

**green  
STEM**

science



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math

## Down Came the Rain: Roofs and Runoff

Grade Levels: 6 - 12

**Objective:** To determine the volume of runoff from a school or home roof. Roof area will be estimated using Google Earth aerial imagery, and online precipitation data will be downloaded from climate data sites.

### Selected National and State Standards:

#### *National Science Education Standards*

Unifying Concepts & Processes; Standard A - Science as Inquiry; Standard D - Earth & Space Science; Standard E - Science & Technology; Standard F - Science in Personal and Social Perspectives

#### *National Council of Teachers of Mathematics Standards*

Numbers & Operations: 6-8; Algebra: 6-8; Geometry: 6-8; Measurement: 6-8; Problem Solving: 6-8; Communication: 6-8; Connections 6-8

#### *National Educational Technology Standards*

Standard 1 - Creativity and Innovation; Standard 2 - Communication and Collaboration; Standard 3 - Research and Information Fluency; Standard 4 - Critical Thinking, Problem Solving, and Decision Making; Standard 6 - Technology Operations and Concepts

#### *AP Environmental Science Focal Areas*

Humans alter natural systems; Environmental problems have a cultural and social context; Human survival depends on developing practices that will achieve sustainable systems



This material is based upon work supported by the Corporation for National and Community Service under Learn and Serve America Grant No. 09KSSVA002. Opinions or points of view expressed in this document are those of the authors and do not necessarily reflect the official position of the Corporation or the Learn and Serve America Program.

### ***Virginia Standards of Learning***

Science: 6.7, 6.9, E.S.1, ES.2, ES.3, ES.7, ES.9, ES.13

Mathematics: 6.6, 6.7, 6.10, 6.18, 7.3, 7.4, 7.5, 7.14, 8.3, 8.7, 8.11

Computer/Technology: 6-8.1, 6-8.5, 6-8.6, 6-8.7, 6-8.8

### ***Maryland State Curriculum (Grade 6-8)***

Science: 1.A, 2.A, 6.A, 6.B

Mathematics: 1.B, 3.B, 3.C

Technology Literacy: 3.A, 5.A, 5.B, 6.A

**Background:** Runoff occurs when water from precipitation flows over land instead of soaking into the ground. Runoff is a component of the water cycle. Natural areas tend to absorb more rainwater and have less runoff than manmade areas. When humans replace natural areas, such as forests, with impervious surfaces, such as buildings and roads, we impact the water cycle by creating excessive runoff. As runoff moves along the ground, it can pick up oil, pesticides, and fertilizers. Runoff containing pollutants is called non-point source pollution. Even the roofs of our buildings can be sources of heavy metals, weatherproofing chemicals, pathogens that cause disease, pesticides that kill insects, and herbicides that prevent plant growth. Polluted runoff can move into drinking water sources, such as groundwater, streams, and rivers. In this activity, we will estimate the volume of runoff from our roof. We will measure our roof using Google Earth and download online precipitation data. We will use the equation  $V=ARC$ , where runoff volume (V) is determined by finding roof area (A) times the amount of precipitation (R); we will convert units (C) to find runoff in gallons. (C = Conversion Factor: 7.48 gal/ft<sup>3</sup>).

### **Materials:**

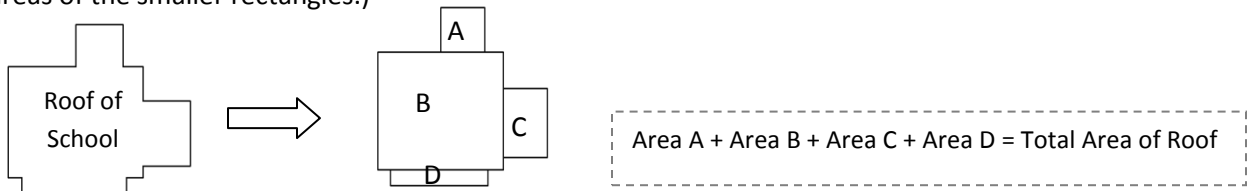
Computers with Internet access and Google Earth installed

Google Earth is a free download available from [www.google.com/earth](http://www.google.com/earth).

Calculators

**Procedure:**

1. Class discussion
  - a. What is runoff?
  - b. Describe some outdoor areas that would absorb rainwater. (Ex. Wetlands, forests, and to a lesser extent lawns.)
  - c. Describe some outdoor areas that would cause runoff. (Ex. Hard, impervious surfaces, such as paved areas, roads and buildings.)
  - d. Why is runoff a problem?
2. Find the area of the building roof in square feet.
  - a. Open the Google Earth application.
  - b. Search for your school or home by typing your school name or address in the “Fly to” box.
  - c. Click the ruler icon on the top toolbar to open the ruler tool. Set the units to feet.
  - d. Use the ruler tool to measure the length of the roof. Record the measurement.
  - e. Use the ruler to measure width of the roof and record.
3. Calculate the area of the roof. (Note: Many roofs are not in the shape of a perfect rectangle. The roof shape can often be broken down into smaller rectangles. To find the total roof area, sum the areas of the smaller rectangles.)



Variation: Obtain blueprints of your school and have students calculate roof area.

4. Find R, the amount of rain in feet.
  - a. Download local precipitation data online. (Note that most sites display precipitation in inches, which must be converted to feet.)
  - b. Suggested sites:
    - i. <http://www7.ncdc.noaa.gov/IPS/coop/coop.html>
    - ii. <http://www.ncdc.noaa.gov/oa/climate/regionalclimatecenters.html>

Variation: Monitor a rain gauge or use the value for your area’s long-term average precipitation

5. Determine  $V$ , the volume of runoff in gallons. You found  $A$ , the area of the roof in square feet and  $R$ , the amount of rain the roof receives in feet. The conversion factor,  $C$ , ( $C = 7.48 \text{ gal/ft}^3$ ) will convert cubic feet to gallons. Use the equation  $V=ARC$  to determine how many gallons of runoff your roof produces.

### **Observations & Conclusions:**

1. What types of contaminants might be present in your roof runoff?
2. Are there contaminants that might come from regional sources? (E.g. Factories in the area may deposit smoke, smut, and chemicals on roof tops.)
3. What are some ways that runoff might affect your local environment? How could runoff affect your watershed?
4. What potential actions could reduce runoff from your roof?

### **Extensions:**

1. Compare the amount of runoff in a day, month, and year. Determine if runoff is greatest in a particular season.
2. Determine the amount of runoff from parking lots, hardtops, and other impervious surfaces at your school.
3. Determine the number and locations of outflows that remove water from the roof. Investigate the vegetation in these areas.
4. Measure the volume of runoff from the roof using 5 gallon buckets.
5. Use Google Earth aerial imagery to identify manmade runoff zones in your area. (Impervious urban areas are gray in color.)
6. Investigate USGS maps that model runoff at <http://waterwatch.usgs.gov/new/index.php?id=romap3>
7. Research the quality of local drinking water at <http://www.ewg.org/tap-water/home>

## Green Jobs:

The Bureau of Labor Statistics (<http://www.bls.gov/green/>) defines green jobs as:

“Jobs in businesses that produce goods or provide services that benefit the environment or conserve natural resources.” And “Jobs in which workers' duties involve making their establishment's production processes more environmentally friendly or use fewer natural resources.”

1. Have students investigate the types of jobs are suited to their personality, skills and interests by using these online resources. The personality test center helps identify career options based on personality indicators and the O\*NET tool uses interests and skills to suggest potential careers. Students can choose to use both tools and compare the results or use each tool individually.

- a. Personality Career Tool Activity: Complete your Meyers Briggs type indicator at the online site.
  - i. Go to [www.personalitytest.net/cgi-bin/q.pl](http://www.personalitytest.net/cgi-bin/q.pl)
  - ii. Answer the 68 quick “either/or” questions. Choose your best answer to each question.
  - iii. When you click “RESULTS” your personality type will be listed.
  - iv. With your four letter reference type, choose an occupation from the list that might help suit your type and is a job that you might be interested in exploring.
  - v. The listing can be found by clicking “Green Jobs List” at <http://www.ctenergyeducation.com/greenjobs.htm>
  - vi. Do a web search of the listed resource sites and other sites to find out more about the job you chose.
    - What training/background is required?
    - What is the entry-level pay or average pay for this occupation?
    - Do there seem to be any jobs available in this occupation? If so where are they?
    - After completing your research are you more or less interested in this occupation that when you started? Explain why.
- b. O\*NET Interest Profiler Activity: Complete the O\*NET Interest Profiler
  - i. Go to <http://www.mynextmove.org/explore/ip> and complete the interest profiler
  - ii. Answer the quick 60 questions with your best answers for each question.
  - iii. When you have finished your interests will be shown in a graph, click Next to see the jobs suited to your interests.

- Where any of the jobs you chose green jobs? If not you can go to [www.onetonline.org/find/green](http://www.onetonline.org/find/green) to search the green economy jobs sector.

iv. For the jobs listed, choose ones you are interested in.

- What training/background is required?
- What is the entry-level pay or average pay for this occupation?
- Do there seem to be any jobs available in this occupation? If so where are they?
- After completing your research are you more or less interested in this occupation that when you started? Explain why.

2. Have the students investigate green jobs related to runoff and stormwater management. Suggested resources:

<http://www.bls.gov/green/greencareers.htm>

[http://www.wowonline.org/green\\_members/documents/StormwaterFinalPPT.pdf](http://www.wowonline.org/green_members/documents/StormwaterFinalPPT.pdf)

### **Service-learning Projects:**

Have students design a service-learning project implementing a green solution at your school or in your community.

1. Local rain barrel workshops are often free or low cost to teachers. Involve the art class and shop class in building and decorating your rain barrel.
2. Create a rain garden with water-loving plants, measure plant growth, and monitor the animals that colonize your green space.
3. Get the students excited about educating their classmates, parents, and community about green solutions.

To learn more about service-learning visit [www.servicelearning.vcu.edu](http://www.servicelearning.vcu.edu) and <http://www.servicelearning.org/what-service-learning>.

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## Student Worksheet (Version 1)

# Down Came the Rain: Roofs and Runoff

Name \_\_\_\_\_

**Objective:** To determine the volume of runoff from a school or home roof. Roof area will be estimated using Google Earth aerial imagery, and online precipitation data will be downloaded. Runoff volume will be determined using the following equation.

$$V = ARC$$

V = volume of runoff (gal)

A = area of roof (ft<sup>2</sup>)

R = amount of rain (ft)

C = Conversion Factor: 7.48 gal/ft<sup>3</sup>

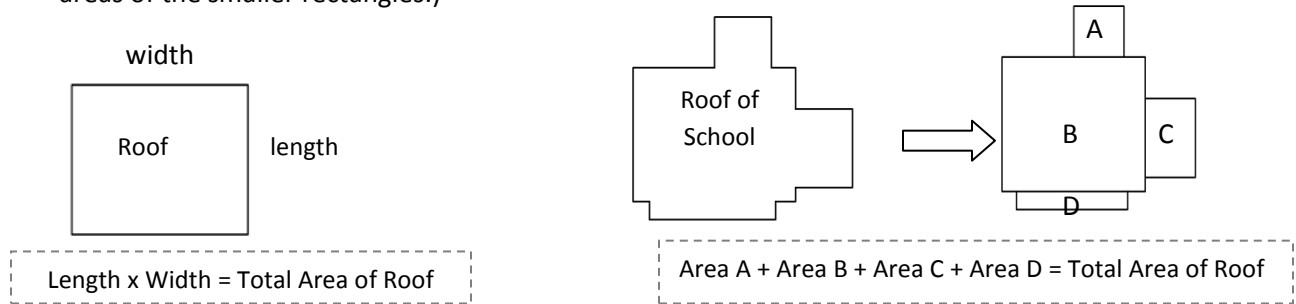
**Procedure:**

1. Find the area of the building roof in square feet.
  - a. Open the Google Earth application.
  - b. Search for your school or home by typing your school name or address in the "Fly to" box.
  - c. Click the ruler icon on the top toolbar to open the ruler tool. Set the units to feet.
  - d. Use the ruler tool to measure the length of the roof. Record the measurement.
  - e. Use the ruler to measure width of the roof and record.



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2. Calculate the area of the roof. (Note: Many roofs are not in the shape of a perfect rectangle. The roof shape can often be broken down into smaller rectangles. To find the total roof area, sum the areas of the smaller rectangles.)



3. Find R, the amount of rain in feet.

- a. Download local precipitation data online. (Note that most sites display precipitation in inches, which must be converted to feet.)
- b. Suggested sites:
  - i. <http://www7.ncdc.noaa.gov/IPS/coop/coop.html>
  - ii. <http://www.ncdc.noaa.gov/oa/climate/regionalclimatecenters.html>

4. Determine V, the volume of runoff in gallons. You found **A**, the area of the roof in square feet and **R**, the amount of rain the roof receives in feet. The conversion factor **C** will convert cubic feet to gallons. Use the equation **V=ARC** to determine how many gallons of runoff your roof produces.

**V=ARC**

**Solve for V.**

A= \_\_\_\_\_

R= \_\_\_\_\_

C= \_\_\_\_\_



**Observations and Conclusions:**

1) What types of contaminants might be present in your roof runoff? Are there contaminants that might come from regional sources? (E.g. Factories in the area may deposit smoke, smut, and chemicals on roof tops.)

2) What are some ways that runoff might affect your local environment? How could runoff affect your watershed?

3) What potential actions could reduce runoff from your roof?



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## Student Worksheet (Version 2)

# Down Came the Rain: Roofs and Runoff

Name \_\_\_\_\_

**Part 1:** Open Google Earth and fly to your home address.

1. Use the ruler to measure your roof length in feet. \_\_\_\_\_ ft
2. Use the ruler to measure your roof width in feet. \_\_\_\_\_ ft
3. Calculate your roof area. (Area = Length x Width) \_\_\_\_\_ ft<sup>2</sup>

My roof has an area of \_\_\_\_\_ square feet.

**Part 2:** Look at the precipitation table provided.

1. How many inches of precipitation fell on your roof in February 2012? \_\_\_\_\_ inches
2. Convert the amount of precipitation from inches to feet.

1 foot = 12 inches

\_\_\_\_\_ inches x (1 foot / 12 inches) = \_\_\_\_\_ feet

My roof received \_\_\_\_\_ feet of rain in February 2012.



**Part 3:** Calculate the amount of runoff from your roof.

$$\text{Runoff} = \text{area of roof} \times \text{amount of rain} \times 7.84 \text{ gal/ft}^3$$

$$\text{Runoff} = \underline{\hspace{2cm}} \text{ ft}^2 \times \underline{\hspace{2cm}} \text{ ft} \times 7.48 \text{ gal/ft}^3$$

$$\text{Runoff} = \underline{\hspace{2cm}} \text{ gallons}$$

My roof created                      gallons of runoff in February 2012.

**Part 4:** If it rained about 4.5 feet in 2011. Calculate the amount of runoff for all of 2011!

$$\text{Runoff} = \text{area of roof} \times \text{amount of rain} \times 7.84 \text{ gal/ft}^3$$

$$\text{Runoff} = \underline{\hspace{2cm}} \text{ ft}^2 \times \underline{\hspace{2cm}} \text{ ft} \times 7.48 \text{ gal/ft}^3$$

$$\text{Runoff} = \underline{\hspace{2cm}} \text{ gallons}$$

My roof created                      gallons of runoff in 2011.

WIS FORM B-91 (03-09)  
 RECORD OF RIVER AND CLIMATOLOGICAL OBSERVATIONS  
 This form was dynamically generated from WeatherCoder 3 data on 2012-04-23 at 11:34 AM EDT.

| STATION (Geographic)         |                    | (River Station, if different)                |                      | MONTH  | Feb 2012 |  |
|------------------------------|--------------------|--|----------------------|--|----------|--|
| STATE                        | COUNTY             | RIVER  | STANDARD TIME IN USE | PRECIPITATION  |          |  |
| VA                           | PRINCE GEORGE      | R  | 16:00                | 0  |          |  |
| TIME (local) OF OBSERVATION  | ELEVATION OF RIVER | FLOOD STAGE                                  | NORMAL POOL STAGE    | PRECIPITATION  |          |  |
| 16:00                        | 0                  | 0  | 0                    | 0  |          |  |
| TYPE OF RIVER GAGE           |                    | ELEVATION OF RIVER                           |                      | PRECIPITATION  |          |  |
| GAGE ZERO                    |                    | GAGE ZERO                                    |                      | 0  |          |  |
| TEMPERATURE                  |                    | 24 HR AMOUNTS                                |                      | PRECIPITATION  |          |  |
| 24 HRS ENDING AT OBSERVATION | AT                 | AT   | AT                   | PRECIPITATION  |          |  |
| MAX                          | MIN                | OBSN   | OSBN                 | PRECIPITATION  |          |  |
| 71                           | 52                 | 71   | 0.00                 | 1 2 3 4 5 6 7 8 9 10 11                                      |          |  |
| 71                           | 52                 | 62   | 0.45                 | 1 2 3 4 5 6 7 8 9 10 11                                      |          |  |
| 71                           | 38                 | 53   | 0.00                 | 1 2 3 4 5 6 7 8 9 10 11                                      |          |  |
| 57                           | 37                 | 50   | 0.01                 | 1 2 3 4 5 6 7 8 9 10 11                                      |          |  |
| 50                           | 38                 | 44   | 0.26                 | 1 2 3 4 5 6 7 8 9 10 11                                      |          |  |
| 52                           | 27                 | 51   | 0.00                 | 1 2 3 4 5 6 7 8 9 10 11                                      |          |  |
| 58                           | 33                 | 58   | 0.00                 | 1 2 3 4 5 6 7 8 9 10 11                                      |          |  |
| 58                           | 36                 | 43   | 0.06                 | 1 2 3 4 5 6 7 8 9 10 11                                      |          |  |
| 49                           | 35                 | 49   | 0.00                 | 1 2 3 4 5 6 7 8 9 10 11                                      |          |  |
| 51                           | 32                 | 48   | 0.00                 | 1 2 3 4 5 6 7 8 9 10 11                                      |          |  |
| 48                           | 34                 | 36   | 0.00                 | 1 2 3 4 5 6 7 8 9 10 11                                      |          |  |
| 38                           | 23                 | 38   | 0.02                 | 1 2 3 4 5 6 7 8 9 10 11                                      |          |  |
| 51                           | 20                 | 49   | 0.00                 | 1 2 3 4 5 6 7 8 9 10 11                                      |          |  |
| 57                           | 39                 | 57   | 0.00                 | 1 2 3 4 5 6 7 8 9 10 11                                      |          |  |
| 60                           | 39                 | 59   | 0.00                 | 1 2 3 4 5 6 7 8 9 10 11                                      |          |  |
| 60                           | 41                 | 48   | 0.14                 | 1 2 3 4 5 6 7 8 9 10 11                                      |          |  |
| 56                           | 43                 | 56   | 0.14                 | 1 2 3 4 5 6 7 8 9 10 11                                      |          |  |
| 61                           | 33                 | 59   | 0.00                 | 1 2 3 4 5 6 7 8 9 10 11                                      |          |  |
| 59                           | 36                 | 36   | 0.06                 | 1 2 3 4 5 6 7 8 9 10 11                                      |          |  |
| 43                           | 33                 | 42   | 0.98                 | 1 2 3 4 5 6 7 8 9 10 11                                      |          |  |
| 56                           | 25                 | 55   | 0.00                 | 1 2 3 4 5 6 7 8 9 10 11                                      |          |  |
| 68                           | 44                 | 66   | 0.00                 | 1 2 3 4 5 6 7 8 9 10 11                                      |          |  |
| 72                           | 45                 | 71   | 0.07                 | 1 2 3 4 5 6 7 8 9 10 11                                      |          |  |
| 80                           | 50                 | 76   | 0.00                 | 1 2 3 4 5 6 7 8 9 10 11                                      |          |  |
| 77                           | 40                 | 49   | 0.91                 | 1 2 3 4 5 6 7 8 9 10 11                                      |          |  |
| 51                           | 28                 | 50   | 0.00                 | 1 2 3 4 5 6 7 8 9 10 11                                      |          |  |
| 61                           | 33                 | 55   | 0.00                 | 1 2 3 4 5 6 7 8 9 10 11                                      |          |  |
| 60                           | 42                 | 59   | 0.00                 | 1 2 3 4 5 6 7 8 9 10 11                                      |          |  |
| 61                           | 39                 | 61   | 0.56                 | 1 2 3 4 5 6 7 8 9 10 11                                      |          |  |
| SUM                          |                    | 3.66   | 1.5                  | 1 2 3 4 5 6 7 8 9 10 11                                      |          |  |
| CONDITION OF RIVER AT GAGE   |                    | CHECK BAR (for wire weight) NORMAL CHECK BAR |                      | DATE   |          |  |
| A. Obstructed by rough ice   |                    | E. Ice gage below gage                       |                      | Fog  |          |  |
| B. Frozen, but open at gage  |                    | F. Broken ice                                |                      | Ice pel  |          |  |
| C. Under way, but ice        |                    | G. River ice                                 |                      | Glaze  |          |  |
| D. Ice gage above gage       |                    | H. Pool stage                                |                      | Thund  |          |  |
|                              |                    |  |                      | Hail   |          |  |
|                              |                    |  |                      | Dam winds  |          |  |
|                              |                    |  |                      | Condition  |          |  |
|                              |                    |  |                      | Gage reading at AM   |          |  |
|                              |                    |  |                      | Tendency   |          |  |
|                              |                    |  |                      | REMARKS (SPECIAL OBSERVATIONS, ETC.)                         |          |  |
|                              |                    |  |                      | n.e. winds, cloudy, rain-snow mix                            |          |  |
|                              |                    |  |                      | n. winds, clear, snowfall during the night, snowfall (. . .) |          |  |
|                              |                    |  |                      | clear, n.w. winds  |          |  |
|                              |                    |  |                      | west winds, part cloudy                                      |          |  |
|                              |                    |  |                      | clear, n.w. winds  |          |  |
|                              |                    |  |                      | w. winds, windy, clear                                       |          |  |
|                              |                    |  |                      | w. winds, clear  |          |  |
|                              |                    |  |                      | w. winds, part cloudy  |          |  |
|                              |                    |  |                      | clear, n.e. winds  |          |  |

OBSERVER VA AMERICAN WATER COMPANY  
 SUPERVISING OFFICE AKQ WAKEFIELD  
 STATION INDEX NO. 44-4101-01