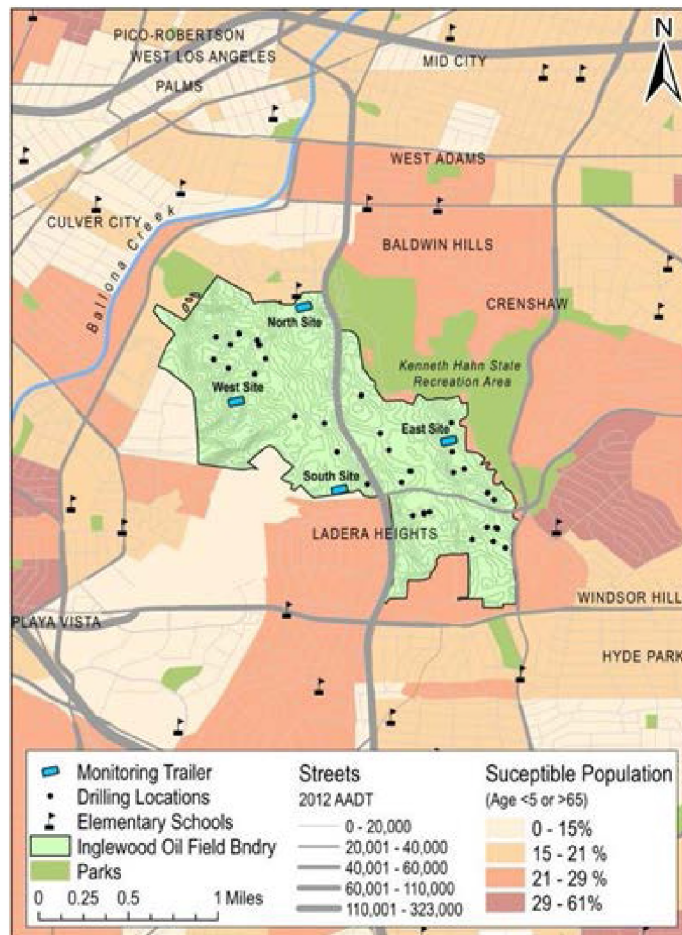


## Baldwin Hills Air Quality Study



Final Report prepared for

Los Angeles County  
Los Angeles, California

February 2015





# **Baldwin Hills Air Quality Study**

## **Final Report**

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## Executive Summary

### Overview

The Inglewood Oil Field operates within the Baldwin Hills Community Standards District (CSD) of Los Angeles County. The County commissioned the Baldwin Hills Air Quality Study as part of an agreement settling legal challenges to an Environmental Impact Report (EIR; Marine Research Specialists, 2008) concerning development at the Oil Field. Multiple community groups around the Oil Field were concerned with potential pollutant impacts due to Oil Field activities. Sonoma Technology, Inc. (STI) developed and conducted the Baldwin Hills Air Quality Study.

The Baldwin Hills Air Quality Study focused on two primary and two secondary objectives set forth by the settlement agreement.

- Primary project objectives
  - Quantify the air toxics emissions from the Inglewood Oil Field (referred to as Oil Field throughout this document) operations, including drilling and well workovers.
  - Assess the health risk of both acute and chronic exposure to air toxics emitted from Oil Field operations.
- Secondary project objectives
  - To the extent feasible, determine and distinguish the major sources of toxic air emission within the areas surrounding the Oil Field.
  - To the extent feasible, assess the Oil Field's contribution to the overall acute and chronic health risk in the areas surrounding the Oil Field.

The Inglewood Oil Field is one of many sources of air pollution within the South Coast Air Basin (Basin). The Basin is a highly urbanized area of over 17 million people. Emissions sources in the Basin include about 11 million motor vehicles and many industrial and commercial operations. The Inglewood Oil Field is located in the western, urbanized portion of the Basin surrounded by major freeways and bisected by La Cienega Boulevard, a busy arterial road. Major industrial emissions sources mostly lie to the south and southeast, and Los Angeles International Airport is about 4 miles to the south-southwest.

### Methods

STI considered the 37 air toxics emitted from the Oil Field and performed a hazard identification to prioritize the air toxics of greatest concern. STI used emissions values from the EIR to compare the pollutants' relative toxicities by weighting these emissions in relation to acute and chronic health benchmark levels from the California Office of Environmental Health Hazard Assessment (OEHHA). Chronic cancer potency risk factors and chronic and acute Reference Exposure Levels (RELs) were obtained from the OEHHA (California Environmental Protection Agency, 2011, 2014) <http://www.oehha.ca.gov/air/allrels.html>. Acute RELs can be either 1-hr, 8-hr, or 24-hr values; the lowest REL was chosen to provide a conservative estimate of acute toxicities. From this weighting of emissions rates, the pollutants were rank-ordered to prioritize the list. Key pollutants identified for characterization included diesel particulate matter

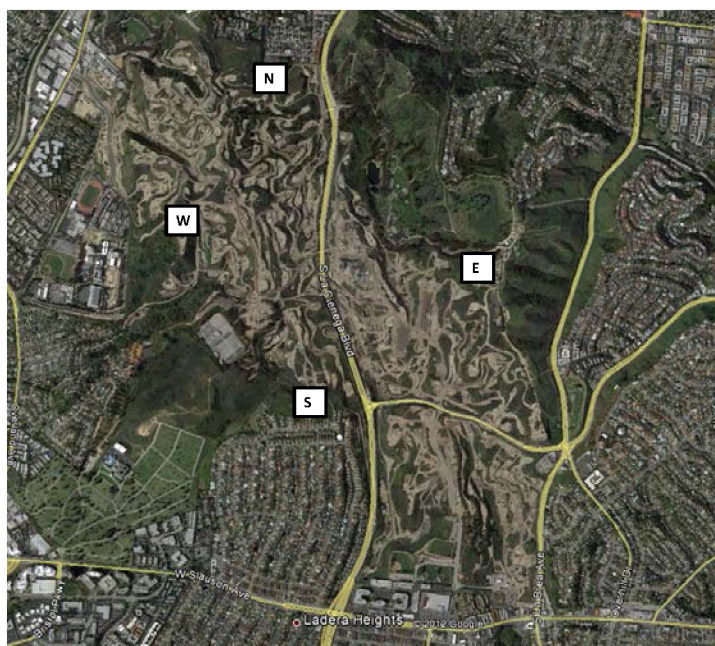
(DPM), cadmium, benzene, nickel, formaldehyde, mercury, manganese, acrolein, arsenic, and lead.

Four types of monitoring were used: (1) Aethalometers to measure black carbon (as a proxy for DPM); (2) X-ray fluorescence spectrometer (XRF) for metals; (3) Proton Transfer Reaction Time of Flight Mass Spectrometry (PTR-TOFMS) for VOCs; and (4) meteorological sensors to help assess the wind patterns, temperature, and humidity that might influence pollutant concentrations.

The field study began in November 2012 and ended in November 2013. **Table ES-1** shows the sampling durations and windows of operation for black carbon (BC), metals, and VOCs. A map of the monitoring locations is shown in **Figure ES-1**.

**Table ES-1.** The four monitoring sites at the Inglewood Oil Field, with corresponding windows of operations and sampling durations for BC (as a surrogate for DPM), metals, and VOCs.

Site Name	Window of Operation and Duration		
	BC	Metals	VOCs
North (N)	11/15/12–11/15/13 1 year	–	–
South (S)	11/15/12–11/15/13 1 year	–	–
East (E)	11/15/12–11/15/13 1 year	11/15/12 – 2/1/13 2.5 months	7/3/13–7/17/13 2 weeks
West (W)	11/15/12–11/15/13 1 year	–	–



**Figure ES-1.** Aerial view of the Inglewood Oil Field, showing the locations of the four monitoring sites: North (N), East (E), South (S), and West (W).



## Results

### Primary Objective 1 – Quantify the air toxics emissions from the Inglewood Oil Field operations, including drilling and well workovers.

STI determined that there were statistically significant increases in concentrations of DPM that are associated with Oil Field operations when winds are from the west-southwest. Black carbon (BC) concentrations increased by 0.036 to 0.056  $\mu\text{g}/\text{m}^3$  on average when winds originated from the west-southwest, compared to annual mean BC concentrations of approximately 0.67  $\mu\text{g}/\text{m}^3$ . West-southwest winds occurred 53% of the time during the study, primarily during daytime hours. BC concentrations across the Oil Field were higher during daytime and weekdays, which correlates with the timing of well workover and maintenance activities, and traffic patterns. BC concentrations declined across the Oil Field when winds were from the east-northeast, which occurred 25% of the time, primarily during nighttime hours. Winds from the north-northwest occurred only 7.8% of the time and were not associated with statistically significant changes in downwind concentrations. Winds from the south-southeast occurred 13.1% of the time and were associated with downwind increases of 0.01 to 0.03  $\mu\text{g}/\text{m}^3$ . In summary, the largest potential for increased exposures from Oil Field operations is found east-northeast of the Oil Field. Diesel emissions from the Oil Field represent a relatively small fraction of the overall health risk from air toxics (both for pollutants measured in this study and for those identified in the LA Basin MATES IV study). Diesel emissions from all sources translate into approximately 250 excess cancer risk per million, of which 6.7 per million are from the Oil Field operations.

Regarding excess cancer risk, the OEHHA states, “For chemicals that are listed as causing cancer, the “no significant risk level” is defined as the level of exposure that would result in not more than one excess case of cancer in 100,000 individuals exposed to the chemical over a 70-year lifetime. In other words, a person exposed to the chemical at the “no significant risk level” for 70 years would not have more than a “one in 100,000” chance of developing cancer as a result of that exposure.”<sup>1</sup> Therefore, 6.7 excess cancer risk per million is less than the OEHHA’s “no significant risk level.”

STI determined that Oil Field operations were associated with potential increases in nickel and manganese concentrations. Case study analysis showed that both of these pollutants were potentially associated with Oil Field operations. Contributions of the Oil Field were not quantified for nickel and manganese because the concentrations were well below dose-response levels of concern.

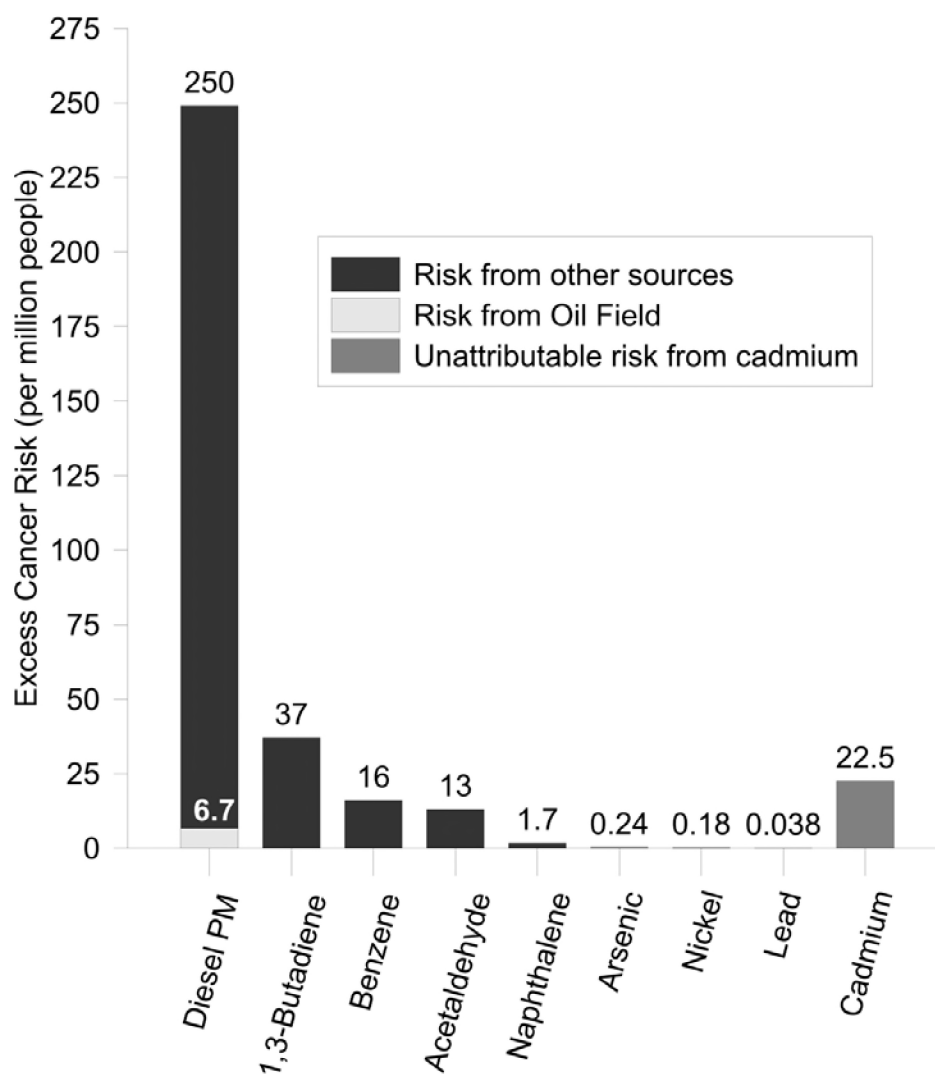
STI determined that Oil Field operations were associated with transient increases in concentrations of toluene, benzene, and acetaldehyde. These transient concentration increases were not large enough to be statistically quantifiable because of the infrequent occurrences during the course of the two-week deployment of the PTR-TOFMS.

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<sup>1</sup> See “Proposition 65 in Plain Language” at <http://www.oehha.ca.gov/prop65/background/p65plain.html>.

**Primary Objective 2 – Assess the health risk of both acute and chronic exposure to air toxics emitted from Oil Field operations.**

**Figure ES-2** shows that estimated diesel particulate matter concentrations in the area constitute the dominant contribution to excess cancer risk from ambient air. The relative contribution from the Oil Field is a small fraction of the total risk. Total risk estimates for each of the air toxics are in reasonable agreement with SCAQMD MATES IV draft estimates of excess cancer risk across the Los Angeles Basin, with the notable exception of cadmium. However, cadmium concentrations are over 50 times higher than the averages reported in MATES IV.



**Figure ES-2.** Individual pollutant contributions to total excess cancer risk (per million people) at the Baldwin Hills Air Quality Study. The graph shows total risk from ambient air and the incremental contribution of the Oil Field. Cadmium risk could not be attributed and should be verified by measurement intercomparisons.



For DPM, STI used black carbon (BC) as a proxy for DPM concentrations. We converted BC concentrations to DPM concentrations using a BC:EC conversion ratio of 1.5 and the EC:DPM conversion ratio of 0.82 from MATES IV. Cancer risk from DPM on the east side of the Oil Field was estimated to be 6.7 to 11.3 excess cancer cases per million as a result of Oil Field operations and roadway traffic. The lower estimate that does not include the possible influence of La Cienega Blvd. is 6.7-per-million excess cancer cases as a result of Oil Field operations. The Oil Field operations had no measurable impact for DPM on residents living west and south of the Oil Field, and an impact of less than 1-per-million excess cancer risk to residents living north of the Oil Field.

No other pollutants had strong statistical evidence of chronic or acute risk resulting from Oil Field operations. We found no evidence of contributions to other key species such as benzene, acetaldehyde, acrolein, or 1,3-butadiene. It is possible that the Oil Field operations could contribute significantly to some of these species, but we have no compelling evidence to suggest it does, based on the two weeks of VOC monitoring. Additionally, the concentrations observed at the Oil Field are generally consistent with concentrations observed in other parts of the Los Angeles Basin, suggesting that any possible contributions of the Oil Field are incremental or marginal, rather than a dominant local source. However, there is indirect and case-study evidence of potential chronic risk from Oil Field operations for other pollutants. These are quantified below.

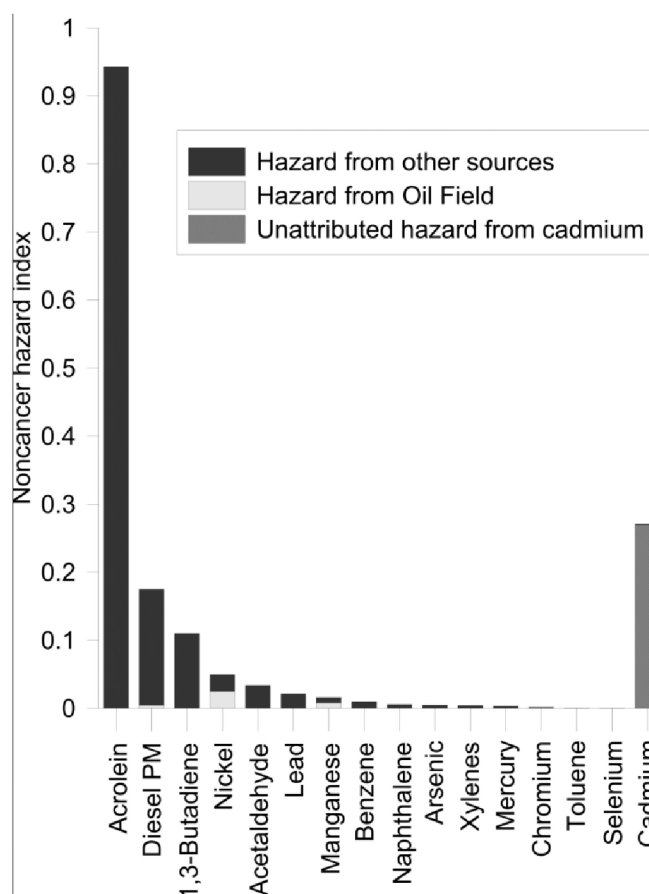
- Cadmium – Cadmium concentrations were not attributable to the Oil Field or other sources. First, the average concentration of cadmium was below the analytical method's method detection limit (MDL) of  $\sim 5.7 \text{ ng/m}^3$ , which indicates that the concentration is relatively uncertain for the 2.5-month monitoring period; 64% of all hourly values were below the MDL. Second, cadmium concentrations were not statistically associated with Oil Field operations (wind direction, time-of-day, or day-of-week). However, concentrations of cadmium were much higher than those measured in the SCAQMD's Multiple Air Toxics Exposure Study (MATES) III and draft MATES IV results,<sup>2</sup> which may indicate a local Oil Field contribution. If we assume the entire excess compared to the Los Angeles Basin background found in MATES IV is attributable to the Oil Field, about  $5 \text{ ng/m}^3$  would be from the Oil Field. It is also possible that methodological issues with the analytical technique may be yielding spuriously high concentrations. We note that internal calibrations of cadmium against a cadmium standard did not reveal any problems. Additional comparison of the XACT 625 XRF cadmium concentrations with concentrations using the methods from MATES IV should be performed to verify the reported concentrations.
- As mentioned above, cadmium concentrations measured at the Oil Field were higher than those reported in MATES III and IV. Given that the cadmium concentrations are about 50 times higher than those measured throughout the Los Angeles Basin in MATES IV's preliminary results, we suspect that the analytical methods employed in the two studies may not be comparable. The potential additional cancer risk from cadmium exposures is as much as an additional 22-per-million cancer risk. Note that this is a very conservative upper estimate that does not make any adjustments for seasonality or potential measurement uncertainty.

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<sup>2</sup> <http://www.aqmd.gov/home/library/air-quality-data-studies/health-studies/mates-iv>.

- Nickel – Oil Field operations may contribute to higher average nickel concentrations. However, average nickel concentrations were below the dose-response screening level for chronic cancer risk (1-in-a-million) and noncancer hazard (0.1 hazard index). Thus, total concentrations were not high enough to warrant further analysis. We also note that a single 1-hr average concentration of nickel exceeded the acute REL. Case study analysis showed that the winds associated with this hourly value were from the northeast and did not originate from the Oil Field.
- Manganese - Oil Field operations may contribute to higher average manganese concentrations. However, average manganese concentrations were below the dose-response screening level for noncancer hazard (0.1 hazard index). Thus, total concentrations were not high enough to warrant further analysis.

**Figure ES-3** shows chronic noncancer hazard quotients for pollutants measured at the Oil Field. A hazard quotient less than a value of one indicates that no adverse health effects are expected as a result of exposure. Only acrolein is near a value of one, and its contributions were not deemed to be originating from Oil Field sources. All other pollutants had hazard quotient values well below the threshold of adverse health effects.



**Figure ES-3.** Relative contributions to the chronic noncancer hazard index for the Baldwin Hills Air Quality Study. This graph shows total chronic noncancer hazard from ambient air and the incremental contribution of the Oil Field. If the noncancer hazard index is below a value of one, then no adverse effects are expected.

**Secondary Objective 1 - To the extent feasible, determine and distinguish the major sources of toxic air emission within the areas surrounding the Oil Field.**

The major sources of air toxics emissions within the areas including the Oil Field were expected to be Oil Field operations and traffic on La Cienega Blvd. Differential analysis of BC concentrations when winds were from the west-southwest showed that concentrations across the Oil Field and La Cienega Blvd. were higher, on average (East minus South pair), than those at the site pair that crossed the Oil Field and not La Cienega Blvd. (North minus West pair). The average difference between the two was  $0.02 \mu\text{g}/\text{m}^3$  of BC, which is equivalent to a 4.7-per-million cancer risk increase from the traffic on La Cienega. The total BC contribution from the Oil Field was  $0.036 \mu\text{g}/\text{m}^3$  when winds were from the west-southwest. When averaged across the yearly wind pattern climatology, this equates to a 6.7-per-million cancer risk increase (because winds were from west-southwest only 53% of the time). Oil Field BC contributions were higher on weekdays than weekends, and higher during the daytime hours than at night. This temporal pattern of higher daytime and weekday BC concentration differentials is consistent with the timing of the operation of Oil Field maintenance and workover rigs. Up to eight rigs were available, and they only operate Monday through Friday from 7:00 a.m. to 5:00 p.m. LST. This diurnal and weekday-weekend pattern is also consistent with heavy-duty truck traffic on surface streets on La Cienega Blvd. and Stocker St. Thus, the East minus South site comparison has an additional increment of diesel PM attributable to onroad vehicle emissions.

In addition to the quantifiable contributions of the Oil Field operations and traffic on La Cienega, case study analysis and receptor model source apportionment studies identified a few cases of transient high concentrations associated with individual operations of the Oil Field. For example, high concentrations of BC, acetaldehyde, acrolein, benzene, and toluene were associated with drilling operations near the East site on July 10 and 11, 2013. High manganese and nickel concentrations were sometimes associated with winds from the Oil Field, although no drilling operations were pinpointed that could be associated with them.

It was not feasible to distinguish other major sources of toxic air emissions in the areas surrounding the Oil Field with the available monitoring resources.

**Secondary Objective 2 - To the extent feasible, assess the Oil Field's contribution to the overall acute and chronic health risk in the areas surrounding the Oil Field.**

The total chronic health risk of all major pollutants targeted and quantified in the study is shown in Figures ES-2 and ES-3 for cancer risk and noncancer hazard, respectively.

Total cancer risk from the measured pollutants summed to 340-per-million people. 74% of the cancer risk was attributable to measured DPM concentrations. An estimate of the Oil Field operations is a contribution of about 6.7-per-million of the total additional cancer risk for residents on the east side of the Oil Field. Note that this incremental risk is likely an upper estimate of the risk for residents, since the DPM will be further diluted and dispersed as it is transported toward the communities east of the Oil Field.

The total chronic noncancer hazard for all major pollutants is shown in Figure ES-3. A noncancer hazard of 1.0 is considered the "health reference level" and is expected to be below

the level at which adverse human health effects would occur. Thus, acrolein, which has the highest noncancer hazard index at 0.94, is expected to have no adverse health impacts. However, we note that for most of the toxics shown in Figure ES-3, there is some additional uncertainty associated with the shorter sampling periods (2.5 months for metals, 2 weeks for VOCs); these values do not necessarily represent true annual mean concentrations. Additionally, we are considering each pollutant's effect individually; these pollutants may have additive or synergistic effects that would lead to higher estimated cumulative risks than the estimates shown below.

The sum of noncancer hazard effects summed across all pollutants is 1.65. The noncancer hazard potentially attributable to Oil Field operations is 0.0047 from DPM, less than 0.05 from nickel, and less than 0.016 from manganese. The total across all pollutants potentially associated with Oil Field operations is less than 0.2, which is below the expected level at which adverse chronic health effects would occur. Cadmium contributes an additional 0.27 noncancer hazard, but its source was not attributed. Nonetheless, it is also below the levels at which adverse chronic health effects would occur.

Finally, we found no evidence of acute concentrations exceeding the REL that were associated with Oil Field operations. The single 1-hr concentration of nickel that was above the 1-hr REL was associated with winds originating from outside of the Oil Field.

## 1. Introduction

The Inglewood Oil Field operates within the Baldwin Hills Community Standards District (CSD) of Los Angeles County. The County commissioned the Baldwin Hills Air Quality Study as part of an agreement settling legal challenges to an Environmental Impact Report (Marine Research Specialists, 2008) concerning development at the Oil Field. Multiple community groups around the Oil Field were concerned with potential pollutant impacts due to Oil Field activities. Sonoma Technology, Inc. (STI) developed and conducted the Baldwin Hills Air Quality Study.

### 1.1 Objectives

The Baldwin Hills Air Quality Study focused on two primary and two secondary objectives.

- Primary project objectives
  - Quantify the air toxics emissions from the Inglewood Oil Field (referred to as Oil Field throughout this document) operations, including drilling and well workovers.
  - Assess the health risk of both acute and chronic exposure to air toxics emitted from Oil Field operations.
- Secondary project objectives
  - To the extent feasible, determine and distinguish the major sources of toxic air emission within the areas surrounding the Oil Field.
  - To the extent feasible, assess the Oil Field's contribution to the overall acute and chronic health risk in the areas surrounding the Oil Field.

As summarized in the Baldwin Hills Community Standard's District Environmental Impact Report (EIR) (Marine Research Specialists, 2008), there are a number of air toxics of concern, including diesel particulate matter (DPM), trace metals, and gaseous volatile organic compounds (VOCs). These different pollutants cannot be measured with a single device, so multiple monitoring and analytical methods were needed. To quantify air toxics emissions from the Oil Field and to assess acute risk from the air toxics of concern, short duration samples were needed. To assess chronic risk, long-term averages that are representative of annual concentrations were needed. Characterizing both short- and long-term concentrations across the large number of air toxics emitted from the Oil Field required that we prioritize the air toxics of greatest concern. We also had to account for hourly and seasonal variations in meteorological patterns, which influence the dispersion and transport of Oil Field emissions to the surrounding community. The challenge of requiring multiple measurement methodologies and short sampling durations, while accounting for variable meteorology, is a common but difficult one.

### 1.2 Hazard Identification

STI considered 37 of the most important air toxics emitted from the Oil Field and performed a hazard identification to prioritize the air toxics of greatest concern. STI used



emissions values from the EIR to compare the pollutants' relative toxicities by weighting these emissions in relation to acute and chronic health benchmark levels from the California Office of Environmental Health Hazard Assessment (OEHHA). Chronic cancer potency risk factors and chronic and acute Reference Exposure Levels (RELs) were obtained from the OEHHA (California Environmental Protection Agency, 2011, 2014) [www.oehha.ca.gov/air/allrels.html](http://www.oehha.ca.gov/air/allrels.html). Acute RELs can be either 1-hr, 8-hr, or 24-hr values; the lowest REL was chosen to provide a conservative estimate of acute toxicities. From this weighting of emissions rates, the pollutants were rank-ordered to prioritize the list. **Table 1-1** shows the final result from this weighting scheme, with the top 13 pollutants listed. Note that this weighting was performed in early 2012, and RELs and cancer potency factors for some of the pollutants have changed since that time. See Section 2, Table 2-4 for the 2014 dose-response factors that are used in the final risk assessment.

For chronic cancer risk, DPM from the diesel generators is the most significant pollutant. This is consistent with the findings from the Multiple Air Toxics Exposure Study (MATES) III and IV, conducted by South Coast Air Quality Management District (SCAQMD), which found DPM (based on proxy measurements of elemental carbon) to be the most important toxic pollutant contributing to risk in the Los Angeles Basin (South Coast Air Quality Management District, 2008). In our analysis, the only other pollutants with cancer risks of 1% or more of the risk from DPM were cadmium (5%), benzene (2%), nickel (1%), and formaldehyde (1%). The cumulative risk from emissions of all other (non-DPM) pollutants was approximately 10% of the estimated risk from emissions of DPM.

For chronic noncancer risks, many pollutants were of similar importance. Nickel presented the highest risk, followed by DPM (86% of nickel), cadmium (78%), chlorine (67%), mercury (39%), formaldehyde (20%), manganese (17%), acrolein (14%), arsenic (13%), and lead (11%). These noncancer risks can be reproductive, respiratory, or neurological, or they may involve a host of other effects. The similar ranking across pollutants indicates that there is no single driver of chronic health impacts based on the emissions and that a number of pollutants may be important to monitor.

For acute noncancer risks, formaldehyde was the most important pollutant, followed by manganese (46% of formaldehyde). Mercury (10%), acrolein (10%), arsenic (5%), and nickel (4%) were also on the list but are of less importance. Acute effects occur on time scales shorter than one day.

The comparison of emissions from the 2005-2006 inventory shows that the key pollutant to measure from a toxicity standpoint is DPM. Unfortunately, no direct measurement method of DPM is possible (as discussed by MATES III), so a proxy was used to estimate DPM concentrations. After DPM, the key pollutants to measure included nickel, cadmium, benzene, formaldehyde, manganese, arsenic, acrolein, and mercury. However, the chemical and physical characteristics of these different pollutants required multiple measurement methodologies. Key pollutants other than DPM can be categorized as metals (nickel, arsenic, lead, manganese, and cadmium), hydrocarbons (benzene), and carbonyls (formaldehyde, acrolein). The results of the hazard identification and dose-response assessment drove our study methodology choices to focus on the key pollutants of concern from a health standpoint.

**Table 1-1.** List of key pollutants and their relative risk-weighted emissions toxicities based on the 2005-2006 EIR emissions and OEHHA dose-response factors from 2011.

Pollutant	Total Lbs/Year	Fraction from Drilling and Well Workovers	Cancer 1-in-a-Million Level <sup>1</sup> (µg/m <sup>3</sup> )	Acute REL (µg/m <sup>3</sup> )	Chronic REL (µg/m <sup>3</sup> )	Cancer Risk Relative to DPM	Chronic REL Relative to Nickel	Acute REL Relative to Formaldehyde	Cancer Rank	Chronic REL Rank	Acute REL Rank
Diesel Exhaust PM	1326.8	0.99	$3.3 \times 10^{-3}$	–	5	1.00	0.86	–	1	2	–
Cadmium	4.8	1.00	$2.4 \times 10^{-4}$	–	0.02	0.05	0.78	–	2	3	–
Formaldehyde	547.9	0.76	$1.7 \times 10^{-1}$	9	9	0.01	0.20	1.00	5	6	1
Nickel	15.3	1.00	$3.8 \times 10^{-3}$	6	0.05	0.01	1.00	0.04	4	1	6
Chlorine	41.6	1.00	–	210	0.2	–	0.67	0.00	–	4	9
Manganese	4.8	1.00	–	0.17	0.09	–	0.17	0.46	–	7	2
Mercury	3.6	1.00	–	0.6	0.03	–	0.39	0.10	–	5	3
Acrolein	14.7	0.70	–	2.5	0.35	–	0.14	0.10	–	8	4
Lead	5.1	1.00	$8.3 \times 10^{-2}$	–	0.15	0.00	0.11	–	–	10	–
Arsenic	0.6	1.00	$3.0 \times 10^{-4}$	0.2	0.015	0.00	0.13	0.05	6	9	5
Benzene	340.9	0.17	$3.4 \times 10^{-2}$	1300	60	0.02	0.02	0.00	3	11	8
PAHs	16.9	0.79	$9.1 \times 10^{-5}$	–	–	0.00	–	–	7	–	–
Acetaldehyde	215.9	0.96	$3.7 \times 10^{-1}$	470	140	0.00	0.01	0.01	8	12	7

PM: Particulate matter

PAHs: Polycyclic aromatic hydrocarbons

Cancer 1-in-a-million level: Concentration in µg/m<sup>3</sup> at which a 70-year exposure would result in one excess cancer case among 1 million people



## 1.3 Report Overview

- Section 2 of this report describes the study methodology, monitoring, timeline, and analysis methods used to address these complex issues.
- Section 3 describes the results of the study. The results are separated into sections based on the monitoring technology used to measure them; a final section describes the Oil Field's quantitative contribution to health risk.
- Section 4 discusses the study results and compares them to the project objectives.
- Section 5 lists the references used for the study.
- Appendix A provides additional well data, and Appendix B provides additional traffic data. Appendix C provides plots for all measured metals species, and Appendix D shows additional results from comparing VOC measurement methods.

## 2. Methods

### 2.1 Overview

In designing a monitoring plan that would yield high-quality data useful for evaluating the Oil Field's contribution to air toxics concentrations in surrounding communities, STI considered the influences of meteorology, topography, land area, and background concentrations from other sources. In addition, we considered the types and timing of Oil Field activities that generate different pollutants and the most appropriate monitoring methods for each pollutant. All these factors affected the frequency of sampling, the duration of sampling, and the placement of the monitors.

STI used a combination of monitoring methods to cover the primary pollutants that are likely to be emitted from the Inglewood Oil Field and have an adverse impact on human health.

1. Choose the best available monitoring methods applicable to the selected species for cost, reliability, detection limits, and overall data quality.
2. Select the monitoring locations, and determine the frequency, duration, and type of sampling to occur at each location. This includes evaluation of diurnal and seasonal meteorological patterns (primarily wind speed and wind direction), local topography, and the spatial distribution of wells, storage tanks, drilling locations, and other potential sources within the Oil Field.
3. Plan the sampling logistics (e.g., power availability, accessibility, and communications) and implement the monitoring.
4. Establish routine protocols with the Oil Field operators and Los Angeles County to maintain an up-to-date log of Oil Field activities that will be used, in conjunction with collected data, to assess Oil Field contributions.

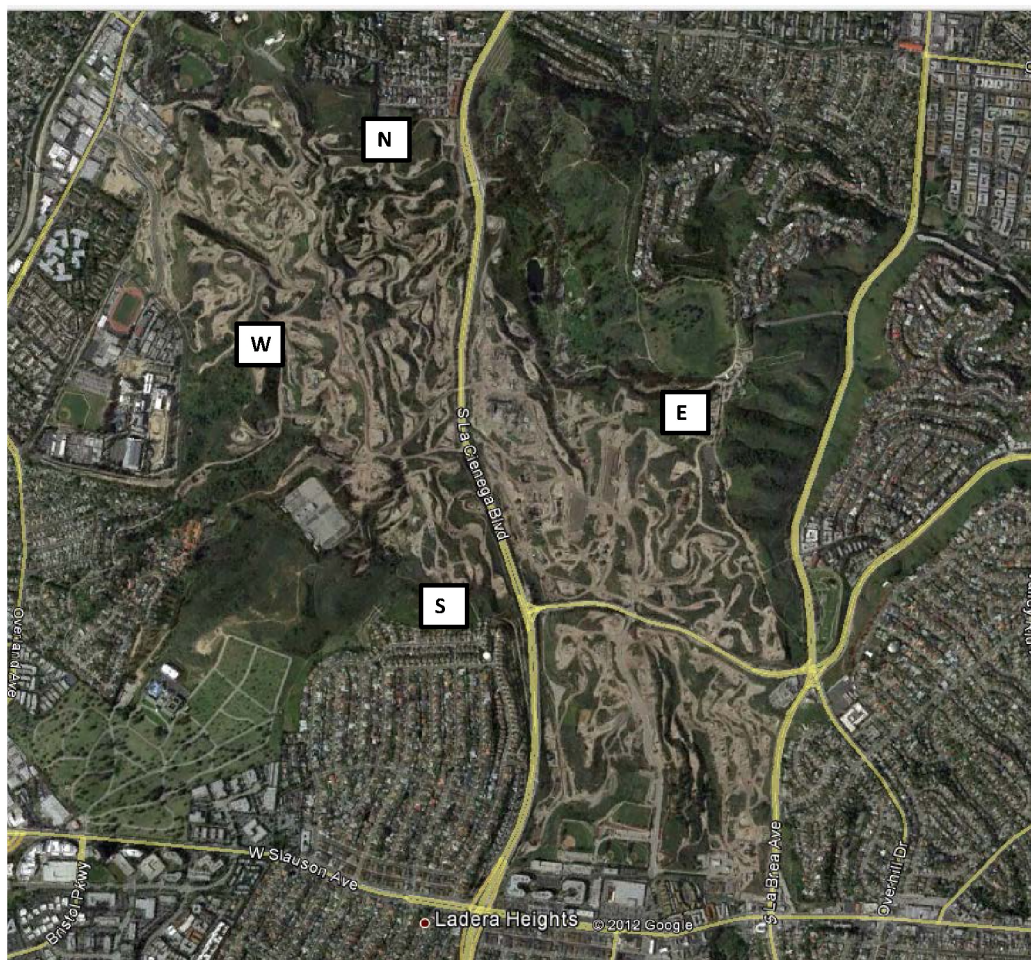
This section describes the monitoring locations (Section 2.2), timeline (Section 2.3), analytical methods (Section 2.4), the health risk assessment approach (Section 2.5), and the data analysis approach (Section 2.6) used to complete the project.

### 2.2 Locations

In determining the best locations for monitoring sites, STI considered the impact of meteorological patterns on the dispersion and transport of air toxics, as well as potential emissions from nearby roadways and other regional sources. Available meteorological data from the existing meteorological tower within the Oil Field, as well as data from the SCAQMD stations at LAX and at West Los Angeles, were evaluated for diurnal and seasonal wind patterns, and the placement of the monitors was based upon these documented wind flows. Local topography and existing obstructions that might influence wind patterns were also considered so that measurements would be made upwind and downwind of the Oil Field, whether the winds were from the west-southwest (onshore) or from the east-northeast (offshore).

Onsite inspections within the Oil Field were made to identify potential areas for monitoring that considered wind patterns, were accessible, and had or could have electrical power available. The decision on the number and placement of the monitors was based upon all the above factors, as well as official siting criteria for air quality monitoring established by the U.S. EPA (U.S. Environmental Protection Agency, 2006).

Four sites were chosen to conduct the continuous monitoring. **Figure 2-1** is an aerial view of the Inglewood Oil Field and neighboring communities. The four sites are shown in this figure, labeled North (N), East (E), South (S), and West (W). Each of these sites was equipped with cellular modems allowing sub-hourly data retrieval and remote access to instrumentation for diagnostics and troubleshooting.



**Figure 2-1.** Aerial view of the Inglewood Oil Field, showing the locations of the four monitoring sites: North (N), East (E), South (S), and West (W).

The primary monitoring site (Site E) was a small trailer that housed a Teledyne-API Model 633 Aethalometer for BC, the XACT 625 semi-continuous XRF spectrometer for metals during its deployment, and the PTR-TOFMS for VOCs during its deployment; the site also



hosted a tower with a full complement of meteorological instrumentation. This main monitoring station's site was chosen to reflect concentrations during both onshore and offshore wind flow conditions.

Besides the main site, three additional sites (N, S, and W) were established to support the semi-continuous Aethalometer measurements of BC. Their placement made it possible to obtain data from both upwind and downwind locations during both onshore and offshore wind flow conditions. **Table 2-1** lists the locations of all monitoring sites and measurements for the study.

**Table 2-1.** Names, locations, and elevations of the four monitoring sites at the Inglewood Oil Field.

Site Name	Location <sup>a</sup> (Lat/Lon)	Elevation (ft)	Pollutants Monitored
North (N)	34° 00' 48" N 118° 22' 37" W	271	BC for 1 year
South (S)	33° 59' 55" N 118° 22' 23" W	375	BC for 1 year
East (E)	34° 00' 18" N 118° 21' 51" W	503	BC for 1 year Metals <sup>b</sup> for 2.5 months VOCs for 2 weeks
West (W)	34° 00' 20" N 118° 22' 53" W	402	BC for 1 year

<sup>a</sup> Latitude and longitude are given to the nearest minute

<sup>b</sup> The plan was to operate a minimum of one month during active drilling operations at each of Sites S and E; however, it was apparent that the South site was rarely downwind of the Oil Field, so the metals monitor was left at the East site where it was frequently downwind of the Oil Field.

## 2.3 Timeline

The field study began in November 2012 and ended in November 2013. **Table 2-2** shows the sampling durations and windows of operation for BC, metals, and VOCs. Details of the analytical methods are provided in Section 2.4.

## 2.4 Analytical Methods

Four types of monitoring were used: (1) Aethalometers to measure black carbon (as a proxy for DPM); (2) X-ray fluorescence spectrometer (XRF) for metals; (3) Proton Transfer Reaction Time of Flight Mass Spectrometry (PTR-TOFMS) for VOCs; and (4) meteorological sensors.

**Table 2-2.** The four monitoring sites at the Inglewood Oil Field, with corresponding windows of operations and sampling durations for BC (as a surrogate for DPM), metals, and VOCs.

Site Name	Window of Operation and Duration		
	BC	Metals	VOCs
North (N)	11/15/12–11/15/13 1 year	–	–
South (S)	11/15/12–11/15/13 1 year	–	–
East (E)	11/15/12–11/15/13 1 year	11/15/12 – 2/1/13 2.5 months	7/3/13–7/16/13 2 weeks
West (W)	11/15/12–11/15/13 1 year	–	–

### 2.4.1 Aethalometer (Black Carbon)

DPM emissions ranked highest among the air toxics of concern associated with activities at the Oil Field. We studied DPM by measuring its surrogate, black carbon (BC) at the four monitoring sites for one year. This amount of continuous (hourly) BC data is enough to represent seasonal variability in DPM concentrations, differences between workdays and non-workdays, and upwind/downwind differences under various meteorological conditions.

Teledyne-API Model 633 dual wavelength Aethalometers were deployed in enclosures at the monitoring sites. These instruments measure the light transmittance through a collection spot on a reel-to-reel filter tape and report data at 5-minute intervals. The aerosol is collected on an area of quartz fiber filter at a moderate face velocity. The sample air stream is drawn through the filter by a continuously operating pump. The optical attenuation of the aerosol deposit on the filter is measured by detecting the intensity of light transmitted through the spot on the filter. Measurements are corrected for optical saturation by using two collection spots where data are collected at different flow rates. Quality control protocols for the Aethalometer BC measurements rely on review of raw data, remotely, on a daily or more frequent basis, as well as routine field maintenance procedures and associated record-keeping.

An integral part of the monitoring study was a web-based data retrieval system to allow routine viewing of real-time BC (and meteorological) data. Data were retrieved from each BC monitoring site frequently (typically, every 10 minutes) by cell phone modem and transferred to STI's web server; the data then underwent auto-screening quality assurance procedures and were posted in graphical format to a password-protected web page for viewing by authorized personnel.

Regularly scheduled site visits were made for routine maintenance, including tape changes (the filter tape that collects BC samples), inlet cleaning, flow checks with a certified reference flow meter, and troubleshooting.

The hourly BC data was further quality-assured by a visual inspection of minimum and maximum data values, stuck values, and baseline shift, as well as by direct comparison with other concurrently measured air quality and meteorological data. The validated BC data were compared to activity logs of the Oil Field for qualitative evaluation of potential sources.

#### **2.4.2 X-Ray Fluorescence Spectrometer (Metals)**

To determine the impact of metal emissions from the Oil Field on the surrounding community, we used a specialized instrument, the XACT 625 semi-continuous X-ray fluorescence spectrometer (XRF). The instrument quantified a suite of 24 metals on an hourly basis for a period of about 2.5 months.

The XACT 625 automated multi-metals monitor is based on reel-to-reel filter tape sampling followed by nondestructive XRF analysis of metals in the resulting particulate matter (PM) deposit (Yadav et al., 2009; Caudill, 2012). The XACT can simultaneously measure up to 24 elements with an atomic number between potassium and uranium. Ambient air is sampled through a PM size-selective inlet and drawn through a filter tape. The resulting PM deposit is then automatically advanced and analyzed by XRF for selected metals while the next sample is being collected. Sampling and analysis is performed continuously and simultaneously, except for the time required to advance the tape (about 20 seconds) and the time required for daily automated quality assurance checks, which were typically performed around midnight each day.

The monitoring plan for metals focused on a 2.5-month period instead of an entire year because the XACT 625 is costly to operate. However, it offered a viable alternative to longer-term 24-hr filter-based sampling and revealed detailed information on the contribution of the Oil Field to this group of elements.

Dr. Rick Peltier of the University of Massachusetts at Amherst was primarily responsible for setting up the XACT 625 spectrometer, overseeing operations, and ensuring daily quality control. He had remote access to the XACT data and most instrument functions on a daily basis. Field support, when needed, was available from STI staff.

The instrument followed a regular protocol of quality assurance by checking energy levels (based on a measurement of pure palladium) during each hourly sample run. Once per day, a more comprehensive QA protocol ran by sequentially quantifying four pure standardized reference materials (Pd, Cr, Cd, Pb) for approximately 7 minutes each ("Upscale Calibration"). These data were reported and reviewed each day to ensure that data were reported accurately and there were no short-term instrument malfunctions or long-term instrument degradation. Sample flow rates were measured by an independent set of flow monitors, each of which has been calibrated against a NIST-traceable primary standard.

#### **2.4.3 PTR-TOFMS (Volatile Organic Compounds)**

VOCs are on the list of air toxics of concern (see Section 1.2), with benzene, formaldehyde, acetaldehyde, and acrolein. Additional species, including 1,3-butadiene, gas-phase naphthalene, toluene, and xylenes were targeted because, although they are lower priority, they potentially represent specific sources among the pollutants ranking fairly high on

the list. A Proton Transfer Reaction Time of Flight Mass Spectrometer (PTR-TOFMS), which offers low detection limits and high time resolution, was deployed to measure these key species.

The Ionicon PTR-TOFMS 8000 is based on whole air sampling through a standard Teflon inlet tube followed by ionization of analytes by proton transfer from  $\text{H}_3\text{O}^+$  to all compounds with a higher proton affinity than water (Jordan et al., 2009). This includes aromatics, most alkenes, aldehydes, ketones, and some longer chain alkanes. Molecular ionization is “soft,” causing minimal fragmentation of molecules. After ionization, molecular ions are pulsed into a time-of-flight mass spectrometer capable of measuring the mass of the parent ion at a resolution of  $5000 \text{ m}/\Delta\text{m}$  (0.02 mass units at a mass of 100 atomic mass units).

The PTR-TOFMS can simultaneously measure dozens of compounds. Sampling and analysis were performed continuously except for the time required for intermittent background checks and calibrations. Background checks were conducted by passing ambient air through a catalytic converter removing all VOCs, and calibrations were done by sending a commercial calibration mixture of aromatic compounds to the instrument at various dilution ratios.

Dr. Shane Murphy of the University of Wyoming deployed and operated the PTR-TOFMS to measure VOC pollutants at 10-second intervals for two weeks. The deployment was brief because the PTR-TOFMS instrument is costly to operate. However, the PTR-TOFMS measurement methodology has the advantages of very high time resolution, more sensitive measurement capabilities, more data (approximately 4,000 measurements over two weeks), and a larger set of compounds (25 target species) compared to other methods. **Table 2-3** lists the pollutants that were measured and some typical sources. This list includes many of the VOCs that we expected to find in the study location, as well as other VOCs that can be used to identify emissions signatures of other sources that might impact the monitoring site. Uncertainties were set as 20% of the measured value. Values for each species are provided in arbitrary units unique to the PTR-TOFMS. In addition, seven species had calibrations performed to provide data in ppb: butadiene, acrolein, benzene, toluene, xylenes, naphthalene, and acetaldehyde.

**Table 2-3.** List of pollutants targeted during this study and their typical sources.

Compound	Sources
Formaldehyde	Photo-oxidation, vehicle emissions, diesel generators
Acetaldehyde	Photo-oxidation, vehicle emissions, diesel generators
Acrolein	Butadiene photo-oxidation, vehicle emissions, diesel generators
Benzene	Vehicle emissions, oil and gas extraction, gas stations, industrial
Toluene	Vehicle emissions, oil and gas extraction, gas stations, industrial
Xylenes and ethylbenzene (isomers)	Vehicle emissions, oil and gas extraction, gas stations, industrial
1,3-Butadiene	Vehicle emissions, industrial, diesel generators
Methyl ethyl ketone	Photo-oxidation
Naphthalene	Vehicle emissions



Five pairs of 24-hr air samples were collected during the two-week monitoring period and were analyzed by GC-FID (TO-14; University of Wyoming) and GC-MS (TO-15; SCAQMD). For the PTR-TOFMS, although some isomeric compounds such as ethylbenzene and the xylenes are indistinguishable, they can be measured as a sum of species. The PTR-TOFMS data for these five days were averaged to match the 24-hr samples and the results were compared. The PTR-TOFMS average concentrations were similar to both the University of Wyoming and SCAQMD results for most species. Overall, these results suggest that the PTR-TOFMS measurements are similar to more regulatory methods, but yield higher-time-resolution data. Appendix D shows the results for these comparisons.

## 2.4.4 Meteorological Variables

A 10-meter meteorological tower was erected next to the trailer at the East site. The tower was equipped with the following RM Young sensors:

- 05305V Wind monitor (wind speed/wind direction)
- 41382VC Temperature and RH sensor
- 41342VC Platinum temperature probes at 2 heights (for Delta-T, a measure of atmospheric mixing)
- 61302V Barometric pressure sensor
- 70201 Solar radiation sensor

All of these sensors collected at 1-minute average duration.

## 2.5 Health Risk Assessment

Health risk assessment comprises four steps, as described by the National Research Council and adopted by the California Office of Health Hazard Assessment (OEHHA) (National Research Council, 1983; California Environmental Protection Agency, 2001):

1. **Hazard identification.** Identify pollutants of potential concern and their associated health impacts.
2. **Dose-response assessment.** Use quantitative benchmark levels to assess risk.
3. **Exposure assessment.** Assess how people are exposed to a pollutant, at what levels, and for how long.
4. **Risk characterization.** Synthesizing the three previous steps, quantitatively evaluate a pollutant's potential to cause illness or disease in the population.

STI followed the health risk assessment protocol to characterize the risk from the ambient air around the Oil Field. Concentration contributions of the Oil Field were determined through the data analyses described in Section 3. These contributions are compared to background Los Angeles Basin levels to assess the relative level of cancer risk and noncancer hazard from the Oil Field compared to other sources in the area.

### 2.5.1 Hazard Identification

For the hazard identification, STI used the 2005-2006 Oil Field emissions used in the Baldwin Hills Community Standards District Environmental Impact Report (Marine Research Specialists, 2008). The EIR lists all toxic air contaminant emissions in pounds per year reported to the SCAQMD.

### 2.5.2 Dose-Response Assessment

STI used dose-response factors recommended by California OEHHA. Measured pollutant dose-response factors are listed in **Table 2-4**. Chronic risk factors and RELs consider a person's lifetime exposure to the pollutant, while acute RELs consider average exposures for 1 hour or 8 hours.

**Table 2-4.** Dose-response factors for target pollutants measured in this study from OEHHA (March 2014).

Pollutant	Cancer ( $\mu\text{g}/\text{m}^3$ for 1-in-a-million risk)	Acute REL ( $\mu\text{g}/\text{m}^3$ )	Chronic REL ( $\mu\text{g}/\text{m}^3$ )
1,3-butadiene	$5.88 \times 10^{-3}$	9	2
Acetaldehyde	$3.70 \times 10^{-1}$	470	140
Acrolein		2.5	0.35
Arsenic	$3.03 \times 10^{-4}$	0.015	0.015
Benzene	$3.45 \times 10^{-2}$	1300	60
Cadmium	$2.38 \times 10^{-4}$		0.02
Diesel exhaust PM	$3.33 \times 10^{-3}$		5
Formaldehyde	$1.67 \times 10^{-1}$	9	9
Lead	$8.33 \times 10^{-2}$		0.15
Manganese		0.17	0.09
Mercury		0.06	0.03
Naphthalene	$2.94 \times 10^{-2}$		9
Nickel	$3.85 \times 10^{-3}$	0.2	0.06
Toluene		37000	300
Xylenes		22000	700

### 2.5.3 Exposure Assessment

In this step of the health risk assessment, STI assessed pathways of exposure, such as inhalation, soil contamination, groundwater, sediment, or contamination of the food chain, to residents of the Baldwin Hills area. Most of the pollutants of interest are transported primarily through the air, and the exposure route of concern is outdoor and indoor inhalation. However, for a subset of the toxic air pollutants, it is plausible that other pathways of exposure may contribute significantly to total risk; we did not evaluate these other pathways.

For the inhalation exposure, we calculated the mean concentrations and maximum 1-hr concentrations for each pollutant with chronic or acute dose-response factors. In addition, average and maximum contributions from the Oil Field were calculated for each target pollutant. These were used to estimate the average and maximum Oil Field contribution to total risk for each pollutant.

## **2.5.4 Risk Characterization**

Risk characterization is a synthesis of the hazard identification, dose-response assessment, and exposure assessment tasks. For the primary risk assessment, we multiplied the observed mean concentrations and maximum observed concentrations calculated per Section 2.5.3 against dose-response factors from Table 2-4. We then used the estimated contributions by pollutant to quantify the absolute and percentage contribution of the Oil Field.

## **2.6 Data Analysis**

Analysis methods for ascertaining the Oil Field's contribution to overall ambient concentrations include (1) diurnal pattern analysis (2) EPA Positive Matrix Factorization (PMF), (3) pollution roses, (4) differential comparisons, and (5) case studies. These methods are briefly described below.

### **2.6.1 Diurnal Pattern Analysis**

Diurnal patterns are characterized using box plots to determine whether concentrations are higher during certain hours of the day. Some pollutants associated with Oil Field activities, such as drilling or well workovers, are associated with daytime hours. Diurnal patterns of each pollutant will be compared to the diurnal patterns listed in McCarthy et al. (2007) and used to categorize possible activities that may be associated with Oil Field operations.

### **2.6.2 Positive Matrix Factorization**

EPA PMF is a freely available multivariate factor analysis tool developed by STI and the EPA (Norris et al., 2008). The tool assigns observed pollutant concentrations to the most likely source types and quantifies the relative contributions of the air pollution sources to ambient air quality. The tool decomposes a matrix of speciated sample data into two matrices—factor contributions and factor profiles—and an analyst then examines the results while considering source-specific tracer species, wind direction, and proximity and direction of local sources to interpret what source types are represented.

PMF uses the variation of each species (by wind direction or by season, for example) and the relative uncertainty across species to determine “factors,” or groups of species, that might be analogous to sources such as vehicle exhaust. These factors are mathematically determined from the variation of individual species over time and with each other. For example, if several species vary together since they are all components of dust emitted from soil disturbances, they are likely to be grouped together as a factor.

Factor profiles are unique ratios of the pollutants. The factor contributions indicate the relative amount of that factor that was apportioned for a given sample.

### 2.6.3 Pollution Roses

Pollution roses illustrate the correlation of pollutant concentrations with wind direction, thus helping analysts identify the wind directions from which concentrations are highest and the direction of likely sources. Petals of the pollution rose point toward the direction from which the wind originates, and their length shows how often the wind comes from that direction.

### 2.6.4 Differential Comparisons

Black carbon concentrations are measured at four sites across the Oil Field. When segregated by wind direction, concentrations at sites upwind as air enters the Oil Field and downwind along the direction of the wind can be treated as a differential. Concentrations at the upwind site are subtracted from the concentrations at the downwind site to assess the contribution of the Oil Field. Since there are four sites, two comparisons are available for each of the two predominant wind directions (winds from west-southwest and from east-northeast).

### 2.6.5 Case Study Analysis

The case study analysis looks at specific cases where a given pollutant was high. Analysts examine wind direction and Oil Field activity to see if there is a correlation between the high concentrations and activity.

## 2.7 Supplementary Emissions Activity Analysis

The Oil Field contribution to DPM is complicated by diesel traffic on La Cienega Boulevard and Stocker Street and by traffic and emissions from diesel engines on drill and workover rigs within the Oil Field itself. Marine Research Specialists provided improved emissions activity data to help STI better identify whether emissions were originating from the Oil Field or other sources (see **Appendices A and B**). Emission inventory activity information included:

- A week of daily and diurnal traffic activity data with vehicle classification by axle length. Vehicles were classified into heavy-duty and light-duty vehicles. Data for three street links were provided:
  - La Cienega Blvd. south of Stocker St.
  - La Cienega Blvd. north of Stocker St.
  - Stocker St.
- A week of gate activity for vehicles entering the Oil Field, classified by heavy-duty and light-duty vehicles. The onfield speed limit is 15 MPH, but no additional activity (e.g., mileage, idling) was available. Gate activity was provided at two gates:
  - Stocker
  - Fairfax

- Onfield operational emissions activity information for drill rigs, workover rigs, and maintenance rigs classified by their distance from the East and North monitoring sites.
  - *One drill rig* – operated 24 hours a day, 7 days of week when drilling, with a diesel particulate filter achieving 90% reduction in PM emissions.
  - *Up to eight (average of six) workover and maintenance rigs* – operated 7:00 a.m. to 5:00 p.m. Monday through Friday. Diesel particulate filters (DPF) were not routinely available on these rigs, but most had Tier 3 or Tier 4 standard on-road diesel engines. **Table 2-5** provides a complete list of rigs, but individual rig activities or locations on the Oil Field are not available.

**Table 2-5.** Workover and maintenance rigs operated on weekdays from 7:00 a.m. to 5:00 p.m.

Rig No.	Standard	DPF/Catalyst
Rig 1011	Tier 3	
Rig 1061	Tier 3	
Rig 0358	Tier 3	
Rig 1068	Tier 3	With DPF and Catalyst
Rig 1069	Tier 3	With DPF and Catalyst
Rig 30	Tier 3	
Rig 36	Tier 3	
Rig 83	Tier 3	With DPF and Catalyst
Rig 94	Tier 4	
Rig 95	Tier 4	
Rig 96	Tier 4	
Rig 1	Tier 3	
Rig 2	Tier 3	
Rig 4	Tier 3	
Rig 5	Tier 3	
Rig 6	Tier 3	
Rig 7	Tier 4	
Rig 8	Tier 2	
Rig 9	Tier 4	

STI used this emissions activity information by time-of-day and day-of-week to clarify refined calculations of the relative contribution of Oil Field sources to DPM air concentrations. STI also refined calculations of the cancer risk from DPM and revised the Study final report to describe this additional data and the resulting calculations and results.





## 3. Results

Analysis results are segregated by monitoring method and then by the risk characterization. First, we discuss Aethalometer BC measurements (proxy for DPM), then XRF trace metals, and then PTR-TOFMS VOCs. Lastly, we discuss the risks and hazards associated with each of our target pollutants and the contribution of the Oil Field operations to those risks.

### 3.1 Aethalometer Black Carbon (Proxy for DPM)

#### 3.1.1 BC Diurnal Patterns by Season

Measurements of BC were examined for diurnal and seasonal patterns that can be associated with emissions activities. **Figure 3-1** shows the notched box whisker plots for the months of December, March, June, and September at the East site. These four months were used to represent the four seasons – data for other months during each season were similar. Box whisker plots show the average concentration (red dot), the median concentration (center of the notch), the interquartile range (end of the boxes), 1.5 times the interquartile range (error bars), and outliers (asterisks and circles).

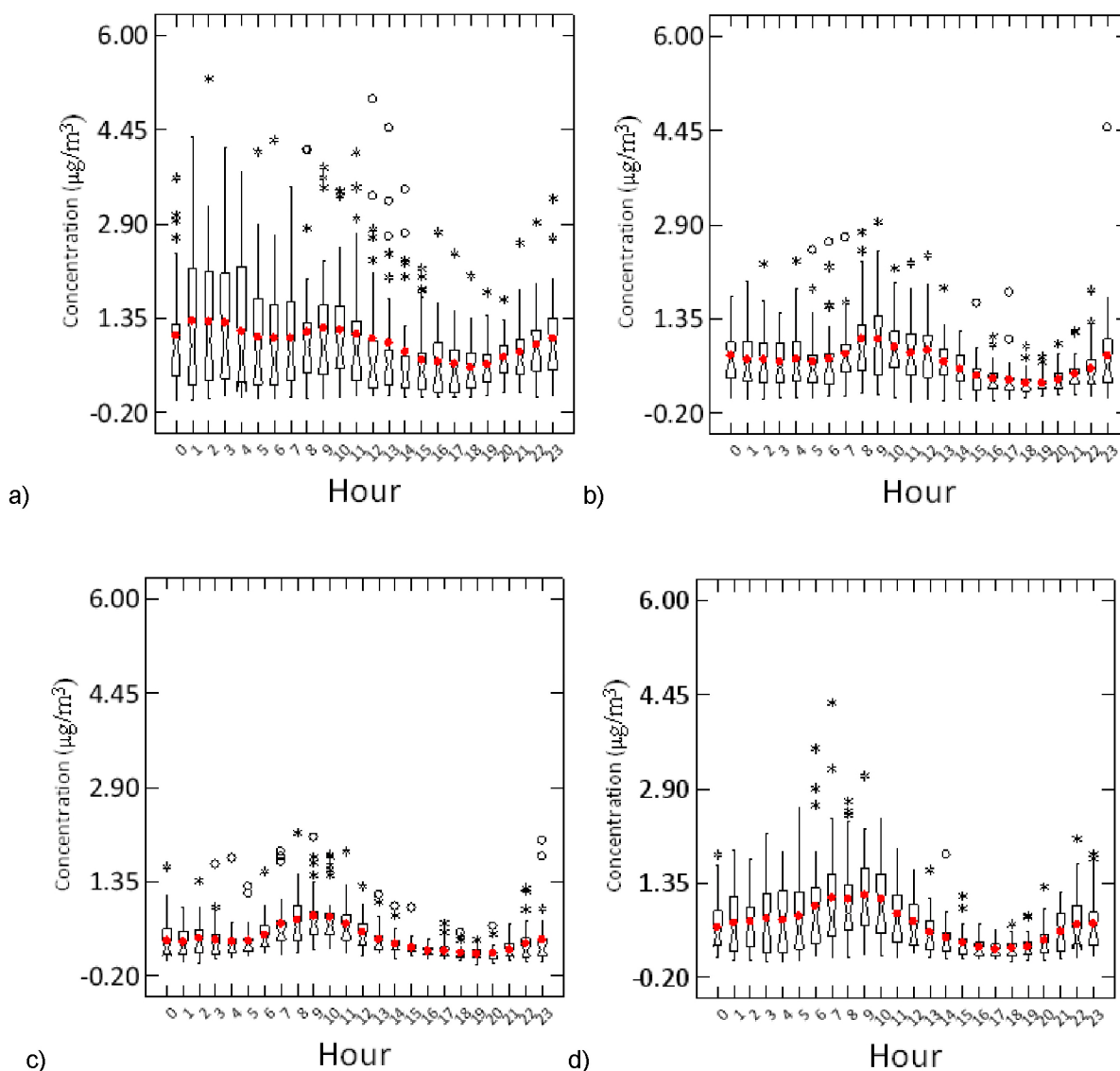
In all months, mean concentrations have a peak in the morning hours (0800 to 1000 LST; local standard time), which is likely associated with rush hour emissions in the Los Angeles Basin and weak morning wind speeds. In December and other winter months, there is also a peak in overnight concentrations. In the other seasons, the concentrations overnight are not as high as the rush hour peak. In all seasons, concentrations drop off after the rush hour peak through an early evening minimum concentration at about 1800 LST. On average, wintertime concentrations are highest and summer concentrations are lowest. All other sites (North, West, and South) had very similar diurnal and seasonal profiles.

Statistics for all hours across all sites are summarized in **Table 3-1**. Average concentrations at each site were between 0.64 and 0.724  $\mu\text{g}/\text{m}^3$ , with narrow confidence intervals. Median, 10<sup>th</sup>, and 90<sup>th</sup> percentile concentrations were also quite similar at all sites, although the West site did have somewhat higher average, median, and 90<sup>th</sup> percentile BC concentration values than the others.

#### 3.1.2 Pollution Roses

Pollution roses display the directions from which the wind originates and the distribution of concentrations associated with that direction. These plots can be used to identify directions associated with higher concentrations of a given pollutant; further analysis can be used to assess if a particular emissions source is associated with that direction.

**Figure 3-2** shows pollution roses for BC at the East site for the months of December, March, June, and September. Wind petals indicate the direction from which winds originate. Winds in the winter months are almost evenly distributed between west-southwest and east-northeast. In other months, winds come predominantly from the west-southwest as a result of

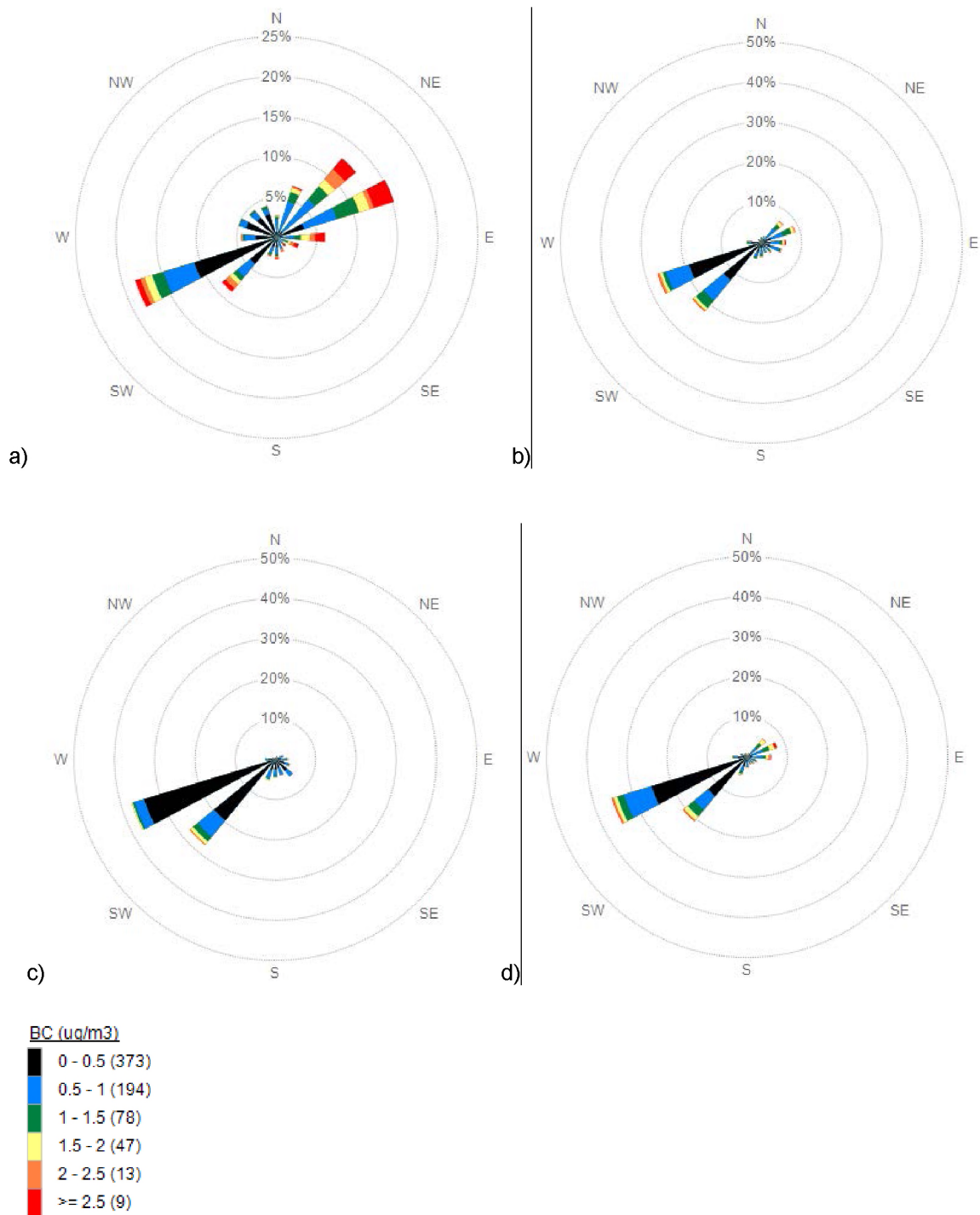


**Figure 3-1.** Box-notch whisker plots of the diurnal profile of BC concentrations ( $\mu\text{g}/\text{m}^3$ ) at the East site in (a) December, (b) March, (c) June, and (d) September.

**Table 3-1.** Summary of statistics for BC concentrations ( $\mu\text{g}/\text{m}^3$ ) at each site for the entire monitoring period.

Site	Count of Valid Hours	Average ( $\mu\text{g}/\text{m}^3$ )	Median ( $\mu\text{g}/\text{m}^3$ )	10 <sup>th</sup> Percentile ( $\mu\text{g}/\text{m}^3$ )	90 <sup>th</sup> Percentile ( $\mu\text{g}/\text{m}^3$ )	Maximum ( $\mu\text{g}/\text{m}^3$ )	95% Confidence Interval ( $\mu\text{g}/\text{m}^3$ )
East	8748	0.676	0.474	0.144	1.467	6.328	0.013
South	7945	0.641	0.423	0.128	1.434	7.761	0.015
West	8405	0.724	0.491	0.143	1.611	8.355	0.015
North	8588	0.672	0.455	0.132	1.474	9.286	0.015





**Figure 3-2.** Pollution roses for BC ( $\mu\text{g}/\text{m}^3$ ) at the East site for the months of (a) December, (b) March, (c) June, and (d) September. The legend shows the concentration bins of BC, which are the same across all months; the numbers in parentheses indicate the number of hourly observations in each bin for the month of September.

onshore flow. Of most interest, the offshore flows from the east-northeast include higher BC concentrations on average than the west-southwest winds coming from the coast. This is not unexpected, as winds originating inland represent emissions for the majority of the Los Angeles area.

Additionally, the offshore flow during the winter months typically occurs overnight, when concentrations at the East site are highest (as shown in Figure 3-1). Concentrations are also slightly higher when the wind is from the southwest rather than the west-southwest; however, southwesterly winds occur about half as often as winds occur from the west-southwest.

### 3.1.3 Differential Comparisons

Concentration gradients segregated by wind directions were used to assess the potential contribution of the Oil Field to BC concentrations on a seasonal and diurnal basis. Based on the pollution roses analysis, winds were segregated into two categories. In both cases, winds at the two pairs of sites were used to represent upwind and downwind BC concentrations. The upwind site concentration was subtracted from the downwind site concentration as listed below for both wind bins and site pairs.

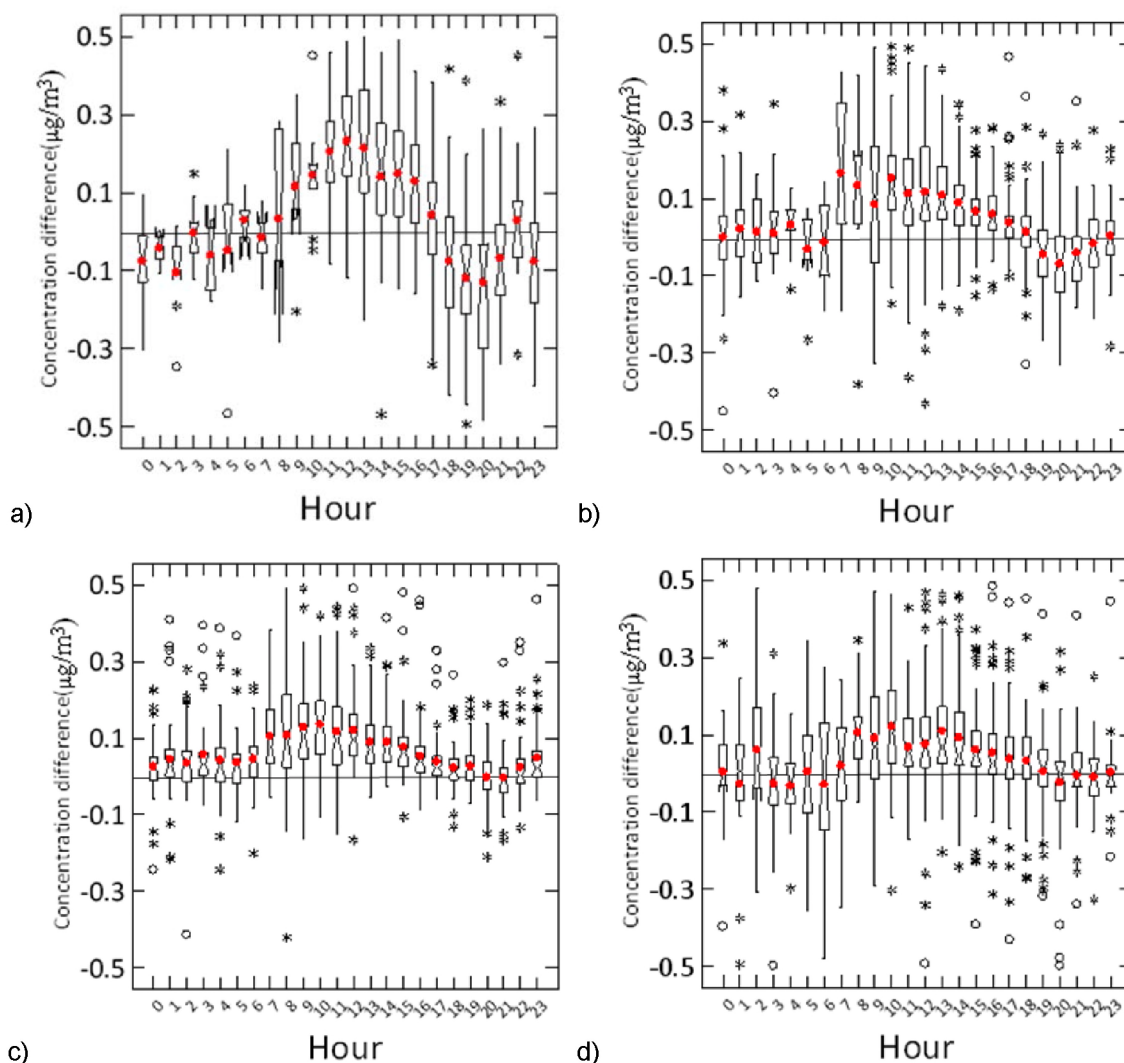
- West-southwest – winds originating between 210° and 300°
  - Pair 1: East minus South
  - Pair 2: North minus West
- East-northeast – winds originating between 30° and 120°
  - Pair 1: South minus East
  - Pair 2: West minus North

Results are shown for the seasonal averages (DJF, MAM, JJA, SON) and with diurnal patterns to assess contributions as a function of season and time of day. **Figure 3-3** shows the seasonal patterns for the East minus South pair. In each plot, the average concentration differential during the overnight hours is typically centered on a value of 0  $\mu\text{g}/\text{m}^3$ , indicating no difference between the upwind and downwind sites. During the daytime hours, the average concentration differential is above 0.1  $\mu\text{g}/\text{m}^3$  for a significant portion of the hours from 0800 to 1200, with declining values thereafter. This differential indicates that daytime concentrations across the Oil Field are higher, likely as a result of Oil Field operations and traffic on La Cienega Blvd.

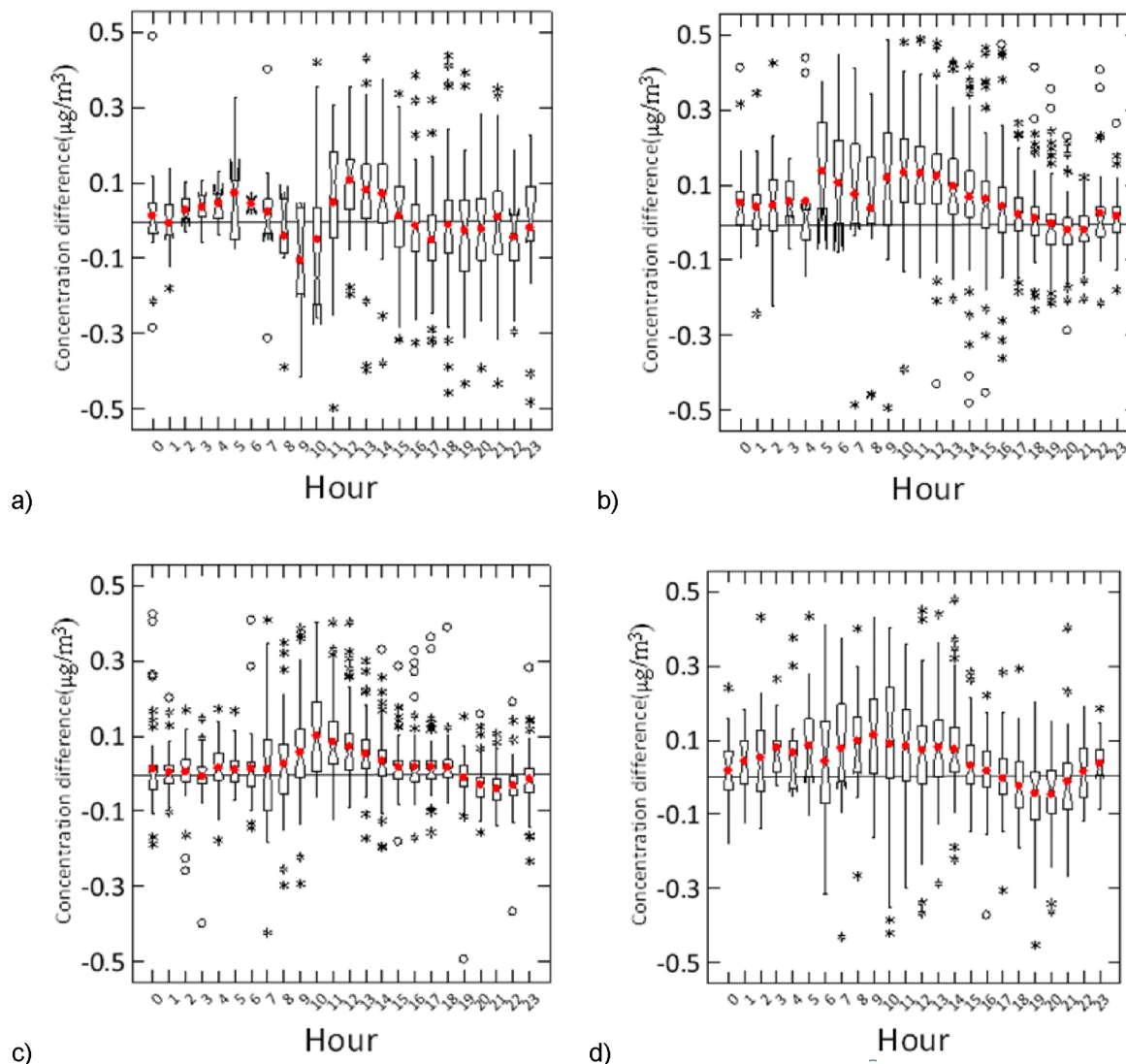
**Figure 3-4** shows the same set of figures for the North minus West pair differentials. The overall pattern for the concentrations is similar, with higher concentrations across the Oil Field during the daytime hours and small or no concentration gradients overnight. Overall, the differential is slightly smaller for the North minus West pair than the East minus South pair. One plausible explanation is that traffic on La Cienega Blvd. is contributing to the differential at the East minus South pair; this road does not influence the North minus West pair differentials because it is not between those two sites.

**Figure 3-5** shows the concentration differential for east-northeast winds in the winter and spring at the South minus East pair and in the winter and autumn at the West minus North pair. First, it is important to note that the frequency of east-northeast winds is much lower than

the frequency of west-southwest winds, leading to wider confidence intervals around the mean concentration differential (i.e., less certainty). Secondly, some daytime hours in the spring and fall had no east-northeast winds, leaving gaps in the diurnal patterns. Third, the summer months had very few east-northeast winds and are thus not shown. Overall, the overnight concentration differentials for both site pairs are centered on a value slightly below zero ( $-0.03 \mu\text{g}/\text{m}^3$ ), indicating that the upwind sites were similar, but slightly higher in concentration than the downwind sites under easterly flow. Daytime concentrations are more uncertain because of less frequent easterly winds. At the South minus East pair, daytime concentrations were significantly more negative than overnight concentrations, indicating lower downwind concentrations during the day. At the West minus North pair, daytime concentrations were about the same at both sites in the winter, and were insignificantly negative during the fall.

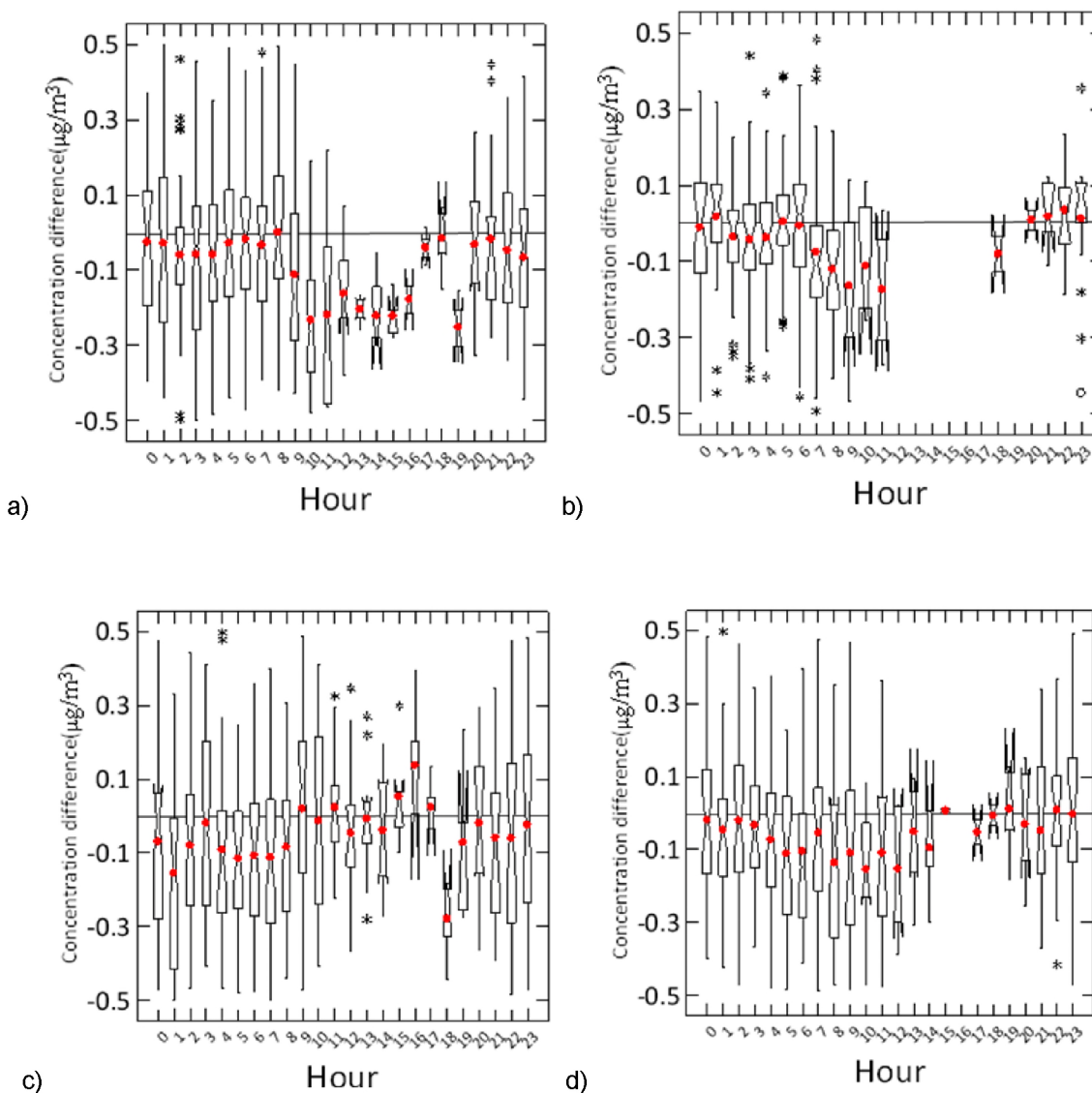


**Figure 3-3.** Diurnal differential analysis plots showing relative BC concentrations ( $\mu\text{g}/\text{m}^3$ ) at the East minus South pair under west-southwest conditions (winds between  $210^\circ$  and  $300^\circ$ ) for the seasons of (a) Dec., Jan., Feb.; (b) March, April, May; (c) June, July, Aug.; and (d) Sept., Oct., Nov. Positive concentrations indicate higher concentrations at the downwind site across the Oil Field.



**Figure 3-4.** Diurnal differential analysis plots showing relative BC concentrations ( $\mu\text{g}/\text{m}^3$ ) at the West minus North pair under west-southwest conditions (winds between  $210^\circ$  and  $300^\circ$ ) for the seasons of (a) Dec., Jan., Feb.; (b) March, April, May; (c) June, July, Aug.; and (d) Sept., Oct., Nov. Positive concentrations indicate higher concentrations at the downwind site across the Oil Field.

The differential analysis plots provide evidence that is consistent with the hypothesis that Oil Field operations are contributing to overall BC concentrations during daytime hours when the winds are from the west-southwest. Overnight concentration differentials show no evidence of Oil Field contributions regardless of wind directions. Winds from the east-northeast do not consistently indicate Oil Field impacts downwind during the daytime hours.



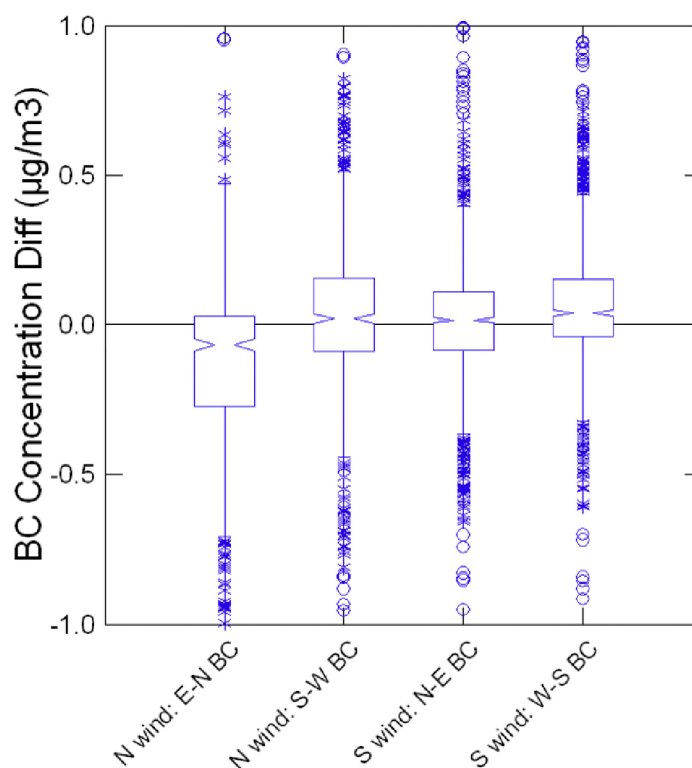
**Figure 3-5.** Diurnal differential analysis plots showing relative BC concentrations ( $\mu\text{g}/\text{m}^3$ ) at the South minus East pair under east-northeast conditions (winds between  $210^\circ$  and  $300^\circ$ ) for the seasons of (a) Dec., Jan., Feb. and (b) March, April, May; and at the West minus North pair for the seasons of (c) Dec., Jan., Feb. and (d) Sept., Oct., Nov. Negative concentrations indicate lower concentrations at the downwind site across the Oil Field.

Winds from the south-southeast (13.1%) and north-northwest (7.8%) were far less frequent than winds from the west-southwest (53%) and east-northeast (25%). As a result, the ability to assess diurnal and seasonal patterns in gradients is reduced. For these two wind directions, we aggregated all winds from all seasons and calculated the differential BC concentrations for the entire monitoring period. Site pairs and wind bins for these less common directions are:



- South-southeast – winds originating between 120° and 210°
  - Pair 1: West minus South
  - Pair 2: North minus East
- North-northwest – winds originating between 300° and 30°
  - Pair 1: South minus West
  - Pair 2: East minus North

The resulting differential comparisons are shown in **Figure 3-6**. When winds are from the north-northwest, the east-north site pair has a negative contribution, while the south-west pair has a slightly positive contribution from the Oil Field. The confidence interval across the south-west site pair (the notch in the box) encompasses the zero line, indicating that the contribution is not statistically significantly different from zero at the 95% level of confidence. In contrast, the more frequent south-southeast winds have tighter confidence intervals, are both statistically significantly greater than zero, and both site pairs show a positive contribution from the Oil Field. This contribution is 0.01 to 0.03  $\mu\text{g}/\text{m}^3$ . This total contribution of BC is lower than that estimated when the winds are from the west-southwest.

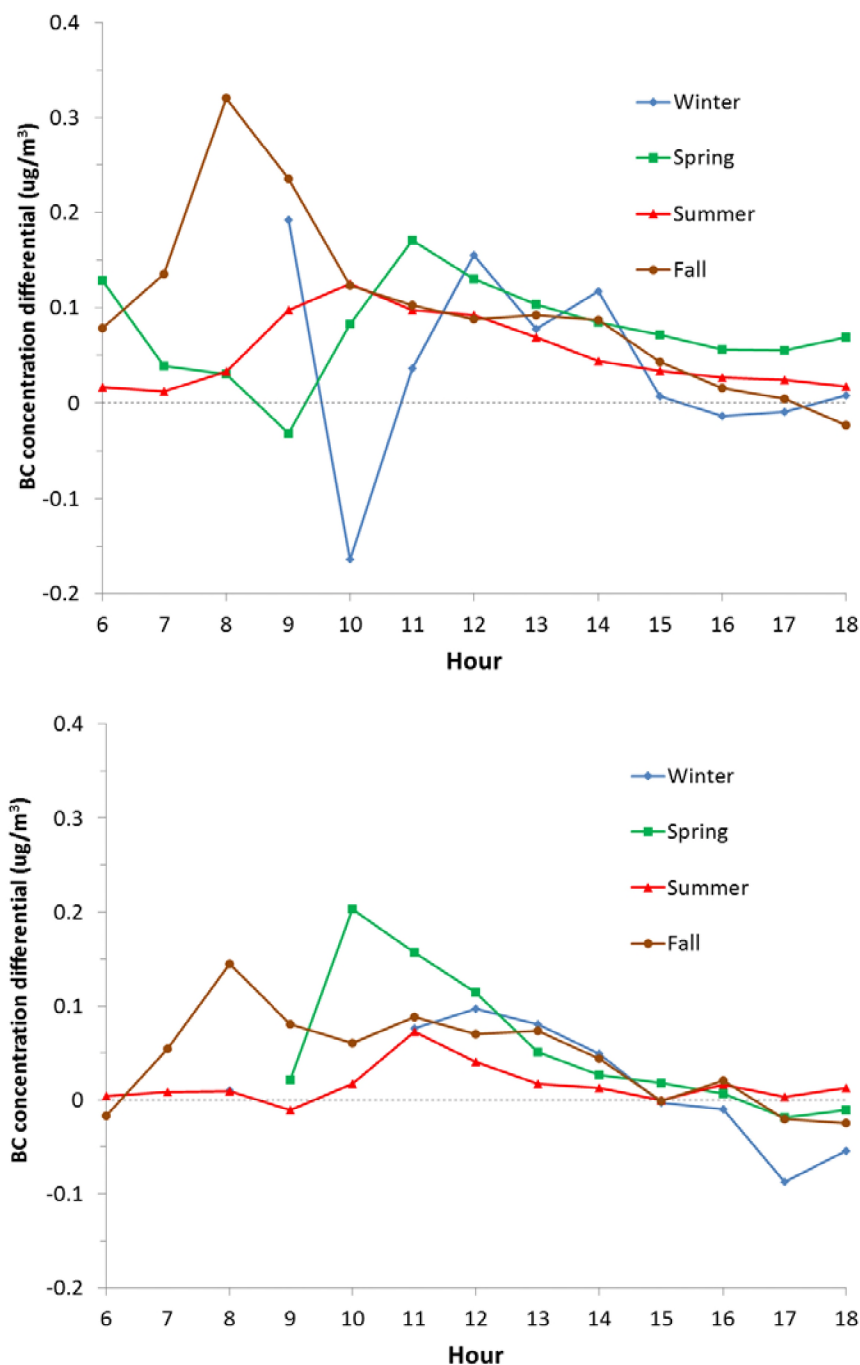


**Figure 3-6.** Differential analysis results for the entire monitoring period for winds from the north-northwest (N wind) and winds from the south-southeast (S wind) directions.

In a supplemental analysis, we also looked at weekday-weekend differences in concentrations of BC across the Oil Field. Some Oil Field operations are consistent regardless



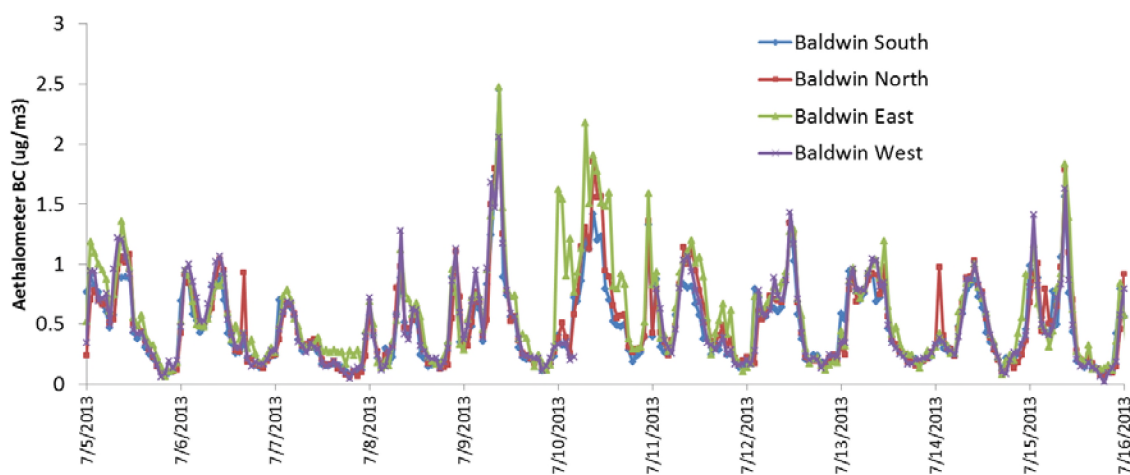
of the day of the week, such as drilling operations and gate traffic. Other operations are constrained to business hours, such as operating maintenance and workover rigs, which occurs during weekdays from 7:00 a.m. to 5:00 p.m. **Figure 3-7** shows the differential analysis for weekday and weekend for the North minus West pair during daytime hours when winds are from the west-southwest. Weekday concentration gradients are higher than weekend concentration gradients, which is consistent with Oil Field rig activity.



**Figure 3-7.** Daytime comparisons of BC differential concentrations ( $\mu\text{g}/\text{m}^3$ ) at the North minus West pair for (top) weekday and (bottom) weekend by meteorological season.

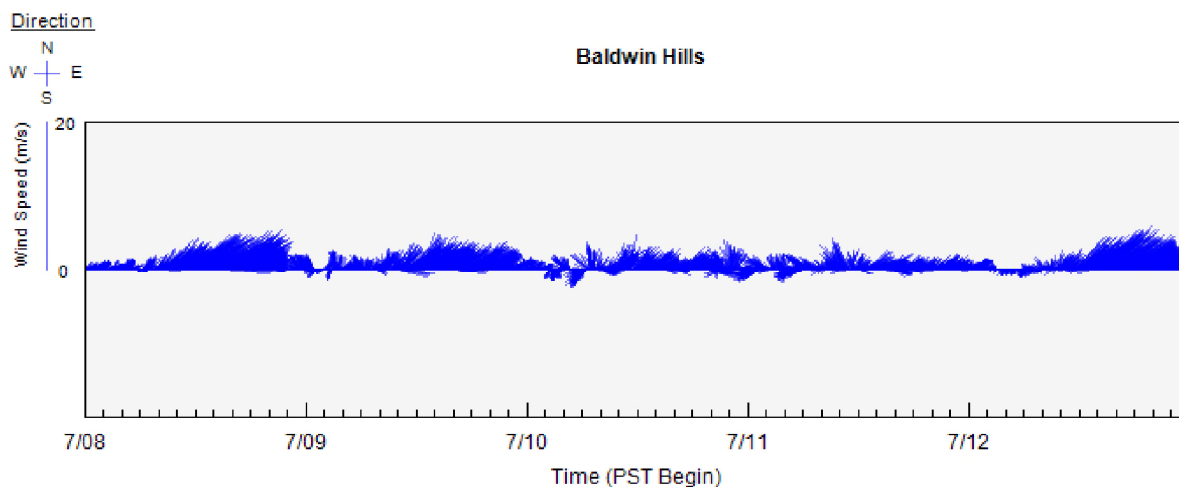
### 3.1.4 Case Study Analysis

STI examined time series of BC concentrations at all four sites to look for Oil Field activity operations that corresponded with peaks in concentrations at individual sites during the intense operating periods (IOP) when the XACT 625 or PTR-TOFMS were deployed. The best example we found of Oil Field operations potentially causing localized spikes in BC concentrations was during the PTR-TOFMS July IOP. The time series of the BC concentrations during the PTR-TOFMS deployment are shown in **Figure 3-8**. BC concentrations at the East site spike a bit higher than other sites starting on July 9, 10, and 11 before settling into a pattern that matches the other sites.



**Figure 3-8.** Time series of BC concentrations ( $\mu\text{g}/\text{m}^3$ ) at all four study sites for the July 5–16 time period. Concentrations are significantly higher at the East site than at other sites on July 10 and July 11.

**Figure 3-9** shows the wind direction and speed for July 8-13. The winds are light and variable very early on July 10; later in the day, they come mostly from the south.



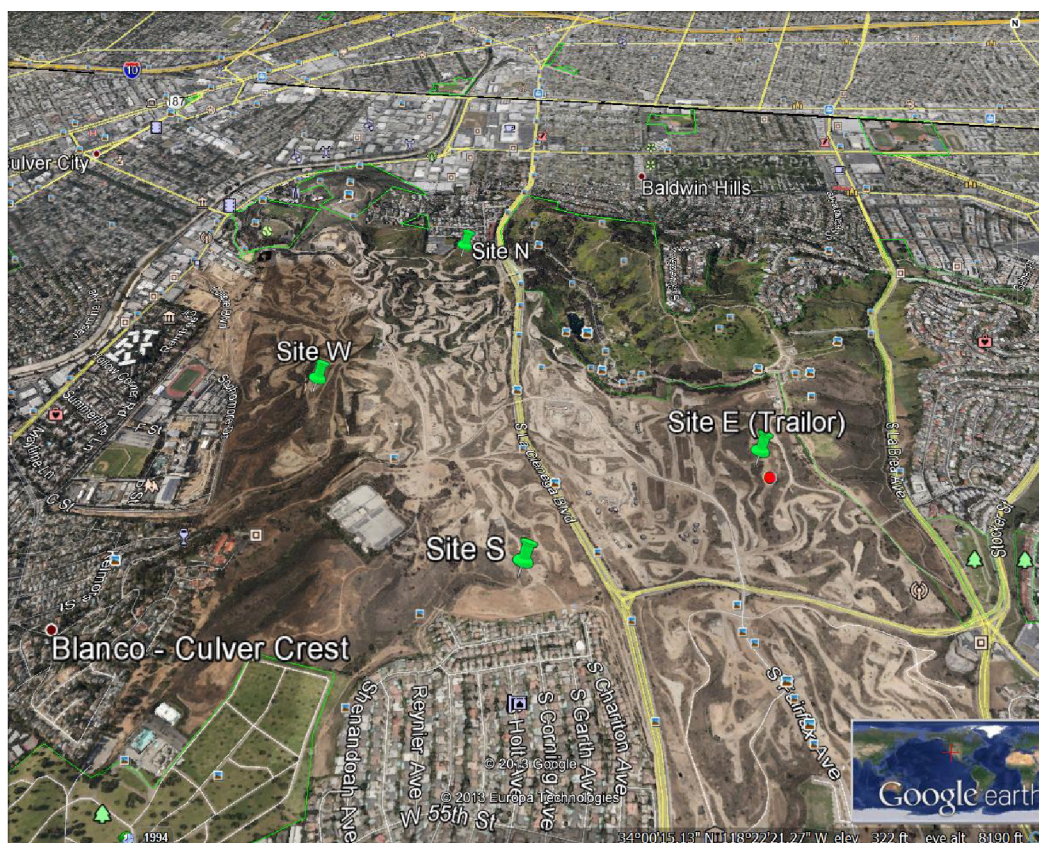
**Figure 3-9.** Wind bristle plot showing the direction the wind is blowing. On the morning of July 10, the winds were light and variable before settling into winds from the south.

Oil field operational notes for the July 3-16, 2013, period are provided in **Table 3-2**. On July 10, a rig was moved to location BC 6533; the rig operated at that location until July 16, when it was moved. Well location BC 6533 was located almost directly south of the East site, as shown in **Figure 3-10**.

**Table 3-2.** Oil Field operational reports during the PTR-TOFMS intense operating period. Comments are from the Oil Field operator.

Well Name	AM Report Date	Drill Start	Drill End	Comments
BC LAI1 5473 (BC STK1 5473)	7/3/2013			Summary, HSM, Load out move off BC 6522. HSM, Move in rig up on BC-LAI1 5473. NOTE: Mike Fernandez gave AQMD 24 hr notice f/ spud. Shut down for night.
BC LAI1 5473 (BC STK1 5473)	7/8/2013		Least 2573'	Cont, Run Platform Express Open Hole log, RD Loggers, RIH t/2573', Circulate clean, L/D drill string, HSM w H&H Casing crew R/U and ran 67jts 9-5/8" 40# K-55 LTC casing. Landed Shoe @ 2561', F/C @ 2481.8', Flag Joints @ 1956" & 1221.7', Circulate, HSM. With 9-5/8" 36# K-55 Shoe landed @ 2561' & Float Collar @ 2481'.
BC 6533	7/10/2013			Rig down & Move rig f/BC LAI 5473 t/ BC 6533. Rig up on BC 6533, Spot sub-structure, Set back end equipment, Raise derrick, Set pipe racks, Shut down for night. Continue rig up in the morning.
BC 6533	7/11/2013	52'	473'	Completed R/U of Ensign rig 516 on BC 6533. Install riser & sound blankets in derrick. Transfer mud to pit & load walk w/directional tools. Spud well @ 1250 hrs on 07/10/2013. M/U directional tools & scribe MWD. Directional drill 14 3/4" hole f/52' to 473'. Wipe hole to shoe @ 52'. Circ hole clean. POOH & L/D directional tools. Run 10 3/4" surface casing w/shoe @ 468' & insert float @ 419'. R/U cementing head & circ hole clean. Cement 10-3/4" 40.5# K55 STC Casing, Shoe at 468' and insert float at 419'. Cement casing in place w/25 bbl cement to surface, Bumped plug t/900 psi, Insert float held, WOC.
BC 6533	7/12/2013			RIH t/ 419'. Test BOPE w/ CDOGGR. 24 Hour Forecast: Finish BOP testing. Drill out float equipment & cement. Directional drill 9 7/8" hole towards TD @ 2454'.
BC 6533	7/16/2013			R/D and tear out rig, Remove sound walls, Replaced drill line, Load out third party mud equipment, Mud docks, Prep for move t/LAI1 5473. Directional drill 9 7/8" hole towards TD @ 2454'.





**Figure 3-10.** Map of the Inglewood Oil Field, site locations, and well number 6533 (red dot). Well number 6533 was the location of a drill rig on July 10–16.

This set of wind patterns, the location of a drill rig, and operational activities are consistent with a small enhancement in local BC concentrations for a two-day period attributable to Oil Field activities. However, our examination of the December and January period, during the metals operational period, revealed little in the way of Oil Field drilling operations that could be correlated with high BC concentrations. During the December and January time period, most operations occurred in the general vicinity of the South site, but were not as close to the South site as well number 6533 was to the East site.

## 3.2 XRF Metals

### 3.2.1 Metals Temporal Variability

We developed box plots to examine diurnal patterns and weekday-versus-weekend differences for metals concentrations, using hourly measurements during the 2.5-month sampling period from November 12, 2012, to January 29, 2013, at the East monitoring site.

**Figure 3-11** presents diurnal box plots for each of the measured metal elements targeted for risk characterization; the interquartile range and median of hourly metals concentrations are shown in a box for each hour of day, with the extent of the hourly

concentrations shown by whiskers, stars, and circles. Box plots for all measured elements are presented in **Appendix C**. Diurnal profiles were different for many of the species. Note that species such as cadmium, nickel, and selenium were often at or below the MDL for the species. For those species, care should be taken in examining absolute concentrations, because they are often below the method's ability to resolve them. In contrast, copper, manganese, and lead all show characteristic diurnal profiles that indicate potential emissions activity profiles during the morning hours. For some metal elements, such as chromium and mercury, a majority of concentration data (over 80%) was below MDL and the box plot therefore showed no specific diurnal profiles.

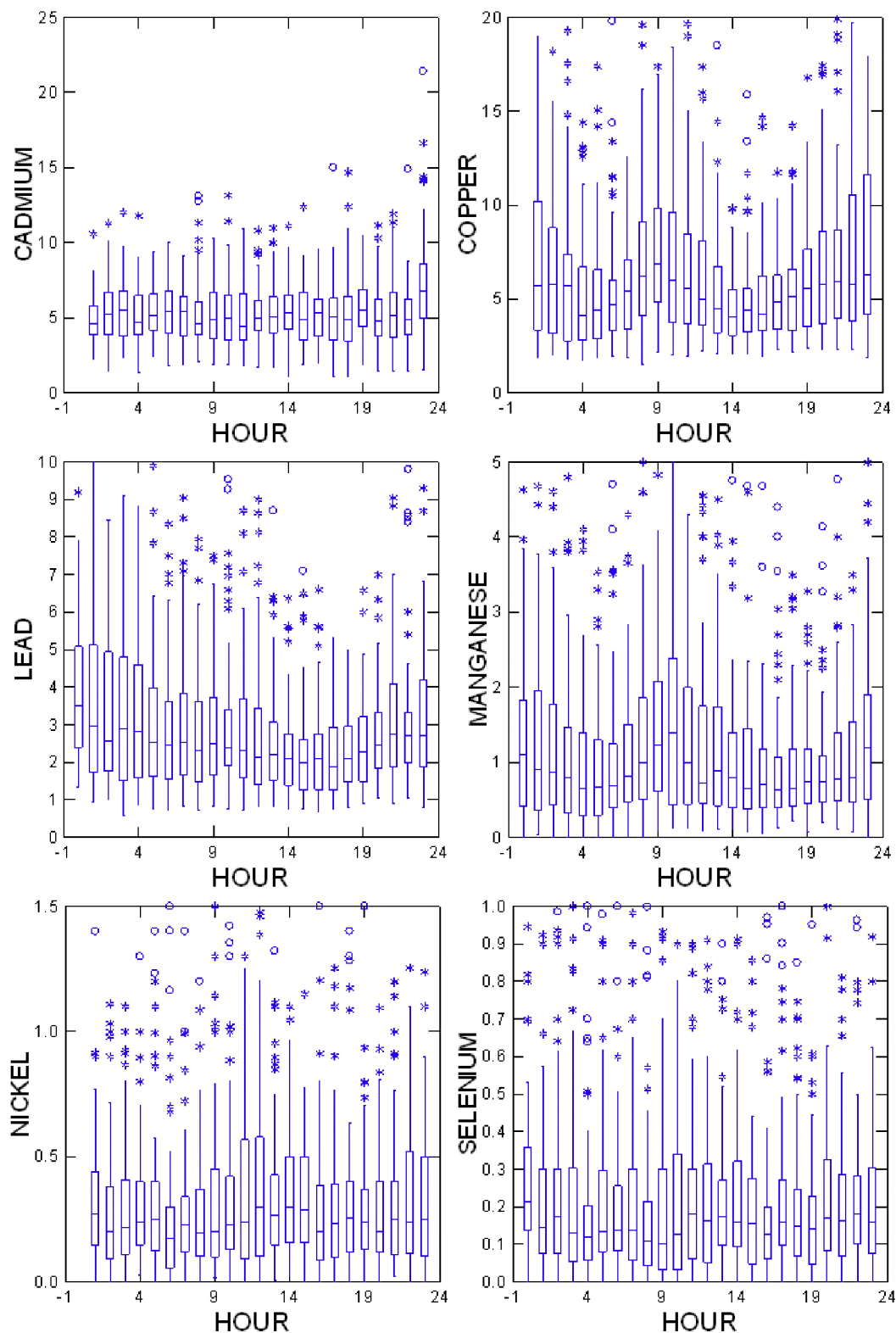
We also developed box plots for weekday and weekend average hourly concentrations. As shown in **Figure 3-12**, average hourly concentrations were higher on weekdays, when Oil Field operations occurred, for copper, lead, manganese, and selenium. Concentrations for cadmium and nickel were not distinguishable between weekdays and weekends.

### 3.2.2 Pollution Roses

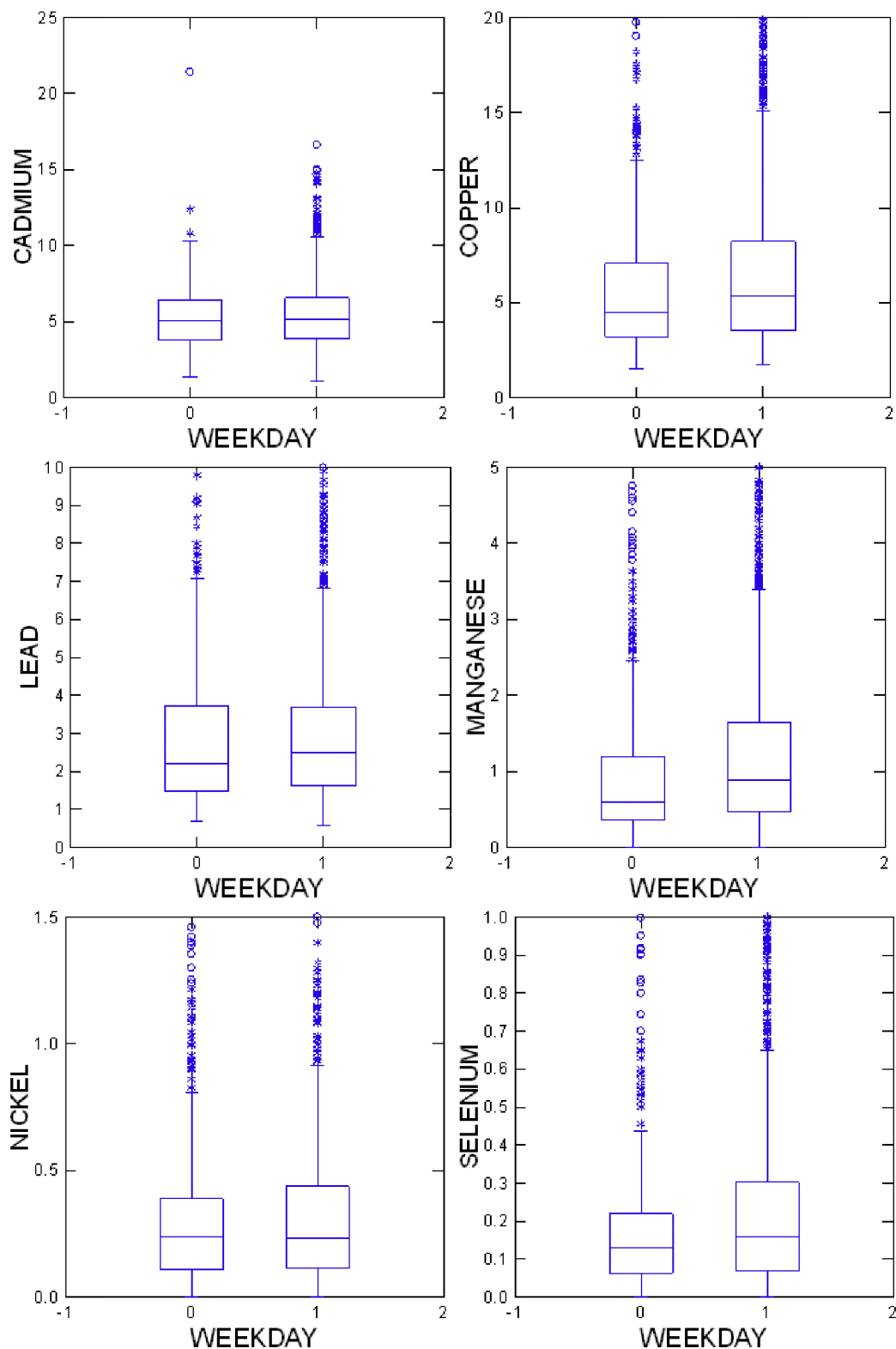
Pollution roses were developed for measured metal concentrations to examine how pollution correlates with wind directions. At the East monitoring site, prevailing wind directions are west-southwest (onshore) or east-northeast (offshore). If a significantly large percentage of high pollutant concentrations is associated with any particular wind direction, it would indicate more pollution activities upwind of the monitoring site in that direction.

**Figure 3-13** presents pollution roses for the six selected metal elements, which summarize hourly metal concentrations according to 16 sectors of wind direction during the sampling time period. Pollution roses were not presented for chromium and mercury, because most of their concentration data were below MDL. Pollution roses for all elements are shown in **Appendix C**. The Oil Field is southwest of the East site. In general, no significantly large percentage of high pollutant concentrations was particularly associated with the southwest wind direction, when the Oil Field was upwind of the East site. Across the six selected metal elements, higher concentrations (red wedges in the plots) were more likely to occur with winds from the east-northeast (12–17% of the time) than from the Oil Field to the west-southwest (3–11% of the time).

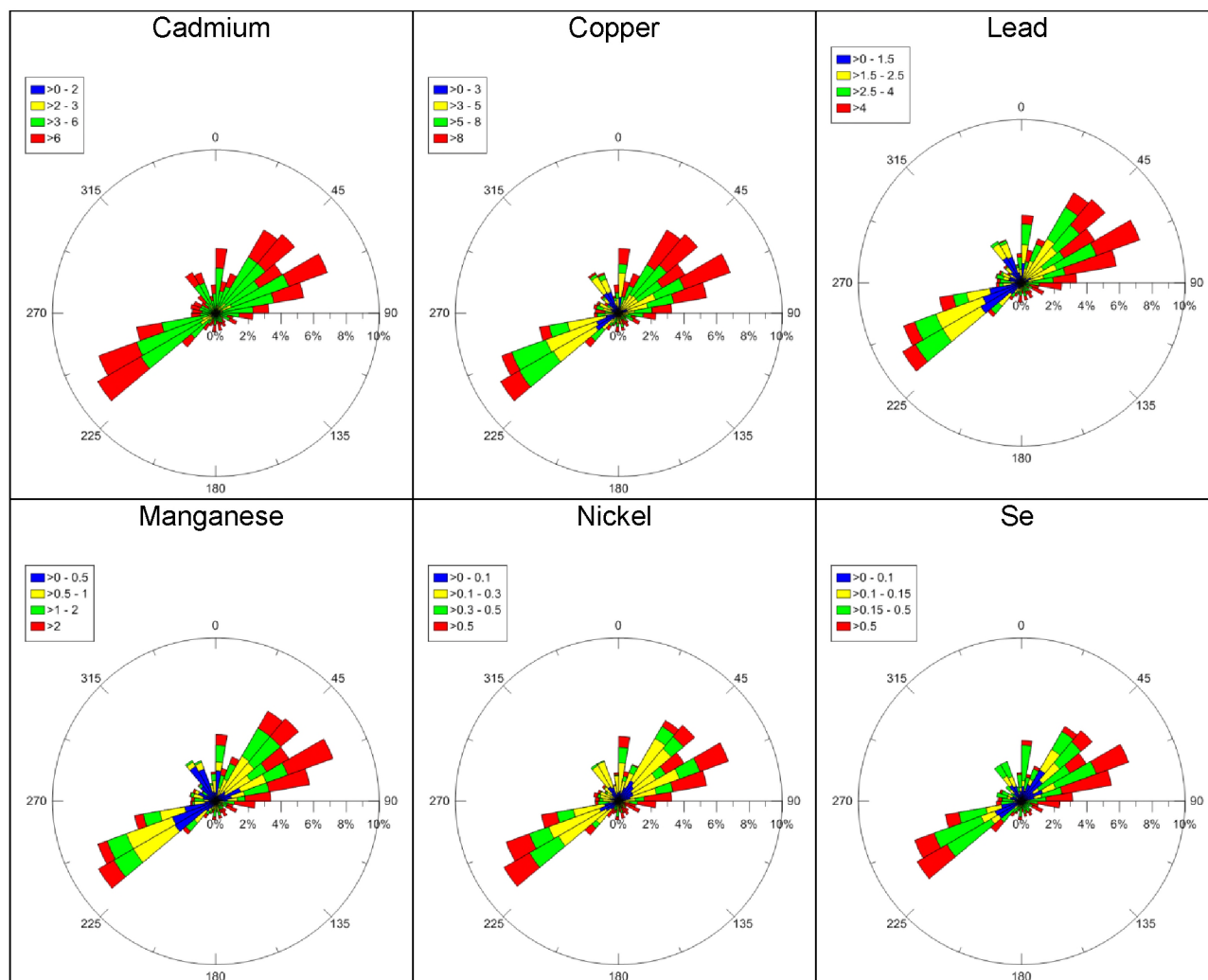




**Figure 3-11.** Box plots of hourly metals concentrations ( $\text{ng}/\text{m}^3$ ) during the 2.5-month sample period. Whiskers represent data within 1.5 times of interquartile range; stars represent data within 3 times of interquartile range; circles represent potential outliers.



**Figure 3-12.** Box plots of average hourly metals concentrations (ng/m<sup>3</sup>) during weekdays ("1") and weekends ("0"). Whiskers represent data within 1.5 times of interquartile range; stars represent data within 3 times of interquartile range; circles represent potential outliers.



**Figure 3-13.** Pollution roses for hourly metals concentrations ( $\text{ng}/\text{m}^3$ ) measured at the East site.

### 3.2.3 PMF Factor Analysis

Positive matrix factorization was applied to examine potential factors that contribute to observed metal concentrations at the East site. Among 24 metal elements with concentration measurements, 10 elements were excluded from PMF runs because of their low signal-to-noise ratios (see Table 3-3). Two potential outliers with very high Ca, Mn, Ni, Zn, and Cu concentrations, corresponding to sampling hours 11/17/12 20:00 and 11/29/12 4:00, were identified on the basis of Dixon's Q-test and were excluded from PMF runs. Samples with missing metal observations were also excluded from PMF runs.

**Table 3-3.** Summary of metal concentration measurements.

Pollutant	Used in PMF?	Signal-to-Noise Ratio	MDL (ng/m <sup>3</sup> )	Min (ng/m <sup>3</sup> )	25th (ng/m <sup>3</sup> )	Median (ng/m <sup>3</sup> )	75th (ng/m <sup>3</sup> )	Max (ng/m <sup>3</sup> )
Sulfur	Yes	2.99	4.00	68.2	125.3	162.7	262.0	4235
Potassium	Yes	2.99	2.37	44.4	71.0	86.5	112.5	1825
Iron	Yes	2.99	0.76	0.7	28.1	60.2	112.8	485.7
Copper	Yes	2.97	0.27	1.5	3.4	5.3	8.1	323.8
Lead	Yes	2.90	0.22	0.6	1.6	2.4	3.9	27.9
Zinc	Yes	2.85	0.23	0.0	2.1	4.8	10.1	256.0
Bromine	Yes	2.81	0.19	0.0	1.3	2.2	4.8	74.6
Calcium	Yes	2.54	0.90	0.0	3.6	10.8	24.3	1924.0
Titanium	Yes	2.52	0.38	0.0	1.3	2.7	5.5	44.6
Manganese	Yes	2.02	0.28	0.0	0.4	0.8	1.7	30.2
Strontium	Yes	1.91	0.45	0.2	0.7	1.0	1.4	36.9
Barium	Yes	1.67	0.95	0.0	0.8	2.2	4.8	96.0
Selenium	Yes	1.22	0.14	0.0	0.1	0.2	0.4	29.3
Nickel	Yes	1.08	0.23	0.0	0.1	0.2	0.5	248.4
Germanium	No	0.89	0.12	0.0	0.1	0.1	0.2	0.7
Cadmium	No	0.65	5.75	1.1	3.9	5.1	6.5	21.4
Silver	No	0.59	4.33	0.0	2.0	3.2	5.0	23.9
Vanadium	No	0.43	0.29	0.0	0.0	0.0	0.2	4.6
Chromium	No	0.29	0.29	0.0	0.0	0.0	0.1	25.4
Rubidium	No	0.26	0.34	0.0	0.0	0.1	0.3	2.4
Scandium	No	0.10	0.55	0.0	0.1	0.2	0.3	1.2
Arsenic	No	0.06	0.11	0.0	0.0	0.0	0.0	2.1
Cobalt	No	0.02	0.32	0.0	0.0	0.0	0.0	12.4
Mercury	No	0.01	0.19	0.0	0.0	0.0	0.0	0.3

As shown in **Table 3-4**, the PMF analysis suggested seven reasonably defined factors associated with 14 metal elements. The identification of these factors was based on their profiles: the concentration of each metal element apportioned to a factor's total concentration (see **Figure 3-14**), diurnal patterns, and changes of factor contributions in relation to wind directions. Time series of PMF factor contributions were also developed and are shown in **Figure 3-15**. These factor profiles and time series do not indicate significant impacts from the Oil Field.

**Table 3-4.** Summary of metal PMF factors.

PMF Factor	Potential Sources	Element/Species	Diurnal Pattern
Se	Coal combustion	Selenium	No clear diurnal pattern.
K/Sr	Wood-burning stove and fireplace	Potassium Strontium	Strong evening peak; high contributions during holiday nights.
S/Br	Marine vessels	Bromine Sulfur	Highly variable time series.
Ti/Fe/Cu/Ba	Crustal materials and industry plants	Barium Copper Iron Titanium	Highly variable time series.
Mn/Ni	Oil operations	Manganese Nickel	Highly variable time series; relatively low contributions during holidays.
Lead/Zinc	General aviation airports or tire wear	Lead Zinc	Highly variable time series.
Calcium	Soil and blowing dust	Calcium	No clear diurnal pattern.

### 3.2.4 Case Study Analysis

The XRF metals analysis, based on examinations of temporal variability, pollution roses, and PMF modeling results, showed no significant impacts from the Oil Field on metal concentrations measured at the East site. We also conducted a few brief case studies to further assess specific patterns of concentrations for several metal elements.

#### Manganese and Nickel

Manganese and nickel were likely related to oil operations and were reasonably identified in the PMF analysis. A factor contribution rose (**Figure 3-16**) showed that a small percentage of higher oil factor contributions could occur with the southwest wind direction (when the East monitoring site is downwind of the Oil Field). This is consistent with the findings from pollution roses presented in Section 3.2.2 (e.g., for nickel). In addition, relatively low factor contributions were found during holidays (e.g., Christmas and New Year), when oil operations were limited (see **Figure 3-17**). However, case study analysis indicated that none of the five highest manganese-nickel hourly concentrations during the monitoring period were associated with drilling operations within 1500 feet of the East site.



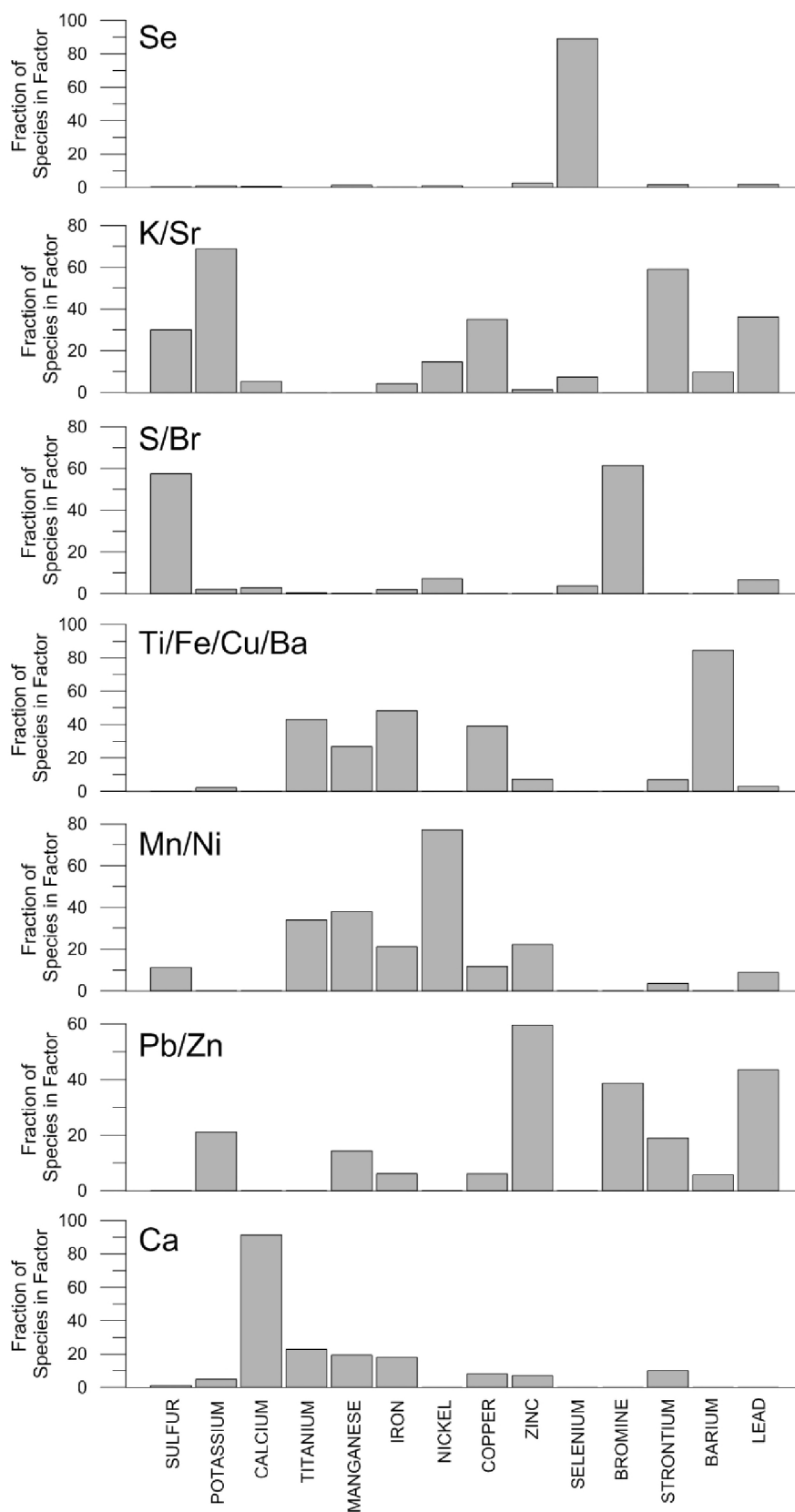
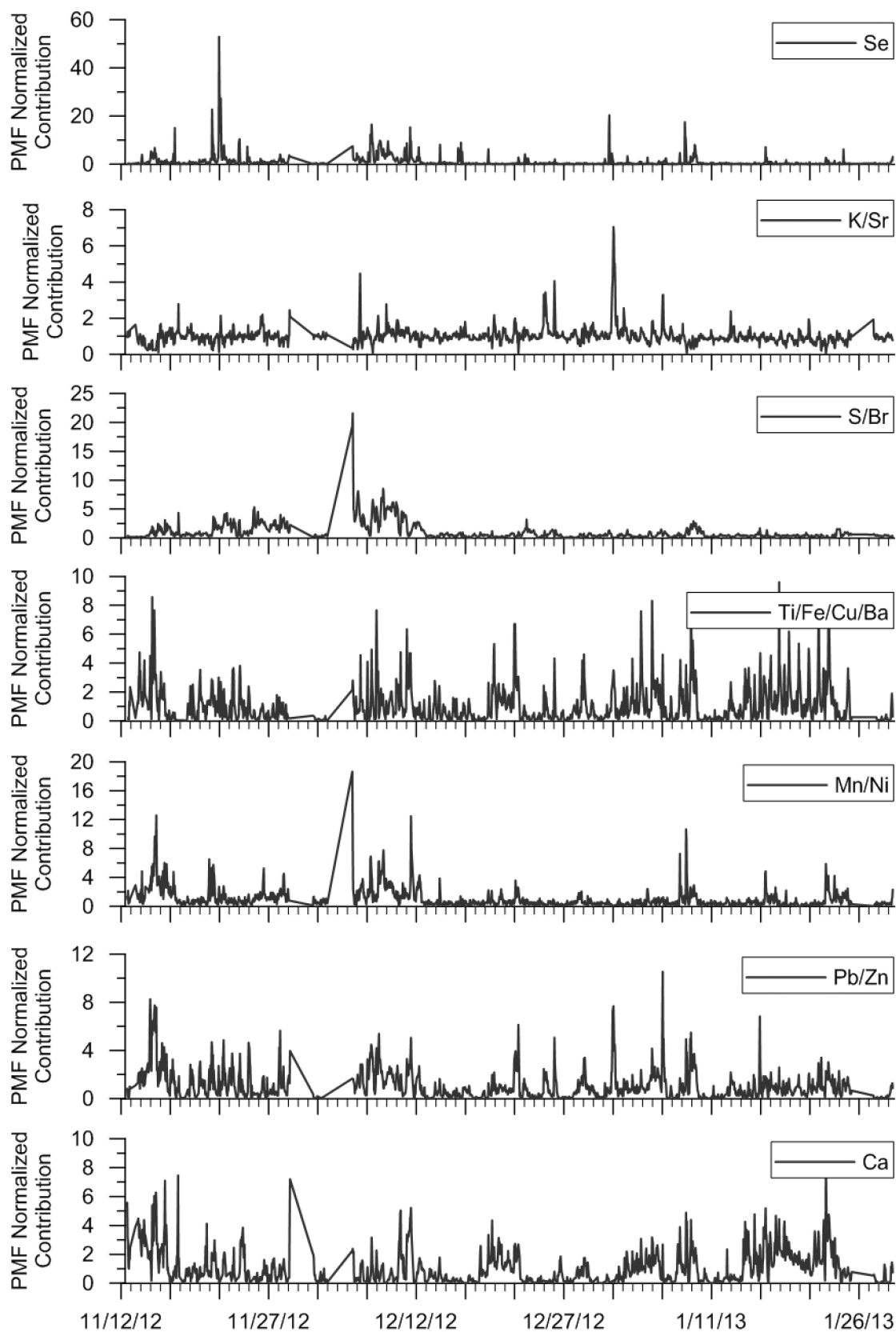
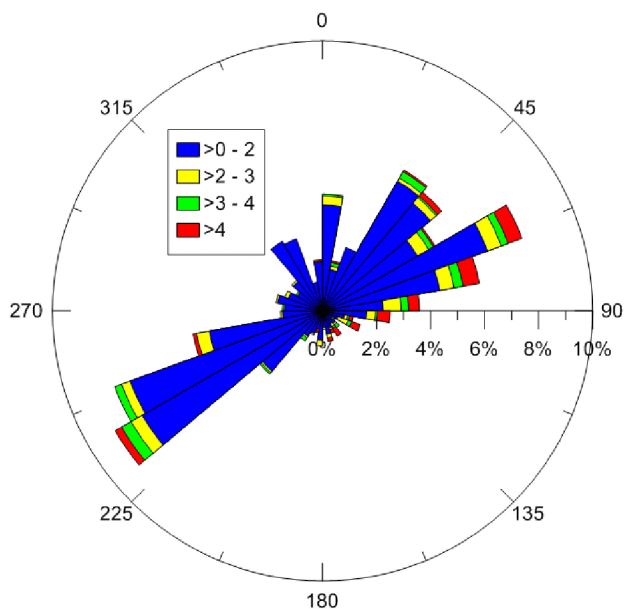


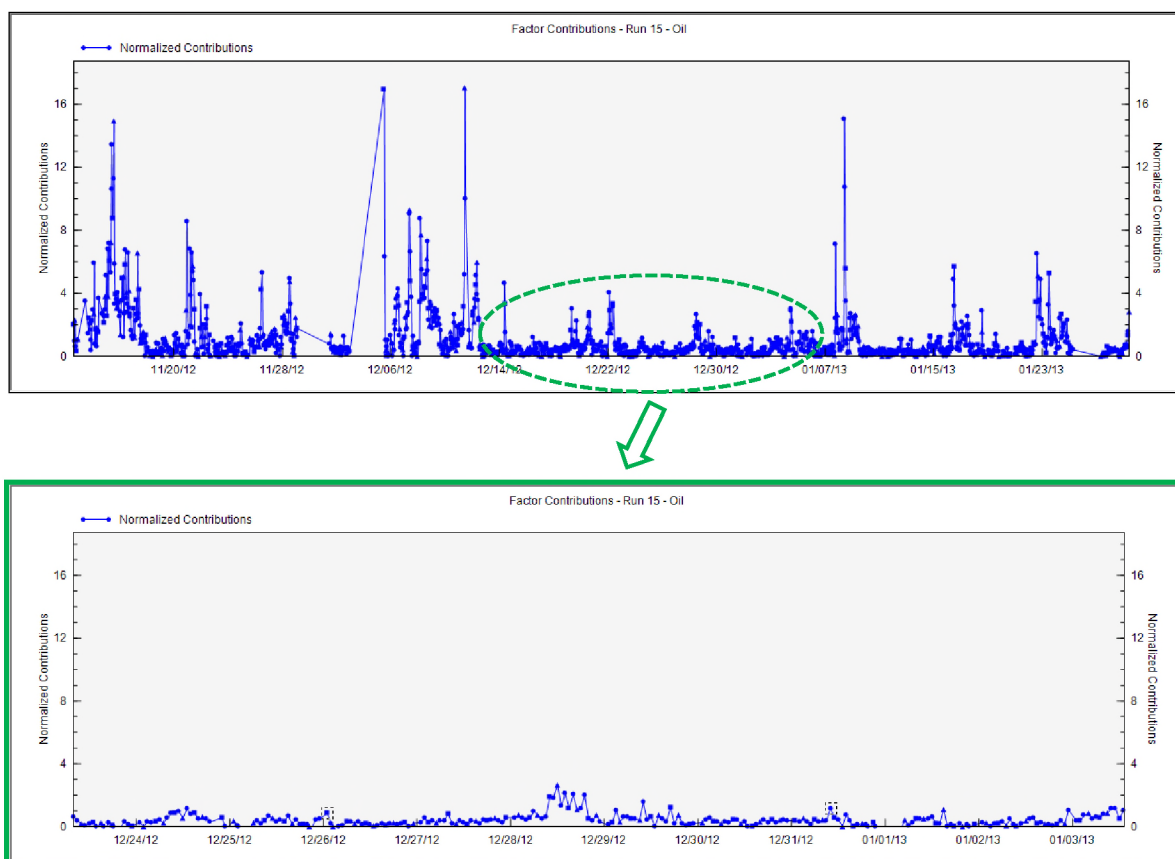
Figure 3-14. PMF factor profiles for metal elements.



**Figure 3-15.** Time series of PMF metal factor normalized contributions.



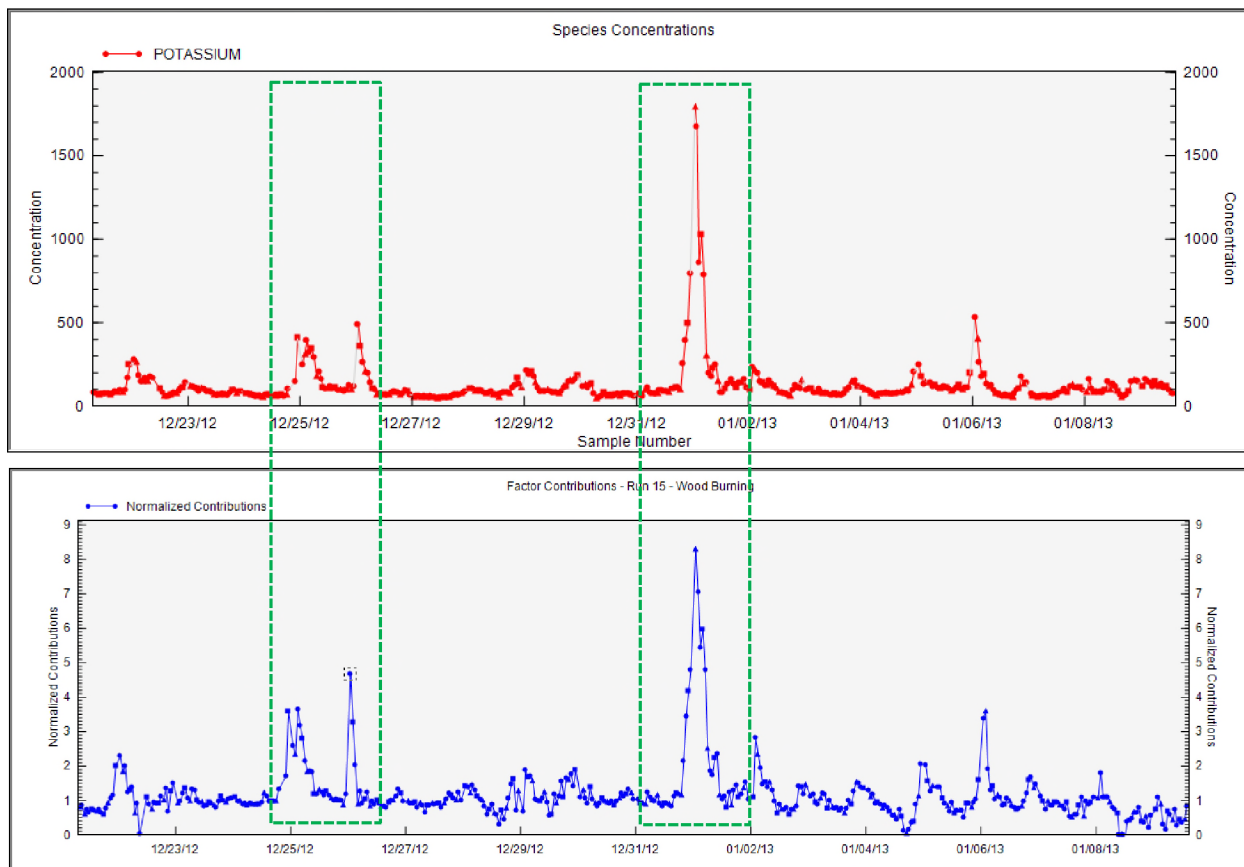
**Figure 3-16.** Contribution rose for the Oil factor (mainly related to Mn and Ni) in the PMF analysis.



**Figure 3-17.** Time series of relatively low normalized contributions associated with the PMF Oil factor.

## Potassium

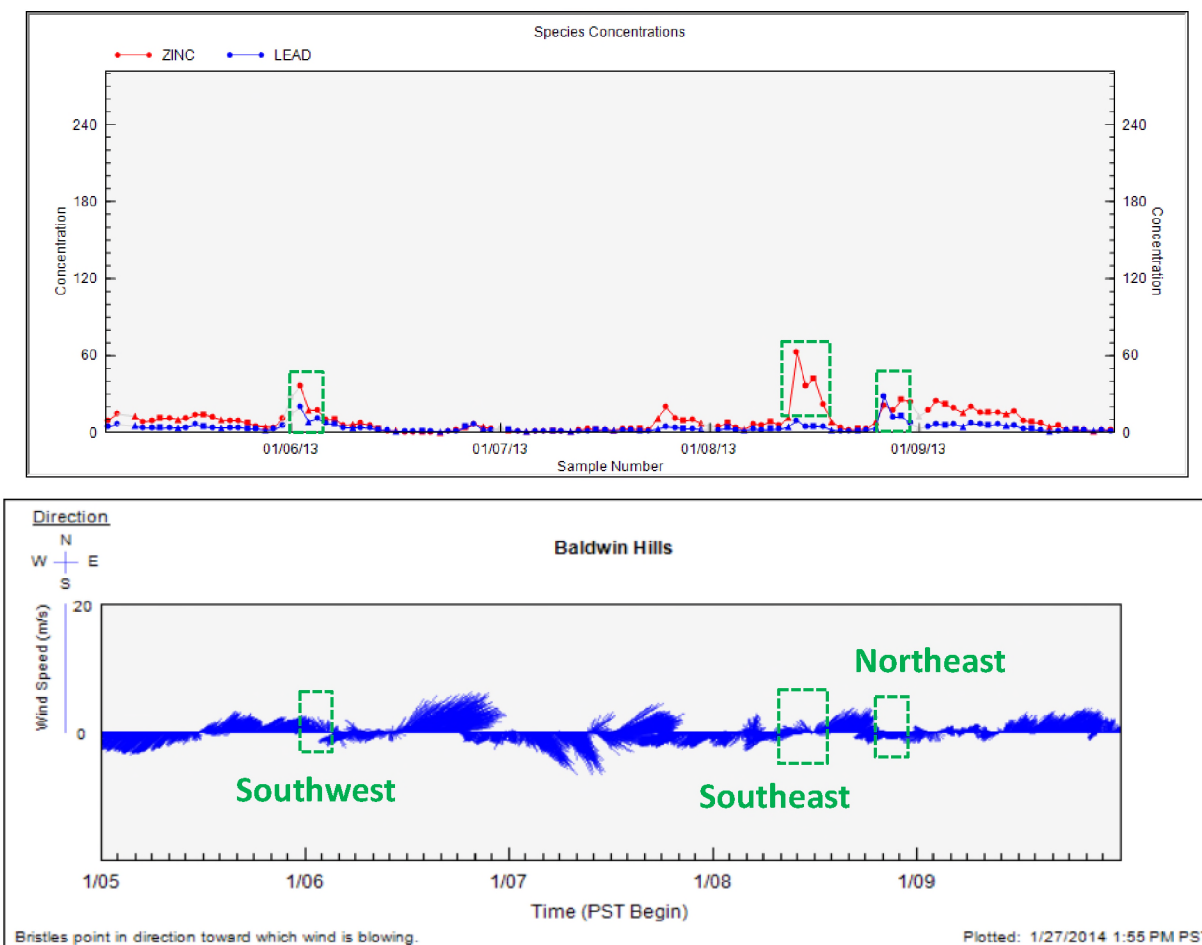
Potassium was related to the wood burning factor identified in the PMF analysis. As shown in **Figure 3-18**, higher potassium concentrations and wood burning factor contributions were observed during holiday nights (e.g., Christmas and New Year), when a lot of wood burning activities likely occurred.



**Figure 3-18.** Time series of high potassium concentrations ( $\text{ng}/\text{m}^3$ ) and normalized contributions associated with the PMF wood burning factor.

## Lead and Zinc

Time series of lead and zinc concentrations were developed and compared with wind directions. As shown in **Figure 3-19**, higher lead or zinc concentrations were associated with various wind directions, suggesting that major impacts on concentrations of these metal elements were not likely from a single source in a particular direction near the monitoring site.



**Figure 3-19.** Time series of high lead and zinc concentrations ( $\text{ng}/\text{m}^3$ ) and wind directions.

## Cadmium

Given the observation of some high concentration measurements and the toxicity of cadmium, we further examined cadmium concentrations to assess its potential patterns and relationship with oil operation activities. During the sampling time period, mean and median cadmium concentrations were  $5.35 \text{ ng}/\text{m}^3$  and  $5.10 \text{ ng}/\text{m}^3$ , respectively; however, 64% of cadmium samples were below the MDL ( $5.75 \text{ ng}/\text{m}^3$ ). Scatter plots showed no correlation between cadmium and other metal elements. Additionally, no correlation was found between cadmium and BC concentration differences for the East minus South pair, used to evaluate potential impacts from oil operational activities.

The time series of cadmium concentrations show no diurnal pattern and high variability through the entire sampling period. There was high variability during holiday weeks (approximately 12/21/12 to 1/8/13, during the Christmas and New Year holidays), when oil operation activities were very limited. We further assessed the top 20 highest cadmium concentrations, and found that these concentrations occurred under various wind directions; only four of these 20 samples occurred during the day. In particular, three of the 20 highest



cadmium concentrations were observed under west-southwest wind direction (when the Oil Field is upwind of the sampling East site), but they were all during evening hours.

In PMF runs (see Section 3.2.3), cadmium was excluded because of a low signal-to-noise ratio. To further evaluate how cadmium may interact with other metal elements in factor contribution analysis, we conducted an extra PMF run to include cadmium as a strong species. The PMF results showed that cadmium was pulled into a factor with potassium and strontium, which is likely related to evening activities such as wood smokes. Cadmium was not shown to have significant contributions to the manganese and nickel factor, which is more likely from oil operational activities.

The case study analyses for cadmium, as described above, suggest no correlation between cadmium and oil operational activities during this sampling period.

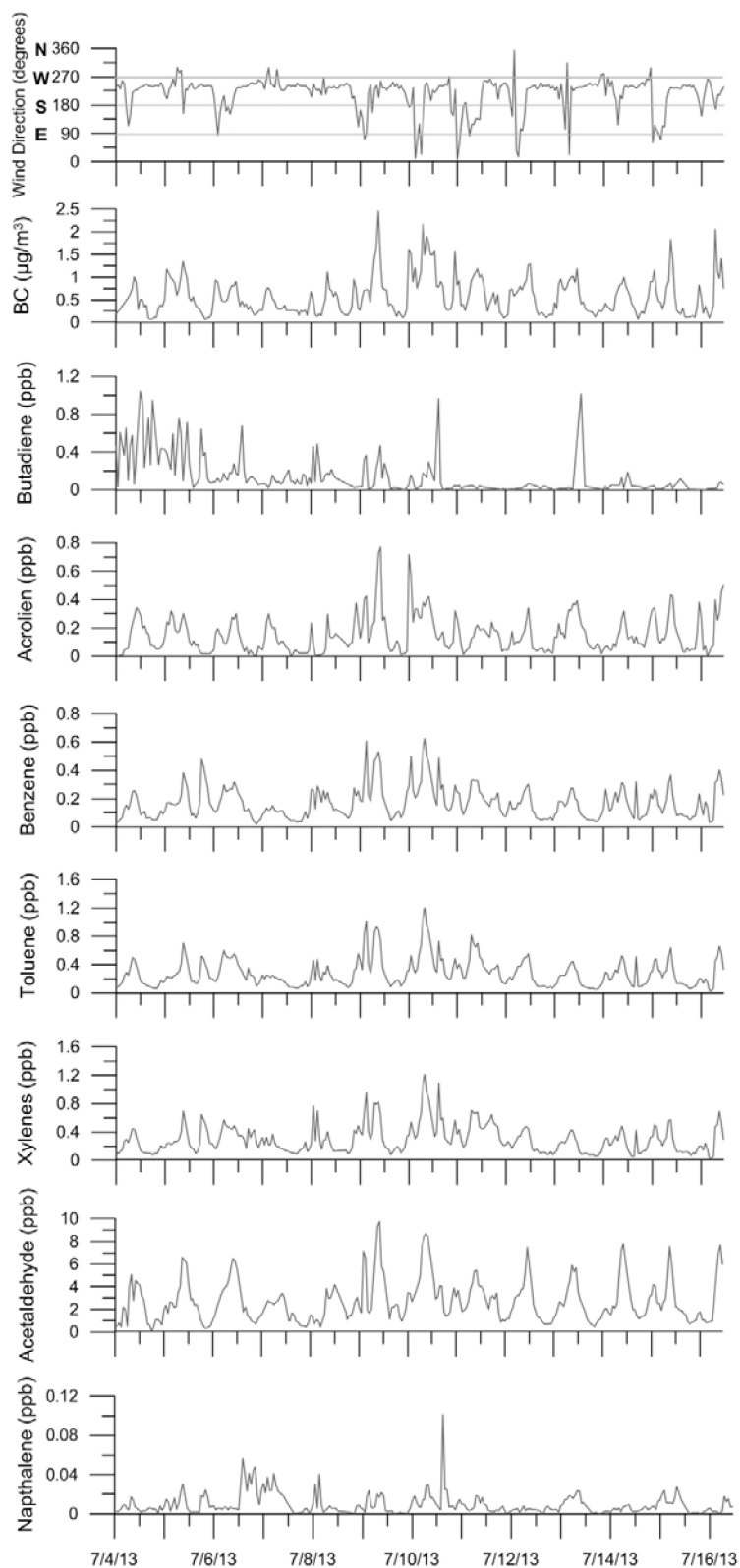
### 3.3 PTR-TOFMS Volatile Organic Compounds

#### 3.3.1 VOC Diurnal Patterns

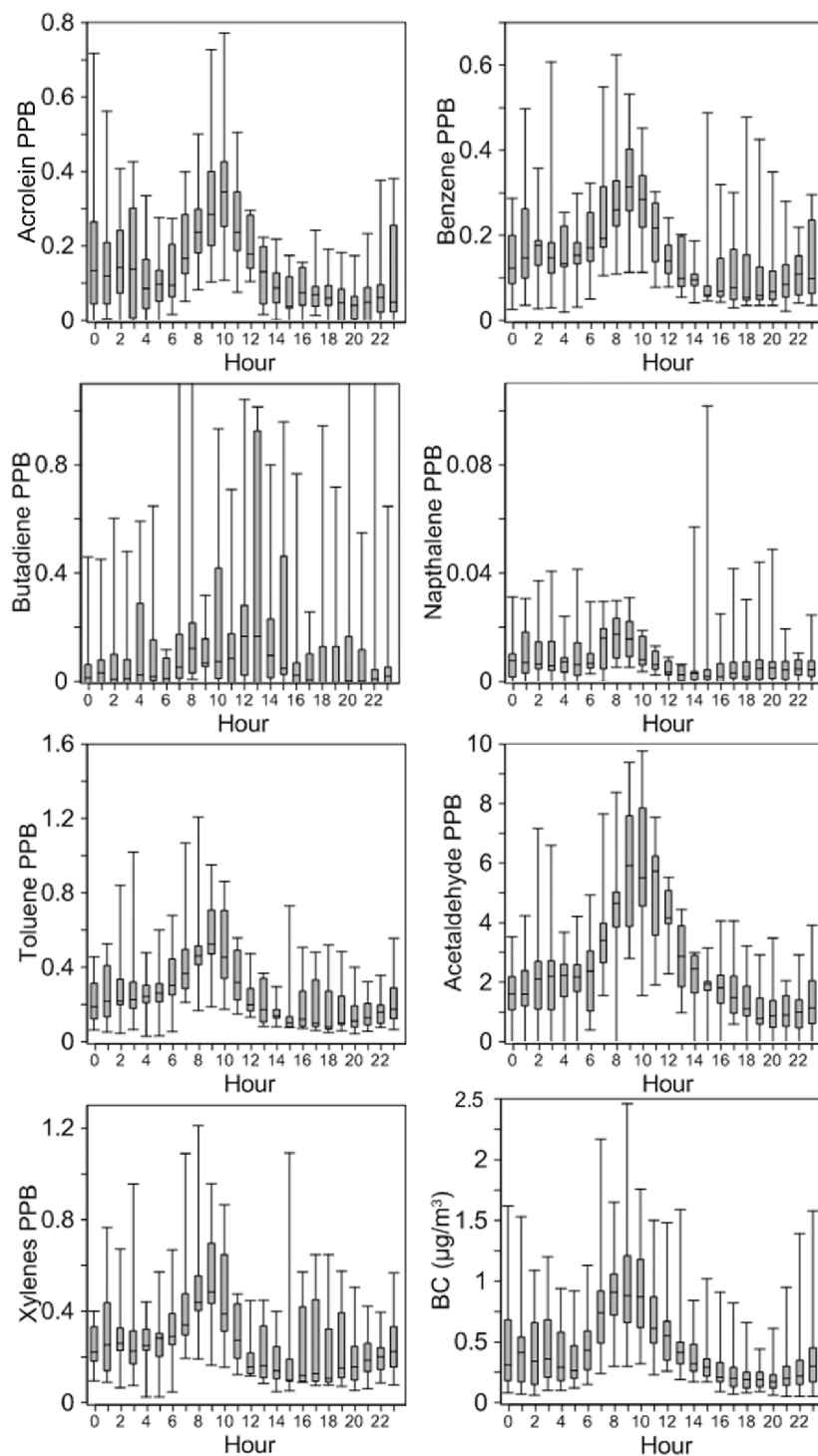
As explained in Section 2.4.3, seven VOCs were measured in units of parts per billion (ppb) as well as the arbitrary units particular to the PTR-TOFMS instrument. We examined the time series and diurnal patterns of these VOCs in context with BC to see (1) whether there were similar temporal patterns among VOC species, indicating similar sources; and (2) whether VOCs had any similarity to variations in BC. Similarities in either case would indicate similar sources for BC and VOCs. The VOCs with ppb units were acetaldehyde, butadiene, acrolein, benzene, toluene, xylenes, and naphthalene.

**Figures 3-20 and 3-21** show the time series and diurnal box plots of the VOCs, BC, and wind direction during the two-week VOC sampling period. In box plots, the interquartile range of the data are shown in a box, and the extent of the concentrations are shown by the whiskers. All species tend to have a morning peak, likely due to peak emissions during local morning rush hour plus influence from the Los Angeles Basin rush hour. Butadiene, acrolein, and naphthalene also have spikes of high concentrations, which are further evaluated in Section 3.3.3. The similar patterns across VOCs and BC suggest they are predominantly from local and regional combustion sources, i.e., vehicular emissions that tend to dominate VOCs in the Los Angeles area.

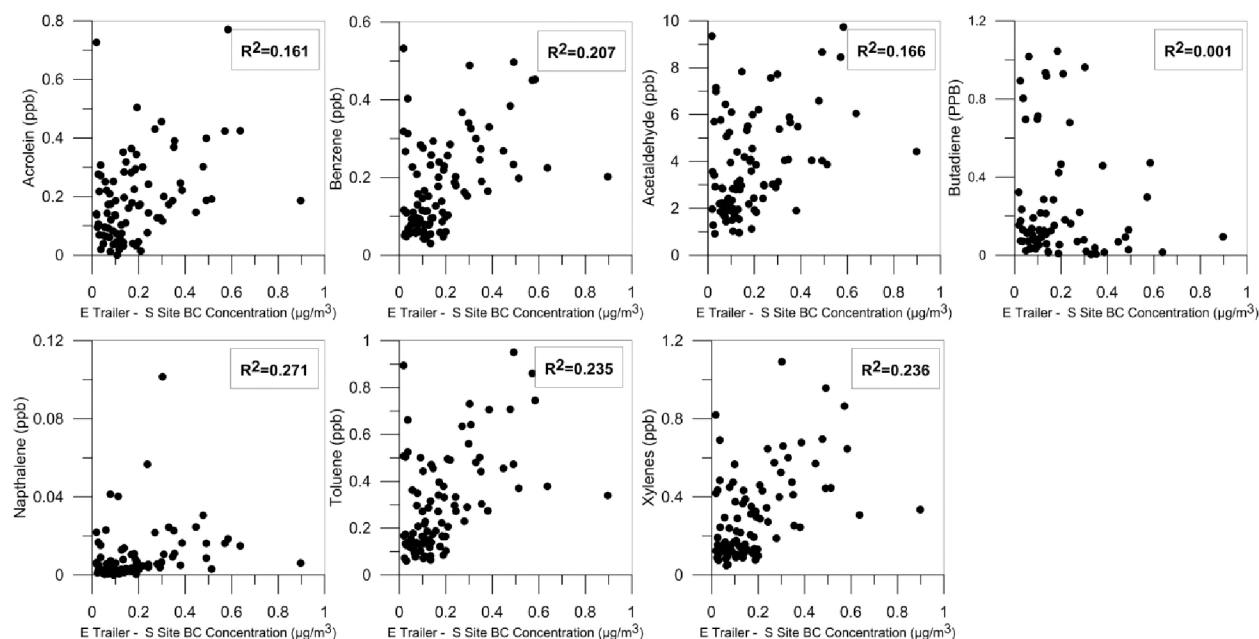
Next, we looked at how each of the seven VOCs compared to the difference in BC concentrations between the East and South sites, which indicates the oil operations' contribution to BC. A modest correlation between this difference and any species would indicate how much of that VOC species is from oil operations. Results are shown in **Figure 3-22**. No VOC had any correlation with the BC difference, though there were some high BC difference values that also had high VOC concentrations of acetaldehyde. These individual high values are used as case study examples in Section 3.3.3. The low correlation of VOC concentrations with BC difference indicates there is likely little consistent influence on VOC levels from the oil operations, although there may be influence for limited hours.



**Figure 3-20.** Time series of hourly VOC (ppb), BC ( $\mu\text{g}/\text{m}^3$ ) and wind direction during the summer VOC intensive operating period.



**Figure 3-21.** Box plots of VOC and BC concentrations by hour (ppb for VOC;  $\mu\text{g}/\text{m}^3$  for BC).



**Figure 3-22.** Scatter plots of VOC concentrations (ppb) with BC difference concentrations ( $\mu\text{g}/\text{m}^3$ ) between the East and South sites.

### 3.3.2 VOC PMF Factor Analysis

A total of 23 VOC species with arbitrary units were measured by the PTR-TOFMS with significant signal-to-noise ratio to be included in the analysis. These include the seven species with ppb values, plus others such as formaldehyde, ethanol, acetone, isoprene, methyl ethyl ketone, and benzaldehyde. Some of these species, however, are identifiable only by their mass-to-charge ratio ( $m/z$ ), with multiple species possible for a given  $m/z$ . In these cases, we use the basic chemical formula of the  $m/z$ , e.g.,  $\text{C}_3\text{H}_7^+$  for  $m/z$  43.0542, which is a combination of n-propyl and isopropyl. **Table 3-5** summarizes the  $m/z$  available for PMF analysis, the ion associated with each  $m/z$ , and, where applicable, the likely VOC species name.

PMF was applied in order to separate out factors that influence the VOCs. No unique tracer for Oil Field operations was identified, so we used a given PMF factor's variation with wind direction, time of day, and the BC signal from the Oil Field to determine whether the PMF factor is likely to be associated with the Oil Field. Typically in PMF analysis of VOC data, the PMF factors are more representative of atmospheric chemical and transport processes, rather than specific sources, since many VOC species have multiple sources and short atmospheric lifetimes. This was the case here, where three PMF factors were identified, two of which—a reactive alkene/alkyne factor and a factor with oxygenated VOCs—were more associated with atmospheric processes. The additional factor was typical of mobile source emissions.

**Table 3-5.** Summary of PTR-TOFMS species including the  $m/z$  available for PMF analysis, the ion associated with each  $m/z$ , and, where applicable, the likely VOC species name.

$m/z$	Ion	Name	Concentrations Calibrated for ppb	Used in PMF?
31.0178	$\text{CH}_2\text{OH}^+$	Formaldehyde	No	Yes
33.0335	$\text{CH}_4\text{OH}^+$	Methanol	No	Yes
41.0391	$\text{C}_3\text{H}_5^+$	Propyne	No	Yes
43.0542	$\text{C}_3\text{H}_7^+$	Propyl groups	No	Yes
45.0335	$\text{C}_2\text{H}_4\text{OH}^+$	Acetaldehyde	Yes	Yes
47.0497	$\text{C}_2\text{H}_6\text{OH}^+$	Ethanol	No	Yes
55.0548	$\text{C}_4\text{H}_7^+$	1,3-Butadiene	Yes	No – signal/noise=0
57.0335	$\text{C}_2\text{H}_5\text{CO}^+$	Acrolein	Yes	Yes
57.0699	$\text{C}_4\text{H}_9^+$		No	Yes
59.0491	$\text{C}_3\text{H}_6\text{OH}^+$	Acetone	No	Yes
69.0699	$\text{C}_5\text{H}_9^+$	Isoprene	No	Yes
71.0491	$\text{C}_3\text{H}_6\text{COH}^+$	Methyl ethyl ketone	No	Yes
71.0855	$\text{C}_5\text{H}_{11}^+$		No	Yes
73.0648	$\text{C}_4\text{H}_8\text{OH}^+$	Methyl vinyl ketone	No	Yes
75.0446	$\text{C}_3\text{H}_6\text{O}_2\text{H}^+$		No	Yes
79.0542	$\text{C}_6\text{H}_8^+$	Benzene	Yes	Yes
83.089	$\text{C}_6\text{H}_{11}^+$		No	Yes
85.0648	$\text{C}_4\text{H}_8\text{COH}^+$		No	Yes
93.0699	$\text{C}_7\text{H}_9^+$	Toluene	Yes	Yes
97.1012	$\text{C}_7\text{H}_{13}^+$		No	Yes
107.049	$\text{C}_7\text{H}_6\text{OH}^+$	Benzaldehyde	No	Yes
107.0855	$\text{C}_8\text{H}_{11}^+$	Xylene	Yes	Yes
111.118	$\text{C}_8\text{H}_{15}^+$		No	Yes
125.132	$\text{C}_9\text{H}_{17}^+$		No	Yes
129.069	$\text{C}_{10}\text{H}_9^+$	Naphthalene	Yes	No – signal/noise=0

**Table 3-6** summarizes the PMF factors; **Figure 3-23** shows the profiles of the three factors; and **Figure 3-24** shows the time series of the three factors, the BC concentrations at the East site, and the BC differential between the East and South sites. **Figure 3-25** shows pollution roses for the three PMF factors. Since the patterns are essentially the same for all three factors, wind direction analysis of VOCs and the VOC PMF factors does not provide information on potential sources. The mobile source factor was composed of species typical of exhaust, such as benzene, toluene and xylenes, as well as ethanol and benzaldehyde, which may be secondarily formed from exhaust. This factor had a strong morning and midday peak, typical of the morning rush hour, and likely came from emissions throughout the Los Angeles



Basin. The alkene/alkyne factor was composed of reactive unsaturated VOCs such as propyne and isoprene. These species have relatively short atmospheric lifetimes, and thus they vary together, forming their own factor. They are likely from multiple sources, including mobile sources and biogenic emissions, but their variations are more influenced by their atmospheric reactivity rather than by variations in emissions. The last factor, composed of oxygenated VOCs such as formaldehyde and acetaldehyde, was similar in that it was composed of VOCs that vary together in the atmosphere and can be from multiple sources. The VOCs in this oxygenates factor are emitted as primary emissions from combustion and can also be formed in the atmosphere; thus, this factor is at least as representative of atmospheric processes as it is of a primary emissions source.

**Table 3-6.** Summary of VOC PMF factors.

Factor	Description	Species	Diurnal Pattern	Correlation with E-S Site BC Difference?
Mobile source	Typical mobile source signature of BTEX, plus methanol	Benzene, Toluene, Xylene, Ethanol, Benzaldehyde	Strong morning and midday peak	No
Alkenes/alkynes	Unsaturated VOCs; very reactive	Propyne, Isoprene, etc.	Highly variable time series	No
Oxygenates	VOCs with oxygens, excluding benzaldehyde and ethanol	Formaldehyde, Methyl ethyl ketone, Methanol, Acetaldehyde, Acrolein, Acetone, etc.	Modest morning, midday peak	No

None of the factor profiles or time series indicated that they were specifically from the oil operations. To further examine the possibility of Oil Field impact, we used the BC concentrations' difference between the East and South sites as an indicator of the oil operations' BC contribution and compared this difference to the factor contributions. A modest correlation or better between a factor's contributions and the BC difference would indicate that the factor may also be from oil operations. **Figure 3-26** shows scatter plots of the BC difference with each factor's contributions, for all hours and for daytime hours only. There is little correlation between the BC difference and the factor contributions, indicating that none of these factors are directly attributable to the oil operations. This is consistent with the observations that individual species had little correlation with the BC difference.

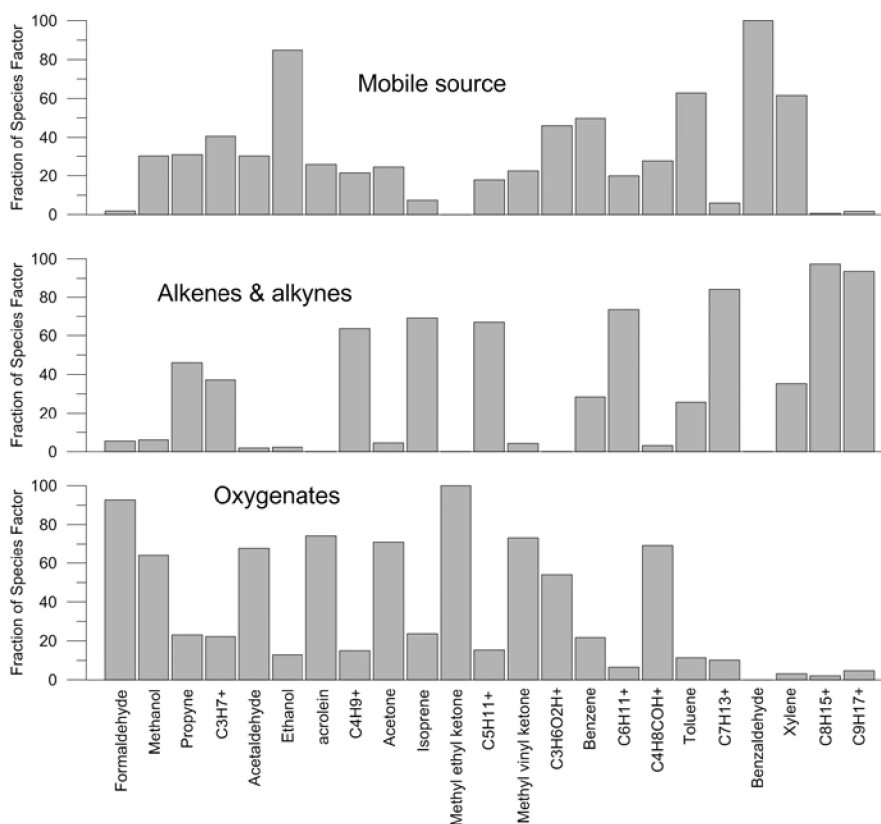
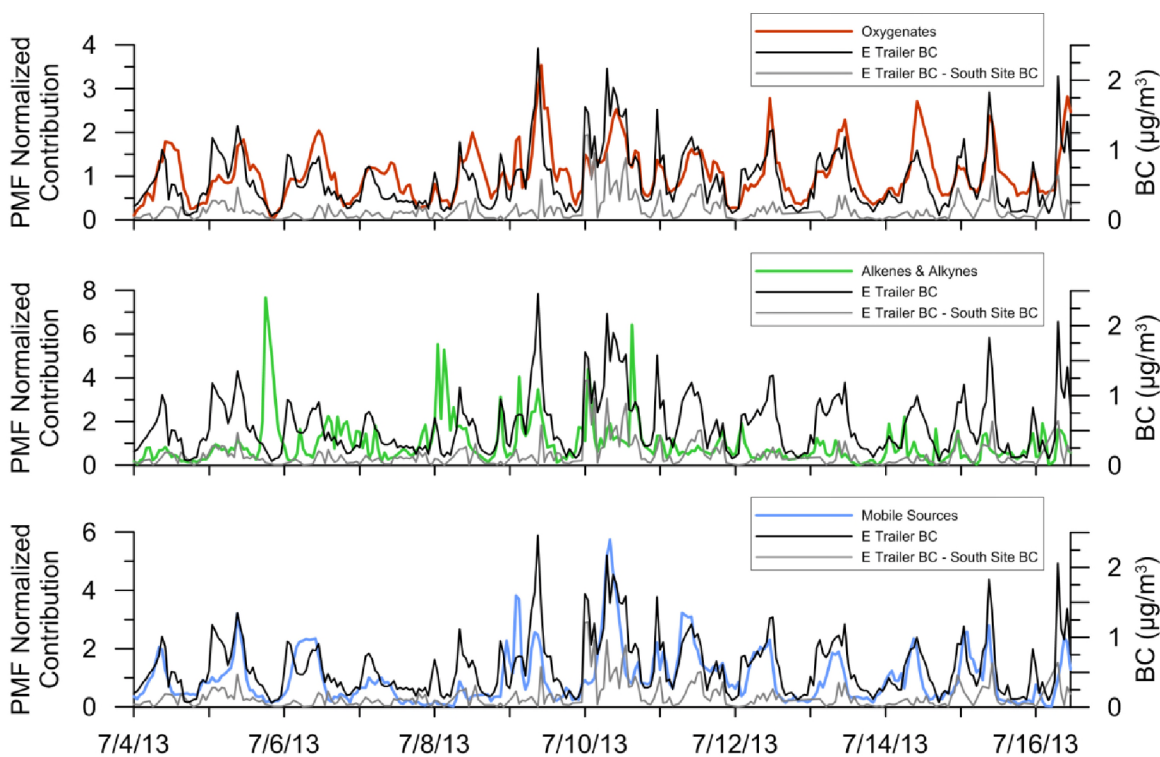


Figure 3-23. PMF VOC factor profiles.

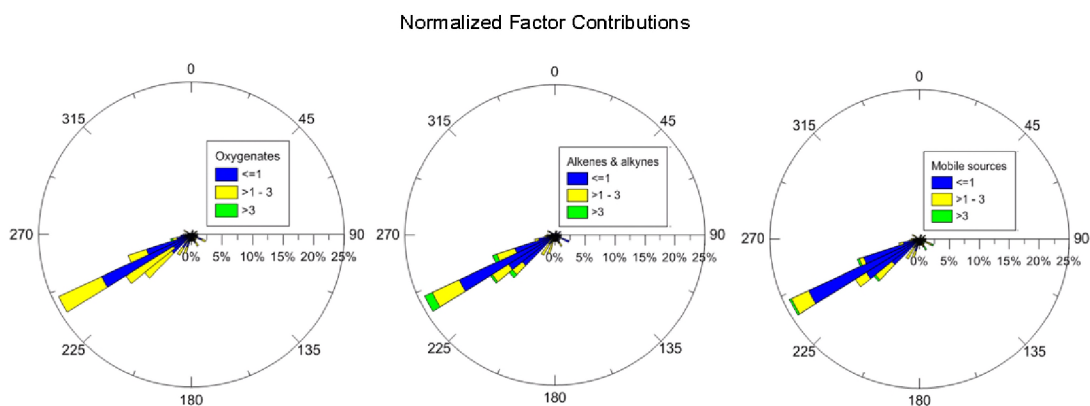
### 3.3.3 VOC Case Study Analysis

While there was no consistent signal in the VOC data from the oil operations seen in earlier analyses, as a last step we examined the highest 5<sup>th</sup> percentile of BC difference concentrations that occurred concurrently with daytime VOC sampling, to see whether times of high BC differences also had high VOC concentrations. High VOC concentrations and the highest BC difference values occurring at the same time might indicate that, for certain specific hours, there was some qualified influence from the oil operations on VOC levels.

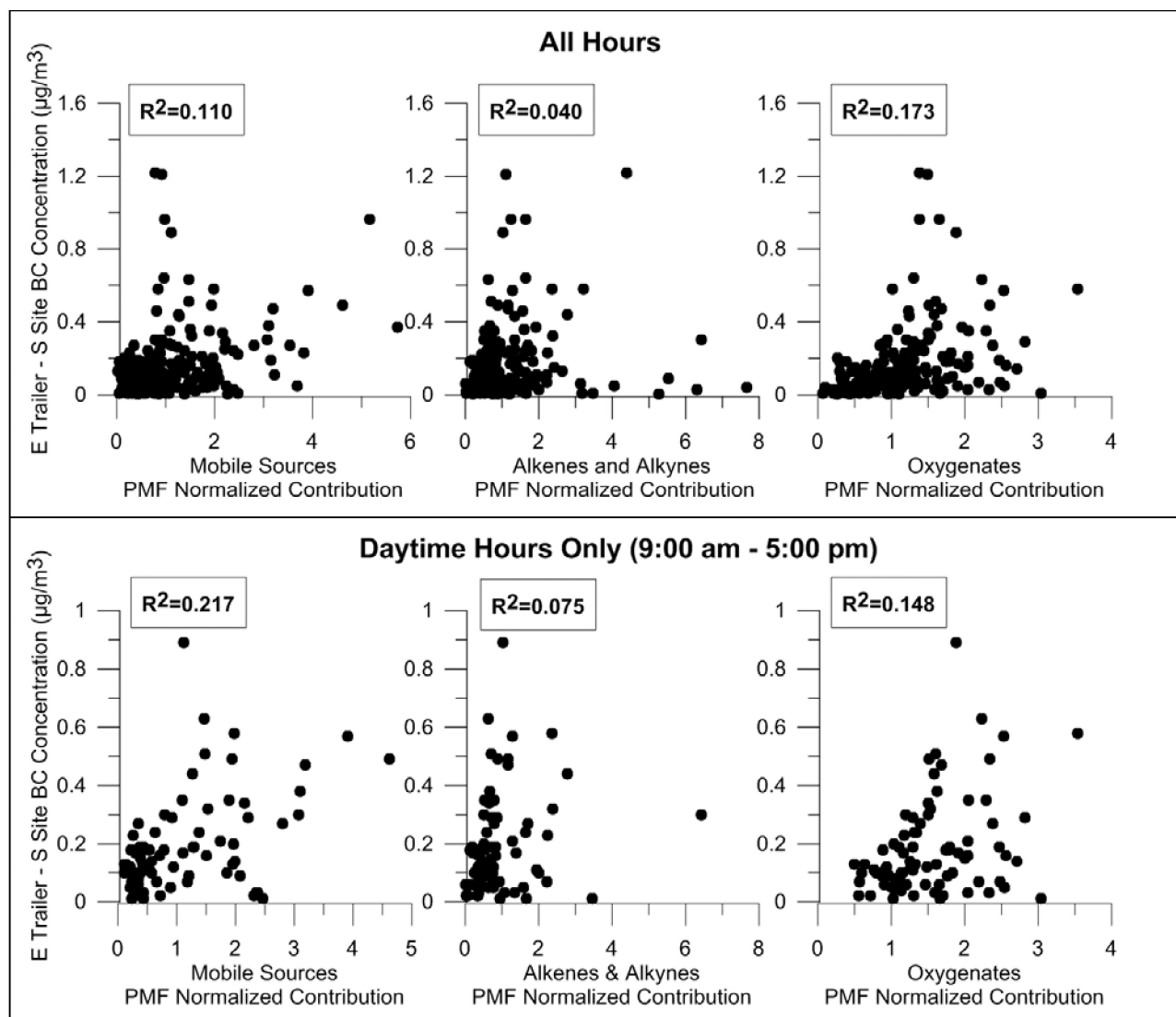
**Table 3-7** summarizes the hourly BC difference and VOC concentrations during the highest 5<sup>th</sup> percentile of BC difference values that occurred during the daytimes of the VOC sampling period. Winds were typically out of the west-southwest. The 1,3-butadiene and naphthalene concentrations were low during these high BC difference periods. Of the six highest BC difference hours, four of these coincided with the highest 5<sup>th</sup> percentile concentrations of acetaldehyde and toluene, and three coincided with the highest 5<sup>th</sup> percentile concentrations of benzene and xylenes. Oil Field operations were active south of the site during these hours, so it appears that on some discrete hours, there is likely a noticeable, if not statistically quantifiable, influence from oil operations on acetaldehyde, benzene, and toluene. Each of the hourly episodes with high VOC concentrations was associated with either drill rig operations 518 feet from the East site, workover rig operations 661 feet from the East site, or both. All of the episodes occurred during workover rig operational hours.



**Figure 3-24.** Time series of PMF factor normalized contributions, BC, and East minus South BC difference.



**Figure 3-25.** Pollution roses for VOC PMF normalized factor contributions.



**Figure 3-26.** Scatter plot of PMF VOC factor normalized contributions and BC difference during all hours and daytime hours (9:00 a.m. to 5:00 p.m.).

**Table 3-7.** Wind direction and concentrations of BC difference and VOCs during the highest 5<sup>th</sup> percentile concentrations of BC difference between the East and South sites. For comparison, the highest 5<sup>th</sup> percentile of each species is shown in bold.

Date and Time	BC Difference µg/m <sup>3</sup>	Wind Direction	1,3-Butadiene (ppb)	Acrolein (ppb)	Benzene (ppb)	Toluene (ppb)	Xylenes (ppb)	Naphthalene (ppb)	Acetaldehyde (ppb)
7/10/13 13:00	0.897	SW	0.093	0.186	0.202	0.340	0.336	0.006	4.423
7/15/13 10:00	0.637	SW	0.016	<b>0.425</b>	0.225	0.378	0.307	0.015	<b>6.051</b>
7/9/13 10:00	0.584	W	0.472	<b>0.771</b>	<b>0.452</b>	<b>0.745</b>	0.646	0.019	<b>9.733</b>
7/10/13 10:00	0.571	SW	0.296	0.423	<b>0.450</b>	<b>0.861</b>	<b>0.865</b>	0.016	<b>8.449</b>
7/11/13 13:00	0.513	SW	0	0.192	0.198	0.370	0.447	0.003	3.874
7/10/13 9:00	0.491	W	0.129	0.399	<b>0.497</b>	<b>0.951</b>	<b>0.957</b>	0.016	<b>8.664</b>
7/11/13 12:00	0.491	SW	0.028	0.187	0.234	0.473	0.445	0.009	4.031
7/5/13 9:00	0.477	SE	0.093	0.302	0.384	<b>0.708</b>	<b>0.696</b>	0.031	6.585
95 <sup>th</sup> percentile concentration	0.491		0.918	0.425	0.403	0.708	0.691	0.025	7.719



### 3.4 Risk and Hazard Characterization

#### 3.4.1 Diesel PM Risk and Hazard Characterization

Black carbon can be used as a proxy for DPM concentrations. In the MATES III exposure study, elemental carbon (EC) concentrations ( $\mu\text{g}/\text{m}^3$ ) were used as a proxy for DPM concentrations. EC concentrations were multiplied by a factor ranging from 1.04 to 1.95 to estimate DPM concentrations (South Coast Air Quality Management District, 2008).

Dozens of studies have compared elemental carbon and black carbon measurement methods and have attempted to compare instrument response. An excellent summary of those studies is available in Appendix 1 of the U.S. Environmental Protection Agency's *Black Carbon Report to Congress* (U.S. Environmental Protection Agency, 2012). Table A1-3 and Figure A1-2 of the EPA report show that more than 65% of intercomparison studies showed BC/EC ratios of between 0.7 and 1.3.

We note that draft MATES IV measurements indicate that BC concentrations in the Los Angeles Basin averaged between  $\sim 0.95$  to  $\sim 1.7 \mu\text{g}/\text{m}^3$  during 2012-2013, with a basin average of about  $1.3 \mu\text{g}/\text{m}^3$ . Our average measurements from November 2011 through November 2012 indicated average BC concentrations of approximately  $0.67 \mu\text{g}/\text{m}^3$  for the four monitoring sites, which is significantly lower than any BC site in MATES IV. Some of this discrepancy may be due to the offset in sampling periods, or due to cleaner coastal air being more influential at the Baldwin Hills sites.

For the purposes of this comparison, we used a BC:EC ratio of 1.5 based on the SCAQMD BC results to bound our estimates of DPM. For the conversion from EC to DPM, we will use the MATES IV draft report ratio of 0.82 to calculate our DPM:EC ratio.

Average DPM concentration estimates are shown in **Table 3-8** for each of the four Baldwin sites. The annual mean BC concentrations at each site is known very well, but the conversion to DPM requires assumptions that reduce our certainty in the estimates of those concentrations. Note that these are total cancer and noncancer estimates that do not identify the fraction of risk attributable to any particular emissions source.

**Table 3-8.** Summary of the average BC, EC, and DPM concentrations, and the corresponding risk and hazard characterization, at each Baldwin monitoring location for the November 2011 through November 2012 monitoring period.

Site	Average BC ( $\mu\text{g}/\text{m}^3$ )	BC:EC ratio of 1.5 ( $\mu\text{g}/\text{m}^3$ )	EC:DPM ratio of 0.82 ( $\mu\text{g}/\text{m}^3$ )	Cancer Risk (per million)	Noncancer Hazard Quotient
East	0.676	1.014	0.83	249	0.17
South	0.641	0.9615	0.79	237	0.16
West	0.724	1.086	0.89	267	0.18
North	0.672	1.008	0.83	248	0.17

Total cancer risks from DPM do not point to the total Oil Field contribution to cancer risks. As shown in Section 3.1.3, under west-southwest winds, daytime concentrations often showed an increment in concentrations. Under east-northeast winds, concentration gradients across the Oil Field were negative or zero, indicating no significant contribution of the Oil Field.

**Table 3-9** summarizes the potential increment of BC concentrations across the Oil Field under west-southwest winds, which account for approximately half of all hourly measurements taken during the year-long study. Average contributions at the East minus South pair are higher than at the North minus West pair in most seasons. Total contributions for the year were estimated by dividing the BC difference for the pair by the BC concentration at the downwind site. Relative Oil Field contributions were estimated to be 5.2% at the North minus West pair and 8.6% at the East minus South pair. It is likely that emissions from traffic on La Cienega Blvd. are contributing to the East minus South pair, which is consistent with the higher contributions from that site pair overall, during most seasons, weekdays, and during average and maximum daytime increments. Finally, we note that the actual exposures to the Oil Field contributions across an annual mean are a little more than half of the values listed because the winds are from directions other than the Oil Field almost half of the time.

**Table 3-9.** Comparison of absolute and percentage contributions of the Oil Field operations to BC concentrations on the east side of the Oil Field when winds are from the west-southwest under a variety of conditions.

Increment Metric	North – West ( $\mu\text{g}/\text{m}^3$ )	East – South ( $\mu\text{g}/\text{m}^3$ )	% Contribution (North – West)	% Contribution (East – South)
WSW annual increment	0.036	0.056	5.2%	8.6%
WSW winter increment	0.023	0.067	3.3%	10.3%
WSW spring increment	0.057	0.037	8.2%	5.7%
WSW summer increment	0.021	0.07	3.0%	10.7%
WSW Fall increment	0.048	0.052	6.9%	8.0%
WSW average daytime positive increment	0.072	0.154	10.3%	23.6%
WSW maximum average hourly increment	0.146	0.242	20.9%	37.0%

We do not display results for when winds are from the east-northeast. Concentration differentials are routinely negative, indicating lower concentrations across the Oil Field. Winds from the east-northeast happened for about 25% of the overall study. Under east-northeasterly winds, residents on the western edge of the Oil Field are typically exposed to BC concentrations that are 0.065 to 0.096  $\mu\text{g}/\text{m}^3$  lower on average than those affecting residents on the eastern side of the Oil Field.

### 3.4.2 Metals Risk Characterization

**Table 3-10** includes a comparison between the mean and maximum 1-hr concentrations of toxic metals and the dose-response factors for this study. The dose-response factors are the non-cancer reference exposure levels (REL) for both chronic (annual) and acute (less than a day) and 1-in-a-million cancer risk benchmark level.

**Table 3-10.** Comparison between dose-response factors and metal concentrations.

Metal Element	Chronic REL <sup>a</sup> (ng/m <sup>3</sup> )	Acute REL <sup>a</sup> (ng/m <sup>3</sup> )	Cancer 1-in-a-Million Level (ng/m <sup>3</sup> )	Mean (Hourly Average in 2.5-Month) (ng/m <sup>3</sup> )	Maximum 1-Hr (ng/m <sup>3</sup> )
Arsenic	15	200 (8-hr)	0.300	0.013	2.112
Cadmium	20		0.238	5.35 <sup>b</sup>	21.4
Chromium	200			0.195	25.4
Copper		100,000 (1-hr)		6.847	323.8
Lead	150		83.0	3.173	27.9
Manganese	90	170 (8-hr)		1.424	30.2
Mercury	30	600 (1-hr)		0.004	0.303
Nickel	14	200 (1-hr)	3.8	0.694	248.4
Selenium	20,000			0.474	29.3

<sup>a</sup> Chronic and acute RELs were obtained from the Office of Environmental Health Hazard Assessment (OEHHA); see <http://oehha.ca.gov/air/allrels.html>.

<sup>b</sup> Average concentrations for cadmium are below the reported method detection limit for the XACT instrument (5.78 ng/m<sup>3</sup>).

Among the metals measured, there was one reported hourly value for any metal that exceeded the acute REL standard; this was for the nickel REL of 200 ng/m<sup>3</sup>. This hourly value occurred on November 17, 2012, at 10:00 PM LST. Multiple other metals had high concentrations on that hour, including manganese, iron, zinc, and potassium. Winds for that hour were from the northeast, which is in the direction of Kenneth Hahn State Park, the opposite direction from the Oil Field. BC concentrations for that same hour were below 1 µg/m<sup>3</sup>. It is unclear what caused the high nickel concentration, but it did not appear to be associated with onsite operations at the Oil Field.

Comparing the mean concentrations for the 2.5-month monitoring period to chronic RELs indicates that no metals were above their dose-response level. The metal with the closest concentration to an REL was cadmium, which was almost a factor of four below the chronic REL value. Moreover, for most of the metals, the maximum 1-hr concentration observed was below the chronic REL value (again, except for nickel).

Finally, comparing the mean 2.5-month concentration to the 1-in-a-million level cancer risk for each of the metals indicates that arsenic, lead, and nickel are all below the level of

concern. In contrast, the mean cadmium concentration measured by the XRF instrument was above the 1-in-a-million level of concern, leading to an excess cancer risk for cadmium of 22.5-in-a-million. STI scientists consider this result uncertain for a number of reasons. First, we note that MDLs for cadmium measurements are at  $5.75 \text{ ng/m}^3$ , and the mean measured concentration was below the MDL. Second, 64% of individual hourly measurements were below the MDL. Third, the lowest 1-hr concentration reported by the XRF instrument was  $1.1 \text{ ng/m}^3$ , which is above the 1-in-a-million benchmark of  $0.238 \text{ ng/m}^3$ . This is almost as high as annual mean measurements of cadmium in the MATES III study, which reported average concentrations of 1.5 to  $1.6 \text{ ng/m}^3$ , based on a  $2.0 \text{ ng/m}^3$  MDL, and it is a factor of 10 higher than average concentrations of  $0.1 \text{ ng/m}^3$  reported in the draft MATES IV study.

Cadmium concentrations showed no wind direction dependence, no distinguishable diurnal pattern, and no weekday-weekend differences. As a result, while cadmium concentrations were higher than the 1-in-a-million risk level value, we cannot attribute what fraction, if any, of the local concentrations may be attributable to the Oil Field. We note that the discrepancy in concentrations between our measurements and the SCAQMD MATES III and MATES IV measurements may be partly a result of our 2.5-month sampling period relative to the annual means calculated in MATES; it is plausible that winter concentrations could be higher than summer concentrations as a result of lower wintertime mixing heights and winds.

### 3.4.3 VOC Risk Characterization

Concentrations of the VOC species were compared to non-cancer and cancer benchmarks, shown in **Table 3-11**. The product of the mean concentration and the 1-in-a-million cancer risk benchmark for a given species was used to assess the cancer risk. No VOC species average was above the chronic REL, although acrolein was very close. Each of the pollutants with cancer risk levels was above the 1-in-a-million level, with 1,3-butadiene having the highest cancer risk for this two-week period, followed by benzene, acetaldehyde, and naphthalene. Note that the two-week average concentration is unlikely to be representative of the annual mean exposure for any of these pollutants, as the seasonal patterns in these pollutants may vary by a factor of three or more (McCarthy et al., 2007). However, these concentrations are similar to those observed in MATES III and are useful as benchmarks for assessing potential risks from the Oil Field operations.



**Table 3-11.** Comparison of VOC concentrations to OEHHA dose-response factors.

Pollutant	Chronic REL ( $\mu\text{g}/\text{m}^3$ )	Acute REL ( $\mu\text{g}/\text{m}^3$ )	Cancer 1-in-a-Million Level	2-Week Average ( $\mu\text{g}/\text{m}^3$ )	1-hr Maximum ( $\mu\text{g}/\text{m}^3$ )	Excess Cancer Risk (per Million)
1,3-Butadiene	2	9	0.00588	0.22	2.31	37
Acrolein	0.35	2.5		0.33	1.77	
Benzene	60	1300	0.0345	0.55	1.70	16
Toluene	5000	37000		1.08	3.58	
Xylenes	300			1.31	4.74	
Naphthalene	9		0.0294	0.05	0.53	1.7
Acetaldehyde	140	470	0.37	4.72	17.5	13

As noted in Section 3.3, the two weeks of five-minute average measurements did not show any statistically significant contributions of Oil Field operations to the identified source factors contributing to concentrations of these toxic air pollutants. Due to the short deployment, it is not possible to rule out Oil Field contributions to ambient VOC concentrations; however, diurnal time series and case studies were not consistent with the hypothesis that the Oil Field was a major contributor to any of the VOCs we examined.

### 3.5 Supplementary Emissions Activity Analysis

Emissions activity data from on-field and roadway activities were used to attempt to distinguish among the different possible sources of higher black carbon concentrations across the Oil Field that occurred when winds were from the west-southwest. The key distinguishing information we had to work with from the BC differential analyses included

- Differentials were greater at the East minus South pair of monitors than at the North minus West pair. It was hypothesized that onroad emissions from motor vehicles were responsible for some of the higher concentrations for the East minus South pair.
- Concentration differentials were highest during daytime business hours, particularly from 8:00 a.m. LST to about 3:00 p.m.
- Concentration differentials were higher on weekdays than weekends.

Emissions activity data were examined to see what Oil Field and traffic activity were consistent with the activity patterns seen in the BC differential analysis. Of the emissions sources with available activity data, we see that the timing of heavy-duty truck traffic, medium-duty vehicle traffic, light-duty vehicle traffic, and maintenance and workover rig operation is consistent with the observed temporal profile of increased BC concentrations across the Oil Field. Each of these sources has higher daytime and weekday emissions activity.



The East minus South pair has a higher BC differential than the North minus West site pairing; this is consistent with both roadway and Oil Field maintenance and workover rig emissions. La Cienega Blvd. north of Stocker is between the East minus South pair; thus we expect some influence from the roadway emissions to the observed differential. Given the available activity data, it is not possible to separate the Oil Field and traffic contributions at this site pairing since the observed patterns are consistent with both traffic and maintenance and workover rig operations.

In contrast, the North minus West pair has no intervening roadway; both sites are west of La Cienega Blvd. Therefore, the BC differential under west-southwesterly winds should not have any roadway influence at the North minus West pair. This site pair still has higher weekday and daytime BC differential concentrations (under WSW winds) than weekend and nighttime conditions. The North minus West pair also has a lower BC concentration differential than the East minus South pair on average during each season. This observational evidence is consistent with the temporal activity patterns of Oil Field maintenance and workover rigs without the confounding traffic influence. Thus, we conclude that this site pair is capturing a small but real source of Oil Field emissions of diesel PM.

**Table 3-12** shows a summary of some characteristics of the supplemental emission sources and a statement of whether or not those characteristics are consistent with the characteristics of the BC differentials. Source characteristics include a qualitative magnitude of the activity and a classification of the diurnal emissions pattern. The BC differential diurnal pattern is consistent with the diurnal pattern of workover and maintenance rigs and with some, but not all, of the on-road diesel activity diurnal patterns on La Cienega Boulevard.

**Table 3-12.** Emission sources temporal activity patterns and consistency with observed BC differential temporal patterns

Emissions Source	Approximate Magnitude	Higher on Weekdays than Weekends?	Higher During Daytime Business Hours?	Peak Hour	Consistent with BC Differential?
La Cienega north of Stocker - Heavy-duty diesel	30 vehicles	Yes	Yes	8:00 AM	Yes
La Cienega south of Stocker - Heavy-duty diesel	100 vehicles	Yes	Yes	6:00 PM	No
La Cienega north of Stocker - Medium-duty vehicles	1,000 vehicles	Yes, but only during AM	Yes	4:00 PM	No
La Cienega south of Stocker - Medium-duty vehicles	1,100 vehicles	Yes, but only during AM	Yes	8:00 AM	Yes
La Cienega north of Stocker - Light-duty vehicles	3,500 vehicles	Yes, but only during AM	Yes	6:00 PM	No
La Cienega south of Stocker - Light-duty vehicles	4,300 vehicles	Yes, but only during AM	Yes	7:00 AM	Yes
Stocker and Fairfax Gate- Car and truck entries	40 vehicles	No	Yes	6:00 AM	No
Stocker and Fairfax Gate- Heavy-duty diesel entries	3 vehicles	No	Yes	10:00 AM	No
Drill rig	1 rig - 3 parts	No	No	Not available	No
Workover and maintenance rigs	6 rigs	Yes	Yes	Not available	Yes



## 4. Discussion

### 4.1 Comparison of Risk and Hazard Across Target Air Toxics

Section 3.4 discusses the individual risk and hazard associated with each pollutant in the Oil Field. **Figures 4-1 and 4-2** compare the total excess cancer risk and noncancer hazard index measured by pollutant in the Baldwin Hills Air Quality Study. Note that all DPM risk and hazard values in this section of the report use the more conservative estimates ( $BC \times 1.5 = EC$ ) that lead to higher cancer risk and noncancer hazard estimates. As expected, Diesel PM had the highest individual contribution to total cancer risk, with values more than ten times higher than the sum of the risk of all other pollutants measured in the study. This cancer risk estimate for DPM is quantitatively comparable to the estimates of total cancer risk in the MATES IV study, which found total risk from Diesel PM to be approximately 285-in-a-million.

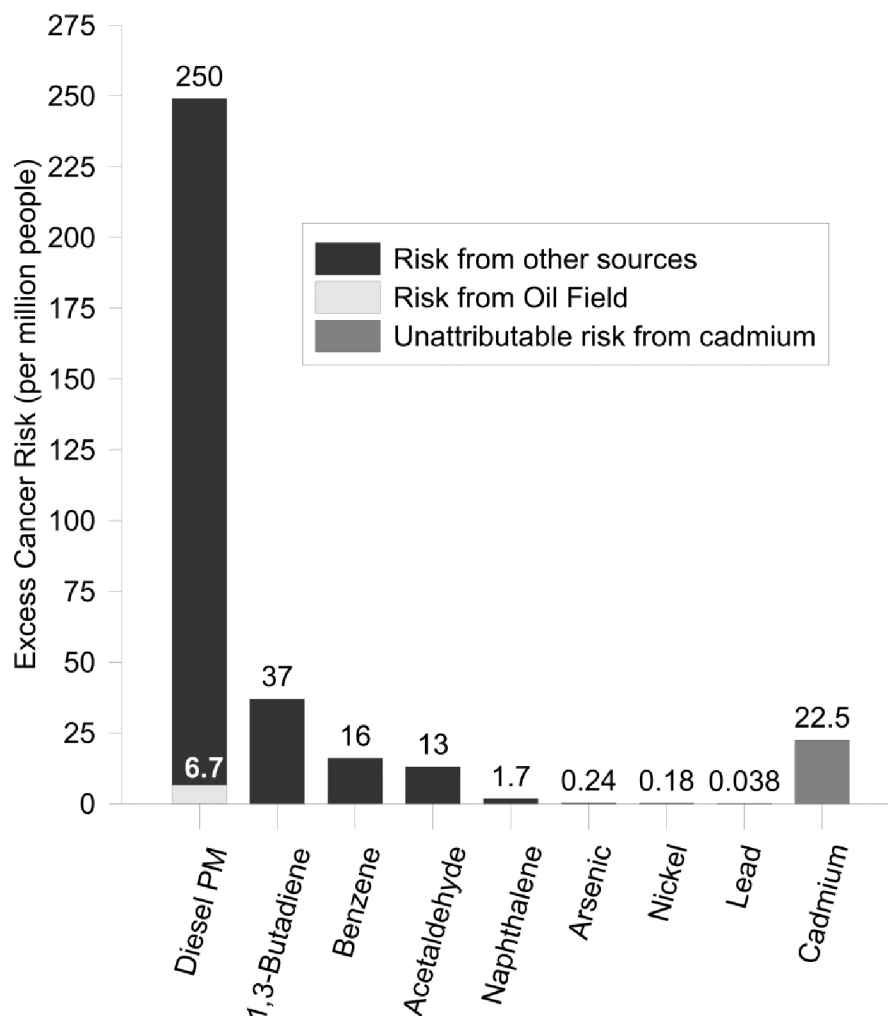
Regarding excess cancer risk, the OEHHA states, “For chemicals that are listed as causing cancer, the “no significant risk level” is defined as the level of exposure that would result in not more than one excess case of cancer in 100,000 individuals exposed to the chemical over a 70-year lifetime. In other words, a person exposed to the chemical at the “no significant risk level” for 70 years would not have more than a “one in 100,000” chance of developing cancer as a result of that exposure.”<sup>3</sup> Benzene, 1,3-butadiene, and the combination of formaldehyde and acetaldehyde were found to make up the largest individual components of risk after Diesel PM. Cadmium was found to contribute slightly to risk, but our estimate is about 50 times higher than the MATES IV estimate, which may be due to instrument measurement differences. We recommend a comparison of ICP-MS and XRF cadmium measurements using filters collected in the western Los Angeles Basin to resolve the potential cadmium discrepancy.

Figure 4-1 shows that estimated diesel particulate matter concentrations in the area constitute the dominant contribution to excess cancer risk from ambient air. The relative contributions from the Oil Field are shown as the smaller bar within the total local risk. Total risk estimates for each of the air toxics are in reasonable agreement with SCAQMD MATES IV estimates of excess cancer risk across the Los Angeles Basin, with the exception of cadmium.

In comparison to the cancer risks, which are well above a screening value of 1-in-a-million excess cancer cases, all noncancer hazard index values shown in Figure 4-2 are below a value of 1.0. A noncancer risk of 1.0 is considered the “health reference level” and is expected to be below the level at which adverse human health effects would occur. Thus, acrolein, which has the highest noncancer hazard index at 0.94, is expected to have no adverse health impacts. However, we note that for most of the toxics shown in Figure 4-2, there is some additional uncertainty associated with the shorter sampling periods (2.5 months for metals, 2 weeks for VOCs); these values do not necessarily represent true annual mean concentrations. Additionally, we are considering each pollutant’s effect individually; these pollutants may have additive or synergistic effects that would lead to higher estimated cumulative risks than the estimates shown below.

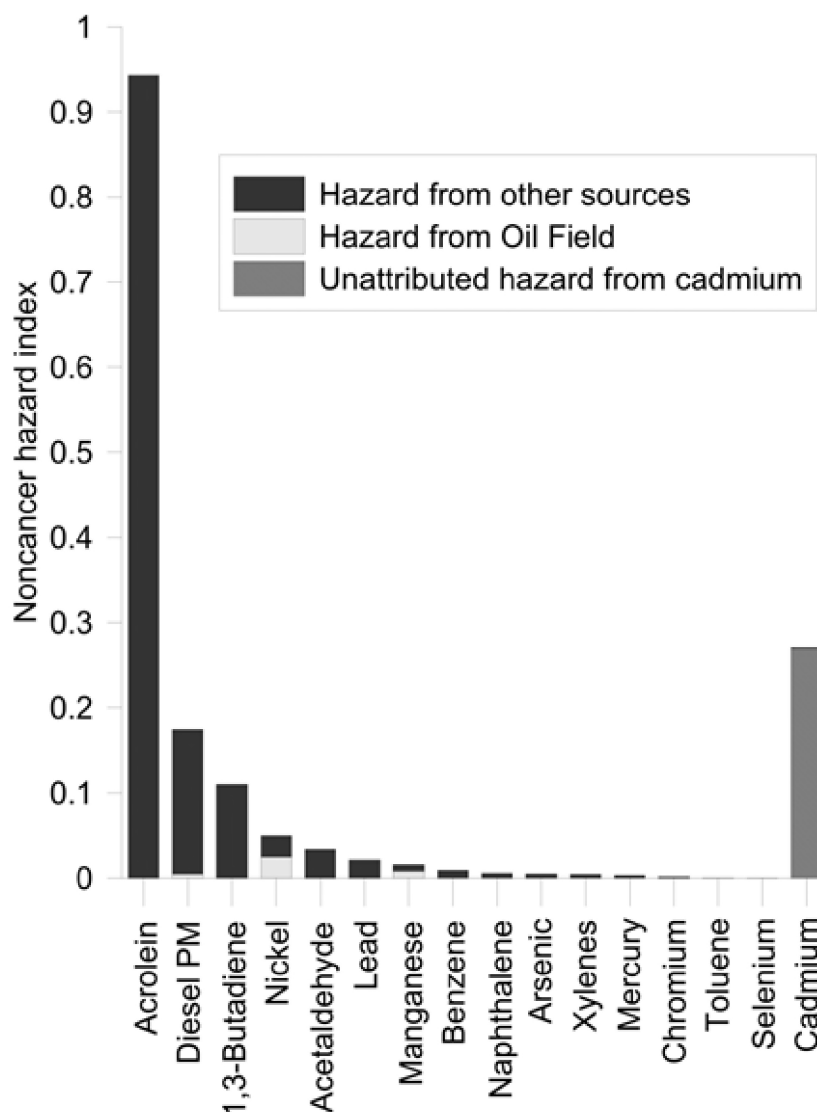
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<sup>3</sup> See “Proposition 65 in Plain Language” at <http://www.oehha.ca.gov/prop65/background/p65plain.html>.



**Figure 4-1.** Individual pollutant contributions to total excess cancer risk (per million people) at the Baldwin Hills Air Quality Study. The graph shows total risk from ambient air and the incremental contribution of the Oil Field. Cadmium risk could not be attributed and should be validated through measurement intercomparison studies.





**Figure 4-2.** Relative contributions to the chronic noncancer hazard index for the Baldwin Hills Air Quality Study. This graph shows total chronic noncancer hazard from ambient air and the incremental contribution of the Oil Field. If the noncancer hazard index is below a value of one, then no adverse effects are expected.

In summary, Diesel PM is the pollutant of most concern identified by this monitoring study based on total ambient concentrations. This finding is consistent with previous risk assessments performed in the SCAQMD and the quantitative results from those larger studies of air quality in the Los Angeles Basin.

## 4.2 Assessment of the Oil Field Contributions to Risk and Hazard

Of the pollutants examined, only Diesel PM showed solid evidence of significant contributions from the Oil Field to chronic cancer risk or noncancer hazard. Under west-southwest conditions, concentrations of DPM across the Oil Field increased by 5.2 to 8.6%

on average. The wind direction frequency bins are shown in **Table 4-1**. West-southwesterly (onshore flow) winds were dominant, occurring 53% of the time. East-northeast winds, or offshore flow, were the second most common, occurring 25% of the time. Winds from the south or north were much less frequent, at 13.1 and 7.8% of the time, respectively.

**Table 4-1.** The percentage of hours during which wind originated from four major directions.

Direction	Wind Direction Angles	Percent of Total Winds
East-northeast	30°–120°	25.0
North-northwest	300°–30°	7.8
South-southeast	120°–210°	13.1
West-southwest	210°–300°	53.0

Under west-southwesterly conditions, residents to the east of the Oil Field were exposed to higher DPM concentrations than those on the west of the Oil Field. However, under other wind regimes, these residents were not exposed to Oil Field contributions. For example, under east-northeast winds, concentrations of DPM on the eastern side of the Oil Field would not be influenced by the Oil Field operations. Similarly, south-southeasterly flow and north-northwesterly flow would not expose residents on the eastern side of the Oil Field to Oil Field contributions. Therefore, the total contribution of pollutants from the Oil Field to residents on the eastern side of the Oil Field comes during the 53% of the time when winds are west-southwesterly. This reduces the estimated contribution to 2.6 to 4.6% of the total DPM exposure. Taking the most conservative estimate of DPM cancer risk of 250 per million, we estimate that the Oil Field may be directly responsible for approximately 6.7 to 11.3 per million of the total DPM risk. Given that the higher estimate of 11.3 per million is likely influenced by traffic on La Cienega Boulevard emissions of DPM, we consider this a conservative upper estimate of total risk to residents on the eastern side of the Oil Field. The contributions to excess cancer risk and to noncancer hazard index are shown in Figures 4-1 and 4-2.

The differential analysis showed a decrease in BC concentrations when winds were from the east-northeast. Therefore, there is no evidence of Oil Field operations contributing to enhanced DPM exposure under those wind conditions.

Winds from the south-southeast and north-northwest were much less frequent than the primary onshore-offshore flow. As a result, Oil Field operations have proportionately less potential impact because residents downwind of the Oil Field in these directions will be exposed much less of the time.

We found no evidence of contributions to other key species such as benzene, acetaldehyde, acrolein, or 1,3-butadiene. It is possible that the Oil Field operations could contribute significantly to some of these species, but we have no compelling evidence to suggest it does, based on the two weeks of VOC monitoring. Additionally, the concentrations observed at the Oil Field are generally consistent with concentrations observed in other parts of

the Los Angeles Basin, suggesting that any possible contributions of the Oil Field are incremental or marginal, rather than a dominant local source.

The contribution of the Oil Field to cadmium concentrations is more complicated because of the detection limit issues with the analytical method. The average cadmium concentration was below the MDL. Wind direction, day-of-week, and time-of-day analyses showed no patterns in concentrations that would suggest Oil Field contributions. However, the average concentration of cadmium was a little more than three times higher than concentrations reported in MATES III and more than 50 times higher than concentrations in the draft MATES IV report. This could be evidence of a local contribution from the Oil Field. It may also indicate higher wintertime concentrations or issues with the analytical method. While cadmium cancer risk in this study is 22.5-in-a-million, attribution of the source of the cadmium is not possible with the available data.

Nickel and manganese concentrations may be influenced by Oil Field operations, but their total cancer risk and noncancer hazard are negligible.

Therefore, we find the total maximum cancer risk that can be plausibly attributed to the Oil Field operations is in excess of 11.3 per million cancer risk. This number is a conservative estimate, and may include contributions from La Cienega Blvd. emissions and does not include any contribution from cadmium.



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## **Appendix A**

### **Well Data Near the East Monitoring Site**

Data from Marine Research Specialists



**Table A-1.** Well activity (workover).

WELL_	WELL_CODE	START_DATE	STOP_DATE	DURATION_D	SURFACE_X	SURFACE_Y	Distance_to_ Estation_ft
BC-115	BC-115	11/26/2012	11/27/2012	1.0	4177019.370	4113499.560	798
LAI1-388	LAI-388	11/29/2012	11/30/2012	1.0	4177464.000	4110570.000	3659
LAI1-BC-404	LAIBC-404	11/6/2012	11/8/2012	2.0	4176449.850	4113379.480	1234
WRZU-349	WRZU-349	11/16/2012	11/21/2012	5.0	4175829.860	4113924.550	1547
TVIC-67	TVIC-67	11/16/2012	11/30/2012	14.0	4172123.160	4114713.590	5247
LAI1-384	LAI-384	11/14/2012	11/20/2012	6.0	4177274.600	4110858.930	3369
LAI1-439	LAI-439	10/29/2012	11/1/2012	3.0	4174655.410	4112957.070	2976
WRZU-344	WRZU-344	9/26/2012	11/10/2012	45.0	4175752.340	4113822.160	1645
LAI1-62	LAI-62	11/15/2012	11/26/2012	11.0	4176910.400	4110031.420	4218
BC 331	BC-331	11/9/2012	11/14/2012	5.0	4177778.250	4111480.290	2780
BC-285	BC-285	10/22/2012	11/1/2012	10.0	4177689.000	4112005.000	2248
LAI1-226	LAI-226	12/4/2012	12/4/2012	0.0	4175073.080	4111692.220	3405
LAI1-5631	LAI-5631	12/18/2012	12/20/2012	2.0	4175294.000	4112627.000	2603
Vickers1-88	VIC1-88	11/28/2012	12/3/2012	5.0	4172463.500	4114196.970	4884
BC-LAI1-446	BCLAI-446	12/10/2012	12/13/2012	3.0	4176889.470	4112001.390	2272
LAI1-56	LAI-56	12/17/2012	12/19/2012	2.0	4175596.550	4112761.080	2283
LAI1-380	LAI-380	12/5/2012	1/4/2013	30.0	4174521.600	4113161.600	3020
LAI1 207	LAI-207	1/22/2013	1/22/2013	0.0	4177914.060	4110359.840	3908
LAI1-257	LAI-257	12/19/2012	1/4/2013	16.0	4175195.220	4112940.380	2507
LAI1-372	LAI-372	1/7/2013	1/9/2013	2.0	4175878.850	4113426.560	1672
BC-LAI1-441	BCLAI-441	1/14/2013	1/17/2013	3.0	4176925.700	4112708.650	1576
LAI1-371	LAI-371	1/22/2013	1/29/2013	7.0	4174414.360	4114280.360	2933
LAI1-387	LAI-387	1/9/2013	1/11/2013	2.0	4177352.460	4110225.240	4001
LAI1-5552	LAI-5552	1/3/2013	1/8/2013	5.0	4175766.000	4113673.000	1675
Vic1-LAI1-4443	VicLAI-4443	1/29/2013	1/31/2013	2.0	4173758.540	4114571.370	3605
Vic1-790	Vic1-790	12/17/2012	1/17/2013	31.0	4173902.020	4114020.450	3451
Vic1-25	Vic1-25	1/14/2013	1/21/2013	7.0	4174240.270	4113180.010	3279
Vic1-45	Vic1-45	1/4/2013	1/14/2013	10.0	4173950.010	4112341.760	3885
WRZU-350	WRZU-350	1/22/2013	1/28/2013	6.0	4175183.190	4114080.120	2169
LAI1-4573	LAI-4573	1/14/2013	1/22/2013	8.0	4174897.520	4113361.690	2598
LAI-VRU-2	LAIVRU-2	2/19/2013	2/21/2013	2.0	4176324.650	4114313.500	1026
LAI1-175	LAI-175	2/1/2013	2/8/2013	7.0	4176419.730	4111496.290	2884
LAI1-292	LAI-292	2/7/2013	2/11/2013	4.0	4174800.020	4112799.110	2920
LAI1-384	LAI-384	2/4/2013	2/6/2013	2.0	4177274.600	4110858.930	3369
LAI1-BC-404	LAIBC-404	2/22/2013	2/25/2013	3.0	4176449.850	4113379.480	1234
Vic1-56	Vic1-56	2/4/2013	2/6/2013	2.0	4173103.900	4114608.450	4261
LAI1-22	LAI-22	2/11/2013	2/28/2013	17.0	4175757.280	4113921.540	1619
LAI1-50	LAI-50	12/20/2012	2/19/2013	61.0	4177788.850	4111000.040	3257
WRZU-345	WRZU-345	2/11/2013	2/21/2013	10.0	4175243.380	4113844.710	2138

WELL_	WELL_CODE	START_DATE	STOP_DATE	DURATION_D	SURFACE_X	SURFACE_Y	Distance_to_ Estation_ft
LAI1-6843	LAI-6843	2/22/2013	2/28/2013	6.0	4177911.420	4110413.610	3855
LAI1-Vic1-4562	LAIVIC1-4562	1/28/2013	2/1/2013	4.0	4174305.280	4113805.220	3071
LAI1-Vic1-4564	LAIVic-4564	1/28/2013	2/5/2013	8.0	4174614.000	4112998.000	2997
BC-LAI1-216	BC-LAI-216	2/28/2013	3/14/2013	14.0	4177294.030	4113975.300	257
LAI1-136A	LAI-136A	3/19/2013	3/21/2013	2.0	4175764.550	4112916.190	2055
LAI1-340RD	LAI-340	2/19/2013	3/11/2013	20.0	4175679.400	4113533.880	1806
BC-6532	BC-6532	3/25/2013	3/27/2013	2.0	4177448.000	4113852.000	388
LAI1-200	LAI-200	3/11/2013	3/14/2013	3.0	4174389.530	4113963.950	2969
LAI1-444	LAI-444	3/12/2013	3/15/2013	3.0	4177011.440	4110954.440	3289
LAI1-358	LAI-358	2/28/2013	3/19/2013	19.0	4176104.160	4113837.770	1303
WRZU-349	WRZU-349	4/23/2013	4/29/2013	6.0	4175829.860	4113924.550	1547
LAI1-339RD1	LAI-339RD1	4/10/2013	4/15/2013	5.0	4176210.000	4113224.000	1516
LAI1-385	LAI-385	4/8/2013	4/9/2013	1.0	4177034.750	4110335.370	3904
BC-115	BC-115	5/21/2013	5/24/2013	3.0	4177019.370	4113499.560	798
Vickers1-934	Vic1-934	5/6/2013	5/20/2013	14.0	4172403.490	4114610.730	4959
LAI1-214	LAI-214	5/16/2013	5/22/2013	6.0	4174191.130	4114482.670	3167
LAI1-413	LAI-413	5/15/2013	5/21/2013	6.0	4176226.600	4111969.600	2520
Vickers1-75A	Vic1-75A	4/16/2013	5/3/2013	17.0	4173569.320	4114554.400	3792
LAI1-5654	LAI-5654	4/30/2013	5/2/2013	2.0	4176402.320	4112421.360	2038
LAI1-946	LAI-946	6/17/2013	6/27/2013	10.0	4174967.040	4112604.280	2881
Vic1-60	Vic1-60	6/13/2013	6/20/2013	7.0	4173646.590	4113527.420	3766
LAI1-380	LAI-380	12/5/2012	6/24/2013	201.0	4174521.600	4113161.600	3020
BC-220	BC-220	5/31/2013	6/6/2013	6.0	4177406.000	4113015.000	1213
LAI1-376	LAI-376	6/10/2013	6/24/2013	14.0	4175598.470	4113213.500	2021
Vickers1-88	VIC1-88	5/22/2013	6/6/2013	15.0	4172463.500	4114196.970	4884
Vickers1-109	VIC1-109	6/4/2013	6/11/2013	7.0	4173633.490	4113539.700	3777
LAI1-5773	LAI-5773	5/28/2013	6/5/2013	8.0	4176743.000	4111194.000	3092
LAI1-81	LAI-81	7/2/2013	7/19/2013	17.0	4175754.810	4113872.000	1632
BC-203	BC-203	7/12/2013	7/19/2013	7.0	4177708.810	4112519.800	1745
BC-236	BC-236	7/9/2013	7/20/2013	11.0	4177628.030	4113628.600	661
LAI1-442	LAI-442	7/22/2013	7/30/2013	8.0	4177722.110	4110239.330	4005
BC-6522	BC-6522	7/24/2013	7/30/2013	6.0	4177420.450	4113848.570	385
Vic1-82	Vic1-82	8/8/2013	8/22/2013	14.0	4173780.690	4112783.970	3847
LAI1-377	LAI-377	8/13/2013	8/14/2013	1.0	4176340.130	4114284.550	1009
LAI1-388	LAI-388	8/12/2013	8/12/2013	0.0	4177464.000	4110570.000	3659
WRZU-347	WRZU-347	8/22/2013	8/26/2013	4.0	4175446.620	4113837.260	1940
LAI1-188A	LAI-188A	8/27/2013	8/28/2013	1.0	4175331.960	4113591.710	2113
LAI1-390	LAI-390	8/15/2013	8/16/2013	1.0	4175382.000	4113307.000	2170
LAI1-Vic1-472	LAIVic-472	8/1/2013	8/2/2013	1.0	4174315.000	4113866.900	3054
LAI1-466	LAI-466	8/23/2013	8/28/2013	5.0	4176447.000	4112687.000	1784



WELL_	WELL_CODE	START_DATE	STOP_DATE	DURATION_D	SURFACE_X	SURFACE_Y	Distance_to _Estation_ft
LAI1-473	LAI-473	8/5/2013	8/12/2013	7.0	4175830.000	4113399.000	1728
LAI1-362	LAI-362	8/2/2013	8/8/2013	6.0	4175167.650	4113090.920	2458
LAI1-BC-128	LAIBC-128	7/29/2013	8/10/2013	12.0	4177510.280	4110883.170	3347
BC-LAI1-5473	BCLAI1-5473	8/8/2013	8/19/2013	11.0	4176908.000	4113953.000	518
LAI1-5762	LAI-5762	8/7/2013	8/16/2013	9.0	4176512.230	4111503.360	2848
BC-6533	BC-6533	7/29/2013	8/1/2013	3.0	4177437.000	4112968.000	1262
BC-6642	BC-6642	8/2/2013	8/7/2013	5.0	4177743.720	4112505.900	1766
BC-6533	BC-6533	9/26/2013	9/26/2013	0.0	4177437.000	4112968.000	1262
WRZU-340	WRZU-340	9/4/2013	9/10/2013	6.0	4174272.220	4114357.120	3078
LAI1-452	LAI-452	9/18/2013	9/23/2013	5.0	4175219.910	4113996.430	2140
LAI1-446	LAI-446	8/28/2013	9/18/2013	21.0	4176464.600	4113403.400	1207
LAI1-197	LAI-197	8/20/2013	9/17/2013	28.0	4176418.290	4110777.530	3572
Vickers1-76	VIC1-76	9/2/2013	10/3/2013	31.0	4173581.580	4114089.840	3768
LAI1-437	LAI-437	10/30/2013	10/31/2013	1.0	4174334.670	4113863.970	3034
LAI1-5773	LAI-5773	9/30/2013	10/1/2013	1.0	4176743.000	4111194.000	3092
LAI-5434	LAI-5434	10/17/2013	10/24/2013	7.0	4175256.000	4113934.000	2112
BC-LAI1-443	BCLAI-443	10/10/2013	10/11/2013	1.0	4177013.500	4111672.500	2576
LAI1-33	LAI-33	10/23/2013	10/29/2013	6.0	4175974.510	4111910.830	2692
LAI1-441	LAI-441	10/21/2013	10/23/2013	2.0	4177077.690	4110362.250	3874
LAI1-459	LAI-459	10/16/2013	10/18/2013	2.0	4176230.000	4112054.000	2443
LAI1-BC-5474	LAIBC-5474	10/14/2013	10/16/2013	2.0	4176528.000	4114077.000	833
LAI1-364RD1	LAI-364RD1	10/4/2013	10/17/2013	13.0	4176472.840	4113320.230	1260
LAI1-417	LAI-417	9/30/2013	10/3/2013	3.0	4175120.820	4113084.380	2502
LAI1-440	LAI-440	10/9/2013	10/15/2013	6.0	4177060.220	4110350.890	3886
Vickers1-114	VIC1-114	9/11/2013	10/15/2013	34.0	4172971.660	4113790.000	4397
Vickers1-934	VIC1-934	9/30/2013	10/3/2013	3.0	4172403.490	4114610.730	4959
BC-6512	BC-6512	10/7/2013	10/9/2013	2.0	4177006.110	4113388.150	905
LAI1-424	LAI-424	10/15/2013	10/23/2013	8.0	4175263.900	4112622.140	2630
LAI1-140	LAI-140	11/5/2013	11/5/2013	0.0	4176198.150	4112473.450	2096
Vickers1-64	VIC1-64	11/1/2013	11/4/2013	3.0	4174211.870	4112543.930	3558
BC-115	BC-115	10/24/2013	11/25/2013	32.0	4177019.370	4113499.560	798
LAI1-410	LAI-410	11/5/2013	11/12/2013	7.0	4175842.000	4113088.100	1887
LAI1-5434	LAI-5434	11/7/2013	11/8/2013	1.0	4175256.000	4113934.000	2112
LAI1-2567	LAI-2567	11/11/2013	11/13/2013	2.0	4177413.000	4111198.000	3029
LAI1-266	LAI-266	11/18/2013	11/20/2013	2.0	4175263.790	4112907.520	2466
LAI1-367	LAI-367	11/11/2013	11/13/2013	2.0	4175911.230	4113370.480	1672
LAI1-429	LAI-429	11/21/2013	11/26/2013	5.0	4176419.420	4111247.950	3120
BC-646	BC-646	10/25/2013	11/4/2013	10.0	4177311.800	4113961.620	267

**Table A-2. Well activity (maintenance).**

PRODUCTION	WELL	DATE	WELL_CODE	SURFACE_X	SURFACE_Y	DURATION	Distance_to _Estation_ft
Nabors # 1521	BC 115	11/5/2012	BC-115	4177019.370	4113499.560	1.0	798
Nabors # 358	BC 121	1/29/2013	BC-121	4177593.630	4111524.530	2.0	2713
Nabors # 1069	BC 123	1/31/2001	BC-123	4177393.200	4112547.260	1.0	1680
Nabors # 1521	BC 132	2/22/2013	BC-132	4177736.940	4112050.730	4.0	2211
Nabors # 1069	BC 17	3/19/2013	BC-17	4176876.260	4114190.920	2.0	472
Nabors # 1523	BC 2167	11/6/2013	BC-2167	4177797.550	4111453.460	3.0	2810
Nabors # 1521	BC 220	11/13/2013	BC-220	4177406.000	4113015.000	3.0	1213
Nabors # 362	BC 273	8/6/2013	BC-273	4177417.000	4112114.000	2.0	2114
Nabors # 1521	BC 34	7/15/2013	BC-34	4177548.720	4112720.780	2.0	1519
Nabors # 1521	BC 650	5/31/2013	BC-650	4177291.700	4113138.000	2.0	1090
Nabors # 1523	BC 6512	11/22/2013	BC-6512	4177006.110	4113388.150	2.0	905
Nabors # 1011	BC 652	11/11/2013	BC-652	4177735.000	4112015.000	4.0	2245
Nabors # 1061	BC 6521	10/6/2014	BC-6521	4177431.000	4113860.000	4.0	376
Nabors # 1521	BC 6641	5/6/2013	BC-6641	4177603.000	4112883.000	1.0	1368
Nabors # 1523	BCLAI 216	11/15/2013	BCLAI-216	4177294.030	4113975.300	2.0	257
Nabors # 1061	BCLAI 441	9/10/2013	BCLAI-441	4176925.700	4112708.650	4.0	1576
Nabors # 1523	BCLAI 442	8/12/2013	BCLAI-442	4177082.000	4111690.000	3.0	2551
Nabors # 1522	BCLAI 443	5/23/2013	BCLAI-443	4177013.500	4111672.500	3.0	2576
Nabors # 1522	BCLAI 445	4/26/2013	BCLAI-445	4176940.850	4113908.700	3.0	516
Nabors # 1061	BCLAI-443	9/27/2013	BCLAI-443	4177013.500	4111672.500	4.0	2576
Nabors # 1523	LAI 137	9/11/2013	LAI-137	4176254.830	4113674.200	6.0	1224
Nabors # 1522	LAI 138	8/6/2013	LAI-138	4175931.610	4114078.110	2.0	1423
Nabors # 358	LAI 144	1/10/2013	LAI-144	4174301.030	4113786.670	1.0	3078
Nabors # 1061	LAI 181	11/8/2013	LAI-181	4174736.880	4114136.220	2.0	2612
Nabors # 1522	LAI 183	8/7/2013	LAI-183	4174731.430	4114145.730	6.0	2617
Nabors # 1521	LAI 184	3/14/2013	LAI-184	4174672.030	4114433.840	3.0	2683
Nabors # 1521	LAI 190	12/7/2012	LAI-190	4177002.340	4110735.730	2.0	3508
Nabors # 358	LAI 2067	11/13/2012	LAI-2067	4177559.930	4110962.860	4.0	3271
Nabors # 1522	LAI 212	11/9/2012	LAI-212	4174299.310	4114002.730	2.0	3056
Nabors # 1521	LAI 220	2/4/2013	LAI-220	4175162.610	4112009.350	2.0	3113
Nabors # 358	LAI 223	12/21/2012	LAI-223	4176786.130	4109522.910	2.0	4737
Nabors # 1069	LAI 262	3/15/2013	LAI-262	4175416.070	4113325.160	2.0	2131
Nabors # 1522	LAI 275	4/2/2013	LAI-275	4174875.230	4113043.670	2.0	2741
Nabors # 1523	LAI 282	11/27/2013	LAI-282	4175625.820	4112020.330	4.0	2798
Nabors # 1069	LAI 288	3/7/2013	LAI-288	4176318.020	4111913.420	4.0	2532
Nabors # 1521	LAI 299	12/18/2012	LAI-299	4174824.460	4113665.100	2.0	2585
Nabors # 1522	LAI 30	6/18/2013	LAI-30	4176389.450	4112293.340	3.0	2158
Nabors # 1523	LAI 309	9/6/2013	LAI-309	4176242.590	4113661.020	4.0	1241
Nabors # 1523	LAI 311	9/20/2013	LAI-311	4174415.200	4114245.400	7.0	2932

PRODUCTION	WELL	DATE	WELL_CODE	SURFACE_X	SURFACE_Y	DURATION	Distance_to _Estation_ft
Nabors # 1521	LAI 311RD1	11/26/2012	LAI-311RD1	4174415.000	4114245.000	3.0	2932
Nabors # 1522	LAI 33	7/23/2013	LAI-33	4175974.510	4111910.830	3.0	2692
Nabors # 1523	LAI 341	10/9/2014	LAI-341	4175164.030	4113789.880	7.0	2227
Nabors # 358	LAI 356	1/15/2013	LAI-356	4175112.390	4114266.060	6.0	2235
Nabors # 358	LAI 357	4/4/2013	LAI-357	4175366.410	4113557.990	2.0	2091
Nabors # 1011	LAI 369	7/10/2013	LAI-369	4175097.480	4114193.840	5.0	2250
Nabors # 1521	LAI 370	6/10/2013	LAI-370	4175352.170	4113569.820	2.0	2100
Nabors # 1061	LAI 372	10/9/2014	LAI-372	4175878.850	4113426.560	4.0	1672
Nabors # 1061	LAI 380	10/30/1931	LAI-380	4174521.600	4113161.600	1.0	3020
Nabors # 1523	LAI 384	8/15/2013	LAI-384	4177274.600	4110858.930	7.0	3369
Nabors # 1521	LAI 400	5/15/2013	LAI-400	4174895.000	4113396.200	2.0	2589
Nabors # 1521	LAI 403	1/22/2013	LAI-403	4174190.700	4114499.400	2.0	3168
Nabors # 1522	LAI 410	10/31/2014	LAI-410	4175842.000	4113088.100	13.0	1887
Nabors # 358	LAI 412	1/16/2013	LAI-412	4175812.400	4112456.300	1.0	2343
Nabors # 1522	LAI 418	10/4/2014	LAI-418	4175869.580	4112399.910	8.0	2350
Nabors # 1061	LAI 424	11/20/2013	LAI-424	4175263.900	4112622.140	1.0	2630
Nabors # 1521	LAI 426	6/6/2013	LAI-426	4176321.670	4114293.910	10.0	1028
Nabors # 358	LAI 429	7/31/2013	LAI-429	4176419.420	4111247.950	2.0	3120
Nabors # 1522	LAI 443	9/5/2013	LAI-443	4177011.410	4110933.670	3.0	3310
Nabors # 1522	LAI 445	6/5/2013	LAI-445	4176225.680	4113239.000	4.0	1495
Nabors # 1521	LAI 452	5/21/2013	LAI-452	4175219.910	4113996.430	3.0	2140
Nabors # 358	LAI 4562	5/21/2013	LAIVIC1-4562	4174305.280	4113805.220	1.0	3071
Nabors # 1521	LAI 466	1/7/2013	LAI-466	4176447.000	4112687.000	2.0	1784
Nabors # 1522	LAI 5	5/30/2013	LAI-5	4177803.610	4110103.880	3.0	4148
Nabors # 1521	LAI 5543	7/25/2013	LAI-5543	4175752.220	4113670.160	12.0	1689
Nabors # 1061	LAI 5544	9/6/2013	LAI-5544	4175655.000	4113182.000	10.0	1989
Nabors # 1011	LAI 5552	10/25/2014	LAI-5552	4175766.000	4113673.000	12.0	1675
Nabors # 358	LAI 5611	2/15/2013	LAI-5611	4175286.000	4112642.000	5.0	2600
Nabors # 1523	LAI 5762	8/16/2013	LAI-5762	4176512.230	4111503.360	1.0	2848
Nabors # 1061	LAI 5784	11/27/2013	LAI-5784	4176756.000	4111167.000	7.0	3116
Nabors # 1522	LAI 64	4/23/2013	LAI-64	4174640.850	4113242.740	3.0	2880
Nabors # 358	LAI 645	1/11/2013	LAI-645	4174842.270	4113369.870	1.0	2648
Nabors # 1521	LAI 646	11/6/2012	LAI-646	4175014.800	4112586.600	2.0	2851
Nabors # 1522	LAI 70	11/1/2012	LAI-70	4174720.560	4114378.110	1.0	2631
Nabors # 1521	LAI 75	7/24/2013	LAI-75	4175228.160	4114297.400	7.0	2120
Nabors # 362	LAI 755	8/9/2013	LAI-755	4176537.000	4113678.000	3.0	979
Nabors # 1521	LAI 756	12/31/2012	LAI-756	4176387.200	4112420.840	1.0	2045
Nabors # 1011	LAI 76	11/27/2013	LAI-76	4174218.340	4114354.410	5.0	3132
Nabors # 1522	LAI 79	9/20/2013	LAI-79	4175721.180	4114269.070	5.0	1627
Nabors # 1522	LAI 81	12/3/2012	LAI-81	4175754.810	4113872.000	2.0	1632

PRODUCTION	WELL	DATE	WELL_CODE	SURFACE_X	SURFACE_Y	DURATION	Distance_to _Estation_ft
Nabors # 1521	LAIBC 128	5/24/2013	LAIBC-128	4177510.280	4110883.170	3.0	3347
Nabors # 1522	LAIBC 4	5/24/2013	LAIBC-4	4176498.520	4113642.950	1.0	1030
Nabors # 1060	LAIBC 404	11/15/2013	LAIBC-404	4176449.850	4113379.480	4.0	1234
Nabors # 1523	LAIBC 405	9/17/2013	LAIBC-405	4176244.900	4111989.000	4.0	2495
Nabors # 1061	LAIBC 5474	10/28/2014	LAIBC-5474	4176528.000	4114077.000	1.0	833
Nabors # 1522	LAIVIC 4562	9/4/2013	LAIVIC1-4562	4174305.280	4113805.220	6.0	3071
Nabors # 1061	LAIVIC 4564	11/19/2013	LAIVIC-4564	4174614.000	4112998.000	5.0	2997
Nabors # 1521	LAIVIC 472	12/21/2012	LAIVIC-472	4174315.000	4113866.900	4.0	3054
Nabors # 1521	LAI 371	6/20/2013	LAI-371	4174414.360	4114280.360	1.0	2933
Nabors # 1522	LAI1-223	9/23/2013	LAI-223	4176786.130	4109522.910	2.0	4737
Nabors # 1522	LAI1-266	6/27/2013	LAI-266	4175263.790	4112907.520	1.0	2466
Nabors # 1521	LAI1-282	6/27/2013	LAI-282	4175625.820	4112020.330	1.0	2798
Nabors # 1523	LAI1-311	9/23/2013	LAI-311	4174415.200	4114245.400	2.0	2932
Nabors # 1521	LAI1-371	6/21/2013	LAI-371	4174414.360	4114280.360	1.0	2933
Nabors # 1521	LAI1-BC-407	6/24/2013	LAIBC-407	4176545.200	4111513.000	1.0	2830
Nabors # 1011	LAI-282	9/27/2013	LAI-282	4175625.820	4112020.330	6.0	2798
Nabors # 1523	LAI-5544	9/27/2013	LAI-5544	4175655.000	4113182.000	2.0	1989
Nabors # 1522	LAI-BC-3	9/26/2013	LAIBC-3	4176429.230	4112044.240	2.0	2368
Nabors # 1521	VIC 119	2/27/2013	VIC1-119	4172466.380	4114141.230	3.0	4882
Nabors # 1522	VIC 125	12/7/2012	VIC1-125	4173809.760	4114250.310	4.0	3538
Nabors # 1060	VIC 132	8/29/2013	VIC1-132	4173117.810	4114602.500	3.0	4246
Nabors # 1521	VIC 36	7/16/2013	VIC1-36	4173462.160	4114616.430	2.0	3905
Nabors # 358	VIC 390	7/17/2013	VIC1-390	4173971.000	4113855.000	4.0	3397
Nabors # 1522	VIC 401	11/7/2013	VIC1-401	4173761.000	4114562.000	2.0	3602
Nabors # 1521	VIC 56	12/28/2012	VIC1-56	4173103.900	4114608.450	2.0	4261
Nabors # 1061	VIC 745	9/16/2013	VIC1-745	4173814.980	4113421.270	8.0	3623
Nabors # 1522	VIC 746	10/21/2014	VIC1-746	4174381.860	4112844.550	3.0	3272
Nabors # 1521	VIC 834	4/9/2013	VIC1-834	4173090.730	4114098.740	4.0	4258
Nabors # 1521	VIC 835	6/4/2013	VIC1-835	4173405.300	4113914.060	8.0	3954
Nabors # 1069	VIC 845	4/22/2013	VIC1-845	4173992.490	4113889.990	1.0	3372
Nabors # 1522	VIC 934	6/3/2013	VIC1-934	4172403.490	4114610.730	1.0	4959
Nabors # 1522	VIC 94	6/7/2013	VIC1-94	4174118.170	4113683.540	2.0	3274
Nabors # 1011	VIC LAI 4443	11/13/2013	VICLAI-4443	4173758.540	4114571.370	10.0	3605
Nabors # 1522	WRZU 349	1/25/2013	WRZU-349	4175829.860	4113924.550	2.0	1547

**Table A-3. Well activity (drilling).**

WELL_	WELL_CODE	START_DATE	END_DATE	DURATION_D	WELL_TYPE	WORK_TYPE	SURFACE_X	SURFACE_Y	Distance_to _Estation_ft
LAI1 4573	LAI-4573	12/26/2012	1/3/2013	8.0	Injector	new well	4174897.520	4113361.690	2598
LAI1 VIC1 4564	LAIVIC-4564	1/6/2013	1/13/2013	7.0	Producer	new well	4174614.000	4112998.000	2997
LAI1 VIC1 4562	LAIVIC1-4562	1/13/2013	1/22/2013	9.0	Producer	new well	4174305.280	4113805.220	3071
LAI1 6843	LAI-6843	2/10/2013	2/16/2013	6.0	Injector	new well	4177911.420	4110413.610	3855
LAI1 5654	LAI-5654	4/13/2013	4/23/2013	10.0	Injector	new well	4176402.320	4112421.360	2038
LAI1 5773	LAI-5773	5/16/2013	5/24/2013	8.0	Injector	new well	4176743.000	4111194.000	3092
BC 6522	BC-6522	6/24/2013	7/1/2013	7.0	Injector	new well	4177420.450	4113848.570	385
BC LAI1 5473	BCLAI1-5473	7/1/2013	7/10/2013	9.0	Producer	new well	4176908.000	4113953.000	518
BC 6533	BC-6533	7/10/2013	7/14/2013	4.0	Injector	new well	4177437.000	4112968.000	1262
LAI1 5762	LAI-5762	7/14/2013	7/22/2013	8.0	Producer	new well	4176512.230	4111503.360	2848
BC 6642	BC-6642	7/22/2013	7/30/2013	8.0	Injector	new well	4177743.720	4112505.900	1766
BC 6512	BC-6512	9/19/2013	10/1/2013	12.0	Producer	new well	4177006.110	4113388.150	905



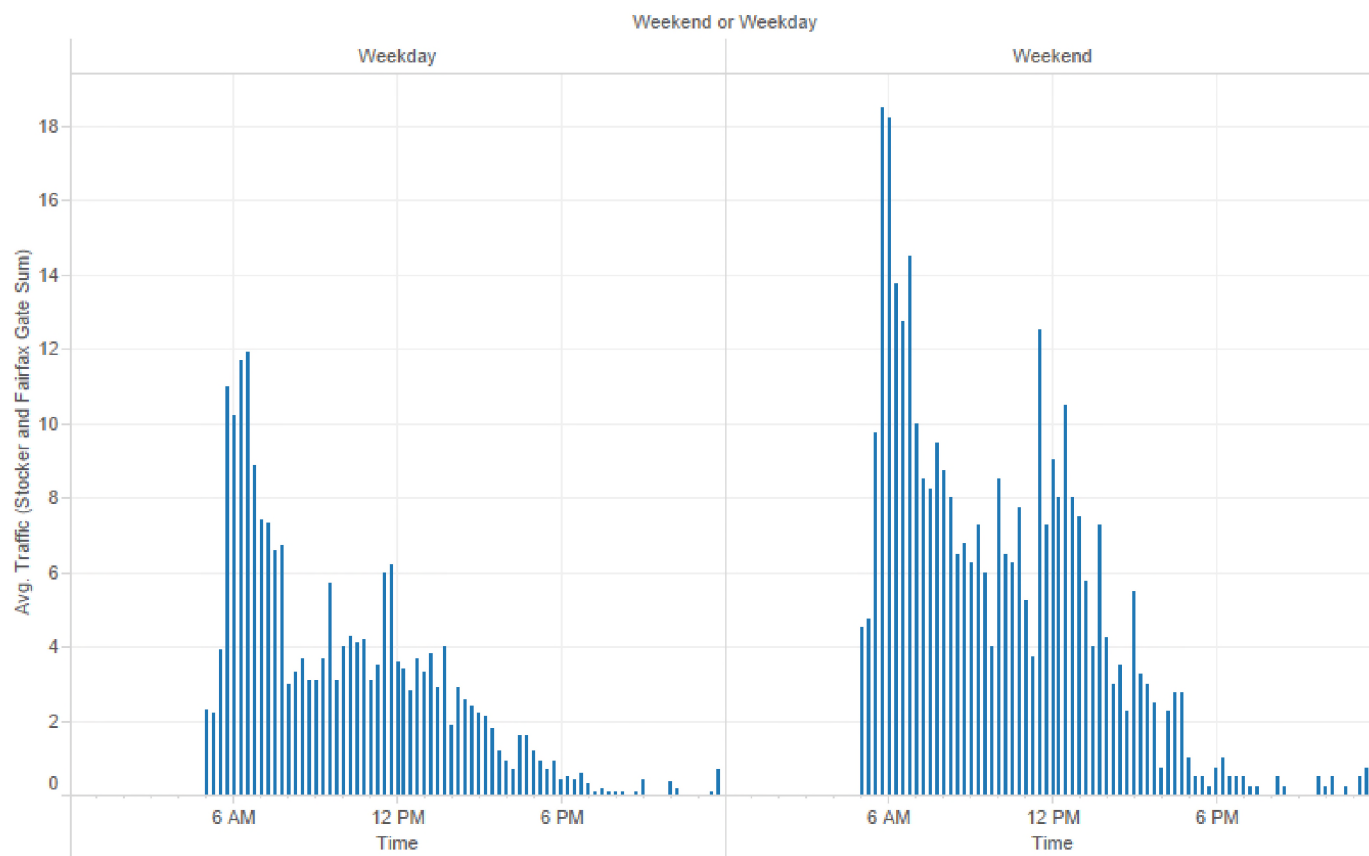


## **Appendix B**

### **Traffic Data**

Data from Marine Research Specialists



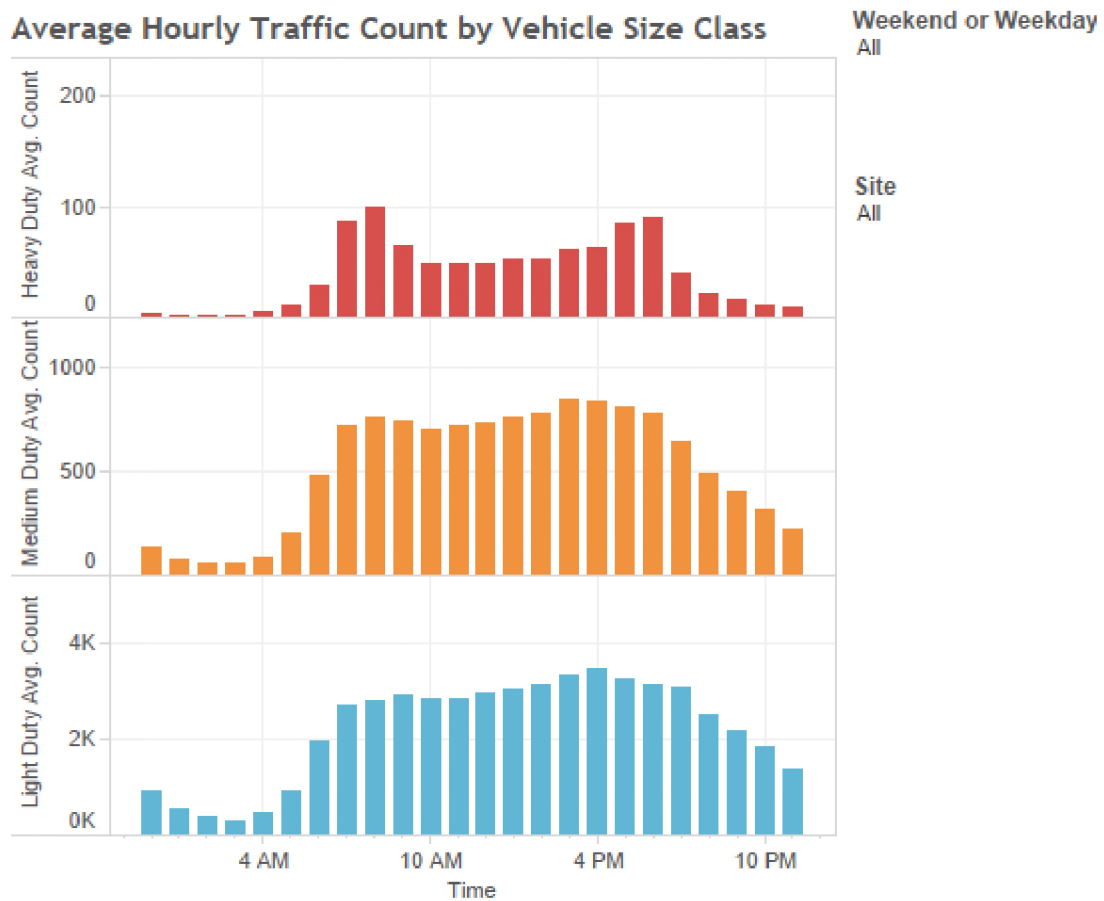
**Oilfield Gates Traffic Count**

The plot of the sum of vehicle counts for each 15 minute time period. The data is filtered on site, weekend or weekday and day.

At the Stocker gate, traffic peaked between 6:00 and 6:30 AM on Friday through Tuesday. There was a fairly even distribution of diesel trucks entering through the gate on Friday through Tuesday, with the peak occurring in the morning on most days. There were few vehicles entering the oilfield through the Stocker gate on Wednesday and Thursday.

At the Fairfax gate, traffic peaked at 5:45 AM. On Saturday and Sunday there was another peak at 12:30 to 1:00 PM. No more than 4 diesel trucks entered the Fairfax gate in any one day. All diesel trucks enter the Fairfax gate between 5:45 and 11:15 AM. No vehicles went through the Fairfax gate on Wednesday or Thursday.

**Figure B-1.** Traffic data (average two-way traffic values) from 9/17/14 to 9/23/14.



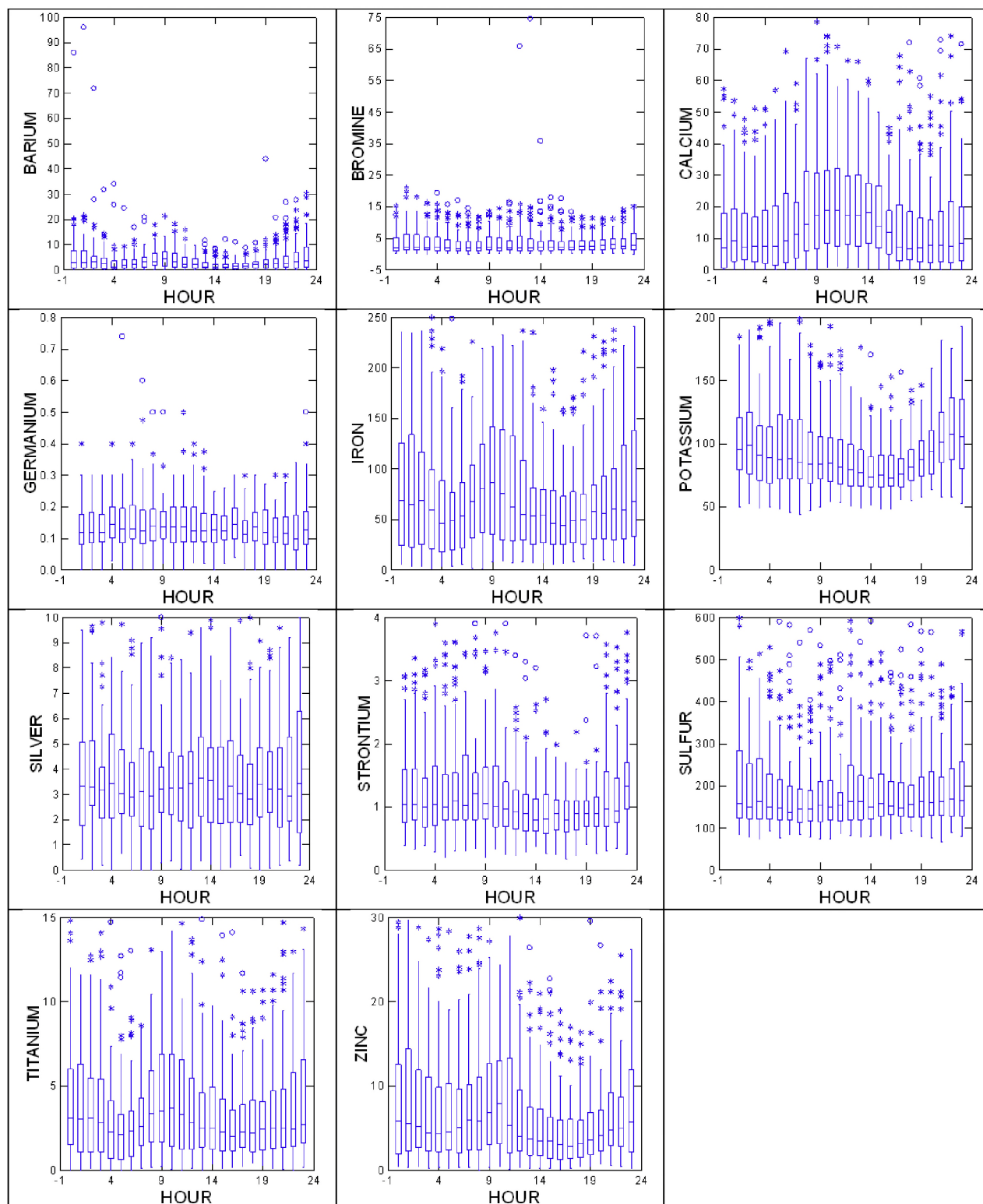
**Figure B-2.** Traffic data (average two-way traffic values) for La Cienega Blvd. from 8/14/14 to 8/20/14.



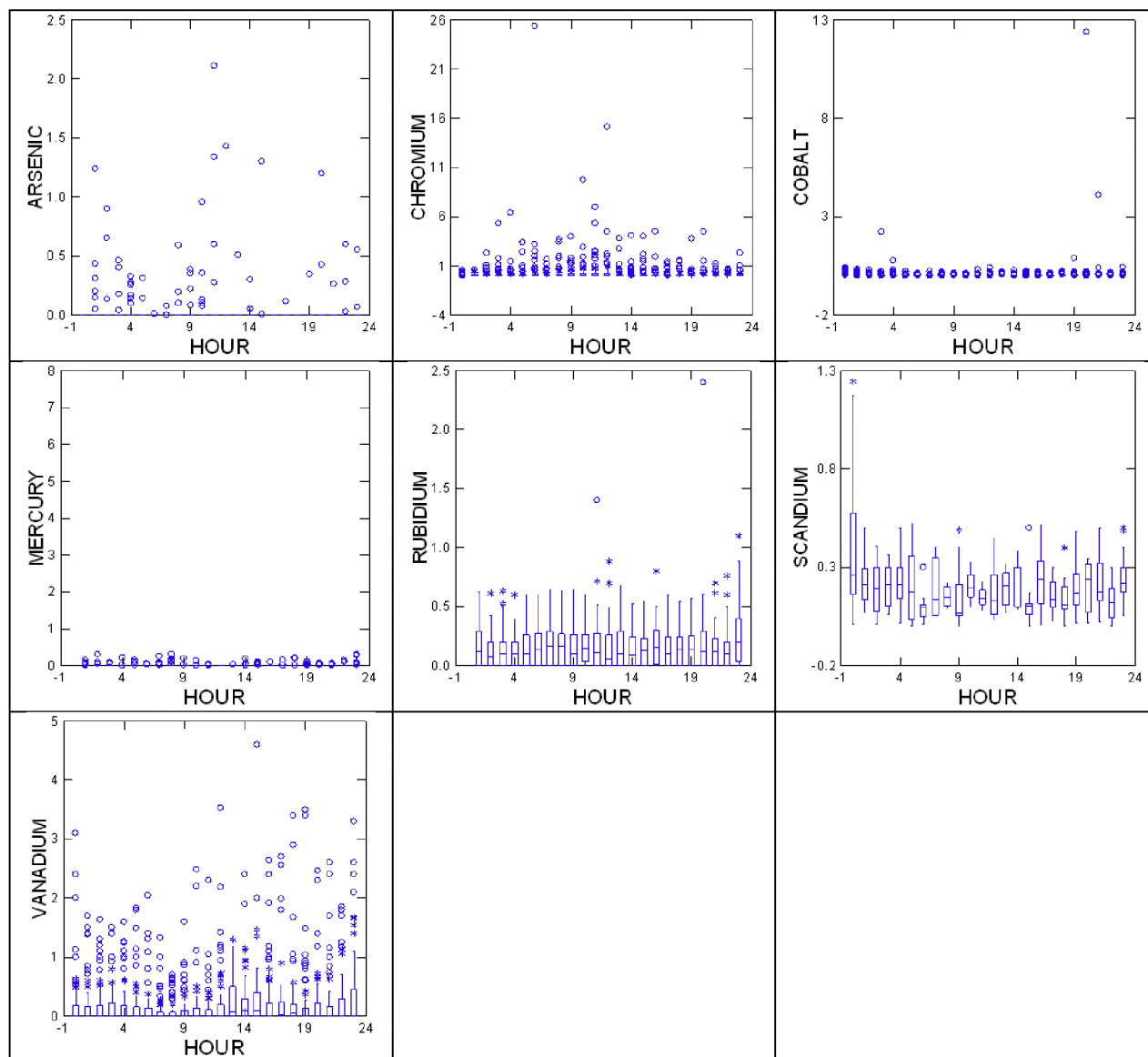
## **Appendix C**

### **Diurnal Plots and Concentration Roses for All Measured Metals Species**

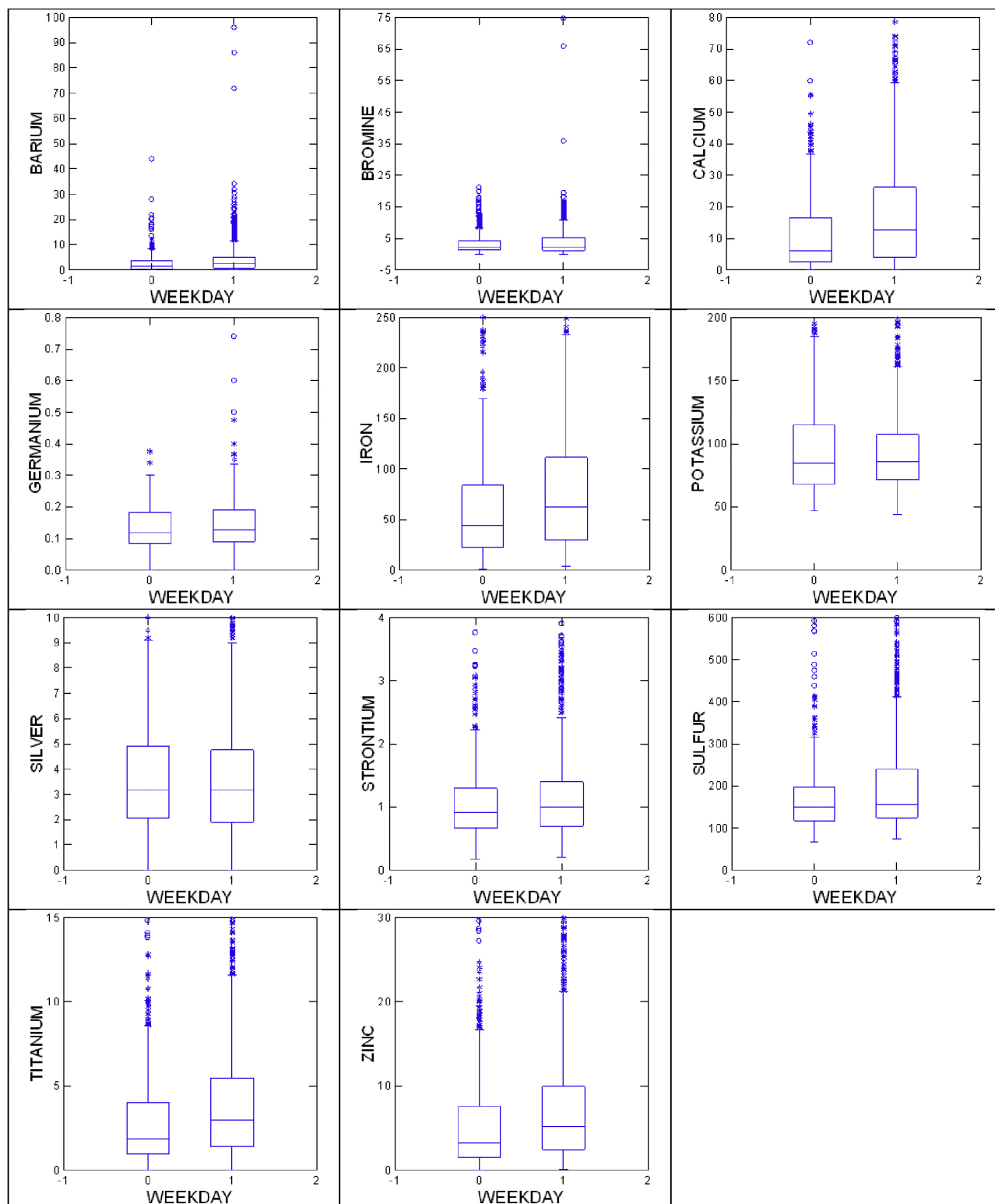




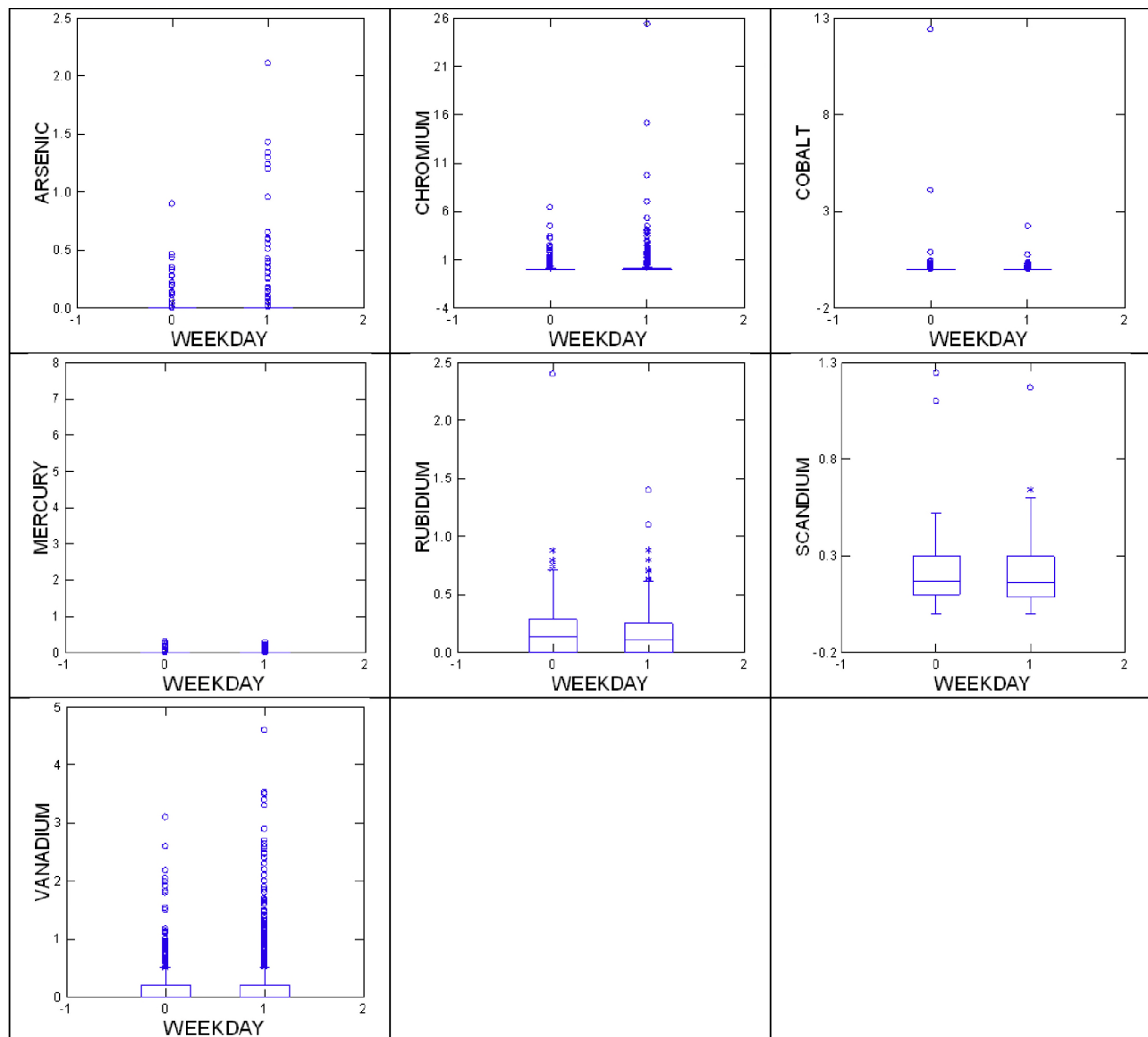
**Figure C-1.** Box plots of hourly metals concentrations (ng/m<sup>3</sup>); several elements, such as calcium, iron, titanium, and zinc, had relatively higher concentrations in morning to early afternoon.



**Figure C-2.** Box plots of hourly metals concentrations (ng/m<sup>3</sup>); a majority of concentration data for these elements was below MDL and box plots showed no specific diurnal patterns.

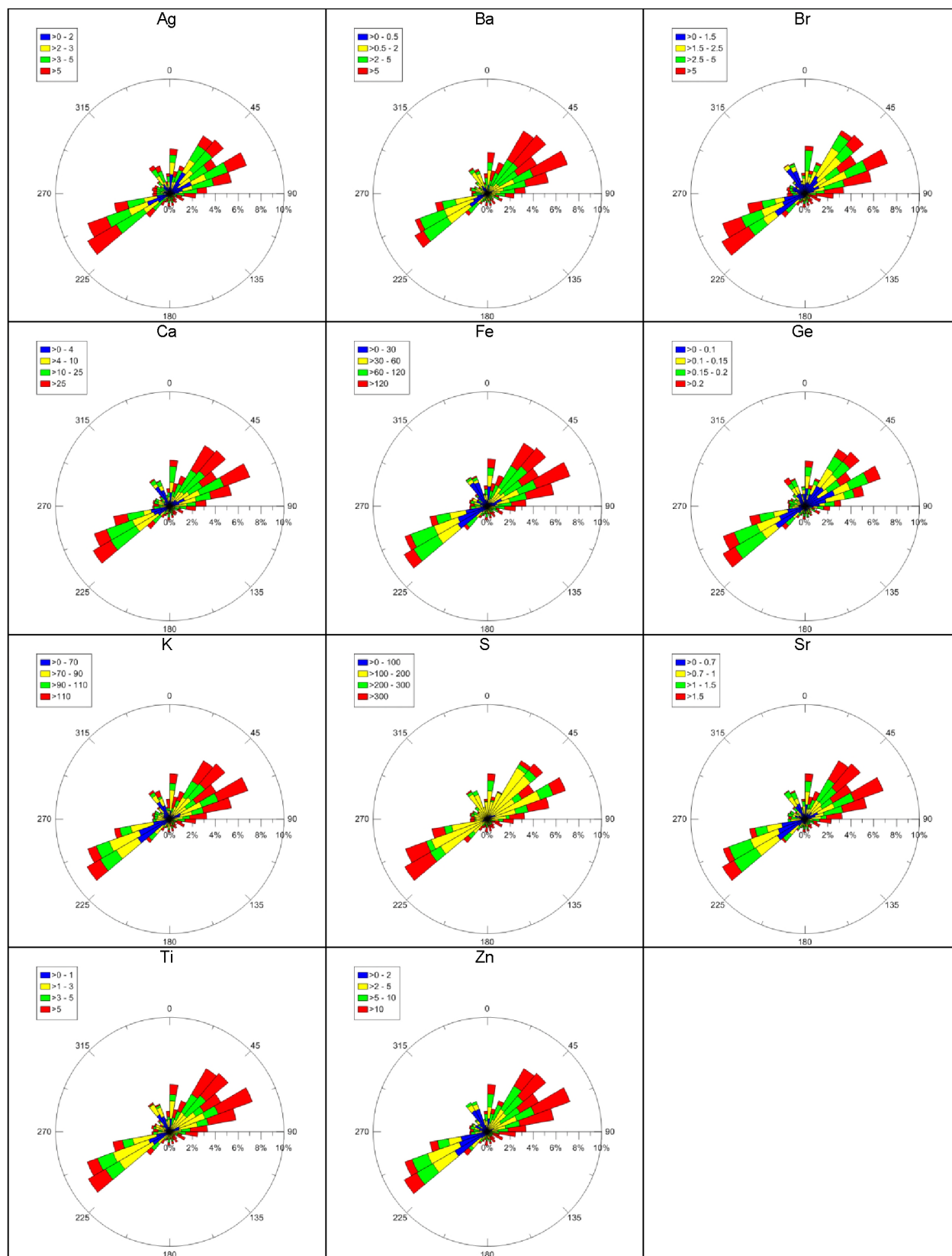


**Figure C-3.** Box plots of hourly metals concentrations (ng/m<sup>3</sup>) during weekdays ("1") and weekends ("0"); several elements, such as calcium, iron, titanium, and zinc, showed higher average concentrations on weekdays than those on weekends.



**Figure C-4.** Box plots of hourly metals concentrations (ng/m<sup>3</sup>) during weekdays ("1") and weekends ("0"); a majority of concentration data for these elements was below MDL and box plots showed no specific weekday versus weekend patterns.





**Figure C-5.** Pollution roses for hourly metals concentrations measured at the East site; in general, high concentrations may occur in various wind directions.



## **Appendix D**

### **Summary of Volatile Organic Compound (VOC) Concentration Comparisons between Multiple Methods**



## VOC Comparisons Between Multiple Methods

Tables D-1 through D-6 show VOC comparison results that were not included in the report.

**Table D-1.** Average VOC concentrations from five 24-hr canister collection samples reported by the University of Wyoming and the SCAQMD, the PTR-TOFMS average VOC concentrations during the same period, and average PTR-TOFMS concentrations during 7/4/2013–7/16/2013. All units ppb.

Species	University of Wyoming Canister Average During 5 24-hr Samples	PTR TOFMS Average During Same 5 24-hr Intervals	SCAQMD Canister Average	PTR TOFMS Average During All Hours 7/4-7/16
Butadiene	-	0.118	0.23	0.104
Acrolein	-	0.190	-	0.148
Benzene	0.223	0.187	0.23	0.171
Toluene	0.393	0.313	0.34	0.285
Xylenes	0.265	0.321	0.26	0.298
Naphthalene	-	0.008	-	0.009
Acetaldehyde	-	2.990	-	2.666

**Table D-2.** 24-hr average concentrations of VOCs from University of Wyoming canister, SCAQMD canister and PTR-TOFMS during 7/4/2013 12:25 LST to 7/5/2013 12:25 LST. Only benzene, toluene, xylenes, and butadiene (SCAQMD only) are available from canister data, and are reported here. Concentrations of other VOCs of interest from the PTR-TOFMS are reported for completeness. All units ppb.

Species	University of Wyoming Canister	PTR TOFMS Average	SCAQMD Canister
Butadiene	-	0.378	0.2
Acrolein	-	0.164	-
Benzene	0.25	0.136	0.3
Toluene	0.34	0.214	0.3
Xylenes	0.24	0.216	<0.3*
Naphthalene	-	0.007	-
Acetaldehyde	-	2.342	-

\* Reported as m+p xylenes= 0.2 and o-xylene <0.1.

**Table D-3.** 24-hour average concentrations of VOCs from University of Wyoming canister, SCAQMD canister and PTR-TOFMS during 7/8/2013 12:30 LST to 7/9/2013 12:30 LST. Only benzene, toluene xylenes, and butadiene (SCAQMD only) are available from canister data, and are reported here. Concentrations of other VOCs of interest from the PTR-TOFMS are reported for completeness. All units ppb.

Species	University of Wyoming Canister	PTR TOFMS Average	SCAQMD Canister
Butadiene	-	0.109	0.4
Acrolein	-	0.279	-
Benzene	0.24	0.274	0.3
Toluene	0.42	0.474	0.4
Xylenes	0.27	0.443	0.2
Naphthalene	-	0.009	-
Acetaldehyde	-	3.917	-

**Table D-4.** 24-hour average concentrations of VOCs from University of Wyoming canister, SCAQMD canister and PTR-TOFMS during 7/9/2013 12:30 LST to 7/10/2013 12:30 LST. Only benzene, toluene, xylenes, and butadiene (SCAQMD only) are available from canister data, and are reported here. Concentrations of other VOCs of interest from the PTR-MS are reported for completeness. All units ppb.

Species	University of Wyoming Canister	PTR TOFMS Average	SCAQMD Canister
Butadiene	-	0.061	0.1
Acrolein	-	0.226	-
Benzene	0.25	0.250	0.2
Toluene	0.51	0.414	0.4
Xylenes	0.30	0.426	0.3
Naphthalene	-	0.009	-
Acetaldehyde	-	3.628	-



**Table D-5.** 24-hour average concentrations of VOCs from University of Wyoming canister, SCAQMD canister and PTR-TOFMS during 7/11/2013 13:00 LST to 7/12/2013 13:00 LST. Only benzene, toluene, and xylenes are available from canister data, and are reported here. Concentrations of other VOCs of interest from the PTR-TOFMS are reported for completeness. All units ppb.

Species	University of Wyoming Canister	PTR TOFMS Average	SCAQMD Canister
Butadiene	-	0.00004	-
Acrolein	-	0.137	-
Benzene	0.22	0.171	0.2
Toluene	0.41	0.309	0.4
Xylenes	0.33	0.359	0.3
Naphthalene	-	0.003	-
Acetaldehyde	-	2.819	-

**Table D-6.** 24-hour average concentrations of VOCs from University of Wyoming canister, SCAQMD canister and PTR-TOFMS during 7/12/2013 13:00 LST to 7/13/2013 13:00 LST. Only benzene, toluene and xylenes are available from canister data, and are reported here. Concentrations of other VOCs of interest from the PTR-TOFMS are reported for completeness. All units ppb.

Species	University of Wyoming Canister	PTR TOFMS Average	SCAQMD Canister
Butadiene	-	0.032	-
Acrolein	-	0.155	-
Benzene	0.16	0.124	0.15
Toluene	0.29	0.191	0.2
Xylenes	0.18	0.189	<0.2*
Naphthalene	-	0.009	-
Acetaldehyde	-	2.454	-

\* Reported as m+p xylenes= 0.1 and o-xylene <0.1.