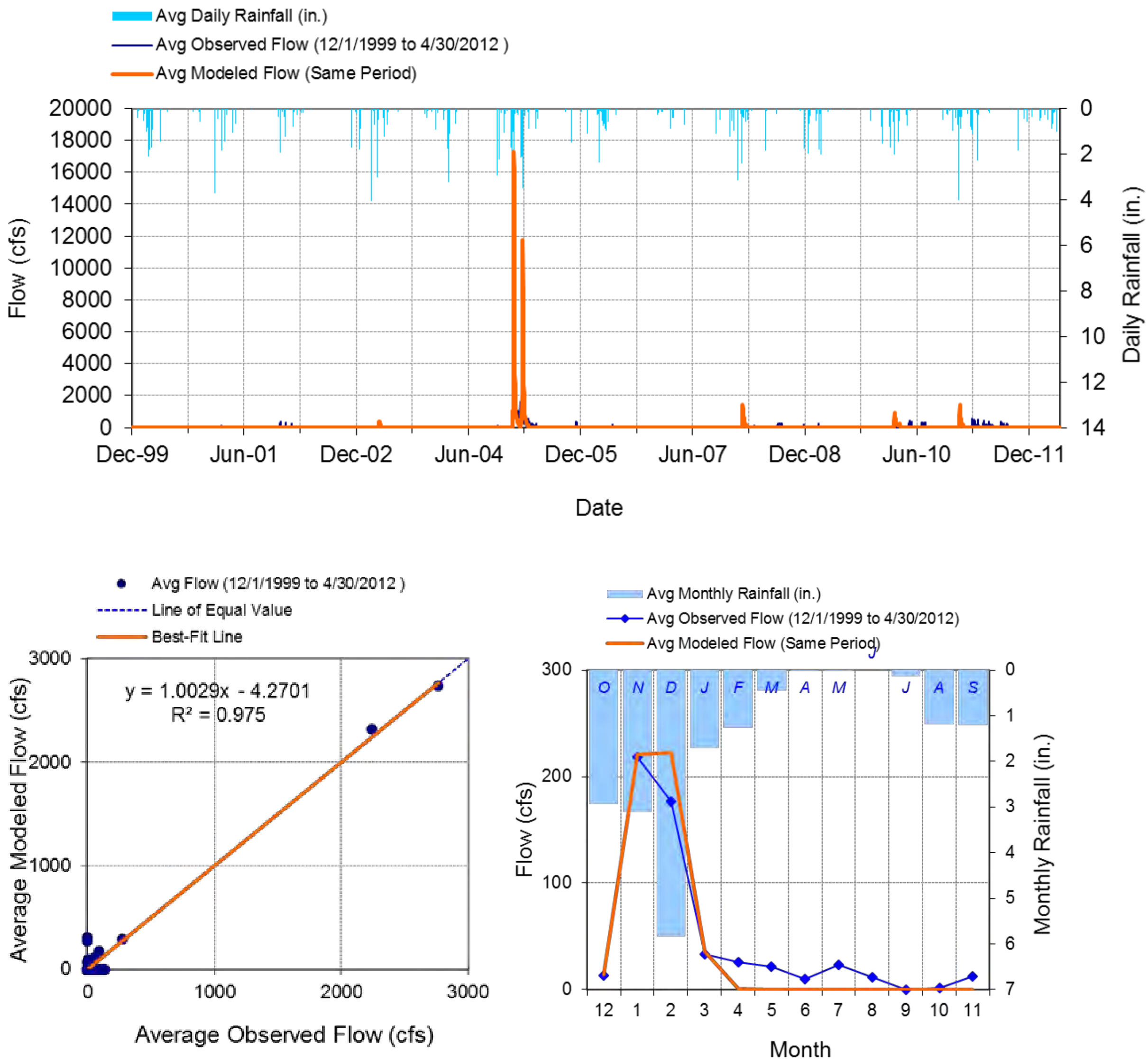

Figure 2-12. Mean Daily Flow: Outlet 5244 vs E281 San Gabriel River below Santa Fe Dam.

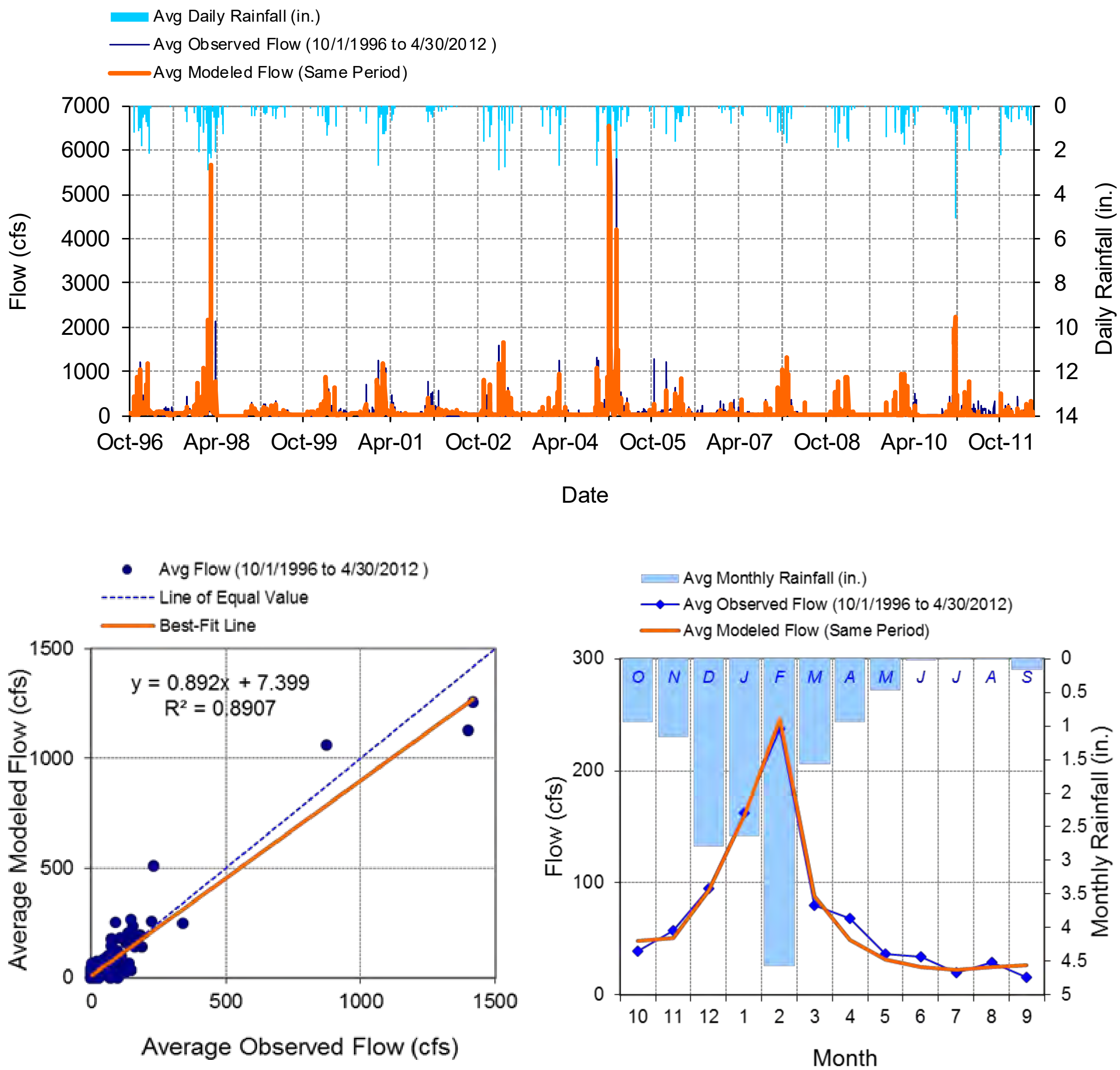

Figure 2-13. Mean Daily Flow: Outlet 5147 vs F263C-R San Gabriel River below S.G. River Parkway.

2.1.2 Watershed Water Quality Model

Water quality simulations build upon the calibrated model hydrology. Pollutant loads were simulated as sediment associated, where metals loading is simulated as associated with the processes of sediment erosion and transport when runoff due to rainfall events or irrigation water application occurs. The updated LSPC model for this project was set up to simulate the source, transport, and fate of sediment and three metals, copper, lead, and zinc. Delivery of pollutants through subsurface pathways (i.e., interflow and groundwater) was also represented. Initial water quality parameterization built upon the previous regional WASOP watershed modeling (Tetra Tech 2010b).

2.1.2.1 Water Quality Calibration

The F319 monitoring location on the Los Angeles River below Wardlow included available water quality data at Mass Emission Station S10. The F263C-R monitoring location on the San Gabriel River below the Whittier Narrows Dam included available water quality data at Mass Emission Station S14. Table 2-6 and Table 2-7 lists the modeled parameters and the available monitoring data and period of record for collected flow weighted concentrations.

Table 2-6. Water Quality Data Summary for S10.

Model Constituent	Date Range	Sample Count	Avg. Conc.	Conc. Unit
TSS	12/9/2006 – 4/26/2012	61	337.21	mg/L
Copper	12/9/2006 – 3/17/2012	22	81.66	µg/L
Lead	12/9/2006 – 3/17/2012	22	77.20	µg/L
Zinc	12/9/2006 – 3/17/2012	22	507.43	µg/L

Table 2-7. Water Quality Data Summary for S14

Model Constituent	Date Range	Sample Count	Avg. Conc.	Conc. Unit
TSS	12/9/2006–4/26/2012	59	91.71	mg/L
Copper	12/9/2006–3/17/2012	21	22.85	µg/L
Lead	12/9/2006–3/17/2012	21	10.38	µg/L
Zinc	12/9/2006–3/17/2012	21	91.5	µg/L

LSPC parameter values developed for the previous WASOP watershed modeling studies (Tetra Tech 2010b) served as a starting point for the model HRUs in the current effort. The model simulates the erosion and transport of sediment and pollutant generation is considered sediment associated, thus pollutant runoff and delivery is tied to simulated sediment loads. Delivery of pollutants through subsurface pathways (i.e., interflow and groundwater) is also represented. Model output generated using this initial setup were then compared to the available metals monitoring data to determine if the timing and relative magnitude of concentrations were the same. Further model calibration used the following comparisons to support the assessment of model output and performance:

- **Pairwise comparison of simulated and observed loads with linear regression slope values** to show model fit.

Time series plots of simulated and observed concentrations at each calibration location**.** The time series plots are useful for making a general comparison of the order-of-magnitude between observed and simulated values.

Simulated and observed land use load/EMC values. These comparisons ensure that the land based source loading is being represented in a reasonable fashion.

Calibration of the LSPC water quality model involved two major components. The first was comparing simulated and observed instream sediment concentrations and loads at the selected monitoring location. Using an iterative approach, sediment parameters were first adjusted, including those that influence the build-up, detachment, and washoff of sediment (KSER, JSER, ACCSDP, REMSDP), instream sediment transport (KSAND/TAUCD, EXPSND/TAUCS), as well as subsurface background concentrations of sediment (SED_IFWO, SED_AGWO). Pairwise comparison, time series, and load duration curve plots for simulated and observed TSS are shown in Figure 2-14 through Figure 2-19 and a comparison of literature and simulated unit-area loads is presented in Table 2-8 and Table 2-9. Simulated land use sediment load values are notable lower than literature values. However, this difference is due to prioritizing site-specific information on EMCs by land use-based sources of trace metals sampled in Los Angeles sites from 2000 through 2005, discussed further below (SCCWRP, 2007).

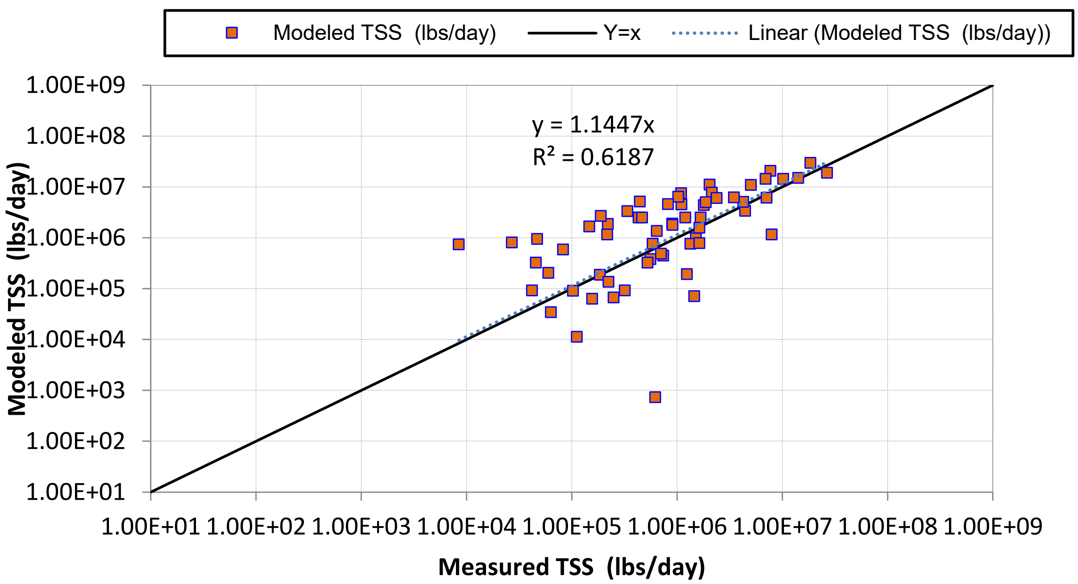

Figure 2-14. Pairwise Comparison of Simulated and Observed TSS Loads at S10.

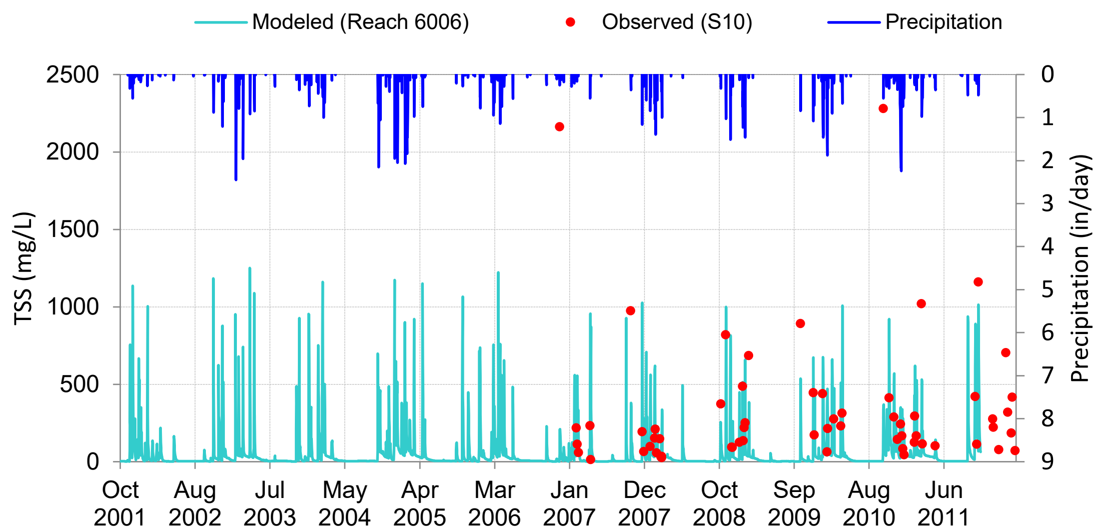

Figure 2-15. Time Series Comparison of Simulated and Observed TSS Concentrations at S10.

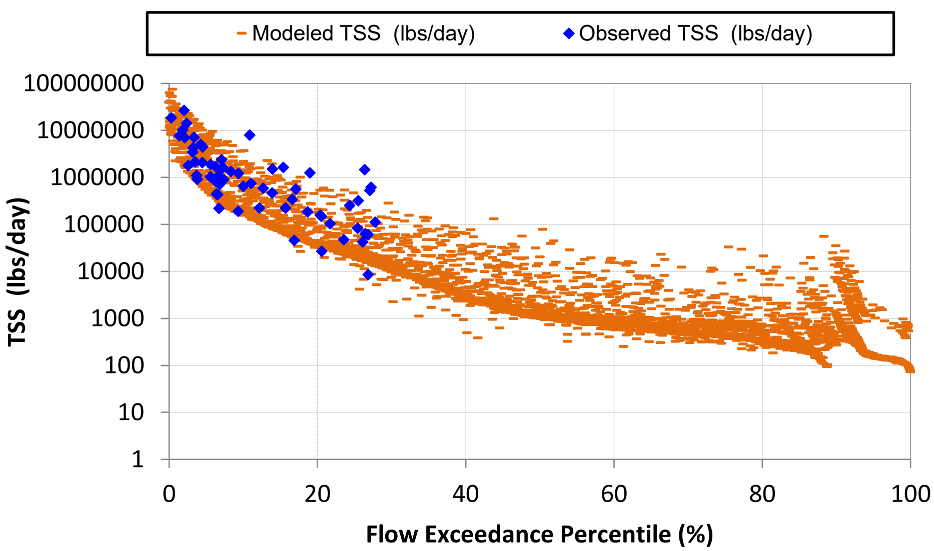

Figure 2-16. Load Duration Curve Comparison of Simulated and Observed TSS Loads at S10.

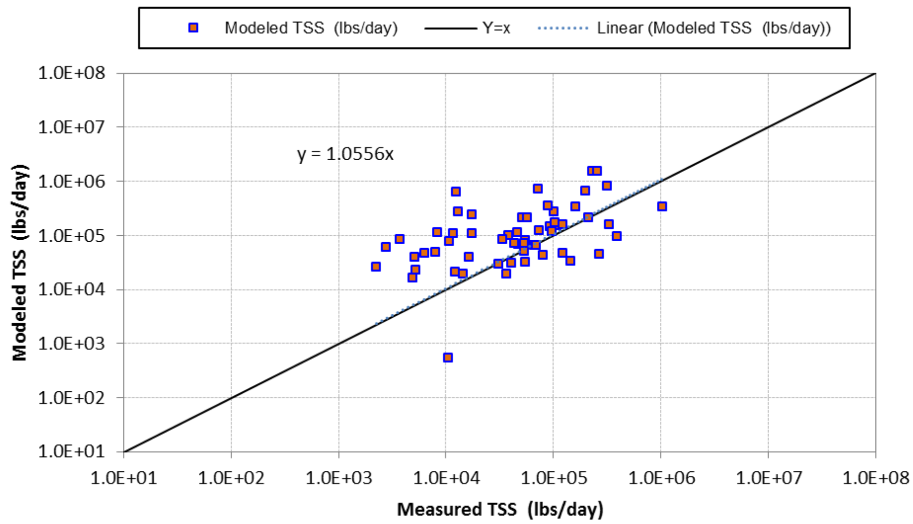

Figure 2-17. Pairwise Comparison of Simulated and Observed TSS Loads at S14.

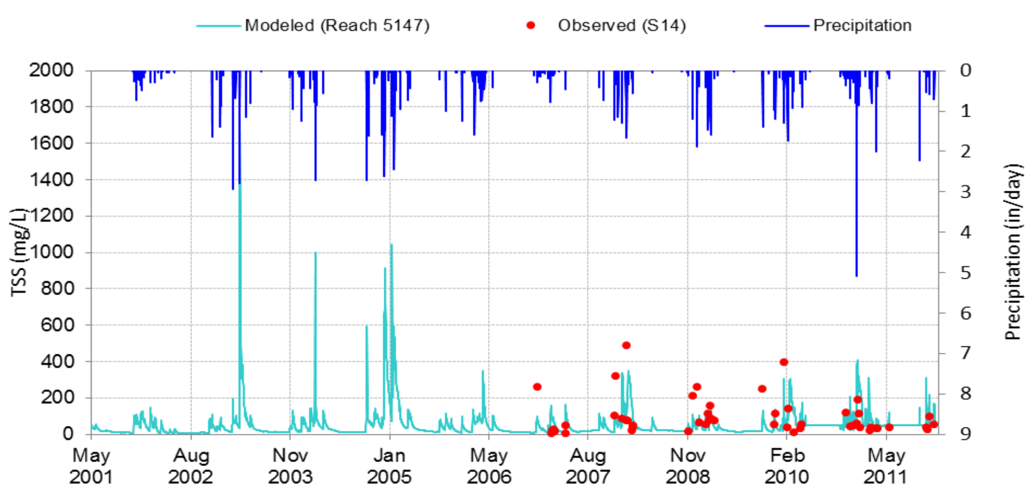

Figure 2-18. Time Series Comparison of Simulated and Observed TSS Concentrations at S14.

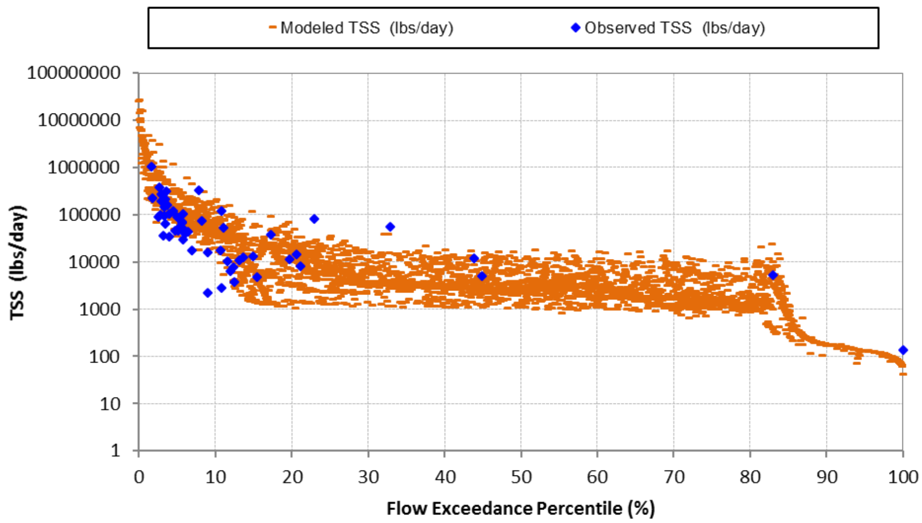

Figure 2-19. Load Duration Curve Comparison of Simulated and Observed TSS Loads at S14.

Table 2-8. Comparison of Simulated and Literature[1] Average Annual Sediment Loads by HRU/Land Use at S14.

Model HRU	Area (ac)	Reference Land Use	Reference Load (tons/ac)	Simulated Load (tons/ac)
HD single-family residential	35,771	Urban	0.2 –1.0	0.761
LD single-family residential moderate slope	921			0.737
LD single-family residential steep slope	491			0.770
Multifamily residential	21,141			0.704
Commercial	18,622			0.934
Institutional	11,222			0.915
Industrial	28,757			0.882
Transportation	11,789			0.992
Secondary roads	33,456			0.982
Urban grass Irrigated	115,273			0.123
Urban grass Non-irrigated	36,040			0.081
Agriculture moderate slope B	566	Conservation Tillage	0.5 –4.0	0.110
Agriculture moderate slope D	2,165			0.152
Vacant moderate slope B	2,518	N/A	N/A	0.087
Vacant moderate slope D	7,036			0.085
Vacant steep slope A	1,077			0.069
Vacant steep slope B	61,370			0.187
Vacant steep slope C	55,520			0.184
Vacant steep slope D	83,532			0.173

[1] Values taken for BASINS Technical Note 9 (USEPA 2006)

Table 2-9. Comparison of Simulated and Literature[1] Average Annual Sediment Loads by HRU/Land Use at S14.

Model HRU	Area (ac)	Reference Land Use	Reference Load (tons/ac)	Simulated Load (tons/ac)
HD single-family residential	11,729	Urban	0.2 –1.0	0.238
LD single-family residential moderate slope	251			0.233
LD single-family residential steep slope	189			0.229
Multifamily residential	3,264			0.239
Commercial	5,373			0.266
Institutional	4,610			0.265
Industrial	9,688			0.262
Transportation	3,048			0.27
Secondary roads	7,787			0.275
Urban grass Irrigated	37,650			0.443
Urban grass Non-irrigated	12,649			0.244
Agriculture moderate slope B	75	Conservation Tillage	0.5 –4.0	0.455
Agriculture moderate slope D	1,915			0.796
Vacant moderate slope B	1,205	N/A	N/A	0.412
Vacant moderate slope D	3,894			0.571
Vacant steep slope A	8,946			0.322
Vacant steep slope B	26,249			0.588
Vacant steep slope C	33,253			2.327
Vacant steep slope D	113,799			2.657

[1] Values taken for BASINS Technical Note 9 (USEPA 2006)

Next, select metal parameters were adjusted, including the instream decay rate (Decay), subsurface concentrations (IOQC and AOQC), atmospheric deposition (ADDC and AWDC), surface accumulation and storage (ACQOP and SQOLIM), and rate of removal by surface runoff (WSQOP). Atmospheric deposition parameters were selected based on measured atmospheric deposition dry flux and EMCs at sites in Los Angeles (SCCWRP, 2006). Subsurface concentrations were calibrated to match general dry-weather conditions. Adjustment to the land based metals loads was achieved by increasing or decreasing the sediment potency factor for each HRU, which defines the sediment pollutant concentration as lb/ton. Potency factors for land use pollutant contributions were adjusted based on EMCs by land use-based sources of trace metals sampled in Los Angeles sites from 2000 through 2005 (SCCWRP, 2007). This site-specific information, show in Figure 2-26, was prioritized over the literature values from the RAA Guidelines. Like for sediment the first calibration step was comparing simulated and observed instream sediment concentrations and loads. Pairwise comparison, time series, and load duration curve plots for simulated and observed metals are shown in Figure 2-20 through Figure 2-25, respectively and a comparison of literature and simulated EMCs for select HRUs is presented in Table 2-10 and Table 2-11.

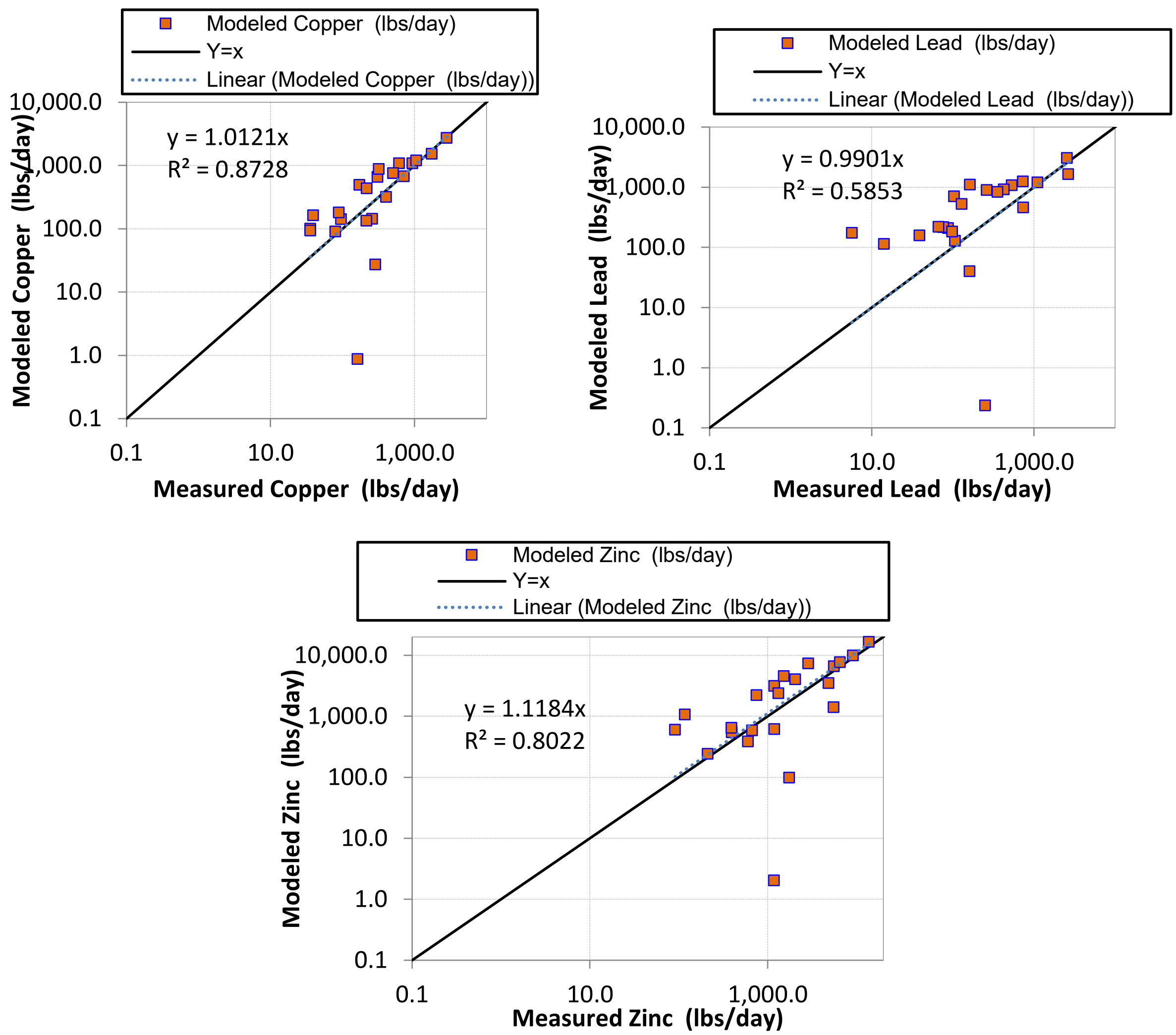

Figure 2-20. Pairwise Comparison of Simulated and Observed Metal Loads at S10.

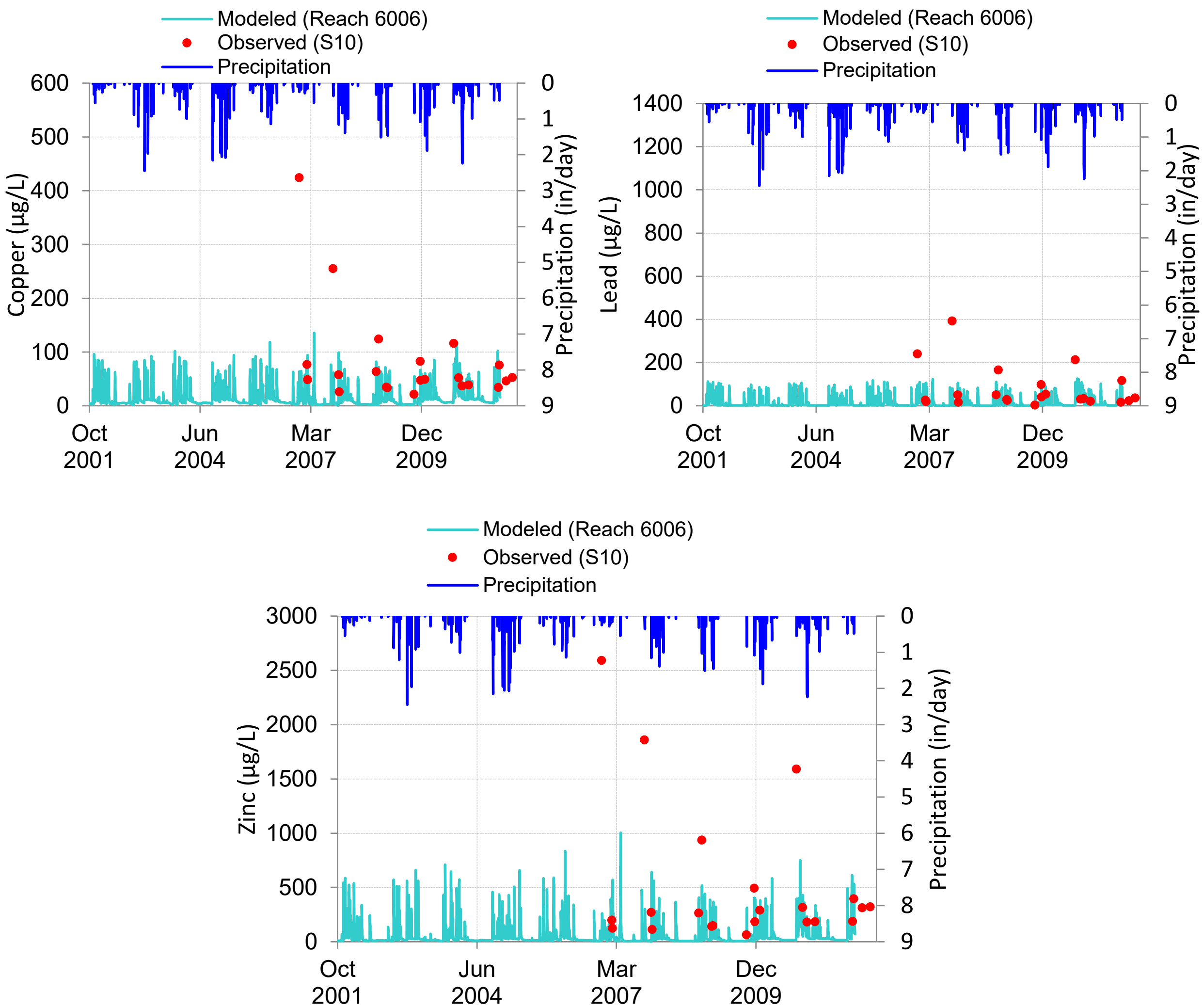

Figure 2-21. Time Series Comparison of Simulated and Observed Metals Concentrations at S10.

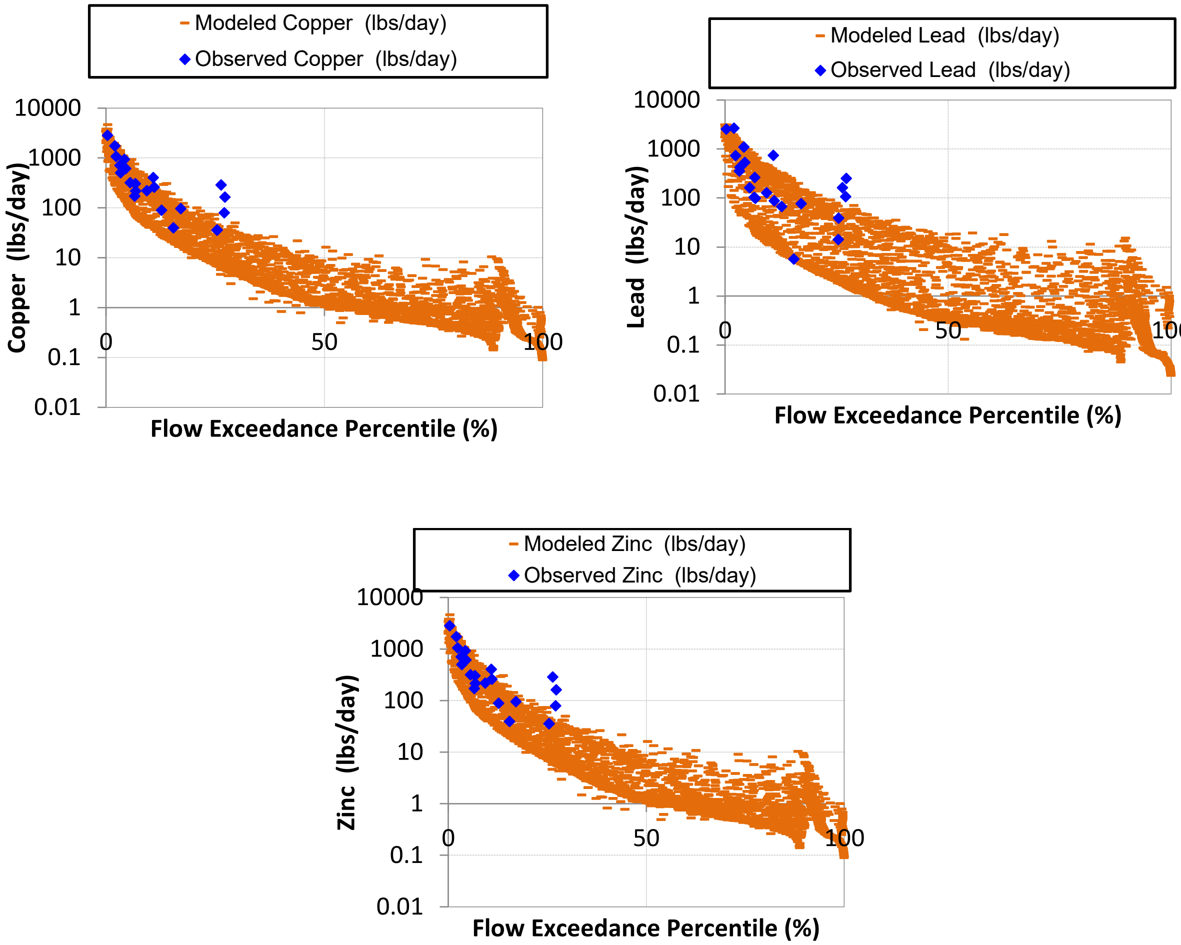

Figure 2-22. Load Duration Curve Comparison of Simulated and Observed Metal Loads at S10.

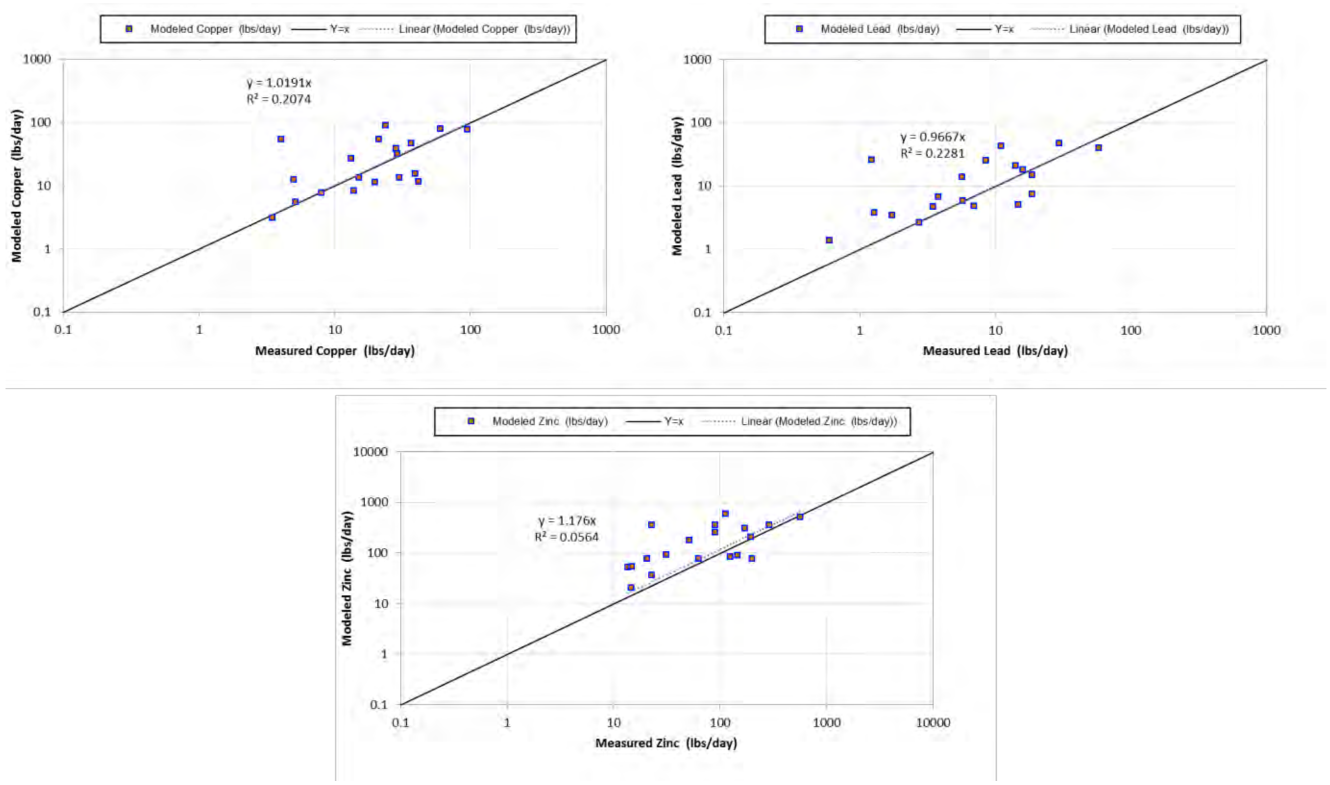

Figure 2-23. Pairwise Comparison of Simulated and Observed Metal Loads at S14.

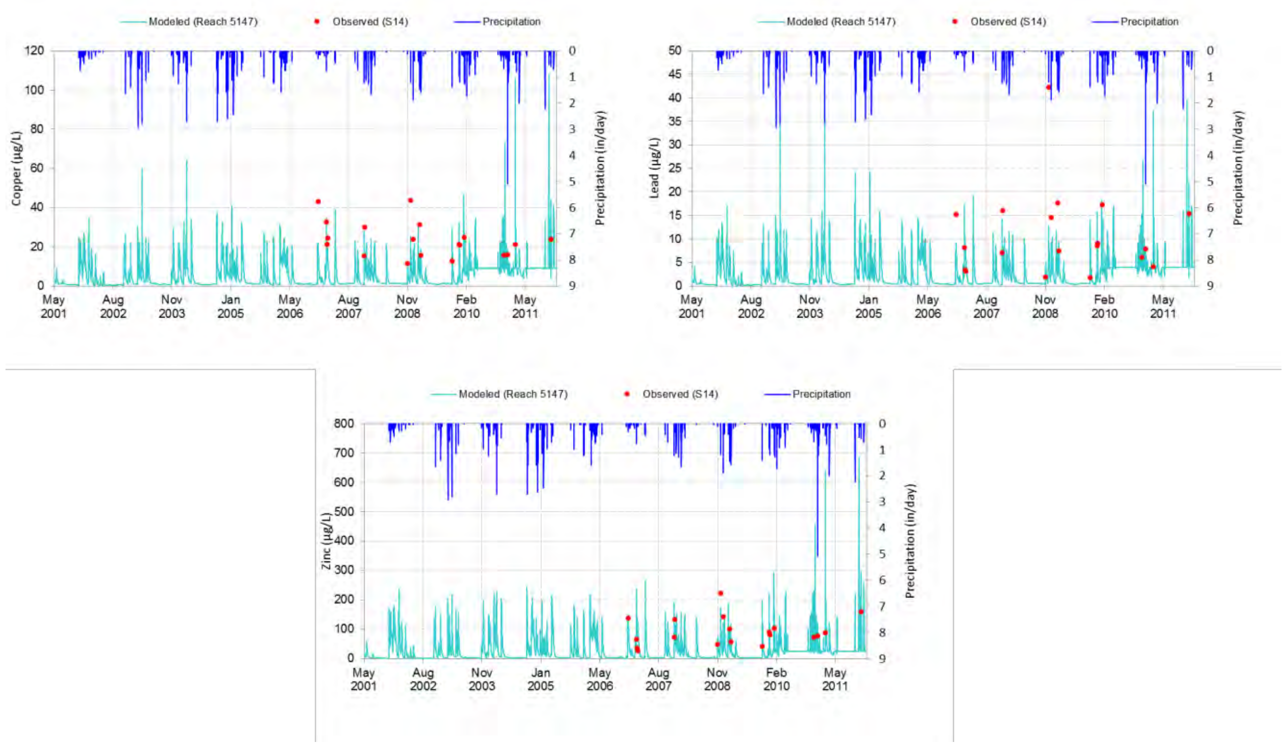

Figure 2-24. Time Series Comparison of Simulated and Observed Metals Concentrations at S14.

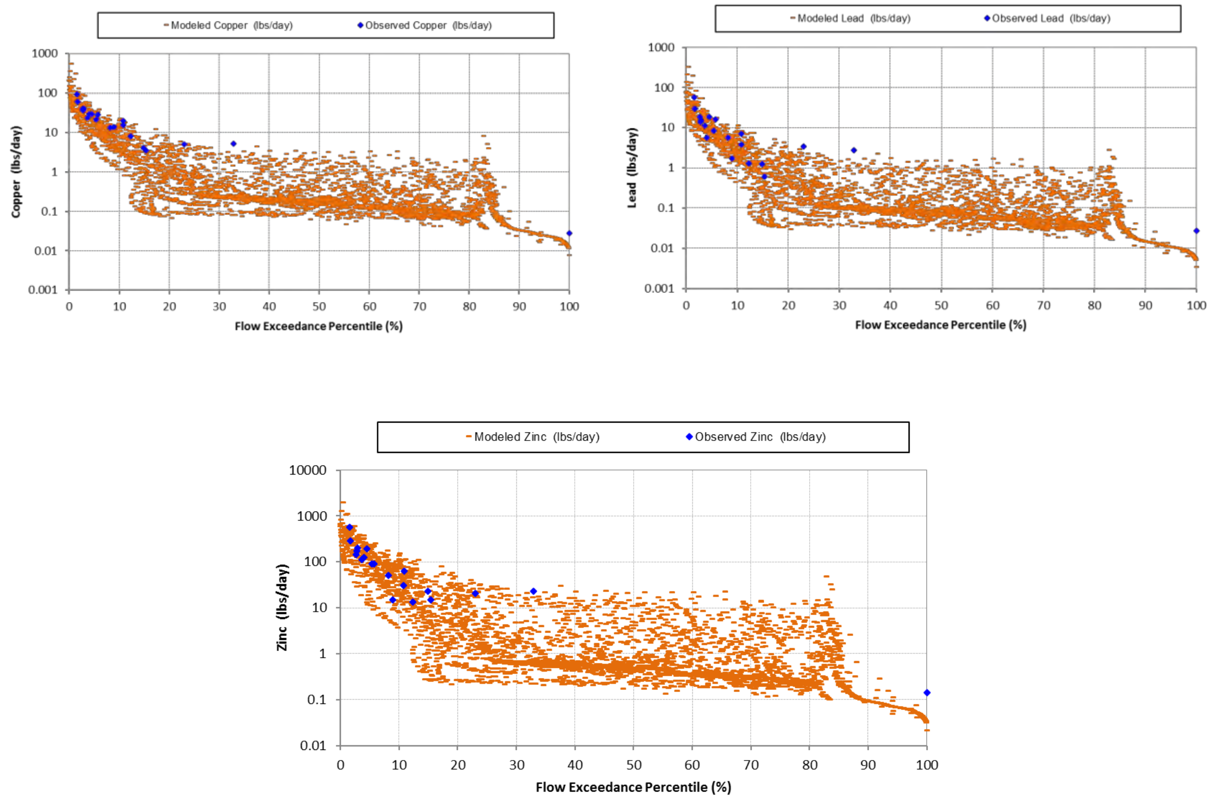

Figure 2-25. Load Duration Curve Comparison of Simulated and Observed Metal Loads at S14.

Table 2-10. Simulated and Literature[1] Average EMCs by HRU/Land Use at S10.

Model HRU	Simulated Cu (µg/L)	RAA Avg. Cu (µg/L)	Simulated Pb (ug/L)	RAA Avg. Pb (µg/L)	Simulated Zn (µg/L)	RAA Avg. Zn (µg/L)
LD single-family residential moderate slope	42.44	18.70	53.41	11.30	106.16	71.90
Multifamily residential	41.92	12.10	72.34	4.50	204.13	125.10
Commercial	63.23	31.40	64.02	12.40	386.95	237.10
Industrial	88.31	34.50	79.86	16.40	647.24	537.60
Transportation	39.46	52.20	53.39	9.20	116.96	292.90
Agriculture moderate slope B	17.15	100.10	5.03	30.30	49.94	274.80
Vacant moderate slope B	16.40	10.60	5.09	3.00	35.90	26.30

[1] RAA Guideline average EMCs (Nguyen, 2014)

Table 2-11. Simulated and Literature[1] Average EMCs by HRU/Land Use at S14

Model HRU	Simulated Cu (µg/L)	RAA Avg. Cu (µg/L)	Simulated Pb (ug/L)	RAA Avg. Pb (µg/L)	Simulated Zn (µg/L)	RAA Avg. Zn (µg/L)
LD single-family residential moderate slope	14.80	18.70	1.87	11.30	35.08	71.90
Multifamily residential	13.73	12.10	14.88	4.50	99.67	125.10
Commercial	22.57	31.40	7.76	12.40	148.53	237.10
Industrial	39.42	34.50	12.54	16.40	207.08	537.60
Transportation	5.34	52.20	2.31	9.20	109.56	292.90
Agriculture moderate slope B	13.81	100.10	5.92	30.30	47.76	274.80
Vacant moderate slope B	9.04	10.60	3.83	3.00	25.22	26.30

[1] RAA Guideline average EMCs (Nguyen, 2014)

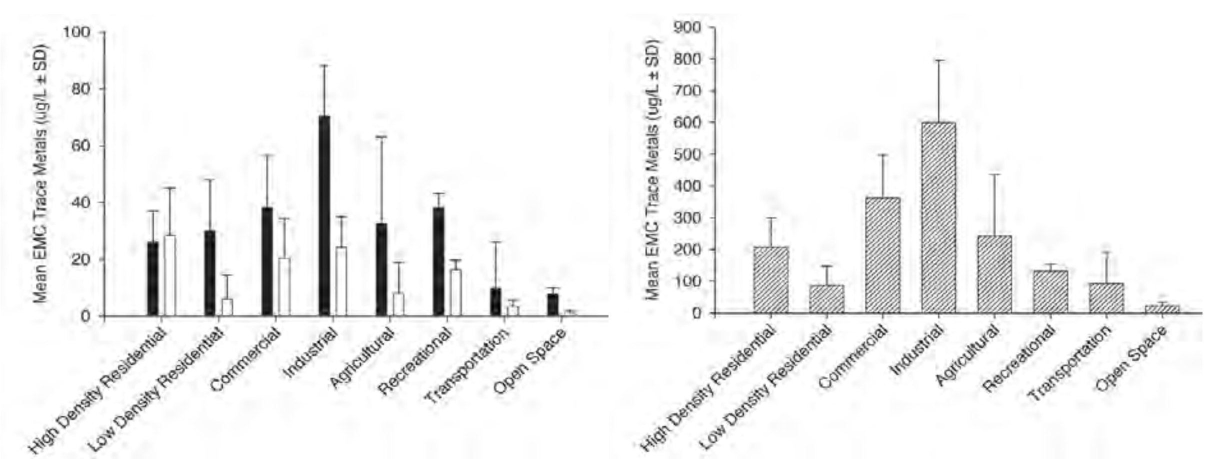

Figure 2-26. EMCs for Copper (left, black), Lead (left, white), and Zinc (right, mixed) by Land Use-based Sources of Trace Metals Sampled in Los Angeles Sites from 2000 through 2005 (SCCWRP, 2007).

The overall assessment of the water quality calibration includes a comparison that uses the RAA Guideline average as the observed data source and an assessment of simulated average annual instream load with linear regression slope as an indicator of model fit. Together these measures provide a basis for determining whether the process based watershed simulations are reasonably capturing observed conditions, where:

- EMC comparisons show that the simulated upland flow and metals loads for the assessed land uses are comparable to observed conditions. These can be thought of edge-of-stream EMCs though they are subject to the in-pipe processes/conditions where they were collected.

- Pairwise comparisons of instream loads can show that modeled instream metal loads are comparable to observed conditions.

If both upland and instream comparisons are reasonable then it can be concluded that the model is properly representing source loading and the intervening processes that ultimately determine instream water quality. In general, the modeled EMC summaries are of the same magnitude and cover the range of EMCs in the observed data for each land use. Pairwise comparison linear regression plots show the relationship between measured and simulated constituents, where we want the slope of this regression to be as close to 1 and the R-squared value to be as close to 1 as well, representing the strength of the linear relationship. Pairwise comparison linear regression slope show values close to 1, indicating that the model generally captures the average instream metals load. For the LAR station, S10, the linear regression slopes range from 0.99 to 1.14, and all R-squared values fall between 0.59 and up to 0.87. For the SGR station, S14, the linear regression slopes range from 0.967 to 1.18, however R-squared values were lower at the SGR station. The load duration plots show the model captures the lower range of observed concentrations, but misses a few peak concentrations for each of the constituents. Such observed peaks seem to be random and are likely due to processes that cannot be captured by the model. As previously discussed, overall trends are prioritized over single events, where supporting causal data to incorporate in the model is not available, which was the case for the discrepancies between the observed and modeled TSS and metal concentrations, particularly at station S14. The quality of the model is limited by the available data and therefore should continue to be assessed and potentially updated as part of the adaptive management process, with additional data from the watershed. Observed data not well simulated by the model is potentially due to specific stormwater pipes discharging on a given day, metal loads being mobilized from channel deposits, or other unpredictable phenomena not represented in the model. Additionally, weak correlations between the observed flow and observed pollutant concentrations were noted, which limits the ability of the watershed model to explain the variability in observed concentrations (which are likely due to random or unpredictable processes, as previously noted).

2.2 WATER QUALITY OBJECTIVES

Water quality objectives are established to protect beneficial uses. Based on the pollutants of concern and applicable TMDL’s, numeric targets are identified for metals based on the California Toxics Rule (CTR). The acute and chronic CTR equations determine concentrations which cannot be exceeded to protect aquatic life health. The acute CTR criteria are used for metal TMDL loading capacities and waste load allocations. Loads are calculated by multiplying the maximum allowable concentration, based on the acute CTR equation (units in µg/l total recoverable metals), by daily volume. Basin Plan Amendment R15-004 established a site-specific water effects ratio (WER) for Copper in the Los Angeles River Watershed of 3.97. The amendment also introduced a recalculated Lead CTR equation. Such updates are used in determining water quality numeric targets, as the objectives still fully protect aquatic life and will not unreasonably affect present and anticipated beneficial uses of the waters.

CTR equations are dependent on hardness values and to convert from dissolved to total recoverable metals are dependent on conversion factors. Hardness values and conversion factors (CF) for Cadmium, Copper, Lead, and Zinc were updated based on more recent monitoring data (1996 – 2017) from Mass Emission Stations S10 (Los Angeles River (LAR) at Wardlow) and S14 (San Gabriel River (SGR)). These are the same stations used in the LAR and SGR metal TMDLs, which base hardness values and conversion factors on data only up to 2002 and 2005 in LAR and SGR, respectively. At S10, the 50th percentile hardness value changed from 80 mg/l to 76 mg/l based on more recent monitoring data. Table 2-12 shows the regression analysis performed, with more recent monitoring data at S10, to determine whether updated conversion factors were allowable. All samples below the reporting limit were removed and outliers were removed according to the formal definition (1.5 times the interquartile range below or above the first and third quartile). At S14, the 50th percentile hardness value changed from 175 mg/l to 155 mg/l. Table 2-13 shows the regression analysis performed at S14, using the same methods as described for S10. The R-squared value for Copper is 0.014, thus following analyses did not use the updated conversion factor for Copper.

To account for uncertainty in the updated conversion factor the 95% confidence interval was calculated. This considers the number of samples and standard deviation in the monitoring data to provide a range of the conversion factor that more confidently contains the true value. The greater the conversion factor, the more stringent the CTR criteria, with a greater fraction of the total recoverable metals attributed to the dissolved component. Therefore, when updating the conversion factors, the upper limits of the 95% confidence intervals were used as the representative conversion factors in the following analyses.

Table 2-12. Regression Analysis for Updated Conversion Factors at S10.

Constituent	CF (slope of regression) (1996 – 2017)	95% Confidence Interval	Number of samples	R^2	Default CF	Previous CF (1996 - 2002)
Cadmium	0.800	0.770 – **0.829**	27	0.992	0.940	0.940
Copper	0.480	0.426 – **0.535**	91	0.723	0.960	0.650
Lead	0.386	0.297 – **0.476**	53	0.719	0.824	0.820
Zinc	0.470	0.402 – **0.538**	74	0.468	0.978	0.610

Table 2-13. Regression Analysis for Updated Conversion Factors at S14.

Constituent	CF (slope of regression) (1996 – 2017)	95% Confidence Interval	Number of samples	R^2	Default CF	Previous CF (1997 - 2005)
Cadmium	0.919	0.847 – **0.991**	7	0.988	0.94	0.940
Copper	0.374	0.315 – 0.432	63	0.014	0.96	**0.960**
Lead	0.464	0.372 – **0.557**	40	0.494	0.709	0.709
Zinc	0.647	0.573 – **0.722**	52	0.591	0.978	0.978

The updated CTR acute criteria, from the updated hardness and updated conversion factors (bolded in Table 2-12 and Table 2-13), are presented in Table 2-14.

Table 2-14. Updated CTR Acute Criteria.

Watershed	CTR Acute Criteria (µg/L total recoverable metals)			
	Cadmium	Copper	Lead	Zinc
LAR	4	77	152	173
SGR	7	21[a]	186	235

a. Updated CF not used due to poor correlation in regression analysis.

2.3 CRITICAL CONDITIONS

An annual critical condition was selected for planning purposes to determine baseline loading and eventually load reduction requirements (discussed in later sections). The critical water year was determined based on the 90th percentile rainfall intensity. Rainfall intensity was defined as the average rainfall per wet day, defined as any day with greater than 0.1 inches of rainfall plus the following 3 days. Rainfall gages within each watershed were aggregated and area-weighted to determine annual average rainfall per wet day. A total of 99 rainfall gages, with data from 1990 – 2012, were utilized in this effort. The water year, within the most recent 10 years of modeling, closest to the 90th percentile average rainfall per wet day was selected (Table 2-15). In the LAR watershed the critical water year was 2003 and in the SGR watershed the critical water year was 2004. A number of other critical conditions were explored, including the critical water year based on the greatest total rainfall (water year 2005), the representative water year based on average annual rainfall (water year 2008), and daily critical conditions, such as the 90th percentile load. Figure 2-27 through Figure 2-29 and Table 2-16 show the total required zinc load reduction and required percent load reduction was the greatest (i.e., most protective) for the selected critical water year. Therefore, the critical water year based on rainfall intensity was identified as the most robust, and overall protective, condition. While the critical water year was used in the planning process to guide selection and design of control measures, Section 4.4 discusses the critical condition to be addressed through this program in terms of meeting water quality objectives on a daily basis assessed over a long-term period (10 years), consistent with the daily expression of the TMDL.

Table 2-15. Selection of Critical Water Year based on Rainfall Intensity (Average Rainfall per Wet Day)

Year	Average Rainfall per Wet Day (in)
2007	0.22
2009	0.22
2011	0.22
2010	0.23
2008	0.23
1999	0.25
1990	0.25
2012	0.25
2002	0.26
1989	0.27
1987	0.27
1997	0.29
1994	0.29
1991	0.29
2005	0.29
1986	0.29
1996	0.30
2006	0.30
2004	0.32

Year	Average Rainfall per Wet Day (in)
2000	0.32
2001	0.32
1992	0.34
2003 **(90th Percentile Most Recent 10 Years)**	**0.35**
1995	0.37
1998	0.37
1993	0.39
1988	0.39
90th Percentile (All Years)	**0.37**

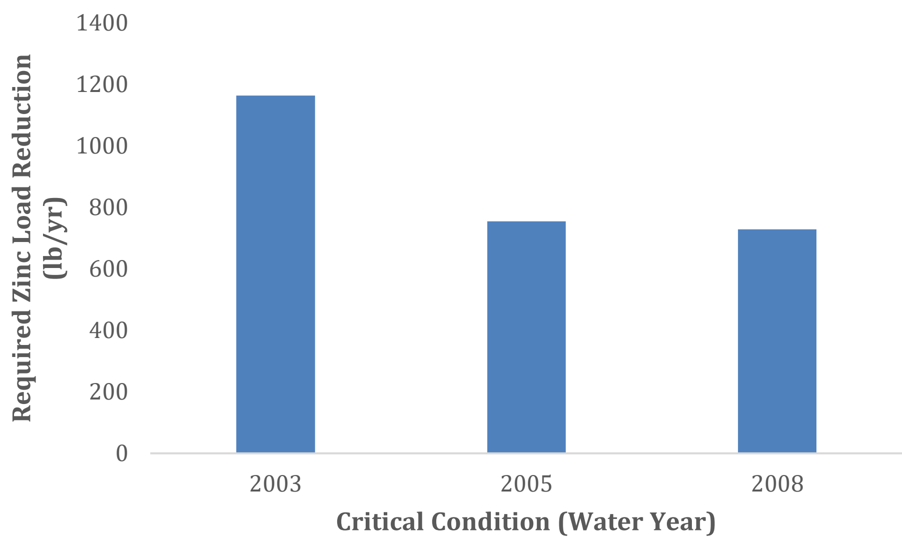

Figure 2-27. Required Annual Zinc Load Reductions for the Rio Hondo Compliance Point Across Different Annual Critical Conditions Investigated.

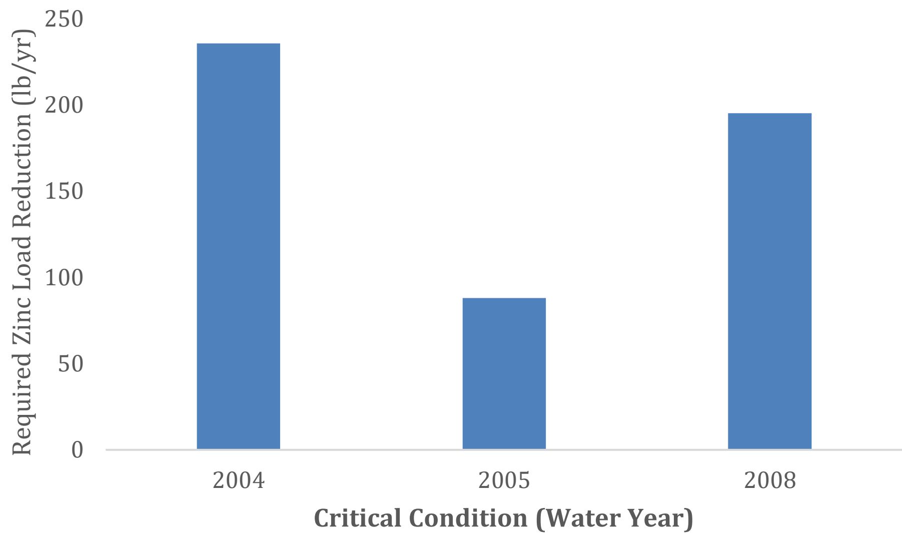

Figure 2-28. Required Annual Zinc Load Reductions for the San Gabriel River Compliance Point Across Different Annual Critical Conditions Investigated.

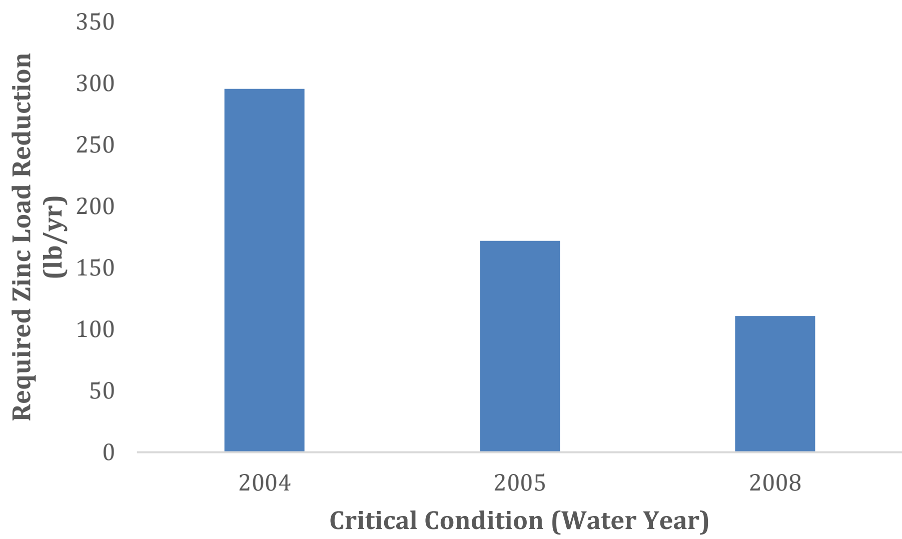

Figure 2-29. Required Annual Zinc Load Reductions for the Big Dalton Wash Compliance Point Across Different Annual Critical Conditions Investigated.

Table 2-16. Required Percent Zinc Load Reduction for Each Compliance Point Across Different Annual Critical Conditions Investigated.

Water Year	Compliance Point		
	Rio Hondo	San Gabriel River	Big Dalton Wash
2003 – LAR Critical Water Year (90th percentile rainfall intensity)	30.4%	--	--
2004 – SGR Critical Water Year (90th percentile rainfall intensity)	--	27.7%	20.0%
2005 – Greatest total rainfall	7.9%	0.6%	2.3%
2008 – Average annual rainfall	21.2%	12.4%	3.3%

2.4 LIMITING PRIORITY POLLUTANT

Section 2.4.2 lists the water body-pollutant combinations per Section 2.2 of the original, accepted 2016 EWMP. Table 2-22 summarizes the water body-pollutant combination categories as well as the impacted reaches. Specific combinations were deprioritized for the following reasons (generally consistent with justification provided in the original 2016 EWMP):

- Nutrients: Targets are based on existing conditions (anti-degradation). The Los Angeles Area Lakes TMDL for Peck Road Park Lake states "This lake is currently achieving the in-lake chlorophyll *a* target and TMDLs are being established at the existing loads." (USEPA, 2012) Nitrogen compounds have shown no exceedances in recent years in Rio Hondo Reach 3 and sources of these compounds are likely other than MS4s.
- Trash: Majority of cities are over 90% compliant.
- Bacteria: Implementation of the metals TMDLs, with earlier compliance deadlines, is expected to address much of the bacteria impairment. Also, base flows and dry-weather discharges from the RH/SGR Water Quality Group area are not suspected to be a large contributor to the impairments identified in the LA Bacteria TMDL. Further investigation of the sources of bacteria impairments are required. See 2.4.1, from section 1.3.2 of the accepted 2016 EWMP on the relevant TMDLS for more detail on this justification.
- Legacy: Constituents are no longer in commercial use. Internal lake dynamics are likely more important than any current loading from the watershed.

Section 2.4.3 presents the prioritization of the water body-pollutant combinations, per Section 2.4 of the accepted 2016 EWMP and Section 2.4.4 presents constituent relationships, per Section 2.5.1 of the accepted 2016 EWMP.

Therefore, metals are the remaining water body-pollutant combination of concern. A limiting priority pollutant can be selected under the RAA guidelines. The limiting pollutant should be the constituent with the highest required reduction or the most difficult to treat. The concept of the limiting pollutant stands if the limiting pollutant reduction requirements are met, necessary reductions to all other constituents should be met as well. Zinc had the greatest reduction requirement at all compliance points (discussed in next section, Table 2-23). However, at the San Gabriel River and Big Dalton Wash compliance point copper had a greater percent reduction requirement. Recall the CTR criteria was not updated for copper in the San Gabriel River watershed given the poor regression, therefore the maximum concentration is significantly stricter. Copper is assumed to be primarily managed through the brake pad replacement program, therefore zinc is the limiting priority pollutant in both watersheds. The selection of zinc as the limiting pollutant is further supported as lead reduction requirements were near zero across the compliance points based on a number of critical conditions initially investigated.

The following subsections are referenced above and were developed in the original, accepted 2016 EWMP, under Section 1.3.2 with the relevant TMDLs, Section 2.4 on the prioritization for the water body-pollutant combinations, and Section 2.5.1 on the constituent relationships.

2.4.1 Relevant TMDLs

TMDLs applicable to the Water Quality Group are listed in Table 2-17. The resolutions and effective dates reflect the most recent amendments to the LAR nitrogen and metals TMDLs. Revised water quality-based effluent limitations (WQBELs) and receiving water limitations (RWLs) are incorporated into the MS4 Permit by the Regional Board after adoption and approval of the TMDL amendment. TMDL impacted reaches are highlighted in Figure 2-30.

The LAR bacteria TMDL is complex, considering dry- and wet-weather conditions, differing implementation strategies, many river segments, allowing for tributary based diversion strategies, and differing implementation schedules that accompany each permutation. Within the RH/SGR area, water operations and management are equally complex and varied. Much of the dry-weather base flow appears to have its origin in rising groundwater or spring flows, which commingle with permitted and non-permitted non-stormwater discharge flows. When these comingled base flows generated in the LAR Watershed portion of the group arrive at Peck Road Park Lake, they are understood to infiltrate and not contribute to the downstream dry-weather impairments that resulted in the adoption of the TMDL. Similarly, base flows emanating from Arcadia Wash, are understood to comingle with flows from other Permittees along the Rio Hondo, primarily members of the Upper Los Angeles River Watershed Group, then infiltrate in unlined river sections behind the western Whittier Narrows Dam or at the downstream County operated Rio Hondo Spreading Grounds. Notwithstanding the incidental water quality benefits, Peck Road Park Lake, San Gabriel River, and the Spreading Grounds are water conservation facilities that provide critical water recharge benefits to the area, and the LACFCD does not consider them to be BMPs. While these facilities are providing a consequential water quality benefit, the primary purpose is flood control and thus are managed as such. Noting that base flows and dry-weather discharges from the group are unlikely to have contributed to the impairments identified in the TMDL, nearly all water bodies within the greater Los Angeles region, have periodic exceedances for bacteria and it is likely that this pollutant can be best addressed along with other impairments.

Table 2-17. TMDLs Applicable to the RH/SGR Water Quality Group and Downstream Areas.

TMDL	LARWQCB Resolution	Effective Date and/or USEPA Approval Date
Los Angeles River Nitrogen Compounds and Related Effects TMDL	2003-009	March 23, 2004
	2012-010	August 7, 2014
Los Angeles River Trash	2007-012	September 23, 2008
	R15-006	June 11, 2015[1]
Los Angeles River Metals TMDL	2007-014	October 29, 2008
	2010-003	November 3, 2011
	R15-004	April 9, 2015[1]
Los Angeles River Bacteria TMDL	2010-007	March 23, 2012
Dominguez Channel and Greater Los Angeles and Long Beach Harbor Waters Toxic Pollutants TMDL	2011-008	March 23, 2012
TMDL for Indicator Bacteria in San Gabriel River, Estuary, and Tributaries	R15-005	June 10, 2015[1]
Los Angeles Area Lakes TMDLs for Peck Road Park Lake	N/A (USEPA TMDL)	March 26, 2012
San Gabriel River Metals and Impaired Tributaries Metals and Selenium TMDL		March 26, 2007

[1] Approved by the LARWQCB (effective date not identified)

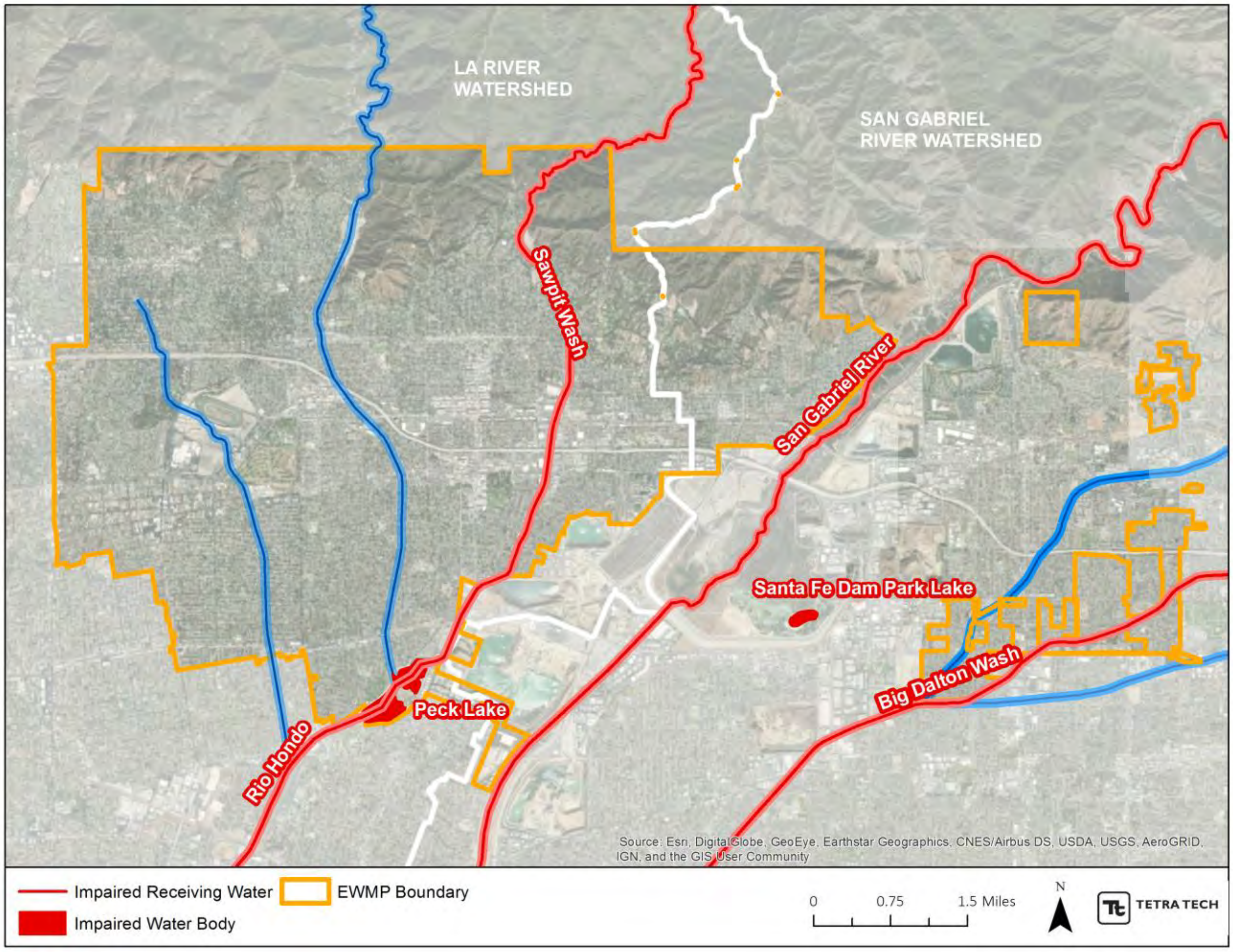

Figure 2-30. RH/SGRWQG Nearby Impaired Water Bodies

Table 2-18 demonstrates which RH/SGRWQG members are affected by each of the TMDLs.

Table 2-18. RH/SGR Water Quality Group TMDLs and Applicability

RH/SGRWQG Member	LAR Watershed Trash TMDL	LAR Nitrogen Compounds and Related Effects TMDL	LAR and Tributaries Metals TMDL	LAR Watershed Bacteria	Los Angeles Area Lakes TMDLs for Peck Road Park Lake	Dominguez Channel and Greater Los Angeles and Long Beach Harbor Waters Toxics TMDL[1]	SGR and Impaired Tributaries Metals and Selenium TMDL	TMDL for Indicator Bacteria in the SGR, Estuary, and Tributaries
Arcadia	X	X	X	X	X		X	X
Bradbury	X	X	X	X	X		X	X
Duarte	X	X	X	X	X		X	X
Monrovia	X	X	X	X	X		X	X
Sierra Madre	X	X	X	X	X			
County of Los Angeles	X	X	X	X	X	X	X	X
LACFCD		X	X	X	X	X	X	X

[1] The Cities of Arcadia, Bradbury, Duarte, Monrovia, and Sierra Madre have a TMDL obligation to monitor at the mouth of the LAR and SGR Estuaries for the Dominguez Channel and Greater Los Angeles and Long Beach Harbor Waters Toxics TMDL.

Regional Board-adopted TMDLs include implementation plans providing interim and final compliance dates. Table 2-19 lists the interim and final compliance dates relevant to the RH/SGR Water Quality Group. There are two compliance paths for the LAR dry-weather bacteria TMDL, based on whether or not each jurisdiction, or the group, develops and implements a LRS. The LRS must quantitatively demonstrate that outfall specific actions are sufficient to result in attainment of the final water quality objectives (WQOs). Additionally, there are required dry-weather “snapshot” monitoring events where, for each event, every flowing outfall is sampled for bacterial indicators. Six snapshot monitoring events are required prior to LRS implementation and three after to assess effectiveness. Completing the LRS process provides regulatory relief by providing seven additional years before final effluent limitations become effective. The LRS due date and corresponding interim and final compliance milestones for the dry-weather bacteria TMDL for the LAR side of the RH/SGR Water Quality Group are included in Table 2-19.

The Regional Board approved an implementation plan for the SGR Metals TMDL on March 4, 2014. For Peck Road Park Lake there is no established implementation plan; therefore, the milestones and ultimate compliance dates for Peck Road Park Lake have been established through the EWMP process. The compliance dates and milestones for the TMDLs applicable to the RH/SGR Water Quality Group are listed in Table 2-19, including those for Peck Road Park Lake. Table 2-20 identifies the WQBELs and Waste Load Allocations (WLAs) for discharges to Peck Road Park Lake.

Table 2-19. Schedule of TMDL Compliance Milestones Applicable to the RH/SGRWQG

TMDL	**LAR Nitrogen**	**LAR Trash**	**LAR Metals**	**SGR Metals**	**LAR Bacteria**			**SGR Bacteria**[5]		**LA Area Lakes**
Water Bodies	All	All	All	All	All			All		Peck Road Park Lake
Constituents	Ammonia, Nitrate, Nitrite, Nitrate +Nitrite	Trash	Copper, Lead, Zinc, Cadmium	Copper, Lead, Zinc	*E. Coli*			*E. Coli*		Total-P, Total-N, Trash Water and Sediment: PCBs, Chlordane, DDT, Dieldrin
Compliance Goal	Meet WQBELs	% Reduction	% of MS4 area Meets WQBELs	% of MS4 area Meets WQBELs[3]	Meet WQBELs			Meet WQBELs		Meet WLAs
Weather Condition	All	All	Wet	Wet	Dry w/o LRS	Dry w/ LRS	Wet	Dry	Wet	All
Compliance Dates and Milestones (Bolded numbers indicate milestone deadlines within the current MS4 Permit term)[1]										
2012	**Pre 2012: Final**	**9/30: 70%**	**1/11: 25%**							USEPA TMDLs, which do not contain interim milestones or implementation schedules. The MS4 Permit (Part VI.E.3.c, page 145) allows MS4 Permittees to propose a schedule as part of this EWMP. See Section 2.5 for established schedules.
2013		**9/30: 80%**								
2014		**9/30: 90%**								
2015		**9/30: 96.7%**								
2016		**9/30: 100%**				**3/23: LRS Due**[4]				
2017				**9/30:10%**[6]						
2020				9/30: 35%						

TMDL	LAR Nitrogen	LAR Trash	LAR Metals	SGR Metals	LAR Bacteria			SGR Bacteria[5]		LA Area Lakes
2023				9/30: 65%	9/23: Final	9/23: Interim				
2024			1/11: 50%							
2026				9/30: 100%				12/1: Final		
2028			1/11:100%							
2030						3/23: Final				
2036									12/1: Final	
2037							3/23: Final			

[1] The MS4 Permit term is assumed to be five years from the MS4 Permit effective date or December 27, 2017.
[3] Alternatively may be demonstrated as percent of required reduction.
[4] LRS requires coordinated effort by all MS4 Permittees within a segment or tributary. An LRS must quantitatively demonstrate that the actions for specific outfalls are sufficient to result in attainment of the *final* WLAs. Requires six snapshot sampling events prior to LRS and three post-LRS snapshot sampling events.
[5] Anticipated schedule assumes TMDL will become effective December 1, 2016. The schedule will be revised through the Adaptive Management Process depending on the effective date.
[6] Extended to March 2019.

Table 2-20. Applicability of WQBELs and WLAs for Peck Road Park Lake

Constituent	Water Column	Suspended Sediment	Fish Tissue
Total Nitrogen	W		
Total Phosphorus	W		
Trash	W		
Total PCB	W	W	Alt
Total Chlordane	W	W	Alt
Dieldrin	W	W	Alt
Total DDT*	W	W	Alt

W = WLA established by TMDL.
Alt = Alternate compliance options if fish tissue targets are met.
*Total DDT measured in suspended sediment, 4-4' DDT measured in water column.

2.4.2 Water Body-Pollutant Classification

Based on available information and data analysis, WBPCs were classified in one of the three MS4 Permit categories of highest priority, high priority, or medium priority. To reflect the sub-categorization outlined in the Regional Board's RAA Guidelines, subcategories are defined to facilitate scheduling decision support for watershed actions determined as part of the RAA and EWMP process. The subcategories are defined in Table 2-21 and the categorization is summarized in Table 2-22.

Table 2-21. Water Body-Pollutant Combination Subcategory Definitions.

Category	Water Body-Pollutant Combinations (WBPCs)	Description
1	**Category 1A:** WBPCs with past due or current MS4 Permit term TMDL deadlines.	WBPCs with TMDLs with past due or current MS4 Permit term interim and/or final limits. These pollutants are the highest priority for the current MS4 Permit term.
	Category 1B: WBPCs with TMDL deadlines beyond the MS4 Permit term.	The MS4 Permit does not require the prioritization of TMDL interim and/or final deadlines outside of the MS4 Permit term or USEPA TMDLs, which do not have implementation schedules. To ensure EWMPs consider long term planning requirements and utilize the available compliance mechanisms these WBPCs should be considered during BMP planning and scheduling, and during CIMP development.
	Category 1C: WBPCs addressed in USEPA TMDL without a Regional Board Adopted Implementation Plan.	
2	**Category 2A:** 303(d) listed WBPCs or WBPCs that meet 303(d) listing requirements.	WBPCs with confirmed impairment or exceedances of RWLs. WBPCs in a similar class[1] as those with TMDLs are identified. WBPCs currently on the 303(d) list are differentiated from those that are not to support utilization of EWMP compliance mechanisms.
	Category 2B: 303(d) listed WBPCs or WBPCs that meet 303(d) listing requirements that are not a "pollutant"[2] (i.e., toxicity).	WBPCs where specific actions may not be identifiable because the cause of the impairment or exceedances is not resolved. Either routine monitoring or special studies identified in the CIMP should support identification of a "pollutant" linked to the impairment and re-prioritization in the future.
3	**Category 3A:** All other WBPCs with exceedances identified through CIMP implementation.	Pollutants that are in a similar class[1] as those with TMDLs are identified.
	Category 3B: All other WBPCs that are not a "pollutant"[2] (i.e., toxicity).	WBPCs where specific actions may not be identifiable because the cause of the impairment or exceedances is not resolved. Either routine monitoring or special studies identified in the CIMP should support identification of a "pollutant" linked to the impairment and re-prioritization in the future.
	Category 3C: WBPCs identified by the RH/SGRWQG members.	The RH/SGRWQG members may identify other WBPCs for consideration in EWMP planning.

[1] Pollutants are considered in a similar class if they have similar fate and transport mechanisms, can be addressed via the same types of control measures, and within the same timeline already contemplated as part of the EWMP for the TMDL. (MS4 Permit Part VI.C.2.a.i).
[2] While pollutants may be contributing to the impairment, it currently is not possible to identify the *specific* pollutant/stressor.

Table 2-22. Summary of RH/SGRWQG WBPC Categories

Class[1]	Constituents	Rio Hondo Reach 3	Monrovia Wash	Sawpit Wash	SGR Reach 5	San Dimas Wash	Big Dalton Wash	Peck Road Park Lake
Category 1A: WBPCs with past due or current term TMDL deadlines.								
Nutrients[2]	Ammonia	F	F	F				
	Nitrate	F	F	F				
	Nitrite	F	F	F				
	Nitrate + Nitrite	F	F	F				
Metals[2]	Copper (Wet)	I	I	I				
	Lead (Wet)	I	I	I	I[3]	I[3]	I[3]	
	Zinc (Wet)	I	I	I				
	Cadmium (Wet)	I	I	I				
Trash[2]	Trash	I/F	I/F	I/F				
Category 1B: WBPCs with TMDL deadlines beyond the current MS4 Permit term.								
Metals[2]	Copper (Wet)	F	F	F				
	Lead (Wet)	F	F	F	F[3]	F[3]	F[3]	
	Zinc (Wet)	F	F	F				
	Cadmium (Wet)	F	F	F				

Class[1]	Constituents	Rio Hondo Reach 3	Monrovia Wash	Sawpit Wash	SGR Reach 5	San Dimas Wash	Big Dalton Wash	Peck Road Park Lake
Bacteria[2]	Fecal Coliform	I/F	I/F[4]	I/F[4]				I/F[4]
	E. coli	I/F	I/F[4]	I/F[4]	I/F	I/F	I/F	I/F[4]
Category 1C: WBPCs addressed in USEPA TMDL without an Implementation Plan.[5]								
Nutrients	Total Nitrogen							X
	Total Phosphorus							X
Legacy	PCB (Sediment)							X
	PCB (Water)							X
	Chlordane (Sediment)							X
	Chlordane (Water)							X
	Dieldrin (Sediment)							X
	Dieldrin (Water)							X
	DDT (Sediment)							X
	DDT (Water)							X

Class[1]	Constituents	Rio Hondo Reach 3	Monrovia Wash	Sawpit Wash	SGR Reach 5	San Dimas Wash	Big Dalton Wash	Peck Road Park Lake
Trash	Trash							X
Category 2B: 303(d) listed WBPCs.								
Metals	Lead (Dry)		303(d)[6]					
Other	Bis(2-ethylhexyl) phthalate			303(d)				
Category 3: WBPCs without a TMDL or 303(d) listing.[7,8]								

[1] Pollutants are considered in a similar class if they have similar fate and transport mechanisms, can be addressed via the same types of control measures, and within the same timeline already contemplated as part of the EWMP for the TMDL (MS4 Permit, Part VI.C.2.a.i).
[2] MS4 discharges from Sawpit Wash, Santa Anita Wash, and direct MS4 discharges to Peck Road Park Lake are subject to the LAR Metals TMDL and the LAR Bacteria TMDL.
[3] Grouped wet-weather WLA, expressed as total recoverable metals discharged to all upstream reaches and tributaries of the SGR Reach 2.
[4] These water bodies are hydrologically disconnected from the Rio Hondo and thus the LAR during dry-weather and during some wet-weather events.
[5] USEPA Los Angeles Area Lakes TMDL states that lead is currently meeting numeric targets for water and sediment during wet- and dry-weather; therefore no WLA has been assigned and it has not been identified as a WBPC.
[6] Monrovia Wash is 303(d) listed for lead; however, the LAR Metals TMDL only assigns a dry-weather load allocation for non-point sources and therefore no WLA is assigned for MS4 sources.
[7] Monitoring of Monitoring and Reporting Plan Table E-2 constituents in the first year at Long Term Assessment sites will identify the Category 3 WBPCs.
[8] Pollutants noted with exceedances that are not associated with an existing TMDL or 303(d) listing have not been identified as Category 3 pollutants because the data analyzed is from areas downstream of the RH/SGRWQG. Once CIMP data has been collected for the group area, Category 3 pollutants will be identified as WBPCs through the Adaptive Management Process, as appropriate. Based on the first CIMP wet-weather monitoring event, exceedances were not detected for potential Category 3 WBPCs.

Notes:
Unless explicitly stated as sediment, constituents are associated with the water column.
I/F = Denotes where the MS4 Permit or newly approved TMDL includes interim (I) and/or final (F) effluent and/or RWLs.
X = Identification of a WBPC, but no corresponding MS4 Permit implementation.
303(d) = WBPC on the 2010 303(d) list where the listing was confirmed during data analysis.

2.4.3 Prioritization

The MS4 Permit outlines a prioritization process that defines how pollutants in the various categories will be considered in scheduling as part of the EWMP. Based on compliance pathways outlined in the MS4 Permit, the scheduling factors considered include the following:

- TMDLs with past due interim and/or final limits and those with interim and/or final limits within the MS4 Permit term (schedule according to TMDL schedule)
- TMDLs with interim and/or final limits outside the MS4 Permit term (schedule according to TMDL schedule)
- Other receiving water exceedances
    - Pollutants in the same class as those addressed in a TMDL (evaluate ability to consider on same timeframe as TMDL)
    - Pollutants on the 303(d) list or in the same class as those on the 303(d) listings (develop schedule to address as soon as possible with milestones)
    - Pollutants with exceedances that are not in the same class as 303(d) listing (conduct monitoring under CIMP to confirm exceedances and if confirmed develop schedule with milestones)
    - Pollutants without exceedances in last 5 years (not prioritized for BMPs, but included in monitoring)

Evaluating whether or not a pollutant is in the same class as either a TMDL or a 303(d) listed pollutant is a critical decision for prioritization and scheduling. The MS4 Permit definition of class is as follows:

> "Pollutants are considered in a similar class if they have similar fate and transport mechanisms, can be addressed via the same types of control measures, and within the same timeline already contemplated as part of the EWMP for the TMDL."

As part of EWMP development and the RAA, prioritizing and sequencing of BMPs considered the aforementioned factors.

2.4.4 Constituent Relationships

Subcategory 1C WBPCs include those identified in the Peck Road Park Lake TMDLs issued by USEPA. As stated in the technical TMDL, recent monitoring data suggest that nutrient loads and related WQOs are being met, but need to be monitored into the future. Although the nutrient WQOs were being met at the time the TMDL was being developed, a timeline consistent with the Machado Lake Nutrients TMDL is most appropriate so that necessary measures are implemented in the event an exceedance was to occur. The Machado Lake TMDLs will serve as the basis for determining the schedule/timeline for the Peck Road Park Lake TMDLs, as both Machado Lake and Peck Road Park Lake are lakes developed in the early 1970s in urban areas with comparable environments, impairments, and sources (as identified in the TMDLs). As was the case with Machado Lake, the schedule/timeline presented in this EWMP is for MS4 discharges into the lake and do not address polluted bed sediments. Once the MS4 discharges have been addressed, the bed sediment will be assessed and addressed as needed. The trash component of this TMDL is being addressed as a requirement of the Los Angeles River Trash TMDL and the schedule for that TMDL also addresses the Los Angeles Area Lakes TMDLs.

Based on pollutant fate and transport characteristics, Peck Road Park Lake legacy pollutant WBPCs milestone schedules/timelines are most appropriately based upon those identified in the Machado Lake TMDLs. At both locations, the pollutants include organochlorine pesticides and PCBs (or Aroclors) which are no longer in commercial use and typically bind to sediment particles which settle out in non-flowing receiving waters. Their environmental fate is typically through natural attenuation or bioremediation, although sediment removal and disposal may be necessary to more rapidly achieve water and sediment quality objectives.

Subcategory 2C WBPCs include State 2010 Integrated Report, or CWA 303(d) list, identified impairments for bis(2-ethylhexyl) phthalate in Sawpit Wash. Phthalates are common plastizers and laboratory contaminants.

Although it is unlikely to still be present, the most appropriate scheduling corollary would be with the Machado Lake Toxics TMDL as the fate and transport of this compound is typical of many organic compounds which tend to bind to particulates and be degraded through natural attenuation. Utilizing the Machado Lake Toxics TMDL timeline will also be consistent with the Peck Road Park Lake timelines discussed above, which is beneficial as Sawpit Wash is tributary to Peck Road Park Lake.

If WBPCs are not assigned to existing TMDL schedules, then the RH/SGR Water Quality Group would be required to develop a detailed time schedule, of specific actions to undertake, that will achieve compliance with the numeric WLAs. For such pollutants, the time schedule requested must be as short as possible, taking into account the time since establishment of the TMDL, technological, operational, and economic factors that affect the design, development, and implementation of the control measures that are necessary to comply with the WLAs. If the requested time schedule exceeds one year, the proposed schedule shall include interim requirements and numeric milestones and the date(s) for their achievement. In assessing appropriate schedules for WBPCs, similar, adopted, Regional Board TMDL implementation schedules will be used to the extent possible based on the rationale that they would meet the requirements in as short a time as is possible and considering other factors identified in the MS4 Permit.

2.5 REQUIRED REDUCTION

Three downstream compliance locations were selected to account for the drainage from water bodies located within the EWMP area. Figure 2-31 shows one is located along the Rio Hondo in the LA River Watershed and two in the San Gabriel River Watershed, one along the San Gabriel River and the second along Big Dalton Wash. Note that, under these assumptions, the Water Quality Group is taking on a proportional responsibility for the upstream areas (above their jurisdictional areas) contributing to the compliance locations. For the Rio Hondo and San Gabriel River compliance points the contributing area outside the jurisdictional boundaries is primarily vacant mountainous terrain. Baseline conditions over the critical condition (wet days during the critical water years - WY2003 in LAR and WY2004 in SGR) are summarized in Figure 2-32 through Figure 2-37 in terms of the daily runoff volume, zinc concentration, and zinc load. Required load reductions are determined by comparing the baseline loading to the target loading, set based on the water quality objectives, on wet days (>0.1 inches rainfall plus the following 3 days). For the critical water year (WY2003 in LAR and WY2004 in SGR), the required load reduction for each wet day exceeding the allowable load were totaled to determine the annual load reduction required. Table 2-23 summarizes the annual load reduction requirements as well as the percent reduction requirements at each compliance location. Table 2-24 through Table 2-26 describe the load reduction analysis required for zinc, the limiting priority pollutant at each compliance location. Figure 2-38 through Figure 2-40 show the required zinc load reductions at each compliance location and where these occur in terms of the percent rank of wet day loads. Note the days requiring load reductions do not necessary occur only for the days with the greatest loads. The water quality criteria are based on the metal concentrations, which may be diluted in cases where there are high flows, thus resulting in a larger load but no required reductions.

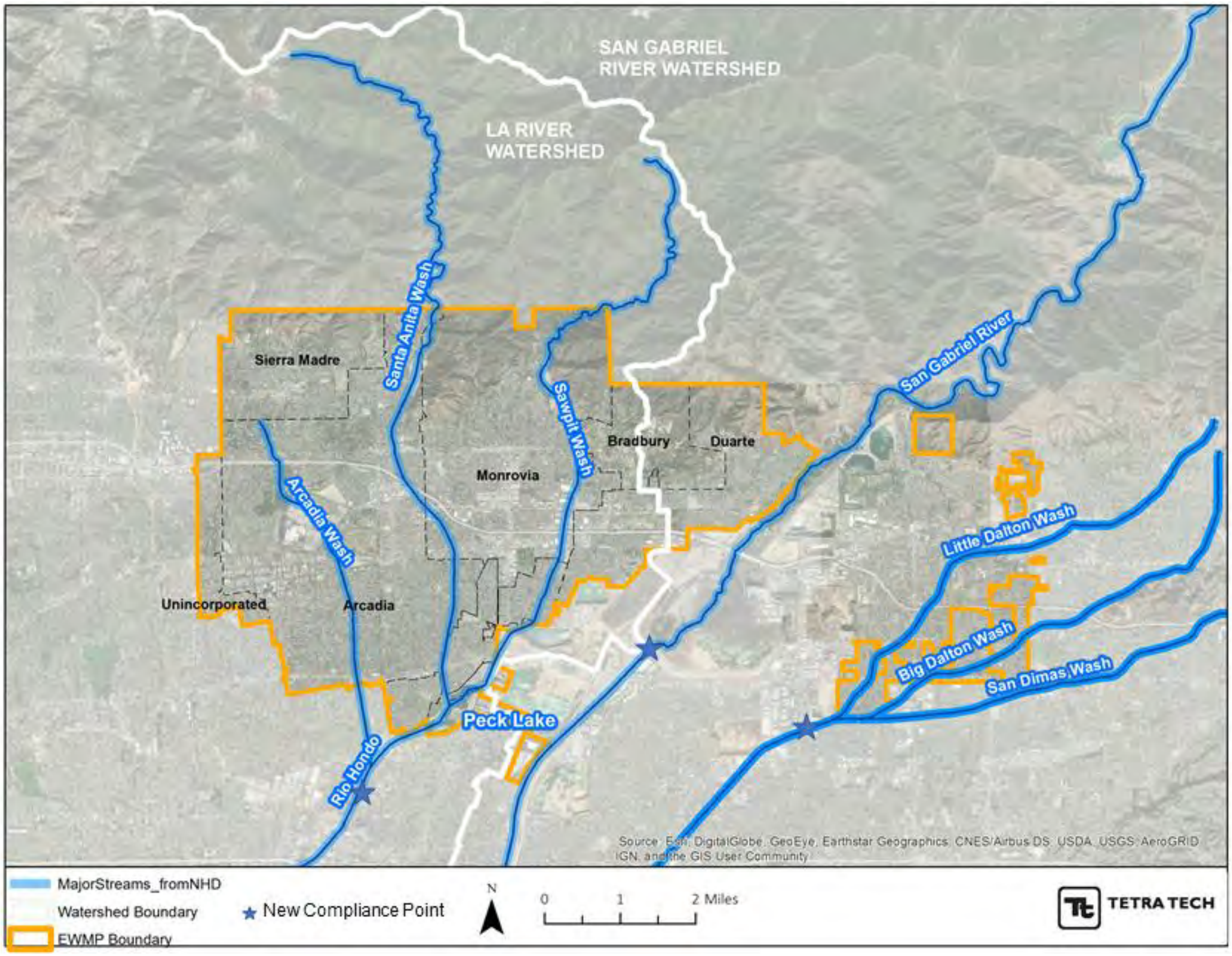

Figure 2-31. Compliance Locations, where Required Load Reductions Assessed.

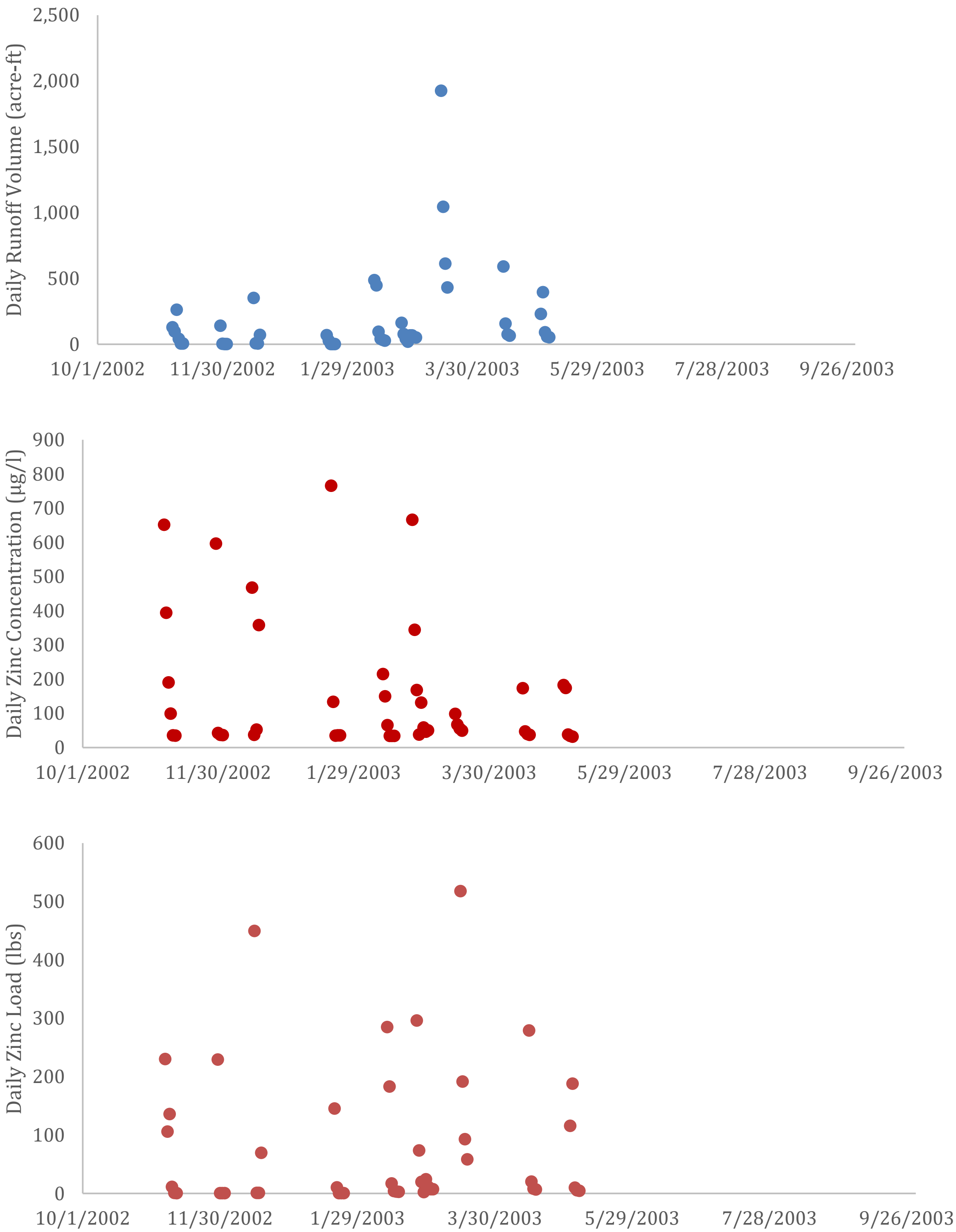

Figure 2-32. Baseline Conditions over the Critical Condition (Wet Days during the Critical Water Year) at the Rio Hondo Compliance Point in terms of the Daily Runoff Volume, Zinc Concentration, and Zinc Load.

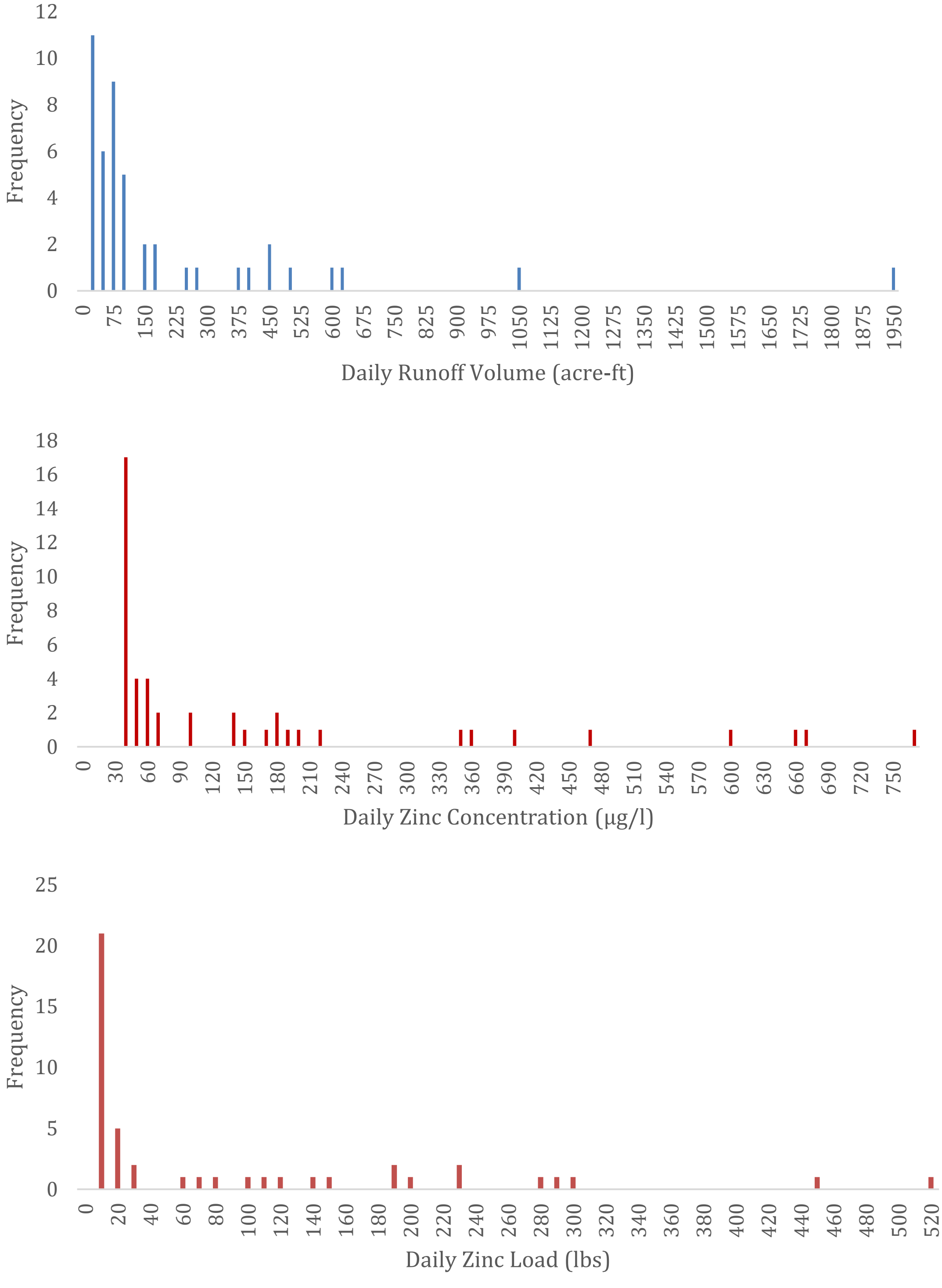

Figure 2-33. Distribution of the Baseline Daily Runoff Volume, Zinc Concentration, and Zinc Load over the Critical Condition (Wet Days during the Critical Water Year) at the Rio Hondo Compliance Point.

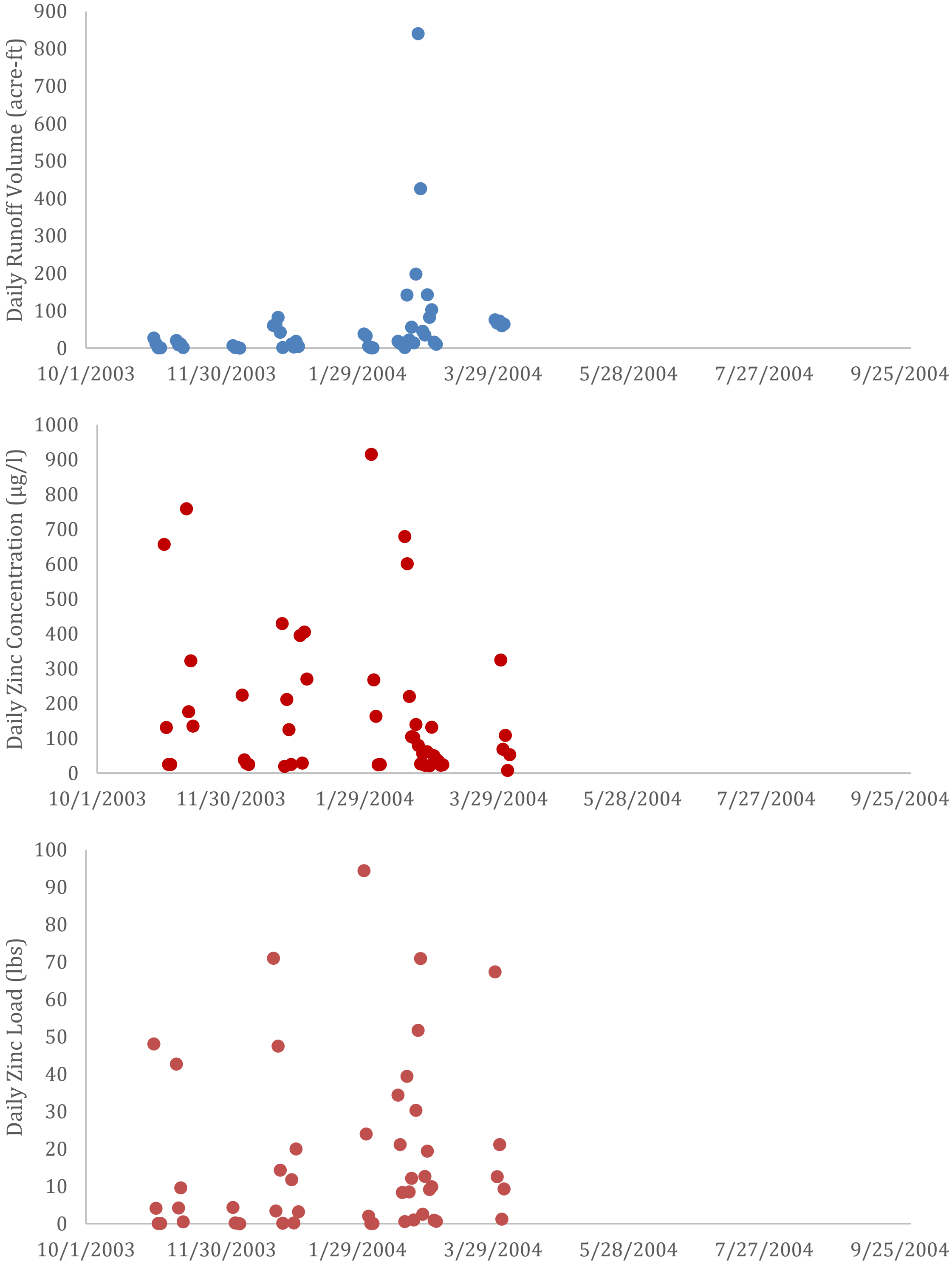

Figure 2-34. Baseline Conditions over the Critical Condition (Wet Days during the Critical Water Year) at the San Gabriel River Compliance Point in terms of the Daily Runoff Volume, Zinc Concentration, and Zinc Load.

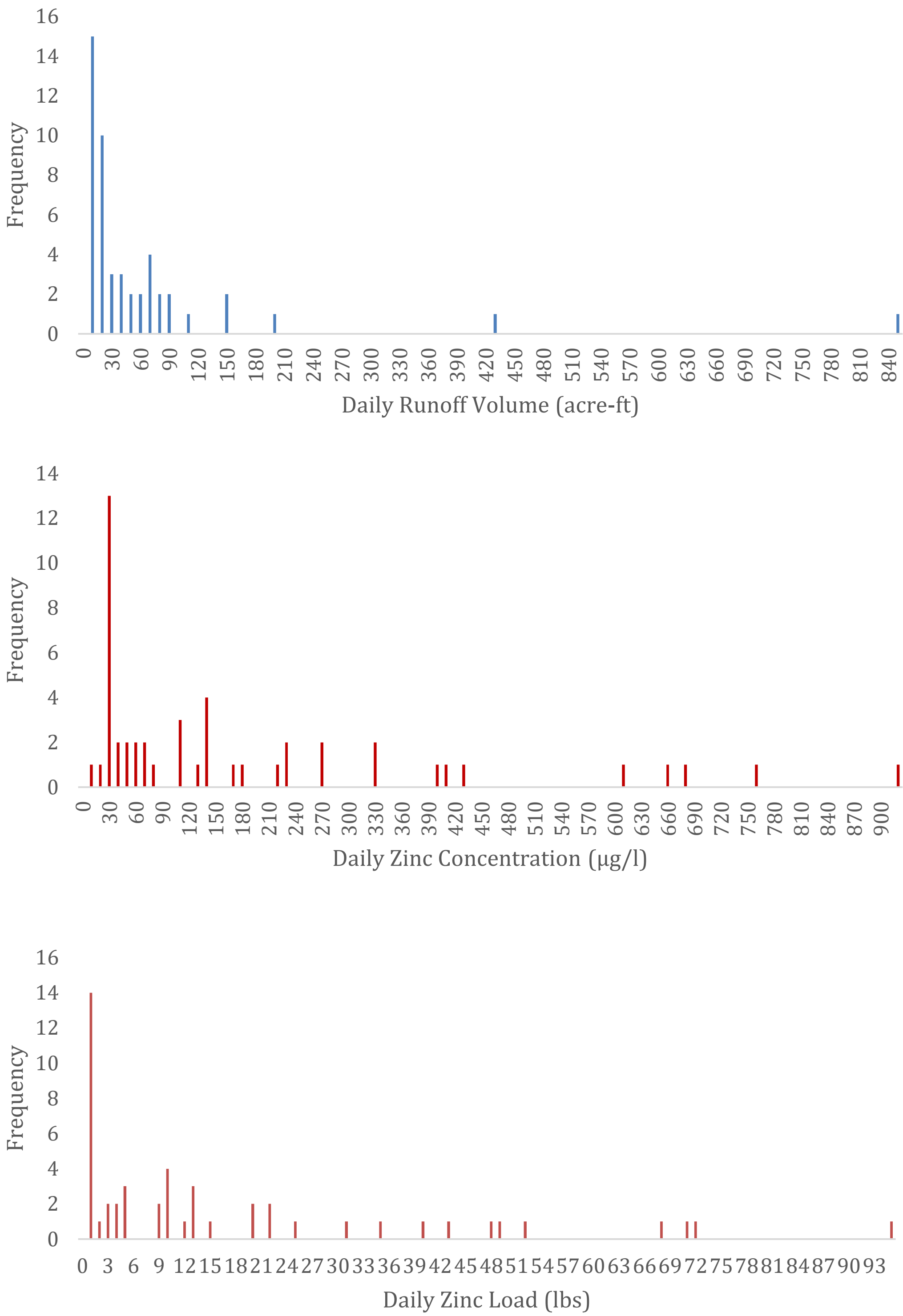

Figure 2-35. Distribution of the Baseline Daily Runoff Volume, Zinc Concentration, and Zinc Load over the Critical Condition (Wet Days during the Critical Water Year) at the San Gabriel River Compliance Point.

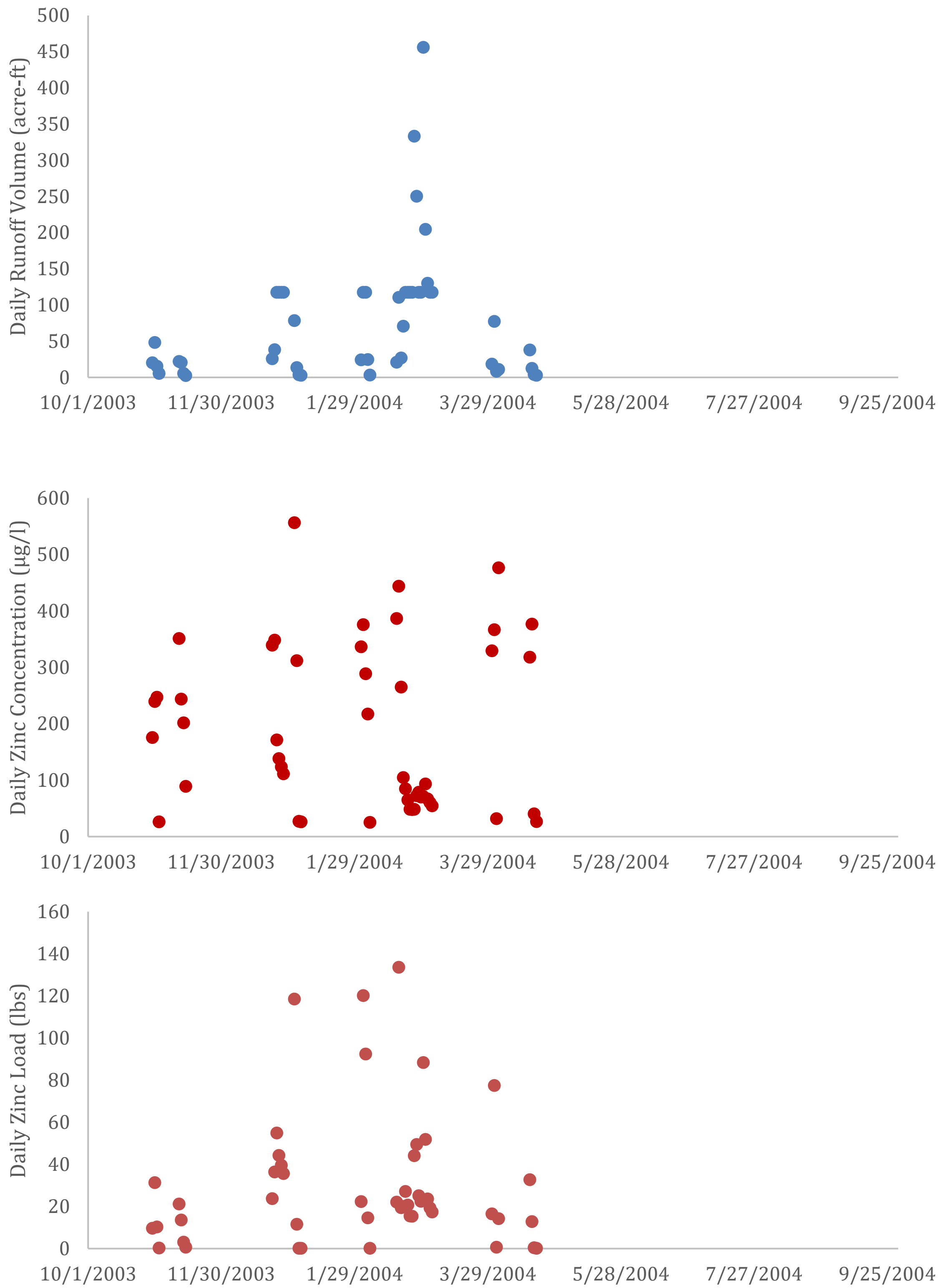

Figure 2-36. Baseline Conditions over the Critical Condition (Wet Days during the Critical Water Year) at the Big Dalton Wash Compliance Point in terms of the Daily Runoff Volume, Zinc Concentration, and Zinc Load.

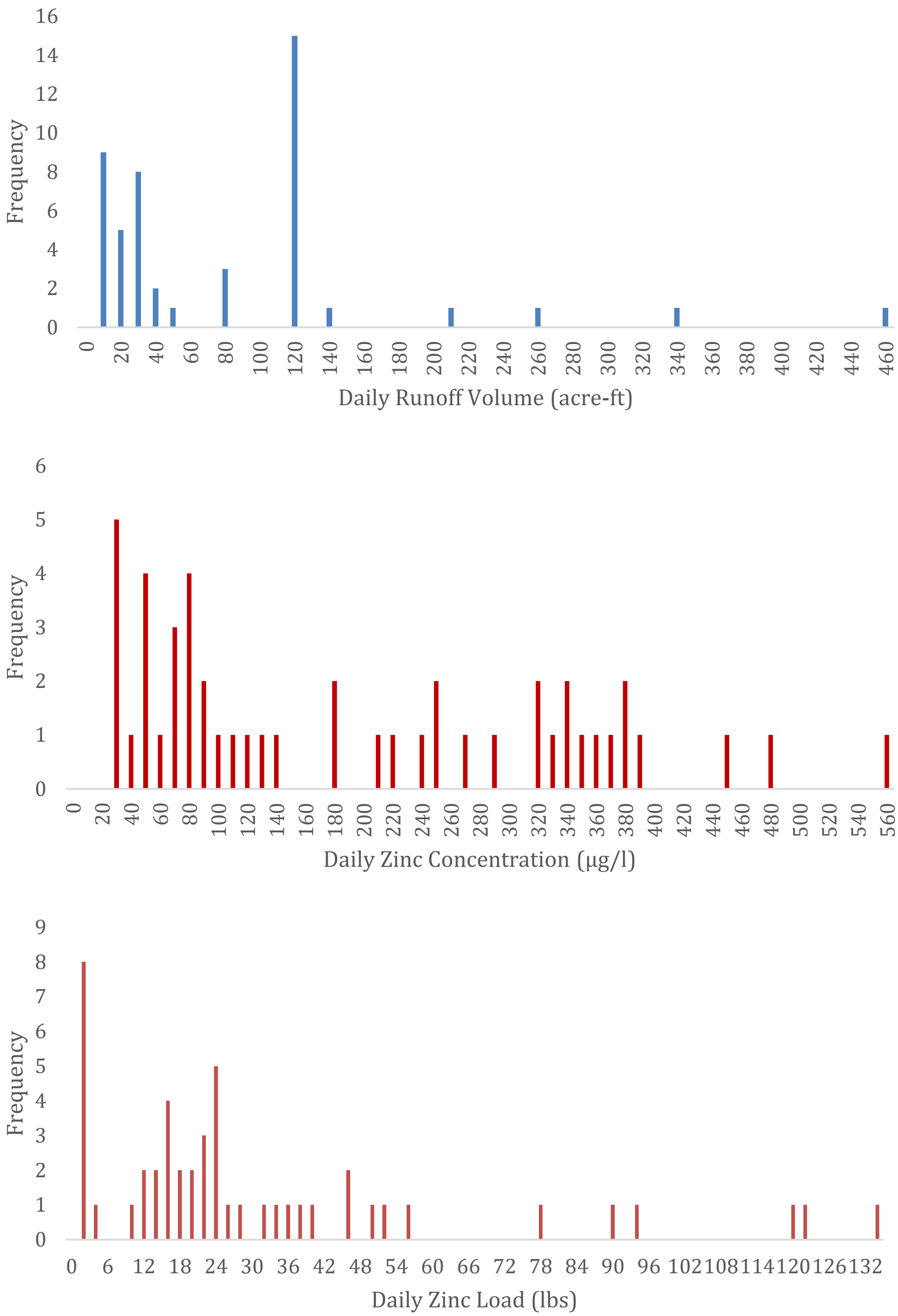

Figure 2-37. Distribution of the Baseline Daily Runoff Volume, Zinc Concentration, and Zinc Load over the Critical Condition (Wet Days during the Critical Water Year) at the San Gabriel River Compliance Point.

Table 2-23. Required Load Reduction at Each Compliance Location for Metals for Wet Days under the Critical Condition.

Constituent	Required Reduction	Compliance Location		
		Rio Hondo	San Gabriel River	Big Dalton Wash
Copper	Load (lb/yr)	23	63	80
	Percent (%)	3.0	39.0	31.9
Lead	Load (lb/yr)	0	0	0
	Percent (%)	0	0	0
Zinc	Load (lb/yr)	1163	236	295
	Percent (%)	30.4	27.7	20.0

Table 2-24. Rio Hondo Load Reduction Analysis for Zinc.

Wet Days Summary	
Total Wet Days (10/1/2002 - 9/30/2003)	46
Total Wet Exceedance Days	13
Total Existing Load (Wet Days) (lbs/yr)	3,822
Total Allowable Load (lbs/yr)	2,659
Required Load Reduction (lbs/yr)	1,163
Required Percent Reduction using 173 µg/L Total Zinc target	30.4%

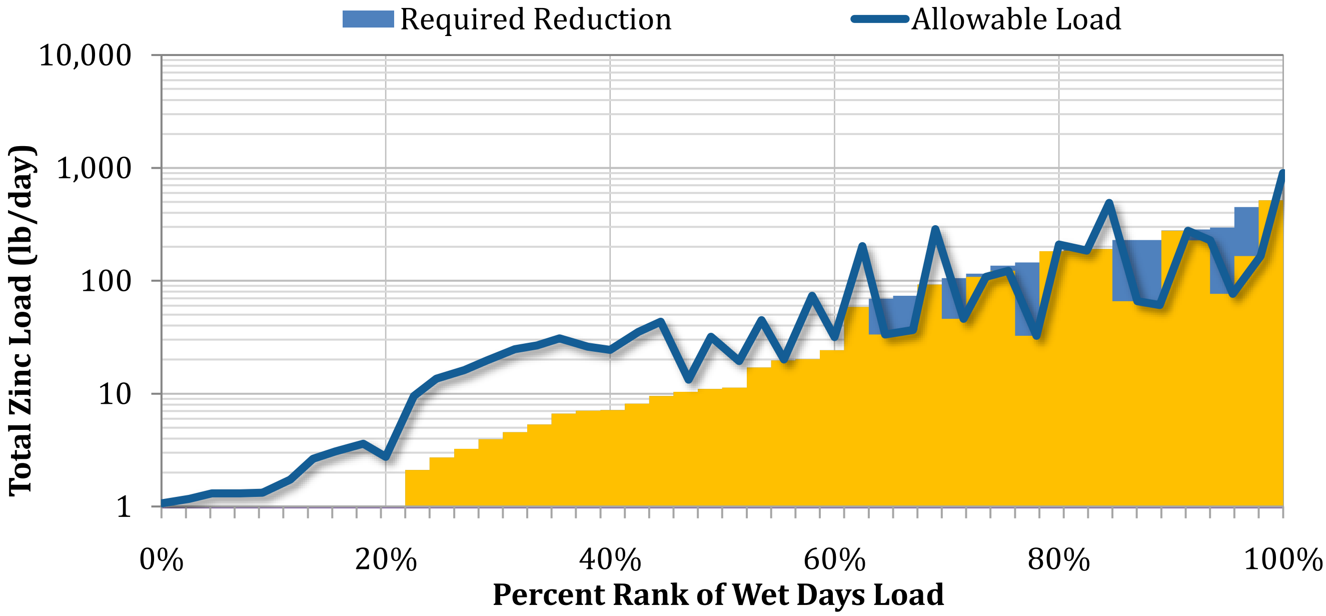

Figure 2-38. Days with Required Zinc Load Reductions at the Rio Hondo Compliance Location, Organized by the Percent Rank of the Daily Zinc Load over Wet Days, based on the Baseline and Allowable Loads.

Table 2-25. San Gabriel River Load Reduction Analysis for Zinc.

Wet Days Summary	
Total Wet Days (10/1/2003 - 9/30/2004)	49
Total Wet Exceedance Days	12
Total Existing Load (Wet Days) (lbs/yr)	852
Total Allowable Load (lbs/yr)	616
Required Load Reduction (lbs/yr)	236
Required Percent Reduction using 235 µg/L Total Zinc target	27.7%

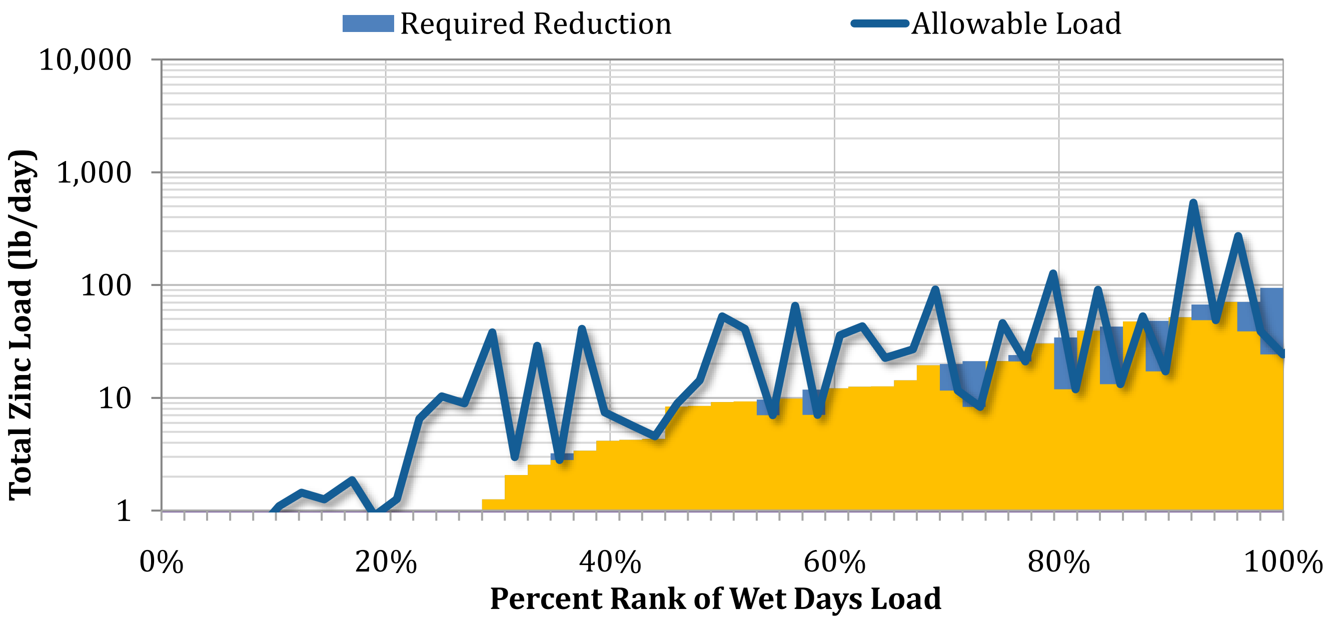

Figure 2-39. Days with Required Zinc Load Reductions at the San Gabriel River Compliance Location, Organized by the Percent Rank of the Daily Zinc Load over Wet Days, based on the Baseline and Allowable Loads.

Table 2-26. Big Dalton Wash Load Reduction Analysis for Zinc.

Wet Days Summary	
Total Wet Days (10/1/2003 - 9/30/2004)	48
Total Wet Exceedance Days	19
Total Existing Load (Wet Days) (lbs/yr)	1,478
Total Allowable Load (lbs/yr)	1,182
Required Load Reduction (lbs/yr)	295
Required Percent Reduction using 235 µg/L Total Zinc target	20.0%

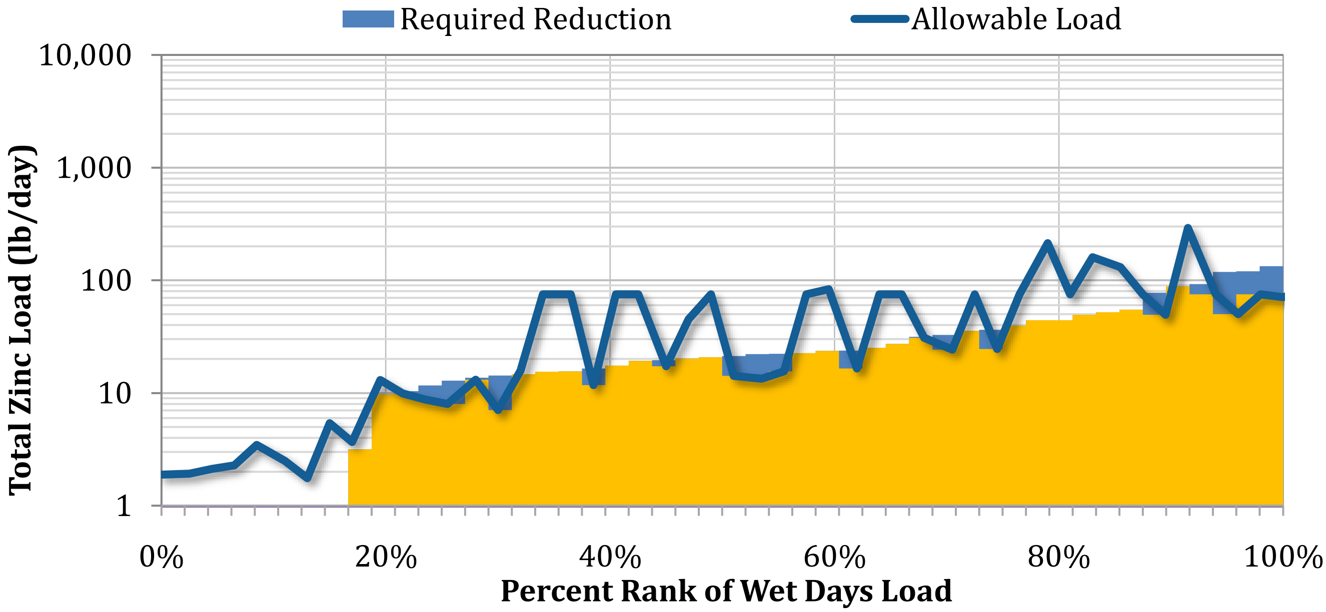

Figure 2-40. Days with Required Zinc Load Reductions at the Big Dalton Wash Compliance Location, Organized by the Percent Rank of the Daily Zinc Load over Wet Days, based on the Baseline and Allowable Loads.

Independent from the load reduction targets defined above for the established compliance points, a small sliver of the EWMP area eventually outfalls downstream from the Rio Hondo compliance point (via Eaton Wash). To define a load reduction target for this area, the reduction ratio computed at the Rio Hondo compliance point (30.4%) was applied to the baseline loading (to define load reduction target of 98.1 pounds of zinc). The RAA for this portion of the watershed is presented herein separately from the RAA for each compliance point.

3.0 REPRESENTATION OF EWMP CONTROL MEASURES

The next step of the RAA is to determine the optimal BMP combination to achieve required load reductions. SUSTAIN was used to represent potential BMP combinations and evaluate performance. A number of assumptions are factored in to the representation of control measures in the model. BMP assumptions were determined based on the best available data. The following subsections discuss methods and key assumptions of the model.

3.1 BMP OPPORTUNITIES

3.1.1 Enhanced Minimum Control Measures and Redevelopment LID

Non-structural BMPs for the participating jurisdictions include enhanced Minimum Control Measures (MCMs) and redevelopment projects.

Enhancements to MCMs are credited a 5% load reduction from the baseline load, as implementation of the required control measures under the 2012 MS4 Permit are expected to reduce pollutant loading as compared to the baseline conditions and calibrated watershed model, the period for which ends on 4/30/2012. Note that the 2016 EWMP applied a weighted average load reduction of 5.2%, but 5% was used in the rEWMP as a more conservative assumption and for consistency with other EWMPs throughout the region.

Permittees were required to develop and implement an LID ordinance under the 2012 MS4 Permit which applies thresholds of disturbance to impervious areas to new and redevelopment projects. The original 2016 EWMP referenced average annual redevelopment rates released by the City of Los Angeles, see Table 3-2, and assumes all redevelopment projects will include BMPs required by the MS4 Permit that provide a load reduction based on capturing the runoff volume associated with the 85th percentile rainfall.

The following subsections were developed in the original 2016 EWMP, under Section 3.4.1.1 through 3.4.1.3, with additional details on the non-structural programs and redevelopment projects planned in each jurisdiction.

3.1.1.1 Minimum Control Measures

MCMs are defined in Part VI.D of the MS4 Permit and are often referred to as institutional BMPs. The MCMs identified in the MS4 Permit include:

- PIPP (VI.D.5)
- Industrial/Commercial Facilities Program (VI.D.6)
- Planning and Land Development Program (VI.D.7)
- Development Construction Program (VI.D.8)
- Public Agency Activities Program (VI.D.9)
- IC/ID Elimination Program (VI.D.10)

The requirements in the 2012 MS4 Permit are more stringent than those previously required, thus it is anticipated that through implementing the required control measures there will be a reduction in pollutant loading as compared to the water quality data used to establish the baseline conditions and calibrate the model, which was collected under the previous MS4 Permit. Table 3-1 identifies potential modifications or enhancements to various MCMs. The enhancements identified in this section are currently being proposed as part of this rEWMP. A baseline load reduction of five percent is credited based on the more stringent requirements of the current MS4 Permit as compared to the previous MS4 Permit.

Table 3-1. Summary of Potential Non-Structural BMP Enhancements

Potential Modification or Enhancement	Justification
PIPP	
Develop a Grassroots Committee.	Community leaders may have stronger community connections, thus a better platform to provide educational and outreach materials.
Additional school outreach programs.	Sending home in school packets educational materials to help educate the students and individuals in the household.
Industrial/Commercial Facilities Program	
Evaluate operations of industrial facilities inspected to verify whether their operations are subject to IGP.	Identifying activities at industrial/commercial facilities where the Standard Industrial Classification (SIC) code does not require coverage under IGP will require facilities to get coverage and comply with requirements in the IGP.
Development Construction Program	
Recommend monitoring and sampling as part of the Erosion and Sediment Control Plan requirements.	Requiring developer to conduct self-inspections and monitoring will most likely result in more thorough BMP implementation by developers and contractors.
Inspect construction sites where Erosion and Sediment Control Plans have been approved.	

Potential Modification or Enhancement	Justification
Public Agency Activities Program	
More frequent street sweeping, especially in areas that lack full capture certified trash control devices.	Implementing a more vigorous street sweeping schedule will allow debris to be captured before it can be transported downstream.
Utilize regenerative air vacuum equipment for street cleaning in land use areas that generate high metals loads.	Vacuum street cleaners are more effective at removing metals compared to sweepers.
Set maximum street sweeper speeds to optimize effectiveness in removing trash, debris, and sediments.	Traveling at speeds recommended by street sweeping manufacturers will improve the sweeping effectiveness at removing pollutants.
Sweeping center median gutters, and "pork chop" islands at street intersections.	Sweeping areas that are not normally swept may capture additional pollutants.
Revise curb miles cleaned as an indicator to volume of trash collected.	Volume of trash collected provides a better indication of the program effectiveness.
Enhanced maintenance of catch basins, especially those with connector pipe screens.	Enhanced maintenance will prevent sediments and debris from accumulating and traveling downstream.
IC/ID Program	
Municipal Codes that include enforcement action such as the issuance of Notice of Violations (NOVs) for illicit connections.	Utilizing violations will give the RH/SGRWQG a greater presence and the threat of a penalty may have a greater influence over developers and others.
Municipal Codes that require follow up inspections within ten days for illicit connections.	Implementing a time schedule for follow up inspections will ensure that the cleanup is completed in a timely manner.
Abatement and cleanup required within one day of discovery.	Current procedures allow for up to 72 hours, therefore a quicker response will positively correlate to a lower load contribution.
Enhanced Irrigation Control	
Promote replacement of grass with xeriscape vegetation.	Installing artificial turf and/or drought tolerant plants, or installing weather based irrigation controllers, will conserve water and reduce runoff associated with irrigation which is often the source of dry-weather flows, which are often the most concentrated with pollutants.
Promote replacement of grass with drought tolerant native plant species.	
Outreach that focuses on the installation of weather based irrigation controllers.	
Perform landscape irrigation audits.	Actions that require residents to become aware of their water usage as well as limiting it may reduce the amount of irrigation occurring, thus reducing runoff due to excess irrigation.
Implement water budgets.	
Inform residents on other types of BMPs or irrigation equipment that may be utilized.	
Downspout Disconnection Program	
Implement a downspout disconnect program.	Implementing a downspout disconnect program will promote water conservation and reuse, by capturing stormwater runoff for irrigation use, thus reducing the volume of water reaching the storm drain system.

All of the areas within the LAR Watershed will have full capture devices to address the LAR Trash TMDL. Additionally, pursuant to Part VI.D.9.h.vii of the MS4 Permit, the SGR Watershed jurisdictions which do not have a trash TMDL, will install trash excluders or other devices on or in Priority A catch basins or outfalls by December 2016. Once the devices are installed the catch basin cleaning frequency will increase, along with street sweeping implementation. These modifications to the currently implemented MCMs support the five percent load reduction previously discussed for changes in the MS4 Permit requirements.

The County Unincorporated Area plans on implementing an enhanced MCM program that involves switching street sweepers from traditional broom sweepers to regenerative air (or vacuum) sweepers. Regenerative air sweepers have a higher efficiency in terms of pollutant removal based on a study conducted in San Diego (San Diego, 2010). The Cities of Arcadia and Monrovia currently use vacuum sweepers. This is not considered an enhancement in these jurisdictions because they have been using vacuum sweepers since before 2012; therefore, the implementation is considered as part of the baseline.

For the County Unincorporated Area, the 2016 EWMP assumed an additional 2 percent load reduction credited for street sweeping enhancements, however as previously mentioned this rEWMP consistently applied a 5% reduction for all enhanced MCMs across the jurisdictions as a more conservative assumption and for consistency with other EWMPs throughout the region.

3.1.1.2 Other Institutional BMPs

Other institutional control measures will also help reduce pollutant loading such as Senate Bill (SB) 346 which requires incremental reductions in the amount of copper in vehicle brake pads. SB 346 requires most brake pads sold in California to contain less than five percent copper by weight after January 1, 2021, and contain less than 0.5 percent copper by weight after January 1, 2025. This control measure is expected to create a 55 percent reduction in copper loads by 2032. This load reduction was not included in the model, but provided further evidence supporting the selection of zinc over copper as the limiting priority pollutant. SB 757 is another control measure that will help reduce pollutant loading, as it requires that "no person shall manufacture, sell, or install a wheel weight in California that contains more than 0.1 percent lead by weight." Load reductions based on SB 757 were not modeled since the load reduction associated with implementation is currently unknown.

3.1.1.3 New and Re-Development

Part VI.C.4.c.i.(1) of the MS4 Permit requires Permittees to develop and implement an LID ordinance applicable to new and re-development projects meeting specified thresholds of disturbance to impervious areas. Average annual new/re-development rates released by the City of Los Angeles (LAR UR2 WMA, 2014) were used to project the area that is expected to be developed between the modeled milestone dates. The new/re-development rates are presented as percentages of an area with the specified land use. It can be assumed that the new and re-development projects will implement post-construction BMPs as required by the MS4 Permit, thus providing a load reduction based on the 85th percentile rainfall. Table 3-2 summarizes the percent of area re-developed at each of the milestone dates. The milestone dates identified include those applicable to the LAR and SGR Watersheds.

Table 3-2. New/Re-Development Rates by Land Use.

Land Use	Annual New/Re-Development Rate (%)	Percent of Area to be Developed by Milestone Year						
		2017	2020	2023	2024	2026	2028	2037
Commercial	0.15	0.30	0.75	1.20	1.35	1.65	1.95	3.30
Education	0.16	0.32	0.80	1.28	1.44	1.76	2.08	3.52
Industrial	0.34	0.68	1.70	2.72	3.06	3.74	4.42	7.48
Residential	0.18	0.36	0.90	1.44	1.62	1.98	2.34	3.96
Transportation	2.70	5.40	13.50	21.60	24.30	29.70	35.10	59.40

3.1.2 Multi-Benefit Regional Projects

Four multi-benefit regional projects were proposed by the participating cities and county as a first step to addressing required load reductions. These projects were selected for their significant water quality improvements, practicability, and multi-benefits. The multi-benefit regional projects are shown in Figure 3-1 and include the Arcadia Arboretum Ecosystem Restoration and Groundwater Recharge Project, Rio Hondo Ecosystem Restoration and Arcadia Wash Water Conservation Diversion Project, Basin 3E Enhancements at Santa Fe Spreading Grounds Project, and Encanto Park Stormwater Capture Project.

Additional required load reductions will primarily be addressed through distributed BMPs, such as green streets.

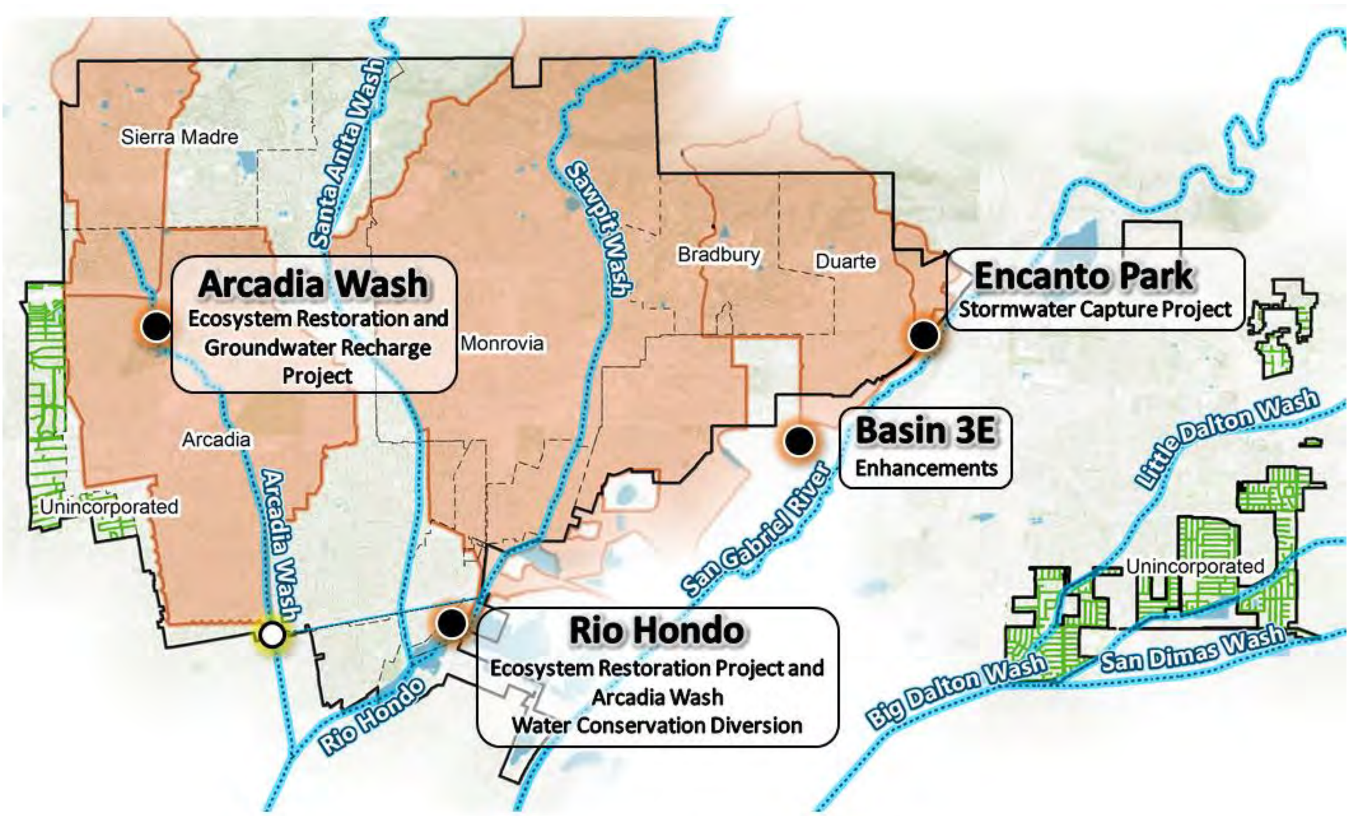

Figure 3-1. Multi-Benefit Regional Project Locations and Potential Green Street Locations.

3.1.3 Distributed BMPs – Green Streets

Green streets were proposed to address remaining required load reductions not achieved by other control measures. Through a spatial opportunity screening process, potential locations for green streets throughout the EWMP area were identified. The process was consistent with methods used in the Upper Los Angeles River, Ballona Creek, Upper San Gabriel River, and Upper Santa Clara River EWMPs; please refer to the technical appendices of those documents for opportunity screening assumptions. The majority of the Rio Hondo drainage area (excepting the portion draining to Eaton Wash) and the entirety of the San Gabriel River drainage area were excluded from the screening, as analyses demonstrate achievement of the total required load reduction through non-structural and Multi-Benefit Regional Projects (see Section 4). Note that, while this analysis provides recommendations at the subwatershed-scale, the green street implementation strategy will be augmented by the results of Los Angeles County's ongoing green streets projects.

3.2 BMP CONFIGURATION

3.2.1 Enhanced MCMs and Redevelopment LID

To account for load reductions resulting from LID a percentage of the impervious area being redeveloped was adjusted to a pervious land use in the watershed model. The percent area changed was determined based on reducing the runoff volume to capture the 85^{th} percentile rainfall. The identified percent change was applied to the percent area to be redeveloped by 2028 for the identified impervious HRUs (except transportation, to avoid double counting with green streets). See Table 3-2 for the percent area to be redeveloped by 2028. Next, a 5% load reduction was assumed for MCMs. For best accuracy, the 5% adjustment was made directly to the timeseries used to model downstream structural BMPs (to simulate the upstream reduction of pollutants by source control practices).

3.2.2 Multi-Benefit Regional Projects

Similar to the watershed model, a BMP model was set up for each of the two watersheds within the group's jurisdictions. There are two multi-benefit regional projects within each watershed, see Figure 3-2 for the respective drainage areas. Table 3-3 lists each jurisdiction participating in the multi-benefit regional projects and the respective proportion of the drainage area. The lead agency for each project is also identified. Note, the proportions do not total to 100%, as the drainage areas for each project include agencies outside of the groups jurisdiction.

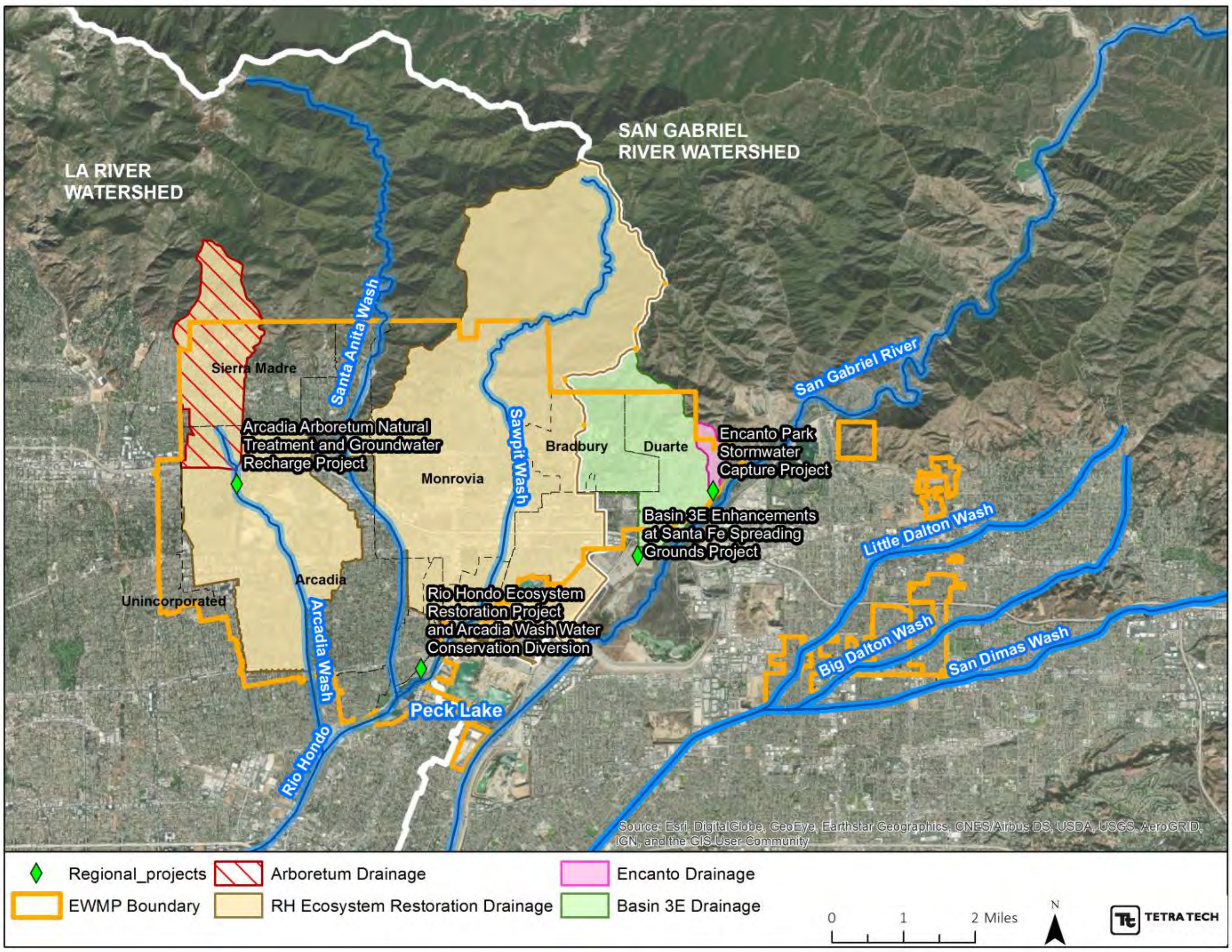

Figure 3-2. Drainage Areas for the Multi-Benefit Regional Projects.

Table 3-3. Participating Agencies for Each Multi-Benefit Regional Project and the Proportion within the Drainage Area Contributing to the Project.

Multi-Benefit Regional Project	Participating Agency	Proportion of Drainage Area from Jurisdiction Contributing to Project
Arcadia Arboretum Ecosystem Restoration and Groundwater Recharge Project	Arcadia[1]	17%
	Sierra Madre	52%
Rio Hondo Ecosystem Restoration Project and Arcadia Wash Water Conservation Diversion	Monrovia[1, 2]	28%
	Arcadia[1, 2]	25%
	Bradbury	3%
	Duarte	5%
	Sierra Madre	5%
	Unincorporated	3%
Basin 3E Enhancements at Santa Fe Spreading Grounds Project	Bradbury[1]	33%
	Duarte	49%
	Unincorporated	1%
Encanto Park Stormwater Capture Project	Duarte[1]	76%

[1] Lead agency for the project
[2] Monrovia is the lead agency for the Rio Hondo Ecosystem Restoration Project and Arcadia is the lead agency for the Arcadia Wash Water Conservation Diversion

In the LAR watershed the Arcadia Arboretum Ecosystem Restoration and Groundwater Recharge (Arboretum) Project will be a constructed wetland with recharge ponds surrounding. Water is diverted from Arcadia Wash into the wetland pond, then spills into recharge ponds on either side. Outflow water from the wetland pond is routed back to Arcadia Wash through an orifice and any outflow from the recharge ponds is also routed back to Arcadia Wash. Further downstream on Arcadia Wash a diversion structure routes water to the Rio Hondo Ecosystem Restoration (Rio Hondo) Project, which will be a constructed wetland. This project also diverts water from Sawpit Wash into the constructed wetland, indicted by the two distinct drainage areas in Figure 3-2. Outflow from the wetland is routed to Peck Road Park Lake.

In the SGR watershed the Encanto Park Stormwater Capture (Encanto) Project will be an underground storage unit. Water is diverted to the unit from an existing storm drain, note the relatively small drainage area. A portion of the treated water will be used for onsite irrigation at the park. This was represented in the model as an hourly release 4am – 7am. The release flowrate was determined based on the yearly irrigation demand of the park for Fiscal Year 2017, assuming a constant daily rate. The remaining water in the storage unit is routed to the San Gabriel River. The Basin 3E Enhancements at Santa Fe Spreading Grounds (Basin 3E) Project will be an enhancement of the existing detention basin that does not require any diversion, as it is located at the outlet of Bradbury Channel. The outflow is routed to the San Gabriel River. Monthly evaporation rates in the BMP models were calculated in each watershed based on representative cells from the Simplified Surface Energy Balance (SSEBop) model, and checked against local CIMIS stations.

In the Rio Hondo BMP model setup, the Arboretum wetland pond had a set width of 50’ and ponding depth of 2.5’. The orifice height was set to 1.5’, with a diameter of 4.3” based on an outflow rate of approximately 1 cfs. The Arboretum recharge ponds were represented as a larger single dry pond, with a set width of 60’ and depth of 3’.

The Rio Hondo wetland had a set width of 150’. The Holton infiltration method was used for all the LAR watershed regional projects. Pollutant removal for the two wetlands was represented with the Kadlec and Knight method, while 1st order decay was assumed for the dry ponds. Background concentrations and removal rates for the Kadlec and Knight method were based on William Mitschs’ and James Gosselinks’ *Wetlands* (Mitsch, 2007). Soil parameters (porosity, field capacity, wilting point, and infiltration rate) were selected based on the soil type identified at the location, unless additional site-specific information was available. For the Arboretum wetland pond soil depth and infiltration rate were set arbitrarily low, as a main function of the wetland pond is settling and pollutant uptake from ponded water and water overflowing into the dry ponds will infiltrate into the groundwater. For the Rio Hondo wetland the infiltration rate was set to the minimum design infiltration rate by the County Standards of 0.3 in/hr.

In the San Gabriel River BMP model set up the Encanto underground storage unit had a set width of 150’ and depth of 10’. The Basin 3E detention basin had a set width of 180’ and depth of 5’ based on available space. The Holtan infiltration method was again used for all the SGR watershed regional projects. Pollutant removal for both projects was based on 1st order decay. Soil parameters were again selected based on the soil type identified.

In the optimization modeling the following parameters were adjustable and maximums were set based on physical limitations:

Rio Hondo Watershed:

- Arcadia Wash diversion to the Arboretum wetland pond: maximum 40 cfs
- Arboretum wetland pond and dry ponds length: maximum 500 ft
- Arcadia Wash diversion to the Rio Hondo wetland: maximum 50 cfs
- Sawpit Wash diversion to the Rio Hondo wetland: maximum 200 cfs
- Rio Hondo wetland length: maximum 3000 ft
- Rio Hondo wetland ponding depth: maximum 4 ft

San Gabriel River Watershed:

- Strom drain diversion to Encanto storage unit: maximum 50 cfs
- Encanto storage unit length: 500 ft
- Basin 3E detention basin length: 1350 ft

3.2.3 Distributed BMPs – Green Streets

Green street opportunities in the County of Los Angeles within the Big Dalton Wash drainage area and the portion of the Rio Hondo EWMP area draining downstream from the Rio Hondo compliance point (via Eaton Wash) were identified through a spatial screening process (Figure 3-3 and Figure 3-4). The remainder of area in the Rio Hondo compliance point drainage area were left out as non-structural and regional BMPs alone achieved the required load reduction. In the drainage area to the San Gabriel River compliance point, green street opportunities in Bradbury and Duarte were left out, as the Non-structural and Regional BMPs were able to reduce the required percent reduction of the wet days load contributed by these cities. However, for County islands which contribute loads to Eaton Wash and the Big Dalton Wash compliance point (where there are no proposed Regional BMPs) green streets were the predominant load reduction method. Ninety-five unique combinations based on the city, soil type, and subwatershed were identified for green street opportunities in these areas. The identified County green street potential opportunities cover a total footprint of 20.2 acres. The County is the lead agency for the required green street projects.

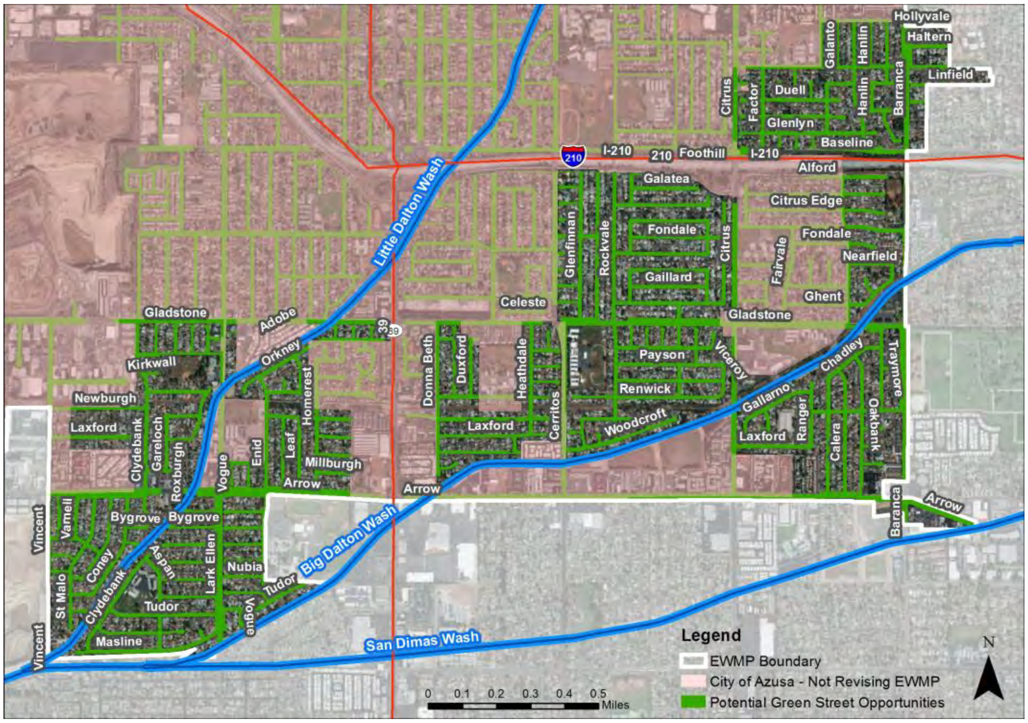

Figure 3-3. Screened Green Street Opportunities in County Islands within the Big Dalton Wash Drainage Area.

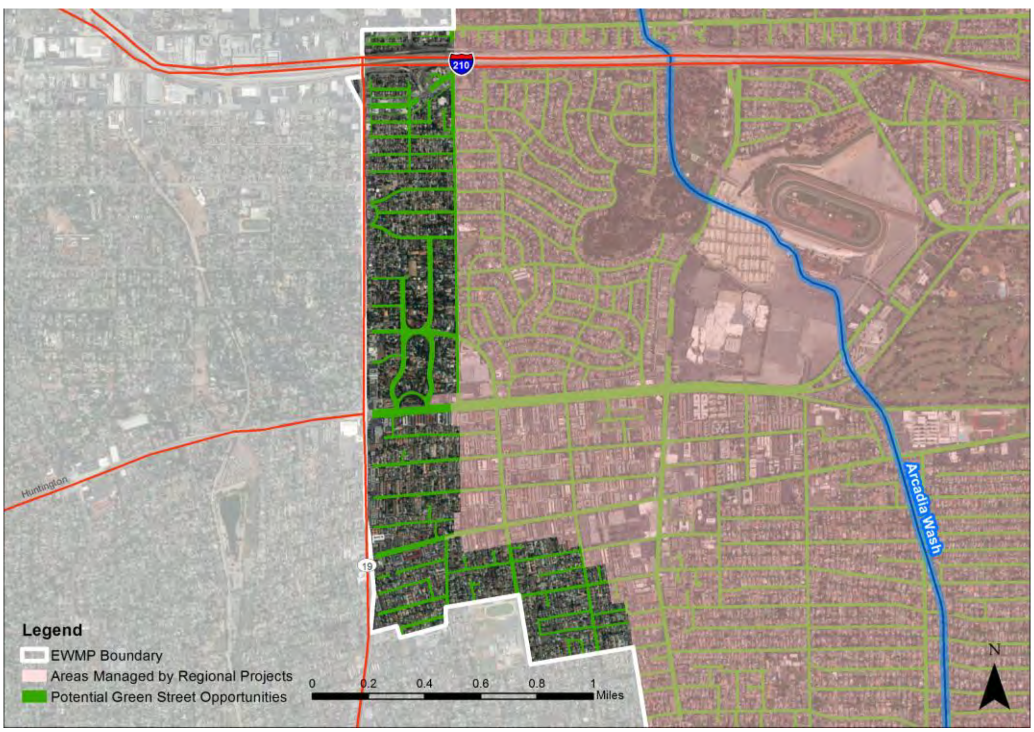

Figure 3-4. Screened Green Street Opportunities in Unincorporated EWMP Areas Draining Downstream from Compliance Point on Rio Hondo (via Eaton Wash)

Bioretention green streets were assumed and sized based on availability. In the optimization modeling, the length of each green street was adjustable starting from zero to the maximum, set based on the availability. The following parameters were assumed for each of the green streets:

- Ponding depth: 7 in
- Width: 4 ft
- Soil depth: 2 ft
- Media porosity: 0.35

If the underlying soils had an infiltration rate less than 0.3 in/hr an underdrain was included, with a depth of 1.5' and media porosity of 0.4.

3.3 COST FUNCTIONS

The following cost functions were used in the BMP modeling to help evaluate optimum BMP configurations. The costs used to generate the cost functions used data from previous projects, industry and local standards, as well as fill-ins from the International BMP Database. Optimization runs were analyzed to maximize load reduction while minimizing total estimated cost. Note the high Rio Hondo Wetland constant cost due to land acquisition requirements. The cost functions presented in Table 3-4 through Table 3-6 were used in earlier stages of project design in order to assess relative project optimization. The updated cost estimates for each project are presented in Section 6 of the main document as well as Attachment B.

Table 3-4. Cost Functions for the Regional BMPs

Multi-Benefit Regional Project	Linear Cost ($)	Area Cost ($)	Total Volume Cost ($)	Media Volume Cost ($)	Underdrain Volume Cost ($)	Constant Cost ($)
Arboretum Wetland Pond	87.34	52.00	2.58	2.87	2.87	87041.90
Arboretum Recharge Ponds	87.34	54.58	2.58	2.87	2.87	87041.90
Rio Hondo Wetland	87.34	41.92	2.58	2.87	2.87	229930094.86
Encanto Underground Storage Unit	21.84	66.90	0.00	0.72	0.72	122961.60
Basin 3E Detention Basin	87.34	44.45	0.00	2.87	2.87	37510.00

Table 3-5. Cost Functions for the Diversions to the Regional BMPs

Diversion	Constant Cost ($)
Arcadia Wash to Arboretum Wetland Pond	6122.94
Arcadia Wash to Rio Hondo Wetland	90108.36
Sawpit Wash to Rio Hondo Wetland	6878.22
Storm Drain to Encanto Underground Storage Unit	5903.68

Table 3-6. Cost Functions for Green Streets

Distributed BMP	Area Cost ($)	Total Volume Cost ($)	Media Volume Cost ($)
Green Streets	56.658	2.165	2.64

4.0 SELECTION OF CONTROL MEASURES FOR EWMP IMPLEMENTATION

The RAA recommends the selection of control measures which result in the attainment of water quality objectives, while maintaining cost-effectiveness. The following subsections discuss the recommended Non-structural, Regional, and Distributed BMPs and the expected performance.

4.1 NON-STRUCTURAL BMPS

Table 4-1 shows the load reductions achieved on the critical water years (Rio Hondo: WY2003; San Gabriel River and Big Dalton Wash: WY2004) through redevelopment projects and MCMs. The non-structural BMP load reductions were applied prior to evaluating reductions from regional and distributed BMPs.

Table 4-1. Load Reductions Resulting from Redevelopment Projects and MCMs in the Critical Water Years.

Compliance Point	Load Reduction (lb/yr)		
	Redevelopment LID	Enhanced MCMs	Combined
Rio Hondo	145	188	333
San Gabriel River	12.3	39.9	52.2
Big Dalton Wash	10.7	69.1	79.8

Independent from the compliance points above, redevelopment LID and enhanced MCMs are predicted to reduce loading from the portion of the EWMP area draining downstream from the Rio Hondo compliance point (via Eaton Wash) by 1.3 lb/yr and 16.1 lb/yr, respectively.

4.2 MULTI-BENEFIT REGIONAL PROJECTS

Following load reductions achieved from Non-structural BMPs, the performance of proposed Multi-Benefit Regional Projects was evaluated. Using Sustain, optimization runs produced many BMP configurations based on the adjustable parameters. Figure 4-1 and Figure 4-2 show the zinc load reduction and associated cost for several configurations of the multi-benefit regional projects in the LAR and SGR, respectively. The curves show the additional load reductions from potential multi-benefit regional project configurations, beyond that already achieved from Redevelopment Projects and MCMs. The cost-effectiveness curves allow for the selection of the optimum configurations which result in achievement of numeric targets. The lower the slope of the curve, the less additional load reduction achieved at the same incremental increase to the cost.

In the LAR, there are many configurations to choose from above the required load reduction target, but the slope of the cost-effectiveness curve above the target demonstrates diminishing returns at the higher costs. In the SGR, a significant decrease in performance is observed beyond a $10 Million-dollar cost. The overall load reduction target for the entire drainage area to the San Gabriel River compliance point cannot be achieved with the Non-structural and Multi-Benefit Regional Projects only. However, a large portion of this area is Azusa, who is not participating in this revised EWMP for their City area. Therefore, the target is adjusted based on the percent of Bradbury, Duarte, and County area from the EWMP boundary that drains to the San Gabriel River compliance point (31.1%), as the Multi-Benefit Regional Projects are focused in these areas. The total required load reduction is 236 lb/yr at the San Gabriel River compliance point, where 52.2 lb/yr reduction is achieved through the non-structural BMPs. The cities of Bradbury, Duarte, and County are responsible for 31.1% of the remaining 183.8 lb/yr required load reduction. Therefore, the additional required load reduction in Bradbury, Duarte, and County areas draining to the San Gabriel River compliance point, in addition to that achieved through non-structural BMPs, is 57.1 lb/yr. With the adjusted target, there are many configurations to choose from above the required load reduction target and before the slope significantly decreases, though the configurations above the target fall within the higher costs of diminishing returns.

To maximize the cost-effectiveness of the multi-benefit regional projects, configurations resulting in load reductions slightly above the target are recommended, where the returns (i.e. increase load reductions) from increased costs are greatest (of the options that meet the requirements). The recommended configurations are outlined in Table 4-2.

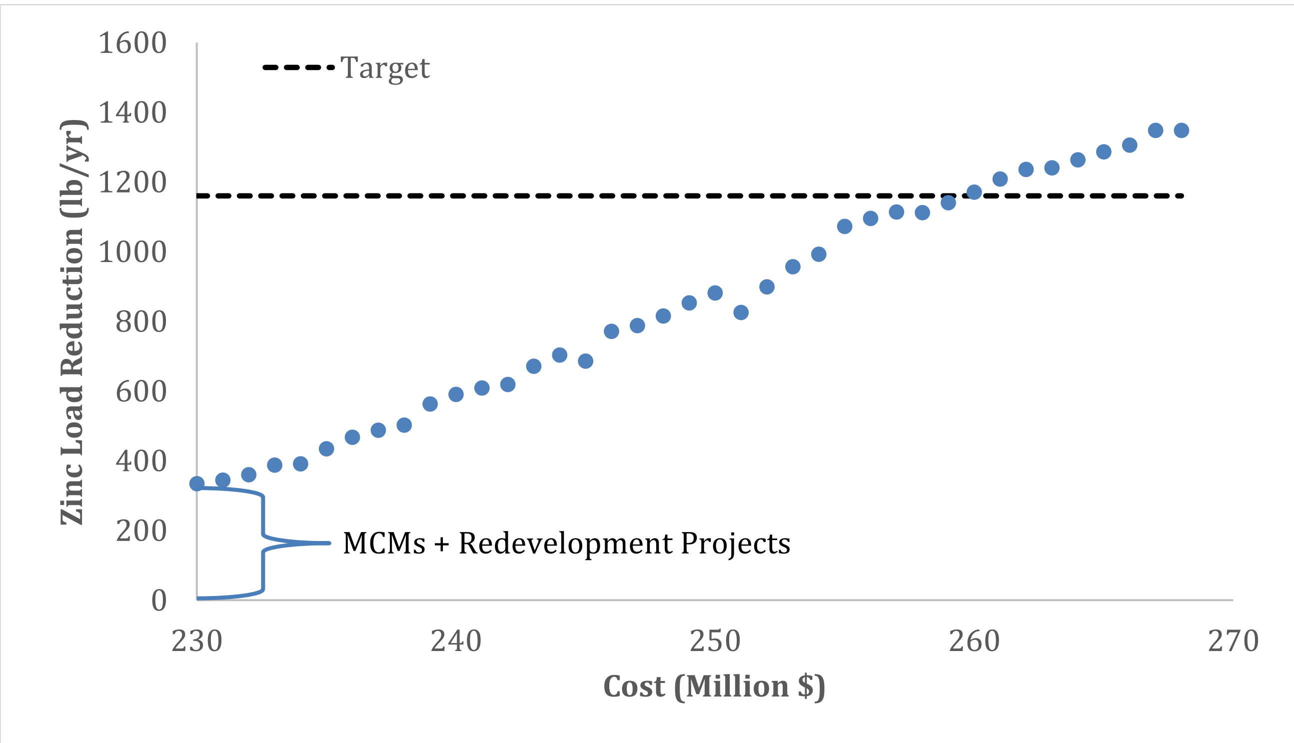

Figure 4-1. Cost-Effectiveness Curve for Multi-Benefit Regional Projects within the Rio Hondo Drainage Area (Modeled Costs are Relative – see Attachment B for Detailed Engineering Cost Estimates).

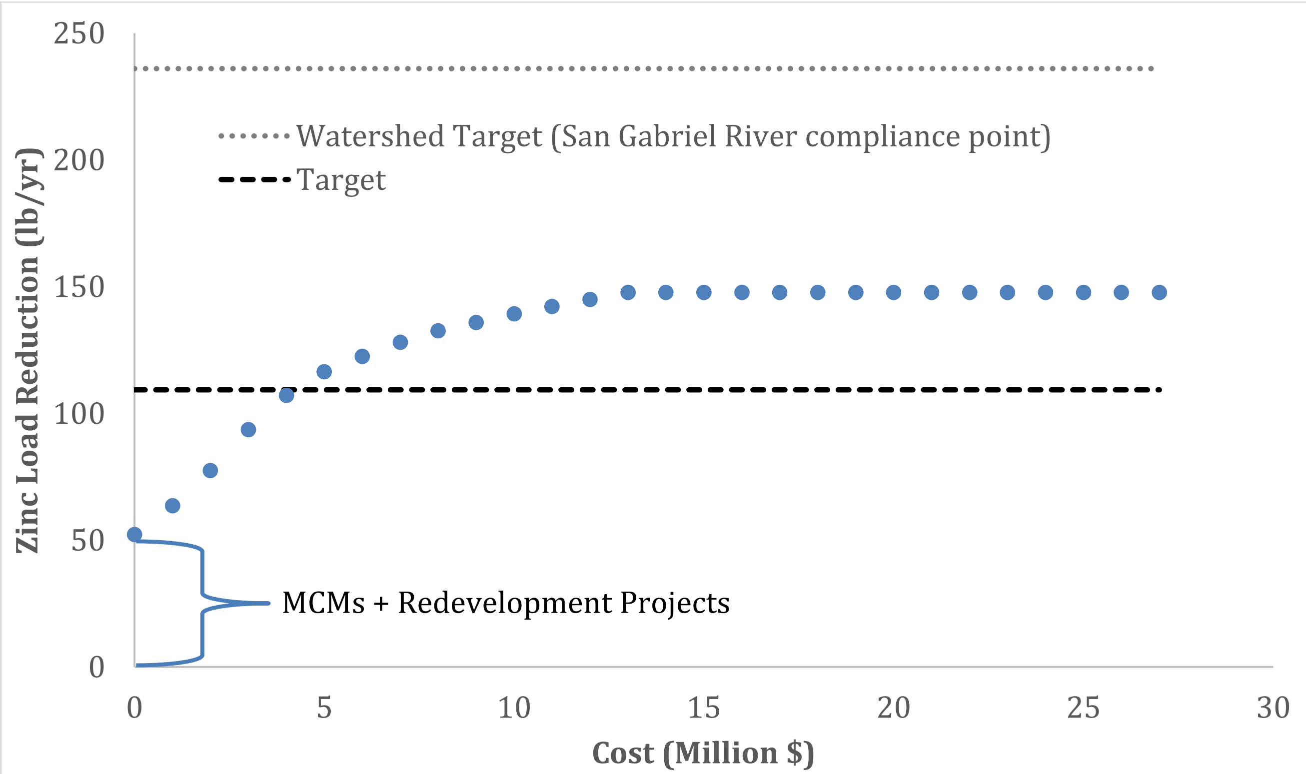

Figure 4-2. Cost-Effectiveness Curve for Multi-Benefit Regional Projects within the San Gabriel River Drainage Area. (Modeled Costs are Relative – see Attachment B for Detailed Engineering Cost Estimates)

Table 4-2. Recommended Multi-Benefit Regional Project configurations.

Parameter	Rio Hondo Multi-Benefit Regional Project			San Gabriel River Multi-Benefit Regional Project	
	Arboretum Wetland Pond	Arboretum Recharge Pond (each side)	Rio Hondo Wetland	Encanto Underground Storage	Basin 3E Detention Basin
Length (ft)	500	500	2400	75	550
Width (ft)	50	30	150	150	180
Height (ft)	2.5	3	4	5	5
Diversion Rate (cfs)	30	N/A	185 (Sawpit Wash) + 37 (Arcadia Wash)	3	N/A
Load Reduction (lb/yr)	854.0[1]			64.3[2]	

[1] The zinc load reduction from the Arboretum Wet Pond and Recharge Ponds was 35.7 lb/yr, while the zinc load reduction from the Rio Hondo Wetland was 818.3 lb/yr.
[2] The zinc load reduction from the Encanto Underground Storage was 2.2 lb/yr, while the zinc load reduction from the Basin 3E Detention Basin was 62.1 lb/yr.

The average annual volume captured by the Multi-Benefit Regional Projects is 1120 ac-ft/yr and 340 ac-ft/yr in the Rio Hondo and San Gabriel River drainage areas, respectively. This is based on a long term (10 year) period and broken up by jurisdiction in Table 4-3, based on the percent area within the EWMP boundary that drains to the respective compliance locations.

Table 4-3. Average Annual Volume Capture Achieved by Multi-Benefit Regional Projects by Jurisdiction.

Jurisdiction	Average Annual Volume Capture by Multi-Benefit Regional Projects (ac-ft/yr)	
	Rio Hondo	San Gabriel River
County	75.1	26.0
Bradbury	34.4	102.7
Sierra Madre	124.1	NA
Monrovia	355.3	NA
Duarte	59.2	211.7
Arcadia	471.4	NA

It is worthwhile to consider alternatives to the current recommendations if additional obstructions or constraints present themselves in the future. A number of additional alternatives were investigated for the RAA:

- Additional Multi-Benefit Regional Projects:
  - A vacant lot is located to the east of Santa Anita Wash, above Like Oak Ave. This presents the opportunity for a storage unit that diverts water from Santa Anita Wash before it reaches Peck Road Park Lake. The potential storage volume at this location is 6.54 acre-ft, with a 12,247 acre drainage area. There is also the opportunity to discharge the stored water to the sanity sewer, located along Live Oak. Discharge to the sanitary sewer would be pending coordination with the Sanitation Districts of Los Angeles County.
  - An additional wetland between the north and south basins of Peck Road Park Lake was investigated. This wetland would intercept Santa Anita Wash before flowing into Peck Road Park Lake. Additionally, the Arcadia Wash Water Conservation Diversion could route to this wetland instead of the Rio Hondo Wetland on the northeast side of the lake. A third option would exclude the diversion from Santa Anita Wash and only treat the Arcadia Wash diversion at this location. The total drainage area ranges from 5,253 acres (if only divert from Arcadia Wash) to 18,096 acres (if divert from Arcadia Wash and Santa Anita Wash). The potential volume of the wetland is 11 acre-ft.
- Adjustments to Existing Multi-Benefit Regional Projects:
  - If infiltration at the Rio Hondo Wetland can reasonably be increased to 0.8 in/hr (currently set to 0.3 in/hr for planning purposes) this would significantly increase the performance of the wetland. Overall a greater load reduction would be achieved with the same size and diversion parameters.
  - The Arboretum Project could exclude the groundwater recharge ponds. All outflow from the wetpond would be routed to Baldwin Lake or back to Arcadia Wash further downstream. In the recommended configuration the recharge ponds account for 16.5 lbs/yr of the load reduction, which is a little under half of the load reduction achieved from the Arboretum project.
  - The Rio Hondo Wetland could add a diversion from Santa Anita Wash, which would treat an additional 12,247 acres.

- o The Rio Hondo Wetland could remove the Arcadia Wash Water Conservation Diversion, which treats an additional 5,242 acres, and only divert water from Sawpit Wash.

No regional projects are proposed within the Big Dalton Wash drainage area. Therefore, the additional required load reductions will be addressed with distributed BMPs.

4.3 DISTRIBUTED BMPS – GREEN STREETS

Following load reductions achieved from Non-structural and Multi-Benefit Regional Projects, the performance of the proposed Distributed BMPs (Green Streets) were evaluated. As the required load reductions are achieved through the Non-structural and Regional BMPs for two of the three compliance points, green streets are only required for the Big Dalton Wash drainage area and the portion of the EWMP area draining downstream from the Rio Hondo compliance point (via Eaton Wash). Using the same optimization modeling, many configurations were identified by varying the length of potential green street opportunities.

For the Big Dalton Wash compliance point drainage area, a large portion is Azusa, who is not participating in this revised EWMP for their City area. Therefore, the target is adjusted to focus on the County area from the EWMP boundary that drains to the Big Dalton Wash compliance point (25.1%), as green streets were focused in the County islands. The total required load reduction is 296 lb/yr at the Big Dalton Wash compliance point, where 79.8 lb/yr reduction is achieved through the non-structural BMPs. The County is responsible for 25.1% of the remaining 216.2 lb/yr required load reduction. Therefore, the additional required load reduction in County islands draining to the Big Dalton Wash compliance point, in addition to that achieved through non-structural BMPs, is 54.3 lb/yr. Figure 4-3 shows the zinc load reduction and associated cost for different combinations of green streets. There are many combinations which achieve a zinc load reduction above the target, before the slope of the curve levels off, where the increased performance diminishes with the increased cost.

The total drainage area and footprint of the combined green streets for the recommended configuration, which is a subsection of the identified potential opportunities from the screening process, is presented in Table 4-4. If an average width of 4 feet is assumed, the recommended green streets would span 7.8 miles. Table 4-4 also includes the total storage capacity of the recommended green streets and the volume captured by the over the critical water year. The average annual volume capture, based on a long term (10 year) period, is 113 ac-ft/yr. The footprint and drainage area for recommended green streets are further broken down by subwatershed in Table 4-5. Recall, two types of green streets were represented in the modeling, infiltrating and filtrating depending on the underlying soils, thus the total storage capacity of both types of recommended green streets within each subwatershed are presented in Table 4-5 as well.

Note that, while this planning-level analysis assumed certain green street cross sections (discussed in Section 3.2), alternative green street configurations of comparable stormwater capture potential may be substituted during implementation.

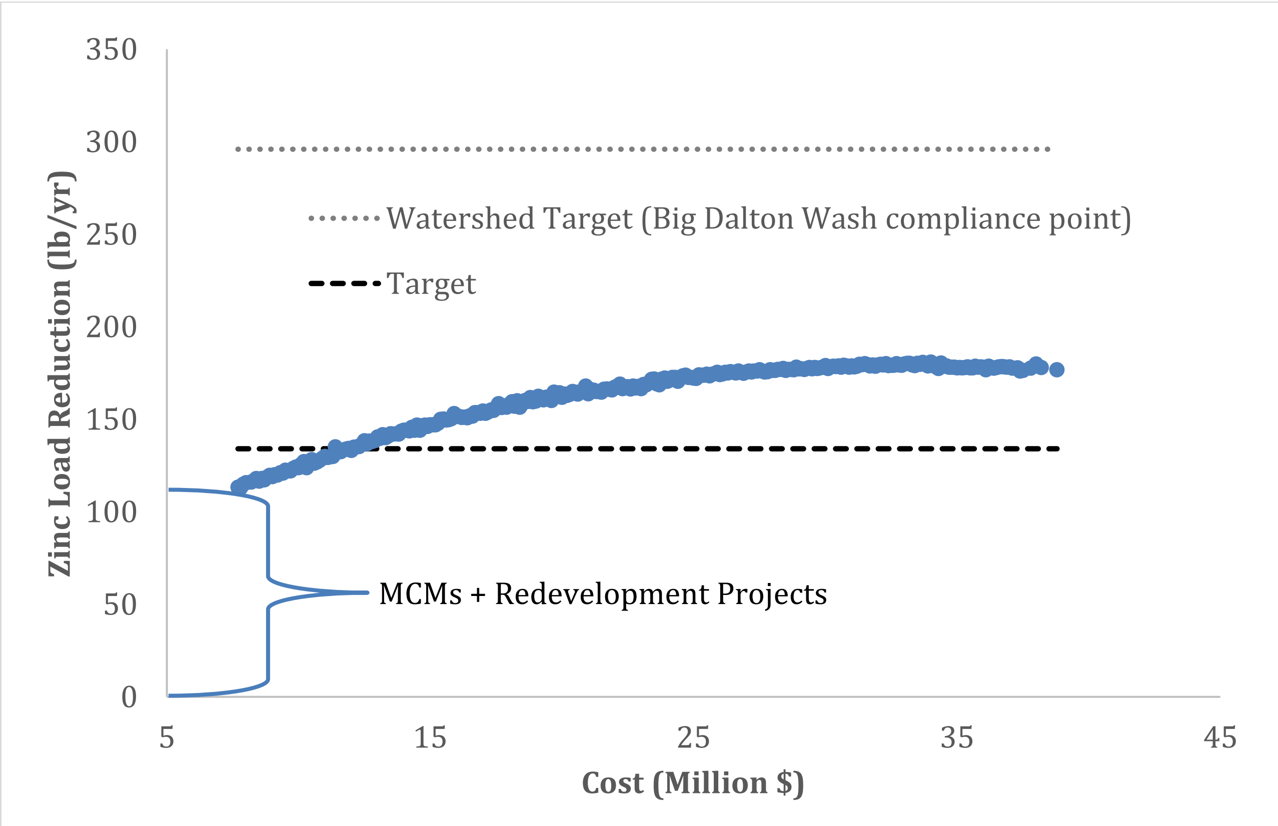

Figure 4-3. Cost-Effectiveness Curve for Green Streets in the County within the Big Dalton Wash Drainage Area.

Table 4-4. Recommended Green Street opportunities in County Islands within the Big Dalton Wash drainage area.

Total Drainage Area (ac)	Total Footprint (ac)	Cost, including 20 years O&M (Million $)	Load Reduction (lb/yr)	Storage Capacity (ac-ft)	Volume Capture (ac-ft/yr)
675	3.77	11.4	54.7	8.3	83.7

Table 4-5. Recommended Green Street opportunities in County Islands within the Big Dalton Wash Drainage Area by Subwatershed.

Subwatershed	Footprint (ac)	Drainage Area (ac)	Storage Capacity of Infiltration Green Streets (ac-ft)	Storage Capacity of Filtration Green Streets (ac-ft)
5431	0.449	45.22	0.865	0.139
5433	0.767	151.76	1.680	0.008
5435	0.118	12.61	0.260	NA
5438	0.522	62.27	NA	NA
5440	0.193	39.58	1.147	NA
5442	0.003	6.27	0.424	NA
5457	0.004	0.11	0.006	NA
5458	0.194	40.00	0.010	NA
5459	0.015	1.91	0.427	NA
5460	0.031	2.18	0.033	NA
5469	0.477	79.41	0.069	NA
5470	0.129	89.45	1.050	NA
5471	0.546	99.74	0.285	NA
5472	0.175	20.91	1.200	NA
5473	0.146	23.29	0.386	NA
Total:	**3.770**	**674.72**	**8.16**	**0.15**

As discussed, green streets were also evaluated for the portion of the EWMP area draining downstream from the Rio Hondo compliance point (via Eaton Wash). The recommended green street implementation is tabulated below in Table 4-6 and broken down by subwatershed in Table 4-7. Note that during future adaptive management--as the RH/SGR Water Quality Group gains more understanding about the projects located in their jurisdictions--the equivalent load and volume reductions provided by these green streets opportunities may be redistributed to multi-benefit regional projects in the Rio Hondo watershed.

Table 4-6. Recommended Green Street Opportunities in Unincorporated County Area Draining Downstream from Rio Hondo Compliance Point (via Eaton Wash).

Total Drainage Area (ac)	Total Footprint (ac)	Cost, including 20 years O&M (Million $)	Load Reduction (lb/yr)	Storage Capacity (ac-ft)	Volume Capture (ac-ft/yr)
327	5.22	15.8	59.5	11.5	83.3

Table 4-7. Recommended Green Street Opportunities in Unincorporated County Area Draining Downstream from Rio Hondo Compliance Point (via Eaton Wash) by Subwatershed.

Subwatershed	Footprint (ac)	Drainage Area (ac)	Storage Capacity of Infiltration Green Streets (ac-ft)
6217	1.114	74.79	2.45
6218	0.029	0.99	0.06
6228	1.456	104.65	3.20
6229	2.618	146.19	5.76
Total:	**5.218**	**326.63**	**11.48**

4.4 RAA VALIDATION

Table 4-8 summarizes the zinc load reductions achieved over the critical water year from the above-mentioned control measures. This demonstrates with reasonable assurance that the total achieved load reductions meet or exceed the required load reduction at each of the compliance points, and that clean water will be achieved by implementing the rEWMP.

Table 4-8. Zinc load reductions (lbs/yr) from the recommended control measures compared to the required load reduction at each compliance point.

Control Measure	Compliance Point		
	Rio Hondo	San Gabriel River	Big Dalton Wash
Enhanced MCMs and Redevelopment LID	333	52.2	79.8
Multi-Benefit Regional Projects	854	64.3	--
Distributed BMPs	--	--	54.8
Total	**1187**	**116.5**	**134.6**
Required	**1163**	**109.3**[1]	**134.1**[1]

[1] Required reductions adjusted to exclude Azusa

The EWMP area draining downstream from the Rio Hondo Compliance point (via Eaton Wash) was evaluated independently from the established compliance points. Table 4-9 reports the load reductions achieved over the critical water year by projects in this area.

Table 4-9. Zinc Load Reductions (lbs/yr) from the Recommended Control Measures Compared to the Required Load Reduction for Areas Draining Downstream from the Rio Hondo Compliance Point.

Control Measure	EWMP Area Draining Downstream from Rio Hondo Compliance Point
Enhanced MCMs and Redevelopment LID	17.4
Multi-Benefit Regional Projects[1]	24.0
Distributed BMPs	59.5
Total	**100.9**
Required	**98.1**

[1] Excess load reduction achieved by projects draining to the Rio Hondo compliance point (see Table 4-8)

The proposed milestones were aligned with the applicable metal TMDLs. The Los Angeles River Metals TMDL applies to the Rio Hondo compliance point and has one interim milestone (50% of final target), whereas the San Gabriel River Metals TMDL applies to the San Gabriel River and Big Dalton Wash compliance points and has two interim milestones (35% and 65% of final target). Table 4-10 shows the load reduction achieved from each control measure to meet interim milestones and final deadlines. Load reductions from enhanced minimum control measures are expected by the first interim milestone in all watersheds. Load reductions from redevelopment LID were based on average annual redevelopment rates at the interim milestones and by the final deadline. In the Rio Hondo and San Gabriel River drainage areas phases of the planned multi-benefit regional projects were established to meet interim milestones. Although primarily a water conservation project, the incidental water quality benefits from the Arcadia Wash Water Conservation Diversion will contribute towards meeting the 50% milestone in Rio Hondo by 2024. This project will divert flow from Arcadia Wash to Sawpit Wash, upstream of Peck Road Park Lake, and result in a load reduction of 468 lbs/yr, during the critical water year. This project is considered an update to the baseline watershed model rather than a water quality BMP. To meet the 65% milestone in San Gabriel River, the first cell of the Basin 3E Detention Basin (250' x 180' x 5') will be built by 2023, and result in a load reduction of 25 lbs/yr, during the critical water year. In the Big Dalton Wash drainage area, a fraction of the green streets is required to meet the 65% milestone. The two highest performing green streets are recommended to be built by 2023, and result in a load reduction of 13.4 lb/yr, during the critical water year. The green streets are in subwatershed 5438 and 5469, with a drainage area of 62.26 acres with a footprint of 0.511 acres and a drainage area of 77.52 acres with a footprint of 0.454 acres, respectively.

Table 4-10. Zinc Load Reduction (lbs/yr) from Control Measures at Each Milestone.

BMP	Cumulative Load Reduced by Each Milestone							
	Rio Hondo		San Gabriel River			Big Dalton Wash		
	50% Milestone (2024)	Final Deadline (2028)	35% Milestone (2020)	65% Milestone (2023)	Final Deadline (2026)	35% Milestone (2020)	65% Milestone (2023)	Final Deadline (2026)
Enhanced Minimum Control Measures	188	188	40	40	40	69	69	69
Redevelopment LID	100	145	6	9	12	5	8	11
Multi-Benefit Regional Projects	468	854	--	25	64	N/A	N/A	N/A
Green Streets	N/A	N/A	N/A	N/A	N/A	--	13	55
Total	757	**1187**	45	73	**116**	74	90	**135**
Milestone Target	*582*	***1163***	*38*	*71*	***109***	*47*	*87*	***134***

The EWMP area draining downstream from the Rio Hondo Compliance point (via Eaton Wash) was evaluated independently from the established compliance points. Table 4-11 reports the load reductions achieved at each Milestone. To meet the 50% milestone, a portion of the excess required load reduction achieved by the implementation of the Arcadia Wash Water Conservation Diversion by 2024 was credited to this area. The excess required load reduction achieved by the final deadline at the Rio Hondo compliance point was also credited to this area.

Table 4-11. Zinc Load Reduction (lbs/yr) from Control Measures in EWMP Area Draining Downstream from Rio Hondo Compliance Point (via Eaton Wash) at Each Milestone.

BMP	Cumulative Load Reduced by Each Milestone	
	Rio Hondo (via Eaton Wash)	
	50% Milestone (2024)	Final Deadline (2028)
Enhanced Minimum Control Measures	16.1	16.1
Redevelopment LID	0.90	1.3
Multi-Benefit Regional Projects	32.1[1]	24[2]
Green Streets		59.4
Total	49.1	**100.8**
Milestone Target	49.1	**98.1**

[1] The Arcadia Wash Water Conservation Diversion will support attainment of the 50% milestone in Rio Hondo EWMP area and results in an excess load reduction of 175 lb/yr (see Table 4-10). A portion of this excess load reduction is credited towards meeting the 50% milestone for the EWMP area draining downstream from the Rio Hondo compliance point (via Eaton Wash)
[2] Excess load reduction achieved by projects draining to the Rio Hondo compliance point (see Table 4-8)

To verify required load reductions and water quality objectives are met under the critical condition the selected control measures were integrated into the watershed model and pollutant loads were reevaluated at the compliance locations. The outputs from the SUSTAIN results for the selected configurations of the multi-benefit regional projects were utilized to evaluate the performance of the BMPs in the watershed model. At the diversion locations, or outlet location along Bradbury Channel into the Basin 3E project, the originally routed flow is removed from the watershed model and the output from the BMPs is included as a point source. This point source includes any non-diverted flows, bypass flows, and flows exiting the BMPs along with the constituent concentrations. The watershed model results show slightly different performance from the selected control measures than the SUSTAIN results, in terms of the annual load reduction on wet days. This is likely due to the more detailed routing and representation of associated environmental factors in the watershed model. Also, the 5% reduction attributed to MCMs had to be applied in post-processing of the watershed model, thus after evaluation of the multi-benefit regional projects (which is in the reverse order of the previous methodology). The difference in this 5% reduction applied pre- versus post-accounting of the multi-benefit regional projects was 55.7 lb/yr in the LAR and 4.5 lb/yr in the SGR, due to the percent reduction applied to a higher initial load in the former method. Load reductions from green streets in the Big Dalton Wash drainage area were not validated through the watershed model, due to the complexity of this integration in the watershed model.

Table 4-12 and Table 4-13 compare the results of the RAA to the baseline load reduction analysis. While the total required load reduction on wet days is achieved, at the LAR compliance point there are still three wet exceedance days. The exceedance days occur on the 10^{th}, 7^{th}, and 4^{th} ranked wet day loads (out of 46 wet days). However, the flow on these days is the three lowest for all wet day loads above the 65th percentile. The required load reductions on each day are 25.7 lbs, 89.2 lbs, and 13.0 lbs and the percent reductions required are 24%, 50%, and 9%. At the SGR compliance point, the annual required load reduction, specific to Bradbury, Duarte, and the County (i.e. excluding Azusa) is achieved by the RAA. There are still three wet exceedance days, however a large portion of the drainage area to this compliance point, Azusa, is not addressed by this RAA.

The impact of the control measures to be implemented through this program were assessed over the long term (10/1/2001 → 9/30/2011) to verify critical conditions in terms of meeting water quality objectives are appropriately addressed. Figure 4-4 and Figure 4-5 are zinc concentration curves, based on daily concentrations, for the Rio Hondo and San Gabriel River compliance points under baseline and after implementation conditions over the long-term. The concentration frequency curves show the percent of wet weather days (along the x-axis) that the zinc concentration (along the y-axis) is exceeded. Where the curves cross the zinc concentration established by the CTR criteria (plotted as the dashed green line), this point indicates the percent of wet days over the long term still exceeding the CTR criteria. These figures demonstrate that, after the control measures are implemented, the CTR criteria was met 96.0% and 94.5% of all wet days at the Rio Hondo and San Gabriel River compliance points, respectively, over the long-term simulation. In other words, the program outlined in this document can be expected to meet water quality criteria for 96.0% and 94.5% of all wet days at the Rio Hondo and San Gabriel River compliance points, respectively. This long-term, daily critical condition is consistent with the expression of the TMDL critical condition, and demonstrates that the recommended program is expected to provide a higher level of water quality protective than the RAA Guidelines-recommended 90th percentile condition. Table 4-14 and Table 4-15 present the number of wet days and percent of wet days exceeding the CTR criteria for each water year over the long-term period. Together with the annual zinc load reduction under the planning critical condition validated above in Table 4-8, management of concentrations during greater than 90% of wet days (i.e., to 90th percentile conditions) provides reasonable assurance that the strategies outlined in this RAA will achieve clean water goals.

Table 4-12. Watershed Model Load Reduction Analysis for the Rio Hondo Compliance Point, Evaluating the RAA Versus the Baseline.

Wet Days Summary	Baseline	After Implementation
Total Wet Days (10/1/2002 - 9/30/2003)	46	46
Total Wet Exceedance Days	9	3
Total Existing Load (Wet Days) (lbs/yr)	3822	2515
Total Allowable Load (lbs/yr)	2659	2387
Required Load Reduction (lbs/yr)	1163	128
Required Percent Reduction using 173 µg/L Total Zinc target	30%	5%

Table 4-13. Watershed Model Load Reduction Analysis for the San Gabriel River Compliance Point, Evaluating the RAA Versus the Baseline.

Wet Days Summary	Baseline	After Implementation
Total Wet Days (10/1/2003 - 9/30/2004)	49	49
Total Wet Exceedance Days	12	3
Total Existing Load (Wet Days) (lbs/yr)	852	672
Total Allowable Load (lbs/yr)	616	629
Required Load Reduction (lbs/yr)	236	43
Required Percent Reduction using 235 μg/L Total Zinc target	28%	7%

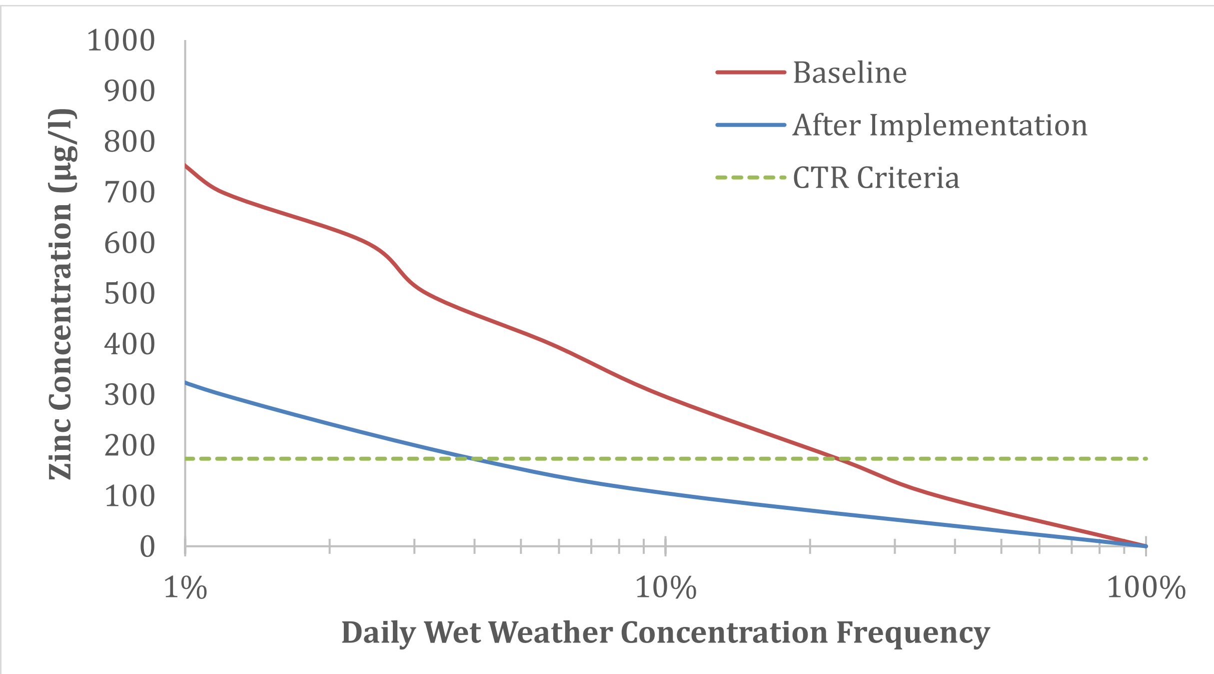

Figure 4-4. Rio Hondo Zinc Concentration Frequency Curves – Log Scale X-Axis.

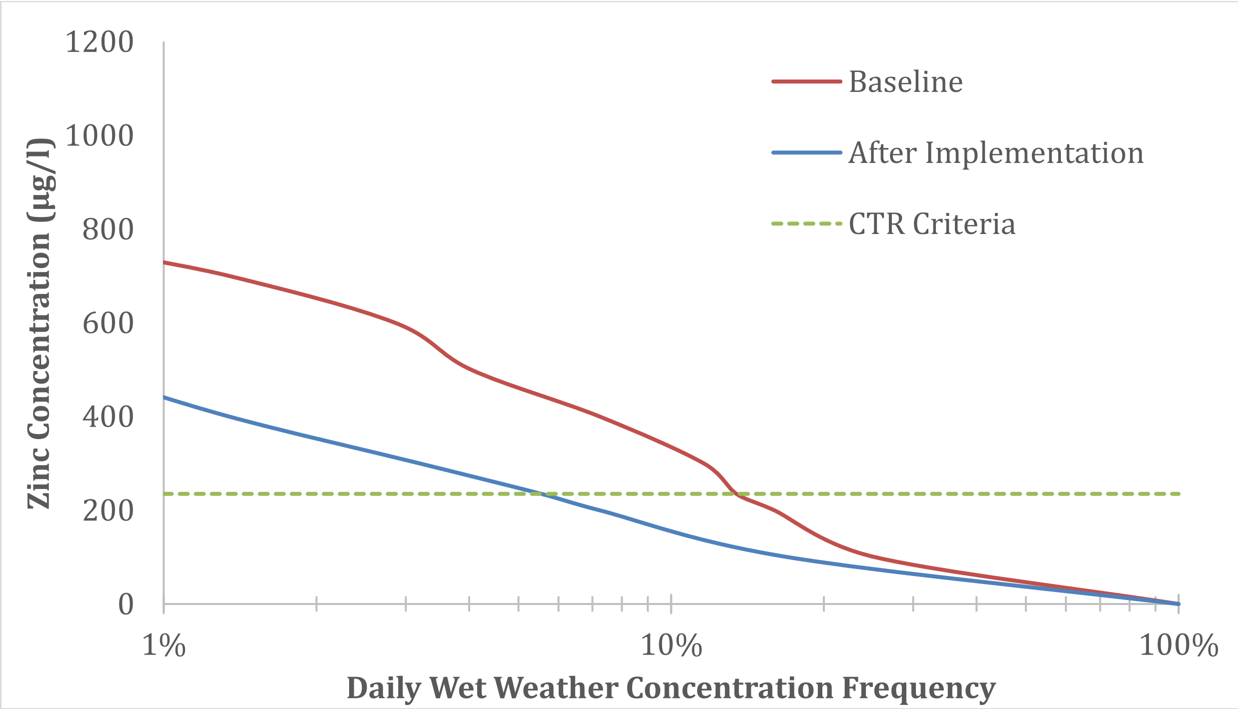

Figure 4-5. San Gabriel River Zinc Concentration Frequency Curves – Log Scale X-Axis.

Table 4-14. Number of Wet Days and the Percent of Wet Days Exceeding WQOs for Each Water Year over the Long-term Period at the Rio Hondo Compliance Point.

Water Year	Total Number of Wet Days	Number of Wet Days Exceeding WQOs	Percent of Wet Days Exceeding WQOs
2002	29	2	6.9%
2003	46	3	6.5%
2004	40	5	12.5%
2005	79	3	3.8%
2006	41	2	4.9%
2007	30	2	6.7%
2008	50	0	0.0%
2009	44	1	2.3%
2010	68	0	0.0%
2011	77	2	2.6%
Total	**504**	**20**	4.0%

Table 4-15. Number of Wet Days and the Percent of Wet Days Exceeding WQOs for Each Water Year over the Long-term Period at the San Gabriel River Compliance Point.

Water Year	Total Number of Wet Days	Number of Wet Days Exceeding WQOs	Percent of Wet Days Exceeding WQOs
2002	39	3	7.7%
2003	55	1	1.8%
2004	49	3	6.1%
2005	97	4	4.1%
2006	63	4	6.3%
2007	40	5	12.5%
2008	64	1	1.6%
2009	46	3	6.5%
2010	66	3	4.5%
2011	76	6	7.9%
Total	**595**	**33**	5.5%

4.5 DRY WEATHER RAA

Implementation of the above control measures is expected to address dry weather compliance, as dry weather flows are captured by the multi-benefit regional projects and green streets. All dry weather flow from Arcadia Wash upstream from Live Oak Ave and all dry weather flow from Sawpit Wash are diverted to a multi-benefit regional project. Dry weather flows from Santa Anita Wash are currently implicitly managed by Peck Road Park Lake. The San Gabriel River is a soft bottom channel, therefore issues with dry weather flows are minimal. Notwithstanding the incidental water quality benefits, Peck Road Park Lake, San Gabriel River, and the Spreading Groups are water conservation facilities that provide critical water recharge benefits to the area, and the LACFCD does not consider them to be BMPs. While these facilities are providing a consequential water quality benefit, the primary purpose is flood control and thus are managed as such. Such characteristics of water bodies throughout the RH/SGR Water Quality Group jurisdiction can help minimize potential issues with dry weather flows. Green streets in the small Unincorporated County Islands in the Big Dalton Wash drainage area are expected to manage nuisance flows. As previously stated in the accepted 2016 EWMP, base flows and dry-weather discharges from the EWMP area are not suspected to be a large contributor to the impairments identified in the LA River Bacteria TMDL, which present the most pressing dry weather issues.

5.0 KEY ASSUMPTIONS

The material presented in this rEWMP incorporates necessary assumptions to develop a detailed program for the RH/SGR Water Quality Group that will address applicable water quality concerns. The current program was structured to be protective of achieving water quality objectives, using the general principle to prioritize any assumptions throughout the rEWMP with the more conservative of potential options to increase confidence that the existing program would achieve the desired outcomes. This section identifies some of the key assumptions, which would benefit from more in-depth studies to verify or potentially revise. As such studies are completed and additional data is gathered throughout the region, the Water Quality Group can elect to update the program through the adaptive management process. This section is not a comprehensive list of all assumptions, but a discussion of some of the key assumptions which are currently perceived to have some uncertainty and/or significant impact on the outcomes of the program. Refining these assumptions and decisions will increase the certainty that the program can achieve the appropriate water quality objects to protect receiving water bodies. As more information and knowledge is gained, the guiding principles of the rEWMP will continue to drive decisions towards meaningful, measurable, and achievable outcomes.

Foundational to the rEWMP, and any similar program, is the identification of the **critical condition**. The critical condition establishes what period of time under which the program can reasonably be expected to manage and achieve water quality objectives. The rEWMP established a longer term critical condition for planning purposes, which is a more robust method of designing BMPs, to ensure the BMPs function under a wider range of conditions (i.e., rather than designing BMPs for one specific storm). This annual condition translated into attainment of the *daily* water quality criteria over 90 percent of wet days . Although the 90th percentile condition and definition of the long-term assessment period are consistent with the recommendations of the RAA Guidelines, it is recommended that the validity of a 90th percentile critical condition be further explored in the future to determine if site-specific conditions may be more appropriate or achievable. An additional layer to the evaluation of a critical condition is the definition of wet weather. Existing Metal TMDLs define wet weather based on flow rates at designated flow gauges. However, the rEWMP defined wet weather based on days with greater than 0.1 inches of rainfall plus the following three days to more accurately capture wet weather as it is occurring over the upstream watershed area, rather than relying on a gauge much further downstream in the watershed where timing of flow at this downstream location will be significantly delayed relative to the actual runoff contributions from the upstream jurisdictions. This approach was considered more conservative because it is expected to better account for the first flush of pollutants. The number of considered days following a significant event --as well as the threshold for defining a “significant” rainfall event--could be further investigated to gain a better understanding of how these assumptions impact the required pollutant reduction and BMP requirements. The applicability of available rainfall data could also be investigated, such as whether rain gauges closest to compliance locations should be the basis versus aggregating and area-weighting rain gauges within the watershed.

Another foundational element of the rEWMP is the accuracy of the **watershed model**, which is related to the quantity and quality of available data, detailed watershed understanding, and ability to represent processes occurring within the watershed. Section 2.1 briefly discussed some of the challenges of developing an accurate watershed model. The parameterization of the model can be improved through incorporation of additional future data for the calibration process. The accuracy of the model can also be improved as scientific and technological advances are made in the understanding and representation of processes throughout the watershed that influence water quality. The watershed model is the tool used to inform decisions made in the rEWMP, thus its accuracy directly impacts the accuracy of the program.

The water quality objectives establish the goals of the program, which are ultimately intended to protect beneficial uses within receiving water bodies. Given that metals were identified as the primary pollutants of concern, the **CTR criteria** are currently used to establish metal concentration thresholds, above which water is considered toxic to aquatic life. The accuracy of these empirical equations could be further investigated, along with the input parameters including hardness and conversion factors (to convert from dissolved to total recoverable metals for planning purposes). Site-specific data was used to calculate hardness and conversion factors for the rEWMP, but the appropriateness of using the 50th percentile hardness value measured at a downstream monitoring station, as referenced in the LA River Metals TMDL, and the upper limit of the 95th percentile conversion factor based on the linear regression of dissolved and total metal concentration data, could be evaluated. Other methods, such as using the partition coefficient, were explored for the calculation of the conversion factors and may be more useful when additional data is available. Site-specific criteria may be further refined through water effects ratio studies. Additionally, the biotic ligand model, or other methods developed in the future, may be more appropriate to evaluate toxicity levels and establish more accurate water quality criteria in terms of protecting beneficial uses.

Another layer of the water quality objectives is the identification of a **limiting priority pollutant**, as recommended by the RAA guidelines. It is a reasonable and defensible argument that if limiting pollutant reductions are met, then necessary reductions for other constituents under the same pollutant category should be met as well. This assumption should be verified following implementation of control measures and continued monitoring.

Lastly, the accuracy of the expected **effectiveness of control measures** is key to the program's success. A general assumption applied to the program is that enhanced MCMs will achieve 5% load reduction. A more detailed analysis of the actual load reductions achieved from these control measures would provide much greater confidence in this assumption and the expected effectiveness. The 5% reduction is a significant portion of the total required load reduction, so verifying the actual reduction would allow other control measures within the program to be more accurately prescribed to meet water quality objectives. Expected load reductions from the structural control measures (redevelopment, multi-benefit regional projects, and green streets) were explicitly modeled using SUSTAIN. As with the watershed model, the accuracy of the BMP modeling is dependent on available data and the ability to represent complex hydraulic and water quality processes. With more data gathered from BMP monitoring, the treatment effectiveness of different BMP types assumed within the SUSTAIN model may be refined. Additionally, more studies are needed in southern California to verify the response of water quality in receiving water bodies to upstream control measures designed for pollutant load reductions; the Coordinated Integrated Monitoring Programs are expected to demonstrate these trends regionally, but care should be taken to ensure that BMP effectiveness is also locally characterized so that permittees can clearly demonstrate the mass of pollutants being captured.

In general assumptions made throughout the rEWMP sided with the more conservative of potential options to increase confidence that the existing program would achieve the desired outcomes. Additional special studies, along with the adaptive management process, will continue to refine assumptions and decrease uncertainties within the rEWMP.

6.0 REFERENCES

Attachment A to Resolution No. R15-004. July 2, 2015. Amendment to the Water Quality Objectives of the Basin Plan

Donigian, Jr., A. S., Imhoff, J. C., Bicknell, B. R., & Kittle, Jr., J. L. 1984. Application Guide for the Hydrological Simulation Program - FORTRAN. EPA 600/3-84-066. Athens, GA: U.S. EPA Environmental Research Laboratory.

Garrick, M., Cunnane, C. & Nash, J. E. 1978. A criterion of efficiency for rainfall–runoff models. J. Hydrol. 38, 375–381.

Lumb, A. M., McCammon, R. B., & Kittle, Jr., J. L. 1994. User's manual for an expert system (HSPexp) for calibration of the Hydrologic Simulation Program-Fortran. U.S. Geological Survey Water-Resources Investigations Report 94-4168.

Mitsch, W. J., Gosselink, J. G. 2007. *Wetlands*. Fourth Edition.

Nash, J. E. & Sutcliffe, J. V. 1970. River flow forecasting through conceptual models. Part I—A discussion of principles. J. Hydrol. 27(3), 282–290.

Nguyen, T., Lai, C.P., Ridgeway, I., Zhu, J. 2014. Guidelines for Conducting Reasonable Assurance Analysis in a Watershed Management Program, Including an Enhanced Watershed Management Program. Prepared by Technical Staff of the Los Angeles Regional Water Quality Control Board, Los Angeles, CA.

Sabin, L.D., J.H. Lim, K.D. Stolzenbach, K.C. Schiff. 2006. Atmospheric dry deposition of trace metals in the coastal region of Los Angeles, California, USA. *Environmental Toxicology and Chemistry* 25: 2334-2341.

Shen, J., Parker, A., & Riverson, J. 2004. A New Approach for a Windows-based Watershed Modeling System Based on a Database-supporting Architecture. *Environmental Modeling and Software*.

Tetra Tech, & USEPA. 2002. *The Loading Simulation Program in C++ (LSPC) Watershed Modeling System – User's Manual.* User Manual.

Tetra Tech. 2010a. Los Angeles County Watershed Model Configuration and Calibration—Part I: Hydrology. Developed for the County of Los Angeles Department of Public Works Watershed Management Division, Alhambra, CA.

Tetra Tech. 2010b. Los Angeles County Watershed Model Configuration and Calibration—Part II: Water Quality. Developed for the County of Los Angeles Department of Public Works Watershed Management Division, Alhambra, CA.

Tiegenthaler, L.L., E.D. Stein and K.C. Schiff. 2007. Watershed and land use-based sources of trace metals in urban stormwater. *Environmental Toxicology and Chemistry* 27: 277-287.

USEPA (U.S. Environmental Protection Agency). 2000. BASINS Technical Note 6. Estimating Hydrology and Hydraulic Parameters for HSPF. Office of Water. EPA-823-R00-012.

USEPA (U.S. Environmental Protection Agency). 2003. *Fact Sheet: Loading Simulation Program in C++.* Retrieved from USEPA Watershed and Water Quality Modeling Technical Support Center Athens, GA: http://www.epa.gov/athens/wwqtsc/LSPC.pdf

USEPA (U.S. Environmental Protection Agency). 2006. BASINS Technical Note 8. Sediment Parameter and Calibration Guidance for HSPF. Office of Water. EPA-823-R00-012.

USEPA (U.S. Environmental Protection Agency). 2009. SUSTAIN—A Framework for Placement of Best Management Practices in Urban Watersheds to Protect Water Quality. EPA/600/R-09/095. U.S. Environmental Protection Agency, Office of Research and

Development, Edison, NJ.

USEPA (U.S. Environmental Protection Agency) Region IX. March 26,2012. Los Angeles Area Lakes Total Maximum Daily Loads for Nitrogen, Phosphorus, Mercury, Trash, Organochlorine Pesticides and PCBs.