Stormwater Runoff Awareness Through Youth Watershed Education

Supplementary Materials

This is the *Supplementary Material* for our Interactive Qualifying Project and was completed through the Worcester Polytechnic Institute Massachusetts Water Resource Outreach Center. This project was completed in collaboration with the Massachusetts Department of Environmental Protection and the Central Massachusetts Stormwater Coalition.

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Appendix A: Data Analysis Tools

Curriculum Analysis Matrix

See Excel Spreadsheet titled "*Watershed Curriculum* Data Analysis Tools" on WPI library database under *Stormwater Runoff Awareness Through Youth Watershed Education*.

Interview Collection Matrix

See Excel Spreadsheet titled "*Watershed Curriculum* Data Analysis Tools" on WPI library database under *Stormwater Runoff Awareness Through Youth Watershed Education*.

Observation Matrix

See Excel Spreadsheet titled "*Watershed Curriculum* Data Analysis Tools" on WPI library database under *Stormwater Runoff Awareness Through Youth Watershed Education*.

Qualitative Detailed Matrix

See Excel Spreadsheet titled "*Watershed Curriculum* Data Analysis Tools" on WPI library database under *Stormwater Runoff Awareness Through Youth Watershed Education*.

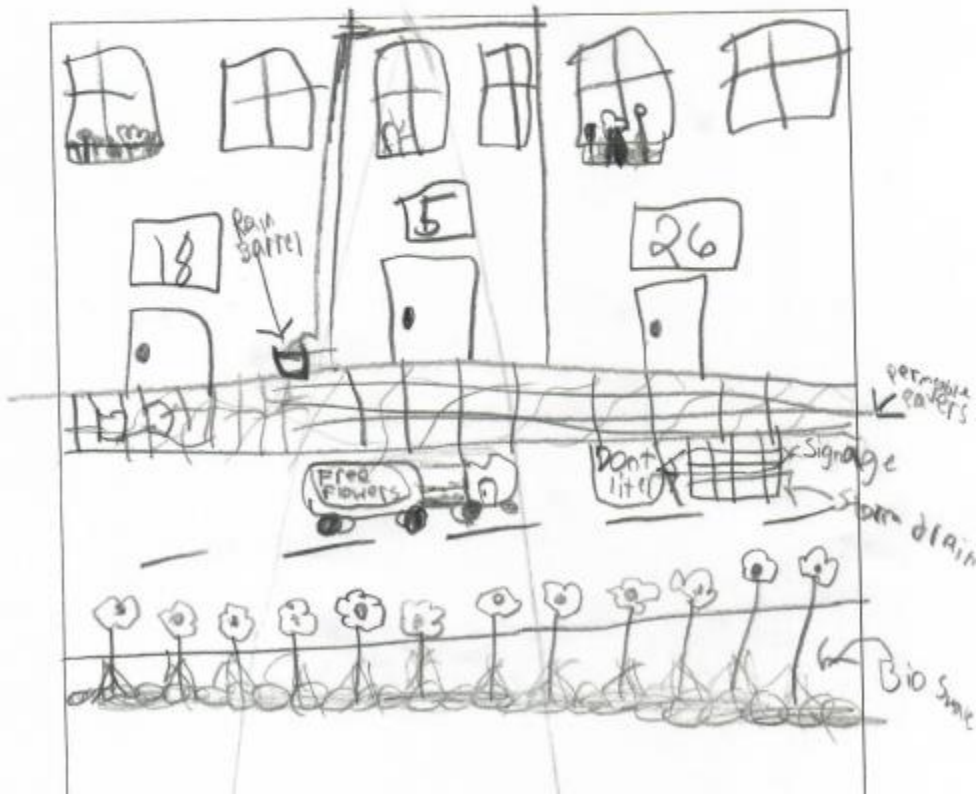
Detailed Matrix

See Excel Spreadsheet titled "*Watershed Curriculum* Data Analysis Tools" on WPI library database under *Stormwater Runoff Awareness Through Youth Watershed Education*.

Appendix B: Student examples

2. Lawyer Laura lives in a high rise apartment building in the highly populated city of Boston, MA. Downhill from her apartment is a large corporate office building with a large parking lot. The entire path from Lawyer Laura's apartment to the parking lot is made of streets and sidewalks. People in the city walk their dogs without picking up after them, drop food wrappers, and do not clean up oil spills from their cars. A large rainstorm is predicted for the next week, and Lawyer Laura calls you for help to prevent polluting the storm water runoff.

Engineer a BMP model to incorporate into a scenario. Use scientific writing to back your reasoning for your design.



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Engineer a BMP model to incorporate into a scenario. Use scientific writing to back your reasoning for your design.

Engineering a Best Management Practice

1. Farmer Joe owns a farm at the very top of a hill overlooking a town. This farm includes many animals, chemically treated plants, and loose soil. A large rainstorm is predicted for the next week, and Farmer Joe calls you for help to prevent polluting the storm water runoff.

Engineer a Best Management Practice model to incorporate into a scenario. Use scientific writing to back your reasoning for your design.

The entire path from Lawyer Laura's apartment to the parking lot is made of streets and sidewalks. People in the city walk their dogs without picking up after them, drop food wrappers, and do not clean up oil spills from their cars. A large rainstorm is predicted for the next week, and Lawyer Laura calls you for help to prevent polluting the storm water runoff.

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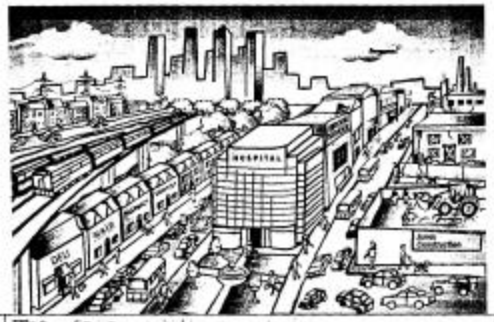
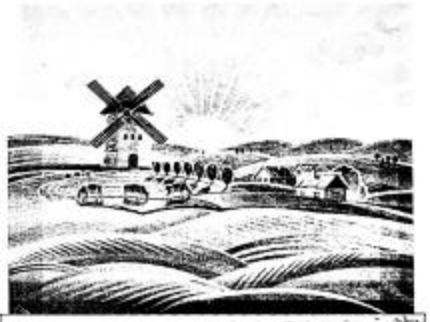
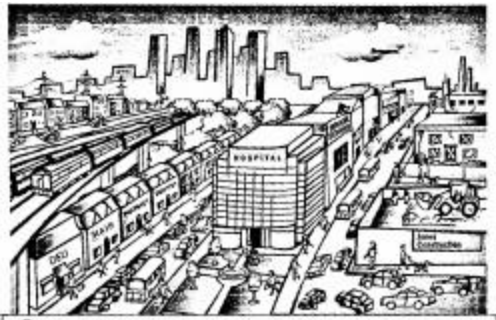




What will happen when it rains?	The rain will go into a storm drain. The water might seep into cracks in the concrete.	the rain can seep into the ground and become ground water.
Where does all the stormwater go?	Storm drain / puddles	Aquifer (ground water)
List sources that increase or decrease stormwater runoff.		
List pollutants that rainwater could pick up.	dust, straws, plastic, trash loose paper, salt, oil, cups animal waste	dead plants, dust, dead bugs, pestisides, chemicals, trash, fertilizer animal waste

		
What will happen when it rains?	Goes into storm-drain and go back into the ocean	seeps into the ground and [illegible] ground water and aquifer.
Where does all the stormwater go?	Storm-drain	Into the ground
List sources that increase or decrease stormwater runoff.		
List pollutants that rainwater could pick up.	Trash, Plastic, paper, wrappers, straws, oil, salt	Dirt, AW, tree branches, rocks, oil, pebbels, trash, fertilizer

Appendix C: Exit Tickets

Exit Ticket Lesson 6

This "Exit Ticket" was used as a data collection method for us to see how well the students retained the knowledge being taught. This was used following the piloted lesson 6 of the *Watershed Curriculum*.

Exit Ticket Lesson 6				
Please write your first name and last name.	Which group of pollutants are most likely to be found on a local farm?	Check off which boxes create an increase in stormwater runoff.	Do cities have more stormwater runoff than farm towns?	Does stormwater runoff carry pollutants into local bodies of water?
Student 1	Animal waste, Oil, Fertilizer	Roof of a Building, Sidewalks, Roads	Yes	Yes
Student 2	Animal waste, Oil, Fertilizer	Roof of a Building, Sidewalks, Roads	Yes	No
Student 3	Animal waste, Oil, Fertilizer	Roof of a Building, Sidewalks, Roads	Yes	Yes
Student 4	Animal waste, Oil, Fertilizer	Roof of a Building, Sidewalks, Roads	Yes	Yes
Student 5	Animal waste, Oil, Fertilizer	Roof of a Building, Sidewalks, Roads	Yes	Yes
Student 6	Animal waste, Oil, Fertilizer	Sidewalks, Roads	Yes	Yes
Student 7	Animal waste, Oil, Fertilizer	Roof of a Building, Sidewalks, Roads	Yes	Yes
Student 8	Animal waste, Oil, Fertilizer	Roof of a Building, Sidewalks, Baseball/Softball Field, Roads	Yes	No
Student 9	Animal waste, Oil, Fertilizer	Roof of a Building, Sidewalks, Roads	Yes	Yes
Student 10	Animal waste, Oil, Fertilizer	Roof of a Building, Sidewalks, Baseball/Softball Field, Roads	Yes	Yes
Student 11	Animal waste, Oil, Fertilizer	Roof of a Building, Sidewalks, Baseball/Softball Field, Roads	Yes	Yes
Student 12	Animal waste, Oil, Fertilizer	Roof of a Building, Sidewalks, Roads	Yes	Yes
Student 13	Animal waste, Oil, Fertilizer	Roof of a Building, Trees, Sidewalks, Baseball/Softball Field, Grass, Roads	No	Yes

Student 14	Animal waste, Oil, Fertilizer	Roof of a Building, Sidewalks, Roads	Yes	No
Student 15	Animal waste, Oil, Fertilizer	Roof of a Building, Sidewalks, Roads	Yes	Yes
Student 16	Animal waste, Oil, Fertilizer	Roof of a Building, Sidewalks, Roads	Yes	Yes
Student 17	Animal waste, Oil, Fertilizer	Roof of a Building, Sidewalks, Baseball/Softball Field, Roads	Yes	Yes
Student 18	Animal waste, Oil, Fertilizer	Roof of a Building, Sidewalks, Roads	Yes	Yes
Student 19	Gum, Banana Peels, Leaves	Roof of a Building	Yes	Yes
Student 20	Animal waste, Oil, Fertilizer	Roof of a Building, Sidewalks, Baseball/Softball Field, Roads	Yes	Yes

Exit Ticket Lesson 7

This "Exit Ticket" was used as a data collection method for us to see how well the students retained the knowledge being taught. This was used following the piloted lesson 7 of the *Watershed Curriculum*.

Exit Ticket Lesson 7				
Please write your first name and last name.	Do Rain Barrels collect stormwater from roofs of buildings?	Do you think more Best Management Practices for stormwater should be built?	Which Best Management Practice for stormwater runoff would you install in a parking lot?	Which Best Management Practice allows stormwater to soak into the soil and has plants to use some of that water?
Student 1	Yes	Yes	Rain Barrel (Collect rain water off roofs)	Rain Garden
Student 2	Yes	Yes	Permeable Pavers (Allows infiltration)	Bio Swale
Student 3	Yes	Yes	Storm Drain	Rain Garden
Student 4	Yes	Yes	Storm drains	Rain Garden
Student 5	Yes	Yes	Storm drain with sign	Rain Garden
Student 6	Yes	Yes	Permeable Pavers (Allows infiltration)	Rain Garden
Student 7	Yes	Yes	Permeable Pavers (Allows infiltration)	Bio Swale
Student 8	Yes	Yes	Permeable Pavers (Allows infiltration)	Aggregate Strip
Student 9	Yes	Yes	Storm Drain	Rain Garden
Student 10	Yes	Yes	Storm drain	Rain Garden
Student 11	Yes	Yes	Rain Garden (Collects rain water in a garden area)	Bio Swale
Student 12	Yes	Yes	Storm drain	Aggregate Strip
Student 13	Yes	Yes	Permeable Pavers (Allows infiltration)	Bio Swale
Student 14	Yes	Yes	Rain Garden (Collects rain water in a garden area)	Aggregate Strip
Student 15	Yes	Yes	Permeable Pavers (Allows infiltration)	Aggregate Strip
Student 16	Yes	Yes	Rain Barrel (Collect rain water off roofs)	Rain Garden
Student 17	Yes	Yes	Permeable Pavers (Allows infiltration)	Aggregate Strip

Student 18	Yes	Yes	Signage	Aggregate Strip
Student 19	Yes	Yes	Permeable Pavers (Allows infiltration)	Rain Garden
Student 20	Yes	Yes	Storm drain	Rain Garden
Student 21	Yes	Yes	Permeable Pavers (Allows infiltration)	Bio Swale
Student 22	Yes	Yes	Permeable Pavers (Allows infiltration)	Rain Garden
Student 23	Yes	Yes	Permeable Pavers (Allows infiltration)	Rain Garden
Student 24	Yes	Yes	Permeable Pavers (Allows infiltration)	Rain Garden
Student 25	Yes	Yes	Permeable Pavers (Allows infiltration)	Rain Barrel
Student 26	Yes	Yes	Permeable Pavers (Allows infiltration)	Aggregate Strip
Student 27	Yes	Yes	Storm drain	Rain Garden
Student 28	Yes	Yes	Permeable Pavers (Allows infiltration)	Rain Garden
Student 29	Yes	Yes	Permeable Pavers (Allows infiltration)	Rain Garden
Student 30	Yes	Yes	Permeable Pavers (Allows infiltration)	Rain Garden
Student 31	Yes	Yes	Permeable Pavers (Allows infiltration)	Aggregate Strip
Student 32	Yes	Yes	Permeable Pavers (Allows infiltration)	Rain Garden
Student 33	Yes	Yes	Rain Garden (Collects rain water in a garden area)	Rain Garden
Student 34	Yes	Yes	Permeable Pavers (Allows infiltration)	Rain Garden
Student 35	Yes	Yes	Permeable Pavers (Allows infiltration)	Rain Garden
Student 36	Yes	Yes	Permeable Pavers (Allows infiltration)	Bio Swale
Student 37	Yes	Yes	Permeable Pavers (Allows infiltration)	Bio Swale
Student 38	Yes	Yes	Permeable Pavers (Allows infiltration)	Rain Garden
Student 39	Yes	Yes	Permeable Pavers (Allows	Bio Swale

			infiltration)	
Student 40	Yes	Yes	Rain Barrel (Collect rain water off roofs)	Bio Swale
Student 41	Yes	Yes	Permeable Pavers (Allows infiltration)	Bio Swale

Appendix D: Interview Questions

Educational Professional

1. Good afternoon Nicole, Andrea got us in contact with you because she said you would have a wealth of information regarding the massachusetts science standards. To give you a little background, our group is teamed with the MassDEP and the CMRSWC to create a new 5th grade watershed curriculum to create public outreach and awareness regarding stormwater. We would really appreciate and it would make our project have more weight if the DOE was backing the curriculum.
2. Andrea said you have experience developing curriculums, what kind of curriculums have you developed in your career?
    a. What is the most difficult part about it?
    b. What are some main things you try and incorporate into curriculums?
3. A goal of the curriculum is to spread awareness and instill pro-environmental behavior within students and the community. How would you advise to incorporate this into the curriculum?
4. Do you know if the Mass Science standards currently address stormwater? From what we have seen looking through the state curriculums stormwater itself is not specifically addressed, and a common problem is that some teachers do not even know about stormwater. We believe that incorporating interactive activities could help create awareness such as rain gardens, take home projects, science fair activities etc.
    a. Additionally, our team is planning to create a tutorial video of some sort. Do you believe teaching the teacher about stormwater would be useful? Or do you have any other ideas?
5. Which parts of the science standards do schools find most difficult complying with?
6. Holden teacher talk
7. What do you think is the most effective way to engage students?
8. How can we make lessons more interactive?
9. How do you define "effective" curriculum?
10. What aspects of a curriculum help incorporate parental involvement?
11. Any further advice?
12. Do you have any additional resources that may be applicable?

Living Labs Curriculum Meeting

1. In what ways do you integrate MS4 requirements into the schools?
    a. In regards to the first control measure, how are you deeming your methods effective?
    b. Do you think your definition of effective will satisfy what the MS4 permit requests?
    c. Do you think a Stormwater curriculum is a good way to induce public awareness?
2. What types of public outreach campaigns have you used?
3. Has there been any collaboration between you and other communities that has helped you comply with the permit?
4. What major problems do you see municipalities facing to comply with the MS4 permit as the deadline approaches? Do you think that the deadline will be pushed back again?
5. Do you encourage student driven learning, where the teacher is more so the facilitator rather than a lecturer?
    a. What are some techniques used?
6. When working with the Science Standards what are good ways to use engineering components?
7. How do you make lessons more interactive? Do students like interactive lesson plans? Is this, in your opinion an effective way to teach? If not, what do you believe is the most effective way to teach?
8. Throughout the year how involved are the parents in the children's academic lives?
    a. What aspects of a curriculum help incorporate parental involvement?
9. Are there state curriculum standards that are difficult to comply with?
10. What are difficulties in general in building curriculum?
11. Any further advice or additional resources?

Town Engineer

1. Good morning Mr. Stone, Andrea got us in contact with you because she said you have a very good understanding regarding the MS4 Permit. To give you a little background, our group is teamed with the MassDEP and the CMRSWC to create a new 5th grade watershed curriculum to create public outreach and awareness regarding stormwater in Shrewsbury and Holden.
2. We understand that Shrewsbury is well ahead of other communities. What are some things you have implemented to help the community comply with the MS4 minimum control measures?
3. How do you think an elementary curriculum could help Shrewsbury comply with the first minimum control measure?
4. In your personal opinion, what do you think "effective" public outreach is in regards to the first minimum control measure?
    a. Are there any public outreach campaigns currently implemented in Shrewsbury?
    b. How do you see Shrewsbury complying with the first minimum control measure?
5. What major problems do you see municipalities facing to comply with the MS4 permit as the deadline approaches? Do you think that the deadline will be pushed back again?
6. In Shrewsbury has there been any effective public outreach campaigns used in the past?
7. Do you have any additional resources that may be applicable?

Teacher

1. Good afternoon Ms. Matthews, Andrea got us in contact with you because she said you expressed the need for a stormwater curriculum. To give you a little background, our group is teamed with the MassDEP and the CMRSWC to create a new 5th grade watershed curriculum to create public outreach and awareness regarding stormwater runoff. MS4...
2. We know The Next Generation Science Standards are new, how are your classes going in regards to that?
    a. How are the kids adapting?/ are they liking it?
    b. What do you have to do differently now when teaching?
    c. Are other teachers adjusting well?
    d. What kind of things would help you the most from our curriculum?
    e. Part of our project is creating a 3-5 min video, what kind of video do you think would be helpful?
3. What teaching methods do you find to be the most effective?
4. What do you think are the most effective ways to engage students?
5. How do you make lessons more interactive? Do students like interactive lesson plans? Is this, in your opinion an effective way to teach? If not, what do you believe is the most effective way to teach?
6. Throughout the year how involved are the parents in the children's academic lives?
    a. What aspects of a curriculum help incorporate parental involvement?
7. Are there state curriculum standards that are difficult to comply with?
8. We want to pilot the curriculum we create with you and we were wondering when we would be able to do that. Ideally we would want to pilot the curriculum between April 9th and April 20th, however we understand this topic may come up another time.
9. Any further advice?
10. Do you have any additional resources that may be applicable?

Newton Tedder

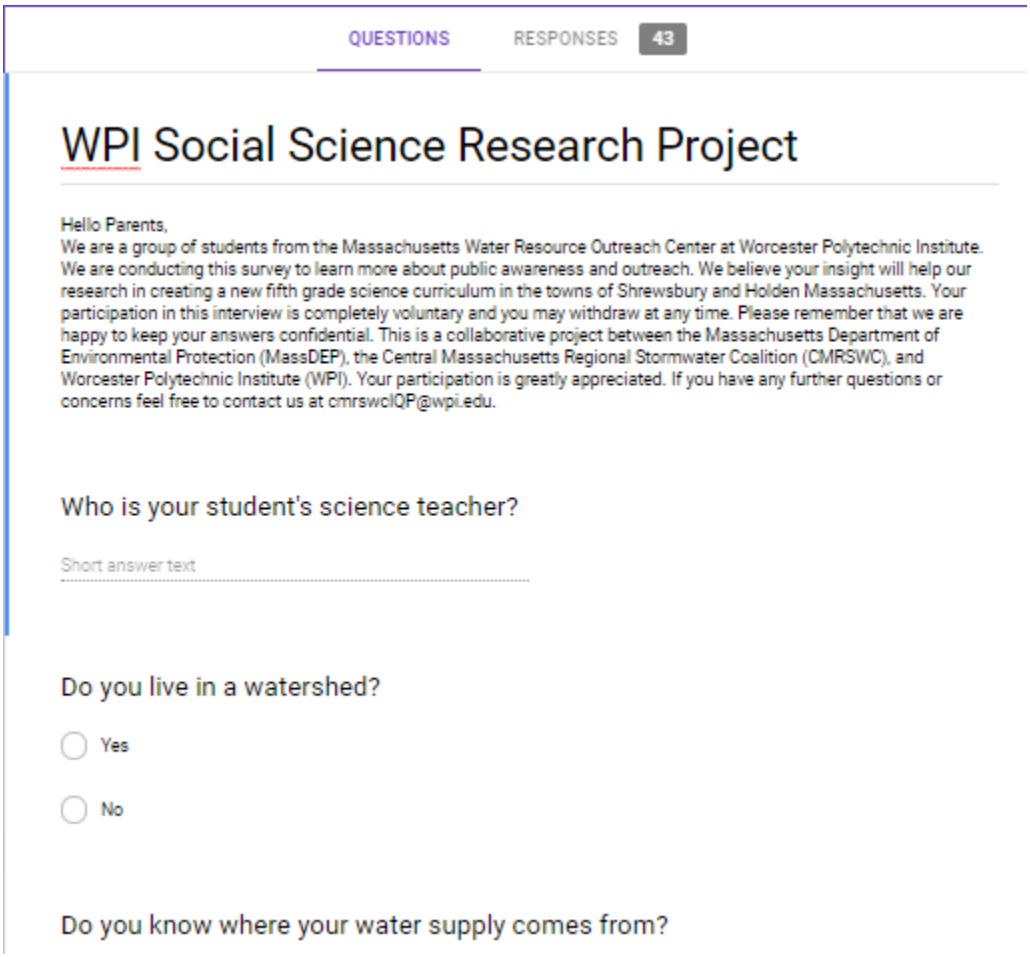
Newton Tedder Interview Questions

1. I understand that you are a physical scientist for the US EPA. Your job seems very interesting could you tell us a little about what your job entails.
2. One obstacle our team has faced is defining "effective" in terms of the first minimum control measure. What do you as a drafter of the permit define as effective?
3. Do you think that a Stormwater/Watershed Curriculum would be a viable tool to be used to help towns comply with the first minimum control measure of the MS4 permit?
    a. We were thinking of interpreting the definition of effectiveness by looking at before/after implementing the curriculum.This would be based on changes in parent involvement, student's opinions and beliefs before and after lessons, and implementation of active learning programs such as the enviroscape.
4. Have you seen any public outreach campaigns that you think were effective?
5. How do you think towns can gauge their own effectiveness?
6. Is there a tangible goal our group can set to attain an effective means of outreach and education?
7. What do you think the hardest part of us proving efficiency in our curriculum will be? This is next question, Also explain how we are going to survey parents before and after.
8. Have any other methods of public outreach and education been approved as effective in regards to the permit?

Educational Resources

1. Our group is working in collaboration with the CMRSWC and the MassDEP, we are creating a 5th grade watershed curriculum in the towns of Shrewsbury and Holden. This new curriculum will help the towns meet the first minimum control measure of the MS4 permit. We have done some research on MA Audobon but would like to hear from you about your program/curriculum/goals.
2. Are you aware of the MS4 permit coming up with the first minimum control measure being public outreach and education. This is where our project stems from. (talk about project)
3. When MA Audobon builds programs/curriculums what are some of the steps/process you go through to create a quality product?
4. What other kinds of public outreach and educational tools does the MassAudobon provide? How could we replicate this in a 5th grade setting?
5. We are going to use the backwards planning process to build our curriculum. This starts by having tangible goals/knowledge that we want students to walk away with. Regarding stormwater in your personal opinion what should some these goals be?
6. We saw MassAudobon provides a program called "Worcester Water and Sewer 101." Could you please tell us more about this? Are there similar programs to this?
7. We read online that MassAudobon teaches students in classrooms and at MassAudobon. Would it be possible to incorporate field trips to MassAudobon into our watershed curriculum?
8. Is it possible to look at some of your rain gardens/LID features and how it is incorporated into your program?

Appendix E: Parent Survey



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WPI Social Science Research Project

Hello Parents,
We are a group of students from the Massachusetts Water Resource Outreach Center at Worcester Polytechnic Institute. We are conducting this survey to learn more about public awareness and outreach. We believe your insight will help our research in creating a new fifth grade science curriculum in the towns of Shrewsbury and Holden Massachusetts. Your participation in this interview is completely voluntary and you may withdraw at any time. Please remember that we are happy to keep your answers confidential. This is a collaborative project between the Massachusetts Department of Environmental Protection (MassDEP), the Central Massachusetts Regional Stormwater Coalition (CMRSWC), and Worcester Polytechnic Institute (WPI). Your participation is greatly appreciated. If you have any further questions or concerns feel free to contact us at cmrswcIQP@wpi.edu.

Who is your student's science teacher?

Short answer text

Do you live in a watershed?

- Yes
- No

Do you know where your water supply comes from?

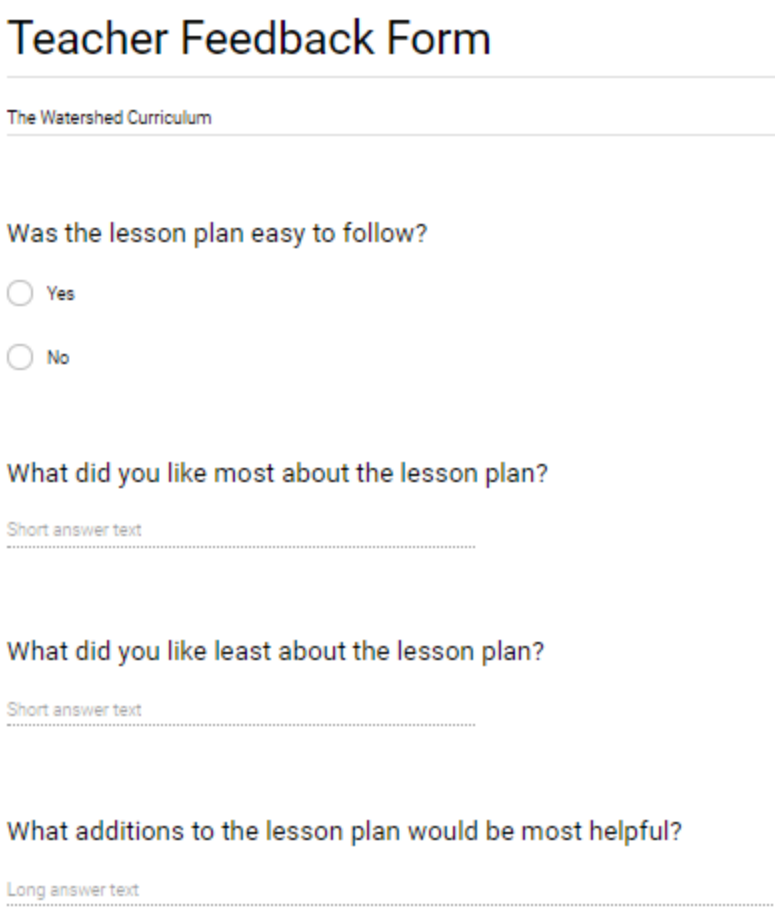
Parent Survey Responses						
Do you live in a watershed?	Do you know where your water supply comes from?	Do storm drains empty into the sewer system?	From 0-100%, what percentage of the bodies of water in central Massachusetts are polluted?	How often do students bring flyers home to you?	How often do you communicate with your child on what was taught that day in school?	On a scale of 1-10, how involved would you say you are in your student's academic life?
No	Yes	Yes	No idea	Never	Every Night	9
No	Yes	Yes	40	Once a week	Every Night	8
Yes	No	Yes	50%	2-3 times a week	2-3 times a week	8
No	Yes	Yes	50	Never	Every Night	8
No	No	No	90	Once a week	2-3 times a week	9
Yes	Yes	No	95	Once a week	Every Night	8
No	Yes	Yes	2%	Never	Every Night	10
No	Yes	Yes	Thirty %	Once a week	Never	10

No	Yes	No		Once a week	Every Night	10
No	Yes	No		Never	2-3 times a week	8
No	Yes	Yes	75%	Once a week	Every Night	9
Yes	Yes	Yes	80	Never	Every Night	10
No	No	Yes	85%	Once a week	Every Night	7
No	No	No	30%	Never	2-3 times a week	6
No	Yes	Yes	37%	Never	Every Night	8
No	No	Yes	65%	Once a week	Every Night	10
No	No	No	30%	Once a week	Every Night	7
No	No	No	not sure	Once a week	Every Night	10
No	No	Yes	50	Never	Every Night	8
No	No	Yes	30%	Once a week	Every Night	8
No	Yes	No	Guessed: 2%	2-3 times a week	2-3 times a week	9
No	Yes	Yes	40	Never	2-3 times a week	10
No	Yes	No	10%	Never	Every Night	10
No	No	Yes	75%	Never	Once a week	5
No	Yes	No	50%	Never	Every Night	10
	Yes	Yes	50	Never	Once a week	7
No	Yes	Yes	50%	Once a week	2-3 times a week	9
No	Yes	Yes	50%	Never	Every Night	10
No	No	Yes	70	Once a week	2-3 times a week	9
Yes	No	Yes	10	Never	Every Night	10
No	No	Yes	45%	Once a week	Every Night	9
No	Yes	Yes		Never	Once a week	5
Yes	Yes	Yes	70%	Never	Every Night	8
Yes	Yes	Yes	75	Once a week	2-3 times a week	9
No	Yes	Yes	30	2-3 times a week	Every Night	10
No	Yes	Yes	25%	2-3 times a week	Every Night	8
Yes	No	Yes	50	Every Night	Every Night	8
Yes	Yes	Yes	25	Once a week	Every Night	9
No	Yes	No	30	Once a week	2-3 times a week	8
No	Yes	Yes	100%	Once a week	Every Night	8

No	Yes	Yes	50%	2-3 times a week	2-3 times a week	8
No	No	Yes	50%	2-3 times a week	Every Night	7
No	Yes	Yes		Never	Every Night	10

Appendix F: Forms

Teacher feedback form



Teacher Feedback Form

The Watershed Curriculum

Was the lesson plan easy to follow?

Yes

No

What did you like most about the lesson plan?

Short answer text

What did you like least about the lesson plan?

Short answer text

What additions to the lesson plan would be most helpful?

Long answer text

Which lesson did you like the best?

- Day 6 "Impervious vs. Pervious"
- Day 7 "Best Management Practices"
- Day 8 "Engineering Best Management Practice"

Why?

Short answer text

Which lesson did you least like?

- Day 6 "Impervious vs. Pervious"
- Day 7 "Best Management Practices"
- Day 8 "Engineering Best Management Practice"

Why?

Short answer text

What would you have liked to see more of within the lesson plan?

Short answer text

Backpack Mail Consent Form

5th Grade Watershed Lesson Plan
Consent Form
Worcester Polytechnic Institute Social Science Research Team
cmrswcIQP@WPI.edu

Dear Parent(s) or Guardian(s),

We are a group of students from the Massachusetts Water Resource Outreach Center at Worcester Polytechnic Institute. We are conducting a social science research project, creating a new fifth grade watershed curriculum in the towns of Shrewsbury and Holden Massachusetts. This is a collaborative project between the Massachusetts Department of Environmental Protection (MassDEP), the Central Massachusetts Regional Stormwater Coalition (CMRSWC), and Worcester Polytechnic Institute (WPI). To do so we will be creating lesson plans regarding the watershed curriculum and will be piloting these inside some 5th grade classrooms. We will be collecting data and taking photos and short videos to evaluate effective methods of education and stormwater runoff awareness. Your student's participation in these piloted lessons is completely voluntary and the students may withdraw at any time. By signing this document you give the CMRSWC Interactive Qualifying Project group permission to teach the created lessons in the classroom and use findings and photos from our research to benefit our project. If you have any further questions or concerns feel free to contact us at cmrswcIQP@wpi.edu. Your child's participation is greatly appreciated.

_____
(Child's name)

_____
(Parent or Guardian's name printed)

_____
(Parent or Guardian's signature)

Appendix G: *Watershed Curriculum*

2018 5th Grade Watershed Curriculum

This curriculum was designed and created by a social science research team at Worcester Polytechnic Institute based out of the Massachusetts Water Resource Outreach Center in Worcester, Massachusetts. The team worked in collaboration with the Massachusetts Department of Environmental Protection and the Central Massachusetts Regional Stormwater Coalition. This curriculum was specifically designed to satisfy the needs of the 5th grade science teachers in the towns of Shrewsbury and Holden Massachusetts.

Developers:

Michelle Hull

Sam Malafronte

Victoria Nassar

Connor Sakowich

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5th Grade Watershed Unit

Massachusetts 2016 Standards Addressed:

5-ESS2-1 Use a model to describe the cycling of water through a watershed through evaporation, precipitation, absorption, surface runoff, and condensation.

5-ESS3-1 Obtain and combine information about ways communities reduce human impact on the Earth's resources and environment by changing an agricultural, industrial, or community practice or process.

5.3-5-ETS3-2 (MA) Use sketches or drawings to show how each part of a product or device relates to other parts in the product or device.

Grade 5 Unit Goals:

1. Students will be able to explain the process of the water cycle.
2. Students will be able to model the process in which pollutants reach bodies of water and how it impacts the water cycle/ environment.
3. Students will be able to use maps and sketches to identify local watersheds and the bodies of water they flow to.
4. Students will be able to identify different materials and their effect on stormwater runoff
5. Students will be able to identify different designs that help protect Earth's resources and the environment.
6. Students will be able to explain the difference between sewer systems and stormwater systems.
7. Students will be able to model a catch basin system and explain its function.

Day	Chapter	Topic	Unit Goal	MA Standard
1	The Water Cycle	Evaporation, Condensation and Precipitation	1	5-ESS2-1
2	The Water Cycle	Modeling the Water Cycle	2	5-ESS2-1
3	Watershed	Pollution's Effect on Water	2	5-ESS2-1
4	Watershed	Mapping how Water Flows	3	5-ESS3-1
5	Watershed	Modeling a Watershed	3	5.3-5-ETS3-2
6	Stormwater Runoff	Urban vs. Rural Runoff	4	5-ESS3-1
7	Stormwater Runoff	Reducing Runoff with BMPs	5	5-ESS3-1
8	Stormwater Runoff	Engineering a BMP	5	5.3-5-ETS3-2
9	Sewer System vs. Stormwater	The Two Separate Systems	6	5.3-5-ETS3-2
10	Sewer System vs. Stormwater	Catch Basin Model	6/7	5.3-5-ETS3-2

Chapter	The Water Cycle	Day 1	Grade level: 5
Title of Topic	Evaporation, Condensation and Precipitation	Time Frame: 40-50 mins	

Desired Outcome from Lesson: Students will be able to explain the process of the water cycle.

Topic of Lesson: The water cycle is the process which water circulates between the Earths oceans, atmosphere and land. This cycle is made of precipitation, condensation, transpiration and evaporation.

Students Goals of the Day:

- Students will be able to know the differences between precipitation, condensation and evaporation.

Essential Vocabulary

- *Hydrosphere*- All the waters on the earth's surface, such as lakes and seas, and sometimes including water over the earth's surface, such as clouds.
- *Precipitation*- Rain, snow, sleet, or hail that falls to the ground.
- *Condensation*- Water that collects as droplets on a cold surface when humid air is in contact with it.
- *Evaporation*- The process of turning water from liquid into vapor.
- *Groundwater*- Water held underground in the soil or in pores and crevices in rock.

Extended Vocabulary

- *Runoff*- Water from rain, snowmelt, or other sources that flows over the land surface.
- *Geosphere*- Any of the almost spherical concentric regions of matter that make up the earth and its atmosphere, as the lithosphere and hydrosphere.
- *Atmosphere*- The envelope of gases surrounding the earth or another planet.
- *Biosphere*- The regions of the surface, atmosphere, and hydrosphere of the earth (or analogous parts of other planets) occupied by living organisms.

Chapter	The Water Cycle	Day 2	Grade level: 5
Title of Topic	Modeling the Water Cycle	Time Frame: 40-50 mins	

Desired Outcome from Lesson: Students will be able to model the process in which pollutants reach bodies of water and how it impacts the water cycle/environment.

Topic of Lesson: Describe the water cycle through a model, demonstration or depiction.

Students Goals of the Day:

- Students will be able to model and explain how water moves through the water cycle.

Essential Vocabulary

- *Hydrosphere*- All the waters on the earth's surface, such as lakes and seas, and sometimes including water over the earth's surface, such as clouds.
- *Precipitation*- Rain, snow, sleet, or hail that falls to the ground.
- *Condensation*- Water that collects as droplets on a cold surface when humid air is in contact with it.
- *Evaporation*- The process of turning water from liquid into vapor.
- *Groundwater*- Water held underground in the soil or in pores and crevices in rock.

Extended Vocabulary

- *Runoff*- Water from rain, snowmelt, or other sources that flows over the land surface.
- *Geosphere*- Any of the almost spherical concentric regions of matter that make up the earth and its atmosphere, as the lithosphere and hydrosphere.
- *Atmosphere*- The envelope of gases surrounding the earth or another planet.
- *Biosphere*- The regions of the surface, atmosphere, and hydrosphere of the earth (or analogous parts of other planets) occupied by living organisms.

Chapter	The Watershed	Day 3	Grade level: 5
Title of Topic	Pollution's Effect on Water	Time Frame: 40-50 mins	

Desired Outcome from Lesson: Students will be able to model the process in which pollutants reach bodies of water and how it impacts the water cycle/ environment.

Topic of Lesson: There are many ways pollutants can enter bodies of water, the soil and the air. Students will learn the dangers human life can cause the watershed and why it is important to minimize pollution.

Student Goals of the Day:

- Students will identify different pollutants and understand how they negatively affect human life and water quality.

Essential Vocabulary:

- *Groundwater*- Water held underground in the soil or in pores and crevices in rock.
- *Runoff*- Water from rain, snowmelt, or other sources that flows over the land surface.
- *Watershed*- An area or ridge of land that separates waters flowing to different rivers, basins, or seas.
- *Pollutant*- a substance that pollutes something, especially water or the atmosphere.

Extended Vocabulary:

- *Non-point source pollution*- When pollutants enter body of water or into the atmosphere not at a single location.
- *Point source pollution*- When pollutants enter a body of water or into the atmosphere at a single location.

Chapter	Watershed	Day 4	Grade level: 5
Title of Topic	Mapping How Water Flows	Time Frame: 40-50 mins	

Desired Outcome from Lesson: Students will be able to use maps and sketches to identify local watersheds and the bodies of water they flow to.

Topic of Lesson: As it precipitates, water flows downhill into bodies of water. Students will learn the importance of understanding and identifying your watershed and where your water comes from.

Students Goals of the Day:

- Students will be able to explain and map how bodies of water connect to larger bodies of water in their watershed.

Essential Vocabulary:

- *Groundwater*- Water held underground in the soil or in pores and crevices in rock.
- *Runoff*- Water from rain, snowmelt, or other sources that flows over the land surface.
- *Watershed*- An area or ridge of land that separates waters flowing to different rivers, basins, or seas.
- *Pollutant*- a substance that pollutes something, especially water or the atmosphere.

Extended Vocabulary:

- *Non-point source pollution*- When pollutants enter body of water or into the atmosphere not at a single location.
- *Point source pollution*- When pollutants enter a body of water or into the atmosphere at a single location.

Chapter	Watershed	Day 5	Grade level: 5
Title of Topic	Modeling a Watershed	Time Frame: 40-50 mins	

Desired Outcome from Lesson: Students will be able to use maps and sketches to identify local watersheds and the bodies of water they flow to.

Topic of Lesson: As it precipitates, water and pollutants flow downhill to a watershed. Models and visuals will be used to convey the process it takes for water to make it into a watershed.

Students Goals of the Day:

- Students will use a model to explain how water travels across a watershed, picks up pollutants and enters different bodies of water.

Essential Vocabulary:

A. *Groundwater*- Water held underground in the soil or in pores and crevices in rock.

B. *Runoff*- Water from rain, snowmelt, or other sources that flows over the land surface.

C. *Watershed*- An area or ridge of land that separates waters flowing to different rivers, basins, or seas.

D. *Pollutant*- a substance that pollutes something, especially water or the atmosphere.

Extended Vocabulary:

- *Non-point source pollution*- When pollutants enter body of water or into the atmosphere not at a single location.
- *Point source pollution*- When pollutants enter a body of water or into the atmosphere at a single location.

Chapter	Stormwater Runoff	Day 6	Grade level: 5
Title of Topic	Urban vs. Rural Runoff	Time Frame: 40-50 mins	

Desired Outcome from Lesson: Students will be able to identify different materials and their effect on stormwater runoff.

Topic of Lesson: Students will understand stormwater runoff, and how it is different in urban and rural environments.

Students Goals of the Day:

- Students will understand and model the difference between pervious and impervious surfaces in an urban and rural environment.

Essential Vocabulary:

- *Stormwater Runoff*- Rainfall that flows over the ground surface.
- *Best Management Practice (BMP)*- a type of water pollution control.
- *Urban Environment*- A human settlement with high population density and infrastructure of built environment. Urban areas are created through urbanization and are categorized by urban morphology as cities, towns, conurbations or suburbs.
- *Rural Environment*- Open land that has few homes or other buildings, and not very many people.
- *Impervious Surfaces*- Surfaces, such as asphalt, roofs, and sidewalks, where water cannot readily absorb into the ground.
- *Pervious Surfaces*- Surfaces where water can readily absorb into the ground.

Extended Vocabulary:

- *Rain Barrel*- A water tank used to collect and store rainwater runoff, typically from rooftops via pipes.
- *Rain Garden*- A planted depression or a hole that allows rainwater runoff from impervious urban areas, like roofs, driveways, walkways, parking lots, and compacted lawn areas, the opportunity to be absorbed.
- *Green Roof*- A roof of a building that is partially or completely covered with vegetation and a growing medium, planted over a waterproofing membrane.

Chapter	Stormwater Runoff	Day 7	Grade level: 5
Title of Topic	Reducing Runoff with BMPs	Time Frame: 40-50 mins	

Desired Outcome from Lesson: Students will be able to identify different designs that help protect Earth's resources and the environment.

Topic of Lesson: Students will learn how runoff can be reduced through best management practices.

Student Goals of the Day

- Students will understand what best management practices are and how they can naturally filter water.

Essential Vocabulary:

- *Stormwater Runoff*- Rainfall that flows over the ground surface.
- *Best Management Practice*- a type of water pollution control.
- *Urban Environment*- A human settlement with high population density and infrastructure of built environment. Urban areas are created through urbanization and are categorized by urban morphology as cities, towns, conurbations or suburbs.
- *Rural Environment*- Open land that has few homes or other buildings, and not very many people.
- *Impervious Surfaces*- Surfaces, such as asphalt, roofs, and sidewalks, where water cannot readily absorb into the ground.
- *Pervious Surfaces*- Surfaces where water can readily absorb into the ground.

Extended Vocabulary:

- *Rain Barrel*- A water tank used to collect and store rainwater runoff, typically from rooftops via pipes.
- *Rain Garden*- A planted depression or a hole that allows rainwater runoff from impervious urban areas, like roofs, driveways, walkways, parking lots, and compacted lawn areas, the opportunity to be absorbed.
- *Green Roof*- A roof of a building that is partially or completely covered with vegetation and a growing medium, planted over a waterproofing membrane.

Chapter	Stormwater Runoff	Day 8	Grade level: 5
Title of Topic	Engineering an BMP	Time Frame: 40-50 mins	

Desired Outcome from Lesson: Students will be able to identify different designs that help protect Earth's resources and the environment.

Topic of Lesson: Students will use a model, sketch, drawing, or other representation of a BMP to solve a stormwater runoff problem in an urban setting.

Students Goals of the Day:

- Students will engineer a BMP model to incorporate into a scenario.
- Students will use scientific writing to back their reasoning for their design.

Essential Vocabulary:

- *Stormwater Runoff*- Rainfall that flows over the ground surface.
- *Best Management Practice (BMP)*- a type of water pollution control.
- *Urban Environment*- A human settlement with high population density and infrastructure of built environment. Urban areas are created through urbanization and are categorized by urban morphology as cities, towns, conurbations or suburbs.
- *Rural Environment*- Open land that has few homes or other buildings, and not very many people.
- *Impervious Surfaces*- Surfaces, such as asphalt, roofs, and sidewalks, where water cannot readily absorb into the ground.
- *Pervious Surfaces*- Surfaces where water can readily absorb into the ground.

Extended Vocabulary:

- *Rain Barrel*- A water tank used to collect and store rainwater runoff, typically from rooftops via pipes.
- *Rain Garden*- A planted depression or a hole that allows rainwater runoff from impervious urban areas, like roofs, driveways, walkways, parking lots, and compacted lawn areas, the opportunity to be absorbed.
- *Green Roof*- A roof of a building that is partially or completely covered with vegetation and a growing medium, planted over a waterproofing membrane.

Chapter	Sewer System vs. Stormwater	Day 9	Grade level: 5
Title of Topic	The Two Separate Systems	Time Frame: 40-50 mins	

Desired Outcome from Lesson: Students will be able to explain the difference between sewer systems and stormwater systems.

Topic of Lesson: Students will understand the stormwater system and sewer system, and how the different parts of each system work together.

Students Goals of the Day:

- Students will be able to identify the different characteristics between a sewer system and a stormwater system.

Essential Vocabulary:

- *Catch Basin*- A reservoir or well into which surface water may drain off.
- *Grate*- Prevents large debris from entering the catch basin.
- *Outflow Pipe*- The pipe in which stormwater is carried from the catch basin to a nearby body of water.

Extended Vocabulary:

- *Wastewater Treatment Plant*- The process of removing contaminants from wastewater. It includes physical, chemical and biological processes to remove physical, chemical and biological contaminants.
- *Sludge*- The residual, semi-solid material that is produced as a by-product during sewage treatment of wastewater.
- *Influent*- The dirty wastewater that flows into a water treatment plant.
- *Effluent*- The cleaned wastewater or final liquid that flows out of a treatment plant.

Chapter	Sewer System vs. Stormwater	Day 10	Grade level: 5
Title of Topic	Catch Basin Model	Time Frame: 40-50 mins	

Desired Outcome from Lesson: Students will be able to model a catch basin system and explain its function.

Topic of Lesson: Catch basins are an integral part of stormwater runoff management. Using a small group experiment, students will create their own catch basin system.

Students Goals of the Day:

- Students will be able to explain and model the function of each part of a catch basin.

Essential Vocabulary:

- *Catch Basin*- A reservoir or well into which surface water may drain off.
- *Grate*- Prevents large debris from entering the catch basin.
- *Outflow Pipe*- The pipe in which stormwater is carried from the catch basin to a nearby body of water.

Extended Vocabulary

- *Wastewater Treatment Plant*- The process of removing contaminants from wastewater. It includes physical, chemical and biological processes to remove physical, chemical and biological contaminants.
- *Sludge*- The residual, semi-solid material that is produced as a by-product during sewage treatment of wastewater.
- *Influent*- The dirty wastewater that flows into a water treatment plant.
- *Effluent*- The cleaned wastewater or final liquid that flows out of a treatment plant.

5th Grade Watershed Curriculum

Lesson Plan Booklet

Lesson 1: Introduction to The Water Cycle
Teacher Guideline

Overview: One of Earth's four major systems is the hydrosphere. This system is made up of precipitation, condensation, transpiration and evaporation.

Note to Educator: Acting as a facilitator, force the students to derive the essential questions by asking triggering questions.

Preparation Materials

- Blank Piece of Paper

Instruction:

- Have the students sit in groups of 3-5.
- Initially, have the students take 5 minutes and write down all the ways they use water. After some time has elapsed have students raise their hand and have them compile the ideas on the board.
- Have the students discuss with their groups if the water on Earth today is the same water dinosaurs used.
- Now let's do a scenario on the board, have a student come up and draw a body of water. Now start explaining that it is a warm summer day, and ask the class what is happening to the water? The student at the board can "Phone a Friend" if they do not know the answer.
- Have another student come up and draw a cloud above the body of water, and have them answer how this happened. This can be a group collaboration to get to the answer.
- Now have students explain what happens when a lot of condensation occurs and the water becomes "heavy". Have the next student explain precipitation, and have them relate that the water comes full circle. Throughout this whole board exercise write the words "Evaporation, Condensation and Precipitation" on the board for the students to visualize what is being taught.
- Next pass out a blank piece of paper, have the students in each group draw their own water cycle. Make the students have as much detail as possible and give explanations of each part of the process.

Lesson 2: The Water Cycle Experiment
Teacher Guideline

Overview: One of Earth's four major systems is the hydrosphere. This system is made up of precipitation, condensation, transpiration and evaporation.

Note to Educator: Acting as a facilitator, force the students to derive the essential questions by asking triggering questions. Force the students using their model to identify various parts of the water cycle.

Preparation Materials

- Beakers for every group
- Small hard plastic cups (So they fit inside beaker)
- Boiling water
- Hair Spray
- Snow or ice

Preparation:
Collect snow or ice into a bowl, have a pot of boiling or hot water, have enough glass beakers for each group, have hard plastic cups that fit into the top of the beaker.

Experimental steps:

1. Have the students break into small groups preferably of 3-4 kids.
2. On the board have questions which engage the students and put them in scenarios where evaporation and condensation and ask them which part of the water cycle it is in each scenario.
3. In each group, assign a material collector. (In more technologically advanced scenarios assign a photographer or videographer who will capture the experiment as it goes.)
4. Have the material collector get one beaker, and a plastic cup full of ice or snow.
5. Walk around with the boiling water and pour 50 mL into each beaker, then have the students place the plastic cup inside the top of the beaker (This should leave space between the plastic cup and the water in the beaker).
6. This is Part 1, have students make observations and write questions for each part. (In this part the students should observe water on the side of the glass as condensation, they might even see water droplets rush down the side of the glass as precipitation. Questions which cover these topics are also a good sign as students are questioning what is happening.)
7. Part 2 begins with having the material collector dump out the now warm water.
8. Once again, walk around and pour 50 mL of water in each beaker and have the students once again place the cup of snow or water into the beaker.
9. Then walk around and spray hairspray into each beaker, the condensed water will attach itself to the hair spray and create a cloud like feature.
10. Once this is done have the students remove the plastic cup from the beaker and watch the cloud of hair spray and also condensed water evaporate into the air.
11. Part 3 is the cloud when the plastic cup is removed.
12. Once the experiment is over, lead a group discussion which the students ask questions they developed throughout the experiment and also have them say where they saw each part of the water cycle (Condensation, evaporation and precipitation).

Lesson 2: Water Cycle Experiment

Name: _____

Directions: As you complete the experiment, fill out the table below with your observations from what you see happening inside the beaker.

Part 1: Observations	Questions
Part 2: Observations	Questions
Part 3: Observations	Questions

Lesson 3: Pollutions Effect on Water

Teacher Guideline

Overview: Youth will describe and identify the link between land use activities within a watershed and water quality.

Note to Educator: Students will evaluate the quality of a "water sample" (a bag of skittles), graph their results, and form a hypothesis about the land use near the location their "sample" was collected.

Preparation Materials

- Candy (skittles)
- Plastic sandwich bags
- Graph paper
- Colored pencils or crayons
- Pollutant labels

Experimental Steps:

Teacher preparation

1. Divide the candy into the sandwich bags (you may want to manipulate the bags so that the assortment of candy represents a particular land use area by adding more of a certain type of pollutant, rather than relying on a random mix).

   PURPLE = Sediment RED = Pesticides GREEN = Fertilizers YELLOW = Oil and Gas ORANGE = Toxic Waste

2. Prepare one bag (30 pieces) per student or one bag per group of students. Each bag represents a water sample from a watershed.

In class

3. Ask students what a pollutant is. Tell them that each color of skittles represents a different kind of pollutant. You can use the visual aids provided to hang up in the classroom.

   PURPLE = Sediment RED = Pesticides GREEN = Fertilizers YELLOW = Oil and Gas ORANGE = Toxic Waste

   Discuss each of these pollutants with the students. Ask the students where the pollutants come from and the positive and negative impacts they have.

4. Distribute the graph paper to each student or group. Tell the students that they will be drawing a bar graph to show the number of pollutants found in their "water sample." Show them the sample graph provided. Have the students label the x-axis with the pollutant types and the y-axis with the amount of pollutants.
5. Give each group a "water sample." Tell the students to separate and count the number of each pollutant and graph them on the paper. Remind the students that they cannot eat the skittles until they are finished with their graph!
6. Ask the students to try and determine what activities are occurring in their watershed according to the "water sample." For example, a water sample from an area with a lot of agricultural use may have more sediment, fertilizer, and pesticides.

7. Discuss how each water sample is different. While some samples might contain an abundance of one type of pollution, almost all types of pollutants can be found in every sample (even if they are small amounts). Discuss strategies to reduce pollution. How can the students do this on a large scale (in their community) or small scale (in their own home)?

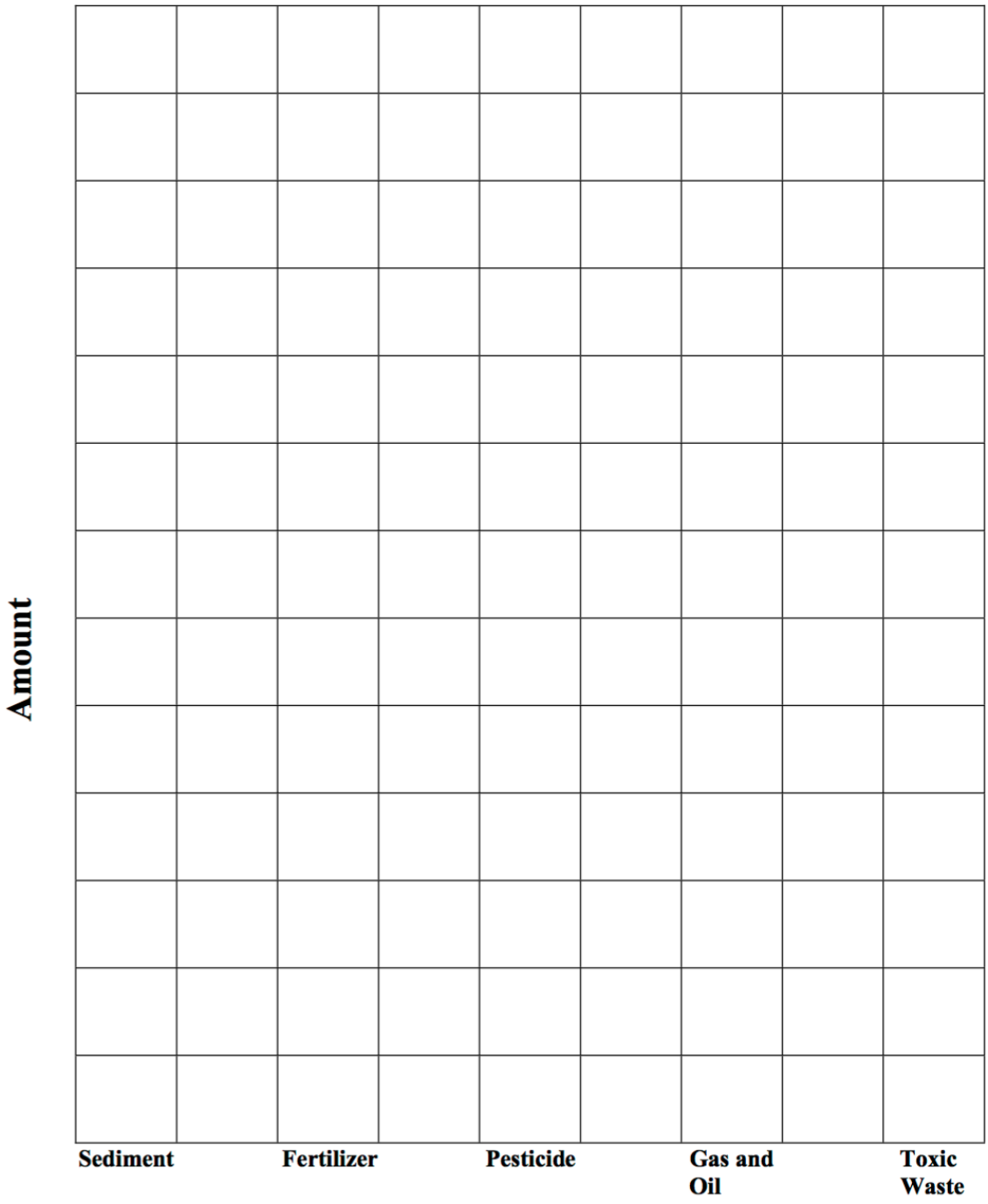
In the community:

- Talk to friends and neighbors about what they have learned
- Pick up trash in your neighborhood

In the home:

- Encourage parents to fix leaky cars
- Talk to parents about using less fertilizers and pesticides
- Recycle items at home
- Do not dump oil, gas, or other pollutants in the storm drains

Water Pollution Graphing Activity



Lesson 3 Continued.

Suggested combinations of skittles for different land uses:

Land use	Purple	Red	Green	Yellow	Orange
Agriculture	8	5	5	2	0
Golf Course	5	5	8	2	0
Factory/Industrial	5	2	5	5	10
Construction	10	0	0	5	0
Neighborhood	2	5	8	5	0

SEDIMENT

FERTILIZERS/ NUTRIENTS

PESTICIDES

OIL AND GAS

TOXIC WASTE

Lesson 4: Enviroscape Demonstration

Teacher Guideline

Overview: Youth will describe and identify how water flows over impervious surfaces and takes pollutants to local bodies of water.

Note to Educator: If looking to purchase Enviroscape table, contact your local DPW official or regional stormwater coalition. Students will be able to visualize and investigate how stormwater runoff travels on impervious surfaces.

Preparation Materials

- Enviroscape
- Baking Soda
- Food coloring
- Cocoa powder
- Water and spray bottle
- Cups

Experimental Steps:

Teacher preparation

- Setup enviroscape by placing animals, houses and trucks on the landscape
- Fill spray bottle with water
- Make different pollutants by adding food coloring to flour
- Place pollutants in different cups and label each pollutant

In class

- Describe the enviroscape to the students.
- Place pollutants in different areas on the landscape and describe them to the kids.
- Pose the question, "What do you think will happen when it rains?"
- Let kids work in groups to come up with answer
- Use spray bottle and spray the landscape
- Ask what they see. "Why is the water flowing on the streets? Why isn't it being absorbed?"
- Explain to the students the difference between pervious and impervious surfaces.
- Ask the students what the water flows into
- Ask them if they can come up with examples of each
    - Pervious: grass, dirt
    - Impervious: streets, roads (any pavement)
- Continue spraying until pollutants end up in river
- Ask the students if they can explain why this happened
    - Answer: stormwater runoff, water flows over impervious surfaces picking up pollutants on the roads, flowing down storm drains and entering local bodies of water.

Lesson 5: Modeling a Watershed

Teacher Guideline

Overview: Students will use maps and sketches to identify local watersheds and the bodies of water they flow to.

Note to Educator: Google Earth will be used to show students a map of the watershed. After the lesson, they will complete an assignment to map their watershed.

Preparation Materials

- Handout

Warm Up

1. Ask if anyone lives in a watershed. Explain that everyone lives in a watershed once the class has a chance to answer.
2. Show ***Dr. Drain the Rain Brain Watershed 101 Video.*** This video is easily found on youtube.com by searching "Dr. Drain the Rain Brain Watershed 101".
3. Write the word watershed on the board and brainstorm possible definitions of a watershed.
4. Once everyone has a chance to give input, explain that a watershed is an area or ridge of land that separates water flowing to a common body of water.

Classroom Instruction

1. Open Google Earth on a projector or on student electronic devices and explain that (insert community) has its own watershed.
2. Ask students to share what body of water in the community they would like to look at first and type it into Google Earth.
3. Explore the geography of the community and show students the different bodies of water that lead into larger bodies of water in the community.
4. Explain that water flows from higher to lower elevation, using a topographic map to show how rivers and streams flow in the community.
5. Explore various locations of different climates and landmarks to show the difference in watersheds.

Homework assignment: Draw a map of your neighborhood's watershed, starting at your house. Sketch the path of sanitary sewer systems in your neighborhood.

Extra involvement: Contact your local Town Engineer and DPW representatives to give a presentation on Geographic Information System (GIS) mapping and to talk about water as a career.

Evaluate

Create a Google Form or a quick type of survey to quickly evaluate if the students comprehended the lesson taught.

Lesson 6: Impervious vs. Pervious Surfaces

Teacher Guideline

Preparation Materials

- 2 Clear Paint Pans
- Enough Soil to Cover Paint Pan
- 2 8 oz. Cups of Water

List of Example Pollutants

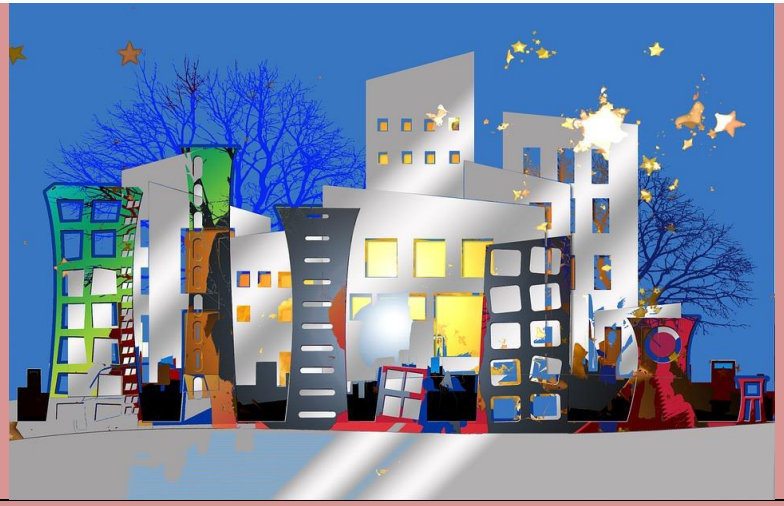
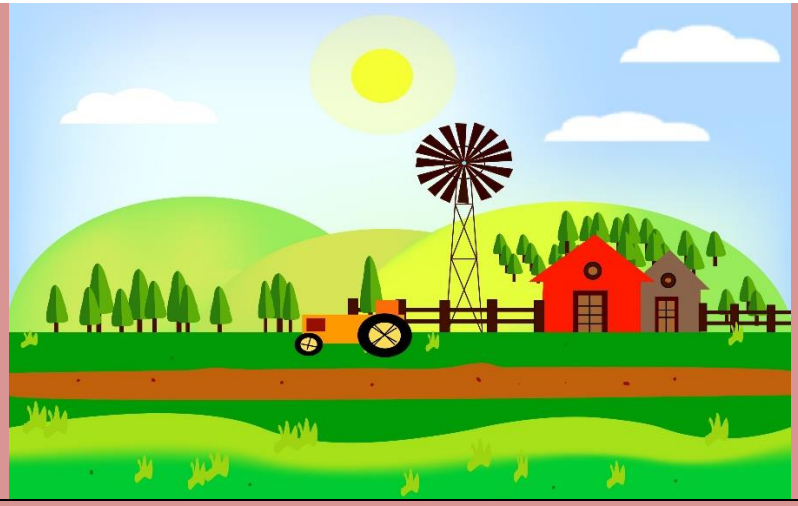
- Salt, sand
- Animal waste
- Fertilizer
- Oil, gas
- Garbage (Cigarettes, wrappers, etc...)

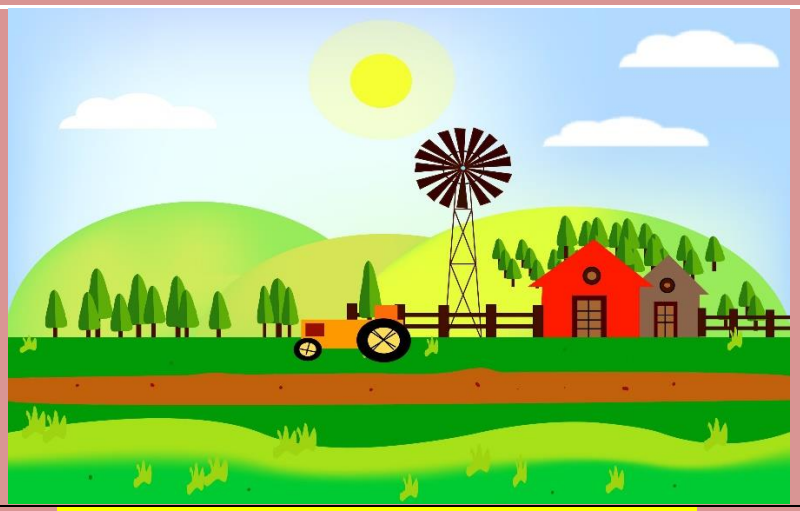
Overview: Urban and Rural environments have different effects on stormwater runoff, a main factor being the increased impervious surface in an urban environment.

Note to Educator: Acting as a facilitator, force the students to derive the essential questions by asking triggering questions.

Instruction:

- First break the students into groups of 3-5.
- Show ***Dr. Drain the Rain Brain Stormwater 101 Video.*** This video is easily found on youtube.com by searching "Dr. Drain the Rain Brain Stormwater 101".
- Have two clear paint pans to demonstrate the difference between impervious and pervious surfaces (This can also be done in groups of 4). Cover one paint pan with soil, and the other with saran wrap. Ask the students what they think each pan represents. Now have a student come to the front of the class and pour 8 oz. of water on the top side of each pan. Ask a driving question of in which environment the water reached the bottom of the pan first. Why? (Explain to the students that these two pans represent different environments, one being a rural environment and one being an urban environment. The saran wrapped pan is the urban environment with a very high percentage of impervious surfaces. The soil pan represents a rural environment where water can infiltrate the ground.)
- Show the students two photos on the worksheet and pass out the worksheet, one being an urban setting, another being a rural setting:
    - Have the students investigate with their group and discuss the differences of what will happen when it rains.
    - Have the groups identify various things that create an increase/decrease in stormwater runoff in each environment.
    - Have the student's think of items stormwater runoff could pick up along its way to the storm drain in an urban environment.
- Extended Learning with Extra Time:
    - Now, pull up google maps on the board (Have the students pull it up on their tablets) and look at the aerial view of your school, have each group identify an impervious area (Parking lots, roofs, streets/sidewalks, compacted clay softball/baseball fields). As each group identifies an area, using google maps calculate the area of that space (Right click, measure distance, place points on each edge of the space) have the students write this area down it will be needed later. (This step can also be done with a printed out aerial view of the school with a grid placed on top of it to manually calculate the area.)
    - Once each group has an area specific to a space in the aerial view, have them identify some pollutants that could be found in that area. Next, explain how in a typical rain storm it can rain more than an inch. Using 1 inch of rain as the event, have the students calculate how many gallons of stormwater runoff is created by their impervious area on the schools lot. (Review volume formula L*W*H, 1 ft^3 to 7.48 gallon conversion, 12 inch to 1 foot conversion)

Lesson 6 Activity		
What will happen when it rains?		
Where does all the stormwater go?		
List sources that increase or decrease stormwater runoff.		
List pollutants that rainwater could pick up.		

Lesson 6 Activity Answer Key		
What will happen when it rains?	• Water will flow from the roads, sidewalks, roofs (gutters) into storm drains	• Water will infiltrate the ground through absorption, Some water will flow on top of the grass into puddles or small ponds
Where does all the stormwater go?	• The stormwater goes into the storm drains and flows through pipes into a local body of water	• Stormwater will absorb back into the water table or flow naturally into bodies of water
List sources that increase or decrease stormwater runoff.	• Increase stormwater runoff- Sidewalks, roads, roofs, decrease in vegetation	• Decrease stormwater runoff- The open space and vegetation will allow absorption
List pollutants that rainwater could pick up.	• Water bottles, leaves, trash, salt and sand, oil and gas	• Fertilizers, paint, animal waste

Lesson 6 Extended Learning Activity

This is an example of an aerial view used in the extended learning part of the lesson. By using Google Earth find an aerial view of your own school. Screen shot this view using the snipping tool, once you have the picture place a grid table on top of the picture to do this activity manually.

Lesson 7: Best Management Practices

Teacher Guideline

Overview: Students will learn how runoff can be reduced through best management practices.

Note to Educator: Students will be given a worksheet and have to determine where best management practices can counteract pollution.

Preparation Materials

- Handout

Warm-up

1. Play video one 1 (Rain Gutter) ask the students what they see and what is happening
    a. https://www.youtube.com/watch?v=EbzLT7dR_1A
2. Now play video 2 (Rain Barrel)
    a. https://www.youtube.com/watch?v=QJdKECi1cAg
3. Ask the students again what is happening
4. Explain to the students that what they see is a rain barrel, a barrel used to collect and store rain water runoff, typically from rooftops via pipes.
5. Explain that a rain barrel is an example of a best management practice, a type of water or pollution control. The rain barrel is an example of pollution control because it collects pollutants from gutters on rooves and can be used as irrigation that naturally gets filtered in the ground. It also prevents water from turning into runoff and further flowing across impervious surfaces.

Classroom Instruction

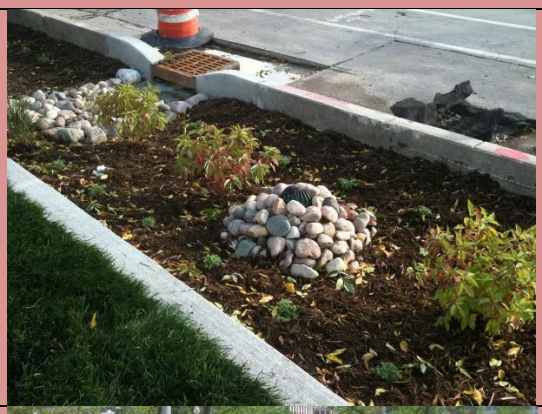
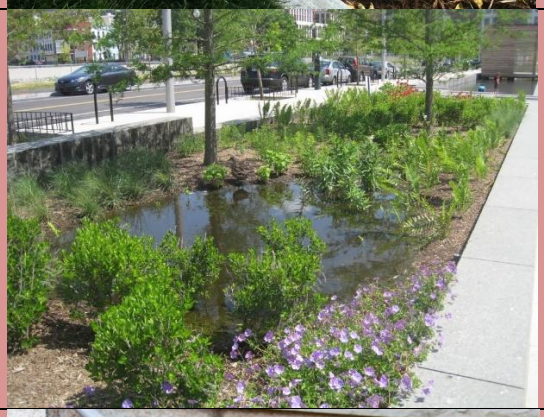
1. Ask if they can describe what best management practices are.
    a. A BMP is a type of water pollution control
2. Ask if they can think of examples of best management practices
3. Pass out the handout attached.
4. Have children work in groups of 3-4 to locate different causes of pollution
5. Bring entire class back together and ask the students to share their discoveries
6. Ask students how these pollutants enter the water
7. Introduce different pollution controls
8. Show pictures of different BMPs in BMP PowerPoint.
    a. Ask students what they think the picture is
    b. Then tell them

Evaluate

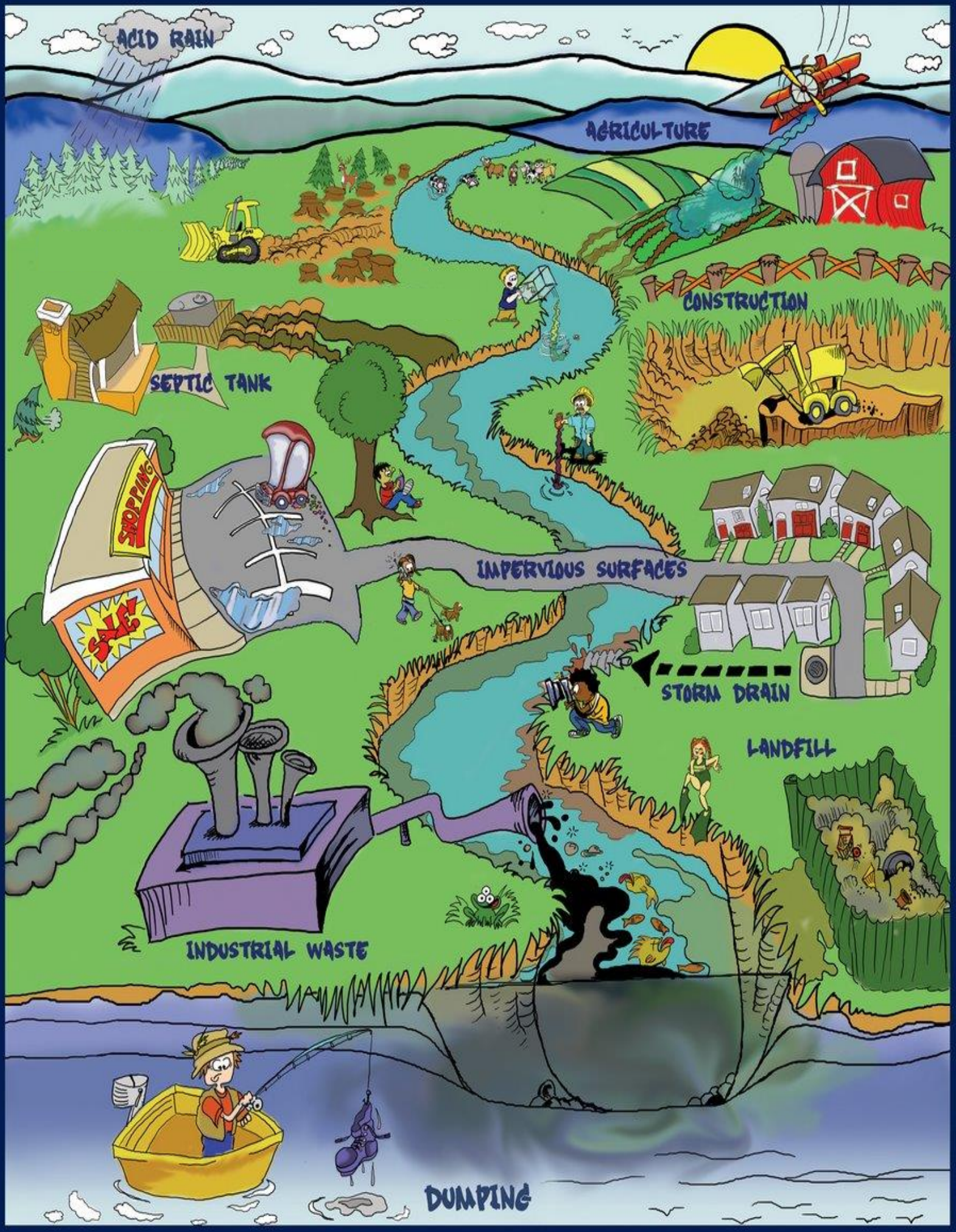
Create a Google Form or a quick type of survey to quickly evaluate if the students comprehended the lesson taught. Some example questions to include in the Exit Ticket are listed below:

- Do rain barrels collect stormwater from roofs of buildings?
- Do you think more BMP's for stormwater should be implemented?
- Which BMP for stormwater runoff would you install in a parking lot?
- Which BMP allows stormwater to soak into the soil and has plants that use some of that water?

Lesson 7: List of Best Management Practices

	Bio Swale- landscape elements designed to concentrate or remove debris and pollution out of stormwater runoff water.
	Rain Garden- is a garden of native shrubs, perennials, and flowers planted in a small depression, which is generally formed on a natural slope. It is designed to temporarily hold and soak in rain water runoff that flows from roofs, driveways, patios or lawns.
	Rain Barrel- is a water tank used to collect and store rain water runoff, typically from rooftops via pipes. Bio Swale- landscape elements designed to concentrate or remove debris and pollution out of stormwater runoff water.

	Permeable Pavers- a method of pavement that allows water to filter through.
	Signage- Making people aware of where pollutants flow too.
	Aggregate Strip-a material or structure formed from loosely compacting rocks.


ACID RAIN
AGRICULTURE
CONSTRUCTION
SEPTIC TANK
SHOPPING
SALE
IMPERVIOUS SURFACES
STORM DRAIN
LANDFILL
INDUSTRIAL WASTE
DUMPING

Lesson 8: Engineering a BMP for Stormwater

Teacher Guideline

Preparation Materials

- Printed out handouts

Overview: To combat stormwater runoff Best Management Practices are implemented. (Including rain barrels, rain gardens, swales, green roofs, silt fences, permeable pavement)

Note to Educator: Acting as a facilitator, force the students to derive the essential questions by asking triggering questions.

Instruction:

- Read the students the two scenarios on top of each handout.
- Have half the class work on scenario one and have the other work on scenario two (Pass out each handout).
- Have the students discuss some BMP's for each scenario in their groups, lead a discussion on each scenario that gives the students ideas of which BMP to design.
- Next, have the students engineer (Draw) the whole scenario including their BMP with labels of parts.
- Then using the following guiding questions have the students scientifically write about their own BMP:
    - What BMP did you choose and why?
    - How do the parts of your BMP work with one another?
    - What is the significance of the BMP's location in the scenario?
    - Explain how your BMP will help mitigate the stormwater runoff issues.

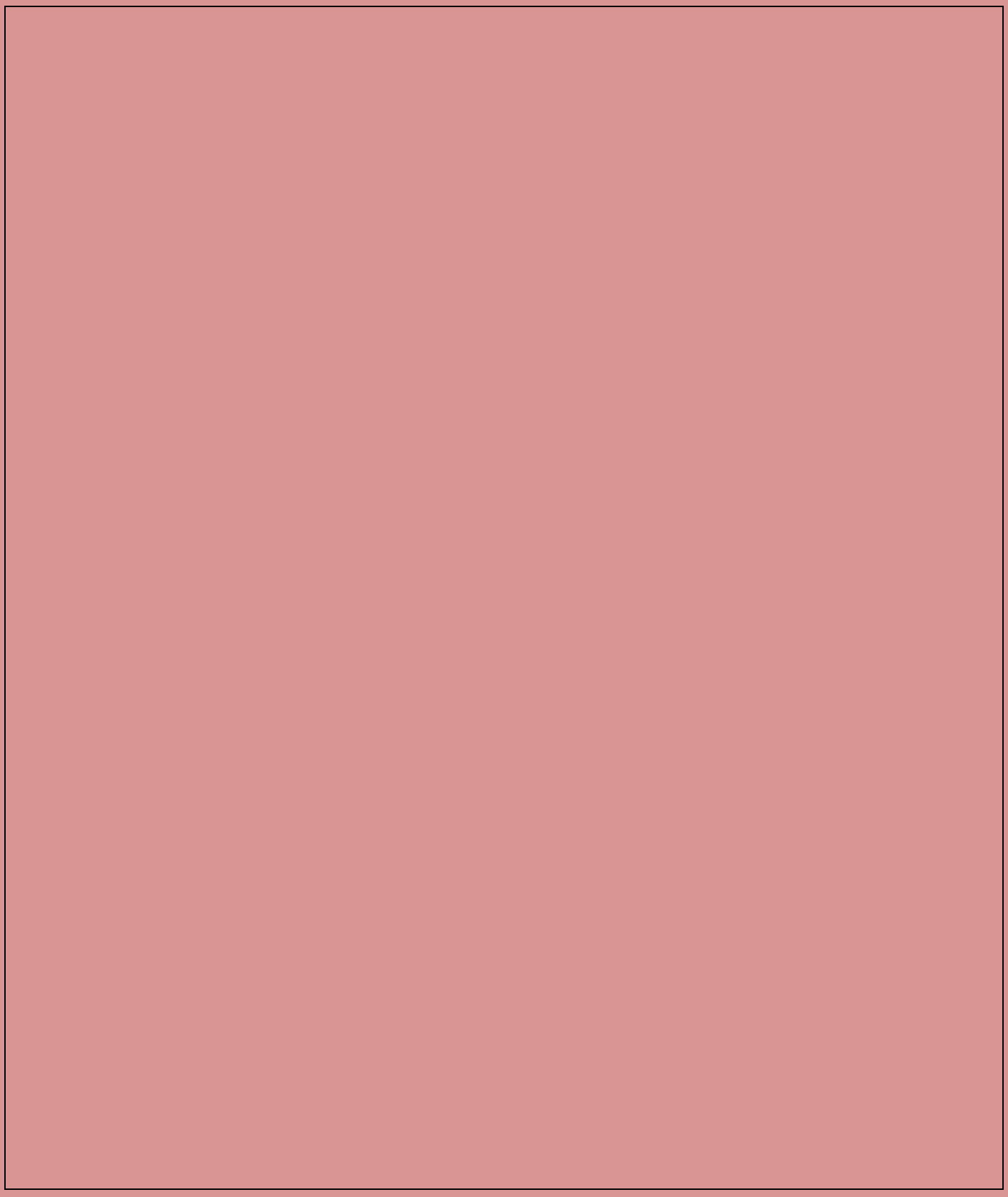
Name: _____

Lesson 8: Engineering a Best Management Practice

1. Farmer Joe owns a farm at the very top of a hill overlooking a town. This farm includes many animals, chemically treated plants, and loose soil. There was a large rainstorm last week and the stormwater runoff carried fertilizer, chemicals, animal droppings, and soil to a river nearby. Farmer Joe calls you, the Town Engineer, for help to prevent polluting the storm water runoff in future storms.

Engineer a Best Management Practice model to incorporate into a scenario. Use scientific writing to back your reasoning for your design.

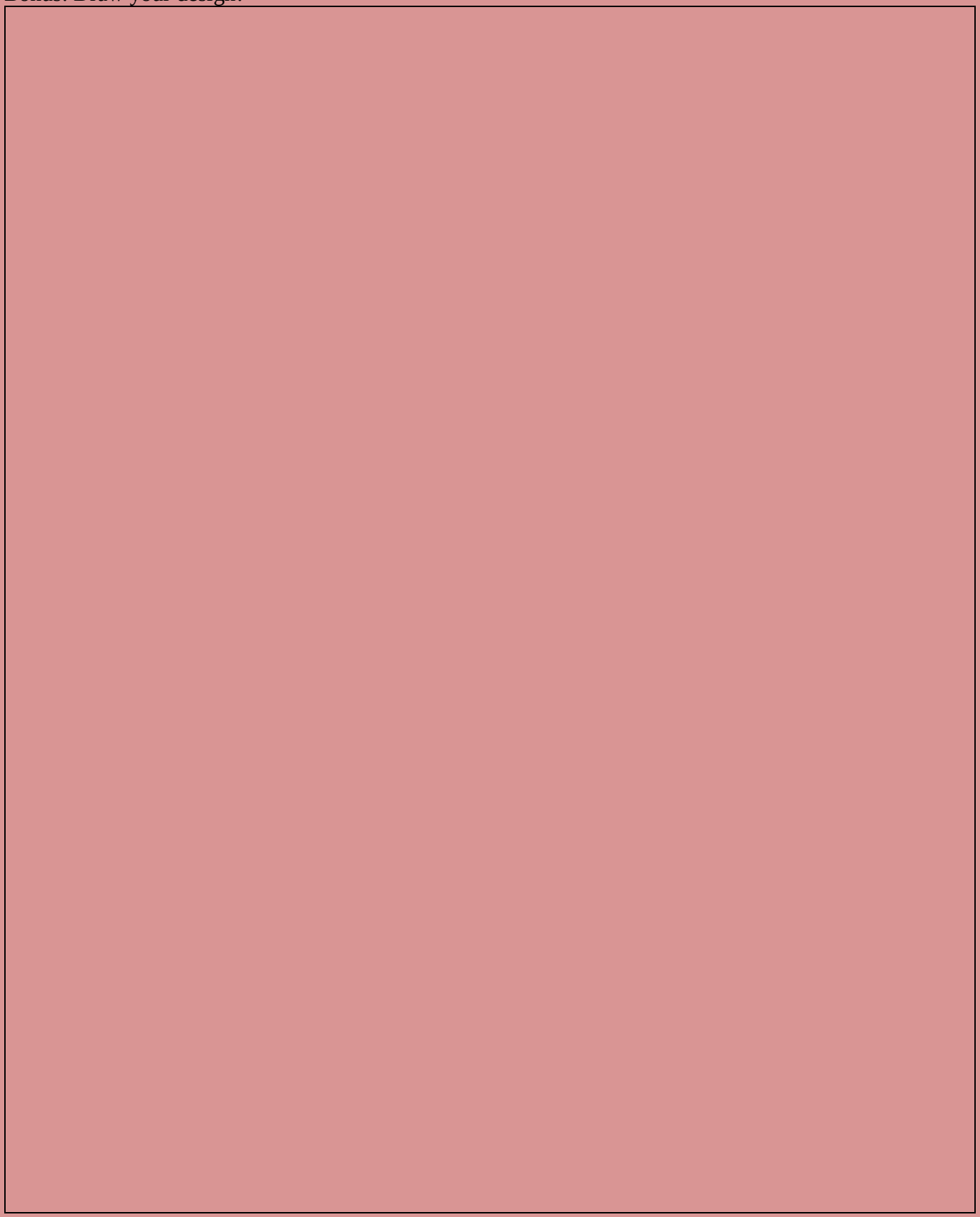
Bonus: Draw your design!



2. Lawyer Laura lives in an apartment building in the highly populated city of Boston, MA. Downhill from her apartment is an office building with a large parking lot. The entire path from Lawyer Laura's apartment to the parking lot is made of streets and sidewalks. People in the city walk their dogs without picking up after them, drop food wrappers, and do not clean up oil spills from their cars. There was a large rainstorm last week and pollutants were carried by the stormwater runoff down storm drains that drain directly to the Boston Harbor. Lawyer Laura calls you, the Town Engineer, for help to prevent polluting the storm water runoff in the future.

Engineer a BMP model to incorporate into a scenario. Use scientific writing to back your reasoning for your design.

Bonus: Draw your design!



Lesson 9: Two Separate Systems

Teacher Guideline

Preparation Materials

- Handout

Overview: Students will learn differences between sanitary sewer systems and stormwater collection systems, the parts of each system, and how they relate to one another.

Note to Educator: Students will watch a short video on a catch basin and complete a worksheet identifying characteristics of each system.

Warm-up

1. Show ***Dr. Drain the Rain Brain Catch Basin 101 Video.*** This video is easily found on youtube.com by searching "Dr. Drain the Rain Brain Catch Basin 101".
2. Ask students what this is.
    a. Reiterate that a catch basin is a reservoir or well into which surface water may drain off.

Classroom Instruction

3. Ask students if the catch basin is the same place that wastewater goes (water from your showers, sinks)
    a. It is not, they are separate!
    b. Explain that this is only for stormwater runoff and that the sludge shown is from pollutants that stormwater runoff collects before it goes down storm drains
4. Explain that a sanitary sewer is a system of underground pipes that carries sewage from bathrooms, sinks, and other plumbing components to a wastewater treatment plant where it is filtered, treated and discharged.
5. Hand out the worksheet for students to work on in groups of 3-4.
6. Have students share their answers once groups are done.

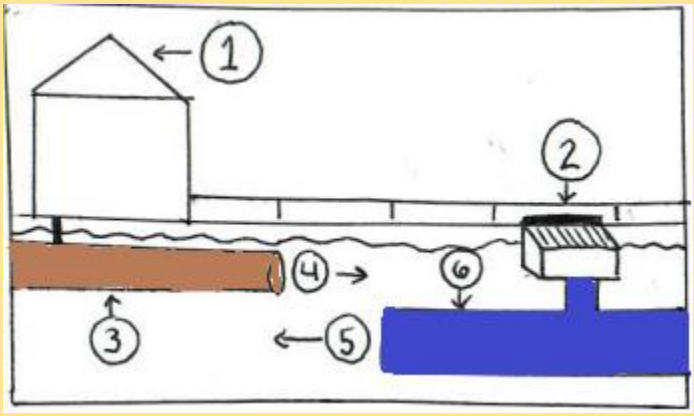
Evaluate

Create a Google Form or a quick type of survey to quickly evaluate if the students comprehended the lesson taught.

Name: _____

Lesson 9: Stormwater Systems and Sanitary Sewer Systems

Below is a picture of a stormwater system and a sanitary sewer system. The parts of each system are labeled with numbers.



1: This is where this system starts. Water flows from here to the next part of the system. What is this?

2: This is where this system starts. Water flows from here to the next part of the system. What is this?

3: What type of pipe is this? (Hint: the type of the pipe is the same as the type of the system!)

4: Where is this water going to?

5: Where is this water going to?

6: What type of pipe is this? (Hint: the type of the pipe is the same as the type of the system!)

Answer Key:

1. Household plumbing (sinks, bathroom, kitchen)
2. Catch basin/storm drain
3. Sanitary Sewer
4. Wastewater treatment plant
5. Natural water bodies
6. Stormwater

Lesson 10: Catch Basins

Teacher Guideline

Overview: Youth will use models to describe how water flows through a catch basin and to reduce pollution.

Note to Educator: Students will build a model of a catch basin, understand common pollutants in storm water runoff and how they arrive in catch basins, and explore methods to reduce pollution.

Preparation Materials

- Plastic cups
- Straws
- Green and brown food coloring
- Three brown, dry twigs
- One cup of a mix of soil, sand, leaves and pebbles
- ¼ cup vegetable oil
- 1 cup of food scraps and food wrappers
- 1 cup yard waste - grass clippings, leaves, nuts and small sticks
- 1 cup paper waste – shredded newspaper, cardboard, tissues and paper
- One copy of list of seven scenarios
- A long stick or yard stick
- Materials brought from students' homes to clean up the water

Experimental Steps:

Teacher preparation

1. Before this experiment, assign students to bring materials from home that could be used to clean polluted water. Examples include sponges, coffee filters, and screens.
2. Cut holes into the side of the plastic cups that the straws will fit snugly into.

In class:

Draw or show a picture of a catch basin to the class and ask the following questions:

Q: What is this?
A: A catch basin

Q: Where are these typically found?
A: At the point where a street gutter discharges into a sewer.

Q: What do they do?
A: Catch and retain matter that would not pass readily through the sewer.

Explain that the class will now make a catch basin.

1. Pass out one cup and two straws to each group of students.
2. Instruct students to place the straw into the holes in the cups. Explain that these straws represent the pipes of the catch basin. Have the class discuss each part of the catch basin and their function.
3. Have students take turns reading descriptions of each pollutant to the class while a student from each group should drop the "pollution" into the "catch basin".
4. Stir the contents as each pollutant is added.
5. Ask students to describe how the quality of the water changed during the activity. Ask what they think happens to each type of pollution in the real world.
6. Discuss the definition of nonpoint source pollution and explain that the pollution in the lesson are examples of nonpoint source pollution.
7. Ask students if nonpoint source pollution impacts the environment. Explain that it effects if people can drink, swim, and fish in the water and that it can be harmful to the animals and plants that live in or near water.

8. Homework assignment (Assigned Beforehand):
    a. Students should create a method that would remove pollutants from stormwater. Students should bring materials to class and test their methods in their catch basins.
    b. Award a prize or certificate for best method.
    c. Explain that the best method is to prevent pollution, not remove it afterwards.

Eight Pollutants (below)

Pollutant 1: Mix 2-3 drops of green food coloring with the water in one of the bottles. Empty this green water into the catch basin. Explain that this represents chemicals sprayed onto plants to drive away or kill insects.

Pollutant 2: Add the mix of soil, sand, leaves and pebbles. This represents soil, sand, leaves, and pebbles that are swept away by a heavy flow of water during erosion.

Pollutant 3: Empty the vegetable oil. This represents automobile oils that leak from cars or are dumped during car maintenance and are carried to local surface water bodies.

Pollutant 4: Add the paper waste. This represents trash and litter that is swept by stormwater runoff down storm drains.

Pollutant 5: Add grass clippings. This represents the waste grass clippings turn into when they are not properly disposed of and left to rot until they are swept down storm drains by stormwater runoff.

Pollutant 6: Add twigs or playdoh logs. This represents pet waste that is left on roads or lawns that stormwater runoff will wash down storm drains.

Pollutant 7: Add food scraps and food wrappers. These represent food trash and wrappers from people who do not throw away their trash.

Pollutant 8: Mix 2-3 drops of brown food coloring. This represents fertilizer and weed killer chemicals that are swept into storm drains by stormwater runoff.