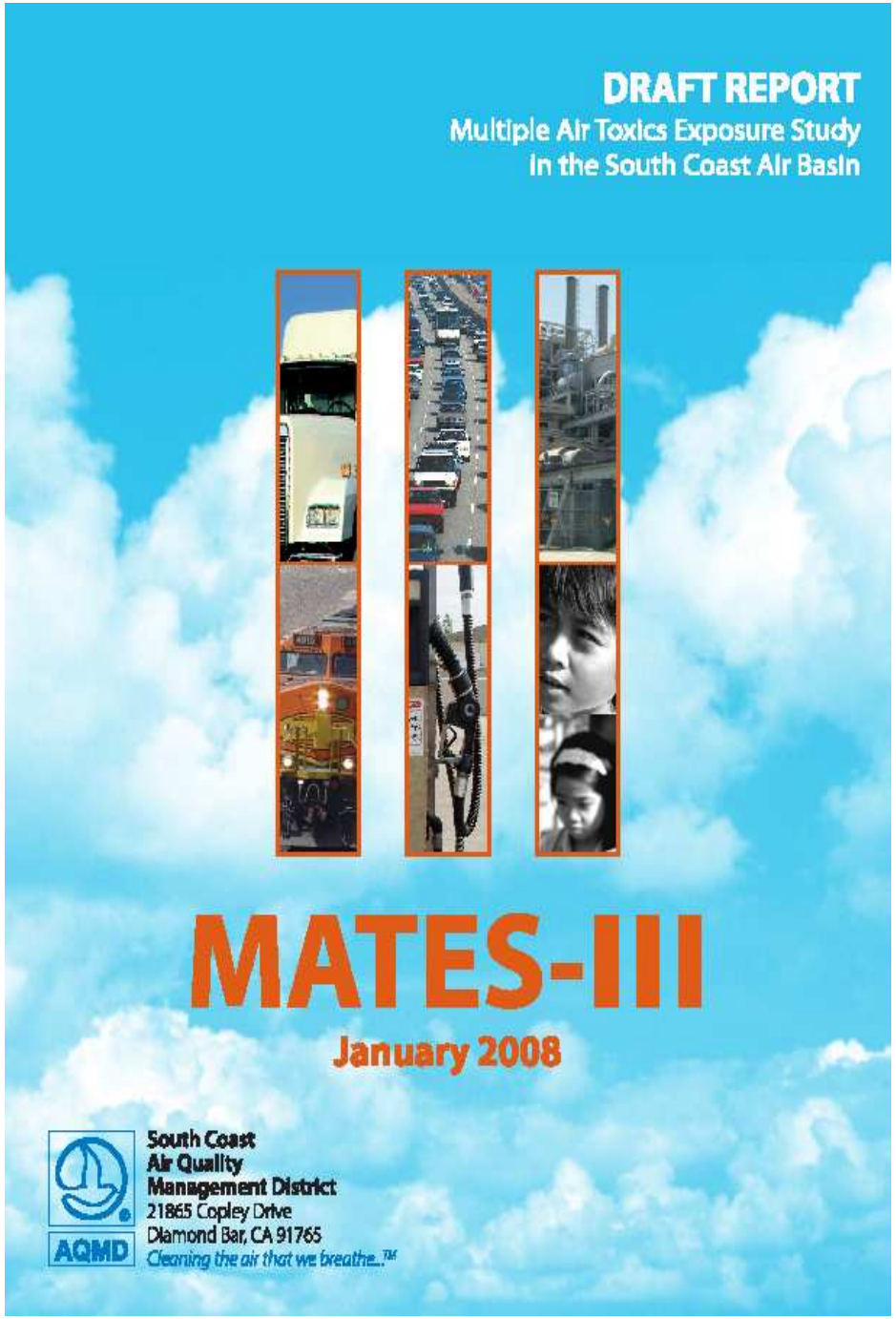
Source Apportionment

MATES III Technical Advisory Group

March 13, 2008



Chemical Mass Balance (CMB) Model

- Used monthly-averaged ambient data with speciated particulate organics
- EPA CMB version 8.2
- Estimate source contributions to ambient concentrations of PM2.5 mass
- Widely used in scientific community
- Suggested by Technical Advisory Group

Governing Equation

$$C_i = \sum_{j=1}^{p} a_{ij} S_j , i = 1,n$$

- C_i : ambient concentration of species *i*
- a_{ij} : fractional concentration of species *i* in the emissions from source *j*
- S_j is the total mass concentration contributed by source *j*
- *p:* number of sources
- *n* : number of species

Mass Balance Model

- Reconciles known source profiles with ambient receptor concentrations
- Number of species $\geq$ number of sources
- Selected species must be conserved from source to receptor
- Selected species should be quantifiable in all source and ambient samples

PM2.5 Chemical Analysis

- Elemental Carbon (EC)
- Organic Carbon (OC)
- Ionic species (NO_3^-, SO_4^{2-}, NH_4^+, Na^+, Cl^-)
- Metals (Al, Si, Fe, etc.)
- Organic compounds (75)
  - Analyses conducted by DRI
  - PAHs (coronene, indeno [1,2,3-cd]pyrene, benzo(ghi)perylene, etc.)
  - Hopanes, steranes (sterane 48, hopane 17, etc.)
  - Alkanes (phytane, docosane, etc.)
  - Polars (guaiacols, syringols, levoglucosan, cholesterol, organic acids, etc.)

Source Profiles Selected

Source Profiles	Reference
Nitrate and sulfate	
Biomass burning	SoCAB, J. Schauer, 1998; J. Chow et al., 2007
Meat cooking	B. Zielinska et al, 1998
Diesel and gasoline	SoCAB profile (E. Fujita et al, 2006) and NFRAQS Colorado profile (B. Zielinska et al, 1998)
Sea salt	
Geological	San Joaquin Valley profile (J. Chow et al, 2003)
Residual oil burning	SoCAB (AQMD, 1987)
Limestone	SoCAB (AQMD, 1987)

Key Chemical Species Selected

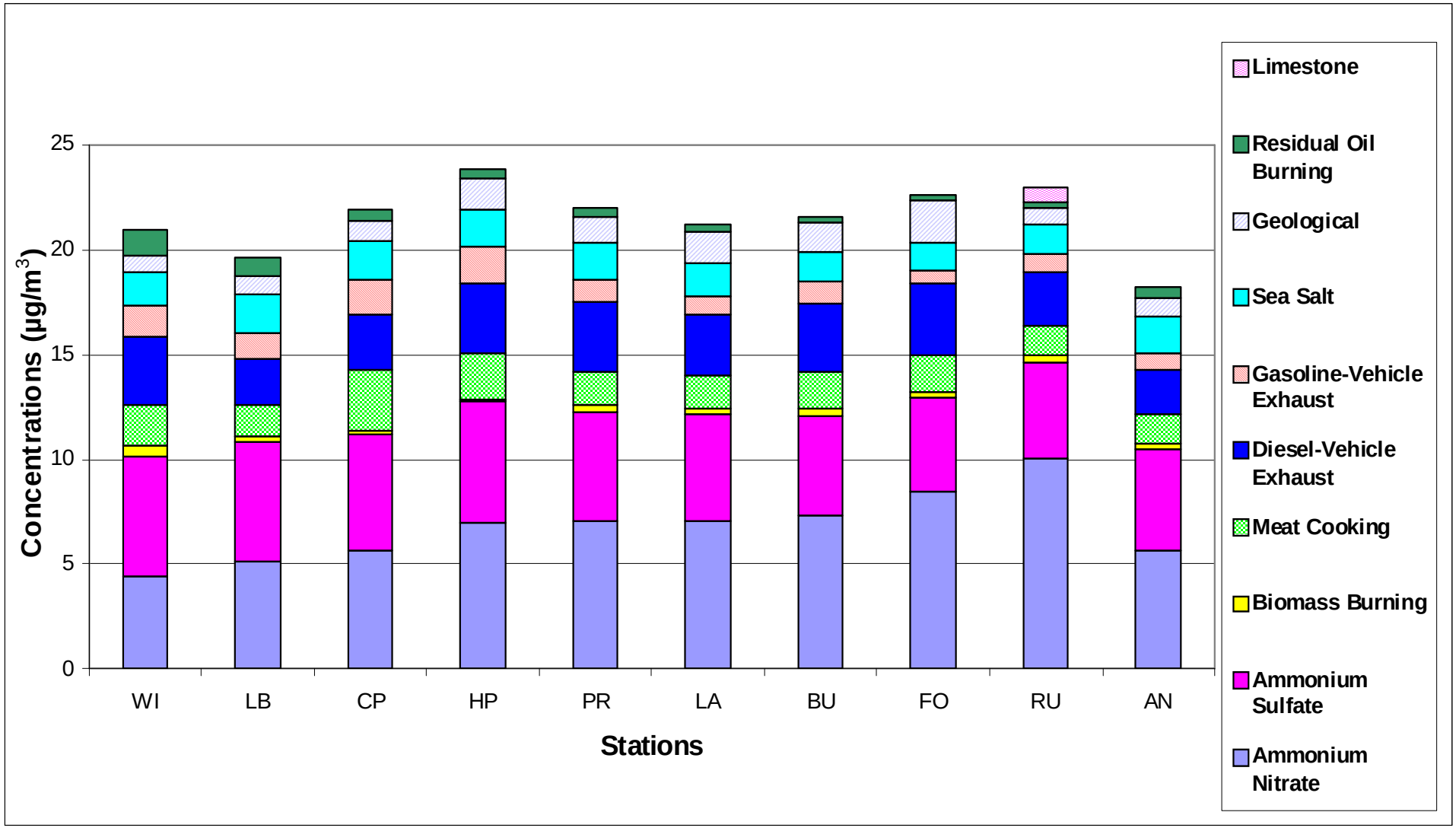
Emission Sources	Chemical Species
Nitrate and sulfate	NO_3^- and SO_4^{2-}
Biomass burning	Levoglucosan, K
Meat cooking	Cholesterol and palmitoleic acid
Diesel-vehicle exhaust	• EC • Steranes 48 and 49 • Hopanes 17,19, 24, and 26
Gasoline-vehicle exhaust	• Indeno[123-cd]pyrene, benzo(ghi)perylene, coronene • Steranes 48 and 49 • Hopanes 17,19, 24, and 26
Sea salt	Na^+ and Cl^-
Geological (incl. limestone)	Si, Ca, and Fe
Residual oil burning	V, Ni

First-Year – NFRAQS Gasoline Profile

- Model performance
  - R^2: 0.93 – 0.96 (goal: 0.8 – 1.0)
  - Chi^2 : 2.02 – 2.94 (goal: ≤ 4.0)
  - % Diff. in mass: 1 – 13% (goal: ≤ 20%)
- Source contributions
  - Secondary sources: 41 - 71%
  - Biomass burning: 1 - 3%
  - Meat cooking: 8 - 13%
  - Diesel-vehicle exhaust: 12 - 16%
  - Gasoline-vehicle exhaust: 3 - 7%
  - Sea salt: 6 - 9%
  - Geological: 3 - 9%
  - Residual oil burning: 1 - 6%
  - Limestone: 3%

First-Year PM2.5 Source Contribution Estimates

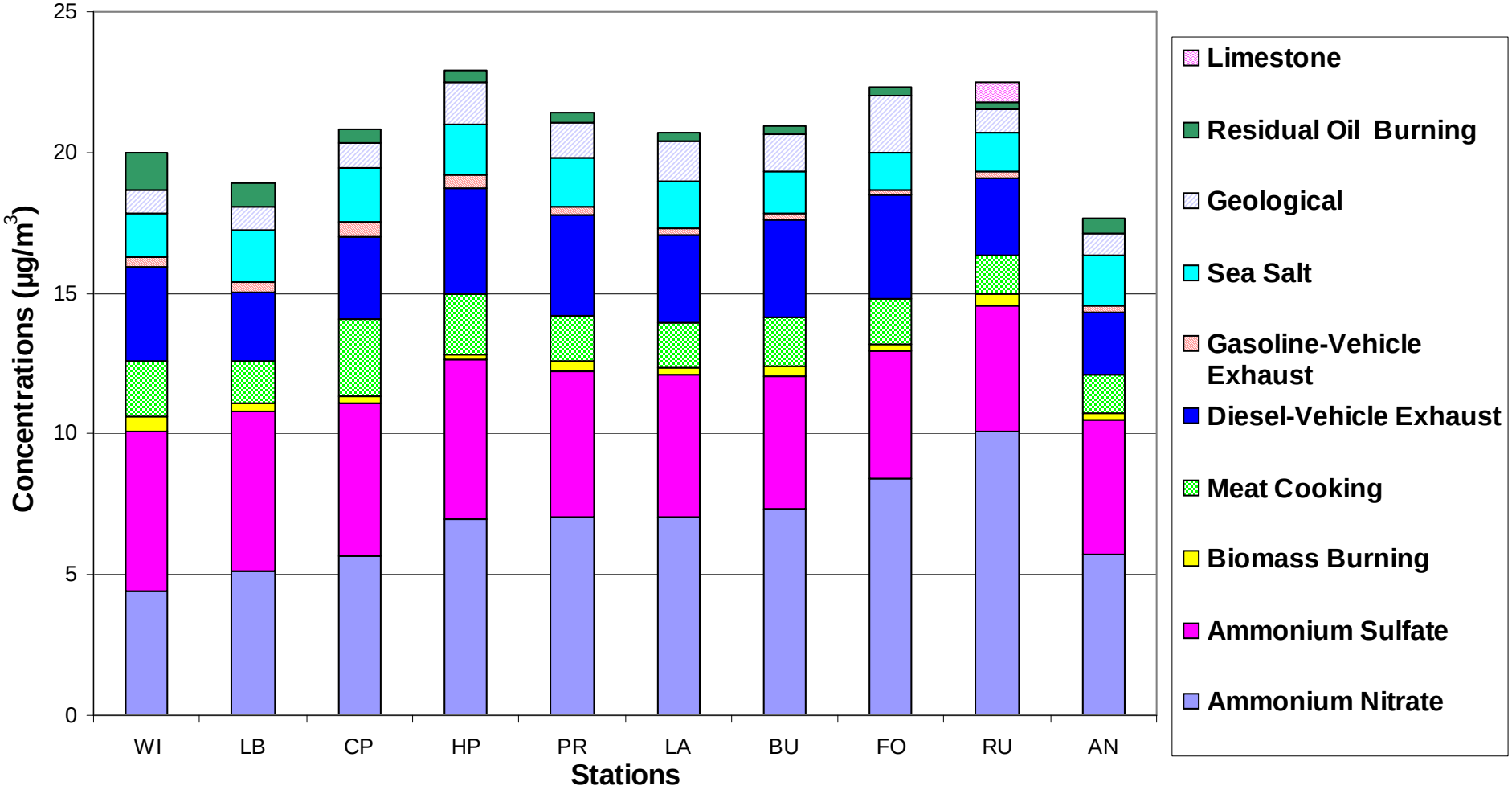
NFRAQS Gasoline Profile



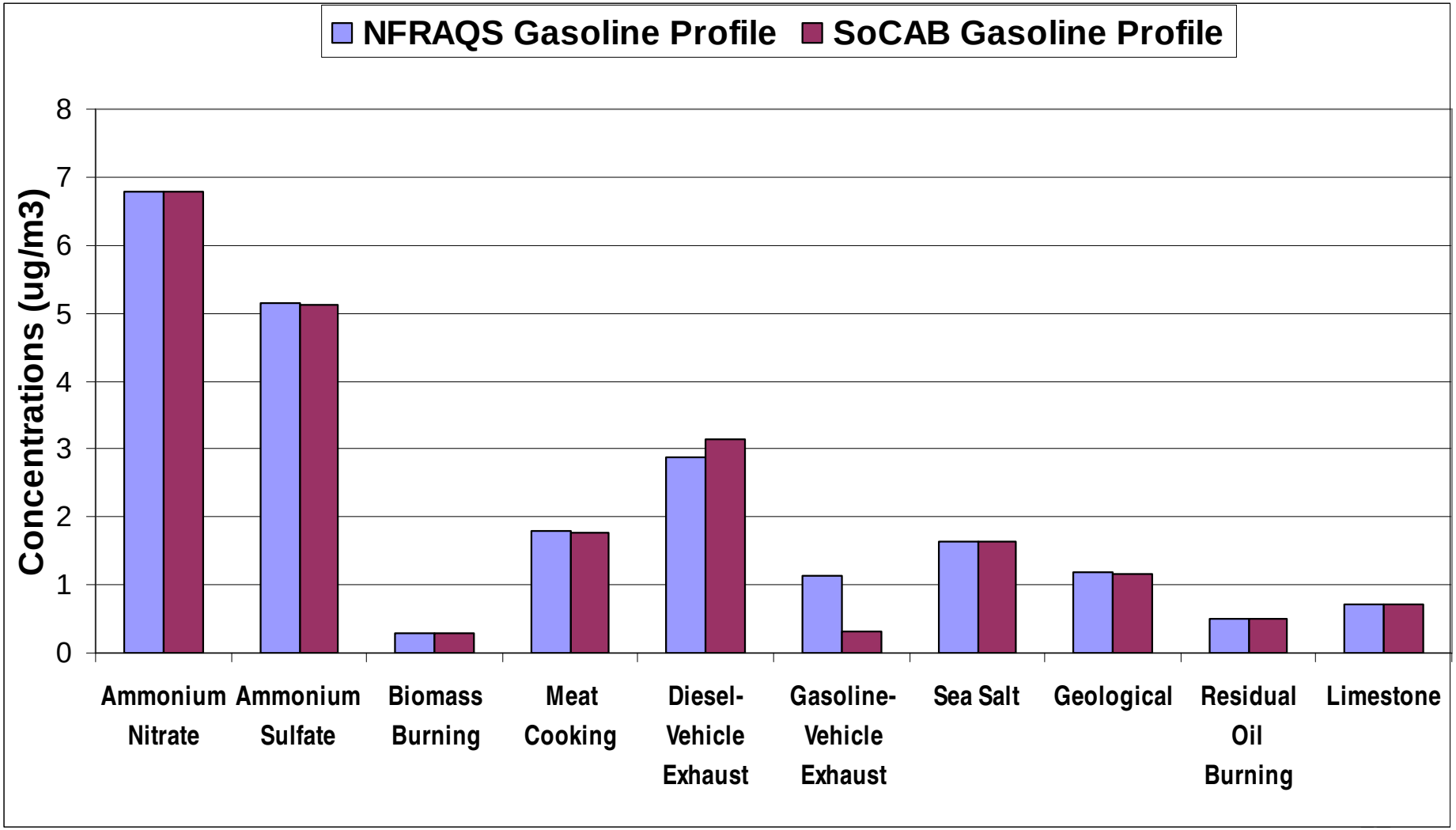
First-Year– SoCAB Gasoline Profile

- Model performance
  - R^2: 0.90 – 0.96 (goal: 0.8 – 1.0)
  - Chi^2 : 2.02 – 3.12 (goal: ≤ 4.0)
  - % Diff. in mass: 1 – 10% (goal: ≤ 20%)
- Source contributions
  - Secondary sources: 42 - 75%
  - Biomass burning: 1 – 3%
  - Meat cooking: 8 - 13%
  - Diesel-vehicle exhaust: 13 - 17%
  - Gasoline-vehicle exhaust: 1– 2%
  - Sea salt: 6 – 9%
  - Geological: 5 - 9%
  - Residual oil burning: 1 – 7%
  - Limestone: 3%

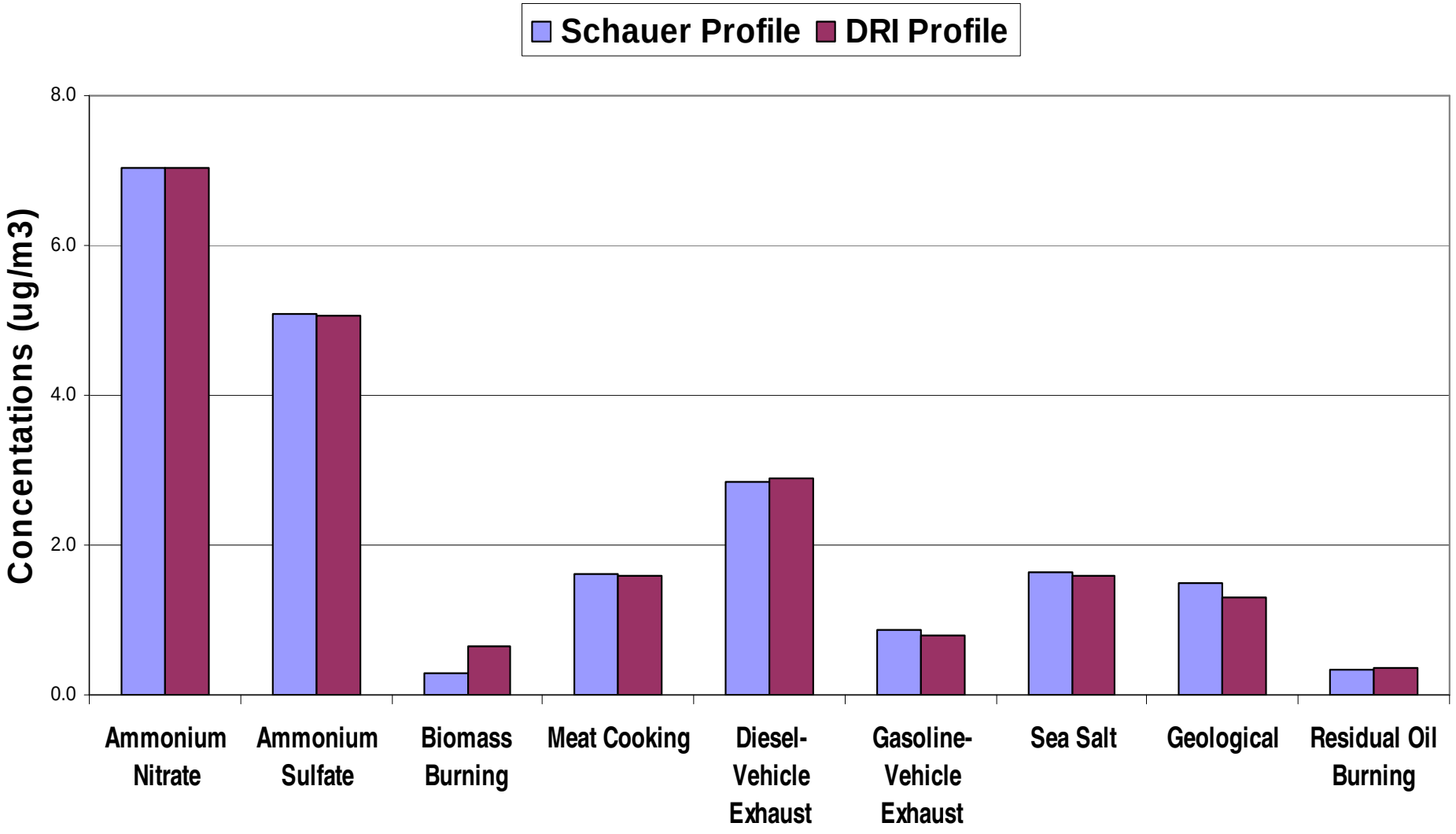
First-Year PM2.5 Source Contribution Estimates
SoCAB Gasoline Profile



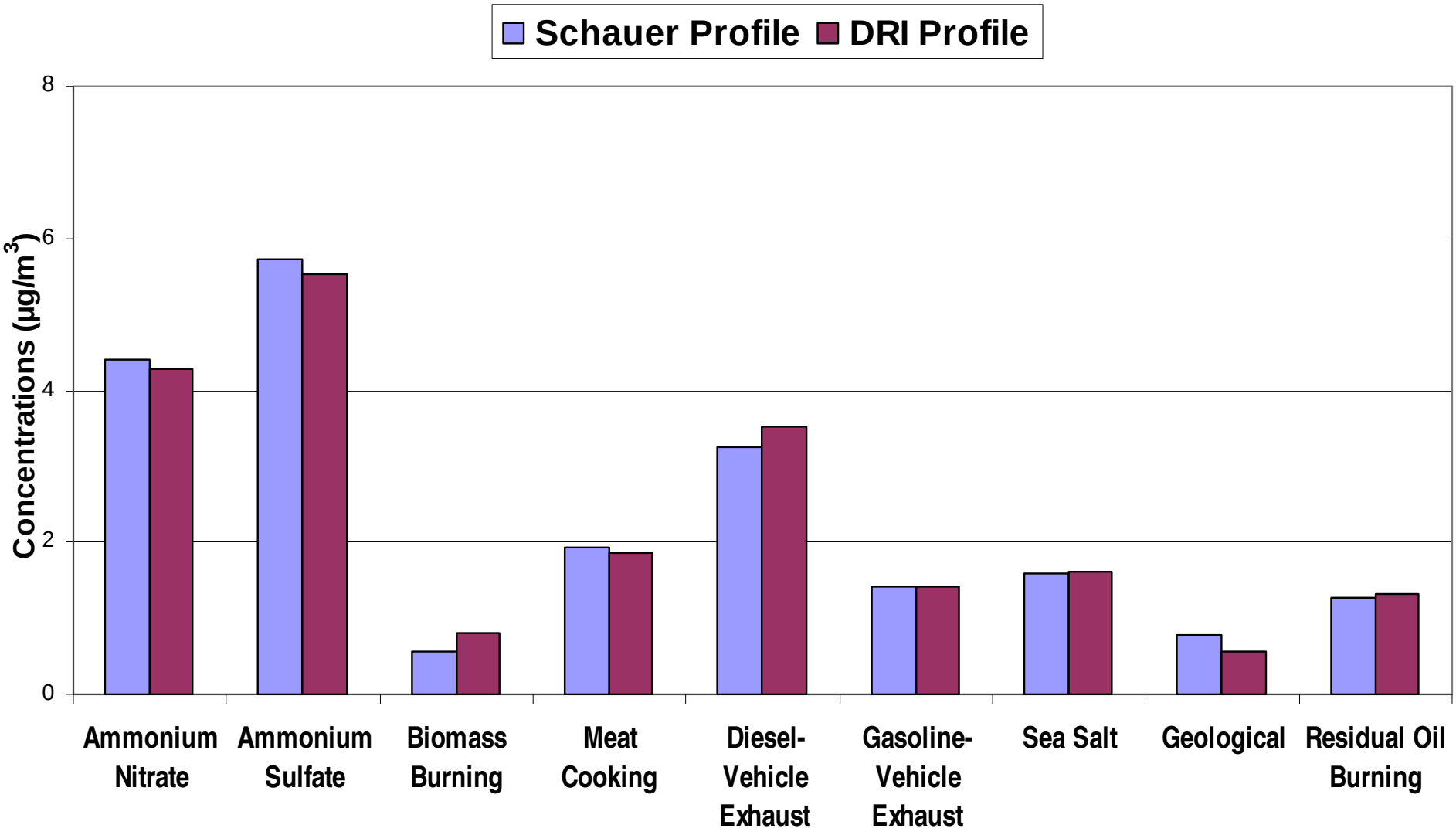
First-Year – 10-site Average Sources Comparison



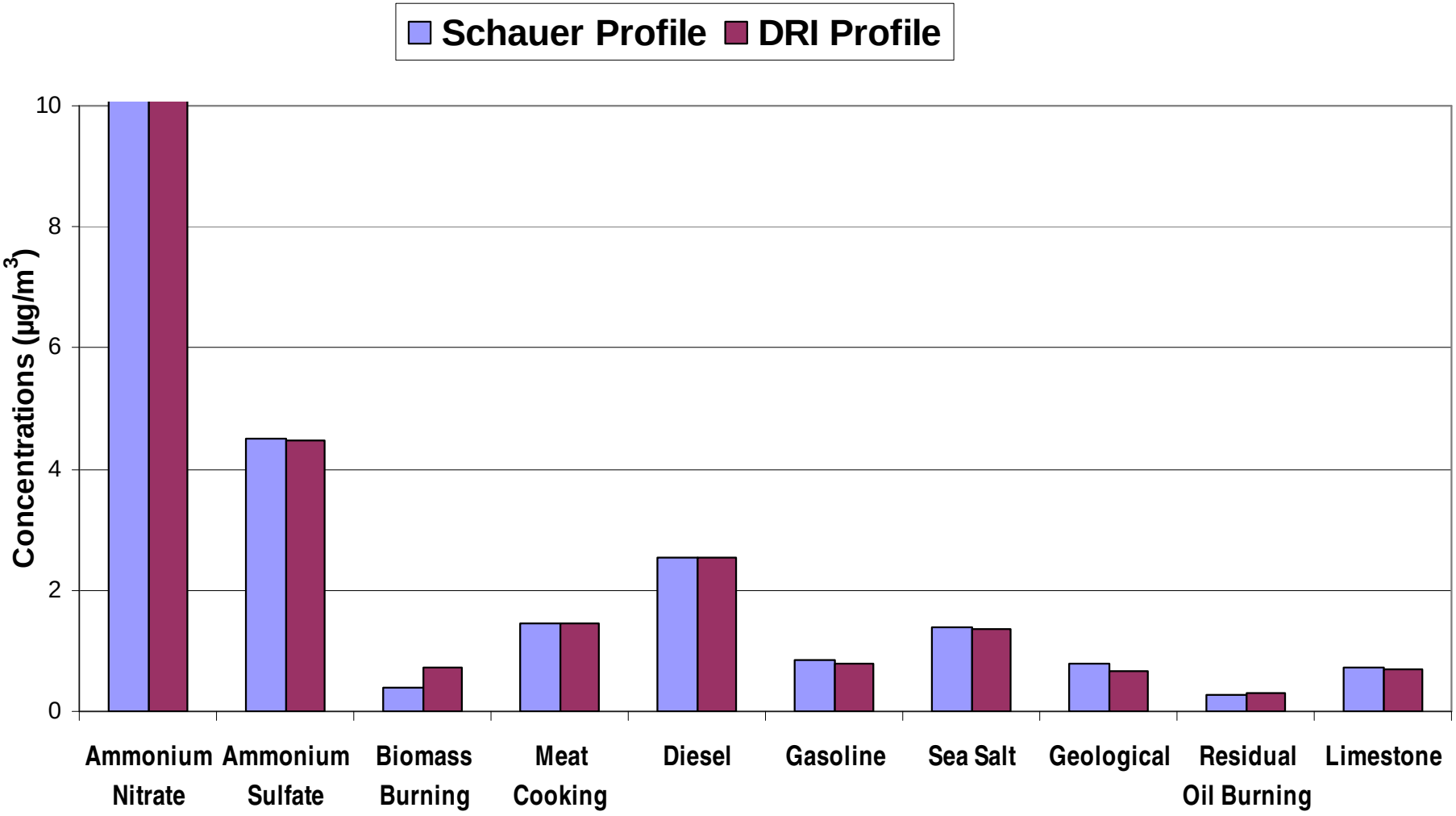
Los Angeles PM2.5 Source Contributions – Using Different Biomass Burning Profiles



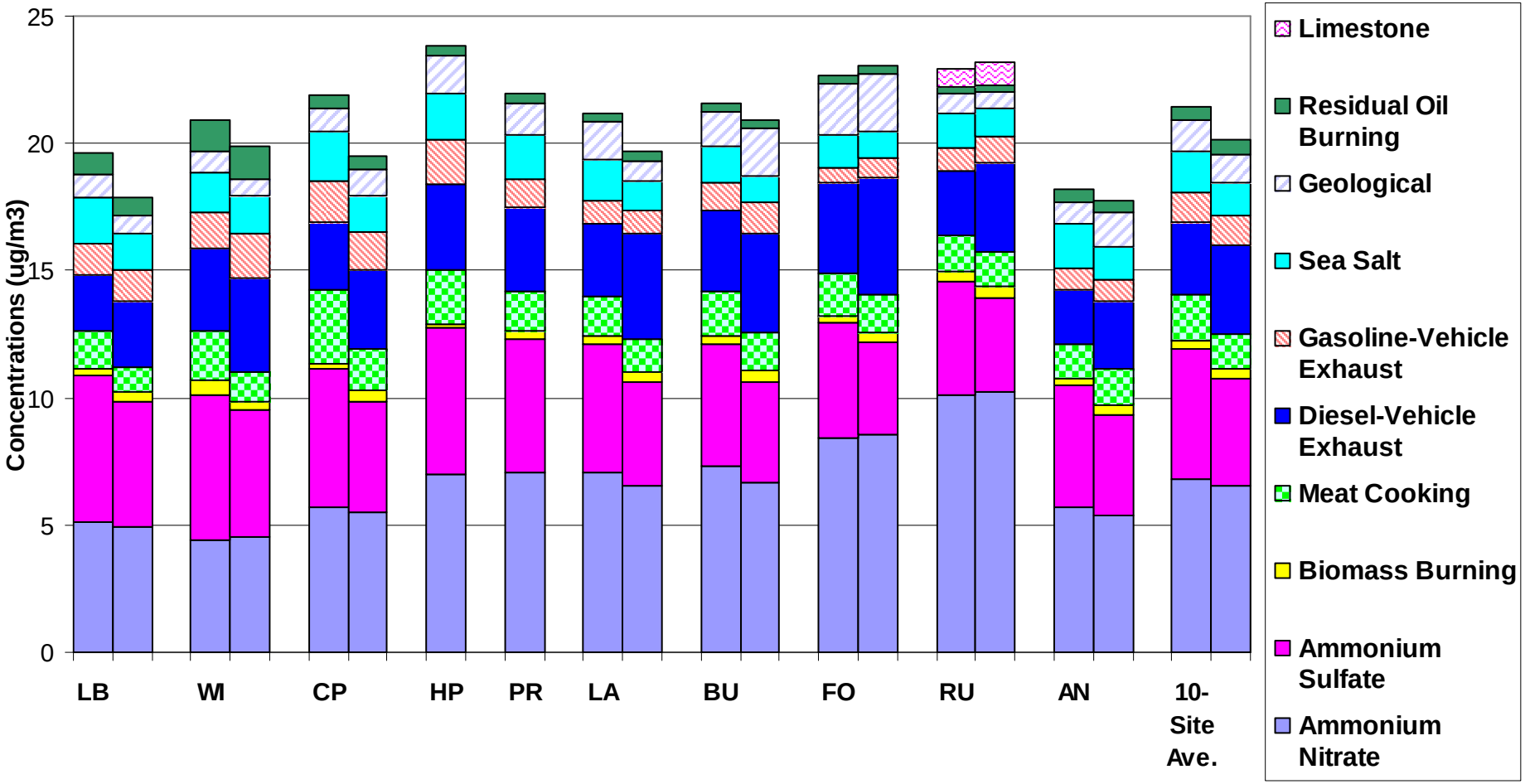
Wilmington PM2.5 Source Contributions – Using Different Biomass Burning Profile



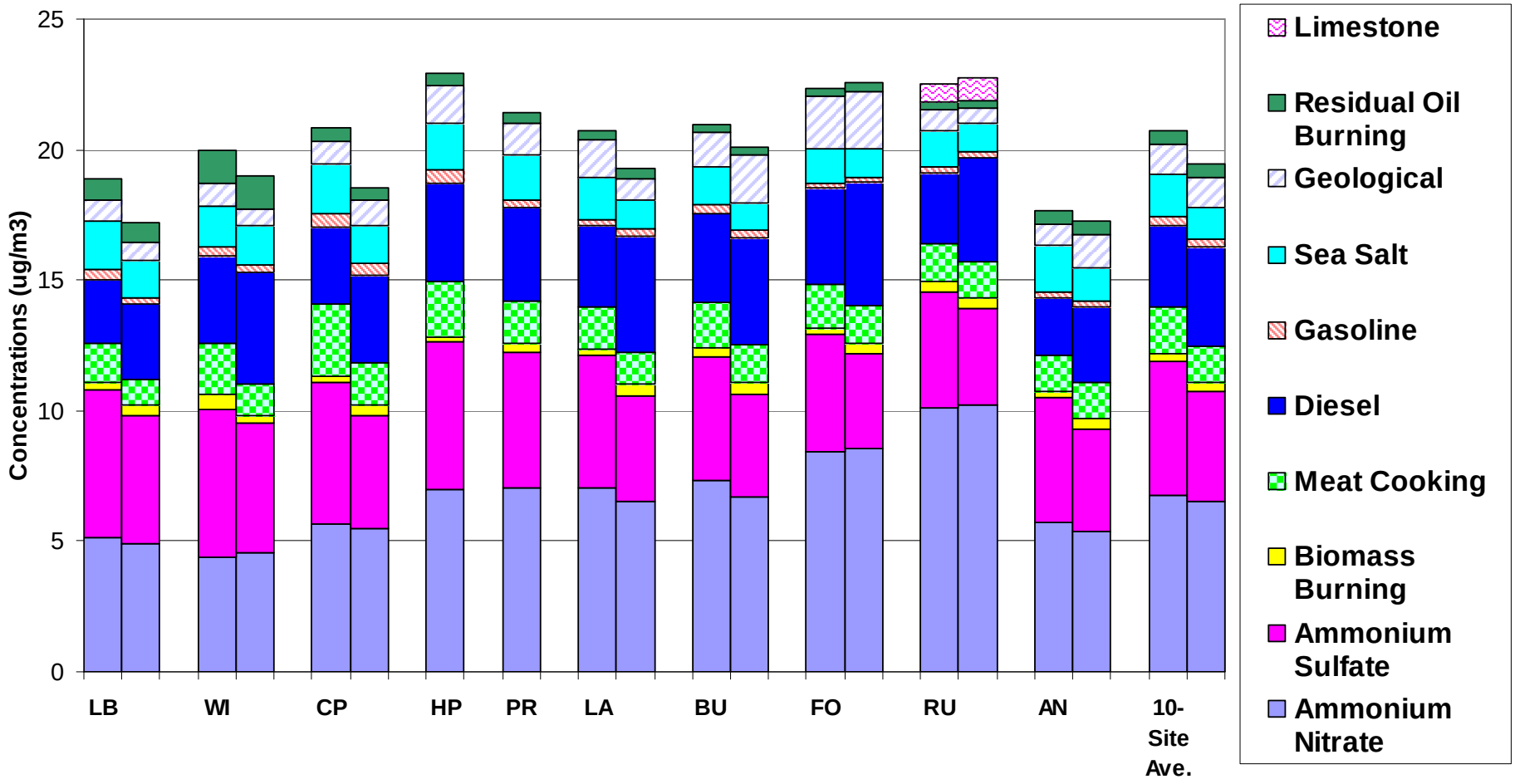
Rubidoux PM2.5 Source Contributions – Using Different Biomass Burning Profile



PM2.5 Source Contribution Estimates
NFRAQS Gasoline Profile: Years 1&2



PM2.5 Source Contribution Estimates
SoCAB Gasoline Profile: Years 1&2



Diesel PM Comparisons

Reference	Diesel ug/m3	Method	Comments
MATES III	2.1 – 4.8	CMB	Annual-Ave.; 2004 – 2006
Grover, 2008	4.3 – 4.9	PMF	Rubidoux; July 2003
Kim, 2007	2.1 – 2.3	PMF	Avg. Los Angeles, Rubidoux; May 2001 to Dec. 2004
Lough, 2007	0.6 – 1.7	CMB	Los Angeles, Azusa; July 2001,
Fujita, 2007	0.7 – 3.3	CMB	Los Angeles, Azusa; July 2001; Total Carbon Only
Chow, 2007	3.6 – 4.2	CMB	Fresno; winter 2000 - 2001
Manchester, 2003	2.4 – 3.6	CMB	So Cal.; Dec. 1994 – Dec. 1995