# Pave It or Plant It

## 7th – 12th Grade Curriculum

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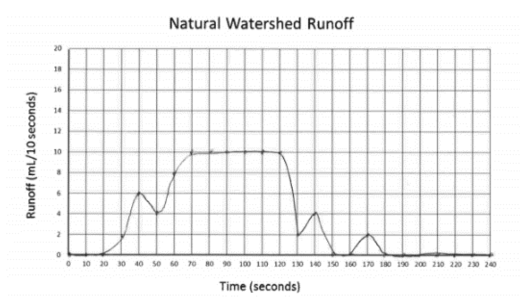


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UtahStateUniversity
WATER QUALITY EXTENSION

# Pave It or Plant It

## Purpose:

This activity explores how the growth of cities and towns (urbanization) in a watershed can alter the timing and volume of storm water runoff. Students also learn how these changes affect physical structure, water quality and aquatic communities in streams that flow through urban areas. The lesson includes an optional mapping exercise and provides opportunities to explore ways to prevent or minimize the impacts urban development has on streams.

Grade level: 7th -12th

Setting: Classroom, Outdoors - (optional field activity)

Duration:
Lab and discussion: 1 hour

Field activity: 1 hour

Curriculum Connections:

7th Grade Math Geometry 7.G6

Mathematics II Geometry GMD.3

Earth Science Standard 4.2d

Natural Resource 1 Standard 4.3

## Summary:

Students will use simple watershed models to measure runoff from natural and urbanized areas. They will graph the data to create and compare the hydrographs of these two different types of watersheds. Students will also map different areas in their neighborhood, calculate the amount of impervious surface in the area, and determine how this affects the volume of stormwater runoff expected from a typical rainstorm.

Finally, students will list different types of pollutants that enter the streams from urban areas and learn about possible impacts to the stream. They will also learn about possible methods of reducing these impacts through community or individual actions.

See additional activities to further explore actual conditions in streams.

## Background:

When it rains or snows, where does all the water go? In addition to soaking into the soil or evaporating back into the atmosphere, some of this water will flow over the land surface, moving downhill to the nearest waterbody. We call this stormwater runoff. As cities and towns grow, natural groundcovers are replaced by roads, parking lots, buildings and other "impervious surfaces" or surfaces that prevent the water from soaking into the soil. Water drains off these surfaces, collecting in gutters, ditches or storm drains, which carry the water (as well as trash, salt, oil and other pollutants) directly to your local stream or lake.

As little as 10% impervious land cover in an urban watershed can greatly increase the amount of stormwater runoff and surface pollutants that drain to water bodies, putting streams and lakes at risk. The more impervious cover, the greater the risk.

# Pave It or Plant It

Classroom Activity: Students will measure and compare runoff from watershed models. Divide the class into groups with a minimum of three students/group.

Materials: For each group of students, provide the following:

- Stop watch
- Clip board
- Data sheets (pages 15-18)
- Calculator
- Ruler
- Cookie Sheet modified with a small notch cut out at one end (see diagram on page 12)
- Spray bottle (with a fine spray) filled with tap water
- Graduated cylinder or other measuring device
- Funnel
- Felt cut to the same size as the cookie sheet
- Clips or Velcro for attaching felt to cookie sheet
- Stand setup (see instructions on pages 12-14)
- Paper towels
- Extra water jug or a sink available to refill the spray bottles

## Class discussion prior to student activity:

**Setting the stage:** This exercise focuses on the precipitation and runoff components of the hydrologic cycle.

1. **Discuss** the different components of the hydrologic cycle (precipitation, infiltration, runoff, evaporation/evapotranspiration, condensation).
2. **Define** runoff as the volume of water moving across the landscape following a storm event (or melting snow event).
3. **Emphasize** that runoff moves across the landscape until it infiltrates into the soil or enters a stream or other water body.
4. **Explain** that infiltration is important because it "recharges" our ground water and provides summer base flow (low flows) in streams.

**Show the students** how to set up their "experimental watershed."

1. **Demonstrate** how to set up the rack and cookie sheet with funnel and collection bottle lined up to collect runoff (see page 12). Start by using a moderate slope.
2. **Tell** the students that the felt represents vegetation of a "natural" watershed area, while the bare cookie sheet represents a paved watershed area (100% impervious area). The students will conduct the runoff experiment with each surface, starting with the natural watershed.

3. **Explain** to students that they will compare runoff from each type of surface by "raining" on the watershed (from spray bottles).

4. **Ask** the students how they think runoff will vary between a vegetated watershed and a paved watershed.

5. **Show** the students the Natural Watershed and Urban Watershed datasheets. Explain that one student will spray the water on the watershed for the entire length of a rainstorm (2 minutes). Another student will time the readings (every 10 seconds), and a third student will record the amount of water in the collection bottle every 10 seconds. If groups have more than three students, they can swap tasks.

Optional: If there is time or interest, students can repeat the exercise with steeper or shallower slopes. See "Extra Runoff Model Activities," page 5.

## Student runoff model activity:

*Note: Teachers may want to have extra felt surfaces available if the activity needs to be repeated. Over soaking the felt can make it difficult to reuse.*

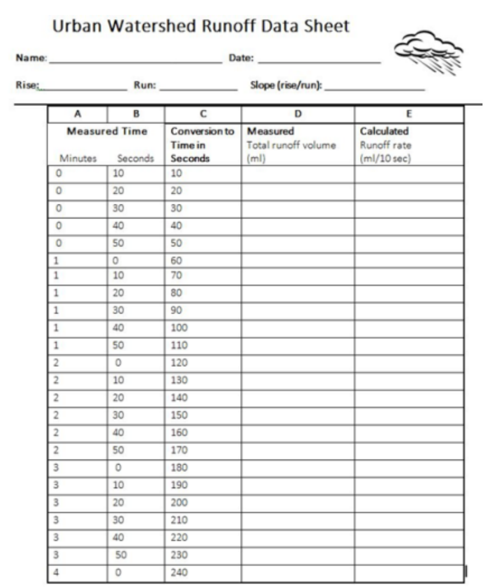
1. Divide the class into groups of three to five students and distribute materials. Have groups decide on task assignments (see #5 above) and set up the rack and cookie sheet "watershed" (see setup on pages 12-14).

2. Have students attach the "natural" felt covering.

3. Explain that after the first "rain storm," the cookie sheet will need to be dried thoroughly with the paper towels.

4. Make sure that spray bottles are adjusted to a relatively gentle spray that will cover as much of the watershed as possible with each spray.

5. Have students conduct their rainstorm experiments. Although the rainstorm will last only 2 minutes the group should measure runoff for an additional 2 minutes, after the "rain" stops.
   - Have one student spray the watershed for 2 minutes.
   - Another student will keep time, calling out 10 second intervals for the entire 4 minutes, starting at the beginning of the rainstorm.
   - Another student will measure and record the



Urban Watershed Runoff Data Sheet

Name: ____________ Date: ____________

Rise: ________ Run: ________ Slope (rise/run): ________

| A | B | C | D | E |
|---|---|---|---|---|
| Measured Time | | Conversion to Time in Seconds | Measured Total runoff volume (ml) | Calculated Runoff rate (ml/10 sec) |
| Minutes | Seconds | | | |
| 0 | 10 | 10 | | |
| 0 | 20 | 20 | | |
| 0 | 30 | 30 | | |
| 0 | 40 | 40 | | |
| 0 | 50 | 50 | | |
| 1 | 0 | 60 | | |
| 1 | 10 | 70 | | |
| 1 | 20 | 80 | | |
| 1 | 30 | 90 | | |
| 1 | 40 | 100 | | |
| 1 | 50 | 110 | | |
| 2 | 0 | 120 | | |
| 2 | 10 | 130 | | |
| 2 | 20 | 140 | | |
| 2 | 30 | 150 | | |
| 2 | 40 | 160 | | |
| 2 | 50 | 170 | | |
| 3 | 0 | 180 | | |
| 3 | 10 | 190 | | |
| 3 | 20 | 200 | | |
| 3 | 30 | 210 | | |
| 3 | 40 | 220 | | |
| 3 | 50 | 230 | | |
| 4 | 0 | 240 | | |

Figure 1. Datasheet for urban setup (without any felt). The natural watershed datasheet looks similar.

accumulated (total) volume of runoff at each 10-second interval. Record this volume in column D of each data sheet.

- Between experimental "rains," students may switch roles for the second set of watershed measurements.

6. Once the "raw data" are collected, students need to do some calculations: Calculate the difference in the accumulated runoff volume (Column E) from the beginning to the end of each 10-second interval. (For example, subtract the 20-second measurement from the 10-second measurement). Record these values in column E of each datasheet, which is the runoff rate for each 10-second interval (units mL/10 sec).
7. Graph the runoff rates from Column E on the urban and natural watersheds graphs (page 17). The x-axis on each of these graphs is time in seconds and the y-axis is the runoff rate in mL for each 10 second interval. Each graph will start at the beginning of the rainstorm (t=0 sec). Graph the runoff rate from the beginning of the rainstorm (t=0 sec) until the end of the experiment (t=240 sec). These graphs are called storm "hydrographs."

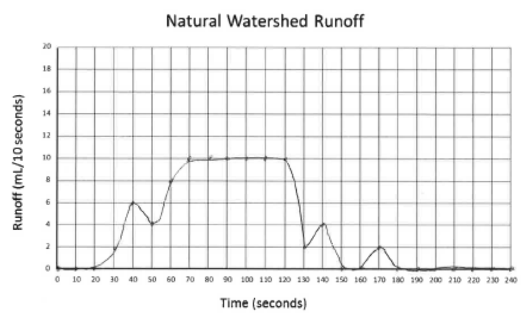
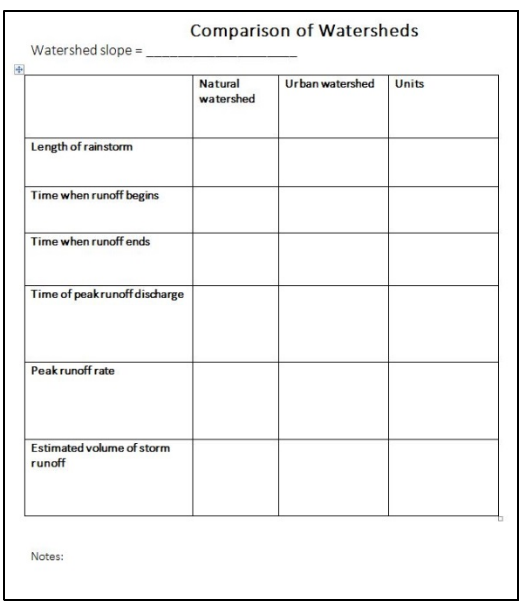



Figure 2. Example graph where students show their data as a hydrograph. Time on the x-axis, Runoff rate on the y-axis.

8. Students will now calculate and fill out the "Comparisons of Watersheds" table. The values are available from their tables or may be read directly from the graphs they have created. Make sure the students record the correct units on the graphs and in their calculations.

- *The length of the rainstorm*: If the students followed the instructions closely, this will be 2 minutes, but students sometimes end up with a different time—make sure the actual storm length is recorded and graphed.



Comparison of Watersheds

Watershed slope = ___________________

| | Natural watershed | Urban watershed | Units |
|---|---|---|---|
| Length of rainstorm | | | |
| Time when runoff begins | | | |
| Time when runoff ends | | | |
| Time of peak runoff discharge | | | |
| Peak runoff rate | | | |
| Estimated volume of storm runoff | | | |

Notes:

Figure 3. Comparison of watersheds datasheet.

- *Time when runoff begins*: Some of the sprayed water clings to the felt or the cookie sheet, so actual runoff is not instantaneous. This happens in a real watershed as well. Note that runoff starts sooner on the "paved" watershed.
- *Time when runoff ends*: After the storm ends, the water continues to drain from the cookie sheet. The "natural watershed" may continue to drip water after the 4 minutes of measurements have ended. Students may want to make a note of that.
- *Time of peak discharge*: This is the time of the highest runoff volume / 10 second interval. Sometimes this rate occurs several times because

spraying is not perfectly even. If this happens, students should note each time.

- *Peak runoff rate*: This is the mL/10 second value associated with the time(s) of peak discharge.
- *Estimated volume of storm runoff*: In your experiment, this is the volume of water collected in the graduated cylinder, but in the "real world," you wouldn't have a big container of runoff. Rather, you would calculate this from the graph – as the "area under the curve," calculated from the graph. Students should count each full square under the runoff curve. When **the graph crosses a square, count it as if 50% of the square is under the curve.**

## Extra runoff model activities:

### Slope Activity

Measure the rise and run of the model and repeat this class experiment with the watershed model set at different slopes. Graph results and fill out the Watershed Comparison table, page 18.

**Explain** that the rack is designed for several "watershed slopes" and that slope is defined as the change in vertical distance (rise) over the change in horizontal distance (run).

**Explain** that the students will repeat the previous runoff activity testing the effect of different slopes on the timing and rate of runoff.

1. Have students measure and record the rise (vertical distance from bottom to top of watershed) and run (horizontal distance from bottom to top of watershed) on the Runoff Data Sheet.
2. Calculate the slope: Divide the measured rise by the run. Note that units will cancel out so slope is unitless. Record this on each datasheet.

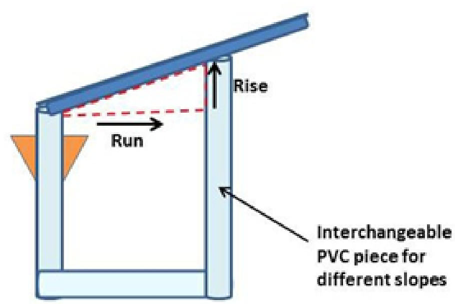



Figure 4. Shows rise vs. run to determine the slope.

Fill out the Comparison of Watersheds datasheet, see activity above for calculations. How did slope make a difference to the timing and rate of runoff?

### Changes in Landscape Activity

The previous runoff activity compared 100% vegetated landscapes with 100% paved landscapes. Using smaller strips of felt, students can explore the effectiveness of strips or areas of vegetation in an urban landscape. Graph results for landscapes with different percentages and configurations of impervious surface area.

Is the vegetation more effective at the bottom or top of the landscape?

# Pave It or Plant It

## Follow -up discussion:

To the right is an "idealized" graph of a vegetated (natural) watershed and an impervious (urbanized) watershed. A full-sized version of this graph, found in the Appendix, can be used in your discussion.

Have students share their results (e.g., tape their graphs and tables on the board to use for the discussion).

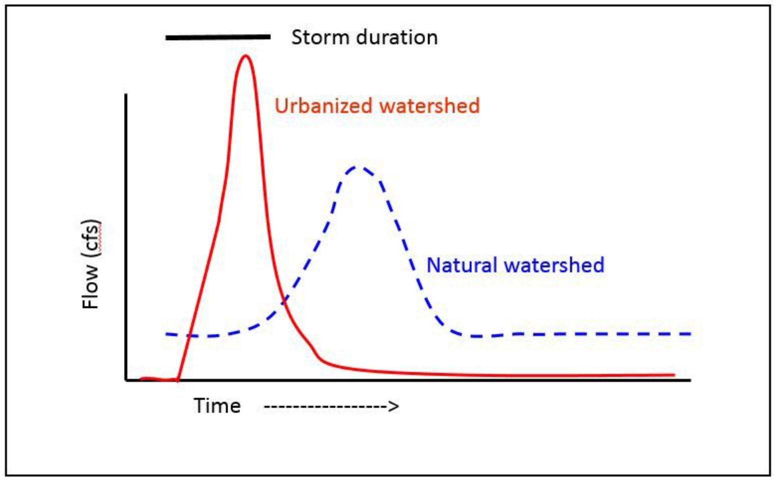



Figure 5. Example of a natural vs. urbanized hydrograph.

### Impacts of urban development on the flow of rivers *(brief answers are provided in italics.)*

- How did the student graphs differ from the "idealized" graph? Why?
  *The idealized graphs are based on large watersheds using a larger amount of data to develop the graphs. While the activity is an excellent simulation of the effect of impervious surfaces, it is not a true example. Additionally there may be discrepancies between students' graphs which could be due to differences in spray rates.*
- What effect did "paving" a watershed have on runoff timing and volume?
  *Water should have run off the land much more quickly and all drained into the container for the "paved" watershed; whereas, the natural watershed would have retained some of the water in the felt and ran off much more slowly.*
- What effect did slope have?
  *A steeper slope should have increased the maximum runoff rate and quicker drainage.*
- Why did runoff start sooner and have a higher peak flow in the urban watershed?
  *The water moved immediately across the land to the container (stormdrain) since there were no plants to slow the flow. The water also drained rapidly creating the higher peak.*
- How did baseflow in the natural and urban watershed compare?
  *Explain that baseflow is the water in a river when there is NO storm or snow melt runoff. This flow is fed by the gradual return of underground water back to a stream. This groundwater is fed by water that infiltrates into the ground during storm events.*
- Based on the experimental results, what are the implications of "paving a watershed" on groundwater levels, and stream flows throughout a year?
  *Explain that water moves more quickly over paved surfaces because there is no longer vegetation and soil to slow it down. This results in "flashy," high flow conditions in streams during and just following rainfall events. Since the water does not infiltrate the soil, ground water levels will be lower with paving of the watershed, and base flow conditions will be lower too.*

# Pave It or Plant It

- Define the terms impervious and pervious surfaces. How would one calculate the percent impervious area?
  *Impervious surfaces are any surfaces where water may not infiltrate (rooftops, roads, concrete, stone, compacted soils, etc.) Pervious surfaces allow the water to percolate and infiltrate into the ground. Use Figure 10 (on page 22) to demonstrate how urban development affects runoff, infiltration and evaporation. The calculation of percent impervious surface is done by measuring the area of rooftops, roads, walkways, etc. (Impervious), and the area of lawns, forests, pastures, etc. (Pervious), within a site. Percent impervious area = (Impervious Area)/(Impervious Area + Pervious Area) x 100*

## Water quality impacts from urban development *(brief answers in italics):*

- Discuss the different types of water quality pollutants.
  *Materials that occur naturally in a watershed include soil, dead leaves or grass, or wildlife waste. When transported to water bodies, often due to poor land management practices, some of these natural materials may become a water pollutant. Materials that do not occur naturally in a watershed (e.g., oil, solvents, fertilizers, pesticides, soaps, domestic animal waste, wastewater from treatment plants, etc.) may cause even more severe environmental and/or health issues when concentrations get too high in a water body (see chart on following page).*
- How will "urbanization" affect the transport and impact of these materials to water bodies?
  *As water moves quickly over the paved surfaces, the water will transport more pollutants more quickly directly to the water bodies. When more pervious surfaces are present, more of the pollutants are trapped or filtered through the soils.*
- Some pollutants dissolve in water (e.g., fertilizers), while others never actually dissolve (e.g., oil or soil particles or suspended pollutants). How will "urbanization" affect whether these dissolved pollutants end up in a stream or lake or end up soaking into the ground?
  *By removing pervious surfaces (vegetation), both dissolved and suspended pollutants move rapidly to the storm drains. Adding more vegetated areas allows the suspended pollutants to be retained by the vegetation and dissolved pollutants to filter into the ground. Many of the dissolved pollutants are readily available to be taken into the plants, but may bio accumulate.*

## Compare changes between urbanized and natural watersheds ***(brief answers in italics):***

- *Runoff starts sooner because far less water infiltrates into the soil.*
- *The peak runoff is much higher and occurs sooner. This increase in peak discharge can cause increased erosion and changes in the stream channel.*
- *Greater volumes of stormwater runoff can alter stream channels and cause flooding.*
- *Reduced infiltration reduces subsurface flows to the stream. These flows feed the stream between storms, so streams may dry up completely during parts of the year. This will kill off fish and the macroinvertebrates they feed on.*

If class conducted extra runoff model activities:

- When the watershed was partially "developed," did the location in the watershed (high or near the base) determine the runoff pattern?
- How much of the watershed needed to have natural covering to retain a "natural" hydrograph?
- How did slope affect the difference between a natural and urban watershed? How might this affect how much vegetation must be retained to protect a "natural" hydrograph?

Further Discussion:

1. What types of pollutants are found in stormwater? What are their sources and impacts? *See summary of urban pollutants in Table 1 below:*

Table 1. Summary of Common Urban Pollutants.

| Water Pollutant | Sources | Impacts |
|---|---|---|
| Oils and greases | Car leaks, dumping in storm drains | Compounds may include toxic petroleum products. Oils reaching the waterways can be harmful to aquatic birds and mammals. |
| Heavy metals | Wearing of brakes, tires, etc. | Teratogenic (affecting embryos and fetus) or carcinogenic (cancer causing). |
| Antifreeze | Car leaks, dumping in storm drains | May be directly toxic. Can deplete oxygen from water. |
| Polycyclic aromatic hydrocarbons (PAHs) | By-product of fossil fuel combustion | Varies with actual compound. May be carcinogenic, mutagenic and teratogenic (affect embryos and fetus, induce mutations in organisms or be cancer-causing). Affects fish, other aquatic life and may accumulate in bodies of these live animals. |
| Plastics | Trash, nets | Can choke or interfere with aquatic organisms. If ingested, interferes with digestion. |
| Sediment (dirt, sand, clay, rock) | Construction, lawns/gardens, bare lots | Fill up space between cobble in streams, interfering with fish spawning or macroinvertebrate habitat. Carries many other pollutants. |
| Nitrogen and phosphorus | Fertilizers, pet waste, yard waste | Excess plant growth in streams and lakes decomposes, consuming dissolved oxygen and harming aquatic life. Some algae are toxic to dogs/livestock.<br>Ammonia can be toxic to fish. Nitrates in drinking water may cause blue baby syndrome. |
| Pesticides / herbicides | Garden/lawn use, household use. | May accumulate in bodies of live animals and have toxic or sub-lethal effects. |

| | | |
|---|---|---|
| Bacterial / other microscopic organisms | Domestic / wild animal waste, failing septic systems | May cause intestinal disease. |
| Vegetation (leaves, yard clippings) | Yard waste left in ditches, drains, dumped in streams | Decomposition can result in low oxygen concentrations, leading to fish kills or sub-lethal impacts on aquatic life. |
| Thermal pollution | Runoff over hot pavement and roofs, loss of riparian shade | Many aquatic organisms are sensitive to warm temperatures. Saturation levels of dissolved oxygen are lower in warm water. Some toxins (e.g., ammonia) are more toxic in warm water. |

3. What are some ways the city controls runoff from impervious surfaces?
   - *Public Participation and involvement – storm drain stenciling, citizen monitoring*
   - *Construction site stormwater runoff control (straw bales, sediment barriers)*
   - *Green infrastructure including detention or retention basins, permeable parking, green roofs, stormwater treatment (i.e., bioretention basins, bioswales, rain gardens)*
   - *Pollution prevention/good housekeeping (e.g., street cleaning, maintain vehicles, proper salt storage)*
   - *Public education and outreach – target homeowners, businesses, students*

*Some communities are "MS4 communities" (municipal separate storm sewer systems) and are required by EPA to obtain an urban stormwater permit and to implement control measures listed above. For more information on urban "best management practices," go to http://extension.usu.edu/waterquality/bmps/.*

4. How can individuals reduce the pollution from parking lots?
   - *Pick up garbage. Don't be a litter bug. Always dispose of trash in a proper container; not in the water.*
   - *Don't rinse down garages or driveways into the street. Wash cars on lawns or at car washes with appropriate water disposal.*
   - *Reduce car traffic. Use public transit, car pool, walk or bike.*
   - *Make sure car doesn't leak oil or antifreeze. This can wash into the water and be dangerous for fish, birds, and even cats and dogs.*
   - *NEVER put anything down storm drains that may pollute downstream water – this includes oils, pesticides, antifreeze, but also pet waste and lawn clippings.*
   - *Participate in community outreach efforts, present class research or project findings at public meetings or forums (e.g., libraries, city council meetings), participate in citizen monitoring efforts, stencil or provide signage to protect storm drains.*

5. Check out other activities and resources in Utah:
   - See USU Water Quality Extension's website (http://extension.usu.edu/waterquality) for information about water science, watershed protection and additional educator

resources.

- Utah Water Watch: Opportunity for schools, families or individuals to collect water quality data that will be included in a statewide database. Tier 1 collection methods are for educational and screening purposes. Visit http://extension.usu.edu/utahwaterwatch
- Find out more about your watershed at www.utahcleanwater.org – Find Your Watershed.
- Stream Side Science contains 12 lesson plans designed around stream science. Most lessons are based on stream monitoring or other exploration. All lessons are aligned to Utah Core curriculum standards and intended learning outcomes. Visit http://streamsidescience.usu.edu for all of the Stream Side Science lessons. Training may be available for interested teachers.
- Learn more about groundwater and infiltration: https://water.usgs.gov/edu/watercycleinfiltration.html

## Appendix Contents

## Setup Instructions

For this activity, you will need a flat metal tray, set at a slope, with a cut notch to direct water into a funnel and graduated cylinder. We have two examples of setup.

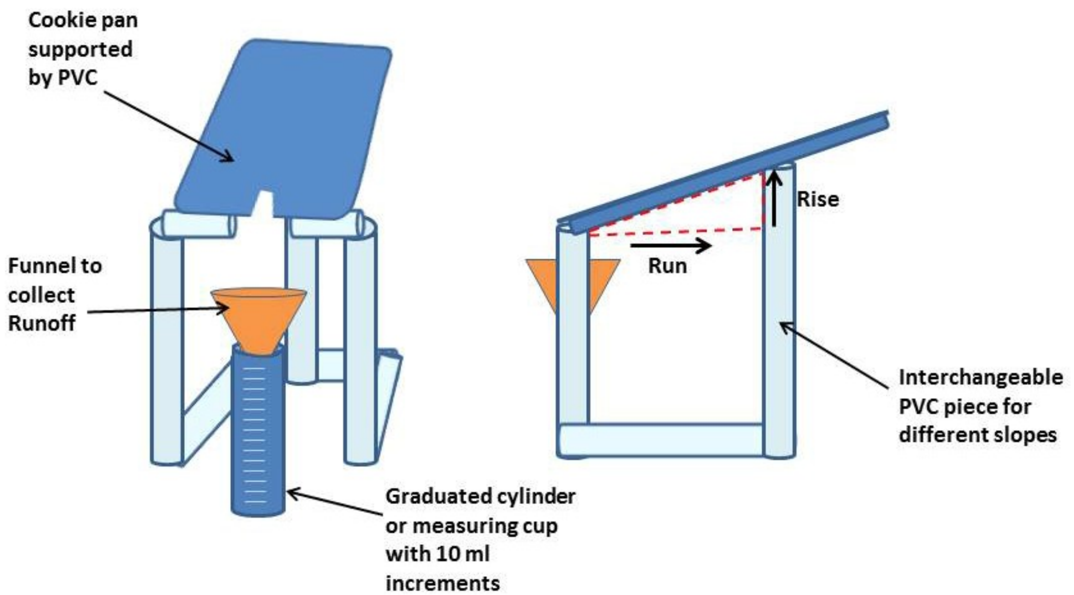



Figure 6. An example setup, showing different parts of the model.

Figure 7. Urban and natural watershed PVC stand setup. Note the Velcro on the urban setup to attach felt pieces. See the setup instructions on the next page.

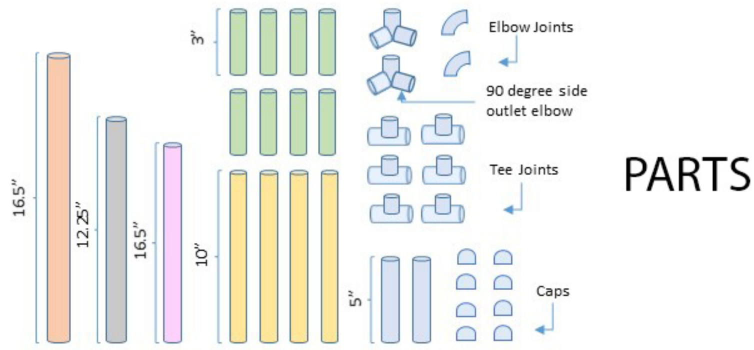
## Setup - PVC Pipe Stand Instructions

Materials needed for one stand:

1 – 10’ length 1/2” pipe will be used to cut the following sections:

- 4 - 10” pipe
- 1 - 16.5” pipe
- 1 – 12.25” pipe
- 1 – 11.25” pipe
- 2 – 5” pipe
- 8 – 3” pipe

2 – 90 degree side outlet elbow
6 – tee joints
2 – slip elbows
8 – caps



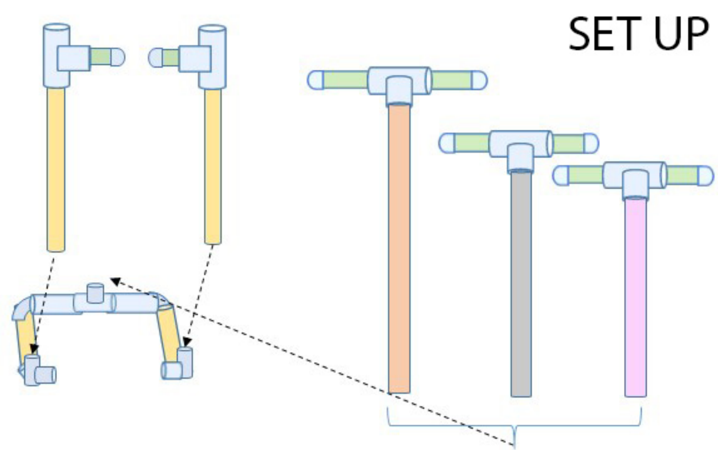




Figure 8. PVC stand setup diagram. The orange, black and pink sections are legs for different slope setups. Only one is used at a time.

Instructions for construction:

1. Measure and cut the pipe pieces from a 10’ length of ½” pipe.
2. Glue the appropriate pieces together (see Figure 5). The PVC stand is glued and stored in six separate sections (as in the setup diagram). This allows for easy storage.
3. Clearly label each of the supporting slope pieces so they can be easily identified during the activity. We used colored tape.

## Alternate setup using a basin or a tub:

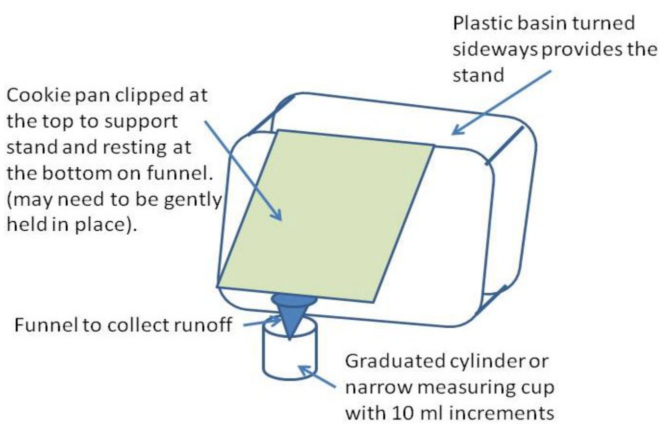



Figure 9. Alternate watershed setup using a tub or basin.

## Natural Watershed Runoff Data Sheet

Name: ______________________________ Date: _____________________

Rise:_______________ Run: _____________ Slope (rise/run): _________________

| A | B | C | D | E |
|---|---|---|---|---|
| Measured Time | | Conversion to Time in Seconds | Measured Total Runoff Volume (mL) | Calculated Runoff Rate (mL/10 sec) |
| Minutes | Seconds | | | |
| 0 | 10 | 10 | | |
| 0 | 20 | 20 | | |
| 0 | 30 | 30 | | |
| 0 | 40 | 40 | | |
| 0 | 50 | 50 | | |
| 1 | 0 | 60 | | |
| 1 | 10 | 70 | | |
| 1 | 20 | 80 | | |
| 1 | 30 | 90 | | |
| 1 | 40 | 100 | | |
| 1 | 50 | 110 | | |
| 2 | 0 | 120 | | |
| 2 | 10 | 130 | | |
| 2 | 20 | 140 | | |
| 2 | 30 | 150 | | |
| 2 | 40 | 160 | | |
| 2 | 50 | 170 | | |
| 3 | 0 | 180 | | |
| 3 | 10 | 190 | | |
| 3 | 20 | 200 | | |
| 3 | 30 | 210 | | |
| 3 | 40 | 220 | | |
| 3 | 50 | 230 | | |
| 4 | 0 | 240 | | |

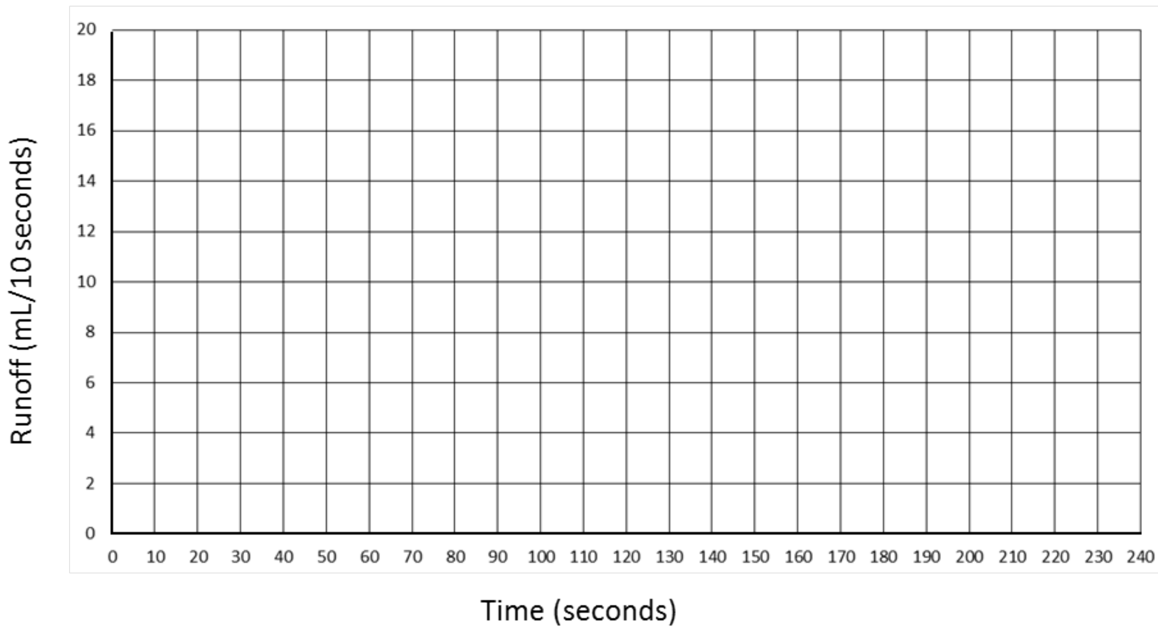
## Urban Watershed Runoff Data Sheet

Name: ________________________________ Date: ______________________

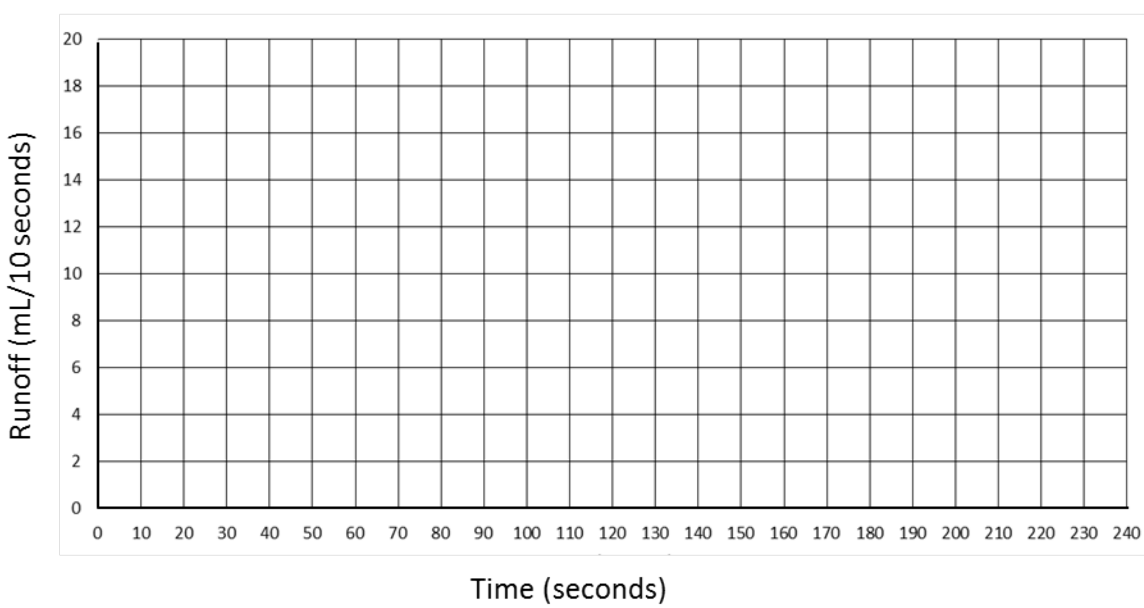
Rise:________________ Run: ______________ Slope (rise/run): __________________

| A | B | C | D | E |
|---|---|---|---|---|
| Measured Time<br>Minutes | <br>Seconds | **Conversion to Time in Seconds** | **Measured** Total Runoff Volume (mL) | **Calculated** Runoff Rate (mL/10 sec) |
| 0 | 10 | 10 | | |
| 0 | 20 | 20 | | |
| 0 | 30 | 30 | | |
| 0 | 40 | 40 | | |
| 0 | 50 | 50 | | |
| 1 | 0 | 60 | | |
| 1 | 10 | 70 | | |
| 1 | 20 | 80 | | |
| 1 | 30 | 90 | | |
| 1 | 40 | 100 | | |
| 1 | 50 | 110 | | |
| 2 | 0 | 120 | | |
| 2 | 10 | 130 | | |
| 2 | 20 | 140 | | |
| 2 | 30 | 150 | | |
| 2 | 40 | 160 | | |
| 2 | 50 | 170 | | |
| 3 | 0 | 180 | | |
| 3 | 10 | 190 | | |
| 3 | 20 | 200 | | |
| 3 | 30 | 210 | | |
| 3 | 40 | 220 | | |
| 3 | 50 | 230 | | |
| 4 | 0 | 240 | | |

Natural Watershed Runoff




Urban Watershed Runoff



## Comparison of Watersheds Data Sheet

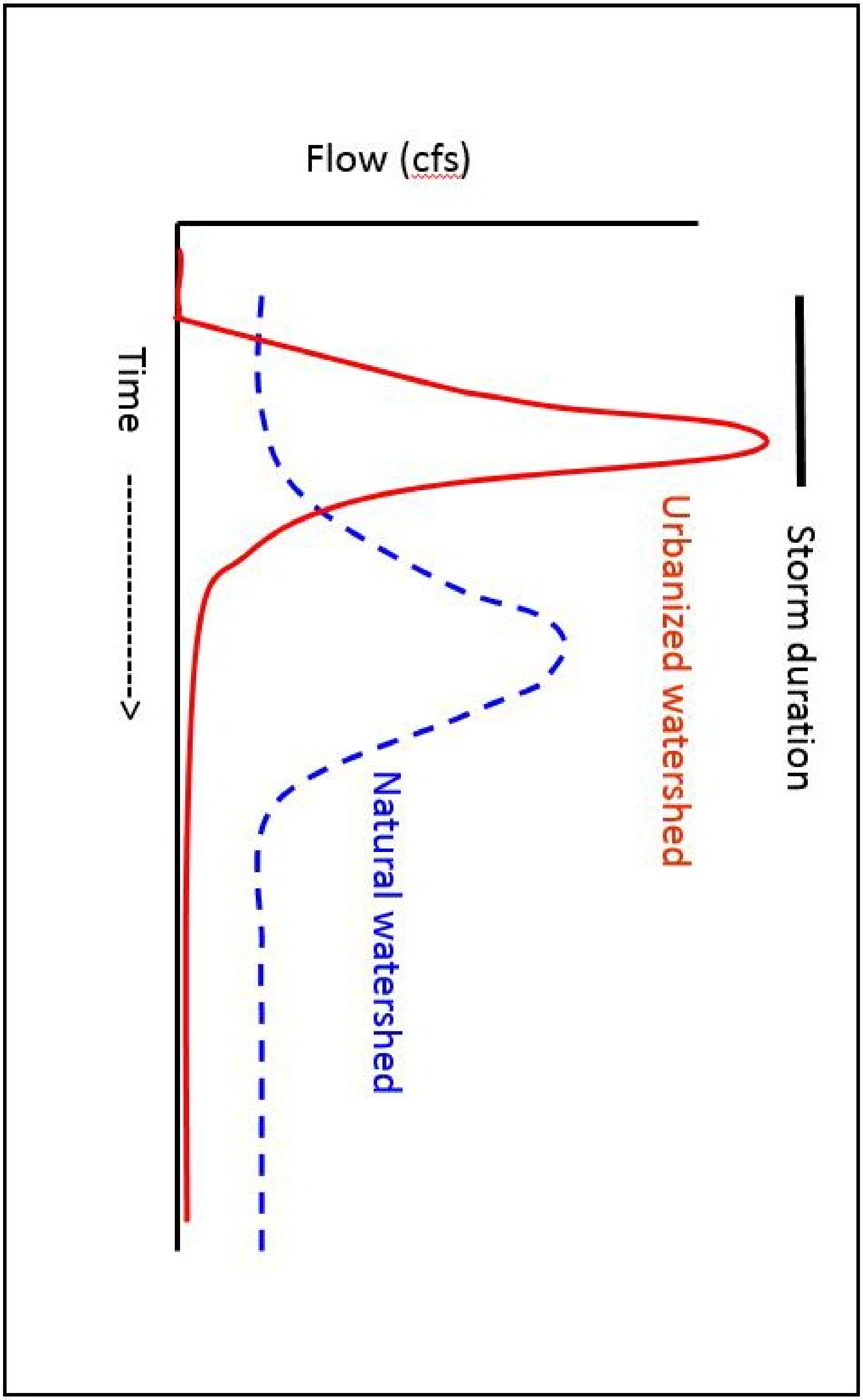
Watershed slope = ______________________

| | Natural watershed | Urban watershed | Units |
|---|---|---|---|
| Length of rainstorm | | | |
| Time when runoff begins | | | |
| Time when runoff ends | | | |
| Time of peak runoff discharge | | | |
| Peak runoff rate | | | |
| Estimated volume of storm runoff | | | |

Notes:

# Pave It or Plant It

Urbanized vs. Natural Watershed Hydrograph



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Optional Field Mapping Activity:

This activity can be done individually or with a group, as a homework assignment or in class field trip. If multiple groups or students do the exercise, you can compare results and simulate different types of land uses.

Materials:

- Clip board
- Datasheet
- Calculator
- Measuring Tape

Student activity:

1. Students will measure the total area of the lot size of their choice (e.g., part of a park, their home or apartment building lot, the school property, commercial areas).
2. Students will then measure individual areas of impervious surfaces on this lot. These will include buildings, driveways, roads and parking lots. Record these areas and sum up the impervious surfaces on the datasheet provided.
3. Calculate the percent impervious surface area of the total area.
[(Total impervious surface area/total area) * 100)].
4. Use Figure 10 and Table 2 on page 22 to calculate runoff from this site. Assume a 1" storm event.

Follow-up questions:

1. What modifications could be made to the lot to reduce runoff? *(grassy swales or depressions, detention basins).*
2. What concerns may there be from runoff off each type of landscape? *(Parking lots contribute oil, sediment, salts, etc.)*
3. Compare the students' results for different landscapes. Are students surprised at the differences?

## Mapping Activity: Calculated areas and runoff

Names: ______________________________________________________

Date: ____________________

| Area Description | Dimensions | Impervious Area | Pervious area |
|---|---|---|---|
| Sidewalk in front of my house. | 3.5 ft X 22.5 ft | 78.75 ft² | --- |
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| | | | |
| | TOTAL: | | |

Impervious + Pervious Area

| |
|---|
| |

Total area (impervious + pervious area) = ________________________ (units: ____)

Convert area to square inches (1 ft² = 144 in²): ___________________

Total volume of a 1-inch rainfall over this watershed area: __________________

Total impervious area: ____________________

Total pervious area: ____________________

Percent impervious: ___________________

Assumed runoff percentage (using Table 1 and Image 1): ____________________

Total runoff (assuming a 1-inch storm event): _____________________

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## Figure and Table for Mapping Activity

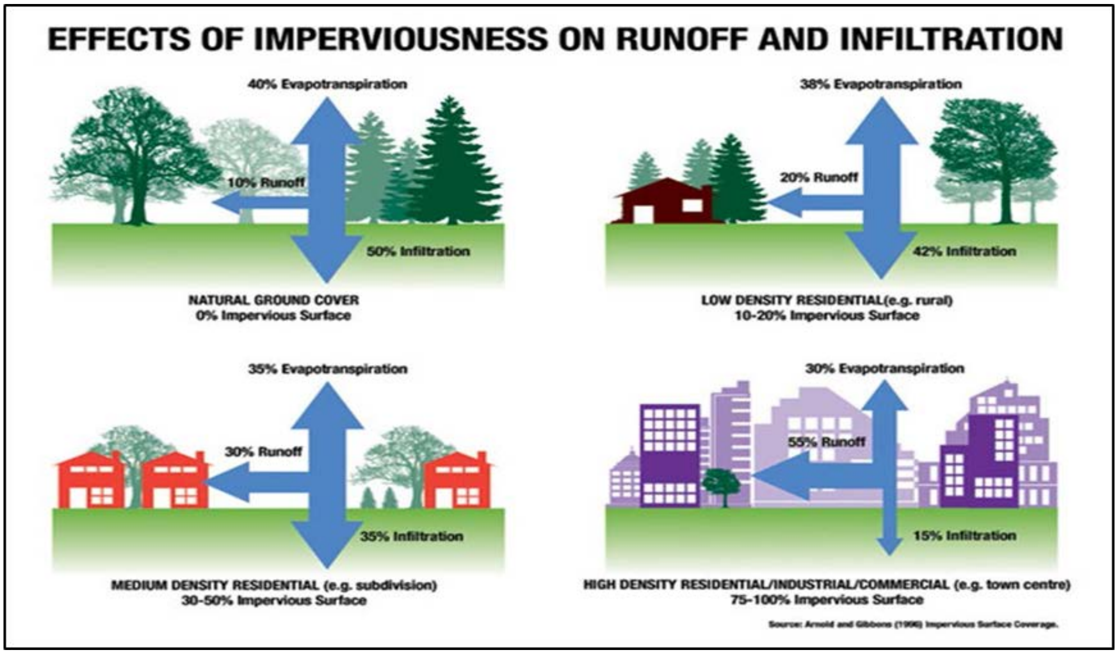


Figure 10. Effect of increased percent impervious surface area on runoff, infiltration and evaporation. (Chester L. Arnold Jr. & C. James Gibbons. 2007. Impervious Surface Coverage: The Emergence of a Key Environmental Indicator. Journal of the American Planning Association 62:2, 243-258.)

Table 2. Watershed characteristics that change with percent impervious surface area. (See Figure 1 from Arnold and Gibbons 2007.)

| Percent Impervious Surface Area | Percent Runoff | Percent infiltration | Percent Evaporation |
|---|---|---|---|
| 0 | 10 | 50 | 40 |
| 10 - 20 | 20 | 42 | 38 |
| 30 - 50 | 30 | 30 | 35 |
| 75 - 100 | 55 | 15 | 30 |