RLP-ESB · RLP Earth Science B — Water, Climate, Resources and Hazards

Unit 4: Resources, Hazards and Human Impacts

Practice Workbook. The same problems, in the same order, as the Practice sections of the online lessons.

Name _____ Period _____

Lesson 4.1 — Living with Hazards: Fire, Shaking, Drought and Sea

FLUENCY

1. A neighborhood has a 1% chance per year of a flood causing $20 million of damage. What is its expected annual loss?

2. A project costs $3 million and saves $600,000 a year for 30 years (ignoring interest). What is its benefit-cost ratio?

3. The Joplin tornado's path was 22.1 miles long. Convert to kilometers (1 mile = 1.609 km).

APPLICATION

4. A town can spend $2 million on seismic retrofits that cut a 2% annual chance of $40 million in damage by 70%, or $2 million on a levee that cuts a 1% annual chance of $60 million in damage by 90%. Compare the 30-year benefit-cost ratios (ignore interest).

5. Explain the difference between hazard, exposure and vulnerability, using a tornado example for each.

6. For each event, name the Earth-science cause and the human response: the 1811-1812 New Madrid earthquakes; the Great Flood of 1993; the 2011 Joplin tornado.

CHALLENGE

7. A home has a 1% chance of serious tornado or flood damage in any year. What is the chance it is damaged at least once in 30 years, assuming each year is independent?

REVIEW

8. Review (Unit 3): at 3.7 mm/yr, how much does sea level rise in 30 years?

Lesson 4.2 — Engineering Runoff: Testing Permeable Surfaces

FLUENCY

1. Convert 25 kPa to atm.

2. 1 cm of rain falls on a 1-hectare (10,000 m^2) parking lot with C = 0.9. How much runoff is produced?

3. In the lab, 500 mL of rain on the impermeable tray produced 430 mL of runoff. What is the runoff coefficient?

4. The permeable tray produced 120 mL of runoff from 500 mL. What is its runoff coefficient?

APPLICATION

5. A 2,000 m^2 school parking lot (C = 0.9) is rebuilt as permeable pavement (C = 0.24, from the lab). How much runoff is avoided in a 2 cm storm?

6. Name one criterion and two constraints for a permeable pavement at a school, and one maintenance issue.

7. Your first design's runoff was 260 mL of 500; after adding a mulch strip it was 150 mL. By what percentage did the refinement reduce runoff?

CHALLENGE

8. A 200 m^2 roof (C = 0.9) drains to a rain garden 0.15 m deep. How large must the garden be to hold the runoff from a 2.5 cm storm?

REVIEW

9. Review (Unit 2): how much energy warms 1.0 kg of water by 10 °C?

Lesson 4.3 — Cobalt, Coal and Wind: Weighing Missouri's Resources

FLUENCY

1. How many MW of solar panels at Missouri's 2024 solar capacity factor (18.5%) produce 100,000 MWh per year? (8,760 hours per year)

2. How many MW of coal-plant capacity at Missouri's 2024 coal capacity factor (47.3%) produce the same 100,000 MWh?

3. A gas plant emits 0.4 t CO_2 per MWh. How much CO_2 for 100,000 MWh?

APPLICATION

4. Using illustrative costs (wind with storage $70/MWh; gas $60/MWh plus $100 per ton of CO_2 at 0.4 t/MWh; coal $50/MWh plus $100 per ton of CO_2 at 1.0 t/MWh), find the full yearly cost of 100,000 MWh from each and rank them.

5. List two costs that the dollar comparison leaves out for each of: a Missouri wind farm, and reprocessing the Fredericktown mine tailings for cobalt.

6. A mitigation project costing $4 million produces benefits of $10 million. Another costing $1 million produces $3 million. Which has the higher benefit-cost ratio, and which delivers more total benefit?

CHALLENGE

7. At what carbon price per ton would coal ($50/MWh, 1.0 t CO_2/MWh) cost the same as wind with storage ($70/MWh)?

REVIEW

8. Review (Unit 3): the atmosphere gains 2.58 ppm in a year. How many GtC is that?

Lesson 4.4 — Simulating Solutions: Fire Spread and Shaking

FLUENCY

1. Weights: safety 5, cost 3, time 2. A solution scores 4, 2, 3. What is its weighted total?

2. Defensible space costs $5,000 and lowers a $600,000 home's annual fire chance from 1% to 0.4%. What are the expected savings per year?

3. For the same home, what is the 10-year benefit-cost ratio (ignore interest)?

APPLICATION

4. NetLogo Fire runs gave average percent burned of 2% at 50% density, 6% at 55%, 25% at 58%, 70% at 60%, 90% at 62% and 97% at 65% (a sample data set). Where is the threshold, and what does it suggest about reducing fuel from 65% to 55%?

5. On the shake table, the unbraced tower's top shifted 38 mm and the braced tower's 6 mm. By what percentage did bracing reduce the shift, and why?

6. State one thing the NetLogo Fire model leaves out and one thing the shake table leaves out, and how each could change a real-world conclusion.

CHALLENGE

7. Two flood solutions for a Missouri River town score as follows (weights: lives 5, cost 3, ecology 2, time 2): raising the levee 4, 3, 2, 4; a voluntary buyout 4, 2, 5, 2. Find both totals, then recompute with the ecology weight raised to 4. Does the ranking change?

REVIEW

8. Compare a magnitude 5.5 earthquake with a magnitude 4.0 earthquake. About how many times larger is the ground-motion amplitude, and about how many times more energy is released?

Unit 4 checkpoint

1. A 5% annual chance of a $10 million loss gives what expected annual loss?
   A. $50,000
   B. $500,000
   C. $5,000,000
   D. $10,000,000
2. True or false: Risk depends on exposure and vulnerability as well as on the hazard.

3. After the Great Flood of 1993, what did the U.S. Fish and Wildlife Service create on flood-damaged Missouri River land bought from willing sellers?
   A. The Big Muddy National Fish and Wildlife Refuge
   B. A new St. Louis floodwall
   C. The Taum Sauk reservoir
   D. The Mark Twain National Forest

4. 500 mL of rain producing 200 mL of runoff gives a runoff coefficient of _____.

5. True or false: In a combined sewer, rainwater from streets and household wastewater flow in the same pipe.

6. Which is a constraint rather than a criterion for a permeable pavement?
   A. Cut runoff by half
   B. It must support buses
   C. Remove 80% of pollutants
   D. Recharge groundwater

7. A project costs $2 million and yields $9 million in benefits. What is its benefit-cost ratio?
   A. 0.22
   B. 4.5
   C. 7
   D. 11

8. True or false: Wind turbines in Missouri produce electricity at their full rated power all year.

9. In the NetLogo Fire model, what happens near 59% tree density?
   A. Nothing special
   B. Percent burned jumps from small to nearly all
   C. Fire always stops
   D. All trees burn at any density

10. Weights 5, 3 and 2 with scores 2, 4 and 5 give a weighted total of _____.