Runoff Volume: The Importance of Land Cover

Grade Level: 9-12

Time: 1 - 2 class periods

Learning Objectives:

- Quantify the volume of water that runs off different land uses in a watershed.
- Analyze the difference between land uses and what characteristics impact runoff.
- Hypothesize impacts that stormwater runoff might have on a community.

Extension Lessons:

This lesson can be adapted for more complex calculations that include watersheds with multiple land use covers. This would require students to calculate a weighted Curve Number.

Rhode Island Grade Span Expectations Addressed:

Science	LS2 (9-11) - 3 Using data from a specific ecosystem, explain relationships or make predictions about how environmental disturbance (human impact or natural events) affects the flow of energy or cycling of matter in an ecosystem.	
	LS2 (9-11) – 3b	Describing ways in which humans can modify ecosystems and describe and predict the potential impact.
	LS4 (9-11) - 9 Use evidence to make and support conclusions about the ways that humans or other organisms are affected by environmental factors or heredity	
	LS4 (9-11) - 9b	Providing an explanation of how the human species impacts the environment and other organisms.
Math	Numbers and Operators	
	M(N&O)–10–4	Accurately solves problems that involve but are not limited to proportional relationships, percents, ratios, and rates. (The problems might be drawn from contexts outside of and within mathematics including those that cut across content strands or disciplines.)
	Geometry and Measurement	
	M(G&M)–10–6	Solves problems involving perimeter, circumference, or area of two-dimensional figures (including composite figures) or surface area or volume of three-dimensional figures (including composite figures) within mathematics or across disciplines or contexts.
Civics and Government	C&G 4: People engage in political processes in a variety of ways.	
	C&G 4 (9-12)–3	Students participate in a civil society by critically reflecting on their own civic dispositions (e.g., recognition of the capacity to make a difference)
	C&G 5: As members of an interconnected world community, the choices we make impact others locally, nationally, and globally.	
	C&G 5 (9-12) -3	Students demonstrate an understanding of how the choices we make impact and are impacted by, an interconnected world by predicting outcomes and possible consequences of a conflict, event, or course of action

Runoff Volume: The Importance of Land Cover

Name: _____ Date: _____

Purpose:

To understand and quantify how different land uses impact the amount of stormwater runoff.

Things to Know

What is Stormwater Runoff?

Precipitation that does not infiltrate into the earth, but flows over the land. Too much runoff can lead to flooding, polluted waters, and reduced groundwater

The surface that rain falls upon will determine whether water will infiltrate into the ground or runoff the landscape. Hydrologists have categorized different land uses and their potential for runoff by assigning *Curve Number* values to various landscapes. Curve numbers were developed by what is currently known as the Natural Resources Conservation Service (NRCS) when they first started studying runoff volume and graphically representing it with rainfall retention curves. Curve numbers help to determine how much water will runoff a surface given a specific rainfall amount. The figures on the following page are examples of curve number values assigned to different landscapes. The higher the curve number, the more rain will runoff the land surface. In the charts below, you will notice that not only does the type of land use determine the curve number, but also the *Hydrologic Soil Group* (A, B, C, D). A group "A" soil is one that has a low runoff potential when thoroughly wet, meaning water will still infiltrate into the soil even after large rainfall events and saturated conditions. A group "B" soil has moderately low runoff potential, a group "C" soil has moderately high runoff potential, and a group "D" soil has a high runoff potential. These soil classifications are typically made by a professional soil scientist. Knowing the type of land cover that resides on a landscape and the hydrologic soil group, one can determine the Curve Number for a site and therefore, how much runoff the landscape will produce.

What is a Curve Number?

A number assigned to a land use type that determines how much water will runoff the landscape.

What are Hydrologic Soil Groups?

A set of four soil groups (A, B, C, D) that are defined by their ability to infiltrate water.

Curve Numbers Resource Page (See Hydrology 101 for footnote definitions):

Cover description		Curve numbers for hydrologic soil group			
Cover type	Hydrologic condition	A	B	C	D
Pasture, grassland, or range—continuous forage for grazing. [2]	Poor	68	79	86	89
	Fair	49	69	79	84
	Good	39	61	74	80
Meadow—continuous grass, protected from grazing and generally mowed for hay.	—	30	58	71	78
Brush—brush-weed-grass mixture with brush the major element. [3]	Poor	48	67	77	83
	Fair	35	56	70	77
	Good	30 [4]	48	65	73
Woods—grass combination (orchard or tree farm). [5]	Poor	57	73	82	86
	Fair	43	65	76	82
	Good	32	58	72	79
Woods. [6]	Poor	45	66	77	83
	Fair	36	60	73	79
	Good	30 [4]	55	70	77
Farmsteads—buildings, lanes, driveways, and surrounding lots.	—	59	74	82	86

Cover description		Curve numbers for hydrologic soil group			
Cover type and hydrologic condition	Average percent impervious area [2]	A	B	C	D
Fully developed urban areas (vegetation established)					
Open space (lawns, parks, golf courses, cemeteries, etc.) [3]:					
Poor condition (grass cover < 50%)		68	79	86	89
Fair condition (grass cover 50% to 75%)		49	69	79	84
Good condition (grass cover > 75%)		39	61	74	80
Impervious areas:					
Paved parking lots, roofs, driveways, etc. (excluding right-of-way)		98	98	98	98
Streets and roads:					
Paved; curbs and storm sewers (excluding right-of-way)		98	98	98	98
Paved; open ditches (including right-of-way)		83	89	92	93
Gravel (including right-of-way)		76	85	89	91
Dirt (including right-of-way)		72	82	87	89
Western desert urban areas:					
Natural desert landscaping (pervious areas only) [4]		63	77	85	88
Artificial desert landscaping (impervious weed barrier, desert shrub with 1- to 2-inch sand or gravel mulch and basin borders)		96	96	96	96
Urban districts:					
Commercial and business	85	89	92	94	95
Industrial	72	81	88	91	93
Residential districts by average lot size:					
1/8 acre or less (town houses)	65	77	85	90	92
1/4 acre	38	61	75	83	87
1/3 acre	30	57	72	81	86
1/2 acre	25	54	70	80	85
1 acre	20	51	68	79	84
2 acres	12	46	65	77	82

Part 1:

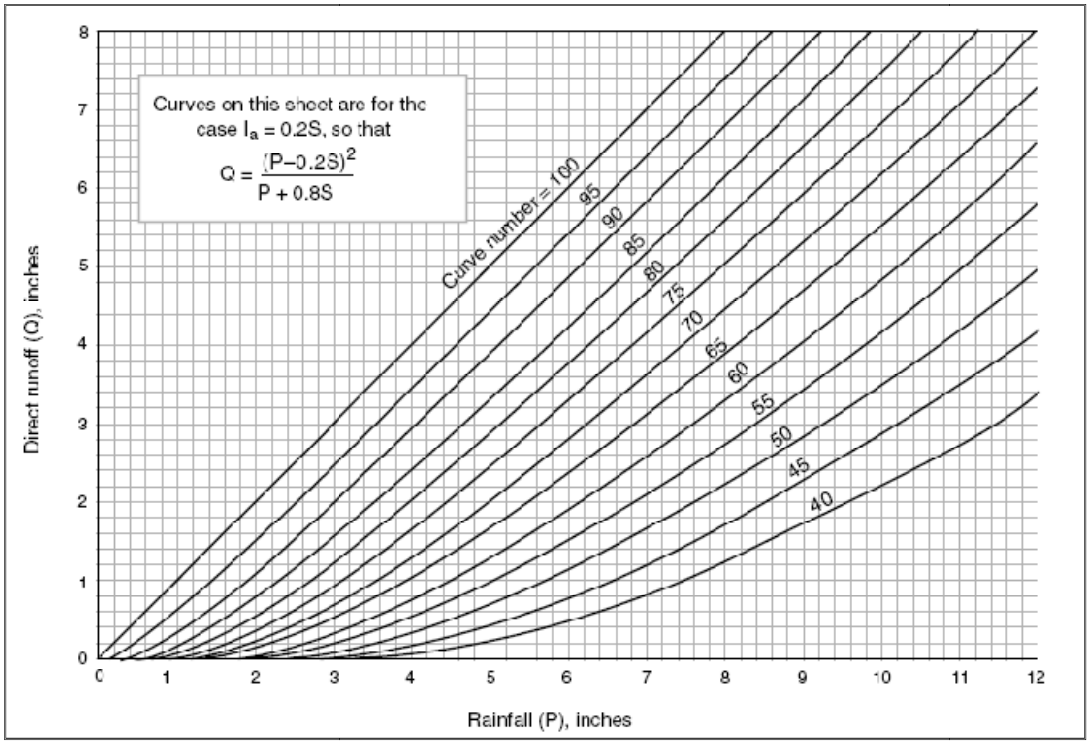
Determine the volume of water that will runoff 100 acres of forest in a typical storm producing 2.8 inches of rain.

Knowns:

Area of land = 100 acres
Rainfall amount = 2.8 inches
Conversion factors:
12 inches = 1 foot
43,560 square feet = 1 acre

If 2.8 inches of rain fall on a 100 acre area, what is the volume of water that will runoff the surface of the land?

1) Determine the curve number for a wooded area in good hydrologic condition with soil Hydrogroup B using the charts above: _____
2) Knowing the amount of rain and the curve number, use the graph below to determine the inches of runoff that would result from a 2.8 in storm: _____



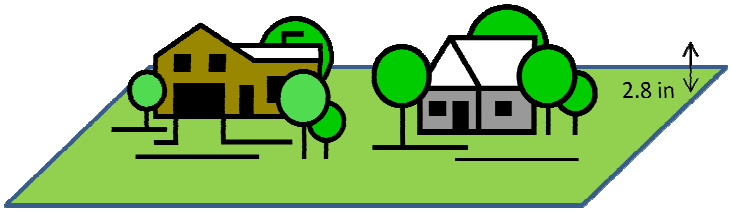
3) In order to determine the total volume of water that runs off, every variable has to have the same units. Convert the area of land to square feet, and the runoff amount to feet.
   Area of land = _____ ft^2
   Direct runoff = _____ ft
4) Calculate the volume (ft^3) of runoff by multiplying the area times the depth of runoff.
   _____

Part 2:

Determine the volume of water that will runoff 100 acres of residential land in a typical storm producing 2.8 inches of rain.

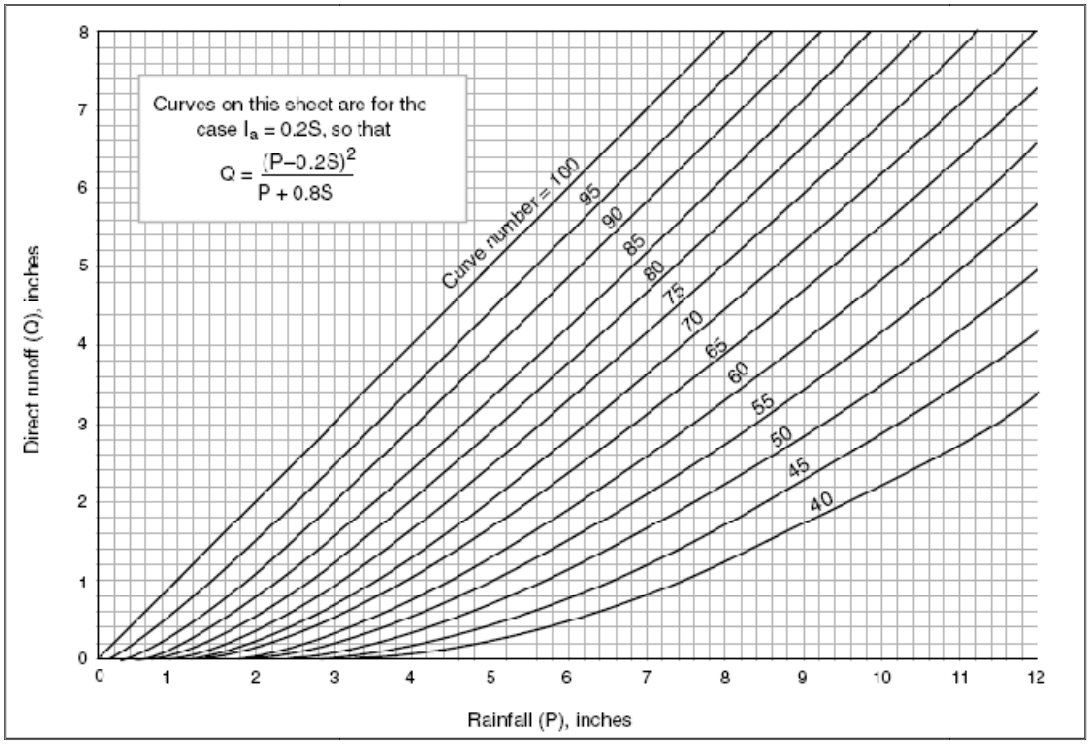
Knowns:

Area of land = 100 acres
Rainfall amount = 2.8 inches
Conversion factors:
12 inches = 1 foot
43,560 square feet = 1 acre



If 2.8 inches of rain fall on a 100 acre area, what is the volume of water that will runoff the surface of the land?

1) Determine the curve number for a residential area with ¼ acre lots sizes and with soil Hydrogroup B using the charts above: _____
2) Knowing the amount of rain and the curve number, use the graph below to determine the inches of runoff that would result from a 2.8 in storm: _____



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   Area of land = _____ ft^2
   Direct runoff = _____ ft
4) Calculate the volume (ft^3) of runoff by multiplying the area times the depth of runoff.
   _____

Analysis Questions:

1) Compare the two runoff volumes for the different land uses. How much larger is the residential runoff volume than the wooded runoff volume?

   _____

2) A football field is a little bit larger than an acre. Consider a 1 acre football field being covered with a foot of water. That is equal to 43,560 cubic feet (ft^3). How many football fields of water came off of the wooded land versus the residential land?

   _____

   _____

3) What are some characteristics of a forested area that prevents rain from running off?

   _____

   _____

4) What are some characteristics of a residential area that cause runoff?

   _____

   _____

5) Impervious surfaces are surfaces that do not allow water to infiltrate. What are some examples of impervious surfaces you would find in a residential neighborhood?

   _____

   _____

6) Cities have a large amount of impervious surfaces. Perform the same calculations as Part 1 and 2 for an urban commercial and business area with hydrologic soil group B.
   Curve Number = _____ Runoff inches = _____
   Volume of runoff in cubic feet = _____

7) How do you think large runoff volumes could impact nearby streams?

   _____

   _____

8) How do you think large runoff volumes could impact a community?

   _____

   _____

9) Think of the kinds of things you or your parents do in your yard or things you see in the street. What kinds of materials could get picked up by runoff and carried to local streams or water bodies?

   _____

   _____

10) Brainstorm some ways you might be able to prevent water from running off the impervious surfaces you have in your yard or school.

    _____

    _____