

Lecture 1: Introduction

- Air Pollution Regulation: Pre Clean Air Act 1970
- Air Pollution: Definition, Concentration, Standards
- Clean Air Act 1970
- Local Agencies (California & Bay Area)

METR 113/ENVS 113
Atmospheric Pollution
Spring 2011
February 1, 2011

Reading

- Other recommended texts ...
 - *Atmospheric Pollution: History, Science, Regulation* by Mark Z. Jacobson.
 - *Earth Under Siege: From Air Pollution to Climate Change* by Richard P. Turco.Both are on course reserve at King Library. These are comprehensive air pollution texts with technical details.
- <http://www.ametsoc.org/sloan/cleanair/index.html>
- Various links in ensuing slides ...
- Familiarize yourself with following websites
 - <http://www.epa.gov/air/> (U.S. EPA air pollution page)
 - <http://www.arb.ca.gov> (California Air Resources Board)
 - <http://www.baaqmd.gov> (Bay Area Air Quality Management District)

Air Pollution Regulation (Pre-Clean Air Act 1970)

Noontime, Donora, Pennsylvania, October 29, 1948



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Los Angeles (1950s)



Hollywood Citizens News Collection, Los Angeles Public Library

Homework

(Have short answer ready for upcoming exam on 2/10/11)

- What were two pollutants discussed? Why?
- Emission sources of these two pollutants?
- Key events & episodes ...
- Working knowledge/timeline of key air pollution regulations in U.S. prior to Clean Air Act of 1970.
- Refer to notes, 'ametsoc' website, Chapters 4.1 and 8.1 of Jacobson text, Chapter 6.1 of Turco text (see 'Reading' slide)

Why study air pollution?

- Causes health problems
- Causes visibility problems
- Causes agricultural and plant damage
- Causes degradation of buildings
- Causes odors
- Causes climate change
- Various other reasons ...

How do air pollution professionals characterize the various air pollutant species?

- By how they are **regulated**
- By their **sources**
- By their **formation** mechanism in the atmosphere
- By their **health effects**
- By their **other effects** (aside from health)
- By whether they are **gas or particle**
- By whether they are of concern **indoor or outdoor**
- By whether they are of concern in **workplace or non-workplace** air.

**Air Pollution:
Definitions, Concentration, Standards**

Los Angeles (July 23, 2000)

Question: Is this air pollution?



Air Pollution: A Common Working Definition ...

“Air pollution occurs when gases or aerosol particles, emitted anthropogenically, build up in **concentrations sufficiently high** to cause direct or indirect damage to humans, plants, animals, other life forms, ecosystems, structures, or works of art.”

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Main things ...

- Air pollution **concentration** is the important thing to know ...
- “Concentrations sufficiently high” implies a **concentration threshold** beyond which we can anticipate a realistic possibility of damage to health, ecosystems, etc ...
- Threshold is often also called a “level of concern” or “standard”
- Relevant Question: Is pollution level below or above threshold?

Air Pollution Concentration

(Two main ways this is expressed...)

- **Mass Per Unit Volume**

- Mass of air pollutant per cubic meter of air
- Used for solid, liquid and gaseous air pollutants
- Grams per cubic meter (g/m^3)
- Milligrams per cubic meter (mg/m^3) = 0.001 g/m^3
- Micrograms per cubic meter ($\mu\text{g/m}^3$) = $0.001 \text{ mg/m}^3 = 1.0 \times 10^{-6} \text{ g/m}^3$

- **Parts Per Million (ppm)**

- # of molecules of air pollutant per million molecules of air
- Used for gaseous air pollutants
- 1 part per billion (ppb) = 0.001 ppm
- 1 part per trillion (ppt) = $0.001 \text{ ppb} = 1.0 \times 10^{-6} \text{ ppm}$

Class Exercise: Part 1 ...

Express the following situations in terms of the air pollution concentration (use metric units).

1. 500 mg of carbon monoxide in a 10 ft x 10 ft x 10 ft room
2. 10 milligrams of ozone in a 1000 cubic-meter warehouse

Note: 10 feet = 3.048 meters

Class Exercise: Part 1 ...

Express the following situations in terms of the air pollution concentration (use metric units).

1. 500 mg of carbon monoxide in a 10 ft x 10 ft x 10 ft room = $500 \text{ mg}/28.3 \text{ m}^3 = 17.7 \text{ mg/m}^3$
2. 10 milligrams of ozone in a 1000 cubic-meter warehouse = $10 \text{ mg}/1000 \text{ m}^3 = 0.01 \text{ mg/m}^3 = 10 \text{ }\mu\text{g/m}^3$

Class Exercise: Part 2 ...

Are the concentration levels of Part 1 of concern in terms of air pollution?

For the threshold value, use the lowest (i.e. most strict) 1-hour concentration standard for carbon monoxide and ozone from class handout.

Class Exercise: Part 2 ...

We looked at following situations ...

1. 500 mg of carbon monoxide in a 10 ft x 10 ft x 10 ft room = 17.7 mg/m³. California 1-hour standard for carbon monoxide is 23 mg/m³. Values are fairly close. Therefore, **yes**, carbon monoxide at this concentration level is of concern in terms of air pollution.
2. 10 milligrams of ozone in a 1000 cubic-meter warehouse = 10 µg/m³. California 1-hour standard for ozone is 183 µg/m³ & 8-hour standard is 137 µg/m³. Value is much less. Therefore, **no**, ozone at this concentration level is not of concern in terms of air pollution ... (see note below).

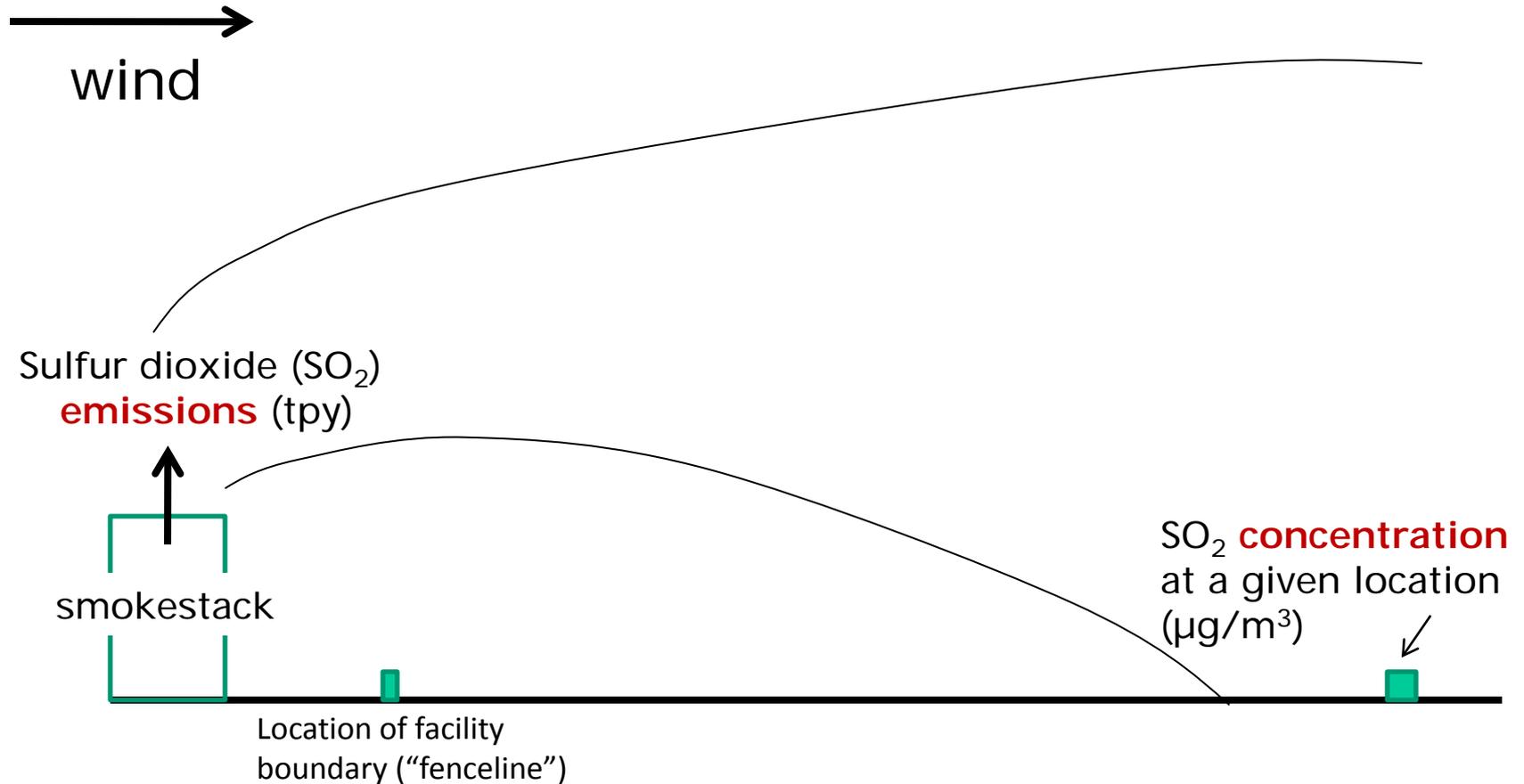
Note: ... unless another standard is introduced that is close in value to 10 µg/m³, indicating that ozone at this concentration is, in fact, of concern at that concentration level.

Air Pollution Emissions

- **Emissions** – The amount of pollutant coming from a pollution source or area over some time.
- Usually expressed as “annual” emissions; tons per year, pounds per year, etc ...
- Other ways: pounds per day, kilograms per day, grams per second, milligrams per second

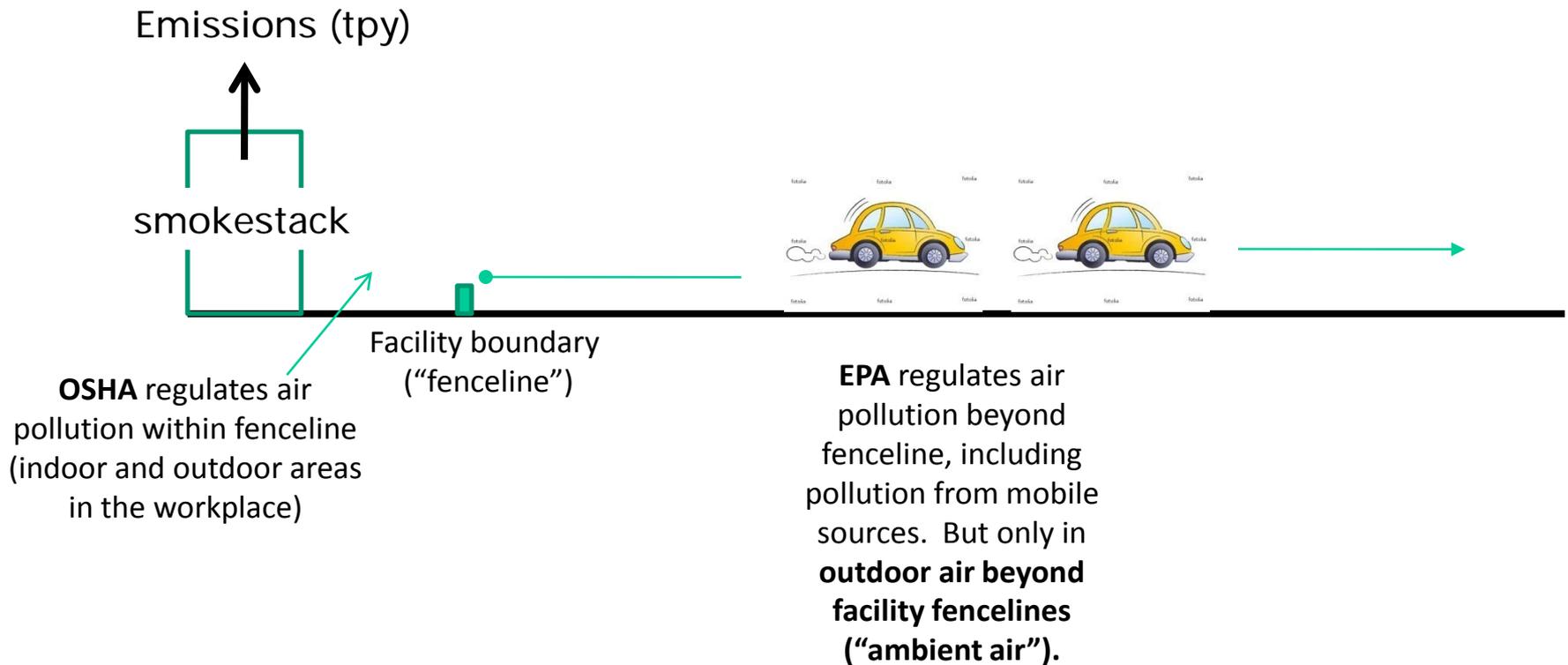
Simple schematic:

Pollution plume from Coal Combustion Power Plant
(Emissions vs. Concentration)



Simple schematic:

Pollution plume from Coal Combustion Power Plant
(Within vs. beyond facility fenceline)



Clean Air Act 1970 and beyond

Clean Air Act

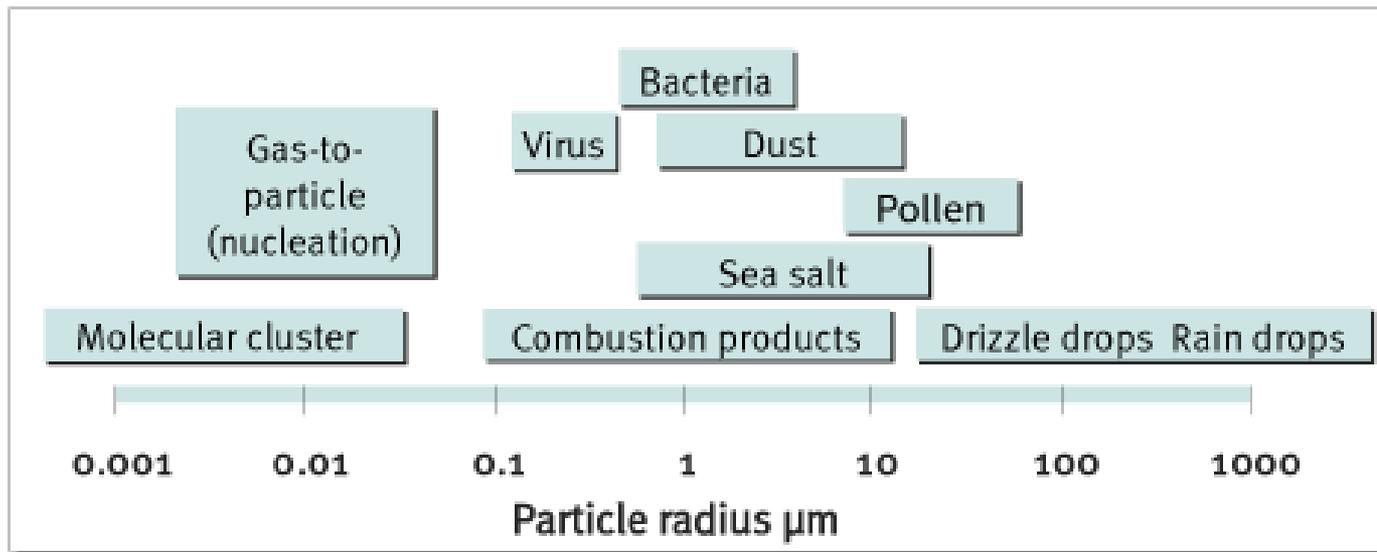
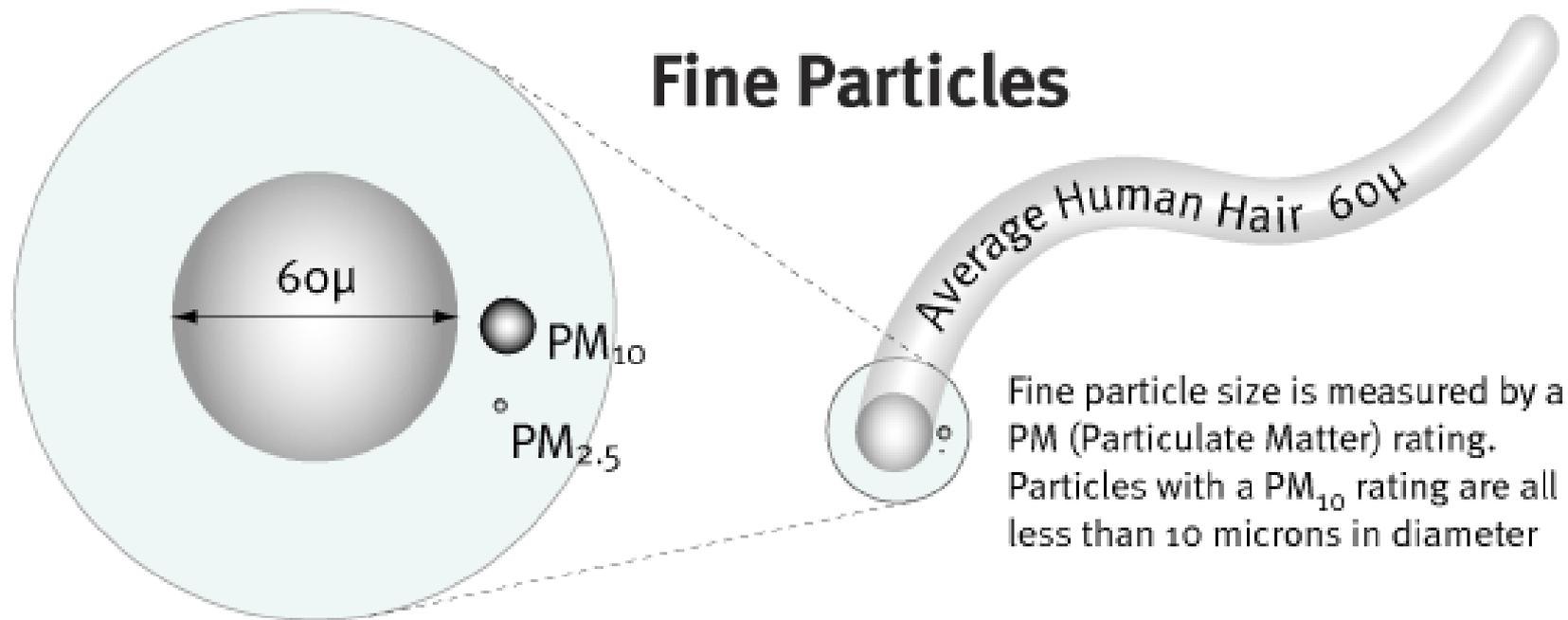
- Created in 1963
- Amendments in 1970, 77, 90 & 97
- Overview of 1970 Amendments...
 - National Ambient Air Quality Standards (NAAQS)
 - National Emission Standards for Hazardous Air Pollutants (NESHAPS)
 - Creation of U.S. EPA in 1971 to enforce
- Overview of 1990 Amendments
 - Expand NESHAPs to 189 specific pollutants
 - Provisions to reduce acid rain
 - Provisions to reduce emissions that cause ozone depletion (“ozone hole”)
- Links
 - <http://www.epa.gov/history/topics/caa70/11.htm>
 - http://epa.gov/oar/caa/caa_history.html
 - <http://www.epa.gov/air/caa/>

National Ambient Air Quality Standards (NAAQS)

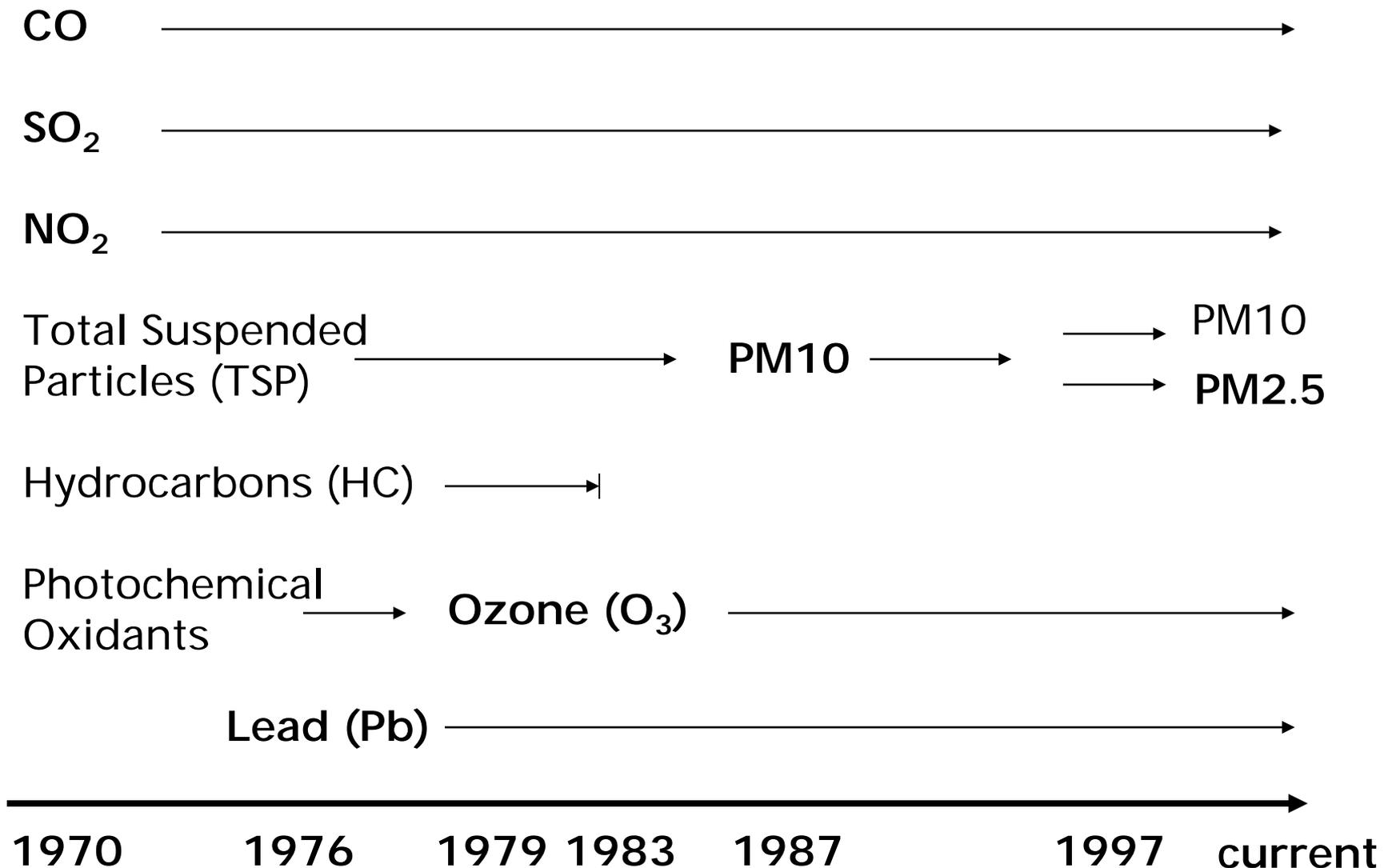
Ambient air concentration standards are set for seven **criteria air pollutants**.

1. Sulfur Dioxide (SO₂)
2. Carbon Monoxide (CO)
3. Nitrogen Dioxide (NO₂)
4. Ozone (O₃)
5. PM10 (particulates < 10 μm diameter)
6. PM2.5 (particulates < 2.5 μm diameter)
7. Lead (Pb)

Fine Particles



Timeline ...



Some Prominent Air Pollutants Regulated under NESHAPS (6 of the list of 189 “Hazardous Air Pollutants”, or HAPS)

- **Asbestos**: Old building material, insulation ...
- **Benzene**: Vapors from gasoline, oils, paints, etc ...
- **Formaldehyde**: Vinyl siding, particle board, industrial (common indoors)
- **Hydrogen Fluoride**: Industrial
- **Methyl Bromide**: Vapors from pesticide application to strawberries
- **Vinyl Chloride**: Plastics, industrial

About HAPS: “Hazardous Air Pollutants” (HAPS) are a class of air pollutants generally known to be toxic and/or otherwise harmful to human health if inhaled at high enough concentration and/or for a long enough period of time. The EPA NESHAPS regulations are therefore geared towards protection of human health (as with NAAQS, towards sensitive populations) due to inhalation of these pollutants. However, whereas the seven criteria air pollutants are regulated according to their concentration in the ambient air and whether this exceeds NAAQS standards, HAPS are regulated according to their emissions from the source according to NESHAPS standards.

Looking more closely at the NAAQS ...

- **Primary standards**

- Health based
- Standards set to be protective for sensitive individuals ...
- ... as opposed to younger, healthier populations.

- **Secondary standards**

- Welfare
- Only one is SO₂ 3-hour standard

- **Different NAAQS for different averaging times**

- 1-hr, 3-hr, 8-hr, 24-hr and annual averages.
- Averaging times of standards depend on pollutant.

- See chart for standards (in-class handout)

- Note: California has its own standards, independent of NAAQS

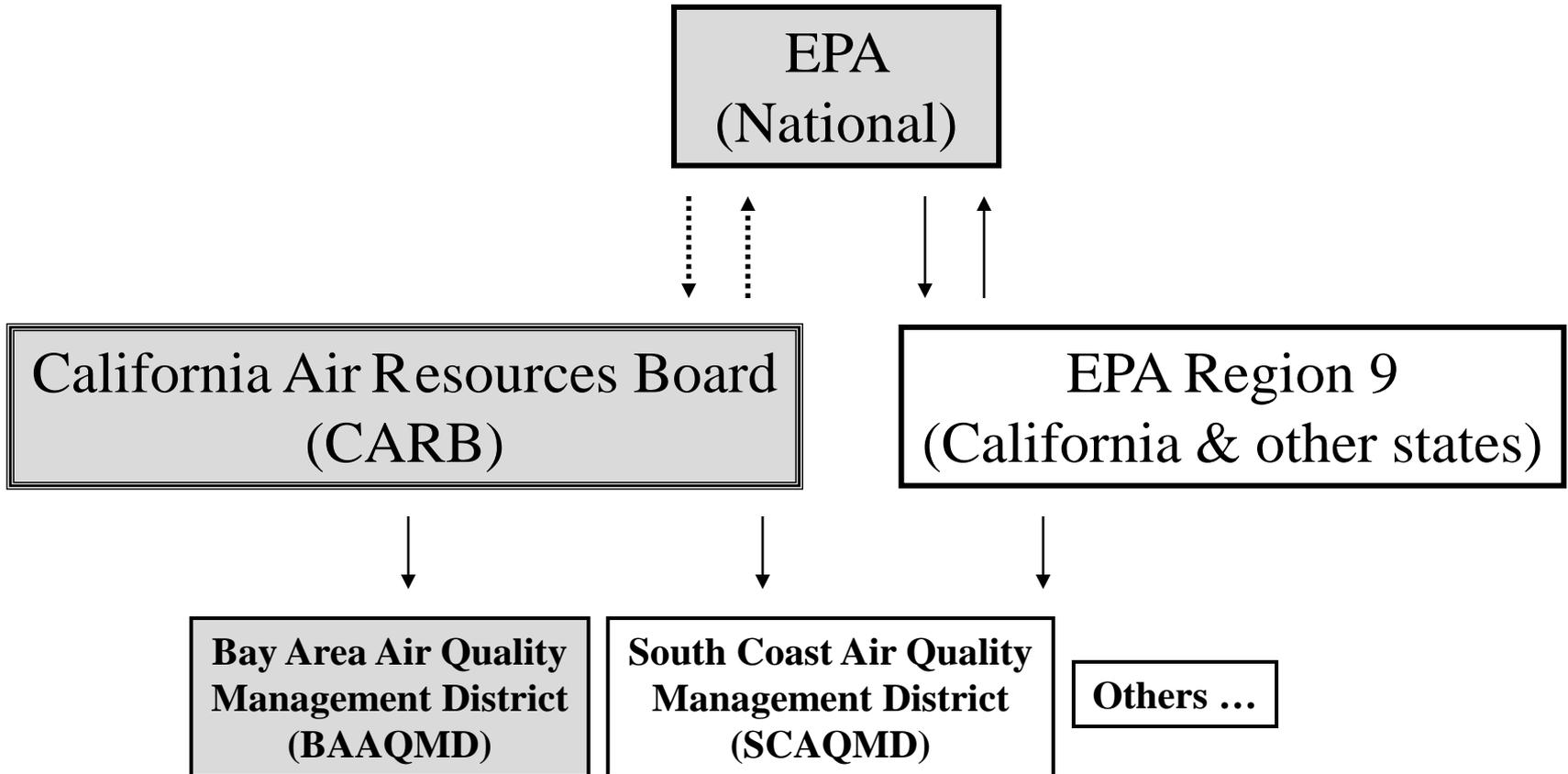
- See also <http://www.arb.ca.gov/research/aaqs/aaqs.htm>

NAAQS: Attainment vs. Non-Attainment

- **Non-attainment area (Concentration > Standard)**
 - Sources must use modern emission control technologies.
 - New sources must offset their anticipated emissions w/ decrease elsewhere.
 - Offsetting usually carried out by purchase of “emission credits”.
- **Attainment area (Concentration < Standard)**
 - Class I areas (National Parks, Wildlife refuges, etc ...) - No new sources
 - Class II & III areas: Some new sources w/ modern emission controls.
 - New sources in Class II and III areas cannot result in violation of NAAQS nor cause “serious deterioration” (even if NAAQS is obeyed) in air quality (Prevention of Serious Deterioration, PSD)

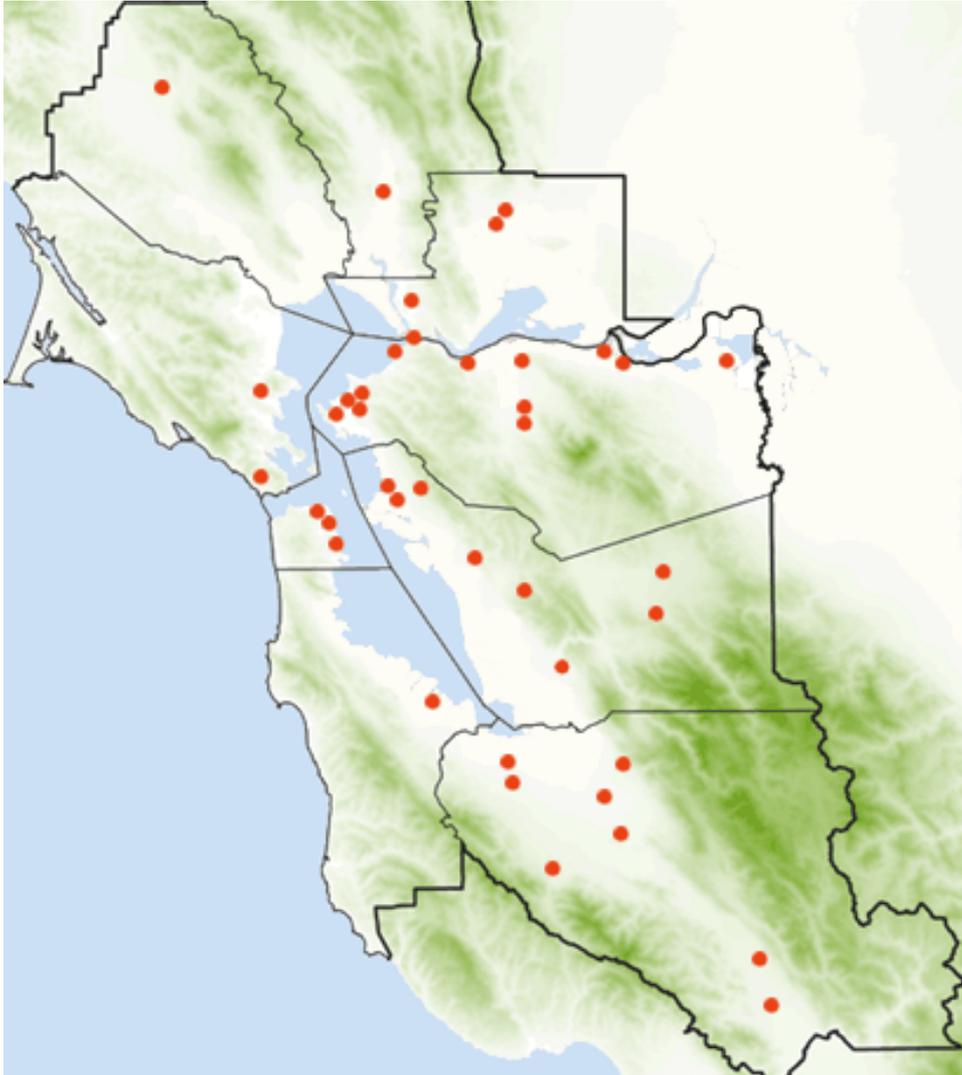
Relevance to Air Permitting: New or expanding facilities that will emit air pollutants above a certain amount must obtain an EPA Title V “air permit” before beginning operations. Nationally, this is done through EPA New Source Review guidelines, in California through Environmental Impact Reports submitted to California EPA are required by CEQA. The air permitting procedure depends on whether the new or expanding facility will be in an “attainment” or “non-attainment” area. The permit application must then demonstrate compliance with the requirements in the above bulletpoints (as well as others) according to whether the facility will be in an attainment of non-attainment area.

Air Pollution Control Agencies Hierarchy (California)



Air Quality Management Districts
(<http://www.arb.ca.gov/capcoa/roster.htm>)

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



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

Turns out ...

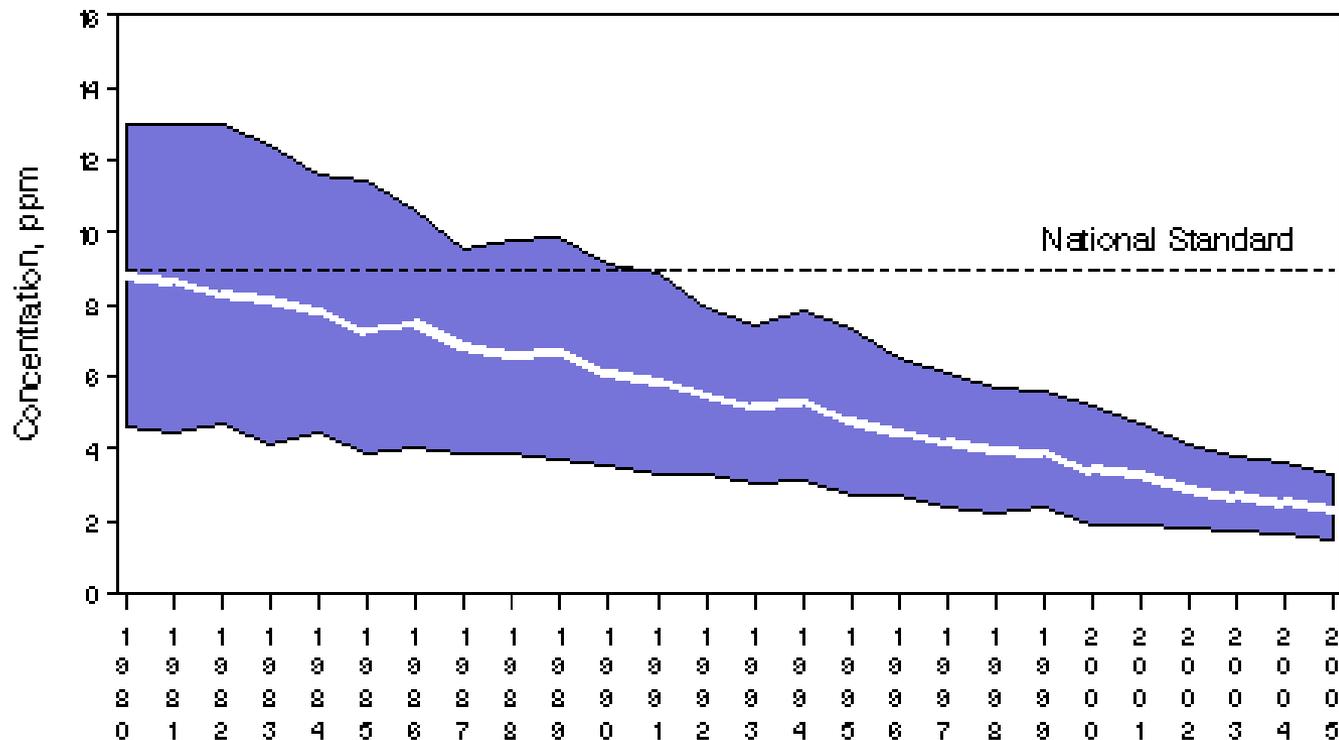
- Bay Area is **not in** compliance with Ambient AQ standards (NAAQS and CA standards) with respect to
 - Ozone
 - PM10
 - PM2.5
- Therefore, Bay Area is a non-attainment area with respect to ozone, PM10 and PM2.5

Homework

- Verify the Bay Area is a non-attainment area on previous slide by looking at data on <http://gate1.baaqmd.gov/aqmet/aq.aspx>. Print out pages showing examples of day/time/year/place/ when and where air concentrations of ozone, ~~PM10~~ and PM2.5 are not in compliance. Circle the data point that is not in compliance. Turn this part in before the exam on Feb. 10.
- Based on your findings, in what parts of the Bay Area, and during what time of year and time of day, are ozone and PM10/PM2.5 subject to high concentrations that are not in compliance with AQ standards? Be prepared to answer this question on the Feb. 10 exam.

Improvements in U.S. Air Quality (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



1980 to 2005 : 74% decrease in National Average

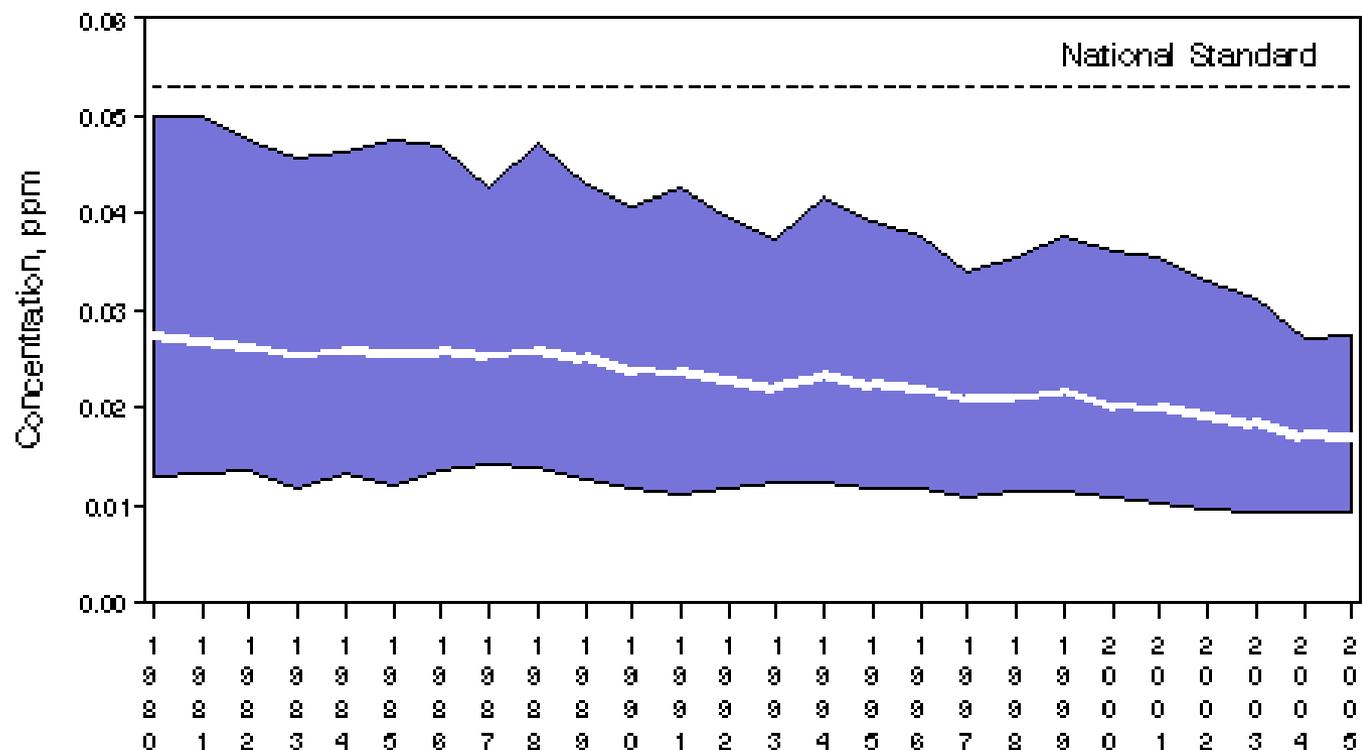
Improvements in U.S. Air Quality

(Annual Average Nitrogen Dioxide Concentration)

NO₂ Air Quality, 1980 — 2005

(Based on Annual Arithmetic Average)

National Trend based on 88 Sites



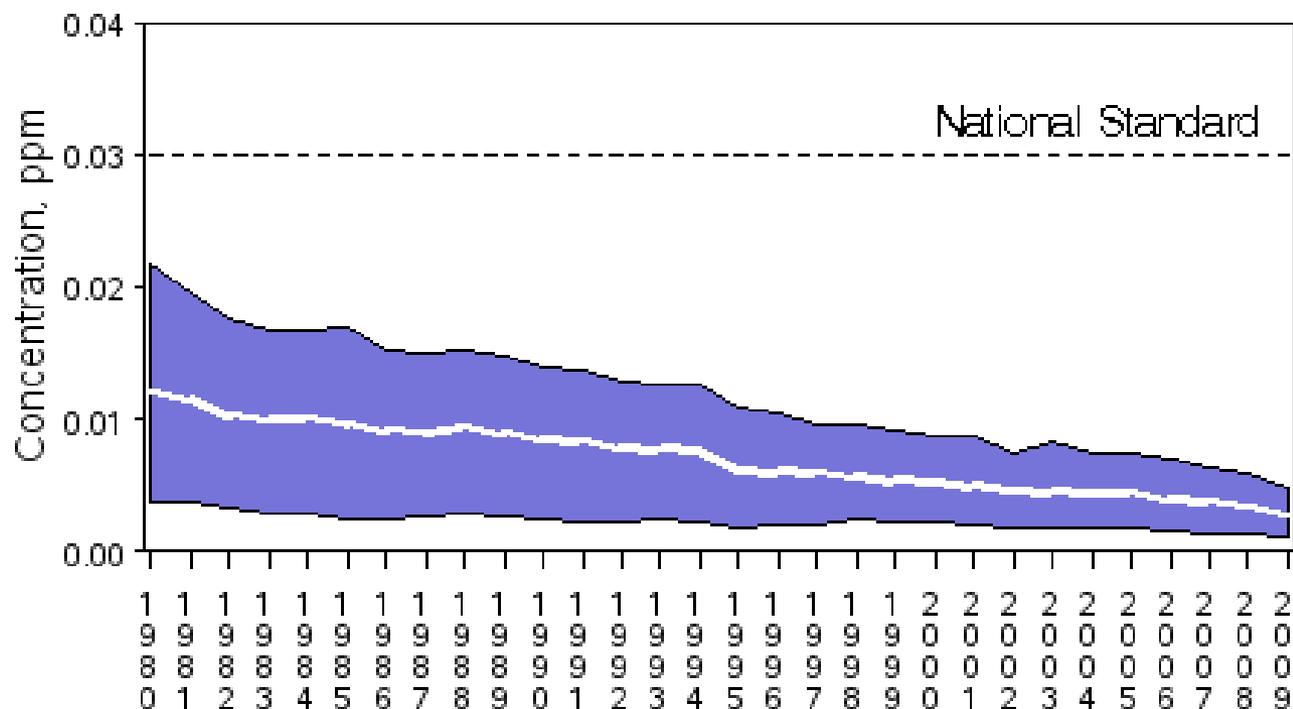
1980 to 2005 : 37% decrease in National Average

Improvements in U.S. Air Quality (Annual Average Sulfur Dioxide Concentration)

SO₂ Air Quality, 1980 - 2009

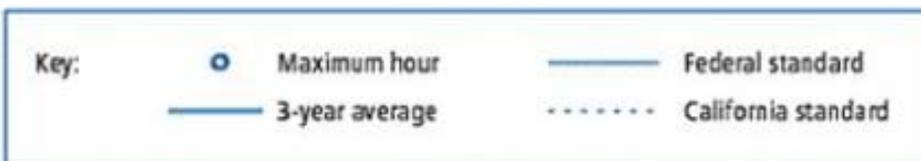
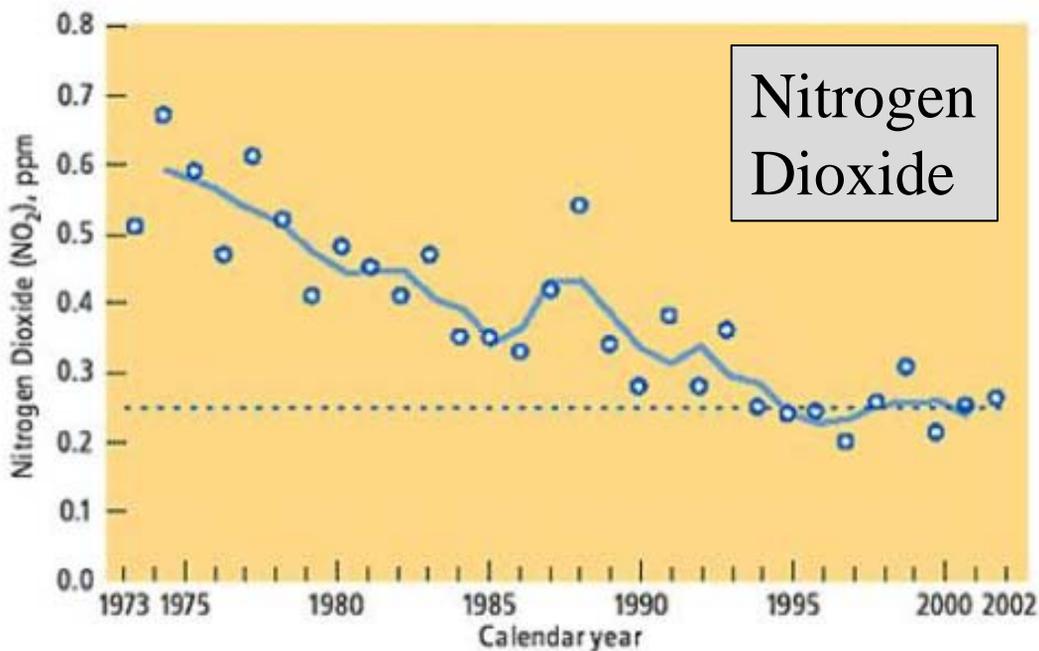
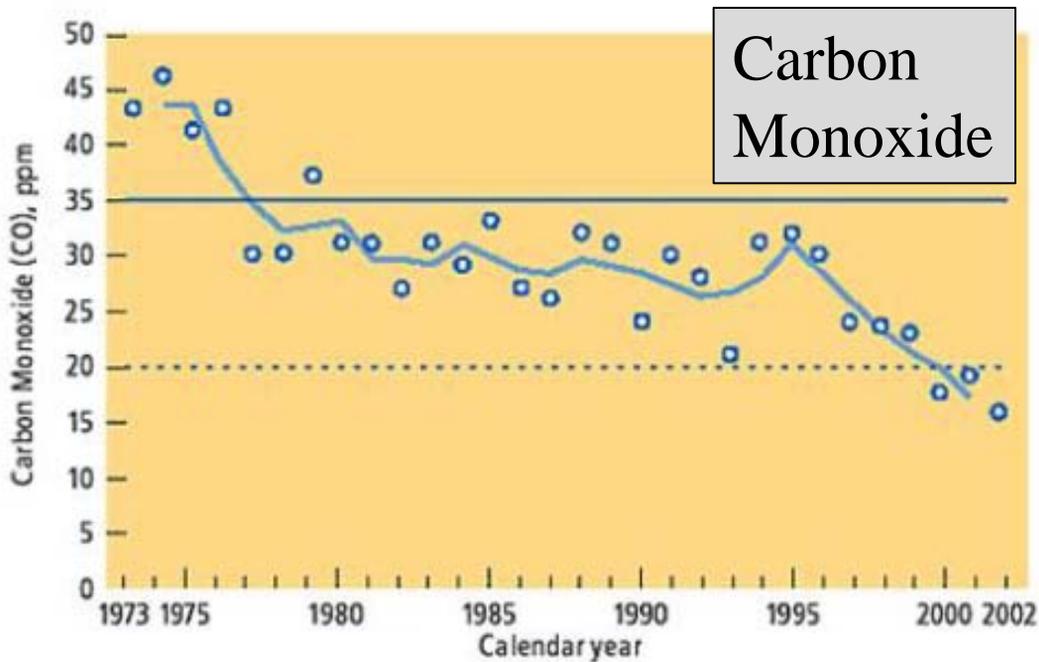
(Based on Annual Arithmetic Average)

National Trend based on 134 Sites



1980 to 2009 : 76% decrease in National Average

Improvements in California Air Quality (Maximum Hourly and Annual Average Concentration)



Improvements in California Air Quality (1-Hour and 8-Hour Ozone Concentrations)

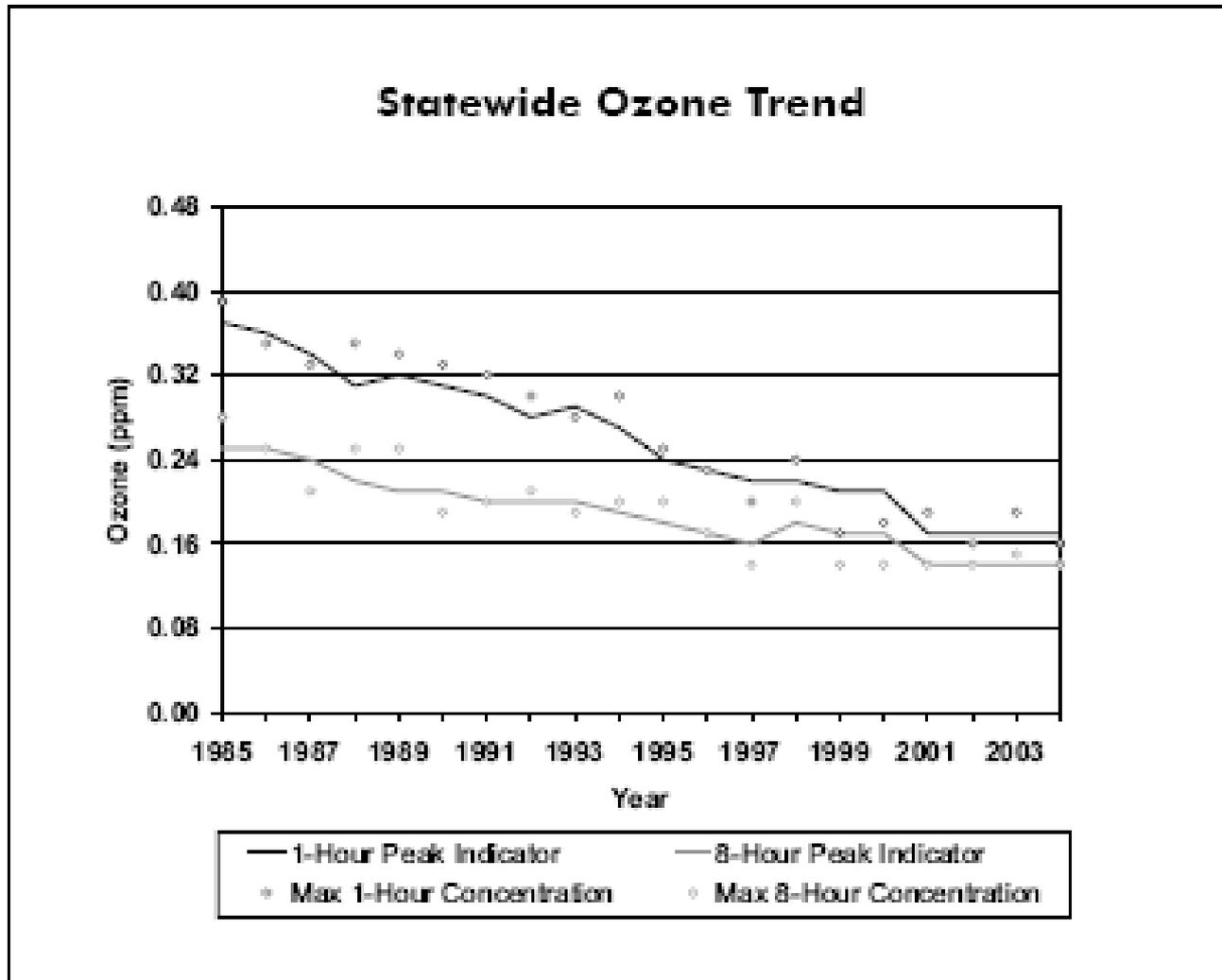


Figure 3-4

Some Pollutants Not Regulated By Either NAAQS nor NESHAPS that you may have heard of ...

- **Chlorofluorocarbons (CFCs), “Freon” Gases**
 - Ozone Layer depleting gases
 - Emissions of CFCs (and other “ozone depleting pollutants”) regulated in Clean Air Act 1990 Amendments
- **Carbon Dioxide, Methane, other “greenhouse gases”**
 - Believed main cause of global warming ...
 - Not yet (fully) regulated (!)
 - Draft regulation working through EPA/U.S. Congress
 - California “Global Warming Solution Act” (AB32) in effect
- **Links**
 - <http://www.epa.gov/ozone/strathome.html>
 - <http://www.epa.gov/climatechange/>
 - <http://www.arb.ca.gov/cc/cc.htm>

Regulations: EPA & CARB

- **Criteria Air Pollutants (seven of them ...)**
 - EPA: NAAQS
 - CARB: Separate Standards, usually more stringent (i.e. lower), some additional pollutants aside from original seven
- **Hazardous Air Pollutants (HAPS)**
 - EPA: NESHAPS on 189 pollutants
 - CARB: AB2588 (“Toxic Hot Spot” Reg.), slightly different list of pollutants that (probably) include original 189 plus some others, called “toxic air contaminants” (TACs) in CARB lingo.
- **Ozone Depleting Pollutants**
 - EPA: Clean Air Act Amendments 1990
 - CARB: ?
- **CO₂ & other greenhouse gases**
 - EPA: no finalized regulations, being debated ...
 - CARB: AB32 “Global Warming Solutions” Act

Practice Questions for Exam #1

Given the following concentration measurements over some air district in the U.S. for certain air pollutants for a certain year, what NAAQS are violated (specific pollutant and averaging times)?

Pollutant (units)	Maximum* Hourly Concentration	Maximum* Daily Average Concentration	Annual Average Concentration
CO ($\mu\text{g}/\text{m}^3$)	30	20	10
NO₂ (ppm)	0.15	0.03	0.02
O₃ (ppb)	100	75	40
PM2.5 ($\mu\text{g}/\text{m}^3$)	50	30	20

* Maximum over the year

Sample Multiple Choice (1)

Which best characterizes the air quality in the SF bay area? ...

- a) Non-Attainment with respect to ozone and carbon dioxide ambient air standards
- b) Non-Attainment with respect to ozone and PM2.5 ambient air standards
- c) Attainment with respect to all ambient air standards except ozone
- d) Attainment with respect to all ambient air standards except carbon dioxide

Sample Multiple Choice (2)

Species 'A' is a chemical that poses a health risk when inhaled. Based on how air pollution is defined, which of the following correctly characterizes whether 'A' is of concern as an "air pollutant"?

- a) The emission rate of 'A' is above or near its health risk threshold.
- b) The concentration of 'A' is above or near its health risk threshold.
- c) The emission rate of 'A' is non-zero. It does not matter whether this value is above or near its health risk threshold.
- a) The concentration of 'A' is non-zero. It does not matter whether this value is above or near its health risk threshold.