

# METR/ENVS 113

## Lecture 5: Ambient Air Pollution (Part 2)

SJSU Fall Semester 2020

Module 2: Outdoor Air Pollution

Frank R. Freedman (Course Instructor)

# Previous Lecture

- **Air Pollution: Definitions**
  - Formal Definition
  - Ambient Air Pollution
- **Air Pollution: Concentration, Duration and Health Effects**
  - Acute versus Chronic Health Effects & Exposure
  - Long-term versus short-term exposure
  - Levels of Concern for Health Effects
- **Air Pollution: Regulation**

# This Lecture

- **Air Pollution: Definitions**

- Formal Definition
- Ambient Air Pollution

- **Air Pollution: Concentration, Duration and Health Effects**

- Acute versus Chronic Health Effects & Exposure
- Long-term versus short-term exposure
- Levels of Concern for Health Effects

- **Air Pollution: Regulation**

# Outline

- **Air Pollution: Regulation**
  - Historical Context
  - Clean Air Act 1970
  - Ambient Air Standards & Criteria Air Pollutants
  - Implementation & Air Quality Agencies
  - Successes & Current Challenges

# Outline

- **Air Pollution: Regulation**
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  - Clean Air Act 1970
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  - Successes & Current Challenges

# Donora, Pennsylvania, October 29, 1948



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# Donora, Pennsylvania, October 29, 1948 ... Noontime!



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# Donora, Pennsylvania, October 29, 1948 ... Noontime!



## About the incident ...

- Major air pollution episode over five days (27-31Oct)
- Emission sources: Major industrial sources (steel and iron mills and smelters, coal fired power plants, boilers and furnaces)
- Meteorological Conditions: Strong high pressure, prolonged stagnant air conditions, temperature inversions
- Air Pollutants: Smoke, SO<sub>2</sub> gas, others
- Health Effects: 20 deaths, estimated 40% of town experiences serious respiratory problems. 50 more deaths occurred within a month after event.
- [https://en.wikipedia.org/wiki/1948\\_Donora\\_smog](https://en.wikipedia.org/wiki/1948_Donora_smog)



# Los Angeles (1950s, 1960s)



## Key Points

- Increasingly bad air pollution in Los Angeles area
- Major air pollution sources (motor vehicles & industry)
- High sunlight and summer-time inversions (“photochemical smog”)
- Photochemical smog – ground-level ozone (O<sub>3</sub>) and related species
- Motivated regulations

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# Clean Air Act & National Ambient Air Quality Standards

- Clean Air Act 1970
  - First major nationwide air quality regulation
  - Established creation of Environmental Protection Agency (EPA)
- National Ambient Air Quality Standards (NAAQS)
  - Thresholds for ambient air concentrations for “criteria air pollutants”.
  - Air concentrations must be less than NAAQS to comply with Clean Air Act.
- NAAQS values are established ...
  - based on health effects research.
  - to be protective for sensitive populations with adequate margin.
- California has independent standards, alongside NAAQS.

# Clean Air Act 1970: Criteria Air Pollutants

- NAAQS are set for seven “criteria” air pollutants
  - Ozone ( $O_3$ )
  - Sulfur Dioxide ( $SO_2$ )
  - Nitrogen Dioxide ( $NO_2$ )
  - Carbon Monoxide (CO)
  - Particulate Matter less than  $10\text{ }\mu\text{m}$  ( $PM_{10}$ )
  - Particulate Matter less than  $2.5\text{ }\mu\text{m}$  ( $PM_{2.5}$ )
  - Lead (Pb)

# Ambient Air Quality Standards: Gaseous

## Pollutants

### California

### NAAQS

#### Ozone

1-hour average

90 ppbv

--

8-hour average

70 ppbv

70 ppbv

#### CO

1-hour average

20 ppmv

35 ppmv

8-hour average

9 ppmv

9 ppmv

#### NO<sub>2</sub>

1-hour average

180 ppbv

100 ppbv

annual average

30 ppbv

53 ppbv

#### SO<sub>2</sub>

1-hour average

250 ppbv

75 ppbv

24-hour average

40 ppbv

--

# Ambient Air Quality Standards: Particulate Pollutants

**PM<sub>2.5</sub>**: (particles smaller than 2.5  $\mu\text{m}$ )

NAAQS (annual): 12  $\mu\text{g}/\text{m}^3$

NAAQS (24-hour): 35  $\mu\text{g}/\text{m}^3$

**PM<sub>10</sub>**: (particles smaller than 10  $\mu\text{m}$ )

California (annual): 20  $\mu\text{g}/\text{m}^3$

California (24-hour): 50  $\mu\text{g}/\text{m}^3$

NAAQS (24-hour): 150  $\mu\text{g}/\text{m}^3$

## Applying ambient air quality standards (Example 1: CA 1-hr ozone standard = 90 ppb)

*“The concentration of ozone measured at air quality monitoring stations across an air district averaged over 1 hour cannot exceed 90 ppb.”*

- If ozone concentration does not exceed standard at all monitoring stations, air district is in “attainment” of the 1-hour ozone standard.
- If ozone concentration exceeds at any monitoring station, air district is in “non-attainment” of the 1-hour ozone standard.

## Applying ambient air quality standards (Example 2: NAAQS 24-hr PM<sub>2.5</sub> Standard = 35 µg/m<sup>3</sup>)

*“The concentration of PM<sub>2.5</sub> measured at air quality monitoring stations across an air district averaged over 24 hours cannot exceed 35 µg/m<sup>3</sup> .”*

- If PM<sub>2.5</sub> concentration does not exceed standard at all monitoring stations, air district is in “attainment” of the 24-hour PM<sub>2.5</sub> standard.
- If PM<sub>2.5</sub> concentration exceeds at any monitoring station, air district is in “non-attainment” of the 24-hour PM<sub>2.5</sub> standard.



## Applying ambient air quality standards (Example 3: CA annual NO<sub>2</sub> standard = 30 ppb)

*“The concentration of nitrogen dioxide measured at air quality monitoring stations across an air district averaged over one year cannot exceed 30 ppb.”*

- If NO<sub>2</sub> concentration does not exceed standard at all monitoring stations, air district is in “attainment” of the annual NO<sub>2</sub> standard.
- If NO<sub>2</sub> concentration exceeds at any monitoring station, air district is in “non-attainment” of the annual NO<sub>2</sub> standard.

# Interpreting the standards: SO<sub>2</sub>

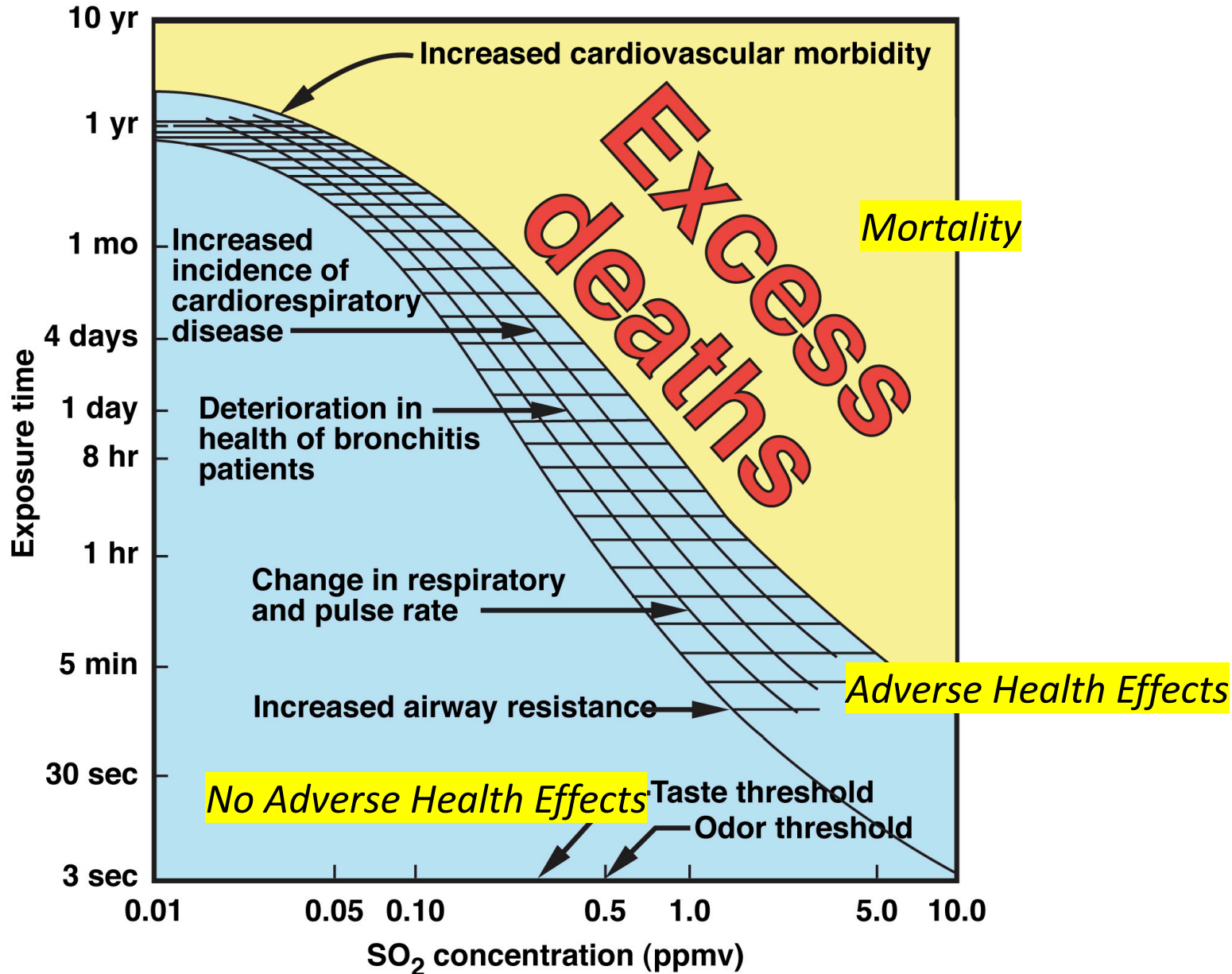
|                                                                                                           | California     | NAAQS          |
|-----------------------------------------------------------------------------------------------------------|----------------|----------------|
| <b>Ozone</b>                                                                                              |                |                |
| 1-hour average                                                                                            | 90 ppbv        | --             |
| <b>8-hour average</b>                                                                                     | <b>70 ppbv</b> | 70 ppbv        |
| <b>CO</b>                                                                                                 |                |                |
| 1-hour average                                                                                            | 20 ppmv        | 35 ppmv        |
| 8-hour average                                                                                            | 9 ppmv         | 9 ppmv         |
| <b>NO<sub>2</sub></b>                                                                                     |                |                |
| 1-hour average                                                                                            | 180 ppbv       | 100 ppbv       |
| annual average                                                                                            | 30 ppbv        | 53 ppbv        |
| <b>SO<sub>2</sub></b>  |                |                |
| 1-hour average                                                                                            | 250 ppbv       | <b>75 ppbv</b> |
| 24-hour average                                                                                           | <b>40 ppbv</b> | --             |

# Natural Background Concentrations in Air

(Current-Day, remote areas ... away from major air pollution sources)

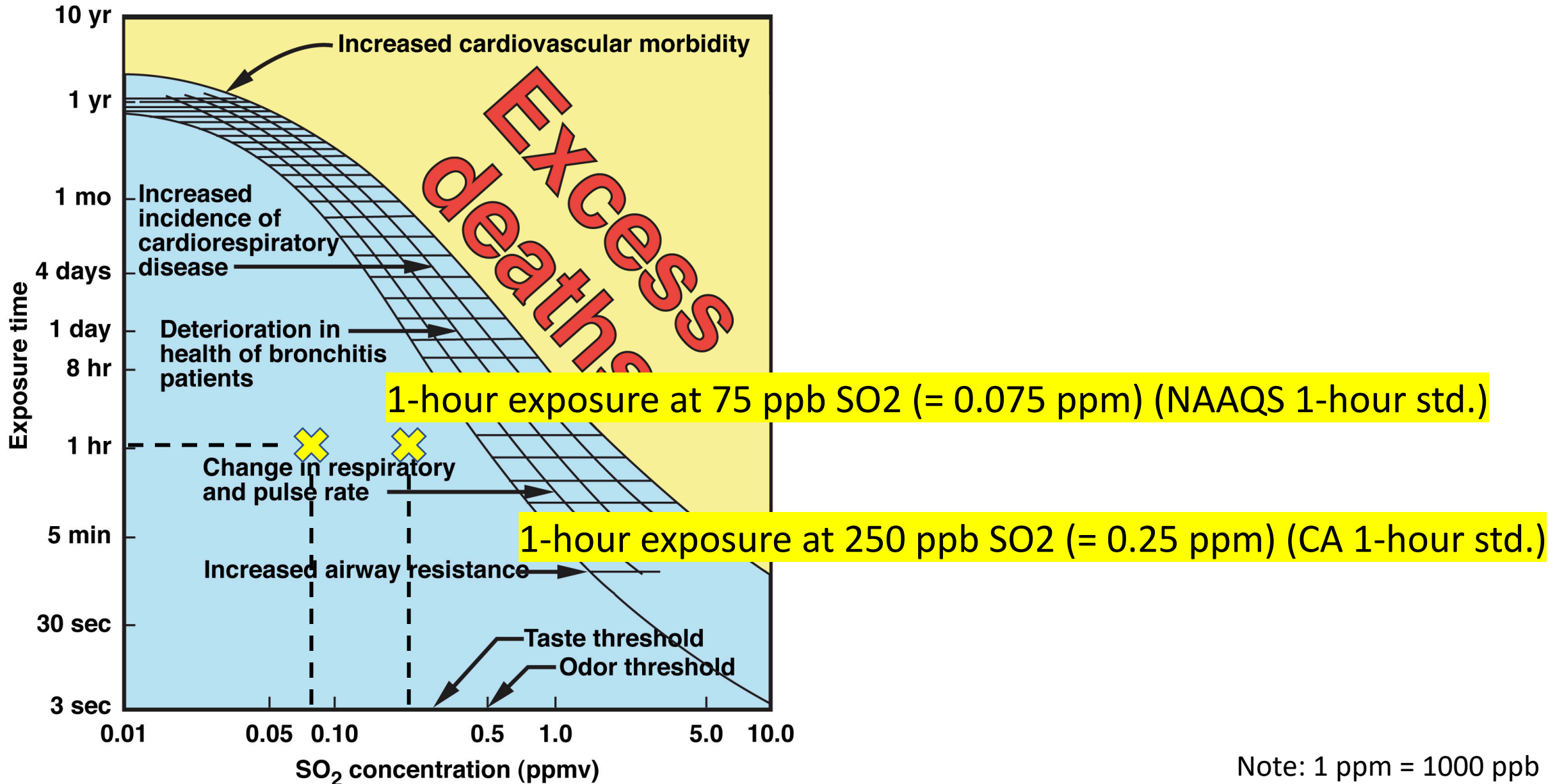
| Pollutant                           | Natural Background Concentrations | Source                                                                                                                                                                                            |
|-------------------------------------|-----------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Carbon Dioxide (CO <sub>2</sub> )   | 410 ppm                           | Mauna Loa (Hawaii)<br><a href="https://www.esrl.noaa.gov/gmd/ccgg/trends/">https://www.esrl.noaa.gov/gmd/ccgg/trends/</a>                                                                         |
| Carbon Monoxide (CO)                | 50 – 120 ppb                      | <a href="http://www.euro.who.int/_data/assets/pdf_file/0020/123059/AQG2ndEd_5_5carbonmonoxide.PDF">http://www.euro.who.int/_data/assets/pdf_file/0020/123059/AQG2ndEd_5_5carbonmonoxide.PDF</a>   |
| Nitrogen Dioxide (NO <sub>2</sub> ) | 0.2 – 5 ppb                       | <a href="http://www.euro.who.int/_data/assets/pdf_file/0017/123083/AQG2ndEd_7_1nitrogendioxide.pdf">http://www.euro.who.int/_data/assets/pdf_file/0017/123083/AQG2ndEd_7_1nitrogendioxide.pdf</a> |
| Sulfur Dioxide (SO <sub>2</sub> )   | < 1 ppb                           | <a href="http://www.temis.nl/products/so2.html">http://www.temis.nl/products/so2.html</a>                                                                                                         |

# Illustration: Sulfur Dioxide (SO<sub>2</sub>)

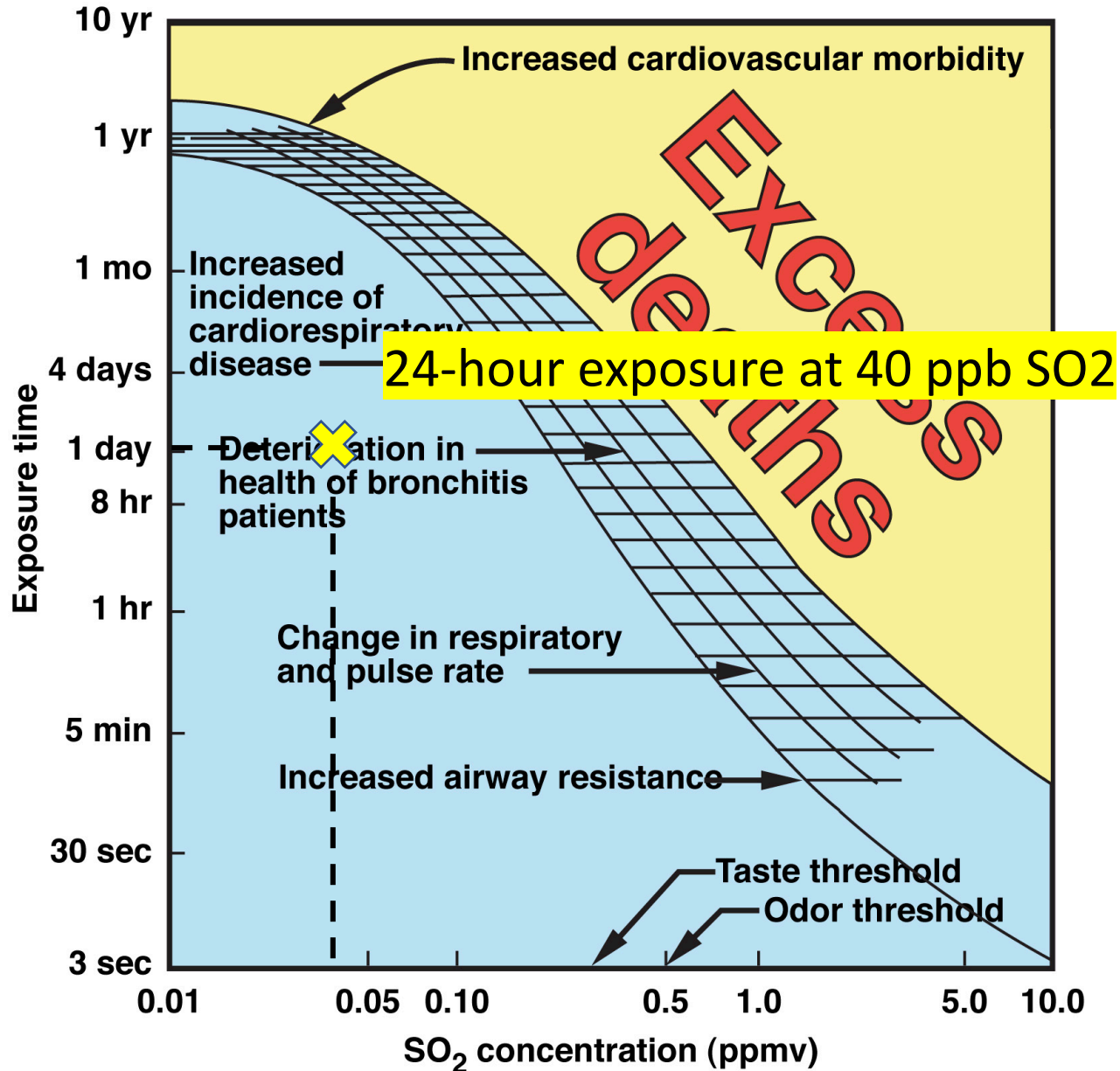


Note: 1 ppm = 1000 ppb

# Illustration: Sulfur Dioxide (SO<sub>2</sub>) 1-hour NAAQS plotted.



# Illustration: Sulfur Dioxide (SO<sub>2</sub>)



# Interpreting the standards: CO

## Ozone

1-hour average

90 ppbv

--

**8-hour average**

**70 ppbv**

70 ppbv

## CO

1-hour average

20 ppmv

35 ppmv

8-hour average

9 ppmv

9 ppmv

## NO<sub>2</sub>

1-hour average

180 ppbv

100 ppbv

annual average

30 ppbv

53 ppbv

## SO<sub>2</sub>

1-hour average

250 ppbv

75 ppbv

24-hour average

40 ppbv

140 ppbv

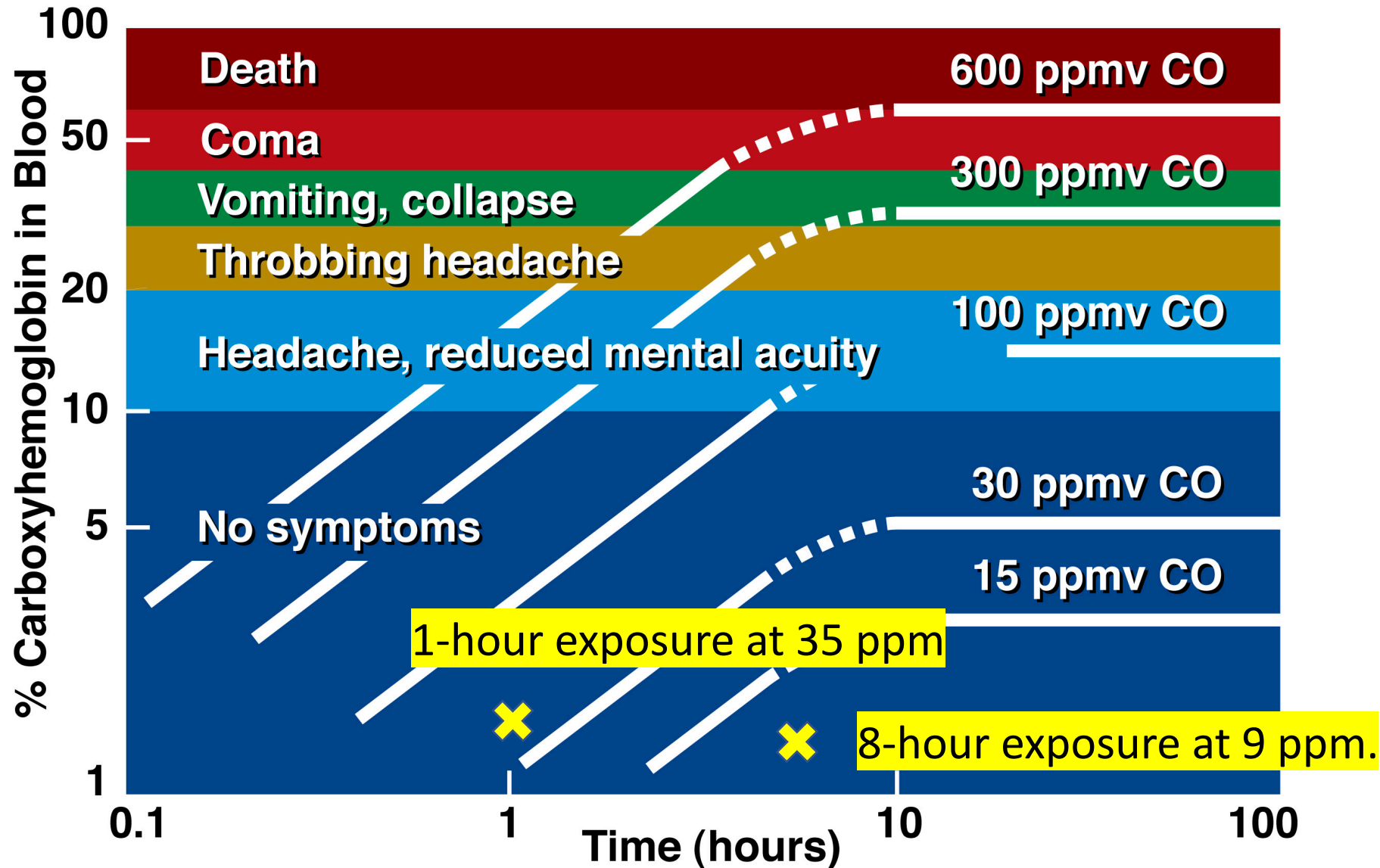
# Natural Background Concentrations in Air

(Current-Day, remote areas ... away from major air pollution sources)

| Pollutant                           | Natural Background Concentrations | Source                                                                                                                                                                                            |
|-------------------------------------|-----------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Carbon Dioxide (CO <sub>2</sub> )   | 410 ppm                           | Mauna Loa (Hawaii)<br><a href="https://www.esrl.noaa.gov/gmd/ccgg/trends/">https://www.esrl.noaa.gov/gmd/ccgg/trends/</a>                                                                         |
| Carbon Monoxide (CO)                | 50 – 120 ppb                      | <a href="http://www.euro.who.int/_data/assets/pdf_file/0020/123059/AQG2ndEd_5_5carbonmonoxide.PDF">http://www.euro.who.int/_data/assets/pdf_file/0020/123059/AQG2ndEd_5_5carbonmonoxide.PDF</a>   |
| Nitrogen Dioxide (NO <sub>2</sub> ) | 0.2 – 5 ppb                       | <a href="http://www.euro.who.int/_data/assets/pdf_file/0017/123083/AQG2ndEd_7_1nitrogendioxide.pdf">http://www.euro.who.int/_data/assets/pdf_file/0017/123083/AQG2ndEd_7_1nitrogendioxide.pdf</a> |
| Sulfur Dioxide (SO <sub>2</sub> )   | < 1 ppb                           | <a href="http://www.temis.nl/products/so2.html">http://www.temis.nl/products/so2.html</a>                                                                                                         |



# Illustration: Carbon Monoxide (CO), NAAQS standards plotted.

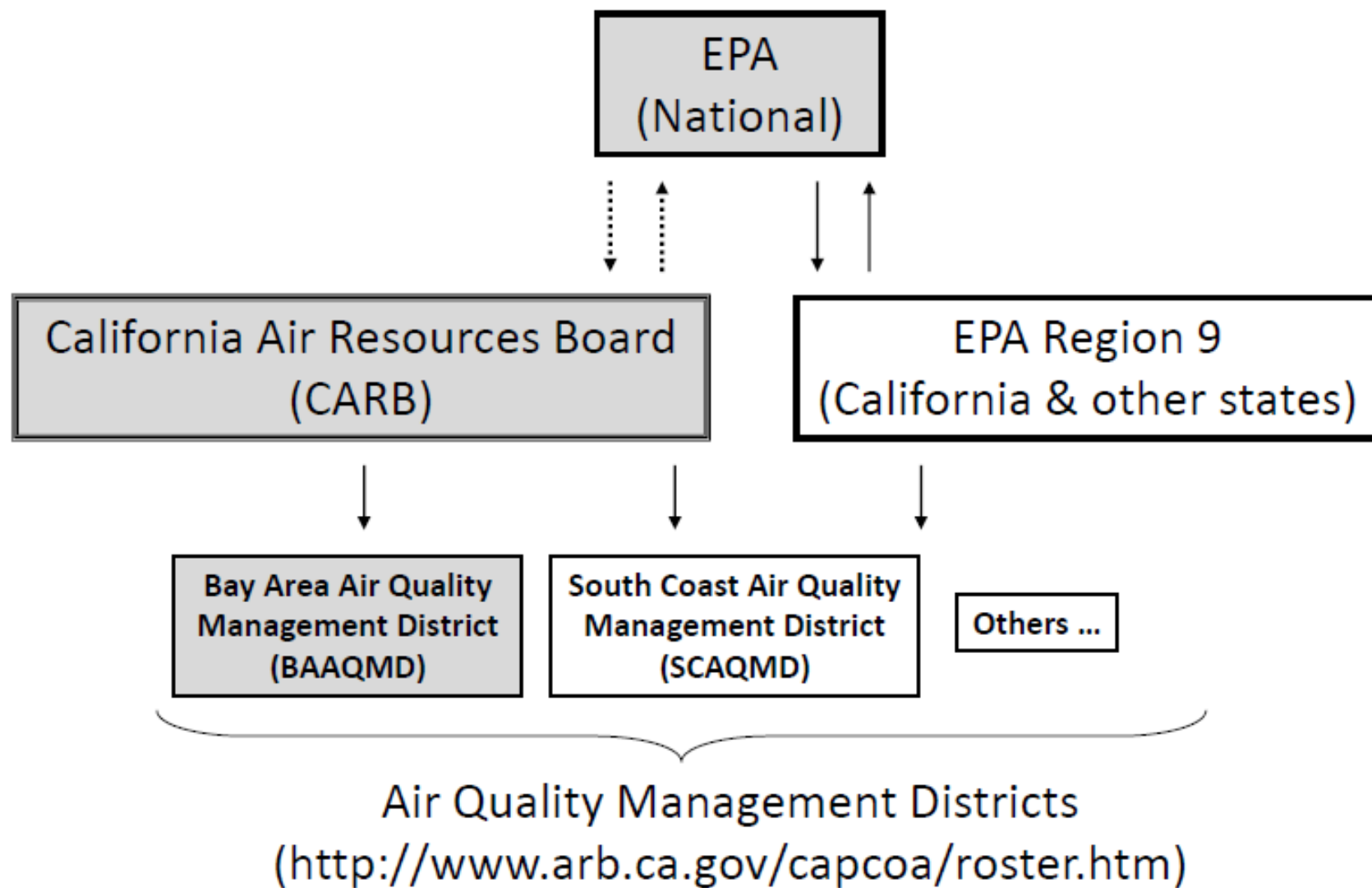


Note: 1 ppm = 1000 ppb

# Outline

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  - Successes & Current Challenges

## Air Pollution Control Agencies Hierarchy (California)



# 10 EPA Regions



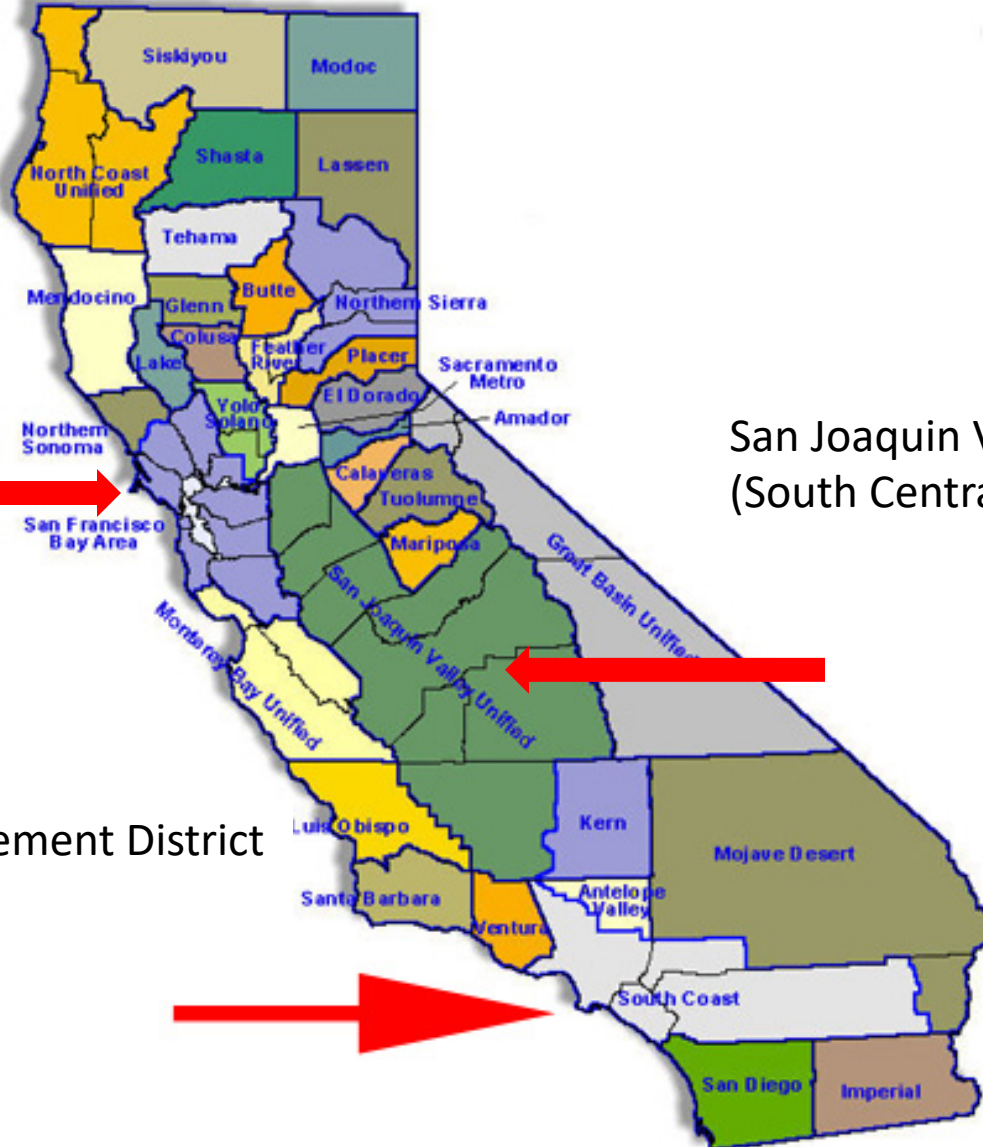
# California's 35 local Air Districts

## California Air Districts

Bay Area Air Quality  
Management District  
(BAAQMD)  
(Bay Area Air Basin)

San Joaquin Valley Air Quality Management District  
(South Central Valley)

South Coast Air Quality Management District  
(SCAQMD)  
(Los Angeles Air Basin)



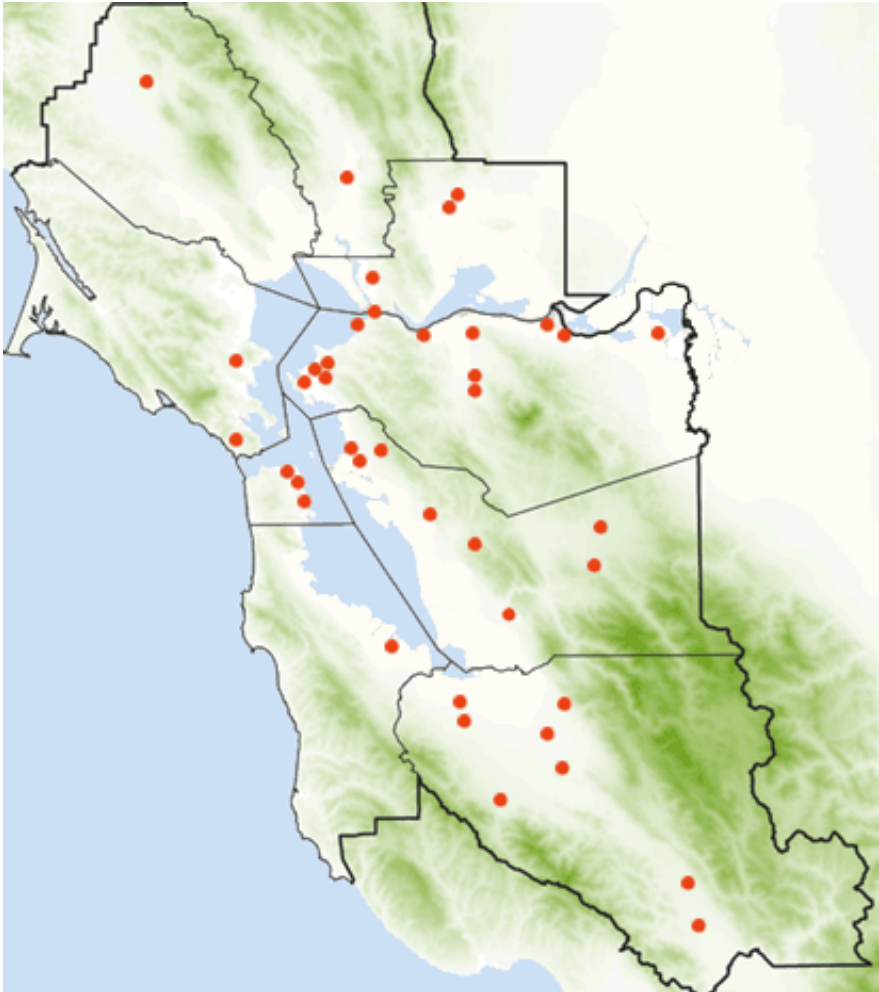
# Bay Area Air Quality Management (BAAQMD) District





# Bay Area Air Quality Management District Air Pollution Monitoring Sites ...

(<https://www.baaqmd.gov/about-air-quality/air-quality-measurement/ambient-air-monitoring-network>)



Compliance in the Bay Area with NAAQS and California state ambient air pollution standards are checked at these sites.

# San Jose: 4<sup>th</sup> and Jackson St. (BAAQMD Air Pollution Monitoring Site)





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# Improvements in U.S. Air Quality since EPA Clean Air Act Regulations

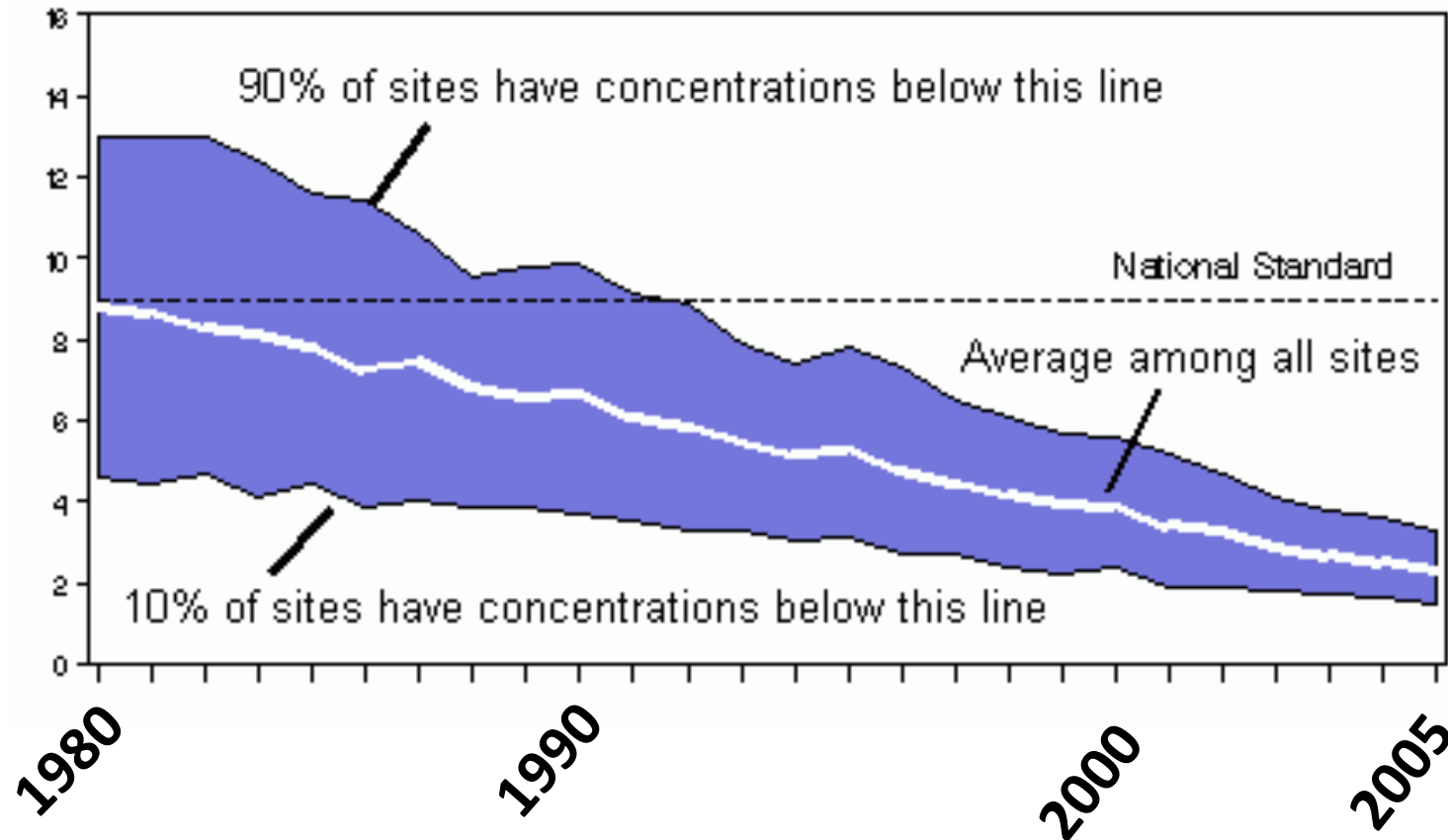
(Example: 8-Hour Average Carbon Monoxide Concentration)

## CO Air Quality, 1980 — 2005

(Based on Annual 2nd Maximum 8-hour Average)

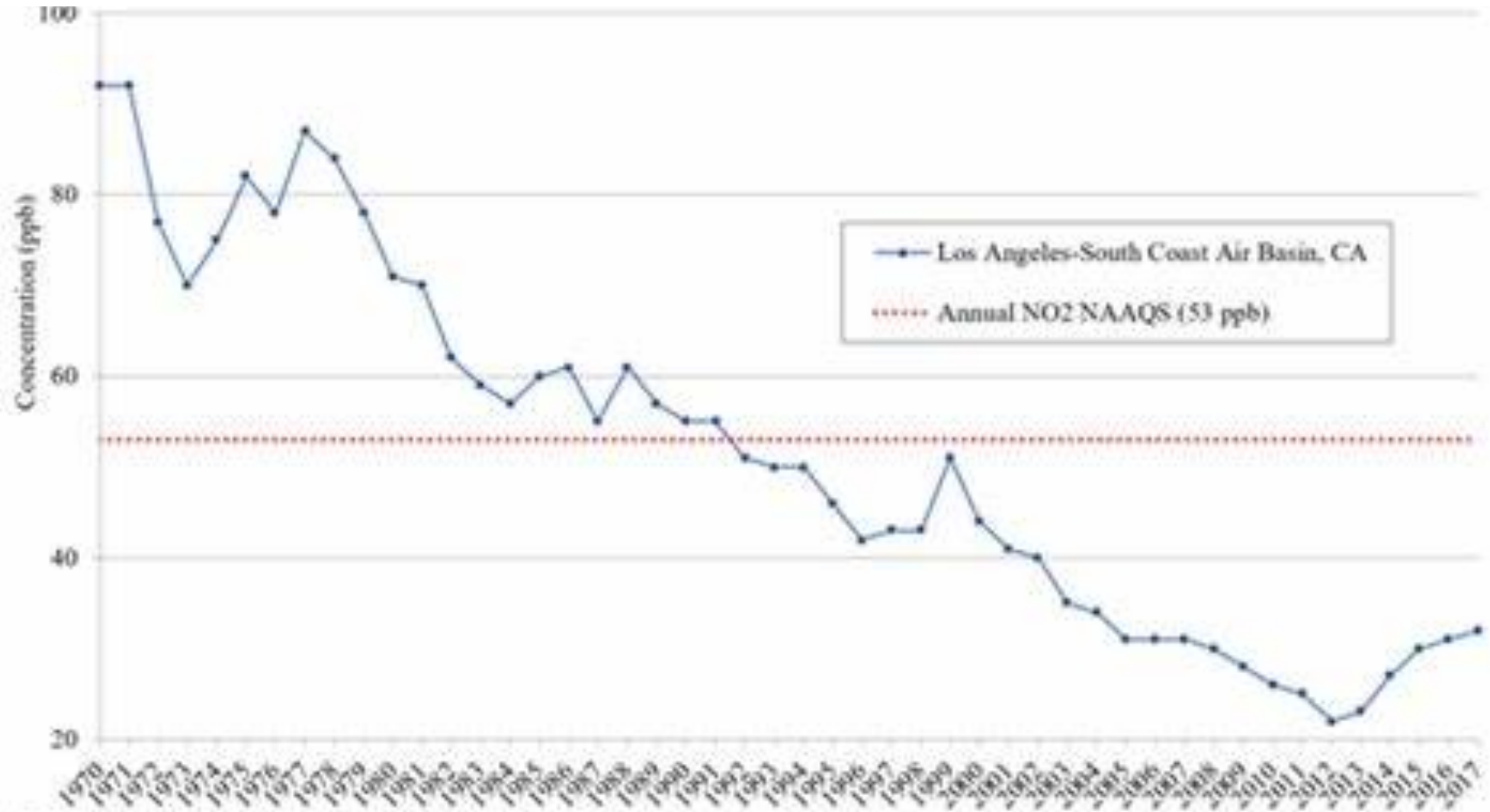
National Trend based on 152 Sites

Concentration  
(ppm)



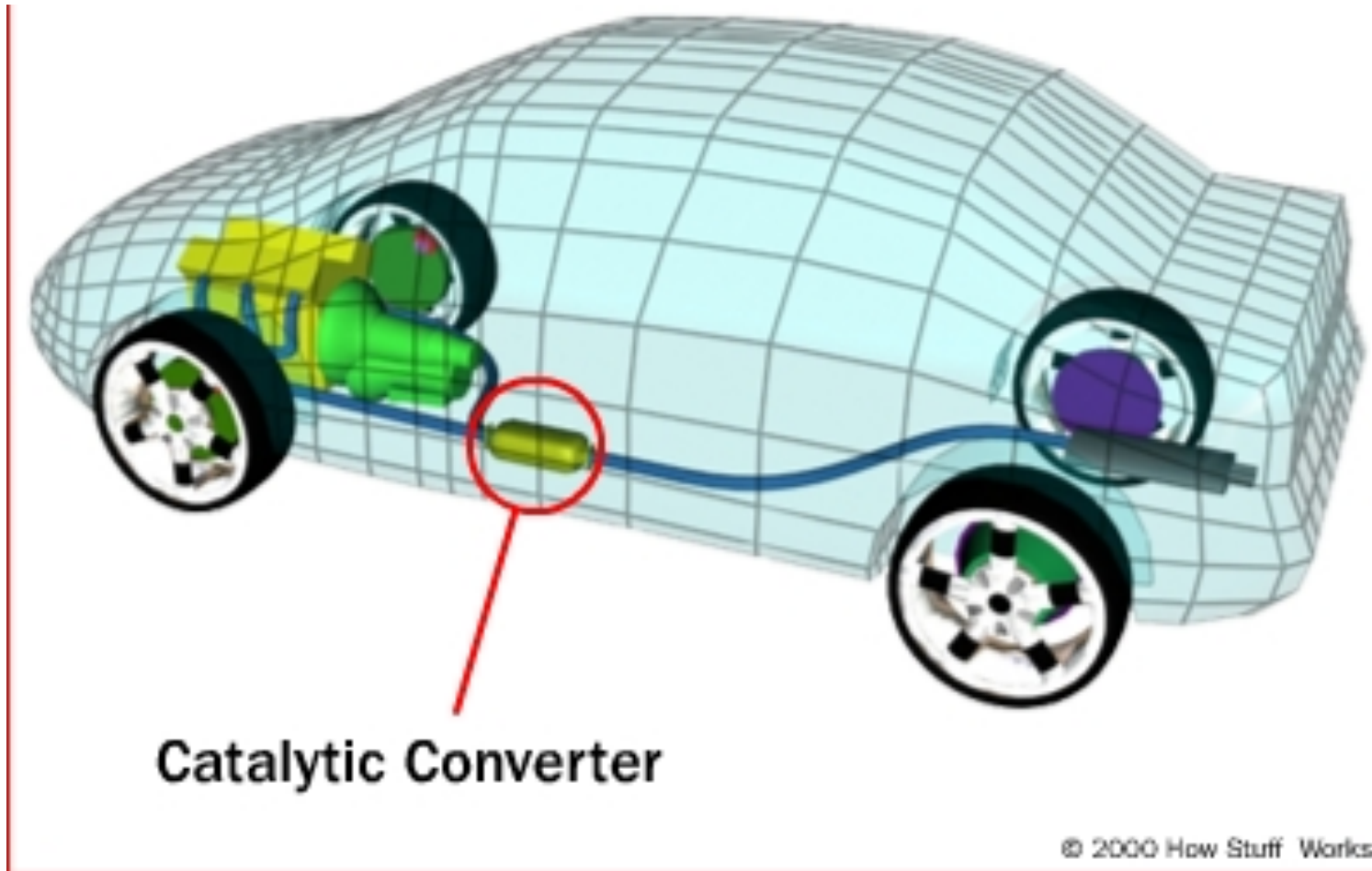
# Improvements in U.S. Air Quality since EPA Clean Air Act Regulations

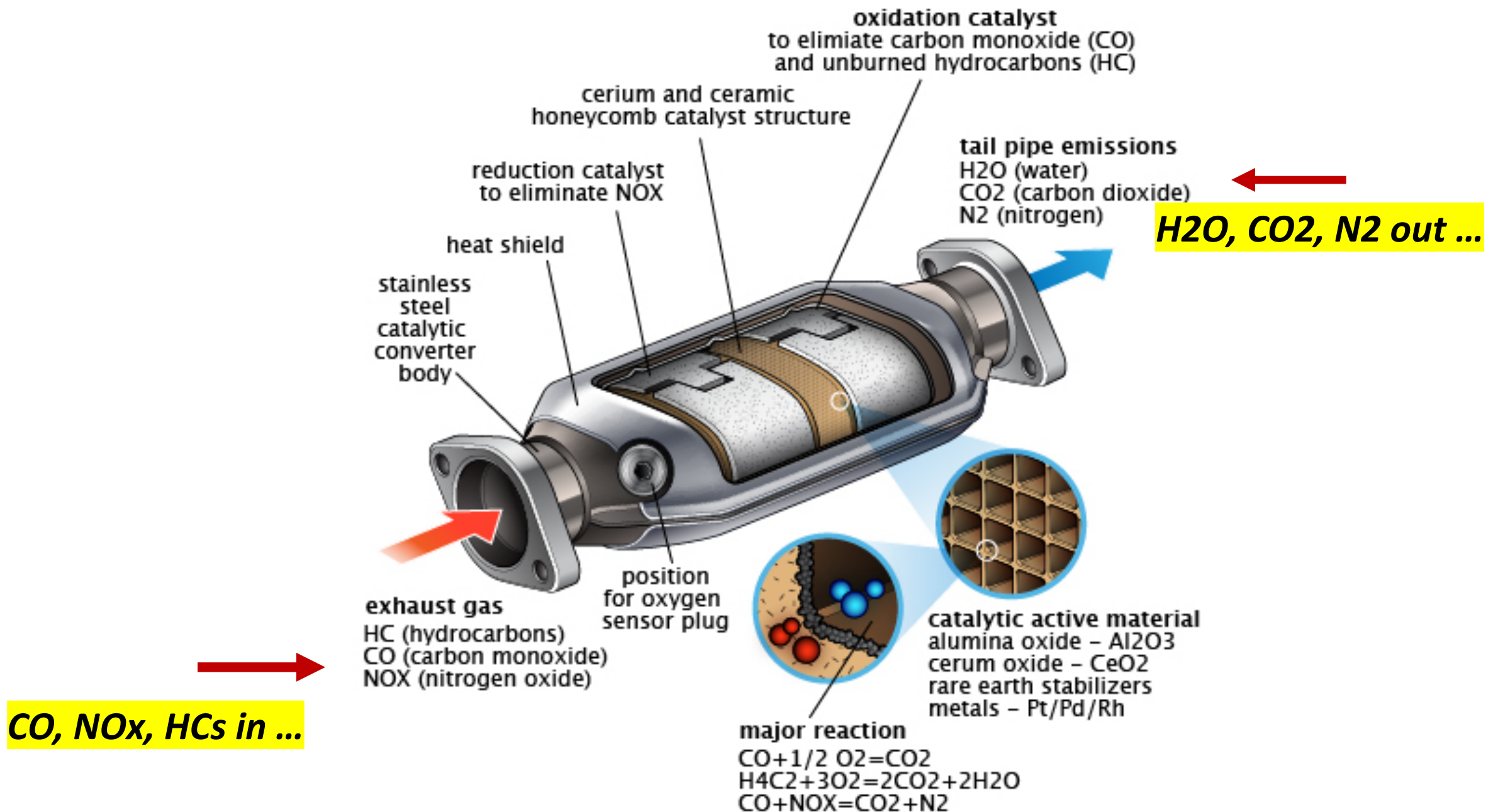
(Example: Annual Average Nitrogen Dioxide Concentration, Los Angeles Basin)



# Catalytic Converter

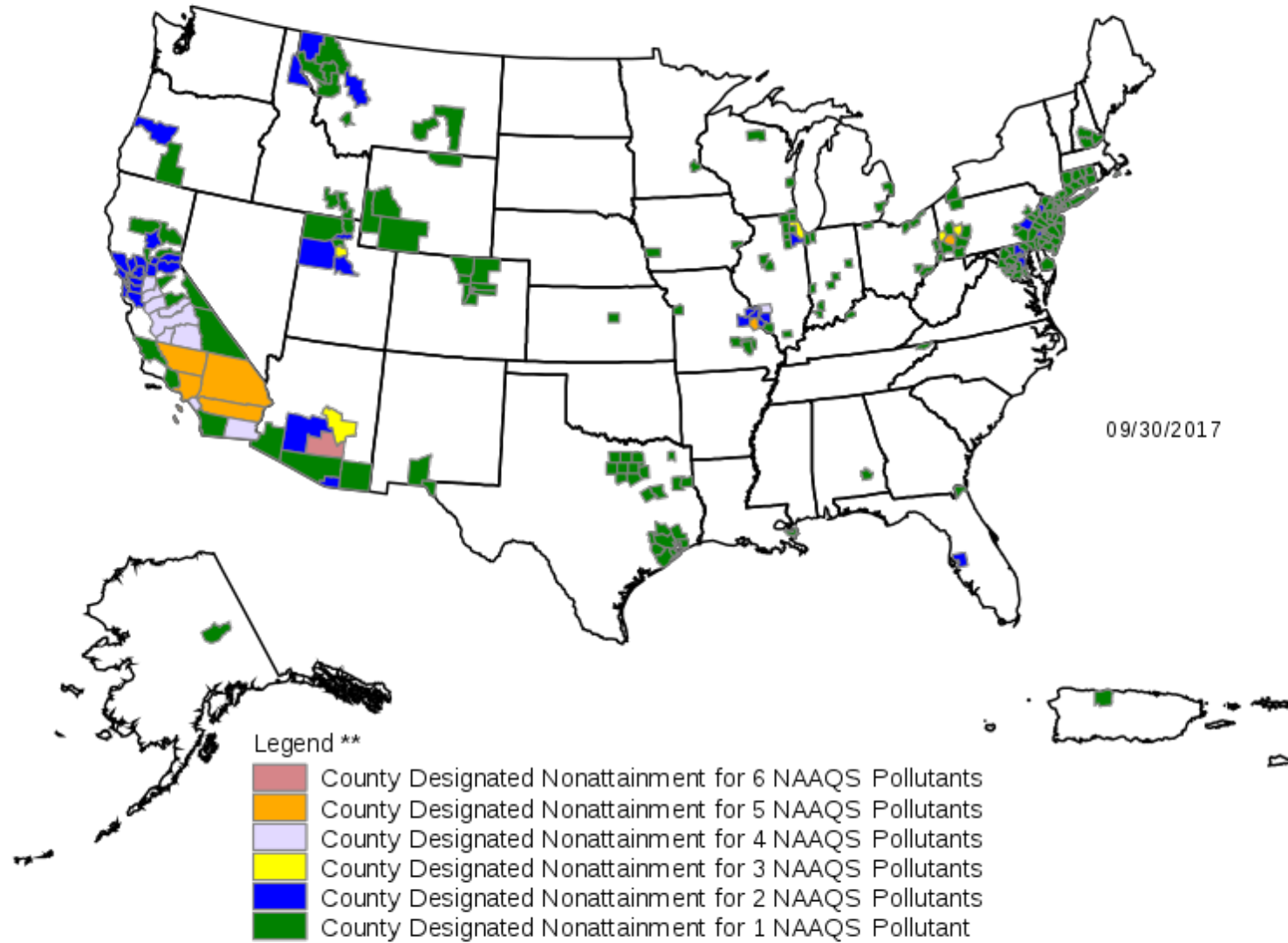
- Technology in response to Clean Air Act regulations
- Standard equipment on all gasoline powered automobiles since mid-1970s
- Reduces CO, NOx and hydrocarbon air pollutants



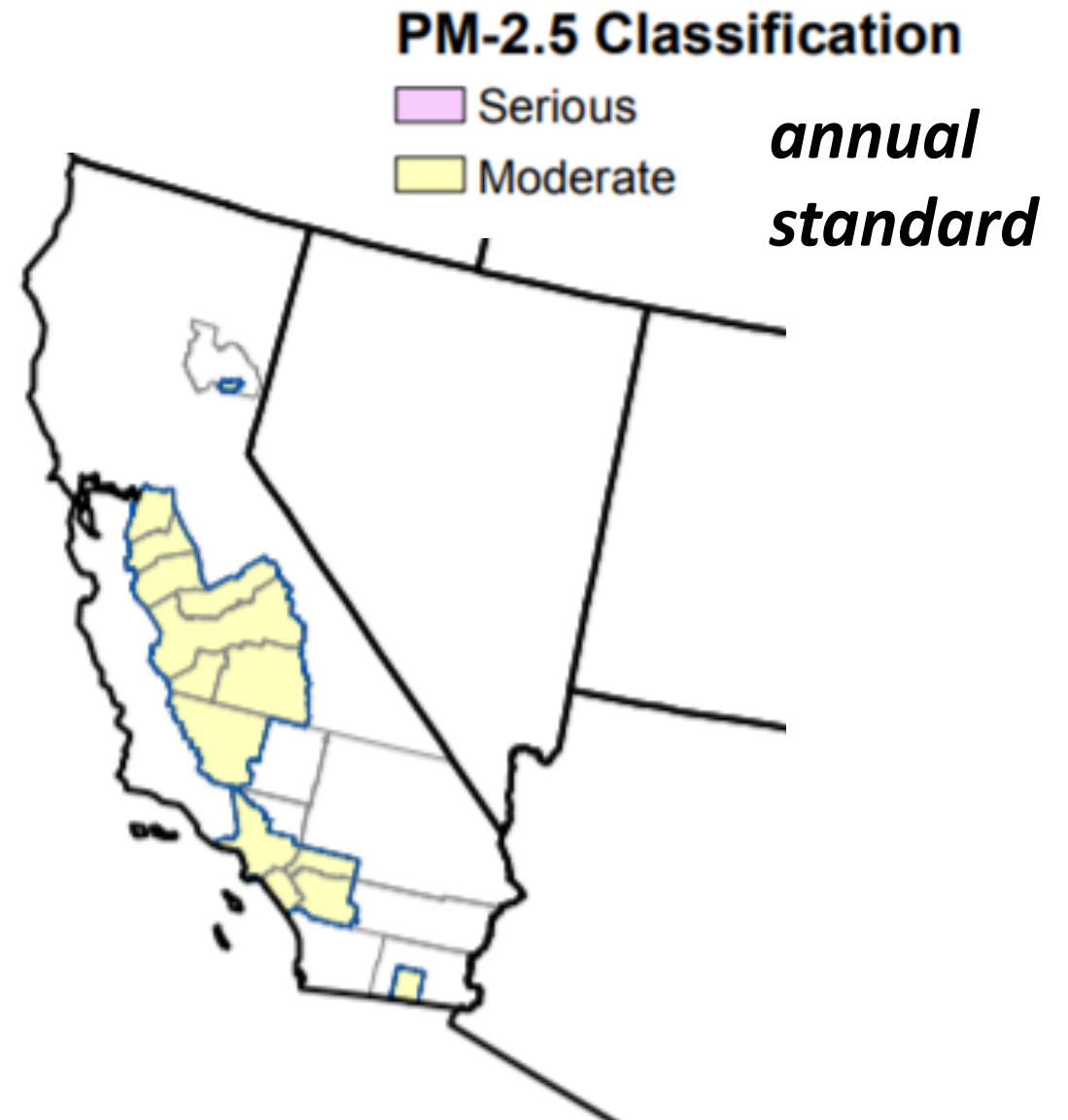
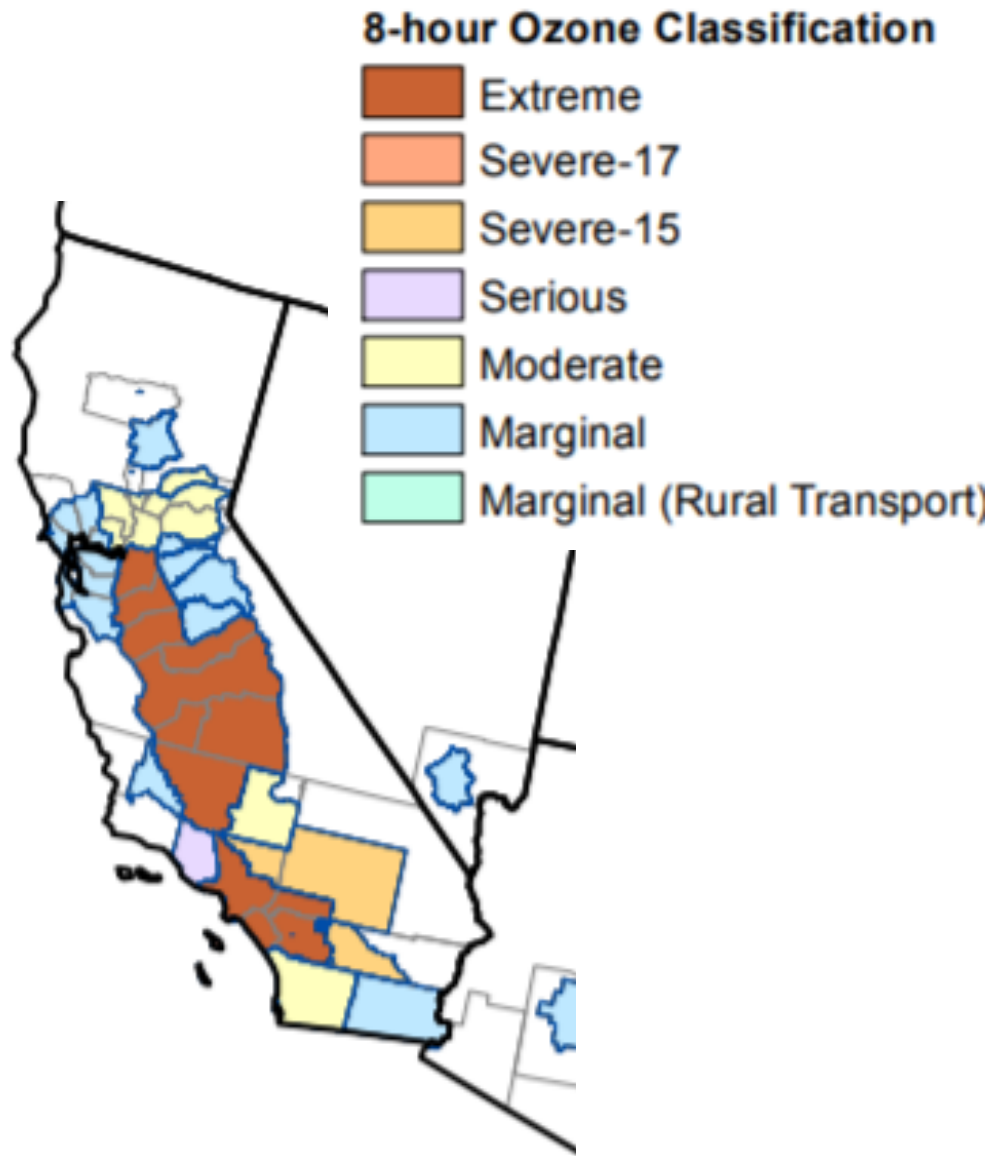


# Counties Designated "Nonattainment"

for Clean Air Act's National Ambient Air Quality Standards (NAAQS) \*







***Current non-attainment areas for ozone (O3) and annual PM2.5 in California***



# Air Quality Index (AQI)

(Common Way Air Quality Communicated to Public)

(Value of 100 set to divide “unhealthy” from “clean” air)

| Air Quality Index<br>Levels of Health<br>Concern | Numerical<br>Value | Meaning                                                                                                                                                                        |
|--------------------------------------------------|--------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Good                                             | 0 to 50            | Air quality is considered satisfactory, and air pollution poses little or no risk                                                                                              |
| Moderate                                         | 51 to 100          | Air quality is acceptable; however, for some pollutants there may be a moderate health concern for a very small number of people who are unusually sensitive to air pollution. |
| Unhealthy for Sensitive Groups                   | 101 to 150         | Members of sensitive groups may experience health effects. The general public is not likely to be affected.                                                                    |
| Unhealthy                                        | 151 to 200         | Everyone may begin to experience health effects; members of sensitive groups may experience more serious health effects.                                                       |
| Very Unhealthy                                   | 201 to 300         | Health alert: everyone may experience more serious health effects                                                                                                              |
| Hazardous                                        | 301 to 500         | Health warnings of emergency conditions. The entire population is more likely to be affected.                                                                                  |