Multiple Air Toxics Exposure Study (MATES-II) in the South Coast Air Basin

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South Coast Air Quality Management District

- # of People Involved
- Papers Presented
  - Study
  - Modeling
  - Emissions
  - Trends
- Main Document on Web (Appendix, Not)
- Detailed Questions: Will Take Back

Guiding Principles

- All Basin residents have right to live in an healthful environment.
- Government is responsible for protecting the public health.
- Public and private sectors have the right to participate in the regulatory process.
- Governing Board is to oversee the the participatory process and protect the public's interests.

Environmental Justice Initiatives

- Town Hall Meetings
- Ambient Monitoring of Air Toxics
- Community Response Teams
- CEQA Commenting
- Environmental Justice Task Force

MULTIPLE AIR TOXIC EXPOSURE STUDY (MATES II)

- Environmental Justice Initiative
- Follow-Up of MATES - I; A Decade Ago

MATES II
Components

- Comprehensive Ambient Toxics Monitoring
- Up-Dated Toxics Emissions Inventory
- Modeling/Risk Assessment
- Characterize SCAB's Air Toxic Risk
- Regional + Limited Local

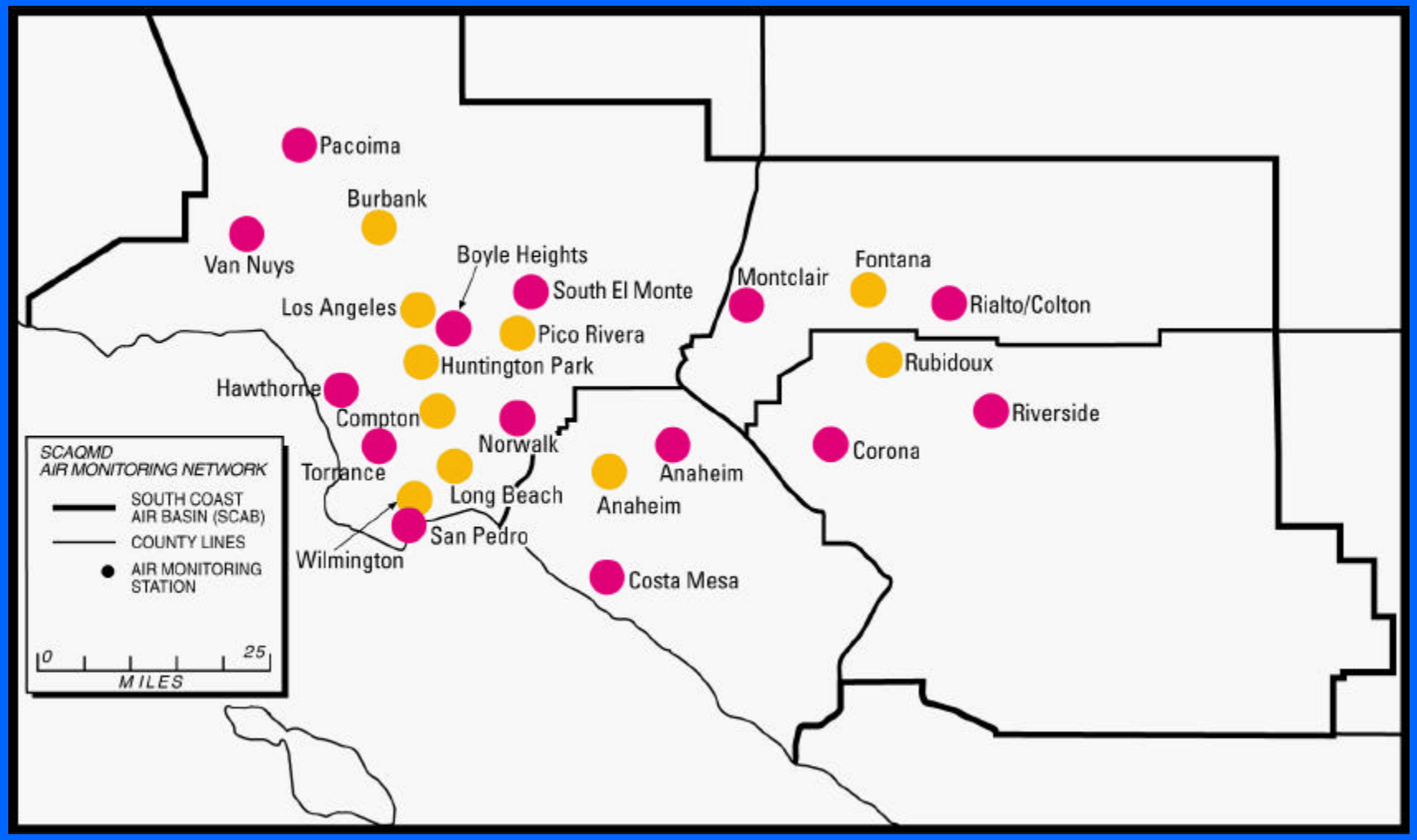
BACKGROUND

- Program Review by Panel of Experts
  Air Toxic Study Technical Review Group (ATSTRG)
  - Academia
  - Environmental Groups
  - Industry & Private Sector
  - Federal, State, Local Agencies
- Sampling Period: April, 1998 to March, 1999

MONITORING

- Input from ATSTRG & E.J. Task Force
- One Year Toxics Monitoring at 10 Sites
  - 5 CARB Long Term Trend Sites
- Based on EPA Guidelines "neighborhood scale monitoring"
- Complementary One-Month Sampling
  - 3 Mobile Platform (Microscale)
  - 14 Communities
- Over 30 Toxic Pollutants Measured
  - Gaseous
  - Particulates

MATES II Monitoring Network



Fixed Sites

Microscale Sites

Equipment at Each Site

- PM Samplers
- VOC Canisters
- Carbonyl Samplers
- Met. Data

Equipment at 5 Long Term Sites

- 0_3
- NOx
- CO
- + Above

Labs

- CARB & District for VOC & PM
- CARB: All PAHs
- SCAQMD: All Carbon (Elemental & Organic)

Table 3-2
Routinely Measured Compounds

CAS No.	Chemical Name	CAS No.	Chemical Name
71432	Benzene	50000	Formaldehyde
7440439	1,3 Butadiene	75070	Acetaldehyde
106467	Dichlorobenzene (ortho- & para)		Acetone
75014	Vinyl Chloride	7440382	Arsenic
10414	Ethyl Benzene		Chromium
	Toluene	7439921	Lead
	Xylene (m-, p-, o-)	7440020	Nickel
	Styrene		Cobalt
56235	Carbon Tetrachloride		Copper
67663	Chloroform		Manganese
75343	Dichloroethane [1,1]	7723140	Phosphorous
	Dichloroethylene [1,1]		Selenium
75092	Methylene Chloride		Silica
127184	Perchloroethylene		Silver
79016	Trichloroethylene		Zinc
74783	Chloromethane		PAHs
			Elemental & Organic Carbon

Table 3-3
Compounds Considered for Measurement Based on Local Factors

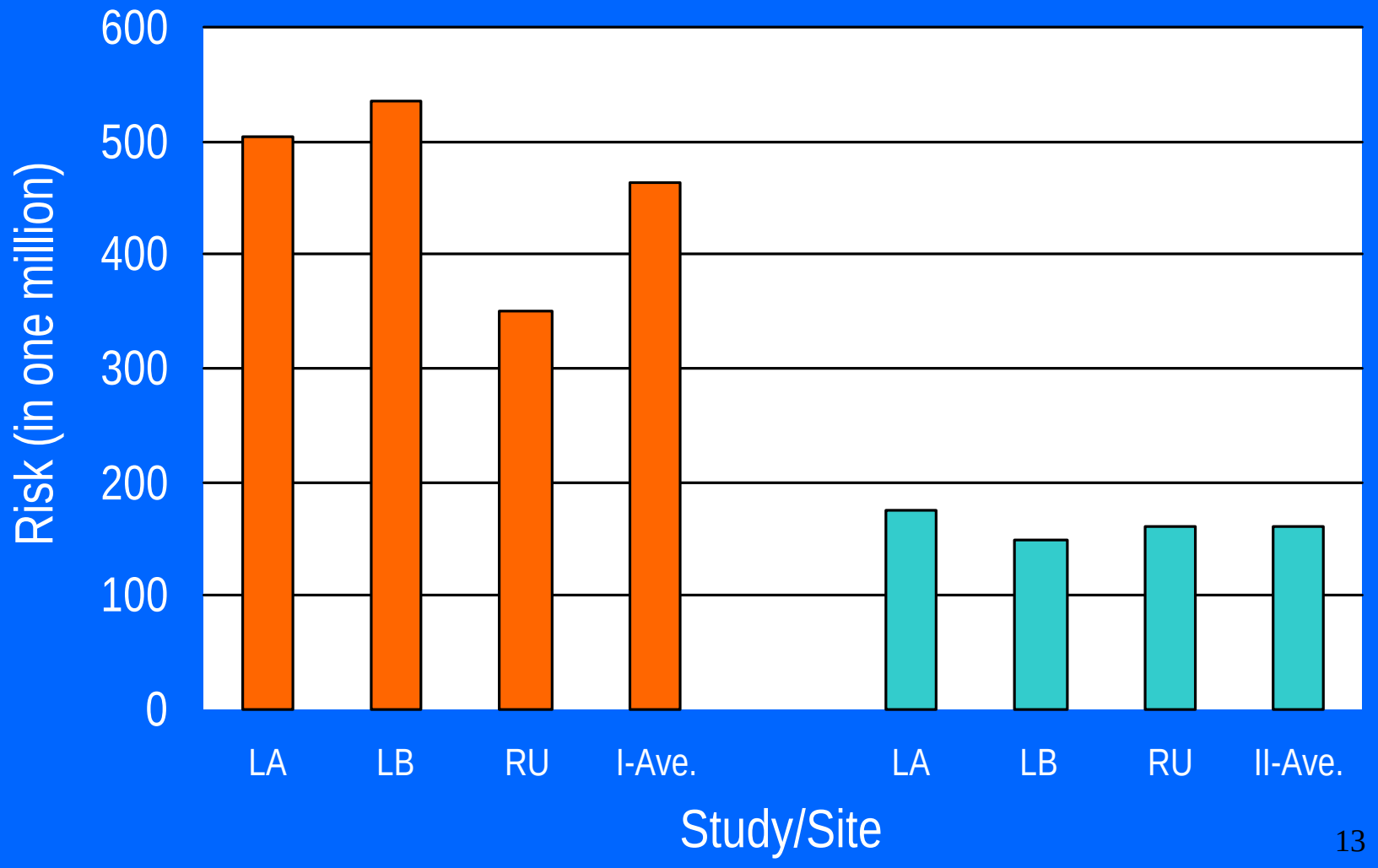
Compound	Compound
Acrylonitrile	Dioxins & Furans
Di(2-ethylhexyl)phthalate	Asbestos
Glycol Ethers	Fine Mineral Fibers
Toluene-2,4-diisocyanate	BaP
Toluene-2,6-diisocyanate	

Laboratory Procedures

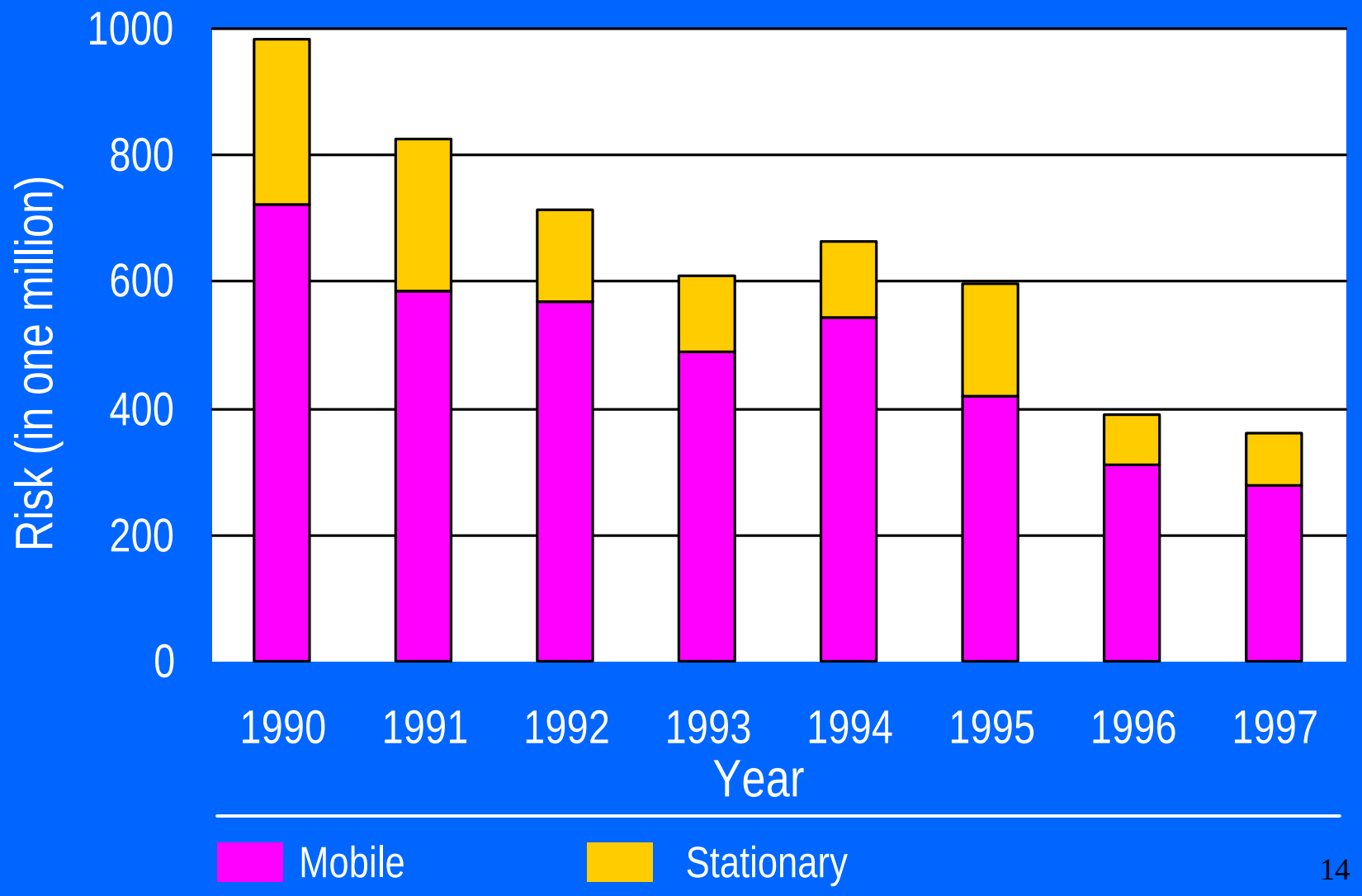
Followed	EPA's PAMS & CARB's SOP
AQMD:	PM10 Filters for Elemental & Organic Carbon
CARB:	Arsenic, Cadmium, PAH < benzo-a-pyrene
QA/QC	Between CARB & AQMD

Comparison of Cancer Risks

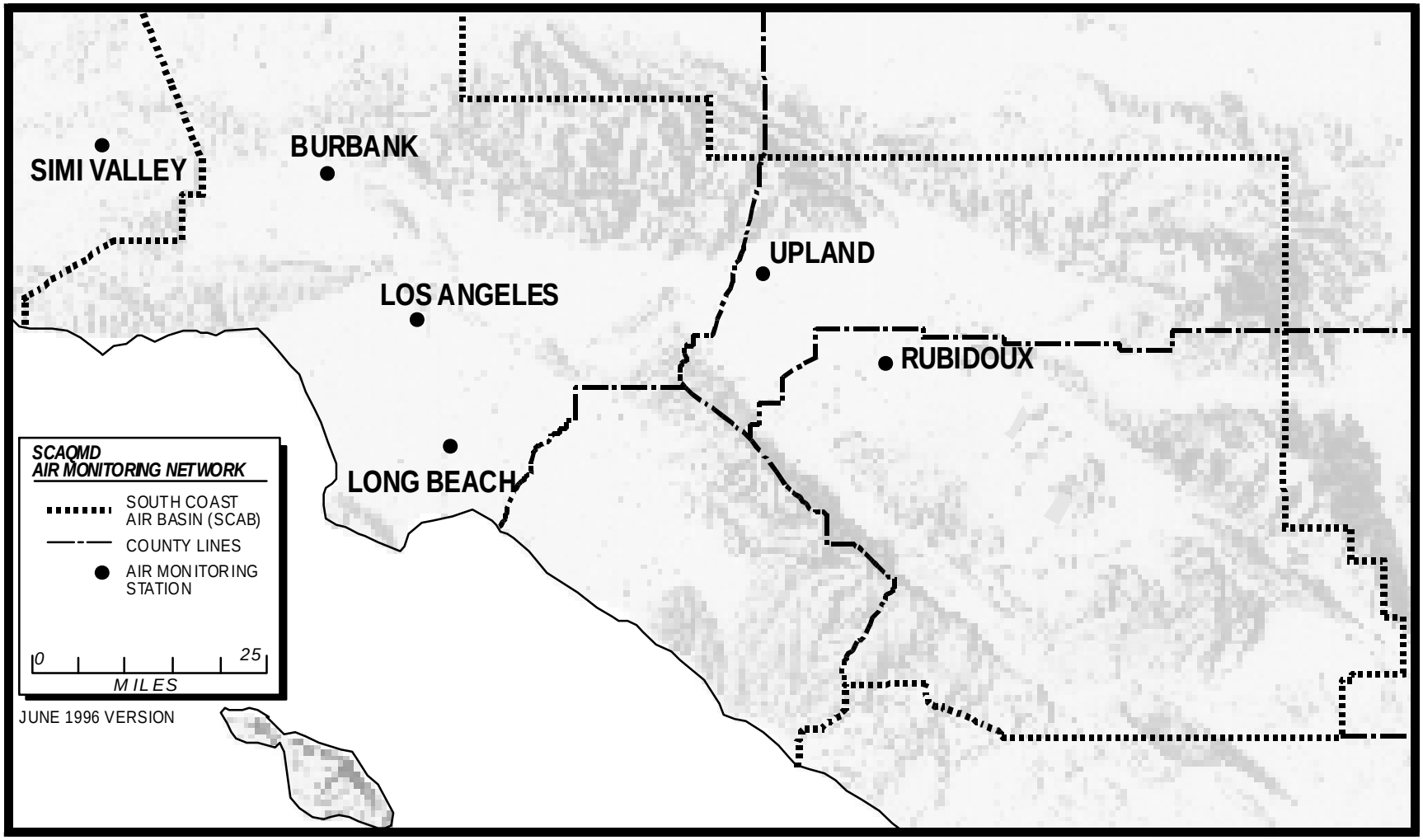
MATES - I vs MATES - II



Trends in Cancer Risk at Burbank



Trend Monitoring Stations



Changes in TACs Since 1990

TAC	Red.	TAC	Red.
Benzene	69.2%	Perchloroethylene	55.1%
1,3 Butadiene	36.8%	Trichloroethylene	58.2%
Carbon tetrachloride	25.8%	Hexavalent chromium	65.3%
Chloroform	-10.8%	Lead	63.6%
Methylene chloride	38.7%	Nickel	21.6%
p-Dichlorobenzene	5.7%		

Reductions in Cancer Risks, 1990-97

Site	Reduction (%)
Burbank	63.6
Los Angeles	44.1
Long Beach	56.1
Rubidoux	48.5
Upland	48.6
Simi Valley	55.9

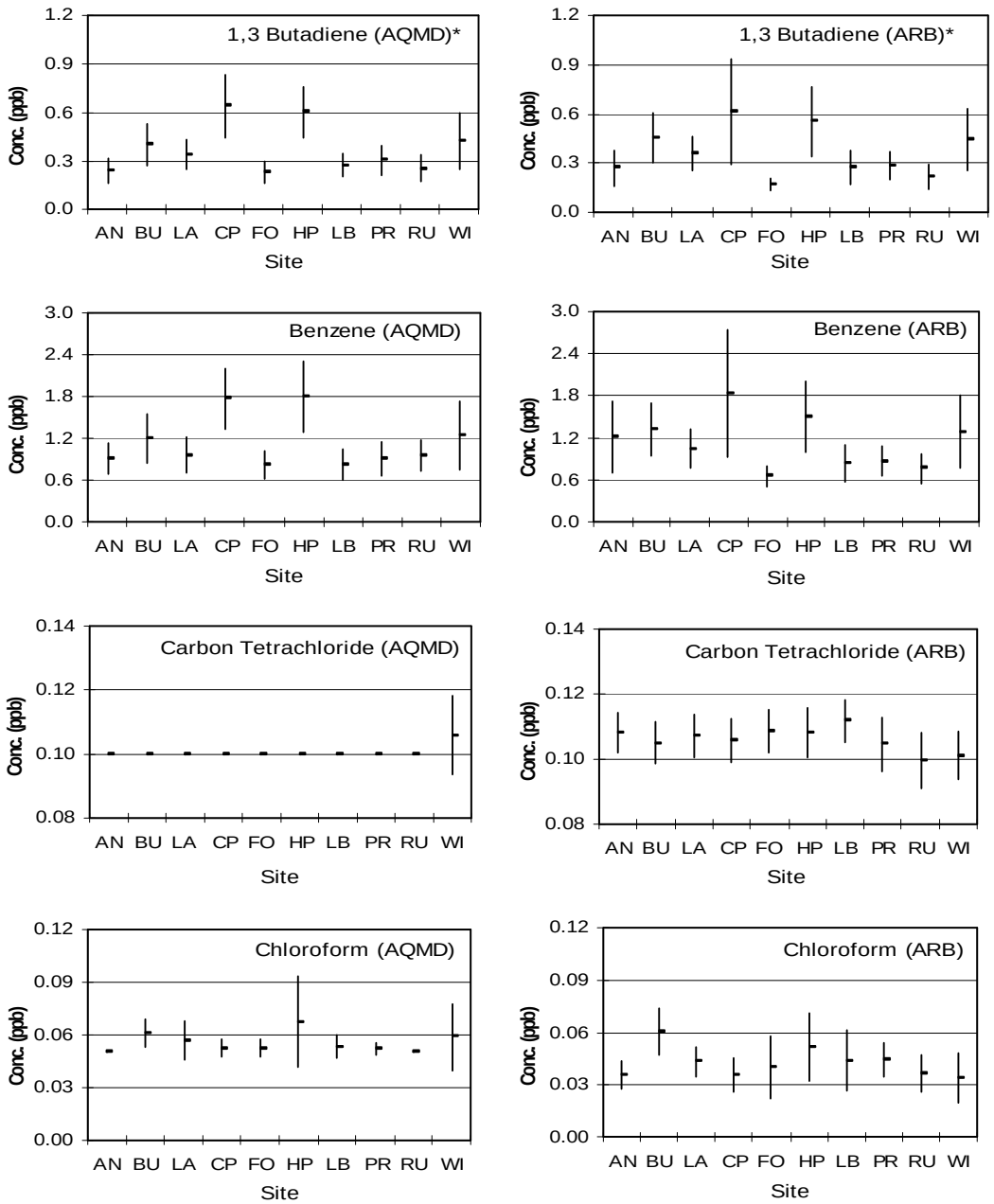


Fig. 3-2

Comparison of Concentrations Among MATES II Sites.

Tick mark represents the mean and the bar represents the 90 percent confidence interval about the mean. *(AQMD) and (ARB) refer to laboratories conducting analysis.

AN – Anaheim	**BU – Burbank**	**LA – Los Angeles**	**CP – Compton**	**FO – Fontana**
HP – Huntington Park	**LB – Long Beach**	**PR – Pico Rivera**	**RU – Rubidoux**	**WI - Wilmington**

Fig. 3-2 Continued

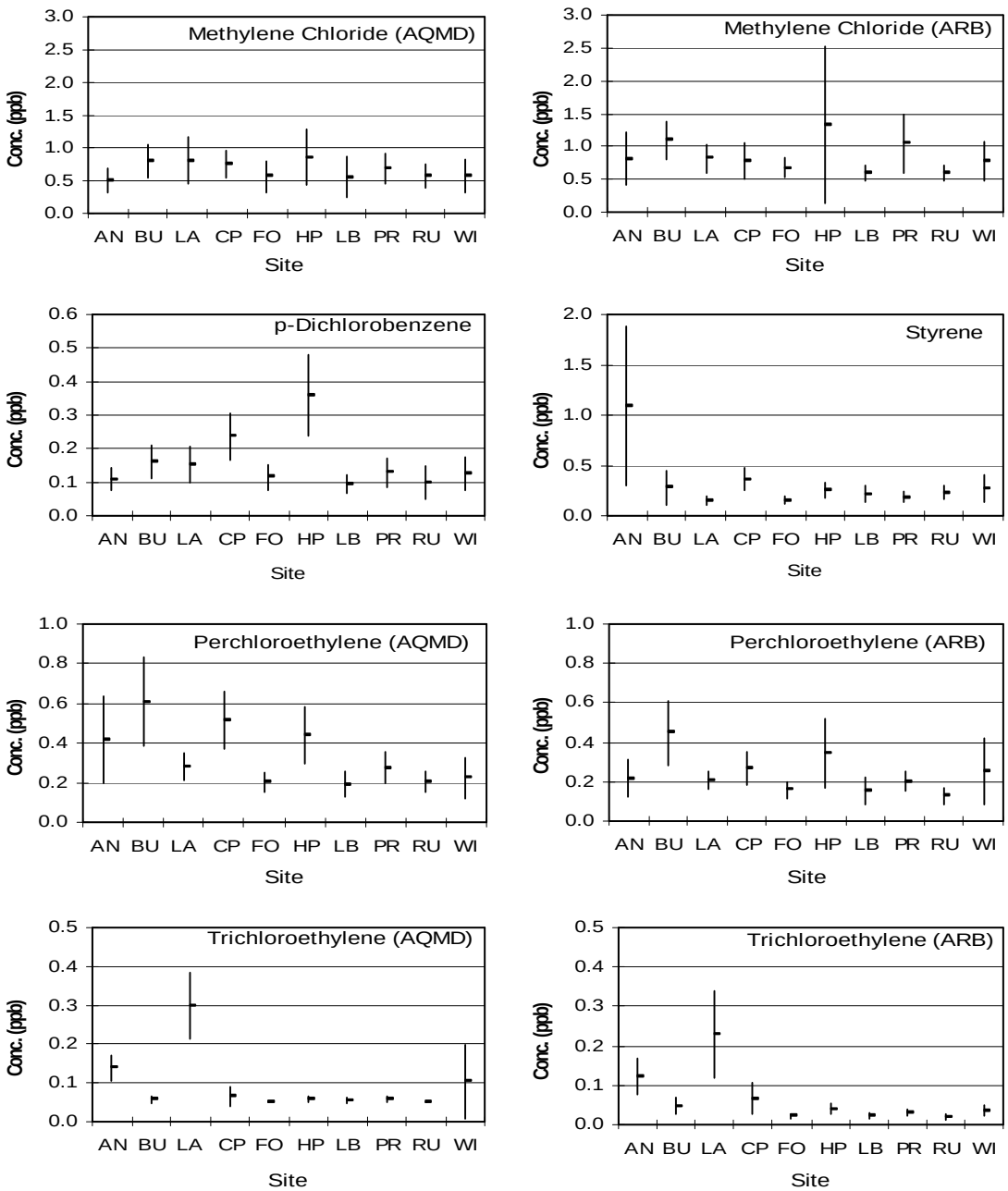


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Fig. 3-2 Continued

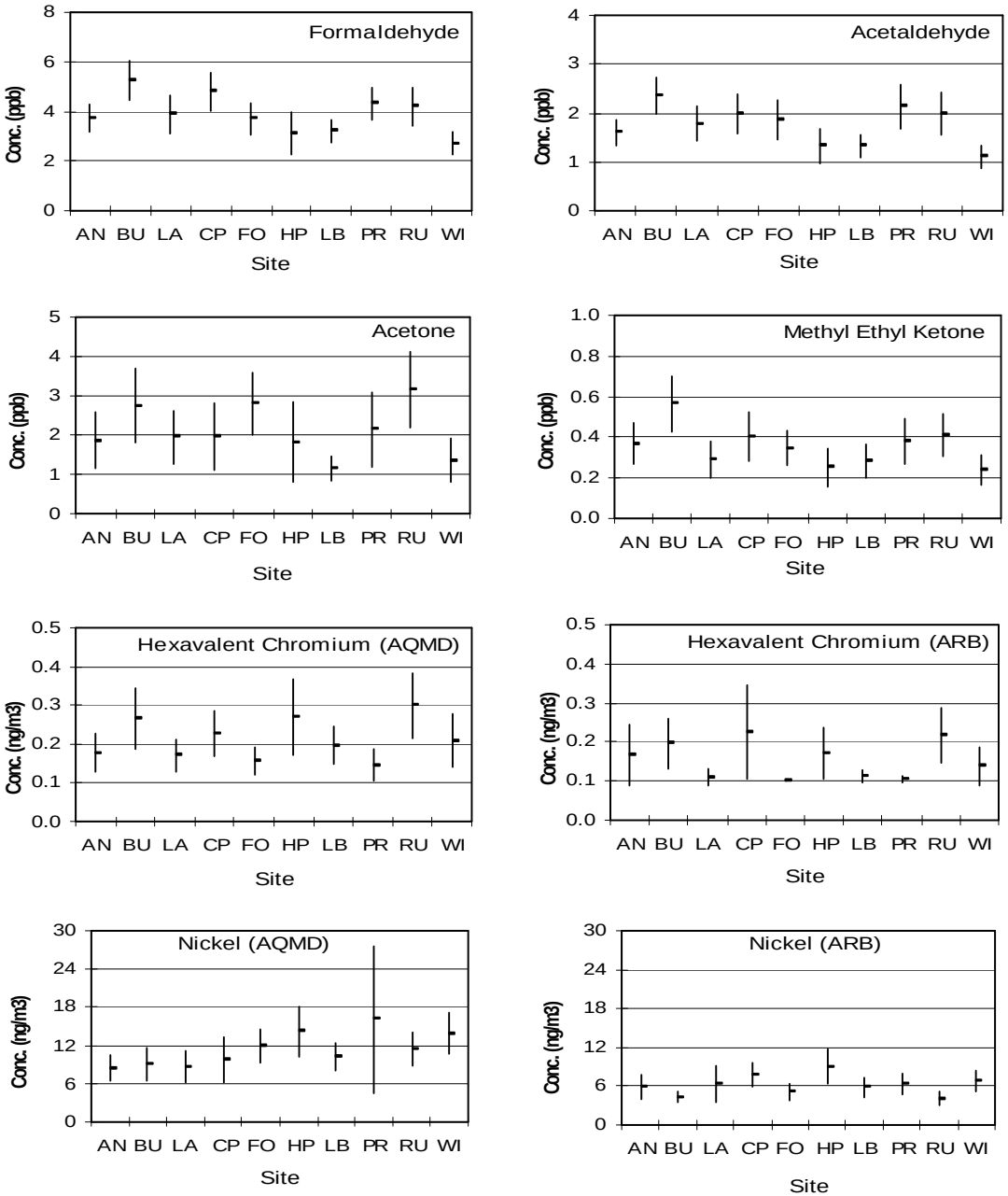

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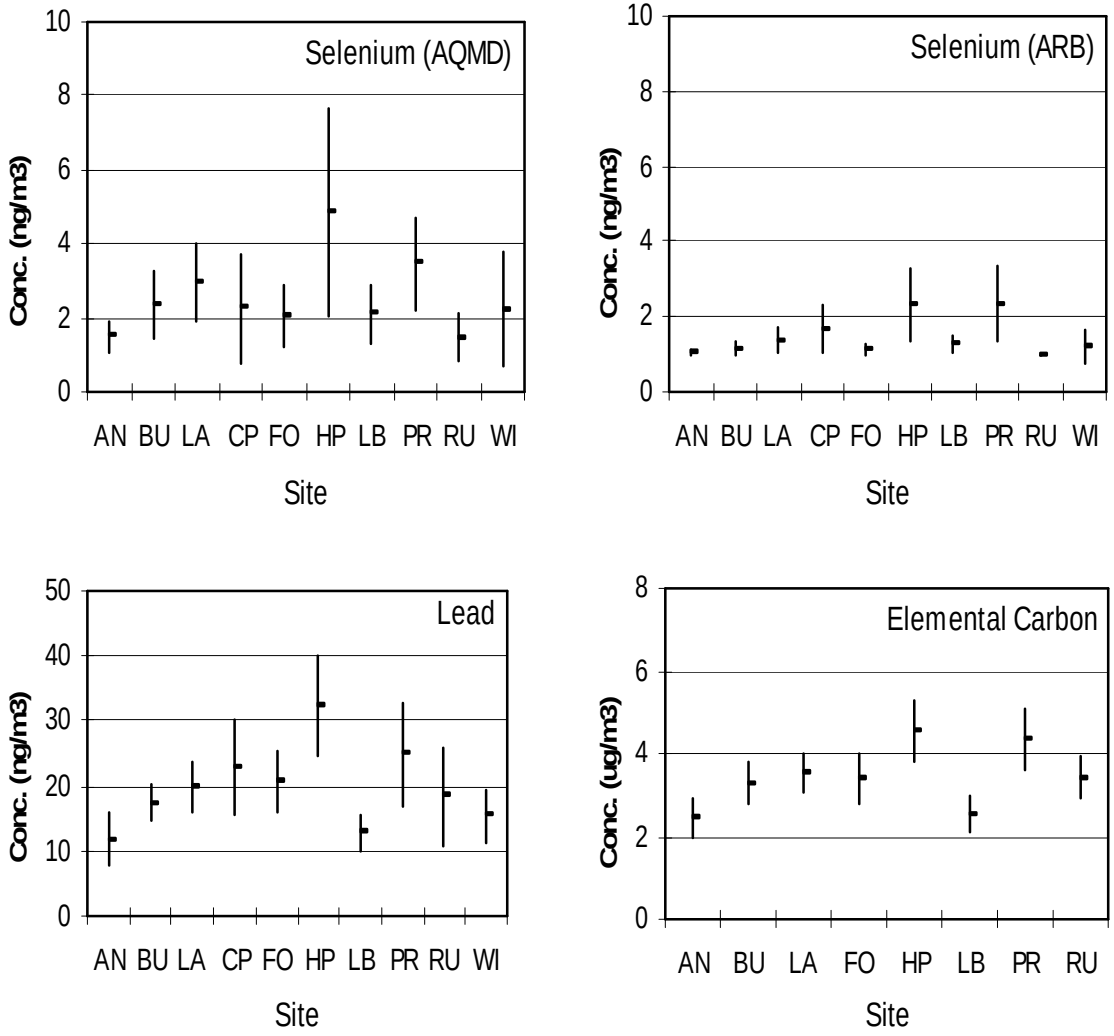
Fig. 3-2 Concluded



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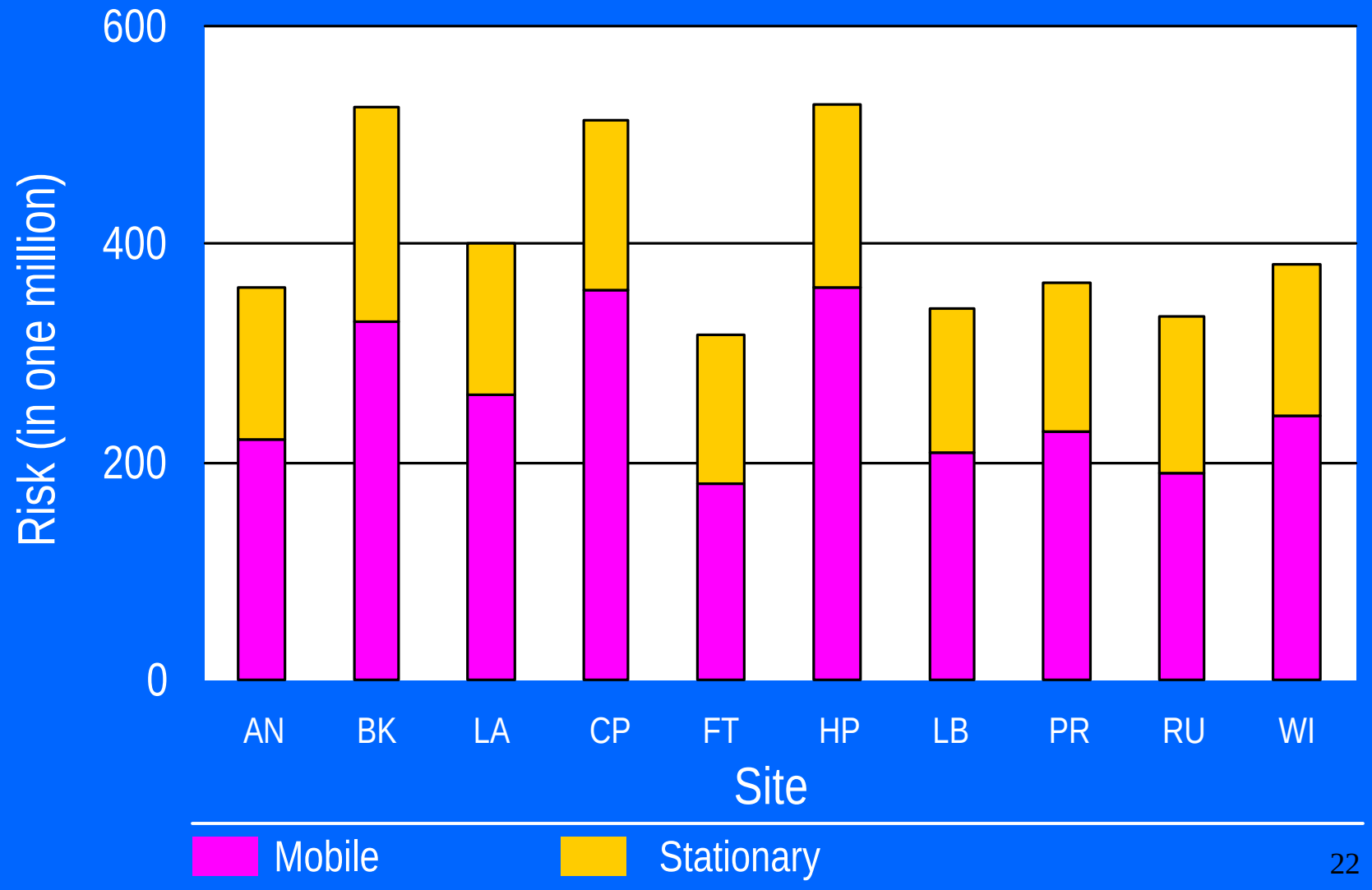
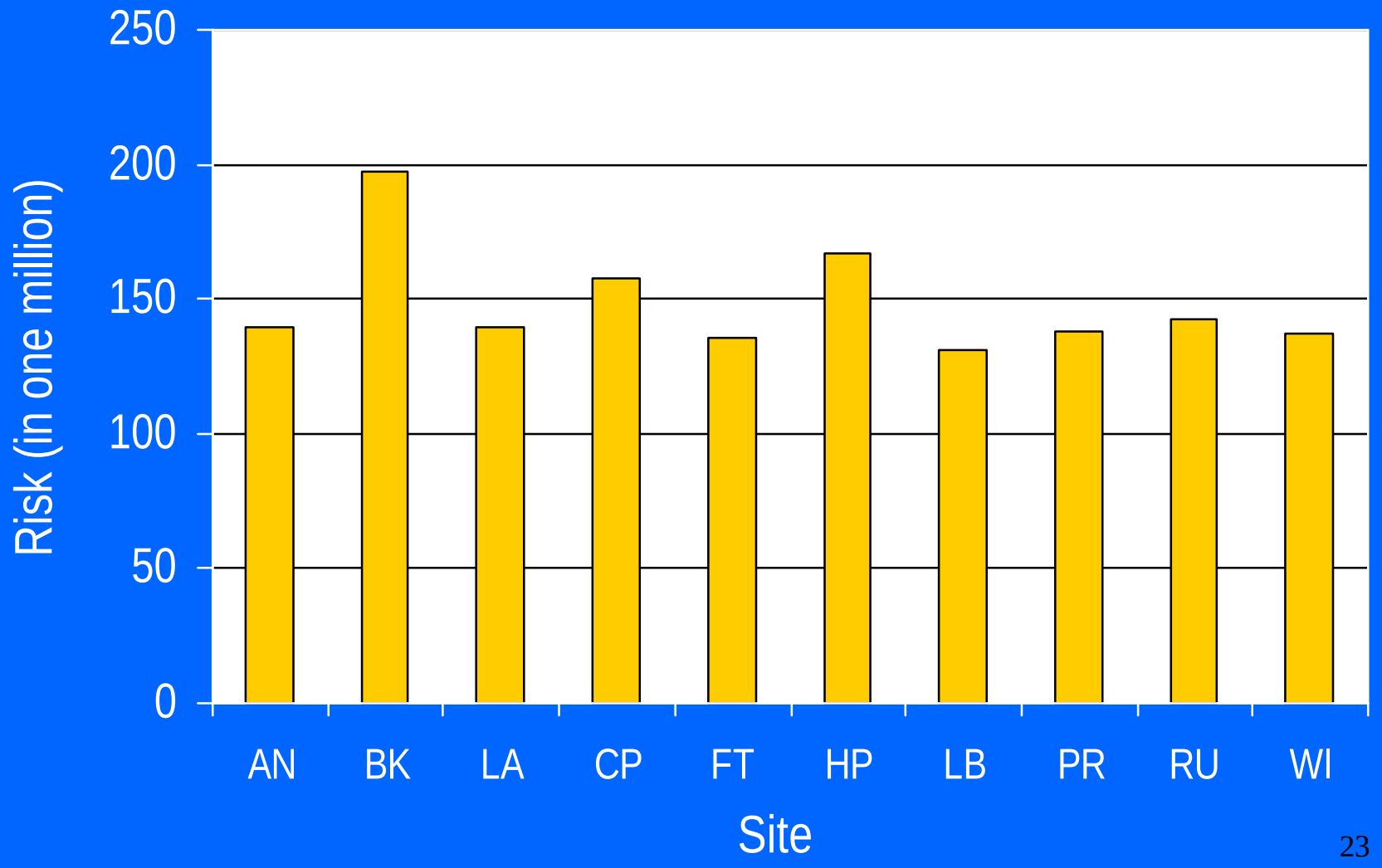
MATES II Cancer Risks

(Excluding Diesel)

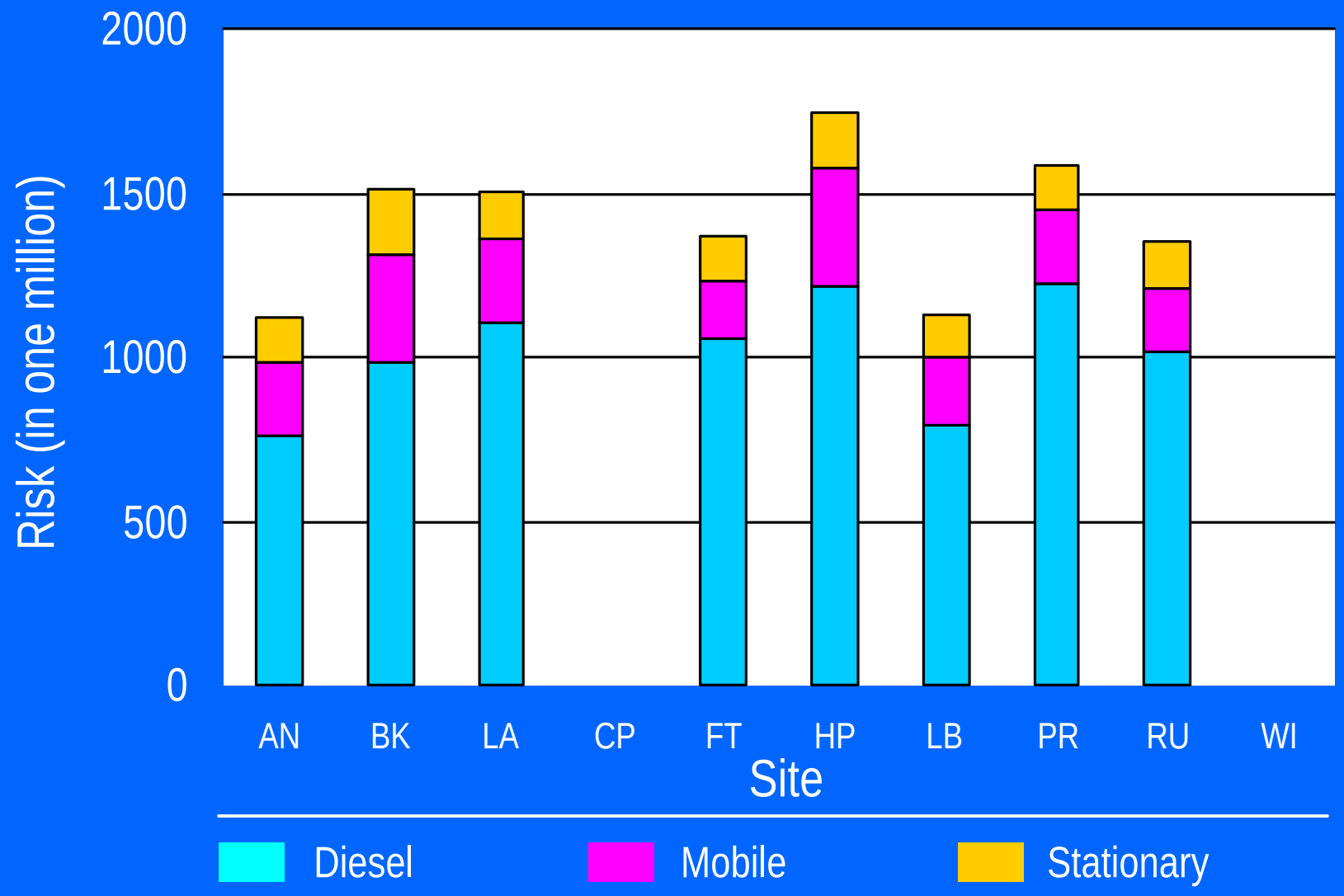


Cancer Risks

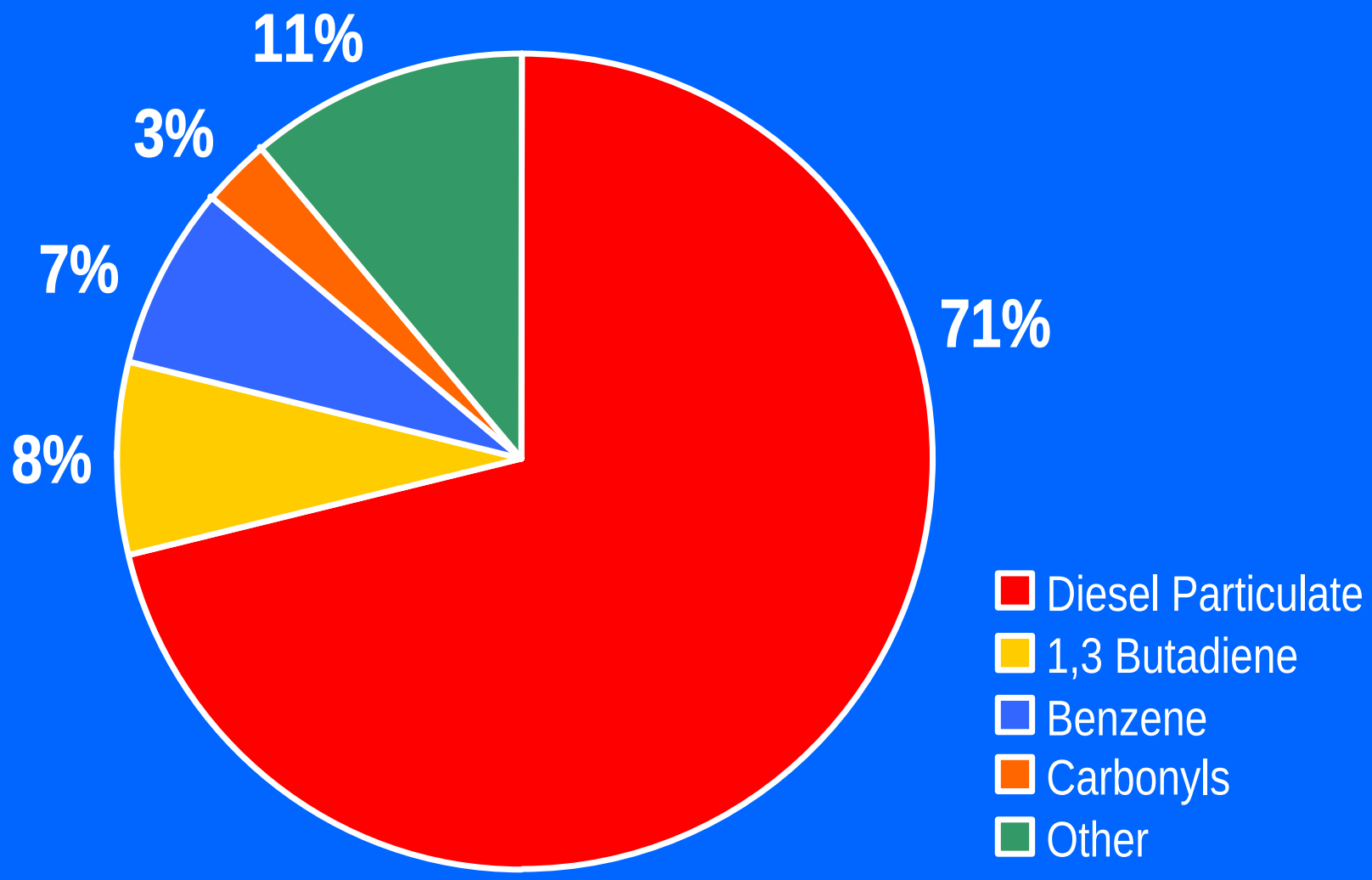
(Stationary Sources Only)



Cancer Risks
(Including Diesel)

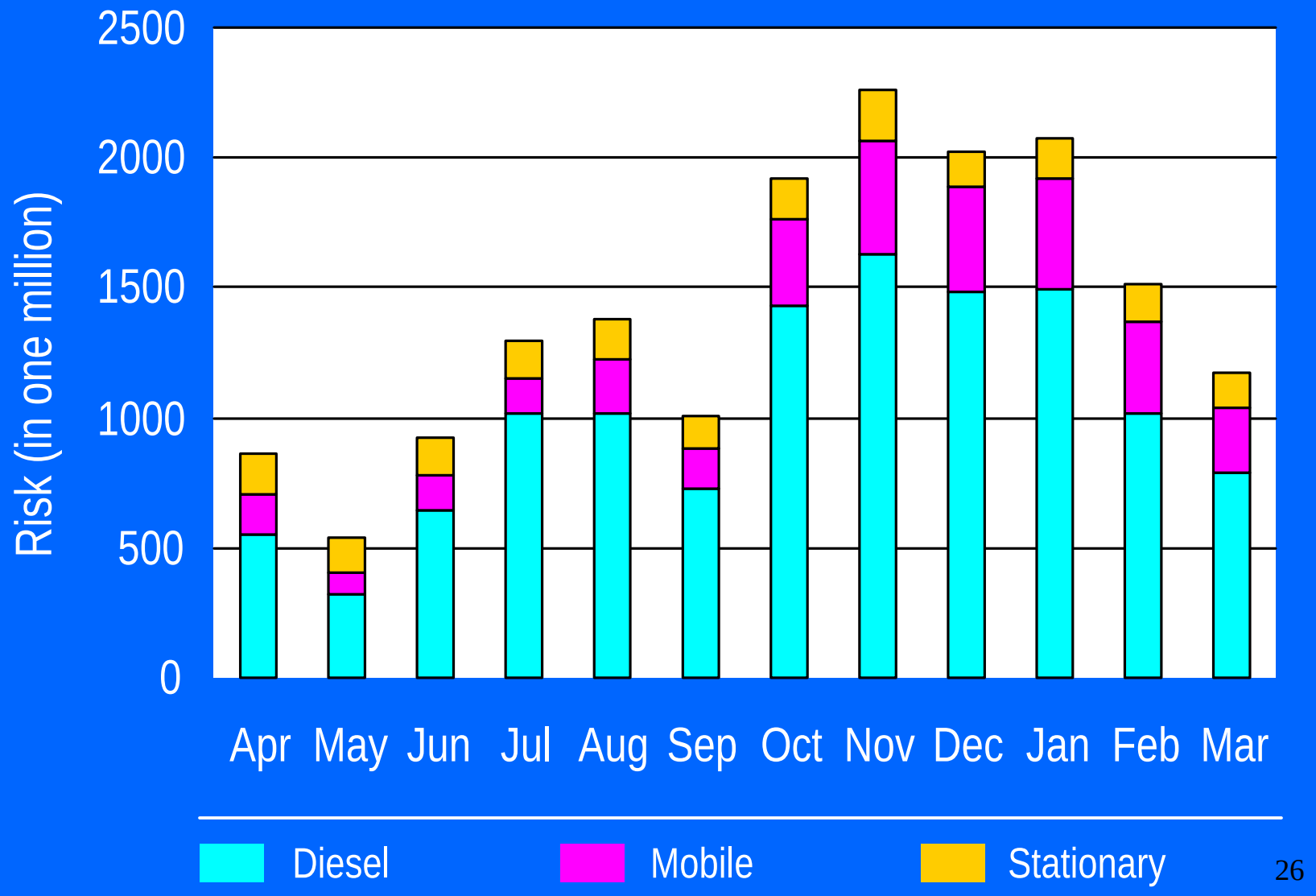


Basinwide Cancer Risks* ~ 1400 in a Million



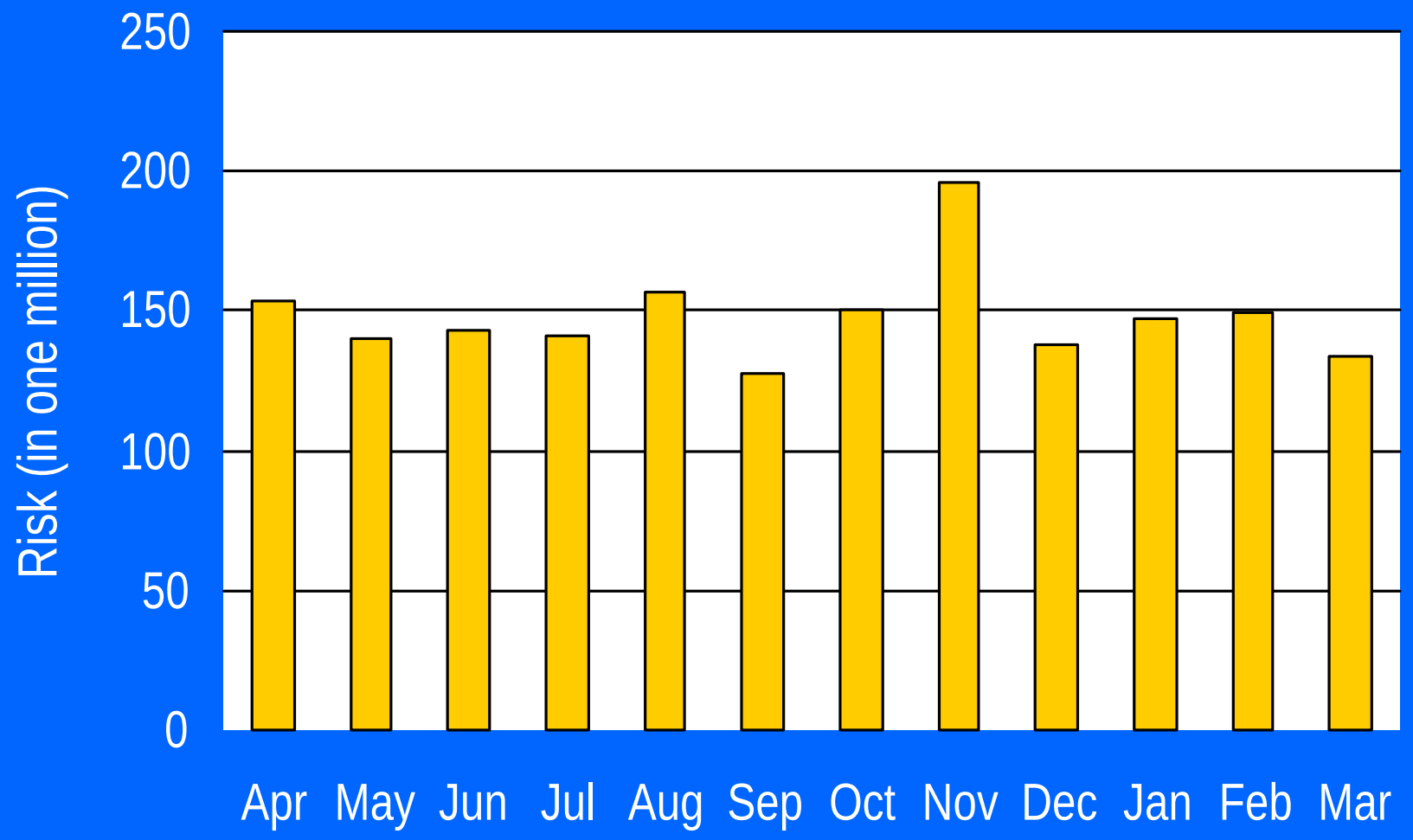
*Based on average concentrations at 8 sites.

Seasonal Risk Levels



Seasonal Risk Levels

(Stationary Sources Only)



Components of MATES II Emissions Inventory

- On-Road Mobile
- Area & Off-Road Mobile
- Major Point Sources (+ 2588)

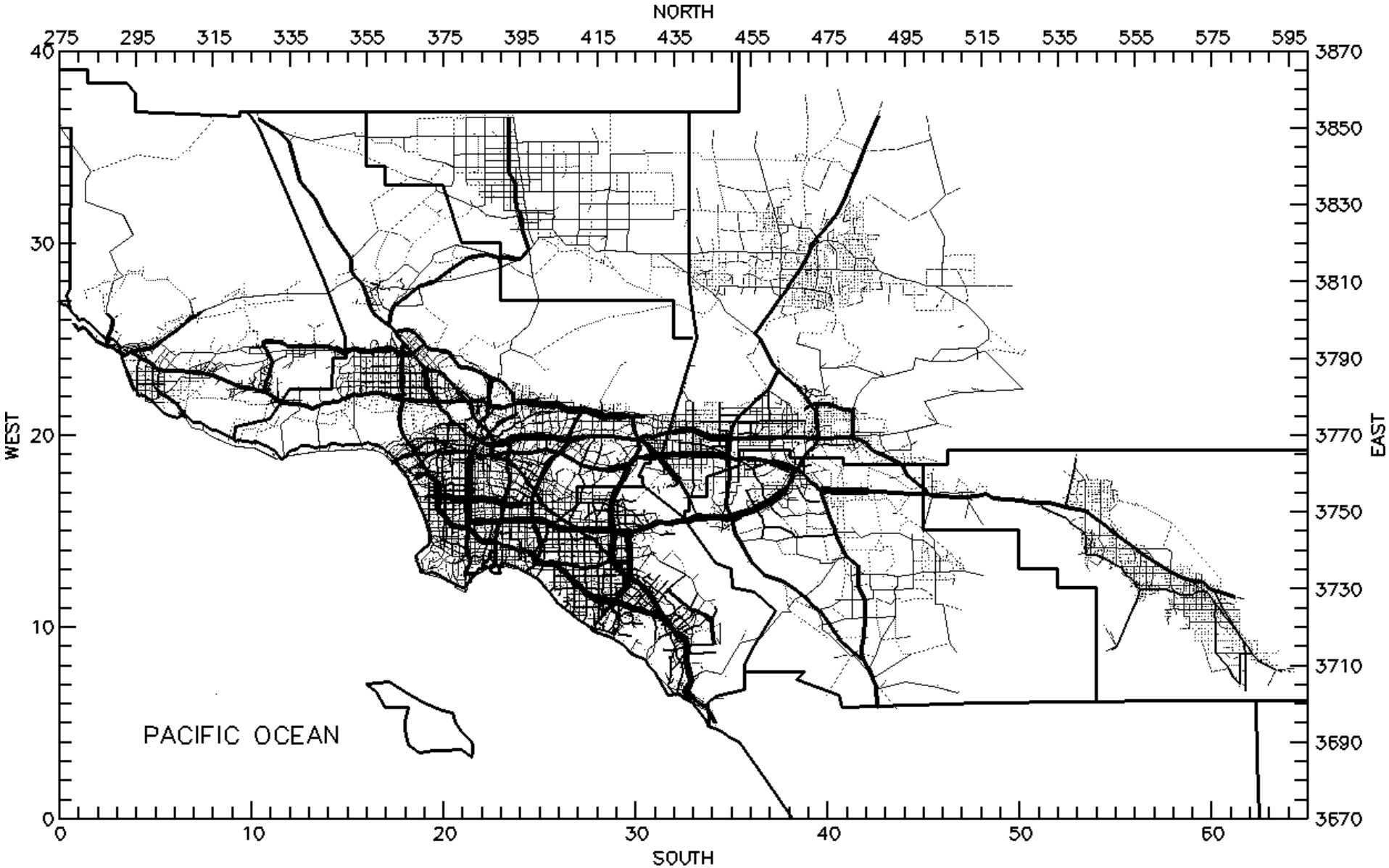
On-Road Mobile Sources

- EMFAC 7G — Emission Factors
- RTP — Link-Based Traffic Volume & Speed

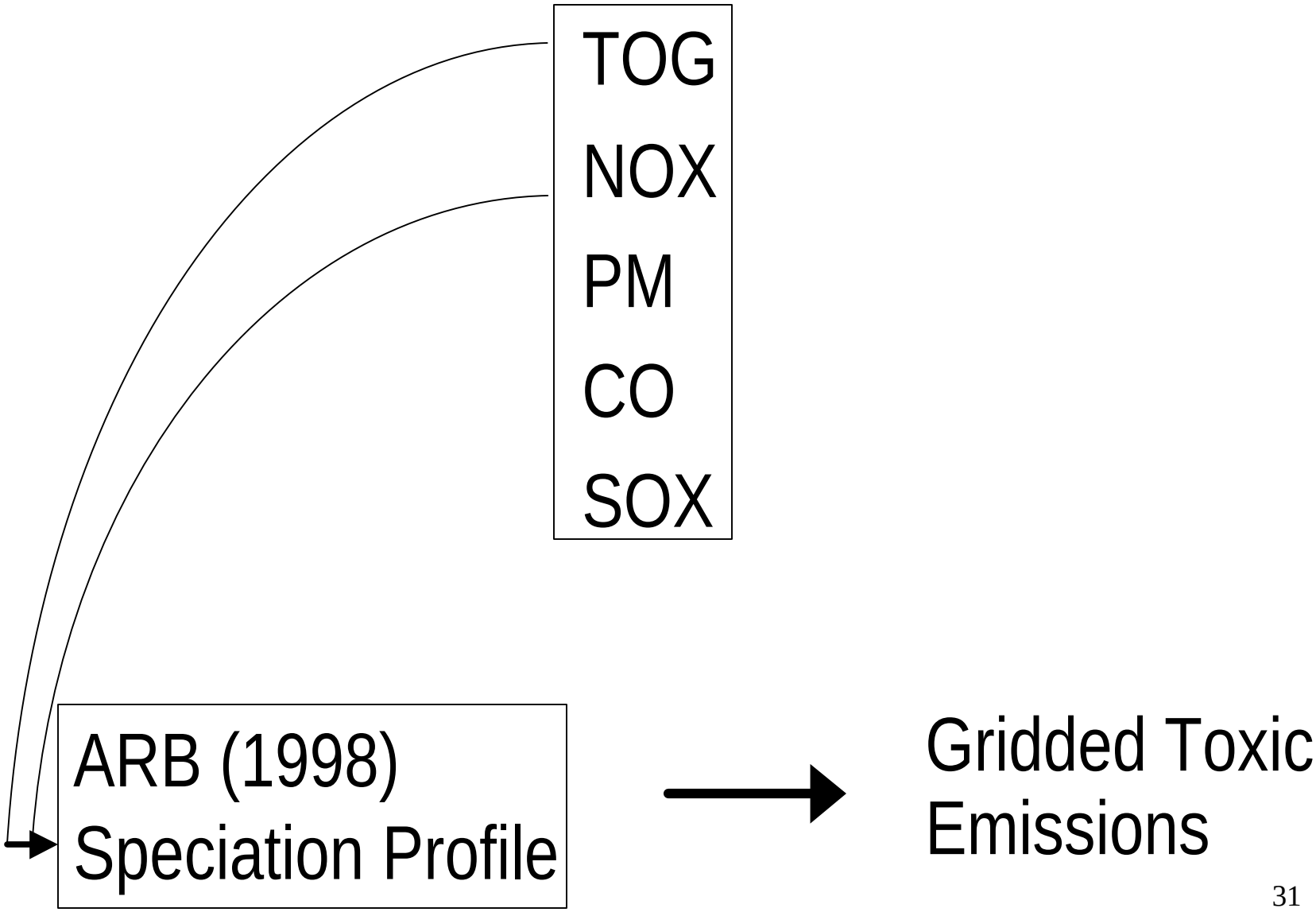
Direct Travel Impact Model (DTIM)

Hourly Gridded Emissions

Roadway Network Used in Transportation Modeling



Output of DTIM:



Stationary Sources

Annual Emissions Reporting (AER)
[3000 Facilities]

- Includes Toxic Emission Data
- Speciated VOC & PM
- Grew & Controlled 1993 to 1998
- Large Facilities Were Reviewed

Toxic Hot Spot (AB2588)
[1800 Facilities]

- Surveyed & Up-Dated 150
- Grew & Controlled the rest

Spatial Allocation

- According to Facility Location

Temporal Allocation

- According to AQMD Emission Files

- **Grew & Controlled 1993-1998**
- **Temporal Variation:**

  Diurnal Profiles of Each Type of Emissions
- **Speciation Profiles Used When Needed**

Area & Off-Road

- Dry Cleaners
- Gasoline Stations
- Auto Body Shops
- Chrome Platers

Distribution Surrogates:

- Population
- Housing
- Employment

Dry Cleaners

- Per County Sales from California Import & Domestic - Production Records
- Distributed by Share of Permitted Emissions
- Allocated to Specific Locations

1300 Facilities

6.6 Tons/Day Perc

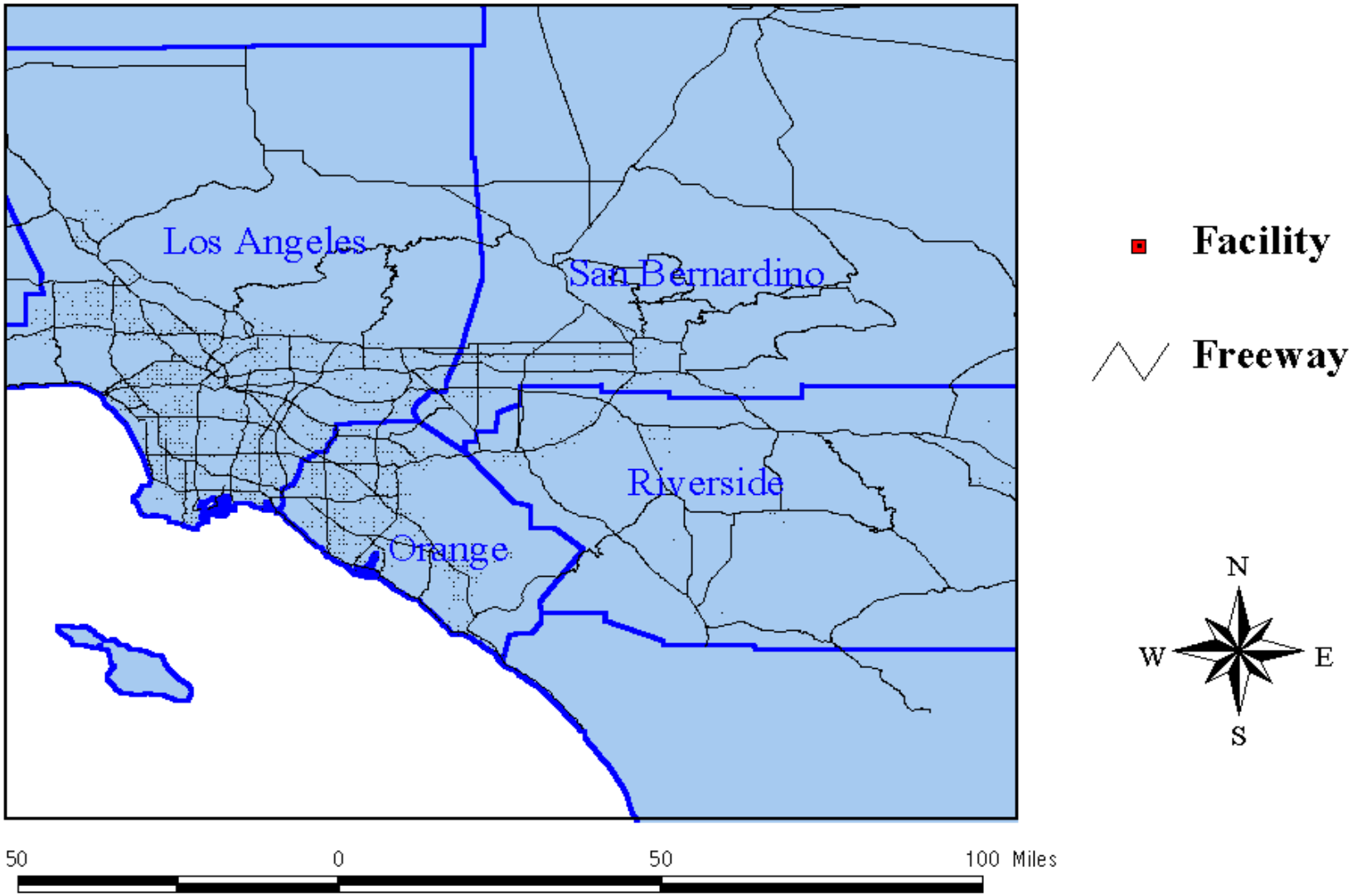
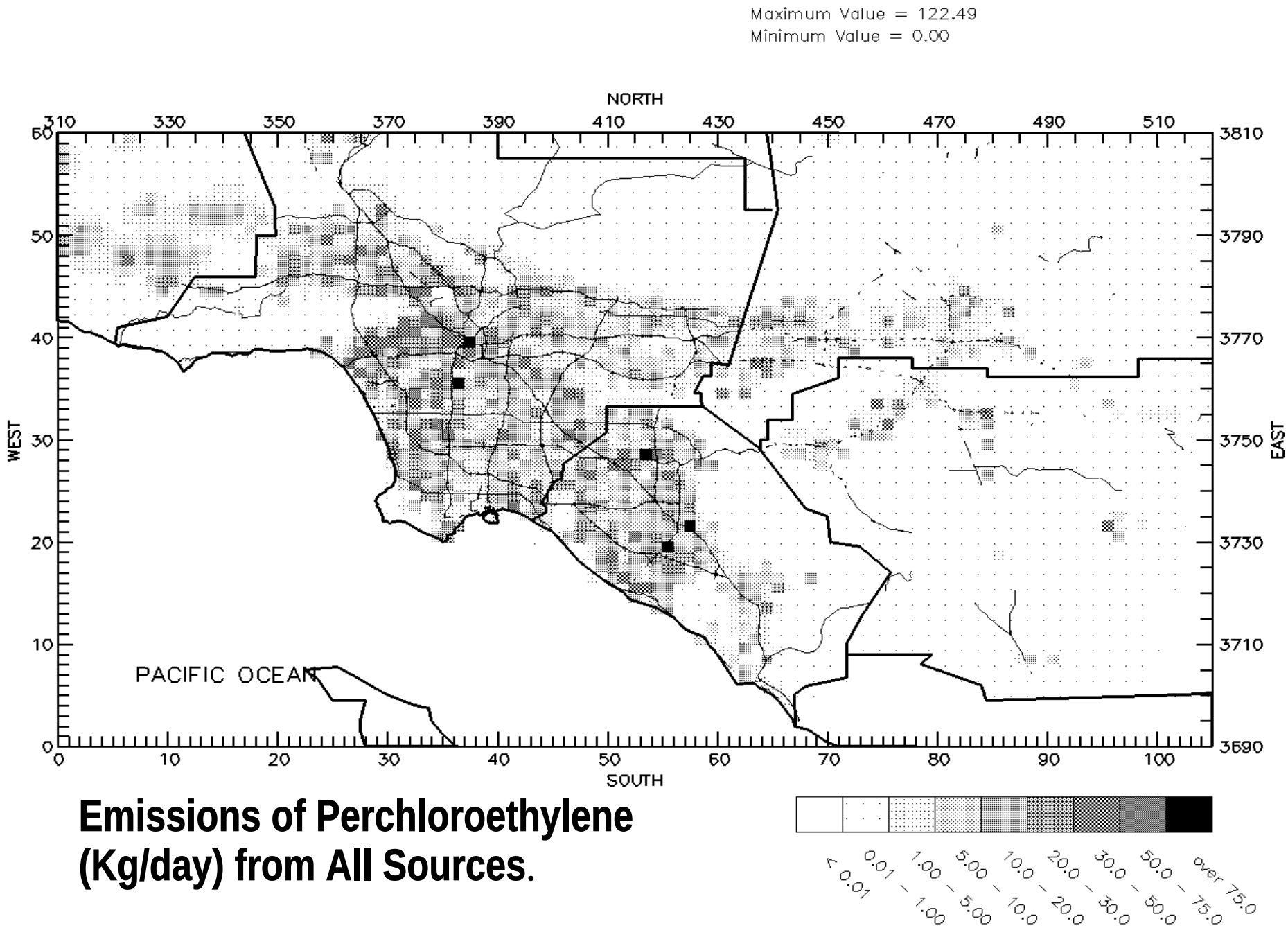


Figure 4.3 Spatial Distribution of Dry Cleaners



Emissions of Perchloroethylene (Kg/day) from All Sources.

Retail Gasoline Stations

- Per County Shipping & Taxable Records
- Countywide Emissions Apportioned by Permitted Amount
- Allocated to Specific Location

  2970 Facilities

  18 Tons/Day

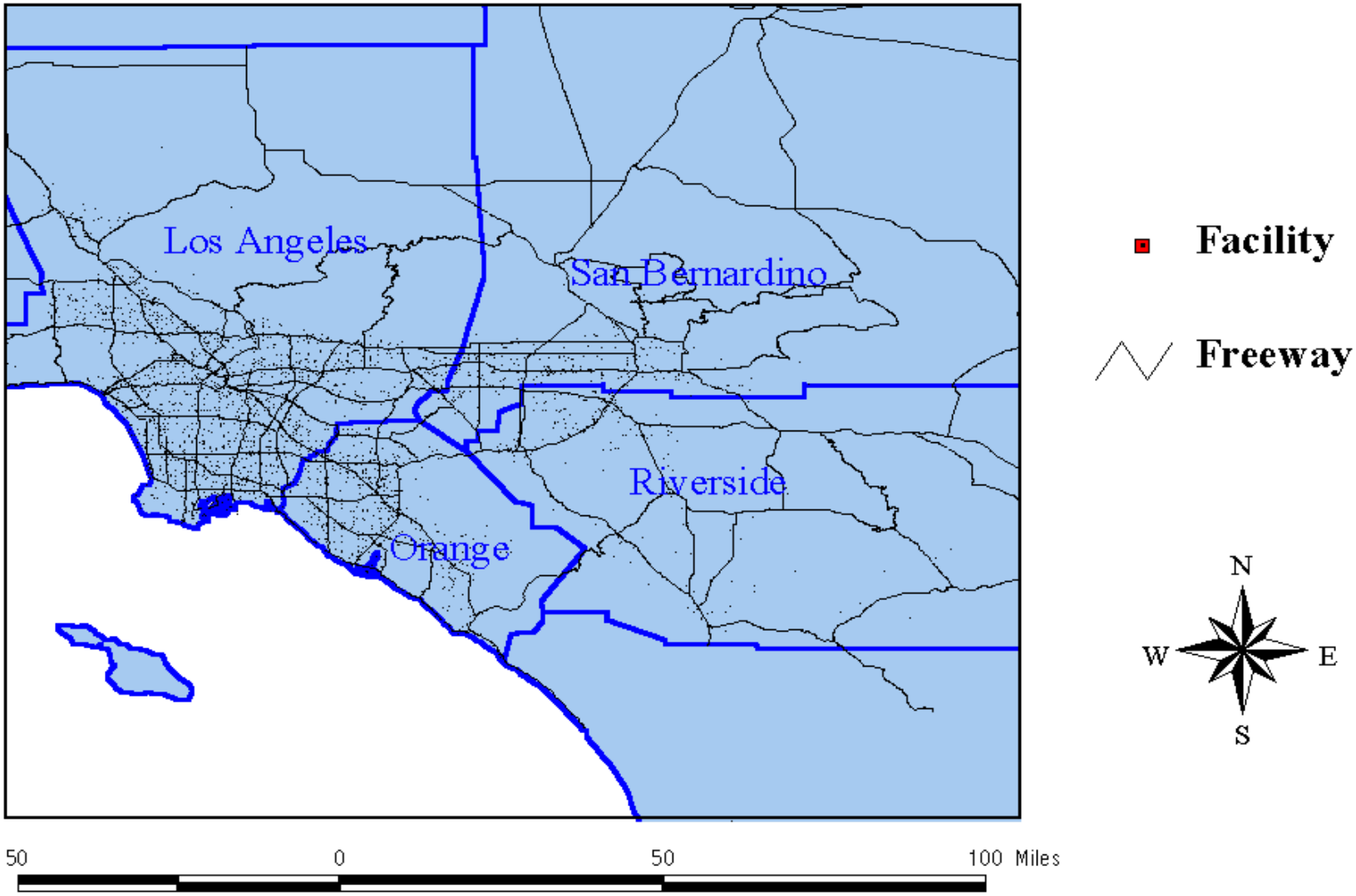
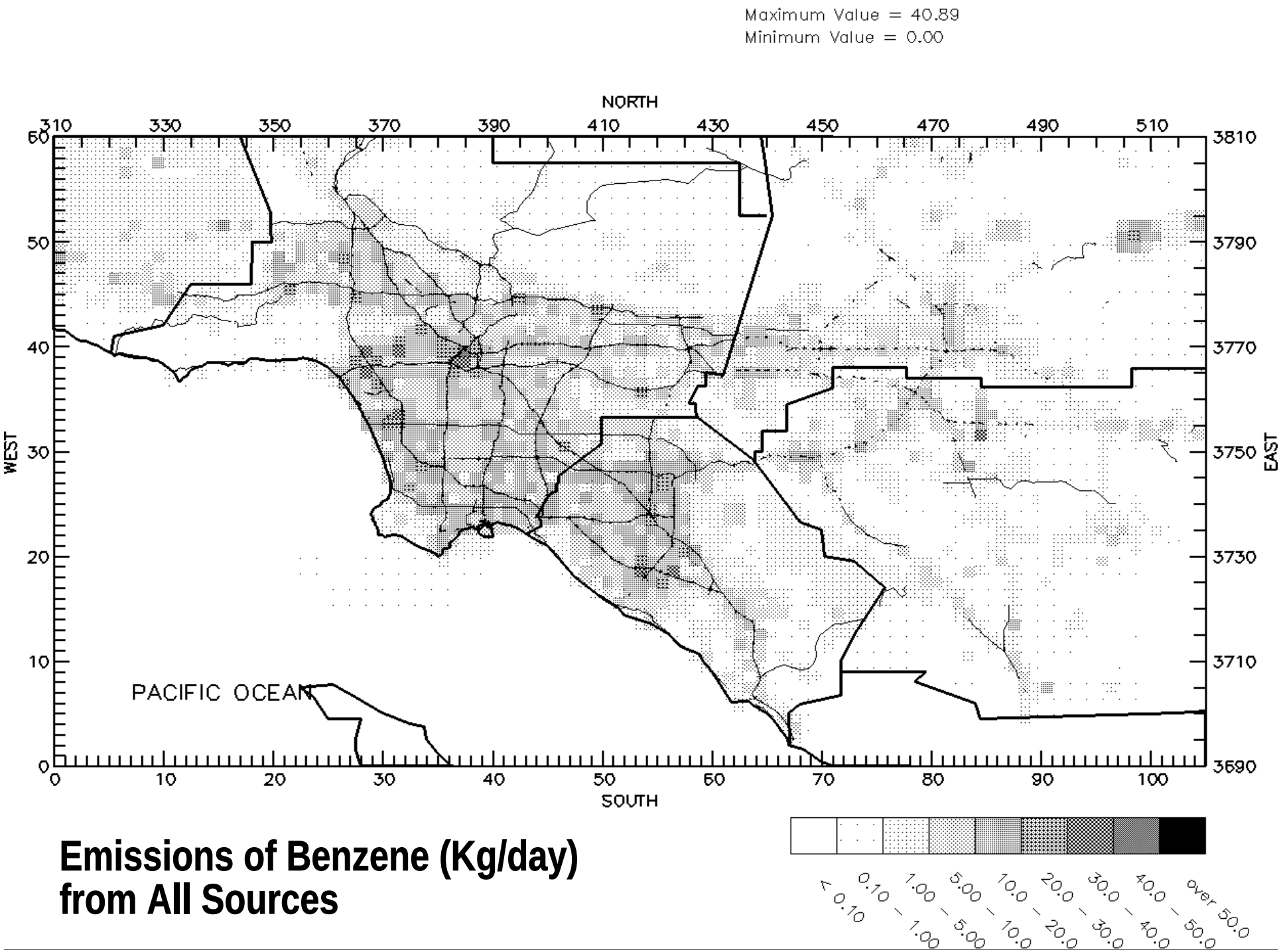


Figure 4.4 Spatial Distribution of Gas Stations



Emissions of Benzene (Kg/day) from All Sources

Hexavalent Chromium Plating

- Toxic Hot Spot Program

  ⇩

  Larger Facility Info. [74]

  ⇩

  Augmented with Permit Info.

  ⇩

  [87] Small Facilities
  - Hard Chrome Plating
  - Decorative Chrome Plating
  - Chrome Anodizing
  - Spray Booths

  +

  [84] Aerospace Facilities

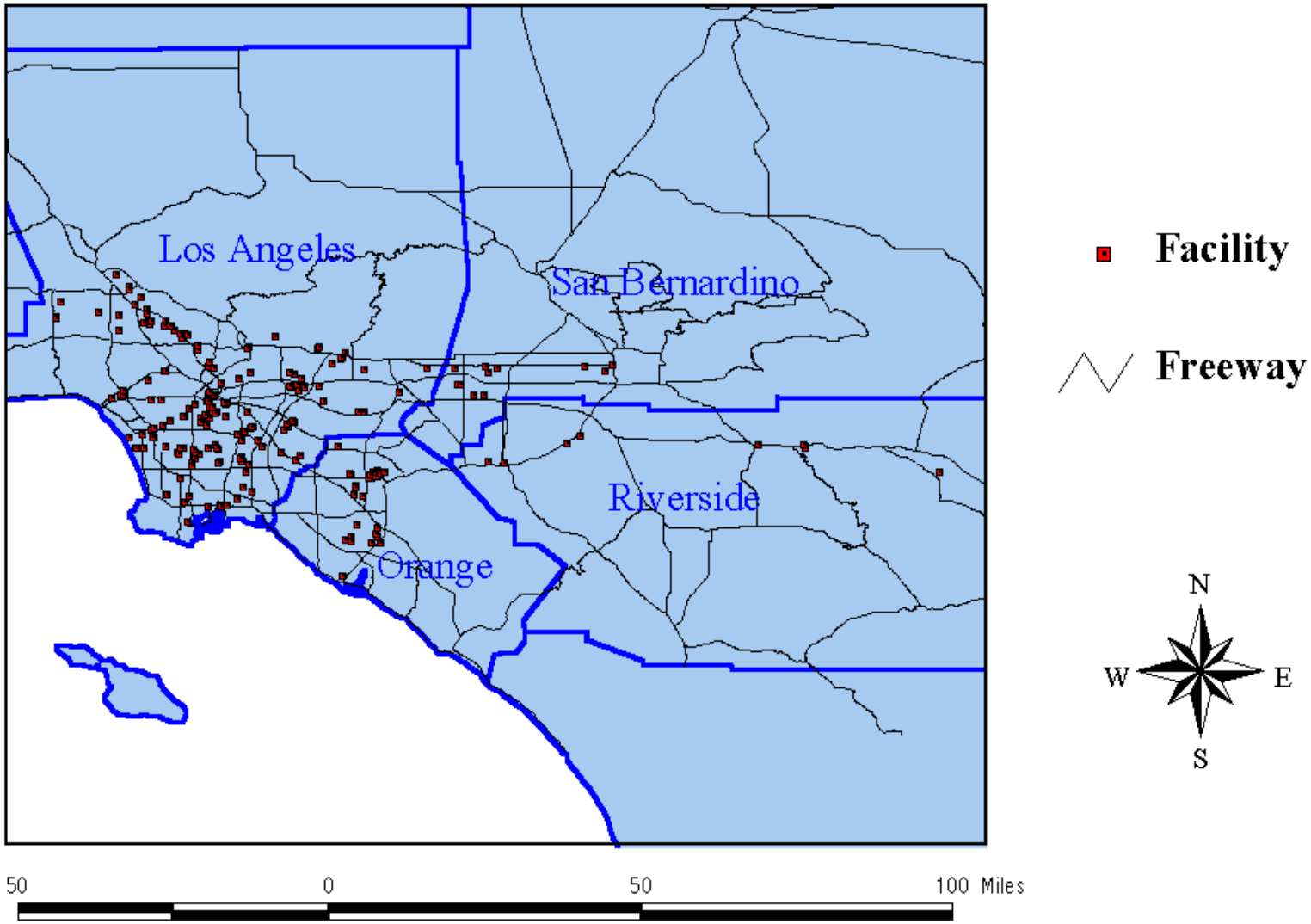


Figure 4.5 Spatial Distribution of Chrome Plating Facilities

Table 1. Annual average day emissions for the south coast air basin

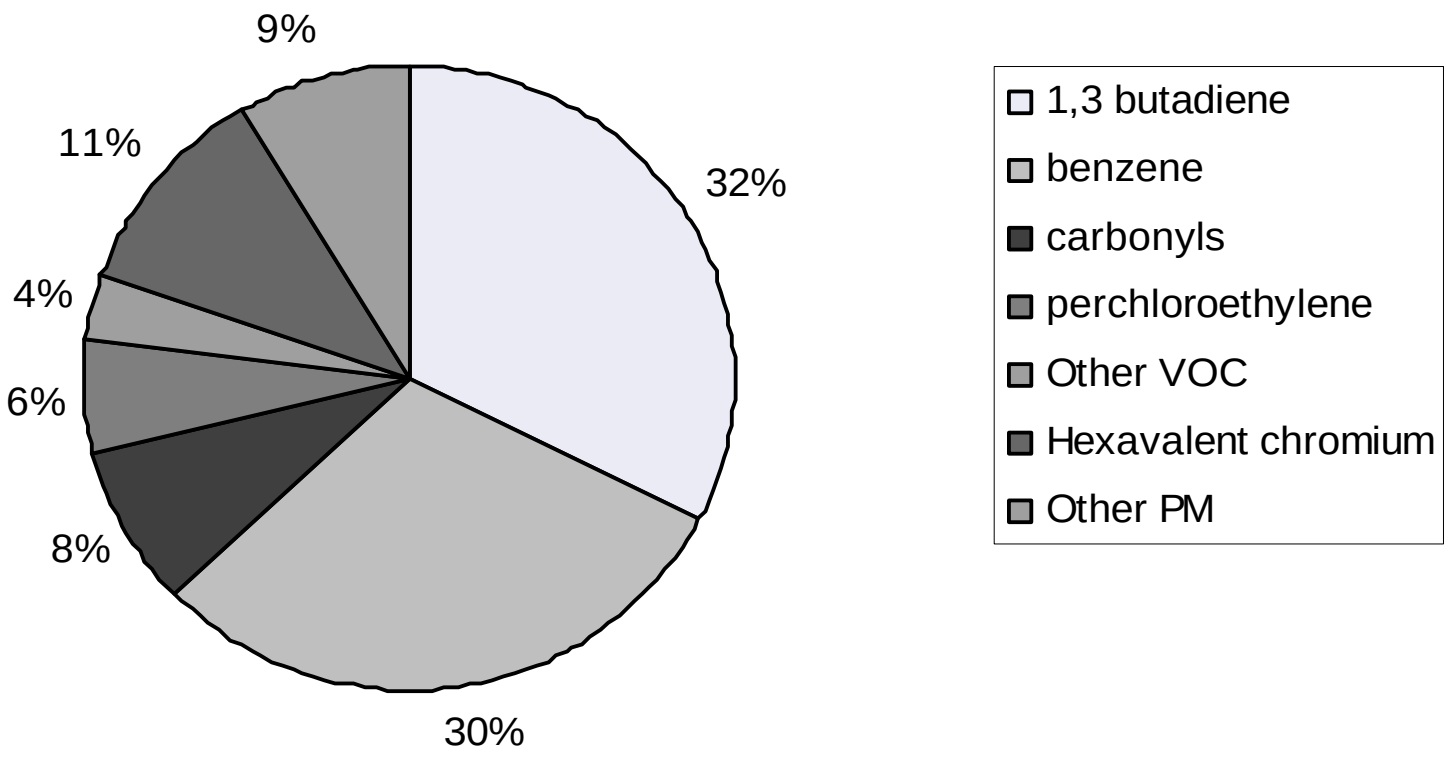
Pollutant	Emissions (lbs/day)					
	On-Road	**Off-Road**	**Point**	**AB 2588**	**Area**	**Total**
Acetaldehyde*	5485.8	5770.3	33.9	57.1	189.1	11536.2
Acetone**	4945.8	4824.7	3543.5	531.4	23447.4	37292.8
Benzene	21945.5	6533.4	217.7	266.8	2495.4	31458.8
Butadiene [1,3]	4033.8	1566.1	6.7	2.0	151.3	5759.9
Carbon tetrachloride	0.0	0.0	8.8	1.8	0.0	10.6
Chloroform	0.0	0.0	0.0	35.5	0.0	35.5
Dichloroethane [1,1]	0.0	0.0	0.0	0.1	0.0	0.1
Dioxane [1,4]	0.0	0.0	0.0	105.0	0.0	105.0
Ethylene dibromide	0.0	0.0	0.0	0.2	0.0	0.2
Ethylene dichloride	0.0	0.0	4.9	17.6	0.0	22.5
Ethylene oxide	0.0	0.0	58.1	12.3	454.1	524.4
Formaldehyde*	16664.9	16499.3	521.6	674.7	1107.5	35468.0
Methyl ethyl ketone*	905.1	906.9	3240.2	385.9	14535.4	19973.5
Methylene chloride	0.0	0.0	1378.6	1673.6	9421.7	12473.9
MTBE	58428.9	2679.2	40.5	434.4	5473.7	67056.7
p-Dichlorobenzene	0.0	0.0	0.0	4.5	3735.6	3740.1
Perchloroethylene	0.0	0.0	4622.0	2249.1	22813.1	29684.2
Propylene oxide	0.0	0.0	0.0	22.3	0.0	22.3
Styrene	1114.8	287.1	447.0	3836.7	21.4	5707.0
Toluene	63187.6	11085.9	5689.6	3682.4	52246.7	135892.2
Trichloroethylene	0.0	0.0	1.1	58.0	2550.3	2609.3
Vinyl chloride	0.0	0.0	0.0	4.3	0.0	4.3
Arsenic	0.1	0.3	2.7	0.7	21.4	25.2
Cadmium	1.6	1.5	0.5	0.7	27.5	31.8
Chromium	2.4	2.3	3.9	2.2	302.2	313.0
Diesel particulate	23906.3	22386.3	0.0	5.4	815.3	47113.4
Elemental carbon***	27572.1	6690.3	702.8	0.0	16770.5	51735.7
Hexavalent chromium	0.4	0.4	0.3	1.0	0.1	2.2
Lead	0.7	0.9	1.9	24.5	1016.3	1044.3
Nickel	2.5	2.2	2.9	21.6	85.6	114.9
Organic carbon	16426.2	15381.8	0.0	0.0	108612.1	140420.2
Selenium	0.1	0.1	3.0	5.7	2.6	11.6
Silicon**	68.6	67.6	167.2	0.0	248614.0	248917.4

* Primarily emitted emissions. These materials are also formed in the atmosphere as a result of photochemical reactions.

** Acetone and silicon are not toxic compounds. Their emissions are included here because they were measured in the sampling program and were subsequently modeled for the purpose of model evaluation.

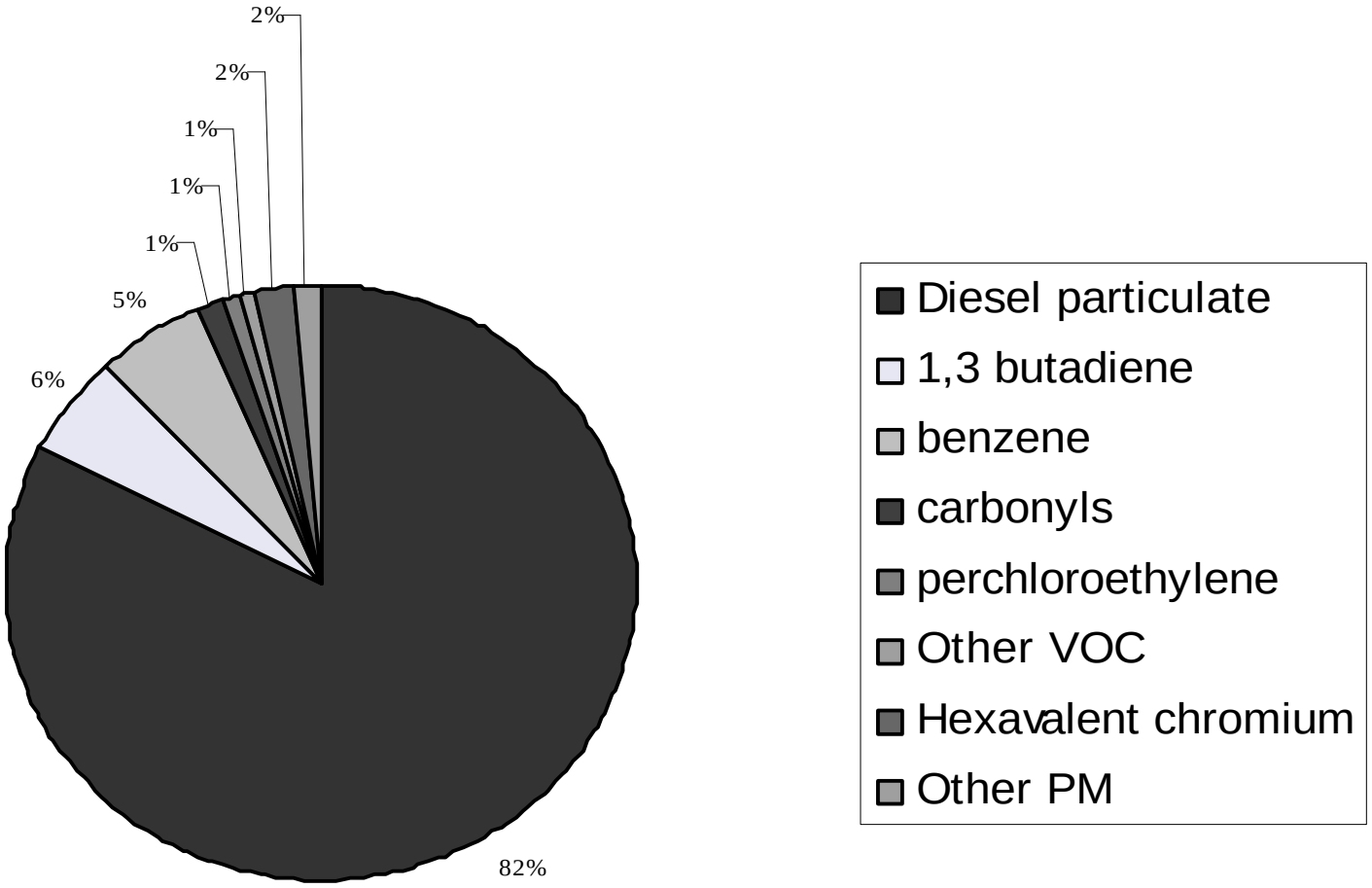
*** Includes elemental carbon from all sources (including diesel particulate).

Excluding Diesel Particulate Toxicity



Species Apportionment Using Toxicity-Weighted Emissions.

Including Diesel Particulate Toxicity



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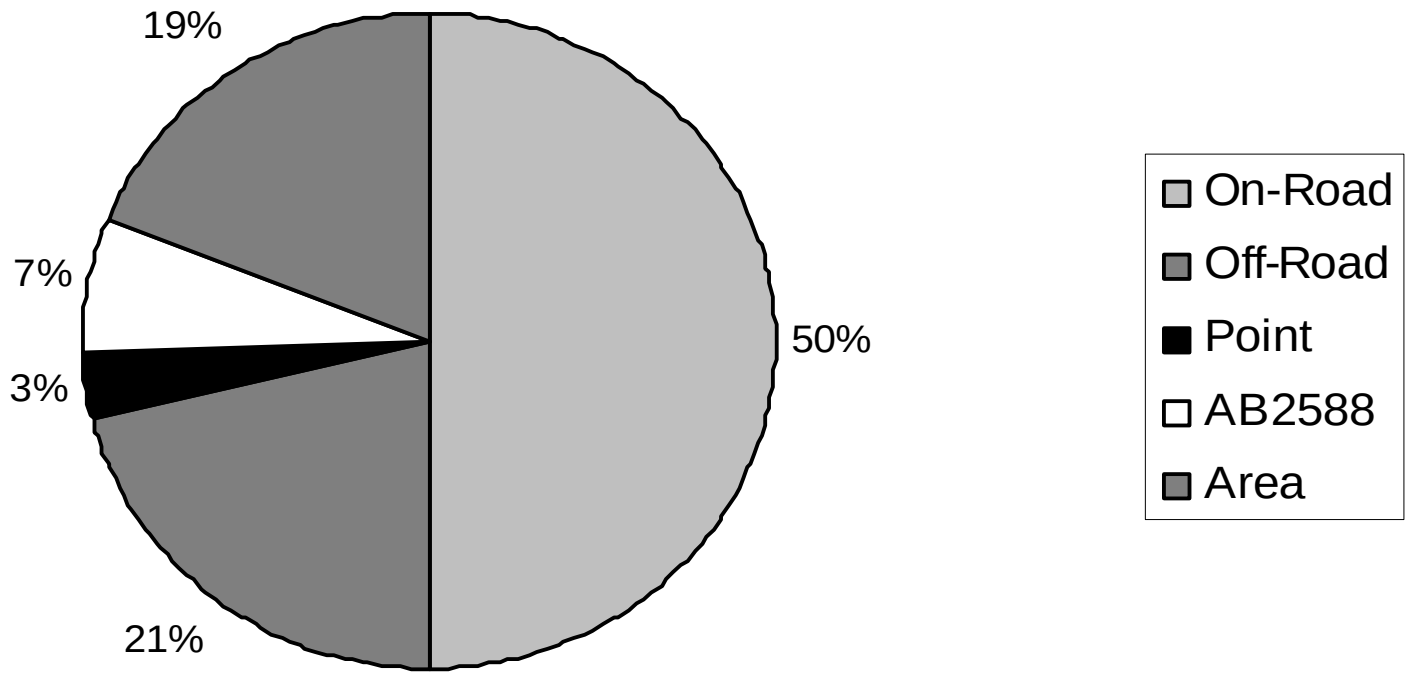
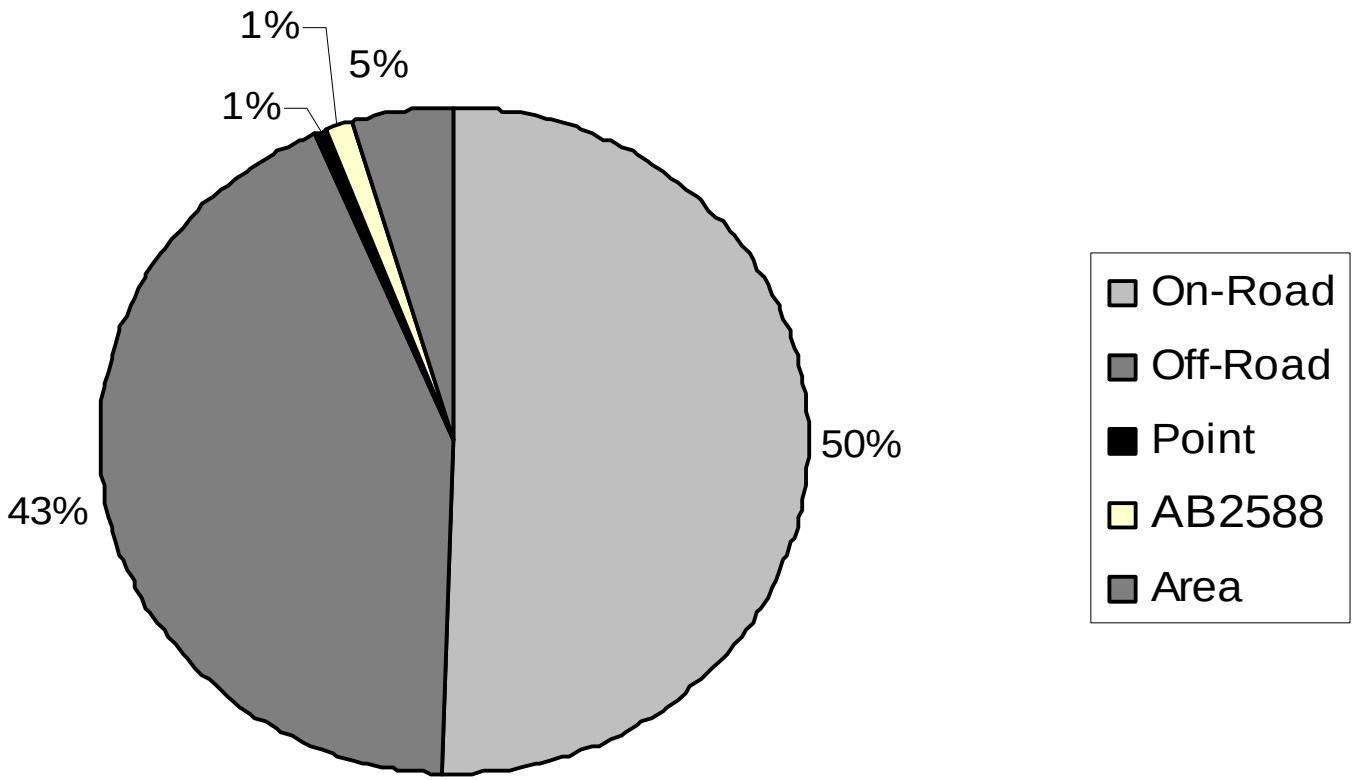


Source Apportionment Using Toxicity-Weighted Emissions.

Including Diesel Particulate Toxicity



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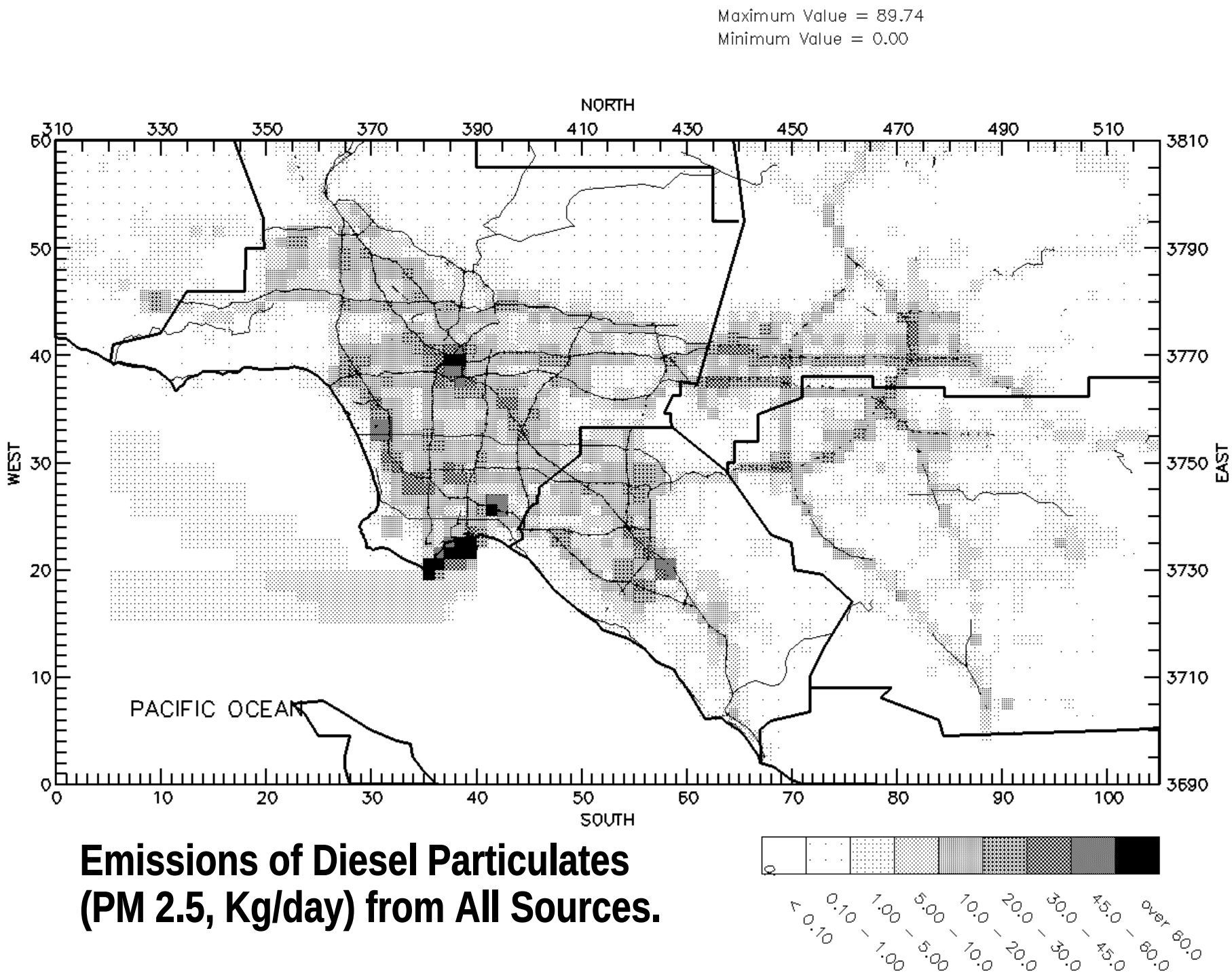


Emissions of Diesel Particulates (PM 2.5, Kg/day) from All Sources.

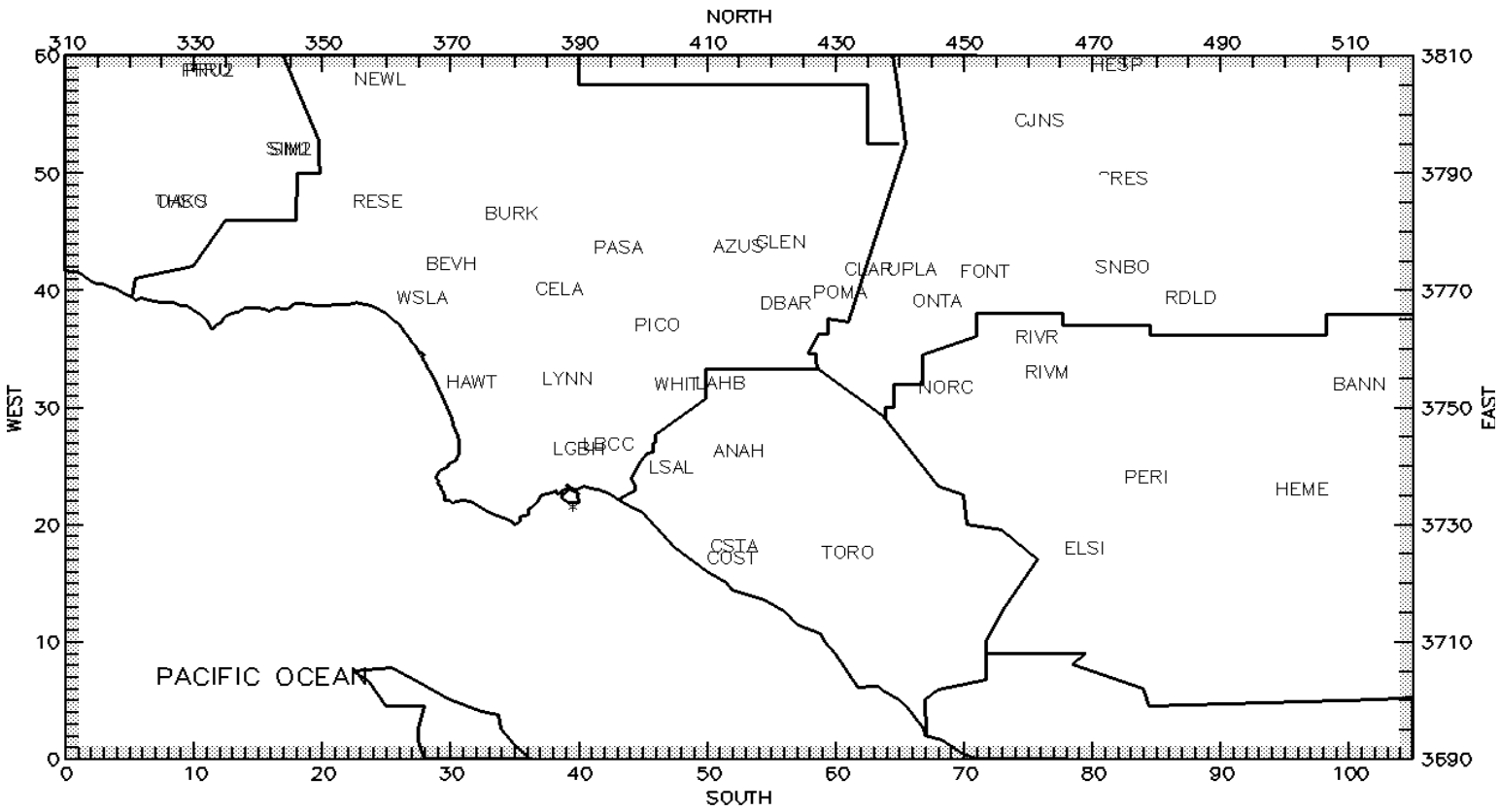
Annual Average Day Emissions South Coast Air Basin

Pollutant	On-Road (lbs/day)	Off-Road (lbs/day)	Stationary (lbs/day)
Diesel PM	23,900	22,400	800
Benzene	22,000	6,500	3,000
1,3 Butadiene	4,000	1,600	200

Modeling System

- Meteorological Modeling
  - CALMET
- Dispersion Modeling
  - UAM-TOX
- Risk Assessment
  - Postprocessing of UAM-TOX concentration files

Modeling Domain



Pollutants Modeled

Pollutant	BC (?g/m^3)	Pollutant	BC (?g/m^3)
Benzene	0.64	1,3 Butadiene	0.008
p-Dichlorobenzene	0.008	Methylene chloride	0.139
Chloroform	0.074	Perchloroethylene	0.237
Trichloroethylene	0.065	Carbon tetrachloride	0.777
Ethylene dibromide	0.008	Ethylene dichloride	0.102
1,4 Dioxane	0.008	Ethylene oxide	0.008
Formaldehyde	0.540	Acetaldehyde	0.008
Diesel PM	0.450	Arsenic	4.1E-5
Cr^{+6}, Cd, Ni	8.2E-14	Lead	1.6E-13

Meteorological Modeling - CALMET

- CALMET consists of
  - diagnostic wind field module
  - micrometeorological module for the boundary layer
- Two step approach
  - Initial guess field adjusted for kinematic effects
  - Objective introduction of the observed winds
- Required surface data (T, p, and wind)
  - 140 surface monitoring stations

Meteorological Modeling - CALMET (continued)

- Required upper air data (wind, T, p, and elevation)
  - 11 sites with radar wind profilers and radio acoustic sounding systems
- CALMET derived information
  - hourly 3-D fields of wind and T
  - hourly 2-D fields of mixing height, u*, convective velocity scale, stability class, Monin-Obukov length

UAM-TOX Simulations

- 2 km by 2 km grid resolution
- 5 vertical layers; 2 layers below and 3 layers above DIFFBREAK
- 2000 m domain height
- Enhanced surface layer influence to aloft layers
- Simulation for a full year

Model Performance - Gases

Pollutant	Pred. (? g/m^3)	Obs. (? g/m^3)	Ratio P/O
Benzene	3.1	3.5	0.89
1,3 Butadiene	0.34	0.79	0.43
Formaldehyde	5.5	4.8	1.14
Acetaldehyde	5.2	3.2	1.64
Methylene chloride	1.1	2.7	0.41
Perchloroethylene	2.5	2.0	1.26
Trichloroethylene	0.26	0.43	0.60

Model Performance - Particulates

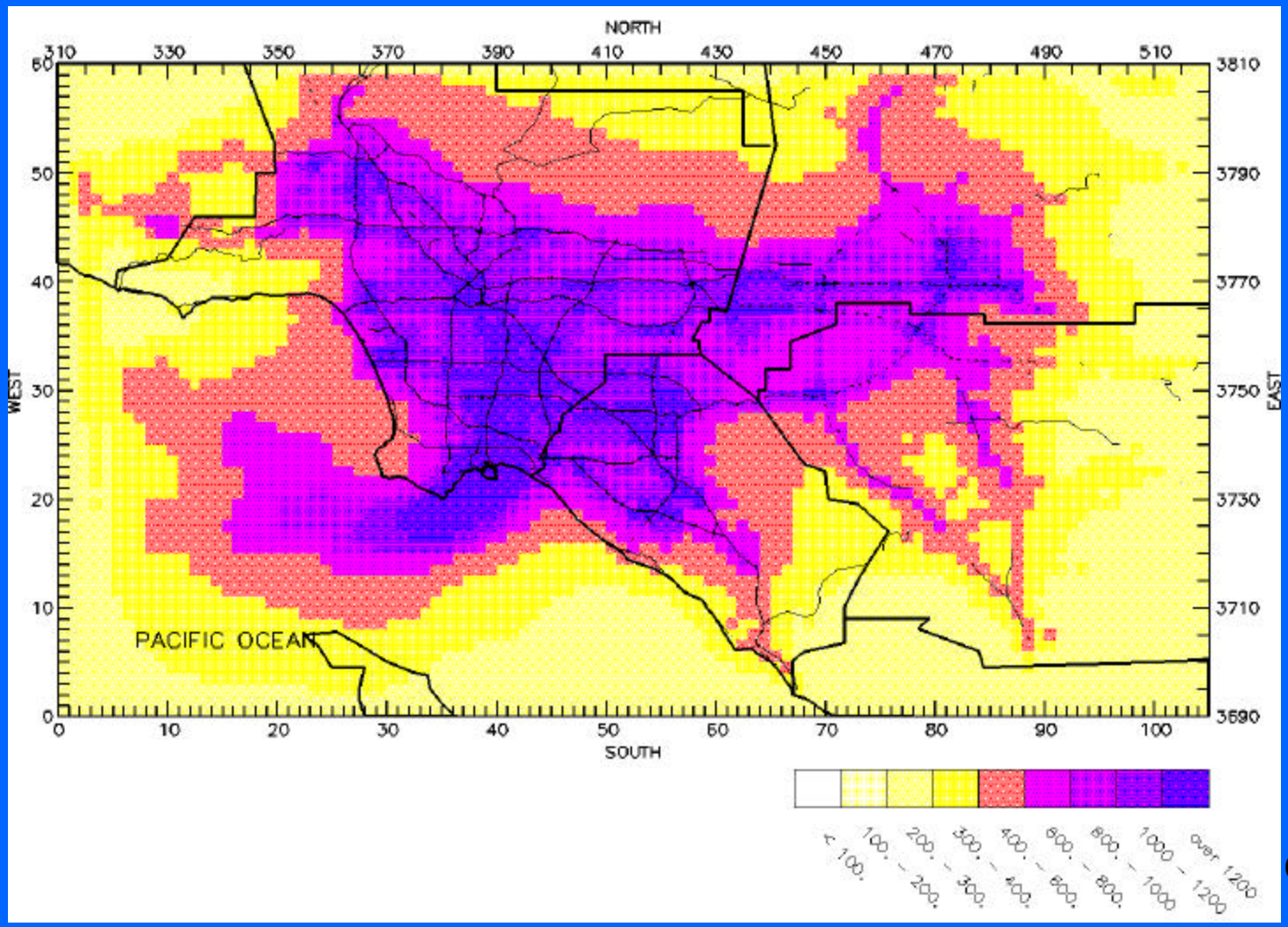
Pollutant	Pred. (?g/m^3)	Obs. (?g/m^3)	Ratio P/O
Elemental carbon	3.4	3.4	1.01
Organic carbon	5.9	6.4	0.92
Hex. Chromium	0.00024	0.00018	1.33
Nickel	0.0078	0.0087	0.89
Lead (point sources)	0.0029	0.019	0.15
Lead (area sources)	0.048	0.019	2.53

Methods and Assumptions for Calculating Cancer Risk

- 70 year lifetime exposure
- Only considering inhalation risk
- Used OEHHA unit risk factors (URF)
  - www.arb.ca.gov/toxics/healthval/healthval.htm
- Units of URF are (? g/m^3)$^{-1}$
  - Benzene: 2.9x10^{-5} (? g/m^3)$^{-1}$
  - Diesel PM: 3.0x10^{-4} (? g/m^3)$^{-1}$
  - Hexavalent chromium: 1.5x10^{-1} (? g/m^3)$^{-1}$
- Cancer risks are additive

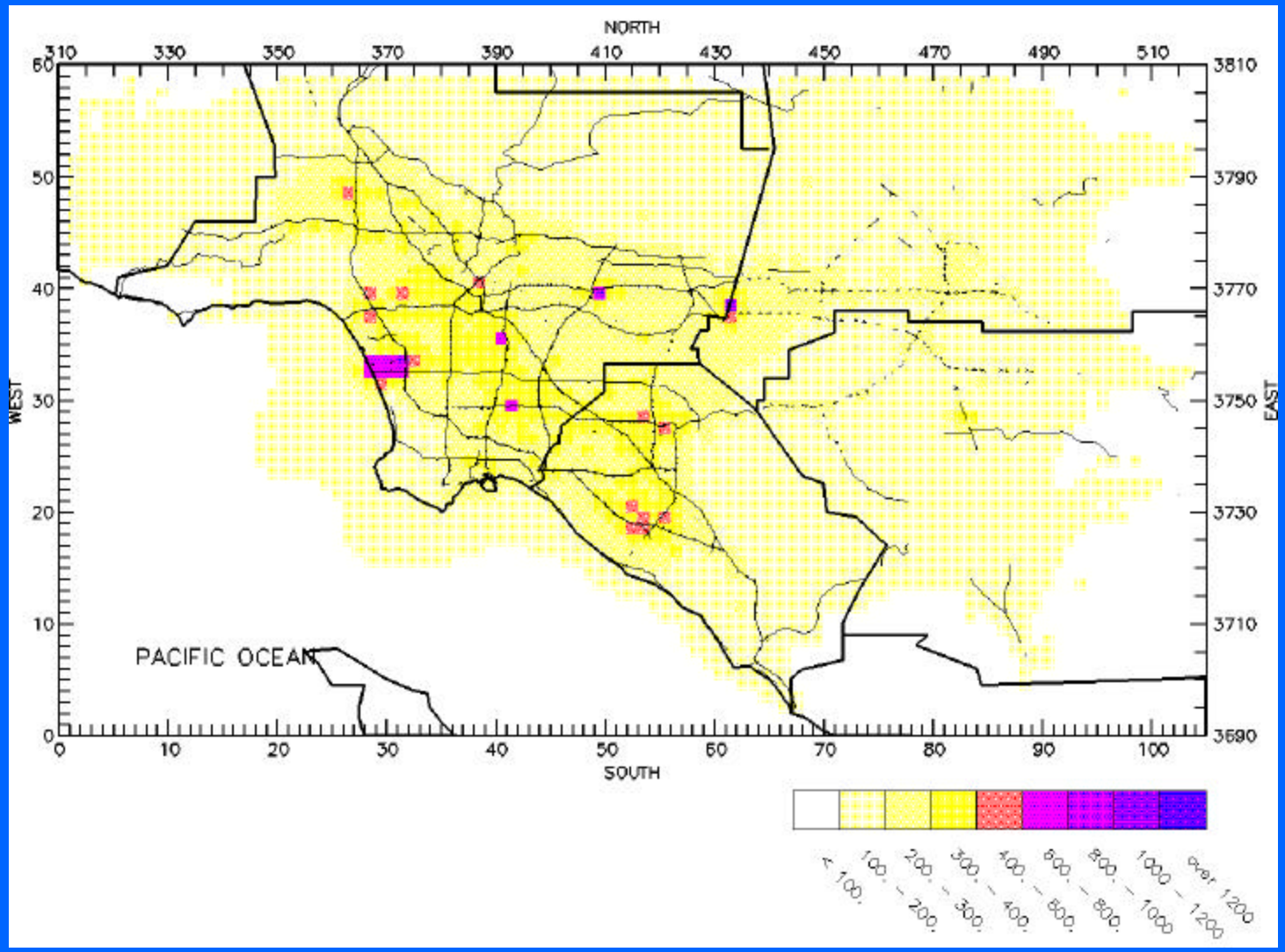
Model Estimated Risk

From All Emission Sources

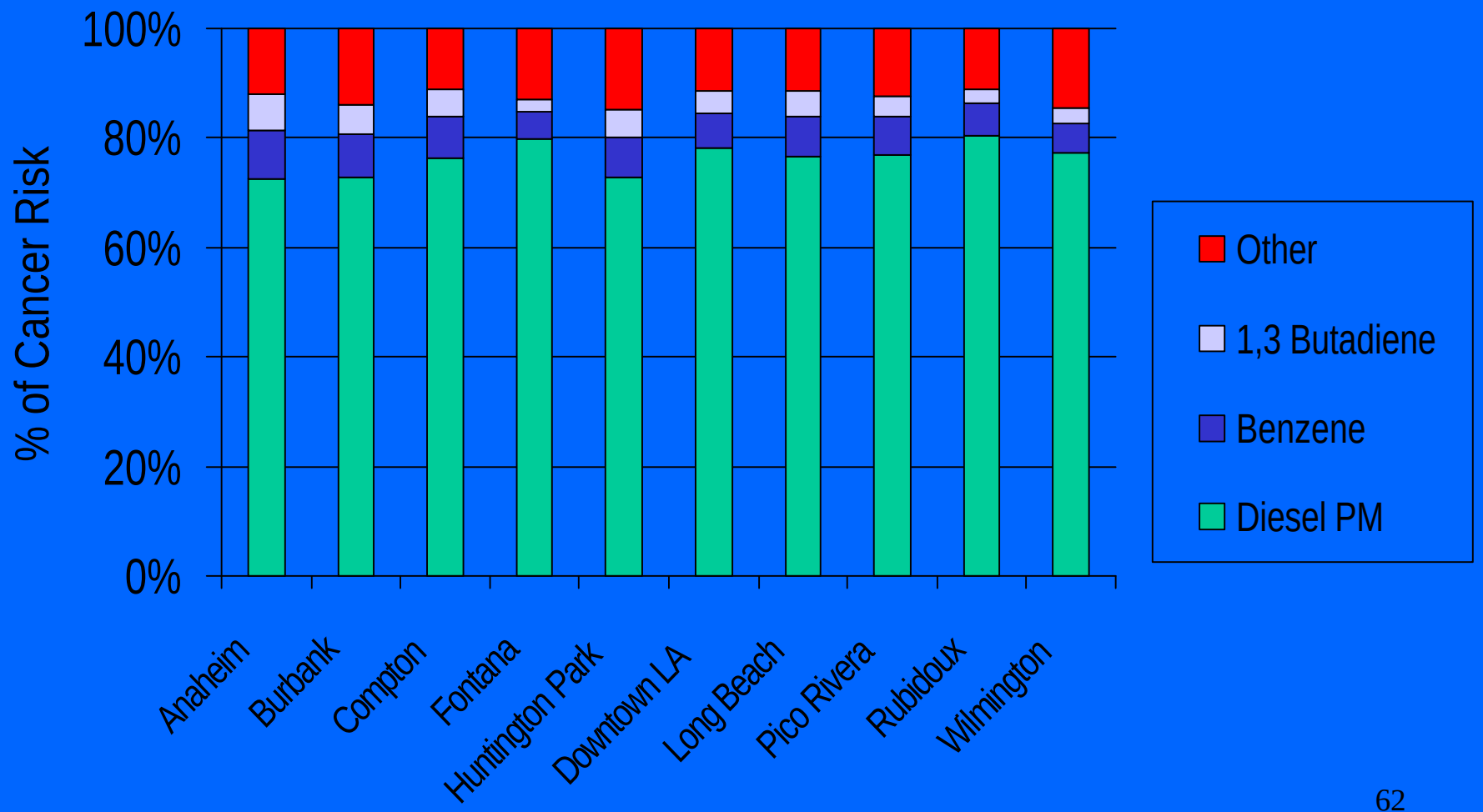


Model Estimated Risk

Excluding Diesel Sources



Species Apportionment



Summary & Conclusions

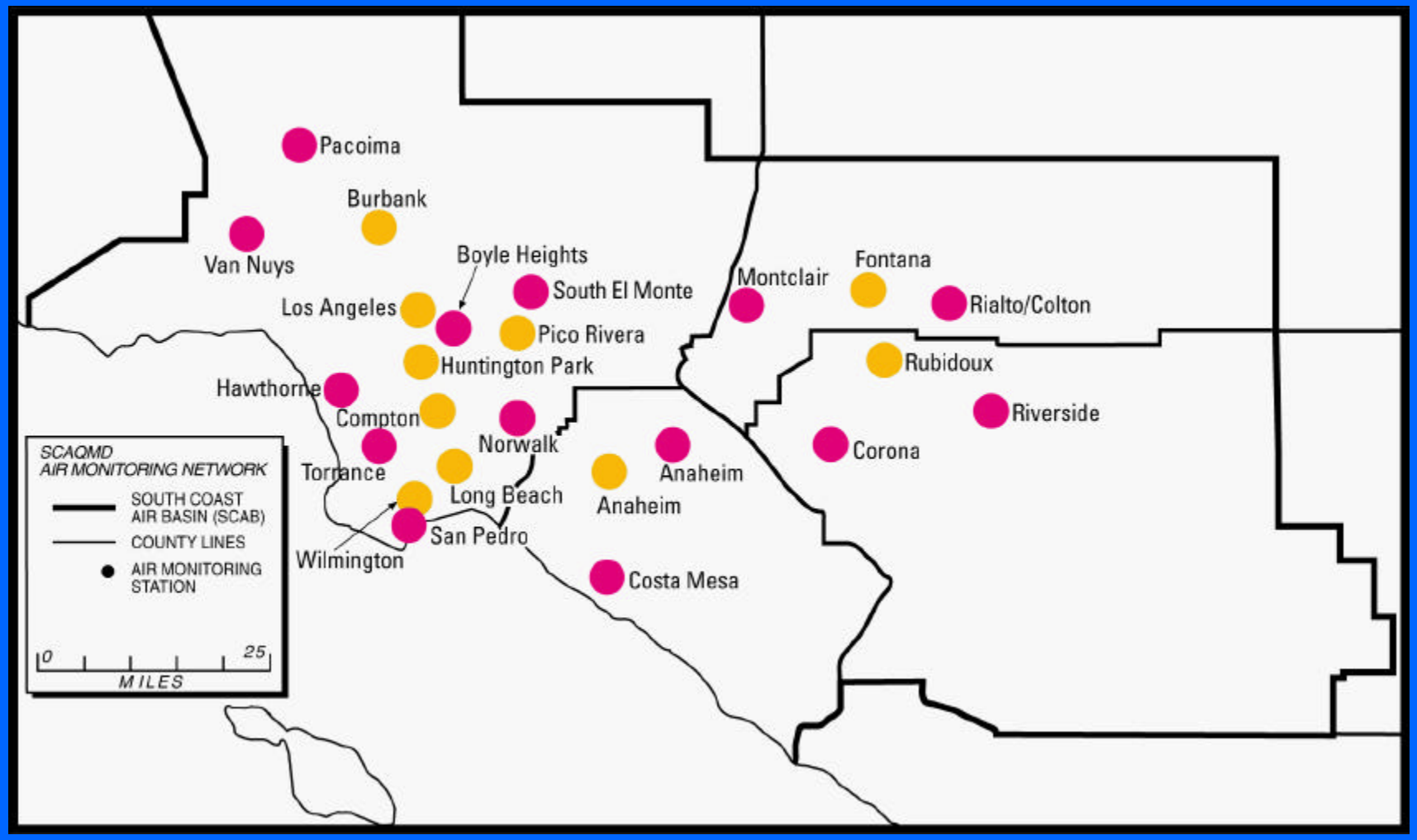
- Concentrations of nearly 30 air toxics were modeled using UAM-TOX
- Overall model predictions were within ?50% of measured annual averages
- Model generally exhibited an underprediction bias, which may be explained by underestimated on-road emissions

Summary & Conclusions (Continued)

- Nearly 90% of the cancer risk attributed to diesel PM, benzene, & 1,3 butadiene
- Mobile sources account for more than 98%, 90%, and 95% of the diesel PM, benzene, and 1,3 butadiene emissions, respectively
- Study demonstrates that regional modeling tools can be used for a regional risk assessment

Microscale Study
To Identify Local Hot Spots

MATES II Monitoring Network



Fixed Sites

Microscale Sites

Microscale

Monitoring

- 14 Sites
- 4-5 Weeks, 2-3 Samples / Week
- Most of Sample Days Coincide with Fixed Site Days

Emissions

- To Inform Monitoring Staff
- To Correct Inconsistencies in Regional Modeling
- To Conduct Modeling
- Wedge of Influence was Defined
- Emissions Calculated: AB2588; AER; Drive-By; Interviews; Permits; MSDS Sheets

Microscale

Modeling

- ISCST3 (Hourly & Annual Output)

  Options Used: URBAN & NOCALM

  Two Sets of Met. Data:

  1981 & 1998 / 1999

  ⬇ ⬇

  Permitting CALMET

  APPENDIX VI

Microscale Monitoring Result

- Limitation: Seasonal Variations at Fixed Sites
  vs.
  Short Duration of Microscale Sites

- Comparison of Fixed & Micro. Sites
  323 Possible Pairs
  (24 Compounds, 13 Paired Sites)

- Styrene in Anaheim ➡ I. D. 3 Sources

Figure 6-2

Styrene Emitters Close to Anaheim Site

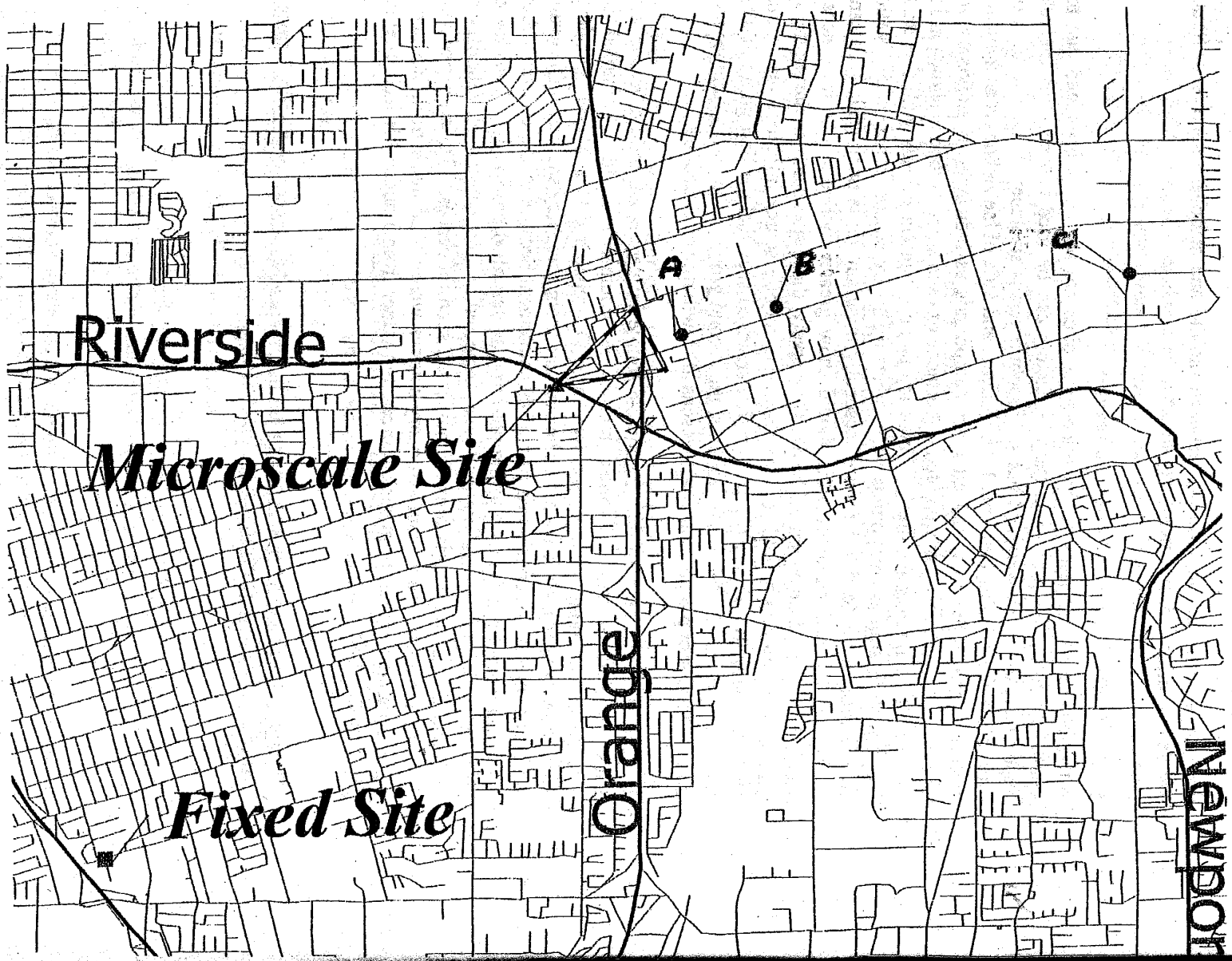
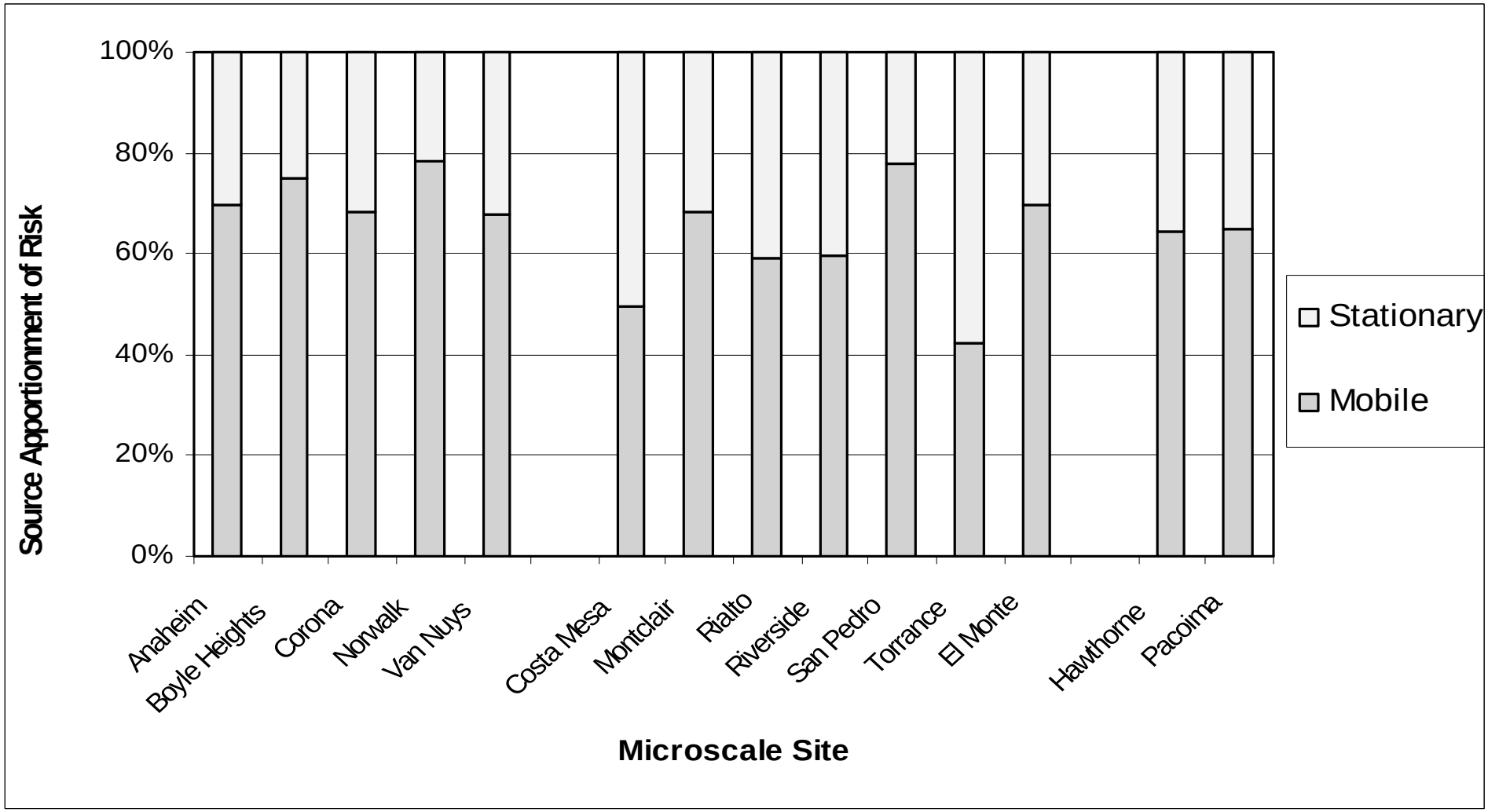


Figure 6-3
Relative Influence of Mobile and Stationary Sources at Microscale Sites, On a Risk-Weighted Basis, Excluding Diesel Particulates



Microscale Modeling Results

None > 10×10^{-6}

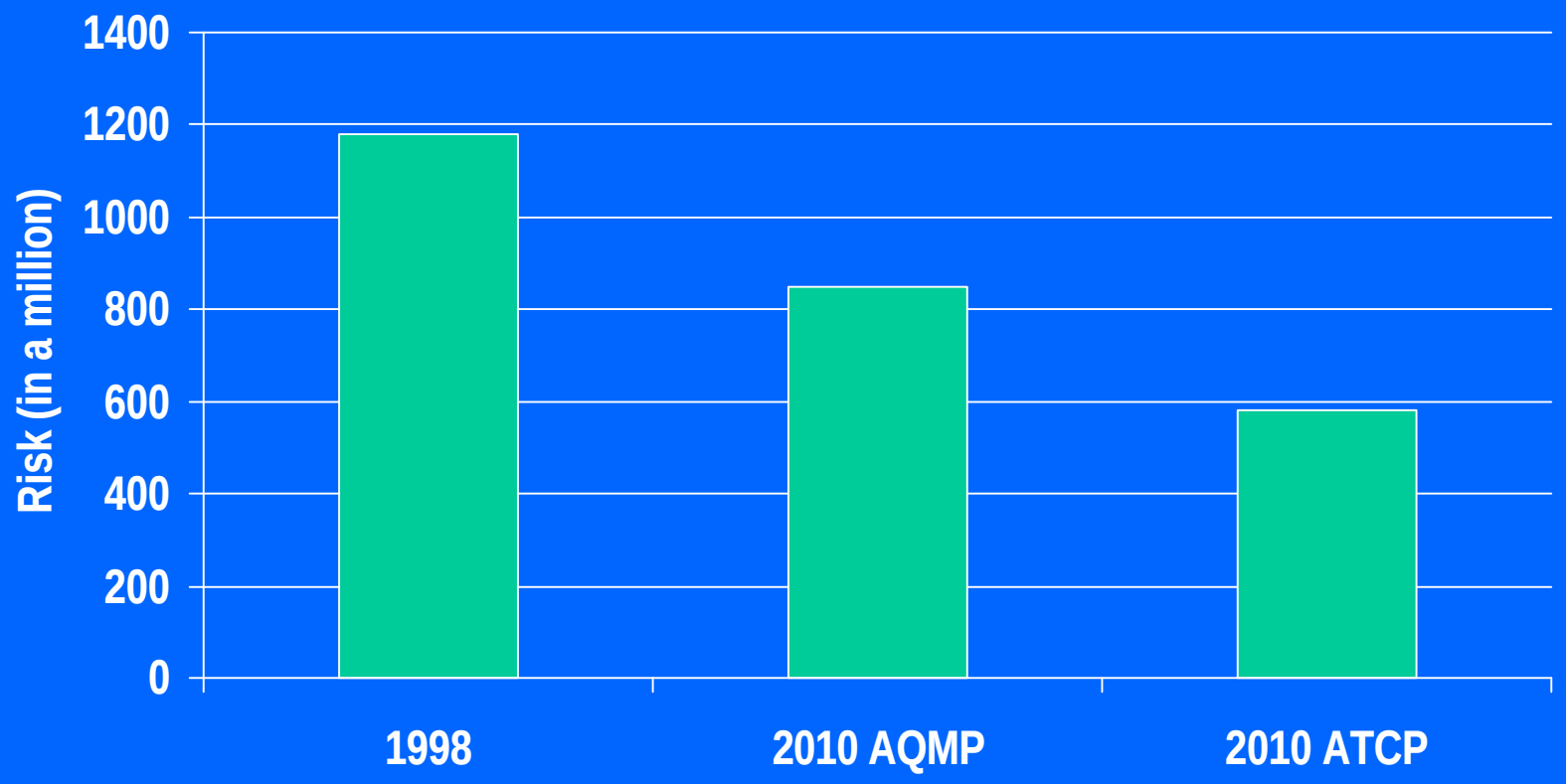
Highest = 5×10^{-6}

- Regional Conditions Overwhelm
- Local Influences

Control Strategy

- Ongoing local, state, and federal emission reduction programs
- Early action activities
  - Amend rules 1401 & 1402
  - Fleet rules
  - Further reductions from gasoline dispensing facilities
- Additional stationary control measures (9)
- Additional mobile source control measures (13)

Model-Predicted Risk Levels



Findings & Conclusions

Monitoring

1. Estimated Risk Based on Measurements

   1120 - 1740
   Ave: 1400

2. Based on Measurements, S. Central & E. Central L. A. ➡ Highest Risks
   Dominated by Mobile Sources

3. 70% ➡ Diesel

   20% ➡ Other Mobile

   10% ➡ Stationary
   (Dry Cleaners & Others)

Findings & Conclusions (Continued)

Monitoring Continued

4. There are Strong Seasonal Variations, Mostly due to Mobile Sources.
5. Risks are Decreasing

Modeling

6. Consistent with Monitorings on an Annual Basis
7. Highest Risk is S. Central L. A. & in Harbor Areas. Basin-Wide Risk 16% Lower than Monitored Sites.
8. Over-All, UAM & UAM-TOX Perform within ± 50-80% of Measured Annual Values.

EMAC 7 G ➡ EMFAC 2000
Will Improve Model Performance

Findings & Conclusions (Continued)

Modeling Continued

9. Highest Concentrations Occur Near the Source

Microscale Program

10. Styrene Higher than Fixed Sites (Anaheim)
11. Mobile Sources the Dominant Contributor to Risk
12. At Four Sites, No Emissions from Stationary Sources Detected.

Findings & Conclusions (Continued)

Microscale Program Continued

13. Microscale Modeling → Risk < 5

14. Most Likely, Sites Other than the Selected Ones, will Have Higher Risks

15. Region-Wide Risks Overwhelm any Potential Local Hot Spot

Uncertainties

(1) Indirect Measurement of Diesel Particulates

(2) Determination of Risk Values (URF's)

(3) Laboratory/Measurement Processes

(4) Model Inputs

(5) Model Computational Algorithms

Species Apportionment
(Sensitivity to Method)

Pollutant	Meas.	Model	Emissions
Diesel PM	71%	76%	82%
Benzene	7%	7%	5%
1,3 Butadiene	8%	4%	6%
Carbonyls	3%	4%	2%
Other	11%	9%	5%

Species Apportionment (Sensitivity to Diesel PM Toxicity)

Pollutant	0.2x	1x	5x
Diesel PM	34%	71%	92%
Benzene	15%	7%	2%
1,3 Butadiene	20%	8%	2%
Carbonyls	6%	3%	1%
Other	25%	11%	3%