Connecting Industry to Mathematics Instruction
NSF ATE Award # 1954291

Stormwater Management

A Solidify Understanding Task

Purpose: *To determine if an area needs a stormwater management system after it has been developed into a new use.*

Career Field: Civil Engineers

Company: CLH Design, PA

In partnership with

WTCC Associate Program of Study and Contact Person:
Civil Engineering Technology
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NC Math 4 Standards:

AF.1 ***Apply properties of function composition to build new functions from existing functions.***
AF.1.1 Execute algebraic procedures to compose two functions.
AF.1.2 Execute a procedure to determine the value of a composite function at a given value when the functions are in algebraic, graphical, or tabular representations.

Unit Alignment:
NC Math 4 - Unit 2: Functions
MAT 121 - Unit 1: Functions

Common Core State Standards for Mathematical Practice

1. Make sense of problems and persevere in solving them.
2. Reason abstractly and quantitatively.
3. Construct viable arguments and critique the reasoning of others.
4. Model with mathematics.
7. Look for and make use of structure.

Prerequisite Skills

These skills could be reviewed in a warm-up and are addressed in the Desmos Activity

- Sum notation ∑
- Unit conversions
- Compare and analyze mathematical findings

Time Required
The time required to complete **Activity 1 (90 minutes)**, **Activity 2 (45 minutes)**.

Materials Needed
- Student Activity Sheet
- Calculator

The Teaching Cycle:

Launch: Students should work in groups of 2-3. Have students complete the Desmos Launch Activity (opens in a new window) [plain text link: https://teacher.desmos.com/activitybuilder/custom/5f88a0b12968912f3bf340fb?collections=5f6cae0049988f0bfcd6f9f8].

The Desmos Launch Activity will address the information discussed in the remainder of the launch.

Begin the activity by showing the video (opens in a new window) [plain text link: https://youtu.be/_ZljTZ88qZo] to introduce CLH Design, a Civil Engineering firm, that specializes in stormwater management.

Stormwater management systems must be designed so that post-development water management is equal to or better than pre-development water management to prevent adverse effects on the environment. This lesson will specifically investigate how a Civil Engineer plans for stormwater management through the construction process.

In the video, the engineer explained what runoff is, ask if there are any questions about this terminology before students begin the task. Brief discussion on impervious and pervious surfaces. Present students with the 4 images provided and ask students to order the images from least runoff to greatest runoff. After students have had a chance to order the images, show the slide with the correct order, description of surface, and coefficient of runoff.

Show students the paired images of sample pre-development and post-development sites. Discuss if students think a stormwater management system is needed for the post-development site based on the picture.

Distribute student activity sheet and have the students read the given task. Give students time to digest the reading and have a brief discussion in pairs to allow students to confirm they understand what the task is expecting them to do. If warm-up was not used, be prepared to answer questions regarding sigma notation and unit conversion. The sigma symbol $\sum$ is called a summation. It adds together everything of the form that follows it. For example, $\sum A_i$ is the sum of the areas. If students question the change in area from the pre-development to the post-development image, explain that the difference is due to the actual construction of the school and the grading of the land on site.

Activity 1 – Water Quantity (55 minutes)

Explore: Questions 1 and 2, students may need a reminder of the application of independent and dependent variables. The last part of question 1 is meant to guide students in making the connection to composing functions. Question 2 is designed to be more of a rhetorical question to start student thinking for question 7.

Students will need to apply the correct function for questions 3 - 6. Questions 3 and 5 will use the runoff coefficient function, and questions 4 and 6 will use the peak runoff function. Circulate and monitor groups to ensure students are on the right track. Students may need guidance in understanding the concept of sigma notation. ***Cfs*** (**c**ubic feet per **s**econd) is an alternate expression for $\frac{ft^3}{s}$. If students are struggling and the warm-ups were used, remind the students of the warm-up problems for sigma notation.

Industry standard applications do not require units of measure to match up exactly due to insignificant differences in decimal values. This shows up with the C runoff coefficient formula to the Q peak runoff formula.

Questions 3 and 5, look for students who add the area values and the coefficient values and then find the product of those sums. You will need to remind students of PEMDAS if this error occurs. As you are walking around, note groups who may be struggling with later questions but solved earlier questions correctly. Ask these students to share solutions with the class for problems 3 - 6. Let these students know they will be presenting, so they can clearly outline their work and be prepared to present.

To prepare for discussing question 7 and 8, look for groups with a variety of explanation, correct or incorrect. Be mindful of how students may react when their work is proven incorrect in front of the class. Possibly have a discussion with the student or group before asking them to present.

Regarding question 8, if students are struggling to connect the task with a class topic, have students reference question 1. If students continue to have questions, remind students that the idea of a composition of functions is the solution of one function used as the input for another function.

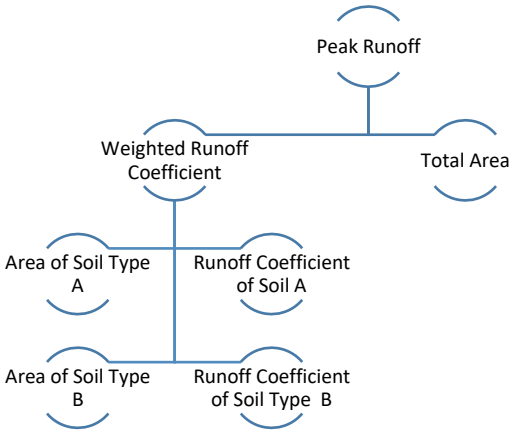
Discuss: Allow students to share solutions to questions 3 – 6 but focus discussion on questions 7 and 8. Encourage the importance of a conversation between students, not just hearing a statement from individual groups. Bring in a discussion on soft skills that CLH and other companies seek from potential employees.

Potential follow-up question (can reference question 2):
Why is the post-development runoff greater than the pre-development runoff?

For question 8, select a group that has made the connection to composition of functions. If students established other connections, ask those groups to share. Below is a possible representation of the connection students may make.

Runoff coefficient and area of soil type builds the weighted runoff coefficient.

The weighted runoff coefficient and the total area build the peak runoff.



If only doing activity 1, all groups should have an opportunity to share. If completing both activities, it is not necessary that all groups present during activity 1, they will have the chance to share during activity 2.

Activity 2 – Water Quality

Explore: Circulate and monitor groups to ensure students are on the right track. Students should be solving for the runoff value, to then compute the volume and area of the wetland.

Watch for students who may use the decimal equivalence instead of the actual percentage when solving for the runoff value. For students who ask why, respond with "that is the industry standard for computing the runoff value function."

If students are struggling with unit conversions and the warm-ups were used, remind the students to reference the warm-up problems for unit conversions. The drainage area is given in acres, but students need to convert to ft^2. You can add this information to the student document.

If a group used the decimal value when solving for runoff and then correctly used the percentage, ask this group to share during the discussion to highlight the difference in the two values they found.

If a group is having a discussion on connecting the second activity to the composition of functions, ask this group to share during the discussion. If not, select a group and guide them through the discussion so they can then share out with the class.

As students are starting to wrap-up their work, look for groups who are discussing the difference/importance of volume and surface area.

Discuss: During the discussion, have one group explain how they solved for the runoff value (preferably a group that used the decimal equivalence for the percentage). Students should highlight the value they used for the % impervious in the discussion. Encourage students to share how they found the % impervious value

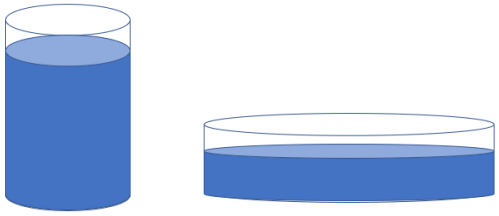
and then substituted that value into the equation to solve for the runoff value. This is another connection to composition of functions.

You can then have a group explain their thought process for solving for volume and a different group explain solving for area. Ask students why we might need to know both the volume and the surface area for the wetland. Try to encourage students to continue making the connection to composition of functions.

Possible student responses:

- Expected (desired) response – "The same volume can fit in different dimensions."
- "I didn't realize we need to know both."
- "Volume measures how much can fit into something."
- "Surface area measures the total area covered by an object."
- "Volume tells you how much stormwater can be held within the wetland."
- "Allows the engineers to plan for overflow."

If students are struggling to make the connection, consider including the provided image comparing the same volume in objects with different surface areas. The focus is not on the exact volume and surface area measurements of the images. The images illustrate equivalent volume can fit in different surface area dimensions.



Connect the surface area back to the launch video where Steve discussed the different systems used to manage stormwater.

Make sure every group has a chance to share with the class at least once.

Exit Ticket/Homework: If time allows, ask the class to begin brainstorming why the design team's plan will or will not work if the design provides **18,000** ft^3 **of volume** (question 10 on activity sheet). This will allow students to start building ideas where they are asked to construct a proposal to the client. During the discussion, students are sharing general ideas as to why the design will or will not work. Their homework is to construct a detailed proposal to the client. Students can upload their written proposal for teacher to review.