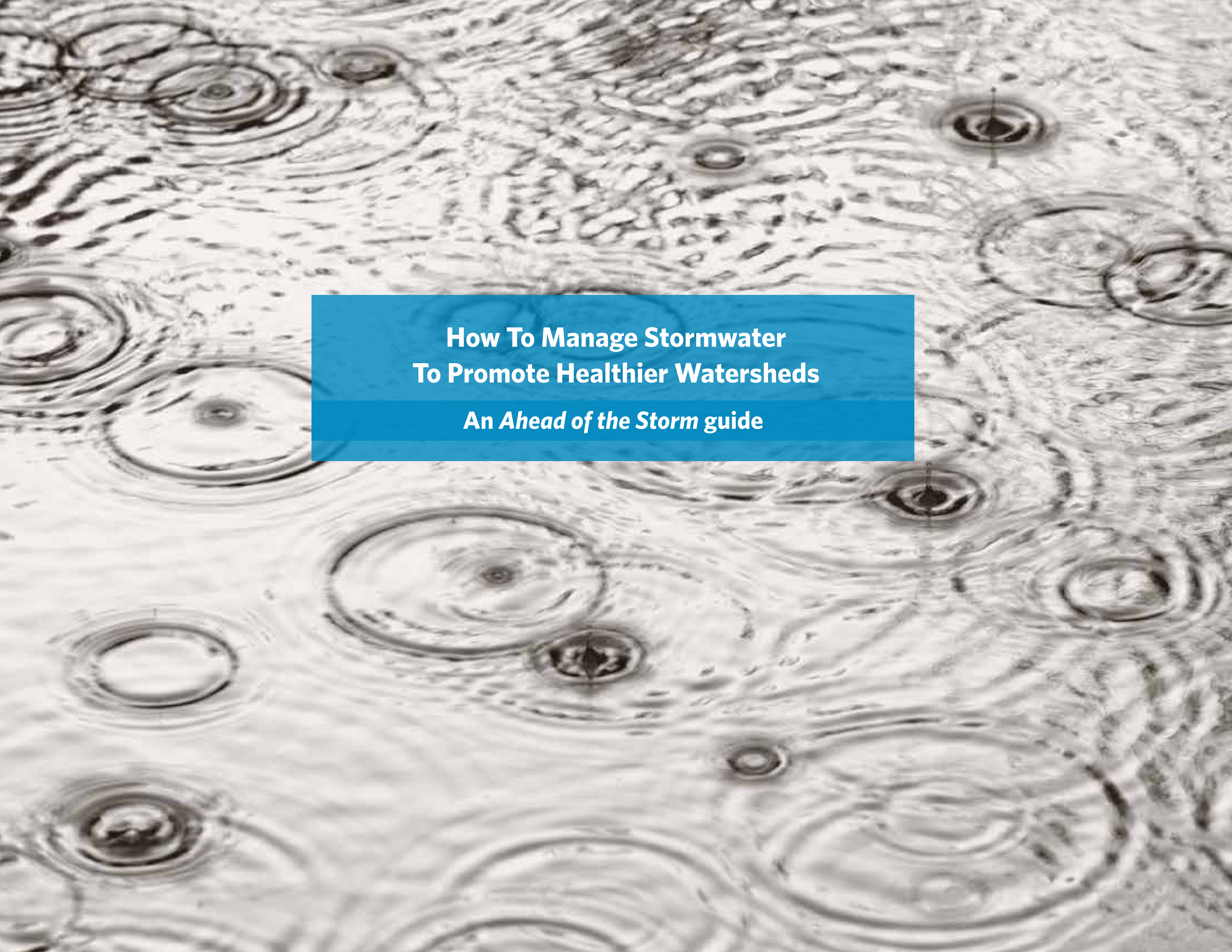


How To Manage Stormwater To Promote Healthier Watersheds

An *Ahead of the Storm* guide

Kevin McCallum/Seven Days

The waters of the Lake Champlain Basin are in trouble, and you can help.

We must work together as individuals, property owners, municipalities, and Vermont and New York state agencies, to restore the health and functioning of our local watersheds and Lake Champlain.

Our actions on land impact the health of our streams and Lake Champlain. The area of land that drains to Lake Champlain is 19 times larger than the lake itself. In our very large 8,234 square mile Lake Champlain watershed, clay soils, management practices, more development, climate change-induced heavier storms and winter rains are accelerating the rate of nutrients and other pollution reaching streams, rivers, and lakes.

This manual, provided by the Lewis Creek Association's Ahead of the Storm program (AOTS, *see pg. 20*), is a how-to approach to managing stormwater on properties of all sizes. It describes how to look at your land to help control and manage runoff, and identify what areas could be improved. This information will guide you to potential solutions, and resources to help. There are many nuances and options based on your landscape; this manual guides you through the process.

Pollution in our rivers and lakes can include gravel and soil – not just fertilizer and oil spills!

CONTENTS:

We can all help improve water quality by applying the three basic principles of stormwater management (the 3 S's): slow it down, spread it out, and soak it in.

1. Slow it down.

Slow down fast-moving water by increasing the roughness of land with rocks and vegetation, and decreasing the slope.

Diffuser stones slow down and spread out water as it leaves a culvert or roof downspout. Stones need to be greater than 3″ in diameter and often greater than 12″ at the end of a culvert where water is moving quickly.

Check dams slow down and hold back water as it travels down a swale.

Trees and taller vegetation increase the roughness of the land, which helps slow down moving water.

2. Spread it out.

Spread out and break up the path water takes, send water to places it can sink into the ground.

Stone level spreaders allow water that otherwise runs directly off the parking lot into the swale to drop into the stones and spread out.

Downspout level spreaders take water from gutter down-spouts and spread it out into the lawn to avoid erosion.

Smooth, crown, and elevate driveways above surrounding land to allow water to run off without eroding the surface.

The 3 S's encourage water to flow more naturally across the land and into the ground. Less erosion and smaller amounts of water reaching our waterbodies lead to improved water quality.

3. Soak it in.

Increase water sinking into ground, minimize hard or compacted surfaces, maximize vegetation.

Rain gardens collect water and allow it to infiltrate into the ground (and provide native pollinator habitat).

Vegetated swales allow water to soak into the ground as it moves instead of being stuck in a pipe.

Planting water-loving species allows plants to soak up the water and nutrients.

Aerated soil creates space for water to sink into the ground.

Infiltration trenches allow water to flow into stones and seep into surrounding ground.

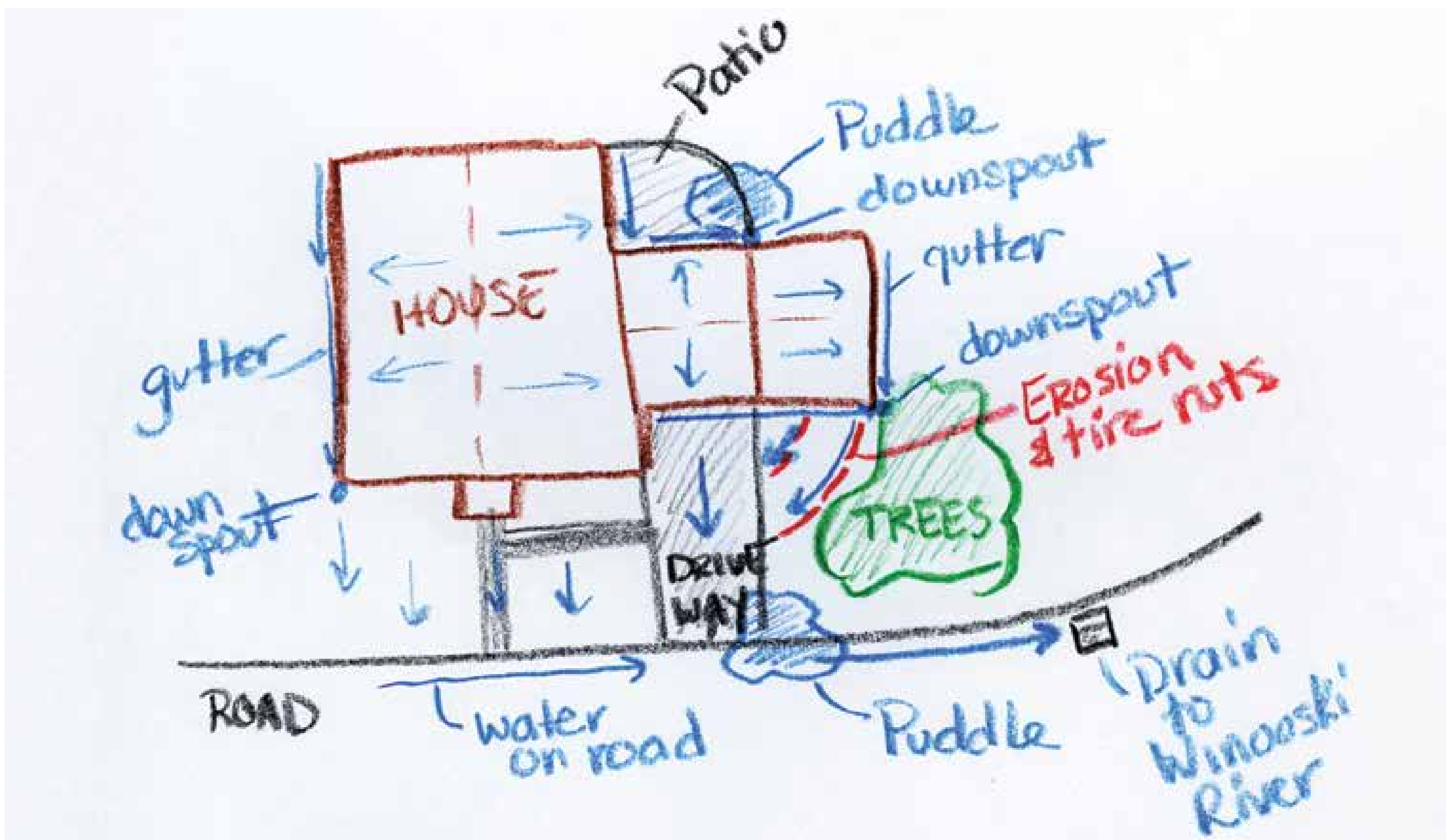
Site assessment and troubleshooting problems

Humans have changed the land (through deforestation, the creation of impervious surfaces & ditching), forcing water to move quickly over the landscape and restricting it to confined areas. These changes do not allow water to soak into the ground. Stronger and faster flows carry more pollutants, and cause erosion of streams and rivers, as well as flooding downstream. Slowing water down, spreading it out, and soaking it into the ground leads to less erosion and healthier waters.

You will be looking at your area, and making notes on where water comes from, moves, what features of your area are helping, and what areas could be improved.

When it is raining, what does water do in your area? What can you do to help water flow more naturally across the land and into the ground, keeping in mind the 3 S's?

A small neighborhood house (*above*) with a hand-drawn map showing its problems (*below*).



1. Prepare materials

Choose how to record your information as you explore the land. Many people use a map. It doesn't need to be to scale, but try to make areas proportional to each other. Consider using:

- Pencil and paper
- Construction paper and crayons
- Print an aerial photograph – use Google Maps or Google Earth, Bing, USGS TopoView, or another map.
- Draw onto a map on a tablet or phone.
- Print a map with more detailed data from VT ANR Natural Resources Atlas.
- Write notes without making a map.

2. Basic drawing

Walk around outside and make observations. Add features to your drawing or notes. Focus first on big features like buildings, driveways, lawns, and woods.

- Draw impervious surfaces – buildings, parking, driveways, patios, walkways – and note if they are paved or gravel.
- Draw other areas important to you – gardens, play areas, highly used spaces like a grill or picnic area.
- Note the land use type and vegetation that is present – meadow, forest, lawn, paved, gravel.
- Note site constraints and anything that does not move – utilities – electrical wires, poles, manholes, valves indicating water lines, septic systems, etc.

3. Add details to your drawing

Walk around outside (ideally while it is raining or shortly after) and make observations. Add what you observe to your drawing or notes. See examples of completed drawings on the previous page and on the next page.

- Identify high and low points in the landscape.
- Sources of stormwater (e.g. a downspout from a building roof, roadside swale, neighbor's property).
- Places where stormwater will flow to (e.g. a storm drain, a stream).
- Take a tennis or other type of ball to test what direction is downhill from any point where you stand. By placing the ball on the ground and seeing the direction it rolls, you can

Water that enters storm drains typically goes straight into a stream, without any treatment to remove sediment and pollutants first.

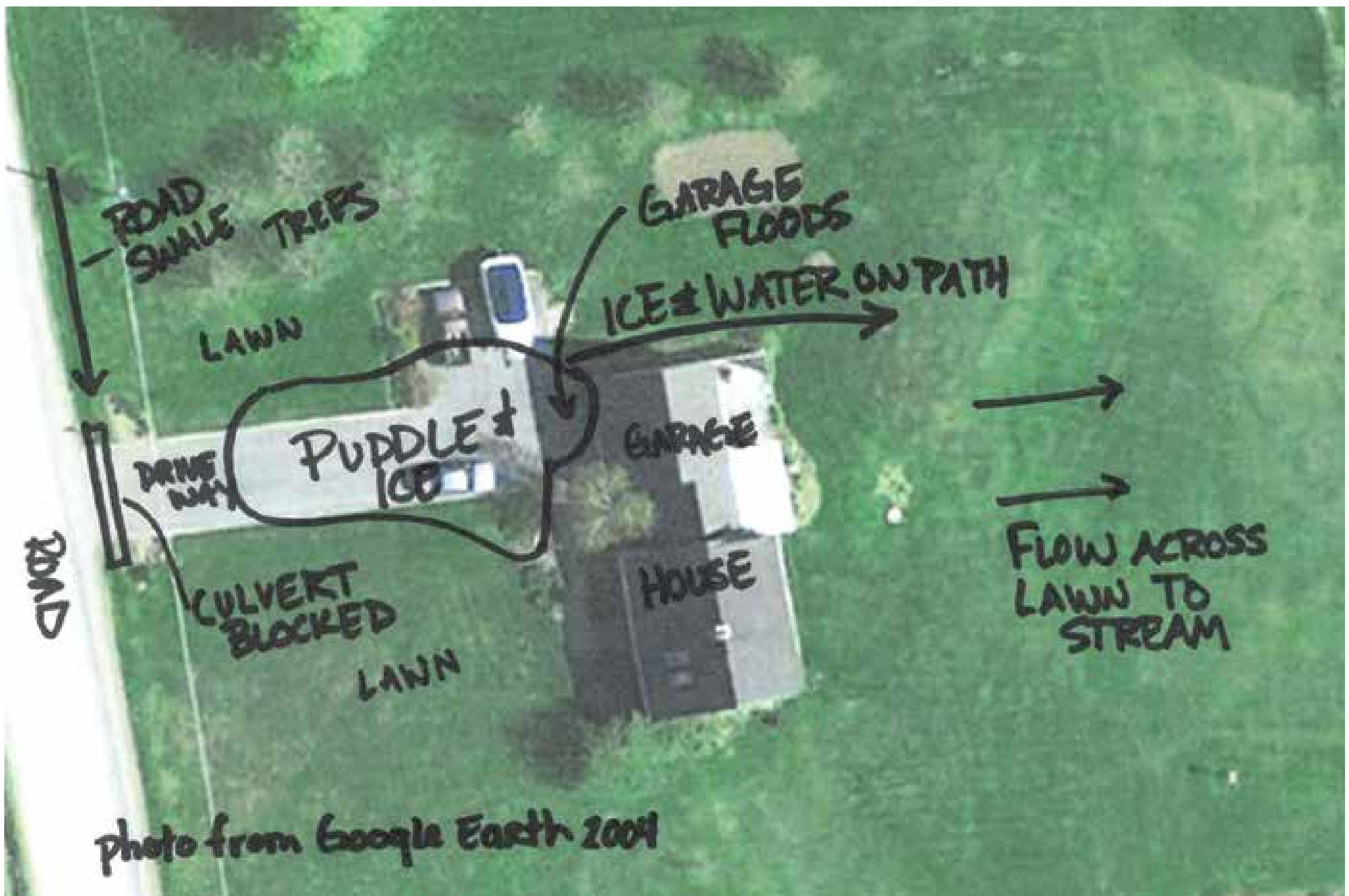
Problem: driveway erosion in wheel ruts

Problem: stormwater and pollutants, like sediment, drain to the Winooski River, with no treatment

visualize the path that stormwater will take to make its way from high points to low points in the landscape. The path the ball takes will represent the path of the arrows you will draw on your map.

- If on a flat lawn or where a ball doesn't roll well, try dumping a 5 gallon bucket of water on the ground to see where it flows.
- Identify and draw arrows showing where water flows; make notes if the water would flow underground in a pipe, in a swale on the surface, or spread out over the ground.
- Locate existing stormwater infrastructure – gutters and downspouts, pipes/culverts, swales (also called ditches), ponds, raingardens, rainbarrels.

A rural house with notes drawn on a Google map showing its problems:



Problem: paths flood

- Record erosion – stream banks, rills, gullies, and gravel moving off a driveway or walkway.
- Identify areas where water collects or puddles – just after a rain? Or is it always wet and possibly a former wetland?
- Take pictures, especially if things change seasonally, like where snow melts, ice forms, or areas that are only wet during part of the year, during a rain or a few hours after.

4. Opportunities

To reiterate, the goals for water are to *slow it down*, *spread it out*, and *soak it in*. Consider both where this already happens and where you could make changes:

- Where do you see water getting slowed down, spread out, or soaked into the ground? Where is water handled well?
- Where is water moving fast, causing erosion, collecting, carrying dirt or gravel?
- Where is there room for improvement? Are there areas where you identified problems where you may be able to make improvements? Are there areas that you do not use that could be changed to better address one of the three S's? Check out the solutions chart on page 10 to see what might work in these identified areas.

Look at examples of opportunities identified at a rural house and small neighborhood house.

Where is there room for improvement? Are there areas that you do not use that could be changed to better address one of the three S's?

Problem: culvert crushed and blocked

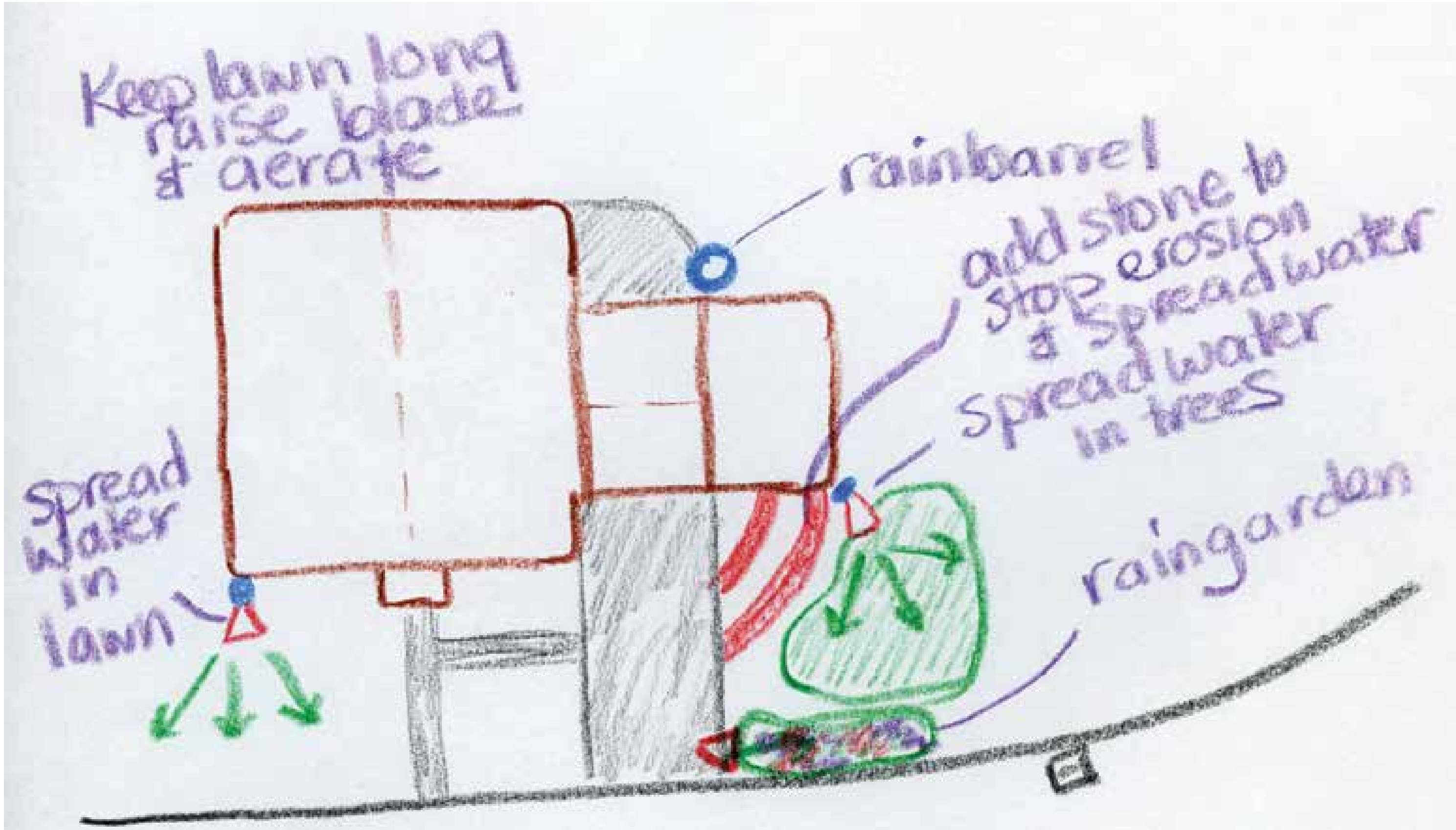
Problem: driveway and garage flood

Small neighborhood house solutions:


Downspout directed to lawn with end piece to spread water


Downspout directed into rain barrel


Downspout directed into trees with end piece




Aerated lawn


Lawn mower blade kept 3" high


Ruts smoothed to direct water to trees

Rural house solutions:

Roof runoff directed to gardens

No-mow meadow area is a buffer to stream

Driveway regraded to direct water to raingarden

Raingarden looks like a flower garden on a dry day

Raingarden after it rains

Good Practices to slow, spread and soak water

✶Direct water into native plantings or other vegetated areas.

✶Keep grass long. Raise the mower blade to 3+ inches.

✶Allow for forested or naturally vegetated areas.

✶Allow for wild-flower and/or no-mow areas.

✶Aerate your lawn.

Possible Solutions (✶*indicates a possible do-it-yourself project*)

1. Wet area in lawn

- ? Is it a temporary puddle (it drains within a few hours)?
  - Choose from the Good Practices (*see green box, left*).
  - Install a rain garden in the affected area. Delineate the watershed and test soils for infiltration using Activities 2 and 3.
- ? Is it always wet?
  - ✶Plant water-loving species
  - Restore the wetland (*Consult an engineer or reach out to your local watershed organization – see resources for help with grants if desired*).

2. Roof runoff

- ? Does your roof have gutters?
  - ✶Direct water into native plantings or other vegetated areas.
  - ✶Install a rain barrel, or install a dry well if space is tight.
  - Install a rain garden in the affected area. Delineate the watershed and test soils for infiltration using Activities 2 and 3.
    - ? Is the drainage area less than 10,000 square feet? (*See the* Rain Garden Manual for Vermont and Lake Champlain Basin *for instructions.*)
    - ? Is the area greater than 10,000 square feet? Consult an engineer or reach out to local watershed organization for help with grants.
- ? Does your roof not have gutters?
  - Install a rain garden (*see roof with gutters, above*).
  - Choose from the Good Practices (*see green box, left*).

3. Lawn runoff or erosion

- Choose from the Good Practices (*see green box, left*).
- Install a rain garden in the affected area. (*see roof runoff, above*).
- Install a vegetated or rock-lined swale – *calculate the slope of the swale using Activity 4. Then see the* Vermont Better Roads *manual for instructions.*
  - ? Is the slope less than 5 percent? Install a vegetated swale.
  - ? Is the slope greater than 5 percent? Install a rock-lined swale with check dams.

4. Driveway, road, or path runoff or erosion

- Choose from the Good Practices (*see green box, left*).
- Install a rain garden (*see roof runoff, left*).
- Install a vegetated or rock-lined swale (*see lawn runoff, left*).
- Reduce paving or replace with pervious pavers.
- ✶Add water bars and turnouts (*see the* Vermont Better Roads *manual for instructions*).
- Smooth out your gravel driveway and ✶direct water into native plantings or other vegetated areas.
- Install a dry well if space is tight.

5. Culvert erosion

- Add diffuser stones.
- ? Is the slope of the swale greater than 5 percent? Install a rock-lined swale with check dams (*see lawn runoff, left*).

6. Flooding or streambank erosion

- Consult an engineer or reach out to local watershed organization for help with grants.

Are you interested in sizing your rain garden or roadside swale for the larger storms we are experiencing with climate change? Consult an engineer or reach out to your local watershed organization after completing Activities described above.

Is water running onto your property? Talk to neighbors about collaborating or the possibility of installing stormwater management on their property, or reach out (in Vermont) to your Clean Water Service Provider.

Definitions

- **Erosion:** The action of surface processes (e.g., water flow in this context) that removes soil, rock, or dissolved material from a location and then transports it to another.

  Stream bank erosion: Erosion on the edge of a river or stream bank. This often looks like raw exposed soil and can have chunks of the original ground surface that have slumped or slid down the side of the river when the ground broke off.

  Rill erosion: A type of narrow shallow channel cut into soil by the erosive action of flowing water.

  Gully erosion: Deep erosion typically with steep side slopes often found on steep areas.

- **Culvert:** A pipe carrying a stream or open swale under a road.

- **Impervious surface:** A surface (such as asphalt, concrete, or building roofs) that does not allow water to penetrate or infiltrate through. Can be highly compacted soil or areas where cars parked.
- **Infiltration:** The downward movement of water into the ground. This does not happen on impervious surfaces.
- **Pervious pavers:** Stone, concrete, or other hard paving block or tile that has spaces between that allow water to flow into the ground between the pavers. Stone is usually used between and under pavers to allow water space to travel before infiltrating.

- **Watershed/Drainage Basin:** the area of land that drains to a specific water body
- **Swale** (also called a ditch): A long area that carries water from one place to another, often along a road or driveway. Swales are man-made features and can have vegetated or stone bottoms. Unlike a ditch, which is often deep and narrow in shape and more prone to erosion, a swale has a wide bottom and shallow side slopes.

- **Turnouts:** A low point, similar to a swale, where water traveling down the edge of a road, driveway, path, or trail is directed away and into a vegetated area to spread out. If these are steep or have a large amount of water they can be lined with stone like a stone swale.

- **Water bars or broad-based dips:** On a road, driveway, path, or trail water can run down the surface of the road causing erosion. A water bar is a low point in the road surface with a small high point (berm of gravel, log, or boards) downstream that directs water to the edge. These are often coupled with turnouts. Broad-based dips are similar and often a wider, shallower feature.

Activity 1: Delineating a Watershed

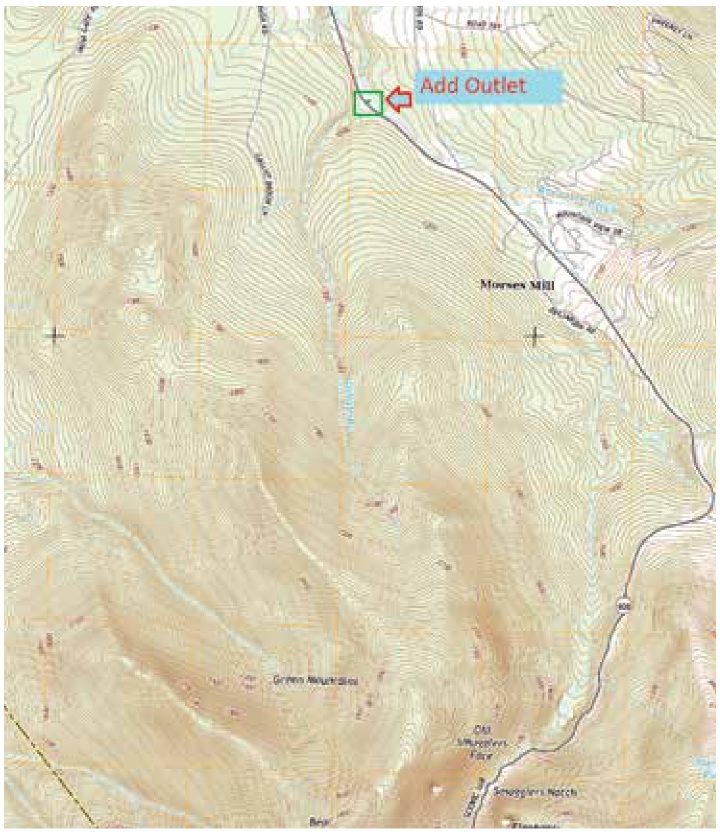
Obtain a topo map of your area (*check with your local Town Hall clerk, or visit your local library to print a map using the USGS TopoView or ANR Atlas*), and follow the steps below to delineate your watershed, with the area of your potential rain garden or property as the outlet point.

1. Identify on your map the following features: contour lines (lines showing equal elevation), rivers, streams, lakes, wetlands, roads, buildings, etc.

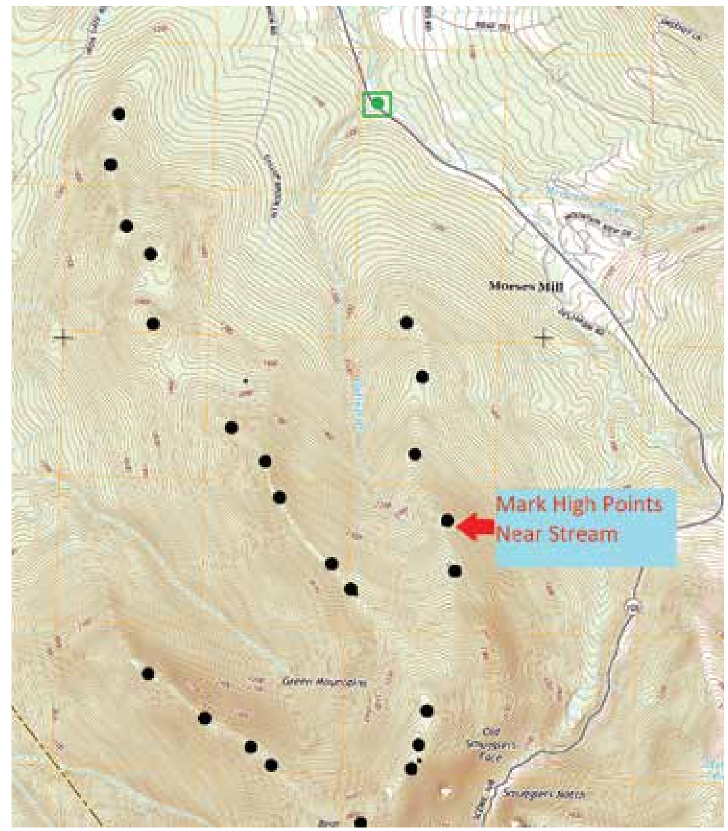
2. Find a river or stream on your map and highlight it. Mark the junction point between that river and a river or lake downstream with a square that has a point in the middle. This is the mouth of the river, also known as the outlet (*see Map 1a, green dot*).

3. When contour lines form a circle or an oval, a peak in elevation is indicated. Mark the high points on the topo map with dots or X's (*see Map 1b*).

You will be reading a topographic map to outline the boundary of a watershed. High points in elevation form the watershed boundary, as water travels from high to low elevation.



Map 1a: Finding the mouth of a river



Map 1b: Marking high points

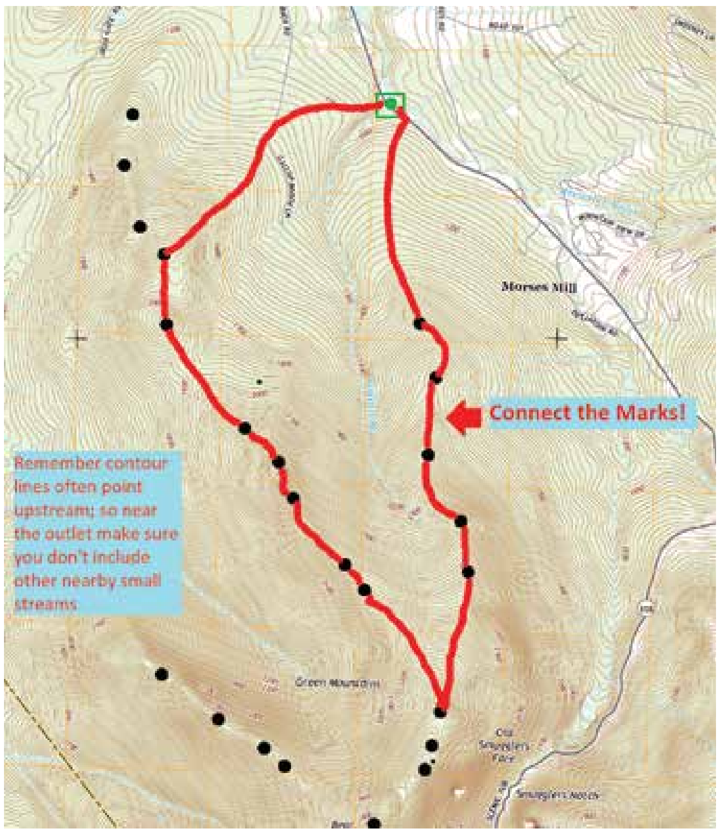
This activity is adapted from Lake Champlain Sea Grant's Soaking Up Stormwater *curriculum.*

See more at: https://www.uvm.edu/seagrant/programs/green-schools/soaking-stormwater-curricula

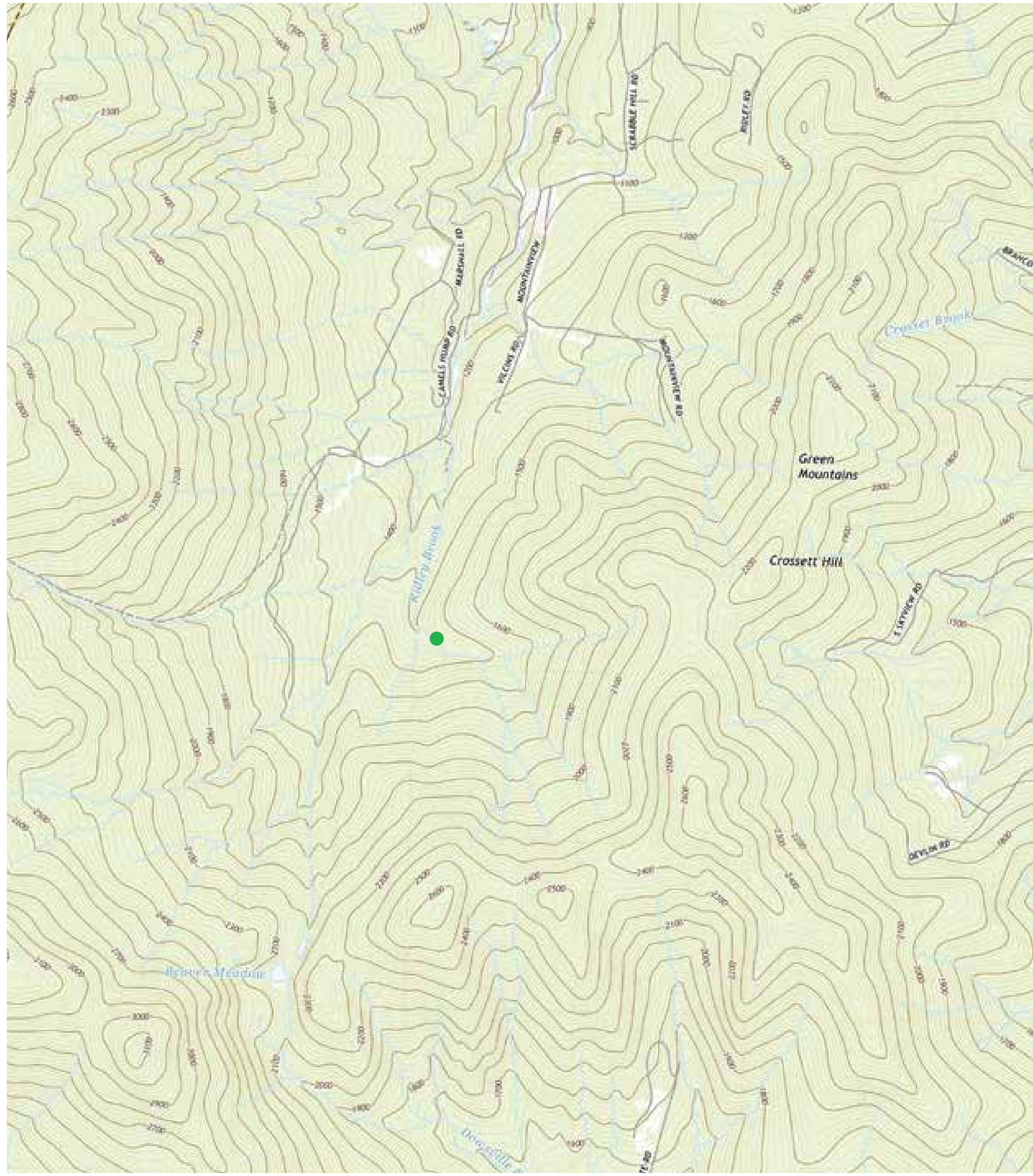
4. To delineate a watershed boundary, begin at an outlet point and draw a line to connect the high point dots or X's from one side of the river to the other. The lines you draw must cross contour lines at a 90-degree angle (the watershed boundary line should be drawn perpendicular to the contour lines). The watershed boundary line should ultimately surround the river and not cross any other streams or rivers. (*see Map 1c*).

5. Do a test delineation using Map 1d Worksheet (*optional*).

6. Now use your map to delineate the watershed to your stormwater practice. Activity 2 will walk you through this process.



Map 1c: Delineating the watershed



Map 1d: Worksheet for test delineation

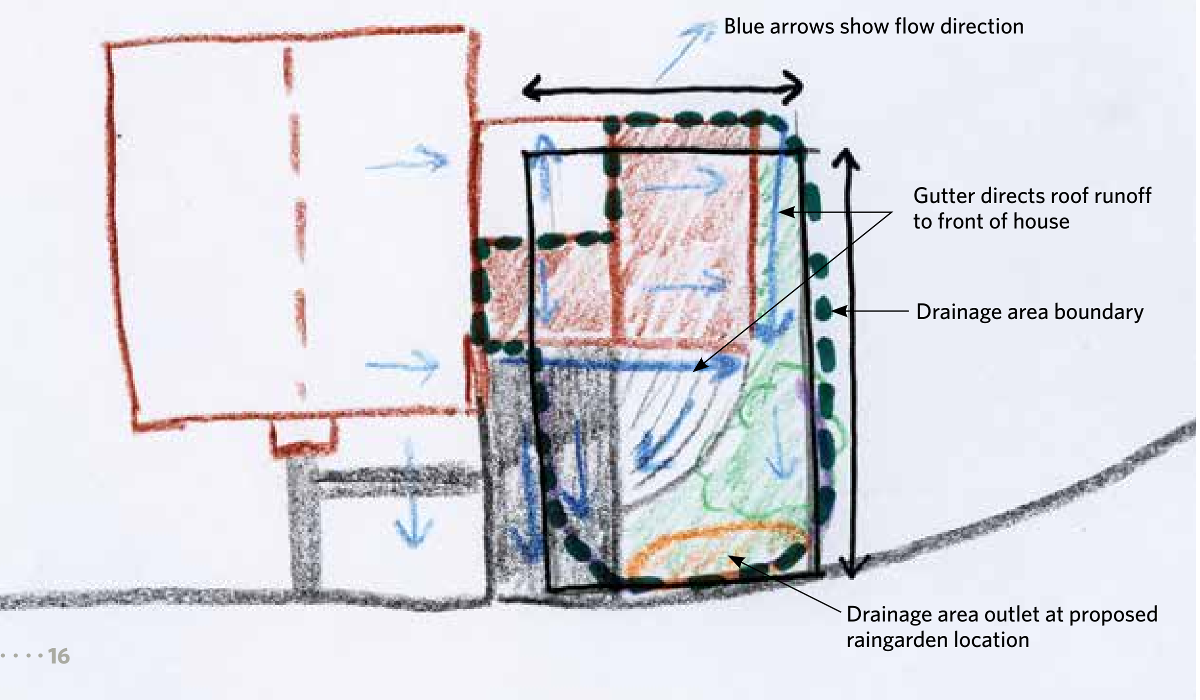
Activity 2: Calculating Stormwater Runoff

In designing green stormwater infrastructure, it is important to make sure it is equipped to handle runoff from all of the impervious surfaces that drain to it. To do this, you will learn how to measure how much water will flow to the green infrastructure practice in a common-sized rain storm. You will be calculating the volume of stormwater of a small watershed in your neighborhood. This could be a roof, parking lot, sidewalk or vegetated area, or a combination of these areas.

- If you will be measuring a roof or part of a roof (e.g. for a rain barrel installation), estimate the area by measuring the footprint of the building as a surrogate.
- If you are measuring the size of a small drainage area to a storm drain or other point to which stormwater drains on the property (e.g. for a rain garden installation), you will need to look for high points on the land surrounding that low point, and draw a boundary line on the map that approximates the area over which water will flow to that drain/area during a rain storm. The drainage area may include part or all of the building's roof in addition to the area on the ground, depending how the roof drainage is designed.

This activity is adapted from Lake Champlain Sea Grant's Soaking Up Stormwater *curriculum.*

See more at: https://www.uvm.edu/seagrant/programs/green-schools/soaking-stormwater-curricula



1. Get ready to go outside.
   You will need:
   - measuring tape or footsteps
   - your map/drawing of your area
   - Activity 2 worksheet
   - writing utensils
   - something on which to write

2. Delineate and draw on your basic map a small watershed based on your assessment of which rain or snowmelt would flow to a certain low point (e.g., to a storm drain) based on the topography and elevation at the site.

3. You will use a common shape that looks most like your drainage area to make an estimate of the drainage area size. Look at your drainage area and decide if a circle, square, or rectangle would be the closest shape to the drainage area you drew.

4. Draw that shape on your map on top of your drainage area boundary. Be careful to draw the circle, triangle or rectangle/square as close as possible in size to the drainage area.
   - Draw the shape so that its boundary falls inside the watershed boundary line about half the time and outside the watershed boundary line about half the time.

5. Use the equations below to determine which components of the equations you must measure to determine the area of a triangle, rectangle/square, or circle based on the watershed area you have drawn. You can use a measuring tape or footsteps to measure.
   - Square/Rectangle: length x width = Area
   - Triangle: ½ (length of base x height) = Area
   - Circle: π x radius^2 = Area

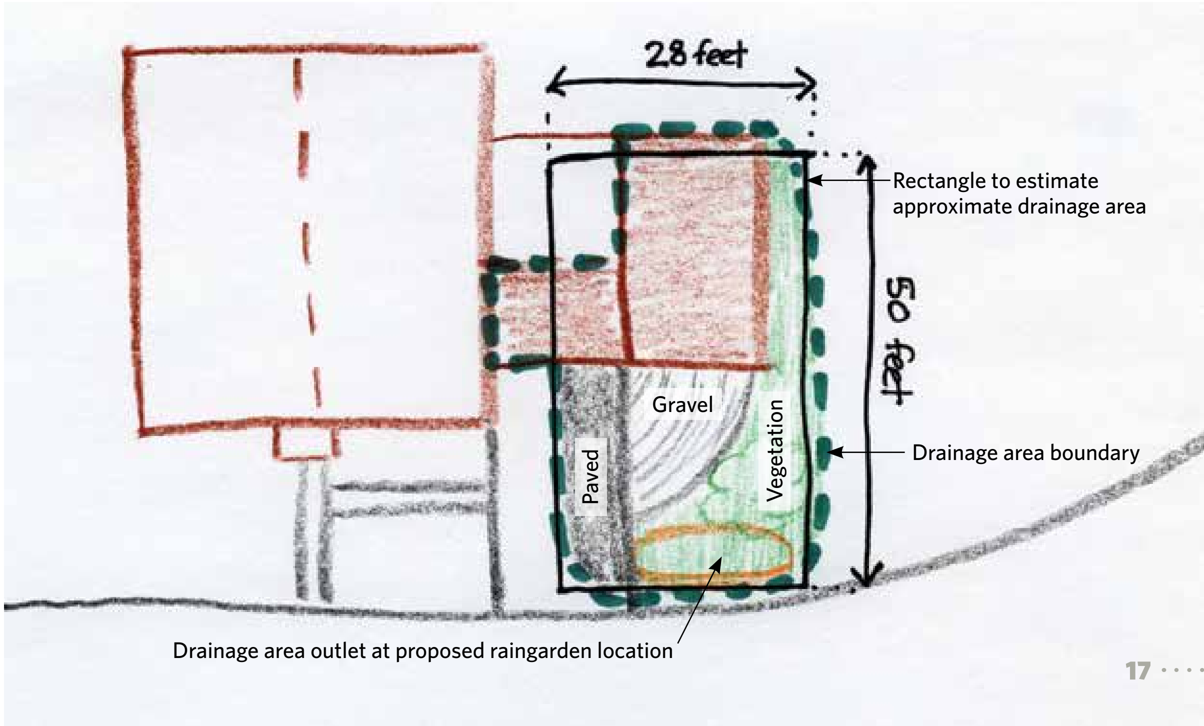
6. In addition to the drainage area, you will need to determine how much rain will, on average, fall in a given storm in your neighborhood. The minimum recommendation is to use a 1.0-inch rainfall value (which will capture 90% of the rainfall events, also known as the Water Quality Volume, WQV). To design for climate change as we try to do through the Ahead of the Storm program, use the Extreme Precipitation in New York and New England: Interactive Web Tool for Extreme Precipitation Analysis website (http://precip.eas.cornell.edu/) which provides average amounts of precipitation over many years. Look up rainfall data for your area to calculate the volume of stormwater runoff in rainstorms of various sizes and use this information to calculate how much runoff is generated from the drainage area you delineated.
   - **a.** Go to the Extreme Precipitation in New York and New England: Interactive Web Tool for Extreme Precipitation Analysis site (http://precip.eas.cornell.edu/).
   - **b.** On the Extreme Precipitation website, go to the Data & Products tab, and enter your address in the Locate by Address box. Check that the Extreme Precipitation Tables – HTML option is selected at the top left, and then click the Submit button at the bottom. A table will appear that displays average rainfall amounts for varied storm sizes.
   - **c.** Look up the 1-year and 10-year rainfalls.
   - **d.** Write these amounts on the Activity 2 Worksheet, number 2a, which will help you see if you have enough space to treat more volume (which is recommended to improve water quality given climate change, and protect your rain garden from damage). The 1-year 24 hour storm size is approximately equal to the volume needed to protect the stream channel from erosion, and the 10-year 24 hour storm size is the amount that may cause down-stream flooding.

7. Another variable needed to determine the volume of runoff expected is the surface type of the drainage area. The amount of runoff depends on the type of surface: pervious surfaces allow water to infiltrate and thus have less runoff than impervious surfaces. A runoff coefficient is used to estimate the proportion of rain that becomes runoff as it moves across pervious and impervious surfaces. If there are multiple surfaces over which rain will flow as it moves to the drain or lowest point in elevation in drainage areas you have measured, do one of the following:
   - **a.** Estimate the percent of each surface type and use the appropriate coefficient for each, multiplying the percent of the area by the appropriate coefficient and then adding their results together.
   - **b.** Choose the predominant surface type and use only that runoff coefficient in the calculations.
   - **c.** Select the surface type that is most impervious and use only that runoff coefficient in the calculations.

8. Calculate the volume using the Activity 2 Worksheet: Calculating Stormwater Runoff (*see next page*).

9. Measure the width of the space you have available for a raingarden, then use the worksheet to estimate if you have enough space to treat a larger volume of water.

Review a video of this activity at: https://bit.ly/stormwater-runoff



Activity 2 Worksheet: Calculating Stormwater Runoff

To calculate the volume of stormwater runoff (V), you need to know three variables:

- Drainage area (A)
- Amount of rainfall (R)
- Average runoff coefficient for drainage area's surface (Cw)

The formula you will use is: V = A x R x Cw

1. Calculate Drainage Area

a. Fill in measurements for the chosen drainage area shape in the table below, then use these in step b.

Shape	Length / Base (ft)	Width / Height (ft)	Radius (ft)
Rectangle/Square			
Triangle			
Circle			

b. Calculate drainage area using the equation for the appropriate drainage area shape below. Enter the Area in table 4a under A.

Square or rectangle drainage area (A):

Length (ft)	x	Width (ft)	=	Area (ft²)
	x		=	

Triangle drainage area (A):

	x	Length of Base (ft)	x	Height (ft)	=	Area (ft²)
0.5	x		x		=	

Circle drainage area (A):

π	x	Radius² (ft²)	=	Area (ft²)
3.1415	x		=	

c. (Optional) Compare the calculated area to the area determined using the Vermont ANR Atlas.

1. Go to https://anrmaps.vermont.gov/websites/anra5/.
2. Type in the address of the site where you are assessing the drainage area.
3. Zoom to that site using the + button.
4. Click on Tools at the top right and then Measurement at the top center. Choose polygon.
5. Create the area that you delineate by clicking to outline that area.
6. When you double click after completing the shape, the area will appear. The default is in acres, but you can change this to square feet in the menu at the top center.

2. Identify Average Rainfall

a. Look up the amount of rainfall in your town for a 1-year, 24-hour storm on the Extreme Precipitation in New York and New England: Interactive Web Tool for Extreme Precipitation Analysis website: (http://precip.eas.cornell.edu/). Go to the Data & Products tab, and enter your address in the Locate by Address box. Check that the Extreme Precipitation Tables – HTML option is selected at the top left, and then click the Submit button at the bottom. A table will appear that displays average rainfall amounts for varied storm sizes. Enter the rainfall for the 1-year, 24-hour storm and 10-year, 24-hour storm below.

Water Quality Volume (WQV) is the amount of stormwater runoff from a storm that should be captured and treated in order to remove a majority of stormwater pollutants (90% of the annual storm events): 1.0 inch

1-year, 24-hour storm size: ___________ inches

10-year, 24-hour storm size: ___________ inches

b. Convert rainfall measurement from inches to feet. Enter the results in Table 4a under R.

Storm Size	Inches of Rainfall	/	Inches per Foot	=	Feet of Rainfall (R)
WQV	1.0	/	12	=	0.083
1-year		/	12	=	
10-year		/	12	=	

3. Determine Runoff Coefficient(s)

a. The runoff coefficient is used to estimate the proportion of rain that becomes runoff as it moves across pervious and impervious surfaces. Estimate the percent of each surface type below. Fill in the table with these percentages (as decimals). Multiply across each row, then add the results together to estimate the average runoff coefficient. Enter this number in table 4a under Cw.

Surface Type	Runoff coefficient	x	Percent of Area (as a decimal)	=	Average Runoff Coefficient (Cw)
Vegetation	0.17	x		=	
Gravel	0.65	x		=	
Asphalt	0.90	x		=	
Rooftop	0.90	x		=	
SUM=Cw					

4. Determine Volume

a. Use the equation Volume (V) = Area (A) x Rainfall (R) x Runoff Coefficient (Cw) to estimate volume of runoff from your site.

Storm Size	A (ft²)	x	R (ft)	x	Cw	=	V (ft³)
WQV		x	0.083	x		=	
1-year		x		x		=	
10-year		x		x		=	

b. Write the volume numbers calculated in 4a in the table in #6.

c. Convert volume to gallons, where 1 cubic foot equals 7.48 gallons.

Storm size	V (ft³)	x	Gallons / ft³	=	Gallons
WQV		x	7.48	=	
1-year		x	7.48	=	
10-year		x	7.48	=	

5. How does the number of gallons you calculated compare to the amount of water in the items listed in the table below?

Item	Average volume of water (gallons)
20′ x 40′ in-ground swimming pool	30,000
Milk tanker truck	8,000
Six-person hot tub	315
Average use per person per day in U.S.	100
Rain barrel	55

6. Use the volumes calculated in 4a to determine the approximate surface area of your potential rain garden. Pick a depth value of either 0.5 foot or 1 foot (try both and see what works better in your space). Write this in the depth column below. Measure the width of the space you have available (in feet) and write this in the width column. Divide the volume for the various storm sizes by the depth and by the width, to calculate the approximate length of the area you'd need to treat that volume of water. Consider choosing the largest area you're able to accommodate to design for climate change.

Storm Size	Volume (ft³)	/	Depth (.5 ft or 1 ft)	/	Width (ft)	=	Length (ft)
WQV		/		/		=	
1-year		/		/		=	
10-year		/		/		=	

7. Consult the *Rain Garden Manual for Vermont and Lake Champlain Basin* for further steps, and make sure to consider the outflow area to protect your and your neighbor's properties from erosion.

Activity 3: Calculating Soil Infiltration Rate

Wherever you are considering stormwater treatment or directing water flow, it is helpful to know if the soils will allow the water to infiltrate. Use this test to determine the infiltration rate.

1. Dig a hole 18” to 3 feet deep. You can set aside the vegetation and dirt to put back after you are done. If your hole has water in it, your groundwater is high and this is not a good location for an infiltration-based treatment. Put something flat like a board across the top of the hole so you have something to measure down from.
2. Fill the hole with water and record the time you start and the time that the hole is empty. Calculate the time it took for the water in the hole to drain out.
3. Two more times repeat filling the hole with water and recording the time it takes to drain. The third test gives the most accurate estimate of how long a treatment area would take to drain.
4. Calculate the infiltration rate by dividing the distance the water dropped (hole depth in inches) by the amount of time it took to drain (hours).

If the rate is more than ½ inch per hour, then the site is good for infiltration. You could put a raingarden or other infiltration treatment type at the location.

If the infiltration rate is less than ½ inch per hour, then the soils do not infiltrate well. If water is directed to the location, then ponding is likely to occur. In this case you could consider planting water-loving plants and look for other locations that might work for infiltration.

Dig a hole, saving the soil and vegetation to put back afterwards.

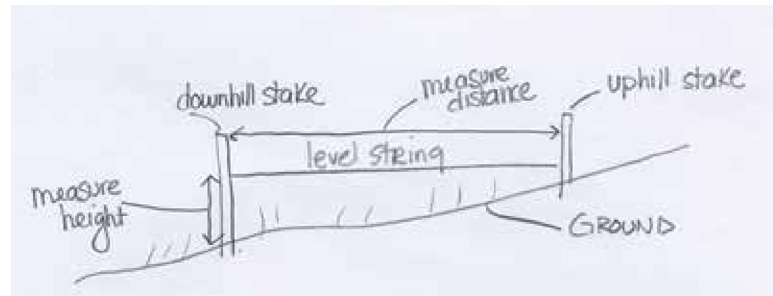
Use a ruler to measure down from the top of the water to the bottom of the hole.

Time how long it takes for the water to drain. Repeat this to get three measurements.

Activity 4: Calculating Slope

The slope of the ground is an important consideration for design. If you are designing a raingarden or other treatment with a flat bottom for ponding, understanding slope will help with your design and layout. If you are designing or altering a swale it is important to understand slope so that you can use stones to reduce erosion potential if the swale is greater than 5% slope.

1. Place a stake at the uphill side of the area where you want to measure the slope and another stake at the downhill side of the area.
2. Tie a string between the two stakes, making sure to make them level. If you don't have a level, you can check if the string is level by holding a glass of water up to the string. The water surface is always level.
3. Measure the length between the stakes along the string.
4. Calculate slope by dividing the height of the string at the downhill stake by the length between the stakes (height of string / length of string). You can multiply by 100 to get a percent.



Clean Water and Ahead Of The Storm

For more information on water quality, go to https://bit.ly/ChamplainWQ

We all require and share the benefits of clean water as an essential component of life. The health and beauty of our communities, the forests, fields, plants, and animals, from the mountains into the valleys, are dependent on clean water. The waters of the Lake Champlain watershed provide drinking water, recreational opportunities, irrigate food crops, and are habitat for the diversity of animals. Historic patterns of human settlement, deforestation, agriculture, manipulation of rivers and streams, urbanization, and increased use of chemicals have all contributed to the degradation of the waters in the Lake Champlain Basin.

Over recent decades, awareness of the need to address the degradation of these waters is increasing locally and statewide. Improving water quality is now imperative to maintaining our health as individuals and communities, as flooding causes property damage and health hazards, cyanobacteria (blue-green algae) blooms close swimming beaches, and wildlife and fish populations decline.

Water moves both underground invisible to us and on the surface. Underground water is critical to animals, plants, and as the supply of drinking water for many households and communities. Surface water provides recreational opportunities, habitat for wildlife and plants, and drinking water. Whether living with water flowing underground or adjacent to a visible body of water, a ditch, stream, river, pond or lake, our land use practices have a direct impact on the health of our waters.

We can all help improve water quality, as demonstrated by Lewis Creek Association's Ahead of the Storm (AOTS) program, which showcases examples of positive land stewardship. Small urban lots and large farms all benefit from applying the three basic principles of stormwater management (the 3 S's). With recent climate trends showing increasing storm frequency, intensity, and magnitude, our management of water is even more important, as these storms accelerate the rate of pollutants getting into the lake.

Ahead of the Storm strives to not only meet current water quality standards and permits, but surpass them when site conditions allow. These "Optimal Conservation Practices" act as a strategy for climate adaptation, and will be able to treat larger volumes of stormwater. The Ahead of the Storm introduction packet provides more background information and details. Visit Lewis Creek Association's Resource Library (https://www.lewiscreek.org/library) to view the full suite of Ahead of the Storm materials currently available, including design plans, site details, and project costs so that these practices can be replicated by community members like you, using this manual as a starting point to explore the land around you.

Resources

Getting Started:

- **A New Type of River Management is Coming**
  This brief (3.5 minute) film describes the importance of allowing water to slow down, spread out, and sink into the ground, and in looking at the entire watershed ("catchment") as a whole.
- **Lake Champlain Sea Grant Homeowner Resources**
  This website provides educational information and ways to protect and improve water quality near your home, covering topics including lawn care, rain barrels, low-salt practices in the winter, and septic system maintenance.
- **Lake Champlain Sea Grant Green Infrastructure Resources**
  This mapping product provides information about environmental features, including stormwater infrastructure, rare plants & animals, soil types, waterways, and more.

Technical Resources:

- **Vermont ANR Natural Resources Atlas**
  This mapping product provides information about environmental features, including stormwater infrastructure, rare plants & animals, soil types, waterways, and more.
- **NY Environmental Resources Mapper**
  This resource is useful for identifying wetlands, rivers, rare animals and plants, and significant natural communities near you, and can help determine if you will need a permit for your project.
- **Rain Garden Manual for Vermont and Lake Champlain Basin**
  This manual (developed for homeowners, landscape architects, city planners, or anyone else interested in installing a rain garden) explains the installation process, demonstrates how rain gardens are cost-effective green stormwater infrastructure tools, and illustrates how they can be incorporated into a variety of landscapes. This is not a guide for regulatory stormwater management. If you are building a rain garden for permit purposes, refer to the Vermont Stormwater Management Manual or the New York State Stormwater Management Design Manual.
- **USGS TopoView**
  This website allows you to find and download a topo map of your area for free. After you type in your town name, make sure you scroll to the bottom of the list to obtain the most recent topo map.
- **Vermont Better Roads Manual**
  Similar to the Vermont Municipal Roads General Permit, but with more diagrams and details, this manual gives details on best management practices for roads, including ditches, culverts, grading techniques, and bank stabilization.
- **Vermont Green Stormwater Infrastructure (GSI) Simplified Sizing Tool for Small Projects**
  This tool (spreadsheet) will help you calculate the sizing for a small GSI practice you hope to implement.
- **Vermont Guide to Stormwater Management for Homeowners and Small Businesses**
  This guide was developed to help homeowners and small business owners who are not subject to stormwater permits and regulations identify ways to improve and protect water quality and manage stormwater runoff at its source. The practices described include a variety of green stormwater infrastructure practices, and can help narrow down which practices might be helpful on your property, with additional information about installation, maintenance, and cost.
- **NRCS Web Soil Survey**
  This map can help you determine what type of soils are common in your area and on your property; this in turn can help you determine what types of projects would work well for you.
- **New York State Stormwater Management Design Manual**
  Published in 2015, this document from New York State Department of Environmental Conservation (NYSDEC) is aimed to guide municipalities in stormwater management as a part of the Phase II State Pollution Discharge Elimination System (SPDES) general permit for stormwater runoff from construction activities from all sizes of disturbance. For information on Green Stormwater Infrastructure Practices, see Chapter 5.
- **Construction Stormwater Toolbox**
  Use this toolbox from NYSDEC to find more in-depth resources for supporting your Green Stormwater Infrastructure projects such as worksheets, Inspection Checklists, and Maintenance Guidance manuals.
- **Vermont Municipal Roads General Permit**
  The Municipal Roads General Permit is intended to achieve significant reductions in stormwater-related erosion from municipal roads, both paved and unpaved. Municipalities will implement a customized, multi-year plan to stabilize their road drainage system. This document gives guidelines for a variety of roads and their associated swales, and can be used to apply to private roads and driveways as well.
- **Vermont Stormwater Management Manual**
  This manual describes the requirements that applications for permits must meet (all applicable criteria for water quality, groundwater recharge, channel protection, overbank flood protection, and extreme flood protection as outlined in the 2017 Vermont Stormwater Management Manual). Further information on permits can be found at Vermont's Operational State Stormwater Permit Application Materials page.

Community:

- **Watersheds United Vermont Watershed Groups**
  This resource includes a map and list of watershed groups, so you can find one near you. These watershed groups are community-based groups working with individuals and communities in their local watersheds to protect and improve water quality, habitat, and flood resilience and to build social and ecological connections with Vermont's waters. They may be able to help you assess your property and find funding to design and complete a project!
- **Lake George Association: Reduce Stormwater Runoff**
  Additional information about stormwater, stormwater management techniques, and general information on how you can assess your property for stormwater can be found using this resource created by the Lake George Association.

This manual was developed by Lewis Creek Association in 2024 using materials previously published, and was edited in collaboration with SLR, Lake Champlain Sea Grant, and the Lake Champlain Committee.

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To download a copy of this manual, go to www.lewiscreek.org/aots-guidance-manual

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