Chapter 11
Water

Section 2

Water Use and Management

According to the World Health Organization, more than **1 billion** people lack access to a clean, reliable source of fresh water.

Global Water Use

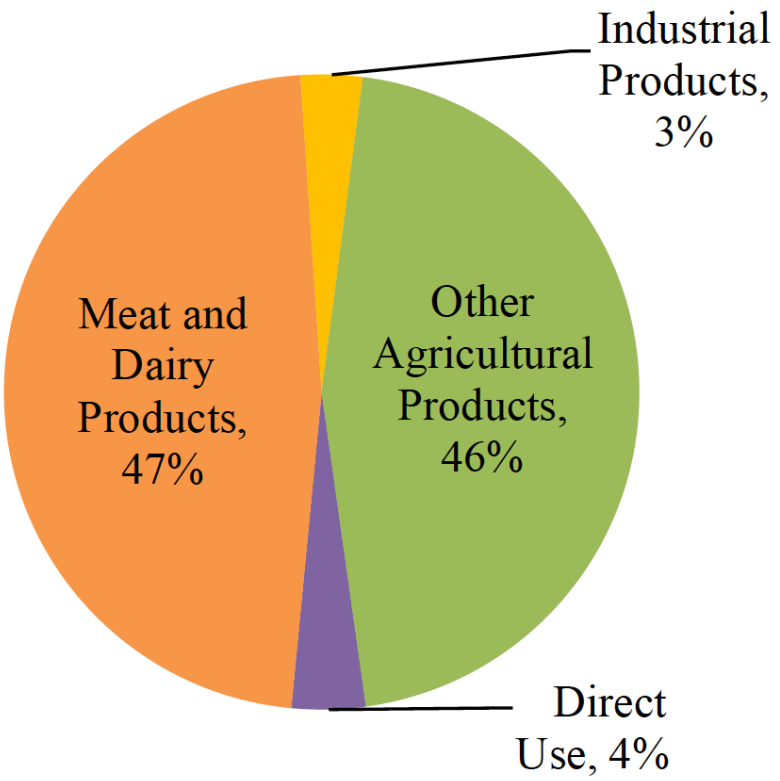


Figure ES 3. California's Water Footprint by Sector

3 major uses for water:

~residential (8%)

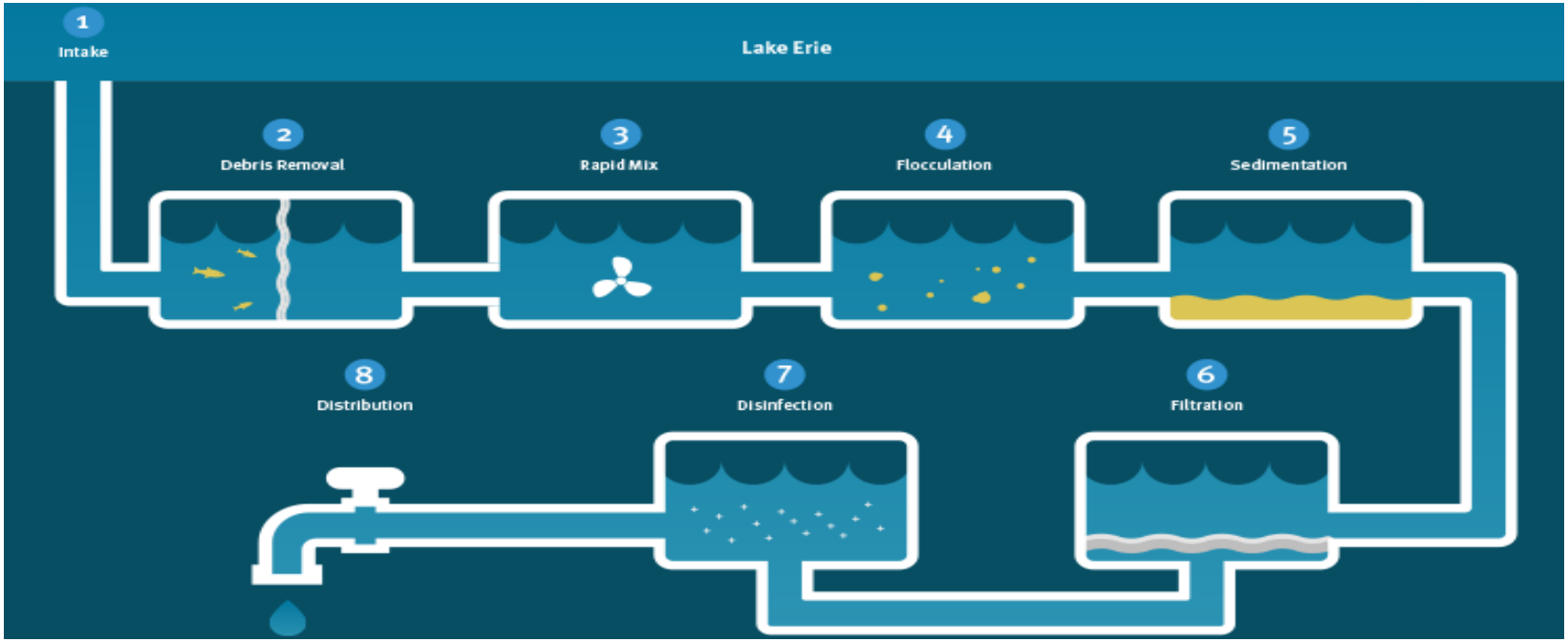
~agricultural (most use)

~industrial (19%)

Water Treatment

Most water must first be made potable (suitable for drinking).

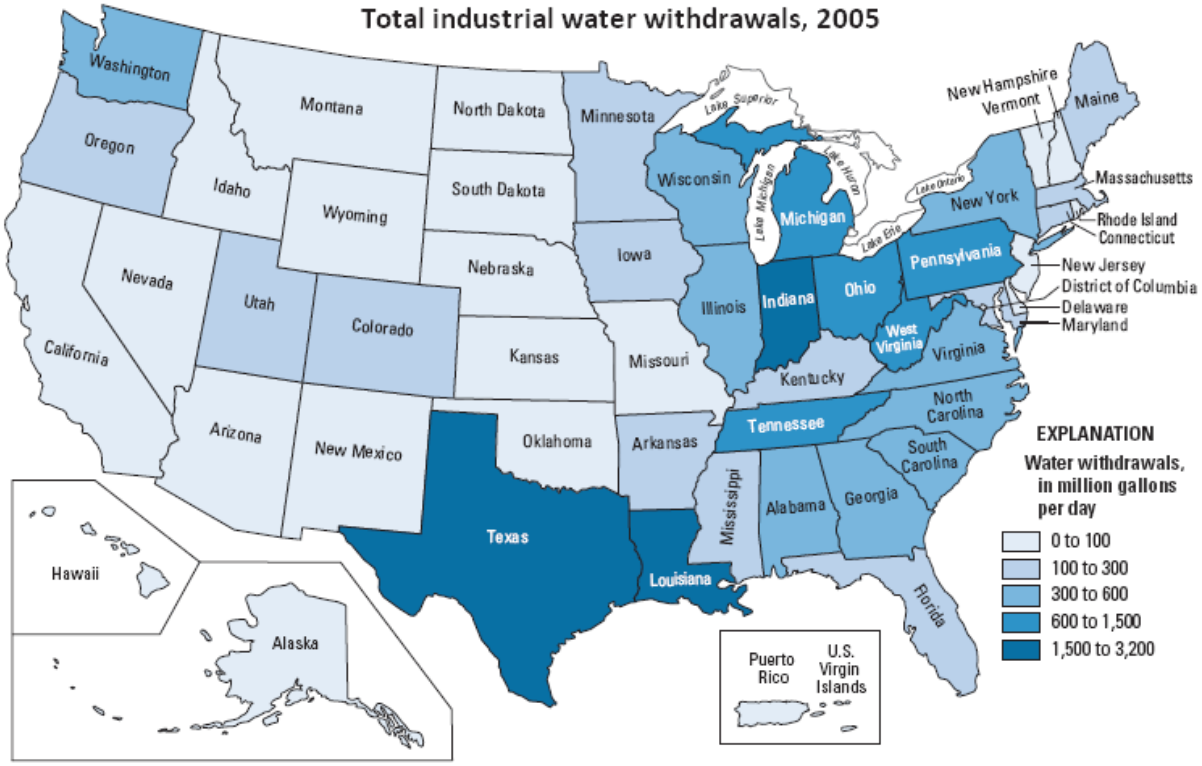
Water treatment removes harmful elements and pathogens



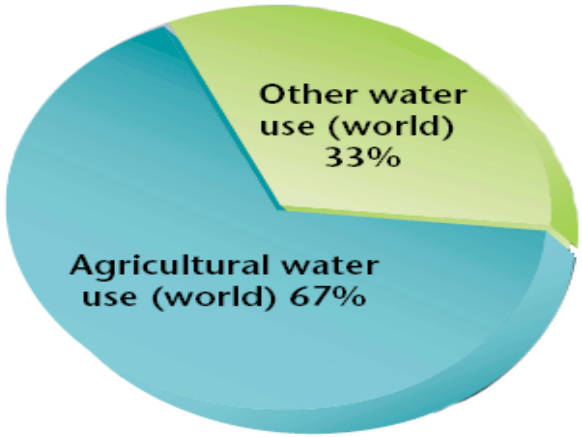
Industrial Water Use

Industry accounts for 19% of water used in the world. Water is used to manufacture goods, to dispose of wastes, & to generate power.

Most water used in industry is used to cool power plants.



Agricultural Water Use



Agriculture accounts for 67% of the water used in the world. Plants require a lot of water to grow, and as much as 80% of the water used in agriculture evaporates.

Dams and Reservoirs

A **dam** is built across a river to control a river's flow.

A **reservoir** is an artificial body of water that usually forms behind a dam. Water from a reservoir can be used for flood control, drinking water, irrigation, recreation, & industry.

Water Conservation

As water sources become depleted, water becomes more expensive.

Water Conservation is one way that we can help ensure that everyone will have enough water at a reasonable price.

Water your yard and outdoor plants early or late in the day to reduce evaporation.

Use a shut-off nozzle on your hose.

Use plants that require less water.

Mulch around plants to hold water in the soil.

Get an Energy Star labeled washing machine.

Wash only full loads.

Use a low flow showerhead.

Take shorter showers — five minutes or less is best.

Turn off the water while soaping hands and brushing teeth.

Turn off sink faucet while scrubbing dishes and pots.

Install new toilets that use less than 1.6 gallons per flush.

Put faucet aerators on sink faucets.

Us a broom, not a hose, to clean driveways and walkways.

Water Conservation in Agriculture

Most of the water loss in agriculture comes from evaporation, seepage, & runoff, so technologies that reduce these problems go a long way toward conserving water.

- Ex. Drip irrigation systems.

Water Conservation at Home

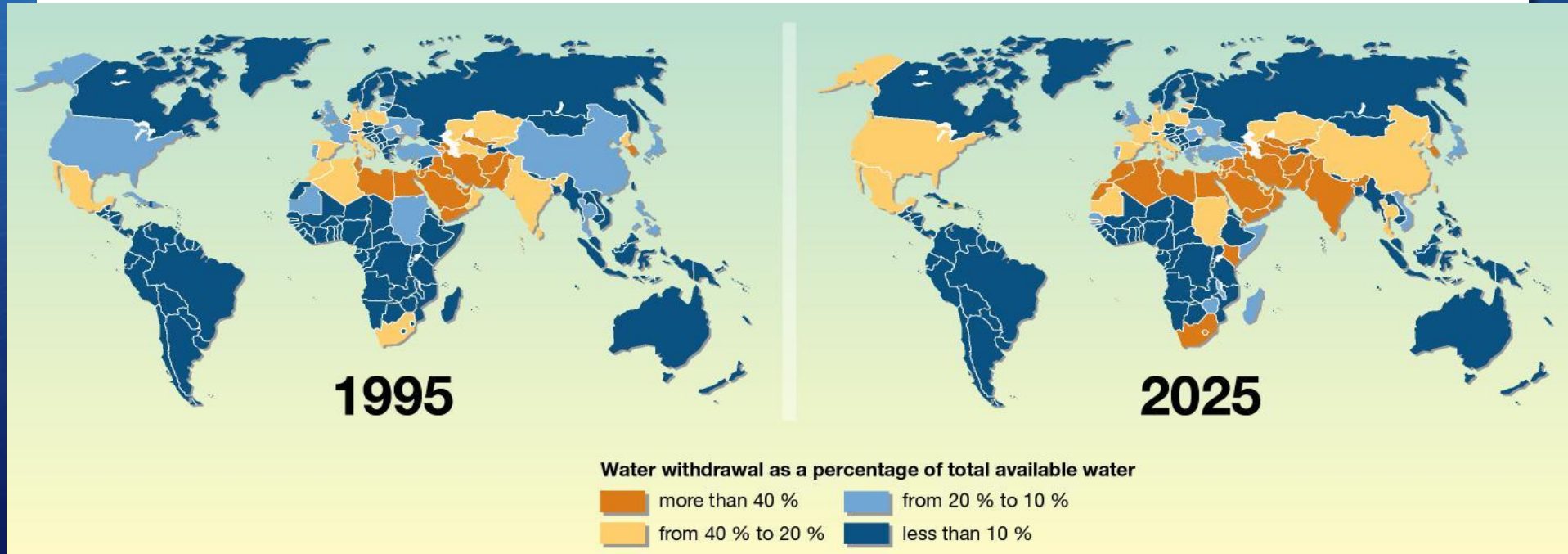
To conserve water, many people water their lawns at night to reduce the amount of evaporation. Another way to conserve water outside the home is by **xeriscaping**, or designing a landscape that requires minimal water use.

Solutions for the Future

In some places, conservation alone is not enough to prevent water shortages, and as populations grow, other sources of fresh water need to be developed.

Two possible solutions are:

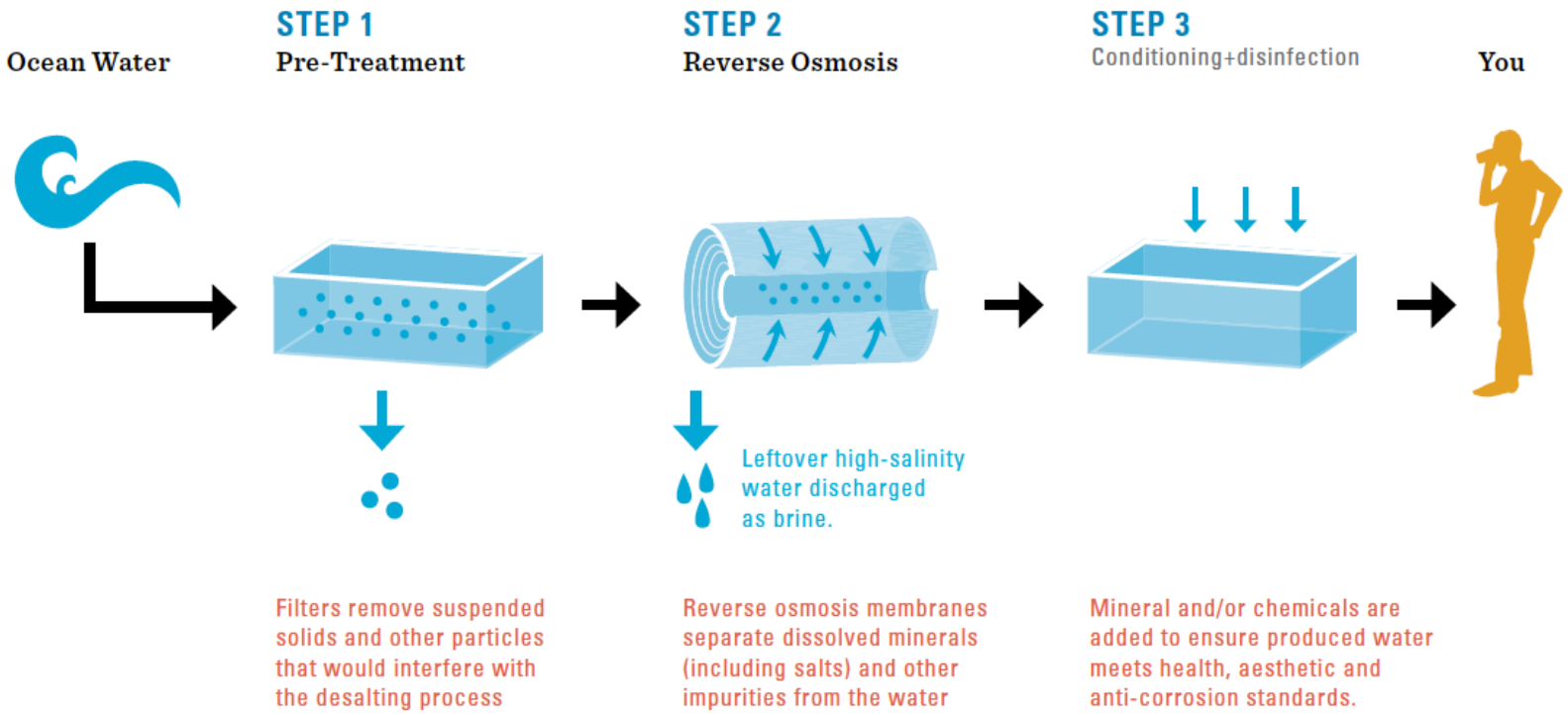
- Desalination
- Transporting Fresh Water



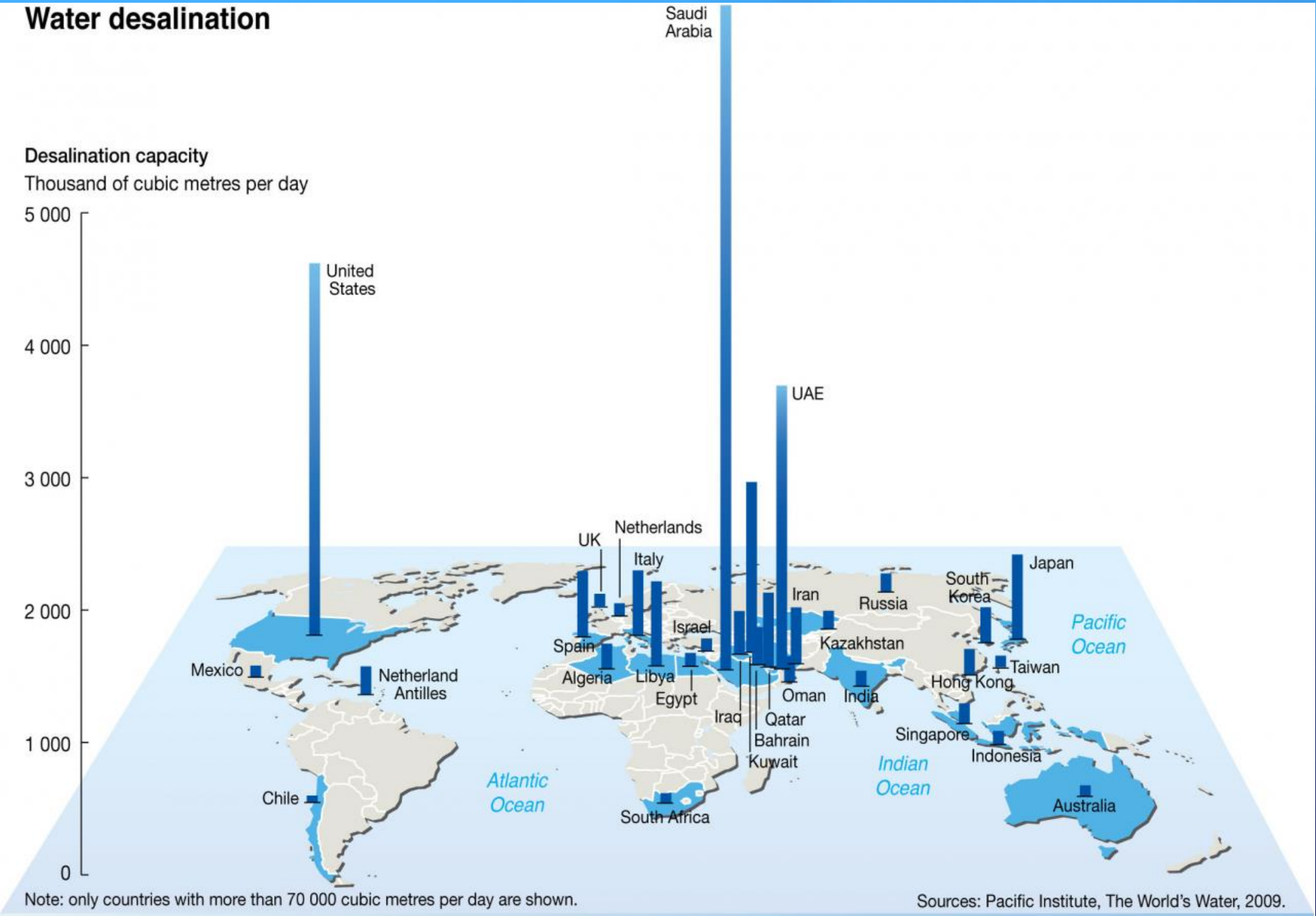
Desalination

The process of removing salt from ocean water

- ~Consumes a lot of energy
- ~Expensive



Water desalination



Note: only countries with more than 70 000 cubic metres per day are shown.

Sources: Pacific Institute, The World's Water, 2009.

Section 3

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Water Pollution

Water with waste matter or chemicals that are harmful to organisms living in the water or to those that drink or are exposed to the water

Almost all of the ways that we use water contribute to water pollution.

2 biggest causes:

industrialization

rapid human population growth

2 types of sources:

point sources (comes from a specific site)

nonpoint sources (comes from many sources)

Point & Nonpoint Sources of Pollution

- leaking septic-tank systems
- leaking storage lagoons for polluted waste
- unlined landfills
- leaking underground storage tanks that contain chemicals or fuels such as gasoline
- polluted water from abandoned and active mines
- water discharged by industries
- public and industrial waste-water treatment plants

Nonpoint Sources of Pollution

- chemicals added to road surfaces (salt and other de-icing agents)
- water runoff from city and suburban streets that may contain oil, gasoline, animal feces, and litter
- pesticides, herbicides, and fertilizer from residential lawns, golf courses, and farmland
- feces and agricultural chemicals from livestock feedlots
- precipitation containing air pollutants
- soil runoff from farms and construction sites
- oil and gasoline from personal watercraft

Pollutant Types and Sources		
Type of pollutant	Agent	Major sources
Pathogens	disease-causing organisms, such as bacteria, viruses, protozoa, and parasitic worms	mostly nonpoint sources; sewage or animal feces, livestock feedlots, and poultry farms; sewage from overburdened wastewater treatment plants
Organic matter	animal and plant matter remains, feces, food waste, and debris from food-processing plants	mostly nonpoint sources
Organic chemicals	pesticides, fertilizers, plastics, detergents, gasoline and oil, and other materials made from petroleum	mostly nonpoint sources; farms, lawns, golf courses, roads, wastewater, unlined landfills, and leaking underground storage tanks
Inorganic chemicals	acids, bases, salts, and industrial chemicals	point sources and nonpoint sources; industrial waste, road surfaces, wastewater, and polluted precipitation
Heavy metals	lead, mercury, cadmium, and arsenic	point sources and nonpoint sources; industrial discharge, unlined landfills, some household chemicals, and mining processes; heavy metals also occur naturally in some groundwater
Physical agents	heat and suspended solids	point sources and nonpoint sources; heat from industrial processes and suspended solids from soil erosion

Wastewater

Water that contains wastes from homes or industry

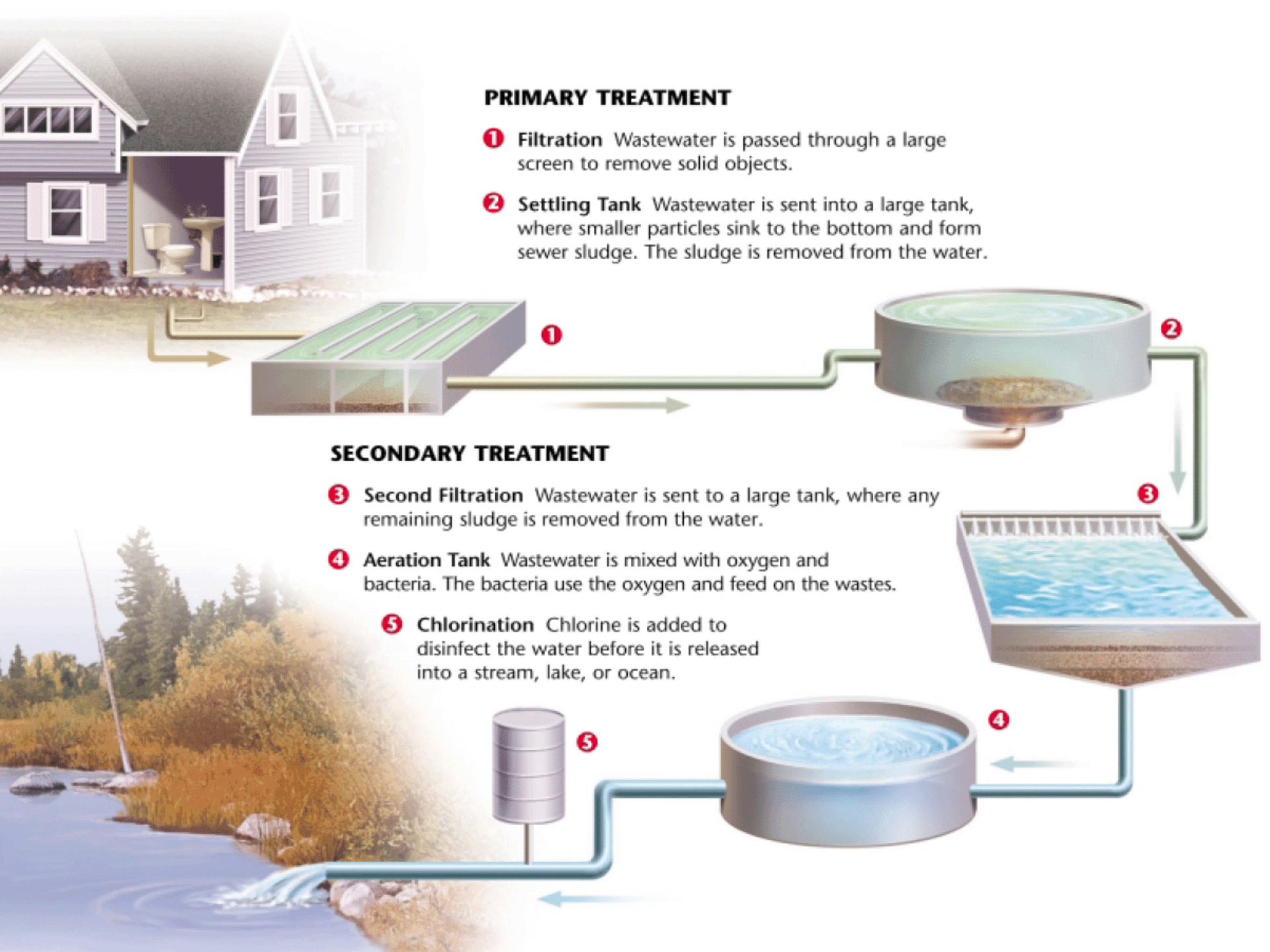
At a wastewater treatment plant, water is filtered & treated to make the water clean enough to return to a river or lake.

Treating Wastewater

Most of the wastewater from homes contains biodegradable material that can be broken down by living organisms.

For example, wastewater from toilets & kitchen sinks contains animal & plant wastes, paper, & soap, all of which are biodegradable.

Some household & industrial water & some storm-water runoff contains toxic substances that can't be removed by the standard treatment.


PRIMARY TREATMENT
1 Filtration Wastewater is passed through a large screen to remove solid objects.
2 Settling Tank Wastewater is sent into a large tank, where smaller particles sink to the bottom and form sewer sludge. The sludge is removed from the water.
SECONDARY TREATMENT
3 Second Filtration Wastewater is sent to a large tank, where any remaining sludge is removed from the water.
4 Aeration Tank Wastewater is mixed with oxygen and bacteria. The bacteria use the oxygen and feed on the wastes.
5 Chlorination Chlorine is added to disinfect the water before it is released into a stream, lake, or ocean.

Sewage Sludge

A product of wastewater treatment is sewage sludge (the solid material that remains after treatment)

When sludge contains dangerous concentrations of toxic chemicals, it must be disposed of as hazardous waste. It is often incinerated, & then the ash is buried in a secure landfill.

Sludge can be an expensive burden to cities as the volume of sludge that has to be disposed of every year is enormous.

The problem of sewage sludge disposal has prompted many communities to look for new uses for this waste.

If the toxicity of sludge can be reduced to safe levels, it can be used as a fertilizer.

It can also be combined with clay to make bricks that can be used in buildings.

Artificial Eutrophication

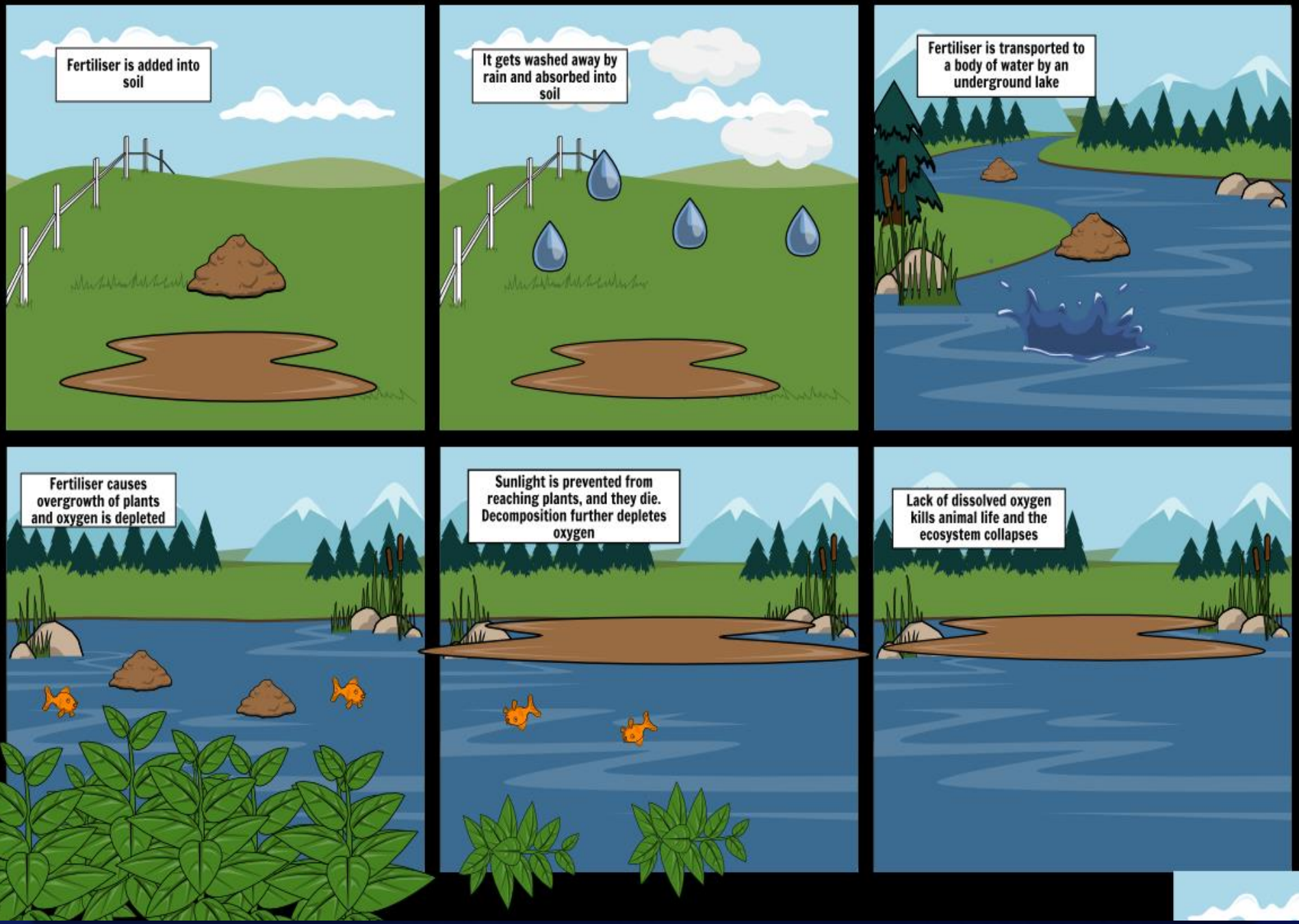
Nutrients are essential, but when lakes & slow-moving streams have too many, they are eutrophic.

When organic matter builds up in a body of water, it will begin to decay & decompose. The process of decomposition uses up oxygen, & as oxygen levels decrease, the types of organisms that live in the water change over time.

The natural process is sped up when inorganic plant nutrients, such as phosphorus & nitrogen, enter the water from sewage & fertilizer runoff.

Artificial eutrophication is a process that increases the amount of nutrients in a body of water through human activities, such as waste disposal & land drainage.

The major causes of eutrophication are fertilizer & phosphates in some laundry detergents.


Fertiliser is added into soil
It gets washed away by rain and absorbed into soil
Fertiliser is transported to a body of water by an underground lake
Fertiliser causes overgrowth of plants and oxygen is depleted
Sunlight is prevented from reaching plants, and they die. Decomposition further depletes oxygen
Lack of dissolved oxygen kills animal life and the ecosystem collapses

Thermal Pollution

A temperature increase in a body of water caused by human activity & that has harmful effect on water quality & on the ability of that body of water to support life

Can occur when power plants & other industries use water in their cooling systems & then discharge the warm water into a lake/river

Can cause large fish kills if the discharged water is too warm for the fish to survive

If the temperature of a body of water rises even a few degrees, the amount of oxygen the water can hold decreases significantly. As oxygen levels drop, aquatic organisms may suffocate and die.

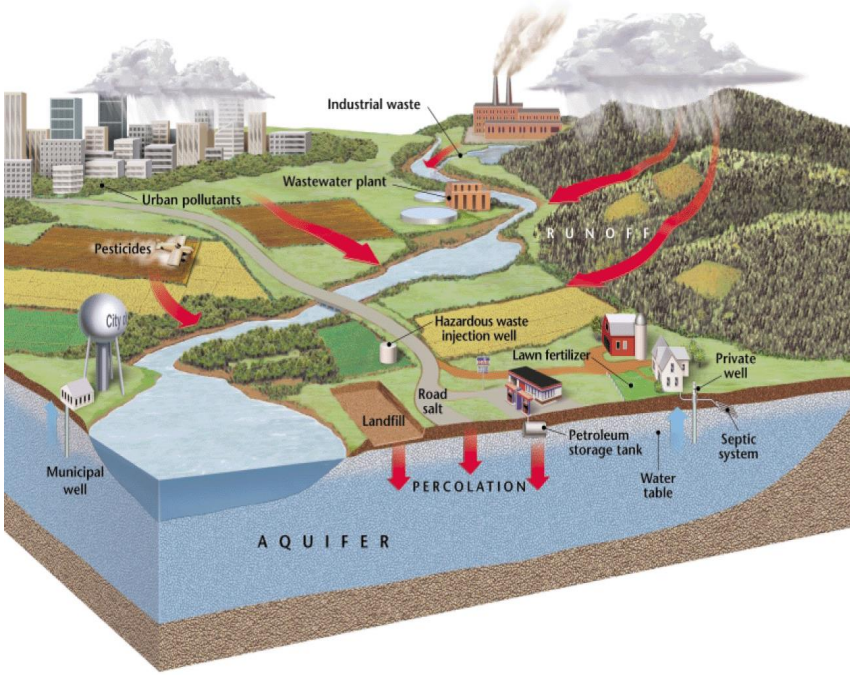
If the flow of warm water into a lake or stream is constant, it may cause the total disruption of an aquatic ecosystem.

Groundwater Pollution

Usually occurs when polluted surface water percolates down

Sources of groundwater pollution:

- Pesticides
- Herbicides
- Fertilizers
- Petroleum products
- Septic tanks
- Unlined landfills
- Industrial Wastewater Lagoons
- Leaking underground storage tanks

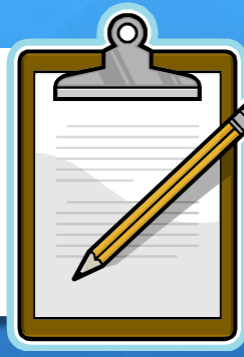


Cleaning Up Groundwater Pollution

Groundwater recharges very slowly, so the process for some aquifers to recycle water & purge contaminants can take hundreds of years.

Pollution can cling to the materials that make up an aquifer, so even if all of the water in aquifer were pumped out & replaced with clean water, the groundwater could still become polluted.

Ocean Pollution



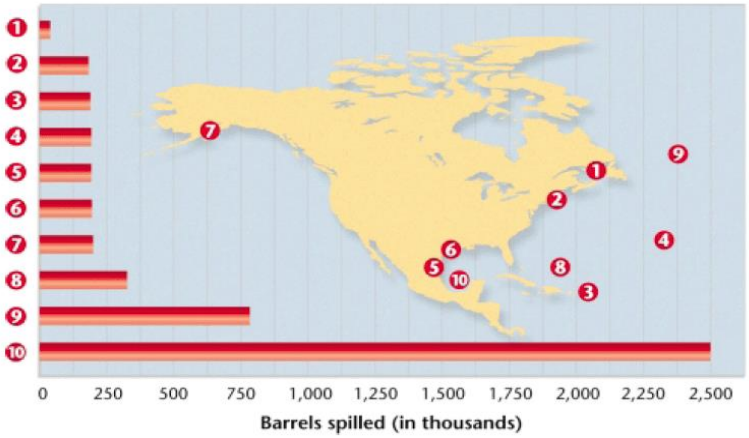
- Pollutants are often dumped directly into the ocean.

  For example, ships can legally dump wastewater & garbage overboard in some parts of the ocean.

- At least 85% of ocean pollution, including pollutants such as oil, toxic wastes, & medical wastes, comes from activities on land, near the coasts.

Oil Spills

- About 37 million gallons of oil from tankers are spilled into the ocean.
- Have dramatic effects, but only account for about 5% of oil pollution in the oceans
- Most of oil pollution in the oceans comes from cities & towns (nonpoint source).



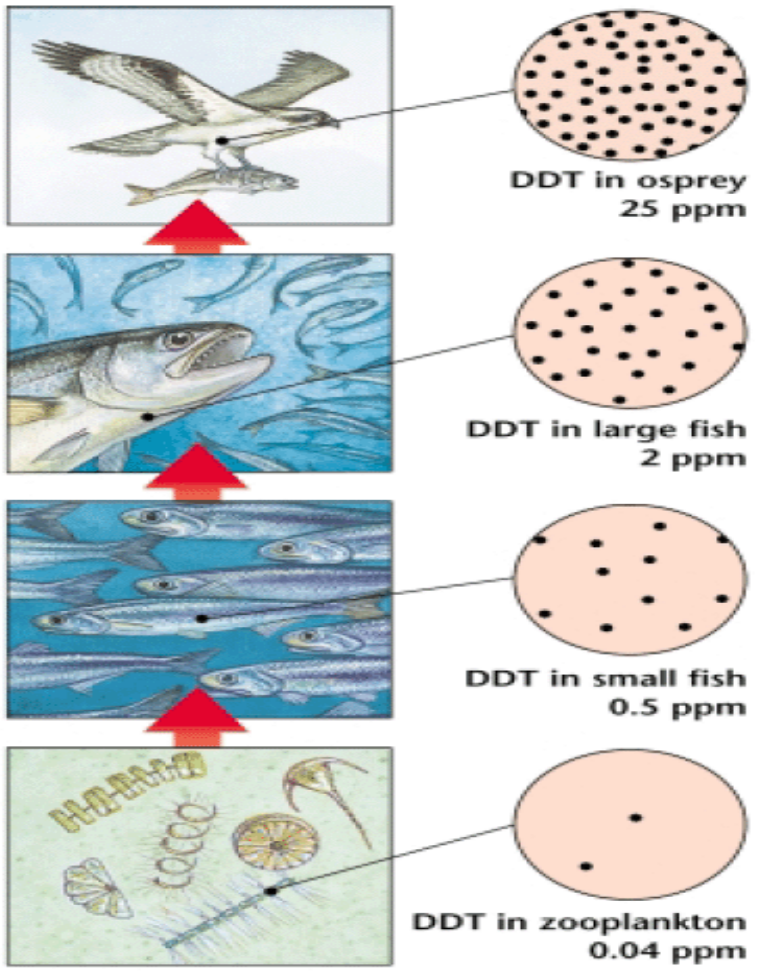
1. *Kurdistan* Gulf of St. Lawrence, Canada, 1979
2. *Argo Merchant* Nantucket, MA, 1976
3. Storage Tank Benuelan, Puerto Rico, 1978
4. *Athenian Venture* Atlantic Ocean, 1988
5. *Unnamed Tanker* Tuxpan, Mexico, 1996
6. *Burmah Agate* Galveston Bay, TX, 1979
7. *Exxon Valdez* Prince William Sound, AK, 1989
8. *Epic Colocotronis* Caribbean Sea, 1975
9. *Odyssey* North Atlantic Ocean, 1988
10. Exploratory Well Bay of Campeche, 1979

Water Pollution & Ecosystems

- *Water pollution can cause immediate damage to an ecosystem, but the effects can be far reaching as some pollutants build up in the environment because they do not decompose quickly.*

- **Biomagnification** is the accumulation of pollutants at successive levels of the food chain.

  Biomagnification has alarming consequences for organisms at the top of the food chain, and is one reason why U.S. limits the amount of fish people can eat from certain bodies of water.



Cleaning Up Water Pollution

The Clean Water Act of 1972 was to designed to "restore and maintain the chemical, physical, & biological integrity of the nation's waters."

The goal of making all surface water clean enough for fishing & swimming by 1983 was never achieved, but much progress has been made since the act was passed.

The number of lakes fit for swimming has increased by 30%, & many states have passed stricter water-quality standards.

The Clean Water Act opened the door for other water-quality legislation.

- *For example, the Marine, Protection, Research, & Sanctuaries Act of 1972 strengthened the laws against ocean dumping.*
- *Also, the Oil Pollution Act of 1990 requires all oil tankers traveling in U.S. waters to have double hulls by 2015 as an added protection against oil spills*

Federal Laws Designed to Improve Water Quality in the United States

1972 Clean Water Act (CWA) The CWA set a national goal of making all natural surface water fit for fishing and swimming by 1983 and banned pollutant discharge into surface water after 1985. The act also required that metals be removed from wastewater.

1972 Marine Protection, Research, and Sanctuaries Act, amended 1988 This act empowered the EPA to control the dumping of sewage wastes and toxic chemicals in U.S. waters.

1975 Safe Drinking Water Act (SDWA), amended 1996 This act introduced programs to protect groundwater and surface water from pollution. The act emphasized sound science and risk-based standards for water quality. The act also empowered communities in the protection of source water, strengthened public right-to-know laws, and provided water system infrastructure assistance.

1980 Comprehensive Environmental Response Compensation and Liability Act (CERCLA) This act is also known as the Superfund Act. The act makes owners, operators, and customers of hazardous waste sites responsible for the cleanup of the sites. The act has reduced the pollution of groundwater by toxic substances leached from hazardous waste dumps.

1987 Water Quality Act This act was written to support state and local efforts to clean polluted runoff. It also established loan funds to pay for new wastewater treatment plants and created programs to protect major estuaries.

1990 Oil Pollution Act This act attempts to protect U.S. waterways from oil pollution by requiring that oil tankers in U.S. waters be double-hulled by 2015.