Chapter 9

Water Resources

Water

- Most critical resource
- Covers 71% of Earth
- We arrange it to fit our needs
  - Drill wells, Dam/divert rivers, etc
- Renewable through hydrologic cycle
- 1.1 Billion lack safe drinking water
- 2.4 billion lack adequate sanitary facilities
- 2 million deaths/year due to lack of water
- 5 million deaths/year due to waterborne infections & diseases

Water on Earth

- Hydrosphere contains 1.36 billion cubic Km of water
- **Outgassing** – continuing process in which water/water vapor emerge from layers deep within and below the crust
  - Released in the form of gas
  - Visible in volcanic eruptions, geyser & seepage

Fig 9.1

Distribution of Earth's Water

- 97.22% - Oceans
- 2.78% - Fresh Water
  - Ice Sheets/Glaciers (geatest)
  - Groundwater (2nd largest)
  - Lakes/Rivers/Streams (less than 1%)

Fig 9.3

Hydrologic Cycle

- **Hydrologic Cycle** – Elaborate open global system of water, water vapor, ice and associated energy
- 3 components
  - Atmosphere
  - Surface
  - Subsurface

Fig 9.4

Water in Atmosphere

- **Evaporation** – Movement of free water molecules away from wet surface into air that is not saturated.
- **Transpiration** – Plants release water vapor into the air through small openings on their leaves called stomata
- **Evapotranspiration** – The water from evaporation & transpiration on all land surfaces

Water @ Surface

- 78% of all precipitation falls back to ocean
- 22% falls on land

- **Infiltration** – Precip that soaks into ground
- **Surface runoff/Overland Flow** – Water that does not soak in will flow downslope

Water in Subsurface

- **Percolation** – Slow passage of water downward into porous substances like soils and rock
- Once soil is saturated, water surplus moves gravitationally into deep groundwater
- Top of the groundwater zone is the water table

Fig 9.5

- Groundwater under natural conditions ultimately flows to the oceans.

Water Budgets & Resource Analysis

- Concept of the **water budget** was created to analyze water resources in specific areas to solve real-world problems.
- Precip is income and it must balance against expenditures:
  - Evap/transp/runoff
- Savings account – subsurface water
- After expenditures, if there is extra water = surplus
- If there was not enough = deficit

Water Budget

- Water Supply
  - Precipitation: rain, sleet, snow, hail
  - Measured with a rain gauge

Fig 9.6

Annual Average precip in North America

Fig 9.7

Water Budget: Water Demand

- Evapotrans is an expenditure

- **Potential Evaporation** – Amount of water that *WOULD* evaporate and transpire under optimum moisture conditions
- Compare: Annual Potential Evapotrans to Annual Precip

Fig 9.8 Fig 9.7

Water Budget: Water Storage

- **Soil-Moisture Storage** – Volume of water in the subsurface soil-moisture zone accessible to plant roots
- **Soil-Moisture Utilization** – When water demand exceeds the precip supply, plant use the moisture in the soil

Water Budget: Deficit & Surplus

- Deficit in Water Budget occurs when potential evapotranspiration cannot be met by precip inputs by soil moisture, or artificial inputs (irrigation)

- Surplus occurs when additional water exists after potential evapotrans is satisfied
- Surplus results in runoff & groundwater recharge

Drought: The Water Deficit

- **Drought**: Less precip & higher Temps make for drier conditions over an extended period of time.
  - Affects: Agriculture/ Water Storage/Socioeconomic (Wild Fires)
- Natural & Recurrent
- Scientists think it's natural climate change (speed increased by humans) a poleward expansion of subtropical dry zones

Surface Water Resources

- Humans require a steady water supply, so we rely on large-scale management projects to redistribute water geographically or to store it.
- Snow & Ice
  - Glaciers, permafrost, polar ice (semi-permanent storage)
- Rivers & Lakes

Fig 9.14

Effects of Climate Change of Lakes

- Increase air Temps are affecting lakes all over the world
- Some levels rise (Increase glacial melt)
- Some levels fall (Drought & High Evap)
- Normal Mixing b/w deep & surface water is on decline

Hydroelectric Power

- Flood control & water supply storage are 2 primary purposes for dam construction
- Power production is an associated benefit
- Hydroelectric power/Hydropower – Electricity generated using power of moving water
  - Supplies 1/5 of world's electricity
  - Most widely used source of renewable energy
  - Hightly variable because it depends on precip
  - In US –we already built dams in best places

Water Transfer Projects

- Transfer of water over long distance in pipelines and aqueducts
- Imp. To dry regions where most dependable resources are far away from population centers

Fig 9.16

- CA Water Project – system of storage reservoirs, aqueducts and pumping plants to rearrange state's water budget

Wetlands

- **Wetlands** – an area that is permananetly or seasonally saturated with water
- Fresh or saltwater
- Marshes, swamps, bogs & peat lands
- Occur along river channels & lake shores
- Recharge groundwater
- Improve water quality by trapping sediment & removing nutrients /pollutants

Groundwater Resources

- Groundwater – Lies beneath the surface, past where most roots can get to it
- Important part of hydrocycle & tied to surface supplies through recharge
- Largest potential freshwater source
  - Larger than all surface streams & lakes combined
- Provides 80% of world's irrigation water
- Provides almost 50% of world's drinking water

Fig 9.17

Groundwater Environment

- Precip is main source of groundwater
- Water percolates down through **Zone of Aeration** into **Zone of Saturation**
- Upper limit of Zone of saturation is called Water Table

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Aquifers & Wells

- Aquifer – Subsurface layer of permeable rock or unconsolidated materials through which groundwater can flow in amounts adequate for wells and springs
  - Unconfined
  - Confined
  - Artesian

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Groundwater at Surface

- Where water table intersects the ground surface (#8) water flows in form of springs, streams, lakes, and wetlands

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- Effluent – Stream received water from ground
  - Ex: Mississippi River
- Influent – Stream feeds groundwater
  - Ex: Colorado/Rio Grande

Overuse of Groundwater

- **Drawdown** – When water table surrounding well becomes lowered because pumping rate exceeds recharge

  P. 244 9.1 examples

  – Creates a **cone of depression** around well
- Groundwater Mining – When aquifers are pumped beyond their flow & recharge capacities

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Desalination

- Declining fresh groundwater near coastlines have led to 14,000 desalination plant worldwide
- **Desalination** – Process that removes salt, organic compouds and debris from seawater, brackish water, and saline groundwater

Collapsing Aquifers

- Possible effect of removing groundwater – ground will lose internal support & collapse
  - Land subsidence
  - Cracks in foundations
  - Changes in surface drainage

Pollution of Groundwater

- If surface water is polluted, groundwater inevitably becomes contaminated during recharge
  - Industrial injection wells
  - Septic tank outflows
  - Seepage from hazardous waste disposal sites
  - Industrial toxic waste
  - Agricultural residue (pesticides, herbicides, fertilizers)
  - Solid waste urban landfills
  - Underground gasoline stroage tanks
  - Shale gas extraction/Fracking

Our Water Supply

- Accessible water supplies are not well coordinated with population distribution or where population growth is greatest

Table 9.1 P. 249

- Water resources are different from other resources because there is no alternative substance to water
- Increased conflict endangers public health
- In America, we must transition away from centralized water development projects & must find community based