SURFACE LESSON 4
ANALYZE SCHOOLYARD SURFACE UHI EFFECT

Teacher Sheet

Objective: Students will:

1. Compare the temperatures of the various surfaces around the schoolyard.
2. Determine if your schoolyard demonstrates temperatures consistent with the definition of an Urban Heat Island (UHI) using surface temperature data collected following the GLOBE protocol throughout the semester.

Curriculum Standards:

- NGSS ESS3.C Human Impacts on Earths Systems
- MD E-Lit Standard 1 Topic A: Environmental Issue Investigation
  - Indicator 5: Use data and references to interpret findings to form conclusions

Students will utilize the surface temperature data collected throughout the semester and compare the results with provided data from an undeveloped reference site. Reference site data can either be temperatures that were collected at the same time students measured temperatures at the schoolyard, or the Hood-CCWS Urban Heat Program website (ccwsscience.org).

Optional second activity: Create a surface heat profile of one transect across the school yard.

A **reference site** is preferably a location that has no influence of development, meaning little to no impervious surface. The reference site could represent the type of land cover the property had prior to the school being built.

Reference site surface temperatures are available on the Hood-CCWS Urban Heat Program website (ccwsscience.org). The location is dependent on your school district.

Materials needed:

- Surface temperature data collected around the school yard (Surface Lesson 3)
- Surface temperature data collected at a reference site at the same dates and times as the schoolyard data. (Visit ccwsscience.org for reference site data)
- Calculator

Background

The increase in temperature in developed and urban areas as compared to rural areas is known as the Urban Heat Island (UHI). Urban Heat Islands occur due to the surface properties of construction materials and impervious surface as well as the condensed activities from large number of human population in the area. UHIs can be measured with **surface temperatures** or **atmospheric temperatures**. This lesson focuses on surface temperatures.

Surface heat islands develop from urban surfaces (e.g., roadways, buildings, sidewalks) heating at different rates than rural vegetated and shaded areas. Surface heat islands are present both day and night, but are strongest during the day when sun is shining and weather is clear.

On average, the difference in daytime surface temperatures between developed and rural areas is 18 to 27°F (10 to 15°C); the difference in nighttime surface temperatures is typically smaller,

at 9 to 18°F (5 to 10°C). The magnitude of surface urban heat islands varies with seasons, due to changes in the sun's intensity as well as ground cover and weather. As a result of such variation, surface urban heat islands are typically largest in the summer.[1]

Table 1: Basic Characteristics of Surface and Atmospheric Urban Heat Islands. [1]

Feature	Surface UHI	Atmospheric UHI
Temporal Development	• Present at all times of the day and night • Most intense during the day and in the summer	• May be small or non-existent during the day • Most intense at night or predawn and in the winter
Peak Intensity (Most intense UHI conditions)	• More spatial and temporal variation: ▪ Day: 18 to 27°F (10 to 15°C) ▪ Night: 9 to 18°F (5 to 10°C)	• Less variation: ▪ Day: -1.8 to 5.4°F (-1 to 3°C) ▪ Night: 12.6 to 21.6°F (7 to 12°C)
Typical Identification Method	• Indirect measurement: ▪ Remote sensing	• Direct measurement: ▪ Fixed weather stations ▪ Mobile traverses
Typical Depiction	• Thermal image	• Isotherm map • Temperature graph

Directions:

Prior to the classroom lesson:

1. Ensure students have access to all the surface temperature data that was collected around their schoolyard for Step 1.
2. Decide ahead of time, whether to provide students with reference site data or, if using a Hood-CCWS reference site, students could use the online data to identify temperatures for Step 2. Visit www.ccwsscience.org, select the 'Data' tab. Be sure to select the reference logger for your school district. Narrow the data graph down to the same date and time of your schoolyard measurements. When you place your cursor over the logger graph line, the temperatures for each record will pop up in a small window. Not seeing the pop up? Narrow the time range down smaller for better resolution of the information.
3. Complete the calculations for temperature averages as directed.
4. Score your schoolyard's urban heat impact using the decision tree provided.

[1] USPEA Urban Heat Island Compendium – Chapter 1 Urban Heat Island Basics. October 2008. https://www.epa.gov/heat-islands/heat-island-compendium

Analyze Schoolyard Surface Temperatures

Objective:

1. Compare the temperatures of the various surfaces around the schoolyard.
2. Determine if your schoolyard demonstrates temperatures consistent with the definition of an Urban Heat Island (UHI) using surface temperature data collected following the GLOBE protocol throughout the semester.

The term "**urban heat island**" (UHI) describes built up areas that are hotter than nearby rural areas. Heat Islands are evaluated by comparing surface and air temperatures to undeveloped or rural areas. Table 1 describes the basic characteristics of a surface and atmonspheric UHI.

Table 1: Basic Characteristics of Surface and Atmospheric Urban Heat Islands. [1]

Feature	Surface UHI	Atmospheric UHI
Temporal Development	• Present at all times of the day and night • Most intense during the day and in the summer	• May be small or non-existent during the day • Most intense at night or predawn and in the winter
Peak Intensity (Most intense UHI conditions)	• More spatial and temporal variation: ▪ Day: 18 to 27°F (10 to 15°C) ▪ Night: 9 to 18°F (5 to 10°C)	• Less variation: ▪ Day: -1.8 to 5.4°F (-1 to 3°C) ▪ Night: 12.6 to 21.6°F (7 to 12°C)
Typical Identification Method	• Indirect measurement: ▪ Remote sensing	• Direct measurement: ▪ Fixed weather stations ▪ Mobile traverses
Typical Depiction	• Thermal image	• Isotherm map • Temperature graph

Compare your schoolyard surface temperatures to the reference site or other undeveloped area taken at similar times. Note: This activity assumes that schoolyard surface temperatures are only collected at daytime hours.

Method:

- Calculate surface temperature averages and compare to the temperatures of the reference site taken at the same time.

Materials:

- Surface temperature data collected around the school yard (Surface Lesson #3)

- Surface temperature data collected at a reference site at the same dates and times as the schoolyard data.
- Calculator

STEP 1: Compare IS to P temperatures and calculate an overall daytime surface temperature at your schoolyard.

From your data, divide the sites into appropriate land surface category and calculate the average temperature for each location:

Impervious surfaces:	**Average Surface Temp (°C)**	**Pervious Surfaces:**	**Average Surface Temp (°C)**
Average Impervious Surface Temp		**Average Pervious Temp**	

How do the temperatures between surface types compare and why?

Calculate the overall surface temperature at the school

Add all the individual surface averages in the above table and divide by the number of surfaces	**°C**

STEP 2: Calculate the overall surface temperature of the reference site using temperatures that best match the times when you collected your data at the schoolyard.

1. In the table below, list the date/times you collected schoolyard surface temperatures from your data table.
2. Using the Hood-CCWS online logger data website OR other reference data, identify the temperatures measured at the reference site at similar times as yours. Record the reference temperatures below.

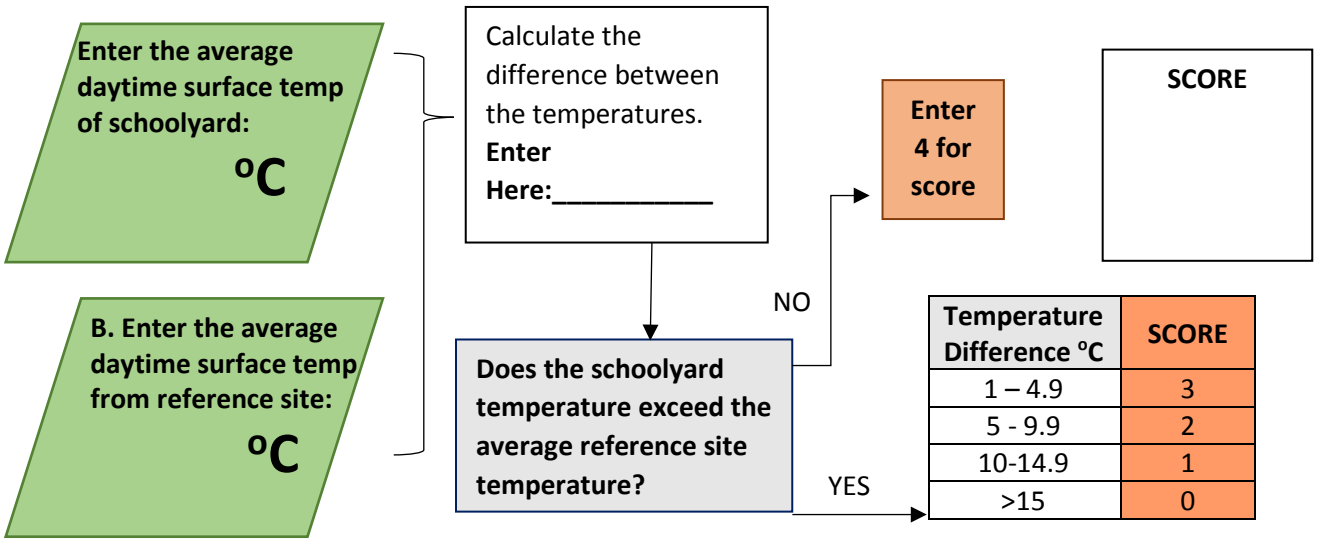
Date/Time you collected surface temps at school	Reference Site Surface Logger	
	Date/Time	**Surface Temp (°C)**
	Average at Reference Site Surface temperature:	

STEP 3: Using your data summary, compare the surface data:

	Temperature of Schoolyard Surface Areas (°C) *(from Step 1)*	**Temperature of Reference site Surface (°C)** *(from Step 2)*	**Temperature Difference**
Schoolyard Impervious Pervious surface average:			
Schoolyard Pervious surface average:			
Overall Schoolyard Average:			

#4 Schoolyard Land Cover / Surface Temperatures as an UHI

Score your schoolyard's potential urban heat impact below:



Temperature Difference °C	SCORE
1 – 4.9	3
5 - 9.9	2
10-14.9	1
>15	0

The highest score that could be achieved is a '4'. Schoolyards with high temperatures compared to the reference will have a lower score.

Answer the following questions

1. Explain why your school received the score it did. Defend your answer using information from your data.

2. List some factors that influence the temperature of surfaces and air.

3. List your schoolyard surfaces from coolest to hottest on the scale below.

cool ⟷ *warm*

4. Describe the variations of surface temperatures, if any, between different land cover (e.g., bare soil, grass, asphalt, concrete, gravel)?

Synthesize the information:

What are some root causes of elevated land cover / surface temperatures	What are the environmental effects from this problem?	Who has the ability to influence change on this problem?
Ex: policies, practices, phenomena		

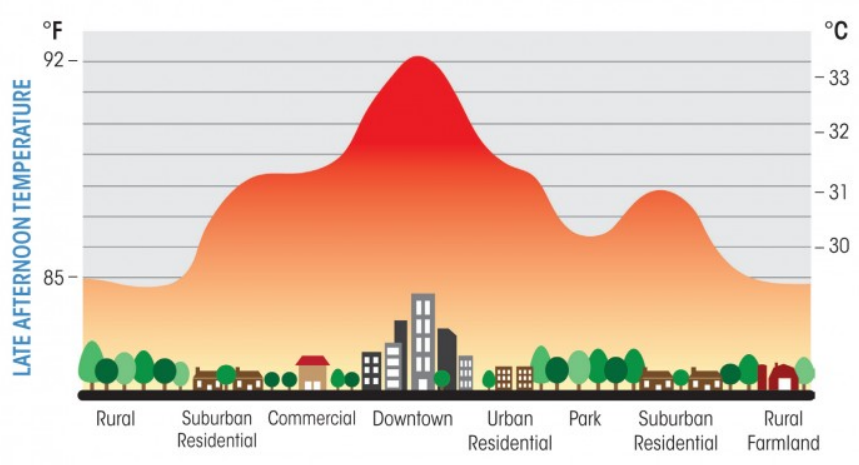
Optional: Urban Heat Island Activity: Creating a surface heat profile graph

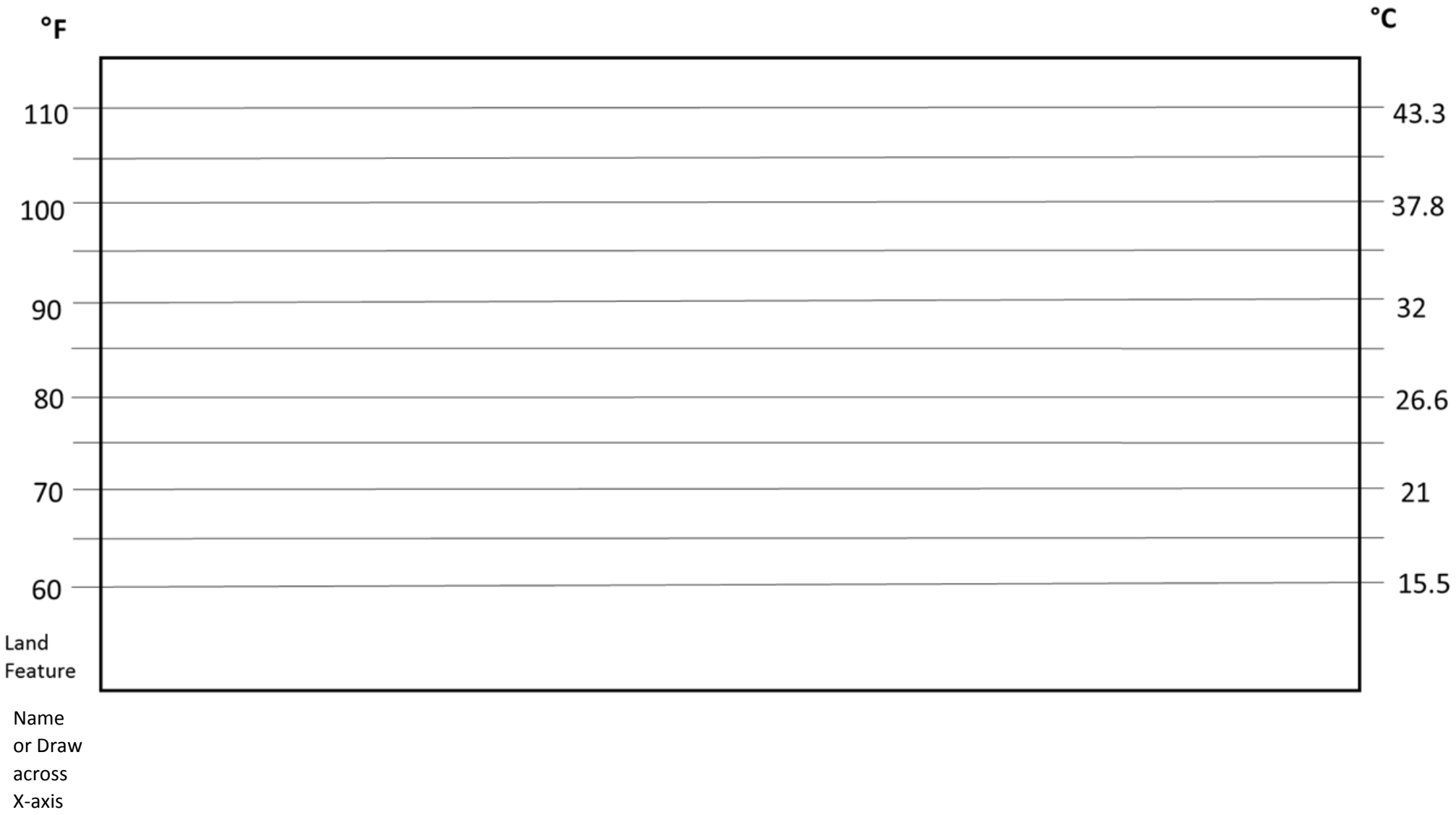
Objective: Students will graph their data points to create a surface heat profile of school grounds, similar to the image below, to represent their schoolyard transect.

Figure 1 Urban Heat Island Graph, Urban Climate Service Center, https://www.urban-climate.be/

Using the blank graph below,

- Students enter the land type identified along their schoolyard transect
- Graph the temperature of the sampling points.
- Optional: Students may color the graph to highlight temperature. Each horizontal graph line could be a different color.




°F
°C
110
100
90
80
70
60
43.3
37.8
32
26.6
21
15.5
Land Feature
Name or Draw across X-axis