## Core Case Study: Environmental Effects of Gold Mining

1. *6* tons of mineral waste is created to make 2 gold wedding rings!
2. What is cyanide heap leaching and why is it so harmful?

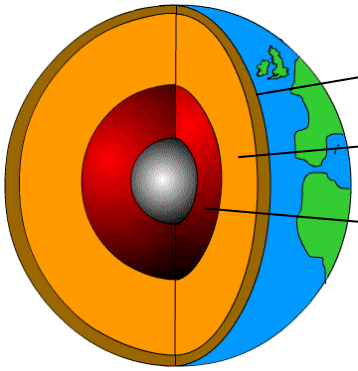
*This is a mining technology in which mountains are leveled in order to extract gold. To extract the gold, miners spray a solution of highly toxic cyanide salt onto open air piles of rock. The solution drains into the storage ponds and the gold is removed.*

In 2000, snow and heavy rains washed out a dam at one of the cyanide leach ponds at a gold mine in *Romania*. This released large amounts of cyanide laced water which contaminated food supplies and killed thousands of fish and aquatic plants.

## What Are the Earth's Major Geological Processes and Hazards?

Define: Geology- *study of the earth's surface and interior*

Label and define the 3 major concentric zones



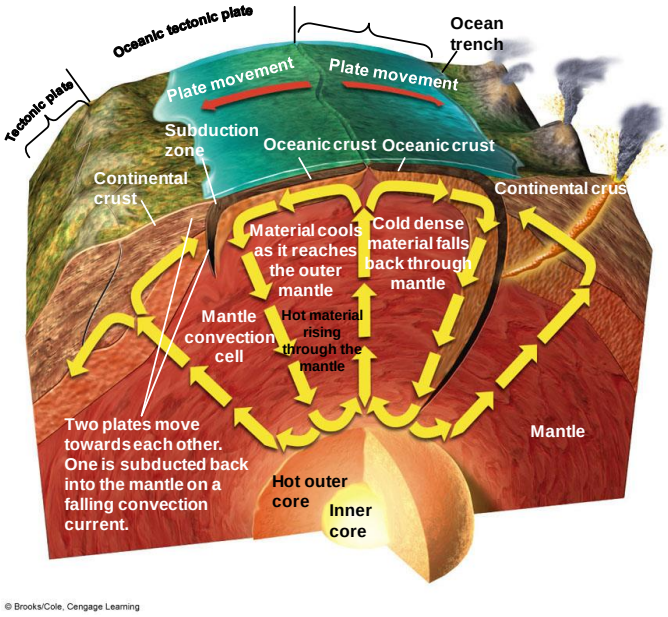
*Crust*- contains oceanic and continental crust, Oxygen is the most abundant element here

*Mantle*- mostly solid rock; includes the asthenosphere- partially melted rock

*Core*- extremely hot, has a solid inner core, and a liquid outer core

*Convection Cells* moves large volumes of rock and heat in loops within the mantle.
- -Magma cools as it reaches the outer mantle and then falls toward the core.
- -Magma heats back up near the core and rises toward outer mantle again.

*Tectonic* plates move very *slowly* atop the denser *mantle* on hot soft rock. The plates are composed of *continental* crust, *oceanic* crust, and the outermost part of the mantle= lithosphere



What happens when…

| oceanic plates move apart from one another: | an oceanic plate collides with a continental plate: | two continental plates collide: | continental plates slide past one another |
|---|---|---|---|
| *DIVERGENT PLATE- magma flows up through the resulting cracks*<br><br>*Results in oceanic ridges*<br><br>← → | *CONVERGENT PLATE- When an oceanic plate collides with a continental plate, the continental plate rides up over the denser oceanic plate; oceanic plate melts= SUBDUCTION*<br><br>*Results in a trench*<br><br>↗ ↙ | *CONVERGENT PLATE-* two continental plates collide<br><br>Results in the formation of mountain ranges<br><br>→ ← | *TRANSFORM FAULT- plates grind against one another*<br><br>*Results in earthquakes*<br><br>↓ ↑ |

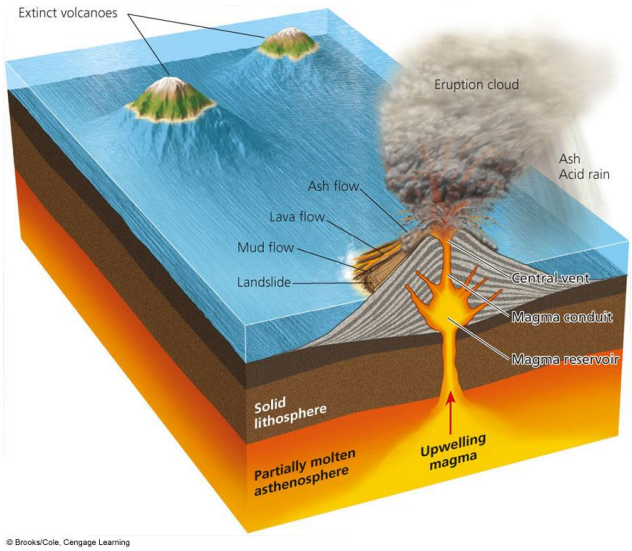
*Internal* Geological Processes- generated by *heat* from the earth's interior and typically build up the earth's surface in the form of continental and oceanic crust.
Ex: *mountains and volcanoes*

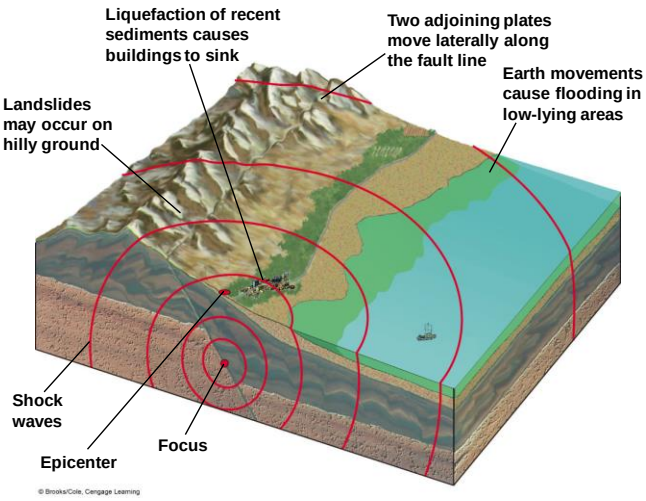
*External* Geological Processes-driven by energy from the *sun* (flowing water and *wind*) and influenced by gravity tend to wear down the earth's surface.
Ex: *Weathering*- breaks rocks into smaller pieces to build *soil*
*Erosion*- material is loosened or worn away and deposited elsewhere
**Glaciers* also cause erosion when they moved down a mountainside

VOLCANOES
- form from *tectonic* plate movement (convergent and subduction) and usually found along boundaries of tectonic plates
- occurs when *magma* reaches earth's surface through a central vent, or *fissure*
- lava= *magma that reaches the earth's surface*
- eruption releases large chunks of lava, liquid lava, ash, gases like $CO_2$ and *$SO_2$*
- benefit: highly fertile *soil* from the weathering of lava

- 1991- Mount Pinatubo- reduced solar energy and cooled atmosphere for 15 months
- 1980- Mount St. Helen's- worst in history

**What is the <u>RING OF FIRE</u> and why does it exist?
*Ring of volcanoes around the Pacific Ocean*






Effects of earthquakes:
*shaking, displacement of the ground and infrastructure*

## EARTHQUAKES

- Cause: *forces inside the earth's mantle and along its surface push, deform, and stress rocks; at some point the stress causes the rocks to suddenly shift or break to produce transform faults; energy that has accumulated over time is released*

Define: Seismic Waves- *vibrations when energy is released*

Focus- *where the earthquake begins below the surface*

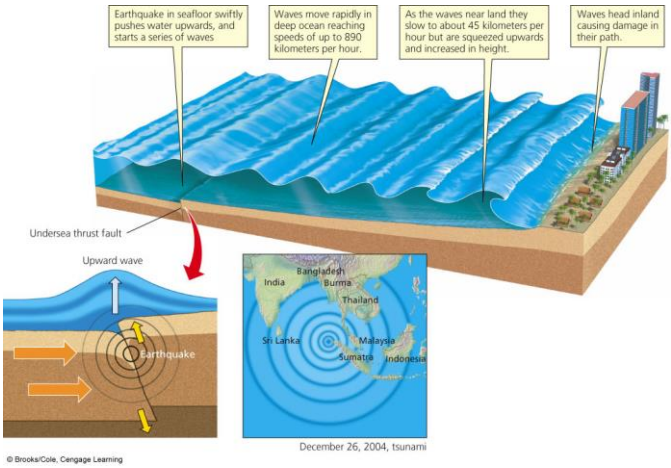
Epicenter- *on the earth's surface above the focus*

Magnitude- *the severity of earthquakes*

Amplitude- *size of the seismic waves*

Seismograph- *instrument used to measure amplitude*

Richter Scale- *scale to measure magnitude of earthquake; each unit is 10x greater than the previous unit*




## TSUNAMIS

- series of large *waves* generated when the ocean floor suddenly rises or falls or underwater earthquake
- detected by ocean *buoys*
  - Dec 2004- tsunami in *Indian* Ocean, earthquake had a magnitude of *9.15* and waves *100* ft high
    - *Mangrove* Forests- reduced death toll by protecting buildings and people from force of the waves

**How Are the Earth's Rocks Recycled?**

*Mineral*- element or inorganic compound that occurs naturally as a solid
EX: *gold, silver, diamonds, sodium chloride*

*Rock*-solid combination of one or more *minerals*
EX: *limestone, quartz*

3 Major Types of Rocks:

| Sedimentary Rock | Igneous Rock | Metamorphic Rock |
|---|---|---|
| *Made of sediments- dead plant and animal remains and existing rocks that are weathered*<br><br>*Sediments are transported and accumulate in layers*<br><br>*EX: shale, sandstone, limestone, bituminous coal* | *Forms below or on the earth's surface when magma wells up from the upper mantle or deep crust and then cools or hardens*<br><br>*Makes up the bulk of the earth's surface*<br><br>*EX: granite, lava rock* | *Forms when preexisting rock is subjected to high temperatures and high pressure*<br><br>*EX: anthracite coal, slate, marble* |

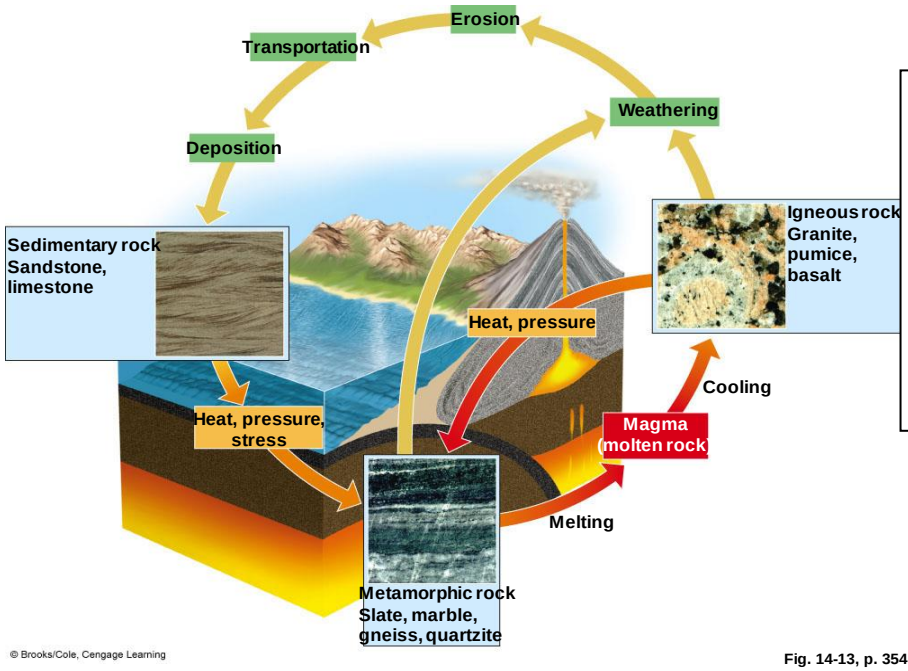



Fig. 14-13, p. 354

ROCK CYCLE
- chemical and physical processes that change rocks from one type to another
- recycles the Earth's 3 types of rocks over millions of years
- slowest of all earth's cyclical processes

**What Are Mineral Resources & What Are the Environmental Effects of Using Them?**

Mineral Resources- concentration of naturally occurring material that can be *extracted* and processed into useful *products* or raw materials at an affordable cost

EX: *fossil fuels, metallic minerals (aluminum, iron, and copper), non-metallic minerals (sand, gravel, limestone)*

| High Grade Ore: | *Ore*- rock that contains large enough concentration of a particular mineral (usually metal) to make a profit | Low Grade Ore: |
|---|---|---|
| *Contains large amounts of the desired resource* | | *Contains a small amount of the desired resource* |

Describe how each is a part of our lives:

| | |
|---|---|
| Aluminum | *Packaging, cans, aircrafts* |
| Manganese, Cobalt, and Chromium | *Steel alloys in lightbulbs, computers, cars* |
| Copper | *Conductor of electricity* |
| Platinum | *Electrical equipment, car pollution control converter* |
| Gold | *Electrical equipment, jewelry, medical implants* |
| Sand | *Glass, bricks, concrete* |
| Limestone | *Roads, concrete, cement* |
| Phosphate salts | *Inorganic fertilizers and some detergents* |

Mineral Resource *Reserve*- estimate of a mineral resource's supply based on ability still be profitable at current prices.

Fill in the typical life cycle of a metal resource:

*Surface Mining* → *Metal Ore* → *Separate Ore* → *Smelting* → *Melting Metal* → *Conversion to product* → *Discard product*

| Advantages: | Mineral Use | Disadvantages: |
|---|---|---|
| *-significant income*<br>*-generates taxes*<br>*-employment*<br>*-useful products* | | *-uses a large amount of energy*<br>*-disturbs land*<br>*-erodes soil*<br>*-produces solid waste*<br>*-creates air and water pollution* |

| ***Types of Mining*** | |
|---|---|
| 1. Surface Mining | • Gigantic equipment strips away the *overburden*- the soil and rock overlying a mineral deposit<br>*Deposited as a waste material called *gangue*, *tailings, or spoils*<br>• Used to extract 90% of *nonfuel* minerals and 60% of *coal* in the US |
| 2. Open Pit Mining | • Type of surface mining where machines dig *holes* and remove ore, sand, gravel, and stone |
| 3. Strip Mining | • Extract deposits that lie *close* to the surface in *horizontal* beds<br>**Area* Strip Mining- terrain is flat and equipment removes overburden, removes mineral deposit, and then fill resulting trench back up with overburden.<br>**Contour* Strip Mining- used to mine *coal* on *hilly or sloped* terrain |
| 4. Mountain Top Removal | • The top of the mountain is removed to expose seams of *coal*<br>• Seen heavily in Appalachian Mountains |
| 5. Subsurface Mining | • Removes coal and metal ore that are *deep underground*<br>• Miners dig vertical *shafts* and blast open tunnels |

Describe 4 ways mining is harmful to the environment:

1. Scarring and disruption of the land surface- *spoils and tailings are left behind that are susceptible to weathering and erosion; regrowth of vegetation is very slow because there is no topsoil; mountains have disappeared;*

2. Subsidence- *the collapse of land above some underground mines*

3. Produces large amounts of solid waste- *¾ of all solid waste in the US comes from mining operations*

4. Water and air pollution- *wind and water erosion cause toxin laced mining wastes to be deposited in areas other than mining sites; water often contains mercury, arsenic and sulfuric acid; toxic chemicals are also released into the air*

    a. *Acid Mine Drainage*-occurs when rainwater seeps through a mine or mining waste pile and carries *sulfuric acid* (produced when aerobic bacteria act on iron sulfide minerals) to nearby streams

Removing Metal From Ores:

Ore has two components:

1. *Ore Mineral*- the desired metal
2. *Gangue*- waste material which produces tailings

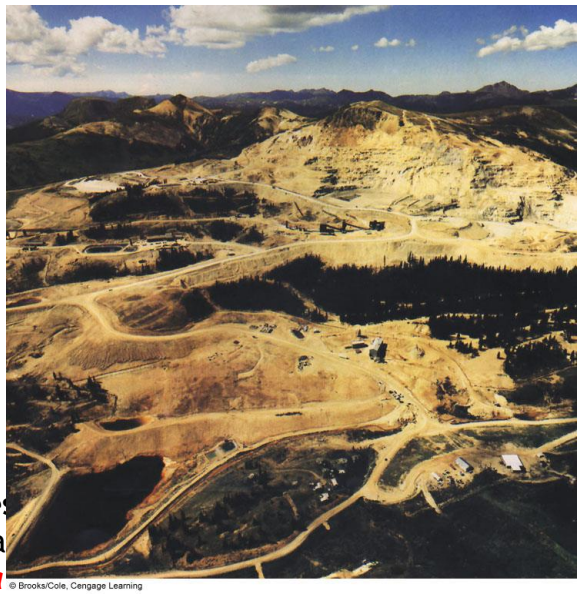
*Particles of toxic metals blow by the wind or leached from tailings by rainfall can contaminate *surface water and groundwater*

After removal of the gangue, *smelting* is used to release metals from the ore.

* Smelting releases many air pollutants like *$SO_2$ and particulates that acidify soil and damage vegetation*

Summitville Gold Mine:

*A Canadian company used the 1872 mining law to buy the land very cheap.
*They spent $1 million to develop the site.
*They mined $98 million worth of gold…
*During the mining process, they used highly toxic cyanide salts to extract gold from ore.
*Then they declared bankruptcy and walked away without cleaning anything up!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**How Long Will Supplies of Nonrenewable Mineral Resources**

Which 5 nations supply the most nonrenewable minera
*US, Canada, Russia, South Africa, and Australia*

The US *imports* some resources (even though they can be found in US) because we use them *faster* than they can be produced.

The future supply of a nonrenewable mineral depends on:

1. *the actual or potential supply* 2. *the rate at which we use it*

A mineral becomes *economically* depleted when it costs more than it is worth to find, extract, transport, etc.

At this point we can do one of five things:

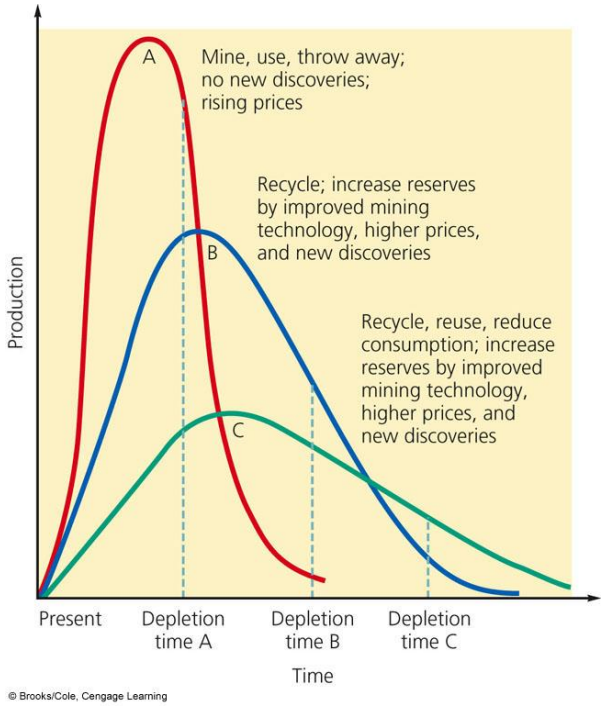
1. *recycle or reuse* existing supplies
2. *waste* less
3. *use* less
4. find a *substitute*
5. do without (I know… crazy!)

*Depletion* Time- time it takes to use of *80*% of the reserve at a given rate

Which curve represents the shortest depletion time? *Curve A*

Which curve relies heavily on recycling or hope that better mining technology will be invented? *Curve C*

Most mineral prices are kept artificially *low* because of government *subsidies* to help promote economic growth.




US General Mining Law of 1872- some people have gotten rich off this little known law!

-designed to encourage mineral *exploration* and the mining of *hard rock* minerals on US lands to help develop the then sparsely populated West.

-allows people to buy land very *cheap* if they file a claim stating that they believe the land contains valuable minerals

Improvements for Mining:

1. Extract minerals from *lower* grade ores to increase supplies
2. Use *bacteria* that can extract minerals- "biomining"
3. *Hydrothermal* ore- deposits form when super-heated water shoots out of vents in the ocean

**How Can We Use Mineral Resources More Sustainably?**

Materials Revolution- *silicon*, ceramics, and *plastics* are used in place of metals.


3M's 3P Program:

1. Redesigned equipment and processes
2. Uses fewer hazardous materials
3. Cut waste and air pollution

Mimic How *Nature* Deals With Waste:

-waste output becomes nutrient input for another

-reuse or recycle mineral products

-resource exchange webs

-ecoindustrial parks- some are being built on abandoned industrial sites, called brownfields

-biomimicry

**Core Case Study: Water Conflicts in the Middle East**

1. Why are Ethiopia, Sudan, and Egypt fighting over water?

   *These countries face water shortages and there is tension over the water they must share from the Nile River. Egypt draws from the river a lot because of very little rainfall. Ethiopia and Sudan plan to divert some of the water from the Nile to meet water and food needs of its growing population. Upstream diversion would reduce the water available downstream.*

2. How can their conflicts be solved?

   *Negotiations on water agreements, slowing population growth, cutting waste water, raising water prices to encourage the improvement of irrigation efficiency, and increasing grain imports*

**Will We Have Enough Usable Water?**

Why is access to water a global health issue?

*The lack of water that is safe for drinking and sanitation is the world's largest cause of illness. 1.6million+ people die each year from preventable waterborne diseases.*

Why is access to water an economic issue?

*Water is a vital for reducing poverty and producing food and energy.*

*Women & children are often the ones responsible for finding water in poor countries.*

Why is access to water an environmental issue?

*Excessive withdrawal of water from rivers and aquifers and pollution of water results in lower water tables, lower river flows, shrinking lakes, losses of wetlands, declining water quality, declining fish populations, species extinction, and degradation of ecosystem services.*

What percentage of freshwater can we readily use? *0.024%*

Define: Groundwater- *precipitation that has infiltrated the ground and percolates downward through spaces in soil, gravel, and rock until an impenetrable layer of rock stops it*

Zone of saturation- *the spaces in soil that are completely filled with water*

Water table- *top of the groundwater zone*

Aquifer- *underground caverns and porous layers of sand, gravel, and bedrock through which groundwater flows very slowly*

How do aquifers recharge?

1. Natural recharge- *replenished by rain that percolates the soil*
2. Lateral recharge- *rivers and streams replenish from the side*

Surface water- *rivers, streams, lakes, wetlands, estuaries, ocean*

Surface runoff- *precipitation that does not infiltrate the ground*

Watershed (drainage) basin- *the land from which surface water drains*

What is the difference between a confined and unconfined aquifer?

*Unconfined Aquifer- aquifer with a permeable water table*

*Confined Aquifer- bounded above and below by less permeable beds of rock*

70% of withdrawn water is used to *irrigate cropland*.
20% of withdrawn water is for *industry*
10% of withdrawn water is for *city and residential use*

Where does most of our water get used:

| EAST COAST | | WEST COAST |
|---|---|---|
| *Energy production, power plant cooling, manufacturing* | MAJOR USE(S) FOR WATER | *Irrigation of crops* |
| *Flooding, occasional urban shortages, occasional droughts* | MAJOR WATER PROBLEM(S) | *Shortages caused by low precipitation, high evaporation, and recurring droughts* |

Define: Drought- *prolonged period in which precipitation is at least 70% lower and evaporation is higher than normal*

Water hotspot- *areas in which competition for scarce water could trigger political and legal conflicts*

How many western states have water hotspots? *17*

List the harmful environmental effects of long-term severe drought:

*. dries out soil*

*. reduces stream flow*

*. decreases tree growth and biomass*

*. lowers NPP*

*. reduces crop yield*

*85%* of Americans get their water from public utilities

What are 2 potential problems with full privatization of water resources?

1. *Private companies may ignore conservation methods in order increase profits.*
2. *The poor will often have to go without water.*

**Is Extracting Groundwater the Answer?**

Aquifers provide *drinking water and irrigation water for farmers.*

Why are water tables are falling in many areas of the world?

*The rate of pumping water from the aquifers exceeds the rate of natural recharge.*

| Advantages | Withdrawing Groundwater | Disadvantages |
|---|---|---|
| • *Useful drinking and irrigation*<br>• *Available year round*<br>• *Renewable if not over-pumped*<br>• *No evaporation losses* | | • *Depletion from over-pumping*<br>• *Land subsidence*<br>• *Aquifers polluted*<br>• *Saltwater intrusion* |

Describe the problem of groundwater depletion in the United States, especially over the Ogallala aquifer.

*Water is being pumped faster than it can be recharged. The Ogallala Aquifer is underneath 8 Midwestern States that constantly pumps massive amounts of water for irrigation.*

List some other harmful effects of overpumping aquifers.

- *Limits future food production*
- *Increased costs associated with the need for deeper wells, bigger pumps, and more electricity*
- *Land subsidence- sinkholes → damages roadways and buildings*

Describe two ways to prevent or control groundwater depletion.

1. *Waste less water*
2. *Set and enforce minimum stream flow levels*

**Is Building More Dams the Answer?**

The main goal of a dam and reservoir system is to:

*Capture and store runoff and release it as needed to control floods, generate electricity, and supply water for irrigation.*

| Advantages | Dams and Reservoirs | Disadvantages |
|---|---|---|
| • *Provides irrigation water*<br>• *Provides drinking water*<br>• *Recreation and fishing*<br>• *Can produce cheap electricity (hydroelectricity)*<br>• *Reduces downstream flooding* | | • *Flooded land destroys forests and displaces people*<br>• *Large losses of water through evaporation*<br>• *Deprives downstream cropland of nutrient rich silt*<br>• *Disrupts migration and spawning of some fish* |

Describe some problems associated with the use of the Colorado River Basin.

1. *The Colorado River Basin includes some of the driest lands in the US and Mexico.*
2. *Modest flow of water*
3. *Legal pacts signed in 1922 allocated more water for human use than the river can supply.*
4. *Since 1950, the amount of water flowing to the mouth of the Colorado River has dropped dramatically.*
5. *The water available is likely to decrease more due to global warming.*

| Advantages | | Disadvantages |
|---|---|---|
| • *Can supply a large amount of energy*<br>• *Helps hold back floodwaters from the Yangtze River*<br>• *Provides cheaper transportation routes for cargo* | China's Three Gorges Dam | • *Displaced over 5 million people*<br>• *A large area had to be flooded for the construction of the dam*<br>• *Downstream farming areas will no longer receive nutrient rich sediments*<br>• *Many worry it will collapse because it is built on a seismic fault* |

**Is Transferring Water from One Place to Another the Answer?**

Describe the California Water Project and the controversy over this water transfer project.

*-uses a maze of dams, pumps, and aqueducts to transport water from the water-rich northern California to the water-poor southern California's heavily populated agricultural regions and cities*

*Arguments:*

*-sending water to the south degrades northern fisheries and reduces the river's power to flush out pollutants*

*-however, sending water to the south will help support food production*

Describe the Aral Sea Disaster.

*-the shrinking Aral Sea is the result of a large scale water transfer project in the former Soviet Union*

*-since 1960, water has been transferred inland for agriculture*

*-this large scale water project has caused regional ecological and economic disaster*

*-the sea's salinity has risen 7fold*

*-water levels have dropped by 72 feet*

*-89% of the volume of water has been moved*

*-turbidity of the water has increased*

*-deadly bacteria has contaminated the water*

Describe China's South-North Water Transfer Project.

*-China has plans to transfer water from 3 southern river basins to its populous and dry northern regions*

*Concerns:*

*-the polluted southern waters will pollute the northern waters*

*-the southern ecosystems, especially wetlands, will be degraded*

**Is Converting Salty Seawater to Freshwater the Answer?**

Define: Desalination- *removing dissolved salts from ocean water or from brackish (slightly salty) water in aquifers or lakes for domestic use*

*Saudi Arabia* has the largest number of desalination plants.

| Distillation | Methods For Desalinating Water | Reverse Osmosis |
|---|---|---|
| • *Heating saltwater until it evaporates (leaving behind the salt) and condenses as freshwater* | | • *Uses high pressure to force saltwater through a membrane filter with pores small enough to remove the salt* |

What are the limitations of desalination and how might they be overcome?

1. *High cost and large energy footprint*
2. *Many marine organisms are killed during the process of pumping in the sea water.*
3. *Produces a large quantity of brine (wastewater that contains a lot of salt) and dumping this back into the ocean increases the salinity at the dump site*

**How Can We use Water More Sustainably?**

*65-70%* of the world's water is wasted unnecessarily.

List two causes of this waste:

1. *evaporation*
2. *leaks*

Main causes of water waste:

1. *Low cost to users because of government subsidies*
2. *Lack of government subsidies to improve efficiency for water use*

Describe four irrigation methods. Sketching a picture of each may be helpful.

1. *Flood Irrigation- large amounts of water are pumped onto the land and gravity causes the water to flow through the field*
   ***much more water is used than needed and about 40% is lost to evaporation*
   ***this is the least efficient type of irrigation method*

2. *Center Pivot Sprinklers- uses pumps to spray water on a crop in circular irrigated areas*
   ***20% of water is lost to evaporation*

3. *Low Energy Precision Application (LEPA) Sprinklers- another form of center pivot sprinklers that is even more efficient*
   ***10% of water is lost to evaporation*

4. *Drip Irrigation- consists of a network of perforated plastic tubes installed at the ground level, small holes deliver drops of water precisely to the crop*
   ***only about 5% of water is lost due to evaporation*
   ***this is the MOST efficient method*

Describe ways you can reduce your own water waste.

*-Use water saving toilets*
*-repair water leaks*
*-wash only full loads of clothes*

*-use recycled water (gray water) for watering lawns, houseplants, and washing cars*
*-water lawns only in the early morning or evening*

**How Can We Reduce the Threat of Flooding?**

Floodplain:

| What makes an area a floodplain? | Advantages of living on a floodplain. | Disadvantages of living on a floodplain. | How are humans making it worse? |
|---|---|---|---|
| *Includes highly productive wetlands that help provide natural flood and erosion control, maintain high water quality, and recharge groundwater* | *-fertile soil*<br>*-ample water for irrigation*<br>*-nearby rivers can be used for transportation*<br>*-recreation area* | *-floods kill thousands each year*<br>*-possible property damage* | *-removal of water absorbing vegetation has led to severe flooding*<br>*-removing mangrove forests have increased flooding and damage from storms*<br>*-building on floodplins* |

Describe why Bangladesh is a dangerous place to live.

*-massive flooding takes place every years or so and is intensified by deforestation, overgrazing, and unsustainable farming*
*-storm surges, tsunamis, and cyclones occur frequently as well*

Describe two ways to reduce flood damage:

1. *Preserve forests and wetlands*

2. *Build levees and dams*