Groundwater Contamination
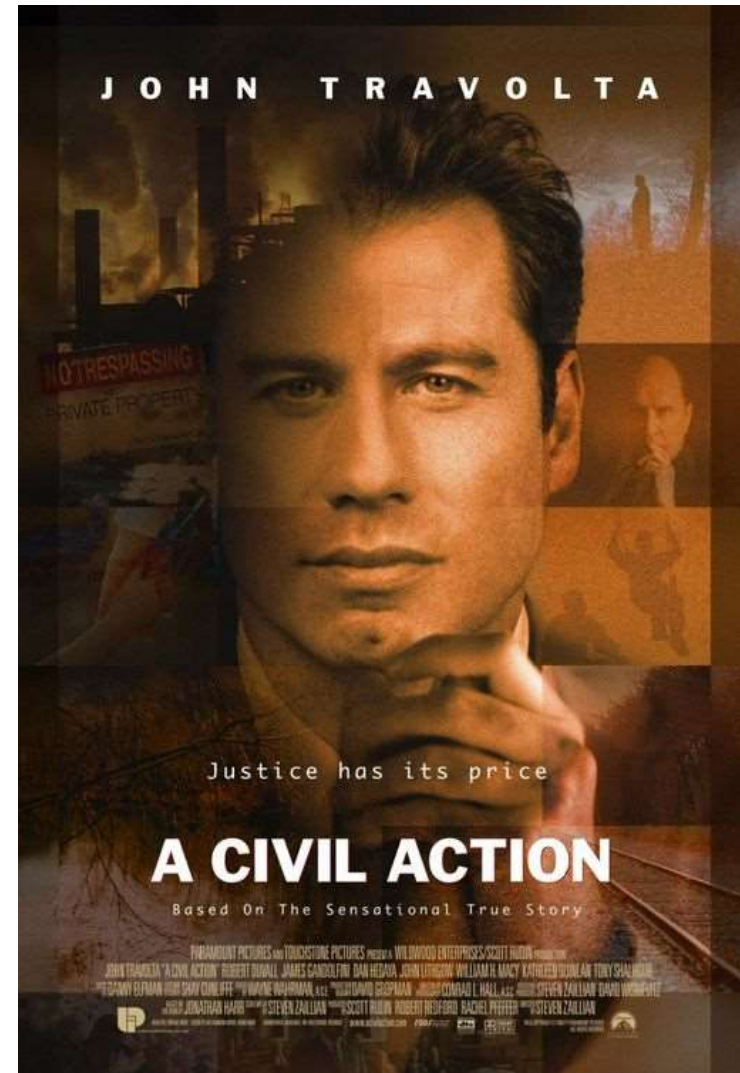
Geohydraulics| CE60113

Lecture:19

Learning Objective(s)

- **To detect groundwater contamination level**

Home Work

Town of Hinkley, CA

- PG&E was responsible for the extensive illnesses residents of Hinkley

- Problem in water supply wells

- PG&E used hexavalent chromium to fight corrosion in the cooling tower.

- The wastewater dissolved the hexavalent chromium from the cooling towers and was discharged to unlined ponds at the site.

- Part of the wastewater percolated into the groundwater, affecting an area near the plant

Site map (Town of Hinkley, CA)
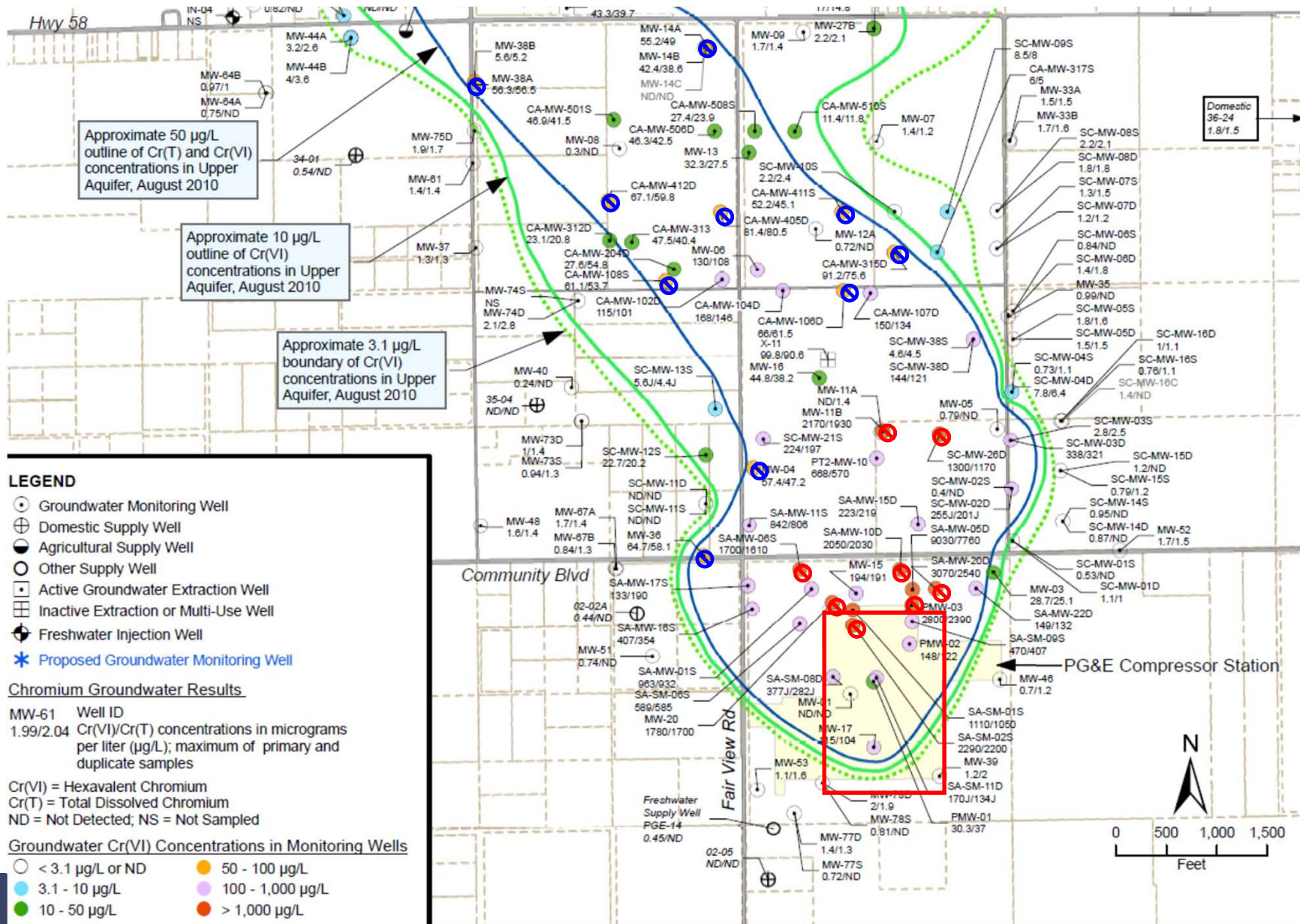
Woburn, Massachusetts
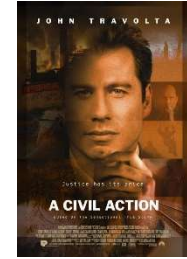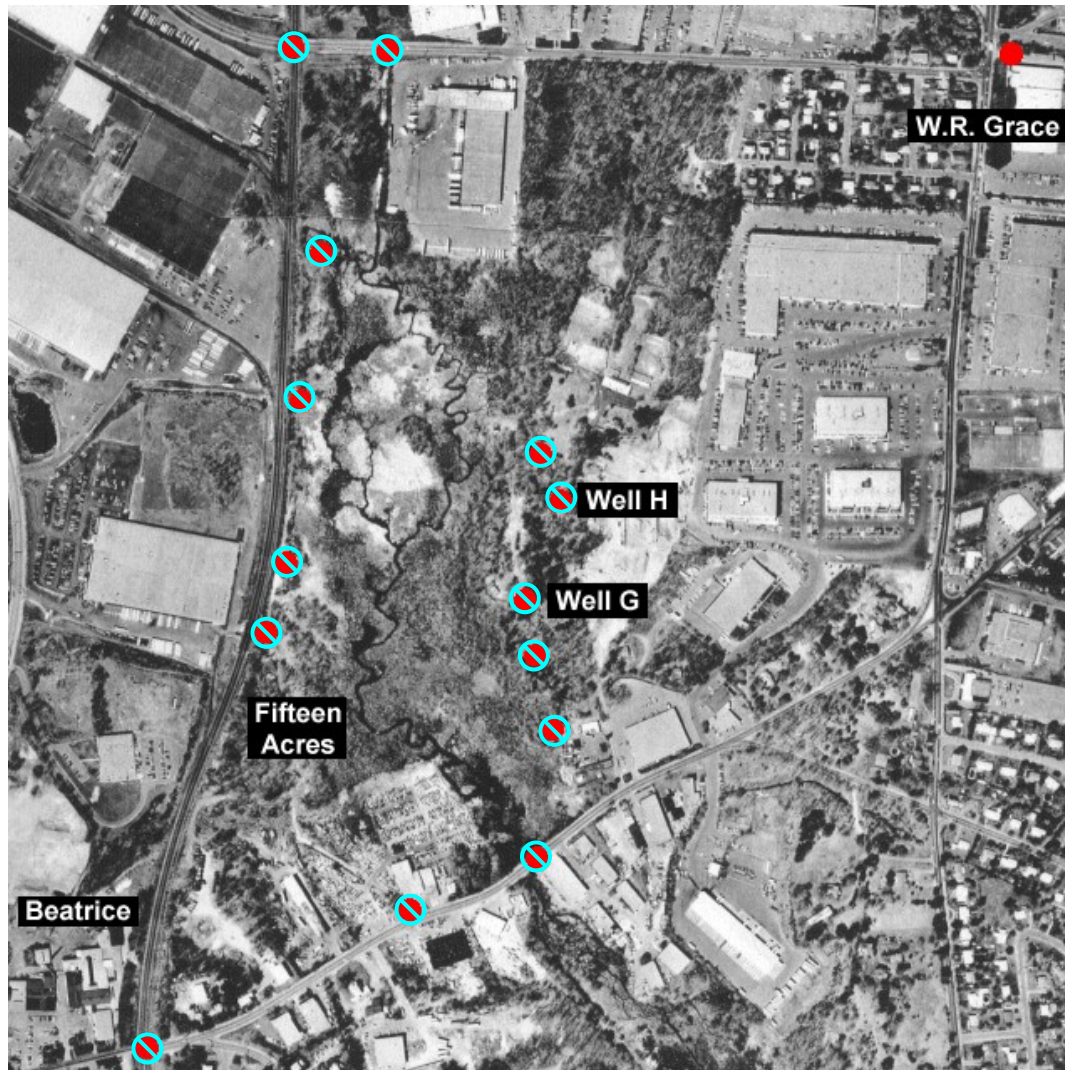
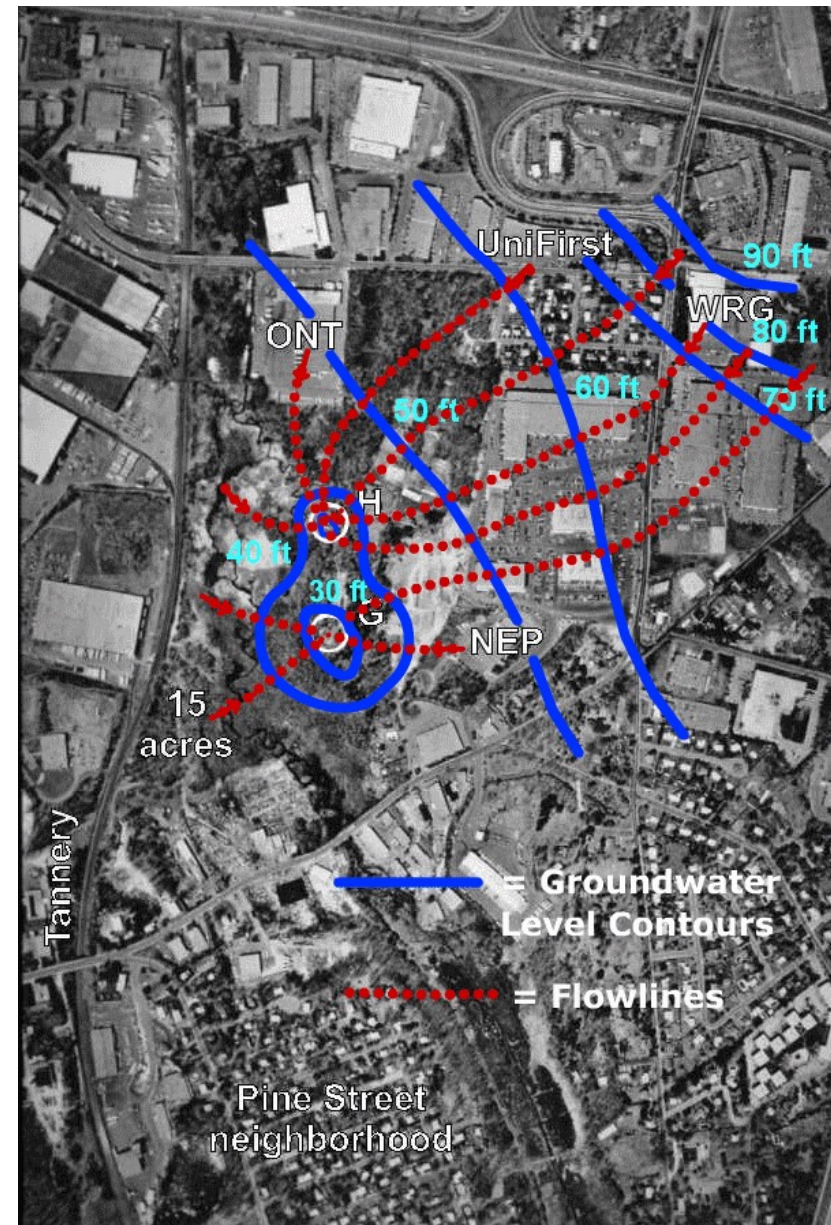

- Concerning the trial to gain compensation for families in a cancer cluster in Woburn, Massachusetts
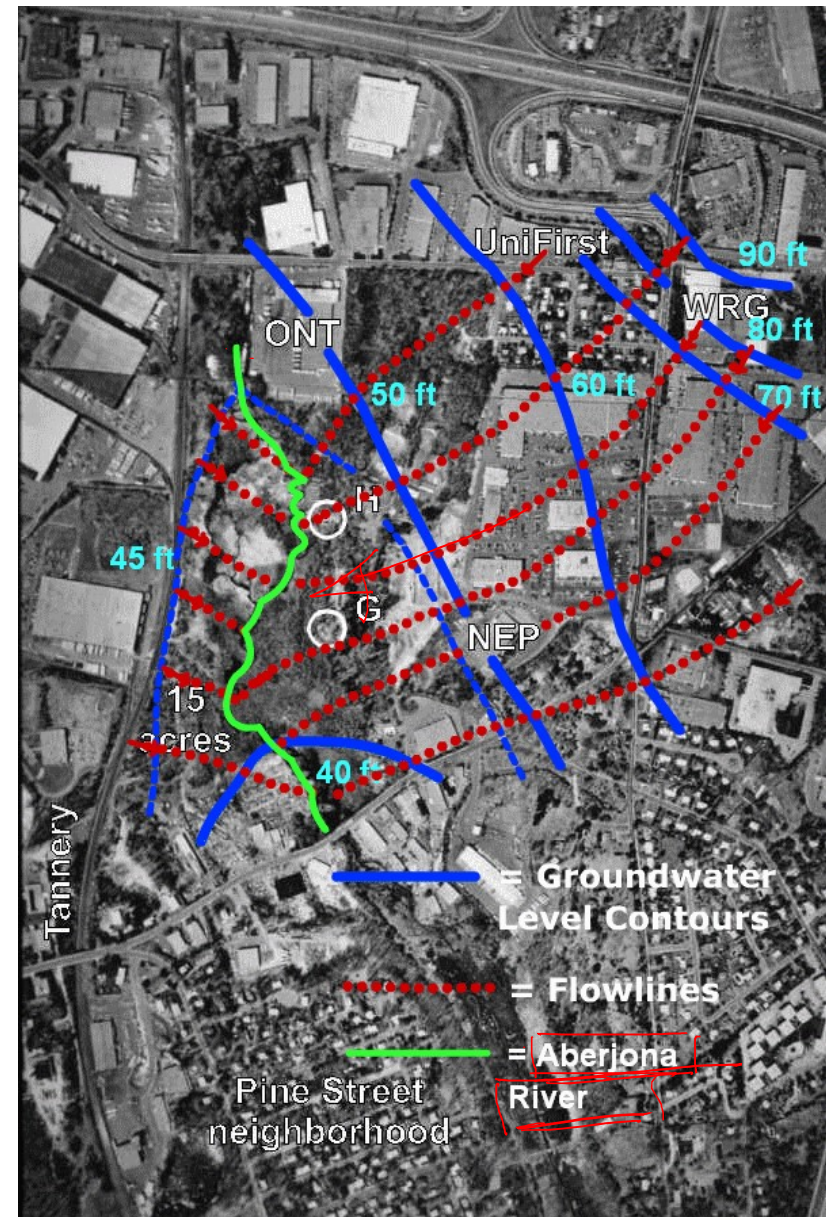
- Companies
  - Beatrice
  - W.R. Grace
  - Unifirst

Flow path with pumping (Woburn, Massachusetts)

Flow path without pumping (Woburn, Massachusetts)

Groundwater Contamination (Contd.)

- SOURCES OF GROUNDWATER CONTAMINATION

  - Disposal of solid wastes

  - Underground petroleum tank leakage

  - Disposal of liquid wastes

  - Sewage disposal on land

  - Agricultural activities
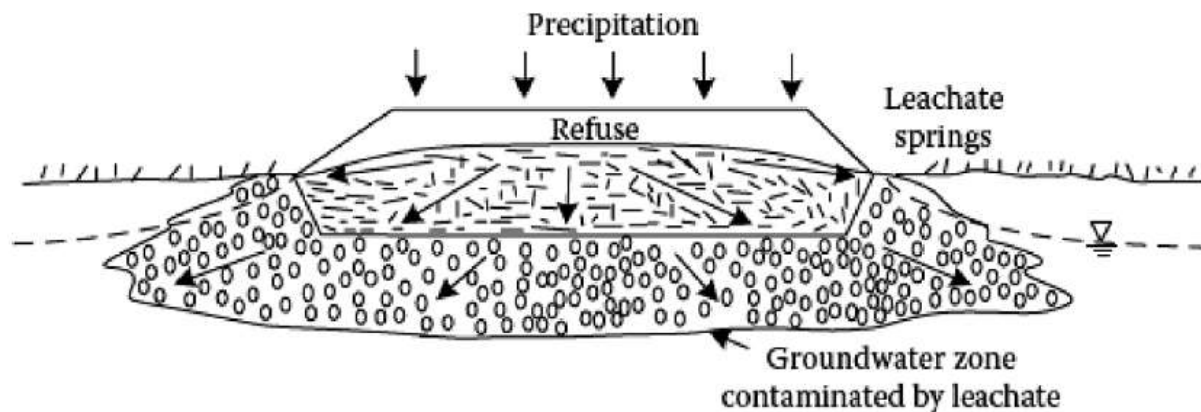
  - Activities of the mining industry

FIGURE 5.2 Water table plume under a landfill, causing leachate springs and migration of contaminants deeper into the groundwater zone.
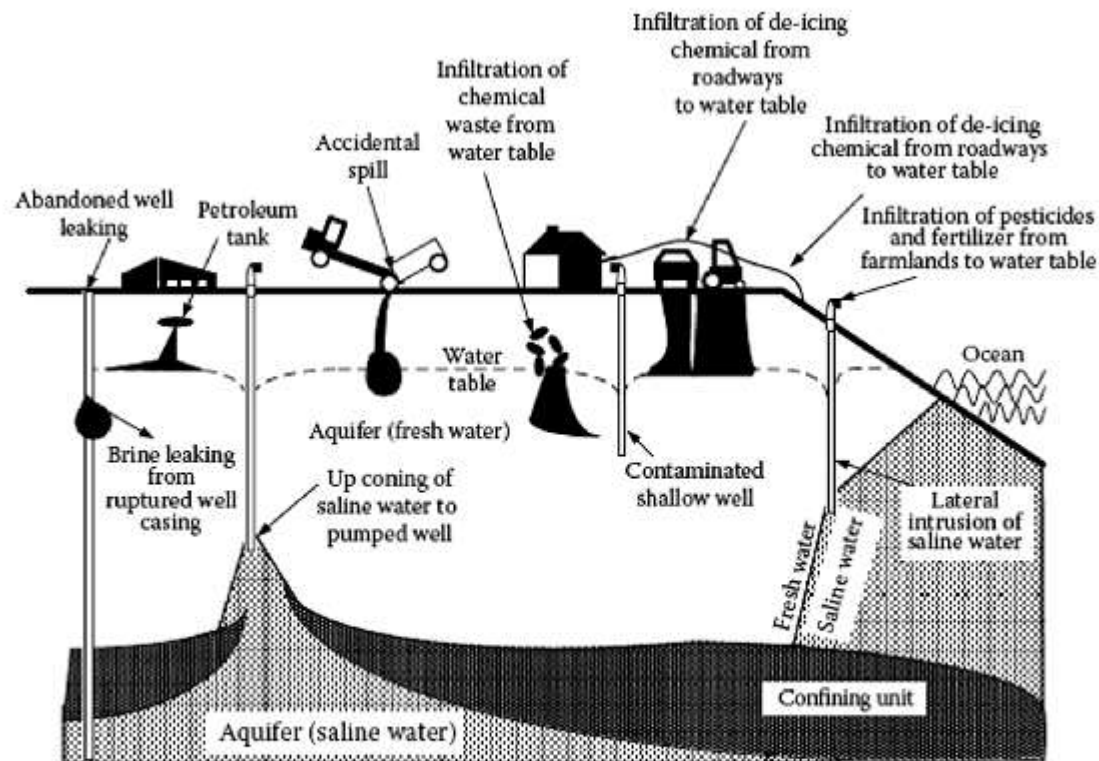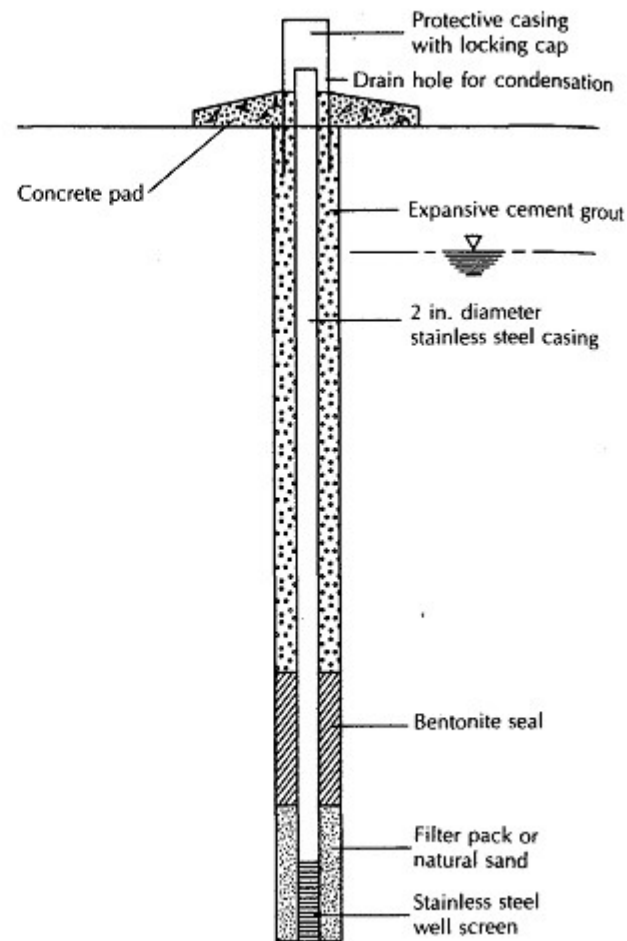
Groundwater Contamination (Contd.)

FIGURE 5.4 Sources of groundwater contamination. (From Delleur, J.W., *The Handbook of Groundwater Engineering*, CRC Press/Springer-Verlag, Boca Raton, FL, 992, 1999.)
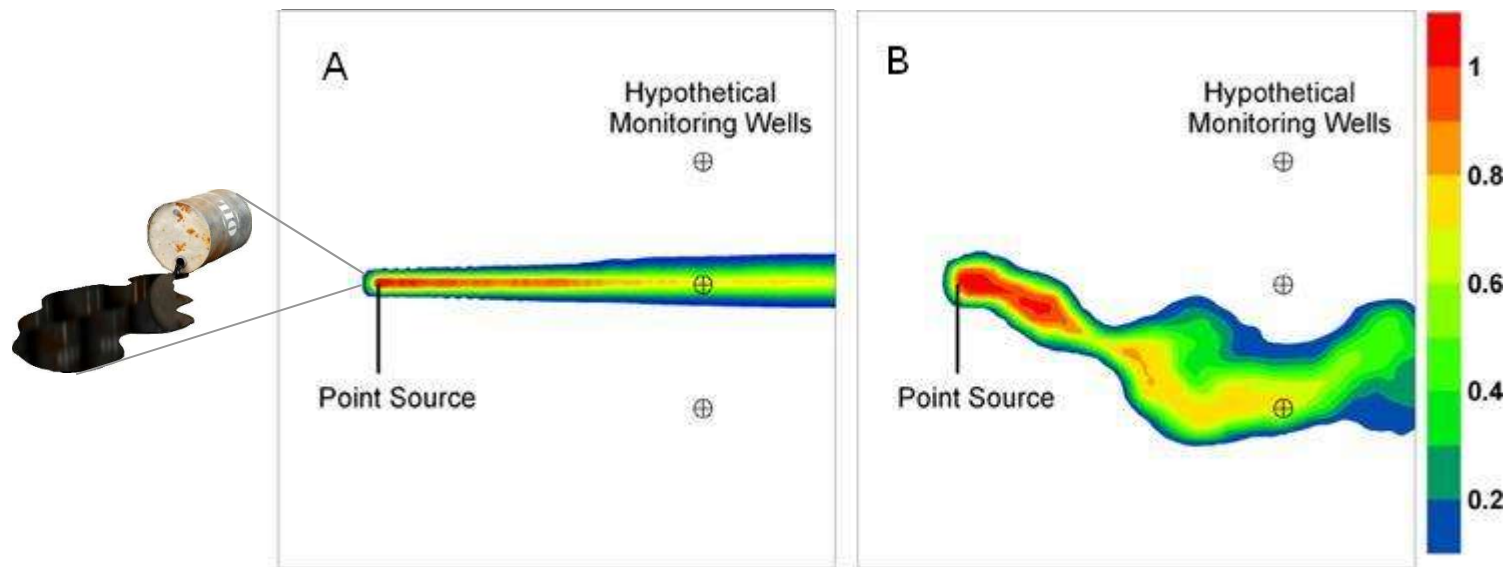
Groundwater Contamination (Contd.)

► FIGURE 10.2
Typical ground-water monitoring well.

Groundwater Contamination (Contd.)

- Monitoring Network

- **Def:** The selection of sampling schedule under budgetary limitation

Groundwater Contamination (Contd.)

Long-term groundwater monitoring

• Ambient monitoring

  ✓Regional, annual monitoring for water safety.

• Detection monitoring

  ✓Watch a dangerous spot

• Compliance monitoring

  ✓Evaluate the progress of a management policy

• Research monitoring

  ✓Monitoring for a specific research purpose

Groundwater Contamination

- Groundwater Constituents And Contaminants

  - Inorganic Contaminants

    o Nitrogen- main form →NO_3 [Other forms: ammonium (NH_4^+), ammonia (NH_3), nitrite (NO_2^-), nitrogen (N_2),nitrous oxide (N_2O), and organic nitrogen]

    o Metals-silver (Ag), cadmium (Cd), chromium (Cr), copper (Cu), mercury(Hg), iron (Fe), manganese (Mn), and zinc (Zn)

   o Nonmetals-carbon, chlorine, sulfur, nitrogen, fluorine, arsenic, selenium, phosphorus, and boron

  - Organic Contaminants

    o Carbon → key element in organic compounds [The compositions H_2CO_3, CO_2, HCO_3^-, and CO_3^{2-} are some exceptions that are not considered as organic components
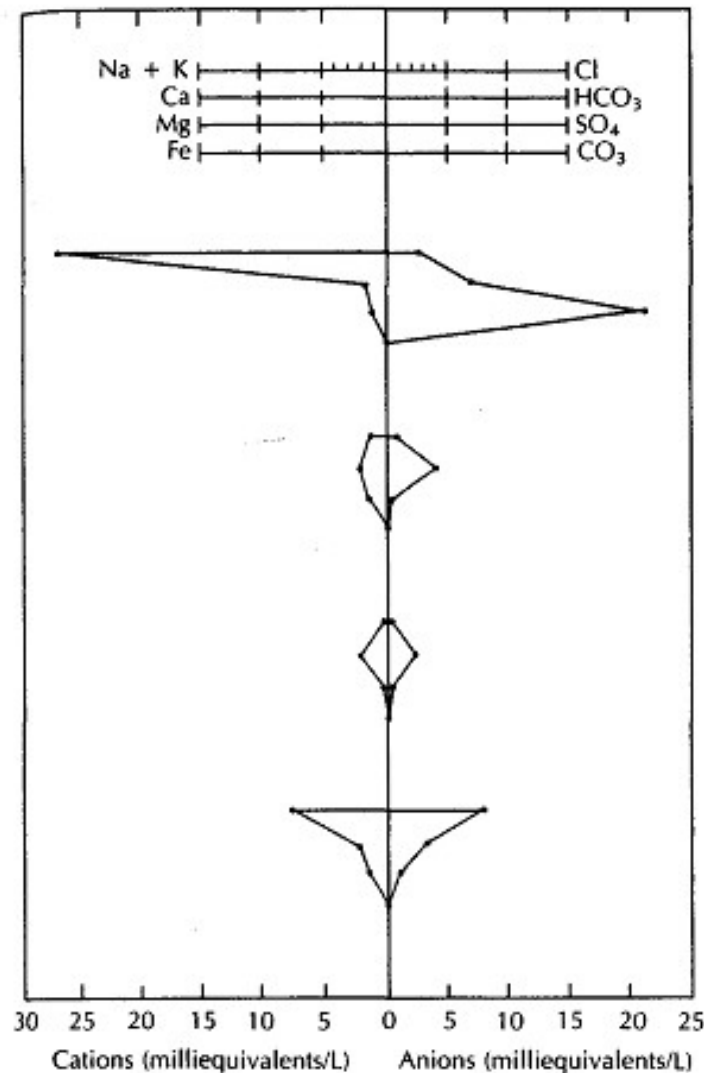
  - Dissolved Gasses

    o natural gases involved in the geochemical cycle of groundwater are carbon dioxide (CO_2), oxygen (O_2), and nitrogen (N_2)

Groundwater Contamination (Contd.)
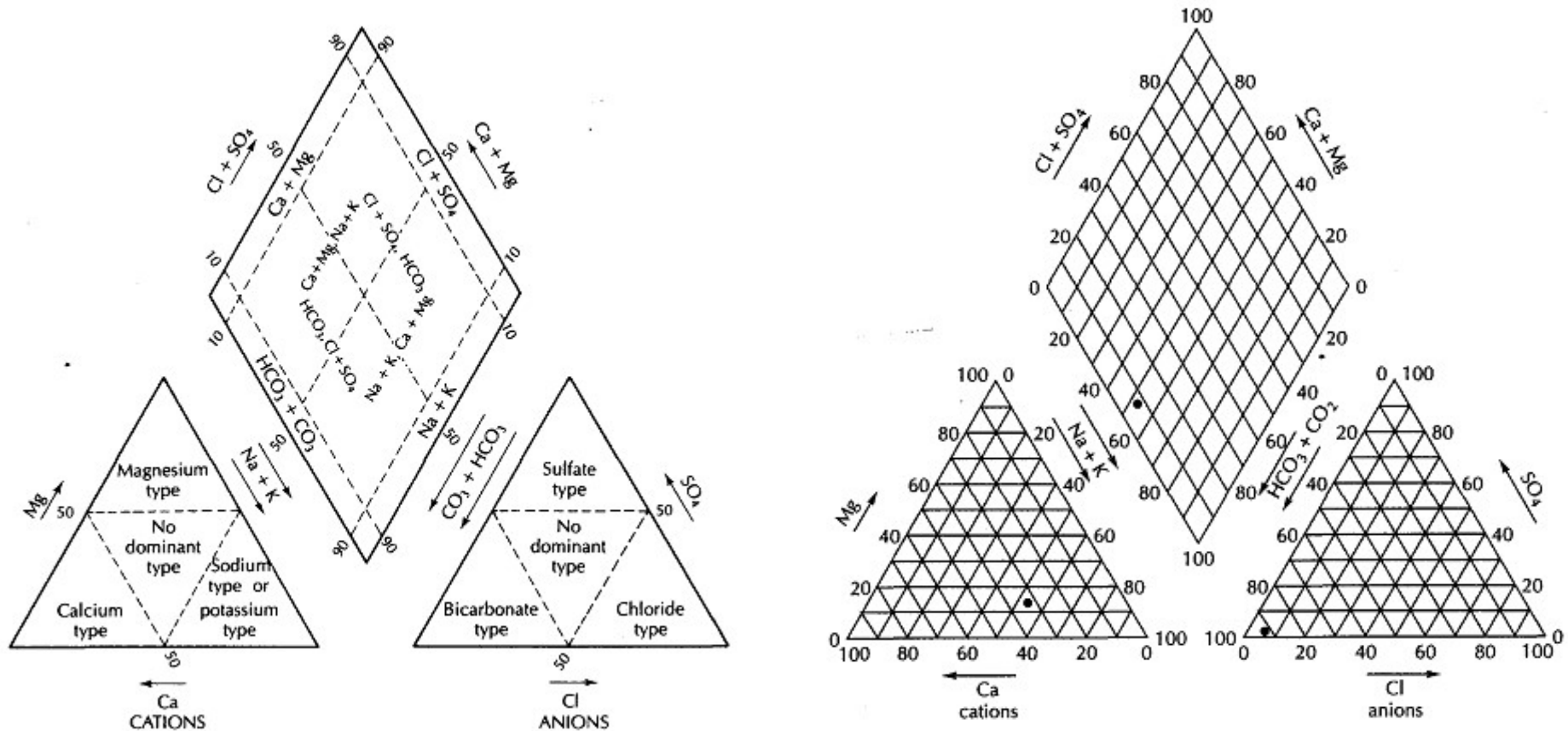
Groundwater Contamination (Contd.)

◄ FIGURE 9.10
Analysis represented by Stiff patterns.
The horizontal distance from the vertical
axis is based on the number of
milliequivalents per liter of each anion or
cation. Use of the lower bar for iron and
carbonate is optional. *Source: J. D. Hem,
U.S. Geological Survey Water-Supply Paper
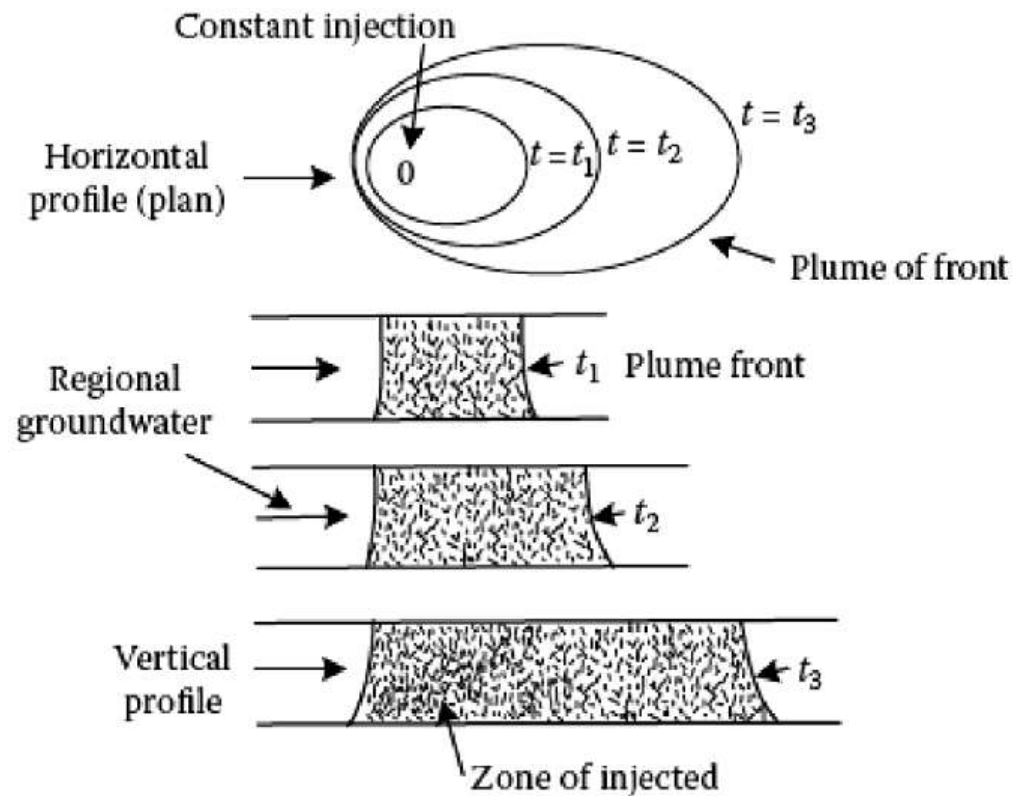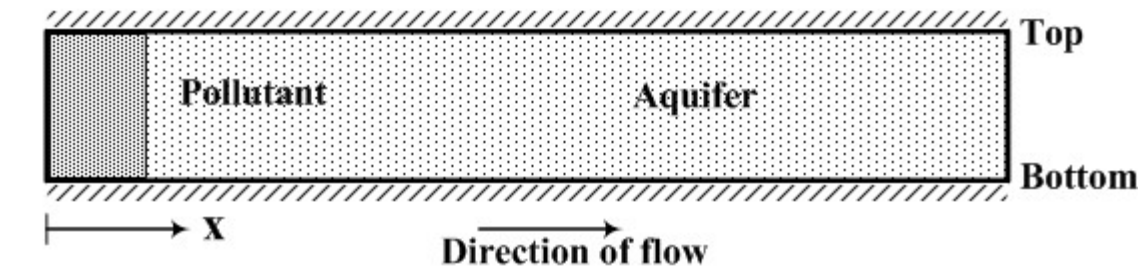2254, 1985.*

Groundwater Contamination (Contd.)

FIGURE 5.3 Potentiometric mound caused by waste disposal injection and the expansion of the affected zone occupied at times t_1, t_2, and t_3.

Groundwater Contamination (Contd.)

Pollutant distribution at t = 0

Top

Pollutant   Aquifer

Bottom

X

Direction of flow

c   Concentration c_0

x = 0

Distance X
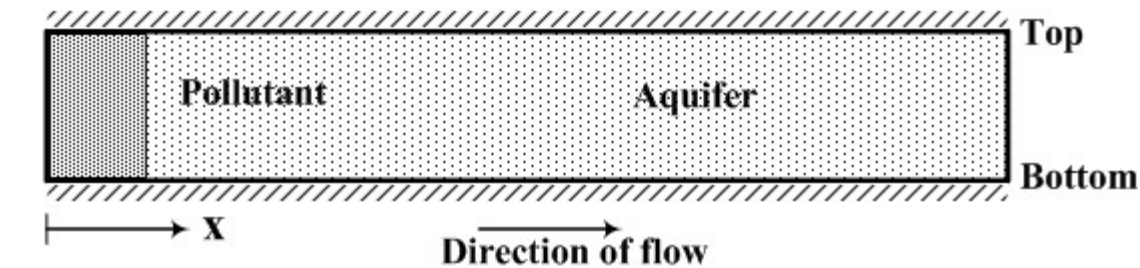
Pollutant distribution at t > 0
Advection

c

x = vt   X

Advection: movement of solutes that are carried along with the flowing groundwater
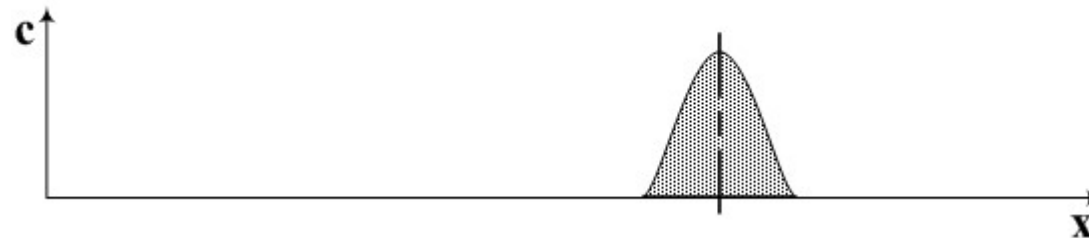
Groundwater Contamination (Contd.)

Pollutant distribution at t = 0

Top

Pollutant   Aquifer

Bottom

X

Direction of flow

c

Concentration c_0

x = 0   Distance X
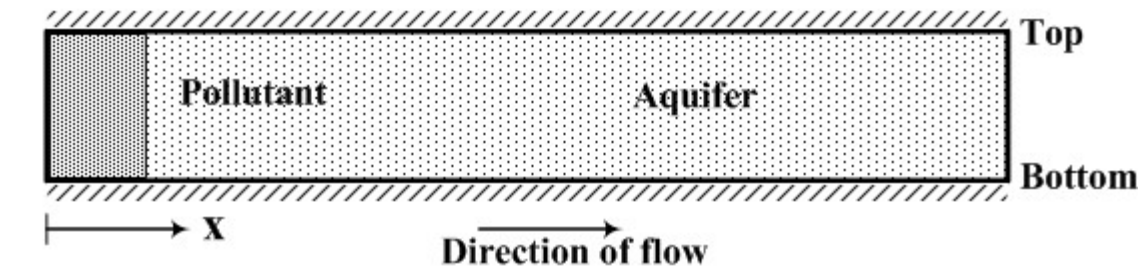
Pollutant distribution at t > 0
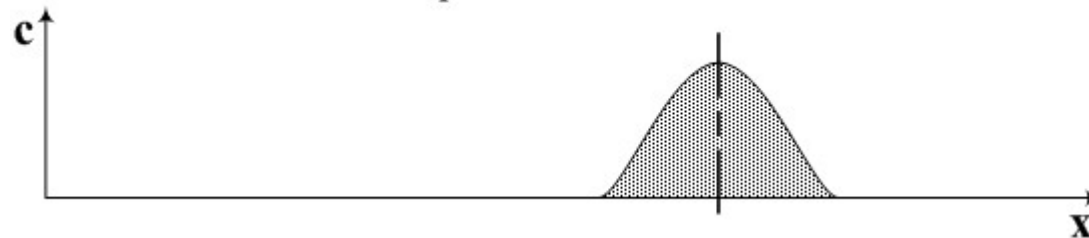Advection + diffusion

c

X

Diffusion: molecular process where constituents are spread
due to differences in concentrations,

Groundwater Contamination (Contd.)
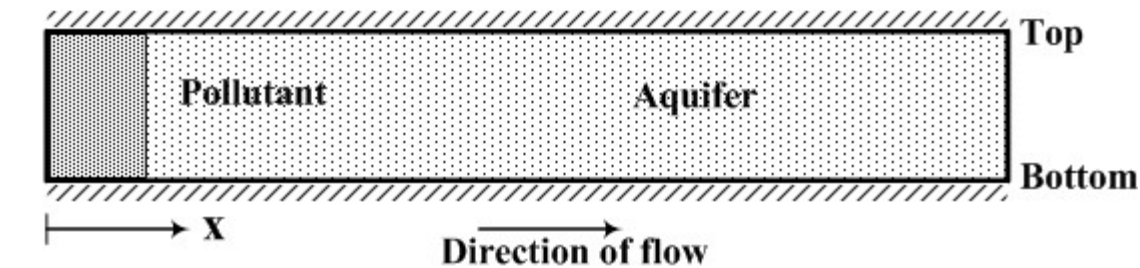
Pollutant distribution at t = 0

Top

Pollutant   Aquifer

Bottom

X

Direction of flow

c   Concentration c_0

x = 0   Distance X

Pollutant distribution at t > 0
Advection + diffusion+ dispersion

c

X

Dispersion: mixing process caused by differences in velocity
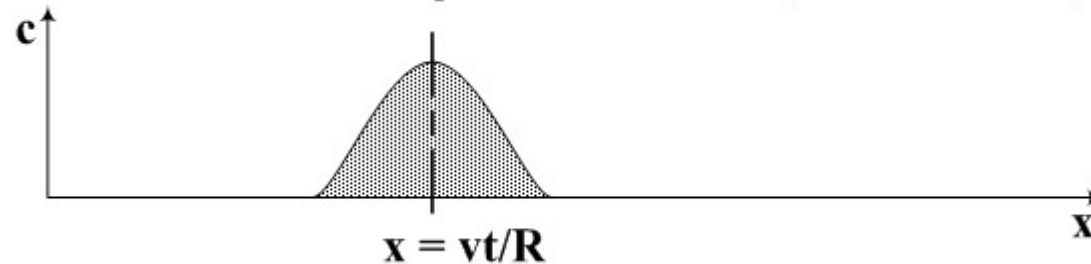(in magnitude and in direction) of water particles,

Groundwater Contamination (Contd.)

Pollutant distribution at t = 0
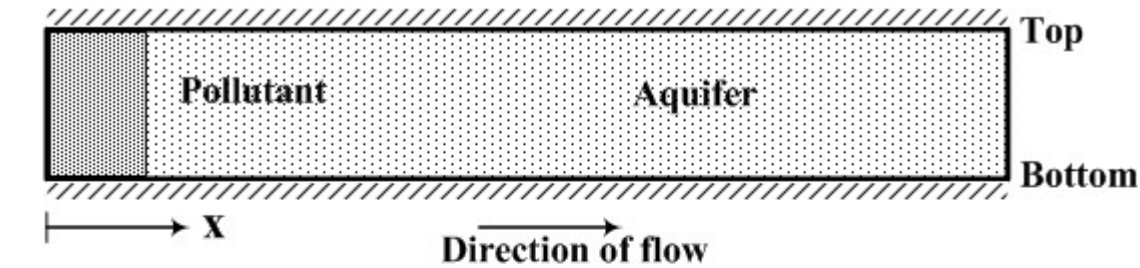

Top

Pollutant   Aquifer

Bottom

$\longmapsto$ X

Direction of flow

c ↑ Concentration c_0

x = 0

Distance X

Pollutant distribution at t > 0
Advection + diffusion + dispersion + retardation (linear isothermal)

c ↑

$x = vt/R$

X

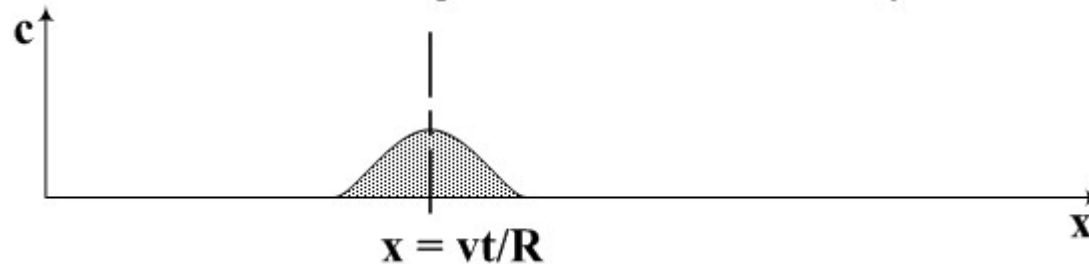**Adsorption:** process where certain constituents are attached to grain material

Groundwater Contamination (Contd.)

Pollutant distribution at t = 0

Top

Pollutant   Aquifer

Bottom

X

Direction of flow

c   Concentration c_0

x = 0   Distance X

Pollutant distribution at t > 0
Advection + diffusion+ dispersion + retardation + decay

c

x = vt/R   X

Decay: change in concentration by biologic or radioactive decline

Thank you