

Water . . . in the news

From National Geographic (Sept 17, 2014):

Amid Drought, New California Law Will Limit Groundwater Pumping for First Time

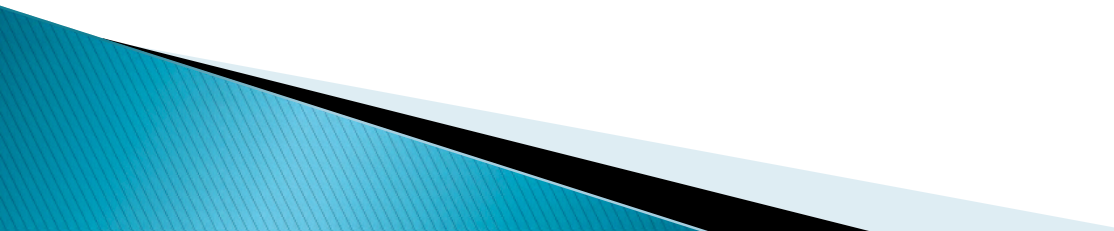
- ▶ But it won't help right away: The limits on pumping won't begin before the 2020s.
- ▶ "California and the rest of the West are really ignoring groundwater's environmental role," - Australian researcher at Stanford University



Tour follow up

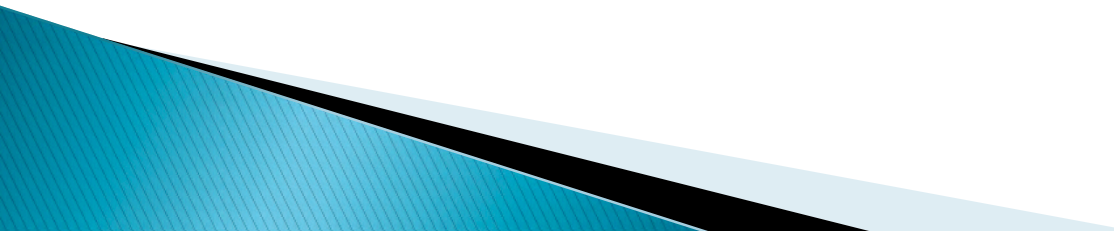
- ▶ Primary treatment: reduces some solids through screening and settling processes
 - ▶ Secondary: further reduces solids, grease and oils and other pollutants
 - ▶ Tertiary: the most stringent. In the

 - ▶ European Union: all communities with more than 15,000 people have secondary treatment since 2000 with all urban centres slated to have tertiary treatment by 2010.
 - ▶ United States: all coastal cities must have secondary treatment.

 - ▶ Canada . . . has no national sewage standards.
- 

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.

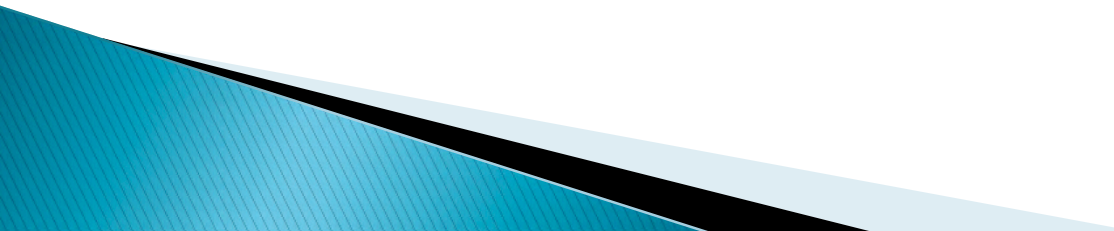


VICTORIA'S SEWAGE PROBLEM

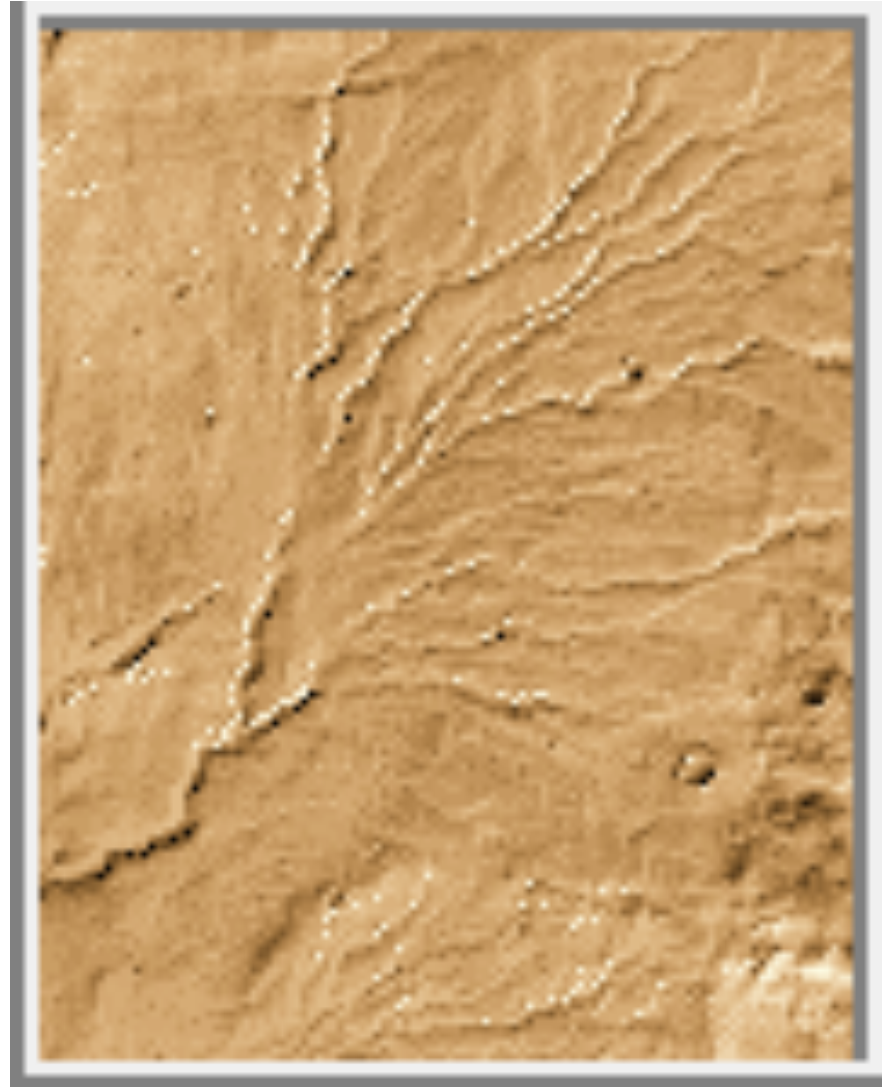


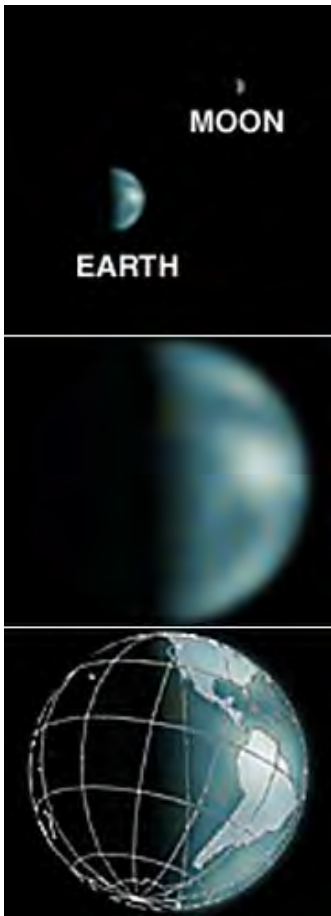
- 1 Macauley Point: Current site of outflow sewage.
- 2 Clover Point: Current site of outflow sewage.
- 3 McLoughlin Point: Future site of liquid waste treatment facility.
- 4 Hartland Landfill: Final destination of sludge from McLoughlin Point via pipeline.

Groundwater

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

Groundwater On Mars



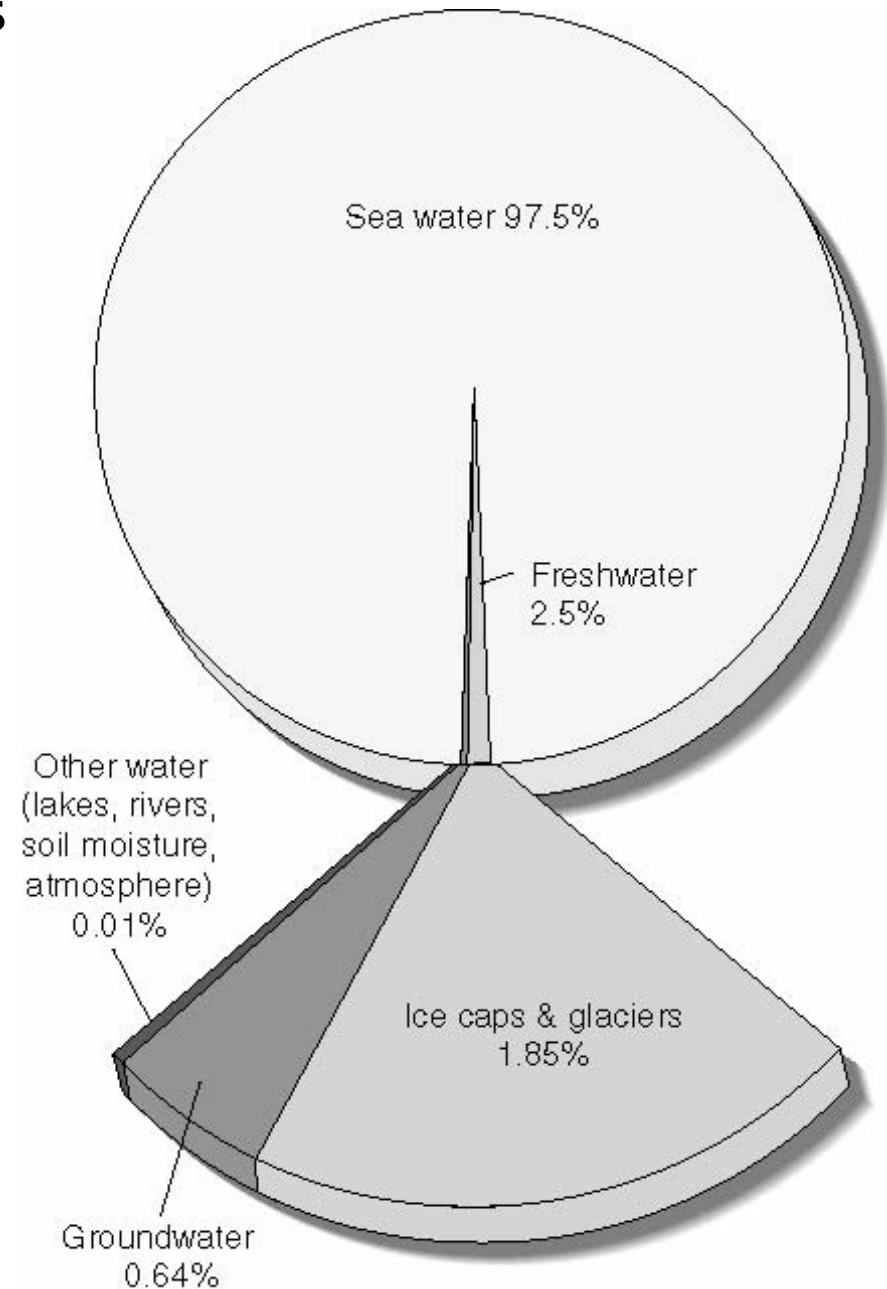


View of Earth from Mars

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 km³
- Compared to:
- 125,000 km³ freshwater lakes
 - 1,250 km³ 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.

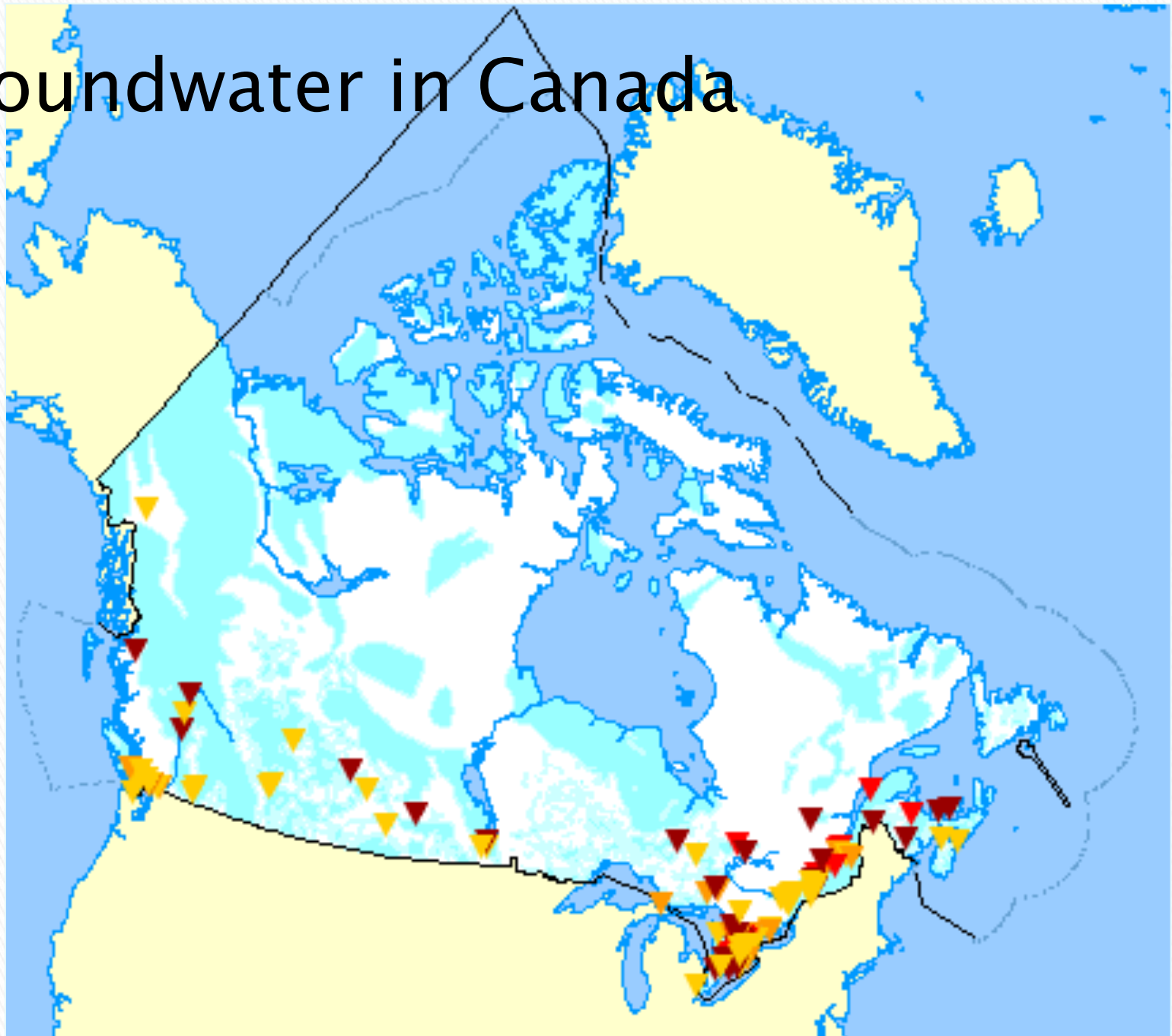
Water use:

Groundwater supports 98 % of freshwater readily available to humans

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

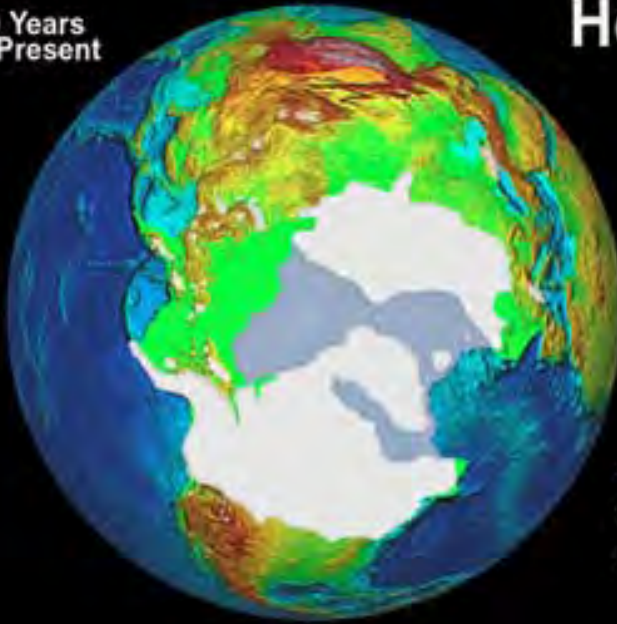
- ▶ Vulnerability:
 - Just 1 litre of gasoline can contaminate 1 million litres of drinking water

Groundwater in Canada



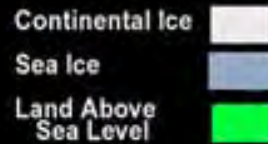
Extent of Glaciation

18,000 Years
Before Present

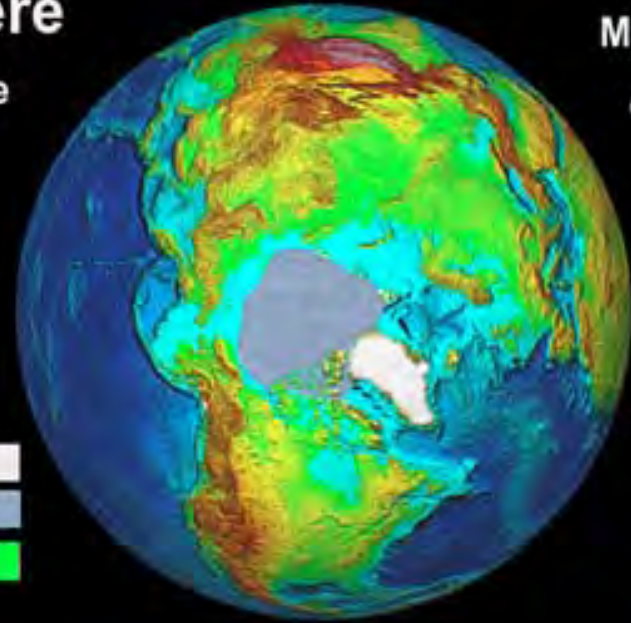


**Northern
Hemisphere**
Ice Coverage

Legend



**Modern
Day**
(August)



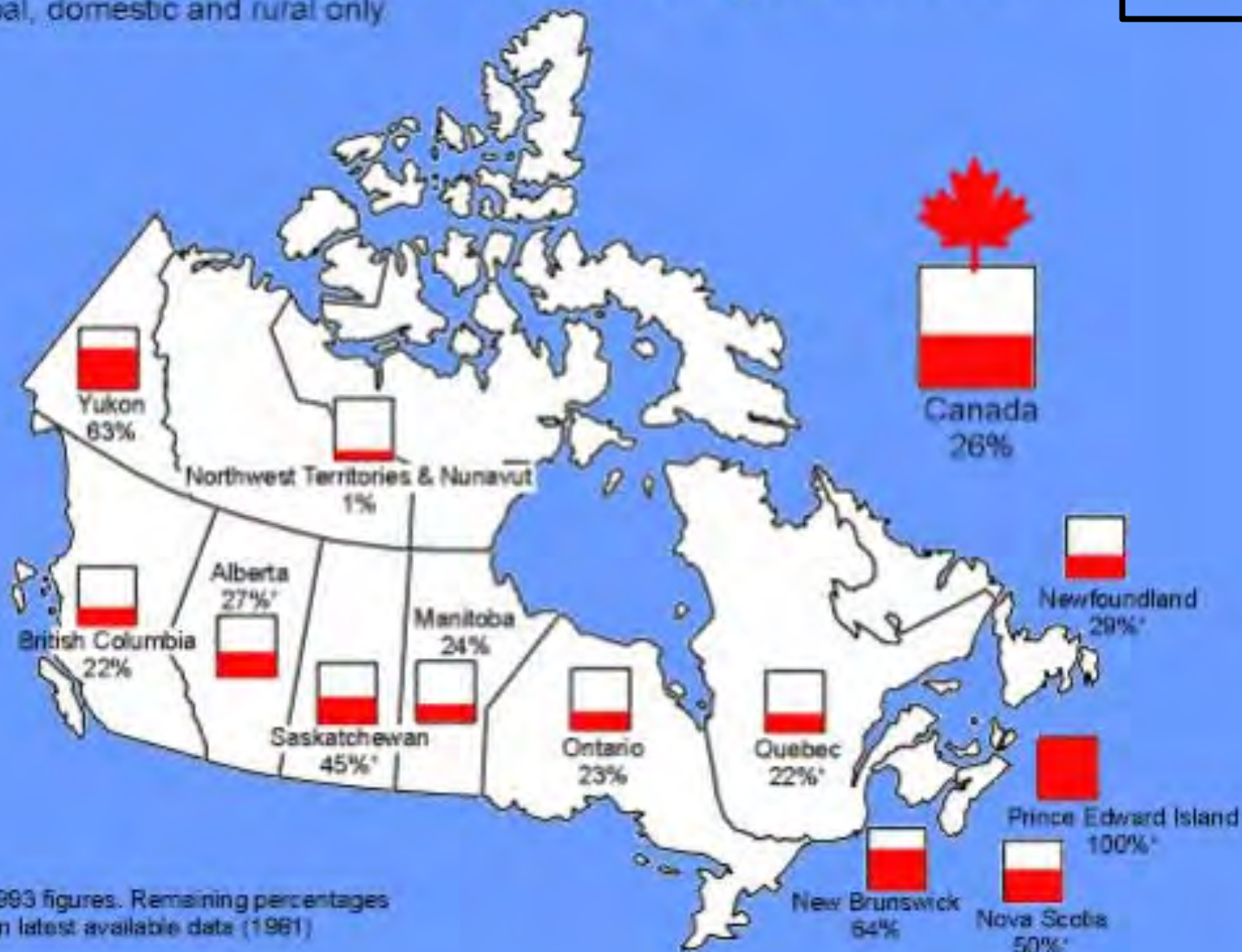
Note: Modern sea ice
coverage represents
summer months.



Percentage of population reliant on groundwater

Municipal, domestic and rural only

1981

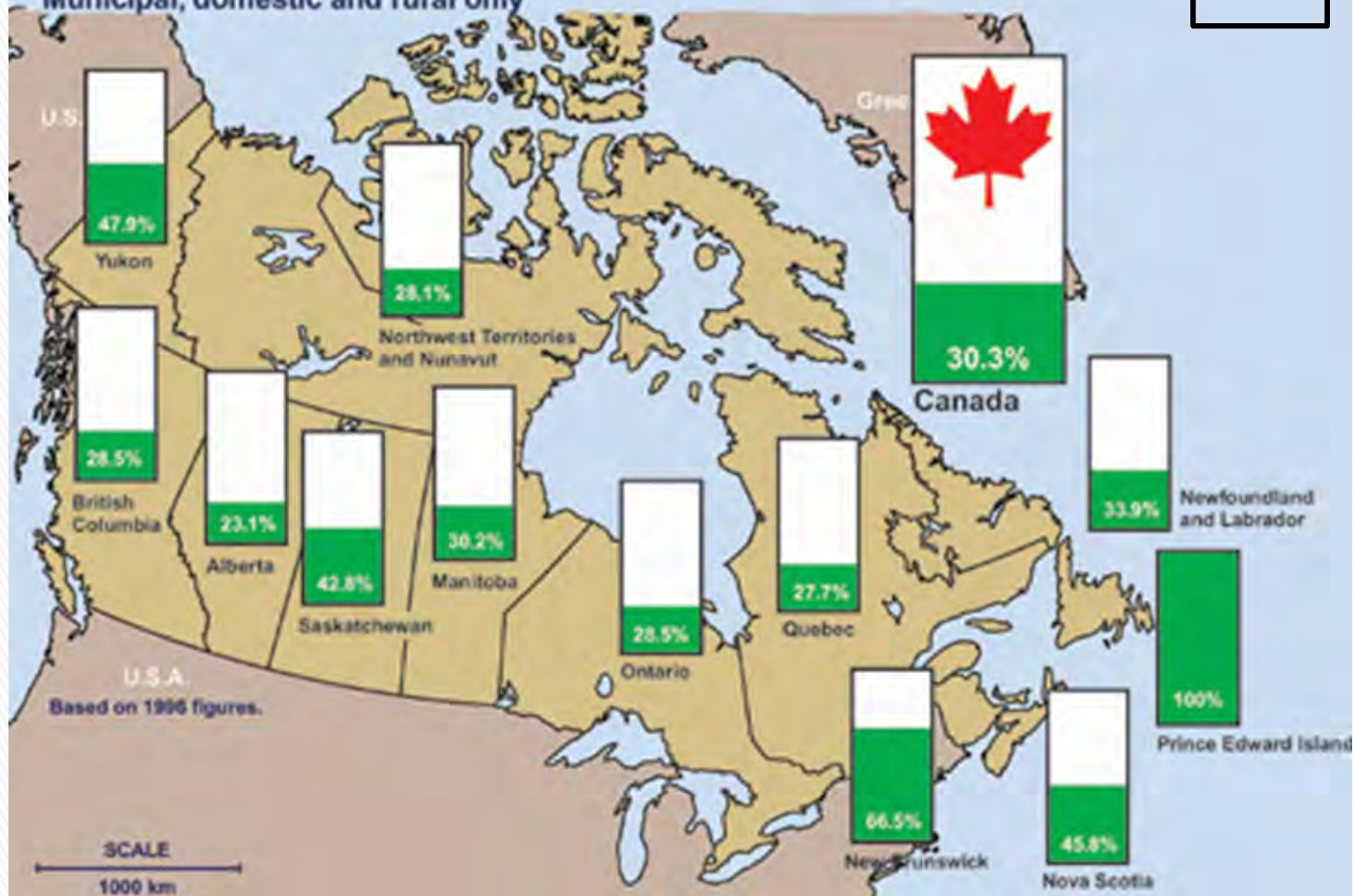


* Based on 1993 figures. Remaining percentages are based on latest available data (1981)

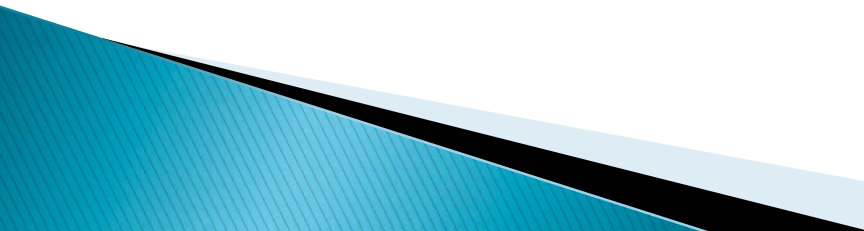
Percentage of population reliant on groundwater

Municipal, domestic and rural only

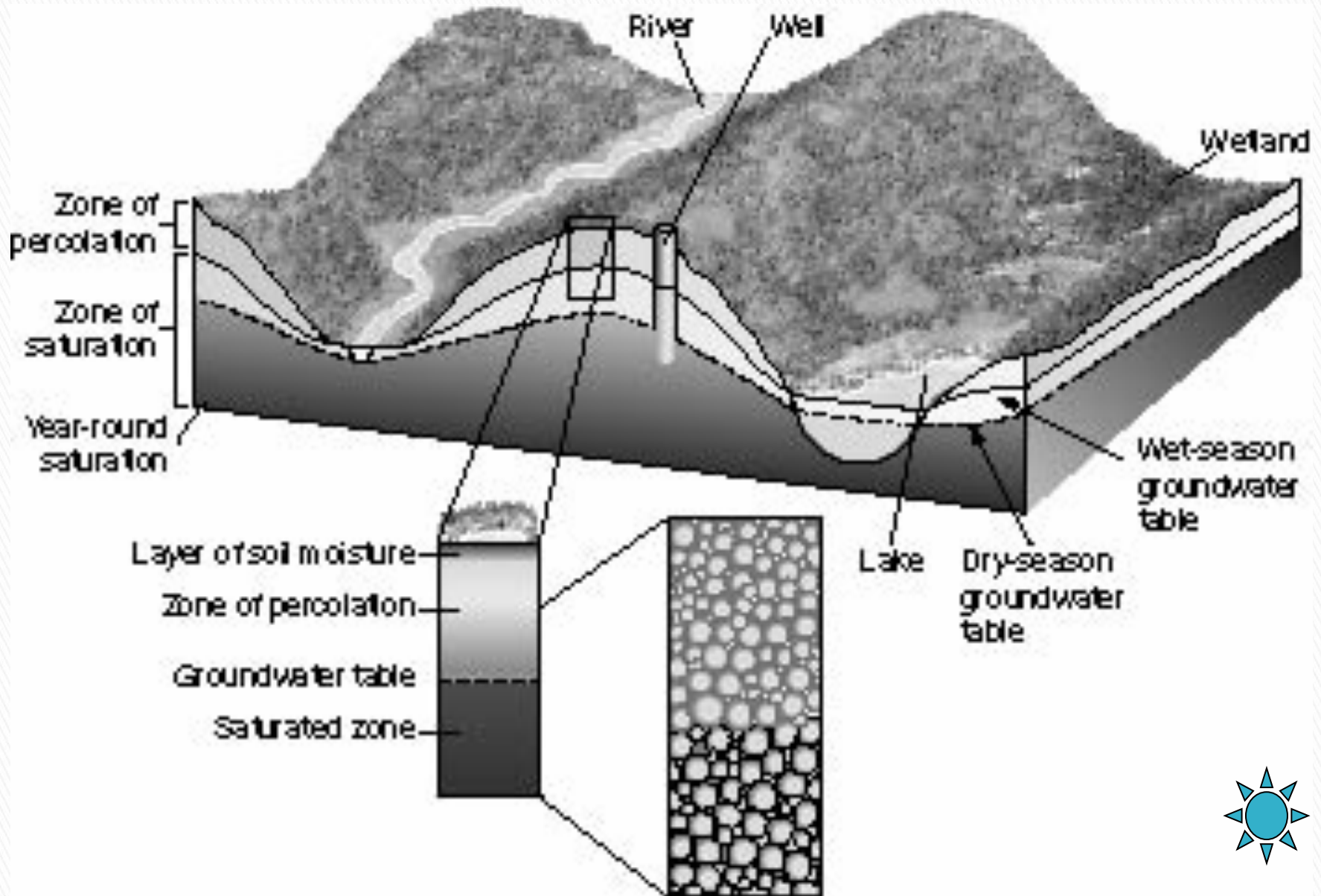
1996



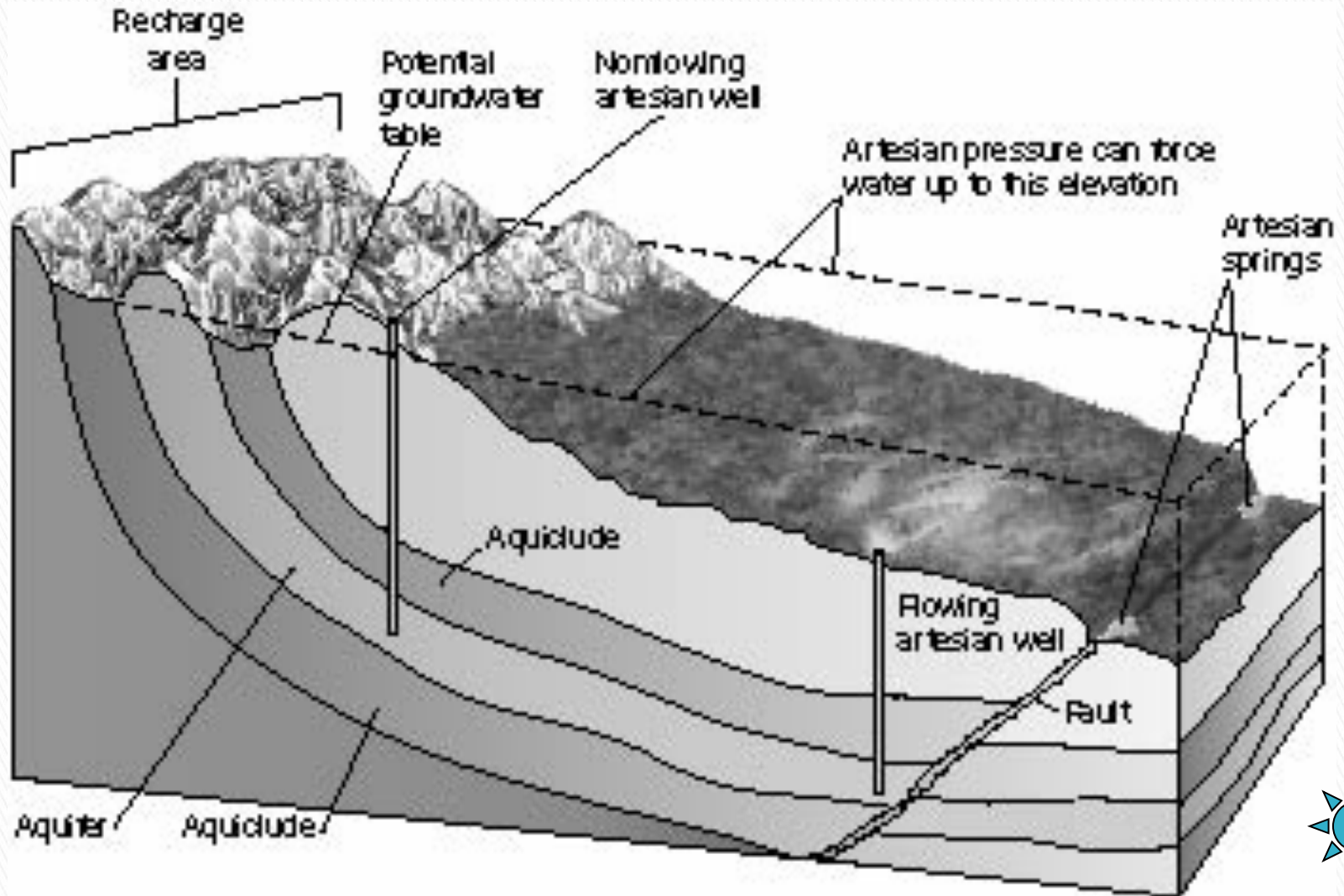
Technical Discussion

- 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>
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Topic One: Groundwater Hydrology



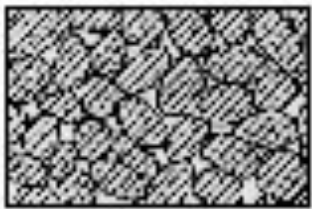
Topic Two: Recharge Potential



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”.

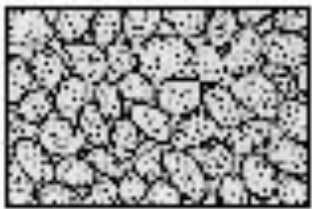
Topic Three: Porosity and Permeability



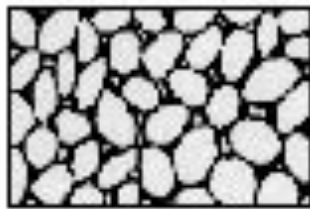
(a)



(b)



(c)



(d)



(e)



(f)

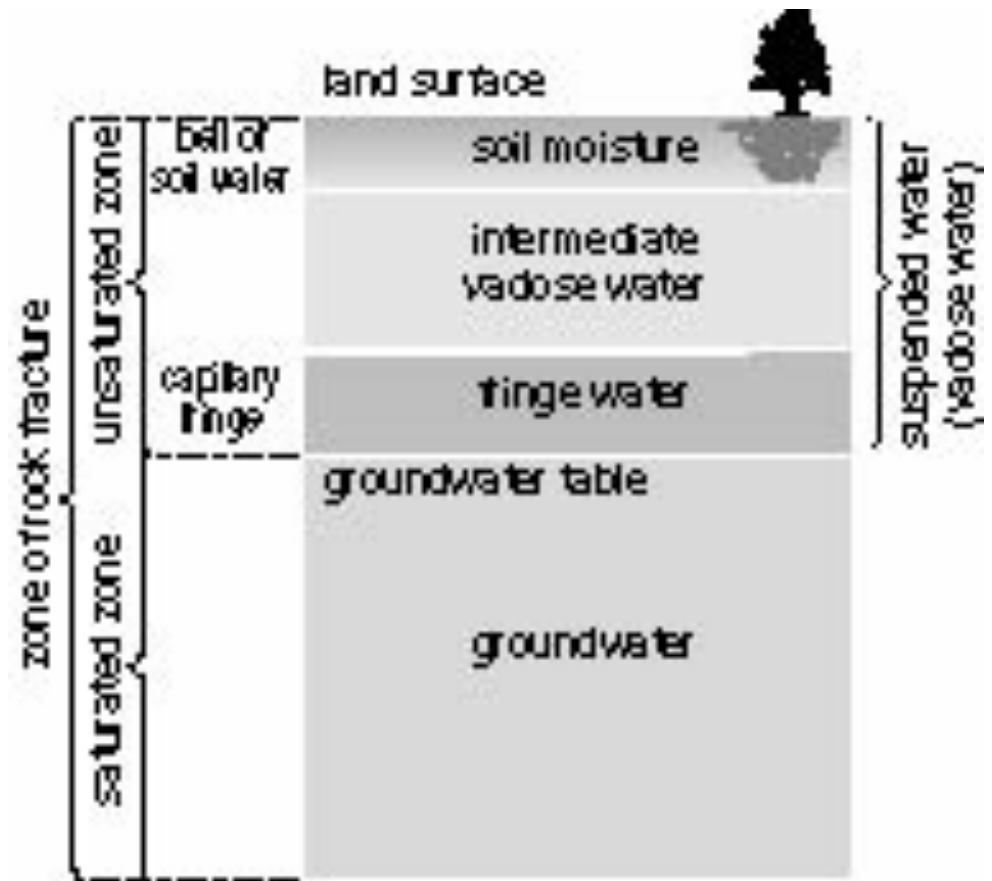
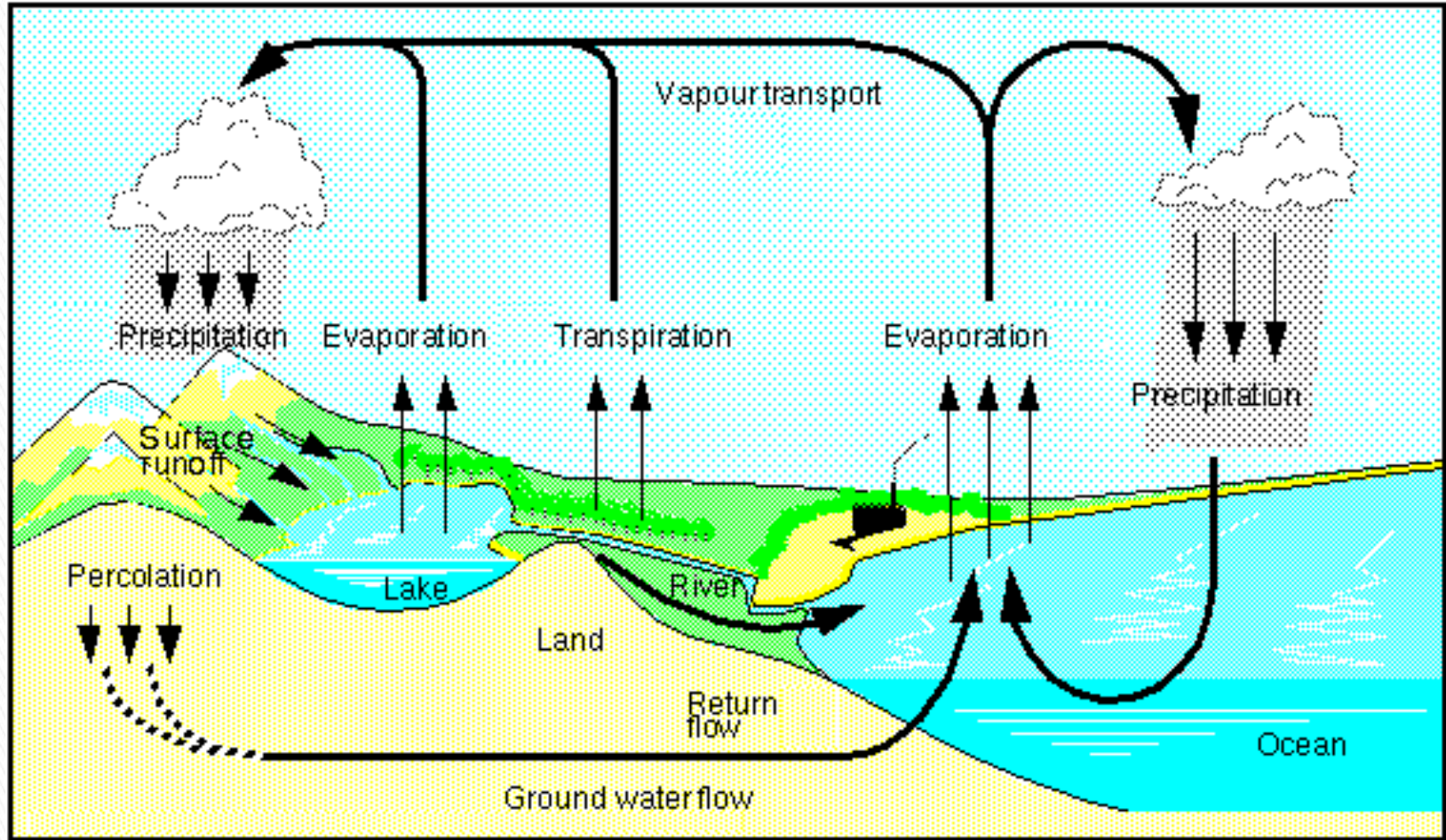


TABLE 4.1 Grain-Size Classification

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



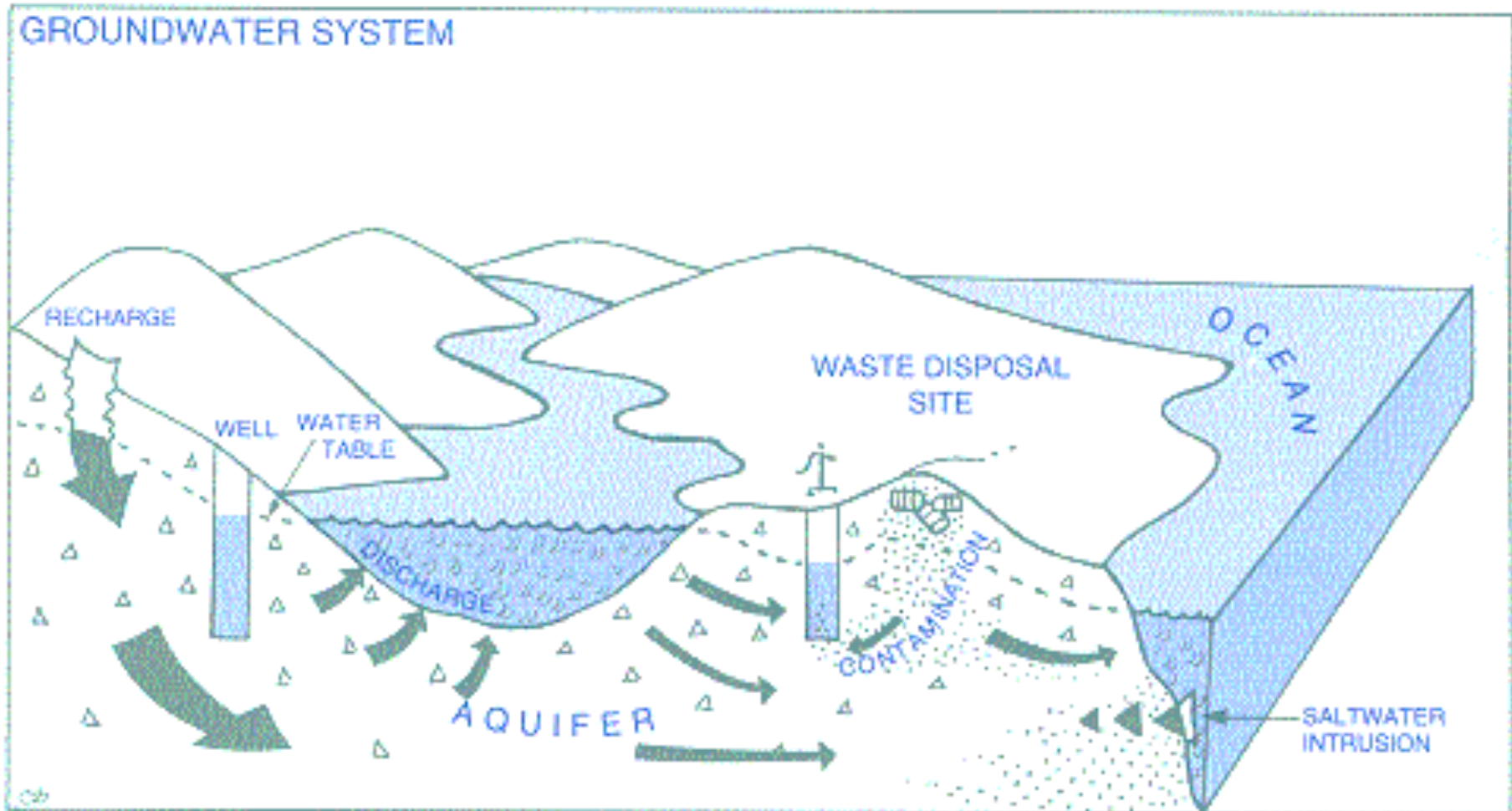
Topic Four: The Groundwater Cycle



Courtesy Erich Roeckner, Max Planck Institute for Meteorology



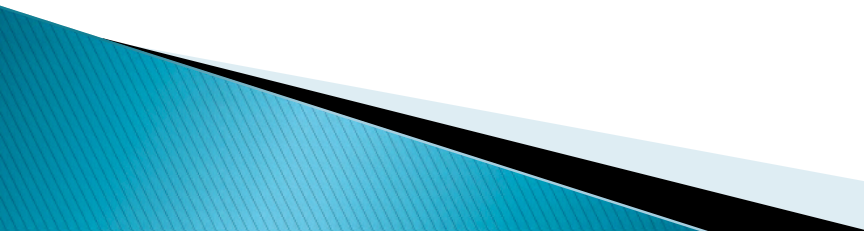
Topic Five: Human Influences to Groundwater System



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

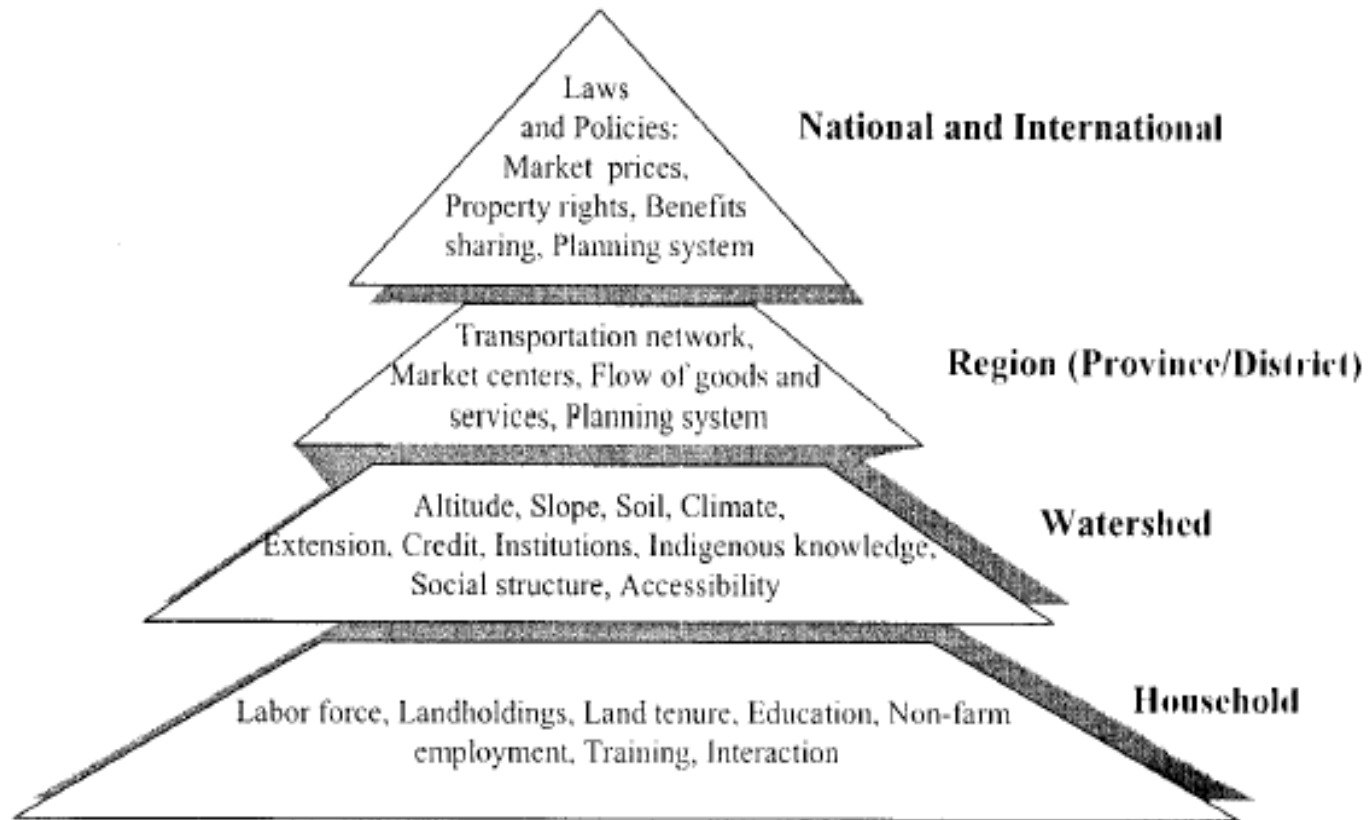
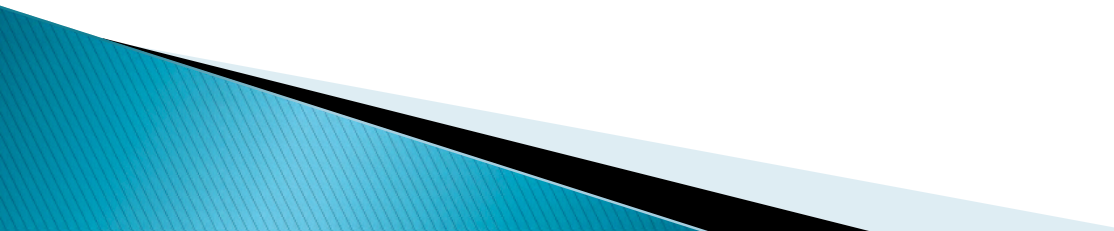


Figure 1. The four-tier hierarchy of factors influencing watershed resources use and management. This is a list of selected multilayer factors influencing watershed resources use and management. Depending on the location-specific situation, the influencing factors vary from one watershed to another.

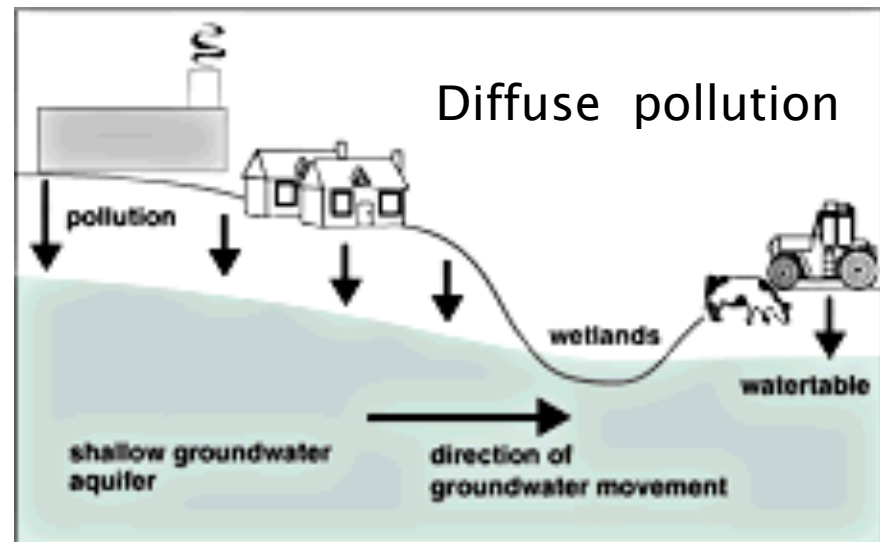
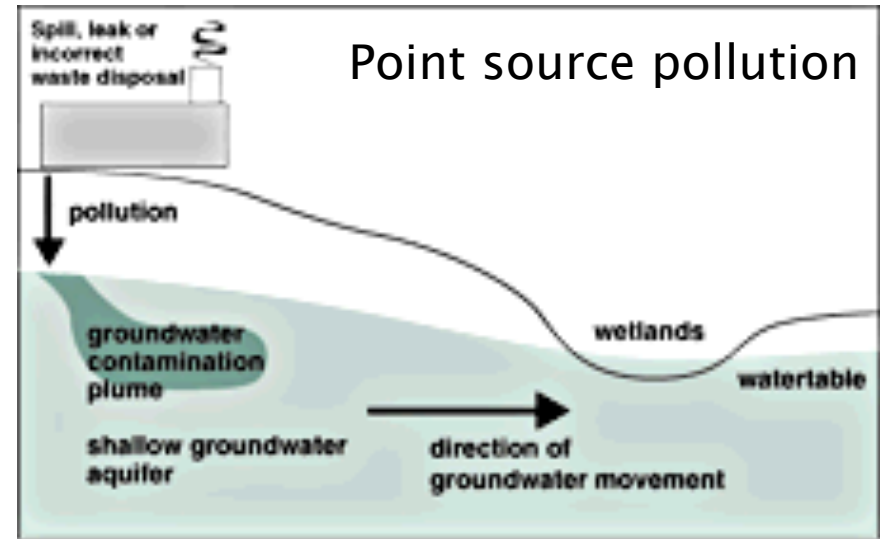
Groundwater Pollution

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.

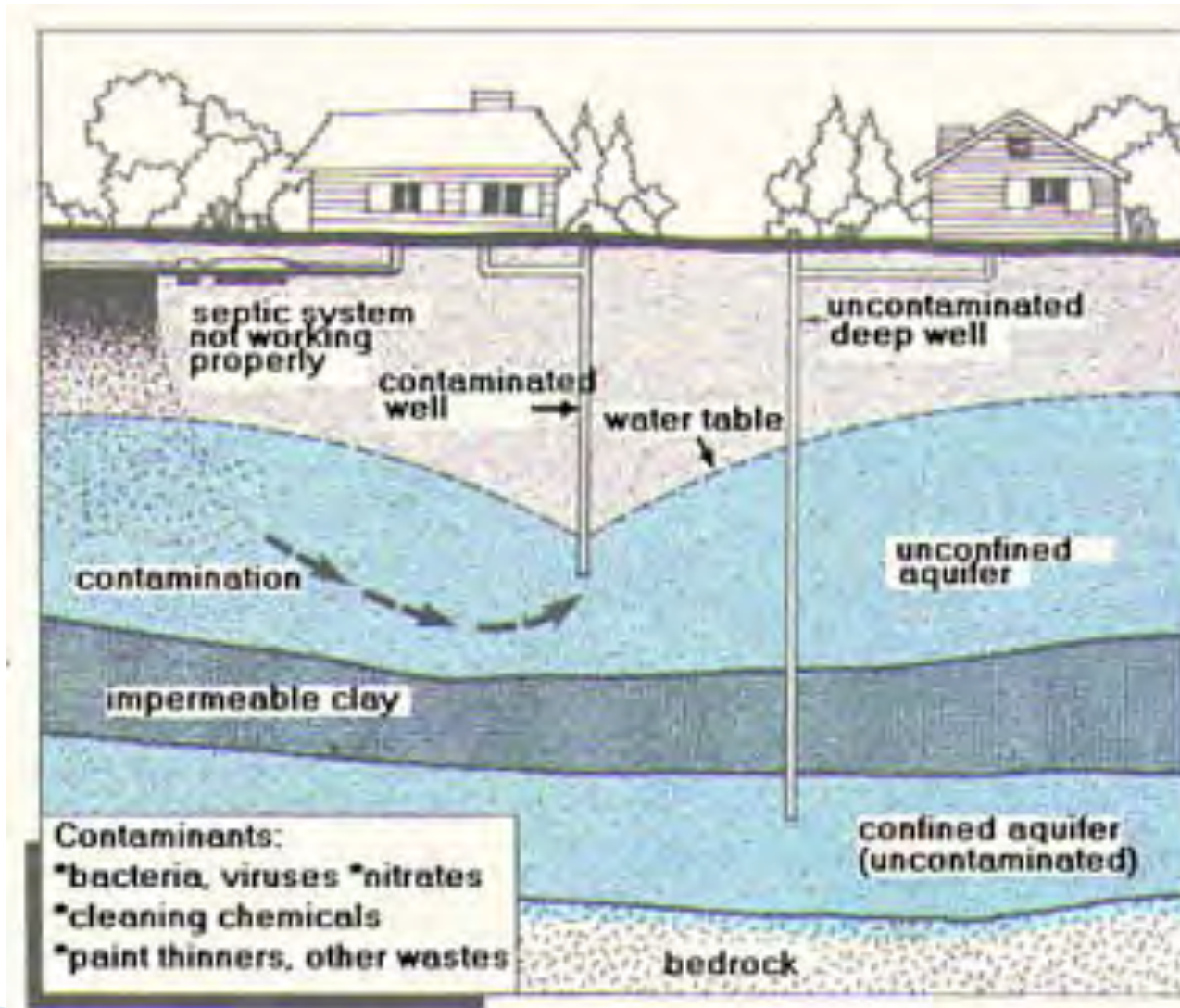
- plant nutrients
 - bacteria, viruses
 - pesticides, herbicides
 - hydrocarbons (including petrol and oil)
 - heavy metals and other toxic chemicals.
- 

Groundwater Pollution

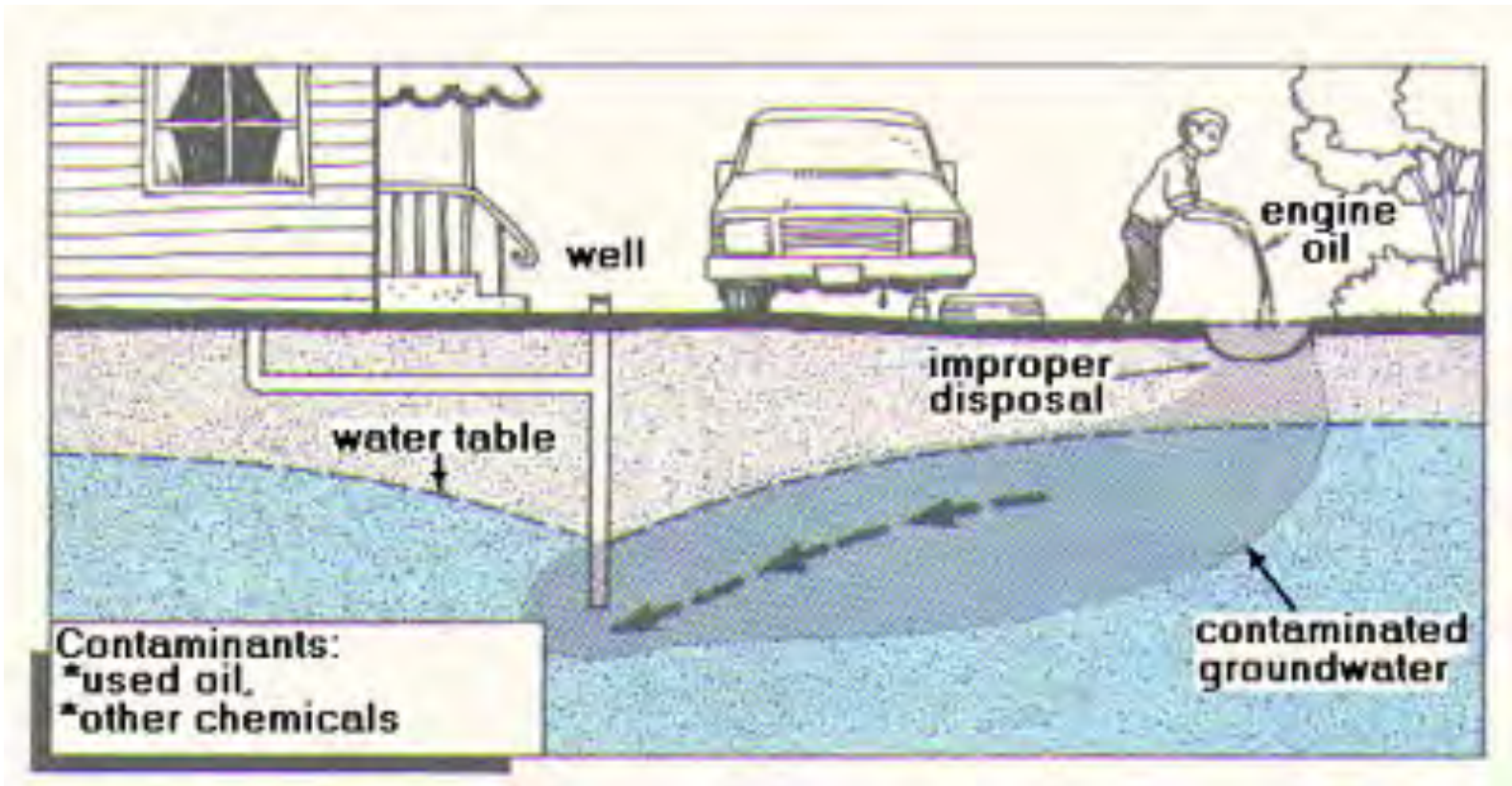
- ▶ livestock watering
- ▶ Irrigation
- ▶ aquaculture (fish farms)
- ▶ Mineral/hydrocarbon extraction
- ▶ Urban Run-Off
- ▶ Human Error (toxic spills)



SEPTIC SYSTEMS



SMALL DISPOSAL PITS



HOUSE AND GARDEN CHEMICALS

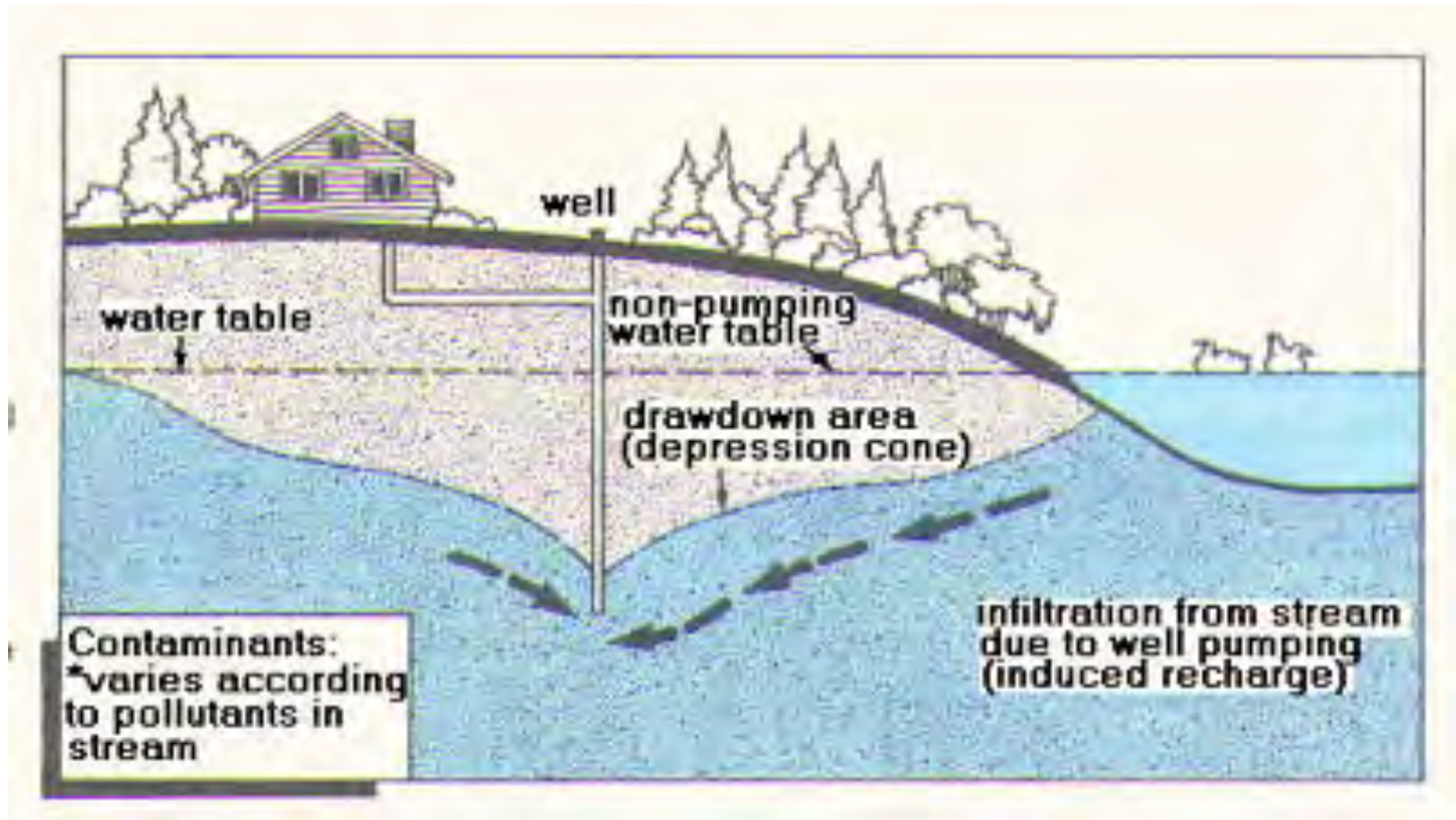


Contaminants:

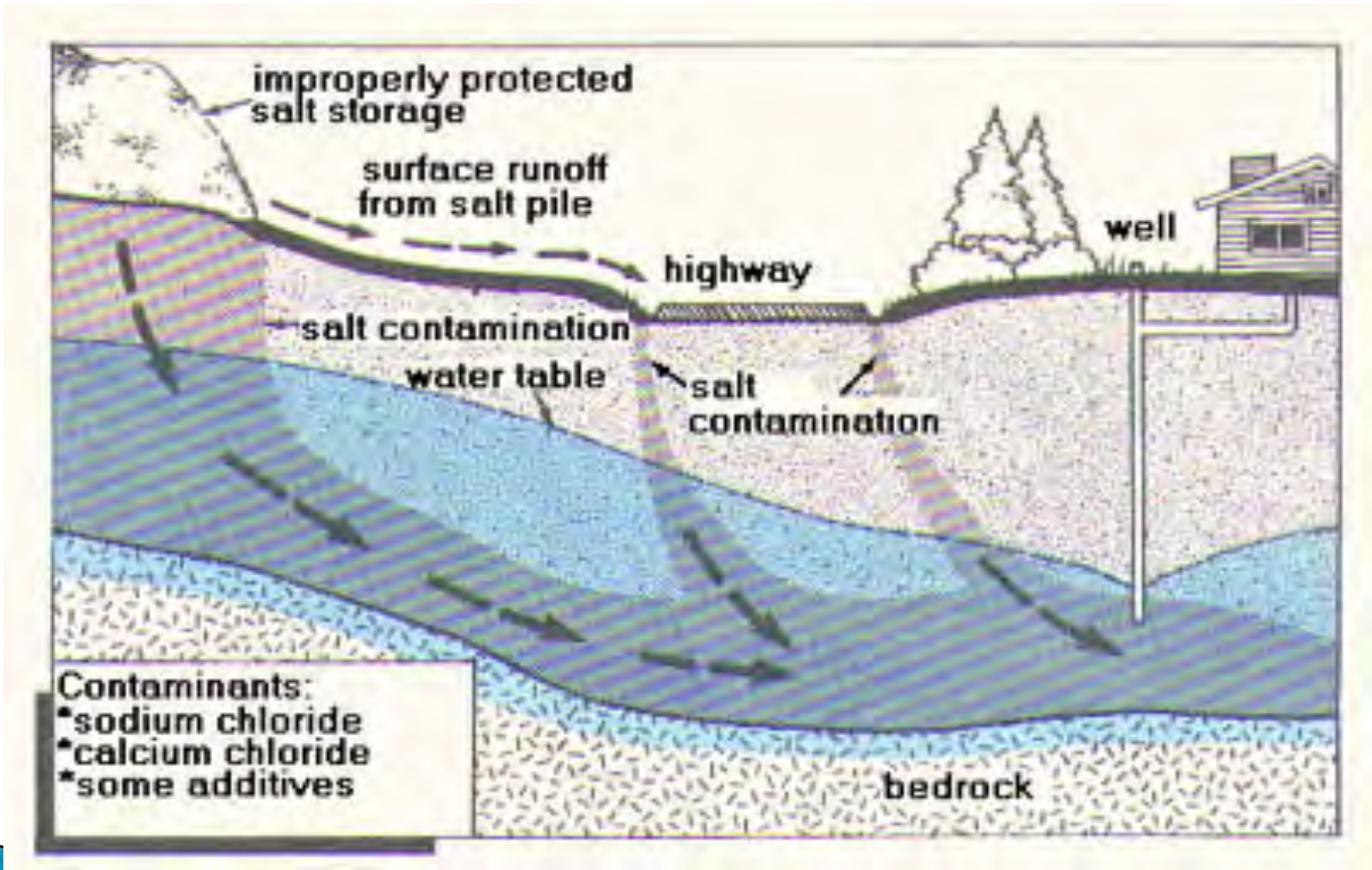
- *paint thinners
- *pesticides
- *chemical cleaners
- *floor care products
- *poisons
- *polishers & degreasers
- *automotive products
- *acids
- *other toxic substances



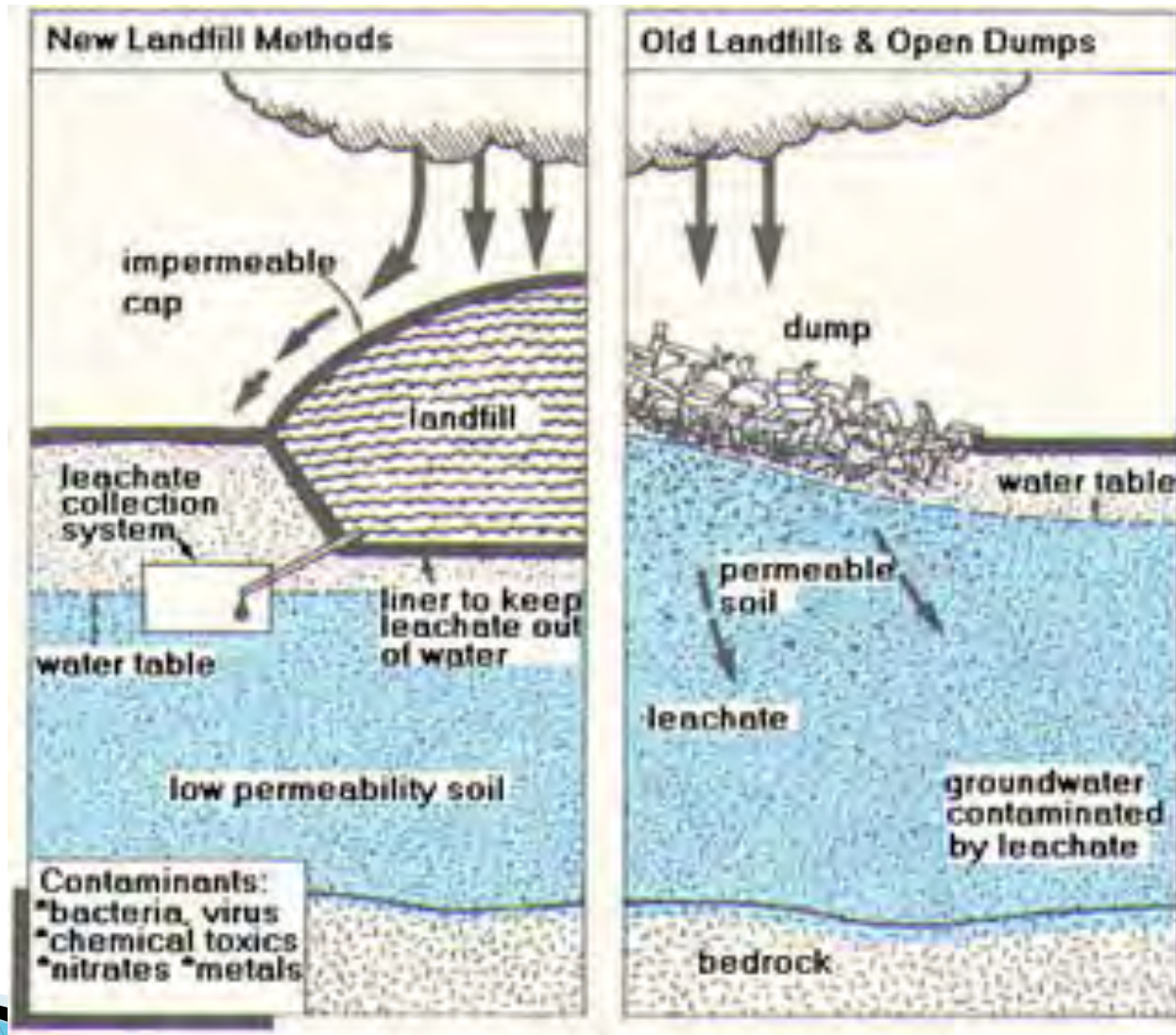
STREAM INFILTRATION



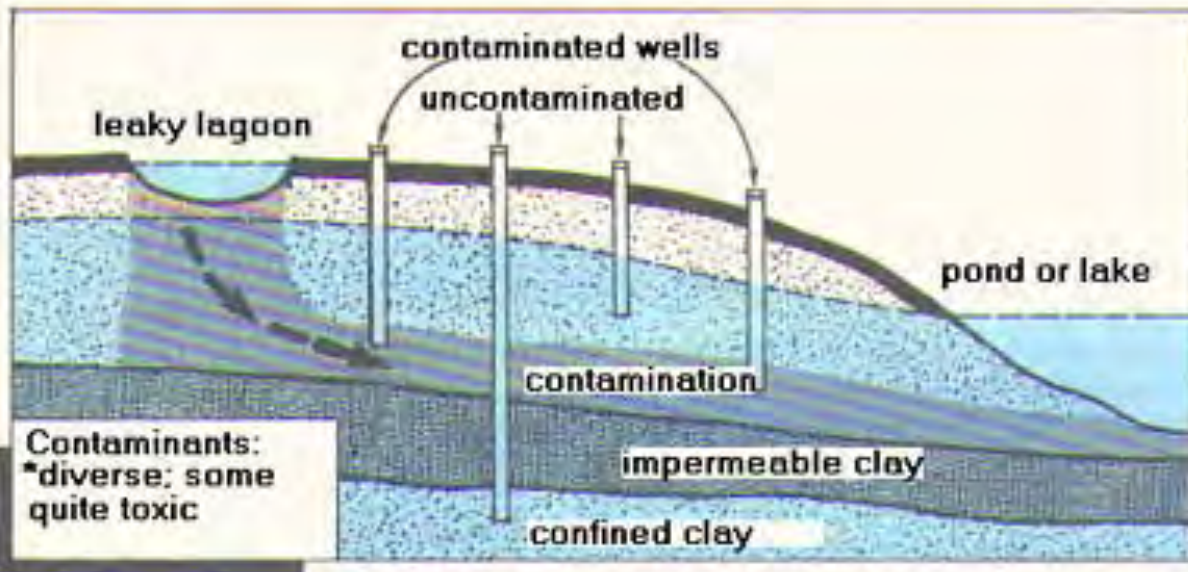
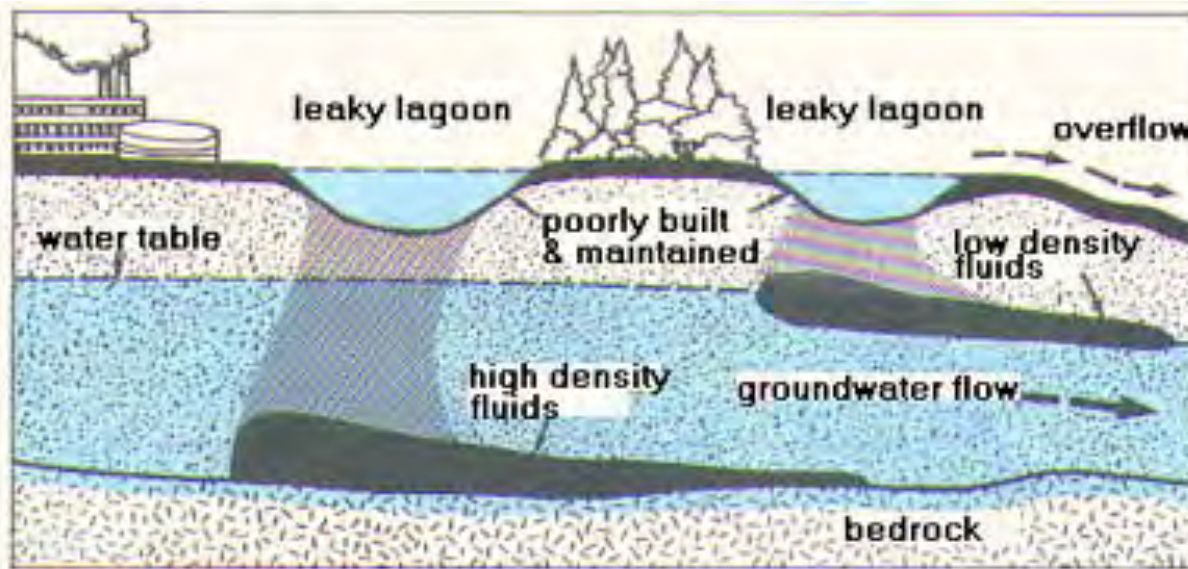
DE-ICING SALTS



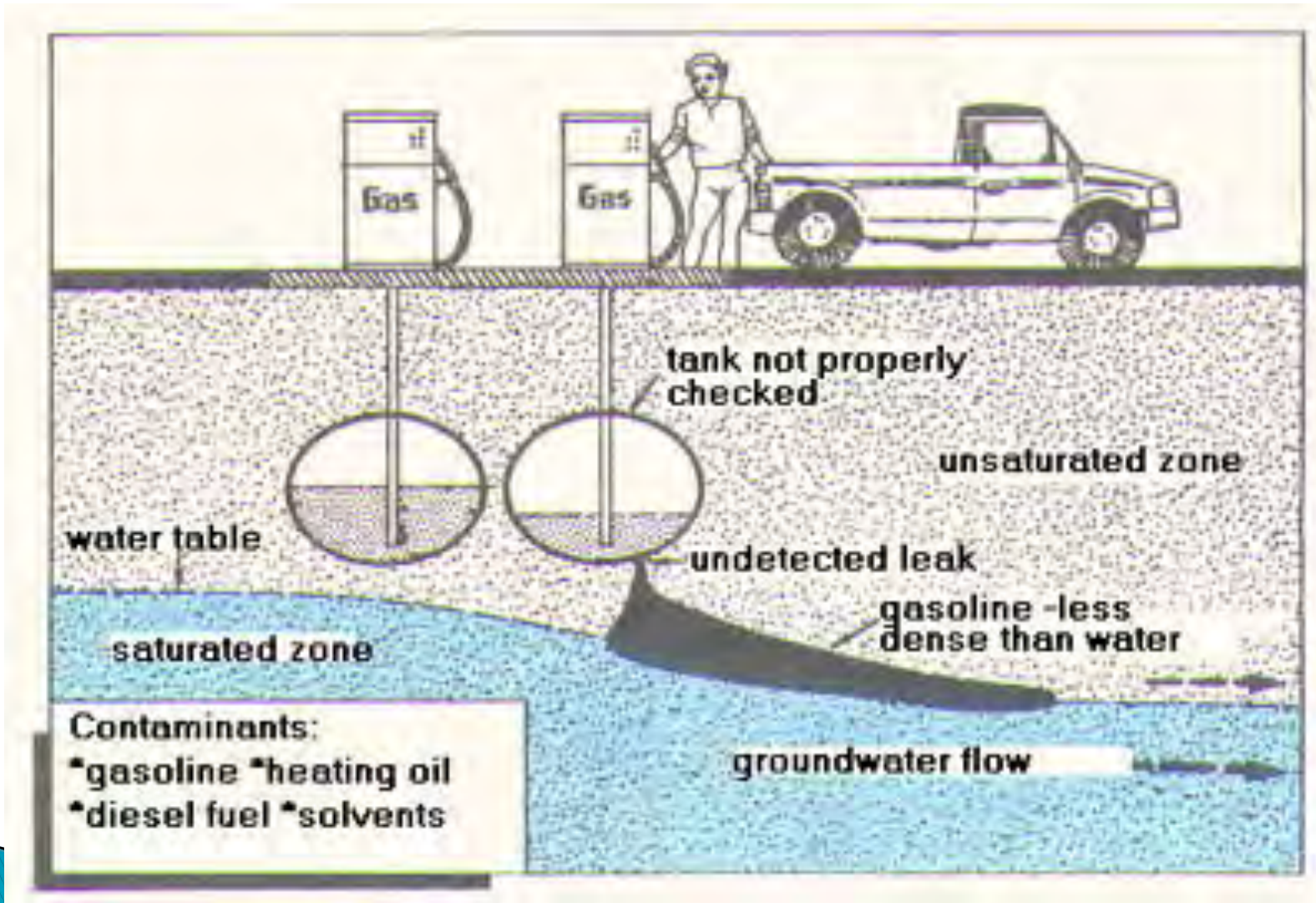
LANDFILLS



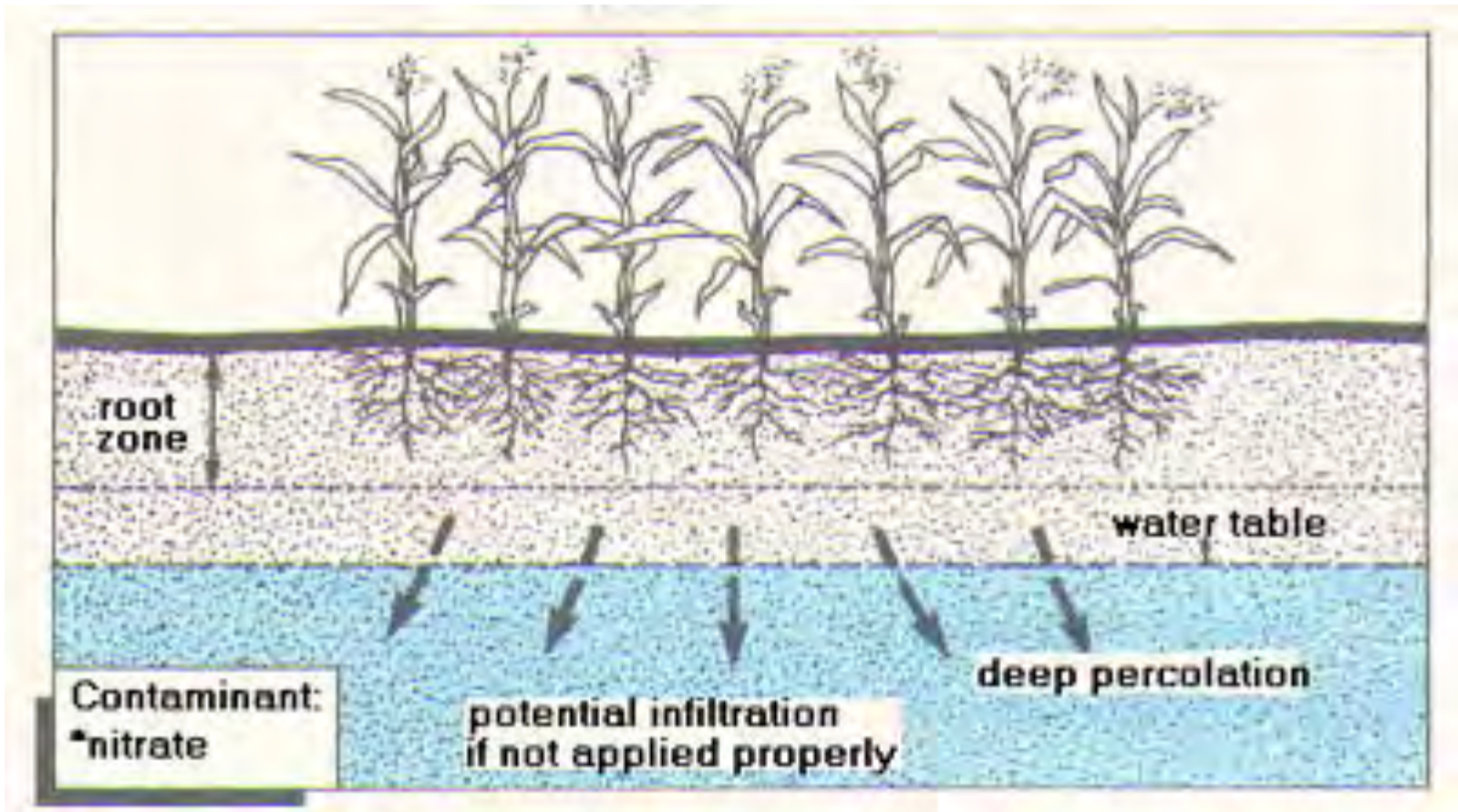
STORAGE LAGOONS



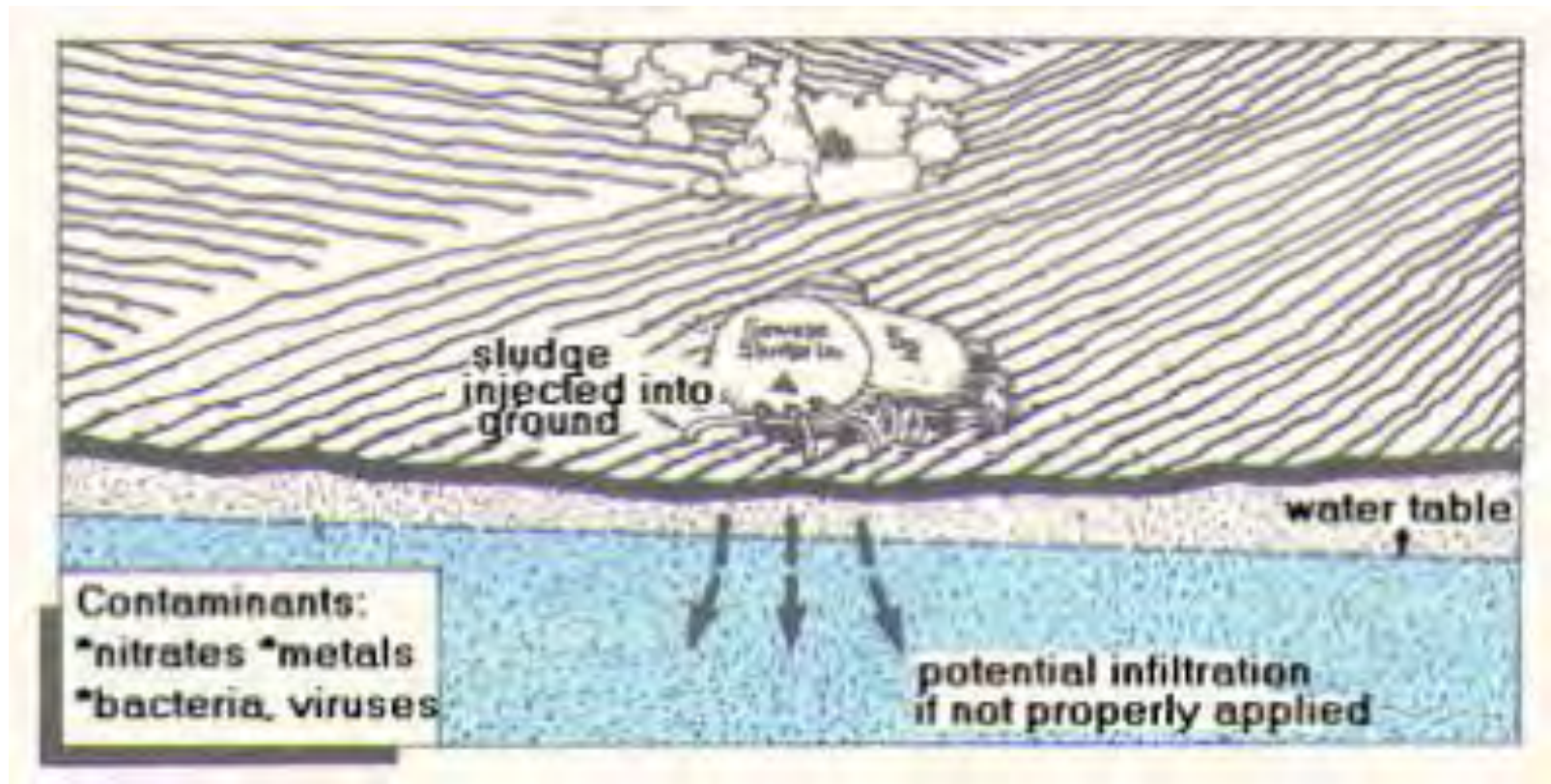
UNDERGROUND STORAGE TANKS



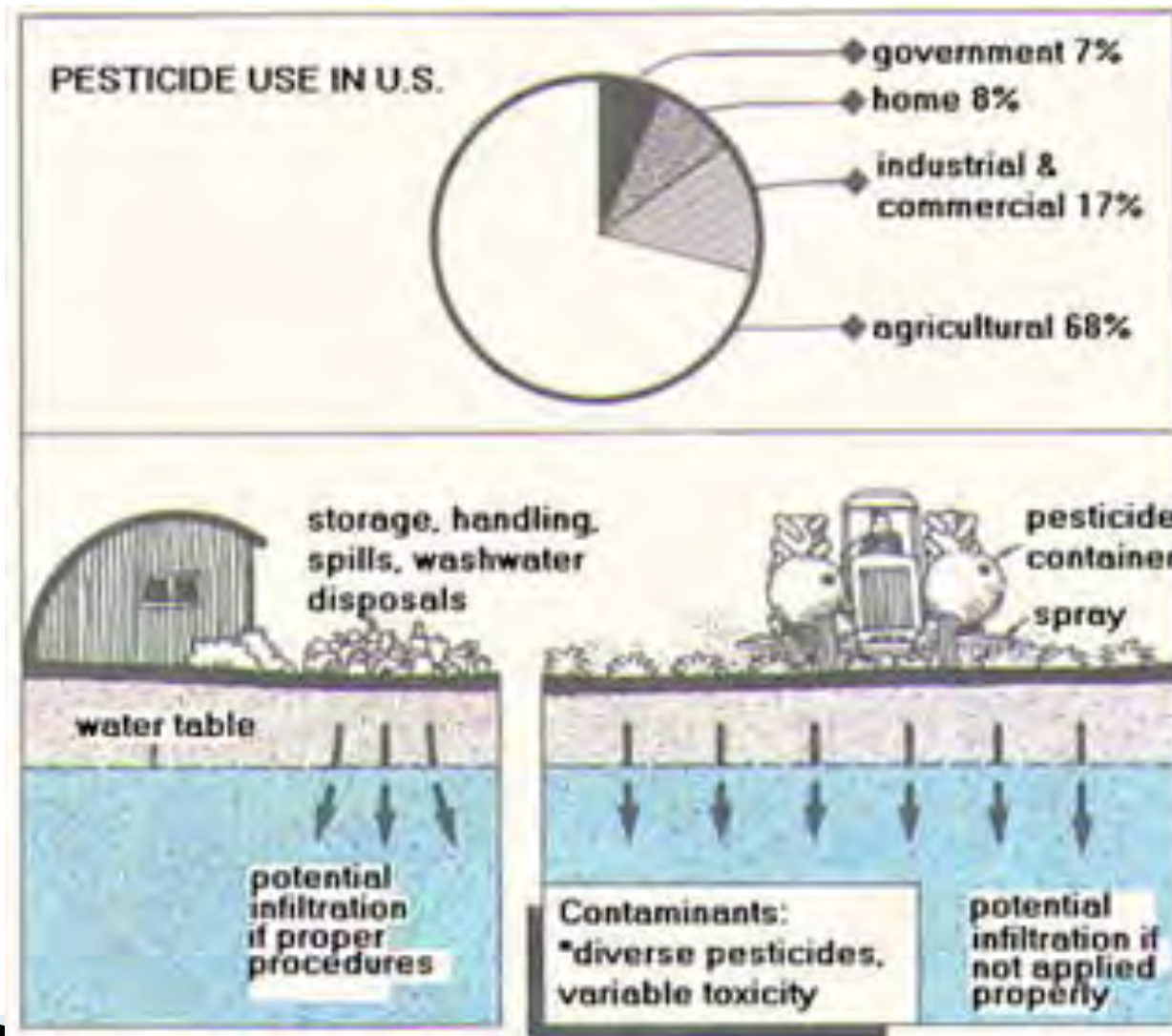
FERTILIZERS



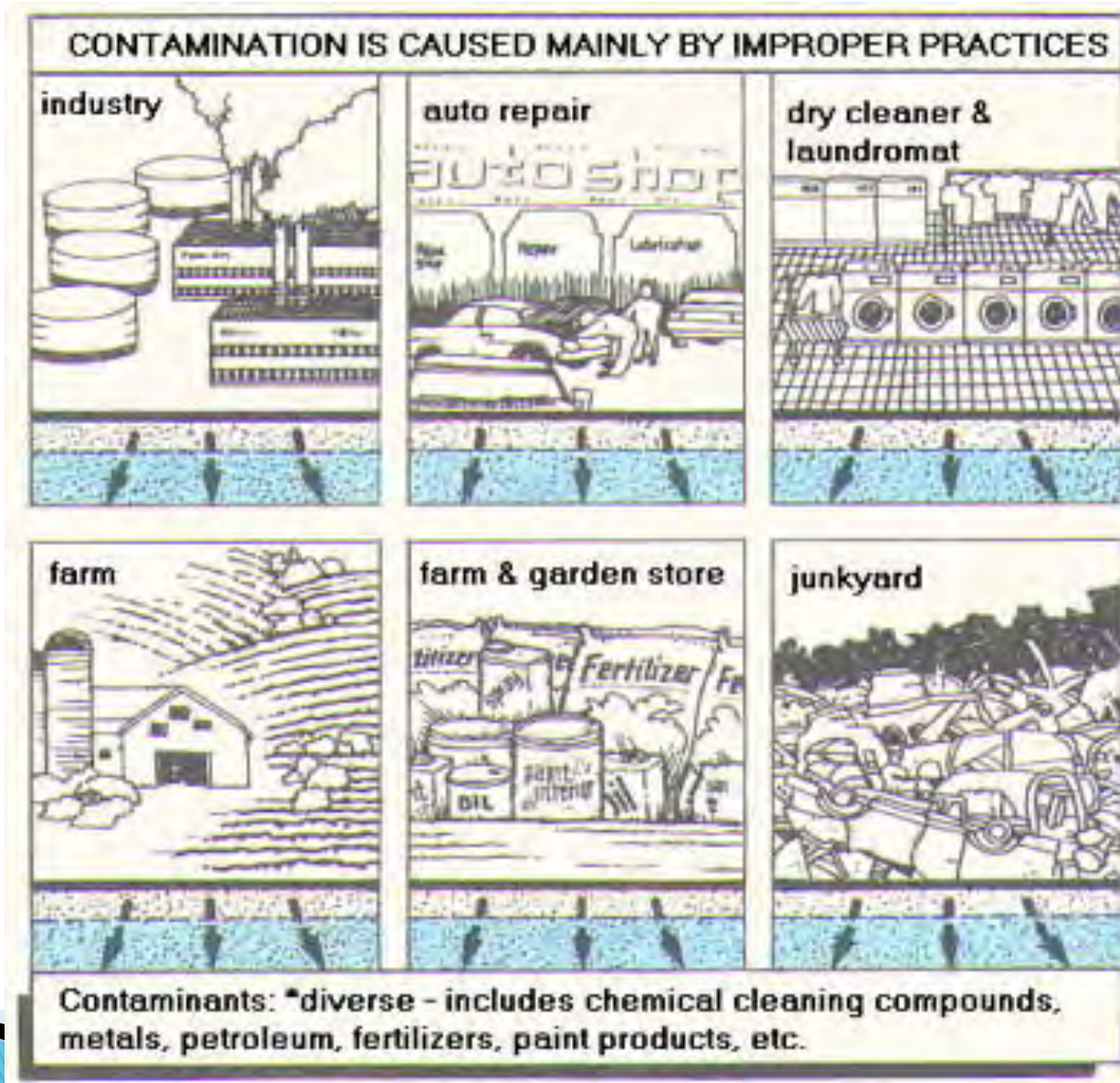
LAND APPLICATION OF SLUDGES AND WASTE WATER



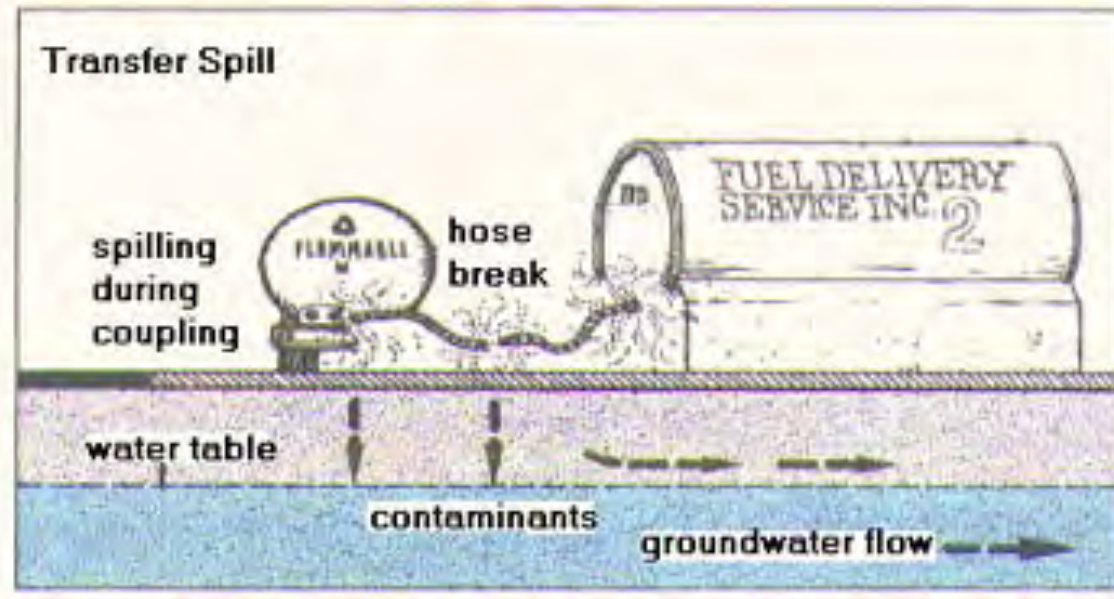
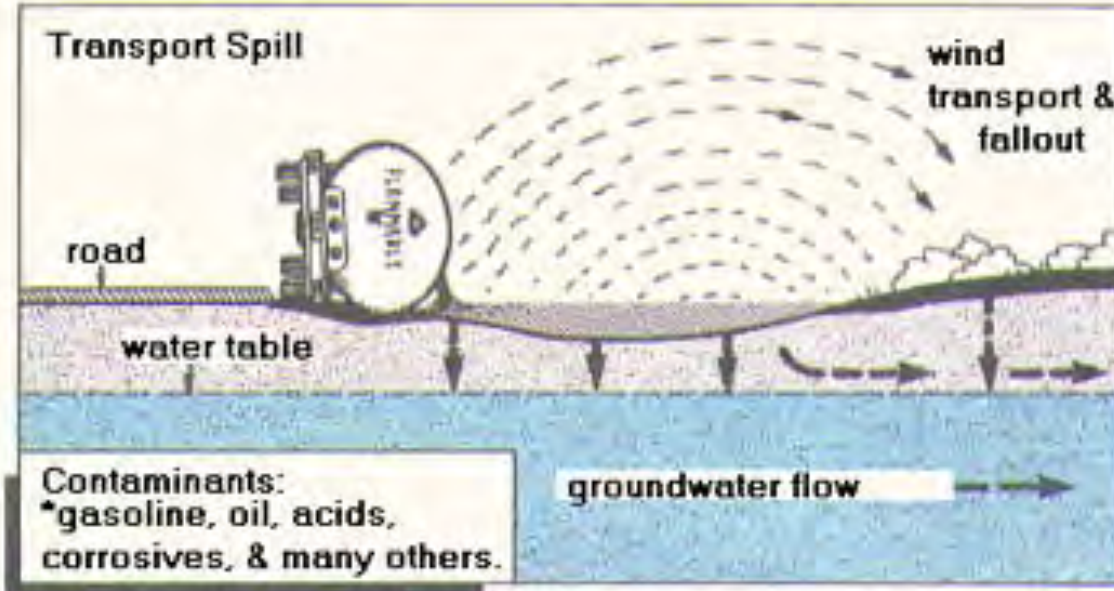
PESTICIDES



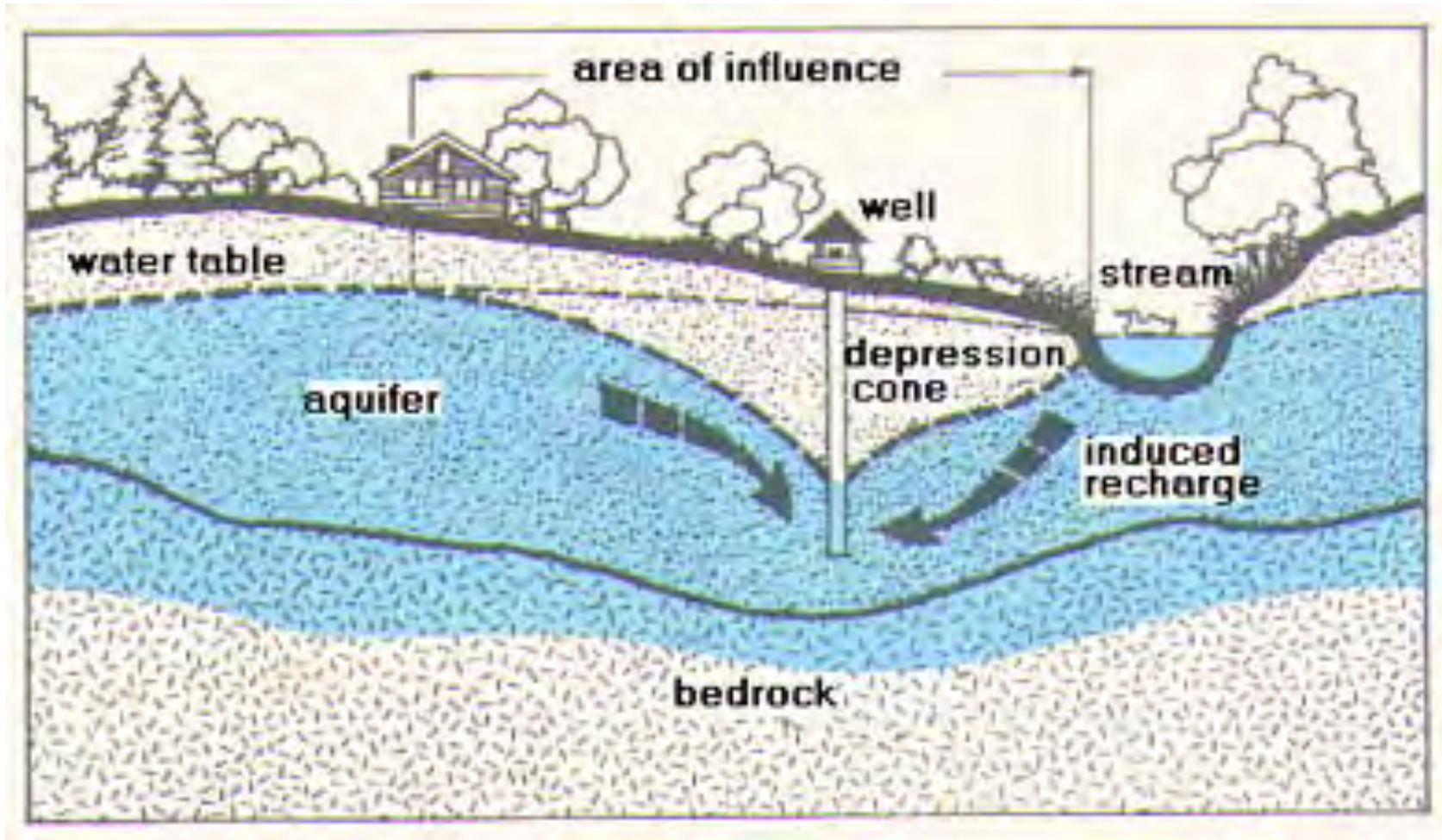
HAZARDOUS MATERIALS



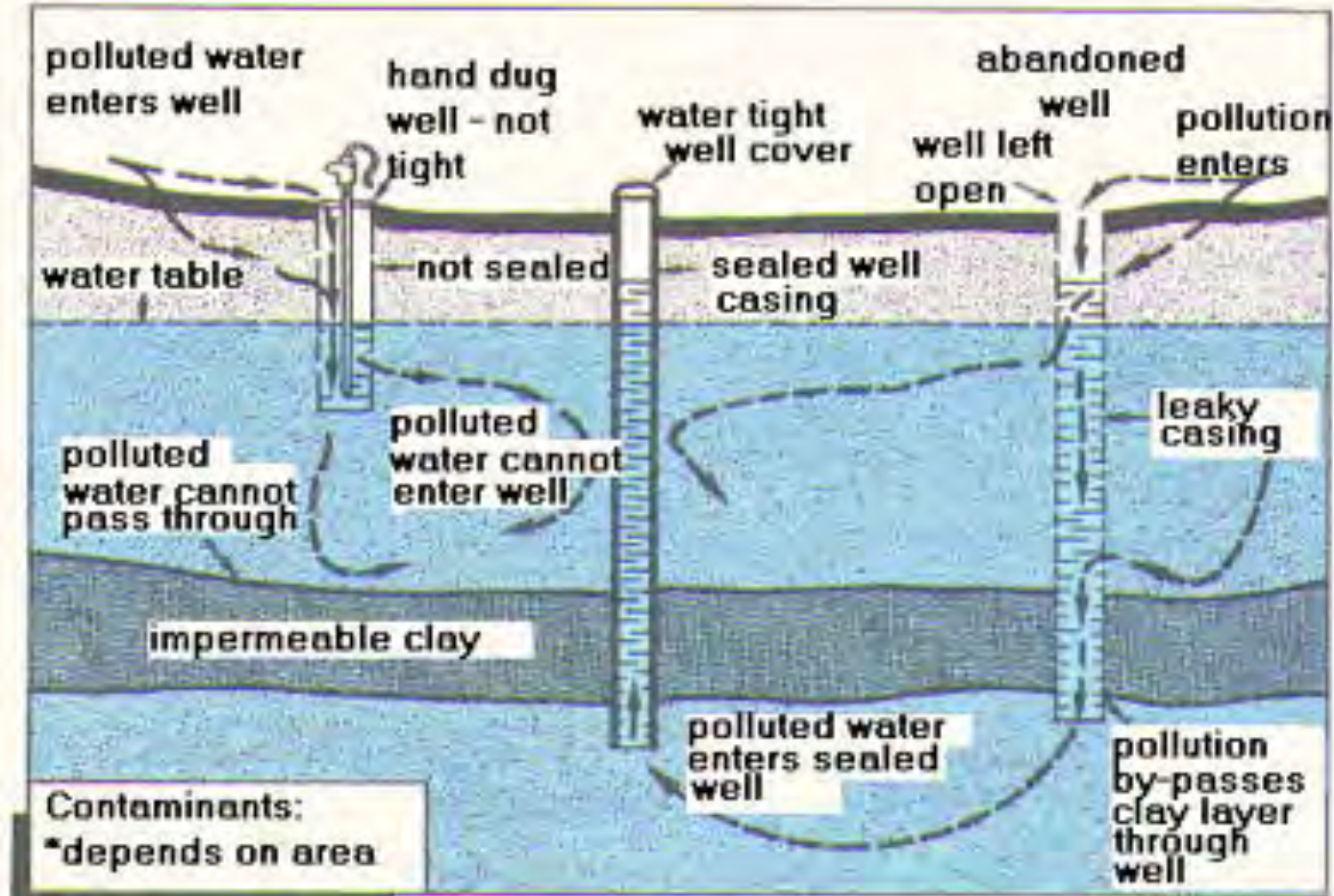
TRANSPORT AND TRANSFER SPILLS



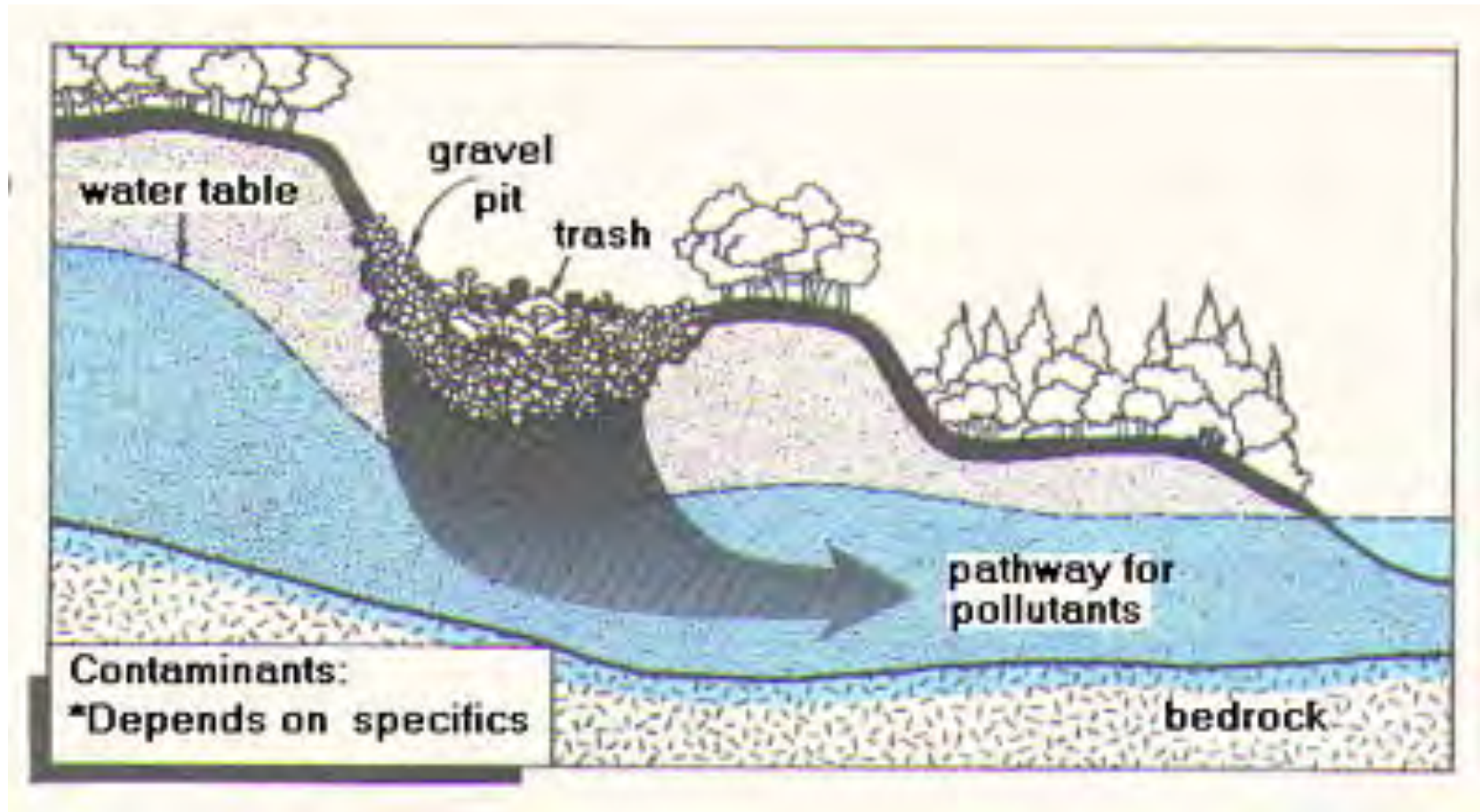
PIPELINES



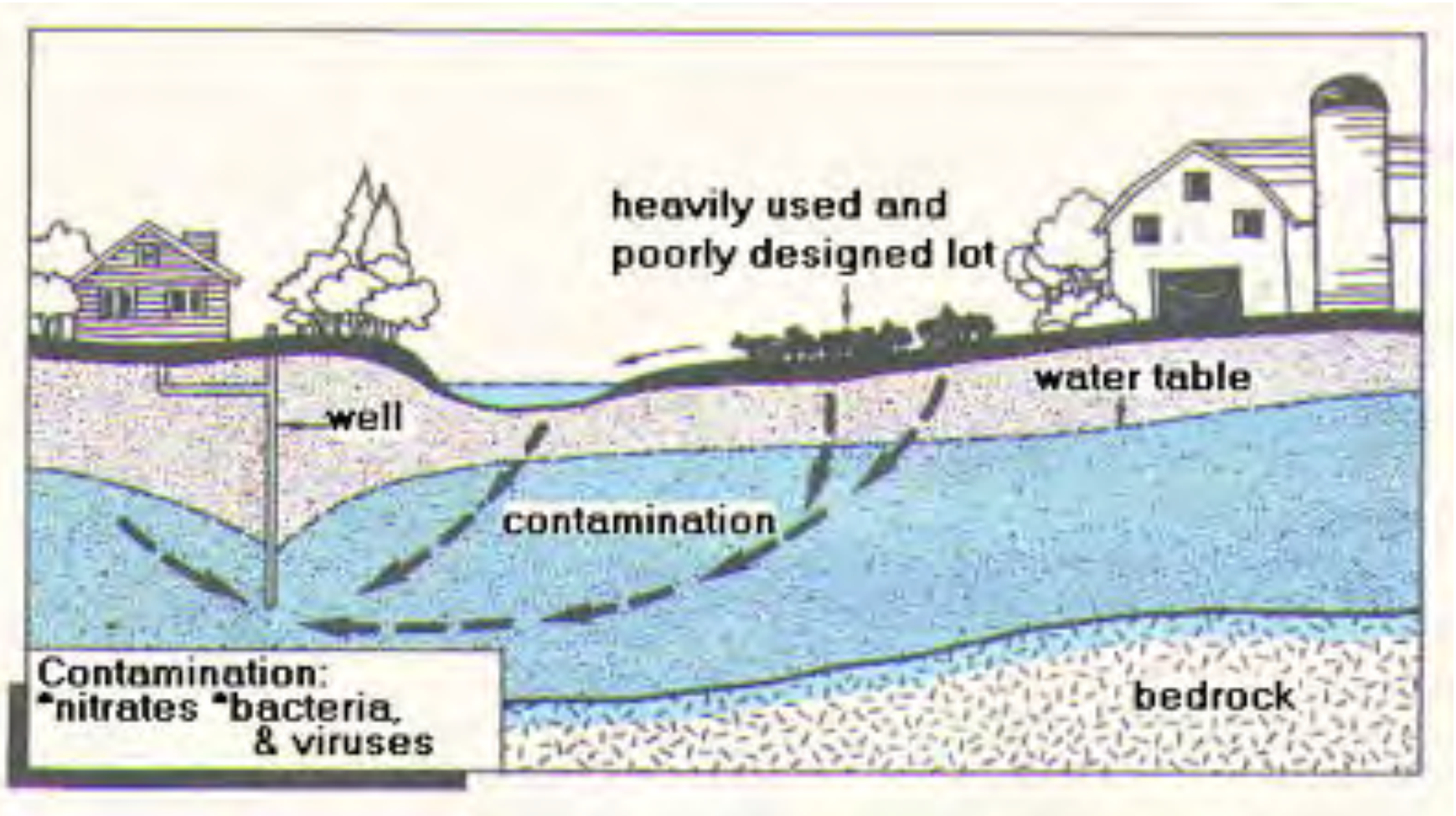
WELLS



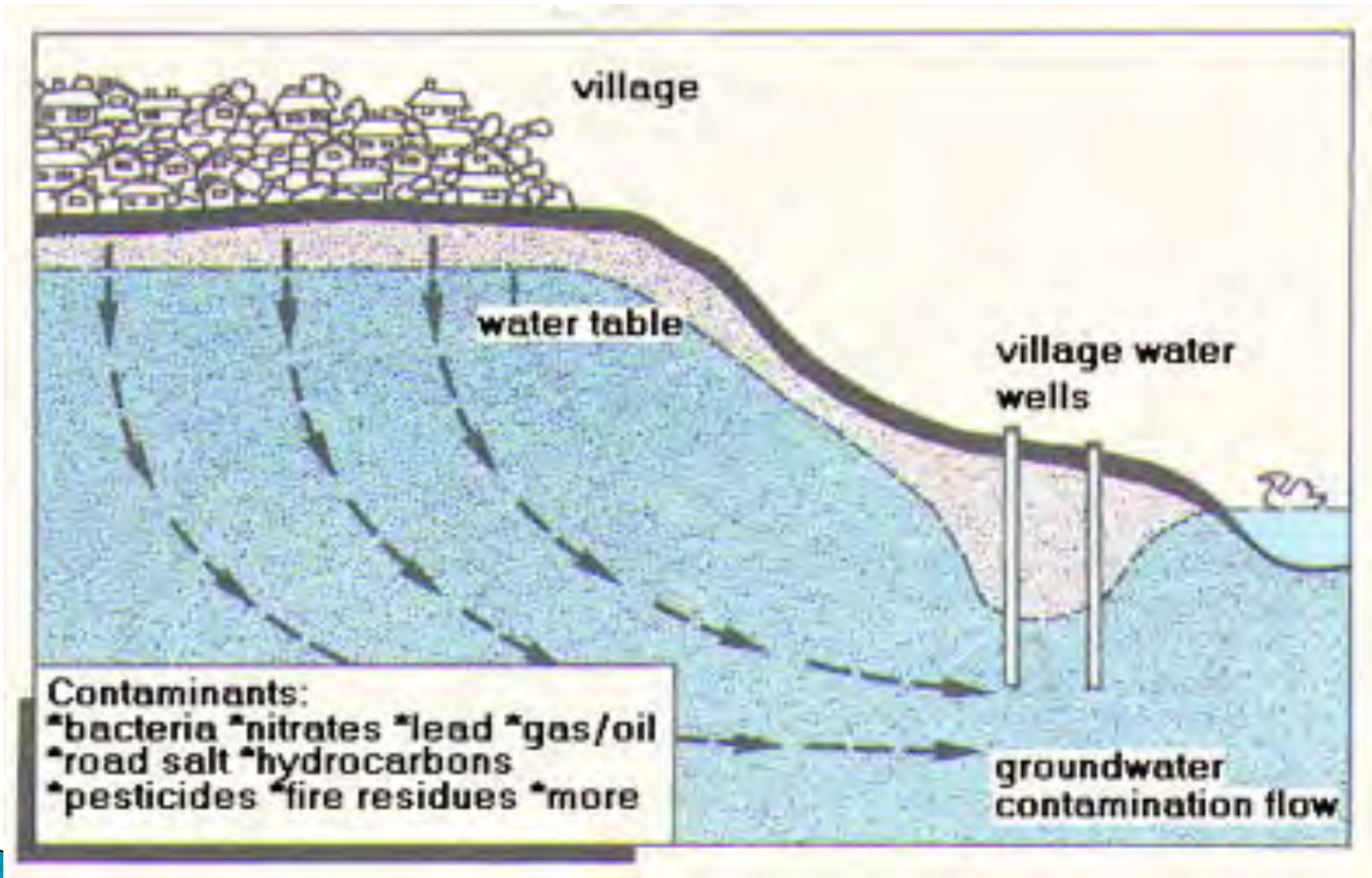
INACTIVE MINING SITES



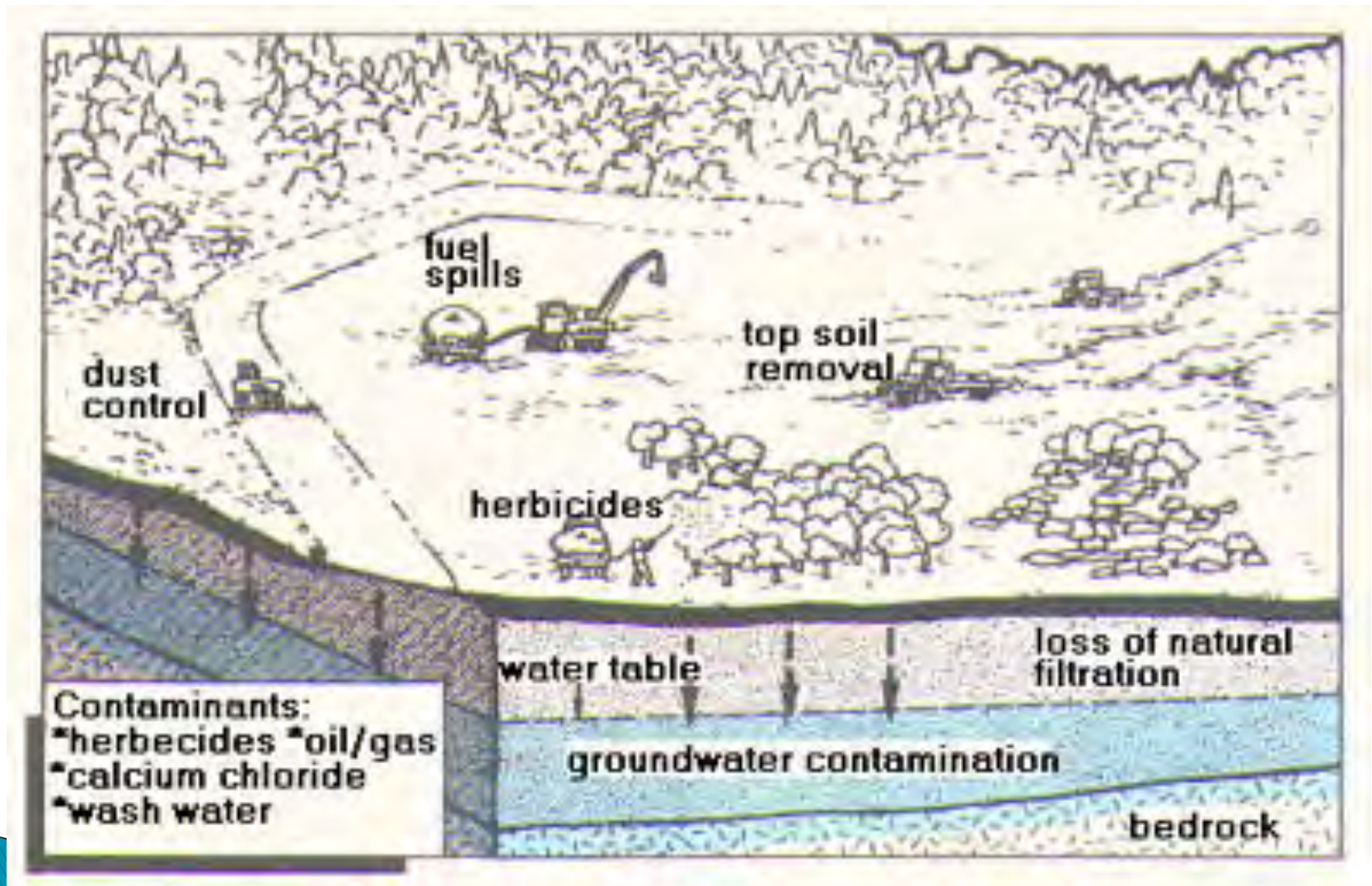
ANIMAL LOTS



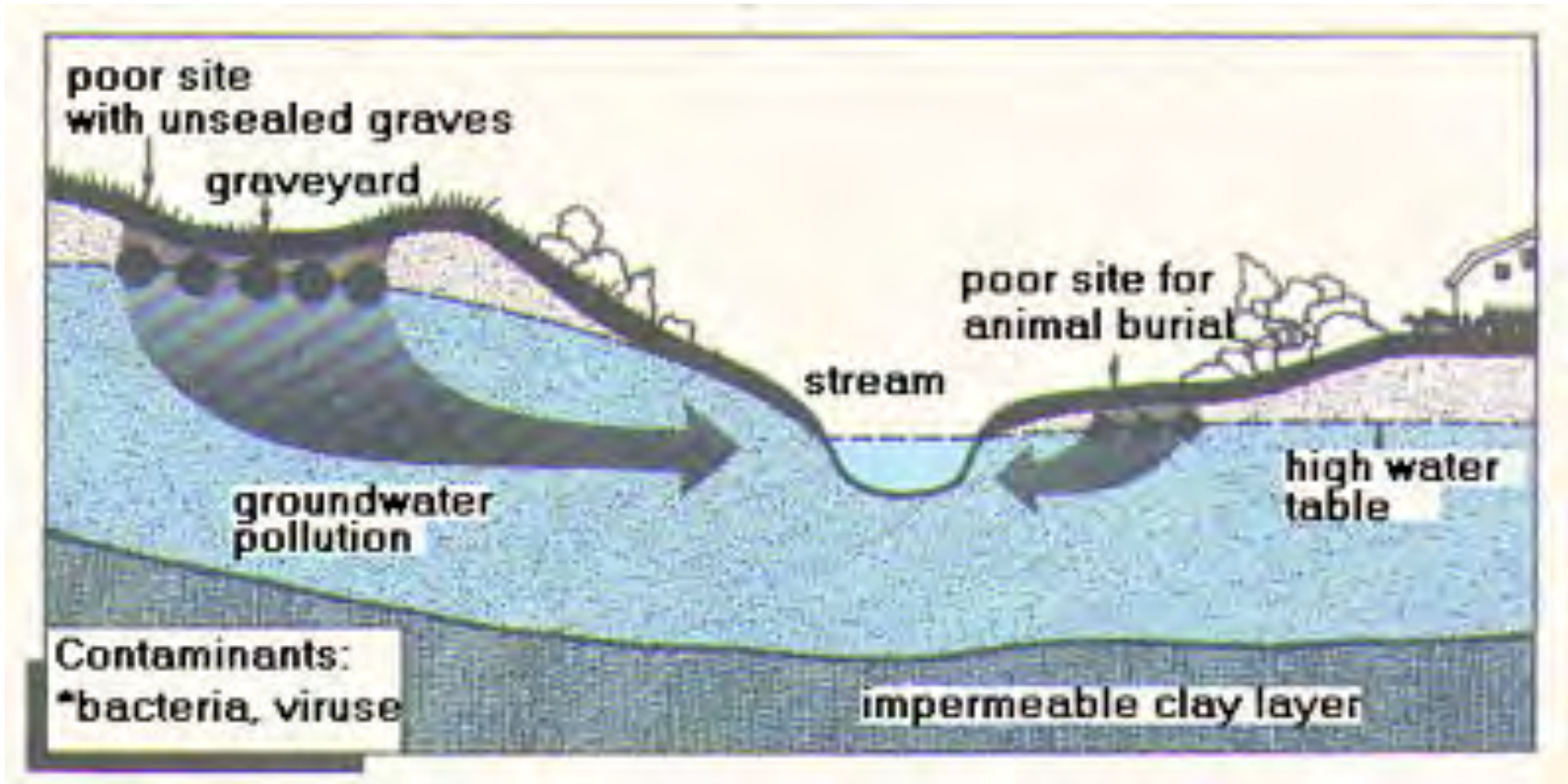
URBAN RUNOFF



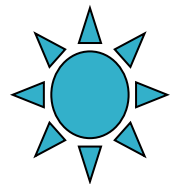
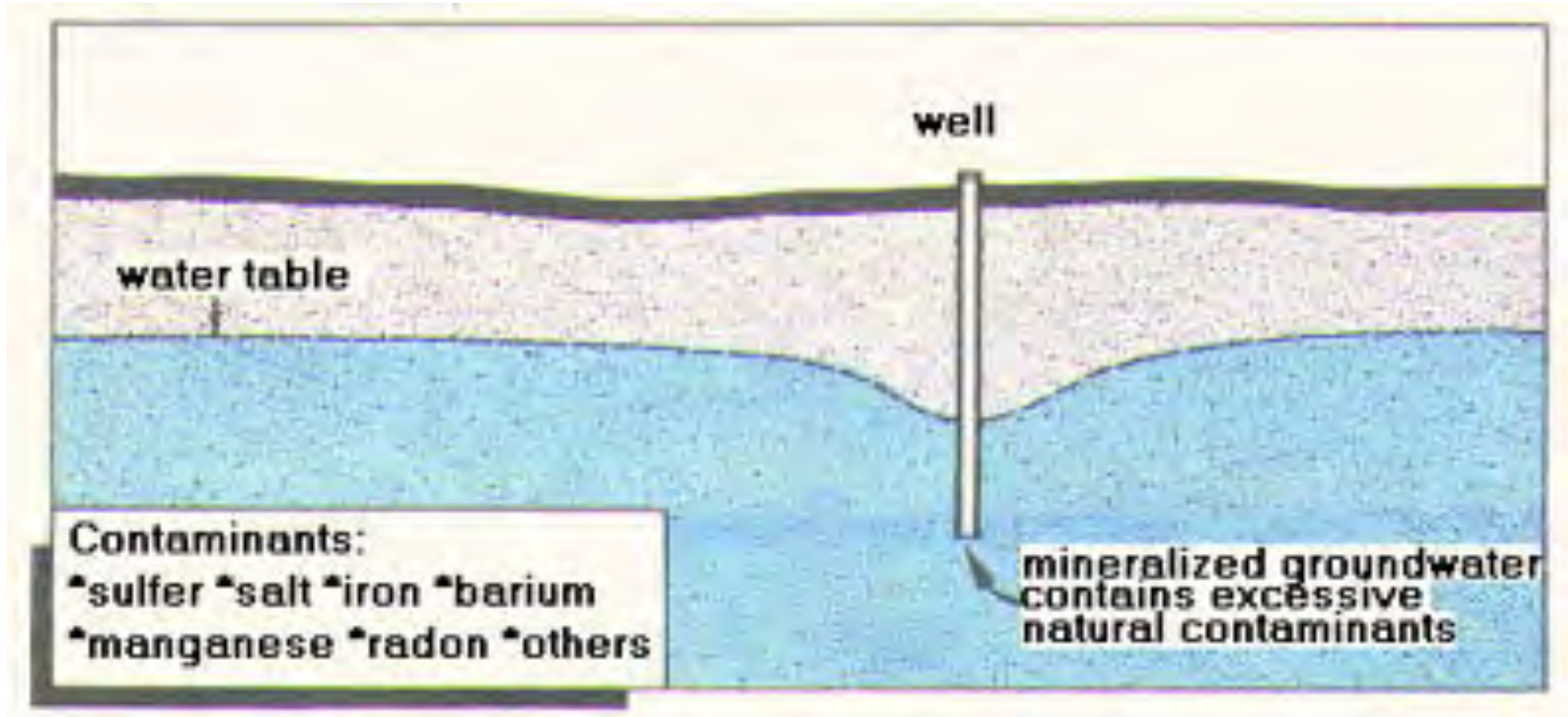
CONSTRUCTION EXCAVATION



CEMETERIES AND EXCAVATION



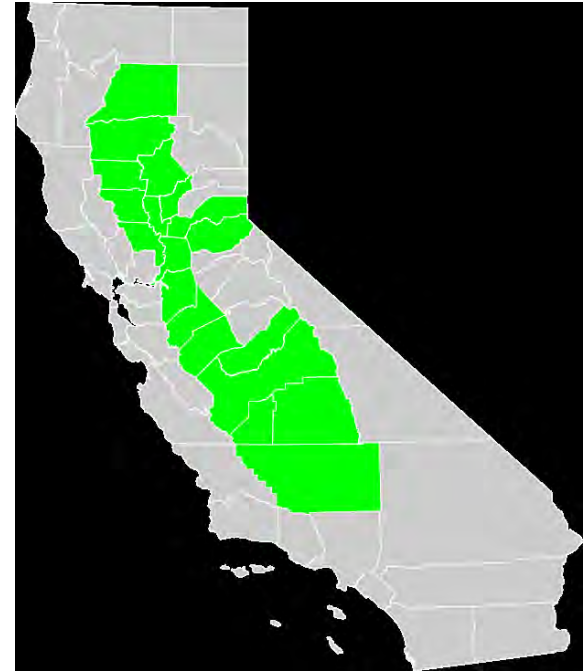
NATURAL SUBSTANCES



Back to water woes in California . .

FROM National Geographic:

- ▶ Aquifers provide 30 – 40 % of the state's water supply in normal years but close to 60 % in drought years.
- ▶ On the edges of the Central Valley, where aquifers are relatively shallow, municipal wells are running dry, forcing small towns to import water at excruciatingly high prices.
- ▶ Many groundwater-fed surface streams have been depleted, threatening the species that depend on them.
- ▶ Over the past decade NASA satellite research has shown that Central Valley farmers are withdrawing groundwater far faster than rain and snowmelt can trickle through soil and rock layers to recharge aquifers.
- ▶ Recent deep and extended droughts, including the current one, have worsened the situation.



More extreme weather events such as drought are occurring with CLIMATE CHANGE.

Climate Change and Water Resources

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