June 19, 2013
Item No. 8
Supporting Document No. 3e

Appendix C-2

Watershed Modeling Report (Tetra Tech 2011)

June 19, 2013
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Supporting Document No. 3e

Watershed Modeling for Simulation of Loadings to San Diego Bay
FINAL

Prepared for:
U.S. Environmental Protection Agency, Region 9
San Diego Regional Water Quality Control Board

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1 Background

To support development of Total Maximum Daily Loads for the San Diego Bay shorelines of Downtown Anchorage and B Street/Broadway Pier, Tetra Tech developed models of the watersheds discharging to these impaired areas. Both watersheds shown in Figure 1 are included entirely within the City limits of San Diego with a total combined area of the watersheds of 7.95 square kilometers (km^2). Most of the watershed area consists of low and high density residential, commercial/institutional, parks/recreation, and open space land uses.

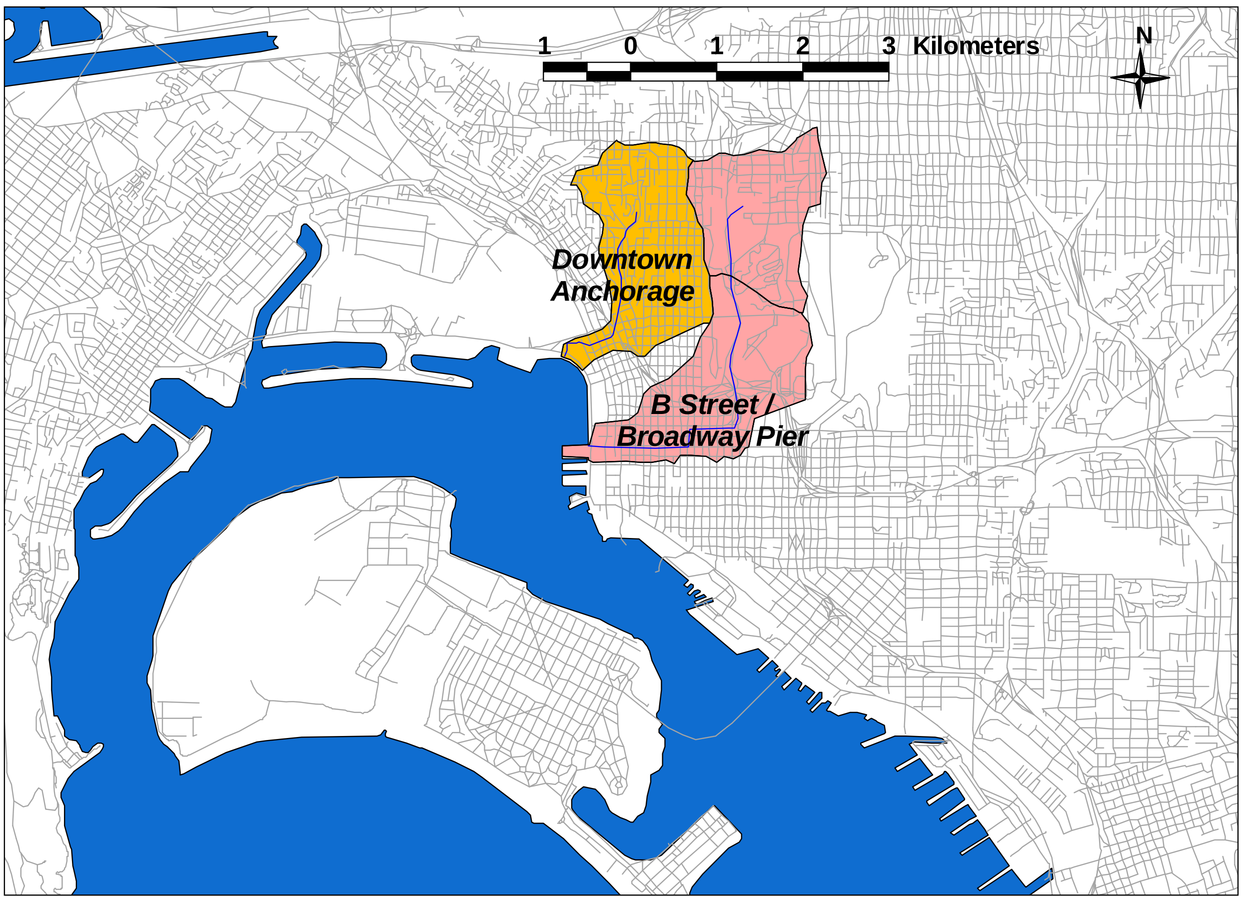


Figure 1. B Street/Broadway Pier and Downtown Anchorage Watersheds

For the watershed modeling, the Loading Simulation Program C++ (LSPC) was used (Shen et al., 2004; USEPA, 2003a). LSPC is a public domain model, supported by the U.S. Environmental Protection Agency (EPA), and has been used in previous TMDLs in the San Diego area (SDRWQCB, 2005, 2006). The LSPC model for this project will provide some of the data required for TMDL development; support the evaluation of potential management scenarios or implementation plans within the watershed; and will link to a separate receiving water model that will simulate processes at the mouth of each watershed.

This report summarizes monthly loadings for zinc and organic pollutants including polycyclic aromatic hydrocarbons [PAHs], polychlorinated biphenyls [PCBs], and chlordane. Most of these pollutants are generally associated with highly urbanized land uses. DDT is considered a legacy pollutant because it is believed that present day uses/sources of the pollutant do not exist. However, because of the persistence of DDT in the environment, reservoirs of the pollutant are often present in the watershed and in the receiving waters. PCBs and chlordane are also referred to as legacy pollutants, and similar to DDT, watershed sources of these pollutants may exist.

Watershed model development required several important steps, including configuration, calibration, and validation. However, no flow and water quality monitoring data are available to support model configuration, calibration, and validation for watersheds of Downtown Anchorage and B St./Broadway Piers. Thus, modeling parameters were adopted from the previous LSPC modeling efforts of SCCWRP and Tetra Tech, Inc. (2007) for the Chollas, Paleta, and Switzer Creek watersheds, which drain to the central San Diego Bay area (see Figure 2). However, SCCWRP and Tetra Tech, Inc. did not explicitly model organic pollutants within these LSPC models. Rather, loading analyses for these watersheds relied on event mean concentrations (EMCs), monitored at the bottom of each watershed, to represent all storm water quality for the creeks used for loading analysis. For the current study, this methodology was revised to include consideration of *both* sediment and associated organics concentrations in loading analyses for Chollas, Paleta, and Switzer Creeks, as well as assumptions that could be extended for assessments of loadings to Downtown Anchorage and B St./Broadway Piers. Results of these revised loading assessments are reported herein.

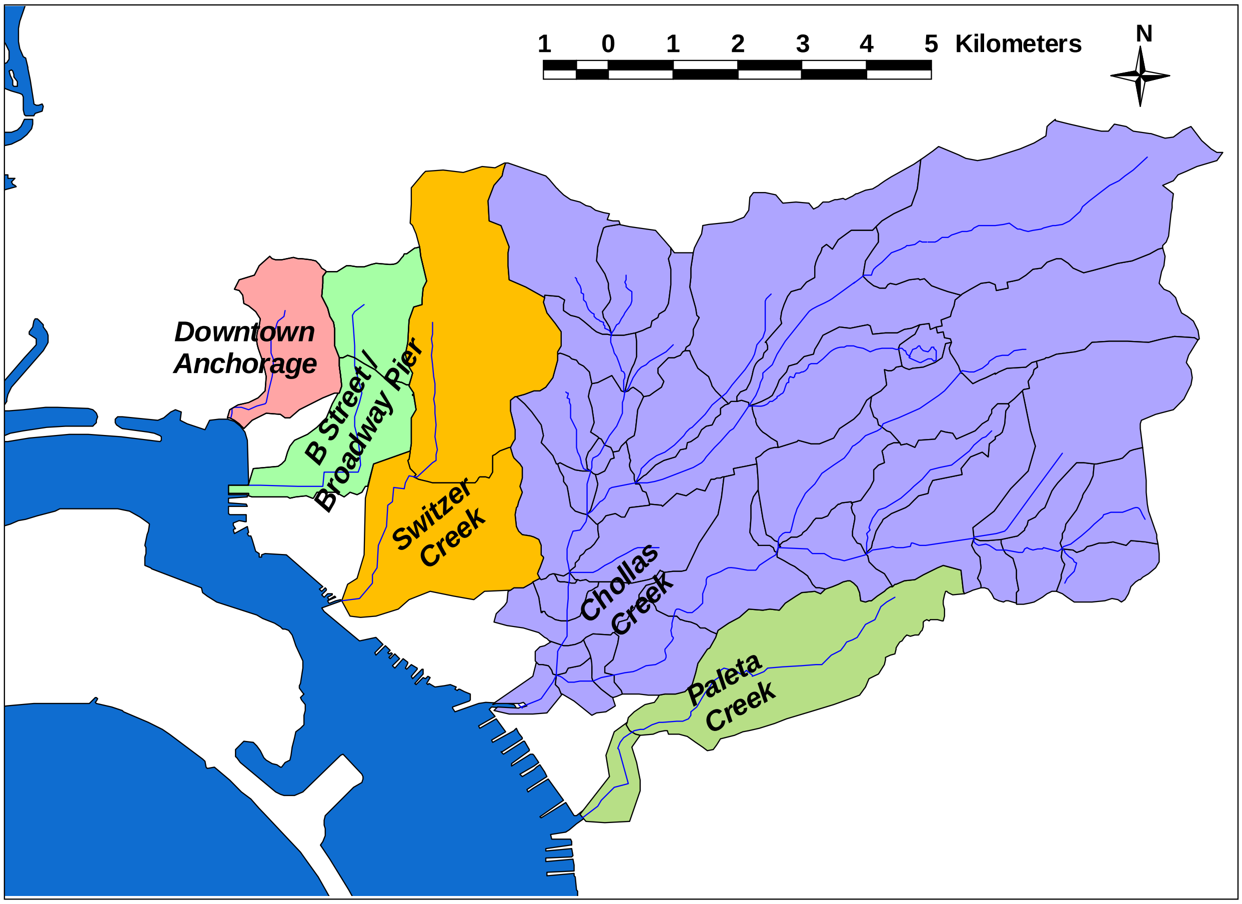


Figure 2. Five Watersheds Modeled

2 Modeling Approach

The transport of metals and organic pollutants during wet-weather events is generally believed to be associated with the detachment and transport of sediment (Buffleben et al. 2002; CALTRANS 2003; Hoffman et al. 1982; Lau and Stenstrom 2005; Loganathan et al. 1997; Stein et al., 2005; Yunker et al. 2002). Specifically, during rainy periods, these pollutant loads are delivered to the waterbody through surface water conveyance (i.e., creeks and rivers) and storm water collection systems.

Specific watershed sources of metals and organic pollutants vary based on location, and type of pollutant, and for some pollutants, concentration “hot spots” that may be present. These “hot spots” are typically associated with spills or other events that lead to higher pollutant concentrations and their presence and impact to receiving waters are difficult to identify/characterize. Additionally, available data to characterize the pollutant sources is often limited. Metals and organic pollutants can also be linked to specific land use types that have higher relative accumulation rates of the pollutant(s), higher relative loads of sediment from the land surface, or are more likely to deliver sediment and associated pollutants to waterbodies due to transport through storm water collection systems.

To assess the link between sources of sediment, metals, and organic pollutants and the receiving waters, a modeling system was utilized that simulates land-use based sources of sediment and associated pollutant loads and the hydrologic and hydraulic processes that affect delivery. The model was directly used to quantify sediment-associated zinc loads. The hydrology model results along with monitoring data were used to determine monthly loadings for PAHs, PCBs, and chlordane to the creeks.

The LSPC model was used to represent the hydrologic and water quality conditions in the B Street/Broadway Pier and Downtown Anchorage watersheds, consistent with methods used for modeling Chollas, Paleta, and Switzer Creeks (SCCWRP and Tetra Tech, Inc., 2007). LSPC is a recoded C++ version of EPA’s Hydrologic Simulation Program – FORTRAN (HSPF) that relies on fundamental, EPA-approved algorithms. LSPC is a component of the EPA’s TMDL Modeling Toolbox (USEPA, 2003b), which has been developed through a joint effort between EPA and Tetra Tech. It integrates comprehensive data storage and management capabilities, a dynamic watershed, and a data analysis/post-processing system into a convenient PC-based windows interface that dictates no software requirements.

LSPC is capable of representing loading and both flow and water quality from non-point and point sources as well as simulating in-stream processes. LSPC can simulate flow, sediment, metals, nutrients, pesticides, and other conventional pollutants for pervious and impervious lands and waterbodies. The model has been successfully applied and calibrated in Southern California for the Los Angeles River, the San Gabriel River, the San Jacinto River, and multiple watersheds draining to impaired beaches of the San Diego Region. As stated previously, for the B Street/Broadway Pier and Downtown Anchorage watersheds, LSPC was used to directly simulate sediment-associated zinc loads. In addition, model-predicted flows and total suspended solids (TSS) concentrations were incorporated with available monitoring data from Chollas, Paleta, and Switzer Creeks to determine monthly loadings for organic compounds.

The watershed model represented the variability of wet-weather runoff source contributions through dynamic representation of hydrology and land practices. The modeling process involves model configuration as well as model calibration and validation. These processes are described below.

2.1 Model Configuration

There are several key components of the watershed modeling that are important during model configuration. These components are listed below and are further described below:

- Watershed segmentation
- Meteorological data
- Land use representation
- Soils
- Reach characteristics
- Point source discharges
- Hydrology representation
- Pollutant representation

2.1.1 Watershed Segmentation

The B Street/Broadway Pier and Downtown Anchorage watersheds are located in southern San Diego County, and discharge to the north portion of San Diego Bay (Figure 1). The watersheds are entirely included within the City of San Diego. The total combined area of the two watersheds is 7.95 km^2.

The contributing drainage area of each watershed was represented by a series of subwatersheds to better evaluate sources contributing to the waterbodies and to represent the spatial variability of these sources. The watersheds were divided into 3 subwatersheds for appropriate hydrologic connectivity and representation (Figure 1). These subdivisions were based on Digital Elevation Model (DEM) data (2001) and GIS defining the storm water conveyance system (obtained from SANGIS).

2.1.2 Meteorology

Meteorological data are a critical component of the watershed model. LSPC requires appropriate representation of precipitation and potential evapotranspiration. Rainfall-runoff processes for each subwatershed were driven by precipitation data from the most representative station. These data provide necessary input to LSPC algorithms for hydrologic and water quality representation.

In general, hourly precipitation data are recommended for nonpoint source modeling. Therefore, only weather stations with hourly-recorded data were considered in the climate data selection process. National Climatic Data Center (NCDC) precipitation data were reviewed based on geographic location, period of record, and missing data to determine the most appropriate meteorological stations to represent the watersheds. Data from Lindbergh Field, the San Diego Airport (COOP ID # 047740), were obtained from NCDC for characterization of meteorology of the modeled watersheds (Figure 3). Lindbergh Field is the most representative weather station for the project watersheds with hourly data. It also has long-term hourly wind speed, cloud cover, temperature, and dew point data. These data are used to calculate hourly potential evapotranspiration, which can be incorporated into the modeling process. In order to use the most current data possible, Lindbergh Field meteorological data were obtained from January 1990 through June 2007.

2.1.3 Land Use Representation

The watershed model requires a basis for distributing hydrologic and pollutant loading parameters. This is necessary to appropriately represent hydrologic variability throughout the basin, which is influenced by land surface and subsurface characteristics. It is also necessary to represent variability in pollutant loading, which is highly correlated to land practices. The basis for this distribution was provided by land use coverage of the entire modeled area. The source of land use data was the San Diego Association of Governments (SANDAG) 2000 land use data set that covers San Diego County.

Although multiple categories in the land use coverage provide much detail regarding spatial representation of land practices in the watershed, such resolution is unnecessary for watershed modeling if many of the categories share hydrologic or pollutant loading characteristics. For example, many urban categories were represented independently in the model (e.g., high density residential, low density residential, industrial, and commercial/ institutional) because they have different levels of impervious cover and their associated pollutant-contributing practices vary. Therefore, many land use categories were grouped into similar classifications, resulting in a subset of categories for modeling, which were consistent with the land uses incorporated in the assessment of metals sources for the Chollas Creek TMDL (SDRWQCB, 2006). Specifically, land uses were grouped into 19 categories for model configuration. Although specific information was not available to provide distinction of modeling parameters between several land uses, these categories were selected by the SDRWQCB to provide capabilities for specific loading analysis as new information and data are collected to refine the model.

Land use areas for the model area are presented in Figure 3 and Table 1. Most of the area in the modeled watersheds consists of commercial/institutional, low density residential, high density residential, parks/recreation, and open space.

In addition, LSPC algorithms require that land use categories be divided into separate pervious and impervious land units for modeling. This division was based on typical impervious percentages associated with different land use types from the Soil Conservation Service's TR-55 Manual (Soil Conservation Service, 1986).

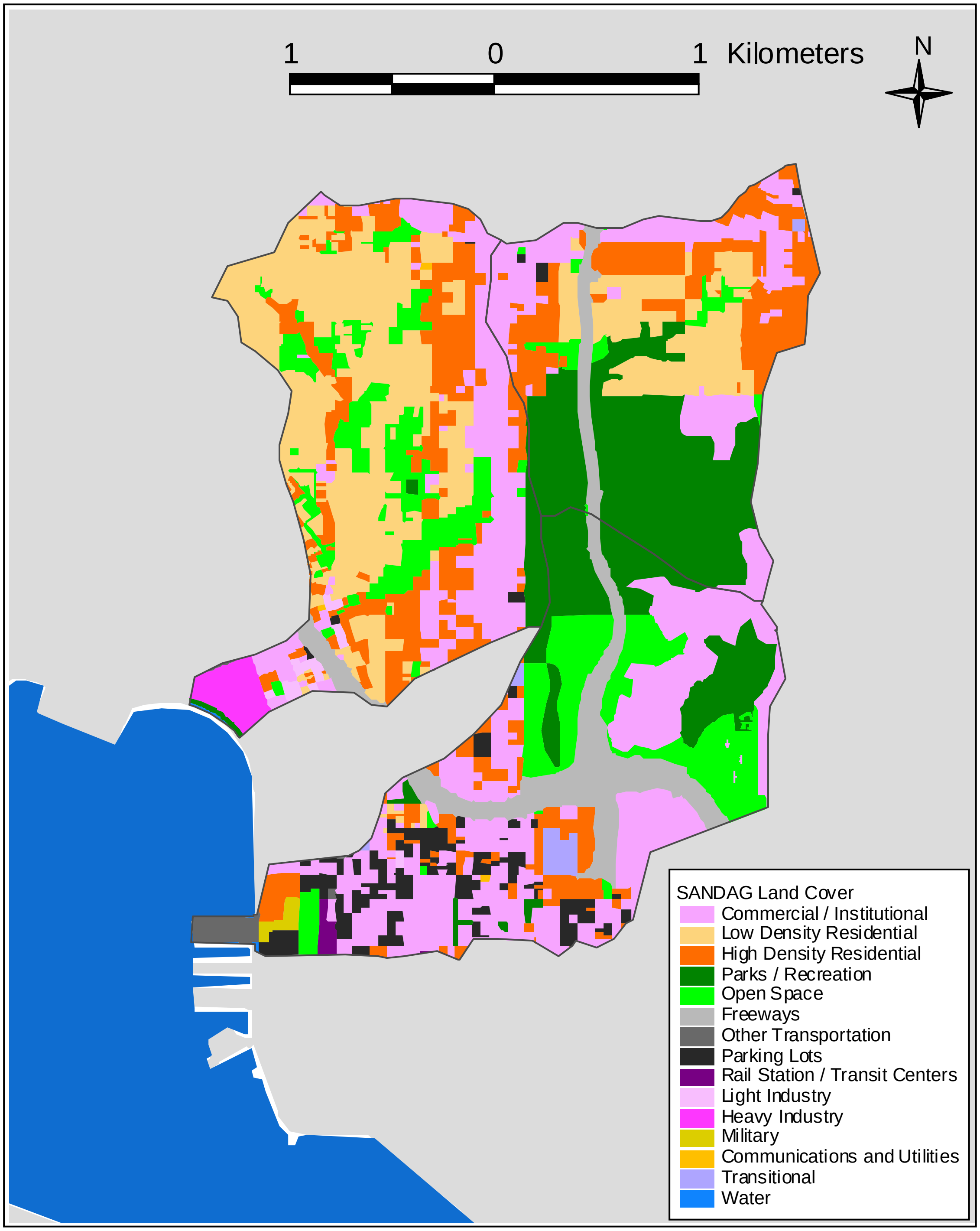


Figure 3. Land Use Representation

Table 1. Modeled Land Use Distribution

Land Use	B Street/Broadway Pier (km^2)	Downtown Anchorage (km^2)
Low Density Residential	0.39	1.09
High Density Residential	0.66	0.60
Commercial / Institutional	1.45	0.51
Communications and Utilities	0.00	0.00
Freeways	0.48	0.04
Heavy Industry	0.00	0.09
Light Industry	0.00	0.03
Other Transportation	0.04	0.00
Parking Lots	0.26	0.01
Rail Station / Transit Centers	0.02	0.00
Military	0.02	0.00
Parks / Recreation	1.21	0.08
Open Space	0.52	0.38
Water	0.00	0.00
Transitional	0.05	0.00
Total	**5.11**	**2.84**

2.1.4 Soils

Soil data for the watershed were obtained from the State Soil Geographic Data Base (STATSGO). There are four main Hydrologic Soil Groups (Groups A, B, C, and D). These groups, which are described below, range from soils with low runoff potential to soils with high runoff potential (Soil Conservation Service, 1986).

The total area associated with each specific soil type was determined for all subwatersheds. The representative soil group for each model subwatershed was based on the dominant soil type found in that subwatershed. Both watersheds represented in the model by Soil Group C.

Group A soils: have low runoff potential and high infiltration rates even when wet. They consist chiefly of sand and gravel and are well drained to excessively-drained.

Group B soils: have moderate infiltration rates when wet and consist chiefly of soils that are moderately-deep to deep, moderately- to well-drained, and moderately course.

Group C soils: have low infiltration rates when wet and consist chiefly of soils having a layer that impedes downward movement of water with moderately-fine to fine texture.

Group D soils: have high runoff potential, very low infiltration rates and consist chiefly of clay soils. These soils also include urban areas.

2.1.5 Reach Characteristics

Each delineated subwatershed was represented with a single stream assumed to be a completely mixed, one-dimensional segment with a trapezoidal cross-section. Reach segments were based on existing storm drainage pipes. Once the representative reach was identified for each subwatershed, slopes were calculated based on DEM data and stream lengths were measured from the storm drainage pipe coverage. DEMs were obtained from EPA's Better Assessment Science Integrating Point and Nonpoint Sources (BASINS) system (USEPA, 1998).

In addition to slope and length, flow dimensions are required to route flow and pollutants through the hydrologically-connected subwatersheds. Mean flow depth and width were estimated using regression curves that relate upstream drainage area to stream/sewer dimensions. The Manning's roughness coefficients varied for each representative reach and ranged between 0.045 – 0.060.

2.1.6 Point Source Discharges

During watershed model configuration, National Pollutant Discharge Elimination System (NPDES) discharges can be incorporated into the model as point sources of flow and pollutants. There were no major point sources located in the B Street/Broadway Pier and Downtown Anchorage watersheds, so this step was excluded during model development.

2.1.7 Hydrology Representation

Watershed hydrology plays an important role in the determination of flow and ultimately loadings to a waterbody. The watershed model must appropriately represent the spatial and temporal variability of hydrologic characteristics within a watershed. Key hydrologic characteristics include interception storage capacities, infiltration properties, evaporation and transpiration rates, and watershed slope and roughness. LSPC's algorithms are identical to those in HSPF. The LSPC/HSPF modules used to represent watershed hydrology for TMDL development included PWATER (water budget simulation for pervious land units) and IWATER (water budget simulation for impervious land units). Detailed descriptions of relevant hydrological algorithms are presented in the HSPF User's Manual (Bicknell et al., 2001).

Key hydrologic parameters in the PWATER and IWATER modules are infiltration, groundwater flow, and overland flow. These parameters were adopted from the previous LSPC modeling efforts for the Chollas, Paleta, and Switzer Creek watersheds (SCCWRP and Tetra Tech, 2007).

2.1.8 Watershed Runoff Pollutant Representation

Previous wet-weather watershed modeling and TMDL efforts have led to the development of a regional watershed modeling approach to simulate hydrology, sediment, and metals (copper, lead, and zinc) transport in Los Angeles watersheds.

The regional modeling approach assumes that metals loadings can be dynamically simulated based on hydrology and sediment transported from land uses in a watershed. Development of the approach resulted from application and testing of models for multiple small-scale land use sites and larger watersheds in the Los Angeles Region. SCCWRP developed watershed models, based on HSPF (Bicknell et al., 2001), of multiple homogeneous land use sites in the region. Sufficient stormflow and water quality data were available at these locations to facilitate calibration of land-use-specific HSPF modeling parameters. These parameters were validated in an additional HSPF model of Ballona Creek (Ackerman et al., 2005; Ackerman and Weisberg, 2006; SCCWRP, 2004), and similar models of the Los Angeles River watershed (Tetra Tech, Inc., 2004) and San Gabriel River watershed (Tetra Tech, Inc, 2005) based on LSPC. These models were used to calculate TMDLs for each of these waterbodies (LARWQCB, 2005a, 2005b).

This regional modeling approach was applied to the B Street/Broadway Pier and Downtown Anchorage watershed models to simulate sediment and zinc. Parameters remained unchanged from the regionally calibrated values; however, in-stream sediment adsorption and desorption parameters, which were not included in the regional approach, were adopted from the previous LSPC modeling efforts for the Chollas, Paleta, and Switzer Creek watersheds (SCCWRP and Tetra Tech, 2007).

2.2 Model Assumptions

Assumptions are inherent to the modeling process as the model user attempts to represent the actual system as accurately as possible. The assumptions associated with the LSPC model and its algorithms are described in the HSPF User's Manual (Bicknell et al., 2001). There were several additional modeling assumptions used in this model. These are described below.

- Land use practices are consistent for all that fall within a given category and associated modeling parameters are transferable between subwatersheds.
- Sediment washoff from pervious areas occurred via detachment of the soil matrix for the wet-weather model. This process was considered uniform over the land area of interest regardless of the land use type or season.
- Sediment in the watershed consisted of 5% sand, 40% clay, and 55% silt.
- Trace metals were linearly related to total suspended solids. As described in SCCWRP (2004), analysis of storm water data supports this assumption.
- Trace metals were bound to a particle during wet-weather washoff until they dissociated upon reaching the receiving waterbody.
- PAHs were assessed as total PAHs, and not separately based on molecular weight.
- Non-detected values of pollutants were assigned a value of one-half of the detection limit while calculating loadings.
- The wet-weather TSS, PAHs, PCBs, and chlordane flow-weighted EMCs observed in Switzer Creek are sufficient to characterize concentrations of all

watershed loadings to Downtown Anchorage and B Street/Broadway Pier. Use of flow-weighted mean concentrations assumes no variability in storm concentrations, first flush, and indication of sediment association.

- Without storm water monitoring available for the Downtown Anchorage and B Street/Broadway Pier watersheds, no further calibration or validation of the model was possible, and previous regional and local (Paleta, Switzer, and Chollas Creek) calibration and validation efforts are assumed sufficient to justify application to the unmonitored sites.

3 Modeling Results

3.1 B Street/Broadway Pier and Downtown Anchorage Watersheds

Pollutant loadings vary throughout the year. For zinc, the LSPC model was run from January 1996 through July 2006 to evaluate temporal trends, and the resulting loads at the mouth of B Street/Broadway Pier watershed were averaged by month. For the additional organic compounds that were not directly modeled with LSPC, model-predicted TSS concentrations from January 1996 through July 2006 were multiplied with mean suspended solids organic concentrations for each watershed, and the resulting loads were averaged by month. The mean suspended solids organic concentrations were represented by dividing observed flow-weighted organic EMCs with flow-weighted EMCs for TSS. Because no observed data are available for the B Street/Broadway Pier and Downtown Anchorage watersheds, flow-weighted EMCs from the Switzer Creek watersheds (SCCWRP and Tetra Tech, 2007) were applied for both watersheds. The Switzer Creek watershed is the closest one among the three watersheds which have observed data (see Figure 2). Observed TSS, PAHs, PCBs, and chlordane flow-weighted EMCs from Switzer Creek, as well as resulting estimates of the concentrations of the organics within the TSS, are presented in Table 2.

Table 2. Organic EMCs and Sediment Concentrations from Switzer Creek

	Flow-weighted EMCs	Concentrations within TSS (ng/mg)
TSS	3.653E+02	
PAHs	5.357E+02	1.466E+00
PCBs	5.000E-01	1.369E-03
Chlordane	4.727E+01	1.294E-01

Units for EMCs: mg/L for TSS and ng/L for organics

Monthly pollutant loadings are presented in Table 3 and Figures 4 through 6 for the B Street/Broadway Pier and in Table 4 and Figures 7 through 9 for the Downtown Anchorage watershed[1]. Generally, the lowest loadings were observed in the summer, while the highest loadings occurred in February and the early spring and winter months.

[1] Results for January through July were based on 11 years of model output (1996-2006), while the August to December results were based on 10 years of model output (1996-2005)

This temporal distribution is expected based on the seasonal variation of rainfall observed in the San Diego region.

Table 3. Monthly Pollutant Loads for B Street/Broadway Pier

Month	Zinc (kg)	PAHs (kg)	PCBs (g)
January	7.77E+01	1.86E-02	1.74E-02
February	4.21E+02	1.40E-01	1.31E-01
March	5.35E+01	7.98E-03	7.45E-03
April	1.99E+01	3.41E-03	3.18E-03
May	5.14E+00	7.47E-04	6.97E-04
June	2.55E-02	7.04E-06	6.57E-06
July	6.36E-01	9.85E-05	9.20E-05
August	1.25E-03	2.81E-07	2.62E-07
September	1.88E+00	6.17E-04	5.76E-04
October	1.53E+02	2.43E-02	2.27E-02
November	1.27E+01	2.11E-03	1.96E-03
December	2.97E+02	8.87E-02	8.28E-02

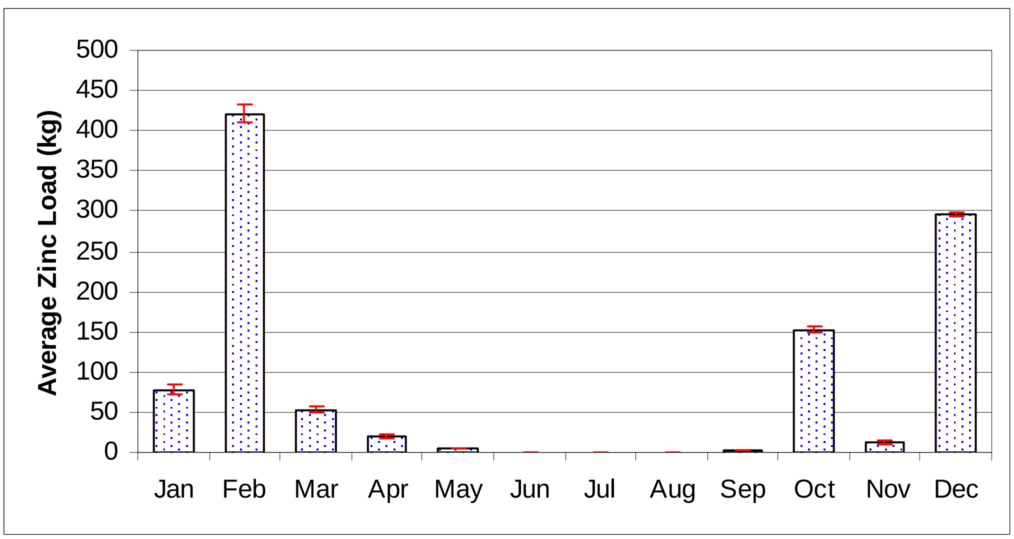


Figure 4. Monthly Zinc Loads for B Street/Broadway Pier [2]

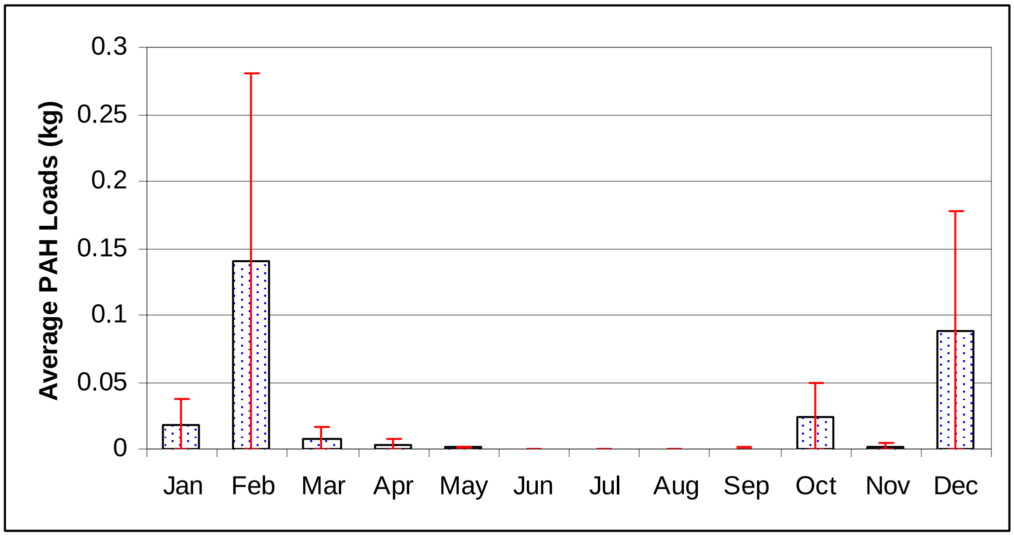


Figure 5. Monthly PAH Loads for B Street/Broadway Pier [2]

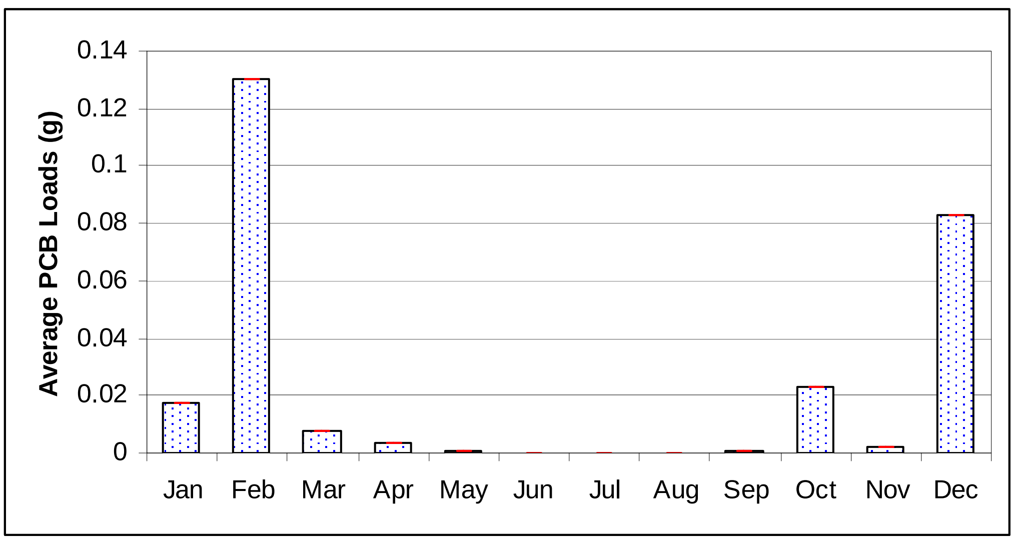


Figure 6. Monthly PCB Loads for B Street/Broadway Pier [3]

[2] Sensitivity ranges were based on plus/minus one standard deviation of EMCs observed in Switzer Creek and reported in SCCWRP and Tetra Tech, Inc. (2007)

[3] Assumes all PCB concentrations are at ½ the detection limit, or 0.5 ng/L, since PCBs were not detected in Switzer Creek (SCCWRP and Tetra Tech, Inc., 2007). Therefore, no sensitivity range could be assessed based on ranges of observed data.

Table 4. Monthly Pollutant Loads for Downtown Anchorage

Month	PAHs (kg)	PCBs (g)	Chlordane (g)
January	8.24E-03	7.70E-03	7.28E-01
February	7.14E-02	6.66E-02	6.30E+00
March	3.53E-03	3.30E-03	3.12E-01
April	1.36E-03	1.27E-03	1.20E-01
May	2.53E-04	2.36E-04	2.23E-02
June	1.84E-06	1.72E-06	1.63E-04
July	2.71E-05	2.53E-05	2.39E-03
August	8.65E-08	8.07E-08	7.63E-06
September	2.57E-04	2.40E-04	2.27E-02
October	1.07E-02	9.96E-03	9.42E-01
November	8.05E-04	7.52E-04	7.11E-02
December	4.55E-02	4.24E-02	4.01E+00

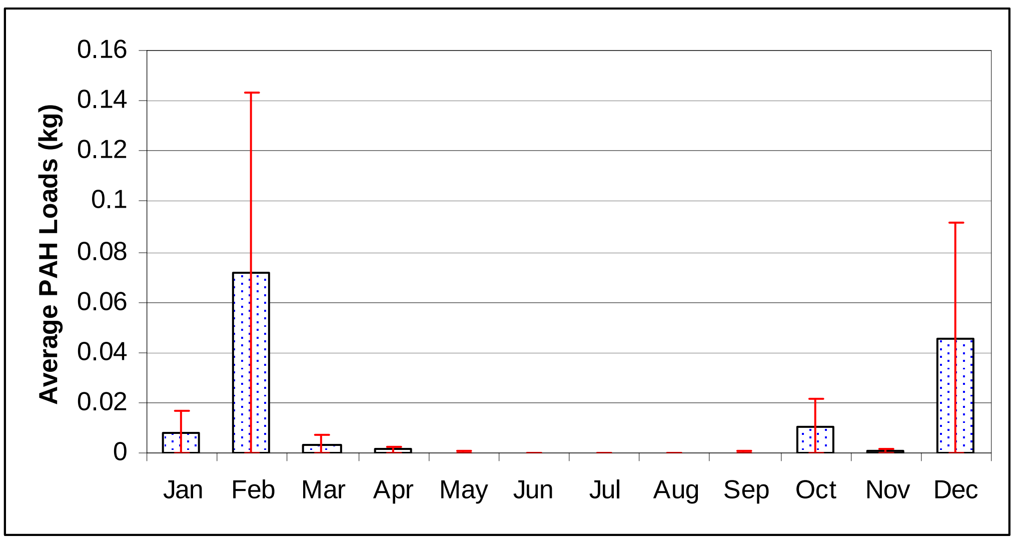


Figure 7. Monthly PAH Loads for Downtown Anchorage [4]

[4] Sensitivity ranges were based on plus/minus one standard deviation of EMCs observed in Switzer Creek and reported in SCCWRP and Tetra Tech, Inc. (2007)

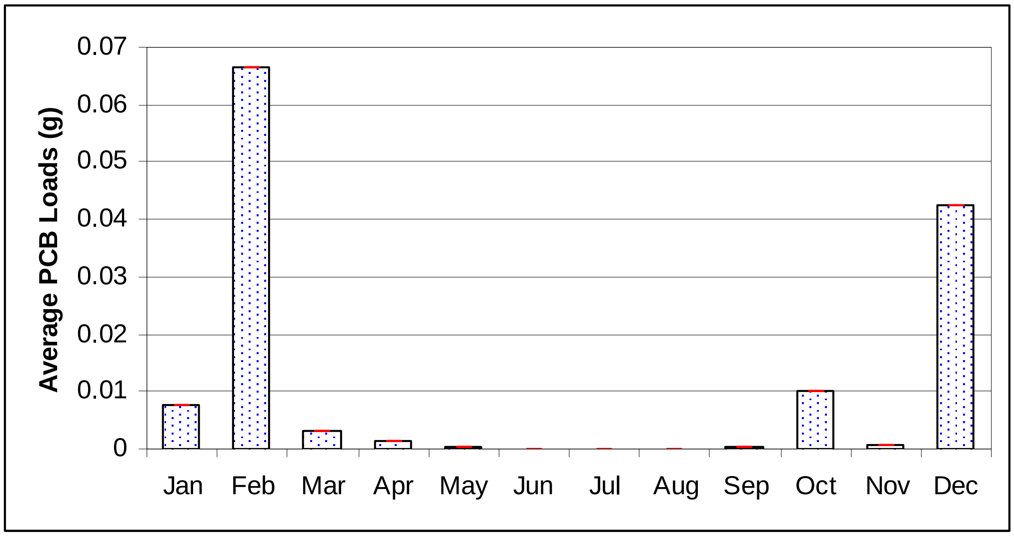


Figure 8. Monthly PCB Loads for Downtown Anchorage [5]

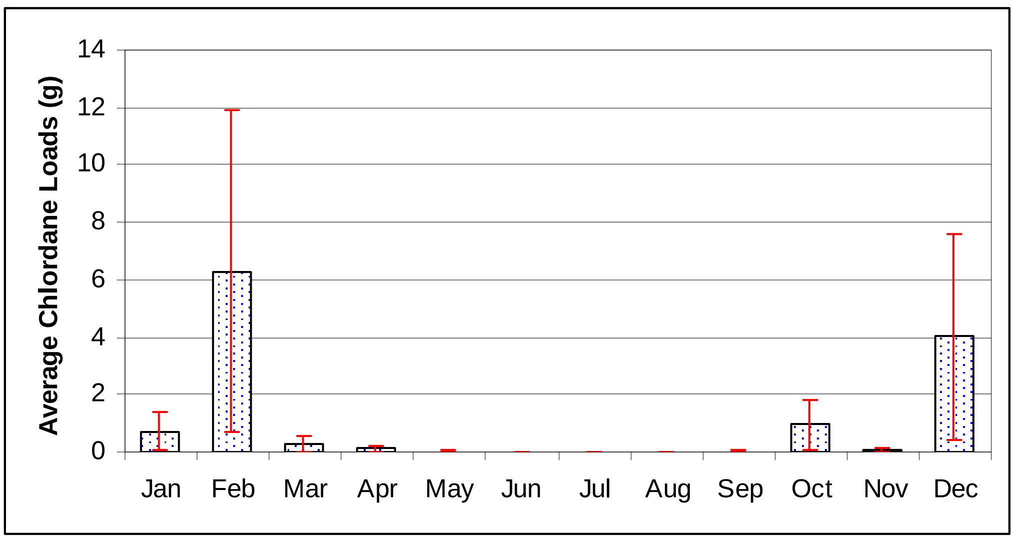


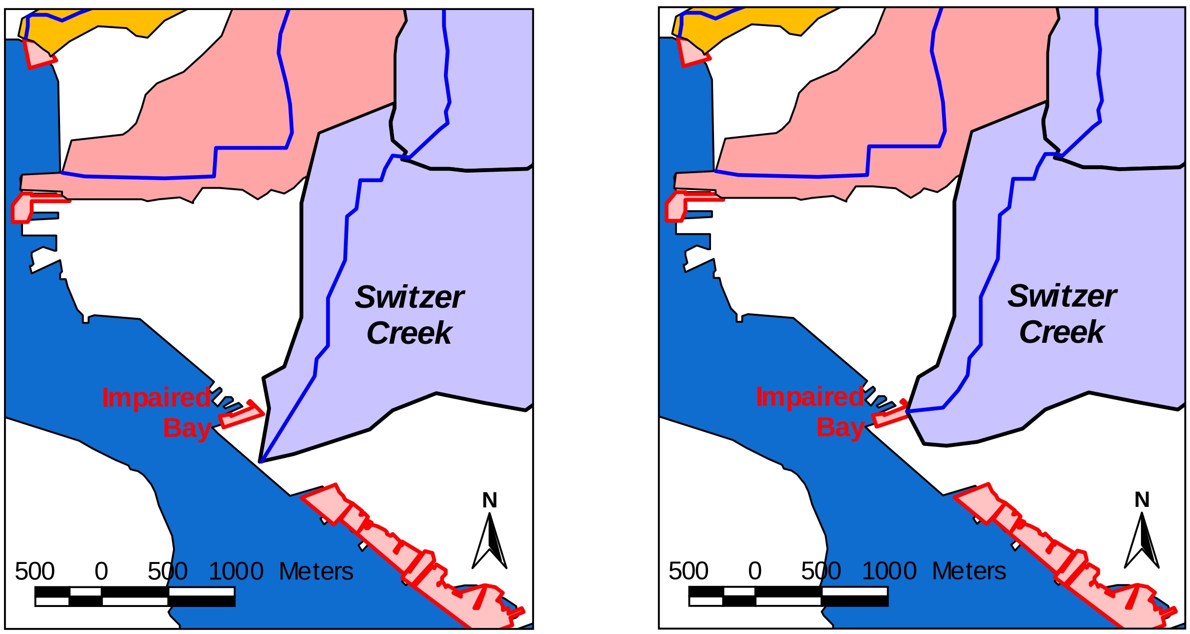
Figure 9. Monthly Chlordane Loads for Downtown Anchorage [6]

[5] Assumes all PCB concentrations are at ½ the detection limit, or 0.5 ng/L, since PCBs were not detected in Switzer Creek (SCCWRP and Tetra Tech, Inc., 2007). Therefore, no sensitivity range could be assessed based on ranges of observed data.

[6] Sensitivity ranges were based on plus/minus one standard deviation of EMCs observed in Switzer Creek and reported in SCCWRP and Tetra Tech, Inc. (2007)

3.2 Updates for Switzer Creek Watershed Model – Subwatershed Representation and Organics Loading

Based on further review of spatial data and field reconnaissance, it was determined that the mouth of the Switzer Creek was incorrectly modeled in the previous study (SCCWRP and Tetra Tech, 2007). In the present study, the LSPC model for the Switzer Creek watershed was re-configured to match with the correct location of the creek mouth. The previous and updated delineations are presented in Figure 10.



a) previous (SCCWRP and Tetra Tech, 2007) b) new

Figure 10. Re-delineating the Reach and Watershed Boundary for Switzer Creek

Based on the correction, LSPC modeling variables for representing land use status and reach conditions were updated. The LSPC model was run again from January 1996 through July 2006 to create outflow time-series at the mouth of the Switzer Creek. For the organic compounds that were not directly modeled with LSPC, the model-predicted TSS concentrations were multiplied by organic concentrations within suspended solids derived from observed TSS and organics EMCs observed in the creek (Table 2). Loading analyses were performed for PAHs, PCBs, chlordane, and lindane, corresponding to those organic pollutants identified by Regional Board staff to require TMDLs and address sediment toxicity impairments. Updated monthly pollutant loadings for Switzer Creek are presented in Table 5 and Figures 11 through 14 [7].

[7] Results for January through July were based on 11 years of model output (1996-2006), while the August to December results were based on 10 years of model output (1996-2005)

Table 5. Monthly Pollutant Loads for Switzer Creek

Month	PAHs (kg)	PCBs (g)	Chlordane (g)	Lindane (g)
January	3.01E-02	2.81E-02	2.66E+00	2.81E-02
February	2.30E-01	2.14E-01	2.03E+01	2.14E-01
March	1.23E-02	1.15E-02	1.08E+00	1.15E-02
April	6.47E-03	6.04E-03	5.71E-01	6.04E-03
May	1.40E-03	1.31E-03	1.24E-01	1.31E-03
June	5.49E-06	5.13E-06	4.85E-04	5.13E-06
July	1.26E-04	1.18E-04	1.11E-02	1.18E-04
August	2.48E-07	2.31E-07	2.19E-05	2.31E-07
September	1.22E-03	1.14E-03	1.08E-01	1.14E-03
October	5.89E-02	5.49E-02	5.19E+00	5.49E-02
November	6.13E-03	5.72E-03	5.41E-01	5.72E-03
December	1.34E-01	1.25E-01	1.18E+01	1.25E-01

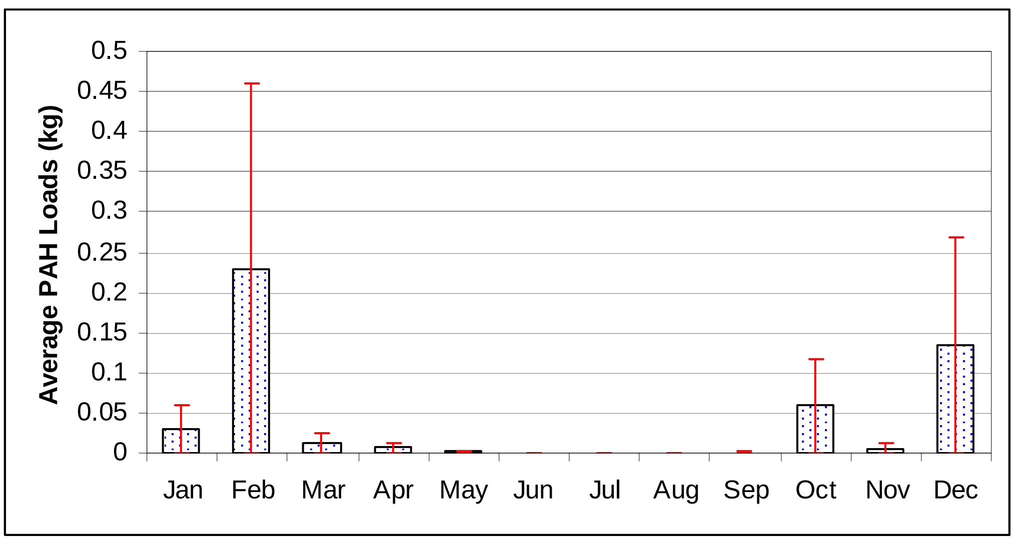


Figure 11. Monthly PAH Loads for Switzer Creek [8]

[8] Sensitivity ranges were based on plus/minus one standard deviation of EMCs observed in Switzer Creek and reported in SCCWRP and Tetra Tech, Inc. (2007)

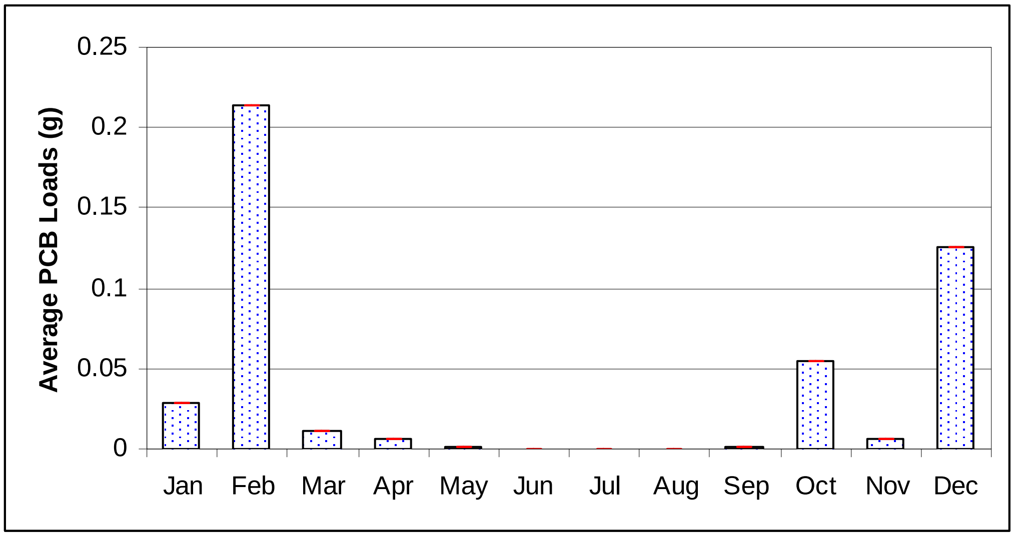


Figure 12. Monthly PCB Loads for Switzer Creek [9]

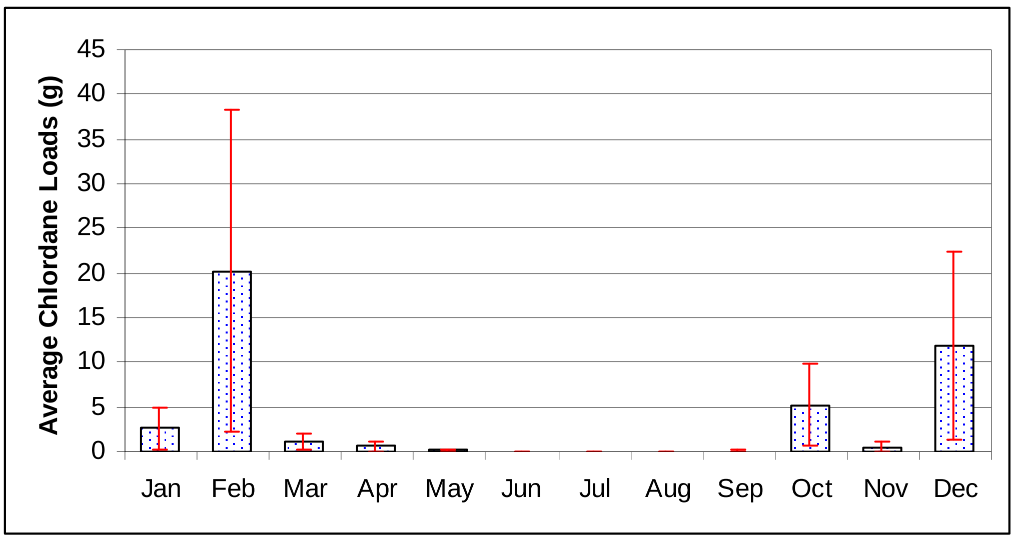


Figure 13. Monthly Chlordane Loads for Switzer Creek [10]

[9] Assumes all PCB concentrations are at ½ the detection limit, or 0.5 ng/L, since PCBs were not detected in Switzer Creek (SCCWRP and Tetra Tech, Inc., 2007). Therefore, no sensitivity range could be assessed based on ranges of observed data.

[10] Sensitivity ranges were based on plus/minus one standard deviation of EMCs observed in Switzer Creek and reported in SCCWRP and Tetra Tech, Inc. (2007)

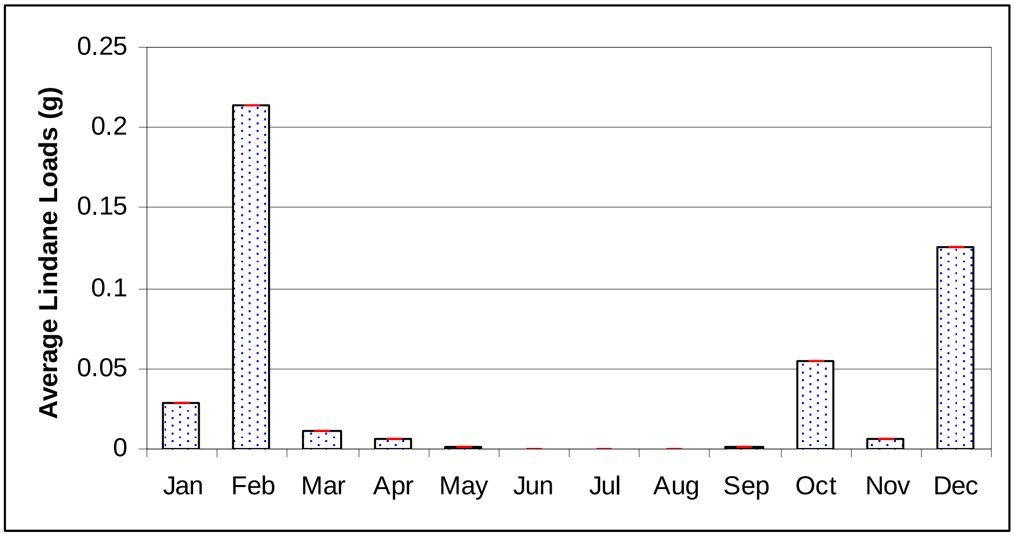


Figure 14. Monthly Lindane Loads for Switzer Creek [11]

In the previous modeling study performed by SCCWRP and Tetra Tech, Inc. (2007), these organic concentrations had been estimated by model-predicted flows and flow-weighted organic EMCs. Annual organic loads from Switzer Creek based on the two estimation methods are compared in Figure 15. As presented in Figure 15, applying suspended solids organic concentrations and using model-predicted TSS to estimate watershed loadings resulted in lower organic loads than applying organic EMCs in water.

[11] Assumes all lindane concentrations are at ½ the detection limit, or 0.5 ng/L, since lindane was not detected in Switzer Creek (SCCWRP and Tetra Tech, Inc., 2007). Therefore, no sensitivity range could be assessed based on ranges of observed data.

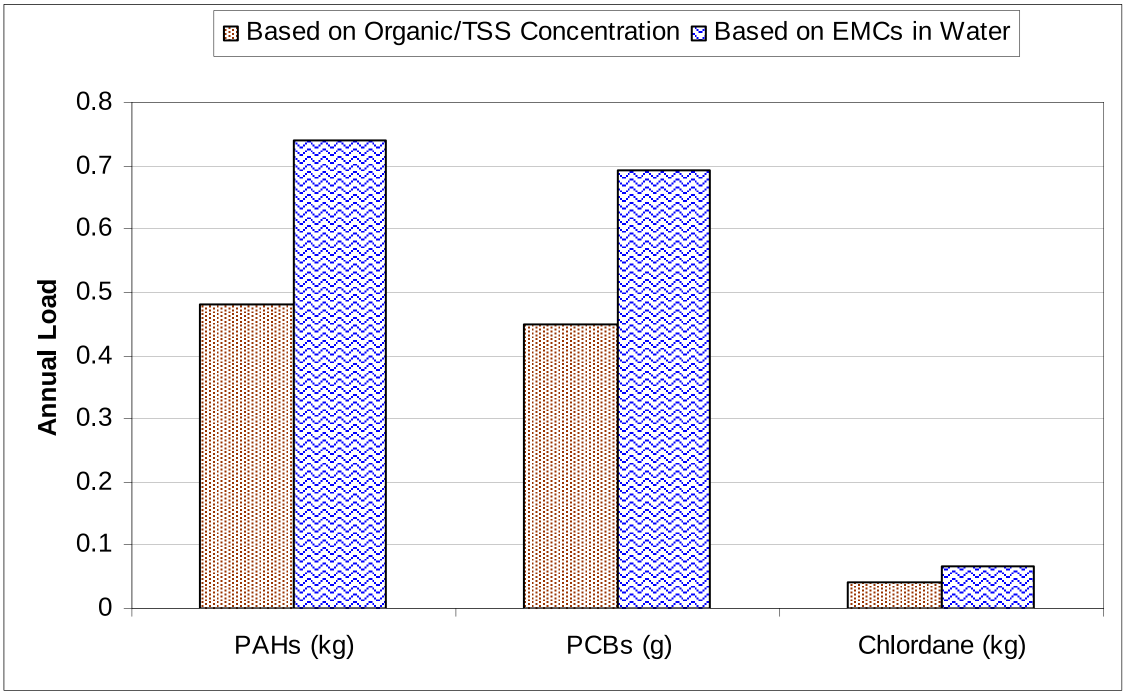


Figure 15. Comparison of Annual Organic Loads from Switzer Creek

3.3 Updates for Chollas and Paleta Creek Watershed Models – Organics Loading

Similar to the method used to estimate loading of organics from Switzer Creek, average flow-weighted TSS and organics EMCs observed in Chollas and Paleta Creek watersheds were used to estimate typical concentrations of organics within the suspended sediment from each watershed (Tables 6 and 7). These results, in combination with LSPC model-predicted flow and TSS concentrations, were used to update loading estimates originally reported in SCCWRP and Tetra Tech, Inc. (2007). The updated results are presented in Tables 8 to 9 and Figures 16 through 21 [12].

Table 6. Organic EMCs and Sediment Concentrations from Chollas Creek

	Flow-weighted EMCs	Concentrations within TSS (ng/mg)
TSS	1.157E+02	
PAHs	8.240E+02	7.119E+00
PCBs	5.000E-01	4.320E-03
Chlordane	2.214E+01	1.913E-01

Units for EMCs: mg/L for TSS and ng/L for organics

[12] Results for January through July were based on 11 years of model output (1996-2006), while the August to December results were based on 10 years of model output (1996-2005)

Table 7. Organic EMCs and Sediment Concentrations from Paleta Creek

	Flow-weighted EMCs	Concentrations within TSS (ng/mg)
TSS	1.661E+02	
PAHs	8.518E+02	5.128E+00
PCBs	5.000E-01	3.010E-03
Chlordane	4.049E+01	2.438E-01

Units for EMCs: mg/L for TSS and ng/L for organics

Table 8. Monthly Pollutant Loads for Chollas Creek

Month	PAHs (kg)	PCBs (g)	Chlordane (g)
January	5.70E-01	3.46E-01	1.53E+01
February	4.18E+00	2.53E+00	1.12E+02
March	2.91E-01	1.77E-01	7.81E+00
April	1.98E-01	1.20E-01	5.32E+00
May	5.53E-02	3.35E-02	1.48E+00
June	2.38E-05	1.44E-05	6.40E-04
July	1.84E-03	1.12E-03	4.94E-02
August	1.02E-06	6.17E-07	2.73E-05
September	3.37E-02	2.05E-02	9.06E-01
October	1.16E+00	7.06E-01	3.12E+01
November	1.76E-01	1.07E-01	4.72E+00
December	2.42E+00	1.47E+00	6.49E+01

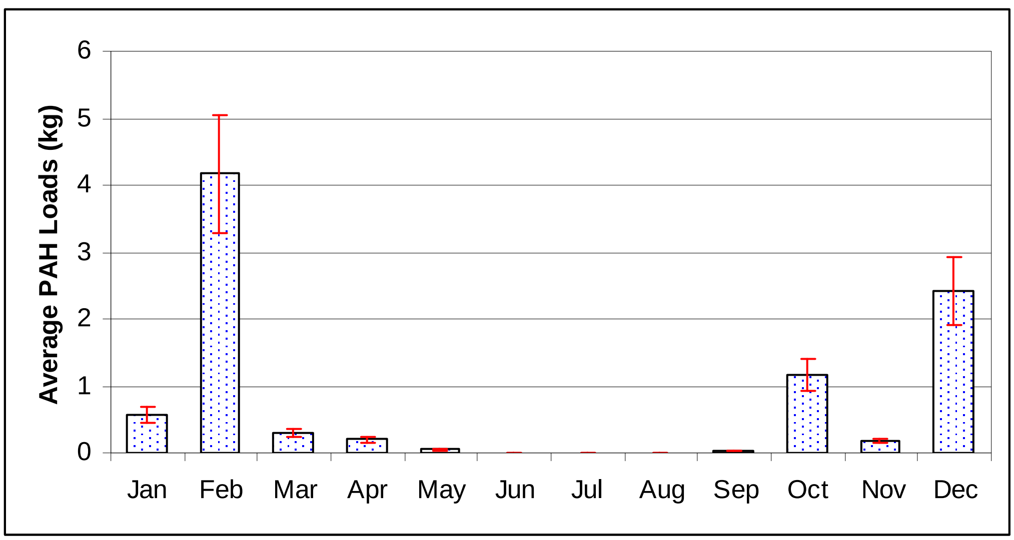


Figure 16. Monthly PAH Loads for Chollas Creek [13]

[13] Sensitivity ranges were based on plus/minus one standard deviation of EMCs observed in Chollas Creek and reported in SCCWRP and Tetra Tech, Inc. (2007)

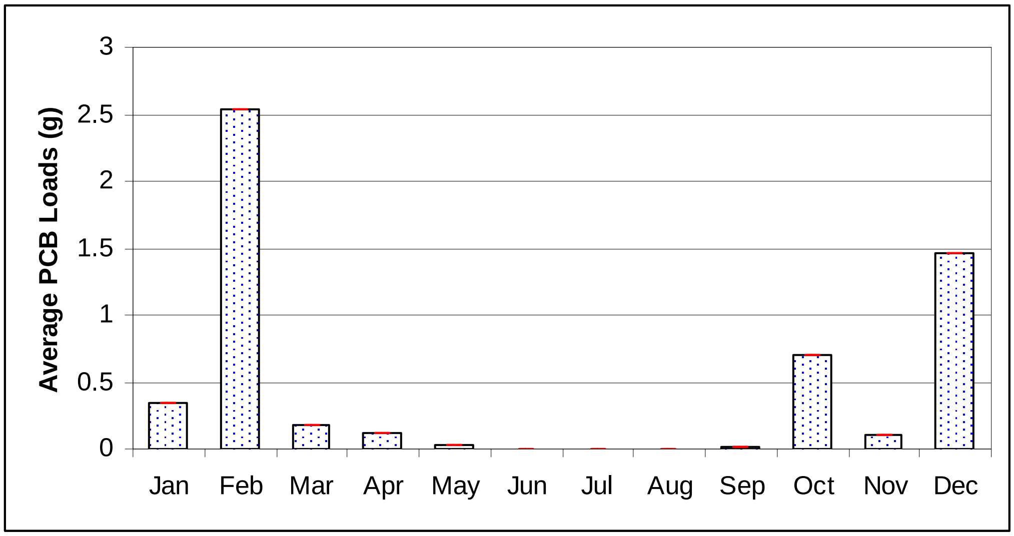


Figure 17. Monthly PCB Loads for Chollas Creek [14]

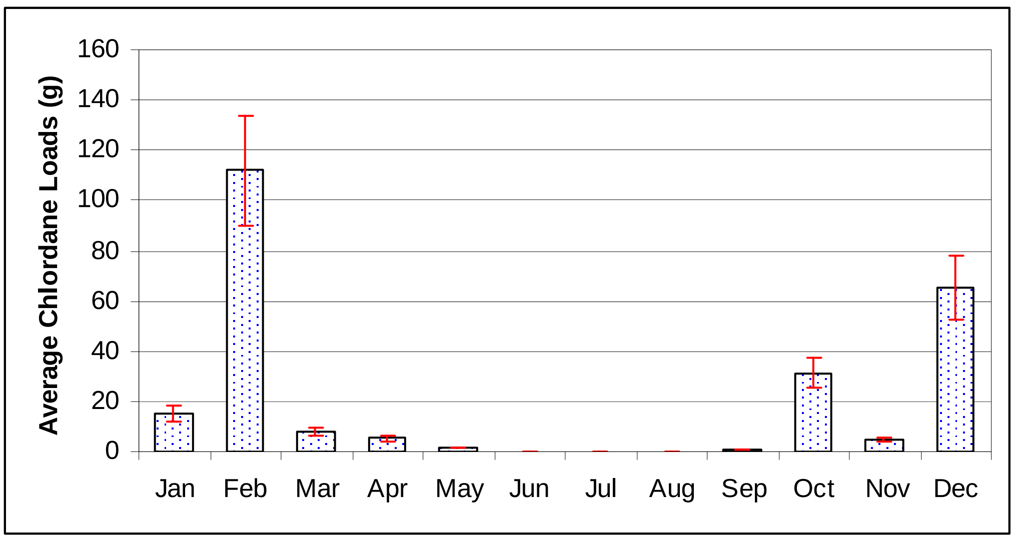


Figure 18. Monthly Chlordane Loads for Chollas Creek [15]

[14] Assumes all PCB concentrations are at ½ the detection limit, or 0.5 ng/L, since PCBs were not detected in Chollas Creek (SCCWRP and Tetra Tech, Inc., 2007). Therefore, no sensitivity range could be assessed based on ranges of observed data.

[15] Sensitivity ranges were based on plus/minus one standard deviation of EMCs observed in Chollas Creek and reported in SCCWRP and Tetra Tech, Inc. (2007)

Table 9. Monthly Pollutant Loads for Paleta Creek

Month	PAHs (kg)	PCBs (g)	Chlordane (g)
January	8.66E-02	5.08E-02	4.11E+00
February	8.38E-01	4.92E-01	3.98E+01
March	4.00E-02	2.35E-02	1.90E+00
April	1.39E-02	8.14E-03	6.59E-01
May	2.91E-03	1.71E-03	1.38E-01
June	2.04E-05	1.20E-05	9.68E-04
July	3.50E-04	2.06E-04	1.67E-02
August	8.67E-07	5.09E-07	4.12E-05
September	2.50E-03	1.47E-03	1.19E-01
October	8.74E-02	5.13E-02	4.15E+00
November	7.67E-03	4.50E-03	3.65E-01
December	5.66E-01	3.32E-01	2.69E+01

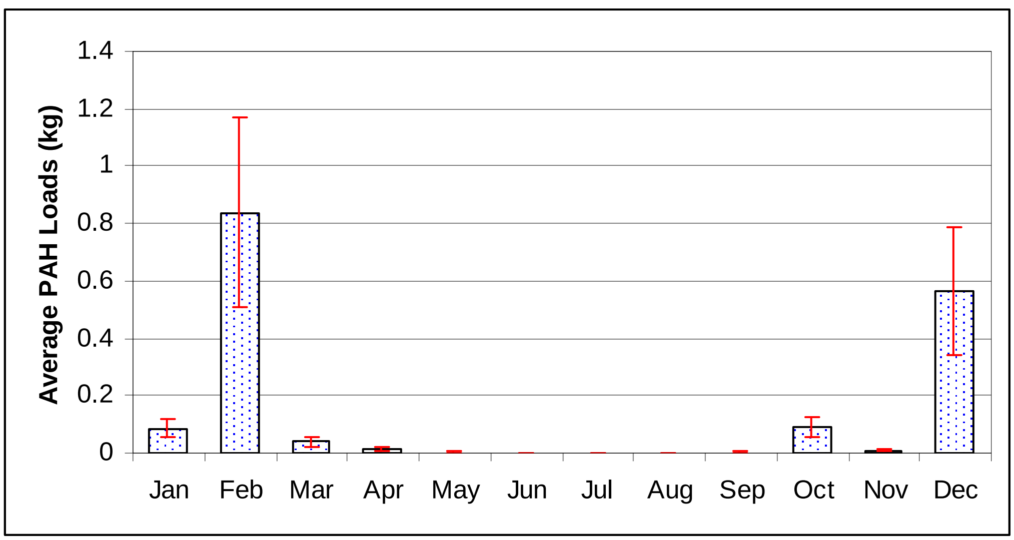


Figure 19. Monthly PAH Loads for Paleta Creek [16]

[16] Sensitivity ranges were based on plus/minus one standard deviation of EMCs observed in Paleta Creek and reported in SCCWRP and Tetra Tech, Inc. (2007)

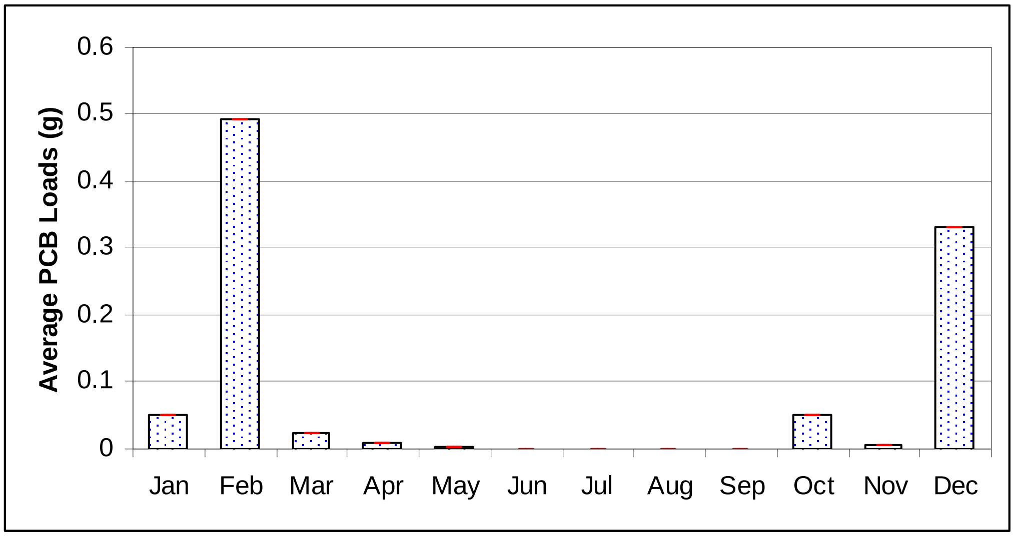


Figure 20. Monthly PCB Loads for Paleta Creek [17]

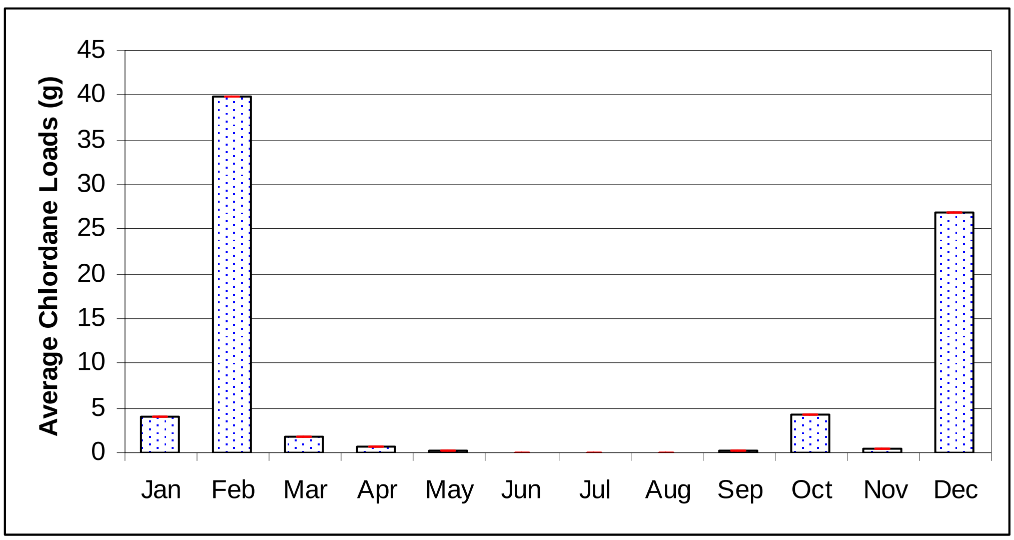


Figure 21. Monthly Chlordane Loads for Paleta Creek [18]

[17] Assumes all PCB concentrations are at ½ the detection limit, or 0.5 ng/L, since PCBs were not detected in Paleta Creek (SCCWRP and Tetra Tech, Inc., 2007). Therefore, no sensitivity range could be assessed based on ranges of observed data.

[18] Assumes all chlordane concentrations are at ½ the detection limit, or 0.5 ng/L, since chlordane was not detected in Paleta Creek (SCCWRP and Tetra Tech, Inc., 2007). Therefore, no sensitivity range could be assessed based on ranges of observed data.

4 Summary and Conclusions

LSPC modeling for the B Street/Broadway Pier and Downtown Anchorage watersheds were performed. Key hydrologic parameters for infiltration, groundwater flow, and overland flow were adopted from the existing LSPC modeling efforts for the Chollas, Paleta, and Switzer Creek watersheds, which are close to the model watersheds and also drain to the San Diego Bay (SCCWRP and Tetra Tech, 2007).

For TSS and zinc, the regional modeling approach was applied, which included parameterizing the model with land use-specific sediment parameters and water quality potency factors that have been previously calibrated and subsequently tested in other southern California watersheds. The sediment-associated land uses relied upon the sediment parameters calibrated for the Los Angeles Region. Adjustments in the in-stream adsorption and desorption parameters from the existing LSPC modeling efforts for the Chollas, Paleta, and Switzer Creek watersheds (SCCWRP and Tetra Tech, 2007) were also adopted in this watershed modeling.

Land use-specific data were not available for the organic compounds, so these pollutants could not be directly simulated. To overcome this data gap, loading assessments were based on modeled flow and TSS concentrations combined with estimates of organics concentrations within suspended solids from each watershed, based on observed average flow-weighted EMCs for organics and TSS from Chollas, Paleta, and Switzer Creeks. Therefore, it was not feasible to analyze loading from individual land uses and future assessment of impacts of alternative management practices in the watershed. As we have discussed before, land use specific water quality data for organics within Chollas, Paleta, and Switzer, or at least within some of their subwatersheds, would have been very useful for this study. This data gap should be considered for future study designs.

A loading analysis by different land use groups was performed to assess the source of zinc within the B Street/Broadway Pier watershed. This information may be helpful to identify the land uses that drive the pollutant loadings. The zinc loadings by land use for the watershed are presented in Table 10 and Figure 22. The land use based analysis indicates that the zinc loads entering the B Street/Broadway Pier area originate mostly from commercial, high density residential, and industrial land use areas.

Table 10. Zinc Loadings by Land Use for the B Street/Broadway Pier

Land Use	Zinc (lbs/yr)
Commercial	958.3
High density residential	838.8
Industrial	555.5
Low density residential	79.6
Mixed urban	58.4
Open	156.9

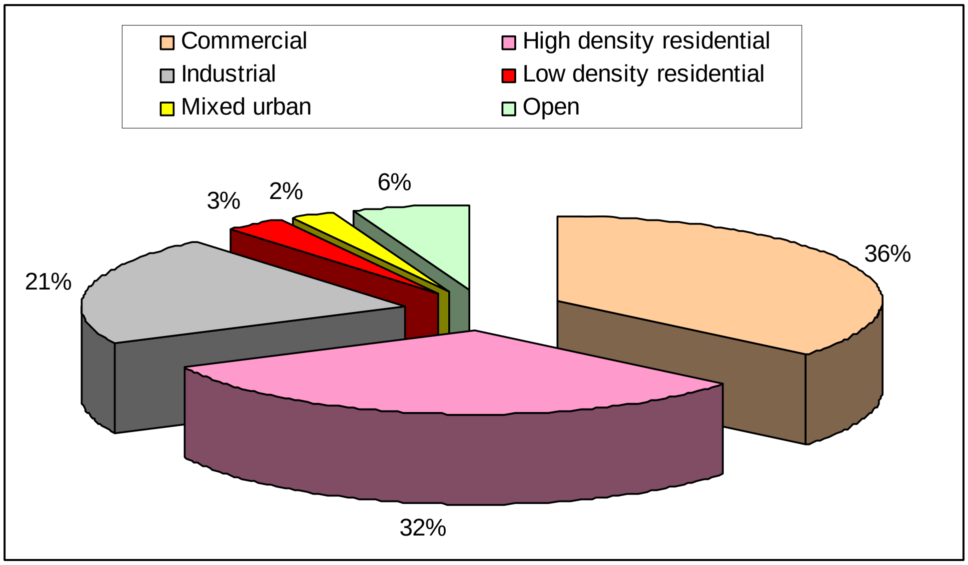


Figure 22. Distribution of Zinc Loadings by Land Use for the B Street/Broadway Pier

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