TRACING WATER AND SUBSTANCES IN WATER THROUGH PATHWAYS IN THE SCHOOLYARD:

A New Perspective on Teaching the Water Cycle

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Project Support

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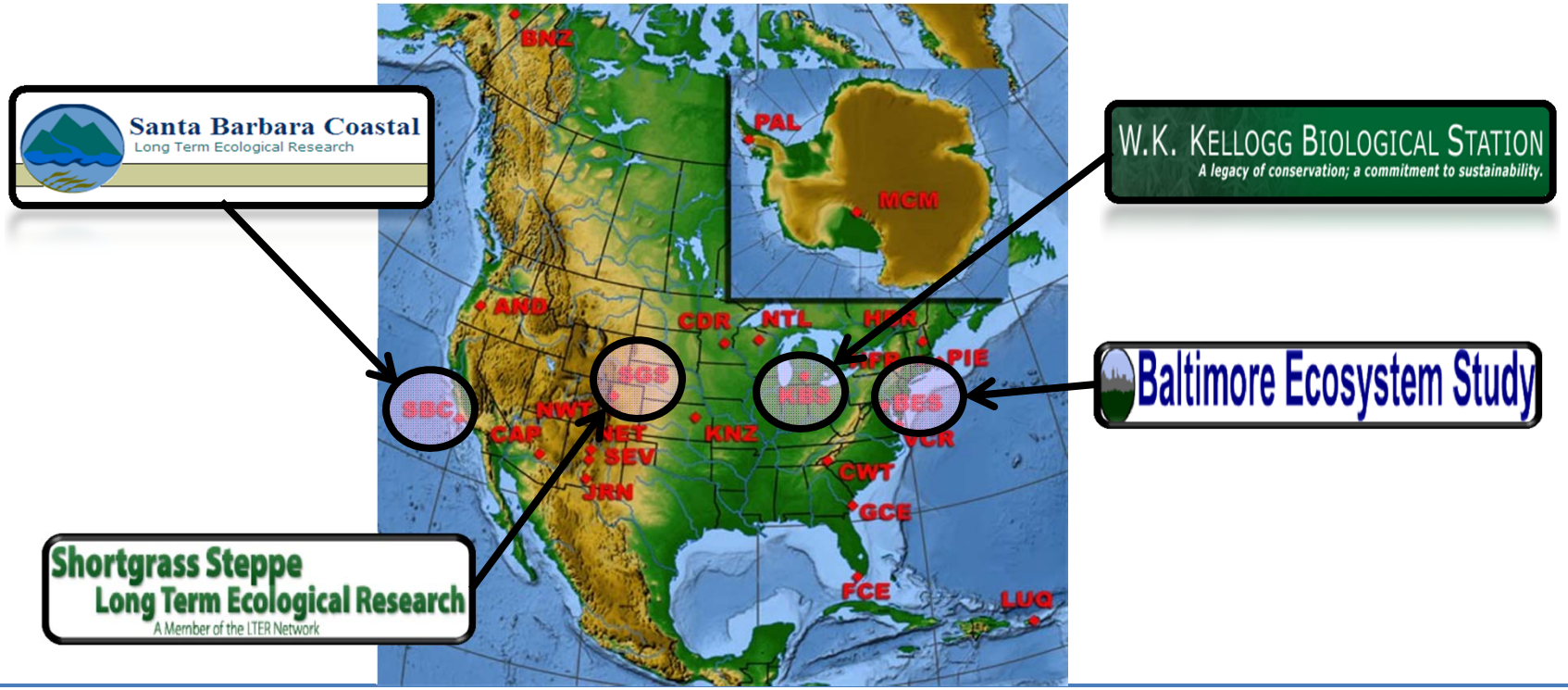
Presentation Outline

- Project Background
- Why Study Schoolyard Water?
- Purpose of Water Budget Unit
- School Water Budget Unit Activities (SWB)
- Substances in Water Unit Extension
- Applying Ideas to Real World Issues
- Evaluating Student Outcomes

Project Background

Culturally Relevant Ecology, Learning Progressions, and Environmental Literacy NSF Math Science Partnership

4 LTER sites comprise the project



Project Background

- **<u>Building learning progressions (LPs)</u>**
  - Research to articulate how students' ideas about water systems change over time --- spanning grades 6-12

- **<u>Professional development</u>**
  - PD with middle and high school science & math teachers
  - Develop new LP-based teaching approaches

- **<u>Institutional change</u>**
  - Advance student environmental science literacy via LP-based **Teaching Experiments**

Project Background

Teaching Experiments

Purpose: To target teaching and learning of water cycle, carbon cycle and biodiversity in a local, more culturally relevant way.

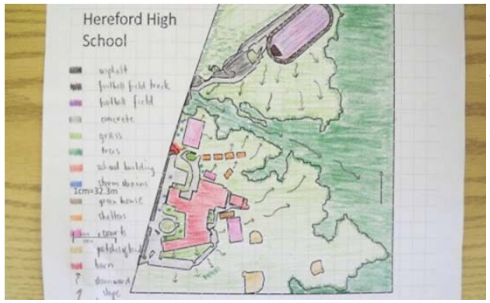
CARBON

Students trace carbon through organisms and ecosystems.

BIODIVERSITY

Students study stream macroinvertebrates to learn components of biodiversity.

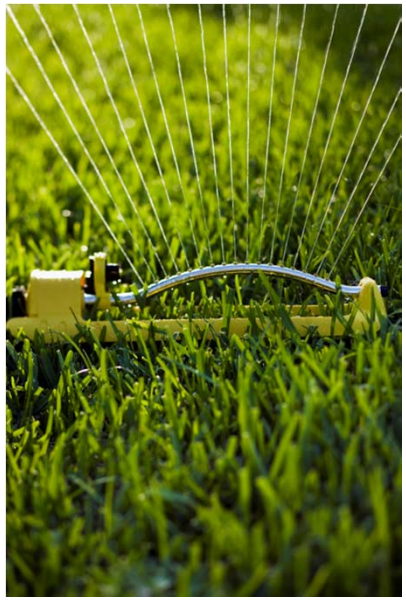
WATER



Students calculate a schoolyard water budget and learn how substances mix and unmix with water.

Purpose of Water Budget Activity

- Engage students in investigation of what happens to water as it moves through the place they live.
  - Place-based experience
- Improve environmental literacy in students to inform their every day decisions regarding water usage.



Why Study Schoolyard Water?

- Water-related issues (e.g., climate change) threaten continuing supply of high-quality fresh water
- Collective action is required as citizens play various roles
  - Private: consumer, worker
  - Public: Voter, advocate, elected official
- Public understanding of science of water systems is thin
- Schoolyard provides local context for students to develop deeper understanding of connected hydrologic system structures and processes

Why Study Schoolyard Water?

- Water cycle representations often lack human components and only represent cycle at large scale
- This can lead students to believe that pathways water travels through water cycle are simple and linear, and disconnected from their community
- Schoolyard water exploration connects water cycle concepts to a local, place-based context for first-hand experiences with connected systems and processes

School Water Budget

- Engage
- Explore
- Explain
- Elaborate
- Evaluate

SWB: Engage Question

How much of the precipitation that falls from the sky in a year within the boundaries of our school's property might be available for our school to use? Could this quantity of precipitation meet our school's water needs?

SWB: Explore Activities

- Annual precipitation vs. school water use
- Explorations of Water Pathways in the Schoolyard
  - Mapping Surfaces
  - Evaporation/Transpiration
  - Infiltration
  - Runoff
- Explorations of Substances in Water Pathways

Explore: Annual Precipitation vs. School Water Usage

- Conduct an internet search for “annual precipitation in *your town*”
- Determine area of your school grounds, and convert annual rainfall to gallons
- Ask administrator how many gallons of water your school uses each year
- Compare amount that falls to amount used

Explore: Mapping Surfaces

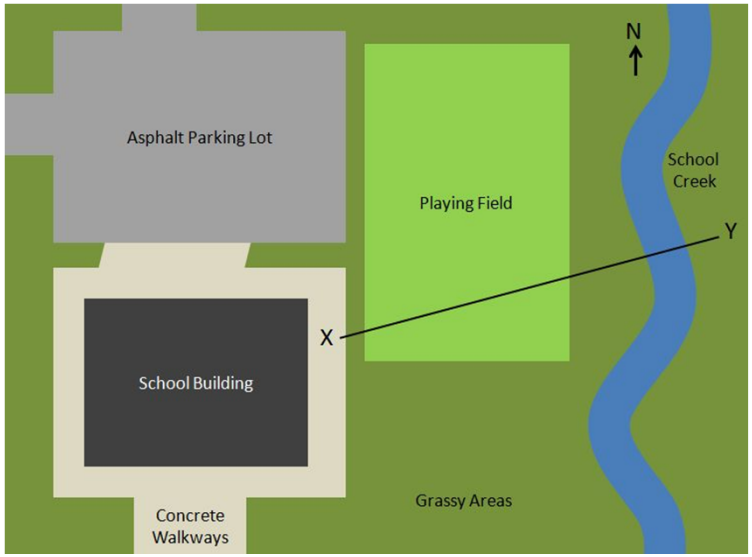
- Addresses students' abilities to make inferences connecting 2-dimensional maps to 3-dimensional landscapes.

Explore: Mapping Surfaces

Step 1: Evaluate prior knowledge with Formative Assessment

1. If you were looking from the side instead of from above, what would the shape (height) of the land be like across the distance from Point X to Point Y? (Circle the answer you think is the best.)

A 	D 
B 	E 
C	F There's no way to know.



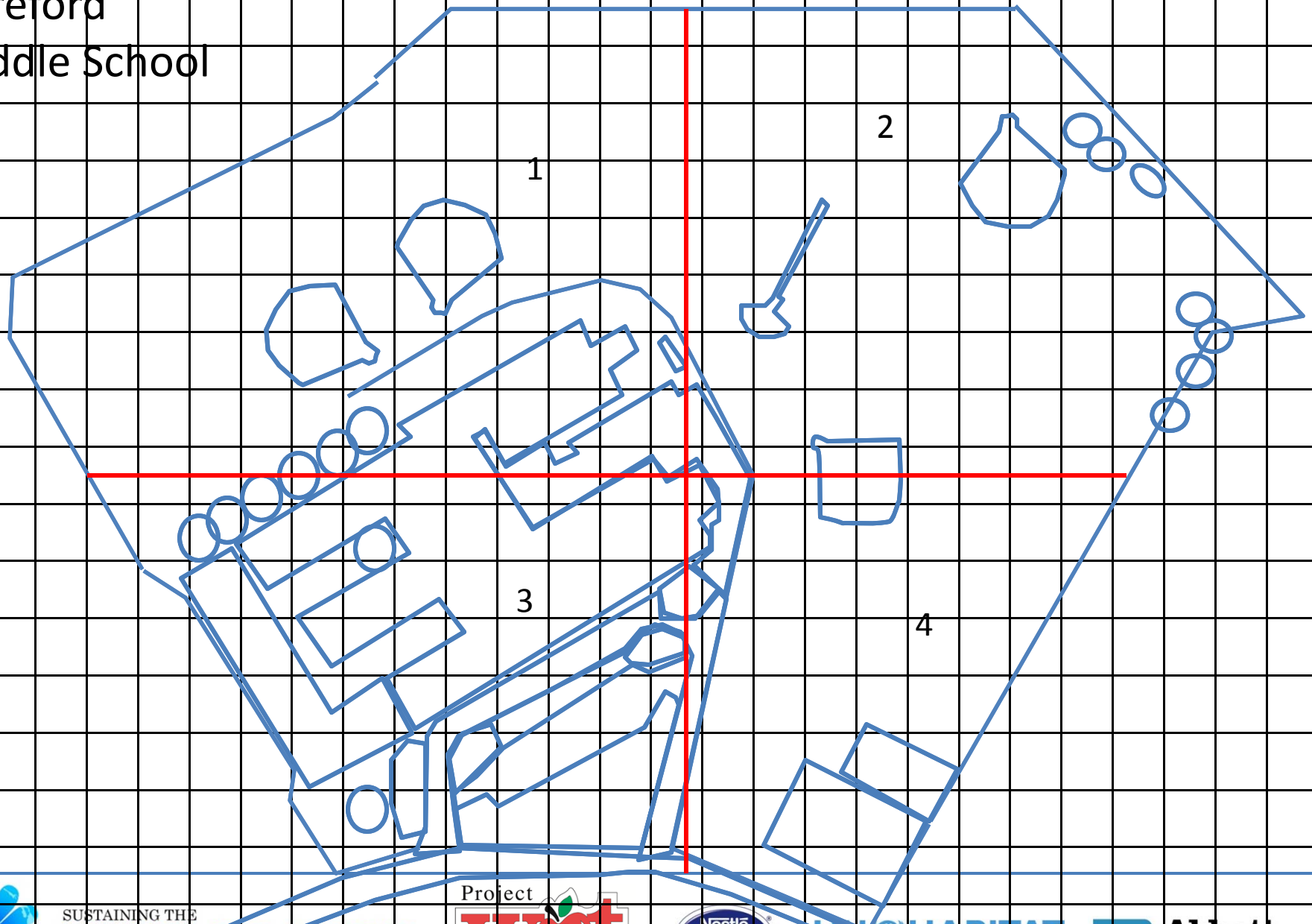
2. Circle which direction you think School Creek is flowing:
a) North
b) South
c) You can't tell from the map

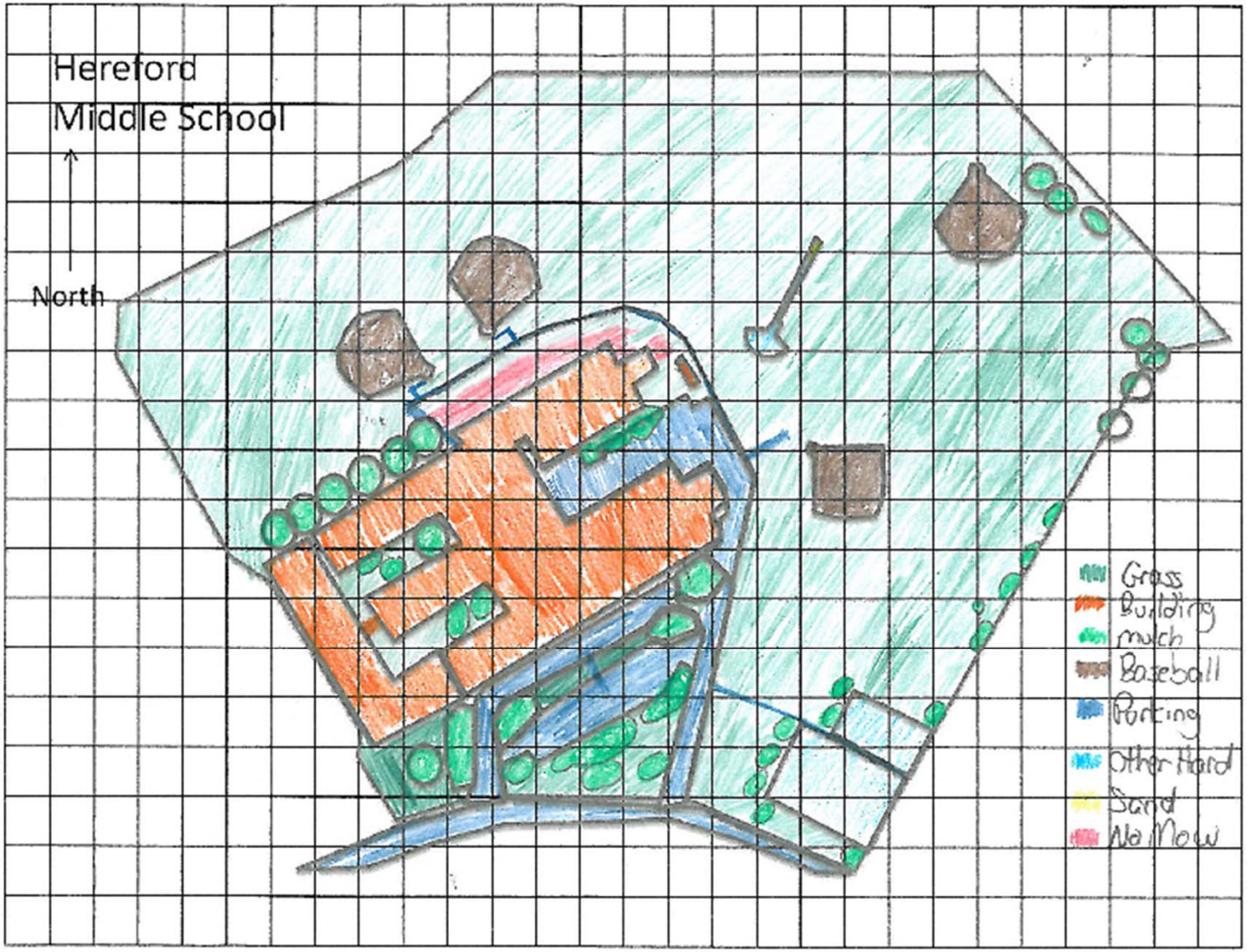
Explore: Mapping Surfaces

Step 2: Map surfaces in schoolyard

Hereford
Middle School

North

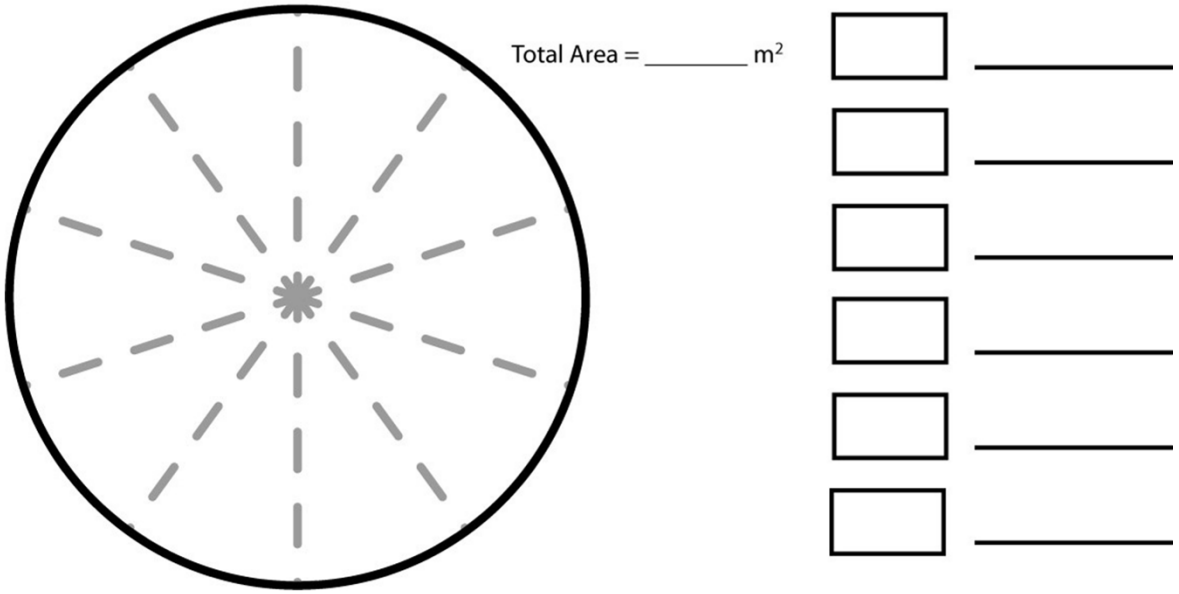




Explore: Mapping Surfaces

Step 3: Determine proportions of surface types in schoolyard

Proportions of Different Surfaces

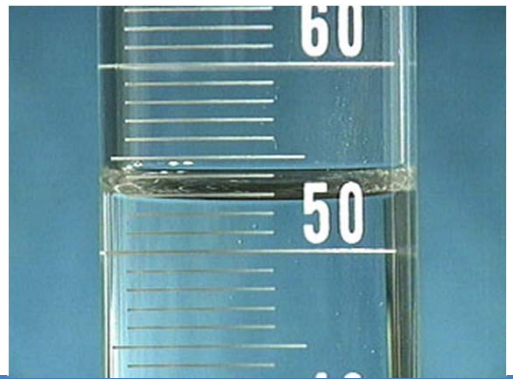


Explore: Evaporation

- Addresses students' ideas about role of evaporation in moving water through hydrologic system

Explore: Evaporation

Step 1: Engagement: How much water evaporates from our schoolyard? Do amounts differ in different places?



Step 2: Set up evaporation pans

- Pour measured amount of water in a wide flat pan
- Weigh down with a stone and cover loosely with screening
- Place pans in locations around schoolyard of varying sun exposure

Explore: Evaporation

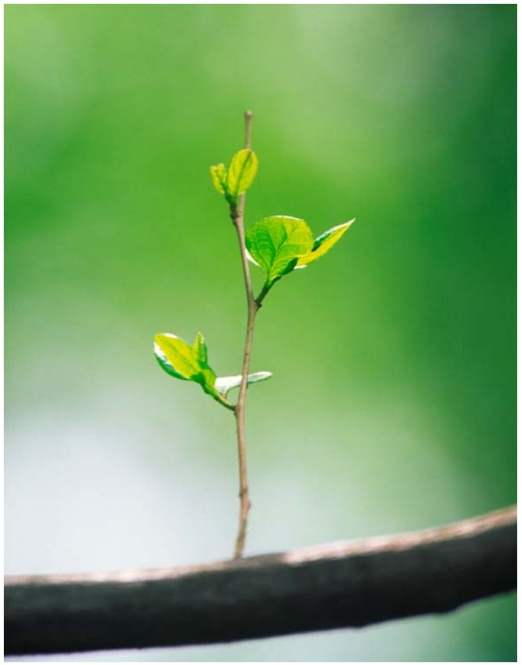
Step 3: Collect data and make estimates

Month: May			
Site Description School yard with very few trees, mostly grassy open areas.			
Pan Location	Day 1 (mL)	Day 2 (mL)	Evaporation Rate (Day 2-Day 1) (inches/day)
10 ft from building shade	400	380	Loss of 20 mL
10 ft from building sun	400	300	Loss of 100 mL

Extrapolate your evaporation rate to a year by multiplying by 365

Explore: Transpiration

- Addresses students' ideas about transpiration
- Activity promotes understanding of:
  1. Major role of plants in transporting water
  2. Total contribution vegetation in schoolyard makes to moving water from land to atmosphere



Explore: Transpiration

Step 1: Evaluate student prior knowledge with Formative Assessment

- Six friends are walking through their neighborhood when they notice someone watering their garden. One friend asks: What happens to the water that enters the plants?
  - Michael responds: The plant stores the water
  - Jason responds: The water will eventually come back out into the soil
  - Tonya responds: The water leaves the plant as a gas
  - Juanita responds: The water makes the plant live and grow
  - Charles responds: The plant evaporates the water
- Who do you agree with the most and why?

Explore: Transpiration

Step 2: Set up transpiration bags

Photo by Bess Caplan, 2011

Step 3: Collect data and make estimates

Month May				
Site Description Large school campus in suburban Maryland; many mature trees				
Tree Type: Norway Maple				
# of leaves in baggie	Volume of water (mL)	Volume of water from 1 leaf (mL)	Estimated number of leaves on tree	Amount transpired per day (ml)
5	10mL	2mL	100,000	200,000mL

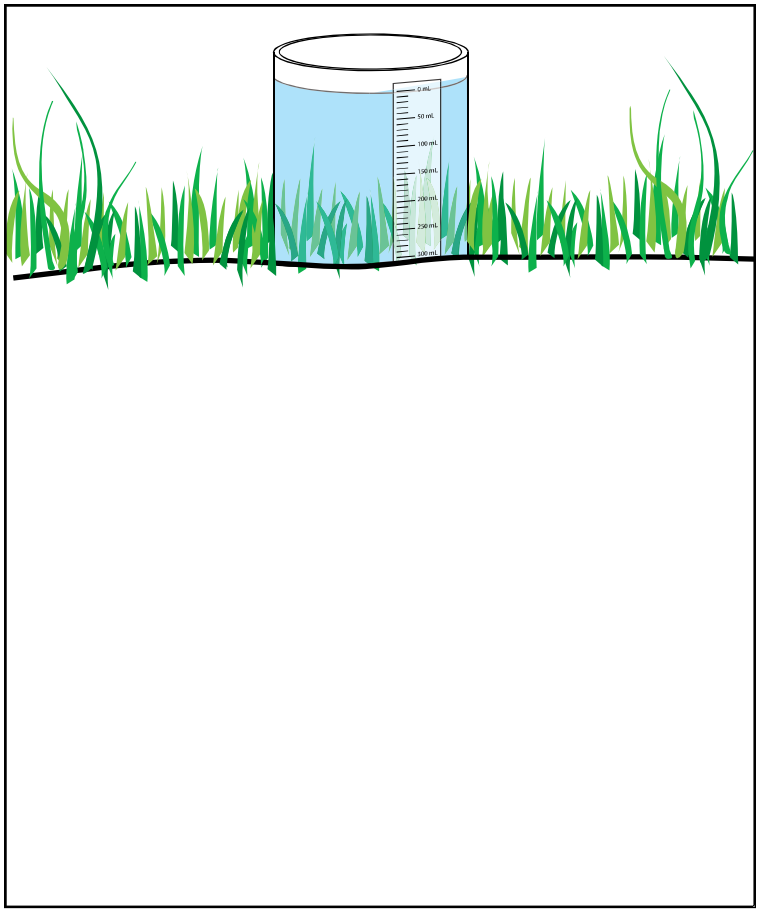
Explore: Infiltration

- Addresses students' ideas about where water goes after it has infiltrated into ground.
  - Students make predictions by ranking permeabilities of surfaces identified in Mapping Exploration
  - Students use infiltrometers to measure rate of infiltration of different surfaces
  - Students revise initial predictions

Explore: Infiltration

Step 1: Evaluate student prior knowledge with Formative Assessment:

- Students draw and label what they think it looks like underground.
- Students use arrows and labels to show where water goes if it is drains out bottom of plastic tube into ground.

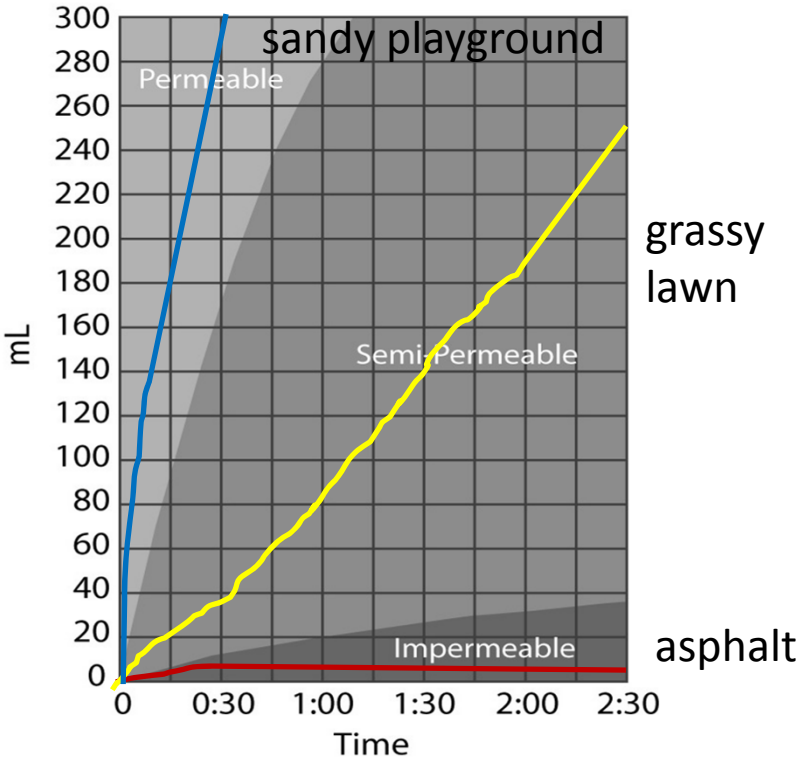


Explore: Infiltration

Step 2: Test at least 3 different surface types in school yard

A teacher measures infiltration rate of school's rubber track.

Step 3: Graph data and rank permeability of surface types



grassy lawn

asphalt

Explore: Runoff

- Addresses student reasoning about where surface water flows and why.

Explore: Runoff

Step 1: Evaluating student prior knowledge with Formative Assessment

Five friends were volunteering for the annual river clean-up in their town. They were finding lots of trash in the river. One friend asked, "If we didn't pick this bottle out of the river, where do you think it would go?"

Alberto: Maybe the bottles follow the water from this river to a smaller river.

Brenda: I think the bottles float downstream.

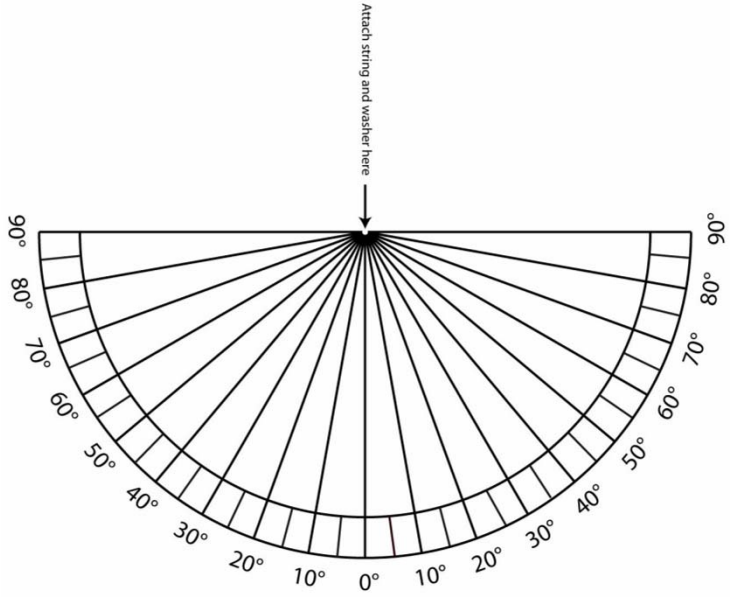
Cheng: I think the bottles float away.

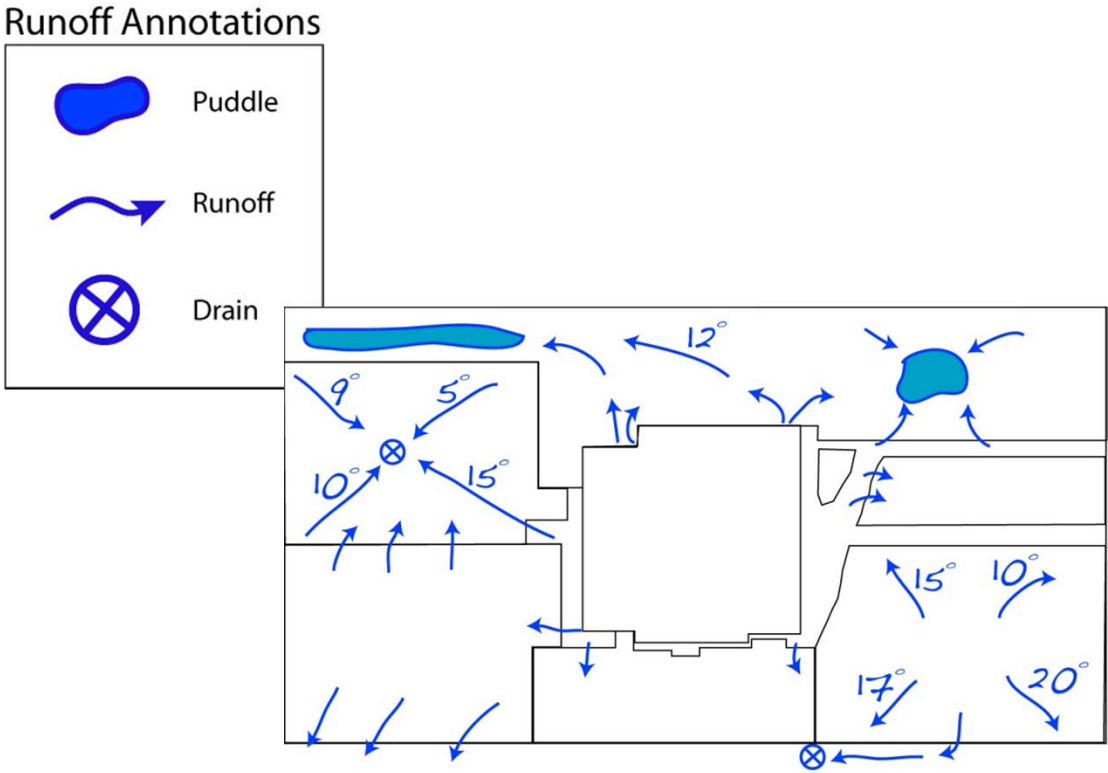
Elan: Well, the bottles could go to the town of Pueblo Rio. The river in Pueblo Rio is connected to this creek.

Deja: I disagree because Pueblo Rio is up in the hills. This river goes to the town of Sweetwater, which is in the lowlands.

Explore: Runoff

Step 2: Collect Data and make estimates

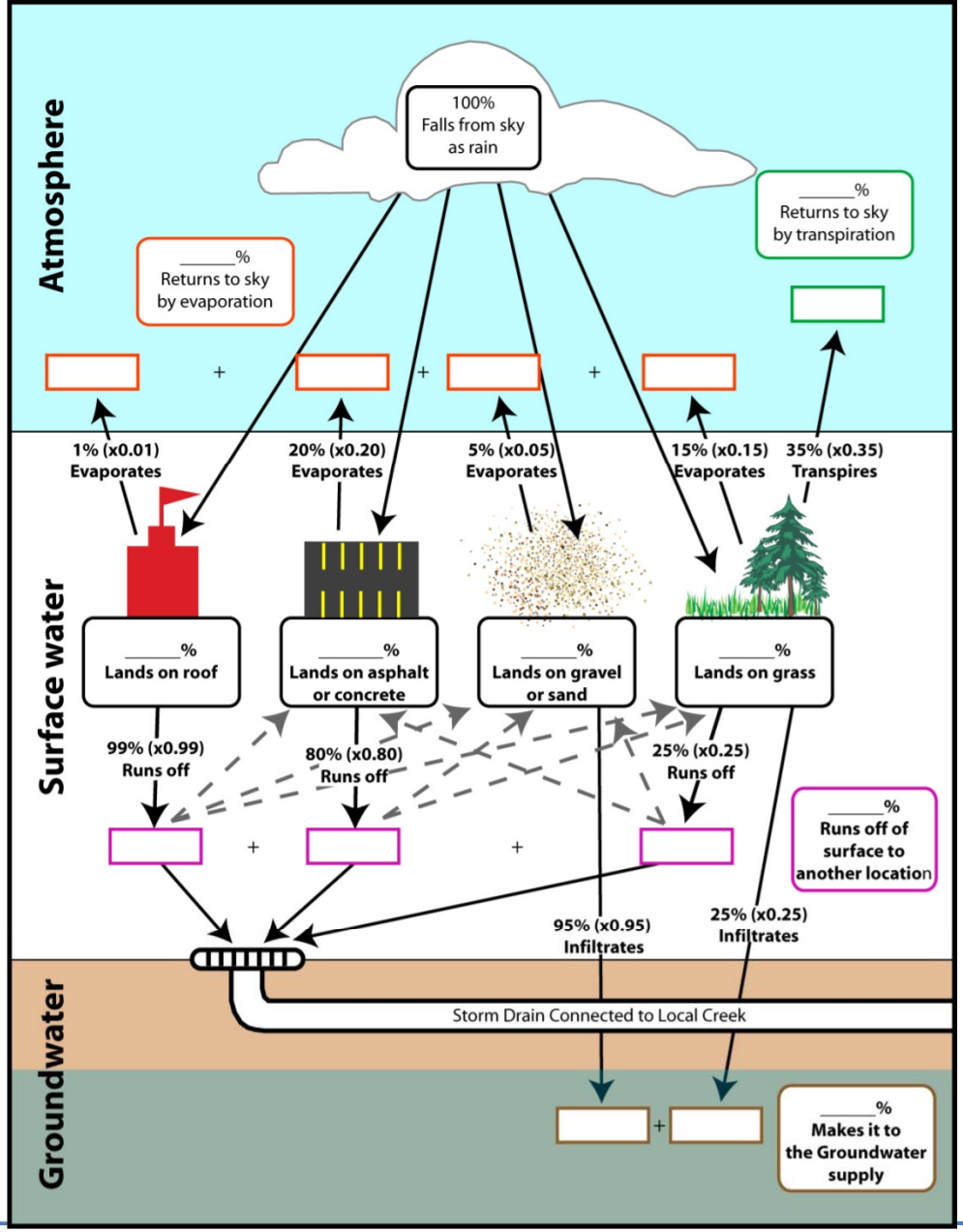




SWB: Synthesize Data, Explain Results

- Using data collected during Schoolyard Explorations, students group proportions of surface types that "treat" water in similar ways into four broad categories:
  - Roof (very high runoff potential)
  - Asphalt/Concrete (high runoff, moderate evaporation)
  - Sand/Gravel (very high infiltration, low evaporation)
  - Vegetation (moderate infiltration/runoff/evaporation, some transpiration)

Logic Model used by students to <u>explain</u> relative proportions of water traveling through different pathways



SWB: Synthesize Data, Explain Results

A11

	A	B	C	D	E	F
1						
2	Instructions: Simply enter the percentages of water falling on the four different surface types.					
3	These should add up to 100%					
4		Precipitates	Runsoff	Infiltrates	Evaporates	Transpirates
5	Percent that lands on roof:	13%	13%	0%	0%	0%
6	Percent that lands on asphalt or concrete:	10%	8%	0%	2%	0%
7	Percent that lands on gravel or sand:	8%	0%	8%	0%	0%
8	Percent that lands on grass:	68%	17%	17%	10%	24%
9		100%	38%	25%	13%	24%
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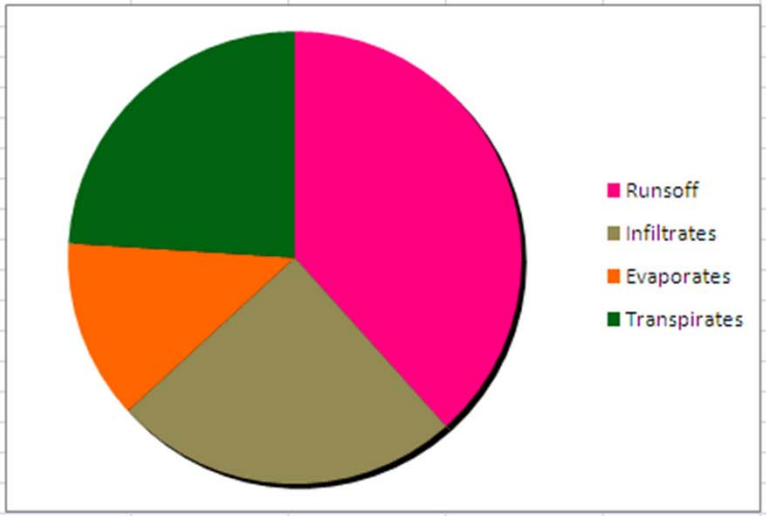


Substances in Water Unit Extension

- What substances are found in schoolyard?
- How do substances mix and unmix with water as they move through schoolyard?
- Where do substances comes from and go to?

Substances in Water

- Addresses students' abilities to:
  - Trace substances in water through connected systems
  - Distinguish between solutions and suspensions
  - Recognize when substances in solution/suspension will mix and unmix from water while moving through connected systems

Formative Assessment (Suspensions)

Construction Site:

A school is doing a construction project and had to dig up some ground. The project left a lot of dirt exposed on surface. Now when it rains, rain could wash away a lot of dirt exposed by construction project. In a rain storm, where might the dirt go?

Could dirt get here?	YES or NO (Circle one)	Explain Your Answer
Groundwater	YES or NO	
A nearby creek that runs by downhill from school	YES or NO	
Inside trees and plants in undisturbed areas around school	YES or NO	

Formative Assessment (Solutions)

The person who takes care of school grounds spread fertilizer on the playing field grass one Friday morning. That Friday afternoon it rained and some of the fertilizer on the grass mixed with water and lay in puddles on the playing field.

Where do you think the fertilizer could end up? Explain your answers.

1)Could fertilizer get into atmosphere and come back down as fertilizer mixed with rain? YES NO

2) Could fertilizer get into School Creek? YES NO

3) Could fertilizer get into groundwater? YES NO

4) Could fertilizer get inside of grass on playing field? YES NO

Substances in Water

- Classroom Explorations:
  - Evaporation with a solar still
  - Effects on plant life with a celery stalk
  - Sunlight availability to plants with a laser
  - Surface flow with a watershed model
  - Groundwater flow with a soil column

Substances in Water

- Solar Still: Do materials in suspension and solution move into atmosphere with water?

Substances in Water

- Do substances in solution and suspension move into and through plants?

Photo by Tamara Newcomer, 2011

Substances in Water

- Which substances could affect the amount of light reaching aquatic plants?

Photo by Tamara Newcomer, 2011

Substances in Water

- Do substances in suspension and solution move with surface water?

Photo by Beth Covitt, 2011

Substances in Water

- Do substances in solution and suspension travel with water into groundwater?

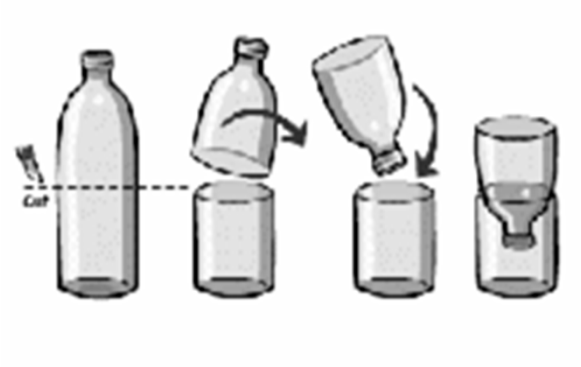


Photo by Beth Covitt, 2011

Elaborate: Apply Ideas to Real Issues

Students return to SWB logic model to test scenarios such as…

- evaluating impact of replacing a paved surface with lawn
- identifying sources of pollution that could contaminate runoff or groundwater

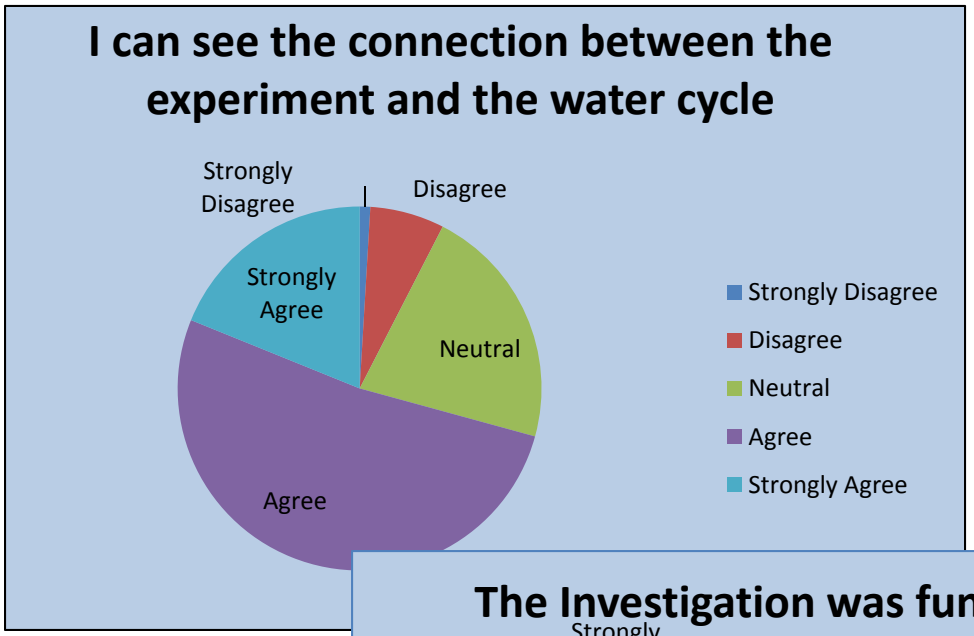
Asphalt removal and replanting in a Baltimore City schoolyard.

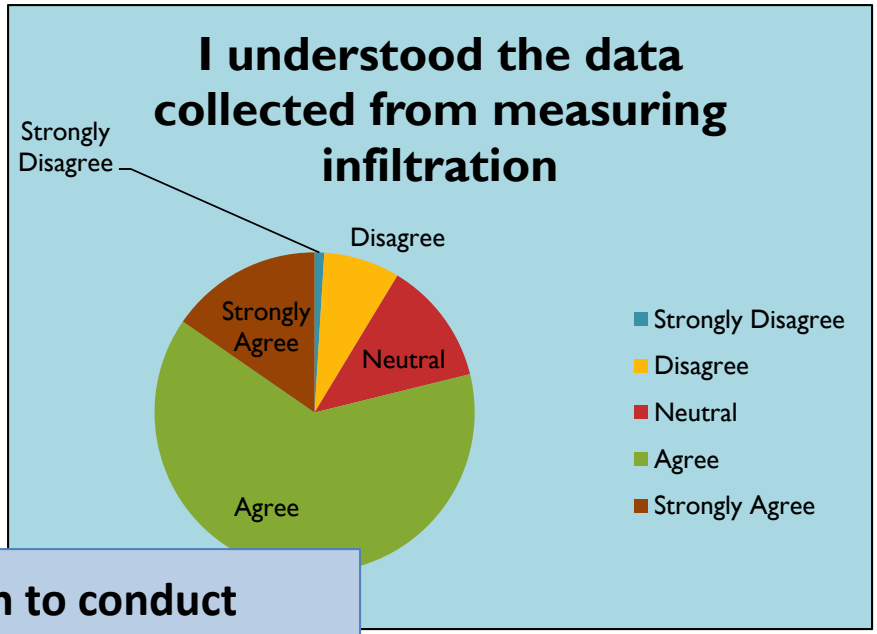
Evaluate: Student Outcomes

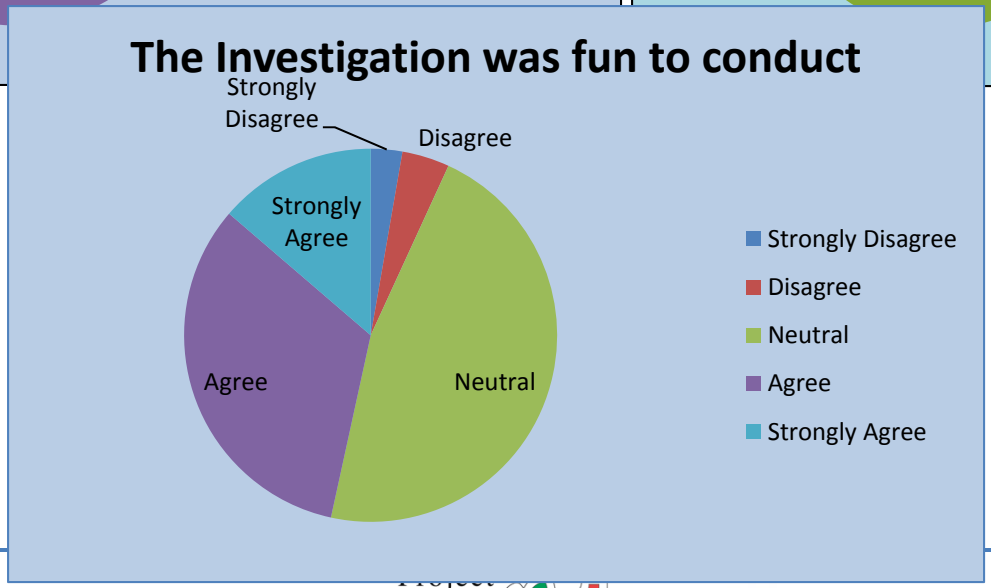
Only preliminary results are available. Future results will include data from the following…

- Formative Assessments used throughout
- Pre and post assessments and student interviews to assess summative student knowledge
- Science notebooks used to record student ideas

Evaluating Student Outcomes







Evaluate: Student Outcomes

- "I understand it more b/c it was hands on."
- "I actually enjoyed the activity, because I had not realized all of the different surfaces our campus has."
- "I enjoyed the activity. It allowed me to have a better understanding and closer look at how surfaces in the environment effect the water cycle."
- "You should conduct more outside activities like this one."
- "I really like the outside activities. It gives me more of a chance to experience nature. The natural environment helps me get a better understanding of what life is about. We need to do more to conserve our resources. I would like to go to different locations and see what their environment is like."

Questions?

- Curriculum may be accessed at the following website:
  - http://www.cns-eoc.colostate.edu/msp-nrel.html
- Contact Bess Caplan for further information:
  - caplanb@caryinstitute.org