Major Water Reservoirs

- Oceans: 95%
- Glaciers and ice sheets: 2.97%
- Groundwater: 1.05%
- Lakes and rivers: 0.009%
- Atmosphere: 0.001%
- Living organisms and soil: 0.0001%
Energy sources: solar and gravity

- $T_{\text{atmosphere}} = \text{days}$
- $T_{\text{oceans}} = 4,000 \text{ years}$
- $T_{\text{groundwater}} = 10,000 \text{ years}$
- $T = \text{Residence time}$
Dilution: the solution to pollution?

Average make-up of beach trash
Oceans: An endless supply of protein?

- Approximately 20% of animal protein in the human diet is derived from the ocean
- Overfishing of key fisheries
- Excess heavy metals in fish
Oceans: Sea level rise

- Who will be effected? Recall where do most of us live
- What processes are taking place? Erosion and subsidence
- What is causing sea level to rise?

Venice: 3” sea level rise (since 1897) along with 6” of subsidence 1996 city flooded 99X
Oceans: sea level rise and coastal erosion

Miami Beach
Major Water Reservoirs

- Oceans 95%
- Glaciers and ice sheets 2.97%
- Groundwater 1.05%
- Lakes and rivers 0.009%
- Atmosphere 0.001%
- Living organisms and soil 0.0001%
Surface Water: Why we should care?

1889 Johnstown flood

Aral Sea

- **Uses:**
  - Drinking water
  - Irrigation
  - Power generation
  - Fishing
  - Recreation
  - Industry
  - Transportation

- **Issues:**
  - Pollution
  - Flooding
  - Subsidence

Hoover Dam
Major Water Reservoirs

- Oceans: 95%
- Glaciers and ice sheets: 2.97%
- **Groundwater**: 1.05%
- Lakes and rivers: 0.009%
- Atmosphere: 0.001%
- Living organisms and soil: 0.0001%
Groundwater: Why care?

- The volume of groundwater is 40x > the volume of all water in fresh-water lakes or flowing in streams.
- We drink it
- We irrigate with it
- We “mine” it
- Most groundwater originates as rain (meteoric water)
- We want to store radioactive waste in it
US Groundwater profiles

Eastern US: New England

- Recharge
- Unsaturated zone
- Air between wet soil particles
- Saturated zone
- Water between particles
- Aquifer
- Net transport (both horizontal and vertical) governed by gravity and Darcy's Law
- Water Table
- River surface - top of water table
US Groundwater profiles

Western US: Nevada-Arizona-California

seasonal recharge

desert washes

lake surface - top of water table

unsaturated zone

Water Table

saturated zone

Net transport of water into the ground - streams soaks into ground (depth to water table 100's of meters)
Fingerprinting Pollutants and Environmental Health in the Built Environment
Our Environmental Spheres
Attitudes Toward Nature

(from a Western worldview)
Group activity (5 minutes)

1. Brainstorm in groups of 3-5 and come up with a list of the top environmental issues that large cities in the 16th-19th centuries faced. In general, who bore the health burden of these environmental problems?

2. Repeat the exercise for the large modern city. What has changed? What has remained the same?
The human relationship to the built environment

- Air pollution
- Water pollution
- Food quality
- Solid and hazardous waste
- Others
15th and 16th century London

“This most excellent canopy, the air, look you, this brave o’erhanging firmament, this majestical roof fretted with golden fire, why, it appears no other thing to me than a foul and pestilent congregation of vapours” (Hamlet, Act 2).

John Evelyn (1620-1706)  
*Fumifugium, or The Inconvenience of the Air and Smoke of London Dissipated* (1661)
Great Smog, London, 1952
Urban air pollution today

Los Angeles

Denver
What causes LA smog?

By 1995: 780 million cars, trucks and motorbikes worldwide
Asthma: an epidemic

Increase of Asthma in America  1982-1996

- Nine million children suffer from asthma.
- During 1982-1996 asthma increased by 84.8%. The cause of this increase has not yet been fully explained. Some expected suspects:
  - Housing issues
  - Changing lifestyles
  - Genetics
  - Diesel fuel use
  - Urban air quality
  - Improved diagnosis

Source: Asthma Trends in America
Cornell University
http://www.crp.cornell.edu/projects/WebGIS_2000/home/asthma_trend_America.asp
Asthma: an epidemic not shared equally

Asthma Mortality Rate:
(Ethnicity per 100,000 from 1970-1997)

- Asthma mortality among blacks and other minorities is 2x as high as that of other ethnicities.
- Asthma mortality among blacks is the highest.

Source: Asthma Trends in America
Cornell University
http://www.crp.cornell.edu/projects/WebGIS_2000/home/asthma_trend_America.asp
The United States Environmental Protection Agency (EPA) defines Environmental Justice as (1991):

"the fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies. Fair treatment means that no group of people, including a racial, ethnic, or socioeconomic group, should bear a disproportionate share of the negative environmental consequences resulting from industrial, municipal and commercial operations or the execution of federal, state, local, and tribal programs and policies.”

Source: Seventeen Principles of Environmental Justice. The First National People of Color Environmental Leadership Summit was held October 24-27, 1991, in Washington, DC. Seventeen (17) principles of Environmental Justice were drafted and adopted.
EJ and Massachusetts

• 14/15 of the most overburdened communities in MA (as measured by density of hazardous facilities and sites) are of lower-income status (median household income less than <$40,000)

• Communities where people of color make up 25% or more of the total population average nine times more hazardous waste sites per mile than communities where less than 5% of the population are people of color
Cities have long experienced air pollution

Environmental health effects: acute to chronic illnesses

Burden of the environmental degradation not equally distributed

Lessons learned: Air pollution

Six out of eight of Manhattan’s diesel bus depots are located uptown. Until the Transit Authority converts these depots and buses to natural gas, deadly diesel exhaust fumes will continue to pollute the air. This puts the health of a half million mostly African Americans and Latinos at risk.

Source: West Harlem Environmental Action, Inc. (WE ACT)
http://www.weact.org/programs/index.html
Deciphering the Geochemical History of Lake Waban

Erdil (2007)
Lake Waban has a complex history

**Henry Woods Sons & Co.:** 1848 – 1928

Paint pigments: PbCrO₄, BaSO₄, Fe₄[Fe(CN)₆]₃

**Boston and Worcester RR:** 1834 – present

**Wellesley Apple Orchards:** 1850s – 1950s

Pesticides: PbHAsO₄, CaHAsO₄, Pb₅OH(AsO₄)₃

**Algaeicide applications:** 1950s – 1980s

NaAsO₂, As₂O₃, CuSO₄

**Leaded gasoline:** peak usage 1970s

Pb, V, S
Motivations for this work

- High concentrations of Pb, Cr, As are present in Lake sediments
- Mobility of metals is unclear
- Ecological impact

Goals: 1) Determine if a chronology of contamination exists in Lake sediments
2) Identify the distribution and bioavailability of metals
Methods

Inlet: Upper Waban Brook
Outlet: Lower Waban Brook

Sediment samples were analyzed using XRF, ICP-MS, and SEM-EDS.
Distribution of Pb in surface sediments

Significantly elevated [Pb] are observed in surface sediments.