Statistical Characterization of Stormwater Runoff and Environmental Implications: Oil and Grease, Heavy Metals

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by

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ABSTRACT OF THE DISSERTATION

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This dissertation examines stormwater quality from highways, and is a part of a larger study by the California Department of Transportation. As a first goal, 22 storm events were examined to determine when a single oil and grease sample (O&G) grab sample most closely approximates a flow-weighted composite sample. The analysis revealed that samples collected within the first hour of the storm overestimate the O&G event mean concentration (EMC) by 20 mg/L or more. The best time to collect a single grab sample ranged from 1 to 6 hours after the beginning of runoff. Correlations also exist between O&G EMC, antecedent dry days, and total rainfall. Correlating with chemical oxygen demand or dissolved organic carbon (DOC) EMCs collected by automated samplers may be the best method for estimating O&G EMC.

The second and third goals of the dissertation examines metals concentrations in highway runoff. Initially 59 storm events from the three UCLA sites were used. The analysis was then extended to 83 additional Caltrans sites. The first set of metal regressions analyzed the relationships between metal event mean concentrations and storm, site, and traffic characteristics, such as antecedent dry days, rainfall, average daily traffic, imperviousness and chatchment area. Regression models developed for the individual and combined UCLA sites were generally good, (R^2 ~ 0.4 to 0.6) with total rainfall and antecedent dry days being the most significant parameters. The regression models were then applied to the Caltrans sites, grouped together by geographic proximity. The correlation coefficients were not as high but still significant, with total rainfall and average daily traffic being most significant.

The second set of metal regressions examined the relationship between metals and conventional constituents, such as total suspended solids (TSS) specific conductivity, and DOC. Regressions were generally good (R^2 ~ > 0.6), with TSS and DOC being the most significant.

The regressions provide a generalized way of estimating metals concentratins in highway runoff water quality from site and event specific parameters, or from conventional constituents. The regressions should be useful in assessing the potential impacts of highway runoff and for developing management plans or total daily mass loads.

CHAPTER ONE

INTRODUCTION

Non-point source (NPS) pollution arises from many distributed sources such as storm or snowmelt events. Runoff scours pollutants from surfaces or washes out pollutants from soils (EPA 1994). NPS runoff carries natural and man-made pollutants and deposits them into various surface water such as wetlands, lakes, rivers, oceans; and ground water aquifers. NPS pollutants include fertilizers, herbicides, and insecticides from agricultural and residential areas; oil and grease (O&G), and toxic chemicals including metals from urban runoff; solids and sediments from construction sites, salt from irrigation practices; bacteria and nutrients form livestock; and solids and ionic constituents from atmospheric deposition (EPA 1994; Harrison and Wilson 1985)

The U.S. Environmental Protection Agency (U.S. EPA) began data collection and research through the Nationwide Urban Runoff Program (NURP) in the late 1970s. Projects were conducted in selected urban areas throughout the country and continued into the early 1980s. The NURP studies were based on ten water quality constituents, i.e. total suspended solids (TSS), biochemical oxygen demand (BOD_5), chemical oxygen demand (COD), total phosphorus, soluble phosphorus, total Kjeldahl nitrogen (TKN), nitrate and nitrite, copper (Cu), lead (Pb), and zinc (Zn). The investigators came into two major conclusions (US EPA 1983):

1. The variances of the event mean concentrations (EMCs) of sites grouped by landuse or geographic regions are so great that differences in the means or medians are often not statistically significant;
2. The median EMCs among the sites are lognormally distributed.

United States Geological Survey (USGS) continued monitoring urban runoff monitoring after the cessation of the NURP studies (Smullen et al. 1999). The USGS urban stormwater runoff database included data for 1,100 station-storms located at more than 97 urban sites. Stormwater data were also collected in some major cities in U.S. as a part of application requirements for the National Pollution Discharge Elimination System (NPDES). Smullen et al. (1999) compared the means and medians of NURP data with the pooled data of the three studies (i.e. NURP, USGS, NPDES) for the original ten water quality constituents. The pooled EMCs were lower for TSS, COD, Cu, Pb, and Zn than the in the original dataset.

The environmental loadings from residential, industrial, agricultural, and commercial wastewaters have been widely compared to loadings from stormwaters. Pollution from stormwater runoff can be significant when compared to these sources. Stormwaters are now considered separately from urban runoff because of increased concerns of their environmental impacts. (Wu et al. 1998). Stormwater management programs are now receiving the same attention as the NPDES program received in the past.

Highways are significant sources of NPS but in most cases, the extent of pollution is undocumented. Water that runs off a motorway surface is laden with suspended matter high in organic and mineral pollutants and salts. Heavy metals and nutrients are usually sorbed to the solids depending on their physical and chemical nature. Highway stormwater runoff shows a high degree of variability of constituents between events and between sites.

The potential environmental impacts of highway stormwaters are mixed. Rural highways often discharge into open areas with less development, but may impact sensitive environments, including ground water aquifers. Urban highways may have a lesser impact on ground water due to the imperviousness associated with developed areas, but may discharge into already stressed environments, and may have high daily traffic. Rural highways often have less daily traffic. Highway stormwater runoff transports dissolved and particulate constituents, which include solids, metals, ions, and nutrients. Many researchers have recently investigated highway stormwater runoff and some special features of highway runoff are discussed in the following paragraphs.

Impervious sites such as highways are thought to show a first flush of pollutants. The concept of the first flush refers to the delivery of a large mass of the constituent with respect to the runoff volume during the early portion of a storm event. Concentrations of pollutants in runoff often are higher at the beginning of a storm event. Many of the stormwater management facilities are designed to capture the initial runoff and thus treat the part of runoff that contains the highest concentrations of pollutants.

Many researchers have noted that the majority of the pollutants are emitted at the beginning of a storm event, and have referred to the phenomenon as the first flush (Geiger 1987; Thornton and Saul 1987; Lau et al. 2002). First flush has been quantitatively characterized by several researchers (Gupta and Saul 1996; Sansalone and Buchberger 1997; Bertrand-Krajewski et al. 1998). Ma et al. (2002) adapted a mathematical concept to define the mass of contaminants contained in the first flush.

The concept of first flush has also been extended to seasonal changes. California's climate is known to have winter and spring rainfall and summer drought, which is often called a Mediterranean climate. The extended dry period provides a long time for pollutant build-up. The first storms in the winter season usually carry higher pollutant concentrations and loads, which is called the seasonal first flush (Lee et al. 2003).

Best management practices (BMPs) are designed to reduce or minimize stormwater pollutant loading. BMPs can be institutional or non-structural, or structural. Non-structural BMPs include utilizing existing technology and physical facilities to discourage the pollutants in to environment (Silverman et. al 1986); economic incentives or penalties and government regulations; street sweeping, and education. The structural measures include treatment systems, such grassed swales and vegetative filter strips (Barrett et al. 1998); infiltration trenches, filter drains, and soakaways (Jeffries et al. 1999); detention basins, sand filters (Urbonas 1999), and catch basin inserts (Lau et al. 2001). Non-structural BMPs are usually preferred to structural BMPs for economic reasons.

The concentration of the pollutant mass varies widely during a storm event. In order to properly characterize the total emission from a storm event, an event mean concentration (EMC) is used. The EMC represents an average concentration of a pollutant for an entire event. The EMC is the average concentration in terms of volume of the flow. Mathematically the EMC can be represented by the following equation (Huber 1993):

$$EMC = \frac{M}{V} = \frac{\int_0^T c(t)q(t)dt}{\int_0^T q(t)dt} \tag{1.1}$$

where M = total mass of pollutant during the entire runoff (kg); V = total volume of runoff (m3); c(t) = time varying pollutant concentration (mg/L); q(t) = time variable flow (L/min); and T = total duration of runoff (min). EMCs will be used extensively in this dissertation.

This dissertation examines data collected from three sites in west Los Angeles (i.e. UCLA sites) and additional highway sites located all over California (Kayhanian et al. 2003). The three UCLA sites were within 20 minutes driving time of the UCLA campus and were monitored as part of a larger multi-year project to determine the characteristics of highway stormwater runoff, sponsored by the California Department of Transportation (Caltrans). The sites were located on the I-405 and US-101 freeways, which are among the busiest in California. The sites had small drainage areas (0.39 to 1.69 ha), were highly impervious (> 95%) and are typical of Caltrans sites. The sites were all close to the UCLA campus so that sampling teams could reach the sites prior to the initiation of runoff. Storm events were monitored during the rainy seasons (October to May) of 1999-00, 2000-01, 2001-02, 2002-03.

Additionally data from sites sampled by Caltrans contractors from 1997 to 2002 were included in the analysis. They were located throughout California, and included different types of adjacent landuses, such as residential, commercial, industrial, agricultural, forest, open, transportation facility, and mixed. The stormwater runoff data were characterized into different groups, such as highway, maintenance, parking, rest area, BMP, bridge etc. The sources of the water quality sample were storm, rain (i.e. rainwater directly collected from atmosphere), snowfall, snowmelt, ground water, non-storm etc. Composite and grab samples were collected and sampling methodology was well documented. The Caltrans database contains conventional pollutants such as TSS, total dissolved solids (TDS), COD, total organic carbon (TOC); dissolved and total metals such as arsenic (As), cadmium (Cd), chromium (Cr), Cu, Pb, nickel (Ni), and Zn; nutrients such as ammonia (NH_3), nitrate (NO_3), nitrite (NO_2), and TKN; major ions and minerals such as calcium (Ca), magnesium (Mg), sodium (Na), and sulfate (SO_4), microbiological parameters such as total coliform (TC) and fecal coliform; oil and grease; and pesticides such as diazinon, chlorpyrifos, and glyphosate.

This results of the various analysis are reported in three chapters and a conclusion chapter. Chapter 2 discusses procedures to collect an O&G grab sample that most nearly approximated the EMC. Several methods to predict the best time to collect the sample were developed, in additional to mathematical relationships to predict O&G EMC from site and storm information such as total rainfall (T_RAIN) and antecedent dry days (ADD). Finally, correlations were developed to predict O&G EMC from constituents such as COD and DOC. This chapter uses only data from the three UCLA sites.

Chapter 3 describes the regression models for the dissolved, particulate, and total metal EMCs using event-specific such as T_RAIN, maximum intensity of rainfall (MAX_RAIN), duration of runoff (D_RUN), and ADD, and site-specific parameters, such as runoff coefficient (RC), catchment area (AREA), average daily traffic (ADT). Data the three UCLA sites and more than 80 Caltrans sites were analyzed.

Chapter 4 describes the statistically-based methods to predict dissolved, particulate, and total metal EMC models from conventional parameters, such as TSS, volatile suspended solids (VSS), electrical conductivity (EC), TDS, COD, DOC, TOC, and TDS. The regression models were first developed for three UCLA sites and the analysis was then extended to additional Caltrans sites.

Each chapter has conclusions specific to that chapter and overall conclusions are presented in Chapter 5.

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CHAPTER TWO

OIL AND GREASE MEASUREMENT IN HIGHWAY RUNOFF — SAMPLING TIME AND EVENT MEAN CONCENTRATIONS

ABSTRACT

The constituent concentration measured from a flow-weighted composite sample is called event mean concentration (EMC), and is usually collected with an automatic, flow-weighted composite sampler. Automatic samplers are not recommended to collect oil and grease (O&G) samples due to interactions with tubing and pumps that may bias the measured concentrations. To measure the EMC without sampler interferences, a series of grab samples (often over 10 samples) must be collected along with the flow measurement to compute the EMC. This dissertation examines 22 O&G pollutographs to determine when a single O&G grab sample most closely approximates a flow-weighted composite sample. The analysis performed in this study revealed that samples collected at the beginning of the storm event (within the first hour) can overestimate the O&G EMC by 20 mg/L or more. Samples collected toward the end of the storm event may underestimate the EMC. The best time to collect a single grab sample ranged from 1 to 6 hours after the beginning of runoff and was related to site or storm-specific factors.

Results obtained from this study also showed that strong correlations (R^2=0.90) exist between O&G and other organic constituents, such as chemical oxygen demand (COD) and dissolved organic carbon (DOC), that are normally collected using automatic samplers. Correlations also exist between O&G EMC, antecedent dry days, and total

rainfall. Depending upon site and regulatory specific factors, correlating COD or DOC EMCs collected by automated samplers may be the best method for estimating O&G EMC.

Keywords

Highway runoff; stormwater management; oil and grease; best time sampling; event mean concentration; regression models.

2.1 INTRODUCTION

Highway stormwater runoff affects the quality of receiving water bodies by washing contaminants that have accumulated on roadway surfaces to receiving waters. Specifically, stormwater runoff includes suspended solids, nutrients, ionic species, metals, and organic constituents. Oil and grease (O&G), chemical oxygen demand (COD), and dissolved organic carbon (DOC) are frequently used to measure the concentration of organic constituents. Because free O&G can be easily observed as rainbow-colored sheens, it attracts public and regulatory interest. O&G that reaches receiving waters can cause problems, varying from toxicity to aquatic life, depressed dissolved oxygen concentration, odor, unsightly conditions and loss of use. O&G may contain a wide variety of hydrocarbon compounds, and some, such as polynuclear aromatic hydrocarbons (Eganhouse and Kaplan 1981), are known to be toxic to aquatic life even at very low concentrations.

Landuses that have large numbers of vehicles such as highways are known to discharge more O&G than other landuses such as residential property (Stenstrom et al. 1984). This concern requires transportation agencies and others to monitor O&G in their stormwater discharges from vehicular-intensive landuses. O&G emissions from vehicles, such as crankcase drippings and partially combusted fuels, are important sources of hydrocarbons. These emissions can be retained on impervious surfaces such as highways and are washed off during a runoff event. Hence, managing the discharge of O&G in stormwater runoff from vehicular-intensive landuses such as highways has potential to improve the water quality.

Monitoring for O&G presents special problems because automated samples are not recommended for O&G samples collection (American Public Health Association 1998). Most stormwater monitoring programs use automated samplers for collecting flow-weighted composite samples. These samplers generally work well, can be left unattended and can be triggered automatically to insure that the very beginning of runoff is sampled. The sampler is programmed to collect many small samples over the entire storm event to insure representativeness. Analysis of a flow-weighted composite sample provides Event Mean Concentration (EMC).

Composite samples are not recommended for analyzing certain constituents, such as O&G. The O&G in the sample can adsorb to the collection tubing and sample containers, which will cause the EMC to be underestimated. Subsequent samples can be contaminated by carry over from earlier samples. In the case of toxicity measurements associated with O&G measurement, artifactual toxicity can result from interaction with sampler materials. In some other cases, the sample can change during the elapsed time in the sample bottle. Therefore, a series of grab samples collected at discrete times are recommended to approximate the EMC of specific constituents such as O&G.

Collecting grab samples can be more difficult and less practical during storm events for several reasons: (i) the sampling crew must standby, awaiting the beginning of rainfall, and may miss important parts of a storm event if it begins at an inconvenient time; (ii) the sampling team may need to travel a great distance in a short time to reach all sampling locations; (iii) the sampling team may not have safe access to sampling locations during rainfall, and (iv) the cost associated with manually collecting grab samples is high. As a result, often only a single, randomly-timed, grab sample is collected, which may not be representative of the EMC. O&G often exhibits a first flush (Lau et al. 2002; Ma et al. 2002), which means samples collected early in storm will have higher concentrations than those collected later in the storm.

This study was undertaken with the following specific objectives:

1. To determine if there exists a “best time” to collect a single grab sample for O&G from highway landuse that most accurately represents the EMC.
2. To develop a mathematical relationship to determine the best time to collect a single O&G grab sample to be more representative of EMC, from site or storm-specific information.
3. To discover mathematical relationships that can be used to accurately correlate the O&G EMC ($EMC_{O\&G}$) from site and storm information and from organic

constituents such as COD and DOC that are commonly collected by automatic samplers.

2.2 BACKGROUND

Event mean concentrations are normally used to represent stormwater pollutant concentrations (Huber 1993). The EMC is the flow-weighted average concentration collected over the entire storm event, and is equal to the total mass emission, divided the total runoff volume. Eq. (1.1) shows the mathematical definition of EMC.

In case of a series of grab samples, the flow-weighted EMC is defined using the following equation:

$$EMC = \frac{\sum_{i=1}^{n} C_i V_i}{\sum_{i=1}^{n} V_i} = \frac{C_1 V_1 + C_2 V_2 + ... + C_n V_n}{V_T} = W_1 C_1 + W_2 C_2 + ... + W_n C_n \tag{2.1}$$

where

$$W_i = \frac{V_i}{V_T} \tag{2.2}$$

$$W_1 + W_2 + ... + W_n = 1 \tag{2.3}$$

where C_i = fractional concentration assigned to the i-th grab sample (mg/L); Wi = weight for the i-th grab sample (dimensionless); V_i = fractional flow volume assigned to the i-th grab sample (L); V_T = total volume of runoff (L); and n = number of grab samples (dimensionless).

EMCs are useful because they can be multiplied by total runoff volume to calculate mass discharge, and avoid the high variability that is associated with grab samples (Ha and Stenstrom 2003). They can be correlated to land use (Stenstrom et al. 1984; Sartor et al. 1974; Smullen et al. 1999). Unit loading rates (mass of pollutant per unit area per unit of rainfall) can be approximated from EMCs and the rational method, as shown in Eq. (2.4). Such procedures are useful in developing Total Maximum Daily Limits (TMDLs).

$$ULF = \frac{EMC \cdot V}{AREA \cdot T\_RAIN} \cdot 10^{-6} \qquad (2.4)$$

where ULF = unit loading rate (pollutant mass per unit area per unit rainfall, kg/ha/mm); V = total runoff volume (L); AREA = catchment area (ha), T_RAIN = total rainfall (mm), V = AREA.T_RAIN.RC.k, RC = rational runoff coefficient (dimensionless), and, k = unit conversion factor (L/ha/mm).

2.3 METHODOLOGY

2.3.1 Site Description

Table 2.1 shows the characteristics of the three sites. These sites were monitored as part of a larger project to determine the characteristics of highway stormwater runoff. The freeways are among the busiest in California, and the construction of the sites is typical of many freeways. The sites are highly impervious. 22 events monitored at these sites during the rainy seasons (October to April) of 1999-00, 2000-01, and 2001-02 were used in this analysis. The sites were all close to the UCLA campus so that sampling teams could reach the sites prior to the initiation of runoff.

2.3.2 Sample Collection and Analysis

Both grab and composite samples were collected as part of this study. Grab samples (4 liters each) were collected at 15-minute intervals during the first hour of runoff and at one-hour intervals over the next seven hours. For those few storms that lasted longer than 8 hours, additional grab samples were collected to capture the end of the storm. Grab samples were collected by bailing from a freefall of runoff exiting a discharge pipe. American Sigma (Loveland, Colorado), model 950 equipped with tilting bucket rain gauge, and area/velocity flow meter was used for flow-weighted composite samples. The automated composite sampler was allowed to run until the end of runoff. A large suite of water quality constituents were monitored (Lau et al. 2002), but for the purposes of this study, only O&G, COD and DOC analyses are presented. O&G was measured using the procedure by Lau and Stenstrom (1997); COD was analyzed using

U.S. EPA 410.1 and DOC was analyzed using U.S. EPA 415.1, with a Tekmar-Dohrman Model Apollo 9000 analyzer (Mason, Ohio).

2.3.3 Timing for Grab Sample Collection

Many constituents exhibit a first flush, which means the concentration declines as the storm progresses (Ma et al 2002). Best time or time-to-EMC (TEMC) is defined as the time from the beginning of runoff to the point that corresponds to EMC. This assumes concentration is monotonically declining. A grab sample collected too early may overestimate the true EMC because of the first flush effect, and a grab sample collected too late may underestimate the actual EMC as a result of pollutant wash-off.

Several best time strategies were evaluated to collect a single grab sample. One strategy was to see if there exists a point in the runoff hydrograph that is routinely more accurate for estimating the EMC. A second strategy was to pick convenient but consistent times, such as 3, 4 or 5 hours after the beginning of runoff. Another strategy is to determine if rainfall or site characteristics have an impact on the best time, determine if the characteristics can be predicted from weather reports and then to use a predicted best time to collect a grab sample.

2.3.4 Statistical Analysis

In order to simulate sampling at different points in a storm, it was assumed that the runoff concentrations were piece-wise linear functions. Under this assumption it is possible to interpolate between data points to simulate sampling at an arbitrary time.

Sampling at a random time was simulated using a random number generator that was programmed to produce random times during the runoff period. O&G concentration was estimated at the random times by interpolating between the measured concentrations that span to random time. Sampling at specific times (1 to 6 hours) after the beginning of runoff was also simulated in this fashion. Analysis was performed using SYSTAT 9 (Richmond, California).

The various events were classified into types based upon concentration and runoff profiles. Next a screening analysis was performed to confirm expected correlations of site and event specific parameters with $EMC_{O\&G}$. From these correlations, further analyses were performed as follows:

1. Strategies to collect a grab sample at timed points in a storm event (i.e., 1, 2, 3 etc. hours after the storm beginning);
2. Strategies to estimate the best time to sample from event and site variables, such as antecedent dry days (ADD), T_RAIN etc.;
3. Strategies to estimate the $EMC_{O\&G}$ directly from event and site variables, without collecting a grab sample;
4. Strategies to estimate $EMC_{O\&G}$ from COD and DOC EMC that are collected from automated composite samplers.

Some of the strategies require only parameters known in advance of the storm, such as ADD, average daily traffic (ADT), and AREA. Other strategies require parameters related to storm characteristics, and include T_RAIN, duration of runoff (D_RUN), total runoff (T_RUN), and the centroid (CENTROID, normalized distance from the beginning of runoff to the centroid of hydrograph), which must be estimated from weather predictions, which were simulated with three levels of accuracy.

2.4 RESULTS AND DISCUSSION

2.4.1 Hydrograph and Concentration Characteristics

Table 2.2 summaries O&G, COD, and DOC the total number of monitored runoff events, runoff types, and pollutograph types for each site. The storm events were divided into 4 types, based upon the shape of each hydrograph, as follows:

1. Type 1 where runoff is continuous.
2. Type 2 where runoff is discontinuous but the discontinuity can be neglected in the analysis.
3. Type 3 where runoff is discontinuous and only the first part of the runoff is used in the analysis.
4. Type 4 where runoff is discontinuous and only the last part of the storm is used in the analysis.

Runoff types are presented in Fig. 2.1, and most were type 1 (13 out of 22). The O&G concentration profile or pollutograph was divided into 3 types:

1. Type 1 where concentration decreases monotonically with time.
2. Type 2 where the concentration profile generally decreases with time.
3. Type 3 where the concentration profile demonstrates abrupt changes or random patterns.

Pollutograph types are presented in Fig. 2.2. Most (13 out of 22) of the O&G pollutographs were type 2, with the remainder being type 1 (9). Type 3 pollutographs were found only for DOC.

The statistical summary of EMCs of relevant constituents are presented in Table 2.3. The mean EMC values of the contaminants were higher for site 1 than other sites. Site 3 had the minimum standard deviation of EMCs. Reasons for differences among sites are not known at this time.

2.4.2 Correlation and Regression Results for Best Time and $EMC_{O\&G}$

Table 2.4 shows the results as a correlation matrix. As shown, the best time to sample for O&G ($TEMC_{O\&G}$) and $EMC_{O\&G}$ were correlated with the 8 independent event-specific and site-specific variables chosen. There exists a strong correlation between $EMC_{O\&G}$ and ADD (R = 0.91), and no strong correlations with other parameters. The time-to-EMC is strongly correlated with, D_RUN, (R = 0.77), T_RUN (R = 0.82), T_RAIN (R = 0.87). This was expected since the emission of O&G should occur over the length of runoff, which is related to the total rainfall and its duration. D_RUN, T_RUN and T_RAIN are highly correlated among themselves, as expected. There is almost no correlation with TEMC and EMC with other site parameters such as RC, ADT, and AREA. CENTROID was poorly correlated with other parameters and the correlations are not reported. ADT would probably not show any correlation in our analysis, since it does not vary greatly among sites. More detailed information on the effects of ADT on water quality can be found in Kayhanian et al. (2003).

Table 2.5 shows the results of all four strategies for estimating $EMC_{O\&G}$. The results for all methods are placed in one large table to facilitate comparisons. They are divided by method: (i) timed samples; (ii) samples collected at a specific times determined by regressions of storm characteristics; (iii) regressions as a function of event and site characteristics, and (iv) regression of $EMC_{O\&G}$ with COD and DOC measured using autosamplers. They are discussed in the following sections.

2.4.3 Best Time for Sample Collection

A simulation was made to determine if specific times for grab sample collection might be a good strategy. Sample collection was simulated by using the pollutograph to determine O&G concentration at specific times, as described previously. Times from 0.25 hour to 6 hours and storm end were evaluated. The results are shown in Table 2.5. It is useful to compare these results to the results of collecting a randomly time sample. Root mean square (RMS) error, bias and number of storms are reported. The number of storms used for analysis decreases at longer sampling times, since not all storms lasted as long as the sampling time. The error and bias are the differences between the EMC calculated from the series of grab samples and the value simulated by the various strategies.

For random timing, the error is 9.4 mg/L with a bias of 1.15 mg/L. Bias is average difference between the measured EMCs and the EMCs estimated by the various strategies. The RMS error is largest for sampling strategies that are early in the runoff, which is expected since O&G typically shows a first flush. The RMS error is roughly equal for samples collected after 1 hour, although the bias decreases to a negative value after 2 hours. Therefore sampling at specific times longer than 1 hour produces much less error than randomly timed samples, but slightly underestimates the $EMC_{O\&G}$. Sampling at the end of the storm is also a good strategy.

2.4.4 Best Time from Event and Site Variables

The $TEMC_{O\&G}$ is determined by finding the intersection of the O&G pollutograph with the EMC calculated from the grab samples and runoff flow rates. The time where this occurs is defined as $TEMC_{O\&G}$, and is shown in Fig. 2.3. For type 1 pollutographs, the O&G concentration equals the EMC value only at a single point. In the case of pollutographs of types 2 and 3, the O&G concentration might equal the EMC at more than one point, as shown in Figure 2.4. For these cases, the first value obtained in the time axis was used to compute the best time for this research. The best times illustrated in Figs. 2.3 and 2.4 are 133 and 54 minutes respectively. The first occurrence of the EMC was used, although other approaches are possible, such as smoothing the curve.

$TEMC_{O\&G}$ was analyzed against the favorable factors (ADD, D_RUN, and T_RAIN). Five forms of equations, namely, linear, power, log, exponential, and inverse were considered for simple and multiple regressions. The linear regression results proved to be better than the nonlinear regressions. Only the four best results are presented, and are shown in Eqs. (2.5) to (2.8), with regression coefficients. Table 2.6 shows the significance.

$$TEMC_{O\&G} = 55.71 + 1.50 \cdot T\_RAIN \qquad R^2 = 0.76 \qquad (2.5)$$

$$TEMC_{O\&G} = 22.29 + 9.12 \cdot D\_RUN \qquad R^2 = 0.59 \qquad (2.6)$$

$$TEMC_{O\&G} = 43.53 + 1.21 \cdot T\_RAIN + 2.55 \cdot D\_RUN \qquad R^2 = 0.78 \qquad (2.7)$$

$$TEMC_{O\&G} = 52.31 + 1.51 \cdot T\_RAIN + 2.47 \cdot D\_RUN - 0.39 \cdot ADD \qquad R^2 = 0.81 \qquad (2.8)$$

The O&G concentrations associated with the different regressions were determined by finding the intersection of the best time and O&G concentration on the pollutograph. Table 2.5 shows values of R^2, RMS error and bias in EMC concentrations. The estimation is better than timed samples for both RMS error and bias. The RMS error is less than 2.8 mg/L with bias less than |0.75|. R^2 values are all above 0.9. Using only the total rainfall provides essentially the best estimate. Adding the D_RUN only marginally improves the estimate, and ADD is not useful for this case. The largest improvement over the timed strategies is the reduced bias, which is essentially within the precision of O&G analysis for the best time strategies.

The problem with this strategy is that some parameters, such as T_RAIN are not known until after the storm, and can only be estimated by weather predictions. To simulate weather prediction, the estimated values of T_RAIN and D_RUN were provided by dividing the post rain data into three categories: low (6 mm and 5 hours), medium (13 mm and 7 hours) and high (25 mm and 12 hours). This assumes that the weather prediction could estimate T_RAIN and D_RUN within this accuracy. These values were substituted into Eqs (2.5)-(2.8). The results are shown in Table 2.5 under strategy 2, predicted parameters. If weather prediction is able to classify rainfall as small, medium or large, this best time strategy is superior to timed strategies. This strategy still requires sampling teams to mobilize and travel to the sampling sites at specific times, and this may not be possible for teams with many sites to sample.

The analysis shows that collecting the first flush at the beginning of the storm does not provide a good estimate of the EMC. This means that sampling teams do not need to standby awaiting the beginning of rainfall to insure collection of the first flush.

2.4.5 $EMC_{O\&G}$ from Event and Site Variables

An analysis was performed to determine if $EMC_{O\&G}$ could be estimated directly from event or site characteristics. This strategy is completely predictive and does not require an O&G sample. Regressions were made between $EMC_{O\&G}$ and the 7 previously described parameters using 5 different models. Simple and multiple regressions were used. Useful results were obtained only when using ADD and T_RAIN. Eq. (2.9) shows the result for ADD.

$$EMC_{\mathrm{O\&G}} = 2.64 + 0.38 \cdot ADD \qquad R^2 = 0.82 \qquad (2.9)$$

The p values for the intercept and ADD were 0.03 and <0.01, respectively. This regression provides nearly the same accuracy as the previously described strategies, but its use is limited to type of rainfall events used in this analysis. No event less than 3.8 mm was analyzed; very low rainfall is usually associated with higher $EMC_{O\&G}$.

Although Eq. (2.9) predicts $EMC_{O\&G}$ reasonably well, it does not include any effects of rainfall or storm duration. There are two primary mechanisms that influence the EMC. The first relates to the build-up phase, which is correlated to ADD and the second is related to the wash-off. Eq. (2.9) considers only the build-up mechanism, which is impacted only by the variables ADD and ADT. The wash-off phase can be impacted by other variables: D_RUN, T_RUN, T_RAIN, and RC. A second regression was performed using ADD and T_TRAIN, and is shown as Eq. (2.10). Eq. (2.10) has slightly better fit (Table 2.5) and includes both build-up and wash-off mechanisms. In this regression, the significance of the intercept ($p = 0.03$) and ADD ($p < 0.01$) coefficient remain high, but the significance of T_RAIN or wash-off is low ($p = 0.50$); therefore, the effect of wash-off is either not important or is not estimated by the linear regression.

$$EMC_{\mathrm{O\&G}} = 3.20 + 0.37 \cdot ADD - 0.02 \cdot T\_RAIN \qquad R^2 = 0.83 \qquad (2.10)$$

Eq. (2.11) shows the same regression except using a log transformation of the data.

$$\log_{10}(EMC_{\mathrm{O\&G}}) = 0.37 + 0.64 \cdot \log_{10}(ADD) - 0.17 \cdot \log_{10}(T\_RAIN) \qquad \mathrm{R}^2 = 0.86 \qquad (2.11)$$

The coefficients are significant with p values of 0.02, <0.01, and 0.09 for the intercept, ADD, and T_RAIN, respectively. Eq. (2.11) is a more realistic model with the possibility of including two separate effects.

2.4.6 $\mathbf{EMC_{O\&G}}$ from Composite COD and DOC Measurement

Another method for estimating $EMC_{O\&G}$ is to correlate the EMC with other parameters measuring organics concentration, such as COD and DOC, or total suspended solids (TSS), which is often used as a surrogate for other water quality parameters in stormwater management. O&G is only a fraction of the compounds that compose COD or DOC and the fraction depends upon landuse (Stenstrom et al. 1986; Fam et al. 1987). Highway runoff is all the same landuse and we can expect the source of the hydrocarbons to be similar.

There exists a significant correlation between the $EMC_{O\&G}$, EMC_{COD}, and EMC_{DOC} (R = 0.95). Eqs. (2.12) and (2.13) show the regressions between $EMC_{O\&G}$ and EMC_{COD} or EMC_{DOC}. The intercept is not significant for DOC and is not reported. In both cases the R^2 are 0.90 and the remaining regression parameters are significant ($p < 0.02$).

$$EMC_{\mathrm{O\&G}} = 3.71 + 0.04 \cdot EMC_{\mathrm{COD}} \qquad R^2 = 0.90 \qquad (2.12)$$

$$EMC_{\mathrm{O\&G}} = 0.15 + 0.28 \cdot EMC_{\mathrm{DOC}} \qquad R^2 = 0.90 \qquad (2.13)$$

TSS and $EMC_{O\&G}$ were not correlated (R = 0.18). In this case, TSS is not a useful surrogate for O&G.

2.5 PRACTICAL APPLICATIONS AND RECOMMENDATIONS

Four alternative methods have been presented to estimate $EMC_{O\&G}$: timed samples; estimates of the best time to collect a grab sample, based upon various storm and site-specific parameters; regression with storm and site specific parameters, and correlation with COD or DOC. All methods are superior to collecting a randomly-timed grab sample and produced RMS errors less than 4 mg/L and R^2 from 0.82 to 0.97. The RMS error associated with a randomly timed sample was 9.4 mg/L. Collecting a sample at the very beginning of a storm event was the worst strategy with RMS error of 32.4 mg/L. Small differences in the performance among the methods were noted. The selection of method should probably be based considerations in addition to accuracy.

The timed sampling strategies require a sampling team or sampling device to collect a sample at a specific time, which may be inconvenient for teams sampling many sites. In addition, it may not be possible to know the exact time the beginning of the storm without local rain gages or flow meters. The best time strategies have the same disadvantage in that a sample must be collected at a specific time, and are more complicated because the sample time must be calculated from a regression and weather prediction.

Regressions with site-specific parameters such as ADD were slightly less accurate than the timed methods, but have the advantage that no sample needs to be collected. Regulatory agencies may not support this strategy, unless the accuracy of the regression is demonstrated.

Correlation of $EMC_{O\&G}$ with EMC_{COD} or EMC_{DOC} is perhaps most promising. It is nearly as accurate as the best of all methods and has no bias. It has the advantage that the result is based upon an actual sample. The sampling team needs to do no extra work, and COD or DOC can be monitored with composite samplers. DOC may be preferable since it is not subject to interferences from inorganic reduced pollutants.

To demonstrate the practical application of methodologies presented in this dissertation, the data collected as part of the California Department of Transportation (Caltrans) was used for comparison. This data set includes water quality measurements from 1997 to 2002 at 94 highway sites. O&G grab samples were collected for each storm even, as well as flow-weighted composite samples that were analyzed for DOC and COD. The timing for grab sample collection was not controlled, but grab samples were generally collected early in the storm, to insure that a sample was obtained. Additionally T_RAIN and ADD were recorded. The various correlations were applied to this data set to allow comparisons of the measured grab samples with the various strategies. Only samples above O&G detection limits were used. The comparison shows the potential impact of the alternate methods on the overall estimation of O&G concentrations.

Table 2.7 shows the comparison, which illustrates the potential impact of the methods on overall O&G concentration estimations. All methods had lower variability than the grab samples, as indicated by the standard deviations. Median values of O&G were lower by approximately 2 mg/L for all methods except correlation to COD [Eq. (2.12)], which was a 2.8 mg/L greater. Mean values for all methods were lower than grab sample mean. This is expected since grab samples were collected early in the storm.

This exercise shows that O&G estimates from gab samples may slightly over estimate the actual concentrations. The new methods produced less variable results and can be performed without collecting grab samples, which should result in substantial cost savings. The approach used in the dissertation might also be useful for other parameters that require grab samples or are difficult to sample with automated composite samplers.

2.6 CONCLUSIONS

This dissertation addresses the question of when to collect a grab sample for oil and grease (O&G) to best approximate the event mean concentration (EMC) for an entire storm event. Twenty-two storm events using three sites during the rainy seasons (October to April) of 1999-2002 were used to determine if there exists a point in the pollutograph that best approximates the (O&G EMC) $EMC_{O\&G}$. Regression analysis were performed to determine if $EMC_{O\&G}$ and best sampling time could be related to storm-specific parameters such as total rainfall, and weather-specific parameter such as antecedent dry days (ADD). Finally, correlations were made between other organic parameters, such as chemical oxygen demand (COD) and dissolved organic carbon

(DOC), to determine if using a correlation to estimate $EMC_{O\&G}$ is a viable strategy. The dissertation provides quantitative relations that support the following conclusions:

1. Collecting a single grab sample at no specific time is a poor strategy for estimating $EMC_{O\&G}$.
2. If a single O&G grab sample is to be collected to characterize the storm event, it should be collected several hours into the storm. Samples collected at the beginning of the storm event (~15 minutes) can overestimate the $EMC_{O\&G}$ by 20 mg/L or more. Samples collected after 1 hour generally had root mean square errors under 4 mg/L, when compared to the EMC. Samples collected toward the end of the storm may underestimate the EMC, but only by 1 to 2 mg/L.
3. There exists a best time to sample for O&G which is related to storm characteristics such as total rainfall (T_RAIN). Greater T_RAIN or storm duration delays the best time to collect a sample.
4. The $EMC_{O\&G}$ values were well correlated to site-specific storm conditions such as antecedent dry days and T_RAIN.
5. There exists a strong correlation (R^2 ~ 0.9) between $EMC_{O\&G}$ and COD or DOC. Using the correlation with EMC_{COD} or EMC_{DOC} is a viable strategy for estimating $EMC_{O\&G}$ for highway runoff.
6. $EMC_{O\&G}$ was not well correlated to total suspended solids EMC (R^2 ~ 0.2).
7. A comparison of the methods presented here with a large California, state-wide stormwater monitoring program suggests that the new methods will have less

variability and will, on average, produce O&G concentrations that are 2 mg/L less than those obtained with grab samples.

NOTATION

ADD = Antecedent dry days (day);

ADT = Average daily traffic (vehicles/day);

AREA = Catchment area (ha);

Caltrans = California Department of Transportation;

C_i = Fractional concentration assigned to the i-th grab sample (mg/L);

COD = Chemical oxygen demand;

CV = Coefficient of variation;

DOC = Dissolved organic carbon;

D_RUN = Duration of runoff total runoff (hr);

EMC = Event mean concentration (mg/L);

M = Total mass of pollutant during the entire runoff (kg);

n = Number of grab samples;

O&G = Oil and grease;

p = Probability value;

R = Correlation coefficient;

RC = Rational runoff coefficient;

RMS = Root mean square;

SD = Standard deviation;

T = Total duration of runoff (min);

TEMC = Best time to sample from the beginning of runoff (min);

TSS = Total suspended solids (mg/L);

T_RAIN = Total rainfall (mm);

T_RUN = Total runoff volume (L);

ULF = Unit loading rate (kg/ha/mm);

V = Total volume of runoff (L);

V_i = Fractional flow volume assigned to the i-th grab sample (L);

V_T = Total volume of runoff (L), and

W_i = Weight for the i-th grab sample.

Table 2.1. Site Characteristics

Site	Location	Highway	No. of events[a]	AREA (ha)	RC	Type of surface	ADT (cars/day)
1	Van Nuys	US-101	6	1.28	0.94	Pavement	328000
2	Getty Center	I-405	6	1.69	0.71	Pavement	260000
3	Santa Monica Blvd	I-405	10	0.39	0.89	Pavement	322000

[a]The number of events is the storms used in the analysis.

Table 2.2. Statistical Summary of Total Number of Monitored Runoff Events, Runoff Types, and Pollutograph Types

	Type[a]	Site 1	Site 2	Site 3	All sites
No. of runoff events		6	6	10	22
No. of hydrographs	1	4	4	5	13
	2	0	2	3	5
	3	2	0	2	4
	4	0	0	0	0
No. of O&G pollutographs	1	2	2	5	9
	2	4	4	5	13
	3	0	0	0	0
No. of COD pollutographs	1	3	3	6	12
	2	3	3	4	10
	3	0	0	0	0
No. of DOC pollutographs	1	2	2	6	10
	2	4	3	4	11
	3	0	1	0	1

[a]Hydrograph type 1: runoff is continuous; type 2: runoff is discontinuous but the discontinuity can be neglected in the analysis; type 3: runoff is discontinuous and only the first part of the runoff is used in the analysis, and type 4: runoff is discontinuous and only the last part of the storm is used in the analysis. Pollutograph type 1: concentration decreases monotonically with time; type 2 concentration profile generally decreases with time, and type 3: concentration profile demonstrates abrupt changes or random patterns.

Table 2.3. Statistical Summary of O&G, COD, and DOC EMC Analysis

Constituent	Statistical summary, mg/L				
	Min	Max	Median	Mean	SD[a]
O&G					
Site 1	1.84	33.85	6.77	8.95	7.43
Site 2	1.44	80.12	6.37	15.53	19.78
Site 3	1.52	41.63	5.54	8.83	8.63
All Sites	1.44	80.12	6.57	11.03	13.22
COD					
Site 1	18.19	257.96	113.12	115.05	73.21
Site 2	31.36	693.78	104.8	157.28	155.44
Site 3	13.76	418.24	66.83	102.93	110.7
All Sites	13.76	693.78	85.23	124.17	118.67
DOC					
Site 1	27.53	819.72	101.16	150.32	175.83
Site 2	31.31	2283	76.72	291.63	521.99
Site 3	22.01	1109.89	70.66	157.58	227.96
All Sites	22.01	2283	84.99	198.6	341.95

[a]Standard deviation.

Table 2.4. Correlation matrix (R) for dependent and independent variables

	$EMC_{O\&G}$	$TEMC_{O\&G}$	ADD	D_RUN	T_RUN	T_RAIN	ADT	RC	AREA
$EMC_{O\&G}$ [a]	1.00								
$TEMC_{O\&G}$ [b]	-0.38	1.00							
ADD	0.91	-0.37	1.00						
D_RUN	-0.30	0.77	-0.22	1.00					
T_RUN	-0.26	0.82	-0.22	0.79	1.00				
T_RAIN	-0.29	0.87	-0.25	0.79	0.96	1.00			
ADT	0.03	-0.18	0.00	-0.33	-0.43	-0.33	1.00		
RC	-0.17	-0.21	-0.06	-0.12	-0.37	-0.36	0.61	1.00	
AREA	0.11	0.23	0.07	0.35	0.46	0.25	-0.70	-0.37	1.00

[a] $EMC_{O\&G}$ = Event mean concentration (mg/L) for O&G.

[b] $TEMC_{O\&G}$ = Best time to sample from the beginning of runoff (min) for O&G.

Table 2.5. Summary of R^2, RMS Error, and Bias Values for Different Methods to Predict $EMC_{O\&G}$

Sampling strategy or regression method	No. of Obs.	R^2	RMS Error (mg/L)	Bias[a] (mg/L)
Random grab sampling time	22	0.54	9.40	1.15
Strategy 1: Timed sample strategies after beginning of runoff				
0.25 hr	22		32.4	23.8
1 hr	22		3.47	1.39
2 hr	22		3.91	-2.07
3 hr	18		3.92	-2.54
4 hr	15		3.59	-0.88
5 hr	14		3.13	-1.21
6 hr	9		2.19	-1.38
Storm end	22		3.52	-1.96
Strategy 2: Best sampling time from event and site variables				
Post storm measured parameters				
Total rainfall Eq. (2.5)	22	0.96	1.99	-0.27
Duration of runoff Eq. (2.6)	22	0.92	2.64	-0.22
Total rainfall and duration of runoff Eq. (2.7)	22	0.96	1.96	-0.26
Total rainfall, duration of runoff, and antecedent dry days Eq. (2.8)	22	0.97	2.72	0.73
Predicted parameters				
Total rainfall Eq. (2.5)	22	0.89	2.98	0.39
Duration of runoff Eq. (2.6)	22	0.95	2.22	-0.40
Total rainfall and duration of runoff Eq. (2.7)	22	0.88	3.19	0.37
Total rainfall, duration of runoff, and antecedent dry days Eq. (2.8)	22	0.92	3.46	1.18
Strategy 3: *EMC* of O&G from site and event variables				
Antecedent dry days Eq. (2.9)	22	0.82	3.84	-0.01
Antecedent dry days and total rainfall Eq. (2.10)	22	0.83	3.79	0.00
Logarithm of Antecedent dry days and total rainfall Eq. (2.11)	22	0.84	3.60	-0.42
Strategy 4: *EMC* of O&G from composite COD or DOC measurement				
COD Eq. (2.12)	22	0.90	2.90	0.07
DOC Eq. (2.13)	22	0.90	2.84	0.01

[a]Positive bias means the calculated value overestimates the actual value.

Table 2.6. R^2 and p Values for Eqs. (2.5) to (2.8)

Equtaion	R^2	p value			
		Intercept	*T_RAIN*	*D_RUN*	*ADD*
Eq. (2.5)[a]	0.76	<0.01	<0.01		
Eq. (2.6)[b]	0.59	0.14		<0.01	
Eq. (2.7)[c]	0.78	<0.01	<0.01	0.23	
Eq. (2.8)[d]	0.81	<0.01	<0.01	0.23	0.17

[a] $$TEMC_{\mathrm{O\&G}} = 55.71 + 1.50 \cdot T\_RAIN \qquad R^2 = 0.76 \tag{2.5}$$

[b] $$TEMC_{\mathrm{O\&G}} = 22.29 + 9.12 \cdot D\_RUN \qquad R^2 = 0.59 \tag{2.6}$$

[c] $$TEMC_{\mathrm{O\&G}} = 43.53 + 1.21 \cdot T\_RAIN + 2.55 \cdot D\_RUN \qquad R^2 = 0.78 \tag{2.7}$$

[d] $$TEMC_{\mathrm{O\&G}} = 52.31 + 1.51 \cdot T\_RAIN + 2.47 \cdot D\_RUN - 0.39 \cdot ADD \qquad R^2 = 0.81 \tag{2.8}$$

Table 2.7. Basic Statistics for Different Methods to Predict $EMC_{O\&G}$ for Highway Runoff Characterization

Method	No. of cases	Min	Max	Median	Mean	SD[a]	CV[b]
Actual values reported	418	1.00	226.00	6.00	10.28	15.00	1.46
Regression with event and site characteristics							
Antecedent dry days Eq. (2.9)[c]	391	2.72	112.84	4.16	8.85	11.94	1.35
Antecedent dry days and total rainfall Eq. (2.10)[d]	391	0.56	110.37	4.46	8.73	11.66	1.34
Logarithm of Antecedent dry days and total rainfall Eq. (2.11)[e]	391	0.29	64.74	3.90	7.05	8.09	1.15
Regression with measured constituents							
COD Eq. (2.12)[f]	102	4.32	19.99	8.89	9.55	3.53	0.37
DOC Eq. (2.13)[g]	228	1.03	88.53	4.02	5.42	8.49	1.57

[a]SD = Standard deviation.

[b]CV = Coefficient of variation.

[c] $EMC_{O\&G} = 2.64 + 0.38 \cdot ADD$ $\qquad R^2 = 0.82 \qquad (2.9)$

[d] $EMC_{O\&G} = 3.20 + 0.37 \cdot ADD - 0.02 \cdot T\_RAIN$ $\qquad R^2 = 0.83 \qquad (2.10)$

[e] $\log_{10}(EMC_{O\&G}) = 0.37 + 0.64 \cdot \log_{10}(ADD) - 0.17 \cdot \log_{10}(T\_RAIN)$ $\qquad R^2 = 0.86 \qquad (2.11)$

[f] $EMC_{O\&G} = 3.71 + 0.04 \cdot EMC_{COD}$ $\qquad R^2 = 0.90 \qquad (2.12)$

[g] $EMC_{O\&G} = 0.15 + 0.28 \cdot EMC_{DOC}$ $\qquad R^2 = 0.90 \qquad (2.13)$

Note: Source: Caltrans discharge characterization study report, CTSW-RT-03-065.51.42.

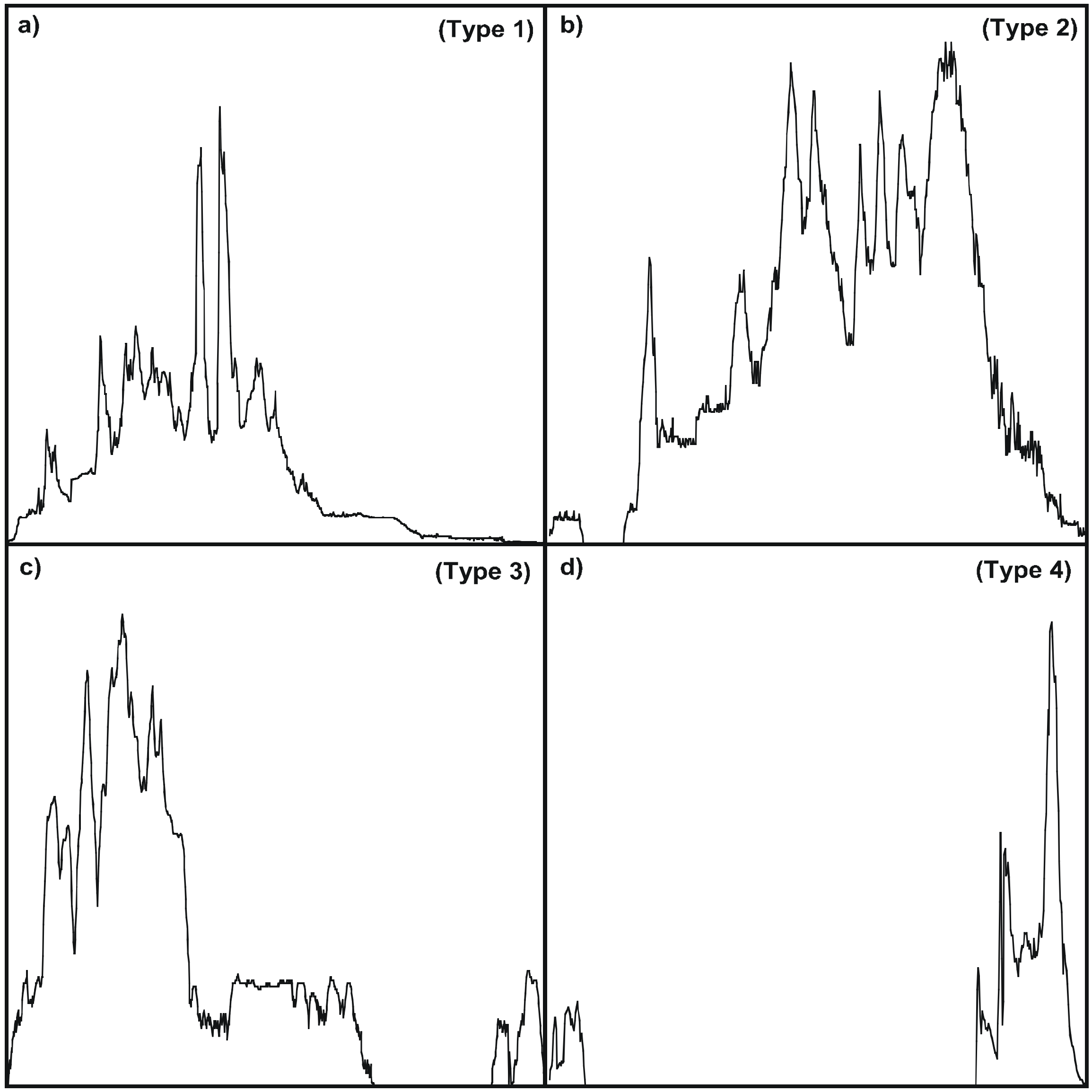

Fig. 2.1. General Classification of Storm Events Based on Various Typical Hydrographs
Note: Hydrograph type 1: runoff is continuous; type 2: runoff is discontinuous but the discontinuity can be neglected in the analysis; type 3: runoff is discontinuous and only the first part of the runoff is used in the analysis, and type 4: runoff is discontinuous and only the last part of the storm is used in the analysis.

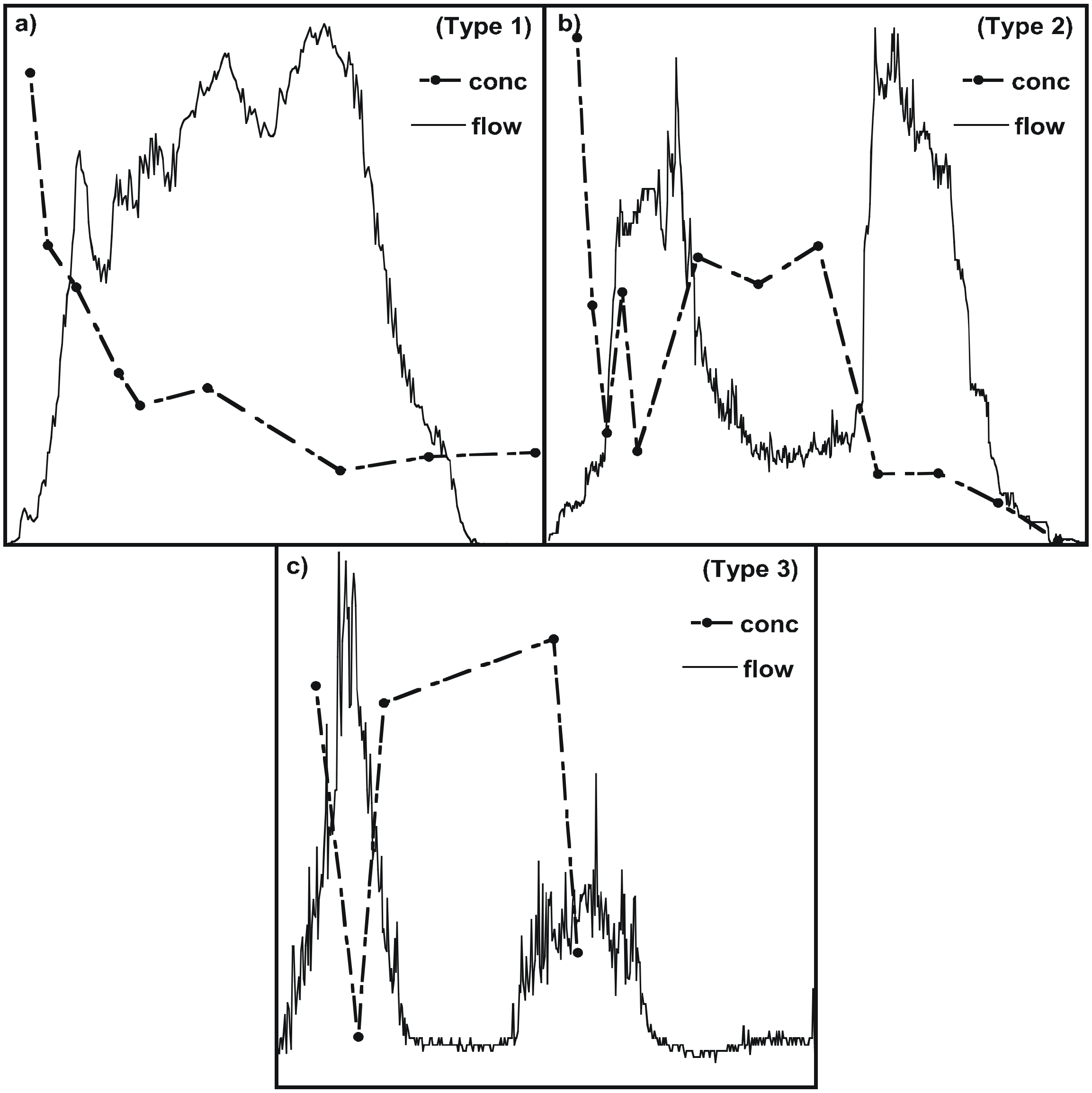

Fig. 2.2. General Classification of Pollutographs

Note: Pollutograph type 1: concentration decreases monotonically with time; type 2 concentration profile generally decreases with time, and type 3: concentration profile demonstrates abrupt changes or random patterns.

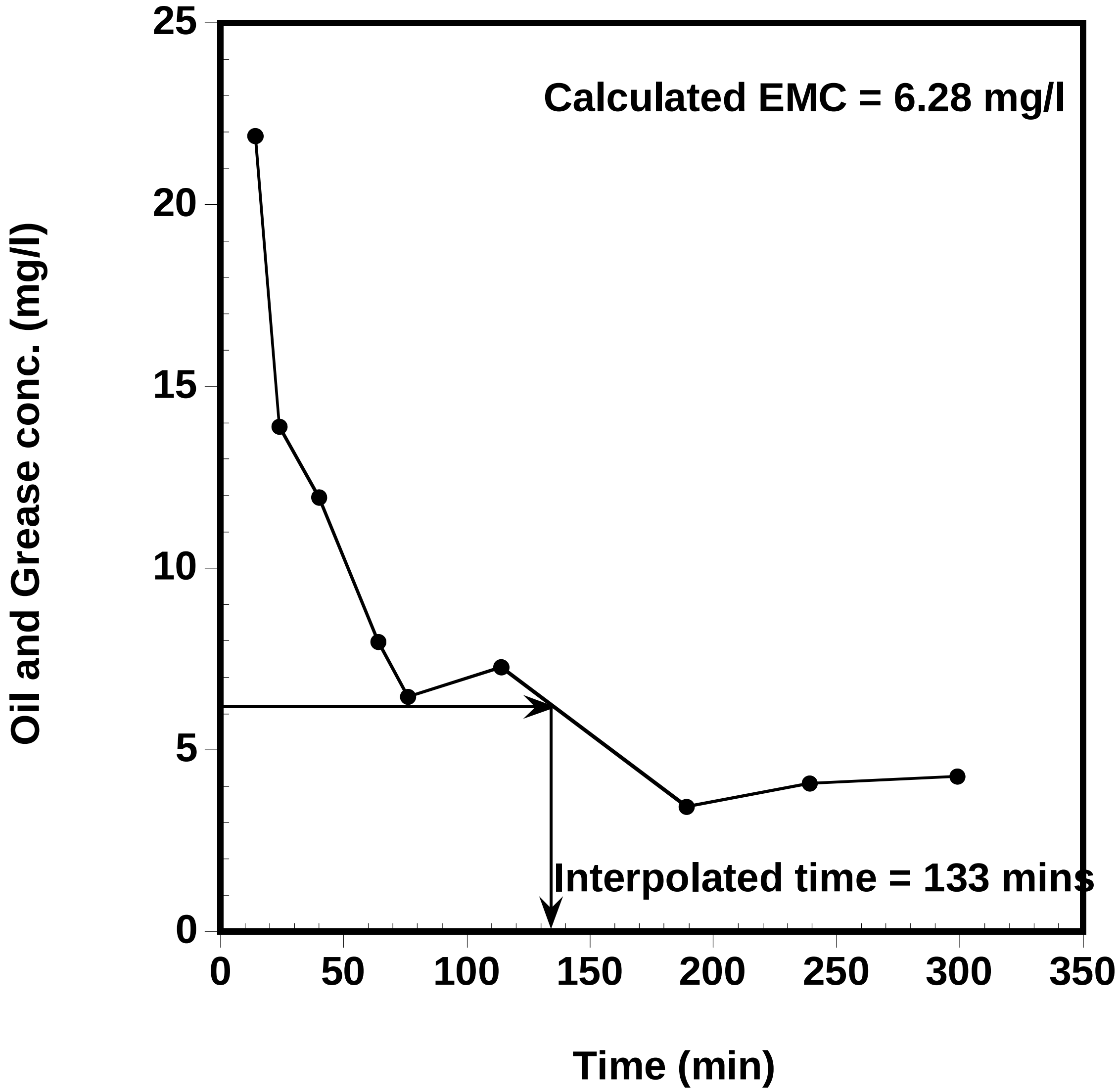

Fig. 2.3. Example of Obtaining Interpolated Time Based on Calculated EMC Value for Pollutographs of Type 1

Note: Pollutograph type 1: concentration decreases monotonically with time.

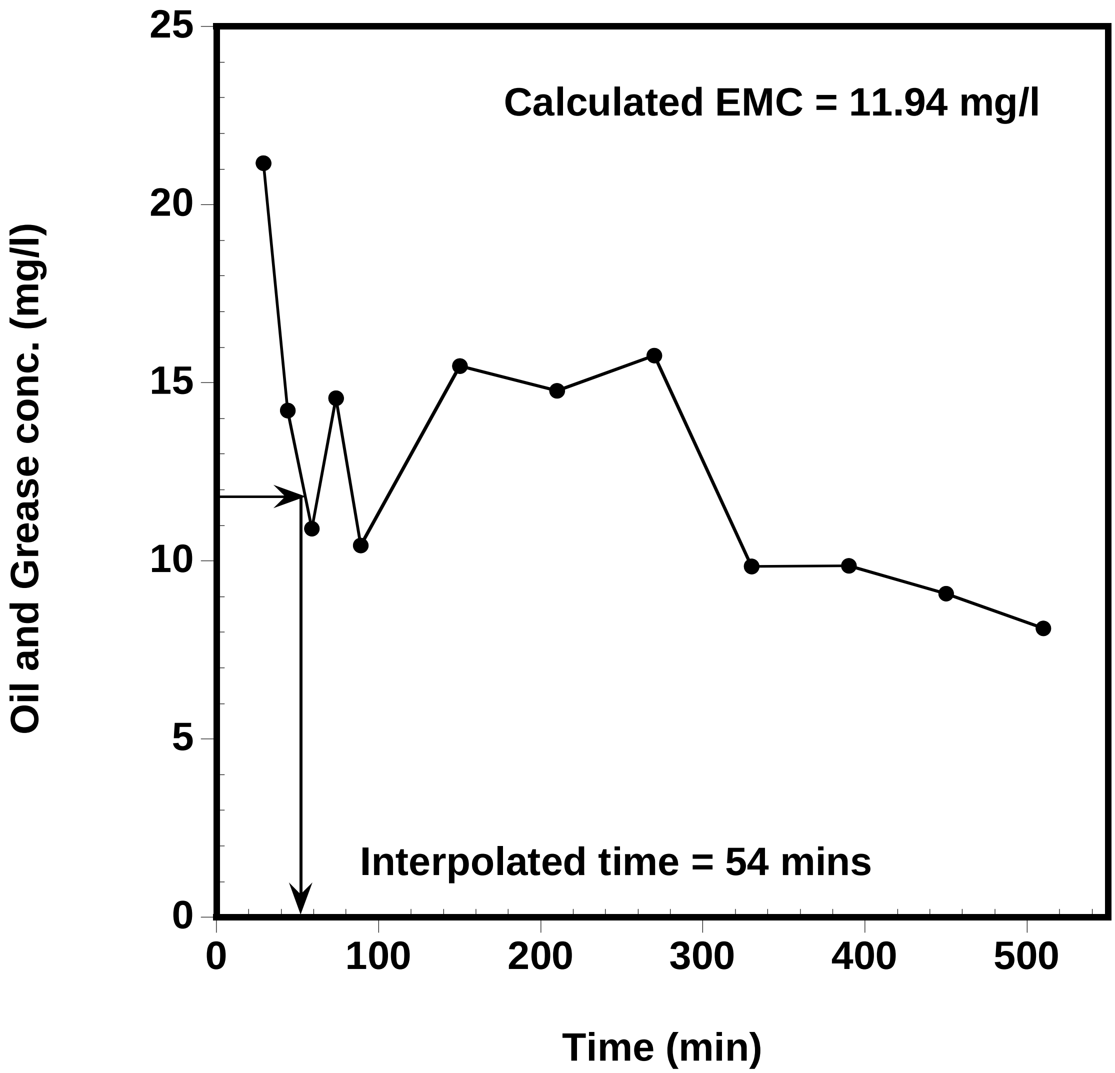

Fig. 2.4. Example of obtaining interpolated time based on calculated EMC value for pollutographs of type 2 and type 3.
Note: Pollutograph type 2 concentration profile generally decreases with time, and type 3: concentration profile demonstrates abrupt changes or random patterns.

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CHAPTER THREE

REGRESSION MODELS FOR ANALYZING HEAVY METALS IN HIGHWAY STORMWATER RUNOFF USING EVENT AND SITE-SPECIFIC VARIABLES

ABSTRACT

Regression models were developed for dissolved, particulate and total metals such as cadmium, chromium, copper, nickel, lead, and zinc event mean concentrations (EMCs). For some metal parameters, the dissolved metal models were better than the particulate models, and vice versa. Either the dissolved or the particulate model was presented in conjunction with the total metal model for all the metals. Four event-specific parameters such as total rainfall (T_RAIN), maximum intensity of rainfall, duration of runoff, and antecedent dry days (ADD) and three site-specific parameters such as runoff coefficient, area of the catchment, and average daily traffic (ADT) were used as independent variables in the regression models. The event-specific variables are dependent on the nature of a storm event, climatic and traffic conditions. Site-specific variables are usually considered constant for a single site but vary in among sites. They are dependent on physical characteristics of the drainage area and vehicular traffic. Additionally, the models were evaluated using linear, semi-log and inverse forms of the independent variables. Four sets of regression models were considered to evaluate metal EMCs. 59 storm events using three sites, i.e. The University of California at Los Angeles (UCLA) sites in Southern California during the rainy seasons (October to May) 1999-2003 were used in the regression analysis. The regression analysis was then extended to

an additional 83 California Department of Transportation (Caltrans) sites. Regression models developed for the individual UCLA sites and combined UCLA sites were generally good with R^2 values greater than 0.50 and greater than 0.40 respectively. T_RAIN and ADD were two of the most significant parameters for the UCLA sites. Regression models developed for the combined Caltrans sites were not good predictors of metal constituent EMCs. For the additional Caltrans sites, 14 zones were selected within the state of California to further improve the analysis. The zones were selected on the basis of geographic proximity. The basic philosophy of the zone approach was to group sites with similar weather conditions. Regression models developed for Caltrans zones were satisfactory. In general, the zones located in the central and southern part of California provided better R^2 values than the northern zones for metal constituent EMCs. Among the Caltrans zones, T_RAIN and ADT were the most influential parameter for all the models in general.

3.1 INTRODUCTION

Highway stormwater runoff is not continuous in time and only occurs during rainfall events. Highway runoff is not concentrated in a single location, depends on surrounding landuse and climatic conditions, and thus a typical non-point source (NPS). Some other examples of NPS pollution are agricultural runoff and atmospheric deposition. As greater treatment of industrial and domestic wastewaters occurs, stormwater pollution is becoming a greater fraction of the total discharge. Highways are known to be significant sources of NPS but in most of the cases, the extent of pollution is unquantified.

Stormwater pollution poses significant threats to the receiving water bodies such drinking water supply watersheds and natural environments in several ways. Stormwaters from transportation landuses may contain chemical, physical or biological contaminants. Stormwater and dry weather runoff must be regarded as a separate component in dealing with all the pollutant producing sources that threaten water bodies. In order to have a sustainable integrated management of the watershed, an extensive understanding of stormwater pollutant runoff characteristics is required.

Highways typically have an efficient drainage system that conveys stormwater to nearby surface waters in order to maintain safe driving conditions and reduce flood risk. This well designed drainage system unfortunately provides an efficient means of delivering pollutants to nearby surface waters. Typical highway pollutants include automobile and truck residues (e.g., exhaust emissions, oil, abraded tire material, and brake dust), dry deposition from surrounding activities, pavement wear and tear, residues from maintenance operations, accidental spills, and litter. Specifically, stormwater runoff includes suspended and dissolved matter, nutrients, ionic species, metals, and organic constituents. Stormwater runoff from highways often includes considerable concentrations of metals. Metals are not degradable and may bioaccumulate which creates additional regulatory concerns.

This research was undertaken to address some of the issues associated with highway stormwater pollution, and had the following specific objectives:

1. To determine the event and site-specific causal variables that influence build-up and wash-off of dissolved, particulate, and total metals at three highway sites [University of California at Los Angeles (UCLA) sites 1, 2 and 3] in southern California.
2. To develop predictive models for metal concentrations that use event-specific independent variables for the UCLA sites.
3. To develop predictive models for the combined UCLA sites that incorporate both the event and site-specific variables.
4. To analyze if the same or similar predictive models can be used for other California Department of Transportation (Caltrans) sites in different locations.

3.2 BACKGROUND

Metals in the highway stormwater runoff are found in two phases: dissolved and particulate. The separation of phases is performed with a filtration test (generally 0.45 μm membrane filtration) as opposed to a strict definition of solubility. The existence of particulate-phase metals suggest that their concentration should be correlated with suspended solids, which has been documented by Hewitt and Rashed (1992).

Metals in highway runoff are generally attributed to traffic activities, and six metals are routinely monitored: cadmium (Cd), chromium (Cr), copper (Cu), nickel (Ni), lead (Pb) and zinc (Zn) (Sartor et al. 1974). Various sources have been identified with specific metals. Tire wear is a large source of Zn (Christensen and Guinn 1979). Hopke et al. (1980) reported brake linings and exhaust emissions as additional sources of Zn. Sansalone et al. (1997) also reported frame and body corrosion as a primary source for Zn. Huntzicker et al. (1975) and Hopke et al. (1980) showed tailpipe emissions as a source of Pb. Hewitt and Rashed (1992) found the Pb to be mainly sorbed to fine particles. Sansalone et al. (1997) reported tires as the primary source of Cd, Cr, Cu, and Ni, and brakes as an additional source of Cu.

Various methods have been proposed to estimate metals in stormwater runoff from highway conditions or sources. Wu et al. (1998) analyzed stormwater data collected from highway sites in North Carolina and developed regression models for event mean concentrations (EMCs) of several water quality parameters such as total dissolved solids (TDS), total suspended solids (TSS) etc.; nutrients such as total Kjeldahl nitrogen (TKN), phosphorus (P), Ortho-phosphate (PO_4), ammonia (NH_3), nitrite (NO_2), nitrate (NO_3) etc.; and metals such as Cd, Cr, Cu, Pb etc. as a function rainfall, atmospheric deposition, and traffic counts. Irish Jr. et al. (1998) developed regression models from stormwater data collected from an expressway in Austin, Texas. Metals, such as Cu, Pb and Zn, etc.

were shown to be functions of event and site-specific variables. Kayhanian et al. (2003) presented regression models for several constituents for the Caltrans sites in terms of some event and site-specific variables, and did not separate different types of adjacent landuses. Regression equations were reported with p (probability) values only and developed for all the Caltrans sites as a whole. The current research expanded on this and previous research and considered more sites with more forms of regression equations.

The previous work generally used the EMC, which are normally used to represent stormwater pollutant concentrations (Huber 1993). The EMC is the flow-weighted average concentration collected over the entire storm event, and is equal to the total mass emission, divided the total runoff volume. EMCs are less variable than grab samples, and were used in this analysis as well. Eq. (1.1) shows the mathematical definition of EMC (Huber 1993). In case of a series of grab samples, the flow-weighted EMC is defined by the Eqs. (2.1), (2.2), and (2.3).

EMCs are useful because they can be multiplied by total runoff volume to calculate mass discharge, and avoid the high variability that is associated with grab samples (Ha and Stenstrom, 2003). They can be correlated to landuse (Stenstrom et al. 1984; Sartor et al. 1974; Smullen et al. 1999). Unit loading rates (mass of pollutant per unit area per unit of rainfall) can also be approximated from EMCs and the rational method, as shown in Eq. (2.4).

3.3 DATA SOURCE

Three sites were monitored as part of a larger project to determine the characteristics of highway stormwater runoff in California. The freeways are among the busiest in California with average daily traffic (ADT) ranging from 260,000 to 328,000 vehicles/day. The sites are typical of many freeways and are highly impervious (i.e. median runoff coefficient, RC = 0.81). The sites were all close to the UCLA campus so that sampling teams could reach the sites prior to the initiation of runoff. The smallest was 0.39 ha and the largest was 1.69 ha in area. 59 events were monitored at these sites during the rainy seasons (October to May) of 1999-00, 2000-01, 2001-02, 2002-03, and were used in this analysis. The dissolved, particulate, and total metal EMCs were obtained from the flow-weighted grab samples. Table 3.1 presents the event, site, and concentration characteristics for the UCLA sites and will be discussed later in the paper.

Data from the state-wide Caltrans monitoring program were also used. This data set included 83 additional sites, and was sampled by Caltrans contractors for years 1997 to 2002. They were located throughout California. Appendices A (1 to 4) and B (1 to 4) lists the sites and their characteristics.

The other Caltrans sites included different types of adjacent landuses. For this analysis, only those sites listed as transportation landuses (e.g., there was no significant contribution of stormwater runoff from non-transportation landuse) were used. Stormwater runoff from highways or freeways under usual conditions were considered (i.e. flows during maintenance, construction etc. were not considered). Also, composite samples representative of the whole storm events were used in the analysis. The Caltrans database contained dissolved and total metal EMCs. The particulate metal EMCs were calculated by subtracting the dissolved concentrations from the total concentrations. Overall data from 1110 monitored events for 86 sites (including three UCLA sites) were used in the analysis.

3.4 SELECTING ZONES

14 zones were selected within the state of California to further improve the analysis. The availability of information by zones will be useful to Caltrans and will help characterize the difference in climate and weather conditions across the state. The locations of the monitoring sites and zones are shown in Fig. 3.1. The highway sites are located in 8 of the 12 Caltrans districts. The zones were selected on the basis of geographic proximity. The basic philosophy of the zone approach was to group areas with similar weather conditions. The zones were numbered in the ascending order from north to south and from west to east. District 7 was a special case with the maximum number of sites and events. The sites in that district were divided into four zones with the Interstate-5 (I-5), which runs north-south, and Interstate-10 (I-10), which runs east-west, being roughly the demarcation lines.

3.5 DATA EVALUATION

Different detection limits existed for different metals and different laboratories. Table 3.2 shows the total number of monitored observations along with the number and the percentage of non-detects, rounded off to the nearest integer. For example, the last two cells in the first data row show the results of dissolved Zn for the combined Caltrans sites, and contain 803 and 15(2). This indicates that out of 803 EMC measurements, 15 values or 2% were non-detects.

Cd had the most non-detects for dissolved and total EMC measurements. For the UCLA sites, 47% of the dissolved Cd were non-detects (28 out of 59). The other Caltrans sites even had a greater number with 57% of non-detects (429 out of 750) for dissolved Cd. The non-detects for the total Cd had higher percentage for UCLA sites with 44% (26 out of 59) than for other Caltrans sites, i.e. 18% (136 out of 754).

There were also a significant number of non-detects values for dissolved Cr with 17% (131 out of 756), dissolved Ni with 28% (208 out of 753), and dissolved Pb with 43% (343 out of 802) for the other Caltrans sites. The number of non-detect values are also shown by zones in the Table 3.2. The other water quality parameters were almost always detected. As the elimination of the non-detect points would bias the regression results, half the detection limit was used for the analysis for the UCLA sites. Half the detection limit was also used for the non-detect EMCs for the other Caltrans sites.

All the laboratory analyses were performed in accordance with the U.S. Environmental Protection Agency (U.S. EPA) methods. The U.S. EPA 200.7 analytical method was employed for the analysis of metals for the three UCLA sites. For the other Caltrans sites, only the metal EMCs measured with U.S. EPA 200.8 were used in this analysis to be consistent.

3.6 METHODOLOGY

Three forms of regression models (i.e. linear, semi-log, and inverse) were used to evaluate all sites. The causal variables were divided into two categories (i.e. event and site-specific) to study their individual effects. Regressions were first performed for the three UCLA first flush sites. Based upon this experience, the entire database of Caltrans sites were studied. Comparisons were made among regression models developed for individual sites and sites grouped by zones. Regression models were developed for dissolved, particulate, and the total metals. For some metal parameters, the dissolved metal models were better than the particulate models, and vice versa. Either the dissolved or the particulate model was presented in conjunction with the total metal model for all the metals. SYSTAT 10 (Richmond, California) was used in analyzing data.

3.6.1 Selection of Causal or Independent Variables

The choice of the causal variables is dependent on whether the eventual regression models are for single sites or multiple sites. Regression models developed for a single site can not use the variables that do not vary within a site, such as, RC, catchment area (AREA), ADT etc. Conversely, regression models that incorporate multiple sites have to consider those variables. The selection of independent variables for single or multiple sites involved a 5-step approach:

1. The entire set of independent variables that have any sort of scientific relevance to the dependent variables, i.e. metal concentrations, was identified.

2. The set of independent variables was reduced by ensuring that no perfectly collinear (i.e. R = 1) variable were used.
3. Variables that can not be identified with a high degree of precision were eliminated (i.e. atmospheric deposition, which is not measured at present).
4. Independent variables that demonstrated a high degree of correlation with other independent variables (i.e., RC is highly correlated to imperviousness) were identified.
5. The independent variables with better correlation coefficients to the dependent variables (e.g., metals concentrations) were selected using a correlation matrix.

In the first step, the set of independent variables that influence metal concentrations were divided into 5 categories: (1) storm-specific, (2) catchment-specific, (3) traffic-specific, (4) climate-specific, and (5) landuse-specific. The variables related to storm include T_RAIN, duration of rainfall (D_RAIN), average intensity of rainfall (AVE_RAIN), maximum intensity of rainfall (MAX_RAIN), total runoff (T_RUN), duration of runoff (D_RUN), average runoff rate (AVE_RUN), and peak flow rate (PEAK_FLOW). The causal variables associated with a specific catchment area are RC and AREA. Traffic characterization variables include ADT, vehicles during a storm event (VDS), antecedent traffic count (ATC), and maximum/average vehicular speed. The ATC is the product of ADT and antecedent dry days (ADD). The climate-specific variables include ADD and temperature during a storm event. Lastly, the independent variables related to the landuse are atmospheric dry and wet depositions. Not all variables were collected or measured for all Caltrans sites.

The second step was to perfectly collinear variables. Among the storm-specific variables, AVE_RAIN is obtained by dividing T_RAIN with D_RAIN. In the same way, AVE_RUN is obtained from T_RUN and D_RUN. Therefore AVE_RAIN and AVE_RUN were eliminated from our analysis.

The third step is to eliminate variables that cannot be measure with great precision. The duration of rainfall was not used because rainfall starts and stops during a storm event were not recorded, or were below the precision of rain gauges. Vehicle traffic during storm events is a useful parameter (Wu et al 1998), but was not measured for either the UCLA sites or the state-wide monitoring program. No data were available for maximum/average vehicular speed and temperature during storm events.

Atmospheric deposition, also known as bulk precipitation (Wu et al. 1998), occurs in the form of dustfall during both dry and wet weather conditions. The surrounding landuse is the key factor in determining the quality and type of deposition. Harrison and Wilson (1985) showed rainwater to be a significant source of suspended solids and several ionic constituents. No comprehensive data were available at the time of our research, although work is underway by various investigators for other sites (Lu et al. 2003).

In the fourth step, the remaining variables were divided into two categories: (1) event-specific and (2) site-specific variables. For our case, the event-specific variables are dependent on the nature of a storm event, climatic and traffic conditions. T_RAIN,

T_RUN, MAX_RAIN, PEAK_FLOW, D_RUN, ADD, and ATC were chosen as event-specific factors. Site-specific variables are usually considered constant for a single site but vary in among sites. They are dependent on physical characteristics of the drainage area and vehicular traffic. RC, AREA, and ADT were identified as site-specific variables.

To further assist our analysis, we grouped the event-specific variables into four sets to characterize the phenomena occurring during storms. The first set characterizes the magnitude of the rain event, and can be indicated by either T_RAIN or T_RUN. The second group characterizes the instantaneous rainfall and can be indicated by either MAX_RAIN or PEAK_FLOW. The third phenomenon is the duration of the storm event, which can be characterized by D_RUN. The final phenomenon is the load producing the contaminants, which can be characterized by ADD or ATC. The objective was to select one variable within each group to avoid correlation among independent variables, and to pick the variables most easily measured or determined. Table 3.3 shows that there are strong correlation between T_RAIN and T_RUN; MAX_RAIN and PEAK_FLOW, and ADD and ATC for the combined and individual UCLA sites. The results justify our initial assumptions to pick one causal variable from each set.

Now the fifth step is to determine which independent variable to pick from each set. Tables 3.4A and 3.4B show the correlation matrix between event-specific variables and, dissolved, particulate, and total metals for the individual and combined UCLA sites. The table does not demonstrate any significant difference in R between T_RAIN and T_RUN; MAX_RAIN and PEAK_FLOW, and ADD and ATC. T_RAIN and MAX_RAIN were preferred over T_RUN and PEAK_FLOW because the former two variables can be obtained from simple rain gage data. ADD was chosen over ATC because ADD is simpler variable. T_RAIN, MAX_RAIN, D_RUN, and ADD were thus selected as event-specific variables, and RC, AREA, and ADT were selected as site-specific variables.

3.6.2 Regression Models

First we short-listed the causal variables with the aid of correlation matrices and then selected 4 sets of models [i.e. Models 1 to 4 as shown by Eqs. (3.1) to (3.4)] each having three forms (i.e. linear, semi-log, inverse), and then coefficients of the causal variables were determined for dissolved, particulate, and total metal EMCs:

$$Model1: EMC = a + b \cdot T\_RAIN + c \cdot MAX\_RAIN + d \cdot D\_RUN + e \cdot ADD \tag{3.1}$$

$$\begin{aligned} Model2: EMC &= a + b \cdot T\_RAIN + c \cdot MAX\_RAIN + d \cdot D\_RUN + e \cdot ADD \\ &+ f \cdot RC + g \cdot AREA + h \cdot ADT \end{aligned} \tag{3.2}$$

$$Model3: EMC = a + b \cdot T\_RAIN + e \cdot ADD \tag{3.3}$$

$$Model4: EMC = a + b \cdot T\_RAIN + e \cdot ADD + f \cdot RC + g \cdot AREA + h \cdot ADT \tag{3.4}$$

All the regression equations had intercepts, because forcing the intercept to zero decreases the precision of the models. Though several regression equations might have multicollinearity among the independent variables, it did not affect the analytical performance of the models; rather it only made the effect of the independent variables on the dependent variable less clear. Another point to note is that model 3 has only two variables (i.e. T_RAIN and ADD). It is imperative to have at least two causal variables in a stormwater quality regression equation; one representing the build-up mechanism (i.e. ADD) and the other relating the wash-off mechanism (i.e. T_RAIN). This is the reason why we kept at least two variables in the regression equations, even if a single causal variable was apparently enough to make good predictions, i.e. ADD for UCLA site 3 had in general good correlations with the metal parameters as shown in Table 3.4A.

For each model, three forms were evaluated: linear form, as shown above; semi-log, where the log of the independent variable was used, and the inverse form, where the reciprocal of each independent variable was used. Eqs. (3.5) and (3.6) are examples of the semi-log and inverse forms for model 1.

$$\begin{aligned} EMC &= a + b \cdot \log_{10}(T\_RAIN) + c \cdot \log_{10}(MAX\_RAIN) \\ &+ d \cdot \log_{10}(D\_RUN) + e \cdot \log_{10}(ADD) \end{aligned} \tag{3.5}$$

$$EMC = a + \frac{b}{T\_RAIN} + \frac{c}{MAX\_RAIN} + \frac{d}{D\_RUN} + \frac{e}{ADD} \tag{3.6}$$

The main criteria of the regression equations are as follows:

1. Model 1 estimates metal concentrations as a function of all four event-specific variables, and can only be used if flow data are available (i.e., after the storm, or using assumed or typical data). Model 2 complements model 1 with site-specific variables that are known in advance. Models 1 and 2 are useful for the analysis of

previous data. The reason for presenting both equations was to show the improvement in the accuracy with the inclusion of site-specific variables.

2. Model 4 complements model 3 with the sites-specific variables as well. Models 3 and 4 include only T_RAIN as a predicted variable, which should be to predictable from weather forecasts; these two equations should be most useful for predictions.

The usual process of inclusion of causal variables in regression models is a trial and error one. Statistical theory requires that the independent variables in the regression equations be reasonably uncorrelated with each other. The previously described selection process reduced the chance of correlation among independent variables, but this criterion is almost impossible to meet with stormwater data because of the nature of the phenomena that affect stormwater production. It is almost impossible to separate the independent variables that can directly affect the runoff quality. For example, as the T_RAIN increases, the D_RUN also tends to increase. Therefore, we picked the independent variables that represented known or accepted mechanisms, as opposed to exploring each regression to determine which independent variable among a set of correlated independent variables provided the best fit.

After choosing the types and forms of the regression equations, we applied them to individual and combined UCLA sites. The regression models with site-specific variables [i.e. Models 2 and 4] do not apply for individual sites. The analysis was then extended to other Caltrans sites, grouped into zones and as a whole.

3.7 RESULTS AND DISCUSSION

The initial set of causal variables was reduced to a smaller set of event and site-specific variables with the aid of correlation matrices presented in Tables 3.3 and 3.4A and 3.4B. Next a set of four equations [i.e. Models 1 to 4] with three different forms (i.e. linear = form 1; semi-log = form 2; inverse = form 3) were chosen for this research. From these equations, additional analyses were performed as follows:

1. Analyses of event, site, and constituent characteristics were presented for UCLA sites and other Caltrans sites and zones.
2. Regression models were developed for models 1 and 3 for the three individual UCLA sites.
3. Regression models 1 to 4 were developed for combined UCLA sites.
4. Regression models were developed for the other Caltrans sites as a whole.
5. Regression models were formulated for individual zones for the other Caltrans sites.
6. A final comparison was made between the UCLA sites and other Caltrans zones and sites.

3.7.1 Analysis of Event, Site, and Constituent Characteristics

The total numbers of runoff events used in the analysis for the individual and combined UCLA sites are presented in Table 3.1 along with even-specific, site-specific, and constituent characteristics in terms of median values except for the site-specific variables (i.e. RC, AREA, and ADT) for the individual sites. Fig. 3.2 shows the comparison among the individual and combined UCLA sites with respect to event-specific variables. Among the UCLA sites, the RC and the ADT values did not vary, whereas the AREA values were significantly different. The T_RAIN per event for site 1 had the greatest value (16.51 mm) and so was the D_RUN (8.97 hrs). Site 3 observed the highest MAX_RAIN (16.77 mm/hr). Though the ADD values were different for the three sites, they were only representative of the storms that were used in the analysis, not the median values of all the storm events for the sites.

The median constituent characteristics for the UCLA sites are shown in Figs. 3.3A, 3.3B, and 3.3C. In general, the dissolved, particulate, and total metal concentrations were higher at site 2, which had the largest catchment area (1.69 ha), and lower for site 1 which had the smallest area (0.39 ha). The exception was site 3, which had the highest median EMCs for dissolved, particulate, and total Pb (3.00, 23.92 , and 27.21 μg/L, respectively).

The site, event, and constituent medians for the Caltrans zones along with combined UCLA and combined other sites are presented in Table 3.5. The graphical representation of Table 3.5 is shown in Figs. 3.4A and 3.4B; and 3.5(A to F). Between combined UCLA and combined other Caltrans sites, The T_RAIN and D_RUN values were higher for the combined Caltrans sites while the ADD values were higher for UCLA sites. MAX_RAIN showed similar values among sites. Also among the site-specific factors AREA and ADT values were higher for UCLA sites, while RC values were lower.

For the dissolved, particulate and total metal concentrations, the median values for the combined UCLA sites were higher than other Caltrans sites with the exception of dissolved Cr; and particulate Cd and Zn. The smaller values of T_RAIN and higher values of ADD and ADT may have caused the higher metals concentrations.

Table 3.5; and Figs. 3.4A and 3.4B show the median values of the site and event-specific parameters for the combined UCLA sites and Caltrans zones. For the combined UCLA sites and Caltrans zones, the median values of RC are high ranging from 0.70 to 1.0, showing that the sites are all relatively impervious. The AREAs are low for all zones except zone 13 and the combined UCLA sites, which are 5 to 20 times larger than most of the other AREAs. Zone 13 is composed for four sites in District 11 (San Diego County). The median ADT values for the zones ranged between 0.13×10^5 and 2.42×10^5 vehicles/day; the UCLA sites had the highest median ADT (i.e. 3.22×10^5). Among the event-specific independent variables, the median T_RAIN (30.99 mm) and ADD (17 days) were the highest for zone 12. Zones 8 and 10 experienced the highest MAX_RAIN values (24.38 mm/hr); whereas, zone 2 had the maximum D_RUN value of17.58 hrs.

The median constituent characteristics for the zones are shown in Table 3.5 and Figs. 3.5 (A to F). The dissolved metal EMCs were more or less consistent throughout the zones. Zone 9 had extremely high median particulate and total EMC values. The event-specific factors for zone 9 were not different than the other zones, with the exception of the ADD value (3.40 days) which was the lowest among all the zones.

There is no obvious reason for the high EMCs for zone 9. Zone 9 consists of two Caltrans sites, i.e. 7-143 and 7-147, which are located in East Los Angeles. East Los

Angeles has traditionally had higher amounts of smog, and atmospheric fall out might be an important source.

3.7.2 Regression Models for Individual UCLA Sites

Regression models 1 and 3 were developed for metal parameters and the results are presented in Tables 3.6A (site 1), 3.6B (site 2), 3.6C (site 3). The metal EMCs were regressed from event-specific variables [i.e. T_RAIN, MAX_RAIN, D_RUN, and ADD for model 1, and T_RAIN and ADD for model 3]. Three forms of equations, namely, linear, semi-log, and inverse were considered for these multiple regressions. Only the best form of the equation was presented for each site and each model. Table 3.6A, 3.6B, and 3.6C show the type of model, values of intercepts, coefficients and p value (obtained from 2-tailed t statistic) associated with each causal variable, values of R^2, p for the entire equation derived from F statistic (p_{Reg}), number of events considered (count), forms of models, and the constituent parameter. In the form column, 'D' denotes dissolved, 'P' denotes particulate, and 'T' denotes total metal. The best equation between the dissolved and the particulate metal is presented along with the total metal equation. Also, 1, 2, and 3 are associated with linear, semi-log, and inverse form respectively. The last column represents the relevant metal constituent. For example, consider the first regression equation representing UCLA site 1 in Table 3.6A for Cd.

$$\begin{aligned} EMC = 0.80 + 1.29 \cdot \log_{10}(T\_RAIN) - 1.09 \cdot \log_{10}(MAX\_RAIN) \\ - 1.10 \cdot \log_{10}(D\_RUN) + 0.14 \cdot \log_{10}(ADD) \end{aligned} \tag{3.7}$$

The p values associated with the intercept and the coefficients of T_RAIN, MAX_RAIN, D_RUN, and ADD are <0.01, 0.01, 0.01, 0.01, and 0.23 respectively. The R2 and p value for the regression model is 0.57 and 0.03 respectively. The count column shows a value of 17, which indicates the number of storm events considered for the model. The form column shows ‘P2’, which in turn indicates that the model was developed for the particulate phase using the semi-log from as shown in Eq. (3.7). In general, R^2 values were greater than 0.50 and the regression equations were significant with 99% confidence interval (i.e. $p<0.01$). In general, the total Pb EMC for sites 1 (R^2 = 0.18, Table 3.6A), 2 (R^2 = 0.07, Table 3.6B), and 3 (R^2 = 0.12, Table 3.6C) for regressions for model 3 were very poor. The particulate Pb EMC for the same model for site 1 showed a low value of R^2 (0.23) as shown in Table 3.6A.

Tables 3.7 and 3.8 show the median R^2 and p values of the regressions for individual UCLA sites. Table 3.7 shows the median values of all the constituent parameters for individual sites in terms of R^2, p_{Reg}, and p values of the event-specific variables. For example, the R^2 (0.64) value for UCLA site 1 in the first data row represents the median of the six R^2 values developed for six dissolved/particulate (i.e. for some metal parameters, the dissolved metal models were better than the particulate models, and vice versa. So dissolved/particulate means either the dissolved or the particulate model was presented) constituents (i.e. Cd, Cr, Cu, Ni, Pb, and Zn) for regression model 1. For the dissolved/particulate metals, R^2 and p_{Reg} values were generally good. The R^2 values for site 2 (Model 1: 0.89; model 3: = 0.87) indicated that the variables provided the best estimate for that site. The R^2 for site 1 [Model 1: 0.64; model 3: = 0.47] indicated the least reliable prediction among the three sites. The accuracy of prediction for site 3 dissolved/particulate EMC [Model 1: 0.78; model 3: = 0.71] fell somewhere in the middle. The median R^2 values for the total metals also showed best results for site 2 and the least reliable result for site 1 for both the models.

The significance of the independent variables for the individual UCLA sites is shown by the median p values associated with their coefficients in Table 3.7. For the dissolved/particulate metals, MAX_RAIN proved to be the most significant variable with the least p value (0.01) for model 1 and ADD was the least significant for models 1 (0.09) and 3 (0.26) for site 1. For UCLA site 2, T_RAIN proved to be by far the significant independent variable in both the models 1 and 3 with p values of 0.01 and <0.01 respectively. Site 3 regression models were dominated by ADD with p values of <0.01 for both the models for dissolved/particulate phase. For the total metals, median p values from the Table 3.7 indicate that ADD was the most dominant (i.e. the term ‘dominant’ is a synonym of ‘most significant’) parameter for UCLA sites 1 and 3, and T_RAIN for site 2 for the regression models 1 and 3.

Table 3.8 shows the median values of all the sites for individual constituent parameters in terms of R^2, p_{Reg}, and p values of the event-specific variables. For example, the R^2 (0.77) value for dissolved/particulate Cd in the first data row represents the median of the three R^2 values developed for three individual UCLA sites for regression model 1. In general, the median R^2 and p_{Reg} values for all the constituent parameters were very good. The model 3 regression for total Pb had the lowest value of R^2 (0.12) for the individual UCLA sites. Among the individual event-specific parameters, T_RAIN and ADD were generally significant for all the models. T_RAIN was the most significant variable for Cd; and ADD was the most significant variable for Cr, Cu, and Ni for dissolved/particulate and total constituents for regression model 1. For dissolved/particulate Zn, T_RAIN and D_RUN were equally significant, and ADD was most significant for total Zn for the individual UCLA sites for the same model. Among the parameters for the UCLA sites, Pb was the odd constituent. T_RAIN and MAX_RAIN were most significant for dissolved/particulate and total Pb respectively for regression model 1. For regression model 3, T_RAIN was the dominant variable for Cd, Cr, and Pb; whereas, ADD was most significant for Cu and Ni for both dissolved/particulate and total phase. T_RAIN was a significant parameter for dissolved /particulate Zn, and ADD was the most significant for total Zn.

Table 3.9 shows the outcome of applying the various models, phases, and forms to the Caltrans zones and UCLA sites. The values generally show the number of times a model for a specific phase (dissolved or particulate), and form (linear, semi-log, inverse) fit best. The “dissolved” and “particulate” rows show the number of times a dissolved or particulate model best fit the data. The number of models adds to six per site, since there are six metals. For example, for model 1, the dissolved phase fit better, 13 times out of 18 for all three UCLA sites. If the sites are pooled, the dissolved phase fit better 5 times out of 6.

The forms of the models are also shown in Table 3.9. Generally, for model 1, form 3 (inverse) fit better 15 out of 36 times for the UCLA sites. Similarly, for model 3, the dissolved phase also fit better, 15 times out of 18 for all three individual UCLA sites. model 3, form 3 (i.e. inverse) fit better 17 out of 36 times. The Table 3.9 shows that no one model or form of the model best fit the various sites.

The median values for model 3 in Tables 3.7 and 3.8 indicated that using 2 causal variables (i.e. T_RAIN and ADD) provided good estimates in terms of R^2 for dissolved/particulate and total metals, and were thus could be useful for prediction. Adding the other two variables (i.e. MAX_RAIN and D_RUN) improved the estimate significantly for the site 1 dissolved/particulate and total values, and to a lesser degree for sites 2 and 3 as indicated by Table 3.7. Table 3.8 shows that adding the two additional independent variables improved only the estimates for total Cr (R^2 = 0.67 versus 0.37) and Pb (R^2 =0.33 versus 0.12) significantly.

3.7.3 Regression Models for Combined UCLA Sites

Regression analysis was performed to determine if metal EMCs could be predicted with a reasonable degree of accuracy for combined UCLA sites. In this case, regression models 2 and 4 were additionally used to account for the site-specific variables. The objective was to formulate regression models for dissolved/particulate and total metal EMCs for the combined UCLA sites. Tables 3.10A and 3.10B show the regression results for dissolved/particulate and total metals respectively. In general, the models proved to be good predictors of the metal constituent EMCs. Only model 3 failed to provide good estimates for total Pb concentration (R^2=0.04, Table 3.10B). All the other regression models were statistically significant at 99% confidence interval. The results suggest that using T_RAIN and ADD as the independent variable (i.e. model 3) gives a good estimate for the dissolved/particulate and total metal EMCs.

Table 3.11 shows the median values of all the regression parameters for the combined UCLA sites. Table 3.11 is similar to Table 3.7, except that Table 3.11 has two additional models, i.e. regression models 2 and 4. For example, the R^2 (0.52) value for the combined UCLA sites in the first data row represents the median of the six R^2 values developed for six dissolved/particulate constituents (i.e. Cd, Cr, Cu, Ni, Pb, and Zn) for regression model 1. For dissolved/particulate metals, all the regressions equations were reasonable predictors of EMCs. The median R^2 values for models 1 to 4 for all the dissolved/particulate metals were 0.52, 0.58, 0.44, and 0.53 respectively. The total metal EMC models were also formulated with reasonable degrees of accuracy. Models 1 to 4 had median R^2 values of 0.45, 0.58, 0.39, and 0.51 respectively as shown in Table 3.11.

The relative contribution of the independent variables can be inferred from the p values in Table 3.11. D_RUN was dominant for the dissolved/particulate fraction for models 1 and 2. For models 3 and 4, T_RAIN and ADD were both highly significant for both dissolved/particulate metals. For the total metals among the combined UCLA sites, ADD proved to be the most significant independent variable for models 1 and 2, i.e. p values of 0.01 and <0.01; and both T_RAIN and ADD for models 3 and 4. In general, the coefficients of D_RUN and ADD were consistently significant for the regression models. The site-specific variables were less significant to the event-specific variables.

The significance of event and site-specific variables on the metal constituents is presented in Tables 3.10A and 3.10B. For the dissolved/particulate metals (as shown in

Table 3.10A), ADD was the dominant variable for Cd for models 1 and 3 with p values of <0.01. ADD was the most significant parameter for models 1 and 2; and both T_RAIN and ADD for models 3 and 4 with p values of <0.01 for dissolved/particulate Cr. Among the site–specific parameters, ADT was a significant parameter for all the relevant models for Cd and Cr. MAX_RAIN dominated regression models 1 and 2 for the dissolved/particulate Cu and Zn with MAX_RAIN, D_RUN, and ADD dominating the same two models for Ni. For models 3 and 4, T_RAIN and ADD were significant for Cu and Ni with <0.01 p values; and T_RAIN alone for Zn considering dissolved/particulate fraction. D_RUN dominated models 1 (0.01) and 2 (0.04) for dissolved/particulate Pb; and T_RAIN for models 3 and 4 with <0.01 p values. AREA was also a controlling parameter for models 2 (0.07) and 4 (0.01) for dissolved/particulate Pb.

For the total metals (as shown in Table 3.10B), ADD seemed to be the most significant independent variable for models 1 and 2; and both the T_RAIN and ADD were dominant for models 3 and 4 for Cd, Cr, Cu, and Ni. ADT was also significant for Cd, Cr, and Cu. D_RUN was the most significant parameter for total Pb EMC model 1 (<0.01) as shown in Table 3.10B. The site-specific variables of RC and ADT were dominant for models 2 and 4 for total Pb. For total Zn, MAX_RAIN controlled models 1 (0.04) and 2 (0.03), and T_RAIN was dominant for models 3 and 4 with <0.01 p values. ADT was also dominant for models 2 (0.07) and 4 (0.05) for total Zn regression models.

Going back to Table 3.9, the dissolved phase models heavily controlled the combined UCLA sites with 22 regression equations out of 24 for models 1 to 4 for the metal parameters. Considering the forms of the regression equations, semi-log form dominated models 3 and 4 with similar numbers, i.e. 7 out of 12. For models 1 and 2, no parameter was obviously dominant being established by any of the form.

3.7.4 Regression Models for Other Caltrans Sites as a Whole

Of concern is the degree to which the regression models are applicable to the estimation of metal concentrations at the other Caltrans sites. Regression models 1 to 4 have parameters that account for the changes in storm, traffic, climatic, and catchment patterns. The models developed for the combined UCLA sites with the same coefficients were applied to all other Caltrans sites as a whole to check their portability. The results are presented in Table 3.12. Table 3.12 is a correlation matrix for the predicted and actual values of dissolved/particulate and total metal concentrations for all other Caltrans site. The correlation results were poor. None of the R values were greater than 0.5 and several of the combined UCLA regression models fit the data more poorly than the mean (i.e., no correlation in Table 3.12, which refers to the case that the regression models provided estimates worse than using the mean of the data set as the estimate) for the other Caltrans sites as a whole, as shown in Table 3.12.

Regression models developed for the UCLA sites were not useful for other Caltrans sites. The landuse pattern; and storm, traffic, climate, and drainage area differences may result in numerical change in the model coefficients. Hence, similar regression models (i.e. models 1 to 4) were developed for the other sites with different model coefficients. The regression model R^2 values are presented in Table 3.13 for dissolved/particulate and total metals. Only the dissolved/particulate and total phase of

Cu and dissolved/particulate phase of Ni showed some degrees fit. No single set of coefficients for any of the models or forms fit the Caltrans sites as a whole. This may was expected since the various sites have widely ranging EMCs as shown in Table 3.5.

3.7.5 Regression Models for Caltrans Zones

Further regression models were developed for dissolved/particulate and total metals for individual Caltrans zones rather than all the sites together. The regression models for the zones are presented in Appendix C. The idea was that the regression models developed for the sites with close geographical proximity should work better as these sites have similar storm, traffic, climate, and surrounding landuse. Table 3.14A, 3.14B, 3.14C, and 3.14D represent the median values of all the constituent parameters for Caltrans zones in terms of R^2, p_{Reg}, and p values of the event and site-specific variables for regression models 1, 2, 3, and 4 respectively. For example, the R^2 (0.28) value for zone 1 in the first data row represents the median of the six R^2 values developed for six dissolved/particulate constituents (i.e. Cd, Cr, Cu, Ni, Pb, and Zn) for regression model 1 as shown in Table 3.14A. Similar median values were developed for regression models 2, 3, and 4 as well.

For Model 1, which has all the four event-specific variables (i.e. T_RAIN, MAX_RAIN, D_RUN, and ADD), the zones located in the central and southern part of California, i.e. zones 5 to 14 showed higher R^2 as compared to other zones for dissolved/particulate models as shown in Table 3.14A. Similar trends were observed for total metals as well. Zone 7 in Caltrans district 7 showed the best R^2 values for both the dissolved/particulate (0.73) and total (0.74) constituent EMCs for regression model 1. The model 2 results were very satisfactory for both the dissolved/particulate and total phase for all the zones in general. Zone 7 again stood out to have the best R^2 (0.75) for dissolved/particulate models and zone 9 (0.76) for particulate models as shown in Table 14B. The inclusion of the three site-specific variables, i.e. RC, AREA, and ADT in regression model 1, i.e. regression model 2, significantly improved the regression R^2 for the zones located in the northern part of California.

For the regression model 3, which has just two independent variables (T_RAIN and ADD), the median R^2 values in Table 3.14C shows that northern zones again provided the poorest regressions as compared to central and southern zones. For the total metals, some central and southern zones, i.e. zones 5, 8, 10, and 13, also provided R^2 values of less than 0.20. Zone 7 again proved to be the best zone in terms of regression R^2 for dissolved/particulate (0.63) and total (0.61) regression models 3. Adding three site-specific variables to regression model 3 significantly improved the R^2 as shown in Table 3.14D for model 4. Most of the zones exhibited very good correlation results. For model 4, zone 7 again provided excellent median R^2 values for dissolved/particulate (0.90) and total (0.89) metal models.

Tables 3.14A, 3.14B, 3.14C, and 3.14D also show the significance of the individual independent variables using median p values and significance of the models using median p_{Reg} values. For example, the p value for D_RUN (0.07) for zone 1 in the first data row represents the median of the six D_RUN p values developed for six dissolved/particulate constituents (i.e. Cd, Cr, Cu, Ni, Pb, and Zn) for regression model 1 as shown in Table 3.14A. The most of the median p_{Reg} values were significant at 99% confidence interval (i.e. $p < 0.01$) for model 1 with total models for zones 2 (0.63) and 13 (0.34) showing less reliable significance as shown in Table 3.14A. For the dissolved/particulate and total phases, T_RAIN and ADD were the significant variables in most of the zones for model 1. For regression model 2, T_RAIN and ADT, among the event and site-specific variables respectively, were consistently significant for the zones as shown in Table 3.14B. T_RAIN was the dominant variable specifically for the zones in the Southern California (i.e. zones 6 to 14) for dissolved/particulate and total phases for model 3 as shown in Table 3.14C. T_RAIN was also significant for model 4 for the metal parameter models (Table 3.14D). ADT once again was a significant parameter for most of the zones for model 4 dissolved/particulate and total phases as shown in Table 3.14D.

Further studies were made for the constituents shown in Table 3.15, which presents the median values of all the zones for individual constituent parameters for R^2, p_{Reg}, and p values of the event and site-specific variables. For example, the R^2 (0.23) value for dissolved/particulate Cd in the first data row represents the median of the fourteen R^2 values developed for 14 Caltrans zones for regression model 1. The median values in Table 3.15 for model 1 suggests that Cd, Cr, and Pb models were less reliable as compared to other metals for both the dissolved/particulate and total models for the Caltrans zones. The Cu and Ni regression models proved to be the best estimates for Caltrans zones with same R^2 values for dissolved/particulate (0.49) and total (0.36) fractions. The model 2 regression results were satisfactory with the inclusion of three site-specific variables for all the metal constituents. The Cd, Cr, and Pb regression results improved significantly for model 2 as compared to model 1. Cu provided the best model 2 results for both the dissolved/particulate (0.63) and total (0.64) fractions.

Model 3 results presented in Table 3.15 indicates that Cd, Cr, and Pb again provided less than reliable estimates for both dissolved/particulate and total models. Adding the site-specific variables to model 3 significantly improved the R^2 as shown by model 4 equations. The satisfactory R^2 values for model 4 for the metals are important for this research. Model 4 which has only one independent variable requiring weather predictions (i.e. T_RAIN) can be very useful for predicting constituent EMCs for dissolved/particulate and total metal constituents. Cu again stood out to have the best regression models with an R^2 of 0.57 for dissolved/particulate and total regression models.

The significance of event and site-specific variables on the metal constituents in terms of median p values were also presented in Table 3.15 along with median p_{Reg} values. For example, the p value (0.01) for dissolved/particulate Cd in the first data row for T_RAIN represents the median of the fourteen R^2 values developed for three individual Caltrans zones for regression model 1. Most of the p_{Reg} values for models 1 to 4 for dissolved/particulate and total metals were significant at 99% confidence interval (i.e. $p_{Reg} < 0.01$). T_RAIN was the most significant variable for models 1 and 2 for the metal parameters. ADD was also significant specifically for model 2. ADT was the most significant independent variable for model 2 with all the median values being significant at 99% confidence interval (i.e. $p < 0.01$) for the dissolved/particulate and total metals as shown in Table 3.15. T_RAIN was consistently significant for models 3 and 4. Once again, ADT proved to be the most significant variable for dissolved/particulate and total metals for model 4 as presented in Table 3.15.

Table 3.9 presents the number of dissolved and particulate models along with the total number of equations for forms 1, 2, and 3 for different zones for different regression models. Among the dissolved and particulate phase models, models 1 (48 out of 78) and 3 (45 out of 84), i.e. the models that contain the event-specific variables only, were dominated by dissolved phase models. Particulate phase dominated models 2 (42 out of 78) and 4 (52 out of 84) for the Caltrans zones. Among the forms, form 2 dominated all the regression models, i.e. 75 out of 156, 57 out of 120, 81 out of 168, and 55 out of 130 for models 1 to 4 respectively.

3.8 COMPARISON OF REGRESSION MODELS

Four sets of regression models were developed to estimate dissolved/particulate and total metal EMCs: individual UCLA sites; combined UCLA sites; combined Caltrans sites, and individual Caltrans zones. To further improve the approximations, regression models were developed for all the individual Caltrans sites. The results are presented in Appendix D. Tables 3.16A and 3.16B present the final comparison for the regression models in terms of R^2. In Tables 3.16A and 3.16B, each group of models consists of six possible R^2 values. First four values of R^2 are values for models 1 to 4 for all the sites in the group considered together, and the last two values are the median R^2 values for all the models developed for individual sites in the same group for models 1 and 3. For example, for the combined UCLA sites, the first four values 0.53, 0.59, 0.43, and 0.59 are the values of R^2 for all the events in the three UCLA sites for models 1 to 4 for dissolved/particulate Cd. The fifth value of 0.77 is the median R^2 value of three values developed for the three individual sites for regression model 1 for dissolved/particulate Cd. Similarly, the following value, i.e. 0.75 is the median R^2 value for model 3. For the Caltrans zones, models 1 to 4 considers all the events in that zone for the respective constituents, and the median values of models 1 and 3 are the median of all the models developed for the individual sites in that zone for the respective constituents.

UCLA site 1 showed lower values of R^2 among the three individual sites. Regression models developed for individual sites were better than combined sites in general. UCLA sites 2 and 3 regression model R^2 values were better than combined UCLA sites for all the metal parameter EMCs. Some of the model R^2 values for site 1 were lower than the combined UCLA sites, for example, model 3 value for total Zn for UCLA site 1 was 0.33 as compared to 0.46 for the combined UCLA sites as shown in Table 3.16B. The median values for regression models 1 and 3 for all the metal constituents were better than combined models. For example, for total Zn, the model 1 and 3 R^2 values for the combined UCLA sites were 0.51 and 0.46 respectively as shown in Table 3.16B. The corresponding median values of R^2 considering three individual sites were 0.78 and 0.75 as shown in Table 3.16B.

The combined Caltrans sites produced the poorest results in terms of R^2 as shown in Tables 3.16A and 3.16B. Only the dissolved/particulate models for Cu showed R^2 values of above 0.3, i.e. 0.31, 0.38, and 0.34 for models 1, 2, and 4 respectively as shown in Table 3.16A. Caltrans zones in general provided satisfactory regression results as discussed before. There were a few cases where the combined Caltrans models were better than individual zones, for example, the dissolved/particulate Cu for model 4 for combined Caltrans sites had a value of R^2 of 0.34 as compared the respective zone 4 value of 0.21 as shown in Table 3.16A. The Tables 3.16A and 3.16B median values also suggest that the individual sites in a zone provide better models than the combined sites in that zone. There were a very few cases in which the median R^2 value for the sites in a zone was less than the value for the combined sites in that zone, for example, the total Ni regression model 3 for Caltrans zone 7 showed an R^2 value of 0.77 which was more than the corresponding median values of the individual sites (0.72) as shown in Table 3.16B.

The regression models developed for the combined UCLA sites and Caltrans zones can also be compared. In most of the cases, the combined UCLA sites provided better predictions in terms of R^2 as compared with the Caltrans zones. The reason might be the case that in general, the sites in the Caltrans zones were more in number and geographically separated than combined UCLA sites. The regression models for the Caltrans zones 7, 9, 11, and 13 were better predictors of dissolved/particulate and total metal EMCs than the combined UCLA sites.

The regression results suggested that the more localized the information was, the better was the regression results. For the UCLA sites, the individual UCLA sites provided better approximations of metal EMCs than the combined UCLA sites. The Caltrans sites as a whole provided the least reliable estimation. The R^2 values for the Caltrans zones improved significantly, whereas, the individual sites provided the best estimates among the other Caltrans sites.

3.8 CONCLUSIONS

Regression models were developed for dissolved, particulate and total metals [cadmium (Cd), chromium (Cr), copper (Cu), nickel (Ni), lead (Pb), and zinc (Zn)] with four event-specific [i.e. total rainfall (T_RAIN), maximum intensity of rainfall (MAX_RAIN), duration of runoff (D_RUN), and antecedent dry days (ADD)] and three site-specific [i.e. runoff coefficient (RC), catchment area (AREA), and average daily traffic (ADT)] parameters as independent variables. 59 storm events using three sites (i.e. UCLA sites) in Southern California during the rainy seasons (October to May) 1999-2003 were used in the regression analysis. The regression analysis was then extended to an additional eighty-three California Department of Transportation (Caltrans) sites. Finally, a comparison was made between the regression results in terms of correlation coefficient (R^2), and probability (p) value.

Four sets of regression models were considered, as follows:

1. Metal EMCs as a function of four event specific variables.
2. Metal EMCs as a function of four event-specific variables and three site specific variables
3. Metal EMCs as a function only of T_RAIN and ADD.

4. Metal EMCs as a function of T_RAIN, ADD, and three site specific variables.

Additionally, the models were evaluated using linear, semi-log and inverse forms of the independent variables.

This paper provided mathematical relations that support the following conclusions:

1. Among the three UCLA sites, site 2 with the largest catchment area (1.69 ha) showed the highest dissolved and total metal EMCs. Site 1 with the smallest catchment area (0.39 ha) showed the lowest EMCs.
2. Between the three UCLA sites and eighty three Caltrans sites, the metal constituent EMCs for the UCLA sites were higher. The smaller values of T_RAIN and higher values of ADD and ADT may have caused the higher metals concentrations for the UCLA sites.
3. Regression models developed for the three individual UCLA sites for the metal EMCs were generally good [R^2 values were greater than 0.50 and the regression equations were significant with 99% confidence interval (i.e. $p_{Reg}<0.01$)] with site 2 providing the best predictions.
4. T_RAIN was the most influential parameter for the UCLA sites 1 and 2; and ADD was for site 3 for the metal constituent regression models.

5. Regression models developed for combined UCLA sites were generally good [R^2 values were greater than 0.40 and the regression equations were significant with 99% confidence interval (i.e. $p_{Reg}<0.01$)].
6. For the combined UCLA sites, D_RUN and ADD were the influential parameters for regression models 1 and 2, and T_RAIN for models 3 and 4 for the metal constituents.
7. The R^2 values for the individual and the combined UCLA sites were good for model 3 with two independent variables of T_RAIN and ADD for dissolved/particulate and total metals, and thus were very useful for the prediction purposes
8. Regression models developed for the combined Caltrans sites were not good predictors of metal constituent EMCs.
9. Regression models developed for Caltrans zones were satisfactory. In general, the zones located in the central and southern part of California (zones 5 to 14) provided better results than the northern zones for metal constituent EMCs.
10. Among the Caltrans zones, T_RAIN and ADT were the most influential parameter for all the models in general.

NOTATION

ADD = Antecedent dry days (day);

ADT = Average daily traffic (×10^5 vehicles/day);

AREA = catchment area (ha);

ATC = Number of cars before a storm event (i.e. product of ADD and ADT);

AVE_RAIN = Average intensity of rainfall (mm/hr);

AVE_RUN = Average runoff rate;

Caltrans = California Department of Transportation;

Cd = Cadmium (µg/L);

Cr = Chromium (µg/L);

Cu = Copper (µg/L);

D_RAIN = Duration of rainfall (hr);

D_RUN = Duration of runoff total runoff (hr);

EMC = Event mean concentration (µg/L);

MAX_RAIN = Maximum intensity of rainfall (mm/hr);

NH_3 = Ammonia;

Ni = Nickel (µg/L);

NO_3 = Nitrate;

NO_2 = Nitrite;

NPS = Non-point source;

P = Total phosphorus;

p = Probability value for individual independent variables (two-tailed t-statistic);

PEAK_FLOW = peak flow of runoff (L/sec);

Pb = Lead (µg/L);

PO_4 = Ortho-phosphate;

p_{Reg} = Probability value for the regression equation as a whole (F-statistic);

R = Correlation coefficient;

RC = Rational runoff coefficient (-);

SC = Specific Conductance;

TDS = Total dissolved solids (mg/L);

TKN = Total Kjeldahl nitrogen;

TSS = Total suspended solids (mg/L);

T_RAIN = Total rainfall (mm);

T_RUN = total runoff volume (L);

UCLA = University of California at Los Angeles;

U.S. EPA = United States environmental protection agency;

VDS = Vehicles during storm, and

Zn = Zinc (µg/L).

Table 3.1. Summary of Event, Site and Metal *EMC* characteristics for the UCLA Sites in Terms of Median[a] Values

		UCLA 1 (7-201)[b]	UCLA 2 (7-202)[b]	UCLA 3 (7-203)[b]	UCLA all[c]
Dissolved (:g/L)	Cd	0.45	0.74	0.10	0.15
	Cr	1.79	2.76	1.36	1.87
	Cu	31.20	55.19	18.89	28.18
	Ni	8.98	10.90	4.37	6.67
	Pb	2.50	2.52	3.00	2.56
	Zn	177.40	276.00	104.76	157.99
Particulate (:g/L)	Cd	0.10	0.56	0.10	0.10
	Cr	4.28	9.48	5.25	6.20
	Cu	16.27	34.32	15.53	17.58
	Ni	2.67	4.46	2.86	3.19
	Pb	8.37	20.81	23.92	19.53
	Zn	66.20	93.62	59.98	67.22
Total (:g/L)	Cd	0.51	1.25	0.10	0.58
	Cr	6.26	12.44	6.22	7.44
	Cu	45.38	89.51	36.96	50.28
	Ni	11.39	15.59	7.95	10.20
	Pb	11.82	23.45	27.21	22.55
	Zn	197.90	361.33	178.93	234.17
Event-specific variables	T_RAIN (mm)	16.51	10.42	12.83	12.19
	MAX_RAIN (mm/hr)	6.10	12.19	16.77	12.19
	D_RUN (hr)	8.97	5.30	5.09	5.48
	ADD (day)	11.68	14.55	6.16	11.53
Site-specific variables	RC (-)	0.81	0.77	0.85	0.81
	AREA (ha)	1.28	1.69	0.39	1.28
	ADT ($\times 10^5$ vehicles/day)	3.28	2.60	3.22	3.22

[a]Site-specific variables for the UCLA sites 1, 2, and 3 don not vary within a site.

[b]Caltrans site ID for the UCLA sites are shown in the parenthesis.

[c]UCLA all includes the three UCLA sites.

Table 3.2. Total Number of monitored Events and Number and Percentage of Non-detects for Different Zones and Sites

Site/Zone	Dissolved											
	Cd		Cr		Cu		Ni		Pb		Zn	
	Total	Non-det[b]	Total	Non-det	Total	Non-det	Total	Non-det	Total	Non-det	Total	Non-det
All[c]	750	429(57)[a]	756	131(17)	802	7(1)	753	208(28)	802	343(43)	803	15(2)
Z 1[d]	69	50(72)	70	44(63)	69	4(6)	70	42(60)	69	55(80)	69	8(12)
Z 2	59	41(69)	59	19(32)	59	0(0)	59	19(32)	59	41(69)	59	0(0)
Z 3	100	72(72)	100	23(23)	100	2(2)	100	39(39)	100	78(78)	100	7(7)
Z 4	101	86(85)	101	3(3)	101	1(1)	101	42(42)	101	68(67)	101	0(0)
Z 5	37	21(57)	37	4(11)	37	0(0)	37	3(8)	37	15(41)	37	0(0)
Z 6	8	4(50)	8	2(25)	10	0(0)	8	3(38)	11	0(0)	10	0(0)
Z 7	16	4(25)	16	4(25)	16	0(0)	16	10(63)	16	4(25)	16	0(0)
Z 8	78	20(26)	78	6(8)	100	0(0)	78	6(8)	100	2(2)	100	0(0)
Z 9	28	11(39)	28	2(7)	28	0(0)	28	1(4)	28	0(0)	28	0(0)
Z 10	105	48(46)	107	12(11)	107	0(0)	106	13(12)	107	54(50)	107	0(0)
Z 11	39	16(41)	39	2(5)	41	0(0)	39	10(26)	40	4(10)	41	0(0)
Z 12	38	13(34)	38	0(0)	38	0(0)	38	4(11)	38	0(0)	38	0(0)
Z 13	31	16(52)	31	7(23)	51	0(0)	31	12(39)	51	18(35)	51	0(0)
Z 14	41	27(66)	44	3(7)	45	0(0)	42	4(10)	45	4(9)	46	0(0)
UCLA all[e]	59	28(47)	59	0(0)	59	0(0)	59	0(0)	59	0(0)	59	0(0)
Site/Zone	Total											
	Cd		Cr		Cu		Ni		Pb		Zn	
	Total	Non-det	Total	Non-det	Total	Non-det	Total	Non-det	Total	Non-det	Total	Non-det
All	754	136(18)	762	26(3)	803	1(0)	756	54(7)	805	38(5)	803	4(0)
Z 1	70	30(43)	70	19(27)	70	0(0)	70	28(40)	70	20(29)	70	3(4)
Z 2	59	10(17)	59	2(3)	59	0(0)	59	3(5)	59	1(2)	59	0(0)
Z 3	100	26(26)	100	3(3)	100	0(0)	100	10(10)	100	9(9)	100	0(0)
Z 4	101	27(27)	101	0(0)	101	0(0)	101	0(0)	101	0(0)	101	0(0)
Z 5	37	7(19)	37	0(0)	37	0(0)	37	0(0)	37	0(0)	37	0(0)
Z 6	9	0(0)	11	0(0)	10	0(0)	8	0(0)	11	0(0)	9	0(0)
Z 7	16	0(0)	16	0(0)	16	0(0)	16	1(6)	16	0(0)	16	0(0)
Z 8	78	3(4)	78	1(1)	100	0(0)	78	2(3)	100	0(0)	100	0(0)
Z 9	28	0(0)	28	0(0)	28	0(0)	28	0(0)	28	0(0)	28	0(0)
Z 10	105	16(15)	107	1(1)	107	0(0)	106	5(5)	107	7(7)	107	0(0)
Z 11	39	1(3)	41	0(0)	41	0(0)	40	0(0)	41	0(0)	41	0(0)
Z 12	38	8(21)	38	0(0)	38	0(0)	38	3(8)	38	0(0)	38	0(0)
Z 13	31	0(0)	31	0(0)	51	0(0)	31	0(0)	51	0(0)	51	0(0)
Z 14	43	8(19)	45	0(0)	45	1(2)	44	2(5)	46	1(2)	46	1(2)
UCLA all	59	26(44)	59	0(0)	59	0(0)	59	0(0)	59	0(0)	59	0(0)

[a]429(57) represents non-detects with the value outside the parenthesis (429) is the number and the value within (57) is the percentage of non-detects for dissolved Cd for the other California Department of Transportation (Caltrans) sites.

[b]Non-detect. [c]**All** includes all the sites excluding the three UCLA sites. [d]Z 1 is the abbreviated form of Zone 1. [e]**UCLA all** includes the three UCLA sites.

Table 3.3. Correlation (R) Matrix for UCLA Sites

Site	TRAIN-TRUN	MAX_RAIN-PEAK_FLOW	ADD-ATC
UCLA 1	0.98	0.83	1.00[a]
UCLA 2	0.98	0.77	1.00[a]
UCLA 3	0.99	0.70	1.00[a]
UCLA all[b]	0.86	0.72	1.00

[a]ADD and ATC values for the individual UCLA sites do not vary.
[b]**UCLA all** includes the three UCLA sites.

Table 3.4A. Correlation (R) Matrix between the Metal *EMCs*, and Event and Site-specific Variables for the Individual UCLA Sites

Site		Dissolved						Particulate						Total					
		Cd	Cr	Cu	Ni	Pb	Zn	Cd	Cr	Cu	Ni	Pb	Zn	Cd	Cr	Cu	Ni	Pb	Zn
UCLA 1	T_RAIN	-0.20	-0.50	-0.33	-0.44	0.01	-0.27	-0.01	-0.30	-0.27	-0.28	-0.04	-0.44	-0.12	-0.38	-0.34	-0.44	-0.03	-0.34
	MAX_RAIN	-0.30	-0.46	-0.33	-0.38	0.08	-0.25	-0.09	-0.40	-0.38	-0.39	-0.27	-0.54	-0.23	-0.46	-0.36	-0.41	-0.21	-0.35
	D_RUN	-0.48	-0.50	-0.27	-0.46	-0.29	-0.15	-0.37	-0.42	-0.32	-0.42	-0.35	-0.62	-0.47	-0.48	-0.30	-0.49	-0.37	-0.27
	ADD	0.08	0.34	0.37	0.34	-0.08	0.26	0.05	0.08	0.13	0.03	-0.08	-0.10	0.05	0.16	0.35	0.31	-0.09	0.21
	T_RUN	-0.19	-0.50	-0.36	-0.44	0.00	-0.28	0.04	-0.29	-0.24	-0.26	0.00	-0.41	-0.09	-0.37	-0.36	-0.44	0.00	-0.34
	PEAK_FLOW	-0.23	-0.39	-0.19	-0.16	0.22	-0.06	0.11	-0.18	-0.08	-0.12	-0.08	-0.21	-0.09	-0.25	-0.18	-0.17	-0.02	-0.10
	ATC	0.08	0.34	0.37	0.34	-0.08	0.26	0.05	0.08	0.13	0.03	-0.08	-0.10	0.05	0.16	0.35	0.31	-0.09	0.21
UCLA 2	T_RAIN	-0.25	-0.42	-0.46	-0.43	-0.37	-0.39	-0.15	-0.43	-0.36	-0.18	0.27	-0.20	-0.25	-0.45	-0.47	-0.43	0.21	-0.40
	MAX_RAIN	-0.31	-0.44	-0.54	-0.45	-0.40	-0.46	-0.12	-0.31	-0.33	-0.08	0.48	-0.15	-0.28	-0.37	-0.53	-0.43	0.43	-0.47
	D_RUN	-0.39	-0.49	-0.49	-0.52	-0.54	-0.44	-0.32	-0.51	-0.29	-0.15	-0.02	-0.22	-0.44	-0.53	-0.48	-0.51	-0.10	-0.45
	ADD	0.30	0.36	0.33	0.31	0.02	0.16	0.30	0.16	0.50	0.36	0.02	0.60	0.37	0.24	0.38	0.35	0.02	0.24
	T_RUN	-0.28	-0.46	-0.50	-0.47	-0.44	-0.42	-0.17	-0.42	-0.35	-0.16	0.31	-0.19	-0.28	-0.45	-0.50	-0.46	0.25	-0.43
	PEAK_FLOW	-0.26	-0.35	-0.41	-0.33	-0.39	-0.34	-0.09	-0.04	-0.09	0.12	0.63	0.02	-0.23	-0.15	-0.37	-0.28	0.58	-0.33
	ATC	0.30	0.36	0.33	0.31	0.02	0.16	0.30	0.16	0.50	0.36	0.02	0.60	0.37	0.24	0.38	0.35	0.02	0.24
UCLA 3	T_RAIN	-0.26	-0.24	-0.30	-0.25	-0.05	-0.25	-0.19	-0.10	0.25	0.25	0.39	0.11	-0.28	-0.17	-0.19	-0.18	0.34	-0.24
	MAX_RAIN	-0.21	-0.13	-0.47	-0.40	-0.11	-0.40	-0.28	0.19	0.10	0.02	0.61	0.35	-0.34	0.08	-0.39	-0.38	0.52	-0.37
	D_RUN	-0.34	-0.37	-0.26	-0.30	-0.22	-0.24	-0.25	-0.31	0.56	0.65	-0.01	-0.03	-0.37	-0.37	-0.06	-0.12	-0.08	-0.24
	ADD	-0.08	0.78	0.79	0.88	0.52	0.87	0.89	0.24	0.16	0.15	-0.29	0.06	0.76	0.49	0.76	0.89	-0.10	0.86
	T_RUN	-0.24	-0.22	-0.30	-0.24	-0.03	-0.25	-0.18	-0.10	0.15	0.14	0.40	0.07	-0.26	-0.16	-0.22	-0.20	0.35	-0.24
	PEAK_FLOW	-0.31	-0.30	-0.41	-0.33	-0.05	-0.33	-0.25	-0.02	0.07	0.06	0.69	0.40	-0.35	-0.13	-0.34	-0.30	0.62	-0.30
	ATC	-0.08	0.78	0.79	0.88	0.52	0.87	0.89	0.24	0.16	0.15	-0.29	0.06	0.76	0.49	0.76	0.89	-0.10	0.86

Table 3.4B. Correlation (R) Matrix between the Metal *EMCs*, and Event and Site-specific Variables for the Combined UCLA Sites

		Dissolved						Particulate						Total					
		Cd	Cr	Cu	Ni	Pb	Zn	Cd	Cr	Cu	Ni	Pb	Zn	Cd	Cr	Cu	Ni	Pb	Zn
UCLA all[a]	T_RAIN	-0.19	-0.30	-0.34	-0.31	-0.12	-0.28	-0.14	-0.22	-0.04	0.06	0.20	-0.14	-0.20	-0.26	-0.30	-0.28	0.16	-0.29
	MAX_RAIN	-0.23	-0.28	-0.42	-0.36	-0.12	-0.35	-0.16	-0.17	-0.14	-0.07	0.27	-0.15	-0.25	-0.22	-0.39	-0.36	0.23	-0.36
	D_RUN	-0.30	-0.38	-0.31	-0.36	-0.33	-0.28	-0.26	-0.35	0.06	0.22	-0.18	-0.23	-0.36	-0.38	-0.24	-0.28	-0.24	-0.30
	ADD	0.04	0.47	0.48	0.64	0.30	0.51	0.65	0.12	0.15	0.13	-0.16	0.11	0.44	0.24	0.44	0.63	-0.09	0.50
	RC	-0.43	-0.38	-0.30	-0.17	0.15	-0.20	-0.12	-0.46	-0.46	-0.11	0.04	-0.40	-0.35	-0.46	-0.37	-0.18	0.07	-0.24
	AREA	0.38	0.33	0.27	0.15	-0.19	0.17	0.09	0.40	0.40	0.07	-0.15	0.37	0.31	0.40	0.33	0.16	-0.18	0.21
	ADT	-0.46	-0.43	-0.29	-0.18	0.01	-0.24	-0.19	-0.53	-0.54	-0.20	-0.29	-0.40	-0.41	-0.53	-0.39	-0.22	-0.27	-0.28
	T_RUN	-0.06	-0.19	-0.25	-0.23	-0.20	-0.22	-0.04	-0.10	0.00	-0.02	0.12	-0.05	-0.05	-0.13	-0.21	-0.22	0.07	-0.21
	PEAK_FLOW	-0.09	-0.17	-0.22	-0.18	-0.13	-0.19	-0.05	0.05	0.08	0.05	0.29	0.11	-0.09	-0.02	-0.16	-0.16	0.24	-0.16
	ATC	0.00	0.44	0.45	0.62	0.31	0.49	0.64	0.08	0.11	0.12	-0.18	0.06	0.41	0.21	0.41	0.61	-0.11	0.48

[a]**UCLA all** includes the three UCLA sites.

Table 3.5. Median Values of Metal *EMCs* and Independent Variables for Different Zones and Sites

		UCLA all	All	Z 1	Z 2	Z 3	Z 4	Z 5	Z 6	Z 7	Z 8	Z 9	Z 10	Z 11	Z 12	Z 13	Z 14
Dissolved (:g/L)	Cd	0.15[a]	0.10	0.10	0.10	0.10	0.10	0.10	0.27	0.25	0.21	0.10	0.20	0.20	0.20	0.10	0.10
	Cr	1.87	2.20	0.50	1.30	2.12	3.57	1.80	1.95	1.45	2.25	2.01	2.20	3.10	3.70	3.10	3.35
	Cu	28.18	10.80	3.70	9.50	8.15	7.78	12.00	14.55	9.50	13.20	18.45	13.00	11.00	17.00	11.00	15.00
	Ni	6.67	2.80	1.00	2.50	2.40	2.26	3.20	3.49	2.25	3.18	2.33	4.30	2.80	3.45	2.70	3.45
	Pb	2.56	1.15	0.50	0.50	0.50	0.50	1.16	2.44	1.60	2.80	8.32	0.50	3.75	9.65	1.50	2.70
	Zn	157.99	41.00	13.00	27.00	26.30	31.00	87.00	72.50	43.50	56.90	25.00	66.00	34.00	44.50	72.00	53.50
Particulate (:g/L)	Cd	0.10	0.30	0.10	0.25	0.20	0.40	0.20	0.68	0.30	0.32	1.78	0.20	0.30	0.30	0.60	0.20
	Cr	6.20	2.90	0.75	2.20	2.63	8.76	3.20	6.72	2.05	1.05	9.89	2.30	3.50	2.30	2.40	3.90
	Cu	17.58	12.00	3.40	12.70	5.65	27.50	10.94	17.45	10.30	12.15	65.05	7.80	13.00	8.00	23.80	11.50
	Ni	3.19	2.70	1.00	2.90	1.75	8.92	3.40	4.60	1.90	2.07	10.22	1.80	2.60	1.30	3.60	2.50
	Pb	19.53	10.00	2.20	6.10	2.37	21.60	8.80	65.20	8.85	25.21	251.80	3.60	12.73	24.50	37.50	8.60
	Zn	67.22	74.50	17.00	54.00	36.95	170.00	80.00	114.00	54.50	91.00	262.40	67.00	65.00	28.50	160.00	70.00
Total (:g/L)	Cd	0.58	0.50	0.27	0.40	0.41	0.53	0.41	0.94	0.55	0.53	1.89	0.40	0.60	0.45	0.78	0.30
	Cr	7.44	5.50	1.65	4.10	5.40	13.20	5.10	7.20	3.25	3.63	12.40	5.00	7.20	6.35	5.40	6.60
	Cu	50.28	24.80	6.00	23.00	15.00	36.20	24.00	42.90	18.50	25.70	85.65	22.00	27.00	26.00	40.00	29.00
	Ni	10.20	6.10	2.40	6.20	4.50	12.30	7.77	14.50	3.70	6.10	12.85	6.50	5.55	5.95	6.30	7.15
	Pb	22.55	12.50	2.80	7.50	3.04	22.10	14.00	67.00	9.90	32.95	264.50	4.80	17.00	39.00	38.00	13.00
	Zn	234.17	130.00	32.00	92.00	71.75	210.00	210.00	205.00	121.50	164.00	299.50	140.00	110.00	79.50	260.00	155.00
Independent Variables	T_RAIN (mm)	12.19	17.53	21.84	14.66	17.27	14.45	12.80	19.30	17.40	17.53	17.40	17.78	26.93	30.99	14.48	19.81
	MAX_RAIN (mm/hr)	12.19	12.19	12.19	9.14	9.60	9.60	15.24	9.14	12.19	24.38	18.29	24.38	18.29	21.34	12.19	21.34
	D_RUN (hr)	5.48	13.58	15.59	17.58	13.88	8.62	9.42	12.00	11.28	11.70	9.52	13.61	12.60	8.84	14.50	12.25
	ADD (day)	11.53	9.00	5.40	7.10	8.00	8.00	12.90	5.20	14.45	4.25	3.40	11.90	11.20	17.00	5.40	15.80
	RC (-)	0.81	0.90	0.79	1.00	0.90	0.90	0.70	1.00	1.00	0.90	1.00	1.00	0.94	0.90	0.88	0.84
	AREA (ha)	1.28	0.13	0.05	0.13	0.06	0.20	0.18	0.40	0.41	0.12	0.25	0.25	0.11	0.06	1.94	0.06
	ADT ($X10^5$vehicles/day)	3.22	0.76	0.13	1.54	0.76	0.14	1.18	2.19	0.99	2.18	2.27	0.48	2.42	1.39	1.88	1.10

[a]The dissolved Cd value (0.15 µg/L) in the first data row for UCLA all sites represents the median of the *EMC* values of the individual storm events for the three UCLA sites combined together.

Table 3.6A. Regression Models Developed for UCLA Site 1

Phase	Model	Coefficient					p value[b]					R^2	p_{Reg}[c]	Count[d]	Form[e]	Parameter
		Intercept	T_RAIN (mm)	MAX_RAIN (mm/hr)	D_RUN (hr)	ADD (day)	Intercept	T_RAIN	MAX_RAIN	D_RUN	ADD					
Dissolved/Particulate[a]	1	0.80	1.29	-1.09	-1.10	0.14	<0.01	0.01	0.01	0.01	0.23	0.57	0.03	17	P2	Cd
	3	0.27	1.17			-0.21	0.05	0.03			0.71	0.30	0.09	17	D3	Cd
	1	9.69	12.62	-13.25	-8.92	2.70	<0.01	0.01	<0.01	0.02	0.03	0.67	0.01	17	P2	Cr
	3	2.37	-1.11			0.78	<0.01	0.01			0.05	0.52	0.01	17	D2	Cr
	1	39.12	49.84	-70.35	-32.71	48.82	0.22	0.35	0.16	0.45	0.01	0.57	0.03	17	D2	Cu
	3	20.75	-22.41			47.02	0.40	0.12			0.01	0.49	0.01	17	D2	Cu
	1	14.75	14.07	-17.97	-12.53	8.97	0.01	0.14	0.05	0.11	<0.01	0.67	0.01	17	D2	Ni
	3	8.40	-6.27			8.41	0.09	0.03			0.01	0.52	0.01	17	D2	Ni
	1	17.76	0.38	-0.51	-0.86	0.06	<0.01	<0.01	<0.01	0.01	0.15	0.61	0.02	17	P1	Pb
	3	7.07	20.23			8.56	0.02	0.07			0.47	0.23	0.16	17	P3	Pb
	1	14.30	-143.26	359.64	162.96	18.19	0.32	0.12	<0.01	0.09	0.70	0.76	<0.01	17	P3	Zn
	3	128.85	-52.68			4.36	<0.01	<0.01			0.80	0.45	0.02	17	P2	Zn
Total	1	1.78	1.92	-1.76	-1.98	0.30	<0.01	0.04	0.04	0.01	0.23	0.54	0.04	17	T2	Cd
	3	0.46	1.67			-0.39	0.08	0.11			0.73	0.18	0.24	17	T3	Cd
	1	12.02	11.40	-13.15	-8.85	3.48	<0.01	0.03	0.01	0.04	0.02	0.67	0.01	17	T2	Cr
	3	7.50	-3.34			3.08	0.02	0.05			0.09	0.37	0.04	17	T2	Cr
	1	66.56	75.55	-100.04	-49.59	55.09	0.07	0.21	0.08	0.31	0.01	0.60	0.02	17	T2	Cu
	3	39.21	-28.57			52.46	0.18	0.09			0.01	0.48	0.01	17	T2	Cu
	1	20.37	17.90	-22.44	-15.73	9.54	<0.01	0.09	0.03	0.07	<0.01	0.69	<0.01	17	T2	Ni
	3	12.40	-7.54			8.84	0.03	0.02			0.02	0.50	0.01	17	T2	Ni
	1	1.96	-37.09	58.66	39.02	17.53	0.58	0.11	0.03	0.10	0.15	0.55	0.04	17	T3	Pb
	3	9.38	21.15			8.89	0.01	0.11			0.53	0.18	0.24	17	T3	Pb
	1	340.11	480.30	-554.45	-278.46	204.50	0.05	0.10	0.04	0.22	0.02	0.53	0.04	17	T2	Zn
	3	187.12	-98.42			189.83	0.19	0.23			0.04	0.33	0.06	17	T2	Zn

[a]For some metal parameters, the dissolved metal models were better than the particulate models, and vice versa. Dissolved/Particulate means either the dissolved or the particulate model was presented. [b]p values for the individual independent variables were obtained from 2-tailed t-statistic. [c]p_{Reg} refers to p value for the entire model obtained from F-statistic. [d]Count is the number of events considered. [e]In form column **D** denotes dissolved, **P** denotes particulate, and **T** denotes total metal. Also, 1, 2, and 3 are linear, semi-log, and inverse forms respectively.

Table 3.6B. Regression Models Developed for UCLA Site 2

Phase	Model	Coefficient					p value[b]					R^2	p_{Reg}[c]	Count[d]	Form[e]	Parameter
		Intercept	T_RAIN (mm)	MAX_RAIN (mm/hr)	D_RUN (hr)	ADD (day)	Intercept	T_RAIN	MAX_RAIN	D_RUN	ADD					
Dissolved/Particulate[a]	1	0.62	4.79	-1.23	-0.85	-0.34	0.08	0.01	0.55	0.50	0.49	0.77	<0.01	16	D3	Cd
	3	0.44	3.70			-0.29	0.05	<0.01			0.53	0.75	<0.01	16	D3	Cd
	1	2.11	7.46	3.09	0.00	-0.54	0.02	0.06	0.52	1.00	0.64	0.76	<0.01	16	D3	Cr
	3	2.30	8.67			-0.52	<0.01	<0.01			0.63	0.75	<0.01	16	D3	Cr
	1	37.98	338.54	54.02	-64.18	-46.90	0.02	<0.01	0.56	0.28	0.06	0.92	<0.01	16	D3	Cu
	3	33.40	313.43			-41.52	0.01	<0.01			0.09	0.90	<0.01	16	D3	Cu
	1	6.11	63.86	12.46	-3.03	-7.49	0.12	<0.01	0.60	0.83	0.21	0.89	<0.01	16	D3	Ni
	3	6.50	66.54			-7.15	0.02	<0.01			0.19	0.89	<0.01	16	D3	Ni
	1	1.06	5.22	4.02	2.77	0.83	0.04	0.04	0.19	0.15	0.26	0.89	<0.01	16	D3	Pb
	3	1.65	8.78			0.65	<0.01	<0.01			0.38	0.85	<0.01	16	D3	Pb
	1	161.08	2498.46	-528.88	-360.15	-	0.14	<0.01	0.42	0.37	0.35	0.91	<0.01	16	D3	Zn
	3	84.43	2033.09			-	0.24	<0.01			0.40	0.90	<0.01	16	D3	Zn
Total	1	1.37	5.33	-1.72	-1.02	-0.91	0.02	0.05	0.59	0.61	0.26	0.64	0.02	16	T3	Cd
	3	1.13	3.92			-0.85	<0.01	<0.01			0.25	0.63	<0.01	16	T3	Cd
	1	11.19	30.67	-14.03	-3.06	-1.54	<0.01	0.02	0.36	0.74	0.68	0.70	0.01	16	T3	Cr
	3	9.95	22.99			-1.44	<0.01	<0.01			0.68	0.67	<0.01	16	T3	Cr
	1	77.16	419.23	19.85	-100.80	-54.41	0.01	<0.01	0.89	0.26	0.14	0.87	<0.01	16	T3	Cu
	3	66.00	354.45			-46.56	<0.01	<0.01			0.18	0.85	<0.01	16	T3	Cu
	1	11.96	73.83	7.17	-10.13	-7.42	0.04	0.01	0.83	0.61	0.36	0.82	<0.01	16	T3	Ni
	3	11.15	69.34			-6.58	0.01	<0.01			0.38	0.81	<0.01	16	T3	Ni
	1	21.68	-0.05	0.54	-0.47	0.17	0.04	0.83	0.22	0.60	0.42	0.30	0.37	16	T1	Pb
	3	25.79	4.21			12.87	<0.01	0.82			0.33	0.07	0.61	16	T3	Pb
	1	269.91	2511.29	-386.71	-401.89	-	0.03	<0.01	0.58	0.35	0.28	0.90	<0.01	16	T3	Zn
	3	196.84	2071.33			-	0.02	<0.01			0.32	0.89	<0.01	16	T3	Zn

[a]For some metal parameters, the dissolved metal models were better than the particulate models, and vice versa. Dissolved/Particulate means either the dissolved or the particulate model was presented. [b]p values for the individual independent variables were obtained from 2-tailed t-statistic. [c]p_{Reg} refers to p value for the entire model obtained from F-statistic. [d]Count is the number of events considered. [e]In form column **D** denotes dissolved, **P** denotes particulate, and **T** denotes total metal. Also, 1, 2, and 3 are linear, semi-log, and inverse forms respectively.

Table 3.6C. Regression Models Developed for UCLA Site 3

Phase	Model	Coefficient					p value[b]					R^2	p_{Reg}[c]	Count[d]	Form[e]	Parameter
		Intercept	T_RAIN (mm)	MAX_RAIN (mm/hr)	D_RUN (hr)	ADD (day)	Intercept	T_RAIN	MAX_RAIN	D_RUN	ADD					
Dissolved/Particulate[a]	1	0.18	0.00	0.00	-0.04	0.02	0.45	0.52	0.93	0.07	<0.01	0.83	<0.01	26	P1	Cd
	3	0.01	0.00			0.02	0.96	0.61			<0.01	0.80	<0.01	26	P1	Cd
	1	1.29	0.00	0.03	-0.08	0.04	0.03	0.74	0.20	0.09	<0.01	0.72	<0.01	26	D1	Cr
	3	1.39	-0.01			0.03	<0.01	0.37			<0.01	0.62	<0.01	26	D1	Cr
	1	-11.41	2.16	294.05	79.54	-3.54	0.30	0.96	<0.01	0.08	0.63	0.76	<0.01	26	D3	Cu
	3	24.86	-0.27			0.93	0.01	0.18			<0.01	0.65	<0.01	26	D1	Cu
	1	12.33	0.11	-0.30	-0.97	0.38	0.01	0.20	0.11	0.01	<0.01	0.85	<0.01	26	D1	Ni
	3	3.44	-0.07			0.40	0.18	0.26			<0.01	0.79	<0.01	26	D1	Ni
	1	2.32	4.42	3.17	4.37	-0.71	0.04	0.32	0.66	0.32	0.32	0.52	<0.01	26	D3	Pb
	3	3.17	8.49			-0.77	<0.01	<0.01			0.27	0.50	<0.01	26	D3	Pb
	1	225.78	1.26	-4.81	-13.25	7.57	0.03	0.52	0.26	0.11	<0.01	0.80	<0.01	26	D1	Zn
	3	94.18	-1.29			7.94	0.08	0.29			<0.01	0.77	<0.01	26	D1	Zn
Total	1	0.88	0.01	-0.01	-0.07	0.02	0.03	0.49	0.41	0.04	<0.01	0.68	<0.01	26	T1	Cd
	3	0.38	-0.01			0.02	0.07	0.24			<0.01	0.60	<0.01	26	T1	Cd
	1	6.67	3.87	0.52	-10.14	3.30	0.03	0.24	0.86	0.01	<0.01	0.60	<0.01	26	T2	Cr
	3	6.47	-1.75			2.97	0.01	0.27			0.02	0.30	0.02	26	T2	Cr
	1	88.31	18.39	-51.87	-48.13	46.42	0.03	0.66	0.17	0.28	<0.01	0.61	<0.01	26	T2	Cu
	3	37.28	-0.12			1.02	<0.01	0.62			<0.01	0.58	<0.01	26	T1	Cu
	1	9.92	0.05	-0.20	-0.25	0.41	0.07	0.62	0.37	0.56	<0.01	0.80	<0.01	26	T1	Ni
	3	5.81	-0.02			0.43	0.03	0.74			<0.01	0.79	<0.01	26	T1	Ni
	1	13.51	8.58	11.22	-12.99	2.84	0.15	0.41	0.22	0.24	0.38	0.33	0.06	26	T2	Pb
	3	26.63	0.11			-0.01	<0.01	0.11			0.84	0.12	0.24	26	T1	Pb
	1	263.83	1.08	-3.57	-12.93	7.72	0.02	0.61	0.43	0.15	<0.01	0.78	<0.01	26	T1	Zn
	3	152.36	-1.18			8.00	0.01	0.36			<0.01	0.75	<0.01	26	T1	Zn

[a]For some metal parameters, the dissolved metal models were better than the particulate models, and vice versa. Dissolved/Particulate means either the dissolved or the particulate model was presented. [b]p values for the individual independent variables were obtained from 2-tailed t-statistic. [c]p_{Reg} refers to p value for the entire model obtained from F-statistic. [d]Count is the number of events considered. [e]In form column **D** denotes dissolved, **P** denotes particulate, and **T** denotes total metal. Also, 1, 2, and 3 are linear, semi-log, and inverse forms respectively.

Table 3.7. Median Values for Individual UCLA Sites

Phase	R^2	p_{Reg} [c]	p value [d]					Model	Site
			Intercept	T_RAIN	MAX_RAIN	D_RUN	ADD		
Dissolved/Particulate [b]	0.64 [a]	0.01	0.01	0.06	0.01	0.05	0.09	1	UCLA 1
Dissolved/Particulate	0.89	<0.01	0.06	0.01	0.53	0.44	0.31	1	UCLA 2
Dissolved/Particulate	0.78	<0.01	0.03	0.52	0.23	0.09	<0.01	1	UCLA 3
Total	0.57	0.03	0.03	0.09	0.04	0.08	0.02	1	UCLA 1
Total	0.76	<0.01	0.02	0.02	0.58	0.60	0.32	1	UCLA 2
Total	0.64	<0.01	0.03	0.55	0.39	0.19	<0.01	1	UCLA 3
Dissolved/Particulate	0.47	0.01	0.03	0.03			0.26	3	UCLA 1
Dissolved/Particulate	0.87	<0.01	0.01	<0.01			0.39	3	UCLA 2
Dissolved/Particulate	0.71	<0.01	0.04	0.27			<0.01	3	UCLA 3
Total	0.35	0.05	0.06	0.10			0.06	3	UCLA 1
Total	0.74	<0.01	<0.01	<0.01			0.33	3	UCLA 2
Total	0.59	<0.01	0.01	0.31			<0.01	3	UCLA 3

[a] The value of R^2 (0.64) for UCLA site 1 in the first data row represents the median of the six R^2 values developed for six dissolved/particulate constituents (i.e. Cd, Cr, Cu, Ni, Pb, and Zn) for regression model 1. Similarly median values of p_{Reg} and p values are presented.

[b] For some metal parameters, the dissolved metal models were better than the particulate models, and vice versa. Dissolved/Particulate means either the dissolved or the particulate model was presented.

[c] p_{Reg} refers to p value for the entire model obtained from F-statistic.

[d] p values for the individual independent variables were obtained from 2-tailed t-statistic.

Table 3.8. UCLA Individual Sites: Median Values for Different Metal Constituents

Phase	Parameter	R^2	pReg[c]	p value[d]					Model
				Intercept	T_RAIN	MAX_RAIN	D_RUN	ADD	
Dissolved/Particulate[b]	Cd	0.77[a]	<0.01	0.08	0.01	0.55	0.07	0.23	1
Dissolved/Particulate	Cr	0.72	<0.01	0.02	0.06	0.20	0.09	0.03	1
Dissolved/Particulate	Cu	0.76	<0.01	0.22	0.35	0.16	0.28	0.06	1
Dissolved/Particulate	Ni	0.85	<0.01	0.01	0.14	0.11	0.11	<0.01	1
Dissolved/Particulate	Pb	0.61	<0.01	0.04	0.04	0.19	0.15	0.26	1
Dissolved/Particulate	Zn	0.80	<0.01	0.14	0.12	0.26	0.11	0.35	1
Total	Cd	0.64	0.02	0.02	0.05	0.41	0.04	0.23	1
Total	Cr	0.67	0.01	<0.01	0.03	0.36	0.04	0.02	1
Total	Cu	0.61	<0.01	0.03	0.21	0.17	0.28	0.01	1
Total	Ni	0.80	<0.01	0.04	0.09	0.37	0.56	<0.01	1
Total	Pb	0.33	0.06	0.15	0.41	0.22	0.24	0.38	1
Total	Zn	0.78	<0.01	0.03	0.10	0.43	0.22	0.02	1
Dissolved/Particulate	Cd	0.75	<0.01	0.05	0.03			0.53	3
Dissolved/Particulate	Cr	0.62	<0.01	<0.01	0.01			0.05	3
Dissolved/Particulate	Cu	0.65	<0.01	0.01	0.12			0.01	3
Dissolved/Particulate	Ni	0.79	<0.01	0.09	0.03			0.01	3
Dissolved/Particulate	Pb	0.50	<0.01	<0.01	<0.01			0.38	3
Dissolved/Particulate	Zn	0.77	<0.01	0.08	<0.01			0.40	3
Total	Cd	0.60	<0.01	0.07	0.11			0.25	3
Total	Cr	0.37	0.02	0.01	0.05			0.09	3
Total	Cu	0.58	<0.01	<0.01	0.09			0.01	3
Total	Ni	0.79	<0.01	0.03	0.02			0.02	3
Total	Pb	0.12	0.24	<0.01	0.11			0.53	3
Total	Zn	0.75	<0.01	0.02	0.23			0.04	3

[a]The value of R^2 (0.77) for dissolved/particulate Cd in the first data row represents the median of the three R^2 values developed for three individual UCLA sites for regression model 1. Similarly median values of p_{Reg} and p values are presented.

[b]For some metal parameters, the dissolved metal models were better than the particulate models, and vice versa. Dissolved/Particulate means either the dissolved or the particulate model was presented.

[c]p_{Reg} refers to p value for the entire model obtained from F-statistic.

[d]p values for the individual independent variables were obtained from 2-tailed t-statistic

Table 3.9. Number of Models of Different Fraction (i.e. Dissolved and Particulate), and Different Forms (i.e. Form 1 = Linear, Form 2 = Semi-log, and Form 3 = Inverse) for Caltrans Zones and UCLA Sites

	Z 1[a]	Z 2	Z 3	Z 4	Z 5	Z 6	Z 7	Z 8	Z 9	Z 10	Z 11	Z 12	Z 13	Z 14	Total[b]	UCLA all[c]	UCLA 1	UCLA 2	UCLA 3	Total[d]	Model
Dissolved	2	6	6	5	5	0	2	5	2	4	2	3	4	2	48	5	2	6	5	13	
Particulate	4	0	0	1	1	0	4	1	4	2	4	3	2	4	30	1	4	0	1	5	
Form 1 (Linear)	1	7	3	6	3	0	0	2	0	7	0	1	5	1	36	4	1	1	7	9	1
Form 2 (Semi-log)	10	3	7	3	5	0	0	7	12	3	10	10	0	5	75	4	9	0	3	12	
Form 3 (Inverse)	1	2	2	3	4	0	12	3	0	2	2	1	7	6	45	4	2	11	2	15	
Dissolved	3	3	2	3	4	0	3	4	1	2	2	2	3	4	36	6					
Particulate	3	3	4	3	2	0	3	2	5	4	4	4	3	2	42	0					
Form 1 (Linear)	1	5	9	9	3	0	0	3	0	6	1	7	11	6	61	4					2
Form 2 (Semi-log)	11	5	1	3	5	0	1	8	12	4	7	5	0	2	64	3					
Form 3 (Inverse)	0	2	2	0	4	0	11	1	0	2	4	0	1	4	31	5					
Dissolved	1	4	6	3	4	2	0	4	2	5	2	2	5	5	45	5	4	6	5	15	
Particulate	5	2	0	3	2	4	6	2	4	1	4	4	1	1	39	1	2	0	1	3	
Form 1 (Linear)	1	7	2	10	8	10	0	0	0	8	0	3	7	1	57	1	0	0	10	10	3
Form 2 (Semi-log)	10	3	7	1	4	2	3	10	12	3	12	8	0	6	81	7	8	0	1	9	
Form 3 (Inverse)	1	2	3	1	0	0	9	2	0	1	0	1	5	5	30	4	4	12	1	17	
Dissolved	2	4	2	1	4	3	0	3	1	3	1	1	3	4	32	6					
Particulate	4	2	4	5	2	3	6	3	5	3	5	5	3	2	52	0					
Form 1 (Linear)	1	6	9	11	8	3	3	7	0	6	0	10	8	2	74	1					4
Form 2 (Semi-log)	11	1	1	1	4	0	8	5	12	0	12	2	1	2	60	7					
Form 3 (Inverse)	0	5	2	0	0	7	1	0	0	6	0	0	3	8	32	4					

[a] Z 1 is the abbreviated form of Zone1.

[b] Values in this column represents the sum of the values of the corresponding rows for Caltrans zones.

[c] **UCLA all** includes the three UCLA sites.

[d] Values in this column represents the sum of the values of the corresponding rows for individual UCLA sites.

Table 3.10A. Regression Models Developed for Combined UCLA Sites for Dissolved/Particulate[a] Metal EMCs.

Model	Coefficent								p value[b]								R^2	pReg[c]	Count[d]	Form[e]	M[f]
	Intercept	T_RAIN (mm)	MAX_RAIN (mm/hr)	D_RUN (hr)	ADD (day)	RC (-)	AREA (ha)	ADT ($\times 10^5$ vehicles/day)	Intercept	T_RAIN	MAX_RAIN	D_RUN	ADD	RC	AREA	ADT					
1	0.51	0.01	-0.01	-0.05	0.01				<0.01	0.02	0.07	<0.01	<0.01				0.53	<0.01	59	P1	Cd
2	-1.75	1.63	-0.10	0.29	-0.08		-0.08	6.49	0.02	0.01	0.90	0.59	0.51		0.31	<0.01	0.59	<0.01	59	D3	Cd
3	0.17	0.00			0.01				0.10	0.55			<0.01				0.43	<0.01	59	P1	Cd
4	-1.85	1.81			-0.08		-0.07	6.79	0.01	<0.01			0.49		0.38	<0.01	0.59	<0.01	59	D3	Cd
1	3.54	-0.10	-0.68	-1.84	1.23				<0.01	0.93	0.50	0.09	<0.01				0.43	<0.01	59	D2	Cr
2	9.03	-0.10	-0.63	-1.82	1.17	-9.54		-13.09	0.07	0.92	0.47	0.07	<0.01	0.60		0.08	0.58	<0.01	59	D2	Cr
3	2.90	-1.49			1.20				<0.01	<0.01			<0.01				0.39	<0.01	59	D2	Cr
4	11.15	-1.43			1.17		-0.10	-17.13	<0.01	<0.01			<0.01		0.89	<0.01	0.55	<0.01	59	D2	Cr
1	10.96	83.97	180.58	44.55	-14.13				0.30	0.10	0.01	0.33	0.16				0.57	<0.01	59	D3	Cu
2	-218.58	76.67	177.13	51.10	-12.41	121.13		245.20	0.18	0.12	0.01	0.26	0.20	0.52		0.37	0.63	<0.01	59	D3	Cu
3	67.75	-52.65			43.63				<0.01	<0.01			<0.01				0.54	<0.01	59	D2	Cu
4	189.20	-51.64			42.49	-147.67		-277.33	0.16	<0.01			<0.01	0.76		0.17	0.61	<0.01	59	D2	Cu
1	17.66	0.17	-0.40	-1.03	0.29				<0.01	0.04	<0.01	<0.01	<0.01				0.59	<0.01	59	D1	Ni
2	84.00	0.17	-0.39	-1.06	0.30	-70.33		-2.86	0.04	0.04	<0.01	<0.01	<0.01	0.31		0.72	0.63	<0.01	59	D1	Ni
3	16.33	-13.69			11.20				<0.01	<0.01			<0.01				0.49	<0.01	59	D2	Ni
4	45.67	-13.45			11.30		-2.73	-61.77	0.03	<0.01			<0.01		0.67	0.15	0.52	<0.01	59	D2	Ni
1	1.68	2.56	0.40	6.63	-0.43				<0.01	0.35	0.91	0.01	0.42				0.47	<0.01	59	D3	Pb
2	-0.92	3.26	1.24	5.21	-0.61		0.67	5.25	0.79	0.23	0.73	0.04	0.25		0.07	0.58	0.50	<0.01	59	D3	Pb
3	2.42	7.48			-0.42				<0.01	<0.01			0.45				0.38	<0.01	59	D3	Pb
4	-2.00	7.39			-0.69		0.93	9.41	0.55	<0.01			0.20		0.01	0.32	0.46	<0.01	59	D3	Pb
1	5.72	390.10	869.81	554.47	-68.98				0.94	0.27	0.07	0.08	0.32				0.50	<0.01	59	D3	Zn
2	-596.67	370.03	873.47	552.08	-64.71		-4.69	1858.44	0.18	0.29	0.06	0.09	0.35		0.92	0.13	0.54	<0.01	59	D3	Zn
3	131.05	1082.18			-83.18				0.01	<0.01			0.24				0.46	<0.01	59	D3	Zn
4	-382.72	1060.03			-81.80	-148.72		2124.72	0.73	<0.01			0.25	0.91		0.27	0.49	<0.01	59	D3	Zn

[a]For some metal parameters, the dissolved metal models were better than the particulate models, and vice versa. Dissolved/Particulate means either the dissolved or the particulate model was presented.

[b]p values for the individual independent variables were obtained from 2-tailed t-statistic. [c]p_{Reg} refers to p value for the entire model obtained from F-statistic. [d]Count is the number of events considered. [e]In form column **D** denotes dissolved and **P** denotes particulate phase. Also, 1, 2, and 3 are linear, semi-log, and inverse forms respectively.

[f]M denotes the metal parameter.

Table 3.10B. Regression Models Developed for Combined UCLA Sites for Total Metal EMCs.

Model	Coefficent								p value[a]								R^2	pReg[b]	Count[c]	Form[d]	M[e]
	Intercept	T_RAIN (mm)	MAX_RAIN (mm/hr)	D_RUN (hr)	ADD (day)	RC (-)	AREA (ha)	ADT ($\times 10^5$ vehicles/day)	Intercept	T_RAIN	MAX_RAIN	D_RUN	ADD	RC	AREA	ADT					
1	1.89	0.68	-0.92	-1.71	0.66				<0.01	0.32	0.13	0.01	<0.01				0.41	<0.01	59	T2	Cd
2	4.35	0.02	-0.03	-0.09	0.02		0.31	-1.05	0.01	0.01	0.01	<0.01	<0.01		0.22	0.03	0.57	<0.01	59	T1	Cd
3	1.17	-0.79			0.65				<0.01	<0.01			<0.01				0.33	<0.01	59	T2	Cd
4	5.96	-0.75			0.64		-0.13	-9.98	<0.01	<0.01			<0.01		0.78	<0.01	0.47	<0.01	59	T2	Cd
1	12.02	-0.36	-0.58	-6.29	3.02				<0.01	0.92	0.86	0.07	0.01				0.35	<0.01	59	T2	Cr
2	38.58	-0.24	-0.41	-6.39	2.75		2.00	-54.38	<0.01	0.93	0.87	0.03	<0.01		0.38	<0.01	0.60	<0.01	59	T2	Cr
3	10.60	-4.00			2.81				<0.01	<0.01			0.01				0.29	<0.01	59	T2	Cr
4	42.40	-3.77			2.70	3.75		-65.18	<0.01	<0.01			0.01	0.94		<0.01	0.54	<0.01	59	T2	Cr
1	105.88	-17.43	-36.01	-28.79	51.80				<0.01	0.65	0.30	0.43	<0.01				0.49	<0.01	59	T2	Cu
2	321.53	-18.53	-34.03	-25.74	50.18	-166.61		-478.71	0.06	0.60	0.27	0.45	<0.01	0.79		0.07	0.61	<0.01	59	T2	Cu
3	84.56	-54.81			52.71				<0.01	<0.01			<0.01				0.48	<0.01	59	T2	Cu
4	316.93	-53.02			51.26	-112.41		-500.82	0.05	<0.01			<0.01	0.85		0.04	0.60	<0.01	59	T2	Cu
1	20.72	0.17	-0.44	-0.88	0.31				<0.01	0.06	<0.01	0.01	<0.01				0.54	<0.01	59	T1	Ni
2	49.90	0.16	-0.42	-0.85	0.31		1.65	-10.14	0.04	0.08	0.01	0.01	<0.01		0.65	0.16	0.59	<0.01	59	T1	Ni
3	18.35	-13.15			12.64				<0.01	<0.01			<0.01				0.47	<0.01	59	T2	Ni
4	60.05	-12.80			12.88		-4.98	-88.20	0.01	<0.01			<0.01		0.47	0.06	0.51	<0.01	59	T2	Ni
1	29.31	0.21	0.01	-1.16	-0.01				<0.01	0.02	0.95	<0.01	0.77				0.24	<0.01	59	T1	Pb
2	-87.07	0.15	0.06	-0.80	0.00	276.79		-36.61	0.03	0.07	0.65	0.01	0.92	<0.01		<0.01	0.46	<0.01	59	T1	Pb
3	22.71	4.49			4.92				<0.01	0.57			0.14				0.04	0.31	59	T3	Pb
4	-117.42	0.07			-0.01	332.59		-42.72	0.01	0.13			0.78	<0.01		<0.01	0.36	<0.01	59	T1	Pb
1	59.97	370.77	1023.93	588.17	-63.27				0.42	0.31	0.04	0.07	0.37				0.51	<0.01	59	T3	Zn
2	-682.55	338.78	1020.79	598.27	-56.17		-12.19	2316.53	0.13	0.34	0.03	0.07	0.42		0.80	0.07	0.57	<0.01	59	T3	Zn
3	200.67	1138.92			-80.19				<0.01	<0.01			0.27				0.46	<0.01	59	T3	Zn
4	-601.27	1111.73			-75.58		-3.17	2460.66	0.19	<0.01			0.30		0.95	0.05	0.51	<0.01	59	T3	Zn

[a] p values for the individual independent variables were obtained from 2-tailed t-statistic.

[b] p_{Reg} refers to p value for the entire model obtained from F-statistic.

[c] Count is the number of events considered.

[d] In form column **D** denotes dissolved and **P** denotes particulate phase. Also, 1, 2, and 3 are linear, semi-log, and inverse forms respectively.

[e] M denotes the metal parameter.

Table 3.11. Median Values for Combined UCLA Sites

Phase	R^2	p_{Reg} [c]	p values [d]								Model
			Intercept	T_RAIN	MAX_RAIN	D_RUN	ADD	RC	AREA	ADT	
Dissolved/Particulate [b]	0.52 [a]	<0.01	<0.01	0.19	0.07	0.04	0.08				1
Total	0.45	<0.01	<0.01	0.31	0.21	0.04	0.01				1
Dissolved/Particulate	0.58	<0.01	0.13	0.17	0.27	0.08	0.22	0.52	0.31	0.25	2
Total	0.58	<0.01	0.04	0.21	0.15	0.02	<0.01	0.40	0.51	0.05	2
Dissolved/Particulate	0.44	<0.01	<0.01	<0.01			<0.01				3
Total	0.39	<0.01	<0.01	<0.01			0.01				3
Dissolved/Particulate	0.53	<0.01	0.09	<0.01			0.10	0.84	0.52	0.16	4
Total	0.51	<0.01	0.01	<0.01			<0.01	0.85	0.78	0.02	4

[a]The value of R^2 (0.52) for combined UCLA sites in the first data row represents the median of the six R^2 values developed for six dissolved/particulate constituents (i.e. Cd, Cr, Cu, Ni, Pb, and Zn) for regression model 1.Similarly median values of p_{Reg} and p values are presented.

[b]For some metal parameters, the dissolved metal models were better than the particulate models, and vice versa. Dissolved/Particulate means either the dissolved or the particulate model was presented.

[c]p_{Reg} refers to p value for the entire model obtained from F-statistic.

[d]p values for the individual independent variables were obtained from 2-tailed t-statistic.

Table 3.12. R values for the Metal Parameters when Combined UCLA Regression Models are Applied to Other Caltrans Sites as a Whole

Parameter	Model	Dissolved/Particulate[a]		Total	
		Form[b]	R	Form[b]	R
Cd	1	P1	0.11	T2	0.09
	2	D3	No correlation[c]	T1	No correlation
	3	P1	0.03	T2	0.19
	4	D3	No correlation	T2	No correlation
Cr	1	D2	0.13	T2	0.14
	2	D2	No correlation	T2	No correlation
	3	D2	0.18	T2	0.26
	4	D2	No correlation	T2	No correlation
Cu	1	D3	No correlation	T2	0.33
	2	D3	No correlation	T2	No correlation
	3	D2	0.48	T2	0.35
	4	D2	No correlation	T2	No correlation
Ni	1	D1	0.27	T1	0.19
	2	D1	0.19	T1	0.10
	3	D2	0.42	T2	0.34
	4	D2	No correlation	T2	No correlation
Pb	1	D3	No correlation	T1	0.06
	2	D3	No correlation	T1	No correlation
	3	D3	0.02	T3	0.00
	4	D3	No correlation	T1	No correlation
Zn	1	D3	No correlation	T3	No correlation
	2	D3	No correlation	T3	No correlation
	3	D3	0.18	T3	0.24
	4	D3	No correlation	T3	No correlation

[a]For some metal parameters, the dissolved metal models were better than the particulate models, and vice versa. Dissolved/Particulate means either the dissolved or the particulate model was presented.

[b]In form column **D** denotes dissolved and **P** denotes particulate phase. Also, 1, 2, and 3 are linear, semi-log, and inverse forms respectively.

[c]No correlation refers to the cases when the combined UCLA regression model fit the combined other Caltrans sites data worse than the mean of the data.

Table 3.13. Regression Model R^2 Values Developed for the Other Caltrans Sites as a Whole

Model	Dissolved/Particulate[a]						Total					
	Cd	Cr	Cu	Ni	Pb	Zn	Cd	Cr	Cu	Ni	Pb	Zn
1	0.06	0.05	0.31	0.24	0.01	0.15	0.05	0.06	0.14	0.14	0.01	0.11
2	0.12	0.11	0.38	0.28	0.12	0.18	0.09	0.07	0.29	0.17	0.12	0.19
3	0.06	0.05	0.24	0.19	0.02	0.15	0.05	0.07	0.13	0.13	0.01	0.10
4	0.12	0.10	0.34	0.22	0.12	0.17	0.10	0.08	0.27	0.15	0.12	0.18

[a]For some metal parameters, the dissolved metal models were better than the particulate models, and vice versa. Dissolved/Particulate means either the dissolved or the particulate model was presented.

Table 3.14A. Median Values for Catrans Zones for Regression Model 1

Phase	R^2	p_{Reg} [c]	p value [d]					Zone	Location
			Intercept	T_RAIN	MAX_RAIN	D_RUN	ADD		
Dissolved/Particulate [b]	0.28 [a]	<0.01	0.02	<0.01	0.71	0.07	<0.01	Z 1 [e]	Northern [f]
	0.10	0.19	<0.01	0.40	0.38	0.36	0.26	Z 2	Northern
	0.24	<0.01	0.35	0.20	0.66	0.55	0.04	Z 3	Northern
	0.15	0.06	0.02	0.50	0.41	0.02	0.22	Z 4	Northern
	0.38	0.03	<0.01	0.01	0.74	0.25	0.18	Z 5	Central
								Z 6	Southern
	0.73	0.04	0.49	0.01	0.53	0.25	0.57	Z 7	Southern
	0.30	<0.01	0.07	<0.01	0.09	0.01	0.01	Z 8	Southern
	0.65	<0.01	<0.01	0.01	0.84	0.36	0.01	Z 9	Southern
	0.24	<0.01	<0.01	0.38	0.50	0.06	0.01	Z 10	Southern
	0.62	<0.01	0.01	0.01	0.34	0.16	<0.01	Z 11	Southern
	0.54	<0.01	<0.01	0.08	0.15	0.15	0.25	Z 12	Southern
	0.29	0.03	0.16	0.55	0.15	0.64	0.16	Z 13	Southern
	0.34	0.01	<0.01	0.24	0.12	0.70	0.07	Z 14	Southern
Total	0.27	<0.01	<0.01	<0.01	0.86	0.08	<0.01	Z 1	Northern
	0.05	0.63	<0.01	0.44	0.72	0.67	0.39	Z 2	Northern
	0.15	0.01	0.03	0.05	0.24	0.63	0.17	Z 3	Northern
	0.07	0.41	<0.01	0.11	0.26	0.63	0.41	Z 4	Northern
	0.21	0.11	<0.01	0.03	0.15	0.25	0.48	Z 5	Central
								Z 6	Southern
	0.74	0.03	0.09	<0.01	0.47	0.15	0.54	Z 7	Southern
	0.26	<0.01	0.04	0.03	0.33	0.23	0.02	Z 8	Southern
	0.63	<0.01	<0.01	0.01	0.89	0.24	0.01	Z 9	Southern
	0.18	0.01	<0.01	0.31	0.42	0.42	0.01	Z 10	Southern
	0.49	<0.01	<0.01	<0.01	0.59	0.28	<0.01	Z 11	Southern
	0.58	<0.01	<0.01	0.01	0.38	0.25	0.10	Z 12	Southern
	0.14	0.34	0.12	0.73	0.20	0.51	0.14	Z 13	Southern
	0.35	0.01	<0.01	0.19	0.09	0.62	0.14	Z 14	Southern

[a] The value of R^2 (0.28) for Zone 1 in the first data row represents the median of the six R2 values developed for six dissolved/particulate constituents (i.e. Cd, Cr, Cu, Ni, Pb, and Zn) for regression model 1. Similarly median values of pReg and p values are presented.

[b] For some metal parameters, the dissolved metal models were better than the particulate models, and vice versa. Dissolved/Particulate means either the dissolved or the particulate model was presented.

[c] p_{Reg} refers to p value for the entire model obtained from F-statistic.

[d] p values for the individual independent variables were obtained from 2-tailed t-statistic.

[e] Z 1 is the abbreviated form of Zone1.

[f] Zone 1 is located in the northern part of California

Table 3.14B. Median Values for Catrans Zones for Regression Model 2

Phase	R^2	p_{Reg}[c]	p value[d]								Zone	Location
			Intercept	T_RAIN	MAX_RAIN	D_RUN	ADD	RC	AREA	ADT		
Dissolved/Particulate[b]	0.55[a]	<0.01	<0.01	<0.01	0.65	0.06	0.02	0.05	0.56	<0.01	Z 1[e]	Northern[f]
	0.37	<0.01	0.03	0.18	0.37	0.50	0.13	<0.01	<0.01	<0.01	Z 2	Northern
	0.45	<0.01	0.08	0.03	0.27	0.59	0.39	0.43	0.01	<0.01	Z 3	Northern
	0.30	0.02	0.65	0.11	0.53	0.22	0.28	0.39	0.27	<0.01	Z 4	Northern
	0.43	0.01	<0.01	0.01	0.59	0.21	0.12	<0.01	<0.01	0.10	Z 5	Central
											Z 6	Southern
	0.75	0.12	0.12	0.14	0.27	0.20	0.34	<0.01	0.07	0.05	Z 7	Southern
	0.45	<0.01	0.06	<0.01	0.40	0.01	0.04	0.11	0.10	0.13	Z 8	Southern
	0.74	<0.01	0.24	0.01	0.57	0.18	<0.01	<0.01	0.01	<0.01	Z 9	Southern
	0.41	<0.01	<0.01	0.26	0.83	0.41	0.63	<0.01	<0.01	<0.01	Z 10	Southern
	0.67	<0.01	0.58	0.01	0.15	0.26	<0.01	0.43	0.67	<0.01	Z 11	Southern
	0.64	<0.01	0.04	0.08	0.28	0.35	0.26	0.01	0.03	<0.01	Z 12	Southern
	0.68	<0.01	0.03	0.38	0.18	0.90	0.42	0.02	0.07	0.08	Z 13	Southern
	0.59	<0.01	0.30	0.10	0.30	0.42	0.48	0.56	0.14	<0.01	Z 14	Southern
Total	0.66	<0.01	<0.01	<0.01	0.66	0.05	0.01	0.11	0.54	<0.01	Z 1	Northern
	0.30	0.01	0.09	0.15	0.19	0.23	0.19	<0.01	0.33	<0.01	Z 2	Northern
	0.44	<0.01	0.07	0.02	0.22	0.56	0.07	0.68	0.01	<0.01	Z 3	Northern
	0.25	0.03	0.12	0.02	0.16	0.50	0.38	0.20	0.18	<0.01	Z 4	Northern
	0.33	0.05	<0.01	0.02	0.07	0.29	0.29	<0.01	<0.01	<0.01	Z 5	Central
											Z 6	Southern
	0.64	0.27	0.48	0.09	0.80	0.31	0.32	<0.01	<0.01	0.47	Z 7	Southern
	0.35	<0.01	<0.01	<0.01	0.30	0.11	0.02	<0.01	<0.01	0.12	Z 8	Southern
	0.76	<0.01	0.20	0.01	0.60	0.17	<0.01	<0.01	0.01	<0.01	Z 9	Southern
	0.41	<0.01	<0.01	0.33	0.31	0.62	0.30	<0.01	<0.01	<0.01	Z 10	Southern
	0.60	<0.01	0.38	0.05	0.46	0.40	<0.01	0.43	0.49	<0.01	Z 11	Southern
	0.73	<0.01	0.04	0.07	0.20	0.34	0.06	0.02	0.06	<0.01	Z 12	Southern
	0.57	<0.01	<0.01	0.26	0.29	0.41	0.10	<0.01	<0.01	<0.01	Z 13	Southern
	0.52	<0.01	0.40	0.29	0.06	0.59	0.44	0.39	0.38	<0.01	Z 14	Southern

[a]The value of R2 (0.55) for Zone 1 in the first data row represents the median of the six R2 values developed for six dissolved/particulate constituents (i.e. Cd, Cr, Cu, Ni, Pb, and Zn) for regression model 2. Similarly median values of pReg and p values are presented.

[b]For some metal parameters, the dissolved metal models were better than the particulate models, and vice versa. Dissolved/Particulate means either the dissolved or the particulate model was presented.

[c]p_{Reg} refers to p value for the entire model obtained from F-statistic.

[d]p values for the individual independent variables were obtained from 2-tailed t-statistic.

[e]Z 1 is the abbreviated form of Zone1.

[f]Zone 1 is located in the northern part of California

Table 3.14C. Median Values for Catrans Zones for Regression Model 3

Phase	R^2	p_{Reg}[c]	p value[d] Intercept	T_RAIN	ADD	Zone	Location
Dissolved/Particulate[b]	0.24[a]	<0.01	<0.01	<0.01	<0.01	Z 1[e]	Northern[f]
	0.08	0.09	<0.01	0.35	0.32	Z 2	Northern
	0.21	<0.01	0.24	0.30	0.01	Z 3	Northern
	0.09	0.09	<0.01	0.33	0.15	Z 4	Northern
	0.31	0.03	<0.01	0.02	0.23	Z 5	Central
	0.49	0.17	0.45	0.61	0.13	Z 6	Southern
	0.63	<0.01	0.42	<0.01	0.71	Z 7	Southern
	0.22	<0.01	0.01	0.01	0.01	Z 8	Southern
	0.61	<0.01	<0.01	<0.01	0.01	Z 9	Southern
	0.21	<0.01	<0.01	0.03	0.01	Z 10	Southern
	0.39	<0.01	<0.01	<0.01	0.05	Z 11	Southern
	0.49	<0.01	<0.01	<0.01	0.61	Z 12	Southern
	0.26	0.03	0.01	0.35	0.03	Z 13	Southern
	0.28	<0.01	0.13	0.02	0.03	Z 14	Southern
Total	0.23	<0.01	<0.01	<0.01	<0.01	Z 1	Northern
	0.04	0.32	<0.01	0.27	0.39	Z 2	Northern
	0.12	<0.01	0.01	0.04	0.14	Z 3	Northern
	0.05	0.26	<0.01	0.17	0.52	Z 4	Northern
	0.17	0.05	<0.01	0.05	0.41	Z 5	Central
	0.48	0.19	0.26	0.44	0.13	Z 6	Southern
	0.61	<0.01	0.21	<0.01	0.82	Z 7	Southern
	0.17	<0.01	0.01	0.06	<0.01	Z 8	Southern
	0.57	<0.01	<0.01	<0.01	0.01	Z 9	Southern
	0.14	<0.01	<0.01	0.01	0.02	Z 10	Southern
	0.34	<0.01	<0.01	<0.01	0.05	Z 11	Southern
	0.54	<0.01	<0.01	<0.01	0.20	Z 12	Southern
	0.07	0.41	0.01	0.53	0.23	Z 13	Southern
	0.21	0.01	0.01	0.01	0.10	Z 14	Southern

aThe value of R^2 (0.24) for Zone 1 in the first data row represents the median of the six R^2 values developed for six dissolved/particulate constituents (i.e. Cd, Cr, Cu, Ni, Pb, and Zn) for regression model 3. Similarly median values of p_{Reg} and p values are presented.

[b]For some metal parameters, the dissolved metal models were better than the particulate models, and vice versa. Dissolved/Particulate means either the dissolved or the particulate model was presented.

[c]p_{Reg} refers to p value for the entire model obtained from F-statistic.

[d]p values for the individual independent variables were obtained from 2-tailed t-statistic.

[e]Z 1 is the abbreviated form of Zone1.

[f]Zone 1 is located in the northern part of California

Table 3.14D. Median Values for Catrans Zones for Regression Model 4

Phase	R^2	p_{Reg}[c]	p value[d] Intercept	T_RAIN	ADD	RC	AREA	ADT	Zone	Location
Dissolved/Particulate[b]	0.53[a]	<0.01	<0.01	<0.01	0.01	0.04	0.76	<0.01	Z 1[e]	Northern[f]
	0.28	<0.01	0.02	0.38	0.08	0.09	<0.01	<0.01	Z 2	Northern
	0.44	<0.01	0.08	0.04	0.46	0.43	0.01	<0.01	Z 3	Northern
	0.22	0.02	0.35	0.12	0.24	0.32	0.13	<0.01	Z 4	Northern
	0.32	0.06	<0.01	0.02	0.22	<0.01	<0.01	0.15	Z 5	Central
									Z 6	Southern
	0.90	<0.01	0.18	0.09	0.71	<0.01	0.22	<0.01	Z 7	Southern
	0.38	<0.01	0.03	0.01	0.05	0.01	0.01	0.18	Z 8	Southern
	0.71	<0.01	0.44	<0.01	<0.01	<0.01	0.01	<0.01	Z 9	Southern
	0.33	<0.01	0.07	<0.01	0.33	0.03	<0.01	0.03	Z 10	Southern
	0.58	<0.01	0.18	<0.01	0.44	0.14	0.61	0.18	Z 11	Southern
	0.63	<0.01	0.03	<0.01	0.37	0.01	0.03	<0.01	Z 12	Southern
	0.60	<0.01	0.02	0.18	0.09	0.01	0.05	0.06	Z 13	Southern
	0.50	<0.01	0.23	0.01	0.01	0.15	0.01	0.17	Z 14	Southern
Total	0.63	<0.01	<0.01	<0.01	<0.01	0.04	0.59	<0.01	Z 1	Northern
	0.23	0.01	0.10	0.40	0.26	<0.01	<0.01	<0.01	Z 2	Northern
	0.41	<0.01	0.08	0.01	0.06	0.60	<0.01	<0.01	Z 3	Northern
	0.21	0.02	0.12	0.04	0.56	0.23	0.18	<0.01	Z 4	Northern
	0.19	0.08	<0.01	0.04	0.41	<0.01	<0.01	0.02	Z 5	Central
									Z 6	Southern
	0.89	<0.01	0.15	0.24	0.62	<0.01	0.37	<0.01	Z 7	Southern
	0.28	<0.01	<0.01	<0.01	0.68	<0.01	<0.01	0.14	Z 8	Southern
	0.72	<0.01	0.33	<0.01	<0.01	<0.01	0.01	<0.01	Z 9	Southern
	0.32	<0.01	0.04	0.01	0.36	0.01	<0.01	0.02	Z 10	Southern
	0.55	<0.01	0.25	<0.01	0.04	0.15	0.52	0.28	Z 11	Southern
	0.70	<0.01	0.07	<0.01	0.08	0.02	0.07	<0.01	Z 12	Southern
	0.53	<0.01	<0.01	0.67	0.20	<0.01	<0.01	<0.01	Z 13	Southern
	0.45	<0.01	0.06	0.01	0.04	0.42	0.24	0.04	Z 14	Southern

[a]The value of R^2 (0.53) for Zone 1 in the first data row represents the median of the six R^2 values developed for six dissolved/particulate constituents (i.e. Cd, Cr, Cu, Ni, Pb, and Zn) for regression model 4. Similarly median values of p_{Reg} and p values are presented.

[b]For some metal parameters, the dissolved metal models were better than the particulate models, and vice versa. Dissolved/Particulate means either the dissolved or the particulate model was presented.

[c]p_{Reg} refers to p value for the entire model obtained from F-statistic.

[d]p values for the individual independent variables were obtained from 2-tailed t-statistic.

[e]Z 1 is the abbreviated form of Zone1.

[f]Zone 1 is located in the northern part of California

Table 3.15. Caltrans Zones: Median Values for Different Metal Constituents

Phase	Parameter	R^2	p_{Reg}	p value: Intercept	T_RAIN	MAX_RAIN	D_RUN	ADD	RC	AREA	ADT	Model
Dissolved/ Particulate	Cd	0.23[a]	0.03	0.00	0.01	0.39	0.18	0.26				1
	Cr	0.28	0.02	0.06	0.03	0.66	0.31	0.15				
	Cu	0.49	0.00	0.00	0.02	0.19	0.28	0.00				
	Ni	0.49	0.00	0.01	0.04	0.43	0.25	0.00				
	Pb	0.24	0.05	0.01	0.12	0.28	0.06	0.21				
	Zn	0.33	0.00	0.02	0.17	0.40	0.09	0.02				
Total	Cd	0.20	0.01	0.00	0.04	0.48	0.30	0.18				
	Cr	0.27	0.03	0.00	0.10	0.61	0.33	0.15				
	Cu	0.36	0.00	0.00	0.01	0.30	0.35	0.01				
	Ni	0.36	0.00	0.00	0.01	0.37	0.51	0.05				
	Pb	0.19	0.09	0.00	0.12	0.20	0.37	0.28				
	Zn	0.27	0.00	0.00	0.01	0.47	0.38	0.12				
Dissolved/ Particulate	Cd	0.42	0.00	0.03	0.06	0.38	0.27	0.17	0.00	0.01	0.00	2
	Cr	0.49	0.00	0.04	0.02	0.58	0.25	0.50	0.01	0.01	0.00	
	Cu	0.63	0.00	0.07	0.05	0.30	0.64	0.11	0.13	0.12	0.00	
	Ni	0.53	0.00	0.21	0.06	0.57	0.32	0.02	0.04	0.03	0.00	
	Pb	0.52	0.00	0.05	0.09	0.13	0.15	0.21	0.02	0.02	0.00	
	Zn	0.58	0.00	0.06	0.02	0.46	0.31	0.04	0.01	0.03	0.00	
Total	Cd	0.44	0.00	0.06	0.06	0.33	0.18	0.07	0.01	0.01	0.00	
	Cr	0.45	0.00	0.07	0.12	0.41	0.45	0.63	0.03	0.02	0.00	
	Cu	0.64	0.00	0.05	0.01	0.27	0.21	0.01	0.00	0.00	0.00	
	Ni	0.41	0.00	0.01	0.01	0.16	0.36	0.04	0.03	0.03	0.00	
	Pb	0.50	0.00	0.06	0.08	0.16	0.26	0.34	0.01	0.00	0.00	
	Zn	0.41	0.00	0.13	0.04	0.33	0.27	0.02	0.00	0.05	0.00	
Dissolved/ Particulate	Cd	0.20	0.01	0.00	0.03			0.19				3
	Cr	0.21	0.02	0.00	0.01			0.12				
	Cu	0.39	0.00	0.00	0.02			0.00				
	Ni	0.35	0.00	0.01	0.00			0.00				
	Pb	0.26	0.02	0.00	0.08			0.28				
	Zn	0.28	0.00	0.00	0.01			0.05				
Total	Cd	0.17	0.02	0.00	0.02			0.25				
	Cr	0.16	0.02	0.00	0.08			0.04				
	Cu	0.31	0.00	0.00	0.01			0.01				
	Ni	0.23	0.00	0.00	0.02			0.05				
	Pb	0.16	0.03	0.00	0.10			0.46				
	Zn	0.20	0.00	0.00	0.01			0.07				
Dissolved/ Particulate	Cd	0.49	0.00	0.02	0.05			0.17	0.00	0.01	0.00	4
	Cr	0.41	0.00	0.01	0.04			0.29	0.02	0.01	0.00	
	Cu	0.57	0.00	0.04	0.01			0.07	0.13	0.08	0.01	
	Ni	0.47	0.00	0.31	0.01			0.00	0.06	0.01	0.00	
	Pb	0.50	0.00	0.03	0.13			0.57	0.02	0.01	0.00	
	Zn	0.48	0.00	0.08	0.01			0.03	0.00	0.02	0.01	
Total	Cd	0.43	0.00	0.01	0.04			0.24	0.00	0.00	0.00	
	Cr	0.40	0.00	0.05	0.09			0.37	0.09	0.10	0.00	
	Cu	0.57	0.00	0.00	0.00			0.01	0.00	0.01	0.00	
	Ni	0.31	0.00	0.02	0.02			0.05	0.01	0.16	0.00	
	Pb	0.48	0.00	0.02	0.13			0.57	0.02	0.00	0.00	
	Zn	0.34	0.00	0.14	0.00			0.06	0.00	0.03	0.08	

[a]The value of R^2 (0.23) for dissolved/particulate Cd in the first data row represents the median of the three R^2 values developed for fourteen individual Caltrans zones for regression model 1.Similarly median values of pReg and p values are presented.

Table 3.16A. Final Comparison of Regression Models for Dissolved/Particulate Phase in Terms of R^2

Model	UCLA 1	UCLA 2	UCLA 3	UCLA all	All	Z 1	Z 2	Z 3	Z 4	Z 5	Z 6	Z 7	Z 8	Z 9	Z 10	Z 11	Z 12	Z 13	Z 14	Parameter
1	0.57	0.77	0.83	0.53	0.06	0.31	0.17	0.23	0.15	0.19		0.74	0.21	0.60	0.11	0.54	0.52	0.20	0.26	Cd
2				0.59	0.12	0.52	0.30	0.42	0.18	0.23		0.74	0.39	0.72	0.30	0.61	0.65	0.52	0.39	Cd
3	0.30	0.75	0.80	0.43	0.06	0.24	0.16	0.09	0.05	0.15	0.46	0.55	0.16	0.55	0.04	0.42	0.51	0.06	0.56	Cd
4				0.59	0.12	0.49	0.29	0.36	0.18	0.17		0.90	0.38	0.68	0.21	0.57	0.63	0.49	0.63	Cd
Median of 1				0.77[a]		0.99	0.49	0.65	0.97	0.63		0.99	0.93	0.90	0.81	0.95	0.88	0.76	0.83[b]	Cd
Median of 3				0.75		0.57	0.06	0.54	0.71	0.26	0.63	0.61	0.75	0.80	0.45	0.63	0.65	0.34	0.62	Cd
1	0.67	0.76	0.72	0.43	0.05	0.31	0.10	0.40	0.12	0.26		0.73	0.28	0.65	0.12	0.42	0.25	0.21	0.35	Cr
2				0.58	0.11	0.63	0.44	0.59	0.34	0.27		0.67	0.49	0.75	0.36	0.48	0.34	0.71	0.62	Cr
3	0.52	0.75	0.62	0.39	0.05	0.24	0.09	0.40	0.11	0.16	0.70	0.53	0.15	0.58	0.07	0.37	0.24	0.18	0.13	Cr
4				0.55	0.10	0.58	0.36	0.56	0.31	0.16		0.90	0.25	0.68	0.32	0.45	0.33	0.66	0.37	Cr
Median of 1				0.72		1.00	0.73	0.78	0.93	0.73		0.97	0.96	0.91	0.65	0.98	0.86	0.97	0.98	Cr
Median of 3				0.62		0.59	0.48	0.25	0.52	0.27	0.90	0.72	0.76	0.81	0.46	0.90	0.68	0.78	0.88	Cr
1	0.57	0.92	0.76	0.57	0.31	0.27	0.17	0.30	0.32	0.49		0.73	0.49	0.72	0.40	0.70	0.57	0.48	0.81	Cu
2				0.63	0.38	0.61	0.43	0.49	0.37	0.53		0.72	0.55	0.78	0.69	0.72	0.63	0.65	0.85	Cu
3	0.49	0.90	0.65	0.54	0.24	0.24	0.16	0.30	0.11	0.47	0.44	0.67	0.41	0.68	0.38	0.41	0.48	0.37	0.37	Cu
4				0.61	0.34	0.58	0.42	0.48	0.21	0.51		0.89	0.47	0.72	0.64	0.62	0.63	0.54	0.60	Cu
Median of 1				0.76		0.98	0.68	0.84	0.99	0.61		0.95	0.93	0.89	0.71	0.94	0.86	0.83	1.00	Cu
Median of 3				0.65		0.62	0.48	0.73	0.82	0.45	0.67	0.69	0.82	0.83	0.64	0.87	0.70	0.63	0.99	Cu
1	0.67	0.89	0.85	0.59	0.24	0.21	0.10	0.25	0.20	0.49		0.72	0.41	0.66	0.26	0.69	0.69	0.64	0.65	Ni
2				0.63	0.28	0.42	0.33	0.39	0.25	0.50		0.76	0.53	0.76	0.37	0.72	0.72	0.78	0.67	Ni
3	0.52	0.89	0.79	0.49	0.19	0.18	0.08	0.23	0.12	0.46	0.59	0.78	0.32	0.65	0.24	0.38	0.63	0.61	0.28	Ni
4				0.52	0.22	0.38	0.23	0.38	0.23	0.47		0.95	0.43	0.71	0.33	0.60	0.65	0.78	0.47	Ni
Median of 1				0.85		0.95	0.63	0.72	0.94	0.58		0.92	0.95	0.92	0.69	0.93	0.84	0.94	0.99	Ni
Median of 3				0.79		0.31	0.28	0.61	0.32	0.48	0.81	0.72	0.84	0.81	0.34	0.68	0.74	0.81	0.90	Ni
1	0.61	0.89	0.52	0.47	0.01	0.29	0.06	0.07	0.16	0.15		0.68	0.14	0.54	0.33	0.69	0.43	0.19	0.24	Pb
2				0.50	0.12	0.43	0.29	0.56	0.19	0.35		0.81	0.16	0.73	0.59	0.73	0.52	0.53	0.50	Pb
3	0.23	0.85	0.50	0.38	0.02	0.24	0.01	0.05	0.05	0.03	0.53	0.61	0.06	0.52	0.28	0.47	0.36	0.07	0.29	Pb
4				0.46	0.12	0.40	0.27	0.55	0.13	0.12		0.90	0.11	0.71	0.56	0.66	0.46	0.35	0.54	Pb
Median of 1				0.61		0.70	0.49	0.64	0.94	0.42		0.93	0.83	0.91	0.79	0.91	0.85	0.75	0.94	Pb
Median of 3				0.50		0.41	0.18	0.46	0.66	0.10	0.54	0.76	0.50	0.87	0.45	0.79	0.77	0.29	0.80	Pb
1	0.76	0.91	0.80	0.50	0.15	0.25	0.11	0.20	0.13	0.62		0.66	0.32	0.66	0.23	0.51	0.67	0.36	0.33	Zn
2				0.54	0.18	0.58	0.42	0.40	0.35	0.64		0.85	0.41	0.73	0.44	0.62	0.79	0.77	0.55	Zn
3	0.45	0.90	0.77	0.46	0.15	0.20	0.04	0.19	0.07	0.61	0.27	0.66	0.28	0.64	0.18	0.37	0.54	0.35	0.20	Zn
4				0.49	0.17	0.57	0.26	0.39	0.34	0.63		0.82	0.39	0.72	0.32	0.51	0.67	0.76	0.45	Zn
Median of 1				0.80		0.92	0.71	0.84	0.96	0.69		0.97	0.94	0.88	0.86	0.96	0.90	0.78	1.00	Zn
Median of 3				0.77		0.49	0.18	0.71	0.72	0.54	0.62	0.72	0.78	0.73	0.66	0.85	0.77	0.48	0.98	Zn

[a] 0.77 is the median R^2 value of three values developed for the three individual UCLA sites for regression model 1 for dissolved/particulate Cd. [b] 0.83 is the median R^2 value of eight values developed for the eight individual (Appendix A) sites in zone 14 for regression model 1 for dissolved/particulate Cd.

Table 3.16B. Final Comparison of Regression Models for Total Phase in Terms of R^2

Model	UCLA 1	UCLA 2	UCLA 3	UCLA all	All	Z 1	Z 2	Z 3	Z 4	Z 5	Z 6	Z 7	Z 8	Z 9	Z 10	Z 11	Z 12	Z 13	Z 14	Parameter
1	0.54	0.64	0.68	0.41	0.05	0.21	0.03	0.14	0.03	0.20		0.77	0.20	0.60	0.05	0.48	0.53	0.15	0.34	Cd
2				0.57	0.09	0.47	0.22	0.44	0.19	0.24		0.67	0.35	0.73	0.24	0.56	0.72	0.61	0.41	Cd
3	0.18	0.63	0.60	0.33	0.05	0.15	0.02	0.08	0.03	0.16	0.37	0.46	0.19	0.56	0.03	0.36	0.49	0.04	0.42	Cd
4				0.47	0.10	0.43	0.19	0.39	0.18	0.17		0.87	0.31	0.69	0.18	0.55	0.69	0.58	0.53	Cd
Median of 1				0.64[a]		0.90	0.21	0.63	0.86	0.62		0.82	0.87	0.88	0.67	0.84	0.70	0.75	0.80[b]	Cd
Median of 3				0.60		0.33	0.07	0.49	0.36	0.22	0.68	0.68	0.51	0.82	0.48	0.53	0.55	0.54	0.38	Cd
1	0.67	0.70	0.60	0.35	0.06	0.27	0.15	0.34	0.06	0.20		0.76	0.27	0.65	0.08	0.39	0.15	0.12	0.36	Cr
2				0.60	0.07	0.67	0.23	0.45	0.26	0.21		0.48	0.49	0.76	0.29	0.44	0.21	0.61	0.62	Cr
3	0.37	0.67	0.30	0.29	0.07	0.25	0.14	0.33	0.06	0.10	0.70	0.58	0.10	0.59	0.05	0.32	0.13	0.09	0.18	Cr
4				0.54	0.08	0.65	0.22	0.42	0.25	0.10		0.92	0.25	0.71	0.22	0.40	0.21	0.60	0.40	Cr
Median of 1				0.67		0.75	0.60	0.70	0.87	0.54		0.68	0.96	0.91	0.65	0.92	0.52	0.88	0.92	Cr
Median of 3				0.37		0.56	0.36	0.22	0.31	0.16	0.70	0.55	0.54	0.81	0.28	0.86	0.41	0.54	0.79	Cr
1	0.60	0.87	0.61	0.49	0.14	0.26	0.05	0.14	0.13	0.36		0.73	0.36	0.55	0.28	0.66	0.64	0.10	0.74	Cu
2				0.61	0.29	0.67	0.42	0.47	0.31	0.54		0.64	0.46	0.75	0.75	0.74	0.73	0.52	0.75	Cu
3	0.48	0.85	0.58	0.48	0.13	0.22	0.04	0.13	0.05	0.30	0.68	0.67	0.36	0.53	0.22	0.40	0.61	0.12	0.33	Cu
4				0.60	0.27	0.64	0.38	0.46	0.21	0.44		0.88	0.45	0.73	0.69	0.65	0.71	0.47	0.50	Cu
Median of 1				0.61		0.90	0.59	0.82	0.59	0.56		0.78	0.94	0.87	0.64	0.89	0.76	0.77	0.99	Cu
Median of 3				0.58		0.34	0.52	0.63	0.37	0.30	0.77	0.58	0.70	0.83	0.51	0.78	0.60	0.35	0.91	Cu
1	0.69	0.82	0.80	0.54	0.14	0.36	0.06	0.15	0.07	0.39		0.77	0.24	0.68	0.24	0.24	0.72	0.53	0.52	Ni
2				0.59	0.17	0.69	0.33	0.30	0.25	0.40		0.64	0.31	0.78	0.41	0.26	0.75	0.75	0.55	Ni
3	0.50	0.81	0.79	0.47	0.13	0.32	0.06	0.12	0.04	0.25	0.41	0.77	0.15	0.66	0.21	0.15	0.71	0.39	0.18	Ni
4				0.51	0.15	0.65	0.23	0.28	0.21	0.25		0.92	0.24	0.75	0.33	0.19	0.74	0.74	0.19	Ni
Median of 1				0.80		0.85	0.63	0.59	0.75	0.63		0.80	0.99	0.91	0.68	0.92	0.82	0.69	0.96	Ni
Median of 3				0.79		0.52	0.36	0.53	0.29	0.37	0.91	0.72	0.74	0.84	0.42	0.70	0.73	0.42	0.92	Ni
1	0.55	0.30	0.33	0.24	0.01	0.28	0.01	0.05	0.08	0.15		0.63	0.08	0.55	0.14	0.62	0.33	0.19	0.22	Pb
2				0.46	0.12	0.44	0.31	0.56	0.16	0.39		0.64	0.10	0.73	0.64	0.68	0.45	0.53	0.50	Pb
3	0.18	0.07	0.12	0.04	0.01	0.24	0.01	0.02	0.04	0.03	0.55	0.61	0.06	0.53	0.10	0.38	0.22	0.02	0.25	Pb
4				0.36	0.12	0.41	0.28	0.55	0.12	0.15		0.90	0.10	0.71	0.60	0.60	0.33	0.35	0.55	Pb
Median of 1				0.33		0.69	0.44	0.46	0.77	0.42		0.74	0.79	0.91	0.55	0.91	0.71	0.72	0.92	Pb
Median of 3				0.12		0.40	0.11	0.32	0.53	0.13	0.56	0.69	0.39	0.87	0.27	0.81	0.65	0.30	0.57	Pb
1	0.53	0.90	0.78	0.51	0.11	0.27	0.05	0.15	0.09	0.22		0.71	0.31	0.70	0.22	0.49	0.62	0.10	0.27	Zn
2				0.57	0.19	0.65	0.29	0.35	0.37	0.27		0.71	0.36	0.79	0.41	0.65	0.78	0.23	0.41	Zn
3	0.33	0.89	0.75	0.46	0.10	0.22	0.04	0.13	0.05	0.18	0.36	0.61	0.30	0.68	0.17	0.33	0.59	0.02	0.18	Zn
4				0.51	0.18	0.62	0.23	0.34	0.32	0.21		0.68	0.35	0.76	0.30	0.55	0.77	0.18	0.34	Zn
Median of 1				0.78		0.53	0.42	0.71	0.77	0.49		0.83	0.83	0.89	0.66	0.88	0.79	0.80	0.94	Zn
Median of 3				0.75		0.42	0.12	0.49	0.32	0.20	0.68	0.79	0.58	0.83	0.54	0.71	0.75	0.32	0.80	Zn

[a]0.64 is the median R^2 value of three values developed for the three individual UCLA sites for regression model 1 for dissolved/particulate Cd. [b]0.80 is the median R^2 value of eight values developed for the eight individual (Appendix A) sites in zone 14 for regression model 1 for dissolved/particulate Cd.

Fig. 3.1. Locations of the UCLA Sites, Other Caltrans Sites Grouped by Zones

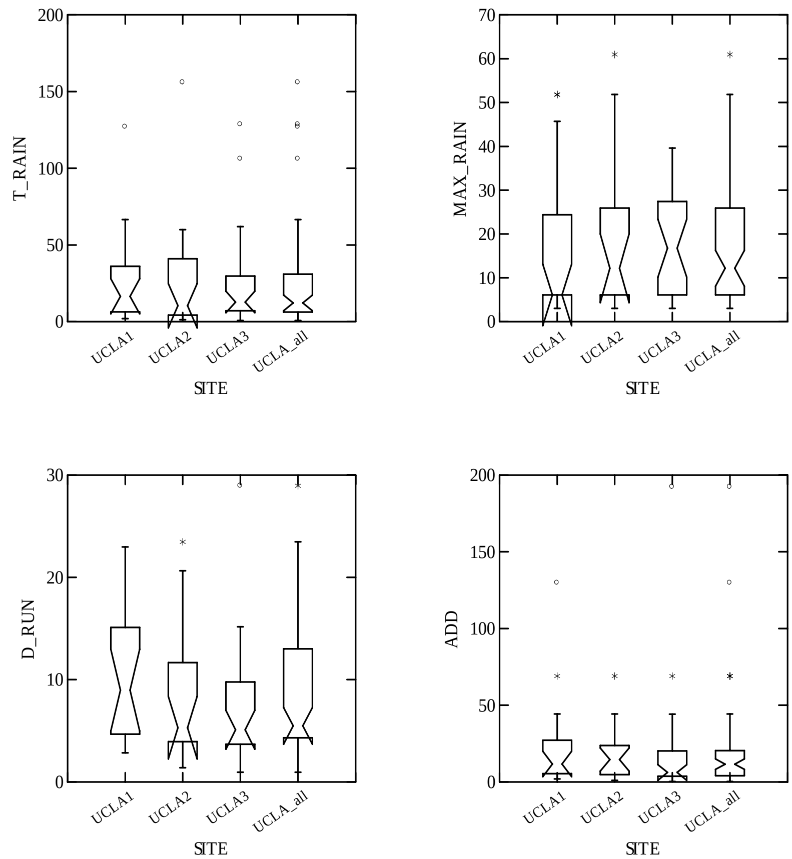

Fig. 3.2. Event-specific Characteristics for UCLA Sites; Total Rainfall (T_RAIN, mm), Maximum Intensity of Rainfall (MAX_RAIN, mm/hr), Duration of Runoff (D_RUN, hr), and Antecedent Dry Days (ADD, day)

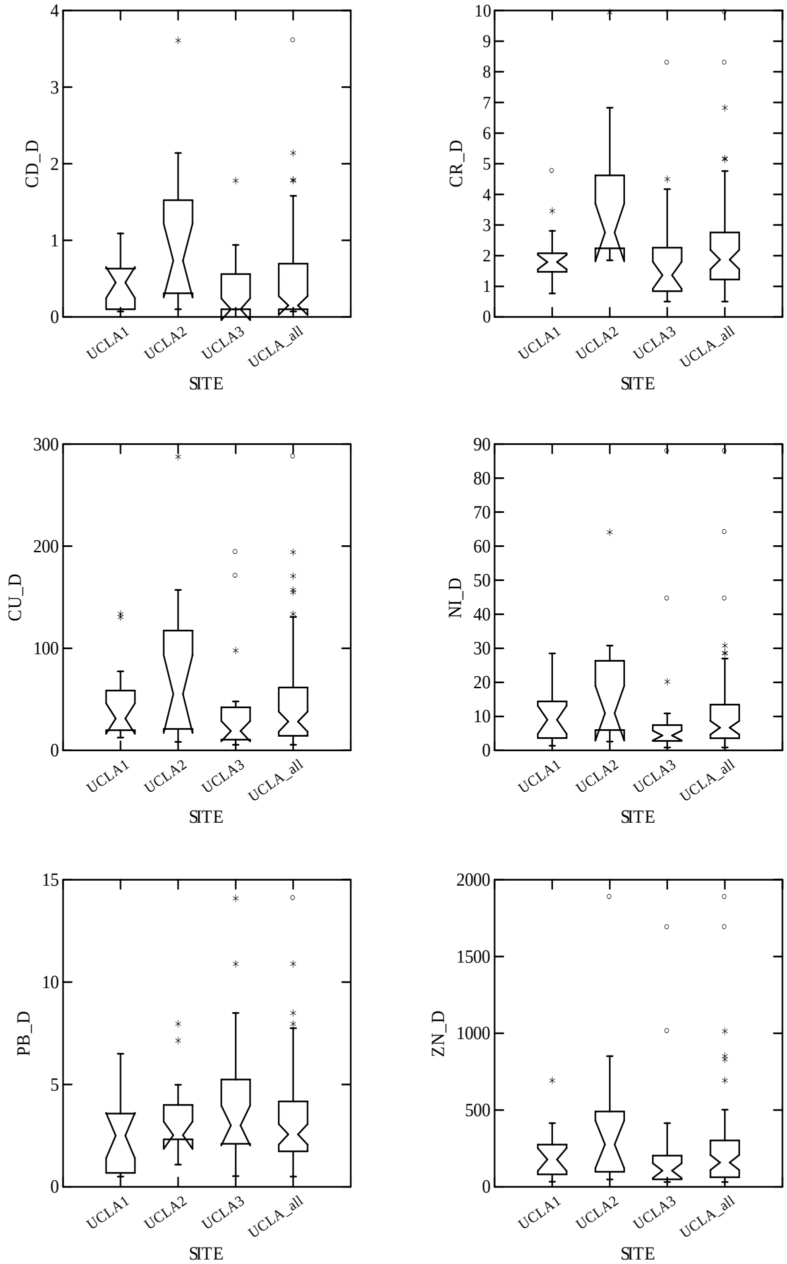

Fig. 3.3A. Dissolved Metal EMC (μg/L) Characteristics for UCLA Sites; CD_D (Dissolved Cadmium), CR_D (Dissolved Chromium), CU_D (Dissolved Copper), NI_D (Dissolved Nickel), PB_D (Dissolved Lead), and ZN_D (Dissolved Zinc)

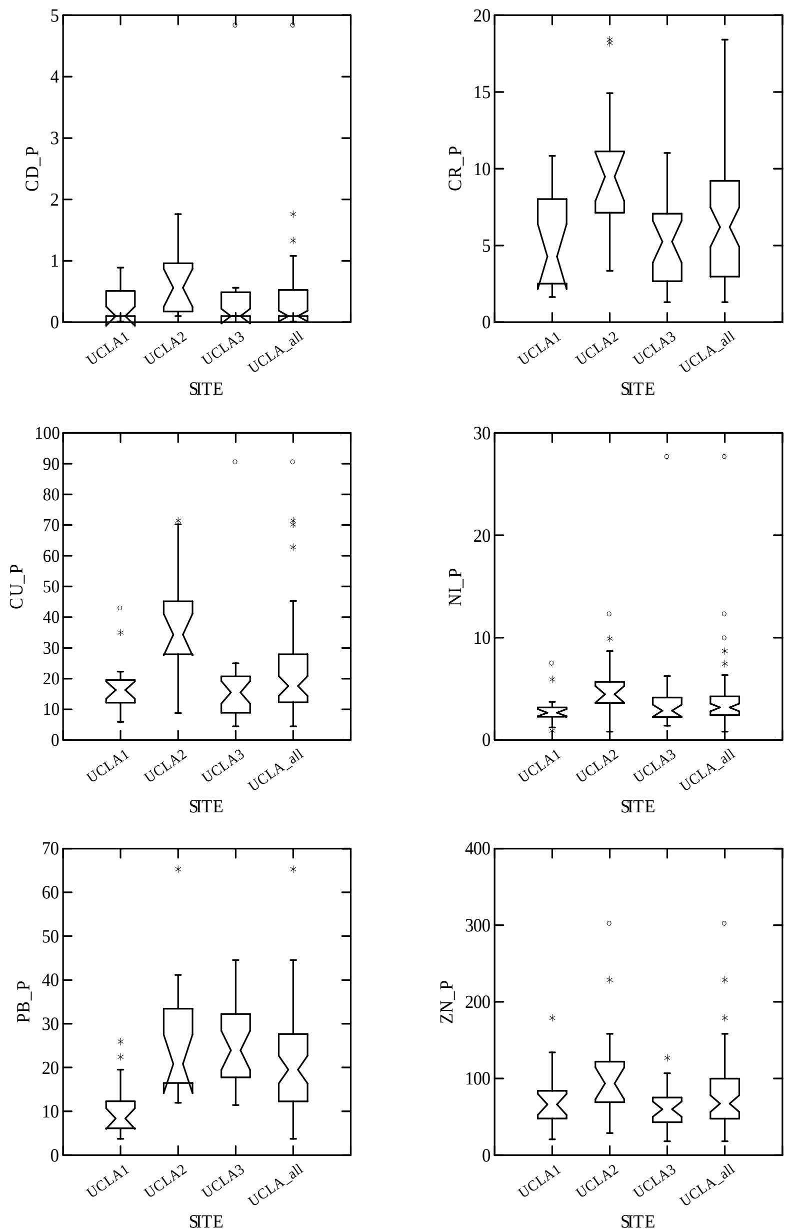

Fig. 3.3B. Particulate Metal EMC (μg/L) Characteristics for UCLA Sites; CD_P (Particulate Cadmium), CR_P (Particulate Chromium), CU_P (Particulate Copper), NI_P (Particulate Nickel), PB_P (Particulate Lead), and ZN_P (Particulate Zinc)

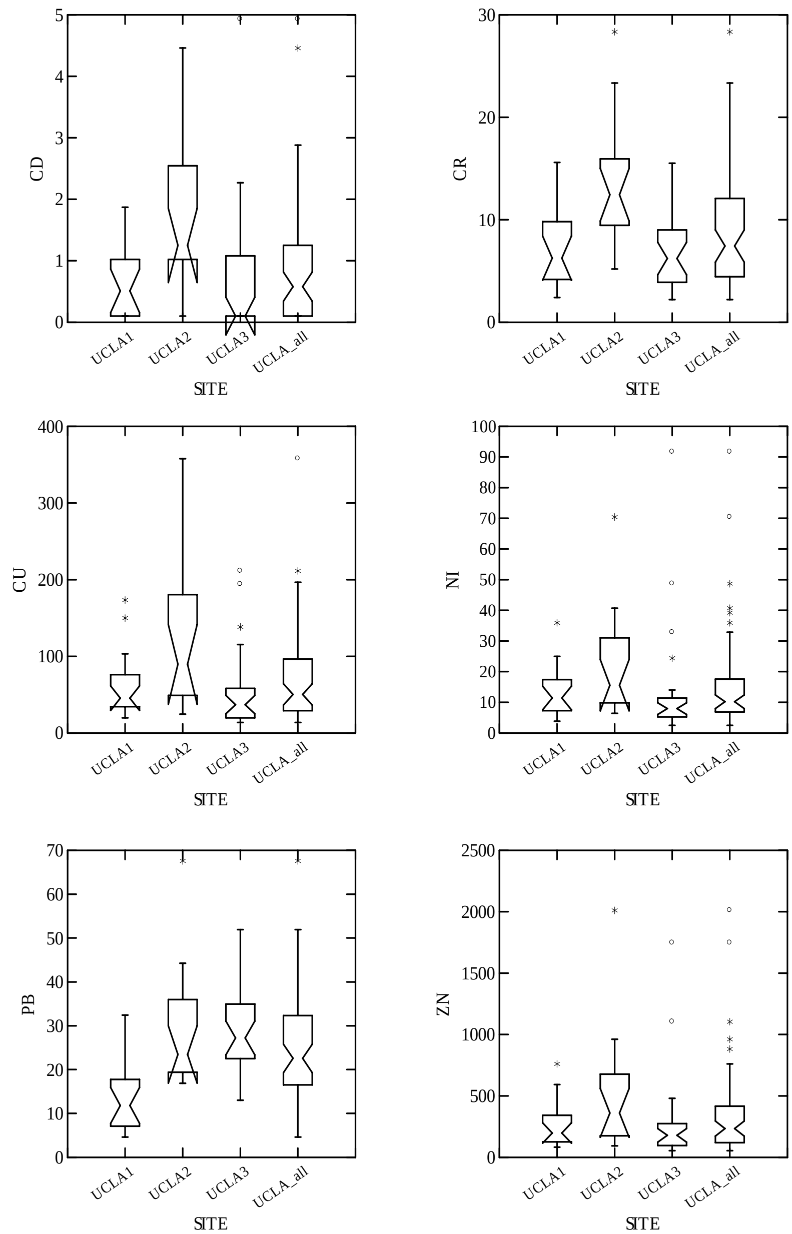

Fig. 3.3C. Total Metal EMC (µg/L) Characteristics for UCLA Sites; CD (Cadmium), CR (Chromium), CU (Copper), NI (Nickel), PB (Lead), and ZN (Zinc)

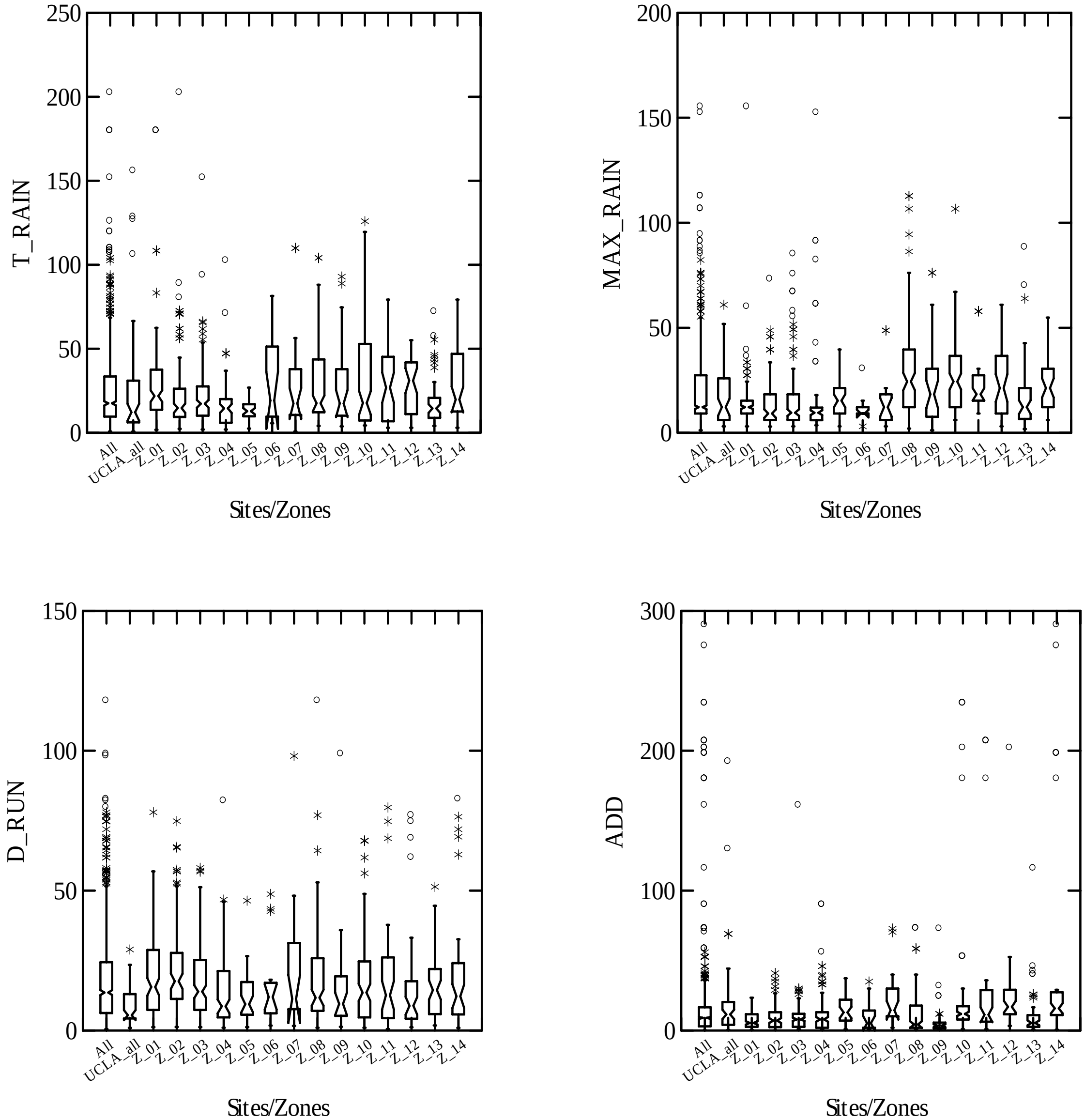

Fig. 3.4A. Event-specific Characteristics for Combined UCLA Sites (UCLA_all), Combined Other Sites (All), and 14 Caltrans Zones (e.g. Z_01 is Zone 1) ; Total Rainfall (T_RAIN, mm), Maximum Intensity of Rainfall (MAX_RAIN, mm/hr), Duration of Runoff (D_RUN, hr), and Antecedent Dry Days (ADD, day)

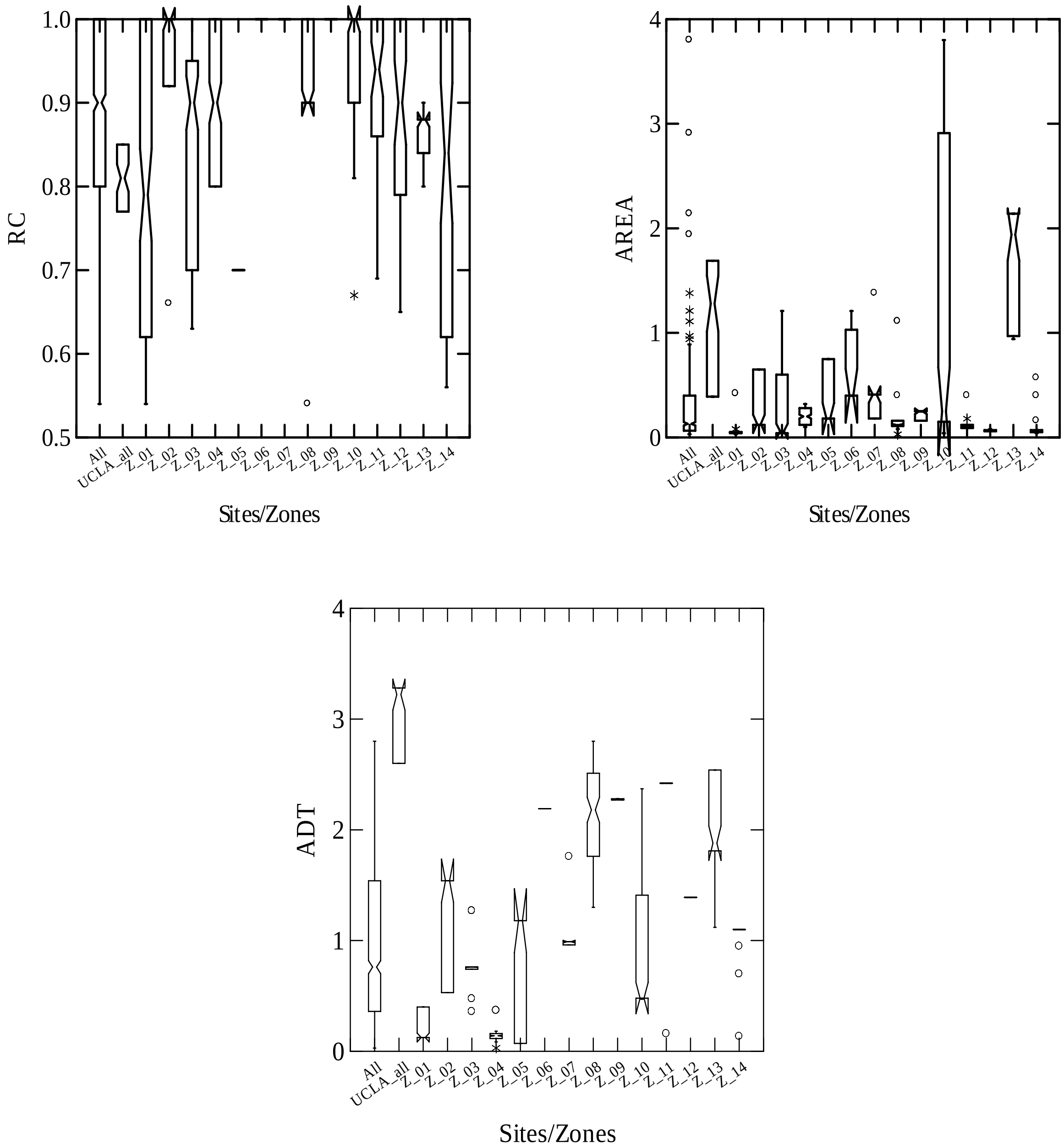

Fig. 3.4B. Site-specific Characteristics for Combined UCLA Sites (UCLA_all), Combined Other Sites (All), and 14 Caltrans Zones (e.g. Z_01 is Zone 1) ; Runoff Coefficient (RC, Dimensionless), Catchment Area (AREA, ha), and Average Daily Traffic (ADT, $\times 10^5$ vehicles/day).

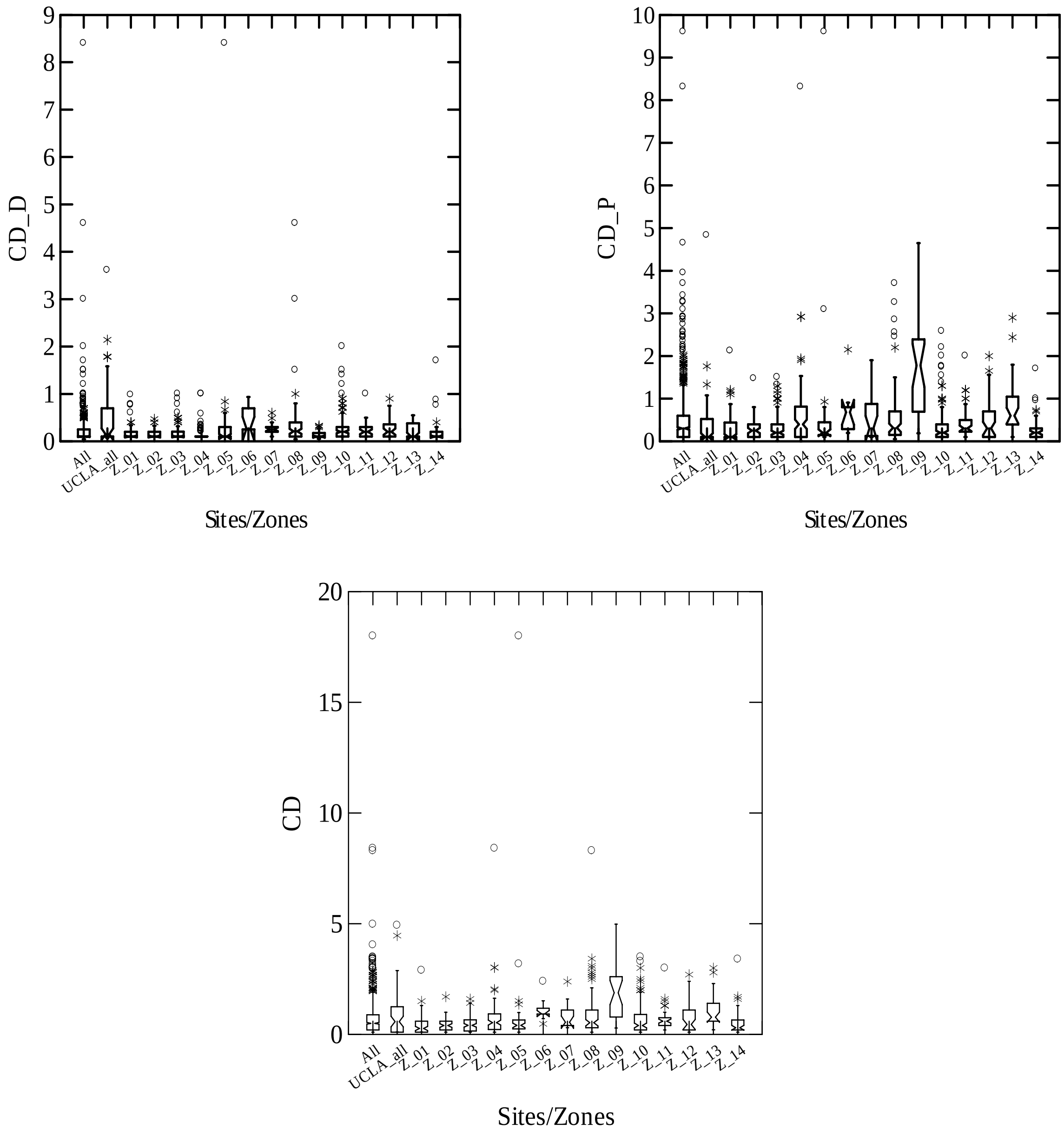

Fig. 3.5A. EMC (μg/L) Characteristics for Combined UCLA Sites (UCLA_all), Combined Other Sites (All), and 14 Caltrans Zones (e.g. Z_01 is Zone 1) for Dissolved (CD_D), Particulate (CD_P), and Total (CD) Cadmium

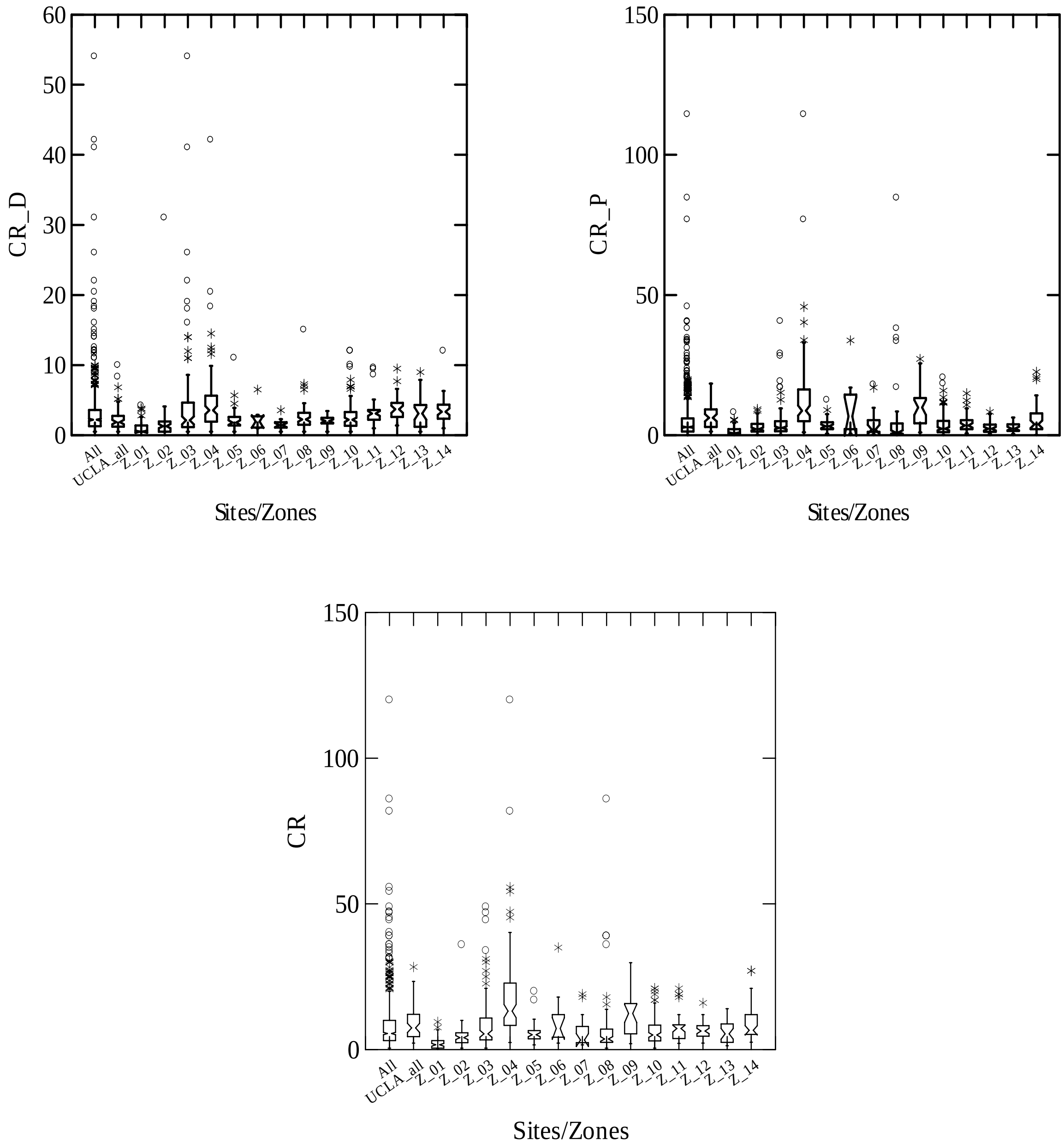

Fig. 3.5B. EMC (µg/L) Characteristics for Combined UCLA Sites (UCLA_all), Combined Other Sites (All), and 14 Caltrans Zones (e.g. Z_01 is Zone 1) for Dissolved (CR_D), Particulate (CR_P), and Total (CR) Chromium

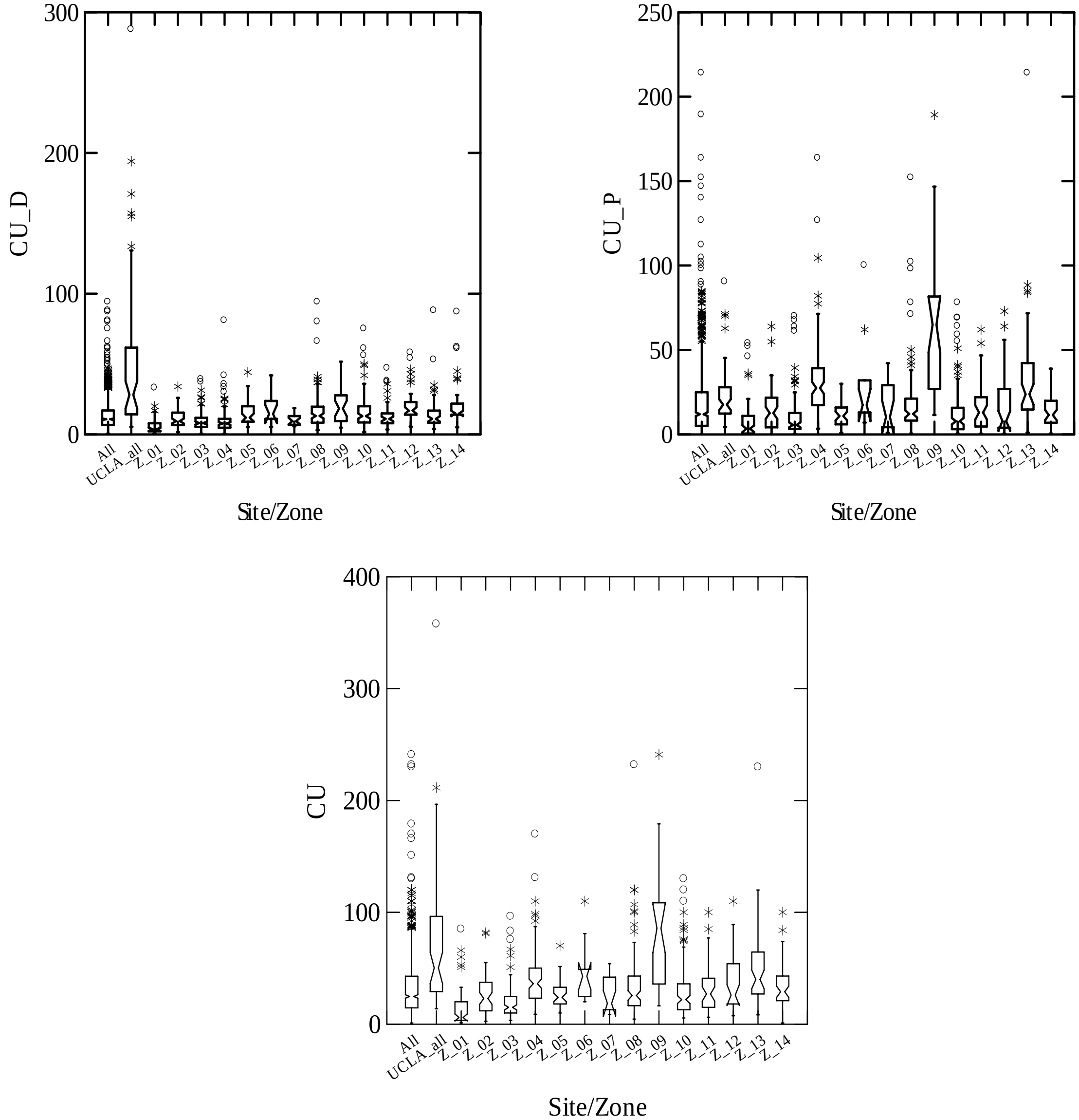

Fig. 3.5C. EMC (μg/L) Characteristics for Combined UCLA Sites (UCLA_all), Combined Other Sites (All), and 14 Caltrans Zones (e.g. Z_01 is Zone 1) for Dissolved (CU_D), Particulate (CU_P), and Total (CU) Copper

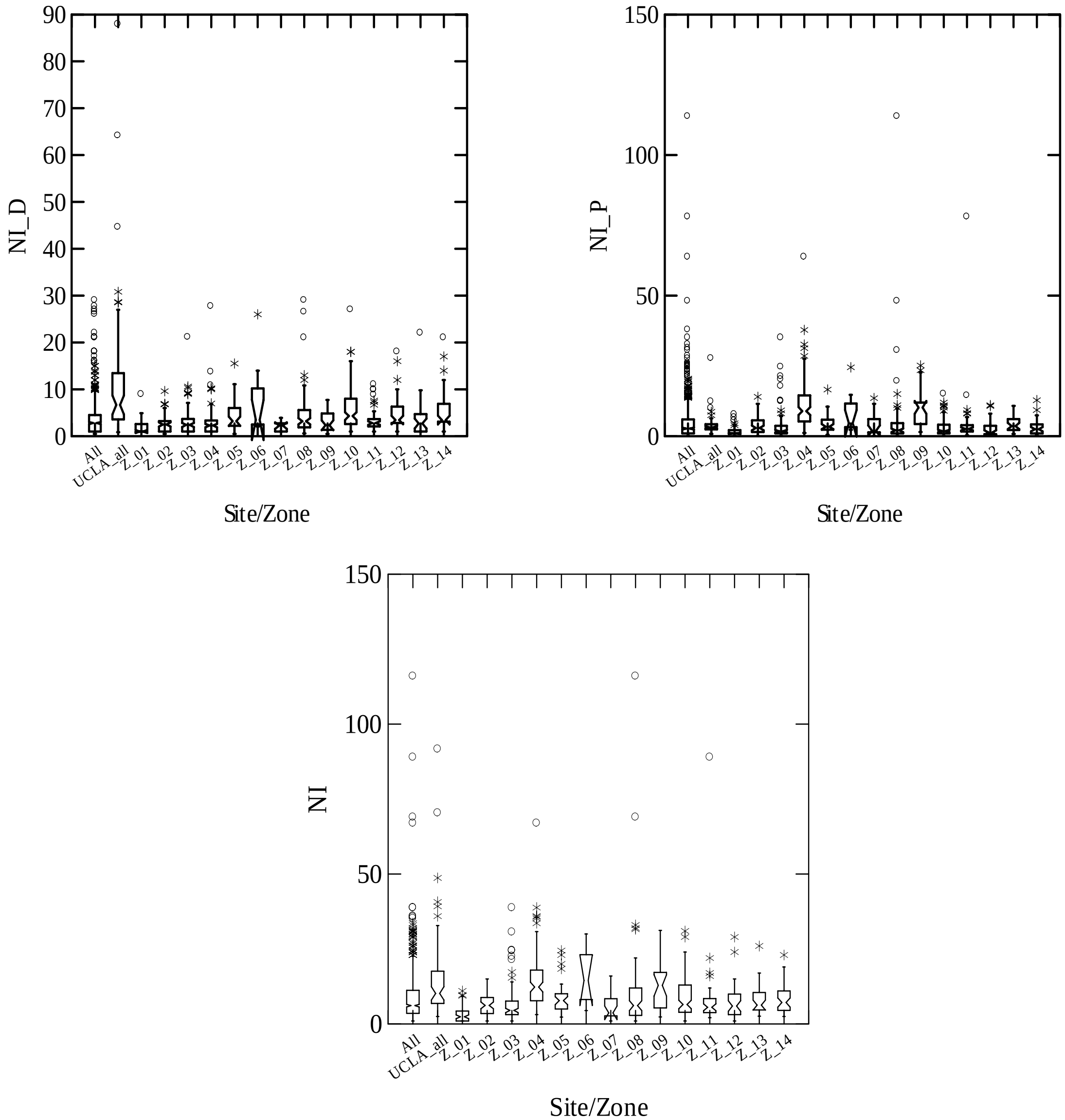

Fig. 3.5D. EMC (μg/L) Characteristics for Combined UCLA Sites (UCLA_all), Combined Other Sites (All), and 14 Caltrans Zones (e.g. Z_01 is Zone 1) for Dissolved (NI_D), Particulate (NI_P), and Total (NI) Nickel

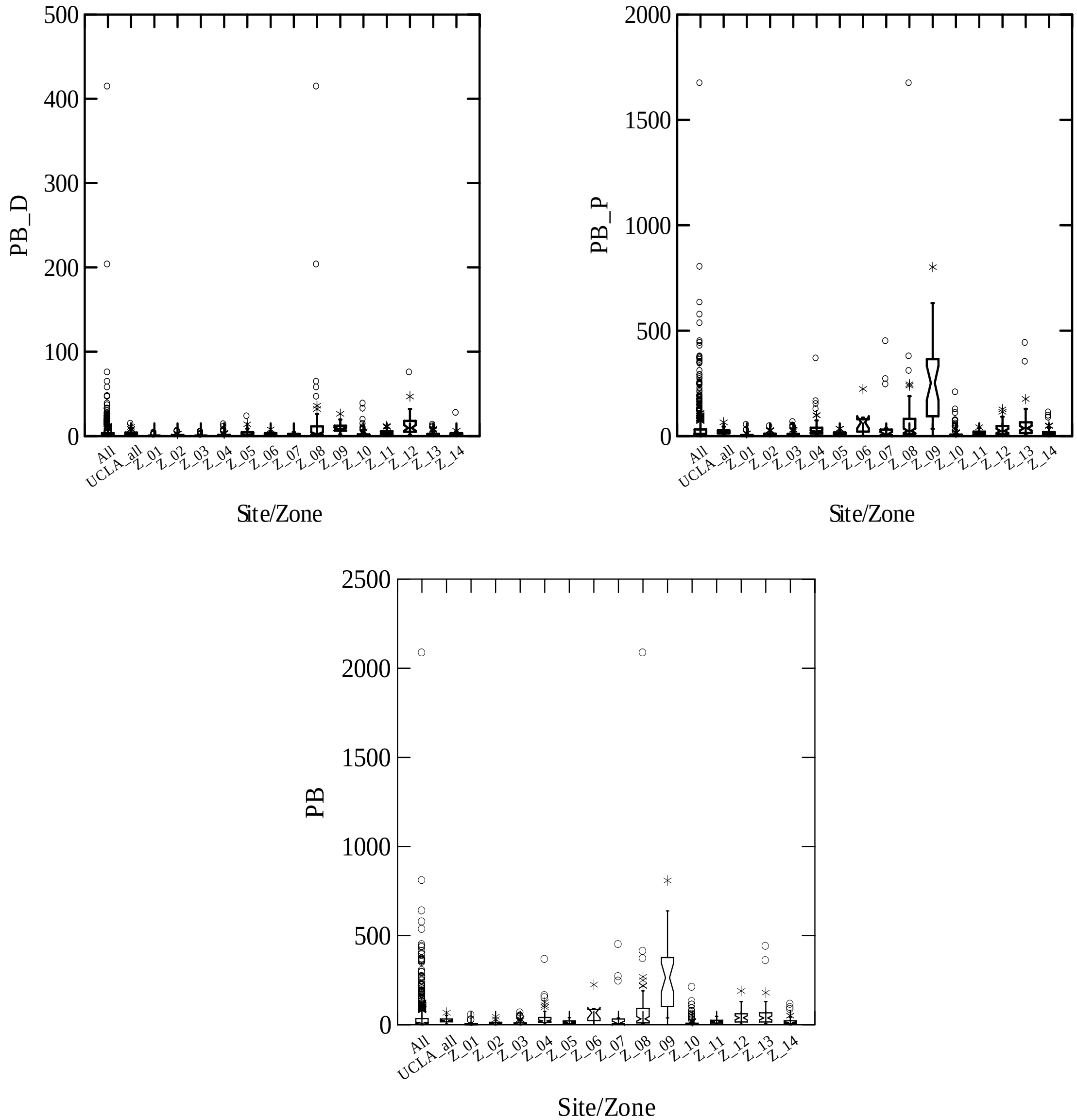

Fig. 3.5E. EMC (μg/L) Characteristics for Combined UCLA Sites (UCLA_all), Combined Other Sites (All), and 14 Caltrans Zones (e.g. Z_01 is Zone 1) for Dissolved (PB_D), Particulate (PB_P), and Total (PB) Lead

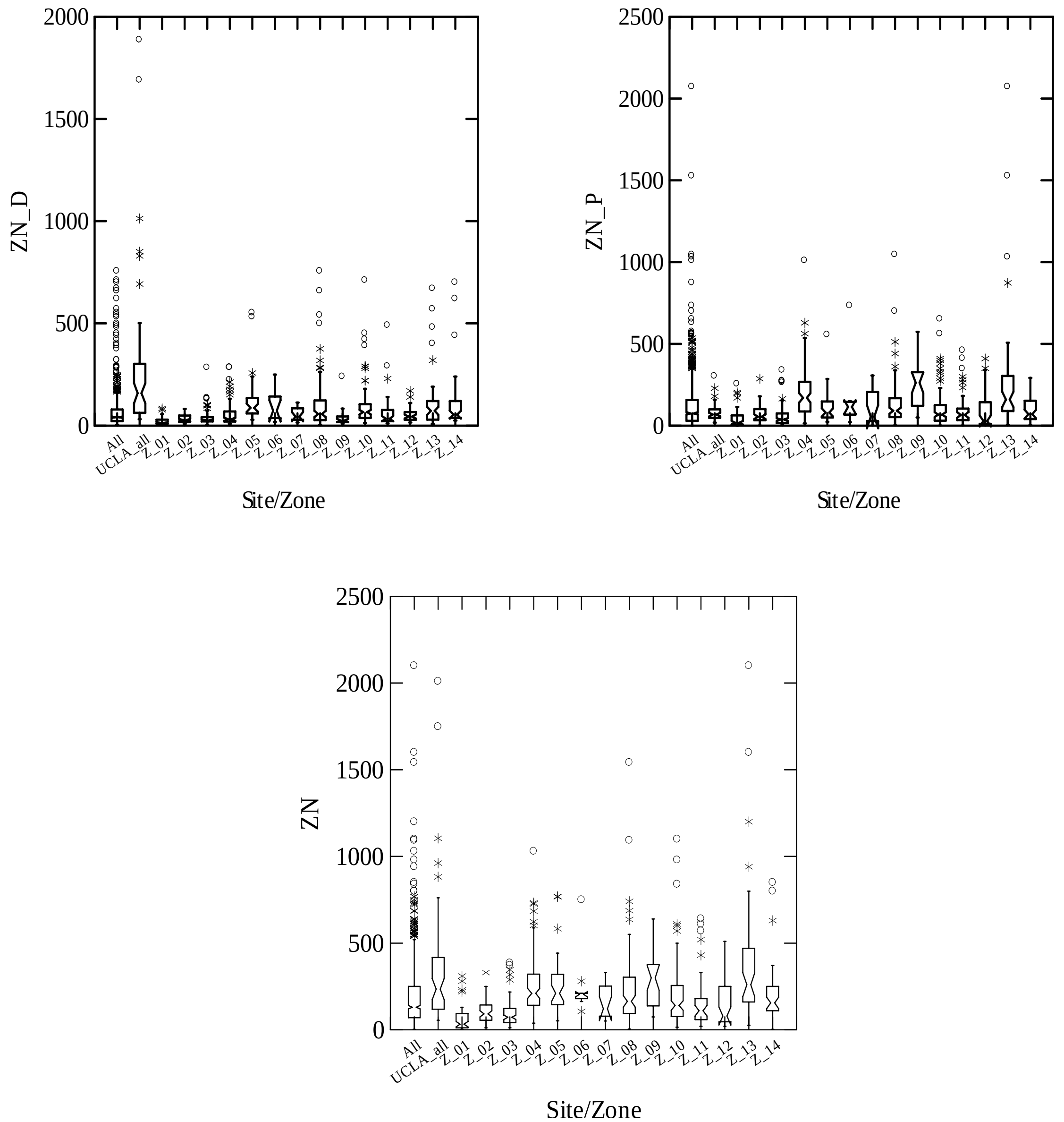

Fig. 3.5F. EMC (µg/L) Characteristics for Combined UCLA Sites (UCLA_all), Combined Other Sites (All), and 14 Caltrans Zones (e.g. Z_01 is Zone 1) for Dissolved (ZN_D), Particulate (ZN_P), and Total (ZN) Lead

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CHAPTER FOUR

REGRESSION MODELS FOR ANALYZING HEAVY METALS IN HIGHWAY STORMWATER RUNOFF USING CONVENTIONAL CONSTITUENTS

ABSTRACT

Best-fit regression models were developed for dissolved, particulate, and total event mean concentrations (EMCs) for six heavy metals: cadmium, chromium, copper, nickel, lead, and zinc. Two conventional constituents from suspended solids group, i.e. total suspended solids (TSS) and volatile suspended solids; two from dissolved solids group, i.e. electrical conductivity (EC) and total dissolved solids; and three from organics group, i.e. chemical oxygen demand (COD), dissolved organic carbon (DOC) were used as independent variables. Total organic carbon (TOC) and DOC values were highly correlated and so TOC values were converted to DOC when it was required. The objective was to choose a maximum of one constituent from each group to reduce any significant correlation among the independent variables in the regression models. For some metal parameters, the dissolved metal models were better than the particulate models, and vice versa. Either the dissolved or the particulate model was presented in conjunction with the total metal model for all the metals. Additionally, the best-fit models were evaluated using linear, semi-log and inverse forms of the independent variables. 59 storm events using three sites, i.e. the University of California at Los Angeles (UCLA) sites in Southern California during the rainy seasons (October to May) 1999-2003 were used in the regression analysis. Best-fit regression models for the individual and

combined UCLA sites had median R^2 values greater than 0.65 for metal EMC_S. TSS and DOC were the most significant parameters in the regression models developed for UCLA sites. The regression analysis was then extended to an additional 83 California Department of Transportation (Caltrans) sites. Best-fit regression models developed for Caltrans sites as a whole produced less than satisfactory results. For the additional Caltrans sites, 14 zones were selected within the state of California to further improve the analysis. The zones were selected on the basis of geographic proximity. The basic philosophy of the zone approach was to group sites with similar weather conditions. For the Caltrans zones, the best-fit models had median R^2 values of greater than 0.50 for most of the metals. For the Caltrans zones, TSS was the most significant parameter, and DOC and EC also were significant in the regression models. Generalized types of regression models were also analyzed. The idea was to develop regression models with the same set of conventional parameters. The generalized regression model was found out to have a linear form with TSS and DOC be the only conventional parameters used as independent variables along with the intercept. Most of the best-fit models were better estimators than the corresponding generalized models. For the UCLA sites, the median R^2 values for the generalized model were greater than 0.70 for the metal EMCs. For most of the Caltrans zones, the median R^2 values were greater than 0.40. For the generalized models, DOC was the most significant constituent for the dissolved and total phase models for the individual and combined UCLA sites. For the Caltrans zones and sites, TSS was the most significant constituent in the particulate and total phase regression models.

4.1 INTRODUCTION

Stormwater runoff from highways is laden with suspended and dissolved matter high in heavy metals, organics, nutrients, and salts. Highway stormwater runoff shows high degree of variability of constituents between events and sites. It is this wide variation which makes the prediction of any constituent very difficult, even between the sites with close proximity. Nonetheless, proper assessment of quality and quantity of runoff is essential in designing drainage and treatment facilities, and assessing the environmental impact.

In order to quantify the concentration and mass loading of various constituents, a sampling program was undertaken at several locations along highways. A comprehensive study on the impacts of highway runoff was undertaken by California Department of Transportation (Caltrans) in association with other organizations and Universities including the Department of Civil and Environmental Engineering at the University of California at Los Angeles (UCLA).

The research is part of the comprehensive study and its main objective was to characterize stormwater runoff in order to better understand its environmental implications. The pollutants resulting from the traffic activities, pavement degradation, and surrounding landuse were investigated. The temporal variation of water quality and the average water quality (i.e. Event mean concentration, EMC) were also studied. First flush of many pollutants was observed in many storm events (Ma et al. 2002).

In general, a highway stormwater sampling program includes, 1) selection of sampling sites; 2) selection of parameters to be investigated which includes the event and site-specific parameters, such as total rainfall (T_RAIN), duration of runoff (D_RUN), maximum intensity of rainfall (MAX_RAIN), antecedent dry days (ADD), runoff coefficient (RC), drainage area (AREA), average daily traffic (ADT) etc.; conventional parameters, such as total suspended solids (TSS), volatile suspended solids (VSS), turbidity, electrical conductivity (EC), hardness, alkalinity, chemical oxygen demand (COD), dissolved organic carbon (DOC), total organic carbon (TOC), total dissolved solid (TDS) etc.; heavy metals, such as cadmium (Cd), chromium (Cr), copper (Cu), nickel (Ni), lead (Pb), zinc (Zn) etc.; nutrients, such as total Kjeldahl nitrogen (TKN), ammonia (NH_3), nitrate (NO_2), nitrite (NO_3), phosphorus (P), phosphate (PO_4) etc.; and ions such as chlorine (Cl), fluorine (F), sulfate (SO_4) etc; 3) installing equipment to automatically measure flow, rainfall and collect composite samples, and 4) standing by in the sampling sites prior to projected rain and collecting samples for later lab measurements. The cost associated with the monitoring and the analysis of data builds up as the number of the water quality parameters to be investigated increases. Thus, a set of constituents can to be selected to be measured in labs and be used as surrogates to other water quality parameters, such as metal constituents. The selected set of surrogates is expected to be inexpensive and easily measured in labs and exhibit good correlations with the metal constituents in interest.

This research was undertaken with the following specific objectives:

1. To select a set of conventional water quality parameters to be used as surrogates for the metal constituents.

2. To develop a statistically-based surrogate-metal constituent relationships for the three sites in Southern California (i.e. UCLA sites).
3. To develop predictive surrogate-metal constituent models for the combined UCLA sites.
4. To extend the analysis for the other Caltrans sites and zones.

4.2 BACKGROUND

Traffic activities are generally responsible for dissolved and particulate metals in stormwater runoff. Six metals, namely, Cd, Cr, Cu, Ni, Pb, and Zn are regularly monitored in stormwater runoff. Various forms of regression models have been analyzed and proposed for metal constituents.

Sansalone et al. (1997) reported tires to be the primary source for Cd, Cr, Cu, and Ni, and brakes as a secondary source for Cu. Huntzicker et al. (1975) and Hopke et al. (1980) reported tailpipe emissions as source of Pb. Tire wear (Christensen and Guinn 1979); and frame and body (Sansalone 1997) were reported to be the primary sources of Zn. Zn also has additional sources, such as brake linings and exhaust emissions (Hopke et al. 1980).

Sansalone and Buchberger (1997) analyzed the partitioning of metal constituents between dissolved and particulate phases from data sampled during five rainfall events in 1995 in an urban highway in Cincinnati. Results showed that Cd, Cu, and Zn were mainly in dissolved phase and aluminum (Al), iron (Fe), and Pb were in particulate phase.

Ball et al. (1998) studied a site in the eastern suburbs of Sydney, Australia. Dry samples were collected from a gutter and the road surface immediately adjacent to the gutter. Analysis was done for the sorbed (i.e. particulate) metals of Cr, Cu, Fe, Pb, and Zn; and compared with the studies of Sartor and Boyd (1972) of a number of U.S. cities. Mean concentrations of metals were higher for the U.S. sites than the Australia site. Ball et al. also analyzed the build-up models for the metal on the roadway surface. They concluded that the power and the hyperbolic models were better estimators of build-up among the regression models.

Barrett et al. (1998) conducted analysis on the water quality including four metals (i.e. Cu, Fe, Pb, and Zn) at three sites on an Expressway in Texas. They observed highest EMCs for the metals in urban sites with the highest ADT. First flush effects of the constituents were also observed in the study.

Lee et al. (2003) investigated the existence of seasonal first flush. California's climate can be characterized by winter and spring rainfall and summer drought; and provides a long period for pollutant build-up. The first storms in the winter season usually carry higher pollutant concentrations, which is also known as seasonal first flush. Conventional water quality parameters, such as COD, specific conductance (SC), TOC, TSS were analyzed along with five metals, i.e. Al, Cu, Ni, Pb, and Zn. The pollutant concentrations were found to be 1.2 to 20 times higher than concentrations near the end of the season.

Stormwater regression models developed to quantify any constituent EMC can be divided into two categories:

1. Regression models that use storm (e.g. T_RAIN, MAX_RAIN, D_RUN), site (e.g. RC, AREA), weather (e.g. ADD), and traffic characteristics [e.g. ADT, vehicles during storm event (VDS)] to predict constituent EMCs.
2. Regression models that use the EMCs of other parameters (e.g. conventional parameters, such as, TSS, TDS, TVS, TOC, hardness, turbidity.

Regression models for the dissolved, particulate and total metal fractions were previously developed for UCLA sites; and other Caltrans sites and zones in terms of event-specific and site-specific parameters as independent variables (Chapter 3). The event-specific variables are functions of storm and climatic conditions. T_RAIN, MAX_RAIN, D_RUN, ADD are some examples of event-specific factors.

The site-specific variables generally remain constant for a single site but vary among different sites. Some examples of site-specific variables are RC, AREA, and ADT, and they are the numeric representation of the physical characteristics of the drainage area and vehicular characteristics.

Grottker (1987) analyzed the data of roadway surface of a site in West Germany. Analysis was made for different water quality constituent along with seven metals, i.e. Cd, Cr, Cu, Fe, Ni, Pb, and Zn. The build-up of metals and other constituents were shown as a function of the maximum load that can accumulate in the roadway surface and ADD. The wash-off of the water quality constituents were shown to be a function of accumulated load on the roadway surface and T_RAIN.

Brezonick et al. (2002) analyzed stormwater runoff loads and concentrations (i.e. EMCs) of ten common pollutants [i.e. six nitrogen (N) and P forms, TSS, VSS, COD, Pb] in the urban watershed of Twin Cities, Minnesota. Storm variables, such as T_RAIN, average intensity of rainfall (AVE_RAIN), D_RUN, and ADD; and watershed variables, such as AREA and RC were used as explanatory (i.e. independent) variables in the regression models. The correlation between the independent variables and pollutants EMCs were found to be weak. Better EMC correlations were found when the sites are grouped according to similar landuse and size.

Lee et al. (2002) analyzed the stormwater data in thirteen watersheds in Korea and analyzed metals, such as Fe and Pb along with some conventional parameters, such as COD, TSS, and TKN. They concluded that first flush was more evident for the conventional parameters than the metals in both residential and industrial areas. However, no correlations were evident between first flush and ADD.

Regression analyses of highway constituent concentrations were performed by Irish Jr. et al. (1998) for sites in Texas, Wu et al. (1998) for sites in North Carolina, and Kayhanian et al. (2003) for sites in California. These researchers all regressed metals concentrations from site and event specific parameters as discussed in chapter 3.

Thomson et al. (1997) used a different approach and found surrogate parameters to predict metals concentrations in Minnesota highway stormwater quality data. They formulated a set of regression models using TSS, TDS, TVS, and TOC as surrogates or independent variables in regression models for metals, ionic species, and nutrients. They also studied the portability of the models, and found that the relationships for ionic species were portable. The regression models for metals and nutrients had limited portability.

The previous work generally used the EMC, which are normally used to represent stormwater pollutant concentrations (Huber 1993). EMC equations for flow-weighted composite [Eq. (1.1)] and grab samples [Eqs. (2.1), (2.2), and (2.3)] are discussed in earlier chapters.

The advantages of the event and site-specific regression models are obvious. They only require values related to storm, site, climate, and traffic conditions. But there are some disadvantages for those models as well. Change in atmospheric deposition, accidental spills, change in constituent concentrations due to changes in traffic patterns, addition of a new pollutant sources are only some of the future events that may change regression parameters. Conversely, correlations among surrogate parameters and metals may be more reliable because source changes should affect both the surrogates and the metals. The use of surrogates may reduce the number of metal analyzes, if the correlations are good.

4.3 DATA SOURCES AND DATA EVALUATION

The data sources and data evaluation techniques are discussed in chapter 3 including the number and percentages of non-detects as shown in Table 3.2. U.S. Environmental Protection Agency (U.S. EPA) methods were employed for the laboratory analysis of the conventional and metal constituent parameters. Table 4.1 summarizes the analytical method and unit for the conventional and metal parameters used in this research. Flow-weighted grab samples were used for evaluating the EMCs for the UCLA sites, where as, composite samples representative of the whole storm events were used for the other Caltrans sites. The Caltrans database contained dissolved and total metal EMCs. The particulate metal EMCs were calculated by subtracting the dissolved concentrations from the total concentrations.

4.4 METHODOLOGY

Three forms of regression models were employed in the analyses, namely, linear, semi-log, and inverse. The independent variables in the regression models were chosen from the conventional pollutants (i.e., COD, TSS etc.). The surrogate-metal regression models were developed first for the UCLA sites and then the study was extended to Caltrans zones grouped together on the basis of geographic proximity. For some metal parameters, the dissolved metal models were better than the particulate models, and vice versa. The regression models were presented for either the dissolved or the particulate phase and for the total metal EMCs. SYSTAT 10 (Richmond, California) was used in analyzing data.

4.4.1 Selection of Conventional Parameters as Independent Variables

A set of conventional parameters were used as independent variables for the regression models. Seven conventional parameters were chosen in the initial set: TSS, VSS, EC, TDS, COD, DOC, and TOC. The initial set of conventional parameters was divided into three categories on the basis of their attachment to the following groups:

1. Suspended solid: TSS, VSS
2. Dissolved solid: EC, TDS
3. Organics: COD, DOC, TOC

The choice of the grouping was based on the premise that we expected the parameters within each group to be correlated. The objective was to select a maximum of one parameter from each group to be used as independent variables for the regression models. Analysis of correlation matrix was employed to justify the initial grouping. First of all, there was almost a perfect correlation observed between DOC and TOC. The correlation coefficient (R) between DOC and TOC with all the available data points (661) for all the Caltrans sites was 0.99. The conversion equation from TOC to DOC (or vice versa) is presented in the follwing:

$$DOC = -0.577 + 0.902 \cdot TOC \qquad R^2 = 0.98 \qquad (4.1)$$

In this research, all the TOC values were converted to DOC, and used in the analysis. In cases when both DOC and TOC values were available, we used the DOC values. So any further mention DOC in this research will include either measured DOC, or DOC values obtained from TOC using Eq. (4.1), or both. Table 4.2 presents the results of other correlations among the UCLA and other Caltrans sites. The TSS and VSS had very high correlations among the individual and combined UCLA sites. For the other

Caltrans sites as whole, they exhibited high correlation (0.79) too. Even for the two Caltrans zones (i.e. 8 and 9), the correlation values were satisfactory, i.e. 0.63 and 0.92 respectively. The COD-DOC correlations provided even better correlations than TSS-VSS for the UCLA sites, and similar correlations for combined Caltrans sites and zones. TDS were not measured for the UCLA sites. For the combined Caltrans sites, the EC-TDS correlation was satisfactory (0.86). Zone 9 provided negative correlations (-0.28), and zones 3 and 7 provided lower values of R^2, i.e. 0.20 and 0.43 respectively between EC and TDS. Thus a maximum of one parameter from each group was selected in a regression model with the exception of zones 3, 7, and 9 where both the EC and TDS were tried in a single regression model.

4.4.2 Regression Analysis

Regression models in this research contained a maximum of one conventional parameter from each group of suspended solid, dissolved solid, and organics with the exception of EC and TDS for Caltrans zones 3, 7, and 9 as explained earlier. For example:

$$EMC = a + b \cdot TSS + c \cdot EC + d \cdot DOC \tag{4.2}$$

Three forms of regression models were evaluated: linear form, as shown above, semi-log, where the log of the independent variable was used. Eqs. (4.3) and (4.4) are examples of semi-log and inverse form for Eq. (4.2).

$$EMC = a + b \cdot \log_{10}(TSS) + c \cdot \log_{10}(EC) + d \cdot \log_{10}(DOC) \tag{4.3}$$

$$EMC = a + \frac{b}{TSS} + \frac{c}{EC} + \frac{d}{DOC} \tag{4.4}$$

The trial and error approach was employed in this research to select the independent variable/variables in the regression models. By grouping the conventional parameters, the chance of correlations among the independent variables was reduced. But there were still significant correlations among the conventional parameters even if they were selected from different groups. For example, TSS and EC were correlated for some regression models even though they are attached to two different groups. The best fit models were chosen with a confidence level of 95% ($p<0.05$) for each independent variable obtained from two-tailed t statistic and a confidence level of 99% ($p_{Reg}<0.01$) for the model as a whole obtained from F statistic.

4.5 RESULTS AND DISCUSSION

The conventional parameters, to be used as independent variables in the regression models, were grouped into three categories based on their attachments to suspended solids, dissolved solids, and organics. Three different forms (i.e. linear = form 1; semi-log = form 2; inverse = form 3) of models were analyzed to get the best-fit models. The analyses performed in this research were as follows:

1. Regression models were developed for the three UCLA sites on the individual basis.
2. Regression analysis was then extended to the UCLA sites on the combined basis.
3. Similar approach was studied and regression models were developed for the other Caltrans sites as a whole.
4. The other Caltrans sites were divided into fourteen zones and similar regression models were developed for each zone. The zones are shown in Fig. 3.1 and the zone selection process is discussed in chapter 3.
5. Generalized regression models were developed for UCLA sites, Caltrans zones and sites.
6. Finally, a comparison was made between the regression models developed for the UCLA sites and the Caltrans sites.

Analysis for event, site, and constituent characteristics for the UCLA sites, and Caltrans zones and sites are discussed in Chapter 3.

4.5.1. Best-fit Regression Models for UCLA Sites on Individual Basis

The Regression models for the metal constituents for the three individual UCLA sites were developed by picking a maximum of one conventional parameter from each group as independent variables. The results are shown in Table 4.3. Three forms of equations, i.e. linear, semi-log, and inverse were considered for those regression models.

For each metal constituent, the best model between the particulate and dissolved phases was presented along with the best-fit total fraction model. Table 4.3 shows the values of the intercepts, and coefficients associated with the independent variables, R^2, number of events considered (count), forms for the metal constituents. ‘D’, ‘P’, and ‘T’ in the form column represent dissolved, particulate, and total phases respectively. Also linear, semi-log, and inverse forms are denoted by the numeric digits of 1, 2, and 3 respectively. The relevant metal constituents are denoted by the last column. All the intercepts and coefficients for the independent variables were statistically significant at 95% confidence level ($p<0.05$, two-tailed t statistic), and the regression models as a whole were significant at 99% confidence level ($p_{Reg}<0.01$, F statistic). For example, let us consider the last data row representing UCLA site 2 in Table 4.3. It is presented in the following equation form, i.e. Eq. (4.5).

$$EMC = 2.92 \cdot TSS + 1.81 \cdot COD - 0.86 \cdot EC \tag{4.5}$$

No intercept was used for the equation because it failed the 95% confidence level test. The R^2 value is 0.96 for the model. Number of storm events considered for the model is 16 as represented by the count column. ‘T1’ in the form column refers to total phase linear model. Also the last column shows that the relevant parameter for this case is Zn. The empty cell for VSS indicates that TSS was picked from suspended solid group ahead of VSS with better regression results. In the same way, COD was chosen ahead of DOC. TDS values were not measured for the UCLA sites; hence EC values were only available for regression models. In some case, no conventional parameters were selected from a group; e.g. first data row for UCLA site 1 representing Cd, does not have either TSS or VSS from suspended solid group and EC from the dissolved solid group. The reason was that the coefficients of those conventional parameters were not significant at 95% confidence level. All the R^2 values, as shown in Table 4.3, for the individual UCLA sites are very satisfactory with the exception of total Pb model for UCLA site 2 (0.15).

For further analysis of the UCLA sites, Table 4.4 is presented. Table 4.4 shows the median values of all the constituent parameters for dissolved/particulate and total phases in terms of R^2. For example, the R^2 (0.69) value for UCLA site 1 in the first data row represents the median of the six R^2 values developed for six dissolved/particulate constituents (i.e. Cd, Cr, Cu, Ni, Pb, and Zn). The median R^2 values indicate that regression models provided very good estimates for the individual UCLA sites. Both the dissolved/particulate (0.96) and total (0.90) phase median R^2 values for UCLA site 3 were outstanding as shown in Table 4.4.

Table 4.5 represents the median values of the three UCLA sites for the metal constituents in terms of R^2. The R^2 value in the last data row (0.96) is the median of three R^2 values developed for three individual UCLA sites for total Zn. All the metal constituents exhibited very good regression results with high R^2 values. Pb was the only metal for which the dissolved/particulate (0.63) and total (0.39) median R^2 values were less reliable to the other metals.

Table 4.6 represents the number of dissolved and particulate models and the number of models with forms 1, 2, and for the UCLA sites and other Caltrans sites and zones. For the individual UCLA sites, the dissolved phase models were more dominant for sites 1 (4 out of 6), 2 (6 out of 6), and 3 (5 out of 6). Also the linear form (i.e. form 1) was the most influential numbering 9, 11, and 11 out of 12 possible models for sites 1, 2, and 3 respectively.

Table 4.7 shows the number of times each conventional parameter was used in the twelve (i.e. six for dissolved/particulate and six for total phase) best-fit models for each group containing individual and combined UCLA sites; combined all other Caltrans sites and Caltrans zones. For the UCLA site 1 and 3, DOC was the most influential conventional parameter which was used in 5 and 7 of the regression models respectively. TSS and COD, being employed 8 times each, were equally dominant for site 2.

4.5.2. Best-fit Regression Models for UCLA Sites on Combined Basis

Regression models were also developed for combined UCLA sites for the metal constituents and the results are presented in Table 4.8. All the intercepts and coefficients for the independent variables were statistically significant at 95% confidence level ($p<0.05$, two-tailed t statistic), and the regression models as a whole were significant at 99% confidence level ($p_{Reg}<0.01$, F statistic) for the combined UCLA sites. The R^2 values for all the models were very satisfactory. The total Pb model with an R^2 of 0.46 provided a less than reliable prediction. Now, going back to Table 4.4, median dissolved/particulate R^2 value of the six constituent models for the combined UCLA sites was 0.78, which indicates reliable predictions for the dissolved/particulate metal fractions. The median R^2 value for the total metals was even better (i.e. 0.80) for the combined UCLA sites.

For the combined UCLA sites, the dissolved phase models were more controlling with 5 out of 6 models as shown in Table 4.6. The linear form (i.e. form 1) was the most dominant with 10 out of 12 models for the metal constituents EMCs. From Table 4.7, it was apparent that TSS and DOC were the two most dominant conventional parameters in the regression models and they were used 10 and 9 times out of 12 regression models regression models for the combined UCLA sites.

4.5.3 Best-fit Regression Models for Other Caltrans Sites on Combined Basis

The best-fit regression models developed for combined UCLA sites with the same coefficients were applied to all other Caltrans sites to test their applicability. The results are presented in Table 4.9, which is a correlation matrix for the predicted and actual values of metal *EMCs* for the combined Caltrans sites. The total constituent *EMC* models showed better correlations than dissolved/particulate phases. The correlation results were not satisfactory. Additional analyses were required to develop better regression models for the other Caltrans sites. Regression models were developed for the other Caltrans sites on a combined basis and the results are presented in Table 4.10. The particulate (0.57) and total (0.52) metal models for Cr showed good results. Also the dissolved/particulate and total phases of Cu, Ni, and Zn showed some promising results.

4.5.4 Best-fit Regression Models for Other Caltrans Sites on Zone Basis

Regression models were developed for the metal constituents for the Caltrans sites grouped by zones and presented in Appendix E. The regression model R^2 results for Caltrans zones were very satisfactory and in general better than the Caltrans sites as a whole. All the intercepts and coefficients for the independent variables were statistically significant at 95% (i.e. $p < 0.05$) confidence level and the regression models as a whole were significant at 99% (i.e. $p_{Reg} < 0.01$) confidence level for all the zones with the exception of zones 5 and 6.

For zone 5, the dissolved and total reported value of Cd for one of the events of site 6-205 located on freeway 180E in Fresno County were 8.4 and 18 µg/L respectively. The two values were roughly tenfold more than nearest values. The median dissolved and total Cd values for that zone were 0.10 and 0.41 µg/L respectively. The T_RAIN, MAX_RAIN, D_RUN, and ADD for that event were 4 mm, 6 mm/hr, 9.25 hrs, and 3.8 days and the values were nothing unusual. The R^2 values calculated for dissolved (0.02) and total (0.12) Cd significantly changes with the omission of those two values. None of the outliers was removed in this research. So the results presented in Appendix E contain all the possible data points unless mentioned in this paper. Appendix F presents the best-fit models for dissolved and total Cd for zone 5 by excluding those two unusual values.

The metal constituent models for zone 6 contain a number of intercepts and coefficient values that were not significant at 95% confidence level as shown in Appendix G. A number of regression models also failed the 99% confidence level test. There are three sites, namely 7-01, 7-211, and 7-213 in zone 6. Further analysis for those three sites individually was not possible insufficient number of data points. The data reported for zone 14 in Appendix E-14 consists of the five Moreno Valley sites (i.e. 8-201, 8-202, 8-203, 8-204, and 8-205). Though the metal EMCs and storm characteristics of the sites in zone 8 were similar but the conventional parameter values were different for the Moreno Valley sites and other three sites (i.e. 8-01, 8-02, and 8-03), specifically sites 8-01 and 8-02 reported two events with large EMC values of TSS, i.e. 4800 and 1200 µg/L, with ADD values of 4 and 1 day respectively. The storm characteristics for those two events were nothing unusual. Any further investigation of sites, 8-01, 8-02, and 8-03 were not possible due to lack of data.

For further analysis of data for the Caltrans zones, Table 4.11 is presented. Table 4.11 (i.e. similar to Table 4.4 for UCLA sites) shows the median values of all the constituent parameters in terms of R^2. For example, the R^2 (0.69) value for zone 1 in the first data row represents the median of the six R^2 values developed for six dissolved/particulate constituents (i.e. Cd, Cr, Cu, Ni, Pb, and Zn). The median value of R^2 for zone 6 (0.10) shows poor predictive performance for total metal EMC models for that zone. Appendix E-6 shows that for total metal, zone 6 provided poor estimates for Cd (0.04), Cr (0.03), Pb (0.02), and Zn (0.15) in terms of R^2. All other zones show very reliable estimates with zone 9 providing the best median values of R^2 for dissolved/particulate (0.92) and total (0.91) metals. Table 4.12 (similar to Table 5 for individual UCLA sites) represents the median values of the fourteen Caltrans zones for the metal constituents in terms of R^2. The R^2 value in the last data row (0.67) is the median of fourteen R^2 values developed for fourteen Caltrans zones for total Zn. All the metals exhibited very good median values with dissolved/particulate (0.72) and total (0.73) Pb showing the best results in terms of R^2.

From Table 4.6, for the Caltrans zones, the particulate phase models were more dominant with 55 models as compared to 29 for the dissolved phase. The linear form (i.e. form 1) largely outnumbered the semi-log (form 2) and inverse (form 3) forms with 147 models out of a total of 178. Now going back to Table 4.7, for the Caltrans zones, TSS was the most influential conventional parameter which was used in 142 (out of 168, i.e. 12 metal parameters multiplied by 14 zones) of the regression models with DOC and EC being employed 67 and 40 times respectively. Zone 9 was the only zone where any other conventional parameter (i.e. DOC for this case) was used in more models (i.e. 11) than TSS (i.e. 9).

4.5.5 Generalized Regression Models for UCLA sites, Caltrans Zones and Sites

The best-fit regression models developed so far considered three forms (i.e. linear, semi-log, and inverse) with different sets of conventional parameters as independent variables for different models. In addition, two phases (i.e. dissolved and particulate) were considered along with the total phase models. Generalized types of regression model were also analyzed. The idea was to develop regression models with the same set of conventional parameters and for same form (e.g. linear) and phase (e.g. particulate). Trial and error approach was employed to find out the best-fit generalized regression model applicable to UCLA sites, Caltrans zones and sites. The results are presented in Appendix H. The generalized regression model was found out to have a linear form (i.e.

form 1) with TSS and DOC to be the only conventional parameters used as independent variables along with the intercept as shown in the following:

$$EMC = a + b \cdot TSS + c \cdot DOC \tag{4.6}$$

where, a = intercept; b = coefficient of TSS; c = coefficient of DOC. In cases where the TOC values were available instead of DOC values, the conversion Eq. (4.1) was used. Most of the p_{Reg} values statistically significant at 99% confidence level ($p_{Reg} < 0.01$, F statistic), but several coefficients associated with TSS and DOC were not significant at 95% confidence level ($p < 0.05$, two-tailed t-statistic). The usual process of trial and error in selecting the independent variables were not used in this case, rather the independent variables (i.e. TSS and DOC) were first selected, which resulted in several of their coefficients to fail 95% confidence level test. To further generalize the dissolved/particulate phase models, only dissolved phase was considered for the UCLA sites because it showed better results than particulate phase in terms of R^2 and p values. For the Caltrans zones and sites, only the particulate phase was chosen for similar reason. Due to the unavailability of either DOC or TOC data for zone 6, the generalized models were not evaluated.

For further analysis, Table 4.13 is presented (similar to Table 4.4) shows the median values of all the constituent parameters in terms of R^2, p_{Reg}, p values of the individual independent variables (i.e. TSS and DOC). For example, the R^2 (0.69) value for UCLA site 1 in the first data row represents the median of the six R^2 values developed for six dissolved constituents (i.e. Cd, Cr, Cu, Ni, Pb, and Zn). The generalized models produced very satisfactory median R^2 results for the individual and combined UCLA sites with site 3 (0.84) and site 2 (0.82) providing the best estimates for dissolved and total phases respectively. The particulate and total phase median R^2 values for the all the Caltrans sites as a whole are 0.31 and 0.24 respectively, which were less than reliable values. The Caltrans sites separated by zones produced much better median R^2 values for particulate and total metals. Zone 10 showed the lowest median values of R^2, i.e. 0.34 for particulate and 0.35 for total; and zone 9 exhibited the highest values with 0.88 for particulate and 0.90 for total metal fractions.

Table 4.13 also presents the median significance values for the models (p_{Reg}) and individual variables (p values) for TSS and DOC for the sites and zones. The value of p_{Reg} (< 0.01) for UCLA site 1 represents the median of the six p_{Reg} values developed for six dissolved constituents (i.e. Cd, Cr, Cu, Ni, Pb, and Zn). All the p_{Reg} values were significant at 99% confidence interval (< 0.01) for dissolved and total fractions for the UCLA sites and particulate and total fractions for Caltrans zones and sites except zone 7 (particulate = 0.02, total = 0.03). For the individual variables, DOC was the most significant parameter for dissolved and total phase models for UCLA sites. Conversely, TSS was significant for the particulate and total phase models for the Caltrans zones and sites.

Table 4.14 (i.e. similar to Table 4.5) shows values for the metal constituents in terms of R^2, p_{Reg}, and p values of the individual independent variables (i.e. TSS and DOC). For the UCLA and Caltrans combined sites, Table 4.14 presents actual values; and for individual UCLA sites and Caltrans zones, median values are presented. For example, the first R^2 value in the first data row (0.71) is the median of three R^2 values developed for three individual UCLA sites for dissolved Cd. For the Caltrans zones, the median values presented are the medians of fourteen R^2 values developed for fourteen zones. The median R^2 for the generalized metal models were generally very good with the exception of total Pb models for individual (0.24) and combined (0.30) UCLA sites. Also, in general, the individual sites provided better predictions for the metal constituents than the combined UCLA sites. Among the other Caltrans sites, the models developed for zones in general were better than the models developed for the Caltrans sites as a whole with the exception of particulate Cr as shown in Table 4.14.

Table 4.14 also presents the median significance values for the models (pReg) and individual variables (p values) for TSS and DOC for the metals. For the metals, the regression models were significant at 99% confidence interval ($p_{Reg} < 0.01$) except for total Pb (0.05) for the individual sites and combined UCLA sites. Among the individual variables, DOC was the most significant parameter for the metals for individual UCLA sites and both the TSS and DOC for the combined UCLA sites. The p_{Reg} values associated with all the particulate and total metals for the combined Caltrans sites and Caltrans zones are significant at 99% confidence interval (i.e. $p_{Reg} < 0.01$). TSS was the most significant parameter for the regression models for the particulate and total metals for combined Caltrans sites and zones with all the p values significant at 99% confidence interval (i.e. $p < 0.01$).

4.5.6 Final Comparison of Regression Models

In this research, four sets of best-fit regression models were developed to predict metal EMCs: individual UCLA sites, combined UCLA sites, combined other Caltrans sites, Caltrans zones. Also four sets of generalized regression models with TSS and DOC as the independent variables were also formulated. The results for final comparison are presented in Table 4.15 in terms of median R^2 values. For example, the first R^2 (0.69) value for UCLA site 1 in the first data row represents the median of the six R^2 values developed for six dissolved/particulate constituents (i.e. Cd, Cr, Cu, Ni, Pb, and Zn). Similarly, the first R^2 (0.71) value for Caltrans zone 1 in the last data row represents the median of the six R^2 values developed for the same six particulate metal constituents.

Among the best-fit models, the median R^2 values in Table 4.15 suggest that the UCLA site 1 dissolved/particulate (0.69) and total (0.68) values were lower than corresponding values of combined UCLA sites (i.e. 0.78 and 0.80 respectively). The median best-fit model R^2 values for sites 2 and 3 were better than combined UCLA sites. Generally, the individual UCLA sites provided better predictive best-fit models than combined UCLA sites. The best-fit models among the Caltrans zones for both the dissolved/particulate and total phases were better in terms of median R^2 than the best-fit models developed for all the Caltrans sites as a whole with the exception of total Pb (0.10).

Among the generalized regression models, UCLA site 1 median R^2 values for dissolved (0.69) and total (0.74) fraction were less than the corresponding models formulated for combined UCLA sites. Though, generally the generalized regression models for individual UCLA sites provided better estimates than combined UCLA sites. For the other Caltrans sites, all the median values for the individual zones for both the particulate and total fraction were better than the corresponding median values of combined Caltrans sites for the generalized models.

Comparison was also made between the best-fit and generalized regression models. Obviously, most of the best-fit models were better estimators than the corresponding generalized models. Some R^2 values for the generalized models were better than the corresponding best-fit models. For example, for UCLA site 1, the total phase generalized model (0.77) had a better R2 value than best-fit model (0.72) for Cr. Almost all the total phase models satisfied the 95% confidence level threshold for the coefficients of the independent variables, but many of the coefficients of the intercept, TSS, and DOC in the generalized model did not meet the criteria as evident in Appendix D. Among the individual and combined UCLA sites, the best-fit model median values were better than corresponding values of generalized models with the exception of total fraction model for site 1 (i.e. 0.68 for best-fit as compared with 0.74 for generalized model) as shown in Table 4.15. For the Caltrans zones, all the dissolved/particulate phase best-fit models were better than the corresponding particulate phase generalized models in terms of median R^2. For the total phase models, few Caltrans zones exhibited better median R^2 values for generalized models over the best-fit models, i.e. zones 2, 5, and 8.

4.6 CONCLUSIONS

Best-fit regression models were developed for dissolved, particulate, and total phases for six heavy metals: cadmium (Cd), chromium (Cr), copper (Cu), nickel (Ni), lead (Pb), and zinc (Zn), with two conventional constituents from suspended solids group [i.e. total suspended solids (TSS), volatile suspended solids (VSS)], two from dissolved solids group [i.e. electrical conductivity (EC), total dissolved solids (TDS)], and three from organics group [i.e. chemical oxygen demand (COD), dissolved organic carbon (DOC), and total organic carbon (TOC)] be used as independent variables. Conventional constituents within each group showed significant correlations for UCLA sites; and Caltrans zones and sites. The objective was to choose a maximum of one constituent from each group to be used as independent variables for the best-fit regression models to reduce any significant correlation among the independent variables in the regression models. For some metal parameters, the dissolved metal models were better than the particulate models, and vice versa. Either the dissolved or the particulate model was presented in conjunction with the total metal model for all the metals. Additionally, the best-fit models were evaluated using linear, semi-log and inverse forms of the independent variables.

Generalized types of regression models were also analyzed. The idea was to develop regression models with the same set of conventional parameters and for same form (e.g. linear) and phase (e.g. particulate). The generalized regression model was found out to have a linear form with TSS and DOC be the only conventional parameters used as independent variables along with the intercept. To further generalize the models, dissolved phases were used for the UCLA sites and particulate phases for Caltrans zones and sites.

Fifty-nine storm events using three sites (i.e. UCLA sites) in Southern California during the rainy seasons (October to May) 1999-2003 were used in the regression analysis. The regression analysis was then extended to an additional eighty-three California Department of Transportation (Caltrans) sites.

This paper provided statistical relations that support the following conclusions:

1. The best-fit regression models provided satisfactory predictions, and the intercepts and coefficients for the independent variables were statistically significant at 95% confidence level ($p<0.05$, two-tailed t statistic), and the regression models as a whole were significant at 99% confidence level ($p_{Reg}<0.01$, F statistic) for the individual and combined UCLA sites.
2. All the individual UCLA sites provided good R^2 values with UCLA site 3 providing the best median values of R^2 for dissolved/particulate (0.96) and total (0.90) phases for the best-fit regression models.
3. The median values of R^2 for the dissolved/particulate (0.78) and total (0.80) metals for combined UCLA sites provided less reliable predictions than individual UCLA sites except UCLA site 1 for the best-fit regression models.
4. The best-fit regression models developed for combined UCLA sites with the same coefficients were applied to all other Caltrans sites and the total constituent EMC

models showed better correlations than dissolved/particulate phases. The correlation results were not satisfactory.

5. Best-fit regression models were developed for the other Caltrans sites on a combined basis and the particulate (0.57) and total (0.52) metal models for Cr showed good results. Also the dissolved/particulate and total phases of Cu, Ni, and Zn showed some promising results.

6. Best-fit regression models were developed for the Caltrans zones and the results provided better approximations than Caltrans sites as a whole in terms of R^2. All the intercepts and coefficients for the independent variables were statistically significant at 95% confidence level and the regression models as a whole were significant at 99% confidence level for all the Caltrans zones with the exception of zones 5 and 6. Zone 9 provided the best estimates for dissolved/particulate (0.92) and total (0.91) metal EMCs in terms of median R^2 values.

7. Regarding the number of times each conventional parameter was used in the regression models, DOC was the most dominant constituent for the regression models for UCLA sites 1 and 3. For UCLA site 2, both TSS and COD were the dominant constituents. For the combined UCLA sites, both TSS and DOC were dominant. TSS (i.e. appeared 147 times out of 178 regression models) was the most dominant parameter for the Caltrans zones followed by DOC (67 times) and EC (40 times).

8. Most of the best-fit models were better estimators than the corresponding generalized models. The combined generalized regression models provided

satisfactory predictions for the individual and combined UCLA sites in terms of R^2. Caltrans sites R^2 values were less than reliable but when sites were separated into zones, the R^2 improved significantly with zone 9 providing the best predictions.

9. For the generalized models, DOC was the most significant constituent for the dissolved and total phase models for the individual and combined UCLA sites. For the Caltrans zones and sites, TSS was the most significant constituent in the particulate and total phase regression models.

NOTATION

ADD = Antecedent dry days (day);

ADT = Average daily traffic (×10^5 vehicles/day);

Al = Aluminum;

AREA = Catchment area (ha);

AVE_RAIN = Average intensity of rainfall;

Caltrans = California Department of Transportation;

Cd = Cadmium (µg/L);

Cl = Chlorine (µg/L);

COD = Chemical oxygen demand (mg/L);

Cr = Chromium (µg/L);

Cu = Copper (µg/L);

DOC = Dissolved organic carbon (mg/L);

D_RUN = Duration of runoff total runoff (hr);

EC = Electrical conductivity (µmhos/cm);

EMC = Event mean concentration (µg/L);

F = Fluorine;

Fe = Iron;

MAX_RAIN = Maximum intensity of rainfall (mm/hr);

NH_3 = Ammonia;

Ni = Nickel (µg/L);

NO_3 = Nitrate;

NO_2 = Nitrite;

P = Total phosphorus;

p = Probability value for individual independent variables (two-tailed t-statistic);

Pb = Lead (μg/L);

PO4 = Ortho-phosphate;

p_{Reg} = Probability value for the regression equation as a whole (F-statistic);

R = Correlation coefficient;

RC = Rational runoff coefficient (-);

SC = Specific Conductance;

SO_4 = Sulfate;

TDS = Total dissolved solids (mg/L);

TKN = Total Kjeldahl nitrogen;

TOC = Total organic carbon (mg/L);

TSS = Total suspended solids (mg/L);

T_RAIN = Total rainfall (mm);

UCLA = University of California at Los Angeles;

U.S. EPA = United States environmental protection agency;

VDS = Vehicles during storm;

VSS = Volatile suspended solids (mg/L), and

Zn = Zinc (μg/L).

Table 4.1. Conventional and Metal Constituents, Analytic Methods, and Units

Constituent	Abbreviation	Analytic method[a]	Unit
Conventional constituents			
Total suspended solids	TSS	U.S. EPA 160.2	mg/L
Volatile suspended solids	VSS	U.S. EPA 160.4	mg/L
Electrical conductivity	EC	U.S. EPA 120.1	µmhos/cm
Total dissolved solids	TDS	U.S. EPA 160.1	mg/L
Chemical oxygen demand	COD	U.S. EPA 410.4	mg/L
Dissolved organic carbon	DOC	U.S. EPA 415.1	mg/L
Total organic carbon	TOC	U.S. EPA 415.1	mg/L
Metals (*total and dissolved*)			
Cadmium	Cd	U.S. EPA 200.8	µg/L
Chromium	Cr	U.S. EPA 200.8	µg/L
Copper	Cu	U.S. EPA 200.8	µg/L
Nickel	Ni	U.S. EPA 200.8	µg/L
Lead	Pb	U.S. EPA 200.8	µg/L
Zinc	Zn	U.S. EPA 200.8	µg/L

[a]Analytic method U.S. EPA 200.7 was used for the analysis of dissolved and total metals for the UCLA sites.

Table 4.2. Correlation (R) Matrix Results between the Conventional Parameters

Site/Zone	TSS-VSS[d]	COD-DOC	EC-TDS
UCLA 1	0.94	0.94	
UCLA 2	0.82	0.94	
UCLA 3	0.90	0.98	
UCLA all[a]	0.88	0.94	
All[b]	0.79	0.76	0.86
Z 1[c]			0.98
Z 2			0.85
Z 3			0.20
Z 4		0.76	0.82
Z 5			0.58
Z 6			
Z 7			0.43
Z 8	0.63		0.81
Z 9	0.92	0.84	-0.28
Z 10			0.70
Z 11			0.76
Z 12			0.78
Z 13			0.91
Z 14			0.86

[a]**UCLA all** includes the three UCLA sites.

[b]**All** includes all the sites excluding the three UCLA sites.

[c]Z 1 is the abbreviated form of Zone 1.

[d]TSS-VSS column shows the correlations between TSS and VSS for different sites and zones

Table 4.3. Regression Models Developed for Individual UCLA Sites

Site	Coefficient						R^2	Count[b]	Form[c]	Parameter (:g/L)	Phase
	Intercept	TSS (mg/L)	VSS (mg/L)	DOC (mg/L)	COD (mg/L)	EC (:mhos/cm)					
UCLA 1				0.01			0.69	17.00	D1	Cd	Dissolved/ Particulate[a]
	1.20				0.00		0.69	17.00	D1	Cr	
			0.92	0.74			0.98	11.00	D1	Cu	
	-31.75				20.32		0.94	17.00	D2	Ni	
		0.32					0.63	17.00	P1	Pb	
		2.16					0.69	17.00	P1	Zn	
				0.02			0.64	17.00	T1	Cd	Total
	3.18			0.11			0.72	17.00	T1	Cr	
			2.20	0.62			0.97	11.00	T1	Cu	
	-33.94				22.82		0.93	17.00	T2	Ni	
		0.39					0.64	17.00	T1	Pb	
	-587.59				419.32		0.63	17.00	T2	Zn	
UCLA 2		0.01			0.00	0.00	0.87	16.00	D1	Cd	Dissolved/ Particulate
	1.63				0.01		0.82	16.00	D1	Cr	
		0.24			0.32	-0.10	0.97	16.00	D1	Cu	
		0.09			0.07	-0.04	0.98	16.00	D1	Ni	
	1.64				0.01		0.66	16.00	D1	Pb	
	-135.02		18.69			-1.14	0.93	11.00	D1	Zn	
		0.01		0.02			0.77	16.00	T1	Cd	Total
	7.84			0.10			0.84	16.00	T1	Cr	
		0.33			0.33		0.96	16.00	T1	Cu	
		0.07			0.06		0.94	16.00	T1	Ni	
		15.24					0.15	16.00	T2	Pb	
		2.92			1.81	-0.86	0.96	16.00	T1	Zn	
UCLA 3			-0.01	0.01		0.00	0.97	19.00	P1	Cd	Dissolved/ Particulate
	1.73			0.06		-0.02	0.87	26.00	D1	Cr	
	6.27				0.18		0.95	26.00	D1	Cu	
	-3.22					0.10	0.96	26.00	D1	Ni	
		0.04				0.01	0.63	26.00	D1	Pb	
	31.45			4.39			0.97	26.00	D1	Zn	
				0.01			0.86	26.00	T1	Cd	Total
	3.57	0.07		0.11		-0.04	0.78	26.00	T1	Cr	
			1.02		0.15		0.93	19.00	T1	Cu	
	4.94		-0.29		0.09		0.95	19.00	T1	Ni	
	33.64	-389.64		48.50			0.39	26.00	T3	Pb	
	91.35			4.44			0.96	26.00	T1	Zn	

[a]For some metal parameters, the dissolved metal models were better than the particulate models, and vice versa. Dissolved/Particulate means either the dissolved or the particulate model was presented. [b]Count is the number of events considered. [c]In form column **D** denotes dissolved, **P** denotes particulate, and **T** denotes total metal. Also, 1, 2, and 3 are linear, semi-log, and inverse forms respectively.

Table 4.4. Median Values for Individual and Combined UCLA Sites

Site	Phase	R^2
UCLA 1	Dissolved/Particulate[b]	0.69[a]
UCLA 2	Dissolved/Particulate	0.90
UCLA 3	Dissolved/Particulate	0.96
UCLA all[c]	Dissolved/Particulate	0.78
UCLA 1	Total	0.68
UCLA 2	Total	0.89
UCLA 3	Total	0.90
UCLA all	Total	0.80

[a]The value of R^2 (0.69) for UCLA site 1 represents the median of the six R^2 values developed for six dissolved/particulate constituents (i.e. Cd, Cr, Cu, Ni, Pb, and Zn).

[b]For some metal parameters, the dissolved metal models were better than the particulate models, and vice versa. Dissolved/Particulate means either the dissolved or the particulate model was presented.

[c]**UCLA all** includes the three UCLA sites.

Table 4.5. Individual UCLA Sites: Median Values for Different Metal Constituents

Parameter	Phase	R^2
Cd	Dissolved/Particulate[b]	0.87
Cr	Dissolved/Particulate	0.82
Cu	Dissolved/Particulate	0.97
Ni	Dissolved/Particulate	0.96
Pb	Dissolved/Particulate	0.63
Zn	Dissolved/Particulate	0.93
Cd	Total	0.77
Cr	Total	0.78
Cu	Total	0.96
Ni	Total	0.94
Pb	Total	0.39
Zn	Total	0.96[a]

[a]The value of R^2 (0.96) for total Zn represents the median of the three R^2 values developed for three individual UCLA sites.

[b]For some metal parameters, the dissolved metal models were better than the particulate models, and vice versa. Dissolved/Particulate means either the dissolved or the particulate model was presented.

Table 4.6. Number of Models of Different Phases (i.e. Dissolved and Particulate), and Different Forms (i.e. Form 1 = Linear, Form 2 = Semi-log, and Form 3 = Inverse) for UCLA Sites and Caltrans Zones and Sites

Site/Zone	Phase		Form		
	Dissolved	Particulate	Form1(Linear)	Form 2 (Semi-log)	Form 3 (Inverse)
UCLA 1	4	2	9	3	0
UCLA 2	6	0	11	1	0
UCLA 3	5	1	11	0	11
Total[a]	15	3	31	4	11
UCLA all[b]	5	1	10	2	0
All[c]	2	4	2	10	0
Z 1[d]	0	6	11	1	0
Z 2	1	5	12	0	0
Z 3	1	5	12	0	0
Z 4	1	5	12	0	0
Z 5	3	3	10	2	10
Z 6	3	3	9	1	2
Z 7	3	3	9	2	1
Z 8	4	2	12	0	0
Z 9	1	5	12	0	0
Z 10	2	4	12	0	0
Z 11	2	4	8	4	0
Z 12	2	4	5	7	0
Z 13	4	2	11	1	0
Z 14	2	4	12	0	0
Total[e]	29	55	147	18	13

[a]Values in this row represents the sum of the values of the corresponding columns for individual UCLA sites.

[b]**UCLA all** includes the three UCLA sites.

[c]**All** includes all the sites excluding the three UCLA sites.

[d]Z 1 is the abbreviated form of Zone 1.

[e]Values in this row represents the sum of the values of the corresponding columns for Caltrans Zones.

Table 4.7. Number of Times Each Conventional Parameter was Used in the Twelve (i.e. Six for Dissolved/Particulate[b] and Six for Total Phases) Best-fit Models for Each group of Sites/Zones

	Intercept	TSS	VSS	DOC	COD	EC	TDS
UCLA 1	5	3[a]	2	5	4	0	
UCLA 2	4	8	1	2	8	5	
UCLA 3	8	3	3	7	3	5	
Total[c]	17	14	6	14	15	10	
UCLA All[d]	4	10	0	9	3	1	
All[e]	12	12	0	11	0	0	3
Z 1[f]	8	12		3		11	0
Z 2	4	11		3		2	0
Z 3	4	12		4		2	2
Z 4	9	11		3	0	1	9
Z 5	4	9		6		3	1
Z 6	8	10			6		
Z 7	7	8		0		1	4
Z 8	1	6	5	8		0	1
Z 9	1	9	2	11	1		
Z 10	3	11		8		5	6
Z 11	4	10		3		8	0
Z 12	9	11		3		2	5
Z 13	2	11		8		2	0
Z 14	6	11		7		3	0
Total[g]	70	142	7	67	7	40	28

[a]For UCLA site 1 regression models TSS appeared 3 times out of 12 possible cases.

[b]For some metal parameters, the dissolved metal models were better than the particulate models, and vice versa. Dissolved/Particulate means either the dissolved or the particulate model was presented.

[c]Values in this row represents the sum of the values of the corresponding columns for individual UCLA sites.

[d]**UCLA all** includes the three UCLA sites.

[e]**All** includes all the sites excluding the three UCLA sites.

[f]Z 1 is the abbreviated form of Zone 1.

[g]Values in this row represents the sum of the values of the corresponding columns for Caltrans Zones.

Table 4.8. Regression Models Developed for Combined UCLA Sites

Phase	Coefficient							R^2	Count[b]	Form[c]	Parameter (:g/L)
	Intercept	TSS (mg/L)	VSS (mg/L)	DOC (mg/L)	COD (mg/L)	EC (:mhos/c)	TDS (mg/L)				
Dissolved/ Particulate[a]				0.01				0.66	59.00	P1	Cd
	0.62	0.02		0.02				0.75	59.00	D1	Cr
		0.22			0.20			0.85	59.00	D1	Cu
		0.03		0.22				0.91	59.00	D1	Ni
	2.26				0.01	-0.01		0.54	59.00	D1	Pb
		1.54		4.31				0.82	59.00	D1	Zn
Total		0.01		0.01				0.78	59.00	T1	Cd
	-12.75	7.82		6.14				0.74	59.00	T2	Cr
		0.51			0.21			0.81	59.00	T1	Cu
	2.79	0.05		0.22				0.87	59.00	T1	Ni
		23.34		-10.32				0.46	59.00	T2	Pb
		2.50		4.40				0.85	59.00	T1	Zn

[a]For some metal parameters, the dissolved metal models were better than the particulate models, and vice versa. Dissolved/Particulate means either the dissolved or the particulate model was presented.

[b]Count is the number of events considered.

[c]In form column **D** denotes dissolved, **P** denotes particulate, and **T** denotes total metal. Also, 1, 2, and 3 are linear, semi-log, and inverse forms respectively.

Table 4.9. R values for the Metal Parameters when Combined UCLA Regression Models are Applied to Combined Other Caltrans Sites

Parameter	Dissolved/Particulate[a]		Total	
	Form[b]	R	Form[b]	R
Cd	P1	0.10	T1	0.28
Cr	D1	0.14	T2	0.49
Cu	D1	0.23	T1	0.33
Ni	D1	0.26	T1	0.52
Pb	D1	0.08	T2	0.20
Zn	D1	0.12	T1	0.47

[a]For some metal parameters, the dissolved metal models were better than the particulate models, and vice versa. Dissolved/Particulate means either the dissolved or the particulate model was presented.

[b]In form column **D** denotes dissolved, **P** denotes particulate, and **T** denotes total metal. Also, 1, 2, and 3 are linear, semi-log, and inverse forms respectively.

Table 4.10. Regression Models Developed for Other Caltrans Sites on a Combined Basis

Parameter (:g/L)	Coefficient							R^2	Count[b]	Form[c]	Phase
	Intercept	TSS (mg/L)	VSS (mg/L)	DOC (mg/L)	COD (mg/L)	EC (:mhos/c)	TDS (mg/L)				
Cd	-0.48	0.43		0.19				0.16	725	P2	Dissolved/Particulate[a]
Cr	2.33	0.01					0.01	0.57	670	P1	
Cu	-11.61	1.80		19.66				0.39	725	D2	
Ni	-3.92	0.43		6.15				0.38	726	D2	
Pb	-65.18	41.28		19.74				0.09	725	P2	
Zn	-153.26	119.16		46.74				0.37	725	P2	
Cd	-0.55	0.43		0.42				0.11	726	T2	Total
Cr	4.70	0.01		0.02			0.01	0.52	670	T1	
Cu	-35.45	18.11		21.77			4.77	0.43	670	T2	
Ni	-11.34	6.78		6.78				0.36	726	T2	
Pb	-70.18	43.40		24.38				0.08	726	T2	
Zn	-229.58	131.74		154.32				0.38	726	T2	

[a]For some metal parameters, the dissolved metal models were better than the particulate models, and vice versa. Dissolved/Particulate means either the dissolved or the particulate model was presented.

[b]Count is the number of events considered.

[c]In form column **D** denotes dissolved, **P** denotes particulate, and **T** denotes total metal. Also, 1, 2, and 3 are linear, semi-log, and inverse forms respectively.

Table 4.11. Median Values for Caltrans Zones

Zone	R^2	Phase
Z 1[b]	0.69[a]	Dissolved/Particulate[c]
Z 2	0.59	
Z 3	0.69	
Z 4	0.67	
Z 5	0.50	
Z 6	0.51	
Z 7	0.78	
Z 8	0.69	
Z 9	0.92	
Z 10	0.43	
Z 11	0.61	
Z 12	0.59	
Z 13	0.84	
Z 14	0.71	
Z 1	0.63	Total
Z 2	0.56	
Z 3	0.68	
Z 4	0.68	
Z 5	0.42	
Z 6	0.10	
Z 7	0.78	
Z 8	0.66	
Z 9	0.91	
Z 10	0.44	
Z 11	0.55	
Z 12	0.52	
Z 13	0.74	
Z 14	0.77	

[a]The value of R^2 (0.69) for Zone 1 represents the median of the six R^2 values developed for six dissolved/particulate constituents (i.e. Cd, Cr, Cu, Ni, Pb, and Zn).

[b]Z 1 is the abbreviated form of Zone 1.

[c]For some metal parameters, the dissolved metal models were better than the particulate models, and vice versa. Dissolved/Particulate means either the dissolved or the particulate model was presented.

Table 4.12. Caltrans Zones: Median Values for Different Metal Constituents

Parameter	R^2	Phase
Cd	0.54	Dissolved/Particulate[b]
Cr	0.61	
Cu	0.69	
Ni	0.68	
Pb	0.72	
Zn	0.68	
Cd	0.49	Total
Cr	0.52	
Cu	0.64	
Ni	0.67	
Pb	0.73	
Zn	0.67[a]	

[a]The value of R^2 (0.67) for total Zn represents the median of the fourteen R^2 values developed for fourteen Caltrans zones.

[b]For some metal parameters, the dissolved metal models were better than the particulate models, and vice versa. Dissolved/Particulate means either the dissolved or the particulate model was presented.

Table 4.13. Median Values of Generalized Regression Models for UCLA Sites; Caltrans Zones and Sites

Phase	R^2	p_{Reg}[c]	Intercept	TSS	DOC	Phase	R^2	p_{Reg}	Intercept	TSS	DOC	Site/Zone
Dissolved	0.69[a]	<0.01[b]	0.13	0.29	0.01	Total	0.74	<0.01	0.07	0.31	0.01	UCLA 1
Dissolved	0.82	<0.01	0.17	0.13	<0.01	Total	0.87	<0.01	0.25	0.11	<0.01	UCLA 2
Dissolved	0.84	<0.01	0.40	0.14	<0.01	Total	0.81	<0.01	0.15	0.18	<0.01	UCLA 3
Dissolved	0.76	<0.01	0.31	<0.01	<0.01	Total	0.76	<0.01	0.12	<0.01	<0.01	UCLA all[d]
Particulate	0.31	<0.01	<0.01	<0.01	0.23	Total	0.24	<0.01	<0.01	<0.01	<0.01	All[e]
Particulate	0.63	<0.01	0.32	<0.01	0.04	Total	0.57	<0.01	0.08	<0.01	0.02	Z 1[f]
Particulate	0.57	<0.01	0.63	<0.01	0.57	Total	0.57	<0.01	0.10	<0.01	0.44	Z 2
Particulate	0.67	<0.01	0.61	<0.01	0.59	Total	0.66	<0.01	0.09	<0.01	0.01	Z 3
Particulate	0.62	<0.01	0.03	<0.01	0.72	Total	0.62	<0.01	<0.01	<0.01	0.04	Z 4
Particulate	0.44	<0.01	0.04	<0.01	0.43	Total	0.43	<0.01	0.03	<0.01	0.03	Z 5
Particulate						Total						Z 6
Particulate	0.59	0.02	0.45	0.03	0.37	Total	0.51	0.03	0.64	0.10	0.24	Z 7
Particulate	0.54	<0.01	0.67	<0.01	0.22	Total	0.67	<0.01	0.37	<0.01	0.11	Z 8
Particulate	0.88	<0.01	0.53	<0.01	0.03	Total	0.90	<0.01	0.34	<0.01	<0.01	Z 9
Particulate	0.34	<0.01	0.21	<0.01	0.21	Total	0.35	<0.01	0.28	<0.01	0.01	Z 10
Particulate	0.44	<0.01	0.67	<0.01	0.19	Total	0.42	<0.01	0.47	<0.01	0.01	Z 11
Particulate	0.45	<0.01	0.78	<0.01	0.14	Total	0.47	<0.01	0.45	<0.01	0.04	Z 12
Particulate	0.61	<0.01	0.67	<0.01	0.71	Total	0.73	<0.01	0.35	<0.01	0.01	Z 13
Particulate	0.61	<0.01	0.14	<0.01	0.65	Total	0.76	<0.01	0.04	<0.01	0.08	Z 14

[a]The value of R^2 (0.69) for UCLA site 1 represents the median of the six R^2 values developed for six dissolved constituents (i.e. Cd, Cr, Cu, Ni, Pb, and Zn).

[b]The value of p_{Reg} (<0.01) for UCLA site 1 represents the median of the six p_{Reg} values developed for six dissolved constituents (i.e. Cd, Cr, Cu, Ni, Pb, and Zn).

[c]p_{Reg} refers to p value for the entire model obtained from F-statistic.

[d]**UCLA all** includes the three UCLA sites. [e]**All** includes all the sites excluding the three UCLA sites.

[f]Z 1 is the abbreviated form of Zone 1.

Table 4.14. Median Values of Generalized Regression Models for Metals

Phase	UCLA Individual Sites					UCLA Combined Sites[d]					Parameter
	R^2	p_{Reg}[c]	Intercept	TSS	DOC	R^2	p_{Reg}[c]	Intercept	TSS	DOC	
Dissolved	0.71[a]	0.00	0.92	0.12	0.01	0.49	0.00	0.47	0.00	0.04	Cd
	0.79	0.00	0.05	0.21	0.00	0.75	0.00	0.00	0.00	0.00	Cr
	0.89	0.00	0.56	0.20	0.00	0.77	0.00	0.92	0.00	0.00	Cu
	0.88	0.00	0.08	0.08	0.00	0.91	0.00	0.99	0.03	0.00	Ni
	0.61	0.00	0.23	0.04	0.01	0.47	0.00	0.00	0.09	0.00	Pb
	0.84	0.00	0.07	0.28	0.00	0.83	0.00	0.14	0.00	0.00	Zn
Total	0.79	0.00	0.37	0.26	0.00	0.78	0.00	0.61	0.00	0.00	Cd
	0.77	0.00	0.02	0.10	0.00	0.71	0.00	0.00	0.00	0.00	Cr
	0.80	0.00	0.21	0.18	0.00	0.73	0.00	0.19	0.00	0.00	Cu
	0.88	0.00	0.03	0.39	0.00	0.87	0.00	0.04	0.01	0.00	Ni
	0.24	0.05	0.01	0.01	0.47	0.30	0.00	0.00	0.00	0.10	Pb
	0.90	0.00	0.16	0.18	0.00	0.85	0.00	0.86	0.00	0.00	Zn

Phase	Caltrans Combined Sites					Caltrans Zones[d]					Parameter
	R^2	p_{Reg}[c]	Intercept	TSS	DOC	R^2	p_{Reg}[c]	Intercept	TSS	DOC	
Particulate	0.12[b]	0.00	0.00	0.00	0.55	0.49	0.00	0.62	0.00	0.45	Cd
	0.48	0.00	0.00	0.00	0.19	0.47	0.00	0.15	0.00	0.39	Cr
	0.29	0.00	0.00	0.00	0.17	0.56	0.00	0.60	0.00	0.22	Cu
	0.33	0.00	0.00	0.00	0.75	0.48	0.00	0.36	0.00	0.35	Ni
	0.06	0.00	0.00	0.00	0.27	0.67	0.00	0.50	0.00	0.07	Pb
	0.33	0.00	0.00	0.00	0.10	0.63	0.00	0.27	0.00	0.27	Zn
Total	0.06	0.00	0.00	0.00	0.07	0.45	0.00	0.26	0.00	0.18	Cd
	0.47	0.00	0.00	0.00	0.00	0.36	0.00	0.00	0.00	0.34	Cr
	0.24	0.00	0.00	0.00	0.00	0.61	0.00	0.26	0.00	0.00	Cu
	0.31	0.00	0.00	0.00	0.00	0.61	0.00	0.24	0.00	0.00	Ni
	0.05	0.00	0.00	0.00	0.22	0.67	0.00	0.11	0.00	0.05	Pb
	0.24	0.00	0.00	0.00	0.00	0.66	0.00	0.15	0.00	0.00	Zn

[a]R^2 (0.71) for dissolved Cd represents the median of the three R^2 values developed for three individual UCLA sites. [b]R^2 (0.12) for particulate Cd is the median of fourteen R^2 values developed for fourteen zones. [c]p_{Reg} refers to p value for the entire model obtained from F-statistic. [d]Values for UCLA combined and Caltrans combined sites are actual values.

Table 4.15. Comparison between Best-fit and Generalized Regression Models

Site/Zone	Best-fit model				Generalized model			
	R^2	Phase	R^2	Phase	R^2	Phase	R^2	Phase
UCLA 1	0.69[a]	Dissolved/Particulate[b]	0.68	Total	0.69	Dissolved	0.74	Total
UCLA 2	0.90	Dissolved/Particulate	0.89	Total	0.82	Dissolved	0.87	Total
UCLA 3	0.96	Dissolved/Particulate	0.90	Total	0.84	Dissolved	0.81	Total
UCLA all[c]	0.78	Dissolved/Particulate	0.80	Total	0.76	Dissolved	0.76	Total
All[d]	0.38	Dissolved/Particulate	0.37	Total	0.31	Particulate	0.24	Total
Z 1[e]	0.69	Dissolved/Particulate	0.63	Total	0.63	Particulate	0.57	Total
Z 2	0.59	Dissolved/Particulate	0.56	Total	0.57	Particulate	0.57	Total
Z 3	0.69	Dissolved/Particulate	0.68	Total	0.67	Particulate	0.66	Total
Z 4	0.67	Dissolved/Particulate	0.68	Total	0.62	Particulate	0.62	Total
Z 5	0.50	Dissolved/Particulate	0.42	Total	0.44	Particulate	0.43	Total
Z 6	0.51	Dissolved/Particulate	0.10	Total		Particulate		Total
Z 7	0.78	Dissolved/Particulate	0.78	Total	0.59	Particulate	0.51	Total
Z 8	0.69	Dissolved/Particulate	0.66	Total	0.54	Particulate	0.67	Total
Z 9	0.92	Dissolved/Particulate	0.91	Total	0.88	Particulate	0.90	Total
Z 10	0.43	Dissolved/Particulate	0.44	Total	0.34	Particulate	0.35	Total
Z 11	0.61	Dissolved/Particulate	0.55	Total	0.44	Particulate	0.42	Total
Z 12	0.59	Dissolved/Particulate	0.52	Total	0.45	Particulate	0.47	Total
Z 13	0.84	Dissolved/Particulate	0.74	Total	0.61	Particulate	0.73	Total
Z 14	0.71	Dissolved/Particulate	0.77	Total	0.61	Particulate	0.76	Total

[a]The value of R^2 (0.69) for UCLA site 1 represents the median of the six R^2 values developed for six dissolved/particulate constituents (i.e. Cd, Cr, Cu, Ni, Pb, and Zn).

[b]For some metal parameters, the dissolved metal models were better than the particulate models, and vice versa. Dissolved/Particulate means either the dissolved or the particulate model was presented.

[c]**UCLA all** includes the three UCLA sites. [d]**All** includes all the sites excluding the three UCLA sites. [e]Z 1 is the abbreviated form of Zone 1.

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CHAPTER FIVE

CONCLUSIONS

This dissertation addressed three topics in highway stormwater management. . The first topic (chapter two) determined the best predictive model for oil and grease (O&G) when collecting only grab samples. The second topic (chapter three) developed regression models for metal event mean concentrations (EMCs) using storm and site-specific parameters. The third research topic (chapter four) formulated regression models for metal EMCs using conventional constituents.

5.1 O&G Measurement in Highway Runoff

Twenty-two storm events using three University of California at Los Angeles (UCLA) sites in Southern California during the rainy seasons (October to April) of 1999-2002 were used to determine if there exists a point in the pollutograph that best approximates the O&G EMC. Regression analysis were performed to determine if O&G EMC and best sampling time could be related to storm-specific parameters such as total rainfall, and weather-specific parameter such as antecedent dry days (ADD). Finally, correlations were made between other organic parameters, such as chemical oxygen demand (COD) and dissolved organic carbon (DOC), to determine if using a correlation to estimate O&G EMC is a viable strategy.

Collecting a single grab sample at the beginning of a storm event (~ 15 minutes) is a poor strategy and overestimates the EMC by 20 mg/L or more. Collecting a grab sample in the range of 1 to 6 hours after the beginning of runoff is a better strategy. The O&G EMC was strongly correlated to the COD or DOC EMC, and was not well correlated to TSS. Correlation to COD or DOC should reduce sample costs, the sampling team does not have to be mobilized to collect the grab sample.

5.2 Metal Regression Models Using Event and Site-specific parameters

Regression models were developed for dissolved, particulate and total metals [cadmium (Cd), chromium (Cr), copper (Cu), nickel (Ni), lead (Pb), and zinc (Zn)] with four event-specific [i.e. T_RAIN, maximum intensity of rainfall (MAX_RAIN), duration of runoff (D_RUN), and ADD] and three site-specific [i.e. runoff coefficient (RC), catchment area (AREA), and average daily traffic (ADT)] parameters as independent variables. Fifty-nine storm events using three UCLA sites during the rainy seasons (October to May) 1999-2003 were used in the regression analysis. The regression analysis was then extended to an additional eighty-three California Department of Transportation (Caltrans) sites. Four sets of regression models were considered, as follows:

1. Metal EMCs as a function of four event specific variables.
2. Metal EMCs as a function of four event-specific variables and three site specific variables

3. Metal EMCs as a function only of T_RAIN and ADD.
4. Metal EMCs as a function of T_RAIN, ADD, and three site-specific variables.

The models were evaluated using linear, semi-log and inverse forms of the independent variables. Regression models developed for the three individual UCLA sites for the metal EMCs were generally good (R^2 values were greater than 0.50 and the regression equations were significant with 99% confidence interval using F-statistics) with site 2 providing the best predictions. T_RAIN was the most significant parameter for the UCLA sites 1 and 2; and ADD was for site 3. Regression models developed for combined UCLA sites were generally good with R^2 values were greater than 0.40. The regressions were significant with 99% confidence interval using F-statistics. For the pooled UCLA sites, T_RAIN, ADD and D_RUN were the most significant parameters.

Regression models developed for the combined Caltrans sites were not good predictors of metal constituent EMCs. Better regression were obtained by dividing the Caltrans sites into geographically similar areas, called zones. Among these zones, T_RAIN and ADD were the most significant parameters.

5.3 Metal Regression Models Using Conventional Parameters

Best-fit regression models were developed for six metals in dissolved, particulate, and total forms with total suspended solids (TSS), volatile suspended solids (VSS), electrical conductivity (EC), total dissolved solids (TDS), and COD, DOC or total organic carbon (TOC). Two types of models were developed: a model that is the best fit of the metal concentrations using one parameter from suspended solids, one from dissolved solids and one from COD or DOC (best-fit model). The second type of model always used TSS and DOC as independent variables (generalized model).

Fifty-nine storm events using three sites (i.e. UCLA sites) in Southern California during the rainy seasons (October to May) 1999-2003 were used in the regression analysis. The regression analysis was then extended to an additional eighty-three California Department of Transportation (Caltrans) sites.

All the individual UCLA sites provided good R^2 values with UCLA site 3 providing the best median values of R^2 for dissolved or particulate (0.96) and total (0.90) metals for the best-fit regression models. The generalized model did not fit the UCLA sites as well but still provided a good fit (R^2 ~ 0.80). The best-fit and generalized models developed for combined UCLA sites provided slightly less R^2 values than the individual UCLA sites. Both models were extended to the other Caltrans sites. The best-fit model R^2 were not as good, but still provided good predictions for the Caltrans zones. The generalized regression models for the Caltrans zones provided good predictions, although R^2 values were not as good as the best-fit models. For the generalized models, DOC was the most significant constituent for the dissolved and total phase models for the individual and combined UCLA sites. For the Caltrans zones and sites, TSS was the most significant constituent in the particulate and total phase regression models.

TSS, DOC, and COD were the significant parameters for the UCLA sites for the regression models. TSS was the most dominant parameter for the Caltrans zones followed by DOC and EC.

Appendix A-1. Summary of Metal EMC Characteristics the Caltrans Sites in Terms of Median Values for Zones 1, 2, 3, and 4

Site	Dissolved (µg/L)						Particulate (µg/L)						Total (µg/L)						Zone
	Cd	Cr	Cu	Ni	Pb	Zn	Cd	Cr	Cu	Ni	Pb	Zn	Cd	Cr	Cu	Ni	Pb	Zn	
2-201	0.10[a]	0.50	9.20	2.50	0.50	35.00	0.49	2.50	16.20	2.50	5.50	68.00	0.64	3.60	26.00	4.70	6.50	100.00	
2-202	0.15	3.10	8.25	3.20	1.45	20.50	0.10	1.60	4.20	1.50	3.05	13.50	0.25	4.70	11.50	5.15	4.35	34.00	
2-203	0.10	0.50	1.45	1.00	0.50	13.00	0.10	0.50	2.35	1.00	1.80	15.65	0.10	1.10	4.50	1.00	2.50	28.00	
2-204	0.10	0.50	2.40	1.00	0.50	5.30	0.10	0.50	0.50	1.00	0.50	3.00	0.10	0.50	2.70	1.00	0.50	6.80	1
2-205	0.10	0.50	2.80	1.00	0.50	9.80	0.10	0.70	0.20	1.00	0.50	2.50	0.10	1.20	3.50	1.00	0.50	10.00	
2-206	0.10	0.80	3.75	2.20	0.50	2.50	0.10	0.40	0.40	0.65	0.50	2.50	0.10	1.25	4.15	2.30	0.50	9.65	
2-207	0.10	0.50	2.05	1.00	0.50	12.50	0.21	0.80	5.30	1.10	2.20	23.50	0.40	1.45	8.50	1.65	2.70	42.00	
4-213	0.10	1.60	17.00	3.10	0.50	44.00	0.37	2.10	20.00	2.50	12.60	79.00	0.59	4.10	41.00	7.60	14.00	130.00	
4-214	0.10	2.45	6.65	2.25	0.50	11.50	0.10	0.15	0.70	0.70	0.80	2.50	0.10	2.60	7.15	2.30	1.55	12.00	2
4-34	0.10	0.50	3.00	1.05	0.50	14.50	0.10	0.50	2.80	1.35	1.75	20.00	0.20	1.45	5.95	2.65	2.25	41.50	
4-35	0.10	1.20	9.10	1.60	0.50	26.00	0.30	4.00	14.25	4.60	5.95	74.50	0.44	5.25	22.50	7.25	6.90	105.00	
3-05	0.10	0.77	8.67	3.74	0.50	41.90	0.12	2.85	5.23	1.25	2.00	33.10	0.27	3.89	16.75	5.01	2.50	91.55	
3-06	0.10	1.20	10.10	2.57	0.50	30.90	0.10	0.92	3.40	1.00	1.40	17.50	0.20	2.30	13.57	3.18	1.94	47.00	
3-07	0.10	2.82	10.70	2.15	0.50	35.85	0.63	6.55	24.07	6.78	22.18	104.30	0.74	9.85	35.70	8.54	23.00	152.00	
3-213	0.10	11.00	3.80	1.00	0.50	12.00	0.35	3.00	8.20	2.20	3.80	49.00	0.48	15.00	13.00	3.90	4.30	60.00	
3-214	0.40	2.70	9.10	2.50	0.50	23.00	0.20	1.60	6.00	1.40	1.40	18.00	0.60	3.80	13.00	3.20	1.90	42.00	3
3-215	0.55	3.85	5.75	2.80	0.50	15.25	0.20	2.05	3.65	0.90	0.65	15.75	0.75	5.90	9.40	3.70	0.90	31.00	
3-216	0.50	5.75	5.15	2.40	0.50	12.75	0.35	4.05	2.40	0.80	0.65	11.25	0.85	9.80	7.55	3.20	0.90	24.00	
3-217	0.45	4.50	9.60	4.60	0.50	20.50	0.30	4.10	2.75	2.00	1.25	12.50	0.75	8.60	12.35	6.10	1.50	33.00	
3-224	0.10	1.40	9.50	2.90	1.00	26.00	0.10	3.20	3.90	1.10	3.00	17.00	0.10	4.00	13.00	4.50	4.80	48.00	
3-201	0.10	6.12	15.20	3.41	0.50	51.00	0.83	12.10	37.22	12.26	42.00	317.20	0.93	17.60	50.40	17.50	42.50	336.00	
3-202	0.10	3.57	7.78	2.22	0.50	25.80	0.72	9.11	31.87	10.90	22.99	234.10	0.82	13.20	41.60	14.50	24.30	273.00	
3-203	0.10	2.70	6.76	2.95	0.50	32.10	0.17	12.18	24.50	8.70	34.70	133.70	0.34	15.30	34.80	12.70	35.20	198.00	
3-218	0.10	1.45	3.66	1.00	0.50	19.40	0.10	5.04	18.17	6.42	8.85	47.87	0.10	6.80	22.60	7.42	9.35	71.80	4
3-219	0.10	6.10	6.63	1.00	0.50	62.55	0.51	6.03	26.72	10.80	23.68	151.30	0.61	15.55	37.60	14.80	24.90	217.50	
3-220	0.10	1.35	5.52	1.00	0.50	19.30	0.18	8.06	28.17	12.60	16.50	170.00	0.28	10.40	29.70	13.60	17.00	187.00	
3-222	0.10	4.72	6.49	2.66	0.50	41.20	0.48	4.53	18.80	6.18	15.27	196.20	0.58	10.10	31.60	9.38	16.70	236.00	
3-223	0.10	3.24	8.88	2.44	0.50	31.30	0.14	7.41	16.60	5.94	14.90	115.40	0.24	11.40	31.60	8.94	15.40	141.00	

[a]The dissolved Cd value (0.10 µg/L) in the first data row for California Department of Transportation (Caltrans) site 2-201 represents the median of the EMC values of the individual storm events.

Appendix A-2. Summary of Metal EMC Characteristics for Caltrans Sites in Terms of Median Values for Zones 5, 6, 7, 8, and 9

Site	Dissolved (µg/L)						Particulate (µg/L)						Total (µg/L)						Zone
	Cd	Cr	Cu	Ni	Pb	Zn	Cd	Cr	Cu	Ni	Pb	Zn	Cd	Cr	Cu	Ni	Pb	Zn	
6-205	0.10[a]	1.73	11.25	3.42	0.80	76.50	0.17	2.39	7.45	3.47	7.35	53.40	0.27	4.58	20.00	6.40	9.81	177.00	5
6-209	0.20	1.92	15.60	3.20	1.30	110.00	0.28	3.30	12.00	3.32	11.90	110.00	0.55	5.86	30.90	8.40	18.50	212.00	
7-01	0.25	1.20	11.00	2.50	2.20	54.00	0.69	12.00	30.00	5.20	73.75	131.50	0.94	9.10	48.00	18.00	79.50	207.50	6
7-211	0.61	2.30	24.65	5.44	2.35	142.00	0.22	3.45	15.15	8.48	10.01	44.00	0.83	5.74	39.80	13.92	12.35	186.00	
7-213	0.62	1.76	11.10	2.05	2.44	37.70	0.91	2.73	13.70	2.41	30.76	68.30	1.52	4.49	24.80	4.46	33.20	106.00	
7-127	0.25	1.00	12.00	2.50	1.90	24.00	1.25	17.00	42.00	11.50	268.50	305.00	1.50	18.00	52.00	14.00	270.00	320.00	7
7-177	0.20	1.30	9.40	1.00	1.60	42.00	0.20	1.50	6.70	1.70	4.60	32.00	0.50	2.80	15.00	2.70	5.40	82.00	
7-180	0.30	1.70	7.00	2.00	1.70	75.00	0.20	1.40	5.00	1.50	4.10	31.00	0.50	3.10	13.00	2.90	6.50	102.00	
7-209	0.49	3.56	18.70	3.62	1.47	67.70	1.90	6.36	31.70	6.08	25.13	176.30	2.39	9.92	50.40	9.70	26.60	244.00	
7-128	0.25	1.80	20.00	2.50	0.53	35.00	2.50	25.20	88.00	17.25	134.47	476.00	2.75	27.00	110.00	21.00	135.00	510.00	8
7-129	0.12	3.35	13.45	2.90	1.27	36.25	0.57	0.50	12.23	2.53	10.03	96.70	0.74	3.47	23.50	6.88	11.25	118.00	
7-131	0.10	2.87	7.98	1.17	0.93	12.20	0.19	0.50	9.90	1.73	9.68	68.07	0.29	2.95	17.10	2.86	10.50	84.40	
7-135	0.10	2.14	8.92	1.88	1.08	18.70	0.16	0.50	7.54	1.08	6.09	71.50	0.22	2.31	15.95	2.46	7.36	107.40	
7-136	0.10	2.44	11.40	2.50	0.93	24.10	0.24	0.53	9.77	1.44	7.40	75.10	0.44	3.23	20.30	3.90	8.91	116.00	
7-162	0.30	1.30	12.00	3.10	14.00	79.00	0.15	1.20	8.80	1.00	19.50	29.00	0.40	1.90	18.00	3.20	40.00	100.00	
7-165	0.40	2.20	19.00	5.30	11.50	157.00	0.40	3.05	15.00	2.90	29.45	120.00	0.90	5.15	34.50	8.00	40.15	346.50	
7-171	0.40	1.20	15.00	4.80	6.70	109.00	0.80	5.10	11.80	4.60	48.00	175.00	1.30	6.30	26.60	9.40	74.20	288.00	
7-174	0.50	3.80	19.95	7.10	41.05	73.75	0.90	4.80	23.20	6.40	158.45	121.30	1.40	10.30	39.50	13.50	196.00	200.50	
7-35	0.20	2.00	8.70	2.30	4.00	54.00	0.20	1.00	10.81	1.00	28.90	59.60	0.40	3.10	21.00	5.90	34.20	119.00	
7-37	0.40	1.50	14.00	3.80	7.00	135.00	0.40	5.20	22.00	3.10	113.80	154.00	0.60	6.70	36.00	6.30	120.00	288.00	
7-143	0.10	2.37	18.55	2.68	7.90	21.05	2.30	11.94	81.35	11.07	343.91	308.95	2.51	14.25	99.30	13.50	353.00	340.00	9
7-147	0.10	1.86	18.45	2.33	8.54	31.15	1.31	7.92	48.41	7.31	188.08	218.15	1.45	9.83	69.35	10.80	201.00	268.50	

[a]The dissolved Cd value (0.10 µg/L) in the first data row for California Department of Transportation (Caltrans) site 6-205 represents the median of the EMC values of the individual storm events.

Appendix A-3. Summary of Metal EMC Characteristics for Caltrans Sites in Terms of Median Values for Zones 10 and 11

Site	Dissolved (µg/L)						Particulate (µg/L)						Total (µg/L)						Zone
	Cd	Cr	Cu	Ni	Pb	Zn	Cd	Cr	Cu	Ni	Pb	Zn	Cd	Cr	Cu	Ni	Pb	Zn	
12-02	0.25[a]	2.50	20.00	6.80	1.90	55.00	0.31	1.50	7.50	2.50	13.63	42.00	0.56	4.05	33.50	8.50	16.00	130.00	10
12-210	0.80	2.50	8.80	9.80	0.50	71.50	0.70	5.80	8.00	4.50	2.35	57.50	1.50	8.05	19.50	16.50	3.25	145.00	
12-214	0.10	1.70	10.00	3.50	0.50	28.00	0.10	1.30	2.00	1.00	1.70	12.00	0.20	3.20	15.00	4.70	2.20	52.00	
12-215	0.15	1.40	10.50	3.40	0.75	115.00	0.20	3.35	9.50	2.90	4.95	130.00	0.30	4.75	23.50	7.05	6.20	280.00	
12-216	0.20	2.70	16.00	4.30	1.00	68.00	0.30	3.60	9.90	2.50	3.40	80.00	0.40	5.10	24.00	5.90	4.30	140.00	
12-220	0.10	1.20	9.50	3.50	0.50	100.00	0.10	1.50	5.00	1.00	3.20	98.00	0.20	2.90	16.00	4.90	4.20	190.00	
12-221	0.10	2.35	16.00	4.05	0.50	66.50	0.15	1.25	4.70	1.00	3.00	47.00	0.30	4.20	22.50	5.00	3.50	115.00	
12-230	0.42	5.50	28.50	9.50	5.00	71.50	0.89	5.20	46.00	6.05	62.80	187.00	1.40	10.50	80.00	16.50	74.00	280.00	
12-231	0.10	3.10	9.70	3.00	3.30	33.00	0.30	3.50	14.00	1.00	12.60	34.00	0.60	6.80	40.00	6.80	19.00	77.00	
12-232	0.10	2.80	9.90	2.60	3.20	18.00	0.10	1.90	3.10	0.70	4.00	12.00	0.10	4.70	13.00	3.30	7.20	30.00	
12-233	0.10	3.35	9.20	1.60	2.00	19.50	0.10	1.00	1.75	0.75	3.25	4.50	0.15	4.50	12.50	2.60	5.10	25.50	
12-01	0.25	1.00	4.45	2.50	0.25	33.00	0.30	7.80	5.60	4.85	9.75	70.50	0.42	5.30	10.05	7.10	9.55	105.00	11
12-225	0.30	2.40	14.50	3.50	4.45	83.00	0.60	3.20	20.50	2.35	15.20	112.00	0.89	5.95	37.00	6.55	22.50	245.00	
12-226	0.20	3.10	13.50	2.90	4.65	36.00	0.45	5.25	23.65	3.75	18.55	92.50	0.60	8.85	36.00	6.25	23.50	130.00	
12-227	0.20	3.40	14.00	2.80	3.80	28.00	0.30	4.40	7.80	3.10	12.30	41.00	0.50	8.00	27.00	5.10	16.00	84.00	
12-228	0.10	2.45	7.65	1.75	3.00	17.50	0.20	1.30	2.20	1.45	5.65	16.50	0.35	3.75	12.40	3.20	8.90	36.00	
12-229	0.10	2.20	7.10	2.20	1.75	20.00	0.10	1.55	3.70	0.95	2.75	7.50	0.20	3.65	10.45	2.65	4.30	27.50	

[a]The dissolved Cd value (0.25 µg/L) in the first data row for California Department of Transportation (Caltrans) site 12-02 represents the median of the EMC values of the individual storm events.

Appendix A-4. Summary of Metal EMC Characteristics for Caltrans Sites in Terms of Median Values for Zones 12, 13, 14, and UCLA Sites

Site	Dissolved (μg/L)						Particulate (μg/L)						Total (μg/L)						Zone
	Cd	Cr	Cu	Ni	Pb	Zn	Cd	Cr	Cu	Ni	Pb	Zn	Cd	Cr	Cu	Ni	Pb	Zn	
11-204	0.38[a]	3.75	22.50	6.25	7.70	71.50	0.75	3.40	31.00	3.50	44.65	146.50	1.30	6.75	57.50	11.50	55.50	255.00	12
11-205	0.15	3.10	17.00	2.90	9.10	36.50	0.10	1.35	5.00	1.00	10.55	18.50	0.25	5.15	21.50	3.30	17.00	55.00	
11-206	0.15	3.25	17.00	2.90	11.65	32.50	0.10	1.50	3.50	0.65	12.85	10.00	0.15	4.85	19.00	3.35	26.00	47.00	
11-207	0.10	3.95	12.50	3.00	12.50	28.00	0.20	2.80	5.50	1.50	28.50	22.50	0.35	8.45	20.00	5.85	46.00	62.50	
11-49	0.10	2.60	8.00	1.00	0.50	22.00	0.44	2.60	22.00	3.30	32.30	108.00	0.58	5.20	31.00	4.70	35.00	130.00	13
11-65	0.35	0.80	15.00	4.40	1.40	190.00	0.42	1.15	13.00	1.85	7.20	110.00	0.73	2.10	34.00	5.35	9.60	330.00	
11-89	0.36	3.85	15.00	4.30	1.70	100.00	1.40	5.20	61.00	7.45	85.50	410.00	1.55	9.45	84.00	12.00	87.00	545.00	
11-94	0.10	4.45	11.00	1.00	1.80	42.00	0.70	2.30	21.00	5.20	48.00	142.00	0.80	6.10	37.00	6.60	58.00	190.00	
8-01	1.29	2.35	34.00	7.60	1.95	124.50	1.22	9.35	34.00	5.40	89.60	212.00	1.65	12.50	68.00	13.50	91.50	325.00	14
8-02	0.25	1.00	8.70	2.50	0.25	35.50	0.60	4.80	7.70	4.30	21.75	56.50	0.73	4.60	18.50	7.20	25.50	96.00	
8-03	0.51	1.75	8.05	9.75	1.10	38.00	0.24	3.80	1.00	2.25	2.90	2.50	0.62	3.65	4.60	10.75	4.00	34.00	
8-201	0.20	3.15	17.00	3.70	2.55	180.00	0.10	2.05	11.50	1.30	5.90	65.00	0.35	5.45	29.50	4.90	8.45	235.00	
8-202	0.10	2.95	15.00	2.95	2.15	48.50	0.15	3.30	10.00	2.20	5.65	51.50	0.20	6.35	26.00	5.80	8.10	120.00	
8-203	0.10	4.20	16.00	3.50	3.30	43.00	0.10	2.90	9.00	1.00	4.50	35.00	0.20	7.20	37.00	7.60	7.00	150.00	
8-204	0.10	4.60	15.00	3.70	3.50	51.00	0.20	6.80	12.00	2.70	9.40	74.00	0.30	12.00	27.00	7.10	13.00	140.00	
8-205	0.10	3.50	14.00	3.40	3.30	52.00	0.20	8.90	18.00	5.10	18.40	155.00	0.30	11.00	38.00	9.30	20.00	200.00	
UCLA 1	0.45	1.79	31.20	8.98	2.50	177.40	0.10	4.28	16.27	2.67	8.37	66.20	0.51	6.26	45.38	11.39	11.82	197.90	UCLA
UCLA 2	0.74	2.76	55.19	10.90	2.52	276.00	0.56	9.48	34.32	4.46	20.81	93.62	1.25	12.44	89.51	15.59	23.45	361.33	
UCLA 3	0.10	1.36	18.89	4.37	3.00	104.76	0.10	5.25	15.53	2.86	23.92	59.98	0.10	6.22	36.96	7.95	27.21	178.93	

[a]The dissolved Cd value (0.38 μg/L) in the first data row for California Department of Transportation (Caltrans) site 11-204 represents the median of the EMC values of the individual storm events.

Appendix B-1. Summary of Location and Event and Site-specific Characteristics for Caltrans Sites in Terms of Median Values for Zones 1, 2, 3, and 4

Site	Latitude (N)	Longitude (W)	Event-specific variables				Site-specific variables[b]			Zone
			T_RAIN (mm)	MAX_RAIN (mm/hr)	D_RUN (hr)	ADD (day)	RC (-)	AREA (ha)	ADT ($\times 10^5$ vehicles/day)	
2-201	40.40	122.28	17.78[a]	9.14	17.50	6.50	1.00[b]	0.08	0.40	
2-202	40.40	122.28	24.13	9.14	14.72	6.50	0.54	0.05	0.40	
2-203	40.62	122.32	21.34	12.19	15.00	4.50	1.00	0.03	0.13	
2-204	40.62	122.32	21.59	12.19	14.17	3.65	0.79	0.04	0.13	1
2-205	40.62	122.32	21.59	12.19	16.38	4.15	0.69	0.04	0.13	
2-206	40.62	122.32	21.84	12.19	14.83	3.80	0.62	0.05	0.13	
2-207	35.09	137.56	37.85	22.73	32.39	9.10	0.90	0.42	0.20	
4-213	38.03	122.54	11.68	9.14	16.25	5.20	1.00	0.13	1.54	
4-214	38.03	122.54	13.46	9.14	20.33	6.15	0.66	0.29	1.54	2
4-34	38.09	122.24	12.86	12.19	17.30	9.30	0.92	0.12		
4-35	38.21	122.14	16.51	9.14	16.92	6.00	1.00	0.65	0.53	
3-05	38.37	121.36	13.60	18.00	17.04	6.00	0.90	0.08	0.48	
3-06	38.88	121.12	24.64	12.19	12.85	8.00	0.90	0.60	0.74	
3-07	38.60	121.28	17.85	10.80	12.66	10.00	0.95	0.70	1.27	
3-213	38.44	121.49	12.70	6.10	16.83	8.60	1.00	0.04	0.76	
3-214	38.44	121.49	13.59	7.62	12.12	8.40	0.89	0.04	0.76	3
3-215	38.44	121.49	14.48	9.14	16.77	8.90	0.74	0.05	0.76	
3-216	38.44	121.49	14.48	9.14	18.67	8.90	0.67	0.05	0.76	
3-217	38.44	121.49	14.48	9.14	9.97	4.10	0.63	0.06	0.76	
3-224	38.47	121.16	15.30	15.60	17.93	8.00	0.70	1.21	0.36	
3-201	38.57	119.57			5.35	8.00	1.00	0.32	0.37	
3-202	38.90	119.57	15.45	10.80	7.58	2.50	1.00	0.12	0.14	
3-203	38.83	120.03	8.97	6.00	7.60	10.00	0.80	0.28	0.12	
3-218	38.99	120.11	13.70	9.60	16.50	3.00	0.90	0.10	0.03	
3-219	39.24	120.04	18.85	9.60	8.63	11.00	0.80	0.20	0.18	4
3-220	39.26	120.05	10.15	7.80	8.62	2.00	0.90	0.10	0.09	
3-222	38.90	119.57	15.00	9.60	14.50	8.00	1.00	0.12	0.14	
3-223	38.83	120.03	10.25	4.80	12.22	11.00	0.80	0.28	0.12	

[a]The T_RAIN value (17.78 mm) in the first data row for California Department of Transportation (Caltrans) site 2-201 represents the median of the T_RAIN values of the individual storm events. [b]Site-specific variables for the sites do not vary within a site. For example the RC value (1.00) for Caltrans site 2-201 was assumed to be constant for the storm events.

Appendix B-2. Summary of Location and Event and Site-specific Characteristics for Caltrans Sites in Terms of Median Values for Zones 5, 6, 7, 8, and 9

Site	Latitude (N)	Longitude (W)	Event-specific variables				Site-specific variables[b]			Zone
			T_RAIN (mm)	MAX_RAIN (mm/hr)	D_RUN (hr)	ADD (day)	RC (-)	AREA (ha)	ADT ($\times 10^5$ vehicles/day)	
6-205	36.75	119.79	11.76[a]	15.60	9.21	12.90	0.70[b]	0.75	0.07	5
6-209	36.78	119.79	13.40	12.00	12.33	14.40	0.70	0.18	1.18	5
7-01	34.05	118.45	20.45		7.13	11.50	1.00	0.40	2.19	6
7-211	34.17	118.48	9.91	9.14	15.83	5.20	1.00	0.85		6
7-213	34.21	118.47	35.56	12.19	30.44	3.35	1.00	1.21		6
7-127	34.12	117.89	5.84		4.92	30.00	1.00	0.40	1.76	7
7-177	34.16	118.22	40.51	16.77	9.55	11.75	1.00	0.18	0.96	7
7-180	34.17	118.24	15.75	9.14	12.48	16.60	1.00	0.41	0.99	7
7-209	34.27	118.37	18.16	15.24	11.87	11.15	1.00	1.38		7
7-128	33.87	118.24	14.23	4.70	7.63	23.00	1.00	0.40	1.87	8
7-129	33.92	118.20	13.72	30.48	11.53	1.90	0.90	0.12	2.18	8
7-131	33.92	118.19	13.46	30.48	11.42	1.90	0.90	0.16	1.76	8
7-135	33.92	118.19	12.95	30.48	11.33	1.90	0.90	0.16	1.76	8
7-136	33.91	118.20	13.21	30.48	11.30	1.80	0.90	0.12	2.18	8
7-162	33.53	118.06	45.21	19.81	18.36	14.95	1.00	0.08	2.80	8
7-165	33.53	118.06	21.08	24.38	9.35	15.50	1.00	0.03	2.80	8
7-171	33.57	118.06	23.62	30.48	11.90	11.70	1.00	0.11	2.22	8
7-174	33.50	118.05	21.08	24.38	8.55	15.50	1.00	0.11	2.22	8
7-35	33.94	118.10	24.38	21.34	25.78	5.50	0.54	1.11	2.51	8
7-37	33.87	118.10	19.56	13.72	14.30	9.50	1.00	0.13	1.30	8
7-143	33.01	117.97	18.29	15.24	9.87	2.00	1.00	0.16	2.28	9
7-147	34.03	118.13	16.51	21.34	9.17	3.65	1.00	0.25	2.27	9

[a]The T_RAIN value (17.76 mm) in the first data row for California Department of Transportation (Caltrans) site 6-205 represents the median of the T_RAIN values of the individual storm events. [b]Site-specific variables for the sites do not vary within a site. For example the RC value (0.70) for Caltrans site 6-205 was assumed to be constant for the storm events.

Appendix B-3. Summary of Location and Event and Site-specific Characteristics for Caltrans Sites in Terms of Median Values for Zones 10 and 11

Site	Latitude (N)	Longitude (W)	Event-specific variables T_RAIN (mm)	MAX_RAIN (mm/hr)	D_RUN (hr)	ADD (day)	Site-specific variables[a] RC (-)	AREA (ha)	ADT ($\times10^5$ vehicles/day)	Zone
12-02	33.73	117.98	13.21[a]		6.04	16.00	1.00[b]	0.40	2.37	10
12-210	33.56	117.68	15.88	19.81	13.61	11.20	0.90	2.91	0.47	
12-214	33.57	117.71	12.95	15.24	16.43	10.50	0.90	3.80	0.48	
12-215	33.57	117.71	10.92	19.81	13.73	10.85	1.00	0.25	0.48	
12-216	33.57	117.71	12.95	15.24	9.93	10.50	1.00	0.17	0.48	
12-220	33.58	117.73	22.61	27.43	11.97	11.90	0.95	0.89	0.51	
12-221	33.58	117.73	23.37	28.96	12.19	11.90	1.00	0.15	0.51	
12-230	33.66	117.78	8.89	18.29	7.41	16.55	1.00	0.04	2.31	
12-231	33.66	117.78	41.15	25.91	26.02	22.30	0.90	0.05	2.31	
12-232	33.66	117.78	70.87	36.58	2.67	15.90	0.81	0.04	2.31	
12-233	33.66	117.78	50.80	32.01	28.99	22.30	0.67	0.09	2.31	
12-01	33.92	117.84	19.05	-1.00	4.79	16.00	1.00	0.40	0.16	11
12-225	33.87	117.74	24.64	18.29	10.72	13.95	1.00	0.09	2.42	
12-226	33.87	117.74	24.64	18.29	8.83	11.10	0.94	0.11	2.42	
12-227	33.87	117.74	27.31	18.29	16.30	13.95	0.86	0.12	2.42	
12-228	33.87	117.74	33.66	22.86	24.95	11.10	0.79	0.11	2.42	
12-229	33.87	117.73	50.93	25.91	12.88	20.00	0.69	0.18	2.42	

[a]The T_RAIN value (13.21 mm) in the first data row for California Department of Transportation (Caltrans) site 12-02 represents the median of the T_RAIN values of the individual storm events. [b]Site-specific variables for the sites do not vary within a site. For example the RC value (1.00) for Caltrans site 12-02 was assumed to be constant for the storm events.

Appendix C-1a. Regression Models Developed for Caltrans Zone 1 for Dissolved/Particulate[a] Metal EMCs.

Model	Coefficent								p value[b]								R^2	pReg[c]	Count[d]	Form[e]	M[f]
	Intercept	T_RAIN (mm)	MAX_RAIN (mm/hr)	D_RUN (hr)	ADD (day)	RC (-)	AREA (ha)	ADT ($\times 10^5$ vehicles/day)	Intercept	T_RAIN	MAX_RAIN	D_RUN	ADD	RC	AREA	ADT					
1	0.11	2.09	2.03	-0.39	-0.22				0.24	<0.01	0.05	0.09	0.04				0.31	<0.01	69	P3	Cd
2	1.22	-0.40	-0.18	0.11	0.25	1.00	0.05	0.53	<0.01	<0.01	0.30	0.20	0.01	0.01	0.71	<0.01	0.52	<0.01	69	P2	Cd
3	0.69	-0.43			0.28				<0.01	<0.01		<0.01	0.01				0.24	<0.01	69	P2	Cd
4	1.09	-0.34			0.22	1.19	0.03	0.53	<0.01	<0.01		<0.01	0.01	<0.01	0.80	<0.01	0.49	<0.01	69	P2	Cd
1	3.06	-1.90	-1.10	0.77	1.71				<0.01	<0.01	0.17	0.07	<0.01				0.31	<0.01	70	P2	Cr
2	5.06	-1.44	-0.86	0.66	1.26	2.50	-0.11	3.43	<0.01	<0.01	0.18	0.05	<0.01	0.08	0.81	<0.01	0.63	<0.01	70	P2	Cr
3	2.37	-1.56			1.55				<0.01	<0.01		<0.01	<0.01				0.24	<0.01	70	P2	Cr
4	4.49	-1.10			1.15	3.48	-0.16	3.44	<0.01	<0.01		<0.01	<0.01	0.02	0.72	<0.01	0.58	<0.01	70	P2	Cr
1	8.81	-8.41	0.88	2.68	5.37				0.01	<0.01	0.79	0.12	<0.01				0.27	<0.01	69	D2	Cu
2	16.09	-7.18	1.94	2.96	3.24	-0.84	-1.65	15.53	<0.01	<0.01	0.45	0.03	0.02	0.88	0.36	<0.01	0.61	<0.01	69	D2	Cu
3	10.20	-6.58			5.71				<0.01	<0.01		<0.01	<0.01				0.24	<0.01	69	D2	Cu
4	18.97	-5.06			3.91	1.58	-0.89	14.86	<0.01	<0.01		<0.01	<0.01	0.78	0.61	<0.01	0.58	<0.01	69	D2	Cu
1	2.48	-1.64	-0.22	0.78	1.24				0.01	<0.01	0.79	0.07	0.01				0.21	<0.01	70	D2	Ni
2	3.44	-1.61	-0.10	1.02	0.80	-4.05	-0.59	2.90	<0.01	<0.01	0.89	0.01	0.05	0.02	0.26	<0.01	0.42	<0.01	70	D2	Ni
3	2.46	-1.34			1.29				<0.01	<0.01		<0.01	<0.01				0.18	<0.01	70	P2	Ni
4	3.94	-1.01			1.02	3.22	-0.06	2.31	<0.01	0.01		<0.01	0.01	0.06	0.90	<0.01	0.38	<0.01	70	P2	Ni
1	10.05	-11.48	-0.32	4.21	6.78				0.03	<0.01	0.94	0.05	<0.01				0.29	<0.01	69	P2	Pb
2	15.71	-9.87	0.77	3.76	5.37	12.08	-0.67	10.75	0.01	<0.01	0.85	0.07	0.01	0.18	0.81	<0.01	0.43	<0.01	69	P2	Pb
3	10.86	-8.82			6.99				<0.01	<0.01		<0.01	<0.01				0.24	<0.01	69	P2	Pb
4	17.75	-7.34			5.87	15.79	0.00	10.10	<0.01	<0.01		<0.01	<0.01	0.07	1.00	0.01	0.40	<0.01	69	P2	Pb
1	61.27	-79.07	14.17	34.02	36.71				0.06	<0.01	0.64	0.03	0.02				0.25	<0.01	69	P2	Zn
2	57.11	-12.75	-1.35	3.59	8.65	50.03	-4.81	45.22	<0.01	0.02	0.87	0.40	0.05	0.01	0.40	<0.01	0.58	<0.01	69	D2	Zn
3	22.11	287.50			-12.72				0.02	<0.01		<0.01	0.42				0.20	<0.01	69	P3	Zn
4	57.08	-10.52			8.71	54.37	-4.55	44.85	<0.01	0.01		<0.01	0.03	<0.01	0.40	<0.01	0.57	<0.01	69	D2	Zn

[a]For some metal parameters, the dissolved metal models were better than the particulate models, and vice versa. Dissolved/Particulate means either the dissolved or the particulate model was presented.

[b]p values for the individual independent variables were obtained from 2-tailed t-statistic. [c]p_{Reg} refers to p value for the entire model obtained from F-statistic. [d]Count is the number of events considered. [e]In form column **D** denotes dissolved and **P** denotes particulate phase. Also, 1, 2, and 3 are linear, semi-log, and inverse forms respectively.

[f]M denotes the metal parameter.

Appendix C-1b. Regression Models Developed for Caltrans Zone 1 for Total Metal EMCs.

Model	Coefficent								p value[a]								R^2	p_{Reg}[b]	Count[c]	Form[d]	M[e]
	Intercept	T_RAIN (mm)	MAX_RAIN (mm/hr)	D_RUN (hr)	ADD (day)	RC (-)	AREA (ha)	ADT ($\times 10^5$ vehicles/day)	Intercept	T_RAIN	MAX_RAIN	D_RUN	ADD	RC	AREA	ADT					
1	1.07	-0.56	-0.32	0.21	0.32				<0.01	<0.01	0.24	0.14	0.03				0.21	<0.01	70	T2	Cd
2	1.77	-0.41	-0.31	0.14	0.24	1.16	0.14	0.76	<0.01	0.01	0.20	0.27	0.07	0.03	0.41	<0.01	0.47	<0.01	70	T2	Cd
3	0.86	-0.47			0.27				<0.01	<0.01			0.05				0.15	<0.01	70	T2	Cd
4	1.53	-0.35			0.19	1.42	0.11	0.78	<0.01	<0.01			0.11	0.01	0.51	<0.01	0.43	<0.01	70	T2	Cd
1	1.49	-0.03	0.00	0.02	0.18				<0.01	<0.01	0.89	0.20	<0.01				0.27	<0.01	70	T1	Cr
2	-1.23	-0.03	0.01	0.02	0.13	0.68	-2.42	9.91	0.20	<0.01	0.56	0.06	<0.01	0.50	0.15	<0.01	0.67	<0.01	70	T1	Cr
3	1.77	-0.03			0.18				<0.01	<0.01			<0.01				0.25	<0.01	70	T1	Cr
4	-1.08	-0.02			0.13	0.86	-1.28	9.84	0.25	<0.01			<0.01	0.39	0.37	<0.01	0.65	<0.01	70	T1	Cr
1	28.35	-22.94	-4.50	8.56	15.08				0.01	<0.01	0.63	0.08	<0.01				0.26	<0.01	70	T2	Cu
2	53.83	-17.29	-1.61	7.43	9.33	26.80	-1.56	43.95	<0.01	<0.01	0.81	0.03	0.01	0.07	0.74	<0.01	0.67	<0.01	70	T2	Cu
3	26.94	-18.12			14.86				<0.01	<0.01			<0.01				0.22	<0.01	70	T2	Cu
4	55.12	-12.71			9.77	34.85	-0.68	43.10	<0.01	<0.01			<0.01	0.02	0.88	<0.01	0.64	<0.01	70	T2	Cu
1	4.30	-3.57	-0.08	1.19	2.93				<0.01	<0.01	0.95	0.07	<0.01				0.36	<0.01	70	T2	Ni
2	7.27	-3.06	0.30	1.31	2.03	-1.26	-0.71	6.38	<0.01	<0.01	0.75	0.01	<0.01	0.54	0.28	<0.01	0.69	<0.01	70	T2	Ni
3	4.54	-2.83			3.01				<0.01	<0.01			<0.01				0.32	<0.01	70	T2	Ni
4	8.05	-2.19			2.23	-0.06	-0.46	6.16	<0.01	<0.01			<0.01	0.98	0.48	<0.01	0.65	<0.01	70	T2	Ni
1	10.78	-11.20	-0.73	3.94	7.21				0.02	<0.01	0.87	0.08	<0.01				0.28	<0.01	70	T2	Pb
2	16.68	-9.38	0.66	3.50	5.50	13.15	-1.22	12.55	0.01	<0.01	0.87	0.10	0.01	0.15	0.67	<0.01	0.44	<0.01	70	T2	Pb
3	11.21	-8.82			7.36				<0.01	<0.01			<0.01				0.24	<0.01	70	T2	Pb
4	18.64	-7.08			6.00	16.41	-0.56	11.98	<0.01	<0.01			<0.01	0.07	0.84	<0.01	0.41	<0.01	70	T2	Pb
1	98.27	-97.40	6.71	38.58	51.40				0.01	<0.01	0.85	0.04	0.01				0.27	<0.01	70	T2	Zn
2	188.19	-72.59	19.57	29.40	33.27	201.04	-0.50	144.75	<0.01	<0.01	0.46	0.03	0.02	<0.01	0.98	<0.01	0.65	<0.01	70	T2	Zn
3	113.61	-72.28			55.59				<0.01	<0.01			<0.01				0.22	<0.01	70	T2	Zn
4	217.96	-52.01			40.37	223.10	7.57	138.29	<0.01	<0.01			<0.01	<0.01	0.67	<0.01	0.62	<0.01	70	T2	Zn

[a] p values for the individual independent variables were obtained from 2-tailed t-statistic.

[b] p_{Reg} refers to p value for the entire model obtained from F-statistic.

[c] Count is the number of events considered.

[d] In form column **D** denotes dissolved and **P** denotes particulate phase. Also, 1, 2, and 3 are linear, semi-log, and inverse forms respectively.

[e] M denotes the metal parameter.

Appendix C-2a. Regression Models Developed for Caltrans Zone 2 for Dissolved/Particulate[a] Metal EMCs.

Model	Coefficent								p value[b]								R^2	pReg[c]	Count[d]	Form[e]	M[f]
	Intercept	T_RAIN (mm)	MAX_RAIN (mm/hr)	D_RUN (hr)	ADD (day)	RC (-)	AREA (ha)	ADT ($\times 10^5$ vehicles/day)	Intercept	T_RAIN	MAX_RAIN	D_RUN	ADD	RC	AREA	ADT					
1	0.12	-0.16	0.18	0.03	0.05				<0.01	0.50	0.34	0.79	0.01				0.17	0.03	59	D3	Cd
2	0.18	-0.22	0.11	0.04	0.05	-0.08	0.01	0.00	0.06	0.33	0.53	0.70	<0.01	0.34	0.07	<0.01	0.30	0.01	51	D3	Cd
3	0.13	-0.03			0.05				<0.01	0.88		<0.01	<0.01				0.16	0.01	59	D3	Cd
4	0.20	-0.14			0.06	-0.09	0.01	0.00	0.03	0.47		<0.01	<0.01	0.28	0.07	<0.01	0.29	<0.01	51	D3	Cd
1	1.40	0.00	0.00	-0.03	0.12				0.21	0.90	0.99	0.46	0.03				0.10	0.21	59	D1	Cr
2	22.26	-0.03	0.09	0.03	0.04	0.00	-19.52	-12.00	<0.01	0.02	0.02	0.24	0.15	<0.01	0.01	<0.01	0.44	<0.01	51	P1	Cr
3	0.99	-0.01			0.12				0.25	0.70		<0.01	0.02				0.09	0.07	59	D1	Cr
4	18.01	-0.01			0.05	0.00	-14.15	-9.00	<0.01	0.50		<0.01	0.08	<0.01	0.04	0.01	0.36	<0.01	51	P1	Cr
1	7.37	25.62	12.00	3.19	1.70				<0.01	0.18	0.41	0.71	0.23				0.17	0.03	59	D3	Cu
2	13.02	13.64	6.99	3.41	1.91	-7.56	1.05	0.00	0.05	0.40	0.57	0.64	0.11	0.19	<0.01	<0.01	0.43	<0.01	51	D3	Cu
3	8.07	35.25			1.92				<0.01	0.02		<0.01	0.15				0.16	0.01	59	D3	Cu
4	14.25	19.64			2.01	-8.13	1.02	0.00	0.03	0.14		<0.01	0.07	0.15	<0.01	<0.01	0.42	<0.01	51	D3	Cu
1	2.82	-0.01	-0.02	0.02	0.02				<0.01	0.22	0.30	0.25	0.46				0.10	0.21	59	D1	Ni
2	29.49	-0.04	0.15	0.01	0.02	0.00	-26.17	-15.63	<0.01	0.08	0.01	0.76	0.67	<0.01	0.02	<0.01	0.33	0.01	51	P1	Ni
3	4.17	-1.35			0.34				<0.01	0.04		<0.01	0.49				0.08	0.11	59	D2	Ni
4	1.47	-0.01			0.03	2.76	-3.11	0.00	0.59	0.13		<0.01	0.22	0.32	<0.01	<0.01	0.23	0.01	51	D1	Ni
1	0.72	-0.01	0.00	0.02	0.01				0.01	0.30	0.79	0.08	0.58				0.06	0.46	59	D1	Pb
2	-20.04	-5.97	7.78	3.61	1.64	0.00	-40.95	-46.91	0.05	0.29	0.20	0.37	0.47	<0.01	<0.01	0.01	0.29	0.01	51	P2	Pb
3	9.65	-0.02			-0.05				<0.01	0.53		<0.01	0.67				0.01	0.76	59	P1	Pb
4	24.10	-19.57			-0.01	-17.62	1.20	0.00	0.01	0.30		<0.01	0.99	0.03	<0.01	<0.01	0.27	<0.01	51	P3	Pb
1	31.03	-0.04	-0.38	0.35	0.28				<0.01	0.71	0.14	0.08	0.29				0.11	0.18	59	D1	Zn
2	-97.21	-0.24	0.10	0.68	0.51	110.29	0.00	11.36	<0.01	0.08	0.75	<0.01	0.04	<0.01	<0.01	0.03	0.42	<0.01	51	D1	Zn
3	76.42	-0.32			0.27				<0.01	0.17		<0.01	0.72				0.04	0.35	59	P1	Zn
4	-78.33	0.01			0.46	99.24	0.00	13.48	0.02	0.86		<0.01	0.09	<0.01	<0.01	0.02	0.26	0.01	51	D1	Zn

[a]For some metal parameters, the dissolved metal models were better than the particulate models, and vice versa. Dissolved/Particulate means either the dissolved or the particulate model was presented.

[b]p values for the individual independent variables were obtained from 2-tailed t-statistic. [c]p_{Reg} refers to p value for the entire model obtained from F-statistic. [d]Count is the number of events considered. [e]In form column **D** denotes dissolved and **P** denotes particulate phase. Also, 1, 2, and 3 are linear, semi-log, and inverse forms respectively.

[f]M denotes the metal parameter.

Appendix C-2b. Regression Models Developed for Caltrans Zone 2 for Total Metal EMCs.

Model	Coefficent								p value[a]								R^2	p_{Reg}[b]	Count[c]	Form[d]	M[e]
	Intercept	T_RAIN (mm)	MAX_RAIN (mm/hr)	D_RUN (hr)	ADD (day)	RC (-)	AREA (ha)	ADT ($\times 10^5$ vehicles/day)	Intercept	T_RAIN	MAX_RAIN	D_RUN	ADD	RC	AREA	ADT					
1	0.49	0.00	0.00	0.00	0.00				<0.01	0.70	0.48	0.86	0.94				0.03	0.83	59	T1	Cd
2	0.22	-0.23	0.17	0.20	0.06	2.43	-0.18	0.00	0.29	0.28	0.45	0.18	0.49	0.01	0.14	<0.01	0.22	0.08	51	T2	Cd
3	0.48	0.00			0.00				<0.01	0.32			0.91				0.02	0.61	59	T1	Cd
4	1.66	-0.54			0.04	-0.97	0.00	-0.12	<0.01	0.45			0.48	<0.01	<0.01	0.09	0.19	0.04	51	T3	Cd
1	4.12	0.00	0.00	-0.04	0.17				<0.01	0.98	0.99	0.36	0.01				0.15	0.06	59	T1	Cr
2	-6.03	-0.02	0.06	-0.01	0.20	10.04	-0.87	0.00	0.46	0.55	0.52	0.90	<0.01	0.20	0.75	<0.01	0.23	0.07	51	T1	Cr
3	3.52	-0.01			0.17				<0.01	0.52			0.01				0.14	0.01	59	T1	Cr
4	-4.28	-0.01			0.21	8.62	-1.03	0.00	0.55	0.56			<0.01	0.23	0.70	<0.01	0.22	0.02	51	T1	Cr
1	30.80	-8.96	-2.26	4.58	3.99				0.01	0.43	0.85	0.58	0.40				0.05	0.63	59	T2	Cu
2	-36.37	-17.17	12.96	12.32	6.53	0.00	-93.42	-107.70	0.05	0.09	0.24	0.09	0.11	<0.01	<0.01	<0.01	0.42	<0.01	51	T2	Cu
3	33.26	-8.15			3.70				<0.01	0.18			0.42				0.04	0.33	59	T2	Cu
4	-21.49	-2.82			5.39	0.00	-88.31	-97.88	0.19	0.60			0.18	<0.01	<0.01	<0.01	0.38	<0.01	51	T2	Cu
1	6.46	-0.02	0.01	-0.01	0.06				<0.01	0.45	0.80	0.70	0.19				0.06	0.46	59	T1	Ni
2	-13.64	-0.06	0.15	0.04	0.06	18.84	1.14	0.00	0.01	0.01	0.02	0.25	0.22	<0.01	0.53	<0.01	0.33	0.01	51	T1	Ni
3	6.36	-0.02			0.06				<0.01	0.23			0.18				0.06	0.18	59	T1	Ni
4	-7.28	-0.02			0.07	14.33	0.40	0.00	0.15	0.28			0.12	0.01	0.83	<0.01	0.23	0.01	51	T1	Ni
1	9.21	-4.39	2.74	1.82	0.80				0.09	0.43	0.64	0.65	0.73				0.01	0.94	59	T2	Pb
2	-20.91	-7.11	8.76	4.66	1.82	0.00	-42.41	-49.28	0.04	0.20	0.15	0.25	0.42	<0.01	<0.01	0.01	0.31	0.01	51	T2	Pb
3	10.60	-0.02			-0.04				<0.01	0.50			0.71				0.01	0.75	59	T1	Pb
4	25.97	-20.78			0.10	-18.39	1.20	0.00	0.01	0.27			0.95	0.02	<0.01	<0.01	0.28	<0.01	51	T3	Pb
1	126.68	-44.37	23.53	-3.03	16.22				<0.01	0.31	0.62	0.92	0.37				0.05	0.63	59	T2	Zn
2	65.89	-87.54	91.16	39.72	25.09	664.31	-5.69	0.00	0.13	0.05	0.06	0.22	0.16	<0.01	0.82	<0.01	0.29	0.01	51	T2	Zn
3	130.92	-30.71			16.68				<0.01	0.19			0.35				0.04	0.31	59	T2	Zn
4	-206.53	-0.25			0.85	319.85	0.00	8.41	0.06	0.35			0.34	<0.01	<0.01	0.65	0.23	0.02	51	T1	Zn

[a] p values for the individual independent variables were obtained from 2-tailed t-statistic.

[b] p_{Reg} refers to p value for the entire model obtained from F-statistic.

[c] Count is the number of events considered.

[d] In form column **D** denotes dissolved and **P** denotes particulate phase. Also, 1, 2, and 3 are linear, semi-log, and inverse forms respectively.

[e] M denotes the metal parameter.

Appendix C-3a. Regression Models Developed for Caltrans Zone 3 for Dissolved/Particulate[a] Metal EMCs.

Model	Coefficent								p value[b]								R^2	pReg[c]	Count[d]	Form[e]	M[f]
	Intercept	T_RAIN (mm)	MAX_RAIN (mm/hr)	D_RUN (hr)	ADD (day)	RC (-)	AREA (ha)	ADT (×10[5] vehicles/day)	Intercept	T_RAIN	MAX_RAIN	D_RUN	ADD	RC	AREA	ADT					
1	0.14	0.00	0.00	0.01	0.00				<0.01	<0.01	0.84	<0.01	0.08				0.23	<0.01	97	D1	Cd
2	0.93	0.00	0.00	0.00	0.00	-0.85	-0.22	0.10	<0.01	0.01	0.72	<0.01	0.02	<0.01	<0.01	0.10	0.42	<0.01	97	D1	Cd
3	0.17	-0.06			0.10				0.06	0.32		<0.01	0.02				0.09	0.01	97	D2	Cd
4	1.11	0.00			0.00	-1.00	-0.26	0.12	<0.01	0.25		<0.01	0.01	<0.01	<0.01	0.07	0.36	<0.01	97	D1	Cd
1	-0.59	80.08	-5.36	-1.84	1.31				0.69	<0.01	0.66	0.77	0.66				0.40	<0.01	97	D3	Cr
2	5.60	80.12	-29.19	-4.92	1.29	-5.94	0.33	0.00	0.26	<0.01	0.01	0.36	0.60	0.22	<0.01	1.00	0.59	<0.01	97	D3	Cr
3	-1.01	76.06			1.29				0.42	<0.01		<0.01	0.66				0.40	<0.01	97	D3	Cr
4	4.66	62.93			1.09	-7.20	0.28	0.58	0.35	<0.01		<0.01	0.67	0.15	<0.01	0.65	0.56	<0.01	97	D3	Cr
1	8.19	-0.04	0.02	-0.01	0.23				<0.01	0.42	0.67	0.84	<0.01				0.30	<0.01	97	D1	Cu
2	-23.24	-0.17	0.09	0.05	0.07	7.75	7.74	30.43	0.08	0.05	0.26	0.66	0.29	0.61	0.03	<0.01	0.49	<0.01	97	P1	Cu
3	8.24	-0.03			0.23				<0.01	0.28		<0.01	<0.01				0.30	<0.01	97	D1	Cu
4	-21.32	-0.10			0.06	7.08	8.15	29.99	0.08	0.05		<0.01	0.34	0.63	0.02	<0.01	0.48	<0.01	97	P1	Cu
1	-0.45	-1.08	1.15	0.73	3.20				0.76	0.35	0.24	0.39	<0.01				0.25	<0.01	97	D2	Ni
2	-5.85	-0.07	0.03	0.02	0.01	0.54	3.36	10.15	0.28	0.04	0.33	0.71	0.58	0.93	0.03	<0.01	0.39	<0.01	97	P1	Ni
3	0.23	0.02			3.28				0.87	0.98		<0.01	<0.01				0.23	<0.01	97	D2	Ni
4	-5.17	-0.05			0.01	0.31	3.50	10.00	0.31	0.02		<0.01	0.65	0.96	0.01	<0.01	0.38	<0.01	97	P1	Ni
1	1.01	-0.65	0.09	0.35	0.11				0.02	0.05	0.76	0.15	0.55				0.07	0.18	97	D2	Pb
2	-20.21	-0.11	0.10	0.05	0.04	-0.31	9.70	29.41	0.06	0.09	0.13	0.52	0.49	0.98	<0.01	<0.01	0.56	<0.01	97	P1	Pb
3	0.70	2.08			-0.30				<0.01	0.07		<0.01	0.38				0.05	0.08	97	D3	Pb
4	-17.93	-0.04			0.03	-1.21	10.10	28.96	0.07	0.32		<0.01	0.59	0.92	<0.01	<0.01	0.55	<0.01	97	P1	Pb
1	-2.69	-0.66	10.93	-4.27	38.52				0.89	0.97	0.40	0.71	<0.01				0.20	<0.01	97	D2	Zn
2	-108.43	-0.84	0.42	0.13	0.38	80.15	36.14	103.89	0.08	0.03	0.28	0.79	0.21	0.26	0.03	<0.01	0.40	<0.01	97	P1	Zn
3	-0.91	3.34			39.01				0.96	0.76		<0.01	<0.01				0.19	<0.01	97	D2	Zn
4	-103.14	-0.60			0.35	80.01	38.70	101.67	0.07	0.02		<0.01	0.24	0.24	0.02	<0.01	0.39	<0.01	97	P1	Zn

[a]For some metal parameters, the dissolved metal models were better than the particulate models, and vice versa. Dissolved/Particulate means either the dissolved or the particulate model was presented.

[b]p values for the individual independent variables were obtained from 2-tailed t-statistic. [c]p_{Reg} refers to p value for the entire model obtained from F-statistic. [d]Count is the number of events considered. [e]In form column **D** denotes dissolved and **P** denotes particulate phase. Also, 1, 2, and 3 are linear, semi-log, and inverse forms respectively.

[f]M denotes the metal parameter.

Appendix C-3b. Regression Models Developed for Caltrans Zone 3 for Total Metal EMCs.

Model	Coefficent								p value[a]								R^2	pReg[b]	Count[c]	Form[d]	M[e]
	Intercept	T_RAIN (mm)	MAX_RAIN (mm/hr)	D_RUN (hr)	ADD (day)	RC (-)	AREA (ha)	ADT ($\times 10^5$ vehicles/day)	Intercept	T_RAIN	MAX_RAIN	D_RUN	ADD	RC	AREA	ADT					
1	0.49	-0.01	0.00	0.01	0.00				<0.01	<0.01	0.93	0.01	0.26				0.14	0.01	97	T1	Cd
2	0.67	-0.01	0.00	0.01	0.00	-0.86	-0.28	0.82	0.06	<0.01	0.33	0.01	0.07	0.04	0.01	<0.01	0.44	<0.01	97	T1	Cd
3	0.56	0.00			0.00				<0.01	0.01			0.22				0.08	0.02	97	T1	Cd
4	0.99	0.00			0.00	-1.11	-0.33	0.83	<0.01	0.08			0.07	0.01	<0.01	<0.01	0.39	<0.01	97	T1	Cd
1	2.95	92.43	-14.63	5.48	2.05				0.13	<0.01	0.35	0.51	0.59				0.34	<0.01	97	T3	Cr
2	12.77	93.15	-34.50	1.09	1.43	-3.56	0.21	-3.69	0.07	<0.01	0.03	0.89	0.69	0.61	0.02	0.04	0.45	<0.01	97	T3	Cr
3	2.62	86.05			1.63				0.11	<0.01			0.67				0.33	<0.01	97	T3	Cr
4	12.97	75.62			0.92	-5.68	0.14	-3.03	0.07	<0.01			0.80	0.42	0.09	0.09	0.42	<0.01	97	T3	Cr
1	19.24	-10.49	7.06	-1.97	11.43				0.04	0.15	0.25	0.72	0.01				0.14	0.01	97	T2	Cu
2	-14.64	-0.22	0.09	0.05	0.30	5.84	12.66	29.96	0.36	0.03	0.40	0.67	<0.01	0.75	<0.01	<0.01	0.47	<0.01	97	T1	Cu
3	20.71	-7.46			11.77				0.02	0.16			0.01				0.13	<0.01	97	T2	Cu
4	-12.34	-0.16			0.29	4.76	12.91	29.61	0.41	0.01			<0.01	0.79	<0.01	<0.01	0.46	<0.01	97	T1	Cu
1	8.65	-7.18	4.17	0.07	2.71				0.01	0.01	0.07	0.97	0.08				0.15	<0.01	97	T2	Ni
2	12.50	-8.60	3.69	1.45	2.61	-3.07	2.79	12.03	<0.01	<0.01	0.10	0.45	0.07	0.83	0.02	0.01	0.30	<0.01	97	T2	Ni
3	10.02	-4.69			2.94				<0.01	0.02			0.06				0.12	<0.01	97	T2	Ni
4	14.78	-5.87			2.79	-2.74	3.17	10.73	<0.01	<0.01			0.05	0.85	<0.01	0.02	0.28	<0.01	97	T2	Ni
1	12.59	-8.85	7.23	-0.93	0.78				0.08	0.12	0.13	0.83	0.81				0.05	0.34	97	T2	Pb
2	-20.30	-0.12	0.10	0.07	0.04	0.30	10.64	29.30	0.06	0.07	0.15	0.44	0.48	0.98	<0.01	<0.01	0.56	<0.01	97	T1	Pb
3	14.54	-5.13			1.16				0.03	0.22			0.72				0.02	0.35	97	T2	Pb
4	-17.51	-0.05			0.03	-1.08	10.90	28.92	0.09	0.26			0.56	0.93	<0.01	<0.01	0.55	<0.01	97	T1	Pb
1	107.97	-57.74	34.03	-14.67	45.12				0.01	0.09	0.22	0.55	0.02				0.15	<0.01	97	T2	Zn
2	-87.08	-1.05	0.54	0.00	1.22	91.75	42.64	100.57	0.28	0.04	0.30	1.00	<0.01	0.33	0.05	<0.01	0.35	<0.01	97	T1	Zn
3	112.91	-46.10			46.63				<0.01	0.06			0.01				0.13	<0.01	97	T2	Zn
4	-87.28	-0.82			1.16	97.66	47.49	97.06	0.25	0.01			<0.01	0.28	0.02	<0.01	0.34	<0.01	97	T1	Zn

[a] p values for the individual independent variables were obtained from 2-tailed t-statistic.

[b] p_{Reg} refers to p value for the entire model obtained from F-statistic.

[c] Count is the number of events considered.

[d] In form column **D** denotes dissolved and **P** denotes particulate phase. Also, 1, 2, and 3 are linear, semi-log, and inverse forms respectively.

[e] M denotes the metal parameter.

Appendix C-4a. Regression Models Developed for Caltrans Zone 4 for Dissolved/Particulate[a] Metal EMCs.

Model	Coefficent								p value[b]								R^2	pReg[c]	Count[d]	Form[e]	M[f]
	Intercept	T_RAIN (mm)	MAX_RAIN (mm/hr)	D_RUN (hr)	ADD (day)	RC (-)	AREA (ha)	ADT (×10[5] vehicles/day)	Intercept	T_RAIN	MAX_RAIN	D_RUN	ADD	RC	AREA	ADT					
1	0.13	-0.23	0.10	0.17	-0.02				<0.01	0.12	0.56	0.01	0.69				0.15	0.07	58	D3	Cd
2	0.89	0.00	0.00	0.00	0.00	-0.57	-2.11	4.35	0.50	0.33	0.72	0.74	0.89	0.65	0.20	0.01	0.18	0.17	58	P1	Cd
3	0.07	0.04			0.03				0.11	0.30		<0.01	0.22				0.05	0.24	58	D2	Cd
4	0.88	0.00			0.00	-0.59	-2.12	4.41	0.50	0.21		<0.01	0.74	0.64	0.18	<0.01	0.18	0.07	58	P1	Cd
1	9.77	-0.10	0.03	0.05	-0.06				<0.01	0.04	0.52	0.35	0.19				0.12	0.13	58	P1	Cr
2	23.53	-0.05	0.01	-0.04	0.03	-21.27	-30.64	45.47	0.01	0.12	0.64	0.25	0.33	0.02	0.01	<0.01	0.34	<0.01	58	D1	Cr
3	10.53	-0.08			-0.05				<0.01	0.07		<0.01	0.17				0.11	0.05	58	P1	Cr
4	22.05	-0.06			0.04	-20.36	-29.10	45.57	0.02	0.04		<0.01	0.10	0.03	0.01	<0.01	0.31	<0.01	58	D1	Cr
1	8.61	0.62	8.01	-10.38	3.30				0.18	0.90	0.12	0.01	0.24				0.32	<0.01	58	D2	Cu
2	0.64	-1.02	10.06	-9.42	1.92	-105.25	-16.56	10.85	0.97	0.84	0.06	0.03	0.54	0.13	0.37	0.15	0.37	<0.01	58	D2	Cu
3	7.39	-0.06			0.22				<0.01	0.52		<0.01	0.01				0.11	0.04	58	D1	Cu
4	76.11	-0.32			-0.13	-48.95	-102.82	141.88	0.10	0.02		<0.01	0.29	0.28	0.08	0.01	0.21	0.03	58	P1	Cu
1	1.12	-0.12	1.83	-1.74	1.70				0.61	0.95	0.30	0.22	0.07				0.20	0.02	58	D2	Ni
2	-2.42	-5.13	1.53	3.27	-2.28	-86.12	-28.90	13.77	0.79	0.10	0.63	0.19	0.22	0.04	0.01	<0.01	0.25	0.03	58	P2	Ni
3	1.86	-0.02			0.07				0.02	0.50		<0.01	0.01				0.12	0.03	58	D1	Ni
4	-0.67	-3.36			-2.18	-87.03	-30.51	14.09	0.94	0.17		<0.01	0.20	0.04	0.01	<0.01	0.23	0.02	58	P2	Ni
1	3.56	2.00	-3.16	-1.83	0.71				0.01	0.06	<0.01	0.03	0.21				0.16	0.06	58	D2	Pb
2	3.18	2.11	-3.21	-1.78	0.89	5.02	2.20	-2.15	0.32	0.05	<0.01	0.04	0.17	0.73	0.57	0.17	0.19	0.13	58	D2	Pb
3	22.13	-0.14			-0.07				<0.01	0.19		<0.01	0.47				0.05	0.26	58	P1	Pb
4	47.12	-0.18			-0.11	-32.92	-19.29	77.27	0.21	0.13		<0.01	0.28	0.37	0.68	0.08	0.13	0.21	58	P1	Pb
1	38.95	13.88	0.57	97.50	-9.19				0.03	0.87	1.00	0.01	0.69				0.13	0.11	58	D3	Zn
2	-11.79	-1.69	0.60	0.71	-1.88	113.91	-349.81	1271.96	0.97	0.08	0.44	0.50	0.03	0.69	0.33	<0.01	0.35	<0.01	58	P1	Zn
3	174.08	-0.87			-1.25				<0.01	0.36		<0.01	0.12				0.07	0.14	58	P1	Zn
4	-7.46	-1.38			-1.62	123.68	-343.21	1243.94	0.98	0.12		<0.01	0.03	0.66	0.33	<0.01	0.34	<0.01	58	P1	Zn

[a]For some metal parameters, the dissolved metal models were better than the particulate models, and vice versa. Dissolved/Particulate means either the dissolved or the particulate model was presented.

[b]p values for the individual independent variables were obtained from 2-tailed t-statistic. [c]p_{Reg} refers to p value for the entire model obtained from F-statistic. [d]Count is the number of events considered. [e]In form column **D** denotes dissolved and **P** denotes particulate phase. Also, 1, 2, and 3 are linear, semi-log, and inverse forms respectively.

[f]M denotes the metal parameter.

Appendix C-4b. Regression Models Developed for Caltrans Zone 4 for Total Metal EMCs.

Model	Coefficent								p value[a]								R^2	pReg[b]	Count[c]	Form[d]	M[e]
	Intercept	T_RAIN (mm)	MAX_RAIN (mm/hr)	D_RUN (hr)	ADD (day)	RC (-)	AREA (ha)	ADT (×10^5 vehicles/day)	Intercept	T_RAIN	MAX_RAIN	D_RUN	ADD	RC	AREA	ADT					
1	0.57	-0.04	0.10	-0.04	-0.29				<0.01	0.96	0.92	0.92	0.18				0.03	0.77	58	T3	Cd
2	1.18	0.00	0.00	0.00	0.00	-0.84	-2.43	5.07	0.41	0.42	0.90	0.67	0.79	0.54	0.17	<0.01	0.19	0.14	58	T1	Cd
3	0.57	-0.01			-0.29				<0.01	0.99			0.18				0.03	0.40	58	T3	Cd
4	1.10	0.00			0.00	-0.80	-2.35	5.08	0.43	0.30			0.88	0.56	0.17	<0.01	0.18	0.05	58	T1	Cd
1	13.99	-0.12	0.03	0.01	-0.02				<0.01	0.10	0.63	0.92	0.72				0.06	0.49	58	T1	Cr
2	41.67	-0.17	0.05	0.03	-0.06	-34.00	-34.83	81.22	0.05	0.02	0.41	0.71	0.37	0.10	0.18	<0.01	0.26	0.03	58	T1	Cr
3	14.22	-0.11			-0.01				<0.01	0.08			0.90				0.06	0.20	58	T1	Cr
4	41.20	-0.15			-0.03	-32.88	-33.60	79.40	0.05	0.02			0.53	0.10	0.19	<0.01	0.25	0.01	58	T1	Cr
1	35.23	-0.34	0.32	0.06	-0.10				<0.01	0.06	0.03	0.77	0.54				0.13	0.10	58	T1	Cu
2	132.21	-0.49	0.37	0.09	-0.13	-105.38	-148.75	208.21	0.01	0.01	0.01	0.64	0.39	0.04	0.02	<0.01	0.31	0.01	58	T1	Cu
3	37.43	-0.29			0.09				<0.01	0.08			0.53				0.05	0.21	58	T1	Cu
4	124.38	-0.42			0.07	-94.59	-135.26	195.34	0.02	0.01			0.59	0.07	0.05	<0.01	0.21	0.02	58	T1	Cu
1	12.15	-0.12	0.06	0.06	-0.03				<0.01	0.09	0.31	0.43	0.68				0.07	0.46	58	T1	Ni
2	54.14	-0.18	0.08	0.07	-0.03	-43.26	-67.46	74.52	0.01	0.01	0.16	0.36	0.67	0.03	0.01	<0.01	0.25	0.03	58	T1	Ni
3	13.16	-0.09			0.00				<0.01	0.14			0.99				0.04	0.32	58	T1	Ni
4	53.93	-0.15			0.01	-41.67	-65.94	71.26	0.01	0.02			0.82	0.04	0.01	<0.01	0.21	0.02	58	T1	Ni
1	21.66	-0.19	0.13	0.10	-0.12				<0.01	0.12	0.22	0.47	0.28				0.08	0.37	58	T1	Pb
2	50.26	-0.23	0.14	0.13	-0.17	-37.34	-19.11	76.70	0.19	0.07	0.16	0.35	0.14	0.31	0.68	0.08	0.16	0.23	58	T1	Pb
3	23.44	-0.14			-0.06				<0.01	0.19			0.52				0.04	0.28	58	T1	Pb
4	49.98	-0.17			-0.10	-34.40	-16.35	70.56	0.19	0.13			0.31	0.35	0.72	0.10	0.12	0.23	58	T1	Pb
1	210.71	-1.63	1.44	0.91	-1.67				<0.01	0.17	0.15	0.49	0.12				0.09	0.28	58	T1	Zn
2	238.46	-2.48	1.69	1.27	-2.25	-122.28	-523.55	1596.96	0.46	0.02	0.05	0.27	0.02	0.70	0.19	<0.01	0.37	<0.01	58	T1	Zn
3	228.38	-1.19			-0.95				<0.01	0.27			0.29				0.05	0.24	58	T1	Zn
4	228.67	-1.86			-1.42	-84.73	-485.19	1527.18	0.48	0.06			0.09	0.79	0.23	<0.01	0.32	<0.01	58	T1	Zn

[a] p values for the individual independent variables were obtained from 2-tailed t-statistic.

[b] p_{Reg} refers to p value for the entire model obtained from F-statistic.

[c] Count is the number of events considered.

[d] In form column **D** denotes dissolved and **P** denotes particulate phase. Also, 1, 2, and 3 are linear, semi-log, and inverse forms respectively.

[e] M denotes the metal parameter.

Appendix C-5a. Regression Models Developed for Caltrans Zone 5 for Dissolved/Particulate[a] Metal EMCs.

Model	Coefficent								p value[b]								R^2	pReg[c]	Count[d]	Form[e]	M[f]
	Intercept	T_RAIN (mm)	MAX_RAIN (mm/hr)	D_RUN (hr)	ADD (day)	RC (-)	AREA (ha)	ADT (×10[5] vehicles/day)	Intercept	T_RAIN	MAX_RAIN	D_RUN	ADD	RC	AREA	ADT					
1	3.33	-2.07	-0.73	0.80	-0.54				0.02	0.06	0.42	0.25	0.33				0.19	0.16	35	D2	Cd
2	3.53	-2.47	-0.71	1.15	-0.78	0.00	0.00	-0.58	0.03	0.06	0.51	0.17	0.24	<0.01	<0.01	0.22	0.23	0.16	35	P2	Cd
3	3.77	-2.48			-0.47				0.01	0.04		<0.01	0.45				0.15	0.08	35	P2	Cd
4	3.50	-2.39			-0.47	0.00	0.00	-0.41	0.02	0.05		<0.01	0.44	<0.01	<0.01	0.36	0.17	0.11	35	P2	Cd
1	5.21	-3.85	0.28	1.76	-0.68				0.01	0.01	0.81	0.06	0.36				0.26	0.06	35	D2	Cr
2	5.56	-3.74	0.06	1.86	-0.71	0.00	0.65	0.00	0.01	0.01	0.96	0.05	0.34	<0.01	0.53	<0.01	0.27	0.09	35	D2	Cr
3	5.96	-3.18			-0.21				<0.01	0.03		<0.01	0.77				0.16	0.07	35	D2	Cr
4	6.08	-3.14			-0.21	0.00	0.37	0.00	<0.01	0.03		<0.01	0.77	<0.01	0.72	<0.01	0.16	0.14	35	D2	Cr
1	13.19	-0.45	0.02	0.13	0.36				<0.01	0.01	0.85	0.25	<0.01				0.49	<0.01	35	D1	Cu
2	15.40	-0.47	0.05	0.13	0.35	0.00	-5.09	0.00	<0.01	0.01	0.62	0.25	<0.01	<0.01	0.12	<0.01	0.53	<0.01	35	D1	Cu
3	13.66	-0.40			0.41				<0.01	0.02		<0.01	<0.01				0.47	<0.01	35	D1	Cu
4	16.16	-0.42			0.40	0.00	-4.83	0.00	<0.01	0.01		<0.01	<0.01	<0.01	0.13	<0.01	0.51	<0.01	35	D1	Cu
1	6.93	-6.65	0.53	1.84	1.79				<0.01	<0.01	0.67	0.06	0.02				0.49	<0.01	35	D2	Ni
2	7.03	-6.76	0.74	1.74	1.82	0.00	0.00	0.31	<0.01	<0.01	0.57	0.08	0.02	<0.01	<0.01	0.57	0.50	<0.01	35	D2	Ni
3	5.23	-0.22			0.11				<0.01	<0.01		<0.01	<0.01				0.46	<0.01	35	D1	Ni
4	5.05	-0.22			0.10	0.00	0.00	0.33	<0.01	<0.01		<0.01	<0.01	<0.01	<0.01	0.56	0.47	<0.01	35	D1	Ni
1	14.38	41.01	-63.66	-2.75	-4.49				<0.01	0.12	0.04	0.74	0.45				0.15	0.27	35	P3	Pb
2	8.12	59.36	-97.28	3.84	-6.78	0.00	1.90	0.00	0.02	0.02	<0.01	0.61	0.21	<0.01	0.01	<0.01	0.35	0.02	35	P3	Pb
3	14.12	-0.23			0.04				<0.01	0.34		<0.01	0.74				0.03	0.62	35	P1	Pb
4	12.66	-0.26			0.04	0.00	0.00	4.29	<0.01	0.27		<0.01	0.76	<0.01	<0.01	0.09	0.12	0.27	35	P1	Pb
1	79.97	-3.41	0.16	0.74	3.91				<0.01	0.01	0.82	0.41	<0.01				0.62	<0.01	35	D1	Zn
2	71.59	-3.54	0.34	0.72	3.88	0.00	0.00	16.74	<0.01	0.01	0.63	0.41	<0.01	<0.01	<0.01	0.20	0.64	<0.01	35	D1	Zn
3	83.49	-3.14			4.17				<0.01	0.01		<0.01	<0.01				0.61	<0.01	35	D1	Zn
4	78.16	-3.26			4.16	0.00	0.00	15.69	<0.01	0.01		<0.01	<0.01	<0.01	<0.01	0.21	0.63	<0.01	35	D1	Zn

[a]For some metal parameters, the dissolved metal models were better than the particulate models, and vice versa. Dissolved/Particulate means either the dissolved or the particulate model was presented.

[b]p values for the individual independent variables were obtained from 2-tailed t-statistic. [c]p_{Reg} refers to p value for the entire model obtained from F-statistic. [d]Count is the number of events considered. [e]In form column **D** denotes dissolved and **P** denotes particulate phase. Also, 1, 2, and 3 are linear, semi-log, and inverse forms respectively.

[f]M denotes the metal parameter.

Appendix C-5b. Regression Models Developed for Caltrans Zone 5 for Total Metal EMCs.

Model	Coefficent								p value[a]								R^2	p_{Reg}[b]	Count[c]	Form[d]	M[e]
	Intercept	T_RAIN (mm)	MAX_RAIN (mm/hr)	D_RUN (hr)	ADD (day)	RC (-)	AREA (ha)	ADT ($\times 10^5$ vehicles/day)	Intercept	T_RAIN	MAX_RAIN	D_RUN	ADD	RC	AREA	ADT					
1	7.22	-4.83	-1.12	1.76	-1.31				0.02	0.04	0.56	0.24	0.28				0.20	0.14	35	T2	Cd
2	8.28	-4.48	-1.78	2.08	-1.41	0.00	1.97	0.00	0.01	0.06	0.37	0.17	0.24	<0.01	0.24	<0.01	0.24	0.14	35	T2	Cd
3	6.92	-4.66			-0.84				0.01	0.04			0.45				0.16	0.07	35	T2	Cd
4	7.34	-4.53			-0.85	0.00	1.26	0.00	0.01	0.04			0.45	<0.01	0.43	<0.01	0.17	0.11	35	T2	Cd
1	5.81	28.24	-24.31	-4.05	-0.28				<0.01	0.02	0.08	0.26	0.91				0.20	0.13	35	T3	Cr
2	5.87	28.70	-25.15	-3.89	-0.34	0.00	0.00	-0.02	<0.01	0.02	0.09	0.31	0.90	<0.01	<0.01	0.88	0.21	0.22	35	T3	Cr
3	11.17	-4.89			-0.16				<0.01	0.08			0.91				0.10	0.20	35	T2	Cr
4	11.05	-4.86			-0.16	0.00	0.00	-0.16	<0.01	0.09			0.91	<0.01	<0.01	0.88	0.10	0.36	35	T2	Cr
1	22.70	-19.11	6.25	7.02	9.39				0.02	0.01	0.30	0.14	0.02				0.36	0.01	35	T2	Cu
2	14.47	-21.79	11.38	4.52	10.16	0.00	-15.28	0.00	0.09	<0.01	0.04	0.27	<0.01	<0.01	<0.01	<0.01	0.54	<0.01	35	T2	Cu
3	25.59	-0.54			0.46				<0.01	0.05			<0.01				0.30	<0.01	35	T1	Cu
4	32.88	-0.59			0.45	0.00	-14.09	0.00	<0.01	0.02			<0.01	<0.01	0.01	<0.01	0.44	<0.01	35	T1	Cu
1	7.72	45.67	-33.26	-7.21	-0.16				<0.01	<0.01	0.02	0.06	0.95				0.39	<0.01	35	T3	Ni
2	6.90	48.06	-37.63	-6.35	-0.45	0.00	0.25	0.00	<0.01	<0.01	0.02	0.11	0.87	<0.01	0.45	<0.01	0.40	0.01	35	T3	Ni
3	12.12	-0.36			0.05				<0.01	<0.01			0.36				0.25	0.01	35	T1	Ni
4	12.59	-0.37			0.05	0.00	-0.91	0.00	<0.01	<0.01			0.37	<0.01	0.70	<0.01	0.25	0.03	35	T1	Ni
1	18.37	41.73	-68.58	-6.34	-2.74				<0.01	0.16	0.05	0.49	0.68				0.15	0.29	35	T3	Pb
2	10.67	64.31	-109.94	1.77	-5.56	0.00	2.34	0.00	0.01	0.02	<0.01	0.83	0.34	<0.01	<0.01	<0.01	0.39	0.01	35	T3	Pb
3	17.46	-0.26			0.06				<0.01	0.35			0.66				0.03	0.62	35	T1	Pb
4	15.49	-0.30			0.06	0.00	0.00	5.81	<0.01	0.26			0.68	<0.01	<0.01	0.04	0.15	0.15	35	T1	Pb
1	219.64	-6.89	2.29	0.69	2.91				<0.01	0.05	0.23	0.77	0.13				0.22	0.10	35	T1	Zn
2	196.32	-7.24	2.79	0.63	2.84	0.00	0.00	46.55	<0.01	0.04	0.15	0.79	0.13	<0.01	<0.01	0.18	0.27	0.09	35	T1	Zn
3	254.90	-6.52			3.33				<0.01	0.05			0.05				0.18	0.04	35	T1	Zn
4	242.40	-6.78			3.29	0.00	0.00	36.76	<0.01	0.04			0.05	<0.01	<0.01	0.28	0.21	0.06	35	T1	Zn

[a]p values for the individual independent variables were obtained from 2-tailed t-statistic.

[b]p_{Reg} refers to p value for the entire model obtained from F-statistic.

[c]Count is the number of events considered.

[d]In form column **D** denotes dissolved and **P** denotes particulate phase. Also, 1, 2, and 3 are linear, semi-log, and inverse forms respectively.

[e]M denotes the metal parameter.

Appendix C-6a. Regression Models Developed for Caltrans Zone 6 for Dissolved/Particulate[a] Metal EMCs.

Model	Coefficent								p value[b]								R^2	pReg[c]	Count[d]	Form[e]	M[f]
	Intercept	T_RAIN (mm)	MAX_RAIN (mm/hr)	D_RUN (hr)	ADD (day)	RC (-)	AREA (ha)	ADT (×10^5 vehicles/day)	Intercept	T_RAIN	MAX_RAIN	D_RUN	ADD	RC	AREA	ADT					
1																					Cd
2																					Cd
3	0.84	-0.01			-0.01				0.03	0.52		<0.01	0.16				0.46	0.30	7	D1	Cd
4																					Cd
1																					Cr
2																					Cr
3	3.63	-0.07			0.65				0.59	0.63		<0.01	0.06				0.70	0.09	7	P1	Cr
4																					Cr
1																					Cu
2																					Cu
3	20.87	-0.40			1.46				0.32	0.59		<0.01	0.10				0.44	0.17	9	P1	Cu
4																					Cu
1																					Ni
2																					Ni
3	3.34	0.26			-0.09				0.59	0.10		<0.01	0.71				0.59	0.17	7	D1	Ni
4																					Ni
1																					Pb
2																					Pb
3	38.32	-0.37			3.42				0.27	0.65		<0.01	0.04				0.53	0.07	10	P1	Pb
4																					Pb
1																					Zn
2																					Zn
3	84.89	-1.48			8.69				0.69	0.83		<0.01	0.28				0.27	0.45	8	P1	Zn
4																					Zn

[a]For some metal parameters, the dissolved metal models were better than the particulate models, and vice versa. Dissolved/Particulate means either the dissolved or the particulate model was presented.

[b]p values for the individual independent variables were obtained from 2-tailed t-statistic. [c]p_{Reg} refers to p value for the entire model obtained from F-statistic. [d]Count is the number of events considered. [e]In form column **D** denotes dissolved and **P** denotes particulate phase. Also, 1, 2, and 3 are linear, semi-log, and inverse forms respectively.

[f]M denotes the metal parameter.

Appendix C-6b. Regression Models Developed for Caltrans Zone 6 for Total Metal EMCs.

Model	Coefficent								p value[a]								R^2	p_{Reg}[b]	Count[c]	Form[d]	M[e]
	Intercept	T_RAIN (mm)	MAX_RAIN (mm/hr)	D_RUN (hr)	ADD (day)	RC (-)	AREA (ha)	ADT ($\times10^5$ vehicles/day)	Intercept	T_RAIN	MAX_RAIN	D_RUN	ADD	RC	AREA	ADT					
1																					Cd
2																					Cd
3	2.36	-1.00			0.04				0.04	0.17			0.91				0.37	0.31	8	T2	Cd
4																					Cd
1																					Cr
2																					Cr
3	3.25	0.00			0.66				0.44	0.98			0.01				0.70	0.02	10	T1	Cr
4																					Cr
1																					Cu
2																					Cu
3	55.05	-27.95			33.40				0.09	0.24			0.02				0.68	0.03	9	T2	Cu
4																					Cu
1																					Ni
2																					Ni
3	4.73	0.26			0.32				0.57	0.19			0.35				0.41	0.35	7	T1	Ni
4																					Ni
1																					Pb
2																					Pb
3	40.99	-0.38			3.47				0.23	0.63			0.04				0.55	0.06	10	T1	Pb
4																					Pb
1																					Zn
2																					Zn
3	199.07	-2.45			8.24				0.29	0.68			0.23				0.36	0.33	8	T1	Zn
4																					Zn

[a] p values for the individual independent variables were obtained from 2-tailed t-statistic.

[b] p_{Reg} refers to p value for the entire model obtained from F-statistic.

[c] Count is the number of events considered.

[d] In form column **D** denotes dissolved and **P** denotes particulate phase. Also, 1, 2, and 3 are linear, semi-log, and inverse forms respectively.

[e] M denotes the metal parameter.

Appendix C-7a. Regression Models Developed for Caltrans Zone 7 for Dissolved/Particulate[a] Metal EMCs.

Model	Coefficent								p value[b]								R^2	pReg[c]	Count[d]	Form[e]	M[f]
	Intercept	T_RAIN (mm)	MAX_RAIN (mm/hr)	D_RUN (hr)	ADD (day)	RC (-)	AREA (ha)	ADT (×10^5 vehicles/day)	Intercept	T_RAIN	MAX_RAIN	D_RUN	ADD	RC	AREA	ADT					
1	0.42	2.76	-1.36	-1.92	-0.12				<0.01	0.01	0.02	0.01	0.72				0.74	0.03	12	D3	Cd
2	0.11	-0.19	0.24	0.19	0.01	0.00	0.18	0.00	0.41	0.17	0.08	0.07	0.84	<0.01	0.14	<0.01	0.74	0.13	11	D2	Cd
3	2.06	-0.98			-0.17				<0.01	<0.01		<0.01	0.53				0.55	0.01	16	P2	Cd
4	-0.61	0.00			0.00	0.00	-0.51	1.18	0.03	0.12		<0.01	0.85	<0.01	0.29	<0.01	0.90	<0.01	15	P1	Cd
1	0.58	46.91	0.37	-8.35	-0.76				0.60	0.01	0.96	0.41	0.89				0.73	0.04	12	P3	Cr
2	-86.24	24.49	5.01	-1.35	-3.31	0.00	0.00	24.34	0.26	0.21	0.51	0.89	0.50	<0.01	<0.01	0.26	0.67	0.23	11	P3	Cr
3	0.51	61.24			-2.14				0.82	<0.01		<0.01	0.82				0.53	0.01	16	P3	Cr
4	36.80	-18.77			-5.89	0.00	0.64	-35.19	<0.01	0.27		<0.01	0.29	<0.01	0.18	<0.01	0.90	<0.01	15	P3	Cr
1	1.93	257.37	12.74	-61.60	-6.70				0.75	0.01	0.77	0.28	0.82				0.73	0.04	12	P3	Cu
2	-677.89	182.94	24.97	-42.49	-19.35	0.00	0.00	190.68	0.13	0.11	0.56	0.45	0.48	<0.01	<0.01	0.13	0.72	0.16	11	P3	Cu
3	3.83	177.95			-6.14				0.43	<0.01		<0.01	0.77				0.67	<0.01	16	P3	Cu
4	-13.23	-0.14			0.03	0.00	-28.33	36.40	0.14	0.03		<0.01	0.77	<0.01	0.10	<0.01	0.89	<0.01	15	P1	Cu
1	1.08	47.15	4.71	-13.19	-4.95				0.37	0.01	0.58	0.23	0.41				0.72	0.04	12	P3	Ni
2	-143.98	36.69	6.03	-11.03	-7.25	0.00	0.00	40.70	0.10	0.10	0.46	0.32	0.19	<0.01	<0.01	0.10	0.76	0.11	11	P3	Ni
3	0.52	55.06			-2.32				0.65	<0.01		<0.01	0.64				0.78	<0.01	16	P3	Ni
4	2.73	-2.77			1.10	0.00	-4.74	31.97	0.27	0.02		<0.01	0.23	<0.01	0.04	<0.01	0.95	<0.01	15	P2	Ni
1	5.60	12.63	-14.52	-21.44	-13.26				<0.01	0.34	0.10	0.06	0.04				0.68	0.06	12	D3	Pb
2	6.38	30.56	-18.06	-26.81	-10.99	0.00	-0.26	0.00	<0.01	0.16	0.07	0.05	0.08	<0.01	0.27	<0.01	0.81	0.07	11	D3	Pb
3	-39.86	1569.29			4.41				0.40	<0.01		<0.01	0.98				0.61	<0.01	16	P3	Pb
4	11.82	-24.66			9.26	0.00	-67.72	1170.73	0.91	0.58		<0.01	0.81	<0.01	0.46	<0.01	0.90	<0.01	15	P2	Pb
1	12.76	1626.22	260.34	-327.09	-206.18				0.80	0.03	0.48	0.48	0.43				0.66	0.08	12	P3	Zn
2	106.51	1052.87	-323.60	-380.10	-167.57	0.00	-3.96	0.00	<0.01	0.02	0.05	0.07	0.09	<0.01	0.29	<0.01	0.85	0.04	11	D3	Zn
3	345.72	-192.98			21.01				<0.01	<0.01		<0.01	0.65				0.66	<0.01	16	P2	Zn
4	148.78	-110.08			19.49	0.00	-118.48	593.23	0.21	0.05		<0.01	0.65	<0.01	0.26	0.01	0.82	<0.01	15	P2	Zn

[a]For some metal parameters, the dissolved metal models were better than the particulate models, and vice versa. Dissolved/Particulate means either the dissolved or the particulate model was presented.

[b]p values for the individual independent variables were obtained from 2-tailed t-statistic. [c]p_{Reg} refers to p value for the entire model obtained from F-statistic. [d]Count is the number of events considered. [e]In form column **D** denotes dissolved and **P** denotes particulate phase. Also, 1, 2, and 3 are linear, semi-log, and inverse forms respectively.

[f]M denotes the metal parameter.

Appendix C-7b. Regression Models Developed for Caltrans Zone 7 for Total Metal EMCs.

Model	Coefficent								p value[a]								R^2	pReg[b]	Count[c]	Form[d]	M[e]
	Intercept	T_RAIN (mm)	MAX_RAIN (mm/hr)	D_RUN (hr)	ADD (day)	RC (-)	AREA (ha)	ADT ($\times 10^5$ vehicles/day)	Intercept	T_RAIN	MAX_RAIN	D_RUN	ADD	RC	AREA	ADT					
1	0.57	18.41	-3.23	-6.78	0.10				0.13	<0.01	0.21	0.06	0.95				0.77	0.02	12	T3	Cd
2	-9.35	6.28	-0.41	-2.60	-0.88	0.00	0.00	2.77	0.39	0.06	0.71	0.12	0.24	<0.01	<0.01	0.37	0.67	0.22	11	T3	Cd
3	0.27	6.52			0.76				0.28	0.01			0.49				0.46	0.02	16	T3	Cd
4	0.49	-0.08			-0.02	0.00	-0.40	3.76	0.22	0.62			0.87	<0.01	0.25	<0.01	0.87	<0.01	15	T2	Cd
1	2.62	69.53	-8.08	-20.96	1.65				0.09	<0.01	0.41	0.12	0.81				0.76	0.03	12	T3	Cr
2	-46.70	36.79	-0.67	-9.92	-1.25	0.00	0.00	13.80	0.62	0.16	0.95	0.45	0.84	<0.01	<0.01	0.60	0.48	0.53	11	T3	Cr
3	1.74	64.49			-1.34				0.41	<0.01			0.88				0.58	<0.01	16	T3	Cr
4	-11.31	-0.02			-0.01	0.00	-2.32	16.53	<0.01	0.39			0.67	<0.01	0.68	<0.01	0.92	<0.01	15	T1	Cr
1	14.82	365.04	-36.23	-99.41	-13.95				0.09	<0.01	0.52	0.19	0.72				0.73	0.04	12	T3	Cu
2	-744.13	236.54	-11.73	-62.05	-31.35	0.00	0.00	212.82	0.19	0.12	0.83	0.40	0.39	<0.01	<0.01	0.18	0.64	0.28	11	T3	Cu
3	11.32	207.14			1.40				0.05	<0.01			0.95				0.67	<0.01	16	T3	Cu
4	20.36	-11.11			2.70	0.00	-22.35	110.19	0.14	0.07			0.58	<0.01	0.07	<0.01	0.88	<0.01	15	T2	Cu
1	3.97	75.00	-8.49	-23.08	-9.27				0.03	<0.01	0.42	0.11	0.23				0.77	0.02	12	T3	Ni
2	-72.94	57.72	-4.99	-17.79	-11.34	0.00	0.00	21.56	0.55	0.10	0.70	0.31	0.20	<0.01	<0.01	0.53	0.64	0.28	11	T3	Ni
3	1.95	61.41			-1.80				0.15	<0.01			0.75				0.77	<0.01	16	T3	Ni
4	4.78	-2.75			1.35	0.00	-3.45	34.32	0.15	0.07			0.26	<0.01	0.24	<0.01	0.92	<0.01	15	T2	Ni
1	6.76	262.90	13.69	-61.07	-38.16				0.42	0.02	0.81	0.41	0.36				0.63	0.10	12	T3	Pb
2	-565.48	351.76	-12.20	-98.50	-37.83	0.00	0.00	160.70	0.41	0.08	0.86	0.31	0.42	<0.01	<0.01	0.41	0.64	0.27	11	T3	Pb
3	-37.39	1564.82			2.76				0.43	<0.01			0.99				0.61	<0.01	16	T3	Pb
4	10.95	-22.85			10.54	0.00	-65.45	1172.10	0.92	0.61			0.78	<0.01	0.48	<0.01	0.90	<0.01	15	T2	Pb
1	106.24	2166.93	47.69	-541.02	-425.71				0.09	0.01	0.90	0.30	0.16				0.71	0.04	12	T3	Zn
2	-2661.83	2888.57	-147.19	-825.16	-403.01	0.00	0.00	777.73	0.58	0.05	0.77	0.24	0.24	<0.01	<0.01	0.56	0.71	0.17	11	T3	Zn
3	366.11	-172.48			27.57				<0.01	<0.01			0.56				0.61	<0.01	16	T2	Zn
4	221.39	-115.71			32.26	0.00	-87.14	379.14	0.14	0.08			0.54	<0.01	0.49	0.16	0.68	0.01	15	T2	Zn

[a] p values for the individual independent variables were obtained from 2-tailed t-statistic.

[b] p_{Reg} refers to p value for the entire model obtained from F-statistic.

[c] Count is the number of events considered.

[d] In form column **D** denotes dissolved and **P** denotes particulate phase. Also, 1, 2, and 3 are linear, semi-log, and inverse forms respectively.

[e] M denotes the metal parameter.

Appendix C-8a. Regression Models Developed for Caltrans Zone 8 for Dissolved/Particulate[a] Metal EMCs.

Model	Coefficent								p value[b]								R^2	pReg[c]	Count[d]	Form[e]	M[f]
	Intercept	T_RAIN (mm)	MAX_RAIN (mm/hr)	D_RUN (hr)	ADD (day)	RC (-)	AREA (ha)	ADT ($\times 10^5$ vehicles/day)	Intercept	T_RAIN	MAX_RAIN	D_RUN	ADD	RC	AREA	ADT					
1	0.48	4.99	-2.10	-1.38	-0.56				<0.01	<0.01	0.01	0.03	0.02				0.21	<0.01	78	D3	Cd
2	2.08	-0.69	0.09	0.20	0.24	10.55	1.94	3.04	<0.01	0.02	0.67	0.39	0.08	<0.01	<0.01	<0.01	0.39	<0.01	78	P2	Cd
3	0.89	-0.47			0.36				0.01	0.03		<0.01	0.02				0.16	<0.01	78	P2	Cd
4	2.15	-0.50			0.22	10.13	1.88	2.98	<0.01	0.01		<0.01	0.10	<0.01	<0.01	<0.01	0.38	<0.01	78	P2	Cd
1	1.64	-0.11	-0.08	0.38	0.10				0.51	0.14	0.18	<0.01	0.15				0.28	<0.01	78	P1	Cr
2	-87.88	-0.20	-0.02	0.41	0.00	99.38	38.73	-3.93	<0.01	0.01	0.72	<0.01	0.97	<0.01	<0.01	0.12	0.49	<0.01	78	P1	Cr
3	1.91	11.51			-0.68				<0.01	<0.01		<0.01	0.36				0.15	<0.01	78	D3	Cr
4	-77.56	0.01			0.01	93.13	38.35	-5.34	<0.01	0.92		<0.01	0.90	<0.01	<0.01	0.07	0.25	<0.01	78	P1	Cr
1	19.92	-26.23	4.14	13.03	13.57				<0.01	<0.01	0.19	<0.01	<0.01				0.49	<0.01	100	D2	Cu
2	12.20	-26.04	3.18	13.61	12.81	27.16	-2.32	26.25	0.07	<0.01	0.30	<0.01	<0.01	0.37	0.72	0.05	0.55	<0.01	100	D2	Cu
3	24.66	-14.40			12.98				<0.01	<0.01		<0.01	<0.01				0.41	<0.01	100	D2	Cu
4	14.50	-14.47			12.35	10.98	-5.18	22.74	0.04	<0.01		<0.01	<0.01	0.73	0.44	0.11	0.47	<0.01	100	D2	Cu
1	2.80	-8.64	3.21	4.34	4.49				0.18	<0.01	0.02	<0.01	<0.01				0.41	<0.01	78	D2	Ni
2	-2.48	-8.49	2.69	4.93	4.44	5.31	-3.30	8.49	0.37	<0.01	0.04	<0.01	<0.01	0.67	0.20	0.15	0.53	<0.01	78	D2	Ni
3	6.03	-3.71			3.91				<0.01	<0.01		<0.01	<0.01				0.32	<0.01	78	D2	Ni
4	-0.73	-3.58			3.94	-5.87	-4.95	6.84	0.80	<0.01		<0.01	<0.01	0.65	0.06	0.28	0.43	<0.01	78	D2	Ni
1	19.47	347.80	-131.40	-97.81	-26.98				0.03	<0.01	0.02	0.01	0.11				0.14	0.01	100	D3	Pb
2	89.61	320.65	-126.91	-87.26	-28.76	-29.55	-0.75	-57.30	0.06	<0.01	0.02	0.02	0.09	0.18	0.33	0.20	0.16	0.02	100	D3	Pb
3	68.74	-45.69			72.01				0.32	0.32		<0.01	0.03				0.06	0.04	100	P2	Pb
4	-887.71	-1.00			0.64	970.64	391.26	0.56	0.03	0.16		<0.01	0.57	0.01	0.02	0.99	0.11	0.06	100	P1	Pb
1	75.88	-156.48	45.82	67.17	112.24				0.11	<0.01	0.16	0.06	<0.01				0.32	<0.01	100	D2	Zn
2	-81.51	-131.95	21.33	62.76	118.35	-648.83	-205.25	-139.10	0.23	<0.01	0.50	0.07	<0.01	0.04	<0.01	0.31	0.41	<0.01	100	D2	Zn
3	110.63	-79.14			109.45				0.02	0.01		<0.01	<0.01				0.28	<0.01	100	D2	Zn
4	-70.83	-74.18			116.40	-735.81	-221.42	-156.53	0.30	0.01		<0.01	<0.01	0.02	<0.01	0.25	0.39	<0.01	100	D2	Zn

[a]For some metal parameters, the dissolved metal models were better than the particulate models, and vice versa. Dissolved/Particulate means either the dissolved or the particulate model was presented.

[b]p values for the individual independent variables were obtained from 2-tailed t-statistic. [c]p_{Reg} refers to p value for the entire model obtained from F-statistic. [d]Count is the number of events considered. [e]In form column **D** denotes dissolved and **P** denotes particulate phase. Also, 1, 2, and 3 are linear, semi-log, and inverse forms respectively.

[f]M denotes the metal parameter.

Appendix C-8b. Regression Models Developed for Caltrans Zone 8 for Total Metal EMCs.

Model	Coefficent								p value[a]								R^2	p_{Reg}[b]	Count[c]	Form[d]	M[e]
	Intercept	T_RAIN (mm)	MAX_RAIN (mm/hr)	D_RUN (hr)	ADD (day)	RC (-)	AREA (ha)	ADT ($\times 10^5$ vehicles/day)	Intercept	T_RAIN	MAX_RAIN	D_RUN	ADD	RC	AREA	ADT					
1	1.00	-1.01	0.10	0.42	0.72				0.08	0.05	0.78	0.30	0.30				0.20	<0.01	78	T2	Cd
2	2.06	-1.42	0.43	0.68	0.58	13.20	2.16	4.06	0.01	<0.01	0.22	0.07	0.01	<0.01	<0.01	0.01	0.35	<0.01	78	T2	Cd
3	1.21	-0.68			0.67				0.02	0.04			<0.01				0.19	<0.01	78	T2	Cd
4	-9.45	-0.01			0.00	9.95	3.73	0.40	<0.01	<0.01			0.82	<0.01	<0.01	0.16	0.31	<0.01	78	T1	Cd
1	4.67	-0.12	-0.09	0.37	0.10				0.07	0.12	0.16	<0.01	0.16				0.27	<0.01	78	T1	Cr
2	-91.97	-0.21	-0.02	0.40	-0.01	105.51	40.55	-3.34	<0.01	<0.01	0.69	<0.01	0.93	<0.01	<0.01	0.19	0.49	<0.01	78	T1	Cr
3	11.67	-11.07			-13.09				<0.01	0.62			<0.01				0.10	0.02	78	T3	Cr
4	-82.06	-0.02			0.00	99.57	40.27	-4.73	<0.01	0.75			0.99	<0.01	<0.01	0.11	0.25	<0.01	78	T1	Cr
1	45.30	-34.61	2.37	8.02	27.77				<0.01	<0.01	0.76	0.35	<0.01				0.36	<0.01	100	T2	Cu
2	80.64	-40.81	8.19	11.72	24.62	295.97	53.24	71.61	<0.01	<0.01	0.27	0.14	<0.01	<0.01	<0.01	0.03	0.46	<0.01	100	T2	Cu
3	48.15	-27.45			27.40				<0.01	<0.01			<0.01				0.36	<0.01	100	T2	Cu
4	82.67	-27.22			24.36	271.92	48.34	67.56	<0.01	<0.01			<0.01	<0.01	<0.01	0.04	0.45	<0.01	100	T2	Cu
1	2.68	-22.85	10.81	12.23	10.16				0.72	<0.01	0.03	0.02	<0.01				0.24	<0.01	78	T2	Ni
2	12.76	-25.59	13.33	11.88	8.37	69.72	21.27	41.44	0.22	<0.01	0.01	0.03	0.01	0.14	0.03	0.06	0.31	<0.01	78	T2	Ni
3	12.65	-7.79			8.45				0.07	0.08			0.01				0.15	<0.01	78	T2	Ni
4	-88.96	-0.21			-0.04	88.23	49.16	6.68	0.01	<0.01			0.71	0.01	<0.01	0.10	0.24	<0.01	78	T1	Ni
1	123.88	922.31	-336.06	-254.29	-167.35				<0.01	0.08	0.20	0.16	0.04				0.08	0.09	100	T3	Pb
2	207.28	-149.79	54.06	78.97	77.69	1151.78	207.29	246.73	0.14	0.10	0.41	0.26	0.06	0.08	0.13	0.38	0.10	0.17	100	T2	Pb
3	89.55	-60.68			86.39				0.30	0.28			0.03				0.06	0.04	100	T2	Pb
4	-1087.68	-1.24			0.65	1152.30	451.87	19.89	0.03	0.16			0.64	0.01	0.03	0.69	0.10	0.08	100	T1	Pb
1	259.78	-234.08	40.98	58.54	187.74				<0.01	<0.01	0.47	0.35	<0.01				0.31	<0.01	100	T2	Zn
2	-1685.47	-4.33	1.00	1.55	2.87	1848.73	700.93	44.67	<0.01	<0.01	0.34	0.29	0.02	<0.01	<0.01	0.32	0.36	<0.01	100	T1	Zn
3	290.51	-165.98			185.31				<0.01	<0.01			<0.01				0.30	<0.01	100	T2	Zn
4	-1480.48	-2.88			3.02	1680.07	632.71	34.81	<0.01	<0.01			0.02	<0.01	<0.01	0.43	0.35	<0.01	100	T1	Zn

[a] p values for the individual independent variables were obtained from 2-tailed t-statistic.

[b] p_{Reg} refers to p value for the entire model obtained from F-statistic.

[c] Count is the number of events considered.

[d] In form column **D** denotes dissolved and **P** denotes particulate phase. Also, 1, 2, and 3 are linear, semi-log, and inverse forms respectively.

[e] M denotes the metal parameter.

Appendix C-9a. Regression Models Developed for Caltrans Zone 9 for Dissolved/Particulate[a] Metal EMCs.

Model	Coefficent								p value[b]								R^2	pReg[c]	Count[d]	Form[e]	M[f]
	Intercept	T_RAIN (mm)	MAX_RAIN (mm/hr)	D_RUN (hr)	ADD (day)	RC (-)	AREA (ha)	ADT (×10[5] vehicles/day)	Intercept	T_RAIN	MAX_RAIN	D_RUN	ADD	RC	AREA	ADT					
1	4.17	-1.84	0.09	-0.62	0.84				<0.01	0.01	0.85	0.18	0.01				0.60	<0.01	27	P2	Cd
2	0.96	-1.64	-0.07	-0.62	0.97	0.00	-4.55	0.00	0.43	0.01	0.86	0.12	<0.01	<0.01	0.01	<0.01	0.72	<0.01	27	P2	Cd
3	3.94	-2.04			0.79				<0.01	<0.01		<0.01	0.02				0.55	<0.01	27	P2	Cd
4	0.60	-1.95			0.93	0.00	-4.67	0.00	0.63	<0.01		<0.01	<0.01	<0.01	0.01	<0.01	0.68	<0.01	27	P2	Cd
1	25.00	-9.56	-0.44	-4.83	6.02				<0.01	0.01	0.87	0.07	<0.01				0.65	<0.01	27	P2	Cr
2	7.70	-8.44	-1.32	-4.85	6.72	0.00	-24.53	0.00	0.28	0.01	0.58	0.04	<0.01	<0.01	0.01	<0.01	0.75	<0.01	27	P2	Cr
3	22.88	-11.95			5.68				<0.01	<0.01		<0.01	<0.01				0.58	<0.01	27	P2	Cr
4	4.94	-11.46			6.43	0.00	-25.03	0.00	0.50	<0.01		<0.01	<0.01	<0.01	0.01	<0.01	0.68	<0.01	27	P2	Cr
1	41.34	-15.56	-6.45	0.08	11.50				<0.01	0.01	0.12	0.98	<0.01				0.72	<0.01	27	D2	Cu
2	2398.88	-14.15	-7.55	0.05	12.39	0.00	0.00	3500.08	0.03	0.01	0.05	0.99	<0.01	<0.01	<0.01	0.03	0.78	<0.01	27	D2	Cu
3	39.38	-20.12			11.79				<0.01	<0.01		<0.01	<0.01				0.68	<0.01	27	D2	Cu
4	2054.05	-19.60			12.59	0.00	0.00	2991.50	0.07	<0.01		<0.01	<0.01	<0.01	<0.01	0.08	0.72	<0.01	27	D2	Cu
1	5.69	-3.33	0.01	0.57	1.83				<0.01	<0.01	0.99	0.40	<0.01				0.66	<0.01	27	D2	Ni
2	7.93	-9.15	-0.48	-3.84	5.74	0.00	-22.72	0.00	0.21	<0.01	0.82	0.06	<0.01	<0.01	0.01	<0.01	0.76	<0.01	27	P2	Ni
3	5.93	-3.08			1.87				<0.01	<0.01		<0.01	<0.01				0.65	<0.01	27	D2	Ni
4	5.68	-11.13			5.50	0.00	-23.45	0.00	0.38	<0.01		<0.01	<0.01	<0.01	0.01	<0.01	0.71	<0.01	27	P2	Ni
1	672.41	-291.06	-18.24	-72.57	123.45				<0.01	0.01	0.83	0.36	0.03				0.54	<0.01	27	P2	Pb
2	27.62	-249.29	-50.99	-73.43	149.69	0.00	-914.01	0.00	0.89	0.01	0.45	0.25	<0.01	<0.01	<0.01	<0.01	0.73	<0.01	27	P2	Pb
3	636.96	-335.29			118.81				<0.01	<0.01		<0.01	0.03				0.52	<0.01	27	P2	Pb
4	-10.58	-317.45			146.08	0.00	-903.22	0.00	0.96	<0.01		<0.01	<0.01	<0.01	<0.01	<0.01	0.71	<0.01	27	P2	Pb
1	597.21	-250.99	-12.94	-47.59	102.70				<0.01	<0.01	0.81	0.36	0.01				0.66	<0.01	27	P2	Zn
2	287.67	-230.94	-28.66	-48.00	115.30	0.00	-438.79	0.00	0.06	<0.01	0.57	0.31	<0.01	<0.01	0.02	<0.01	0.73	<0.01	27	P2	Zn
3	573.66	-280.70			99.70				<0.01	<0.01		<0.01	0.01				0.64	<0.01	27	P2	Zn
4	262.16	-272.12			112.82	0.00	-434.50	0.00	0.08	<0.01		<0.01	<0.01	<0.01	0.02	<0.01	0.72	<0.01	27	P2	Zn

[a] For some metal parameters, the dissolved metal models were better than the particulate models, and vice versa. Dissolved/Particulate means either the dissolved or the particulate model was presented.

[b] p values for the individual independent variables were obtained from 2-tailed t-statistic. [c] p_{Reg} refers to p value for the entire model obtained from F-statistic. [d] Count is the number of events considered. [e] In form column **D** denotes dissolved and **P** denotes particulate phase. Also, 1, 2, and 3 are linear, semi-log, and inverse forms respectively.

[f] M denotes the metal parameter.

Appendix C-9b. Regression Models Developed for Caltrans Zone 9 for Total Metal EMCs.

Model	Coefficent								p value[a]								R^2	p_{Reg}[b]	Count[c]	Form[d]	M[e]
	Intercept	T_RAIN (mm)	MAX_RAIN (mm/hr)	D_RUN (hr)	ADD (day)	RC (-)	AREA (ha)	ADT ($\times 10^5$ vehicles/day)	Intercept	T_RAIN	MAX_RAIN	D_RUN	ADD	RC	AREA	ADT					
1	4.35	-1.83	0.02	-0.63	0.89				<0.01	0.01	0.96	0.18	0.01				0.60	<0.01	27	T2	Cd
2	1.02	-1.62	-0.14	-0.63	1.03	0.00	-4.72	0.00	0.41	0.01	0.73	0.11	<0.01	<0.01	0.01	<0.01	0.73	<0.01	27	T2	Cd
3	4.10	-2.08			0.85				<0.01	<0.01			0.01				0.56	<0.01	27	T2	Cd
4	0.66	-1.99			0.99	0.00	-4.80	0.00	0.59	<0.01			<0.01	<0.01	<0.01	<0.01	0.69	<0.01	27	T2	Cd
1	28.05	-10.72	-0.26	-4.64	6.09				<0.01	0.01	0.93	0.09	<0.01				0.65	<0.01	27	T2	Cr
2	8.92	-9.48	-1.23	-4.66	6.87	0.00	-27.12	0.00	0.22	0.01	0.61	0.05	<0.01	<0.01	0.01	<0.01	0.76	<0.01	27	T2	Cr
3	26.06	-12.90			5.76				<0.01	<0.01			0.01				0.59	<0.01	27	T2	Cr
4	6.26	-12.36			6.59	0.00	-27.62	0.00	0.40	<0.01			<0.01	<0.01	0.01	<0.01	0.71	<0.01	27	T2	Cr
1	188.00	-72.12	-8.55	-20.81	40.23				<0.01	0.02	0.71	0.33	0.01				0.55	<0.01	27	T2	Cu
2	19869.68	-60.34	-17.78	-21.06	47.63	0.00	0.00	29220.11	<0.01	0.02	0.32	0.21	<0.01	<0.01	<0.01	<0.01	0.75	<0.01	27	T2	Cu
3	176.81	-87.17			39.04				<0.01	<0.01			0.01				0.53	<0.01	27	T2	Cu
4	19476.55	-82.18			46.68	0.00	0.00	28657.37	<0.01	<0.01			<0.01	<0.01	<0.01	<0.01	0.73	<0.01	27	T2	Cu
1	29.64	-13.52	0.34	-3.25	6.92				<0.01	<0.01	0.91	0.24	<0.01				0.68	<0.01	27	T2	Ni
2	10.44	-12.28	-0.63	-3.27	7.70	0.00	-27.22	0.00	0.17	<0.01	0.80	0.17	<0.01	<0.01	0.01	<0.01	0.78	<0.01	27	T2	Ni
3	28.42	-14.67			6.66				<0.01	<0.01			<0.01				0.66	<0.01	27	T2	Ni
4	8.55	-14.13			7.50	0.00	-27.71	0.00	0.25	<0.01			<0.01	<0.01	0.01	<0.01	0.75	<0.01	27	T2	Ni
1	686.84	-289.92	-20.08	-76.17	121.67				<0.01	0.01	0.81	0.34	0.03				0.55	<0.01	27	T2	Pb
2	40.24	-248.03	-52.92	-77.04	147.99	0.00	-916.56	0.00	0.84	0.01	0.43	0.22	<0.01	<0.01	<0.01	<0.01	0.73	<0.01	27	T2	Pb
3	649.33	-337.02			116.84				<0.01	<0.01			0.03				0.53	<0.01	27	T2	Pb
4	0.11	-319.12			144.19	0.00	-905.59	0.00	1.00	<0.01			<0.01	<0.01	<0.01	<0.01	0.71	<0.01	27	T2	Pb
1	656.75	-271.37	-8.67	-65.48	135.24				<0.01	<0.01	0.88	0.23	<0.01				0.70	<0.01	27	T2	Zn
2	285.75	-247.33	-27.51	-65.97	150.34	0.00	-525.89	0.00	0.06	<0.01	0.58	0.17	<0.01	<0.01	0.01	<0.01	0.79	<0.01	27	T2	Zn
3	627.16	-305.73			130.72				<0.01	<0.01			<0.01				0.68	<0.01	27	T2	Zn
4	249.32	-295.31			146.63	0.00	-527.03	0.00	0.10	<0.01			<0.01	<0.01	0.01	<0.01	0.76	<0.01	27	T2	Zn

[a] p values for the individual independent variables were obtained from 2-tailed t-statistic.

[b] p_{Reg} refers to p value for the entire model obtained from F-statistic.

[c] Count is the number of events considered.

[d] In form column **D** denotes dissolved and **P** denotes particulate phase. Also, 1, 2, and 3 are linear, semi-log, and inverse forms respectively.

[e] M denotes the metal parameter.

Appendix C-10a. Regression Models Developed for Caltrans Zone 10 for Dissolved/Particulate[a] Metal EMCs.

Model	Coefficent								p value[b]								R^2	pReg[c]	Count[d]	Form[e]	M[f]
	Intercept	T_RAIN (mm)	MAX_RAIN (mm/hr)	D_RUN (hr)	ADD (day)	RC (-)	AREA (ha)	ADT ($\times 10^5$ vehicles/day)	Intercept	T_RAIN	MAX_RAIN	D_RUN	ADD	RC	AREA	ADT					
1	0.24	0.13	1.48	1.02	-0.67				0.03	0.91	0.46	0.01	0.31				0.11	0.03	92	P3	Cd
2	-2.61	0.00	0.01	0.00	0.00	2.54	0.15	0.45	<0.01	0.52	0.09	0.27	0.83	<0.01	<0.01	<0.01	0.30	<0.01	92	P1	Cd
3	0.34	1.54			-0.52				<0.01	0.05		<0.01	0.41				0.04	0.15	94	P3	Cd
4	-2.24	0.00			0.00	2.28	0.13	0.38	0.01	0.92		<0.01	0.46	0.01	<0.01	<0.01	0.21	<0.01	94	P1	Cd
1	2.59	-0.01	-0.01	0.03	0.01				<0.01	0.51	0.52	0.09	0.03				0.12	0.02	92	D1	Cr
2	-7.86	-0.01	0.00	0.03	0.00	9.09	0.21	1.87	0.04	0.31	0.96	0.07	0.90	0.01	0.28	<0.01	0.36	<0.01	92	D1	Cr
3	2.65	0.00			0.01				<0.01	0.60		<0.01	0.01				0.07	0.03	96	D1	Cr
4	1.32	1.28			1.83	0.10	0.16	-0.01	0.70	0.68		<0.01	0.30	0.96	<0.01	0.98	0.32	<0.01	96	D3	Cr
1	14.95	-0.12	-0.06	0.11	0.16				<0.01	0.02	0.46	0.18	<0.01				0.40	<0.01	92	D1	Cu
2	42.05	-7.20	0.61	-1.92	0.55	257.14	7.23	59.91	<0.01	0.08	0.91	0.54	0.87	<0.01	0.01	<0.01	0.69	<0.01	92	P2	Cu
3	15.11	-0.11			0.16				<0.01	<0.01		<0.01	<0.01				0.38	<0.01	96	D1	Cu
4	46.85	62.22			-8.45	-36.48	1.09	-4.21	0.01	<0.01		<0.01	0.36	<0.01	<0.01	0.18	0.64	<0.01	96	P3	Cu
1	5.74	-0.04	0.00	0.00	0.05				<0.01	0.04	1.00	0.90	<0.01				0.26	<0.01	92	D1	Ni
2	-15.61	-0.04	0.02	0.01	0.04	18.56	1.29	2.32	0.03	0.03	0.62	0.79	<0.01	0.01	<0.01	<0.01	0.37	<0.01	92	D1	Ni
3	5.77	-0.04			0.04				<0.01	<0.01		<0.01	<0.01				0.24	<0.01	95	D1	Ni
4	-11.52	-0.03			0.04	15.09	1.14	1.82	0.09	0.01		<0.01	<0.01	0.02	<0.01	0.01	0.33	<0.01	95	D1	Ni
1	0.24	0.00	-0.03	0.09	0.07				0.83	0.95	0.48	0.02	<0.01				0.33	<0.01	92	D1	Pb
2	71.34	-10.25	-1.77	-3.69	-5.33	402.85	14.42	106.32	<0.01	0.22	0.87	0.56	0.42	<0.01	0.01	<0.01	0.59	<0.01	92	P2	Pb
3	0.62	0.01			0.07				0.40	0.50		<0.01	<0.01				0.28	<0.01	96	D1	Pb
4	69.23	122.42			1.16	-52.91	1.41	-12.23	0.05	<0.01		<0.01	0.95	0.03	0.01	0.05	0.56	<0.01	96	P3	Pb
1	57.48	242.27	64.72	237.32	-205.79				<0.01	0.25	0.86	<0.01	0.08				0.23	<0.01	92	P3	Zn
2	1496.15	135.42	82.27	235.28	-142.43	-848.87	-16.61	-246.45	<0.01	0.47	0.79	<0.01	0.19	<0.01	<0.01	<0.01	0.44	<0.01	92	P3	Zn
3	90.17	-0.67			0.22				<0.01	<0.01		<0.01	0.08				0.18	<0.01	96	D1	Zn
4	66.32	-0.63			0.34	58.13	-11.13	-23.70	0.41	<0.01		<0.01	0.01	0.46	0.01	<0.01	0.32	<0.01	96	D1	Zn

[a]For some metal parameters, the dissolved metal models were better than the particulate models, and vice versa. Dissolved/Particulate means either the dissolved or the particulate model was presented.

[b]p values for the individual independent variables were obtained from 2-tailed t-statistic. [c]p_{Reg} refers to p value for the entire model obtained from F-statistic. [d]Count is the number of events considered. [e]In form column **D** denotes dissolved and **P** denotes particulate phase. Also, 1, 2, and 3 are linear, semi-log, and inverse forms respectively.

[f]M denotes the metal parameter.

Appendix C-10b. Regression Models Developed for Caltrans Zone 10 for Total Metal EMCs.

Model	Coefficent								p value[a]								R^2	p_{Reg}[b]	Count[c]	Form[d]	M[e]
	Intercept	T_RAIN (mm)	MAX_RAIN (mm/hr)	D_RUN (hr)	ADD (day)	RC (-)	AREA (ha)	ADT ($\times 10^5$ vehicles/day)	Intercept	T_RAIN	MAX_RAIN	D_RUN	ADD	RC	AREA	ADT					
1	0.59	0.00	0.01	0.00	0.00				<0.01	0.49	0.38	0.69	0.06				0.05	0.31	92	T1	Cd
2	-3.01	0.00	0.01	0.00	0.00	2.95	0.25	0.55	0.02	0.32	0.10	0.69	0.54	0.02	<0.01	<0.01	0.24	<0.01	92	T1	Cd
3	0.66	0.00			0.00				<0.01	0.65			0.12				0.03	0.26	94	T1	Cd
4	-2.41	0.00			0.00	2.55	0.23	0.46	0.06	0.88			0.84	0.04	<0.01	<0.01	0.18	<0.01	94	T1	Cd
1	4.90	-0.01	0.01	0.04	0.03				<0.01	0.77	0.71	0.33	0.02				0.08	0.12	92	T1	Cr
2	-21.83	-0.01	0.04	0.04	0.01	23.60	0.92	3.68	<0.01	0.62	0.29	0.26	0.63	<0.01	0.02	<0.01	0.29	<0.01	92	T1	Cr
3	5.48	0.01			0.03				<0.01	0.65			0.03				0.05	0.07	96	T1	Cr
4	12.83	-1.98			-3.32	-5.71	0.18	-0.76	0.08	0.76			0.37	0.25	0.10	0.55	0.22	<0.01	96	T3	Cr
1	40.02	-13.80	-18.91	-4.61	32.41				<0.01	0.14	0.13	0.52	<0.01				0.28	<0.01	92	T2	Cu
2	67.55	-15.19	-6.00	2.52	10.20	376.59	7.81	82.70	<0.01	0.01	0.43	0.56	0.03	<0.01	0.03	<0.01	0.75	<0.01	92	T2	Cu
3	29.21	-21.77			24.48				<0.01	<0.01			<0.01				0.22	<0.01	96	T2	Cu
4	104.86	98.72			-19.40	-70.08	1.41	-10.97	<0.01	<0.01			0.14	<0.01	<0.01	0.02	0.69	<0.01	96	T3	Cu
1	7.99	-0.06	0.03	0.00	0.07				<0.01	0.03	0.50	0.93	<0.01				0.24	<0.01	92	T1	Ni
2	-30.19	-0.07	0.06	0.00	0.05	33.67	1.87	4.33	<0.01	0.02	0.17	0.97	<0.01	<0.01	<0.01	<0.01	0.41	<0.01	92	T1	Ni
3	8.50	-0.05			0.06				<0.01	0.01			<0.01				0.21	<0.01	95	T1	Ni
4	-22.56	-0.04			0.04	27.70	1.57	3.34	0.02	0.02			0.01	<0.01	<0.01	<0.01	0.33	<0.01	95	T1	Ni
1	34.70	-5.05	-24.14	-10.52	27.41				0.06	0.68	0.15	0.28	<0.01				0.14	0.01	92	T2	Pb
2	74.64	-8.21	-5.35	-1.88	-1.92	466.29	16.20	119.43	<0.01	0.33	0.64	0.77	0.77	<0.01	<0.01	<0.01	0.64	<0.01	92	T2	Pb
3	18.20	-18.83			19.69				0.12	0.01			0.01				0.10	0.01	96	T2	Pb
4	88.65	110.30			-4.01	-64.89	1.59	-14.61	0.02	<0.01			0.83	0.01	<0.01	0.02	0.60	<0.01	96	T3	Pb
1	231.22	-125.26	48.90	-60.79	86.48				<0.01	0.01	0.45	0.10	0.02				0.22	<0.01	92	T2	Zn
2	2203.25	174.81	422.74	277.11	-300.48	-1238.66	-25.41	-345.53	<0.01	0.50	0.33	<0.01	0.05	<0.01	<0.01	<0.01	0.41	<0.01	92	T3	Zn
3	250.16	-122.83			65.11				<0.01	<0.01			0.04				0.17	<0.01	96	T2	Zn
4	-191.74	-1.27			0.29	442.01	-22.82	-4.96	0.33	<0.01			0.35	0.02	0.03	0.79	0.30	<0.01	96	T1	Zn

[a] p values for the individual independent variables were obtained from 2-tailed t-statistic.

[b] p_{Reg} refers to p value for the entire model obtained from F-statistic.

[c] Count is the number of events considered.

[d] In form column **D** denotes dissolved and **P** denotes particulate phase. Also, 1, 2, and 3 are linear, semi-log, and inverse forms respectively.

[e] M denotes the metal parameter.

Appendix C-11a. Regression Models Developed for Caltrans Zone 11 for Dissolved/Particulate[a] Metal EMCs.

Model	Coefficent								p value[b]								R^2	pReg[c]	Count[d]	Form[e]	M[f]
	Intercept	T_RAIN (mm)	MAX_RAIN (mm/hr)	D_RUN (hr)	ADD (day)	RC (-)	AREA (ha)	ADT ($\times 10^5$ vehicles/day)	Intercept	T_RAIN	MAX_RAIN	D_RUN	ADD	RC	AREA	ADT					
1	1.17	-0.69	0.27	-0.18	0.09				<0.01	<0.01	0.39	0.21	0.45				0.54	<0.01	37	P2	Cd
2	0.36	-0.59	0.33	-0.21	0.08	1.06	-0.73	0.00	0.81	<0.01	0.29	0.15	0.47	0.68	0.62	<0.01	0.61	<0.01	37	P2	Cd
3	1.36	-0.58			-0.08				<0.01	<0.01		<0.01	0.49				0.42	<0.01	39	P2	Cd
4	1.12	-0.59			0.01	2.02	-0.08	0.50	0.33	<0.01		<0.01	0.90	0.41	0.96	0.51	0.57	<0.01	39	P2	Cd
1	5.95	-3.68	0.82	-1.95	3.79				0.06	0.03	0.78	0.12	<0.01				0.42	<0.01	37	P2	Cr
2	26.78	-3.76	1.47	-1.21	3.51	40.32	21.00	0.00	0.06	0.03	0.61	0.36	<0.01	0.10	0.13	<0.01	0.48	<0.01	37	P2	Cr
3	6.48	-4.05			2.81				<0.01	<0.01		<0.01	0.01				0.37	<0.01	39	P2	Cr
4	27.08	-3.60			2.80	47.84	25.45	14.37	0.01	<0.01		<0.01	0.01	0.04	0.05	0.05	0.45	<0.01	39	P2	Cr
1	26.82	-7.79	-16.90	0.12	17.57				<0.01	0.04	0.01	0.97	<0.01				0.70	<0.01	37	D2	Cu
2	30.22	-6.67	-15.84	0.24	17.30	37.90	4.45	0.00	0.34	0.08	0.02	0.94	<0.01	0.48	0.88	<0.01	0.72	<0.01	37	D2	Cu
3	10.52	-7.63			11.93				0.04	0.02		<0.01	<0.01				0.41	<0.01	41	D2	Cu
4	86.99	-20.15			0.57	190.27	53.52	48.18	0.04	<0.01		<0.01	0.86	0.03	0.28	0.08	0.62	<0.01	41	P2	Cu
1	0.32	3.23	91.22	0.17	-19.54				0.66	0.40	<0.01	0.88	<0.01				0.69	<0.01	37	D3	Ni
2	1.93	2.24	85.62	0.16	-19.56	-2.21	0.14	0.00	0.83	0.56	<0.01	0.88	<0.01	0.65	0.72	<0.01	0.72	<0.01	37	D3	Ni
3	3.40	-2.59			2.98				0.02	<0.01		<0.01	<0.01				0.38	<0.01	39	D2	Ni
4	1.77	-3.09			3.94	11.44	-0.01	5.14	0.81	<0.01		<0.01	<0.01	0.46	1.00	0.29	0.60	<0.01	39	D2	Ni
1	34.93	-16.96	0.20	-7.29	10.00				<0.01	<0.01	0.98	0.02	<0.01				0.69	<0.01	37	P2	Pb
2	63.59	-15.91	2.09	-6.27	9.38	87.93	29.96	0.00	0.06	<0.01	0.75	0.05	<0.01	0.12	0.35	<0.01	0.73	<0.01	37	P2	Pb
3	32.39	-16.81			4.48				<0.01	<0.01		<0.01	0.10				0.47	<0.01	40	P2	Pb
4	75.56	-16.39			5.11	134.03	55.86	43.07	0.01	<0.01		<0.01	0.03	0.02	0.08	0.02	0.66	<0.01	40	P2	Pb
1	253.18	-185.11	99.94	-71.20	48.48				0.02	<0.01	0.29	0.09	0.19				0.51	<0.01	37	P2	Zn
2	-88.20	-4.30	7.09	-2.52	0.19	315.40	-506.68	0.00	0.85	<0.01	<0.01	0.09	0.55	0.38	0.72	<0.01	0.62	<0.01	37	P1	Zn
3	320.76	-161.85			1.14				<0.01	<0.01		<0.01	0.97				0.37	<0.01	41	P2	Zn
4	330.87	-138.23			-3.14	834.47	32.90	112.60	0.33	<0.01		<0.01	0.91	0.25	0.94	0.61	0.51	<0.01	41	P2	Zn

[a]For some metal parameters, the dissolved metal models were better than the particulate models, and vice versa. Dissolved/Particulate means either the dissolved or the particulate model was presented.

[b]p values for the individual independent variables were obtained from 2-tailed t-statistic. [c]p_{Reg} refers to p value for the entire model obtained from F-statistic. [d]Count is the number of events considered. [e]In form column **D** denotes dissolved and **P** denotes particulate phase. Also, 1, 2, and 3 are linear, semi-log, and inverse forms respectively.

[f]M denotes the metal parameter.

Appendix C-11b. Regression Models Developed for Caltrans Zone 11 for Total Metal EMCs.

Model	Coefficent								p value[a]								R^2	pReg[b]	Count[c]	Form[d]	M[e]
	Intercept	T_RAIN (mm)	MAX_RAIN (mm/hr)	D_RUN (hr)	ADD (day)	RC (-)	AREA (ha)	ADT (×10[5] vehicles/day)	Intercept	T_RAIN	MAX_RAIN	D_RUN	ADD	RC	AREA	ADT					
1	1.73	-0.81	0.01	-0.18	0.25				<0.01	<0.01	0.99	0.36	0.15				0.48	<0.01	37	T2	Cd
2	0.52	-0.67	0.08	-0.22	0.24	1.39	-1.09	0.00	0.80	0.01	0.85	0.27	0.15	0.70	0.59	<0.01	0.56	<0.01	37	T2	Cd
3	1.65	-0.73			0.03				<0.01	<0.01			0.83				0.36	<0.01	39	T2	Cd
4	1.15	-0.75			0.18	2.69	-0.28	0.69	0.46	<0.01			0.24	0.41	0.88	0.50	0.55	<0.01	39	T2	Cd
1	8.40	-5.43	2.13	-2.30	5.45				0.07	0.03	0.61	0.21	<0.01				0.39	<0.01	37	T2	Cr
2	55.65	14.56	50.14	1.18	-23.92	-27.23	-2.06	0.00	0.02	0.12	0.15	0.66	<0.01	0.03	0.04	<0.01	0.44	0.01	37	T3	Cr
3	9.56	-4.81			3.73				<0.01	<0.01			<0.01				0.32	<0.01	41	T2	Cr
4	33.26	-4.47			3.53	56.25	29.23	18.36	0.03	0.01			0.01	0.09	0.11	0.07	0.40	<0.01	41	T2	Cr
1	70.29	-32.29	-8.18	-11.25	25.47				<0.01	<0.01	0.58	0.08	<0.01				0.66	<0.01	37	T2	Cu
2	83.19	-27.44	-3.61	-10.78	24.32	161.04	17.46	0.00	0.21	<0.01	0.79	0.09	<0.01	0.15	0.78	<0.01	0.74	<0.01	37	T2	Cu
3	56.04	-30.45			13.53				<0.01	<0.01			0.02				0.40	<0.01	41	T2	Cu
4	110.46	-26.71			11.91	265.56	70.56	66.90	0.05	<0.01			0.01	0.03	0.29	0.07	0.65	<0.01	41	T2	Cu
1	-1.52	29.87	248.57	-0.89	-53.09				0.80	0.34	0.03	0.92	0.05				0.24	0.06	37	T3	Ni
2	-10.01	25.41	231.78	-0.46	-52.98	-0.92	1.16	0.00	0.90	0.43	0.06	0.96	0.06	0.98	0.72	<0.01	0.26	0.14	37	T3	Ni
3	17.76	-11.54			5.50				0.03	0.02			0.21				0.15	0.05	40	T2	Ni
4	12.01	-10.85			5.87	32.89	-5.01	4.46	0.82	0.05			0.19	0.77	0.94	0.90	0.19	0.19	40	T2	Ni
1	40.52	-16.54	-4.87	-5.96	12.93				<0.01	<0.01	0.56	0.11	<0.01				0.62	<0.01	37	T2	Pb
2	71.80	-14.86	-2.36	-4.85	12.15	110.56	33.18	0.00	0.08	<0.01	0.77	0.20	<0.01	0.11	0.39	<0.01	0.68	<0.01	37	T2	Pb
3	32.74	-16.00			6.78				<0.01	<0.01			0.03				0.38	<0.01	41	T2	Pb
4	78.75	-14.29			5.94	160.54	58.04	45.36	0.02	<0.01			0.02	0.02	0.13	0.03	0.60	<0.01	41	T2	Pb
1	434.03	-233.64	-60.86	-47.94	164.50				0.01	0.01	0.66	0.43	<0.01				0.49	<0.01	37	T2	Zn
2	-380.91	452.88	3282.25	47.95	-730.51	-4.78	44.95	0.00	0.55	0.10	<0.01	0.54	<0.01	0.99	0.11	<0.01	0.65	<0.01	37	T3	Zn
3	361.92	-210.97			78.16				<0.01	<0.01			0.08				0.33	<0.01	41	T2	Zn
4	187.87	-162.67			72.56	1230.66	-173.23	54.97	0.69	<0.01			0.06	0.22	0.76	0.86	0.55	<0.01	41	T2	Zn

[a] p values for the individual independent variables were obtained from 2-tailed t-statistic.

[b] p_{Reg} refers to p value for the entire model obtained from F-statistic.

[c] Count is the number of events considered.

[d] In form column **D** denotes dissolved and **P** denotes particulate phase. Also, 1, 2, and 3 are linear, semi-log, and inverse forms respectively.

[e] M denotes the metal parameter.

Appendix C-12a. Regression Models Developed for Caltrans Zone 12 for Dissolved/Particulate[a] Metal EMCs.

Model	Coefficent								p value[b]								R^2	pReg[c]	Count[d]	Form[e]	M[f]
	Intercept	T_RAIN (mm)	MAX_RAIN (mm/hr)	D_RUN (hr)	ADD (day)	RC (-)	AREA (ha)	ADT (×10^5 vehicles/day)	Intercept	T_RAIN	MAX_RAIN	D_RUN	ADD	RC	AREA	ADT					
1	1.84	-0.86	-0.07	-0.14	0.04				<0.01	<0.01	0.81	0.41	0.81				0.52	<0.01	38	P2	Cd
2	-9.13	-0.01	0.00	0.00	0.00	5.72	75.76	0.00	<0.01	0.05	0.38	0.40	0.17	<0.01	0.01	<0.01	0.65	<0.01	38	P1	Cd
3	1.77	-0.96			0.00				<0.01	<0.01		<0.01	0.99				0.51	<0.01	38	P2	Cd
4	-9.00	-0.01			0.00	5.63	73.91	0.00	<0.01	<0.01		<0.01	0.17	<0.01	0.01	<0.01	0.63	<0.01	38	P1	Cd
1	5.21	-2.96	0.79	-0.07	0.48				0.01	0.03	0.60	0.94	0.58				0.25	0.04	38	P2	Cr
2	-28.62	-0.04	0.00	-0.01	0.00	16.05	289.88	0.00	0.09	0.10	0.84	0.57	0.91	0.06	0.04	<0.01	0.34	0.04	38	P1	Cr
3	5.77	-2.54			0.36				<0.01	<0.01		<0.01	0.65				0.24	0.01	38	P2	Cr
4	-27.50	-0.05			0.00	15.58	278.05	0.00	0.09	0.01		<0.01	0.78	0.06	0.04	<0.01	0.33	0.01	38	P1	Cr
1	51.18	-1.69	-23.94	-7.74	9.08				<0.01	0.79	<0.01	0.06	0.03				0.57	<0.01	38	D2	Cu
2	-278.89	-0.46	-0.02	-0.06	0.05	185.27	2253.34	0.00	0.02	0.01	0.91	0.68	0.45	<0.01	0.03	<0.01	0.63	<0.01	38	P1	Cu
3	58.73	-33.99			3.58				<0.01	<0.01		<0.01	0.56				0.48	<0.01	38	P2	Cu
4	-272.71	-0.49			0.04	182.76	2189.22	0.00	0.02	<0.01		<0.01	0.49	<0.01	0.02	<0.01	0.63	<0.01	38	P1	Cu
1	15.46	-4.33	-4.67	-1.21	2.18				<0.01	0.01	0.02	0.25	0.05				0.69	<0.01	38	D2	Ni
2	59.62	-3.29	-4.86	-1.13	2.21	34.36	36.47	0.00	0.14	0.06	0.01	0.29	0.04	0.15	0.26	<0.01	0.72	<0.01	38	D2	Ni
3	11.99	-7.40			2.34				<0.01	<0.01		<0.01	0.03				0.63	<0.01	38	D2	Ni
4	50.29	-6.55			2.41	30.25	31.74	0.00	0.23	<0.01		<0.01	0.03	0.23	0.35	<0.01	0.65	<0.01	38	D2	Ni
1	111.02	-27.15	-21.98	-22.89	8.76				<0.01	0.13	0.28	0.05	0.45				0.43	<0.01	38	P2	Pb
2	1077.09	-14.95	-25.79	-27.25	10.21	573.21	791.28	0.00	0.01	0.41	0.18	0.02	0.35	0.02	0.02	<0.01	0.52	<0.01	38	P2	Pb
3	62.83	-1.04			0.04				<0.01	<0.01		<0.01	0.74				0.36	<0.01	38	P1	Pb
4	-455.60	-0.83			0.02	276.67	4126.51	0.00	0.04	<0.01		<0.01	0.86	0.02	0.03	<0.01	0.46	<0.01	38	P1	Pb
1	85.13	-0.34	-0.93	-0.58	0.52				<0.01	0.23	<0.01	0.02	<0.01				0.67	<0.01	38	D1	Zn
2	-314.87	-0.05	-0.97	-0.54	0.49	246.55	2692.61	0.00	0.05	0.83	<0.01	0.01	<0.01	<0.01	0.05	<0.01	0.79	<0.01	38	D1	Zn
3	69.28	-0.99			0.51				<0.01	<0.01		<0.01	<0.01				0.54	<0.01	38	D1	Zn
4	-1685.27	-3.26			0.44	1109.32	13644.92	0.00	0.01	<0.01		<0.01	0.25	<0.01	0.02	<0.01	0.67	<0.01	38	P1	Zn

[a]For some metal parameters, the dissolved metal models were better than the particulate models, and vice versa. Dissolved/Particulate means either the dissolved or the particulate model was presented.

[b]p values for the individual independent variables were obtained from 2-tailed t-statistic. [c]p_{Reg} refers to p value for the entire model obtained from F-statistic. [d]Count is the number of events considered. [e]In form column **D** denotes dissolved and **P** denotes particulate phase. Also, 1, 2, and 3 are linear, semi-log, and inverse forms respectively.

[f]M denotes the metal parameter.

Appendix C-12b. Regression Models Developed for Caltrans Zone 12 for Total Metal EMCs.

Model	Coefficent								p value[a]								R^2	p_{Reg}[b]	Count[c]	Form[d]	M[e]
	Intercept	T_RAIN (mm)	MAX_RAIN (mm/hr)	D_RUN (hr)	ADD (day)	RC (-)	AREA (ha)	ADT ($\times 10^5$ vehicles/day)	Intercept	T_RAIN	MAX_RAIN	D_RUN	ADD	RC	AREA	ADT					
1	2.69	-0.94	-0.36	-0.36	0.11				<0.01	0.01	0.39	0.12	0.64				0.53	<0.01	38	T2	Cd
2	-12.76	-0.01	-0.01	-0.01	0.00	8.12	105.22	0.00	<0.01	0.09	0.12	0.11	0.07	<0.01	<0.01	<0.01	0.72	<0.01	38	T1	Cd
3	2.39	-1.27			0.03				<0.01	<0.01			0.89				0.49	<0.01	38	T2	Cd
4	-12.41	-0.02			0.00	7.90	100.61	0.00	<0.01	<0.01			0.09	<0.01	<0.01	<0.01	0.69	<0.01	38	T1	Cd
1	7.70	10.60	-8.60	-2.12	-10.89				<0.01	0.34	0.51	0.40	0.06				0.15	0.25	38	T3	Cr
2	-28.75	-0.06	0.01	0.01	0.00	16.03	349.28	0.00	0.26	0.12	0.74	0.87	0.88	0.22	0.11	<0.01	0.21	0.25	38	T1	Cr
3	7.21	4.38			-10.82				<0.01	0.43			0.05				0.13	0.10	38	T3	Cr
4	-28.59	-0.05			0.00	16.09	349.23	0.00	0.24	0.06			0.85	0.20	0.10	<0.01	0.21	0.09	38	T1	Cr
1	107.34	-36.35	-19.53	-12.93	14.96				<0.01	0.01	0.17	0.11	0.07				0.64	<0.01	38	T2	Cu
2	509.41	-24.51	-21.39	-10.86	15.06	354.26	333.57	0.00	0.07	0.04	0.09	0.14	0.04	0.03	0.14	<0.01	0.73	<0.01	38	T2	Cu
3	91.93	-52.00			12.99				<0.01	<0.01			0.10				0.61	<0.01	38	T2	Cu
4	-209.18	-0.85			0.15	176.32	1741.04	0.00	0.14	<0.01			0.07	0.02	0.14	<0.01	0.71	<0.01	38	T1	Cu
1	22.52	-10.99	-2.54	-0.95	3.24				<0.01	<0.01	0.37	0.54	0.05				0.72	<0.01	38	T2	Ni
2	108.48	-9.27	-2.90	-0.97	3.32	61.96	70.81	0.00	0.07	<0.01	0.29	0.54	0.04	0.08	0.14	<0.01	0.75	<0.01	38	T2	Ni
3	20.60	-12.77			3.23				<0.01	<0.01			0.04				0.71	<0.01	38	T2	Ni
4	100.60	-11.30			3.35	58.72	66.13	0.00	0.08	<0.01			0.03	0.09	0.16	<0.01	0.74	<0.01	38	T2	Ni
1	133.62	2.41	-50.12	-39.84	13.40				<0.01	0.92	0.07	0.01	0.38				0.33	0.01	38	T2	Pb
2	1497.26	20.27	-55.53	-45.63	15.39	819.99	1117.32	0.00	0.01	0.39	0.03	<0.01	0.28	0.01	0.02	<0.01	0.45	<0.01	38	T2	Pb
3	75.16	-0.99			0.04				<0.01	<0.01			0.80				0.22	0.01	38	T1	Pb
4	-558.28	-0.73			0.02	338.28	5038.39	0.00	0.06	0.04			0.91	0.03	0.05	<0.01	0.33	0.01	38	T1	Pb
1	426.53	-288.26	53.75	-36.54	61.62				<0.01	<0.01	0.46	0.38	0.14				0.62	<0.01	38	T2	Zn
2	-2061.14	-3.84	0.22	-0.40	1.02	1367.86	16787.99	0.00	<0.01	<0.01	0.82	0.61	0.01	<0.01	<0.01	<0.01	0.78	<0.01	38	T1	Zn
3	460.79	-270.64			42.63				<0.01	<0.01			0.29				0.59	<0.01	38	T2	Zn
4	-1995.21	-3.96			0.93	1344.97	16157.72	0.00	<0.01	<0.01			0.02	<0.01	<0.01	<0.01	0.77	<0.01	38	T1	Zn

[a] p values for the individual independent variables were obtained from 2-tailed t-statistic.

[b] p_{Reg} refers to p value for the entire model obtained from F-statistic.

[c] Count is the number of events considered.

[d] In form column **D** denotes dissolved and **P** denotes particulate phase. Also, 1, 2, and 3 are linear, semi-log, and inverse forms respectively.

[e] M denotes the metal parameter.

Appendix C-13a. Regression Models Developed for Caltrans Zone 1 for Dissolved/Particulate[a] Metal EMCs.

Model	Coefficent								p value[b]								R^2	pReg[c]	Count[d]	Form[e]	M[f]
	Intercept	T_RAIN (mm)	MAX_RAIN (mm/hr)	D_RUN (hr)	ADD (day)	RC (-)	AREA (ha)	ADT (×10^5 vehicles/day)	Intercept	T_RAIN	MAX_RAIN	D_RUN	ADD	RC	AREA	ADT					
1	0.10	-0.41	1.58	0.06	0.12				0.27	0.64	0.03	0.78	0.26				0.20	0.20	31	D3	Cd
2	43.88	0.00	0.01	0.00	0.01	-46.33	4.87	-5.98	<0.01	0.71	0.29	0.94	0.16	<0.01	<0.01	<0.01	0.52	0.01	31	P1	Cd
3	0.22	0.00			0.00				<0.01	0.92		<0.01	0.21				0.06	0.41	31	D1	Cd
4	41.70	0.00			0.01	-44.03	4.64	-5.65	<0.01	0.59		<0.01	0.18	<0.01	<0.01	<0.01	0.49	<0.01	31	P1	Cd
1	0.70	13.44	1.66	1.92	2.00				0.42	0.13	0.81	0.39	0.06				0.21	0.18	31	P3	Cr
2	102.08	-0.05	0.03	0.02	0.00	-107.71	12.18	-13.86	<0.01	0.02	0.07	0.39	0.91	<0.01	<0.01	<0.01	0.71	<0.01	31	P1	Cr
3	1.08	14.76			1.80				0.16	0.05		<0.01	0.07				0.18	0.06	31	P3	Cr
4	-16.49	-1.36			-0.17	-604.31	94.38	-138.45	<0.01	0.08		<0.01	0.70	<0.01	<0.01	<0.01	0.66	<0.01	31	P2	Cr
1	1.72	33.37	98.08	4.57	5.31				0.69	0.42	<0.01	0.71	0.38				0.48	<0.01	47	D3	Cu
2	796.96	65.67	76.55	-0.39	-2.27	-650.69	126.42	-214.94	0.10	0.08	<0.01	0.97	0.68	0.09	0.13	0.16	0.65	<0.01	47	D3	Cu
3	14.31	-0.17			0.40				<0.01	0.13		<0.01	<0.01				0.37	<0.01	49	D1	Cu
4	73.30	-0.21			0.36	-41.61	12.55	-22.15	0.63	0.04		<0.01	<0.01	0.80	0.41	0.25	0.54	<0.01	49	D1	Cu
1	2.80	0.03	-0.03	-0.05	0.15				0.01	0.58	0.43	0.37	<0.01				0.64	<0.01	31	D1	Ni
2	26.87	-0.02	0.00	-0.01	0.14	-21.18	5.30	-7.74	0.57	0.60	0.96	0.87	<0.01	0.68	0.27	0.22	0.78	<0.01	31	D1	Ni
3	2.36	-0.02			0.15				0.01	0.56		<0.01	<0.01				0.61	<0.01	31	D1	Ni
4	30.29	-0.03			0.14	-24.81	5.64	-8.21	0.46	0.25		<0.01	<0.01	0.57	0.17	0.13	0.78	<0.01	31	D1	Ni
1	34.67	-0.58	1.76	-0.18	-0.21				0.05	0.52	0.01	0.83	0.63				0.19	0.05	47	P1	Pb
2	3406.58	-1.09	1.81	0.61	0.09	-3639.57	368.48	-445.85	<0.01	0.15	<0.01	0.39	0.80	<0.01	<0.01	<0.01	0.53	<0.01	47	P1	Pb
3	3.70	-14.56			0.00				<0.01	0.09		<0.01	1.00				0.07	0.21	49	D3	Pb
4	13650.66	71.99			-22.49	-10892.91	2259.15	-4330.78	<0.01	0.72		<0.01	0.57	<0.01	<0.01	<0.01	0.35	<0.01	49	P3	Pb
1	83.74	1.09	-1.62	-1.00	4.21				0.03	0.57	0.27	0.56	<0.01				0.36	<0.01	47	D1	Zn
2	-2341.27	-0.59	-0.69	-0.09	3.34	2948.24	-172.72	97.42	0.06	0.65	0.46	0.94	<0.01	0.03	0.16	0.54	0.77	<0.01	47	D1	Zn
3	68.58	-0.53			4.23				0.04	0.64		<0.01	<0.01				0.35	<0.01	49	D1	Zn
4	-2383.80	-1.13			3.32	2994.48	-182.34	105.19	0.03	0.12		<0.01	<0.01	0.01	0.10	0.45	0.76	<0.01	49	D1	Zn

[a]For some metal parameters, the dissolved metal models were better than the particulate models, and vice versa. Dissolved/Particulate means either the dissolved or the particulate model was presented.

[b]p values for the individual independent variables were obtained from 2-tailed t-statistic. [c]p_{Reg} refers to p value for the entire model obtained from F-statistic. [d]Count is the number of events considered. [e]In form column **D** denotes dissolved and **P** denotes particulate phase. Also, 1, 2, and 3 are linear, semi-log, and inverse forms respectively.

[f]M denotes the metal parameter.

Appendix C-13b. Regression Models Developed for Caltrans Zone 13 for Total Metal EMCs.

Model	Coefficent								p value[a]								R^2	pReg[b]	Count[c]	Form[d]	M[e]
	Intercept	T_RAIN (mm)	MAX_RAIN (mm/hr)	D_RUN (hr)	ADD (day)	RC (-)	AREA (ha)	ADT (×10[5] vehicles/day)	Intercept	T_RAIN	MAX_RAIN	D_RUN	ADD	RC	AREA	ADT					
1	0.50	-1.47	3.97	0.90	0.66				0.18	0.69	0.18	0.33	0.13				0.15	0.35	31	T3	Cd
2	43.78	0.00	0.01	0.00	0.01	-45.74	5.07	-6.24	<0.01	0.65	0.22	0.74	0.06	<0.01	<0.01	<0.01	0.61	<0.01	31	T1	Cd
3	0.80	1.35			0.46				0.02	0.66			0.28				0.04	0.55	31	T3	Cd
4	42.38	0.00			0.01	-44.27	4.91	-6.01	<0.01	0.68			0.08	<0.01	<0.01	<0.01	0.58	<0.01	31	T1	Cd
1	2.52	16.24	5.51	4.32	3.33				0.20	0.40	0.72	0.38	0.15				0.12	0.47	31	T3	Cr
2	253.32	-0.05	0.04	0.01	0.04	-269.12	26.86	-31.65	<0.01	0.35	0.36	0.81	0.15	<0.01	<0.01	<0.01	0.61	<0.01	31	T1	Cr
3	3.44	20.44			2.82				0.05	0.20			0.19				0.09	0.28	31	T3	Cr
4	238.20	-0.01			0.03	-253.13	25.30	-29.44	<0.01	0.67			0.16	<0.01	<0.01	<0.01	0.60	<0.01	31	T1	Cr
1	33.54	27.27	72.97	-8.67	24.15				<0.01	0.79	0.21	0.78	0.12				0.10	0.36	47	T3	Cu
2	1465.48	-0.49	0.32	0.52	0.41	-1517.22	177.93	-216.00	<0.01	0.17	0.22	0.12	0.02	<0.01	<0.01	<0.01	0.52	<0.01	47	T1	Cu
3	24.58	234.03			30.41				0.04	0.03			0.12				0.12	0.05	49	T3	Cu
4	6392.47	237.09			0.25	-5116.96	1038.40	-1962.66	<0.01	0.01			0.99	<0.01	<0.01	<0.01	0.47	<0.01	49	T3	Cu
1	0.52	6.09	72.31	-2.50	5.19				0.81	0.77	<0.01	0.64	0.04				0.53	<0.01	31	T3	Ni
2	268.10	-0.09	0.04	0.05	0.17	-276.52	31.08	-39.26	<0.01	0.14	0.45	0.42	<0.01	<0.01	<0.01	<0.01	0.75	<0.01	31	T1	Ni
3	7.29	-0.04			0.15				<0.01	0.42			<0.01				0.39	<0.01	31	T1	Ni
4	239.26	-0.04			0.17	-245.92	28.19	-35.16	<0.01	0.24			<0.01	<0.01	<0.01	<0.01	0.74	<0.01	31	T1	Ni
1	37.25	-0.54	1.76	-0.21	-0.23				0.04	0.55	0.01	0.80	0.62				0.19	0.05	47	T1	Pb
2	3480.74	-1.06	1.81	0.59	0.08	-3717.05	374.68	-453.94	<0.01	0.17	<0.01	0.40	0.82	<0.01	<0.01	<0.01	0.53	<0.01	47	T1	Pb
3	65.17	0.15			-0.55				0.01	0.85			0.39				0.02	0.64	49	T1	Pb
4	13835.02	57.98			-22.59	-11037.60	2292.38	-4392.56	<0.01	0.77			0.57	<0.01	<0.01	<0.01	0.35	<0.01	49	T3	Pb
1	209.11	0.79	-0.60	7.19	3.77				0.06	0.89	0.88	0.15	0.17				0.10	0.33	47	T1	Zn
2	7236.59	-1.18	-0.66	9.08	4.14	-7392.74	996.95	-1198.07	0.18	0.83	0.87	0.09	0.13	0.20	0.07	0.09	0.23	0.14	47	T1	Zn
3	326.16	1.79			2.79				<0.01	0.64			0.36				0.02	0.64	49	T1	Zn
4	7159.36	0.63			3.45	-7217.59	1083.08	-1244.17	0.20	0.86			0.25	0.23	0.06	0.08	0.18	0.12	49	T1	Zn

[a] p values for the individual independent variables were obtained from 2-tailed t-statistic.

[b] p_{Reg} refers to p value for the entire model obtained from F-statistic.

[c] Count is the number of events considered.

[d] In form column **D** denotes dissolved and **P** denotes particulate phase. Also, 1, 2, and 3 are linear, semi-log, and inverse forms respectively.

[e] M denotes the metal parameter.

Appendix C-14a. Regression Models Developed for Caltrans Zone 14 for Dissolved/Particulate[a] Metal EMCs.

Model	Coefficent								p value[b]								R^2	pReg[c]	Count[d]	Form[e]	M[f]
	Intercept	T_RAIN (mm)	MAX_RAIN (mm/hr)	D_RUN (hr)	ADD (day)	RC (-)	AREA (ha)	ADT ($\times 10^5$ vehicles/day)	Intercept	T_RAIN	MAX_RAIN	D_RUN	ADD	RC	AREA	ADT					
1	0.37	3.31	-5.43	-0.08	1.23				<0.01	0.30	0.02	0.68	0.06				0.26	0.06	35	P3	Cd
2	-0.97	1.61	-0.65	-0.06	-0.04	0.32	0.03	0.00	0.04	0.14	0.38	0.35	0.85	0.05	0.01	<0.01	0.39	0.02	35	D3	Cd
3	0.05	4.16			-0.71				0.30	<0.01		<0.01	0.03				0.56	<0.01	41	D3	Cd
4	-0.20	6.19			-1.03	0.03	0.01	-0.05	0.59	<0.01		<0.01	0.01	0.83	0.23	0.09	0.63	<0.01	41	D3	Cd
1	-8.86	4.64	4.35	2.40	-0.85				0.09	0.49	0.49	0.31	0.63				0.35	0.01	35	P2	Cr
2	-9.13	0.07	0.16	-0.05	0.00	-3.38	219.98	0.00	0.62	0.37	0.20	0.40	0.93	0.77	0.23	<0.01	0.62	<0.01	35	P1	Cr
3	1.15	1.82			-0.03				0.37	0.02		<0.01	0.95				0.13	0.06	44	D2	Cr
4	11.29	-5.96			-16.20	4.02	-0.44	-1.29	0.09	0.79		<0.01	0.02	0.17	0.01	0.15	0.37	<0.01	43	P3	Cr
1	19.14	-0.36	0.40	-0.04	0.20				<0.01	0.02	0.13	0.72	<0.01				0.81	<0.01	35	D1	Cu
2	29.16	-0.33	0.31	-0.01	0.21	3.52	-238.06	26.51	0.42	0.03	0.21	0.94	<0.01	0.88	0.51	<0.01	0.85	<0.01	35	D1	Cu
3	21.74	-13.04			14.01				0.02	0.02		<0.01	<0.01				0.37	<0.01	45	D2	Cu
4	16.44	-0.22			0.12	16.14	-66.01	0.96	0.37	0.01		<0.01	<0.01	0.13	<0.01	0.94	0.60	<0.01	45	D1	Cu
1	8.28	-7.00	0.61	-0.17	5.29				<0.01	0.06	0.85	0.89	<0.01				0.65	<0.01	35	D2	Ni
2	-10.90	-6.81	0.03	0.27	5.34	-7.53	-14.13	0.00	0.71	0.07	0.99	0.83	<0.01	0.69	0.50	<0.01	0.67	<0.01	35	D2	Ni
3	7.32	-3.98			2.70				0.01	0.01		<0.01	0.01				0.28	<0.01	42	D2	Ni
4	-20.40	102.99			-25.39	7.38	0.68	0.61	<0.01	<0.01		<0.01	<0.01	0.01	<0.01	0.20	0.47	<0.01	42	D3	Ni
1	18.39	43.69	-176.82	-8.37	36.84				<0.01	0.78	0.11	0.39	0.24				0.24	0.08	35	P3	Pb
2	-55.79	-0.05	0.58	-0.19	-0.01	20.49	821.48	0.00	0.17	0.74	0.04	0.15	0.80	0.42	0.05	<0.01	0.50	<0.01	35	P1	Pb
3	6.91	242.81			-37.44				0.20	<0.01		<0.01	0.18				0.29	<0.01	45	P3	Pb
4	58.30	207.02			-47.08	-6.72	-1.69	-9.09	0.02	0.01		<0.01	0.05	0.53	<0.01	<0.01	0.54	<0.01	45	P3	Pb
1	139.83	1409.07	-2005.26	-5.53	363.03				<0.01	0.17	0.01	0.93	0.08				0.33	0.02	35	P3	Zn
2	-1194.85	4552.94	-922.44	-77.76	-443.86	311.42	41.83	0.00	0.09	0.01	0.40	0.44	0.17	0.20	0.03	<0.01	0.55	<0.01	35	D3	Zn
3	169.63	-114.04			76.91				0.05	0.04		<0.01	0.02				0.20	0.01	46	D2	Zn
4	-18.83	-0.90			0.66	385.71	-552.37	-119.26	0.92	0.28		<0.01	<0.01	<0.01	0.01	0.33	0.45	<0.01	46	D1	Zn

[a] For some metal parameters, the dissolved metal models were better than the particulate models, and vice versa. Dissolved/Particulate means either the dissolved or the particulate model was presented.

[b] p values for the individual independent variables were obtained from 2-tailed t-statistic. [c] p_{Reg} refers to p value for the entire model obtained from F-statistic. [d] Count is the number of events considered. [e] In form column **D** denotes dissolved and **P** denotes particulate phase. Also, 1, 2, and 3 are linear, semi-log, and inverse forms respectively.

[f] M denotes the metal parameter.

Appendix C-14b. Regression Models Developed for Caltrans Zone 14 for Total Metal EMCs.

Model	Coefficent								p value[a]								R^2	p_{Reg}[b]	Count[c]	Form[d]	M[e]
	Intercept	T_RAIN (mm)	MAX_RAIN (mm/hr)	D_RUN (hr)	ADD (day)	RC (-)	AREA (ha)	ADT ($\times 10^5$ vehicles/day)	Intercept	T_RAIN	MAX_RAIN	D_RUN	ADD	RC	AREA	ADT					
1	0.51	4.64	-7.45	-0.01	1.80				<0.01	0.18	<0.01	0.95	0.01				0.34	0.01	35	T3	Cd
2	-1.47	4.83	-7.58	0.02	1.84	0.77	0.05	0.00	0.31	0.16	<0.01	0.92	0.01	0.13	0.23	<0.01	0.41	0.01	35	T3	Cd
3	0.22	7.15			-1.11				0.08	<0.01			0.14				0.42	<0.01	43	T3	Cd
4	0.91	7.80			-1.25	-0.14	-0.02	-0.19	0.21	<0.01			0.10	0.64	0.31	<0.01	0.53	<0.01	43	T3	Cd
1	-7.55	5.54	4.81	2.59	-0.50				0.20	0.46	0.50	0.33	0.80				0.36	0.01	35	T2	Cr
2	14.25	0.07	0.19	-0.05	0.00	-17.20	39.06	0.00	0.50	0.42	0.19	0.42	1.00	0.20	0.85	<0.01	0.62	<0.01	35	T1	Cr
3	5.70	0.11			0.00				<0.01	0.01			0.91				0.18	0.01	45	T1	Cr
4	13.77	-12.49			-14.87	5.30	-0.43	-1.56	0.04	0.59			<0.01	0.08	0.01	0.03	0.40	<0.01	45	T3	Cr
1	39.57	-47.27	26.26	0.63	25.24				<0.01	<0.01	0.06	0.90	<0.01				0.74	<0.01	35	T2	Cu
2	26.71	-46.87	25.39	1.18	25.33	-0.74	-9.78	0.00	0.83	<0.01	0.08	0.83	<0.01	0.99	0.91	<0.01	0.75	<0.01	35	T2	Cu
3	34.02	-14.93			17.22				0.01	0.05			<0.01				0.33	<0.01	45	T2	Cu
4	41.02	-29.35			17.56	12.93	-13.30	35.24	<0.01	<0.01			<0.01	0.63	0.22	0.05	0.50	<0.01	45	T2	Cu
1	4.07	-6.09	3.55	1.09	5.57				0.27	0.20	0.43	0.51	<0.01				0.52	<0.01	35	T2	Ni
2	-2.72	-0.04	0.18	-0.04	0.05	1.96	100.56	0.00	0.87	0.52	0.13	0.48	<0.01	0.85	0.54	<0.01	0.55	<0.01	35	T1	Ni
3	8.29	-2.68			2.85				0.01	0.15			0.02				0.18	0.02	44	T2	Ni
4	7.40	-3.36			2.77	-6.12	-1.11	-2.25	0.09	0.20			0.03	0.43	0.75	0.68	0.19	0.14	44	T2	Ni
1	21.47	41.57	-175.11	-9.15	36.77				<0.01	0.80	0.13	0.37	0.27				0.22	0.10	35	T3	Pb
2	-45.44	-0.05	0.58	-0.18	0.00	14.37	763.77	0.00	0.28	0.76	0.05	0.18	0.87	0.59	0.07	<0.01	0.50	<0.01	35	T1	Pb
3	8.21	230.59			-8.32				0.12	<0.01			0.65				0.25	<0.01	46	T3	Pb
4	69.50	177.96			-33.32	-8.62	-1.96	-9.70	<0.01	0.02			0.05	0.40	<0.01	<0.01	0.55	<0.01	46	T3	Pb
1	179.33	6394.17	-3465.93	47.13	47.32				<0.01	0.01	0.03	0.73	0.92				0.27	0.05	35	T3	Zn
2	-1414.70	6079.35	-3045.38	-54.36	-50.86	475.17	48.52	0.00	0.13	0.01	0.05	0.69	0.90	0.14	0.06	<0.01	0.41	0.02	35	T3	Zn
3	169.91	1171.06			-261.63				<0.01	0.01			0.06				0.18	0.01	46	T3	Zn
4	207.11	1958.51			-241.15	-92.22	5.27	-35.10	0.30	<0.01			0.09	0.30	0.26	0.05	0.34	<0.01	46	T3	Zn

[a] p values for the individual independent variables were obtained from 2-tailed t-statistic.

[b] p_{Reg} refers to p value for the entire model obtained from F-statistic.

[c] Count is the number of events considered.

[d] In form column **D** denotes dissolved and **P** denotes particulate phase. Also, 1, 2, and 3 are linear, semi-log, and inverse forms respectively.

[e] M denotes the metal parameter.

Appendix D-1. Regression Models Developed for Site 2-201.

Phase	Model	Coefficient					R^2	Count[b]	Form[c]	Parameter
		Intercept	T_RAIN (mm)	MAX_RAIN (mm/hr)	D_RUN (hr)	ADD (day)				
Dissolved/Particulate[a]	1	1.20	-0.60	-0.29	0.07	0.47	0.40	21.00	P2	Cd
	3	0.95	-0.59			0.48	0.37	21.00	P2	Cd
	1	3.70	-2.25	-1.43	1.35	2.46	0.53	21.00	P2	Cr
	3	2.68	-1.74			2.97	0.39	21.00	P2	Cr
	1	6.78	-9.89	6.15	4.23	6.23	0.36	21.00	D2	Cu
	3	13.49	-7.34			8.44	0.31	21.00	D2	Cu
	1	0.76	-0.08	0.07	0.10	0.10	0.51	21.00	D1	Ni
	3	2.69	-1.70			2.60	0.25	21.00	P2	Ni
	1	12.01	-17.79	1.46	6.64	12.38	0.45	21.00	P2	Pb
	3	14.93	-14.50			15.38	0.41	21.00	P2	Pb
	1	56.65	-96.85	48.87	34.32	69.48	0.41	21.00	P2	Zn
	3	110.15	-76.25			87.37	0.37	21.00	P2	Zn
Total	1	1.29	-0.68	-0.20	0.08	0.63	0.34	21.00	T2	Cd
	3	1.12	-0.66			0.65	0.33	21.00	T2	Cd
	1	1.92	-0.07	0.04	0.09	0.19	0.50	21.00	T1	Cr
	3	2.47	-1.09			3.85	0.38	21.00	T2	Cr
	1	32.32	-24.43	0.42	10.04	22.05	0.37	21.00	T2	Cu
	3	35.05	-19.62			26.48	0.34	21.00	T2	Cu
	1	3.99	-3.68	0.81	1.36	4.03	0.53	21.00	T2	Ni
	3	5.06	-2.96			4.67	0.50	21.00	T2	Ni
	1	11.91	-17.88	1.87	6.92	12.95	0.44	21.00	T2	Pb
	3	15.28	-14.42			16.10	0.40	21.00	T2	Pb
	1	96.46	-113.86	47.74	45.07	79.53	0.46	21.00	T2	Zn
	3	151.41	-88.25			102.08	0.42	21.00	T2	Zn

[a]For some metal parameters, the dissolved metal models were better than the particulate models, and vice versa. Dissolved/Particulate means either the dissolved or the particulate model was presented. [b]Count is the number of events considered. [c]**D** denotes dissolved, **P** denotes particulate, and **T** denotes total metal. Also, 1, 2, and 3 are linear, semi-log, and inverse forms respectively.

Appendix D-2. Regression Models Developed for Site 2-202.

Phase	Model	Coefficient					R^2	Count[b]	Form[c]	Parameter
		Intercept	T_RAIN (mm)	MAX_RAIN (mm/hr)	D_RUN (hr)	ADD (day)				
Dissolved/Particulate[a]	1	-0.08	0.00	2.50	0.63	-0.99	1.00	4.00	P3	Cd
	3	0.09	2.40			-0.36	0.98	4.00	P3	Cd
	1	7.36	0.00	-102.25	-17.88	46.44	1.00	4.00	P3	Cr
	3	1.68	-0.03			0.09	0.62	4.00	P1	Cr
	1	-0.23	0.00	-23.32	8.28	48.61	1.00	4.00	P3	Cu
	3	24.98	-14.19			2.76	1.00	4.00	P2	Cu
	1	1.16	0.00	-13.12	0.64	11.86	1.00	4.00	P3	Ni
	3	5.79	-3.46			1.35	1.00	4.00	P2	Ni
	1	21.60	0.00	-314.12	-47.71	122.36	1.00	4.00	P3	Pb
	3	2.91	-0.14			0.55	0.99	4.00	P1	Pb
	1	-18.65	0.00	183.33	93.50	49.63	1.00	4.00	P3	Zn
	3	72.94	-66.34			52.92	1.00	4.00	D2	Zn
Total	1	0.18	0.00	-1.59	0.60	0.94	1.00	4.00	T3	Cd
	3	1.19	-1.02			0.71	1.00	4.00	T2	Cd
	1	22.15	0.00	-311.50	-54.87	143.00	1.00	4.00	T3	Cr
	3	4.99	-0.08			0.26	0.59	4.00	T1	Cr
	1	4.88	0.00	21.58	27.49	9.23	1.00	4.00	T3	Cu
	3	39.36	-26.69			15.88	0.98	4.00	T2	Cu
	1	12.45	0.00	-127.69	-19.73	51.98	1.00	4.00	T3	Ni
	3	5.17	-0.06			0.20	0.97	4.00	T1	Ni
	1	30.13	0.00	-412.95	-64.59	155.67	1.00	4.00	T3	Pb
	3	3.81	-0.17			0.73	0.96	4.00	T1	Pb
	1	14.12	0.00	-170.28	86.80	189.28	1.00	4.00	T3	Zn
	3	176.21	-133.99			76.14	1.00	4.00	T2	Zn

[a]For some metal parameters, the dissolved metal models were better than the particulate models, and vice versa. Dissolved/Particulate means either the dissolved or the particulate model was presented. [b]Count is the number of events considered. [c]**D** denotes dissolved, **P** denotes particulate, and **T** denotes total metal. Also, 1, 2, and 3 are linear, semi-log, and inverse forms respectively.

Appendix D-3. Regression Models Developed for Site 2-203.

Phase	Model	Coefficient					R^2	Count[b]	Form[c]	Parameter
		Intercept	T_RAIN (mm)	MAX_RAIN (mm/hr)	D_RUN (hr)	ADD (day)				
Dissolved/Particulate[a]	1	-0.05	1.10	1.95	-0.22	-0.13	0.33	20.00	D3	Cd
	3	0.26	0.00			0.01	0.09	20.00	P1	Cd
	1	0.46	-0.01	0.02	-0.01	0.09	0.64	21.00	P1	Cr
	3	0.58	-0.01			0.09	0.62	21.00	P1	Cr
	1	4.11	-5.81	-0.75	4.07	3.11	0.45	20.00	D2	Cu
	3	3.78	-2.63			3.21	0.22	20.00	D2	Cu
	1	3.20	-1.20	-1.70	0.62	1.23	0.36	21.00	D2	Ni
	3	1.05	-0.01			0.07	0.29	21.00	P1	Ni
	1	1.23	-0.05	0.18	-0.01	0.19	0.31	20.00	P1	Pb
	3	2.39	-0.05			0.28	0.27	20.00	P1	Pb
	1	37.29	-20.35	-15.66	11.21	13.20	0.38	20.00	D2	Zn
	3	16.93	-0.45			2.72	0.32	20.00	P1	Zn
Total	1	1.25	-0.34	-0.76	0.10	0.31	0.24	21.00	T2	Cd
	3	0.70	-0.36			0.17	0.15	21.00	T2	Cd
	1	-0.04	-0.03	0.09	0.03	0.10	0.68	21.00	T1	Cr
	3	0.89	-0.02			0.16	0.56	21.00	T1	Cr
	1	4.65	-0.08	-0.07	0.07	0.41	0.38	21.00	T1	Cu
	3	4.75	-0.07			0.41	0.34	21.00	T1	Cu
	1	1.86	-3.30	1.05	1.80	1.93	0.54	21.00	T2	Ni
	3	1.43	-0.03			0.21	0.50	21.00	T1	Ni
	1	1.72	-0.06	0.20	-0.01	0.17	0.31	21.00	T1	Pb
	3	3.07	-0.05			0.27	0.28	21.00	T1	Pb
	1	36.49	-0.56	-0.25	-0.17	3.69	0.45	21.00	T1	Zn
	3	33.14	-0.61			3.48	0.44	21.00	T1	Zn

[a]For some metal parameters, the dissolved metal models were better than the particulate models, and vice versa. Dissolved/Particulate means either the dissolved or the particulate model was presented. [b]Count is the number of events considered. [c]**D** denotes dissolved, **P** denotes particulate, and **T** denotes total metal. Also, 1, 2, and 3 are linear, semi-log, and inverse forms respectively.

Appendix D-4. Regression Models Developed for Site 2-204.

Phase	Model	Coefficient					R^2	Count[b]	Form[c]	Parameter
		Intercept	T_RAIN (mm)	MAX_RAIN (mm/hr)	D_RUN (hr)	ADD (day)				
Dissolved/Particulate[a]	1	0.11	0.00	0.00	0.00	0.00	0.90	7.00	D1	Cd
	3	0.10	0.00			0.00	0.57	7.00	P1	Cd
	1	-0.04	-7.18	24.58	1.23	-1.74	0.75	7.00	D3	Cr
	3	0.70	-0.01			0.06	0.45	7.00	D1	Cr
	1	-0.76	-0.15	20.29	0.90	-0.96	0.76	7.00	P3	Cu
	3	0.76	0.00			-0.02	0.62	7.00	P1	Cu
	1							-1.00	P3	Ni
	3							-1.00	P3	Ni
	1							-1.00	P3	Pb
	3							-1.00	P3	Pb
	1	11.34	-0.01	-0.94	0.14	0.46	0.84	7.00	P1	Zn
	3	4.35	0.02			-0.01	0.14	7.00	D1	Zn
Total	1	0.11	0.00	0.00	0.00	0.00	0.90	7.00	T1	Cd
	3	0.12	-0.06			-0.02	0.05	7.00	T3	Cd
	1	-0.04	-7.18	24.58	1.23	-1.74	0.75	7.00	T3	Cr
	3	0.70	-0.01			0.06	0.45	7.00	T1	Cr
	1	-0.76	-4.55	70.54	2.87	-4.09	0.67	7.00	T3	Cu
	3	4.61	-1.52			0.80	0.24	7.00	T2	Cu
	1							-1.00	T3	Ni
	3							-1.00	T3	Ni
	1							-1.00	T3	Pb
	3							-1.00	T3	Pb
	1	-0.06	-17.51	148.38	13.98	-8.67	0.44	7.00	T3	Zn
	3	10.66	-2.53			1.56	0.07	7.00	T2	Zn

[a]For some metal parameters, the dissolved metal models were better than the particulate models, and vice versa. Dissolved/Particulate means either the dissolved or the particulate model was presented. [b]Count is the number of events considered. [c]**D** denotes dissolved, **P** denotes particulate, and **T** denotes total metal. Also, 1, 2, and 3 are linear, semi-log, and inverse forms respectively.

Appendix D-5. Regression Models Developed for Site 2-205.

Phase	Model	Coefficient					R^2	Count[b]	Form[c]	Parameter
		Intercept	T_RAIN (mm)	MAX_RAIN (mm/hr)	D_RUN (hr)	ADD (day)				
Dissolved/Particulate[a]	1	0.16	0.00	-0.01	0.00	0.01	1.00	5.00	D1	Cd
	3	0.09	0.00			0.01	0.97	5.00	D1	Cd
	1	-24.27	-880.80	832.19	227.24	-97.06	1.00	5.00	P3	Cr
	3	0.40	-0.01			0.10	0.97	5.00	D1	Cr
	1	-80.08	-2918.56	2724.97	751.53	-319.63	1.00	5.00	P3	Cu
	3	-0.01	0.02			-0.05	0.98	5.00	P1	Cu
	1							-1.00	P3	Ni
	3							-1.00	P3	Ni
	1	-0.12	0.02	0.04	-0.04	-0.01	1.00	5.00	P1	Pb
	3	0.29	0.02			-0.03	0.99	5.00	P1	Pb
	1	-589.82	-21193.88	19969.71	5449.17	-2330.33	1.00	5.00	P3	Zn
	3	0.02	0.16			-0.35	1.00	5.00	P1	Zn
Total	1	7.93	252.11	-251.07	-64.68	28.36	1.00	5.00	T3	Cd
	3	0.08	0.00			0.01	0.96	5.00	T1	Cd
	1	68.48	2160.30	-2168.59	-552.21	243.85	1.00	5.00	T3	Cr
	3	0.86	-0.01			0.08	0.68	5.00	T1	Cr
	1	-6.76	-569.88	394.36	157.21	-57.15	1.00	5.00	T3	Cu
	3	2.98	0.02			-0.04	0.29	5.00	T1	Cu
	1	-27.05	-1013.41	950.22	261.00	-111.38	1.00	5.00	T3	Ni
	3	0.91	0.01			-0.02	0.99	5.00	T1	Ni
	1	-78.03	-2837.54	2660.61	730.81	-311.86	1.00	5.00	T3	Pb
	3	0.25	0.02			-0.04	0.99	5.00	T1	Pb
	1	-376.85	-15010.13	13443.06	3897.76	-1625.28	1.00	5.00	T3	Zn
	3	4.36	0.16			-0.12	0.88	5.00	T1	Zn

[a]For some metal parameters, the dissolved metal models were better than the particulate models, and vice versa. Dissolved/Particulate means either the dissolved or the particulate model was presented. [b]Count is the number of events considered. [c]**D** denotes dissolved, **P** denotes particulate, and **T** denotes total metal. Also, 1, 2, and 3 are linear, semi-log, and inverse forms respectively.

Appendix D-6. Regression Models Developed for Site 2-206.

Phase	Model	Coefficient					R^2	Count[b]	Form[c]	Parameter
		Intercept	T_RAIN (mm)	MAX_RAIN (mm/hr)	D_RUN (hr)	ADD (day)				
Dissolved/Particulate[a]	1	0.90	-0.03	-0.83	0.02	0.23	1.00	6.00	D2	Cd
	3	0.10	0.00			0.00	0.50	6.00	P2	Cd
	1	-0.47	1.84	0.07	-0.68	-1.04	1.00	6.00	P2	Cr
	3	0.24	-1.03			0.70	0.59	6.00	P3	Cr
	1	-11.65	-10.81	19.32	4.85	-2.17	1.00	6.00	P2	Cu
	3	1.76	-0.06			0.08	0.16	6.00	P1	Cu
	1	2.43	-3.88	2.02	1.77	0.67	0.95	6.00	D2	Ni
	3	0.89	-0.84			-0.66	0.31	6.00	P3	Ni
	1							-1.00	P3	Pb
	3							-1.00	P3	Pb
	1	-8.90	56.61	187.53	-10.20	-14.02	1.00	6.00	P3	Zn
	3	5.63	-38.44			6.58	0.49	6.00	D3	Zn
Total	1	0.90	-0.03	-0.83	0.02	0.23	1.00	6.00	T2	Cd
	3	0.14	-0.15			-0.03	0.12	6.00	T3	Cd
	1	3.52	0.01	-0.26	-0.01	0.16	0.69	6.00	T1	Cr
	3	1.31	-4.56			0.40	0.27	6.00	T3	Cr
	1	7.84	-0.21	-0.31	0.10	0.43	0.94	6.00	T1	Cu
	3	5.19	-0.09			0.17	0.19	6.00	T1	Cu
	1	4.82	-3.60	-0.34	1.47	1.21	0.94	6.00	T2	Ni
	3	2.90	-0.04			0.07	0.30	6.00	T1	Ni
	1							-1.00	T3	Pb
	3							-1.00	T3	Pb
	1	8.34	29.35	-31.55	-11.06	4.32	0.53	6.00	T3	Zn
	3	7.97	-28.84			5.19	0.27	6.00	T3	Zn

[a]For some metal parameters, the dissolved metal models were better than the particulate models, and vice versa. Dissolved/Particulate means either the dissolved or the particulate model was presented. [b]Count is the number of events considered. [c]**D** denotes dissolved, **P** denotes particulate, and **T** denotes total metal. Also, 1, 2, and 3 are linear, semi-log, and inverse forms respectively.

Appendix D-7. Regression Models Developed for Site 2-207.

Phase	Model	Coefficient					R^2	Count[b]	Form[c]	Parameter
		Intercept	T_RAIN (mm)	MAX_RAIN (mm/hr)	D_RUN (hr)	ADD (day)				
Dissolved/Particulate[a]	1	0.04	-2.32	1.21	0.24	0.30	0.99	6.00	D3	Cd
	3	0.04	-0.09			0.37	0.98	6.00	D3	Cd
	1	0.63	-6.98	0.28	2.85	-0.05	1.00	6.00	D3	Cr
	3	0.20	22.90			-0.01	0.48	6.00	P3	Cr
	1	-0.84	82.04	19.44	3.45	-0.89	0.98	6.00	D3	Cu
	3	-0.85	118.10			0.17	0.92	6.00	D3	Cu
	1	0.16	29.50	-2.32	1.03	0.33	0.98	6.00	D3	Ni
	3	0.33	24.49			0.15	0.91	6.00	D3	Ni
	1	0.15	0.00	-0.01	0.02	0.19	0.70	6.00	P1	Pb
	3	0.40	0.02			0.14	0.38	6.00	P1	Pb
	1	3.26	194.09	20.83	42.15	0.00	0.92	6.00	D3	Zn
	3	7.65	214.14			-0.43	0.56	6.00	D3	Zn
Total	1	0.05	0.01	-0.01	0.01	0.02	0.90	6.00	T1	Cd
	3	0.17	2.81			0.34	0.66	6.00	T3	Cd
	1	2.14	-0.59	-0.60	0.13	1.09	0.77	6.00	T2	Cr
	3	2.63	-1.11			0.71	0.70	6.00	T2	Cr
	1	9.28	-0.06	-0.16	0.02	0.61	0.90	6.00	T1	Cu
	3	3.20	153.06			0.06	0.43	6.00	T3	Cu
	1	2.45	-0.04	-0.02	0.02	0.10	0.77	6.00	T1	Ni
	3	5.73	-2.59			0.43	0.54	6.00	T2	Ni
	1	0.26	0.01	-0.02	0.02	0.23	0.69	6.00	T1	Pb
	3	0.47	0.02			0.17	0.40	6.00	T1	Pb
	1	-8.12	0.26	-0.39	0.84	3.68	0.76	6.00	T1	Zn
	3	0.57	0.79			2.15	0.29	6.00	T1	Zn

[a]For some metal parameters, the dissolved metal models were better than the particulate models, and vice versa. Dissolved/Particulate means either the dissolved or the particulate model was presented. [b]Count is the number of events considered. [c]**D** denotes dissolved, **P** denotes particulate, and **T** denotes total metal. Also, 1, 2, and 3 are linear, semi-log, and inverse forms respectively.

Appendix D-8. Regression Models Developed for Site 4-213.

Phase	Model	Coefficient					R^2	Count[b]	Form[c]	Parameter
		Intercept	T_RAIN (mm)	MAX_RAIN (mm/hr)	D_RUN (hr)	ADD (day)				
Dissolved/Particulate[a]	1	0.18	0.21	0.33	-0.94	0.04	0.49	23.00	D3	Cd
	3	0.17	-0.19			0.06	0.30	23.00	D3	Cd
	1	-0.78	-0.02	0.01	-0.03	0.61	0.60	23.00	D1	Cr
	3	-1.18	-0.03			0.61	0.59	23.00	D1	Cr
	1	13.90	48.40	15.19	-51.69	1.44	0.44	23.00	D3	Cu
	3	13.20	24.83			2.76	0.31	23.00	D3	Cu
	1	2.35	-4.57	0.19	5.10	0.60	0.41	23.00	D2	Ni
	3	0.62	2.29			0.23	0.12	23.00	P2	Ni
	1	-0.01	-0.05	0.06	0.06	0.01	0.31	23.00	D1	Pb
	3	16.56	-29.38			0.02	0.04	23.00	P3	Pb
	1	33.28	-0.32	0.02	1.00	-0.33	0.57	23.00	D1	Zn
	3	51.94	-83.64			2.70	0.09	23.00	D3	Zn
Total	1	0.68	0.62	0.33	-2.46	-0.01	0.13	23.00	T3	Cd
	3	0.62	-0.73			0.05	0.03	23.00	T3	Cd
	1	0.39	-0.03	0.06	-0.02	0.69	0.63	23.00	T1	Cr
	3	0.38	-0.01			0.70	0.62	23.00	T1	Cr
	1	17.66	-29.32	10.14	32.36	8.43	0.19	23.00	T2	Cu
	3	39.19	-3.17			4.89	0.02	23.00	T2	Cu
	1	8.59	-3.42	0.97	-15.63	0.30	0.16	23.00	T3	Ni
	3	8.19	-12.65			0.59	0.10	23.00	T3	Ni
	1	0.67	-13.18	11.58	12.09	4.57	0.12	23.00	T2	Pb
	3	17.81	-32.20			0.13	0.05	23.00	T3	Pb
	1	33.21	-80.14	47.97	95.21	32.15	0.14	23.00	T2	Zn
	3	144.71	-212.46			2.67	0.05	23.00	T3	Zn

[a]For some metal parameters, the dissolved metal models were better than the particulate models, and vice versa. Dissolved/Particulate means either the dissolved or the particulate model was presented. [b]Count is the number of events considered. [c]**D** denotes dissolved, **P** denotes particulate, and **T** denotes total metal. Also, 1, 2, and 3 are linear, semi-log, and inverse forms respectively.

Appendix D-9. Regression Models Developed for Site 4-214.

Phase	Model	Coefficient					R^2	Count[b]	Form[c]	Parameter
		Intercept	T_RAIN (mm)	MAX_RAIN (mm/hr)	D_RUN (hr)	ADD (day)				
Dissolved/Particulate[a]	1									Cd
	3									Cd
	1	0.15	-18.05	11.58	0.00	-0.15	1.00	4.00	P3	Cr
	3	0.00	10.70			-0.36	0.94	4.00	P3	Cr
	1	0.57	679.44	-299.13	0.00	-11.77	1.00	4.00	P3	Cu
	3	-3.96	6.31			0.17	0.97	4.00	D2	Cu
	1	-0.77	127.53	-42.50	0.00	0.65	1.00	4.00	P3	Ni
	3	-0.24	21.98			1.43	0.86	4.00	P3	Ni
	1	1.48	187.50	-89.55	0.00	-5.14	1.00	4.00	P3	Pb
	3	-1.08	0.02			0.12	0.99	4.00	P1	Pb
	1	3.75	-444.06	186.04	0.00	5.12	1.00	4.00	P3	Zn
	3	7.28	0.01			0.54	0.58	4.00	D1	Zn
Total	1									Cd
	3									Cd
	1	2.19	176.32	-87.16	0.00	-0.35	1.00	4.00	T3	Cr
	3	3.28	-40.14			1.24	0.80	4.00	T3	Cr
	1	8.98	742.42	-367.13	0.00	-13.76	1.00	4.00	T3	Cu
	3	0.02	0.13			0.22	0.90	4.00	T1	Cu
	1	2.55	206.31	-105.86	0.00	-2.46	1.00	4.00	T3	Ni
	3	-4.21	3.92			0.15	0.82	4.00	T2	Ni
	1	1.61	220.92	-103.19	0.00	-3.19	1.00	4.00	T3	Pb
	3	0.09	0.03			0.05	0.80	4.00	T1	Pb
	1	10.63	1493.13	-645.25	0.00	-23.86	1.00	4.00	T3	Zn
	3	6.09	0.06			0.53	0.83	4.00	T1	Zn

[a]For some metal parameters, the dissolved metal models were better than the particulate models, and vice versa. Dissolved/Particulate means either the dissolved or the particulate model was presented. [b]Count is the number of events considered. [c]**D** denotes dissolved, **P** denotes particulate, and **T** denotes total metal. Also, 1, 2, and 3 are linear, semi-log, and inverse forms respectively.

Appendix D-10. Regression Models Developed for Site 4-34.

Phase	Model	Coefficient					R^2	Count[b]	Form[c]	Parameter
		Intercept	T_RAIN (mm)	MAX_RAIN (mm/hr)	D_RUN (hr)	ADD (day)				
Dissolved/Particulate[a]	1	0.18	-4.49	3.70	-0.23	-0.16	0.62	8.00	D3	Cd
	3	0.13	0.00			0.00	0.06	8.00	P1	Cd
	1	0.51	-7.63	8.14	-1.80	0.09	0.85	8.00	D3	Cr
	3	0.89	0.00			-0.01	0.37	8.00	D1	Cr
	1	2.89	-0.02	0.10	-0.13	0.24	0.83	8.00	D1	Cu
	3	1.90	-0.03			2.29	0.50	8.00	D2	Cu
	1	0.98	-2.12	2.66	0.01	0.10	0.86	8.00	P2	Ni
	3	0.73	-0.01			0.85	0.34	8.00	D2	Ni
	1	2.63	38.80	-40.35	0.44	0.36	0.68	8.00	P3	Pb
	3	0.42	0.00			0.01	0.32	8.00	D1	Pb
	1	2.00	964.81	-812.52	517.66	2.16	0.85	8.00	P3	Zn
	3	18.05	7.16			-4.95	0.05	8.00	D3	Zn
Total	1	0.32	-7.66	5.26	0.48	-0.24	0.65	8.00	T3	Cd
	3	0.31	-1.11			-0.10	0.12	8.00	T3	Cd
	1	0.85	0.00	-0.03	0.05	-0.03	0.58	8.00	T1	Cr
	3	1.04	6.28			-0.25	0.10	8.00	T3	Cr
	1	6.73	13.94	12.39	-7.44	-6.06	0.82	8.00	T3	Cu
	3	6.39	28.62			-5.87	0.81	8.00	T3	Cu
	1	0.45	-1.52	2.81	-0.12	1.08	0.96	8.00	T2	Ni
	3	0.50	0.91			1.09	0.53	8.00	T2	Ni
	1	3.21	37.71	-39.29	-0.56	0.28	0.70	8.00	T3	Pb
	3	3.38	-10.94			-0.75	0.17	8.00	T3	Pb
	1	108.03	-70.35	90.68	-71.55	14.53	0.60	8.00	T2	Zn
	3	43.09	11.46			-14.74	0.13	8.00	T3	Zn

[a]For some metal parameters, the dissolved metal models were better than the particulate models, and vice versa. Dissolved/Particulate means either the dissolved or the particulate model was presented. [b]Count is the number of events considered. [c]**D** denotes dissolved, **P** denotes particulate, and **T** denotes total metal. Also, 1, 2, and 3 are linear, semi-log, and inverse forms respectively.

Appendix D-11. Regression Models Developed for Site 4-35.

Phase	Model	Coefficient					R^2	Count[b]	Form[c]	Parameter
		Intercept	T_RAIN (mm)	MAX_RAIN (mm/hr)	D_RUN (hr)	ADD (day)				
Dissolved/Particulate[a]	1	0.15	0.00	0.01	0.00	0.00	0.20	24.00	P1	Cd
	3	0.29	0.00			0.00	0.04	24.00	P1	Cd
	1	2.88	-0.05	0.14	0.03	0.02	0.22	24.00	P1	Cr
	3	0.89	2.52			0.77	0.14	24.00	D3	Cr
	1	5.95	-0.04	-0.05	0.12	0.27	0.52	24.00	D1	Cu
	3	7.10	-0.01			0.25	0.46	24.00	D1	Cu
	1	3.44	-0.06	0.22	0.03	0.02	0.26	24.00	P1	Ni
	3	1.84	-0.01			0.05	0.23	24.00	D1	Ni
	1	5.19	-0.06	0.23	0.02	-0.02	0.20	24.00	P1	Pb
	3	7.24	-0.02			0.01	0.04	24.00	P1	Pb
	1	20.09	-0.14	-0.08	0.42	0.86	0.30	24.00	D1	Zn
	3	25.00	-0.02			0.80	0.26	24.00	D1	Zn
Total	1	0.28	0.00	0.01	0.00	0.00	0.21	24.00	T1	Cd
	3	0.43	0.00			0.00	0.07	24.00	T1	Cd
	1	4.24	-0.06	0.12	0.06	0.02	0.23	24.00	T1	Cr
	3	5.97	-0.02			0.03	0.10	24.00	T1	Cr
	1	13.62	-0.18	0.41	0.24	0.30	0.35	24.00	T1	Cu
	3	19.90	-0.04			0.33	0.22	24.00	T1	Cu
	1	5.06	-0.07	0.20	0.05	0.08	0.31	24.00	T1	Ni
	3	7.25	-0.02			0.10	0.19	24.00	T1	Ni
	1	5.89	-0.07	0.22	0.05	0.00	0.18	24.00	T1	Pb
	3	8.25	-0.02			0.02	0.05	24.00	T1	Pb
	1	91.68	-102.85	122.05	10.78	20.17	0.23	24.00	T2	Zn
	3	119.28	-0.38			1.04	0.12	24.00	T1	Zn

[a]For some metal parameters, the dissolved metal models were better than the particulate models, and vice versa. Dissolved/Particulate means either the dissolved or the particulate model was presented. [b]Count is the number of events considered. [c]**D** denotes dissolved, **P** denotes particulate, and **T** denotes total metal. Also, 1, 2, and 3 are linear, semi-log, and inverse forms respectively.

Appendix D-12. Regression Models Developed for Site 3-05.

Phase	Model	Coefficient					R^2	Count[b]	Form[c]	Parameter
		Intercept	T_RAIN (mm)	MAX_RAIN (mm/hr)	D_RUN (hr)	ADD (day)				
Dissolved/Particulate[a]	1	-0.30	0.09	-0.08	-0.01	0.04	0.82	7.00	D1	Cd
	3	0.04	0.00			0.02	0.66	7.00	D1	Cd
	1	10.03	99.23	-46.02	-90.26	-14.48	0.95	7.00	P3	Cr
	3	2.28	-0.03			0.00	0.27	7.00	D1	Cr
	1	-5.22	3.93	-3.40	-0.43	1.69	0.94	7.00	D1	Cu
	3	10.87	-0.20			0.77	0.80	7.00	D1	Cu
	1	-5.08	2.81	-2.40	-0.35	1.02	0.90	7.00	D1	Ni
	3	5.08	-0.11			0.40	0.71	7.00	D1	Ni
	1	-0.15	0.10	-0.08	-0.01	0.06	0.79	7.00	D1	Pb
	3	0.16	0.00			0.04	0.74	7.00	D1	Pb
	1	62.34	-2105.28	1276.81	559.88	-54.80	0.95	7.00	P3	Zn
	3	33.51	-0.83			6.41	0.76	7.00	D1	Zn
Total	1	0.07	0.09	-0.08	-0.01	0.03	0.98	7.00	T1	Cd
	3	0.36	-0.01			0.02	0.86	7.00	T1	Cd
	1	10.68	65.47	-13.14	-78.76	-15.64	0.99	7.00	T3	Cr
	3	4.34	25.46			-3.97	0.22	7.00	T3	Cr
	1	9.68	3.42	-2.98	-0.61	1.44	0.96	7.00	T1	Cu
	3	18.00	-0.24			0.80	0.89	7.00	T1	Cu
	1	-3.48	2.90	-2.49	-0.35	1.05	0.97	7.00	T1	Ni
	3	7.47	-0.13			0.40	0.76	7.00	T1	Ni
	1	1.16	0.08	-0.07	-0.02	0.17	0.68	7.00	T1	Pb
	3	1.28	0.00			0.16	0.68	7.00	T1	Pb
	1	-46.20	53.72	-44.71	-8.27	15.97	0.96	7.00	T1	Zn
	3	99.32	-0.98			5.73	0.65	7.00	T1	Zn

[a]For some metal parameters, the dissolved metal models were better than the particulate models, and vice versa. Dissolved/Particulate means either the dissolved or the particulate model was presented. [b]Count is the number of events considered. [c]**D** denotes dissolved, **P** denotes particulate, and **T** denotes total metal. Also, 1, 2, and 3 are linear, semi-log, and inverse forms respectively.

Appendix D-13. Regression Models Developed for Site 3-06.

Phase	Model	Coefficient					R^2	Count[b]	Form[c]	Parameter
		Intercept	T_RAIN (mm)	MAX_RAIN (mm/hr)	D_RUN (hr)	ADD (day)				
Dissolved/Particulate[a]	1	0.12	0.00	0.00	0.00	0.00	0.54	25.00	P1	Cd
	3	0.12	0.00			0.00	0.42	25.00	P1	Cd
	1	1.65	-25.93	30.02	0.47	-3.15	0.10	25.00	P3	Cr
	3	2.55	-0.02			0.01	0.03	25.00	P1	Cr
	1	17.53	-4.74	-9.95	2.53	13.32	0.75	25.00	D2	Cu
	3	9.09	-5.11			13.14	0.67	25.00	D2	Cu
	1	4.41	-2.26	-2.17	1.61	2.97	0.59	25.00	D2	Ni
	3	2.16	-1.27			3.10	0.52	25.00	D2	Ni
	1	0.30	6.70	1.75	-1.51	-0.07	0.54	25.00	D3	Pb
	3	1.56	-0.01			0.02	0.44	25.00	P1	Pb
	1	30.97	7.40	-31.41	-0.04	39.28	0.81	25.00	D2	Zn
	3	7.51	-1.83			37.42	0.70	25.00	D2	Zn
Total	1	0.28	-0.04	-0.26	0.17	0.16	0.56	25.00	T2	Cd
	3	0.02	0.05			0.17	0.32	25.00	T2	Cd
	1	4.37	0.02	-0.04	-0.05	0.00	0.08	25.00	T1	Cr
	3	3.77	-0.02			0.01	0.02	25.00	T1	Cr
	1	21.57	-4.99	-10.39	1.08	16.08	0.76	25.00	T2	Cu
	3	13.38	-6.95			15.64	0.70	25.00	T2	Cu
	1	6.36	-5.42	0.03	2.47	3.35	0.36	25.00	T2	Ni
	3	5.40	-2.93			3.74	0.34	25.00	T2	Ni
	1	2.39	0.00	-0.01	-0.02	0.02	0.55	25.00	T1	Pb
	3	2.20	-0.01			0.02	0.49	25.00	T1	Pb
	1	76.37	-0.54	-0.35	-0.08	0.85	0.56	25.00	T1	Zn
	3	71.28	-0.66			0.87	0.54	25.00	T1	Zn

[a]For some metal parameters, the dissolved metal models were better than the particulate models, and vice versa. Dissolved/Particulate means either the dissolved or the particulate model was presented. [b]Count is the number of events considered. [c]**D** denotes dissolved, **P** denotes particulate, and **T** denotes total metal. Also, 1, 2, and 3 are linear, semi-log, and inverse forms respectively.

Appendix D-14. Regression Models Developed for Site 3-07.

Phase	Model	Coefficient					R^2	Count[b]	Form[c]	Parameter
		Intercept	T_RAIN (mm)	MAX_RAIN (mm/hr)	D_RUN (hr)	ADD (day)				
Dissolved/Particulate[a]	1	0.11	0.00	0.00	0.00	0.00	0.34	22.00	D1	Cd
	3	0.10	0.00			0.00	0.27	22.00	D1	Cd
	1	14.22	-0.72	0.11	0.56	0.14	0.36	22.00	P1	Cr
	3	27.19	-14.60			1.78	0.24	22.00	P2	Cr
	1	9.58	-0.28	-0.03	0.36	0.27	0.41	22.00	D1	Cu
	3	8.60	-0.04			0.35	0.23	22.00	D1	Cu
	1	23.09	-22.95	7.11	7.73	-1.47	0.36	22.00	P2	Ni
	3	27.51	-13.47			-1.15	0.28	22.00	P2	Ni
	1	0.84	12.31	-3.38	-3.37	-0.42	0.61	22.00	D3	Pb
	3	0.47	7.99			-0.35	0.51	22.00	D3	Pb
	1	167.58	-5.16	0.59	4.10	0.10	0.27	22.00	P1	Zn
	3	267.83	-113.07			2.68	0.21	22.00	P2	Zn
Total	1	0.70	-0.02	0.01	0.02	0.01	0.22	22.00	T1	Cd
	3	0.73	0.00			0.01	0.05	22.00	T1	Cd
	1	21.98	-29.34	12.04	11.61	1.94	0.33	22.00	T2	Cr
	3	29.26	-14.34			2.41	0.21	22.00	T2	Cr
	1	43.65	-1.50	0.20	1.37	0.53	0.37	22.00	T1	Cu
	3	67.86	-27.57			8.67	0.21	22.00	T2	Cu
	1	23.06	-26.03	9.38	9.77	0.46	0.34	22.00	T2	Ni
	3	28.83	-13.83			0.86	0.24	22.00	T2	Ni
	1	31.87	-35.71	15.75	18.86	1.86	0.24	22.00	T2	Pb
	3	41.89	-13.45			2.69	0.10	22.00	T2	Pb
	1	296.01	-244.41	59.82	93.99	14.38	0.35	22.00	T2	Zn
	3	337.18	-143.77			18.82	0.28	22.00	T2	Zn

[a]For some metal parameters, the dissolved metal models were better than the particulate models, and vice versa. Dissolved/Particulate means either the dissolved or the particulate model was presented. [b]Count is the number of events considered. [c]**D** denotes dissolved, **P** denotes particulate, and **T** denotes total metal. Also, 1, 2, and 3 are linear, semi-log, and inverse forms respectively.

Appendix D-15. Regression Models Developed for Site 3-213.

Phase	Model	Coefficient					R^2	Count[b]	Form[c]	Parameter
		Intercept	T_RAIN (mm)	MAX_RAIN (mm/hr)	D_RUN (hr)	ADD (day)				
Dissolved/Particulate[a]	1	0.29	-1.82	2.78	-0.53	-0.02	0.27	21.00	P3	Cd
	3	0.20	-0.18			-0.12	0.06	21.00	D3	Cd
	1	7.79	120.09	-48.11	12.10	-4.74	0.72	21.00	D3	Cr
	3	4.71	98.66			-3.94	0.66	21.00	D3	Cr
	1	12.64	-20.92	4.57	-5.31	-7.50	0.21	21.00	P3	Cu
	3	12.37	-19.25			-7.14	0.19	21.00	P3	Cu
	1	0.88	-0.01	0.01	0.03	0.06	0.23	21.00	D1	Ni
	3	1.25	0.00			0.06	0.13	21.00	D1	Ni
	1	0.44	-0.01	0.00	0.01	0.00	0.38	21.00	D1	Pb
	3	4.78	-7.79			-0.87	0.10	21.00	P3	Pb
	1	34.97	-0.31	0.62	-0.17	2.21	0.24	21.00	P1	Zn
	3	35.56	-0.18			2.31	0.22	21.00	P1	Zn
Total	1	0.48	-2.29	2.96	-0.66	-0.15	0.32	21.00	T3	Cd
	3	0.69	-0.96			-0.21	0.07	21.00	T3	Cd
	1	11.67	103.67	-47.64	21.74	-5.88	0.63	21.00	T3	Cr
	3	9.95	83.31			-6.10	0.52	21.00	T3	Cr
	1	8.01	-0.04	0.18	0.05	0.33	0.19	21.00	T1	Cu
	3	9.34	0.03			0.36	0.13	21.00	T1	Cu
	1	2.51	-0.02	0.02	0.02	0.14	0.26	21.00	T1	Ni
	3	2.78	-0.01			0.14	0.25	21.00	T1	Ni
	1	2.07	-0.03	0.17	0.00	0.11	0.33	21.00	T1	Pb
	3	2.81	0.02			0.13	0.10	21.00	T1	Pb
	1	38.40	-0.38	0.86	0.21	2.61	0.24	21.00	T1	Zn
	3	44.58	-0.05			2.75	0.21	21.00	T1	Zn

[a]For some metal parameters, the dissolved metal models were better than the particulate models, and vice versa. Dissolved/Particulate means either the dissolved or the particulate model was presented. [b]Count is the number of events considered. [c]**D** denotes dissolved, **P** denotes particulate, and **T** denotes total metal. Also, 1, 2, and 3 are linear, semi-log, and inverse forms respectively.

Appendix D-16. Regression Models Developed for Site 3-214.

Phase	Model	Coefficient					R^2	Count[b]	Form[c]	Parameter
		Intercept	T_RAIN (mm)	MAX_RAIN (mm/hr)	D_RUN (hr)	ADD (day)				
Dissolved/Particulate[a]	1	0.05	-1.05	0.28	0.79	0.83	1.00	5.00	P3	Cd
	3	-0.22	4.55			1.27	0.95	5.00	D3	Cd
	1	1.01	-14.29	4.38	4.13	1.88	1.00	5.00	P3	Cr
	3	9.02	-0.23			-0.20	0.98	5.00	D1	Cr
	1	12.59	3.43	-32.61	0.88	-11.34	1.00	5.00	P3	Cu
	3	16.07	-50.75			-27.08	0.91	5.00	D3	Cu
	1	4.59	-10.73	-9.27	1.21	-3.93	1.00	5.00	P3	Ni
	3	3.24	-0.08			0.01	0.93	5.00	D1	Ni
	1	3.56	-15.82	-0.72	5.81	-7.10	1.00	5.00	P3	Pb
	3	2.19	-0.05			-0.06	0.47	5.00	D1	Pb
	1	-26.06	76.02	71.70	137.53	54.66	1.00	5.00	P3	Zn
	3	66.16	-272.49			-117.07	0.96	5.00	D3	Zn
Total	1	-0.24	3.41	0.44	0.99	2.20	1.00	5.00	T3	Cd
	3	3.31	-1.35			-1.20	0.70	5.00	T2	Cd
	1	3.21	4.76	-1.86	6.40	1.30	1.00	5.00	T3	Cr
	3	11.52	-0.23			-0.28	0.69	5.00	T1	Cr
	1	25.83	-53.19	-21.11	6.07	-35.61	1.00	5.00	T3	Cu
	3	24.20	-62.61			-37.71	0.56	5.00	T3	Cu
	1	4.06	1.96	-4.36	3.89	-3.43	1.00	5.00	T3	Ni
	3	9.31	-0.20			-0.21	0.73	5.00	T1	Ni
	1	4.30	-18.32	-0.61	7.71	-9.12	1.00	5.00	T3	Pb
	3	9.16	-0.23			-0.25	0.40	5.00	T1	Pb
	1	47.41	-178.20	34.56	128.85	-67.75	1.00	5.00	T3	Zn
	3	146.24	-3.37			-3.65	0.43	5.00	T1	Zn

[a]For some metal parameters, the dissolved metal models were better than the particulate models, and vice versa. Dissolved/Particulate means either the dissolved or the particulate model was presented. [b]Count is the number of events considered. [c]**D** denotes dissolved, **P** denotes particulate, and **T** denotes total metal. Also, 1, 2, and 3 are linear, semi-log, and inverse forms respectively.

Appendix D-17. Regression Models Developed for Site 3-224.

Phase	Model	Coefficient					R^2	Count[b]	Form[c]	Parameter
		Intercept	T_RAIN (mm)	MAX_RAIN (mm/hr)	D_RUN (hr)	ADD (day)				
Dissolved/Particulate[a]	1	-0.01	0.00	0.00	0.00	0.01	0.75	11.00	P1	Cd
	3	0.10	0.00			0.00	0.82	11.00	D3	Cd
	1	-0.90	42.22	16.77	-25.11	6.94	0.84	11.00	P3	Cr
	3	1.55	-0.01			0.01	0.11	11.00	D1	Cr
	1	5.21	0.02	-0.01	0.02	0.52	0.95	11.00	D1	Cu
	3	5.02	0.02			0.54	0.95	11.00	D1	Cu
	1	1.52	0.01	-0.01	0.02	0.17	0.86	11.00	D1	Ni
	3	1.41	0.01			0.18	0.83	11.00	D1	Ni
	1	3.49	-1.21	-2.98	3.55	-1.26	0.68	11.00	D2	Pb
	3	1.83	0.05			0.30	0.20	11.00	P1	Pb
	1	29.00	0.28	-0.32	-0.37	0.98	0.86	11.00	D1	Zn
	3	17.32	0.02			1.25	0.72	11.00	D1	Zn
Total	1	0.02	0.00	0.00	0.00	0.01	0.70	11.00	T1	Cd
	3	0.06	0.00			0.01	0.66	11.00	T1	Cd
	1	0.18	38.94	25.49	-26.59	6.80	0.76	11.00	T3	Cr
	3	3.51	0.00			0.05	0.04	11.00	T1	Cr
	1	3.03	-0.06	0.09	0.13	0.97	0.87	11.00	T1	Cu
	3	6.46	0.02			0.91	0.84	11.00	T1	Cu
	1	1.02	-0.04	0.03	0.09	0.31	0.81	11.00	T1	Ni
	3	2.54	0.00			0.30	0.75	11.00	T1	Ni
	1	9.40	78.41	-22.14	-53.88	-4.88	0.36	11.00	T3	Pb
	3	2.59	0.05			0.37	0.24	11.00	T1	Pb
	1	3.84	-0.26	0.43	0.38	5.05	0.87	11.00	T1	Zn
	3	18.43	0.05			4.66	0.85	11.00	T1	Zn

[a]For some metal parameters, the dissolved metal models were better than the particulate models, and vice versa. Dissolved/Particulate means either the dissolved or the particulate model was presented. [b]Count is the number of events considered. [c]**D** denotes dissolved, **P** denotes particulate, and **T** denotes total metal. Also, 1, 2, and 3 are linear, semi-log, and inverse forms respectively.

Appendix D-18. Regression Models Developed for Site 3-202.

Phase	Model	Coefficient					R^2	Count[b]	Form[c]	Parameter
		Intercept	T_RAIN (mm)	MAX_RAIN (mm/hr)	D_RUN (hr)	ADD (day)				
Dissolved/Particulate[a]	1	0.81	0.46	-0.98	0.13	0.15	0.46	14.00	P2	Cd
	3	0.08	0.00			0.00	0.44	14.00	D1	Cd
	1	8.84	-0.13	-0.06	0.20	-0.01	0.48	14.00	P1	Cr
	3	11.57	-0.11			-0.07	0.30	14.00	P1	Cr
	1	13.95	3.23	-33.44	-9.29	-3.83	0.52	14.00	D3	Cu
	3	11.67	-20.78			-4.98	0.32	14.00	D3	Cu
	1	4.50	2.36	-11.18	-4.69	-1.34	0.45	14.00	D3	Ni
	3	3.60	-5.88			-1.83	0.26	14.00	D3	Ni
	1	-0.37	0.08	0.01	0.02	-0.02	0.70	14.00	D1	Pb
	3	-0.06	0.09			-0.02	0.66	14.00	D1	Pb
	1	166.25	-694.35	1224.74	-356.55	10.70	0.41	14.00	P3	Zn
	3	270.25	-1.90			-2.08	0.24	14.00	P1	Zn
Total	1	0.89	0.60	-1.10	0.15	0.14	0.45	14.00	T2	Cd
	3	0.71	0.01			-0.01	0.25	14.00	T1	Cd
	1	13.59	-0.10	-0.09	0.16	0.01	0.28	14.00	T1	Cr
	3	15.75	-0.10			-0.07	0.18	14.00	T1	Cr
	1	37.23	-0.39	0.29	0.37	-0.24	0.20	14.00	T1	Cu
	3	42.30	-0.24			-0.08	0.07	14.00	T1	Cu
	1	9.55	-1.60	-3.97	7.63	1.36	0.33	14.00	T2	Ni
	3	15.51	-0.11			-0.04	0.12	14.00	T1	Ni
	1	20.88	-0.27	-0.03	0.45	-0.13	0.45	14.00	T1	Pb
	3	27.06	-0.20			-0.21	0.31	14.00	T1	Pb
	1	258.73	-1.64	-0.02	3.79	-2.19	0.38	14.00	T1	Zn
	3	310.21	-0.93			-2.69	0.31	14.00	T1	Zn

[a]For some metal parameters, the dissolved metal models were better than the particulate models, and vice versa. Dissolved/Particulate means either the dissolved or the particulate model was presented. [b]Count is the number of events considered. [c]**D** denotes dissolved, **P** denotes particulate, and **T** denotes total metal. Also, 1, 2, and 3 are linear, semi-log, and inverse forms respectively.

Appendix D-19. Regression Models Developed for Site 3-203.

Phase	Model	Coefficient					R^2	Count[b]	Form[c]	Parameter
		Intercept	T_RAIN (mm)	MAX_RAIN (mm/hr)	D_RUN (hr)	ADD (day)				
Dissolved/Particulate[a]	1	0.04	0.03	-0.01	-0.01	0.01	0.80	9.00	P1	Cd
	3	-0.02	0.01			0.01	0.75	9.00	P1	Cd
	1	13.26	-3.60	9.01	1.70	-8.50	0.72	9.00	P2	Cr
	3	7.92	-1.02			9.94	0.37	9.00	P3	Cr
	1	46.93	11.27	-18.16	-35.08	0.72	0.72	9.00	D2	Cu
	3	14.59	8.08			14.54	0.18	9.00	P3	Cu
	1	4.91	-4.72	9.71	4.71	-6.05	0.71	9.00	P2	Ni
	3	5.43	-3.22			7.12	0.32	9.00	P3	Ni
	1	22.05	22.09	-75.77	17.16	36.70	0.80	9.00	P3	Pb
	3	21.84	-21.67			18.59	0.22	9.00	P3	Pb
	1	96.08	-17.13	110.91	32.33	-100.51	0.96	9.00	P2	Zn
	3	114.06	59.29			-68.50	0.56	9.00	P2	Zn
Total	1	0.11	0.03	-0.01	-0.02	0.01	0.86	9.00	T1	Cd
	3	0.00	0.01			0.01	0.79	9.00	T1	Cd
	1	13.00	10.45	-27.60	2.43	13.65	0.68	9.00	T3	Cr
	3	11.38	-3.01			8.38	0.31	9.00	T3	Cr
	1	23.75	72.87	-83.01	25.89	25.01	0.56	9.00	T3	Cu
	3	36.28	-7.88			0.83	0.02	9.00	T2	Cu
	1	9.10	12.87	-21.73	3.43	9.15	0.60	9.00	T3	Ni
	3	8.44	1.28			4.48	0.12	9.00	T3	Ni
	1	23.45	19.57	-69.41	18.13	33.77	0.72	9.00	T3	Pb
	3	24.23	-22.07			16.34	0.18	9.00	T3	Pb
	1	109.44	62.39	-153.81	117.06	137.43	0.77	9.00	T3	Zn
	3	124.92	3.44			-0.79	0.24	9.00	T1	Zn

[a]For some metal parameters, the dissolved metal models were better than the particulate models, and vice versa. Dissolved/Particulate means either the dissolved or the particulate model was presented. [b]Count is the number of events considered. [c]**D** denotes dissolved, **P** denotes particulate, and **T** denotes total metal. Also, 1, 2, and 3 are linear, semi-log, and inverse forms respectively.

Appendix D-20. Regression Models Developed for Site 3-218.

Phase	Model	Coefficient					R^2	Count[b]	Form[c]	Parameter
		Intercept	T_RAIN (mm)	MAX_RAIN (mm/hr)	D_RUN (hr)	ADD (day)				
Dissolved/Particulate[a]	1	-0.03	-0.26	1.55	0.10	0.00	0.94	11.00	D3	Cd
	3	0.04	0.15			0.18	0.38	11.00	D3	Cd
	1	-0.55	1.26	15.79	1.50	0.84	0.83	11.00	D3	Cr
	3	6.02	-2.57			-2.14	0.52	11.00	D2	Cr
	1	-6.94	-4.94	73.29	20.07	5.89	0.94	11.00	D3	Cu
	3	-1.55	16.99			13.65	0.44	11.00	D3	Cu
	1	-0.75	-3.27	18.45	3.69	0.00	0.94	11.00	D3	Ni
	3	10.60	-0.11			-0.28	0.29	11.00	P1	Ni
	1	-5.03	-7.70	61.72	6.57	-0.04	0.94	11.00	D3	Pb
	3	28.61	-4.59			-16.61	0.43	11.00	P2	Pb
	1	13.09	-61.50	217.48	-26.21	-126.31	0.73	11.00	P2	Zn
	3	89.04	4.60			-64.17	0.43	11.00	P2	Zn
Total	1	0.29	-0.01	0.04	0.00	-0.02	0.39	11.00	T1	Cd
	3	0.75	-0.31			-0.21	0.18	11.00	T2	Cd
	1	12.49	-0.14	-0.12	0.03	-0.26	0.48	11.00	T1	Cr
	3	18.09	-5.93			-6.59	0.45	11.00	T2	Cr
	1	37.64	-0.37	-0.70	0.18	-0.52	0.47	11.00	T1	Cu
	3	52.60	-16.96			-16.71	0.37	11.00	T2	Cu
	1	10.59	-0.14	0.05	0.07	-0.26	0.39	11.00	T1	Ni
	3	16.45	-3.97			-6.66	0.29	11.00	T2	Ni
	1	5.04	-7.28	25.01	-0.64	22.49	0.54	11.00	T3	Pb
	3	5.82	-1.05			25.63	0.53	11.00	T3	Pb
	1	146.30	-1.45	-2.22	1.18	-2.77	0.46	11.00	T1	Zn
	3	215.31	-54.72			-88.57	0.32	11.00	T2	Zn

[a]For some metal parameters, the dissolved metal models were better than the particulate models, and vice versa. Dissolved/Particulate means either the dissolved or the particulate model was presented. [b]Count is the number of events considered. [c]**D** denotes dissolved, **P** denotes particulate, and **T** denotes total metal. Also, 1, 2, and 3 are linear, semi-log, and inverse forms respectively.

Appendix D-21. Regression Models Developed for Site 3-219.

Phase	Model	Coefficient					R^2	Count[b]	Form[c]	Parameter
		Intercept	T_RAIN (mm)	MAX_RAIN (mm/hr)	D_RUN (hr)	ADD (day)				
Dissolved/Particulate[a]	1	0.03	-1.91	0.89	2.08	-0.21	0.97	8.00	D3	Cd
	3	0.08	0.00			0.01	0.92	8.00	D1	Cd
	1	6.42	248.73	-62.47	-41.69	-16.12	0.93	8.00	P3	Cr
	3	-0.94	194.23			-16.80	0.87	8.00	P3	Cr
	1	0.38	-198.59	28.76	298.77	-23.52	0.99	8.00	D3	Cu
	3	2.25	-0.55			1.53	0.91	8.00	D1	Cu
	1	-0.13	-68.95	9.40	103.21	-12.18	0.99	8.00	D3	Ni
	3	-0.82	-0.20			0.56	0.96	8.00	D1	Ni
	1	22.77	580.39	-202.68	-105.56	-36.22	0.94	8.00	P3	Pb
	3	0.60	418.28			-36.43	0.86	8.00	P3	Pb
	1	189.89	4285.71	-1542.53	-939.93	-319.79	0.94	8.00	P3	Zn
	3	13.19	2984.40			-330.72	0.83	8.00	P3	Zn
Total	1	0.55	20.76	-6.44	-1.21	-2.05	0.84	8.00	T3	Cd
	3	-0.03	16.67			-1.91	0.78	8.00	T3	Cd
	1	6.26	339.47	-64.76	3.23	-33.35	0.92	8.00	T3	Cr
	3	1.33	305.96			-30.90	0.88	8.00	T3	Cr
	1	25.41	622.17	-205.31	132.38	-80.96	0.95	8.00	T3	Cu
	3	107.99	-99.46			59.97	0.79	8.00	T2	Cu
	1	8.89	181.17	-63.25	58.61	-30.38	0.95	8.00	T3	Ni
	3	34.22	-34.30			22.99	0.85	8.00	T2	Ni
	1	19.72	529.71	-153.02	-82.77	-34.98	0.92	8.00	T3	Pb
	3	2.81	405.79			-35.35	0.87	8.00	T3	Pb
	1	171.67	4679.02	-1326.27	-235.74	-419.57	0.87	8.00	T3	Zn
	3	53.17	3843.27			-389.95	0.82	8.00	T3	Zn

[a]For some metal parameters, the dissolved metal models were better than the particulate models, and vice versa. Dissolved/Particulate means either the dissolved or the particulate model was presented. [b]Count is the number of events considered. [c]**D** denotes dissolved, **P** denotes particulate, and **T** denotes total metal. Also, 1, 2, and 3 are linear, semi-log, and inverse forms respectively.

Appendix D-22. Regression Models Developed for Site 3-220.

Phase	Model	Coefficient: Intercept	T_RAIN (mm)	MAX_RAIN (mm/hr)	D_RUN (hr)	ADD (day)	R^2	Count[b]	Form[c]	Parameter
Dissolved/Particulate[a]	1	-1.34	14.09	5.89	-3.30	-0.54	1.00	6.00	P3	Cd
	3	0.10	0.00			0.00	0.71	6.00	D3	Cd
	1	48.34	-34.47	-24.25	7.47	6.14	0.98	6.00	D2	Cr
	3	3.09	-0.17			0.32	0.73	6.00	D1	Cr
	1	31.56	-24.58	-7.23	9.49	-6.58	1.00	6.00	D2	Cu
	3	0.34	36.17			4.89	0.87	6.00	D3	Cu
	1	-58.43	662.95	268.90	-160.60	-27.05	0.75	6.00	P3	Ni
	3	24.73	-82.56			-1.36	0.16	6.00	P3	Ni
	1	-50.26	590.96	258.74	-188.06	-10.10	0.77	6.00	P3	Pb
	3	-9.90	32.41			-9.39	0.27	6.00	P2	Pb
	1	80.00	-440.82	-295.70	-17.46	87.74	0.99	6.00	D3	Zn
	3	-2.22	124.32			37.62	0.83	6.00	D3	Zn
Total	1	-1.41	15.52	6.62	-3.48	-0.72	0.98	6.00	T3	Cd
	3	0.61	-2.21			-0.03	0.27	6.00	T3	Cd
	1	-37.74	449.82	177.72	-90.28	-22.44	0.87	6.00	T3	Cr
	3	16.47	-22.08			-3.67	0.15	6.00	T3	Cr
	1	-92.68	1167.71	445.51	-283.54	-37.33	0.59	6.00	T3	Cu
	3	36.17	0.57			-0.96	0.08	6.00	T1	Cu
	1	-57.43	662.95	268.90	-160.60	-27.05	0.75	6.00	T3	Ni
	3	25.73	-82.56			-1.36	0.16	6.00	T3	Ni
	1	-49.76	590.96	258.74	-188.06	-10.10	0.77	6.00	T3	Pb
	3	-9.40	32.41			-9.39	0.27	6.00	T2	Pb
	1	10036.22	-649.12	-709.48	356.03	-312.64	0.60	6.00	T1	Zn
	3	176.43	6.38			-8.76	0.14	6.00	T1	Zn

[a]For some metal parameters, the dissolved metal models were better than the particulate models, and vice versa. Dissolved/Particulate means either the dissolved or the particulate model was presented. [b]Count is the number of events considered. [c]**D** denotes dissolved, **P** denotes particulate, and **T** denotes total metal. Also, 1, 2, and 3 are linear, semi-log, and inverse forms respectively.

Appendix D-23. Regression Models Developed for Site 3-222.

Phase	Model	Coefficient					R^2	Count[b]	Form[c]	Parameter
		Intercept	T_RAIN (mm)	MAX_RAIN (mm/hr)	D_RUN (hr)	ADD (day)				
Dissolved/Particulate[a]	1	1.72	-0.01	0.10	-0.01	-0.17	1.00	5.00	P1	Cd
	3	0.24	0.35			2.67	0.36	5.00	P3	Cd
	1	-2.98	42.55	-57.39	6.57	111.00	1.00	5.00	P3	Cr
	3	6.57	11.45			-38.36	0.52	5.00	D3	Cr
	1	7.92	133.13	-124.52	-5.85	146.39	1.00	5.00	P3	Cu
	3	15.32	23.25			-105.81	0.82	5.00	D3	Cu
	1	-1.79	20.86	-35.90	22.45	89.16	1.00	5.00	P3	Ni
	3	2.88	-0.04			0.01	0.90	5.00	D1	Ni
	1	10.07	121.62	-66.27	-52.71	41.12	1.00	5.00	P3	Pb
	3	25.98	-0.27			-0.40	0.75	5.00	P1	Pb
	1	213.78	1201.52	-392.76	-845.98	-425.71	1.00	5.00	P3	Zn
	3	268.20	-2.38			-2.77	0.72	5.00	P1	Zn
Total	1	-0.05	-0.86	-1.68	2.55	7.89	1.00	5.00	T3	Cd
	3	0.34	0.35			2.67	0.36	5.00	T3	Cd
	1	1.68	31.08	-40.30	24.75	80.66	1.00	5.00	T3	Cr
	3	6.19	31.02			5.65	0.60	5.00	T3	Cr
	1	24.53	146.63	-98.51	-9.66	9.07	1.00	5.00	T3	Cu
	3	26.20	90.47			-76.82	0.69	5.00	T3	Cu
	1	1.81	34.09	-32.61	15.08	60.95	1.00	5.00	T3	Ni
	3	4.80	30.10			7.12	0.72	5.00	T3	Ni
	1	10.64	118.91	-58.97	-51.48	34.33	1.00	5.00	T3	Pb
	3	26.91	-0.28			-0.42	0.80	5.00	T1	Pb
	1	224.97	1405.49	-739.02	-582.08	-70.38	1.00	5.00	T3	Zn
	3	333.81	-3.13			-2.49	0.74	5.00	T1	Zn

[a]For some metal parameters, the dissolved metal models were better than the particulate models, and vice versa. Dissolved/Particulate means either the dissolved or the particulate model was presented. [b]Count is the number of events considered. [c]**D** denotes dissolved, **P** denotes particulate, and **T** denotes total metal. Also, 1, 2, and 3 are linear, semi-log, and inverse forms respectively.

Appendix D-24. Regression Models Developed for Site 3-223.

Phase	Model	Coefficient					R^2	Count[b]	Form[c]	Parameter
		Intercept	T_RAIN (mm)	MAX_RAIN (mm/hr)	D_RUN (hr)	ADD (day)				
Dissolved/Particulate[a]	1	0.59	2.09	-1.40	-0.13	-4.29	1.00	5.00	P3	Cd
	3	-0.02	0.67			-0.40	1.00	5.00	P2	Cd
	1	74.42	656.55	-272.81	-48.08	-954.39	1.00	5.00	P3	Cr
	3	4.08	12.05			-26.71	0.71	5.00	D3	Cr
	1	105.62	956.18	-399.64	-68.75	-1302.99	1.00	5.00	P3	Cu
	3	2.71	2.47			-1.10	0.97	5.00	D1	Cu
	1	49.61	452.40	-180.36	-32.61	-652.39	1.00	5.00	P3	Ni
	3	1.46	0.42			-0.22	0.82	5.00	D1	Ni
	1	5.37	140.72	-22.13	24.90	-124.84	1.00	5.00	P3	Pb
	3	14.56	2.11			-1.36	0.99	5.00	P1	Pb
	1	130.99	1935.40	-569.10	2.65	-2100.61	1.00	5.00	P3	Zn
	3	-13.20	12.74			-3.73	1.00	5.00	D1	Zn
Total	1	0.95	1.90	-2.20	-0.12	-5.44	1.00	5.00	T3	Cd
	3	-0.13	1.60			-1.02	1.00	5.00	T2	Cd
	1	71.48	652.43	-252.35	-41.87	-941.82	1.00	5.00	T3	Cr
	3	12.73	0.27			-0.24	0.18	5.00	T1	Cr
	1	188.82	1511.19	-682.59	-99.74	-2207.56	1.00	5.00	T3	Cu
	3	31.08	2.72			-1.87	0.75	5.00	T1	Cu
	1	57.81	595.77	-215.86	-32.09	-847.19	1.00	5.00	T3	Ni
	3	9.34	0.42			-0.31	0.31	5.00	T1	Ni
	1	23.92	130.70	-56.13	10.24	-178.25	1.00	5.00	T3	Pb
	3	14.16	1.80			-1.01	0.98	5.00	T1	Pb
	1	527.78	4470.49	-1756.25	-104.30	-6567.08	1.00	5.00	T3	Zn
	3	109.47	18.87			-9.88	0.99	5.00	T1	Zn

[a]For some metal parameters, the dissolved metal models were better than the particulate models, and vice versa. Dissolved/Particulate means either the dissolved or the particulate model was presented. [b]Count is the number of events considered. [c]**D** denotes dissolved, **P** denotes particulate, and **T** denotes total metal. Also, 1, 2, and 3 are linear, semi-log, and inverse forms respectively.

Appendix D-25. Regression Models Developed for Site 6-205.

Phase	Model	Coefficient					R^2	Count[b]	Form[c]	Parameter
		Intercept	T_RAIN (mm)	MAX_RAIN (mm/hr)	D_RUN (hr)	ADD (day)				
Dissolved/Particulate[a]	1	-1.81	18.70	19.67	-4.77	0.90	0.67	17.00	D3	Cd
	3	-1.50	20.26			0.67	0.40	17.00	D3	Cd
	1	0.11	29.71	13.27	-6.70	-1.09	0.71	17.00	D3	Cr
	3	0.12	26.03			-1.52	0.42	17.00	D3	Cr
	1	11.36	-0.49	0.00	0.15	0.43	0.81	17.00	D1	Cu
	3	11.51	-0.40			0.45	0.75	17.00	D1	Cu
	1	2.63	35.04	-9.50	-4.96	-4.19	0.60	17.00	D3	Ni
	3	8.49	-7.09			2.75	0.47	17.00	D2	Ni
	1	6.75	-0.59	0.42	0.13	0.05	0.46	17.00	P1	Pb
	3	3.01	-0.13			0.08	0.15	17.00	D1	Pb
	1	69.15	-4.19	-0.49	1.19	5.17	0.85	17.00	D1	Zn
	3	61.57	-3.47			5.32	0.81	17.00	D1	Zn
Total	1	-3.55	43.93	35.23	-10.67	2.05	0.67	17.00	T3	Cd
	3	-3.12	43.84			1.46	0.40	17.00	T3	Cd
	1	3.06	63.06	-7.60	-12.08	-2.52	0.55	17.00	T3	Cr
	3	2.11	43.54			-3.52	0.29	17.00	T3	Cr
	1	13.93	-24.78	10.12	10.20	12.29	0.54	17.00	T2	Cu
	3	21.51	-0.56			0.47	0.33	17.00	T1	Cu
	1	5.88	75.26	-36.33	-11.69	-2.69	0.51	17.00	T3	Ni
	3	19.62	-12.21			1.26	0.24	17.00	T2	Ni
	1	8.10	-22.71	16.30	4.27	4.25	0.40	17.00	T2	Pb
	3	16.97	-0.62			0.19	0.19	17.00	T1	Pb
	1	233.08	950.15	-2206.39	-25.76	227.08	0.41	17.00	T3	Zn
	3	230.02	-6.88			3.91	0.15	17.00	T1	Zn

[a]For some metal parameters, the dissolved metal models were better than the particulate models, and vice versa. Dissolved/Particulate means either the dissolved or the particulate model was presented. [b]Count is the number of events considered. [c]**D** denotes dissolved, **P** denotes particulate, and **T** denotes total metal. Also, 1, 2, and 3 are linear, semi-log, and inverse forms respectively.

Appendix D-26. Regression Models Developed for Site 6-209.

Phase	Model	Coefficient					R^2	Count[b]	Form[c]	Parameter
		Intercept	T_RAIN (mm)	MAX_RAIN (mm/hr)	D_RUN (hr)	ADD (day)				
Dissolved/Particulate[a]	1	0.19	-0.17	0.43	-0.54	0.38	0.58	18.00	P2	Cd
	3	0.19	0.00			0.13	0.11	19.00	P2	Cd
	1	2.61	-0.85	4.51	-6.70	3.34	0.75	18.00	P2	Cr
	3	1.79	0.70			1.49	0.12	18.00	D3	Cr
	1	13.38	-11.05	15.47	-15.53	10.30	0.40	18.00	P2	Cu
	3	16.81	-6.62			7.56	0.15	19.00	D2	Cu
	1	4.22	23.20	-34.43	8.66	-0.15	0.56	18.00	P3	Ni
	3	4.87	-0.18			0.11	0.50	18.00	D1	Ni
	1	11.22	-8.16	18.08	-19.14	10.47	0.38	18.00	P2	Pb
	3	10.17	0.59			-0.11	0.06	19.00	P1	Pb
	1	96.65	-3.51	1.33	-0.27	3.15	0.53	18.00	D1	Zn
	3	98.48	-1.53			2.85	0.27	19.00	D1	Zn
Total	1	0.49	0.00	0.01	-0.03	0.02	0.58	18.00	T1	Cd
	3	0.53	0.00			0.00	0.03	19.00	T1	Cd
	1	4.32	-1.94	5.30	-4.59	2.05	0.53	18.00	T2	Cr
	3	5.99	-4.49			0.30	0.04	19.00	T3	Cr
	1	32.32	-25.35	17.80	-10.61	15.41	0.57	18.00	T2	Cu
	3	33.20	-12.43			10.54	0.27	19.00	T2	Cu
	1	9.66	-0.27	0.12	-0.16	0.14	0.74	18.00	T1	Ni
	3	10.82	-0.27			0.07	0.51	18.00	T1	Ni
	1	15.28	0.05	0.50	-1.01	0.42	0.44	18.00	T1	Pb
	3	13.91	0.66			-0.14	0.06	19.00	T1	Pb
	1	288.12	-5.76	1.96	-9.70	7.35	0.57	18.00	T1	Zn
	3	280.80	-5.74			2.56	0.26	19.00	T1	Zn

[a]For some metal parameters, the dissolved metal models were better than the particulate models, and vice versa. Dissolved/Particulate means either the dissolved or the particulate model was presented. [b]Count is the number of events considered. [c]**D** denotes dissolved, **P** denotes particulate, and **T** denotes total metal. Also, 1, 2, and 3 are linear, semi-log, and inverse forms respectively.

Appendix D-27. Regression Models Developed for Site 7-01.

Phase	Model	Coefficient					R^2	Count[b]	Form[c]	Parameter
		Intercept	T_RAIN (mm)	MAX_RAIN (mm/hr)	D_RUN (hr)	ADD (day)				
Dissolved/Particulate[a]	1									Cd
	3	0.24	10.66			-1.63	0.63	4.00	P3	Cd
	1									Cr
	3	-0.70	12.85			20.80	0.90	5.00	D3	Cr
	1									Cu
	3	33.48	298.17			-43.86	0.67	6.00	P3	Cu
	1									Ni
	3	-4.54	59.35			88.61	0.81	5.00	D3	Ni
	1									Pb
	3	71.71	-0.89			2.58	0.54	7.00	P1	Pb
	1									Zn
	3	-119.65	4610.10			166.73	0.62	5.00	P3	Zn
Total	1									Cd
	3	0.35	11.19			0.11	0.68	5.00	T3	Cd
	1									Cr
	3	8.51	-4.97			13.00	0.70	7.00	T2	Cr
	1									Cu
	3	47.26	311.36			-50.52	0.77	6.00	T3	Cu
	1									Ni
	3	-4.73	186.04			93.72	0.91	5.00	T3	Ni
	1									Pb
	3	73.08	-0.89			2.65	0.56	7.00	T1	Pb
	1									Zn
	3	-23.33	4267.01			108.21	0.68	5.00	T3	Zn

[a]For some metal parameters, the dissolved metal models were better than the particulate models, and vice versa. Dissolved/Particulate means either the dissolved or the particulate model was presented. [b]Count is the number of events considered. [c]**D** denotes dissolved, **P** denotes particulate, and **T** denotes total metal. Also, 1, 2, and 3 are linear, semi-log, and inverse forms respectively.

Appendix D-28. Regression Models Developed for Site 7-177.

Phase	Model	Coefficient					R^2	Count[b]	Form[c]	Parameter
		Intercept	T_RAIN (mm)	MAX_RAIN (mm/hr)	D_RUN (hr)	ADD (day)				
Dissolved/Particulate[a]	1	1.08	-0.02	0.00	0.00	-0.02	1.00	4.00	P1	Cd
	3	0.09	0.58			0.91	0.84	5.00	D3	Cd
	1	-5.45	0.00	33.30	31.23	16.07	1.00	4.00	P3	Cr
	3	2.13	-0.01			-0.04	0.96	5.00	D1	Cr
	1	-41.04	0.00	234.94	202.83	112.82	1.00	4.00	P3	Cu
	3	1.78	256.43			-3.91	0.87	5.00	P3	Cu
	1	8.77	-0.16	0.00	0.03	-0.09	1.00	4.00	P1	Ni
	3	0.54	58.67			-1.71	0.93	5.00	P3	Ni
	1	-78.08	0.00	371.51	378.71	199.08	1.00	4.00	P3	Pb
	3	-7.42	448.81			12.29	0.96	5.00	P3	Pb
	1	-493.42	0.00	2360.91	2402.69	1284.30	1.00	4.00	P3	Zn
	3	-37.58	2812.58			40.29	0.95	5.00	P3	Zn
Total	1	-0.92	0.00	6.43	5.18	3.18	1.00	4.00	T3	Cd
	3	0.11	7.39			1.01	0.81	5.00	T3	Cd
	1	-6.20	0.00	41.83	35.20	22.30	1.00	4.00	T3	Cr
	3	14.00	-5.60			-2.14	0.85	5.00	T2	Cr
	1	-30.12	0.00	237.68	197.02	93.30	1.00	4.00	T3	Cu
	3	9.04	272.97			6.25	0.85	5.00	T3	Cu
	1	-7.73	0.00	51.02	46.85	22.36	1.00	4.00	T3	Ni
	3	1.09	61.00			1.93	0.91	5.00	T3	Ni
	1	-78.09	0.00	381.73	378.52	198.42	1.00	4.00	T3	Pb
	3	-7.33	460.07			17.61	0.95	5.00	T3	Pb
	1	-569.28	0.00	2907.88	2956.22	1473.56	1.00	4.00	T3	Zn
	3	-38.51	3621.64			191.23	0.95	5.00	T3	Zn

[a]For some metal parameters, the dissolved metal models were better than the particulate models, and vice versa. Dissolved/Particulate means either the dissolved or the particulate model was presented. [b]Count is the number of events considered. [c]**D** denotes dissolved, **P** denotes particulate, and **T** denotes total metal. Also, 1, 2, and 3 are linear, semi-log, and inverse forms respectively.

Appendix D-29. Regression Models Developed for Site 7-180.

Phase	Model	Coefficient					R^2	Count[b]	Form[c]	Parameter
		Intercept	T_RAIN (mm)	MAX_RAIN (mm/hr)	D_RUN (hr)	ADD (day)				
Dissolved/Particulate[a]	1	0.45	3.30	-1.79	-2.65	0.54	0.98	7.00	D3	Cd
	3	0.21	0.00			0.00	0.38	7.00	D1	Cd
	1	2.16	7.21	-14.74	-2.92	8.61	0.94	7.00	D3	Cr
	3	2.22	-0.03			0.02	0.48	7.00	P1	Cr
	1	5.18	-9.28	19.86	2.00	-5.64	0.91	7.00	D2	Cu
	3	9.57	-0.13			0.08	0.51	7.00	P1	Cu
	1	2.19	0.00	-0.07	-0.02	0.05	0.85	7.00	P1	Ni
	3	1.98	-0.02			0.02	0.50	7.00	P1	Ni
	1	5.83	24.23	-30.50	-17.37	-2.42	0.86	7.00	D3	Pb
	3	-2.03	0.23			3.45	0.56	7.00	D2	Pb
	1	99.94	1081.93	-604.25	-302.48	35.97	0.95	7.00	D3	Zn
	3	53.72	-36.82			57.53	0.50	7.00	D2	Zn
Total	1	0.49	0.00	0.00	0.00	0.00	0.64	7.00	T1	Cd
	3	0.45	-0.17			0.22	0.55	7.00	T2	Cd
	1	3.68	-0.02	0.04	-0.01	-0.01	0.36	7.00	T1	Cr
	3	3.61	-0.02			0.01	0.26	7.00	T1	Cr
	1	17.72	-0.21	0.50	-0.08	-0.01	0.55	7.00	T1	Cu
	3	22.61	-10.20			6.49	0.31	7.00	T2	Cu
	1	4.42	-0.05	0.02	-0.04	0.08	0.61	7.00	T1	Ni
	3	4.08	-0.06			0.08	0.53	7.00	T1	Ni
	1	12.88	-0.21	0.17	-0.05	0.17	0.47	7.00	T1	Pb
	3	12.58	-0.20			0.24	0.44	7.00	T1	Pb
	1	146.19	-1.88	0.70	-0.84	2.46	0.66	7.00	T1	Zn
	3	139.99	-2.04			2.69	0.62	7.00	T1	Zn

[a]For some metal parameters, the dissolved metal models were better than the particulate models, and vice versa. Dissolved/Particulate means either the dissolved or the particulate model was presented. [b]Count is the number of events considered. [c]**D** denotes dissolved, **P** denotes particulate, and **T** denotes total metal. Also, 1, 2, and 3 are linear, semi-log, and inverse forms respectively.

Appendix D-30. Regression Models Developed for Site 7-128.

Phase	Model	Coefficient					R^2	Count[b]	Form[c]	Parameter
		Intercept	T_RAIN (mm)	MAX_RAIN (mm/hr)	D_RUN (hr)	ADD (day)				
Dissolved/Particulate[a]	1	0.00	0.11	0.33	0.07	-0.08	1.00	4.00	P1	Cd
	3	-0.27	0.23			-0.04	0.61	4.00	P1	Cd
	1	92.76	0.00	-272.53	-163.14	203.70	1.00	4.00	P3	Cr
	3	17.85	-1.33			0.27	0.50	4.00	D1	Cr
	1	152.58	0.00	-479.69	-114.81	739.42	1.00	4.00	P3	Cu
	3	-25.51	40.51			-1.45	0.88	4.00	D2	Cu
	1	82.80	0.00	-196.99	-204.66	120.97	1.00	4.00	P3	Ni
	3	4.11	-36.77			29.11	0.91	4.00	D3	Ni
	1	391.46	0.00	-985.97	-801.85	1111.72	1.00	4.00	P3	Pb
	3	-0.09	0.03			0.00	0.38	4.00	D1	Pb
	1	1540.53	0.00	-3819.65	-3251.96	3626.42	1.00	4.00	P3	Zn
	3	56.19	-0.56			-0.58	0.93	4.00	D1	Zn
Total	1	1.51	0.00	-8.78	4.89	34.69	1.00	4.00	T3	Cd
	3	-0.02	0.23			-0.04	0.61	4.00	T1	Cd
	1	94.08	0.00	-226.38	-161.61	69.05	1.00	4.00	T3	Cr
	3	39.55	-128.18			-78.63	0.03	4.00	T3	Cr
	1	152.27	0.00	-479.64	-31.86	862.87	1.00	4.00	T3	Cu
	3	22.03	6.12			-0.63	0.23	4.00	T1	Cu
	1	78.26	0.00	-187.15	-183.42	163.19	1.00	4.00	T3	Ni
	3	27.88	0.10			-0.39	0.18	4.00	T1	Ni
	1	390.56	0.00	-983.22	-797.02	1112.65	1.00	4.00	T3	Pb
	3	131.04	3.05			-2.14	0.20	4.00	T1	Pb
	1	1605.93	0.00	-3888.25	-3400.50	3743.37	1.00	4.00	T3	Zn
	3	554.05	7.28			-7.63	0.16	4.00	T1	Zn

[a]For some metal parameters, the dissolved metal models were better than the particulate models, and vice versa. Dissolved/Particulate means either the dissolved or the particulate model was presented. [b]Count is the number of events considered. [c]**D** denotes dissolved, **P** denotes particulate, and **T** denotes total metal. Also, 1, 2, and 3 are linear, semi-log, and inverse forms respectively.

Appendix D-31. Regression Models Developed for Site 7-129.

Phase	Model	Coefficient: Intercept	T_RAIN (mm)	MAX_RAIN (mm/hr)	D_RUN (hr)	ADD (day)	R^2	Count[b]	Form[c]	Parameter
Dissolved/Particulate[a]	1	0.85	-0.10	0.01	0.12	-0.05	0.84	8.00	P1	Cd
	3	0.13	0.00			0.00	0.47	8.00	D1	Cd
	1	0.07	-0.06	0.06	-0.01	0.12	0.92	8.00	P1	Cr
	3	-1.85	1.39			2.72	0.63	8.00	P2	Cr
	1	5.41	8.94	1.60	-7.65	7.00	0.93	8.00	P2	Cu
	3	14.30	-0.24			0.97	0.72	8.00	D1	Cu
	1	-0.36	-1.65	-0.53	3.52	4.91	0.95	8.00	D2	Ni
	3	2.76	-0.04			0.24	0.82	8.00	D1	Ni
	1	9.08	-0.25	0.30	-0.22	0.52	1.00	8.00	P1	Pb
	3	1.10	-0.16			0.73	0.65	8.00	D2	Pb
	1	-46.93	8.24	-31.33	65.14	105.94	0.95	8.00	D2	Zn
	3	36.16	18.16			90.76	0.78	8.00	P2	Zn
Total	1	0.96	-0.11	0.01	0.12	-0.05	0.83	8.00	T1	Cd
	3	2.74	-1.22			-0.81	0.18	8.00	T2	Cd
	1	3.49	-0.08	0.06	-0.03	0.15	0.96	8.00	T1	Cr
	3	1.97	0.21			3.41	0.79	8.00	T2	Cr
	1	7.99	1.99	-3.61	7.51	28.10	0.97	8.00	T2	Cu
	3	10.98	3.63			26.30	0.92	8.00	T2	Cu
	1	6.48	0.08	-0.04	-0.14	0.29	1.00	8.00	T1	Ni
	3	3.36	0.25			5.21	0.90	8.00	T2	Ni
	1	10.31	-0.29	0.31	-0.21	0.55	1.00	8.00	T1	Pb
	3	1.70	4.11			13.27	0.62	8.00	T2	Pb
	1	-6.04	-62.69	15.87	107.25	184.44	0.91	8.00	T2	Zn
	3	15.14	40.72			181.09	0.83	8.00	T2	Zn

[a]For some metal parameters, the dissolved metal models were better than the particulate models, and vice versa. Dissolved/Particulate means either the dissolved or the particulate model was presented. [b]Count is the number of events considered. [c]**D** denotes dissolved, **P** denotes particulate, and **T** denotes total metal. Also, 1, 2, and 3 are linear, semi-log, and inverse forms respectively.

Appendix D-32. Regression Models Developed for Site 7-131.

Phase	Model	Coefficient					R^2	Count[b]	Form[c]	Parameter
		Intercept	T_RAIN (mm)	MAX_RAIN (mm/hr)	D_RUN (hr)	ADD (day)				
Dissolved/Particulate[a]	1	0.08	0.00	0.00	0.00	0.01	0.93	9.00	D1	Cd
	3	0.08	0.00			0.01	0.93	9.00	D1	Cd
	1	-0.50	-0.09	0.10	-0.03	0.19	0.92	9.00	P1	Cr
	3	3.62	-1.05			0.63	0.77	9.00	D2	Cr
	1	5.43	-0.63	0.56	-0.02	0.57	0.95	9.00	P1	Cu
	3	9.51	-0.13			0.97	0.87	9.00	D1	Cu
	1	0.41	-0.12	0.13	-0.05	0.18	0.92	9.00	P1	Ni
	3	1.83	-0.03			0.22	0.84	9.00	D1	Ni
	1	1.53	-0.66	0.69	-0.17	0.84	0.95	9.00	P1	Pb
	3	1.86	-0.68			-0.02	0.44	9.00	D2	Pb
	1	10.98	-0.40	-0.18	0.55	4.23	0.96	9.00	D1	Zn
	3	8.59	-0.25			4.46	0.94	9.00	D1	Zn
Total	1	0.39	-0.03	0.02	0.01	0.02	0.75	9.00	T1	Cd
	3	0.74	-0.41			0.43	0.47	9.00	T2	Cd
	1	1.75	-0.14	0.12	-0.01	0.23	0.98	9.00	T1	Cr
	3	1.88	-0.30			4.45	0.51	9.00	T2	Cr
	1	14.83	-0.92	0.56	0.24	1.45	0.92	9.00	T1	Cu
	3	14.51	-4.37			29.61	0.68	9.00	T2	Cu
	1	1.92	-0.21	0.15	0.02	0.39	0.89	9.00	T1	Ni
	3	1.64	-0.78			7.72	0.65	9.00	T2	Ni
	1	2.79	-0.71	0.70	-0.13	0.83	0.95	9.00	T1	Pb
	3	4.77	0.02			15.95	0.24	9.00	T2	Pb
	1	82.21	-231.93	132.34	72.19	108.09	0.61	9.00	T2	Zn
	3	122.43	-53.09			104.70	0.43	9.00	T2	Zn

[a]For some metal parameters, the dissolved metal models were better than the particulate models, and vice versa. Dissolved/Particulate means either the dissolved or the particulate model was presented. [b]Count is the number of events considered. [c]**D** denotes dissolved, **P** denotes particulate, and **T** denotes total metal. Also, 1, 2, and 3 are linear, semi-log, and inverse forms respectively.

Appendix D-33. Regression Models Developed for Site 7-135.

Phase	Model	Coefficient					R^2	Count[b]	Form[c]	Parameter
		Intercept	T_RAIN (mm)	MAX_RAIN (mm/hr)	D_RUN (hr)	ADD (day)				
Dissolved/Particulate[a]	1	0.14	-0.01	0.01	0.00	0.01	0.60	10.00	P1	Cd
	3	0.26	-0.11			0.20	0.40	10.00	P2	Cd
	1	1.66	18.19	-1.98	-4.22	-0.30	0.91	10.00	D3	Cr
	3	1.72	11.11			-0.65	0.81	10.00	D3	Cr
	1	15.32	-7.38	-3.08	3.12	11.48	0.95	10.00	D2	Cu
	3	16.69	-9.02			11.55	0.89	10.00	D2	Cu
	1	2.95	-0.84	-0.29	-0.25	2.12	0.73	10.00	D2	Ni
	3	2.92	-1.35			2.08	0.73	10.00	D2	Ni
	1	4.37	-0.19	0.21	-0.09	0.63	0.90	10.00	P1	Pb
	3	2.88	0.93			10.30	0.59	10.00	P2	Pb
	1	56.65	79.37	71.99	327.13	-59.10	0.88	10.00	P3	Zn
	3	63.09	430.04			-41.41	0.59	10.00	P3	Zn
Total	1	0.24	-0.01	0.01	0.00	0.01	0.52	10.00	T1	Cd
	3	0.39	-0.16			0.17	0.31	10.00	T2	Cd
	1	3.65	-3.29	0.79	0.87	2.66	0.89	10.00	T2	Cr
	3	3.79	-1.82			2.79	0.88	10.00	T2	Cr
	1	24.77	-9.02	-1.21	-0.57	17.86	0.95	10.00	T2	Cu
	3	24.78	-10.80			17.73	0.95	10.00	T2	Cu
	1	5.10	-3.21	0.23	0.36	3.22	0.90	10.00	T2	Ni
	3	5.17	-2.71			3.27	0.90	10.00	T2	Ni
	1	5.32	-0.24	0.22	-0.05	0.65	0.90	10.00	T1	Pb
	3	4.38	0.46			10.67	0.60	10.00	T2	Pb
	1	91.48	164.91	34.29	294.51	-80.03	0.82	10.00	T3	Zn
	3	173.48	-77.50			46.60	0.61	10.00	T2	Zn

[a]For some metal parameters, the dissolved metal models were better than the particulate models, and vice versa. Dissolved/Particulate means either the dissolved or the particulate model was presented. [b]Count is the number of events considered. [c]**D** denotes dissolved, **P** denotes particulate, and **T** denotes total metal. Also, 1, 2, and 3 are linear, semi-log, and inverse forms respectively.

Appendix D-34. Regression Models Developed for Site 7-136.

Phase	Model	Coefficient: Intercept	T_RAIN (mm)	MAX_RAIN (mm/hr)	D_RUN (hr)	ADD (day)	R^2	Count[b]	Form[c]	Parameter
Dissolved/Particulate[a]	1	0.08	0.00	0.00	0.00	0.02	0.93	11.00	D1	Cd
	3	0.08	0.00			0.02	0.90	11.00	D1	Cd
	1	1.22	-0.09	0.06	-0.05	0.11	0.75	11.00	P1	Cr
	3	1.62	8.26			0.15	0.54	11.00	D3	Cr
	1	11.03	-0.37	-0.01	0.35	1.07	0.89	11.00	D1	Cu
	3	11.74	-0.18			1.17	0.85	11.00	D1	Cu
	1	2.69	-0.12	0.01	0.08	0.34	0.87	11.00	D1	Ni
	3	2.89	-0.06			0.37	0.85	11.00	D1	Ni
	1	10.92	-0.64	0.42	-0.22	0.55	0.78	11.00	P1	Pb
	3	1.36	-0.50			0.49	0.46	11.00	D2	Pb
	1	51.12	-88.65	5.16	52.46	103.15	0.83	11.00	D2	Zn
	3	48.83	-1.21			6.48	0.79	11.00	D1	Zn
Total	1	0.47	-0.02	0.01	-0.01	0.02	0.81	11.00	T1	Cd
	3	0.48	-0.01			0.03	0.39	11.00	T1	Cd
	1	3.59	-0.11	0.07	-0.04	0.09	0.77	11.00	T1	Cr
	3	3.26	-0.68			2.29	0.29	11.00	T2	Cr
	1	24.56	-0.92	0.39	0.02	1.42	0.89	11.00	T1	Cu
	3	22.35	-7.73			29.39	0.72	11.00	T2	Cu
	1	4.70	-0.19	0.07	0.02	0.40	0.89	11.00	T1	Ni
	3	4.05	-1.83			7.70	0.80	11.00	T2	Ni
	1	11.93	-0.69	0.43	-0.17	0.56	0.79	11.00	T1	Pb
	3	7.50	-0.71			14.31	0.28	11.00	T2	Pb
	1	210.83	-361.29	180.60	82.50	84.75	0.83	11.00	T2	Zn
	3	169.87	-73.23			142.73	0.58	11.00	T2	Zn

[a]For some metal parameters, the dissolved metal models were better than the particulate models, and vice versa. Dissolved/Particulate means either the dissolved or the particulate model was presented. [b]Count is the number of events considered. [c]**D** denotes dissolved, **P** denotes particulate, and **T** denotes total metal. Also, 1, 2, and 3 are linear, semi-log, and inverse forms respectively.

Appendix D-35. Regression Models Developed for Site 7-162.

Phase	Model	Coefficient					R^2	Count[b]	Form[c]	Parameter
		Intercept	T_RAIN (mm)	MAX_RAIN (mm/hr)	D_RUN (hr)	ADD (day)				
Dissolved/Particulate[a]	1	0.76	9.46	-6.74	-4.63	-1.14	1.00	5.00	P3	Cd
	3	-0.27	18.77			0.83	0.87	5.00	D3	Cd
	1	4.72	47.29	-23.62	-31.73	-8.26	1.00	5.00	P3	Cr
	3	12.12	-0.11			-0.29	0.83	5.00	D1	Cr
	1	20.70	620.10	-275.96	-121.55	-15.19	0.99	7.00	D3	Cu
	3	-0.78	545.65			-4.78	0.88	7.00	D3	Cu
	1	3.55	24.82	-14.99	-19.68	-6.31	1.00	5.00	P3	Ni
	3	-3.37	174.03			8.80	0.91	5.00	D3	Ni
	1	23.40	1458.67	-587.73	-334.14	1.97	0.96	7.00	D3	Pb
	3	-28.60	1296.46			29.49	0.83	7.00	D3	Pb
	1	114.82	4533.21	-2029.51	-862.57	-87.62	0.98	7.00	D3	Zn
	3	-40.54	3987.23			-13.29	0.87	7.00	D3	Zn
Total	1	1.83	18.25	-16.48	-9.40	-2.38	1.00	5.00	T3	Cd
	3	-0.07	17.29			0.67	0.80	5.00	T3	Cd
	1	9.63	91.57	-77.55	-51.43	-13.91	1.00	5.00	T3	Cr
	3	-0.06	87.92			1.77	0.80	5.00	T3	Cr
	1	31.24	646.14	-258.40	-177.29	-20.33	0.94	7.00	T3	Cu
	3	5.84	573.35			-6.07	0.80	7.00	T3	Cu
	1	16.37	215.91	-204.34	-78.85	-22.34	1.00	5.00	T3	Ni
	3	-3.28	199.38			8.65	0.86	5.00	T3	Ni
	1	52.28	1287.28	-314.41	-348.58	-11.62	0.86	7.00	T3	Pb
	3	10.33	1192.26			15.16	0.76	7.00	T3	Pb
	1	228.64	4313.20	-2375.98	-1247.14	-191.34	0.95	7.00	T3	Zn
	3	27.02	3662.48			-87.46	0.76	7.00	T3	Zn

[a]For some metal parameters, the dissolved metal models were better than the particulate models, and vice versa. Dissolved/Particulate means either the dissolved or the particulate model was presented. [b]Count is the number of events considered. [c]**D** denotes dissolved, **P** denotes particulate, and **T** denotes total metal. Also, 1, 2, and 3 are linear, semi-log, and inverse forms respectively.

Appendix D-36. Regression Models Developed for Site 7-165.

Phase	Model	Coefficient					R^2	Count[b]	Form[c]	Parameter
		Intercept	T_RAIN (mm)	MAX_RAIN (mm/hr)	D_RUN (hr)	ADD (day)				
Dissolved/Particulate[a]	1	0.44	8.25	-2.55	-2.04	-0.24	0.91	6.00	D3	Cd
	3	0.10	5.88			0.23	0.49	6.00	D3	Cd
	1	6.58	45.15	-85.58	-13.28	-6.62	0.86	6.00	D3	Cr
	3	7.32	-0.07			-0.10	0.76	6.00	P1	Cr
	1	21.52	326.32	5.93	-79.83	-38.51	0.96	8.00	D3	Cu
	3	11.59	112.89			-21.58	0.74	8.00	P3	Cu
	1	4.27	9.08	-33.72	-1.69	-6.86	1.00	6.00	P3	Ni
	3	2.59	3.69			-4.54	0.77	6.00	P3	Ni
	1	53.41	290.06	-228.15	-75.19	-72.47	0.58	8.00	P3	Pb
	3	40.79	146.79			-69.58	0.44	8.00	P3	Pb
	1	227.63	4329.78	-1181.79	-1099.25	-342.34	0.94	8.00	D3	Zn
	3	114.44	2655.31			-277.93	0.55	8.00	D3	Zn
Total	1	1.05	13.29	-8.30	-3.31	-1.22	0.76	6.00	T3	Cd
	3	2.11	-0.02			-0.02	0.47	6.00	T1	Cd
	1	9.58	81.29	-120.62	-18.05	-11.00	0.71	6.00	T3	Cr
	3	12.87	-0.11			-0.16	0.54	6.00	T1	Cr
	1	37.20	488.54	-62.26	-107.25	-61.30	0.96	8.00	T3	Cu
	3	27.91	335.51			-54.46	0.70	8.00	T3	Cu
	1	21.96	205.00	-257.13	-58.77	-31.50	0.99	6.00	T3	Ni
	3	4.13	116.98			-6.78	0.51	6.00	T3	Ni
	1	63.11	366.06	-226.96	-101.09	-78.62	0.56	8.00	T3	Pb
	3	48.79	189.00			-73.92	0.39	8.00	T3	Pb
	1	437.06	5895.91	-2845.97	-1538.48	-540.59	0.96	8.00	T3	Zn
	3	239.22	3319.85			-462.75	0.54	8.00	T3	Zn

[a]For some metal parameters, the dissolved metal models were better than the particulate models, and vice versa. Dissolved/Particulate means either the dissolved or the particulate model was presented. [b]Count is the number of events considered. [c]**D** denotes dissolved, **P** denotes particulate, and **T** denotes total metal. Also, 1, 2, and 3 are linear, semi-log, and inverse forms respectively.

Appendix D-37. Regression Models Developed for Site 7-171.

Phase	Model	Coefficient					R^2	Count[b]	Form[c]	Parameter
		Intercept	T_RAIN (mm)	MAX_RAIN (mm/hr)	D_RUN (hr)	ADD (day)				
Dissolved/Particulate[a]	1	-0.20	-2.72	18.33	6.74	0.23	1.00	5.00	P3	Cd
	3	0.31	0.00			0.02	0.90	5.00	P1	Cd
	1	2.15	-11.18	24.47	30.89	-4.89	1.00	5.00	P3	Cr
	3	2.44	-0.02			-0.02	0.97	5.00	D1	Cr
	1	8.06	-0.86	0.23	1.11	0.75	0.90	9.00	P1	Cu
	3	13.66	-0.23			0.68	0.82	9.00	P1	Cu
	1	0.52	0.83	85.97	20.04	-1.45	1.00	5.00	P3	Ni
	3	2.77	-0.02			0.11	0.94	5.00	P1	Ni
	1	42.20	-1.88	0.89	1.16	1.42	0.83	9.00	P1	Pb
	3	52.30	-0.64			1.34	0.74	9.00	P1	Pb
	1	48.72	-3.11	1.36	3.81	2.91	0.95	9.00	D1	Zn
	3	71.71	-0.43			2.66	0.83	9.00	D1	Zn
Total	1	0.51	5.24	18.32	0.74	-0.68	1.00	5.00	T3	Cd
	3	1.00	-0.01			0.02	0.96	5.00	T1	Cd
	1	3.97	-3.02	-7.34	34.51	-8.27	1.00	5.00	T3	Cr
	3	4.76	42.03			-9.38	0.96	5.00	T3	Cr
	1	23.23	-1.58	0.60	1.73	0.91	0.96	9.00	T1	Cu
	3	33.56	-0.37			0.80	0.79	9.00	T1	Cu
	1	3.96	88.28	186.24	-35.90	-6.34	1.00	5.00	T3	Ni
	3	7.26	-0.05			0.18	0.96	5.00	T1	Ni
	1	63.59	-1.66	0.98	0.12	1.22	0.76	9.00	T1	Pb
	3	70.44	-0.73			1.21	0.67	9.00	T1	Pb
	1	219.50	-4.38	2.07	1.64	4.44	0.71	9.00	T1	Zn
	3	239.03	-1.89			4.32	0.67	9.00	T1	Zn

[a]For some metal parameters, the dissolved metal models were better than the particulate models, and vice versa. Dissolved/Particulate means either the dissolved or the particulate model was presented. [b]Count is the number of events considered. [c]**D** denotes dissolved, **P** denotes particulate, and **T** denotes total metal. Also, 1, 2, and 3 are linear, semi-log, and inverse forms respectively.

Appendix D-38. Regression Models Developed for Site 7-174.

Phase	Model	Coefficient					R^2	Count[b]	Form[c]	Parameter
		Intercept	T_RAIN (mm)	MAX_RAIN (mm/hr)	D_RUN (hr)	ADD (day)				
Dissolved/Particulate[a]	1	6.72	19.33	-27.54	-38.27	-10.81	0.96	6.00	D3	Cd
	3	-0.82	23.32			1.57	0.54	6.00	D3	Cd
	1	14.52	3.24	-107.05	-33.09	-18.31	0.96	6.00	D3	Cr
	3	-5.39	179.64			6.11	0.61	6.00	P3	Cr
	1	30.20	365.65	13.11	-199.69	-43.74	0.86	8.00	D3	Cu
	3	7.02	337.58			-16.93	0.71	8.00	D3	Cu
	1	77.83	195.60	-364.67	-411.41	-130.41	0.94	6.00	P3	Ni
	3	3.07	81.06			-2.36	0.62	6.00	D3	Ni
	1	140.79	2046.99	113.20	-1574.75	-202.75	0.76	8.00	D3	Pb
	3	-41.71	1827.54			8.77	0.50	8.00	D3	Pb
	1	159.78	2437.06	135.91	-1456.83	-240.45	0.79	8.00	D3	Zn
	3	-8.03	2240.12			-44.45	0.62	8.00	D3	Zn
Total	1	13.46	31.25	-60.09	-68.79	-22.05	0.94	6.00	T3	Cd
	3	-0.56	37.27			0.85	0.51	6.00	T3	Cd
	1	62.16	158.84	-326.31	-295.33	-98.90	0.96	6.00	T3	Cr
	3	-1.09	177.28			3.60	0.58	6.00	T3	Cr
	1	67.96	1069.53	116.32	-585.43	-105.98	0.75	8.00	T3	Cu
	3	2.56	1002.42			-26.57	0.62	8.00	T3	Cu
	1	105.90	267.15	-479.57	-531.93	-173.49	0.93	6.00	T3	Ni
	3	-3.22	312.11			4.52	0.55	6.00	T3	Ni
	1	625.03	9581.79	1821.45	-7000.44	-972.93	0.70	8.00	T3	Pb
	3	-142.67	8863.35			-19.02	0.49	8.00	T3	Pb
	1	457.49	7339.21	868.66	-4708.58	-720.09	0.75	8.00	T3	Zn
	3	-70.67	6786.44			-82.16	0.57	8.00	T3	Zn

[a]For some metal parameters, the dissolved metal models were better than the particulate models, and vice versa. Dissolved/Particulate means either the dissolved or the particulate model was presented. [b]Count is the number of events considered. [c]**D** denotes dissolved, **P** denotes particulate, and **T** denotes total metal. Also, 1, 2, and 3 are linear, semi-log, and inverse forms respectively.

Appendix D-39. Regression Models Developed for Site 7-35.

Phase	Model	Coefficient					R^2	Count[b]	Form[c]	Parameter
		Intercept	T_RAIN (mm)	MAX_RAIN (mm/hr)	D_RUN (hr)	ADD (day)				
Dissolved/Particulate[a]	1	0.14	0.00	0.00	0.00	0.01	0.76	7.00	D1	Cd
	3	0.12	0.00			0.01	0.75	7.00	D1	Cd
	1	-1.92	1.08	0.31	-0.24	1.51	0.98	7.00	D2	Cr
	3	-1.98	1.22			1.48	0.97	7.00	D2	Cr
	1	8.66	-0.05	-0.07	0.04	0.34	0.80	13.00	D1	Cu
	3	8.93	-0.08			0.33	0.77	13.00	D1	Cu
	1	1.49	-0.02	0.01	0.02	0.08	0.94	7.00	D1	Ni
	3	2.19	-0.02			0.07	0.92	7.00	D1	Ni
	1	1.96	0.01	-0.10	0.10	0.34	0.72	13.00	D1	Pb
	3	3.04	-0.04			0.34	0.65	13.00	D1	Pb
	1	25.66	0.04	-0.58	0.52	3.09	0.77	13.00	D1	Zn
	3	30.97	-0.24			3.08	0.74	13.00	D1	Zn
Total	1	-0.21	0.00	-0.01	0.02	0.01	0.87	7.00	T1	Cd
	3	0.28	0.00			0.01	0.59	7.00	T1	Cd
	1	-13.00	4.10	-0.55	4.19	5.03	0.66	7.00	T2	Cr
	3	-3.96	2.24			3.92	0.42	7.00	T2	Cr
	1	19.72	-0.12	-0.11	0.21	0.44	0.63	13.00	T1	Cu
	3	22.68	-0.15			0.45	0.58	13.00	T1	Cu
	1	-5.20	1473.81	-1385.09	399.54	12.98	0.74	7.00	T3	Ni
	3	65.46	-0.64			-0.70	0.28	7.00	T1	Ni
	1	31.35	-0.13	-0.63	1.73	0.68	0.23	13.00	T1	Pb
	3	11.97	10.53			36.50	0.08	13.00	T2	Pb
	1	77.51	0.01	-1.48	2.56	4.24	0.55	13.00	T1	Zn
	3	112.94	-0.50			4.29	0.46	13.00	T1	Zn

[a]For some metal parameters, the dissolved metal models were better than the particulate models, and vice versa. Dissolved/Particulate means either the dissolved or the particulate model was presented. [b]Count is the number of events considered. [c]**D** denotes dissolved, **P** denotes particulate, and **T** denotes total metal. Also, 1, 2, and 3 are linear, semi-log, and inverse forms respectively.

Appendix D-40. Regression Models Developed for Site 7-37.

Phase	Model	Coefficient: Intercept	T_RAIN (mm)	MAX_RAIN (mm/hr)	D_RUN (hr)	ADD (day)	R^2	Count[b]	Form[c]	Parameter
Dissolved/Particulate[a]	1	-0.32	0.35	0.32	-0.48	0.36	0.98	7.00	P2	Cd
	3	0.19	0.00			0.01	0.79	7.00	P1	Cd
	1	-9.04	-0.80	0.34	1.24	0.29	1.00	7.00	P1	Cr
	3	1.69	-0.01			0.03	0.66	7.00	D1	Cr
	1	13.34	-4.26	77.80	23.98	-14.68	0.64	13.00	P3	Cu
	3	14.70	-0.12			0.31	0.60	13.00	D1	Cu
	1	0.73	-3.78	3.65	0.32	2.10	1.00	7.00	P2	Ni
	3	5.98	-2.98			1.18	0.83	7.00	P2	Ni
	1	58.70	-43.91	417.29	61.32	44.51	0.46	13.00	P3	Pb
	3	4.54	0.10			0.09	0.29	13.00	D1	Pb
	1	142.44	-298.23	-250.22	526.64	-79.77	0.74	13.00	D3	Zn
	3	261.96	-2.39			-1.66	0.58	13.00	P1	Zn
Total	1	0.71	2.09	-4.21	2.06	-0.24	0.98	7.00	T3	Cd
	3	0.50	0.00			0.02	0.68	7.00	T1	Cd
	1	-8.31	-0.84	0.39	1.26	0.32	1.00	7.00	T1	Cr
	3	-74.15	44.45			25.93	0.30	7.00	T2	Cr
	1	59.37	-5.24	-6.86	-17.07	12.92	0.63	13.00	T2	Cu
	3	44.30	-0.40			0.38	0.59	13.00	T1	Cu
	1	4.81	47.09	-26.98	14.53	-1.55	0.99	7.00	T3	Ni
	3	7.57	-0.06			0.14	0.74	7.00	T1	Ni
	1	68.46	-92.94	410.20	71.43	54.10	0.43	13.00	T3	Pb
	3	155.97	-0.98			-0.25	0.17	13.00	T1	Pb
	1	661.45	-185.89	22.86	-139.26	48.87	0.84	13.00	T2	Zn
	3	702.31	-327.81			71.41	0.74	13.00	T2	Zn

[a]For some metal parameters, the dissolved metal models were better than the particulate models, and vice versa. Dissolved/Particulate means either the dissolved or the particulate model was presented. [b]Count is the number of events considered. [c]**D** denotes dissolved, **P** denotes particulate, and **T** denotes total metal. Also, 1, 2, and 3 are linear, semi-log, and inverse forms respectively.

Appendix D-41. Regression Models Developed for Site 7-143.

Phase	Model	Coefficient					R^2	Count[b]	Form[c]	Parameter
		Intercept	T_RAIN (mm)	MAX_RAIN (mm/hr)	D_RUN (hr)	ADD (day)				
Dissolved/Particulate[a]	1	2.52	-0.04	0.01	-0.02	0.14	0.94	10.00	P1	Cd
	3	2.54	-0.04			0.13	0.89	10.00	P1	Cd
	1	14.14	-0.24	0.09	-0.15	0.86	0.98	10.00	P1	Cr
	3	14.32	-0.22			0.80	0.88	10.00	P1	Cr
	1	183.04	5.36	-72.78	-46.12	83.04	0.98	10.00	P2	Cu
	3	100.30	-1.51			5.14	0.90	10.00	P1	Cu
	1	13.50	-0.28	0.13	-0.08	0.72	0.97	10.00	P1	Ni
	3	13.96	-0.20			0.68	0.85	10.00	P1	Ni
	1	406.42	-8.47	2.14	-0.74	23.35	0.99	10.00	P1	Pb
	3	415.42	-6.87			22.84	0.96	10.00	P1	Pb
	1	178.54	284.79	1956.23	268.76	-170.18	0.92	10.00	P3	Zn
	3	529.77	-240.08			194.49	0.71	10.00	P2	Zn
Total	1	2.66	-0.04	0.01	-0.02	0.14	0.93	10.00	T1	Cd
	3	2.67	-0.04			0.13	0.89	10.00	T1	Cd
	1	16.75	-0.23	0.08	-0.17	0.87	0.98	10.00	T1	Cr
	3	16.85	-0.23			0.80	0.88	10.00	T1	Cr
	1	226.79	1.65	-92.39	-46.85	102.28	0.98	10.00	T2	Cu
	3	123.42	-1.84			6.50	0.92	10.00	T1	Cu
	1	16.51	-0.42	0.17	0.02	0.91	0.98	10.00	T1	Ni
	3	17.36	-0.25			0.89	0.91	10.00	T1	Ni
	1	417.77	-8.54	2.18	-0.75	23.17	0.99	10.00	T1	Pb
	3	426.94	-6.91			22.65	0.96	10.00	T1	Pb
	1	664.20	-66.33	-169.36	-138.55	279.40	0.95	10.00	T2	Zn
	3	574.78	-270.53			283.31	0.88	10.00	T2	Zn

[a]For some metal parameters, the dissolved metal models were better than the particulate models, and vice versa. Dissolved/Particulate means either the dissolved or the particulate model was presented. [b]Count is the number of events considered. [c]**D** denotes dissolved, **P** denotes particulate, and **T** denotes total metal. Also, 1, 2, and 3 are linear, semi-log, and inverse forms respectively.

Appendix D-42. Regression Models Developed for Site 7-147.

Phase	Model	Coefficient					R^2	Count[b]	Form[c]	Parameter
		Intercept	T_RAIN (mm)	MAX_RAIN (mm/hr)	D_RUN (hr)	ADD (day)				
Dissolved/Particulate[a]	1	0.68	17.75	-2.33	1.24	-0.79	0.85	17.00	P3	Cd
	3	3.67	-1.95			0.52	0.72	17.00	P2	Cd
	1	5.02	97.61	-10.19	8.83	-6.15	0.84	17.00	P3	Cr
	3	6.18	72.03			-5.58	0.74	17.00	P3	Cr
	1	29.62	446.92	-46.66	43.95	-22.85	0.79	17.00	P3	Cu
	3	37.97	-19.42			9.65	0.75	17.00	D2	Cu
	1	4.38	97.37	-9.87	6.91	-4.94	0.87	17.00	P3	Ni
	3	5.36	72.20			-4.49	0.77	17.00	P3	Ni
	1	84.43	2433.07	-200.03	126.76	-85.25	0.83	17.00	P3	Pb
	3	103.23	1920.16			-76.99	0.77	17.00	P3	Pb
	1	145.87	2253.40	-221.68	151.85	-132.94	0.84	17.00	P3	Zn
	3	167.68	1687.62			-123.03	0.76	17.00	P3	Zn
Total	1	0.87	17.07	-2.14	1.30	-0.89	0.83	17.00	T3	Cd
	3	3.82	-1.99			0.57	0.75	17.00	T2	Cd
	1	6.75	102.81	-10.53	9.13	-6.87	0.84	17.00	T3	Cr
	3	7.95	76.39			-6.28	0.74	17.00	T3	Cr
	1	46.58	551.64	-46.93	43.88	-37.20	0.77	17.00	T3	Cu
	3	151.13	-73.80			23.77	0.74	17.00	T2	Cu
	1	7.08	117.82	-12.12	6.14	-7.30	0.85	17.00	T3	Ni
	3	27.33	-14.38			4.72	0.77	17.00	T2	Ni
	1	92.24	2407.39	-192.45	136.89	-84.73	0.83	17.00	T3	Pb
	3	111.61	1917.40			-75.79	0.77	17.00	T3	Pb
	1	186.92	2283.53	-203.10	117.56	-152.58	0.83	17.00	T3	Zn
	3	205.05	1760.15			-144.93	0.78	17.00	T3	Zn

[a]For some metal parameters, the dissolved metal models were better than the particulate models, and vice versa. Dissolved/Particulate means either the dissolved or the particulate model was presented. [b]Count is the number of events considered. [c]**D** denotes dissolved, **P** denotes particulate, and **T** denotes total metal. Also, 1, 2, and 3 are linear, semi-log, and inverse forms respectively.

Appendix D-43. Regression Models Developed for Site 12-02.

Phase	Model	Coefficient					R^2	Count[b]	Form[c]	Parameter
		Intercept	T_RAIN (mm)	MAX_RAIN (mm/hr)	D_RUN (hr)	ADD (day)				
Dissolved/Particulate[a]	1									Cd
	3									Cd
	1									Cr
	3	-0.44	0.13			0.02	0.92	4.00	D1	Cr
	1									Cu
	3	-5.22	1.14			0.16	0.97	4.00	D1	Cu
	1									Ni
	3									Ni
	1									Pb
	3	-0.26	0.07			0.05	1.00	4.00	D1	Pb
	1									Zn
	3	-5.12	2.59			0.77	0.99	4.00	D1	Zn
Total	1									Cd
	3									Cd
	1									Cr
	3	15.33	-0.50			-0.03	0.61	4.00	T1	Cr
	1									Cu
	3	61.15	-271.36			-28.50	0.96	4.00	T3	Cu
	1									Ni
	3									Ni
	1									Pb
	3	59.70	-1.87			-0.14	0.65	4.00	T1	Pb
	1									Zn
	3	132.98	234.18			-63.43	0.99	4.00	T3	Zn

[a]For some metal parameters, the dissolved metal models were better than the particulate models, and vice versa. Dissolved/Particulate means either the dissolved or the particulate model was presented. [b]Count is the number of events considered. [c]**D** denotes dissolved, **P** denotes particulate, and **T** denotes total metal. Also, 1, 2, and 3 are linear, semi-log, and inverse forms respectively.

Appendix D-44. Regression Models Developed for Site 12-210.

Phase	Model	Coefficient					R^2	Count[b]	Form[c]	Parameter
		Intercept	T_RAIN (mm)	MAX_RAIN (mm/hr)	D_RUN (hr)	ADD (day)				
Dissolved/Particulate[a]	1	0.54	0.00	0.03	-0.04	0.02	0.81	12.00	P1	Cd
	3	0.71	0.01			-0.02	0.45	12.00	P1	Cd
	1	2.92	-0.11	0.23	-0.28	0.26	0.65	12.00	P1	Cr
	3	8.29	-15.93			-12.04	0.26	12.00	P3	Cr
	1	5.56	7.94	117.06	0.76	-27.73	0.79	12.00	D3	Cu
	3	12.45	-10.75			11.22	0.52	12.00	D2	Cu
	1	2.85	-0.04	0.13	-0.17	0.13	0.69	12.00	P1	Ni
	3	6.54	-11.38			-7.95	0.27	12.00	P3	Ni
	1	1.88	-0.02	0.05	-0.15	0.10	0.80	12.00	P1	Pb
	3	2.74	2.09			-6.67	0.24	12.00	P3	Pb
	1	38.45	173.98	919.36	-8.39	-246.38	0.86	12.00	D3	Zn
	3	106.69	-102.17			100.03	0.66	12.00	D2	Zn
Total	1	-0.89	-1.04	3.02	-0.13	0.23	0.67	12.00	T2	Cd
	3	1.12	1.03			-0.54	0.25	12.00	T2	Cd
	1	-3.17	-4.05	10.89	-3.43	5.01	0.53	12.00	T2	Cr
	3	10.74	-16.14			-13.72	0.28	12.00	T3	Cr
	1	14.13	11.62	110.06	7.02	-46.00	0.64	12.00	T3	Cu
	3	15.75	-11.62			16.00	0.47	12.00	T2	Cu
	1	13.08	-0.17	0.24	-0.08	0.18	0.29	12.00	T1	Ni
	3	17.64	1.61			-17.20	0.14	12.00	T3	Ni
	1	2.85	-0.01	0.04	-0.14	0.08	0.62	12.00	T1	Pb
	3	3.38	3.14			-7.13	0.23	12.00	T3	Pb
	1	95.70	276.22	714.95	93.20	-353.80	0.72	12.00	T3	Zn
	3	130.51	633.90			-401.91	0.57	12.00	T3	Zn

[a]For some metal parameters, the dissolved metal models were better than the particulate models, and vice versa. Dissolved/Particulate means either the dissolved or the particulate model was presented. [b]Count is the number of events considered. [c]**D** denotes dissolved, **P** denotes particulate, and **T** denotes total metal. Also, 1, 2, and 3 are linear, semi-log, and inverse forms respectively.

Appendix D-45. Regression Models Developed for Site 12-214.

Phase	Model	Coefficient					R^2	Count[b]	Form[c]	Parameter
		Intercept	T_RAIN (mm)	MAX_RAIN (mm/hr)	D_RUN (hr)	ADD (day)				
Dissolved/Particulate[a]	1	0.54	0.00	0.03	-0.04	0.02	0.81	12.00	P1	Cd
	3	0.71	0.01			-0.02	0.45	12.00	P1	Cd
	1	2.92	-0.11	0.23	-0.28	0.26	0.65	12.00	P1	Cr
	3	8.29	-15.93			-12.04	0.26	12.00	P3	Cr
	1	5.56	7.94	117.06	0.76	-27.73	0.79	12.00	D3	Cu
	3	12.45	-10.75			11.22	0.52	12.00	D2	Cu
	1	2.85	-0.04	0.13	-0.17	0.13	0.69	12.00	P1	Ni
	3	6.54	-11.38			-7.95	0.27	12.00	P3	Ni
	1	1.88	-0.02	0.05	-0.15	0.10	0.80	12.00	P1	Pb
	3	2.74	2.09			-6.67	0.24	12.00	P3	Pb
	1	38.45	173.98	919.36	-8.39	-246.38	0.86	12.00	D3	Zn
	3	106.69	-102.17			100.03	0.66	12.00	D2	Zn
Total	1	-0.89	-1.04	3.02	-0.13	0.23	0.67	12.00	T2	Cd
	3	1.12	1.03			-0.54	0.25	12.00	T2	Cd
	1	-3.17	-4.05	10.89	-3.43	5.01	0.53	12.00	T2	Cr
	3	10.74	-16.14			-13.72	0.28	12.00	T3	Cr
	1	14.13	11.62	110.06	7.02	-46.00	0.64	12.00	T3	Cu
	3	15.75	-11.62			16.00	0.47	12.00	T2	Cu
	1	13.08	-0.17	0.24	-0.08	0.18	0.29	12.00	T1	Ni
	3	17.64	1.61			-17.20	0.14	12.00	T3	Ni
	1	2.85	-0.01	0.04	-0.14	0.08	0.62	12.00	T1	Pb
	3	3.38	3.14			-7.13	0.23	12.00	T3	Pb
	1	95.70	276.22	714.95	93.20	-353.80	0.72	12.00	T3	Zn
	3	130.51	633.90			-401.91	0.57	12.00	T3	Zn

[a]For some metal parameters, the dissolved metal models were better than the particulate models, and vice versa. Dissolved/Particulate means either the dissolved or the particulate model was presented. [b]Count is the number of events considered. [c]**D** denotes dissolved, **P** denotes particulate, and **T** denotes total metal. Also, 1, 2, and 3 are linear, semi-log, and inverse forms respectively.

Appendix D-46. Regression Models Developed for Site 12-215.

Phase	Model	Coefficient					R^2	Count[b]	Form[c]	Parameter
		Intercept	T_RAIN (mm)	MAX_RAIN (mm/hr)	D_RUN (hr)	ADD (day)				
Dissolved/Particulate[a]	1	0.15	0.00	0.00	0.00	0.00	0.42	12.00	D1	Cd
	3	0.18	0.00			0.00	0.22	12.00	D1	Cd
	1	2.45	-0.05	0.06	0.07	-0.09	0.57	12.00	P1	Cr
	3	1.84	-7.96			3.67	0.45	12.00	D3	Cr
	1	7.90	-0.15	0.18	0.07	0.04	0.38	12.00	D1	Cu
	3	11.46	-0.08			0.04	0.22	12.00	D1	Cu
	1	2.45	-0.05	0.07	0.02	0.01	0.56	12.00	D1	Ni
	3	3.78	-0.01			-0.05	0.28	12.00	P1	Ni
	1	3.22	-0.03	0.07	0.05	-0.05	0.22	12.00	P1	Pb
	3	1.33	-0.11			-2.68	0.11	12.00	D3	Pb
	1	85.95	-1.63	3.13	-0.01	0.25	0.43	12.00	D1	Zn
	3	193.74	-1.01			-1.02	0.16	12.00	P1	Zn
Total	1	0.05	-0.44	0.63	0.23	-0.21	0.25	12.00	T2	Cd
	3	0.45	0.00			-0.01	0.07	12.00	T1	Cd
	1	3.09	-0.05	0.08	0.09	-0.08	0.61	12.00	T1	Cr
	3	5.50	1.33			-2.74	0.15	12.00	T2	Cr
	1	17.04	-0.29	0.28	0.22	0.03	0.35	12.00	T1	Cu
	3	23.77	-0.13			0.00	0.20	12.00	T1	Cu
	1	5.29	-0.09	0.11	0.05	-0.04	0.68	12.00	T1	Ni
	3	7.56	-0.04			-0.04	0.37	12.00	T1	Ni
	1	6.08	-40.64	36.91	14.82	-11.74	0.22	12.00	T3	Pb
	3	6.66	-9.07			-4.76	0.09	12.00	T3	Pb
	1	239.43	-3.59	4.74	1.40	-0.59	0.33	12.00	T1	Zn
	3	332.69	-1.74			-0.78	0.17	12.00	T1	Zn

[a]For some metal parameters, the dissolved metal models were better than the particulate models, and vice versa. Dissolved/Particulate means either the dissolved or the particulate model was presented. [b]Count is the number of events considered. [c]**D** denotes dissolved, **P** denotes particulate, and **T** denotes total metal. Also, 1, 2, and 3 are linear, semi-log, and inverse forms respectively.

Appendix D-47. Regression Models Developed for Site 12-216.

Phase	Model	Coefficient					R^2	Count[b]	Form[c]	Parameter
		Intercept	T_RAIN (mm)	MAX_RAIN (mm/hr)	D_RUN (hr)	ADD (day)				
Dissolved/Particulate[a]	1	0.15	1.91	-1.32	-1.42	1.66	0.80	11.00	P3	Cd
	3	0.13	-0.27			1.20	0.46	11.00	P3	Cd
	1	2.73	-0.03	0.03	0.17	-0.11	0.82	11.00	P1	Cr
	3	0.59	-6.08			24.13	0.75	11.00	D3	Cr
	1	4.97	79.92	-62.43	-29.12	88.71	0.67	11.00	D3	Cu
	3	4.45	22.71			70.50	0.62	11.00	D3	Cu
	1	0.08	-4.64	3.36	4.08	-0.78	0.90	11.00	P2	Ni
	3	1.07	1.86			28.55	0.67	11.00	D3	Ni
	1	0.17	5.03	-4.80	-1.92	9.13	0.60	11.00	D3	Pb
	3	0.13	1.02			7.76	0.58	11.00	D3	Pb
	1	51.38	102.53	-65.82	-142.01	280.99	0.64	11.00	P3	Zn
	3	48.98	-92.10			250.95	0.54	11.00	P3	Zn
Total	1	0.33	2.71	-2.86	-1.92	2.72	0.81	11.00	T3	Cd
	3	0.29	-0.63			1.83	0.55	11.00	T3	Cd
	1	6.69	37.50	-52.75	-37.69	46.74	0.67	11.00	T3	Cr
	3	6.03	-26.62			30.08	0.45	11.00	T3	Cr
	1	11.21	119.39	-81.00	-57.79	133.48	0.62	11.00	T3	Cu
	3	10.20	21.03			107.91	0.54	11.00	T3	Cu
	1	3.99	53.17	-36.05	-30.39	37.66	0.67	11.00	T3	Ni
	3	10.74	-0.05			-0.20	0.42	11.00	T1	Ni
	1	3.36	5.86	-5.62	-6.27	16.31	0.52	11.00	T3	Pb
	3	3.25	-3.69			14.31	0.47	11.00	T3	Pb
	1	84.46	240.61	-111.26	-138.26	448.07	0.49	11.00	T3	Zn
	3	82.09	34.46			407.22	0.46	11.00	T3	Zn

[a]For some metal parameters, the dissolved metal models were better than the particulate models, and vice versa. Dissolved/Particulate means either the dissolved or the particulate model was presented. [b]Count is the number of events considered. [c]**D** denotes dissolved, **P** denotes particulate, and **T** denotes total metal. Also, 1, 2, and 3 are linear, semi-log, and inverse forms respectively.

Appendix D-48. Regression Models Developed for Site 12-220.

Phase	Model	Coefficient					R^2	Count[b]	Form[c]	Parameter
		Intercept	T_RAIN (mm)	MAX_RAIN (mm/hr)	D_RUN (hr)	ADD (day)				
Dissolved/Particulate[a]	1	0.10	0.00	0.00	0.00	0.00	0.26	11.00	D1	Cd
	3	0.11	0.00			0.00	0.12	11.00	P1	Cd
	1	0.80	-0.09	0.14	0.33	-0.32	0.64	11.00	D1	Cr
	3	1.43	-0.83			1.68	0.13	11.00	P2	Cr
	1	14.97	-4.26	-3.61	-1.36	6.62	0.58	11.00	D2	Cu
	3	12.25	-5.92			5.18	0.52	11.00	D2	Cu
	1	2.88	-0.05	0.04	0.10	-0.06	0.49	11.00	D1	Ni
	3	5.48	-2.41			0.70	0.31	11.00	D2	Ni
	1	2.54	-0.42	-2.48	0.34	2.23	0.71	11.00	D2	Pb
	3	0.84	-1.00			1.58	0.32	11.00	D2	Pb
	1	264.43	-136.01	-58.87	20.64	97.54	0.68	11.00	D2	Zn
	3	225.88	-143.96			85.37	0.63	11.00	D2	Zn
Total	1	0.22	-0.84	1.34	0.52	-0.71	0.17	11.00	T3	Cd
	3	0.14	-0.08			0.19	0.12	11.00	T2	Cd
	1	2.62	-0.10	0.13	0.29	-0.24	0.65	11.00	T1	Cr
	3	5.46	-0.03			-0.03	0.10	11.00	T1	Cr
	1	17.82	-6.27	-1.79	-6.94	16.61	0.30	11.00	T2	Cu
	3	15.60	-9.89			14.25	0.26	11.00	T2	Cu
	1	3.55	-0.07	0.07	0.11	-0.04	0.37	11.00	T1	Ni
	3	4.92	-0.04			0.05	0.22	11.00	T1	Ni
	1	4.33	-1.45	-1.27	-1.74	5.89	0.32	11.00	T2	Pb
	3	3.20	-2.59			5.05	0.29	11.00	T2	Pb
	1	362.79	-186.20	-28.91	-122.51	307.33	0.41	11.00	T2	Zn
	3	325.50	-249.35			266.54	0.37	11.00	T2	Zn

[a]For some metal parameters, the dissolved metal models were better than the particulate models, and vice versa. Dissolved/Particulate means either the dissolved or the particulate model was presented. [b]Count is the number of events considered. [c]**D** denotes dissolved, **P** denotes particulate, and **T** denotes total metal. Also, 1, 2, and 3 are linear, semi-log, and inverse forms respectively.

Appendix D-49. Regression Models Developed for Site 12-221.

Phase	Model	Coefficient					R^2	Count[b]	Form[c]	Parameter
		Intercept	T_RAIN (mm)	MAX_RAIN (mm/hr)	D_RUN (hr)	ADD (day)				
Dissolved/Particulate[a]	1	0.19	-0.07	0.00	-0.02	0.06	0.40	11.00	D2	Cd
	3	0.19	-0.08			0.06	0.39	11.00	D2	Cd
	1	0.60	7.70	-10.17	6.99	-1.97	0.55	11.00	P3	Cr
	3	1.83	14.67			-2.84	0.33	11.00	D3	Cr
	1	24.54	-12.11	-0.76	-2.16	10.17	0.67	11.00	D2	Cu
	3	23.72	-13.30			9.45	0.67	11.00	D2	Cu
	1	8.70	-3.69	-0.69	-0.31	1.20	0.67	11.00	D2	Ni
	3	8.18	-4.03			0.92	0.66	11.00	D2	Ni
	1	0.26	-6.45	17.47	3.85	-3.03	0.60	11.00	D3	Pb
	3	4.33	-0.02			-0.06	0.17	11.00	P1	Pb
	1	139.18	-77.81	-22.89	20.80	44.13	0.90	11.00	D2	Zn
	3	125.77	-75.18			41.99	0.82	11.00	D2	Zn
Total	1	0.58	-0.15	-0.12	0.00	0.04	0.54	11.00	T2	Cd
	3	0.50	-0.18			0.00	0.48	11.00	T2	Cd
	1	1.86	10.65	12.67	11.98	-9.22	0.72	11.00	T3	Cr
	3	2.76	27.22			-6.48	0.50	11.00	T3	Cr
	1	40.20	-14.97	-4.90	-6.42	13.69	0.71	11.00	T2	Cu
	3	35.92	-19.27			10.77	0.67	11.00	T2	Cu
	1	3.02	49.65	-21.68	4.36	-6.70	0.77	11.00	T3	Ni
	3	2.98	46.93			-8.45	0.72	11.00	T3	Ni
	1	1.84	-3.56	11.38	17.90	-6.91	0.55	11.00	T3	Pb
	3	3.09	18.69			-3.61	0.18	11.00	T3	Pb
	1	72.68	781.18	-353.38	255.98	-155.35	0.66	11.00	T3	Zn
	3	83.39	927.63			-162.06	0.53	11.00	T3	Zn

[a]For some metal parameters, the dissolved metal models were better than the particulate models, and vice versa. Dissolved/Particulate means either the dissolved or the particulate model was presented. [b]Count is the number of events considered. [c]**D** denotes dissolved, **P** denotes particulate, and **T** denotes total metal. Also, 1, 2, and 3 are linear, semi-log, and inverse forms respectively.

Appendix D-50. Regression Models Developed for Site 12-230.

Phase	Model	Coefficient					R^2	Count[b]	Form[c]	Parameter
		Intercept	T_RAIN (mm)	MAX_RAIN (mm/hr)	D_RUN (hr)	ADD (day)				
Dissolved/Particulate[a]	1	-0.05	0.41	8.74	1.19	3.01	0.84	12.00	P3	Cd
	3	0.26	5.07			3.68	0.71	12.00	P3	Cd
	1	2.66	-33.69	95.30	3.15	1.31	0.71	12.00	D3	Cr
	3	1.74	-0.43			3.32	0.46	12.00	P2	Cr
	1	23.45	54.97	195.42	11.33	28.94	0.71	12.00	P3	Cu
	3	28.73	140.03			48.30	0.66	12.00	P3	Cu
	1	12.71	-9.63	-3.73	7.86	4.78	0.60	12.00	D2	Ni
	3	10.92	-0.09			0.04	0.34	12.00	D1	Ni
	1	-4.32	16.89	-18.08	6.02	9.69	0.79	12.00	D2	Pb
	3	-18.39	14.09			10.22	0.62	12.00	D2	Pb
	1	73.08	-0.25	-1.05	1.18	0.25	0.87	12.00	D1	Zn
	3	366.02	-170.04			24.01	0.51	12.00	P2	Zn
Total	1	0.31	-0.50	12.68	0.99	2.50	0.77	12.00	T3	Cd
	3	0.68	5.34			3.68	0.65	12.00	T3	Cd
	1	13.93	0.05	-0.25	0.05	0.02	0.58	12.00	T1	Cr
	3	9.15	-1.49			3.42	0.20	12.00	T2	Cr
	1	104.84	-0.78	-1.01	1.00	0.00	0.72	12.00	T1	Cu
	3	65.87	183.14			-44.52	0.31	12.00	T3	Cu
	1	19.52	-0.21	-0.15	0.19	0.04	0.72	12.00	T1	Ni
	3	17.67	-0.14			0.06	0.53	12.00	T1	Ni
	1	17.22	-182.23	927.40	28.67	223.80	0.50	12.00	T3	Pb
	3	39.45	189.64			322.91	0.38	12.00	T3	Pb
	1	418.84	-124.68	-46.86	-44.70	78.79	0.57	12.00	T2	Zn
	3	386.58	-175.55			72.29	0.55	12.00	T2	Zn

[a]For some metal parameters, the dissolved metal models were better than the particulate models, and vice versa. Dissolved/Particulate means either the dissolved or the particulate model was presented. [b]Count is the number of events considered. [c]**D** denotes dissolved, **P** denotes particulate, and **T** denotes total metal. Also, 1, 2, and 3 are linear, semi-log, and inverse forms respectively.

Appendix D-51. Regression Models Developed for Site 12-231.

Phase	Model	Coefficient					R^2	Count[b]	Form[c]	Parameter
		Intercept	T_RAIN (mm)	MAX_RAIN (mm/hr)	D_RUN (hr)	ADD (day)				
Dissolved/Particulate[a]	1	-17.47	-52.34	205.07	224.07	64.41	1.00	5.00	P3	Cd
	3	-0.04	0.00			0.00	0.99	5.00	D1	Cd
	1	-405.82	-1314.60	4741.75	5201.92	1511.21	1.00	5.00	P3	Cr
	3	-20.54	10.04			4.95	0.58	5.00	D2	Cr
	1	-1260.38	-3766.59	14679.50	16173.74	4622.97	1.00	5.00	P3	Cu
	3	-6.96	0.25			0.22	0.93	5.00	D1	Cu
	1	-268.47	-801.35	3121.25	3386.70	1001.10	1.00	5.00	P3	Ni
	3	-1.78	0.06			0.06	0.97	5.00	D1	Ni
	1	-650.40	-2166.41	7658.78	8590.78	2350.50	1.00	5.00	P3	Pb
	3	-18.13	8.62			5.26	0.60	5.00	D2	Pb
	1	-3528.33	-11481.86	41152.06	45446.88	13151.40	1.00	5.00	P3	Zn
	3	14.41	0.06			0.33	0.90	5.00	D1	Zn
Total	1	-7.92	-6.90	95.50	107.98	23.63	1.00	5.00	T3	Cd
	3	0.59	17.81			-8.13	0.81	5.00	T3	Cd
	1	-337.73	-1179.29	4071.84	4387.89	1244.24	1.00	5.00	T3	Cr
	3	19.49	-205.93			-113.14	0.23	5.00	T3	Cr
	1	-711.54	-1471.06	8586.04	9511.95	2321.83	1.00	5.00	T3	Cu
	3	48.17	678.19			-536.71	0.69	5.00	T3	Cu
	1	-74.84	1.46	899.32	1050.21	206.88	1.00	5.00	T3	Ni
	3	6.08	246.69			-91.76	0.83	5.00	T3	Ni
	1	-584.28	-2002.26	7012.93	7793.30	2089.30	1.00	5.00	T3	Pb
	3	36.84	-237.80			-245.16	0.24	5.00	T3	Pb
	1	-2703.99	-7131.41	31885.94	35092.44	9813.03	1.00	5.00	T3	Zn
	3	111.57	763.70			-806.02	0.26	5.00	T3	Zn

[a]For some metal parameters, the dissolved metal models were better than the particulate models, and vice versa. Dissolved/Particulate means either the dissolved or the particulate model was presented. [b]Count is the number of events considered. [c]**D** denotes dissolved, **P** denotes particulate, and **T** denotes total metal. Also, 1, 2, and 3 are linear, semi-log, and inverse forms respectively.

Appendix D-52. Regression Models Developed for Site 12-233.

Phase	Model	Coefficient					R^2	Count[b]	Form[c]	Parameter
		Intercept	T_RAIN (mm)	MAX_RAIN (mm/hr)	D_RUN (hr)	ADD (day)				
Dissolved/Particulate[a]	1	0.08	0.00	7.24	-0.22	-2.67	1.00	4.00	P3	Cd
	3	-0.26	0.00			0.01	0.87	4.00	D1	Cd
	1	0.19	0.00	-5.58	3.59	11.33	1.00	4.00	P3	Cr
	3	2.93	-0.03			-0.02	0.64	4.00	P1	Cr
	1	-6.09	0.00	86.87	23.59	53.34	1.00	4.00	P3	Cu
	3	8.57	-0.05			0.13	0.96	4.00	D1	Cu
	1	-0.24	0.00	-0.64	0.17	19.82	1.00	4.00	P3	Ni
	3	0.86	-0.01			0.06	1.00	4.00	D1	Ni
	1	-4.57	0.00	113.70	10.20	34.16	1.00	4.00	P3	Pb
	3	4.99	-0.06			0.05	0.99	4.00	P1	Pb
	1	-9.80	0.00	300.03	7.29	52.46	1.00	4.00	P3	Zn
	3	13.27	738.82			-166.02	1.00	4.00	D3	Zn
Total	1	0.03	0.00	18.34	-0.25	-6.64	1.00	4.00	T3	Cd
	3	-0.48	0.00			0.02	0.92	4.00	T1	Cd
	1	1.91	0.00	32.26	3.19	17.21	1.00	4.00	T3	Cr
	3	5.46	-0.02			0.00	0.92	4.00	T1	Cr
	1	-4.19	0.00	252.96	32.41	56.54	1.00	4.00	T3	Cu
	3	5.44	594.63			-95.72	1.00	4.00	T3	Cu
	1	-3.66	0.00	99.86	7.17	26.08	1.00	4.00	T3	Ni
	3	3.50	-0.04			0.04	0.90	4.00	T1	Ni
	1	-5.18	0.00	158.03	10.61	49.78	1.00	4.00	T3	Pb
	3	6.57	-0.06			0.06	0.77	4.00	T1	Pb
	1	-8.44	0.00	613.32	47.53	75.25	1.00	4.00	T3	Zn
	3	29.37	-0.29			0.41	1.00	4.00	T1	Zn

[a]For some metal parameters, the dissolved metal models were better than the particulate models, and vice versa. Dissolved/Particulate means either the dissolved or the particulate model was presented. [b]Count is the number of events considered. [c]**D** denotes dissolved, **P** denotes particulate, and **T** denotes total metal. Also, 1, 2, and 3 are linear, semi-log, and inverse forms respectively.

Appendix D-53. Regression Models Developed for Site 12-01.

Phase	Model	Coefficient					R^2	Count[b]	Form[c]	Parameter
		Intercept	T_RAIN (mm)	MAX_RAIN (mm/hr)	D_RUN (hr)	ADD (day)				
Dissolved/Particulate[a]	1									Cd
	3									Cd
	1									Cr
	3									Cr
	1									Cu
	3	6.55	1.89			-3.90	1.00	4.00	P3	Cu
	1									Ni
	3									Ni
	1									Pb
	3									Pb
	1									Zn
	3	266.97	-132.49			-48.04	0.99	4.00	P2	Zn
Total	1									Cd
	3									Cd
	1									Cr
	3	16.64	-0.53			-0.04	1.00	4.00	T1	Cr
	1									Cu
	3	8.52	35.72			-3.15	0.99	4.00	T3	Cu
	1									Ni
	3									Ni
	1									Pb
	3	27.27	-13.39			-2.71	0.83	4.00	T2	Pb
	1									Zn
	3	23.48	2.99			0.53	0.77	4.00	T1	Zn

[a]For some metal parameters, the dissolved metal models were better than the particulate models, and vice versa. Dissolved/Particulate means either the dissolved or the particulate model was presented. [b]Count is the number of events considered. [c]**D** denotes dissolved, **P** denotes particulate, and **T** denotes total metal. Also, 1, 2, and 3 are linear, semi-log, and inverse forms respectively.

Appendix D-54. Regression Models Developed for Site 12-225.

Phase	Model	Coefficient					R^2	Count[b]	Form[c]	Parameter
		Intercept	T_RAIN (mm)	MAX_RAIN (mm/hr)	D_RUN (hr)	ADD (day)				
Dissolved/Particulate[a]	1	1.08	-0.02	0.02	0.00	0.00	0.60	12.00	P1	Cd
	3	1.85	-0.84			-0.06	0.58	12.00	P2	Cd
	1	1.77	18.03	-4.53	4.58	0.74	0.49	12.00	P3	Cr
	3	2.04	18.82			0.60	0.44	12.00	P3	Cr
	1	14.62	-3.60	-13.75	4.80	16.60	0.70	12.00	D2	Cu
	3	62.11	-29.91			0.55	0.65	12.00	P2	Cu
	1	2.03	-2.83	95.72	-2.13	-22.81	0.74	12.00	D3	Ni
	3	2.16	-3.49			5.92	0.61	12.00	D2	Ni
	1	37.17	-19.86	4.09	-4.08	3.58	0.79	12.00	P2	Pb
	3	39.65	-19.94			2.27	0.76	12.00	P2	Pb
	1	236.18	-20.50	-307.68	43.77	230.57	0.93	12.00	D2	Zn
	3	-42.44	-108.08			266.20	0.78	12.00	D2	Zn
Total	1	2.11	-0.94	-0.11	0.05	0.17	0.40	12.00	T2	Cd
	3	2.02	-0.96			0.19	0.40	12.00	T2	Cd
	1	5.29	15.21	13.49	2.85	-8.29	0.17	12.00	T3	Cr
	3	6.21	17.53			-8.05	0.17	12.00	T3	Cr
	1	68.97	-34.24	-2.47	-3.81	20.15	0.56	12.00	T2	Cu
	3	65.28	-36.42			19.43	0.56	12.00	T2	Cu
	1	0.73	27.01	307.13	-3.19	-71.53	0.20	12.00	T3	Ni
	3	24.42	-21.17			13.41	0.17	12.00	T2	Ni
	1	38.69	-17.73	-0.48	-1.59	6.99	0.59	12.00	T2	Pb
	3	37.67	-18.45			6.65	0.58	12.00	T2	Pb
	1	523.44	-269.06	-114.46	-49.86	281.25	0.65	12.00	T2	Zn
	3	396.69	-325.07			278.54	0.64	12.00	T2	Zn

[a]For some metal parameters, the dissolved metal models were better than the particulate models, and vice versa. Dissolved/Particulate means either the dissolved or the particulate model was presented. [b]Count is the number of events considered. [c]**D** denotes dissolved, **P** denotes particulate, and **T** denotes total metal. Also, 1, 2, and 3 are linear, semi-log, and inverse forms respectively.

Appendix D-55. Regression Models Developed for Site 12-226.

Phase	Model	Coefficient					R^2	Count[b]	Form[c]	Parameter
		Intercept	T_RAIN (mm)	MAX_RAIN (mm/hr)	D_RUN (hr)	ADD (day)				
Dissolved/Particulate[a]	1	0.64	0.02	-0.36	-0.16	0.12	0.91	8.00	D2	Cd
	3	1.39	-0.60			-0.03	0.63	8.00	P2	Cd
	1	15.45	-1.29	-10.54	-3.31	7.78	0.98	8.00	P2	Cr
	3	6.40	-6.24			7.34	0.90	8.00	P2	Cr
	1	3.96	72.74	254.10	-10.04	-51.32	0.90	8.00	D3	Cu
	3	16.11	-10.45			11.44	0.70	8.00	D2	Cu
	1	-0.26	14.42	82.06	-1.94	-12.60	0.93	8.00	D3	Ni
	3	3.94	-2.80			2.95	0.68	8.00	D2	Ni
	1	6.19	89.63	265.99	-1.80	-57.20	0.91	8.00	P3	Pb
	3	41.04	-22.42			9.22	0.79	8.00	P2	Pb
	1	0.58	44.89	987.52	-7.91	-135.10	0.87	8.00	D3	Zn
	3	333.27	-196.33			48.95	0.66	8.00	P2	Zn
Total	1	2.03	-0.21	-0.60	-0.51	0.20	0.82	8.00	T2	Cd
	3	1.76	-0.79			0.06	0.65	8.00	T2	Cd
	1	0.42	8.31	225.71	2.14	-41.65	0.92	8.00	T3	Cr
	3	12.01	-8.23			8.07	0.75	8.00	T2	Cr
	1	16.58	235.75	450.04	-22.28	-117.70	0.81	8.00	T3	Cu
	3	64.63	-36.17			21.05	0.67	8.00	T2	Cu
	1	-2.23	38.33	231.36	-2.82	-40.30	0.92	8.00	T3	Ni
	3	12.81	-9.82			7.94	0.70	8.00	T2	Ni
	1	6.97	84.88	340.20	-3.30	-50.19	0.91	8.00	T3	Pb
	3	44.56	-21.60			9.61	0.79	8.00	T2	Pb
	1	25.78	1418.00	2338.86	-127.32	-530.97	0.79	8.00	T3	Zn
	3	367.28	-217.94			82.67	0.66	8.00	T2	Zn

[a]For some metal parameters, the dissolved metal models were better than the particulate models, and vice versa. Dissolved/Particulate means either the dissolved or the particulate model was presented. [b]Count is the number of events considered. [c]**D** denotes dissolved, **P** denotes particulate, and **T** denotes total metal. Also, 1, 2, and 3 are linear, semi-log, and inverse forms respectively.

Appendix D-56. Regression Models Developed for Site 12-227.

Phase	Model	Coefficient					R^2	Count[b]	Form[c]	Parameter
		Intercept	T_RAIN (mm)	MAX_RAIN (mm/hr)	D_RUN (hr)	ADD (day)				
Dissolved/Particulate[a]	1	-0.03	0.17	4.94	0.40	-0.65	0.95	9.00	D3	Cd
	3	0.31	0.00			0.00	0.61	9.00	D1	Cd
	1	3.18	8.32	-11.51	20.62	-9.73	0.95	9.00	D3	Cr
	3	3.95	15.00			-12.92	0.52	9.00	D3	Cr
	1	37.49	-9.76	-23.36	-3.67	23.53	0.94	9.00	D2	Cu
	3	13.91	-18.84			24.34	0.83	9.00	D2	Cu
	1	-0.15	5.15	83.69	6.91	-19.41	0.89	9.00	D3	Ni
	3	4.25	-4.17			3.99	0.67	9.00	D2	Ni
	1	10.12	0.96	-7.75	-1.26	4.15	0.87	9.00	D2	Pb
	3	4.44	-0.03			0.04	0.70	9.00	D1	Pb
	1	106.60	-19.00	-106.93	18.88	63.23	0.96	9.00	D2	Zn
	3	39.42	-0.50			0.56	0.93	9.00	D1	Zn
Total	1	0.09	0.18	5.36	3.11	-0.76	0.84	9.00	T3	Cd
	3	1.02	-0.60			0.29	0.45	9.00	T2	Cd
	1	6.61	8.55	-4.38	39.84	-19.28	0.87	9.00	T3	Cr
	3	11.22	-6.13			4.32	0.41	9.00	T2	Cr
	1	7.42	34.83	391.54	122.21	-113.46	0.89	9.00	T3	Cu
	3	42.93	-33.05			26.06	0.61	9.00	T2	Cu
	1	1.64	4.47	95.43	25.72	-25.77	0.86	9.00	T3	Ni
	3	8.56	-6.80			6.01	0.58	9.00	T2	Ni
	1	4.73	0.76	297.03	66.79	-61.63	0.85	9.00	T3	Pb
	3	23.76	-17.35			16.38	0.58	9.00	T2	Pb
	1	14.52	107.46	1331.76	402.04	-302.63	0.88	9.00	T3	Zn
	3	154.45	-110.56			76.25	0.61	9.00	T2	Zn

[a]For some metal parameters, the dissolved metal models were better than the particulate models, and vice versa. Dissolved/Particulate means either the dissolved or the particulate model was presented. [b]Count is the number of events considered. [c]**D** denotes dissolved, **P** denotes particulate, and **T** denotes total metal. Also, 1, 2, and 3 are linear, semi-log, and inverse forms respectively.

Appendix D-57. Regression Models Developed for Site 12-228.

Phase	Model	Coefficient					R^2	Count[b]	Form[c]	Parameter
		Intercept	T_RAIN (mm)	MAX_RAIN (mm/hr)	D_RUN (hr)	ADD (day)				
Dissolved/Particulate[a]	1	0.38	0.00	-5.48	2.58	-0.50	1.00	4.00	P3	Cd
	3	0.40	-3.16			-1.85	0.78	4.00	P3	Cd
	1	4.32	0.00	-45.39	-17.09	-4.31	1.00	4.00	P3	Cr
	3	-5.85	2.55			2.71	1.00	4.00	P2	Cr
	1	11.51	0.00	-124.41	-60.72	-17.93	1.00	4.00	P3	Cu
	3	12.24	-172.40			-70.48	1.00	4.00	P3	Cu
	1	2.18	0.00	-16.60	-37.89	13.82	1.00	4.00	P3	Ni
	3	2.59	71.20			-33.03	0.90	4.00	D3	Ni
	1	7.05	0.00	50.50	64.04	-76.20	1.00	4.00	P3	Pb
	3	10.36	-89.27			-65.21	1.00	4.00	D3	Pb
	1	44.60	0.00	-286.17	60.51	-230.18	1.00	4.00	P3	Zn
	3	45.88	-227.37			-314.19	0.98	4.00	P3	Zn
Total	1	0.47	0.00	-10.02	4.56	1.81	1.00	4.00	T3	Cd
	3	0.16	0.00			0.00	0.53	4.00	T1	Cd
	1	10.36	0.00	-96.25	-26.91	-16.69	1.00	4.00	T3	Cr
	3	10.89	-116.41			-53.65	1.00	4.00	T3	Cr
	1	20.25	0.00	-49.29	201.47	-176.84	1.00	4.00	T3	Cu
	3	20.10	122.31			-156.12	0.89	4.00	T3	Cu
	1	4.98	0.00	5.53	20.87	-37.40	1.00	4.00	T3	Ni
	3	4.92	23.02			-31.72	0.98	4.00	T3	Ni
	1	17.01	0.00	-22.38	42.34	-113.18	1.00	4.00	T3	Pb
	3	17.04	14.00			-112.82	0.99	4.00	T3	Pb
	1	66.18	0.00	-350.23	464.41	-429.28	1.00	4.00	T3	Zn
	3	67.00	51.65			-460.19	0.90	4.00	T3	Zn

[a]For some metal parameters, the dissolved metal models were better than the particulate models, and vice versa. Dissolved/Particulate means either the dissolved or the particulate model was presented. [b]Count is the number of events considered. [c]**D** denotes dissolved, **P** denotes particulate, and **T** denotes total metal. Also, 1, 2, and 3 are linear, semi-log, and inverse forms respectively.

Appendix D-58. Regression Models Developed for Site 12-229.

Phase	Model	Coefficient					R^2	Count[b]	Form[c]	Parameter
		Intercept	T_RAIN (mm)	MAX_RAIN (mm/hr)	D_RUN (hr)	ADD (day)				
Dissolved/Particulate[a]	1	0.38	0.00	15.01	-4.05	-6.90	1.00	4.00	P3	Cd
	3	-0.12	0.00			0.00	0.88	4.00	P1	Cd
	1	6.51	0.00	254.95	-66.46	-125.32	1.00	4.00	P3	Cr
	3	-0.17	0.04			0.02	1.00	4.00	D1	Cr
	1	7.30	0.00	370.23	-65.21	-190.69	1.00	4.00	P3	Cu
	3	0.81	-0.03			0.21	0.91	4.00	P1	Cu
	1	4.85	0.00	467.01	-104.82	-182.87	1.00	4.00	P3	Ni
	3	3.61	-49.59			-10.71	0.69	4.00	D3	Ni
	1	16.87	0.00	758.25	-199.28	-359.05	1.00	4.00	P3	Pb
	3	-2.27	0.08			0.01	0.99	4.00	D1	Pb
	1	46.25	0.00	3118.63	-776.74	-1284.82	1.00	4.00	P3	Zn
	3	-27.18	0.67			0.18	0.77	4.00	P1	Zn
Total	1	0.48	0.00	15.01	-4.05	-6.90	1.00	4.00	T3	Cd
	3	-0.02	0.00			0.00	0.88	4.00	T1	Cd
	1	11.05	0.00	241.27	-76.11	-138.09	1.00	4.00	T3	Cr
	3	-2.53	0.09			0.09	0.96	4.00	T1	Cr
	1	16.70	0.00	120.70	-21.41	-143.75	1.00	4.00	T3	Cu
	3	5.80	-0.04			0.32	1.00	4.00	T1	Cu
	1	7.99	0.00	276.20	-73.46	-132.02	1.00	4.00	T3	Ni
	3	-1.57	0.07			0.06	0.89	4.00	T1	Ni
	1	22.61	0.00	808.41	-232.28	-398.55	1.00	4.00	T3	Pb
	3	-10.70	0.26			0.17	0.92	4.00	T1	Pb
	1	74.34	0.00	1156.45	-403.10	-775.99	1.00	4.00	T3	Zn
	3	-11.99	0.55			0.70	0.98	4.00	T1	Zn

[a]For some metal parameters, the dissolved metal models were better than the particulate models, and vice versa. Dissolved/Particulate means either the dissolved or the particulate model was presented. [b]Count is the number of events considered. [c]**D** denotes dissolved, **P** denotes particulate, and **T** denotes total metal. Also, 1, 2, and 3 are linear, semi-log, and inverse forms respectively.

Appendix D-59. Regression Models Developed for Site 11-204.

Phase	Model	Coefficient					R^2	Count[b]	Form[c]	Parameter
		Intercept	T_RAIN (mm)	MAX_RAIN (mm/hr)	D_RUN (hr)	ADD (day)				
Dissolved/Particulate[a]	1	0.12	-0.81	1.62	1.29	0.29	0.57	16.00	D3	Cd
	3	1.25	-0.02			0.00	0.50	16.00	P1	Cd
	1	5.17	-10.00	4.12	-0.88	-7.68	0.34	16.00	D3	Cr
	3	5.00	-6.58			-7.46	0.31	16.00	D3	Cr
	1	11.64	-41.36	135.27	45.07	-23.01	0.66	16.00	D3	Cu
	3	27.86	-13.49			10.27	0.39	16.00	D2	Cu
	1	1.58	13.11	23.31	13.78	-6.18	0.69	16.00	D3	Ni
	3	10.88	-6.80			3.22	0.57	16.00	D2	Ni
	1	11.21	-257.84	223.39	92.96	-28.55	0.72	16.00	D3	Pb
	3	-24.95	21.96			12.27	0.28	16.00	D2	Pb
	1	93.31	0.37	-1.35	-0.55	0.49	0.72	16.00	D1	Zn
	3	73.71	-0.61			0.52	0.50	16.00	D1	Zn
Total	1	1.85	-0.02	-0.01	0.00	0.00	0.56	16.00	T1	Cd
	3	1.71	-0.02			0.00	0.52	16.00	T1	Cd
	1	8.49	-5.75	4.82	0.88	-14.72	0.15	16.00	T3	Cr
	3	8.67	-2.00			-14.91	0.14	16.00	T3	Cr
	1	79.57	-0.79	-0.36	0.05	0.11	0.56	16.00	T1	Cu
	3	74.94	-0.96			0.12	0.51	16.00	T1	Cu
	1	15.70	-0.27	-0.05	0.08	0.05	0.68	16.00	T1	Ni
	3	17.14	-10.95			5.31	0.66	16.00	T2	Ni
	1	22.81	-249.64	359.42	255.54	-51.83	0.56	16.00	T3	Pb
	3	46.58	-10.37			25.48	0.07	16.00	T2	Pb
	1	337.14	-5.23	0.17	0.38	0.96	0.61	16.00	T1	Zn
	3	340.63	-4.97			0.96	0.61	16.00	T1	Zn

[a]For some metal parameters, the dissolved metal models were better than the particulate models, and vice versa. Dissolved/Particulate means either the dissolved or the particulate model was presented. [b]Count is the number of events considered. [c]**D** denotes dissolved, **P** denotes particulate, and **T** denotes total metal. Also, 1, 2, and 3 are linear, semi-log, and inverse forms respectively.

Appendix D-60. Regression Models Developed for Site 11-205.

Phase	Model	Coefficient					R^2	Count[b]	Form[c]	Parameter
		Intercept	T_RAIN (mm)	MAX_RAIN (mm/hr)	D_RUN (hr)	ADD (day)				
Dissolved/Particulate[a]	1	1.21	-0.14	-0.59	-0.23	0.20	0.96	8.00	D2	Cd
	3	0.53	-0.32			0.08	0.87	8.00	P2	Cd
	1	0.95	21.05	7.17	-0.33	-4.70	0.83	8.00	P3	Cr
	3	1.16	22.25			-4.97	0.75	8.00	P3	Cr
	1	-6.14	192.62	476.75	9.59	-44.77	0.95	8.00	D3	Cu
	3	0.16	252.12			-26.79	0.90	8.00	P3	Cu
	1	0.08	32.71	63.89	0.54	-10.13	0.92	8.00	D3	Ni
	3	-0.53	55.67			-1.05	0.89	8.00	P3	Ni
	1	16.36	-0.29	-0.05	-0.51	0.71	0.93	8.00	P1	Pb
	3	48.43	-35.03			14.11	0.81	8.00	P2	Pb
	1	-6.83	1360.89	-107.02	-9.93	-93.57	0.97	8.00	P3	Zn
	3	-13.67	1356.29			-91.55	0.96	8.00	P3	Zn
Total	1	0.50	-0.01	0.00	-0.01	0.01	0.93	8.00	T1	Cd
	3	0.60	-0.01			0.00	0.79	8.00	T1	Cd
	1	5.92	42.34	-19.00	-1.98	-11.77	0.55	8.00	T3	Cr
	3	4.65	41.72			-11.44	0.49	8.00	T3	Cr
	1	-7.87	437.66	527.21	8.82	-69.88	0.97	8.00	T3	Cu
	3	82.25	-58.94			26.77	0.70	8.00	T2	Cu
	1	-1.33	95.12	72.79	0.76	-13.46	0.97	8.00	T3	Ni
	3	15.74	-11.51			4.73	0.80	8.00	T2	Ni
	1	32.05	-0.32	-0.27	-0.77	0.99	0.94	8.00	T1	Pb
	3	43.01	-0.79			0.41	0.72	8.00	T1	Pb
	1	6.41	1677.92	405.57	-12.56	-169.88	0.97	8.00	T3	Zn
	3	280.53	-183.26			50.80	0.92	8.00	T2	Zn

[a]For some metal parameters, the dissolved metal models were better than the particulate models, and vice versa. Dissolved/Particulate means either the dissolved or the particulate model was presented. [b]Count is the number of events considered. [c]**D** denotes dissolved, **P** denotes particulate, and **T** denotes total metal. Also, 1, 2, and 3 are linear, semi-log, and inverse forms respectively.

Appendix D-61. Regression Models Developed for Site 11-206.

Phase	Model	Coefficient: Intercept	T_RAIN (mm)	MAX_RAIN (mm/hr)	D_RUN (hr)	ADD (day)	R^2	Count[b]	Form[c]	Parameter
Dissolved/Particulate[a]	1	0.11	3.70	-1.70	-0.04	-0.16	0.88	8.00	P3	Cd
	3	0.03	3.44			-0.11	0.71	8.00	P3	Cd
	1	0.42	76.90	-27.94	-1.15	0.00	0.97	8.00	P3	Cr
	3	-0.89	72.01			0.82	0.85	8.00	P3	Cr
	1	3.93	122.37	257.79	-1.11	-18.68	0.97	8.00	D3	Cu
	3	-4.73	307.29			-2.69	0.82	8.00	P3	Cu
	1	0.23	32.40	48.03	-0.54	-2.84	0.99	8.00	D3	Ni
	3	-1.33	67.62			0.46	0.75	8.00	P3	Ni
	1	6.35	717.55	-230.22	-11.98	-20.58	0.82	8.00	P3	Pb
	3	-4.86	674.30			-13.96	0.75	8.00	P3	Pb
	1	60.97	-0.29	-0.58	-0.52	0.59	0.98	8.00	D1	Zn
	3	-59.43	2498.49			9.83	0.81	8.00	P3	Zn
Total	1	0.16	6.04	-3.29	-0.18	0.31	0.76	8.00	T3	Cd
	3	0.00	5.41			0.41	0.57	8.00	T3	Cd
	1	3.69	108.31	-32.68	-2.29	-6.92	0.96	8.00	T3	Cr
	3	2.01	101.48			-6.00	0.88	8.00	T3	Cr
	1	105.84	-46.02	-15.39	-3.40	10.56	0.99	8.00	T2	Cu
	3	84.83	-50.08			11.62	0.96	8.00	T2	Cu
	1	0.13	109.14	15.04	-1.47	-3.34	1.00	8.00	T3	Ni
	3	19.05	-11.37			1.82	0.97	8.00	T2	Ni
	1	14.62	822.36	-214.49	-17.29	-2.96	0.70	8.00	T3	Pb
	3	3.31	774.86			2.92	0.65	8.00	T3	Pb
	1	5.69	2885.50	-811.77	-28.25	-32.88	0.96	8.00	T3	Zn
	3	-31.85	2749.48			-8.85	0.89	8.00	T3	Zn

[a]For some metal parameters, the dissolved metal models were better than the particulate models, and vice versa. Dissolved/Particulate means either the dissolved or the particulate model was presented. [b]Count is the number of events considered. [c]**D** denotes dissolved, **P** denotes particulate, and **T** denotes total metal. Also, 1, 2, and 3 are linear, semi-log, and inverse forms respectively.

Appendix D-62. Regression Models Developed for Site 11-207.

Phase	Model	Coefficient					R^2	Count[b]	Form[c]	Parameter
		Intercept	T_RAIN (mm)	MAX_RAIN (mm/hr)	D_RUN (hr)	ADD (day)				
Dissolved/Particulate[a]	1	0.09	0.00	0.01	0.00	0.00	0.87	6.00	P1	Cd
	3	0.31	0.00			-0.01	0.60	6.00	P1	Cd
	1	3.78	-11.26	68.01	-50.92	12.86	0.90	6.00	D3	Cr
	3	5.55	-0.08			0.10	0.62	6.00	D1	Cr
	1	3.94	-0.16	0.36	-0.02	-0.02	0.77	6.00	P1	Cu
	3	4.06	222.33			16.73	0.58	6.00	D3	Cu
	1	1.55	29.60	9.40	-4.95	6.76	0.76	6.00	D3	Ni
	3	1.40	47.15			4.57	0.72	6.00	D3	Ni
	1	-9.28	-299.43	314.03	309.47	-12.04	0.88	6.00	D3	Pb
	3	-3.05	316.14			83.68	0.80	6.00	D3	Pb
	1	-6.78	103.07	502.76	240.29	-25.20	0.83	6.00	D3	Zn
	3	-2.85	1072.78			37.31	0.73	6.00	D3	Zn
Total	1	0.14	0.00	0.01	-0.01	0.00	0.64	6.00	T1	Cd
	3	0.45	0.00			-0.01	0.53	6.00	T1	Cd
	1	4.71	-88.96	85.94	94.94	-36.82	0.49	6.00	T3	Cr
	3	6.66	80.14			-6.98	0.34	6.00	T3	Cr
	1	4.39	475.67	-123.84	140.96	-32.17	0.51	6.00	T3	Cu
	3	56.31	-18.63			-7.60	0.41	6.00	T2	Cu
	1	0.77	28.34	5.33	93.65	-26.98	0.46	6.00	T3	Ni
	3	7.44	-0.03			-0.06	0.38	6.00	T1	Ni
	1	101.91	-0.82	0.12	1.10	-2.52	0.71	6.00	T1	Pb
	3	146.18	-25.48			-51.39	0.65	6.00	T2	Pb
	1	-7.17	2152.16	-493.64	678.48	-179.98	0.62	6.00	T3	Zn
	3	115.23	-1.08			-0.73	0.49	6.00	T1	Zn

[a]For some metal parameters, the dissolved metal models were better than the particulate models, and vice versa. Dissolved/Particulate means either the dissolved or the particulate model was presented. [b]Count is the number of events considered. [c]**D** denotes dissolved, **P** denotes particulate, and **T** denotes total metal. Also, 1, 2, and 3 are linear, semi-log, and inverse forms respectively.

Appendix D-63. Regression Models Developed for Site 11-49.

Phase	Model	Coefficient					R^2	Count[b]	Form[c]	Parameter
		Intercept	T_RAIN (mm)	MAX_RAIN (mm/hr)	D_RUN (hr)	ADD (day)				
Dissolved/Particulate[a]	1	0.25	0.04	-0.03	-0.01	0.02	0.69	7.00	P1	Cd
	3	0.17	0.00			0.02	0.35	7.00	P1	Cd
	1	6.35	-16.41	-22.38	-1.02	-4.17	0.99	7.00	D3	Cr
	3	2.14	0.00			0.06	0.69	7.00	P1	Cr
	1	8.36	0.59	-0.56	0.78	0.21	0.76	14.00	P1	Cu
	3	5.11	47.71			-2.34	0.61	15.00	D3	Cu
	1	7.00	-7.77	-5.30	-35.24	-4.23	0.91	7.00	P3	Ni
	3	-1.65	2.44			2.27	0.75	7.00	P2	Ni
	1	17.76	2.01	-1.46	0.52	-0.05	0.76	14.00	P1	Pb
	3	15.51	36.12			-22.40	0.39	15.00	P2	Pb
	1	34.95	46.55	-36.63	3.31	4.68	0.77	14.00	P1	Zn
	3	-135.46	512.27			-183.93	0.17	15.00	P2	Zn
Total	1	0.41	0.04	-0.03	-0.01	0.02	0.50	7.00	T1	Cd
	3	0.31	0.00			0.02	0.30	7.00	T1	Cd
	1	10.45	-23.24	-23.64	-3.82	-6.86	0.88	7.00	T3	Cr
	3	-2.46	3.96			3.49	0.63	7.00	T2	Cr
	1	17.59	0.42	-0.53	0.86	0.30	0.68	14.00	T1	Cu
	3	32.46	0.27			-0.15	0.12	15.00	T1	Cu
	1	1.70	0.86	-0.54	0.95	1.45	0.42	7.00	T2	Ni
	3	2.20	0.86			1.54	0.36	7.00	T2	Ni
	1	22.96	2.04	-1.46	0.41	-0.18	0.72	14.00	T1	Pb
	3	19.42	36.31			-24.79	0.41	15.00	T2	Pb
	1	72.01	46.85	-37.15	3.18	4.40	0.78	14.00	T1	Zn
	3	-90.97	498.95			-187.53	0.17	15.00	T2	Zn

[a]For some metal parameters, the dissolved metal models were better than the particulate models, and vice versa. Dissolved/Particulate means either the dissolved or the particulate model was presented. [b]Count is the number of events considered. [c]**D** denotes dissolved, **P** denotes particulate, and **T** denotes total metal. Also, 1, 2, and 3 are linear, semi-log, and inverse forms respectively.

Appendix D-64. Regression Models Developed for Site 11-65.

Phase	Model	Coefficient					R^2	Count[b]	Form[c]	Parameter
		Intercept	T_RAIN (mm)	MAX_RAIN (mm/hr)	D_RUN (hr)	ADD (day)				
Dissolved/Particulate[a]	1	1.02	0.53	-0.86	-0.17	-0.03	0.82	8.00	P2	Cd
	3	0.37	0.00			0.00	0.33	8.00	P1	Cd
	1	-0.03	-0.01	0.03	0.03	0.03	0.95	8.00	D1	Cr
	3	0.23	0.02			0.03	0.89	8.00	D1	Cr
	1	-13.17	302.91	86.07	4.31	19.05	0.91	11.00	D3	Cu
	3	-22.95	559.90			27.20	0.88	11.00	D3	Cu
	1	0.28	69.80	43.54	-13.35	-0.20	0.97	8.00	D3	Ni
	3	5.20	-0.07			0.15	0.88	8.00	D1	Ni
	1	2.51	-0.04	0.31	0.05	0.04	0.78	11.00	P1	Pb
	3	5.75	3.99			8.09	0.28	11.00	P3	Pb
	1	9.78	5420.35	-746.80	-62.08	-30.85	0.79	11.00	D3	Zn
	3	624.46	-358.67			131.62	0.77	11.00	D2	Zn
Total	1	0.44	3.88	1.28	-0.52	0.21	0.93	8.00	T3	Cd
	3	0.24	6.82			0.38	0.78	8.00	T3	Cd
	1	1.01	0.03	0.02	-0.01	0.03	0.88	8.00	T1	Cr
	3	1.48	0.01			0.03	0.85	8.00	T1	Cr
	1	1.84	223.37	125.29	-12.01	34.42	0.85	11.00	T3	Cu
	3	-14.60	598.25			45.07	0.77	11.00	T3	Cu
	1	0.89	62.56	59.30	-10.99	0.34	0.96	8.00	T3	Ni
	3	7.06	-0.09			0.16	0.87	8.00	T1	Ni
	1	4.54	0.03	0.27	-0.04	0.05	0.72	11.00	T1	Pb
	3	5.88	14.60			10.51	0.36	11.00	T3	Pb
	1	-17.03	6333.75	-707.00	-155.94	221.23	0.81	11.00	T3	Zn
	3	48.69	4227.74			146.14	0.79	11.00	T3	Zn

[a]For some metal parameters, the dissolved metal models were better than the particulate models, and vice versa. Dissolved/Particulate means either the dissolved or the particulate model was presented. [b]Count is the number of events considered. [c]**D** denotes dissolved, **P** denotes particulate, and **T** denotes total metal. Also, 1, 2, and 3 are linear, semi-log, and inverse forms respectively.

Appendix D-65. Regression Models Developed for Site 11-89.

Phase	Model	Coefficient					R^2	Count[b]	Form[c]	Parameter
		Intercept	T_RAIN (mm)	MAX_RAIN (mm/hr)	D_RUN (hr)	ADD (day)				
Dissolved/Particulate[a]	1	0.71	-0.01	0.04	0.00	0.06	0.55	10.00	P1	Cd
	3	0.89	0.01			0.06	0.25	10.00	P1	Cd
	1	4.17	-0.06	0.07	0.03	0.04	0.38	10.00	P1	Cr
	3	3.34	12.87			0.39	0.14	10.00	P3	Cr
	1	21.38	-0.07	-0.17	-0.09	0.36	0.54	13.00	D1	Cu
	3	19.15	-0.19			0.32	0.41	14.00	D1	Cu
	1	-1.73	2.70	37.97	2.23	3.78	0.61	10.00	D3	Ni
	3	1.28	26.95			1.58	0.32	10.00	D3	Ni
	1	92.00	-1.87	3.42	-1.27	-0.25	0.59	13.00	P1	Pb
	3	-3.56	5.09			0.65	0.28	14.00	D2	Pb
	1	440.02	-5.97	6.52	-3.44	4.70	0.39	13.00	P1	Zn
	3	299.87	3707.05			-154.91	0.28	14.00	P3	Zn
Total	1	1.22	-0.01	0.03	-0.01	0.06	0.57	10.00	T1	Cd
	3	1.26	0.01			0.05	0.24	10.00	T1	Cd
	1	3.79	-9.29	36.98	4.56	3.88	0.26	10.00	T3	Cr
	3	9.78	-0.04			0.06	0.10	10.00	T1	Cr
	1	80.18	-0.62	0.58	-0.50	0.53	0.40	13.00	T1	Cu
	3	48.26	536.31			-4.08	0.34	14.00	T3	Cu
	1	3.51	2.89	59.01	1.21	4.62	0.41	10.00	T3	Ni
	3	12.54	-0.08			0.14	0.27	10.00	T1	Ni
	1	93.21	-1.79	3.43	-1.25	-0.28	0.57	13.00	T1	Pb
	3	103.74	694.51			-56.99	0.12	14.00	T3	Pb
	1	547.85	-5.98	5.72	-3.47	5.81	0.35	13.00	T1	Zn
	3	380.98	3935.32			-158.86	0.31	14.00	T3	Zn

[a]For some metal parameters, the dissolved metal models were better than the particulate models, and vice versa. Dissolved/Particulate means either the dissolved or the particulate model was presented. [b]Count is the number of events considered. [c]**D** denotes dissolved, **P** denotes particulate, and **T** denotes total metal. Also, 1, 2, and 3 are linear, semi-log, and inverse forms respectively.

Appendix D-66. Regression Models Developed for Site 11-94.

Phase	Model	Coefficient: Intercept	T_RAIN (mm)	MAX_RAIN (mm/hr)	D_RUN (hr)	ADD (day)	R^2	Count[b]	Form[c]	Parameter
Dissolved/Particulate[a]	1	0.96	-0.01	-0.05	0.05	0.03	0.98	6.00	P1	Cd
	3	0.47	0.00			0.02	0.90	6.00	P1	Cd
	1	-0.96	32.46	26.76	-6.25	0.20	1.00	6.00	P3	Cr
	3	-0.41	32.11			0.13	0.87	6.00	P3	Cr
	1	-7.16	-32.83	39.68	6.62	22.21	0.95	9.00	P2	Cu
	3	25.10	-18.46			9.94	0.65	9.00	D2	Cu
	1	2.64	-0.12	-0.12	0.16	0.16	1.00	6.00	D1	Ni
	3	1.38	-0.06			0.15	0.96	6.00	D1	Ni
	1	0.17	-0.19	3.66	-0.80	0.80	0.74	9.00	P1	Pb
	3	3.62	-30.52			13.22	0.30	9.00	D3	Pb
	1	-36.36	-295.90	353.72	7.32	176.31	0.98	9.00	P2	Zn
	3	95.39	-77.88			54.23	0.67	9.00	D2	Zn
Total	1	1.06	-0.01	-0.05	0.05	0.03	0.98	6.00	T1	Cd
	3	0.57	0.00			0.02	0.90	6.00	T1	Cd
	1	-11.60	-12.74	27.25	-4.78	4.93	1.00	6.00	T2	Cr
	3	7.58	-4.21			4.19	0.46	6.00	T2	Cr
	1	12.19	-54.21	48.17	4.85	34.26	0.92	9.00	T2	Cu
	3	36.95	-20.84			23.28	0.37	9.00	T2	Cu
	1	7.95	-0.37	-0.25	0.60	0.26	1.00	6.00	T1	Ni
	3	5.19	-0.05			0.21	0.49	6.00	T1	Ni
	1	7.60	-0.72	3.43	0.08	0.74	0.77	9.00	T1	Pb
	3	28.93	1.16			0.16	0.25	9.00	T1	Pb
	1	34.62	-398.43	396.60	7.16	240.64	0.97	9.00	T2	Zn
	3	119.26	1892.47			-311.28	0.32	9.00	T3	Zn

[a]For some metal parameters, the dissolved metal models were better than the particulate models, and vice versa. Dissolved/Particulate means either the dissolved or the particulate model was presented. [b]Count is the number of events considered. [c]**D** denotes dissolved, **P** denotes particulate, and **T** denotes total metal. Also, 1, 2, and 3 are linear, semi-log, and inverse forms respectively.

Appendix D-67. Regression Models Developed for Site 8-01.

Phase	Model	Coefficient					R^2	Count[b]	Form[c]	Parameter
		Intercept	T_RAIN (mm)	MAX_RAIN (mm/hr)	D_RUN (hr)	ADD (day)				
Dissolved/Particulate[a]	1									Cd
	3									Cd
	1									Cr
	3	-12.70	77.39			36.03	0.98	4.00	D3	Cr
	1									Cu
	3	39.29	-11.99			3.38	1.00	4.00	P2	Cu
	1									Ni
	3									Ni
	1									Pb
	3	2.41	-0.10			0.01	0.95	4.00	D1	Pb
	1									Zn
	3	-443.12	228.29			367.98	1.00	4.00	D2	Zn
Total	1									Cd
	3	1.82	-0.04			0.01	1.00	4.00	T1	Cd
	1									Cr
	3	23.88	-44.90			-42.40	0.90	4.00	T3	Cr
	1									Cu
	3	107.98	-63.44			8.17	0.97	4.00	T2	Cu
	1									Ni
	3	19.75	-0.92			-0.01	0.92	4.00	T1	Ni
	1									Pb
	3	58.84	1.63			0.17	0.39	4.00	T1	Pb
	1									Zn
	3	379.02	-12.95			1.95	0.99	4.00	T1	Zn

[a]For some metal parameters, the dissolved metal models were better than the particulate models, and vice versa. Dissolved/Particulate means either the dissolved or the particulate model was presented. [b]Count is the number of events considered. [c]**D** denotes dissolved, **P** denotes particulate, and **T** denotes total metal. Also, 1, 2, and 3 are linear, semi-log, and inverse forms respectively.

Appendix D-68. Regression Models Developed for Site 8-02.

Phase	Model	Coefficient					R^2	Count[b]	Form[c]	Parameter
		Intercept	T_RAIN (mm)	MAX_RAIN (mm/hr)	D_RUN (hr)	ADD (day)				
Dissolved/Particulate[a]	1									Cd
	3									Cd
	1									Cr
	3									Cr
	1									Cu
	3	72.82	-54.79			-2.31	1.00	4.00	P2	Cu
	1									Ni
	3									Ni
	1									Pb
	3									Pb
	1									Zn
	3	-175.62	2815.44			60.28	1.00	4.00	P3	Zn
Total	1									Cd
	3									Cd
	1									Cr
	3	-7.03	168.23			0.10	0.98	4.00	T3	Cr
	1									Cu
	3	5.26	183.51			0.23	0.78	4.00	T3	Cu
	1									Ni
	3									Ni
	1									Pb
	3	63.11	-2.09			-0.09	0.85	4.00	T1	Pb
	1									Zn
	3	852.42	-603.16			-49.95	0.93	4.00	T2	Zn

[a]For some metal parameters, the dissolved metal models were better than the particulate models, and vice versa. Dissolved/Particulate means either the dissolved or the particulate model was presented. [b]Count is the number of events considered. [c]**D** denotes dissolved, **P** denotes particulate, and **T** denotes total metal. Also, 1, 2, and 3 are linear, semi-log, and inverse forms respectively.

Appendix D-69. Regression Models Developed for Site 8-201.

Phase	Model	Coefficient					R^2	Count[b]	Form[c]	Parameter
		Intercept	T_RAIN (mm)	MAX_RAIN (mm/hr)	D_RUN (hr)	ADD (day)				
Dissolved/Particulate[a]	1	0.37	-0.38	0.17	0.06	0.11	0.83	8.00	D2	Cd
	3	0.31	-0.19			0.15	0.75	8.00	D2	Cd
	1	0.39	-0.29	0.45	0.37	1.76	0.90	8.00	D2	Cr
	3	0.05	0.42			1.97	0.88	8.00	D2	Cr
	1	15.27	-0.26	0.40	-0.19	0.39	0.99	8.00	D1	Cu
	3	19.08	-0.18			0.36	0.98	8.00	D1	Cu
	1	3.02	-0.09	0.15	-0.05	0.10	0.99	8.00	D1	Ni
	3	4.12	-0.05			0.09	0.97	8.00	D1	Ni
	1	5.10	186.60	-98.02	0.24	-1.99	0.89	8.00	P3	Pb
	3	1.41	0.01			0.02	0.74	8.00	D1	Pb
	1	77.63	12572.14	-1471.30	-161.64	-1865.72	0.99	8.00	D3	Zn
	3	49.03	10654.35			-2133.28	0.93	8.00	D3	Zn
Total	1	0.28	14.95	-8.78	-0.07	0.94	0.87	8.00	T3	Cd
	3	0.23	6.28			-1.11	0.28	8.00	T3	Cd
	1	2.37	0.01	0.08	-0.03	0.03	0.94	8.00	T1	Cr
	3	0.65	0.57			2.89	0.87	8.00	T2	Cr
	1	59.31	-64.51	13.71	-1.09	45.95	0.99	8.00	T2	Cu
	3	58.98	-53.95			46.83	0.99	8.00	T2	Cu
	1	4.21	-0.13	0.22	-0.06	0.10	1.00	8.00	T1	Ni
	3	12.54	-13.19			11.41	0.97	8.00	T2	Ni
	1	11.04	-14.70	11.95	-0.34	3.35	0.98	8.00	T2	Pb
	3	6.38	135.33			-34.98	0.78	8.00	T3	Pb
	1	140.68	15479.60	-3024.48	-127.56	-1809.89	0.99	8.00	T3	Zn
	3	108.91	12171.15			-2464.50	0.92	8.00	T3	Zn

[a]For some metal parameters, the dissolved metal models were better than the particulate models, and vice versa. Dissolved/Particulate means either the dissolved or the particulate model was presented. [b]Count is the number of events considered. [c]**D** denotes dissolved, **P** denotes particulate, and **T** denotes total metal. Also, 1, 2, and 3 are linear, semi-log, and inverse forms respectively.

Appendix D-70. Regression Models Developed for Site 8-202.

Phase	Model	Coefficient					R^2	Count[b]	Form[c]	Parameter
		Intercept	T_RAIN (mm)	MAX_RAIN (mm/hr)	D_RUN (hr)	ADD (day)				
Dissolved/Particulate[a]	1	0.10	0.00	0.00	0.00	0.00	0.83	6.00	D3	Cd
	3	0.09	0.00			0.00	0.50	6.00	P1	Cd
	1	6.54	-335.45	-96.50	81.92	95.24	1.00	6.00	P3	Cr
	3	1.58	0.02			0.01	0.97	6.00	D1	Cr
	1	18.89	-0.38	0.60	-0.17	0.21	1.00	6.00	D1	Cu
	3	36.86	-32.39			27.68	1.00	6.00	D2	Cu
	1	3.05	-0.05	0.07	-0.01	0.06	1.00	6.00	D1	Ni
	3	2.88	-0.02			0.06	0.99	6.00	D1	Ni
	1	1.88	-0.02	0.04	0.00	0.01	0.99	6.00	D1	Pb
	3	1.83	-0.54			0.98	0.93	6.00	D2	Pb
	1	54.60	-0.90	0.73	0.14	0.46	1.00	6.00	D1	Zn
	3	99.79	-73.82			56.31	0.98	6.00	D2	Zn
Total	1	0.31	-6.91	-7.13	2.69	4.40	0.75	6.00	T3	Cd
	3	0.12	0.00			0.00	0.44	6.00	T1	Cd
	1	9.94	-396.31	-120.44	104.60	111.63	0.99	6.00	T3	Cr
	3	2.65	0.09			0.01	0.61	6.00	T1	Cr
	1	21.54	-0.08	0.30	-0.14	0.25	0.99	6.00	T1	Cu
	3	21.51	-0.01			0.25	0.98	6.00	T1	Cu
	1	3.38	0.08	-0.08	-0.02	0.06	0.99	6.00	T1	Ni
	3	3.85	0.02			0.05	0.96	6.00	T1	Ni
	1	13.05	-464.42	-210.59	141.91	161.37	0.91	6.00	T3	Pb
	3	3.46	0.12			0.01	0.64	6.00	T1	Pb
	1	117.09	-3677.89	-2216.35	1630.32	1528.70	0.90	6.00	T3	Zn
	3	70.36	0.61			0.49	0.67	6.00	T1	Zn

[a]For some metal parameters, the dissolved metal models were better than the particulate models, and vice versa. Dissolved/Particulate means either the dissolved or the particulate model was presented. [b]Count is the number of events considered. [c]**D** denotes dissolved, **P** denotes particulate, and **T** denotes total metal. Also, 1, 2, and 3 are linear, semi-log, and inverse forms respectively.

Appendix D-71. Regression Models Developed for Site 8-203.

Phase	Model	Coefficient					R^2	Count[b]	Form[c]	Parameter
		Intercept	T_RAIN (mm)	MAX_RAIN (mm/hr)	D_RUN (hr)	ADD (day)				
Dissolved/Particulate[a]	1	0.17	-0.01	0.02	0.00	0.00	0.83	7.00	P1	Cd
	3	0.05	0.00			0.00	0.30	7.00	P1	Cd
	1	0.65	0.01	-0.05	0.18	0.00	0.96	7.00	P1	Cr
	3	-1.90	0.15			0.00	0.61	7.00	P1	Cr
	1	20.04	-0.45	0.74	-0.21	0.21	1.00	7.00	D1	Cu
	3	41.67	-35.03			27.29	0.99	7.00	D2	Cu
	1	20.37	-30.88	33.05	-7.60	-1.13	0.99	7.00	D2	Ni
	3	2.62	174.33			-37.89	0.84	7.00	D3	Ni
	1	3.88	-36.98	34.71	-4.29	-11.35	0.93	7.00	D3	Pb
	3	3.73	-9.09			-1.62	0.78	7.00	D3	Pb
	1	51.75	-1.01	1.37	-0.23	0.35	1.00	7.00	D1	Zn
	3	95.61	-66.46			45.45	0.98	7.00	D2	Zn
Total	1	0.32	-0.01	0.03	0.00	0.00	0.76	7.00	T1	Cd
	3	0.21	0.00			0.00	0.25	7.00	T1	Cd
	1	7.40	-0.32	0.68	-0.01	-0.03	0.86	7.00	T1	Cr
	3	4.62	0.13			-0.01	0.36	7.00	T1	Cr
	1	66.27	-102.34	83.98	-5.92	18.91	0.96	7.00	T2	Cu
	3	23.93	865.27			-218.83	0.85	7.00	T3	Cu
	1	5.60	-0.23	0.42	-0.01	0.04	0.93	7.00	T1	Ni
	3	3.47	-2.99			6.85	0.74	7.00	T2	Ni
	1	12.73	-0.66	1.32	-0.13	-0.05	0.75	7.00	T1	Pb
	3	16.93	-100.37			-8.96	0.16	7.00	T3	Pb
	1	149.21	-7.97	14.88	-1.77	-0.18	0.77	7.00	T1	Zn
	3	134.54	1043.86			-434.31	0.22	7.00	T3	Zn

[a]For some metal parameters, the dissolved metal models were better than the particulate models, and vice versa. Dissolved/Particulate means either the dissolved or the particulate model was presented. [b]Count is the number of events considered. [c]**D** denotes dissolved, **P** denotes particulate, and **T** denotes total metal. Also, 1, 2, and 3 are linear, semi-log, and inverse forms respectively.

Appendix D-72. Regression Models Developed for Site 8-204.

Phase	Model	Coefficient					R^2	Count[b]	Form[c]	Parameter
		Intercept	T_RAIN (mm)	MAX_RAIN (mm/hr)	D_RUN (hr)	ADD (day)				
Dissolved/Particulate[a]	1	0.10	0.00	0.00	0.00	0.00	0.87	7.00	P1	Cd
	3	0.03	0.00			0.00	0.76	7.00	P1	Cd
	1	1.20	0.07	0.00	0.22	-0.01	0.99	7.00	P1	Cr
	3	-2.00	0.24			0.01	0.89	7.00	P1	Cr
	1	12.22	616.48	-46.97	-71.81	-70.66	0.99	7.00	D3	Cu
	3	10.72	486.31			-106.66	0.95	7.00	D3	Cu
	1	-0.69	-0.03	0.13	0.07	0.01	0.99	7.00	P1	Ni
	3	-2.30	0.12			0.02	0.80	7.00	P1	Ni
	1	3.39	-0.01	0.01	0.05	-0.01	0.95	7.00	D1	Pb
	3	-0.53	0.26			0.02	0.71	7.00	P1	Pb
	1	77.20	-59.29	7.03	26.91	22.73	0.89	7.00	D2	Zn
	3	56.83	-26.24			30.65	0.83	7.00	D2	Zn
Total	1	0.18	0.00	0.01	0.00	0.00	0.83	7.00	T1	Cd
	3	0.10	0.01			0.00	0.74	7.00	T1	Cd
	1	4.91	0.12	-0.04	0.24	-0.02	0.95	7.00	T1	Cr
	3	1.61	0.28			0.00	0.88	7.00	T1	Cr
	1	20.39	-0.31	0.65	0.09	0.14	0.94	7.00	T1	Cu
	3	16.25	0.19			0.17	0.81	7.00	T1	Cu
	1	3.76	0.00	0.03	0.10	0.03	0.91	7.00	T1	Ni
	3	2.16	0.10			0.04	0.81	7.00	T1	Ni
	1	7.24	-0.07	0.18	0.30	-0.02	0.92	7.00	T1	Pb
	3	2.06	0.29			0.01	0.72	7.00	T1	Pb
	1	93.12	-1.65	3.46	1.56	0.11	0.88	7.00	T1	Zn
	3	55.57	1.87			0.33	0.57	7.00	T1	Zn

[a]For some metal parameters, the dissolved metal models were better than the particulate models, and vice versa. Dissolved/Particulate means either the dissolved or the particulate model was presented. [b]Count is the number of events considered. [c]**D** denotes dissolved, **P** denotes particulate, and **T** denotes total metal. Also, 1, 2, and 3 are linear, semi-log, and inverse forms respectively.

Appendix D-73. Regression Models Developed for Site 8-205.

Phase	Model	Coefficient					R^2	Count[b]	Form[c]	Parameter
		Intercept	T_RAIN (mm)	MAX_RAIN (mm/hr)	D_RUN (hr)	ADD (day)				
Dissolved/Particulate[a]	1	0.05	0.00	0.03	-0.03	0.00	0.81	7.00	P1	Cd
	3	0.10	0.00			0.00	1.00	7.00	D1	Cd
	1	2.43	0.13	-0.21	0.05	0.00	1.00	7.00	D1	Cr
	3	-18.28	19.62			-1.76	0.61	7.00	P2	Cr
	1	3.71	-0.01	1.71	-1.14	0.12	0.99	7.00	P1	Cu
	3	6.17	530.26			-79.74	0.94	7.00	D3	Cu
	1	-0.01	0.06	0.34	-0.24	0.02	0.74	7.00	P1	Ni
	3	-10.12	9.68			0.20	0.51	7.00	P2	Ni
	1	4.03	0.14	1.85	-1.34	0.09	0.96	7.00	P1	Pb
	3	2.87	-30.33			16.66	0.80	7.00	D3	Pb
	1	55.61	-1.29	14.63	-8.52	0.51	1.00	7.00	P1	Zn
	3	28.29	796.55			48.94	0.84	7.00	D3	Zn
Total	1	0.15	0.00	0.03	-0.03	0.00	0.83	7.00	T1	Cd
	3	-0.51	0.74			-0.13	0.38	7.00	T2	Cd
	1	3.59	0.24	0.44	-0.43	0.03	0.91	7.00	T1	Cr
	3	-17.06	21.76			-2.32	0.70	7.00	T2	Cr
	1	25.43	-0.37	1.83	-0.97	0.20	1.00	7.00	T1	Cu
	3	11.09	2.79			15.91	0.58	7.00	T2	Cu
	1	4.02	0.05	0.41	-0.30	0.05	0.90	7.00	T1	Ni
	3	-4.55	7.27			2.18	0.46	7.00	T2	Ni
	1	8.39	0.14	1.78	-1.30	0.08	0.93	7.00	T1	Pb
	3	-31.43	40.95			-5.01	0.50	7.00	T2	Pb
	1	145.46	-1.68	13.15	-7.59	0.45	0.97	7.00	T1	Zn
	3	280.59	-2411.60			116.90	0.37	7.00	T3	Zn

[a]For some metal parameters, the dissolved metal models were better than the particulate models, and vice versa. Dissolved/Particulate means either the dissolved or the particulate model was presented. [b]Count is the number of events considered. [c]**D** denotes dissolved, **P** denotes particulate, and **T** denotes total metal. Also, 1, 2, and 3 are linear, semi-log, and inverse forms respectively.

Appendix E-1. Best-fit Regression Models Developed for Caltrans Zone 1

Parameter (:g/L)	Coefficient							R^2	Count[b]	Form[c]	Phase
	Intercept	TSS (mg/L)	VSS (mg/L)	DOC (mg/L)	COD (mg/L)	EC (:mhos/c)	TDS (mg/L)				
Cd	0.08	0.00				0.00		0.75	69	P1	Dissolved/Particulate[a]
Cr	0.55	0.02				0.00		0.62	69	P1	
Cu		0.14				0.01		0.54	69	P1	
Ni	0.55	0.02				0.00		0.46	69	P1	
Pb		0.08		-0.12		0.02		0.91	69	P1	
Zn		0.72				0.05		0.76	69	P1	
Cd	0.15	0.00				0.00		0.67	69	T1	Total
Cr	-2.88	1.48				2.00		0.36	69	T2	
Cu	3.98	0.17				0.03		0.59	69	T1	
Ni	0.98	0.03		0.08				0.54	70	T1	
Pb		0.08		-0.10		0.03		0.90	69	T1	
Zn	15.01	0.85				0.06		0.72	69	T1	

[a]For some metal parameters, the dissolved metal models were better than the particulate models, and vice versa. Dissolved/Particulate means either the dissolved or the particulate model was presented.

[b]Count is the number of events considered.

[c]In form column **D** denotes dissolved, **P** denotes particulate, and **T** denotes total metal. Also, 1, 2, and 3 are linear, semi-log, and inverse forms respectively.

Appendix E-2. Best-fit Regression Models Developed for Caltrans Zone 2

Parameter (:g/L)	Coefficient							R^2	Count[b]	Form[c]	Phase
	Intercept	TSS (mg/L)	VSS (mg/L)	DOC (mg/L)	COD (mg/L)	EC (:mhos/c)	TDS (mg/L)				
Cd		0.00						0.60	59	P1	Dissolved/Particulate[a]
Cr				-0.17		0.05		0.61	54	D1	
Cu		0.23						0.56	59	P1	
Ni	1.14	0.05						0.40	59	P1	
Pb		0.14						0.57	59	P1	
Zn		1.15						0.73	59	P1	
Cd	0.13	0.01						0.56	59	T1	Total
Cr		0.05		-0.24		0.06		0.53	54	T1	
Cu		0.30		0.53				0.50	59	T1	
Ni	2.79	0.06						0.55	59	T1	
Pb		0.15						0.57	59	T1	
Zn	25.89	1.31						0.71	59	T1	

[a]For some metal parameters, the dissolved metal models were better than the particulate models, and vice versa. Dissolved/Particulate means either the dissolved or the particulate model was presented.

[b]Count is the number of events considered.

[c]In form column **D** denotes dissolved, **P** denotes particulate, and **T** denotes total metal. Also, 1, 2, and 3 are linear, semi-log, and inverse forms respectively.

Appendix E-3. Best-fit Regression Models Developed for Caltrans Zone 3

Parameter (:g/L)	Coefficient							R^2	Count[b]	Form[c]	Phase
	Intercept	TSS (mg/L)	VSS (mg/L)	DOC (mg/L)	COD (mg/L)	EC (:mhos/c)	TDS (mg/L)				
Cd	0.13	0.00						0.51	100	P1	
Cr		0.07						0.46	100	P1	
Cu		0.19						0.78	100	P1	Dissolved/Particulate[a]
Ni		0.01		0.16			0.01	0.69	100	D1	
Pb		0.15						0.77	100	P1	
Zn	13.25	0.77						0.69	100	P1	
Cd	0.13	0.00				0.00		0.40	100	T1	
Cr		0.08				0.05		0.23	100	T1	
Cu		0.22		0.58				0.73	100	T1	Total
Ni		0.07		0.21				0.66	100	T1	
Pb		0.16						0.77	100	T1	
Zn	19.51	0.89		1.16			0.09	0.70	100	T1	

[a]For some metal parameters, the dissolved metal models were better than the particulate models, and vice versa. Dissolved/Particulate means either the dissolved or the particulate model was presented.

[b]Count is the number of events considered.

[c]In form column **D** denotes dissolved, **P** denotes particulate, and **T** denotes total metal. Also, 1, 2, and 3 are linear, semi-log, and inverse forms respectively.

Appendix E-4. Best-fit Regression Models Developed for Caltrans Zone 4

Parameter (:g/L)	Coefficient							R^2	Count[b]	Form[c]	Phase
	Intercept	TSS (mg/L)	VSS (mg/L)	DOC (mg/L)	COD (mg/L)	EC (:mhos/c)	TDS (mg/L)				
Cd	0.10					0.00		0.29	101	D1	Dissolved/Particulate[a]
Cr		0.01					0.01	0.75	101	P1	
Cu	3.19	0.02					0.00	0.64	101	P1	
Ni	4.62	0.01						0.66	101	P1	
Pb		0.03					0.01	0.74	101	P1	
Zn	65.75	0.13					0.03	0.67	101	P1	
Cd	0.28	0.00						0.25	101	T1	Total
Cr	5.38	0.01					0.01	0.72	101	T1	
Cu	20.62	0.02		0.10			0.00	0.65	101	T1	
Ni	6.37	0.01		0.03			0.00	0.68	101	T1	
Pb		0.03					0.01	0.74	101	T1	
Zn	114.38	0.14		0.33			0.04	0.68	101	T1	

[a]For some metal parameters, the dissolved metal models were better than the particulate models, and vice versa. Dissolved/Particulate means either the dissolved or the particulate model was presented.

[b]Count is the number of events considered.

[c]In form column **D** denotes dissolved, **P** denotes particulate, and **T** denotes total metal. Also, 1, 2, and 3 are linear, semi-log, and inverse forms respectively.

Appendix E-5. Best-fit Regression Models Developed for Caltrans Zone 5

Parameter (:g/L)	Coefficient							R^2	Count[b]	Form[c]	Phase
	Intercept	TSS (mg/L)	VSS (mg/L)	DOC (mg/L)	COD (mg/L)	EC (:mhos/c)	TDS (mg/L)				
Cd				0.38				0.02	37	D2	Dissolved/Particulate[a]
Cr		0.02					0.02	0.53	36	P1	
Cu	7.75			0.37				0.48	36	D1	
Ni	1.95	0.03						0.52	36	P1	
Pb		0.09		0.19				0.48	36	P1	
Zn				5.56				0.51	37	D1	
Cd		-2.44				2.67		0.12	27	T2	Total
Cr		0.02				0.04		0.39	27	T1	
Cu	11.26	0.06		0.47				0.54	36	T1	
Ni		0.03				0.05		0.54	27	T1	
Pb	8.43	0.09						0.45	36	T1	
Zn		0.76		7.34				0.28	36	T1	

[a]For some metal parameters, the dissolved metal models were better than the particulate models, and vice versa. Dissolved/Particulate means either the dissolved or the particulate model was presented.

[b]Count is the number of events considered.

[c]In form column **D** denotes dissolved, **P** denotes particulate, and **T** denotes total metal. Also, 1, 2, and 3 are linear, semi-log, and inverse forms respectively.

Appendix E-6. Best-fit Regression Models Developed for Caltrans Zone 6

Parameter (:g/L)	Coefficient							R^2	Count[b]	Form[c]	Phase
	Intercept	TSS (mg/L)	VSS (mg/L)	DOC (mg/L)	COD (mg/L)	EC (:mhos/c)	TDS (mg/L)				
Cd		0.00			0.00			0.64	5	D1	Dissolved/Particulate[a]
Cr	-37.66	26.90						0.72	8	P2	
Cu					0.17			0.27	7	D1	
Ni		0.12			-0.06			1.00	4	P1	
Pb	108.71	-2746.83						0.38	11	P3	
Zn					0.85			0.22	7	D1	
Cd	1.19	0.00						0.04	9	T1	Total
Cr	11.08	0.00						0.03	11	T1	
Cu	32.91	-0.02			0.30			0.35	7	T1	
Ni	2.01	0.09			0.03			0.98	4	T1	
Pb	61.94	0.02						0.02	11	T1	
Zn	343.20	-5916.31						0.15	9	T3	

[a]For some metal parameters, the dissolved metal models were better than the particulate models, and vice versa. Dissolved/Particulate means either the dissolved or the particulate model was presented.

[b]Count is the number of events considered.

[c]In form column **D** denotes dissolved, **P** denotes particulate, and **T** denotes total metal. Also, 1, 2, and 3 are linear, semi-log, and inverse forms respectively.

Appendix E-7. Best-fit Regression Models Developed for Caltrans Zone 7

Parameter (:g/L)	Coefficient							R^2	Count[b]	Form[c]	Phase
	Intercept	TSS (mg/L)	VSS (mg/L)	DOC (mg/L)	COD (mg/L)	EC (:mhos/c)	TDS (mg/L)				
Cd	0.13						0.00	0.54	13	D1	Dissolved/Particulate[a]
Cr		0.07						0.81	16	P1	
Cu	4.44						0.09	0.72	13	D1	
Ni	4.23						-103.67	0.84	13	D3	
Pb	-58.13	1.68						0.79	16	P1	
Zn		1.40						0.76	16	P1	
Cd						0.01		0.57	13	T1	Total
Cr		0.08						0.79	16	T1	
Cu	-52.76	44.71						0.71	16	T2	
Ni	-17.09	13.14						0.76	16	T2	
Pb	-56.24	1.68						0.79	16	T1	
Zn		2.05					0.53	0.81	13	T1	

[a]For some metal parameters, the dissolved metal models were better than the particulate models, and vice versa. Dissolved/Particulate means either the dissolved or the particulate model was presented.

[b]Count is the number of events considered.

[c]In form column **D** denotes dissolved, **P** denotes particulate, and **T** denotes total metal. Also, 1, 2, and 3 are linear, semi-log, and inverse forms respectively.

Appendix E-8. Best-fit Regression Models Developed for Caltrans Zone 8

Parameter (:g/L)	Coefficient							R^2	Count[b]	Form[c]	Phase
	Intercept	TSS (mg/L)	VSS (mg/L)	DOC (mg/L)	COD (mg/L)	EC (:mhos/c)	TDS (mg/L)				
Cd	-0.19	0.01		0.01				0.65	72	D1	Dissolved/Particulate[a]
Cr			0.04					0.37	36	P1	
Cu			0.09	0.65				0.93	36	D1	
Ni			0.02	0.14				0.81	36	D1	
Pb		1.27						0.40	98	P1	
Zn				5.80			0.83	0.73	36	D1	
Cd		0.01		0.01				0.68	72	T1	Total
Cr			0.09					0.49	36	T1	
Cu		0.32		0.92				0.86	72	T1	
Ni			0.09	0.10				0.64	36	T1	
Pb		1.54						0.39	98	T1	
Zn		2.17		6.14				0.79	72	T1	

[a]For some metal parameters, the dissolved metal models were better than the particulate models, and vice versa. Dissolved/Particulate means either the dissolved or the particulate model was presented.

[b]Count is the number of events considered.

[c]In form column **D** denotes dissolved, **P** denotes particulate, and **T** denotes total metal. Also, 1, 2, and 3 are linear, semi-log, and inverse forms respectively.

Appendix E-9. Best-fit Regression Models Developed for Caltrans Zone 9

Parameter (:g/L)	Coefficient							R^2	Count[b]	Form[c]	Phase
	Intercept	TSS (mg/L)	VSS (mg/L)	DOC (mg/L)	COD (mg/L)	EC (:mhos/c)	TDS (mg/L)				
Cd		0.01		0.03				0.88	28	P1	Dissolved/Particulate[a]
Cr		0.04		0.14				0.92	28	P1	
Cu				1.40				0.89	28	D1	
Ni		0.04		0.10				0.95	28	P1	
Pb			2.54	10.15				0.91	20	P1	
Zn		0.74			0.38			0.97	8	P1	
Cd		0.01		0.04				0.88	28	T1	Total
Cr		0.04		0.24				0.91	28	T1	
Cu		0.17		3.14				0.87	28	T1	
Ni		0.04		0.31				0.96	28	T1	
Pb			2.52	10.65				0.91	20	T1	
Zn	51.16	0.62		7.50				0.94	28	T1	

[a]For some metal parameters, the dissolved metal models were better than the particulate models, and vice versa. Dissolved/Particulate means either the dissolved or the particulate model was presented.

[b]Count is the number of events considered.

[c]In form column **D** denotes dissolved, **P** denotes particulate, and **T** denotes total metal. Also, 1, 2, and 3 are linear, semi-log, and inverse forms respectively.

Appendix E-10. Best-fit Regression Models Developed for Caltrans Zone 10

Parameter (:g/L)	Coefficient							R^2	Count[b]	Form[c]	Phase
	Intercept	TSS (mg/L)	VSS (mg/L)	DOC (mg/L)	COD (mg/L)	EC (:mhos/c)	TDS (mg/L)				
Cd		0.00		0.00			0.00	0.59	103	P1	Dissolved/Particulate[a]
Cr		0.03				0.01		0.38	102	P1	
Cu				0.48			0.03	0.45	103	D1	
Ni		0.01		0.13		0.02		0.61	102	D1	
Pb		0.07					0.07	0.19	103	P1	
Zn	51.87	0.91		1.49		-0.49		0.41	102	P1	
Cd		0.01					0.00	0.55	103	T1	Total
Cr	2.89	0.03		-0.06			0.02	0.45	103	T1	
Cu		0.08		0.83				0.34	103	T1	
Ni		0.03		0.13		0.02		0.69	102	T1	
Pb		0.07					0.09	0.18	103	T1	
Zn	87.10	1.24		4.91		-0.89		0.44	102	T1	

[a]For some metal parameters, the dissolved metal models were better than the particulate models, and vice versa. Dissolved/Particulate means either the dissolved or the particulate model was presented.

[b]Count is the number of events considered.

[c]In form column **D** denotes dissolved, **P** denotes particulate, and **T** denotes total metal. Also, 1, 2, and 3 are linear, semi-log, and inverse forms respectively.

Appendix E-11. Best-fit Regression Models Developed for Caltrans Zone 11

Parameter (:g/L)	Coefficient							R^2	Count[b]	Form[c]	Phase
	Intercept	TSS (mg/L)	VSS (mg/L)	DOC (mg/L)	COD (mg/L)	EC (:mhos/c)	TDS (mg/L)				
Cd		0.00						0.28	39	P1	Dissolved/Particulate[a]
Cr		0.02				0.03		0.59	37	P1	
Cu				0.82				0.67	37	D1	
Ni				0.20				0.62	37	D1	
Pb	-53.49	24.18				13.31		0.72	37	P2	
Zn	-427.95	209.66				78.87		0.40	37	P2	
Cd		0.00				0.00		0.45	37	T1	Total
Cr		0.03				0.06		0.67	37	T1	
Cu		0.17				0.20		0.64	37	T1	
Ni	-45.72	16.37				13.49		0.25	37	T2	
Pb	-56.58	26.08				15.64		0.72	37	T2	
Zn		0.72		5.89				0.38	37	T1	

[a]For some metal parameters, the dissolved metal models were better than the particulate models, and vice versa. Dissolved/Particulate means either the dissolved or the particulate model was presented.

[b]Count is the number of events considered.

[c]In form column **D** denotes dissolved, **P** denotes particulate, and **T** denotes total metal. Also, 1, 2, and 3 are linear, semi-log, and inverse forms respectively.

Appendix E-12. Best-fit Regression Models Developed for Caltrans Zone 12

Parameter (:g/L)	Coefficient							R^2	Count[b]	Form[c]	Phase
	Intercept	TSS (mg/L)	VSS (mg/L)	DOC (mg/L)	COD (mg/L)	EC (:mhos/c)	TDS (mg/L)				
Cd		0.00		0.02		0.00		0.46	37	P1	Dissolved/Particulate[a]
Cr	0.91	0.02						0.63	38	P1	
Cu	6.59			0.33			0.05	0.70	38	D1	
Ni		0.01		0.07			0.02	0.65	38	D1	
Pb	-61.77	54.66						0.55	38	P2	
Zn	-220.80	182.61						0.43	38	P2	
Cd	-1.20	1.10						0.44	38	T2	Total
Cr	-5.05	4.36				2.13		0.50	37	T2	
Cu	-80.24	40.08					25.94	0.60	38	T2	
Ni		0.04					0.04	0.63	38	T1	
Pb	-62.68	63.18						0.49	38	T2	
Zn	-396.79	208.53					97.83	0.53	38	T2	

[a]For some metal parameters, the dissolved metal models were better than the particulate models, and vice versa. Dissolved/Particulate means either the dissolved or the particulate model was presented.

[b]Count is the number of events considered.

[c]In form column **D** denotes dissolved, **P** denotes particulate, and **T** denotes total metal. Also, 1, 2, and 3 are linear, semi-log, and inverse forms respectively.

Appendix E-13. Best-fit Regression Models Developed for Caltrans Zone 13

Parameter (:g/L)	Coefficient							R^2	Count[b]	Form[c]	Phase
	Intercept	TSS (mg/L)	VSS (mg/L)	DOC (mg/L)	COD (mg/L)	EC (:mhos/c)	TDS (mg/L)				
Cd		0.01						0.54	31	P1	Dissolved/Particulate[a]
Cr	-11.62	7.34						0.57	31	D2	
Cu		0.01		0.90				0.94	31	D1	
Ni	-2.03			0.36				0.84	31	D1	
Pb		0.54		-0.87				0.83	31	P1	
Zn		-0.35		14.63		-0.74		0.88	31	D1	
Cd		0.01						0.53	31	T1	Total
Cr		0.04				0.01		0.76	31	T1	
Cu		0.31		0.77				0.72	31	T1	
Ni		0.02		0.34				0.80	31	T1	
Pb		0.56		-0.83				0.83	31	T1	
Zn		1.48		12.31				0.66	31	T1	

[a]For some metal parameters, the dissolved metal models were better than the particulate models, and vice versa. Dissolved/Particulate means either the dissolved or the particulate model was presented.

[b]Count is the number of events considered.

[c]In form column **D** denotes dissolved, **P** denotes particulate, and **T** denotes total metal. Also, 1, 2, and 3 are linear, semi-log, and inverse forms respectively.

Appendix E-14. Best-fit Regression Models Developed for Caltrans Zone 14

Parameter (:g/L)	Coefficient							R^2	Count[b]	Form[c]	Phase
	Intercept	TSS (mg/L)	VSS (mg/L)	DOC (mg/L)	COD (mg/L)	EC (:mhos/c)	TDS (mg/L)				
Cd		0.00						0.40	35	P1	Dissolved/Particulate[a]
Cr		0.03		-0.11		0.05		0.75	35	P1	
Cu	6.59			0.63				0.83	35	D1	
Ni		0.01		0.15				0.71	35	D1	
Pb		0.06						0.71	35	P1	
Zn	27.28	0.34						0.63	35	P1	
Cd	0.17	0.00						0.45	35	T1	Total
Cr	2.79	0.03		-0.11		0.05		0.85	35	T1	
Cu	9.24	0.05		0.68				0.81	35	T1	
Ni		0.02		0.11		0.02		0.79	35	T1	
Pb	2.91	0.06						0.75	35	T1	
Zn		0.47		3.73				0.19	35	T1	

[a]For some metal parameters, the dissolved metal models were better than the particulate models, and vice versa. Dissolved/Particulate means either the dissolved or the particulate model was presented.

[b]Count is the number of events considered.

[c]In form column **D** denotes dissolved, **P** denotes particulate, and **T** denotes total metal. Also, 1, 2, and 3 are linear, semi-log, and inverse forms respectively.

Appendix F

Zone 5

$$Cd(Dissolved) = 0.2 \cdot \log_{10}(DOC) \qquad R^2 = 0.29$$

$$Cd(Total) = 0.26 \cdot \log_{10}(TSS) - 0.026 \cdot \log_{10}(EC) \qquad R^2 = 0.21$$

Units:

Cd (Cadmium) = µg/L;

DOC (Dissolved organic carbon) = mg/L;

EC (Electrical conductivity) = µmhos/cm, and

TSS (Total suspended solids) = mg/L.

Appendix G. Best-fit Regression Models Developed for Caltrans Zone 6

Parameter (:g/L)	Coefficient			p value[b]			R^2	p_{Reg}[c]	Count[d]	Form[e]	Phase
	Intercept	TSS (mg/L)	COD (mg/L)	Intercept	TSS	COD					
Cd		0.00	0.00		0.11	0.79	0.64	0.03	5	D1	Dissolved/Particulate[a]
Cr	-37.66	26.90		<0.01	<0.01		0.72	<0.01	8	P2	
Cu			0.17			<0.01	0.27	<0.01	7	D1	
Ni		0.12	-0.06		<0.01	<0.01	1.00	<0.01	4	P1	
Pb	108.71	-2746.83		<0.01	<0.01		0.38	0.04	11	P3	
Zn			0.85			<0.01	0.22	0.01	7	D1	
Cd	1.19	0.00		<0.01	0.63		0.04	0.63	9	T1	Total
Cr	11.08	0.00		<0.01	0.62		0.03	0.62	11	T1	
Cu	32.91	-0.02	0.30	0.32	0.39	0.31	0.35	0.42	7	T1	
Ni	2.01	0.09	0.03	0.55	0.11	0.39	0.98	0.14	4	T1	
Pb	61.94	0.02		0.02	0.68		0.02	0.68	11	T1	
Zn	343.20	-5916.31		<0.01	0.30		0.15	0.30	9	T3	

[a]For some metal parameters, the dissolved metal models were better than the particulate models, and vice versa. Dissolved/Particulate means either the dissolved or the particulate model was presented.

[b]p values for the individual independent variables were obtained from 2-tailed t-statistic.

[c]p_{Reg} refers to p value for the entire model obtained from F-statistic.

[d]Count is the number of events considered.

[e]In form column **D** denotes dissolved, **P** denotes particulate, and **T** denotes total metal. Also, 1, 2, and 3 are linear, semi-log, and inverse forms respectively.

Appendix H-1. Generalized Regression Model Developed for UCLA Site 1

Parameter (:g/L)	Coefficient			p value[a]			R^2	p_{Reg}[b]	Count[c]	Form[d]	Phase
	Intercept	TSS (mg/L)	DOC (mg/L)	Intercept	TSS	DOC					
Cd	0.01	0.01	0.01	0.93	0.12	0.01	0.74	<0.01	17	D1	Dissolved
Cr	0.89	0.01	0.02	0.01	0.30	0.03	0.64	<0.01	17	D1	
Cu	12.00	-0.25	1.23	0.20	0.48	<0.01	0.76	<0.01	17	D1	
Ni	2.74	-0.03	0.25	0.06	0.61	<0.01	0.86	<0.01	17	D1	
Pb	0.93	0.07	-0.01	0.23	0.04	0.49	0.32	0.07	17	D1	
Zn	125.71	-2.71	4.86	0.06	0.28	0.01	0.44	0.02	17	D1	
Cd	-0.08	0.01	0.01	0.61	0.09	0.03	0.71	<0.01	17	T1	Total
Cr	2.32	0.06	0.08	0.02	0.10	0.01	0.77	<0.01	17	T1	
Cu	17.49	0.08	1.26	0.09	0.83	<0.01	0.80	<0.01	17	T1	
Ni	3.71	0.04	0.25	0.02	0.52	<0.01	0.88	<0.01	17	T1	
Pb	3.63	0.34	-0.03	0.09	<0.01	0.59	0.71	<0.01	17	T1	
Zn	143.08	-0.83	4.76	0.05	0.76	0.02	0.48	0.01	17	T1	

[a] p values for the individual independent variables were obtained from 2-tailed t-statistic.

[b] p_{Reg} refers to p value for the entire model obtained from F-statistic.

[c] Count is the number of events considered.

[d] In form column **D** denotes dissolved and **T** denotes total metal. Also, **1** means linear form.

Appendix H-2. Generalized Regression Model Developed for UCLA Site 2

Parameter (:g/L)	Coefficient			p value[a]			R^2	p_{Reg}[b]	Count[c]	Form[d]	Phase
	Intercept	TSS (mg/L)	DOC (mg/L)	Intercept	TSS	DOC					
Cd	0.03	0.00	0.01	0.92	0.32	<0.01	0.71	<0.01	16	D1	Dissolved
Cr	1.15	0.01	0.03	0.05	0.13	<0.01	0.79	<0.01	16	D1	
Cu	-8.05	0.26	1.09	0.56	0.13	<0.01	0.89	<0.01	16	D1	
Ni	-3.41	0.09	0.20	0.27	0.02	<0.01	0.88	<0.01	16	D1	
Pb	1.37	0.01	0.02	0.05	0.45	0.01	0.64	<0.01	16	D1	
Zn	-192.38	3.10	5.26	0.07	0.02	<0.01	0.84	<0.01	16	D1	
Cd	0.32	0.00	0.02	0.29	0.26	<0.01	0.79	<0.01	16	T1	Total
Cr	6.59	0.02	0.09	<0.01	0.15	<0.01	0.86	<0.01	16	T1	
Cu	14.15	0.31	1.29	0.31	0.07	<0.01	0.92	<0.01	16	T1	
Ni	0.70	0.09	0.22	0.83	0.04	<0.01	0.88	<0.01	16	T1	
Pb	21.72	0.11	-0.06	0.01	0.18	0.47	0.14	0.37	16	T1	
Zn	-107.08	3.01	5.88	0.20	0.01	<0.01	0.90	<0.01	16	T1	

[a] p values for the individual independent variables were obtained from 2-tailed t-statistic.

[b] p_{Reg} refers to p value for the entire model obtained from F-statistic.

[c] Count is the number of events considered.

[d] In form column **D** denotes dissolved and **T** denotes total metal. Also, **1** means linear form.

Appendix H-3. Generalized Regression Model Developed for UCLA Site 3

Parameter (:g/L)	Coefficient			p value[a]			R^2	p_{Reg}[b]	Count[c]	Form[d]	Phase
	Intercept	TSS (mg/L)	DOC (mg/L)	Intercept	TSS	DOC					
Cd	-0.04	0.01	0.00	0.79	0.06	0.44	0.24	0.04	26	D1	Dissolved
Cr	0.69	0.01	0.02	0.06	0.21	<0.01	0.80	<0.01	26	D1	
Cu	4.42	0.17	0.52	0.56	0.20	<0.01	0.89	<0.01	26	D1	
Ni	2.96	-0.05	0.23	0.08	0.08	<0.01	0.96	<0.01	26	D1	
Pb	0.87	0.04	0.02	0.38	0.03	<0.01	0.61	<0.01	26	D1	
Zn	23.81	0.15	4.37	0.43	0.77	<0.01	0.97	<0.01	26	D1	
Cd	0.17	0.00	0.01	0.37	0.75	<0.01	0.87	<0.01	26	T1	Total
Cr	1.59	0.08	0.02	0.14	<0.01	<0.01	0.71	<0.01	26	T1	
Cu	15.77	0.28	0.52	0.21	0.18	<0.01	0.76	<0.01	26	T1	
Ni	6.67	-0.04	0.23	0.03	0.39	<0.01	0.89	<0.01	26	T1	
Pb	20.11	0.18	-0.04	<0.01	0.01	0.14	0.24	0.05	26	T1	
Zn	49.81	0.80	4.31	0.16	0.18	<0.01	0.96	<0.01	26	T1	

[a] p values for the individual independent variables were obtained from 2-tailed t-statistic.

[b] p_{Reg} refers to p value for the entire model obtained from F-statistic.

[c] Count is the number of events considered.

[d] In form column **D** denotes dissolved and **T** denotes total metal. Also, **1** means linear form.

Appendix H-4. Generalized Regression Model Developed for Combined UCLA Sites

Parameter (:g/L)	Coefficient			p value[a]			R^2	p_{Reg}[b]	Count[c]	Form[d]	Phase
	Intercept	TSS (mg/L)	DOC (mg/L)	Intercept	TSS	DOC					
Cd	-0.08	0.01	0.00	0.47	<0.01	0.04	0.49	<0.01	59	D1	Dissolved
Cr	0.62	0.02	0.02	<0.01	<0.01	<0.01	0.75	<0.01	59	D1	
Cu	0.63	0.37	0.62	0.92	<0.01	<0.01	0.77	<0.01	59	D1	
Ni	0.01	0.03	0.22	0.99	0.03	<0.01	0.91	<0.01	59	D1	
Pb	1.63	0.01	0.02	<0.01	0.09	<0.01	0.47	<0.01	59	D1	
Zn	-50.65	2.06	4.33	0.14	<0.01	<0.01	0.83	<0.01	59	D1	
Cd	-0.06	0.01	0.01	0.61	<0.01	<0.01	0.78	<0.01	59	T1	Total
Cr	2.98	0.07	0.03	<0.01	<0.01	<0.01	0.71	<0.01	59	T1	
Cu	10.19	0.59	0.64	0.19	<0.01	<0.01	0.73	<0.01	59	T1	
Ni	2.79	0.05	0.22	0.04	0.01	<0.01	0.87	<0.01	59	T1	
Pb	15.78	0.17	-0.04	<0.01	<0.01	0.10	0.30	<0.01	59	T1	
Zn	-5.60	2.56	4.40	0.86	<0.01	<0.01	0.85	<0.01	59	T1	

[a] p values for the individual independent variables were obtained from 2-tailed t-statistic.

[b] p_{Reg} refers to p value for the entire model obtained from F-statistic.

[c] Count is the number of events considered.

[d] In form column **D** denotes dissolved and **T** denotes total metal. Also, **1** means linear form.

Appendix H-5. Generalized Regression Model Developed for Combined Other Caltrans Sites

Parameter (:g/L)	Coefficient			p value[a]			R^2	p_{Reg}[b]	Count[c]	Form[d]	Phase
	Intercept	TSS (mg/L)	DOC (mg/L)	Intercept	TSS	DOC					
Cd	0.37	0.00	0.00	<0.01	<0.01	0.55	0.12	<0.01	725	P1	Particulate
Cr	2.28	0.02	0.01	<0.01	<0.01	0.19	0.48	<0.01	726	P1	
Cu	12.55	0.03	0.03	<0.01	<0.01	0.17	0.29	<0.01	725	P1	
Ni	2.76	0.01	0.00	<0.01	<0.01	0.75	0.33	<0.01	726	P1	
Pb	18.96	0.06	0.13	<0.01	<0.01	0.27	0.06	<0.01	725	P1	
Zn	76.00	0.20	0.22	<0.01	<0.01	0.10	0.33	<0.01	725	P1	
Cd	0.55	0.00	0.00	<0.01	<0.01	0.07	0.06	<0.01	726	T1	Total
Cr	4.61	0.02	0.03	<0.01	<0.01	<0.01	0.47	<0.01	726	T1	
Cu	22.84	0.03	0.23	<0.01	<0.01	<0.01	0.24	<0.01	726	T1	
Ni	5.26	0.01	0.07	<0.01	<0.01	<0.01	0.31	<0.01	726	T1	
Pb	22.30	0.06	0.16	<0.01	<0.01	0.22	0.05	<0.01	726	T1	
Zn	124.45	0.19	1.27	<0.01	<0.01	<0.01	0.24	<0.01	726	T1	

[a] p values for the individual independent variables were obtained from 2-tailed t-statistic.

[b] p_{Reg} refers to p value for the entire model obtained from F-statistic.

[c] Count is the number of events considered.

[d] In form column **D** denotes dissolved and **T** denotes total metal. Also, **1** means linear form.

Appendix H-6. Generalized Regression Model Developed for Caltrans Zone 1

Parameter (:g/L)	Coefficient			p value[a]			R^2	p_{Reg}[b]	Count[c]	Form[d]	Phase
	Intercept	TSS (mg/L)	DOC (mg/L)	Intercept	TSS	DOC					
Cd	0.03	0.00	0.01	0.49	<0.01	0.03	0.68	<0.01	69	P1	Particulate
Cr	0.29	0.02	0.03	0.16	<0.01	0.03	0.57	<0.01	70	P1	
Cu	0.26	0.14	0.12	0.88	<0.01	0.33	0.53	<0.01	69	P1	
Ni	0.63	0.01	0.03	0.01	<0.01	0.06	0.41	<0.01	70	P1	
Pb	-2.76	0.10	0.23	<0.01	<0.01	<0.01	0.76	<0.01	69	P1	
Zn	-1.90	0.75	0.51	0.73	<0.01	0.21	0.74	<0.01	69	P1	
Cd	0.07	0.01	0.01	0.25	<0.01	0.03	0.57	<0.01	70	T1	Total
Cr	1.12	0.02	0.04	<0.01	<0.01	0.13	0.32	<0.01	70	T1	
Cu	0.53	0.19	0.41	0.82	<0.01	0.01	0.56	<0.01	70	T1	
Ni	0.98	0.03	0.08	<0.01	<0.01	<0.01	0.54	<0.01	70	T1	
Pb	-2.33	0.10	0.23	0.01	<0.01	<0.01	0.74	<0.01	70	T1	
Zn	10.42	0.91	0.57	0.15	<0.01	0.28	0.70	<0.01	70	T1	

[a] p values for the individual independent variables were obtained from 2-tailed t-statistic.

[b] p_{Reg} refers to p value for the entire model obtained from F-statistic.

[c] Count is the number of events considered.

[d] In form column **D** denotes dissolved and **T** denotes total metal. Also, **1** means linear form.

Appendix H-7. Generalized Regression Model Developed for Caltrans Zone 2

Parameter (:g/L)	Coefficient			p value[a]			R^2	p_{Reg}[b]	Count[c]	Form[d]	Phase
	Intercept	TSS (mg/L)	DOC (mg/L)	Intercept	TSS	DOC					
Cd	0.02	0.00	0.00	0.74	<0.01	0.45	0.62	<0.01	59	P1	Particulate
Cr	1.55	0.03	-0.04	0.01	<0.01	0.19	0.38	<0.01	59	P1	
Cu	0.83	0.22	0.02	0.75	<0.01	0.87	0.56	<0.01	59	P1	
Ni	1.48	0.05	-0.03	0.05	<0.01	0.49	0.40	<0.01	59	P1	
Pb	-0.52	0.14	0.04	0.75	<0.01	0.65	0.57	<0.01	59	P1	
Zn	5.74	1.11	-0.18	0.53	<0.01	0.71	0.73	<0.01	59	P1	
Cd	0.08	0.01	0.00	0.17	<0.01	0.26	0.57	<0.01	59	T1	Total
Cr	3.80	0.02	-0.02	0.01	0.11	0.76	0.05	0.27	59	T1	
Cu	4.37	0.28	0.37	0.24	<0.01	0.06	0.51	<0.01	59	T1	
Ni	2.18	0.06	0.05	<0.01	<0.01	0.22	0.57	<0.01	59	T1	
Pb	0.29	0.14	0.04	0.86	<0.01	0.63	0.57	<0.01	59	T1	
Zn	25.96	1.31	-0.01	0.02	<0.01	0.99	0.71	<0.01	59	T1	

[a] p values for the individual independent variables were obtained from 2-tailed t-statistic.

[b] p_{Reg} refers to p value for the entire model obtained from F-statistic.

[c] Count is the number of events considered.

[d] In form column **D** denotes dissolved and **T** denotes total metal. Also, **1** means linear form.

Appendix H-8. Generalized Regression Model Developed for Caltrans Zone 3

Parameter (:g/L)	Coefficient			p value[a]			R^2	p_{Reg}[b]	Count[c]	Form[d]	Phase
	Intercept	TSS (mg/L)	DOC (mg/L)	Intercept	TSS	DOC					
Cd	0.17	0.00	0.00	<0.01	<0.01	0.16	0.52	<0.01	100	P1	Particulate
Cr	0.42	0.06	0.03	0.61	<0.01	0.53	0.47	<0.01	100	P1	
Cu	0.63	0.19	-0.03	0.60	<0.01	0.65	0.79	<0.01	100	P1	
Ni	-0.14	0.07	0.00	0.81	<0.01	0.92	0.64	<0.01	100	P1	
Pb	-0.48	0.16	-0.05	0.65	<0.01	0.36	0.77	<0.01	100	P1	
Zn	14.33	0.76	-0.08	0.02	<0.01	0.80	0.69	<0.01	100	P1	
Cd	0.19	0.00	0.01	<0.01	<0.01	0.01	0.39	<0.01	100	T1	Total
Cr	4.72	0.07	0.03	<0.01	<0.01	0.75	0.22	<0.01	100	T1	
Cu	2.89	0.21	0.47	0.07	<0.01	<0.01	0.74	<0.01	100	T1	
Ni	-0.38	0.07	0.22	0.58	<0.01	<0.01	0.66	<0.01	100	T1	
Pb	-0.12	0.16	-0.04	0.91	<0.01	0.52	0.77	<0.01	100	T1	
Zn	13.49	0.89	2.27	0.10	<0.01	<0.01	0.66	<0.01	100	T1	

[a] p values for the individual independent variables were obtained from 2-tailed t-statistic.

[b] p_{Reg} refers to p value for the entire model obtained from F-statistic.

[c] Count is the number of events considered.

[d] In form column **D** denotes dissolved and **T** denotes total metal. Also, **1** means linear form.

Appendix H-9. Generalized Regression Model Developed for Caltrans Zone 4

Parameter (:g/L)	Coefficient			p value[a]			R^2	p_{Reg}[b]	Count[c]	Form[d]	Phase
	Intercept	TSS (mg/L)	DOC (mg/L)	Intercept	TSS	DOC					
Cd	0.20	0.00	0.00	0.10	<0.01	0.79	0.25	<0.01	101	P1	Particulate
Cr	2.76	0.01	0.01	0.06	<0.01	0.51	0.53	<0.01	101	P1	
Cu	13.94	0.03	0.00	<0.01	<0.01	0.97	0.61	<0.01	101	P1	
Ni	4.71	0.01	0.00	<0.01	<0.01	0.65	0.66	<0.01	101	P1	
Pb	-0.98	0.05	0.07	0.79	<0.01	0.05	0.67	<0.01	101	P1	
Zn	83.99	0.17	-0.04	<0.01	<0.01	0.79	0.62	<0.01	101	P1	
Cd	0.28	0.00	0.00	0.02	<0.01	0.88	0.25	<0.01	101	T1	Total
Cr	5.85	0.02	0.03	<0.01	<0.01	0.05	0.57	<0.01	101	T1	
Cu	21.47	0.02	0.10	<0.01	<0.01	<0.01	0.61	<0.01	101	T1	
Ni	6.72	0.01	0.03	<0.01	<0.01	<0.01	0.64	<0.01	101	T1	
Pb	0.43	0.05	0.07	0.02	<0.01	0.05	0.67	<0.01	101	T1	
Zn	121.28	0.18	0.37	<0.01	<0.01	0.02	0.62	<0.01	101	T1	

[a] p values for the individual independent variables were obtained from 2-tailed t-statistic.

[b] p_{Reg} refers to p value for the entire model obtained from F-statistic.

[c] Count is the number of events considered.

[d] In form column **D** denotes dissolved and **T** denotes total metal. Also, **1** means linear form.

Appendix H-10. Generalized Regression Model Developed for Caltrans Zone 5

Parameter (:g/L)	Coefficient			p value[a]			R^2	p_{Reg}[b]	Count[c]	Form[d]	Phase
	Intercept	TSS (mg/L)	DOC (mg/L)	Intercept	TSS	DOC					
Cd	0.55	0.00	0.00	0.31	0.98	0.84	<0.01	0.98	36	P1	Particulate
Cr	1.53	0.02	0.01	0.02	<0.01	0.59	0.45	<0.01	36	P1	
Cu	4.05	0.06	0.13	0.04	<0.01	0.05	0.42	<0.01	36	P1	
Ni	1.54	0.03	0.02	0.04	<0.01	0.35	0.53	<0.01	36	P1	
Pb	3.63	0.08	0.12	0.08	<0.01	0.07	0.53	<0.01	36	P1	
Zn	73.71	0.38	0.71	0.03	0.11	0.50	0.09	0.19	36	P1	
Cd	1.04	0.00	0.01	0.29	0.71	0.74	0.01	0.89	36	T1	Total
Cr	3.47	0.02	0.02	<0.01	<0.01	0.56	0.26	0.01	36	T1	
Cu	11.26	0.06	0.47	<0.01	<0.01	<0.01	0.54	<0.01	36	T1	
Ni	2.60	0.03	0.15	0.04	<0.01	<0.01	0.52	<0.01	36	T1	
Pb	5.54	0.08	0.15	0.02	<0.01	0.05	0.51	<0.01	36	T1	
Zn	89.13	0.43	5.60	0.06	0.17	<0.01	0.36	<0.01	36	T1	

[a] p values for the individual independent variables were obtained from 2-tailed t-statistic.

[b] p_{Reg} refers to p value for the entire model obtained from F-statistic.

[c] Count is the number of events considered.

[d] In form column **D** denotes dissolved and **T** denotes total metal. Also, **1** means linear form.

Appendix H-11. Generalized Regression Model Developed for Caltrans Zone 7

Parameter (:g/L)	Coefficient			p value[a]			R^2	p_{Reg}[b]	Count[c]	Form[d]	Phase
	Intercept	TSS (mg/L)	DOC (mg/L)	Intercept	TSS	DOC					
Cd	-0.14	0.01	0.02	0.70	0.25	0.61	0.25	0.23	13	P1	Particulate
Cr	-0.24	0.03	0.11	0.83	0.13	0.42	0.40	0.08	13	P1	
Cu	-3.96	0.17	0.54	0.48	0.05	0.41	0.52	0.03	13	P1	
Ni	-0.74	0.04	0.10	0.42	0.01	0.33	0.67	<0.01	13	P1	
Pb	-8.01	0.24	0.65	0.09	<0.01	0.21	0.76	<0.01	13	P1	
Zn	-52.35	1.57	4.56	0.12	0.01	0.23	0.72	<0.01	13	P1	
Cd	0.03	0.01	0.04	0.94	0.34	0.44	0.25	0.23	13	T1	Total
Cr	0.89	0.03	0.11	0.56	0.14	0.52	0.36	0.12	13	T1	
Cu	2.65	0.19	0.81	0.72	0.09	0.35	0.47	0.04	13	T1	
Ni	-0.06	0.03	0.26	0.97	0.11	0.13	0.55	0.02	13	T1	
Pb	-6.89	0.24	0.73	0.11	<0.01	0.14	0.80	<0.01	13	T1	
Zn	-23.09	1.77	7.16	0.47	<0.01	0.07	0.80	<0.01	13	T1	

[a] p values for the individual independent variables were obtained from 2-tailed t-statistic.

[b] p_{Reg} refers to p value for the entire model obtained from F-statistic.

[c] Count is the number of events considered.

[d] In form column **D** denotes dissolved and **T** denotes total metal. Also, **1** means linear form.

Appendix H-12. Generalized Regression Model Developed for Caltrans Zone 8

Parameter (:g/L)	Coefficient			p value[a]			R^2	p_{Reg}[b]	Count[c]	Form[d]	Phase
	Intercept	TSS (mg/L)	DOC (mg/L)	Intercept	TSS	DOC					
Cd	0.05	0.01	0.01	0.62	<0.01	0.05	0.46	<0.01	72	P1	Particulate
Cr	-0.01	0.04	0.08	0.99	0.03	0.39	0.11	0.02	72	P1	
Cu	-0.72	0.24	0.17	0.73	<0.01	0.08	0.74	<0.01	72	P1	
Ni	0.10	0.12	-0.13	0.96	<0.01	0.24	0.28	<0.01	72	P1	
Pb	-66.42	2.37	-0.69	0.01	<0.01	0.54	0.64	<0.01	72	P1	
Zn	10.22	1.46	0.99	0.53	<0.01	0.20	0.63	<0.01	72	P1	
Cd	-0.13	0.01	0.02	0.30	<0.01	0.01	0.69	<0.01	72	T1	Total
Cr	1.48	0.05	0.12	0.45	0.02	0.21	0.15	<0.01	72	T1	
Cu	-0.35	0.32	0.93	0.88	<0.01	<0.01	0.87	<0.01	72	T1	
Ni	-0.90	0.14	0.12	0.70	<0.01	0.30	0.45	<0.01	72	T1	
Pb	-89.10	2.92	-0.44	<0.01	<0.01	0.75	0.65	<0.01	72	T1	
Zn	-24.99	2.23	6.83	0.25	<0.01	<0.01	0.79	<0.01	72	T1	

[a] p values for the individual independent variables were obtained from 2-tailed t-statistic.

[b] p_{Reg} refers to p value for the entire model obtained from F-statistic.

[c] Count is the number of events considered.

[d] In form column **D** denotes dissolved and **T** denotes total metal. Also, **1** means linear form.

Appendix H-13. Generalized Regression Model Developed for Caltrans Zone 9

Parameter (:g/L)	Coefficient			p value[a]			R^2	p_{Reg}[b]	Count[c]	Form[d]	Phase
	Intercept	TSS (mg/L)	DOC (mg/L)	Intercept	TSS	DOC					
Cd	0.02	0.01	0.03	0.90	<0.01	0.05	0.88	<0.01	28	P1	Particulate
Cr	0.26	0.04	0.13	0.74	<0.01	0.10	0.92	<0.01	28	P1	
Cu	4.14	0.15	1.79	0.56	<0.01	0.01	0.81	<0.01	28	P1	
Ni	0.68	0.04	0.08	0.22	<0.01	0.14	0.95	<0.01	28	P1	
Pb	-17.69	0.77	7.49	0.50	<0.01	0.01	0.88	<0.01	28	P1	
Zn	46.90	0.46	7.65	0.04	<0.01	<0.01	0.85	<0.01	28	P1	
Cd	0.11	0.01	0.04	0.52	<0.01	0.02	0.88	<0.01	28	T1	Total
Cr	1.58	0.04	0.18	0.05	<0.01	0.02	0.92	<0.01	28	T1	
Cu	5.65	0.16	2.93	0.44	<0.01	<0.01	0.87	<0.01	28	T1	
Ni	0.76	0.04	0.28	0.24	<0.01	<0.01	0.96	<0.01	28	T1	
Pb	-8.19	0.76	7.64	0.76	<0.01	0.01	0.88	<0.01	28	T1	
Zn	51.16	0.62	7.50	<0.01	<0.01	<0.01	0.94	<0.01	28	T1	

[a] p values for the individual independent variables were obtained from 2-tailed t-statistic.

[b] p_{Reg} refers to p value for the entire model obtained from F-statistic.

[c] Count is the number of events considered.

[d] In form column **D** denotes dissolved and **T** denotes total metal. Also, **1** means linear form.

Appendix H-14. Generalized Regression Model Developed for Caltrans Zone 10

Parameter (:g/L)	Coefficient			p value[a]			R^2	p_{Reg}[b]	Count[c]	Form[d]	Phase
	Intercept	TSS (mg/L)	DOC (mg/L)	Intercept	TSS	DOC					
Cd	0.04	0.00	0.00	0.52	<0.01	1.00	0.54	<0.01	103	P1	Particulate
Cr	1.93	0.03	-0.03	<0.01	<0.01	0.15	0.36	<0.01	103	P1	
Cu	1.46	0.07	0.22	0.60	<0.01	0.02	0.25	<0.01	103	P1	
Ni	0.66	0.02	0.01	0.11	<0.01	0.54	0.48	<0.01	103	P1	
Pb	-7.25	0.09	0.45	0.15	0.01	0.01	0.19	<0.01	103	P1	
Zn	20.77	0.76	0.69	0.27	<0.01	0.27	0.33	<0.01	103	P1	
Cd	0.12	0.01	0.00	0.26	<0.01	0.35	0.48	<0.01	103	T1	Total
Cr	3.60	0.03	0.00	<0.01	<0.01	0.99	0.35	<0.01	103	T1	
Cu	4.32	0.07	0.73	0.29	0.01	<0.01	0.35	<0.01	103	T1	
Ni	0.62	0.04	0.18	0.42	<0.01	<0.01	0.63	<0.01	103	T1	
Pb	-5.68	0.09	0.49	0.30	0.01	0.01	0.17	<0.01	103	T1	
Zn	34.87	0.91	3.35	0.26	<0.01	<0.01	0.31	<0.01	103	T1	

[a] p values for the individual independent variables were obtained from 2-tailed t-statistic.

[b] p_{Reg} refers to p value for the entire model obtained from F-statistic.

[c] Count is the number of events considered.

[d] In form column **D** denotes dissolved and **T** denotes total metal. Also, **1** means linear form.

Appendix H-15. Generalized Regression Model Developed for Caltrans Zone 11

Parameter (:g/L)	Coefficient			p value[a]			R^2	p_{Reg}[b]	Count[c]	Form[d]	Phase
	Intercept	TSS (mg/L)	DOC (mg/L)	Intercept	TSS	DOC					
Cd	0.04	0.00	0.00	0.73	<0.01	0.36	0.49	<0.01	37	P1	Particulate
Cr	0.65	0.02	0.10	0.49	0.01	0.02	0.37	<0.01	37	P1	
Cu	-0.11	0.13	0.22	0.98	<0.01	0.22	0.48	<0.01	37	P1	
Ni	-3.50	0.04	0.25	0.40	0.15	0.17	0.15	0.06	37	P1	
Pb	0.33	0.09	0.34	0.89	<0.01	<0.01	0.64	<0.01	37	P1	
Zn	-16.96	0.89	1.75	0.61	<0.01	0.23	0.40	<0.01	37	P1	
Cd	0.09	0.00	0.01	0.52	<0.01	0.06	0.44	<0.01	37	T1	Total
Cr	2.20	0.03	0.16	0.09	0.01	0.01	0.41	<0.01	37	T1	
Cu	1.26	0.14	0.94	0.80	<0.01	<0.01	0.62	<0.01	37	T1	
Ni	-3.53	0.05	0.43	0.43	0.13	0.03	0.24	0.01	37	T1	
Pb	3.42	0.09	0.44	0.20	<0.01	<0.01	0.61	<0.01	37	T1	
Zn	-18.79	0.78	6.36	0.70	0.02	<0.01	0.39	<0.01	37	T1	

[a] p values for the individual independent variables were obtained from 2-tailed t-statistic.

[b] p_{Reg} refers to p value for the entire model obtained from F-statistic.

[c] Count is the number of events considered.

[d] In form column **D** denotes dissolved and **T** denotes total metal. Also, **1** means linear form.

Appendix H-16. Generalized Regression Model Developed for Caltrans Zone 12

Parameter (:g/L)	Coefficient			p value[a]			R^2	p_{Reg}[b]	Count[c]	Form[d]	Phase
	Intercept	TSS (mg/L)	DOC (mg/L)	Intercept	TSS	DOC					
Cd	0.01	0.00	0.01	0.94	<0.01	0.08	0.39	<0.01	38	P1	Particulate
Cr	0.79	0.02	0.01	0.04	<0.01	0.55	0.63	<0.01	38	P1	
Cu	-0.34	0.15	0.20	0.94	<0.01	0.13	0.44	<0.01	38	P1	
Ni	-0.15	0.02	0.05	0.81	<0.01	0.02	0.46	<0.01	38	P1	
Pb	4.30	0.31	0.13	0.52	<0.01	0.49	0.53	<0.01	38	P1	
Zn	-9.35	0.92	1.15	0.74	<0.01	0.16	0.41	<0.01	38	P1	
Cd	0.07	0.00	0.01	0.69	<0.01	0.05	0.41	<0.01	38	T1	Total
Cr	4.14	0.02	0.02	<0.01	<0.01	0.34	0.43	<0.01	38	T1	
Cu	6.81	0.16	0.69	0.22	<0.01	<0.01	0.58	<0.01	38	T1	
Ni	0.21	0.03	0.18	0.86	<0.01	<0.01	0.61	<0.01	38	T1	
Pb	15.80	0.37	0.04	0.07	<0.01	0.88	0.47	<0.01	38	T1	
Zn	11.50	1.03	2.08	0.72	<0.01	0.03	0.46	<0.01	38	T1	

[a] p values for the individual independent variables were obtained from 2-tailed t-statistic.

[b] p_{Reg} refers to p value for the entire model obtained from F-statistic.

[c] Count is the number of events considered.

[d] In form column **D** denotes dissolved and **T** denotes total metal. Also, **1** means linear form.

Appendix H-17. Generalized Regression Model Developed for Caltrans Zone 13

Parameter (:g/L)	Coefficient			p value[a]			R^2	p_{Reg}[b]	Count[c]	Form[d]	Phase
	Intercept	TSS (mg/L)	DOC (mg/L)	Intercept	TSS	DOC					
Cd	-0.06	0.01	0.00	0.76	<0.01	0.70	0.54	<0.01	31	P1	Particulate
Cr	0.79	0.02	0.00	0.15	<0.01	0.97	0.49	<0.01	31	P1	
Cu	8.43	0.26	-0.32	0.13	<0.01	0.17	0.68	<0.01	31	P1	
Ni	0.40	0.03	0.01	0.59	<0.01	0.72	0.65	<0.01	31	P1	
Pb	-0.87	0.55	-0.85	0.91	<0.01	0.01	0.83	<0.01	31	P1	
Zn	1.03	2.09	0.26	0.99	<0.01	0.91	0.57	<0.01	31	P1	
Cd	0.05	0.01	0.01	0.08	<0.01	0.18	0.58	<0.01	31	T1	Total
Cr	0.63	0.04	0.01	0.44	<0.01	0.85	0.73	<0.01	31	T1	
Cu	6.68	0.28	0.63	0.26	<0.01	0.02	0.73	<0.01	31	T1	
Ni	-1.38	0.03	0.37	0.19	<0.01	<0.01	0.81	<0.01	31	T1	
Pb	1.99	0.55	-0.88	0.79	<0.01	0.01	0.83	<0.01	31	T1	
Zn	-7.74	1.51	12.48	0.89	<0.01	<0.01	0.66	<0.01	31	T1	

[a] p values for the individual independent variables were obtained from 2-tailed t-statistic.

[b] p_{Reg} refers to p value for the entire model obtained from F-statistic.

[c] Count is the number of events considered.

[d] In form column **D** denotes dissolved and **T** denotes total metal. Also, **1** means linear form.

Appendix H-18. Generalized Regression Model Developed for Caltrans Zone 14

Parameter (:g/L)	Coefficient			p value[a]			R^2	p_{Reg}[b]	Count[c]	Form[d]	Phase
	Intercept	TSS (mg/L)	DOC (mg/L)	Intercept	TSS	DOC					
Cd	0.09	0.00	0.00	0.13	<0.01	0.71	0.46	<0.01	35	P1	Particulate
Cr	1.67	0.03	-0.04	0.15	<0.01	0.13	0.65	<0.01	35	P1	
Cu	4.09	0.04	0.04	0.04	<0.01	0.35	0.58	<0.01	35	P1	
Ni	0.68	0.01	0.00	0.36	<0.01	0.99	0.46	<0.01	35	P1	
Pb	1.33	0.05	-0.02	0.50	<0.01	0.58	0.71	<0.01	35	P1	
Zn	27.19	0.34	0.00	0.08	<0.01	0.99	0.63	<0.01	35	P1	
Cd	0.20	0.00	0.00	<0.01	<0.01	0.53	0.45	<0.01	35	T1	Total
Cr	4.30	0.03	-0.03	<0.01	<0.01	0.16	0.76	<0.01	35	T1	
Cu	9.24	0.05	0.68	<0.01	<0.01	<0.01	0.81	<0.01	35	T1	
Ni	1.14	0.02	0.14	0.15	<0.01	<0.01	0.76	<0.01	35	T1	
Pb	3.42	0.06	-0.02	0.08	<0.01	0.68	0.76	<0.01	35	T1	
Zn	69.76	0.31	2.78	0.15	0.04	0.01	0.24	0.01	35	T1	

[a] p values for the individual independent variables were obtained from 2-tailed t-statistic.

[b] p_{Reg} refers to p value for the entire model obtained from F-statistic.

[c] Count is the number of events considered.

[d] In form column **D** denotes dissolved and **T** denotes total metal. Also, **1** means linear form.