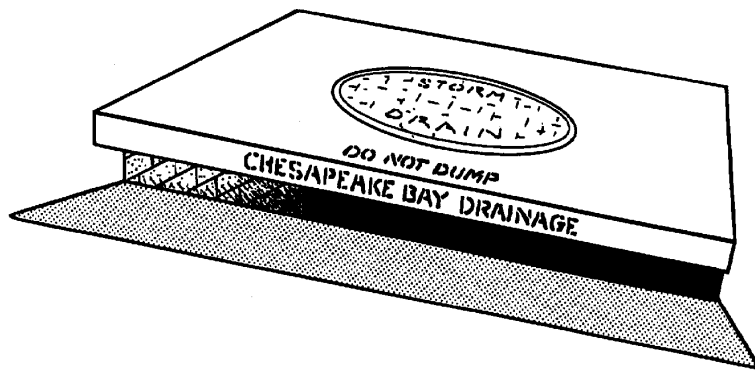


URBAN WATERSHEDS



It all starts HERE!

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An impervious surface is an impermeable surface, water does not infiltrate or soak-in. Which materials would be considered impervious?

How is a highway or driveway going to respond to rainfall?

Would a highway engineer construct the highway to act like the plastic cups above? Explain.

How would you characterize the following materials?

Material	Impervious?
forest floor	YES NO
asphalt	YES NO
wood chip trail	YES NO
crushed stone driveway	YES NO
roof tops	YES NO

Why do puddles formed by rain on the Eastern Shore disappear shortly after the rain stops?

Welcome to Impervia

The town of Impervia, once an area of dense forest, was built by C. Les Leaves Corporation. The small community of homes, on large lots with paved streets, is similar to typical communities found in many areas of Prince George's and surrounding counties.

Since an impervious surface is impermeable to water, the water runs off these surfaces.

Using the map showing houses, streets, driveways, and parking lots, determine the area (in square meters) of the following:

Look at the map and estimate the percentage of impervious surface: _____

Area of rooftops: _____

Area of transport systems (streets, driveways, parking lots): _____

Total area of impervious surface: _____

Total land area of town (large dotted box): _____

Calculate the percentage of impervious surface using the formula below:

$$\% \text{ impervious surface} = \frac{\text{total area of impervious surface}}{\text{total land area}} \times 100$$

The following formulas may be helpful:

1. using the map scale to estimate distances in meters, where x is the length of the scale bar in centimeters

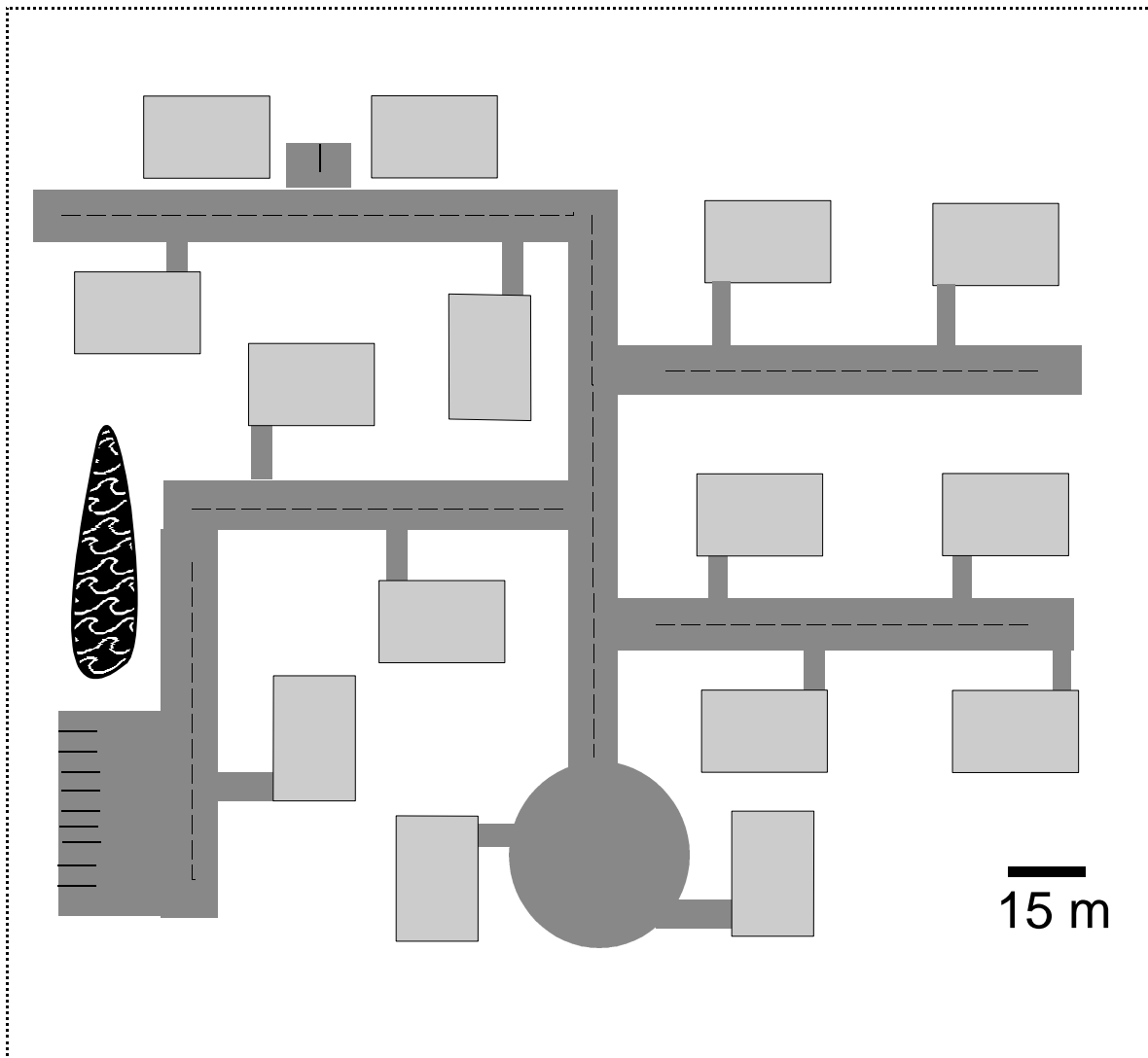
$$\frac{x \text{ cm}}{15 \text{ m}} = \frac{\text{measured cm}}{? \text{ m}}$$

$$\text{then } ?\text{m} = \frac{\text{measured cm}}{x \text{ cm}} \times 15 \text{ m}$$

2. area of rectangle = length x width
3. area of circle = $3.14 (\text{diameter}/2)^2$

The math is not difficult because the C. Les Leaves Corporation was helped by Wright Angle Designers!

The Town of Impervia



How close was your estimate to the calculated value of impervious surface?

What is the larger fraction of impervious surface - rooftops or transport systems?

The town was considering the addition of sideways. What will this do to the percentage of impervious surface?

Suggest ways the impervious surface could have been minimized when the town was constructed?

Meadow vs. Parking Lot

Obtain a cooking sheet or tray and three small wooden wedges. Elevate the tray (about 5 cm) such that one corner is low compared to the other three. Place the low corner off the edge of the table over a bucket. Cover the tray with sponges and sprinkle 300 mL of water over the area. Record your observations. Repeat the above procedure without the sponges covering the tray.

"Meadow" Tray with sponges	"Parking Lot" Tray - bare

How does rainfall (the sprinkle bottle) respond to impervious surface?

How does development (houses, streets, shopping centers) influence the hydrologic cycle?

Flash flooding warnings are commonly issued after heavy rains in this area. Considering the bucket as the stream where water is delivered from the land surface, what is a flash flood?

What is the crucial ingredient from the land surface to increase flash flooding?

Stormwater

The water collected from impervious surfaces, such as highways, houses, and parking lots, is referred to as stormwater. It carries, both suspended and dissolved, any materials from the impervious surfaces.

Take a walk through your school parking lot and neighborhood streets. Make a list of any materials found on the impervious surfaces.

Stormwater also runs off lawns and fields, what materials could be contributed?

Any materials found will be transported (carried) to the nearest storm drain and then to a stream. In an effort to try to control the amount of stormwater delivered to a stream, and allow some chance for materials to settle out or be removed by biological processes, ponds are constructed to intercept stormwater prior to discharge to a stream. These ponds are referred to as stormwater management ponds. These are features in areas of new development and are not found in older urbanized areas.

Can you find any stormwater management ponds in the area where you live or go to school? If so, describe their location. Describe what the water looks like too!

When fast-moving (high velocity) stormwater flows into a slow-moving (low velocity) open pond, what will suspended material do?

The stormwater is held in the pond for a period of time. Since the pond was constructed in the natural soil or sediment of the area, how will bottom materials behave to the standing water?

Many ponds have fringe wetlands (plants around the water's edge). What are their purposes?

Over time with the addition of suspended materials, what will happen to the pond?

Many communities have their storm drains labeled with "DO NOT DUMP -- CHESAPEAKE BAY DRAINAGE." Why? Could you explain the reason to another person?

How to Make a Flash Flood - Prince George's County Largest Impervious Surface

The new Redskin stadium on the Wilson Farm property in Landover will have approximately 22,700 spaces for parking.

Have students measure the dimensions of a parking space. Calculate the area (in square meters) of one parking space.

How many square kilometers will the stadium parking lot occupy? (1 km = 1000 m)

What will happen to the parking lot runoff including oil and road salt?

Because of the large amount of runoff from the parking lot being delivered into the headwaters of streams, storm water management will be extremely important.


If one inch of rain falls on the lot (a large summer thunder storm), how many cubic meters of water will run off? (1 inch = 2.5 cm; 1m = 100 cm)

In a typical year, rainfall for the Washington area is 90 cm. What is the annual volume (m³) of runoff from the parking lot?

The stadium is located on the drainage divide of the Patuxent and Potomac Rivers in the headwater streams of Southwest Branch and Anacostia River. Headwater streams typically have small discharges or flow volumes of water. Even with the best management, ponds have capacities. How is the stormwater going to affect these headwater streams?

How Impervious is Your Backyard or Schoolyard?

Houses, schools, streets, and parking lots increase the amount of runoff delivered to streams or water contributed to storm drains and then streams. Urban areas are always cautioned about flash floods, a rapid increase in stream volume. Development alters the hydrologic cycle by decreasing infiltration and increasing runoff. Determine the dimensions of you school or home property, the house or school, and any driveway, parking lots, or sidewalks. Calculate the area of each item. Most of items will be rectangles, whose area is length times width.

Items	Dimensions	Area
school or house		
driveway		
Sum of Areas		
property		

The percentage of impervious surface can be calculated by the following formula:

$$\% \text{ impervious surface} = \frac{\text{sum of areas} \times 100}{\text{area of property}}$$

The table below lists the average percentage of impervious surface for various residential lot sizes and non-residential areas. How does your home or school compare? The more impervious an area, the greater the amount of runoff and increased chances of flash flooding.

Land Use	% Impervious Surface	Land Use	% Impervious Surface
Residential - 1.0 acre	20	Residential - 0.13 acre	65
Residential - 0.50 acre	25	Industrial	75
Residential - 0.33 acre	30	Commercial	85
Residential - 0.25 acre	38	Shopping Centers	95

Source: Arnold and Gibbons (1996)

FAL's - An Unwanted Commodity

As you travel along an urban stream, inventory (list items and tally the quantity) the various floating objects of man-made origin.

Where did you see some of these objects before?

How did they get to the stream?

Why do we find them compared to glass bottles or metal cans?

Urban streams often contain numerous FAL's or *floating aquatic litter*. Since many plastic containers are less dense than water, they are washed down storm drains and carried by stormwater into streams. Parking lots and street litter are common sources of these items.

How can FAL's be reduced?

Stream Environment Comparison

TO THE TEACHER: Field trips to both sites are an excellent and eye-opening experiences for students. Stream visits may vary from just observational to making quantitative measurements. Pre-class field trip visits are recommended to check access and hazards. You may want to address specific questions and or measurements for your particular sites.

Compare an urban stream to a rural or forest stream.

Parameter	Rural/Forest Stream	Urban Stream
name/location of stream		
stream channel		
stream banks		
shoreline features and land use		
temperature		
water quality		
overall impression (man-made vs. natural)		

Urban Watersheds

Urbanization or development has a profound impact on watersheds and the water quality of streams. Next time it rains in your neighborhood watch where the water from your lawn or driveway flows. How far did you have to walk to get to a storm drain? Any lawn chemical or petroleum product from your car that drips or is spilled flow to the storm drain and hence to the nearest stream.

Hydrologic (Water) Cycle

The continual exchange of water through the Earth's atmosphere, oceans, and continents driven by solar radiation. The cycle consists of six steps:

- precipitation rainfall or snowfall (any form of water falling from atmosphere)
- evaporation liquid water that is converted to gaseous water
- transpiration water vapor released by plants (water obtained from soil)
- overland flow runoff of water on surface (when in channels referred to as stream)
- infiltration soaking of water into ground (important for soil moisture)
- subsurface flow flow of water in porous Earth materials (sediment, rock),
sometimes referred to as groundwater

Urbanization alters the hydrologic cycle! Housing developments, shopping centers, industrial parks, highways, and parking lots reduce infiltration capacity by rendering the surface impervious to precipitation, hence forming stormwater. The result is lower proportion of water contributed to groundwater and a greater contribution to runoff. Where does all the runoff go?

Impervious Surface or Imperviousness

Imperviousness is the sum of roads, parking lots, sidewalks, rooftops, and any other impermeable surface in the urban landscape. It is the percentage area that is "NOT GREEN". Stream degradation starts to occur at 10-20% impervious surface.

Types of Imperviousness: *rooftops* under which we live, work, and shop; and the *transport* system (roads, driveways, and parking lots). Transport component typically exceeds the rooftop component in total impervious area created.

In most urban areas, 40 to 80% of the land surface is covered by rooftops and paved surfaces. This impervious surface has a two-fold effect: more stormwater is converted to runoff; and the larger volume of stormwater gets to streams much faster!

Changes in the Watershed

The amount (discharge, volume/sec) of runoff reaching streams can increase 2-5 times pre-development discharges and it reaches the stream in much shorter time. A large volume of water delivered quickly to a stream is a recipe for a *flash flood*.

Increased runoff volumes lead to higher and more frequent floods. Urban streams flow out of their banks 2-5 times more often than rural streams, which usually overflow once per year. Erosion of stream banks (undercutting and more suspended material) increases dramatically. Also since less infiltration occurs for groundwater replenishment, stream flow is reduced during dry weather conditions.

Humans modify the stream environment even further to control flooding by channelizing (concrete channels), culverting, rerouting, and even burial. Here are some examples in Prince George's County.

Southwest Branch behind Hampton Hall	channelized and rerouted to not flow through parking lot
Paint Branch in College Park	rerouted
Crow Branch in Laurel	buried between divided north and south lanes of US Rt. 1 (just south of Rt. 198)
Anacostia River in Bladensburg	man-made levee for flood control and seawall for bank stabilization

Water Quality in Urban Streams

Impervious surfaces do not generate nonpoint pollution directly, they

- î cause changes to the hydrologic cycle that degrade streams;
- í are large parts of the land uses that do generate pollution;
- î prevent natural infiltration processes that remove pollutants, and;
- ï serve as collection and conveyance systems for pollutants to streams.

Temperature rises 6-15°C (10-20°F) due to the loss of shade provided by the riparian zone compared to a forested stream. Most macroinvertebrates are influenced by only 2-6°C temperature changes. Beside the loss of shade, urban stream receive less groundwater inflow, which is normally cooler than ambient air temperature.

Pollutants washed or carried in by stormwater:

- T sediment especially at construction sites;
- T nutrients from fertilizers;
- T bacteria from animal waste and sanitary sewer overflows;

- T toxic substances such as antifreeze, oil, pesticides, many household products such as detergents from washing your car;
- T road deicing salts (calcium chloride) in winter;
- T metals such as zinc from cars (lead from gasoline is no longer a problem), and;
- T floating aquatic litter such as plastic containers (soda bottles and styrofoam cups).

Next time you pass a lush green lawn (or toxic green lawn) think about the fertilizer and pesticides it has contributed to the Bay! Does your car leak oil?

Stream Health

Most urban streams are characterized by a decrease in total numbers of fish and macroinvertebrates, which show less diversity and more pollutant-tolerant species.

A simple bioassay using lettuce seeds (see reference below) can be used to indicate overall health as measured against a control (to check seeds) and a healthy rural stream.

Various chemical tests can be performed, especially nitrate from fertilizers and dissolved oxygen (lowered due to increased temperature).

Sources of Information and Further Activities

Center for Watershed Protection, *Teacher's Guide for Creating a Water Monitoring Program*, 1995 draft. Activities at middle school level but especially for urban streams.

Joe Rathbun, A simple bioassay using lettuce seeds, *Volunteer Monitor* 8 (1), Spring 1996, p.18. A simple way to judge water quality by measuring germination and stem length. Statistical part can be simplified to mean and range. Great science process for K-12.

Monitoring Urban Watershed Issue, *Volunteer Monitor* 7 (2), Fall 1995, 24 pp. Good general and readable background information.

Thomas Schueler, The importance of imperviousness, *Watershed Protection Techniques* 1 (3), Fall 1994, pp. 100-111. For the serious person, explains how the increase in impervious surface influences water quality.

Chester L. Arnold and C. James Gibbons, Impervious surface coverage: The emergence of a key environmental indicator, *J. Amer. Planning Assoc.* 62 (2), Spring 1996, pp. 243-258. For the serious person, explains how various land uses influence the amount of impervious surface, with a wide range of strategies to reduce problems.

Karen Firehock, *Hands On Save Our Streams: The Save Our Streams Teacher's Manual*, Izaak Walton League of America, 1994. Activities (K-12) including unit on land use and water quality.