Development of a Preliminary Emission Inventory of Toxic Air Contaminants (TACs) for the Bay Area

Presented by:
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Presented to:
The Bay Area Air Quality Management District
San Francisco, CA
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Introduction

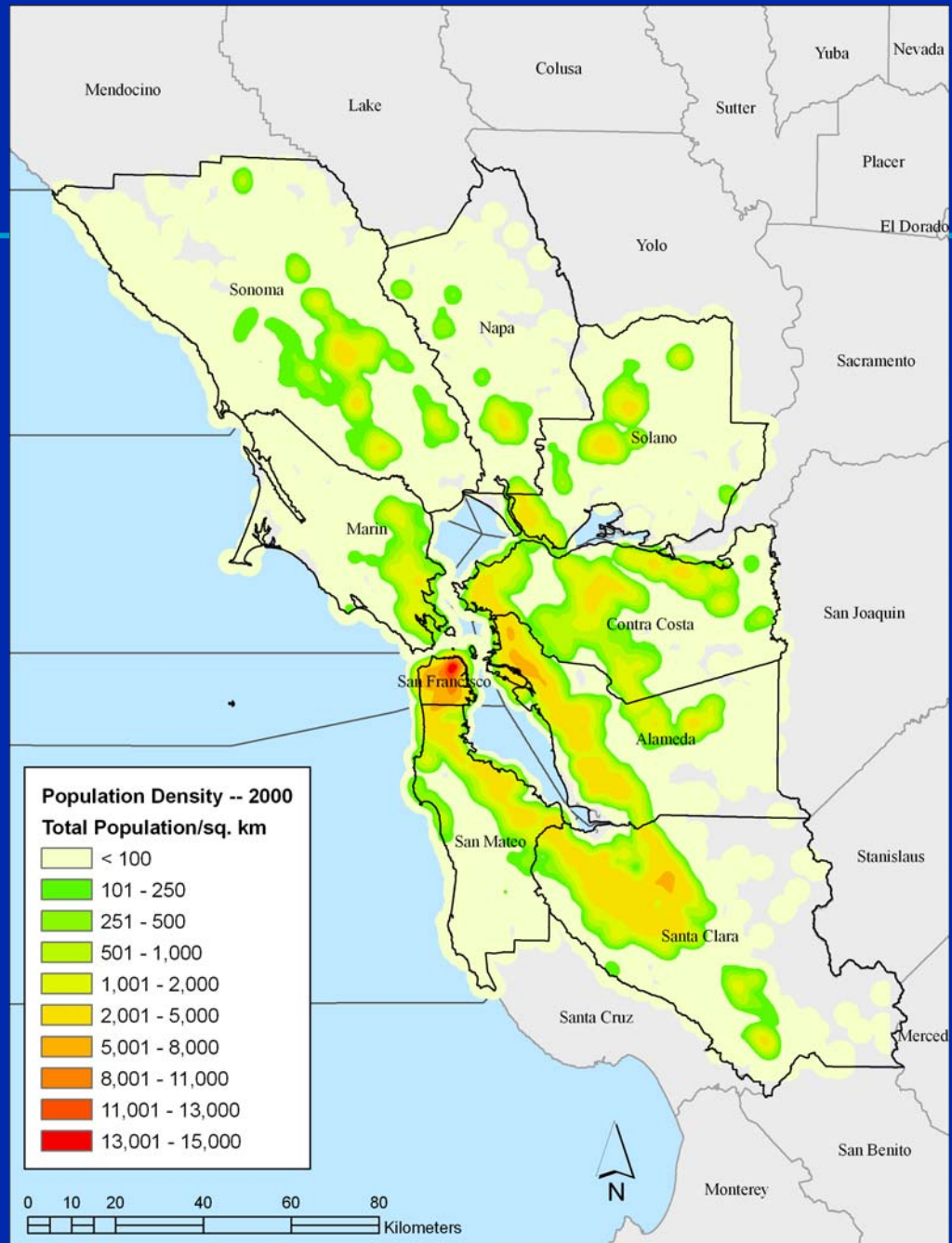Purpose of the TAC Emission Inventory: Support screening-level assessments of population exposures and selection of a study community.

Objective: Develop a first-draft emission inventory for the Bay Area using existing information suitable for use with dispersion and exposure models.
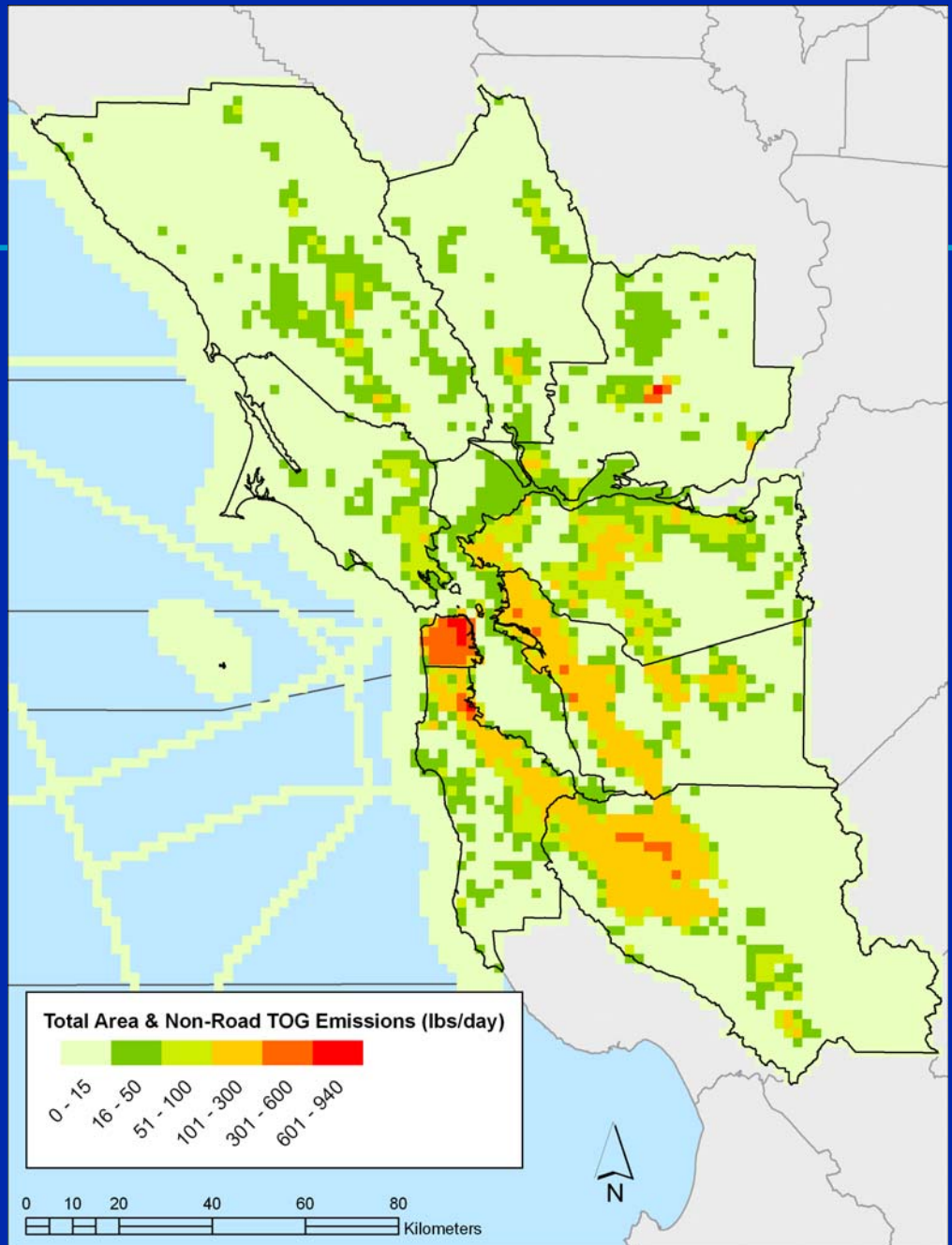
General Approach

1. Begin with existing criteria pollutant inventories.

2. Apply available chemical speciation profiles.

3. Apply available cancer and non-cancer unit risk factors.

4. Spatially allocate emissions.

Bay Area Population Density (2000)

Population Density -- 2000
Total Population/sq. km

	< 100
	101 - 250
	251 - 500
	501 - 1,000
	1,001 - 2,000
	2,001 - 5,000
	5,001 - 8,000
	8,001 - 11,000
	11,001 - 13,000
	13,001 - 15,000

2000 Area & Non-Road TOG Emissions

Total Area & Non-Road TOG Emissions (lbs/day)

0 - 15   16 - 50   51 - 100   101 - 300   301 - 600   601 - 940

0   10   20   40   60   80   Kilometers

N

2000 On-Road TOG Emissions

Total On-Road TOG Emissions (lbs/day)

< 50 | 51 - 100 | 101 - 300 | 301 - 500 | 501 - 1,000 | 1,001 - 1,665

0 10 20 40 60 80 Kilometers

N
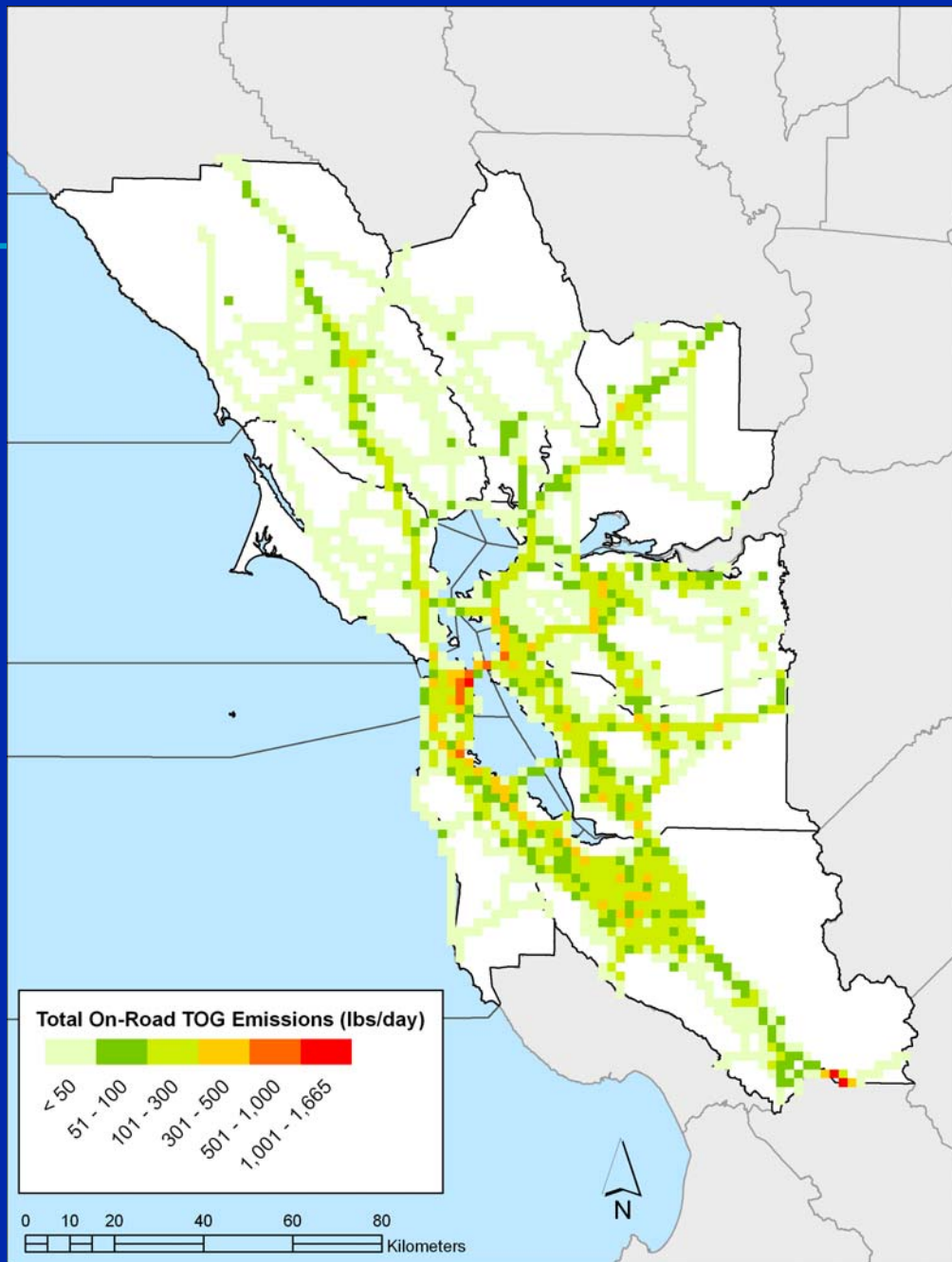
2000 Benzene Emissions from Point Sources

Benzene Total Point Source Emissions (lbs/day)

< 0.1   0.2 - 1.0   1.1 - 5.0   5.1 - 20.0   20.1 - 35.0   35.1 - 55.0

0   10   20   40   60
Kilometers

N
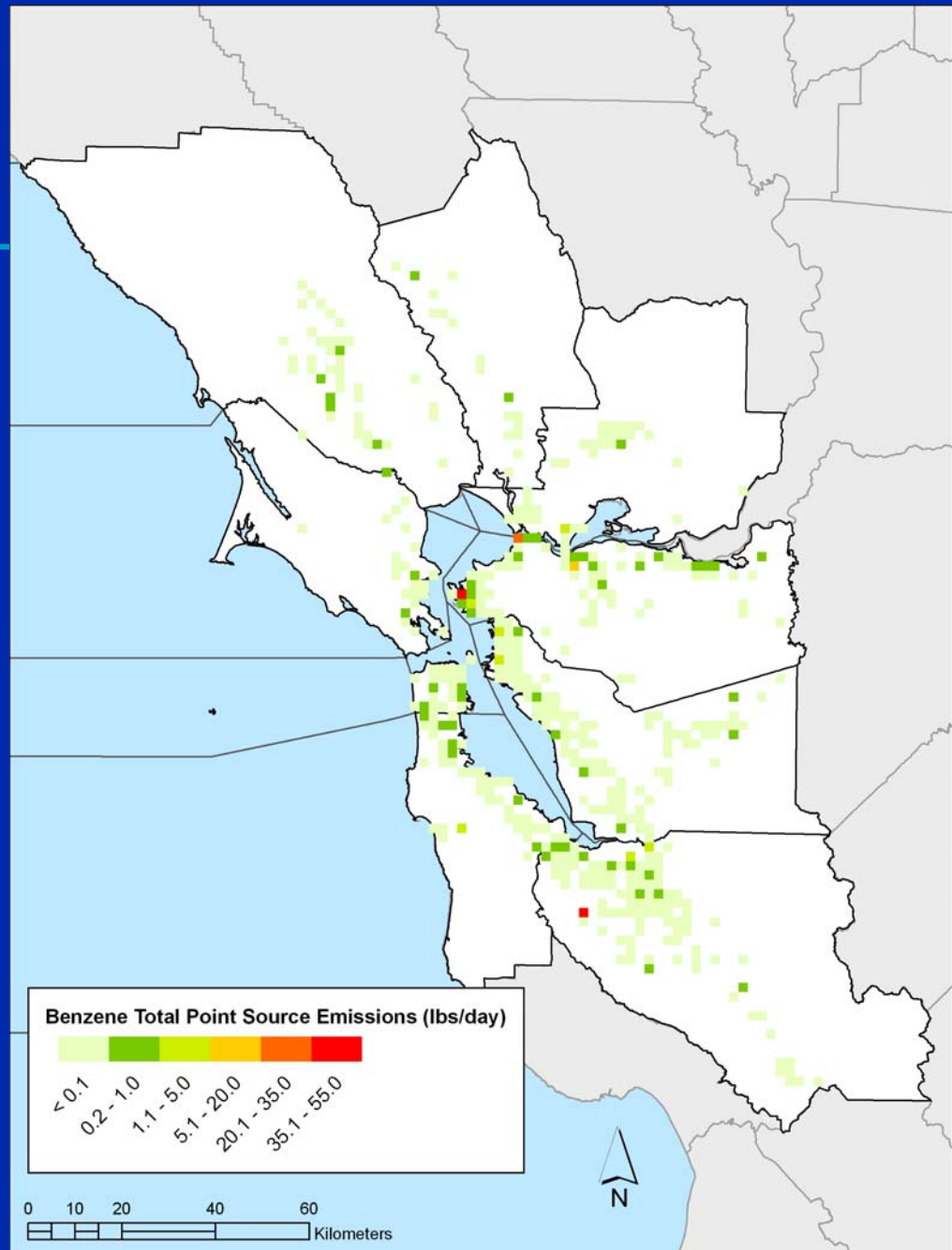
Chemical Speciation

Existing speciation profile libraries

- ARB

- EPA (Speciate 3.2)

- Desert Research Institute (DRI)

Chemical Speciation

CAS No.	Pollutant	Percent
67641	ACETONE	2.14
123864	N-BUTYL ACETATE	2.6
71363	N-BUTYL ALCOHOL	1.82
	C-9 CYCLOPARAFFINS	7.3
	C10 PARAFFINS	16.78
	C4 SUBSTITUTED CYCLOHEXANE	17.04
	C7-C16 PARAFFINS	2.82
	C9 PARAFFIN	5.32
141786	ETHYL ACETATE	0.74
64175	ETHYL ALCOHOL	2.44
67630	ISOPROPYL ALCOHOL	2.84
67561	METHYL ALCOHOL	0.08
78933	METHYL ETHYL KETONE	4.16
108101	METHYL ISOBUTYL KETONE	1.4
	PARAFFINS/OLEFINS (C12-C16)	6.7
109604	N-PROPYL ACETATE	0.18
108883	TOLUENE	6.7
71556	1,1,1-TRICHLOROETHANE	1.76
	ISOMERS OF UNDECANE	9.62
	UNIDENTIFIED	4.44
1330207	ISOMERS OF XYLENE	3.12

EPA TOG Profile #6003: Architectural Coatings

Chemical Speciation

Cross-Reference Table

EIC Code	Description	Profile#
52052091050000	Primers & Sealers	6003
53053032250000	Pesticides	1000
54059004000000	Asphalt Roofing	2400

Speciation Profile Library

Profile#	CAS#	Pollutant	Percent
6003	67641	ACETONE	2.15
6003	123864	N-BUTYL ACETATE	2.60
6003	71363	N-BUTYL ALCOHOL	1.82

Unit Risk Factors

Cancer risk is approximated as a linear function of ambient concentration

URF Units of Measure =

No. Cases of Effects per Hundred Thousand Persons Exposed $\div$ Ambient Concentration

Example – Benzene

- Ambient concentration = 2 µg/m^3

- URF = 2.9 x 10^{-5} · 10^{-5} · (µg/m^3)$^{-1}$

- Risk = concentration x URF
  = 5.8 x 10^{-10} or "58 in 100 billion"

Reference Concentrations

Reference Concentration (RfC) is a regulatory definition.

RfC = Concentration at which no adverse effects are expected,

plus a safety margin for uncertainty,

plus a safety margin based on expert toxicologists' judgment.

RfC Units of Measure = Concentration

Example – Benzene

- Ambient concentration = 2 μg/m^3
- RfC = 60 μg/m^3 for chronic effects and 1300 μg/m^3 for acute effects
- Risk = negligible at the observed concentration

Sources of Information

Sources of Inhalation URFs and RfCs

- ARB-Approved Risk Assessment Health Values
- EPA Office of Environmental Health Hazard Assessment (OEHHA)
- EPA Integrated Risk Information System (IRIS)
- Risk Assessment Information System

Risk-weighted Emissions

- Best available URFs and RfCs were selected for each TAC in the speciated inventories.

- Risk-weighted emissions were calculated.

- Uncertainty ranges were documented where applicable.

- A database of risk-weighted emissions by TAC and source category was prepared.

Risk-weighted Emissions ("RWE")

Cancer $RWE_i = E_i \times UR_i \div UR_X$

Chronic or Acute $RWE_i = E_i \div RfC_i \times RfC_Y$

  i denotes TAC species i

  E = Mass-based emissions; lbs/day

  UR = Unit risk factor; $10^{-5} \cdot (\mu g/m^3)^{-1}$

  RfC = Reference concentration; $\mu g/m^3$

  UR_X = UR for hypothetical species "X"

    $\equiv 1 \cdot 10^{-5} \cdot (\mu g/m^3)^{-1}$ (similar to dioxins or furans, which are extremely toxic)

  RfC_Y = RfC for hypothetical species "Y"

    $\equiv 1 \ \mu g/m^3$ (similar to aniline or acrylic acid, which are moderately toxic)

Spatial Allocation

Area and Non-road Sources —

  Apply spatial allocation factors (SAFs)

On-road Mobile Sources —

  Already resolved to 2-km x 2-km grid

Point Sources —

  Assign to facility location coordinates

Spatial Allocation

SAFs were developed from geographic information systems (GIS) databases.

- Demographic data (e.g., population density)
- Landuse/landcover data sets (e.g., residential versus agricultural land use)
- Line length (railroad tracks)
- Facility locations
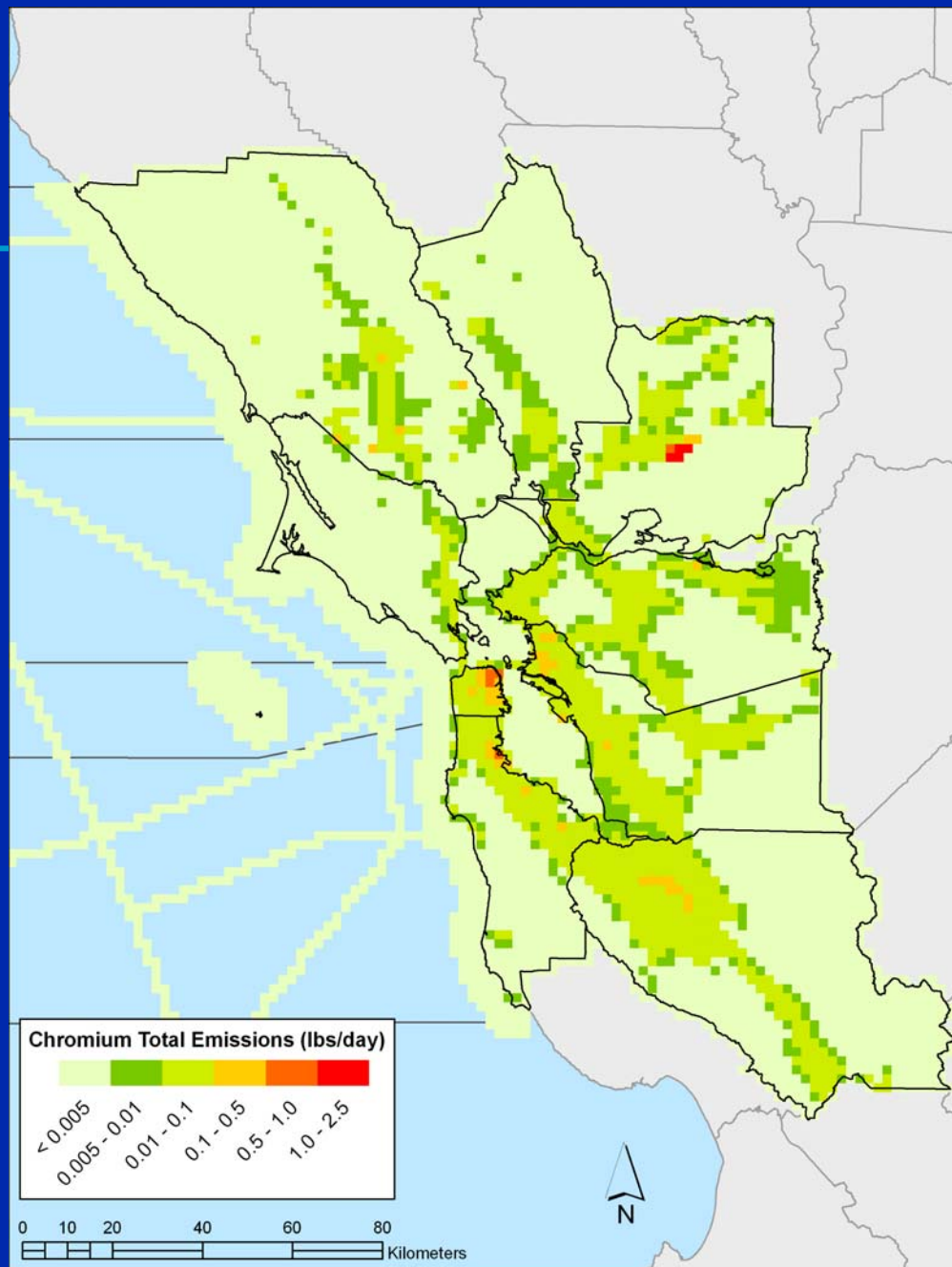- Other available GIS databases

Cancer Risk-weighted Emissions
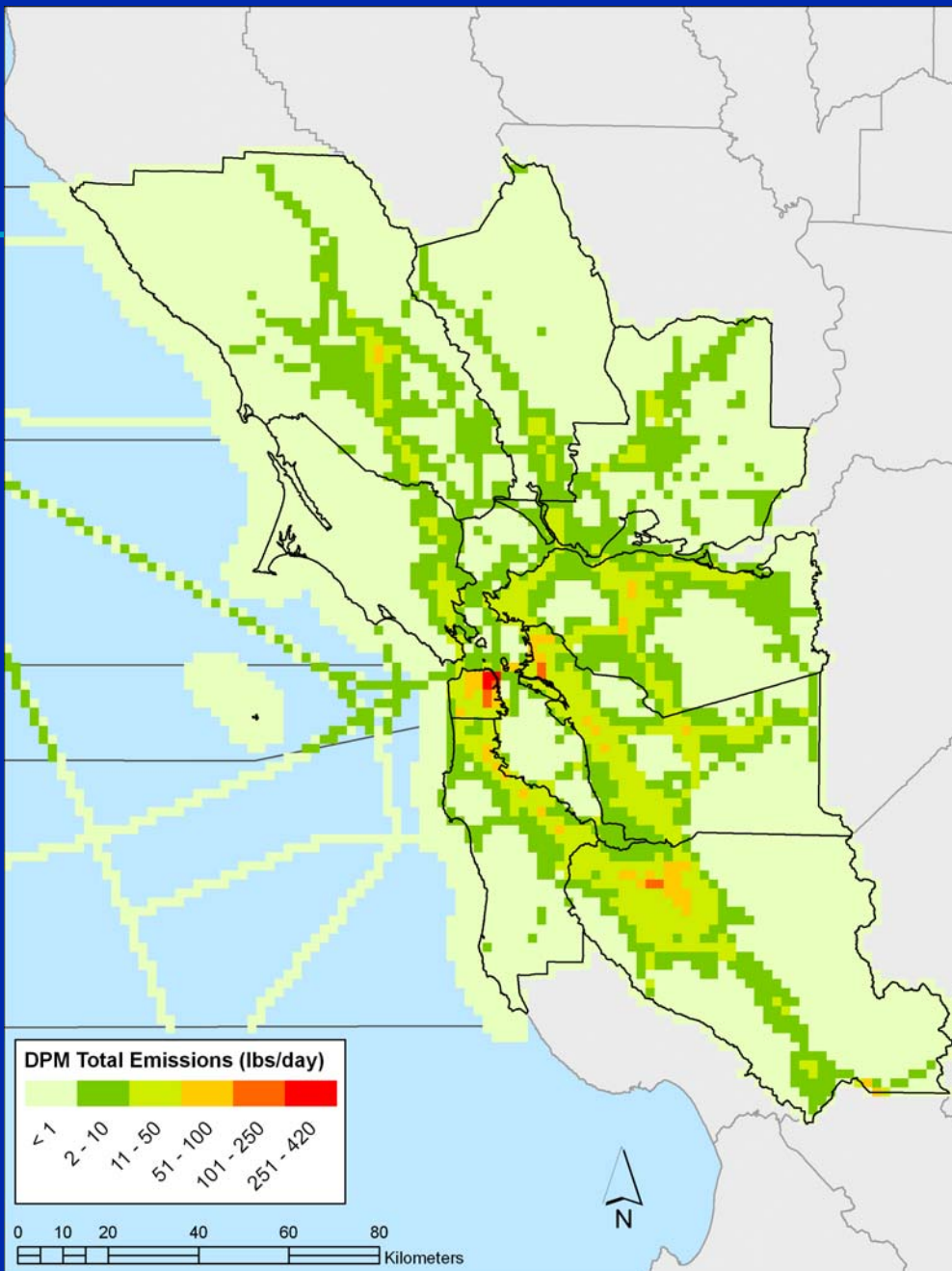## 16 equivalent pounds/day

Legend:
- Chromium*
- Diesel Particulates
- 1,3-Butadiene
- Benzene
- Formaldehyde
- Other

49%
42%
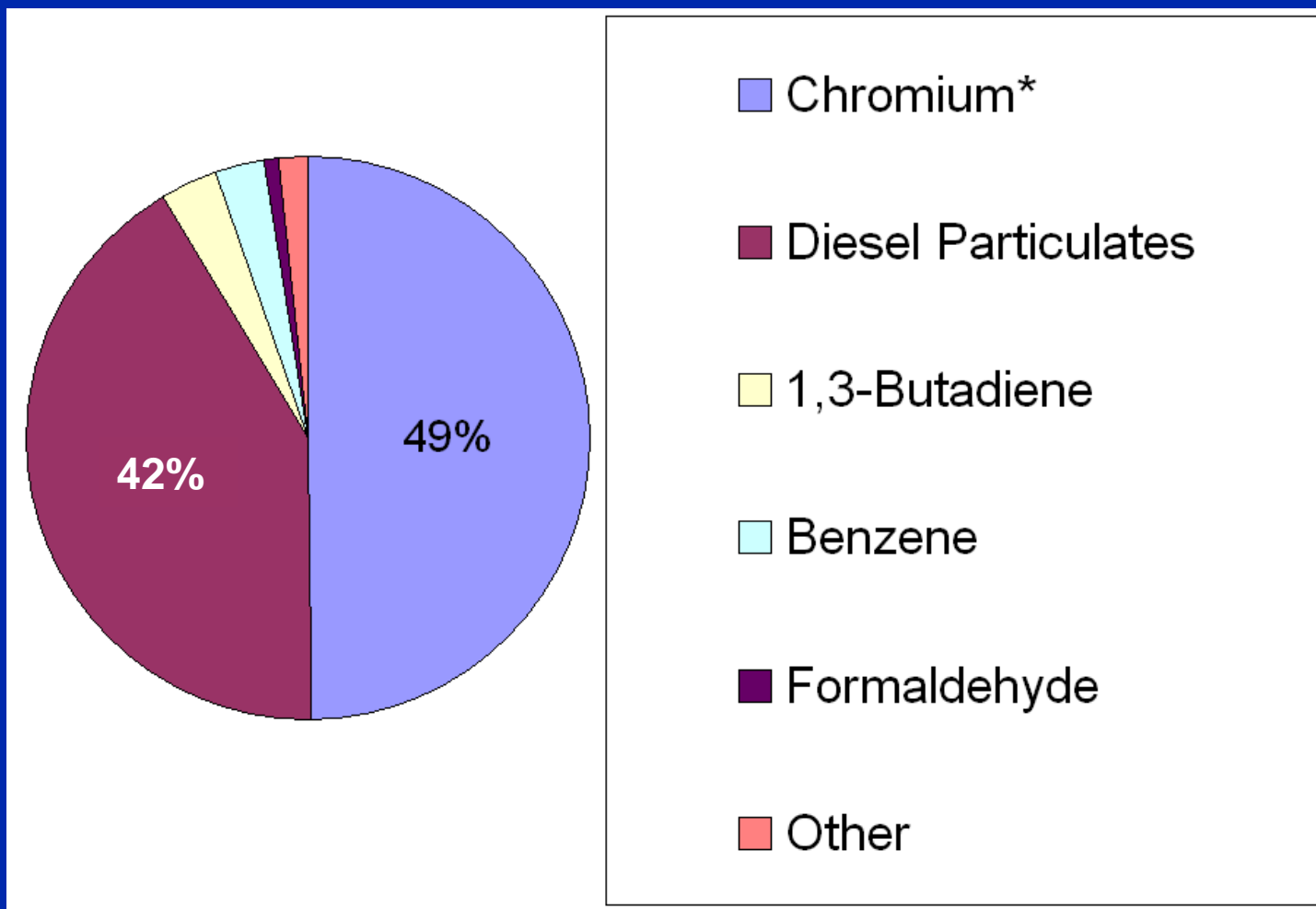
* denotes TACs with large uncertainties

Geographic Distribution of Total Chromium Emissions

Chromium Total Emissions (lbs/day)

< 0.005 | 0.005 - 0.01 | 0.01 - 0.1 | 0.1 - 0.5 | 0.5 - 1.0 | 1.0 - 2.5

0   10   20   40   60   80   Kilometers

Geographic Distribution of Total DPM Emissions

DPM Total Emissions (lbs/day)

< 1 | 2 - 10 | 11 - 50 | 51 - 100 | 101 - 250 | 251 - 420

0   10   20   40   60   80   Kilometers

N

Cancer Risk-weighted Emissions
16 equivalent pounds/day

Legend:
- On-road Mobile
- Construction & Demolition*
- Construction Equipment
- Aircraft
- Livestock Waste
- Fugitive Windblown Dust*
- Paved Road Dust*
- Farm Equipment
- Other

Pie chart values: 23%, 22%, 19%, 10%, 4%, 15%
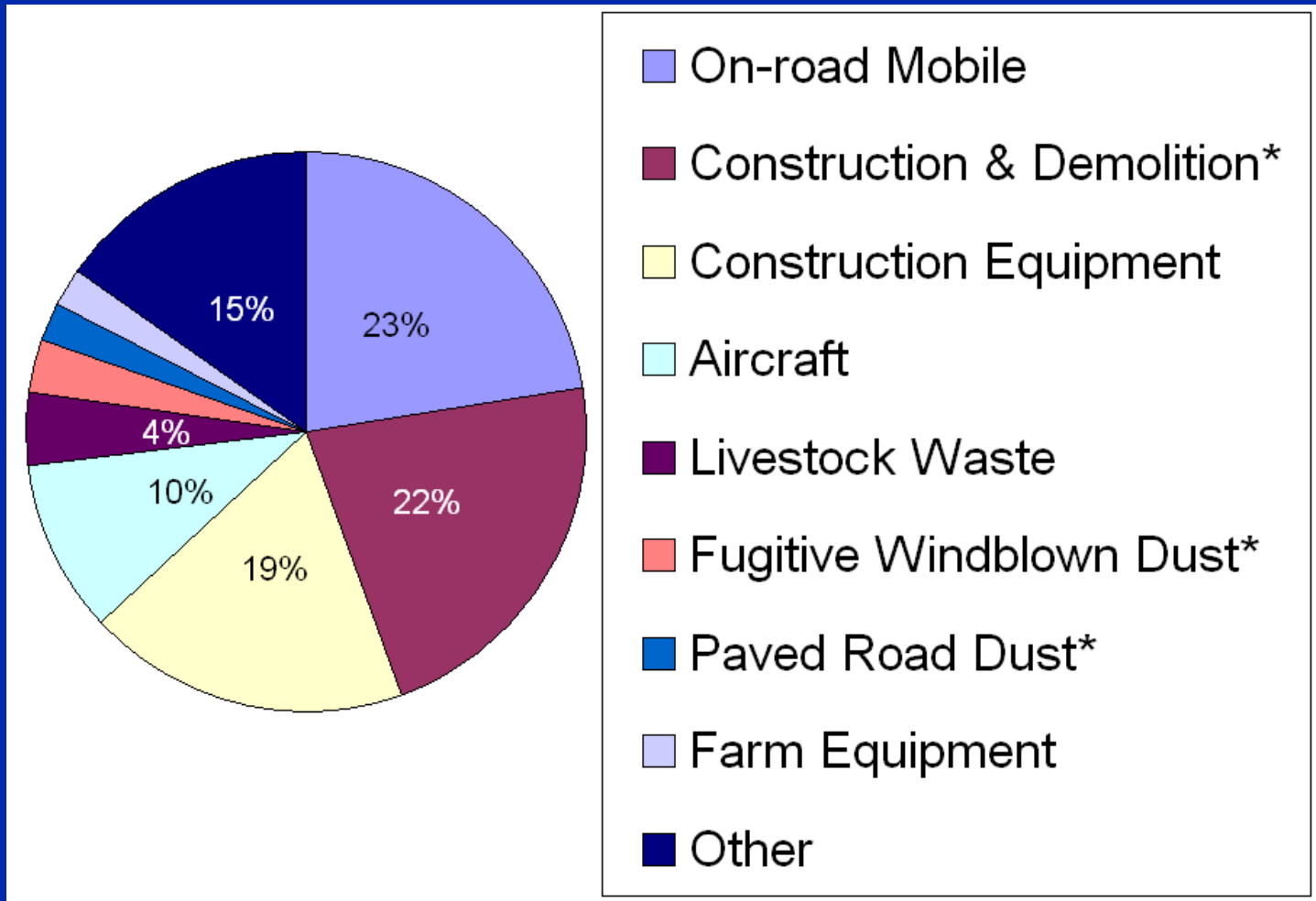
* denotes categories with large uncertainties

Chronic Risk-weighted Emissions
25 equivalent tons/day
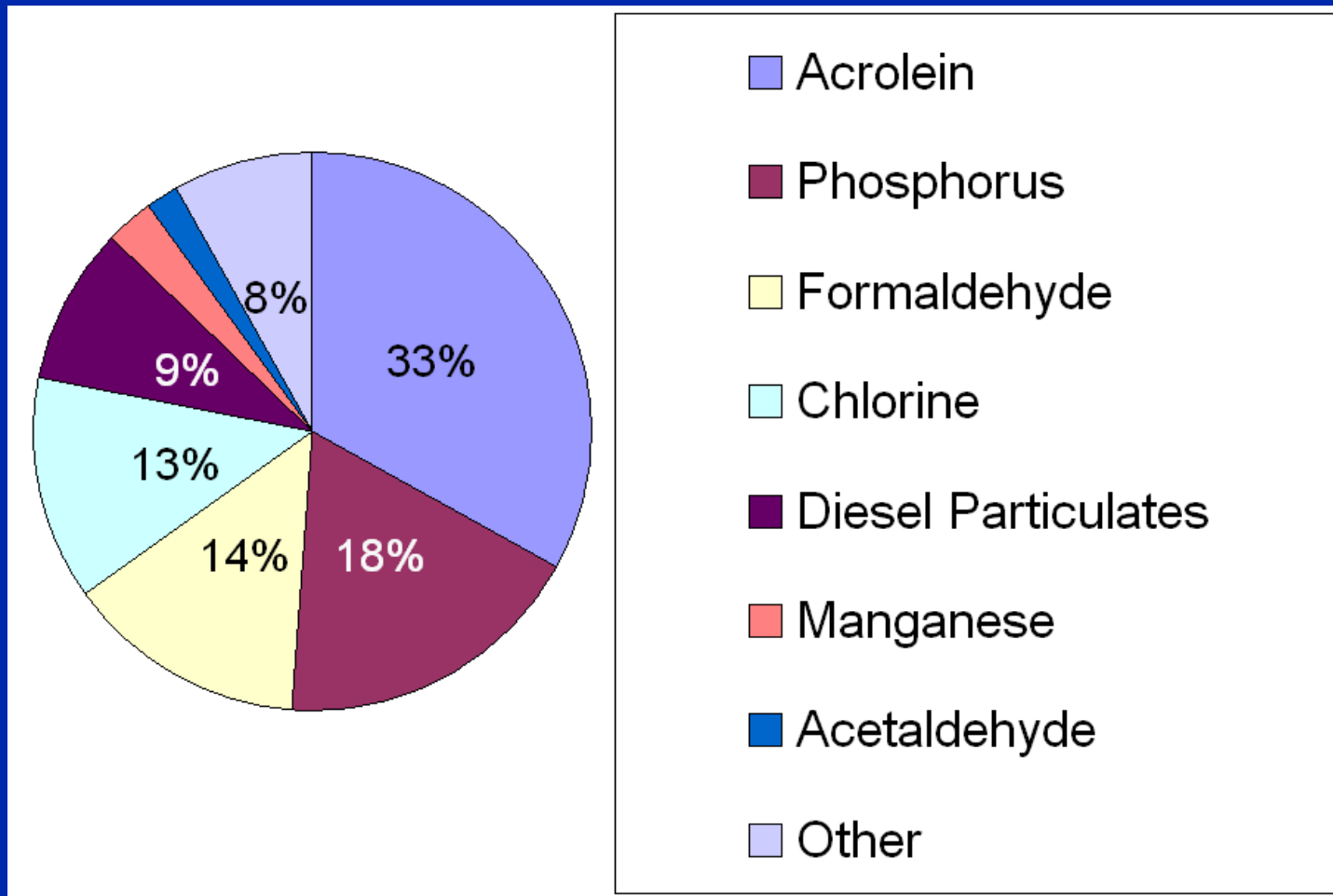
Pie chart:
- Acrolein: 33%
- Phosphorus: 18%
- Formaldehyde: 14%
- Chlorine: 13%
- Diesel Particulates: 9%
- Manganese
- Acetaldehyde
- Other: 8%

Chronic Risk-weighted Emissions
25 equivalent tons/day

Pie chart legend:
- Onroad Mobile Sources — 24%
- Aircraft — 16%
- Paved Road Dust — 13%
- Construction & Demolition — 11%
- Construction & Mining Equipment — 7%
- Lawn & Garden Equipment — 5%
- Residential Fuel Combustion — 5%
- Other — 19%

Acute Risk-weighted Emissions
2.8 equivalent tons/day

Pie chart legend:
- Acrolein
- Formaldehyde
- Arsenic
- Benzene
- Chlorine
- Other

95%

Acute Risk-weighted Emissions
2.8 equivalent tons/day

Pie chart:
- Aircraft — 39%
- Onroad Mobile Sources — 39%
- Lawn & Garden Equipment — 9%
- Recreational Boats — 6%
- Other — 7%
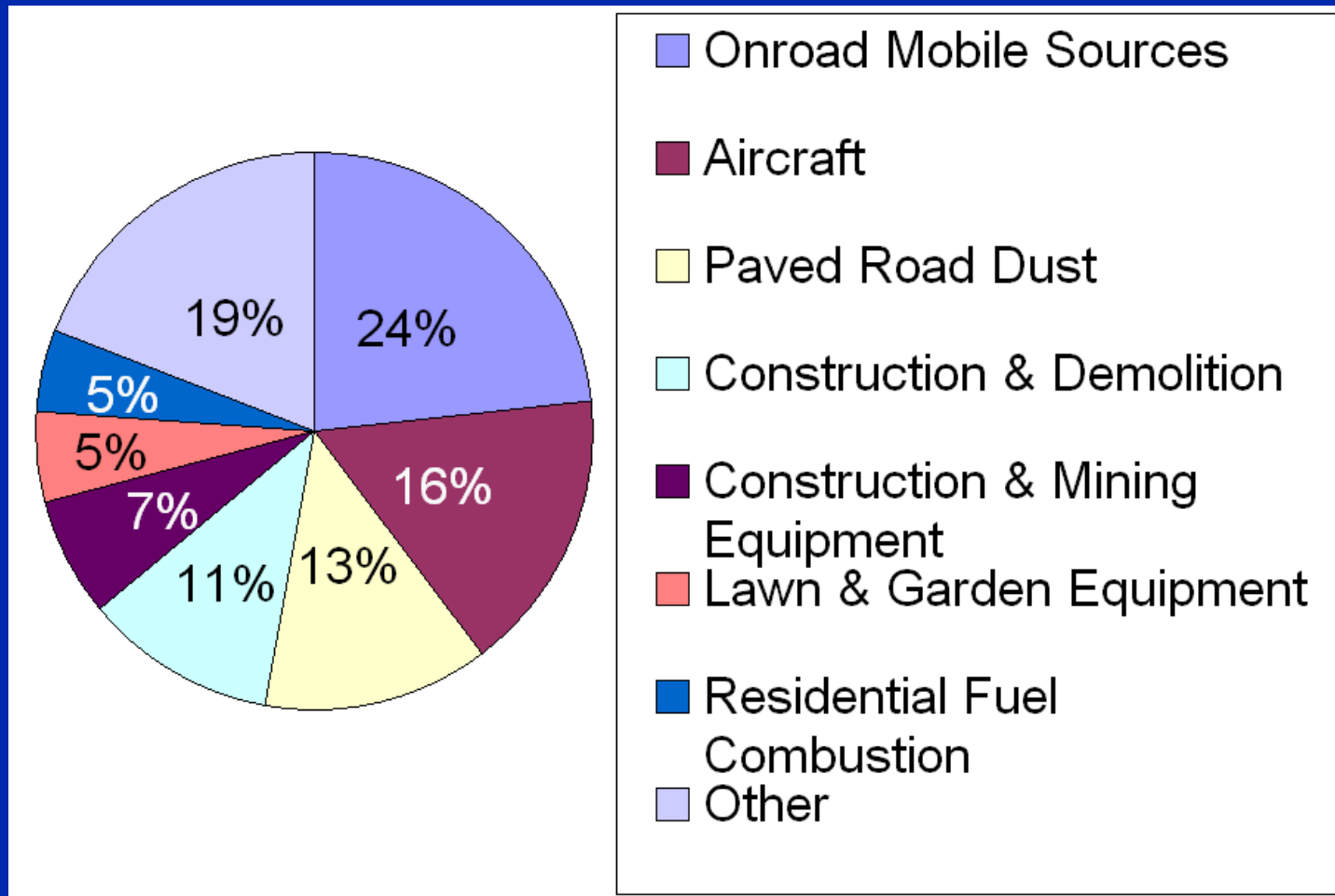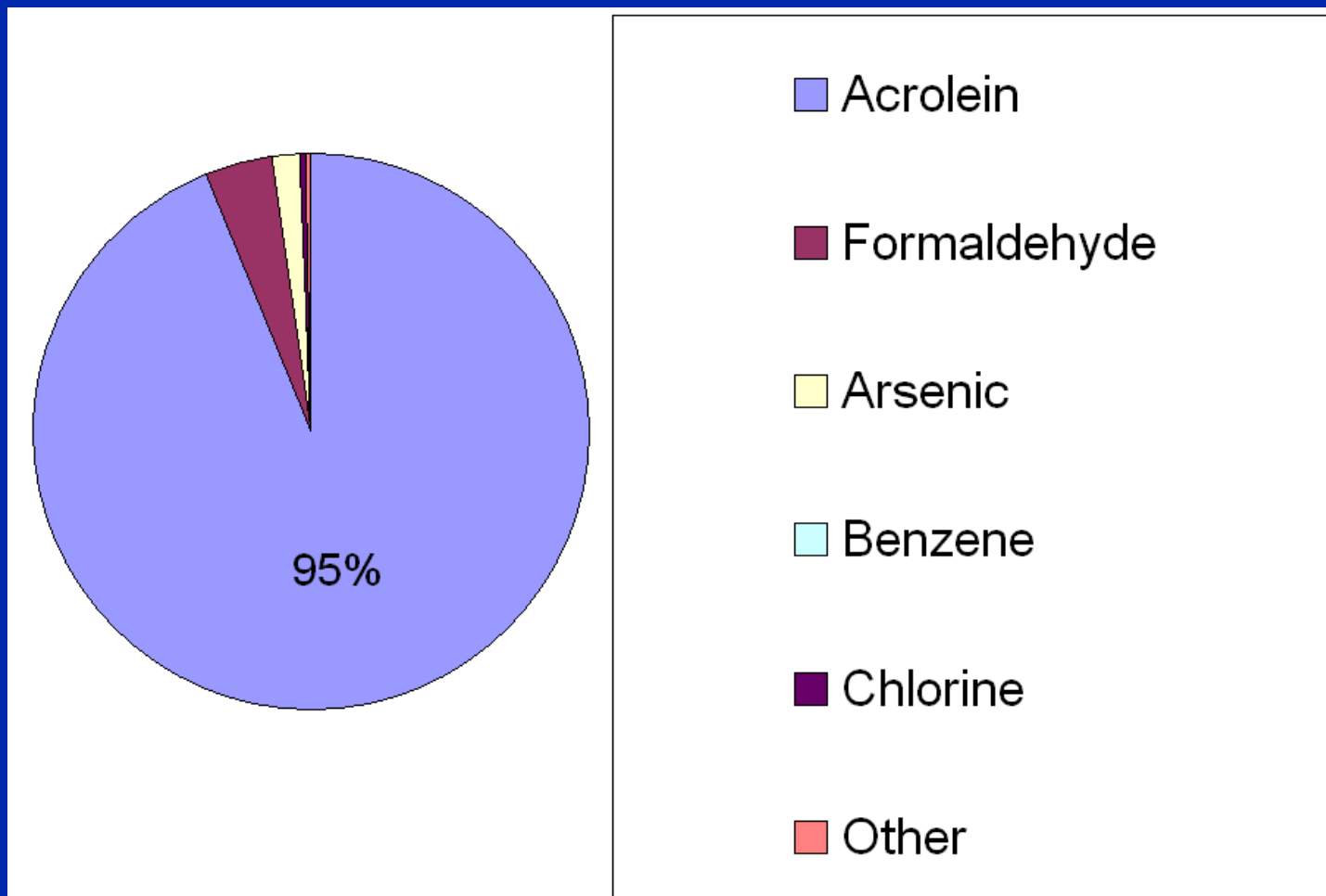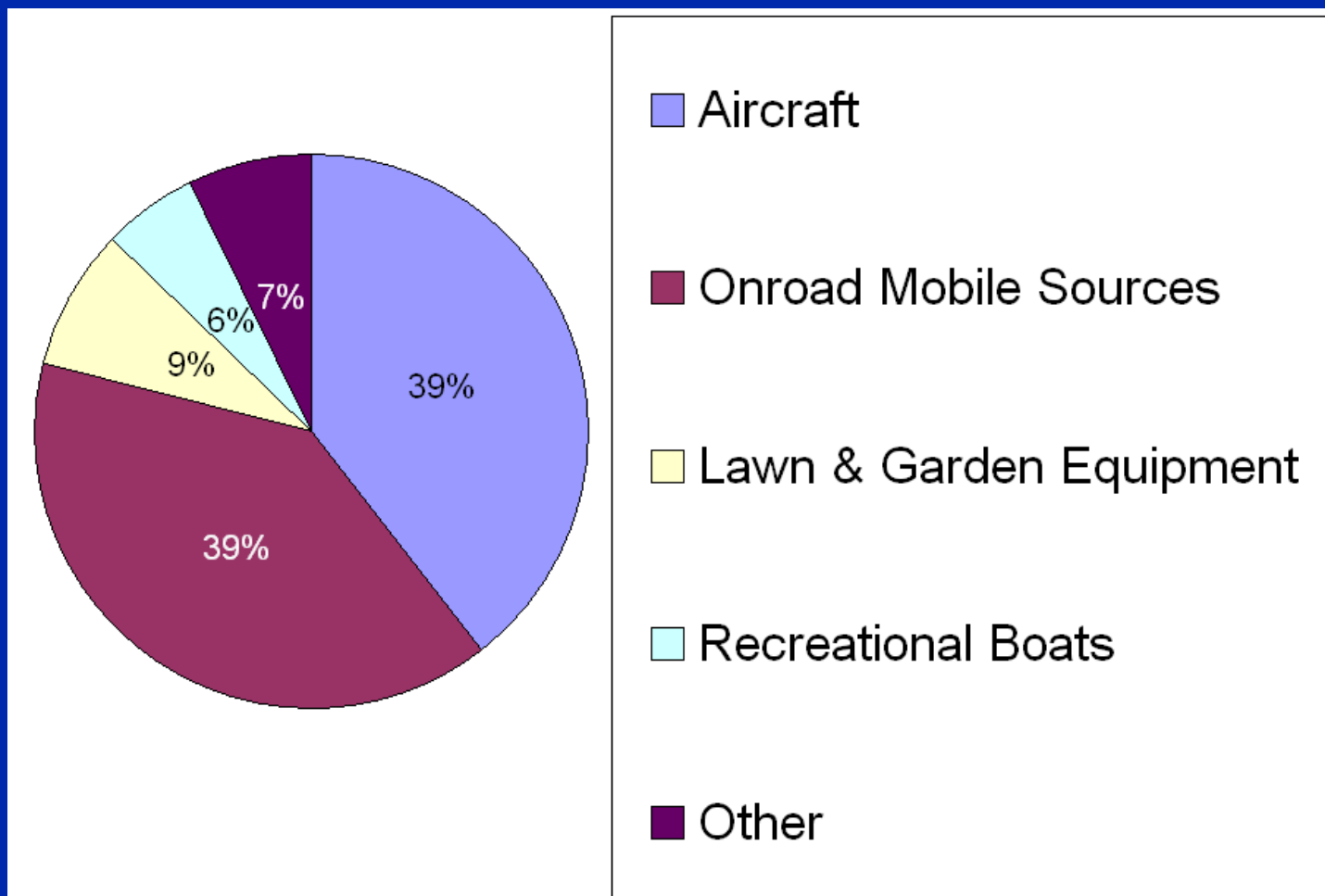
Geographic Distribution of Total Acrolein Emissions

Acrolein Total Emissions (lbs/day)

< 2.0 | 2.1 - 10.0 | 10.1 - 25.0 | 25.1 - 40.0 | 40.1 - 55.0 | 55.1 - 72.0

0   10   20   40   60   80   Kilometers

N
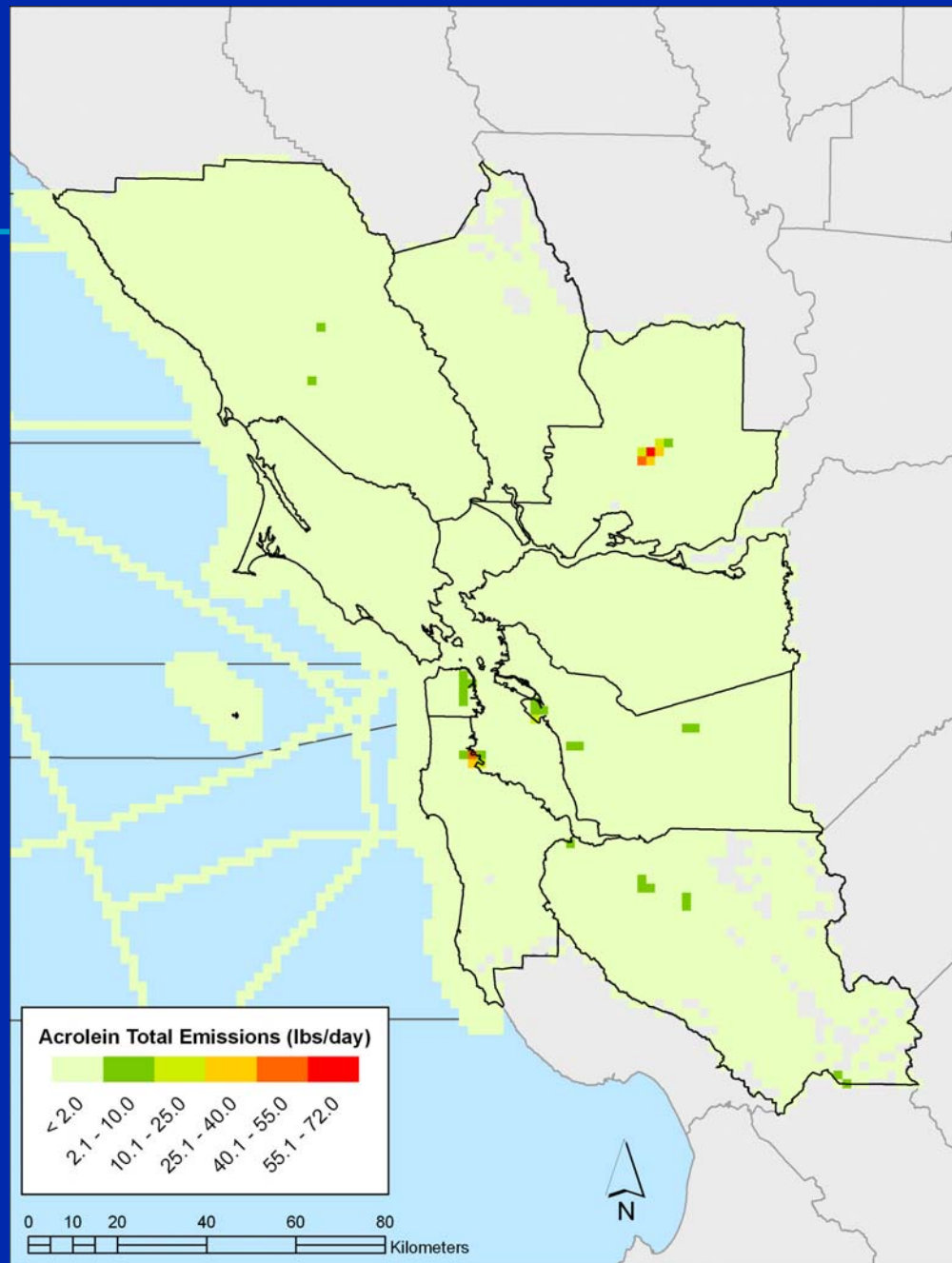
Geographic Distribution of Total MTBE Emissions

MTBE Total Emissions (lbs/day)

< 5   6 - 25   26 - 75   76 - 200   201 - 300   301 - 440

0   10   20   40   60   80   Kilometers

N
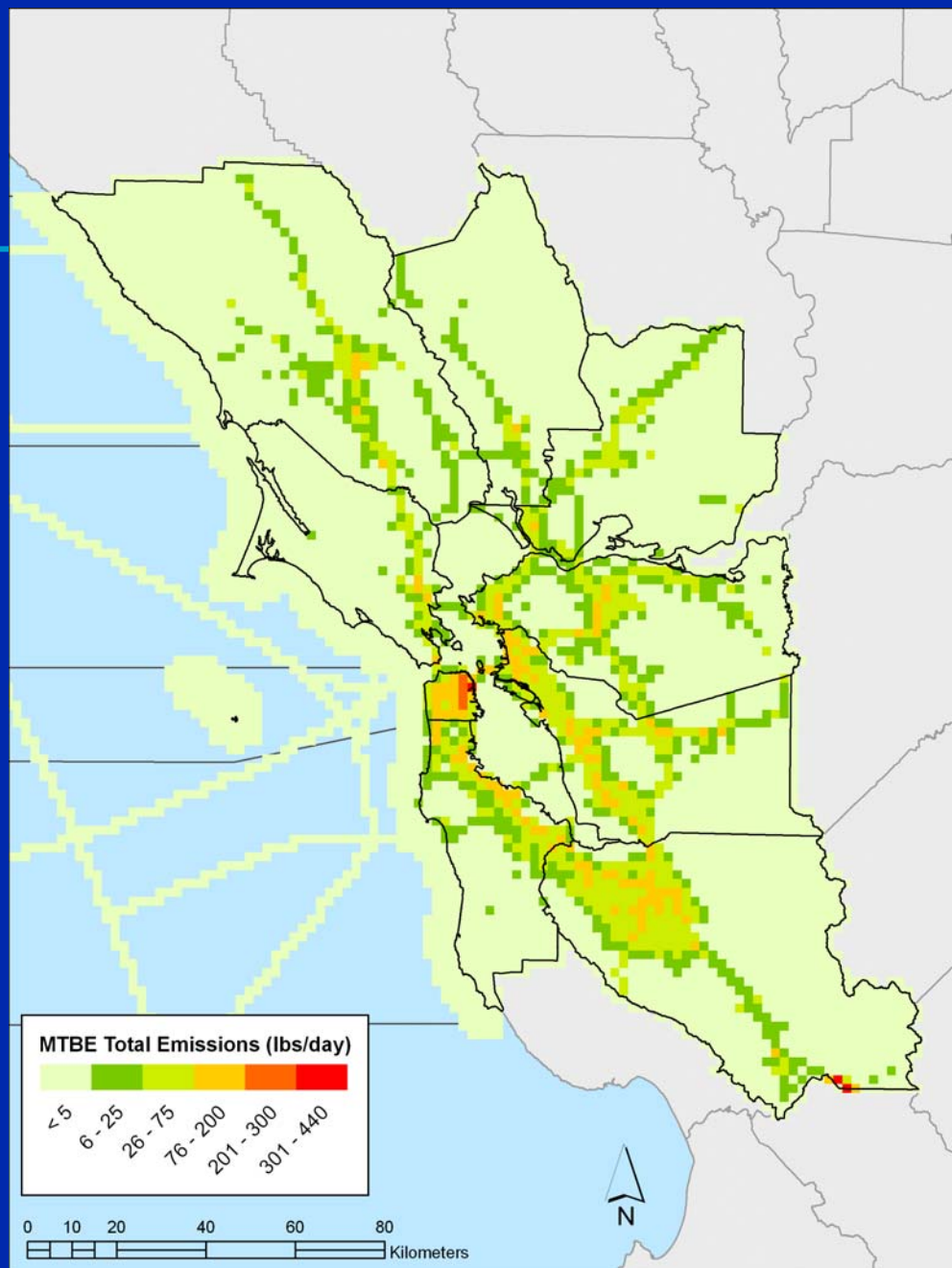
Geographic Distribution of Formaldehyde Emissions

Formaldehyde Total Emissions (lbs/day)

< 5   6 - 25   26 - 50   51 - 100   101 - 250   251 - 480

0   10   20   40   60   80   Kilometers

N
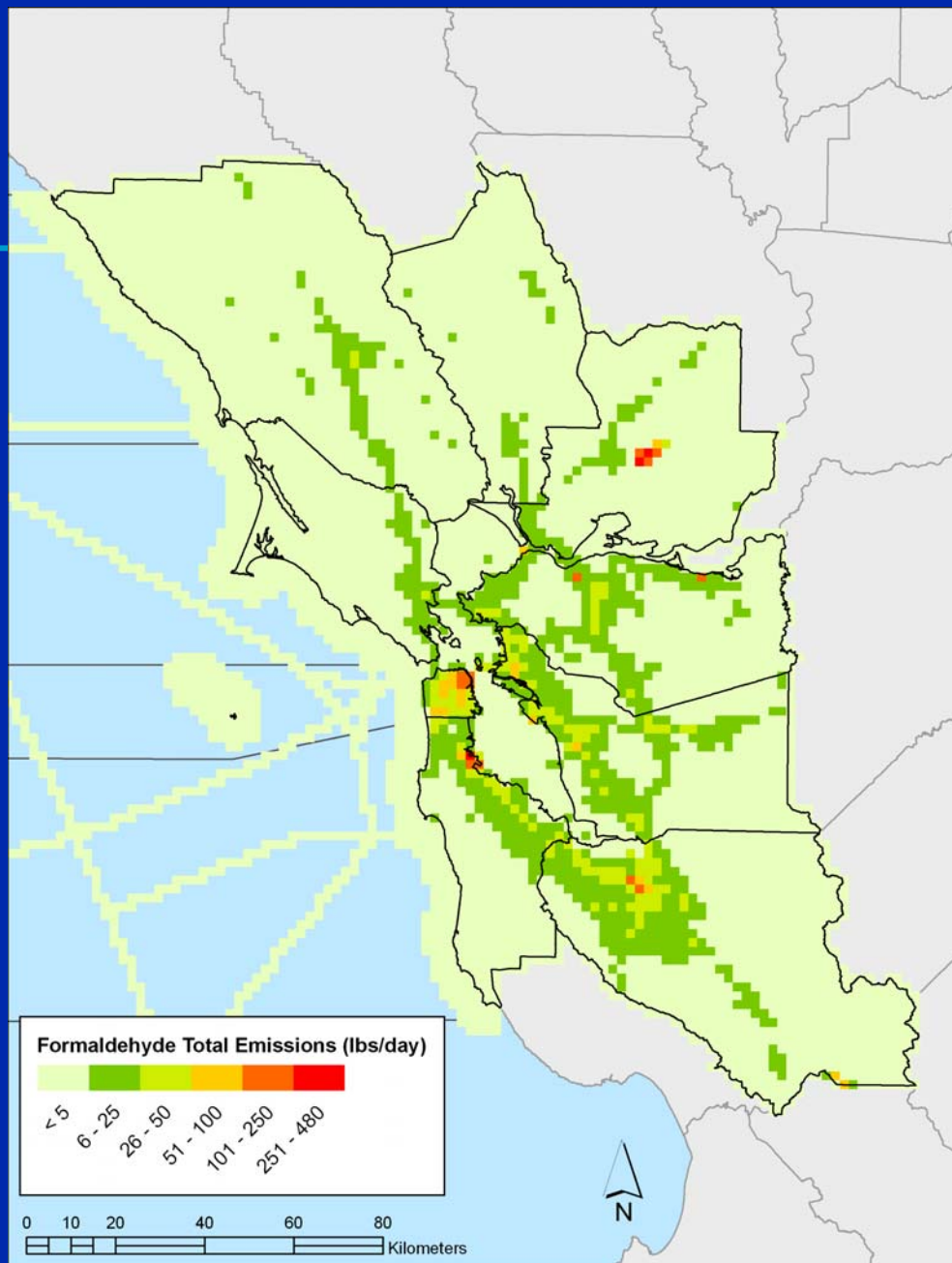
Strengths of the TAC Inventories

- Emissions for on-road mobile sources were estimated with EPA-recommended methods and California-specific chemical speciations.

- Emissions for point sources were directly reported.

- Spatial allocations are accurate and well-resolved for the modeling grid (2 km × 2 km).

Weaknesses of the TAC Inventories

- Some TACs are likely omitted (not components of TOG or PM_{10} or infrequently measured for chemical speciation profiles).
  - Quinoline and hydrazine are among the EPA's designated urban air toxics.
  - Others include radionuclides, titanium tetrachloride, hydrochloric acid, hydrofluoric acid, and sulfuric acid.
- Chemical speciation profiles contain significant uncertainties.
- Conservative assumptions were applied. For example, chromium compounds are emitted as chromium (VI) rather than chromium (III).

Primary Recommendations

- Prioritize TACs and continue inventory development and revisions using bottom-up methods.

- Add emissions for omitted TACs.

- Investigate emissions of chromium (VI) from sources of fugitive dust.

Emission Inventory-Based Site Evaluation

Legend:
- **School Locations** ●
- **Freeway/Interstate** ∿

DPM Cancer RWE × Total Population

Impacts of DPM on Population