WATERSHEDS 101
http://streamsidescience.usu.edu
AGENDA

• WHAT IS A WATERSHED?
• HOW DOES WATER MOVE THROUGH A WATERSHED?
• WHAT IS THE CONNECTION BETWEEN WATERSHEDS AND WATER QUALITY?
• WHAT CAN YOU MEASURE AND WHY?
WHAT IS A WATERSHED?

GEOGRAPHIC AREA WITHIN WHICH ALL WATER DRAINS TO A COMMON POINT.
WATERSHEDS ARE DEFINED BY STRUCTURE AND BY FUNCTION
ELEMENTS OF WATERSHED STRUCTURE

- GEOGRAPHY
  Size, latitude, longitude, elevation, aspect

- CLIMATE
  Total precipitation, precipitation patterns

- GEOLOGY
  Formation - volcanic, sedimentary, basic rock types, soil types and depth, erosion potential

- VEGETATION/ANIMALS
  Type, native/non native, riparian areas, uplands, patterns of use and migration

- HUMAN USES
  Development and land use patterns
Functions of watersheds

- Collect
- Transport
- Process and store

- Water
- Sediments, soils
- Dissolved minerals, metals, nutrients
- Biological material
• Watersheds are nested

• The scale you work at depends on the question you want to answer
What is causing “dead zones” in the Gulf of Mexico?
What is causing the scum in my back yard pond?
WATERSHEDS ARE THE LOGICAL GEOGRAPHIC UNIT FOR PLANNING:
How does a river change as it moves from headwaters to base of watershed?

Stream Order helps characterize types of streams.
- Tree canopy dominates the stream
- Most aquatic insects shred leaves
- Terrestrial insects abundant

- Some sunlight reaches the stream
- Aquatic insects collect and gather leaf bits, graze/scrape algae

- More sunlight reaches the stream
- Most aquatic insects graze/scrape algae, filter fine food particles
How to “delineate” a watershed...
DELINEATE YOUR WATERSHED
DELINEATE WATERSHED

• INSTRUCT STUDENTS TO USE THE BLUE MARKER TO TRACE THE MAIN CHANNEL (MAIN STEM) OF THE BEAR RIVER. HAVE STUDENTS START FROM THE RIVER’S MOUTH AT THE GREAT SALT LAKE AND CONTINUE TO THE HEADWATERS IN THE UINTA MOUNTAINS WILDERNESS AREA.

• 2. HAVE STUDENTS USE THE RED MARKER TO TRACE THE TRIBUTARIES OF THE BEAR RIVER. TO DO THIS, THEY SHOULD START AT GREAT SALT LAKE AGAIN. EACH TIME THEY ENCOUNTER A TRIBUTARY CONNECTING DIRECTLY TO THE BEAR RIVER, WHICH IS NOW TRACED IN BLUE, THEY SHOULD TRACE THE UNMARKED TRIBUTARY FROM ITS MOUTH TO ITS HEADWATERS WITH A RED MARKER.


• 4. FIND A SPOT ABOVE THE TOP OF EACH RIVER MARKED IN RED OR GREEN AND MARK IT WITH A PURPLE DOT TO INDICATE THE DIVIDE. USE THE EXAMPLE OF A SHALLOW BOWL TO EXPLAIN HOW TO IDENTIFY THE DIVIDE OF THE WATERSHED. THE RIM OF A BUCKET INCLUDES ITS HIGHEST POINTS, JUST LIKE A WATERSHED. FOR THE BEAR RIVER WATERSHED, HAVE STUDENTS MARK THE DIVIDE POINTS ON THE OUTSIDE OF THE WATERSHED ONLY. REMEMBER THAT STREAMS FLOW FROM HIGHER ELEVATIONS TO LOWER ELEVATIONS. THUS, EACH TRIBUTARY OR STREAM ACTUALLY BEGINS AT SOME POINT ON THE LAND ABOVE THE HEADWATERS, USUALLY A HILL, MOUNTAIN, OR SOME OTHER HIGH POINT. THESE HIGH POINTS DIVIDE THIS WATERSHED FROM THE ONE(S) NEXT TO IT.

• 5. HAVE STUDENTS TRACE THE DIVIDE BY CONNECTING THE DOTS WITH THE PURPLE MARKER. START AT THE MOUTH OF THE BEAR RIVER AT THE GREAT SALT LAKE AND MOVE IN A CLOCKWISE DIRECTION AROUND THE MAINSTEM. CONTINUE TO CONNECT THE DOTS ALL THE WAY AROUND UNTIL THE PURPLE LINE MEETS ITSELF BACK AT THE GREAT SALT LAKE.
The Water Cycle

- Precipitation
- Infiltration
- Water table
- Groundwater flow
- Runoff
- Water-vapor transport
- Condensation
- Solar energy
- Evapotranspiration
- Evaporation
NATURAL HYDROGRAPHS:

Oct  →  Sept

Flow (cfs)
NATURAL VARIABILITY

Little Bear River at Paradise, UT

cfs
MODIFIED HYDROGRAPHS:

![Graph showing modified hydrographs with urbanization and reservoir effects between October (Oct) and September (Sept), with flow (cfs) on the y-axis and time on the x-axis. The urbanization line is red, and the reservoirs line is green, with the reservoirs line being lower and smoother than the urbanization line.](image-url)
URBAN IMPACTS
The Water Cycle

- Precipitation
- Infiltration
- Water table
- Groundwater flow
- Runoff
- Water-vapor transport
- Evaporation
- Evapotranspiration
- Condensation
- Solar energy
- Ocean

The cycle starts with solar energy heating the water, leading to evaporation, which then forms clouds. Condensation occurs in the clouds, forming precipitation which can fall as rain or snow, replenishing the water table and starting the cycle again.
Less infiltration and more runoff
What is the connection between watersheds and water quality?

Everything that happens in a watershed can affect the quality of the water downstream

....“we all live downstream”
WATER QUALITY IS REGULATED THROUGH CLEAN WATER ACT (1972)

• WATERS OF U.S. MUST BE “FISHABLE AND SWIMMABLE” BY 1983

• ELIMINATE ALL POLLUTION DISCHARGE TO WATERS BY 1985

Cuyahoga River, June 22 1969

What is Clean Water?

Safe to drink?

Distilled?

Crystal clear?
There is no single definition of clean water.

The Clean Water Act defines clean water according to how we use it.
How do we use water?

Beneficial uses:

- Drinking water
- Agriculture
- Recreation
- Fisheries and other aquatic life
- Aesthetics
- Industry

What pollutants affect the use of a drinking water source?

Bacteria, metals, organic pollutants, nitrates, pH, sediments, PPCPs
What pollutants affect the use of an agriculture water source?

Salts and a few metals
What pollutants affect the use of a recreation water source?

Bacteria, pH, turbidity, nitrate, phosphorus, sediments
What pollutants affect the use of a water source for aquatic life?

Metals, organic pollutants, pH, temperature, dissolved oxygen, ammonia, sediments
HOW DO YOU KNOW IF YOU HAVE CLEAN WATER?
Elements to Consider:

• Physical

• Biological

• Chemical
Physical Monitoring
(stream form, substrate)

Advantages:
- Reflects hydrologic impacts
- Relatively low cost

Disadvantages:
- May not reflect actual water quality
- May be subjective
- Lack of repeatability
Biological Monitoring
(macroinvertebrates, algae, fish)

Advantages:

Integrates impacts over time
Biological impacts = loss of beneficial use
Easy to collect

Disadvantages:

Need for reference sites
High degree of heterogeneity in samples

http://www.youtube.com/watch?v=4UjlT7fqlJg
Chemical Monitoring
(water column)

Advantages:

- Standardized Methods
  (Repeatable, Comparable)
- Easy to Collect
- Related to toxicity or other impacts

Disadvantages:

- Discontinuous in time and space
Pollution Source Types:

Point sources

Nonpoint sources
Water quality testing targets the pollutants that affect different beneficial uses.
Water measurements and observations we will make in the field are:

- Temperature
- Dissolved Oxygen
- Nitrates
- pH
- Turbidity
- Land uses
- Flow (qualitative)
Features of the watershed and sources of pollutants that may cause water quality to change.

<table>
<thead>
<tr>
<th>Structural Elements</th>
<th>Human Impacts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Narrow valley, steep, fast river</td>
<td>Pipes</td>
</tr>
<tr>
<td>Wide valley, wide slow river</td>
<td>Canals coming in</td>
</tr>
<tr>
<td>Shade near the stream</td>
<td>Changes in flows</td>
</tr>
<tr>
<td>Vegetated banks</td>
<td>“rip rap”</td>
</tr>
<tr>
<td></td>
<td>Nearby land uses</td>
</tr>
<tr>
<td></td>
<td>Animals</td>
</tr>
</tbody>
</table>
Temperature
Why do we care about temperature?

• Fish and other aquatic life

• Other effects....
  • How much oxygen water can absorb
  • The toxicity of ammonia
What causes temperatures to rise?

**Natural causes:**
- Seasons
- Length of river
- Location of river
- Hot springs

**Human causes:**
- Removal of streamside vegetation (shade)
- Runoff over concrete and other heated surfaces
- Changes in stream shape
- Reductions in flow
- Impoundments
- Industrial discharges
Temperature standards for fish in Utah

In Utah…:

Maximum Temperature:

for warmwater fish is 27°C (80.6°F)

for coldwater fish is 20°C (68°F)
Dissolved Oxygen
Why do we care about dissolved oxygen (DO)?

• Fish and other aquatic life

• Other effects…
  • Oxygen in water affects solubility of metals and other chemicals
What causes oxygen concentrations to change?

**Natural causes:**
- Uptake by organisms
- Natural increases in temperature
- Quiet water (low re-oxygenation)

**Human causes:**
- Any source of biological material that will decay in water
- High temperatures or low flows
- Excessive plant growth in water
### DO standards for fish in Utah

<table>
<thead>
<tr>
<th></th>
<th>Cold water</th>
<th>Warm water</th>
<th>Nongame water</th>
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</thead>
<tbody>
<tr>
<td>30 Day Average</td>
<td>6.5</td>
<td>5.5</td>
<td>5.0</td>
</tr>
<tr>
<td>1 Day Average</td>
<td>8.0/4.0</td>
<td>5.0/3.0</td>
<td>3.0</td>
</tr>
</tbody>
</table>

In Utah…: Minimum Dissolved Oxygen (mg/L or ppm)
Nitrates
The Nitrogen Cycle

Source: Gilbert Graphics
Why do we care about nitrates?

• Excessive plant growth

• Health concerns
What causes nitrogen concentrations to change?

Natural causes:
  Seasonal changes
  Plant uptake

Human causes:
  Land uses in the watershed
    • Fertilizers, animal manure
    • Malfunctioning septic systems
    • Discharges from sewage facilities and acid precipitation
Nitrate Standards for Utah

- The maximum concentration of nitrate allowed in drinking water is 10 mg/L.

- The state of Utah considers nitrate concentrations of 4 mg/L to be an indicator of pollution problems.
pH
pH = the level of acidity or alkalinity in a solution

**pH Scale:**

- Pure Hydrochloric Acid
- Vinegar, Wine, Orange Juice
- Milk
- Baking Soda
- Bleach
- Pure Sodium Hydroxide

- 0.0: Gastric Fluids, Lemon Juice
- 7.0: Rain Water 5.6, Sea Water
- 14.0: Household Ammonia, Oven Cleaner
Why do we care about pH?

• Low pH can affect membranes
  (eg. gills of fish or macroinvertebrates and eggs)

• At low pH, causes some metals to dissolve into a more toxic form

• At high pH, ammonia is more toxic
What causes pH to rise or fall?

Natural causes:
- Rain is naturally acidic
- Rapid snow melt
- Photosynthesis in water $\rightarrow$ higher pH

Human causes:
- Combustion causes acids in the atmosphere
  $\rightarrow$ acid precipitation
- Industrial discharge
- Mine drainage
An acceptable pH range is 6.5 – 9.0
Sediment (Turbidity)
Why do we care about sediments in streams and lakes?

• Can fill space between cobble in stream and smother fish eggs and tiny aquatic life

• Very cloudy water affects visual predators

• Sediments fill in reservoirs

• Sediments bring nutrients, metals, and more into water
What are sources of sediment in rivers?

**Natural causes:**

- Natural “reworking” of flood plain as stream meanders
- Remobilized bedload sediment under high flows
- Seasonal effects

**Human causes:**

- Runoff (construction, agriculture, forestry, mining)
- Stream banks erosion
Turbidity should not increase rapidly from site to site.

An increase of more than 10 NTUs violates water quality criteria.
Macroinvertebrates

- Good Water Quality vs. Poor Water Quality
Pollution Sensitive
Pollution Tolerant
Somewhat Tolerant
Education and Outreach

- Curricula and teacher training
- Citizen Monitoring – Utah Water Watch

http://extension.usu.edu/waterquality
https://extension.usu.edu/utahwaterwatch/
Education and outreach

➢ Program delivery

- Over 8,000 kids per year
  - Camps and field days
  - Classrooms and water fairs
FOR MORE INFORMATION, CONTACT USU WATER QUALITY EXTENSION AT (435)797-2580 OR VISIT HTTP://EXTENSION.USU.EDU/WATERQUALITY/
HTTPS://EXTENSION.USU.EDU/UTAHWATERWATCH/
Utah Water

- http://ut.water.usgs.gov/
- http://www.usclimatedata.com/climate/utah/united-states/3214
- http://lakepowell.water-data.com/