Groundwater in Canada

Some updates
WPCP
Lake Superior speaker

Tour follow up

- Primary treatment: reduces some solids through screening and settling processes
- Secondary: further reduces solids, grease and oils and other pollutants
- Tertiary: the most stringent.
- In the European Union: all communities with more than 15,000 people have secondary treatment since 2000 with all urban centres tertiary treatment by 2010.
- United States: all coastal cities must have secondary treatment.

- Canada . . . has no national sewage standards.

- TBFN Annual Dinner Meeting
- Current Recreation Community Centre
- Sunday, February 25, 2018. Symposium 4:30 pm, Supper 5:45pm. There will be a cash bar. Tickets $30 . . . $15 for students
- **This year's guest speaker is Dr. Tom Beerys, social scientist and educator with Minnesota Sea Grant at the University of Minnesota Duluth. His presentation is**

Climate Change and Lake Superior

Note – Tickets will not be available at the door.

Message on the Environment and Climate Change Canada website

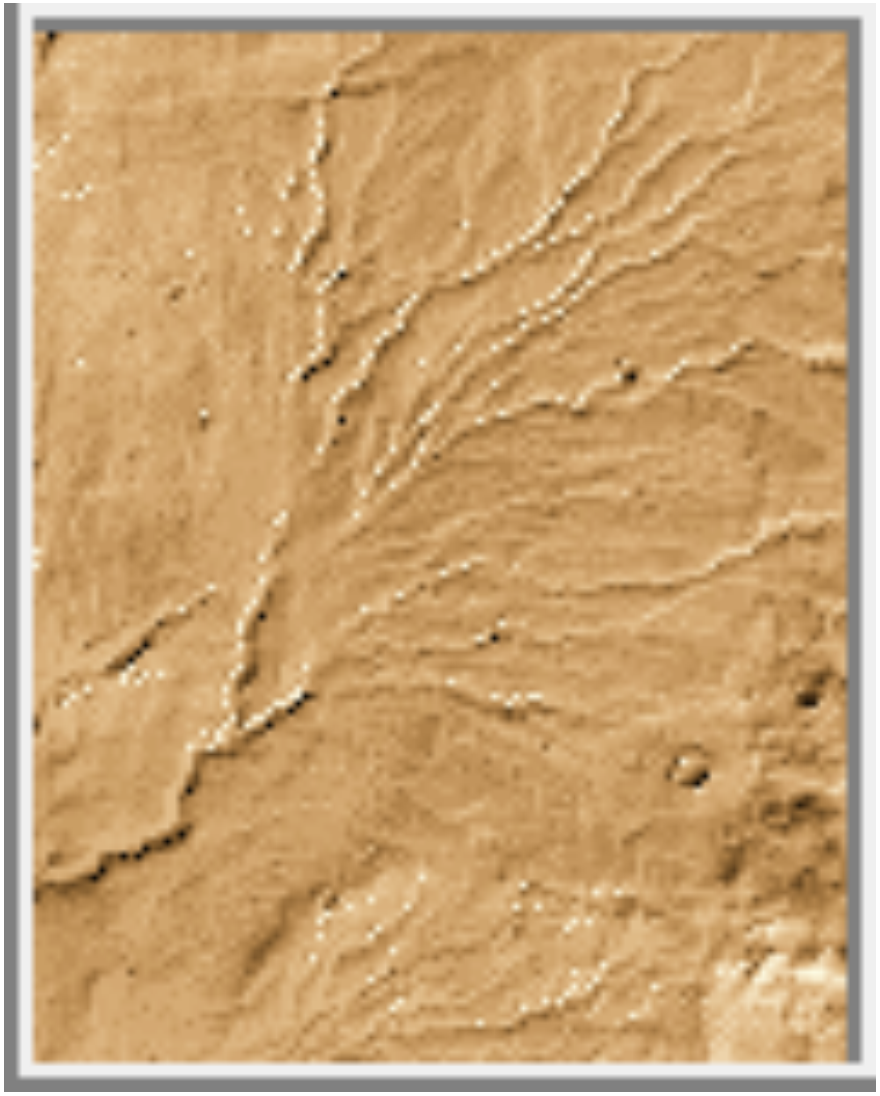
Cleaning up the nation's largest source of water pollution is a priority. In Canada over 150 billion litres of untreated and undertreated wastewater (sewage) is dumped into our waterways every year. This is an environmental, human health and economic issue.

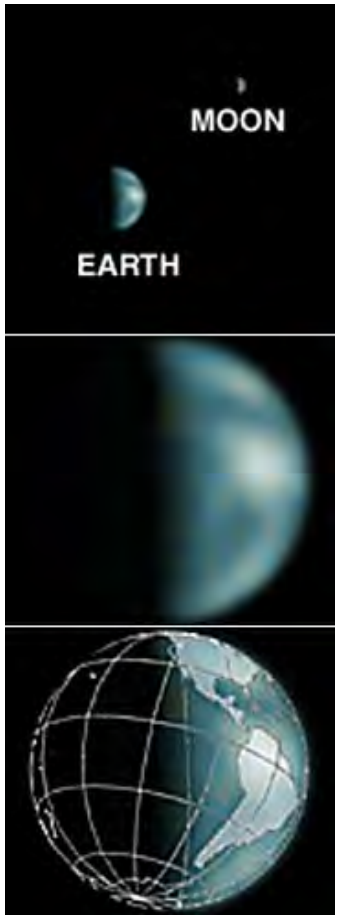
- Discharge an average of 130 million litres a day into the ocean with some screening, but little "primary" treatment
- Health advisory signs posted on 28 local beaches (200 fecal coliforms per 100 millilitres [fc/100] for beaches, and 14 [fc/100] for shellfish harvesting)
- Ordered by Federal and BC governments to clean up
- Potential construction cost of more than $1 billion
- None of this is "news"; Victoria has been pooping in the ocean for more than a century

Groundwater

- Groundwater the invisible resource
- Groundwater in Canada
- Technical discussion of groundwater
- Groundwater pollution

Groundwater On Mars





View of Earth from Mars

Groundwater On Earth:

- Small but integral part of hydrological cycle
- Within 1 km of earth's surface
- Estimated volume of groundwater is 4.2 million km^3

Compared to:

- 125,000 km^3 freshwater lakes
- 1,250 km^3 in streams

'the invisible resource'

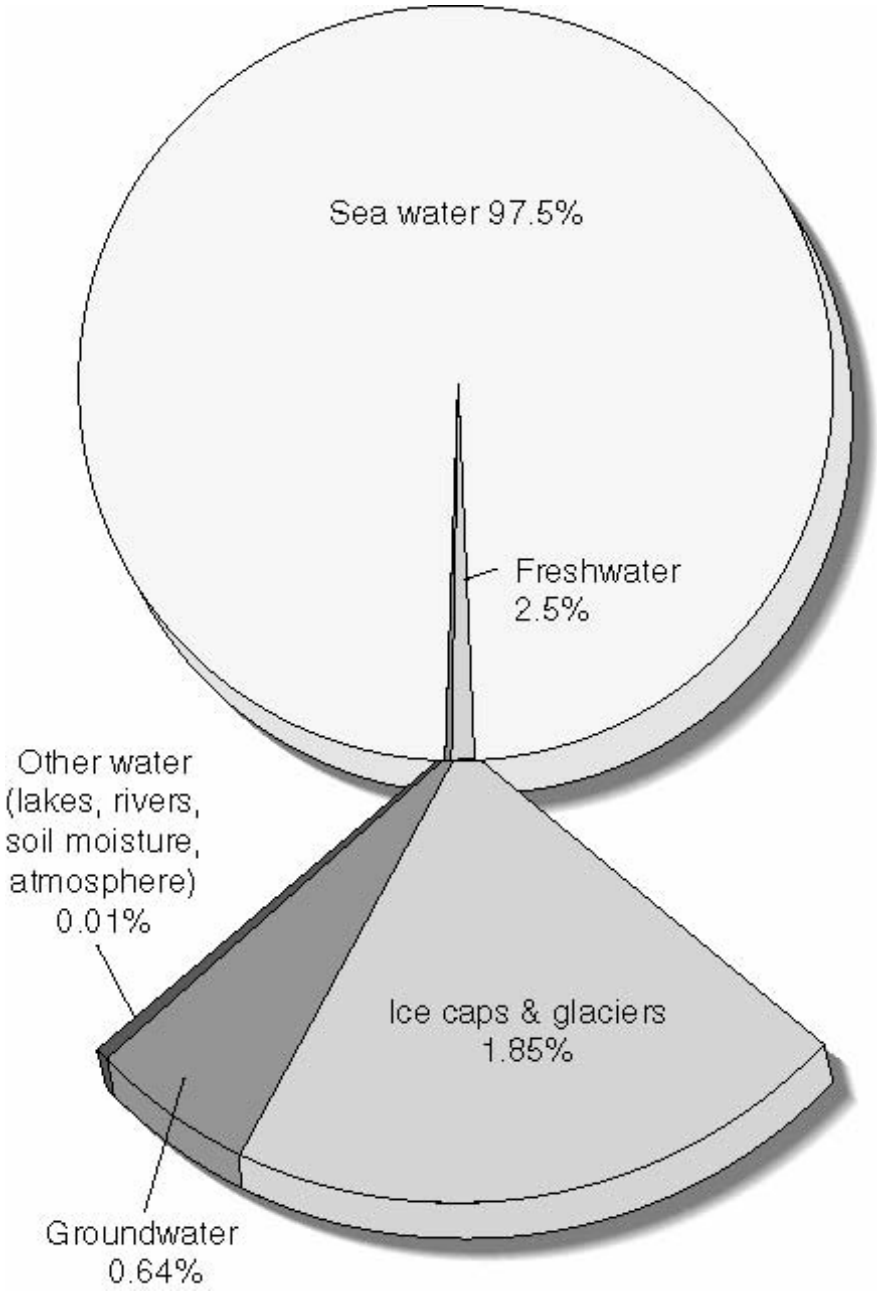


TABLE 4.4 Estimated Residence Time of the World's Water Supply

Water Type	Residence Time
Oceans and seas	4000 years (approx.)
Lakes and reservoirs	10 years (approx.)
Swamps	1–10 years (approx.)
Rivers	2 weeks
Soil moisture	2 weeks–1 year
Groundwater	2 weeks–10,000 years
Icecaps and glaciers	10–1000 years
Atmospheric water	10 days

Source: Adapted from R. Allen Freeze and John A. Cherry, *Groundwater* (Englewood Cliffs, NJ: Prentice-Hall, 1979), 5.

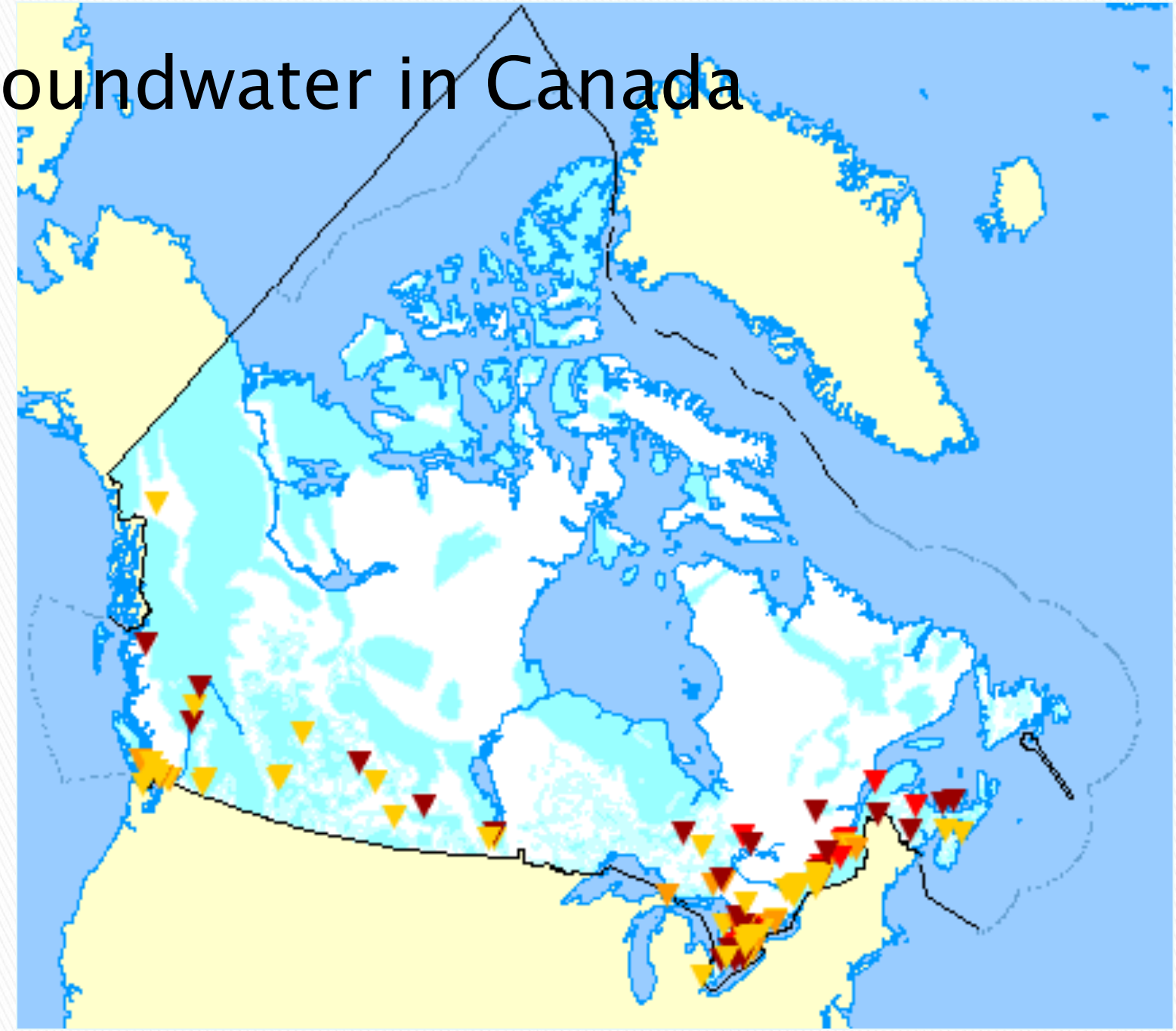
Water use:

Groundwater supports 98 % of freshwater readily available to humans

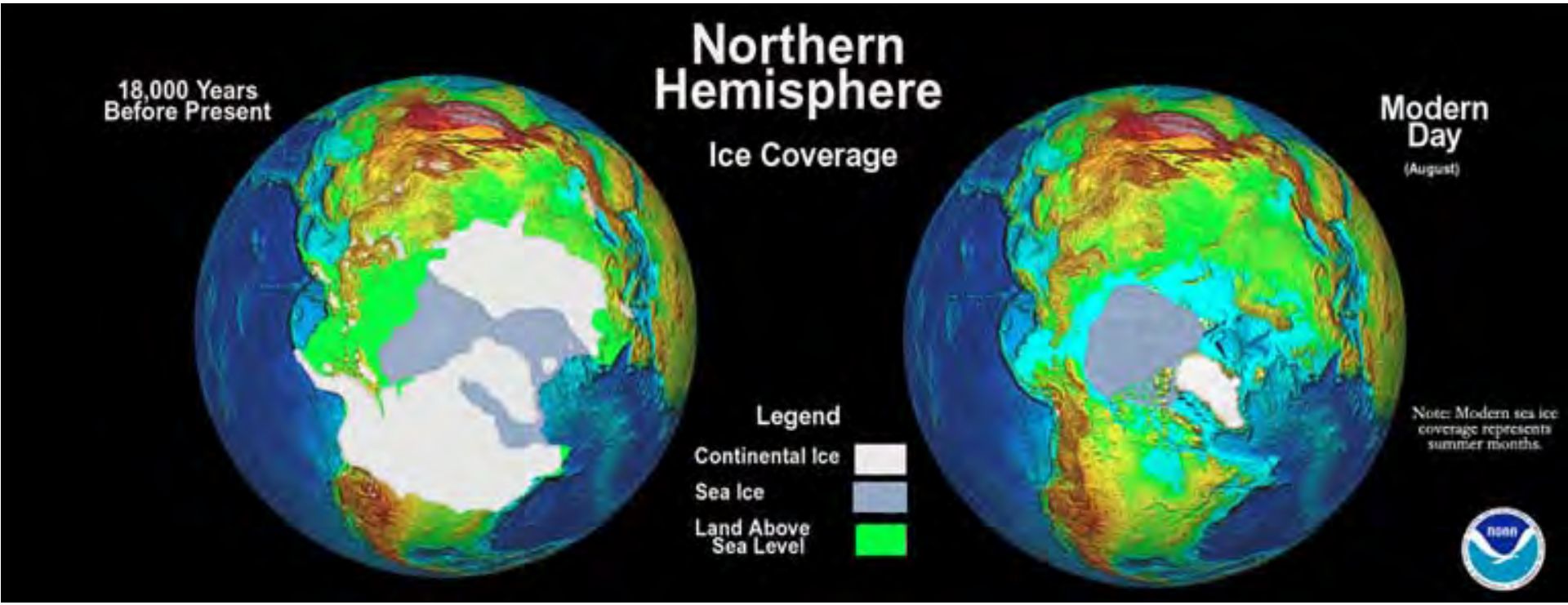
- US – 50% of population (37% of irrigation)
- Canada – more than 30% of population

- Vulnerability:
  - Just **1 litre** of gasoline can contaminate **1 million litres** of drinking water

Groundwater in Canada



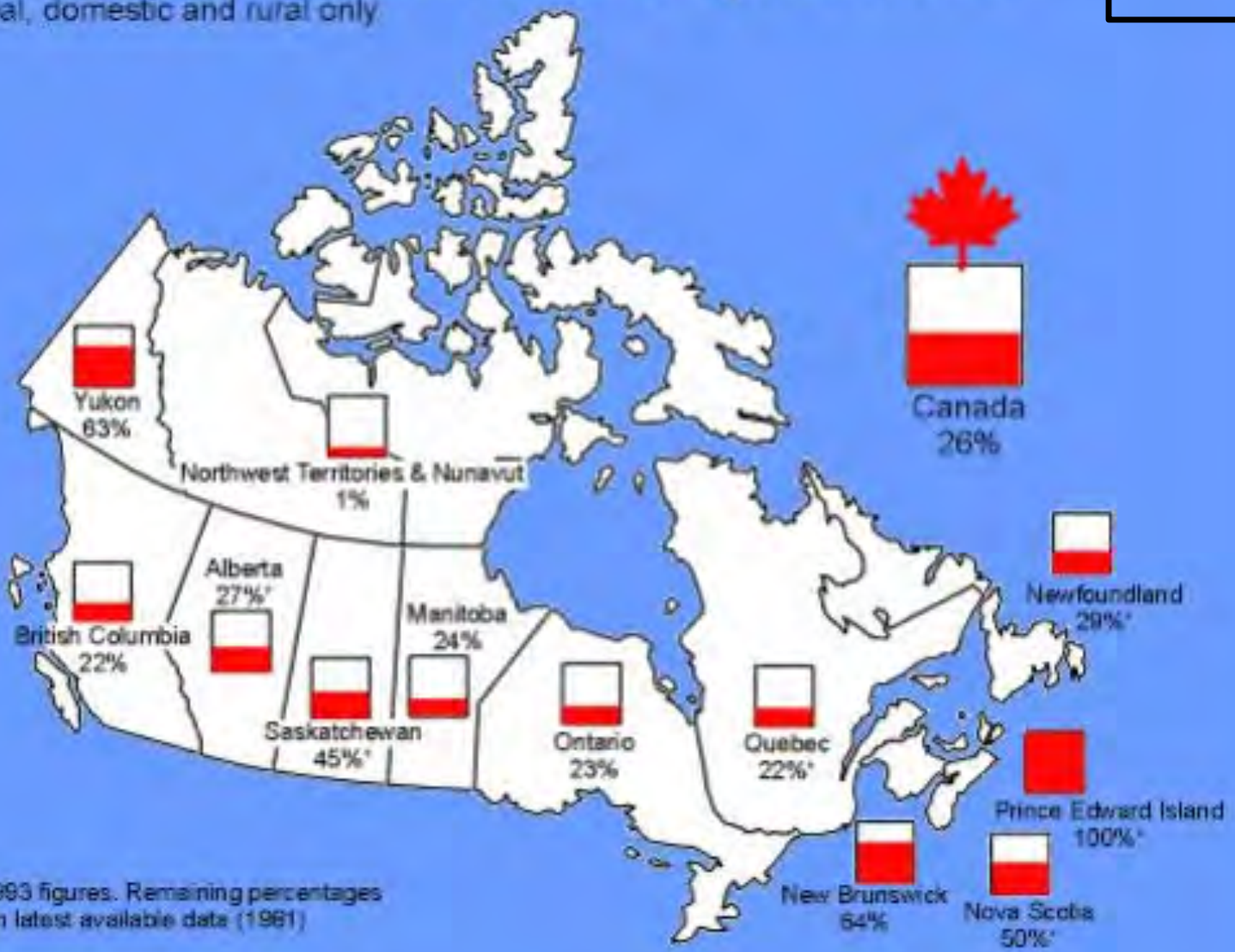
Extent of Glaciation



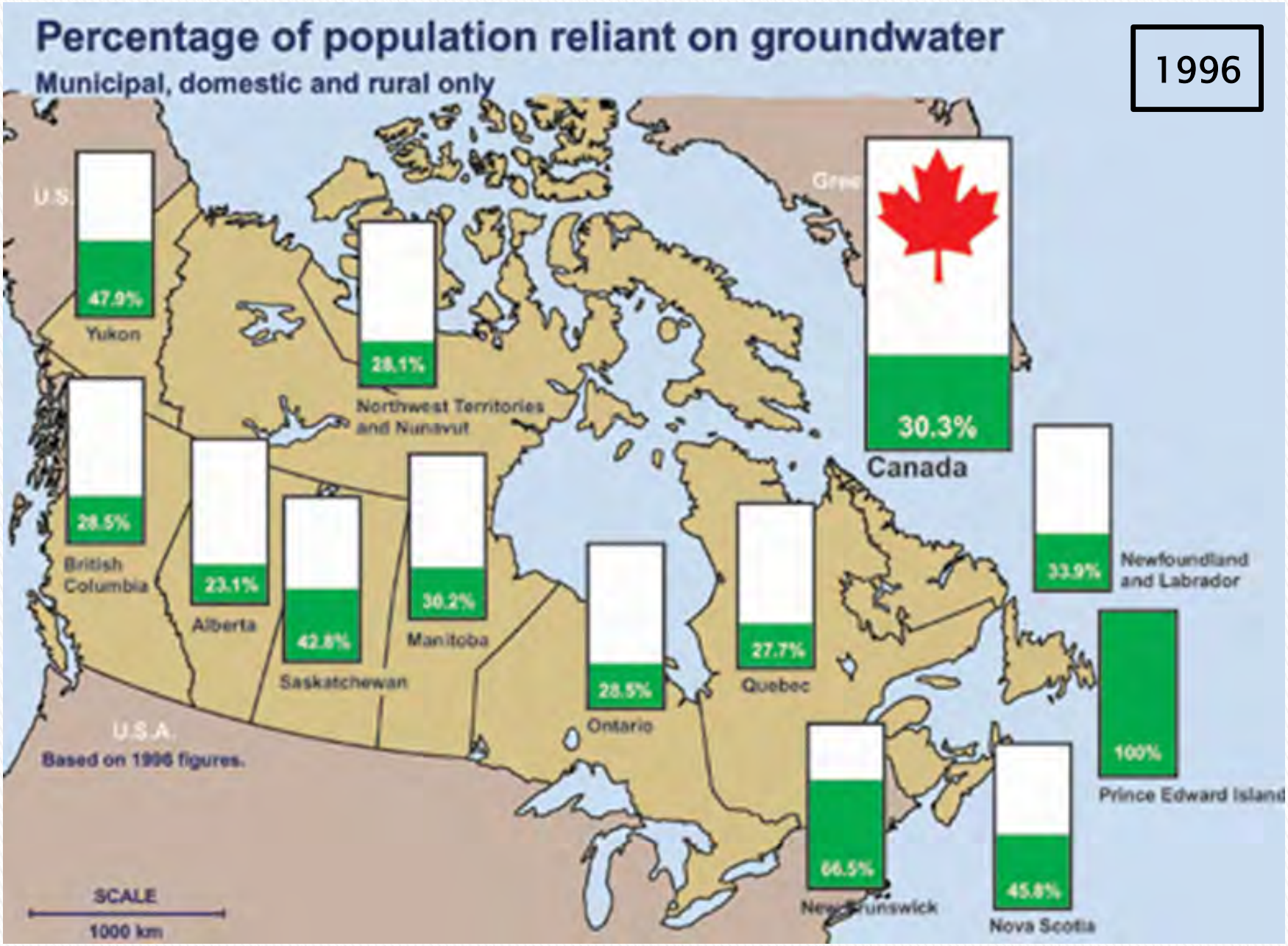
Percentage of population reliant on groundwater

Municipal, domestic and rural only

1981



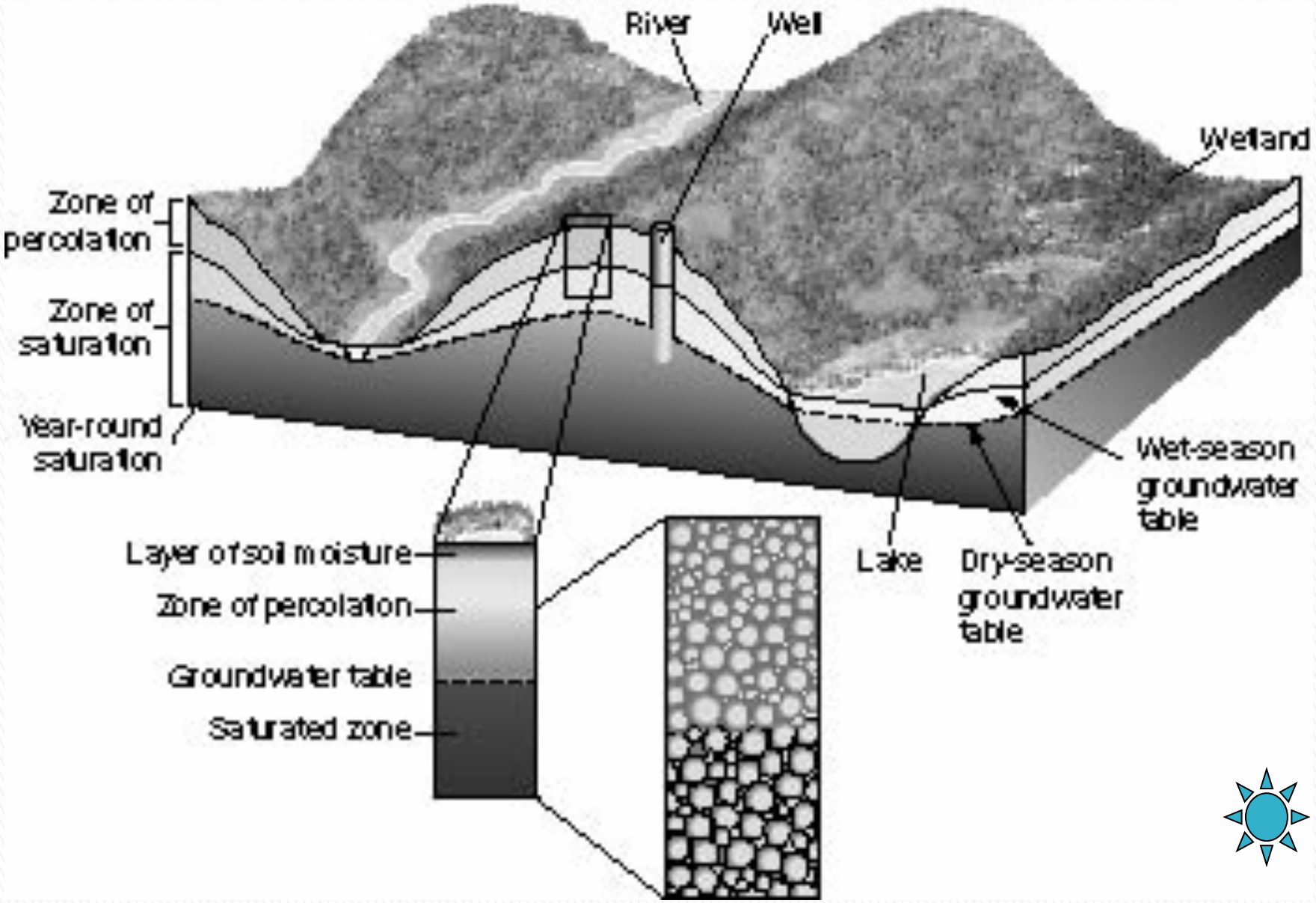
* Based on 1993 figures. Remaining percentages are based on latest available data (1981)


Percentage of population reliant on groundwater
Municipal, domestic and rural only
1996
47.9%
Yukon
28.1%
Northwest Territories and Nunavut
30.3%
Canada
28.5%
British Columbia
23.1%
Alberta
42.8%
Saskatchewan
30.2%
Manitoba
28.5%
Ontario
27.7%
Quebec
33.9%
Newfoundland and Labrador
100%
Prince Edward Island
66.5%
45.8%
Nova Scotia
U.S.A.
Based on 1996 figures.
SCALE
1000 km

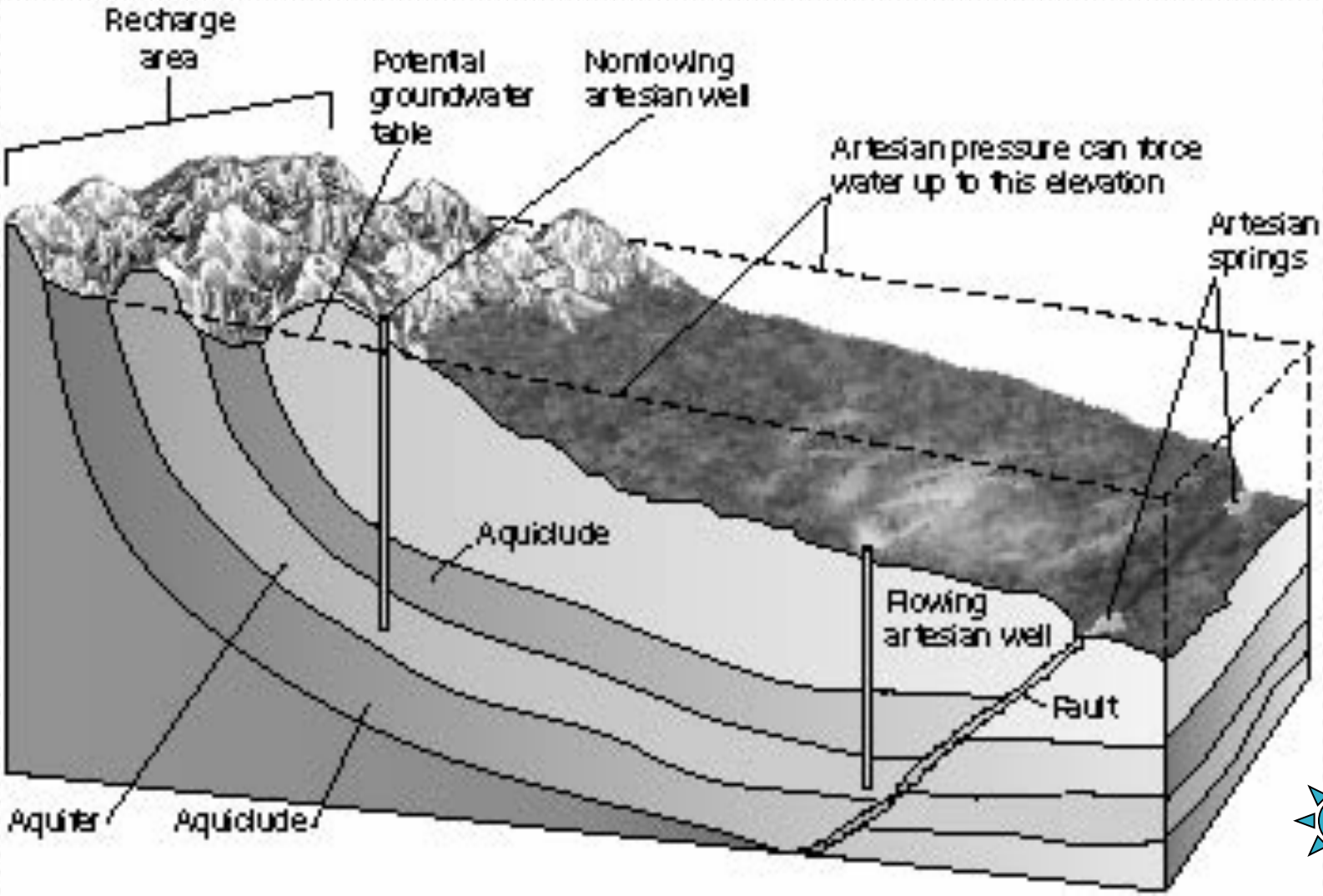
Technical Discussion

- How is groundwater formed?
- What does geology play in the movement of surface water into groundwater settings?
- How does groundwater interact with surface water?
- What methods are used to measure the movement of groundwater?
- How are groundwater quantities quantified?
- Further discussion: https://www.ec.gc.ca/eau-water/default.asp?lang=En&n=300688DC-1

Topic One: Groundwater Hydrology



Topic Two: Recharge Potential

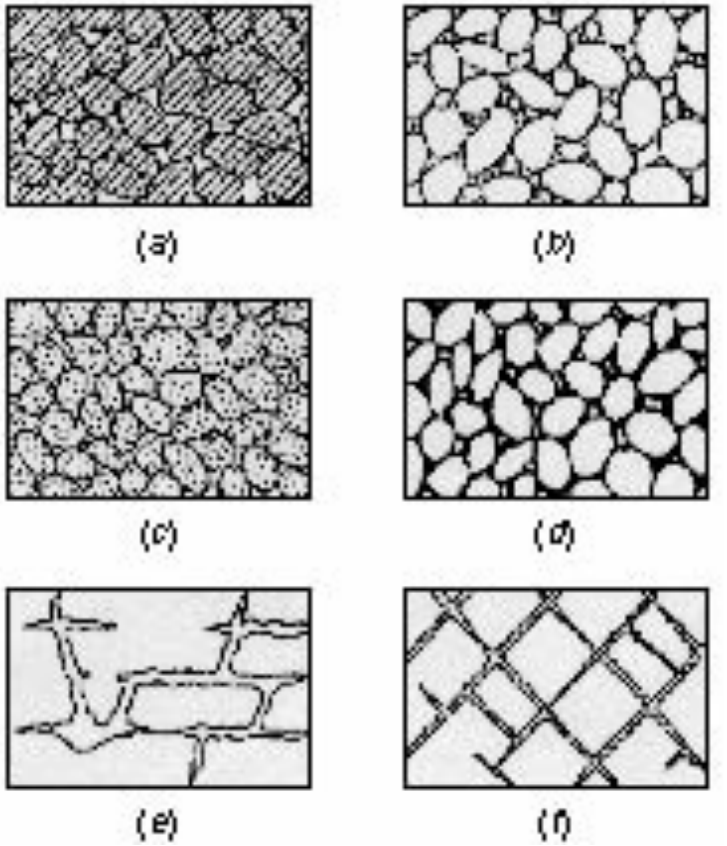


Bottled Water

- Bottling of artesian springs is worldwide
- UNICEF reports consumption was non-existent in 1950s:
  - Grew to 3.2 billion litres in 1984
    - then 11.2 billion litres in 1997
  - Now, 50 billion litres/year (about 30 bl in USA)

- Nearly half of bottled water is not “springwater”.

Topic Three: Porosity and Permeability



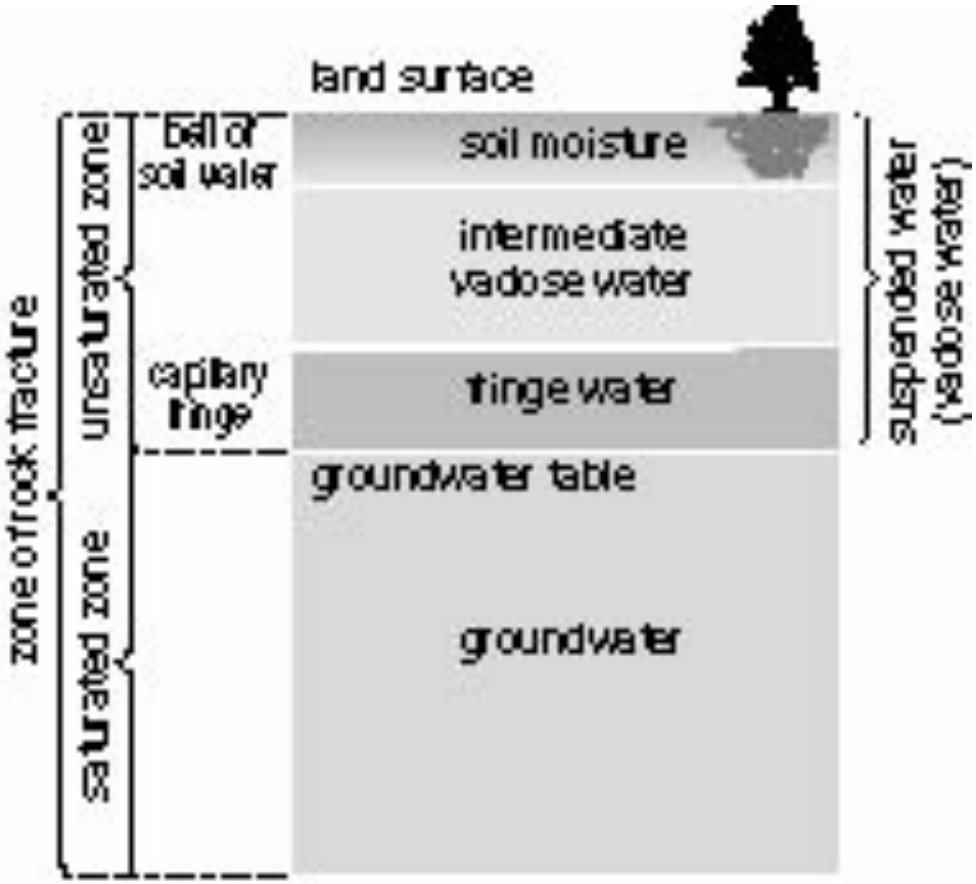
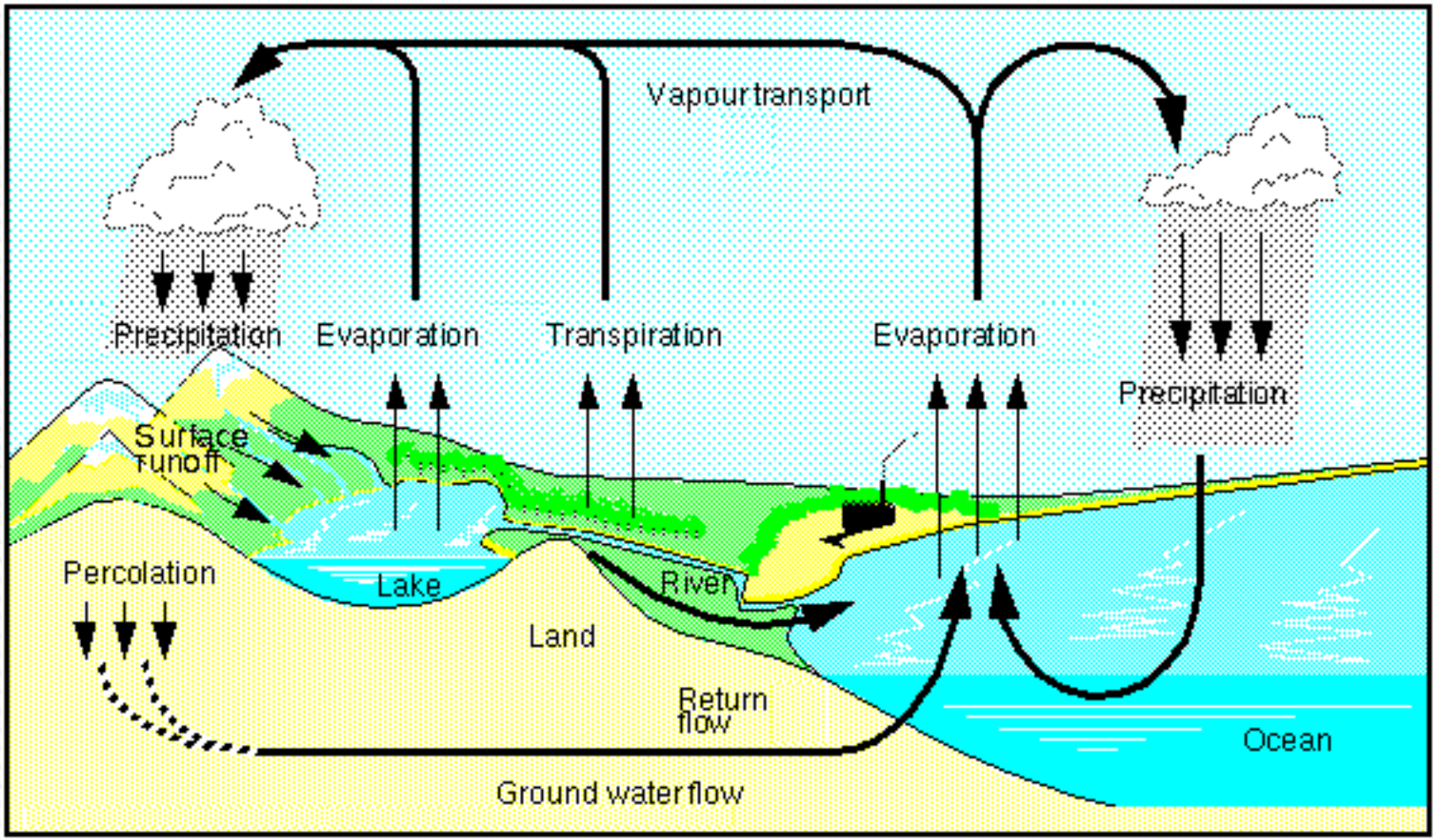


TABLE 4.1 Grain-Size Classification

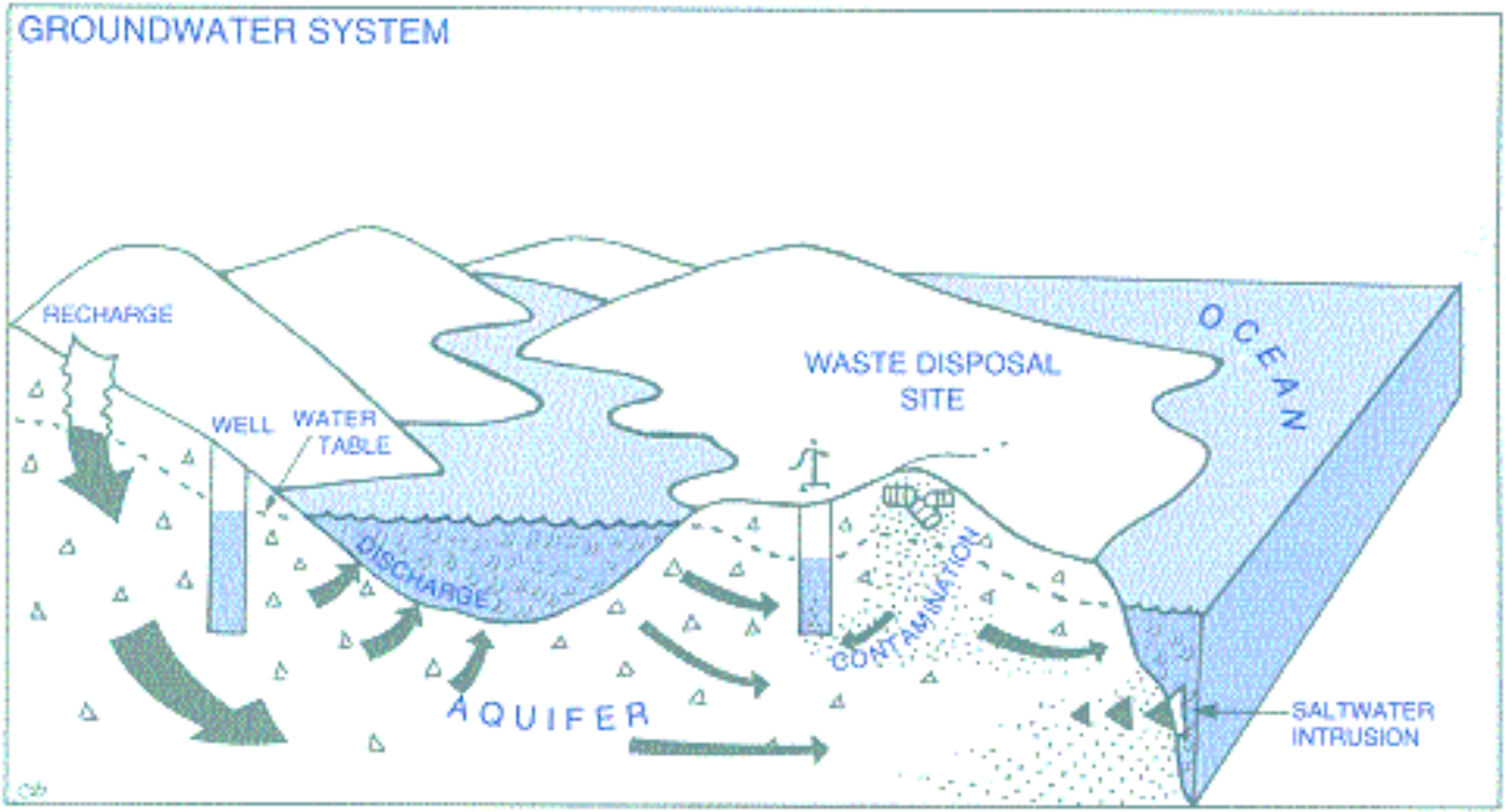
Material	Size (inches)	Size (mm)	Example
Boulder	>12	>300	Basketball
Cobbles	3–12	75–300	Grapefruit
Coarse gravel	0.7–3	18–75	Grape
Fine gravel	0.2–0.7	5–18	Pea
Coarse sand	0.08–0.2	2–5	Water softener salt
Medium sand	0.02–0.08	0.5–2	Table salt
Fine sand	0.003–0.02	0.075–0.5	Powdered sugar
Fines	<0.003	<0.075	Talcum powder

Topic Four: The Groundwater Cycle



Courtesy Erich Roeckner, Max Planck Institute for Meteorology

Topic Five: Human Influences to Groundwater System



WATER SUPPLY AND WATER QUALITY

Water supply is the provision of water for different types of human use, such as drinking, domestic use, irrigation and urban-industrial supply.

Two basic problems are related to the balance between demand and availability and the quality of water:

1. Supply is dependent on the physical principles of the hydrologic cycle
2. Demand is related to the density of population.

Thapa, 2001

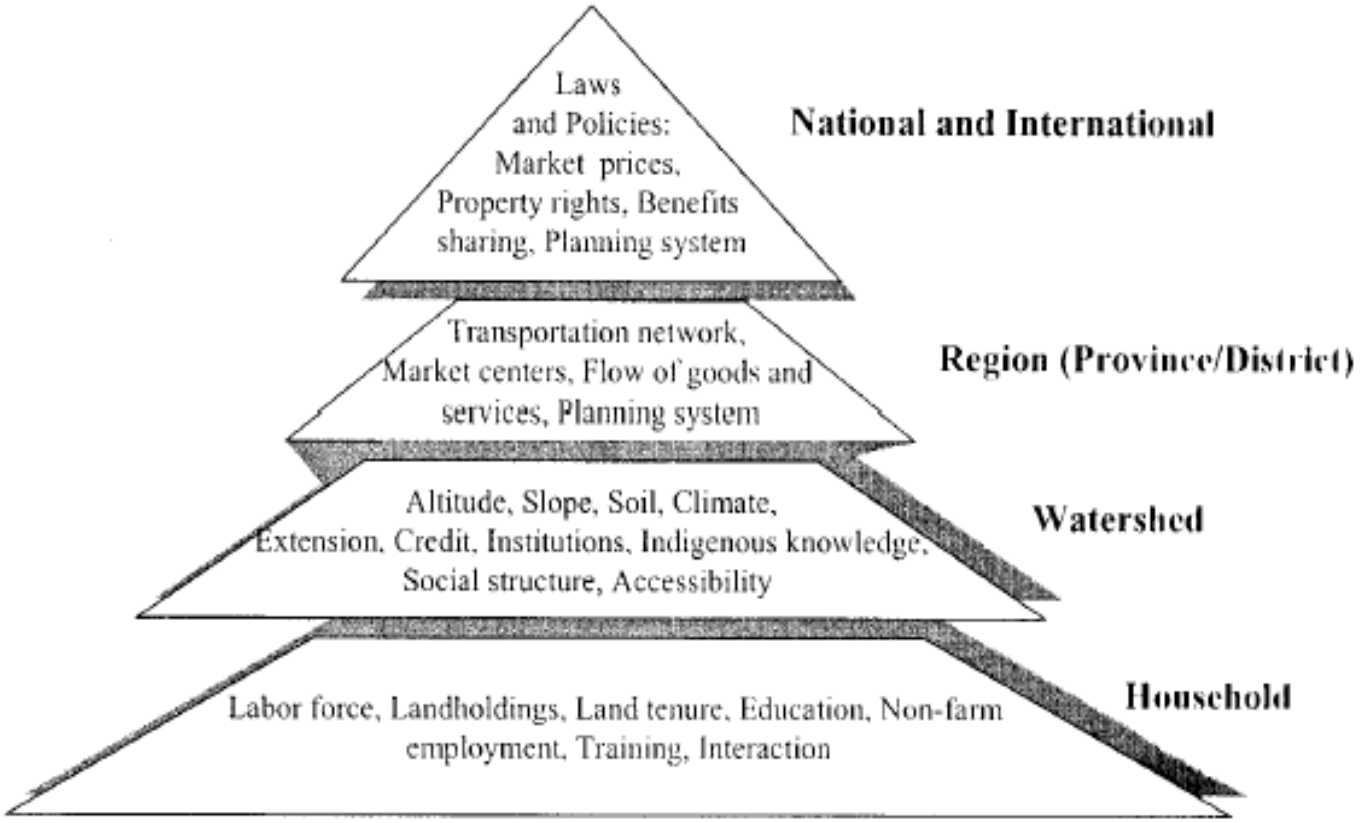


Figure 1. The four-tier hierarchy of factors influencing watershed resources use and management. This is a list of selected multilayer factors influencing watershed resources use and management. Depending on the location-specific situation, the influencing factors vary from one watershed to another.

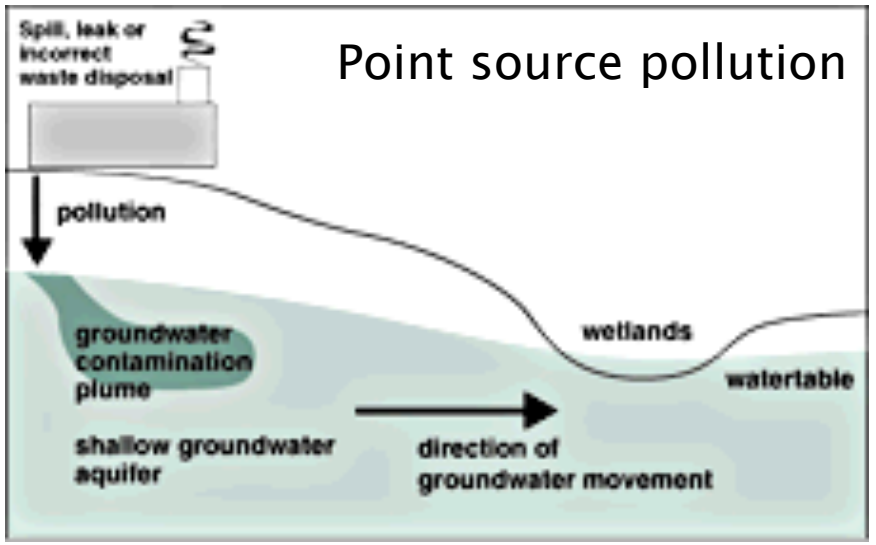
Groundwater Pollution

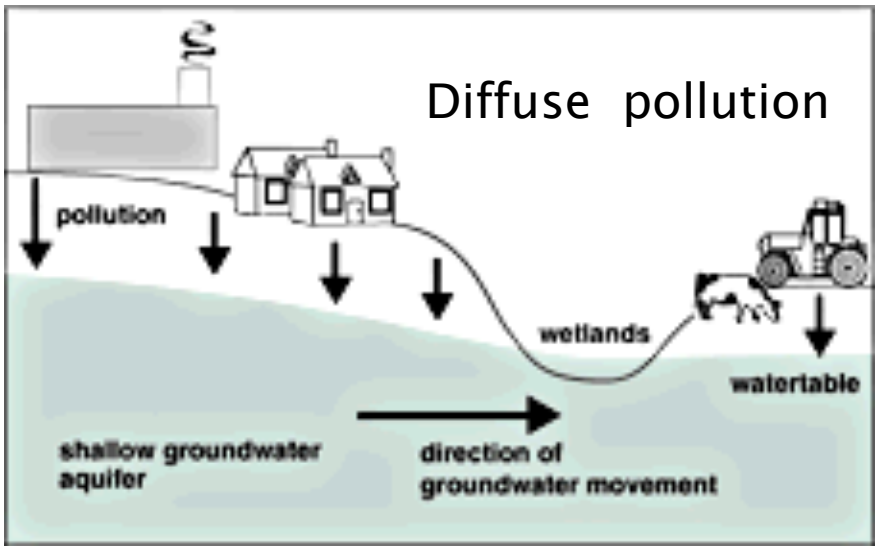
Groundwater pollution occurs when waste products or other substances change the chemical or biological characteristics of the water and degrade water quality so that animals, plants or human uses of the water are affected.

- plant nutrients
- bacteria, viruses
- pesticides, herbicides
- hydrocarbons (including petrol and oil)
- heavy metals and other toxic chemicals.

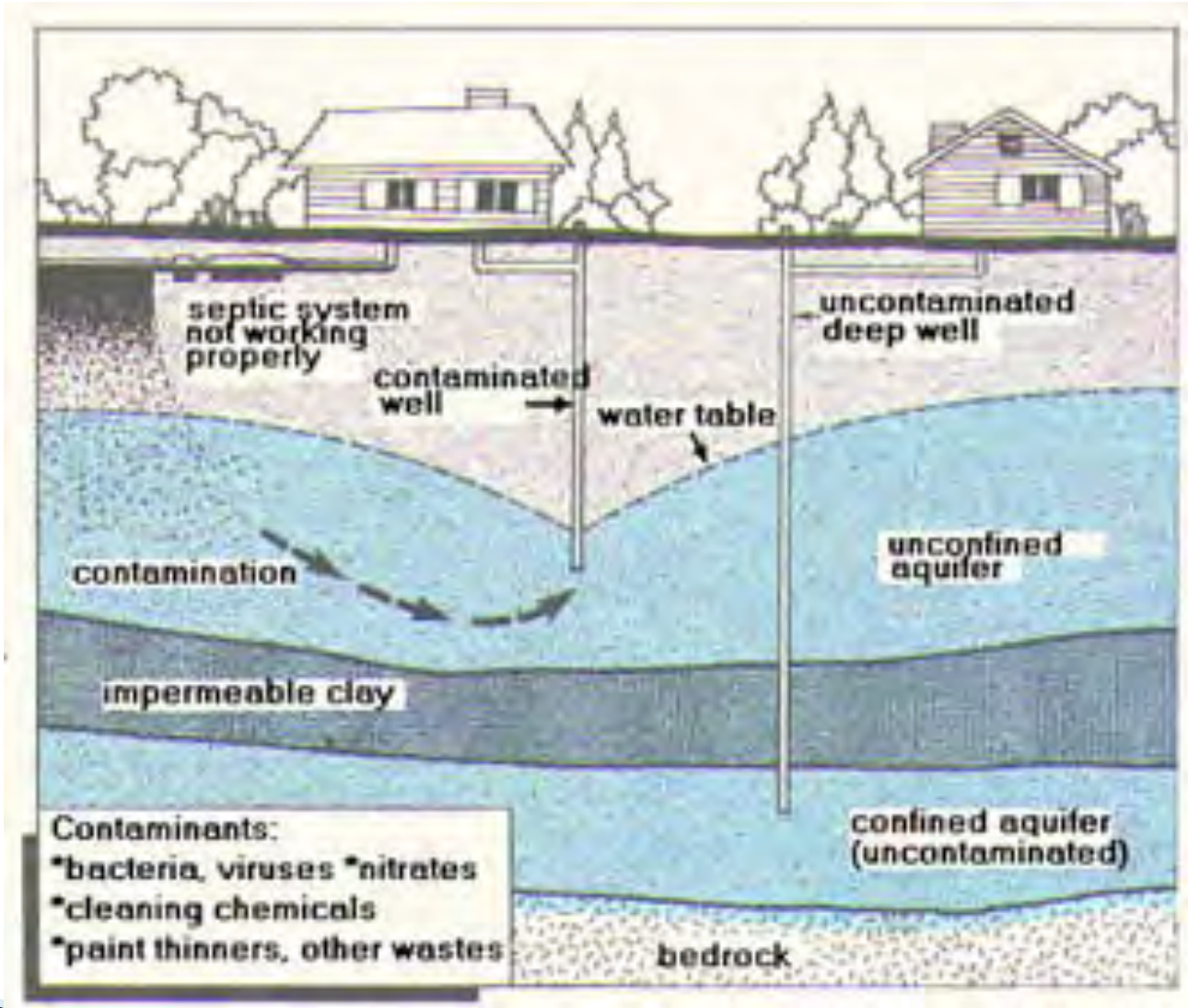
Groundwater Pollution

- livestock watering
- Irrigation
- aquaculture (fish farms)
- Mineral/hydrocarbon extraction
- Urban Run-Off
- Human Error (toxic spills)

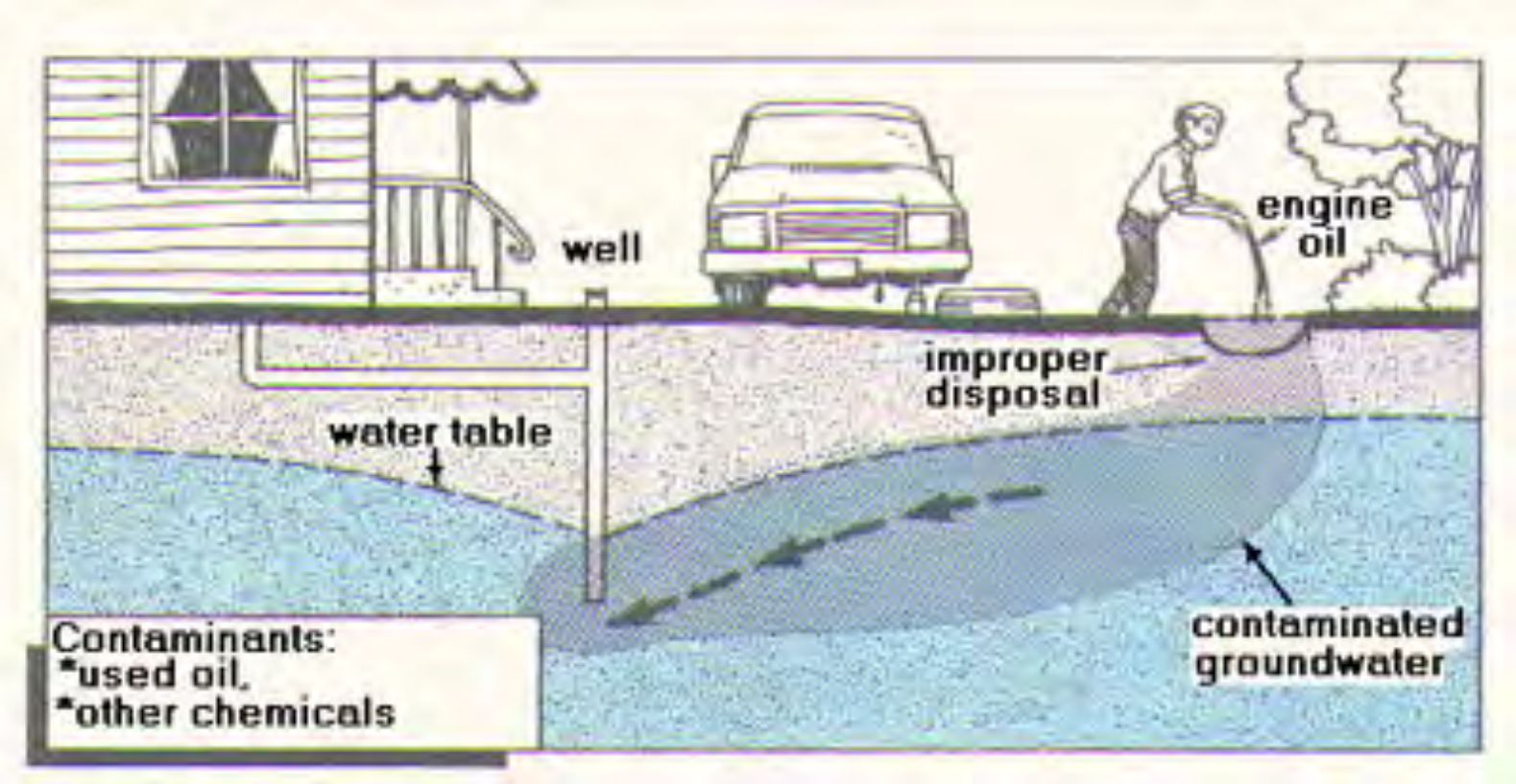




SEPTIC SYSTEMS



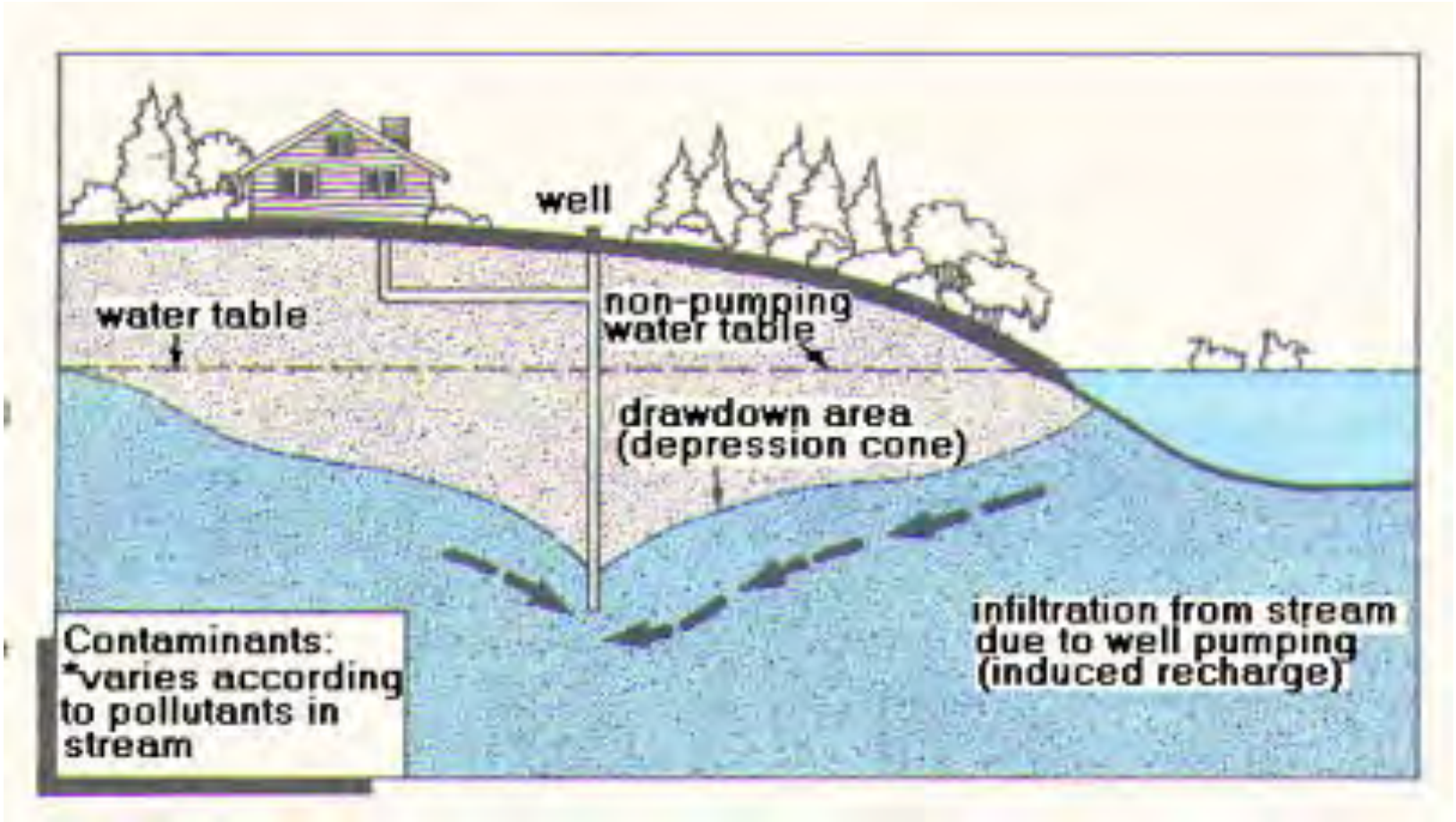
SMALL DISPOSAL PITS



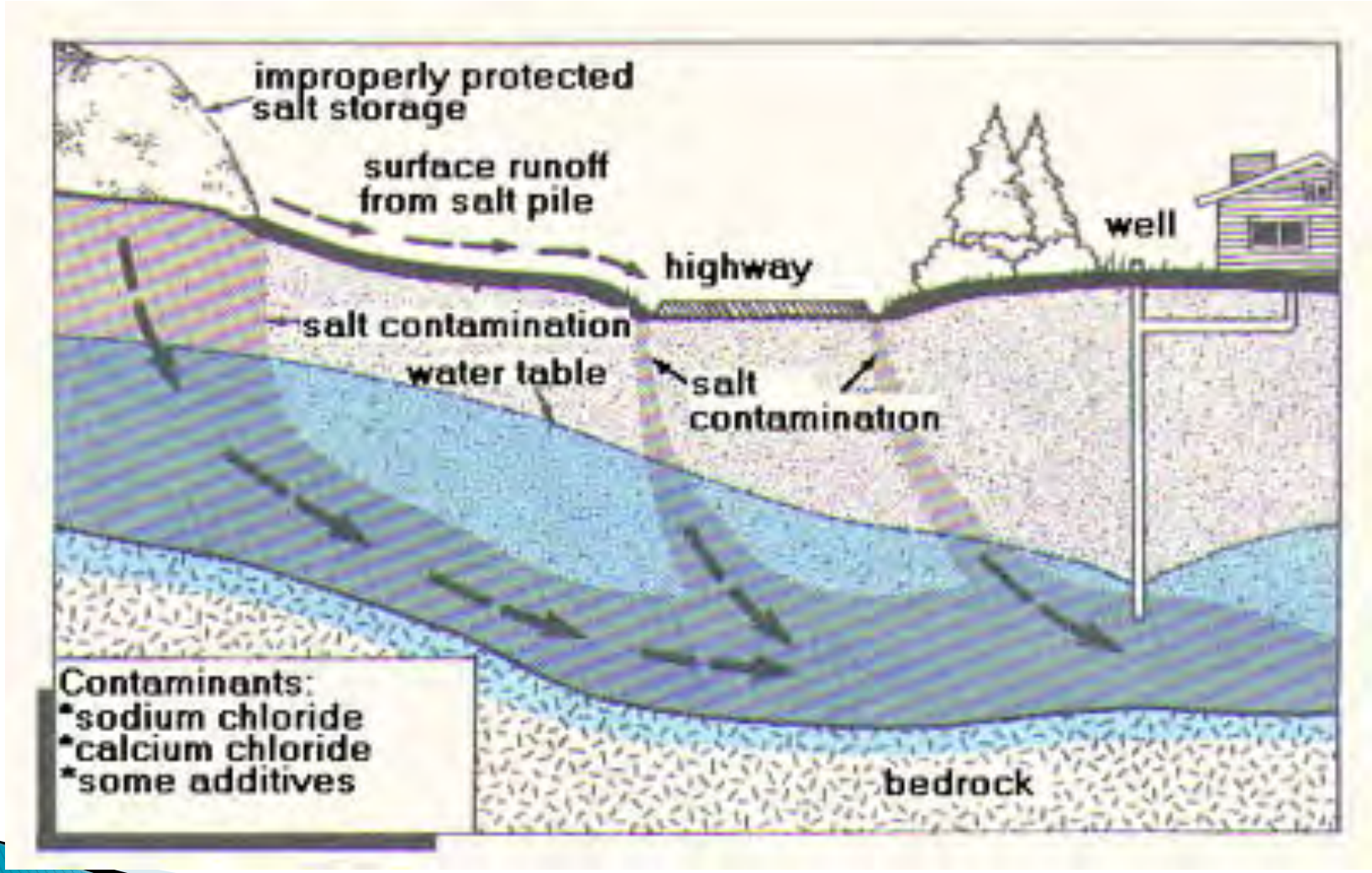
HOUSE AND GARDEN CHEMICALS

Contaminants:
*paint thinners *pesticides
*chemical cleaners
*floor care products *poisons
*polishers & degreasers
*automotive products
*acids *other toxic substances

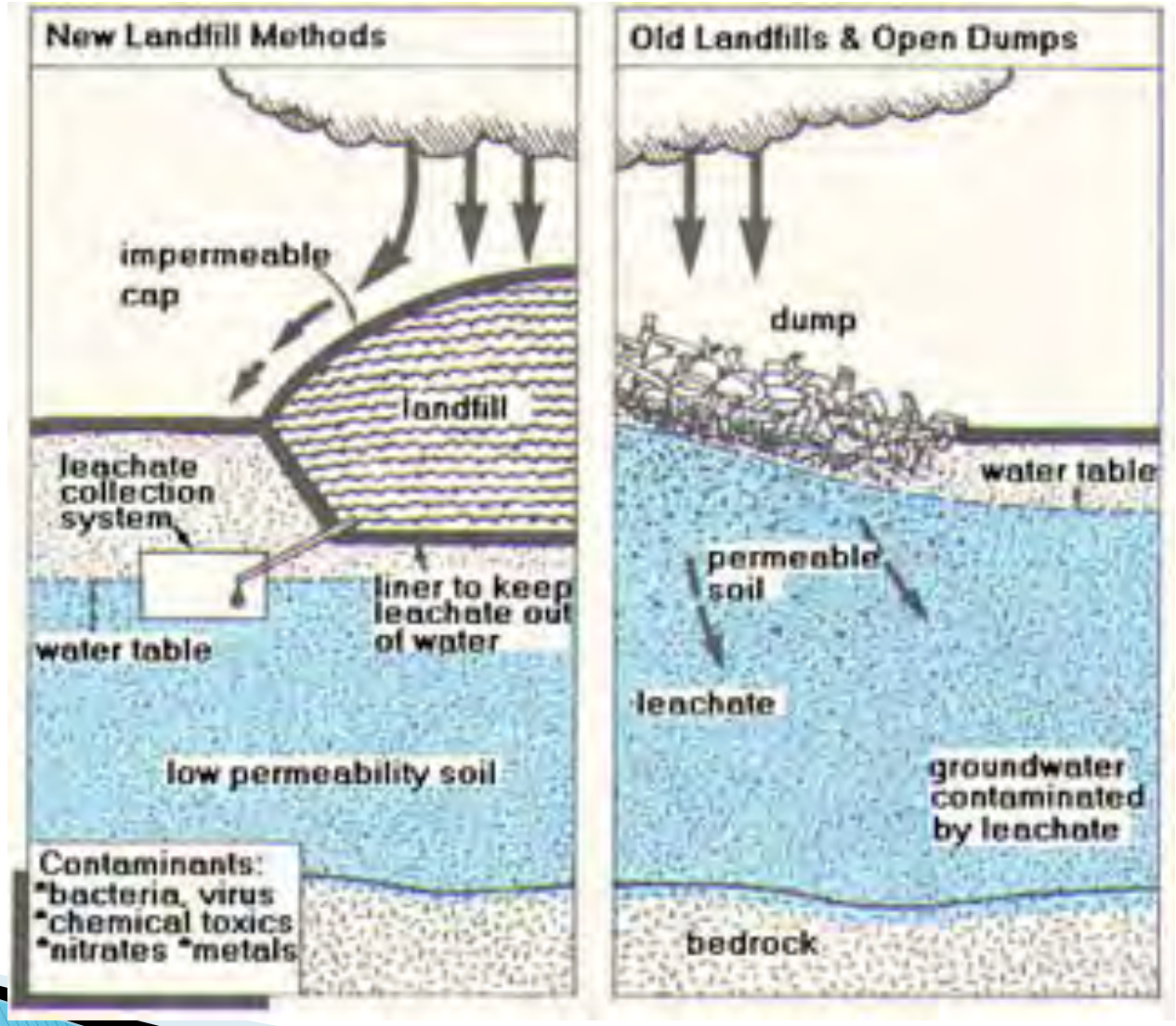
STREAM INFILTRATION



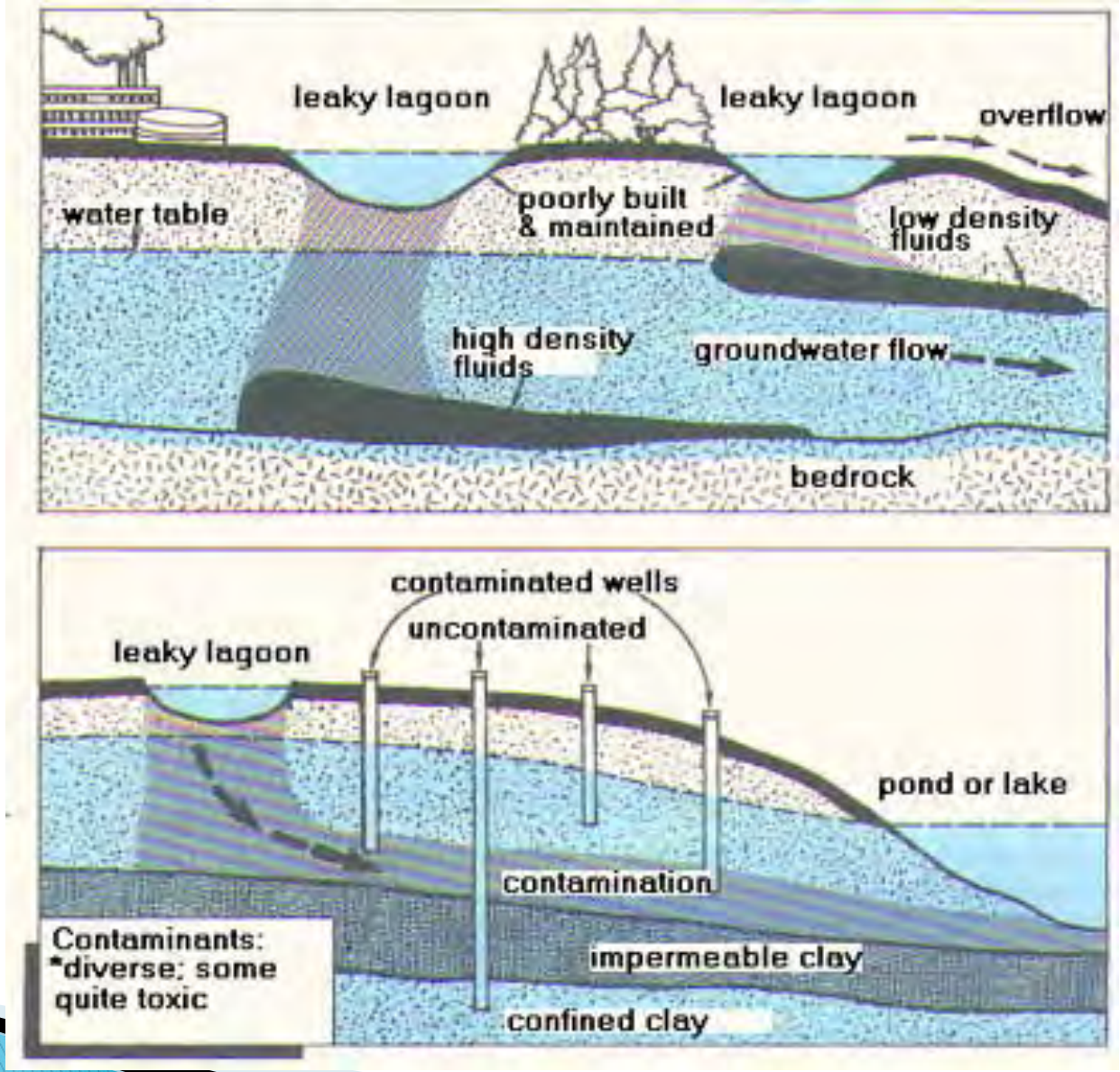
DE-ICING SALTS



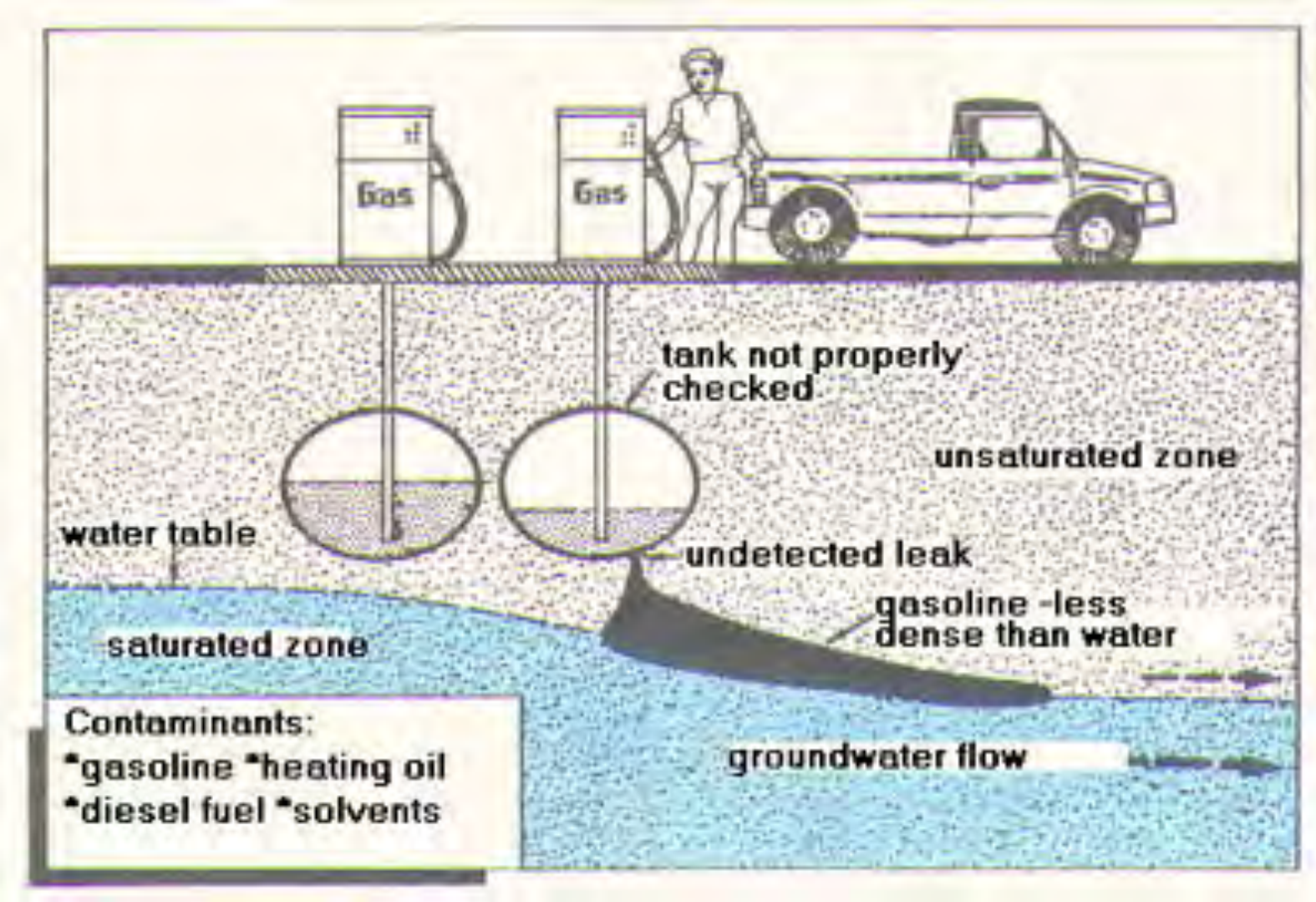
LANDFILLS


New Landfill Methods
impermeable cap
landfill
leachate collection system
liner to keep leachate out of water
water table
low permeability soil
Contaminants:
*bacteria, virus
*chemical toxics
*nitrates *metals
Old Landfills & Open Dumps
dump
water table
permeable soil
leachate
groundwater contaminated by leachate
bedrock

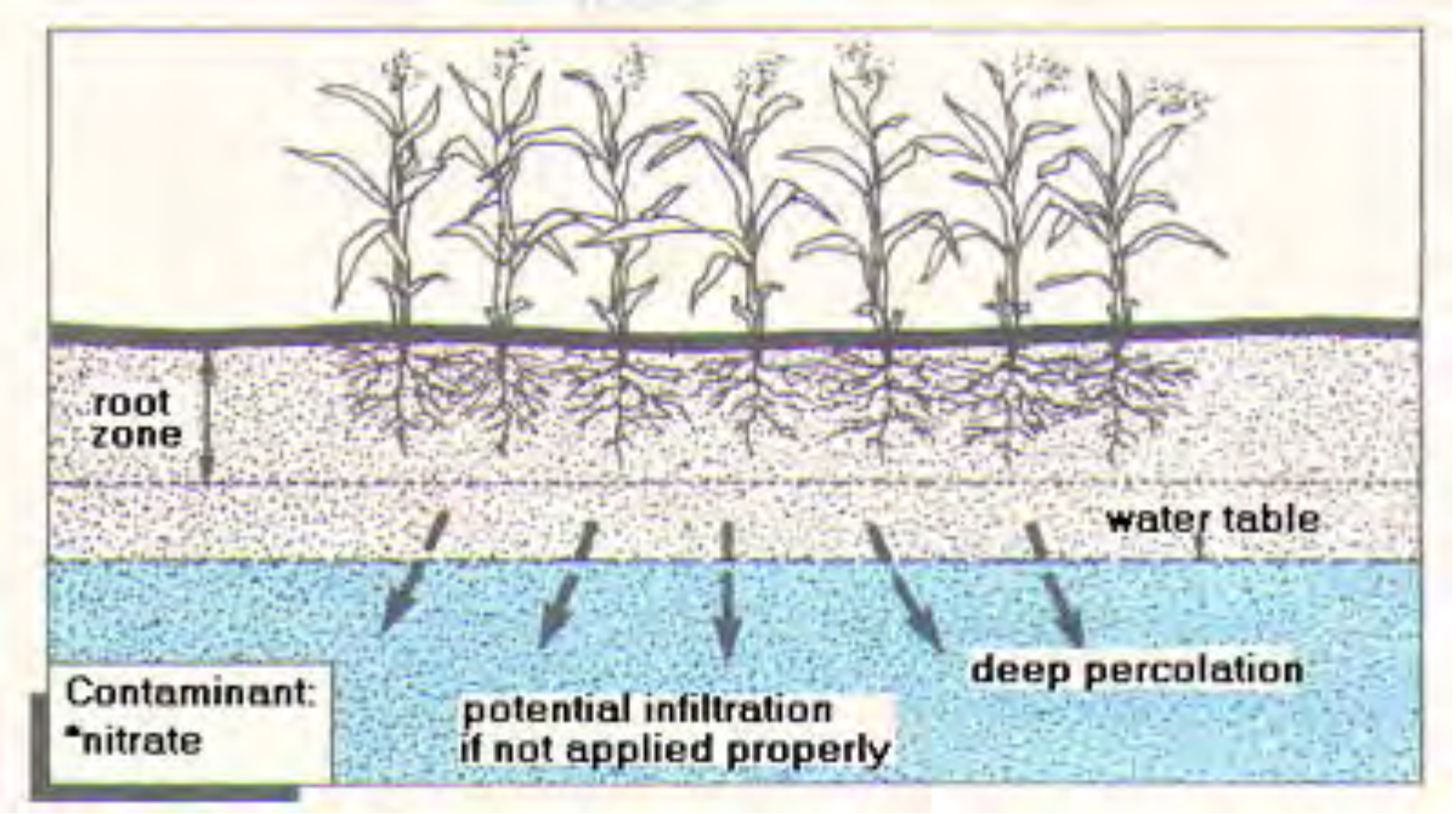
STORAGE LAGOONS



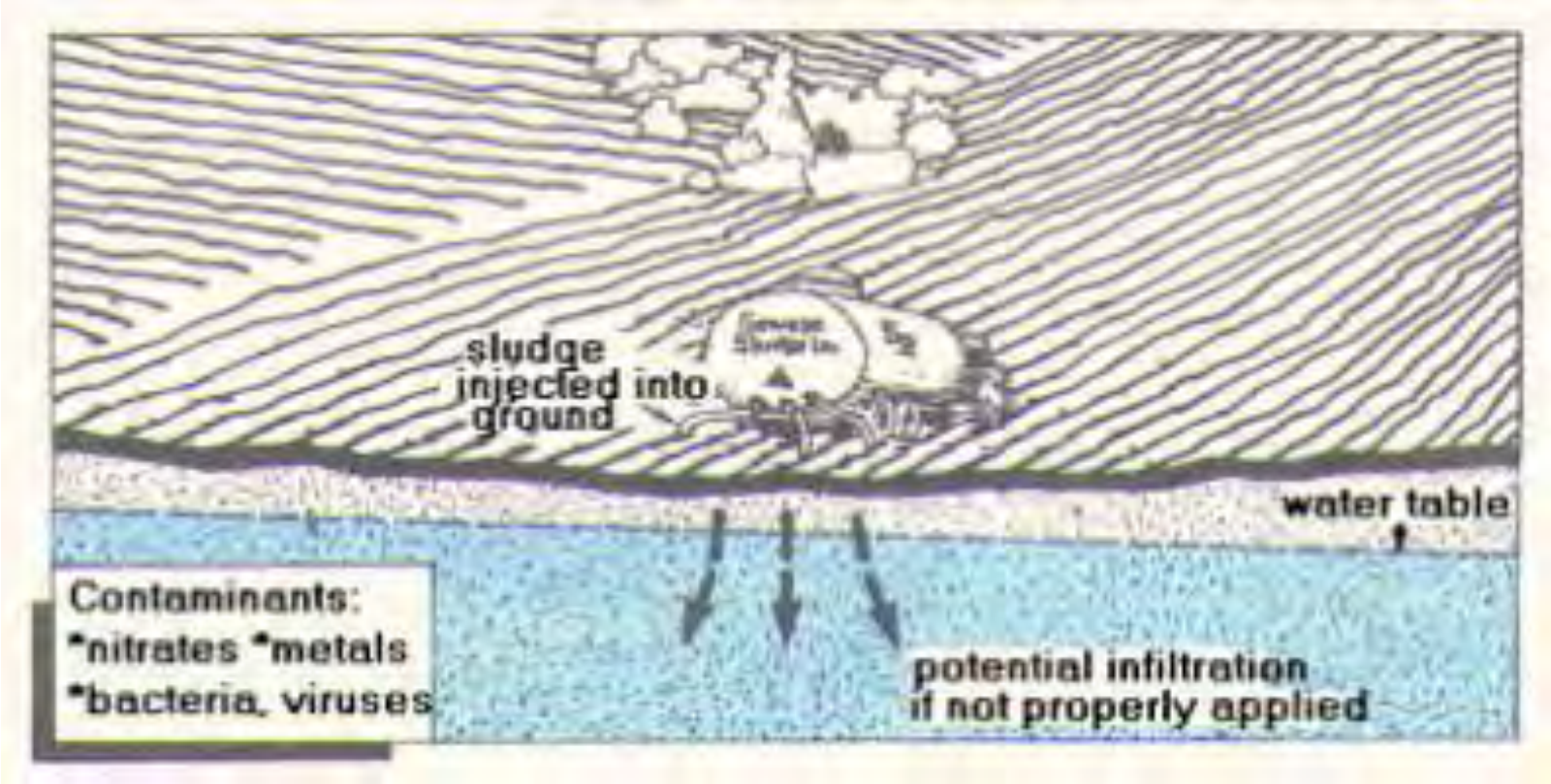
UNDERGROUND STORAGE TANKS



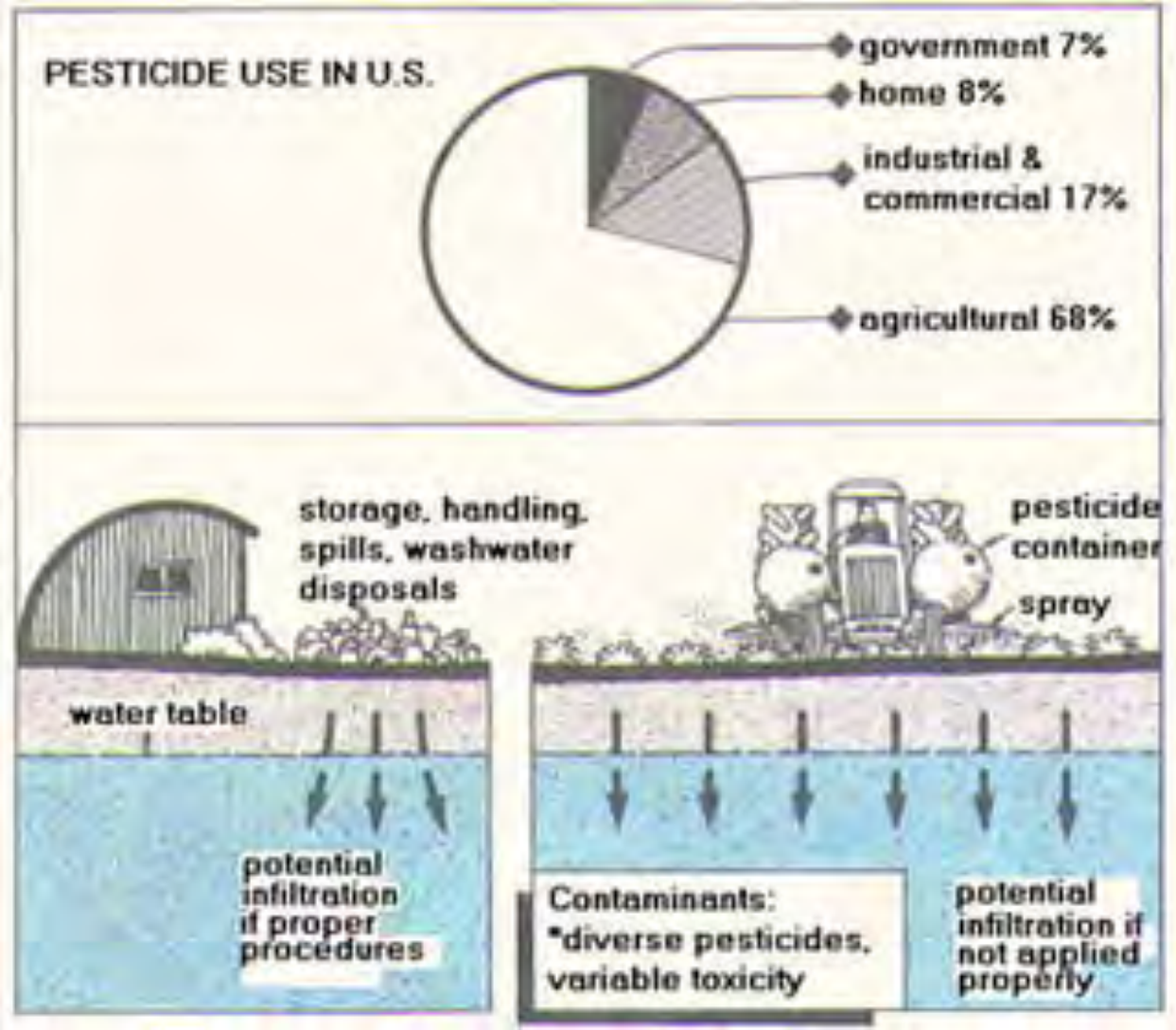
FERTILIZERS



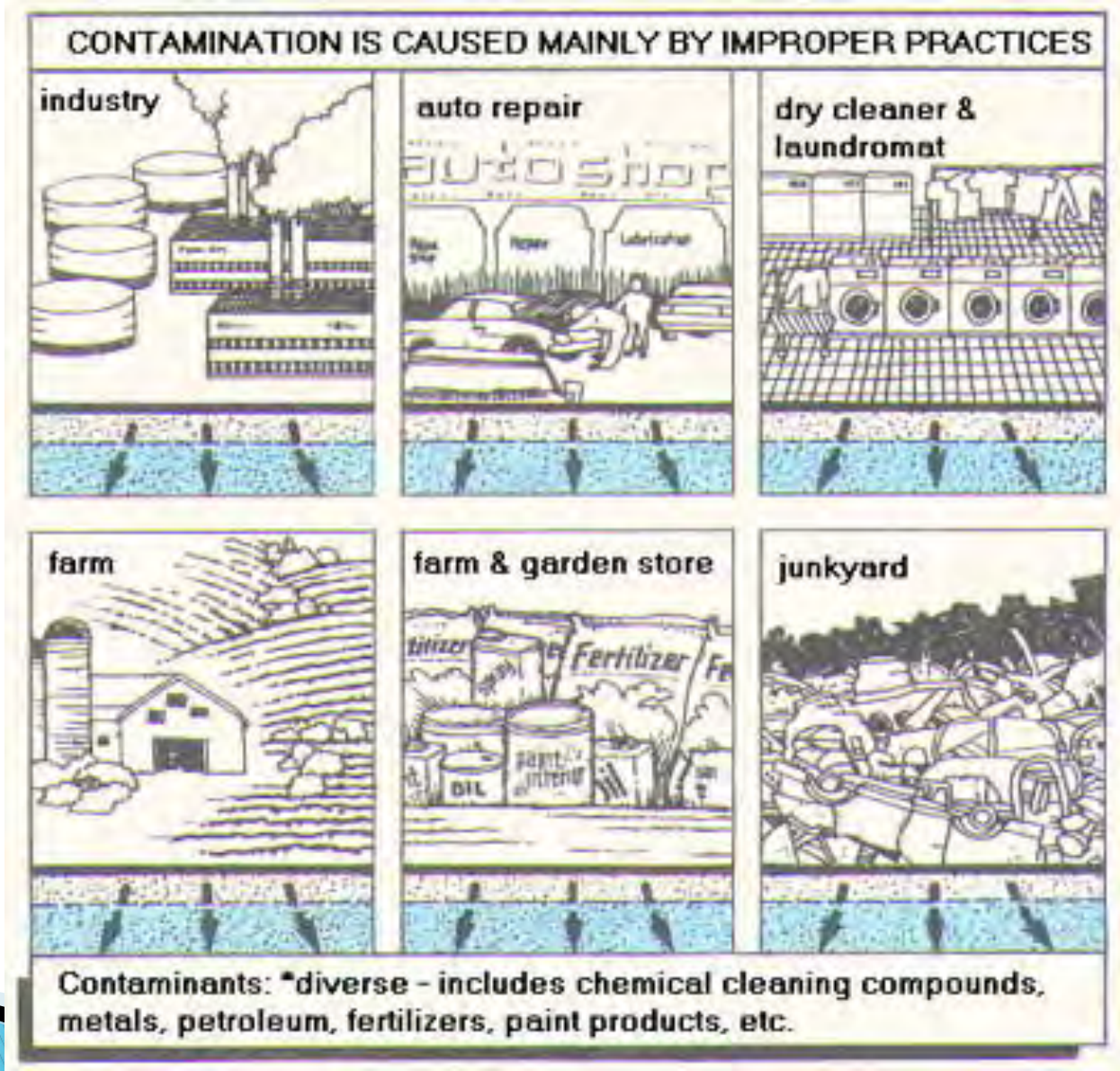
LAND APPLICATION OF SLUDGES AND WASTE WATER



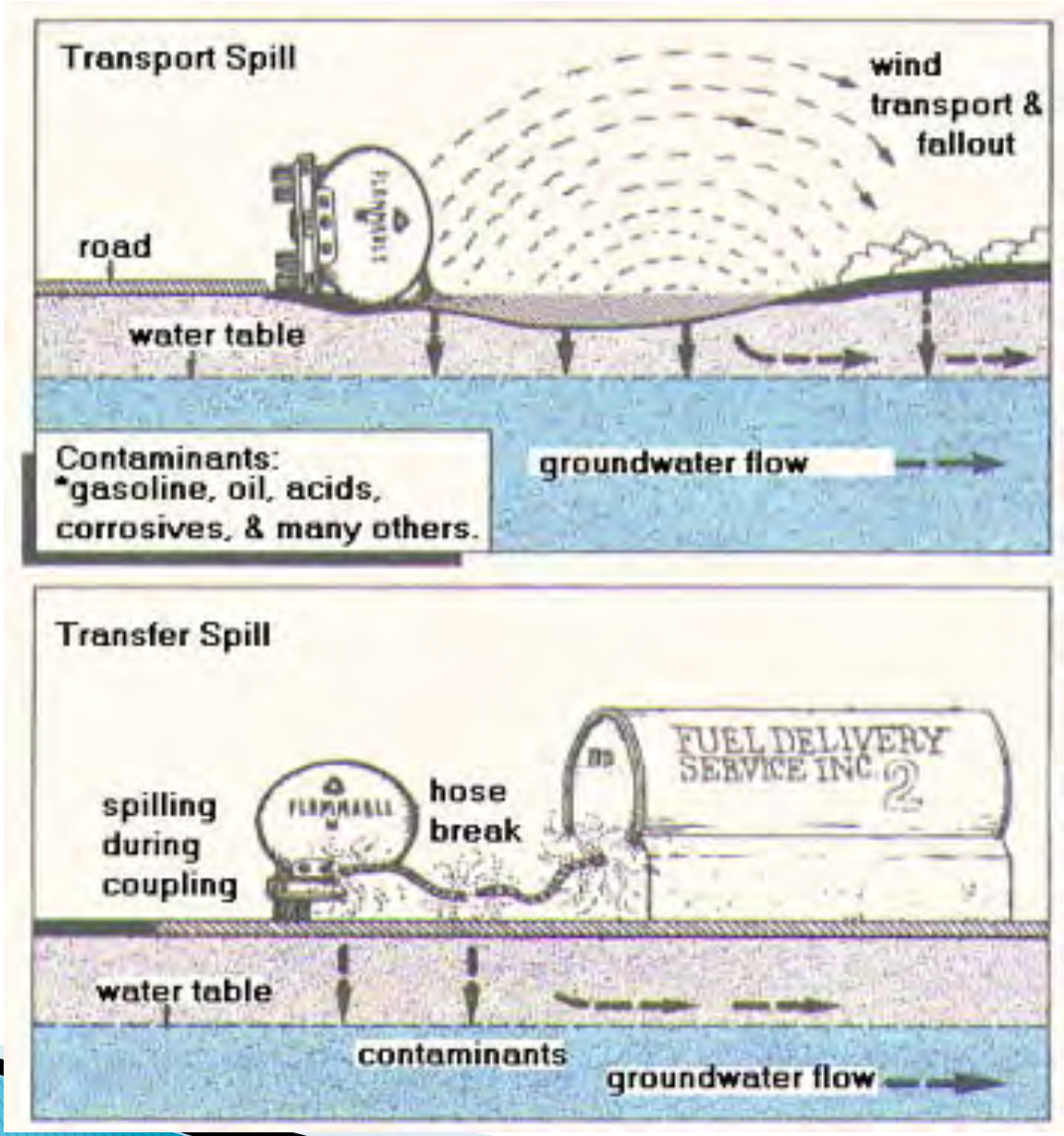
PESTICIDES


PESTICIDE USE IN U.S.
government 7%
home 8%
industrial & commercial 17%
agricultural 68%
storage, handling, spills, washwater disposals
pesticide container
spray
water table
potential infiltration if proper procedures
Contaminants:
•diverse pesticides, variable toxicity
potential infiltration if not applied properly

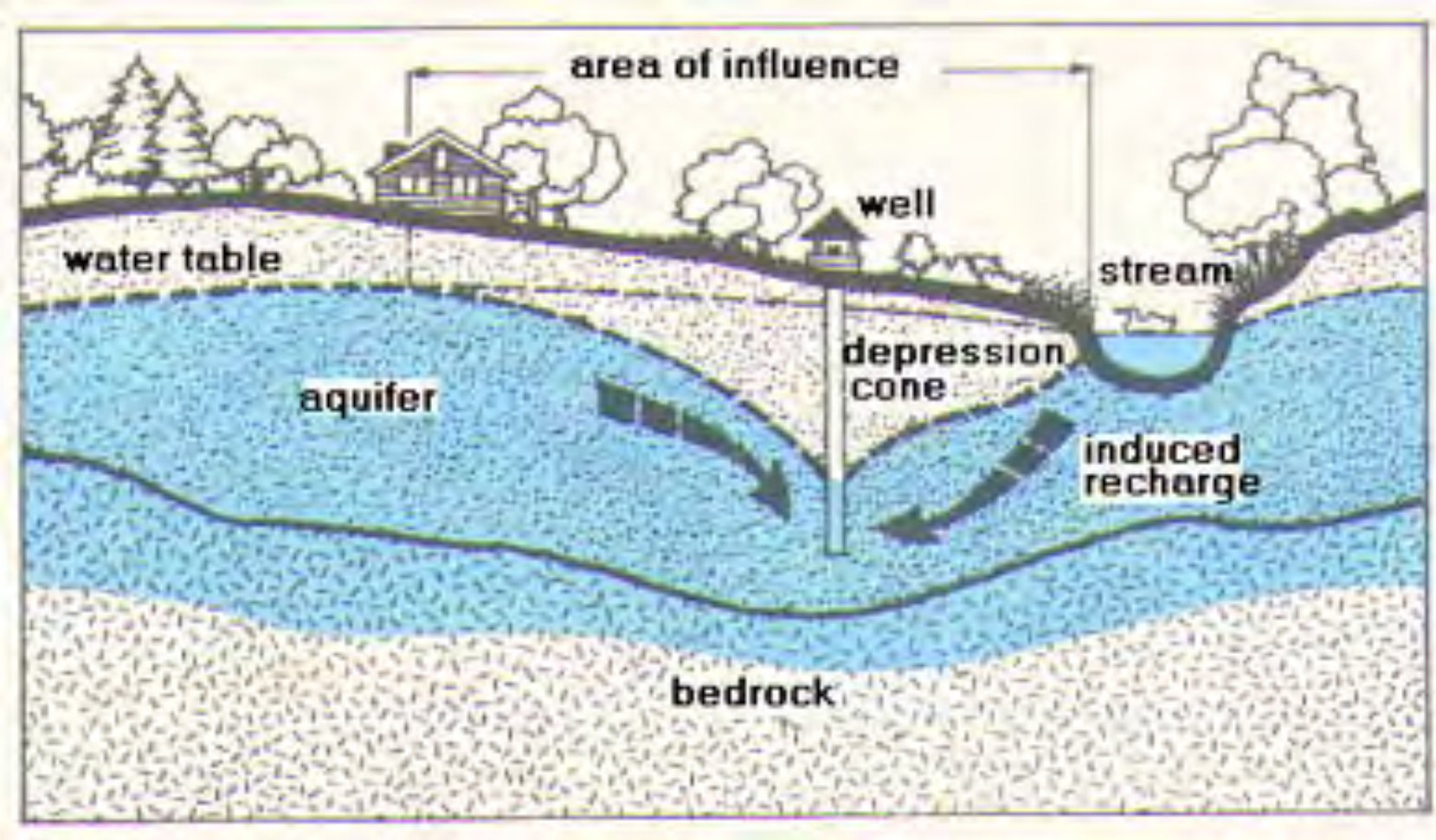
HAZARDOUS MATERIALS



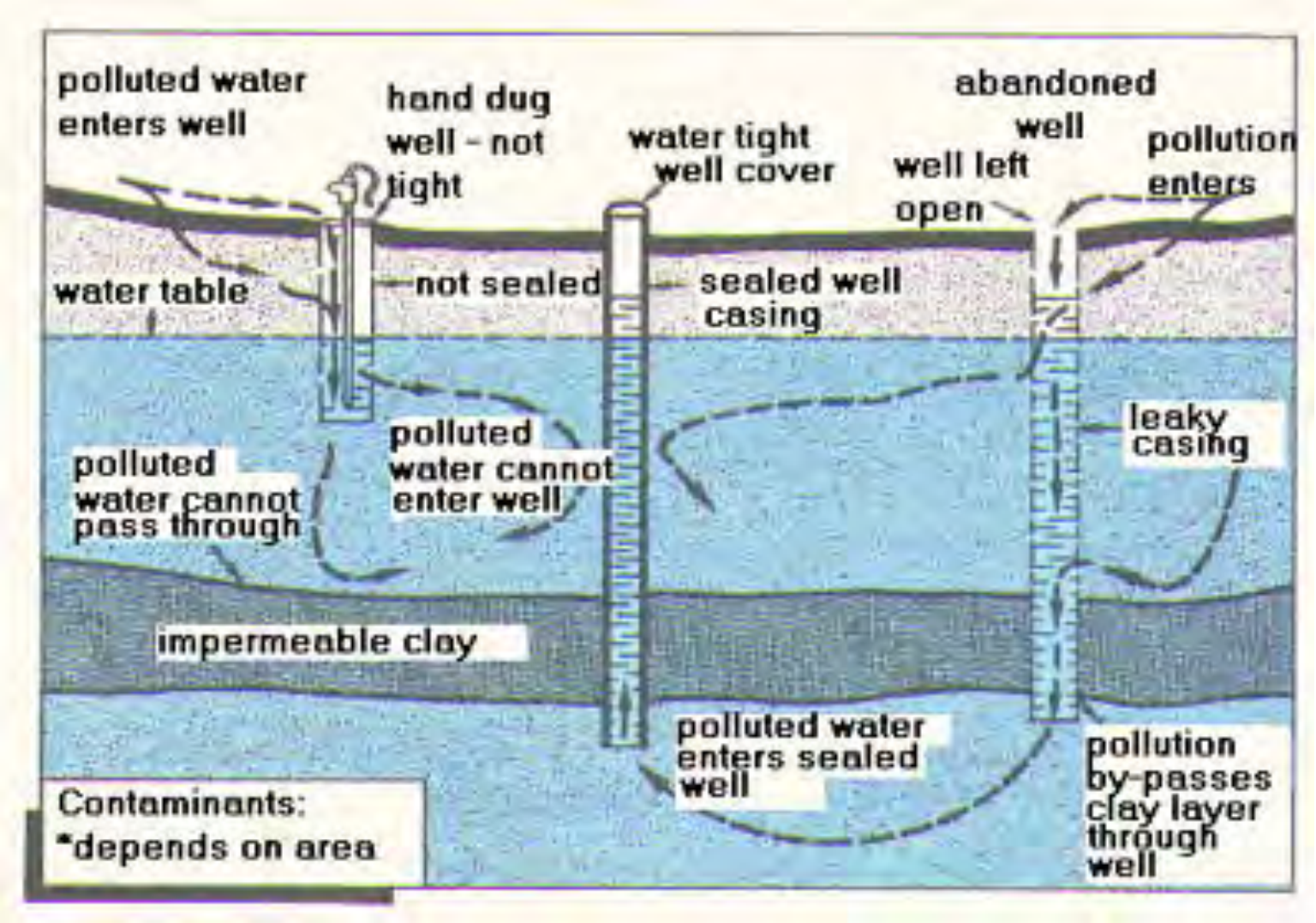
TRANSPORT AND TRANSFER SPILLS



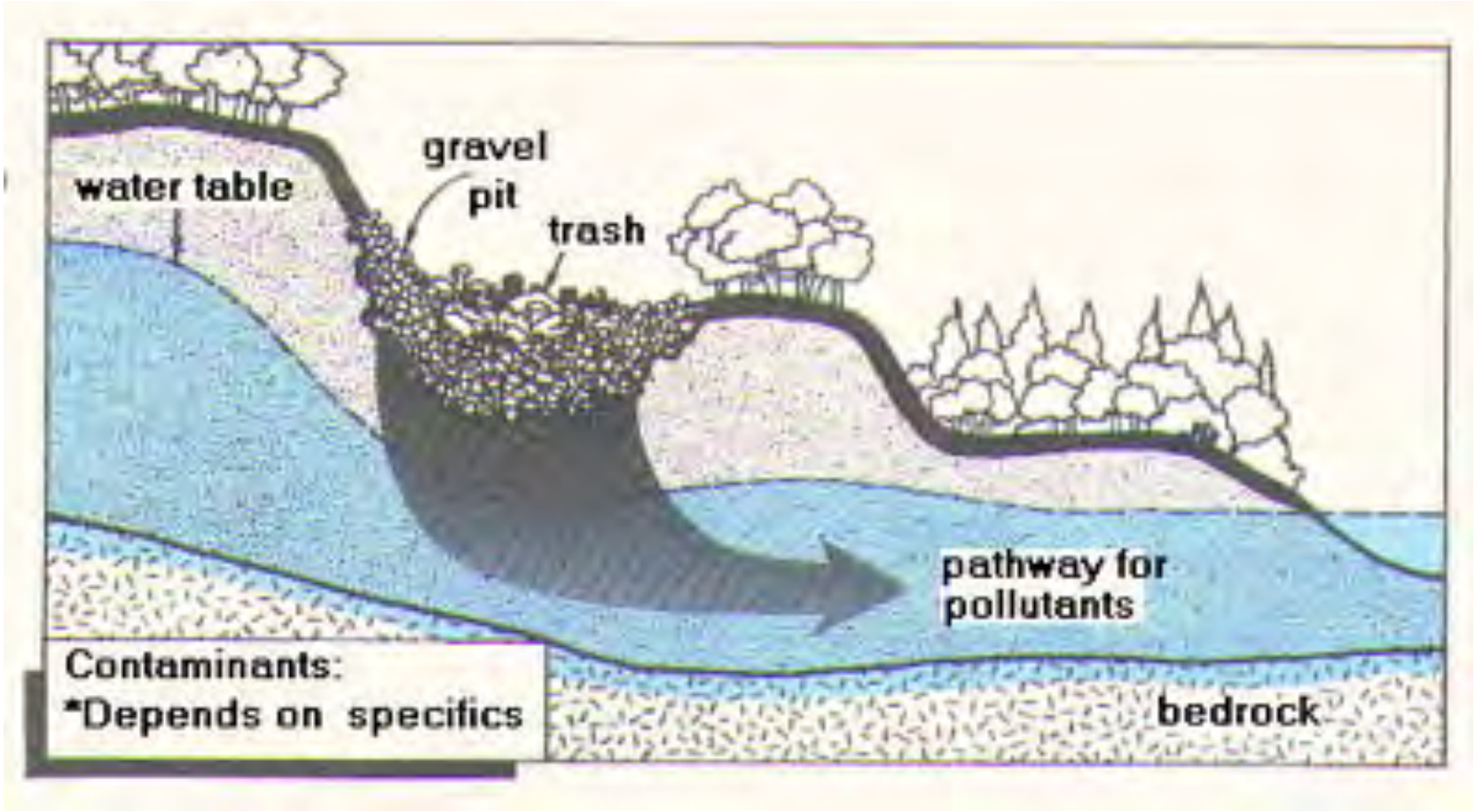
PIPELINES


area of influence
well
water table
stream
depression cone
aquifer
induced recharge
bedrock

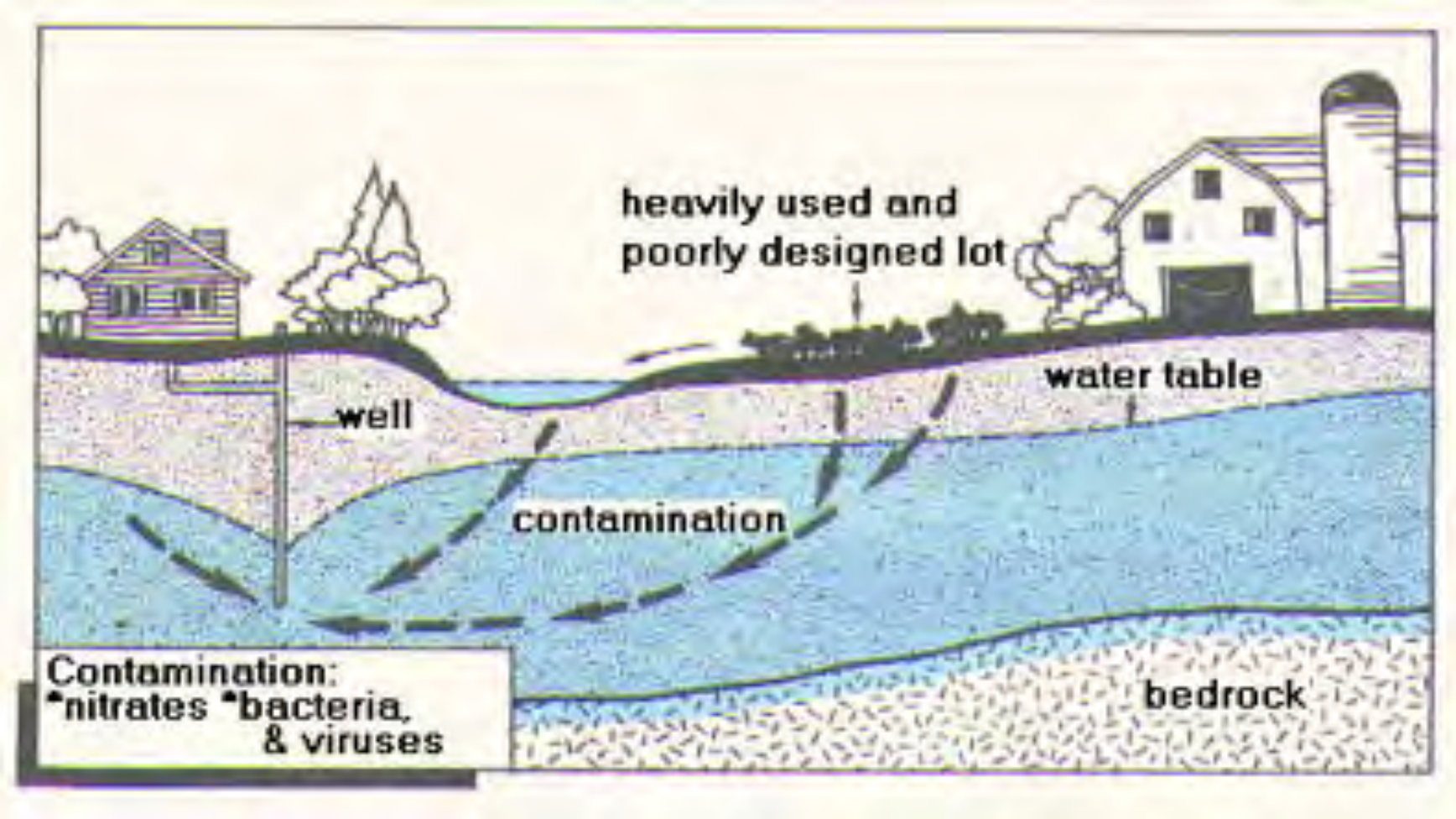
WELLS


polluted water enters well
hand dug well - not tight
water tight well cover
abandoned well
well left open
pollution enters
water table
not sealed
sealed well casing
polluted water cannot pass through
polluted water cannot enter well
leaky casing
impermeable clay
polluted water enters sealed well
pollution by-passes clay layer through well
Contaminants:
*depends on area

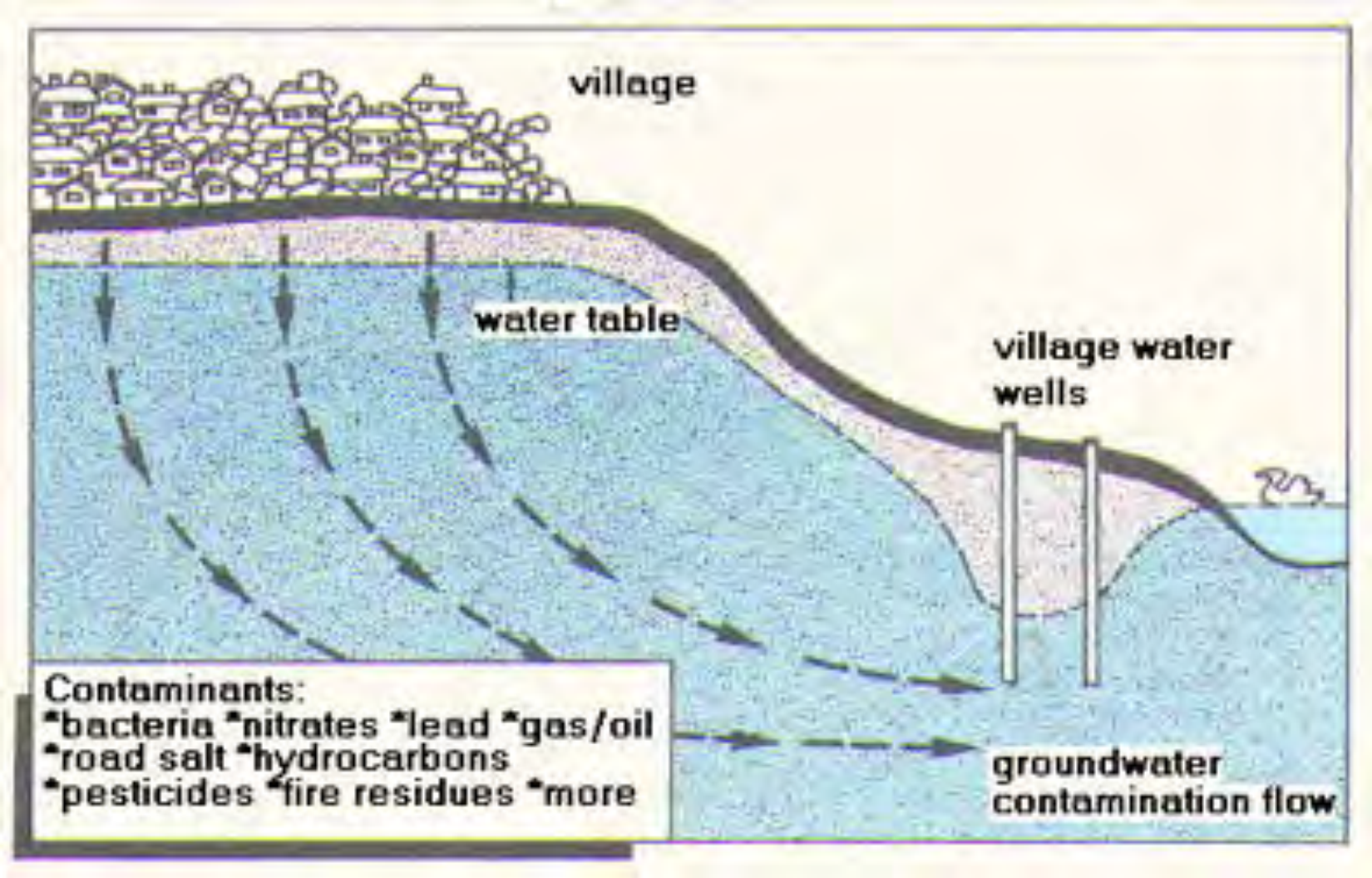
INACTIVE MINING SITES



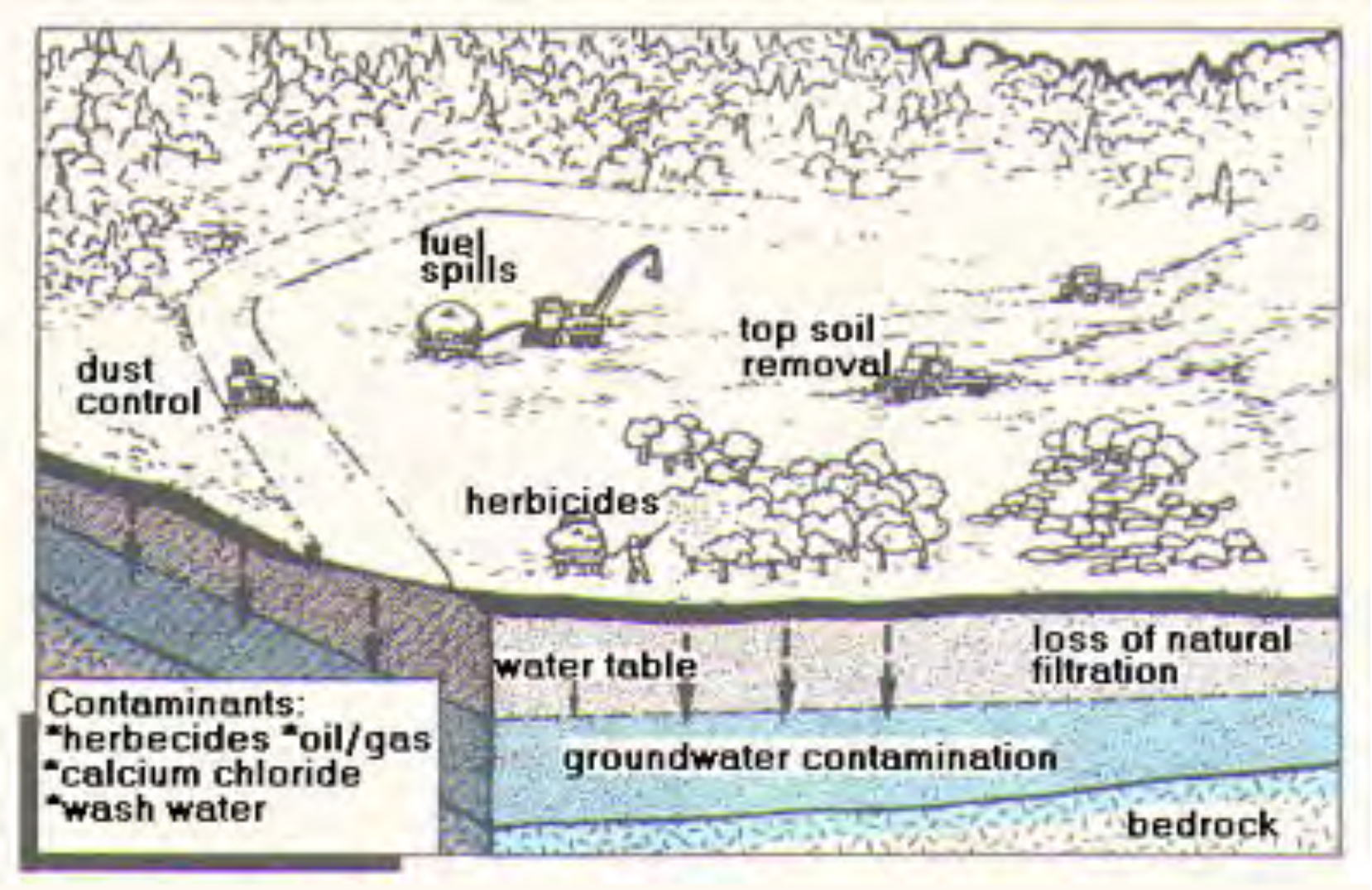
ANIMAL LOTS


heavily used and
poorly designed lot
water table
well
contamination
Contamination:
•nitrates •bacteria,
& viruses
bedrock

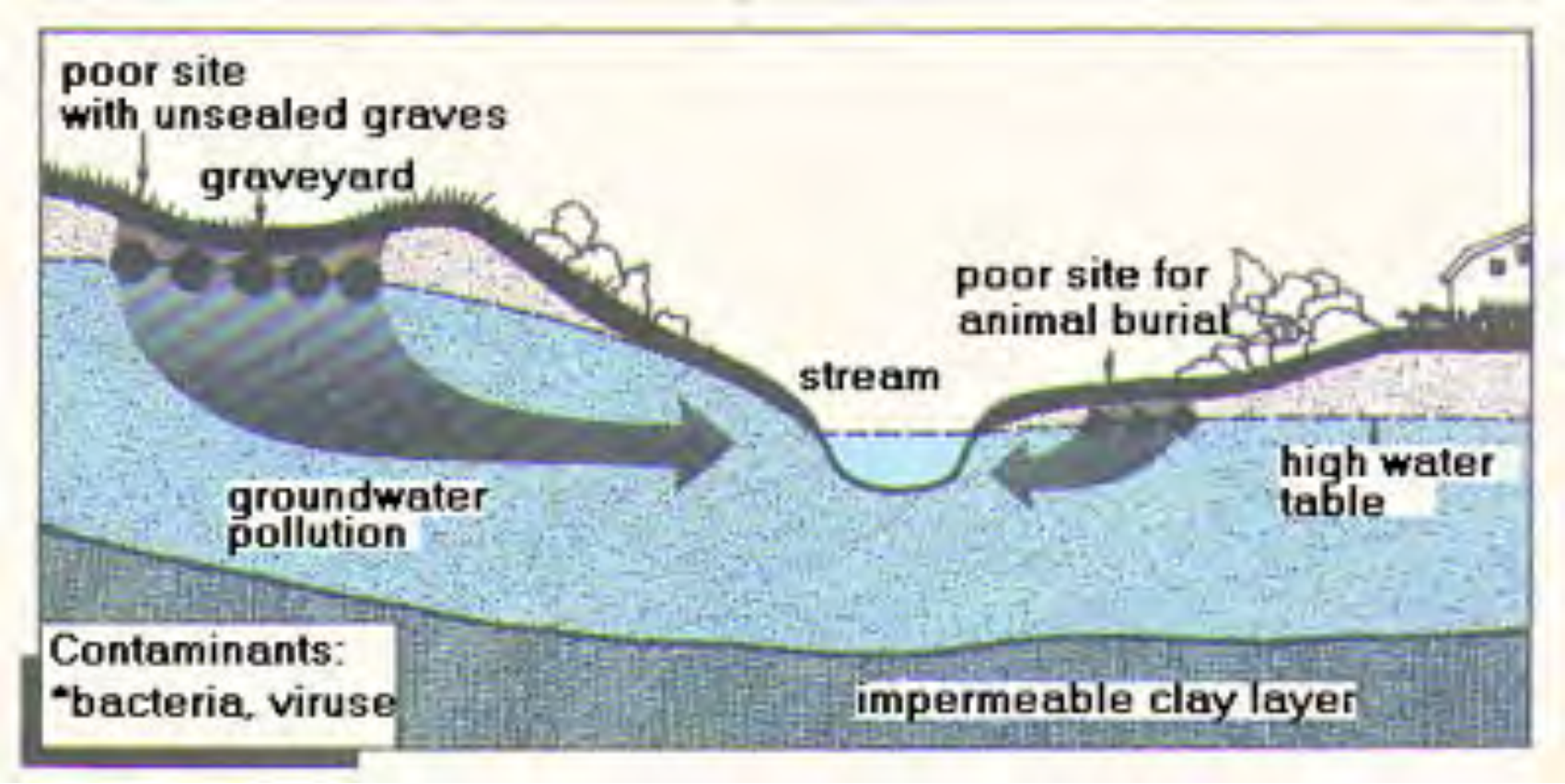
URBAN RUNOFF



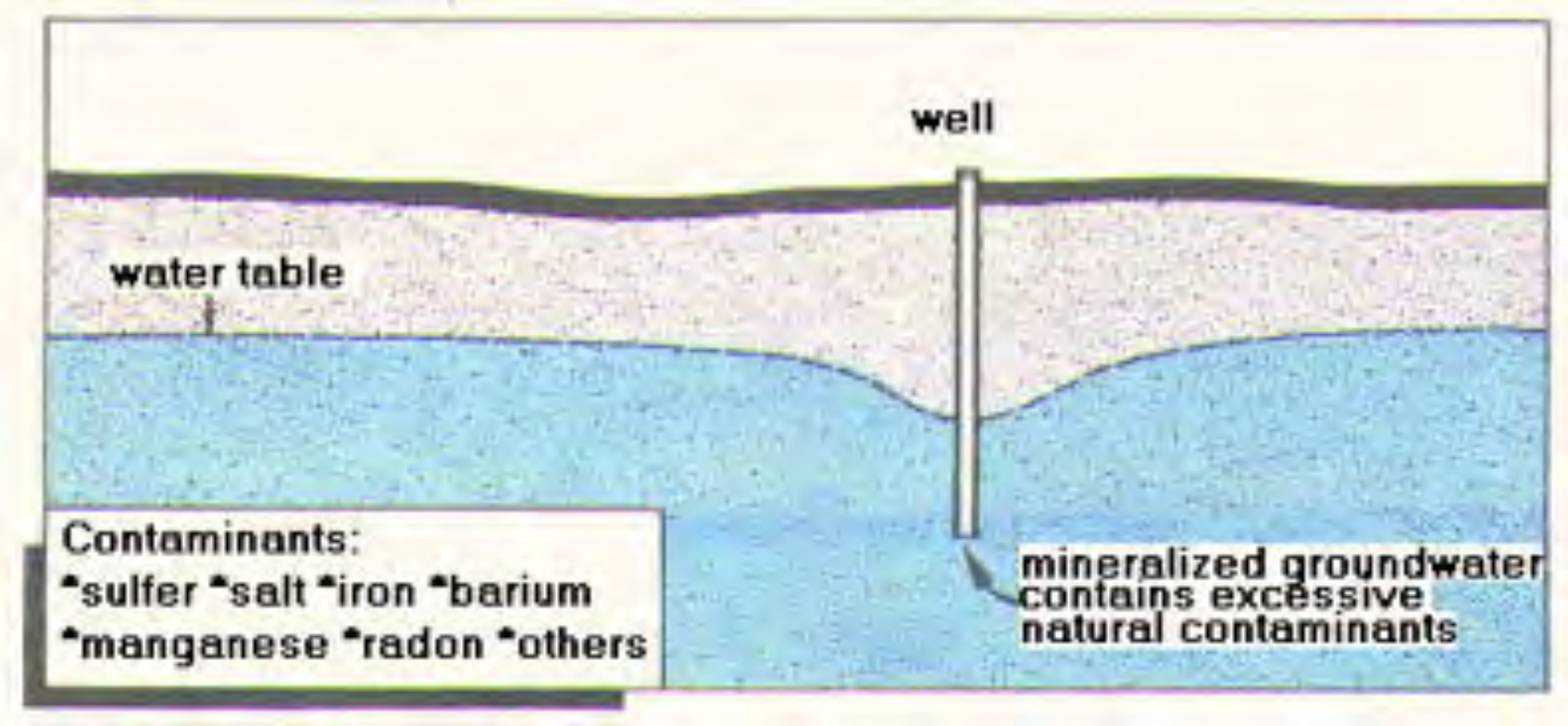
CONSTRUCTION EXCAVATION



CEMETERIES AND EXCAVATION



NATURAL SUBSTANCES



Climate Change and Water Resources

- The impacts of climate change are profoundly affecting water resources and their management.

Assignment 2

Due February 3, 2018 (PPt for Presentation on February 6)