

1  **Water Resources**

Chapter 14

2  **Water's Unique Properties**

- **Hydrogen bonding**
- **Liquid over wide temperature range**
- **High specific heat**
- **High heat of evaporation**
- **Good polar solvent**
- **Neutral pH**
- **Adhesion / cohesion**
- **Less dense as a solid; most dense at 4C**

3  **Supply of Water Resources**

4  **Surface Water**

- **Surface runoff: doesn't infiltrate**
- **Reliable runoff: stable source of water, not lost to flooding**
- **Watershed: drainage basin**

5  **Groundwater**

- **Groundwater: the water that infiltrates and percolates through spaces**
- **Zone of saturation: no spaces**
- **Water table: top of zone of saturation**
- **Zone of aeration: above water table**
- **Aquifer: water saturated layers of sand, gravel or bedrock**
- **Recharge area: area where water infiltrates/percolates to aquifer**
- **Discharge area: water moving from aquifer to spring, lake, well, geyser, stream, ocean**

6

7  **Use of Water Resources**

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9  **Water and Grain Wars in Middle East**

- **Nile supplies Ethiopia, Sudan, and then Egypt**
- **Tigris and Euphrates supply Turkey, Syria, Iraq, Jordan, and then Israel**
- **As each country diverts more water for growing populations, less is available downstream for irrigation**
- **Less water for farming means more imported grain**
- **Dams impair ecological services**

10

11  **Uses of Water**

- Some of the water we use, as in irrigation, or manufacturing or residential can or is returned to the hydrologic cycle
- Consumptive water use: water can't be returned to its source due to evaporation or contamination

12  **Freshwater Use in US**

1 WEST

- Irrigation 85%
- Low runoff/low precipitation
- High evaporation
- Recurring prolonged drought
- Aquifer depletion

2 EAST

- Energy production
- Cooling/ manufacturing
- A lot of water available
- Flooding
- Occasional urban shortages
- pollution

13

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15  **Paucity of Freshwater**

- Dry climate
- Drought (21 days, 70% lower)
- Desiccation
  
- Water stressed: vol / person < 1700 m<sup>3</sup>y<sup>-1</sup>
- scarcity: volume/ person < 1000 m<sup>3</sup>y<sup>-1</sup>
- Hydrologic poverty: can't afford safe drinking water

16  **Means to > Water Supply**

- Build dams/reservoirs
- Transport surface water
- Tap groundwater
- Desalination
- Waste less
- Import food (reduce irrigation)

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- 19  **Population: Water Supply**
- Developed countries: live where climate is favorable and transport water from other watersheds
  - Developing countries: live near water source or capture necessary precipitation
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- 21  **“Poverty is principal cause of hunger, malnutrition, and lack of access to sufficient water, regardless of how much water is available.”**
- Miller, G.T. Living in the environment, 13<sup>th</sup> ed, 2004, p 318.
- 22
- 23  **Ecological Services Provided by Rivers**
- Deliver nutrients to the sea, sustaining coastal fisheries.
  - Deposit silt that maintains deltas
  - Purify water
  - Renew and nourish wetlands
  - Provide habitats for aquatic life
  - Conserve species diversity
- 24  **Transferring Water from One Place to Another**
- Watershed transfer
  - California water project
  - Central Arizona Project
  - James Bay
- 25  **Colorado River Basin**
- Flows from Colorado to Gulf of California
  - 14 major dams; many smaller dams; aqueducts
  - Supplies energy and water to 7 states
  - Legally, water drained is more than water present-no longer drains in Gulf of CA
  - No spawning, no estuaries, saltwater intrusion
  - Fighting over water rights moot if no water
- 26
- 27  **Other Major Projects**
- China’s Three Gorges Dam on Yangtze

- Aswan High Dam on Nile
- California Water Project Sacramento River
- Canada James Bay Watershed Transfer (19 rivers)
- Aral Sea, Syr Dar'ya, Amu Dar'ya

28

29  **Withdrawing Groundwater**

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- Advantages
- Removed as needed, no seasons
  - No evaporation losses
  - Less expensive than dams/reservoirs/ aqueducts
  - Drinking water; irrigation

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- Disadvantages
- Water table lowering
  - Aquifer depletion
  - Aquifer subsidence
  - Saltwater intrusion
  - Polluted groundwater drawn into wells
  - Reduced stream flow (less discharge)
  - Can be contaminated by human activities
  - Used unsustainably

30

31  **Areas of Decreasing Water Table**

- North China Plain
- Southern Great Plains in US (Ogallala aq)
- SW US (CA central valley)
- Parts of India (Punjab)
- Parts of Saudi Arabia
- Northern Africa (Libya & Tunisia)
- Southern Europe
- Middle East
- Mexico
- Thailand
- Pakistan

32  **Tragedy of Commons**

- Degradation of renewable free access resources
- Examples include aquifers, groundwater, air, ocean, migratory birds, wildlife species, publicly owned lands, gases in troposphere, space
- Owned by no one govt, available to many at no charge, cared for/regulated by few or none

33

- 34  **Aquifer depletion**
- Overpumping product of better technology-diesel and electric pumps
  - Industry and cities outcompete agriculture for water, limiting future food production

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- 37  **Ogallala Aquifer**
- World's largest aquifer
  - 20% of US agriculture (\$32 billion, 2003)
  - nonrenewable since recharge rate slow
  - Govt subsidies designed to increase crop production increase depletion of aquifer
  - Farmers could switch crops, irrigate efficiently, or irrigate less land
  - City inhabitants could reduce water consumption

38

- 39  **Tapping Groundwater**
- Year-round use
  - No evaporation losses
  - Often less expensive
  - Potential problems:

- 40  **Problems with Using Groundwater**
- Water table lowering
  - Depletion
  - Subsidence
  - Saltwater intrusion
  - Chemical contamination
  - Reduced stream flows

- 41  **Methods of Slowing Groundwater Depletion**
- Control population growth
  - Shift to drought resistant crops
  - Develop crop strains that require less water
  - Efficient irrigation methods
  - Import grain

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44  **Methods of Reducing Water Waste in Industries**

- Redesign manufacturing processes
- Landscape yards with plants that require little water
- Use drip irrigation
- Fix water leaks
- Use water meters & charge for all municipal water use
- Raise water prices
- Require water conservation in water-short cities
- Use water-saving toilets, showerheads, & front loading washers
- Collect & reuse household water to irrigate lawns and nonedible plants
- Purify & reuse water for houses, apts, & office buildings

45  **Desalination**

- Methods: distillation, reverse osmosis
- Supplies 0.2% of global water requirements
- Expensive: costs 2x conventional purification methods
- Produces large quantities of briny water

46  **Other Methods to Obtain Freshwater**

**Cloud seeding**

**Ice Floes**

47  **Using Water More Efficiently**

- **Reduce losses due to leakage**
- **Reform water laws (subsidies/privatize)**  
doctrine of riparian rights  
principle of prior appropriation  
common law (ground water)
- **Improve irrigation efficiency**
- **Improving manufacturing processes**
- **Water efficient landscaping**
- **Water efficient appliances**

48  **Effects of Flooding**

- Water overflows onto floodplain
- Provides natural flood control
- Provides erosion control
- Maintains water quality
- Recharges groundwater
- Soil is fertile
- water for irrigation
- Refill wetlands

49  Why flood severity is greater

- Vegetation has been removed
- Wetlands have been drained
- Urbanization-> impervious surfaces

50  Too Much Water: Floods

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54  Ways to Reduce Flood Risk

- Channelization of streams (increases flow rate, erosion, habitat reduction)
- Levees (increases flow rate, no protection against unusually high floodwaters)
- Dams (store water, all usual problems associated w dams)

55  Sustainable Use of Water

- No aquifer depletion
- Preserving ecological health of aquatic systems
- Preserving water quality
- Integrated watershed management
- Agreements among regions and countries sharing surface water resources
- Outside party mediation of water disputes between nations
- Marketing of water rights
- Wasting less water
- Decreasing government subsidies for supplying water
- Increasing government subsidies for reducing water waste
- Slowing population growth

56  Solutions: Achieving a More Sustainable Water Future

- **Efficient irrigation**
- **Water-saving technologies**
- **Improving water management**

57  If water is not used sustainably...

- Economic and health problems
- Increased environmental degradation
- Loss of biodiversity
- Tensions and economic competition over water supplies and food imports
- Larger numbers of environmental refugees from water scarce regions

58  Water Resources Objectives

- Describe Earth's water supply, comparing amounts of salt water to freshwater. Describe amount of freshwater available for human use.
- Summarize water use in the US and the world.
- List four causes of water scarcity. Describe the factors which play into a positive feedback loop creating water stress. Assess the significance of water resources for international relations.

59  Objectives

- List 5 ways to increase the water supply. List advantages and disadvantages of each strategy. Summarize a key lesson learned from the following case studies: Colorado River, Egypt's Aswan High Dam, California water project, James Bay project, the Aral Sea disaster.
- Describe the role of groundwater in supplying freshwater. Assess our current use of groundwater is it sustainable use?

60  Objectives

- Distinguish between riparian rights and prior appropriation as to regulate water use. Determine which principles are best illustrated by the Ogallala Aquifer experience.
- State the percentage of water wasted throughout the world. Briefly describe measures which can be taken to reduce water losses through irrigation, industry, and home use.

61  Objectives

- Describe the history of the development of the Columbia River Basin. Summarize the lessons learned from the problems that were generated and the plans to address those problems.
- List 3 ways that humans contribute to flooding. List 4 strategies humans employ to minimize the risks of flooding. Analyze the water problems of Bangladesh or New Orleans.

62  Objectives

- List and describe 4 ways humans use to control flooding. Evaluate which of these strategies is likely to have the best long-term results.
- Describe ways to contribute to sustainable water use.