Student Handout—Calculating Runoff

Square inches or cm are AREA measurements, as is an acre. But, if square inches are multiplied by another inch (or cm), the resulting unit is a CUBIC inch, which is a unit of volume, just like gallons, liters, etc. This volume unit is what is needed to calculate run off. Since cubic inches do not translate into gallons, we must convert inches to cm, cm to liters, then liters to gallons.

Example: Conversions:
1) 1 inch = 2.54 cm
2) 1 cubic inch = (2.54 cm)^3
3) 1 cm^3 = 1 ml
4) 1000 ml = 1 liter
5) 1 gallon = 3.8 liters
6) 1 foot = 12 inches

EXAMPLE of how to use conversion factors:
96 eggs =? dozen
We know that 12 eggs = 1 dozen
96 eggs x 1 dozen = In this step, the "eggs" unit will cancel out, leaving the "dozen" unit
1 = 12 eggs
96 dozen = 8 dozen
12

Data for Williams, Arizona:
Williams, AZ has an annual average rainfall of about 22.3 inches.
The average ground absorption rate is 50%.
The average shopping mall and surrounding parking areas is 25 acres.
1 acre = 43,560 feet (208 feet x 208 feet)

Converting

Step 1: Convert inches of rain into centimeters of rain
_______________ inches per year of rain x 2.54 centimeters = _______________cm of rain
per year

Step 2: Converting acres into cm^2
# acres x 43650 ft^2 x (conversion #6)^2 x (conversion #1)^2 = # cm^2
_________ acres x 43650 ft^2 /1acre x (12 inches/1ft)^2 x (2.54 cm/1 inch)^2 =
_________________________ cm^2
Step 3: Finding the volume in centimeter and in milliliters
Step 1 answer \times \text{Step 2 answer}
\text{\underline{\hspace{2cm}}} \text{cm} \times \text{\underline{\hspace{2cm}}} \text{cm}^2 = \underline{\hspace{14cm}} \text{cm}^3\text{, which is the same as milliliters.}

Step 4: Converting cm$^3$ to liters
Step 3 answer \times \text{conversion 3} \times \text{conversion 4} = \text{liters}
\underline{\hspace{2cm}} \text{cm}^3 \times 1 \text{ml/cm}^3 \times 1 \text{liter/1000 ml} = \underline{\hspace{14cm}} \text{liters}

Step 5: Converting liters to gallons
Step 4 answer \times \text{conversion 5} = \# \text{ gallons}
\underline{\hspace{2cm}} \text{liters} \times 1 \text{ gallon/3.8 liters} = \underline{\hspace{14cm}} \text{gallons}

Step 6: Finding the absorption amount
Step 5 answer \times \text{percent absorption} = \# \text{ gallons lost to runoff}
\underline{\hspace{2cm}} \text{gallons} \times 50\% \text{ absorption} = \underline{\hspace{14cm}} \text{gallons}

My Local Area Runoff

Step 1: Convert inches of rain into centimeters of rain
\underline{\hspace{2cm}} \text{inches per year of rain} \times 2.54 \text{ centimeters} = \underline{\hspace{14cm}} \text{cm of rain per year}

Step 2: Converting acres into cm$^2$
\# \text{ acres} \times 43650 \text{ ft}^2 \times (\text{conversion \#6})^2 \times \text{conversion \#1)}^2 = \# \text{ cm}^2
\underline{\hspace{2cm}} \text{acres} \times 43650 \text{ ft}^2 / \text{1acre} \times (12 \text{ inches/1ft})^2 \times (2.54 \text{ cm/1 inch})^2 = \underline{\hspace{14cm}} \text{cm}^2

Step 3: Finding the volume in centimeter and in milliliters
Step 1 answer \times \text{Step 2 answer}
\[ \text{ cm} \times \text{ cm}^2 = \text{ cm}^3, \text{ which is the same as milliliters.} \]

**Step 4: Converting cm\(^3\) to liters**

Step 3 answer \( \times \) conversion 3 \( \times \) conversion 4 = liters

\[ \text{ cm}^3 \times 1\text{ml/cm}^3 \times 1\text{ liter/1000 ml} = \text{ liters} \]

**Step 5: Converting liters to gallons**

Step 4 answer \( \times \) conversion 5 = # gallons

\[ \text{ liters} \times 1\text{ gallon/3.8 liters} = \text{ gallons} \]

**Step 6: Finding the absorption amount**

Step 5 answer \( \times \) percent absorption = # gallons lost to runoff

\[ \text{ gallons} \times 50\% \text{ absorption} = \text{ gallons} \]

**Conclusion Questions:**

Is your runoff greater or lesser than the runoff calculated in the example used in the Converting section of your worksheet? ______________________

How many malls can you think of that are located in your area? __________

Multiply this times the runoff amount and put that answer here:________________________

Now, add in other shopping centers, businesses, roads, and GUESS how many MORE gallons are lost in this area: ____________________________ (your answer may be different from other students)

Consider that most malls, shopping centers, office parks, etc., have empty stores or offices.

What could we do to reduce the number or area of parking lots and buildings? __________

___________________________________________________________________________

___________________________________________________________________________

What else could we do to increase the amount of water absorption from rainfall?
Explain why urban areas are more likely to have a water shortage than farmlands, even though farms use about the same amount of water.

How would the absorption rate be different if we had a different type of soil? Be specific.

What else could we do as a society to decrease the amount of land we use for building, while still not compromising the need to grow as populations increase?
Homework—My House

You will need to measure the base of your house and any driveways, storage building, etc., that would keep water from soaking into your ground. Then you need to measure the total size of your lot. If you live in a multifamily dwelling (example: an apartment), approximate the size of the land in the complex that would be your yard.) Then you need to calculate how much of an acre your yard would be.

My House Runoff

Step 1: Convert inches of rain into centimeters of rain

_____________ inches per year of rain x 2.54 centimeters = ______________cm of rain per year

Step 2: Converting acres into cm²

# acres x 43650 ft² x (conversion #6)² x (conversion #1)² = # cm²

_________ acres x 43650 ft² /1acre x (12 inches/1ft)² x (2.54 cm/1 inch)² = ________________ cm²

Step 3: Finding the volume in centimeter and in milliliters

Step 1 answer x Step 2 answer

_________ cm x ________ cm² = __________________________ cm³, which is the same as milliliters.

Step 4: Converting cm³ to liters

Step 3 answer x conversion 3 x conversion 4 = liters

__________ cm³ x 1ml/cm³ x 1 liter/1000 ml = ________________________ liters

Step 5: Converting liters to gallons

Step 4 answer x conversion 5 = # gallons

________________ liters x 1 gallon/3.8 liters = ________________________ gallons
Step 6: Finding the absorption amount

Step 5 answer x percent absorption = # gallons lost to runoff

_______ gallons x 50% absorption = ____________________ gallons

Is your runoff greater or lesser than the runoff calculated in the My Local Area Runoff section of your worksheet? ____________________
Student Handout—Calculating Runoff  Answer Key

Square inches or cm are AREA measurements, as is an acre. But, if square inches are multiplied by another inch (or cm), the resulting unit is a CUBIC inch, which is a unit of volume, just like gallons, liters, etc. This volume unit is what is needed to calculate run off. Since cubic inches do not translate into gallons, we must convert inches to cm, cm to liters, then liters to gallons.

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The average shopping mall and surrounding parking areas is 25 acres.
1 acre = 43,560 feet (208 feet x 208 feet)

Converting

Answers using Williams data

Step 1: Convert inches of rain into centimeters of rain

\[
\text{\underline{22.3}} \text{ inches per year of rain} \times 2.54 \text{ centimeters} = \text{\underline{56.64}} \text{ cm of rain per year}
\]

Step 2: Converting acres into cm²

\[
\# \text{ acres} \times 43650 \text{ ft}^2 \times (\text{conversion #6})^2 \times (\text{conversion #1})^2 = \# \text{ cm}^2
\]

\[
\text{\underline{25}} \text{ acres} \times 43650 \text{ ft}^2 / \text{1acre} \times (12 \text{ inches/ft})^2 \times (2.54 \text{ cm/1 inch})^2 = \text{\underline{33,261,300}} \text{ cm}^2
\]
Step 3: Finding the volume in centimeter and in milliliters
Step 1 answer x Step 2 answer

\[
56.6 \text{ cm} \times 33,261,300 \text{ cm}^2 = 1,882,572.6 \text{ cm}^3,
\]
which is the same as milliliters.

Step 4: Converting cm\(^3\) to liters
Step 3 answer x conversion 3 x conversion 4 = liters

\[
1,882,572.6 \text{ cm}^3 \times 1 \text{ ml/cm}^3 \times 1 \text{ liter/1000 ml} = 1882.5726 \text{ liters}
\]

Step 5: Converting liters to gallons
Step 4 answer x conversion 5 = \(\#\) gallons

\[
1882.5726 \text{ liters} \times 1 \text{ gallon/3.8 liters} = 495.4138 \text{ gallons}
\]

Step 6: Finding the absorption amount
Step 5 answer x percent absorption = \(\#\) gallons lost to runoff

\[
495.4138 \text{ gallons} \times 50\% \text{ absorption} = 247.7069 \text{ gallons lost to runoff}
\]

My Local Area Runoff Answers will vary upon your location

Step 1: Convert inches of rain into centimeters of rain

\[
\text{inches per year of rain} \times 2.54 \text{ cm/1 inch} \text{ per year}
\]

Step 2: Converting acres into cm\(^2\)

\[
\text{acres} \times 43650 \text{ ft}^2 \times \text{(conversion #6)}^2 \times \text{(conversion #1)}^2 = \text{ cm}^2
\]

\[
\text{acres} \times 43650 \text{ ft}^2 / \text{1 acre} \times (12 \text{ inches/1 ft})^2 \times (2.54 \text{ cm/1 inch})^2 = \text{ cm}^2
\]

Step 3: Finding the volume in centimeter and in milliliters
Step 1 answer x Step 2 answer

\[
\text{cm} \times \text{cm}^2 = \text{ cm}^3, \text{ which is the same as milliliters.}
\]
Step 4: Converting cm³ to liters
Step 3 answer x conversion 3 x conversion 4 = liters
____________ cm³ x 1 ml/cm³ x 1 liter/1000 ml = ___________________________ liters

Step 5: Converting liters to gallons
Step 4 answer x conversion 5 = # gallons
____________ liters x 1 gallon/3.8 liters = ___________________________ gallons

Step 6: Finding the absorption amount
Step 5 answer x percent absorption = # gallons lost to runoff
_________ gallons x 50% absorption = ___________________________ gallons

Conclusion Questions: Answers will vary due to your location.

Is your runoff greater or lesser than the runoff calculated in the example used in the Converting section of your worksheet? ___________________________

How many malls can you think of that are located in your area? __________
Multiply this times the runoff amount and put that answer here:___________________

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What else could we do to increase the amount of water absorption from rainfall?

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What else could we do as a society to decrease the amount of land we use for building, while still not compromising the need to grow as populations increase?
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My House Runoff  Answers will vary due to location

Step 1: Convert inches of rain into centimeters of rain
________________ inches per year of rain x 2.54 centimeters = _____________ cm of rain per year

Step 2: Converting acres into cm²
# acres x 43650 ft² x (conversion #6)² x (conversion #1)² = # cm²
_________ acres x 43650 ft² /1acre x (12 inches/1ft)² x (2.54 cm/1 inch)² = ______________ cm²

Step 3: Finding the volume in centimeter and in milliliters
Step 1 answer x Step 2 answer
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Step 4: Converting cm³ to liters
Step 3 answer x conversion 3 x conversion 4 = liters
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Step 4 answer x conversion 5 = # gallons
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Step 6: Finding the absorption amount
Step 5 answer x percent absorption = # gallons lost to runoff
_________ gallons x 50% absorption = _______________________________ gallons

Is your runoff greater or lesser than the runoff calculated in the My Local Area Runoff section of your worksheet? ________________________
Assessment Essay Questions

1. In a short paragraph (5-8 sentences) compare your home location to that of Williams, Arizona. Which environment has more rain? Which environment has more gallons lost to runoff? What are some ways that runoff could be decreased in both environments? Why is it important to have more water becoming part of our groundwater?

2. Describe the invention that you and your partner designed (or another classmate designed that you think it a better idea) to decrease the amount of runoff from a residential or commercial site. Be sure to explain how it would work to reclaim and conserve water.