Lesson Plan: Levees

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Inspired By: *Living with Streams-Engineer and Build Your Own Levee* Dr. Barbara Munn, CSUS Geology Department, Dr. Kevan Shafizadeh and Dr. Matthew Salveson, CSUS Civil Engineering Department

Target Grade: 3rd Grade

Teacher Prep Time: 1 hour set-up + 45 minutes of clean-up (If you have materials purchased, levee boxes made, and rain cups made.)

Lesson Time: 3.75 hours (We recommend doing this lesson over four days.)

- Part 1:
  - 45 min – Reading and Questions
- Part 2:
  - 45 min – Material Exploration
  - 45 min – Designing Levees
- Part 3:
  - 1 hour – Building Levees
- Part 4:
  - 30 min – Levee Testing and Evaluation
  - 45 min – Discussion Questions

Lesson Overview: In this lesson, students will read and answer questions to learn about levees and their uses. Students will then explore how five materials interact with water. Using these findings, students will design and build a levee in groups. As a class, they will develop an evaluation tool to help them assess three levees based on both cost and performance. The levees will be tested by allowing it to rain on the levee and having water raise to the ½ maximum predicted flood height, followed by the maximum predicted flood height. Students will also discuss how building a levee can have a negative effect on surrounding areas.

Learning Objectives:

- Students will be able to state what a levee is and what it is used for.
- Students will be able to construct a levee. Students will generate criteria to evaluate levee design as a class, and use the criteria to evaluate three levee designs individually.
- Students will understand both positive and negative environmental impacts to building levees.

NGSS: 3-ESS3-1 Make a claim about the merit of a design solution that reduces the impacts of a weather-related hazard.*

3-5-ETS1-2 Generate and compare multiple solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.

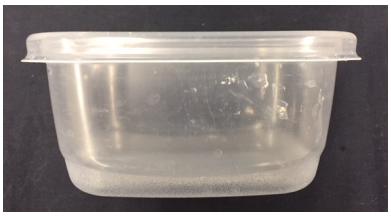
- **Science and Engineering Practice**
  - #6 Constructing Explanations (for science) and Designing Solutions (for engineering) (Activity focuses on Designing Solutions)
    - Constructing explanations and designing solutions in 3-5 builds on K-2 experiences and progresses to the use of evidence in constructing explanations that specify variables that describe and predict phenomena and in design multiple solution to design problems.
      - Generate and compare multiple solutions to a problem based on how well they meet the criteria and constraints of the design solution.

- **Disciplinary Core Idea**
  - ESS3.B Natural Hazards
    - A variety of natural hazards results from natural processes. Humans cannot eliminate natural hazards but can take steps to reduce their impacts.
  - ETS1.B Designing Solutions to Engineering Problems
    - Testing a solution involves investigating how well it performs under a range of likely conditions.
- **Crosscutting Concept**
  - #6 Structure and Function
    - In grades 3-5, students learn different materials have different substructures, which can sometimes be observe; and substructures have shapes and parts that serve functions.
- **Environmental Principal and Concept**
  - #3 Natural Systems Change in Ways that People Benefit From and Can Influence
    - Natural systems proceed through cycles that humans depend upon, benefit from, and can alter.
      - Concept A: Natural systems proceed through cycles and processes that are required for their functioning.
      - Concept C: Human practices can alter the cycles and processes that operate within natural systems.

Where This Lesson Fits in: This lesson should be done after students have discussed natural disasters such as floods.

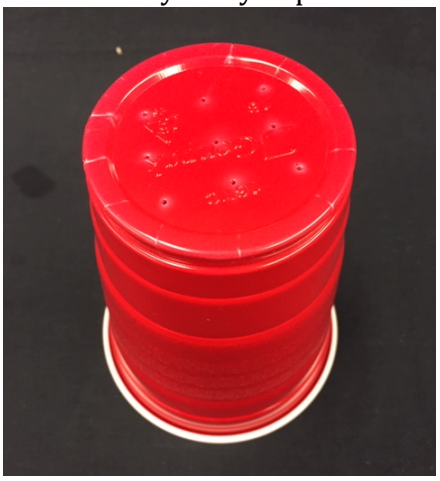
Materials Needed: (It is recommended that you have no more than 6 groups in your class. Groups should have at least 3 students each.)

- Student worksheets (1 per student)
- Levees reading (1 per student)
- PowerPoint of colored pictures in Levee Reading
- Levee Evaluation Tool (1 copy for the teacher)
- Fake money for students, start by giving each group 2 - $100, 8 - $20, and 4 - $10 bills, but have extra money for the bank. (If you have 6 groups you should have 12 - $100, 50 - $20, and 25 - $10 bills.)
- Squirt bottles, known as a water truck (1 per group)
- Water
- Spoons, known as a backhoe (2 per group)
- (30 oz.) Bowls, known as a dump truck (1 per group)
- ~1" Rocks, can purchase from Home Depot (a 5 cubic feet bag will be plenty)
- 3/8" Gravel, can purchase from Home Depot (a 5 cubic feet bag will be plenty)
- Fire clay, can purchase from Bedrock Building Supplies in Santa Barbara (a 10 lb. bag will be plenty)
- Sand, can be purchased from Home Depot (a 50 lb. bag will be plenty)
- 5 cm x 5 cm pieces of towels, I used green dishtowels or towels from Bed, Bath, and Beyond. (group will need ~7 pieces each)
- 100 mL graduated cylinder (1 per group)
- 3 oz. bathroom cups, label the cups with R (for rocks), G (for gravel), S (for sand), C (for clay) (~120 cups). For 6 groups you will need approximately 20 cups with R, 20 cups with G, 20 cups with S, and 12 cups with C.
- Sharpie, used for writing "½" on 3 oz. cups when students purchase ½ cups
- ~3 cup plastic containers for materials testing (1 per group)



- Levee boxes, shoebox sized plastic container (7 in wide × 10.5 in long × 4.5 in high). On side of container, mark the land side and the water side. Put marks every ½ inch up the side of the container. At the 2-inch mark, write "½ Flood" and at the 3-inch mark, write "Max Flood." (1 per group)

- Rain cup, 18 oz. Solo cup with 9 holes in the bottom made with a pushpin. Make sure to test the cups to make sure that the holes are big enough for water to come out. If they are not, twist the pins in the holes to make them bigger. The last ~20 mL of water will not come out. If the cup is made out of plastic that is too thin, it will crush when you try to poke a hole in the bottom. (1 per group)



- Water containers, students will need ~½ L of water for the materials tests. You will need ~1 L for each of the levee tests.
- Timer

Teacher Prep:

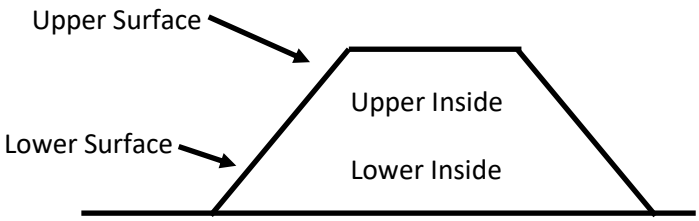
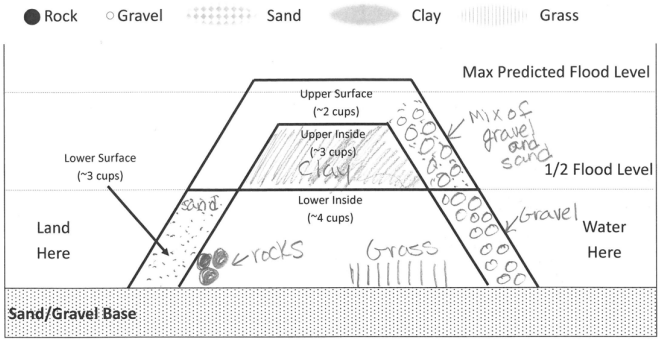
- Part 1 (Reading and Questions)
  - Have the video showing a levee failing ready to show https://www.youtube.com/watch?v=6nFEdNmn5kI
  - Have colored pictures from reading in PowerPoint to show students
  - Have levee notebooks and readings for students.
- Part 2 (Material Exploration)
  - Break the class into 6 groups.
  - Have the following reusable materials for each group: 3-cup plastic container, spoon, 100 mL graduated cylinder, and rain cup.
  - Have the following consumable materials for each group: gravel (3 oz.), rocks (3 oz.), sand (3 oz.), clay (3 oz.), "grass" (3 pieces), and water (~500 mL).
- Part 2 (Designing Levees)
  - There is no prep for this part.
- Part 3 (Building Levees)
  - Cut up money for students. (It is helpful to print the different denominations on different colored paper.)
  - Make the levee boxes and rain cup as described above.
  - In each levee box, put ~1 inch of a 3:2 mixture of sand and gravel in the bottom.
  - Label 3 oz. cups with R, G, S and C.
  - Prep appropriately labeled 3 oz. cups with rocks, gravel, sand, and clay.
  - Cut up 5 cm x 5 cm grass pieces.
  - Have Levee Evaluation Tool ready to develop with students.
  - Have the following material to give to each group: 2 spoons, 1 bowl, and 1 squirt bottle.
- Part 4 (Levee Testing)
  - Pour 100 mL portions of water (1 for each group).
  - Have the following to use for testing: rain cup, water container, and timers.
- Part 4 (Discussion Question)
  - Have the video about the negative impacts of levees ready to show https://projects.propublica.org/graphics/levees

Lesson Sequence:

Part 1: 45 minutes	**Reading and Questions**
	1. Show students the video https://www.youtube.com/watch?v=6nFEdNmn5kI that shows a levee failing. While students are watching the video, have them share out what they see, think, and wonder.
	   - It is most useful to play the first 2 minutes of the video. You can play if for them twice because most likely the first time the will not see the start of the breach.
	2. As a class, read "Levees" together
	   - While reading, display the colored pictures for the students.
	   - The two nearest levees to Santa Barbara are the Santa Maria River Levee and the Ventura River Levee. The picture on page 2 of the reading is the Ventura River Levee.
	3. Go over questions 1-9 as a class and have students fill in the answers in their notebooks as you fill in the answers in an example notebook under the document camera.
	   - Make sure that students know the following vocabulary terms: levee, breaching, and overtopping.

Part 2(a): 45 minutes	**Material Exploration** 1. Separate the students into groups. It is suggested to have no more than 6 groups in a classroom. 2. Explain the problem to students, "The city of Lowlandia has contacted several engineering firms and requested that each firm put together a bid and a scale model of a levee that they would construct for the town. The firm with the 'best' levee design will be hired to build the town's new levee." 3. Explain that before building a levee, students will need to explore the materials that they can use to build their levee. Show them these materials and tell them the purchase prices: rocks ($20), gravel ($20), sand ($20), clay ($100), and grass (a piece of towel) ($10 per 5 cm x 5 cm piece). 4. Tell them that we will test the materials in the following ways: o Pour 50 mL of water behind the levee and let it sit for 30 s to see how well the levee holds up to flooding. o Use the rain cup (see picture above) to allow water to "rain" on their levee for 10 s. 5. Tell students that they will rate each material (on a scale of 1-5) on how much they agree with the statement: the material held back floodwater. Ask students what they think this means. Make sure students understand that if water is poured behind the levee and no water gets through, the material did hold back floodwater. This means they should rate the statement a 5 because they should agree with it. If the water gets through freely, they should rate the statement a 1 because they should disagree with it. 6. They will also rate (on a scale of 1-5) on how much they agree with the statement: the material eroded with rain. Ask students what they think this means. Make sure students understand that if it rains on the levee and the material moves, the material eroded with rain. That means they should rate the statement a 5 because they should agree with it. If it rains on the levee and the material does not move, they should rate the statement a 1 because they should disagree with it. 7. Tell students that they will not be able to touch the materials with their hands at any point during the testing and construction phases. 8. Assign each student in the group a number. 9. Tell students each of them is going to have a specific job during the material testing. They will get to rotate into all jobs during the materials testing phase so not to worry if they like someone else's job more than theirs. Explain the jobs. o Levee Builder: Use the backhoe (spoon) to mold the material into a levee in the middle of the test container. ▪ When introducing this job title show students the backhoe/spoon that they can use to move the material. o Flood Maker: Fill the graduated cylinder with 50 mL of water and pour it behind the levee when the site supervisor (the teacher) gives the ok. o Rain Maker: Pour water into the rain cup (1/4 full) and let it rain on the levee when the site supervisor (the teacher) gives the ok. o Observer/Reporter: Observe what it happening and be ready to report to your group and to the class what you saw. (If there are only three people in the group, have the Levee Builder also be the Observer/Reporter.) o Material Hauler: Get the materials from the quarry (front of the room) and drive them to the work site (your desk). (If there are only three or

	four people in the group have the Rain Maker also be Materials Hauler.) 10. Assign each number a role. o It is easier to keep track of the roles if you write them on the board and put the number of the person that is responsible for each role next to the job title for that trial. 11. Pass out a 3-cup plastic container, spoon, and 100 mL graduated cylinder to each group. 12. Have the Material Hauler get the first material, rocks. Have students draw a picture of what the rocks look like in question 10. 13. Have the Levee Builder build the levee. Perform the flood and rain tests and answer the questions in #10. 14. Have students share out what they learned about the rocks and record it on the board. ESR: Rocks Did not prevent flooding Does not move when water is poured on top. 15. Repeat the process for the gravel, sand, clay, and grass, answering questions, 11-14. For the grass, give students 2 squares. Make sure to rotate the students between jobs for each trial. Examples of what might be recorded on the class chart at the end of the materials testing are shown below. ESR: Gravel Held back a little more water than rock but does not do a good job with floods. Stays in the same place when water is poured on top. ESR: Sand Kept water back longer than rock or gravel. The water made pits when poured on top. ESR: Clay Held back all of the water. The water made pits when poured on top. ESR: Grass Does not withstand floods but soaks up water. Did not move when water was poured on it.
Part 2(b): 45 minutes	**Designing Levees** 1. Tell students that they will now design a levee in their groups. Once their levees are built, they will be tested in the following ways: o Test 1: 100 mL of rain will fall on the levee. o Test 2: The floodwater will rise to half the maximum predicted flood height and will sit for 30 seconds. o Test 3: The floodwaters will rise to the maximum predicted flood height and will sit for 30 seconds. 2. Remind students that they are acting like engineers and engineers care about two things: performance and cost. Tell students that their levee will be evaluated on both of these things. They will be given $400 dollars to build their levee and it will take ~10 cups of materials to construct. Remind students of the materials that they can use and their costs: rock ($20), gravel ($20), sand ($20), clay ($100), and grass ($10). They will also have access to the following tools: a water truck (squirt bottle), two backhoes (spoons), and a dump truck (bowl).

	3. Go over the vocabulary with students in the picture at the bottom of page 4 (shown below).  4. In their groups, have students go through and answer questions 15-20, which help students determine what materials they will use and where they will put them in their levee. 5. Use the picture on top of page 7 (question 21) to show students the symbols that they are going to use for each material and how to draw them into the appropriate area. Show them that if they plan to mix materials, how they will draw them in their picture. It is suggested you draw materials in locations that are "not good" in your example so that students do not copy yours. For example, draw grass in the lower inside or sand on the lower surface since these are locations in which each material would not be useful. An example of what you might draw for students is shown below. Remind students that within their group they should all have the same picture because they are building the same levee. Therefore, they will need to talk to each other before they draw their picture. Tell them they will also need to decide if they can afford their levee. Remind them that they will only get $400 total, and clay alone costs $100 per cup. Ask them if they could fill the entire lower inside with clay. Expected Student Response: No because the lower inside needs ~4 cups and that would use all of their money. Have students fill out questions 21 and 22. Tell them that if needed they can go back and revise questions 15-21. 21) Draw a picture of your levee using the following symbols  22) Will you be able to afford your levee? Keep in mind that you only have $400. Yes NO* *If you answered no go back and modify questions 15-20.
Part 3: 45 minutes	**Building Levees** 1. Tell students that levees will be evaluated on how well they perform and on their cost. As a class, use the Levee Evaluation Tool to develop a rubric for evaluating the levees when they are tested. One possible example is shown below. When developing the tool with your class, use student suggestions which may differ from the example below.

Levee Evaluation Tool

As a class decided on how you are going to evaluate the levees. You will rate your own levee as well as 2 other firm's levees. Each category will be scored from 1-4 it is up to the class to decide what a levee has to do to get a specific score.

	Levee Performance
Score	Requirement to Receive Score
1	Does not pass any of the tests
2	Passes one either rain or 1/2 flood
3	Passes both rain and 1/2 flood tests
4	Passes all three tests: rain, 1/2 flood, and full flood

	Cost
Score	Requirement to Receive Score
1	Cost $400 and ran out of materials
2	Cost $400 but had enough materials
3	Cost between $350—$400
4	Cost $350 or less

2. Show students the tools that they will have. They will have two backhoes (spoons), one dump truck (bowl), and one water track (squirt bottle).
3. Tell students the union rules for building their levee and inform them that the union rep (you) will fine them $10 each time they break a rule.
    - Workers (they) cannot touch the soil with their hands.
    - Workers can only use one tool at a time. (For example, they cannot be touching both the backhoe and the dump truck. One student must hold the dump truck and the other must operate the backhoe.)
4. Tell student that when they want to purchase materials, they can send one group member with the appropriate amount of money to the store. They should save the cups that the materials come in so that they can record how many cups of each material they used after they finish building their levee. They will be allowed to return materials to the store for credit as long as the materials are unused and unmixed with other materials.
5. Have students construct their levee. Make sure that students keep the materials cups so that they know what their levee was built from. If students want a ½ cup of material, dump out ½ of the materials and use a Sharpie to mark the cup with "½."
6. Once groups are finished building their levee, have them fill out the Levee Statistics by counting the number of cups of each material they have and recording it on the table. In addition, have them determine the cost of their levee by subtracting the amount of money that they have left from $400.

Part 4(a): 30 minutes

Levee Testing

1. Students will be evaluating their levee and two other firms' (groups) levees.
2. Give each group a number. Tell students that if their firm is an odd number they will be evaluating firms with odd numbers (1, 3, 5) and if their firms is an even number they will be evaluating firms with even numbers (2, 4, 6). Remind students that if a levee is in a firm that they are not evaluating they can just watch the testing and do not need to write anything down.
3. Put the levee evaluation criteria up in front of the class for all students to see.

	4. Bring the firm 1's levee up to the front of the class and put it under the document camera. 5. Have students that will be evaluating that levee raise their hands. 6. Have the group who built the levee tell the class how much the levee cost and what materials they built it out of. 7. Have students that are evaluating the levee write down the cost as well as the score based off of the Levee Evaluation Tool on the chart on page 8. 8. Perform Test 1. Under the document camera, pour 100 mL of water into a rain cup and have it rain onto the crown and side of the levee. a. Note: Only ~75 mL will come out as rain. Tell students that the last ~25 mL is a heavy rain and pour it on the crown of the levee. 9. Have students that are evaluating the levee mark if the levee passed the rain test and record any observations in their notebooks. 10. Perform Test 2. Under the document camera, add water to the ½ predicted flood height (one inch above the ground level.) Then, use the timer to wait for 30 s. 11. Have students that are evaluating the levee mark if the levee passed the ½ flood test and record any observations in their notebooks. 12. Perform Test 3. Under the document camera, add water to the maximum predicted flood height (two inches above the ground level). Then, use the timer to wait for 30 s. 13. Have students that are evaluating the levee mark if the levee passed the max flood test and record any observations in their notebooks. Then use the Levee Evaluation Tool to score the performance of the levee. 14. Repeat the process with the next group (firm 2) and continue in order until all levees have been tested. a. This will result in students recorded data from every other levee. 15. As a group, discuss what general patterns they saw between the levees when they were tested.
Part 4(b): 45 minutes	**Discussion Questions** 1. Have groups talk about how their levee held up to rain and normal erosion (test 1) and then have them share out and fill out question 23. 2. Have groups talk about how their levee held up to flooding (test 2 and 3) and then have them share out and fill out question 24. 3. Discuss if they think that levee cost and levee performance are equally important and if they think all people will agree with them. Then have them fill out questions 25-26. 4. Have students individually fill out question 27 and then share out which levee they think should get the contract and why. 5. As a class, go over questions 28-37, which have students look at structural differences between two levees, identify the purpose of the structure, and determine the better design. Have students share out their thoughts, and once a class consensus has been reached, write the answer in an example student notebook under a document camera. Have students copy it into their worksheet. 6. Show students the video https://projects.propublica.org/graphics/levees that discusses the negative impacts of levees, then have them fill out question 38. 7. As a class discuss what they saw and if they think levees are positive or negative and why.

Example Student Work

Name: Darby

Levees

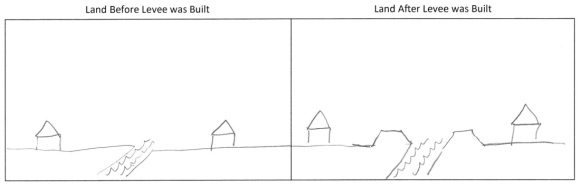
Part 1: *Reading Questions*

1) What causes rivers to flood? too much rain

2) Does flooding affect people? (Yes) No

3) What can engineers do to protect people from flooding? build levees

4) Draw the following pictures



5) Raised sides (Structure of the Levee) allow the levees to hold back water. (Function)

6) Rock along the side of the levee (Structure of the Levee) allow the levee to withstand erosion (Function)

7) What factors do people need to think about when designing a levee? performance
cost
appearance

8) Do all people agree that all factors are equally important? Yes (No)

9) How do levees fail? overtopping
breaching

Part 2: *Material Exploration*

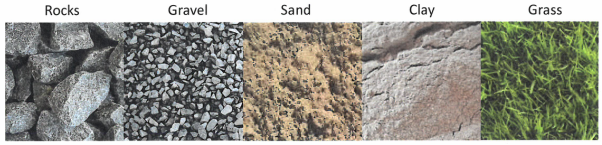
Engineering Problem

The city of Lowlandia has contacted several engineering firms and requested that each firm put together a bid and a scale model of a levee that they could construct for the town. The firm with the "best" levee will be hired to build the towns new levee.

Earth Materials

Lowlandia has the following materials that can be used to build the levee:

Rocks Gravel Sand Clay Grass



Testing Earth Materials

For each of the materials above, construct a levee solely out of that material. Test how well the levee holds back flood waters by pouring 50 mL of water behind the levee and letting it sit for 30 s. Then test how well the levee withstands erosion from rain by filling the rain cup 1/4 of the way full of water and letting it rain on the levee for 10 seconds.

10) Rocks (Cost: $20 per cup)

Drawing of Material

The material held back floodwater (water behind levee).
Agree 1 2 3 4 (5) Disagree

The material eroded with rain (water on top of levee).
Agree 1 2 3 4 (5) Disagree

What function could rocks serve in the levee? to stop erosion on the side of levee

11) Gravel (Cost: $20 per cup)

Drawing of Material

The material held back floodwater (water behind levee).
Agree 1 2 (3) 4 5 Disagree

The material eroded with rain (water on top of levee).
Agree 1 2 3 (4) 5 Disagree

What function could gravel serve in the levee? to slow down erosion on the sides

12) Sand (Cost: $20 per cup)

Drawing of Material

The material held back floodwater (water behind levee).
Agree 1 2 3 (4) 5 Disagree

The material eroded with rain (water on top of levee).
Agree 1 (2) 3 4 5 Disagree

What function could sand serve in the levee? to slow down floods

13) Clay (Cost: $100 per cup)

Drawing of Material

The material held back floodwater (water behind levee).
Agree 1 2 3 4 (5) Disagree

The material eroded with rain (water on top of levee).
Agree (1) 2 3 4 5 Disagree

What function could clay serve in the levee? to stop floods

14) Grass (Cost: $10 per 5 cm x 5 cm square (size of drawing box below))

Drawing of Material

The material held back floodwater (water behind levee).
Agree 1 2 3 (4) 5 Disagree

The material eroded with rain (water on top of levee).
Agree 1 2 3 4 (5) Disagree

What function could grass serve in the levee? the grass can absorb some of the floodwaters

Part 2: *Designing Levees*

Levee Testing

To see how the levees perform, the following tests will be done:

Test 1: 100 mL of rain will fall on the levee.

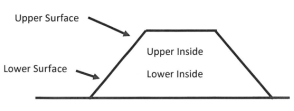
Test 2: The floodwaters will rise to half the maximum predicted flood height and will sit for 30 seconds.

Test 3: The floodwaters will rise to the maximum predicted flood height and will sit for 30 seconds.

Levees will be evaluated on how well they perform and their cost.

Preliminary Levee Design

As a group, use your findings about how the Earth materials interact with water to help you design the best levee for Lowlandia. Lowlandia has set your budget to be $400. City planners think you will need ~10 cups of material in your final levee construction. Use the terms in the picture below when deciding where to use materials. In the city yard are the following tools that you can use: a water truck (squirt bottle), a backhoe (spoon), and a dump truck (bowl).



Levee Material	Price per Unit
Rocks	$20 per cup
Gravel	$20 per cup
Sand	$20 per cup
Clay	$100 per cup
Grass	$10 per square (5 cm x 5 cm)

15) We will use **rocks** in our levee: (yes) no (if no, skip to gravel)

Rocks will be used in the following locations: (circle all that apply)

Upper Surface (Lower Surface) Upper Inside Lower Inside

We are putting rocks here because:

- ☒ It is resistant to rain or normal erosion
- ☐ It helps hold water back
- ☒ It is cheap
- ☐ It is expensive
- ☐ Other:_____

16) We will use **gravel** in our levee: (yes) no (if no, skip to sand)

Gravel will be used in the following locations: (circle all that apply)

(Upper Surface) Lower Surface Upper Inside Lower Inside

We are putting gravel here because:

- ☒ It is resistant to rain or normal erosion
- ☐ It helps hold water back
- ☒ It is cheap
- ☐ It is expensive
- ☐ Other:_____

17) We will use **sand** in our levee: (yes) no (if no, skip to clay)

Sand will be used in the following locations: (circle all that apply)

Upper Surface Lower Surface (Upper Inside) (Lower Inside)

We are putting sand here because:

- ☐ It is resistant to rain or normal erosion
- ☒ It helps hold water back
- ☒ It is cheap
- ☐ It is expensive
- ☐ Other:_____

18) We will use **clay** in our levee: (yes) no (if no, skip to grass)

Clay will be used in the following locations: (circle all that apply)

Upper Surface Lower Surface (Upper Inside) (Lower Inside)

We are putting clay here because:

- ☐ It is resistant to rain or normal erosion
- ☒ It helps hold water back
- ☐ It is cheap
- ☒ It is expensive
- ☐ Other:_____

19) We will use **grass** in our levee: yes no

Grass will be used in the following locations: (circle all that apply)

Upper Surface Lower Surface Upper Inside Lower Inside

We are putting grass here because:

- ☐ It is resistant to rain or normal erosion
- ☐ It helps hold water back
- ☐ It is cheap
- ☐ It is expensive
- ☐ Other:_____

20) Use the checklist below to verify you have materials for each section of the levee, if not go back and modify questions 15-19.

Inside Levee

The **Upper Inside** of the levee will be made from (check all that apply) :

☐ rocks ☐ gravel ☒ sand ☒ clay ☐ grass

The **Lower Inside** of the levee will be made from (check all that apply) :

☐ rocks ☐ gravel ☒ sand ☒ clay ☐ grass

Outside Levee

The **Upper Outside** of the levee will be made from (check all that apply):

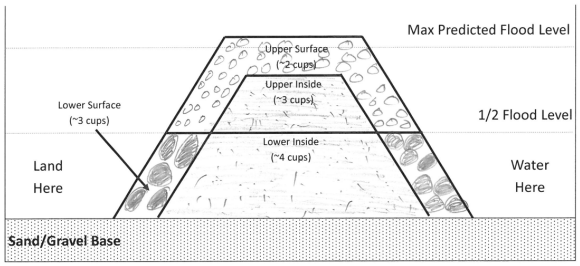
☐ rocks ☒ gravel ☐ sand ☐ clay ☐ grass

The **Lower Outside** of the levee will be made from (check all that apply) :

☒ rocks ☐ gravel ☐ sand ☐ clay ☐ grass

21) Draw a picture of your levee using the following symbols

● Rock ○ Gravel Sand Clay Grass



22) Will you be able to afford your levee? Keep in mind that you only have $400. (Yes) NO*

*If you answered no go back and modify questions 15-20.

Part 3: *Building Levees*

Levee Evaluation

As a class, fill out the levee evaluation tool, so that all levees will be evaluated the same after they are constructed.

Building Your Levee

As a group, construct your levee. You must follow the union rules below during construction.

1) Workers (you) cannot touch the soil with their hands.
2) Workers can only use one tool at a time.

Any time that your firm does not obey the rules you will be fined $10, which will come out of your $400 levee budget.

Buying Materials

To get materials you will need to give the store the correct amount of money.

You can buy full cups or half cups of materials. Grass must be bought in 5 cm x 5 cm pieces. Unused, unmixed materials can be returned to the store for credits, if needed.

Levee Statistics

Levee Material	Price per Unit	Amount Used	
		Full Cups	Half Cups
Rocks	$20 per cup	3	
Gravel	$20 per cup	5	
Sand	$20 per cup	2	
Clay	$100 per cup	2	
		5 cm x 5 cm Squares	
Grass	$10 per square		
Total Cost: $400 -$ 60 (Money Left) =$ 340			

Part 4: *Levee Testing and Evaluation*

Levee Ratings

Fill out the form below as you test your levee and 2 others levees. Make sure that you use the evaluation tool to give a score (1-4) for the cost and the performance.

	Firm 1	Firm 2	Firm 3
Levee Cost:	$ 380	$ 320	$ 340
Cost Score:	3	4	4
Performance: (Check box if test is passed)	☒Rain ☒1/2Flood ☐Flood	☒Rain ☒1/2Flood ☐Flood	☒Rain ☒1/2Flood ☐Flood
Performance Score:	3	3	3
Total Score:	6	7	7
Observations:	grass soaked up water ½ levee breached	grass soaked up water water breached through hole in grass	Levee overtopped

Part 4: *Discussion Questions*

- Think about how your levee performed in Test 1 (rain).
- Discuss with your firm how your levee held up to **rain and normal erosion**.

23) How could you change your levee to better withstand rain and erosion? we could add grass to the crown

- Think about how your levee performed in Test 2 (half flood) and Test 3 (full flood).
- Discuss with your firm how your levee held up to **flooding**.

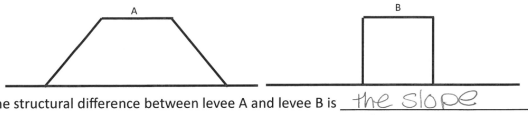
24) How could you change your levee to better withstand flooding? we could make the levee taller so it would not breach as easy

25) Are levee cost and levee performance equally important why or why not? No levee performance is more important because people get hurt when levees fail.

26) Do you think that all people will agree with this (circle one)? Yes (No)

27) I think firm (1 (2) 3) deserves the contract because they pass the same test as the other 2 firms but did so at a smaller cost

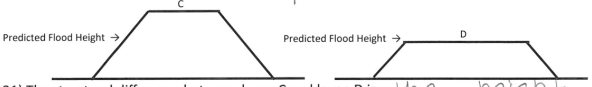
Circle One



28) The structural difference between levee A and levee B is the slope

29) The function of this feature is to stop erosion

30) Levee A is the better design because the sides will not erode as easily



31) The structural difference between levee C and levee D is the height

32) The function of this structure is to stop overtopping

33) Levee C is the better design because it is taller so floodwaters can be heigher before overtopping

34) The structural difference between levee E and levee F is the location of the material

35) The function of this structure is to stop erosion because different material behave differently

36) Levee F is the better design because rocks stop erosion and need to be outside

37) What is the purpose of a levee? to stop water from flooding towns

Before answering the next question watch the levee video.

38) Are there any negative impacts to building levees, if so what are they? yes it can cause flooding in other areas.