



Watershed Forensics: Four Teams, Ten Lessons

DRIVING QUESTION

How does a grain of rock get from solid bedrock to the bottom of the bayou, and where does the rain that carries it end up?

YOUR CHALLENGE

Build it. Make it work. Teach it. Your team is the class expert on three lesson parts, and your build is how you teach them.

THE PROJECT

The phenomenon

A storm that used to soak into the ground now reaches the bayou in a couple of hours, and the water runs brown with mud. That mud started as solid rock far upstream. Weathering broke the rock apart, and water, wind, ice, and gravity moved the pieces. Some of the rain soaked into the ground instead and is still moving slowly underneath us. To read this watershed you need all of Module 2. No one team can learn it all in time, so each team becomes the expert on one part and teaches it.

THE PROJECT

How it works

- Your group forms on your Scholar Dashboard and picks one focus.
- Each focus covers three Module 2 lesson parts.
- Each teammate leads one of your three lesson parts.
- In a group of four, the fourth teammate is the Verifier.
- Your team builds something that works.
- It is not a poster.
- It has to do something you can test.
- Your team keeps one shared group note in Note Studio.
- Everyone types in it at the same time.
- You photograph your build.
- When Dr. Ijezie approves the photos, they appear on the Module 2 page.
- On teach-back day your team teaches its three lesson parts with the build.
- Everyone learns all ten lessons.
- Each of you turns in the group note to the Assessment Center, like notes homework.

TEAMS

Four teams, four focuses

Three teams of three and one team of four. Every focus is part of the same driving question: how does rock become sediment, how does it move, and where does the water go?

TEAM	FOCUS QUESTION
Team 1 • Force Sculptors Mechanical weathering, wind, and glaciers	How do ice, wind, and plain force break rock apart and move the pieces, without changing what the rock is made of?
Team 2 • Rock Rot Chemical weathering, soil, and caves	How does water change the minerals in rock, turn rock into soil, and dissolve caves underground?
Team 3 • Sediment Trail Erosion, runoff, streams, and wetlands	When rain lands on a slope, where does it go, and how does moving water carve the land and build it back up?
Team 4 • Soak and Slide Soil water, mass movements, and groundwater	What happens to rain that soaks into the ground, and when does that water make a slope give way?

TEAMS

Form your group

Groups form on your Scholar Dashboard. First come, first served: once a group takes a focus, no other group can take it.

1. Talk with your partners first and agree on the focus you want, plus a backup.
2. When Dr. Ijezie opens group forming, a pop-up appears on your Scholar Dashboard.
3. Your dashboard shows the opening time before then.
4. One person signs in to the Scholar Dashboard with their alias and PIN.
5. That person adds each partner by typing at least 3 letters of their alias.
6. Then they pick the group's focus and press Create group.
7. Taken focuses are crossed out.
8. Groups are 3 people.
9. One group in the class can have 4.
10. Everyone in the group now sees the group and focus on their own dashboard.
11. To change a group, talk to Dr. Ijezie.

WHO DOES WHAT

Team roles

EVERY TEAM

Lead Investigator

- Runs the lab investigation and the build tests, and records every setting and reading.
- Keeps the team on schedule and checks each day's checkpoint in the group note.
- Leads one of your three lessons.

Hands the raw readings to the Data Analyst by the end of Day 2.

EVERY TEAM

Data Analyst

- Does the team's calculation and checks it with the self-check.
- Builds the data table in the group note, with units on every number.
- Leads one of your three lessons.

Hands a checked table and one finished calculation to the Communicator by the end of Day 3.

EVERY TEAM

Science Communicator

- Leads the build and takes the build photos for approval.
- Plans the teach-back so every lesson gets equal time.
- Leads one of your three lessons.

Uploads at least two approved-quality photos by the test day.

ONLY THE TEAM OF FOUR

Verifier

- Repeats every test and calculation on their own and settles differences.
- Checks every number in the group note against its source.
- Helps each lesson lead and builds the strongest argument against the team's claim before teach-back.

Turns in a one-page verification log with the team's products. In a team of three, the Analyst writes the uncertainty statement and the Lead writes the counter-argument.

WHAT YOU MAKE

What every team makes

- **Working build** (Presented in class · Day 4).
 1. The thing your team builds.

- 2. It must pass its 'It works when' tests at least twice.
- **Build photos** (Group note · Day 4).
 - 1. At least two clear photos of the build only (no faces or people), uploaded in your group note.
 - 2. Approved photos appear on the Module 2 page.
- **Group note** (Note Studio → Assessment Center · Day 6).
 - 1. Your shared Note Studio group note: your three lesson parts, build plan, test data, results, teach-back plan, and each teammate's own contribution and reflection.
 - 2. Each of you turns in your copy like notes homework.
- **Teach-back lesson** (Presented in class · Day 6).
 - 1. A ten-minute lesson: show the build working, then each lesson lead teaches their lesson part with it and asks one check question.

Your Note Studio group note

Open Note Studio and choose **ESS Group Project**. Your team types in one shared note at the same time, and nobody can erase a teammate's section.

Build plan and materials

- Sketch description.
- Materials list.
- Who brings what.

What this lesson teaches (one per lesson)

- Two to four key ideas.
- Vocabulary.
- One example.
- The lesson lead writes this; teammates add.

Build log and test data

- Every try:
- Date.
- What you changed.
- Results with units.

What our build shows and what it leaves out

- Claim.
- Evidence from your tests.
- One limit of the build.

Teach-back plan and check questions

- Who teaches what.
- In what order.
- One check question per lesson with the answer.

What I did (each scholar, only you type here)

- Your own work on each day.
- Only you type here.

My reflection (each scholar, only you type here)

- What you learned from another team.
- One thing you would change.

Turn in your copy

Photos: at least two of the build only, no faces or people. Dr. Ijezie approves them before they appear on the Module 2 page. On teach-back day:

1. Each of you presses Update my turn-in copy.
2. Turn it in on the Assessment Center.

THE PLAN

Six days, six checkpoints

DAY	WHAT HAPPENS	CHECKPOINT
Day 1 Wed, Sep 23	Form up and plan. Know your three lesson parts and plan the build. • Form your group on the Scholar Dashboard. • Pick your focus. • Open your group note in Note Studio. • Choose who leads each lesson part. • Read your lessons in the textbook and the Module 2 slides. • In the note, write two key ideas from each. • Sketch the build. • List the materials.	Group note: lesson leads chosen, two key ideas per lesson part, build sketch and materials list.
Day 2 Thu, Sep 24	Learn deeply. Become the expert on your lesson part. • Each lesson lead fills in their lesson section: key ideas, vocabulary, one example. • Run your team's Watershed Sandbox investigation. • Record every setting and reading. • Gather materials. • If your build needs ice, freeze it tonight. • If it needs crystals to grow, start them today.	Every lesson section filled in; lab readings recorded with units.
Day 3 Mon, Sep 28	Build. Build the thing and make it run once. • Build it. • Follow your build steps. • Try it once. • Write what happened and what you will fix. • Start anything that needs time: freezing, drying, or crystals growing. • Take progress photos (build only, no faces).	Build log in the group note; first try recorded.

DAY	WHAT HAPPENS	CHECKPOINT
Day 4 Tue, Sep 29	Test and photograph. Prove it works. • Run every 'It works when' test at least twice. • Record results with units. • Upload at least two photos of the finished build in the group note. • Do your team's calculation. • Check it.	Test data complete; two photos uploaded for approval.
Day 5 Wed, Sep 30	Improve and rehearse. Fix what failed, plan the lesson, and practise it. • Fix one thing that did not work. • Test again. • Plan the ten-minute teach-back: two minutes of demo, then each lesson lead teaches with the build. • Write one check question per lesson part, with an answer key. • Rehearse with another team. • They give one strength, one question, one fix. • Every teammate practises every part. • Each of you writes your own contribution and reflection in the group note.	Retest recorded; teach-back plan and three check questions in the group note; every teammate's contribution filled in.
Day 6 Thu, Oct 1	Teach-back day. Teach your lessons and learn all the others. • Each team teaches for ten minutes with its build. • Everyone takes learning notes. • Everyone answers every check question. • Press 'Update my turn-in copy' in the group note. • Turn it in to the Assessment Center. • Last-day partner review in the Assessment Center.	Teach-back given; learning notes; group note turned in; partner review done.

Force Sculptors

FOCUS QUESTION

How do ice, wind, and plain force break rock apart and move the pieces, without changing what the rock is made of?

Your team covers the mechanical side of Module 2: rock broken by force, and the two sculptors that grind and carry it, wind and ice. Rock Rot covers the chemical side, so listen to their lesson and compare.

Your lessons

1. Weathering — Mechanical Weathering

Publisher lesson: your textbook pages. Dr. Ijezie shares the pages in class.

2. Wind

Publisher lesson: your textbook pages. Dr. Ijezie shares the pages in class.

3. Glaciers

Publisher lesson: your textbook pages. Dr. Ijezie shares the pages in class.

Also read: Module 2 Slides — Earth's Surface & Water. Read the slide 'Two Ways Rock Comes Apart' (the mechanical side: frost wedging, unloading, thermal cycling, abrasion, and roots), the slide 'Sculptors of Wind & Ice', and the two glacial-deposit panels on till and outwash.

Big ideas you will use

- Mechanical weathering breaks rock into smaller pieces without changing its minerals. Frost wedging works because water expands about 9% when it freezes.
- Breaking rock multiplies its surface area. That gives chemical weathering more rock to attack.
- Wind carries little mass, so it sorts grains: dust floats away, sand hops along (saltation), and gravel stays behind.
- Glaciers pluck and scrape bedrock. Ice drops till, which is unsorted. Meltwater streams drop outwash, which is sorted by size.

Sculptor workbench: frost, wind, and ice

Build three working setups on one bench. Each one makes a mechanical process happen in front of the class: frost splitting rock, wind sorting sand, and a glacier carving a valley.

Materials

- A straight-sided plastic cup, water, a ruler, a marker, and a freezer (school or home)
- A plastic tub or deep box (the wind tunnel) and a hair dryer with a cool setting
- Dry sand mixed with small gravel
- A block of ice with gravel frozen into its bottom (freeze it in a small plastic tub the night before)
- A tray of modeling clay or damp, packed sand (the valley floor), and a handful of mixed sand and gravel
- Goggles and a timer

Your model must show

1. Mechanical weathering: water rises as it freezes, the push that splits rock in frost wedging.
2. Wind: moving air carries sand away in hops and leaves the heavier gravel behind.
3. Glaciers: gravel-studded ice scratches grooves into the valley floor and pushes an unsorted pile (a moraine) in front of it.

Build steps

1. Frost: pour water into the cup to exactly 5.0 cm deep and mark the level.
2. Freeze it overnight, then measure the height of the ice.
3. Wind: spread the sand-and-gravel mix 1 cm deep at one end of the tub.
4. Hold the hair dryer low and level, about 20 cm away, and blow cool air across the mix for 30 seconds.
5. Measure how far the sand moved and look at what stayed behind.
6. Glacier: sprinkle a thin layer of the mixed sand and gravel along the valley floor.
7. Press the ice block, gravel side down, onto the floor and push it slowly 20 cm down the valley.
8. Look for grooves and the pile at its front.
9. Leave it to melt at the end and check where the meltwater carried the grains.
10. Label each setup with its lesson.

It works when

- The top of the ice stands at least 0.3 cm above the 5.0 cm water mark.
- After 30 seconds of wind, gravel is left on top at the upwind end, and sand has piled up at least 10 cm downwind.
- The ice leaves grooves that run the same way it moved, and a mixed, unsorted pile at its front.

Test it: Run each setup twice. Record the water and ice heights in cm, the wind time in seconds, the distance the sand moved in cm, and the groove length in cm.

Safety: Wear goggles at the wind tunnel and keep the sand inside the tub. Keep the fan or hair dryer and its cord away from water and melting ice. Wipe spills right away.

Watershed Sandbox: Investigation D, The storm and the century are different questions

1. On Storm Sandbox, read the Event soil loss in tonnes per hectare per storm.
2. Switch to Century Time-Lapse.
3. Set Erosive storms per year to 8.
4. Record the yearly soil loss A in t/ha/yr and compare it with the USDA tolerance range of 2.2 to 11.2 t/ha/yr shown in the lab.
5. Set Vegetation cover to 0% and then 100%.
6. Record A each time.
7. Set Conservation practice to Terraces and record how far A falls.
8. Press Play century and find the year the soil runs out at your settings.

Calculate: Frost expansion and surface area

1. Water expands about 9% when it freezes.
2. A crack in a rock holds 20.0 cm³ of water.
3. Find the volume of the ice, and how much extra space the ice must force open.
4. Next, a 6 cm rock cube has a surface area of $6 \times 6 \text{ cm} \times 6 \text{ cm} = 216 \text{ cm}^2$.
5. Find the total surface area when each edge splits into 2 parts (8 small cubes), then into 3 parts (27 small cubes).

Self-check: Ice: $20.0 \times 1.09 = 21.8 \text{ cm}^3$, so 1.8 cm³ of extra space; $1.8 \div 20.0 = 9\%$. Surface area: $216 \rightarrow 432 \rightarrow 648 \text{ cm}^2$. It multiplies by the number of parts per edge.

Real data

- **Construction-site erosion rules** · U.S. EPA, Stormwater Discharges from Construction Activities. Find what construction sites must do to control soil erosion and sediment. Use it for your two fixes.
<https://www.epa.gov/npdes/stormwater-discharges-construction-activities> · Quote only what the page says.

A choice people make

1. Leaving soil bare, for example on a construction site, where wind and rain can carry it away.

Two options to compare

- Fences or rows of trees that slow the wind near the ground
- Covering bare soil quickly with seed, mulch, or erosion-control blankets

Your map hotspot

1. Mark the most open, bare ground on your map, where wind and rain can reach loose soil.

Trap to avoid

Weathering and erosion are not the same process. Frost can crack a rock in place for years without moving it anywhere.

TEACH IT

Show your build working, then teach:

1. Mechanical weathering breaks rock without changing its minerals; freezing water expands about 9% and pries cracks open.
2. Wind sorts grains: sand hops along and piles into dunes, and the gravel stays behind.
3. Glaciers scrape bedrock and drop unsorted till; their meltwater drops sorted outwash.

Check question: Why can water freezing in a crack split a rock apart?

Texas standards

- **ESS.9B** Investigate and model how surface water and ground water change the lithosphere through chemical and physical weathering and how they serve as valuable natural resources. §112.49(c)(9)(B) *You model how water changes rock by physical weathering (frost wedging).*
- **ESS.9C** Model the processes of mass wasting, erosion, and deposition by water, wind, ice, glaciation, gravity, and volcanism in constantly reshaping Earth's surface. §112.49(c)(9)(C) *You model erosion and deposition by wind and glaciers.*
- **ESS.2C** Use mathematical calculations to assess quantitative relationships in data. §112.49(c)(2)(C) *You calculate ice expansion and the surface area of broken rock.*
- **7.6C** Distinguish between physical and chemical changes in matter. §112.27(b)(6)(C) *Grade 6–8 foundation.*

Word bank: mechanical weathering · frost wedging · abrasion · saltation · deflation · loess · glacier · moraine

Rock Rot

FOCUS QUESTION

How does water change the minerals in rock, turn rock into soil, and dissolve caves underground?

Your team covers the chemical side of Module 2: rock that turns into new substances, the soil it becomes, and the caves that groundwater dissolves. Force Sculptors covers the mechanical side, so listen to their lesson and compare.

Your lessons

1. Weathering — Chemical Weathering

Publisher lesson: your textbook pages. Dr. Ijezie shares the pages in class.

2. Soil — How Soil Forms

Publisher lesson: your textbook pages. Dr. Ijezie shares the pages in class.

3. Groundwater Weathering and Deposition

Publisher lesson: your textbook pages. Dr. Ijezie shares the pages in class.

Also read: Module 2 Slides — Earth's Surface & Water. Read the slide 'Two Ways Rock Comes Apart' (the chemical side: hydrolysis, oxidation, and carbonation), the slide 'Soil — The Skin Where Four Spheres Meet' with its horizons and five soil-forming factors, and the Edwards Aquifer panel on the 'Groundwater Architecture' slide.

Big ideas you will use

- Chemical weathering changes the minerals in rock. Hydrolysis turns feldspar into clay, oxidation rusts iron, and carbonation dissolves limestone.
- Warm, wet climates speed up chemical weathering. Quartz resists it, which is why it lasts long enough to become beach sand.
- Soil forms in layers called horizons: O, A, E, B, C, and R. Five factors shape it: climate, organisms, relief, parent material, and time.
- Slightly acidic groundwater dissolves limestone into caves and sinkholes. Dripping water can leave the mineral behind as stalactites and stalagmites.

BUILD IT

Rock-rot bench: fizz, soil column, and cave

Build three working setups that make chemical change happen in front of the class: rock reacting with acid, rain moving through a soil profile, and groundwater dissolving a cave.

Materials

- Chalk that fizzes in vinegar or limestone chips (test one piece first: some chalk does not fizz), white vinegar, two clear cups, and a kitchen scale that reads to 0.1 g
- A clear plastic bottle with its top cut off, gravel, sand, clay-rich soil, dark potting soil, dead leaves, and food colouring
- Sugar cubes, damp sand, and a clear cup with small holes poked in its bottom
- Epsom salt, warm tap water, two jars, cotton string, and a saucer
- Goggles, a ruler, and a timer

Your model must show

1. Chemical weathering: acid reacts with carbonate rock and gives off gas, and crushed pieces react faster than one whole piece.
2. How soil forms: a soil column shows the horizons in order, and rain carries dissolved material down through them (leaching).
3. Groundwater weathering and deposition: water dissolves the buried "limestone" to make a sinkhole, and dripping mineral water leaves crystals behind like a stalactite.

Build steps

1. Fizz test: weigh each cup with 100 mL of vinegar.
2. Add 5.0 g of crushed chalk to one and one 5.0 g whole piece to the other.
3. Weigh both again after 10 minutes.
4. The lost mass is carbon dioxide gas.
5. Soil column: fill the bottle from the bottom up with gravel (R), gravel and sand (C), clay-rich soil (B), light sand (E), and dark potting soil (A).
6. Put three drops of food colouring on the A layer, then cover it with dead leaves (O).
7. Label each layer on the outside.
8. Pour 200 mL of water slowly on top.
9. Cave: bury a stack of four sugar cubes under 2 cm of damp, packed sand in the cup with holes.
10. Drip 100 mL of water slowly onto the sand above the sugar and watch the side of the cup.
11. Stalactite: dissolve Epsom salt in two jars of warm tap water until no more dissolves.
12. Run a wet cotton string between the jars so it sags over the saucer.
13. Check it every day.

It works when

- In 10 minutes, the cup with crushed chalk loses more mass than the cup with the whole piece (record both in g).
- After 200 mL of "rain", the colour has moved at least 3 cm down the soil column, and the layers are still in order.

- The dripped water leaves a hollow or sinkhole at least 2 cm wide where the sugar was, and crystals grow on the string and saucer within 3 days.

Test it: Run the fizz test and the cave twice with fresh materials. Record masses in g, times in minutes, the distance the colour moved in cm, the sinkhole width in cm, and a daily photo of the crystals.

Safety: Wear goggles with vinegar. Never taste anything, including the Epsom salt water. Use warm tap water, not hot. Wipe spills right away and wash hands after the soil column.

Watershed Sandbox: Investigation C, Confined is not just deeper

1. On Storm Sandbox set Aquifer setting to Confined + unconfined.
2. Move the well pair to about 100 m from the channel.
3. Record the level in the shallow well and the head in the deep well.
4. Drag Aquifer conductivity from 10^{-5} toward 10^{-7} .
5. Describe how the water table changes shape.
6. Find a position where the deep well is labelled ARTESIAN.
7. Explain why the water rises without a pump.

Calculate: Reaction rate and gas mass

1. Two cups of vinegar each get 5.0 g of chalk that fizzes (calcite).
2. One gets crushed pieces, the other one whole piece.
3. The mass that leaves the cups is carbon dioxide gas.
4. In 10 minutes the crushed cup loses 0.9 g and the whole-piece cup loses 0.3 g.
5. Find each rate in g per minute, and how many times faster the crushed chalk reacted.
6. Then: every 100.09 g of calcite that dissolves gives off 44.01 g of carbon dioxide.
7. What is the most carbon dioxide 5.0 g of calcite could give off?

Self-check: Rates: $0.9 \div 10 = 0.09$ g/min and $0.3 \div 10 = 0.03$ g/min, so crushed is $0.09 \div 0.03 = 3$ times faster. Most gas: $5.0 \times 44.01 \div 100.09 = 2.2$ g. Check: $2.2 \div 5.0 = 0.44$, and $44.01 \div 100.09 = 0.44$.

Real data

- **Your campus soil** · USDA NRCS Web Soil Survey. Draw an area of interest around the campus. Record the soil map unit name and its parent material. Decide whether the soil formed in place (residual) or from material that was carried in (transported).

<https://websoilsurvey.nrcs.usda.gov/app/> · Look this up yourself. Record the date you read it.

A choice people make

1. Building and paving on top of limestone where rainwater sinks fast into the aquifer below, like the Edwards Aquifer recharge zone.

Two options to compare

- Rules that limit what can be built over the recharge zone
- Catching and filtering runoff before it sinks into the rock

Your map hotspot

1. Mark where water on your map could sink straight into the ground, and where a spill there would go.

Trap to avoid

Chemical weathering is not just rock getting wet. The minerals change into new substances, like feldspar into clay.

TEACH IT

Show your build working, then teach:

1. Chemical weathering changes minerals: acid dissolves carbonate rock and gives off carbon dioxide, faster when the rock is crushed.
2. Soil forms in horizons from leaf litter down to bedrock, and water carries dissolved material down through them.
3. Groundwater dissolves limestone into caves and sinkholes, and dripping water leaves minerals behind.

Check question: How can groundwater make a cave without any stream cutting through the rock?

Texas standards

- **ESS.9B** Investigate and model how surface water and ground water change the lithosphere through chemical and physical weathering and how they serve as valuable natural resources. §112.49(c)(9)(B) *You model how water changes rock by chemical weathering, and how groundwater carves caves.*
- **ESS.9D** Evaluate how weather and human activity affect the location, quality, and supply of available freshwater resources. §112.49(c)(9)(D) *You evaluate how human activity above a limestone aquifer affects freshwater quality.*
- **ESS.12E** Predict how human use of Texas's naturally occurring resources such as fossil fuels, minerals, soil, solar energy, and wind energy directly and indirectly changes the cycling of matter and energy through Earth's systems. §112.49(c)(12)(E) *You predict how using Texas soil and groundwater changes Earth systems.*
- **6.6E** Identify the formation of a new substance by using the evidence of a possible chemical change, including production of a gas, change in thermal energy, production of a precipitate, and color change. §112.26(b)(6)(E) *Grade 6–8 foundation.*

Word bank: chemical weathering · oxidation · carbonation · hydrolysis · soil horizon · parent material · karst · stalactite

Sediment Trail

FOCUS QUESTION

When rain lands on a slope, where does it go, and how does moving water carve the land and build it back up?

Your team follows water across the surface: how it wears land away and drops the pieces, how rain becomes runoff and streams, and how lakes and wetlands slow it down.

Your lessons

1. Erosion and Deposition

Publisher lesson: your textbook pages. Dr. Ijezie shares the pages in class.

2. Surface Water Movement

Publisher lesson: your textbook pages. Dr. Ijezie shares the pages in class.

3. Streams, Lakes, and Wetlands

Publisher lesson: your textbook pages. Dr. Ijezie shares the pages in class.

Also read: Module 2 Slides — Earth's Surface & Water. Read the slide 'The Watershed' (discharge, stream load, competence, and capacity), Concept Trap #1 on the Hjulström curve, and the slide 'From Weathering to Sediment Sink'.

Big ideas you will use

- Erosion is the moving step: water, wind, ice, and gravity carry sediment away. Deposition happens where the carrier slows down, biggest grains first.
- Rain soaks in (infiltration) or runs off. Runoff gathers into streams. A watershed is all the land that drains to one outlet.
- Discharge is how much water passes each second: $Q = A \times v$. Faster water can move bigger grains (competence). More discharge can carry more sediment in all (capacity).
- A stream cuts into the outside of a bend and drops sand on the inside. Lakes and wetlands slow water down, store it, and trap sediment.

BUILD IT

Stream table with a lake and a wetland

Build a working stream that erodes, carries, and drops sediment into a lake. Then add a wetland and show how it changes the water.

Materials

- A rain gutter with end caps or a long plastic tray, about 1 m long
- Mixed gravel, sand, and soil
- A plastic cup with about 10 small holes in its bottom (the rain maker) and a measuring cup
- A kitchen sponge cut into a strip (the wetland)
- Books or blocks to tilt the gutter
- A ruler and a timer

Your model must show

1. Erosion and deposition: the stream carries sediment and drops it in the lake as a delta, coarse grains first and fine mud last.
2. Surface water movement: rain soaks in first, then runs off and gathers into the channel.
3. Streams, lakes, and wetlands: the stream cuts the outside of its bend, and a wetland slows the water and traps sediment before the lake.

Build steps

1. Raise the high end of the gutter 3 to 5 cm.
2. Fill the upper two-thirds with the sediment mix, 3 cm deep, and carve a channel with one bend.
3. Pour 2 cm of water into the empty lower third: that is the lake.
4. Hold the rain cup 20 cm above the high end and pour 500 mL through it over about 60 seconds.
5. Time when runoff starts and when water first reaches the lake.
6. Measure the length of the delta, how far the outside of the bend was cut back, and where the coarse and fine grains ended up.
7. Reset the sediment and the channel, and refill the lake with clean water.
8. Lay the sponge strip across the channel just above the lake and run the same rain again.

It works when

- A delta at least 3 cm long builds where the stream enters the lake, with coarse grains near the mouth and fine mud farthest out.
- The outside of the bend is cut back and sand is dropped on the inside of the bend.
- With the wetland strip in place, water reaches the lake later (record the seconds) and the lake water is clearer than without it.

Test it: Run the stream twice without the wetland and twice with it. Record the rain volume in mL, runoff start and arrival times in seconds, the delta length in cm, and how far the bend was cut back in cm.

Safety: Work over a tub or on a towel. Keep water away from laptops. Mop spills right away.

Watershed Sandbox: Following the load

1. On Flood Hydrograph, set Land use to Forest.
2. Record the peak discharge and the largest grain the flow can move (read from the Hjulström panel).
3. Change Land use to City.
4. Record the new peak discharge and largest grain.
5. Find the grain size where the Hjulström curve is lowest.
6. Explain why clay is not at the bottom of the curve.
7. On Century Time-Lapse, press Play century and describe where the delta grows and why.

Calculate: Continuity: $Q = A \times v$

1. Suppose a bayou gauge reads 530 ft³/s.
2. Convert it to m³/s (1 ft³/s = 0.0283 m³/s).
3. The channel is 20 m wide and 3 m deep.
4. Find the speed of the water.
5. Then the channel narrows to 10 m wide with the same depth and the same discharge.
6. Find the new speed.

Self-check: $530 \times 0.0283 = 15.0$ m³/s. Wide part: $20 \times 3 = 60$ m², so $v = 15.0 \div 60 = 0.25$ m/s. Narrow part: $10 \times 3 = 30$ m², so $v = 15.0 \div 30 = 0.50$ m/s. Half the area, double the speed. Width $\times$ depth $\times$ speed gives back 15.0 m³/s both times.

Real data

- **Buffalo Bayou discharge** · USGS monitoring location 08074000, Buffalo Bayou at Houston, TX. Record today's discharge and the peak discharge from a recent storm, both in ft³/s, then convert them. The gauge drains 336 square miles and has records back to 1929.
<https://waterdata.usgs.gov/monitoring-location/08074000/> · Drainage area and record start were read from the USGS page on 2026-09-23. Discharge changes every day, so read it yourself.
- **Hurricane Harvey rainfall** · NOAA Climate.gov, Reviewing Hurricane Harvey's catastrophic rain and flooding. Compare the rain on your stream table with a real storm. NOAA reports 48.20 inches at a rain gauge on Clear Creek at I-45 near Houston, and 35.6 inches at Houston Hobby Airport from August 26 to 29, 2017.
<https://www.climate.gov/news-features/event-tracker/reviewing-hurricane-harveys-catastrophic-rain-and-flooding> · Figures read from the NOAA page on 2026-09-23.
- **How paving changes runoff** · USGS Water Science School, Impervious Surfaces and Flooding. Use it as background for your claim and your fixes.
<https://www.usgs.gov/special-topics/water-science-school/science/impervious-surfaces-and-flooding> · Read on 2026-09-23. Background reading, no numbers to copy.

A choice people make

1. Paving ground and straightening channels so rain reaches the bayou faster.

Two options to compare

- Lined, straightened channels that move floodwater out quickly
- Restored wetlands and floodplains where water can spread out, slow down, and drop sediment

Your map hotspot

1. Mark where the channel widens or meets slower water, where sediment should settle.

Trap to avoid

Fine clay is not the easiest sediment to erode. Sand is picked up at the lowest speed, because packed clay sticks together.

TEACH IT

Show your build working, then teach:

1. Water erodes where it moves fast and deposits where it slows down, biggest grains first.
2. Rain soaks in first. When it falls faster than the ground can soak it up, or the ground is full, it runs off and gathers into channels.
3. Streams cut the outside of bends, and wetlands and lakes slow water down and trap sediment.

Check question: Where in a stream would you expect to find the finest mud, and why?

Texas standards

- **ESS.9C** Model the processes of mass wasting, erosion, and deposition by water, wind, ice, glaciation, gravity, and volcanism in constantly reshaping Earth's surface. §112.49(c)(9)(C) *You model erosion and deposition by moving water.*
- **ESS.9D** Evaluate how weather and human activity affect the location, quality, and supply of available freshwater resources. §112.49(c)(9)(D) *You evaluate how wetlands and paving change where freshwater goes.*
- **ESS.12C** Analyze the natural and anthropogenic factors that affect the severity and frequency of extreme weather events and the hazards associated with these events. §112.49(c)(12)(C) *You analyze human factors that make flooding more severe.*
- **ESS.2C** Use mathematical calculations to assess quantitative relationships in data. §112.49(c)(2)(C) *You use $Q = A \times v$ and a unit conversion to test a quantitative relationship.*
- **7.11A** Analyze the beneficial and harmful influences of human activity on groundwater and surface water in a watershed. §112.27(b)(11)(A) *Grade 6–8 foundation.*

Word bank: erosion · deposition · runoff · infiltration · watershed · discharge · delta · wetland

Soak and Slide

FOCUS QUESTION

What happens to rain that soaks into the ground, and when does that water make a slope give way?

Your team follows water down into the ground: how soil texture controls soaking in, how soaked slopes fail, and how groundwater is stored in aquifers under this city.

Your lessons

1. Soil — Texture and Water

Publisher lesson: your textbook pages. Dr. Ijezie shares the pages in class.

2. Mass Movements

Publisher lesson: your textbook pages. Dr. Ijezie shares the pages in class.

3. Groundwater

Publisher lesson: your textbook pages. Dr. Ijezie shares the pages in class.

Also read: Module 2 Slides — Earth's Surface & Water. Read the slides 'Gravity's Ledger & the Angle of Repose' and 'Mass Movement: A Spectrum of Speed', the slide 'Groundwater Architecture' on porosity and permeability, and Concept Trap #3, 'Groundwater Is Not an Underground River'.

Big ideas you will use

- Soil texture is the mix of sand, silt, and clay in a soil. Sandy soil lets water soak in fast; clay-rich soil drains slowly.
- Factor of Safety compares the forces holding a slope to the forces pulling it down. Below 1, the slope fails. Dry, loose sand stands at about 30 to 35 degrees.
- Water soaking into a slope carries part of the load and lowers the friction between grains. That is why landslides often follow heavy rain.
- Groundwater fills the pores between grains below the water table. Porosity is how much water a material can hold; permeability is how easily water flows through it.

Soak-and-slide tank

Build a see-through tank and drain cups that show how water moves into soil, when a soaked slope fails, and how an aquifer holds water that a well can pump.

Materials

- A clear plastic tub or storage box
- Sand, small gravel, and clay-rich soil
- Three cups with the same small holes poked in their bottoms, each lined with a coffee filter, and two measuring cups
- A protractor, a ruler, and a timer
- A clear straw with a piece of coffee filter taped over one end (the well), and a large syringe whose tip fits snugly in the straw (the pump)
- Water with a drop of food colouring, and toothpicks as "roots"

Your model must show

1. Soil texture: the same pour of water drains through sand and gravel faster than through clay-rich soil.
2. Mass movements: a soaked slope slumps at a gentler angle than a dry one, and "roots" let it stand steeper.
3. Groundwater: water fills the spaces between grains, and pumping a well lowers the water table around it.

Build steps

1. Drain cups: fill the three cups to the same height with sand, gravel, and clay-rich soil.
2. Pour 100 mL of water on each and measure how much drains out in 60 seconds.
3. Slope: pile dry sand at one end of the tub as steep as it will stand and measure the angle.
4. Pour water slowly onto the top until it seeps out of the face, then measure the angle after it slumps.
5. Rebuild it with toothpick roots and test again.
6. Porosity: fill one measuring cup to 100 mL with dry sand.
7. Measure water in the other cup and pour it in slowly until it just reaches the top of the sand.
8. The water you used is the pore space.
9. Aquifer: stand the straw, filter end down, against one side wall of the tub, and spread the sand flat around it.
10. Add coloured water until you can see the water table through the side.
11. Push the syringe tip into the straw and pull out 50 mL.
12. Watch the water table next to the well and at the far wall.

It works when

- The sand cup drains more water in 60 seconds than the clay-rich soil cup (record both in mL).
- Dry sand stands between 25° and 40°, and the soaked slope slumps to a lower angle than the dry one.
- 100 mL of dry sand holds 25 to 45 mL of water, and pumping lowers the water table more next to the well than at the far wall.

Test it: Run each test twice. Record drained water in mL, slope angles in degrees, pore water in mL, and water-table heights near the well and at the far wall in cm.

Safety: Pump with the syringe or baster, never your mouth. Keep water away from laptops. Sweep up sand and wipe spills right away.

Watershed Sandbox: Investigation A, Roots hold the hill up

1. On Storm Sandbox set Soil texture to Sand, Storm intensity to 0, and Vegetation cover to 0%.
2. Raise the Hillslope angle until FS drops below 1.00.
3. Record the angle.
4. Raise Storm intensity to 90 mm/hr and Storm duration to 240 min.
5. Find the new failure angle and record it.
6. Keep that angle and raise Vegetation cover to 100%.
7. Record the new FS and name the term in the readout that changed.
8. Repeat the first step with Clay and with Silt loam.
9. Record each failure angle.

Calculate: Factor of Safety and porosity

1. For a dry, loose slope, $FS = \tan(\text{friction angle}) \div \tan(\text{slope angle})$.
2. Use a friction angle of 32° .
3. Find FS for slope angles of 20° , 25° , 30° , and 35° , and say which slopes are stable.
4. Then: 100 mL of dry sand took 34 mL of water to fill its spaces.
5. What is its porosity as a percent?

Self-check: $\tan 32^\circ = 0.625$. $FS = 1.72$ (20°), 1.34 (25°), 1.08 (30°), 0.89 (35°). FS is above 1 exactly when the slope angle is less than 32° , so only 35° fails. Porosity = $34 \div 100 = 34\%$.

Real data

- **The Gulf Coast Aquifer** · Texas Water Development Board, Gulf Coast Aquifer. TWDB describes the aquifer as layers of sand, silt, clay, and gravel, including the Chicot, Evangeline, and Jasper aquifers. It reports that in Harris, Galveston, Fort Bend, Jasper, and Wharton counties, water levels fell as much as 350 feet, which led to land subsidence.
<https://www.twdb.texas.gov/groundwater/aquifer/majors/gulf-coast.asp> · Figures read from the TWDB page on 2026-09-23.
- **How much the region sank** · USGS Fact Sheet 110-02 (InSAR monitoring of Houston-Galveston subsidence). USGS reports more than 10 feet of subsidence near Pasadena from 1906 to 1995, mainly from pumping groundwater. It also reports that since the late 1970s subsidence largely slowed along the ship channel and in Baytown and Pasadena after pumping was cut and the area switched to surface water.
https://pubs.usgs.gov/fs/FS_110-02/Fact%20Sheet%20110-02.htm · Figures read from the USGS fact sheet on 2026-09-23.
- **Today's subsidence rules** · Harris-Galveston Subsidence District. Find how the district limits groundwater pumping today. Use it as evidence for your two fixes.
<https://hgsubsidence.org/> · Quote only what the page says, and record the date you read it.

A choice people make

1. Pumping groundwater faster than it is replaced.

Two options to compare

- Switching to surface water from rivers and lakes, with rules that limit pumping
- Using less water through conservation and reuse

Your map hotspot

1. Mark the part of your watershed nearest the area USGS reports sank the most, and say what lower ground means for flooding there.

Trap to avoid

Groundwater is almost never an underground river or a hidden lake. It seeps slowly through pores and cracks. Cave streams form only in limestone that water has dissolved.

TEACH IT

Show your build working, then teach:

1. Soil texture controls how fast water soaks in: sandy soil drains fast, clay-rich soil slowly.
2. A slope fails when the pull down beats the grip holding it, and soaking water lowers the grip.
3. Groundwater fills pores between grains, and pumping a well lowers the water table around it.

Check question: Why do slopes often slide right after a heavy rain?

Texas standards

- **ESS.9C** Model the processes of mass wasting, erosion, and deposition by water, wind, ice, glaciation, gravity, and volcanism in constantly reshaping Earth's surface. §112.49(c)(9)(C) *You model mass wasting by gravity and water.*
- **ESS.9B** Investigate and model how surface water and ground water change the lithosphere through chemical and physical weathering and how they serve as valuable natural resources. §112.49(c)(9)(B) *You investigate groundwater and how it serves as a valuable natural resource.*
- **ESS.9D** Evaluate how weather and human activity affect the location, quality, and supply of available freshwater resources. §112.49(c)(9)(D) *You evaluate how pumping affects the supply of available freshwater.*
- **ESS.2C** Use mathematical calculations to assess quantitative relationships in data. §112.49(c)(2)(C) *You use the Factor of Safety and a porosity calculation to test quantitative relationships.*
- **7.11A** Analyze the beneficial and harmful influences of human activity on groundwater and surface water in a watershed. §112.27(b)(11)(A) *Grade 6–8 foundation.*
- **6.10A** Differentiate between the biosphere, hydrosphere, atmosphere, and geosphere and identify components of each system. §112.26(b)(10)(A) *Grade 6–8 foundation.*

Word bank: soil texture · infiltration · angle of repose · Factor of Safety · pore water · porosity · permeability · water table

Day 6: teach, learn, decide

Teach-back day. Every team teaches its three lesson parts, so everyone leaves knowing all ten lessons.

ABOUT 40 MINUTES

Teach-back lessons

Each team teaches for ten minutes: two minutes showing the build working, then each lesson lead teaches their lesson part with the build and asks one check question. Every visitor writes an answer.

ABOUT 7 MINUTES

Council

Mixed groups answer the driving question using evidence from all four teams: follow one grain from bedrock to the bayou.

ABOUT 8 MINUTES

On your own

Exit ticket, then turn in your group note and do the partner review.

Your learning notes, for every team's lesson

- Team and lessons
- What the build showed
- Key idea from each lesson part
- My answers to their check questions
- A question I still have

SCORING

The rubric

One rubric for every ESS team project. Your team is scored together on the first four rows; the last row is scored for you alone. Read it before you start and check your work against it before teach-back day.

STRAND	4 • EXEMPLARY	3 • PROFICIENT	2 • DEVELOPING	1 • BEGINNING
Lesson science Content accuracy across all your lessons • 25% • team	Every lesson is correct and complete, uses the right vocabulary, and connects to the other lessons and the driving question.	Every lesson is correct, with key ideas and vocabulary.	One lesson has errors or gaps, or the ideas are listed without explanation.	Lessons are missing or mostly wrong.
The build works Function, testing, and photos • 25% • team	The build passes every 'It works when' test at least twice, the results have units, one fix improved it, and clear approved photos show it.	The build passes its tests, with recorded results and photos.	The build works only partly, or the tests are not recorded.	The build does not work or was not tested.
Teaching the class Teach-back and check questions • 20% • team	Each lesson lead teaches clearly with the build; most classmates answer the check questions correctly; timing is right.	Every lesson is taught with the build, and check questions are asked.	Some lessons are rushed or taught without the build.	The lesson is missing or unclear.
Group note Note Studio group note and evidence • 20% • team	Every section is complete, data has units and sources, the claim matches the evidence, and it names one limit of the build.	Every section is complete, with data and a claim.	Some sections are thin or missing.	The note is mostly empty.
My contribution Individual work, partner and teacher ratings • 10% • each scholar	You led your lesson well, did your role on time, and made a teammate's work better. Your contribution section, partner ratings, and teacher rating agree.	You led your lesson and did your role on time.	Your part was late or only partly done.	Little evidence of your part.

The first four rows are scored for the team. My contribution, your learning notes, and your exit ticket are scored for you alone.

ON YOUR OWN

Exit ticket

1. Pick a lesson another team taught. Explain its main idea in two or three sentences.
2. Mechanical and chemical weathering were taught by two different teams. Name one difference between them and one way they help each other.
3. Name one test from another team's build and what it proved, with its number and unit.
4. Name the part of your team's work you did yourself, and one thing you would rebuild.

Sentence starters

- *Our team claims that ____ because ____.*
- *We observed _____. From that we infer _____.*
- *The evidence that supports this is _____, which shows _____.*
- *In the Sandbox, when we changed _____, the _____ went up / went down by _____.*
- *The data came from _____, and we read it on _____.*
- *One limit of our model is _____.*
- *Explanation _____ fits the evidence better, because _____.*
- *I agree with _____ because _____. I would add _____.*
- *I have a different idea. The evidence _____ suggests _____.*
- *Can you explain how _____ connects to _____?*

Supports you can use

- Every packet has a word bank. Look up any word in the Ascent Lexicon.
- You may draft in the language you think in best and then write the final version in English.
- Use the sentence starters above in your claim, your lesson, and the council.
- The teach-back lesson can be split between teammates, and it can use the slide's pictures and numbers as notes.
- Ask your teacher for a printed packet, a larger-print copy, or extra time on any checkpoint.

STANDARDS

Standards for the whole project

These are selected connections to the Texas standards for Earth Systems Science (19 TAC §112.49), not a claim that this project fully covers each one. No engineering-design (HS-ETS) standard is claimed.

- **ESS.3B** Communicate explanations and solutions individually and collaboratively in a variety of settings and formats. §112.49(c)(3)(B) *Every team teaches its lessons to the class and explains its build.*
- **ESS.3C** Engage respectfully in scientific argumentation using applied scientific explanations and empirical evidence. §112.49(c)(3)(C) *The council argues from evidence across all four teams.*

SOURCES

Where the numbers come from

1. U.S. Geological Survey. Buffalo Bayou at Houston, TX, monitoring location 08074000. <https://waterdata.usgs.gov/monitoring-location/08074000/> (read 2026-09-23)
2. U.S. Geological Survey. Fact Sheet 110-02: InSAR monitoring of land-surface subsidence in the Houston-Galveston region. https://pubs.usgs.gov/fs/FS_110-02/Fact%20Sheet%20110-02.htm (read 2026-09-23)
3. Texas Water Development Board. Gulf Coast Aquifer. <https://www.twdb.texas.gov/groundwater/aquifer/majors/gulf-coast.asp> (read 2026-09-23)
4. NOAA Climate.gov. Reviewing Hurricane Harvey's catastrophic rain and flooding. <https://www.climate.gov/news-features/event-tracker/reviewing-hurricane-harveys-catastrophic-rain-and-flooding> (read 2026-09-23)
5. U.S. Geological Survey Water Science School. Impervious Surfaces and Flooding. <https://www.usgs.gov/special-topics/water-science-school/science/impervious-surfaces-and-flooding> (read 2026-09-23)
6. NOAA National Weather Service. Precipitation Frequency Data Server (Atlas 14). <https://hdsc.nws.noaa.gov/pfds/> (live data)
7. USDA Natural Resources Conservation Service. Web Soil Survey. <https://websoilsurvey.nrcs.usda.gov/app/> (live data)
8. U.S. Environmental Protection Agency. Stormwater Discharges from Construction Activities. <https://www.epa.gov/npdes/stormwater-discharges-construction-activities> (live data)
9. Harris County Flood Control District. <https://www.hcfd.org/> (live data)

10. Harris County Flood Warning System. <https://www.harriscountyfws.org/> (live data)

11. Harris-Galveston Subsidence District. <https://hgsubsidence.org/> (live data)

Watershed Forensics: Four Teams, Ten Lessons · drijezie.com/courses/earth-systems-science/projects/watershed-forensics/