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POTENTIAL BACKGROUND CONSTITUENT LEVELS IN STORM WATER AT BOEING'S SANTA SUSANA FIELD LABORATORY

Prepared
for

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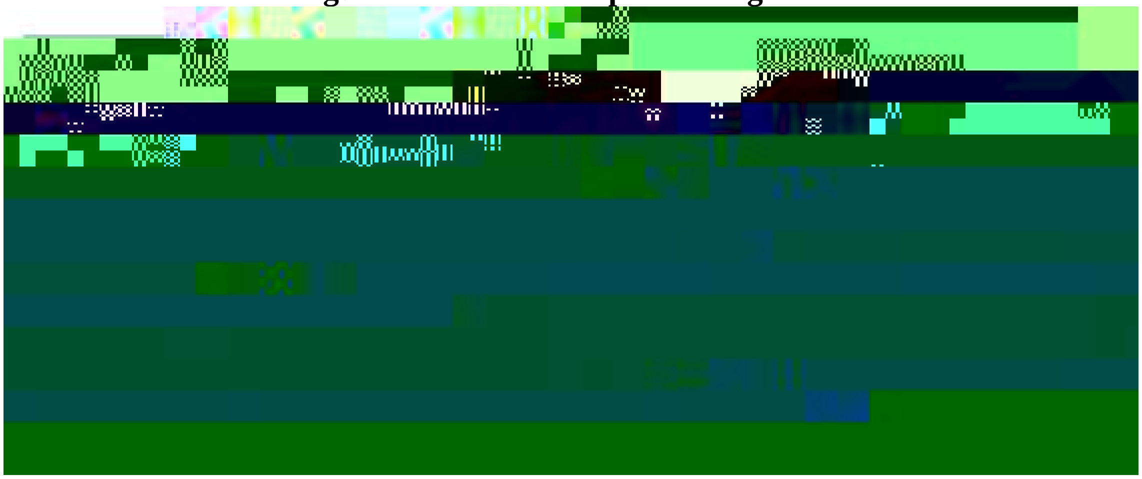
Rainwater. Rainwater samples collected at the SSFL show reported dioxin concentrations in excess of SSFL permit limits for storm flows. Estimated concentrations of mercury in precipitation are at or near SSFL permit limits.

Native soils. Samples of soils collected both at SSFL and off-site show the presence of regulated constituents. Soil concentrations off-site are similar, both in magnitude and variability, to concentrations measured on-site at the SSFL. Order-of-magnitude calculations show that erosion of native soils will contribute concentrations of regulated constituents to storm flows, often in concentrations that approach or exceed SSFL permit limits.

Storm water runoff. Concentrations of metals in storm water runoff from the SSFL are similar to (and often lower than) concentrations in storm water runoff from other open space, natural areas, in storm water runoff from certain major land use types (light industry, transportation, and commercial), and in the Los Angeles River during storm events. Average concentrations of dioxin in storm water runoff from the SSFL are lower than average dioxin concentrations in wet weather samples collected in the Santa Monica Basin, and are lower than average dioxin concentrations in industrial process water discharges, storm water discharges, and Los Angeles River receiving water samples, as shown by data gathered by the Los Angeles Regional Water Quality Control Board ("Regional Board").

Boeing has also conducted extensive tests of materials considered for use in on-site best management practices (BMPs). These tests were conducted to facilitate the selection of "clean" materials and to determine the potential for materials introduced to the site to contribute to the presence of regulated constituents in storm water runoff. In general, the materials used in BMPs on the site are not expected to directly cause permit exceedances, although they will contribute small amounts of regulated constituents to storm flows. For some constituents, including antimony, copper, iron, lead, manganese, mercury, and dioxins, test results show that BMP materials could contribute to permit exceedances. These tests are described in this report and full test results are provided to the Regional Board in the hope that they will be useful to the Regional Board and to other dischargers considering BMPs for control of storm flow water quality.

Figure 1 –Location Map of Boeing SSFL



at levels in excess of NPDES permit limits. The SSFL is located on the border of the South Central Coast Air Basin (including parts of San Luis Obispo, Santa Barbara, and Ventura Counties) and South Coast Air Basins (including parts of Los Angeles, Orange, Riverside, and San Bernardino Counties). Primary emissions sources for metals and dioxins, including automobile and other transportation emissions, waste incineration, residential waste burning (referred to as backyard barrel burning by CARB) are included in Table 1. Potentially large emissions from forest fires are not included in Table 1.

Table 1 – 2004 Estimated Air Basin Emissions for Key SSFL Constituents of Concern (Excluding Wildland Fires)[4]

Pollutant	Los Angeles County (kg/yr)	Ventura County (kg/yr)
Cadmium	921	229
Chromium	5395	1791
Chromium, Hexavalent	281	1.9
Dioxins/Benzofurans*	0.024	0.000031

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Table 2 – Atmospheric Concentrations and Deposition Fluxes of Metals within the Los Angeles Basin

Constituent	Average Concentrations (ng/m^3)*		Average Daily Deposition Flux ($\mu g/m^2/day$)		Estimated Deposition to Los Angeles Basin Watersheds (MT/yr)**	
	All Urban Sites	Non-Urban Site	All Urban Sites	Non-Urban Site	Total Basin Deposition	Range (95% Confidence)
Chromium	1.7	0.41	5.3	1.1	5.3	(3.3-7.5)
Copper	9.3	2.9	24	3.7	25.8	(16.9-34.6)
Lead	4.8	0.62	16	1.4	17.3	(8.0-26.5)
Nickel	2	0.84	5.9	1.3	6.2	(3.8-8.7)
Zinc	38	4.5	129	15	140.8	(82.1-205.5)

Source: Sabin et al. 2004 .
* Concentrations for "all urban sites" were averaged from data collected at 6 Los Angeles Basin urban sites. The non-urban site is measured in the Malibu Creek Watershed, generally upwind of metropolitan Los Angeles.
** Estimated Deposition to Los Angeles Basin is the sum of estimated deposition mass fluxes for the Los Angeles River, Ballona Creek, Dominguez Channel, Lower Santa Ana River, and Malibu Creek watersheds.

Subsequent availability of trace metals from atmospheric deposition to storm water runoff is highly variable and dependent upon deposition surface characteristics, BMPs utilized (if any), metals re-suspension fluxes, rainfall intensity, and pH, among other factors. Sabin et al. (2005) reported that atmospheric deposition (both wet and dry) accounted for 57-100% of the annual trace metals load in storm water runoff from a small, highly urbanized catchment during the October 2003 to April 2004 study period (i.e., "transmission efficiencies" of 57-100%). For the overall Los Angeles River watershed, Sabin et al. (2004) estimated transmission efficiencies of 9% to 43%, indicating that the metals loads in storm water during the study period (the 2003 water year) were approximately 9% to 43% of the metals masses deposited to the watershed via dry deposition. Transmission efficiencies will vary with hydrologic conditions, and will be greater in wet years than in dry years. While transmission efficiencies may be lower for non-urbanized areas such as the SSFL, a substantial portion of storm water runoff metals loads may derive from atmospheric deposition.

The presence of metals in runoff from predominantly natural areas, such as the Sawpit Creek and Malibu Creek watersheds, lends support to this conclusion. Table 3 shows maximum observed metals concentrations (as reported by the Los Angeles County Department of Public Works (LACDPW)) for three watersheds with significant portions of natural areas. In addition, metals concentrations have been measured by LACDPW in runoff from additional land use types and in the region's receiving waters. These are discussed in greater detail in Section 3.4 below.

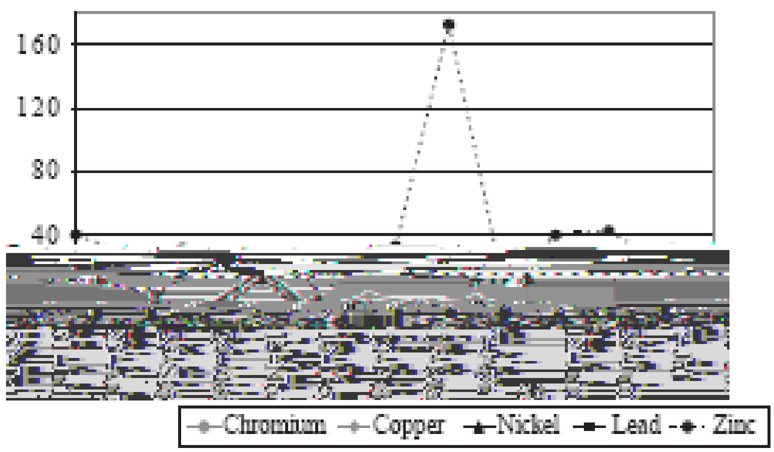
$$\log(\text{dioxin and benzofuran flux}) = 0.512 + 0.401\,(\log NO_x) \qquad (1)$$

Table 5 – Potential Daily Atmospheric Deposition of Metals due to Off-site Forest Fire (approximately 30 miles from Piru/Simi Fire boundary)

Metal	Long-term Dry Deposition (Non-fire), San Fernando Valley (μg/m^2/day)		Forest Fire Factor Increase	Calculated Daily Deposition Rates during Fires (μg/m^2/day)
	Average	Measured Range		
Chromium	1.3	0.7-1.8	4	5
Copper	9.4	5.3 – 14	4	38
Lead	5.4	1.1 – 10	8	46
Nickel	3.7	0-8.0	13	48
Zinc	39	14 – 64	6	230

Source: Sabin et al., 2005.

Figure 2 – Atmospheric Concentrations of Trace Metals in the San Fernando Valley. Note the spike in concentrations during Southern California 2003 Forest Fire Season



026 Tw[cions duAtmospheric Concentration in ng/m^3 (MDL = 0.03) Based on Sampling Times/Air Volumes Collected.
Source: Sabin et al., 2005.

2.2.2 Forest Fire Dioxin Emissions

Forest fires are also a significanmrnq272.1 0 0 152.1 170.8 refc0.1283 T18.84 reW nq21119

20 pg/m^3 [(6)], with before and after fire background atmospheric concentrations at non-detect levels. A recent memorandum published by the South Coast Air Quality Management District (SCAQMD) reported dioxin concentrations of 211 fg (femtograms, or 10^{-15} grams) TEQ/ m^3 at the Chatsworth Park Elementary School on September 30, 2005, during the Chatsworth/ Topanga Fire (Liu 2005). (See Appendix Table A-7 for a discussion of units.) By contrast, average SCAQMD ambient concentrations for dioxin range from 9 to 59 fg TEQ/m^3, or a factor of 3.5 or more times lower than atmospheric dioxin concentrations during the Topanga fire. The SCAQMD concludes that the source of the increased dioxin levels "may be reflective of dioxins and furans…released during wildfire combustion (processes)." This conclusion is consistent with recent reports published by Gullet and Touati (2003) and Meyer et al. (2004).

An order of magnitude estimate for the mass equivalent of dioxins emitted by southern California forest fires may be made by assuming a dioxin emission rate similar to that measured from wood stoves. Based on residential wood stove studies performed in Europe by Schatowitz et al. (1993) and Vickelsoe et al. (1993), wood stoves release approximately 2 nanograms Toxic Equivalent (TEQ) per kilogram of wood burned. Ward et al. (1976)

Table 6 – Estimated Dioxin Total Equivalence (TEQ) Mass Emissions from Recent Southern California Forest Fire Events

Fire Event	Forest fire Area (acres)[*]	Biomass Consumption Forest Fire (kg)[**]	Estimated Total Dioxin Emissions (g TEQ)[***]	Range of Estimated Dioxin Emissions (g TEQ)
Topanga (2005)	24,000	2.3×10^8	0.45	0.14 – 1.4
Burbank (2005)	700	6.6×10^6	0.01	0.004 – 0.04
Cedar Fire (2003)	280,000	2.6×10^9	5.3	1.7 – 17
Total Southern California Fires (2003)[****]	744,000	7.0×10^9	14	4.4 – 44

[*] Forest fire acreage is reported by North County Times (2003), and City of Calabasas (2005).
[**] Ward et al. (1976) estimate that the biomass is consumed at a rate of 9.4 metric tons/acre.
[***] Schatowitz et al. (1993) and Vickelsoe et al. (1993) estimate a dioxin emission rate of 2 ng TEQ/kg wood burned.
[****] 2003 Southern California Fires include Cedar, Mountain, Camp Pendleton, Dulzura, Grand Prix, Old, Padua, Paradise, Piru, Simi Valley, and Verdale Fires.

2.2.3 Forest Fire Impacts on Native Soils and Storm Water Loads

Forest fires can significantly change soil chemistry and runoff parameters in burn areas, thereby changing the availability of constituent loading via storm water runoff. An amplified and lower-duration hydrologic response is often observed in watersheds after wildfires (Meixner and Wohlegunth 2004, Bhoi and Qu 2005, Woodhouse 2004, SAWPA 2004). Although the degree of hydrologic amplification and duration reduction is largely dependent upon fire intensity, fire duration, terrain and soil characteristics, and precipitation characteristics, fire-induced watershed changes can greatly increase the sediment load of the watershed. The Santa Ana Watershed Project Authority (SAWPA) estimated that storm flows could increase by as much as 5 times and sediment loads could increase by 30-50 times above average levels due to impacts from the Padua, Grand Prix, and Old Fires (SAWPA 2004). Significant increases in storm flow and sediment runoff will be associated with corresponding increases in loads and concentrations of naturally occurring nutrients, metals, and certain organic pollutants, including dioxins, that strongly sorb to sediments.

These conclusions are consistent with post-fire storm water monitoring conducted in other areas. The Los Alamos National Laboratory (LANL) has recently released reports summarizing the effects of the 2000 Cerro Grande Fire in New Mexico. That fire burned nearly 50,000 acres, including 7,000 acres of LANL lands. Hinojosa et al. (2004b) found that post-fire surface water concentrations for 28 analytes[7] were higher than pre-fire levels due to forest fire effects. Of these 28 constituents, roughly an order of magnitude increase in storm water runoff concentrations was noticed for silver, arsenic, boron, cobalt, chromium,

[7] Hinojosa et al. (2004b), p. 153, lists these 28 anal

Table 7 – Metals Atmospheric Concentration and Deposition Data for SSFL

Metal	Average Air Concentration (ng/m^3)			Average Daily Atmospheric Deposition Flux (µg/m^2/day)			Estimated Annual Deposition to SSFL (Malibu to Tillman range shown in parenthesis) (kg/yr)
	Tillman Water Recla-mation Plant	Malibu Creek	Estimated SSFL (Avg. of Malibu Creek & Tillman)	Tillman Water Recla-mation Plant	Malibu Creek	Estimated SSFL (Avg. of Malibu Creek & Tillman)	
Chromium	1.1	0.41	0.755	3.2	1.1	2.15	9.1 (1.6-13.5)
Copper	5.2	2.9	4.05	11	3.7	7.35	30.9 (15.6-46.3)
Lead	2.2	0.62	1.41	8.3	1.4	4.85	20.4 (5.9-34.9)
Nickel	1.1	0.84	0.97	3.8	1.3	2.55	10.7 (5.5-16.0)
Zinc	19	4.5	11.75	69	15	42	177 (63.1-290.4)

Source: Sabin et al. , 2004a.

Storm water loading of constituents deposited from the atmosphere will depend upon many factors, including surface permeability, re-suspension fluxes, rainfall intensity, rainfall pH, and other hydrologic factors. As previously noted, Sabin et al. (2005) estimated that approximately 57%-100%[9]fiss-1.1efficienciesx(a)-0mo40ated

Table 8 – Estimated Average Metals Concentration in Storm Water Resulting from Atmospheric Deposition at SSFL.

Constituents	Average Yearly Rainfall at SSFL (in/yr)	Average Volume of Rainfall at SSFL (L)*	Estimated Runoff Volume at SSFL (L)**	Estimated Average Annual Metals Concentration in Storm Water Runoff due to Atmospheric Deposition (% of 2006 Tentative NPDES Permit Level) (µg/L)***	2006 NPDES Permit Daily Limit (µg/L)	2006 NPDES Permit Monthly Limit (µg/L)
Chromium				0.4 – 2.1 (3% - 13% Daily Max) (5% -27% Monthly Avg)	16.3	8.1
Copper				1.5 – 7.3 (11% - 52% Daily Max) (21% - 104% Monthly Avg)	14	7.1
Lead	18	5.3 $x10^9$	$2.1x10^9$	1.0 – 4.8 (19% - 93% Daily Max) (37% - 186% Monthly Avg)	5.2	2.6
Nickel				0.5 – 2.5 (0.5% - 3% Daily Max) (2% - 7% Monthly Avg)	96	35
Zinc				8.4 – 41.9 (7% - 35% Daily Max) (16% - 78% Monthly Avg)	119	54

* Estimated rainfall volume was calculated by applying average rainfall rate of 18 in/yr across SSFL area, 2850 acres.

** An estimated Runoff Coefficient of 0.4 (Dunne and Leopold, 1978, p. 300) has been applied to the average annual rainfall volume to determine average annual runoff.

*** Annual Atmospheric Deposition Rates were taken from Table 7. The transmission factor to storm water was assumed to range from 10% and 50% was applied to the annual load. This storm water mass load was then divided by Estimated Runoff Volume to estimate the annual metals concentration in storm water runoff from atmospheric deposition.

3.1.2 Atmospheric Deposition of Dioxins at SSFL

Long-term background atmospheric deposition rates for dioxins at the SSFL may be estimated by using the average of Los Angeles and Ventura County dioxin and benzofuran deposition rates found in Table 4. The mass of dioxins and benzofurans deposited to the SSFL site annually is estimated to be about 0.47 g/yr, as shown in Table 9. The estimates in Tables 4 and 9 do not include the effects of wild fires; data in these tables are presented in terms of annual dioxin mass, while permit limits for storm water discharges from the SSFL use units of TEQ (total dioxin equivalents). To convert dioxin mass to TEQ, a Toxicity Equivalence Factor (TEFTDrm Tb 1xin equiva equi5 Te permit e units0[(for effL)]T 0Aleff L14 ss of wi4 -

average storm water volume leaving the SSFL.

where storm water, soil and ash samples were collected are shown in Table A-5 and in Figure A-1. Continued sampling and assessment of these ambient surface water drainages is planned.

3.2.1 Boeing Measurements of Soil and Ash Before and Following the Topanga Fire

Prior to the Topanga Fire in September 2005, Boeing characterized naturally occurring soil conditions at and surrounding the SSFL as part of the RCRA program being conducted under the regulatory oversight of the California Department of Toxic Substances Control (DTSC). DTSC-approved soil background data and comparison levels for metals and dioxins are provided in Tables A-1 and A-2 (MWH 2005, California DTSC 2005). Tables A-1 through A-4 in Appendix A provide metals and dioxins concentrations in ambient soils (pre- and post-fire) and in ash (post-fire) collected both from the SSFL and off-site.[11] These results are also summarized below.

Soil and ash samples have been taken at five background sites that burned, and one sample has been taken at a background site that did not burn but received ash fall out. Soil and ash samples were also collected in and around the vicinity of the SSFL and at the Burbank (Harvard) fire site. Initial soil and ash samples were taken between September 30, 2005 and October 18, 2005. Soil and ash results to date show that the analytes barium, boron, cadmium, copper, lead, manganese, zinc, thallium, potassium, and sodium were measured at concentrations above background levels approved by DTSC for the SSFL in multiple samples.

Table 10 shows the results to date for ash and soil concentrations of key constituents at off-site and DTSC approved SSFL background locations. Average concentrations are shown with corresponding minimum and maximum observed concentrations in parenthesis. There is considerable variability in constituent concentrations at all locations, but concentrations

Table 10 Concentrations of Metals and Dioxin in Ash and Soil Samples Collected On-Site[12], Off-Site, and Background Samples

Constituent	Units	DTSC Pre Fire SSFL Soil Background Comparison Value	Post Fire Soil Concentrations from SSFL Background Sites: Average (Range)	Post Fire Soil Concentrations in Off-site Samples Average (Range)	Post Fire Ash Concentrations from SSFL Background Sites: Average (Range)	Post Fire Ash Concentrations in Off-site Samples Average (Range)

soil, ash, and storm water from both on- and off-site locations. This report will be updated and results transmitted to the Regional Board when available.

3.2.2 Chatsworth Topanga Fire Impacts on Dioxin Deposition at the SSFL

Dioxin emissions from the 2005 Topanga Fire can be estimated for both the portions of the SSFL site that burned and for the overall Topanga Fire area. Table 11 applies the wood stove estimates developed in Table 6 to estimate the possible range of dioxin emissions from these areas and from other major southern California fires.

Table 11 – Estimated Dioxin Emissions at SSFL for Topanga Fire (2005)

Fire Location	Fire Size (acres)	Estimated Dioxin Emitted by Forest Fire (g TEQ)	Potential Forest Fire Dioxin Emission Range (g TEQ)
SSFL 2005 Fire (Part of Topanga Fire)	2,000	0.04	(0.01-0.12)
Topanga, 2005	24,000	0.45	(0.14-1.4)
Burbank Fire, 2005	700	0.013	(0.0042-0.042)
Piru/Simi Valley, 2003	172,195	2.6	(0.82-8.2)
Total Southern California Fires (2003) *	744,345	14	(4.4-44)

*2003 Southern California Fires include Cedar, Mountain, Camp Pendleton, Dulzura, Grand Prix, Old, Padua, Paradise, Piru, Simi Valley, and Verdale Fires

The methodology used in Table 8 can be used to provide an order of magnitude estimate of potential dioxin concentrations in storm water due to the recent Chatsworth Topanga Fire at SSFL. This order-of-magnitude calculation, as shown in Table 12, was made assuming that dioxins will have transmission efficiencies similar to metals, and indicates that average storm water concentrations due to dioxin emissions following the 2005 Topanga fire at the SSFL may be one to three orders of magnitude greater than the 2006 NPDES permit limit. The range of potential dioxin storm water concentrations presented in Table 13 also falls within the range of dioxin storm water concentrations measured at the SSFL in October and November of 2005, and presented in Figure 8 in Section 3.4.1.

Table 12 – Order of Magnitude Estimate for Dioxin Concentration in Storm Water Due to Topanga Fire (2005)

Average Volume of Rainfall at SSFL (L)*	Estimated Average Annual Runoff (L) **	Dioxin Emissions Resulting From SSFL ***

Table 13: Statistical Distribution of SSFL TSS Loads

	Pre Fire TSS Distribution			Post Fire Data		
TSS Data Comparison	Pre Fire Geometric Mean	Pre Fire Max Observed	Data Size (# Detects / # Samples)	Post Fire Geo Average	Post Fire Max Observed	Data Size (# Detects / # Samples)
North Slope (Outfalls 003-007, 009, 010)	14	300	(55/98)	264.0	4000	(12/12)
South Slope (Outfalls 001, 002, 008, 011, 018)	9	760	(58/140)	1300*	--*	(1/1)

[redacted]

[TSS 14 (6-760) (mg/L)] (µg/L)	Maximum Permit Level (µg/L)	Average Permit Limit (µg/L)
0.1 (0.05-6.6)	6	--
0.2 (0.1-11.4)	10	--
1.4 (0.8-106)	1000	--
0.01 (0.01-0.8)	4	--
0.1 (0.06-7.4)	1	--
0.01 (0.01-0.8)	4	2

background locations were greater than dioxin concentrations in post-fire soils [0.59 to 3.2 ng (TEQ)/kg for ash), the presence of ash in storm water runoff from the site will increase dioxin concentrations beyond those that result from the presence of background site soils only. As discussed above in Section 3.2.1, dioxin concentrations in on-site soils and ash are

Pre-fire samples from Outfalls 001 and 002 (40 samples for copper, 28 samples for lead, and 5 samples for zinc from October 2004 to April 2005). No post-fire runoff data are available for Outfalls 001 and 002 at this time, as these outfalls had no flow in the October and November 2005 sampling events.

The results shown in these graphs include the average, minimum, and maximum measured concentrations.

LACDPW Land Use Storm Water Data Set (red square): The Los Angeles County Department of Public Works (LACDPW) monitored storm water constituent concentrations in samples collected from various land use types from 1994-2000. Catchments representative of the eight dominant land use types within the County were used for these sampling events (see the Los Angeles County 1994-2000 Integrated Receiving Waters Impact Report, on line at http://ladpw.org/wmd/NPDES/IntTC.cfm). LACDPW reports the average and median concentrations and the coefficient of variation for each data set. The graph above presents the average concentration with error bars at plus or minus one

mG51he Los R9(4(u)0R9(2p2ec)165)-2.4(4(u)uR9(2p2edR9(2p2ee)165)-s)165dng.4(4(u)hR9(2p2ee from September 2004 to November 2005 were analyzed and reported at a limit of 0.20 (µg/L).

As seen in Figures 5, 6, and 7 average concentrations of total copper, total lead, and total zinc in storm water samples collected from the SSFL before the 2005 Topanga fire are lower than average concentrations in storm water samples collected from several land use types (light industrial, transportation, commercial, and multi-family residential) within the Los Angeles Region, and are significantly lower than average concentrations in the Los Angeles River following storm events. Figures 5 and 7 also show that even the maximum observed concentrations of total copper and total zinc in pre-fire storm water runoff from the SSFL are lower than the average measured concentrations of these metals in storm water runoff from several land use types and lower than the average measured concentrations of these metals in samples collected from the Los Angeles River following storm events.

Figure 5: Total Copper Concentrations in Storm Water Runoff from the SSFL, from Los Angeles Region Land Use Types, and in Surface Water

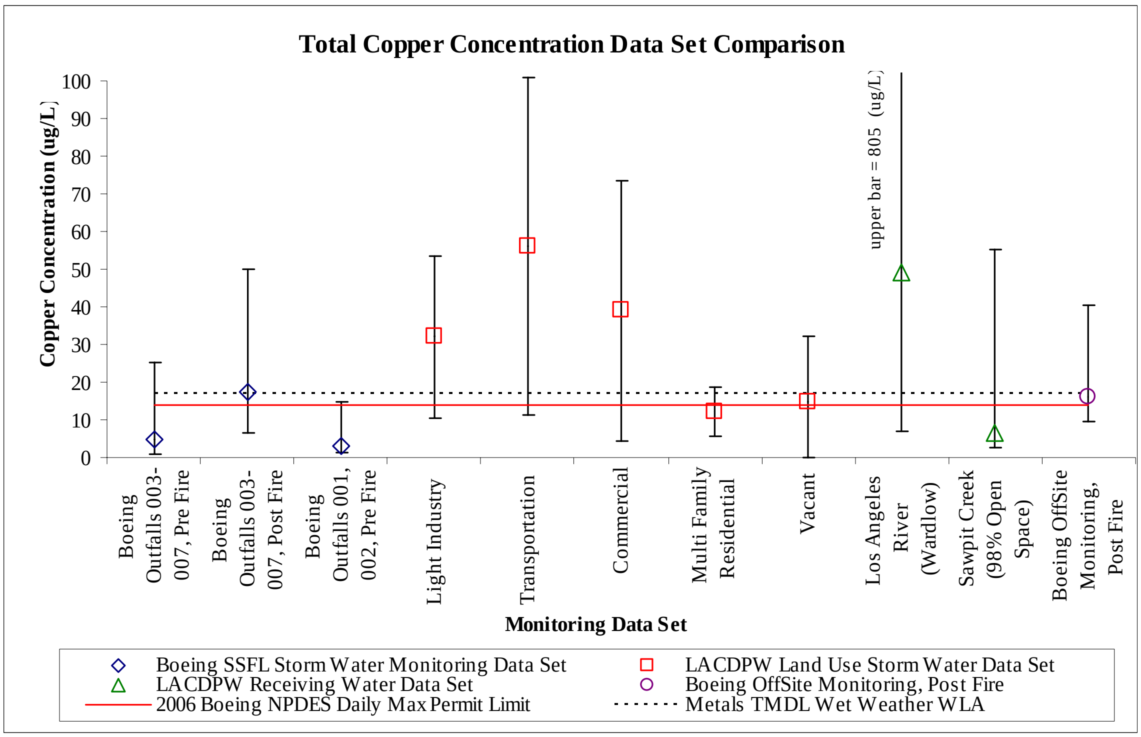
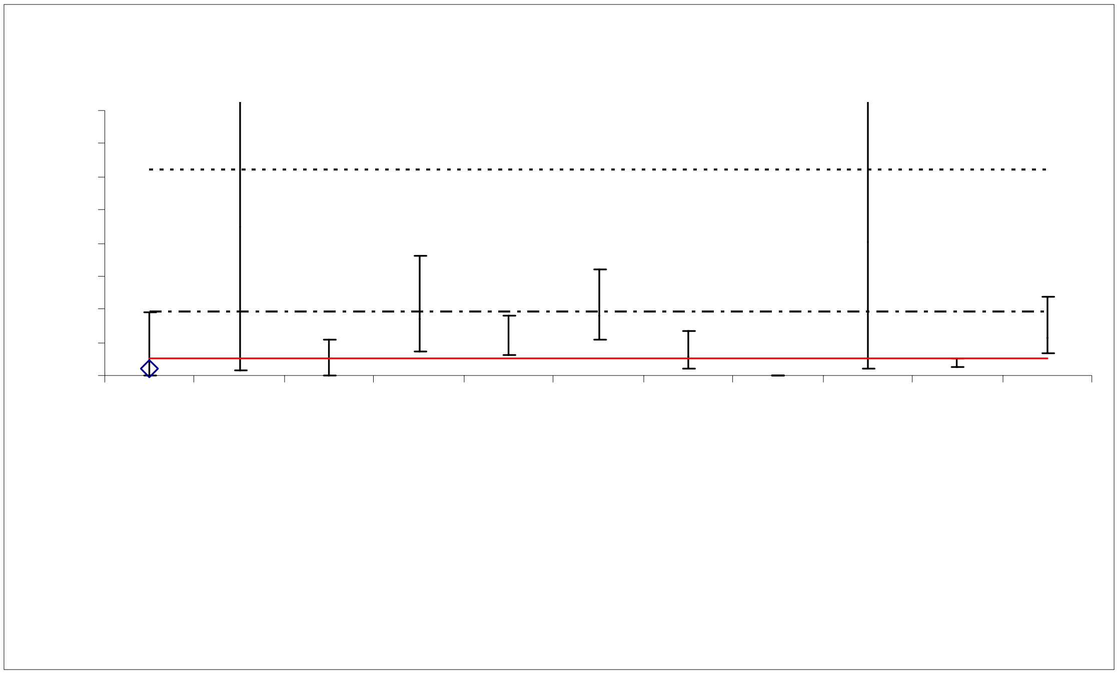


Figure 6: Total Lead Concentrations in Storm Water Runoff from the SSFL, from Los Angeles Region Land Use Types, and in Surface Water



3.4.2 Concentrations of Dioxin in storm wate

Figure 8: Comparison of Dioxin [TCDD (TEQ)] Concentrations in Storm Water Runoff from the SSFL, from Los Angeles Region Land Use Types, and in Surface Water

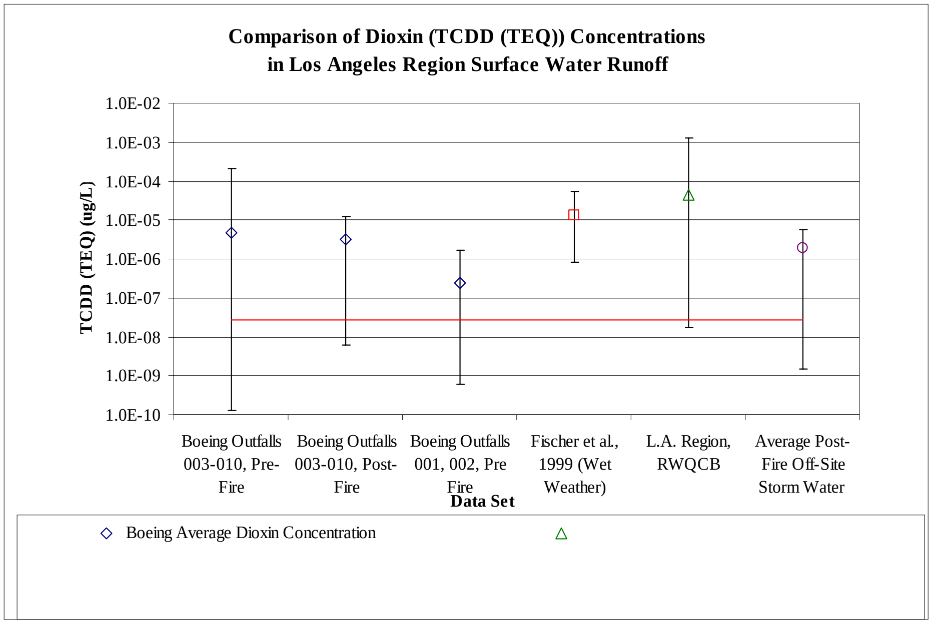


Table 16 – BMP and Erosion Control Materials and Testing Procedures

Sample ID	BMP/ Erosion Control Material Group	BMP Material	Variable Testing Procedures
IOJ1924-01 DIWET	Sand	Colorado filter sand	Leached (1 hr.), filtered
IOJ1924-01RE1 DIWET	Sand	Colorado filter sand	Rinsed, leached (1 hr.), filtered
IOJ1924-02	Sand	Colorado filter sand	Rinsed, leached (1 hr.)
IOJ1924-03	Sand	Colorado filter sand	Rinsed, soaked (1 hr.)
IOJ1924-04	Sand	Colorado filter sand	Rinsed, soaked (15 min.)
IOJ1230-01 DIWET	Sand	Corona filter sand	Leached (24 hr.), filtered
IOJ1230-01RE1 DIWET	Sand	Corona filter sand	Leached (1 hr.), filtered
IOJ1230-01RE2 DIWET	Sand	Corona filter sand	Rinsed, leached (1 hr.), filtered
IOJ1230-02	Sand	Corona filter sand	Rinsed, leached (1 hr.)
IOJ1230-03	Sand	Corona filter sand	Rinsed, soaked (1 hr.)
IOJ1230-04	Sand	Corona filter sand	Material from IOJ1230-02 used, soaked (15 min.)
IOK0111-01	Gravel	Road gravel	Rinsed, soaked (15 min.), filtered and unfiltered
IOK0111-02	Gravel	Pea bag gravel	Rinsed, soaked (15 min.), filtered and unfiltered
IOK0111-03	Gravel	Birds eye gravel	Rinsed, soaked (15 min.), filtered and unfiltered
IOK1695-01	Hydromulch	Naka Hydroseed	Leached, soaked (15 min.), filtered and unfiltered
IOK0964-01	Hydromulch	Soil Set	Liquid material analysis
IOK0964-02	Hydromulch	StarTak 600	Water analysis, filtered and unfiltered
IOK0964-03	Hydromulch	Eco Fibre	Water analysis, filtered and unfiltered
IOK0964-04	Hydromulch	Eco Aegis	Water analysis, filtered and unfiltered
IOK0964-05	Hydromulch	Applegate N/D	Water analysis, filtered and unfiltered
IOK0964-06	Hydromulch	Applegate W/D	Water analysis, filtered and unfiltered
IOK0964-07	Hydromulch	Soil Guard	Water analysis, filtered and unfiltered
IOK0964-08	Hydromulch	Mat Fibre	Water analysis, filtered and unfiltered
IOK0964-09	Hydromulch	Eco Blend	Water analysis, filtered and unfiltered
IOK0964-10	Hydromulch	StarTak 600	Solid material analysis
IOK0964-11	Hydromulch	Eco Fibre	Solid material analysis
IOK0964-12	Hydromulch	Eco Aegis	Solid material analysis
IOK0964-13	Hydromulch	Applegate N/D	Solid material analysis
IOK0964-14	Hydromulch	Applegate W/D	Solid material analysis
IOK0964-15	Hydromulch	Soil Guard	Solid material analysis
IOK0964-16	Hydromulch	Mat Fibre	Solid material analysis
IOK0964-17	Hydromulch	Eco Blend	Solid material analysis

Source: Boeing, 2005.

Table 17 – Regulated Constituents Analyzed During BMP and Erosion Control Materials Testing

	Constituent	SSFL 2006 NPDES Permit Limit (Daily Maximum)
	Antimony	6.0 µg/l
	Arsenic*	50 µg/l
	Barium*	1.0 mg/l
	Beryllium	4.0 µg/l
	Boron**	1.0 µg/l
	Cadmium	4.0 µg/l
	Chromium*	16.3 µg/l
	Copper	14.0 µg/l
	Iron*	0.3 mg/l
	Lead	5.2 µg/l
	Manganese*	50 µg/l
	Mercury	0.10 µg/l
	Nickel*	96 µg/l
	Selenium*	8.2 µg/l
	Silver*	4.1 µg/l
	Thallium	2.0 µg/l
	Zinc*	119 µg/l
	Dioxin TEQ	2.8×10^{-8} µg/l

Source: SSFL 2006 NPDES Permit (Order No. R4-2006-008).
* These constituents have permit limits for Outfalls 001, 002, 011, and 018 only.
** This constituent has a permit limit only at Outfalls 003-007, 008, and 010.

4.2 BMP MATERIALS TESTING RESULTS

Given that the BMP materials, once emplaced, function as filters at the site, the passive soaking methodology likely best represents concentrations that would result from contact of storm water with BMP materials emplaced on site. Thus, results presented in this section are a subset of the complete results of Boeing's BMP materials testing program as described above. (Complete results are presented in Appendix B.) The results summarized in Tables 18a through 18q include data from tests where BMP materials were soaked and the supernatant was not filtered. In the sand and gravel cases presented in Table 18, the materials were also rinsed before soaking, mimicking a steady-state, long-term condition of BMP materials at the site. Since SSFL 2004 NPDES Permit Limits are expressed in terms of total, not dissolved, metals, test results from unfiltered samples are presented.

After reviewing the results of these tests, Boeing selected the Corona filter sand and the Bird's eye gravel for use in the BMPs emplaced at the SSFL site. Hydromulch materials used at the site consisted of a mixture of the Applegate, Mat Fiber and the Soil veg parts A and B.

Table 18a – Contributions to ANTIMONY concentrations from BMP materials testing

BMP/Erosion Control Material Type	**BMP Material**	**Concentration (µg/L)**	**SSFL 2006 NPDES Daily Max Permit Limit (µg/L)**	**Sample Result / Permit Limit**
Sand	Colorado Filter Sand	0.18	6	0.03
Sand	Corona Filter Sand	0.24	6	0.04
Gravel	Birds Eye Gravel	0.48	6	0.08
Gravel	Pea Bag Gravel	1.7	6	0.28
Gravel	Road Gravel	0.74	6	0.12
Hydromulch	Applegate N/D	76	6	**12.67**
Hydromulch	Applegate W/D	41	6	**6.83**
Hydromulch	Eco Aegis	17000	6	**2833.33**
Hydromulch	Eco Blend	4.4	6	0.73
Hydromulch	Eco Fibre	11	6	**1.83**
Hydromulch	Mat Fibre	5.2	6	0.87

Table 18d – Contributions to BERYLLIUM

Table 18e – Contributions to CADMIUM concentrations from BMP materials testing

BMP/Erosion Control Material Type	BMP Material	Concentration (µg/L)	SSFL 2006 NPDES Permit Limit	Sample Result / Permit Limit
Sand	Colorado Filter Sand	0.15	4	0.04
Sand	Corona Filter Sand	0.045	4	0.01
Gravel	Birds Eye Gravel	1.4	4	0.35
Gravel	Pea Bag Gravel	0.77	4	0.19
Gravel	Road Gravel	0.63	4	0.16
Hydromulch	Applegate N/D	0.13	4	0.03
Hydromulch	Applegate W/D	0.15	4	0.04
Hydromulch	Eco Aegis	0.18	4	0.05
Hydromulch	Eco Blend	0.11	4	0.03
Hydromulch	Eco Fibre	0.24	4	0.06
Hydromulch	Mat Fibre	0.041	4	0.01
Hydromulch	Naka Hydroseed	0.31	4	0.08
Hydromulch	Soil Guard	0.47	4	0.12
Hydromulch	Soil Set	0.70	4	0.18
Hydromulch	Star Tak	ND	4	0.00

Source: Boeing, 2005.

Table 18f – Contributions to CHROMIUM

Table 18g – Contributions to COPPER concentrations from BMP materials testing

BMP/Erosion Control Material Type	BMP Material	Concentration (µg/L)	SSFL 2006 NPDES Permit Limit	Sample Result / Permit Limit
Sand	Colorado Filter Sand	17	14	**1.21**
Sand	Corona Filter Sand	22	14	**1.57**
Gravel	Birds Eye Gravel	32	14	**2.29**
Gravel	Pea Bag Gravel	86	14	**6.14**
Gravel	Road Gravel	25	14	**1.79**
Hydromulch	Applegate N/D	7.1	14	0.51
Hydromulch	Applegate W/D	10	14	0.71
Hydromulch	Eco Aegis	8.4	14	0.60
Hydromulch	Eco Blend	4.2	14	0.30
Hydromulch	Eco Fibre	11	14	0.79
Hydromulch	Mat Fibre	2.8	14	0.20
Hydromulch	Naka Hydroseed	9.2	14	0.66
Hydromulch	Soil Guard	5.9	14	0.42
Hydromulch	Soil Set	140	14	**10.00**
Hydromulch	Star Tak	30	14	**2.14**

Source: Boeing, 2005.

Table 18h – Contributions to IRON concentrations from BMP materials testing

BMP/Erosion Control Material Type	BMP Material	Concentration (µg/L)	SSFL 2006 NPDES Permit Limit	Sample Result / Permit Limit
Sand	Colorado Filter Sand	7	0.3	**22.33**
Sand	Corona Filter Sand	15	0.3	**50.00**
Gravel	Birds Eye Gravel	35	0.3	**116.67**

Table 18i – Contributions to LEAD concentrations from BMP materials testing

BMP/Erosion Control Material Type	BMP Material	Concentration

Table 18k – Contributions to MERCURY concentrations from BMP materials testing

BMP/Erosion Control Material Type	BMP Material	Concentration	SSFL 2006 NPDES Daily Maximum Permit Limit	Sample Result / Permit Limit
Sand	Colorado Filter Sand	ND	0.1	0.00
Sand	Corona Filter Sand	ND	0.1	0.00
Gravel	Birds Eye Gravel	0.086	0.1	0.86
Gravel	Pea Bag Gravel	0.23	0.1	**2.30**
Gravel	Road Gravel	0.12	0.1	**1.20**
Hydromulch	Applegate N/D	ND	0.1	0.00
Hydromulch	Applegate W/D	ND	0.1	0.00
Hydromulch	Eco Aegis	ND	0.1	0.00
Hydromulch	Eco Blend	ND	0.1	0.00
Hydromulch	Eco Fibre	ND	0.1	0.00
Hydromulch	Mat Fibre	ND	0.1	0.00
Hydromulch	Naka Hydroseed	ND	0.1	0.00
Hydromulch	Soil Guard	ND	0.1	0.00
Hydromulch	Soil Set	ND	0.1	0.00
Hydromulch	Star Tak	ND	0.1	0.00

Source: Boeing, 2005.

Table 18l – Contributions to NICKEL concentrations from BMP materials testing

BMP/Erosion Control Material

Table 18m – Contributions to SELENIUM concentrations from BMP materials testing

BMP/Erosion Control Material Type	BMP Material	Concentration (µg/L)	SSFL 2006 NPDES Daily Maximum Permit Limit	Sample Result / Permit Limit
Sand	Colorado Filter Sand	0.96	8.2	0.12
Sand	Corona Filter Sand	1.5	8.2	0.18
Gravel	Birds Eye Gravel	12	8.2	**1.46**
Gravel	Pea Bag Gravel	ND	8.2	0.00
Gravel	Road Gravel	1.1	8.2	0.13
Hydromulch	Applegate N/D	ND	8.2	0.00
Hydromulch	Applegate W/D	ND	8.2	0.00
Hydromulch	Eco Aegis	ND	8.2	0.00
Hydromulch	Eco Blend	ND	8.2	0.00
Hydromulch	Eco Fibre	ND	8.2	0.00
Hydromulch	Mat Fibre	ND	8.2	0.00
Hydromulch	Naka Hydroseed	0.51	8.2	0.06
Hydromulch	Soil Guard	ND	8.2	0.00
Hydromulch	Soil Set	1.9	8.2	0.23
Hydromulch	Star Tak	1.9	8.2	0.23

Source: Boeing, 2005.

Table 18n – Contributions to SILVER concentrations from BMP materials testing

BMP/Erosion Control Material Type	BMP Material	Concentration (µg/L)	SSFL 2006 NPDES Daily Maximum Permit Limit	Sample Result / Permit Limit
Sand	Colorado Filter Sand	0.05	4.1	0.01
Sand	Corona Filter Sand	ND	4.1	0.00
Gravel	Birds Eye Gravel	0.092	4.1	0.02
Gravel	Pea Bag Gravel	0.54	4.1	0.13
Gravel	Road Gravel	0.12	4.1	0.03
Hydromulch	Applegate N/D	0.039	4.1	0.01
Hydromulch	Applegate W/D	0.026	4.1	0.01
Hydromulch	Eco Aegis	0.042	4.1	0.01
Hydromulch	Eco Blend	ND	4.1	0.00
Hydromulch	Eco Fibre	0.038	4.1	0.01
Hydromulch	Mat Fibre	ND	4.1	0.00
Hydromulch	Naka Hydroseed	0.052	4.1	0.01
Hydromulch	Soil Guard	ND	4.1	0.00
Hydromulch	Soil Set	ND	Set	0.01

Table 18o – Contributions to THALLIUM concentrations from BMP materials testing

SSFL 2006

BMP/Erosion Control Material Type	BMP Material	Concentration (µg/L)

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