Baldwin Hills Air Quality Study: Final Results

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Presented to Baldwin Hills CSD
Community Advisory Panel
Los Angeles, CA
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Air Quality Research and Innovative Solutions

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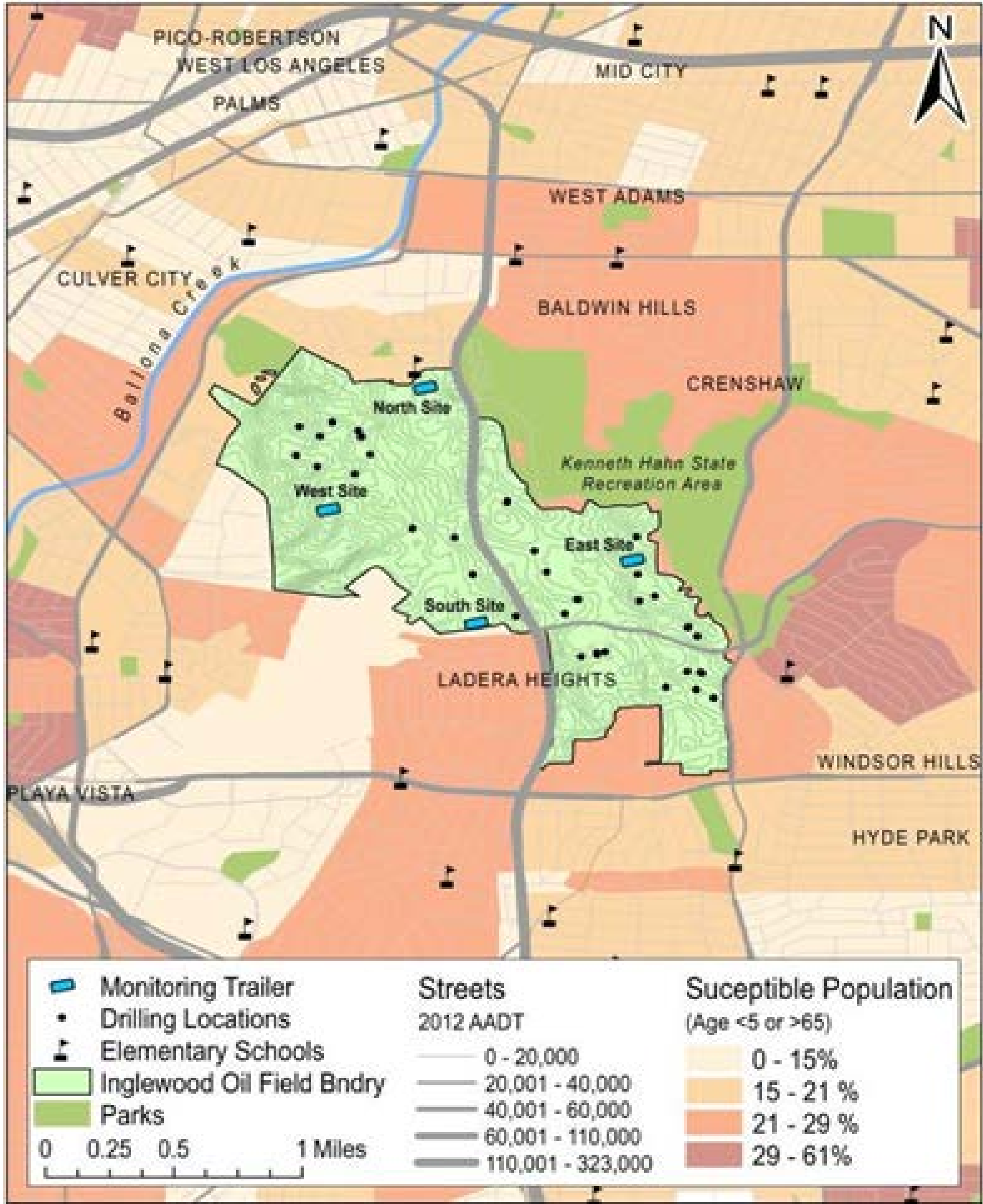
Overview of Tonight's Presentation

- Study objectives
- Study background and design
- Measurement methods
- Important study issues and examples
- Approaches to using study results to address objectives
- Study results and air toxics risks
- Opportunity to ask more questions at the March 26th CAP meeting

AQ Study Objectives from LA County

- Primary objectives
  - Quantify the air toxics from the Inglewood Oil Field operations, including drilling and well work-overs.
  - Assess the health risk of both acute and chronic exposure to air toxics from Oil Field operations.
- Secondary objectives
  - To the extent feasible, determine and distinguish the major sources of air toxics near the Oil Field.
  - To the extent feasible, assess the Oil Field's contribution to the overall acute and chronic health risk near the Oil Field.

What air toxics are from the Oil Field, and how do they affect the surrounding communities?



AQ Study Technical Approach

- Prioritize among pollutants emitted from the Oil Field.
- Select measurement methods for the highest priority pollutants.
- Select the measurement sites, duration of measurements, and frequency.
- Ensure adequate quality assurance for study.
- Collect Oil Field operational activity data.

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Prioritize Among Pollutants from the Oil Field

Prioritize the oil field emissions (from the Baldwin Hills Community Standards District EIR) in relation to acute and chronic health benchmark screening levels:

- Chronic cancer potency risk factors
- Chronic and acute Reference Exposure Levels (RELs)
- REL is the exposure level below which adverse health impacts are not expected over a lifetime

Prioritize Key Pollutants

Pollutant	Total Lb/Year	Fraction from Drilling and Well Workovers
Diesel Exhaust PM	1326.8	0.99
Cadmium	4.8	1.00
Formaldehyde	547.9	0.76
Nickel	15.3	1.00
Chlorine	41.6	1.00
Manganese	4.8	1.00
Mercury	3.6	1.00
Acrolein	14.7	0.70
Lead	5.1	1.00
Arsenic	0.6	1.00
Benzene	340.9	0.17
PAHs	16.9	0.79
Acetaldehyde	215.9	0.96

PM: Particulate matter
PAHs: Polycyclic aromatic hydrocarbons

Emissions from 2005-2006 Environmental Impact Report

Emissions X Toxicity = *Prioritizable values*

Toxicity = short- or long-term health effects

Toxicity values are from California OEHHA (see report for details)

37 toxics considered, but all the rest (ammonia, hydrogen sulfide, etc.) had lower risks

Key Pollutants and Emissions

Pollutant	Total Lb/Year	Fraction from Drilling and Well Workovers
Diesel Exhaust PM	1326.8	0.99
Cadmium	4.8	1.00
Formaldehyde	547.9	0.76
Nickel	15.3	1.00
Chlorine	41.6	1.00
Manganese	4.8	1.00
Mercury	3.6	1.00
Acrolein	14.7	0.70
Lead	5.1	1.00
Arsenic	0.6	1.00
Benzene	340.9	0.17
PAHs	16.9	0.79
Acetaldehyde	215.9	0.96

PM: Particulate matter
PAHs: Polycyclic aromatic hydrocarbons

Emissions from 2005-2006 EIR

Key Pollutants, Emissions, and Toxicities

Pollutant	Total Lb/Year	Fraction from Drilling and Well Workovers	Cancer 1-in-a-Million Level (μg/m³)	Acute REL (μg/m³)	Chronic REL (μg/m³)
Diesel Exhaust PM	1326.8	0.99	3.3E-03	–	5
Cadmium	4.8	1.00	2.4E-04	–	0.02
Formaldehyde	547.9	0.76	1.7E-01	9	9
Nickel	15.3	1.00	3.8E-03	6	0.05
Chlorine	41.6	1.00	–	210	0.2
Manganese	4.8	1.00	–	0.17	0.09
Mercury	3.6	1.00	–	0.6	0.03
Acrolein	14.7	0.70	–	2.5	0.35
Lead	5.1	1.00	8.3E-02	–	0.15
Arsenic	0.6	1.00	3.0E-04	0.2	0.015
Benzene	340.9	0.17	3.4E-02	1300	60
PAHs	16.9	0.79	9.1E-05	–	–
Acetaldehyde	215.9	0.96	3.7E-01	470	140

PM: Particulate matter
PAHs: Polycyclic aromatic hydrocarbons

Emissions from 2005-2006 EIR
Toxicities from OEHHA health benchmark levels

Key Pollutants and Relative Toxicities

Pollutant	Total Lb/Year	Fraction from Drilling and Well Workovers	Cancer 1-in-a-Million Level (µg/m³)	Acute REL (µg/m³)	Chronic REL (µg/m³)	Cancer Risk Relative to DPM	Chronic REL Relative to Nickel	Acute REL Relative to Formaldehyde
Diesel Exhaust PM	1326.8	0.99	3.3E-03	–	5	1.00	0.86	–
Cadmium	4.8	1.00	2.4E-04	–	0.02	0.05	0.78	–
Formaldehyde	547.9	0.76	1.7E-01	9	9	0.01	0.20	1.00
Nickel	15.3	1.00	3.8E-03	6	0.05	0.01	1.00	0.04
Chlorine	41.6	1.00	–	210	0.2	–	0.67	0.00
Manganese	4.8	1.00	–	0.17	0.09	–	0.17	0.46
Mercury	3.6	1.00	–	0.6	0.03	–	0.39	0.10
Acrolein	14.7	0.70	–	2.5	0.35	–	0.14	0.10
Lead	5.1	1.00	8.3E-02	–	0.15	0.00	0.11	–
Arsenic	0.6	1.00	3.0E-04	0.2	0.015	0.00	0.13	0.05
Benzene	340.9	0.17	3.4E-02	1300	60	0.02	0.02	0.00
PAHs	16.9	0.79	9.1E-05	–	–	0.00	–	–
Acetaldehyde	215.9	0.96	3.7E-01	470	140	0.00	0.01	0.01

PM: Particulate matter
PAHs: Polycyclic aromatic hydrocarbons

Emissions from 2005-2006 EIR
Toxicities from OEHHA health benchmark levels
37 toxics considered, but all the rest (ammonia, hydrogen sulfide, etc.) had lower risks.

Key Pollutants and Toxicity Rankings

Pollutant	Total Lb/Year	Fraction from Drilling and Well Workovers	Cancer 1-in-a-Million Level (μg/m³)	Acute REL (μg/m³)	Chronic REL (μg/m³)	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	3.3E-03	–	5	1.00	0.86	–	1	2	–
Cadmium	4.8	1.00	2.4E-04	–	0.02	0.05	0.78	–	2	3	–
Formaldehyde	547.9	0.76	1.7E-01	9	9	0.01	0.20	1.00	5	6	1
Nickel	15.3	1.00	3.8E-03	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	8.3E-02	–	0.15	0.00	0.11	–	–	10	–
Arsenic	0.6	1.00	3.0E-04	0.2	0.015	0.00	0.13	0.05	6	9	5
Benzene	340.9	0.17	3.4E-02	1300	60	0.02	0.02	0.00	3	11	8
PAHs	16.9	0.79	9.1E-05	–	–	0.00	–	–	7	–	–
Acetaldehyde	215.9	0.96	3.7E-01	470	140	0.00	0.01	0.01	8	12	7

PM: Particulate matter
PAHs: Polycyclic aromatic hydrocarbons

Emissions from 2005-2006 EIR
Toxicities from OEHHA health benchmark levels

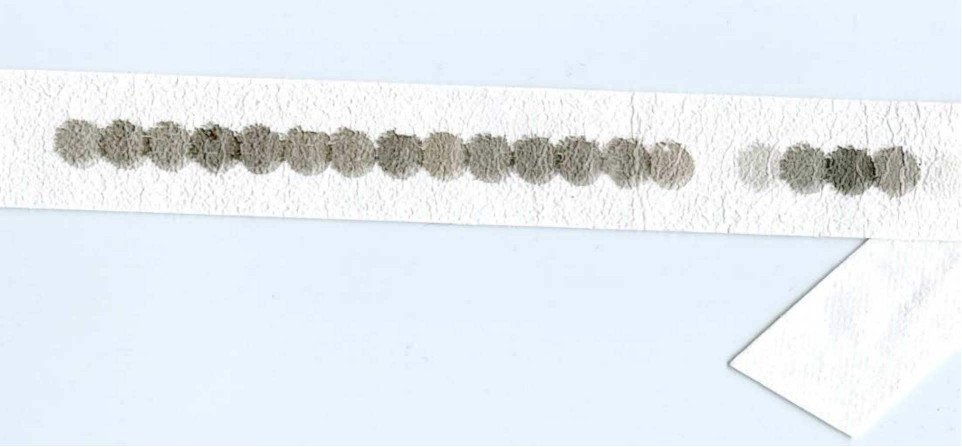
Thus, need to measure:
- Diesel particulate matter (DPM)
- metals (e.g., nickel, cadmium, manganese)
- carbonyls (formaldehyde, acetaldehyde)
- volatile organic compounds (VOCs)

Selection of the Most Appropriate Monitoring Methods

- Separate measurement technologies needed for DPM, metals, VOCs, carbonyls
- Confounding factors of multiple regional sources nearby (e.g., LAX, I-10, I-405, etc.), plus local traffic on La Cienega Blvd.
- Consider using surrogate species (e.g., black carbon for DPM)
- Consider cost/benefit of methods available for each pollutant
- Select state-of-the-science methods to achieve the lowest level of detection at high time resolution.

Black Carbon Measurements

- Diesel particulate matter (DPM) – there is no direct or official measurement method for DPM
- We used Aethalometer measurements of black carbon (BC) as a surrogate for DPM
- 5-minute measurements at four monitoring sites around the Oil Field for a full year



Example of Collected Filter

PM collected on 1″ wide filter tape; note different degrees of black

Metals Measurements

Element	Atomic Weight	LOD	Element	Atomic Weight	LOD	Element	Atomic Weight	LOD
Sulfur	16	3.7	Iron	26	0.759	Bromine	35	0.185
Potassium	19	0.837	Cobalt	27	0.317	Rubidium	37	0.344
Calcium	20	0.319	Nickel	28	0.226	Strontium	38	0.447
Scandium	21	0.55	Copper	29	0.267	Silver	47	4.37
Titanium	22	0.38	Zinc	30	0.231	Cadmium	48	5.748
Vanadium	23	0.29	Germanium	32	0.121	Barium	56	0.945
Chromium	24	0.288	Arsenic	33	0.114	Mercury	80	0.189
Manganese	25	0.283	Selenium	34	0.141	Lead	82	0.218

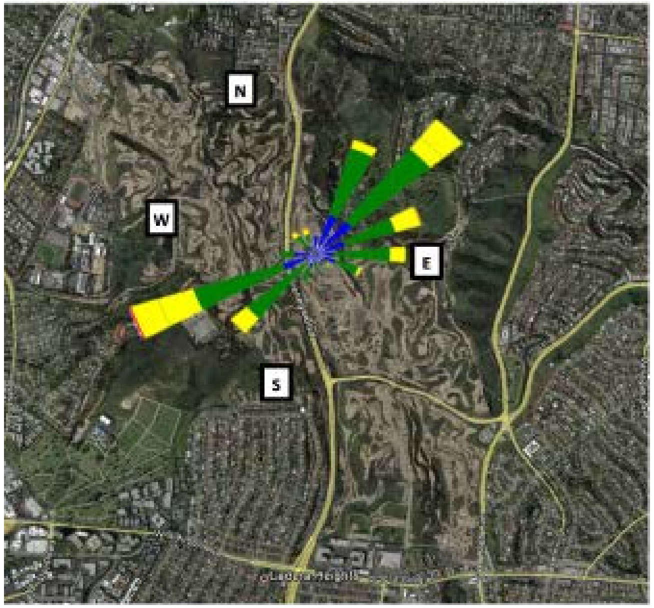
XACT 625 semi-continuous X-Ray Fluorescence (XRF) spectrometer.
LOD is Limit of Detection in nanograms per cubic meter at standard temperature and pressure, for a one-hour sample collection and analysis period.

VOC, Carbonyl, and PAH Measurements

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
Decane	Vehicle emissions
Naphthalene	Vehicle emissions
Trimethylbenzenes	Vehicle emissions
Phenol	Vehicle emissions
Butenes	Refineries, vehicle emissions

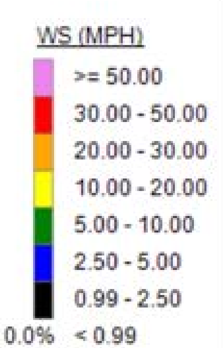
Proton Transfer Reaction Time-of-Flight Mass Spectrometer (PTR-TOFMS)

Typical Wind Speeds and Directions November and August 2011



Inglewood Oil Field
November
711 1-hr values

Inglewood Oil Field
August
741 1-hr values



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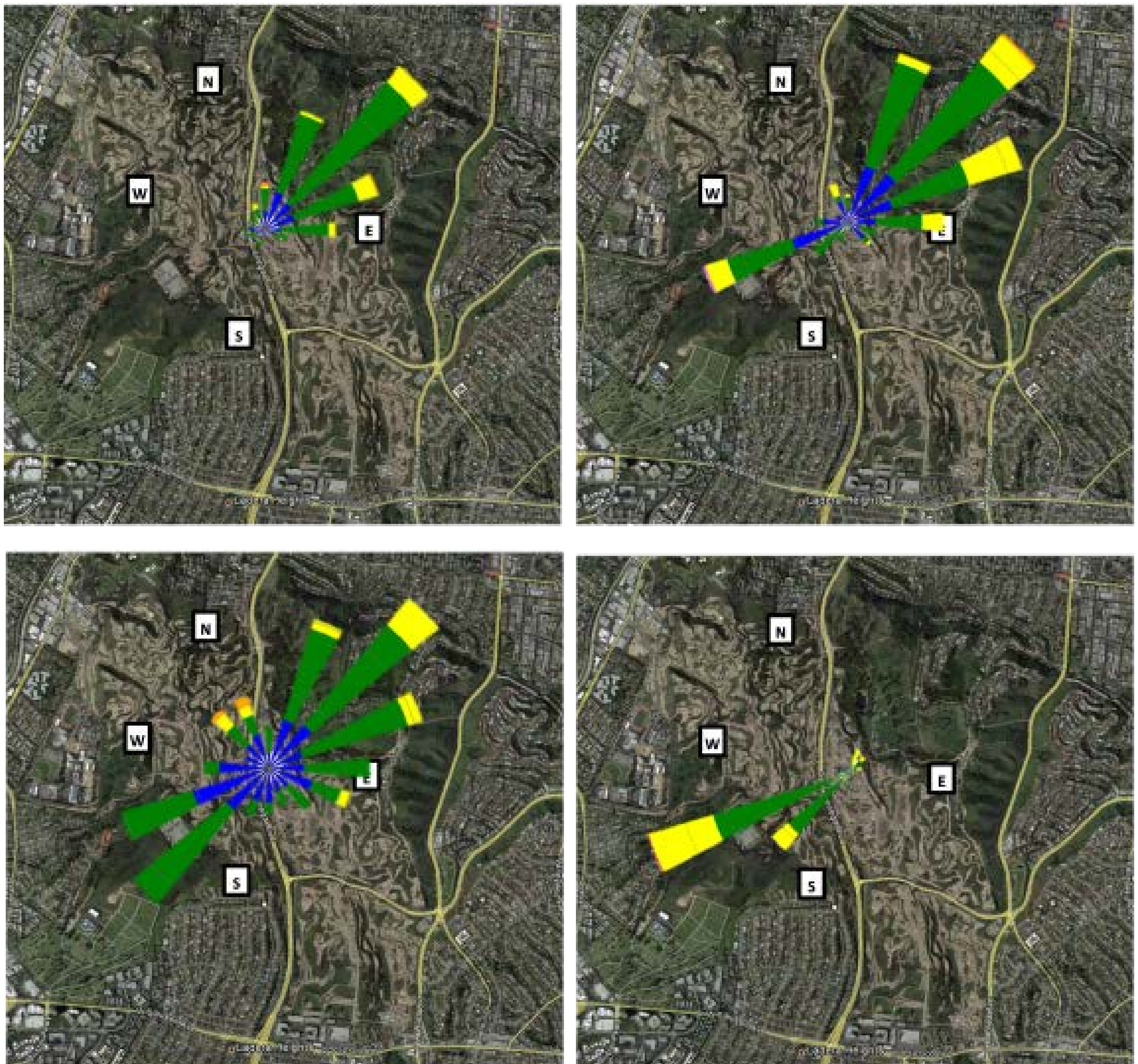
Diurnal Wind Patterns November 2011

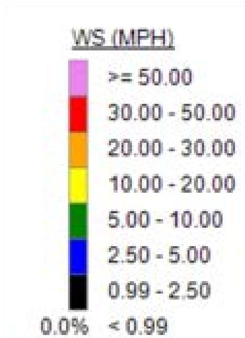


Upper left:
11/1/11-12/31/11
00:00-06:00
425 1-hr values

Upper right:
11/1/11-12/31/11
07:00-12:00
360 1-hr values

Bottom right:
11/1/11-12/31/11
13:00-18:00
363 1-hr values

Bottom left:
11/1/11-12/31/11
19:00-23:00
304 1-hr values



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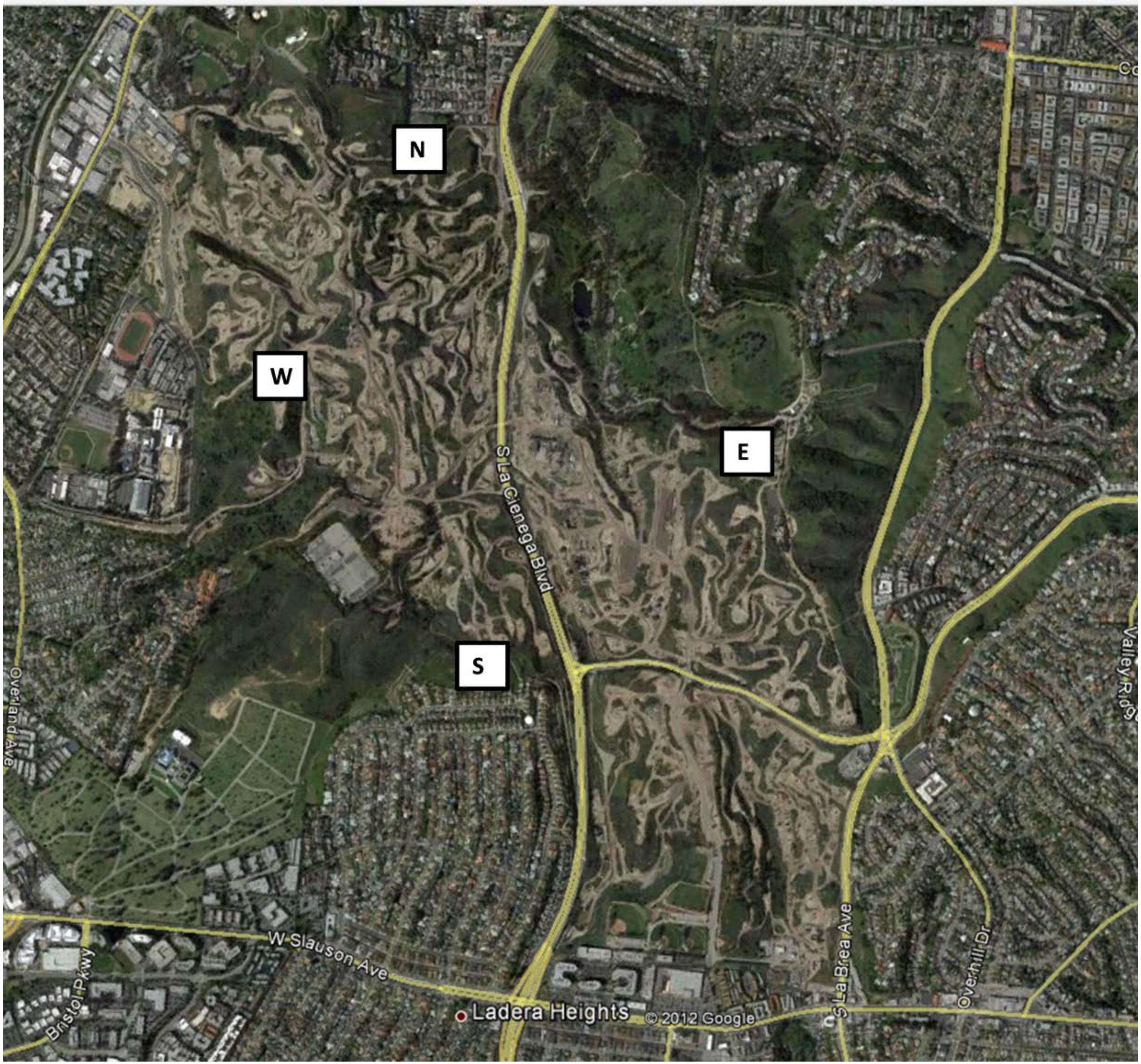
Selected Monitoring Locations



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Measurements, Duration, Frequency

- Diesel Particulate Matter – aethalometer black carbon (BC) as a proxy
- Metals (e.g., cadmium, nickel, manganese) – semi-continuous XACT 625 x-ray spectrometer
- VOCs (e.g., acrolein, benzene, acetaldehyde, naphthalene) – Proton-transfer reaction time-of-flight mass spectrometer

Site Name	Window of Operation and Duration		
	BC	Metals	VOCs
North (N)	11/15/12–11/15/13 Hourly; 1 year	–	–
South (S)	11/15/12–11/15/13 Hourly, 1 year	–	–
East (E)	11/15/12–11/15/13 Hourly, 1 year	11/15/12 – 2/1/13 Hourly, 2.5 months	7/3/13–7/17/13 5 minutes; 2 weeks
West (W)	11/15/12–11/15/13 Hourly 1 year	–	–

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East Site Looking West, and the BC and Metals Instruments

The Metals and VOC Instruments at the East Site

North and West Sites

East and South Sites

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Quality Control/Quality Assurance

QC and QA are separate components of the Data Quality Control Plan.

- QC consists of operational techniques and activities, such as on-site instrument maintenance and verification procedures.
- QA incorporates systematic activities to provide confidence that the requirements for quality are fulfilled, e.g., field audits, measurement comparisons, and post-processing data validation protocols.

Major QC and QA Activities

Quality Control/Quality Assurance Protocol	Instrument/Parameter				
	Teledyne-API 633 Black Carbon Monitors	XACT 625 Metals Monitor	PTR-MS VOC monitor	Meteorological Sensors	Shelter Temperature
Daily review of data and diagnostics, clock checks	✔	✔	✔	✔	✔
Periodic flow checks against NIST-traceable reference	✔	✔	✔		
Standardized reference checks (hourly, daily)		✔	✔		
Routine monthly maintenance (e.g., visual inspection, tape changes, inlet cleaning, pump maintenance)	✔	✔	✔	✔	✔
Documentation by manual log notes (each site visit)	✔	✔	✔	✔	✔
Meteorological sensor audits (at install, 6 months, removal)				✔	
Co-located intercomparison of the four T-API Model 633 Aethalometers	✔				
24-hr 1-in-6 day VOC sampling			✔		

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Oil Field Operational Data

Times and locations of operating drill rigs and well work-over rigs

- Start and end date of activity
- Location of activity

We used wind and concentration data to

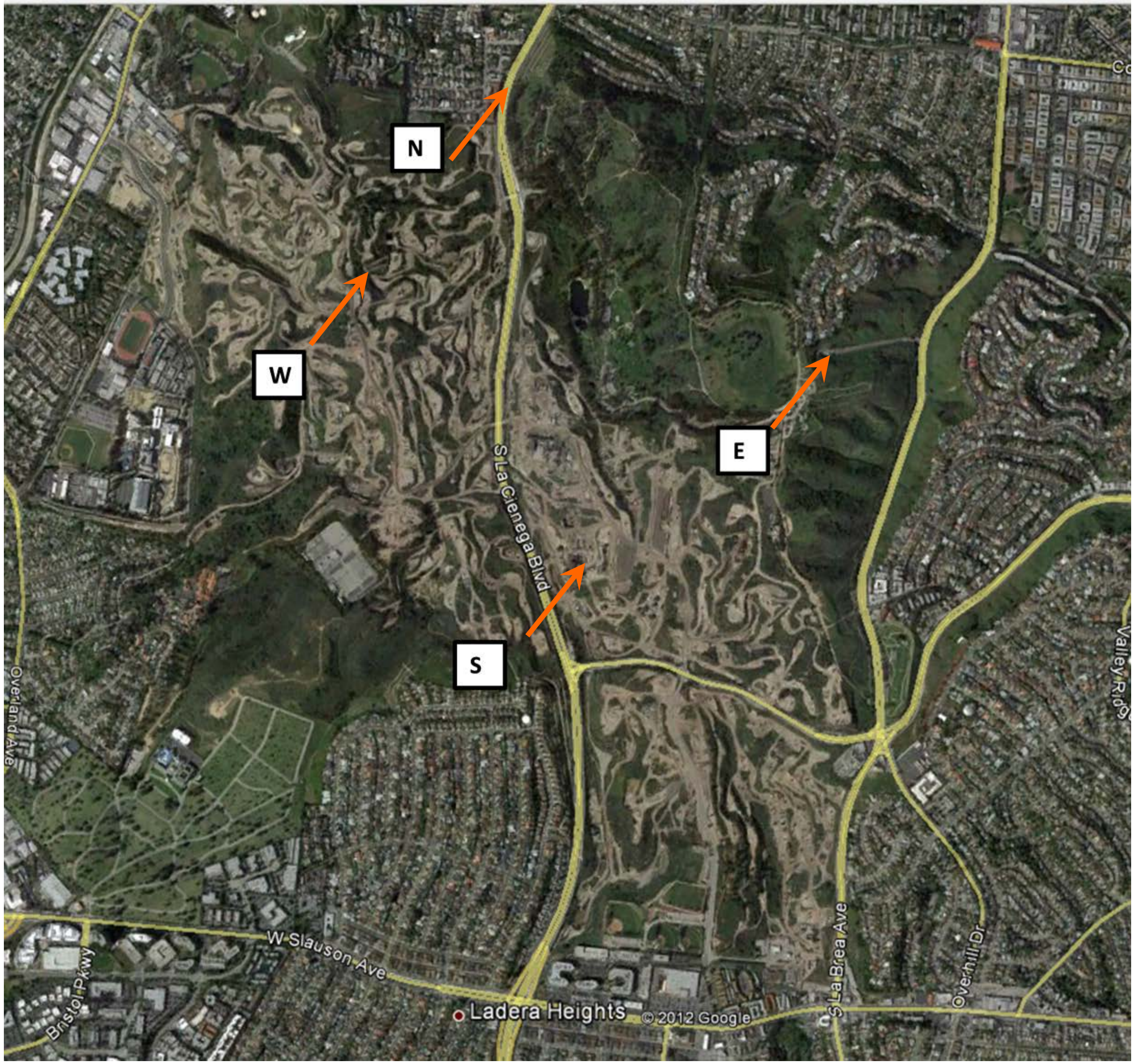
- Identify sources of measured pollutant concentrations
- Determine relative contributions of oil field sources to measured concentrations

Data Analysis (to meet study objectives)

- Emissions source characterization
  Separate measured toxics concentrations into contributions from source "fingerprints."
- Spatial and temporal characterization
  Evaluate measured toxics concentrations binned by wind direction and wind speed. Estimate oil field contributions by (downwind concentration – upwind conc.).
- Risk characterization
  Compare measured toxics concentrations to health screening levels.

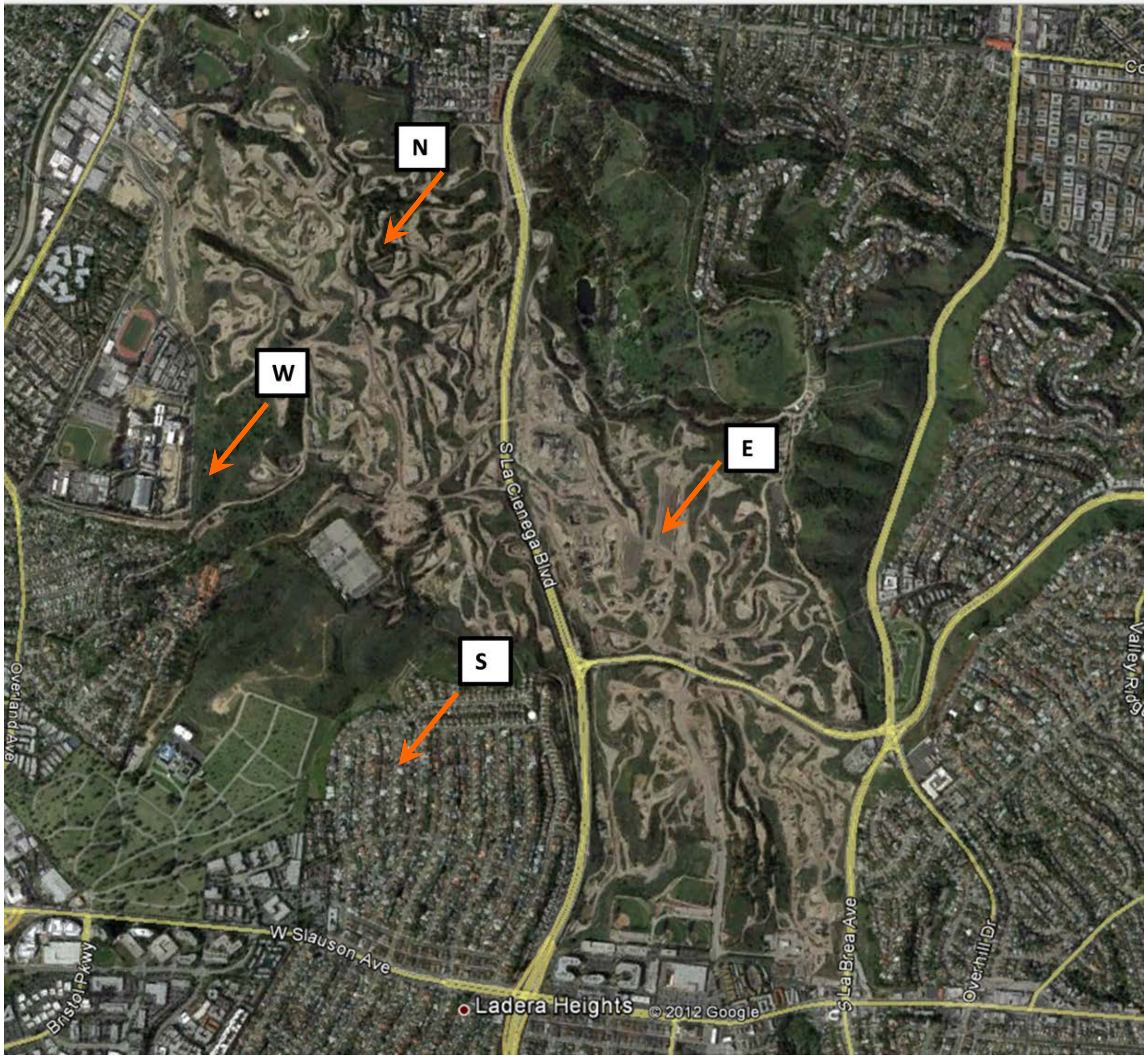
Spatial Characterization Example

- Winds predominantly blow from the southwest or northeast.
- When winds blow from the southwest, pair the sites W and N, and S and E.
- Compare [BC] at E (downwind) with [BC] at S (upwind); difference is contribution of oil field plus La Ciengega



Spatial Characterization Example

- If winds flow from the northeast, now E is upwind and S is downwind.
- Compare BC concentrations at the sites upwind and downwind of the oil field; the difference will be an estimate of any contribution of the oil field.



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Baldwin Hills Air Quality Study

What we have covered:

- Study objectives
- Summary of technical approach
- Toxicity ranking of oil field emissions
- Measurement methods
- Critical factors: frequency, siting, duration
- Quality control and quality assurance
- Oil field operational activity data

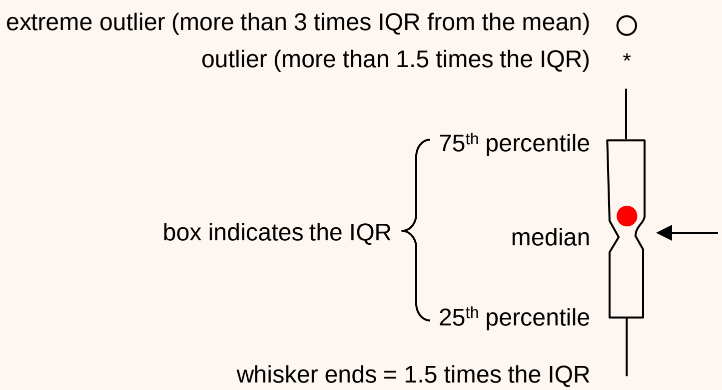
Next: Example results

- Black carbon
- Metals
- VOCs
- Risk characterization

Measured Concentrations

How to Interpret Notched Box-Whisker Plots

A notched box-whisker plot illustrates the distribution of concentrations. The notch is centered on the median concentration, widening to the width of the box to illustrate the 95% confidence interval in the median concentration value. The edges of the box illustrate the 25th and 75th percentile concentrations. The whiskers indicate values that are 1.5 times the interquartile range (IQR). Star outliers fall between 1.5 and 3 times the IQR. Circle outliers are greater than 3 times the IQR.



The notch and the extents of the notch indicate the 95% confidence interval; when comparing notched box-whisker plots, if the notch of one box does not overlap with the notch of another box, the median values are statistically significantly different at the 95% confidence interval. If the notches overlap, the median values are not statistically significantly different.

● Red dot = Average concentration

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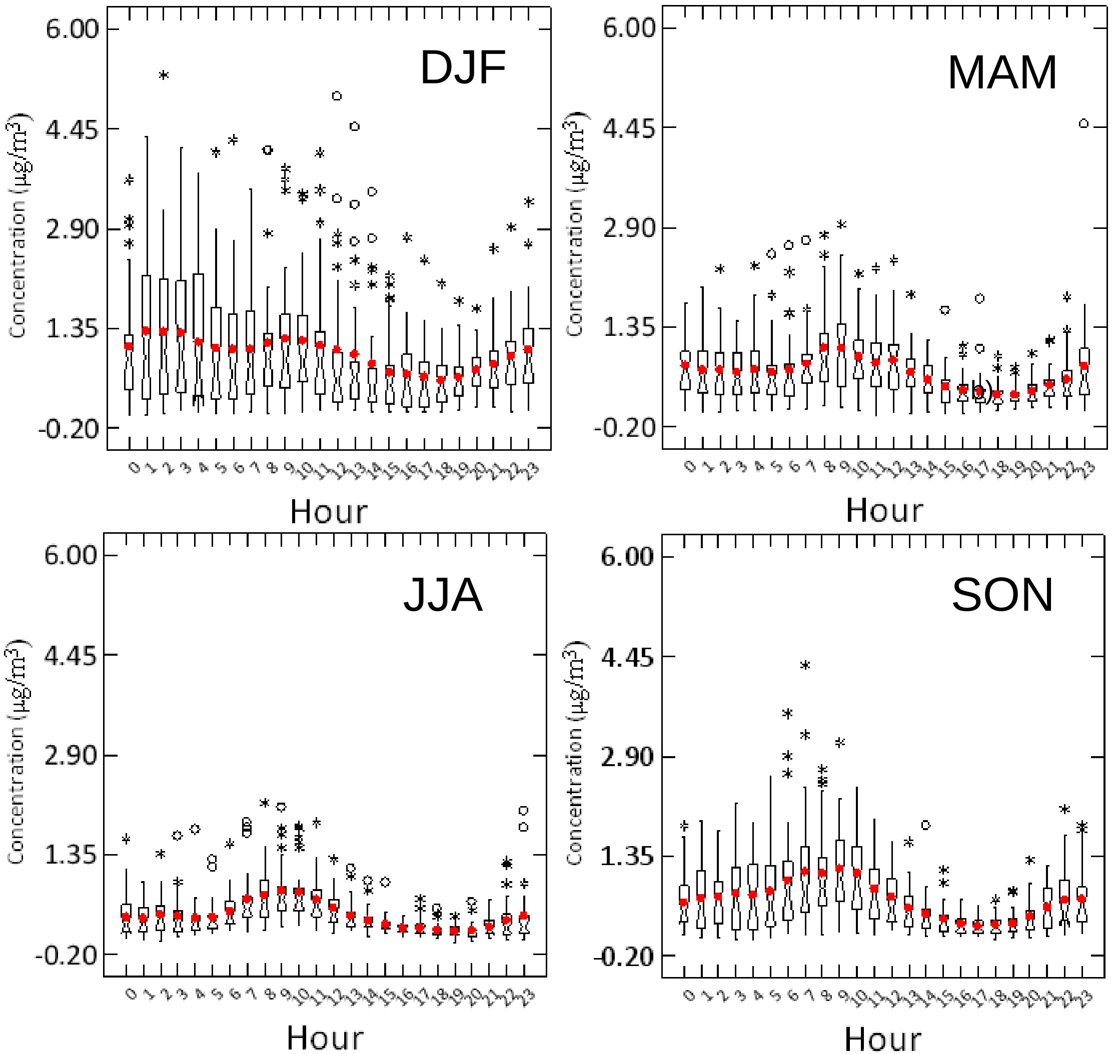
Black Carbon Diurnal Patterns



Diurnal patterns in black carbon concentrations by season.

Concentrations were usually highest in the early morning between 0800 and 1000 LST.

Concentrations were always lowest in the early evening between 1500 and 1900 LST.

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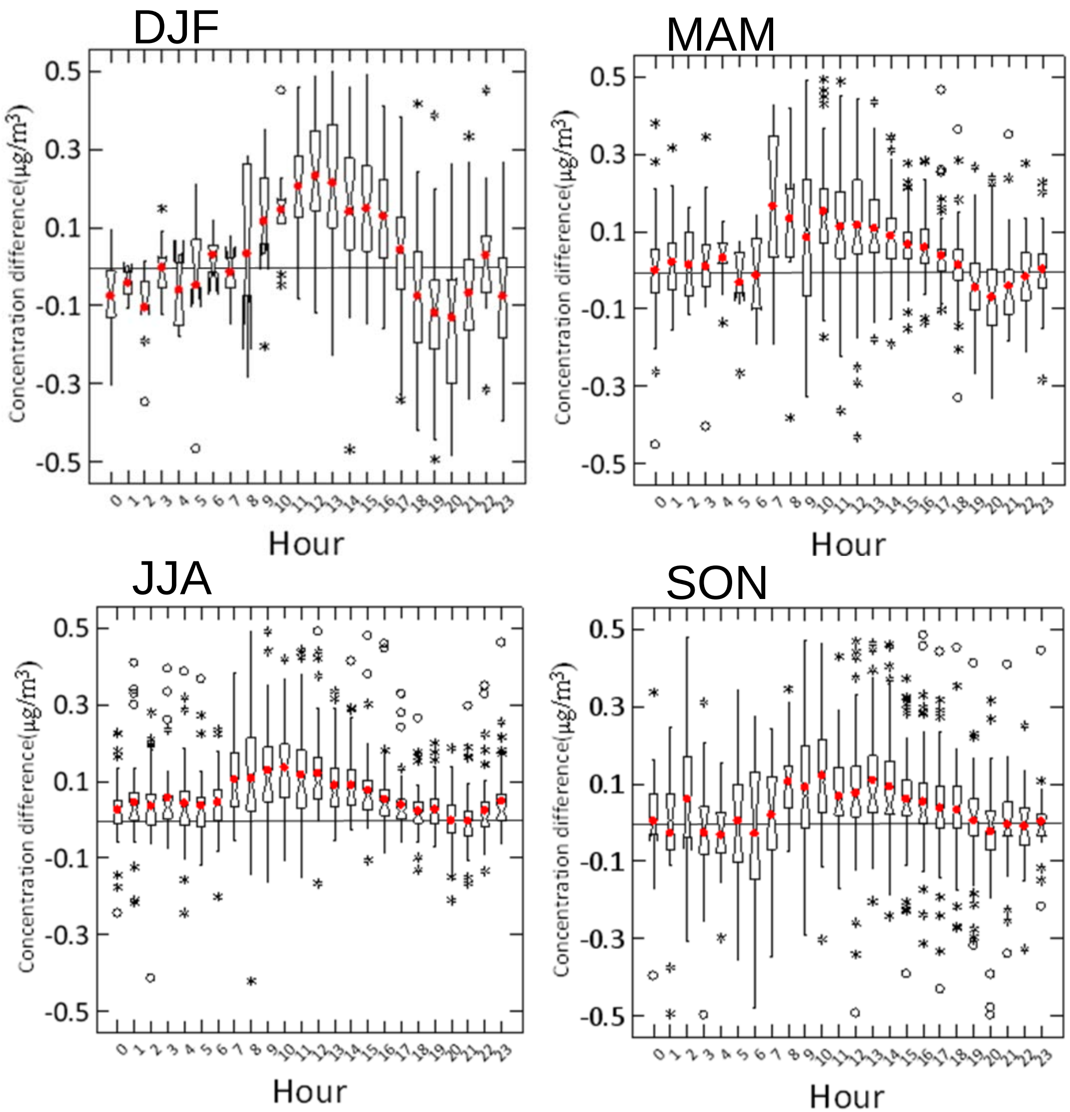
Black Carbon Diurnal Differentials – WSW Winds



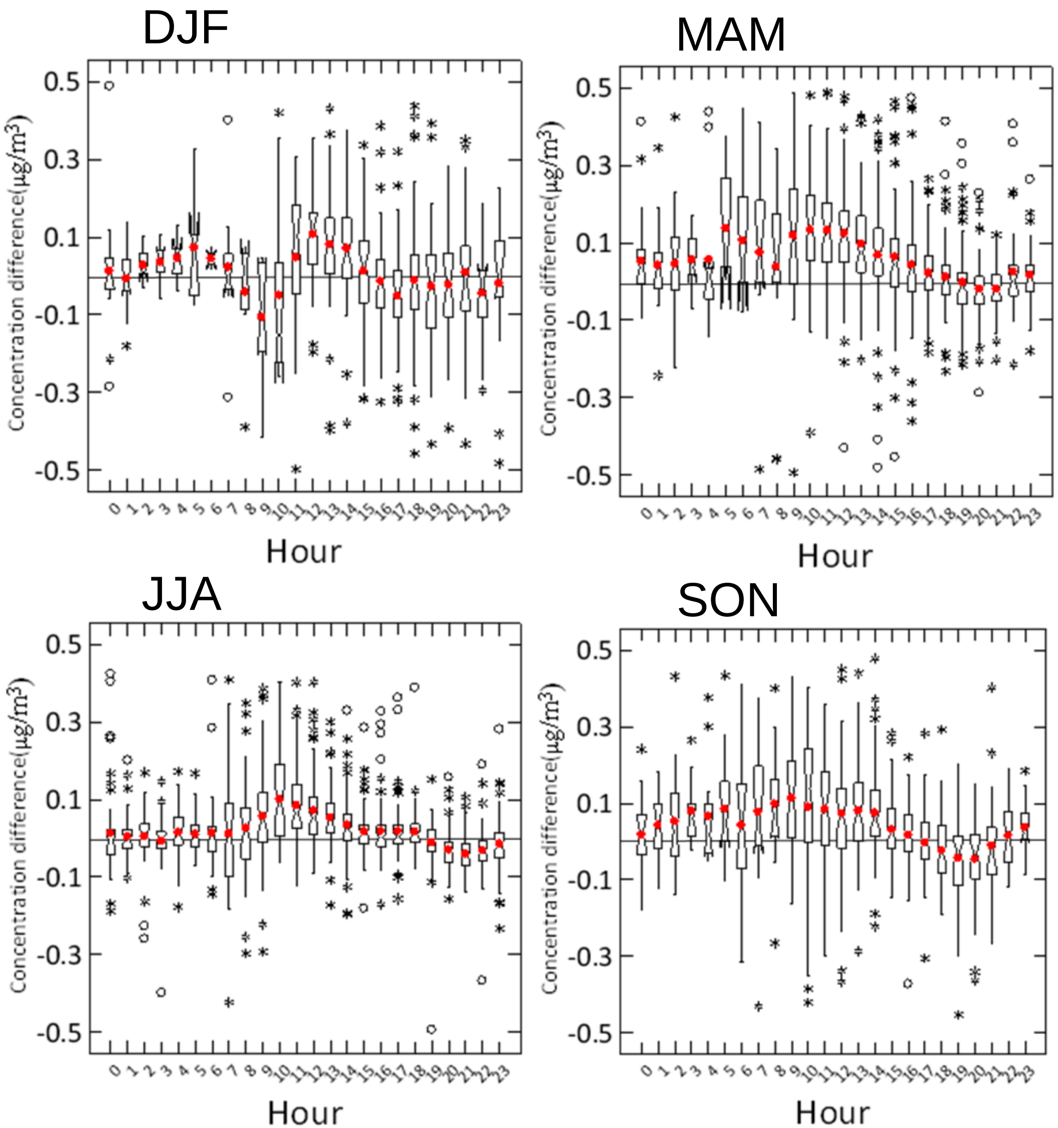
Diurnal patterns in concentration differentials of black carbon at the east minus south sites by season.

Concentrations across the field increased the most during daytime hours (0700 to 1700 LST).

Concentrations across the field did not increase overnight.

This differential includes potential contributions from La Cienega Blvd. and Stocker St.

Black Carbon Diurnal Differentials – WSW Winds



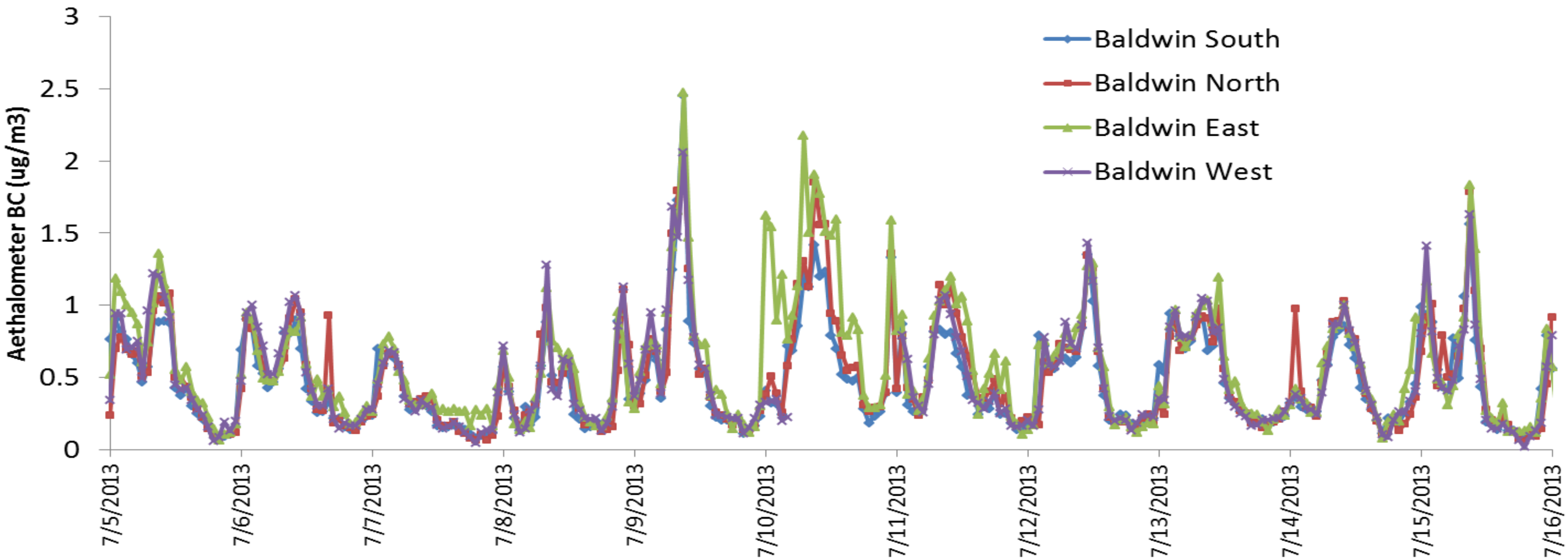
Diurnal patterns in concentration differentials of black carbon at the north minus west sites by season.

Concentrations across the field increased the most during daytime hours (0700 to 1700 LST).

Concentrations across the field did not increase overnight.

Concentrations across the oil field were not as high; this site pair does not include contributions from La Cienega Blvd.

Black Carbon Case Study Analysis



Drilling setup and operations occurred about five hundred feet from the East site on July 10 and 11.

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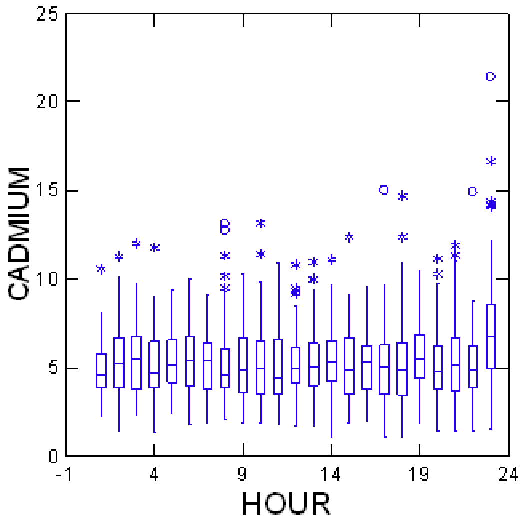
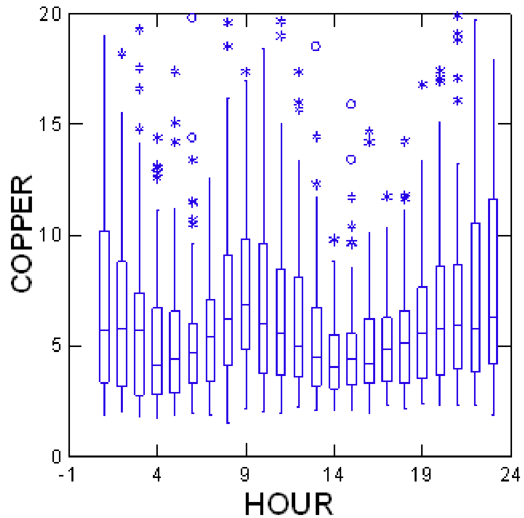
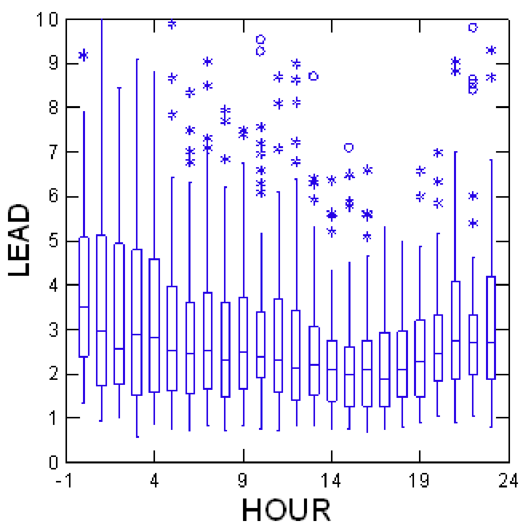
Metals Diurnal Patterns

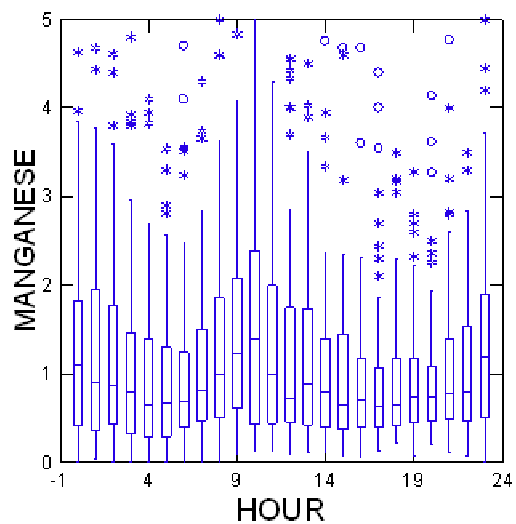


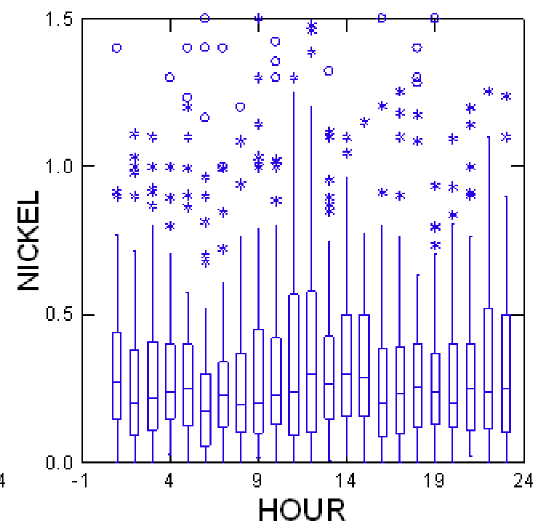


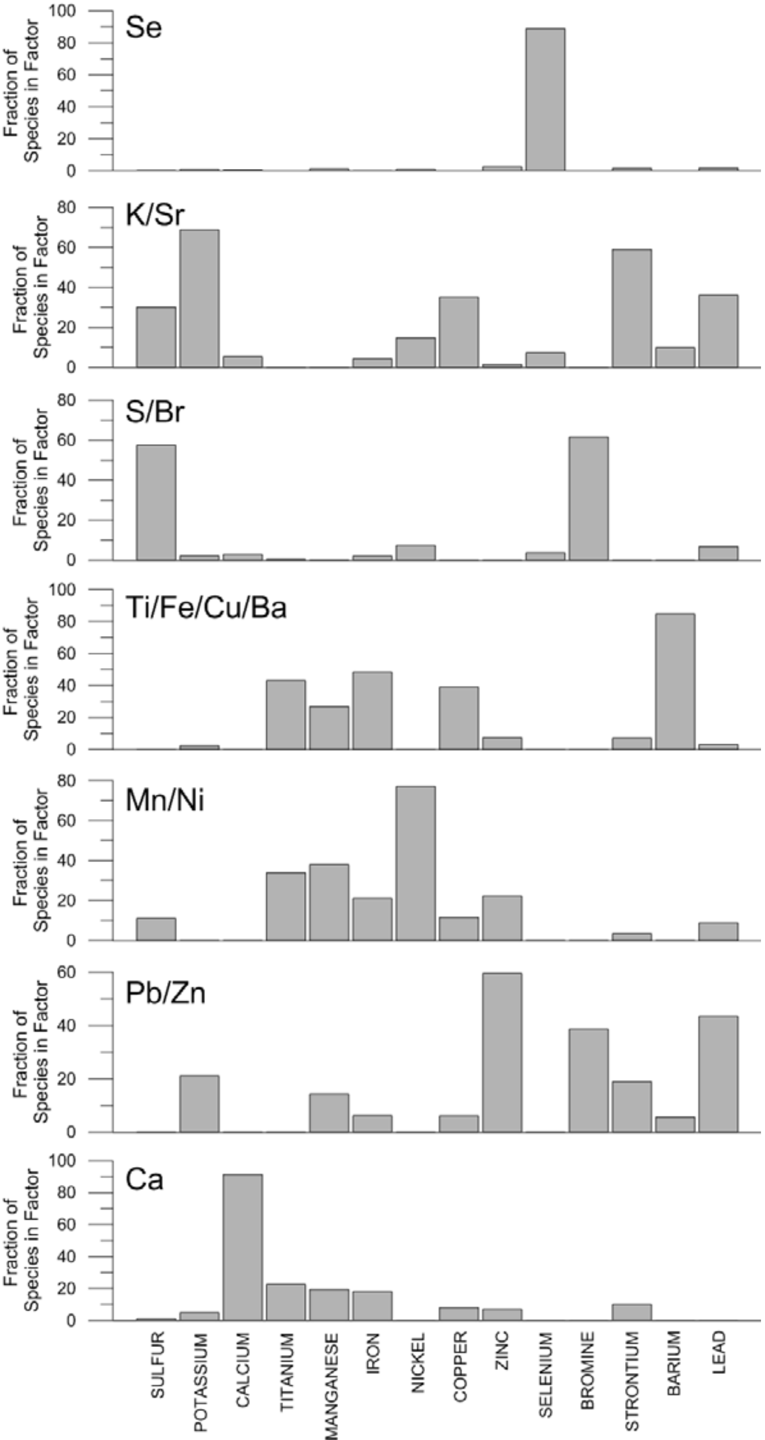
Diurnal patterns in concentrations of selected metals at the east site.

Concentrations of copper and manganese were higher during morning hours. Lead was highest at night. Other pollutants were fairly constant.









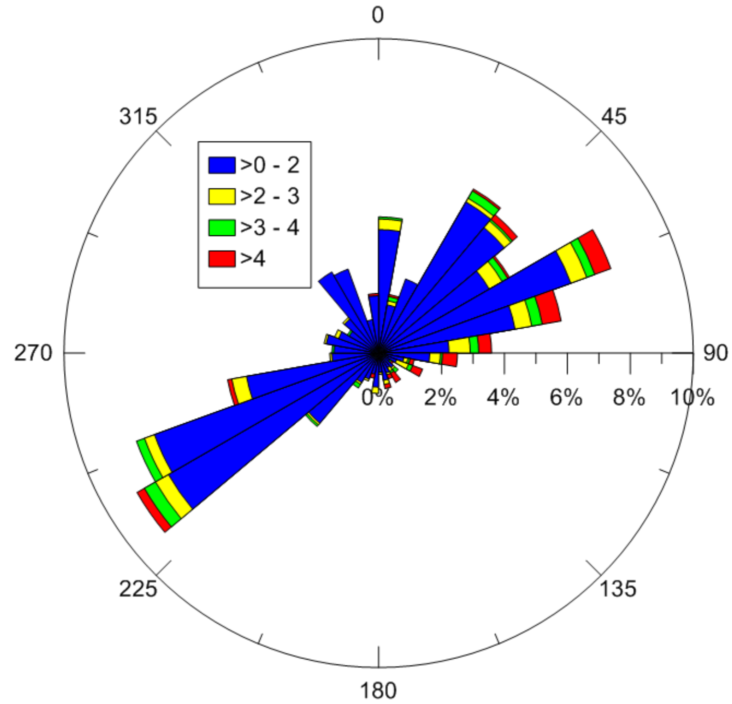
Metals Source Apportionment

A receptor model (EPA PMF v5.1) was used to apportion metals into their “source categories.” Sources are grouped by the collinearity of temporal profiles; pollutants that vary together in characteristic ways are likely to be from the same emissions source.

The factors shown were named by the key species present in each factor.

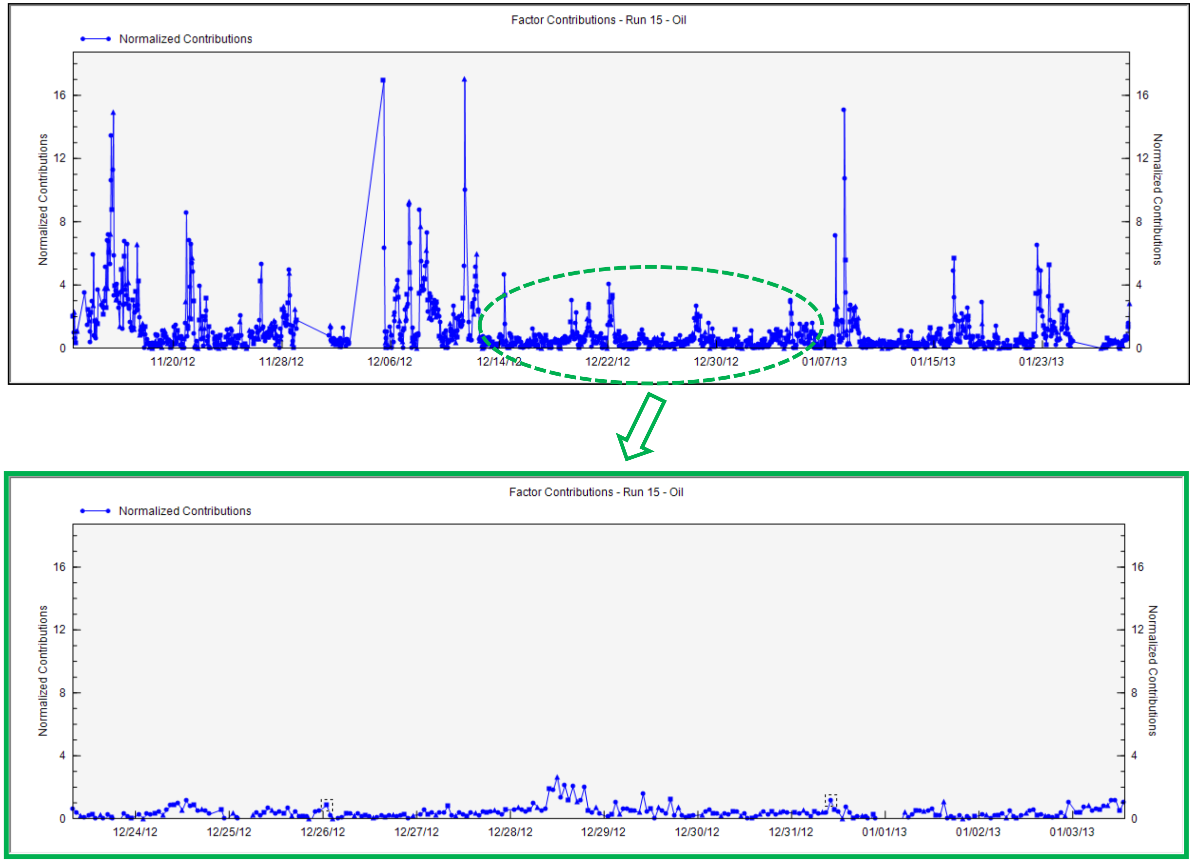
Of the seven factors identified, only the manganese/nickel (Mn/Ni) factor was associated with oil field operations.

Contribution Rose for the Oil Field Factor in the PMF Analysis



The rose shows the direction the wind is coming from at different Oil Field Factor levels (see colors). The Oil Field factor is mainly related to Mn and Ni.

The Oil Field Factor is Lower During the Holiday Period, When Oil Operations were Limited



In addition, case study analyses indicated that none of the five highest manganese-nickel hourly concentrations were associated with drilling operations within 1500 feet of the site.

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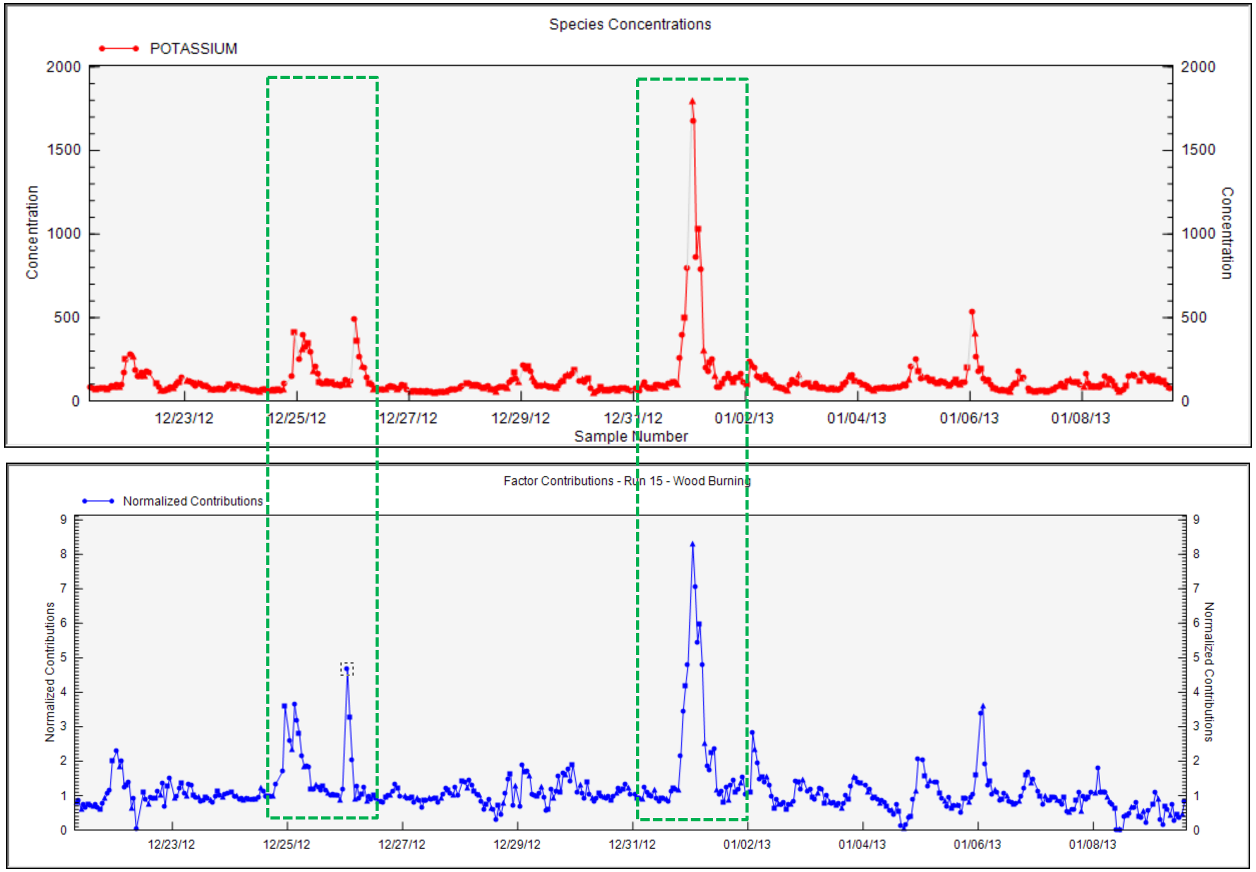
Potassium Concentrations Associated with the Wood Burning Factor



Higher potassium concentrations and wood burning factor contributions were observed on holiday nights (e.g., Christmas and New Year), when a lot of wood burning activities likely occurred.

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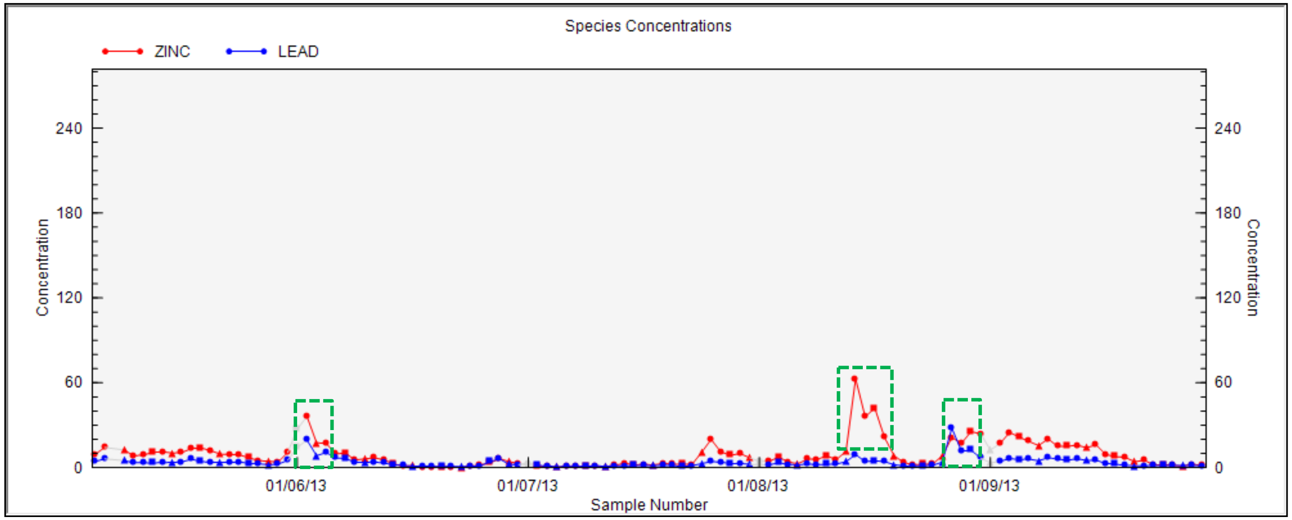
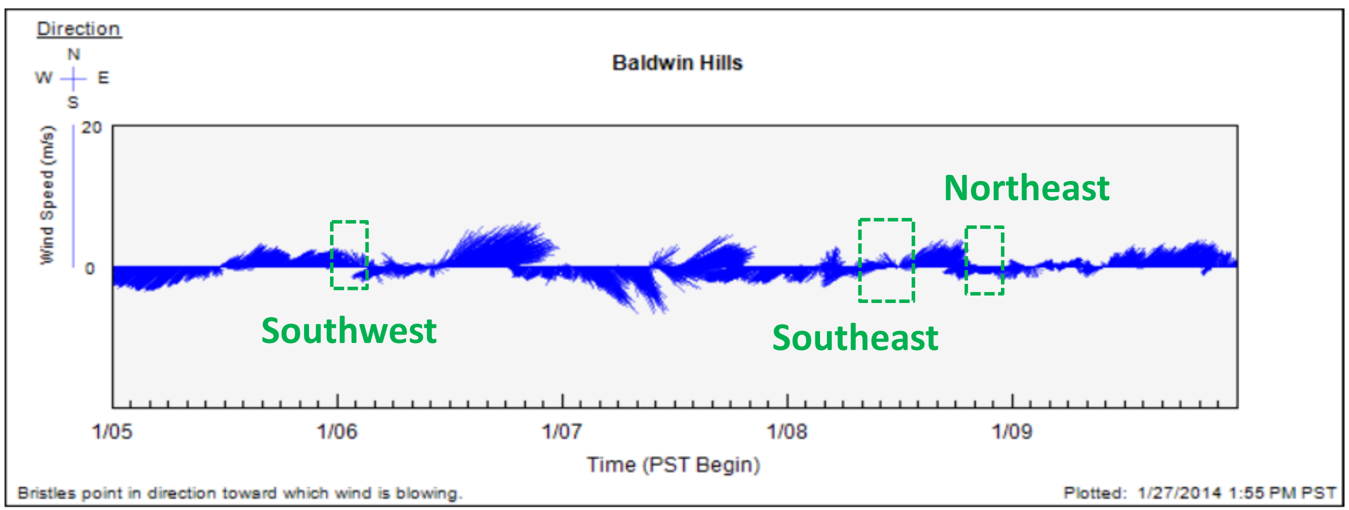
High Lead and Zinc Concentrations Associated with Various Wind Directions





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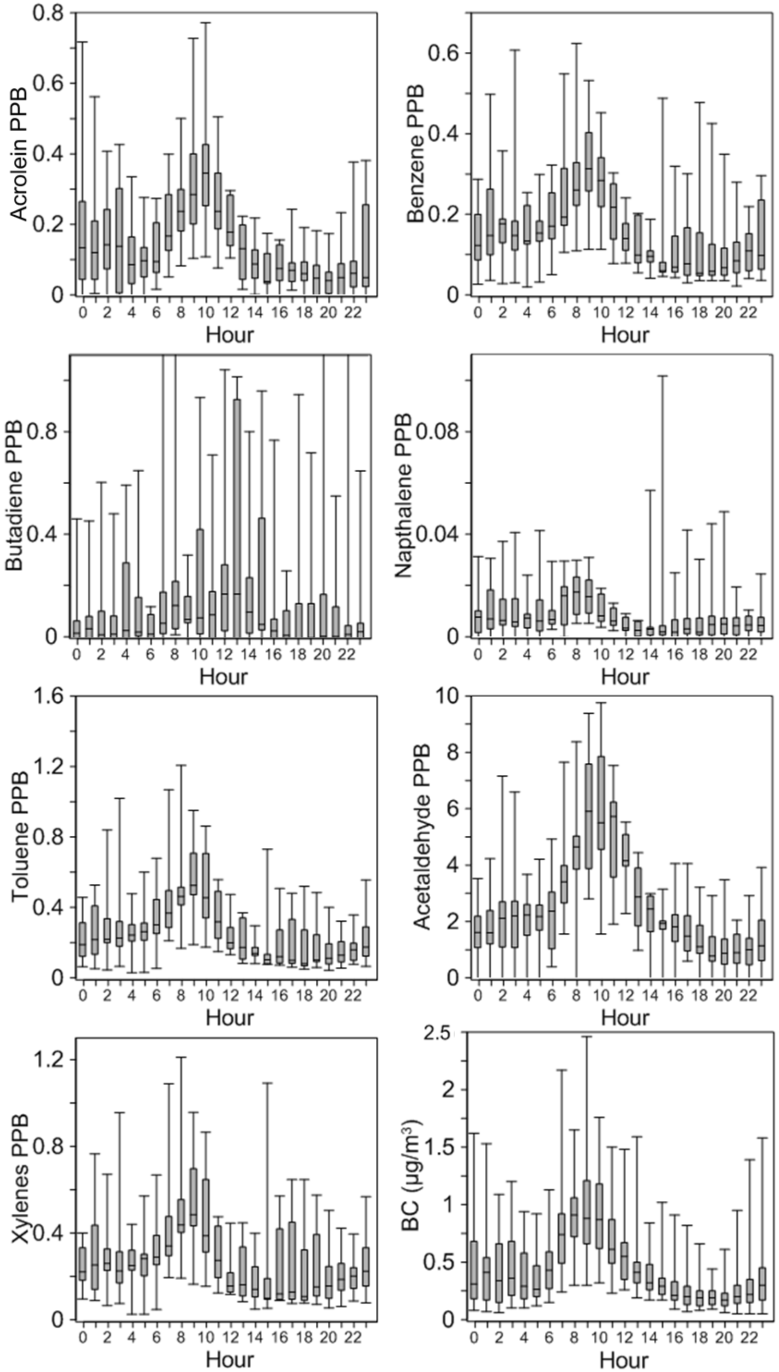

VOC Species Diurnal Patterns

Hourly interval diurnal patterns of VOCs measured at the Inglewood Oil Field east site in July 2013.

Concentrations of most pollutants peaked in the mid-morning, around 9 a.m. LST.

VOC diurnal patterns were similar to BC patterns (shown on the bottom right) during the same time period.

Butadiene and naphthalene concentrations were very close to detection limits.

Baldwin Hills Air Quality Study

What we have covered:

- Black carbon (BC) concentrations and patterns
- BC differentials
- Metals patterns
- Volatile organic compounds patterns

Next: Air Toxics Risks

- Black carbon
- All air toxics
- Comparisons to other results
- Noncancer risks
- Acute (short-term) impacts

Diesel PM Risk Characterization

Site	Average BC (µg/m³)	EC BC:EC ratio of 1.5 (µg/m³)	DPM EC:DPM ratio of 0.82 (µg/m³)	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

Note that this is total Diesel PM risk measured at the four sites, not just the Oil Field contribution.

*Incremental lifetime cancer risk = air concentration (µg/m³) * fraction of time exposed * cancer unit risk (µg/m³)$^{-1}$*

*Hazard quotient = air concentration (µg/m³) * fraction of time exposed/reference exposure level (µg/m³)*

100% exposure is assumed.

Diesel PM Oil Field % Contribution to Total BC

Increment Metric	North – West (µg/m³)	East – South (µg/m³)	% 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%

Winds are from the WSW 53% of the time. Other 90 degree bins represented less than 25% of winds and none had as high an increment as the predominant WSW direction.

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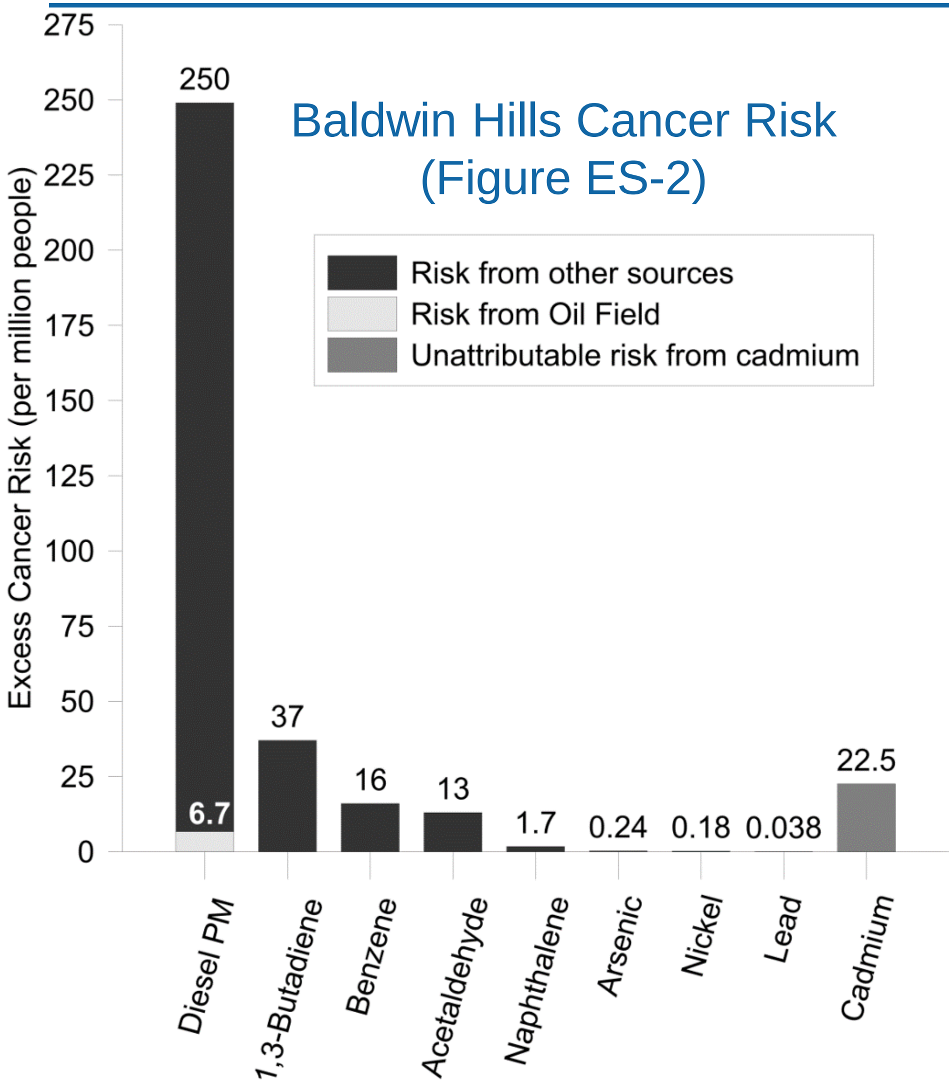
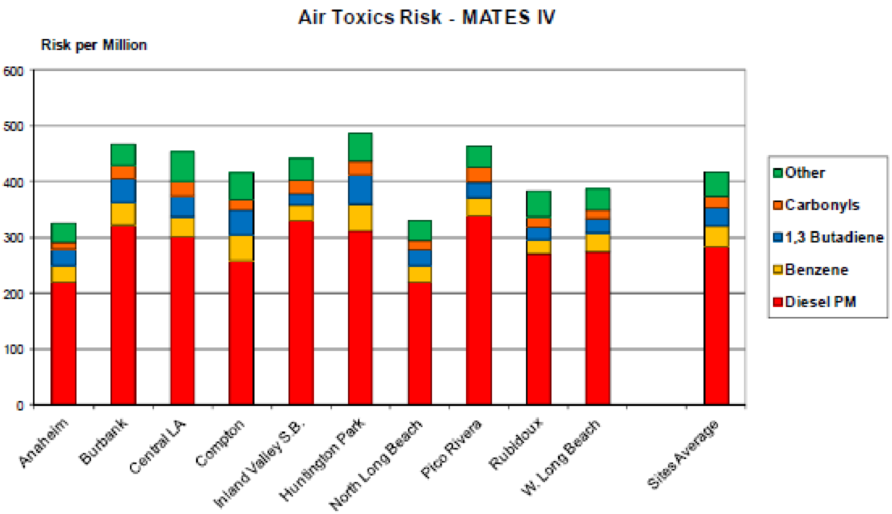
Assess the Health Risk of Exposure to Air Toxics from Oil Field Operations (1 of 3)



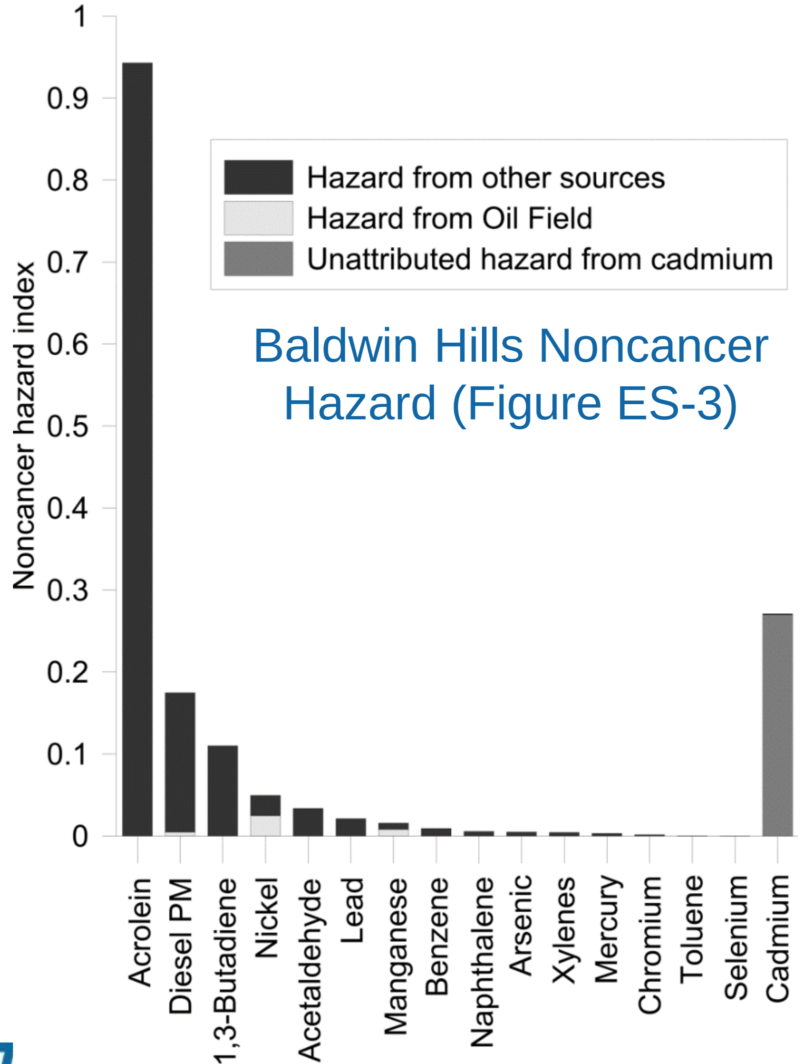


Draft MATES IV Cancer Risk (Figure ES-3)

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

- Cancer risk is primarily attributed to Diesel PM.
- Cancer risk is comparable to other LA Basin measurements
- Oil Field contributions to cancer risk are an increment of 6.7 per million above background

Assess the Health Risk of Exposure to Air Toxics from Oil Field Operations (2 of 3)



- Noncancer hazard were below thresholds of concern for all pollutants
- Acrolein concentrations are near the noncancer hazard quotient threshold of 1. A full annual measurement (rather than our two-week intensive measurement period) may indicate this is above the threshold
- Oil Field contributions to noncancer effects are small and negligible relative to levels of concern.

*Hazard quotient = air concentration (μg/m^3) * fraction of time exposed/ reference exposure level (μg/m^3)*

100% exposure is assumed.

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Assess the Health Risk of Exposure to Air Toxics from Oil Field Operations (3 of 3)

Acute impacts

- One hourly concentration of nickel was measured at a level above the acute reference exposure level. Case study analysis showed that this measurement was associated with winds originating from the northeast, upwind of the oil field measurement site. In other words, this event was not associated with Oil Field operations.
- All other measurements were below short-term (one-hour or eight-hour) reference exposure levels set by the California Office of Environmental Health and Hazard Assessment.

Summary

- We measured prioritized air toxics species
  - to assess Oil Field contributions
  - to assess community risk from Oil Field contributions
- Multiple methods were used
  - Black carbon (BC) as a surrogate for diesel particulate matter (DPM) at four sites for one year
  - Metals (e.g., arsenic, cadmium) at one site for two and a half months
  - Volatile organic compounds and carbonyls (e.g., benzene, acrolein) for two weeks at one site
- Analyses demonstrated Oil Field contributions to local concentrations and associated health risks
  - Oil Field contribution versus total contribution
  - Comparison of concentrations to short- and long-term California health benchmarks and to results from other parts of LA

Overview of Tonight's Presentation

- Study objectives
- Study background and design
- Measurement methods
- Important study issues and examples
- Approaches to using study results to address objectives
- Study results and air toxics risks
- Opportunity to ask more questions at the March 26th CAP meeting.

Acknowledgments

- The Baldwin Hills AQ Study was funded by LA County Department of Regional Planning.
- South Coast Air Quality Management District staff for their review of the draft work plan and report, and for laboratory analyses of intercomparison samples.
- PXP (now FCX Oil and Gas, Inc.) for allowing placement of monitoring sites on their property and for providing emissions activity information.
- Luis Perez of Marine Resources Specialists for assisting with the emissions and activity data and for review of the draft report.