Earth Resources: Geologic Controls, Human Use, and Associated Wastes

- Water
- Minerals
- Energy

**Renewable vs. Non-Renewable**

- Water in general
- Solar energy
- Hydroelectric power
- Wind energy
- Ground water in arid regions
- Fossil Fuels
- Metallic minerals

![Diagram of Resources and Reserves](image-url)
Population and Resource Use

Limits to Sustainability: The Ecological Footprint

A measure of one’s use of Earth’s “natural capital”, quantified in terms of the area of biologically productive land required to sustain resource and waste flows.

Assignment for next time: Take the Ecological Footprint Quiz at www.myfootprint.org
Water Resources

Reading
• Today: Ch 10 to pg 243
• Next week: Ch 10 to end

Sources of Fresh Water

(See Table 10.1 in Montgomery)

<table>
<thead>
<tr>
<th>Reservoir</th>
<th>% Fresh</th>
<th>% Unfrozen</th>
</tr>
</thead>
<tbody>
<tr>
<td>Atmosphere</td>
<td>0.04</td>
<td>0.2</td>
</tr>
<tr>
<td>Ice</td>
<td>73.9</td>
<td>---</td>
</tr>
<tr>
<td>Lakes + Streams</td>
<td>0.36</td>
<td>1.4</td>
</tr>
<tr>
<td>Ground water</td>
<td>25.7</td>
<td>98.4</td>
</tr>
</tbody>
</table>

Residence time – 11 days

decades to 1000s of yrs

1000 to >10,000 yrs  weeks to decades
Common misconceptions about ground water

Water held in “pores”

Porosity (%) = (vol. pores ÷ total vol. of solid+pores) x 100

- Volcanic rocks (basalt): 1-30*
- Fractured igneous and metamorphic rocks: <1-5
- Unconsolidated sediment: 25-55
- Carbonate rocks: 1-10*
- Fractured and bedded sedimentary rocks: 5-30
Ground Water Occurrence – Water Below the “Water Table”

Darcy’s Law and Permeability

\[ Q = -KA\frac{\Delta h}{L} \]

- **Q**: Flow rate
- **A**: Cross-sectional area
- **L**: Distance
- **K**: Permeability
- **\( \Delta h \)**: Head loss
- **DATUM**: Reference level

**K** depends on porosity, size of pores, connectedness and fluid properties

Intrinsic permeability
Ranges of Permeability (K)

Aquifers

Aquitards

Mapping Directions of Ground Water Flow
Unconfined and Confined Aquifers

Unconfined and Confined Aquifers
Major Aquifers in Wisconsin

Unconsolidated Deposits

Irrigation in Central Wisconsin
Major Aquifers in Wisconsin –
Dolomite of Eastern WI

Wequiock Falls
NE of Green Bay

Major Regional Confining Unit –
The Maquoketa Shale

Wequiock Falls
NE of Green Bay
Major Aquifers in Wisconsin – Cambrian-Ordovician Sandstone

Igneous and Metamorphic Rocks – mostly NOT aquifers
Impacts of Pumping Wells

Green Bay Cone of Depression

>100 years of pumping near Chicago and Milwaukee

Madison’s Cone of Depression

Pumping centers in Dane County
(Circles proportional to pumping)

Drawdowns in the Sandstone Aquifer
(Contours in feet)
Pumping in Coastal Areas – Saltwater Intrusion

Natural Conditions

Salt-Water Intrusion

Pumping from basins with interbedded sand and clay – Land Subsidence
Project “Moses” proposal to prevent flooding in Venice

Acceleration or triggering of sinkholes