

Mass Wasting, Tsunamis and Floods: Mastery Check

Learning target: I can explain what controls slope failure, tsunami speed and height, and flood chances, use data to forecast hazards, and match mitigation to the warning time a hazard gives.

Retrieval and mastery check

About 35 min

Individual

MS-ESS3-2 · assesses

MS-ETS1-3 · supports

independent practice

writing

Standards connections

MS-ESS3-2 (assesses, forecasting from hazard data and linking forecasts to mitigation): Items 4, 7, 9 and 11 ask students to calculate arrival times and flood chances and to tell a forecast from an exact prediction, and the synthesis asks them to name the data that forecast two hazards and match mitigation to each hazard's warning time. Together these give direct evidence toward the PE.

MS-ETS1-3 (supports, recalling how combined fixes improved the DART design): Item 6 checks that students remember how engineers combined three fixes into a more reliable DART system. Recalling the case does not require students to analyze test data, so the item supports rather than assesses this PE.

Purpose: assess · **Time:** about 35 minutes · **Format:** individual

Answers with reasoning

Part A: Retrieval (items 1-11)

1. Which change would make a hillside **most** likely to fail?

2 pts

Answer: B. A week of storms that saturates its soil.

Why: Saturation adds weight and reduces friction between grains. Roots (A) and a gentler angle (D) make a slope more stable; a dry summer (C) leaves soil drier, not weaker in the same way.

Also acceptable: None.

2. Give two ways that saturated soil is weaker than dry or damp soil, and name the force that then moves the slope.

3 pts

Answer: Saturated soil is heavier, because the pore spaces are filled with water, and water pressure in the pores pushes grains apart, so friction between them drops. (Damp soil can actually hold together better than dry soil, but saturation removes that help.) Gravity then moves the slope downhill.

Why: Both mechanisms plus the driving force are required for full credit.

Also acceptable: Accept 'water pushes the grains apart so they don't grip each other' for the second mechanism.

- Added weight
- Reduced friction or grip between grains from water pressure
- Names gravity

3. Fence posts on a hillside lean a little farther downhill each year, and tree trunks curve at their bases. Which kind of mass wasting is this? 2 pts

Answer: C. Creep.

Why: Slow, year-by-year tilting of posts and curved trunks are the classic signs of creep. Rock falls and debris flows are very fast, and storm surge is not mass wasting.

Also acceptable: None.

4. Over ocean about 4,000 m deep, a tsunami travels about 700 km/h. An undersea earthquake strikes at 9:00 p.m. How long will the first wave take to reach an island 2,100 km away across water of that depth, and at what time should it arrive? 3 pts

Answer: Time = $2,100 \text{ km} \div 700 \text{ km/h} = 3.0 \text{ hours}$. 9:00 p.m. + 3 hours = 12:00 a.m. (midnight).

Why: Arrival time is distance divided by speed, added to the earthquake time.

Also acceptable: Accept 'midnight' or '12:00 a.m.' with the calculation shown.

5. Why does a tsunami grow much taller as it reaches the coast? 2 pts

Answer: B. It slows down in shallow water, so the back of the wave catches up with the front and the water piles up.

Why: Speed depends on depth; as the front slows, the wave is compressed and its height grows. Wind, the Moon and rivers do not cause this.

Also acceptable: None.

6. Early DART stations had 'data dropouts,' when readings from the seafloor sensor did not reach the buoy. How did engineers make the system reliable? 2 pts

Answer: B. They combined three fixes: a wider sound beam from the acoustic modem, a tiltmeter to check the sensor's alignment, and software that asks for lost data to be sent again.

Why: This is the lesson's engineering case: each fix targeted one of the two likely causes of dropouts, and the combination worked better than any one fix. The sensor stays on the still seafloor because the surface is always moving.

Also acceptable: None.

7. In 2011, waves from the earthquake off Japan reached Crescent City, California, about 10 hours after the quake, but they reached the coast of northeastern Japan within minutes. Explain the difference and what it meant for warnings. 3 pts

Answer: Warning time depends on distance from the source. Crescent City is about 7,500 km from the 2011 earthquake, so the waves needed about 10 hours to cross the Pacific, giving time to detect the earthquake, confirm the waves and clear the waterfront. Northeastern Japan was close to the source, so waves arrived within minutes, before many people could reach safety even with an advanced warning system.

Why: Tsunamis travel hundreds of km/h; the farther the coast, the more hours of warning.

Also acceptable: Accept answers that mention DART buoys confirming the waves while they were still crossing the ocean.

- Explains the difference by distance from the source
- Connects long travel time to time for warnings
- Notes that a nearby source leaves only minutes

8. True or false: 'Our river had a 50-year flood last spring, so the chance of a flood that big this year is less than 2 percent.' Circle your answer and explain. 2 pts

Answer: False. A 50-year flood has a 2 percent chance ($1 \div 50$) of happening every year, regardless of when the last one occurred, so this year's chance is still 2 percent.

Why: Recurrence intervals are averages; each year is independent.

Also acceptable: None.

- Marks false
- States the 2 percent chance applies every year
- Says the last flood does not lower the chance

9. A streamgage has 39 years of annual peak flows. The third-largest peak in the record has rank $m = 3$. Use $T = (n + 1) \div m$ to find its recurrence interval, then find the chance of a flood at least that big in any one year. 3 pts

Answer: $T = (39 + 1) \div 3 = 40 \div 3 \approx 13.3$ years. Chance = $1 \div 13.3 = 3 \div 40 = 0.075$, or 7.5 percent each year.

Why: $n = 39$, so $n + 1 = 40$. The yearly chance is the reciprocal of T .

Also acceptable: Accept 13 years and about 7.5 to 7.7 percent.

10. Draw a cross-section of a hillside above a road after a week of heavy rain. Show and label: the saturated zone in the soil, a clay layer or bedrock below it, the surface along which the slope is likely to slide, an arrow for the direction of movement, and one mitigation (such as a drain or a retaining wall) placed where it would work. 4 pts

Answer: A slope above a road with: a labeled saturated zone in the soil (shaded, often thickest near the base of the soil); a labeled clay layer or bedrock beneath it; a curved or sloping slip surface along the base of the saturated soil, often at the top of the clay or bedrock; an arrow pointing downhill along that surface; and a mitigation in a working position, such as horizontal drain pipes running into the saturated zone, a retaining wall at the toe above the road, or a surface ditch carrying water away from the top of the slope.

Why: The drawing shows the model: water collects above a less permeable layer, the slope fails along that weak surface, and mitigation either removes water or holds the toe.

Also acceptable: Accept a planar slip surface; accept plants or a cover on the slope as a mitigation if labeled with how it reduces water entering the soil.

- Saturated zone labeled
- Clay layer or bedrock labeled below
- Slip surface drawn at the base of the weak, wet material
- Arrow shows downhill movement
- One mitigation placed where it would work and labeled

11. Which statement is a **forecast**, not an exact prediction? 2 pts

Answer: B. Canyons below this burn scar have a high chance of debris flows this winter if rain falls harder than 24 mm per hour for 15 minutes.

Why: A forecast states a likelihood for a place and time window, tied to data. A and D give exact times that no one can know; C is an absolute claim that is not true.

Also acceptable: None.

Part B: Synthesis (item 12)

- 12.** A coastal California town has a steep, cracked hillside above Main Street, a river running through downtown and a small harbor. Choose **two** of the three hazards it faces (landslide, river flood, tsunami). For each one: (a) name the data scientists would use to forecast it, (b) say how much warning the town could expect, and (c) describe one mitigation that fits that warning time. End with one or two sentences explaining why the town should combine several defenses instead of relying on one. 8 pts

Answer: Example. Landslide: (a) maps of slope steepness and rock and soil type, the locations of old slides, measurements of cracks or movement on the hillside, and rainfall totals; (b) the hazard map shows where years ahead, and movement monitoring or a very wet week can warn that danger is rising over days, but the exact moment of failure cannot be forecast, and an earthquake-triggered slide would give no warning; (c) horizontal drains to keep the slope from saturating and a retaining wall at its foot, plus closing Main Street when movement speeds up. River flood: (a) streamgage records of past floods turned into recurrence intervals and yearly chances, flood maps, and forecasts of atmospheric-river storms; (b) the flood map tells where years ahead, and river forecasts can give hours to several days of warning before a big storm flood; (c) keep new buildings out of the 1 percent floodplain, raise existing ones, and evacuate low areas when the river forecast calls for flooding. Combining: each defense covers a different time scale and a different weakness of the others, structures can be overwhelmed by a bigger event than they were designed for, and warnings protect lives when structures fail, so a combination lowers risk more than any single defense.

Why: The synthesis checks the chapter's main ideas: the data that forecast each hazard, the difference between where-forecasts and when-warnings, matching mitigation to warning time, and the value of combined defenses.

Also acceptable: A tsunami answer should name seismic networks and DART buoys, give hours for a distant source and minutes for a nearby one, and pair them with warnings and evacuation for distant sources and hazard maps, evacuation routes and drills for nearby ones.

- For each of two hazards, names appropriate forecasting data
- For each, gives a realistic warning time (including 'where, not when' for maps)
- For each, gives a mitigation that fits that warning time
- Explains why combining defenses is better than relying on one
- Uses chapter vocabulary accurately

Teacher notes

Total points: 36 (items 1-11 are worth 28, item 12 is worth 8). Suggested scoring for item 12: 3 points per hazard (data, warning time, mitigation) and 2 points for the combined-defense explanation. Items 4, 7, 9 and 11 are the most direct evidence of the PE's forecasting half; item 12 is the most direct evidence of the mitigation half. Item 6 checks the lesson's DART engineering case. The 700 km/h speed in item 4 is a rounded value of the long-wave speed over 4,000 m (about 713 km/h). Common errors: dividing m by n + 1 in item 9 (giving 0.075 years), and choosing D in item 1 because 'cutting' sounds like digging; reread the option with students if needed.

Scaffold offered to students: Synthesis planner

Before writing item 12, make a small table on scrap paper with two rows (your two hazards) and three columns: Data, Warning time, Mitigation. For warning time, choose from: none or seconds, minutes, hours, days, or 'where but not when.' Fill every cell with a few words, then turn each row into two or three sentences.

Extension: Write a question that fools people

Write one new multiple-choice question about this chapter whose wrong answers are based on real misconceptions, such as 'tidal wave,' 'the flood is due' or 'water lubricates slopes.' Give the correct answer and explain why each wrong option would tempt someone. Then trade with a classmate and check whether their question has exactly one defensible answer.