

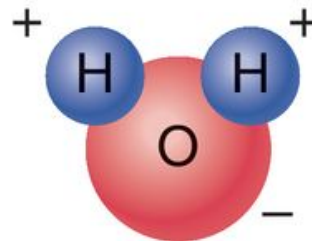
WATER RESOURCES

- Water use and Resource Problems
- Management and Conservation



WATER

- ▶ Covers 3/4ths of Earth's surface
- ▶ Regulates climate (*heating capacity*)
- ▶ Exists as solid, liquid or gas
- ▶ Life survival depends on it
 - ▶ Unicellular to Humans
- ▶ Composed of 2 Hydrogen and 1 oxygen
- ▶ Polar - Forms hydrogen bonds between 2 water molecules



IMPORTANCE OF WATER

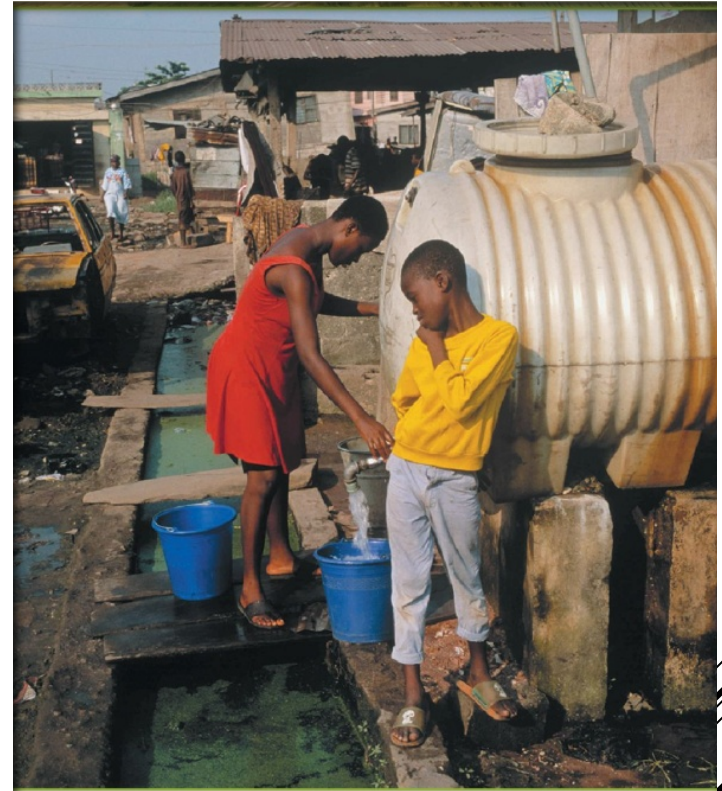
- ▶ Multiple Human uses
- ▶ Use of freshwater is increasing (why?)
 - ▶ Cooking & washing (11%)
 - ▶ Agriculture (70%)
 - ▶ Transportation
 - ▶ Manufacturing (19%)
 - ▶ Mining and Energy production
 - ▶ Waste disposal



Jodi Cobb/ National Geographic Creative

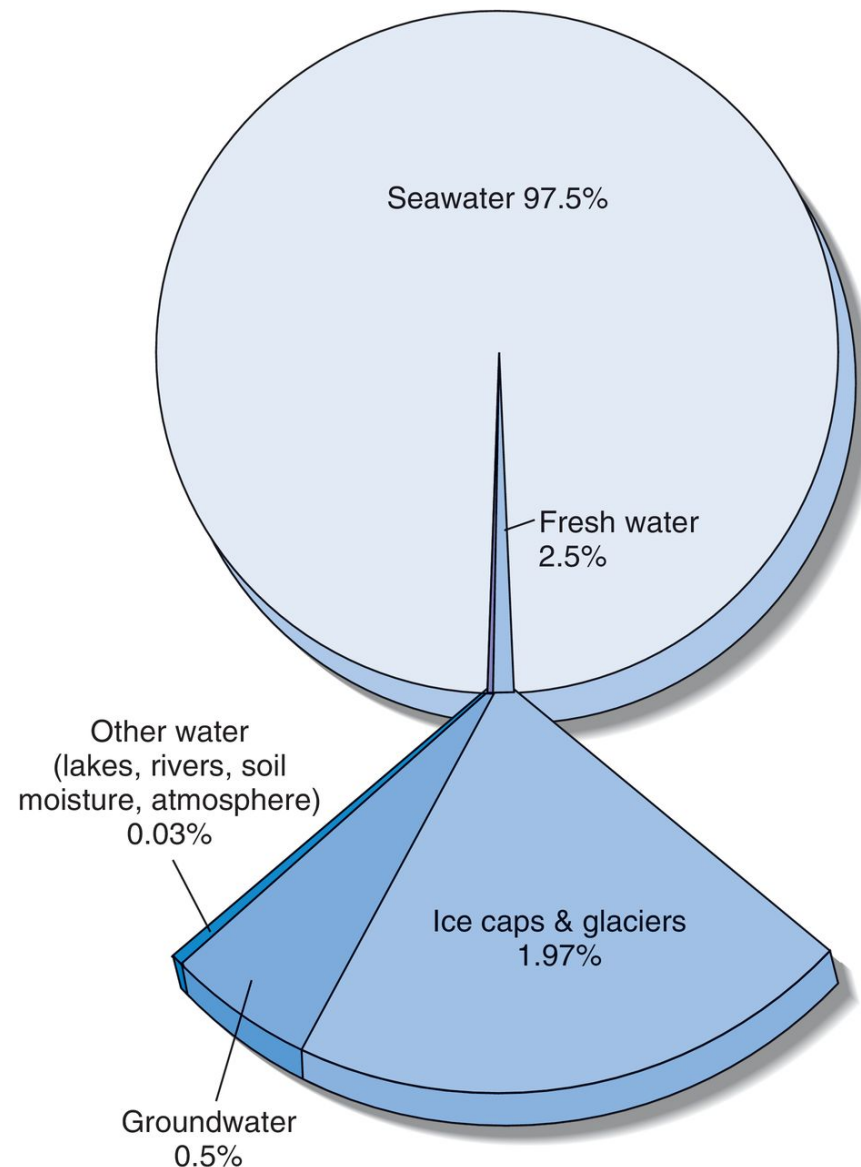
WATER SCARCITY

- ▶ Humans use well over 50% of freshwater
- ▶ Lack of adequate water
 - ▶ 765m people worldwide <10L of clean water/day (Americans use ~340L, 90 gal/day)
 - ▶ Poor can pay ~20% of income on water
 - ▶ Water infrastructure lowers cost but is lacking in many places
 - ▶ "Universal solvent" characteristic that makes it easily polluted .



SUPPLY OF FRESH WATER

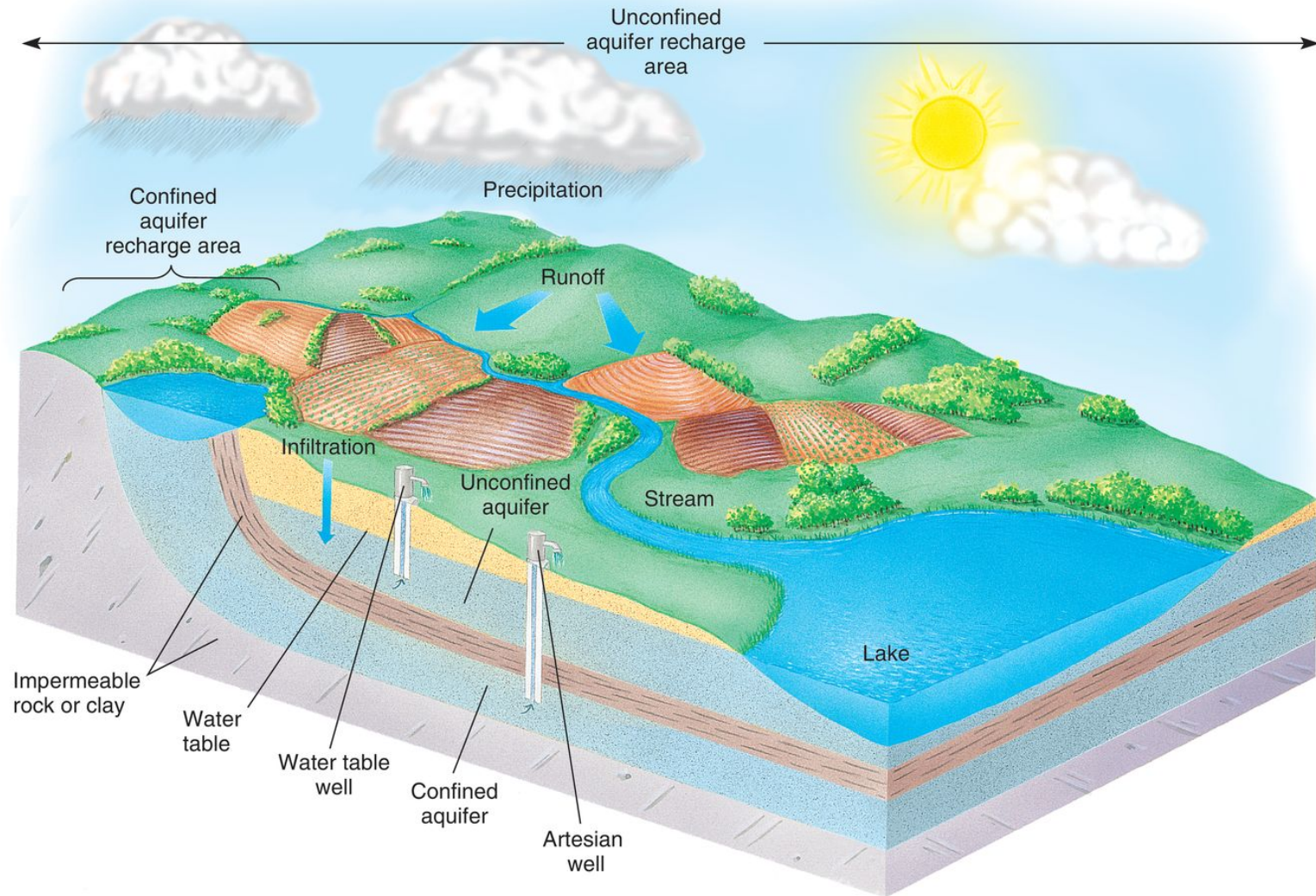
- ▶ Total amount is constant (finite), being renewed by the water cycle.
- ▶ <2.5% of water on earth is freshwater
- ▶ Only ~0.5% on earth is available (in streams, rivers, lakes, ponds, etc.)



FRESHWATER TERMINOLOGY

- ▶ Surface water
 - ▶ Precipitation that remains on the surface and does not seep into soil
- ▶ Runoff
 - ▶ Movement of surface water to lakes, rivers, etc.
- ▶ Watershed (drainage basin)
 - ▶ Land area that delivers water into a stream or river system
- ▶ Groundwater
 - ▶ Freshwater under the earth's surface stored in aquifers
- ▶ Aquifer
 - ▶ Underground caverns and porous layers of sand, gravel and rock in which groundwater is stored

WATERSHED



FRESHWATER AQUIFER

WATERSHEDS

- ▶ Also known as catchment basin
 - ▶ Watersheds are essential for water access

Table 13.1 The World's 10 Largest Watersheds

<i>Watershed</i>	<i>Region</i>	<i>Area of Watershed (thousand km²)</i>
Amazon	South America	6145
Congo	Africa	3731
Nile	Africa	3255
Mississippi	North America	3202
Ob	Asia	2972
Paraná	South America	2583
Yenisey	Asia	2554
Lena	Asia	2307
Niger	Africa	2262
Yangtze	Asia	1722

Source: Water Resources of the World, World Resources Institute (2010).

WATER USE AND RESOURCE PROBLEMS

Fall into Three Categories

1. Too much water
2. Too little water
3. Poor quality/contamination

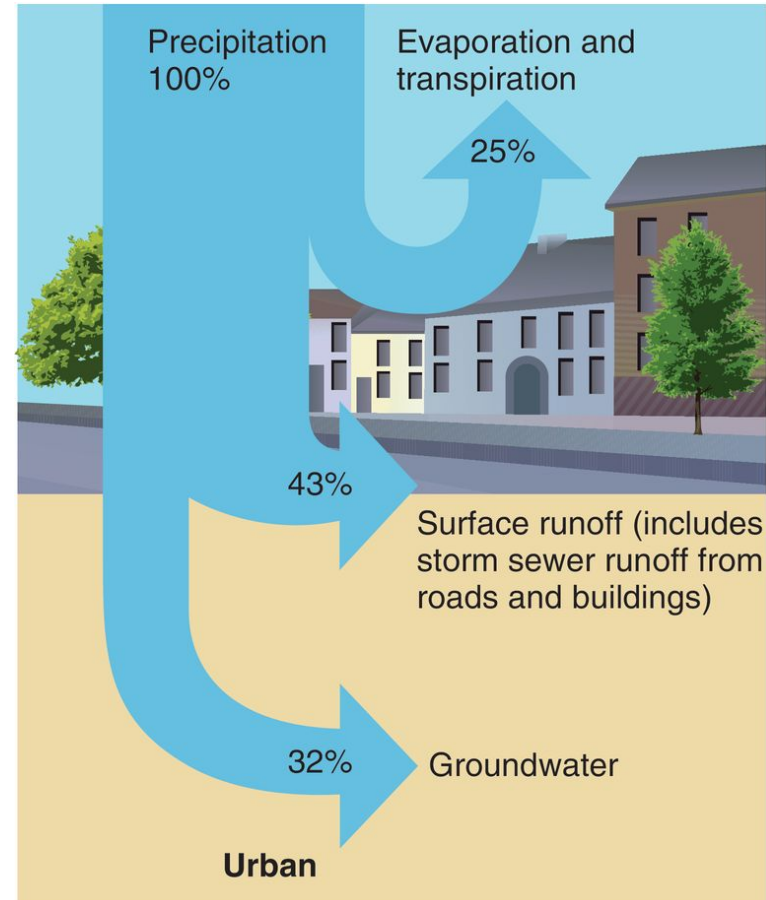
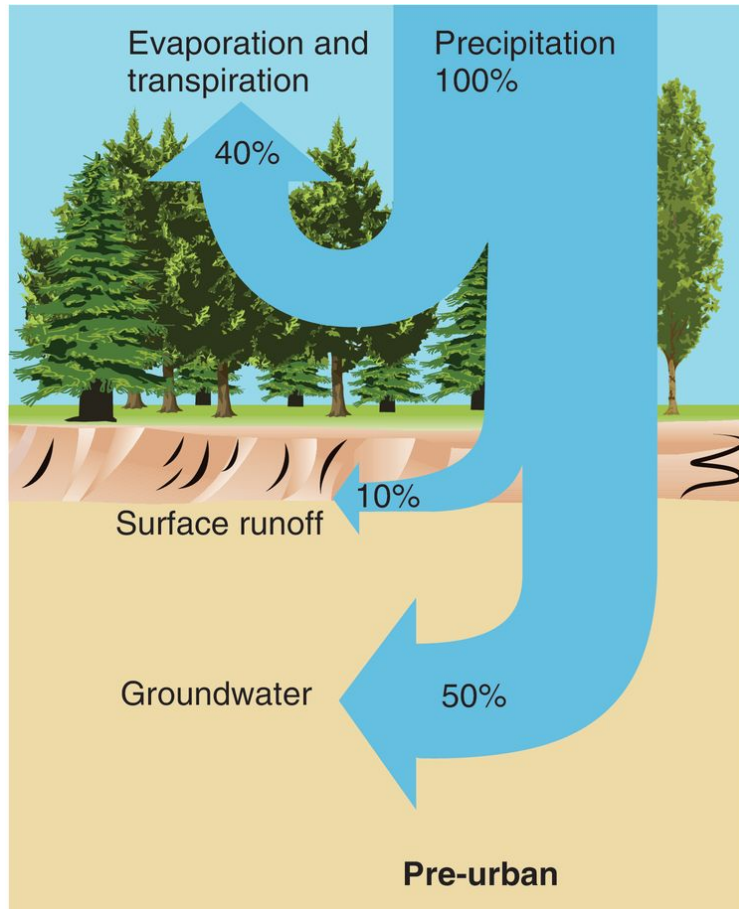
1. TOO MUCH WATER

- ▶ Flooding
 - ▶ Both natural and human-induced
- ▶ Modern floods are highly destructive
 - ▶ Humans have removed water-absorbing plant cover from soil
 - ▶ Humans construct buildings on floodplains



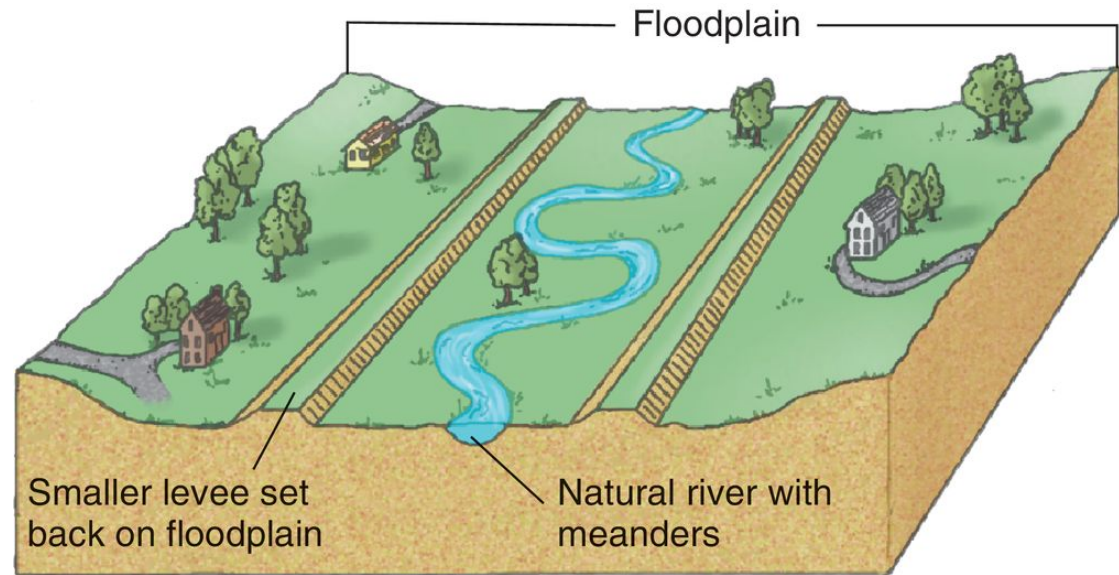
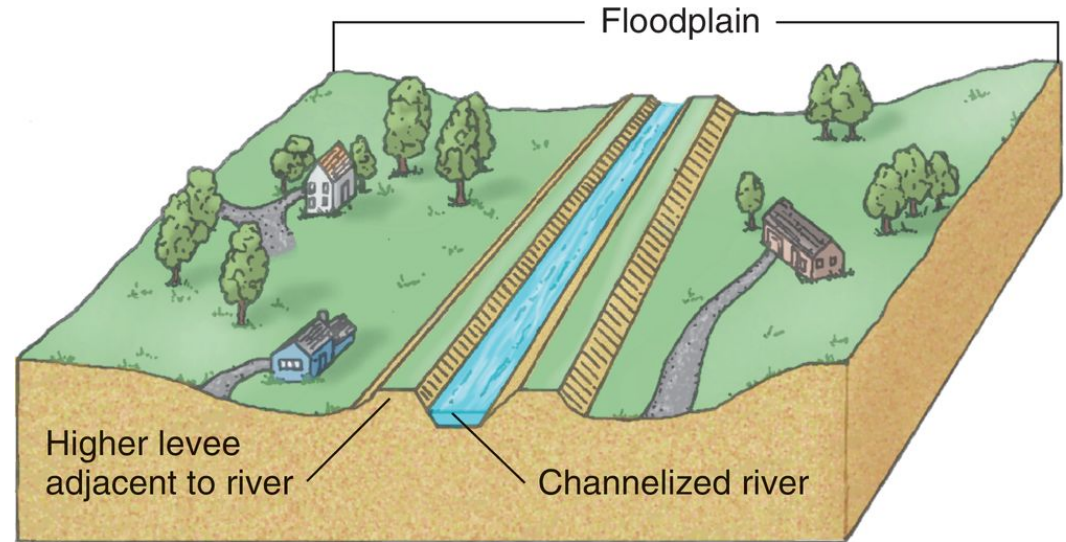
AP Photo/The Merced Sun-Star, Jack Bland

URBAN VS. PRE-URBAN FLOODPLAINS



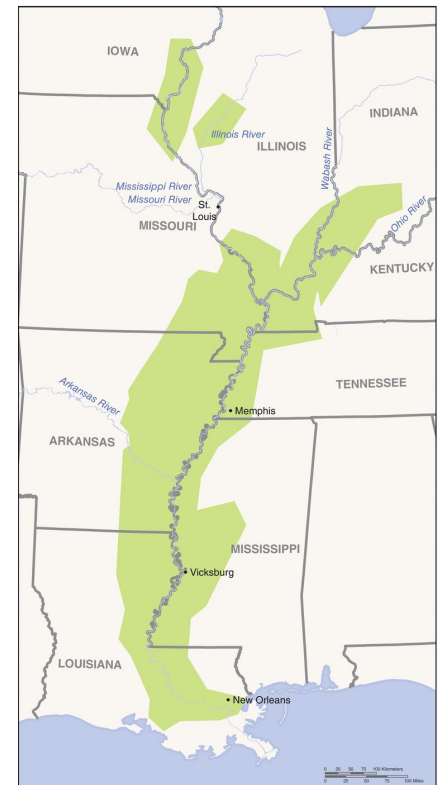
FLOODPLAIN

- Area bordering a river channel that can flood
 - ▣ We increasingly build on floodplains
- ▶ Levees can fail
- ▶ Rather than rebuild levees adjacent to rivers, experts suggest allowing some floodplains to flood



FLOODS OF SUMMER 2011

- ▶ Heavy rains and abundant snowmelt high in Mississippi River watershed
- ▶ Debate over the degree of river alteration and building in floodplain
- ▶ Alteration in precipitation with climate change?



© STR/Reuters/Corbis

2. TOO LITTLE WATER

- ▶ Typically found in arid and semiarid lands
- ▶ Problems
 - ▶ Drought
 - ▶ Overdrawing water for irrigation purposes
 - ▶ Wetlands dry up
 - ▶ Aquifer depletion
 - ▶ Subsidence or Sinkholes

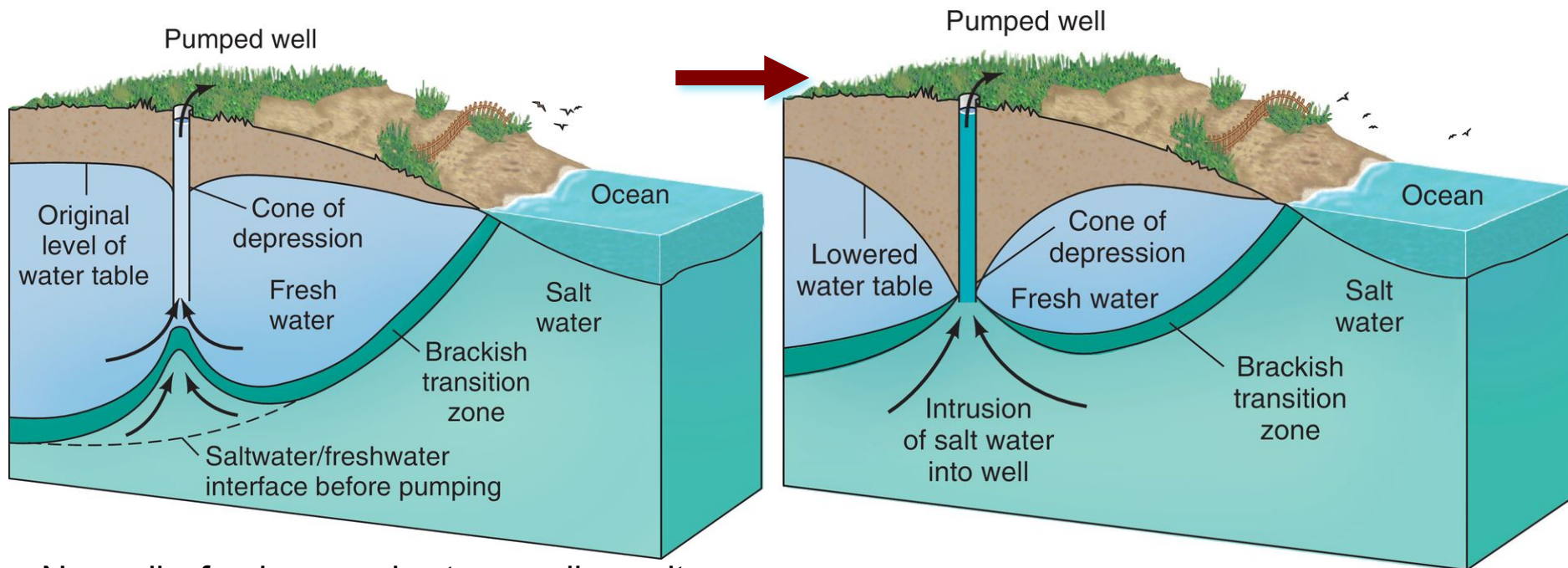


Bryan and Cherry Alexander/Science Source

2. TOO LITTLE WATER

► Problems (continued)

- Saltwater Intrusion along coastal areas when groundwater is depleted faster than it recharges



Normally, fresh groundwater overlies salty groundwater.

If excessively pumped, the well draws up salty groundwater unfit to drink.

WATER PROBLEMS IN U.S. AND CANADA

- ▶ Overall, U.S. has a plentiful supply of freshwater
- ▶ Many areas have severe shortages
 - ▶ Geographical/seasonal variations
 - ▶ Aquifer depletion



COLORADO RIVER BED IN MEXICO

Colorado River Basin

- Provides water for 27 million people
- Numerous dams for Hydropower
- Colorado River rarely reaches ocean – dries up before as a result of diversion for irrigation and other uses.



PETE MCBRIDE/National Geographic Creative

3. POOR QUALITY/CONTAMINATION

- ▶ Water pollution
 - ▶ Any physical or chemical change in water that adversely affects the health of humans and other organisms
- ▶ Eight categories of pollutants (many overlaps among categories)
 - ▶ Sewage, disease-causing agents, sediment pollution, inorganic plant and algal nutrients, organic compounds, inorganic chemicals, radioactive substances, and thermal pollution



SEWAGE POLLUTION

- ▶ The release of wastewater from drains or sewers (often contains disease-causing agents)
- ▶ Causes 2 serious environmental problems:
 - ▶ **Enrichment:** Fertilization of a body of water by high levels nitrogen and phosphorus
 - ▶ **Increase in Biological Oxygen Demand (BOD):** Amount of oxygen needed by microorganisms to decompose biological wastes
 - ▶ Via cellular respiration
 - ▶ As BOD increases, Dissolve Oxygen (DO) decreases

SEWAGE ENRICHMENT

Oligotrophic: unenriched, clear water that supports small populations of aquatic organisms



© Media Bakery

Eutrophic: water enriched by inorganic plant and algal nutrients such as phosphorus



Michael P. Gadowski / Science Source

DISEASE-CAUSING AGENTS

- ▶ Infectious organisms that cause diseases
 - ▶ Originate in the wastes of infected individuals
- ▶ Common bacterial or viral diseases:
 - ▶ Typhoid, cholera, bacterial dysentery, polio, and infectious hepatitis
- ▶ Monitored by testing for presence of *E. coli* in the water via a fecal coliform test

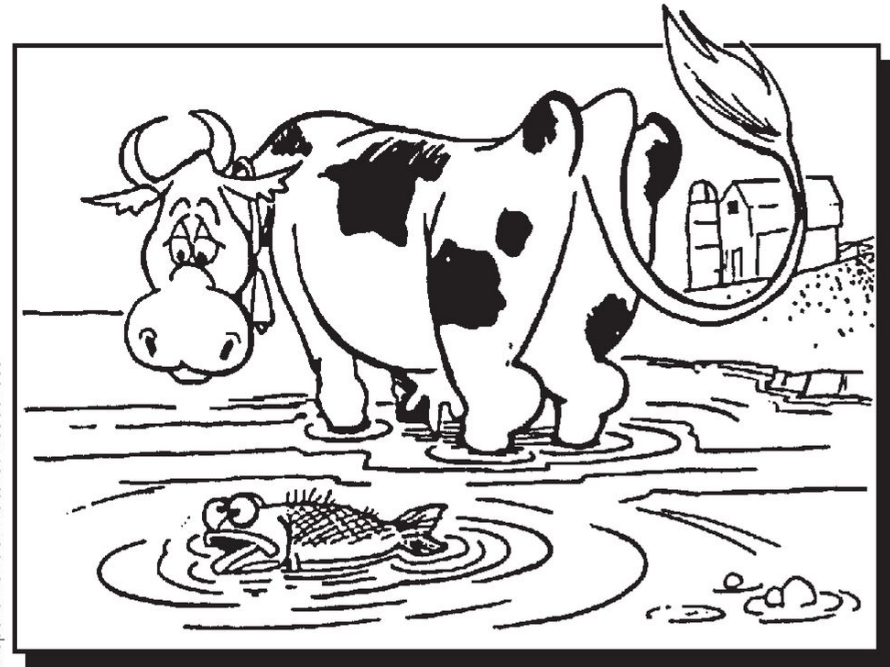
Table 21.1 Some Human Diseases Transmitted by Polluted Water

Disease	Infectious Agent	Type of Organism
Cholera	<i>Vibrio cholerae</i>	Bacterium
Dysentery	<i>Shigella dysenteriae</i>	Bacterium
Enteritis	<i>Clostridium perfringens</i> , other bacteria	Bacterium
Typhoid	<i>Salmonella typhi</i>	Bacterium
Infectious hepatitis	Hepatitis virus A	Virus
Poliomyelitis	Poliovirus	Virus
Cryptosporidiosis	<i>Cryptosporidium</i> sp.	Protozoon
Amoebic dysentery	<i>Entamoeba histolytica</i>	Protozoon
Schistosomiasis	<i>Schistosoma</i> sp.	Fluke
Ancylostomiasis	<i>Ancylostoma</i> sp.	Hookworm

INORGANIC PLANT AND ALGAL NUTRIENTS

- ▶ Nitrogen and phosphorus that stimulate the growth of plants and algae
 - ▶ Harmful in large concentrations
- ▶ Sources:
 - ▶ Human and animal wastes, plant residues, atmospheric deposition, and fertilizer runoff
- ▶ Results in:
 - ▶ Enrichment, bad odors, and a high BOD

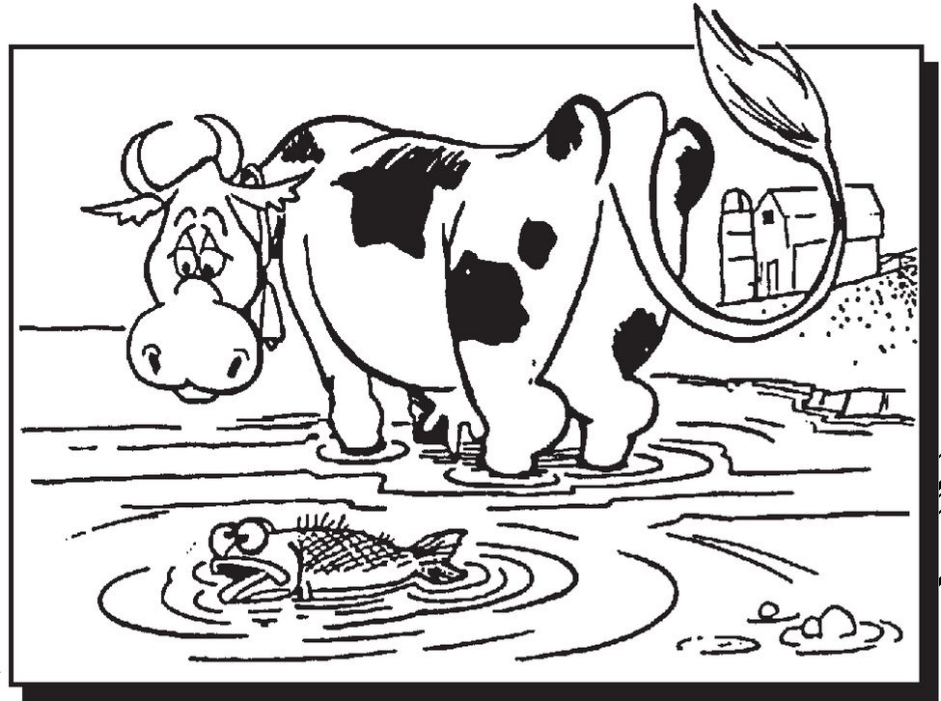
Courtesy University of Wisconsin-Extension and the Wisconsin Department of Natural Resources



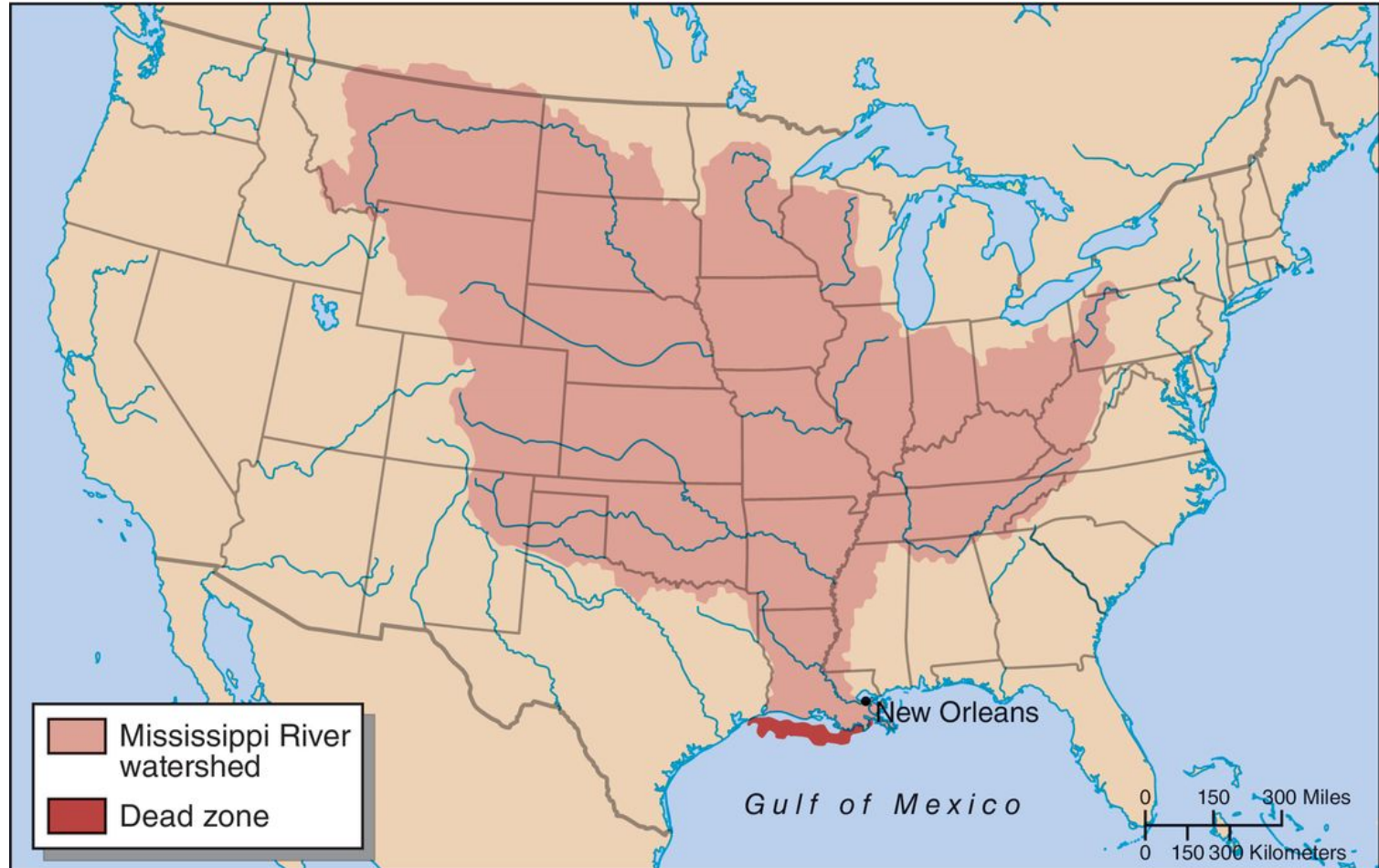
INORGANIC PLANT AND ALGAL NUTRIENT- THE DEAD ZONE

- ▶ Livestock produce 20x feces and urine of humans
- ▶ Laws do not require waste treatment
- ▶ High BOD can result in hypoxia
 - ▶ Low O₂ zones

Courtesy University of Wisconsin-Extension and the Wisconsin Department of Natural Resources



INORGANIC PLANT AND ALGAL NUTRIENT- THE DEAD ZONE



ORGANIC COMPOUNDS

- ▶ Chemicals that contain carbon and hydrogen atoms
 - ▶ Natural examples: sugars, amino acids, and oils
 - ▶ Human-made examples: pesticides, solvents, industrial chemicals, and plastics
 - ▶ Endocrine disruptors: Organic chemicals that mimic hormones
 - ▶ Some chemicals cause problems at very low concentrations

Table 21.2 Some Synthetic Organic Compounds Found in Polluted Water

<i>Compound</i>	<i>Some Reported Health Effects</i>
Aldicarb (pesticide)	Attacks nervous system
Benzene (solvent)	Associated with blood disorders (bone marrow suppression); leukemia
Carbon tetrachloride (solvent)	Possibly causes cancer; liver damage; may also attack kidneys and vision
Chloroform (solvent)	Possibly causes cancer
Dioxins (TCDD) (chemical contaminants)	Some cause cancer; may harm reproductive, immune, and nervous systems
Ethylene dibromide (EDB) (fumigant)	Probably causes cancer; attacks liver and kidneys
Polychlorinated biphenyls (PCBs) (industrial chemicals)	Attack liver and kidneys; possibly cause cancer
Trichloroethylene (TCE) (solvent)	Probably causes cancer; induces liver cancer in mice
Vinyl chloride (plastics industry)	Causes cancer

Source: Adapted from the International Agency for Research on Cancer, an agency of the World Health Organization.

YOU TUBE BREAK

Plastic Ocean – pollution in the seas and oceans

https://www.youtube.com/watch?v=ju_2NuK5O-E

INORGANIC CHEMICALS

- ▶ Contaminants that contain elements other than carbon
 - ▶ Acids, salts, heavy metals
- ▶ Do not degrade easily
- ▶ Lead
 - ▶ Found in old paint, industrial pollutants, leaded gasoline
- ▶ Mercury
 - ▶ Mercury bioaccumulates in the muscles of top predators of the open ocean (e.g. tuna)



© David R. Frazier Photolibrary, Inc./Alamy

RADIOACTIVE SUBSTANCES

- ▶ Contain atoms of unstable isotopes that spontaneously emit radiation
- ▶ Sources
 - ▶ Mining and processing radioactive materials (e.g. Uranium)
 - ▶ Medical and Research Facilities
 - ▶ Nuclear power plants



Acid mine drainage in the Rio Tinto River.

THERMAL POLLUTION

- ▶ Occurs when heated water produced during industrial processes is released into waterways
 - ▶ Commonly released from nuclear power plants in cooling off operations
- Organisms affected
 - Temperature affects reproductive cycles, digestion rates, and respiration rates
 - Warm water holds less DO than cold water

GLOBAL WATER PROBLEMS

- ▶ Amount of freshwater on planet CAN meet human needs
 - ▶ BUT, it is unevenly distributed and some places lack stable runoff
 - ▶ Dependent amount of runoff every month
- ▶ Problems:
 - ▶ Weather and Climate change
 - ▶ Sharing Water Resources Among Countries

GLOBAL WATER PROBLEMS

▶ Water and Climate

- ▶ Climate change affects the type and distribution of precipitation
- ▶ Potential issues:
 - ▶ Reduced snowfall (or variable runoff) will impact water resources downstream
 - ▶ Ex: Californian drought 2014-2015
 - ▶ Sea level rise will cause saltwater intrusion into drinking water supplies

GLOBAL WATER PROBLEMS

- ▶ Sharing Water Resources among Countries
 - ▶ Rhine River Basin (right)
 - ▶ Countries upstream discharged pollutants into river
 - ▶ Countries downstream had to pay to clean the water before they could drink it



WATER MANAGEMENT AND CONSERVATION

- ▶ Main Goal: Provide sustainable supply of high-quality water
 - ▶ Dams and Reservoirs
 - ▶ Water Diversion Projects
 - ▶ Desalinization

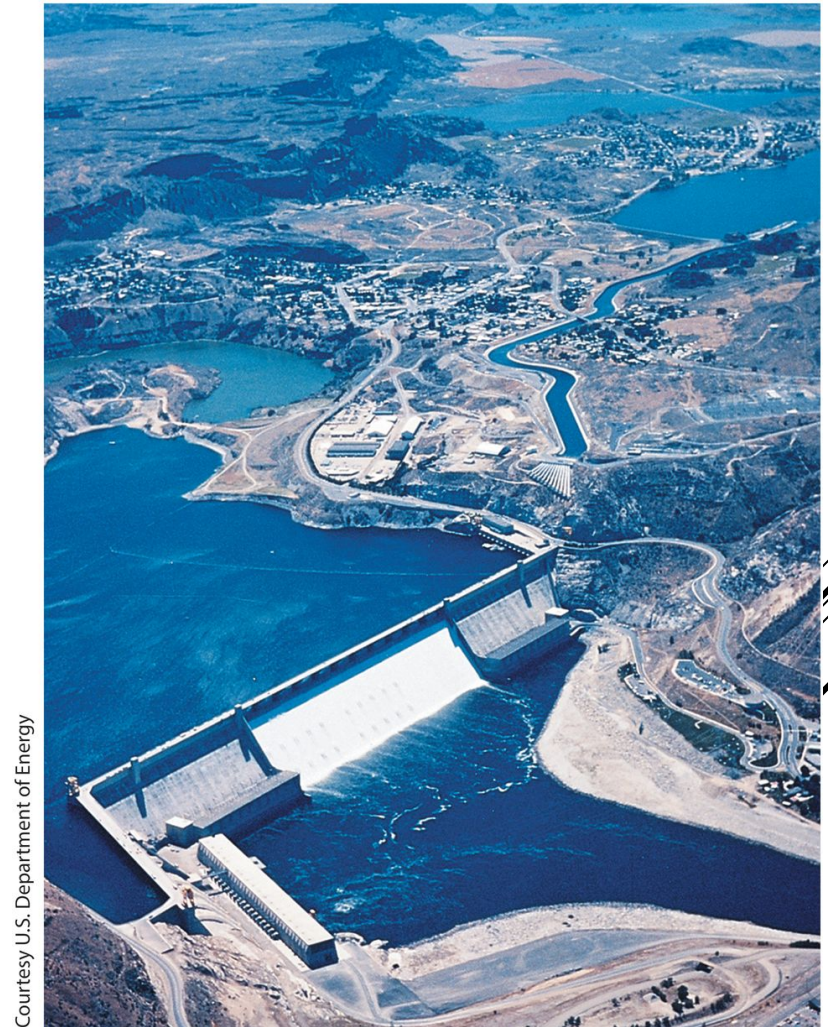
DAMS AND RESERVOIRS

► Benefits:

- Ensure year-round supply of water with regulated flow
- Generate electricity
- Provide recreational activities

► Disadvantages

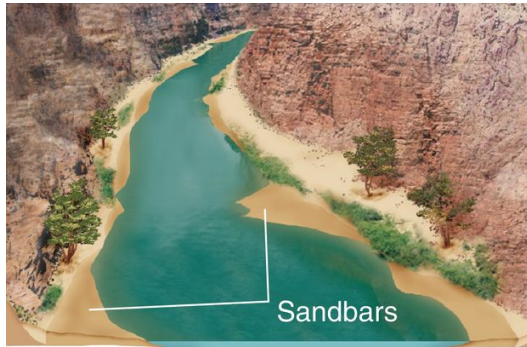
- Alter the ecosystem
- Reduce sediment load
- Less habitat for species



Courtesy U.S. Department of Energy

DAMS AND RESERVOIRS

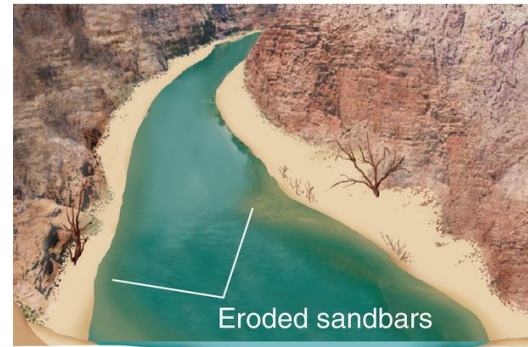
Glen Canyon Dam in the Colorado River



Before dam construction, natural floods carried sediment that built and maintained sandbars.

Sandbars

Thin layer of sand on river floor



After dam construction, sandbars eroded and sand accumulated on river bottom.

Eroded sandbars

Thick layer of sand on river floor



During regulated flood, river water is turbid with sediment.

Canyon floor flooded with sediment-laden water



After regulated flood, sandbars are partially restored.

Restored sandbars

Thin layer of sand on river floor

DAMS AND RESERVOIRS

- ▶ Salmon population in Columbia River very low due to dams that impede migration
- ▶ Fish ladders help, but are not highly effective

Tim Matsui/Getty Images



WATER DIVERSION PROJECTS

- ▶ Water diverted to areas that are deficient
- ▶ Using aqueducts
- ▶ Much of Southern CA receives its water supply from diverted water from Northern CA
- ▶ Controversial and expensive



WATER PROBLEMS IN U.S. AND CANADA

Water shortages in West and Southwest

Water is diverted and transported via aqueducts

©Jim West / Alamy



Aqueduct in California's Mojave Desert

DESALINIZATION

- ▶ Removal of salt from ocean or brackish water
- ▶ Two methods:
 - ▶ **Distillation** - salt water is evaporated, and water vapor is condensed into freshwater
 - ▶ **Reverse Osmosis**- involves forcing salt water through a membrane permeable to water, but not salt
- ▶ Very expensive, but becoming more economical due to technology and demand
 - ▶ Huge industry in Africa and Middle East (where water is scarce)

WATER CONSERVATION

- ▶ Reducing Agricultural Water Waste
 - ▶ Agriculture is very inefficient with water
 - ▶ Microirrigation: irrigation that conserves water by piping to crops through sealed systems
 - ▶ Also called drip or trickle irrigation



Courtesy U.S. Department of Agriculture

WATER CONSERVATION

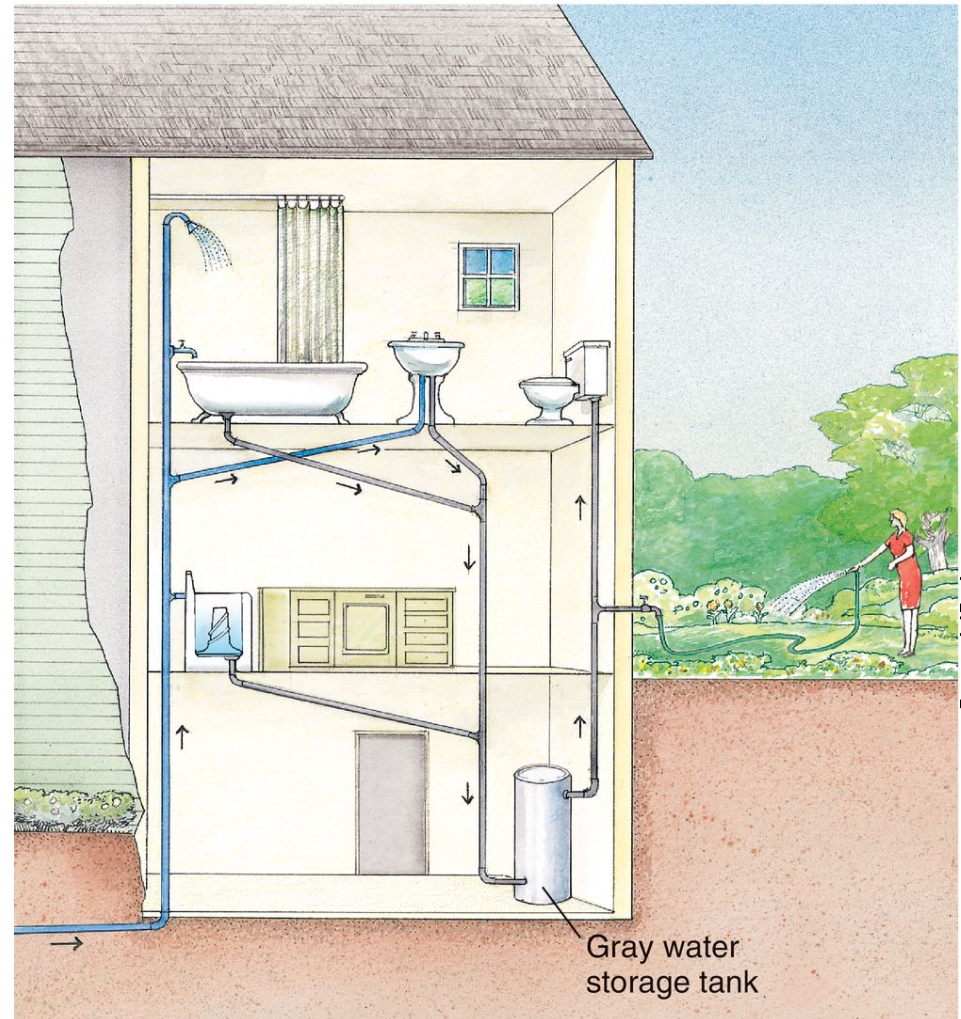
- ▶ New technologies to aid conservation strategies
 - ▶ Low-energy precision application (LEPA) irrigation tied to geographic information systems (GIS)
 - ▶ Water used when needed or conserved when not needed

WATER CONSERVATION

- ▶ Reducing Industrial Water Waste
 - ▶ Stricter laws provide incentive to conserve water
 - ▶ Water scarcity encourages further industrial recycling
 - ▶ Potential to conserve water is huge

WATER CONSERVATION

- ▶ Reducing Municipal Water Waste
- ▶ Gray Water
 - ▶ Can be used to flush toilets, wash car or water lawn
- ▶ Water saving household fixtures
- ▶ Government incentives



CONSERVING AT HOME

- ▶ Install water-saving shower heads and faucets
- ▶ Install low-flush toilets
- ▶ Fix leaky fixtures
- ▶ Purchase high efficiency appliances
- ▶ Modify personal habits
- ▶ Use the dishwasher when full instead of washing by hand

