

Chapter 22: Water Pollution and Treatment

Water Pollution

- Refers to degradation of water quality.
 - Generally look at the intended use of the water
 - How far the water departs from the norm
 - Its effects on public health
 - Or its ecological impacts

Water Pollution

- Water pollutants include
 - Heavy metals
 - Sediment
 - Certain radioactive isotopes
 - Heat
 - Fecal coliform bacteria
 - Phosphorus
 - Nitrogen
 - Sodium, and other useful (even necessary) elements
 - Pathogenic bacteria and viruses

Water Pollution

- Primary water pollution problem is the lack of clean, disease free drinking water.
 - Outbreaks of waterborne disease affects several billion people worldwide
 - E.g. cholera
- Quality of water determines its potential uses.
- All segments of society may contribute to water pollution.

Table 22.1 **Some Sources and Processes of Water Pollution**

<i>Surface Water</i>	<i>Groundwater</i>
Urban runoff (oil, chemicals, organic matter, etc.) (U, I, M)	Leaks from waste-disposal sites (chemicals, radioactive materials, etc.) (I, M)
Agricultural runoff (oil, metals, fertilizers, pesticides, etc.) (A)	Leaks from buried tanks and pipes (gasoline, oil, etc.) (I, A, M)
Accidental spills of chemicals including oil (U, R, I, A, M)	Seepage from agricultural activities (nitrates, heavy metals, pesticides, herbicides, etc.) (A)
Radioactive materials (often involving truck or train accidents) (I, M)	Saltwater intrusion into coastal aquifers (U, R, I, M)
Runoff (solvents, chemicals, etc.) from industrial sites (factories, refineries, mines, etc.) (I, M)	Seepage from cesspools and septic systems (R)
Leaks from surface storage tanks or pipelines (gasoline, oil, etc.) (I, A, M)	Seepage from acid-rich water from mines (I)
Sediment from a variety of sources, including agricultural lands and construction sites (U, R, I, A, M)	Seepage from mine waste piles (I)
Air fallout (particles, pesticides, metals, etc.) into rivers, lakes, oceans (U, R, I, A, M)	Seepage of pesticides, herbicide nutrients, and so on from urban areas (U)
	Seepage from accidental spills (e.g., train or truck accidents) (I, M)
	Inadvertent seepage of solvents and other chemicals including radioactive materials from industrial sites or small businesses (I, M)

Key: U = urban; R = rural; I = industrial; A = agricultural; M = military.

Water Pollution

- Increasing population often results in the introduction of more pollutants.
 - As well as demands on finite water resources
 - ~36 million people in US supplied w/ water from systems that violated federal standards.
- EPA sets thresholds and limits on some but not all pollutants
 - 700 identified drinking water contaminants

Table 22.2**National Drinking Water Standards**

<i>Contaminant</i>	<i>Maximum Contaminant Level (mg/l)</i>
Inorganics	
Arsenic	0.05
Cadmium	0.01
Lead	0.015 action level ^a
Mercury	0.002
Selenium	0.01
Organic chemicals	
Pesticides	
Endrin	0.0002
Lindane	0.004
Methoxychlor	0.1
Herbicides	
2,4-D	0.1
2,4,S-TP	0.01
Silvex	0.01
Volatile organic chemicals	
Benzene	0.005
Carbon tetrachloride	0.005
Trichloroethylene	0.005
Vinyl chloride	0.002
Microbiological organisms	
Fecal coliform bacteria	1 cell/100 ml

^a Action level is related to the treatment of water to reduce lead to a safe level. There is no maximum contaminant level for lead.

Source: U.S. Environmental Protection Agency.

Table 22.3**Categories of Water Pollutants**

<i>Pollutant Category</i>	<i>Examples of Sources</i>	<i>Comments</i>
Dead organic matter Pathogens	Raw sewage, agricultural waste, urban garbage Human and animal excrement and urine	Produces biochemical oxygen demand and diseases. Examples: Recent cholera epidemics in South America and Africa; 1993 epidemic of cryptosporidiosis in Milwaukee, Wisconsin. See discussion of fecal coliform bacteria in Section 22.3.
Drugs	Urban wastewater, painkillers, birth control pills, antidepressants, antibiotics	Pharmaceuticals flushed through our sewage treatment plants are contaminating our rivers and groundwater. Hormone residues or hormone mimickers are thought to be causing genetic problems in aquatic animals.
Organic chemicals	Agricultural use of pesticides and herbicides (Chapter 12); industrial processes that produce dioxin (Chapter 15)	Potential to cause significant ecological damage and human health problems. Many of these chemicals pose hazardous-waste problems (Chapter 30).
Nutrients	Phosphorus and nitrogen from agricultural and urban land use (fertilizers) and wastewater from sewage treatment	Major cause of artificial eutrophication. Nitrates in groundwater and surface waters can cause pollution and damage to ecosystems and people.
Heavy metals	Agricultural, urban, and industrial use of mercury, lead, selenium, cadmium, and so on (Chapter 15)	Example: Mercury from industrial processes that is discharged into water (Chapter 15). Heavy metals can cause significant ecosystem damage and human health problems.
Acids	Sulfuric acid (H_2SO_4) from coal and some metal mines; industrial processes that dispose of acids improperly	Acid mine drainage is a major water pollution problem in many coal mining areas, damaging ecosystems and spoiling water resources.
Sediment	Runoff from construction sites, agricultural runoff, and natural erosion	Reduces water quality and results in loss of soil resources.
Heat (thermal pollution)	Warm to hot water from power plants and other industrial facilities	Causes ecosystem disruption (Chapter 15).
Radioactivity	Contamination by nuclear power industry, military, and natural sources (Chapter 20)	Often related to storage of radioactive waste. Health effects vigorously debated (Chapters 15 and 20).

Dissolved Oxygen

- Bacteria in stream decompose dead organic matter carrying, this decay use oxygen.
 - Larger amount of bacterial activity = little oxygen in the water available to fish and other organisms
 - Can be reduced to levels so low that they may die.
- A stream with an inadequate oxygen level is considered polluted for those organisms that require dissolved oxygen.

Biochemical Oxygen Demand (BOD)

- Amount of oxygen required for biochemical decomposition is BOD.
- BOD is commonly used in water quality management.
 - Measures the amount of oxygen consumed by microorganisms as they break down organic matter.
 - Routinely measured as part of water quality at waste water treatment plants.

Biochemical Oxygen Demand (BOD)

- Dead organic matter, which produces BOD
 - Added to stream and river from natural sources, agricultural runoff and urban sewage
- US EPA defines the threshold for water pollution alert as
 - Dissolved oxygen content of less than 5 mg/l of water



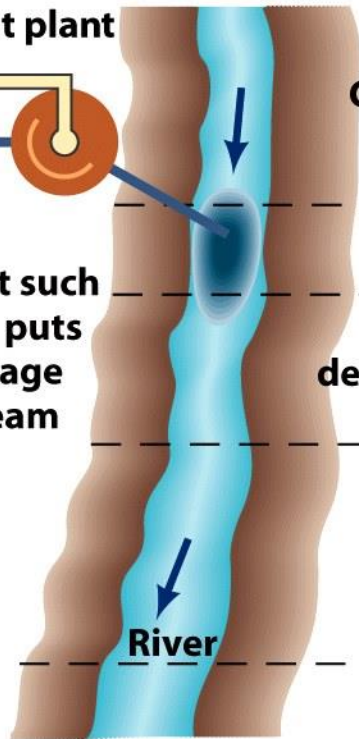
Biochemical Oxygen Demand (BOD)

- When a spill takes place three zones are identified:
 - 1. A pollution zone, where a high BOD exists.
 - 2. An active decomposition zone, where the dissolved oxygen content reaches a minimum.
 - 3. A recovery zone, where the dissolved oxygen increases and the BOD is reduced.

Sewage treatment plant



Accident such as flood puts raw sewage into stream



Clear, clean water

Pollution zone

Active decomposition zone

Recovery zone

River

Distance downstream

BOD

Dissolved oxygen

Sufficient oxygen for healthy, vigorous life in stream

Low oxygen concentrations; life in stream restricted to species that tolerate high organic content and low dissolved oxygen

Conditions returning to those necessary to maintain high-quality stream environment

**Low → High
Dissolved oxygen or BOD**

Waterborne Diseases

- Primary waterborne pollution problem
 - Effects vary from an upset stomach to death
 - In the early 1990s cholera caused widespread suffering and death in SA
- NA is not immune to outbreaks of waterborne disease.

Outbreak in Milwaukee, WI

- Largest outbreak in US history
 - April 1993
 - Cryptosporidium
 - Gastrointestinal parasite that causes flu like symptoms
 - Caused 400,000 people to become ill for ~9 days
 - 100 died

Outbreak in Milwaukee, WI

- Parasite resistant to chlorination
 - Source unknown
 - Treatment plant met all fed and state quality standards
- Wake up call concerning US water quality
 - Upgrades to treatment plants is cost effective mechanism for reducing waterborne diseases

Fecal Coliform Bacteria

- Difficult to monitor disease carrying organisms
 - Instead we use fecal coliform bacteria as a standard measure and indicator of disease
 - Indicates that fecal matter is present
 - Normal constituent of human and animal intestines
- US EPA places thresholds on levels
 - 200 cells/ 100 ml of water for swimming
 - None for drinking water

Warning!

Water may contain bacteria that could cause illness.
Avoid contact with water in this creek/stormdrain
and the area where water enters the ocean.



¡Aviso!

El agua puede contener bacteria que puede causar enfermedades.
Evite contacto con el agua de este arroyo y la zona
donde el arroyo desemboca al mar.

For information about creek and ocean water pollution, contact Santa Barbara County
Environmental Health Services at 805-681-4900
or visit the Project Clean Water web site at www.sbcphd.org/cleanwater

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PLEASE CLEAN UP
AFTER YOUR PET
S.B. CO CODE 26-54

Fecal Coliform Bacteria

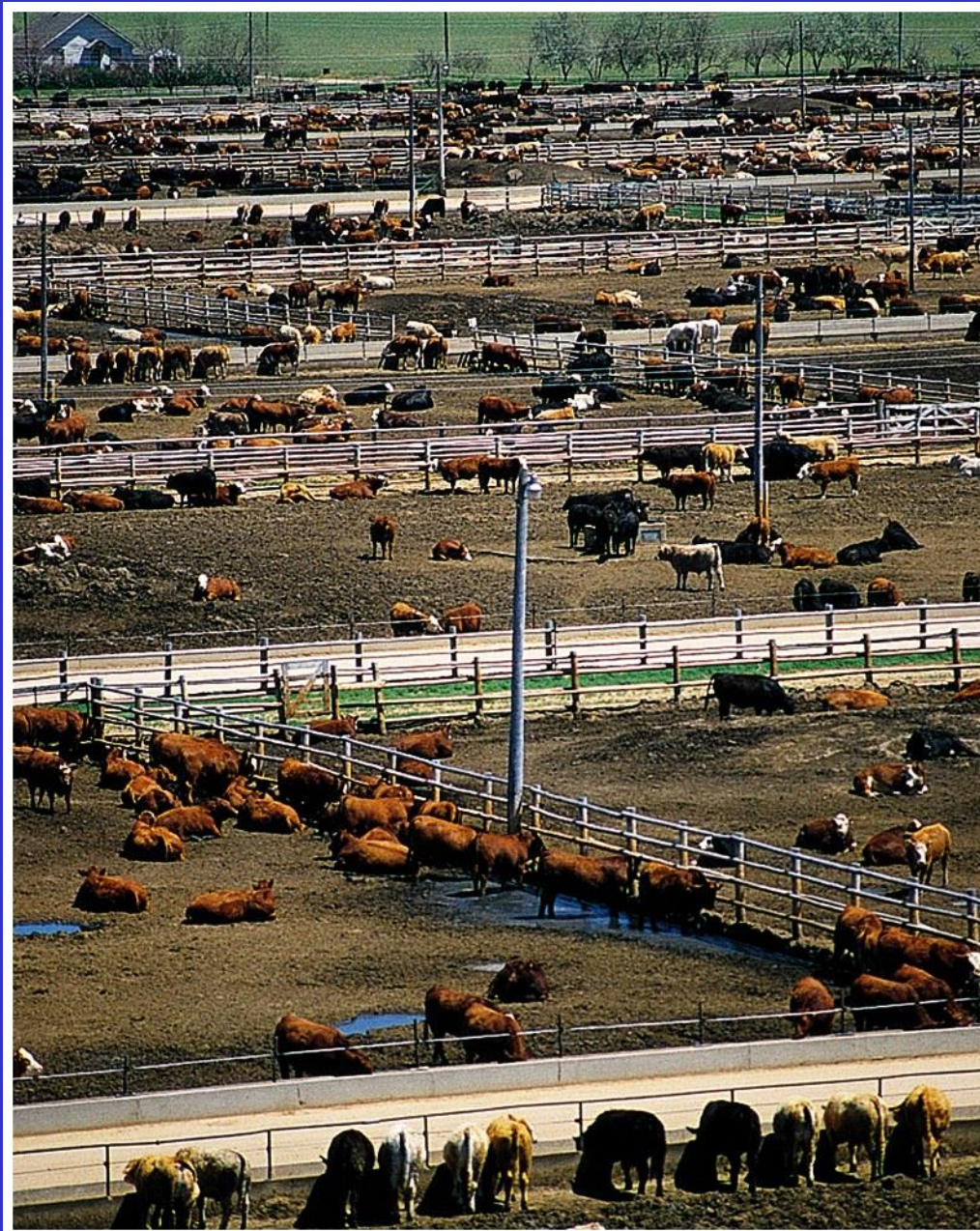
- *Escherichia coli* (*E. coli*)
 - Responsible for human illness and death
 - Eating contaminated food or drink
- Presence of fecal coliforms may also indicate presence of
 - Virus like hepatitis

Outbreak in Walkerton, Ontario

- Cow mature washed into water supply by heavy rains and flooding
 - May 12, 2000
 - Local utility knew of contamination by may 18th but did not report it
 - By may 26th 5 dead, 20 in ICU and over 500 ill
 - If people notified earlier such of the sickness could have been avoided

Nutrients

- Two important nutrients that cause water pollution are phosphorous and nitrogen
 - Both released from source related to land use
 - Highest levels found in agricultural areas



Eutrophication

- The process by which a body of water develops a high concentration of nutrients.
 - Cause a large growth in aquatic plants and photosynthetic bacteria and algae.
 - The bacteria and algae then die
 - As they decompose BOD increases
 - Oxygen content is sufficiently lower and fish and other organisms may die.

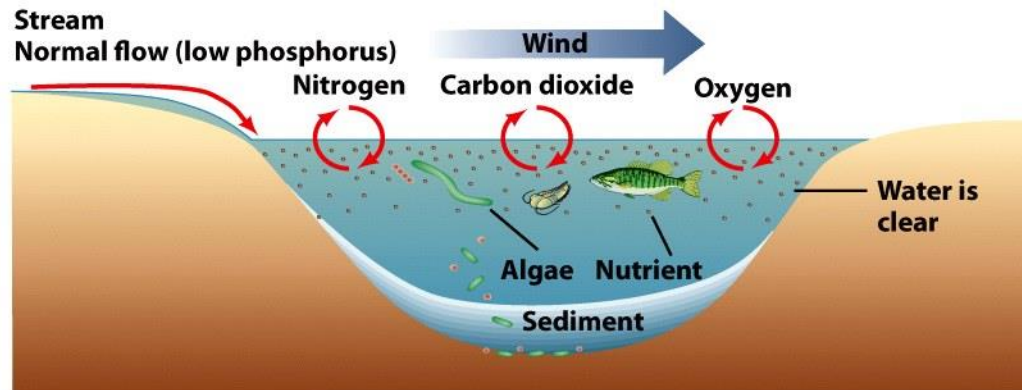


Eutrophication

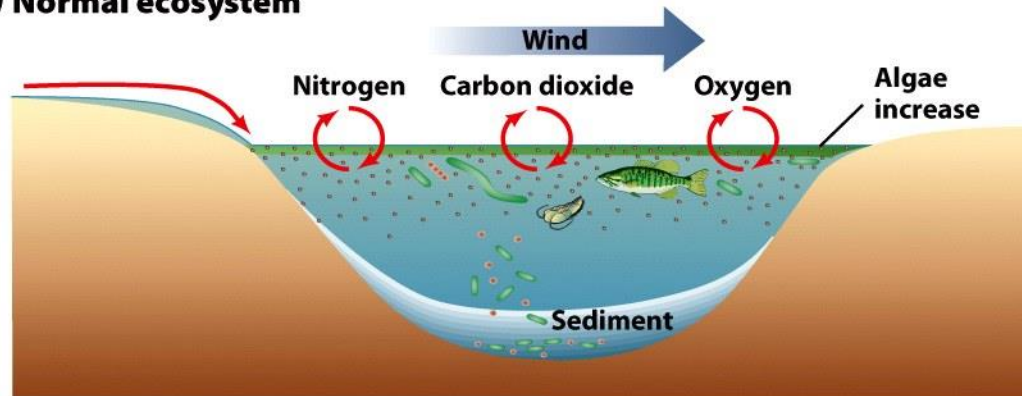
- Oligotrophic lake
 - Lake w/ relatively low concentration of chemical elements required by life
 - Clear water
 - Low abundance of life
- Eutrophic lake
 - Lake w/ high concentration of chemical elements
 - Often w/ mats of algae and murky water
 - Abundance of life

Eutrophication

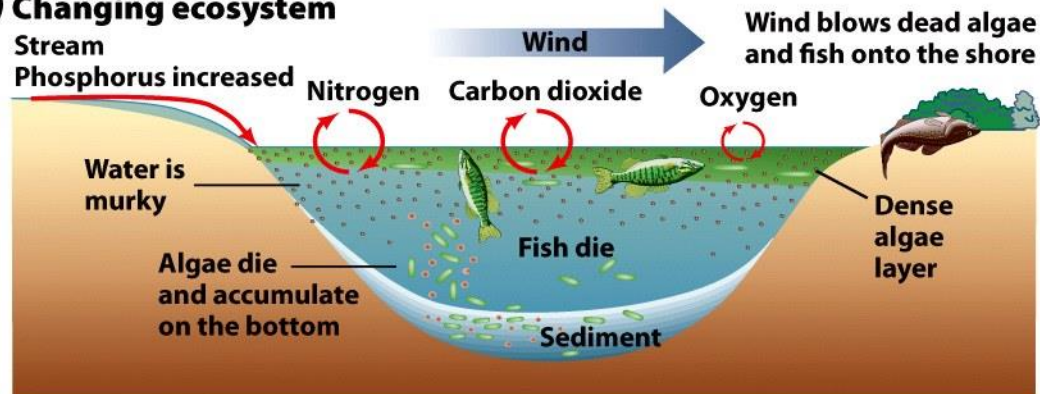
- Cultural eutrophication
 - Human processes that add nutrients to water
- Solution fairly straightforward
 - Ensuring that high concentrations do not enter water
 - Accomplished by
 - use of phosphate-free detergents
 - controlling nitrogen runoff
 - disposing or reusing treated wastewater
 - advanced water treatment methods



(a) Normal ecosystem



(b) Changing ecosystem



(c) Degraded ecosystem

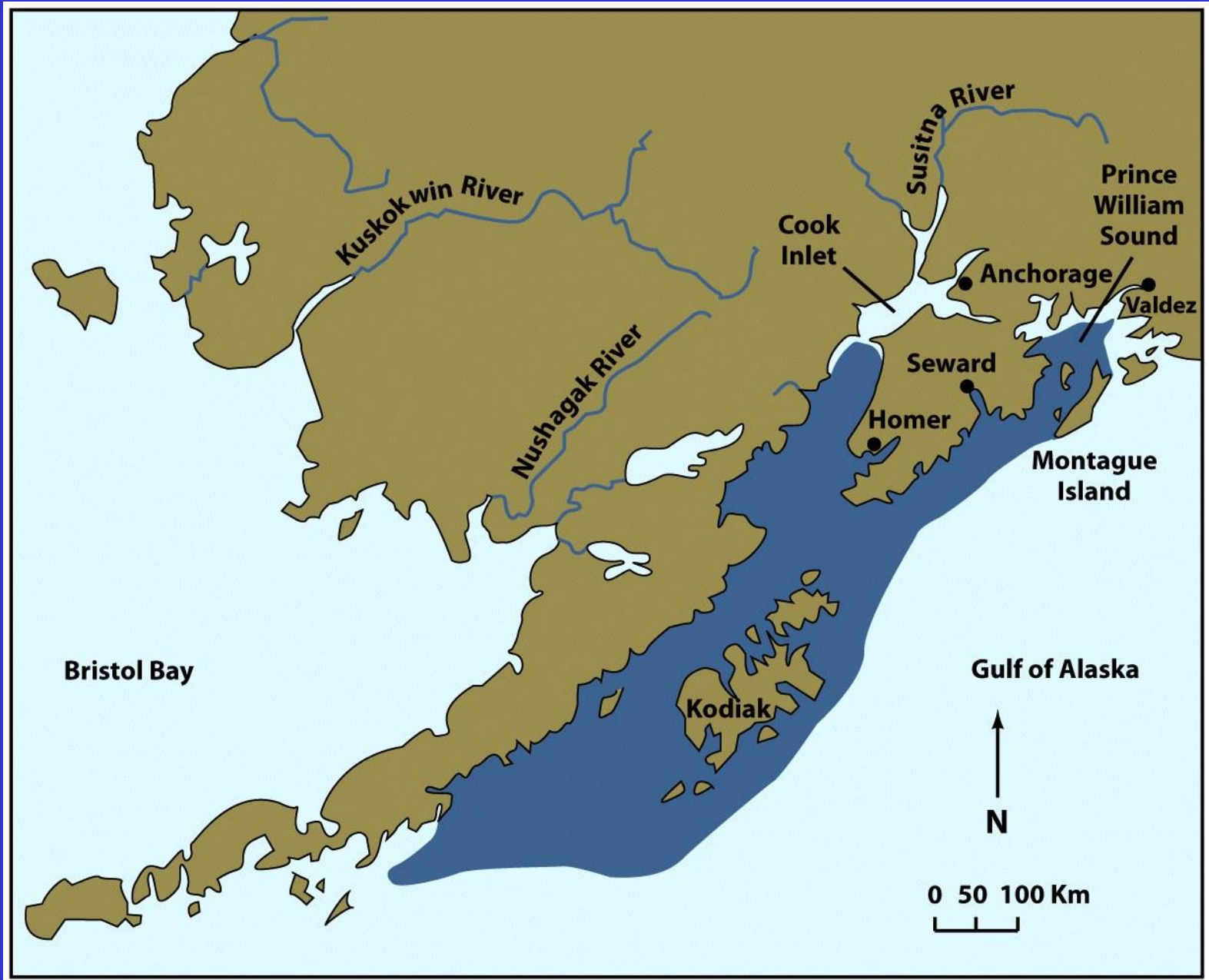
Oil

- Oil discharged into surface water has caused major pollution problems.
- Large spills make headlines but normal shipping activities probably release more oil over a period of years than is released by a single spill.

Exxon Valdez: Prince William Sound, AK

- March 24, 1989
- Exxon Valdez ran aground, ruptured tanks dumped 250,000 barrels of oil into sound
 - Some of the oil offloaded to another ship
- Spilled into one of the most pristine and ecologically rich marine environments.
 - Killed 13% of seals, 28% of sea otters and 100,000-645,000 sea birds.
 - W/in days the spill spread





Exxon Valdez

- Before spill typically believed oil industry could deal w/ spills
 - Even after 3 billion spent in clean up few people satisfied.
 - Clean up difficult and possibly futile
- Long term effects of the spill uncertain.
 - But demonstrates technology for dealing with spills inadequate.



Oil

- Avoiding spills and clean up methods include
 - Double hulled ships
 - Pump the oil out of the tanker as soon as it occurs
 - Collection of oil at sea
 - Cleaning birds and mammals
 - Spreading absorbent material on beaches

Jessica: Galapagos Islands

- January 22, 2001
- Small tanker off the coast of Ecuador ran aground spilling light diesel oil
 - Small spill compared to Valdez
 - But set off state of emergency because the Galapagos are an environmental treasure

Sediment

- Sediment consisting of rock and mineral fragments
 - Ranging in size from gravel ($>2\text{mm}$) to finer sand, silt and clay to even finer particles
 - Cause sediment pollution
 - By volume and mass, greatest water pollutant

Sediment

- Two fold problem
 - Results from erosion, which depletes a land resource (soil) at its site of origin
 - Reduces the quality of water resource it enters
- Land use changes result in erosion and sedimentation
 - Forested areas more stable
 - Agricultural practices can lead to large soil loss
 - Large quantities of sedimentation during construction phase of urbanization



Acid Mine Drainage

- Refers to water w/ a high concentration of sulfuric acid that drains from mines.
 - Coal mines often associated w/ pyrite (iron sulfide)
 - When it come into contact w/ oxygen and water it weathers
 - A product of weathering is sulfuric acid
 - Water runs through the mine tailings



Acid Mine Drainage

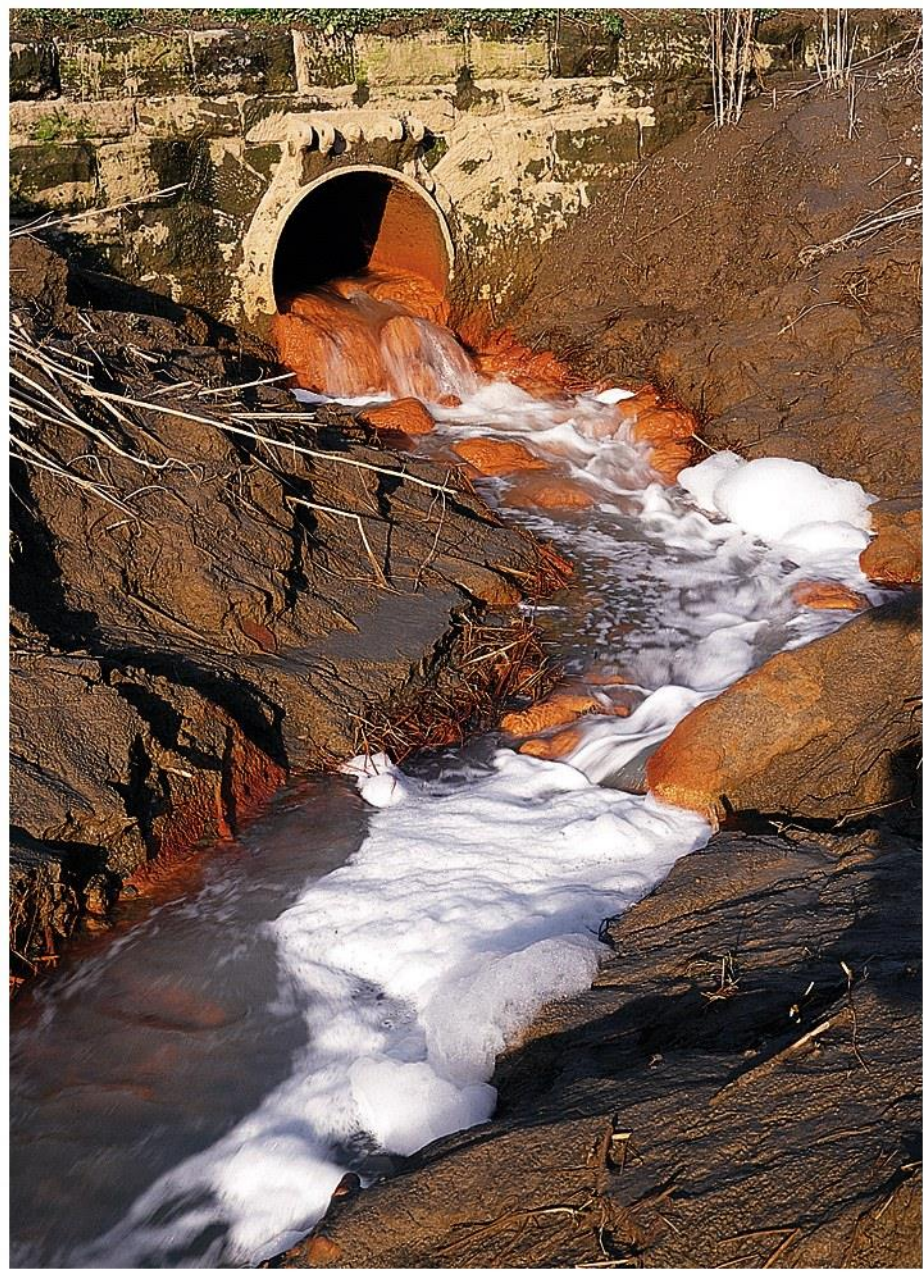
- If the acid-rich water runs into natural water source significant pollution and environmental damage may result.
 - Acidic water toxic to plants and animals of aquatic ecosystems
 - Can also seep in to pollute groundwater
 - Thousands of km of streams damaged
 - Abandoned mines also a continuing problem

Surface Water Pollution

- Pollution of surface waters occurs when
 - Too much of an undesirable or harmful substance flows into a body of water
 - Exceeding the natural ability of that water body to
 - remove the undesirable material
 - dilute it to a harmless concentration
 - or convert it to a harmless form

Surface Water Pollution

- Emitted from point or nonpoint source
- Point source are distinct and confined
 - Pipes from municipal or industrial sites that empty into a stream or river
- Nonpoint source are diffused and intermittent
 - Such as runoff.
 - Influenced by land use, climate, hydrology, topography, native vegetation, and geology.
 - Difficult to monitor and control



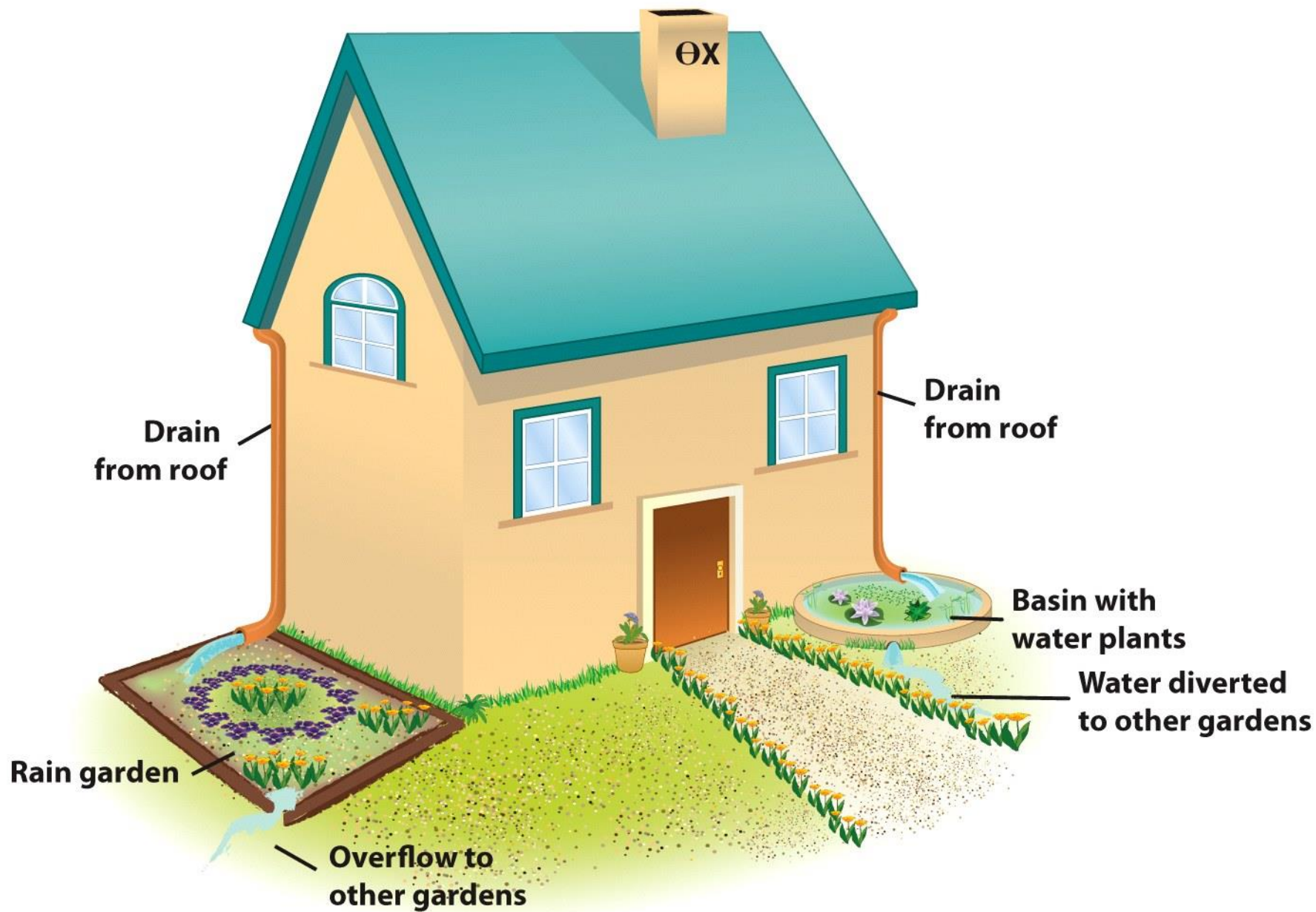
Surface Water Pollution

- Two approaches to dealing with surface water pollution are
 - 1. To reduce the sources
 - 2. To treat the water to remove pollutants or convert them to forms that can be disposed of safely.

Surface Water Pollution

- Many large US cities in the US not river that were almost destroyed by pollution nad concrete.
 - Today there is a movement to restore urban rivers and adjacent lands to greenbelts, park, and environmentally sensitive developments.
 - Other approaches include nanotechnology and close loop local landscapes.







Groundwater Pollution

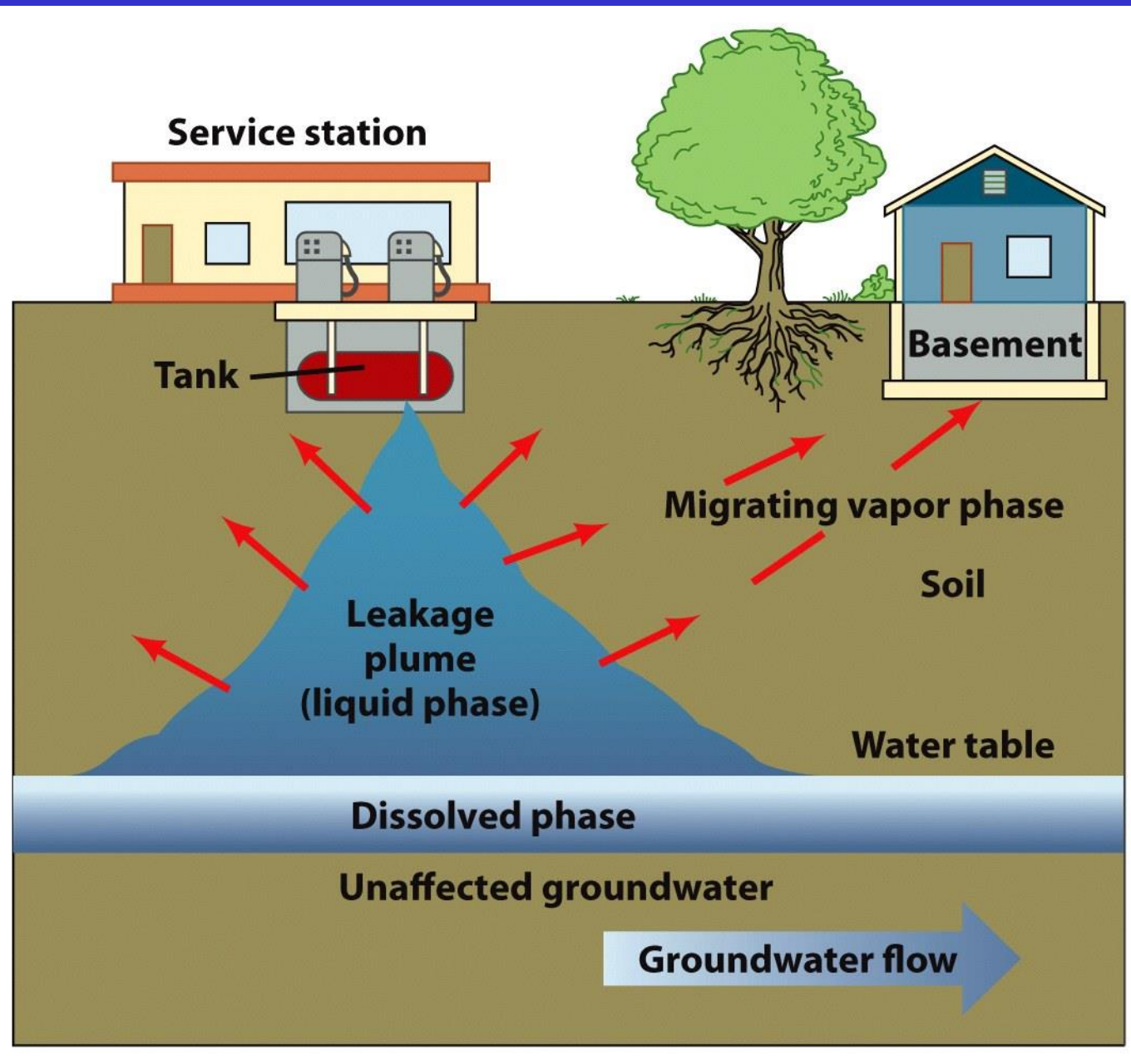
- ~1/2 of all people in US depend on groundwater for drinking
 - Long believed to be pure and safe to drink
 - Can be contaminated from a number of sources
 - May become worse as human population pressures increase

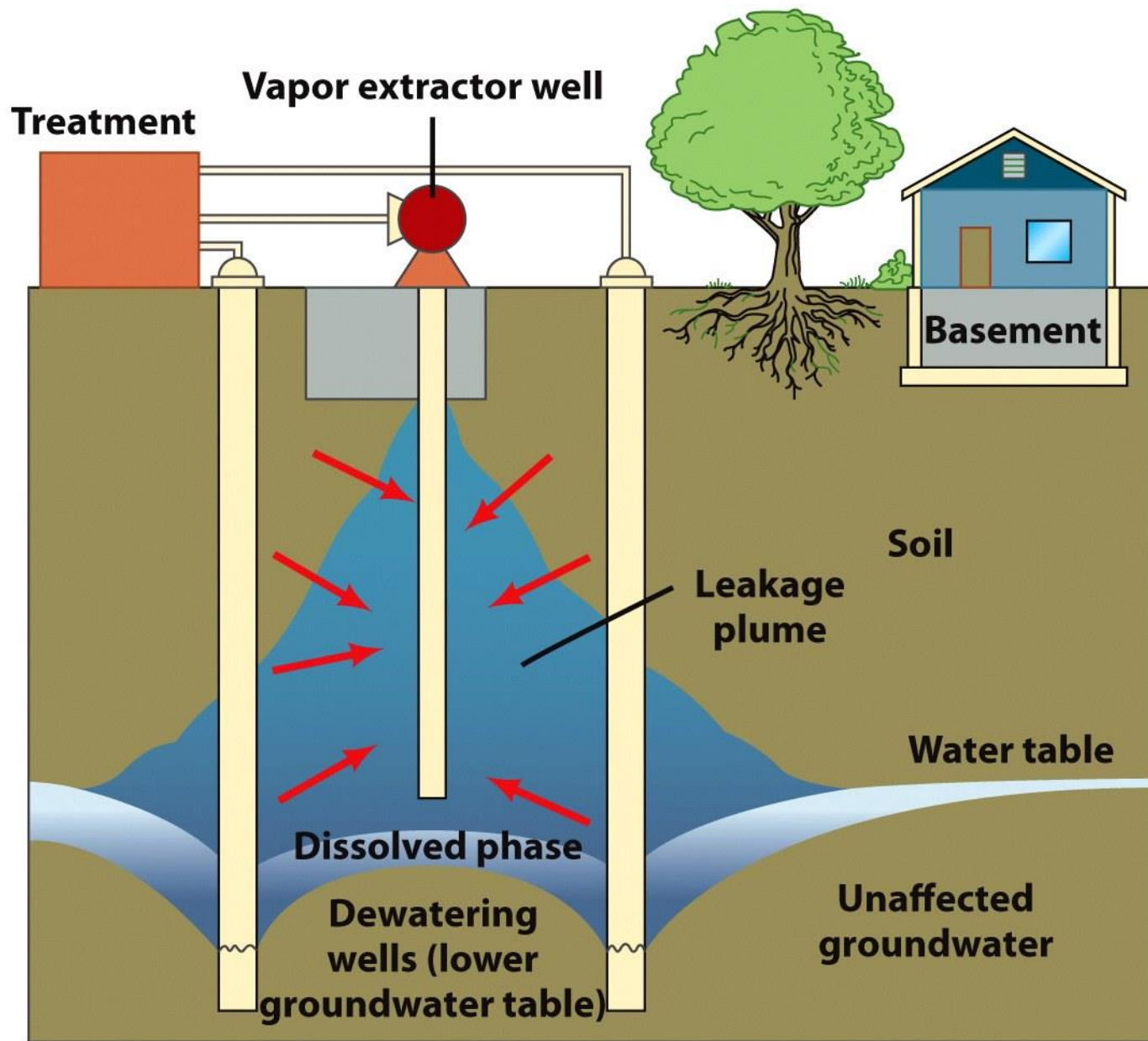
Groundwater Pollution

- The hazard presented by a particular groundwater pollutant depends on:
 - Concentration or toxicity of the pollutant
 - Degree or exposure of people or other organisms to the pollutant

Principles of Groundwater Pollution: An Example

- Pollution leaking from buried gasoline tanks from service stations
 - Wide spread problem
 - Many thousands of old tanks removed and surrounding groundwater and soil treated
 - Disposal of soil, vapor extraction of water and use of microorganisms (bioremediation)





Principles of Groundwater Pollution: An Example

- Pollution from leaking buried gasoline tanks emphasizes some important points about groundwater pollutants:
 - Some pollutants, such as gasoline, are lighter than water and thus float on the groundwater.
 - Some pollutants have multiple phases: liquid, vapor, and dissolved.
 - Some pollutants are heavier than water and sink or move downward through groundwater.

Principles of Groundwater Pollution: An Example

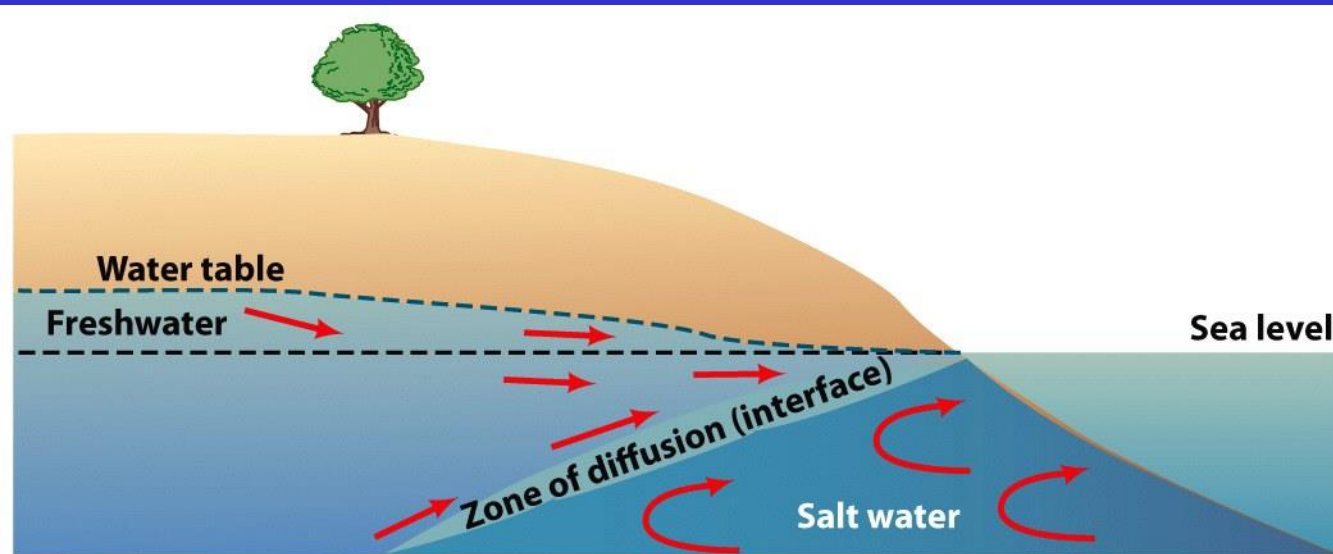
- The method used to treat must take into account the physical and chemical properties of the pollutant and how these interact with water.
- Emphasis should be on preventing pollutants from entering groundwater in the first place.

Principles of Groundwater Pollution: An Example

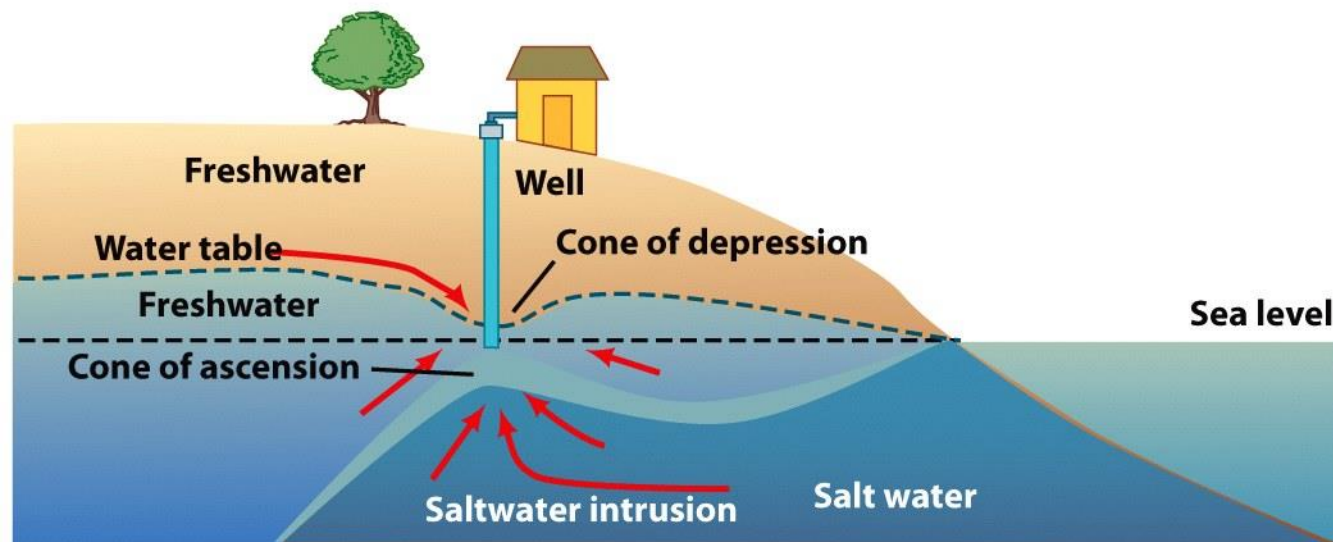
- Pollution in groundwater differs from surface water pollution in several ways
 - Groundwater lacks oxygen but may provide environment for anaerobic bacteria
 - Channels through which groundwater moves often small and variable
 - Rate of movement is low and opportunity for dispersion and dilution limited

Long Island, New York

- Two counties in Long Island (Nassau and Suffolk) depend entirely on groundwater
- Two major problems in Nassau:
 - Intrusion of salt water and shallow aquifer contamination



(a) Before pumping



(b) After pumping

Long Island, NY

- Saltwater intrusion has become a problem for south shore communities
 - Must pump water from a deeper aquifer
 - Below and isolated from saltwater
- Most serious problem is shallow aquifer pollution associated w/ urbanization
 - Pollutants enter surface waters then migrate downward

- 1 Seepage to streams
- 2 Subsurface outflow
- 3 Evapotranspiration
- 4 Spring flow

General movement of
fresh groundwater

West

East

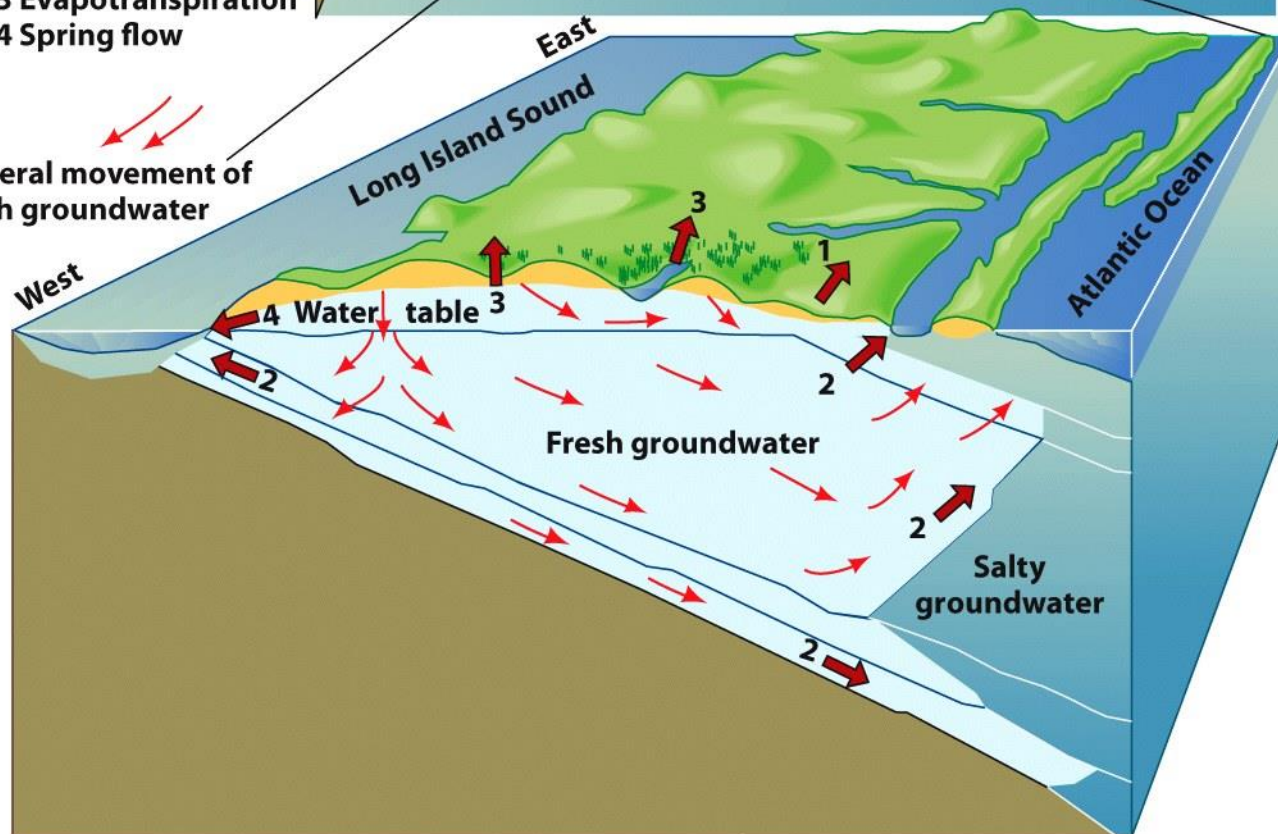
Long Island Sound

Atlantic Ocean

Water table

Fresh groundwater

Salty groundwater

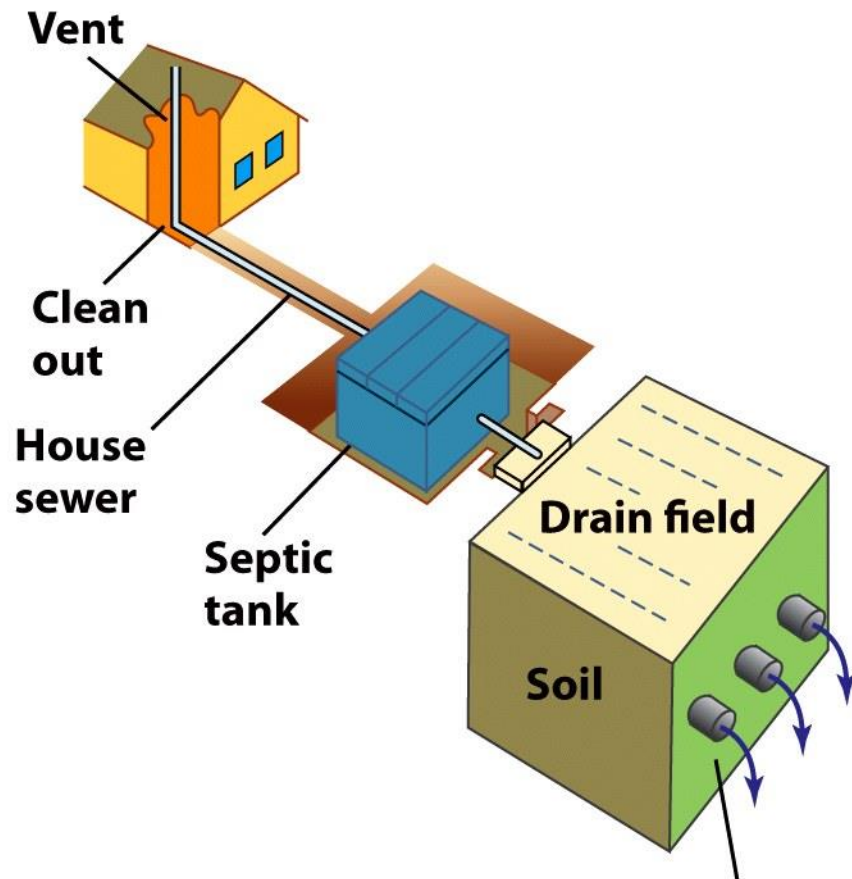
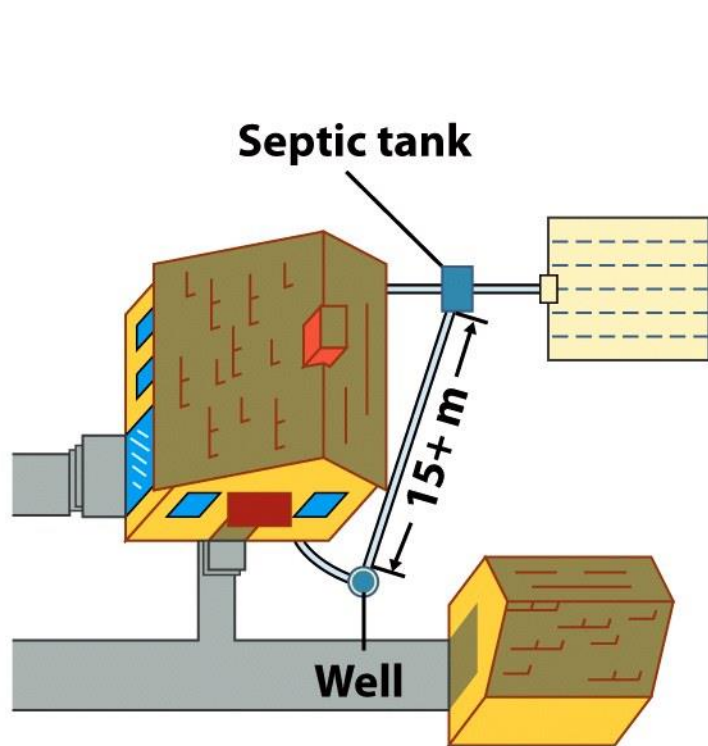


Wastewater Treatment

- Water used for industrial and municipal purposes is often degraded during use
 - Addition of suspended solids, salts, nutrients, bacteria, and oxygen demanding material.
 - Water must be treated before released
- Wastewater treatment
 - \$20 billion a year industry
 - Conventional methods; septic tanks and centralized treatment

Septic-Tank Disposal Systems

- Common in many rural areas and outlying areas of cities.
- Basic parts of a septic-tank disposal system
 - Sewer line from house to underground tank
 - Tank separates solids from liquids
 - Digest and store solids
 - Liquid sent to absorption field
 - By the time water reaches any fresh water should be safe.



Buried leach lines (pipes with holes) from which wastewater from the septic tanks drains into the soil

Septic-Tank Disposal Systems

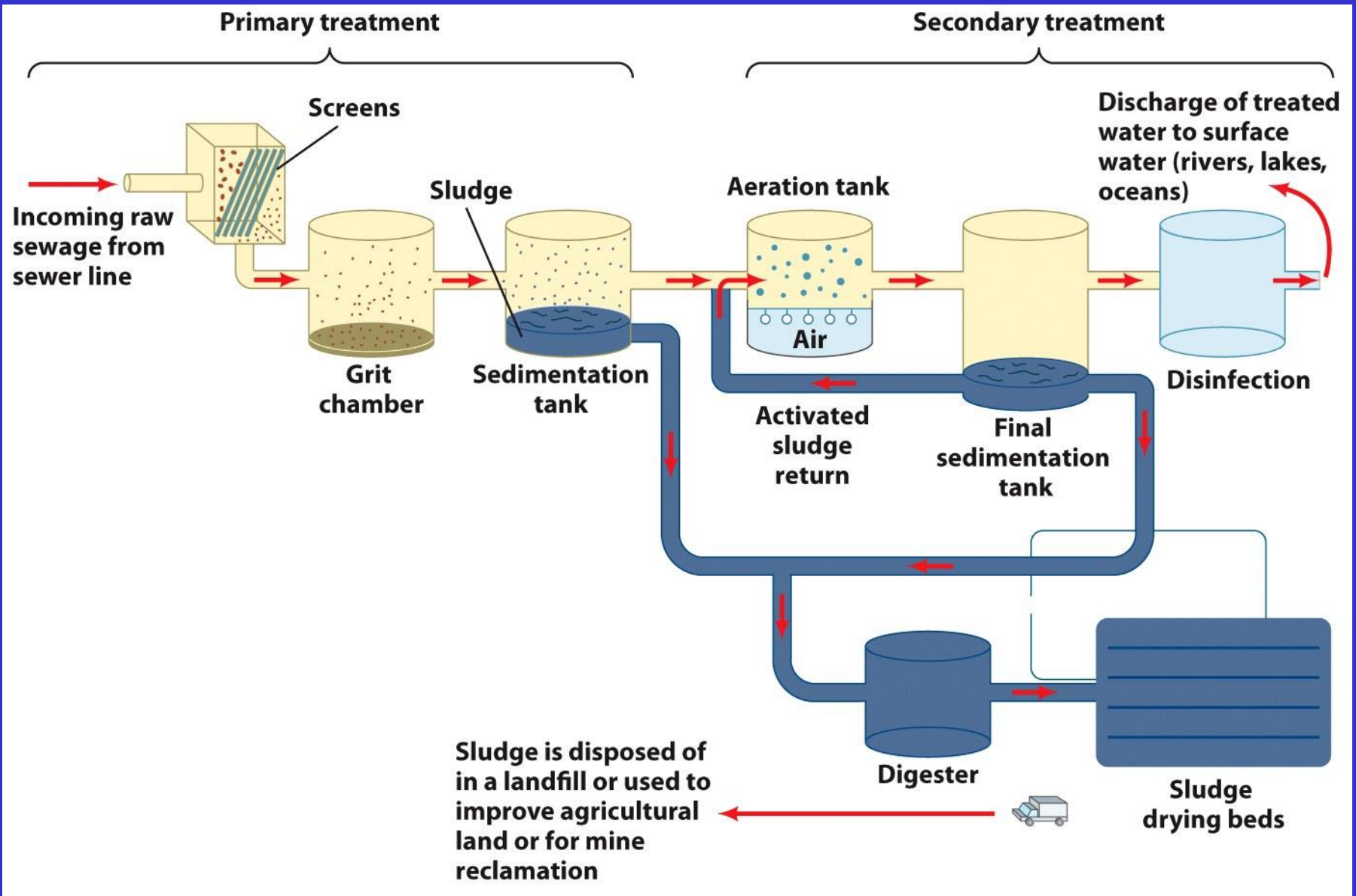
- Absorption fields may fail for several reasons.
 - Failure to pump out tank when full of solids
 - Poor soil drainage which allows the effluent to raise to surface in wet weather.

Wastewater Treatment Plants

- Specially designed plants that accept municipal sewage from homes, businesses and industrial sites.
- Delivered to plant by network of pipes
- Following treatment discharged into surface water
 - Main purpose is to breakdown and reduce BOD and kill bacteria w/ chlorine

Wastewater Treatment Plants

- Methods usually divided into three categories:
 - Primary treatment
 - Secondary treatment
 - Advanced wastewater treatment
- Primary and secondary required by law.



Primary Treatment

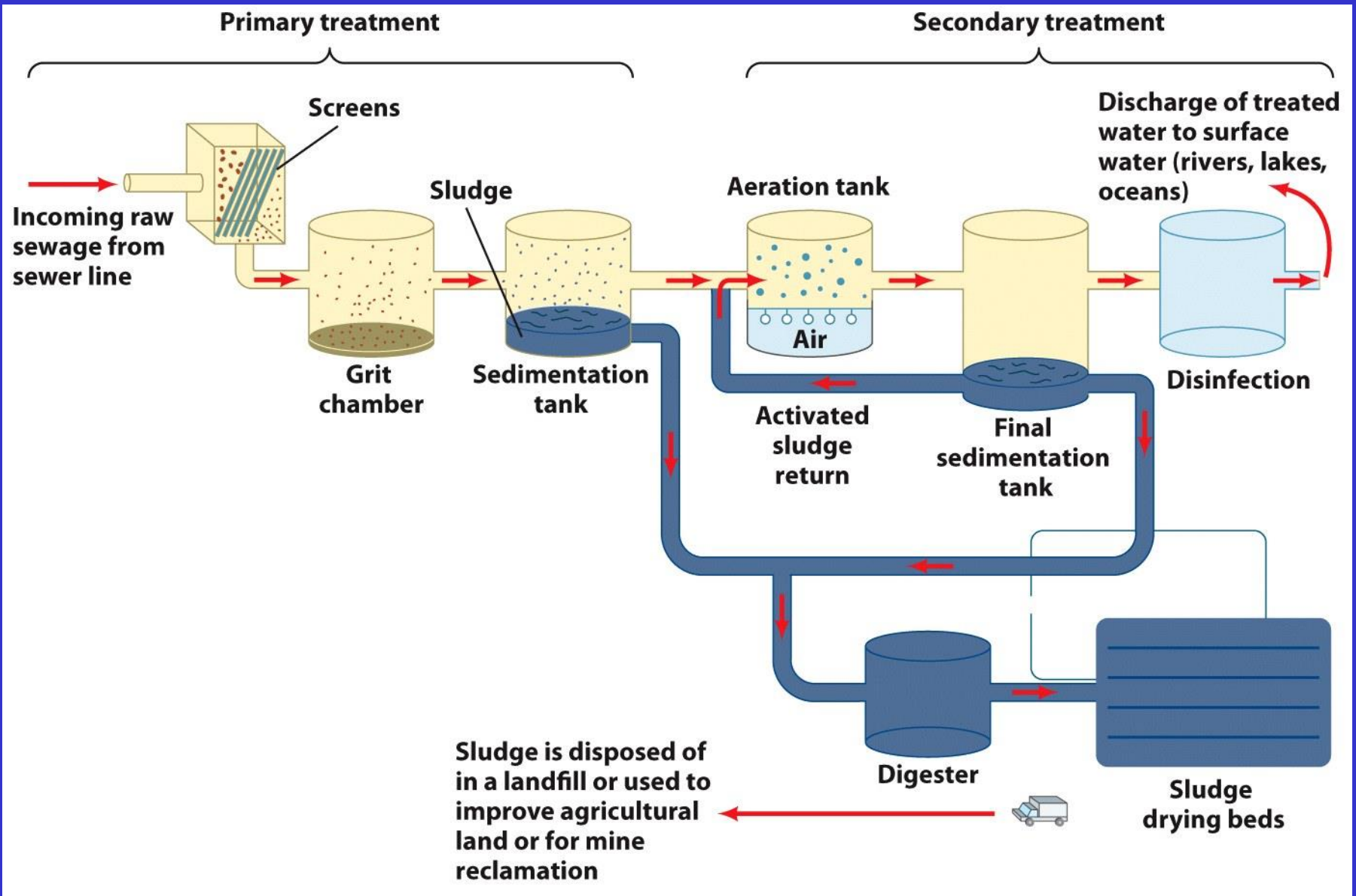
- Incoming raw sewage enters plant
- Passes through series of screens
 - Remove large floating organic material
- Next enters a grit chamber
 - Sand, small stones and grit removed
- Then enters sedimentation tank
 - Particulate matter settles out to form a sludge
- Sludge is removed and transported to a digester
- Primary treatment removes ~35% of BOD

Secondary Treatment

- Most common treatment, activated sludge.
- Wastewater from primary sedimentation tank enters the tank
- Then enters the final sedimentation tank
 - Sludge settles out
 - Some activated sludge used again in aeration
- Most of the sledge transported to digester
- Wastewater from final tank is disinfected w/ chlorine and discharged

Secondary Treatment

- Secondary treatment removes ~90% of BOD
- Sludge from the digester is dried and disposed of in a landfill or applied to improve soil.



Advanced Wastewater Treatment

- Additional pollutants can be removed by adding more treatment steps.
 - Sand filters, carbon filters and chemicals applied to assist removal process.
- Treated water can then be used for agricultural or municipal irrigation

Chlorine Treatment

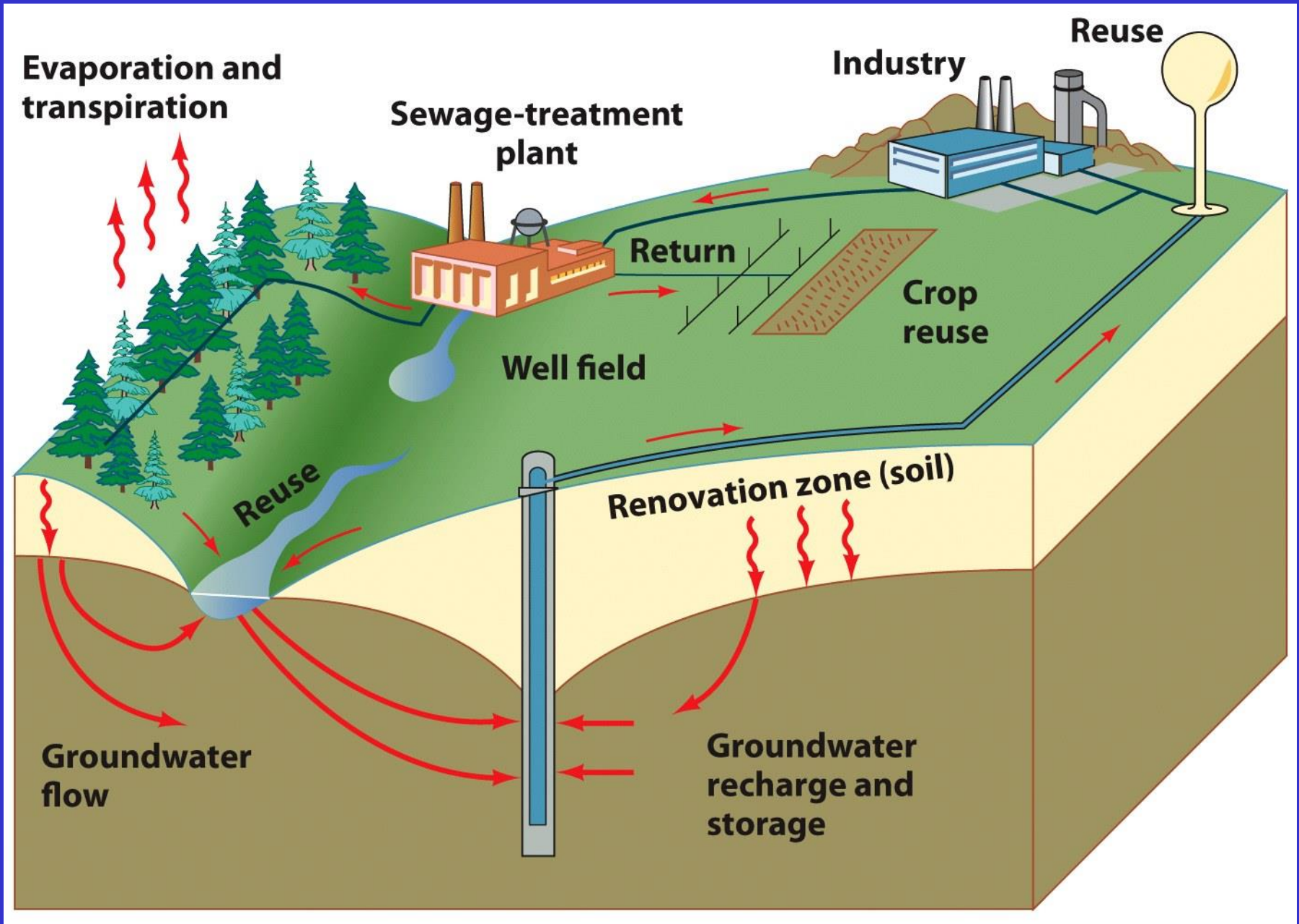
- Chlorine is very effective in killing the pathogens that historically caused outbreaks
 - Chlorine treatment byproducts may pose hazard to fish and cancer risk to humans.

Land Application of Wastewater

- Land application of wastewater was practiced for hundreds of years before the development of treatment plants.
 - Now the process is sanitized through reduction of BOD and use of chlorination.

The Waste Renovation and Conservation Cycle

- Major steps in the cycle:
 - 1. Return of treated wastewater to crops via a sprinkler or other irrigation system.
 - 2. Renovation, or natural purification by slow percolation of the wastewater into the soil, to eventually recharge the groundwater resource with clean water.
 - 3. Reuse of the treated water, which is pumped out of the ground for municipal, industrial, institutional, or agricultural purposes.

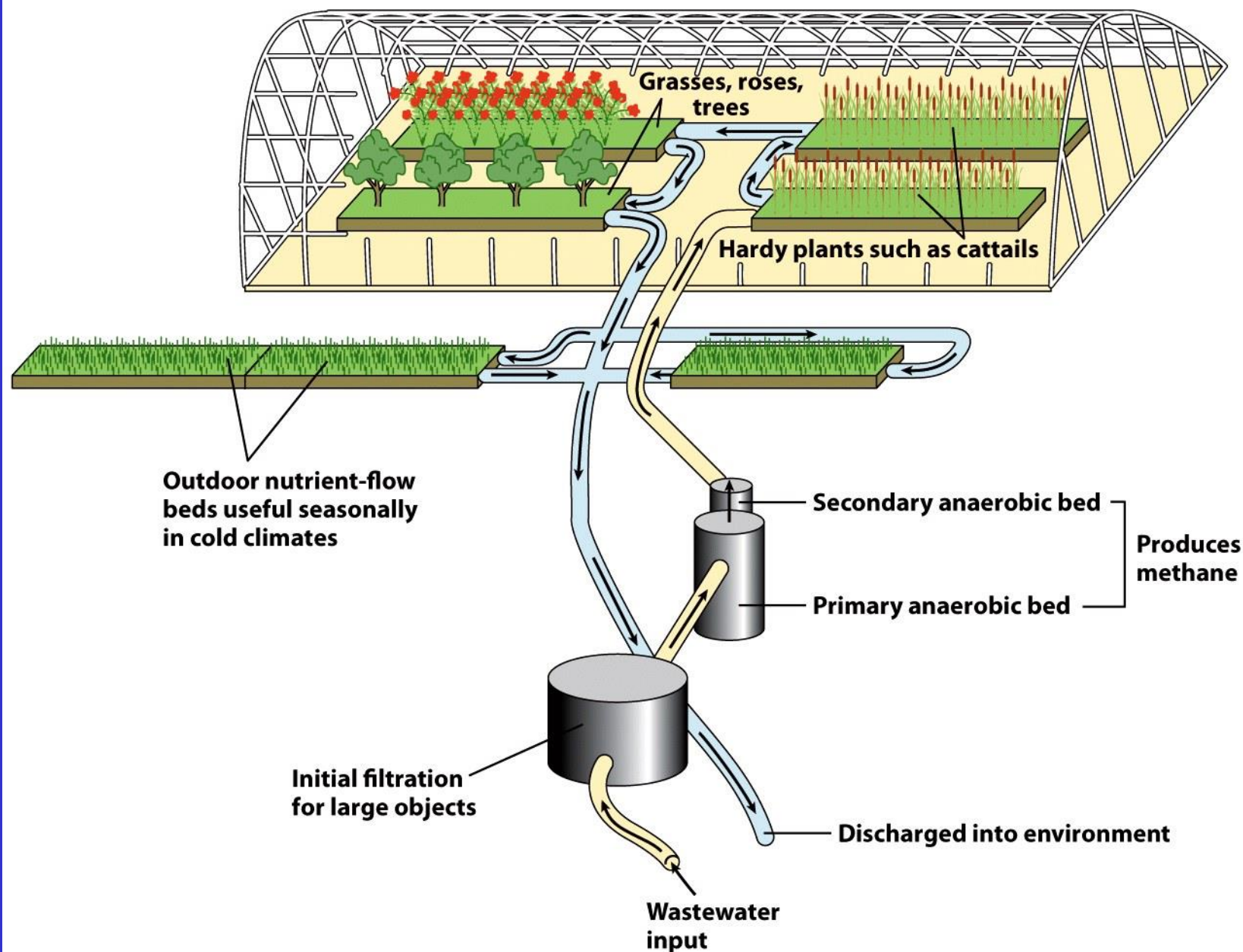


The Waste Renovation and Conservation Cycle

- Technology for wastewater treatment is rapidly evolving.
 - Resource recovery wastewater treatment plant
 - Refers to the production of resources such as methane and ornamental plants.
- The process
 - 1. The wastewater is run through filters to remove large objects.

The Waste Renovation and Conservation Cycle

- 2. The water undergoes anaerobic processing.
 - Produces methane
- 3. The nutrient rich water flows over an incline surface containing plants



The Waste Renovation and Conservation Cycle

- Technology must overcome several problems before it is likely to be used widely.
 - There has been a tremendous investment in traditional wastewater treatment plants.
 - Economic incentive to provide for new technologies are not sufficient.
 - There are not sufficient personal trained to design and operate new types of plants.

Wastewater and Wetlands

- Wastewater is being applied successfully to natural and constructed wetlands.
- Effective in treating the following water quality problems:
 - Municipal wastewater from primary or secondary treatment plants (BOD, pathogens, phosphorus, nitrate, suspended solids, metals).





Wastewater and Wetlands

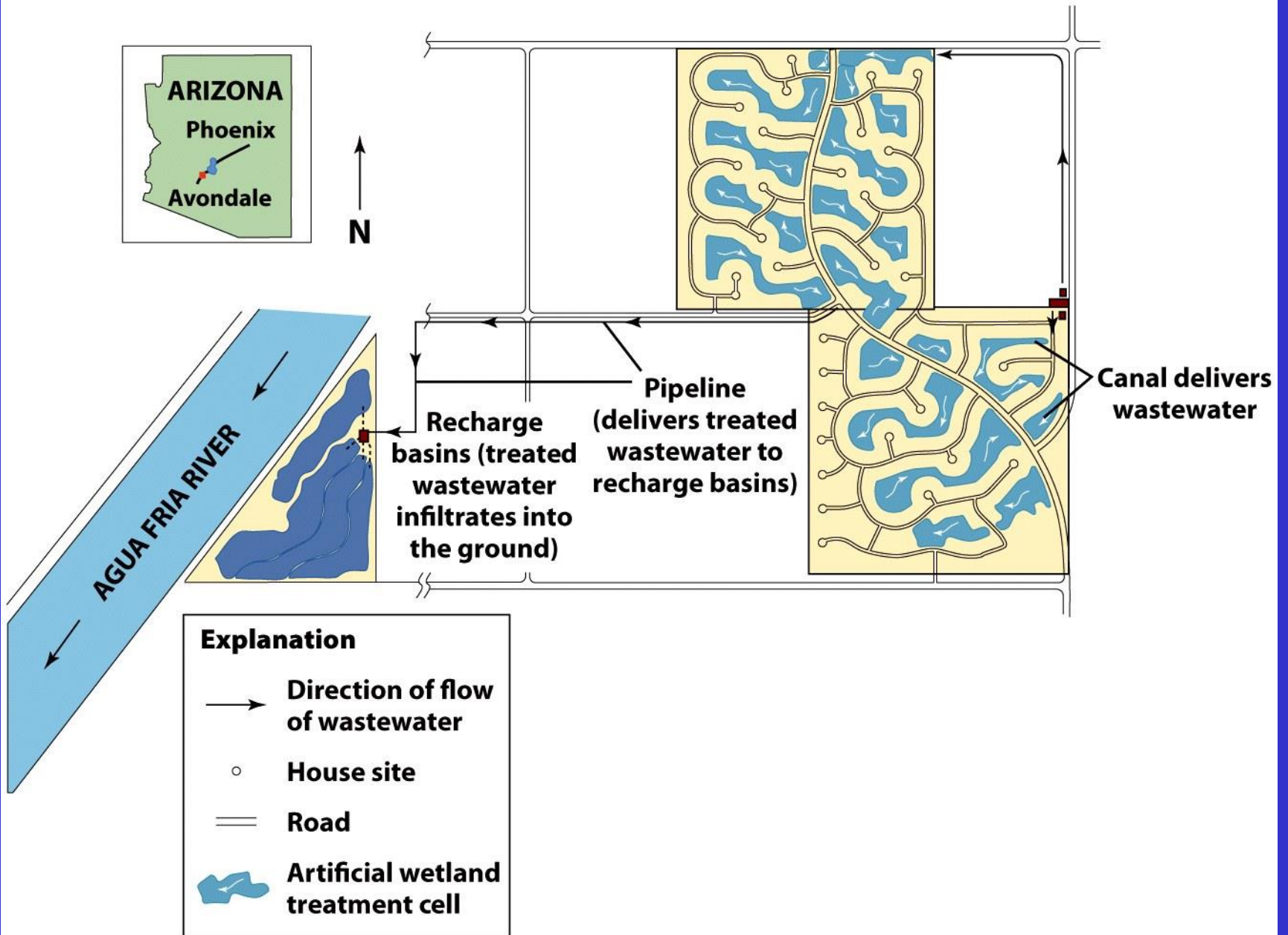
- Stormwater runoff (metals, nitrate, BOD, pesticides, oils).
- Industrial wastewater (metals, acids, oils, solvents).
- Agricultural wastewater and runoff (BOD, nitrate, pesticides, suspended solids).
- Mining waters (metals, acidic water, sulfates).
- Groundwater seeping from landfills (BOD, metals, oils, pesticides).

Louisiana Coastal Wetlands

- State of Louisiana leader in development of advanced treatment.
- Nitrogen and phosphorus rich wastewater increases the production of wetland plants.
 - Improving water quality
 - Helping wetlands accrete
- Significant economic savings each year

Phoenix, Arizona: Constructed Wetlands

- Wetlands can be constructed in arid regions to treat poor quality water.
- E.g. Avondale, AZ
 - Wetland treatment facility for agricultural wastewater sited in residential community.
 - Designed to treat 4.5 million gal/day
 - Naturally occurring bacteria breakdown nitrates





Water Reuse

- Water reuse can be inadvertent, indirect or direct.
- Inadvertent
 - Results when water is withdrawn, treated, used, treated, and returned to the environment.
 - Followed by furtherer withdrawal and use.
 - Common for people who live along large rivers.

Water Reuse

- Risks associated with inadvertent reuse:
 - 1. Inadequate treatment facilities may deliver contaminated or poor-quality water to downstream users.
 - 2. Environmental health hazards of treated water remain uncertain.
 - 3. Every year, new potentially hazardous chemicals are introduced into the environment. Ingested in low concentrations over many years, effects on humans difficult to evaluate.

Water Reuse

- Indirect water reuse
 - A planned endeavor.
 - Several thousand cubic meters of treated water per day applied to surface recharge areas.
 - Eventually enters the groundwater.

Water Reuse

- Direct water reuse
 - Refers to use of treated wastewater that is piped directly from a treatment plant to the next user.
 - Normal for industrial processes. Also used for fountain and other water displays in Las Vegas.
 - Little direct use for human consumption.
 - Orange County, CA developing program to processes 70 million gal/day



Water Pollution and Environmental Law

- Branch of law dealing with conservation and use of natural resources and control of pollution.
 - Federal laws to protect water go back to Refuse Act of 1899
 - Each major piece of legislation has significant impact on water quality issues.
 - Laws for clean up and prevention

Table 22.4**Federal Water Legislation**

<i>Date</i>	<i>Law</i>	<i>Overview</i>
1899	Refuse Act	Protects navigable water from pollution.
1956	Federal Water and Pollution Control Act	Enhances the quality of water resources and prevents, controls, and abates water pollution.
1958	Fish and Wildlife Coordination Act	Mandates the coordination of water resources projects such as dams, power plants, and flood control must coordinate with U.S. Fish and Wildlife Service to enact wildlife conservation measures.
1969	National Environmental Policy Act	Requires environmental impact statement prior to federal actions (development) that significantly affect the quality of the environment. Included are dams and reservoirs, channelization, power plants, bridges, and so on.
1970	Water Quality Improvement Act	Expands power of 1956 act through control of oil pollution and hazardous pollutants and provides for research and development to eliminate pollution in Great Lakes and acid mine drainage.
1972 (amended in 1977)	Federal Water Pollution Control Act (Clean Water Act)	Seeks to clean up nation's water. Provides billions of dollars in federal grants for sewage treatment plants. Encourages innovative technology, including alternative water treatment methods and aquifer recharge of wastewater.
1974	Federal Safe Drinking Water Act	Aims to provide all Americans with safe drinking water. Sets contaminant levels for dangerous substances and pathogens.
1980	Comprehensive Environmental Response, Compensation, and Liability Act	Established revolving fund (Superfund) to clean up hazardous waste disposal sites, reducing groundwater pollution.
1984	Hazardous and Solid Waste Amendments to the Resource Conservation and Recovery Act	Regulates underground gasoline storage tanks. Reduces potential for gasoline to pollute groundwater.
1987	Water Quality Act	Established national policy to control nonpoint sources of water pollution. Important in development of state management plans to control nonpoint water pollution sources.

Water Pollution and Environmental Law

- In July 2000 new water pollution regulations aimed at protection from non-point sources.
 - Regulations to be administered by EPA
 - Acknowledge nonpoint source pollution as a serious problem that is difficult to regulate.
 - Plan opposed by many groups.
 - Marks a new phase in water pollution control measures.