Chapter 12 Project: Urban Runoff Scorecard

Names ____ Block # _________

1. Introduction

When people think of water pollution, they often envision big factories dumping toxic waste or raw sewage into a stream, lake or ocean. Although industrial polluters certainly wreak havoc on water quality, surface water runoff from agricultural fields, construction sites, city streets and lawns probably contribute more to the nation's water pollution problems.

In urban settings, water flows across **impervious surfaces** (surfaces that cannot be penetrated by water) such as streets, parking lots, and hard-packed soils, picking up contaminants like oil, sediment, pathogens and heavy metals along the way. This polluted "urban runoff" flows into the storm-water system (via grates in the pavement) and then to waste-water treatment plants, or directly into water bodies. **Pervious surfaces** (surfaces that allow water to penetrate) allow rain and melting snow to infiltrate into the ground, which helps recharge groundwater and remove or break down pollutants.

This project will focus on types of land-use in urban settings that contribute to water pollution through runoff or help prevent water pollution through infiltration. For this project, your group will measure 7 categories of land-use for a sample block in a neighborhood. The categories are:

1) surface area of roofs of buildings (also known as building footprint)
2) surface area of pedestrian pavement
3) surface area of vehicle pavement
4) surface area of gravel
5) surface area of grass
6) surface area of shrubs
7) number of large trees

Categories 1-3 will give you an indication of the amount of impervious surface on your block, where as Categories 4-6 indicate the amount of pervious surface. Large trees (Category 7) reduce surface water runoff by soaking up water and releasing it slowly into the ground and air.

Towards the end of this project, you will compute the **Urban Runoff Index** (URI) for your block. The URI gives a "rank" or "score" for your block's land-use characteristics that contribute to surface water runoff, as measured against other sample blocks.

2. Obtaining sample block and neighborhood information

Your instructor will provide information on:

1) How to obtain a map for your group's sample block.

2) The dimensions of the neighborhood where all sample blocks are located

3) The layout and method of selection of the sample blocks.

Obtain this information now, and then answer the following 2 questions:

a) What is the approximate area of the neighborhood? Express your answer in square feet and in square miles. Show calculations.

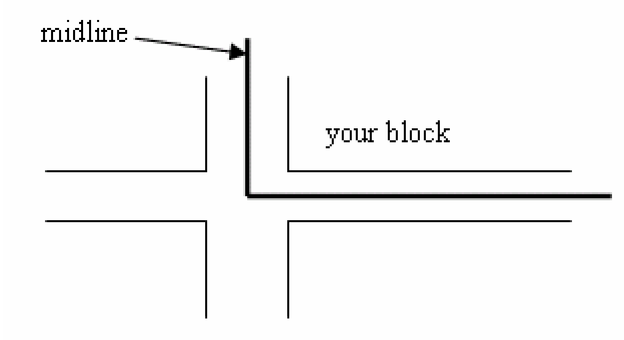
b) Would you say that the sample blocks constitute a random, systematic or convenience sample? A mixture of the three, or neither? Explain.

3. Your sample block

a) Examine the map for your block. What is the scale of the map?

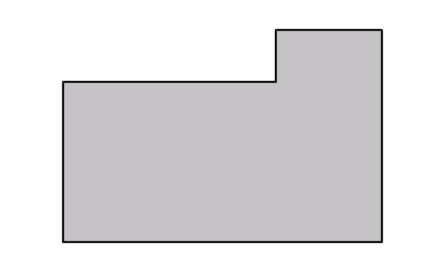
1 inch =

b) Your block is surrounded by the principal streets labeled on the map. For this project, you will designate the boundaries of your block by the **midlines** of the streets that surround your block. Each midline runs from the center of one street intersection to another. On your map, draw in each midline with a dark heavy line (as shown below).



c) Measure the **map dimensions** (in inches) of your block boundaries. Convert each of these map dimensions to **real feet**, using the scale, then calculate the **area** of your block in square feet. Show all work below. *Record the total block area on the Group Data Sheet.*

d) Later in this project you will calculate the areas (footprints) of buildings on your block using your map. For practice, compute the real area of the building footprint displayed below. Measure lengths with your ruler, and convert to real distances using the map scale. Show work.



4. Field work and calculations

As a team, you'll need to walk around your sample block several times to measure dimensions of land-use regions and count large trees. All direct measurements must be taken from the public right-of-way (the sidewalks and the streets). Even if standing on public land, you should be polite and courteous to the property owners. Under no circumstances should you walk onto private land, even if granted permission. People may approach you and ask what you're doing—be polite, tell them the truth, and you should have no problems. We do not recommend working at night.

Your group is provided with a tape measure. Measurements (again, on public land *only*) should be done to the **nearest half foot**.

A. Perimeter drawings

Walk around the perimeter of your block. If your block has sidewalks, measure the width of the "beauty strip" (usually grass) between the street and the sidewalk, and measure the width of the sidewalk. Draw these regions on your map using the correct scale. If there are driveways, walkways, etc. that cross the sidewalks, measure their widths and record their approximate positions on the map.

B. Area estimations and tree count

Walk around the sidewalk or street of your block to take direct measurements of the land-use regions. There will be times when you will have to make a judgment call as to the category of surface. Many regions behind buildings will not be visible from the public right-of-way, so you will need to make assumptions as to what portion of these regions constitute pavement, grass, bushes, etc. *Include the areas of these invisible regions into the totals.* Finally, keep a record of all computations and submit with your final report.

1) **Buildings, patios and decks**
   Walk your block to determine if there are any buildings missing from the map. *Estimate* dimensions of these missing buildings and draw them on the map using the correct scale. For buildings on the map that no longer exist, re-categorize the land-use. Using your map, determine the total surface area (in square feet) of impervious surface of all buildings in your block. Record on your Group Data Sheet.

2) **Pedestrian pavement**
   On your map, draw to scale all paved regions (sidewalks, walkways, steps, etc.) for pedestrians. The widths of many of the sidewalks and walkways can be measured directly in the field; the lengths can often be determined from the map. Some widths and lengths will need to be "eyeballed" from the sidewalk or street. Compute the total area of pedestrian pavement. Record on your Group Data Sheet.

3) **Vehicle pavement**
   Determine the dimensions and locations of all paved areas used by cars and

other vehicles (streets, roadways, driveways, parking lots, etc.). On your map, draw to scale these paved regions. Using direct field measurements, map measurements and estimations, compute the total area of vehicle pavement. Record on the Group Data Sheet.

4) **Gravel**
Determine the locations of gravel walkways, gravel roads, etc. On your map, draw to scale these regions. Compute the total area of gravel, and record on your Group Data Sheet.

5) **Grass**
Determine the locations of grass lawns, grass beauty strips, etc. On your map, draw to scale these regions. Compute the total area of grass and record on your Group Data Sheet.

6) **Shrubs, etc.**
Determine the locations of shrubs, bushes, perennials, flower beds, etc. Draw these regions to scale on your map, compute the total area and record on your Group Data Sheet.

7) **Large trees**
From the sidewalk or street you should be able to view most trees that are 15 feet or taller. Indicate these trees on your map with a small circled T:

Ⓣ

Count the total number large trees in your sample area and record on your Group Data Sheet.

5. Summarize data

a) Completely fill in your Group Data Sheet by calculating percentages and tree density.
b) Explain below how you divided the "invisible" regions into land-use categories:

6. Color map compilation

Compile the information on the 7 categories to make a color map. You don't need to include the dimensions, rather just the locations of the land-use categories. Each category should have its own color or symbol, and there should be a legend on the map. Use colored pencils, markers, etc.

With your final project hand-in, attach the color map, other map(s) that were used for field work, and area computations.

7. Assessing your sample

a) What percent of your sample block is impervious?

b) Name and briefly describe one un-sampled area in the neighborhood that is significantly more impervious than your block. And one un-sampled area that is significantly less impervious.

c) How well does your sample block represent the neighborhood (the population) as a whole, in terms of impervious surface? Discuss.

d) Estimate the total amount of impervious surface in the neighborhood (in square feet). Take account of your answers to the previous questions. Explain your work below.

8. Compiling and analyzing class data

Copy values for each of the 7 runoff categories from each group onto the 2 Class Data Sheets which are attached at the end of this project. Compute the mean and standard deviation for each category; then compute the z-score for your block for each of the seven categories. Record the mean and standard deviation using 2 decimal places of precision.

9. The Urban Runoff Index (URI)

The mayor of your city wants to assign an environmental rating to each block in the neighborhood. You must somehow combine the 7 environmental z-scores into one ranking number. The result will be called the **URI**, which stands for **Urban Runoff Index**. The URI will assign the highest score for the block that is "best environmentally overall," and the lowest score for the block that is "worst environmentally overall."

a) The URI will be based upon the 7 z-scores for a block. Recall that z-scores often fall between -3 and 3. Using values between -3 and 3, assign z-scores for a (hypothetical) environmentally "**best block**." *Hint: for which categories is it good to be above the mean, and for which is it good to be below the mean?*

z_1 = ______ z_2 =______ z_3 =______ z_4 =______ z_5 =______ z_6 =______ z_7 =______

A person in the class says, "I know. Let's just add up all 7 z-scores to form the URI. Then a block with the highest URI will be the most environmentally friendly." Symbolically, this is what the student is suggesting:

$$URI\ \#1 = z_1 + z_2 + z_3 + z_4 + z_5 + z_6 + z_7$$

b) Calculate URI #1 for the hypothetical "best block." Then explain why this approach is incorrect.

Another student suggests that a **signed sum of z-scores** would be more appropriate. This student's formula is

$$URI\ \#2 = -z_1 - z_2 - z_3 + z_4 + z_5 + z_6 + z_7$$

c) Calculate URI #2 for the hypothetical "best block." Then explain why URI #2 makes more sense.

A third student suggests that a **weighted sum of z-scores** would be more appropriate. This student's formula is

$$URI\ \#3 = w_1 z_1 + w_2 z_2 + w_3 z_3 + w_4 z_4 + w_5 z_5 + w_6 z_6 + w_7 z_7$$

In this formula, the weights (w_1, w_2, etc.) can equal any number between –10 and 10. The weights are environmental ratings that depend upon water runoff characteristics of each of the 7 land-use categories. The categories that negatively impact surface water runoff should get the lowest weight, while those that help manage surface water runoff get the highest weight. The signs of the weights need to be considered, also. Lastly, the weights need to be chosen independent of the z-scores for any particular block, to ensure that URI #3 is most fair.

class discussion

At this point, your class will meet to discuss the relative runoff merits of the 7 land-use categories, and decide on values for w_1 through w_7. You should come to this discussion with some idea of how *you* would assign the seven weights. Be ready to defend your numbers!

d) In the class's opinion, what should be the values of the weights w_1, w_2, etc.?

$w_1 =$ ______ $w_2 =$ ______ $w_3 =$ ______ $w_4 =$ ______ $w_5 =$ ______ $w_6 =$ ______ $w_7 =$ ______

e) Describe **why** the class assigned the weights that it did for w_1, w_5, and w_7. Comment on both the *sign* and *magnitude* of the weights.

w_1:

w_5:

w_7:

f) Discuss why URI #3's weighted sum makes the most sense, and why this improves upon URI #2.

g) Calculate the weighted URI #3 for the "best block":

h) Now you are ready to answer to the mayor. Using URI #3, calculate the environmental rating for *your* block.

i) How does the URI #3 rating for your block compare to that of the other blocks?

10. Changing the Planet

a)   Your mayor wants to raise URI scores for the neighborhood, but only with low-cost improvements. The mayor proposes a partnership in which the city matches the money spent by each homeowner—up to $500 for each parcel. Describe one activity by *property owners* that will improve the *impervious quality* of your block. This action should have a big, positive impact on your URI #3. Explain.

b) Suppose that each homeowner *in the whole neighborhood* planted $500 worth of trees. Explain what might happen to the URI #3 score *for your block*.

11. A Hard Rain is Gonna Fall

a)   Suppose a small storm dumps 1.5 inches of rain in 24 hours. How many feet of rain is that? Show work.

b) Suppose that the 1.5 inches falling on impervious surfaces flows into the storm drains and makes it way to the water treatment plant. Calculate the volume of water (in cubic feet) that would flow from your block to the treatment plant. Show units work.

12. BONUS

According to the National Resources Defense Council, “Stormwater discharge from one square mile of roads and parking lots can yield approximately 20,000 gallons of residual oil per year.” Estimate the amount of oil that would flow from your block to the water treatment plant *during the storm event in Question 11*, and determine the concentration of the oil in the storm water.

Group Data Sheet	**Names:**	
Block #	**Total Block Area:** **(From question 3)**	
Impervious Surface	area in square feet (round to nearest 1 sq. ft.)	% of total block area (record to 1 decimal place)
buildings		
pavement (pedestrian)		
pavement (cars)		
total impervious surface		
Pervious Surface	area in square feet (round to nearest 1 sq. ft.)	% of total block area (record to 1 decimal place)
gravel		
grass		
shrubs		
total pervious surface		
Number of Large Trees:	**Your block's tree density:** **(trees per 1,000 sq. ft)**	

Class Data Sheet –page 1 **Your block # _____**

Category 1: Impervious surface area of buildings							
Block #	%	Block #	%	Block #	%	Block #	%
1		6		11		16	
2		7		12		17	
3		8		13		18	
4		9		14		19	
5		10		15		20	

mean ________ standard deviation _________ your block's z-score: z_1 = _______

Category 2: Impervious surface area of pedestrian pavement							
Block #	%	Block #	%	Block #	%	Block #	%
1		6		11		16	
2		7		12		17	
3		8		13		18	
4		9		14		19	
5		10		15		20	

mean ________ standard deviation _________ your block's z-score: z_2 = _______

Category 3: Impervious surface area of vehicle pavement							
Block #	%	Block #	%	Block #	%	Block #	%
1		6		11		16	
2		7		12		17	
3		8		13		18	
4		9		14		19	
5		10		15		20	

mean ________ standard deviation _________ your block's z-score: z_3= _______

Category 4: Pervious surface area of gravel							
Block #	%	Block #	%	Block #	%	Block #	%
1		6		11		16	
2		7		12		17	
3		8		13		18	
4		9		14		19	
5		10		15		20	

mean ________ standard deviation _________ your block's z-score: z_4 _______

Class Data Sheet –page 2 **Your block # _____**

Category 5: Pervious surface area of grass							
Block #	%	Block #	%	Block #	%	Block #	%
1		6		11		16	
2		7		12		17	
3		8		13		18	
4		9		14		19	
5		10		15		20	

mean ________ standard deviation _________ your block's z-score: z_5 = _______

Category 6: Pervious surface area of shrubs							
Block #	%	Block #	%	Block #	%	Block #	%
1		6		11		16	
2		7		12		17	
3		8		13		18	
4		9		14		19	
5		10		15		20	

mean ________ standard deviation _________ your block's z-score: z_6 = _______

Category 7: Tree density (number per 1,000 sq. ft.)							
Block #	density	Block #	density	Block #	density	Block #	density
1		6		11		16	
2		7		12		17	
3		8		13		18	
4		9		14		19	
5		10		15		20	

mean ________ standard deviation _________ your block's z-score: z_7 = _______