# Surface Sleuths
# Project Guide

**PROJECT NAME:** Surface Sleuths

**PROJECT FOCUS:** Impact of man-made surfaces on the environment.

**INTRODUCTION:** The kinds of surfaces present in a city can greatly impact both the city's environment and climate. Concrete and asphalt surfaces and even the materials used for building roofs can heat up quickly in the sun and increase the temperature in a city by 6 to 10 degrees Fahrenheit. These surfaces also do not allow water to soak into the ground – they are **impermeable**. Even the grass used to seed lawns can form such a thick mat of roots and stems that very little water soaks through. Instead, water runs off these surfaces and into the sewers, taking anything on these surfaces with it, such as pesticides, oils, and fertilizers. The result is increased flooding and a decrease in water quality. Using permeable pavers for new parking lots, driveways, and patios; diverting downspouts into rain barrels and using the water from rain to water the garden; and increasing the number of trees and native plants in gardens are just a few ways to help decrease the amount of runoff during rain storms. In addition, the latter action can increase the amount carbon dioxide removed from the atmosphere.

During this project, Club members will conduct a surface audit of the school grounds to determine the type of surfaces present, how warm they get on sunny days, how permeable they are, and the number of trees present. The Club will then focus on issues of permeability on the school yard. They will keep track of the rain fall for the year and, if appropriate, install a rain barrel to divert stormwater running off of the school roof for productive use. They will calculate the amount of water taken up and the amount of carbon sequestered by the trees on the school grounds. Club members will then use the information from the audit, as well as additional information they research, to transform the school grounds into an interpretive space to educate the community about the impact of surfaces on the environment. At a kick-off event to introduce the school and community to the new interpretive space, Club members will conduct tours, hold information sessions, and distribute rain barrels and native seeds. A new tree will also be planted on the school grounds to help increase the amount of water and carbon dioxide stored on the school grounds.

**MATERIALS:**

**General C3 Club supplies:**

- 3 packs of low-odor markers
- 1 ream of assorted recycled paper (8.5” x 11”)
- 10 recycled-paper posterboards
- 2 rolls of tape
- C3 Club Network Supplies *(distributed at Kickoff Meeting on 9/ 24)*

**Project-specific materials (provided):**

For Phase 1:
- Rain gauge
- 5 recycled plastic rulers
- 5 stopwatches
- 5 thermometers

For Phase II:
- Wooden garden stakes
- 2 pairs of work gloves

For Phase III:
- Rain barrels to distribute
- Native plant seeds to distribute
- Tree sapling for the school yard

**Materials for teacher to provide:**
- 5 soup or vegetable cans with tops and bottoms removed for Phase I (ask for donations)
- Yarn or string for Phase I
- Calculators
- Meter stick or tape measure for Phase I
- Additional art supplies as necessary
- Small rubber mallet (optional, for Phase I)
- Borrow a staple gun and hammers from school engineer (for attaching signs to wooden stakes and then getting the stakes into the ground)
- Used 2-liter bottles, or some other vessel to carry water

*Note: Optional extension activities will require additional materials*

 

**OBJECTIVES:**

1. Conduct a surface audit to determine the permeability and temperature of surfaces on the school grounds.
2. If appropriate, install a rain barrel and calculate the amount of water collected. Use this number and the area of the school roof to estimate how much water could be prevented from running off of the roof if additional rain barrels/ cisterns were installed.
3. Calculate the amount of carbon taken in by trees on the school grounds. Perform calculations for the amount of water taken up by trees.
4. Plant a new tree on the school grounds and calculate the amount of carbon it will sequester once fully grown.
5. Transform the school grounds into an interpretive space to educate the school and community about permeability issues, carbon sequestration by plants, and other environmental issues related to surfaces in an urban environment.
6. Distribute or sell rain barrels to the community and use the number to estimate the amount of water that will be prevented from running off into the sewers.
7. Plan and hold a kick-off event for the new interpretive space for the community, including information sessions, tours, native seed give-aways, and other activities.

**PERFORMANCE MEASURES:**

The success of your project will be tracked with several performance measures. These measures are designed so that you will have quantitative successes to report at the end of your project. Part of Phase I: ("Learn") is to audit or assess the current situation of these measures at your school, then to set goals to accomplish by the end of the year. In Phase IV ("Thinking Back & Looking Ahead"), you will re-assess the situation to track the difference that your project has made.

| | Performance Measure | **Current Amount** (measure during Phase I) | **End-of-the-Year Goals** (set during Phase I) | **Final Amount** *(measure during Phase IV)* |
|---|---|---|---|---|
| 1 | Number of students actively involved in your C3 Club | | | |
| 2 | Amount of carbon that will be sequestered by the trees on the school grounds over the next 100 years | | | |
| 3 | Number of rain barrels distributed | | | |
| 4 | Amount of water that will be collected annually by the rain barrels distributed to the community | | | |
| 5 | Number of attendees at launch of the interpretive site | | | |
| 6 | Number of signed pledges collected | | | |

## PROJECT TIMELINE, MILESTONES, AND REPORTING:

This timeline is designed to give you milestones to guide you in your project development, implementation, and evaluation. At the end of each project phase, you will submit an online report (4 total reports), where you will sign off on having completed each of the milestones below. Remember that this timeline is just a starting point to plan your project, which you will tailor to address the needs of your individual school community.

To fill out your online report, sign in at www.chicagoconservationcorps.org. Please be sure to submit your report on time, even if you haven't yet completed all of the milestones. Remember that teacher stipend checks are contingent on the timely completion of reports. Due dates are listed below.

 

## Phase I: Learn

October 27 -November 26
***Online Report Due: Wednesday, November 26***

- ☐ MILESTONE #1: Get **permission** from the principal to conduct the audit.
- ☐ MILESTONE #2: **Install** rain gauge and begin recording numbers for average rainfall.
- ☐ MILESTONE #3: **Organize** the Club for the school grounds surface audit.
- ☐ MILESTONE #4: Conduct a **surface audit** of the school grounds.
- ☐ MILESTONE #5: Calculate the amount of carbon sequestered by trees located on the school grounds.
- ☐ MILESTONE #6: Fill out **performance measure amounts** for "Current Amount" and set numbers for "End-of-the-Year Goals".
- ☐ MILESTONE #7: **Complete Online Report:** Due November 26.

## Phase I Procedures

☐ **Read through the steps outlined for Phase I, and contact the DOE with any questions. Please note: These milestones can be adapted so that they most effectively meet the needs of your individual school community; however, please communicate any major changes to DOE staff early on in the process.**

**MILESTONE #1: Get permission from the principal to conduct the audit (teacher preparation at least one week before the first Club Surface Sleuths meeting).**

☐ **Describe the procedures for the school ground surface audit and the delivery of a new tree for the school grounds to the appropriate members of your administration.** List key talking points regarding the school ground surface audit so that you are prepared for you talks with the administrators at your school. If the administration requires additional chaperones for taking students outside into the school grounds, make arrangements for other teachers or parents to be present.

Also explain that as part of the project, a new tree will be planted on the school grounds.

☐ **Choose a date and locations for conducting the audit.** This audit is dependent on weather. The permeability portion of the audit works best when it is had been dry for a few days. The heat island portion of the audit works best on a sunny, or mostly sunny, day. Select some back up dates in the event of bad weather. Identify several surfaces on the school grounds for students to test permeability and temperature, for example, grassy areas, asphalt, concrete, gravel areas, woodchip areas, etc. It is probably a good idea to conduct the carbon sequestration measurements and calculations on a second day.

☐ **Ensure that any teachers, staff, or parents who will be assisting on the day of the audit understand the procedures and data that will be collected.** If additional supervision will be required for Club members while they are on the school grounds, make sure that the chaperones have some understanding of the procedures and data that the Club members will be collecting so that they can assist as necessary.

☐ **Gather additional materials for the school grounds surface audit.** Gather all needed materials. Remove the bottoms of the cans with a can opener to create a cylinder with two open ends. For both of these items collect enough for each pair of Club members.

**MILESTONE #2: Install rain gauge outside and begin recording numbers for average rainfall**
**(Ongoing)**

☐ **Find a secure place either outside of the classroom window or on the school grounds to place the rain gauge.** Make sure the rain gauge is placed in a secure location that is not under a ledge or tree, which could alter the data. A window sill outside of the Club meeting location might make a good location. Make sure that the gauge is mounted so that it is easy to read and that it can be taken down temporarily to empty any water after a rain event.

☐ **Begin collecting data after precipitation events.** Explain to Club members that as part of the Surface Sleuths project they will be exploring which surfaces on the school grounds absorb water when it rains and which do not. To help them understand how much water is running off the school property and into the sewers during any given rain event, they will be collecting data on how much rain falls during each precipitation event. They will use this data to calculate the average precipitation fall for each month to begin to get a sense of the precipitation patterns in Chicago. Demonstrate how to read the rain gauge and explain that it needs to be emptied after the data for an event has been collected. The first time the gauge is read, do it as a Club. After that, Club members can rotate the responsibility for checking the rain gauge, using the “Keeping Track of the Rain” worksheet on page 24 in the appendix. Remember that the rain gauge should be checked the day of the rain event – if you wait too long, water will evaporate out of the gauge, giving you an inaccurate reading. Create a schedule to keep track of who will be checking the gauge and when.

☐ **Rainfall amounts can still be calculated during the winter.** Explain to the Club that they will continue to collect rainfall amounts throughout the year, including in winter. Explain that when it snows, instead of using the rain gauge, they will measure the depth of the snow in inches, or get the snow fall amounts from the news. Since 10 inches of snow is approximately equivalent to 1 inch of rain, Club members can simply divide the inches of snow by 10 to figure out the equivalent amount of rainfall for that event.

**MILESTONE #3: Organize the Club for the school grounds surface audit. (1 meeting)**

☐ **Send permission slips home if necessary along with requests for used soup and vegetable cans.** If it is necessary to document permission from the Club members' parents or legal guardians to take them outside for the school grounds surface audit, send home permission slips with the Club members after the first Surface Sleuths meeting. At the same time, send home a request for empty soup and vegetable cans. They need to be washed out well and, if possible, have the bottom as well as the top removed with a can opener. These cans will be used to conduct the permeability tests on the school grounds.

☐ **Lead a discussion about the impact of various surfaces on the environment.** Introduce the topics that the Club members will be investigating. Create a list of the types of surfaces found on the school grounds. Discuss with Club members how these surfaces might impact the environment. In particular, discuss three areas:

1. How the color of a surface can influence how much light it absorbs and, therefore, how hot the surface becomes. This can influence the air temperature and contribute to the urban heat island effect.
2. Some surfaces allow water to enter the ground, i.e. they are *permeable*, while other surfaces do not allow water to penetrate, i.e. they are *impermeable*. On these surfaces, water simply runs off into sewers. An area of impermeable surfaces can have a large environmental impact leading to erosion, flooding, and decreased water quality.
3. The numbers and types of plants growing in an area can influence both of the above, in addition to the amount of carbon dioxide ($CO_2$) taken out of the atmosphere. In particular, trees are one category of plant that can take large amounts of $CO_2$ out of the air.

If time allows, do the Urban Heat Island and Pollution Solution activities with the Club members to introduce some of these topics (see Appendix).

☐ **Create a map of the school grounds.** Guide Club members in making a map of the school grounds. Indicate the types of surfaces found on the school grounds and indicate the approximate location of any trees found on the school grounds. Have Club members hypothesize about which surfaces they think will be permeable or impermeable, and which might heat up the most on a sunny day. Estimate the area of each major surface, including the school roof, and record those areas on the map or on a separate sheet of paper. The school engineer may be able to help determine some of the areas, in particular the area of the school roof.

☐ **Gather and organize materials for the surface audit.** Explain to the Club members that on the day of the audit, they will be working in pairs to take the temperature and determine the permeability of the surfaces on the school grounds. They will also determine the circumference and diameter of the trees on the grounds in order to calculate how much carbon they are sequestering. Have the Club members help gather together the thermometers, rulers, stopwatches, and soup/vegetable cans. If necessary, have them help take the bottoms off of the cans using can openers. Also collect some containers, such as bottles and pitchers, to carry water outside. If time allows, demonstrate the procedure for measuring the rate at which water permeates a surface. Tell students that because they will be working outside, they might want to bring or wear old pants and appropriate shoes.

**MILESTONE #4: Conduct a surface audit of the school grounds. (1-2 meetings)**

☐ **Divide Club members into pairs and distribute materials.** Hand out the cans, thermometers, rulers, stopwatches, containers of water, and data sheets. Proceed outside.

☐ **Explain the procedure for taking temperatures of the surfaces on the school grounds (see "Urban Heat Island Audit" in Appendix).** Tell Club members that as time allows, each pair will be recording temperatures for each of the major surfaces found on the school grounds. Later they will average the temperatures from all of the pairs to get a more accurate temperature of each surface. Have the Club members look at the Urban Heat Island data sheet. Explain that they will be taking four temperature readings. The first will be at about waist height of one of the members of the pair, the second will be 12 inches above the surface, the third at 6 inches above the surface, and the forth on top of the surface. This will provide a sense of how far above the surface the temperature is being affected. Tell the Club members that tonight they should watch the weather and write down the official high temperature for the day. This will give them an idea of whether the heat from that type of surface might increase the temperature on any given day.

☐ **Explain the procedure for determining the permeability of the surfaces on the school grounds (see Surface Permeability Audit in Appendix).** Tell the Club members that as time allows, they will also be determining the permeability of each major surface found on the school grounds. Later they will average the permeability rates from all pairs to get a more accurate permeability of each surface. On applicable surfaces, Club members will twist the soup/vegetable can into the ground using the rubber mallet to sink it 3-5 cm. Otherwise they will simply hold the can against the surface. One Club member will hold a ruler inside of the can so that the "0" is resting on the surface. The other Club member will pour in water to the 5 cm mark on the ruler. As the water is being poured, the Club member holding the ruler should start the stopwatch. The pair will then record the depth of the water in the can every minute for 10 minutes. When they are done, they should remove the can and move to a new surface. If the surface is impermeable, that is the water is not soaking into the ground, the pair can release the water from the can and should note what direction it is flowing. For example, is it flowing towards the street and subsequently the sewer or towards a permeable surface like the grass?

☐ **Give the Club members time to collect their data and then clean up.** After the data has been collected, gather up the materials and head back inside. Later combine the data and calculate the averages for the temperature and permeability of the surfaces. On the maps that the Club members made of the school grounds, have them indicate which areas have permeable surfaces and which do not. If they observed that water flowed in particular directions across any of the surfaces, have the Club members indicate that on their maps using arrows.

**MILESTONE #5: Calculate the amount of carbon sequestered by trees located on the school grounds.**
**(1/2-1 meeting)**

☐ **Measure the circumferences of the trees on the school grounds (see "Carbon Sequestration by Trees" in Appendix).** Take the Club members outside, or do this the same day as the surface audit. Tell them that they will be figuring out how much carbon these trees are taking out of the atmosphere and storing. To do this they will first measure the circumference of each tree at "breast height," about 4.5 feet from the ground, using a piece of string or yarn. They will then use these numbers to figure out the *diameter at breast height* (dbh) and the amount of carbon each tree will sequester per year. If the administration has agreed to the planting of a new tree on the school grounds, tell the Club members about it and that once the tree is planted they can calculate the additional amount of carbon that the new tree will sequester as it grows. Use the worksheet in the appendix to help with these calculations.

**MILESTONE #6: Fill out performance measure amounts for "Current Amount" and set numbers for "End-of-the-year Goals".**
**(1/2 meeting)**

☐ **Compile results and calculate averages from the audit.** If not already done, calculate the temperature and permeability averages from the students' audits and compile them on one worksheet. Calculate the amount of carbon sequestered on the school ground each year by the trees. Also calculate the average rainfall/precipitation per day or per month that has fallen since the rain gauge was installed.

☐ **Focus on the permeability data.** If the Club was able to calculate the areas for the major surfaces on the school grounds, calculate the amount of runoff from the impermeable surfaces. First, convert the average inches of rainfall to average feet of rainfall by simply dividing the number by 12. Club members can either use the averages calculated from the amounts collected in the rain gauge or use 3 inches, which is the average rainfall per month for Chicago. These calculations can also be done for single rain events based on the amount of water collected in the rain gauge.

Then multiply the area of the surface by the average feet of rain, and then by 7.48 gallons/$ft^3$ to determine the average maximum gallons of water running off of the surface:
(surface area ($ft^2$)) x (rainfall (ft)) x 7.48 gal/$ft^3$ = maximum runoff (gal)

Because even impermeable surfaces can absorb small amounts of water and some water will evaporate off of the surface even during a rain event, the Club members can also calculate the net runoff from the surfaces based on the type of material. Simply multiply the maximum runoff for each surface by the runoff coefficient for that material listed in the table below. The runoff coefficient is simply a percentage indicating the approximate amount of water that is actually running off of the surface.

| Material | Runoff Coefficient |
|---|---|
| Asphalt (or black top) | 0.95 |
| Concrete | 0.95 |
| Brick | 0.85 |
| Gravel | 0.75 |
| Conventional rooftop | 0.95 |
| Bare earth | 0.55 |
| Grass/lawn | 0.35 |

☐ **Discuss the results with the Club.** Ask a Club member(s) to take notes during the discussion. The following questions can be used to stimulate discussion.
- Which surfaces heated up more than others and why?
- Considering that the types of surfaces found on the school grounds are used all over the city, how might the temperatures above these surfaces affect the temperature of the city as a whole? What kinds of problems might that cause, for example, needing to use more air conditioning in the summer?
- Which surfaces were found to be impermeable? Permeable?
- Which surfaces produce the most runoff during a rain event?
- What might be the impact on flooding?
- Runoff will carry other substances on those surfaces with it. Based on what they observed and what they know about how the spaces on the school grounds are used, have Club members brainstorm possible substances that might be washed away by runoff. Where might these substances go? How might they affect the environment?

☐ **Brainstorm ideas for decreasing runoff and increasing the amount of carbon sequestered on the school grounds.** Begin to develop a list of ideas for decreasing runoff and increasing carbon sequestration. Have a Club member record their ideas. As the Club members conduct more research on these issues during the subsequent phases, add any new ideas to the list. These ideas can be used later to create a list of recommendations for the administration for the future as they look to resurface areas or improve the school grounds.

☐ **Discuss with the Club the direction for the rest of the project.** Explain to the club that they will address the issue of runoff from impermeable surfaces in a few ways over the course of the year. They will be working to convert the school grounds into an interpretive space to educate the school and community about the data they collected during their audit and about ways to address issues related to the urban heat island, permeability and runoff, and carbon sequestration by trees. Brainstorm with the club ways to convey this kind of information, for example, signs, handouts, information sessions, etc. They will also hold a kick-off for the interpretive space at which they will sell rain barrels, which can be used to collect water from rooftops through the downspout. From that they can estimate the amount of runoff prevented from leaving the property and entering the sewer system. At the kick-off they will also conduct tours and information sessions and have attendees sign pledges. Finally, if the administration has agreed to this, tell them that a new tree will be planted on the school grounds.

**MILESTONE #7: Complete online report for Phase I, due Wednesday, November 26.**

## Phase II: Act

December 1-March 13
***Online Report Due: Friday, March 13***

- ☐ MILESTONE #8: **Meet with administration** to update them on the project plans and goals, and to ask for their support.

- ☐ MILESTONE #9: Visit the **Chicago Center for Green Technology** to learn about increasing permeability and carbon sequestration and decreasing runoff and the urban heat island and to see how they have made their facility into an interpretive space. (This milestone is **recommended** but not required.)

- ☐ MILESTONE #10: Based on the data collected during the audit and information collected through research, begin developing **materials** for the interpretive space, including handouts and signs.

- ☐ MILESTONE #11: Begin preparations for the **rain barrel distribution day** and interpretive space kick-off.

- ☐ MILESTONE #12: **Complete Online Report:** Due March 13.

## Phase II Procedures

☐ **Read through the steps outlined for Phase II, and contact the DOE with any questions. Please note: These milestones can be adapted so that they most effectively meet the needs of your individual school community; however, please communicate any major changes to DOE staff early on in the process.**

**MILESTONE #8: Meet with administration to update them on the project plans and goals, and to ask for their support.**
**(1/2 meeting or outside meeting time)**

☐ **Invite guests to your next Club meeting.** If members of the administration or other school staff had expressed interest and support in the project, invite them to a Club meeting. Have Club members present some of the data they collect during the surface audit and how they want to educate the school and surrounding community about their findings. Ask for reactions, feedback, and ideas from staff.

OR

☐ **Update the administration and staff about your progress.** If administration and staff are unable to attend a Club meeting, pass on key findings and how the Club would like to share these findings with the school and surrounding community. In particular, the administration will need to approve the planting of a new tree on the school grounds, attaching a rain barrel to a smaller building on the school property if such a building exists, and putting signs out on the school grounds as part of converting it into an interpretive/educational space.

☐ **Obtain administrative approval as needed.** It may be necessary to obtain administrative approval for the activities listed under Milestone #9 (visiting the Chicago Center for Green Technology). In addition, approval should be obtained for creating the interpretive space on the school grounds and hosting the rain barrel distribution day, before planning for these begins.

**MILESTONE #9: Visit the Chicago Center for Green Technology (CCGT) to learn about increasing permeability and carbon sequestration and decreasing runoff and the urban heat island and to see how they have made their facility into an interpretive space. (This milestone is recommended but not required.) Note: If a trip to CCGT is not possible, discuss the center with your students using guidance from the steps below.**
**(1 meeting, optional)**

☐ **Make arrangements to visit the Chicago Center for Green Technology.** Seek approval for the field trip from the administration. If taking the Club to the Chicago Center for Green Technology, contact them for assistance in making arrangements for the visit – e-mail greentech@cityofchicago.org. Schedule a date for the trip and send permission slips to the parents and legal guardians of the Club. Arrange for chaperones as needed. Make reservation for a bus or arrangements to take public transportation. If there is someone available to give a tour of the Center while your Club is there, make arrangements for the tour.

☐ **Prepare Club members for the trip.** Discuss with the Club members what the Chicago Center for Green Technology is and its purpose. If internet access is available have the Club members spend some time exploring the CCGT website: http://www.cityofchicago.org/Environment/GreenTech/. If a trip to CCGT is not possible, still introduce the Club to the location and have them explore the website. There is plenty of information there that will be useful for the Club members as they continue with this project.

☐ **Explore the Chicago Center for Green Technology.** Once at CCGT, allow the Club members to explore the site. In particular, point out the permeable pavers, bioswales, rain cisterns, and the heat island test plots outside of the building. Have Club members pay close attention to and take notes about the kind and amount of signage and information CCGT used as part of its interpretive space.

☐ **Debrief after the trip.** Have the Club members share and describe their experiences while at CCGT. What thing did they find interesting? What did they learn? Discuss with the Club the kinds of information CCGT had on its signage and in its handouts and how it was displayed. Use this to lead into a discussion about what they Club would like to do to create the school's interpretive space. Some guiding questions might include:
- What general kinds of information should be included?
- What kinds of information need to be researched to include?
- How should the information be displayed?

**MILESTONE #10: Based on the data collected during the audit and information collected through research, begin developing materials for the interpretive space, including handouts and signs.**
**(4-5 meetings and ongoing as needed)**

☐ **Explain the purpose for the interpretive.** Talk to Club members about the reason for creating an interpretive space on the school grounds. Discuss how educating people about an issue is one of the first steps in encouraging them to make different choices and change their behavior to help the environment.

☐ **Brainstorm topics for the signs and handouts for the interpretive space.** Revisit the data collected during the audit. Ask Club members what information they want to focus on from the audit. What information might be helpful to share with the community? Some possibilities include the amount of runoff from the various surfaces, the temperature of surfaces compared to the official temperature for the day, and how much carbon the trees sequester. Brainstorm other information to include about the urban heat island, permeability and runoff, and carbon sequestration. For example, Club members might want to include information about what the urban heat island is, why permeability and runoff are a problem. They might also want to include information on solutions to these issues, for example, increasing the amount of green space, using lighter colored roofing, using permeable pavers, installing rain barrels, planting trees, etc.

 

☐ **Research any additional information needed.** Once the Club has brainstormed ideas for topics they might want to include as part of the interpretive space, give them some time to begin researching any additional information they might need. This will give them a clearer idea of what areas they want to focus on for signs and handouts.

☐ **Decide on specific topics for the interpretive signs.** Once the Club members have done some initial research, revisit the list of ideas to include for the interpretive space. Identify specific topics for the signs that will be posted on the school grounds. At the minimum, 2 signs should be created for each topic: urban heat island, surface permeability and runoff, and carbon sequestration. A place to start would be with three signs for each topic: one that addresses the problem or issue, one that describes some of the data collected by the Club during the audit, and one that describes actions that individuals can take to help mitigate the problem. Additionally, a sign could be created for the rain barrel and signs could be created for each tree to describe how much carbon that tree is sequestering. It is better to start with fewer signs and then make more if time allows. Discuss what kinds of graphics might need to be created for the signs, for example data tables, pictures, or diagrams of how a concept works. Assign teams to organize and research any additional information necessary to create the signs.

☐ **Decide on specific topics for any handouts to be distributed to the school and surrounding community.** Some topics and information researched might make good handouts for the school and community. Handouts should focus on information and action ideas that people can do at home. Decide on topics for at least 2-3 handouts. Some possibilities might include a handout on carbon sequestration by trees and what trees grow well in this area and a handout on easy ways to conserve water and prevent runoff. Assign teams to organize and research any additional information necessary to create the handouts.

☐ **Create drafts for the signs and handouts.** Teams can meet during Club meetings if time allows or at other times, such as during lunch, to develop plans for the signs and handouts. Encourage teams to actually sketch the lay out for the signs.

☐ **Exchange sign and handout drafts for peer review.** At a following meeting, have Club members exchange their drafts with another team for peer review. The reviewers should identify at least two parts of the plan that are great ideas, and at least one suggestion for improvement or question requiring clarification. Have them write the comments on a separate piece of paper that they attach to the drafts and return them to the original team. Teams can meet to discuss drafts and revisions if necessary.

☐ **Create final drafts and sketches.** Based on the suggestions for revision, create final drafts of the signs and handouts. They should create revised sketches of the signs if necessary. At the next Club meeting, have teams share their drafts with the rest of the club.

☐ **Begin creating signs and handouts.** Once everyone feels that the drafts are solid, teams can begin creating the final signs and handouts. Teams can use the paper provided or use other paper or poster board. Completed signs should be laminated to make them weather resistant.

**MILESTONE #11: Begin preparations for the rain barrel distribution day and interpretive space kick-off.**
**(4-5 meetings)**

☐ **Set a date and time for the distribution and kick-off.** Choose a date sometime during Phase III to host the rain barrel distribution day and interpretive space kick-off. Sometime in April might be ideal to allow additional time to complete materials and to allow for somewhat nicer weather.

☐ **At least 4 weeks before the event, contact the DOE to reserve your rain barrels.** The DOE may also be able to supply materials for the rain barrel demonstration and handouts such as the **Rain Barrel Installation and Maintenance** handout, **C3 Brochures, Stormwater Management** brochures, etc. Arrange for the delivery of the materials.

☐ **Research information on rain barrels.** Club members should become experts on rain barrels. Have them read through and discuss the **Rain Barrel Installation and Maintenance** handout if you have not already done so (see Appendix). Have Club members research additional information, for example on the DOE website.

☐ **Decide on activities and demonstrations for the distribution day and kick-off.** Explain to the Club that on the day of the distribution and kick-off it would be good to plan some activities and information sessions to share with attendees. There should definitely be a demonstration of how to install and maintain rain barrels. Brainstorm additional ideas for activities, demonstrations, or information sessions, for example demonstrations of the methods used to collect data during the surface audit and tours of the interpretive space.

☐ **Create a flier for the day.** Have Club member work on creating a flier to distribute to the school and community. The information on the flier should include:

- Location, date and time of the distribution and kick-off
- Some of the activities and/or demonstrations that will take place
- The price of rain barrels
- How to reserve a rain barrel
- Contact information

Once completed, fliers can be distributed to the school community so that students can take them home to their parents and legal guardians. Club members can also visit local businesses and ask if they can display a flier in the store window.

☐ **Begin brainstorming ideas for pledges.** At the event, the Club will provide pledges for attendees to sign. These pledges should be simple actions that they can take at home to conserve water. Research and brainstorm ideas for the pledges – see “Online Resources” section below.

**MILESTONE #12: Complete online report for Phase II, due Friday, March 13.**

 

## <u>Phase III: Make a Difference</u>

March 16-April 24
***Online Report Due: Friday, April 24***

- ☐ MILESTONE #13: **Complete** development of the signs and handouts for the school ground interpretative space.
- ☐ MILESTONE #14: **Complete** preparation of presentations and materials for the rain barrel distribution day and interpretive site kick-off.
- ☐ MILESTONE #15: **Install** a rain barrel on the school grounds and begin calculating the amount of water collected after rain events.
- ☐ MILESTONE #16: **Complete** additional preparations for the rain barrel distribution day and interpretive site kick-off.
- ☐ MILESTONE #17: **Host** the rain barrel distribution day and interpretive site kick-off.
- ☐ MILESTONE #18: **Collect pledges** to conserve water at home.
- ☐ MILESTONE #19: Plant a new tree on the school grounds.
- ☐ MILESTONE #20: **Complete Online Report:** Due Friday April 24.

## Phase III Procedures

☐ **Read through the steps outlined for Phase III, and contact the DOE with any questions. Please note: These milestones can be adapted so that they most effectively meet the needs of your individual school community; however, please communicate any major changes to DOE staff early on in the process.**

**MILESTONE #13: Complete development of the signs and handouts for the school ground interpretation.**
**(1-2 meetings as needed)**

☐ **Create final handouts.** Once team members feel that they have a completed version of their handout, have them share it with other Club members one more time. The Club members should make any final suggestions or edits they feel necessary. After additional changes are complete, make photocopies of the handouts to be distributed at the kick-off and to have available for the school community.

☐ **Create the final signs.** Have teams complete the graphics and information for the signs. Once signs are complete, have them laminated to protect them from the weather. Borrow a staple gun from the School Engineer to attach the signs to the wooden stakes. If more stakes are needed, find sticks, ask the Engineer for wood scraps, or purchase some more. Wear work gloves while working with the stake to prevent splinters.

☐ **Post the signs.** As a Club, identify the locations on the school grounds where you want to display the signs. This can be all in the same location or distributed around the grounds. Once the locations have been identified, use the rubber mallet and/or hammers borrowed from the School Engineer to stick the signs into the ground. Make sure that any Club member helping with this wears work gloves.

**MILESTONE #14: Complete preparation of presentations and materials for the rain barrel distribution day and interpretive site kick-off.**
**(1-2 meetings as needed)**

☐ **Revisit the topics decided on for presentations at the kick-off during Phase II.**

☐ **Assign presentation teams for each topic.** Club members should form teams to present each of the activities, presentations, and/or tours decided upon. They can meet during the Club meeting time, and/or outside of Club meeting time as necessary to discuss plans.

☐ **Plan the presentations.** Allow for at least one club meeting for teams to meet and discuss their presentation plans. The plans should include: how to explain the topic, what background information to share and what materials they will need if any. If any teams are leading a tour of the interpretive space, they should also include plans for how they will lead attendees around the site.

☐ **Gather and prepare materials for the presentations.** Set aside time for the teams to practice their presentations. Club members should provide feedback to the teams leading each presentation. From the practices, identify what works and what needs revision before presentating at the kick-off.

☐ **Finalize the pledges.** If not done already, work as a Club to finalize and create the pledges for attendees to sign. Create pre-printed pledges or create a form for attendees to fill out and a list of options for which to pledge.

**MILESTONE #15: If appropriate, install a rain barrel on the school grounds and begin calculating the amount of water collected after precipitation events or snow melts.** ***Note: This is not a mandatory milestone. Your school might not be a good candidate for a rain barrel because of the size of your roof and other logistical details. Work with a C3 staff member to determine whether or not a rain barrel is a good idea for your school.*** **(1 meeting and ongoing)**

☐ **Discuss the reason for using rain barrels.** Talk with the Club members about what rain barrels are and how they are used. Explain that in Chicago, most downspouts drain directly into the sewer system. During heavy rains this means that the sewer can easily overflow causing flooding. By disconnecting downspouts and directing them into rain barrels, some of this problem can be mitigated. Rain collected in rain barrels can be used to water the plants and grass instead of using water from the hose. This has the added benefit of decreasing the water bill for the building. If administrative approval has been received, tell the Club members that they will be installing a rain barrel on the school property. Share with the Club members the **Rain Barrel Installation and Maintenance** sheet from the DOE and discuss the installation process (see appendix).

☐ **Get assistance from the School Engineer to install the rain barrel.** With help from the School Engineer, identify a downspout on the school grounds to attach the rain barrel to. A small shed, trailer, or other small building is probably the best choice. Using the directions in the **Rain Barrel Installation and Maintenance** sheet, have the Engineer help attach the rain barrel to the downspout.

☐ **Begin collecting data from the rain barrel.** Once the rain barrel is attached, the Club members can actually calculate the amount of water collected in the rain barrel after rain events and snow melts. Use the worksheet in the appendix to help with this.

☐ **Educate the school community about the uses for water collected in the rain barrel.** Have the Club members create a flier to distribute to the administration, teachers, staff, and engineers about the uses for the water collected in the rain barrel or hold an information session. Encourage members of the school community to use the water in the barrel to water plants on the school grounds, clean equipment used on the school grounds, or even to water plants in the classrooms, instead of using water from hoses or taps. Club members can even create pledges for staff to sign that say they will check and use water in the rain barrel for these purposes before heading to a tap.

**MILESTONE #16: Complete additional preparations for the rain barrel distribution day and interpretive site kick-off.**
**(1 meeting and outside meeting time)**

☐ **At least 4 weeks before the event, contact the DOE about acquiring rain barrels.** The DOE may also be able to supply materials for the rain barrel demonstration and handouts such as the **Rain Barrel Installation and Maintenance** handout, **C3 Brochures, Stormwater Management** brochures, etc. Arrange for the delivery of the materials.

☐ **Secure additional help.** Secure other teachers and school staff members to help on the day of the rain barrel distribution and interpretive site kick-off. Additional people will be needed to help supervise, collect checks for the rain barrels, pass out the rain barrels, etc.

 

☐ **Create any additional materials necessary.** In particular create a sign-in sheet for participants.

☐ **Discuss procedures for the day of the distribution and kick-off.** Discuss where the rain barrels will go, where people will sign in, how checks will be collected and where they will be kept, a schedule for the Club led presentations, etc.

**MILESTONE #17: Host the rain barrel distribution day and interpretive site kick-off.**
**(event day + 1 meeting)**

☐ **Conduct the rain barrel distribution and interpretive site kick-off events.** Club members and volunteer teachers and school staff, will collect payments for the rain barrels, distribute rain barrels, and conduct the presentations and activities for the day. Collect pledges signed by attendees.

☐ **Hold a debrief after the event.** During a Club meeting, discuss the distribution and kick-off. What went well? What challenges did the Club face? What would they do differently if they were to hold such an event again? Celebrate the completion of this phase of the project by totaling the number of pledges signed and the number of people who attended, recording the number of rain barrels sold, and sending the checks for the rain barrels to the DOE.

**MILESTONE #18: Collect pledges to conserve water at home.**
**(event day + ½ meeting)**

☐ **Collect pledges during the rain barrel distribution and interpretive site kick-off.** Give everyone who signs a pledge a packet of native seeds.

☐ **Post the pledges.** If possible post the pledges collected on a bulletin board. The pledges would make a good backdrop for a Club photo.

☐ **Report the pledges to administration and staff.** Meet with involved administration to share the success of the project with them.

**MILESTONE #19: Plant a new tree on the school grounds.**
**(1/2-1 meeting)**

☐ **Arrival of the tree.** Work with the DOE and administration to arrange for the delivery and planting of the new tree. Try to arrange for the tree to be delivered and planted at a time that Club members can attend. Have the Club work with the administration to choose a good spot on the school grounds to plant the tree. In choosing a location have the Club members think about what they learned in the surface audit. For example, if a tree is planted near a surface that heats up a lot during the day, once the tree grows large enough it will shade some of that surface.

☐ **Calculate the amount of carbon sequestered by the new tree.** Just as in Phase I, Club members should measure the circumference of the new tree to determine the diameter at breast height (dbh) and the amount of carbon that will be sequestered per year. Use the worksheet in the appendix to help with these calculations.

**MILESTONE #20: Complete online report for Phase III, due Friday, April 24.**

## Phase IV: Thinking Back & Looking Ahead

April 27-June 5
***Online Report Due: Friday, June 5***

☐ MILESTONE #21: Calculate the estimated amount of water diverted during the project.

☐ MILESTONE #22: Fill in performance measure amounts for "Final Amount".

☐ MILESTONE #23: Reflect and plan ahead for future projects.

☐ MILESTONE #24: **Complete Online Report:** Due Friday, June 5.

### Phase IV Procedures

☐ **Read through the steps outlined for Phase IV, and contact the DOE with any questions. Please note: These milestones can be adapted so that they most effectively meet the needs of your individual school community; however, please communicate any major changes to DOE staff early on in the process.**

**MILESTONE #21: Calculate the estimated amount of water diverted during the project.**
**(1 meeting)**

☐ **Calculate the estimated amount of water diverted per month based on the number of rain barrels distributed (see "Estimating Water Diverted by Rain Barrels at School" in Appendix).** Considering that Chicago's average rainfall is 3 inches per month and a typical 1,000 square roof accepts 620 gallons during a one-inch rain storm, a single barrel installed at a typical 4-downspout home can divert 465 gallons of water a month. Therefore, assuming it rains 3 inches per month and each barrel is installed at a typical home, the estimated amount of water the barrels divert from the sewer can be found using the following equation:

Gallons of water diverted per month = Number of barrels distributed x 465 gallons

Note: Not all of this water is actually used—some of it over flows and is absorbed by the surface under the barrel.

☐ **Calculate the estimated amount of water conserved per month based on the number of rain barrels distributed.** Assuming that a rain barrel is emptied 3 times per month and that the barrel is full each time it is emptied, a barrel can conserve 165 gallons of water per month. Therefore, the estimated amount of water the rain barrels will conserve each month can be found using the following equation:

Gallons of water conserved per month = Number of barrels installed x 165 gallons

☐ **Calculate the estimated water diverted if the school had rain barrels attached to the school roof.** Using the calculations sheet provided, calculate the estimated amount of water that could be diverted per month if rain barrels were connected to the school downspouts.

**MILESTONE #22: Fill in performance measure amounts for "Final Amount". (2 meetings)**

☐ **Complete final calculations.** If not done already, finish any calculations and compile any numbers for the performance measures. For the carbon sequestration on the school grounds, add the amount sequestered by the new tree to the amount calculated for all of the trees on the school grounds in Phase I.

☐ **Present your findings.** Create a poster to display that summarizes the successes of the Club leading up to and at the rain barrel distribution day and interpretive space kick-off. This can include the number of rain barrels distributed and the estimated amount of water diverted by those rain barrels, the amount of water diverted by the school rain barrel, and the amount of carbon that will be sequestered by the new tree as it grows. Club members can also create a list of recommendations to share with the school administration based on what they found. For example, they could share the estimated amount of water that could be diverted from the sewer if rain barrels that were attached to the school downspouts; or share information on permeable paving options for various areas of the school grounds.

**MILESTONE #23: Reflect and plan ahead for future projects. (1 meeting… and beyond)**

☐ **Think big!** If your Club is inspired to continue on with the project, brainstorm some ways to extend it. For example, Club members can identify areas on the school grounds where water collects after rain events and plant a rain garden in those areas. Club members could also work with the school staff to create gardens of native plants that need less watering. The Club could also hold school and community information sessions that focus more specifically on topics brought up during the project, for example creating rain gardens and native plantings; or what kinds of roofing materials help reduce the urban heat island effect and increase energy efficiency; or what kinds of alternative pavers can be used for driveways or patios. Another topic for the Club to explore that is related to these issues, but not addressed in the project, is green roofs. See the resources section for contact information and more ideas.

**MILESTONE #24: Complete online report for Phase IV, due Friday, June 5.**

## CLUB ACTION PROJECT WORKSHOPS*

**Attendance is mandatory for at least one teacher representative per school. Dinner will be provided. Workshop Location: Chicago Center for Green Technology, 445 North Sacramento Blvd.*

- October 21, 5:00 – 8:00 p.m.
- February 19, 5:00 – 8:00 p.m.
- April 28, 5:00 – 8:00 p.m.
  *5:00-6:00p.m. – Club Action Project Wrap-up*
  *6:00-8:00p.m. – C3 Teacher Network Celebration*

## ADDITIONAL RESOURCES:

### ***C3 Year One Project Guides to Refer Back to:***

- Water Audit Guide
- Save the Source Project Guide

### ***Online Resources:***

- American Water and Energy Savers, "Save Water 49 Ways". www.americanwater.com/49ways.htm
- Chicago Center for Green Technology, www.cityofchicago.org/Environment/GreenTech/
- Chicago Department of Environment, www.cityofchicago.org/Environment
- Chicago Department of Water Management, www.cityofchicago.org/Water
- Chicago Wilderness, "Landscaping with Native Plants", www.chicagowilderness.org/wildchi/landscape/index.cfm
- "Here Comes the Urban Heat Island", science.nasa.gov/headlines/y2000/essd16mar_1m.htm
- $H_2$OUSE, "Landscaping", www.h2ouse.org/tour/landscaping.cfm
- "Rain Barrel Guide", www.rainbarrelguide.com/
- "Simplified Guide to Measuring DBH", phytosphere.com/treeord/measuringdbh,htm
- U.S. EPA, "Heat Island Effect", www.epa.gov/hiri/
- U.S. EPA, "Water", www.epa.gov/ebtpages/water.html
- U.S. EPA, water page for high school students www.epa.gov/highschool/water.htm
- Water: Use it Wisely education tools, www.wateruseitwisely.com/toolsLinks/index.shtml

**PROJECT APPENDIX**

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## Keeping Track of the Rain

Keep track of the precipitation amounts during the month. At the end of the month, calculate the total amount of rain that fell. When it snows, find out the number of inches and divide by 10 to convert it to inches of rain.

| Month: | | | | | | |
|---|---|---|---|---|---|---|
| 1 | | | | | | |
| 2 | | | | | | |
| 3 | | | | | | |
| 4 | | | | | | |
| 5 | | | | | | |
| 6 | | | | | | |
| 7 | | | | | | |
| 8 | | | | | | |
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| 10 | | | | | | |
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| 16 | | | | | | |
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| 20 | | | | | | |
| 21 | | | | | | |
| 22 | | | | | | |
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| 25 | | | | | | |
| 26 | | | | | | |
| 27 | | | | | | |
| 28 | | | | | | |
| 29 | | | | | | |
| 30 | | | | | | |
| 31 | | | | | | |
| **Total:** | | | | | | |
| **Average (total/# days):** | | | | | | |

# Surface Permeability Audit

## Introduction:

One way to examine surface characteristics is through infiltration rates, or how quickly water soaks into the ground. Infiltration rates are an indication of how permeable a surface is. The greater the infiltration rate the greater the permeability of the surface, the smaller the infiltration rate the lower the permeability. How well rain infiltrates depends on different factors including the material that makes up the surface, the slope of the land, texture of the soil, type of vegetation present, and how much water is already present in the soil. Permeability is an important property of soil and other surfaces. Rainwater that does not penetrate a surface will run off quickly, contributing to flooding and soil erosion and taking any pollutants on the surface with it, thereby affecting water quality. Rainwater that enters a surface, and ultimately the soil, will provide water to plants and will replenish ground water supplies.

## Definitions:

Infiltration: water flow into the surface of soil
Soil texture: the combination of soil particles of different sizes
Permeability: the rate that water moves through the soil

## Materials:

Students will work in pairs to conduct infiltration tests at the major surfaces on the school grounds. For each surface, one member of the pair will assume a role: timer/recorder and pourer/measurer. Each surface should be sampled by at least 3 teams to get more accurate data.

- Soup can with bottom and top removed
- Ruler
- Stopwatch
- Container of water
- Rubber mallet (optional)
- Data sheets #1 and #2
- Clipboard or other hard writing surface

## Procedure:

1. Choose a level spot to conduct the infiltration test. If possible, twist the can into the surface, using the rubber mallet to sink the can about 4cm into the surface. If the surface is too solid to get the can into it, such as concrete or asphalt, then hold the can firmly against the surface. If possible, use duct tape or electrical tape to secure the can to the surface and create a seal.

2. Set stopwatch to 0:00. The pourer/measurer should insert ruler into the can so the "0" is resting on the soil surface. Pour water into the can up to the 5cm mark on the ruler. The timer/recorder should begin timing as the pourer pours water into the can.

3. The water level of the pre-measured amount of water is 5cm, which is already recorded on the data sheet. Record the depth of water in the soup can every minute for 10 minutes. If possible, leave the ruler in the can to ensure that measurements are taken in the same location each time. If all the water infiltrates completely before 10 minutes, indicate so on the data sheet.

4. If the water level does not decrease, or if water is simply seeping out from under the can instead of infiltrating into the surface, record a “0” on the data sheet indicating no change in depth due to infiltration. Lift up the can to release the water and make note of what direction the water is flowing.

5. Repeat this procedure for each major surface on the school grounds.

6. Once all the data has been collected return to classroom for analysis. Fill in the remaining columns with calculation from the collected data.

7. After each group has performed initial calculations, consolidate all the data. Use class data to calculate an average infiltration rate for each surface.

 

## Surface Permeability Audit Data Sheet #1

**Club member names:** ____________________

**Surface type:** ____________________

**Infiltration test**

| Time (in minutes) | Water Depth (mm) (1 cm = 10 mm) | Change in Depth (mm) | Infiltration Rate (mm change / min) |
|---|---|---|---|
| 0 | 50 | | |
| 1 | | | |
| 2 | | | |
| 3 | | | |
| 4 | | | |
| 5 | | | |
| 6 | | | |
| 7 | | | |
| 8 | | | |
| 9 | | | |
| 10 | | | |
| | | **Average rate / min:** | |
| | | **Average rate / hour:** (mulitply rate/min by 60) | |

## Surface Permeability Audit Data Sheet #2

| Group | Surface: ____________ Average Infiltration Rate (mm/hr) | Surface: ____________ Average Infiltration Rate (mm/hr) | Surface: ____________ Average Infiltration Rate (mm/hr) | Surface: ____________ Average Infiltration Rate (mm/hr) | Surface: ____________ Average Infiltration Rate (mm/hr) | Surface: ____________ Average Infiltration Rate (mm/hr) |
|---|---|---|---|---|---|---|
| A | | | | | | |
| B | | | | | | |
| C | | | | | | |
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|---|---|---|---|---|---|---|
| **Average** | | | | | | |

Which surfaces are the most permeable? Which are the least?

# Urban Heat Island Audit

## Introduction:

Different surfaces and materials absorb and reflect different amounts of light. The more light a surface or material absorbs, the faster it heats up. Darker colors and heavier materials tend to absorb more light and, therefore, heat up faster than lighter materials. A completely black surface will absorb 100% of the light that strikes it and a completely white surface will reflect 100% of the light. Surfaces that absorb light will feel warm or even hot to the touch. Surfaces that reflect light feel cool in comparison.

As surfaces absorb light and heat up, they also radiate, or give off, increasing amounts of heat causing the air right above the surface to heat up. This phenomenon, referred to in cities as the urban heat island, has become a big problem in densely populated cities. Urban centers use a large amount of dark colored paving and roofing materials, like asphalt and tar. These materials absorb and radiate large amounts of heat. For example, a conventional tar roof can reach 169°F on a 90°F day. Therefore, temperatures in a city can be 6-10 degrees Fahrenheit warmer than in rural areas. The urban heat island effect is particularly noticeable at night. While the temperatures in non-urban areas decrease as the sun goes down, the temperatures in cities can remain significantly higher as materials that absorbed the sun's heat during the day continue to release it at night.

Urban heat islands have several significant consequences. Because they cause an increase in daily temperatures, they can increase the strength and duration of heat waves in cities. This can lead to an increase in heat related health problems and even deaths. Urban heat islands cause an increase in energy usage for air conditioning and refrigeration, especially at night. Urban heat islands can also change the local weather. For example, they can alter wind patterns, increase the development of clouds, cause the formation of thunderstorms, and increase the amount of lightning, especially heat lightning.

Increasing the use of white and reflective materials to cover roofs and for roads and other paved surfaces can reduce the heat island effect. These materials reflect more of the sun's light out into space. The urban heat island effect can also be reduced by increasing the amount of vegetation in a city through parks, gardens, and other plantings and by installing green roofs, roofs that are partially or completely covered by some form of vegetation.

## Materials:

Students will work in pairs to conduct temperature tests at the major surfaces on the school grounds. Each surface should be sampled by at least 3 teams to get more accurate data.

- Ruler
- Thermometer
- Data sheet #1 and #2

## Procedure:

1. The sampling for this audit works best on a sunny day.

2. Measure the temperature of each major surface on the school grounds from at least 2 different heights: 12 inches above the surface and directly on top of the surface. If time allows, the temperature can also be taken at other heights, for example, 6 inches above the surface or at waist height.

3. Once all data has been collected return to the classroom.

4. Combine the data collected by all teams for each surface and calculate the averages to get a more accurate temperature for the surface.

5. Answer and discuss the questions about the temperatures of these surfaces and their potential contribution to the urban heat island.

## Discussion:

1. Which surfaces were the warmest? Which are the coolest? Why?

2. Was it only warm at the top of the surface or did heat radiate above the surface? Why or why not?

3. What was the average temperature for the day you recorded data? Were the surfaces warmer or cooler than this temperature? Why or why not? If the surfaces that you measured were spread out everywhere, how might they have affected the average temperature in the entire city?

4. What other factors might have influenced how warm the surfaces in the school yard got on the day you collected data? Hint: Think about factors like the season, time of day, and cloud cover.

# Urban Heat Island Audit Data Sheet #1

**Club member names:** ______________________________________________

| **Surface type** | **Temperature (℉) on surface or 0in** | Temperature (℉) at 6in above surface *(optional)* | **Temperature (℉) at 12in above surface** | Temperature (℉) at waist height *(optional)* |
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# Urban Heat Island Audit Data Sheet #2

| | Surface: | | Surface: | | Surface: | | Surface: | | Surface: | | Surface: | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Group | Temp at 0in | Temp at 12in | Temp at 0in | Temp at 12in | Temp at 0in | Temp at 12in | Temp at 0in | Temp at 12in | Temp at 0in | Temp at 12in | Temp at 0in | Temp at 12in |
| A | | | | | | | | | | | | |
| B | | | | | | | | | | | | |
| C | | | | | | | | | | | | |
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| | | | | | | | | | | | | |
| Average | | | | | | | | | | | | |

# Carbon Sequestration by Trees

Trees use carbon to grow, to make food, and to reproduce. They take in carbon in the form of carbon dioxide, $CO_2$, a greenhouse gas. Through the process of photosynthesis, the $CO_2$ is converted into a form that they tree can more readily use, a sugar called glucose. Because trees take in carbon and store it, they are considered "carbon sinks." The storage of carbon is also called *carbon sequestration*. Planting more trees is one way to decrease the amount of $CO_2$ in the atmosphere.

Different sized trees will take in and store different amounts of carbon per year. Scientists have come up with general amounts of carbon sequestered based on the diameter at breast height (dbh). Dbh is measured at a height of about 4.5 feet and can be calculated using a specially calibrated measuring tape or by measuring the circumference and using the following equation to determine the diameter:

$$\text{Diameter (cm)} = \text{Circumference (cm)} \div 3.14$$

## Procedure:

1. Before beginning, it is helpful to assign each tree a number to keep better track of them. If possible, also identify the species of each tree.

2. For each tree on the school grounds, wrap a piece of string or yarn around the trunk at a height of about 4.5 feet and cut it so it is the exact size of the circumference. Measure the length of string or yarn in centimeters using a ruler.

3. For each tree, use the above equation to determine the diameter of the tree in centimeters, or diameter at breast height (dbh).

4. Based on the dbh, use the following table to determine the pounds of carbon sequestered by the tree each year.

| **Dbh class of tree (cm range)** | **Carbon sequestered (lb/tree/yr)** |
|---|---|
| 0-7 cm | 2.2 |
| 8-15 cm | 9.7 |
| 16-30 cm | 20.7 |
| 31-46 cm | 42.0 |
| 47-61 cm | 76.1 |
| 62-76 cm | 121.7 |
| 77+ cm | 203.9 |

5. Total the pounds of carbon sequestered per year by each tree to determine the total pounds of carbon sequestered on the school grounds each year.

6. When the new tree is planted on the school grounds use the same procedure to determine how much carbon it will sequester per year.

## Carbon Sequestration by Trees Data Sheet – Part I

| Tree # | Tree species (optional) | Circumference (cm) | Diameter (cm) = circumference ÷ 3.14 | Dbh class (cm range) | Carbon sequestered (lb/tree/yr – see p. 33) |
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|---|---|
| **Total carbon sequestered on school grounds (lb/year):** | |

## Carbon Sequestration by Trees Data Sheet – Part II

1. If all the trees on the school grounds maintain the same diameter at breast height (dbh) for the rest of their lifetime, how much carbon will they have sequestered in: *Hint: Simply multiply the pounds of carbon sequestered per year by the number of years.*

| **Tree #** | **Current dbh class (cm range)** | **Carbon sequestered (lb/tree/yr) (reference p. 33)** | **Pounds of carbon sequestered in 20 years (lb/tree/yr x 20)** | **Pounds of carbon sequestered in 50 years (lb/tree/yr x 50)** | **Pounds of carbon sequestered in 100 years (lb/tree/yr x 100)** |
|---|---|---|---|---|---|
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|---|---|---|---|
| **Total pounds of carbon sequestered on school grounds:** | | | |

## Carbon Sequestration by Trees Data Sheet – Part III

2. Assuming that an average tree in ideal conditions adds about 1 centimeter to its diameter each year, how much carbon will the trees on the school ground sequester in: *Hint: Calculate the new diameter, and therefore the new dbh class, of each tree and use the table to determine how much carbon a tree of that size would sequester per year.*

| **Tree #** | **Current dbh (cm)** | **Dbh in 20 years (cm)** ***= current dbh + 20*** | **New dbh class in 20 years (cm range)** | **Pounds of carbon sequestered in 20 years** | **Dbh in 50 years (cm) =** ***current dbh + 50*** | **New dbh class in 50 years (cm range)** | **Lbs carbon seq. in 50 years** | **Dbh in 100 years (cm)** ***= current dbh + 100*** | **New dbh class in 100 years (cm range)** | **Lbs carbon seq. in 100 years** |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | |
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| | | | | | | | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |
| **Total pounds of carbon sequestered on school grounds:** | | | | | | | | | | |

# Carbon Sequestration by Trees Data Sheet – Part IV

3. After the new tree is planted, calculate the additional amount of carbon that will be sequestered on the school grounds.

| | New tree species: |
|---|---|
| Circumference (cm): | |
| Diameter (cm): | |
| Dbh class (cm): | |
| Carbon sequestered (lb/tree/yr): | |

Add the pounds of carbon sequestered per year by the new tree to the previous total calculated for the existing trees on the school grounds to get the new total amount of carbon sequestered per year from all trees:

**New total carbon sequestered by all trees =______________________(lb/year)**

4. If the new tree adds on average 1 centimeter to its diameter each year, how much carbon will it sequester in 20 years? 50 years? 100 years?

# Rain Barrel Installation and Maintenance

**City of Chicago Departments of Environment and Water Management**

## Placing Your Rain Barrel

- Choose a downspout on your house or garage that is close to the plants and garden you water most, and where your rain barrel's overflow will soak into your own yard, and not your neighbors' property.
- Place your rain barrel on a pervious (e.g., landscaped) surface that allows overflow from your rain barrel to soak into the ground. If placed on an impervious (e.g., paved) surface, rain barrel water overflow during heavy rains could pool or seep into your house or garage foundation.
- You may want to place the rain barrel on concrete blocks if you are going to use a hose to direct water to your garden (gravity will help move the water), or if you want to fill up a watering can from the spigot (so the can fits underneath the spigot).

## Connecting Your Downspout to Your Rain Barrel

**Tools:** Rain barrel. Hacksaw. Aluminum downspouts: 6 screws and a screwdriver. PVC downspouts: PVC cement.

- Place your barrel near the downspout you have selected, and plan out how you will direct the downspouts.
- Disconnect your downspout from the sewer system by sawing the downspout above where the top of the rain barrel will be, leaving room for the elbow to be attached.
- Attach a downspout elbow to the end of your downspout so that water from your downspout is directed into the rain barrel through the plastic screen vent on top.
- If you have an aluminum downspout, secure it to the elbow with screws.
- If you have a PVC downspout, secure it to the elbow with PVC cement.
- Place your rain barrel under the downspout elbow.
- Optional: Attach a hose to the spigot, and/or to the overflow hole on the top-side of the barrel. Make sure that the overflow is directed into your own yard.

## **Using Rain Barrel Water**

- Water your flowers, trees, shrubs, and lawn.
- Wash your car or pets. Rinse hands and feet, tools, or muddy boots.
- Keep your rain barrel lid on tight at all times to prevent children and animals from entering or falling in.
- DO NOT DRINK WATER from your rain barrel.

# Rain Barrel Installation and Maintenance (continued)

**City of Chicago Departments of Environment and Water Management**

## Maintaining Your Rain Barrel

- Keep your rain barrel spigot closed when you are not using the water so that the rain barrel can collect water. Overflow water will spill from the black vent on the top and the overflow hole on the side near the top.
- Regularly check your gutters, downspouts, rain barrel water intake screen, rain barrel mosquito screen and rain barrel spigot for leaks, obstructions or debris.
- Keep your rain barrel lid sealed.
- Drain your rain barrel before temperatures drop below freezing.
- In the winter, keep your rain barrel spigot open so that water does not accumulate in the rain barrel and freeze.

## Preventing Mosquitoes

Your rain barrel should be equipped with a mosquito-proof screen over all openings to keep mosquitoes and other insects out.

- Place your barrel on a pervious (water-absorbing) surface, so that overflow water soaks into the ground instead of pooling on paved surfaces.
- Keep your rain barrel lid sealed.
- Keep your barrel free of organic material.
- During the rainy season, every 3-4 days use your hand to splash off any water that may collect on the top of the barrel. Mosquitoes need at least 4 days of standing water to develop as larva.
- If you believe mosquitoes are breeding in your rain barrel, empty your barrel completely. This will kill all mosquito larvae that may be in your barrel. If your mosquito netting is intact and there are no leaks, your rain barrel should be mosquito-free.

## Disclaimer

With proper installation, maintenance and use, your rain barrel should function properly. The City of Chicago, the Chicago Department of Environment and the Chicago Department of Water Management assume no liability for the installation, maintenance or use of your rain barrel. We are not responsible for any rain barrel malfunction, property damage, or injury associated with your rain barrel, its accessories or contents.

## Further Contact

If you have any questions or comments regarding rain barrel installation or maintenance, please contact the Chicago Dept. of Environment at **(312) 743-WATER** or rainbarrel@cityofchicago.org

## Estimating Water Diverted by Rain Barrels at School

If a rain barrel was connected to a structure at the school and the Club is able to, keep track of the average amount of water it collected per month; use those numbers for the following calculations (substitute for the number of gallons listed in the equation below).

If the Club was not able to keep track of the rain collected in the rain barrel, or if a rain barrel could not be connected to any part of the school use the average number in the equation.

**# of downspouts at the school = ___________**

**Estimated gallons of water that could be diverted per month if a rain barrel is connected to all downspouts at the school:**

Number of downspouts x 465 gallons = Gallons of water diverted per month

________________ x ___________ gallons = ________________ gallons for other uses per month

**Estimated gallons of water that could be conserved per month if a rain barrel is connected to all downspouts at the school:**

Number of downspouts x 165 gallons = Gallons of water conserved per month

________________ x ___________ gallons = ________________ gallons per month

**Did you know…?**

For buildings as big as your school, MASSIVE rain barrels called *cisterns* are actually used. There are some great examples of cisterns at the Chicago Center for Green Technology. Rainwater from the entire roof empties into 4 cisterns. If you can't check them out in person, check them out on-line! Visit CCGT's website, and look at the link for "How Cisterns Work". www.cityof**chicago**.org/Environment/**Green**Tech

# Extension Activities: The Urban Heat Island

## Lesson Summary

Students will perform an experiment that demonstrates how some surfaces and materials in a city absorb the sun's heat and some reflect it. They will use the results of the experiment to understand the urban heat island effect.

**Time Allotment**
50 minutes

**Materials**
- Black asphalt shingle
- White roofing shingle
- Red brick
- Bowl of water
- Grass (see Advanced Preparation)
- Wood block
- Pan of pebbles or gravel
- Concrete brick

Per group:
- Heat lamp
- Ruler
- Thermometer
- Colored pencil set

Per student:
- Data sheet

**Advance Preparation**
For grass, use pet grass and trim so it is even.

Make copies of the data sheet.

Arrange students in five groups.

## Lesson Objectives

- Conduct an experiment to compare the differences in how much heat various surfaces and materials found in a city absorb.
- Understand what kinds of surfaces absorb the sun's heat and what surfaces reflect it.
- Understand and explain the urban heat island effect.

## Illinois Goals and Standards for Middle / Junior High School

Science:
Goal 11: A.3a, A.3b, A.3c, A.3d, A.3e, A.3f
Goal 12: C.3a, E.3a

Math:
Goal 7: A.3b, B.3
Goal 10: A.3a, B.3

Language Arts:
Goal 4: A.3c

## Vocabulary

Absorb
Green roof
Radiate
Reflect
Urban heat island

## Background Information

Different surfaces and materials **absorb** and **reflect** different amounts of light. The more light a surface or material absorbs, the faster it heats up. Darker colors and heavier materials tend to absorb more light and, therefore, heat up faster than lighter materials. A completely black surface will absorb 100 percent of the light that strikes it and a completely white surface will reflect 100 percent of the light. Surfaces that absorb light will feel warm or even hot to the touch. Surfaces that reflect light feel cool in comparison.

As surfaces absorb light and heat up, they also **radiate**, or give off, increasing amounts of heat causing the air right above the surface to heat up. This phenomenon, called the **urban heat island**, has become a big problem in densely populated cities. Urban centers use a large amount of dark colored paving and roofing materials, like asphalt and tar. These materials absorb and radiate large amounts of heat. For example, a conventional tar roof can reach 169°F on 90°F day. Therefore, temperatures in a city can be 6 to 10 degrees Fahrenheit warmer than in rural areas. The urban head island effect is particularly noticeable at night. While the temperatures in non-urban areas decrease as the sun goes down, the temperatures in cities can remain significantly higher as materials that absorbed the sun's head during the day continue to release it at night.

Urban heat islands have several significant consequences. Because they cause an increase in daily temperatures, they can increase the strength and duration of heat waves in cities. This can lead to an increase in heat related health problems and even deaths. Urban heat islands cause an increase in energy usage for air conditioning and refrigeration, especially at night. Urban heat islands can also change the local weather. For example, they can alter wind patterns, increase the development of clouds, cause the formation of thunderstorms, and increase the amount of lightning, especially heat lightning.

Increasing the use of white and reflective materials to cover roofs and build pavements and roads can reduce the heat island effect. These materials reflect more of the sun's light out into space. The urban heat island effect can also be reduced by increasing the amount of vegetation in a city. This can be done by increasing the amount of green space, like parks and gardens, and by installing **green roofs**, roofs that are partially or completely covered by some form of vegetation.

## Initial Discussion

1. To give the surfaces time to heat up, the experiment needs to be set up before anything else is done.

2. Give each group one of the eight surfaces, a ruler, and a heat lamp. Have them plug in the heat lamp, turn it on, and place the surface under it. Position the lamps so they are six inches above the surface. When they are finished have them return to their seats.

3. Ask the students where they would prefer to be during the summer if they have to be outside. Why? Accept all answers.

4. Ask the students what surfaces outside feel the hottest on a sunny summer day and which feel the coolest. Make a list for each category on the board. If necessary prompt the students by giving them choices, for example which is hotter, asphalt or grass, water or sand, etc.

5. Ask them why they think some of these surfaces feel hotter than others. Accept all answers.

6. Explain that some types of surfaces and some colors reflect much of the sun's light. These surfaces don't heat up very much even in direct sunlight. Other surfaces and colors absorb the sun's light. They can feel warm or even hot on a sunny day and the air right above the surface heats up too.

## Hands-On Activity

7. Pass out the data sheets. Tell the students that at the beginning of class they set up an experiment to determine which materials hold more heat.

 

8. Explain that each material represents a surface they might find in the city. Go through each surface and what it represents. *Note: The asphalt shingle can represent both an asphalt parking lot and a shingled roof.*

9. Have the students complete the hypothesis in the space provided on the data sheet.

10. Tell the students that they will be comparing the temperatures of the materials in two ways. They will be doing a touch test and also measuring the temperatures with thermometers.

11. Explain that two students from each group will perform the touch test. Starting with their own group, both students should feel the surface and then decide together and circle the category on their data sheet they feel best describes how warm or cool the surface feels. When they are done they should move to the next group.

12. Explain that at the same time, the other two students will use the thermometer to measure the temperature of their group's surface. They should hold the thermometer perpendicular to the surface and wait until the bar stops moving to take the temperature. Remind them that because this is an experiment, they should record the temperature in degrees Celsius.

13. Draw the temperature test table on the board. Tell the students that once their group has the temperature for their surface, they should record it on their data sheet and on the chalkboard. When all of the temperatures from all of the surfaces are recorded on the board, they should copy them onto their data sheet.

14. Have the students create a bar graph of the temperatures of the eight surfaces. They should also write a brief conclusion for the experiment in the space provided.

## Relate Activity to Concept

15. Discuss the results of the experiment with the students. Questions might include: Did the touch test and the temperature test give the same results? If not, why? Which surface(s) was the hottest? Why? Which stayed the coolest? Why?

16. Explain that much of the building materials used in cities, like asphalt and tar, absorb the sun's light and radiate it as heat. This is enough to raise the daily temperature in the city by 6 to 10 degrees Fahrenheit especially during the summer. This effect is called the urban heat island (see Background Information).

17. Ask the students which of the building materials tested would contribute the least to the urban head island effect (the lighter colored surfaces like the white shingle and the grass).

18. Tell the students that in many cities, including Chicago, there are initiatives to install green roofs on city buildings to help reduce the heat island effect. Green roofs involve partially or completely covering roofs with some form of vegetation (see Background Information). These roofs provide other benefits as well, such as increasing wildlife habitat, filtering pollutants from air and water, providing insulation that reduce energy costs, and reducing storm water runoff.

*Adapted from Follow the Front by Ranger Rick's Nature Scope.*

## Assessment

Collect and grade data sheets.

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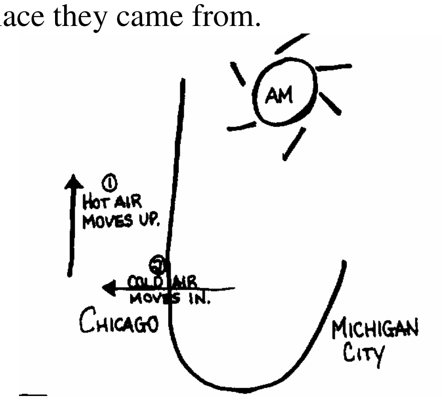
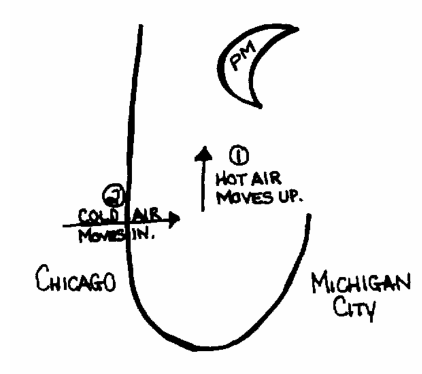
## Extensions

**Documenting the Urban Heat Island Effect**
Take students outside on a warm or hot sunny day to observe and measure the urban heat island effect in action. Have students measure the temperature of several different surfaces around the school. Try to include green areas, asphalt areas, concrete, etc. Once students have collected the data, have them graph the results and explain them using the information they learned in this lesson. This experiment can be set up using the scientific method.

**Land and Lake Breezes**
The difference in temperature between the water and the land accounts for a phenomenon known as "Lake, or Sea, Breezes" and "Land Breezes." Winds and breezes are always named from the direction or place they came from.




In the daytime, the sun shines on both the water and the land. The land heats up more quickly than the air over the water. This warm land air begins to rise and is replaced by cooler heavier air pushing in from the water. This creates a "lake or sea breeze" (see illustration above). This is also why during the spring and summer it is often cooler near the lake.




At night, the air over the land cools down more quickly than the air over the water. The warmer water air rises and the cooler, heavier land air pushes in. This creates a "land breeze."

## Heat Island Data Sheet Name: ______________________________

**Purpose:** Which materials absorb more light and, therefore, feel the hottest?

**Hypothesis:** I think that the _________________________ material will absorb the most light and feel the hottest because________________________________________

______________________________________________________________________________

____________________________________________________________

**Materials:**

Heat lamps
Black asphalt shingle
Gravel
Grass
Thermometers
White shingle
Concrete brick
Bowl of water
Rulers
Wood
Red brick

**Procedure:**

a. Plug in the heat lamps, turn them on, and place one of the materials under each lamp. Use the ruler to position the lamp so it is approximately 6 inches above the top surface of the material. Wait 20-30 minutes before performing the following tests.

b. **Touch test:** Feel the surface of each material and rate how warm or cool the surface feels. Circle a heat category for that material in the table.

c. **Temperature test:** Measure the temperature of each material by placing the bulb of the thermometer on or slightly in the material and holding the thermometer upright, or perpendicular, to the surface. Wait until the bar stops moving to read the temperature and record it in the table.

**Data:**

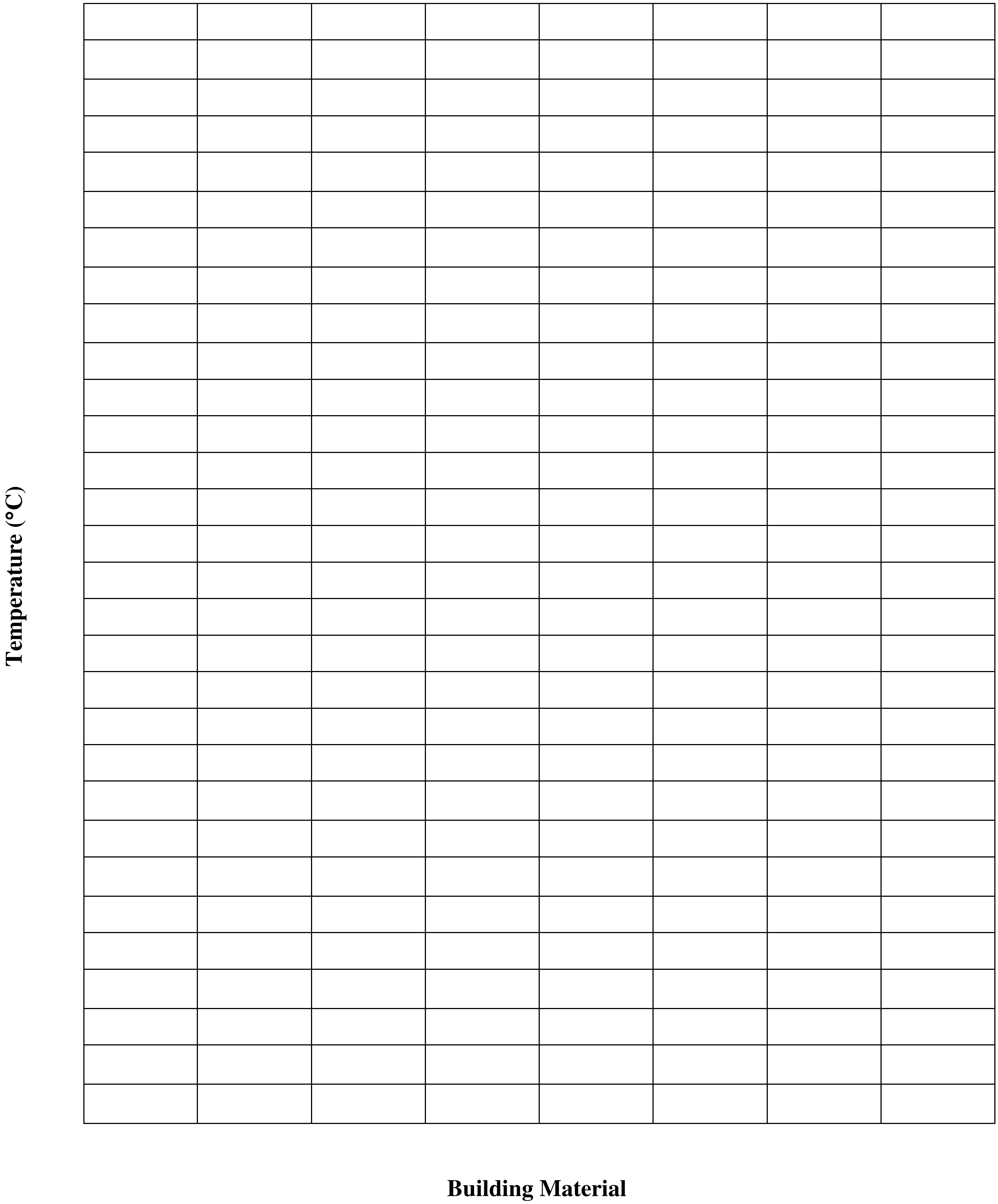
| **Touch Test** | | | | |
|---|---|---|---|---|
| **Material** | **Rating (circle one)** | | | |
| Black asphalt shingle | cold | cool | warm | hot |
| White shingle | cold | cool | warm | hot |
| Wood | cold | cool | warm | hot |
| Gravel | cold | cool | warm | hot |
| Concrete brick | cold | cool | warm | hot |
| Red Brick | cold | cool | warm | hot |
| Grass | cold | cool | warm | hot |
| Water | cold | cool | warm | hot |

| Temperature Test | |
|---|---|
| **Material** | **Temperature (°F)** |
| Black asphalt shingle | |
| White shingle | |
| Wood | |
| Gravel | |
| Concrete brick | |
| Red brick | |
| Grass | |
| Water | |

**Graph:** Create a bar graph of the temperature data using the graph paper on the next page.

**Results:** Write in words what the tables and graph show.

**Conclusion:**


Temperature (°C)
Building Material

# Extension Activities: Pollution Solution

## Lesson Summary

Nonpoint source pollution (NPS) is a serious problem in urban areas. Students will learn about the causes of NPS pollution and perform an experiment to test how ground cover affects the amount of NPS pollution in runoff.

**Materials**

- 8 Small square plastic containers
- 8 Aluminum foil squares
- 8 Florist foam blocks
- 2 sets of sample materials including pet grass, gravel, black plasticine, and white crayola modeling clay
- Aerial photo of school or surrounding neighborhood
- 8 transparencies with grids

Per group:

- Small bottle of lemon juice
- 2 pH test strips
- pH color indicator chart
- 100 mL beaker
- Spray bottle of water

Per student:

- Copy of data sheet.

## Lesson Objectives

- Perform an experiment using the scientific method.
- Understand the difference between point source and nonpoint source pollution.
- Use a grid to estimate ground cover.
- Learn how to reduce stormwater runoff.

## Illinois Goals and Standards for Middle / Junior High, Early High School, and Late High School

Science:

Goal 12:
Goal 13: B.3d, B.3f, B.4d, B.5c

## Vocabulary

Impermeable Surface
Nonpoint Source Pollution
Pollution
Point Source Pollution
Runoff

## Background Information

Pollution can come in many different forms. The most common types of pollution are air, water, and ground pollution. **Pollution** can be any substances in the air, water, or soil that cause a threat to human health or the environment.

Pollution can come from two sources, known as point source or nonpoint source pollution. **Point source** pollutants are pollutants that are discharged from any identifiable source, including pipes, sewers, smoke stacks, automobile exhausts, etc. **Nonpoint source** pollutants are pollutants that do not originate from one specific location. Instead, these pollutants accumulate in water as it flows over a widespread area.

Water, in the form of precipitation, collects on the ground and flows into lakes and streams. As the water, or **runoff,** flows it picks up debris and pollutants from the ground. These pollutants can include fertilizers from lawns, pesticides from agricultural fields, oil and salts from roadways and parking lots, and other trash and debris from sidewalks. All of these pollutants make their way into lakes and streams, contaminating the waterways.

Nonpoint source pollution is difficult to cleanup, but there are ways to prevent the pollution to begin with. One way is to encourage people to properly dispose of harmful chemicals and wastes rather than dumping them on the ground. Another way to reduce nonpoint source pollution is to reduce the amount of impermeable surfaces. An **impermeable surface** is a hard surface that does not allow water to seep through to the ground, which leads to runoff. Increasing the amount of permeable surface area with ground cover such as grasses, native plants, or special pavers that allow water to seep through can reduce the amount of runoff, which will lead to less nonpoint source pollution in waterways.

## Initial Discussion

1. Tell the class that you have come to visit them to talk about pollution. Ask for a definition of pollution. If necessary ask for words that they think describes pollution.

2. Next, ask the students to list types of pollutants (air, water, noise, light, etc.) or examples of pollutants (garbage, chemicals, etc.). List the ideas in one column.

3. Now, ask the students to state where each of the pollutants comes from. Put these answers in an adjacent column. Some of the pollutants may have unknown or multiple sources. Next to these, write Nonpoint source pollution (NPS).

4. Begin a discussion about NPS. Start by reviewing the water cycle with students. Ask students what happens to rain as it falls to the ground. Define runoff and explain how contaminants are picked up by water as it flows towards streams and lakes (See Background Information).

5. Ask students how ground cover might affect the flow of runoff. Is it better to have more permeable surfaces, which allow water to flow into the ground, or to have more impermeable surfaces, where water runs off? Which type of ground cover would reduce NPS pollution?

## Hands-On Activity

6. Tell students they will setup an experiment that will examine how ground cover affects NPS pollution.

7. Begin by having students create a list of types of ground cover. As they read their lists aloud, keep track of their answers on the board. Be sure that the list contains the following: soil w/plants (grass), gravel, asphalt, and concrete.

8. Based on the list they created, ask students to make a hypothesis about which material will protect a water body the best from NPS pollution.

9. Arrange students in groups and give each group a plastic container, an aluminum foil square, and a data sheet. Have them create a basin that will hold water and place it on one side of the container. Assign each group a test material and have them fill the other side of their basin with their material according to the instructions on their data sheet.

10. Have one member from each group come to the front and get a 100mL beaker, a spray bottle of water, 2 pH test strips, and a small bottle of lemon juice.

11. Ask students to come up with a way to test how much pollution is in the water. What instruments or tools do scientists use to determine if water is polluted or not? Tell students they will measure the pH of the water in order to determine how polluted it is. The pH is a measure of how acidic or how basic the water is.

The pH of a non-polluted water body is between 6.5 and 8.2.

12. Have the students carefully follow the procedure on their data sheet. Make sure they record their data and complete all the questions.

13. When all the groups have finished, create a chart on the board and have each group record their results on the chart.

## Relate Activity to Concept

14. Ask students which material polluted the water the most? How about the least? How did the permeability of the material affect the amount of pollution that entered into the water?

15. Ask students to think about the ground cover that surrounds their school. What types of surfaces are permeable? What types of surfaces are impermeable? Have students estimate the amount of surface (percentage) that is permeable and impermeable.

16. Give students an aerial photograph of their school building and the surrounding landscape. Tell students they will use a grid-system to visually estimate how much impermeable surface surrounds the school.

17. Have students place the transparent grid system over the aerial photo. Have them count up all of the squares that are contained within the previously defined impermeable areas. Students can then calculate the percentage of impermeable surface area with the following equation: (number of squares of impermeable surface)/(total number of squares within the entire aerial photograph) X 100.

18. Have students discuss the results. Is there a body of water near the school? (look at the aerial photo) If not, where is the runoff going?

19. Ask students to research the following: (1) Where does Chicago's stormwater runoff go? (2) What can students do to help reduce runoff in urban areas? (3) What can students do to reduce NPS pollution in urban areas?

## Variations

- Leave out the school ground cover assessment if time is short.

## Assessment

Collect and grade data sheets.

## Data Sheet

**Name:** ______________________

What is the **purpose** of the experiment?

What is your **hypothesis**?

What **materials** did you use?

Plastic square container
Aluminum foil square = lake basin
Foam block = underground
Pipette
Sample materials…? = surfaces

100 mL beaker full of water = lake water
Spray bottle = rain producer
Lemon juice = pollution on ground
2 pH test strips

Ground cover sample _________________________

What is the **procedure** of the experiment?

1. Using the aluminum foil, create a basin in one-half of the plastic container that is capable of holding water.
2. Place the foam block in the empty side of the container. The sloped edge of the foam block should be facing the aluminum foil basin.
3. Smooth the inner wall of the foil basin along the sloped edge of the foam block. Make sure that the foil is not higher than the foam.
4. Take the sample material and place it on top of the foam block.
5. Fill the beaker with 100mL of water and pour it into the aluminum basin.
6. Using a pH indicator strip, test the pH of the water by dipping the strip into the water for 2 seconds. Compare the wet end of the strip with the color indicator chart. Record the pH in Table 1.

7. Fill the pipette with lemon juice. Sprinkle 20 drops of lemon juice evenly over the sample material.
8. Using the spray bottle, make it "rain" by gently spraying the sample material surface for 10 seconds.
9. Measure the pH of the water in the aluminum basin again. Record the results in Table 1

**Table 1**

| | Before rain event | After rain event |
|---|---|---|
| **pH of water** | | |

What are the **results** of the experiment?

What is your **conclusion**?