How Much Water?

What are ways to slow the source of stormwater runoff from roofs to ease the burden on water municipalities during high demand? *Calculating Stormwater Runoff*

(5 Days)

Authors

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SUBJECT/GRADE LEVEL

General Science
Math
Grade Level: 7

Materials

- Electronic device with internet access per group
- Video projection equipment
- Worksheet 1, 2A-2D, 3, 4
- Accountable Talk/Question Stems for Gallery Walks
- Edpuzzle: Stormwater Pollution and Green Infrastructure Solutions
- TedTalk: Green Infrastructure for Runoff
- Rainwater Catchment System in Action
- Shifting from Gray to More Green Infrastructure
- Jamboards: 1. Engagement 'How Much Water?' and 2. Evaluation 'How Much Water?'
- Quizizz: How Much Water
- Inexpensive baking dishes, one per group
    - (same or different sizes)
    - Or something rectangle to measure area
- Ruler per group
- Access to water
- Calculator
- Measuring cup or beaker
- Measuring Wheel or blue prints of your school

STANDARDS

Next Generation Science Standards [Link to MS-ETS1 Engineering Design Standards]

- MS-ETS1-1. Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.
- MS-ETS1-2. Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.

Mathematics Standards | Common Core State Standards

- CCSS.Math.Content.7RP.A.1: Compute unit rates associated with ratios of fractions, including ratios of lengths, areas and other quantities measured in like or different units.
- CCSS.Math.Content.7.G.A.1: Solve problems involving scale drawings of geometric figures, including computing actual lengths and areas from a scale drawing and reproducing a scale drawing at a different scale.
- CCSS.Math.Content.7.G.B.6: Solve real-world and mathematical problems involving area, volume and surface area of two- and three-dimensional objects composed of triangles, quadrilaterals, polygons, cubes, and right prisms.

English Language Arts Standards | Common Core State

- CCSS.ELA-Literacy.SL.7.1: Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 7 topics, texts, and issues, building on others' ideas and expressing their own clearly.
- CCSS.ELA-Literacy.SL.7.3: Delineate a speaker's argument and specific claims, evaluating the soundness of the reasoning and the relevance and sufficiency of the evidence.
- CCSS.ELA-Literacy.SL.7.4: Present claims and findings, emphasizing salient points in a focused, coherent manner with pertinent descriptions, facts, details, and examples; use appropriate eye contact, adequate volume, and clear pronunciation.

LESSON OBJECTIVE(S)

Students will explain how stormwater collection can improve water quality and provide a wide range of services, calculate surface area for multiple rooftop scenarios and apply knowledge of rain water runoff across different scenarios.

CAREER CONNECTION(S)

Mentor Background: Dr. Kyle McKay, Research Civil Engineer; U.S. Army Engineer Research and Development (ERDC); Vicksburg, Mississippi. "Our team's work focuses broadly on trade-offs between

human and ecological uses of water resources with applications in ecosystem restoration, flood management, and ecological modeling. The team is currently seeking to better understand natural infrastructure and the potential role of ecosystems in infrastructure portfolios, and we are partnering closely with the Network for Engineering with Nature." https://n-ewn.org

STEM Careers: Environmental Engineering, Civil Engineering

CENTRAL FOCUS

The main focus should be that students understand how waste water management works, how contamination can happen in flood/overflow situations and the green measures that can be taken to alleviate stress on water systems.

This unit incorporates math and science with multiple opportunities for data analysis and collaboration among students. They will learn how to calculate the amount of stormwater runoff by finding the surface area and how that volume correlates to storage in rain barrels per their amount of localized rainfall. This unit spans 5 days–and there is a quiz at the end which can be taken prior to and after the final lesson to create a benchmark of learning; beginning with background information of stormwater gained by watching several videos (what it is, how it plays a role in the environment, and what we can do about it) that hopefully lead to robust classroom discussions.

Finally, students should understand water deficiencies and safety issues exist around the world. The global issue of clean water for all still remains a problem needing to be solved.

ENGAGEMENT

Brief Description:
Students will gain background information of stormwater runoff by watching the included videos. They will be able to see how stormwater is collected and just how precious water is. While watching the videos in small groups, students will respond to Jamboard prompts then will come together as a large group to engage in discussion of the prompts.

Procedures:
Background Content for Teachers:

Teachers should emphasize that all the contaminants on surfaces like roads, parking lots, cars, or grass are washed away when it rains. Specifically, within the first inch of rain the contaminants are washed away. Knowing how much water could be collected from a rooftop will allow us to create rain gardens that can handle the calculated amount of water.

-infographic to show the importance of stormwater runoff

https://www.dot.state.pa.us/public/Bureaus/BOMO/raindrainbrochure.pdf

https://epa.ohio.gov/static/Portals/47/facts/ReduceStormWaterInfographic.pdf

Day 1 Procedures

-Driving question: Why is rainwater runoff a concern?

1. Place students into groups of 2 or 3, with at least a laptop per group..

2. Edpuzzle w/Questions (9min) Stormwater Pollution and Green Infrastructure Solutions
3. TedTalk(12min) Understanding Green and Gray Infrastructure
4. TedTalk (14:45) Green Infrastructure for Runoff
5. Off Grid Rainwater Catchment (4:42 min) https://www.youtube.com/watch?v=wd8_cOYiE5E
6. Jamboard 1: Jamboard 1: Engagement 'How Much Water?' In groups, students reflect on their own experiences of flooding and on the videos watched. Students should be encouraged to discuss as a group and post a well developed response to each of the 6 boards.

    -Questions listed on Jamboard are:

    - Discuss with your group then list here: Share experiences with flooding you have had or witnessed on the news.
    - TedTalk: How can runoff be critical to help keep urban water clean? Use DATA from the video!
    - TedTalk: Explain how older cities utilize a combined sewer system and its potential issues for public health.
    - Edpuzzle: Why has the EPA listed stormwater as the "number one threat" to our waterways?
    - Edpuzzle: What are some characteristics of rain gardens?
    - Edpuzzle: What was the goal for stormwater runoff? To redirect water how?

EXPLORATION

Brief Description: Keeping stormwater runoff in mind, we switch gears to learn about surface area and volume. Students may need a review of surface area and volume or may need to be taught the concept. In this section, we are trying to relate the roof area to the amount of rainwater runoff a school can create. In small groups, students will begin by measuring the surface area of the bottom of a baking dish then filling the dish with an inch of water to help visualize volume. Students then progress to calculating the rooftop stormwater volume of a sample school.

Procedures:
Background Content for Teachers:

Teachers should be familiar with how to find the surface area of a rooftop, and be able to convert measurements to liters, gallons, inches and centimeters.

Day 2 Procedures

1. Begin class by explaining what area is.
2. Worksheet 1: How can we begin to calculate stormwater runoff?
    a. In small groups, students will use rulers to measure the length and width of the bottom of the baking pan to calculate the surface area. The worksheet #1 will guide students through this step.
    b. Step 2-Students will calculate volume in the third box then they will measure an inch up from the bottom of the pan, make a mark, and fill with water to the line.
    c. On their Worksheet #1, students just calculated the volume of water they just added to the baking pan, now they will check their calculations by pouring the water from the pan

into a beaker. Students should get the same amount of liquid they calculated as they see in the beaker.. *Take the opportunity to practice unit conversions (cups to gallons or liters to kiloliter.)*

3. Gallery walk to discuss calculating volume process. Students then perform a gallery walk (half the group stays at table/half rotates to groups) for 2 minutes per group/2 rotations. Teacher listens/prompts students to ask questions and formulate responses as well as make recommendations and share mistakes made in the process.
4. Driving question: How does the scale of a building change our units of measurement?
    a. Worksheet 2A, 2B, 2C, 2D: Each group should have a different version of "Sample School A, B, C, D." The school is already sketched with measurements and units. Students will be prompted to calculate the surface area of the roof and the volume of stormwater it would contain if the rainfall was at a rate of 1 inch per hour.
5. Wrap-up: Have each group share their school with the dimensions and the amount of stormwater runoff it will produce. Collect worksheets for students' feedback and return the next day.

EXPLANATION

Brief Description: Groups have practiced calculating the amount of roof rainwater runoff for various roofs. Students will take that base knowledge and apply that to creating a sketch of their school then using a distance measuring wheel walk the perimeter of the school. Using the distance data in the classroom, students will calculate their school roof surface area to calculate the amount of water that the roof could collect.

Procedures:

Background Content for Teacher:

Teachers should reach out to local conservation units to find resources for rain barrels, looking for funds or blueprints or examples of rain barrels.

Day 3 Procedures

1. Begin class with an area warm-up, put 2 or 3 simple roof top area questions up for students to work on while they enter the room.
2. Review how to calculate roof top surface area and why we are measuring this…
    a. We are measuring the rooftop surface area to see how much water falls on the roof that we can collect and reuse in a planter or in a rain barrel.
3. Worksheet 3 accompanies this step. Either use a distance wheel and walk the perimeter of the school to find the length of the edges of the roof -OR-use school blueprints to find the lengths of the roof.
    a. While outside, have students sketch the shape of the roof then explain that they will need to break up complex shapes into basic shapes. (If school is T shaped, then you would break the T into two rectangles.)
    b. After sketching the school, the groups can work to solve the surface area.

c. Come together and have the groups share their answers discussing any discrepancies and where the errors were made.

4. Return to the classroom to complete the last box of Worksheet #3 where the students expand their knowledge and look at different areas of the United States.
    a. Groups will choose a city from the list on the link: Handout of Average Rainfall per US City Data Set then calculate the monthly average rainfall for the city. Using that data, calculate the volume of rainfall that would land on your schools' roof per month. (As if your school that you sketched in Step 1 was located in the city that the group is investigating) *Students will be expected to be able to realize that the "Average Rainfall Handout" link is in **years** and would need to be averaged into months.*
    b. Gallery Walk 2-3 Rotations. Students should point out the differences between the city they live in and their city they choose.
5. Wrap-up: Share differences in rainfall around the United States and then brainstorm how cities deal with stormwater runoff.

ELABORATION

Brief Description: Now that groups have an understanding of the amount of water that is coming off the roof, we will challenge students to create a proposal to install rain barrels to collect the water. Students will research rain barrels or downspout planters to build interest in purchasing or constructing them.

Procedures:
Background Content for Teacher:

Using the data from Worksheet 3, students will be able to calculate rain barrel or downspouting needs.

Day 4 Procedures

1. Using Worksheet 4: Rain Barrels, students will calculate how many rain barrels they will need at their school in order to collect the average monthly rainfall.
2. In small groups, students research types, sizes and prices of rain barrels. Knowing the volume of average monthly rainfall, students will create a proposal for the number of barrels needed at their school.
3. Groups then create a proposal to purchase or make the rain barrels or downspouting planter boxes. Once proposals are completed–typed up, includes pictures of proposed barrel or planter, with a price tag, use a gallery walk or class presentation to share ideas. Proposals could be voted on by peers, placed in a high traffic area and voted on by teachers or other students, or have a community member from the local water municipalities come by for a class presentation and make comments on presentations.

EVALUATION

Brief Description: Evaluation is composed of a jamboard or a Quizziz. Students will complete jamboard

in a group and can do the Quizizz alone or with a group.

Procedures:
Day 5 Procedures

-Jamboard 2: How Much Water? Evaluation Jamboard. Students will visit the Jamboard and complete the four boards together. NOTE: Board 4 can be used as a project based assessment if preferred, or students can gallery walk and check the calculations; random cities can be chosen/assigned so each group is different.

-Quizizz: Finally, students should individually complete the following quizizz "How Much Water?" as an assessment. Students may review videos and calculation processes as a review.

ENGINEERING EXTENSION

Downspouting planter boxes AKA bioretention planter

When access to the roof is limited, you can still harness the rooftop water via the downspouting. Downspouting planter boxes have become an attractive and functional part of the water cycle. These planter boxes are not only attractive but also provide some filtration of the water that is coming off the roof. Building a Rainwater planter box, also called a bioretention planter can easily be achieved by following this detailed handout from the Watershed Institute. The design of the planter can fluctuate according to your needs, and the plants should be carefully chosen to be native plants. You could even challenge students to incorporate a rain barrel component to the planter for dry spells.

REFERENCES

- Teacher background: https://www.dot.state.pa.us/public/Bureaus/BOMO/raindrainbrochure.pdf https://epa.ohio.gov/static/Portals/47/facts/ReduceStormWaterInfographic.pdf
- Quizizz: https://quizizz.com
- Jamboard: https://jamboard.google.com
- Edpuzzle: https://edpuzzle.com
- YouTube: https://www.youtube.com/watch?v=ATNy-vaIPXI
- TedTalk: https://youtu.be/jAenu6Vshs8 stormwater green infrastructure-rooftops
- TedTalk: https://www.youtube.com/watch?v=4jwTnsxuDG8; green/gray infrastructure explained
- Rainwater Catchment in Action: https://www.youtube.com/watch?v=wd8_cOYiE5E
- Using Rain barrels in outdoor classrooms (proposal ideas):
- https://www.eealliance.org/uploads/1/2/9/7/129730705/ocs_resource_guide_06_part5.pdf
- Handout of Average Rainfall per US City Data created from data of this site: https://www.infoplease.com/math-science/weather/climate-of-100-selected-us-cities
- Questioning: https://www.hunschool.org/resources/questions-for-critical-thinking
- Accountable Talk Stems (p.27): https://masscharterschools.org/wp-content/uploads/legacy/docs/mcpsa_pdfs/let_them_talk.pdf
- Downspouting planter boxes: The Watershed Institute