Friday, October 3

Vans leaving @ 8 am tomorrow
river material & sediment transport
rivers represent a tiny fraction of Earth’s water
only 3% of water on land
of that, 99% in inland seas, ice & groundwater
hydrologic cycle (water cycle)

**Infiltration:** groundwater system

**Runoff:** surface water system

runoff = precipitation – (infiltration + evaporation)
Stream Systems

Each stream drains a specific portion of the landmass, this is called the **watershed** or **drainage basin**

Drainage basins are separated by **drainage divides**

Drainage divides may be distinct (mountain ridges) or much more subtle
Stream Systems

anatomy of a drainage basin
Tributaries are any smaller streams that feed larger streams within a drainage basin.
base level

level below which a river or stream cannot incise
what happens if base level changes?
stream order

A method of classifying or ordering the hierarchy of natural channels.

Stream order correlates well with drainage area, but is also regionally controlled by topography & geology.
rivers vs. streams

*stream* and *river* can be used interchangeably;

a stream is a small river
some definitions

A stream (or river) is a body of water that:

- Flows downslope along a clearly defined natural passageway
- Transports particles and/or dissolved substances (load)

The passageway is called the stream’s channel

The quantity (volume) of water passing by a point on the stream bank in a given interval of time is the stream’s discharge

A stream’s discharge may vary because of changes in precipitation or the melting of winter snow cover.

In response to varying discharge and load, the channel continuously adjusts its shape (and location).
Factors Controlling Stream Behavior

**gradient/slope**
rise over run, meters per kilometer \([S]\)

**cross-sectional area**
width \(\times\) average depth, expressed in square meters \([A]\)

**velocity of waterflow**
expressed in meters per second \([V]\)

**discharge**
expressed in cubic meters per second \([Q]\)

**load**
expressed as kilograms per cubic meter
dissolved matter generally does not affect stream behavior
Cross section profile

width [W] & depth [D]

\[ A = W \times D \]

Flat terrain \( W \gg D \)

Steep terrain \( W \sim D \)
Discharge \([Q]\)

Channel dimensions times the average velocity

Simple channel:

\[
Q = W \times D \times V
\]
downstream evolution

due to tributary contributions, discharge increases downstream but how do $W$, $D$, and $V$ adjust to the increasing discharge?

\[ Q = W \cdot D \cdot V \]

Traveling down a typical stream from its head to its mouth:
- Discharge increases
- Gradient decreases
- Stream cross-sectional area increases
- Width to depth ratio increases
Long profile

Gradient = \frac{\text{rise}}{\text{run}} = \frac{\text{elevation}}{\text{distance}}

i.e.: \text{ft/mi} or \text{m/km}
where does the stream move fastest?
Headwater streams move slowest

Mouth of stream moves fastest

Deeper stream moves faster than shallow streams -- less resistance from the stream bed
Discharge Measurement

- Velocity measurements $V$

0.6D

D
Velocity determination: Float Method

Inexpensive and simple

Measures surface velocity

Basic idea: measure the time that it takes an object to float a specified distance downstream
stage rating curves

river levels are typically measured as a stage.

Stage must be converted to discharge via a rating curve.
Field data generally indicate that channel width varies approximately as the square root of discharge.

\[ W \sim a(Q)^{1/2} \]

a is some multiplier...
The ratio of channel width to channel depth generally increases down stream.
Floods

A flood occurs when a stream’s discharge becomes so great that it exceeds the capacity of the channel, therefore causing the stream to overflow its banks.

Geologists view floods as normal and expected events.

**Recurrence interval:** the average time between floods of a given size

A flood having a recurrence interval of 10 years is called a “10-year flood.”
hydrographs

stream discharge is not constant with time
discharge varies with:
  seasonal climate variation
  individual rainfall events – note lag between rainfall peak & Q peak
floods

recurrence interval

magnitude
flood frequency

Bankfull flood occurs on average about every 1 to 2 years.

100 year flood occurs on average about every 100 years.
Floods

With an increased discharge and velocity during a flood, a channel can carry a greater load.

As discharge falls, the stream is unable to transport as much sediment.

At the end of the flood it returns to its pre-flood dimensions.
The material transported by a river is called its load.

There are three basic classes of load:

**Bed load**: sediment rolling, bouncing, and creeping along the river bed.

**Suspended load**: sediment that is fine enough to remain in suspension in stream (size depends on velocity and turbulence).

**Dissolved load**: the invisible load of dissolved ions (e.g. Ca, Mg, K, HCO₃).
The bed load generally constitutes between 5 and 20 percent of the total load of a stream. Particles move discontinuously by rolling or sliding at a slower velocity than the stream water. The bed load may move short distances by saltation (series of short intermittent jumps).
suspended load

Particles tend to remain in suspension when upward moving currents exceed the velocity at which particles of silt and clay settle toward the bed under the pull of gravity.

They settle and are deposited where velocity decreases, such as in a lake or in the oceans.
Dissolved Load

All stream water contains dissolved ions and anions

The bulk of the dissolved content of most rivers consists of seven ionic species:

- Bicarbonate (HCO$_3^-$)
- Calcium (Ca$^{++}$)
- Sulfate (SO$_4^{--}$)
- Chloride (Cl$^-$)
- Sodium (Na$^+$)
- Magnesium (Mg$^{++}$)
- Potassium (K$^+$)
- Dissolved silica as Si(OH)$_4$
### Sediment Size

<table>
<thead>
<tr>
<th>Type</th>
<th>Size (mm)</th>
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</thead>
<tbody>
<tr>
<td>Boulders</td>
<td>$&gt; 256$</td>
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<tr>
<td>Cobbles</td>
<td>80 - 256</td>
</tr>
<tr>
<td>Gravel</td>
<td>2 - 80</td>
</tr>
<tr>
<td>Sand</td>
<td>0.05 - 2</td>
</tr>
<tr>
<td>Silt</td>
<td>0.002 - 0.05</td>
</tr>
<tr>
<td>Clay</td>
<td>$&lt; 0.002$</td>
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</tbody>
</table>
The ability of a stream to pick up particles of sediment from its channel and move them along depends on the velocity of the water.
Downstream Changes in Particle Size

The size of river sediment normally decreases in size downstream
boulders in mountain streams → silt and sand in major rivers

2 primary reasons:
coarse bed load is gradually reduced in size by abrasion
coarser, heavier materials generally settle out first...
When a river eventually reaches the sea, its bed load may consist mainly of sand and silt.
and...

have a good weekend
see some of you before 8 am tomorrow

**SATURDAY...SHOWERS. SNOW LEVEL 6000 FEET.**

<table>
<thead>
<tr>
<th></th>
<th>FRI</th>
<th>FRI NIGHT</th>
<th>SAT</th>
<th>SAT NIGHT</th>
<th>SUN</th>
</tr>
</thead>
<tbody>
<tr>
<td>PARADISE (5420 FT)</td>
<td>45</td>
<td>37</td>
<td>42</td>
<td>32</td>
<td>45</td>
</tr>
<tr>
<td></td>
<td>S 9</td>
<td>S 16</td>
<td>SW 16</td>
<td>W 15</td>
<td>W 10</td>
</tr>
<tr>
<td>LONGMIRE (2700 FT)</td>
<td>52</td>
<td>45</td>
<td>50</td>
<td>39</td>
<td>55</td>
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<tr>
<td></td>
<td>SE 9</td>
<td>S 15</td>
<td>SW 14</td>
<td>W 14</td>
<td>W 11</td>
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Monday: beyond the beach...