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

Prepared
for

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On Behalf of

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Executive Summary

The Boeing Santa Susana Field Laboratory (SSFL) is approximately 2850 acres in size and straddles the Santa Susana Mountains at the border of Ventura and Los Angeles Counties. Runoff from the SSFL eventually flows into both the Los Angeles River and Calleguas Creek Watersheds. The numeric limits contained in adopted and proposed Orders for the SSFL include numeric limits for storm water discharges that are very low. Boeing has expressed concern about its ability to comply with these limits. To investigate these concerns, this report presents information on sources of constituents that are regulated at the site.

The data detailed in this report describe the impact of atmospheric deposition, erosion of native soils, and forest fires on storm water concentrations of metals and dioxin. In addition, concentrations of regulated constituents, including metals and dioxin, in storm water runoff from the SSFL are compared to concentrations of these constituents in storm water flows and in receiving waters throughout the region. Major conclusions of this report are described below.

- **Atmospheric deposition.** Many of the metals and dioxins that are regulated in storm flows from the site are present in ambient air in southern California. The mass loading of these constituents deposited on land via dry deposition is large, and studies have shown that significant fractions of this mass can be transmitted to receiving waters during storm events. Two studies performed by Sabin et al. (2004 and 2005) are particularly relevant, and demonstrated that dry deposition metals loads to the Los Angeles Region far exceeded mass loadings of metals in storm flows (storm flow mass loadings of metals were 9-43% of the annual atmospheric deposition load to the Los Angeles Region between October 2003 and April 2004), and that atmospheric deposition in one small, urbanized catchment accounted for as much as 57-100% of the annual trace metals load in storm water. Thus, a substantial portion of the metals concentrations and loads in storm water from the SSFL may derive from atmospheric deposition unrelated to site activities.
- **Wild fires.** Wildland fires release significant amounts of metals and dioxins, and storm water runoff following forest fire events has been observed to carry significantly higher concentrations and loads of these constituents. Atmospheric deposition rates of metals have been observed to rise several-fold during fires. Elevated atmospheric concentrations of dioxin have been observed during fires. Fires also leave behind ash and destroy vegetation, resulting in significant changes in the hydrologic response of watersheds, including higher runoff volumes, higher flow rates, and higher concentrations of total suspended solids (TSS), which in turn carry regulated constituents. These effects have been widely documented and have been observed at the SSFL site, 70% of which burned during the fall 2005 wild fires.

- **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.

1. INTRODUCTION

The Boeing Santa Susana Field Laboratory (SSFL) straddles the Santa Susana Mountains of southeastern Ventura County, and contributes runoff to both the Los Angeles River and Calleguas Creek Watersheds, both of which are listed as 303(d) impaired waters for certain constituents. Past and current NPDES waste discharge requirements for the SSFL have utilized a Reasonable Potential Analysis (RPA) to determine the likelihood that runoff containing certain constituents in storm water runoff would exceed Water Quality Based Effluent Limits (WQBELs). Several analytes, including cadmium, copper, lead, mercury, and 2,3,7,8- Tetrachlorodibenzo-p-dioxin (TEQ) [TCDD (TEQ)]¹, were found by the Regional Board to have reasonable potential to exceed WQBELs at one or more designated outfalls.² However, storm water runoff from the site will contain significant concentrations and loads of these constituents from background sources not related to site activities, including:

- (1) Atmospheric deposition, which may include:
 - (a) urban traffic and atmospheric emissions
 - (b) products of native soil erosion by wind
- (2) Sediment loads from native soil erosion by runoff
- (3) Combustion products, smoke, and ash from forest fires

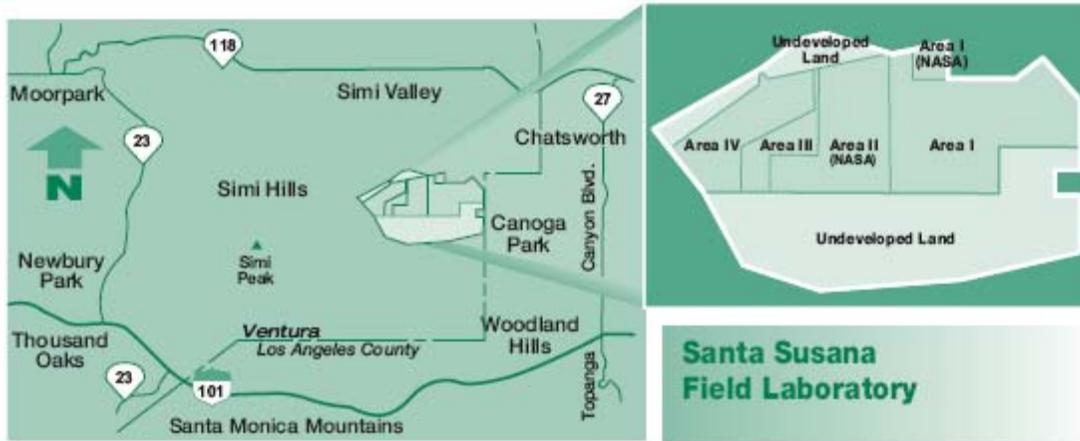
Each of these sources contributes to the annual load and to concentrations of constituents of concern in storm water runoff. Available information regarding these background sources can be used to calculate order-of-magnitude estimates for ambient constituent loadings in surface water at the SSFL.

This report also presents the results of tests of materials, including sand and gravel, that were considered for use in best management practices (BMPs) at SSFL. In addition to these BMP materials, hydromulch materials were also evaluated. Several different types of tests were conducted to assess the potential for these materials to contribute regulated constituents to storm water runoff, and to enable Boeing to select the cleanest materials available for use at the SSFL site.

¹ The Regional Board requires measurement of dioxins as a 2,3,7,8-TCDD toxic equivalent (TEQ). This mass TEQ is equal to the sum of each dioxin-like congener's mass multiplied by a congener-specific toxicity equivalence factor determined by the EPA and World Health Organization.

² Los Angeles Regional water Quality Control Board, Order No R4-2004-0111, Waste Discharge Requirements for the Boeing Company, July 1, 2004. pp. 25-26. Note that comments on the reasonable potential analyses and interim and final numeric effluent limits calculated by the Regional Board have been provided separately by Boeing on December 30, 2005, and January 5, 2006.

Figure 1 –Location Map of Boeing SSFL



2. REGIONAL SOURCES FOR CONSTITUENTS OF CONCERN IN SOUTHERN CALIFORNIA STORMWATER RUNOFF

2.1 Atmospheric Sources

Air quality in Southern California is regarded as some of the worst in the nation. Atmospheric emissions, concentrations, and deposition of metals, chlorinated dibenzodioxins³ and chlorinated dibenzofurans (herein “dioxin”), polycyclic aromatic hydrocarbons (PAHs), organochlorine and organophosphate pesticides, and polychlorinated biphenyls (PCBs) have been observed in the major air basins of southern California. Atmospheric deposition monitoring data from Southern California and from other areas with similar climates and similar levels of urban development have been reviewed to evaluate the importance of atmospheric deposition to storm water concentrations of regulated constituents in the Southern California Region.

2.1.1 Emissions of SSFL Runoff Constituents of Concern

The California Air Resources Board recently released the State’s toxics emissions data for 2004. These data include emissions estimates for stationary, area-wide, mobile, and natural sources for 33 toxic compounds, reported for the entire state and by region. Emissions estimates are based on modeled emissions factors, permit levels applied to emissions, and quality control emissions surveys, and do not include emissions from wildland or forest fires. Available CARB emissions estimates for Los Angeles and Ventura Counties are summarized below in Table 1 for analytes observed in storm water runoff from the SSFL site

³ The Environmental Protection Agency defines dioxins as “a group of chemical compounds that share certain chemical structures and biological characteristics. Several hundred of these compounds exist and are members of three closely related families: the chlorinated dibenzo-*p*-dioxins (CDDs), chlorinated dibenzofurans (CDFs) and certain polychlorinated biphenyls (PCBs). (Often times) the term dioxin is also used to refer to the most studied and one of the most toxic dioxins, 2,3,7,8-tetrachlorodibenzo-*p*-dioxin (TCDD).” Definition found on line at <http://www.epa.gov/ncea/dioxinqa.htm#g1>.

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
Lead	16664	3506
Manganese	58457	11473
Mercury	1290	157
Nickel	6413	682

Note: Dioxins/Benzofurans are listed as total mass kg/yr, not in the World Health Organization's 2,3,7,8 TCDD toxicity equivalence scale (kg Toxicity Equivalence (TEQ)/yr).

* Note: Major transportation sources are not included in these estimates for dioxins and benzofuran emissions in Los Angeles and Ventura Counties.

2.1.2 Atmospheric Concentrations, Deposition Rates, and Storm Water Concentrations of Metals

Technical reports published by the Southern California Coastal Water Research Project (SCCWRP) have summarized atmospheric concentrations and deposition rates of metals in Southern California watersheds. Table 2 summarizes estimated regional atmospheric concentrations, deposition fluxes, and a range of deposition estimates for the Los Angeles Basin as reported by SCCWRP for 2003.

⁴ California Air Resources Board, "2004 California Toxics Inventory by Air Basin". On line at <http://www.arb.ca.gov/toxics/cti/cti.htm> .

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

Constituent	Average Concentrations (ng/m ³)*		Average Daily Deposition Flux (µg/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.

Table 3 – Maximum Observed Total Metals Concentrations for Storm Water from Watersheds with Significant Natural (Open Space) Areas

Watershed	% -Natural	Maximum Observed Storm Water Concentrations (µg/L)		
		Copper	Lead	Zinc
Sawpit Creek (November 1998 – March 2001)	98	51	5.05	229
Malibu Creek (November 2001 – March 2005)	80	91.6	21.5	102
Los Angeles River (at Wardlow) (October 1998 – January 2005)	44	805	1070	1235
Boeing SSFL Tentative 2006 NPDES Permit Daily Average Levels	---	13.5 -14.0	5.2	119

Source: “Los Angeles County 1994-2000 Integrated Receiving Water Impacts Report” and “Los Angeles County 1994-2005 Integrated Receiving Water Impacts Report”, LACDPW.

Note: Concentrations are in terms of total metal, not dissolved metal.

Additional studies by SCCWRP and others are currently underway or are in planning stages; these studies are intended to help assess atmospheric deposition rates, to refine estimates of transmission efficiencies, particularly from natural areas, and to quantify the relative contribution of atmospheric deposition to storm water metals concentrations and loadings. Nonetheless, the data presented by Sabin et al. (2004 and 2005) and the analysis presented in this report indicate that atmospheric deposition is likely a significant source of metals in storm water.

2.1.3 Atmospheric Deposition of Dioxins

Global atmospheric deposition rates for dioxins have been estimated in multiple studies through a mass balance between emissions and deposition of dioxins measured in soils, surface water, and in plant uptake. Wagrowski and Hites (2000) estimated global emissions at 1,800 to 3,000 kg/yr, but atmospheric deposition of dioxins was estimated at 5,500 kg/yr. Wagrowski and Hites (2000) reasoned that the discrepancy between emissions and deposition is made up by atmospheric volatilization of other Persistent Organic Pollutants (POPs), predominantly pentachlorophenol, into dioxin congeners. Wagrowski and Hites (2000) also studied emission sources and nearby localized deposition rates, and estimated that dioxin emissions travel through the atmosphere for relatively limited distances, roughly 60 to 125 miles, before depositing to the earth’s surface. Once deposited, fate and transport of dioxins will depend upon surface, hydrologic, and atmospheric conditions.

Wagrowski and Hites (2000) found that anthropogenic fluxes of nitrogen oxides (NO_x) correlated well with atmospheric deposition fluxes of dioxins and benzofurans, and developed a model for estimating atmospheric deposition of dioxins and benzofurans to soils based upon a logarithmic regression with regional emissions of NO_x. This is shown in equation (1).

$$\log(\text{dioxin and benzofuran flux}) = 0.512 + 0.401 (\log \text{NO}_x) \quad (1)$$

The mass of dioxins and benzofurans deposited from the atmosphere within Ventura and Los Angeles Counties has been estimated using this model, as shown in Table 4.

Table 4 – Estimated Atmospheric Deposition of Dioxins and Benzofurans to Los Angeles and Ventura Counties

Region	Area (m²)	2004 NO_x Emissions (tons/yr)*	Estimated Dioxin and Benzofuran Deposition Rate (ng/m²/yr)	Deposition Estimated for Regional Area** (g/yr)
Los Angeles County	1.1x10 ¹⁰	630	46	480
Ventura County	4.8 x10 ⁹	80	27	130
Los Angeles + Ventura County	1.5 x10 ¹⁰	710	41	610

*Source: California Air Resources Board toxics emissions data for 2004.

Dioxin deposition estimates in Table 4 are one to four orders of magnitude greater than Dioxin emissions estimates in Table 1. It is important to note that emissions estimates for dioxins and benzofurans in Table 1 **do not include emissions from transportation sources or wildland fires. Table 4 NO_x emission estimates **do** include transportation sources, but **do not** include wildland fire sources. These sources may produce the majority of dioxins and benzofurans in the southern Californian region.

2.2 Forest Fire Impacts

2.2.1 Forest Fire Metals Deposition

Periodic forest fires throughout the southern California region have the potential to release significant amounts of metals and dioxins. Santa Ana winds, characteristic of weather patterns during the Southern California forest fire season, may distribute these atmospheric constituents across Southern California Air Basins. The relatively short-term nature of forest fires can lead to strong spikes in atmospheric deposition rates of trace metals and dioxins. Storm water runoff following forest fire events has been observed to carry significantly higher loads of these constituents, as discussed below.

Sabin et al. (2005) report that during the severe 2003 southern California forest fire season, which included the 2003 Piru/Simi Fires, atmospheric deposition rates for copper, lead, and zinc, went up by factors of four, eight, and six, respectively, at an unburned site⁵ in the San Fernando Valley that was approximately 30 miles from the southeastern border of the Piru/Simi Fires. Table 5 shows average daily atmospheric trace metals deposition rates for 2004 and the increase in deposition rates that would result from forest fires. Figure 2 shows the increase in air concentrations of metals in the Los Angeles Basin during the 2003 forest fire season.

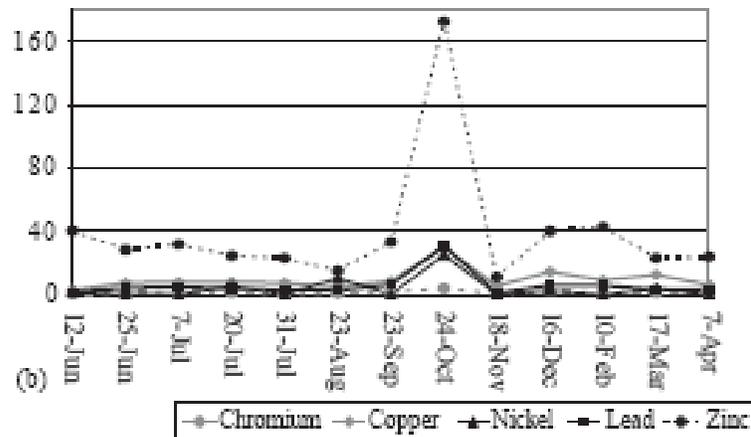
⁵ Sabin et al. 2005 report this site as the Tillman Water Reclamation plant in the San Fernando Valley.

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 ($\mu\text{g}/\text{m}^2/\text{day}$)		Forest Fire Factor Increase	Calculated Daily Deposition Rates during Fires ($\mu\text{g}/\text{m}^2/\text{day}$)
	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



Atmospheric 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 significant source of dioxin due to emissions, resuspension, and volatilization (Nestrick et al. (1983) and Sheffield et al. (1985)). Tashiro et al. (1990) and Clement and Tashiro (1991) reported increases in atmospheric concentrations of dioxins during forest fires in Ontario, Canada. Forest fires in Ontario produced estimated atmospheric concentrations ranging from 15 to 400 pg/m^3 , with an approximated average of

20 pg/m³⁽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/ m³ 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/m³, 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) estimated biomass consumption rates from forest fires at roughly 9.4 metric tons/acre. From these data and the area of forest fires in southern California, an estimate can be made of the mass of TEQs (dioxin-like substances) emitted due to fires. Because available biomass, biomass conversion rates, and dioxin emission rates may vary significantly, a range of TEQ mass emissions, utilizing the estimated dioxin emission level as the geometric mean with a factor of 10 between high and low range estimates, has been calculated. Table 6 summarizes estimated dioxin emissions for recent Southern California fires. These emission rates are of the same order as dioxin emission rates reported by the SCAQMD (see Table 1). Thus, it appears that forest fires are a significant source of dioxins, particularly for land areas located near the fires.

⁶ Note that these airborne concentrations of dioxins have not been converted into mass TEQ/volume units and cannot be compared to the SCAQMD air concentrations reported in TEQ/volume units.

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 analytes⁷ 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 analytes as bicarbonate, calcium, cyanide, magnesium, nitrogen, phosphorus, potassium, aluminum, arsenic, barium, boron, cadmium, chromium, cobalt, copper, iron, lead, manganese, nickel, selenium, strontium, vanadium, zinc, americium-241, cesium-137, plutonium-238, plutonium – 239, 240, strontium-90, and uranium.

manganese, nickel, tin, strontium, thallium, vanadium, and zinc. Furthermore, Hinojosa et al. (2004a) report that the dioxin congeners OCDD and HpCDD were above reporting limits⁸ in most post-fire soil samples, with the highest TCDD total equivalent measurement of 2.9×10^{-5} TEQ mg/kg. Hinojosa et al. (2004b) note that “although there are no pre-fire results to compare against, the detection of dioxin in the ash-rich sediment deposits upstream of LANL supports the possibility that dioxins were formed by the Cerro Grande fire.” Likewise, no pre-fire measurements for dioxin-like compounds were taken for the Rio Grande River running through LANL, but post-fire TCDD equivalent concentrations were found in three of 24 water samples, ranging from 7×10^{-8} (TEQ $\mu\text{g/L}$) to 6.3×10^{-6} (TEQ $\mu\text{g/L}$). These values are 5 to 450 times greater than the California Toxics Rule (CTR) value of 1.4×10^{-8} ($\mu\text{g/L}$) for human consumption of organisms, which is the basis for the 2004 and 2006 Tentative NPDES permit limits for storm water at SSFL. Appendix A of Boeing’s Response to the Revised Tentative Waste Discharge Requirements, dated December 30, 2005 and Section 3.2 from Boeing’s Response to the Tentative Cease and Desist Order R4-2006-XXX dated January 5, 2006 provide a more in depth summary of the Cerro Grand Fire impacts to water quality and stream flow near the LANL.

2.3 Native Soils Sources

Native soils in southern California contain significant quantities of copper, lead, mercury, zinc, dioxins, and other constituents. When mobilized in large storm events, sediments and soils from natural areas may contribute a significant quantity of these naturally-occurring metals to storm water via natural sediment transport processes. As discussed below, site-specific background soils concentrations at SSFL can be used to estimate the concentration of metals in storm water as a result of the erosion of native sediments.

3. REGIONAL SOURCE DATA APPLIED TO THE BOEING SSFL SITE

3.1 Atmospheric Deposition

3.1.1 Atmospheric Deposition of Metals at SSFL

Atmospheric deposition rates for metals at the SSFL site can be estimated using data from Sabin et al. (2004a). Sabin et al. (2004a) measured atmospheric deposition fluxes in the Malibu Creek watershed and in the Los Angeles River watershed at the Tillman Reclamation plant. These stations were the closest monitoring stations to the SSFL, so annual deposition rates of metals across the area of the SSFL (11.5 km^2) were calculated using the average of atmospheric deposition flux rates from these two locations. The estimated atmospheric deposition loads of various metals to the SSFL are shown in Table 7.

⁸ Hinojosa et al (2004a), p. 8, notes that OCDD and HpCDD were the only dioxin congeners detected above reporting limits in the soils analyzed. All other dioxin congener groups were below detection limits for the soil samples analyzed.

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 Reclamation Plant	Malibu Creek	Estimated SSFL (Avg. of Malibu Creek & Tillman)	Tillman Water Reclamation 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 of storm water metals loads in a small predominantly impervious catchment resulted from background urban atmospheric deposition in the San Fernando Valley. This transmission efficiency may be lower for non-urban areas such as the SSFL site. Even if transmission efficiencies from natural areas are lower (say between 10% and 50%), atmospheric deposition will still be a dominant sources of metals in storm flows. As noted previously (Table 3), storm flows from watersheds that are largely natural and open (e.g., Sawpit Creek and Malibu Creek) experience high metals concentrations. Atmospheric deposition and/or erosion of native soils are likely the dominant sources of metals in these watersheds.

Order-of-magnitude estimates of the average metals concentrations in storm water runoff at the SSFL resulting from atmospheric deposition can be made assuming that:

- The average storm water runoff at the SSFL is equal to an average year’s rainfall at SSFL multiplied by a runoff coefficient.
- Between 10 % to 50 % of the metals deposited from the atmosphere at the SSFL are transported in an average year’s rainfall.

Table 8 compares the order-of-magnitude estimate for metals concentrations in storm water runoff at the SSFL due to atmospheric deposition with the NPDES permit limits that apply to storm water discharges from the SSFL. As shown in Table 8, the atmospheric deposition of copper, lead, and zinc may provide substantial contributions to permit exceedances at the SSFL.

⁹ Sabin et al. 2005 reports average ± one standard deviation concentrations (µg/L) for storm water at the Tillman Water Reclamation Plant during the 2003-2004 wet season as: Copper (27 ± 24), Lead (12 ± 10), and Zinc (160 ± 130), illustrating the high variability in metals concentrations in storm water.

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	18	5.3 x10 ⁹	2.1x10 ⁹	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				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 (TEF) of 0.0001 has been used. This is the TEF for OCDD, the most prevalent TCDD congener group (see Wagrowski and Hites (2000)). Using this conversion factor, annual dioxin deposition rates to the SSFL are estimated to be 4.7x10⁻⁵ TEQ (g/yr). Although no estimates of transmission efficiencies could be found for dioxins, a transmission efficiency of 60% applied to the annual mass of dioxin deposited to the SSFL from the atmosphere (and excluding any dioxin from fires) would result in storm water concentrations that exceed the monthly average TCDD (TEQ) NPDES permit limit for the estimated

average storm water volume leaving the SSFL. Thus, even in the absence of fires, atmospheric deposition clearly has the potential to contribute significantly to both concentrations and loads of dioxin in storm water from the SSFL.

Table 9 - Atmospheric Deposition of Dioxins and Benzofurans to the SSFL

Estimated Dioxin and Benzofuran Deposition Rate to SSFL, 2004 (ng/m ² /yr)*	Estimated Range of Dioxin Deposition Rates to SSFL, 2004 (ng/m ² /yr)	SSFL Area (m ²)	Estimated 2004 Dioxin Deposition at SSFL (g/yr)	Estimated Range, 2004 (Applying LA and Ventura County as upper and lower limits.) (g/yr)
41	27-46	1.2x10 ⁷	0.47	(0.31-0.53)

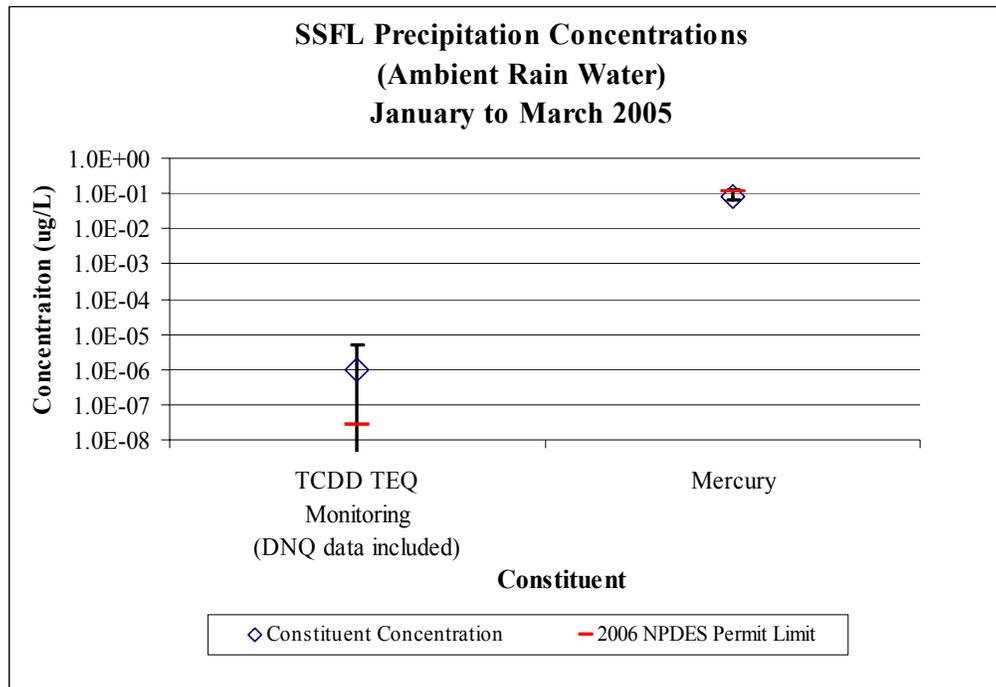
*See Table 4 for dioxin and benzofuran deposition rate of Los Angeles and Ventura County.

Note: Deposition rates are in total mass of dioxin and benzofurans and have not been converted into mass TEQ. These estimates do not include the effects of wild fires.

3.1.3 Ambient Precipitation Concentrations of Metals and Dioxins at the SSFL

Recent ambient rainwater sampling conducted by Boeing and MWH during five rainfall events between January and March 2005 showed that rainwater contains significant concentrations of dioxins and mercury. Figure 3 shows the average concentrations of these constituents measured in rainwater collected at the SSFL with error bars indicating minimum and maximum observed values. These data show that dioxin concentrations in rain water at times exceed the permit limits that are applied to storm water from the SSFL site. In addition, mercury concentrations in precipitation may be at or near NPDES permit limits. (Concentrations of other metals were also measured, but were present at levels below NPDES permit limits and are not shown here.)

Figure 3 – SSFL Precipitation Constituent Concentrations



Sampling Notes:

1. Rainwater sampling occurred on 1/7/05, 2/11/05, 2/18/05, 3/4/05, 3/23/05. Only three of these samples were analyzed for dioxins. Figure 3 was generated using the same data criteria and summation methods employed by the Regional Board in Reasonable Potential Analyses conducted for storm water runoff from the SSFL.
2. Four rainwater samples have been validated for mercury. Mercury concentrations represent laboratory estimated concentrations, and were reported with a J or U qualifier. One of the four estimated values was above the 2006 NPDES Permit Limit of 0.1 (µg/L). Estimated values for each of the four samples were >0.05 (µg/L). These data criteria and summation methods employed by the Regional Board in Reasonable Potential Analyses conducted for storm water runoff from the SSFL.

3.2 Fire Impacts at the SSFL

The Chatsworth Topanga fire of 2005 burned roughly 70% of the land area at SSFL in addition to ten buildings, seven of which were completely destroyed. The overall fire area was about 24,000 acres. Following the Topanga Fire, Boeing initiated a sampling effort to quantify recent fire impacts in ambient conditions at the SSFL and in surrounding areas. Soil and ash samples were collected in early October 2005 from undeveloped locations, within and adjacent to the burn areas of the Topanga and Burbank (Harvard) Fires, soon after these fires occurred in September 2005. Samples were collected both at the DTSC-approved soil background locations for the SSFL, and within undeveloped, ambient drainages at on- and off-Site locations. Surface water runoff samples were collected in October 2005, November 2005, and in early January 2006 from those surface water drainages that had storm water discharges at the time of sampling.¹⁰ All results validated to date are included in Appendix A of this report and are discussed in greater detail below. Sampling locations

¹⁰ Initial data collected from these locations were provided in Appendix A to Boeing’s “Response to Tentative Cease and Desist Order R4-2006-0XXX” (January 5, 2006).

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 are generally consistent between in off-site and background media.

¹¹ Tables A-1 through A-4 were generated using the same data criteria and summation methods employed by the Regional Board in Reasonable Potential Analyses conducted for storm water runoff from the SSFL.

Table 10 Concentrations of Metals and Dioxin in Ash and Soil Samples Collected On-Site¹², 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)
TCDD TEQ	(ng/kg)	0.98	0.53 (0.12-1.3)	0.12 (0.01-0.57)	1.6 (0.59-3.2)	2.9 (0.009-17.4)
Antimony	(mg/kg)	8.7	1.2 (0.81-1.7)	0.09 (0.03-0.19)	2.1 (1.6-3.5)	0.3 (0.06-0.7)
Arsenic	(mg/kg)	15	4.9 (2.7-11)	5.99 (0.9-13)	2.6 (1.2-3.9)	3.6 (0.6-10)
Barium	(mg/kg)	140	83 (59-110)	100 (42-230)	260 (130-360)	325 (180-630)
Beryllium	(mg/kg)	1.1	0.51 (0.45-0.62)	0.5 (0.2-0.8)	0.53 (0.4-0.88)	0.6 (0.2-1.1)
Boron	(mg/kg)	9.7	4.5 (1.0-6.6)	6.3 (1-14)	88 (48-160)	140 (58-330)
Cadmium	(mg/kg)	1	0.55 (0.47-0.62)	0.15 (0.03-0.52)	0.7 (0.4-1.1)	0.4 (0.08-1.5)
Chromium	(mg/kg)	36.8	16 (12-18)	14.6 (3.6-23)	10 (2.3-18)	15 (3.8-35)
Copper	(mg/kg)	29	10 (8-13)	14.4 (4.7-30)	34 (15-64)	46 (21-84)
Iron	(mg/kg)	28000	17200 (15000-19000)	19300 (9300-32000)	9600 (4200-17000)	15500 (5700-33000)
Lead	(mg/kg)	34	17 (9.5-27)	8.7 (2.4-14)	28 (5.2-64)	18 (9.4-42)
Manganese	(mg/kg)	495	320 (260-390)	480 (180-1700)	470 (220-610)	620 (270-1400)
Mercury	(mg/kg)	0.09	0.009 (0.003-0.17)	0.005 (0.003-0.12)	0.018 (0.003-0.058)	0.01 (0.003-0.3)
Nickel	(mg/kg)	29	14 (11-21)	11 (3.1-18)	15 (7-24)	18 (4.5-37)
Selenium	(mg/kg)	0.655	1.5 (1.0-2.2)	0.7 (0.2-3.2)	2.6 (2-4.4)	1.0 (0.25-3.8)
Silver	(mg/kg)	0.79	0.62 (0.4-0.87)	0.04 (0.02-0.06)	1.1 (0.8-1.8)	0.14(0.08-0.23)
Thallium	(mg/kg)	0.46	2.8 (1.8-4.5)	0.3 (0.1-0.4)	2.5 (1.6-3.5)	0.21(0.16-0.34)
Vanadium	(mg/kg)	62	30 (23-37)	34 (14-80)	21 (8.4-35)	35 (11-71)
Zinc	(mg/kg)	110	59 (51-67)	63 (30-100)	115 (57-190)	160 (47-350)

All Samples were taken between October 2005 and January 2006.

These results show the variability of constituent concentrations in ash and soil following a wildfire event. Additionally, Table 10 illustrates that soil and ash constituent concentrations at SSFL following the Chatsworth Topanga Fire are very similar to off-site constituent concentrations. Furthermore, results to date show that the upper range of observed SSFL post-fire background and off-site soil concentrations for barium, boron, copper, iron, manganese, selenium, thallium, sodium, and vanadium exceed DTSC pre-fire background concentration comparison values. Likewise, results to date show that the upper range for ash constituent concentrations at both background locations and regional off-site drainage locations are above DTSC pre-fire approved background concentrations for the constituents dioxin, barium, boron, cadmium, copper, iron, lead, manganese, nickel, selenium, thallium, zinc, potassium, sodium, and vanadium. Boeing intends to continue to collect samples of

¹² Boeing SSFL's post-fire background location soil sampling occurred at six DTSC-approved background locations. The DTSC pre-fire background comparison values were determined using samples from 29 locations on the SSFL determined to be representative of background conditions. The larger sample sizes exhibit a greater range in observed concentrations.

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*** (g TEQ)	Storm Water Transmission Factor	Estimated Average Storm Water Concentration and Range from SSFL during an Average Precipitation Year*** (µg TEQ/L)	2006 Dioxin (TCDD) NPDES Permit Daily Max**** (µg TEQ/L)
4.39x10 ⁹	1.76x10 ⁹	0.04 (0.01-0.12)	10%	1.9x10 ⁻⁶ (4.7x10 ⁻⁷ to 6.64x10 ⁻⁶)	2.8x10 ⁻⁸
			50%	9.5x10 ⁻⁶ (2.4x10 ⁻⁷ to 3.3x10 ⁻⁵)	

* 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, p. 300) has been applied to the average annual rainfall volume to determine average annual runoff.

*** See Table 11

**** Assumes that 10% and 50% of dioxin emissions at SSFL from the Topanga Fire are transmitted to storm water runoff at SSFL over an average year.

3.3 Erosion of Native Soils at the SSFL

3.3.1 Erosion of Native Soils Contribution to SSFL Runoff

Because soils naturally contain metals and other constituents that are regulated at the SSFL, erosion of soils has the potential to contribute to metals concentrations and loads in storm water runoff. Measured concentrations of these constituents in site soils and measured TSS concentrations in storm water runoff from the site can be used to estimate the likely concentrations and loads in storm water runoff from the SSFL. To characterize the TSS concentrations and loads in storm water runoff from the site, drainages were grouped by slope and downstream receiving water. TSS data for Outfalls 001, 002, 008, 011, and 018 were pooled as representative of the south slope drainage into Bell Creek. TSS data for Outfalls 003-007, 009, and 010 were pooled as representative of the north slope drainages into the Arroyo Simi. Pre-fire and post-fire TSS concentrations have been characterized by calculating a geometric mean of all data points, assuming that non-detect values were equal to half of the reporting limit (5 mg/L or 10 mg/L). TSS data for storm water runoff from the site, including maximum observed TSS values, have been compiled in Table 13.

Table 13 shows that the geometric mean TSS concentrations in storm water runoff following the Topanga Fire are more than one order of magnitude greater than the TSS concentration in pre-fire runoff samples. The maximum TSS concentrations in storm water runoff from the SSFL’s north slope are similarly about one order of magnitude greater than the pre-fire maximum observed TSS concentration.

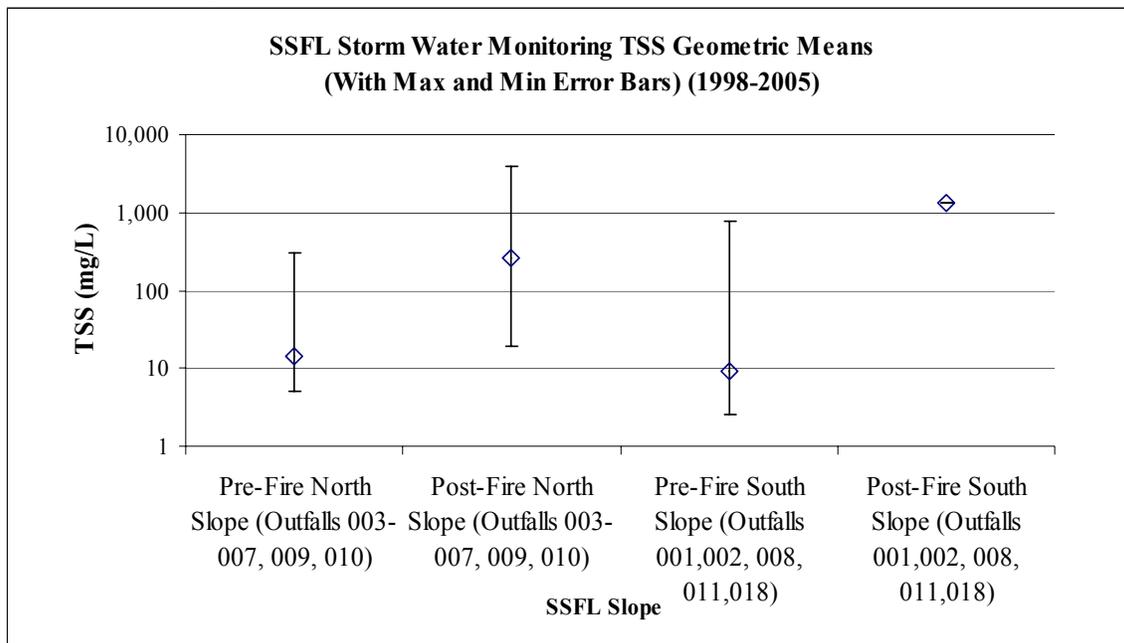
Table 13: Statistical Distribution of SSFL TSS Loads

TSS Data Comparison	Pre Fire TSS Distribution			Post Fire Data		
	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)

* The only south slope outfall that experienced flow in the fall following the fires is Outfall 008, which had flow on October 18, 2005. South slope outfalls experienced flow in January 2006, but sample results are not yet available for these storm events.

Note: Determination of the statistical distribution assumed that non-detect TSS loads were equal to the detection limit of 10 mg/L.

Figure 4 Statistical Distribution of TSS Loads at the SSFL



Note: Only one post fire TSS data point is available for south slope outfalls, and was taken at Outfall 008 on October 15, 2005.

3.3.2 Contribution of Native Sediments and Ash to Surface Water Runoff Constituent Concentrations at the SSFL

Erosion of native soils at SSFL may contribute significant constituent loads in storm water, particularly in runoff with high TSS loads. The concentrations of metals and dioxin in storm water associated with TSS in storm flows can be estimated using measured concentrations of trace elements in background soils at the SSFL. As presented in Section 3.2.1, soil samples have been taken from DTSC approved background sites at the SSFL. By assuming that the

TSS load in storm water results from erosion of native soils, a range of potential background constituent loadings due to the erosion of native sediments may be estimated by multiplying average background soil concentrations (see in Section 3.2.1) by the catchment-specific TSS concentrations (see Section 3.3.1). The contribution of native soils to storm water constituent concentrations is presented in Table 14a. Post-fire estimates were made using the average post-fire soil concentrations, average post-fire ash concentrations, and post-fire TSS concentrations, and are shown in Table 14b. As shown in Table 11 and Appendix A, concentrations of regulated constituents are often higher in ash than they are in post-fire soils, although the post-fire soils data set is limited in size. Thus, the presence of ash in storm water runoff could result in even higher concentrations of regulated constituents than are presented in Tables 15a and 15b.

Table 14 – Estimated storm water constituent concentrations from erosion of soils at the SSFL

Table 14a: Estimated Pre Topanga Fire Native Soils Storm Water Constituent Load

Metal	SSFL DTSC Pre Fire Background Soil Comparison Concentration (mg/kg)	Pre-Fire SSFL TSS Associated Storm Water Concentration, North Slope [TSS 19 (10-300) (µg/L)]	Pre-Fire SSFL TSS Associated Storm Water Concentration, South Slope [TSS 14 (6-760) (µg/L)]	2006 NPES Daily Maximum Permit Level (µg/L)	2006 NPDES Monthly Average Permit Limit (µg/L)
Antimony	8.7	0.12 (0.09-2.6)	0.1 (0.05-6.6)	6	--
Arsenic *	15	0.21 (0.15-4.5)	0.2 (0.1-11.4)	10	--
Barium *	140	2.0 (1.4-42)	1.4 (0.8-106)	1000	--
Beryllium *	1.1	0.02 (0.01-0.3)	0.01 (0.01-0.8)	4	--
Boron **	9.7	0.14 (0.10-2.9)	0.1 (0.06-7.4)	1	--
Cadmium	1	0.01 (0.01-0.3)	0.01 (0.01-0.8)	4	2
Chromium *	36.8	0.5 (0.4-11)	0.4 (0.2-28)	16.3	8.1
Copper	29	0.4 (0.3-8.7)	0.4 (0.2-22)	14	7.1
Iron *	28000	390 (280-8400)	280 (170-21,300)	300	--
Lead	34	0.5 (0.3-10.2)	0.3 (0.2-26)	5.2	2.6
* Manganese	495	6.9 (5.0-150)	5.0 (3.0-380)	50	--
Mercury	0.09	0.001 (0.001-0.03)	0.001 (0.001-0.07)	0.1	0.05
Nickel *	29	0.4 (0.3-8.7)	0.3 (0.2-22)	96	35
Selenium *	0.655	0.01 (0.01 -0.2)	0.01 (0.004-0.5)	8.2	4.1
Silver *	0.79	0.01 (0.01 -0.2)	0.01 (0.005-0.6)	4.1	2
Thallium	0.46	0.01 (0.005-0.1)	0.01 (0.003-0.35)	2	--
Zinc *	110	1.5 (1.1-33)	1.1 (0.66-83.6)	119	54

* 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.

Referenced 2006 NPDES permit limits are listed as the lowest constituent permit limits for the SSFL

Table 14b: Estimated Constituent Concentrations from Native Soils in Storm Water following the Topanga Fire

Metal	SSFL DTSC Pre Fire Background Soil Comparison Concentration (mg/kg)	SSFL Background Location Post-Fire Soil Concentration Average (Range) (mg/kg)	Post-Fire SSFL TSS Associated Storm Water Concentration, North Slope [TSS 264 (19-4,000) (mg/L)] (µg/L)	Post-Fire SSFL TSS Associated Storm Water Concentration, South Slope [TSS 1,300 (mg/L)] (µg/L)	2006 NPES Daily Maximum Permit Level (µg/L)	2006 NPDES Monthly Average Permit Limit (µg/L)
Antimony	8.7	1.2 (0.8-1.7)	0.3 (0.02-5.0)	1.6 (0.02-6.8)	6	--
Arsenic *	15	4.9 (2.7-11)	1.3 (0.1-20)	6.4 (0.05-44)	10	--
Barium *	140	83 (59-110)	22 (1.6-330)	110 (1.1-440)	1000	--
Beryllium *	1.1	0.5 (0.5-0.6)	0.1 (0.01-2.1)	0.7 (0.01-2.5)	4	--
Boron **	9.7	4.5 (1.0-6.6)	1.2 (0.1-18)	5.8 (0.02-26)	1	--
Cadmium	1	0.5 (0.5-0.6)	0.1 (0.01-2.2)	0.7 (0.01-2.5)	4	2
Chromium *	36.8	16 (12-18)	4.2 (0.3-63)	21 (0.2-72)	16.3	8.1
Copper	29	10 (8-13)	2.7 (0.2-41)	13 (0.15-52)	14	7.1
Iron *	28000	17,200 (15,000-19,000)	4,500 (330-68700)	22,000 (290-76000)	300	--
Lead	34	16.6 (9.5-27)	4.4 (0.3-66)	22 (0.2-108)	5.2	2.6
Manganese *	495	320 (260-390)	85 (6.1-1280)	420 (5.0-1600)	50	--
Mercury	0.09	0.009 (0.003-0.7)	0.002 (0.001-0.04)	0.01 (0.0001-0.07)	0.1	0.05
Nickel *	29	14 (11-21)	3.6 (0.3-54)	18 (0.2-84)	96	35
Selenium *	0.655	1.6 (1.0-2.2)	0.4 (0.03-6.2)	2.0 (0.02-8.8)	8.2	4.1
Silver *	0.79	0.6 (0.4-0.9)	0.2 (0.01-2.5)	0.8 (0.01-3.5)	4.1	2
Thallium	0.46	2.8 (1.8-4.5)	0.8 (0.1-11)	3.7 (0.03-18)	2	--
Zinc *	110	59 (51-67)	15 (1.1-230)	76 (1.0-270)	119	54

Note: Only one post fire TSS data point is available for south slope outfalls, and was taken at Outfall 008 on October 15, 2005.

* 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.

Referenced 2006 NPDES permit limits are the lowest constituent permit limits for the SSFL.

As seen above in Table 14b, post-fire estimated storm water concentrations from the erosion of native soils at the SSFL may exceed the Metals TMDL concentration-based waste load allocations for copper, lead, and zinc in the Los Angeles River at Wardlow and for selenium in Reach 6 of the Los Angeles River.¹³ Again, the presence of ash in storm water runoff could result in even higher concentrations of these constituents than are shown in Table 14b.

Concentrations of dioxin in storm water that would result from the presence of soil in storm water can be estimated in a similar manner, as shown in Table 15. This estimate shows that even pre-fire, background soil dioxin concentrations could result in exceedances of permit limits for dioxin. Post-fire, these concentrations would increase by about an order of magnitude. Because measured dioxin concentrations in ash samples collected from DTSC

¹³ The Los Angeles River Metals TMDL wet weather concentration-based WLAs for the Los Angeles River at Wardlow are: cadmium= 3.1 (µg/L), copper = 17 (µg/L), lead = 62 (µg/L), and zinc = 159 (µg/L). The dry weather concentration-based WLA for selenium in Reach 6 of the Los Angeles River is 5 (µg/L). (Los Angeles River Metals TMDL Staff Report)

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 comparable to those measured in off-site soils and ash, indicating that this phenomenon is not unique to the SSFL site.

Table 15: Estimated SSFL Native Soils Storm Water Dioxin Load

	TSS Distribution [Geometric Mean (Range)] (mg/L)	SSFL Background Dioxin Soil Concentration (ng(TEQ)/kg)	Range of Dioxin TSS Associated Storm Water Concentrations (µg/L)	2006 NPDES Daily Maximum Permit Level (µg/L)	2006 NPDES Monthly Average Permit Limit (µg/L)
Pre-Fire North Slope	13 (5-300)	0.29 (0-0.98)	Non Detect to 2.9×10^{-7}	2.8×10^{-8}	1.4×10^{-8}
Pre-Fire South Slope	9 (6-760)	0.29 (0-0.98)	Non Detect to 7.4×10^{-7}		
Post-Fire North Slope	264 (19-4000)	0.53 (0.12-1.3)	2.3×10^{-9} to 5.2×10^{-6}		
Post-Fire South Slope	13000	0.53 (0.12-1.3)	6.9×10^{-7}		

Note: Only one post fire TSS data point is available for south slope outfalls, and was taken at Outfall 008 on October 15, 2005.

3.4 COMPARISON OF STORM WATER RUNOFF FROM SSFL WITH STORM WATER RUNOFF FROM VARIOUS LAND USE TYPES AND WITHIN RECEIVING WATERS WITHIN THE LOS ANGELES REGION

3.4.1 Concentrations of Metals in storm water runoff from SSFL, from Los Angeles Region land use types, and within receiving waters

The concentrations of metals in storm water discharges from the SSFL can be compared to storm water runoff from regional catchments affected by wildfires, storm water discharges from other land use types, and from other facilities within the Region. As an example, see Figures 5, 6, and 7, which provide a summary of measured copper, lead, and zinc concentrations in storm water, including the computed average and observed range in concentrations. Data sets were collected by Boeing and by the Los Angeles County Department of Public Works and are described below.

Data shown in Figures 5, 6, and 7 are characterized as follows:

- **Boeing SSFL Storm Water Monitoring Data Set (blue diamond):** Storm water monitoring data from samples collected from September 2004 to November 2005 were divided into three representative data sets, as follows:
 - Pre-fire samples from Outfalls 003-007 (86 samples for copper, 82 samples for lead, and 5 samples for zinc from October 2004 to April 2005)
 - Post-fire samples from Outfalls 003-007 (14 samples for copper, 13 samples for lead, and no samples for zinc from October to November 2005)

- 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 standard deviation, assuming data are normally distributed.
- **LACDPW Receiving Water Data (green triangle):** LACDPW collects storm water samples from the Los Angeles River at the Wardlow Gage Station (near the Los Angeles River estuary) and from Sawpit Creek, a catchment that is 98% open space and that is located in the foothills of the San Gabriel Mountains. The plot includes the average, minimum, and maximum measured concentrations for samples collected from October 1998 to January 2005 (Los Angeles River) and November 1998 to October 2001 (Sawpit Creek). Sampling data were taken from the LACDPW's annual storm water quality reports (on line at http://ladpw.org/wmd/NPDES/report_directory.cfm).
- **Boeing Post Chatsworth Topanga Fire Regional Drainage Storm Water Monitoring (purple circle):** This data set is described in Section 3.2.1, and laboratory data can be found in Table A-3 in Appendix A. A total of four surface water wet weather samples were collected from four sites in October 2005, following the Topanga Fire. (Note that surface water samples have been and will continue to be taken by Boeing at seven background sites in and around the SSFL. Two additional site locations are in the area of the 2005 Burbank (Harvard) Fire. These samples have been or will be analyzed for a variety of constituents, including metals, dioxins, TSS, pH, and nitrate, and results will be provided to the Regional Board when available.)

Analysis of the data discussed above assumed that non-detect values were half of the detection limit. [Reporting limit for copper = 5 (µg/L), lead = 5 (µg/L), and zinc = 50 (µg/L).]

Note that a similar comparison could not be made for mercury. LACDPW data could not be included, as the LACDPW laboratory analysis method for mercury uses a detection limit of 1 (µg/L). Almost all LACDPW samples resulted in non-detect levels of mercury (i.e., concentrations below 1 (µg/L)). Mercury concentrations in samples collected from the SSFL

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

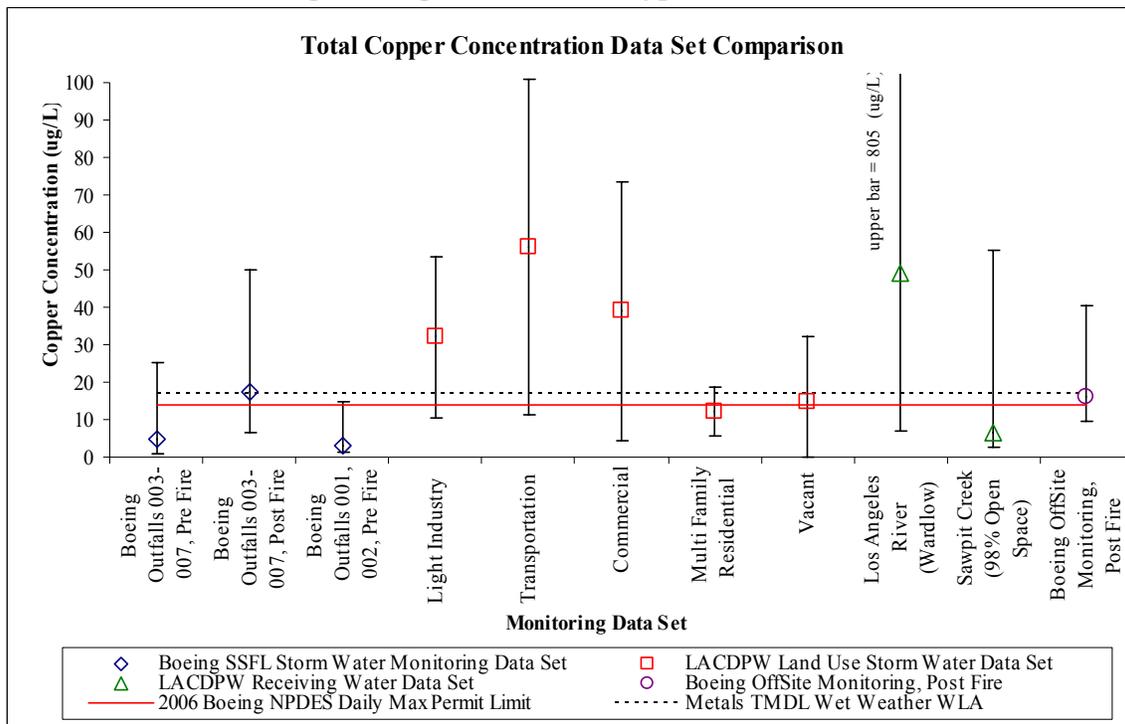
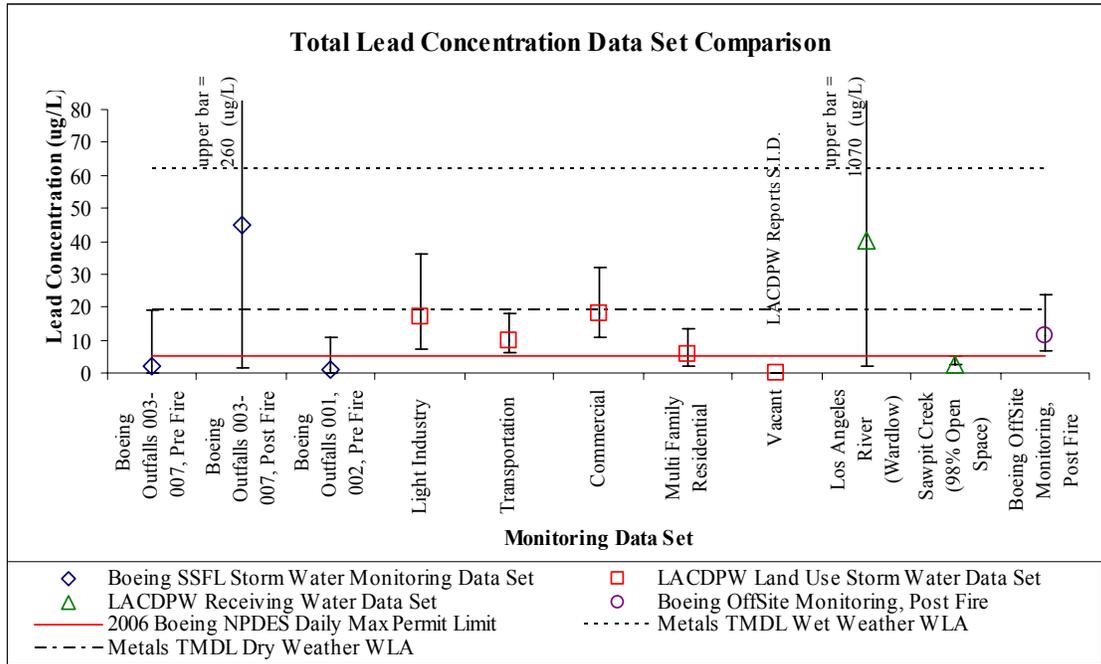
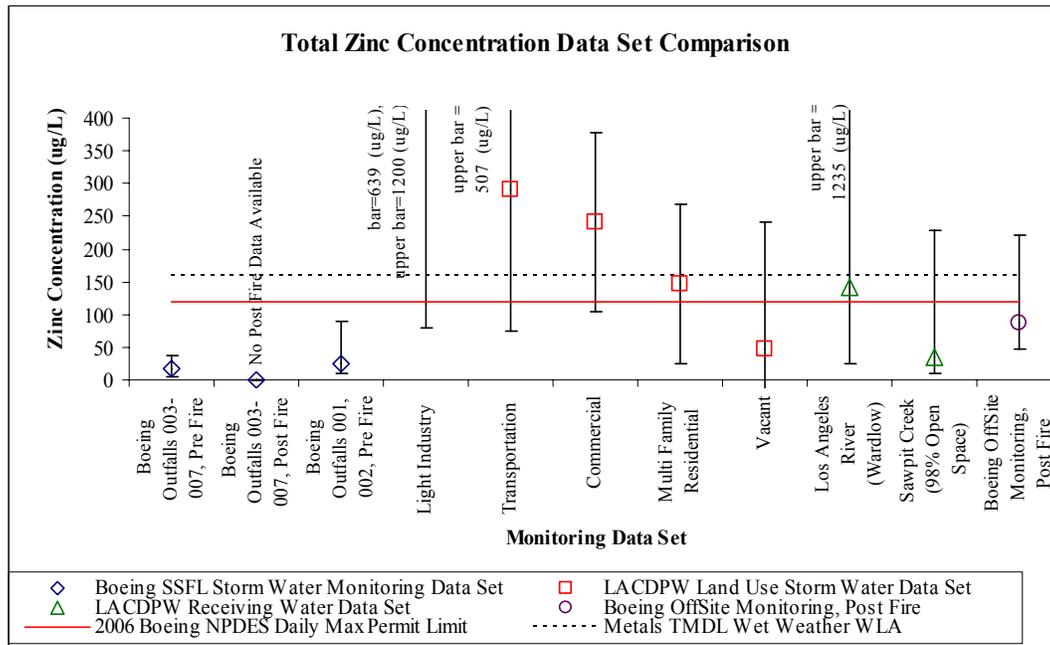


Figure 6: Total Lead Concentrations in Storm Water Runoff from the SSFL, from Los Angeles Region Land Use Types, and in Surface Water



S.I.D. = Statistically Invalid Data, not enough data above detection limit collected

Figure 7: Total Zinc 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 water runoff from SSFL, from Los Angeles Region land use types, and within receiving waters

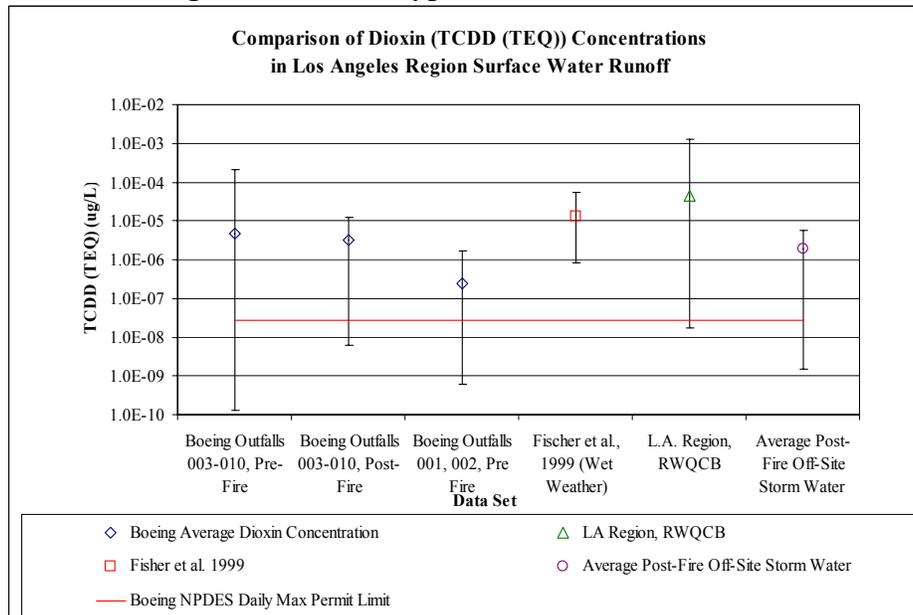
Figure 8 summarizes available information on dioxin concentrations in storm flows from industrial facilities and in urban runoff throughout the Los Angeles Region and in runoff from the SSFL site. Data shown in Figure 8 can be characterized as follows:

- **Boeing SSFL Storm Water Monitoring Data Set (blue diamond):** Storm water monitoring data from samples collected from September 2004 to November 2005 were divided into three representative data sets, as follows:
 - Pre-fire samples from Outfalls 003-007 (74 samples from October 2004 to April 2005)
 - Post-fire samples from Outfalls 003-007 (11 samples from October to November 2005)
 - Pre-fire samples from Outfalls 001 and 002 (31 samples 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.

- **Fisher et al., 1999, data set (red square):** Fisher et al. collected eighteen samples, including 12 dry weather samples and 6 wet weather samples, in 1988-1989, from 4 sampling sites in the Santa Monica Basin. The average, minimum, and maximum TCDD (TEQ) concentrations from wet weather events are shown in this figure.
- **Los Angeles Regional Board data set (green triangle):** The Los Angeles Regional Board issued a 13267 data request on August 3, 2001 requesting monitoring data for priority pollutants regulated pursuant to the California Toxics Rule, including TCDD (TEQ) (“dioxin”). Preliminary review of records received by the Los Angeles Regional Board for storm water samples collected by ten different permittees and at two nonpermitted sites are shown in Figure 8. This plot shows the preliminary data analysis for the average, minimum, and maximum concentrations from 38 samples collected at 21 sites between September 2001 and March 2005. Samples were collected during both wet and dry weather conditions from industrial process water, storm flow runoff, and receiving waters. (Note that Boeing participated in this survey and submitted data on dioxin concentrations measured in storm water from the SSFL. Samples results from samples collected by Boeing were not included in the data represented by the green triangle.)
- **Boeing Post Chatsworth Topanga Fire Regional Drainage Storm Water Monitoring (purple circle):** This data set is outlined in Section 3.2.1 with accompanying Table A-3 in Appendix A. Post Topanga Sampling occurred at four sites with a total of four surface water wet weather samples from October 2005.

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



As shown in Figure 8, dioxin concentrations in storm water runoff are highly variable, and average dioxin concentrations in storm water runoff from the SSFL site are lower than both average dioxin concentrations in wet weather samples collected in the Santa Monica Basin and average dioxin concentrations in industrial process water discharges, storm water discharges, and Los Angeles River receiving water samples reported to the Los Angeles Regional Board pursuant to a 13267 data request.

Fire effects on storm water runoff from the SSFL following the Topanga Fire of 2005 will likely be similar to effects of the Cerro Grande Fire that impacted LANL and surrounding lands. After the Cerro Grande Fire, increases in constituent concentrations and loads were observed over a multi-year time period for barium, iron, nitrates, manganese, arsenic, cyanide, cadmium, chromium, copper, lead, selenium, nickel, silver, thallium, zinc, and dioxins. At the SSFL, increases in concentrations of copper, mercury, antimony, and dioxin (and exceedances of NPDES permit limits) were noted in storm flows in October and November 2005. As discussed above, exceedances are likely for additional constituents following the fires.

4. RESULTS OF TESTS OF BMP AND HYDROMULCH MATERIALS

4.1 BMP AND HYDROMULCH MATERIALS TEST METHODOLOGY

Boeing conducted a series of tests in 2005 to estimate the concentrations of regulated constituents in various best management practice (BMP) materials and to facilitate selection of materials that would minimize the potential for exceedances of permit limits in storm water runoff from the SSFL site. BMP materials are used to manage and filter storm water runoff at multiple locations on the SSFL site.

A wide range of BMP materials were tested, including several types of sand and gravel. Hydromulch materials considered for use following the 2005 Topanga fire were also tested. Several testing procedures were followed for each type of material. For the sands, 200-gram samples were either leached using 200 milliliters of de-ionized water for a certain time period (i.e., the sample was mixed with de-ionized water and continually agitated), or samples were simply combined with the water, stirred once, and set aside to soak for a certain time period, as specified in Table 16. Following either leaching or soaking, the water was decanted and analyzed for a range of metals (both total and dissolved) and dioxin toxicity equivalent (TEQ). In some cases, the sand was rinsed with de-ionized water prior to leaching or soaking.

For the gravels, 200-gram samples were soaked in 200 milliliters of de-ionized water and set aside for a certain time period, decanted, and the water was analyzed for metals and dioxin TEQ. In some cases gravel samples were rinsed prior to soaking, and in some cases the decanted water was filtered prior to analysis, again leaving only dissolved constituents.

For hydromulch samples, generally, 50-gram samples of material were mixed with two liters of water and set aside to soak (for mercury analyses 10-gram samples were mixed with 200 milliliters of water, and for dissolved analyses 20-gram samples were mixed with two liters of water). After soaking, the solid and liquid were separated and each was analyzed individually (see Table 16). One hydromulch material—Soil Set—is a liquid, and so this material was simply analyzed in its liquid state. Table 16 summarizes the specific materials tested and those testing procedures that varied from sample to sample. Table 17 summarizes the specific regulated constituents analyzed for each sample, and corresponding SSFL 2006 NPDES Permit Limits.

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 x 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.

Results for each permitted constituent are presented in Table 18, and include the ratio of the tested concentration to the permit limit for each constituent. Cases where this ratio is greater than 1.0—i.e., where the soak test result for a particular BMP material exceeded the permit limit—are in boldface. Note that as shown in Appendix B, several test methods (particularly the leaching method) produced constituent concentrations far higher than those shown in Table 18. Although these test results are not believed to be as representative of materials emplaced at the SSFL as the results presented in Table 18, they do indicate that the BMP materials themselves contain significant quantities of the constituents regulated in storm water runoff from the SSFL site.

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
Hydromulch	Naka Hydroseed	590	6	98.33
Hydromulch	Soil Guard	9.1	6	1.52
Hydromulch	Soil Set	0.68	6	0.11
Hydromulch	Star Tak	0.65	6	0.11

Source: Boeing, 2005.

Table 18b– Contributions to ARSENIC 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	ND	50	0.00
Sand	Corona Filter Sand	14	50	0.28
Gravel	Birds Eye Gravel	13	50	0.26
Gravel	Pea Bag Gravel	70	50	1.40
Gravel	Road Gravel	11	50	0.22
Hydromulch	Applegate N/D	ND	50	0.00
Hydromulch	Applegate W/D	ND	50	0.00
Hydromulch	Eco Aegis	12	50	0.24
Hydromulch	Eco Blend	ND	50	0.00
Hydromulch	Eco Fibre	ND	50	0.00
Hydromulch	Mat Fibre	ND	50	0.00
Hydromulch	Naka Hydroseed	6.8	50	0.14
Hydromulch	Soil Guard	ND	50	0.00
Hydromulch	Soil Set	ND	50	0.00
Hydromulch	Star Tak	ND	50	0.00

Source: Boeing, 2005.

Table 18c – Contributions to BARIUM concentrations from BMP materials testing

BMP/Erosion Control Material Type	BMP Material	Concentration (mg/L)	SSFL 2006 NPDES Daily Max Permit Limit (µg/L)	Sample Result / Permit Limit
Sand	Colorado Filter Sand	0.056	1	0.06
Sand	Corona Filter Sand	0.052	1	0.05
Gravel	Birds Eye Gravel	0.32	1	0.32
Gravel	Pea Bag Gravel	0.78	1	0.78
Gravel	Road Gravel	0.23	1	0.23
Hydromulch	Applegate N/D	0.024	1	0.02
Hydromulch	Applegate W/D	0.016	1	0.02
Hydromulch	Eco Aegis	0.017	1	0.02
Hydromulch	Eco Blend	0.022	1	0.02
Hydromulch	Eco Fibre	0.029	1	0.03
Hydromulch	Mat Fibre	0.014	1	0.01
Hydromulch	Naka Hydroseed	0.050	1	0.05
Hydromulch	Soil Guard	0.064	1	0.06
Hydromulch	Soil Set	0.028	1	0.03
Hydromulch	Star Tak	ND	1	0.00

Source: Boeing, 2005.

Table 18d – Contributions to BERYLLIUM 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	ND	4	0.00
Sand	Corona Filter Sand	2.8	4	0.70
Gravel	Birds Eye Gravel	ND	4	0.00
Gravel	Pea Bag Gravel	3.3	4	0.83
Gravel	Road Gravel	1.1	4	0.28
Hydromulch	Applegate N/D	ND	4	0.00
Hydromulch	Applegate W/D	ND	4	0.00
Hydromulch	Eco Aegis	ND	4	0.00
Hydromulch	Eco Blend	ND	4	0.00
Hydromulch	Eco Fibre	ND	4	0.00
Hydromulch	Mat Fibre	ND	4	0.00
Hydromulch	Naka Hydroseed	ND	4	0.00
Hydromulch	Soil Guard	ND	4	0.00
Hydromulch	Soil Set	ND	4	0.00
Hydromulch	Star Tak	ND	4	0.00

Source: Boeing, 2005.

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

BMP/Erosion Control Material Type	BMP Material	Concentration (mg/L)	SSFL 2006 NPDES Daily Max Permit Limit (µg/L)	Sample Result / Permit Limit
Sand	Colorado Filter Sand	ND	1	--
Sand	Corona Filter Sand	ND	1	--
Gravel	Birds Eye Gravel	ND	1	--
Gravel	Pea Bag Gravel	0.064	1	0.06
Gravel	Road Gravel	0.010	1	0.01
Hydromulch	Applegate N/D	0.40	1	0.40
Hydromulch	Applegate W/D	0.17	1	0.17
Hydromulch	Eco Aegis	0.030	1	0.03
Hydromulch	Eco Blend	ND	1	--
Hydromulch	Eco Fibre	0.041	1	0.04
Hydromulch	Mat Fibre	ND	1	--
Hydromulch	Naka Hydroseed	0.057	1	0.06
Hydromulch	Soil Guard	0.012	1	0.01
Hydromulch	Soil Set	0.0084	1	0.01
Hydromulch	Star Tak	ND	1	--

Source: Boeing, 2005.

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 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	10	16.3	0.61
Sand	Corona Filter Sand	15	16.3	0.92
Gravel	Birds Eye Gravel	58	16.3	3.56
Gravel	Pea Bag Gravel	100	16.3	6.13
Gravel	Road Gravel	38	16.3	2.33
Hydromulch	Applegate N/D	2.0	16.3	0.12
Hydromulch	Applegate W/D	ND	16.3	0.00
Hydromulch	Eco Aegis	3.3	16.3	0.20
Hydromulch	Eco Blend	2.5	16.3	0.15
Hydromulch	Eco Fibre	4.0	16.3	0.25
Hydromulch	Mat Fibre	ND	16.3	0.00
Hydromulch	Naka Hydroseed	4.3	16.3	0.26
Hydromulch	Soil Guard	ND	16.3	0.00
Hydromulch	Soil Set	ND	16.3	0.00
Hydromulch	Star Tak	ND	16.3	0.00

Source: Boeing, 2005.

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
Gravel	Pea Bag Gravel	160	0.3	533.33
Gravel	Road Gravel	35	0.3	116.67
Hydromulch	Applegate N/D	0.22	0.3	0.73
Hydromulch	Applegate W/D	0.15	0.3	0.50
Hydromulch	Eco Aegis	0.42	0.3	1.40
Hydromulch	Eco Blend	0.057	0.3	0.19
Hydromulch	Eco Fibre	0.38	0.3	1.27
Hydromulch	Mat Fibre	0.061	0.3	0.20
Hydromulch	Naka Hydroseed	2.6	0.3	8.67
Hydromulch	Soil Guard	0.11	0.3	0.37
Hydromulch	Soil Set	0.46	0.3	1.53
Hydromulch	Star Tak	0.11	0.3	0.37

Source: Boeing, 2005.

Table 18i – Contributions to LEAD 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	6	5.2	1.21
Sand	Corona Filter Sand	2	5.2	0.29
Gravel	Birds Eye Gravel	8.1	5.2	1.56
Gravel	Pea Bag Gravel	87	5.2	16.73
Gravel	Road Gravel	19	5.2	3.65
Hydromulch	Applegate N/D	0.67	5.2	0.13
Hydromulch	Applegate W/D	0.56	5.2	0.11
Hydromulch	Eco Aegis	5.5	5.2	1.06
Hydromulch	Eco Blend	8.9	5.2	1.71
Hydromulch	Eco Fibre	2.9	5.2	0.56
Hydromulch	Mat Fibre	0.24	5.2	0.05
Hydromulch	Naka Hydroseed	3.7	5.2	0.71
Hydromulch	Soil Guard	0.40	5.2	0.08
Hydromulch	Soil Set	2.5	5.2	0.48
Hydromulch	Star Tak	0.32	5.2	0.06

Source: Boeing, 2005.

Table 18j – Contributions to MANGANESE 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	61	50	1.22
Sand	Corona Filter Sand	140	50	2.80
Gravel	Birds Eye Gravel	400	50	8.00
Gravel	Pea Bag Gravel	3300	50	66.00
Gravel	Road Gravel	610	50	12.20
Hydromulch	Applegate N/D	65	50	1.30
Hydromulch	Applegate W/D	44	50	0.88
Hydromulch	Eco Aegis	300	50	6.00
Hydromulch	Eco Blend	63	50	1.26
Hydromulch	Eco Fibre	540	50	10.80
Hydromulch	Mat Fibre	67	50	1.34
Hydromulch	Naka Hydroseed	280	50	5.60
Hydromulch	Soil Guard	190	50	3.80
Hydromulch	Soil Set	33	50	0.66
Hydromulch	Star Tak	ND	50	0.00

Source: Boeing, 2005.

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 Type	BMP Material	Concentration (µg/L)	SSFL 2006 NPDES Daily Maximum Permit Limit	Sample Result / Permit Limit
Sand	Colorado Filter Sand	4	96	0.05
Sand	Corona Filter Sand	12	96	0.13
Gravel	Birds Eye Gravel	26	96	0.27
Gravel	Pea Bag Gravel	59	96	0.61
Gravel	Road Gravel	27	96	0.28
Hydromulch	Applegate N/D	ND	96	0.00
Hydromulch	Applegate W/D	ND	96	0.00
Hydromulch	Eco Aegis	ND	96	0.00
Hydromulch	Eco Blend	ND	96	0.00
Hydromulch	Eco Fibre	2.2	96	0.02
Hydromulch	Mat Fibre	ND	96	0.00
Hydromulch	Naka Hydroseed	4.1	96	0.04
Hydromulch	Soil Guard	3.4	96	0.04
Hydromulch	Soil Set	7.2	96	0.08
Hydromulch	Star Tak	ND	96	0.00

Source: Boeing, 2005.

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	4.1	0.00
Hydromulch	Star Tak	ND	4.1	0.00

Source: Boeing, 2005.

Table 18o – Contributions to THALLIUM 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	0.22	2	0.11
Sand	Corona Filter Sand	0.15	2	0.08
Gravel	Birds Eye Gravel	0.42	2	0.21
Gravel	Pea Bag Gravel	1.7	2	0.85
Gravel	Road Gravel	0.46	2	0.23
Hydromulch	Applegate N/D	ND	2	0.00
Hydromulch	Applegate W/D	ND	2	0.00
Hydromulch	Eco Aegis	ND	2	0.00
Hydromulch	Eco Blend	ND	2	0.00
Hydromulch	Eco Fibre	ND	2	0.00
Hydromulch	Mat Fibre	ND	2	0.00
Hydromulch	Naka Hydroseed	ND	2	0.00
Hydromulch	Soil Guard	ND	2	0.00
Hydromulch	Soil Set	ND	2	0.00
Hydromulch	Star Tak	ND	2	0.00

Source: Boeing, 2005.

Table 18p – Contributions to ZINC 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	38	119	0.32
Sand	Corona Filter Sand	88	119	0.74
Gravel	Birds Eye Gravel	83	119	0.70
Gravel	Pea Bag Gravel	590	119	4.96
Gravel	Road Gravel	110	119	0.92
Hydromulch	Applegate N/D	48	119	0.40
Hydromulch	Applegate W/D	22	119	0.18
Hydromulch	Eco Aegis	32	119	0.27
Hydromulch	Eco Blend	26	119	0.22
Hydromulch	Eco Fibre	41	119	0.34
Hydromulch	Mat Fibre	15	119	0.13
Hydromulch	Naka Hydroseed	51	119	0.43
Hydromulch	Soil Guard	67	119	0.56
Hydromulch	Soil Set	54	119	0.45
Hydromulch	Star Tak	ND	119	0.00

Source: Boeing, 2005.

Table 18q – Contributions to DIOXIN TEQ 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
Hydromulch	Star Tak	0.000012	0.000000028	429
Hydromulch	Eco Fibre	0.0000013	0.000000028	46
Hydromulch	Eco Aegis	0.0000077	0.000000028	275
Hydromulch	Applegate N/D	0.0000012	0.000000028	43
Hydromulch	Applegate W/D	0.0000021	0.000000028	75
Hydromulch	Soil Guard	0.0000033	0.000000028	118
Hydromulch	Mat Fibre	0.00000027	0.000000028	10
Hydromulch	Eco Blend	0.0000018	0.000000028	64

Source: Boeing, 2005.

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